In Situ Precipitation Dataset in High Latitudes of the Northern Hemisphere

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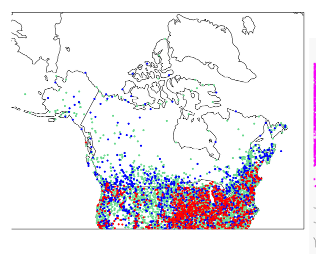
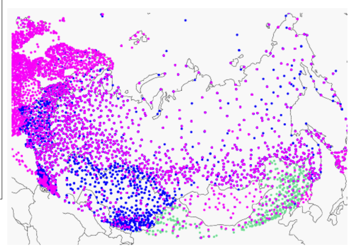
Part 1. Building up the Precipitation DataSet for the Northern Extratropics

Meteorological stations north of 40°N (Eurasia) and 30°N (America)



Long-term meteorological stations in North America (~40 years). Stations depicted by red dots have more than 100 and by blue dots have more than 60 years of data.

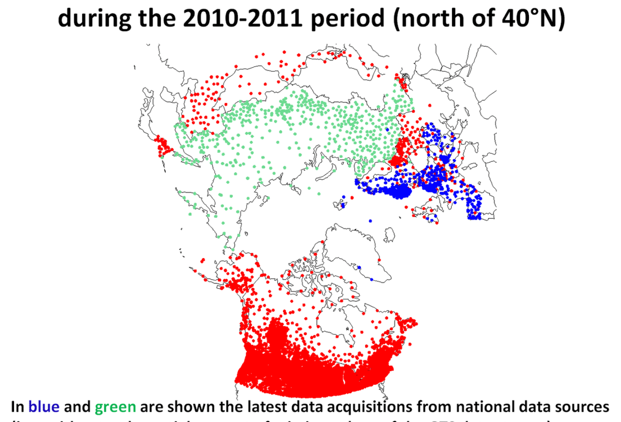


Meteorological stations in Northern Eurasia. Stations depicted in pink color are those included in the WMO-A list.

Global Historical Climatology Network-Daily (GHCND, v. 2)

- This global data set was significantly reworked in 2011 by NCDC. P. Groisman transferred into this data set all his national daily data holdings for the former USSR, Canada, Mexico, Russia, Ukraine, Belarus, and Uzbekistan. But, only for the USA and (to some extent) for Canada, NCDC has been receiving late reports and national updates beyond the GTS network. For example:
  - For Russia in 2011, NCDC got daily data only for 438 of 985 stations and most of those that arrived have numerous missing days making the calculations of monthly precipitation totals unreliable. Prior to 2000 (when we got national archive of this country), the same Russian stations had practically no missing daily data.
  - For Norway, from ~200 stations received within this project, GHCND includes only 21 stations (8 of them have data for 2011 each having numerous missing values).
- Remedy:
  - Joint work within NOAA-Roshydromet to continue high-quality archived data exchange (in Nov.2011 NCDC will host the RIHMI-WDC delegation where plans for such exchange will be ratified and expedited for the data exchange for the 2001-2010 period) and
  - Immediate operative SYNOP data exchange for CIS between NCDC and the HydrometCentre of Russia that has been negotiated under the auspices of the NEESPI program by P. Groisman.
  - recent GHCND collaboration with the EU international meteodata bank (Dr. Klein Tank, The Netherlands) increased the GHCND data holdings in Europe by 1018 additional stations.

High latitude stations available in GHCN-D during the 2010-2011 period (north of 40°N)



In blue and green are shown the latest data acquisitions from national data sources (i.e., without substantial amount of missing values of the GTS data stream)

Current work on bias-adjustments

Canada: A near real-time daily and monthly time series are generated for an operational subset of the national data for the needs of the North American drought monitoring at NCDC. At the same time, a comprehensive data set is being accumulated with a 1-2 years time lag.

USA: This project. Work is based on US Climate Reference Network.

