J10.5 MULTIPLE SATELLITE BLENDED SEA SURFACE WINDS AND THEIR APPLICATIONS TO OFFSHORE RENEWABLE ENERGY

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ABSTRACT

The wind pattern is one factor that determines the optimal siting locations of the wind/wave farms offshore. We have developed 6-hourly and 1/4-degree global sea surface wind climatology from decade long multiple satellite observations (http://www.ncdc.noaa.gov/oa/rsad/air-sea.html). This product has been used by several ocean energy researchers and consulting firms. Here we present the wind patterns in selected regions that are of interest to the ocean energy industry and seek feedback for product improvements. The close relationship between wind patterns and sea surface temperature fronts are also explored. This presentation seeks to promote collaboration among the ocean energy industry and government agencies that develop ocean observations and products.

1. Multi Satellite Blended and Gridded Sea Winds at 10 m above Sea Surface

Since July 1987, sea surface wind speed has been retrieved from satellites. Blended products from the cross-calibrated multiple satellite observations have the advantage of increased accuracy and resolution (Zhang et al 2006a,b and 2009). In particular, global 0.25-degree grid and 6-hourly 10-m wind products have been operationally produced and serviced by NOAA's National Climatic Data Center (NCDC). A version with enhanced quality controls is produced with a latency of one month; this version is more suited for climate study. A near-real-time (NRT) version is also produced for applications with near-real-time needs, such as NOAA Coral Reef Watch (http://coralreefwatch.noaa.gov/satellite/doldrums_v2/index.html).

NCDC archives and serves NOAA's satellite as well as in-situ data. Figure 1 shows the end-to-end process for its product development and services. After data were ingested into NCDC, quality control was performed. Then the data are blended to generate gridded products. The globally gridded products are served to the community through interactive data services, such as

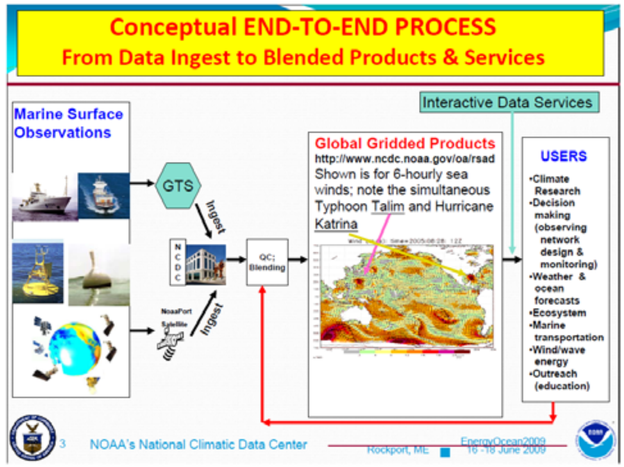

Figure 1 Conceptual diagram that shows the end-to-end process of the Blended Seawinds at NOAA NCDC.

through OPeNDAP and THREDDS, the Live Access Server (LAS), as well as traditional ftp. These interactive data services facilitate applications of the products.

In addition to the globally gridded 0.25° and 6-hourly, daily and monthly blended seawinds that are available since July 1987, climatological monthlies are also computed from 11-year's data, from 1995 to 2005. Note that wind is a vector parameter, thus the mean wind speeds computed from the vector average and scalar average are very different for the climatological monthlies, as shown in Figure 2. The strongest contrasts are in the mid-latitude bands as well as the equatorial Indian Ocean: less than 2 m/s in vector means and greater than 6 m/s in scalar means. Users are advised to use the appropriate means for their applications from our datasets (both are available). For example, for most physical oceanographic research, the vector means should be used. For offshore wind energy applications, the wind speeds from the scalar means may be more relevant.

For the global sea surface wind speed pattern from scalar means, the strongest winds are over the circumpolar region, with annual mean speeds over 10 m/s in a large portion of the area. The second strongest wind regions are over the subpolar Atlantic and Pacific, with annual mean speeds over 9 m/s.

For the global ocean surface vector mean patterns, the most persistent and strongest winds are the

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circumpolar winds over the Southern Ocean and the Trade Winds over the subtropics.

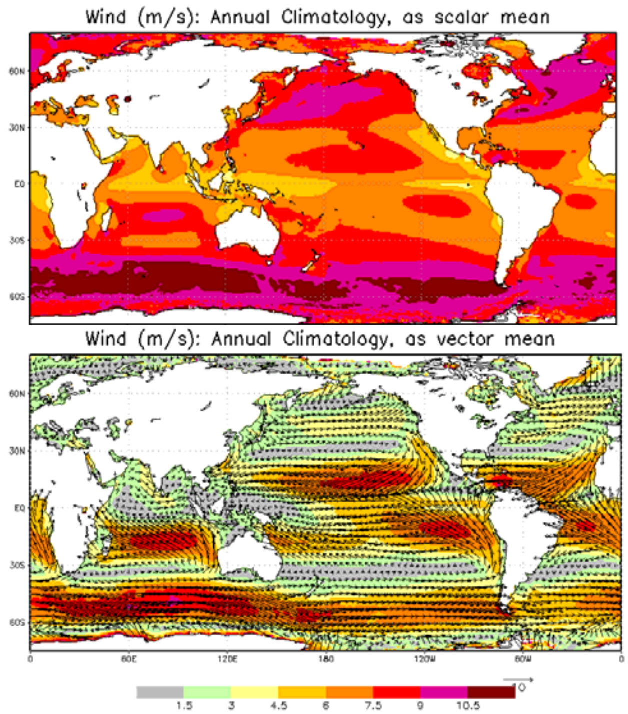

Figure 2 Climatological mean winds (1995 - 2005), showing the global and regional patterns and the differences of vector and scalar means for wind speed. Note that the two panels use the same color bar for the wind speed.

