The BYU ASCAT sigma0/TRMM PR rain/ECMWF wind collocation dataset

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14 Jan 2022

Summary

The Brigham Young University (BYU) ASCAT sigma0/TRMM-PR rain/ECMWF wind (ATE) data set contains a set of collocations of European Space Agency (ESA) Advanced Scatterometer-A (ASCAT-A) radar backscatter (sigma0) measurements, Japanese Space Exploration Agency (JAXA) Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (TRMM-PR) near surface rain estimates, and European Centre for Medium-Range Weather Forecasts (ECMWF) near surface wind vectors during 2009. The dataset is available separately in either ASCII comma-separated (.csv) or ASCII space-separated (.dat) forms. Each type is packaged in separate zip archives containing individual files data, each of which represents one intersection of ASCAT-A and TRMM PR orbit swaths that occurs within 30 mins of each other. The time difference of individual measurements is recorded to create finer temporal collocations. Individual measurements are collocated to within 5 km. The Collocation Methodology section describes how the data was collocated.

Introduction

The goal of this product is to provide data to research studying the relationship between rain, wind, and C-band backscatter. To do this, a year-long temporally and spatially collocated data set was created for ASCAT, TRMM-PR, and to provide wind information, ECMWF near surface wind fields. This document briefly describes the input data and the file format of the collocated data. While a somewhat longer data set could have been generated (TRMM-PR and ASCAT overlap from mid-2007 through early 2015), our resources precluded a longer collocated data set. Nevertheless, we hope the data set is useful in stimulating research in the field.

Background

The TRMM mission operated from 1997 to Apr 2015 in a low-inclination angle orbit, collecting rain measurements [1], including Ku-band (14.25 GHz) range profile measurements with its precipitation radar. In 2009 the TRMM-PR collected 5 km resolution rain profile measurements over a 247 km swath. The TRMM-PR 2A25 (V7) product [2] includes near surface rain rate estimates which are extracted for use in the BYU ATE dataset. There were approximately 16 92.5 min long orbits per day. Ground coverage was restricted to approximately +/- 37 deg around the equator.

The C-band (5.225 GHz) ASCAT-A scatterometer flew on ESA's European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) meteorological operational satellite (MetOp-A) platform [3]. Launched in Oct 2006, it began operation in May 2007, collecting normalized radar cross-section (sigma0) measurements over two 500 km wide swaths on either side of the spacecraft ground track. The sigma0 measurements were collected at three azimuth angles and incidence angles ranging from about 15 deg to 55 deg. In a polar orbit with approximately 15 orbits/day at an altitude of 837 km, ASCAT covers essentially the entire range of latitudes of the Earth [4].

While focused on European weather, ECMWF generates global weather forecast information using numerical weather prediction (NWP) techniques [5]. One of ECWMWF's NWP products supplied to NASA, includes 4 times daily (00:00, 06:00, 12:00, 18:00) global near-surface wind fields on a 50 km grid with an estimated effective resolution of no finer than about 175 km due to the filtering employed in the NWP used to generate the wind fields.

Collocation Methodology

The orbits and swath coverage of TRMM-PR and ASCAT are very different. Figure 1 illustrates particular single orbits of each that have nadir tracks that intersect within 30 mins. Shown are the lat/lon points of the measurements collected during the orbit. The TRMM-PR swath extends both sides of the spacecraft nadir track, while ASCAT has two swaths separated by a ~500km nadir gap. Blue asterisks indicate the points at which the TRMM-PR nadir track intersects the center of each of the ASCAT subswaths.

The collocation process was split into two steps: 1) identify orbit crossings within a small-time window, and 2) for each crossing, spatially collocate individual measurements. Only unflagged (highest quality) measurements from V7 TRMM-PR 2A25 (near surface rain) and ASCAT L1B fine resolution (slice) sigma-0 files are used.

In step 1, orbit crossings (passes) are identified. In step 2, for each of these passes, ASCAT-A L1B full resolution (slice) sigma-0 measurements of an enlarged area are processed into a 2.5 km local Earth-center (i.e., map) grid centered about the intersection point using Scatterometer Image Reconstruction (SIR) algorithm [6]. This has the effect of doing a weighted interpolation of the original final resolution ASCAT sigma0 measurements onto the 2.5 map grid. The effective resolution of the interpolated sigma0 is estimated to be 6-8 km, i.e., coarser than the grid spacing, but finer resolution than the original measurements. The SIR processing is done separately for the ASCAT azimuths fore, middle, and aft. Incidence and azimuth angles are also separately interpolated.

