Gauge Precipitation and Snow Depth Measurements

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Status of Observations

- **Gauge network**: global coverage with various operational, national/regional networks.
- **Gauge network data:** long-term and fundamental, defining global snowfall/climate regimes and changes.
  - Manual and automatic gauges, measuring water equivalent (amount), not snow particle size.
  - Manual gauges can measure snowfall (rate) at 6-hour to daily time intervals, and auto gauges can provide hourly (or sub-hourly) snowfall (rate).

- **Snow rulers / snow depth sensor:** snowfall observations at the national/regional networks, providing snow depth info, not SWE.

- **Snow pillow/snowboard:** snow accumulation changes over time - (in)direct measurement of snowfall.

Arctic Precipitation Issues

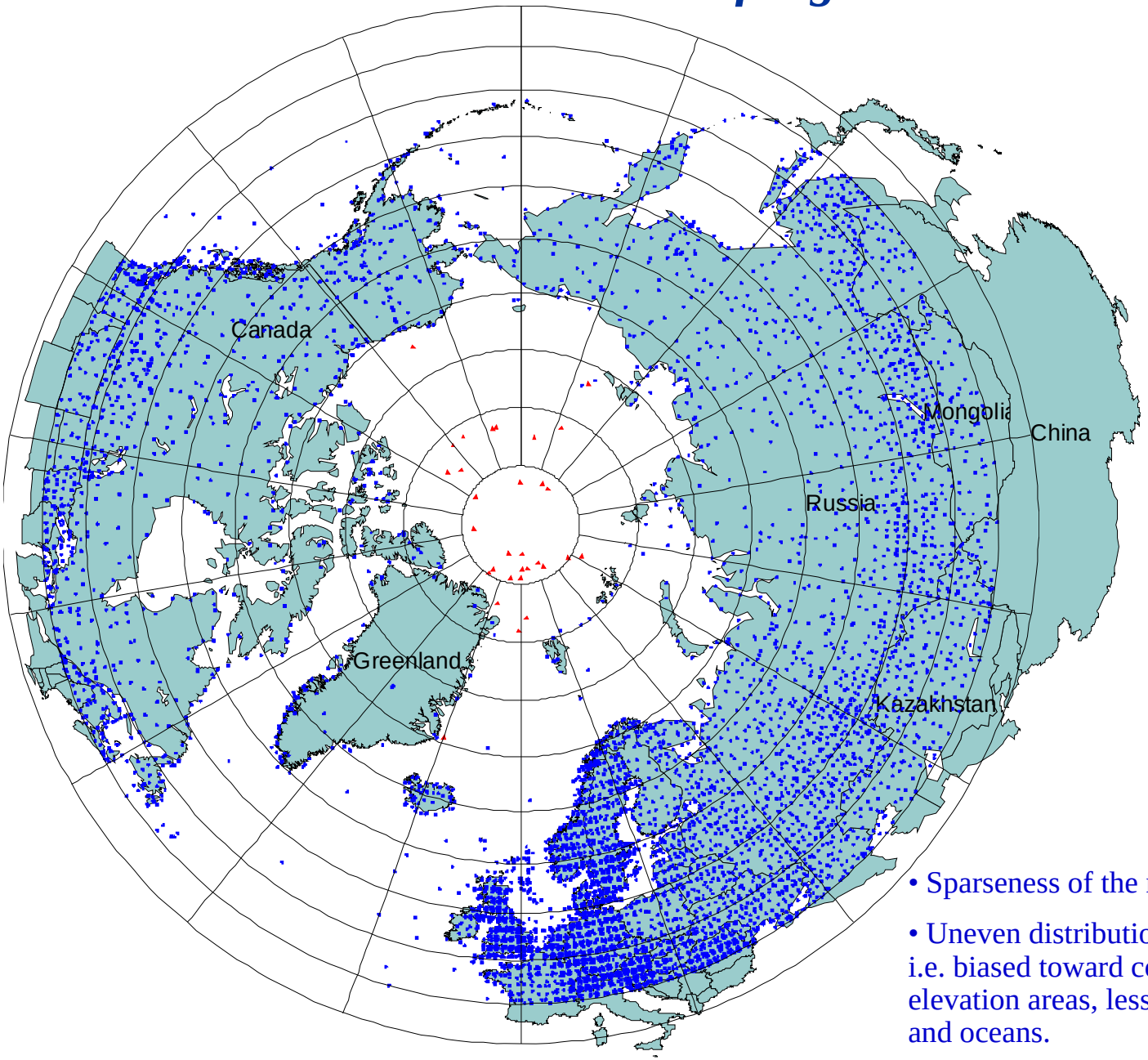
- *Operational networks – our knowledge base*
  - *Decline of the networks in the northern regions, including Siberia, Alaska and N. Canada*
  - *Few stations in the mountain regions*
  - *How to sustain and improve the operational networks*

- *Data quality and compatibility across national boundaries*
  - *Large biases in gauge measurements of solid precipitation*
  - *Incompatibility of precipitation data due to difference in instruments and methods of data processing*
  - *Difficulties to determine precipitation changes in the arctic regions*

- Validation of precip data, including satellite and reanalysis products and fused products at high latitudes.

Various networks

Synoptic/climate stations on land above 45°N and the Arctic Ocean drifting stations



- Sparseness of the networks.
- Uneven distribution of measurement sites, i.e. biased toward coastal and the low-elevation areas, less stations over mountains and oceans.

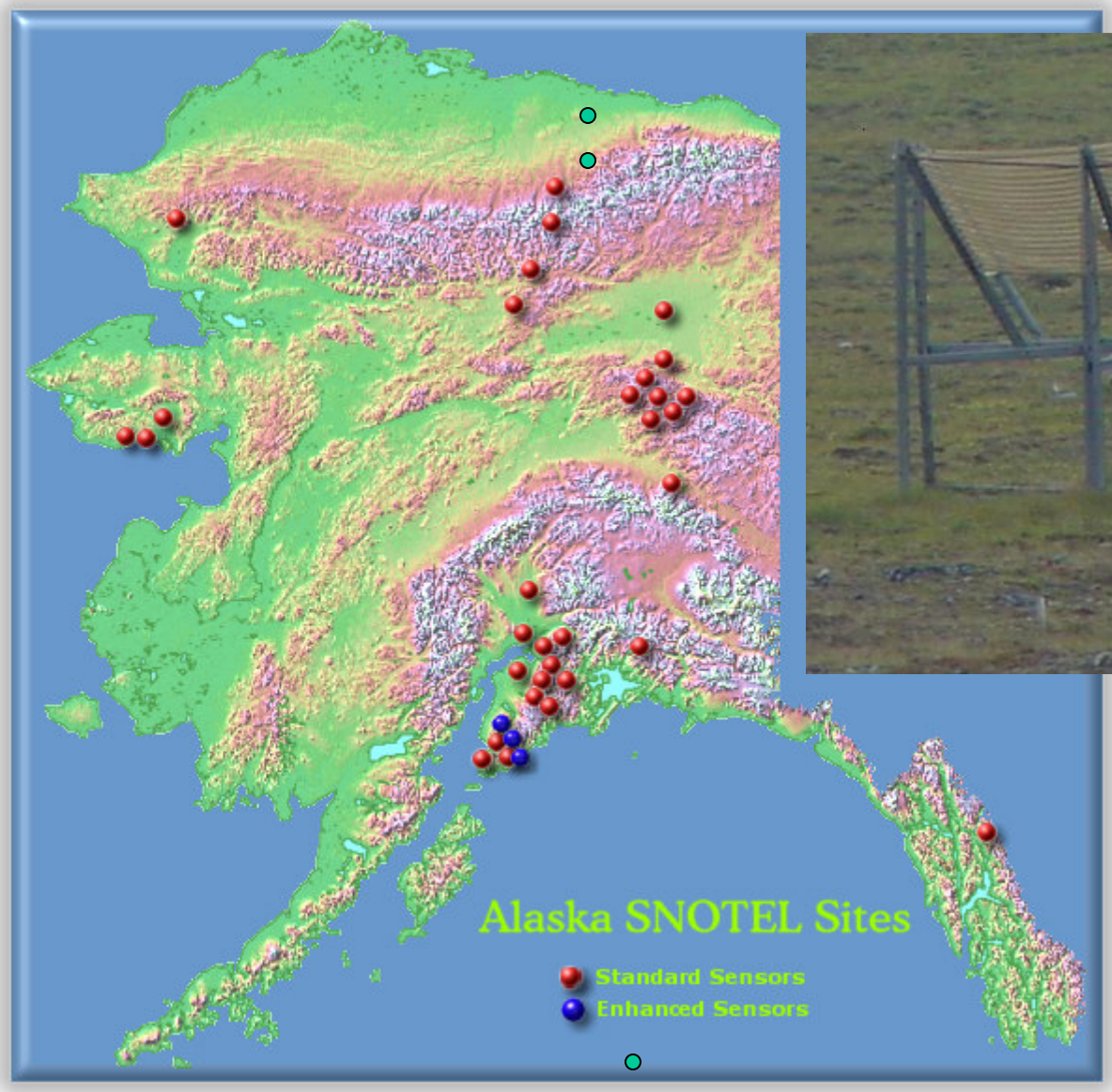
NWS Climate Station Network

http://climate.gi.alaska.edu/Stations/Arctic/index.html

AMBLER (1994 - 95)	HAPPY VALLEY CAMP (1970 - 77)	POINT HOPE (1924 - 82)
AMBLER WEST (1981 - 92)	KILLIK (1981)	PRUDHOE BAY (1986 - 99)
BARTER ISLAND AP (1947 - 1988)	KIVALINA (1973 - 75)	**SAG RIVER DOT (2000 - present)**
CANDLE (1903 - 50)	KOBUK (1953 - 79)	SELAWIK (1953 - 55)
CAPE THOMPSON (1960 - 63)	**KUPARUK (1983 - present)**	SHISHMAREF (1919 - 1973)
COLVILLE VILLAGE (1996 - present)	LONELY (1977 - 81)	SHUNGNAK CAA (1949 - 1950)
DEADHORSE AIRPORT (1999 - present)	NOATAK (1917 - 24)	UMIAT ARPT (1945 - 2001)
GALBRAITH (1970 - 80)	NOORVIK (1997)	WAINWRIGHT (1935 - 1968

