BOOK OF ABSTRACTS OF

XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA

APRIL 7 - 12 , 2024 • SÃO PAULO - SP, BRAZIL

LIDAR PROCESSING PIPELINE (LPP) SCHOOL

Juan Vicente Pallotta, Silvânia Alves de Carvalho, Fabio Juliano da Silva Lopes, Alexandre Cacheffo, Eduardo Landulfo, and Henrique Melo Jorge Barbosa

During this lecture, a comprehensive overview and a hands-on demonstration of the Lidar Processing Pipeline (LPP) are described. LPP is a collaborative project between researchers from Brazil and Argentina that aims to develop fully open-source software to automatically and easily process elastic lidar signals. With just a single text file, you can configure all the data levels to be processed. It is capable of handling all the steps involved in elastic lidar analysis, from cloud screening to optical retrievals. The lecture will describe the main features of the software, and there will be a hands-on session where you can see how the software works by using sample lidar signals to demonstrate its functionality.

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PREFACE

The WLMLA is a biannual meeting, gathering Latin American researchers and students to promote local communication and international cooperation between members of the Latin-American Lidar Network (LALINET) and the international scientific community. A special aim of all workshops is to strengthen our community by sharing knowledge and planning future projects together. The event is a great opportunity for lidar and environmental companies to contact potential clients in Latin America, especially researchers working on lidar, radiometry, and other remote sensing techniques for atmospheric aerosols, gases and clouds. The XII Workshop Lidar Measurements in Latin America (WLMLA) was held this time in an on-site (face-to-face) format, from 7th to 12th April, 2024, and hosted by the Nuclear and Energy Research Institute (IPEN), Sao Paulo, Brazil, and promoted by LALINET and many national and international supporters. Scientific Sessions

GOALS and Scientific Sessions

The XII WLMLA hosted 6 Scientific Session with oral and poster presentations covering different aspects of Lidar and remote sensing applications. The sessions are:

- Remote sensing of tropospheric aerosols
- Remote sensing of gases
- Remote sensing of stratospheric aerosols
- Remote sensing of clouds
- Lidar networks
- Satellite remote sensing

School on Lidars

The School on Lidars happens just before the main event, and was devoted to train future scientists and young researchers in Latin America on laser remote sensing and related techniques. Over 100 students attended our school, from Latin-American and rest of the world countries, many of which are now pursuing they career abroad, or have become established researchers. Our school was conducted during two first day of the XII WLMLA on 7th and 8th of April, the following topics were covered:

- Lidar Processing Pipeline, theory and hands-on practices – April 7, 2024
- Stratospheric Aerosol processing – April 7, 2024
- GRASP (Generalized Retrieval of Aerosol and Surface Properties) theory and Hands-on practices – April 8, 2024.

The workshop covered the following 9 (six) sessions:

1. Troposphere
2. Stratosphere
3. Mesosphere
4. Satellite
5. Data Processing
6. Clouds
7. Networks
8. Green House Gases
9. Poster

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Dr. Pablo Ristori, CITEDEF, Argentina.

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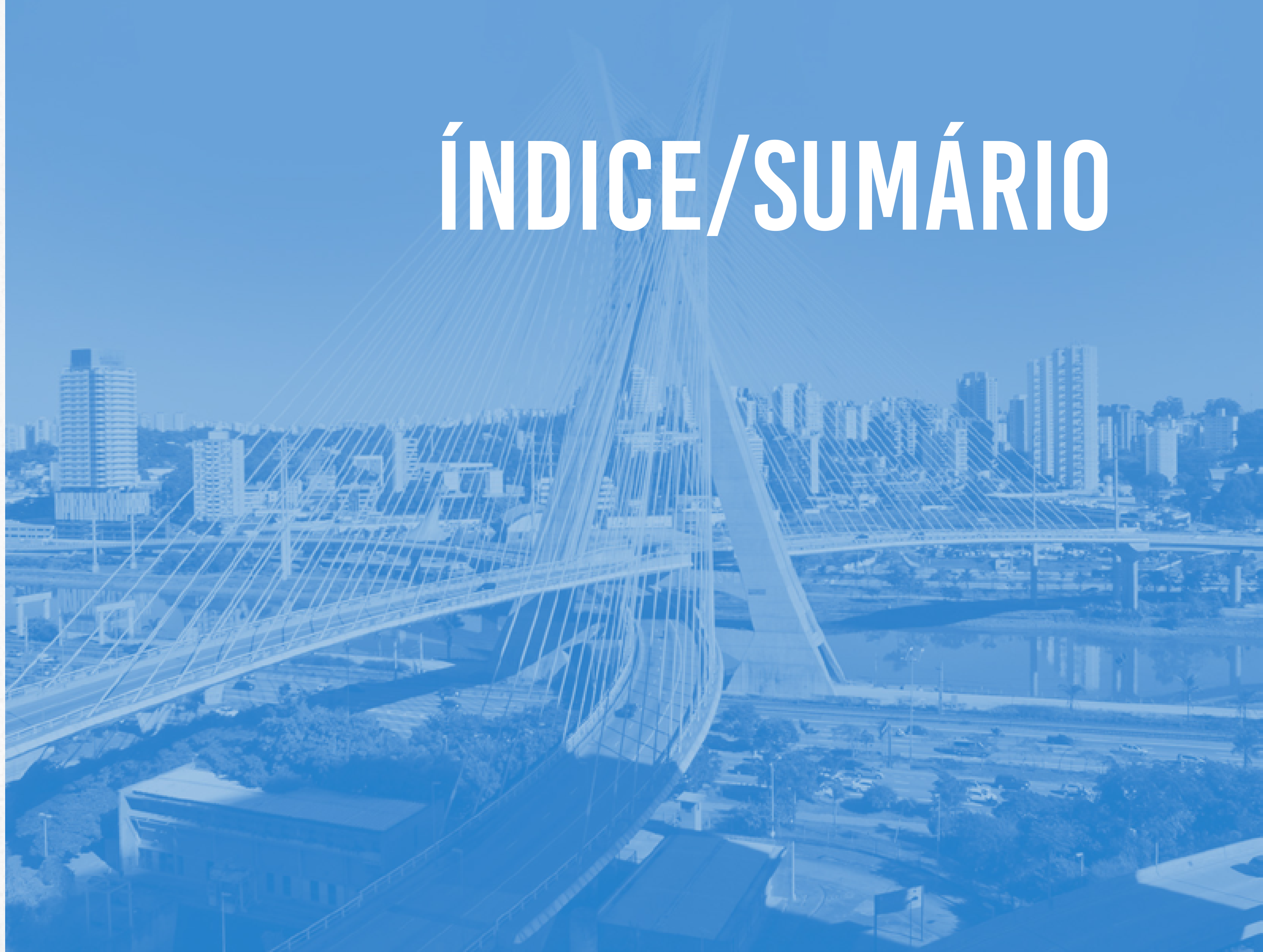

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Status and Update on the WMO GAW Aerosol Lidar Observation Network (GALION) – Judd Ellsworth Welton – OP-LN-03

Global Atmosphere Watch Science and Implementation Plan 2024-2027 and the importance of its Contributing Networks – Sergio Moreno – OP-LN-04

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INAUGURAL TALK

CHARACTERIZATION OF ATMOSPHERIC AEROSOL BASED MIE-RAMAN-FLUORESCENCE LIDAR OBSERVATIONS

I.Veselovskii[1,2], Q.Hu[2], P.Goloub[2], T.Podvin[2], M.Korenskii[1], B.Barchunov[1], N. Kasianik[1]

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Abstract

The interaction of laser with atmospheric particles involves various physical processes, including Mie scattering, polarization state changes, Raman scattering, and laser-induced fluorescence. A joint analysis of corresponding backscatters provides valuable insights into particle properties. In this presentation, we will focus on several key topics related to fluorescence lidar measurements.

Particle Classification Based on Fluorescence Measurements: Utilizing fluorescence and depolarization lidar measurements together enables the identification of main aerosol types, such as dust, smoke, pollen, and urban particles.

Analysis of Aerosol Mixture: By combining fluorescence and depolarization measurements, we can separate the contributions of dust, smoke, and urban particles to the overall backscattering coefficient.

Analysis of Depolarization Ratio of Fluorescence Backscatter: Aerosol fluorescence contaminates water vapor measurements provided by Raman lidar. Measuring the depolarization ratio of water vapor and fluorescence allows us to correct this effect.

Aerosol Fluorescence Inside Ice Clouds: Fluorescence measurements allow to estimate aerosol concentration near the cloud base and inside the ice cloud using conversion factors. These values help study ice formation in the presence of dust, pollen, and smoke particles.

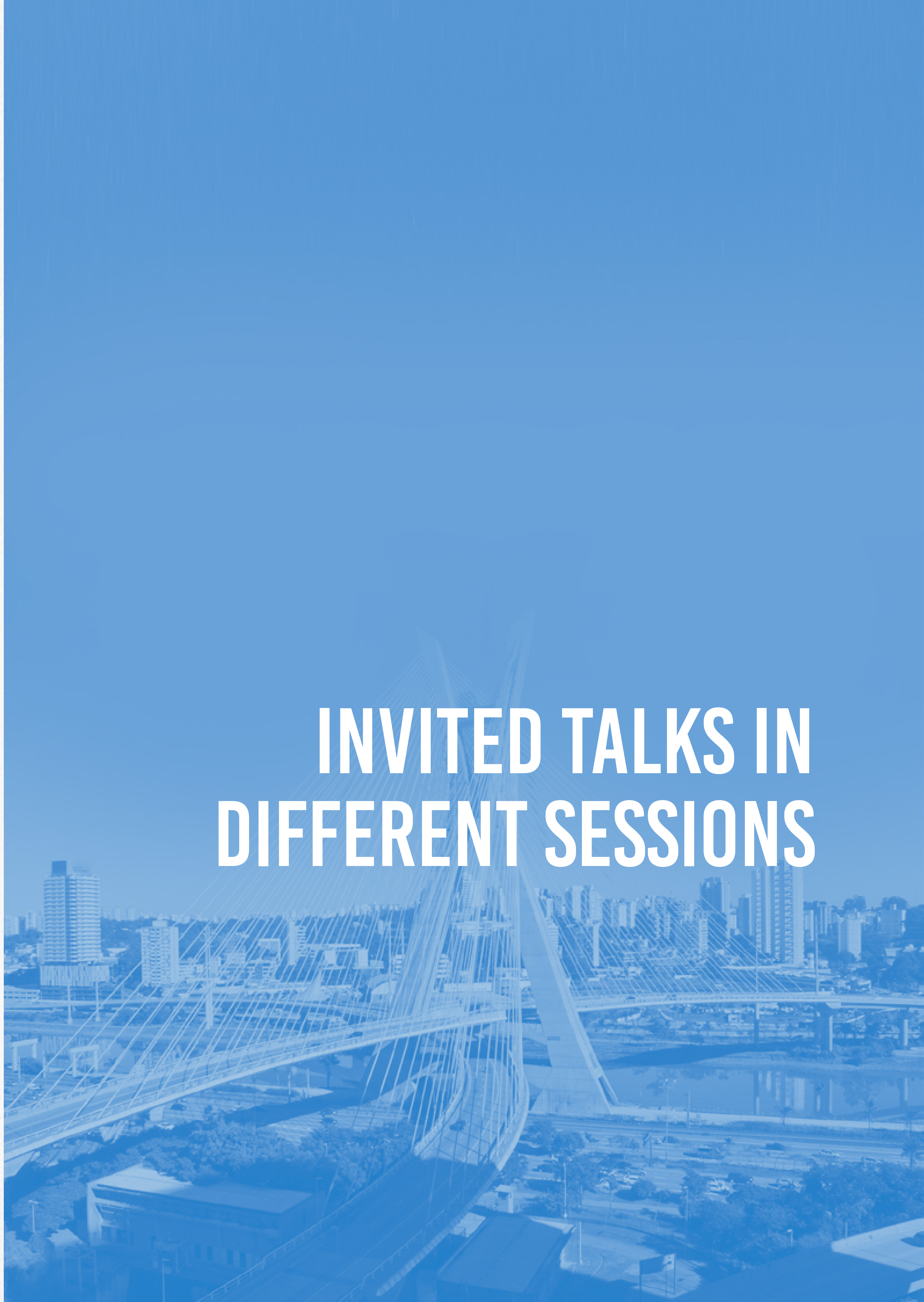
Water Uptake by Particles During Hygroscopic Growth: Water uptake increases elastic backscattering but typically does not alter chemical components. Thus, the total amount of fluorescent molecules within a particle remains unchanged. Multiwavelength and fluorescence lidar measurements synergize to estimate volume fractions of dry matter and water in the particle.

Multichannel Fluorescence Measurements: A new 5-channel fluorescence lidar system developed at the General Physics Institute, Moscow, allows for evaluating fluorescence spectra.

Keywords: lidar; aerosol; Fluorescence.

XII WLMLA Topic: Inaugural Talk

ID: Inaugural Talk



INVITED TALKS IN DIFFERENT SESSIONS

CALIPSO, AND WHAT COMES NEXT

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Abstract

Launched in April 2006, CALIPSO recently completed 17 years of on-orbit observations. Flying in formation with the CloudSat radar, CALIPSO established a baseline for the global 3D distribution and variability of aerosols and clouds and produced a wide variety of scientific results. Development of the final version of CALIPSO data products, to be released next year, is underway now. CALIPSO will soon be followed by the ATLID high spectral resolution lidar, launching on EarthCARE later this year. Space lidar observations will be continued into the next decade by the international Atmospheric Observing System (AOS). This presentation will discuss what we learned from CALIPSO, plans for the final version of CALIPSO data products, and expectations for upcoming space lidars.

Keywords: CALIPSO; Atmospheric Observing System (AOS); DAta Products.

XII WLMLA Topic: Satellite Remote Sensing

ID: Invited Talk OP-SRS-02

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STATUS AND UPDATE ON THE WMO GAW AEROSOL LIDAR OBSERVATION NETWORK (GALION)

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Abstract

The WMO Global Atmospheric Watch (GAW) Aerosol Lidar Observation Network (GALION) was formed in 2008 as a collaboration of lidar networks, and includes the Asian Dust and Aerosol Lidar Observation Network (AD-Net), the European Aerosol Research Lidar Network (EARLINET), the Latin American Lidar Network (LALINET), the Micro Pulse Lidar Network (MPLNET), and lidar sites in the Network for the Detection of Atmospheric Composition Change (NDACC). The goal of GALION was to utilize a network of networks approach to share information, best practices, develop frameworks and techniques for quality data, and eventually provide an easier method of searching for and obtaining ground-based lidar data globally. A brief overview of GALION and its network members will be provided, along with a status update. We will provide an overview of the creation of the GALION data center, and our efforts to develop interoperability between the individual lidar network data centers and the WMO Observing Systems Capability Analysis and Review tool (OSCAR) to develop a database of lidar network capabilities. The GALION data center provides a first ever ability to examine global and regional coverage gaps and address coordinated site planning for the support of field campaigns, modeling and forecasting, satellite validation, and various other scientific studies. We will also present cross-network activities relevant to harmonizing the data products and quality across GALION, including intercomparison campaigns and formal work projects. Finally, we will discuss future plans to provide standard GALION data products and application support for air quality and volcanic plume monitoring, and consideration of including ceilometer networks in GALION.

Keywords: Galion; data sharing; Lidar Network.

XII WLMLA Topic: Lidar Networks.

ID: Invited Talk OP-LN-03

NOVEL MICROLIDAR-SPECTROMETER COMBO FOR GREEN HOUSE GASES MONITORING FROM SPACE

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Abstract

A new generation of satellites using novel LiDAR concept could provide more accurate monitoring of greenhouse gas emissions, helping to improve our understanding of the role of human activity in climate change. The use of satellite constellations for this purpose has several advantages. First, it would allow for near-global coverage, providing a more complete picture of emissions than is possible with ground-based monitoring. Second, the use of LiDAR would allow for more accurate measurements, as it can provide aerosols and subvisible clouds extinction and scattering properties, and measure local winds correcting the bias & error in Radiative Transfer algorithms. This would be a valuable tool for understanding and mitigating climate change, as it would provide more accurate data on emissions from different regions and sectors. It could also help to identify areas where emissions reductions are most urgently needed. The main goal of the project is to explore an approach of deploying a network of new data sources for GHG monitoring with high temporal and special resolution. The target parameters are 50m resolution for CH_4 with 4 passes per day over the area of interest. This will enable new emissions monitoring applications to combat the climate crisis by delivering L2 level data about greenhouse gas emissions concentrations on the predefined location. The deployment of such a system would require significant investment, but the benefits would be considerable. It is therefore worth considering as part of the efforts to combat climate change. This paper will explore the state of the art in this area and discuss future directions.

Keywords: LIdar; Atmosphere; Green House Gases.

XII WLMLA Topic: Remote sensing of gases

ID: Invited Talk OP-RSG-02

PRECIPITATION-INDUCED AEROSOL REDUCTION USING MPLNET LIDAR AND MICRO-RAIN RADAR OBSERVATIONS

Simone Lolli[1], Jasper R. Lewis[2,4], Erica K. Dolinar[3], James R. Campbell[3], Ellsworth J. Welton[4]

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Abstract

This research main goal is to assess the influence of precipitation on atmospheric aerosol concentrations, employing sophisticated remote sensing techniques via the NASA Micro-Pulse Lidar Network (MPLNET) and micro-rain radar profiles at NASA Goddard Space Flight Center (GSFC). Comprehensive aerosol backscatter analysis, conducted before and after precipitation events, discloses significant alterations in central tendencies, dispersion characteristics, and morphologies of the data distributions. This analysis provides a nuanced understanding of the dynamics governing the interactions between precipitation and atmospheric aerosols, delineating the cleansing impacts of rainfall by examining changes in aerosol distribution patterns. The collated data delineate a detailed narrative of diurnal atmospheric dynamics, accentuating the complex relationship between backscattered coefficients and precipitation mechanisms.

Keywords: precipitation; aerosols; lidar.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Invited Talk OP-RSSA-01

AN EARTHCARE SENSITIVITY STUDY USING ATLID LIDAR SIMULATOR AND UPCOMING PLANS FOR THE VALIDATION OF EARTHCARE AEROSOL PRODUCTS

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Gerd-Jan van Zadelhoff[3], Kalliopi Artemis Voudouri[1,2], and Vassilis Amiridis[1]

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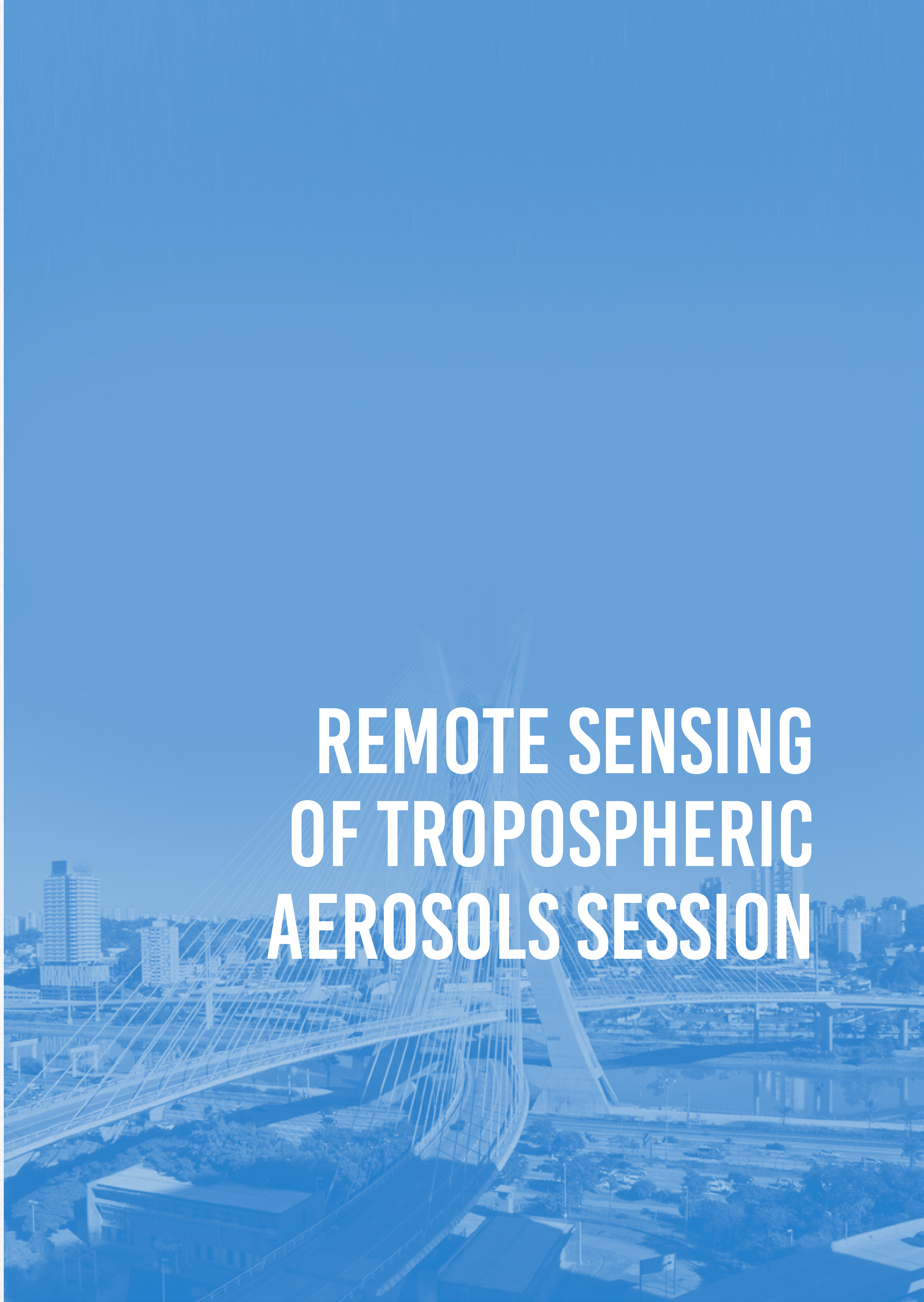
Abstract

EarthCARE is a joint mission of the European Space Agency (ESA) and the Japan Aerospace Exploration Agency for monitoring the aerosols, clouds, and precipitation, and for radiation closure studies. Onboard EarthCARE, a High Spectral Resolution Lidar operating at 355 nm will be deployed, the Atmospheric Lidar (ATLID), for providing profiles of the optical properties of aerosols and optically thin clouds. In the pre-launch phase of EarthCARE, a lidar simulator named CARDINAL Campaign Tool (CCT) has been developed aiming to provide realistic simulations of the ATLID lidar signals and the Level 1 (L1) products of the attenuated particulate backscatter, the attenuated molecular backscatter, and the attenuated cross-polar backscatter. Upon EarthCARE launch, the CCT is foreseen to be used from the cal/val teams for the optimum assessment and validation of the ATLID L1 products. In this study, measurements of eVe lidar for different aerosol layers and cirrus clouds from the ASKOS campaign (Cabo Verde, 2021/2022), are used as an input in the simulator tool to obtain realistic ATLID L1 profiles. The simulated ATLID L1 profiles will be used in the L2A processing chain to derive realistic ATLID L2A profiles. The realistic ATLID L2A profiles will be compared with the corresponding L2 eVe lidar profiles to investigate the detection sensitivity of ATLID products on real aerosol layers. eVe lidar is a combined linear/circular polarization Raman lidar operating at 355 nm for aerosol profiling and consists ESA's ground reference system for cal/val of the ESA Aeolus and EarthCARE missions. The key aspects on the exploitaion of eVe lidar measurements will also be presented. The system will undergo upgrade to enhance its capabilities for the cal/val activities of EarthCARE, retaining its combined linear/circular configuration while incorporating state-of-the-art equipment tailored for measurements on multiple scattering effects and automations to enhance the measurement procedures.

Keywords: ATLID Level 1 simulator; EarhCARE cal/val; eve lidar.

XII WLMLA Topic: Satellite remote sensing

ID: Invited Talk OP-SRS-01



RATIOS OF EXTINCTION, MASS, SURFACE AREA TO BACKSCATTER, AND MASS AND SURFACE AREA TO EXTINCTION DERIVED FROM 30 YEARS OF MID LATITUDE OPC MEASUREMENTS

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Abstract

Stratospheric aerosol measurements detailed enough to provide some geophysical quantities of interest such as aerosol number, size, surface area, and volume/mass are only fully available from in situ measurements which are limited in space and time. Remote sensing of these aerosol are, however, both global (from satellite) and more frequent (from lidar), if not as detailed. The challenge has been to use remote sensing data to infer geophysical quantities of interest and the lidar ratio extinction:backscatter. Here 30 years of in situ stratospheric aerosol measurements in the mid latitudes are used to derive: ratios of extinction (E), mass (m), and surface area (s) to backscatter (B), and mass and surface area to extinction, to allow remote sensors to more efficiently supply these geophysical quantities of interest. The results indicate that from 10-30 km m:B and m:E are nearly independent of altitude, while E:B and s:B have some altitude dependence. Still all ratios except s:B have a nearly linear relationship in log space, independent of altitude, implying these relationships can nearly be represented by a single value for the ratio. These results for: E:B, m:B, and m:E are 43, 18, 0.46. The ratios involving s cannot be so easily quantified.

Keywords: Stratospheric Aerosol; northern midlatitudes.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSTA-01

COMPREHENSIVE ANALYSIS OF CANADIAN SMOKE ENTRAINMENT IN THE GRANADA ATMOSPHERIC BOUNDARY LAYER THROUGH REMOTE SENSING AND IN-SITU TECHNIQUES

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Abstract

During wildfire events, smoke particles are released and either dispersed or transported in the atmosphere, affecting regional circulation and cloud dynamics. Within the free troposphere, aerosols can travel long distances, led by the atmospheric global circulation, and later, re-enter in the atmospheric boundary layer (ABL) far from the source. Hence, deepening the study on the long-distance aerosol entrainment in the ABL is crucial to understand such episodes.

This work presents the analysis of the unprecedented outbreak of Canadian wildfire smoke over Granada (Spain) occurred at the end of June 2023. A synergistic combination of satellite and ground-based remote sensing techniques, along with in-situ methods is used. Aerosol Absorbing Index (AAI) from Sentinel-5P is used to identify and monitor the smoke plume from the emission zone to the Iberian Peninsula. Integrated-column aerosol optical and microphysical properties are assessed using the available data from AERONET sun-photometers. Biomass burning aerosols (BBA) are detected by means of the Raman lidar ALHAMBRA. The ABL dynamics is studied based on Doppler lidar 3D-wind field. Particle absorption coefficient registered at the mountain station (2610 m asl) shows unusual black carbon concentrations and increased UV-absorbing particles, pointing to the presence of BBA. However, no significant changes are detected at the urban station (680 m asl), likely masked by the local pollution.

The tracking of the smoke plume transport and the consistency between ground-based remote sensing and in-situ measurements are clear evidence of the long-distance BBA entrainment into the Granada's ABL.

This work is supported by the Spanish national projects PID2020-120015RB-100 (grant PRE2021-098351), PID2022-142708NA-I00, PID2021-128008OB-I00, PID2020-117825GB-C21/22, and grants EQC2019-006192-P/006423-P, ATMO-ACCESS and ACTRIS-IMP No 101008004 and 871115 and Scientific Unit of Excellence: Earth System (UCE-PP2017-02)..

Keywords: Canadian Smoke; entrainment; synergy.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Oral OP-RSTA-02

EXPLORING THE RELATIONSHIP BETWEEN PLANETARY BOUNDARY LAYER HEIGHT AND PARTICULATE MATTER DYNAMICS IN SOUTHWESTERN COLOMBIA: A CASE STUDY OF SANTIAGO DE CALI

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Abstract

Santiago de Cali—located in southwest Colombia (3°27' N 3°27' N)—experiences unique meteorological conditions influenced by tropical easterly winds shaped by mountainous terrain and marked by dry-wet seasons. Furthermore, as Colombia's third largest city and a strategic economic location, Cali has been overwhelmed by rapid development associated with significant urban expansion and a rapid increase in the vehicle fleet, raising environmental concerns such as deteriorating air quality. Given its complex meteorological patterns and air pollution problems, Cali is an interesting case study to understand the intricate relationship between atmospheric dynamics and pollutants.

In this line, in 2019, the Centre for Bioinformatics and Photonics (CIBioFi) installed a ground-based LiDAR station—the only LiDAR station in southwestern Colombia—that allows measuring the dynamics of the planetary boundary layer (PBL) for the first time. By implementing PBL height (PBLH) estimation algorithms—wavelet covariance transform (WTC), Kalman filtering (KF), and deep learning methods—we observe the temporal variation of the PBLH. Then, based on the LiDAR-CIBioFi station and official environmental station measurements (during 2019-2022), we investigate the relationship between Cali's PBLH and particulate matter (PM), assessing how dry-wet seasons and wind pattern—horizontal transport, local atmospheric phenomena, and ventilation rate—affect the PBLH-PM correlation.

We find that the PBLH-PM correlation is typically negative, but its magnitude and significance can vary with wind speed-direction regimes and location. This research advances our understanding of aerosol interactions with the PBL and improves the performance of meteorological and chemical dispersion models. These findings are crucial for developing effective environmental management and air quality regulation policies in Santiago de Cali.