Russia: The work is being conducted within the framework of three funded projects:

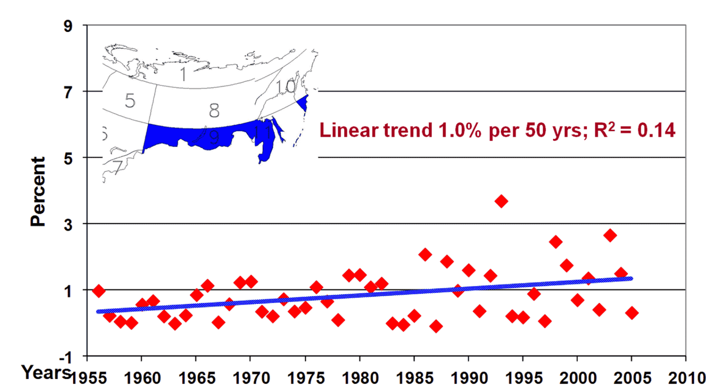
- "Precipitation time series homogenization over the Commonwealth of Independent States (CIS) and Baltic States during the period of instrumental observations…" (2011-2013). PI: O. Bulygina (RIHMI, Obninsk, Russia), Co-Is A. Mescherskaya and E. Bogdanova (VMGO, St. Petersburg, Russia). Funded by Roshydromet.
- "The nature of extreme precipitation over Europe and North America" (2012-2013). PI: S. Gulev (RAS IO, Moscow, Russia), Co-I: Groisman. Funded by Russian Dept. of Science and Education in the framework of US-Russia Bilateral Presidential Commission (BPC) on Scientific Collaboration.
- "North Eurasia Earth Science Partnership Initiative (NEESPI) Project Scientist Service". PI: P.Groisman. Funded annually by the NASA LCLUC Program.

Part 3. Dataset of Scientific Quality: Supporting Studies of Precipitation Changes in the Northern Extratropics

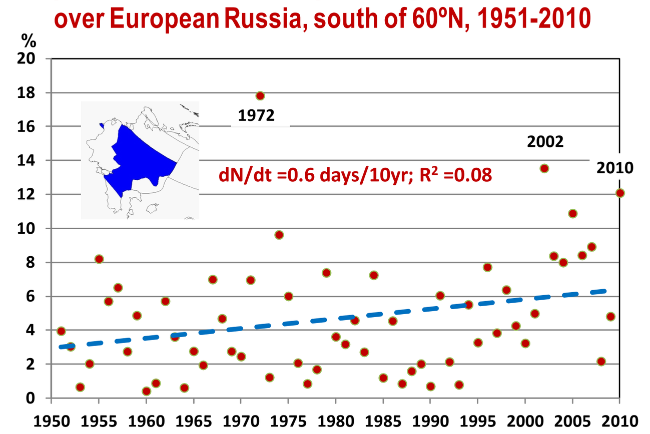
Related references:

- Groisman, P.Y., Gutman, G., and Reissell A., 2011: Chapter 1. Introductio and Land-Cover Changes in the Arctic, In: Gutman, G. and A. Reissell (e land cover and land use in a changing climate: Focus on Eurasia. VI, Spr Amsterdam, The Netherlands, 306 pp.
- Groisman P.Y. and V.I. Lyalko (eds), 2011: "Earth System Change over Eas Europe". Naukova Dumka Publ. House, Kiev, Ukraine (in English).
- Zhang, X., J.Wang, F.W. Zwiers, and P.Ya. Groisman, 2010: The influence o scale climate variability on winter maximum daily precipitation over No America. J. Climate, 23/11, 2902-2915.
- Shi, X., P.Ya. Groisman, S.J. Déry, and D.P. Lettenmaier, 2011: The role of energy fluxes in pan-Arctic snow cover changes. Environ. Res. Lett., 6, doi:10.1088/1748-9326/6/3/035204, (8pp).
- Walsh, J.E., J.E. Overland, P.Y. Groisman, and B. Rudolf, 2012: Ongoing C Change in the Arctic. Ambio (in press)
- Groisman P.Y. and G. Gutman (Eds.) 2012: "Environmental Changes in Si Regional Changes and their Global Consequences" The book is to be sub Springer Publishing House this autumn.

