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Remote Sensing Systems

Radiometer Rain Colocations with JPL RapidScat Winds on L2B Swath Grid

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1. Introduction

Here we describe an ancillary dataset that has been created to provide useful information about the presence of rain at the time of the wind measurements from the RapidScat scatterometer mounted on the International Space Station. RapidScat is a Ku-band (13.4 GHz) scatterometer operating since October 2014. With a swath width of about 900 km, it enables the retrievals of wind vectors over the global ocean between 57S-57N with 14 orbits per day. The RapidScat winds are operationally processed at NASA JPL, and distributed as swath data at NASA PO.DAAC.

At the RapidScat Ku-band frequency, the wind observations are impacted by the presence of rain, due to the attenuation and the backscatter of the radar signal by rain droplets, and due to the alteration of the ocean surface by the splashing rain [Draper and Long, 2004; Hilburn et al, 2006; Ricciardulli and Wentz, 2015] . These effects are very difficult to model and to effectively remove from the returned radar signal. A neural network approach [Stiles and Dunbar, 2010; Stiles et al, 2015] has been applied to the wind retrieval algorithm to correct for the rain effects and provide the users with a rain-corrected wind vector dataset. Alternately, for the highest quality of rain-free retrievals, the users can choose to disregard wind retrievals potentially contaminated by rain by using rain observations from microwave radiometers.

To assist with the rain correction development and provide users with auxiliary information regarding the rain conditions at the RapidScat time of observation, Remote Sensing Systems (RSS) has created ancillary rain and total cloud liquid water observations from various satellite microwave radiometers (SSM/I, SSMIS, AMSR2, GMI, and WindSat) currently in operation and processed at RSS [Wentz et al 2012; 2013; 2014; 2015], as measured at the RapidScat time of observation.

2. Radiometer colocations

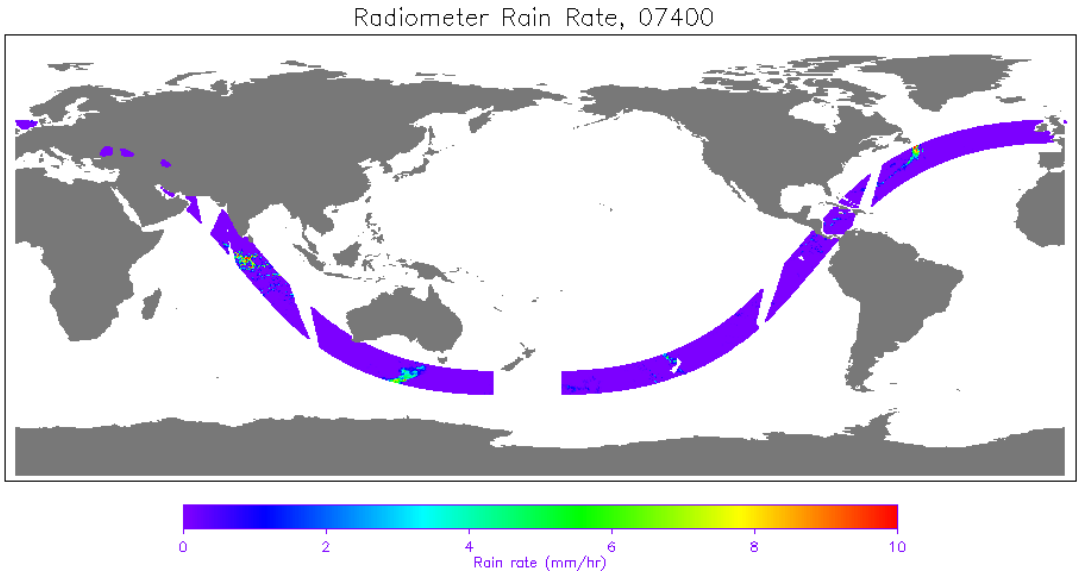
The radiometer observations are tightly colocated in time with the RapidScat wind observations, and they are provided to the users on the same 12.5 km swath grid as the RapidScat wind data. We use a maximum colocation time window of 3 hours, and search for the closest radiometer observation of rain rate (mm/hr) within that time window. If no rain was detected within 3 hours, a value of 0.0 mm/hr is assigned. If no radiometer observation is available within the time window, a missing value is provided. Similarly, the closest radiometer observations for total cloud liquid water (mm) and wind speed (m/s) are searched and reported in the ancillary files. Radiometer winds are valid only in rain-free areas, except for WindSat which can retrieve wind speeds in all weather conditions, even storms, due to a special all-weather algorithm [Meissner and Wentz, 2009] and the presence of a 6 GHz channel (not available on other radiometers). The ancillary files therefore contain rain rate, cloud liquid water and wind radiometer products. When rain is present, there will be no radiometer wind value unless WindSat is within the colocation window. When there is no rain, the radiometer winds are included. The original resolution of the radiometer observations is about 10-25 km for rain rates, 10-30 km for cloud water, and 20-40 km for the wind speed, depending on the sensor (GMI higher, SSMI lower resolution). The colocations with RapidScat are searched using radiometer data Earth-gridded (L3) at about 25 km resolution.

