Impacts of High Resolution SST Fields on Objective Analysis of Wind Fields, and Practical Constraints Related to Sampling

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1. Introduction

High resolution SSTs are used to add information to an overly smooth vector wind field. The key diagnostic for this study is the spectra density (spatial) of wind vector components. Wind fields are derived from a reanalysis pressure field without SST information, and the finer spatial scales are shown to be limited by smoothing. The winds are determined through the University of Washington Planetary Boundary Layer (UWPBL) model, which can also use air temperature information to consider additional physics. For simplicity, it is assumed that the air temperature is equal to the SST in Reynolds 0.25° GHRSST product. The wind fields derived with this temperature information are smoothing limited at much smaller spatial scales. Knowledge of these scales can also be used to determine the averaging scales used in determining tuning parameters in objective analyses.

2. Data

- Two data sets are used in this study:
  - Reynolds GHRSST product *(Reynolds et al. 2007)*
  - Modern Era Retrospective-Analysis For Research AND Applications (MERRA) sea level pressures *(Bosilovich et al. 2008)*
- The MERRA sea level pressures (0.5°x0.66°) are interpolated to the grid spacing of the Reynolds GHRSST product (0.25°x0.25°)
  - A spline fit is used to greatly reduce spurious spatial derivatives
  - The magnitude of the vector wind components is related to the pressure gradient; therefore, the vector wind is sensitive to spurious changes in the pressure field
- The UWPBL model is used to find a field of vector winds based on the pressure or the pressure and the SSTs
- The time period of examination is February 2003. The MERRA data are hourly; however, only the data for 01Z are examined herein. The Reynolds SST product has a daily time step.

3. Sampling Limitations of Orbiting Satellites

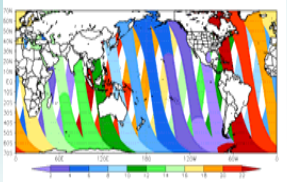

Figure 1. Sampling characteristics of orbiting satellites. Times (in hours) of descending and ascending orbits for SSM/I F13.

- Measurements are made discretely in space and time (Figure 1)
  - Limits spatial and temporal resolution
  - Short-term fluctuations are undersampled and data voids present
- Filling data voids "correctly" is vital to the utility of derived data sets
  - Excessive smoothing reduces kinetic energy in wind field
  - Satellite tracks evident in spatial derivatives

4. Improving Resolution Via Additional Data Sources

- Resolution can arguably be improved by including data from other sources: satellites *(Atlas 1996; Zhang et al. 2006)*, numerical weather prediction *(Liu et al. 1998)*, reanalyses *(Chin et al. 1998; Morey et al. 2006)*, or a combination there of *(Yu and Weller 2007)*
- Using multiple satellites reduces data voids and increases the number of times a particular region is observed throughout the course of a day (Figure 2)
  - Spatially, sampling density is not homogeneous (due to orbital characteristics of platforms and regions of persistent cloud cover)
  - Temporal resolution limited by redundant observations and distribution of data throughout averaging period

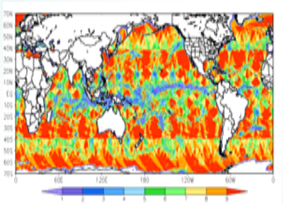

Figure 2. Number of observations per 0.25° grid cell for 01 January 2003 using multiple satellites: SSM/I F13, SSM/I F14, SSM/I F15, AMSR-E, QuikSCAT, and TMI.

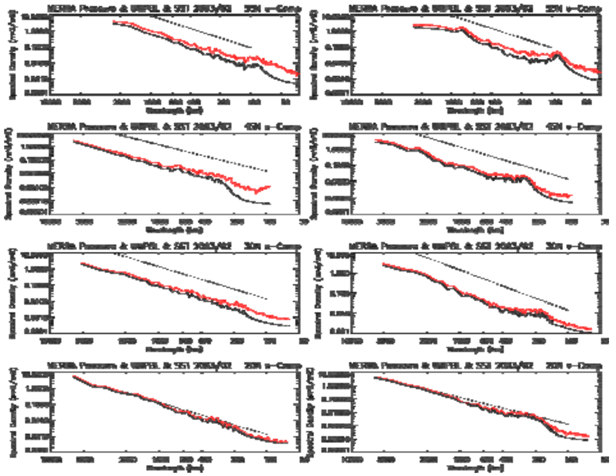

Figure 3. Spectral density for zonal (left) and meridional (right) vector wind components at 55°N, 45°N, 30°N, and 20°N. The black lines assume isothermal surface temperatures and the red lines assume air temperature equals SSTs. The dotted line represents a slope of -2.0, typical of geophysical data.

5. Adding Information To Wind Field Through SSTs

- Two sets of vector wind fields are generated:
  1) Air temperature is ignored, i.e., no surface temperature gradient
     - The spectral density of these winds is shown as the black lines in figure 3 for latitudes of 55°N, 45°N, 30°N, and 20°N
     - The influence of excessive smoothing is quite evident in the zonal component (left column) for 55 and 45°N where there is a sharp increase in the rate of change of the log of spectral density with respect to the log of the wavelength
       - 55°N → at a wavelength of roughly 100km
       - 45°N → at a wavelength of roughly 200km
     - The spectral density of the meridional vector component has a strange bump at roughly 200km wavelength (100km at 55°N). If there were substantial errors in interpolation they are highly unlikely to be manifested at that wavelength. Consequently, these features are very likely found in the MERRA data set
  2) Air temperature set equal to SSTs
     - Reynolds GHRSST data used with MERRA sea level pressures
     - The spectral densities for these wind vector components are shown as the red lines in figure 3
     - Changes is slope associated with smoothing are largely removed
- The SST data are remarkably effective for adding information to the wind field
  - More testing is required through different approach

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6. Application To Objectively Derived Gridded Wind Vectors

- Information gained from additional physics provides potential benefits to objectively derived gridded wind vector fields (especially in data voids)
- Developing a global multi-satellite blended ocean surface wind (speed and direction) product
  - Direct minimization approach *(Pegion et al. 2000)*
  - UWPBL model utilized as a physical constraint
- Provided input parameters (e.g., surface pressure, SST, & air temperature), the UWPBL model solves for the velocity profile in the boundary layer

7. Summary

- A physically-based methodology can be used to exchange information between wind fields and SST fields
  - Each field can be enhanced
- It seems likely that such an approach will improve the quality of diurnal variability, particularly in the wind fields
- If more inter-calibrated wind observations are available, in a manner that greatly improves temporal sampling, then the wind data could also be used to improve diurnal variability in the SSTs