Area Rain Flagging: What is it and Why is it Necessary when using Satellite Microwave Data?

DISCOVER
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Deborah K. Smith , Kyle Hilburn, Frank J. Wentz
Remote Sensing Systems, Santa Rosa, CA
smith@remss.com

What is Needed to Make a Climate Product?

- Careful intercalibration of brightness temperatures
- Uniform algorithms and consistency in processing
- Full data set reprocessing to incorporate important changes
- Checks of global consistency over time

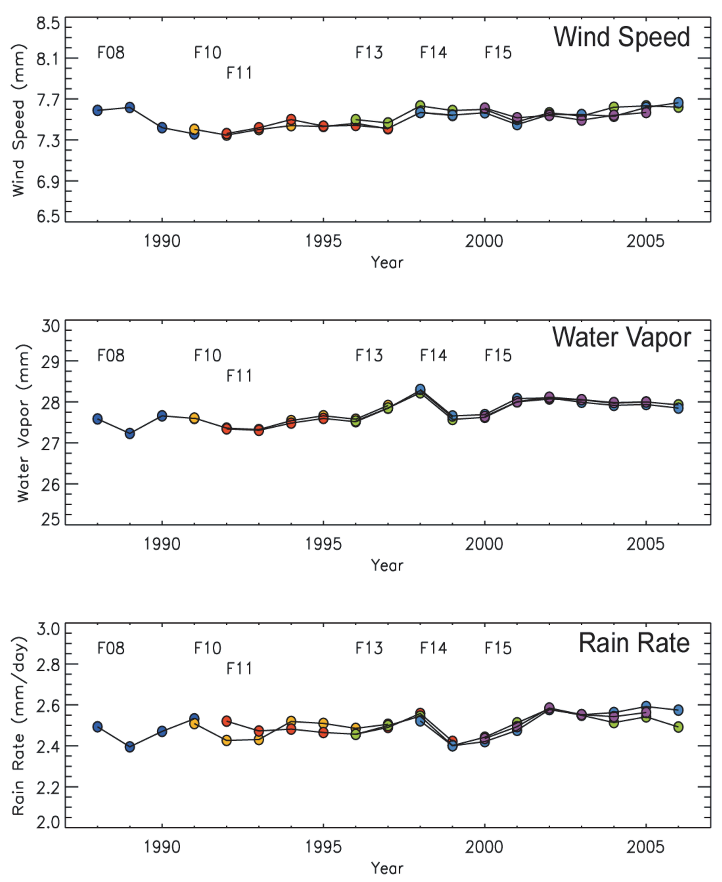

Figure 1. DISCOVER SSM/I wind speed, water vapor, and rain rate from 6 instruments spanning 20 years. Agreement between instruments is less than 0.06 m/s, 0.01 mm and 0.2 mm/day for each.

DISCOVER is a NASA funded project that provides carefully calibrated, long-term, climate quality ocean data products to the scientific community. These products include ocean surface winds, atmospheric water vapor, cloud liquid water, rain rates, and sea surface temperatures. These data products can be confidently used to study the hydrologic cycle or global ocean weather patterns over the more than 20-years of satellite radiometers (1987 to 2008).

DISCOVER data have been carefully inter-calibrated at the brightness temperature level to a precision of 0.1 K. This 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. The plots of wind speed, water vapor and rain rate in Figure 1 show the agreement between all SSM/I instruments over time.

To create the time series, time-of-day effects for each satellite were removed using diurnal offsets determined using TMI data. The diurnal corrections applied are available from support@remss.com. For more information on algorithm improvements, see Wentz,2007 and Hilburn, 2008a.

How Should You Use DISCOVER Data in Climate Studies?

DISCOVER data are produced for many types of users, therefore, to use the DISCOVER data for climate studies, it is necessary to follow these guidelines:

- **Begin with daily data.** The monthly averaged data provided by DISCOVER have some rain included and there is no threshold for the number of counts per cell which contributes to errors.

- **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 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 correction that works well for wind and vapor, but is too poorly characterized for cloud and rain to used in climate work. It is unknown at this time if the correction is stable over time.

- **Apply adjustments to rain** - As described in Hilburn, 2008a, latitudinal band adjustments are necessary to account for snow which can not be measured by radiometers.