US NWS 8" precipitation gauge

NRCS SNOTEL / Wyoming gauge network

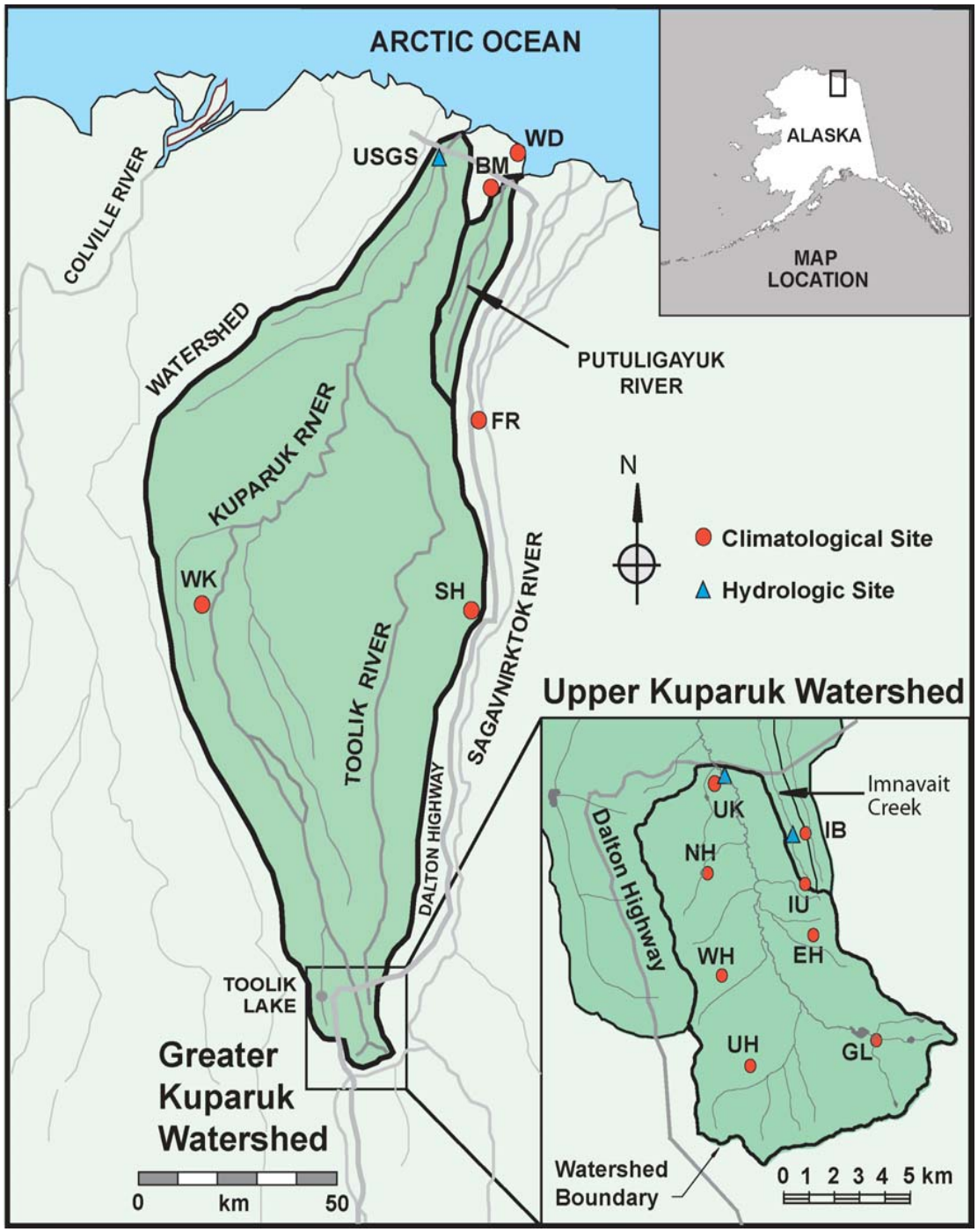


NRCS National Water and Climate Center

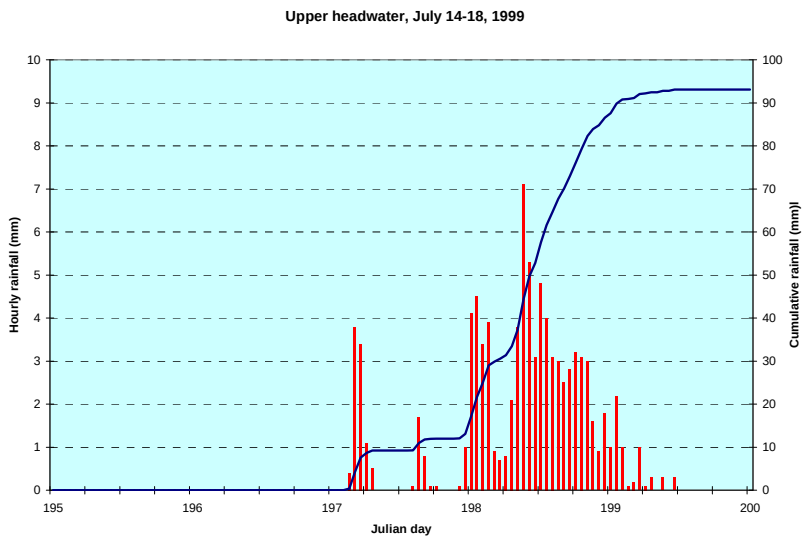
*www.wcc.nrcs.usda.gov/**snotel**/Alaska/alaska.html*

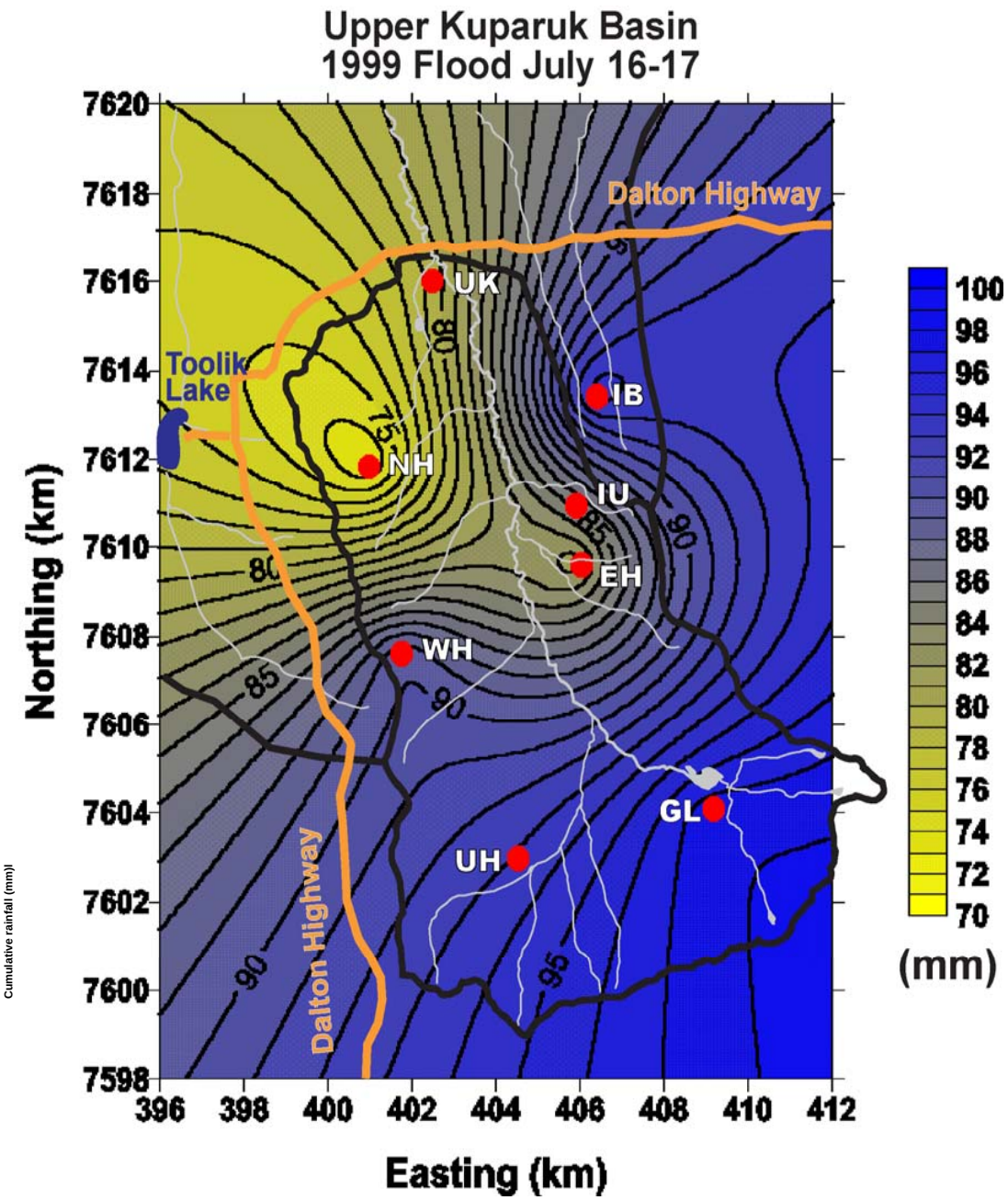
UAF/WERC Kuparuk basin rain gauge stations