One ancillary data file is provided for each RapidScat orbit (identified by the orbit number) and includes:

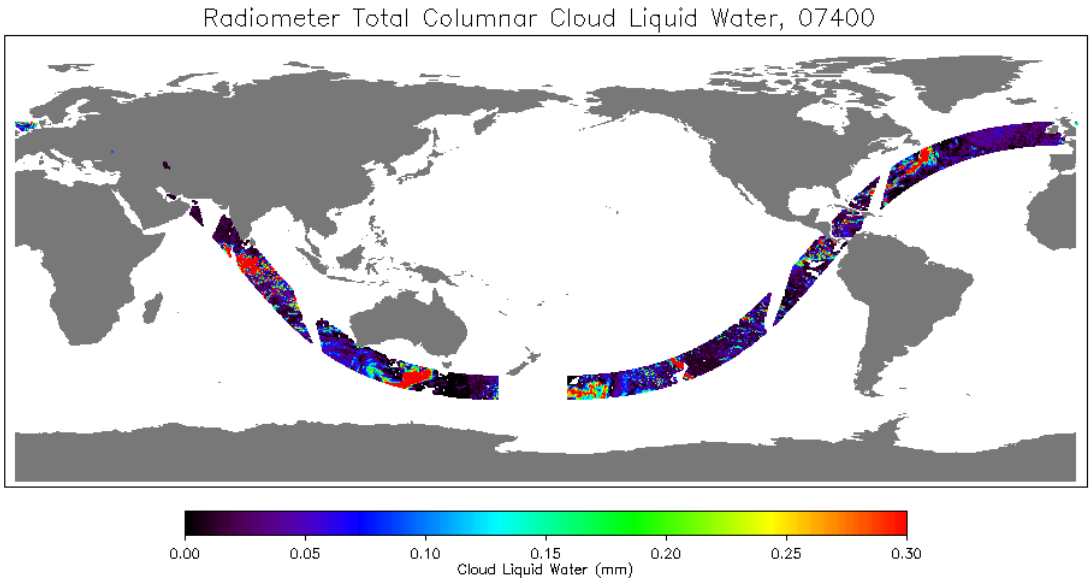
- the closest-in-time radiometer rain observation (mm/hr)
- the closest-in-time radiometer total columnar cloud liquid water (mm)
- the closest-in-time radiometer wind speed observation (m/s)
- the time difference between RapidScat and the radiometer observation (min)
- an index value that identifies which radiometer was the closest in time
- latitude and longitude of the measurements
- time of the RapidScat observation (seconds since 1999-01-01, GMT)

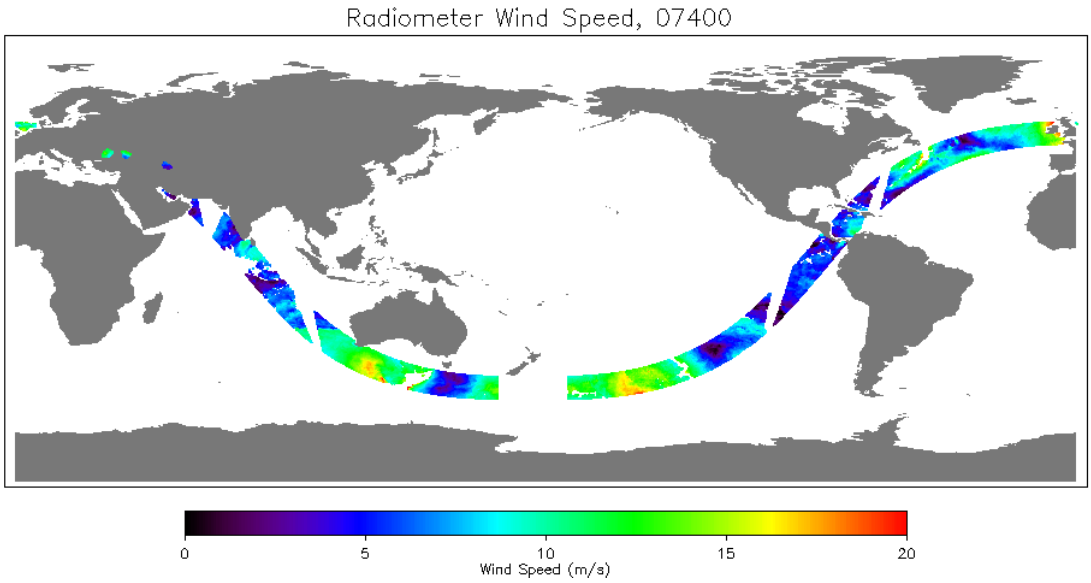
Rain rates are reported in the range 0 to 25 mm/hr; Wind speeds are within 0 to 50 m/s; and cloud liquid water ranges from -0.05 to 2.45 mm. The reason for cloud water being allowed a small negative value is a measure of the uncertainty of the radiometer measurements: The cloud probability distribution function (PDF) maximum is at zero (cloud-free sky) so discarding negative values would have the unphysical effect of having the cloud PDF maximum at a positive non-zero value.

