remote sensing

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Editorial

Editorial for the Special Issue "Remote Sensing of Clouds"

Filomena Romano

Institute of Methodologies for Environmental Analysis, National Research Council (IMAA/CNR), 85100 Potenza, Italy; filomena.romano@imaa.cnr.it

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Remote sensing of clouds is a subject of intensive study in modern atmospheric remote sensing. Cloud systems are important in weather, hydrological, and climate research, as well as in practical applications. Because they affect water transport and precipitation, clouds play an integral role in the Earth's hydrological cycle. Moreover, they impact the Earth's energy budget by interacting with incoming shortwave radiation and outgoing longwave radiation. Clouds can markedly affect the radiation budget, both in the solar and thermal spectral ranges, thereby playing a fundamental role in the Earth's climatic state and affecting climate forcing. Global changes in surface temperature are highly sensitive to the amounts and types of clouds. Hence, it is not surprising that the largest uncertainty in model estimates of global warming is due to clouds. Their properties can change over time, leading to a planetary energy imbalance and effects on a global scale. Optical and thermal infrared remote sensing of clouds is a mature research field with a long history, and significant progress has been achieved using both ground-based and satellite instrumentation in the retrieval of microphysical cloud parameters.

This Special Issue (SI) presents recent results in ground-based and satellite remote sensing of clouds, including innovative applications for meteorology and atmospheric physics, as well as the validation of retrievals based on independent measurements. The aim of this SI is to provide an overview of recent scientific and technological advances in the field of cloud remote sensing. In particular, the papers published in this SI focus on (i) new methodologies for cloud detection and classification [1–5], (ii) the retrieval of optical [6] and micro- [7–9] and macro-physical [10] cloud parameters, (iii) the prediction of hazards [11,12], and (iv) the study of mesoscale convective systems and precipitation [13,14].

The papers that discuss new methods for cloud detection and classification constitute an enormous contribution to improving this important aspect of this research area, and they cover a wide range of approaches using several instruments, ranging from ground-based [2,4] to satellite [1,5] and airborne [3] approaches. In 2016, the authors of [2] used cloud radar to observe clouds and precipitation in China, and an algorithm for the quality control of Doppler spectral density data was developed by exploiting the different radar operating modes. The recalculated moments of the Doppler spectra were of better quality than those merged from raw data. Taking a different approach, the authors of [4] used all-sky imaging, and their work was focused on the assessment of a modified k-means++ color-based segmentation algorithm, which was specifically adjusted to the WILLIAM (WIde-field aLL-sky Image Analyzing Monitoring system) ground-based remote all-sky imaging system for cloud detection. The authors of [1] developed a cloud detection method by exploiting the advantages of the GaoFen4 geostationary satellite. Specifically, the algorithm was based on the spatial and spectral uniformity of clouds and primarily targeted situations that feature a variety of underlying surfaces, such as coastal regions, which represents a major challenge in cloud detection. The authors of [5] implemented an unsupervised k-means/k-means++ clustering algorithm on daily images of standardized anomalies of brightness temperature (Tb) derived from the Geostationary Operational Environmental Satellite (GOES)-13 infrared data acquired from 1 December 2010 to 30 November 2016. Each Tb image was separated into four clusters to capture the characteristics of different cloud regimes.

The second group of papers published in this Special Issue, as mentioned above, primarily target the retrieval of crucial cloud parameters. The authors of [6] performed a study on black-sky cloud albedo, which was obtained from UV (340 nm) observations from NOAA and NASA satellites. The aim was to infer long-term (1980–2018) shortwave cloud albedo variations induced by volcano eruptions, the El Niño–Southern Oscillation, and decadal warming. No long-term trend was evident after 1980, but the study highlights statistically significant reductions over the North Atlantic and over the marine stratocumulus decks off the coast of California; additionally, an increase in cloud albedo was found in Southeast Asia and over cloud decks off the coast of South America. Combining different data sources is a key element in the remote sensing of clouds and the retrieval of cloud parameters. The authors of [7] used a ground-based infrared cloud measuring instrument with a ceilometer to perform retrievals of cloud effective emissivity. Through an inversion procedure, the authors found that the uncertainty of the derived effective emissivity was largely associated with errors in the radiance measurement and the simulated radiance of clear sky and blackbody cloudy sky. The results are in good agreement with MODIS/AQUA MYD06 Collection 6 (C6) cloud products. The authors of [8], similarly to those of [2], used ground-based radar measurements to estimate raindrop size distribution (DSD) and liquid water content. Comparing the measurements with in situ airplane observations revealed an overall agreement. The authors of [9] performed an analysis based on lidar measurements and focused on the observation of falling mixed-phase virga from a thin supercooled liquid layer cloud base. The diameters of the ice crystals in the virga were estimated using an ice particle sublimation model along with lidar and radiosonde observations. The results indicated that the ice crystal particles in these virgae tended to have smaller mean diameters and narrower size distributions with increasing altitude. Another work [10] was also focused on the retrieval of cloud properties, particularly optical and geometrical properties, such as the optical thickness of clouds. This study showed that the mean extinction coefficient of cirrus clouds increased with temperature. Conversely, the measurements indicated that the linear particle depolarization ratio decreased with increasing temperature, as determined from lidar and radiosonde measurements.

Importantly, this Special Issue also includes works that focus on the prediction of severe rainfall events. The authors of [11] investigated the potential use of several predictors of convective initiation based on infrared satellite observations. They used MSG-SEVIRI Rapid Scan to distinguish convective weak precipitation events from those leading to intense rainfall. The authors of [12] detected atmospheric aviation hazards using multispectral (two channels or more) infrared imaging from an aircraft perspective. Their results show that it is possible to use this information to provide tactical awareness tools for aviators.

