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INTRODUCTION

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Introducing the Bulletin of Atmospheric Science and Technology

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The rapid technological development of the past few decades has allowed for an unprecedented wealth of data about ourselves and our planet. The cost reduction of space platforms, the microelectronic revolution and the nearly exponential increase in computer power have been generating novel opportunities to explore and understand the world around us. Tools and theoretical approaches, capable of putting together all the insights we may possibly gain from all these new streams of data in a multidisciplinary framework, are still being developed. We are hence faced with both a unique challenge and an opportunity to make a significant progress in many scientific fields, first and foremost in the atmospheric and climate sciences.

We are pleased to announce here the launch of the *Bulletin of Atmospheric Science and Technology (BAST),* a new peer-reviewed journal which is meant to bridge this gap in the broad area of the atmospheric sciences. The journal encourages a cross-disciplinary approach with an emphasis on new sensor technologies and systems, combined observational and modeling techniques, innovative numerical methods, data analysis, and retrieval techniques. *BAST* offers a platform to share new ideas and fresh developments to stimulate research activities focusing on urban, coastal, marine, rural, and mountain environments. Particular attention will be given to cross-disciplinary studies, especially those involving citizens for the collection of crowd-sourced data and those devoted to the characterization of uncertainties and homogenization of methods.

BAST aims at connecting weather and climate communities using both observational and modeling approaches, creating a forum hosting discussion and brainstorming activities. The journal also hopes to attract contributions reporting approaches or techniques from other scientific fields that can be applicable to atmospheric sciences, as well as contributions where technological developments are discussed alongside with their scientific and societal impacts. In this sense *BAST* will provide a new platform to support the technological revolution towards

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a climate-smart society through the collection and exploitation of big data. The journal will give visibility to international experiments and projects in atmospheric science and technology, illustrating preliminary or consolidated results from these initiatives. Additional fields of interest are : environmental protection; observation, understanding, and modeling of hazardous and extreme events and mitigation of their impacts; development of new sensing tools integrating satellite information with surface or airborne measurements; operation of unmanned and remotely piloted air vehicles equipped with sensors of small size and weight, especially remote sensors, pushing electro-optical-mechanical components towards a continuously increasing miniaturization.

Research articles, Review articles, Technical reports, Brief reports, Letters and News are welcome. While keeping the focus of the journal on scientific research, the "Bulletin" format provides appropriate visibility to contributions from the operational side, i.e., meteorological services and private companies developing sensors and products of interest to the atmospheric science and technology community. Below we provide a more detailed description of the topics that will be emphasized and fostered in *BAST*.

1 Meso- and microscale processes

Microscale meteorology aims at studying short-lived atmospheric phenomena smaller than mesoscale (i.e., about 10^3 m or less). The accuracy of NWP models depends on the discrete representation of the governing equations of motion. The accurate representation of unresolved small-scale motions (e.g., boundary-layer turbulence and cloud microphysics) has a very important effect on the resolved larger-scale motion and the effectiveness of data assimilation systems used for model initialization significantly affect the skill of numerical simulations. Thus, advances in atmospheric prediction require the development of accurate and computationally efficient numerical models and effective data assimilation systems, together with an improved representation of currently unresolved atmospheric processes. We encourage contributions on studies aimed at understanding mesoscale (10^3–10^6 m) and microscale (10^{-6}–10^3 m) physical processes, that are necessary to accurately predict weather and climate features (e.g., the timing, location, intensity, and type of precipitation). Among the small-scale meteorological processes mostly affecting the accuracy of weather and climate predictions, we particularly welcome observational and modeling studies on the physics of clouds and precipitation (e.g., ice-particle initiation), as well as on turbulence and surface exchange.

1.1 Turbulence in the planetary boundary layer

In the last few decades, advances in observation technology and in computing power allowed to observe and simulate explicitly atmospheric motions at smaller and smaller scales. As grid spacing approaches the sub-kilometer scale, operational limited-area NWP models enter the turbulence gray zone, i.e. the range of spatial resolutions in which the energy-containing scales of turbulent motions are partially resolved. *BAST* welcomes contributions on all aspects of atmospheric modeling in the turbulence gray zone, particularly on the development of scale-aware turbulence closures. In addition, *BAST* is particularly interested in new observational evidence and theoretical advancements on the properties of non-isotropic and nonstationary atmospheric turbulence. This is motivated by the urgent need of gaining progress in quantitative turbulence modeling. The accuracy of the most commonly used scaling laws, which are generally derived from similarity theory, is often impaired by the underlying restrictive assumptions on turbulence properties, including isotropy and stationarity. Studies that provide new perspectives on this problem by using innovative approaches such as machine learning will be strongly considered for publication.

