Precipitation Measuring Missions (PMM) Land Surface Working Group
GPM Ground Validation Experiments for Focus Study Areas

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Background

At the GPM Ground Validation (GV) meeting in Toronto in July 2012, the LSWG was encouraged to take advantage of the wealth of data collected during recent GPM-sponsored field campaigns, in particular the MC3E (April 22-June 6, 2011) and GCPEx (January 15-February 29, 2012) field experiments. These field experiments included aircraft overpasses with onboard radar (HIWRAP, APR-2) and radiometer (AMPR, CoSMIR) observations, including several dedicated "clear air" flight lines dedicated for land studies, and many ground-located data (land-based radars, radiometers, disdrometers, etc.). In the past, PMM-related GV data have been analyzed almost exclusively for the days with precipitation events, and the "no precipitation" days are typically left unanalyzed. In light of the importance of the land surface state (in particular, microwave surface emissivities for the various radiometers that will make up the GPM constellation, and surface backscatter cross sections for the TRMM and GPM space radars) for the GPM algorithms, it is advantageous to situate over-land "focused study" regions over areas surrounding and during these experiments. This provides a common setting to carry out emissivity and radar cross section studies under different conditions, where participants can use other GV or GV-related observations, ancillary data, etc. from these experiments as desired. A secondary goal is to identify selected satellite overpasses that can be independently analyzed and used as test cases for the radiometer (GPROF) retrieval framework.

In the initial LSWG targeted-area study (IEEE TGRS paper in press), the time series of the emissivity from each satellite overpass over a number of one-degree "postage stamp" regions were compared over a multi-year period. While the study provided valuable comparisons across seasons, it was often difficult to draw conclusions since each technique used different source datasets and ancillary data (e.g., surface temperature). Also, emissivity is not routinely measured so there was no "ground truth". To compensate, emissivities derived from some sensors (e.g., SSMI) were analyzed by the emissivity "response" to previous-time precipitation, to study change with respect to the timing, duration and intensity of previous-time precipitation.

Follow-on Study

The idea for the follow-on study is to focus on specific satellite overpasses encompassing and surrounding the two GV sites mentioned above, during the approximate six weeks duration of each campaign. For MC3E there are abundant AMSR-E overpasses over the central and upper Great Plains that occur during early afternoon (1330 local) and at night (near 0130 local), providing strong day-night surface temperature conditions, many good cases of developing convection and also several "clear-sky" days. Also, MC3E occurred during the time of 2011 springtime flooding on the Mississippi and many tributaries, which provides the opportunity to study dynamically changing emissivity and test the retrieval quality under a wide range of soil moisture conditions. For cold season precipitation conditions during GCPEx, SSMIS data from DMSP F-16, F-17 and F-18 are the best routine conical imager data available (AMSR-E had ceased functioning by this time), which have the 150 and 183 GHz capabilities but lack 10 GHz (towards the end of GCPEx, the 150H GHz channel on F-18 is not available).

Dataset Content and Examples

Individual Aqua and DMSP satellite overpasses over these two sites have been processed for all overpasses passing within 700-km of the MC3E and GCPEx experiment sites, respectively. Corresponding satellite radiance-level data were extracted whenever the satellite track subpoint passed within ±15 degree latitude of the site (approximate 8-minute segment). In order for all users to use common ancillary fields, NASA/GMAO MERRA atmospheric and land reanalysis products were interpolated in space and time to each of the low-resolution channel locations (the 19/22/37 GHz coordinates for SSMIS, and 10/19/23/37 of AMSR-E). MERRA includes the 42-layer temperature and specific humidity profile, total column vapor, and the surface, 2-m and 10-m air temperatures. The daily NOAA Interactive Multisensor Snow and Ice Mapping System (IMS) snow cover flag is supplied for the current day and previous 9 days (10 total). To know the precipitation conditions at the satellite overpass time, the 1-km resolution NOAA NEXRAD mosaic (NMQ) surface rain (averaged to a 25x25 km region surrounding the low-resolution coordinates) is provided for the NMQ 5-minute mosaic closest in time to the satellite overpass time. For previous precipitation, the NMQ accumulated 1, 3, 6, 12 and 24-hour precipitation totals are included. To easily assess each overpass case, an eight-panel quicklook image is provided.