Keywords: planetary boundary layer height; particulate matter; tropical conditions.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Oral OP-RSTA-03

A COMPARATIVE STUDY OF THE URBAN BOUNDARY LAYER HEIGHT ESTIMATED FROM ELASTIC LIDAR DATA AND WRF MODEL IN THE METROPOLITAN REGION OF SÃO PAULO DURING THE 2023 CAMPAIGN OF THE BIOMASP+ PROJECT

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Abstract

The BIOgenic emissions, chemistry and impacts in the MetropolitAn Region of São Paulo (BIOMASP+) is a Brazil-France scientific collaboration project, coordinated by the Instituto de Astronomia, Geofísica e Ciências Atmosféricas (IAG) of University of São Paulo (USP) and the Laboratoire de Météorologie Physique (LaMP) of the Observatoire de Physique du Globe de Clermont-Ferrand (OPGC), with the main objective of characterizing urban emissions of biogenic volatile organic compounds (B-VOC) in the Metropolitan Region of São Paulo (RMSP). Knowledge of the properties of the urban boundary layer (UBL) is essential to describe the vertical distribution and dispersion mechanisms of B-VOCs in the atmosphere. This work presents two UBL height comparisons. Firstly, it was performed a comparison between the UBL height provided by two different methodologies: elastic lidar data and the Weather Research and Forecasting (WRF) model (Solar-WRF, 4 nested grids, of 27, 9, 3 and 1 km), which was centered at lidar location (23.560° S; 46.752° W). Then, the UBL height provided by the elastic lidar was compared with WRF results centered a Cotia (23. 391° S; 46.589° W), a semi-rural region, in order to evaluate the horizontal UBL height variation in the RMSP. 34 cases (days) (between April 11 and July 11, 2023) were analyzed, so that in the absence of significant meteorological disturbances, there is a significative level of agreement between the values estimated through lidar data and WRF in both regions. Such a results demonstrates as WRF can provided reliable UBL height, and in addition they reinforce the hypothesis that, in the most urbanized fraction of the RMSP, there is little spatial variability in UBL height during the convective period..

Keywords: Urban Boundary Layer Heigth; Elastic Lidar; WRF.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Oral OP-RSTA-04

NOVEL DOPPLER LIDAR TECHNIQUE FOR ASSESSING AEROSOL PARTICLE EXCHANGES IN ARID ENVIRONMENTS

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Abstract

Aerosol particles' impact on the climate is known but still entails significant uncertainties. It is vital to accurately characterize and quantify their exchanges in ecosystems (particle fluxes). In this study, the eddy covariance technique was applied to Doppler lidar profiles of vertical wind speed and the attenuated backscatter coefficient in order to determine aerosol particle fluxes within the boundary layer. The emission velocities of the exchanges were obtained through a normalization of the covariances. The instrument was deployed in dry land environments during three campaigns (BLOOM, BLOOM II and SCARCE) over two consecutive years, identifying distinct patterns and evaluating the impacts of various atmospheric conditions.

Similar emissions were measured during BLOOM and BLOOM II (0.7 ± 2.4 cm s-1 and 0.8 ± 2.9 cm s-1, respectively) in Guadiana (inland extensive olive field), despite the drier soil conditions during the second. SCARCE, conducted in Aguamarga (coastal protected ecosystem), exhibited slightly lower emissions than Guadiana, despite the drier soil conditions of the ecosystem. Significant emissions were recorded when the turbulent kinetic energy dissipation rate exceeded 10-4 m2 s-3, typically associated with high convection or wind shear. Additionally, significant horizontal wind gusts were observed to induce increases in the emission velocities.

While soil conditions were expected to impact aerosol particle fluxes over ecosystems, this characteristic was not as prominent as the atmospheric conditions, which fluctuate from day to day. The lowermost region, below 200 m asl, exhibited greater dependence on soil conditions and station. However, processes occurring above 200 m asl could be notably influenced not only by the ecosystem itself, as during transported dust outbreaks.

This work was supported by the project PID2020-117825GB-C21 and PID2020-117825GB-C22 (INTEGRATYON3) funded by MCIN/AEI/10.13039/501100011033, and by the Cost Action PROBE.

Keywords: Doppler lidar; aerosol particle fluxes; drylands.

XII WLMLA Topic: Remote sensing of tropospheric aerosols.

ID: Oral OP-RSTA-05

CONTINUOUS ATMOSPHERIC MONITORING AND AEROSOL TYPING USING CE376 DUAL-WAVELENGTH LIDAR

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Abstract

We propose to present the capabilities of our CE376 compact, autonomous, dual-wavelength, elastic depolarisation lidar for aerosol classification and continuous monitoring at different sites of interest for atmospheric studies. Dust cases recorded near the source (at Izaña Observatory, IZO, Spain) and transported at long-range (at Lille, France, ATOLL ACTRIS station). Furthermore, aerosols from Cumbre Vieja volcano eruption on La Palma Island, Spain, transported at close distance (at IZO, Spain) and at long range (at ATOLL, France) were observed and analysed at the two sites. Four new such CE376 lidars will be installed on site in 2024-2025 in the frame of OBS4CLIM project: in La Paz, Bolivia, on the Amsterdam Island, on Ivory Coast, Africa, and one on a mobile platform such as a ship or a car, offering new observations for climate studies. We will also discuss the limits of the elastic lidars and introduce the capabilities of our new CE710 research, multi-wavelength, Raman, fluorescence lidar.

Keywords: elastic lidar; aerosol typing; continuous monitoring.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: OP-RSTA-06

ADVANTAGES AND PROSPECTS OF CW RANGE-IMAGING S-LIDARS FOR REMOTE SENSING OF THE ENVIRONMENT

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Abstract

In the last years, lidars for remote sensing of the environment have found more and more applications. In the class of such lidars, continuous-wave (CW) S-lidars (S comes from Scheimpflug) have established themselves as a recent but very promising type of laser sensors. To create compact and cost-effective remote sensors, their operating principles [1-7] utilize low-power CW diode lasers, triangular range control combined with unconventional depth-of-field extension technique, and latest advances in nanophotonic technology.

The purpose of this presentation is to give a clear understanding of the principle of operation, advantages and prospects of a new class of lidars and to show what new niche S-lidars occupy among common approaches and types of environmental lidars. We consider the peculiarities of the theoretical description of the interaction "laser radiation - investigated medium"; as applied to S-lidars. The specificity of S lidar design will be considered as a combination of non-traditional approaches and modern technologies. Characteristics and features of traditional pulsed and CW modulated lidars will be compared with those of S-lidars. Finally, we will give examples of S-lidar applications, emphasizing the advantages of their use.

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Keywords: Lidar remote sensing; S-Lidar; Range imaging; Triangular range control; Depth-of-field extension technique; Position-sensitive detection; CCD/CMOS Si/InGaAs arrays.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Oral OP-RSTA-07

REMOTE SENSING OF STRATOSPHERIC AEROSOLS SESSION

LIDAR MEASUREMENTS AT REUNION ISLAND IN THE SOUTHERN TROPICS

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Abstract

Located at 21.0° South and 55.5° East, Reunion is a French island in the southern tropics of the Indian Ocean. For over 30 years, Reunion University has partnered with the French National Science Research Centre (CNRS) and Météo-France to develop atmospheric observation activities using remote sensing (active and passive) and in-situ measurements. Reunion's exceptional infrastructure and atmospheric instruments, combined with its tropical location, make it a unique observation station for developing original research topics and scientific collaborations on national and international scales. The Reunion Atmospheric Observatory is part of several atmospheric and climate monitoring networks, such as GAW, NDACC, and SHADOZ. At the European level, it is part of the ACTRIS programs for TNA, ICOS, and NORS strands.

Most of the measurements at the Reunion Observatory rely on LiDAR remote sensing systems, which measure various parameters throughout the atmosphere, in the troposphere, stratosphere, and mesosphere. This presentation will focus on the LiDAR measurements that are operational in Reunion, with an emphasis on aerosol, temperature, and ozone measurements using different techniques (Rayleigh-Mie, Raman, and DIAL).

Keywords: Lidar; Southern Tropics.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-03

BOOK OF ABSTRACTS OF XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA SÃO PAULO, BRAZIL, 2024

THE AEROSOL LIMB IMAGER – CANADA'S NEXT GENERATION OF LIMB SCATTER INSTRUMENTS

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Abstract

The interaction of clouds, aerosols and water vapour in the upper troposphere and lower stratosphere remains a large uncertainty in understanding Earth's changing climate. However, high resolution measurements of these parameters have been historically difficult, with no single system capable of monitoring the interaction. To help address this gap, Canada will launch the High altitude Aerosols, Water vapour and Clouds (HAWC) observation system as part of NASA's Atmosphere Observing System (AOS). The Aerosol Limb Imager (ALI) is one of three instruments on HAWC and will take two-dimensional multi-spectral images of Earth's limb from the ground to 45 km, providing information on aerosol extinction and microphysics. This work showcases how ALI can improve the current understanding of high-altitude aerosols both independently and in collaboration with other AOS instruments.

Keywords: clouds; aerosols and water vapour; HAWC.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-04

THE CALBUCO VOLCANIC PLUME OBSERVATIONS AND TRANSPORT IN THE SOUTHERN HEMISPHERE

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Abstract

Stratospheric aerosols affect the chemical and radiation balance of the atmosphere. It has been established that stratospheric aerosols are mostly composed of sulfuric acid droplets with some more complex characteristics in the stratosphere where organic compounds and meteoritic dust can also contribute to its composition (Froyd et al., 2009). The main sources of stratospheric sulfur are sulfur dioxide (SO2), which is being significantly enhanced after volcanic eruptions (Carn et al., 2015). In the present work, the space-time evolutions (distribution and transport) of the volcanic aerosol plume over the Southern Hemisphere following the 2015 Calbuco eruption (41.2°S, 72.4°W; Chile) are investigated.

This study involves the use of observations (ground-based, in situ aerosol counting, satellites) performed over Southern America, Southern Africa and Reunion Island.

The Calbuco aerosol plume reached the Indian Ocean one week after the eruption. The well- known technic of sun-photometry was applied on the CIMEL sun-photometer measurements performed at 6 South American and 3 African sites. Over the South African sites, the AOD anomalies induced by the spread of the plume were quite homogeneously distributed between the east and west coast. The optical characteristics of the plume near source region was consistent with a bearing-ash plume. Conversely, the South Africa sites were influenced by ash-free plume. Microphysical measurements obtained before, during and after the eruption reflecting the impact of the Calbuco eruption on the lower stratospheric aerosol content have been analyzed over the Reunion Island site. During the passage of the plume, the volcanic aerosol was characterized by an effective radius of 0.16 ±0.02 µm with a unimodal size distribution for particles above 0.2 µm diameter. The aerosol number concentration was ~20 times higher than that observed before and one year after the eruption.

The MIMOSA simulations revealed that the volcanic aerosol plume is advected eastward in the Southern Hemisphere and its latitudinal extent is clearly bounded by the subtropical barrier and the polar vortex.

Keywords: Atmospheric aerossol; ash volcanic plume; aerosols optical properties.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-05

BOOK OF ABSTRACTS OF XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA SÃO PAULO, BRAZIL, 2024

SSIRC: STRATOSPHERIC SULFUR & ITS ROLE ON CLIMATE. LIDAR DATA RESCUE AND GLOSSAC IMPROVEMENTS

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Abstract

SSiRC (Stratospheric Sulphur Processes and their role in Climate) is an established APARC (Atmospheric Processes And their Role in Climate) a core project of the WMO-WCRP (World Climate Research Programme). SSiRC goal is to foster collaboration across observational and modelling communities allowing a better understanding of the stratospheric aerosol layer and the processes governing its observed variations, in particular the ones from intense explosive volcanic eruptions The SSiRC Data Rescue Activity is aimed to recover, re-digitize and re-calibrate historic stratospheric aerosol data sets currently not publicly available, and invite scientists to contribute to this activity and to provide advice and expertise on how best to recover other incomplete long term observations of stratospheric composition. The focus so far has been oriented to lidar and searchlight datasets an important complement of space-borne measurements. So far, a total of five datasets, four from lidars and one from a searchlight, have been rescued digitized and stored at PANGAEA, a public data repository. The presentation briefly lists and describes the rescued datasets. Also are provided details of the cases when a re-calibration was conducted explaining the procedure conducted and the validation of the results. For all the rescued lidar/searchlight datasets estimates of the errors in the rescued/recalibrated aerosol extinction profiles are provided. Another current SSiRC activity is pursuing the GloSSaC (Global Space-based Stratospheric Aerosol Climatology) improvement. GloSSAC was created to support the WCRP Coupled Model Intercomparison Project Phase 6 (CMIP6). The importance of filling the gap in the SAGE II satellite aerosol extinction in the tropical stratosphere during approximated 6 months after Pinatubo is one of the focus. The existence of the gap and its temporal extension is shown using the available lidar profiles. The capabilities to fill the gap using lidar stratospheric aerosol profiles is discussed, showing the improvements that will be incorporated in GloSSaC for that period. The limitations and obstacles to conduct the proposed gap filling are discussed and the potential solutions are also shown and discussed. Incomplete long term observations of stratospheric composition. The focus so far has been oriented to lidar and searchlight datasets an important complement of space-borne measurements. So far, a total of five datasets, four from lidars and one from a searchlight, have been rescued digitized and stored at PANGAEA, a public data repository. The presentation briefly lists and describes the rescued datasets. Also are provided details of the cases when a re-calibration was conducted explaining the procedure conducted and the validation of the results. For all the rescued lidar/searchlight datasets estimates of the errors in the rescued/recalibrated aerosol extinction profiles are provided. Anther current SSiRC activity is pursuing the GloSSaC (Global Space-based Stratospheric Aerosol Climatology) improvement. GloSSAC was created to support the WCRP Coupled Model Intercomparison Project Phase 6 (CMIP6). The importance of filling the gap in the SAGE II satellite aerosol extinction in the tropical stratosphere during approximated 6 months after Pinatubo is one of the focus. The existence of the gap and its temporal extension is shown using the available lidar profiles. The capabilities to fill the gap using lidar stratospheric aerosol profiles is discussed, showing the improvements that will be incorporated in GloSSaC for that period. The limitations and

obstacles to conduct the proposed gap filling are discussed and the potential solutions are also shown and discussed.

Keywords: Stratospheric Aerosol; Remote sensing; Lidar; Searchlight.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-06

OBSERVATIONS OF DUST PLUMES LEFT BY THE ERUPTION OF THE HUNGA TONGA-HUNGA HÁ'APAI VOLCANO OVER SÃO JOSÉ DOS CAMPOS, BY CBJLSW NA-K LIDAR

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Abstract

On January 15th, 2022, a volcanic eruption occurred on the island of Hunga Tonga-Hunga Ha apai, in the South Pacific. The base of the island is part of the earthquake-prone Tonga-Kermadec arc, formed by a chain of underwater volcanoes. The volcano is submerged a few tens to hundreds of meters below sea level, but this depth did not suppress the full force of the explosion, but allowed conditions to make this eruption different, ocean water reached high altitudes.

According to NASA researchers, based on data from Geostationary satellites, GOES-17 and Himawari-8, the Hunga Tonga-Hunga Ha apai volcanic plume reached the highest altitude ever recorded for this type of phenomenon, reaching approximately 58 km. The highest previously recorded height was 35 km and belonged to the plume from the eruption of the Pinatubo volcano in the Philippines in 1991.

Soon after Tonga's eruption, researchers from around the world organized themselves to monitor the plumes it left behind. On January 17th, 2022, the Na-K LIDAR of China-Brazil Joint Laboratory for Space Weather (CBJLSW) was in full operation in São José dos Campos, measuring the mesosphere region and Tonga's plumes was not observed at this day. Unfortunalety after that the laser had some technical problems and return to operate on February 16th, showing two huge peaks at 24.5 and 26 km height. The group decided to introduce an iris in the optical path to lower the laser intensity and after that was possible to observe strong scatterings around 25 km height without signal saturation. The evolution of Tonga's plumes was monitored from March 2022 until August 2023 and the results are in good agreement with satellite data.

Keywords: Tonga plumes; Aerosols; Lidar scattering.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-07

EVALUATION OF THE IMPACTS OF STRATOSPHERIC AEROSOLS ON SÃO PAULO AFTER THE 2019-2020 WILDFIRES IN AUSTRALIA (BLACK SUMMER)

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Abstract

In August 2019, a series of wildfires erupted in Australia, later termed "Black Summer," rapidly spreading across various states and consuming a total area of approximately 103,000 square kilometers. This study employed the MSP-Lidar I, an advanced remote sensing system, to analyze aerosol disturbances in the stratosphere above São Paulo, with a focus on altitudes ranging from 15-30 km during January 2020. Through lidar measurements at three different wavelengths, we successfully identified and analyzed the vertical dispersion of aerosol plumes. By utilizing atmospheric modeling, HYSPLIT, the study traced the path of these plumes across the Pacific Ocean to São Paulo. The analysis revealed three distinct plumes at specific altitudes, all originating from the regions affected by the Australian wildfires. This research underscores the effectiveness of the MSP-Lidar I in tracking complex atmospheric phenomena and significantly enhances our understanding of the long-term dynamics of aerosol dispersion. These findings are crucial for air quality and global climate change studies, as they underscore the far-reaching transcontinental impacts of large-scale wildfires. The study highlights the urgent need for international collaboration in monitoring and mitigating the effects of such fires on global atmospheric conditions.

Keywords: stratospheric aerosol; Australia Wildfires.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-08

LIDAR MONITORING IN THE FRAME OF SAVERNET LIDAR NETWORK, ARGENTINA

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Abstract

The South American Environmental Risk Management Network (SAVER-Net) stands as a comprehensive instrumentation composed primarily of lidars, aimed at delivering real-time information essential for atmospheric hazard monitoring and effective risk management across Argentina. In this work, the current status and configuration of the network are described and shed light on the scientific collaboration within the Latin American Lidar Network (LALINET). Furthermore, the document articulates plans for the seamless operation and integration of SAVER-Net into major international collaborative endeavors and renew compromises with World Meteorological Organization about Global Aerosols Lidar Network.

Keywords: Saver Net; aerosols; lidar.

XII WLMLA Topic: Remote sensing of Stratospheric Aerosols

ID: Oral OP-RSSA-09

MESOSPHERE SESSION

AN APPROACH TO MONITORING THE STRATOSPHERIC AEROSOLS USING THE NARROW BAND CBJLW DUAL-BEAM NA-K LIDAR

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Abstract

The China-Brazil dual-beam Na-K lidar has been operating almost continuously since November 2016 in São José dos Campos (23°S, 46°W) at INPE facilities. This LIDAR comprises two narrow-band lasers set at 589.158 nm and 770.108 nm, with a pulse repetition of 50 Hz and a telescope of 1 m diameter. For mesosphere Sodium and Potassium concentration purposes, the system configuration allows 20 s and 96 m of time and height resolution, respectively. However, data for Mie scattering by aerosols in the stratosphere had not been exploited yet. Although the INPE's LIDAR group has historically contributed to monitoring the stratospheric aerosols, we could not test this new system since there was no substantial aerosol injection in the stratosphere after Pinatubo in 1991. Hence, with the Hunga Tonga-Hunga Ha'apai volcanic eruption that occurred on January 15th, 2022, we started the development of a new approach to monitor these aerosols. Because CBJLSW Na-K LIDAR has a powerful signal, we reduced the signal energy to overcome the saturation issue. This work presents all the methodologies we used to get the stratospheric aerosol scattering ratio. Monitoring the aerosols with two different wavelengths can contribute to a better understanding of the kind of particles present in the Stratosphere.

Keywords: Stratorpheric Aerosols; Resonant lidar; Hunga-Tonga volvano aerosols.

XII WLMLA Topic: Mesosphere

ID: Oral OP-M-01

SIMULTANEOUS RESPONSES OF NEUTRAL AND IONIZED ATMOSPHERE TO AM ENERGETIC PARTICLE PRECIPITATION OVER THE SAMA REGION

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Abstract

This work investigates an anomalous intensification of a sporadic potassium (K) and sodium (Na) layer during an event of energetic particle precipitation (EPP) over the South American Magnetic Anomaly (SAMA). Simultaneous data collected by the K/Na LIDAR installed over the low-latitude region at São José dos Campos – SJC - Brazil (23.1°S; 45.9°W) registered a short and anomalous intensification of the background Na and K layers during the night of 23 June 2023 at about 02:30 UT (Na and K layers). The ionograms of Cachoeira Paulista, a station very close to SJC, showed clear evidences of EPP effects on the ionosphere during the time occurrence of both Na and K layers. It was also observed that the ionosphere over this day was probably affected by the gravity waves and disturbed electric fields. The preliminary results are presented and discussed in this work.

Keywords: neutral layers; ionized layer; energetic particle precipitation.

XII WLMLA Topic: Mesosphere

ID: Oral OP-M-02

REMOTE SENSING OF CLOUDS SESSION

ON ICE CRYSTALS OF CIRRUS CLOUDS FOR LIDAR APPLICATIONS

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Abstract

The study of cirrus clouds is crucial for climate modeling and improving calculations of the planet's radiation balance. Since direct methods of studying cirrus clouds are very expensive, the primary approach is to use active and passive remote sensing methods. While passive methods are more cost-effective, only polarization lidar sensing methods can provide a comprehensive understanding of the microphysical cloud's profile.

The main challenge in interpreting lidar data lies in the absence of a theoretical solution for light scattering on ice crystal particles in cirrus clouds. This is primarily due to the dependence of the light scattering problem on numerous microphysical parameters, such as the shape, orientation, size, and concentration of particles within the cloud. Until recently, there was no available method to solve this problem. Only recently, a solution became attainable with the introduction of the physical optics method.

The report presents the database of solutions for the light scattering problem involving various ice crystal particles commonly found in cirrus clouds. These particles include hexagonal ice plates and columns, droxtals and bullets, irregular particles, and particle aggregates. The solutions were obtained for particles ranging in size from 10 up to 1000 μm, considering the main wavelengths used in lidar sensing: 0.355, 0.532, 1.064, and 1.55 μm. Special attention is given to cases where particles in the cloud reveal preferential spatial orientation. This applies to both vertically oriented lidar sensing and tilted lidar sensing.

Keywords: light scattering; ice crystals; cirrus.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-01

SIMULATION OF THE LIDAR SIGNAL WITH ANGULAR SCANNING OF CIRRUS CLOUDS CONTAINING A MIXTURE OF RANDOMLY AND QUASI-HORIZONTALLY ORIENTED CRYSTALS

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Abstract

Cirrus clouds significantly impact Earth's radiation balance and the climate. Most theoretical studies have assumed that the cirrus cloud particles are randomly oriented in space. However, vertically oriented lidars often experience "blinding" due to specular reflections from quasi-horizontally oriented plate-like ice crystals in cirrus clouds. As a result, lidars typically deviate from the vertical axis. When crystals in cirrus clouds are randomly oriented, the lidar signal is independent of the lidar's angle of inclination. In contrast, the presence of quasi-horizontally oriented crystals introduces a strong dependence on the lidar's tilt angle. Therefore, scanning lidars have become the primary tool for studying oriented crystals.

The simple model of a monodisperse cloud allows us to draw several important conclusions. First, the data allows us to estimate the microphysical parameters of a mixture of randomly oriented particles with quasi-horizontally oriented particles. This estimation is based on the difference in the depolarization ratio between the case of lidar tilt angles of 20-30° and that during vertical sensing. Second, we thoroughly investigated the law of particle orientation in space. The scientific community has traditionally used the normal distribution law to describe horizontally oriented particles. Our observations indicate that the exponential law more accurately characterizes particle behavior within the cloud. Third, given the wide variety of shapes, sizes, and orientations of crystals in cirrus clouds, extensive experimental observations with scanning polarization lidar are necessary to gather statistical information about the microphysical parameters of ice crystals. This information is vital for addressing applied problems and will also help determine how common the depolarization ratio peak near lidar tilt angles of 30° is in the overall set of observations.

Keywords: lidar; cirrus clouds; depolarization ratio.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-02

EXPLORING THE IMPACT OF CIRRUS CLOUDS IN SÃO PAULO: LONG-TERM ANALYSIS USING CALIPSO LEVEL 2 DATA

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Abstract

Cirrus clouds play a role in the greenhouse effect by interacting with the outgoing thermal radiation released by the Earth's surface. There has been a growing interest in studying these clouds in recent decades, and scientists globally have been gathering data on their physical and optical characteristics. Understanding their impact on climate is crucial for improvements in atmospheric models. The positive impact of cirrus clouds on the radiative budget is attributed to their thickness and their ability to allow shortwave solar radiation while blocking longwave radiation emitted from the surface. These clouds have extensive coverage across the globe, particularly in tropical regions, significantly influencing the climate. This study presents an extensive analysis of cirrus cloud characteristics in the São Paulo state region using data collected by the CALIPSO satellite over eleven years (2007-2017). The investigation covers various aspects of cirrus clouds, including their distribution, altitude, thickness, temperature, and optical properties. Yearly distributions reveal prevalent cirrus clouds occurring between 10 and 15 km, with little variations over the years. Monthly distributions highlight seasonal dynamics in base and top altitudes, while cirrus thickness remains relatively consistent. This study explores cirrus cloud optical depth (COD), showing variations across different thicknesses. This research aims to contribute to a deeper understanding of cirrus cloud behavior in South America and its implications for atmospheric processes.

Keywords: Cirrus Clouds; CALIPSO; CALIOP.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-03

DIURNAL AND SEASONAL CYCLE OF OPTICAL AND GEOMETRIC PROPERTIES OF CIRRUS CLOUDS IN THE AMAZON RAINFOREST

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Abstract

Cirrus clouds, crucial in regulating Earth's energy balance, pose challenges in climate modeling due to their complex interactions with solar and terrestrial radiation. To address this, our study employed 19,943 hours of lidar measurements (July 2011 - December 2017) in the Amazon rainforest. We applied an automated algorithm for detecting cloud base and top heights and a combination of the Klett and transmission methods to invert the lidar signals and derive optical properties. These were corrected for multiple scattering effects. Here we discuss the diurnal cycle, seasonality, and long-term trends of cirrus clouds' optical and geometric characteristics.

Our findings indicate a 70.9% frequency of cirrus clouds, with thin cirrus (COD 0.03-0.3) most frequent at 38.7%, followed by subvisual cirrus (COD < 0.03) at 22.3%, and opaque cirrus (COD > 0.3) at 14.1%. The study detailed cloud base/top heights (mean 13.0 ± 2.2 km / 14.5 ± 1.8 km), geometric thickness (1.50 ± 1.17 km), and optical depth (0.24 ± 0.38). Lidar ratios varied by cirrus type, with opaque cirrus showing higher values (mean 26.1 ± 8.3 sr), indicating diverse ice crystal structures.

The data revealed a strong correlation between cirrus occurrence and local convection patterns, with notable diurnal and seasonal fluctuations. The analysis also indicated higher cirrus cloud frequencies during the rainy season (79.9%) compared to the dry season (55.4%), with significant peaks in spring and fall.

Challenges were faced in detecting long-term trends due to the limitations of ground-based lidar, particularly in data quality affected by low clouds. Nevertheless, the study observed a downward trend in cirrus occurrence and variations in their optical and geometric properties, aligning with other literature but lacking statistical significance.

This research provides critical insights into the behavior of cirrus clouds in tropical forests, offering contributions to climate prediction models.

Keywords: Amazon; Cirrus clouds; Optical properties.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-04

AEROSOLS AND CLOUD RESEARCH WITH LIDAR AND SYNERGY WITH OTHER INSTRUMENTS IN PUNTA ARENAS, CHILE

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Abstract

Punta Arenas is located in the southern tip of South America. This location is in the Southern Hemisphere mid-latiude, near of the Antarctic region. This is a one of the pristine site in the world, with the influence of the westerly winds comming from the Pacific Ocean. For over 30 years, University of Magallanes in collaboration of different national and international institutions and research projects has develop atmospheric observation activities using remote sensing (active and passive) and in-situ measurements. The Atmospheric Research Laboratory (LIA, acronysm in spanish for Laboratorio de Investigaciones Atmosféricas) was created in 1991 with the objective to develop these activities. One collaboration project SAVERNET funded by the japanesse goverment and one measurement campaign project DACAPO PESO conducted in collaboration with Leibniz Institute for Tropospheric Research (TROPOS) from Germany are the last two actions reinforcing the activities in the site. There are two measurements sites maintened by LIA in the region, a site in the University campus, with different remote sensing instruments and the site in a mountain with in situ measurements instruments. The combination of the exceptional pristine location, infrastructure and measurement instruments, make these two observational stations suitable for developing research topics and national and international scientific collaborations.

This presentation will focus on the raman LIDAR measurements that are operational in Punta Arenas since 2016, with an emphasis on aerosol and clouds measurements in sinergy with other instruments.

Keywords: clouds; Punta Arenas; lidar synergy with other instruments.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-05

THEORETICAL AND EXPERIMENTAL RESEARCH PROGRESS ON THE DETECTION OF CIRRUS CLOUD CHARACTERISTICS USING LIDAR

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Abstract

The lidar and radar soundings are promising devices providing active remote sensing of the cirrus clouds. Simultaneous measurement of their backscattering signals returned from the same cirrus clouds is a prospective method for retrieving the cloud microphysics, such as the size and the shape of cloud particles. All of them are related to the spectral dependence law of the cirrus cloud backscattering, which can be obtained from the color ratio and the lidar-radar ratio. A multi-wavelength (355 nm, 532 nm, and 1064 nm) lidar and a 35 Ghz radar are employed to measure the properties of cirrus clouds in Hefei City of East China. The quantities responsible for microphysics can be extracted and explained as the dimensionless values, such as the color ratio, and the lidar-radar ratio.

