9.2

GLOBAL MAPS OF ZONAL AND MERIDIONAL KINETIC ENERGY SPECTRA FROM QuikSCAT SURFACE WINDS, 2000-2006

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1. INTRODUCTION

We revisit global distributions of kinetic energy (KE) *vs.* wavenumber (k) spectral slopes for zonal and meridional surface wind components from scatterometer data. The global spectral slope distributions are examined here for the 7-year QuikSCAT data record, to quantify year-to-year variabilities and to qualify sensitivities to rainflags in the latest QuikSCAT data release (R2). Milliff et al. (1999) first introduced maps of annual average KE *vs.* k slopes in $8°$ bins tiling the global ocean from $60°N$ to $60°S$. KE *vs.* wavenumber spectra are averaged from along-track spatial series as demonstrated in Figure 1. Spectra derive from the power accumulated in nested wavelet basis functions for scales of $8°$, $4°$, $2°$ and $1°$ (see Chin et al., 1998). Spectral slopes are reported for log-log representations of the KE *vs.* k space. Comparisons with Fourier transform spectra will demonstrate equivalence and advantages of the nested wavelet-based approach.

2. GLOBAL MAPS

The average spectra are remarkably linear for every bin, suggesting power-law relations and/or inertial sub-range explanations for the underlying physics. Numerous papers and presentations have noted that spectral slopes based on zonal winds exhibit a global pattern wherein shallower slopes occur in the tropics, and steeper slopes occur in middle and higher latitudes. Figure 2 (top) demonstrates this is indeed the case for the 7-year average dataset. A broad region of spectral slopes very near $k^{-5/3}$ is centered on the warm pool region of the western Pacific, whereas the baroclinic regions of the mid-latitude stormtracks exhibit spectral slopes slopes centered on k^{-2}. It has been noted repeatedly that these slopes correspond to inverse- and forward-cascade regimes in two-dimensional turbulence theory.

Figure 2 (bottom) depicts the global distribution of KE *vs.* k spectral slopes for the meridional wind component. The global spatial patterns are different from the zonal wind case. A persistent maximum in spectral slope occurs just north of the equator in the eastern Pacific. At higher latitudes, the slope distribution is zonal, and more similar to the zonal wind case. Spectra for the sub-regions of the Pacific basin (indicated in red on Figs. 2) will be compared in the talk.

3. INTERANNUAL VARIABILITY

Figures 3 provide one measure of year-to-year variability. The annual average, zonal average, spectral slopes are shown for each of the 7 calendar years in the QuikSCAT record, for zonal (Fig 3, top) and meridional (Fig 3, bottom) winds. Vertical bars on each curve depict the range in zonal average estimates for 10 sub-samples of the annual average-zonal average at every $8°$ latitude interval (i.e. corresponding to the bins noted in Fig. 1). Interrannual variability is within the spread among sub-samples for a given year at all latitudes except in a belt north of the equator for zonal winds (Fig 3, top) and very near the equator for meridional winds (Fig 3, bottom).

Large interrannual differences at the highest latitudes coincide with similarly large sub-sample spreads. These uncertainties reflect the smaller number of samples in $8°$ bins at high latitudes, and the seasonal reductions in these numbers due to ice cover.

4. RAIN FLAG SENSITIVITY

The R2 data benefit from a careful re-examination of the rainflag procedures in QuikSCAT surface vector wind retrievals. Part of that re-examination involved comparisons of scatterometer rainflags from the SeaWinds system on Adeos-2 with rain detection based on the AMSR instrument that was also on-board the Adeos-2 platform. To quantify potential rainflag impacts on KE *vs.* k spectral slope estimates, we compared zonal average slopes for SeaWinds on Adeos-2 winds that a) mimic the QuikSCAT retrieval and exclude rain-flagged data, and b) used AMSR rain estimates to correct the rain-flagged data (so-called “AMSR-corrected”).

