P3.5

AREA RAIN FLAGGING: WHAT IS IT AND WHY IS IT NECESSARY WHEN USING SATELLITE MICROWAVE DATA?

Deborah K. Smith*, Kyle Hilburn and Frank J. Wentz
Remote Sensing Systems, Santa Rosa, CA

1. DISCOVER DATA

The DISCOVER Project (Distributed Information Services for Climate and Ocean products and Visualizations for Earth Research) is a NASA funded Earth Science REASoN project that provides highly accurate, carefully calibrated, long-term microwave climate data records and near-real-time ocean products suitable for the most demanding Earth research applications via easy-to-use display and data access tools. We provide sea surface temperatures, surface wind speeds, columnar water vapor, cloud liquid water content, and rain rates from satellite microwave radiometers for use in operational and climate research.

Currently, more than 20 years of data are available (1987 to 2009) from a series of more than ten radiometers, all intercalibrated to a brightness temperature precision of 0.1K. The process removes small intersatellite offsets and instrumental drifts and leads to data products that agree over time and between different instruments. By applying uniform algorithms and consistent processing techniques to all SSM/I, TMI and AMSR-E observations we have obtained ocean products best suited for climate study. For more information on algorithms and dataset improvements, see Wentz, et al. (2007) and Hilburn et al. (2008a).

2. HOW SHOULD ONE USE DISCOVER DATA?

DISCOVER data are produced for many types of users, therefore, to use the DISCOVER data for climate studies (especially for climate change and trend studies), it is necessary to follow these guidelines:

- Begin with daily data. The monthly averaged data provided by DISCOVER have some rain included in order to have data in persistent rainy areas. Also, the monthly average data have no threshold for the number of counts per cell per month, which contributes to errors – especially for highly variable parameters like rain.
- Area rain flag the data. The radiometer footprint is larger than the 0.25 deg grid cell and therefore can be affected by nearby rain. Removal is necessary for climate study.
- Extend land and ice buffers. Instrument side lobes and reduced sampling along boundaries result in poorer quality data at land and ice edges. For best quality, omit cells next to land and ice.
- Do not use F15 SSM/I data past August 2006 - A radcal beacon was turned on during August 2006 that produces a 10K mean brightness temperature offset for the 22GHz F15 SSM/I observations as described in Hilburn (2008b). We have implemented a simple correction that is acceptable for weather and visualization purposes, but is unsuitable for climate studies. This is because the RADCAL interference varies in time due to thermal effects.
- Apply adjustments to rain. As described in Hilburn (2008a), an adjustment is needed to account for time-of-day effects and other inter-satellite discrepancies.
- Apply adjustments to wind. As described in Wentz (2007, see the supplementary online material), characteristic biases were found between radiometer winds and buoy winds. One small (0.1-0.5 m/s) yearly correction is applied to SSM/I data to bring the winds into better agreement with the buoys. This process also brings the SSM/I and scatterometer winds into better agreement.

Of these guidelines, we describe in this document the process of area rain flagging in more detail as it is crucial for climate wind analyses using satellite microwave data and is often the most common error-causing step omitted by users of microwave data.

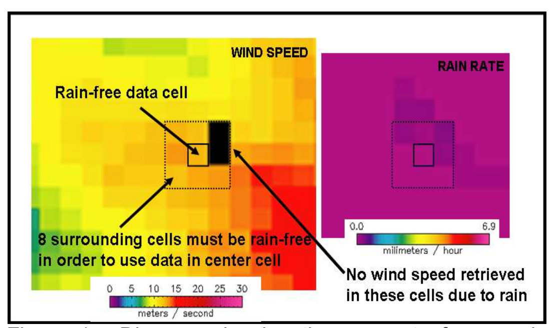

Figure 1. Diagram showing the concept of area rain flagging. SSM/I wind speed is shown greatly magnified on the left, with the rain rate for the same region shown on the right. Note that several of the nearby cells show rain, though the center cell is rain-free.

* *Corresponding author address*: Deborah K. Smith, Remote Sensing Systems, 438 First St., Suite 200, Santa Rosa, CA 95401; e-mail: smith@remss.com.

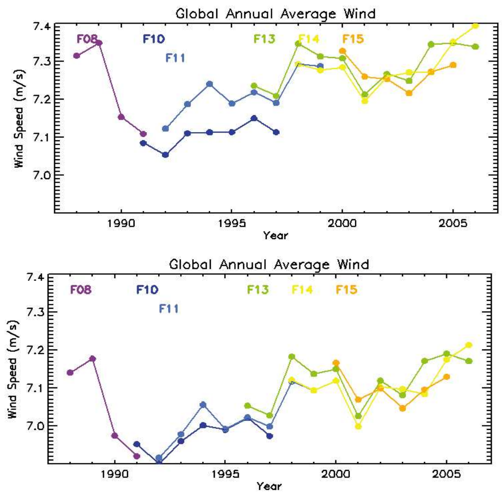

Figure 2. Global annual average wind speed for each SSM/I instrument without rain flagging (top) and with area rain flagging (bottom) for 20-years of successive instrument operation.