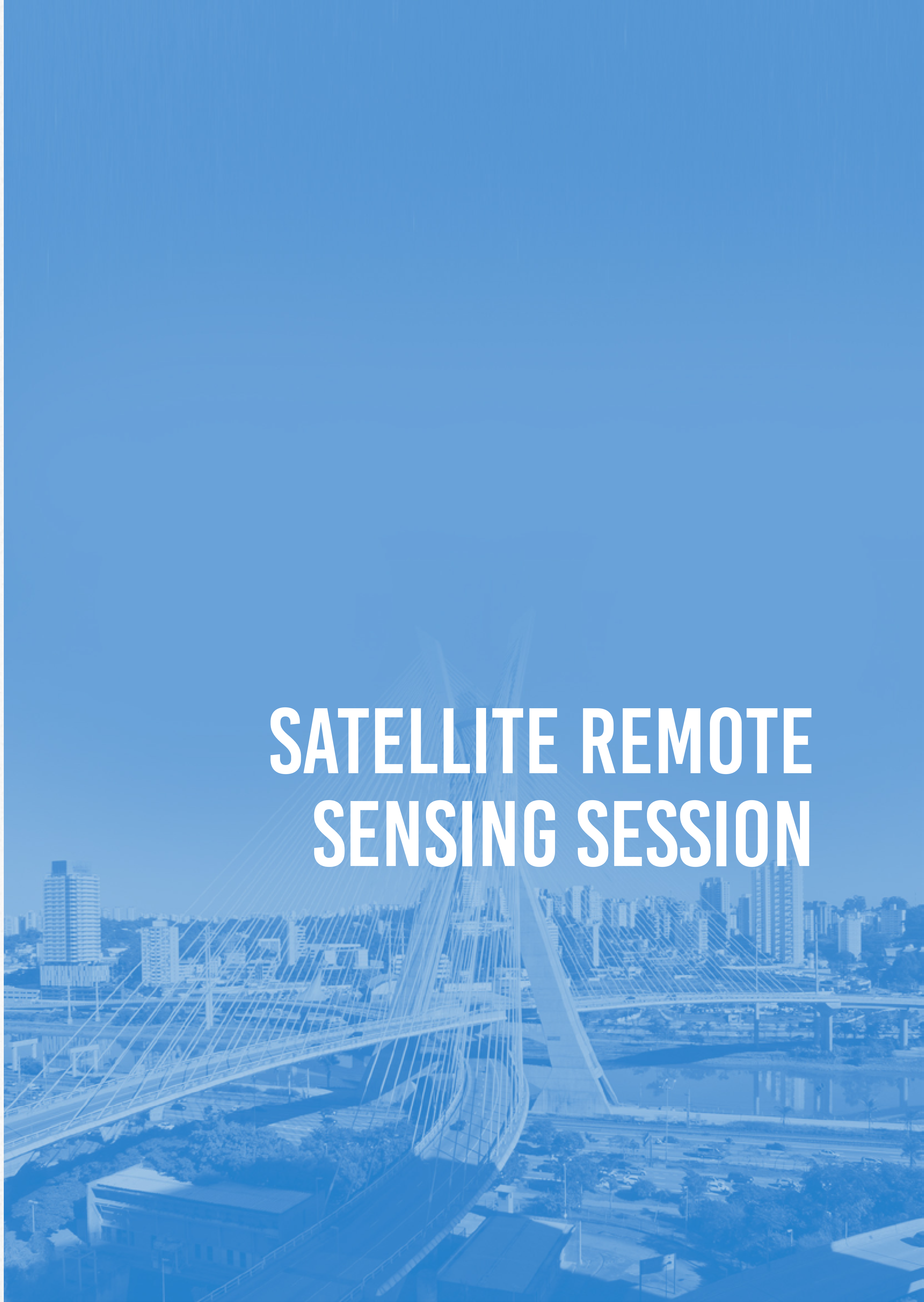
Then the characteristics for cirrus cloud during campaigns are analyzed and discussed in an experimental and theoretical point of view.

Keywords: cirrus clouds; lidar; optical properties.

XII WLMLA Topic: Remote sensing of clouds

ID: Oral OP-RSC-06

SATELLITE REMOTE SENSING SESSION



VALIDATION OF AEOLUS L2B WIND PRODUCT AT PORTO VELHO - BRAZIL

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Abstract

The Atmospheric Dynamics Mission ADM-Aeolus was successfully launched in August 2018 by the European Space Agency (ESA). The Aeolus mission carried a single instrument, the first-ever Doppler Wind Lidar (DWL) in space, called Atmospheric LAser Doppler INstrument (ALADIN). Circling the Earth in a polar sun-synchronous orbit at about 320 km altitude and a repeat cycle of 7 days, ALADIN operated at an ultraviolet (UV) wavelength of 355 nm, at a frequency of 50 Hz, providing vertical profiles of horizontal line-of-sight (HLOS) winds on a global scale. Aeolus's mission exceeded scientific expectations, initially designed for a 3-year lifetime, providing global coverage of wind profiles for almost five years. At the end of April 2023, the satellite initiated the assisted reentry process, and on July 28, 2023, it safely burned up upon reentering the Earth's atmosphere over Antarctica. In this study, we assessed the accuracy of the L2B wind products by collecting radiosonde data from the Porto Velho station in the North Region of Brazil (8.76 S, 63.91 W). The Aeolus satellite passed over the station twice weekly in two different orbits: the descending orbit at 10:04 UTC on Thursdays and the ascending orbit at 22:25 UTC on Saturdays. In this long-term validation, we focus on the descending orbit overpasses, comparing Aeolus L2B wind products and radiosondes launched daily at 12:00 UTC. Statistical validation was performed from October 2018 to March 2023, encompassing the entire period of the Aeolus mission.

Keywords: Aeolus; L2B wind product; statistical validation.

XII WLMLA Topic: Satellite remote sensing

ID: Oral OP-SRS-03

A CASE STUDY OF METEOR ENTRANCE OBSERVED ON JULY 26TH, 2018 IN THE SODIUM (NA) AND POTASSIUM (K) LAYERS AT 23º S

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Abstract

We present a case study of the nocturnal analyses of July 26th 2018, showcasing a five-element meteor trail profile. This study employs observations of meteor trails utilizing a dual-beam Na/K LIDAR system installed at Sao Jose dos Campos (23.1 °S, 45.9 °W), Brazil. This system uses two different wavelengths of 589nm and 770nm for Na and K, respectively. The vertical profiles are taken using 1000 shots which allows a time resolution of 20s and 96m height resolution. The Na/K LIDAR operating owing to the Cooperative Agreement between INPE (Brazil) and NSSC(China). Employing a rigorous computational analysis, we investigate the altitude distribution of meteor trails and evaluate their temporal variability. The study offers valuable insights into the characteristics of meteor trails. Variations in trail intensity, duration, and frequency are systematically explored, shedding light on the dynamic nature of these celestial phenomena. Furthermore, the research delves into potential correlations with external factors, such as meteor showers, solar activity, or atmospheric conditions, contributing to comprehensive understanding of meteor trail dynamics. Our findings highlight that the preponderance of most of the meteor trails for this night occurs within the altitude range of 84 to 86 kilometers at 8 AM.

Keywords: Meteor Trails; Dual-Beam LIDAR; Temporal Variability.

XII WLMLA Topic: Data processing

ID: OP-DP-01

AN APPLICATION OF THE GRASP DYNAMIC ERROR ESTIMATES: THE ASSURING QUALITY OF THE RETRIEVED DATA

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Abstract

The error estimates provide important information about the accuracy and reliability of the data that can be used with confidence in subsequent analysis to select quality filtering criteria.

The quality assurance and quality flagging are very important factors for the realistic analysis of the satellite data. In most satellite applications the quality assurance of retrieved parameters strictly relies on validation analysis and empirically derived tendencies. This happens, first of all, due to the fact that pixel errors estimates are not commonly provided.

GRASP (Generalized Retrieval of Atmosphere and Surface Properties, Dubovik et al., 2021) algorithm has the capability to provide the dynamic error estimates for the different retrieved parameters and they can be used for defining the quality assurance criteria. Certainly, the accuracy of generated error estimates themselves also has a number of limitations, therefore it is not expected that use of these estimates fully replaces the conventional quality assurance approaches but rather considered as complementary input for defining the quality flags and criteria.

In this study we describe and analyze the use of the dynamic error estimates provided by GRASP algorithm for the selection of criteria quality filters. We consider the magnitude of the estimated retrieval errors as well as the consistency of these errors across different measurements ensuring that the selected criteria effectively filter out the majority of data with unacceptable error levels without a substantial loss in the amount of data recovered. The tests were performed for the full 2008 year of PARASOL/GRASP over 19 AERONET sites. The evaluation of different filters are shown mainly based on the AOD error at 560 nm.

Keywords: error estimates; PARASOL/GRASP.

XII WLMLA Topic: Data Processing

ID: Oral OP-DP-02

DEVELOPMENT OF PORTABLE POLARIZATION LIDAR FOR AEROSOL PROFILE OBSERVATION IN NORTHERN ARGENTINA

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Abstract

In northern Argentina, biomass burning smoke and mineral dust are transported from the Amazon region and the Andes dry region, respectively, having impacts on air quality. Black carbon in smoke can heat atmosphere by absorbing solar light and thus affecting atmospheric stability. Moreover, smoke aerosols have complex properties because their optical properties and cloud condensation nucleation ability can change when mixing with hygroscopic aerosols during the transportation. Therefore comprehensive observation with lidar and radiometric observation as well as chemical analysis of aerosols are needed near the source regions of smoke and in downwind regions to understand the effect of aerosols on regional air quality and climate. The SAVER-Net lidar network were developed over Argentina and Chile in the framework of a tri-national project (FY2013–FY2017). The AERONET sun photometer was also installed in the network. There are three SAVER-Net stations in northern Argentina: Buenos Aires, Pilar Córdoba, and Tucumán, but aerosol lidar at Tucumán is no longer operational. Aiming at resumption of aerosol profile measurement at Tucumán, a portable polarization lidar has been developed. The lidar has a simple configuration with a 50 mm diameter refracting telescope and a laser head mounted on a single aluminum plate. The transmitter employs an air-cooled diode-pumped laser, which is compact and easy to handle. We conducted an intercomparison observation with SAVER-Net lidar in Buenos Aires from July to October 2023. The portable lidar will be relocated at Tucumán before biomass burning smoke season in 2024. After the installation, we can analyze aerosol component using depolarization ratio separating aerosol types into non-spherical (dust) and spherical (smoke) component, and we can further investigate absorption properties using AERONET measurement in northern Argentina.

Keywords: Lidar; Aerosols; Biomass burning smoke.

XII WLMLA Topic: Data Processing

ID: Oral OP-DP-03

DESIGN AND DEVELOPMENT OF A RAMAN LIDAR FOR CHERENKOV GAMMA ARRAY EXPERIMENTS

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Abstract

Future Cherenkov Gamma Ray experiments, will reach a sensitivity and energy resolution never obtained until now by any other high energy gamma–ray experiment. It is well known that atmospheric conditions contribute particularly in this aspect. Several Raman lidars, operating at various wavelengths will provide extinction profiles, to continuously assess the atmospheric extinction across the observed science targets. To precisely characterize extinction profiles up to altitudes of 30 km, the Raman lidars should use powerful lasers and large mirrors. Since the telescopes need to re-point frequently, the Raman lidars must therefore be able to measure the extinction profiles within short time scales (less that 100 secs) at very high efficiency. We present such a Raman Lidar in this presentation.

Keywords: Raman Lidar; CTA; HESS.

XII WLMLA Topic: Data Processing

ID: Oral OP-DP-04

BUILDING A NATIONWIDE LIDAR NETWORK WITH UNIFORM SYSTEMS AND DISTRIBUTED INFRASTRUCTURE - SOME RECOMMENDATIONS

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Abstract

The construction of a uniform and distributed lidar network over an extensive territory requires the practical resolution of a series of problems in mechanics, electricity, electronics, optoelectronics, optics, computer science, and specific communication aspects.

This stage intentionally excludes topics related to the operation of systems, which, while fundamental for maintaining network functionality over time, exceed the goal of this article. However, the different alternatives considered during the construction of the network will be mentioned without delving into their analysis.

Unlike laboratory systems, issues such as assembly, disassembly, modularity, and ease of subsystem coupling, rapid alignment and calibration of equipment with time persistence, the operation of LiDARs with minimal maintenance, and their preparation for eventual repair in the face of critical failures become design parameters of utmost importance in systems that need to be transported, installed, aligned, and connected to the monitoring network in less than a week.

This work aims to describe the practical solutions we have implemented in building the lidar network in Argentina and Chile, the challenges we have addressed during associated projects, and the problems we have identified that still need resolution.

Keywords: Lidar network; calibration; infrastructure.

XII WLMLA Topic: Data Processing

ID: Oral OP-DP-05

DATABASE PRELIMINARY URBAN INTER ANDEAN POLLUTION MONITORING RESULTS USING IN SITU AND REMOTE SENSING MEASUREMENTS: 4DAIR INITIATIVE

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Abstract

In the framework of the 4DAir-MOLIS Project [1], aimed at the estimation of urban pollution using surface, in situ, and remote sensing measurements and data assimilation, we have developed and calibrated a: 1. scanning depolarization lidar system (SDLS) with spatial and scanning resolutions of 3.75m and 1°, respectively. Our SDLS uses an Nd:YAG laser (20 Hz, 200 mJ @532 nm), a 7X beam expander, a 9.25" telescope, a laser line filter (2.02-3.72nm FWHM), a PBS, and two PMTs. Data is acquired using a LICEL TR40-16Bit-3U [2]. The mechanics and optomechanics were carefully designed and produced at the University, allowing for future cost-effective and flexible modifications; 2. a complementary local network of surface in situ measurements of CO, NO_x, NH_3, O_3, NO_2, PM1, PM2.5, PM10 and meteorologic variables georeferenced using a CanSat technology named Simple 4, these devices have a cylindrical array structure, a mass of 1,5 kg, and a volume of 1,0 liter, with a highly efficient wireless communication using Wi-Fi and LoRa WAN to send data in real time [3]; 3. a mixed device called W-bee, KBee y Q-bee for in situ UAV-based measurements of trace gases, PM2.5, meteorology and hyperspectral images at VIS (400 - 700 nm) and NIR (825 - 875 nm) bands, a mass of 1,5 kg and a volume of 1,6 liters; 4. a processing algorithm for retrieved slant column density of trace gases from MAX-DOAS measurements [4]. The challenge has been to use this air pollution data to validate numerical models like meteorological forecasting (WRF), chemical transport [5] and the WRF-Chem models [6]. In this work, we present preliminary results of scanning Lidar measurements, in situ data, the estimation of PBL [7], and the model assimilations of PM 2.5 [8] and NO_2 [9].

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Keywords: Air pollution monitoring; Remote sensing; Synergy of techniques and methods in urban atmospheric studies.

XII WLMLA Topic: Data Processing

ID: Oral OP-DP-06

REMOTE SENSING OF GASES SESSION

DEVELOPMENT OF A RAMAN LIDAR SYSTEM FOR AEROSOL AND METHANE MONITORING EMISSIONS OF INDUSTRIAL FLARES

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Abstract

Recent studies indicate that human-induced emissions of non-CO2 greenhouse gases (GHGs), particularly methane (CH4) and nitrous oxide (N2O) from agricultural activities, constitute a progressively larger share of total GHG emissions, even in the presence of stringent mitigation measures. These findings underscore the possibility that the objectives outlined in the Paris Agreement, aimed at limiting the global temperature rise to 1.5 to 2°C, may prove challenging to achieve. Within the framework of GHG reduction strategies, an additional obstacle emerges in effectively monitoring CH4 emissions from flares employed in the fossil fuel industry. Studies reveal that due to the low burning efficiency of flares, approximately 90% of methane destruction is achieved. This inefficiency translates to an estimated 4 to 10% increase in methane emissions beyond the projections, particularly noteworthy in the context of the United States. To establish a robust mitigation process for methane and greenhouse gas (GHG) emissions, the implementation of an efficient emissions monitoring system is imperative. Addressing this need, the Flare And Methane Emission System (FAMES) project is currently in progress, aiming to monitor greenhouse gas and particulate matter emissions in flares installed on FPSO (Floating Production, Storage, and Offloading) platforms. This is achieved through the utilization of a Rayleigh-Mie and Raman scattering lidar system. The primary objective of the FAMES project is to provide near-real-time monitoring of the optical properties of particulate matter and GHGs such as methane and CO2. This allows for the estimation of methane concentration, contributing to the optimization of the burning process and facilitating an assessment of operational processes in industrial production lines. In this work we intend to present the development of the conceptual design and initial quality tests of the lidar system.

Keywords: Raman Lidar; Methane; aerosol.

XII WLMLA Topic: Remote sensing of gases

ID: Oral OP-RSG-01

INVERSION OF METHANE TROPOMI DATA APPLIED TO METROPOLITAN REGION OF SÃO PAULO

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Abstract

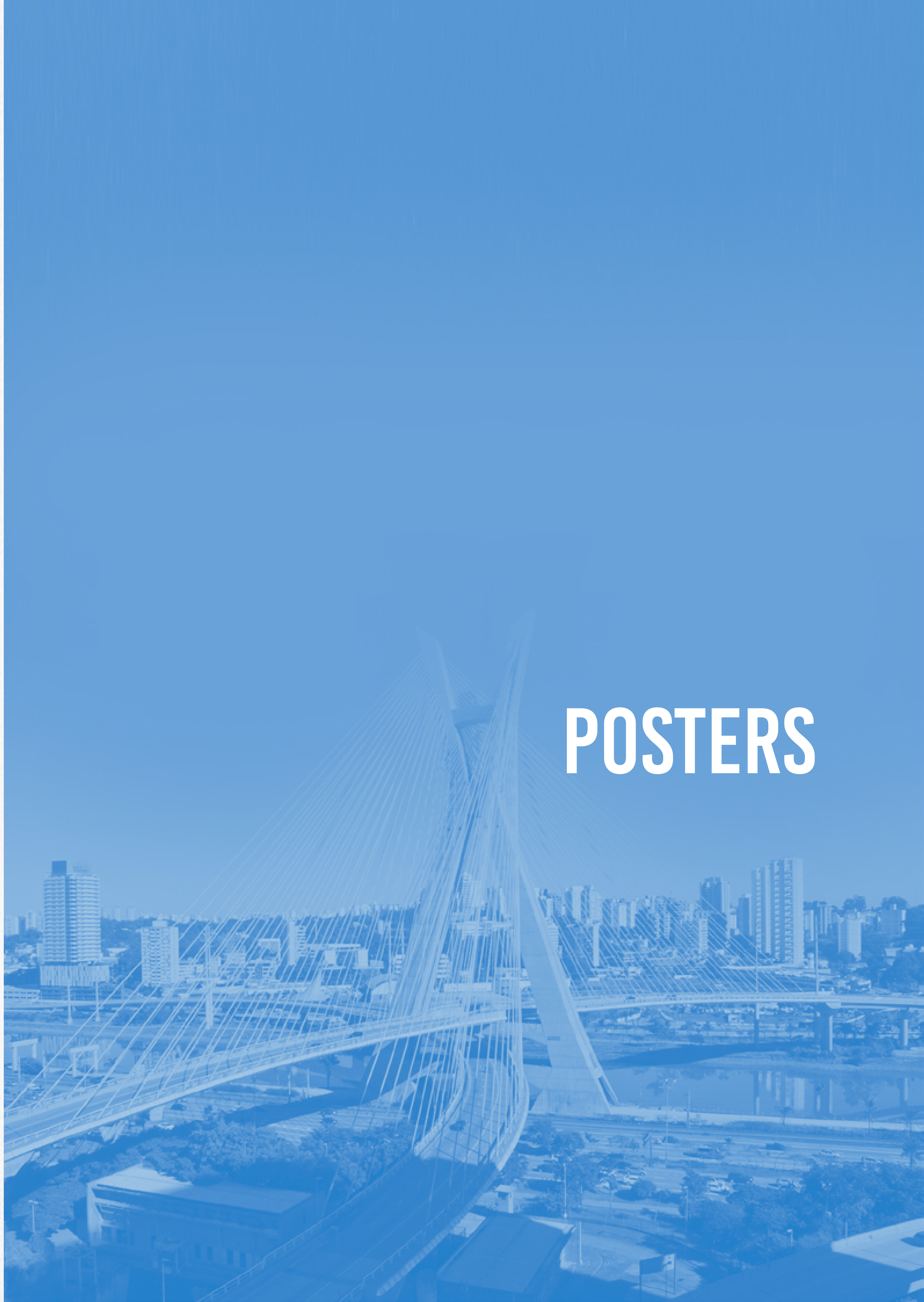
Despite having numerous sources of methane emissions, the Metropolitan Region of São Paulo (MRSP), has a deficit in data related to emissions, especially in the identification of greenhouse gas sources in this region. Thus, the use of satellite data becomes a powerful tool to obtain estimates of methane emissions. The Sentinel 5-P satellite provides daily data on methane, so the application of an inverse method of these data makes it possible to estimate methane emissions from MRSP. We use Integrated Methane Inversion (IMI), this tool makes an inversion process that utilizes a highly sophisticated research-grade algorithm performing a straightforward inversion with a grid and default prior emission estimates. Inversions were performed, in the months of August, September, and October, due to the years of 2019, 2020, and 2021. This work presents the preliminary results of this study, which proved that IMI is a promising tool to obtain emission data of the MRSP.

Keywords: Methane; Emissions; Sentinel 5-P.

XII WLMLA Topic: Remote sensing of gases

ID: OP-RSG-03

POSTERS



FIRST RESULTS OF NO2 SLANT COLUMN DENSITY RETRIEVED BY GROUND-BASED MAX-DOAS MEASUREMENTS AT ABURRÁ VALLEY (COLOMBIA)

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Abstract

The Aburrá Valley has a topography that leads to the accumulation of air pollutants. These pollutants can cause smog, acid rain, and other health issues. It is crucial to continuously measure air quality in this urban area, particularly by monitoring atmospheric aerosols and gases through in situ and remote sensing methods. As part of the 4DAir-MOLIS Project, the Airyx GmbH SkySpec Compact MAX-DOAS instrument has been installed at Universidad EAFIT in Medellín, Colombia. This instrument is the first of its kind in the Aburrá Valley and is used to measure trace gases like NO2, O3, and SO2. It consists of a telescope unit connected to a spectrometer that saves spectra data every two minutes. The spectrometer's characteristics, such as spectral coverage and resolution, have been calibrated. The study utilizes the Differential Optical Absorption Spectroscopy - DOAS technique, which separates spectral structures into narrowband and broadband components. This allows for the detection of changes in narrowband absorptions. The slant column density (DSCD) is calculated by integrating the concentration of a specific absorber along the light path. The three-stage processing algorithm developed for this work includes offset and dark current removal, wavelength calibration, selection of wavelength range, calculation of reference absorption cross section, and calculation of differential optical density and column density for the trace gas. In the upcoming will involve studying the spatial and temporal variations of trace gases like NO2, O3, and SO_2. The concentration results will be compared with in situ measurements taken at the same location. Additionally, the goal is to retrieve concentration profiles as a function of altitude and contribute to constructing a three-dimensional spatial distribution of urban pollution in the Aburrá Valley, in conjunction with Lidar measurements.

Keywords: Atmospheric trace gases; Remote sensing; Differential Optical Absorption Spectroscopy.

XII WLMLA Topic: Remote sensing of gases

ID: Poster P101

THE FIRST RESULTS OBTAINED BY A POLARIZATION LIDAR LOCATED AT LA PAZ, BOLIVIA, AND ITS RELATION TO THE CHACALTAYA (CHC) GLOBAL GAW STATION

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Abstract

The well-being of the Andean snowpack and glaciers has been a longstanding concern, given their critical role as freshwater sources and the alarming acceleration of melting attributed to climate change and pollution. The health of these vital ecosystems is under threat, posing significant challenges to the delicate balance of our environment. In response to these environmental concerns, the world's highest-elevation Global Atmosphere Watch (GAW) station was established at Mt Chacaltaya in 2011. Equipped with cutting-edge instruments, the station continuously monitors atmospheric composition, providing valuable data to better understand and address the complex challenges facing these high-altitude environments. The CHC-GAW station (16.3505 S, 68.1314 W,) is located at 5240m a.s.l. near the summit of Mount Chacaltaya in the Bolivian Andes.It is at approximately 17 km north and 1.6 km above the La Paz - El Alto metropolitan area. The air masses reaching the CHC station and the cities of La Paz and El Alto are shaped by a complex interplay of influences from the Amazon, the Altiplano plateau, the Pacific Ocean, and the local complex topography around the region. To improve our understanding of aerosol distribution in the region, a one-channel (532 nm) elastic lidar system with scanning capabilities was installed in La Paz City (3420 m asl) in 2009. Recently, the lidar system has undergone several upgrades. Notably, a second channel was added, transforming it into a polarization lidar for more comprehensive data collection. The polarization lidar can measure non-spherical aerosols separately from spherical aerosols. In this presentation, we will show the first results obtained by our polarization lidar and the challenges we are facing to understand the aerosol sources, transport mechanisms, aerosol formation and growth mechanisms, and the properties of aerosols at the metropolitan area of La Paz/ElAlto, and therefore aerosols that arrive to the CHC station.

Keywords: polarization lidar; Aerosol; Global Atmosphere Watch.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P102

INFLUENCE OF ABL DYNAMICS ON SURFACE OLEA POLLEN LEVELS IN AN OLIVE GROVE IN SOUTH-EASTERN SPAIN

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Abstract

Several research studies on pollen dispersion at short and long-distance present limitations due to a small sample size, lack of continuous measurements and of vertical resolution. It is important to explore turbulent mixing in the Atmospheric Boundary Layer (ABL) as this process might impact the transport and dispersion of bioaerosol particles, highly variable in time and space. In this context, Doppler lidar can be used to retrieve the 3D wind field and turbulent properties. This study investigates the potential links between the release/suspension of Olea pollen and micrometeorological conditions using data gathered during BLOOM and BLOOM II campaigns. They took place during the Olea Main Pollen Season (MPS) in 2022 and 2023, in the rural station GDN-UGR, an ACTRIS/AGORA facility located in an olive grove in Spain (37.91° N, 3.23° W, 370 m a.s.l.). During the campaigns, two Hirst-type volumetric suction samplers installed at 1.5 and 7.5 m a.g.l. measured pollen concentrations and a co-located Doppler lidar system retrieved variables related to the ABL dynamics such as turbulent kinetic energy (TKE) dissipation rate, wind shear and the 3D wind field in different height ranges. Spearman's correlations and Generalized Linear Models (GLM) were used to find the influence of variables related to the ABL dynamics on the Olea concentrations. It was found that the ABL dynamics variables can explain more than 40 % of the variability of pollen concentrations in some cases. Therefore, the ABL dynamics closer to the surface can explain a large variability of surface Olea pollen concentrations in areas of high pollen emission such as an olive grove. This work was supported by the project PID2020-117825GB-C21 and PID2020-117825GB-C22 funded by MCIN/AEI/10.13039/501100011033, by the Cost Action PROBE (CA18235) and by A-RNM-430-UGR20 and P20_00016 C-EXP-366-UGR23 funded by the Government of Andalusian and the European Union throughthe European Regional Development Fund (ERDF)

Keywords: Doppler lidar; pollen; ABL.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P105

BOOK OF ABSTRACTS OF XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA SÃO PAULO, BRAZIL, 2024

LONG-TERM LIDAR MEASUREMENTS OF TROPOSPHERIC WATER VAPOUR PROFILES AT THE ACTRIS AGORA STATION IN GRANADA

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Abstract

Water vapour plays a crucial role in the global radiation budget and energy transport mechanisms in the atmosphere. The monitoring of water vapour is a challenging task due to its high temporal and spatialvariability. Raman lidar technique provides water vapour profiles with high spatial and temporal resolution,using the ratio of rotational–vibrational Raman scattering intensities from water vapour (detection at 408 nm) and nitrogen molecules (detection at 387 nm). In this study, we employed simultaneous and co-located radiosonde data to calibrate water vapour measurements acquired by a Raman lidar system operated at the ACTRIS AGORA station in Granada, Spain. Water vapour observations were analysed over a period of 18 years. Different calibration approaches have been evaluated to determine the optimal calibration constant for the lidar measurements. The first approach involves calculations of a calibration constant as the ratio between the water vapour mixing ratio profiles obtained from radiosonde and the uncalibrated profiles from the Raman lidar. The second method employs calibration through linear regressions to determine the optimal least squares fits (Navas-Guzmán et al., 2014). The obtained calibration constants have been applied to retrieve the water vapour profiles from the Raman lidar system over Granada during the study period (2005-2022). A comprehensive statistical analysis was undertaken to characterize the vertical distribution of water vapour over the Granada. Additionally, the integrated profiles from the lidar were compared with the Integrated Water Vapour (IWV) measurements from different techniques including microwave radiometer, Sun photometer, and Global Navigation Satellite System (GNSS). This work was supported by Grants PID2021-128008OB-I00, PID2022-142708NA-I00 funded by MCIN/AEI/10.13039/501100011033/ FEDER "A way of making Europe".

Keywords: water vapour; Raman lidar; calibration.

