Global Precipitation Measurement (GPM) Retrieval Performance
Gail Skofronick-Jackson, Code 612, NASA/GSFC and 17 Co-Authors

Integrated Multi-satelliteE Retrievals for GPM (IMERG)

18 Sept 2017 08:30 UTC

Left Image: GPM’s IMERG product provides precipitation estimates every 30 min at a 0.1° x 0.1° grid box and with a 4-5 hour latency (for application users) and ~3 month latency (for science users). Right Image: IMERG and GPM-Core Observatory (GPM- CO) precipitation product zonal mean averages (DPR, Ku-band, CORRA, and GPROF) are in good agreement. At high latitudes where much of the precipitation is light, GPM-CO zonal accumulations underestimate with respect to established precipitation estimates (GPCP and MCTA2) because GPM’s minimum detectable precipitation rate is ~0.2 mm h⁻¹.
References:

Data Sources: NASA GPM Version 05 precipitation retrievals, available from the NASA Precipitation Processing System (PPS, pps.gsfc.nasa.gov), were used in this analysis including products from the Dual-frequency Precipitation Radar (DPR, using both using Ku- and Ka-band radar data), the GPM Microwave Imager (GMI) radiometer in version 05 data products called the Goddard Profiling Algorithm (GPROF), the Ku (using only GPM Ku-band radar for comparison with the Tropical Rainfall Measuring Mission (TRMM) Ku-only product), the DPR + GMI Combined Radar-Radiometer Algorithm (CORRA), as well as Version 04 of the Integrated Multi-satellite REtrievals for GPM (IMERG). These GPM products are compared to Global Precipitation Climatology Project (GPCP, version 2.3) (Adler et al. 2003) and, over ocean, the Merged CloudSat, TRMM, and Aqua version 2 (MCTA2) dataset (Behrangi et al. 2014).

Technical Description of Figures:
Graphic Upper Left: IMERG precipitation estimates for 18 Sept 2017 at UTC 08:30. This image captures Hurricanes Jose and Maria, Tropical Depression Lee, and Tropical Storms Norma and Otis. IMERG combines GMI data with 10 other satellite-based microwave estimates, geostationary infrared observations, and rain gauge analyses.

Graphic Right: Zonal precipitation averages (mm day−1) for the full annual cycle during 2015. The five estimates are GPM DPR (red), GPM GPROF (blue), GPM Ku band (green), GPM CORRA (orange), IMERG (purple), GPCP global estimates (light blue), and MCTA2 estimates over ocean (black, covering the years 2007–10). Both GPCP and MCTA2 include a variety of input datasets selected for their utility in precipitation estimation at both low and high latitudes. The GPM zonal accumulations underestimate with respect to the MCTA at higher latitudes. This is mostly attributable to the fact that the DPR minimum detectable reflectivities correspond to minimum rain rates of approximately 0.2 mm h−1. Since much of the higher-latitude precipitation is light, and CORRA and GPROF are based on DPR estimates, GPM-derived accumulations are biased low in the higher latitudes.

Scientific significance, societal relevance, and relationships to future missions: The GPM Core Observatory (GPM-CO) spacecraft, a NASA–JAXA partnership, was launched in February 2014 and operates in a non-sun-synchronous orbit with an inclination angle of 65°. This orbit allows the GPM-CO to sample precipitation across all hours of the day from the tropics to the Arctic and Antarctic circles and for observing hurricanes and typhoons as they transition from the tropics to the midlatitudes. The GPM-CO has sophisticated satellite instrumentation, intercalibrates datasets from 10 other microwave radiometers from partners sharing data, coordinates merged precipitation datasets, has reduced latency for delivering data products, simplified data access, expanded global ground-validation efforts, and integrated user applications. Because of the application focus of GPM, the public release of precipitation products is required in near–real time (1–5 h after the observations are downlinked to the ground stations). GPM-CO’s well-calibrated instruments allow for scientifically advanced observations of precipitation in the midlatitudes, where a majority of Earth’s population lives.

Earth Sciences Division - Atmospheres
We have developed a thermal technique for MODIS to derive smoke plume height from wildfires ($H_s$). Images illustrate smoke height retrievals for the Rocky Mountains wildfires on summer of 2008. The arrow identifies the thermal contrast created by the rising smoke plume. Each row represents a different day. The columns correspond to the MODIS RGB image, MAIAC cloud mask (CM; clear, cloud, shadow, detected fire), aerosol optical depth (AOD), plume height above ground, and 11 µm brightness temperature ($T_b$).
Name: Alexei Lyapustin, NASA/GSFC Code 613
E-mail: Alexei.I.Lyapustin@nasa.gov
Phone: 301-614-5998

References:

Lyapustin, A., Y. Wang, S. Korkin, R. Kahn, Thermal Technique to Derive Smoke Plume Height from MODIS, Geophys. Res. Lett., to be submitted.


Data Sources: MODIS Terra and Aqua Level 1B data, MISR MINX aerosol plume height project.