http://www.uaf.edu/water



Heavy rainfall events in summer of 1999

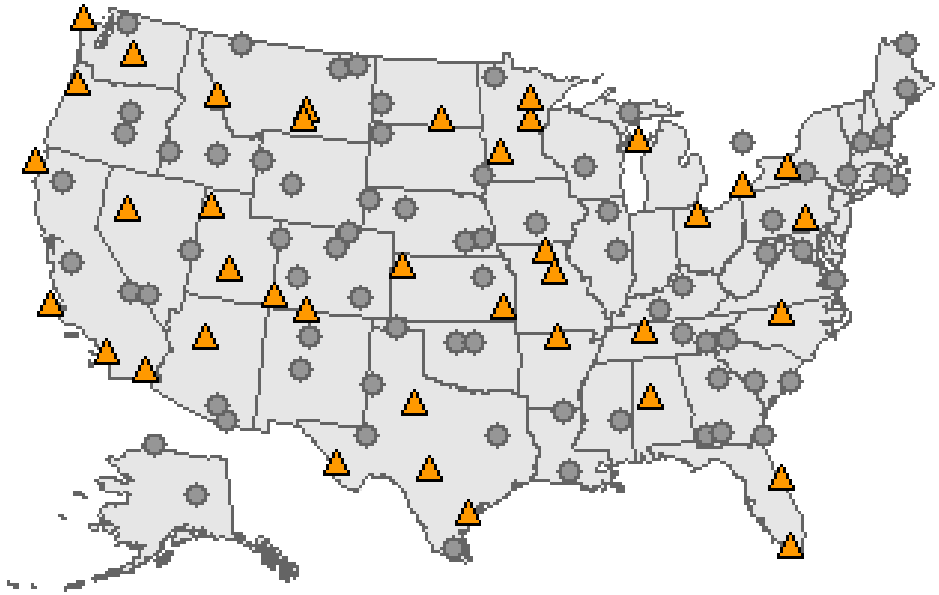




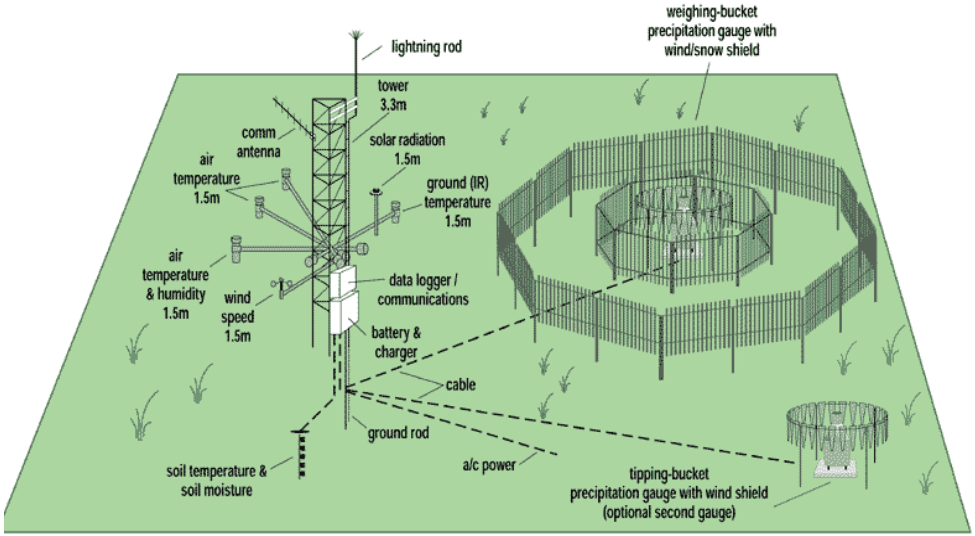
NOAA US CRN

US Climate Reference Network

http://www.ncdc.noaa.gov/oa/climate/uscrn/

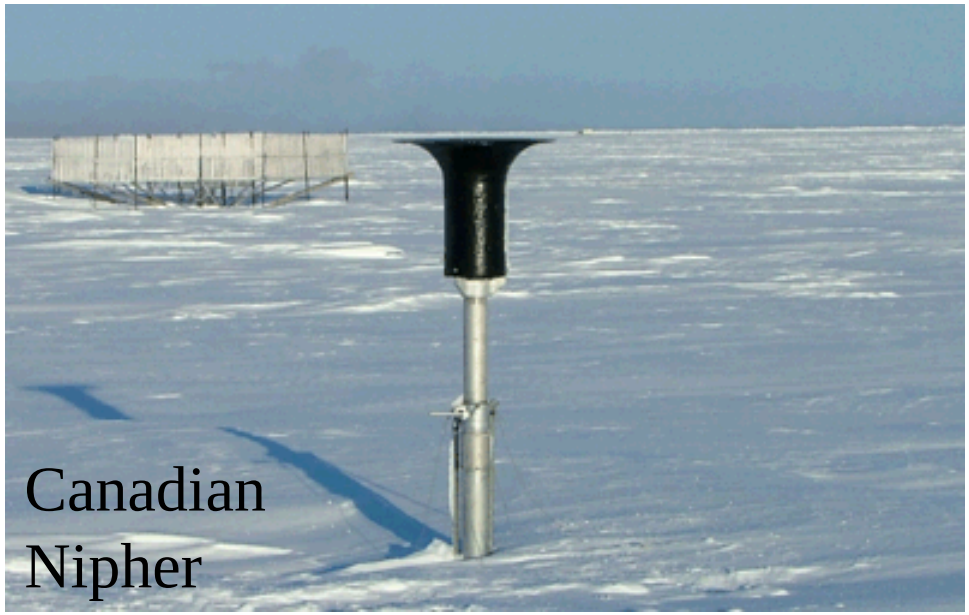


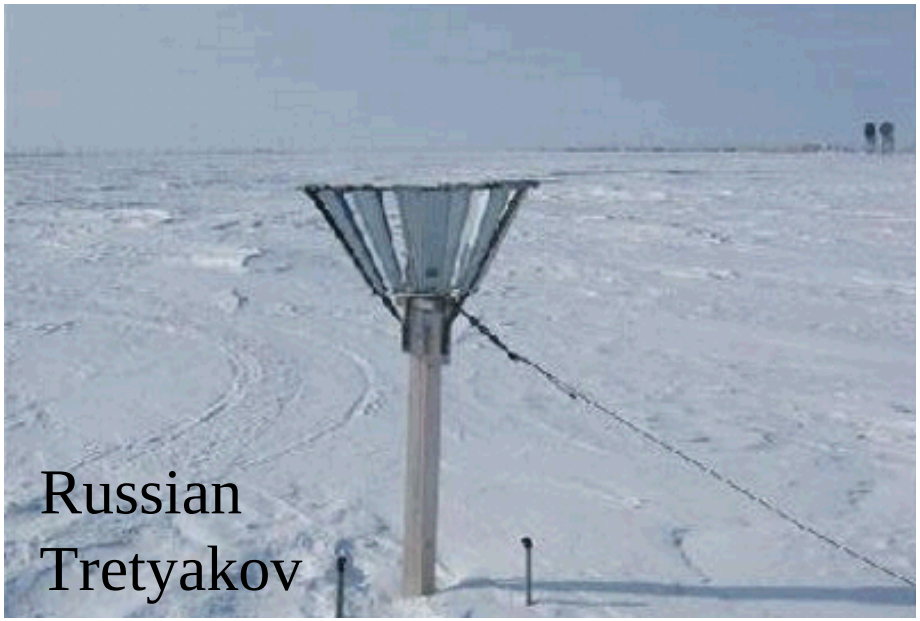
Proposed Typical CRN Station Configuration

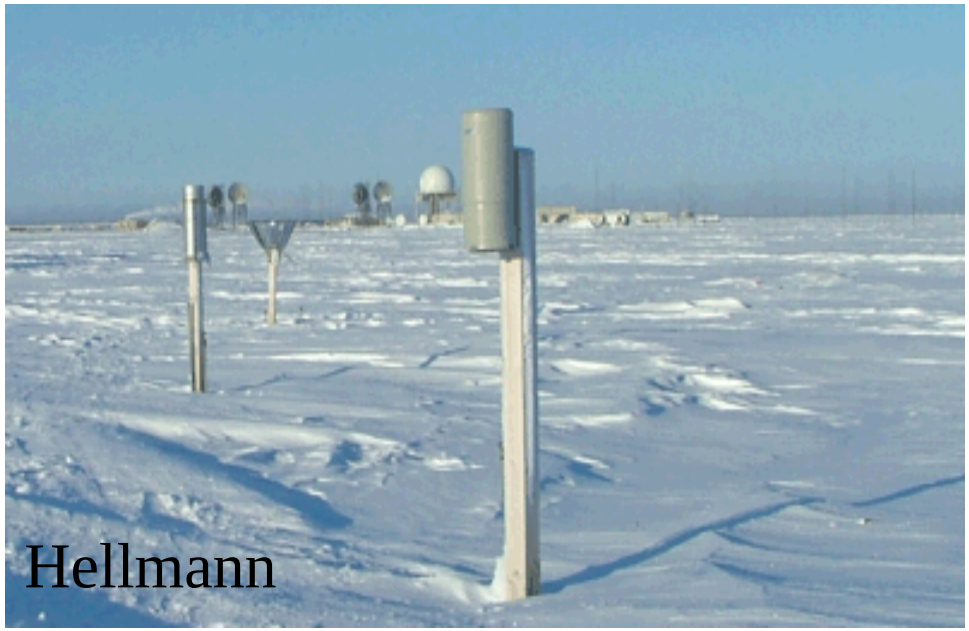


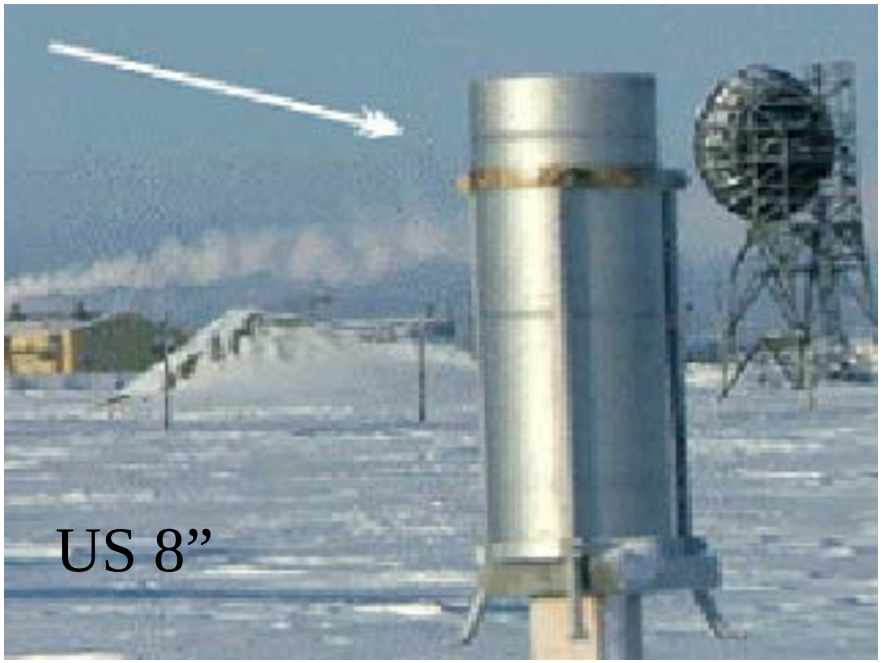
Various gauges and snow fences

National standard gauges tested in Barrow









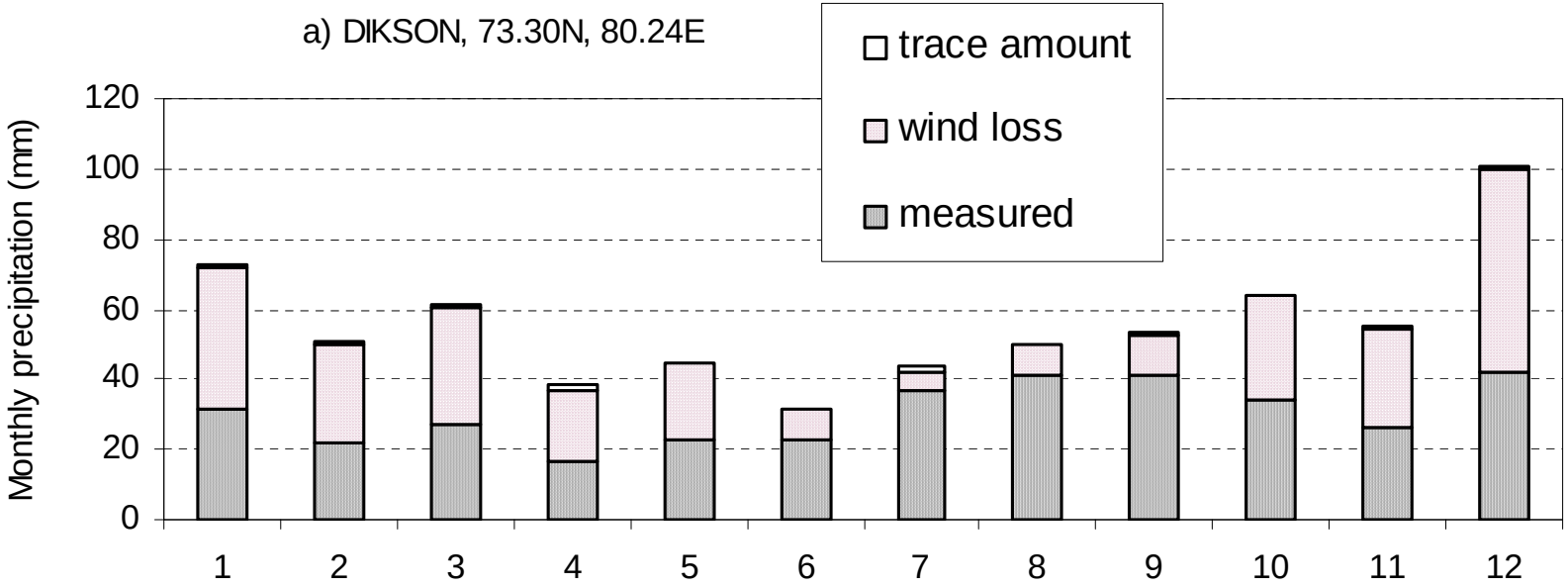
Blowing snow impact: blocking snow fence

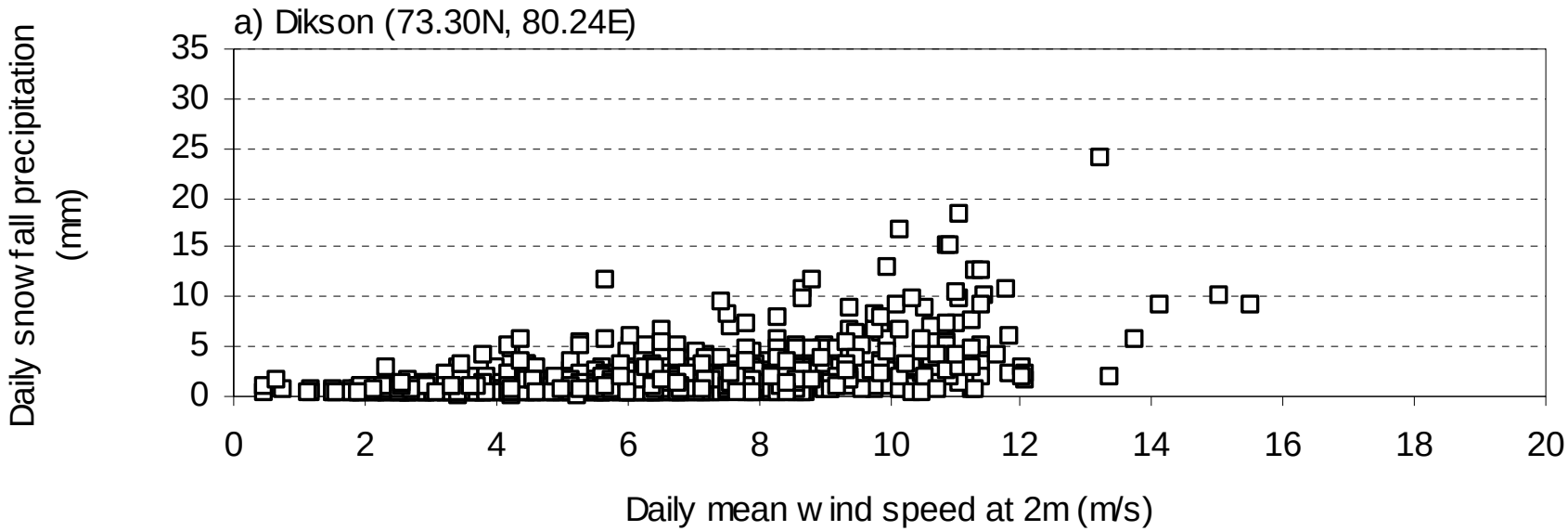
Blowing snow blocking gauge / wind shield

NOAA ETI recording gauge at 1m, Barrow, Mar 3/03

Tretyakov gauge in the DFIR Barrow, Mar 3/03

Blowing snow impact: gauge overcatch?