1.2 Biosphere-atmosphere exchange

Energy, momentum, and mass exchange between the atmosphere and the biosphere are of paramount importance for processes such as the planetary carbon budget, climate change, greenhouse gas emissions from soils, air pollutant uptake by vegetation, water cycle, and all biogeochemical cycles. The most common measuring technique to detect vertical fluxes is eddy covariance (EC), but very few gaseous species have been measured so far because of the lack of fast and accurate gas detectors. *BAST* welcomes contributions aiming at expanding EC applicability to new chemical species, as well as developing low-cost methodologies suitable for long-term measurements both above natural ecosystems and agro-ecosystems. Contributions on new computational tools and methodologies to process data from very long campaigns are also welcome. Since plant stomata play an active role in all vertical exchanges when vegetation is involved, papers describing methodologies to derive or model the stomatal behavior will be welcome, especially those reporting methodologies overcoming the intrinsic limitations of the big-leaf approach. Studies quantifying the different deposition pathways, as well as clarifying the nature of the so called non-stomatal deposition processes and their related drivers, are also welcome. Model studies with significant improvement of the deposition schemes will also be considered for publication, especially if a solid comparison with direct measurements is presented.

1.3 Land-atmosphere-ocean interaction

Land, ocean, and the atmosphere represent a coupled system. The interaction between air, land, and sea surface occurs through the surface layer and the Planetray Boundary Layer (PBL), and as such, the PBL modulates the Earth's water and energy cycles. Land-atmosphere-ocean system feedbacks can be analyzed through the application of the governing budget equations, with PBL moisture being simultaneously influenced by both the surface energy balance and the entrainment fluxes at the PBL top. Progress in the observation and modeling of these feedback processes are fundamental for the understanding and the appropriate modeling of the Earth system. Papers contributing to these efforts are strongly encouraged.

1.4 Mesoscale dynamics

Mesoscale in meteorology defines the spatial (and temporal) scales of phenomena that are situated between the synoptic scale (about 10^6 m) and the scales of turbulence and cumulus clouds (about 10^3 m or smaller). Therefore, mesoscale dynamics include studies/observations/modeling of mesoscale cyclones (polar lows and medicanes), tropical cyclones, sub-synoptic phenomena connected with mid-latitude cyclones (fronts, rainbands, upper and low-level jets), mesoscale circulations (land-sea and valley-mountain breezes, density currents), orographic lee waves and strong winds, and organized convection (squall lines, convective complexes, supercells, tornadoes). Mesoscale dynamics characterizes the most severe weather events, including heavy precipitation, which are therefore relevant to address scientific and operational challenges from an observational and forecasting perspective.

1.5 Microphysical processes and their parameterization in numerical models

The representation of the microphysics of clouds and precipitation (including effects of aerosols and dust) is critically important for weather and climate studies. Better understanding of aerosol and cloud microphysics has an impact on the ability to make both more accurate weather predictions of the timing, location, amount, and type of precipitation events and more reliable climate projections of the distribution, frequency, and type of precipitation events around the world. *BAST* welcomes research papers on fundamental models and/or observations of precipitation formation processes, on parameterizations of microphysical processes for weather and climate models, new techniques and/or algorithms for the analysis and detection of clouds, and precipitation including, among others, active remote sensing from traditional ground-based and/or spaceborne instruments.

1.6 Modeling computational techniques

The ever increasing computational power allows for numerical models of the Earth system with continuously higher spatial resolution. Nowadays global circulation models run at resolutions of around 10 km for operational forecasting purposes, and they usually harbor nested domains at much higher resolutions, down to hundreds of meters, to capture the details of the fine mesoscale motions, and to meters if large-eddy simulations (LES) are run to represent turbulent motions. Therefore, in practice, convergence between meteorological models and computational fluid dynamics (CFD) codes is taking place. While CFD codes have to incorporate static stability effects, which they usually neglect, high-resolution meteorological models must develop spatial discretization techniques allowing them to adequately treat the characteristics of complex terrain at small scales. One further challenge is to obtain a high-resolution representation of surface parameters, incorporating their evolution in time, implying that a dynamic link with remote-sensing products of the Earth surface will be needed.