Next, TRMM-PR and ASCAT sigma0 values on the grid are collocated. For each valid TRMM-PR measurement the closest 2.5 km map grid location that contains a valid ASCAT sigma0 value is determined. Only locations within (a) 0.1 deg of latitude and longitude and (b) 1 hour of time are retained. The measurements, their time difference, their locations, and their geometry are written to the output file. Also written are the tri-linearly ECMWF surface wind fields (separately interpolated U and V wind components) for the time and location of the TRMM-PR measurements.

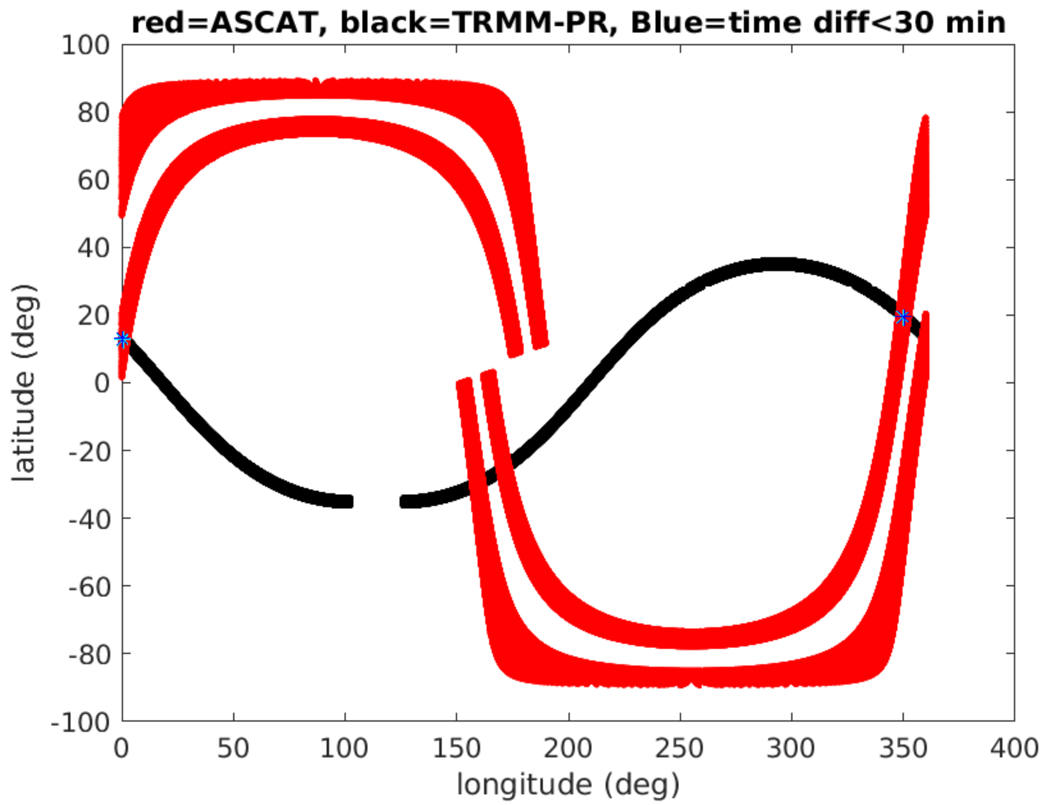

Figure 1. Plots of the locations of ASCAT-A (red) and TRMM-PR measurements for one orbit of each. The blue asterisks are where the TRMM-PR nadir track and ASCAT subswath center intersect within 30 mins.

There are about 5600 collocated measurements per pass, though the exact value varies significantly from pass to pass. For 2009, 3609 individual passes meeting the collocation criterial were identified.

Example Data

Figures 2-7 illustrate the contents of a particular ATE data file. These images were created using the Matlab routine plotATE.m, which is included with the data set. To create these images, a colored dot is plotted at the latitude, longitude position of the measurement. Gaps result from invalid and/or missing measurements. For these plots, the time difference was further restricted to ±15 mins.

