NASA deployed its Precipitation Imaging Processor (PIP) in support of the 2018 Winter Olympics in Pyeongchang, South Korea. The PIP is a Wallops-built instrument that uses high resolution video to capture falling snow. One of the unique abilities of this instrument/software package is its ability to estimate the effective density of snow, based on the observed fall speed of the snowflakes. Density is needed to retrieve the liquid water content of the falling snowflakes and hence water flux, which is critical to closing the hydrological cycle.
References:
The International Collaborative Experiment – PyeongChang Olympics and Paralympics (ICE-POP) 2018 field campaign was hosted by the Korean Meteorological Administration (KMA) for the purpose of improving understanding, measurement and prediction of snowfall over mountainous terrain. Eleven countries and 20 agencies participated. ICE-POP was sanctioned and facilitated by the World Meteorological Organization (WMO). The WMO has facilitated several of these types of experiments in the past, the last winter experiment being during the Sochi Olympics, and prior to that the Vancouver 2010 winter games. This is the first time that NASA has participated. ICE-POP provided a unique opportunity to examine the consistency between model, satellite and ground observed mountain snowfall amounts and to tie disagreements to the type and physics of the snow event.

Data Sources: Two Precipitation Imaging Package (PIP) instruments and two Micro Rain Radars (MRR) were shipped to South Korea for the campaign. ICE-POP will help provide GPM ground validation to characterize falling snow in mountainous terrain during the 2018 Winter Olympics.

Technical Description of Figures:
Top Left: NASA’s Precipitation Imaging Processor (PIP). The unit consists of a halogen light source and a video camera that captures falling precipitation at 400 frames per second over an area of 64 mm x 48 mm (640 x 480 pixels) with 0.1 mm resolution (Courtesy of Kwonil Kim, Kyungpook National University).
Bottom Left: Example of one frame of video showing multiple snow particles in the field of view. In this image the particles consist of mostly large aggregates.
Right: Analysis figures for a snowfall event case during ICE-POP on February 2, 2018. For each minute of precipitation, the basic data products are: a) visualization of falling particles; (b) a particle size distribution and (c) a fall speed distribution. The top left panel shows the time series of particle size distribution, where the colors represent the number of particles observed in each size bin (mm-1 m-3). The top right panel shows the precipitation rate and accumulations over time for both liquid, mixed and snow particles. The bottom left panel shows the measured fall speed of the snow particles. The fall speed of the snow flakes are compared to the theoretical terminal velocity of rain drops. Raindrops (water) fall at close to terminal velocity, whereas non-raindrops (particles that contain ice, such as sleet and snow) fall at slower speeds. This distinguishing trait is used to assign rain and non-rain classification to each size within a particle size distribution and to estimate the effective density “eDensity” of the precipitation particles.

Scientific significance, societal relevance, and relationships to future missions: NASA is interested in developing better measurements of mountain snowfall from space- this involves obtaining a better understanding the physics of snow that produce the signals we see with satellite remote sensors. In a connected fashion, we also want to investigate how improved understanding of snowfall might help improve weather prediction because one ultimate goal is to be be able to combine a forecast model snow amounts with satellite and available ground measurements to produce a highly accurate snowfall map. In a sense we are trying to ensure a triangle of consistency between ground observations, satellite measurements and model-predicted snowfall amount.
Assimilation of NASA Satellite Observations of Precipitation brings crucial information into modeling of West Africa Monsoon in data sparse regions

S.Q. Zhang, (Code 612,NASA/GSFC and SAIC), T. Matsui, (612 and UMD/ESSIC)
S. Cheung (UC-Davis), M. Zupanski (CSU/CIRA), C. Peters-Lidard (610)

NASA’s Global Precipitation Measurement (GPM) mission provides global coverage of precipitation observations. Assimilation of this data brings crucial information about precipitation and hydrological cycles into our Earth environment modeling systems and is particularly significant in data sparse regions. The experiments of assimilating GPM multi-sensor multi-channel precipitation-sensitive radiances into the NASA Unified Weather Research and Forecasting (NU-WRF) model show remarkable improvement to West African monsoon rain band location and intensity. It also has a better representation of continental tropical convective cloud systems that enhances the connection between tropical waves and storm initiation and propagation.

