Quantifying Variance Due to Temporal and Spatial Difference between Ship and Satellite Winds

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Background and Motivation

- Equivalent neutral winds measured by the SeaWinds scatterometer onboard the QuikSCAT satellite can be validated with comparison in situ data. Because in situ observations that are ideally collocated in both time and space with the satellite overpass are rare, in situ observations that are within a certain time and space range to the satellite overpass are used as comparison data.
- This approach results in a total amount of variance associated with three primary sources: the satellite dataset, the in situ dataset, and the temporal and/or spatial difference between the observations.

Previous studies

- Kent et al. (1999) determined the random observational error variance for individual voluntary observing ship (VOS) variables using pairs of VOS observations within a four-month period. The error variance focused on the spatial separation.
- Bourassa et al. (2003) identified different sources of uncertainty, including the spatial difference, between SeaWinds and research vessel observations; however, the temporal difference was not considered.

This study

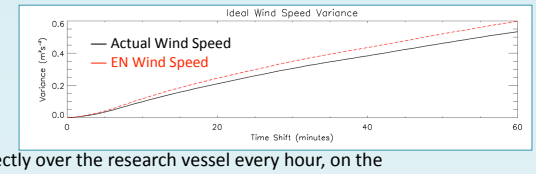
- Temporal and spatial resolutions are much finer than those used by Kent et al. (1999).
- A more extensive dataset is used herein to provide more robust results than those found by Bourassa et al. (2003).
- Goal 1: Quantify the amount of variance associated with the temporal and/or spatial difference between two observations
- Goal 2: Quantify the combined amount of variance associated with the datasets

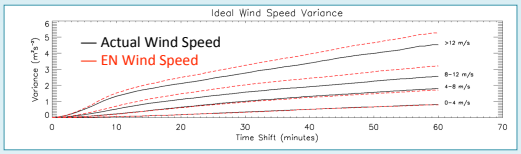
Equivalent Neutral Wind

- Equivalent neutral (EN) wind speeds assume neutral stratification, but nonneutral friction velocity and roughness length values.
- Scatterometer winds are calibrated into a 10-meter EN wind speed. Therefore, the in situ measured wind speeds must also be converted into an EN wind speed and height adjusted to 10 meters to be comparable to the scatterometer data.
  - The one-minute in situ observations in this study are collected through the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (Smith et al. 2010).

Idealized Scenario

- Goal: Examine variability associated with a temporal difference between two observations





Method

- Only one-minute SAMOS data are used.
- A pseudosatellite is assumed to pass directly over the research vessel every hour, on the hour.
- For each hour, a wind-speed-dependent averaging window centered on the hour is defined as an ideal collocation. The averaging window is then shifted away from the hour in one-minute increments from 0 to 60 minutes.
- The wind speed is binned into 4 ms^{-1} ranges to determine the effect of wind speed on the error calculated.
- The variance of the difference between the hourly averages and the time-shifted averages is calculated for each one-minute shift.

Results

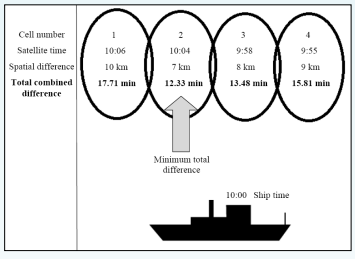
- As the time difference increases, the amount of variance increases.
- There is a larger amount of variance associated with higher wind speeds.
- For unstable conditions, the EN winds are larger than the actual winds.
- For low wind speeds, EN winds have less variability than winds because changes in wind are compensated for by changes in atmospheric stability.

Real World Scenario

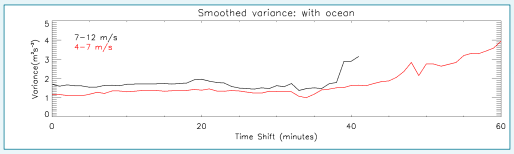
- Goal: Verify idealized scenario method and results

Method

- Compare only EN winds since that is what SeaWinds provides.
- For each satellite overpass, the closest collocation in both time and space is determined by using Taylor's hypothesis to convert spatial differences into temporal differences. This method allows for the total difference in minutes to be calculated for each collocation.



- The variance of the difference between the SeaWinds-measured wind speeds and the converted SAMOS EN wind speeds is calculated for each one-minute difference for wind speeds between 4-7 ms^{-1} and 7-12 ms^{-1}.
- The variance associated with wind speeds less than 4 ms^{-1} is not examined here because of the large time-averaging window for the SAMOS data and SeaWinds not being able to adequately measure very low wind speeds.



Results

- For less than a 25-minute (equivalent) difference, the variance associated with the temporal and spatial difference is offset by the variance associated with the datasets; therefore,

$$\sigma^2_{total} = \sigma^2_{sat} + \sigma^2_{ship}$$
$$= 1.5 m^2 s^{-2} \quad \text{7-12 ms}^{-1}$$
$$= 1.0 m^2 s^{-2} \quad \text{4-7 ms}^{-1}.$$

- For greater than a 25-minute (equivalent) difference, the variance associated with the temporal and spatial difference should be taken into consideration with the total variance.
- At differences less than the equivalent of 25 minutes, the expected increase in variance with increasing space/time difference is not apparent because the distribution of wind speeds shifts to lower wind speeds as the space/time differences increase!

References

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