Finally, the last two works also focus on precipitation but address mesoscale events and their lifecycle [13] and warm clouds [14]. The analysis in [13] was conducted through a combination of a geostationary satellite (Himawari), ground-based radar, and gauge measurements, while the authors of [14] used cloud radar, a disdrometer, and a ceilometer. The integration of different instruments allowed the authors to exploit the advantages of each one in order to investigate the vertical structure and diurnal variation of clouds and precipitation, as well as the raindrop size distribution.

The published papers discussed above cover a wide range of topics involving several characteristics and variables, thereby representing a large and complete set of methodologies based on various instruments. The different approaches presented in these papers (ground and satellite measurements, as well as measurements in different spectral regions) reflect the substantial interest in this topic and demonstrate how each work increases the current knowledge about cloud formation, detection, and microphysics. Many measurement systems have been designed for specific applications and thus have limitations, including range, coverage, resolution, precision, and continuity. A synergistic approach that uses ground-based and satellite measurements, aided by numerical modeling, appears to be a promising avenue to further improve cloud knowledge.

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References

1. Wang, Z.; Du, J.; Xia, J.; Chen, C.; Zeng, Q.; Tian, L.; Wang, L.; Mao, Z. An Effective Method for Detecting Clouds in GaoFen-4 Images of Coastal Zones. *Remote Sens.* **2020**, *12*, 3003. [CrossRef]
2. Liu, L.; Zheng, J. Algorithms for Doppler Spectral Density Data Quality Control and Merging for the Ka-Band Solid-State Transmitter Cloud Radar. *Remote Sens.* **2019**, *11*, 209. [CrossRef]
3. Magurno, D.; Cossich, W.; Maestri, T.; Bantges, R.; Brindley, H.; Fox, S.; Harlow, C.; Murray, J.; Pickering, J.; Warwick, L.; et al. Cirrus Cloud Identification from Airborne Far-Infrared and Mid-Infrared Spectra. *Remote Sens.* **2020**, *12*, 2097. [CrossRef]
4. Krauz, L.; Janout, P.; Blažek, M.; Páta, P. Assessing Cloud Segmentation in the Chromacity Diagram of All-Sky Images. *Remote Sens.* **2020**, *12*, 1902. [CrossRef]
5. Yuchechen, A.; Lakkis, S.; Caferri, A.; Canziani, P.; Muszkats, J. A Cluster Approach to Cloud Cover Classification over South America and Adjacent Oceans Using a k-means/k-means++ Unsupervised Algorithm on GOES IR Imagery. *Remote Sens.* **2020**, *12*, 2991. [CrossRef]
6. Weaver, C.; Wu, D.; Bhartia, P.; Labow, G.; Haffner, D. A Long-Term Cloud Albedo Data Record Since 1980 from UV Satellite Sensors. *Remote Sens.* **2020**, *12*, 1982. [CrossRef]
7. Liu, L.; Zhang, T.; Wu, Y.; Niu, Z.; Wang, Q. Cloud Effective Emissivity Retrievals Using Combined Ground-Based Infrared Cloud Measuring Instrument and Ceilometer Observations. *Remote Sens.* **2018**, *10*, 2033. [CrossRef]
8. Liu, L.; Ding, H.; Dong, X.; Cao, J.; Su, T. Applications of QC and Merged Doppler Spectral Density Data from Ka-Band Cloud Radar to Microphysics Retrieval and Comparison with Airplane in Situ Observation. *Remote Sens.* **2019**, *11*, 1595. [CrossRef]
9. Cheng, C.; Yi, F. Falling Mixed-Phase Ice Virga and their Liquid Parent Cloud Layers as Observed by Ground-Based Lidars. *Remote Sens.* **2020**, *12*, 2094. [CrossRef]
10. Dai, G.; Wu, S.; Song, X.; Liu, L. Optical and Geometrical Properties of Cirrus Clouds over the Tibetan Plateau Measured by LiDAR and Radiosonde Sounding during the Summertime in 2014. *Remote Sens.* **2019**, *11*, 302. [CrossRef]
11. Gallucci, D.; De Natale, M.; Cimini, D.; Di Paola, F.; Gentile, S.; Geraldi, E.; Larosa, S.; Nilo, S.; Ricciardelli, E.; Viggiano, M.; et al. Convective Initiation Proxies for Nowcasting Precipitation Severity Using the MSG-SEVIRI Rapid Scan. *Remote Sens.* **2020**, *12*, 2562. [CrossRef]
12. Prata, F. Detection and Avoidance of Atmospheric Aviation Hazards Using Infrared Spectroscopic Imaging. *Remote Sens.* **2020**, *12*, 2309. [CrossRef]
13. Chen, D.; Guo, J.; Yao, D.; Feng, Z.; Lin, Y. Elucidating the Life Cycle of Warm-Season Mesoscale Convective Systems in Eastern China from the Himawari-8 Geostationary Satellite. *Remote Sens.* **2020**, *12*, 2307. [CrossRef]
14. Zheng, J.; Liu, L.; Chen, H.; Gou, Y.; Che, Y.; Xu, H.; Li, Q. Characteristics of Warm Clouds and Precipitation in South China during the Pre-Flood Season Using Datasets from a Cloud Radar, a Ceilometer, and a Disdrometer. *Remote Sens.* **2019**, *11*, 3045. [CrossRef]