Dry episodes above 30 days during the warm season over Asian Russia east of 85°E, south of 55°N



Dry episodes above 30 days during the warm season over European Russia, south of 60°N, 1951-2010



Changes of the maximum snow water equivalent over Russia (Bulygina et al. 20

Zone, region	Change in 1967-2010
• Arctic	No changes
• Fields of European Russia, north of 55°N	Increase by 4 to 6%/10yr
• Southeast of "-"-"-"-"-" (ER)	Decrease by 4.5%/10y
• Steppe-forest steppe of ER	No changes
• Fields of West Siberia	Increase by 6%/10yr
• Central East Siberia	Slight increase
• South of East Siberia	No changes
• Fields of Russian Far East	Increase by 3 to 6%/10yr

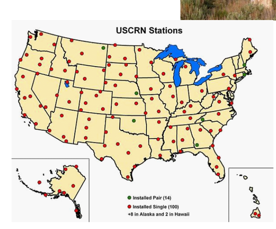
Part 2. Precision and Biases of Precipitation Measurements; Internal Structure of the Point Rainfall Information; Constrains for Frozen Precipitation

Related references:

- Palecki, M.A. and P. Ya. Groisman, 2011: Observing Climate at High Elevations Using United States Climate Reference Network Approaches., *J. Hydrometeorol.* **12**, 1137-1143.
- Groisman, P. Ya., R. W. Knight, and T. R. Karl, 2011: Changes in Intense Precipitation over the Central U.S. *J. Hydrometeorol.* (in press; currently is available online)
- Groisman, P. Ya, Peck, E.L., and Quayle, R. G., 1999: Intercomparison of recording and standard non-recording U.S. gages. *J. Atmos. Oceanic Technol.* , **16,** No. 5, 602-609.
- Bogdanova, E.G., B. M. Ilyin, and I. V. Dragomilova, 2002: Application of a Comprehensive Bias-Correction Model to Precipitation Measured at Russian North Pole Drifting Stations. *J. Hydrometeorol.*, **3**, 700-713.
- Bulygina, O.N., P.Ya. Groisman, V.N. Razuvaev, and N.N. Korshunova, 2011: Changes in Snow Cover Characteristics over Northern Eurasia since 1966. *Environ. Res. Lett.*, **6**, 045204, doi:10.1088/1748-9326/6/4/045204 (10pp)

US Climate Reference Network

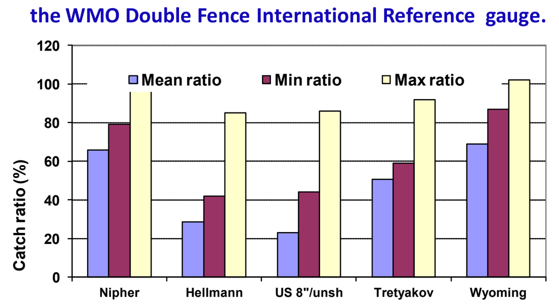
Intercomparison of the US COOP and HPD precipitation data with USCRN is on the way.



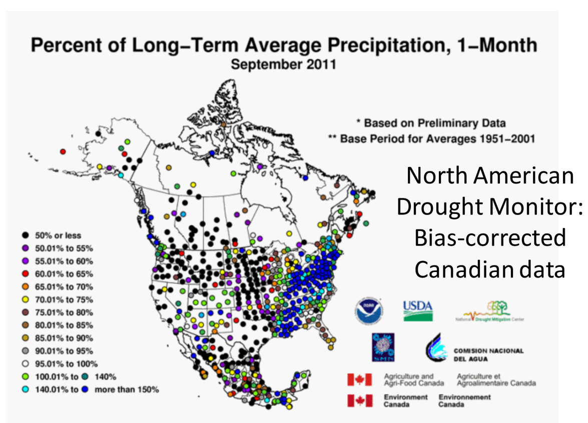
- The USCRN station near Montrose, CO. Note the triplicate configuration of shielded and aspirated platinum resistance thermometers on the tower at left, and a weighing bucket gauge with triplicate wires for measuring precipitation amount inside the small double fence intercomparison reference fencing on the right.

International rain gauge testing at the Barrow experimental site.

Mean snow catch ratios (%) versus the WMO Double Fence International Reference gauge.

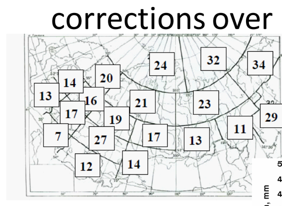


Canadian Nipher-shielded, German Hellmann, Russian Tretiakov, and US unshielded and Wyoming-shielded 8" rain gauges were tested.