- **Apply adjustments to wind** - As described in Wentz, 2007 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 use this poster to describe 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 the data.

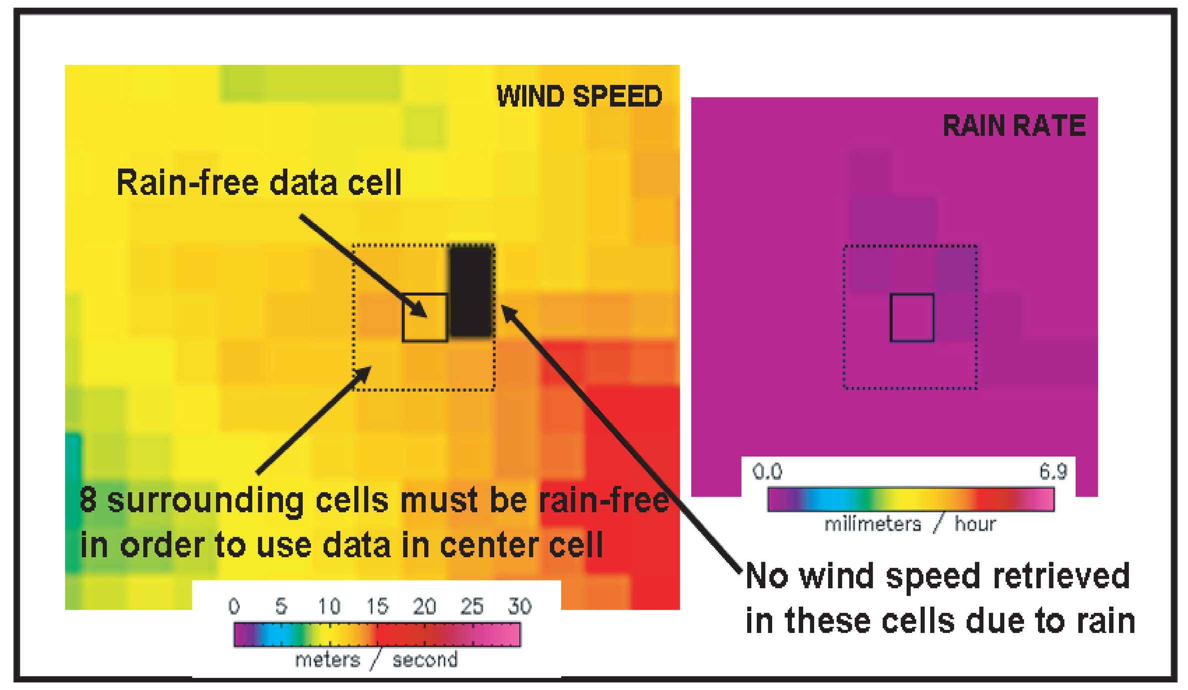

Figure 2. Diagram showing the concept of area rain flagging. SSM/I wind speed is shown greatly magnified on the left, with the rain rate for the same region shown on the right.

Area Rain Flagging?

The concept of area rain flagging is shown in Figure 2. All DISCOVER microwave ocean products are mapped to a 0.25 degree grid. To area rain flag, we check all cells encircling the 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. There are several reasons why nearby rain effects a given cell, including a rain feature that moves 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.