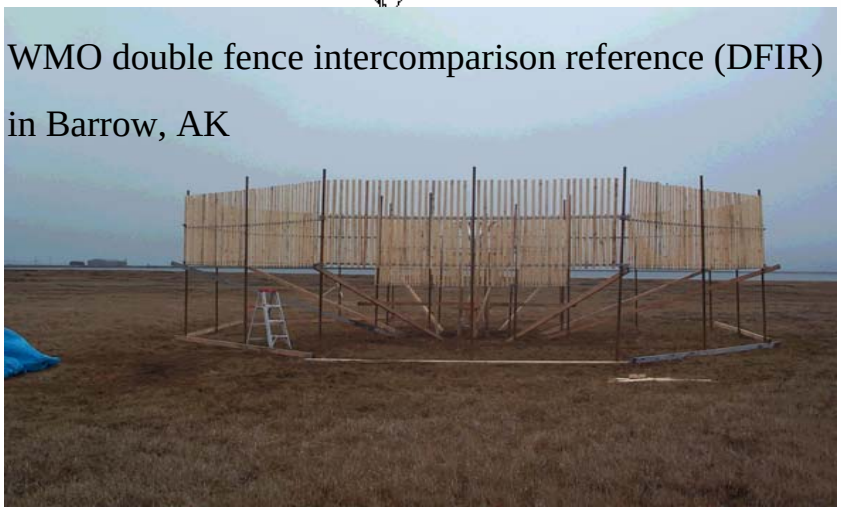


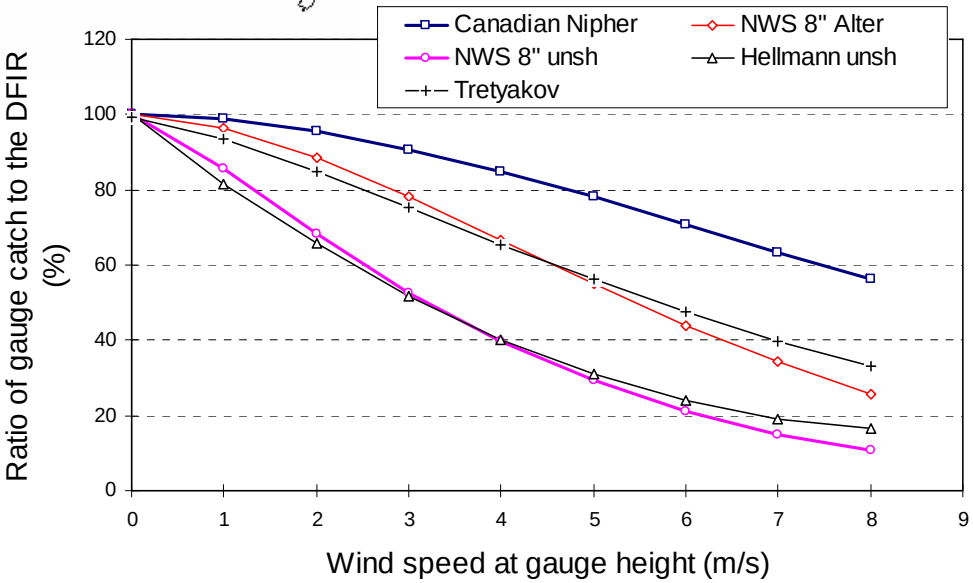
Biases in Gauge Measurements

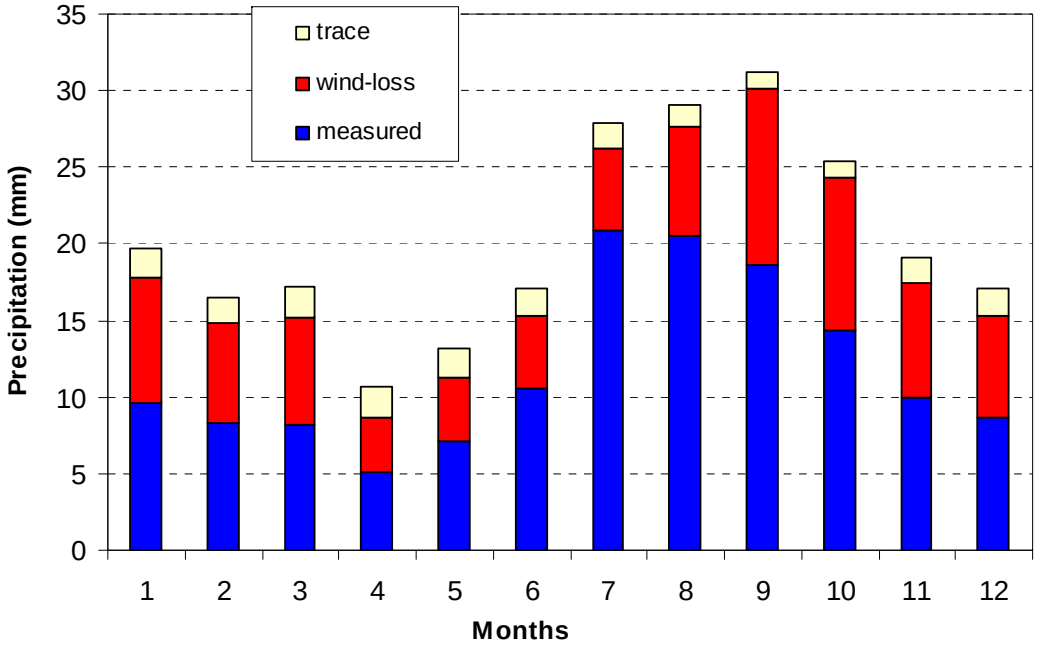
- Wind-induced gauge under-catch
- Wetting and evaporation losses
- Underestimate of trace precipitation events
- Blowing snow into gauges at high winds
- Uncertainties in auto gauge systems

WMO Solid Precipitation Intercomparison

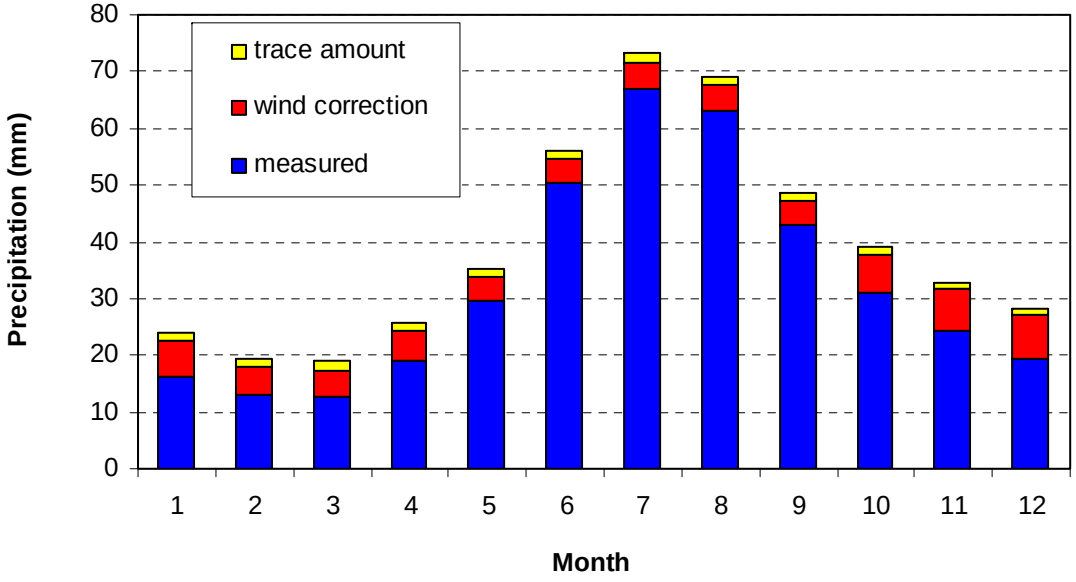
Goodison, B.E., P.Y.T. Louie, and D. Yang, 1998: WMO solid precipitation measurement intercomparison, final report, WMO/TD-No. 872, WMO, Geneva, 212pp.







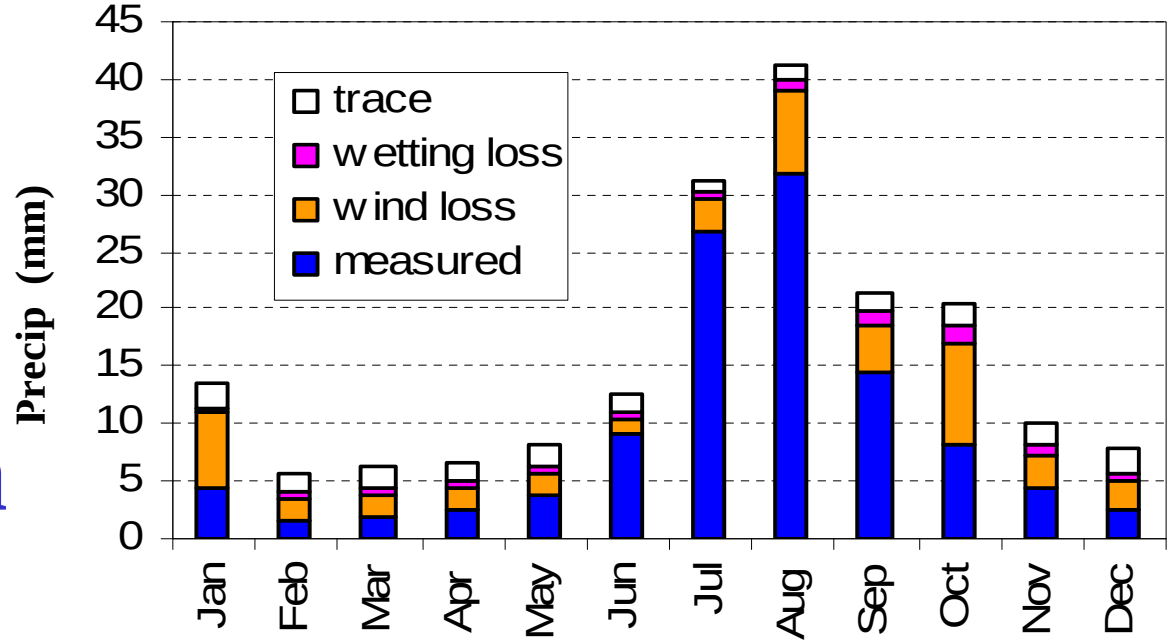
Overall mean for the NP drifting stations, 1957-90 (*Yang, 1999*)

