Further Examination of Diurnal and Sub-Diurnal Wind Vector Variability using the Constellation of Scatterometers and Radiometers

Summary

The constellation of satellite-based ocean surface wind observations since 1999 consists of a collection of both non-synchronous and asynchronous orbiting satellite platforms, both wind vector-capable (RapidScat, QuikSCAT) including its non-spinning data. SeaWinds, ASCAT, OceanVector, WindSat, ScatterSat and speed-only radometers (TMR, GMI, AMSR, AMSR-2, SMSIS). The speed-only radometers provide additional constraints (when an insufficient number of scatterometer observations were available on any given day) to examine diurnal wind variability. The formulation extends Giles et al. (2005), by modeling the diurnal wind using an elliptical variability, with the addition of the speed-only radometers, the sub-diurnal terms, the error variance, and the capability to examine each day over the 2003-current period (when at least two scatterometers were jointly operating).

\[
\begin{align*}
\mathbf{v}_{\text{daily}} &= \mathbf{A}_{\text{daily}} \mathbf{a}_{\text{daily}}, \\
\mathbf{v}_{\text{sub-diaily}} &= \mathbf{A}_{\text{sub-diaily}} \mathbf{a}_{\text{sub-diaily}}, \\
\mathbf{v}_{\text{error}} &= \mathbf{A}_{\text{error}} \mathbf{a}_{\text{error}}, \\
\mathbf{v}_{\text{observations}} &= \mathbf{A}_{\text{observations}} \mathbf{a}_{\text{observations}}, \\
\mathbf{v}_{\text{total}} &= \mathbf{A}_{\text{total}} \mathbf{a}_{\text{total}}.
\end{align*}
\]

For the speed-only (v) radometers, since the relation between the u and v components is non-linear, hypothetical vectors are created by varying the directions one degree at a time (e.g., for one radometer)

\[
\mathbf{v}_{\text{u,v}} = \mathbf{a}_{\text{u,v}} \mathbf{u}_{\text{u,v}},
\]

In either case, these expressions can be expressed in matrix form, where \(\mathbf{v}\) and \(\mathbf{a}\) are diagonal matrices with the variance of the u and v observations.

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Zonal Variability over the Tropical Pacific Ocean

The grid above shows the zonal wind component for 1-degree boxes spread across the TAO array area. All figures have the same scale, with local time on the abscissa (for example, 0800 local) and wind speed on the ordinate between 2 m/s. The daily mean zonal wind component have been removed. Positive (negative) values indicate westerly (easterly) winds relative to the daily mean. The zonal wind is dominated by a semi-diurnal component.

The figure below shows a similar analysis (Deser and Smith, 1999), using 3-year averages at TAO buoy locations at similarly spaced locations.

Meridional Variability over the Tropical Pacific Ocean

Same labels as left, but for meridional wind component. Positive (negative) values indicate southerly (northerly) winds relative to the daily mean.

The TAO analysis below from Deser and Smith (1998) clearly identifies the dominant diurnal wind variability. The scatterometer-plus-radiometer results do not exhibit as clear of a dominant diurnal signal, especially at the equator. Further analysis needs to be done to examine data sufficiency and proper insertion of the radiometer winds during lengthy periods of scatterometer revisit, and separation by the presence of nearby convective precipitation.

Diurnal Wind Vector Variability

Using TAO buoy data in the tropical Pacific Ocean, the zonal wind variability has been shown to be dominated by the semi-diurnal component, and the meridional variability by the diurnal component (Deser and Smith, 1998). Uyama and Deser (2003) in this presentation, regions of diurnal and sub-diurnal wind variability are investigated over the tropical Pacific Ocean (8S-8N, 170E-110W). The collection of scatterometers and radometers (mid-2007-early 2017) is analyzed for days when the observations are spaced in time such that all 10 larsen (4L) can be estimated with at least two extra degrees of freedom.