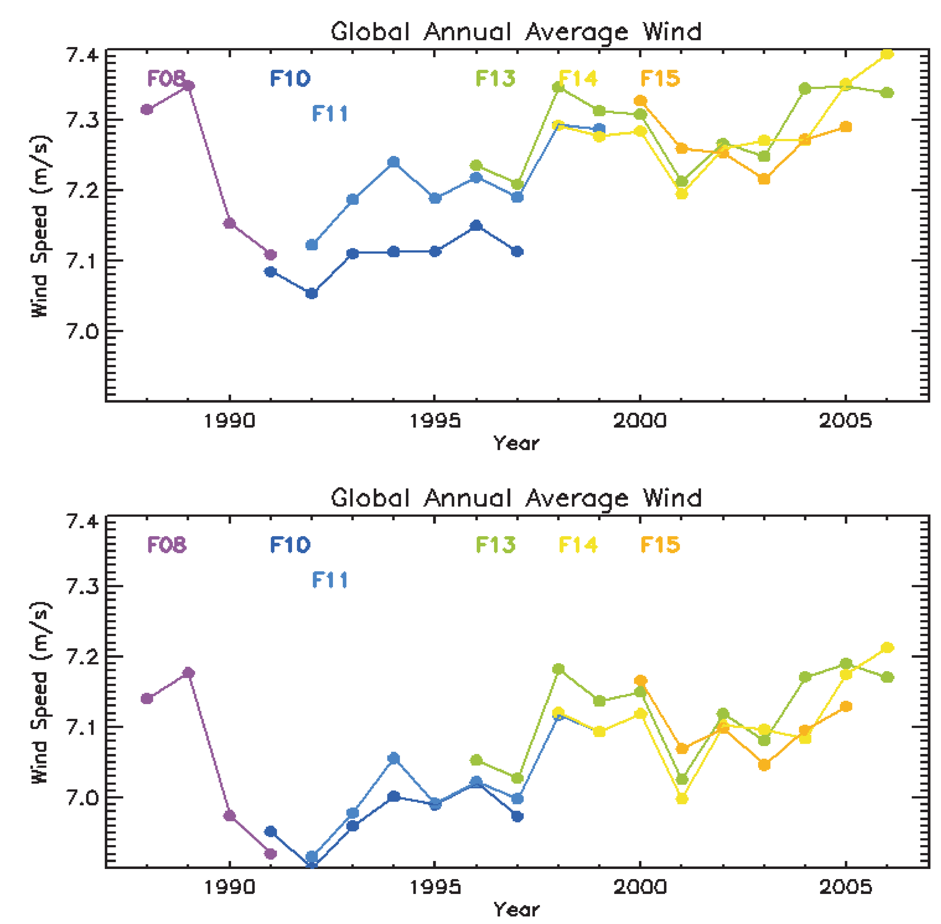

Figure 3. Global annual average wind speed for each SSM/I instrument without rain flagging (top) and with area rain flagging (bottom).

References

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

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

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

This work is supported by the NASA REASoN Project. Continued funding under the NASA MEaSUREs Project will begin in April 2009.

What Difference Does it Make?

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. Figure 3 shows how the global annual wind speed average decreases from around 7.3 m/s to round 7.1 m/s when area rain flagging is used to remove nearby rain from data cells. Figure 4 shows two maps of 2004 mean wind speeds for the SSM/I on the F15 satellite. On the left, the mean winds were calculated by adding up all valid winds for each grid cell. On the right, area rain flagging was used and only rain-free data were averaged into each cell. Note the decrease in wind speeds at higher latitude storm beltregions and in tropical rain band areas.

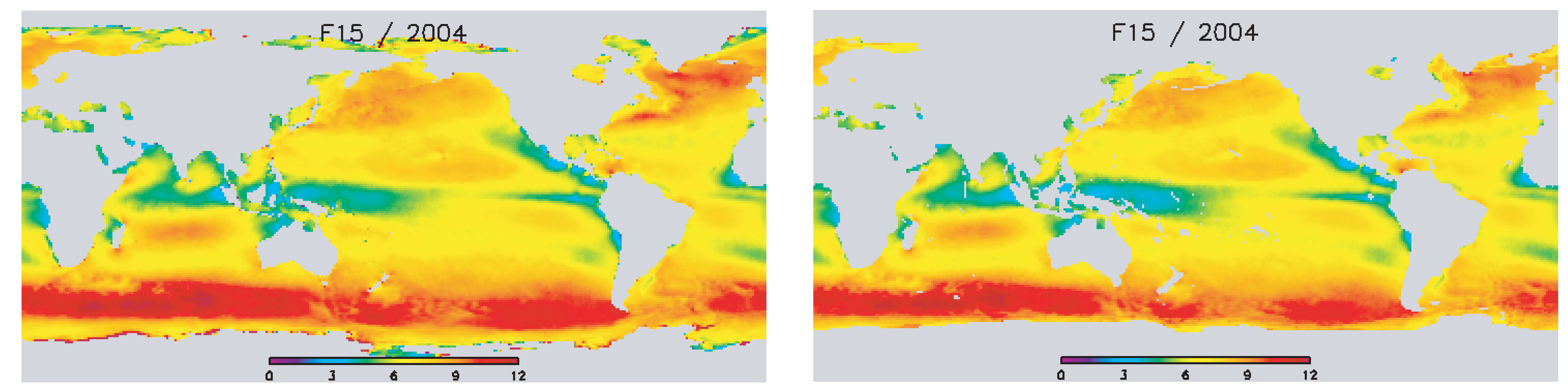

Figure 4. Two maps of mean wind speeds for F15 SSM/I during 2004. Left is all winds, right is using area rain flagging to remove nearby rain. Speeds are in m/s.

