SSMI WIND SPEED MEASUREMENTS OVER THE SOUTHERN HEMISPHERE OCEANS

David Halpern

Earth and Space Sciences Division
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109, U.S.A.

1. INTRODUCTION

Long time series of monthly mean wind speed distributions, which cover the global ocean or an entire ocean basin, are becoming *de rigueur* for studies of the seasonal cycle and year to year variations. That *in situ* surface wind data are very sparsely sampled in space and time over most of the global ocean, especially south of 20°N, dictates a need to use measurements from satellite-borne instrumentation. The January 1988 to December 1991 mean and monthly variations of surface wind speed over the Southern Hemisphere (SH) are described from satellite measurements.

A Hughes Aircraft 7-channel, 4-frequency, linearly-polarized, passive microwave radiometer, called the Special Sensor Microwave Imager (SSMI), was launched on 19 June 1987 on the U.S. Air Force Defense Meteorological Satellite Program (DMSP) spacecraft F8. A second SSMI was launched on the DMSP spacecraft F10 on 1 December 1990, but only F8 SSMI data are used in this paper. Intensity of microwave radiation emitted at the ocean surface is affected by roughness of the sea surface, which is correlated with the 10-m height wind speed. The Remote Sensing Systems, Santa Rosa, California, routinely process 25-km x 25-km areal averaged SSMI 37-GHz radiances into 10-m height wind speed (Wentz, 1989, 1991), S_{10}, which are available from the NASA Ocean Data System (Halpern, 1991).

All 25-km x 25-km S_{10} values located within nonoverlapping 1/3° x 1/3° squares were arithmetically averaged each day. Just slightly more than 3 seconds are required for the spacecraft to fly 25 km in the along track direction. Coverage of 1/3° x 1/3° S_{10} data over the global ocean between about 65°S and 65°N is nearly complete every 3 days (Halpern *et al., 1992).* Most 1/3° x 1/3° areas contained about 2 SSMI wind measurements per day.

The accuracy of monthly mean 1/3° x 1/3° S_{10} data was determined (Halpern, 1992) by comparisons with moored-buoy wind measurements during January 1988 to December 1989. Results for 1988 were virtually identical with that of 1989. The root-mean-square difference of 697 monthly mean matchups of the composite 1988 and 1989 data set was 1.2 m s^{-1}. In low latitudes the rms difference was 0.9 m s^{-1}; in middle latitudes the rms difference was 1.3 m s^{-1}. For monthly SSMI standard deviations of 1-2, 2-3, and 3-4 m s^{-1}, the average absolute values of the monthly mean difference between SSMI and moored-buoy wind speeds were 0.6, 0.9, and 1.4 m s^{-1}, respectively.

All 1/3° x 1/3° monthly mean S_{10} data were averaged within nonoverlapping 2.5° x 2.5° areas.

2. ANNUAL MEAN WIND SPEED

The geographical distribution of the 1988-1991 mean wind speed over the global ocean is shown in Figure 1, which also outlines the arbitrary boundaries of the world ocean used in this study. The 4-year mean global features of the SSMI data were similar to the climatological-mean annual wind speed estimated from ship reports (Esbensen and Kushnir, 1981; Hsiung, 1986). Southward of 40°S, where Hsiung (1986) did not show results because of lack of suitable measurements and where Esbensen and Kushnir (1981) showed tentative results for the same reason, the SSMI indicated many areas with wind speeds greater than 11 m s^{-1}, which was 10% greater than that of Esbensen and Kushnir (1981). Along the Pacific equator the mean wind speed was maximum at 6-7 m s^{-1} from 155°W to 140°W, and decreased towards the east and west by 2 - 3 m s^{-1}. This pattern was different than that along the equator in the Atlantic and Indian oceans, where wind speeds were nearly uniform along the equator.

The latitude band of the 4-year minimum longitudinally averaged wind speed (≈ 5.0 m s^{-1}) was 2.5°S -0° (Figure 2). The zonally averaged wind speed along the equator was least in 1991, an El Niño year, and largest in 1988, a La Niña year. The range of wind speeds along the Pacific equator was equal to the mean during El Niño and La Niña episodes. Throughout 35°S to 35°N the meridional profile of the zonally averaged wind speed was virtually symmetrical about the equator. The maximum zonal averaged wind speed was nearly 1.3 m s^{-1} greater in the SH than in the Northern Hemisphere (NH). A smaller amount of interannual variability was associated with the SH maximum than the corresponding NH value.

3. MONTHLY VARIATIONS

Time series of area-weighted 60°S -0° monthly mean wind speeds indicated that the South Indian had the largest wind speeds throughout the year (Figure 3); minimum speeds generally occurred in the South Pacific. The 4-year SH area-weighted 60°S -0° mean (± standard deviation) wind speed was 7.5 ± 0.55 m s⁻¹. The 4-year area-weighted 60°S -0° mean wind speeds over the South Pacific, South Atlantic, and South Indian oceans were 7.3 ± 0.43, 7.64 0.63, and 8.2 ± 0.76 m s-', respectively. The Student's *t* lest (Press *et* al., 1986) showed that the differences between the mean values over the 60°S -0° Pacific, Atlantic, and Indian were significantly different at the 95% confidence level. The monthly mean values displayed an annual cycle for each region (Figure 3). The *F* test (Jenkins and Watt, 1968) indicated that the standard deviations were significantly different at the 95% confidence level.

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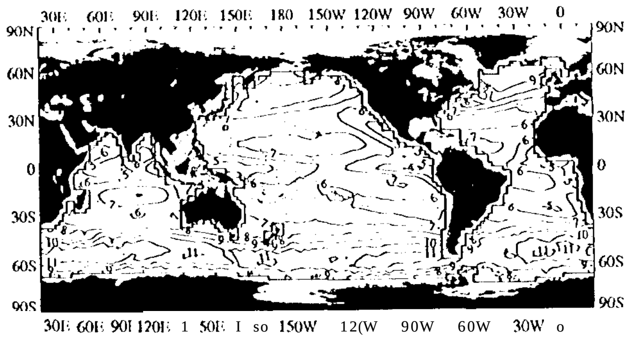

Figure 1. Distribution of 4 -year mean SSMI surface wind speed (m s^{-1}) during January 1988 to December 1991.

Figure 3. Time series of area-weighted 60°S -0° monthly mean SSMI surface. wind speeds for the Southern Hemisphere and for each ocean basin within the Southern Hemisphere. The boundaries of the Pacific Ocean arc shown in Figure 1.

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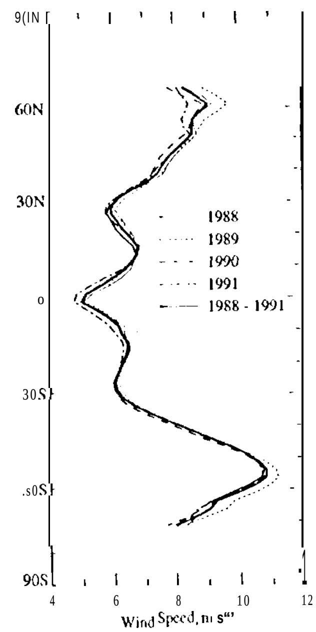

Figure 2. North-south distribution of 4-year mean and annual mean values of zonally averaged SSMI wind speed .