The figures below illustrate the content of the files for the sample orbit 7400 January 12, 2016. Notice that almost all locations along the RapidScat swath are rain-free. For the few rainy areas in this orbit, the rain intensity is usually below 10 mm/hr.

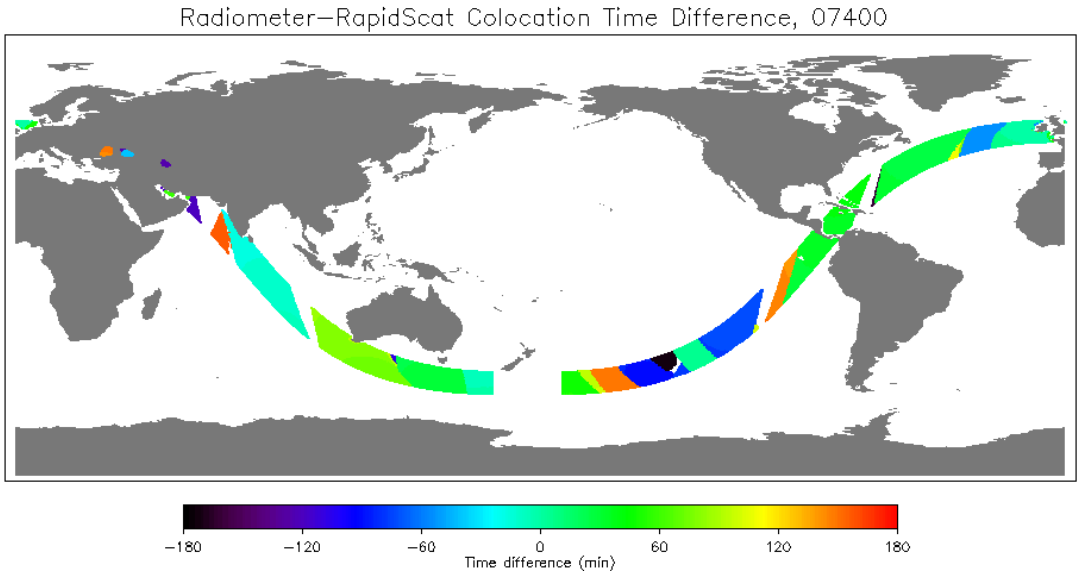


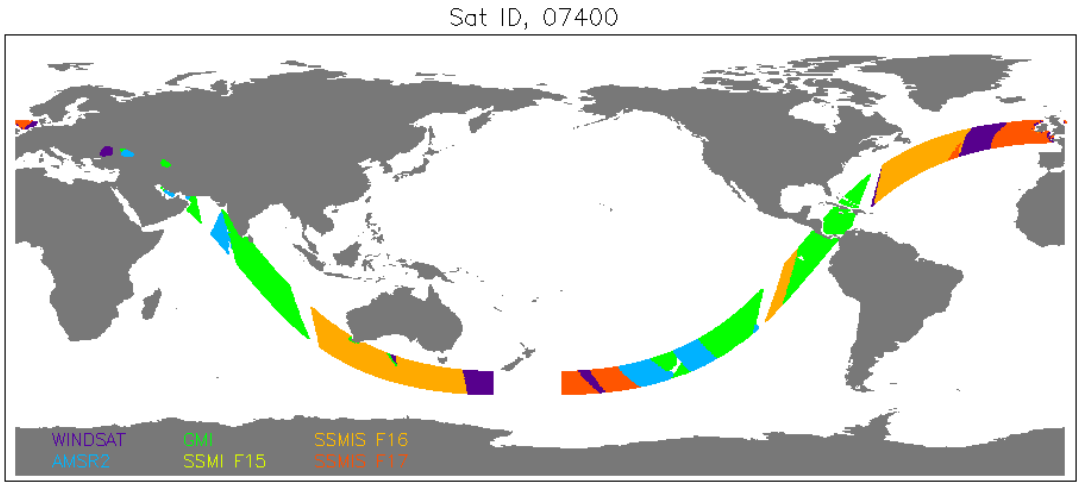
The following two figures illustrate the radiometer total cloud liquid water (which includes rain water) in the atmospheric column above the RapidScat observation cell, and the colocated radiometer wind speed. Notice that most of the radiometer winds are for rain-free regions.





Finally, the next two figures show the RapidScat minus Radiometer time difference (minutes) at each location along the orbit, and the satellite ID number that identifies which radiometer provided the closest colocation in time with RapidScat.





Radiometer	Satellite ID
WindSat	4
AMSR2	8
GMI	12
SSMI F15	15
SSMI/S F16	16
SSMI/S F17	17
SSMI/S F18	18

3. File distribution

The orbital files for radiometer observations on the RapidScat L2B swath grid were produced at RSS as binary files and rewritten in NetCDF-4 format at NASA JPL. They are distributed to users at the NASA Physical Oceanography Distributed Active Archive Center.

Acknowledgements
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