Multi-Satellite Gridded Ocean Surface Wind Product

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1. Introduction

The ocean, covering roughly 71% of the Earth's surface, plays a major role in driving both regional and global climate variability via the exchange of heat, moisture, momentum, gases, and particulate matter across the air-sea interface. The fluxes of energy and matter exhibit variability on multiple temporal scales, thus in order to better understand the coupled climate system the ocean surface variables need to be observed on scales ranging from intra-daily to inter-decadal and beyond. To accurately represent phenomena on desired sub-daily (3 to 6 hour) temporal scales, information from multiple orbiting satellites is required. The ultimate goal of this work is to objectively construct a global high resolution multi-satellite blended ocean surface wind (speed and direction) product using data obtained from the Remote Sensing Systems (RSS). A direct minimization approach is utilized with the University of Washington Planetary Boundary Layer (UWPBL; *Patoux and Brown 2002*) model acting as a physical constraint. However, this study will focus on several fundamental issues associated with constructing gridded products from in situ and/or satellite observations. Namely, (1) Do the available observations satisfy the aforementioned needed temporal resolutions? and (2) To what extent do the observations accurately represent the averaging period?

2.Data

- Daily surface wind speed data obtained from Remote Sensing Systems (RSS; http://www.remss.com)
  - 0.25° grid spacing
  - Uniform retrieval algorithms for the multiple satellites over the whole time period
- Hourly 10m wind data obtained from 120-hour Weather Research and Forecasting (WRF) Model simulation
  - 12km resolution with 60 second time step

3. Sampling Limitations of Single Orbiting Satellite

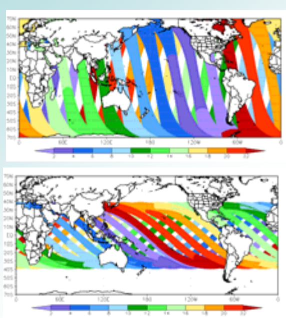


Figure 1. Sampling characteristics of orbiting satellites. Times (in hours) of descending and ascending orbits for SSM/I F13 (top) and TMI (bottom) on 01 January 2003. Orbital characteristics restrict TMI observations between 40°S and 40°N

- Measurements are made asyoptically, i.e., discrete in time and space
- Nearly global coverage throughout the coarse of a day (Figure 1)
  - Data voids present
  - In tropics and mid-latitudes, a particular region is sampled at most twice
- Discrete sampling limits spatial and temporal resolution *(Salby 1989)*
  - Short-term fluctuations are undersampled
  - Unresolved behavior can influence larger scales
- To accurately represent phenomena on intra-daily temporal scales information from multiple orbiting satellites is required

References

1) Salby, M. L., 1989: Climated monitoring from space: asynoptic sampling considerations, J. Clim., 2, 1091-1105
2) Patoux, J., and R.A. Brown, 2002: A gradient wind correction for surface pressure fields retrieved from scatterometer winds, J. Appl. Meteor., 41, 133-143
3) Patoux, J., and R.A. Brown, 2002: Global pressure fields from scatterometer winds, J. Appl. Meteor., 42, 813-826
4) Zhang, H., J.J. Bates, R.W. Reynolds, 2006: Assessment of composite global sampling: sea surface wind speed, Geo. Res. Letters, 33, L17714

Acknowledgements: NASA OVWST

4. Multi-Satellite Sampling

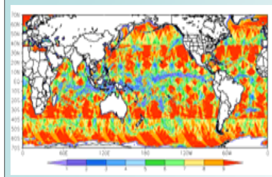


Figure 2. Number of observations per 0.25° grid cell for 01 January 2003 using multiple satellites: SSM/I F13, SSM/I F14, SSM/I F15, AMSR-E, QuikSCAT, and TMI.

- 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
- Thinking in terms of constructing global high resolution (sub-daily) gridded products:
  1) Is the averaging period sampled each day?
  2) How is the data distributed throughout averaging period?
  3) Does temporal distribution of data matter?
     - Large vs. small temporal variability
     - Constant vs. time dependent variability
  4) How representative is the available data of the averaging period

Is the averaging period sampled each day?

- For a 6-hourly (centered at 12UTC) product for January 2003, six satellites required for quasi-daily sampling of 09 – 15UTC time period (Figure 3)
  - Requirement slackened for larger averaging period (not shown)