Storm observed by TRMM satellite

Modeling clouds and precipitation via assimilation of GPM data

Modeling West African monsoon rain band via assimilation of GPM data
References:


Data Sources:
NASA PMM multi-sensor calibrated microwave radiance (level-1C: TMI, SSMIS, SSMI, AMSR)
NOAA operational ground-based conventional data; AMSU-A clear-sky radiances; GOES-IR radiances.
NASA CloudSat radar reflectivity; NASA PMM level-2 retrievals

Technical Description of Figures:
Graphic 1 (left): A monsoon storm observed from space by NASA TRMM TMI, at 0600 UTC 13 August 2006, shown as brightness temperature depression (in blue shaded area) in TMI channel of 85 GHz (V), indicating a well organized convective storm.

Graphic 2 (middle): Vertical cross section of the model cloud and precipitation (in g kg$^{-1}$) from the storm area observed by TRMM in graphic 1. The model microphysics responds to the precipitation-sensitive radiance data assimilated in the region to produce well organized convective clouds and precipitation distribution that agrees with the observed storm structure and intensity. This result demonstrates the positive data impact to the monsoon convective storm modeling.

Graphic 3 (right): Accumulated precipitation 10 days after the monsoon onset. The precipitation-sensitive radiance data assimilated into the high-resolution NU-WRF improves the simulation of West Africa monsoon (WAM) precipitation. The WAM rain band has an accurate location and realistic intensity distribution, verified by independent observations in the region.

Scientific significance, societal relevance, and relationships to future missions:
The precipitation of the West African monsoon (WAM) not only provides vital water resources to the region, but also modulates tropical climate, influences the initiation of tropical cyclones and, is potentially impacted by global climate change. NASA’s Global Precipitation Measurement (GPM) mission provides crucial observations over the data sparse continent. We developed an innovative, ensemble-based data assimilation technique to optimally integrate a high-resolution numerical model prediction and observed precipitation-sensitive radiances from GPM constellation satellites, where the resulting forecast error covariance can propagate observation information into regions where it matters most: storms and severe weather areas. This data assimilation system developed for GPM science applications pioneered the direct assimilation of precipitation-sensitive radiances over land surfaces into cloud-resolving forecast, and results obtained from this study verified the positive data impact of precipitation-sensitive microwave observations. Satellite observations and cloud-resolving prediction models allow us to forecast and study the evolution of precipitating systems such as the WAM, providing timely data to impacted populations and expanding our knowledge of the Earth system. Cloud-scale dynamical models will benefit from the Clouds, Convection, and Precipitation targeted observable designated by the National Academies Earth Science Decadal Survey.
Long-term Satellite Data Suggest Models Underestimate Future Warming and Internal Variability

Tianle Yuan (UMBC), Lazaros Oreopoulos, Steven E. Platnick, Kerry Meyer, Code 613, NASA/GSFC

When sea surface temperature data are analyzed jointly with MODIS and ISCCP cloud data, a consistent positive low cloud feedback with distinct spatiotemporal patterns and physical meaning emerges. The results demonstrate the important role of low cloud feedback for internal climate variability and global warming. Most current models underestimate this feedback, and thus likely also internal variability and future warming.

Acronyms:
- IPO: Interdecadal Pacific oscillation
- MCA: Maximum covariance Analysis
- EIS: Estimated inversion strength
- LCC: Low cloud cover
- EOF: Empirical orthogonal function
References:

Data Sources: NASA MODIS low cloud cover, ISCCP bias-corrected low cloud cover, SST output from couple CMIP5 Global Climate Models, observed SST dataset HadSST, and low cloud cover processed through a satellite simulator from AMIP5 Atmospheric GCM integrations.

Technical Description of Graphic:
Top: Sea surface temperature anomalies corresponding to one standard deviation of expansion coefficients from Maximum Covariance Analysis (MCA), representing the Interdecadal Pacific Oscillation (IPO), a long-term oscillation of sea-surface temperatures in the Pacific Ocean that can last from 20 to 30 years. Middle: The same for low-cloud cover (LCC) using 36 years of International Satellite Cloud Climatology Project (ISCCP) data. Bottom: Time series of the indices of IPO, and of the MCA-derived spatial patterns of SST (middle) and LCC (bottom), all highly correlated.

Scientific significance, societal relevance, and relationships to future missions:
Our research uses NASA observations to show current state-of-the-art models underestimating critical cloud feedback and implies future warming may be stronger than current consensus estimates. It also suggests that for unearthing cloud feedbacks, it is critical to have long time series of cloud properties from satellite observations.