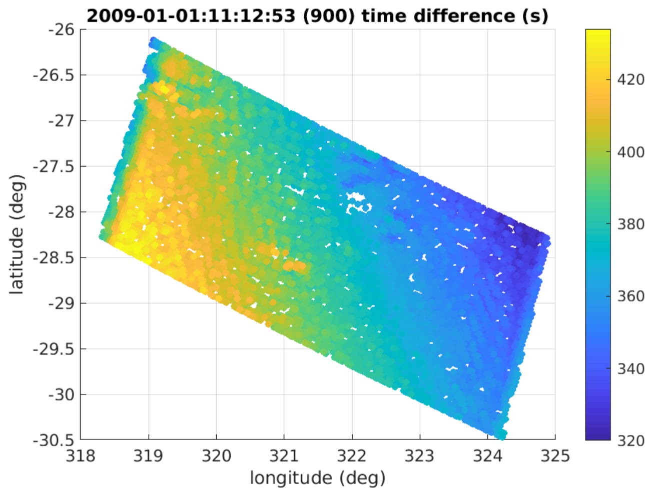

Figure 2. Visualization of the time difference for a particular ATE file.

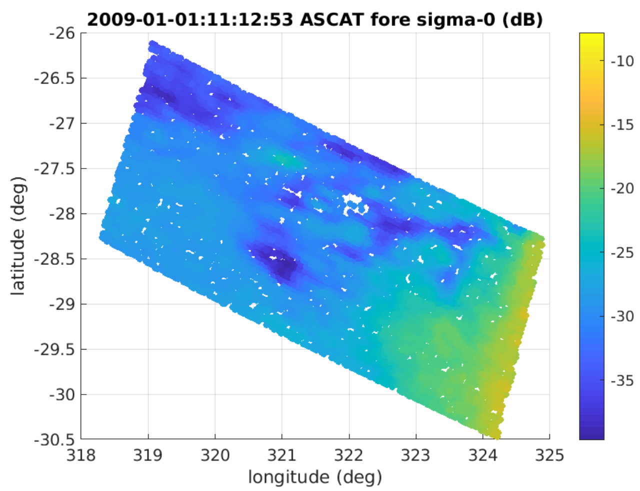

Figure 3. Visualization of the fore sigma0 for a particular ATE file.

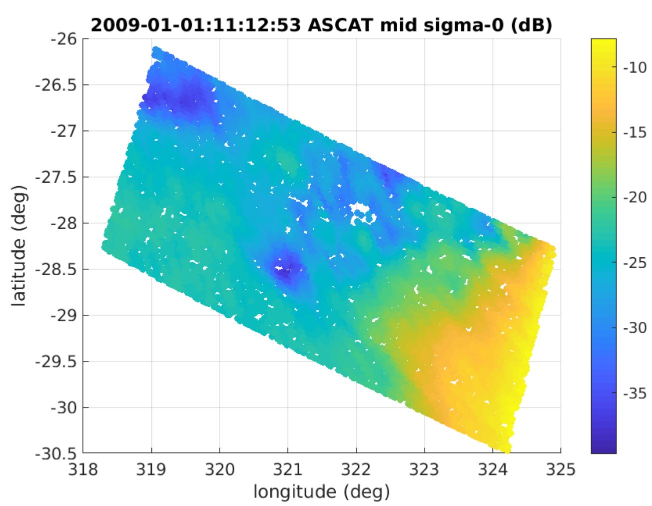

Figure 4. Visualization of the mid sigma0 for a particular ATE file.

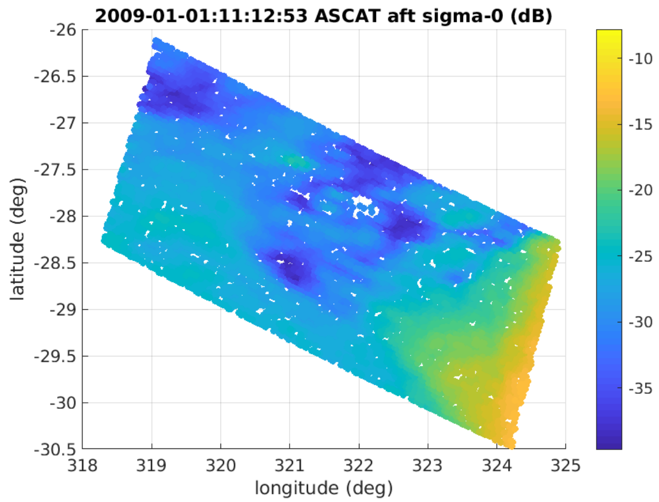

Figure 5. Visualization of the aft sigma0 for a particular ATE file.