Figure 4 demonstrates the zonal average slope profiles for zonal (black curves) and meridional (red

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curves) winds from standard SeaWinds on Adeos-2 retrievals (solid lines) and AMSR-corrected retrievals (dashed lines). The zonal averages are averaged over the entire Adeos-2 data record from April through October 2003. The AMSR-corrections make little difference in the average spectral slope estimates at most latitudes. However, the spectral slopes for meridional winds near the equator are steeper by an amount larger than the sub-sample spread.

5. OPINION

The global distributions of high-wavenumber spectral slopes for surface wind components retrieved from scatterometer observations are a robust, reproducible, property of the global ocean surface wind field. The implied kinetic energies occur on spatial scales commensurate with the upper ocean mesoscale, and therefore represent important signals for air-sea interaction including the transfers of momentum, heat and material properties. Numerous works (e.g. see Wikle et al, 1999; Milliff et al., 2004; Chelton et al, 2006, and many others) have demonstrated that surface winds derived from weather-center analyses and forecast models are grossly deficient in the kinetic energies on these important scales; even when scatterometer wind data have been assimilated.

New methods for extending scatterometer wind information to regular global grids are being considered now (i.e. so-called Level 3 surface vector wind products). The spectral slopes of the next generation Level 3 surface winds should adhere closely to the regional and monthly slopes derivable from scatterometer observations as demonstrated here.

6. REFERENCES

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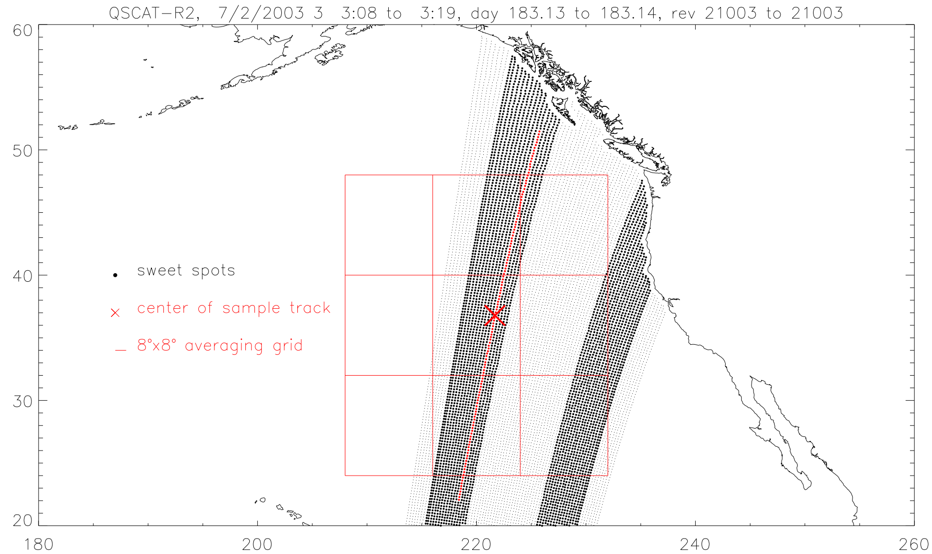

FIG. 1: **Figure 1.** Data sampling. Scatterometer swath data are sampled in along-track segments (N=135, $30°$, at $25\,km$ resolution), and are collected in $8° \times 8°$ bins that tile the entire open ocean. The QuikSCAT Level 2 DIRTH ("Direction Interval Retrieval with Thresholded Nudging") winds are used, with all rain-flagged data excluded. Only "sweet spot" regions of the swath are included; i.e. where the across-swath wind vector cell (WVC) index is between 10-25 or 52-67. For segments to be included, the maximum number of missing WVC can only be four per segment, and the largest contiguous gap can be no more than two WVC.