1.7 Data assimilation

Data assimilation (DA) is the technique used to provide physically consistent initial conditions (IC) for weather forecasting at all scales. The variational data assimilation technique is the most used in the operational practice, and the implementation of 4D-VAR at most meteorological centers has defined a step forward in weather forecasting at the global scale allowing, for example, for effectively using satellite data. The scientific challenges for NWP at meso- and local scales include the provision of IC at high resolution, by the assimilation of new and nonconventional observations possibly related to convection, and the exploitation of new techniques like the localized ensemble transform Kalman filter (LETKF) or hybrids between variational and ensemble methods. A properly addressing of these challenges requires the availability of high-performance computing and new observing systems, and is relevant both to the research and operational forecasting communities.

1.8 Ensemble methods and predictability

Accurate simulation of convective systems is one of the outstanding challenges of NWP models. To cope and deal with the limited predictability of convection, ensemble and data assimilation methodologies need to be specifically developed for convection-permitting models, as those developed for synoptic scales are no longer appropriate. Initial/boundary conditions and model errors, as well as observations uncertainties, have to be properly taken into account. The submission of papers illustrating high-resolution ensemble forecast applications and the exploitation of nonconventional and local observations, post-processing methods, and predictability analyses using ensembles are strongly encouraged in *BAST*.

2 The climate system

The current imbalance between the incoming shortwave radiation and the outgoing longwave radiation is the primary driver of the changes that have been observed in the climate system over the past few decades. New observational platforms and techniques, jointly with new modeling capabilities, provide us with an unprecedented information about the Earth's climate and its modifications. Never in our history has the study of the climate had such an important role in guiding our decisions and informing our policies. However, in spite of such high societal importance, there are several fundamental scientific questions whose answers remain at best underconstrained. The expected increase in the climate sensitivity of the new CMIP6 runs is just a tangible demonstration of our incomplete understanding and modeling of the climate system. Gaining new observational evidence about specific climatic processes gives us the possibility to better represent them in models and better constrain future projections. The increase in available computational power allows for improving both the complexity and the resolution of models. This in turn opens up new challenges related, for example, to the extraction and the post-processing of data and the distillation of relevant information in usable storylines relevant to policy makers and decision makers they target.

2.1 Climate projections

Global climate simulations driven by changes in the concentration of greenhouse gases and aerosols, and in land-use will drive future scenarios. In the course of the last four decades, both resolution and complexity of these models have increased steadily leading to the development and implementation of Earth system models. Uninitialized climate projections can only provide information about future climate (i.e., statistical characterization of the weather) rather than offering information on the precise time sequencing of specific events. The Climate Projections Inter-comparison Programme (CMIP) provides an essential input into the assessment report of the Intergovernmental Panel on Climate Change and is of high interest for *BAST*.

2.2 Earth system modeling

Earth system modeling aims at simulating all relevant physical, chemical, and biological processes of the Earth system, thus being more comprehensive than global climate modeling, which typically represents only the physical atmospheric and oceanic processes. Earth system models benefit from the inclusion of biological and chemical processes that feedback into the physics of the climate, thus aiming at a proper representation of the global carbon cycle, dynamic vegetation, atmospheric chemistry, ocean biogeochemistry and continental ice sheets. It is thus not surprising that the Earth system modeling approach is often considered as a particularly important tool for addressing the climate dilemma. Papers illustrating Earth system modeling applications are strongly encouraged in *BAST*.

2.3 Regional climate modeling

Regional climate modeling (RCM) allows for a dynamical downscaling of global climate models simulations at high space and time resolution. Taking into account small-scale features (e.g., complex orography, land use), RCMs simulate climate variability at regional scale and provide comprehensive high-resolution regional climate projections. Recently, these models have been run at convection-permitting scales, thus allowing for a reduction of model errors associated with the parameterization of convection. The evolution of these tools is shaped by two opposing forces: (i) on the one hand, the realization that, especially in areas characterized by steep topography, the regional simulations may depict future scenarios which are very different from those portrayed by the driving global climate models; (ii) on the other hand, the continuously growing resolution of global models, which can in the foreseeable future reach convection-permitting scales too. RCM applications and developments are among the topics of interests of *BAST*.

2.4 Climate services

Climate services—a fast-growing area of activity in the field of climate—represent a way of providing climate information to help individuals and organizations make climate smart decisions. The main objective of a climate service is to transform raw climate data into information and tools for addressing sector-specific problems in a wide range of fields such as energy, water management, health, transport, agriculture, tourism, infrastructure design, and disaster risk reduction. Given the diversity of users and stakeholders and the problems tackled, a suitable combination of historical observations, reanalyses, initialized predictions, and regional and global climate projections is typically used. Results based on exploitation of climate services are of interest for *BAST*.