Technical Description of Figures:

Image: Illustration of smoke plume height retrieval from MODIS for the Rocky Mountains wildfires of the summer of 2008. An arrow identifies the thermal contrast created by the rising smoke plume. This contrast against smoke-free background along with MAIAC smoke detection [Lyapustin et al., 2011; 2012] is used in the smoke plume height retrieval. The columns show the MODIS RGB image, MAIAC cloud mask (CM), aerosol optical depth (AOD), plume height above ground, and 11 μm brightness temperature (Tb). The cloud mask legend is as follows: clear, cloud, shadow, detected fire. Each row corresponds to a different day of 2008, specifically 190, 191, 202 and 224.

Graph a): Histogram of MODIS-MISR plume height difference for 1089 digitized MISR MINX plumes over North America available for the period 2000-2008. MAIAC values are lower by about 200m in the maximum of histogram, and by 448m on average. This is expected, as the 11 μm weighting function tends to sample deeper in the column than the level-of-maximum-contrast identified in the MISR MINX retrieval. Nevertheless, 59.3% of MAIAC plume heights are found within ±500m of MISR MINX values, which is comparable to the accuracy of MISR.

Graph b): Standard deviation of retrieved plume heights for MODIS (red) and MISR (blue). MAIAC shows smaller standard deviation of retrieved plume heights, σH=179.3m, vs 299.6m for MISR. To first order, this also reflects differences in the way the two techniques sample plumes.

Scientific significance, societal relevance, and relationships to future missions: Wildfire smoke plume height (Hs) is an important parameter for constraining aerosol chemical transport models in GCMs. It determines whether emitted smoke remains a local phenomenon limited to the atmospheric boundary layer, or whether it is injected into a free troposphere and can travel greater distances. Hs is currently available from the CALIPSO space lidar CALIOP [Vaughan et al., 2009] and the MISR multi-angle radiometer on the Terra platform [Nelson et al., 2013]. The MODIS-based retrievals implemented in the MAIAC algorithm will significantly expand the retrieval coverage and provide data for both morning and afternoon orbits. The new method is also directly applicable to VIIRS.
New Concerns for Ozone Recovery
Qing Liang¹, Susan E. Strahan¹, and Eric L. Fleming² (614)

¹ NASA GSFC/USRA GESTAR, ² NASA GSFC/SSAI

Unregulated manmade ozone depleting substances (ODSs), incomplete compliance with the Montreal Protocol (MP), and climate change present emerging concerns for ozone layer recovery.

The equivalent effective stratospheric chlorine (EESC) in the Antarctic Lower stratosphere is a key measure of stratospheric ozone depletion.

- Large emissions of unregulated dichloromethane (DCM) are unlikely to have much impact on ozone because DCM is very short-lived in the atmosphere.
- Improved MP compliance of the regulated long-lived ODSs, e.g. CCl₄, is of greater concern to ozone recovery.
- The biggest uncertainty comes from the human-induced climate impact that will increase natural ODS emissions.

As a result of successful regulation by the Montreal Protocol (MP), atmospheric halogen concentrations have been decreasing since the 1990s. Recent observations show rising emissions of some regulated and unregulated ozone-depleting substances (ODS), which may delay the recovery of stratospheric ozone. As shown by the scenarios above, the individual impacts of these issues are small, but their combined effect will decrease the Antarctic total column ozone by ~10% between 2050 and 2100, posing a substantial concern.
References:

Data Sources: Model simulations are conducted using the NASA Goddard 3-D GEOS-5 chemistry climate model, GEOSCCM. Monthly mean surface observations of ozone-depleting substances from the the Advanced Global Atmospheric Gases Experiment (AGAGE) network and the National Oceanic and Atmospheric Administration – Global Monitoring Division (NOAA-GMD) network. Airborne measurements of ozone-depleting substances are from multiple NASA aircraft field campaigns from the previous two decades.

Technical Description of Figures:
Graphic 1: Estimated equivalent effective stratospheric chlorine (EESC) in the Antarctic lower stratosphere between 1950-2100. The baseline estimate assumes atmospheric DCM concentration remains at the present level, zero CCl₄ emissions from present to 2100, and zero climate-induced changes in the natural emissions. Four additional EESC scenarios are also shown, a DCM scenario with ~2 ppt/yr increase until 2100 (dark green dashed line), a CCl₄ scenario with a continued 35 Gg/yr emissions (teal solid line), a climate scenario with 30% increase in natural emissions between 1950 and 2100 (yellow solid line), a DCM+CCl₄+Climate scenario (orange dashed line) showing the summed impact of all three. The vertical lines indicate the expected recovery year for the Antarctic ozone to return to the 1980 level for each scenario.

Scientific significance, societal relevance, and relationships to future missions: Reactive halogen gases containing chlorine (Cl) or bromine (Br) destroy stratospheric ozone via catalytic cycles. The main sources of atmospheric reactive halogens are the long-lived synthetic chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride (CCl₄), methyl chloroform (CH₃CCl₃), and bromine-containing halons, all of which persist in the atmosphere for many years. These ozone-depleting substances are now controlled under the Montreal Protocol and its amendments. Natural methyl bromide (CH₃Br) and methyl chloride (CH₃Cl) emissions are also important long-lived sources of atmospheric reactive halogen. Recent research has highlighted rising concentrations of very-short-lived substances (VSLSs) with atmospheric lifetimes of less than half a year and their potential contribution to future stratospheric ozone depletion. A greater concern to ozone recovery is incomplete compliance with the Montreal Protocol, which will impact stratospheric ozone for many decades, as well as rising natural emissions as a result of climate change.