MAR15-2014-020309

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Big science with little data: separating random waves from vortices in atmosphere and ocean fluid dynamics[1]

OLIVER BUHLER, Courant Institute of Mathematical Sciences, New York University

How to extract physical and conceptual meaning from limited data sets has been a perennial problem in atmosphere ocean science. This is especially pressing in the current era of large-scale numerical models that seek, for the first time, to simulate directly all the most energetic scales in these systems. This effort requires observational guidance at unprecedented small spatial scales. Progress in extracting physical meaning from data is therefore inseparable from progress in climate simulation and forecasting overall. For example, the successful planning of costly satellite missions depends crucially on the physical nature of the expected motions that are to be observed. In many cases, data are obtained along one-dimensional ship or flight tracks, in which case there are both kinematic and dynamic aliasing effects that obscure the physical meaning of the data. Here kinematic refers to well-known aliasing effects that arise when three-dimensional flow fields are observed only along a line. Dynamics aliasing refers to the more subtle situation when physically different processes project into the same data stream. Indeed, it is well known in atmosphere ocean science that random waves and vortices overlap and intermingle in a complex wave-turbulence jig-saw puzzle, which we need to solve! This talk describes recent progress on this problem, which led to a new method to decompose one-dimensional data into its wave and vortex constituents. The new method works by combining a new Helmholtz decomposition method for one-dimensional velocity spectra with a theoretical energy equipartition result that allows fingerprinting and identifying the random wave component in the track data. Applications of the new method to oceanic data sets and to the famous Gage–Nastrom spectrum in the atmosphere are presented, with surprising results.

[1]This work was supported by NSF grants CMG-1024180, DMS-1312159, and DMS-1009213.