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Editorial

Data in Astrophysics and Geophysics: Novel Research and Applications

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1. Introduction

Rapid development of communication technologies and constant technological improvements as a result of scientific discoveries require the establishment of specific databases. The associated challenges in the management of such databases are not only related to the size of the data but also to the rate at which they are obtained and made freely available to the broader scientific community.

One innovative approach is to develop cooperation and effective synergies between disciplines such as space exploration, atmospheric and Earth observations (EOs), laboratory and field experiments, and numerical modeling, where all of these have great potential for direct application in research on Earth and different planetary environments [1].

Modeling various atmospheres using supercomputers' capacity and diagnosing astrophysical and laboratory plasma using atomic and molecular datasets rely on the development and improvement of theoretical approaches and methods of the calculation of different data parameters such as collisional cross-sections, rate coefficients, Stark broadening parameters (the shape of atomic spectral lines in plasma contains information on the plasma's parameters and can be used as a diagnostic tool), etc. (see, e.g., [2–5]). Space and Earth's layers are permanently exposed to influences of numerous perturbations characterized by time- and space-dependent intensity. The detection of astrophysical and terrestrial events and their influences, as well as the development and application of various models, is based on observation data, where challenges related to data volume, variety, and data flow are similar in terms of astro- and geo-observations [6,7]. Recent achievements in remote sensing technology, including satellite observations, and the analysis of huge amounts of data using supercomputing and machine learning techniques have significantly supported the advancement of geophysical research, particularly climate change.

In order to address complex climate issues and corresponding impacts, multi-instrument and multi-disciplinary expertise is required [8,9]. Furthermore, the increasing volume of data indicates increased usage of automated instruments and retrieval algorithms. The new knowledge and retrieval products can be readily used for model evaluation, data assimilation, satellite validation, and studies of various processes in the atmosphere and on Earth.

This Special Issue, "2nd Edition of Data in Astrophysics & Geophysics: Research and Applications", as a continuation of a prior series [10], aims to encourage communication between disciplines by identifying and grouping relevant research solutions. Its goals are to engage a broad community of researchers to make new discoveries enabled by the growth of data and technology and to continue interdisciplinary exchanges of ideas and methodologies between fields. To this end, articles addressing, but not limited to, the following topics were invited to be submitted to this Special Issue: big data in astrophysics and geophysics, data processing, visualization and acquisition, atomic and molecular data

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in astrophysics, Earth observation data, climate data records, natural hazards and disasters, and remote sensing.

The compilation of published datasets should be useful to both end users, for practical applications, and researchers, for their further scientific studies.

2. Contributions to this Special Issue

This Special Issue encompasses 14 open access papers that present scientific studies covering a wide range of applications in terms of both measured and modeled data exploitation and processing methods used.

In the paper by López-Espinoza et al. (contribution 1), daily precipitation data records from 136 sites located within the Mexico City Metropolitan Area were systemized for the period 1930–2015. The obtained dataset covered the rainy months for each location for at least 20 years. Having high spatial resolution, the presented precipitation dataset could be useful for extreme event studies, and particularly atmospheric modeling. In addition, the development of applications for precipitation mapping and flood forecasting could be important to contribute to obtaining data, bearing in mind the vulnerability of this region to tropical weather events.

Besides playing an important role in many research fields, meteorological parameters also have a significant impact on vector diseases. In the paper by Musah et al. (contribution 2), the development of an early warning detection system and prediction of increased mosquito populations in two Brazilian cities previously exposed to the Zika virus epidemic are discussed. The authors evaluate the accuracy of weather forecasts of temperature and humidity from an online weather platform with respect to the actual measurements collected from weather stations in order to test whether historical and future weather forecasts can be used for the modeling and prediction of vector diseases.

Using any available database for further research must be handled carefully, taking into account the quality of the data. Usually, data included in a database are categorized into different levels, meaning that the files have to overcome basic quality controls (for example, the presence of technical problems in the data files), advanced quality control (checking the data from a physical point of view) or, in some cases, the climatological data obtained from the fully quality controlled data, providing useful combined information to end users. The importance of the quality control procedure on total precipitation measurements for Montane Valley and Ridge Sites in southwestern Alberta, Canada, was discussed in the paper by Bames et al. (contribution 3). The authors presented different procedures for quality control and measurement error corrections for totalizing precipitation gauge data. The obtained results pointed out that, after applying the QC procedure, the annual cumulative precipitation on the ridge differed from 39% to 49%, while in the valley these corrections were in a range from −4% to 1%.

Mitigation and adaption strategy related to climate change is one of the research fields that requires a huge amount of EO data. Among many other disciplines, assessing the performance of buildings under different climate scenarios and providing long-term effects in terms of sustainable development and energy efficiency have become two of the top priorities in recent years. In the study by Gaur et al. (contribution 4), the authors provided the necessary climate data for building simulations in Canada. The dataset contains climate data for the period 1991–2021, as well as for future periods corresponding to various levels of temperature increase. Besides practitioners in Canada who can use the obtained information for building characteristic evaluation, the results of the study will be useful for applications relating to other regional projections.

While climate change has a significant impact across many geophysical disciplines, agriculture is one of the most directly influenced sectors, especially in vulnerable regions such as Africa. Adaptation and mitigation strategies in such regions have become more challenging; thus, requirements for weather and climate data to support timely decisions with respect to different climate scenarios are needed. In the paper by Moeletsi et al. (contribution 5), a description of the weather station network in South Africa is presented together with relevant data retrieval and processing information, calibration, and maintenance protocols. Such a detailed documented database should lead to more efficient utilization of available datasets for application in this important area.

