BAMS Meeting Summary

Advancing Our Understanding of Cloud Processes and Their Role in the Earth System through Cloud Object Tracking

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Algorithms;
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Oxford Cloud Tracking Workshop

What: 172 scientists from around the world met in a hybrid format to assess the status and application of cloud tracking algorithms and discuss the current and future development of these analysis methods.

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Where: Oxford, United Kingdom

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Algorithms to detect and track clouds through space and time are used in both research and forecasting for a wide range of weather systems. The Oxford Cloud Tracking Workshop was held to bring together the international research community working on the scientific applications and technical development of cloud object tracking. Although cloud tracking approaches have existed since the early 1980s (e.g., Maddox 1980; Dixon and Wiener 1993), the development and utilization of tracking tools has recently accelerated rapidly around understanding big data and scientific interest in cloud processes and life cycles. The Oxford Cloud Tracking workshop represents the first known community workshop dedicated to the development and scientific applications of object-based, automated cloud tracking.

Workshop themes

The workshop was arranged around four primary themes pertinent to current and future cloud research:

Morphology and life cycle of mesoscale convective systems (MCSs). Understanding the spatial and temporal patterns of clouds, especially large-scale organized systems like MCSs, is vital to studying their impacts on rainfall, extreme weather, and climate. MCSs are typically well captured by cloud tracking algorithms, enabling new research in MCS dynamics and patterns.

Dynamical processes and convective organization. Improved knowledge of in-cloud dynamics, storm life cycle, and how storms organize upscale is crucial in understanding their response to local environments and their variations in changing climates. The workshop attendees discussed that using multiscale and multivariate tracking (i.e., tracking on multiple variables simultaneously) is a promising way forward to link the impact of local environmental factors and large-scale synoptic factors to the behavior of convective systems.

Microphysical cloud processes. Microphysical processes represent a major uncertainty in convection-permitting simulations as their scales dictate that such processes are parameterized as opposed to explicitly resolved. The ability to examine the complete cloud life cycle using tracking techniques enables better studies of evolution and importance of microphysical processes.

Upcoming satellite missions. Cloud tracking plays a major role in the formulation, algorithm development, and analysis of the observation datasets in a number of upcoming satellite missions, including NASA's INvestigation of Convective UpdraftS (INCUS) mission, ESA's EarthCARE mission, and NASA's Atmosphere Observing System (AOS). The potential of high-temporal-resolution datasets are significant, in particular, in the context of the emergence of global kilometer-scale climate models with nearly matching spatial resolution. Many workshop attendees felt that when building next-generation datasets useful for cloud tracking, such as Georing and the International Satellite Cloud Climatology Project-Next Generation (ISCCP-NG), spatial and temporal consistency is of the greatest importance.

Conclusions

The Oxford Cloud Tracking Workshop brought together the international cloud tracking community and helped to shape our vision for future work and collaborations. A primary conclusion of the workshop was the need to enhance our development of tracking algorithms that facilitate multivariate and multiscale tracking of clouds and other geophysical objects within multiple datasets to better understand atmospheric processes and interactions. New satellite missions and kilometer-scale convective-resolving models require cloud tracking algorithms, as manual tracking is not feasible on such large datasets. An intercomparison of available cloud tracking algorithms is also needed to understand the sensitivity of scientific conclusions reached using different tracking approaches. Finally, we should promote the use of open-source tracking algorithms and datasets in order to support reproducible and transparent science, as well as ensure constructive future development of such analytical tools and avoiding unnecessary duplication of efforts.

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References

Dixon, M., and G. Wiener, 1993: TITAN: Thunderstorm Identification, Tracking, Analysis, and Nowcasting—A radar-based methodology. *J. Atmos. Oceanic Technol.*, **10**, 785–797, https://doi.org/10.1175/1520-0426(1993)010<0785:TTITAA>2.0.CO;2.

Maddox, R. A., 1980: An objective technique for separating macroscale and mesoscale features in meteorological data. *Mon. Wea. Rev.*, **108**, 1108–1121, https://doi.org/10.1175/1520-0493(1980)108<1108:AOTFSM>2.0.CO;2.