An example is shown in Figure 1 for the Aqua/AMSR-E nighttime overpass over the central US during the MC3E experiment on 26 May 2011. The 10 GHz TB (upper left) shows overall lower TB over parts of the states of Iowa, Indiana and Illinois relative to the surrounding areas, which is consistent with increased soil moisture conditions noted in the previous 24-hour NMQ precipitation (second panel on lower row). The majority of the precipitation is stratiform, with a few small convective cells are noted over Kentucky, Alabama and Mississipi. This case provides a science opportunity to study the response of land surface emissivity to very recent changes in soil moisture, and to test the retrieval algorithm's adaptability to these same changing conditions. Figure 2 shows another example from the F-18 SSMIS centered upon the GCPEx domain on 23 January 2012 at 1430 UTC. At the higher latitudes, overall scattering-induced TB depressions are weak in all of the higher-frequency channels (91 GHz and higher). The NMQ precipitation type at this time shows a snow/rain boundary stretching across the Great Lakes, and a distinct snowcover edge or boundary in the land surface cover from the IMS analysis. This case provides an opportunity to study cold-season surface emissivity changes and their representation within the land surface models. From an algorithm testing perspective, this case would examine the robustness of the S0-type ("surface blind") retrieval formulations to detect and carry precipitation across snow-covered land surface changes.

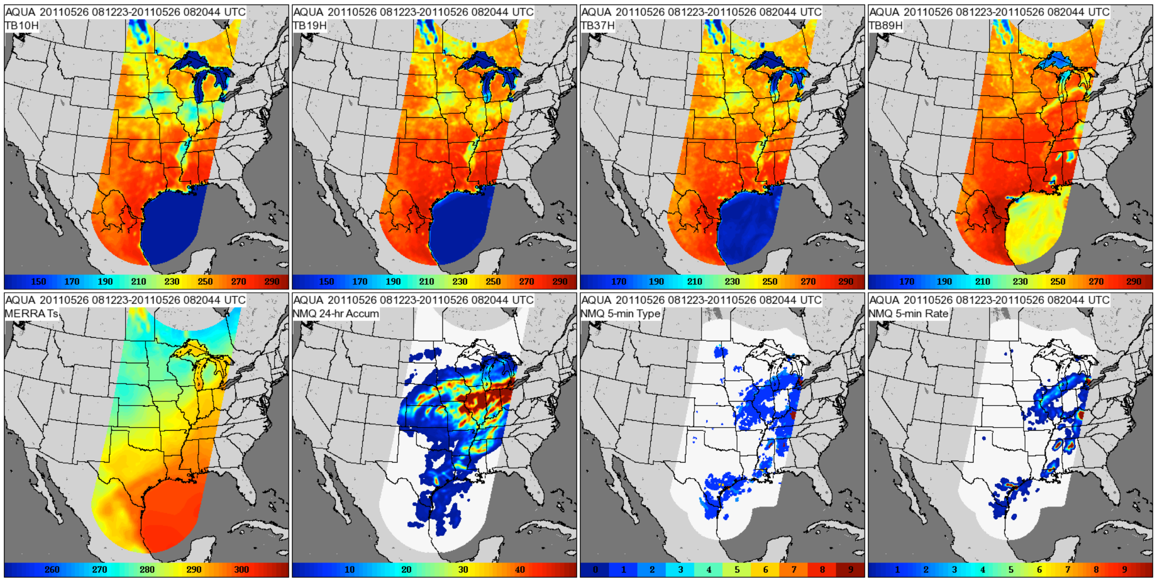

Figure 1. Descending (local evening) Aqua overpass between 0812-0820 UTC on 26 May 2011 during the MC3E field experiment. (**Top row**) AMSRE 10H, 19H, 37H and 89H GHz channels. (**Lower row, left to right**) MERRA surface temperature (K), NMQ 24-hr accumulated precipitation prior to the satellite overpass, NMQ rain type from nearest 5-minute NMQ mosaic (2=stratiform, 3=snow; see next page for other codes), and NMQ rainrate in mm hr^{-1} from the same 5-minute NMQ mosaic.