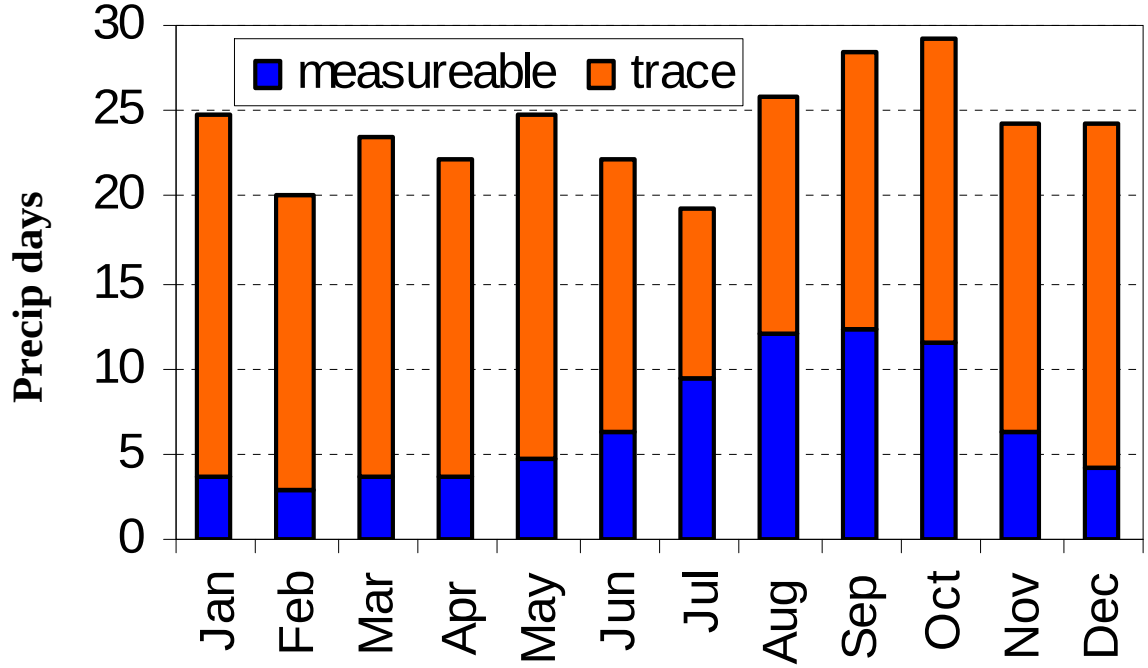


Overall mean for 61 climate stations in Siberia, 1986-92 (*Yang and Ohata, 2001*)

Bias corrections of daily precipitation data, Barrow, 1982-83

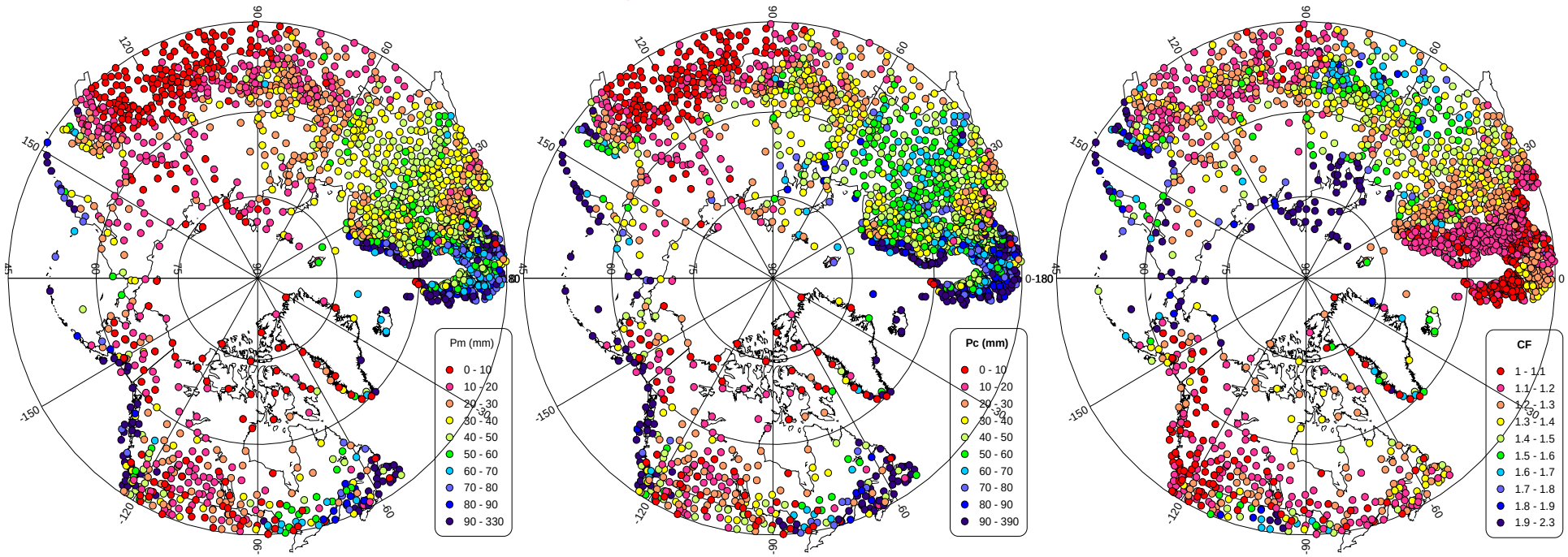
(*Yang et al., 1998*)





Mean Gauge-Measured (Pm) and Bias-Corrected (Pc) Precipitation, and Correction Factor (CF) for January

Yang et al., 2005, GRL

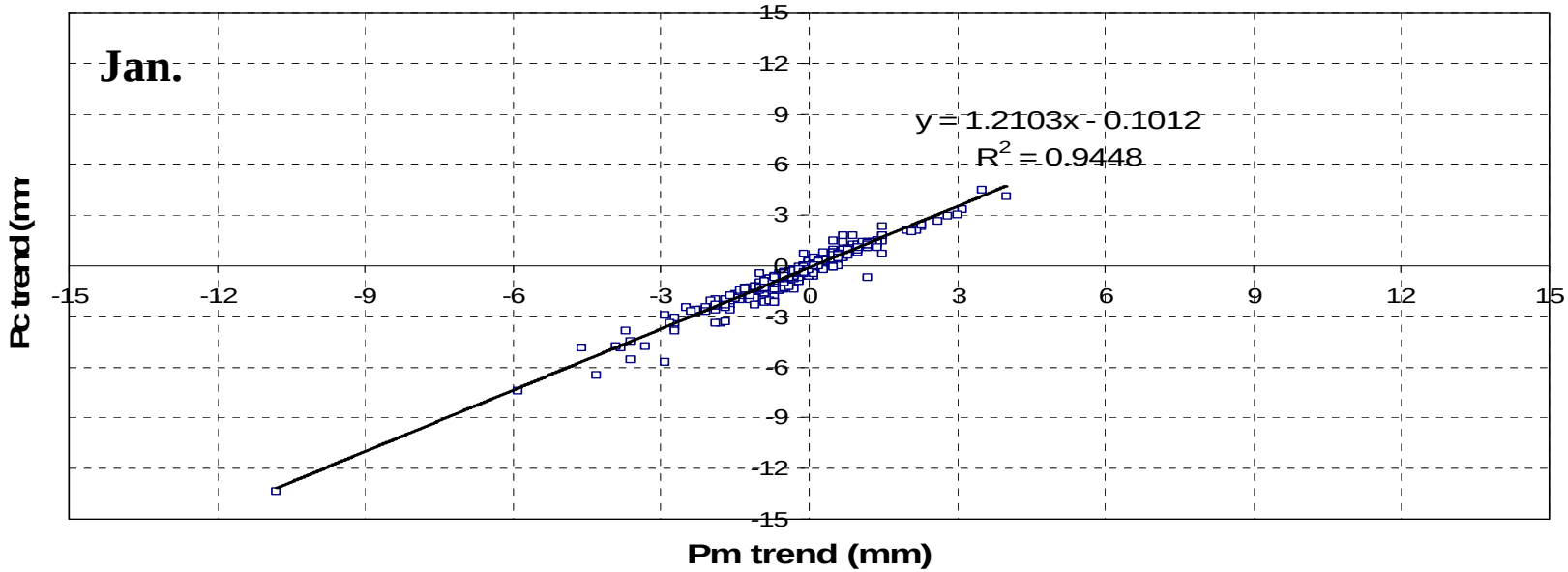


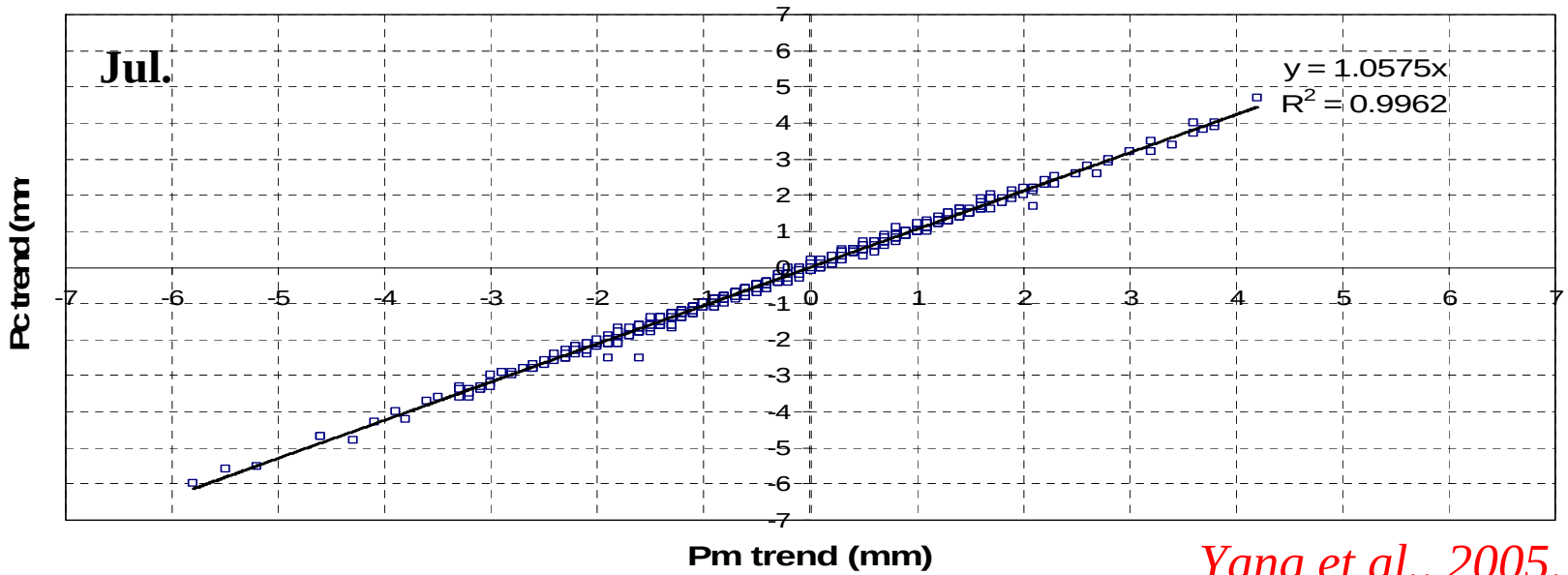
a) Pm (mm) *b) Pc (mm)* *c) CF*

- Total 4827 stations located north of 45N, with data records longer-than 15 years during 1973-2004.
- Similar Pm and Pc patterns – corrections did not significantly change the spatial distribution.
- CF pattern is different from the Pm and Pc patterns, very high CF along the coasts of the Arctic Ocean.