XII WLMLA Topic: Remote sensing of gases

ID: Poster P106

ASSESSING AEROSOL BACKSCATTER PROFILES FROM REMOTE SENSING INSTRUMENTATION WITH BALLOON-BORNE MEASUREMENTS

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Abstract

Remote sensing techniques are essential to monitor and characterise atmospheric aerosol. Ceilometers have been proved to be a good tool to detect and monitor not only clouds, but also aerosol. In this study, we assess the vertical profiles of the aerosol backscatter coefficient (βaer) derived from CHM15K ceilometer measurements with co-located balloon-borne measurements using COBALD sondes. These sondes operate at two wavelengths and provide high precision in situ measurements of βaer. A total of 30 COBALD sondes have been used for this validation launched at the aerological station of MeteoSwiss at Payerne (Switzerland) and the Richard Assmann Observatorium (DWD, MOL-RAO), in Lindenberg, Germany. To ensure a rigorous comparison of the two techniques, different corrections were implemented, including wavelength conversion to address spectral dependence, as well as vertical and temporal interpolations. Following these corrections, a comprehensive statistical study was conducted to validate the profiles. In addition to different retrieval techniques, such as forward and backward inversions for the ceilometermeasurements, synergetic products from ceilometer and sun-photometers measurements using GRASP (General Retrieval of Aerosol and Surface Properties) algorithm have been evaluated. This synergetic approach not only enhances the spectral information of the aerosol optical properties from the ceilometer, but also enables thederivation of vertically resolved microphysical parameters.This work was supported by Grant PID2021- 128008OB-I00 funded by MCIN/AEI/10.13039/501100011033/FEDER "A way of making Europe", and the AEROMOST project (ProExcel_00204) by the Junta de Andalucía.Francisco Navas-Guzmán received funding from the Ramón y Cajal program (ref. RYC2019-027519-I) of theSpanish Ministry of Science and Innovation.

Keywords: Ceilometer; COBALD sound; GRASPpac .

XII WLMLA Topic: Remote sensing of tropospheric aerosols XII Workshop on Lidar Measurements in Latin America São Paulo, Brazil, 2024

ID: Poster P107

POLLUTANT LEVELS IN SÃO PAULO'S METROPOLITAN REGION AND THE SARS-COV-2 PANDEMIC: INTEGRATING REMOTE SENSING AND SURFACE DATA WITH ARTIFICIAL NEURAL NETWORKS APPROACHES

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Abstract

In this work, we demonstrate how the variation in vehicular traffic due to the SARS-CoV-2 pandemic and the resumption of activities affected the concentrations of some pollutants (CO, NO2, PM2.5, andvPM10) in the Metropolitan Region of São Paulo. For this purpose, we estimate the convective boundary layer (CBL) height from lidar measurements and radiosonde retrievals and calculate the ventilation coefficient, an essential parameter to evaluate the air pollutants' dispersion level. In addition, it was observed the variation of some meteorological variables (air surface temperature, humidity, and rainfall rate) to identify the occurrence of conditions that can favor pollutant dispersion. Finally, based on the time series of the pollutants previously mentioned, we created an Artificial Neural Network (ANN) to identify what will be the concentration of thesepollutants in normal conditions (no pandemic period). The results demonstrated that during the pandemic period, there was no significant change in the meteorological variables studied. However, there was a significant reduction in the concentration of pollutants whose main source is vehicular traffic (CO and NO2) and a significant increase with the resumption of activities, with the pre-pandemic level having already been reached within a few weeks. The findings here shown indicate that integrating remote sensing tools, surface data, and artificial intelligence techniques significantly enhances understanding of pollutant dynamics. Properly trained ANN algorithms offer the potential for applying this methodology in other regions.

Keywords: Remote Sensing; COVID-19; Artificial Neural Network.

XII WLMLA Topic: Data processing

ID: Poster P108

FINE AND COARSE MODE AEROSOL OPTICAL DEPTH FROM NASA/ AERONET MEASUREMENTS IN THE CENTRAL AMAZONIA

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Abstract

The Amazon rainforest, due to its vast size and immense biodiversity, behaves like a biogeochemical reactor, regulating local and global climate processes. The region's atmospheric fine and coarse mode aerosols are an important contributor to the Earth's radiative balance. However, their impacts on the radiative forcing are still an open and relevant scientific question, as these particles are significantly diverse due to their different sources and formation mechanisms. This study aims to characterize the seasonality and distribution of fine and coarse mode aerosol optical depths (AODs and their respective contribution to regional radiative forcing in central Amazonia, at the ATTO site, using NASA/AERONET (AErosol RObotic NETwork) photometer measurements. The AOD data used in the analyses considered the time period from 2016 to 2023. The results show a marked seasonal pattern for the fine and coarse mode AOD, with non-coincident maxima and minima. The fine mode peaks are of much higher magnitude than the coarse mode peaks in the historical series. In particular, at the ATTO site, the AOD of the coarse mode has two different peaks, one in the wet (May,0.06) and the other in the dry (October, 0.08) season, due to mainly long-range transport and regional biomass-burning, respectively. At fine mode, the peak is only observed during the dry season (September, 0.19), associated to biomass burning. In contrast, the minimum AOD values for the coarse and fine modes were in June (0.03) and April (0.04), respectively. It was observed that during the wet season, the coarse mode has an identical contribution to the total AOD as the fine mode. During the dry season, in contrast, the fine mode dominates. The results show different contributions and importance of each size mode in different seasons, which may have direct impacts on the radiative forcing. Future analyses will quantify the impacts of each component on the local radiative budget.

Keywords: Aerosol; Radiative balance; AERONET.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P109

ALGORITHMIC ANALYSIS OF TROPOPAUSE HEIGHT VARIABILITY IN SÃO PAULO UTILIZING RADIOSONDE DATA

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Abstract

The tropopause, a fundamental boundary between the troposphere and stratosphere, serves as a crucial indicator of atmospheric stability, influencing the distribution of key trace gases. This paper offers a comprehensive decade-long analysis (2013-2023) of tropopause height variations over São Paulo, examining two distinct definitions: the Cold Point Tropopause (CPT) and the Lapse Rate Tropopause (LRT).

Utilizing Radiosonde data to capture vertical profiles of temperature and pressure, our algorithm calculates both CPT and LRT, illustrating their evolution over time. This analysis enables the exploration of seasonal, interannual, and long-term trends, providing valuable insights into the region's atmospheric stability and potential correlations between tropopause variations and significant meteorological events.

The results underscore the algorithm's efficiency in extracting tropopause heights from radiosonde data,

elucidating the strengths and limitations of both CPT and LRT definitions. Additionally, the findings shed light on the region's climate patterns, offering a foundation for future atmospheric sciences and climate research.

Keywords: tropopause height; radiosonde; algorithm.

XII WLMLA Topic: Data processing

ID: Poster P110

EVALUATION OF BIOGENIC AEROSOLS FORMATION AT PANTANAL WETLAND

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Abstract

Atmospheric aerosols are defined as solid or liquid particles released either by natural sources, such as sea waves, living organisms, and other natural activities, or by anthropogenic sources, including the burning of biomass, fossil fuels and heavy metal industrial emission. These particles remain suspended in the atmosphere until they are deposited through various processes. Aerosols exhibit distinct characteristics depending on their emission source and participate in reactions with the gaseous constituents of the atmosphere (Seinfeld & Pandis, 2006). The contemporary interest in characterizing aerosols under environmental conditions aims to elucidate issues related to their formation (Santos et al., 2021). One of the main sources of uncertainty in climate models lies in the microphysical parameters of aerosols, notably their size, composition, and structure, which govern their optical properties (Bzdek, Reid, & Cotterell, 2020). The aerosol sampling methodology allows for the verification of changes associated with the aging of these particles in the atmosphere through highly sensitive measurements. The objective is to infer this kinetics by collecting aerosols during their "early stages" following precipitation episodes at short intervals, to monitor changes in the surface and electronic structure. To this end, XPS, XANES, and EXAFS synchrotron-based techniques will be used on aerosol samples (Ouf et al., 2016) throughout the evolutionary process of these particles. The results obtained have the potential to directly contribute to the understanding of climate change, cloud formation, and human health. Furthermore, we intend to integrate these results with micrometeorological data to understand the effects of aerosols on precision agriculture, combining them with micrometeorological modeling based on fixed stations.

Keywords: aerosols; synchrotron; sample holder, formation kinetic.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P111

FOUR YEARS OF ATMOSPHERIC BOUNDARY LAYER HEIGHT RETRIEVALS ON GLOBAL SCALE USING COSMIC-2 SATELLITE DATA

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Abstract

Satellite data are useful for global scale studies due to their spatial coverage. Particularly, COSMIC-2 mission makes use of the radio-occultation technique to monitor the atmosphere. Since October 2019, it has provided more than 4000 high-quality profiles of meteorological variables such as temperature, pressure, humidity, and refractivity. This work aims to study the atmospheric boundary layer height (ABLH) from COSMIC-2 refractivity data over the spatial domain ±45°, attempting to improve the current ABLH identification algorithms and analyzing the spatial and seasonal distribution. By means of a validation analysis involving different methodologies, the optimal ABLH is based on the lowest refractivity gradient negative peak whose magnitude is at least /100 times the magnitude of the minimum refractivity gradient, where is a fit parameter representing the minimum peak strength relative to the refractivity gradient absolute minimum. Different values were retrieved depending on the moment of the day and the underlying surface. Results evince a clear relationship between ABLH and several parameters, led by surface type and latitude, apart from season. ABLHs tends to be higher over the oceans, but extreme values are reached over southern tropical latitudes in Africa and South America during boreal summer. Lowest ABLHs usually occur over continental equatorial latitudes, western zones of continents and the intertropical convergence zone. Seasonal behavior is principally noticeable over land (weaker over oceans). In intertropical latitudes (±30o), ABLHs are generally greater (lower) during the local winter (summer) season. This work was supported by the project PID2020-117825GB-C21 and PID2020-117825GB-C22 funded by MCIN/AEI/10.13039/501100011033, by EC under the project IBERIA (grant 101008004) and by projects P20_00016 C EXP 366 UGR23 and PP2022.PP.34. Authors also acknowledge the exchange of expertise in the framework of the Cost Action PROBE.

Keywords: atmospheric boundary layer height; COSMIC-2; refractivity profile.

XII WLMLA Topic: Satellite remote sensing

ID: Poster P112

CLOUD HYDROMETEOR CLASSIFICATION BASED ON CLOUD-RADAR DOPPLER VELOCITY SPECTRA

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Abstract

Clouds, composed of hydrometeors such as supercooled liquid droplets, ice crystals and snowflakes, play a critical role in the Earth's energy budget. They pose challenges in their representation within climate models and lack a comprehensive theoretical framework. Specifically, mixed-phase clouds, characterized by the coexistence of multiple hydrometeors, are the most difficult to understand and represent. Regarding remote sensing, Doppler cloud radar allows for deriving the Doppler velocity spectrum from which information on the motion of atmospheric targets can be analyzed. Cloud radars provide the Doppler velocity spectrum from which information on the motion of atmospheric targets can be analyzed. Traditional analysis methodologies primarily focus on extracting statistical moments from the spectrum, such as mean velocity and spectral width. The current investigation presents an innovative approach designed to detect the number of modes in the Doppler velocity spectra from Doppler velocity spectra. Using an algorithm to analyze the Doppler spectrum shape. This paper introduces novel techniques for analyzing multimodal spectra. These techniques represent significant advancements in the identification of aliasing, quantification of spectrum modes, and comparison of relative hydrometeor weights.

This work is part of the Spanish national projects PID2020-120015RB-100, PID2020-117825GB-C21, PID2020-117825GB-C22, PID2021-128008OB-I00, PID2022-142708NA-I00 and infrastructure grants EQC2019-006192-P and EQC2019-006423-P founded by MCIN/AEI/10.13039/501100011033, founded by MCIN/AEI /10.13039/501100011033, ATMO-ACCESS grant agreement No 101008004, ACTRIS-IMP grant agreement No 871115, and Scientific Unit of Excellence: Earth System (UCE-PP2017-02). Sol Fernández-Carvelo received funding from the Spanish Ministry of Research and Innovation (Agencia Estatal de Investigación), grant PRE2021-098351 (co-funded by the European Social FundPlus).

Keywords: Clouds; Remote sensing; Doppler velocity spectra.

XII WLMLA Topic: Remote sensing of clouds

ID: Poster P201

INTEGRATYON3 PROJECT: INTEGRATED MONITORING OF THE COMPLEX GREENHOUSE GASES AND AEROSOL PARTICLE EXCHANGES BETWEEN ATMOSPHERE, ECOSYSTEM AND VADOSE ZONE IN DRYLANDS

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Abstract

Recent decades have seen increasing concern about climate change and air quality, and how natural and anthropogenic processes affect them. However, certain atmospheric components and mechanisms remain inadequately understood or measured, resulting in high uncertainties, as highlighted by the Fifth IPCC Assessment Report and related studies. To address these challenges and support climate change mitigation strategies, international initiatives are focusing on monitoring various components of the climate system. These efforts aim to generate standardized, high-precision, and long-term observations at different spatial levels, with ACTRIS concentrating on aerosols, clouds and trace gases, ICOS on the carbon balance, and LifeWatch-ERIC1XII Workshop on Lidar Measurements in Latin America São Paulo, Brazil, 2024on biodiversity. While members of INTEGRATYON3 actively contribute to these initiatives, a lack of clear collaboration exists among the three e-infrastructures.

Collaboration is particularly crucial in understanding surface/atmosphere exchanges. INTEGRATYON3 proposes to enhance knowledge of greenhouse gases and aerosol particle exchanges in drylands, considering atmosphere, ecosystem, and vadose zone spatial levels. The project's objectives include understanding drivers controlling CO2 emissions in the vadose zone and quantifying particle emissions and atmospheric dispersion drivers in the Atmospheric Boundary Layer ABL) over drylands.

Thus, INTEGRATYON3 combines measurements for advanced studies on CO2 and natural and anthropogenic aerosol particle emissions, focusing on land surface fluxes, ABL dynamics, and soil features. INTEGRATYON3distinguishes itself through its multidisciplinary approach, utilizing a novel experimental design that integratesinstrumentation from the three e-infrastructures. This approach improves the evaluation and understanding ofsurface/atmosphere exchanges and turbulent processes.

This work was supported by the project PID2020-117825GB-C21 and PID2020-117825GB-C22 funded by MCIN/AEI/10.13039/501100011033.

Keywords: aerosols; greenhouse gases; drylands.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P202

DISENTANGLING THE ENERGY CLOSURE IMBALANCE: AN APPROACH BASED ON DOPPLER LIDARAND EDDY COVARIANCE TECHNIQUES

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Abstract

The eddy covariance (EC) technique is widely used to measure ecosystem-atmosphere exchangesof energy as well as greenhouse gases fluxes. However, the energy balance closure (EBC) obtained by EC presents an imbalance of its components net radiation (Rn), soil heat flux (G) and sensible (H) and latent (λE) heat. In this context, the atmospheric boundary layer (ABL) directly influences the mass and energy transfers between ecosystem and atmosphere, so its characterization may help to understand the atmospheric features affecting this imbalance. This work investigates the atmospheric features and ABL turbulence in relation to the degree of EBC during May-June 2022 and April-May 2023 in an olive grove in the South-Eastern Iberian Peninsula. In order to characterize ABL dynamics in terms of zonal (u), meridional (v) and vertical (w) windspeed components, horizontal wind speed (Uh), wind shear, turbulent kinetic energy dissipation rate, vertical wind speed skewness and attenuated backscatter coefficient, a Doppler lidar (DL) was used. To estimate the EBC a four-component radiometer measured Rn, two soil moisture probes, thermocouples and heat flux plates were used to calculate G, and a three-axis sonic anemometer and an enclosed-path infrared gas analyzer λ_E and H. EC and DL data were combined at 30 min temporal resolution by applying generalized linear models at different EBC intervals and height ranges. In cases of EBC 0.75-0.90 the common statistical significant explanatory variables were the EC measured variables evapotranspiration and relative humidity together with (but except for the 70-200 m height range) U_h,w_{EC} and v_{EC}. By contrast, for EBC 0.90-1.00 there were different explanatory variables according to height ranges. This work is part of I+D+i PID2020-117825GB-C21 and PID2020-117825GB-C22 projects funded by MCIN/AEI/10.13039/501100011033/, and also the projects A-RNM-430-UGR20, B-RNM-60-UGR20, P18-RT-3629 and PP2022.PP.34.

Keywords: Doppler lidar; eddy covariance; energy balance closure.

XII WLMLA Topic: Data processing

ID: Poster P203

A NEW LOW-COST LIDAR APPROACH WITH APPLICATION IN WIND RESOURCE MEASUREMENT IN SOUTHERN PATAGONIA, ARGENTINA

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Abstract

Atmospheric aerosols play a crucial role in various atmospheric processes. Lidar Light Detection and Ranging allows vertically resolved measurements of these parameters from the interaction between aerosols and wind dynamics in the troposphere. Lidar systems can be classified into two primary categories: Time-of-Flight (ToF) and Lidar by Triangulation. ToF Lidar utilizes light in short pulses in the nanosecond range with high peak power and high-speed electronics and detector. Triangulation Lidars use determined geometric configurations between the receiver and emitter. This work introduces a new approach that uses low-cost components and a triangulation principle to characterize the wind profile through tropospheric aerosols over the southern hemisphere. In addition, to understand the limitations in range, sensitivity, and temporal and spatial resolution, the entire system equations were modeled using Python scripting. This simulation facilitated the analysis of the reception area, beam divergence, and píxel sensitivity as a function of the emission power. Advantages of the system include low energy consumption, portability, use of off-the-shelf components, and high temporal and spatial resolution. An expected implication of this design is the potential ongoing development of low-cost systems that enable the renewable energy industry to assess high-altitude wind resources in the troposphere using Lidar.

Keywords: Simulation; Image sensor; Lidar.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P204

PRELIMINARY STUDY OF GREENHOUSE GASES NEAR TO SANTOS AND SÃO SEBASTIÃO PORTS

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Abstract

In nature, the carbon biogeochemical cycle involves various compartments: atmosphere, ocean, terrestrial and marine biota, and mineral reservoirs. The major fluxes occur between atmosphere and terrestrial biota and between atmosphere and superficial ocean waters. There are some studies discussing how CO2 and CH4 increasing in the atmosphere are related to climate changes and how the increase of these gas species is linked to anthropogenic activities. In relation to the coastal systems, increasing of GHG could affect the environment in different ways and the ports can play a special role in the carbon cycle, in function of the enormous flux of ships. This study highlighting the GHG over hydrological systems near the port zones intends to know these concentrations. Santos and São Sebastião ports are located at the coast of São Paulo state. Santos Port, the major Port in Latin America due a large flow of loads. The São Sebastião Port even though to be less than Santos Port in flow of loads, it has a private terminal of oil (Petroleum terminal) that supply some refineries in the state of São Paulo by means of pipelines São Sebastião - Guararema and Santos - Sebastião. In order to obtain preliminary data of GHG (CH_4 and CO_2) about the ocean, was realized a campaign along a part of the São Paulo state measuring CH_4 and CO_2 for 27 hours using a portable Greenhouse Gas Analyzers (LGR-ICOS ™ GLA Series), which was installed on the research ship Albacora from de Oceanographic Institute of University of São Paulo including the two-port neighborhood. The results for this campaign obtained for a first time were promising with valor above the found in the literature on main for to CO_2 data were ~ 420 ppm for CO_2 near the Santos port and in São Sebastião, above 450 ppm.

Keywords: METHANE; CARBON DIOXIDE; GHG.

XII WLMLA Topic: Remote sensing of gases

ID: Poster P205

INVESTIGATING METHANE EMISSIONS FROM LANDFILL IN THE METROPOLITAN REGION OF SÃO PAULO

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Abstract

This research addresses the escalating global levels of atmospheric methane, emphasizing the critical need for understanding its sources and behavior. Landfills are identified as methane super emitters, because its rates range from 1,000 to 3,000 kg/h. Focusing on the Landfill in the district of Sao Mateus, in the city of São Paulo, the study aims to investigate the significance of landfills in the rising methane levels, emphasizing the impact of super emitters and methane hotspots. Field campaigns conducted on February 15 and April 06, 2023, utilized a portable greenhouse gas analyzer (ABB) to measure methane concentrations. Meteorological parameters from ERA5 and the AERMOD Modeling System were used for a comprehensive analysis. The results highlight elevated methane concentrations around the Landfill, emphasizing its role as a significant methane super emitter. The study underscores the importance of such analyses in understanding the impact of landfills on atmospheric methane levels.

Keywords: Methane; Landfills; Microportable greenhouse gas analyzer.

XII WLMLA Topic: Remote sensing of gases

ID: Poster P206

ASSESSMENT OF METHANE CONCENTRATIONS IN ESTUARINE REGIONS ON THE COAST OF THE STATE OF SÃO PAULO

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Abstract

We evaluated concentrations of atmospheric CH4, which is considered one of the main gases causing global warming. We observed methane concentrations in the Cananéia-Iguape estuarine system on the southern coast of the state of São Paulo, Brazil and in the Santos estuary, Baixada Santista region, coast of the state of São Paulo, Brazil. The south coast region is widely studied as it presents very well-preserved fauna and flora and thus offers an important background on natural emissions. Data acquisition was carried out by a portable gas analyzer (LGR-ICOSTM GLA131), this equipment has a high sensitivity in detecting the gases under study and was placed on board the research vessels Albacora and Alpha Delphini owned by the Institute of Oceanography at the University of São Paulo in campaigns that were carried out between 2021 and 2023 in specific periods. The concentrations observed during the exploratory campaigns in the estuaries on the coast of the State of São Paulo (Iguape Cananéia Estuarine-Lagunar Complex and Santos Estuary) behaved as described in the literature, regions with greater anthropic impact present higher values of methane concentrations in the atmosphere, low-impact regions have lower methane concentrations.

Keywords: Greenhouse gas; Wetlands; Estuaries.

XII WLMLA Topic: Remote sensing of gases

ID: Poster P207

ANALYSIS OF THE HORIZONTAL VARIABILITY OF THE ATMOSPHERIC BOUNDARY LAYER HEIGHT IN THE SÃO PAULO CITY USING CEILOMETER AND ELASTIC LIDAR DATA

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Abstract

Understanding the dynamics of the Atmospheric Boundary Layer Height (ABLH) is essential for carrying out studies on pollutant dispersion and/or air quality, since this atmospheric variable acts as a vertical limiter in the distribution of aerosols in the troposphere. Currently, ground-based remote sensing equipment elastic lidar and Doppler, microwave radiometer, etc. has been widely used to estimate the ABLH, providing results with high spatial and temporal resolution. However, such systems have low vertical representation, since they only represent a specific point. In this scenario, seeking to understand the vertical variability of the CLP in the city of São Paulo, this work presents a comparison between the ABLH estimated from data from an elastic lidar system located at IPEN (23.560° S; 46.752° W and a ceilometer, belonging to the Metroclima project (http://www.metroclima.iag.usp.br/, located in the CIENTEC park (-23.649° S; 46.623° W)). Measurements taken between 2021 and 2023, from 9 am to 6 pm, were compared, with the aim of evaluating only the convective period and also considering only the period in which the Convective Boundary layer is above the overlap of both instruments. The results demonstrate that in the absence of low clouds, the results obtained in both locations only present differences arising from the topography. This result validates some previous studies that were carried out, but with a shorter time interval. In addition, it was possible to validate the horizontal representativity of ABLH estimated from lidar/ceilometer data in non-complex regions.

Keywords: Elastic Lidar; Ceilometer; Atmospheric Boundary Layer Height.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P208

BOOK OF ABSTRACTS OF XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA SÃO PAULO, BRAZIL, 2024

A COMPARISON BETWEEN THE PLANETARY BOUNDARY LAYER HEIGHT ESTIMATED BY COSMIC-2 AND AN ELASTIC LIDAR: A CASE STUDY TO SÃO PAULO CITY

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Abstract

The Planetary Boundary Layer Height (PBLH) is one of the most important variables for studies related to pollutant dispersion, serving as an input parameter for weather forecast models and prediction of pollutant concentration and/or air quality indices. However, obtaining such a parameter is not an easy task and itis restricted to regions that have radiosoundings and/or remote sensing equipment, e.g. elastic or Doppler lidars, which, due to their high cost and the need for specialist operators, have low availability in several countries, such as Brazil, for example. Based on this scenario, the present work presents a comparison between the PBLH estimated using Constellation Observing System for Meteorology Ionosphere and Climate – 2 (COSMIC-2 satellite data and MSP-1 (an elastic lidar located at Center for Lasers and Applications – CELAP for the city of São Paulo. The results demonstrate that in situations where the PBLH is well developed and there is not low clouds, both instruments present very similar results. Based on this result, it is possible to replicate the methodology presented in this work for other regions, so that it is possible, even with a low temporal resolution, to estimate the PBLH for regions that do not have measuring instruments.

Keywords: COSMIC-2; Elastic Lidar; Atmospheric Boundary Layer Height.

XII WLMLA Topic: Data processing

ID: Poster P209

LIDAR PROCESSING PIPELINE AND SINGLE CALCULUS CHAIN RETRIEVAL COMPARISON

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Abstract

Lidar Processing Pipeline (LPP) is an ongoing open-source software project for retrieving elastic lidar signals. It is based on a fully configurable and automated algorithm capable of performing all the steps required for the analysis, from the correction of lidar signals to the retrieval of aerosol optical properties. The first results have been presented, using both synthetic and real lidar signals from different LALINET (Latin American Lidar Network) sites, which demonstrated promising results that are consistent with calibrated aerosol instrumentation. This work presents a comparison with Single Calculus Chain (SCC) using data from the São Paulo lidar station. The SCC is a well-established inversion chain from the European Aerosol Research Lidar Network (EARLINET), under the ACTRIS (Aerosol, Clouds and Trace gases Research InfraStructure Network) infrastructure. Since LPP and SCC are algorithms focused on heterogeneous lidar networks, a comparison of the usage, configuration, and automatization of both systems is provided. In addition, a retrieval comparison is conducted between the two algorithms, demonstrating good agreement between the two systems.

Keywords: lidar inversion; aerosols; Lidar Processing Pipeline.

XII WLMLA Topic: Data processing

ID: Poster P212

REMOTE SENSING OF AEROSOLS AND CLOUDS USING CL31 CEILOMETERS IN CHILEAN URBAN AND AIRPORT ENVIRONMENTS

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Abstract

This presentation shows advancements in the visualization of level 2 data from ceilometers VAISALA CL31 model, providing clouds and aerosols information. Our focus involves visualizing the backscattering signal from four strategically positioned ceilometers in major urban centers of Chile. These ceilometers were provided by the Chilean Ministry of the Environment and administered by Chilean Weather Service. Administrative negotiations are in progress to visualize data from 25 ceilometers situated in Chilean airports, expanding the scope of our aerosol and cloud analysis. These efforts are the first steps to create a network of ceilometers all connected and working together to monitor the vertical structure of aerosols and clouds in the atmosphere. This potential network will cover different latitudes and different environments from pristine to highly contaminated sites. This preliminary dataset from the first four ceilometers will facilitate in a near future a comprehensive comparison of aerosol data within city limits and in airport surroundings, allowing for correlation analyses with air quality monitoring stations providing PM10 and PM2.5 data. In the future we will be able to compare our data with satellite missions and study the latitudinal transport of aerosols and clouds.

Keywords: aerosols; clouds; ceilometer.