3 Observations of the atmosphere

Within the last two decades, the increasing accuracy and space-time resolution of atmospheric observations, in combination with high-resolution modeling, has provided an enhanced comprehension of the Earth system and has resulted in significant advances in numerical weather prediction and climate research applications. The increased capability of models to properly forecast weather and simulate future climate scenarios relies on an accurate representation of sub-grid scale processes, such as sensible and latent heat fluxes from the Earth's surface, land surface and turbulent transport processes, vertical moisture transport throughout the atmosphere, cloud condensation, and precipitation. These processes to date remain not thoroughly understood, and their effective parameterization in models need to be investigated based on the availability of accurate and high-resolution measurements of atmospheric dynamic, thermodynamic, and compositional properties. This calls for the implementation of global scale networks of evenly distributed surface and upper-air sensors, in combination with ground-based, airborne, and space-borne remote sensors, exploiting new sensor technologies and synergies, and combined observation-modeling approaches. In this regard, *BAST* also intends to represent a forum for discussing different approaches and strategies to measure atmospheric variables, recognizing the importance of properly assessing the specifications and uncertainty sources affecting different sensors, and homogenizing approaches for their quantification.

3.1 Field experiments

From an observational point of view, recent advances in the understanding and modeling of the Earth water and energy cycles, as well as the genesis and evolution of hazardous and extreme events, have often been achieved throught dedicated international field projects. *BAST* intends to provide visibility to international experiments and projects in atmospheric sciences, taking place in Europe or elsewhere, illustrating primary or consolidated results from these initiatives or plans for forthcoming ones, with a specific focus on field programs and efforts aimed at testing new technological solutions and novel applications. Field campaigns related to wind, solar, and hydropower applications, such as measurements of the wake effects of wind farms, the thermal feedbacks of photovoltaic panels, or the impacts on physical or biological systems from wave or tidal systems, are especially encouraged.

3.2 Remote sensing and satellite meteorology

Remote sensing includes a comprehensive set of methodologies and techniques spanning from forward to inverse problems, from active to passive sensors, from ultraviolet up to radio frequencies, and from ground-based to spaceborne platforms. Atmospheric remote sensing is a key discipline that includes several observation techniques, such as weather radar and lidar meteorology, microwave and infrared radiometry, wind profiling, and sun photometry. Satellite meteorology, as a part of the Earth observation system, provides a unique set of atmospheric thermodynamic and chemical-physical parameters at the global scale, using electromagnetic sensors aboard geostationary or near-polar spacecrafts. The capability to model wave-matter interactions, to devise new techniques, and to develop advanced retrieval algorithms is significantly relevant to the atmospheric sciences for process studies, forecast assessment, and data assimilation. *BAST* aims at acting as a privileged forum for reporting new accomplishments in the fields of remote sensing and satellite meteorology.

3.3 New atmospheric sensors

In addition to discussing advances in remote sensing, *BAST* also aims at focusing on new in situ and laboratory measurement techniques for the characterization of atmospheric constituents and properties, with a strong interest in the development, intercomparison, and validation of different instruments and measurement techniques. We also aim at focusing on the exploitation of new low-cost sensors for measuring atmospheric thermodynamic properties, as well as atmospheric composition, with a specific focus on reactive gaseous air pollutants (CO, NOx, O_3, SO_2), particulate matter, and greenhouse gases (CO_2 and CH_4).

3.4 Remotely piloted aircraft systems

Remotely piloted aircraft systems (RPAS), also known as drones or unmanned aircraft systems, are remotely controlled aircrafts that can carry relatively small and light atmospheric sensors. RPAS fill the gap between ground-based and satellite measurements at very competitive cost and risk. They can fly autonomously based on pre-programmed flight paths or more complex dynamic automation systems, and perform high spatial resolution and long-term monitoring. Deployable sensors include conventional ones (e.g., for pressure/temperature/humidity and visible and thermal imaging), as well as a growing range of miniaturized atmospheric sensors including particle counters and instruments for physical/chemical characterization. Nowadays, RPAS allow 3D observations relevant to meteorology, air quality, and climate change, including aerosol-cloud interactions, particle aging and lifetime, radiative forcing, and other chemical/physical/optical properties. *BAST* strongly encourages the submission of papers focusing on RPAS applications.

