remote sensing

Editorial

Editorial for the Special Issue "Optical and Laser Remote Sensing of the Atmosphere"

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This Special Issue of Remote Sensing continues a long line of related research papers covering the use of optical and laser remote sensing for quantitative measurement and imaging of chemical species and physical parameters of the atmosphere. Over the past 60 years since the invention of the laser in 1960 and the first lidar remote sensing of water vapor in the atmosphere in 1964, an ever increasing and sophisticated technology has developed for the remote measurement and imaging of atmospheric parameters and constituents, including atmospheric aerosol properties, smoke plumes, chemical species concentrations, wind fields, water vapor transport, and mapping of atmospheric aerosol flow. References [1–3] are reviews of techniques that enable these measurement capabilities. These reviews cover a period of nearly 30 years, including references to early historical investigations on the topics represented here in this issue (e.g., aerosol backscatter lidar [4], Raman lidar for aerosol extinction [5], Doppler wind lidar [6], laser-induced fluorescence [7,8], and integrated-path differential absorption lidar [9,10]), and as a group they tell a story of the extent to which the field has advanced over that period.

The papers presented in this Special Issue cover a diverse range of important and novel remote sensing research of the atmosphere and environmental constituents. They include investigations in aerosol science, Doppler measurements of atmospheric wind profiles and turbulent motions, fluorescence spectroscopy, and retrievals of carbon dioxide concentration levels over regional and global scales.

The research by Lopes, et al. [11] provides detailed satellite and ground based lidar sensing of aerosols, pyroclastic material, and sulfates injected into the atmosphere by the eruption of the 2015 Calbuco volcano; spaceborne detailed mapping and temporal flow of the volcanic plume was measured along with important ground based calibration of the lidar signals.

Research on aerosol optical depth over east China developed from polarized satellite optical data is covered in the paper by Zhang, et al. [12] They compare observations using the PARASOL lidar looking at multi-angle polarized signals from fine aerosols and a grouped residual error sorting technique to retrieve the aerosol density with good accuracy over a large geographical area.

A new algorithm used for lidar remote sensing data is described in a paper by Di, et al. [13] which showed an increase in accuracy for aerosol particle parameter determination using multi-wavelength Raman and high-spectral resolution lidar measurement data. The new averaging procedure was carried out for three main types of aerosols, and yielded good results and comparison with airborne collected aerosol particle measurements.

The ADM Aeolus satellite mission of the European Space Agency (ESA) and research work leading up to the first wind lidar successful launch in 2018 is covered in the paper by Marksteiner, et al. [14] They describe the expected atmospheric wind observations of the Earth-orbiting ALADIN Direct Detection (Mie-Rayleigh) Doppler wind lidar which is contained within the Aeolus satellite system. In addition, airborne wind lidar calibration and comparison measurements were made with the ALADIN Airborne Demonstrator instrument and the more well established coherent 2-μm wind lidar. Differences between the Airborne Demonstrator and the satellite instrument are highlighted.

An exciting and novel paper on laser induced fluorescence lidar measurements of natural pollens floating in the atmosphere is presented by Yasu Saito, et al. [15] They investigated over 25 different pollens using 355 nm laser excitation and studied the fluorescence spectral peaks as a discriminant including cedar and ragweed pollens at a lidar distance of about 20 m. Such a technique can be used to not only measure the pollen count/density but to also easily classify the pollen origins.

Banakh and Smalikho [16] describe a high-spatial resolution and detailed temporal lidar study of the wind turbulence within a stable atmospheric boundary layer using a coherent Doppler lidar system. They found that the turbulence and dissipation rate was weak at the central location of low-level jets within the boundary layer, and that the integral scale of turbulence in the jet was about 100 m.

Two papers are studies relating to high-precision measurements of atmospheric carbon dioxide concentration levels. A detailed simulation of the effect of atmospheric CO_2 in regional urban areas using spaceborne CO_2 lidar measurements is given in the paper by Han, et al. [17]. They conducted a feasibility study on obtaining urban-scale column CO_2 volume mixing ratios using the lidar measurements from an IPDA-DIAL system. With a lidar orbit height of 450 km, their simulations indicate that random errors less than 0.3% should be feasible. In addition, a related paper by Matvienko [18] covers the use of neural networks to provide additional information from retrievals of the CO_2 atmospheric concentration as measured by the IPDA-DIAL system.

Finally, the research paper by Hara, Nashizawa, and Sugimoto et al. [19] covers the retrieval of aerosol components (black carbon, sea salt, air pollution, mineral dust) using a multi-wavelength Mie-Raman lidar and direct comparison and calibration with ground based aerosol sampling measurements. They measured lidar and backscatter coefficients at 355 nm, 532 nm, and 1064 nm and vertical distributions of extinction coefficients. Their results showed excellent agreement after introducing a new internal mixture model of black carbon and water soluble substances, as well as a new technique for better classifying mixtures and showing good agreement with in-situ measurement.