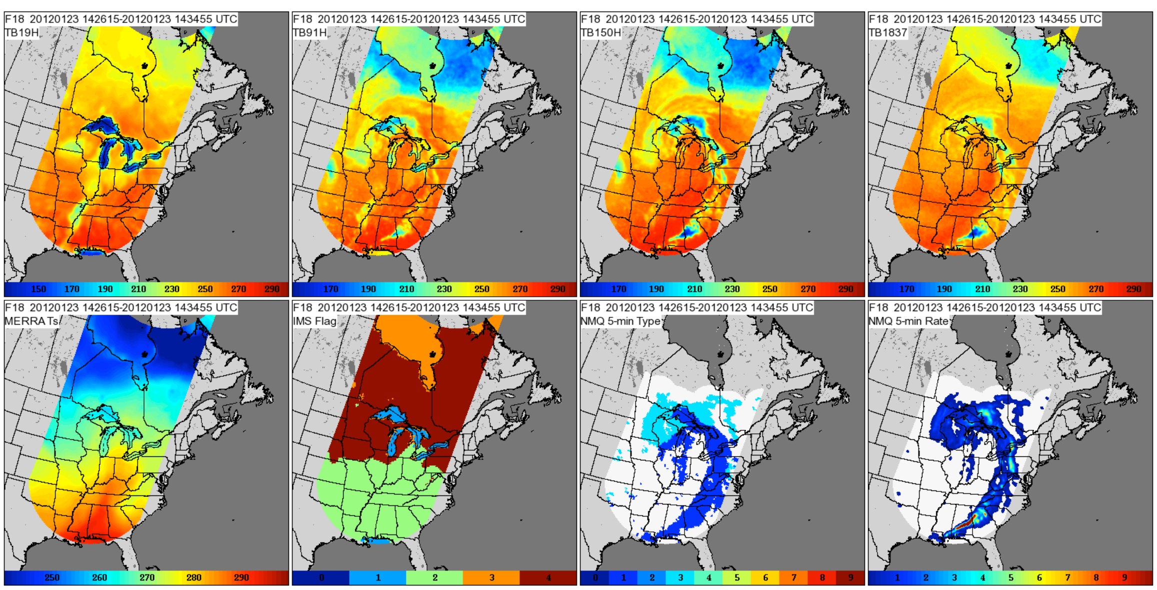

Figure 2. Descending (local morning) DMSP F-18 overpass between 1426-1434 UTC on 23 January 2012 during the GCPEx field experiment. (**Top row**) SSMIS 19H, 91H, 150H, and 183±7 GHz channels. (**Lower row, left to right**) MERRA surface temperature (K), NOAA IMS snowcover flag (2=land, 4=snowcover; see next page for other codes), NMQ rain type from nearest 5-minute NMQ mosaic (2=stratiform, 3=snow; see next page for other codes), and NMQ rainrate in mm hr^{-1} from the same 5-minute NMQ mosaic.

Suggested Studies

The main goal of the study is to analyze not just the "point" type data that was carried out during the first LSWG study, but rather analyze the full satellite overpass scene for different cases. There are already a number of investigations ongoing with the multitude of datasets collected during these experiments (e.g., precipitation microphysics and dynamics), and there are just a few selected topics listed below that relate to land surface properties.

1) Rather than compare small-scale "point" emissivities like the original LSWG study, examine the capability of an emissivity technique(s) to replicate the full satellite-observed scenes. The atmospheric profile information provided is sufficient to run clear-scene microwave radiative transfer simulations, but other sources of temperature, humidity or land surface conditions can be used.

2) From GCPEx, examine snowfall detectability for a set of passive microwave channels given the underlying natural variability in atmospheric and land surface conditions.