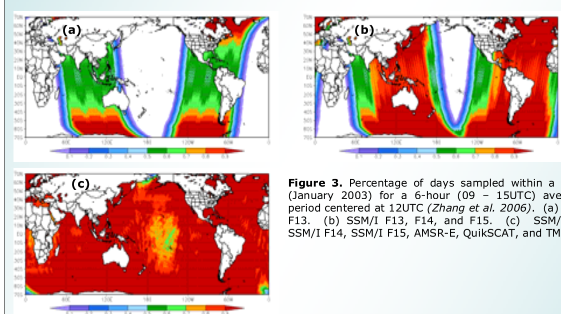
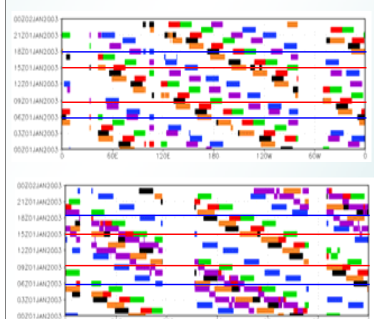


Figure 3. Percentage of days sampled within a month (January 2003) for a 6-hour (09 – 15UTC) averaging period centered at 12UTC *(Zhang et al. 2006)*. (a) SSM/I F13. (b) SSM/I F13, F14, and F15. (c) SSM/I F13, SSM/I F14, SSM/I F15, AMSR-E, QuikSCAT, and TMI.

How is data distributed throughout averaging window?



- Sampling times spread throughout desired averaging period (Figure 4)
- Distribution NOT homogeneous with respect to
  - Time & space

Figure 4. Sampling times along Equator (top) and 30°S (bottom) for 01 January 2003. Black – SSM/I F13, Red – SSM/I F14, Green – SSM/I F15, Blue – AMSR- E, Orange – QuikSCAT, and Purple – TMI. Blue (red) lines signify times included in 12-hourly (6-hourly) averages centered at 12UTC.

How representative are the observations of the averaging period?

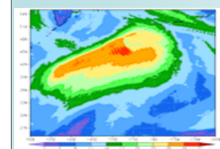


Figure 5. Hourly maximum wind speed for 21 October 2008 from 120-hour WRF simulation. Depicts storm motion and expansion of wind field within said 24-hour time period.

- 120-hour WRF simulation assumed to be "truth"
- 12-hourly and 6-hourly averages are constructed from hourly model output (Figure 6)
- Largest variability associated with center of storm, expanding wind field, frontal region (Figures 5 and 6)
  - Frequent observations needed to accurately capture temporal variability
- Variability of surrounding environment roughly constant with respect to time (Figure 6)
  - Less frequent observations needed to accurately represent averaging period

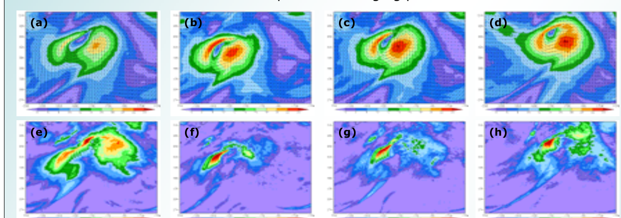


Figure 6. Wind speed averages (ms^{-1}) constructed from hourly WRF output for 21 Oct. 2008. (a) 12-hourly centered at 12UTC. (b) 6-hourly centered at 06UTC. (c) 6-hourly centered at 12UTC. (d) 6-hourly centered at 18UTC. (e – h) Corresponding standard deviation from time period mean. The WRF simulation is assumed to represent "truth".

- Spatially, patterns of variability associated with 12-hourly average derived from satellite observations compares favorably to "truth" (Figures 6e and a)
- For 6-hourly satellite derived averages, the variability is highly depended on number of satellite overpasses and number of good observations, i.e., not contaminated by rain (Figures 7b-d and Figures 7f-h)
  - 12UTC average (Figures 7c & g) almost entirely derived from one AMSR-E overpass

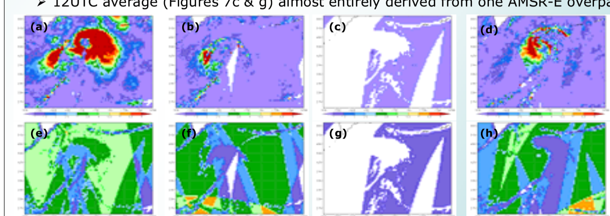


Figure 7. Standard deviations corresponding to wind speed averages (ms^{-1}) constructed from satellite observations for 21 Oct. 2008. (a) 12-hourly centered at 12UTC. (b) 6-hourly centered at 06UTC,. (c) 6-hourly centered at 12UTC. (d) 6-hourly centered at 18Z. (e – h) Number of observations per 0.5° grid cells. Satellites include: SSM/I F13, SSM/I F15, AMSR-E, QuikSCAT, and TMI. SSM/I F14 data not available.

5. Summary

- For time periods examined (January 2003 & 21 October 2008):
  - Is averaging period sampled each day? **~ YES**
  - How is data distributed throughout averaging period? **NOT HOMOGENEOUS**
  - How representative are observations of averaging period?
    - For satellite derived 12-hourly average, sampling appears to be sufficient in both time and space
    - Accuracy of 6-hour averages limited by number of overpasses & rain flagged data (phenomena are undersampled or data is redundant)