Detection and Characterization of Diurnal Winds using QuikScat Data

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***Abstract-* Analysis of SeaWinds Scatterometer data show coastal regions exhibiting a greater than 5 m/s wind speed difference between averaged morning (ascending) and evening (descending) observations. This diurnal wind variability is strongest at several Indian Ocean locations including Madagascar, northern Australia, and Sri Lanka, as well as the west coast of South America and on the Pacific Coast of Central America. Two of these regions are discussed here in greater detail.**

INTRODUCTION

The twice-daily sampling of the ocean surface by QuikScat has proven useful in studies where frequent observation of regional winds are necessary such as in tropical cyclone development [1]. This study demonstrates that by averaging the QuikScat data we can derive a more complete understanding of the diurnal variation of coastal winds. The results of such an analysis will prove useful to the global wind generation industry as they begin to place large generators in offshore locations [2].

QuikScat is the name often used for the NASA SeaWinds scatterometer onboard the Quikbird satellite, a dedicated platform launched in a semi-polar orbit in June 1999. We now have over two years of quality wind data for use in scientific studies. This dual-pencil-beam conical scanning radar sends and receives Ku-band (~14GHz) microwave pulses to the earth surface. A good description of the instrument is found in [3]. Reflected microwave signals are processed to 10-meter ocean surface vector winds using a geophysical model function that relates Bragg scattering surface wavelets to surface wind stress.

In this study, we use QuikScat ocean surface wind vectors derived using the Ku-2001 model function and retrieval algorithms. The selected wind vectors are mapped to a 0.25-degree Earth grid. In doing so, wind data within any grid cell are averaged if there is a small time difference, such as at higher latitudes, and overwritten by newer data if the time difference is large. These earth-gridded data files are described in greater detail and are available on the Remote Sensing Systems web site located at *http://www.remss.com*. Each file contains wind speed, wind direction and includes collocated microwave radiometer rain rates (where available) and a stand-alone scatterometer rain flag values. The Ku-band microwave signals emitted by the QuikScat instrument at fairly high incidence angles (46 and 54 degrees) have proven to be altered by the presence of rain within the signal path. The scatterometer rain flag allows us to use only rain-free data in this analysis, thereby removing the apparent large wind speed differences caused by the rain-elevated winds.

The broad coverage and twice-daily sampling by QuikScat provides the opportunity to detect and characterize daily changes in wind patterns in coastal regions on a global scale over monthly or seasonal time periods. We have two goals of this analysis, 1) to determine what spatial patterns exist to QuikScat wind speed and wind vector difference maps and 2) to associate the climate, topography, and ancillary data for a given large difference area to the patterns found in the QuikScat winds.

METHOD

We processed two full years of QuikScat data into four seasonal maps, Dec/Jan/Feb, Mar/Apr/May, Jun/Jul/Aug, and Sep/Oct/Nov, and also into monthly regional maps centered on specific large difference locations. The maps are 0.25-degree monthly averaged morning (ascending) minus evening (descending) QuikScat wind speed and vector difference maps. For each calendar day, both the morning and evening data had to exist and both had to be flagged as rain-free by the scatterometer rain flag. We then used the seasonal or monthly mean wind speeds to normalize the differences. This reduces wind speed differences found in the higher latitude ocean regions where strong synoptic fronts pass. In two years, we expect a maximum of 180 pairs for each cell in a seasonal map (30 days x 3 months x 2 years). Due to rain filtering, orbital precession, and the overwriting of data in byte-map production only a maximum of 148 was found for a given cell. Many regions contain far fewer difference pairs as shown in Fig. 1.

