Making Better Estimates of Extreme Precipitation with TRMM Data

L. Demirdjian\(^1\), Y. Zhou\(^2,3\), G.J. Huffman\(^4\)

\(^1\)UCLA, \(^2\)Morgan State Univ., \(^3\)NASA/GSFC 613, \(^4\)NASA/GSFC 612

Average Return Interval precipitation estimates extracted from 16 years of the TRMM Multi-satellite Precipitation Analysis in the new Point Process analysis are closer to the 65-year NOAA/Climate Prediction Center rain gauge map than the values produced by the previous Zhou et al. Generalized Extreme Value analysis.
References:


Data Sources: Version 7 TRMM Multi-satellite Precipitation Analysis (TMPA; using precipitation estimates from Aqua, DMSP, METOP, NOAA, and TRMM satellites, and the Global Precipitation Climatology Centre monthly precipitation gauge analyses), and NOAA/Climate Prediction Center (CPC) Average Return Interval (ARI) maps. Support was provided by a Burroughs Welcome Fund Population and Laboratory Based Sciences Award at UCLA, the NASA/GSFC internship program, NASA PMM, and NASA Terra/Aqua.

Technical Description of Figures:
The new Point Process (PP) statistical model was developed to address perceived issues in the initial Zhou et al. (2015) extreme value analysis. That study fitted a Generalized Extreme Value (GEV) probability distribution to the set of annual maximum daily precipitation accumulations that TMPA provided in each latitude/longitude grid box separately. This approach gave relatively noisy estimates for ARIs longer than the 16-year data record (lower right) when compared to the NOAA/CPC analysis of daily precipitation gauge data (upper right). [The CPC analysis uses 65 years of data over some 8,000+ stations, and is considered the standard of comparison.] In the new study, the entire domain was partitioned into clusters of about 30 gridboxes based on the 90th percentile daily precipitation, and then event-maximum daily values (for days exceeding the 99th percentile) were pooled. A PP analysis was used to create fitted extreme parameters for each cluster. The PP results are relatively smooth and close to the NOAA/CPC analysis. Despite a better overall pattern, the PP generally gives somewhat higher values than the CPC in the eastern half of the country.

As well, a version of the PP was created to account for the seasonal cycle so that it is possible to evaluate events in the context of “typical” for the time of year. [The previous study lacked this capability.] The eastern part of the U.S. showed a relatively modest seasonal cycle in ARI values, but the Southwest, and California, in particular, showed strong seasonality, as expected.

Scientific significance, societal relevance, and relationships to future missions: Although demonstrated here just for the Coterminous United States, the analysis has been performed for the entire latitude belt 50°N-S, providing extreme value estimates for all areas, land and ocean, without regard to the density of surface observations. The new estimation approach makes much better use of the available short record of satellite data, giving much more confidence in the values provided. Such information is critical for for scientifically and practically evaluating current and previous precipitation events. As well, it supports the definition of design standards for infrastructure, including siting buildings, laying out transportation grids, and sizing water management projects. When the new Integrated Multi-satellite Retrievals for Global Precipitation Measurement (GPM) mission (IMERG) datasets are extended to cover both the TRMM and GPM eras, this methodology will be directly applicable.
Over Arctic sea ice, aerosol microphysical effects in thin, predominantly liquid clouds decrease cloud droplet size, optical depth, and occurrence of precipitation and mixed-phase clouds

L. Zamora\textsuperscript{1,2}, R. Kahn\textsuperscript{1}; \textsuperscript{1}Code 613 NASA/GSFC, \textsuperscript{2}ESSIC

Differences between clean and aerosol-polluted clouds were identified over Arctic sea ice using CALIPSO/CloudSat data and an aerosol transport model. We focused on a small subset of susceptible nighttime clouds with high confidence in aerosol conditions. Microphysical effects were varied and were larger over sea ice than over open ocean. This is a preliminary step toward a first regional observation-based estimate of aerosol indirect effects on the Arctic surface.
References:

Data Sources: Most data in this study were obtained from CALIPSO and CloudSat. Information from the NASA ARCTAS campaign and output from the FLEXPART aerosol transport model and SBDART 1-D radiative transfer model were also used.

Technical Description of Figures:
*Left figure:* Profile locations over the Arctic Ocean of the cloud subset studied here, which consists of thin, nighttime, predominantly liquid clouds over the Arctic Ocean, in a) clean background conditions, b) all conditions, and c) polluted conditions.

*Right figure:* CALIPSO and CloudSat data showing examples of median cloud subset characteristics in clean (blue), all (grey) and polluted (orange) conditions over sea ice. The cloud properties under clean conditions were significantly different at the 95% confidence level. Bars denote the interquartile range of the data. Cloud droplet effective radius, and percent precipitating and mixed phase cloud occurrence data were only available for clouds with bases > 750 m above sea level and with CloudSat reflectivities > -29 dBZ.

Scientific significance, societal relevance, and relationships to future missions:
The Arctic is changing rapidly. Currently, our ability to predict future changes is hampered, in part, by both a poor understanding of Arctic cloud-aerosol interactions, which affect the regional energy budget, and the inability of models to accurately represent key Arctic cloud properties. Here, we studied the approximately 5% of clouds over the Arctic Ocean for which aerosol conditions were determined with highest confidence (i.e., nighttime, predominantly liquid, optically thin clouds). Clouds in this subset were sensitive to the aerosols, particularly over sea ice. For example, such thin clouds can precipitate over the Arctic given the extremely cold temperatures, but over sea ice, polluted clouds in the subset precipitated less. The polluted, thin clouds also contained fewer observable ice particles. These findings suggest that aerosols might affect freezing, which is useful information for those seeking to represent the cloud droplet freezing mechanisms in regional climate models. Quantifiable reductions in cloud optical depth would impact cloud emissivity. All else being equal (e.g., assuming standard temperature profiles), this effect suggests that aerosols may reduce regional-scale cloud-based surface heating by up to 8% over sea ice, excluding cloud fraction effects. Aerosol-cloud interactions were less significant over open ocean. Although we focused on a very small subset of all clouds and did not assess aerosol impact on cloud fraction, these results are an important early step toward obtaining the first observation-based estimate of regional cumulative aerosol indirect effects on the Arctic surface. This information is critically needed for constraining models of the Arctic energy balance. Our findings also highlight the need to continue developing active sensors and high quality aerosol modeling over polar regions, and they will provide valuable context for future aircraft campaigns in the Arctic.

Earth Sciences Division - Atmospheres