3) Compare S0- and S1-based (e.g., TELSEM) surface emissivity formulations in radiometer retrievals (GPROF-GPM) using the NMQ-provided data as a common reference.

4) Examine changes in the land surface properties (soil moisture, vegetation water content, type) and/or other measureables (e.g., polarization indices, NDVI, radar backscatter e.g. scatterometer data) to the modeled or retrieved microwave emissivity structure.

5) There are a number of non-land related investigations ongoing with the multitude of datasets collected during these experiments. For example, simulated GPM radar modeling of the precipitating scenes could employ aircraft radar data for microphysics and different formulations for land surface emissivities.

Datafile Format

Each satellite overpass is written out on the low-resolution (i.e., the 10-37 GHz channels) scan basis, in a common ASCII format, the same for all sensors. A sample C-based reader is provided.

Line 1:

1) radiometer scan line number
2) radiometer scan pixel number for the lo-resolution (10-37 GHz) channels
3) surface flag (1=land, 2=water, 3=coast)
4) latitude (degrees)
5) longitude (degrees)
6) 4-digit year
7) 2-digit month

8) 2-digit day
9) 2-digit hour
10) 2-digit minute
11) 2-digit second

Line 2:
(16 values) Set of radiometer TB (Kelvin) for the scene.

SSMIS has 16 channels provided, order is: 19.35V, 19.35H, 22.235V, 37.1V, 37.1H, 91V, 91H, 150H, 183±1, 183±3, 183±7, 50.3H, 52.8H, 53.596H, 54.4H, 55.5H.

AMSR-E has 10 channels provided (no 6 GHz provided), order is: 10.65V, 10.65H, 18.7V, 18.7H, 23.8V, 23.8H, 36.5V, 36.5H, 91.0V, 91.0H. Remaining 6 values are empty.

Line 3:
(10 values) NOAA Interactive Mapping System (IMS) nearest 24-km surface flag.

The first value is the IMS flag on day of the overpass. The next 9 values provide this flag for the 9 days prior to the overpass (e.g., the day before the overpass, the day before that, etc). 0=no data, 1=open water, 2=land, 3=sea ice, 4=snowcover, -1=missing.

Line 4:
(7 values) NMQ radar products. NMQ data are native 1-km resolution, and are averaged over a 25x25 km region (625 NMQ pixels) surrounding each TB scene. A value of -2 indicates no datafile found, -1=missing or no NMQ coverage.

1) Nearest 5-minute NMQ rain type flag (0=no precipitation, 1=stratiform, 2=bright band, 3=snow, 4=overshooting, 6=convective, 7=hail, 9=warm rain/tropical). The flag reported is the most common value within all 625 pixels.
2) Nearest 5-min NMQ rainrate (mm/hr).
3) Accumulations (mm) for the previous 1 hour.
4) Accumulations (mm) for the previous 3 hours.
5) Accumulations (mm) for the previous 6 hours.
6) Accumulations (mm) for the previous 12 hours.
7) Accumulations (mm) for the previous 24 hours.

There is currently a bug with the accumulations, whereby areas between 20-55N latitude that have “no radar coverage” are given as a zero value, rather than a missing value (-1). This is not an issue for the 5-minute NMQ data.

Line 5:
(5 values) Environmental products taken from MERRA reanalysis data, interpolated in space and time to the time and location of the lo-resolution channels.

1) surface temperature (K)

2) 2-meter air temperature (K)
3) 10-meter air temperature (K)
4) total vapor column (mm)
5) nlayers+1, for the temperature/moisture profile (below).

Line 6 onwards:
(nlayers+1) Temperature and moisture profile at each layer interface. There are nlayers and the surface for a total of nlayers+1 lines to read.

The first nlayer lines provide the environmental profile from MERRA, where each line is: level number (1=top), level geopotential height (meters), level pressure (hPa), level temperature (K), level specific humidity (g/g). The final line (nlayers+1) is the surface, so for the last line the values are interpreted as surface geopotential height, surface pressure, surface temperature (set to -1 but given in line 5) and surface specific humidity (set to -1).