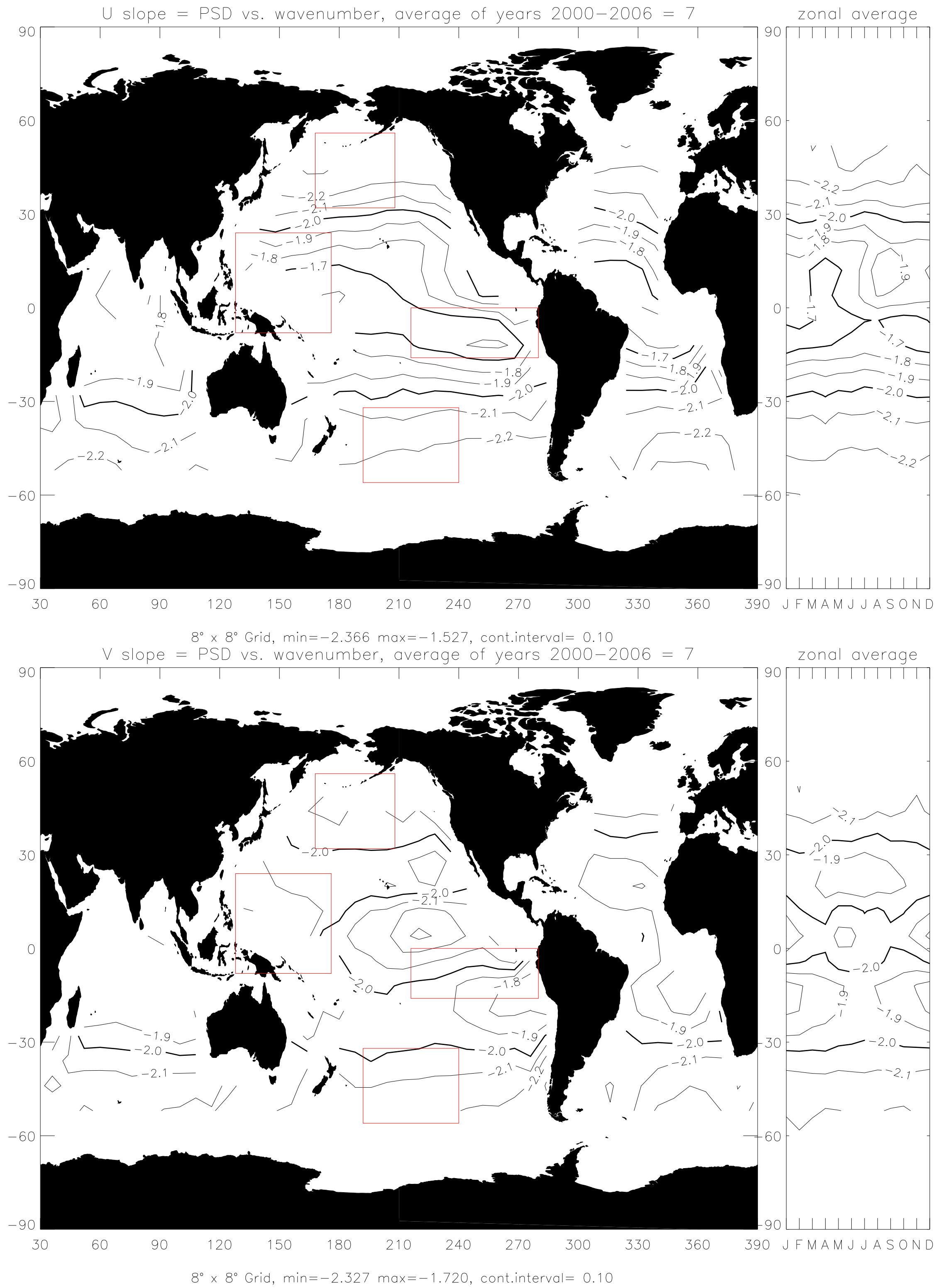

FIG. 2: Global ocean distributions for seven-year average KE *vs.* k spectral slopes for zonal (top panel) and meridional (bottom panel) surface winds from QuikSCAT; years 2000 through 2006. Red boxes delineate four regions of the Pacific basin that will be discussed in greater detail in the presentation. The side panels depict the month-by-month annual march in zonal average slopes for each wind component.