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References

1. Killinger, D.K.; Mooradian, A. *Optical and Laser Remote Sensing*; Springer: Berlin, Heidelberg, 1983.
2. Weitkamp, C. *Lidar, Range-Resolved Optical Remote Sensing of the Atmosphere*; Springer: Berlin, Heidelberg, 2005.
3. Prasad, S.; Bruce, L.; Chanussot, J. *Optical Remote Sensing*; Springer: Berlin, Heidelberg, 2011.
4. Fernald, F.G.; Herman, B.M.; Reagan, J.A. Determination of Aerosol Height Distributions by Lidar. *J. Appl. Meteorol.* **1972**, *11*, 482–489. [CrossRef]
5. Ansmann, A.; Riebesell, M.; Weitkamp, C. Measurement of atmospheric aerosol extinction profiles with a Raman lidar. *Opt. Lett.* **1990**, *15*, 746–748. [CrossRef] [PubMed]
6. Huffaker, R.M.; Post, M.J.; Lawrence, T.R.; Priestley, J.T. Feasibility studies for a global wind measuring satellite system (Windsat): analysis of simulated performance. *Appl. Opt.* **1984**, *23*, 2523–2533. [CrossRef] [PubMed]
7. Lakowicz, J.R. *Principals of Fluorescence Spectroscopy*, 3rd ed.; Springer: New York, NY, USA, 2006.
8. Svanberg, S. Fluorescence Lidar monitoring of Vegetation Status. *Phys. Scr.* **1995**, *T58*, 79–88. [CrossRef]

9. Menzies, R.T.; Chahine, M.T. Remote Atmospheric Sensing with an Airborne Laser Absorption Spectrometer. *Appl. Opt.* **1974**, *13*, 2840–2849. [CrossRef] [PubMed]
10. Killinger, D.K.; Menyuk, N. Laser Remote Sensing of the Atmosphere. *Science* **1987**, *235*, 37–45. [CrossRef] [PubMed]
11. Lopes, F.; Silva, J.; Marrero, J.; Taha, G.; Landulfo, E. Synergetic Aerosol Layer Observation After the 2015 Calbuco Volcanic Eruption Event. *Remote Sens.* **2019**, *11*, 195. [CrossRef]
12. Zhang, Y.; Li, Z.; Liu, Z.; Zhang, J.; Qie, L.; Xie, Y.; Hou, W.; Wang, Y.; Ye, Z. Retrieval of the Fine-Mode Aerosol Optical Depth over East China Using a Grouped Residual Error Sorting (GRES) Method from Multi-Angle and Polarized Satellite Data. *Remote Sens.* **2018**, *10*, 1838. [CrossRef]
13. Di, H.; Wang, Q.; Hua, H.; Li, S.; Yan, Q.; Liu, J.; Song, Y.; Hua, D. Aerosol Microphysical Particle Parameter Inversion and Error Analysis Based on Remote Sensing Data. *Remote Sens.* **2018**, *10*, 1753. [CrossRef]
14. Marksteiner, U.; Lemmerz, C.; Lux, O.; Rahm, S.; Schafler, A.; Witschas, B.; Reitebuch, O. Calibrations and Wind Observations of an Airborne Direct-Detection Wind LiDAR Supporting ESA's Aeolus Mission. *Remote Sens.* **2018**, *10*, 2056. [CrossRef]
15. Saito, Y.; Ichihara, K.; Morishita, K.; Uchiyama, K.; Kobayashi, F.; Tomida, T. Remote Detection of the Fluorescence Spectrum of Natural Pollens Floating in the Atmosphere Using a Laser-Induced-Fluorescence Spectrum (LIFS) Lidar. *Remote Sens.* **2018**, *10*, 1533. [CrossRef]
16. Banakh, V.; Smalikho, I. Lidar Studies of Wind Turbulence in the Stable Atmospheric Boundary Layer. *Remote Sens.* **2018**, *10*, 1219. [CrossRef]
17. Han, G.; Xu, H.; Gong, W.; Liu, J.; Du, J.; Ma, X.; Liang, A. Feasibility Study on Measuring Atmospheric CO_2 in Urban Areas Using Spaceborne CO_2-IPDA LIDAR. *Remote Sens.* **2018**, *10*, 985. [CrossRef]
18. Matvienko, G.; Sukhanov, A. Application of neural networks for retrieval of the CO_2 concentration at aerospace sensing by IPDA-DIAL lidar. *Remote Sens.* **2019**, *11*, 659. [CrossRef]
19. Hara, Y.; Nishizawa, T.; Sugimoto, N.; Osada, K.; Yumimoto, K.; Uno, I.; Kudo, R.; Ishimoto, H. Retrieval of Aerosol Components Using Multi-Wavelength Mie-Raman Lidar and Comparison with Ground Aerosol Sampling. *Remote Sens.* **2018**, *10*, 937. [CrossRef]