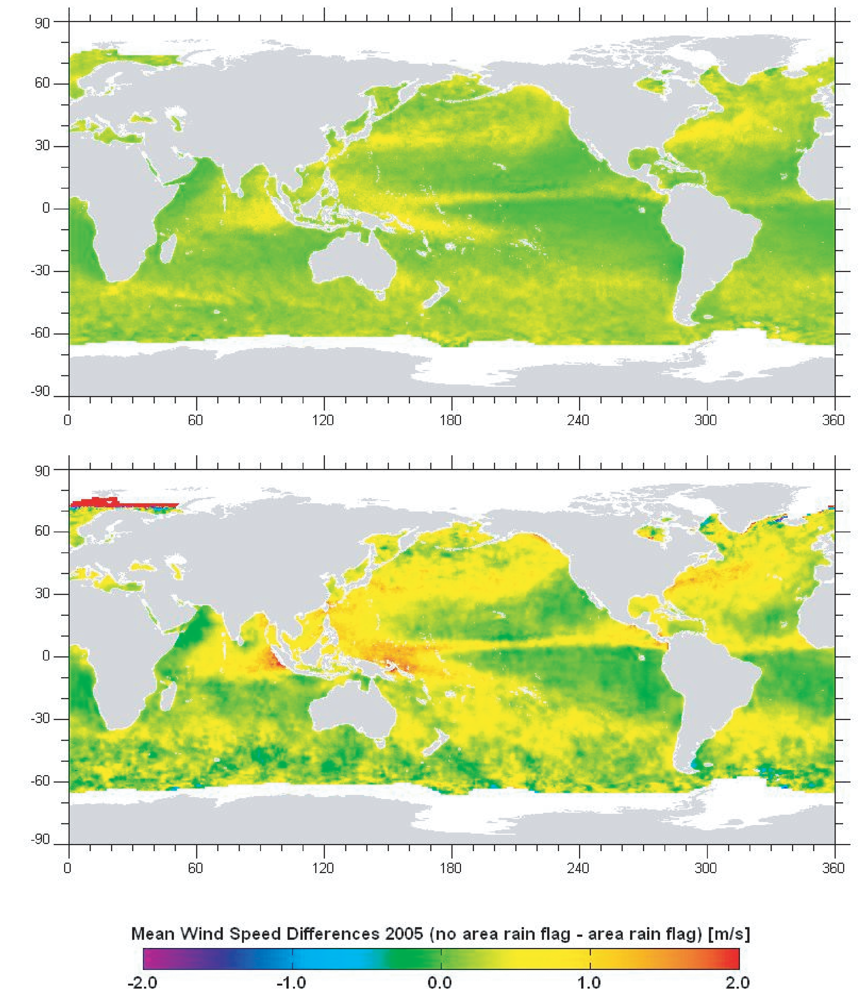

Figure 5. Wind speed difference maps for SSM/I (top) and QuikScat (bottom) showing effect of nearby rain on derived winds.

Figure 5 contains two maps. Each is a wind speed difference map : Mean Wind calculated without area rain flagging minus Mean Wind calculated using area rain flagging.

The SSM/I F13 2005 difference is on top, QuikScat 2005 difference on bottom. Note that average winds over 2m/s greater are obtained for the scatterometer. This is because the Ku-band instrument has severely (up to 10 m/s) overestimated winds at low (<8 m/s) wind speeds. These low winds occur in rainy tropical regions such as the western warm pool.

Mean wind speeds more than 1 m/s in error can be obtained from both instruments.

What is DISCOVER?

Distributed Information Services for Climate and Ocean Products and Visualizations for Earth Research

We provide multi-sensor, multi-platform highly accurate, long-term satellite microwave data products suitable for Earth research applications via easy-to-use display and data access tools.

We are funded by the NASA REASoN Project and are a Federation Type-II ESIP member. Our funding will continue under the NASA MEaSUREs Project. We are a collaboration between:

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