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Scalar Winds from SSM/I in the Norwegian and Greenland Seas During Norcsex

Per Gloersen and Paul Hubanks

Abstract

Data acquired with the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) during the Norwegian Coastal Sea Experiment (NORCSEX) in March 1988 have been utilized to estimate scalar winds was first developed for the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) in order to investigate scalar winds during Polar Lows Experiment in February 1984; the coefficients in this algorithm have been tuned to accommodate differences in the SSM/I and SMMR instruments.

crowave radiance is commonly given in units of degrees kelvin and referred to as brightness temperature. The radiance also depends linearly on the emissivity of the radiating surface. For calm seas, the emissivities are typically about 0.5 and 0.2 for the vertically and horizontally polarized channels, respectively (Gloersen and Barath, 1977). When subjected to wind stress, the reflectivity of the oceanic surface decreases from its specular, calm seas value due to the formation of waves and whitecaps. Therefore, the emissivity of a wind-swept ocean increases, resulting in a nonlinear increase in radiance from the ocean with increasing near-surface wind (Hollinger, 1971; Webster et al., 1976). The horizontally polarized radiance increases at a higher rate than the vertically polarized (Gloersen and Barath, 1977).

Estimation of scalar near-surface oceanic winds from observations of microwave radiances is complicated by atmospheric interference arising from fluctuations in atmospheric water vapor and cloud water content. It is further complicated by variations in the ocean surface temperature in two ways, by the direct dependence mentioned earlier and by a temperature dependence on the onset of whitecapping (Monahan and O'Muircheartaigh, 1986). All of these complications are minimized by restricting these estimations to polar waters, where the ranges of sea surface temperature and the atmospheric water vapor are small. Variation in cloud water content is also generally smaller in the polar regions, but must be taken into account when estimating winds.

FUNCTIONAL FORM OF THE ALGORITHM

In order to minimize further the dependence of wind estimation from microwave radiance on oceanic surface temperature, the microwave polarization, defined as the ratio of the difference of the vertically and horizontally polarized radiances at a given wavelength and their sum, is used as the independent variable. In this way, the effect of sea surface temperature is eliminated to first order. As has been shown previously (Gloersen et al., 1989), this approach has the additional advantage of a linear relationship between the oceanic scalar winds and the observed polarization. Either the polarization at the 0.8 or 1.55 cm wavelength could be used for these estimates, but the longer of the two is less subject to interference from clouds and is therefore selected. Since the sensitivity of polarization to wind is about the same at either wavelength, but not the same for cloud water, the difference in the polarizations at the two wavelengths is used to detect cloud water amount.

Defining the polarization at 1.55 cm as PR and the difference in the polarizations at 0.8 and 1.55 cm as DP, estimates of the near-surface scalar winds, W, and cloud liquid water amount, L, are obtained as follows:

$$W = W_1 * (PR - W_0) + W_2 * (DP - L_0) \quad \text{(knots)} \quad (1)$$

$$L = L_1 * (PR - W_0) + L_2 * (DP - L_0) \quad \text{(cm)} \quad (2)$$

where, tentatively,

$W_0 = 0.242$ $L_0 = 0.056$
$W_1 = -806.4$ $L_1 = -0.217$
$W_2 = -618.3$ $L_2 = 0.499$

The above coefficients are the same as those for SMMR (Gloersen et al., 1989). The justification for tentatively using this set of coefficients is that when overlapping data from SMMR and SSM/I during July-August 1987 were compared on a DP, PR scatter diagram, the points were found to fall in essentially the same area and with similar patterns. Ultimately, the same statistical procedure used to obtain the SMMR coefficients by comparison of SSM/I data with in situ data (Gloersen et al., 1989) will be used to obtain refined coefficients for SSM/I.

ILLUSTRATIONS OF SURFACE WIND AND CLOUD WATER ESTIMATES FROM SMMR

In lieu of SSM/I images from NORCSEX which are not available as of this writing, we show in Figures 1-2 grid-print maps of near-surface oceanic scalar winds and cloud liquid water content in the Norwegian, Greenland, and Barents Seas for the ascending nodal pass of the SMMR on 27 February 1984, which occurs at approximately 1000 GMT. The polar low observed at 69°N and 3°W by Shapiro et al. (1987) can be seen as well in Figures 1 and 2 at the same location. In both figures, the '*' points to the center of the storm, located near the edge of the SMMR orbital swath. (The wedge-shaped data gap is the space between adjacent swaths.) Winds ranging from 30-70 knots can be seen in this vicinity. An area of strong wind extends all the way from the sea ice edge near Greenland to the coast of Norway. This is a marked change from the situation 9 hours earlier when the winds were generally weaker. The cloud patterns (Figure 2) are in the form of circular bands to the east of the storm center, with one band just off the coast of Norway and another about 300 Km to the west. They are approximately centered on the polar low.

SUMMARY

Multispectral microwave radiances obtained from the SSM/I have been compared to SMMR data during a period when both instruments were in operation. As a result, it was found that the algorithm coefficients for the SMMR would serve as a satisfactory initial set of coefficients for SSM/I. An example of a polar low observed with the SMMR is shown to illustrate the technique. SSM/I data showing two high wind events during NORCSEX will be described at the IGARSS'89 symposium.