4 Impact and cross-disciplinary applications

Cross-disciplinary research applications in atmospheric sciences have expanded substantially over the past 50 years to include biology, oceanography, economics, and societal impacts. Some of the highest impact and innovative research in atmospheric sciences has taken place at disciplinary boundaries, with major accomplishments in climate modeling having depended upon cross-disciplinary connections. *BAST* aims at becoming a forum for reporting cross-disciplinary research efforts in the field of atmospheric sciences.

4.1 Urban meteorology

In the context of urban meteorology, both field and numerical studies highlighting small-scale dynamics processes, influencing the formation of the urban heat island, and affecting pollutant dispersion at street and neighborhood scale are welcome. Within this area of research, the submission of papers demonstrating the possible use of nonconventional data sources (e.g., emerging low-cost sensors) to calibrate numerical models is strongly encouraged. Moreover, *BAST* has a specific interest in publishing methodological articles suitable for the assessment of the reliability and limitation of data from nonconventional instruments.

4.2 Hydrometeorology

BAST will consider contributions aiming at analyzing and forecasting heavy rainfall events, from both a meteorological perspective, through the assessment of the role of large-scale and mesoscale forcing, microphysics and turbulence in the formation of severe convective systems, and a hydrological perspective, through the assessment of the impact at the ground in terms of discharge. Studies of the impact and forecasting of floods associated with synoptic scale systems and localized flash floods events, in large-, medium-, and small-scale watersheds are solicited.

4.3 Agricultural meteorology

BAST is also interested in studies on the relationship between atmospheric variables and crops or forests, with particular regard to their distribution within vegetation and extreme events. New studies on turbulence within forests or crops are also very welcome, as well as the illustration of new sensors and applications for agriculture and nature protection.

4.4 Energy meteorology

Extracting solar and wind energy from the atmosphere is an important area of research that is of interest to *BAST*. Topics include fundamental and theoretical issues, such as understanding geophysical limits and environmental consequences of harvesting energy from the atmosphere, as well as practical and technological issues, such as identifying the optimal location of solar and wind farms or assessing the effect of atmospheric stability or climate change on the performance of energy systems.

4.5 Weather forecast applications

All aspects of our economical, social, and organizational life are greatly influenced by climate and weather. In the last few decades, thanks to the remarkable scientific and technological advancements, the quality of our forecasts has increased considerably. At the same time, the level of expectation by all users has also increased, from the individual citizen to the entities responsible for safeguarding our lives and our properties. The value of forecasts must be evaluated with metrics that are appropriate for the different specific applications. For example, the needs of the agricultural sector are different from those required by a civil protection agency that must optimize actions in order to reduce the impact of adverse weather conditions such as those associated with flash floods. As it often happens, it is necessary to improve the link between the scientific and operational communities and end users. It is important to convey to users the intrinsic limitations of predictability, the uncertainty associated with a forecast, and the importance of reliable information that avoids unnecessary and harmful sensationalism. The connection between those who produce forecasts and those who use them is fundamental to identify and develop appropriate post-processing techniques that, applied to the raw model output, can provide products optimized, and tailored to the specific user needs.

4.6 Hazardous/extreme events and mitigation of their impacts

One of the consequences of global warming is an increased intensity of extratropical and tropical cyclones and associated wind storms, intense rainfalls, floods, and other types of extreme weather, including, on the opposite side, heat waves and droughts. Their impact depends not only on the nature of the hazards but also on the vulnerability and exposure of communities. *BAST* will consider contributions aiming at improving our understanding of severe atmospheric phenomena, covering different temporal (from weather to climate) and spatial scales (from local to continental scale), present-day analysis, and climate change assessment and attribution studies.

4.7 Environmental protection

Meteorology and climate dynamics are the drivers of a large variety of impacts on human health and other biological systems. *BAST* aims at collecting research efforts focusing on new observational and modeling studies illustrating improvements in the monitoring and prediction of (i) atmospheric pollutants dispersion, (ii) chemical processes in the atmosphere, (iii) emission and deposition of compounds, and (iv) interaction of atmospheric gas and aerosol with radiation, clouds, and biological systems. New developments and applications aimed at characterizing the toxicity of air pollutants, their exposure diagnosis and reduction strategies, and the effects of short-lived climate pollutants are among the focus topics related to the role of meteorology in environmental protection activities.

5 Conclusions

As outlined above, a distinctive purpose of *BAST* is that of integrating science and technology; theory and applications; and theoretical, observational, and numerical modeling approaches, promoting the development of combined and complementary measurement and modeling systems and covering all processes that are relevant to meteorology and climate science and applications.

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