Comparing upper level winds to the marine boundary layer

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The primary research objective of this miniproject would be to compare two sources of atmospheric velocity data to help us understand the origins of observed scaling behaviour that contradicts earlier assumptions related to the butterfly effect.

Until about 10 years ago, the only atmospheric velocity fields over large scales came from reanalysis, a process in which velocities are inferred from the observed motions by codes that assimilate data and make predictions, currently on grids that are at best 250 horizontal kilometers.

Then scatterometers were launched. This new class of Earth-observing satellites determines winds in the marine boundary layer. providing a window into a largely unrecorded part of the atmosphere giving horizontal velocities down to 25 kilometer resolution. Recently, G King (formerly Warwick and now in Lisbon) and I found a new use for these measurements for elucidating the scaling behaviour of horizontal kinetic energy transfer in the marine boundary layer over the Pacific Ocean. This work is being written up. See: http://www.eng.warwick.ac.uk/staff/rmk/kerr/struc.html

The primary conclusion is that we support scaling found from aircraft data. and we would now like to understand how this is connected to actual motions. For example, we have discovered that vortices and jets in the boundary layer have strong and competitive roles, but need to know how these are connected to the flows above. We want to know: Are the vortices are related to cyclones? This could mean the scatterometers velocities could identify incipient storms far from land. And are the jets an artifact of the motion of the underlying ocean, or connected to jet streams in the atmosphere?

New background that would be necessary is an elementary understanding of large-scale atmospheric motions. There are lecture notes available for the Climate and Weather module that Prof. Ball has taught and I have hand-written lecture notes from when I taught introductory Atmospheric Science at the University of Arizona.

What would be compared are marine boundary layer winds from dates from 2006-2008 that Dr. King has not yet analysed to reanalysis data for the same dates and same area above the Pacific Ocean. The reason these dates have not been done is that our work started before 2006 and global (outside NW Europe and the N. Atlantic) upper level weather charts were not archived in the UK until 2006 at Appleton Rutherford Lab, where there is someone to help the student navigate these archives.

The scatterometer data would be horizontal winds at 10 meters that can be downloaded from JPL in California. These winds have been processed from the original data for microwave scattering from capillary waves on the ocean surface. Dr. King has MatLab programs that can take the downloaded data and generate surface velocity plots.

The primary deliverable would be input for the next paper by Dr. King and myself into what the dynamical origin of the atmospheric energy cascades is. Is it a type of stratified turbulent energy cascade, or is it more associated with convergence into storm centres?

In the longer term, there are many other uses for the scatterometer data. One area is what the scatterometer winds were originally meant for: Assimilation into global weather prediction codes. Another direction would be parameterisation of the small-scale kinetic energy transfer. Existing models assume this energy moves from small-to-large scales via the butterfly-effect. But when this assumption was put in the latest global models, observational spectra were not produced. The reason, based on our results and the aircraft data, is that most of the energy moves from large-to-small scales. This is similar to three-dimensional turbulence, but in a regime where different sub-grid energy parameterisations might be required.