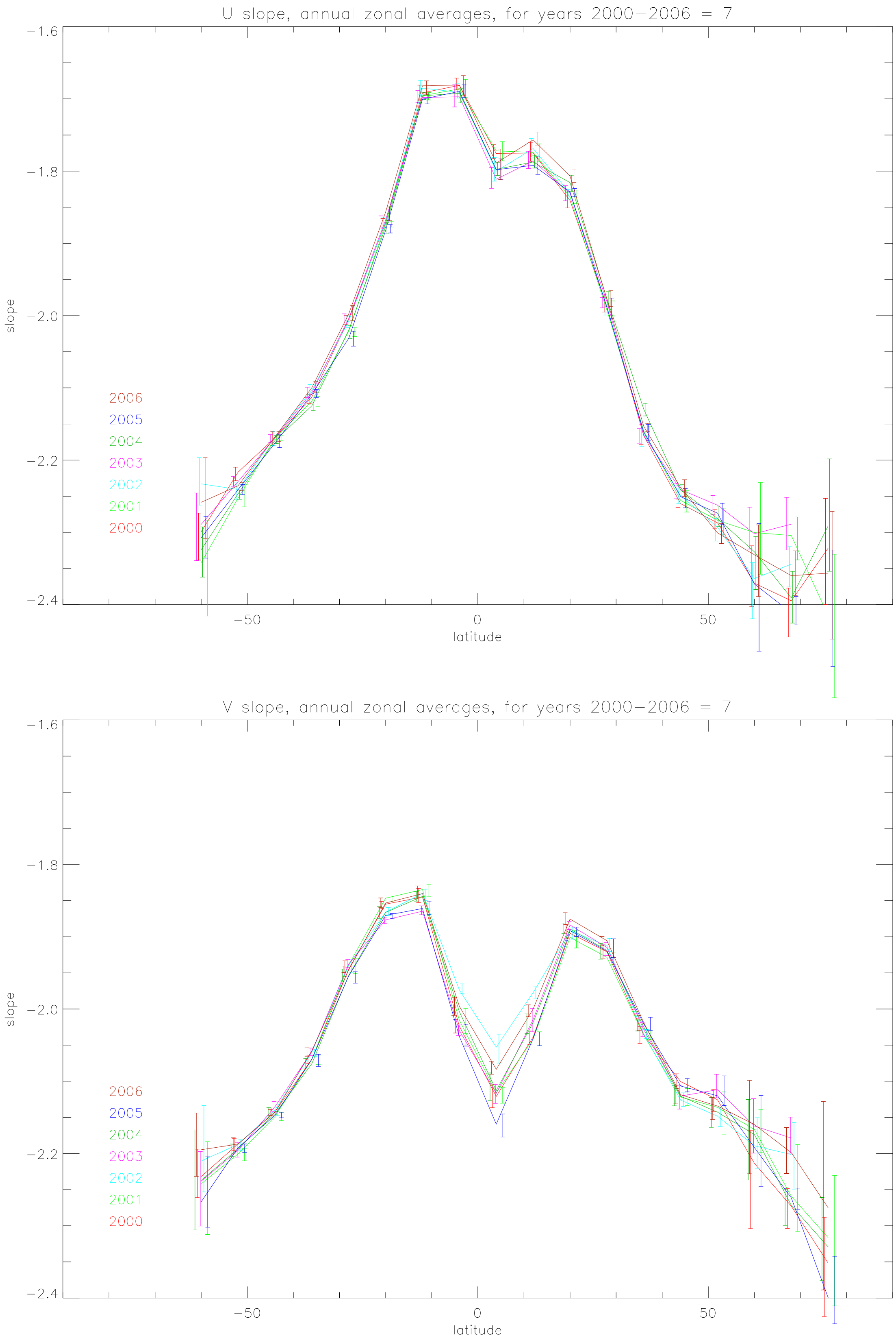

FIG. 3: Zonal average, annual average KE *vs.* k spectral slopes, every $8°$ of latitude from about $60° N$ to $60° S$ for each year 2000 through 2006 (see color coding), for zonal (top panel) and meridional (bottom panel) winds from QuikSCAT. Vertical bars (every $8°$) demonstrate the spread in 10 sub-samples of the zonal average, annual average estimates.