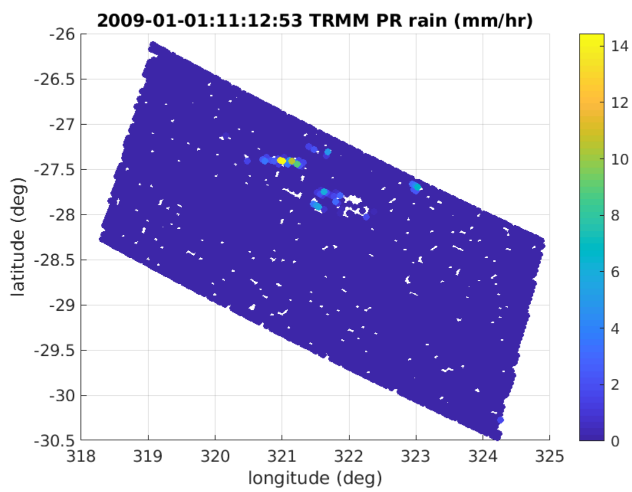

Figure 6. Visualization of the surface rain for a particular ATE file.

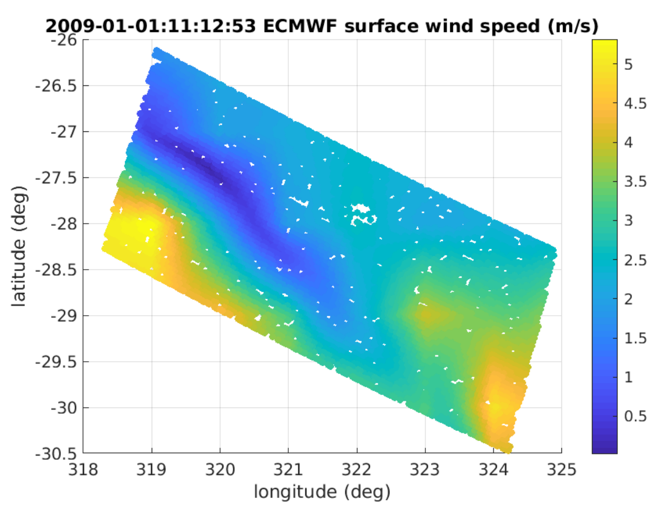

Figure 7. Visualization of the ECMWF wind speed for a particular ATE file.

Data Format

The ATE data set for 2009 consists of 3609 files. These are available either as comma separated ASCII files (.csv) or as space-separate files (.dat). (The values are identical in both sets of files.) Each ASCII file contains 23 fixed-format columns with contents described in Table 1.

Table 1. ATE Column Contents.

Column	Content
1	Time difference between ASCAT-A and TRMM-PR measurements (seconds)
2	year
3	month
4	day of month
5	hour (24 hr)
6	minute
7	seconds
8	Latitude of TRMM-PR rain (deg)
9	Longitude of TRMM-PR rain (deg)
10	Latitude of ASCAT sigma-0 (deg)
11	Longitude of ASCAT sigma-0 (deg)
12	ASCAT sigma0 fore beam (dB)
13	ASCAT sigma0 mid beam (dB)
14	ASCAT sigma0 aft beam (dB)
15	ASCAT azimuth angle relative fore beam (deg)
16	ASCAT azimuth angle relative mid beam (deg)
17	ASCAT azimuth angle relative aft beam (deg)
18	ASCAT incidence angle fore beam (deg)
19	ASCAT incidence angle mid beam (deg)
20	ASCAT incidence angle aft beam (deg)
21	TRMM-PR 2A25 near surface rain (mm/hr)
22	U component ECMWF wind (m/s)
23	V component ECMWF wind (m/s)

References

[1] https://gpm.nasa.gov/missions/trmm (14 Jan 2022).
[2] https://disc.gsfc.nasa.gov/datasets/TRMM_2A25_7/summary (Visited 14 Jan 2022).
[3] https://www.eumetsat.int/ascat (Visited 14 Jan 2022).
[4] https://www.eumetsat.int/media/45987 (Visited 14 Jan 2022).
[5] https://www.ecmwf.int/ (Visited 14 Jan 2022).
[6] R. Lindsley and D.G. Long, Enhanced-Resolution Reconstruction of ASCAT Backscatter Measurements, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 54, No. 5, pp. 2589-2601, doi:10.1109/TGRS.2015.2503762, 2016.