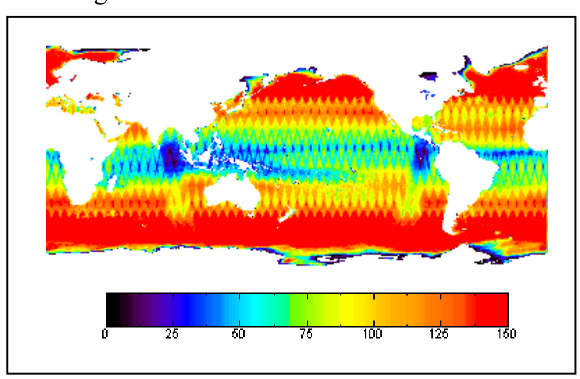

Figure 1. Sampling distribution of valid QuikScat morning/evening wind vector pairs for Dec/Jan/Feb. Fewer data exist in the tropical regions due removal of rain contaminated data and in the location of the two “seams” where the first and last pass of the day meet and data are overwritten.

DIURNAL WIND VARIATION

Analysis of the QuikScat data in the manner described above shows coastal regions where the wind speed varies greatly during the day throughout much of a season. Differences greater than 3 m/s with some higher than 8 m/s are found in select coastal regions, while little difference (<2 m/s) exists in most of the world's oceans. Most of the large difference regions agree with coastal locations where diurnal wind variations can occur. Two of the global seasonal maps produced are shown in Fig. 2. The color scale was designed to remove from view the noisy low differences. The main features of the Dec/Jan/Feb map are the large region of higher evening winds off the coast of Chile and the region of higher morning winds along the coast of Honduras. The Jun/Jul/Aug map shows higher evening wind located at Madagascar, Sri Lanka and Northwest Australia. We selected one region from each of these maps to describe in further detail. The Northwest Australia and Coastal Chile examples were selected because of their difference magnitude. Vector difference maps were also produced (not shown here) that show diurnal wind variations ringing many of the continental coasts.

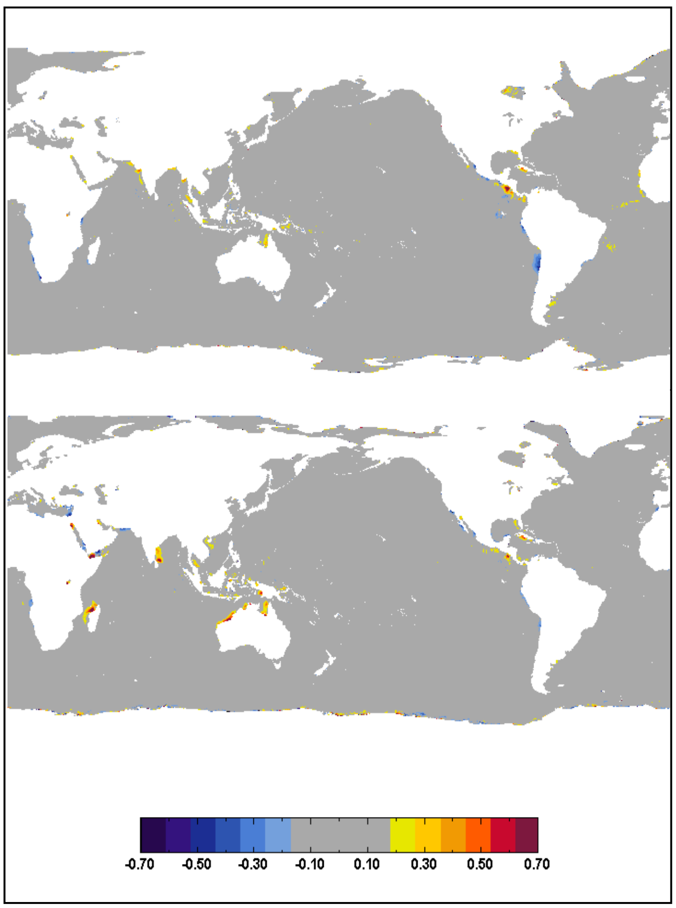

Figure 2. Global maps showing regions where the mean morning QuikScat wind speeds are either higher (reds) or lower (blues) than the mean evening wind speeds. To normalize the data, the wind speed difference for each 0.25-degree grid cell was divided by the seasonal mean wind speed for that cell.