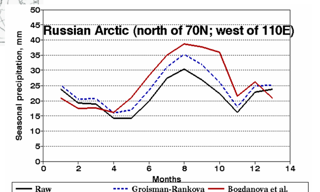
North American Drought Monitor: Bias-corrected Canadian data

Size of precipitation bias corrections over Northern Eurasia

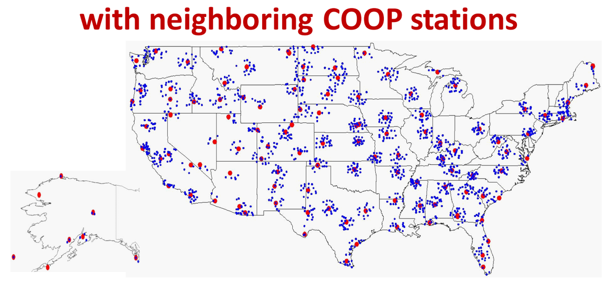


Increase (%) in mean annual precipitation totals throughout the former USSR compared to measured precipitation

Largest and very specific biases in precipitation measurements are in the Arctic (as well as in the steppe and coastal areas) where wind gauge undercatch competes with blow-in during snow flurries.



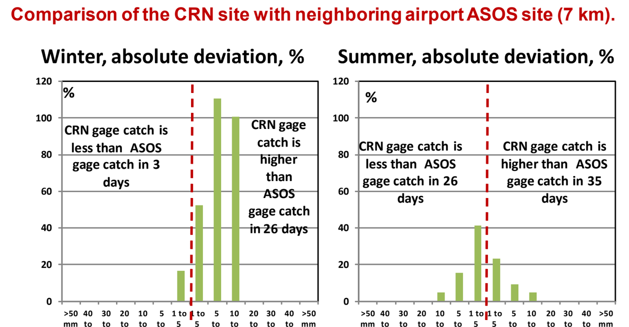
Intercomparison of US CRN (red dots) with neighboring COOP stations



- We shall interpolate COOP station data onto the CRN sites, bias-adjust the result of the interpolation, and (a) develop regional gridcell clusters of bias-corrected precipitation and (b) construct transfer functions for daily precipitation measured by each new type of the US rain gauges.
- Next four panels show examples of initial comparison.

Barrow, Alaska

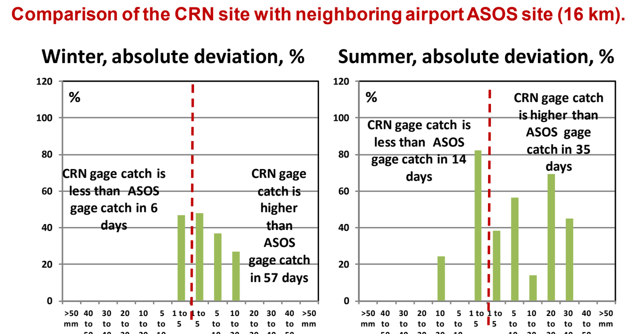
Comparison of the CRN site with neighboring airport ASOS site (7 km).



Deviations from the CRN daily precipitation were sorted within the precipitation intensity bins and by their signs; then they were normalized by the mean bin P.

Lander, Wyoming

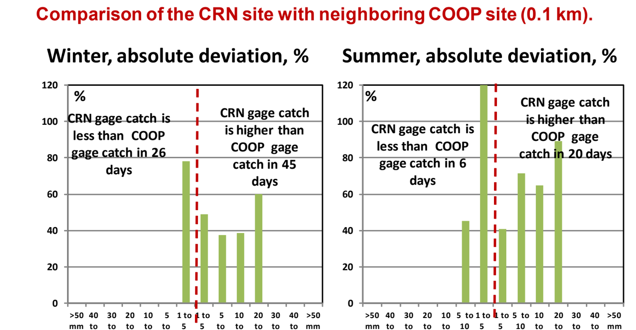
Comparison of the CRN site with neighboring airport ASOS site (16 km).



Deviations from the CRN daily precipitation were sorted within the precipitation intensity bins and by their signs; then they were normalized by the mean bin P.

Murphy, Idaho

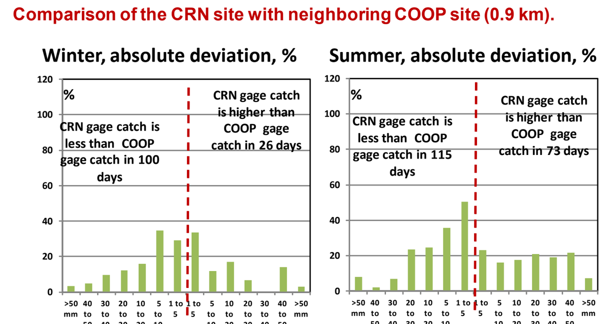
Comparison of the CRN site with neighboring COOP site (0.1 km).



