1.6 ACTIVE-PASSIVE MICROWAVE REMOTE SENSING WITH SEAWINDS AND AMSR

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1. INTRODUCTION

The Japanese Earth science spacecraft Midori-II operated from December 2002 through October 2003, at which point the satellite suffered a catastrophic failure. Although the mission was short lived, the unique combination of an active microwave scatterometer (SeaWinds) and a passive microwave radiometer (AMSR) is providing important information on the benefits of active-passive microwave remote sensing.

The first spacecraft to fly both a microwave scatterometer and radiometer was SeaSat in 1978 (Born et al., 1978). In spite of an aborted mission (only 3 months) and sensor calibration problems, SeaSat provided the foundation for active-passive remote sensing. Unfortunately, we had to wait 24 years for the next scatterometer/radiometer joint mission: Midori-II. The microwave sensors on Midori-II are much improved over those on SeaSat and are providing the means to study in detail the physical processes that mutually affect both active and passive measurements.

There are many important synergisms obtained by combining the active and passive microwave observations. Here we investigate three: 1) precise rain flagging along with a rain correction for the scatterometer vector winds; 2) sea-surface temperature (SST) retrievals that are relatively free of errors due to wind speed and direction, and 3) overall improvement in wind vector retrieval accuracy.

We have developed retrieval algorithms that make full use of these synergisms. Over the world's oceans, these algorithms produce simultaneous imagery of the sea-surface temperature and vector wind (through clouds), as well as atmospheric temperature and moisture (vapor, cloud, rain) to an accuracy previously unattainable.

In addition to the geophysical retrievals, the Midori-II observations are allowing us to improve our knowledge of the dependence of sea-surface emissivity on wind speed and direction and on sea surface temperature.

2. RAIN CORRECTION OF VECTOR WINDS

Rain affects scatterometer measurements in three ways. It attenuates the radar signal as it goes from the spacecraft to the Earth surface and then back to the satellite. This two-way attenuation has the effect of decreasing the return signal. The second effect is raindrops scattering the transmitted signal back to the satellite before the signal reaches the surface. This backscattering from raindrops increases the radar return. The third effect is the sea-surface roughness being modified by the rain hitting the ocean surface. This splash effect can either increase or decrease the return signal, depending on wind speed. A simple physical model is used to characterize these three effects and the model is tuned using combined SeaWinds/AMSR observations.

The rain model is used operationally to correct the scatterometer measurements given the coincident rain rate derived from AMSR. Figure 1 shows the vector wind field for a portion of a Midori-II orbit that passes over a tropical rainfall system. The figure shows the vector wind field before and after applying the rain correction. The AMSR-derived rain field and the NCEP wind field are also shown for reference. For this case, the primary correction is to reduce the winds that are spuriously high due to the backscattering that is occurring in areas of heavy rain.

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3. COMPARISON OF ACTIVE AND PASSIVE WIND SPEED RETRIEVALS

A necessary condition for combining SeaWinds and AMSR observations is that the wind speed retrievals from SeaWinds be consistent with those from AMSR. To verify this consistency, we compare the SeaWinds and AMSR winds in several ways. Statistics are accumulated for collocated scatterometer and radiometer footprints at a resolution of 25 km. For these individual retrievals the rms difference is 0.78 m/s. Monthly wind maps from SeaWinds and AMSR are also compared to locate regional biases. Except for a few isolated areas, regional biases are less than 0.5 m/s. Case studies are also done in which the SeaWinds and AMSR wind fields are visually compared. Figure 2 shows Midori-2 passing over a storm approaching North California. There is obviously a high correlation between the SeaWinds and AMSR wind fields. Both sensors are able to delineate the areas of very low winds near Vancouver Island and around 25°N. In the Trades (8°N to 16°N), the AMSR winds are somewhat higher that SeaWinds, possibly due to fetch effects. In areas of rain, both SeaWinds and AMSR are biased high relative to the NCEP winds. This is most likely due to rain corrupting the retrievals. (For this case, we did not apply a rain correction to SeaWinds.)

4. IMPROVED SST RETRIEVALS

One of the major sources of error in microwave SST retrievals can be wind speed and wind direction. In general, a well-designed retrieval algorithm can compensate for the wind speed effect by using information contained in the polarization signature of the observations. However, the removal of the influence of wind-direction is a more difficult task given just the passive observations.

The addition of a microwave scatterometer provides the ancillary information on wind direction that is needed to correct the SST retrievals. To develop an algorithm for doing the wind-direction correction, we first plotted the SST error (AMSR minus Reynolds SST) versus the relative wind direction obtained from SeaWinds. This error is related to the directional characteristics of the sea-surface emissivity model. The directional emissivity model is tuned to agree with the observations, and the AMSR data are reprocessed, this time using SeaWinds wind direction as ancillary information. Statistics on the improved performance are compiled.