NORTHWEST AUSTRALIA

In the northwest region of Australia the Great Sandy Desert borders Eighty Mile Beach from 117 to 122 degrees longitude at about –20 deg latitude. Two seasons exist here, a wet season extending from December to March with a northwesterly monsoonal flow and a moderately cool and very dry season extending from April to November with southeast trade winds. Comparison of monthly averaged morning and evening wind maps show distinct wind direction changes suggesting that afternoon sea breeze conditions are still observable at the 6pm satellite crossing time. Two patterns exist. In the wet season, the NW winds speed up slightly and turn towards the coast. In the dry season, the SE trade winds are slowed to calm (< 2 m/s) by the 6pm observations. This example is shown in Fig. 3, morning, evening and difference maps for August 2000. The averaged morning map shows a southeasterly, off-continent wind at approximately 7 m/s. The heating of the dessert during the day introduces the conditions for a local onshore sea breeze that serves to weaken the southeasterly wind right along the coast. This effect can be seen within 4 to 5 grid cells from the coast or a distance of approximately 100 km.

COASTAL CHILE

The west coast of South America is flanked by the Andes, mountains with elevations greater than 3000 meters. North winds blow nearly year-round with the maximum intensity region shifting north and south with the seasons. Fog frequently occurs along the Chilean coast. During January 2000, higher 6pm winds are found at distances greater than 200 km offshore as shown in Fig 4. Here, we see little change in the wind directions between the 6am and 6pm observations, unlike the northwest Australia example. The higher solar insolation occurring during the southern hemisphere summer months may cause the higher wind speeds. We propose that air-sea interaction processes along the Peru-Humboldt current produce the higher afternoon ocean surface winds observed by QuikScat during the southern summer season. The increase in wind speed difference has a yearly cycle as shown in Fig. 5. The wind speed differences for a nine grid cell region located at –28 degrees latitude and –72 degrees longitude were fit with a curve representing the first harmonic of the yearly cycle with an arbitrary phase.

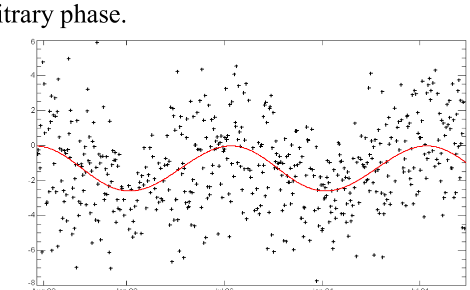

Figure 5. Time series of wind speed differences for a 3x3 cell region centered on –72.0 degrees longitude and –28.0 degrees latitude. The first harmonic of the yearly cycle with an arbitrary phase is shown in red.