Impact of Bias-Corrections on Precip Trend

Pm & Pc Trend Comparison, Selected Stations with Data > 25 Yrs during 1973-04

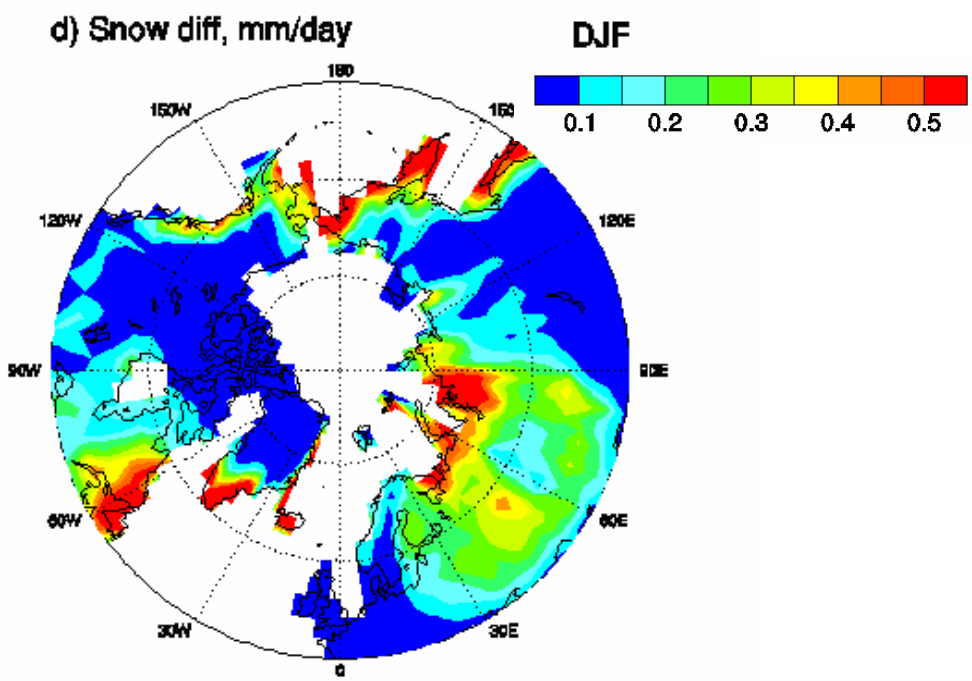


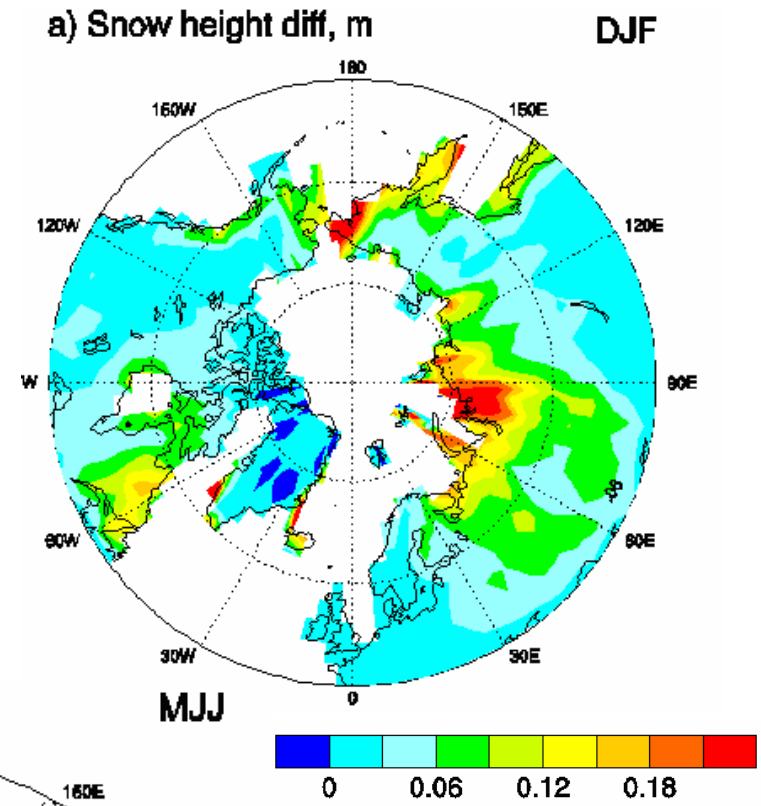


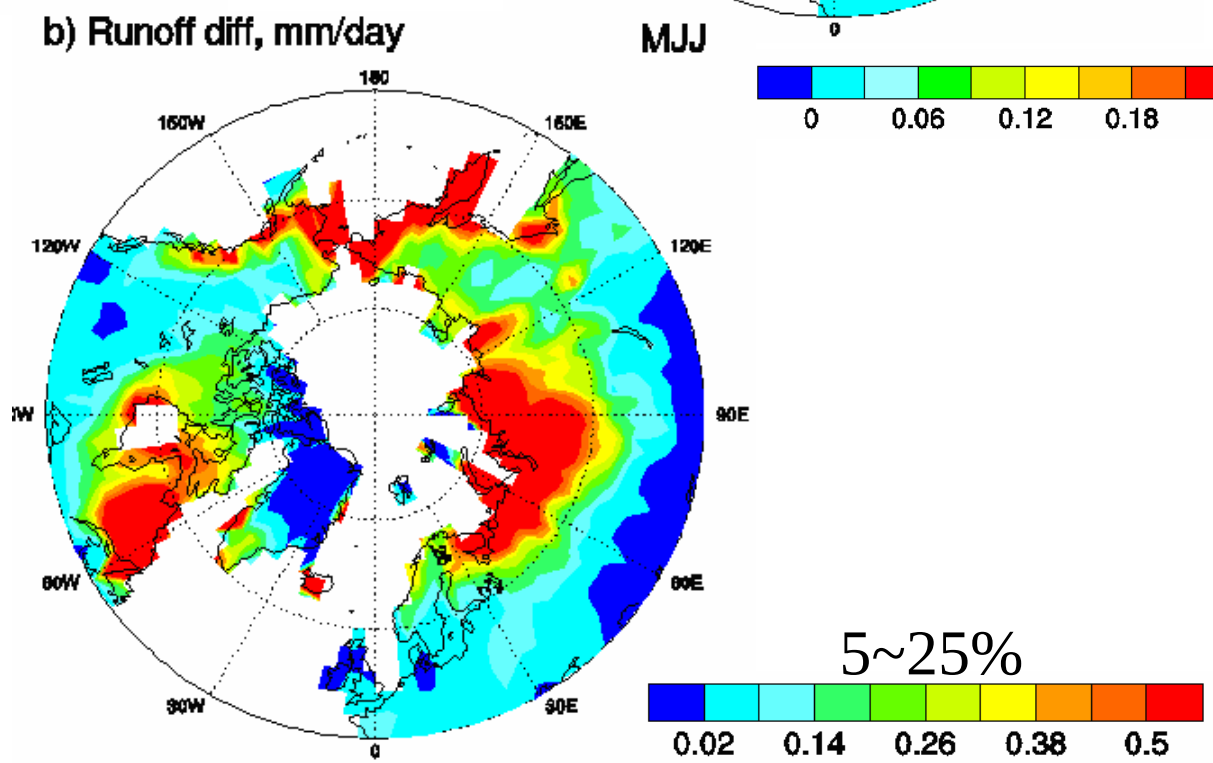
Yang et al., 2005, GRL

Impact of Bias-Corrections on Northern Hydrology:

CLM3 simulations with/without P corrections, 1973-04



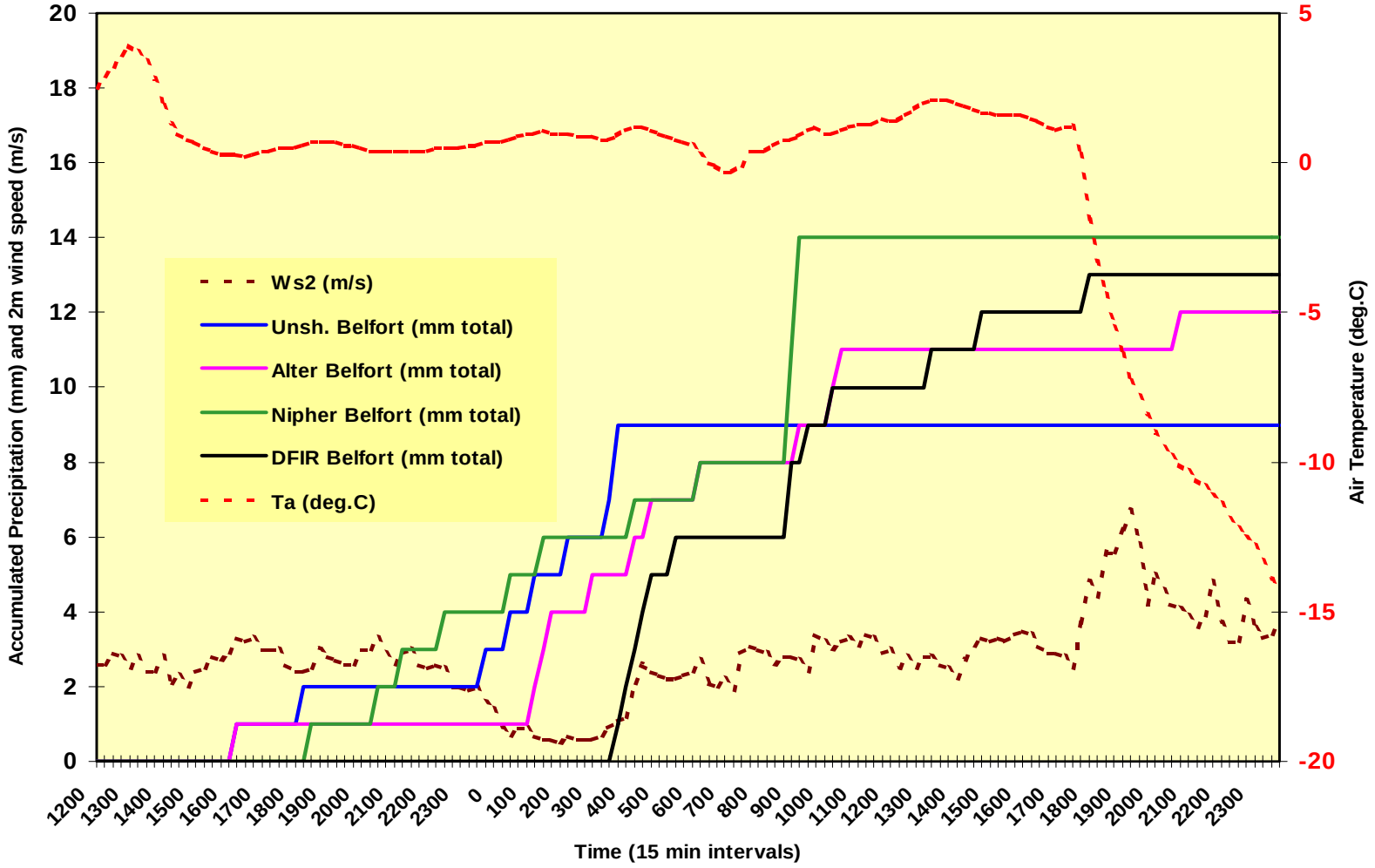




Auto gauges and snow depth sensor

Challenges for auto QA/QC

Automation of precipitation measurements

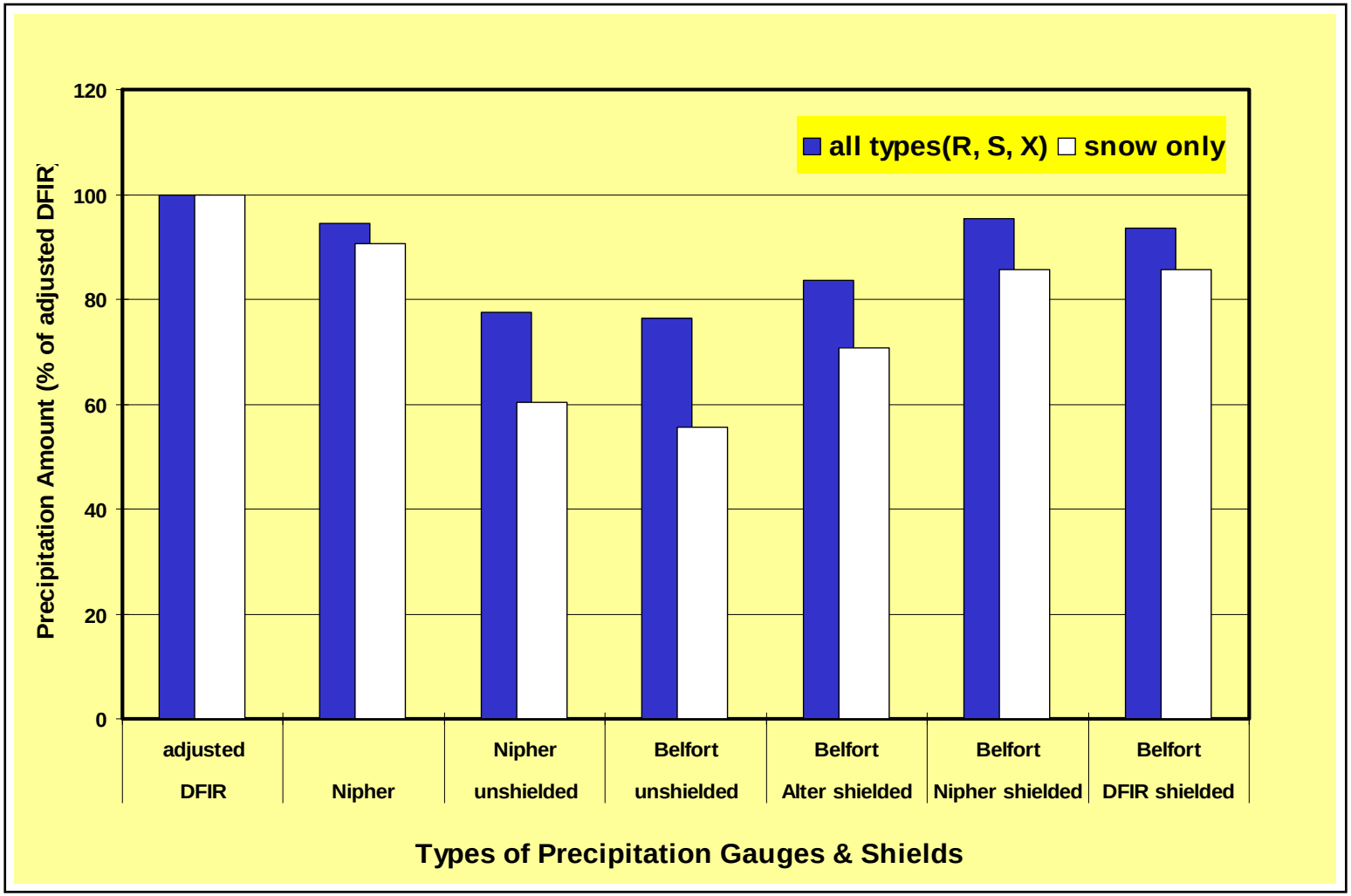


WMO Study: Timing and catch differences of Belfort Gauges at Kortright, Ontario Feb. 19-20/1988

Environment Canada
Meteorological Service of Canada
Climate Research Branch

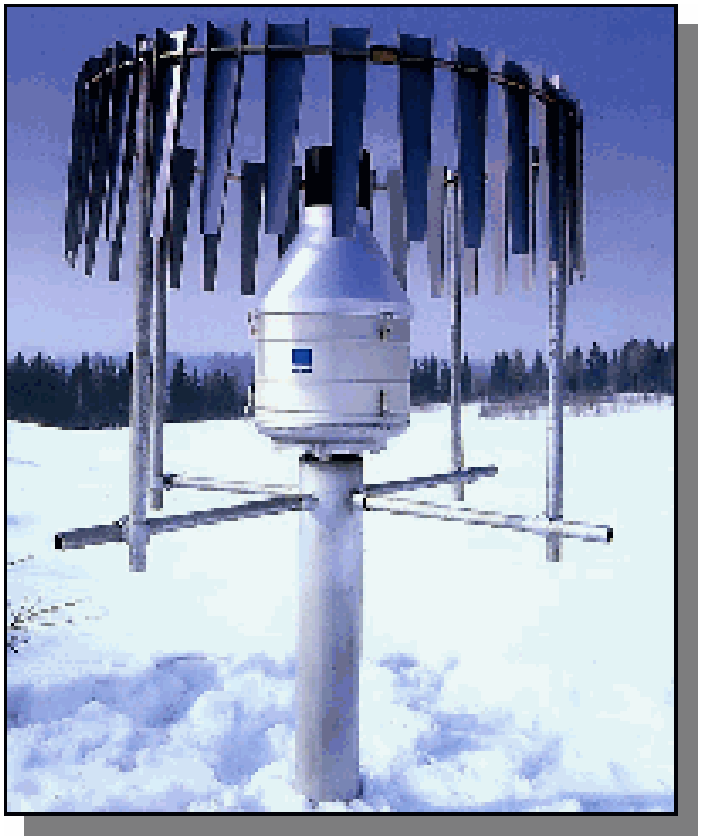
Environnement Canada
Service météorologique du Canada
Direction de la recherche climatologique

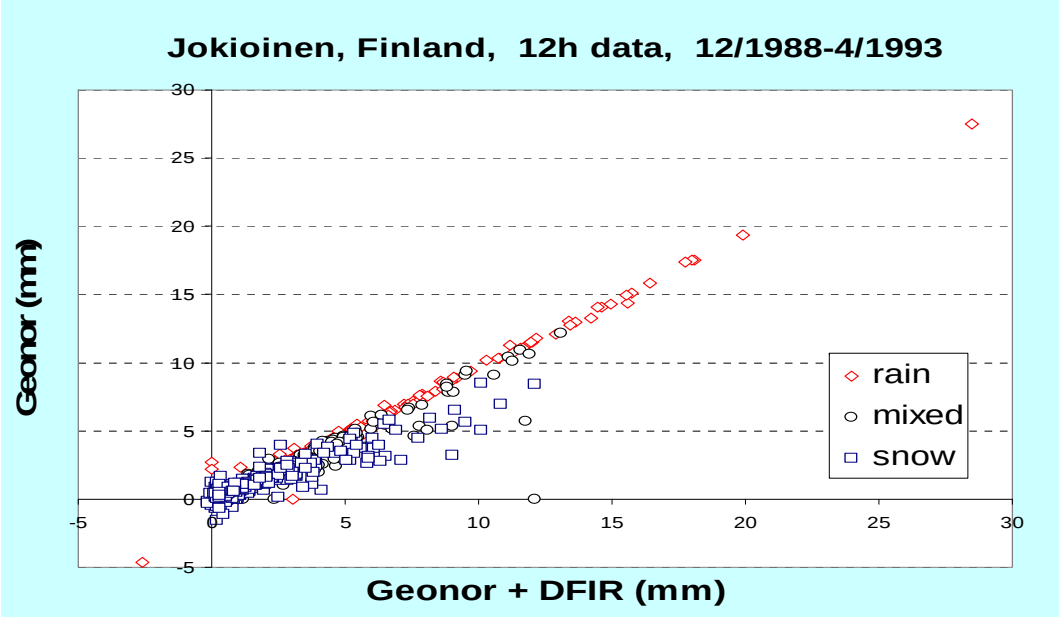
Need for adjustments

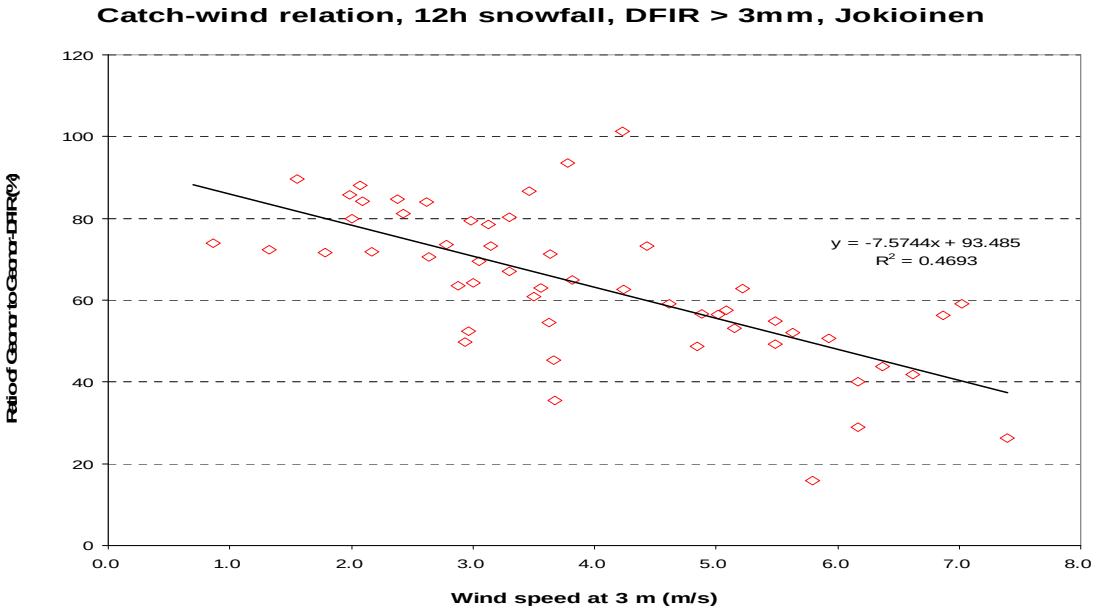


Mean annual accumulated winter precipitation ≥ 3.0 mm, of different gauge types and shielding as a percentage of DFIR (adjusted for catch deficiency) at the Canadian Evaluation Station at Kortright Centre, Ontario from 1987-1991.