XII WLMLA Topic: Remote sensing of clouds

ID: Poster P213

INSTALLATION OF A LIDAR SYSTEM AT THE GEODESIC CENTER OF LATIN AMERICA

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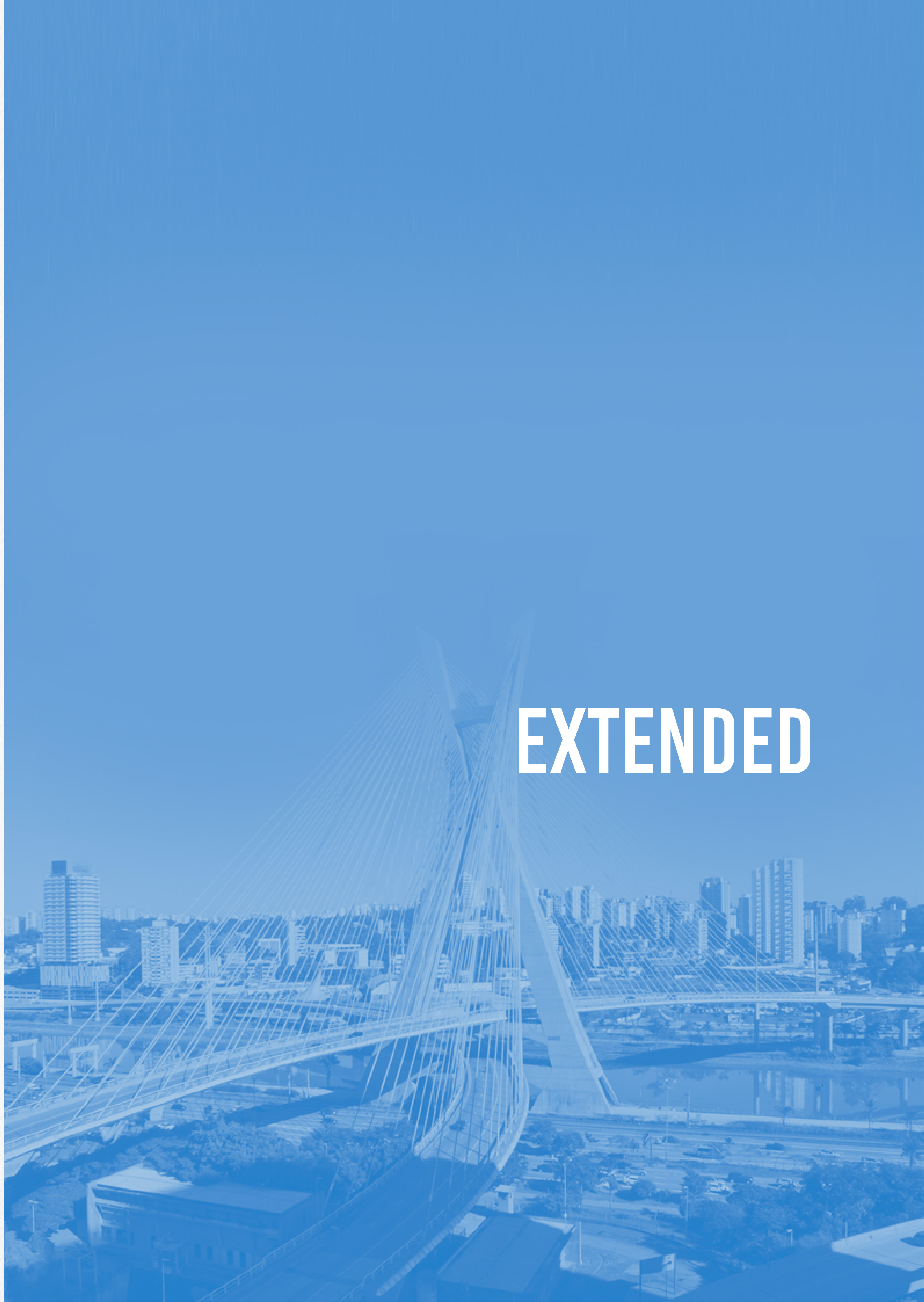
Abstract

A project aimed at installing a Lidar System in the Pantanal of Mato Grosso. The Lidar technique has emerged as a powerful tool for acquiring data and conducting atmospheric studies. However, despite its wide application in various regions of the world, there are continental regions in Brazil without this type of atmospheric monitoring, such as the Pantanal biome, located in Mato Grosso, Brazil, at the Geodesic Center of Latin America. This location is privileged, being far from the continent's edges in all directions. Other important characteristics of this location include the Pantanal itself being the largest flooded plain in South America and a transition between various ecosystems, presenting a unique wealth of biodiversity and complex environmental processes. The Lidar System, through laser and remote sensing, provides precise measurements of atmospheric elements such as aerosols and clouds, essential for understanding regional climatic phenomena. This contributes to the analysis of climate trends, monitoring air quality, and forecasting events.

Keywords: Pantanal biome; Lidar System; atmospheric studies.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P214



THEORETICAL AND EXPERIMENTAL RESEARCH PROGRESS ON THE DETECTION OF CIRRUS CLOUD CHARACTERISTICS USING LIDAR

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Abstract

Cirrus clouds consisting mainly of ice crystals are important components of the atmosphere which essentially modulate the radiative budget of the Earth. Until now, the microphysical properties (i.e., size and shape) of the ice crystals as well as their number density are poorly known because of their great variability in time and space and difficulties of field measurements. The lidar and radar soundings are promising devices providing active remote sensing of the cirrus clouds. Simultaneous measurement of their backscattering signals returned from the same cirrus clouds is a prospective method for retrieving the cloud microphysics, such as the size and the shape of cloud particles. All of them are related to the spectral dependence law of the cirrus cloud backscattering, which can be obtained from the color ratio and the lidar-radar ratio. A multi-wavelength (355 nm, 532 nm, and 1064 nm) lidar and a 35 Ghz radar are employed to measure the properties of cirrus clouds in Hefei City of East China. The quantities responsible for microphysics can be extracted and explained as the dimensionless values, such as the color ratio, and the lidar-radar ratio. Then the characteristics for cirrus cloud during campaigns are analyzed and discussed in an experimental and theoretical point of view.

Introduction

Clouds strongly regulate radiative transfer and the hydrological cycle, which are important parts of Earth's weather and climate[1-2]. Cirrus clouds consisting mainly of ice crystals are important components of the atmosphere, which cover more than 30% of Earth's surface and which essentially modulate the radiative budget of the Earth. The optical and microphysical properties of cirrus clouds are needed to incorporate in the up-to-date numerical models of weather forecasting and climate change[3]. However, these properties of cirrus clouds are poorly known now because of the strong spatial and temporal variability of them. Fortunately, radars and lidars, as two active remote sensing instruments, can estimate characteristics of cirrus clouds at various temporal and spatial scales.

The idea to use simultaneously lidars and radars for studying the cirrus clouds was suggested by many researchers. For example, the authors[4] measured simultaneously the lidar backscattering profile and radar reflectivity profile of cirrus clouds in 1993. As a result, they were successful to retrieve the effective crystal size. And some similar works are carried out in Germany[5] and in China[6]. Lidars emit shorter wavelengths than radars. Both of them can detect and characterize cloud particles in the nanometer to millimeter size range. So, a combined use of lidar and radar sounding simultaneously a cirrus cloud is a promising method for retrieving microphysical properties of the ice crystals.

Methods

The spectral or color ratio for two given wavelengths is equal to

$$\chi_{\lambda_2}^{\lambda_1} = \frac{\beta(\lambda_1)}{\beta(\lambda_2)} = \frac{\sigma(\lambda_1)}{\sigma(\lambda_2)} \quad (1)$$

Where the color ratio for combined radar/lidar measurements was also used to retrieve size of ice crystals in cirrus clouds in the paper [4].

Experiments

Simultaneous measurements of cirrus cloud are made in Hefei city by using the multi-wavelength lidar and 35 Ghz Radar during a field campaign in the summer time of 2019. In total, 96 profiles averaged over 500 s with a 7.5 m vertical resolution have been observed in each day by lidar. As for radar, the measurement is operated continuously with 10 s and 30 m resolution when cloud is overpassed.

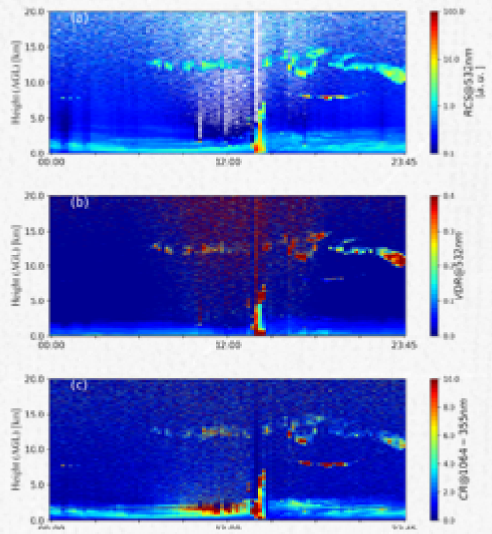

Figure 1: Time series of cirrus clouds using lidar in Hefei on Aug. 06th, 2019

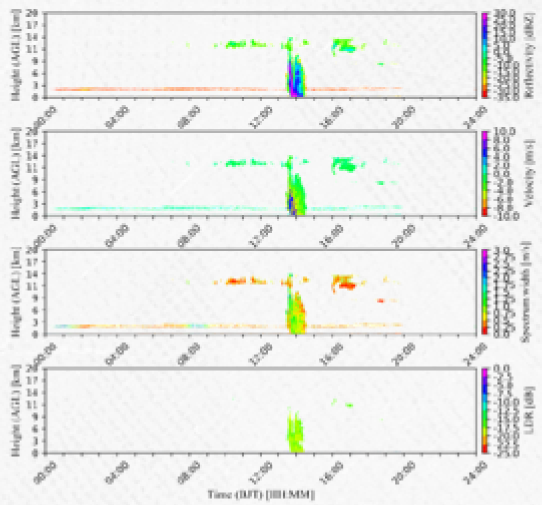

Figure 2: Time series of cirrus clouds using radar (simultaneously as in Fig. 1)

Here the first panel in fig.1 gives the lidar backscattering profile at the wavelength of 532 nm, the second panel is the depolarization ratio at 532 nm, and third one is the color ratio for two wavelengths 1064 nm and 355 nm. The radar data are presented in fig. 2, they are the radar reflectivity, the crystal particle speed, the spectrum width reflecting the diversity of the particle speeds, and the radar depolarization ratio.

Calculations

To date, the theoretical problem of light backscattering by ice crystals of cirrus clouds has been solved for more realistic crystal shapes[7-11]. In this paper, in order to simply the Mueller matrix in the backward scattering direction, the case of randomly oriented ice crystals are used in calculations.

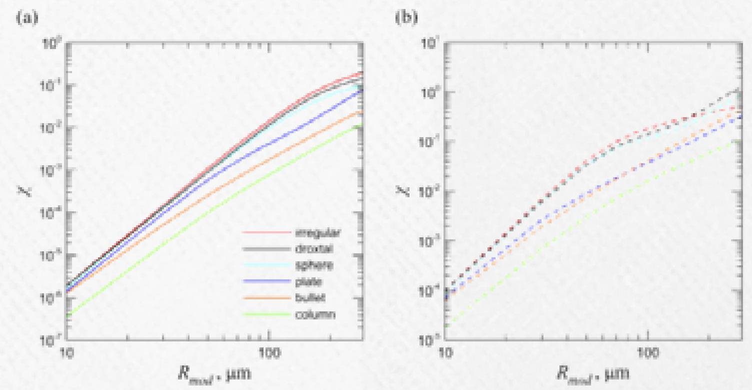

Figure 3: Lidar-radar ratio for the statistical ensembles of ice crystals with the same shapes but distributed over size versus the modal size of the distribution

Taking into account the wide distribution of ice crystals over their sizes, it is only the modal size R mod that should be retrieved from any measurable data. Therefore the radar-lidar ratio for the statistical ensembles of ice crystals of the same shapes but distributed over their sizes has been calculated and presented in Figure 3 shows that if a radar-lidar ratio is found experimentally for a cloud with unknown crystal shapes, this quantity allows us to find a rather narrow interval for possible modal sizes in this cloud [12].

Conclusions

In this study, the properties of cirrus cloud are discussed using observational cases obtained from the lidar and radar system over Hefei in 2019. The backscattering signals, the effective reflectivity factor, and depolarization ratios for cirrus cloud are used from measurements and calculations. The lidar depolarization ratio and lidar-radar color ratio focused simultaneously on the same cloud maybe the effective measurable values for retrieving the ice crystal shapes and sizes, including the lidar ratio[13] as well.

The characteristic cirrus of MMHC is identified using CALIOP data. The observed MMHC characteristic cirrus accounts for approximately 20% of all observed cirrus clouds [14-15], and its impact on radiative forcing throughout the earth system cannot be ignored. We will mainly focus on in this topic in the near future.

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SODIUM AND POTASSIUM LIDAR STUDY OF METEOR TRAILS: ALTITUDINAL DISTRIBUTION AND TEMPORAL VARIABILITY, A CASE STUDY ON APRIL 18TH 2018

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Abstract

We report the first simultaneous observation of meteor trails using the dual beam sodium and potassium (Na/K) LIDAR system installed at São José dos Campos (23.1 ° S, 45.9 ° W), Brazil. The primary aim is to accurately outline the properties of meteor trails through concurrent Na/K LIDAR measurements. Our investigation encompasses the temporal and vertical evolution of meteor trails, their altitude profiles, variability, densities, sodium to potassium ratios, and spatial characteristics. Leveraging LIDAR data collected during meteor events, quantitative insights into meteor trail morphology, including trail width, column abundance, time of occurrence, and amplitude, were derived. Our findings underscore the efficacy of employing simultaneous Na/K LIDAR measurements in unraveling the intricate dynamics and structural attributes of meteor trails, thereby advancing our understanding of these transient phenomena.

Introduction

The mesopause region, spanning altitudes between 80 km and 105 km, harbors a compelling phenomenon: the widespread presence of free metal atom layers. Predominantly composed of Fe, Ca, Na, and K, these atoms are thought to arise from meteoric ablation processes (Plane, J. M. C. 2003). Sodium and potassium LIDAR measurements offer a unique avenue for exploring this phenomenon by capturing meteoric trails. Meteor Trails are ionized trails left by meteors as they enter the Earth's atmosphere (Hays et. al, 1997). Through a meticulous examination of the temporal and spatial evolution of these trails and their elemental compositions, our study aims to unravel the intricate interplay between meteoric influx and the formation of metal atom layers. By bridging meteoric phenomena with atmospheric chemistry, this research provide some insights into the underlying mechanisms shaping the chemical composition and dynamics of the mesopause region. Our investigation seeks to advance our comprehension of how meteoric trails contribute to the creation of free metal atom layers, thereby shedding light on a pivotal facet of upper atmospheric science.

Method and Data Analysis

The dataset employed in this investigation was sourced from the sodium and potassium Dual-Beam LIDAR system, operational at São José dos Campos (23.1°S, 45.9°W, SJC), Brazil, since November 20, 2016. Developed through a collaborative initiative between the National Space Science Center (China) and the National Institute for Space Research (Brazil), this LIDAR system employs two laser beams operating at wavelengths of 589 and 770 nm. By leveraging resonant scattering phenomena within the Mesosphere and Lower Thermosphere (MLT), the instrument facilitates simultaneous measurements of sodium (Na) and potassium (K) densities. The vertical profiles are taken using 1000 shots which allows a time resolution of 20s and 96m height resolution. To subtract background noise, average

photon echoes received within the height range of 120 km - 130 km is applied. Leveraging these meticulously processed profiles and employing the LIDAR equation (1), we obtain the Sodium and Potassium number density (NNa /K) profiles, enabling a comprehensive analysis of the atmospheric constituents within the MLT region (Andrioli et al 2020).

$$N_{Na/K}(r) = \frac{(n_{Na/K}(r) - n_B)\sigma_R(Na/K)}{(n_R(r_R) - n_B)\sigma_{eff}(Na/K)} \cdot \frac{4\pi N_R(r_R) r^2}{r_R^2} \quad (1).$$

Where NNA/K = Sodium and Potassium atoms photocount
NR (rR) = atmospheric number density at reference height from MSIS model
nR = respective photocount at reference height
nB = background noise of each wavelength
r = distance between scattering object and LIDAR receiving system
rR = reference height (~48km)
σeff = effective fluorescence scattering cross section of K or Na atoms
σR (Na/K) (Na/K) = Rayleigh scattering cross section for respective wavelength.

Table 1 shows the main system characteristics of the LIDAR system at São José dos Campos, Brazil.

Table 1: LIDAR technical features

Parameters	Sodium (Na)	Potassium (K)
Wavelenght	589 nm	770 nm
Pulse width	~10 ns	~10 ns
Pulse repetition	50 Hz	50 Hz
Pulse Energy	≥ 35 mJ	≥ 35 mJ
Telescope Diameter	1 m	1 m
Line widht	1.5 GHz	1.5 GHz

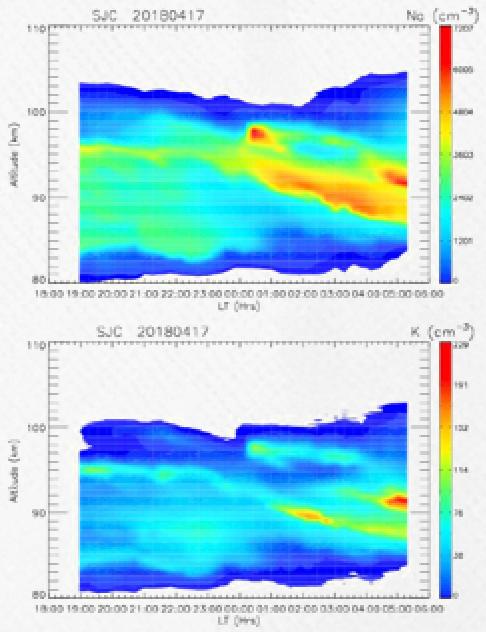

Figure 1: Density profiles for Sodium and Potassium from 19:00 April 17th 2018 to 05:15 on April 18th

To study the meteor trails, we need to first analyze the sodium and potassium lidar density profiles. Figure 1. Shows the sodium and potassium LIDAR density profiles from São João dos campos (SJC) on April 17 - 18, 2018, from 19:00 to 05:00 LT. Sodium and Potassium concentration profile reveals dynamic variations between 85 km and 105 km altitude influenced by atmospheric processes such as sporadic Na/K, gravity waves, tides or Na/K cloud due to meteor ablation. Both metal layer profiles show significant enhancements between 1:00 and 5:00 LT at approximately 95 km, which might indicate wave-driven events, but sodium densities reach higher maximum values compared to potassium. The presence of wave-like structures in both profiles suggests that gravity waves play a significant role in modulating these metal layers (Gardner, C. S., et al. 1993). While both layers exhibit regions of depletion and enhancement, potassium shows less pronounced density variations, reflecting differences in their atmospheric chemistry (Plane, J. M. C. 2003).

For us to identify the meteor trails after obtaining the density and time profile through an algorithm developed here at Sao Jose dos Campos, Brazil, we were able to go further with another code to visualize the meteor trails and obtain their parameters.

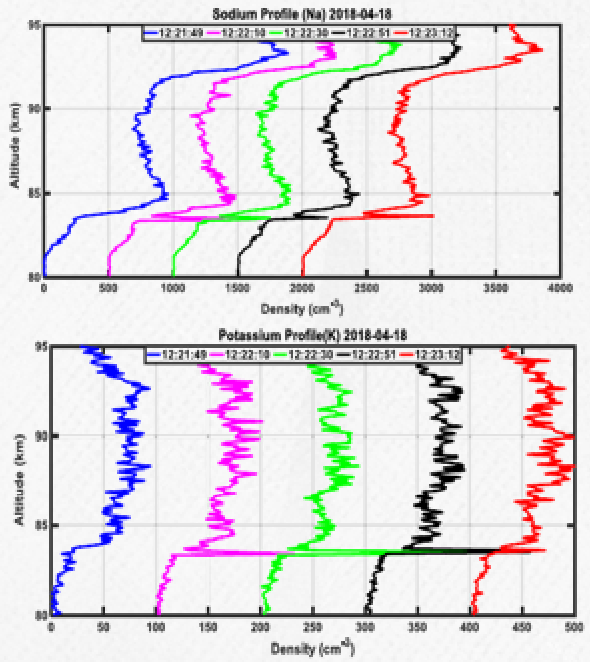

Figure 2: Combination of the meteor trails profiles for April 18th 2018

Results and Discussion

On the morning of April 18th 2018, in figure 2, Sodium and Potassium profiles illustrate how the density of their atoms varies with altitude over the course of the night, and highlight specific instances where meteor trails are evident. The four element trails were observed and the different colors represent different times in local time (LT): blue (12:21:49), magenta (12:22:10), green (12:22:30), black (12:22:51), and red (12:23:12) which are already on the early morning of April 18th 2018. These profiles show the simultaneously variability in sodium and potassium density, reflecting atmospheric processes indicating meteoric input as suggested that meteor disintegration is characterized by enhancement in sodium atoms (Pimenta et. al 2022). Some of the parameters extracted are shown in table 2 for each parameter on the event of April 18th 2018.

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Table 2: Meteor Trails Parameters.

Parameters	Na	K
Peak altitude (km)	83.62	83.62
Peak density (cm^{-3})	3015	472
Column abundance (cm^{-2})	452.27	55.85
RMS width (km)	0.32	0.25
Na/K ratio	~8: 1	
Time of occurence (hh: mm: ss:	12:22:10	12:22:30

The trails observed exhibit its highest peak altitude at 83.62 km and its lowest at 83.42 simultaneous in both metal specie. The RMS width value 0.32 (Na) and 0.25 (K) indicate that sodium width is wider than that of potassium and the concentration from the column abundance shows that sodium is significantly eight times present in the trails than that of potassium. The peak density of sodium is also ~ 6 times greater than that of potassium. Despite all the characteristics of sodium shown as extracted in the parameters, the spike in potassium is more prolonged than that of sodium as we can see in figure 3.

To obtain the parameters listed in Table 2, regarding the enhancement in both metal species, we performed statistical analyses. These analyses allowed us to record the column abundance, amplitude, RMS width, and several other parameters for further study.

Figure 3 displays the parameters obtained for the enhancement in Na/K using the trails at 12:22:10 LT on April 18th, 2018, for Sodium and at 12:22:30 LT on April 18th, 2018, for Potassium. These profiles are represented by the magenta line for sodium and the green line for potassium, as shown in Figure 2. These specific profiles were chosen because they represent the maximum value for the metal layers column abundance presented in table 2 and part of some of the values that were not presented in table 2.

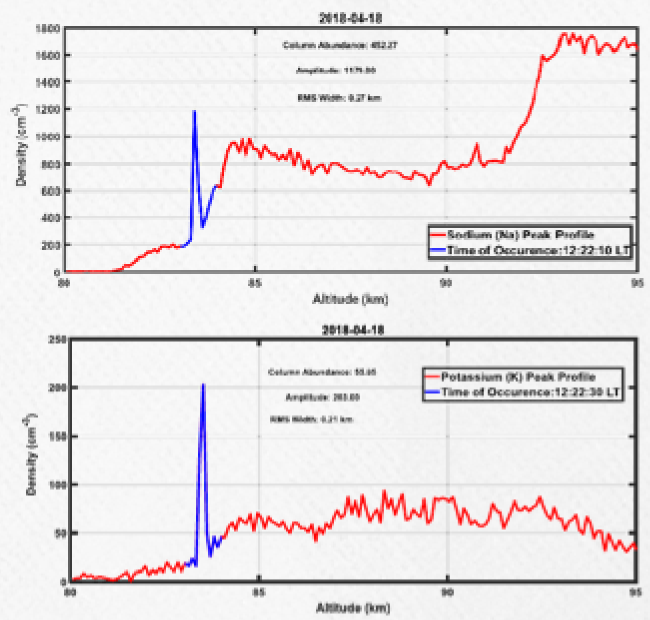

Figure 3: Parameters extraction for meteor trails profiles for Sodium and Potassium at 12:22:10 and 12:22:30 LT on April 18th, for both metal layers respectively

Summary

We have been able for the first time, at São José dos Campos using LIDAR data to simultaneously study the altitude and time of occurrence of the meteor trails in the Na and K density profiles as shown in Figure 2. A prominent enhancement representing the meteor trail is visible between the range of 83.42 km to 83.62 km of altitude in the four profiles on the night of study. With a mean height of 83.52km altitude in both Sodium and Potassium confirming that the same trail is responsible for the enhancement. The profiles exhibit a four-element trail between 12:22:10 and 12:23:12 within 80 seconds duration which is above 1 minute.

We have been able to analyze and present the report of the case study of the observed meteor trails in the Na/K LIDAR, column abundance, time of occurrence, RMS width, density and altitude distribution.

We now have a suitable method to perform statistical analysis, measure the acuity alterations for a longer period to be able to obtain, the Na/K density, the Na/K ratio, meteor trails characteristics during, before and after meteor showers, study long time trend and also to be able to accrete the strange ones to sporadic meteors.

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SIMULATION OF THE LIDAR SIGNAL WITH ANGULAR SCANNING OF CIRRUS CLOUDS CONTAINING A MIXTURE OF RANDOMLY AND QUASI-HORIZONTALLY ORIENTED CRYSTALS

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Abstract

Scanning lidars have become the primary tool for studying oriented crystals. The simple model of a monodisperse cloud allows us to draw several important conclusions. First, the data enables us to estimate the microphysical parameters of a mixture of randomly oriented particles with quasi-horizontally oriented particles. Second, we thoroughly investigated the law of particle orientation in space. Third, given the wide variety of shapes, sizes, and orientations of crystals in cirrus clouds, extensive experimental observations with scanning polarization lidar are necessary to gather statistical information about the microphysical parameters of ice crystals. This information is vital for addressing applied problems and will also help determine how common the depolarization ratio peak near lidar tilt angles of 30° is in the overall set of observations.

Introduction

Cirrus clouds significantly influence the Earth's radiation balance and climate. Most theoretical studies have assumed that cirrus cloud particles are randomly oriented in space. However, vertically oriented lidars often experience "blinding" due to specular reflections from quasi-horizontally oriented plate-like ice crystals in cirrus clouds [1]. As a result, lidars usually deviate from the vertical axis [2]. When the crystals in cirrus clouds are randomly oriented, the lidar signal is independent of the lidar's tilt angle. On the contrary, the presence of quasi-horizontally oriented crystals leads to a strong dependence on the tilt angle of the lidar.

Quasi-horizontally oriented plate-like crystals can cause phenomena known as glint and halo. However, there is currently no systematic data on the spatial orientation of particles in cirrus clouds. Contact methods, such as aircraft sampling, disrupt the natural spatial orientation, and vertically oriented lidars are unable to determine the angle of inclination of particles within a cloud (flutter). The main promising tool for determining flutter is scanning lidar [3-11].

Results of calculation

Common quantities measured with a polarization scanning lidar are the backscatter coefficient and the linear depolarization ratio. Unlike the backscatter coefficient, the depolarization ratio is independent of crystal density and can therefore be used to reconstruct the microphysical properties of cirrus clouds, such as the size, shape, and spatial orientation of ice crystals. Figure 1 shows these values calculated for a quasihorizontally oriented hexagonal plate, here the deviation of the quasi-horizontally oriented plate from the horizontal orientation is determined by a Gaussian (normal) probability distribution. Calculations were carried out using our physical optics approximation [12]. The resulting curves have two features. First, the backscattering cross-section in Fig. 1a has a sharp maximum at $\theta = 0°$. This feature is characteristic of any plate-like quasihorizontally oriented crystals due to specularreflection of light from quasi-horizontally oriented crystal faces [13]. The second feature, observed in Fig. 1b, is a sawtooth behavior at large values of θ.

Our previous calculations showed that backscattering occurs mainly due to reflections from internal quasi-vertically oriented faces [14]. Such reflections were also accompanied by several grazing reflections from quasihorizontally oriented faces. In this case, the 90° dihedral angle between the hexagonal and rectangular faces of hexagonal prisms plays a decisive role in backscattering. The 90° dihedral angle significantly enhanced backscattering, which was called the corner reflection effect. The maximum at about 30° in Fig. 1a is due precisely to the effect of corner reflection. Regarding the depolarization ratio shown in Fig. 1b, we see a step function with two steps around 30° and 50°. Although the backscatter cross section was created by 1-3 types of beam trajectories [14], we numerically proved that these depolarization ratio steps were created by only 3 types of beam trajectories.

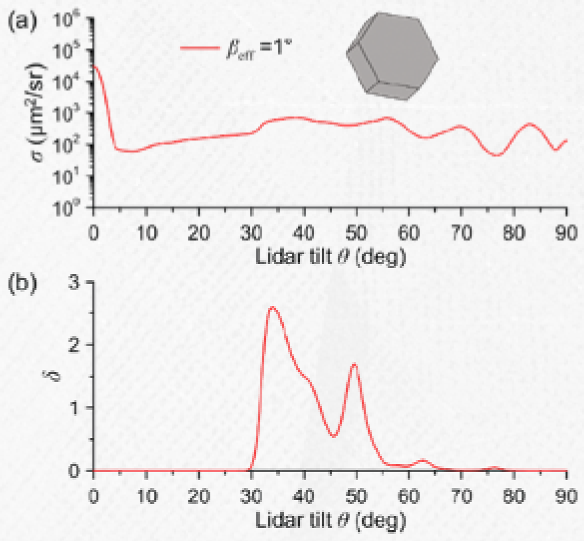

Figure 1: Backscatter cross section σ (a) and linear depolarization ratio δ (b) for a quasihorizontally oriented plate. Wavelength is 0.532 μm, diameter of the hexagonal facets D is 100 μm, height h is 15.97 μm, flutter is 1°

The step of depolarization ratio at approximately 30° is a feature inherent only in quasi-horizontally oriented plate ice crystals of regular shape. Such steps would not appear if the shape of the crystals were irregular. To prove the above statement, we calculated the backscattering of ice particles, in which the shape of an ideal hexagonal plate is slightly distorted, as shown in Fig. 2. An ideal hexagonal plate (a) is characterized by two dihedral angles of 90° and 60°. On plates (c) and (d), the dihedral angles of 60° and 90° are distorted; both hexagons on the plate (b) are replaced by truncated triangles; and in particle (e), the upper hexagon is complemented by a truncated hexagonal cone.

The results of our calculations allow us to draw the following conclusions. First, distorting the dihedral angle by 90° significantly reduces the backscattering cross section. This can easily be explained by the suppression of the corner reflection effect with such distortions. Secondly, in Fig. 2, we see sharp steps in the depolarization ratio with only an ideal hexagonal plate and a plate where both hexagons are replaced by truncated triangles. The remaining distortions lead to similar steps, but the steps are shifted towards larger angles θ. Consequently, we come to the conclusion that the appearance of

a step in the depolarization ratio at $\theta \approx 30°$ is a feature inherent in the dihedral angle of 60° among quasi-vertically oriented faces. Thirdly, small changes in the 90° angle in plate (c) already lead to the disappearance of this step in the depolarization ratio.

