Climate Applications of Ocean Surface Vector Winds

Dudley B. Chelton
Oregon State University

Ralph F. Milliff
Northwest Research Associates
Colorado Research Associates Division

Issues:

- Accuracy
- Spatial Resolution
- Global Coverage
- Continuity of Data Record
- Length of Data Record
2-Month Average Wind Stress Magnitude

QuikSCAT, January–February 2003

Wind Stress

N m$^{-2}$
2-Month Average Wind Stress Magnitude
(Spatially High-Pass Filtered)
QuikSCAT, January–February 2003
2-Month Average Wind Stress Magnitude and SST
(Spatially High-Pass Filtered)

QuikSCAT, January–February 2003
2-Month Average Wind Stress Magnitude
(Spatially High-Pass Filtered)

QuikSCAT, January–February 2003
2-Month Average Wind Stress Magnitude
(Spatially High-Pass Filtered)

ECMWF, January–February 2003
2-Month Average Wind Stress Magnitude
(Spatially High-Pass Filtered)
NCEP, January–February 2003
Wavenumber Spectra of Zonal Wind
January - December 2000

(20°–50°N, 180°–220°E)

Power Spectral Density (m²/s²)

Wavenumber (rad/km)

QuikSCAT
NCEP
NCEP Reanalysis
South Indian Ocean Region

Filtered 2-Year Average QuikSCAT Wind Stress Magnitude and AMSR Sea Surface Temperature Contours

August 2002 - July 2004
Meridional Eddy Heat Transport in the South Indian Ocean
(O’Neill et al., 2006)

The MOM2 model was forced with 4-year average QuikSCAT winds in two ways:

- Raw 25-km QuikSCAT wind stress
- QuikSCAT wind stress spatially smoothed to retain only the large scales that are resolved by the NCEP global forecast model.

Result:

The meridional heat transport is twice as strong in the model forced by the unsmoothed QuikSCAT wind stress field.
Wind Stress Vectors and SST, 12 December 2001
Fig. 3. Vertically integrated zonal transport/unit width (m² s⁻¹) from (top) ADCP observations, (middle) model, and (bottom) the Sverdrup balance [Eq. (5)]. Red colors indicate eastward transport, blue colors westward. The colored area in the top panel shows areas sampled by ADCP observations. Observed and model transports are integrated from the bottom of the ADCP sampling and the model, respectively; about 400 m in each case.
29-Day Average QuikSCAT Wind Stress Field Centered on 18 August 2002

\( \tau \) and SST

\( \nabla \times \tau \) and Crosswind \( \nabla T \)

\( \nabla \cdot \tau \) and Downwind \( \nabla T \)

Heavy Contour = 0.12 N m\(^{-2}\)

5 N m\(^{-2}\) per 10\(^4\) km

= 45 cm d\(^{-1}\) upwelling at 40°N

SST (°C)

N m\(^{-2}\) per 10\(^4\) km
29-Day Average QuikSCAT Wind Stress Field Centered on 14 September 2003

τ and SST

Heavy Contour = 0.12 N m⁻²

∇\times\tau and Crosswind ∇T

5 N m⁻² per 10⁴ km = 45 cm d⁻¹ upwelling at 40°N

∇\cdot\tau and Downwind ∇T

SST (°C)

N m⁻² per 10⁴ km
29-Day Average QuikSCAT Wind Stress Field Centered on 5 September 2004

\[ \tau \text{ and SST} \]

Heavy Contour = 0.12 N m\(^{-2}\)

\[ \nabla \times \tau \text{ and Crosswind } \nabla T \]

5 N m\(^{-2}\) per 10\(^4\) km

= 45 cm d\(^{-1}\) upwelling at 40°N

\[ \nabla \cdot \tau \text{ and Downwind } \nabla T \]
QuikSCAT and AMSR
QuikSCAT and AMSR

Scripps Coupled Ocean-Atmosphere Regional Model
(Seo et al., 2006)
QuikSCAT vs. WindSat Global Zonally Averaged Wind Stress Curl
(11-month average, February - December 2003)
Conclusions

- QuikSCAT has established a 7-year data record that reveals previously unknown persistent and pervasive SST-induced small-scale structure in the surface wind field.
  - *This small-scale structure is poorly represented in all other wind datasets.*

- The QuikSCAT data record is only now approaching a length that is useful for climate research applications.
  - *How can the continuity of this data record be maintained?*

- QuikSCAT data are nonetheless proving to be extremely useful for assessing the accuracy and resolution limitations of operational forecast models, climate models, and coupled ocean-atmosphere models.

- QuikSCAT data are beginning to be analyzed to investigate climate variability in both the atmosphere and the ocean:
  - *Is there a link between SST and atmospheric variability above the boundary layer?*
  - *What are the feedback effects of SST-induced small-scale variability in the wind stress field on the ocean circulation?*

- Analyses conducted to date expose serious concerns about the utility of passive polarimetric measurements of surface winds for research applications.