Climate change and precipitation also influence rivers' water resources; thus, many previous studies have used global and regional hydrological models to assess runoff predictions for the largest basins all over the world. In the paper by Ayzel (contribution 6), the simulated runoff for 425 river basins in Russia is presented, covering a period ranging from 1979 to 2016 and offering a prediction for the 2017–2099 period. Different climate scenarios were used in order to assess changes in river runoff and potential floods. The results can potentially be used for both research and mitigation strategy regarding climate change.

The mapping of terrestrial ecosystems, including vegetation index, soil typing, etc., is of particular interest. Previous as well as currently operating Earth observation satellite missions have provided freely available data which are useful in many applications. Each mission focuses on a specific aspect (land monitoring, atmospheric, oceanic) of Earth observation. By combining machine learning algorithms and high-resolution imagery from Sentinel-1 and Sentinel-2 missions in the paper by Abera et al. (contribution 7), the authors provided a land cover map of Taita Taveta County in southern Kenya. This specific region is part of one of the world's biodiversity hotspots. The obtained results can be used for the monitoring of land cover changes and future managing.

In Lemenkova's study (contribution 8), the processing of complex geophysical data related to the Bolivian Andes is presented. This region is known for its complex geological parameters, with high seismic activity and risk of earthquakes. The author demonstrated the usage of the Generic Mapping Tools (GMTs) and Geographic Information System (GIS) scripting tool set for complex data processing in an integrated framework. The study is based on available data mostly derived from remote sensing open sources and script-based techniques, providing more flexibility in data processing and analysis. The identification of the distribution and magnitude of earthquakes in this specific region in the context of the geologic, geophysical, and topographic situations is presented.

The ability to combine hyperspectral scans with 3D point cloud representations has expanded the mapping of various geological objects. Rapid progress in artificial intelligence and machine learning algorithm application in earth sciences has enabled fast and effective characterization of geological structures in a three-dimensional environment. Based on previously developed open-source software for processing non-nadir hyperspectral scenery with different corrections, Lorenz et al. (contribution 9) provided a three-dimensional, km-scale, hyperspectral dataset of a well-exposed mineral deposit—the Black Angel at Maarmorilik, West Greenland. Extended documentation on the data processing workflow could be useful for application in various disciplines.

Seismic monitoring data for the Italian region is provided in the paper by Megna et al. (contribution 10). The authors presented the seismic network operating in the area of Montefeltro from 2018. The data available from this mobile network should reveal, with high temporal resolution, regions with the seismic activities of lower-intensity, thus improving currently operating models.

Besides earthquakes, one of the most frequently occurring natural hazards is landslides. Improving the regional inventory of landslides has become particularly important not only from a scientific point of view but also for different communities, ranging from local/regional stakeholders to various industries. In the paper by Li et al. (contribution 11), the authors presented an inventory of landslides based on multi-temporal high-resolution remote sensing images for the area of Baoji City, Shaanxi Province, China. Datasets of each identified landslide in shp format are provided and will be useful for the better characterization of large-scale landslides in regions of interest.

In the paper by Papenmeier et al. (contribution 12), geomorphological data, including maps of bathymetry, depth, and slope angle of detonation craters in the Fehmarn Belt, Baltic Sea, were presented. Many explosives remaining in marine waters worldwide after the world's military conflicts have been recognized as a serious threat to marine traffic and ecosystems. Investigation of the impact on the environment of controlled blast-in-place is of particular interest for future monitoring and clearance strategies.

Besides the investigation of seafloor morphological changes in coastlines, modeling coastal change during extreme weather events has attracted increasing attention. In the study by Mickey and Passeri (contribution 13), the authors provided a dataset of seamless cross-shore sandy coast profiles of the U.S. Atlantic and the Gulf of Mexico based on lidar (Light Detection And Ranging)-derived topography and available bathymetry. The database, containing various morphological metrics, will be useful for broader geophysical studies.

Spectroscopy is widely used to study plasmas in a variety of fields, including astronomy, atmospheric research, and applied physics. The availability of spectroscopic information related to both atoms and ions is crucial for a wide range of processes, from astrophysical- to thermal- and plasma-related practices. In the paper by Srećković et al. (contribution 14), the spectral absorption rate coefficients and average cross-sections for small molecular ions AlH^+, HeH^+, and HK^+ under different conditions (temperatures and wavelengths) have been provided using a quantum mechanical method. The obtained results are useful for industry and technology application as well as for theoretical interdisciplinary studies, including the modeling of various atmospheric processes.

To sum up the presented studies, they have all introduced a relevant observed and modeling dataset related to astrophysics and geophysics with potential applications in wide research areas, from climate change to astronomy.

3. Conclusions and Future Research Initiatives

This Special Issue was open to scientists with expertise coming from various research areas and disciplines. All papers in this issue were subjected to thorough peer review and were evaluated by at least two reviewers. Considering all of the contributions, this Special Issue demonstrates the high benefit of using a multi-disciplinary approach to analyze various geophysical and astrophysical phenomena. We believe that the quality of the papers and open access dataset provided, followed by accompanied data descriptions, will ensure the success of this Special Issue. By publishing work from a vast community of academics, both users and contributors will benefit from new findings and this will trigger further interdisciplinary exchanges of ideas and approaches.

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