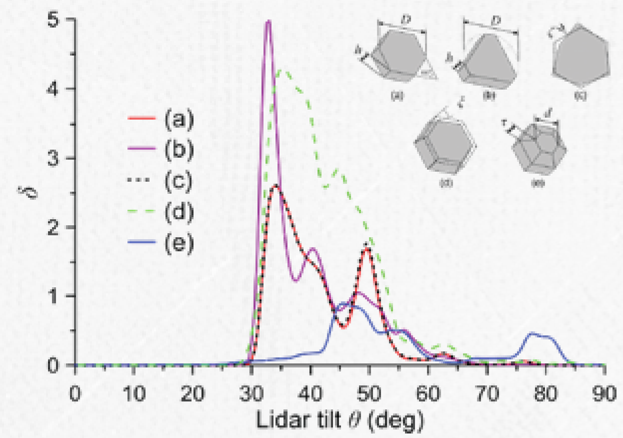

Figure 2: Linear depolarization ratio δ for the distorted hexagonal ice plates

In nature, a cirrus cloud consists of a mixture of ice crystals of different shapes and orientations. The question arises whether the step for the mixture will remain at $\theta \approx 30°$. Our calculations for a mixture of hexagonal plates and randomly oriented columns showed that a step at $\theta \approx 30°$ is also discernible for mixtures. Thus, it becomes possible to interpret recently obtained experimental data [15] by comparing the experimental data with depolarization ratios calculated for certain mixtures of ice crystals of different shapes and orientations. The measurements were carried out in Tomsk (Russia) using the polarization scanning lidar LOSA-M3.

To interpret the experimental data, a database of backscattering matrices was calculated for quasi-horizontally oriented particles with different flutter angles. Figure 3 presents an example of our numerical simulation of a scanning lidar signal for both the normal orientation distribution of an ideal ice hexagonal plate in a cloud and the exponential distribution.

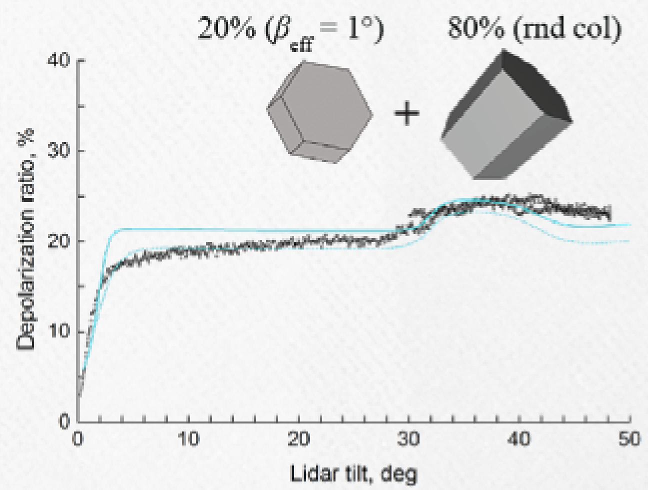

Figure 3: Linear depolarization ratio in cirrus clouds observed in Tomsk (May 21, 2021). Solid lines correspond to the normal law of particle orientation in mixture, dots correspond to the exponential law

The compositions of model mixtures M_1, M_2, M_3 were tested in various proportions, consisting of quasi-horizontal plates, randomly oriented hexagonal columns and particles of irregular shape. We calculated the root-meansquare deviation of the experimental data from the compositions of each model mixture (see Table 1). In particular, the curve presented in Fig. 3 corresponds to a numerical model of a mixture M_2 consisting of 20% oriented hexagonal plates with a flutter angle of 1° (QP1) and 80% randomly oriented hexagonal columns (rnd col). We see good agreement between the results of experimental observations and numerical simulation data. As can be seen in Fig. 3, the results of numerical simulations demonstrate the closest agreement with experimental observations when choosing an exponential particle orientation law for the cloud.

By analogy, we performed the same procedure for other experimental curves and obtained the following results. The purple line corresponds to a cloud model consisting of 20% ideal plates with 3° flutter, 65% randomly oriented columns, and 15% randomly shaped particles. The orange line represents a cloud model consisting of 80% partially truncated plates with 9° flutter, 10% randomly oriented columns, and 10% randomly shaped particles. The black line corresponds to a cloud model consisting of 97% truncated plates with 9° flutter and 3% randomly oriented columns.

Table 2: Root-mean-square deviation between the experimental data and model mixture compositions.

Mixture	Range of lidar tilts		
	0 – 45°	0 – 5°	0 – 45°
M_1 (10% QPI+90% rnd col)	0.02016	0.03211	0.01806
M_2 (20% QPI+80% rnd col)	0.01792	0.02843	0.00890
M_3 (30% QPI+70% rnd col)	0.02170	0.03886	0.01433

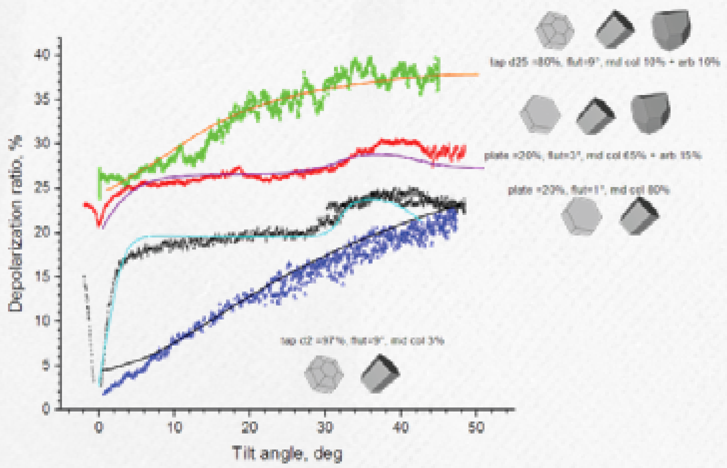

Figure 1: Linear depolarization ratio in cirrus clouds observed in Tomsk for different dates: black curve – May 21, red curve – 31 May, blue curve – June 18, green curve – July 01 (2021). Solid lines correspond to the exponential law

Summarizing the results of this paper we could propose the following scheme for studying cirrus clouds with a scanning lidar:

I. The depolarization ratio should be measured near the vertical direction. If the depolarization ratio dips to the abnormally small value, it means that the quasi-horizontally oriented plate-like crystals are predominant crystal shapes in the cloud. The angular size of this gap indicate the flutter.

II. The depolarization ratio would be measured at the lidar tilts of about 30°. If a step of depolarization ratio is not observable, it means that the transverse shapes of the plate-like crystals are irregular like snowflakes. Otherwise, if the step of depolarization ratio is observable, the transversal shapes of the platelike crystals are regular like the conventional hexagonal plate.

The calculation of the backscattering Mueller matrixes for randomly oriented particles was supported by the Ministry of Science and Higher Education of the Russian Federation (V.E. Zuev Institute of Atmospheric Optics of Siberian Branch of the Russian Academy of Sciences). The calculation of backscattering Mueller matrixes for mixtures of ice crystals with various shape and orientation was carried out with financial support of the Russian Science Foundation (Grant No. 21-77-10089).

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BOOK OF ABSTRACTS OF XII WORKSHOP ON LIDAR MEASUREMENTS IN LATIN AMERICA SÃO PAULO, BRAZIL, 2024

PRELIMINARY STUDY OF GREENHOUSE GASES NEAR TO SANTOS AND SÃO SEBASTIÃO PORTS

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Abstract

The carbon biogeochemical cycle in nature involves the atmosphere, ocean, terrestrial and marine biota, and mineral reservoirs, with major fluxes between the atmosphere and both terrestrial biota and ocean waters. Studies link the increase of CO_2 and CH_4 (GHG) to climate change and anthropogenic activities. Coastal zones have a significant impact on the carbon cycle. This study examines GHG concentrations in estuary systems close to port zones, focusing on Santos and São Sebastião ports in São Paulo, Brazil. Santos Port, the largest in Latin America, and São Sebastião Port, with a petroleum terminal, can be significant contributors of GEE. A preliminary campaign measured CO_2 and CH_4 for 27 hours using a portable GHG analyzer on the research vessel Albacora from the University of São Paulo's Oceanographic Institute. Results showed promising GHG concentrations, with CO_2 levels above 420 ppm near Santos and above 450 ppm near São Sebastião, for methane, the major concentration was ~3 ppm, but in short period of acquisitions, in the major part of traject the level was between ~1.8 - ~1.9 ppm.

Introduction

Coastal areas represent only 7% of the total ocean surface but play an important role in biogeochemical cycles among continents, atmosphere, and oceans [1]. In 2019, CO_2 concentrations detected were the highest recorded in at least 2 million years, and CH_4 concentrations were the highest in at least 800,000 years. Since 1750, increases in CO_2 and CH_4 concentrations far exceed those observed in natural atmospheric changes observed in glacial and interglacial periods [2]. Due to this increase in the concentration of these gasses and their high potential to interfere with radiative forcing during the last decade, GHG (greenhouse gas) dynamics have been further investigated in various environments, which also include coastal areas, making estuaries very promising regions for GHG studies [3]. The main purpose of this work is to study Greenhouse gasses (GHG), such as CO_2 and CH_4, on the waters of the coastal region of São Paulo. The data were collected in situ on a vessel provided by the Institute of Oceanography of São Paulo University (IOUSP). The campaign was conducted in early spring 2021 from the northern region to the south of the coast of São Paulo, traveling through cities with more and less anthropogenic impacts. For these in situ measurements a portable gas analyzer Microportable Greenhouse Gas Analyzers (LGR-ICOS ™ GLA Series) - was used to detect the CO_2 and CH_4 spectra through the Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS) technique.

Methods

The Albacora I Campaign, which took place in an approximately 27-hour Journey along the Coast of São Paulo state, Brazil. The route crossed the coast of cities with greater anthropic impact such as the Baixada Santista Metropolitan Region and other regions of low anthropic impacts located in Litoral North and South of São Paulo state (Figure 1).

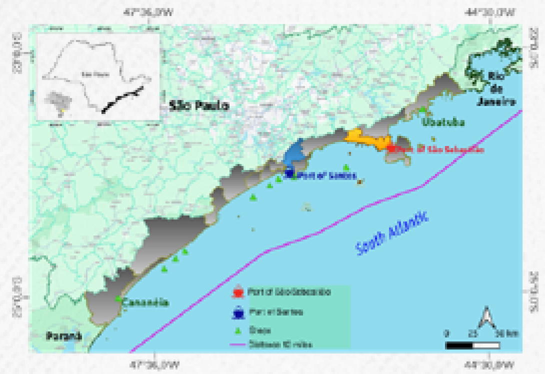

Figure 1: Map coast of São Paulo. It highlights the cities which located the São Sebastião and Santos Ports

Figure 2: Microportable Greenhouse Gas Analyzer LGR-ICOS™ GLA Series

For data collection, a portable gas analyzer - Microportable Greenhouse Gas Analyzer LGR-ICOS™ GLA Series - (see Figure 2) was used. This instrument has a high sensibility, resulting in a very fast gas flow response time (1 second) [4],it's based on the Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS), a technique that is widely utilized for gas detection due to its rapid response, high sensitivity, and stability [5], achieve obtain a precision of <0.9 ppb (1 second) for CO2 and <350 ppb for CH4 (1 second). A Teflon tube of ¼ was coupled to the INLET, which extended up to about 3 meters above sea level and was positioned above the cabin of the captain of the vessel at half ship. At the end of this tube a PFA 47-mm Savillex filter holder was attached, and inside this support a Zefluor membrane of 2.0 µm was used (Figure 3).

Figure 3: Vessel IOUSP, in highlight the position inlet of portable gas analyzer

Results

As a result of this first experiment we obtained the following results. The campaign lasted about 27 hours. The initial data acquisition began at 6 pm (UTC) in the research base "Clarimundo de Jesus" in Ubatuba's city, which belongs to Institute Oceanography of University of São Paulo. The GHG analyzer maintained continuous measures until the final destination around 8 pm (UTC) in the research base "Dr. João de Paiva Carvalho" - Cananéia city (see Figure 1) also of the Institute Oceanography of University of São Paulo.

We obtained the following findings based on the dataset values in this sampling. The data archive for the line graphs (Figures 4 and 5) was averaged every 180 seconds from the raw data, which was initially measured at 1-second intervals.

This preliminary examination reveals that concentrations of both gasses, CH_4 and CO_2, showed some peaks than ran commonly accepted background levels by 1,87 ppm for CH_4 and 415 ppm for CO_2 in 2020 [6], but almost all the time the concentrations, mainly the methane are accordingly the background.

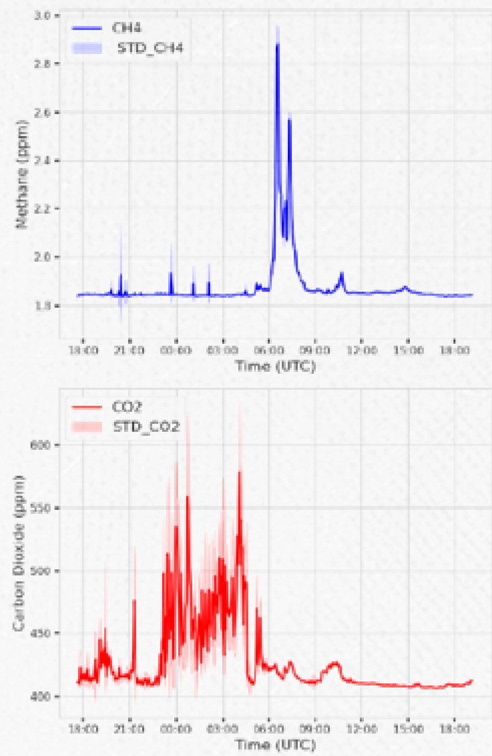

Figure 4: Illustrates the concentration of methane along the coast of São Paulo in Campaign Albacora I

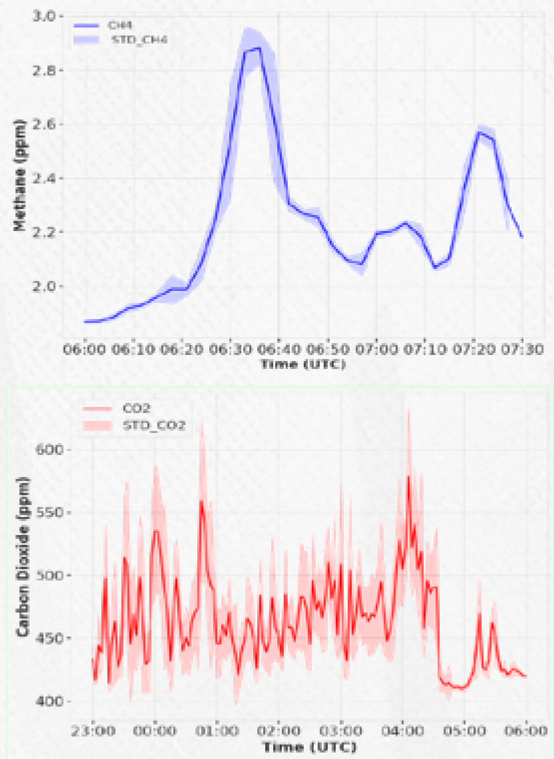

Figure 5: Displays the concentration of methane and carbon dioxide during two moments: 6 am to 7:30 am for methane and 11 pm at 6 am for carbon dioxide

As we can observe the data of CH_4 there was a greater increase in concentration between 6 - 7 am (UTC-time) with peaks of approximately 3 ppm. When we look at the CO_2 data the variability is higher, with peaks ranging between ~415 and ~575 ppm, it is observed that the data set that presents more these values were between 11 pm to 6 am (UTC-time).

Figure 5 shows the two moments cited above, when the concentrations of CH_4 and CO_2 obtained were higher. For the concentrations for methane the vessel steps near a Port of Santos for approximately two hours, the point of step is indicated in the map on Figure 1 with the symbol blue. In the case of CO_2 the data show higher concentrations (above 420 ppm in more longer time period (around 8 hours). The vessel in this period crosses the traject between the two ports (São Sebastião and Santos), see Figure 1, where there is much traffic of vessels.

Conclusion

The data presented here, as previously mentioned, is data from a first campaign that aimed to explore a coastal region and verify the concentrations of CO_2 and CH_4 along the coast of the State of São Paulo with a portable GHG analyzer. Although it was a first use of this equipment for this purpose, the results were promising, because they detected results that define well the regions covered, mainly as the that in more populous cities and close to the ports of São Sebastião and Santos showed a greater concentration of this gas. Despite the promising results, it is important to stress that some aspects have to be taken into account in future work, it is necessary that some parameters are taken into account, such as wind direction, which would help to identify where the highest peaks of concentration of these gasses in each region come from, it would also be interesting to have a more comprehensive sampling with more days of measurements in the same regions and in different seasons, for better analysis of results.

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Keywords: Pantanal biome; Lidar System; atmospheric studies.

XII WLMLA Topic: Remote sensing of tropospheric aerosols

ID: Poster P214

INVESTIGATING METHANE EMISSIONS FROM LANDFILL IN THE METROPOLITAN REGION OF SÃO PAULO

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Abstract

This research addresses the escalating global levels of atmospheric methane, emphasizing the critical need for understanding its sources and behavior. Landfills are identified as methane super emitters, because its rates range from 1,000 to 3,000 kg/h. Focusing on the Landfill in the district of São Mateus, in the city of São Paulo, the study aims to investigate the significance of landfills in the rising methane levels, emphasizing the impact of super emitters and methane hotspots. Field campaigns conducted on February 15th and April 06th, 2023, utilized a portable greenhouse gas analyzer (ABB) to measure methane concentrations. Meteorological parameters from ERA5 and the AERMOD Modeling System were used for a comprehensive analysis. The results highlight elevated methane concentrations around the Landfill, emphasizing its role as a significant methane super emitter. The study underscores the importance of such analyses in understanding the impact of landfills on atmospheric methane levels.

Introduction

One of the main Greenhouse Gases (GHGs) that is very important to study is Methane (CH_4), as it is a gas with a high global warming potential. Its natural concentration is about 2.0 ppm. The waste sector is the second largest emitter of CH_4 in Brazil, through landfills due to decomposition of organic matter disposal through microbial production. A landfill is considered a super emitter of methane due to its high emission rate, between 1,000 and 3,000 kg/h [1-5].

The production of biomethane, generated by power generation plants using the gas, is one of the actions that has the most potential to recover the CH_4 emitted, reducing emissions [6]. There is a growing interest in researching methane emissions from landfills due to the substantial amount emitted and the gas's potential to contribute to global warming. The CH_4 map visualization platform, Spectra Basic, created by GHGSat, presents events with high concentrations of CH_4 in several sectors, including the waste sector, with emission rates varying between 1.815 kg/h, on July 31st, in a landfill in Bahia, Brazil, and 5.776 kg/h on August 22nd, in Rio Grande do Sul, Brazil [7].

The landfill in the district of São Mateus (latitude: -23.63559444, longitude: - 46.42729722), located in the Metropolitan Region of São Paulo, Brazil, receives about 7,000 tons of waste per day. To comprehend CH_4 dynamics, a case study of the landfill was conducted to observe its elevated emission rates and concentrations. To observe emissions from the landfill, CH_4 was measured at a nearby point (latitude: -23.64163056, longitude: -46.42104444).

Materials and Methods

Greenhouse Gases Analyzer

To assess methane concentrations near the landfill site, a portable device designed for analyzing GHG such as CH_4, CO_2 and H_2O was used. The ultra-sensitive analyzer utilizes Off-Axis Integrated Cavity Output Spectroscopy technology (OA-ICOS), which enhances laser absorption, thereby enhancing the accuracy of collected data [8]. The gas concentration is determined by measuring the variation in light absorption intensity by the gas [9]. With the gas analyzer, in a car, the researchers went to a point that was as close as possible to the landfill disposal area, that is, at a stopping point on the landfill's side highway. The inlet of the equipment was positioned outside the car window so that concentrations could be monitored continuously.

Air Quality Dispersion Modeling

Recommended by the U.S. EPA, the AERMOD is a steady-state plume model that employs Gaussian dispersion to simulate how topography affects plume behavior. The model incorporates air dispersion based on the turbulence structure of the planetary boundary layer, surface and elevated sources, and simple and complex terrains [10,11]. This methodology is composed of the following elements:

- AERMAP: Organizes topographic data to be used in the model, resulting in more accurate modeling. The topography used for the research was estimated by the GMTED2010 (Global Multi-Resolution Terrain Elevation Data 2010) elevation model [12,13];
- AERMET: Processes and organizes meteorological data for the model. One of the most significant impacts is observed in the utilization of roughness, where higher roughness values lead to increased dispersion of pollutants. Other meteorological data used were reanalysis data provided by ECMWF, called ERA5, which provides hourly estimates of wind and surface parameters, with a resolution of 31 km [14,15];
- AERMOD: Processes source data, topography data, and meteorological data, results of the pre processors AERMAP and AERMET. By adjusting the peak concentration, the mean concentration is derived by summing the resultant concentrations [16]. The inverse modeling technique calculated by AERMOD uses a transfer matrix, which determines how each aspect of scattering from a point source with an emission rate affects a receiver, resulting in a net concentration [17];
- AERPLOT: Uses AERMOD output data to visualize graphical data, representing pollution plumes.

The processors were used to simulate the CH_4 plume, estimating the concentrations, which would later be compared with the concentrations measured in the field, with the analyzer. This way, it would be possible to estimate the methane emission rate for the measurement days.

Results

Methane Concentration Measurements

To observe the values of methane concentrations in locations close to the waste disposal area of the São Mateus landfill, a GHG analyzer was used. The following chats present two observations regarding the representation of the data obtained. The blue dotted line represents the raw data, that is, the data from the equipment per second. The solid orange line represents the average methane concentration at every minute.

On February 15th, 2023, the measurement took place at a point near the waste disposal of the landfill for about 1 h, observing a CH_4 concentration mean of approximately 22 ppm (Figure 1), that is 11 times the background value.

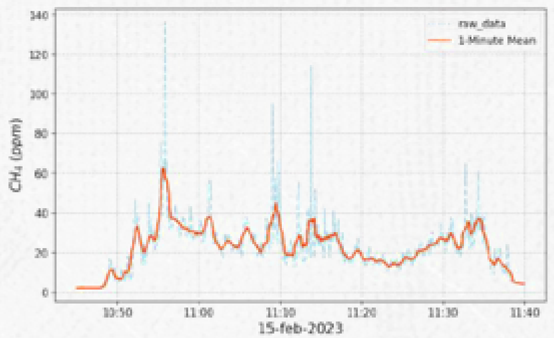

Figure 1: Chart of raw data concentration at every second and the one-minute mean for February 15th

On April 06th, 2023, the measurement took place at the same place as the other measurement day, for approximately 1 hour (Figure 2), during which the concentrations were unstable. The average concentration on this measurement day was about 4 ppm, but it is visible that, at certain moments, the concentration mean was over 10 ppm, which means 5 times the background value.

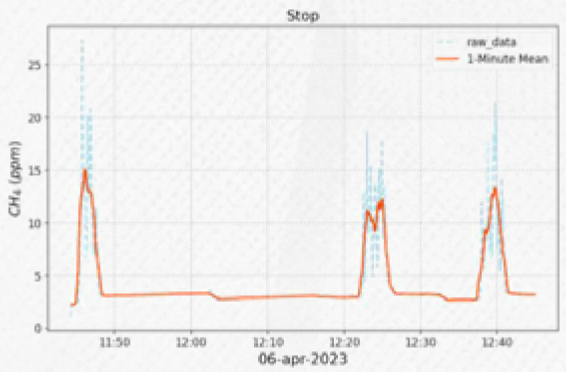

Figure 2: Chart of raw data concentration at every second and the one-minute mean for April 06th

Plumes and Emission Rates with AERMOD

The dimensions of the landfill were considered as a rectangular area, 500 meters width and 930 meters length. The roughness value was estimated at 0.19. Emission rates were estimated until the concentration at the point was in accordance with the concentration measured at the same location and with previous studies, likewise.

The visualizations in Google Earth show the contours lines of the receptor points estimated by the model, colored to reflect their concentration values. Blue indicates the concentrations farthest from the source (lower), and red, the concentrations closest to the source (highest). Below the results images is the table legend of the graphic representations of each day, showing the variation of concentration values for each line.

On February 15th, the reference was 22.25 ppm (white x in Figure 3) at the measurement point near the landfill, and the emission rate was estimated at 25,344.36 kg/h.

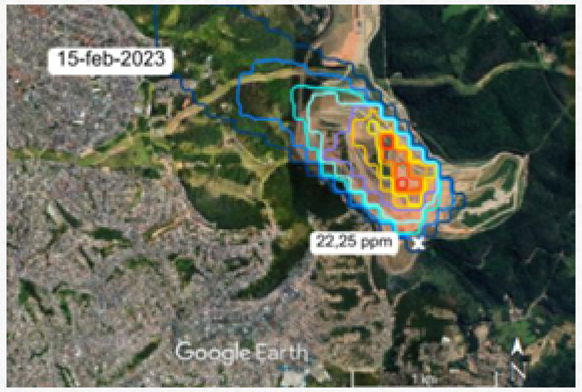

Figure 3: Representation of the graphic data, showing the concentration reference (white x) for February 15th, 2023

Table 1: Subtitle for Figure 3 of the ranges of concentration values in μg/m, as a result of the model, and in ppm, on February 15th, 2023.

	Concentrations	
	83.260 $\mu g/m^3$ up to Maximum	127,96 ppm up to Maximum
	75.690 $\mu g/m^3$ up to 83.260 $\mu g/m^3$	116,33 ppm up to 127,96 ppm
	68.120 $\mu g/m^3$ up to 75.690 $\mu g/m^3$	104,69 ppm up to 116,33 ppm
	60.550 $\mu g/m^3$ up to 68.120 $\mu g/m^3$	93,06 ppm up to 104,69 ppm
	52.980 $\mu g/m^3$ up to 60.550 $\mu g/m^3$	81,43 ppm up to 93,06 ppm
	45.410 $\mu g/m^3$ up to 52.980 $\mu g/m^3$	69,79 ppm up to 81,43 ppm
	37.850 $\mu g/m^3$ up to 45.410 $\mu g/m^3$	58,17 ppm up to 69,79 ppm
	30.280 $\mu g/m^3$ up to 37.850 $\mu g/m^3$	46,54 ppm up to 58,17 ppm
	22.271 $\mu g/m^3$ up to 30.280 $\mu g/m^3$	34,23 ppm up to 46,54 ppm
	15.140 $\mu g/m^3$ up to 22.271 $\mu g/m^3$	23,27 ppm up to 34,23 ppm
	7.569 $\mu g/m^3$ up to 15.140 $\mu g/m^3$	11.63 ppm up to 23,27 ppm
	Minimum up to 7.569 $\mu g/m^3$	Minimum up to 23,27 ppm

On April 06th, the reference was 4.41 ppm (white x in Figure 4), at the measurement point near the landfill, resulting in the estimated emission rate of 1,145.02 kg/h.

Figure 4: Representation of the graphic data, showing the concentration reference (white x) for April 06th, 2023

Table 2: Subtitle for Figure 4 of the ranges of concentration values in µg/m, as a result of the model, and in ppm, on April 06th, 2023.

	Concentrations	
◆	31.210 $\mu g/m^3$ up to Maximum	47,24 ppm up to Maximum
◆	28.380 $\mu g/m^3$ up to 31.210 $\mu g/m^3$	42,96 ppm up to 47,24 ppm
◆	25.540 $\mu g/m^3$ up to 28.380 $\mu g/m^3$	38,66 ppm up to 42,96 ppm
◆	22.700 $\mu g/m^3$ up to 25.540 $\mu g/m^3$	34,36 ppm up to 38,66 ppm
◆	19.860 $\mu g/m^3$ up to 22.700 $\mu g/m^3$	30,06 ppm up to 34,36 ppm
◆	17.030 $\mu g/m^3$ up to 19.860 $\mu g/m^3$	25,78 ppm up to 30,06 ppm
◆	14.190 $\mu g/m^3$ up to 17.030 $\mu g/m^3$	21,48 ppm up to 25,78 ppm
◆	11.350 $\mu g/m^3$ up to 14.190 $\mu g/m^3$	17,18 ppm up to 21,48 ppm
◆	8.513 $\mu g/m^3$ up to 11.350 $\mu g/m^3$	12,89 ppm up to 17,18 ppm
◆	5.675 $\mu g/m^3$ up to 8.513 $\mu g/m^3$	8,59 ppm up to 12,89 ppm
◆	2.838 $\mu g/m^3$ up to 5.675 $\mu g/m^3$	4,30 ppm up to 8,59 ppm
◆	Minimum up to 2.838 $\mu g/m^3$	Minimum up to 4,30 ppm

Conclusions

The concentrations of CH_4 were investigated to understand the influence of landfill emissions in the atmosphere. Areas close to waste disposal have high levels of CH_4.

The estimated emission rates are in accordance with the concentrations measured by the gas analyzer. Although the estimated values are similar to other researches, the lack of updated and accurate data was an obstacle that influenced the effectiveness of the data. Topography, meteorological and landfill information data were estimated to fit the expectations.

The findings reveal a correlation between the two methodologies, where higher concentrations correspond to higher emission rates. In this instance, the average observed concentrations were ten times and twice higher on each measurement day, as the methane natural value is 2.0 ppm.

The research highlights the importance of reducing methane emissions from landfills to combat climate change, hence the growing interest in this area. For future research in this area, the ideal would be to use more current and accurate data. The research highlights the importance of reducing methane emissions from landfills to combat climate change.