3. WHAT IS AREA RAIN FLAGGING?

The concept of area rain flagging is shown in Figure 1. All DISCOVER microwave ocean products are mapped to a 0.25 degree grid. To area rain flag, one should check all cells encircling the center data cell and omit the center cell from analysis if there is rain in any of the surrounding cells. This process is necessary as nearby rain can result in the rain climate signal aliasing into the wind signal and creating spurious trends in global and regional wind patterns. Figure 2 shows the effect rain can have. The two figures contain global annual average wind speeds for each SSM/I instrument over time, one calculated without rain flagging (top) and one calculated using the area rain flagging (bottom). Note the improvement in agreement of wind speeds between instruments when using the area rain flagging technique.

There are several reasons why nearby rain can affect retrievals for a given cell, including rain features that move in the time difference between two different instrument observations, the presence of a very wet cloud that is really rain, or the rain affecting the side lobe portion of the antenna pattern.

4. WHY USE AREA RAIN FLAGGING?

Rain affects both radiometer and scatterometer ocean surface wind data, causing higher winds to be retrieved for most wind speed ranges. Using area rain flagging to remove the influence of nearby rain reduces the mean wind speed obtained from the instrument. In Figure 2, the global annual wind speed average decreased from approximately 7.3 m/s to 7.1 m/s when area rain flagging is used to remove data cells affected by nearby rain.

Maps of mean wind speeds look very similar to the eye, but distinct differences exist. Figure 3 shows a set of two wind speed difference maps. Each plot is the difference of the mean wind speed for 2005 minus the mean wind speed calculated when using the area rain flag technique. The SSM/I F13 difference is on top, QuikScat difference on the bottom. Mean wind speeds more than 1 m/s in error are obtained from both instruments. While the process of area-rain flagging reduces the number of data in regions of persistent rain, it is a necessary step as seen in these plots. In particular, note the decrease in wind speeds in higher latitude storm belt regions and in tropical rain band areas.

Note that in regions of lower wind speeds and persistent rain, scatterometer winds can be elevated by greater than 2 m/s on average. This is because the Ku-band instrument has severely (up to 10 m/s) overestimated winds at low (<8 m/s) wind speeds.

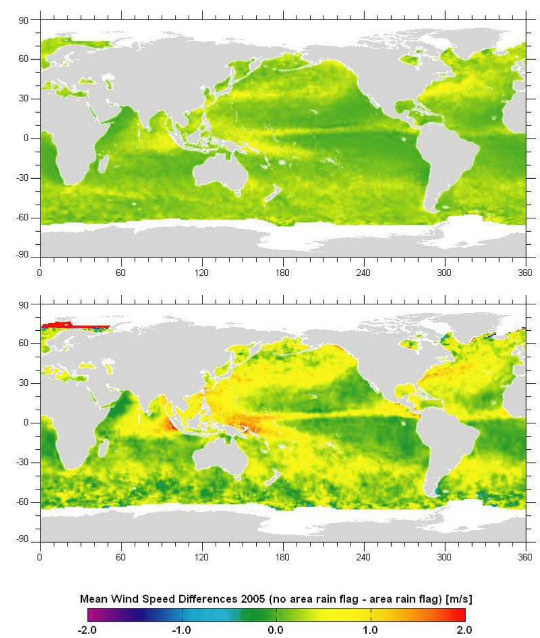

Figure 3. 2005 Annual mean wind speed difference maps for SSM/I (top) and QuikScat (bottom) showing effect of nearby rain on derived winds. Scatterometer data are more greatly affected by rain.

Though it may look like Figure 3 implies that the scatterometer is more affected by rain, this is not necessarily the case for two reasons. First, much rain is already removed from the radiometer data (in that we do not retrieve a wind when rain in present) and both wind and rain are derived from the radiometer at the same time, so nearby rain does not have as much effect. Secondly, the scatterometer geophysical model function retrieves a vector wind no matter what the rain conditions. We then use collocated radiometer data to remove rain affected winds in calculating our mean winds. The time difference (usually up to 30 minutes) between the radiometer and scatterometer data allow for storm movement into the center cell from nearby cells. For this reason, a greater improvement results from area rain flagging the scatterometer data.

5. ACKNOWLEDMENTS

DISCOVER data are produced by Remote Sensing Systems and are sponsored by the NASA Earth Science REASoN DISCOVER Project. Visit www.discover-earth.org for data access. Continued funding under the NASA MEaSUREs Project begins in April 2009

6. REFERENCES

K. A. Hilburn and F. J. Wentz, 2008a: "Intercalibrated passive microwave rain products from the unified microwave ocean retrieval algorithm (UMORA)," Journal of Applied Meteorology and Climatology, 47, 778-794.

K. A. Hilburn and F. J. Wentz, 2008b: "Mitigating the impact of RADCAL beacon contamination on F15 SSM/I ocean retrievals," Geophysical Research Letters, 35, L18806, doi:10.1029/2008GL034914.

F. J. Wentz, L. Ricciardulli, K. A. Hilburn, and C. A. Mears, 2007: "How much more rain will global warming bring?," Science , 317, 233-235, 2007. Supplementary online material available at www.remss.com.