

Preface

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1. Motivation and objectives

The American Meteorological Society (AMS) was founded in 1919 and is the nation's premier scientific and professional organization promoting and disseminating information about the atmospheric and related sciences. During the 100 years of its existence, incredible progress has been made in several key fundamental areas of research, with much of this research published in AMS journals or presented at meetings sponsored by AMS. To celebrate AMS's centennial, a collection of articles has been assembled to review 100 years of progress in fundamental areas of research and to present a vision of the grand challenges in these areas of research in the coming decades.

The idea for the Centennial Monograph was at first pursued independently by both the AMS Monographs Chief Editor and the AMS Publications Commissioner as both were searching for an appropriate venue to recognize the accomplishments of AMS in its centennial. The AMS Monographs series is the ideal location for the collection of papers reviewing the progress in atmospheric and related sciences over the last 100 years because the series was refocused in 2016 (McFarquhar and Rauber 2019) to include collections of papers that summarize state-of-the-art knowledge not only in an established discipline but also in fields where rapid developments are currently being made. A monograph dedicated to a century of progress in the atmospheric and related sciences fits this description perfectly.

The articles in this monograph were written by leading experts in the atmospheric and related sciences. They summarize the current state of understanding in the appropriate subfield as well as impediments to future progress in these areas, with a vision to how these

impediments might be overcome. Even though comprehensive reference lists are provided in each chapter, the articles do not represent review articles in the sense that they do not document all accomplishments made in the appropriate discipline in the last 100 years. Indeed, it would be nearly impossible to include all references and to adequately summarize all accomplishments in the past 100 years. Instead, the articles emphasize the key accomplishments that were transformative in that they had a big impact in shifting the direction of research and operations. Even though this monograph is designed to celebrate the centennial of AMS, the reviews are not limited to work published solely in AMS journals and conferences. The international nature of the atmospheric and related sciences would make such a task impossible if the most important breakthroughs are to be adequately represented.

Each article is written from the perspective of the relevant authors and reflects their interpretation of the progress and accomplishments in their disciplines. Attempts were made to ensure that the summary was inclusive and accounted for contributions of a wide range of investigators through involvement of appropriate coauthors and through a comprehensive review process. But, inevitably, the wealth of accomplishments over the last 100 years means that there will certainly be some contributions that have been omitted.

It is hoped that these articles will provide an important reference and record for years to come. The articles can serve as an ideal introduction for graduate students or investigators new to a topic in order to quickly introduce them to significant findings in the appropriate area of research, as well as to alert them to coming challenges. More experienced investigators will also gain from the concise summary of accomplishments as well as from the description of future problems that may help focus future efforts in the atmospheric and related sciences.

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2. Chapter guide

The choice of topics for the chapters was determined in consultation with several members of the AMS Publications Commission. Based on nominations from the Publications Commission, lead authors for each of the chapters were then invited. The authors of the individual chapters had the freedom to invite whichever coauthors they chose, and they also were at liberty to organize their chapter in whatever form they felt appropriate, provided that they gave an overview of the significant findings in the last 100 years and identified significant challenges that lie ahead. Inevitably, the authors also had their own interpretation of what topics their assigned chapters included.

Although there can be no perfect way to organize the chapters of the monograph in a sequential manner, we have tried to do this as logically as possible. The first chapter summarizes the role of AMS in supporting the scientific community over the 100 years of its existence (Seitter et al. 2019). Thereafter, because the atmospheric and related sciences are primarily observationally driven, the next chapters summarize the systems that have been used to observe the atmosphere and the ocean, both through conventional and in situ techniques (Stiith et al. 2019; Davis et al. 2019) and through instruments installed on satellite platforms (Ackerman et al. 2019; Fu et al. 2019). Given the importance of the general circulation of the atmosphere (Held 2019) and ocean (Wunsch and Ferrari 2019) in determining properties and phenomena, these topics are summarized next along with chapters describing the dynamics of atmosphere–ocean variability (Battisti et al. 2019) and Earth’s middle atmosphere (Baldwin et al. 2019). Other important topical areas that impact and are impacted by atmospheric circulations are discussed next, including boundary layer meteorology (LeMone et al. 2019), gas-phase atmospheric chemistry (Wallington et al. 2019), and cloud physics and aerosols (Kreidenweis et al. 2019). The next chapters summarize the important role that numerical models have had in the atmospheric and related sciences, describing the development of weather and climate models (Randall et al. 2019) and the progress that has been made in forecasting and numerical weather prediction applications (Benjamin et al. 2019). Given the importance of Earth’s changing climate, a chapter is devoted to the understanding of Earth’s climate and climate forcing (Ramaswamy et al. 2019). Phenomena occurring in specific conditions or present at locations around the world are discussed in the next chapters, including an examination of tropical cyclones (Emanuel 2019), extratropical cyclones (Schultz et al. 2019), mesoscale convective systems (Houze 2019), convective storms (Brooks et al. 2019), nonconvective mesoscale meteorology (Kristovich et al. 2019), mountain meteorology (Smith

2019), and polar meteorology (Walsh et al. 2019). The important role of applied meteorology (Haupt et al. 2019a,b,c) and its impact is discussed in the next chapters before summarizing accomplishments in the field of hydrology (Peters-Lidard et al. 2019). The last topical chapter emphasizes the growing importance of social sciences by looking at its relationship with climate change (Lemos et al. 2019) with an epilogue offering a glimpse to the future (McFarquhar and Rauber 2019).