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NOVEL MICROLIDAR-SPECTROMETER COMBO FOR GREEN HOUSE GASES MONITORING FROM SPACE

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Abstract

A new generation of satellites using novel LiDAR concept could provide more accurate monitoring of greenhouse gas emissions, helping to improve our understanding of the role of human activity in climate change. The use of satellite constellations for this purpose has several advantages. First, it would allow for near-global coverage, providing a more complete picture of emissions than is possible with ground-based monitoring. Second, the use of LiDAR would allow for more accurate measurements, as it can provide aerosols and subvisible clouds extinction and scattering properties, and measure local winds correcting the bias & error in Radiative Transfer algorithms. This would be a valuable tool for understanding and mitigating climate change, as it would provide more accurate data on emissions from different regions and sectors. It could also help to identify areas where emissions reductions are most urgently needed. The main goal of the project is to explore an approach of deploying a network of new data sources for GHG monitoring with high temporal and special resolution. The target parameters are 50m resolution for CH_4 with 4 passes per day over the area of interest. This will enable new emissions monitoring applications to combat the climate crisis by delivering L2 level data about greenhouse gas emissions concentrations on the predefined location. The deployment of such a system would require significant investment, but the benefits would be considerable. It is therefore worth considering as part of the efforts to combat climate change. This paper will explore the state of the art in this area and discuss future directions.

Introduction

The European Commission adopted a set of proposals to make the EU's climate, energy, transport, and taxation policies fit for reducing net greenhouse gases (GHG) emissions by at least 55% by 2030, compared to 1990 levels [1]. This highly depends on the amount and quality of data available to provide valuable analytics on carbon and methane footprints. Data and knowledge around global greenhouse gas (GHG) emissions, trends and sources are becoming key levers to support national and international climate policymaking. Current GHG assessment methods are not able to satisfy the emerging urgent need for neutral and reliable data sources. To decrease the carbon footprint, the real impact from human activities must be observed and measured. This is possible only by global and continuous measurements from space.

Existing space-enabled solutions for GHG monitoring are not sufficient. Datasets generated by large public satellites such as GOSAT-2, OCO-2 or Sentinel 5 allow middle precision and low revisit rate (average 7 days revisit rate, 1 km² spatial resolution) [2]. Small satellites can significantly improve the coverage, while the technology still does not allow to reach high accuracy and precision to use the data for reporting and validation. While small satellites have proved that such measurements are possible (GHGSat), the focus area of point sources shrinks the application span and limitations of the technology significantly decrease the sensitivity of measurements especially in presence of winds and aerosols. While there are promising projects on the horizon enabling medium precision and higher revisit rate (SCARBO, Planet & Carbon Mapper, Merlin, Methansat) these missions are still targeting specific applications (plumes detection for oil and gas sector) or do not provide sufficient data quality. Most of existing spacecrafts can sense the leaks of methane over very large areas but have poor resolution at the local level, at the scale of a leaking pipeline. And those systems that can capture these details will lack the wide-area coverage and the timely return to a particular location. Currently there is no solution which enables the daily carbon dioxide and methane monitoring, quantification and localisation with high resolution and high sensitivity. Market demands global and near real time detection of GHG emissions with higher granularity to allocate emissions to specific facilities, factories, and farms.

Current project is dedicated to validating a novel LiDAR-based technology for GHG emissions tracking and localisation through development of instrument demonstrator and test campaigns support and validation of the market demand via supplying potential customers with data sets collected during test campaign.

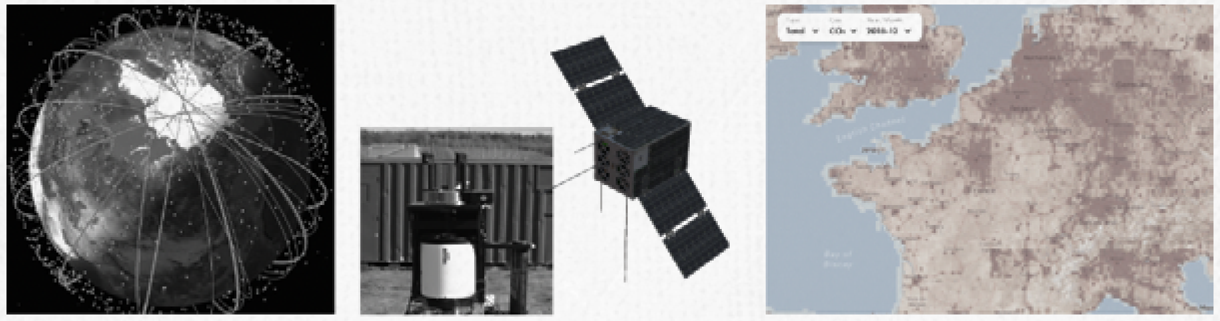
The end target for current In Orbit Demonstration Mission (IoD) project, is to provide commercial service of global GHG observations with daily coverage at 50x50 m² resolution and a sensitivity better than 2 ppm in XCO_2 and 4 ppb in XCH_4. To achieve this goal, and limit the systematic error, LiDAR measurements of vertically resolved aerosols, thin clouds and surface winds that are important for hot-spot outflow tracking & measurements, will be acquired and will so enable the retrieval process to better account for cloud, winds and aerosol scattering effects. Low water clouds and thin cirrus also affect the CO_2 retrieval process.

Our GHG IOD satellite concept is aimed to address and resolve two major current limitations of available operating systems, namely: geographical coverage and effect of atmosphere on the GHG data accuracy. Regarding geographical coverage, CubeSat (or small sat) constellation has a great advantage of costs vs distribution of nodes on orbit balance. Utilisation of COTS components, availability of launch opportunities made CubeSat platform extremely attractive for missions with high time/space resolution requirements. With regard to atmosphere's effects on achievable accuracy, the influence of aerosols, sub-visible clouds, surface winds are well known issues. Light scattering by clouds and aerosol introduces uncertainties in the optical path length that affect the accuracy of the XCO_2 retrieval. Information about aerosol scattering is contained in the spectra of the O_2-A band and the strong CO_2 band at 2.0 μm. Nevertheless, the flux inversion models all indicate high sensitivity to biased data, which is reflected in the required high accuracy of the CO_2 observations. Several papers (see reference section) discuss the effect of thin clouds and aerosol scattering on the accuracy and the number of successful retrievals of XCO_2.

Mission Components

Project will offer a unique continuous and global GHG emissions monitoring service. It will supply data on CO_2 and CH_4 with high resolution high sensitivity, emissions visualisation aligned to the map and historical database with raw data. The service is enabled by several modules: payload assembly of novel instruments, satellite constellation carrying it, data processing block enabled by both satellite on-board data analysis and ground data processing and service delivery via web platform.

Since global coverage is required for GHG emissions monitoring, a CubeSat constellation of at least 12 satellites is foreseen in the sun synchronous orbit in 4 different orbital planes with separation of 45 degrees between planes. Spacecrafts will be launched in several launches while passive or active orbital phasing will deliver them to the dedicated orbital spots. The propulsion modules installation



Satellite constellation

LiDAR ground test-model and CubeSat model

L2 data processing and visualisation

Figure 1: AIRMO service components

decision is to be made in the scope of the activity. 12 satellites provide sufficient revisit rate accordingly to mission requirements and global coverage. Thus, baseline service deployment foresees 4 separate launches, but will be revised in the RR.

The emissions monitoring of GHGs needs to be constantly measured which calls for a satellite constellation to avoid latency while maintaining continuous coverage of areas of interest. The satellite configuration will follow the Walker Delta Pattern – circular orbits with set altitude and inclination for optimal coverage of land area which is the focus of observations to be made based on the literature review to observe mainly industrial areas. Aiming for 3-4 years maximum lifetime for the constellation to generate enough data, the altitude is initially set at 450 km.

The base size of one satellite shall be coherent with 12U or 16U CubeSat. It will require deployable solar panels and an active attitude control system with low jitter to enable high pointing stability for image acquisition, propulsion system for station keeping maneuvers.

Table 1: Mission high level parameters

Budgets	Value or range of values	Units
Mission/Constellation Level		
Launch date	IoD – Q2 2025	
Lifetime	3-4 years	
Launcher/deployer	Exolaunch, Falcon 9	
Number of satellites	12	
Orbital description	SSO, 98 degrees inclination	
System/Satellite Level		
Satellite mass	Up to 30	Kg
Continuous payload power	Up to 45	W
Dimensions (stowed deployed)	12U – 16U CubeSat	U
AOCS Description	3 Axis stabilized, 0.01 deg pointing requirements, star tracker integrated	
OB Computer/Architecture	Up to 50 Gb of storage memory	Gb
Downlinking	From 15	Mbps
OB processing	Pre-processing, calibration and filtering	

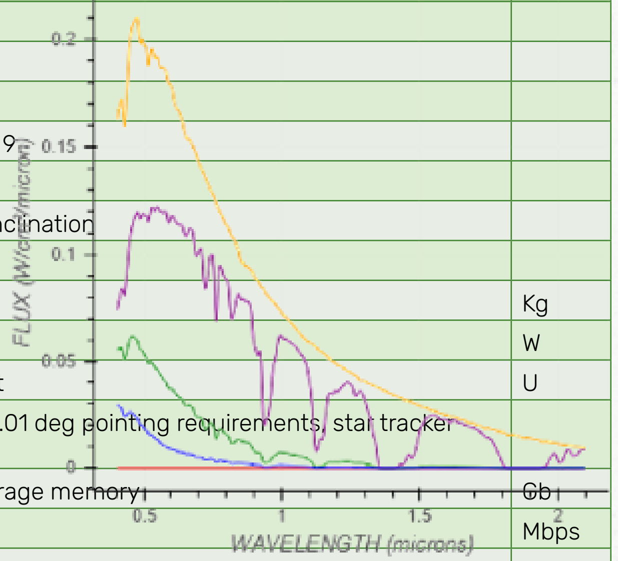


Figure 2: RTM runs giving irradiance vs wavelength for 70 deg

Payload Assembly

The innovative measurement approach is based on the fusion of raw data from several instruments enables high resolution emission data retrieval fitting in the small satellite form factor. Those instruments are SWIR spectrometer, micro-LiDAR and VIS Camera. Detecting the weak CO_2 and CH_4 band is the main target since there are few other gas absorption bands in this area, and it is much easier to separate the band from neighbouring bands. The chosen observation technique, to be compatible with Small Sat approach, is the SWIR spectrometry performed with a medium to high-resolution Grating-Spectrometer, supplemented by a VIS Camera, for scene recognition & precise geolocation.

SWIR Spectrometry relies on analysis of the reflected sunlight and can only be used while the satellite passes over illuminated areas of the planet. For this, solar-based spectroscopy is vulnerable to errors introduced by uncertainties in path length, atmospheric transmission, presence of thin clouds or aerosols, altitude/range errors, etc. For these reasons, here it is proposed to combine the Spectrometer with an atmospheric LiDAR to add and complement retrieval-important atmospheric information and minimise retrieval errors. The basic idea behind the measurement approach goes along these steps:

1. The on-board spectrometer point measurements allow to generate the scene radiance (from the telescope incoming solar irradiance to detector array);
2. The elastic LiDAR inversion algorithm, embedded in the on-board processor, will supply information on vertically resolved aerosols layers, thin & subvisible clouds and backscattering & extinction coefficient. In the IOD, due to Cubesat resource limitations, lidar will provide only AOD, wind to be implemented in a post IOD mission;
3. The radiative transfer model (RTM) will incorporate the LiDAR data and generate the scene corresponding simulated radiance;
4. Tuning the RTM parameters will converge faster & more accurately than previously done towards the measured radiance.

For the micro-LiDAR, operating here as a Flash-light with Analog InGaAs APD or SiPM for photon-counting. For the Camera solution, several possibilities for Cubesat operation do exist already space qualified. The RGB camera images will serve as geolocation for the GHD data as well as for enhancing the AOCS attitude performance to few m ground resolution. End-to-end simulations for the AIRMO scenario yielding the expected SNR have been carried out for both the micro-LiDAR using the baselined laser and for the grating spectrometer. Adequate SNR has been predicted > 100 in the SWIR region. The LiDAR simulation are based on realistic LiDAR scenario. RTM model has been used to calculate the input Irradiance at varying SZA angle, at 400 and 0.1 ppm concentration of CO_2 and CH_4, is shown below. With respect to the Radiance, an accuracy of better than 10% is considered based on initial analysis. No on-board Calibration implemented at this stage. The micro-processor of instrument operation will be updated with calibration as detected.

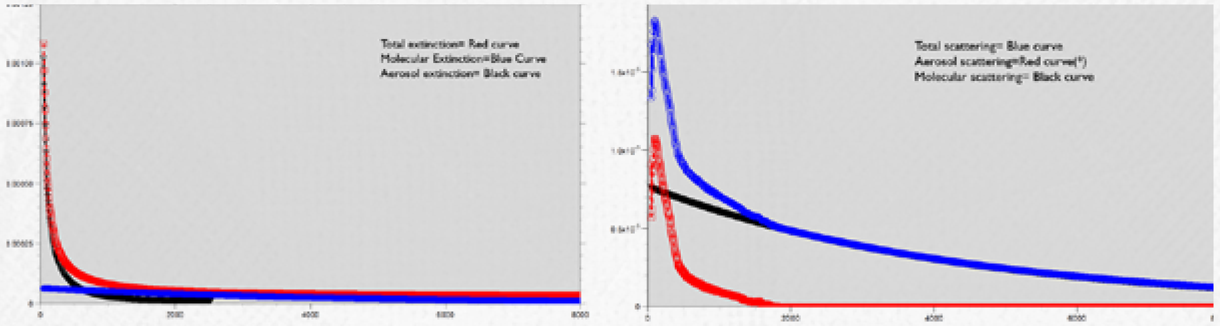


Figure 3 Left: Aerosol and Molecular Extinction coefficients obtained by the Lidar signal, Right: Aerosol and Molecular backscattering coefficients obtained by the Lidar signal

The satellite will measure surface or local winds by splitting the laser beam in two via a DOE element and applying the algorithms previously developed for wind retrieval. A recent paper discussing the retrieval precision on the GHGsat -D1 [3], for the CO_2 and CH_4 gases, clearly shows that neglecting aerosols and local winds add an important error in the retrieval accuracy. Developed payload and processing retrieval approach will remove these important errors source for GHG gases and mostly important for CH_4 plumes (and for CO_2 too) emission from local sources by adding local wind information [4]. All local information on aerosols loads, cirrus, thin clouds (backscattering & extinction coefficient) and winds can be obtained by our novel micro-LiDAR concept as already reported in the literature [5].

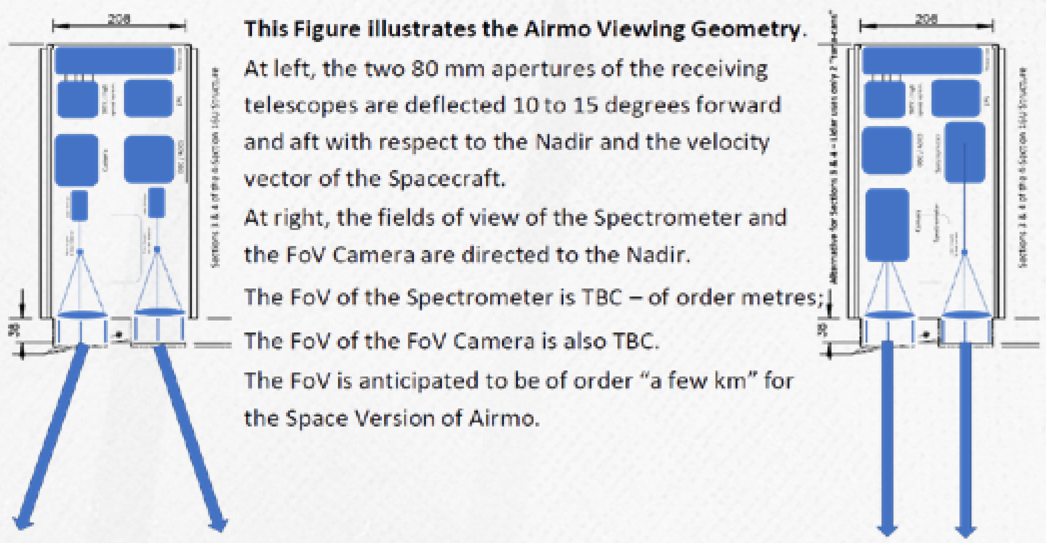


Figure 4: Airmo Payload showing Lidar viewing geometry

The E2E (End to End) simulations show how the Lidar can improve the overall system accuracy performance via AOD lidar inversion.

Figure 5 infact shows that the measured Spectrometer Radiance is very sensitive to atmospheric aerosol (AOD), hence the GHG concentrations, which are extracted from the Radiance measurements, will vary according to the Aerosol load for the same real concentration values impact system accuracy.

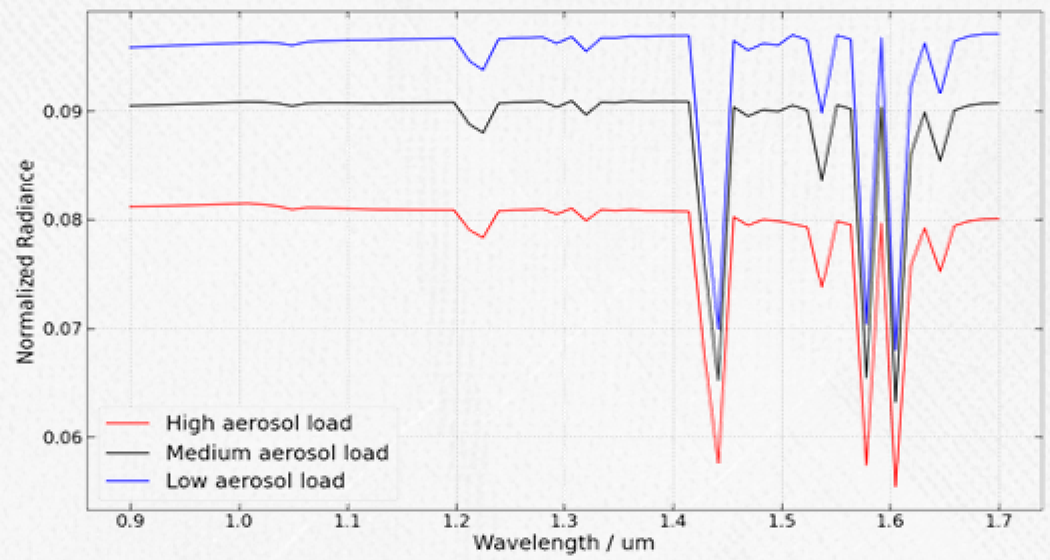


Figure 5: Effect of aerosols optical density on the Absolute radiance retrieval from Spectrometer

Performance Assesment

Preliminary performance requirements on the end-products (GHG) with consolidated units and reference to current state of the art is consolidated below. Assuming L4 data products, critical characteristics are Swath width, Spatial pixel size, Precision, Pixel size + Precision = Detection Threshold (what proportion of emissions can be detected), Update rate. Target performance of final data products is shown in Table 2.

Table 2: Target Performance characteristics

Area Mapping	CO2	CH4	Aerosols
20 Km Swath	1.57, 1.61	1.67	1.55
Bands and spectral ranges, um	0.5	0.5	0.1
Spectral resolution, nm	20	20	20
Field-of-View, km2	50	50	50
Spatial Resolution, m	L2, L4	L2, L4	L2, L4
Processing level	< 1 day	< 1 day	< 1 day
Revisit period, day	>200	>100	>100
SNR	1 ppm	< 4ppb	<2ppm
Uncertainty (Random error)	< 2 ppm	≤100 kg/hr	NA
Precision/point source emission	< 1%	<1	NA
Spectral sensitivity to Concentration changes in the column, %			

Preliminary performance requirements on the individual LiDAR, spectrometer and camera data products expected to be injected into the data-fusion (e.g. spatial resolution of wind information, accuracy on the radiance). LiDAR Preliminary Performance Requirements:

- Range resolution: <1 m
- LiDAR GSD=Spectrometer GSD<50 m

- Repetition rate= 10-100 Khz
- Wavelength= 1.55 micron
- InGaAs APD

Spectrometer & Camera Preliminary Performance Requirements:

- Pixel size [µm] : 15
- Camera array dimensions: 640x512 pixels
- Spectral range [nm]: 1.5 –1.7 micron
- Spectral resolution: < 1 nm
- Ground sampling distance (GSD): 50 m.
- Field of view: 50 km

The retrieval of the desired species concentration is based on three steps algorithms:

1. Reconstruct the actual scene Radiance
2. End-to-end simulation of the instrument function.
3. Inverse methods to obtain the species volume mixing ratio (vmr)

During this process there are many sources of errors during computation of Step 1 and 3: primarily associated with poor knowledge of the atmospheric conditions, and mostly presence of thin clouds and Aerosols which are undetected by the VIS Camera, and which can lead to large errors in the vmr's values. For this the Spectrometer & Camera are supported by a cloud/aerosol LiDAR, which is the simplest of all active LiDAR instruments, but will be able to detect and characterize with high vertical resolution and accuracy the presence of Aerosols and clouds.

The AIRMO Level 1B product list are calibrated and geo-located spectral radiances. Each Level 1B product will contain a unique record for every sounding that the payload instruments acquire while viewing the Earth during a single spacecraft orbit, consisting of atmospheric column spectra. The Level 1B product also includes error measures and indicators that assess the quality of each acquired spectrum. These indicators denote which spectra are suitable for subsequent processing. The full Constellation of AIRMO small satellites will be correspondingly generating thousands of Gbs of data daily. Certain pre-processing algorithms will enable on board compression and pre-processing (L01b) while the final intelligence products (L2) will be processed on the Ground segment.

Data Processing Design Concept is a several steps process:

Applications of ad-hoc software and implementation on a FPGA. During the 1st steps the following processes occur:

a. acquisition of raw data from instruments (co-located camera images;
b. Radiance calculations per spectral band;
c. LiDAR data of backscattering profiles per line-of-sight, retrieval clouds/aerosol layering, retrieval of extinction and backscattering profile per line-of-sight, generation of point-cloud image of the co-located scene (with camera & spectrometer;
d. Performing Radiative Transfer Models (RTM) for the atmosphere column investigated with inputs from the three sensors;
e. final step of matching RTM Radiance to measured Radiance and extraction of the GHG gas profiles fitting the matched Radiance profiles.

Second step is concerned with FPGA implementation.

To identify anthropogenic emissions, which are typically very localised (e.g. power plants), small changes need to be detectable given a large background signal that is present also in unperturbed areas. Observations are typically affected by different types of errors which are both of random and systematic type. The error sources originate either from instrumental or spacecraft related effects, the observation geometry or from an incorrect modelling of the observed atmospheric scene. Examples for the former type are: Line of sight pointing or geolocation knowledge errors, Insufficient characterisation of the Instrument Spectral Response Function (ISRF), Detection noise, Spectral calibration errors, etc. Such errors are usually attributed to the **Level 1B** processing component. Error sources of the latter type include:

- Level 1B input errors due to random
- Presence of non-detected clouds or aerosol layers
- Erroneous atmospheric state parameters (pressure, temperature profiles, profiles of contaminants, …)
- Errors in additiona– - static or semi-stati– - modelling parameters (spectroscopy data, solar irradiance, surface albedo, terrain height …)

Such errors are generally attributed to the **Level 2** component of the ground processor. Table 3 shows the resulting retrieval error contributions

Table 3: Retrieval error contributions for selected systematic effects

XCO2 retrieval error – impact of selected systematic instrument effects			
Error type	Radiometric offset	Radiometric gain	Spectral shift
Error	+20 % of Sun-normalised radiance (averaged over spectral range 1595-1615 nm)	+20 % (applied to Sun normalised radiance)	+0.3 nm
Contribution to total XCO2 retrieval error [ppm]	-0.59	-0.54	+0.04

Conclusion

Using novel lidar-based observation technology, satellite constellation will be capable of attributing emissions directly to individual facilities. The emissions data will be later transformed into actionable insights with our in-house analytics, helping customers to optimize their operations, reduce emissions and uphold environmental standards. The innovative measurement approach powered by LiDAR and Short-wave infrared (SWIR) spectrometer proposed by AIRMO is the core of the proposed service. Fusion of raw data from these novel instruments enables high resolution emission data retrieval both in day and night all over the globe.

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PRECIPITATION-INDUCED AEROSOL REDUCTION USING MPLNET LIDAR AND MICRO-RAIN RADAR OBSERVATIONS

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Abstract

This research main goal is to assess the influence of precipitation on atmospheric aerosol concentrations, employing sophisticated remote sensing techniques via the NASA Micro-Pulse Lidar Network (MPLNET) and micro-rain radar profiles at NASA Goddard Space Flight Center (GSFC). Comprehensive aerosol backscatter analysis, conducted before and after precipitation events, discloses significant alterations in central tendencies, dispersion characteristics, and morphologies of the data distributions. This analysis provides a nuanced understanding of the dynamics governing the interactions between precipitation and atmospheric aerosols, delineating the cleansing impacts of rainfall by examining changes in aerosol distribution patterns. The collated data delineate a detailed narrative of diurnal atmospheric dynamics, accentuating the complex relationship between backscattered coefficients and precipitation mechanisms.

Introduction

Aerosols, tiny particles suspended in the air from natural and anthropogenic sources, significantly impact human health and environmental processes. Their temporary presence, lasting from days to weeks, can exacerbate respiratory and cardiovascular diseases, particularly affecting vulnerable populations like the elderly and children. In urban areas, aerosols influence the urban heat island effect [1] and human comfort during heat waves. They also play a critical role in scattering and absorbing solar radiation, affecting energy production and Earth's energy balance. While some aerosols promote cooling by reflecting solar radiation [2], others, such as black carbon, cause localized warming by absorbing it. Aerosols impact atmospheric stability, large-scale circulation, and regional hydrological patterns [3], making them crucial for understanding climate sensitivity. Their interaction with precipitation, which removes aerosols from the atmosphere through processes like washout and rainout, affects their levels, distribution, and properties, thereby influencing visibility, cloud formation, and climate systems. This research aims to elucidate the mechanisms and effects of precipitation on aerosol levels, providing insights into their complex relationships with climate and meteorological events.

Methodology

To quantitatively assess the impact of precipitation on aerosol atmospheric profiles, we analyzed the variations in the backscatter atmospheric profile before and after precipitation events. The study focused on two precipitation events on May 4th and 5th, 2021, at the MPLNET [4] observation site at NASA Goddard Space Flight Center (GSFC) [. Due to cloud coverage, obtaining pre-precipitation backscatter profiles was challenging. For the first event, we used a 20-minute averaged backscatter profile from 20:06UTC to 20:26UTC on May 4th, with precipitation recorded from 20:56UTC to 22:30UTC. Post-precipitation backscatter profiles were averaged from 03:10UTC to 03:30UTC on May 5th.

Our methodology involved several steps:

1. **Data Extraction and Examination**: We used atmospheric backscatter data as a proxy for aerosol concentration and gathered detailed precipitation characteristics from the Micro-Rain Radar (MRR).
2. **Descriptive Statistics and Visualization**: We generated histograms and kernel density plots for backscatter profiles before and after precipitation and calculated key statistical metrics (mean, median, standard deviation, skewness, kurtosis).
3. **Altitude Segmentation**: We segmented the aerosol backscatter data into 300-meter altitude bands up to 3 km, quantifying aerosol loading before and after precipitation and calculating the percentage change.
4. **Rain Rate Analysis**: Using the MRR dataset, we calculated the average rain rate for each altitude band, correlating it with changes in aerosol concentration.

Results were compiled into a table comparing changes in aerosol loading with average rain rates across different altitudes, providing insights into how precipitation intensity affects aerosol removal at various heights.

This comprehensive approach, combining advanced lidar [5,6] data with detailed statistical analysis, offers a robust framework for understanding the scavenging effect of precipitation on aerosol concentrations in the atmosphere.

Results

In this study, we analyze a precipitation events that occurred on 04 and 05 May 2021 at the NASA MPLNET Goddard Space Flight Center permanent observational site.

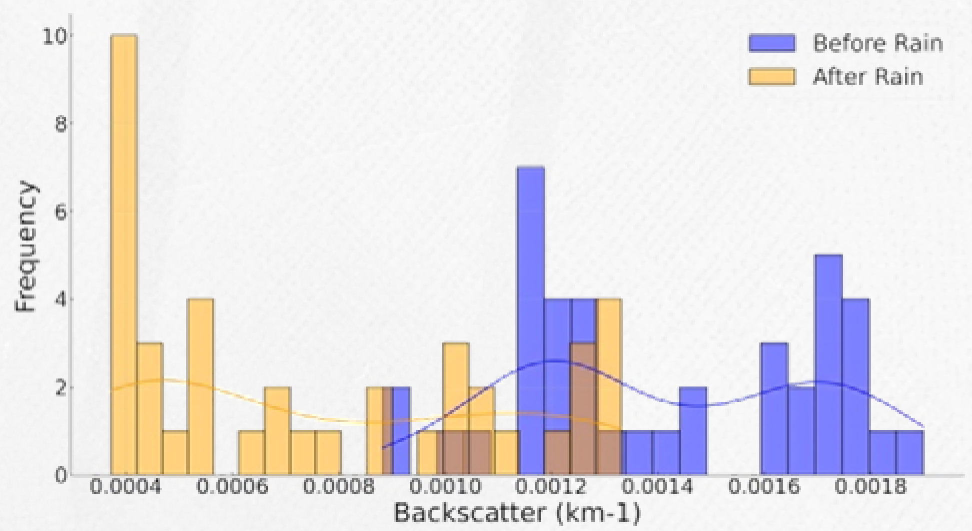

Figure 1: Histogram of the backscatter coefficient (km-1 sr-1) before and after precipitation on 05 May 2021 at NASA GSFC

To quantitatively assess changes in aerosol loading, we analyze histograms and kernel density plots of the backscatter profiles in the range 0-3km. Figure 1 provides a visual comparison before and after precipitation that lasted at about 11:40 UTC on 05 May 2021.