5. CONCLUSIONS

Midori-2 SeaWinds/AMSR provides us with a unique opportunity to clearly demonstrate the advantages of active-passive microwave remote sensing. We find that the rain information coming from AMSR can be used to both flag and correct the SeaWinds vector winds. The active and passive winds speeds are in very close agreement. Individual wind retrievals show a 0.78 m/s rms difference, and regional biasing is less that 0.5 m/s. The passive winds are more sensitive to rain than the active retrievals. Finally, the ancillary information on wind direction provided by SeaWinds improves the AMSR SST retrievals

6. REFERENCES

Borne, G. H., J. A. Dunne, and D. B. Lame: SeaSat Mission Overview. *Science*, **204**, 1405-1406.

7. ACKNOWLEDGMENTS

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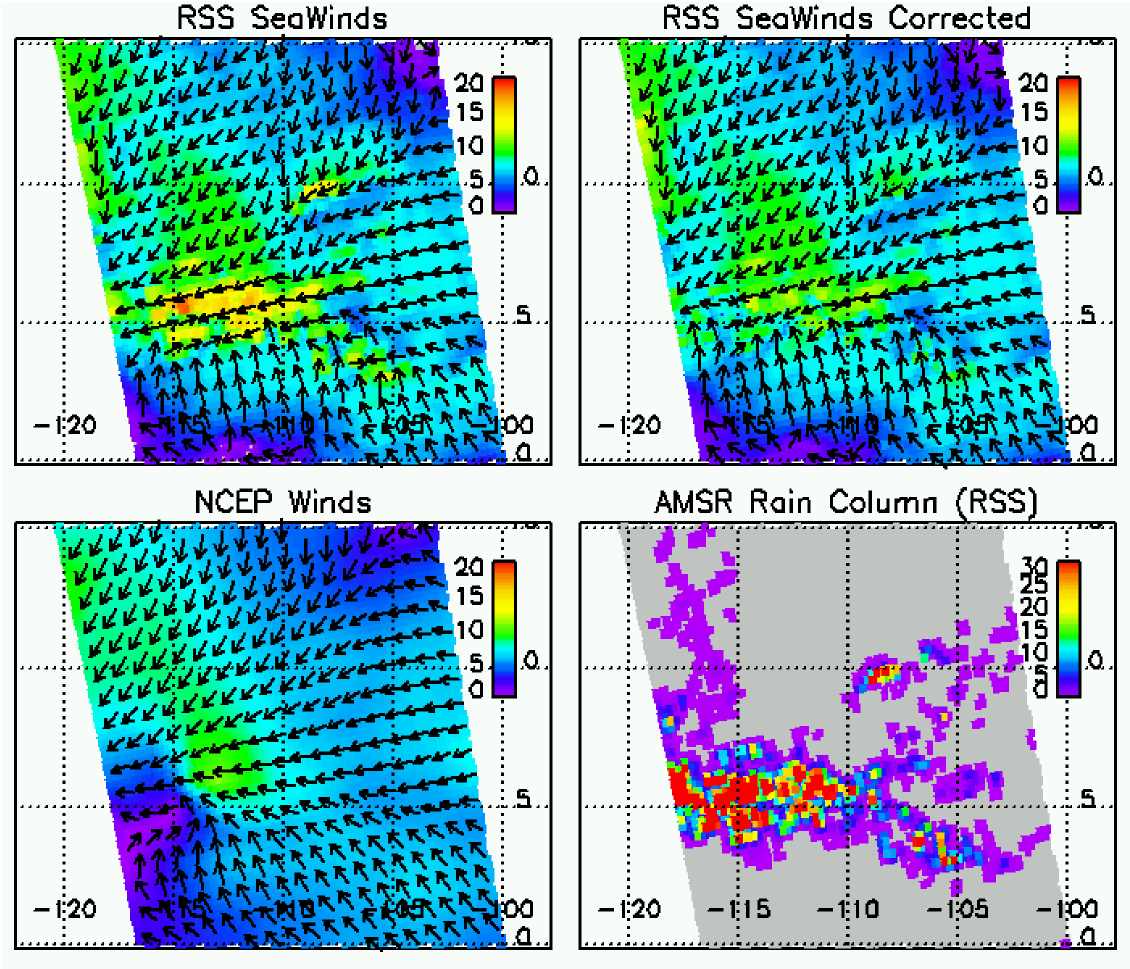

Figure 1. A Midori-II orbit that passes over a tropical rainfall system. The upper two panels show the SeaWinds vector wind retrievals. The upper left panel is before applying the AMSR rain correction, and the right panel shows the results after applying the correction. The lower left panel shows the corresponding NCEP wind field. The background color for these three panels indicates wind speed going from 0 to 20 m/s. The lower right panel shows the AMSR rain retrievals. In this case the background color indicates columnar rain rate (rain rate times rain column height) going from 0 to 30 km mm/hr.