In summary, this monograph not only outlines the significant accomplishments made in atmospheric and related sciences over the last 100 years, but it also discusses pressing problems and potential solutions that may be a foundation of work in the atmospheric and related sciences in coming decades. By the time of the AMS bicentennial in 2120, it will be interesting for future generations to assess the degree to which these conjectures hold true, and to recognize the progress made in other fields, topics, or techniques that we have been unable to foresee in this monograph.

REFERENCES

- Ackerman, S. A., and Coauthors, 2019: Satellites see the world’s atmosphere. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-18-0009.1>.
- Baldwin, M., and Coauthors, 2019: 100 years of progress in understanding the stratosphere and mesosphere. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-19-0003.1>.
- Battisti, D., D. J. Vimont, and B. P. Kirtman, 2019: 100 years of progress in understanding the dynamics of coupled atmosphere–ocean variability. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-18-0025.1>.
- Benjamin, S. G., J. M. Brown, G. Brunet, P. Lynch, K. Saito, and T. W. Schlatter, 2019: 100 years of progress in forecasting and NWP applications. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-18-0020.1>.
- Brooks, H., and Coauthors, 2019: 100 years of severe convective storm research and forecasting. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-18-0026.1>.
- Davis, R. E., and Coauthors, 2019: 100 years of progress in ocean observing systems. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHIS-D-18-0014.1>.
- Emanuel, K., 2019: 100 years of progress in tropical cyclone research. *A Century of Progress in Atmospheric and Related*

- Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0016.1>.
- Fu, L.-L., T. Lee, W. T. Lui, and R. Kwok, 2019: 50 years of satellite remote sensing of the ocean. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0010.1>.
- Haupt, S. E., R. M. Rauber, B. Carmichael, J. C. Knievel, and J. L. Cogan, 2019a: 100 years of progress in applied meteorology. Part I: Basic applications. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0004.1>.
- , S. Hanna, M. Askelson, M. Shepherd, M. A. Fragomeni, N. Debbage, and B. Johnson, 2019b: 100 years of progress in applied meteorology. Part II: Applications that address growing populations. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0007.1>.
- , B. Kosović, S. W. McIntosh, F. Chen, K. Miller, M. Shepherd, M. Williams, and S. Drobot, 2019c: 100 years of progress in applied meteorology. Part III: Additional applications. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0012.1>.
- Held, I. M., 2019: 100 years of progression in understanding the general circulation of the atmosphere. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0017.1>.
- Houze, R. A., Jr., 2019: 100 years of research on mesoscale convective systems. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0001.1>.
- Kreidenweis, S., M. Petters, and U. Lohmann, 2019: 100 years of progress in cloud physics, aerosols, and aerosol chemistry research. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0024.1>.
- Kristovich, D., E. Takle, G. S. Young, and A. Sharma, 2019: 100 years of progress in mesoscale planetary boundary layer meteorological research. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0023.1>.
- LeMone, M. A., and Coauthors, 2019: 100 years of progress in boundary layer meteorology. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0013.1>.
- Lemos, M. C., H. Eakin, L. Dilling, and J. Worl, 2019: Social sciences, weather, and climate change. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0011.1>.
- McFarquhar, G. M., and R. M. Rauber, 2019: Epilogue. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-19-0007.1>.
- Peters-Lidard, C. D., F. Hossain, L. R. Leung, N. McDowell, M. Rodell, F. J. Tapiador, F. J. Turk, and M. Wood, 2019: 100 years of progress in hydrology. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0019.1>.
- Ramaswamy, V., and Coauthors, 2019: Radiative forcing of climate: The historical evolution of the radiative forcing concept, the forcing agents and their quantification, and applications. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-19-0001.1>.
- Randall, D. A., and Coauthors, 2019: 100 years of Earth system model development. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0018.1>.
- Schultz, D. M., and Coauthors, 2019: Extratropical cyclones: A century of research on meteorology's center piece. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0015.1>.
- Seitter, K. L., J. Nathans, and S. Mankins, 2019: American Meteorological Society: 100 years of supporting the scientific community. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0005.1>.
- Smith, R. B., 2019: 100 years of progress in mountain meteorology research. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0022.1>.
- Stith, J. L., and Coauthors, 2019: 100 years of progress in atmospheric observing systems. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0006.1>.
- Wallington, T. J., J. H. Seinfeld, and J. R. Barker, 2019: 100 years of progress in gas-phase atmospheric chemistry research. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0008.1>.
- Walsh, J. E., D. H. Bromwich, J. E. Overland, M. C. Serreze, and K. R. Wood, 2019: 100 years of progress in polar meteorology. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0003.1>.
- Wunsch, C., and R. Ferrari, 2019: 100 years of the ocean general circulation. *A Century of Progress in Atmospheric and Related Sciences: Celebrating the American Meteorological Society Centennial, Meteor. Monogr.*, No. 59, Amer. Meteor. Soc., <https://doi.org/10.1175/AMSMONOGRAPHS-D-18-0002.1>.