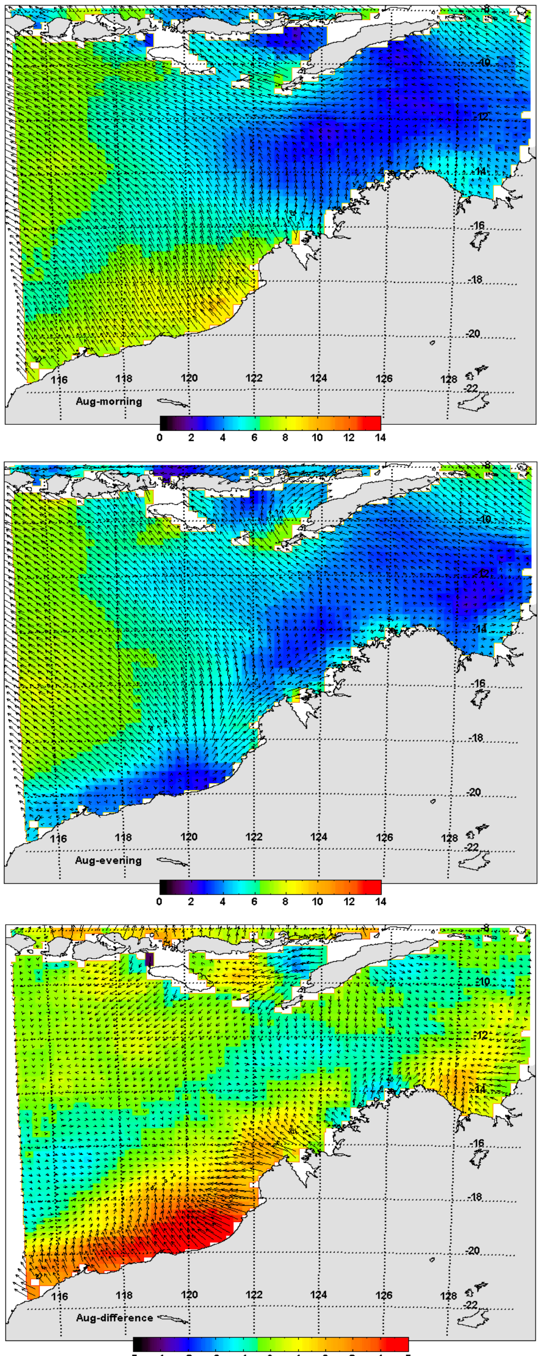

Figure 3. August 2000 averaged morning (top), and evening (middle) wind vectors (m/s) for the Eighty Mile Beach region of Northwest Australia. The morning minus evening wind vector differences (bottom) show the change in wind direction, from a SE trade in the morning to calm with some alongshore winds by evening.

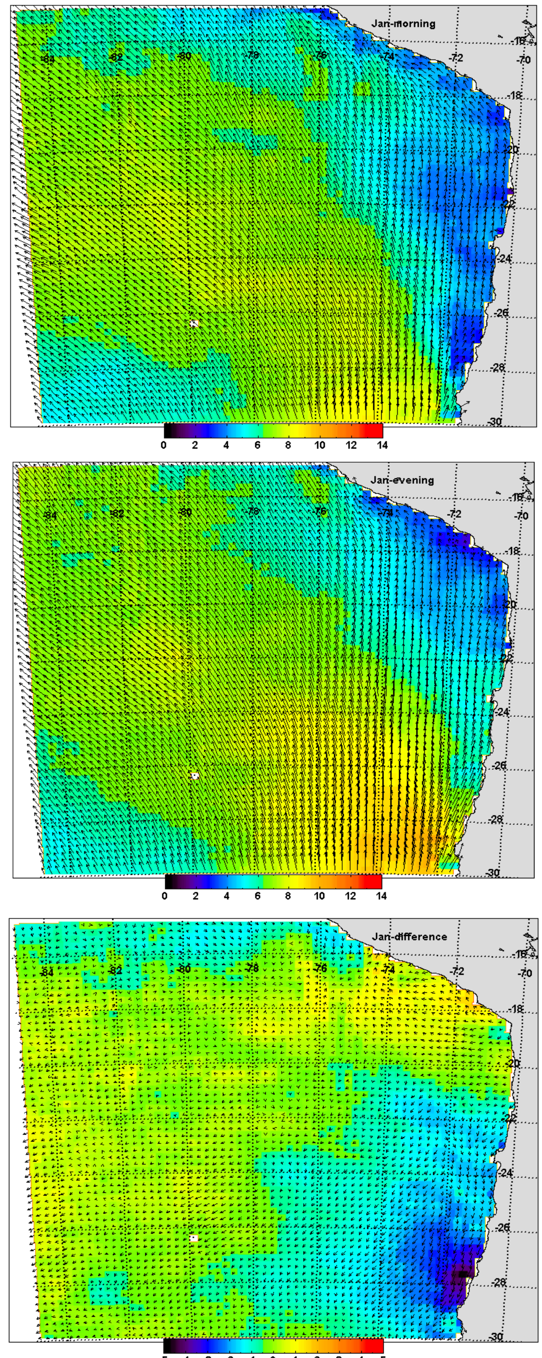

Figure 4. January 2000 averaged morning (top) and evening (middle) wind vectors (m/s) for Coastal Chile. Morning minus evening wind differences (bottom) show that while there are large wind speed differences overall, the wind direction does not change except just north of –30 degrees latitude where the wind turn towards the coast.

ACKNOWLEDGMENT

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