Deviations from the CRN daily precipitation were sorted within the precipitation intensity bins and by their signs; then they were normalized by the mean bin P.

Asheville, North Carolina

Comparison of the CRN site with neighboring COOP site (0.9 km).

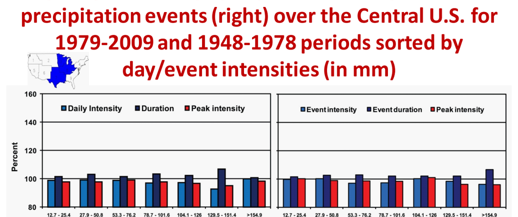


Deviations from the CRN daily precipitation were sorted within the precipitation intensity bins and by their signs; then they were normalized by the mean bin P.

Lowest reporting values, internal structure

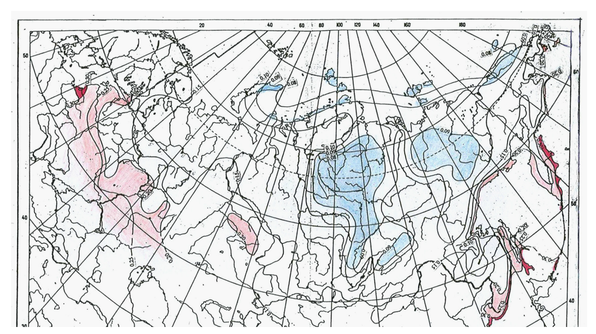
- Canadian gauges: 0.2 mm; up to 70% of days with precipitation are reported as traces in the Canadian Arctic
- Russian Tretiakov gauge: 0.1 mm; wetting adjustment makes traces infrequently reported even in the Arctic.
- US COOP and ASOS gauges: 0.01" = 0.24 mm (historically, 0.01" reports were not consistent with time; increased)
- US Climate Reference Network - 0.2 mm; no trace reporting.
- Most of the US Hourly Precipitation Network (HPD): 0.1" = 2.4 mm; a residual fraction of the HPD (about 20%): 0.01" = 0.24 mm.
- Next slide demonstrates that with time (as well as with global and/or regional warming and ENSO state changes; not shown), the internal structure of hourly precipitation over CONUS (peak intensity, duration, mean intensity) remains unchanged within nation' regions and daily intensity bins.

Comparison of mean and peak intensity and duration of hourly precipitation for intense precipitation days (left) and multi-day intense precipitation events (right) over the Central U.S. for 1979-2009 and 1948-1978 periods sorted by day/event intensities (in mm)



Estimates of precipitation characteristics for these 31-yr periods were averaged and their ratios (in percent per station) are shown

Mean intensity of frozen precipitation, I, mm h^{-1}



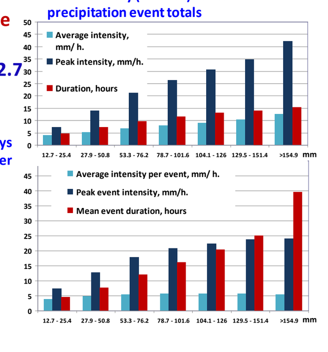
Blue areas: I < 0.09 mm h^{-1}; Pink areas: I > 0.2 mm h^{-1}; Red areas: I > 0.3 mm h^{-1}. Estimates are based on sub-daily snowfall and synoptic information.

Precipitation duration in the extratropics estimated by recording gauges in Northern Eurasia and the United States. Only intense daily events (>12.7 mm) are considered for the U.S.

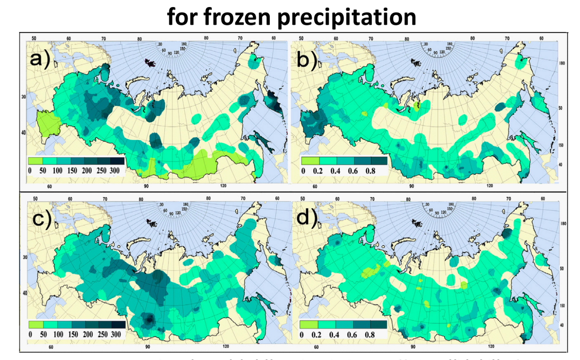
Mean rainfall duration in July days with precipitation over the former USSR (hours)