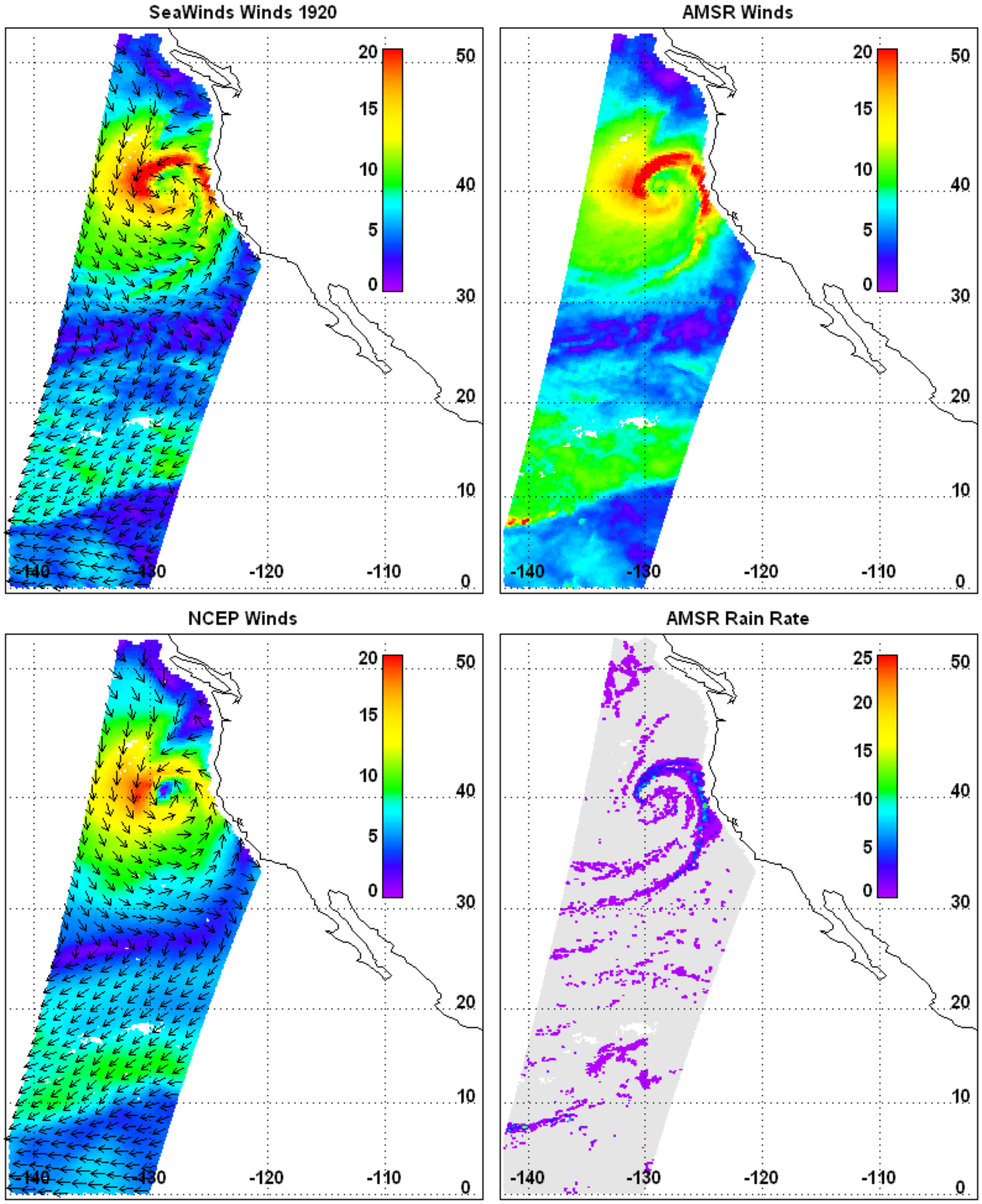

Figure 2. A Midori-II orbit that passes over a storm moving into Northern California. The upper two panels show the SeaWinds vector wind retrievals (left) and the AMSR wind speed (right). The lower left panel shows the corresponding NCEP wind field. The background color for these three panels indicates wind speed going from 0 to 20 m/s. The lower right panel shows the AMSR rain retrievals. In this case the background color indicates rain rate going from 0 to 25 mm/hr.