Figure 3 shows the climatological annual mean wind speed over the North Atlantic Ocean and Gulf of Mexico. The strongest, Greenland Tip Wind, is clearly shown. The next strongest winds (> 10 m/s) are over the Gulf Stream and the North Atlantic Current (shown by the cyan color line) as well as the subpolar front regions. These enhanced winds on the warm side of the strong SST fronts are more evident in the February map (not shown). These are the results of the positive feedback from ocean to the atmosphere, as have been discussed in numerous studies (Sweet et al 1981; Wallace et al 1989; Chelton et al 2004; Xie 2004; de Szoeke and Bretherton 2004). Near strong SST fronts, as cold air passes over warm water, enhanced vertical turbulent mixing deepens the boundary layer and mixes momentum downward from aloft, thus accelerating the surface winds. This is an example of the "two-way" exchanges of the coupled air-sea system. While the gyre-scale upper ocean currents were largely driven by the basin-scale windstress, the ocean feedback modifies the atmospheric winds.

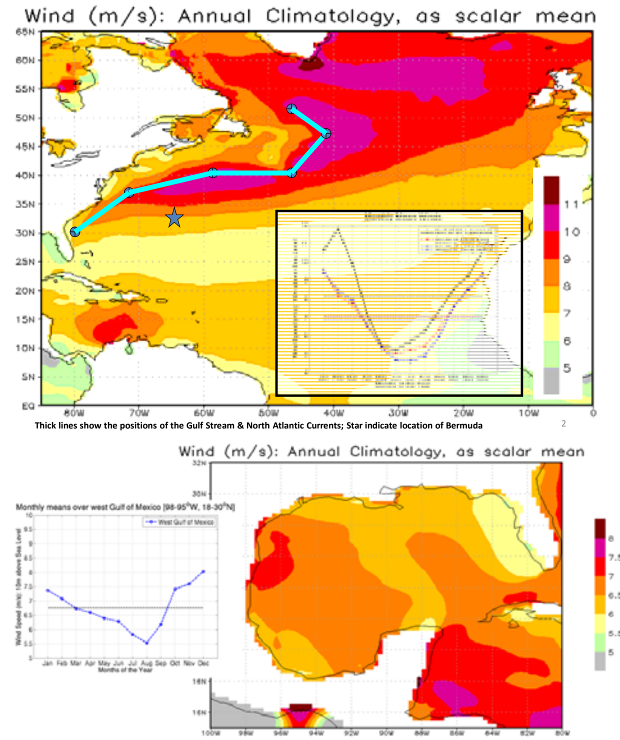

Figure 3 Wind patterns over the North Atlantic Ocean and Gulf of Mexico. Strongest winds are along the Gulf Stream, the Gulf Stream Extension and the North Atlantic Current. The insets show the seasonal variations over selected regions: Gulf of St. Lawrence, south of Cape Cod, and south of Long Island, NY (upper panel), and western Gulf of Mexico (lower panel).

2. Conversion of 10-m Winds to Offshore Wind Turbine Heights

The above-described NCDC Blended Seawinds are neutral winds at 10 m above sea surface. However, offshore wind turbines are placed high above 10 meters. An assessment against in situ measurements indicated that the Blended Seawinds are overestimating the higher wind speeds. Correction factors have been developed and can be applied to the blended data from NCDC. Furthermore, the corrected Seawinds dataset has been used as a starting point for wind speeds and directions at 10 m height and then an algorithm was developed to interpolate wind speeds and directions at the offshore wind turbine hub heights of 50 m, 70 m and 90 m. Boundary layer physics are taken into account, such as turbulence from surface roughness and the Ekman spiral. This is necessary to give an accurate power output assessment. The converted turbine-height winds were validated by an external certification body, and around 94% correlation with mast measurements for monthly mean wind speeds and 98% correlation with yearly means have been consistently achieved at hub heights of 50, 70 and 90m.

Under development is a “weather windows” product which will use Seawinds data combined with wave data. This will be a statistical analysis piece of software that will analyze the historical wind/wave conditions at a particular offshore location in combination with certain offshore operation parameters. This provides a planning tool to identify the best times of the year to schedule offshore installation and maintenance operations.

The UK is a world leader in offshore wind energy, having 600 MW in operational wind farms, 1250 MW under construction and a further 3600 MW approved. The Seawinds database was used as a baseline and calibrated accordingly to improve accuracy at hub height. Using this dataset we were able to determine differences in the expected turbine output at different points in the North Sea. We found that within single development zones there was up to 14% difference in the expected power output, depending on where the turbines are sited. The scale of the coastal effect resulting from the surface roughness over the land was surprising since the zones are many tens of miles offshore. This is a significant find as it may mean the difference between a viable and non-viable project, and may affect the choice of turbines and heavily influence the siting of the turbines.

3. Data Access

More detailed data descriptions and accesses of the NCDC Blended Seawinds can be found through the links at the NCDC Website: http://www.ncdc.noaa.gov/oa/satellite.html, then click on your desired products. Most of the datasets are accessible by multiple methods, including ftp, OPeNDAP/TDS, and interactive graphic interface such as Live Access Server (LAS), from which one can do subsetting and downloading in one’s desired formats (e.g., ascii/text, images, netCDF, IEEE binary, arcGIS, etc).

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