- Kamchatka 8 - 9
- Russian Arctic 7 - 8
- Forest and steppe zones of N. Eurasia 2 – 5
- Central Asia 0.5 - 2

Climatology for the contiguous U.S. of various characteristics of hourly intense precipitation as a function of daily (top) and multi-day (bottom) intense precipitation event totals



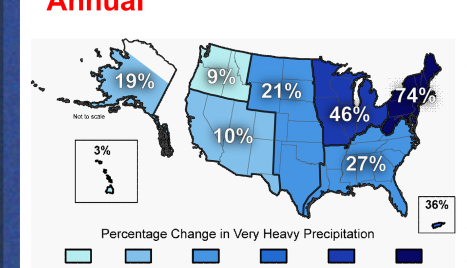
Snow water equivalent as an independent constraint for frozen precipitation



- Long-term mean values (mm; (a), (c)) and variation coefficient ((b), (d)) of maximum snow water equivalent in the field ((a), (b)) and in the forest ((c), (d)) (1966–2010) [Bulygina et al. 2011].

Part 4. Emergency Reactions to the NOAA Leadership Requests

Observed Increases in Very Heavy Precipitation during the 1958 to 2010 period (USGCRP 2009)

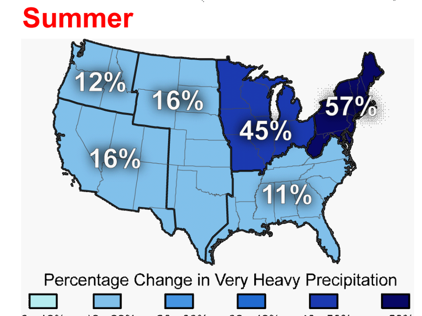


Percent increases in the amount falling in very heavy rain events defined as the heaviest 1 percent of all daily events from 1958 to 2010 for each region

Changes in the Eastern half of the nation are statistically significant at the 0.05 or higher levels and over the Great Plains, at the 0.1 level

Observed Increases in Very Heavy Summer Precipitation during the 1958 to 2011 period

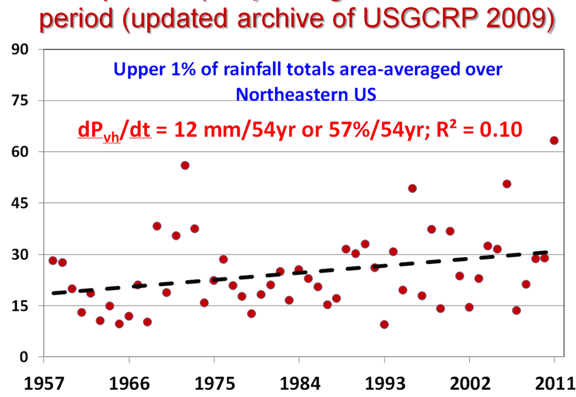
(archive of USGCRP 2009 updated)

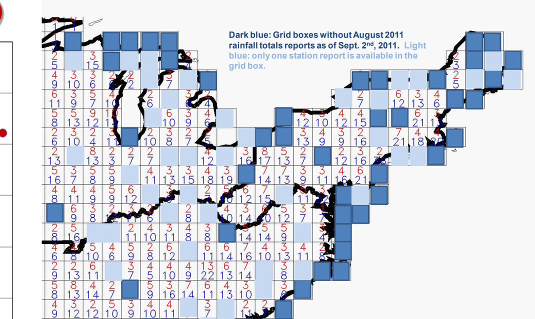


Percent increases in the amount falling in very heavy rain events defined as the heaviest 1 percent of all daily events from 1958 to 2011 in the summer season for each region

Changes over the northcentral and northeastern parts of the nation are statistically significant at the 0.01 and 0.05 levels respectively; all other trends are insignificant

Observed Changes in Very Heavy Summer Precipitation (mm) during the 1958 to **2011** period (updated archive of USGCRP 2009)





Future Steps/Objectives

- Keep our data sets updated
- Develop a suite of grid cells across the northern extratropics with bias-adjusted precipitation with known errors of regional representativeness
- Continue servicing NOAA and international Earth Science community with our data and the information about climate changes in the Northern Extratropics
- Taking into account that the initial GPM algorithm will not rely upon the mass in situ data, be prepared (when the first GPM products will be available) to test them across the extratropics and, in collaboration with the GPM team, assess these products and (if needed) suggest algorithm improvements