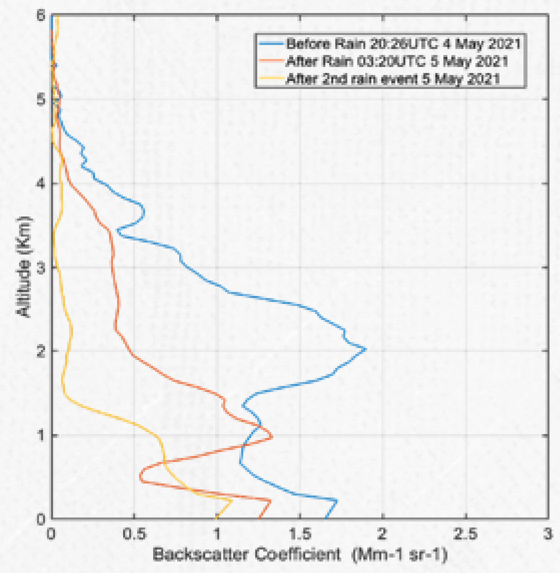

Figure 2: Backscatter coefficients before and after two precipitation events that started at 22:30UTC of 04 May 2021 and at 11:40UTC of 05 May 2021.

The backscatter coefficient, measured in units of km^{-1} sr^{-1}, is examined before and after precipitation in different altitude ranges from 0m to 3000m in Table 1. The backscatter coefficient is associated with the overall aerosol loading before and after rainfall, the observed changes in backscatter coefficient and the average rainfall rates in units of mm hr-1 for each altitude range. These data offer valuable insights into the vertical distribution and behavior of aerosols in response to precipitation events, highlighting the atmospheric cleansing effect at various altitudes.

Table 1: Effect of precipitation on aerosol loading along the vertical profile from 0 to 3km, aggregated in 300m bins.

Range	Before Rain	After Rain	Change (%)	Rain Rate
0m - 300m	0.00675	0.00515	-23.721	0.925
300m - 600m	0.00536	0.00287	-46.46	1.022
600m - 900m	0.00462	0.00311	-32.521	1.35
900m - 1200m	0.005080	0.00508	4.92	1.89
1200m - 1500m	0.00479	0.004261	-11.13	1.117
1500m - 1800m	0.00593	0.00328	-44.781	2.571
1800m - 2100m	0.00726	0.00212	-70.730	0.661
2100m - 2400m	0.00703	0.001646	-76.58	3.352
2400m - 2700m	0.00598	0.00161	-73.25	NaN
2700m - 3000m	0.00392	0.00153	-60.690	NaN

Conclusions

In summary, the observed case study presents a compelling picture of the daily atmospheric dynamics, highlighting the intricate interplay between backscatter coefficients and precipitation processes. The distinct diurnal pattern and the altitude-dependent changes in backscatter coefficients and rain rate underscore the complexity of atmospheric behavior, warranting further investigation to unravel the underlying mechanisms driving these variations.

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ASSESSMENT OF METHANE CONCENTRATIONS IN ESTUARINE REGIONS ON THE COAST OF THE STATE OF SÃO PAULO

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Abstract

We evaluated concentrations of atmospheric CH4, which is considered one of the main gases causing global warming. We observed methane concentrations in the Cananéia-Iguape estuarine system on the southern coast of the state of São Paulo, Brazil and in the Santos estuary, Baixada Santista region, coast of the state of São Paulo, Brazil. The south coast region is widely studied as it presents very well-preserved fauna and flora and thus offers an important background on natural emissions. Data acquisition was carried out by a portable gas analyzer (LGR-ICOSTM GLA131), this equipment has a high sensitivity in detecting the gases under study and was placed on board the research vessels Albacora and Alpha Delphini owned by the Institute of Oceanography at the University of São Paulo in campaigns that were carried out between 2021 and 2023 in specific periods. The concentrations observed during the exploratory campaigns in the estuaries on the coast of the State of São Paulo (Iguape Cananéia Estuarine-Lagunar Complex and Santos Estuary) behaved as described in the literature, regions with greater anthropic impact present higher values of methane concentrations in the atmosphere, low-impact regions have lower methane concentrations.

Introduction

Methane (CH_4) is one of the most important greenhouse gas (GHG), being ranked in second when the question is the radiative forcing[1]. Methane has a several sources, being the naturals crucial to the maintenance of its concentrations in atmosphere. The production from soil occurs when organic matter is anaerobically degraded. Several bacteria degrade organic material through a complex food net where the final step in this process is carried out by methanogenic, methaneproducing bacteria [2]. Many studies demonstrate the natural wetlands are the origin of main sources of atmospheric methane, several researchers have attempted to quantify global emissions from wetland environments [3].

Methodos

Microportable Greenhouse Gas Analyzers (LGR-ICOS™ GLA Series), have high sensitivity and a very fast response time, approximately 1 second. Based on the integrated cavity spectroscopy technique (OAICOS), which is widely used for detecting trace gases, due to its numerous advantages such as fast response, high sensitivity, and stability. The portable gas analyzer has a diode laser and its wavelength is adjusted according to the "target" gas molecule. In this work, equipment was used that has two lasers at wavelengths 1,600 nm and 1,650 nm and measures the concentrations of the gases CO_2, CH_4, and H_2O_v. Its operation is similar to non-portable benchtop equipment for the analysis of trace gases, where the gas sample enters the equipment through the INLET, where the gas is filtered and goes through pressure adjustment to guarantee a specific set point contributing to the efficiency of the equipment, immediately after this step the sample passes again through another highefficiency filtration system, which removes particles of up to 0.01 m and goes to the optical cell cavity, where the light is transmitted along the cavity, being The variability of light is detected and transformed into a digital signal and stored on a computer.

Figure 1: Microportable Greenhouse Gas Analyzers (LGR-ICOS™ GLA Series)

Results

For data acquisition, the equipment was placed at two fixed points, also in 5 navigation campaigns with the Albacora Research Boat in partnership with the Institute of Oceanography in different periods. Below we present the locations for data acquisition.

Figure 2: Cananéia-Iguape estuarine system on the southern coast of the state of São Paulo

Figure 3: Santos estuary, Baixada Santista region, coast of the state of São Paulo

In figure 4 we did not observe high variability in methane concentrations during the campaign or between day and night periods. Averages of 1.81 ppm, minimum of 1.79 ppm, 1.96 ppm at night and 2.055 ppm during the day.

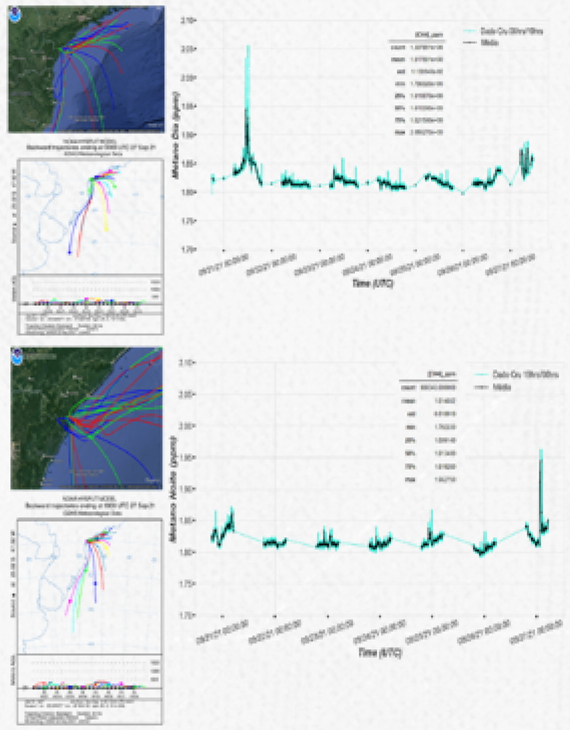

Figure 4: Methane values (ppm) observed in the City of Cananeia in September 2021

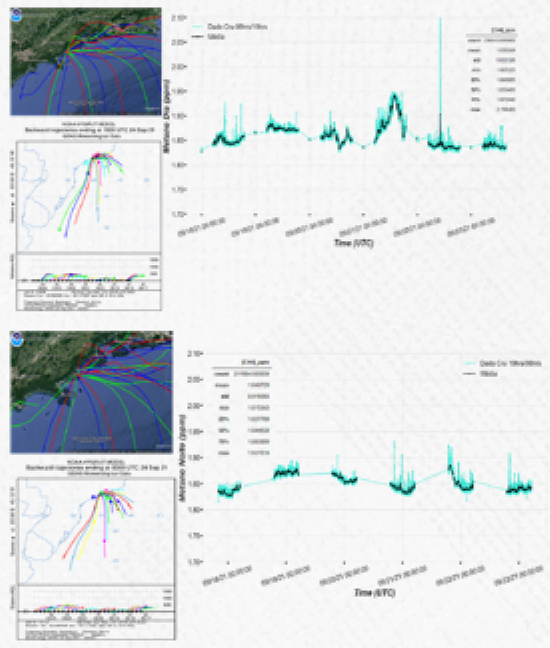

Figure 5: Methane values (ppm) observed in the City of Ubatuba in September 2021

In figure 5, the concentrations observed in the Ubatuba region were 1.81 ppm and 1.93 ppm, maximum and minimum respectively, and an average concentration of 1.85 ppm, not showing significant variability during the exploratory campaign.

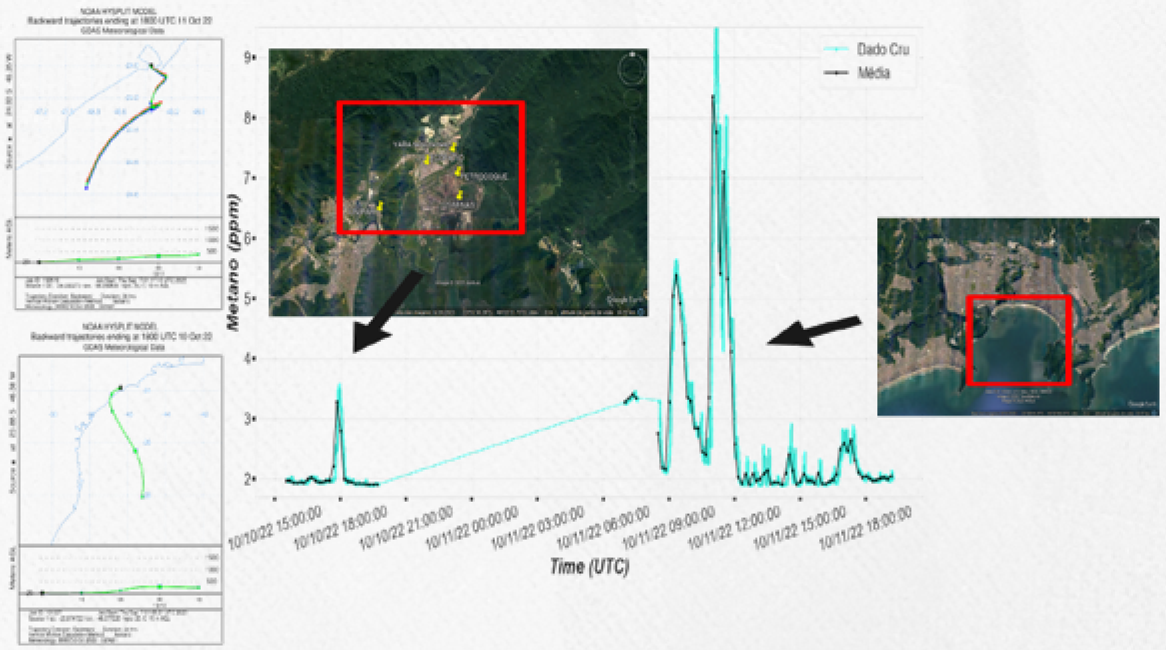

Figure 6: Methane values (ppm) observed in the City of Santos in October 2022

The average concentrations were 2.07 ppm and maximum value 3.56 ppm observed on the first day of data collection in the Santos region, this area includes many industries in the chemical sector. Concentrations during the second day of data acquisition were a minimum of 1.89 ppm and a maximum of 10.59 ppm, with an average of 2.82 ppm. The observed region is impacted by the emission of domestic waste ($5.3m^3s^{-1}$). We observed values above 4 ppm for 4 consecutive hours.

Conclusion

The concentrations observed during the exploratory campaigns in the estuaries on the coast of the State of São Paulo (Iguape Cananéia Estuarine-Lagunar Complex and Santos Estuary) behaved as described in the literature, regions with greater anthropic impact present higher values of methane concentrations in the atmosphere, low-impact regions have lower methane concentrations.

The data observed during the displacement campaigns in the Iguape Cananéia Estuarine-Lagunar Complex had average values of 1.8 ppm and 1.9 ppm, at times the methane concentrations were slightly below the methane concentration values expected in the atmosphere by literature (1,903 ppm)

In the Santos Estuary region, we observed concentration values above those expected in the literature, with average concentration values around 2 ppm, but with significant peaks along the displacement, mainly close to the Santos submarine outfall.

The literature proposes that estuaries are a possible source of greenhouse gas emissions, but we observed few moments in which concentrations were above expected values. When we observe the Iguape Cananéia Estuarine-Lagunar Complex, we can evaluate the system's emissions without human interference and thus evaluate the natural contributions. To confirm this trend we need constant monitoring of the regions.

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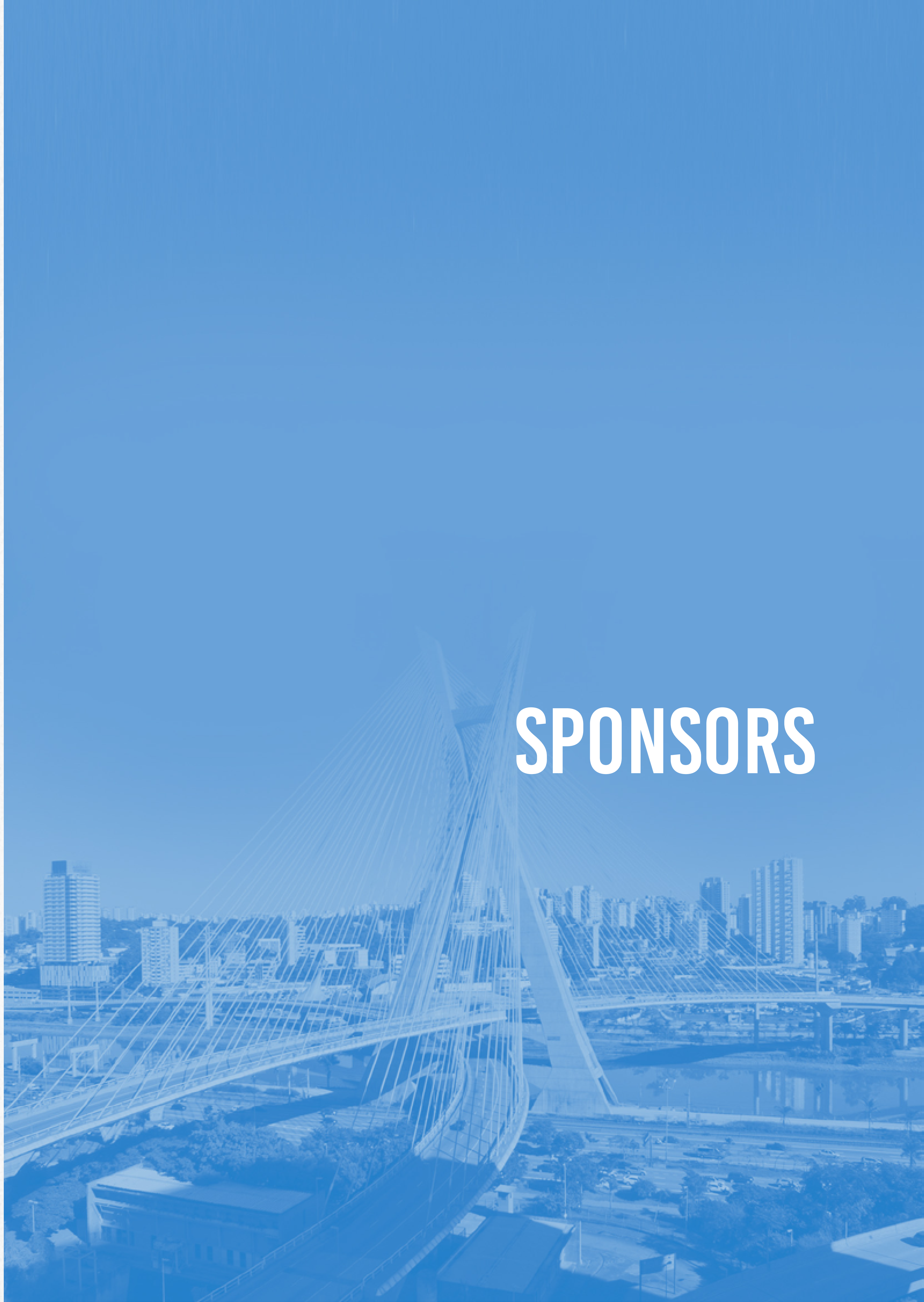

The Latin America Environmental Solutions Group (LAESG) is an umbrella corporation overseeing two subsidiary Brazilian companies: **SOLEN – Environmental Solution and SCINK – Carbon Management through Science**.

SOLEN was established in 2018 to provide innovation for environmental impact, quality management, and climate change projects. Over the first five years, the company has set benchmarks in these areas, collaborating with significant companies such as Emerson, ArcelorMittal, Tetra Tech, and the Brazilian Government.

SCINK, a Brazilian company, was established with the goal of introducing innovation to the carbon market. Beyond offering traditional services related to emission inventories, SCINK has developed solutions geared towards estimating emissions and carbon sequestration. This involves utilizing high-resolution measurements and modeling, constituting a versatile technology designed to enhance the reliability and accuracy of projects focused on Greenhouse Gas (GHG) emissions and Designation of Origin (DO).

Both companies share a common ideology, aiming to bridge the gap between scientific knowledge derived from the founders' academic background and the requirements of the market. In alignment with this philosophy, LAESG continues to engage in scientific projects and maintain a portfolio of solutions for private companies. The studies range from identifying groundwater contamination through isotope analysis to atmospheric carbon accounting.

If you want to learn more about the companies, please visit the websites:

www.laesg.com

www.solenlab.com

www.scink.com.br

IPEN

The Institute of Energy and Nuclear Research (IPEN) is an autarchy linked to the Secretariat of Science, Technology, and Innovation (SCTI) of the São Paulo Government and managed technically and administratively by the National Nuclear Energy Commission (CNEN) of the Ministry of Science, Technology and Innovation (MCTI), of the Federal Government.

Located in the São Paulo University (USP) "campus", occupying an area of 500,000 square meters, IPEN has today a prominent performance in various sectors of nuclear activity among them, in the applications of radiation and radioisotopes, nuclear reactors, materials, and in the fuel cycle, in radioprotection and dosimetry, whose results have

been providing significant advances in the field of technologies, in the production of materials and the provision of services of economic and strategic value to the country, extending the benefits of nuclear power to larger segments of our population.

The multidisciplinarity of the nuclear sector activities has allowed IPEN to conduct a broad and varied program of research and developments in other areas. Among these, in the area of Biotechnology, in the area of Nuclear Physics and Radiochemistry, in the area of Advanced Materials, Nanotechnology, and obtaining and preparing special ceramics, biomaterials, and growth of monocrystals for use in lasers.

A rigorous nuclear safety and radiological control program is conducted at all IPEN nuclear and radioactive facilities. This program includes radiological, personal and environmental monitoring, care for radiological emergencies, radiological analysis, radiosanitary evaluations, calibration of radiation monitors, treatment and packaging of low-activity nuclear waste.

IPEN is also responsible, in association with USP, for conducting graduate programs at the master's and doctoral levels. CAPES, of the Ministry of Education, has evaluated the postgraduate courses of IPEN granting in all its evaluations the best concepts placing it among the best postgraduate courses in the country. In 2020, it reached the level of three thousand degrees, between a Master's and a Doctorate. Since 2019 offered the Stricto Sensu Professional Master Course in Radiation Technology in Health Sciences.IPEN is also responsible, in association with USP, for conducting graduate programs at the master's and doctoral level. CAPES, of the Ministry of Education, has evaluated the postgraduate courses of IPEN granting in all its evaluations the best concepts placing it among the best postgraduate courses in the country. In 2020, it reached the level of three thousand degrees, between Masters and Doctorate. Since 2019 offers the Stricto Sensu Professional Master Course in Radiation Technology in Health Sciences.

LEAL

In 2000 the Center for Lasers and Applications (CLA) belonging to the Institute of Energy and Nuclear Research - IPEN, opened his activities in the atmospheric science field by establishing the Laser Environmental Applications Laboratory (LEAL). From that time, LEAL started the activities in the study of the aerosol and clouds vertical distribution, investigating their optical and physical properties and the role of air pollution in the Metropolitan Area of São Paulo-Brazil. LEAL is part of The Latin America Lidar Network (LALINET) since 2001, when LALINET was created during the First Workshop on Lidar Measurements in Latin America (WLMLA) in March 2001. In November 2013 LALINET was recognized as a contributing network for the World Meteorological Organization Global Atmosphere Watch Programme (WMO/GAW), and LEAL was considered a WMO/GAW contributing aerosol observation station called SPU Lidar Station.

OURONOVA

Ouronova is a deep tech venture builder continually investing in developing innovative, disruptive, and incremental solutions to support the operations of different industry segments.

Our expertise, consolidated over a decade as a provider of cutting-edge solutions for the oil and gas sector, enables us to expand our range of operations and offer our inventive capacity to other sectors that use technology intensively.

The open innovation model is not just about combining partner competencies to innovate and build new businesses to sell products. It's about fostering a collaborative environment where every partner feels included and valued.

Our purpose is to make an impact through innovation. This impact will translate into greater operational safety and reliability, the integrity of assets and people, and lower human and environmental risks. It will also minimize climate change and accelerate the energy transition.

ouronova has consolidated a robust portfolio of projects in partnership with global companies and universities. The generation of almost 20 patents and the achievement of technological innovation awards reflect our capacity and expertise.

EUROPEAN SPACE AGENCY (ESA)

The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world, dedicated to the peaceful exploration and use of space for the benefit of all. Founded in 1975,

ESA is an international organization with 22 Member States. By coordinating the financial and intellectual resources of its members, it can undertake programs and activities far beyond the scope of any single European country. ESA makes space accessible to everyone. They build and launch rockets and satellites, train astronauts, observe the Earth, explore space and try to answer the big scientific questions about the Universe.

Satellites offer a unique perspective of our planet. From space, it is easier to see the effects of climate change, the extent of floods and forest fires, or simply whether it is going to rain today! ESA helps make this global conversation possible with satellite technology. ESA also help industries and innovations that will shape the telecommunications of the future.

https://www.esa.int/
https://www.esa.int/About_Us/ESA_Publications/This_is_ESA
https://discover.esa.int/#/en

RAYMETRICS SA.

Raymetrics is a technology and software company with global presence. The company design and manufacture atmospheric LIDAR solutions. Their proprietary technology based on artificial intelligence (AI) and machine learning (MLR) algorithms allow us to address complex environmental challenges.

Raymetrics was founded in 2002. We are the first atmospheric LIDAR company in the world. We aim to be the pioneer in addressing the environmental challenges through our software platform and unique integrating capabilities. These allow us to analyze the data provided by a constellation of LIDARs and other advanced sensors.

METEOROLOGY

Systematic and structured weather monitoring and recording is essential in developing vast databases of historic weather conditions. Advanced AI and MLR software can provide valuable predictions of extreme weather phenomena and prevent catastrophes. https://raymetrics.com/meteorology/

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Air quality and air decarbonization are essential for humanity's wellbeing and preservation of our planet's ecosystem. Our unique sensor technologies (LIDARs) combined with our proprietary platform capabilities have evolved into impactful environmental applications. https://raymetrics.com/environment/

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WHY RAYMETRICS MAKES THE DIFFERENCE?

01_Supporting industries that affect everyone

Our proprietary and advanced technology solutions support the seamless operations of heavy industry (pollutant reduction and elimination), aviation, meteorology, water management, oil & gas, civil and environmental protection among a few to mention

02_Building better air quality and safer environment

We contribute to a healthy planet and a better living by providing quality data for a more sustainable climate, cleaner air and safer environment

03_Delivering innovative and integrated solutions

The present and future requirements as on the collection of data lead us to continuously develop new products and services. Integrated technology, faster processing, higher accuracy and minimum human dependency are our driving forces

LINKS:

https://raymetrics.com/

https://www.youtube.com/channel/UCotDZ47apTVLz_KtJuYr_1A/featured

https://x.com/Raymetrics

https://www.linkedin.com/company/raymetrics-advanced-lidar-systems/?viewAsMember=true

UNIVERSIDAD DE MAGALLANES

University of Magallanes (Universidad de Magallanes (UMAG) in Spanish) was founded as the headquarters of the former Universidad Técnica del Estado in 1961, the Universidad de Magallanes is a public, state-owned, secular institution with a solid tradition in the Chilean university system that develops teaching, research and outreach activities aimed mainly at the growth of the southernmost region of the country.

It currently has an enrollment of more than four thousand students, focusing its activities in Punta Arenas where the Central Campus is located, which houses its five faculties, the School of Medicine, the GAIA Antarctic Research Center and other student and administrative facilities. On the other hand, in the same city is located the Institute of Patagonia along with the Museum of Remembrance, which is one of the most visited tourist attractions; the Teaching and Research Assistance Center CADI-UMAG, established on land adjacent to the Clinical Hospital of Magallanes, the Conservatory of Music, the Building of the Vice-Rectory of Linking with the Environment and, outside the urban radius are located some specific laboratories such as Bahía Laredo and E-Combustibles.

More than sixty years after its beginnings, the University has been able to expand progressively in southern Patagonia. In the Region of Magallanes and Chilean Antarctica it is present in the various provinces, with the Puerto Natales University Center, the Territorial Office in Porvenir, the Cape Horn University Center with its Subantarctic Center and the wonderful natural laboratory "Omora Park" located in Puerto Williams. In the Aysén Region there is the Coyhaique University Center .

UMAG
Universidad de Magallanes

With a differentiating character, the University aims to be a national and international reference regarding the generation of knowledge in Patagonia, Tierra del Fuego, Subantarctic and Antarctic territory, prioritizing, according to its development plan, areas such as: Human settlement in high latitudes; Antarctic and sub-Antarctic biodiversity, energy and environment.

In the commitment to deliver a wide formative quality, our University is accredited until December 2028 in the areas of Undergraduate Teaching, Institutional Management, Research and Outreach, being so far one of the few institutions of higher education accredited in the field of research.

In Research, Development and Innovation, UMAG focuses its actions on strengthening studies and publications in the various disciplines that make up the humanities, social sciences, engineering and natural sciences, mainly in the Region of Magallanes and Chilean Antarctica.

One of the disciplines or research theme in UMAG is the Atmospheric Science and Climatology. The Atmospheric Research Laboratory (LIA, Laboratorio de Investigaciones Atmosféricas, in Spanish) have the mission to develop the research in this area, conducting activities in three themes: ozone, atmospheric radiation, and aerosols and clouds.

Links:

http://www.umag.cl/

http://www.youtube.com/user/radiotvumag

https://x.com/udemagallanes

http://www.facebook.com/udemagallanes

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https://www.linkedin.com/school/udemagallanes/mycompany/

PHOTO GALLERY

Fotos: Fernanda Macedo

Welcome and accreditation place.

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XII WLMLA opening, with Juan Vicente Pallotta, from UNIDEF - Inidad de Investigación y Desarrollo Estratégicos para la Defensa, National Scientific and Technical Research Council and LALINET member.

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XII WLMLA opening, with Juan Carlos Antuña-Marrero, from Camaguey Meteorological Center (CMC) and LALINET member.

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Talk session with Dr. Igor Veselovskii, from Researcher at Physics Instrumentation Center. Moscow - Russia.

Fotos: Fernanda Macedo

Talk session with Dr. Dong Lyu, from Atmospheric Environmental Remote Sensing Society - AERSS, China.

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Talk session with Dr. Eduardo Landulfo from IPEN, Energy and Nuclear Research Institute, member and coordinator of LALINET.

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Participants and members of LALINET, at XII WLMLA.

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Members of XII WLMLA organizing committee, MSc. Elaine Cristina Araújo, MSc. Izabel da Silva ANdrade, Dr. Fernanda de Mendonça Macedo, Dr. Fábio Juliano da Silva Lopes, MSc. Thaís Correa and Ms. Luisa D'Antola de Mello.

Researchers of Atmospheric Environmental Remote Sensing Society - AERSS of China and the Institute of Energy and Nuclear Research - IPEN. Dr. Zhenzhu Wang, Dr. Niklaus Ursus Wetter, Dr. Yingjian Brawang, Dr. Isolda Costa, Dr. Eduardo Landulfo and Dr. Dong Lyu.

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Researchers from the Society of Atmospheric Environmental Remote Sensing - AERSS of China and the Institute of Energy and Nuclear Research - IPEN sign formal collaboration by ENSO Monitoring Network and the IPEN Laser Environmental Applications Laboratory (LEAL). Dr. Dong Lyu, Dr. Eduardo Landulfo, Dr. Zhenzhu Wang, Dr. Isolda Costa and Dr. Yingjian Brawang.

Foto: Fernanda Macedo

Participants of the XII WLMLA.

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