WMO result: Geonor vs. DFIR



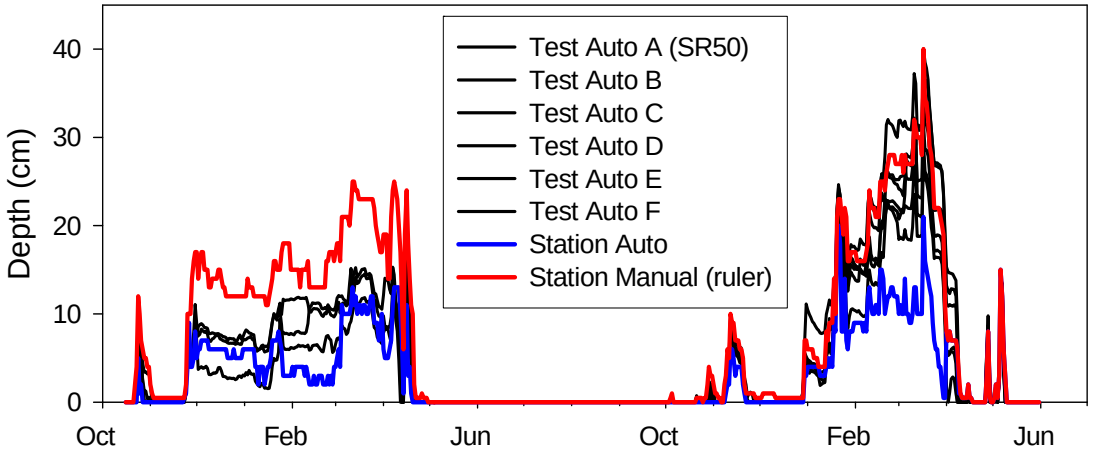




Snow Depth Spatial Variability and Fixed-Point Measurements

Edmonton International Airport
open landscape

- **see a high degree of spatial variability even over a short distance (3 to 300m)**
- **of six temporary and a fixed station SR50, and manual ruler measurements, none are statistically similar to each other**



Challenges:

- ***to provide the best quality measurements to the research community***
- ***for the research community to recognize these issues when using the data (e.g. comparisons with spaceborne data)***

Arctic Precipitation Issues

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  - Decline of the networks in the northern regions, including Siberia, Alaska and N. Canada
  - Few stations in the mountain regions
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- Data quality and compatibility across national boundaries
  - Large biases in gauge measurements of solid precipitation
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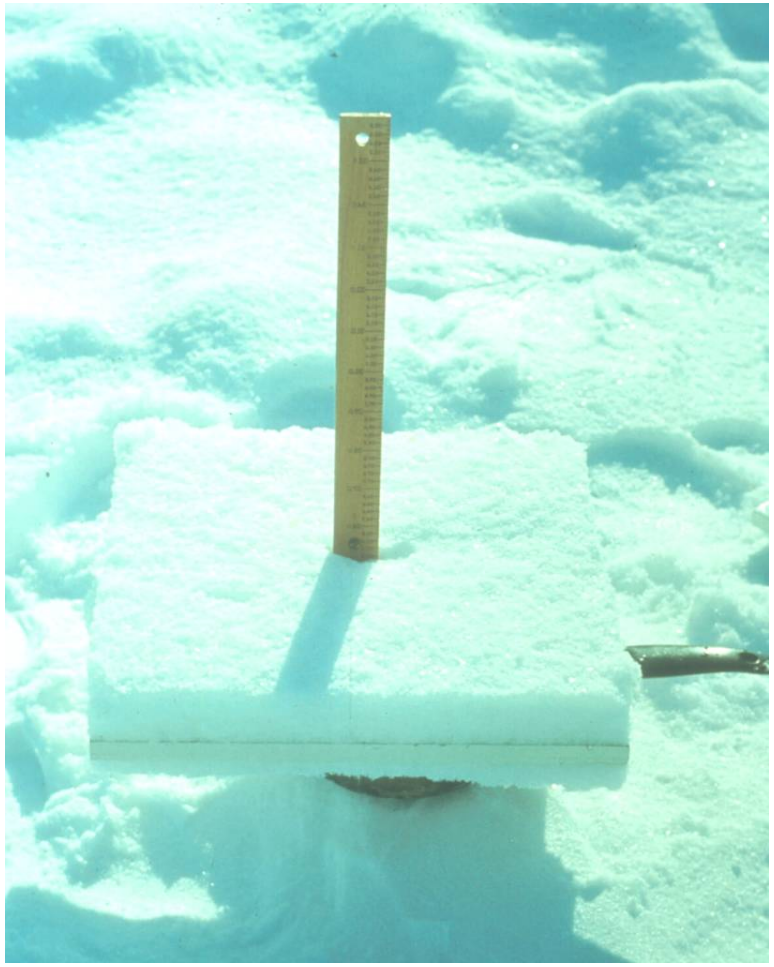
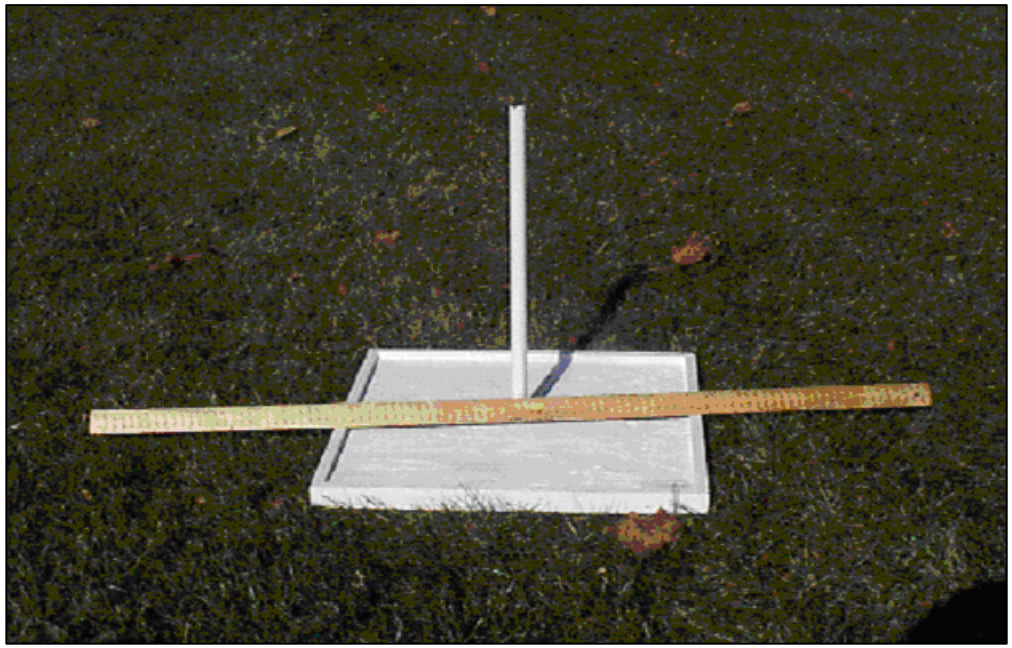
- Validation of precip data, including satellite and reanalysis products and fused products at high latitudes.

Measuring freshly fallen snowfall with Snow Boards



Original

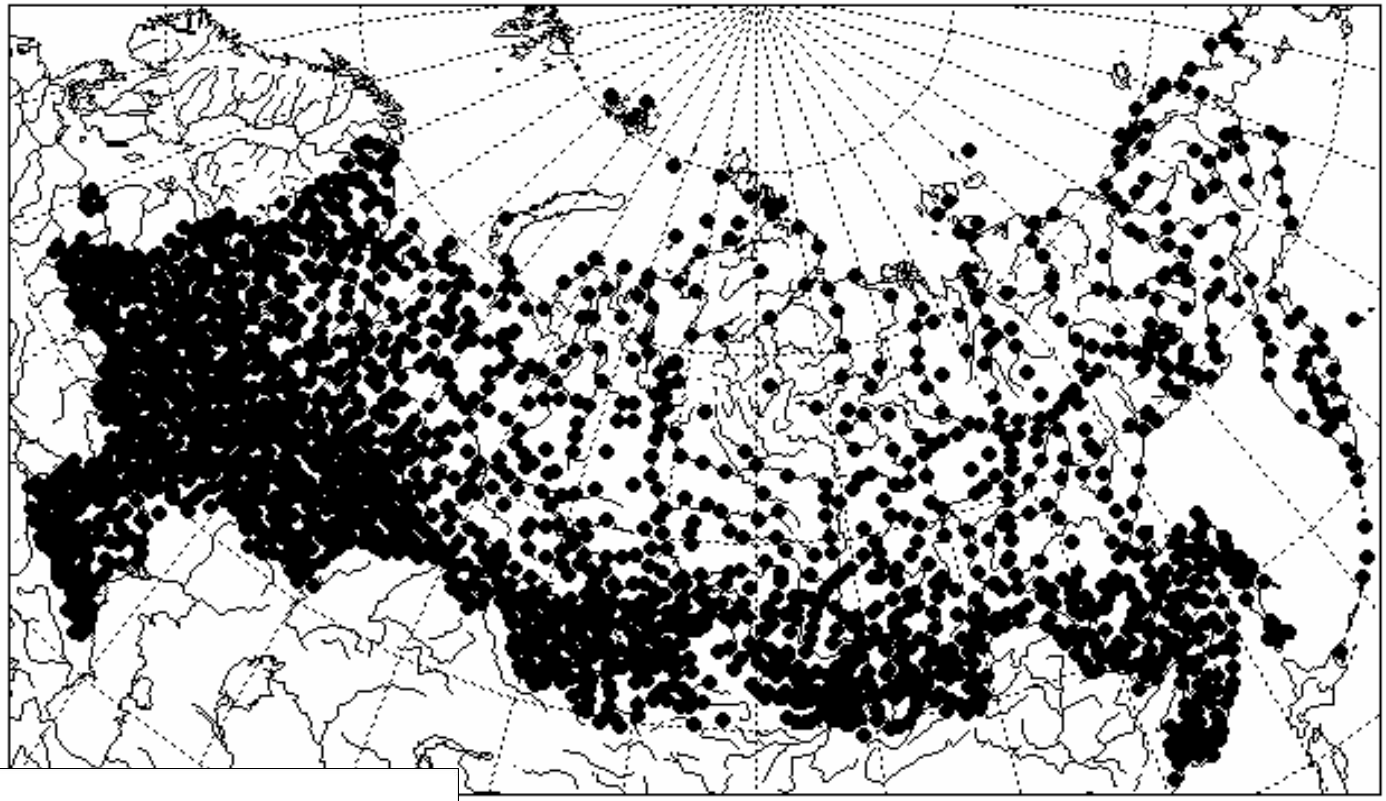


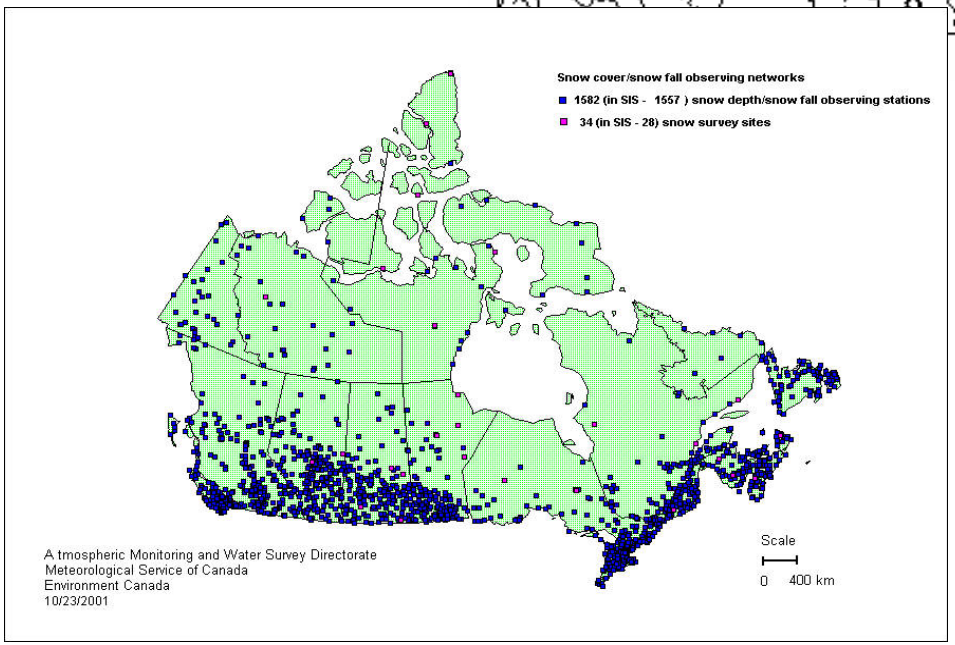
Weaverboard 2000

for use as an Observer's aid

10cm snowfall is 10mm precipitation

Russian Meteorological stations





MSC Networks – precip/Snow Cover