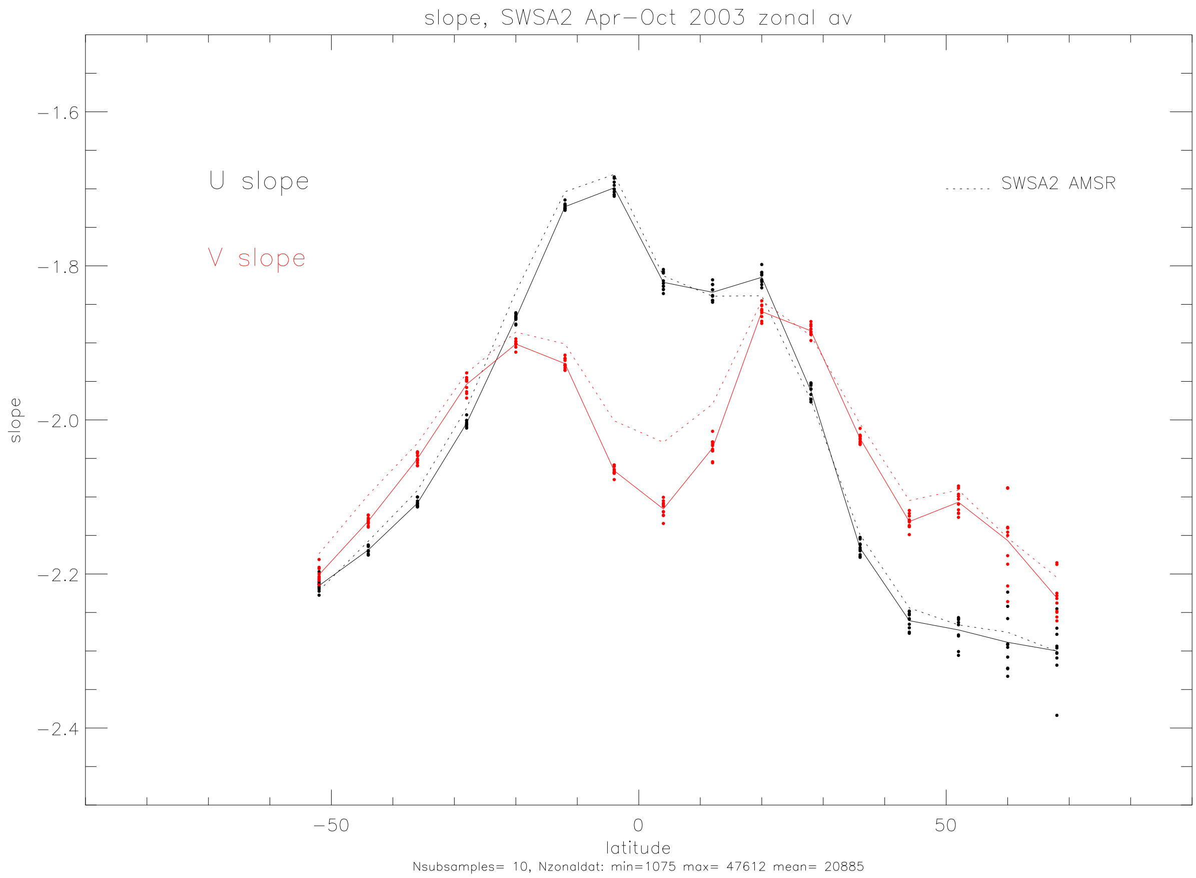

FIG. 4: Zonal average KE *vs.* k slope comparisons for zonal (black lines) and meridional (red lines) surface winds from SeaWinds on Adeos-2 (SWSA2; solid lines) using the standard QuikSCAT retrieval and rain flags *vs.* SeaWinds Adeos-2 retrievals and rain flags corrected by AMSR data (SWSA2 AMSR; dashed lines). The SeaWinds data from Adeos-2 spans the $6.5\,mo.$ period Apr 10 - Oct 24, 2003. Black (red) dots every $8°$ depict the spread in 10 sub-samples of the SWSA2 zonal (meridional) averages.