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National Snow and Ice Data Center

Advancing knowledge of Earth's frozen regions

Observed Atmosphere and Water Cycle Change

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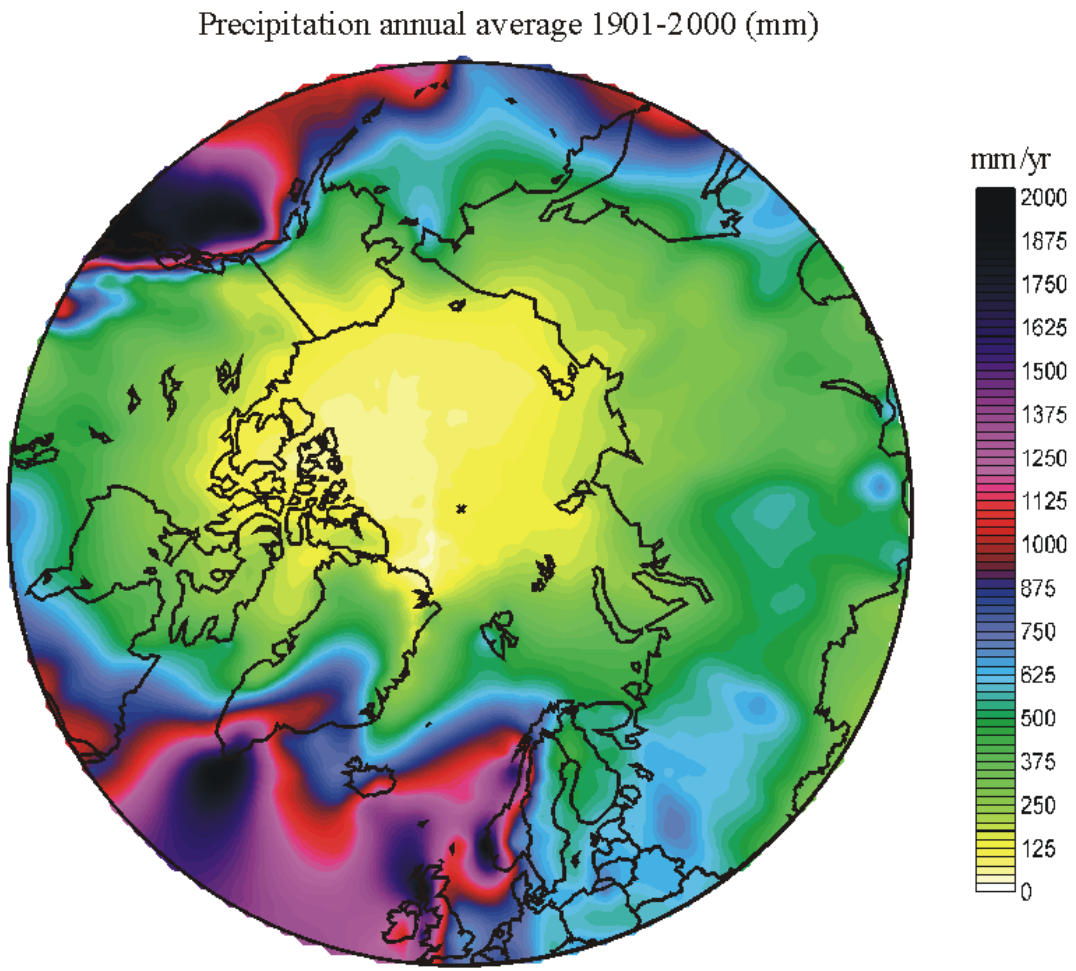
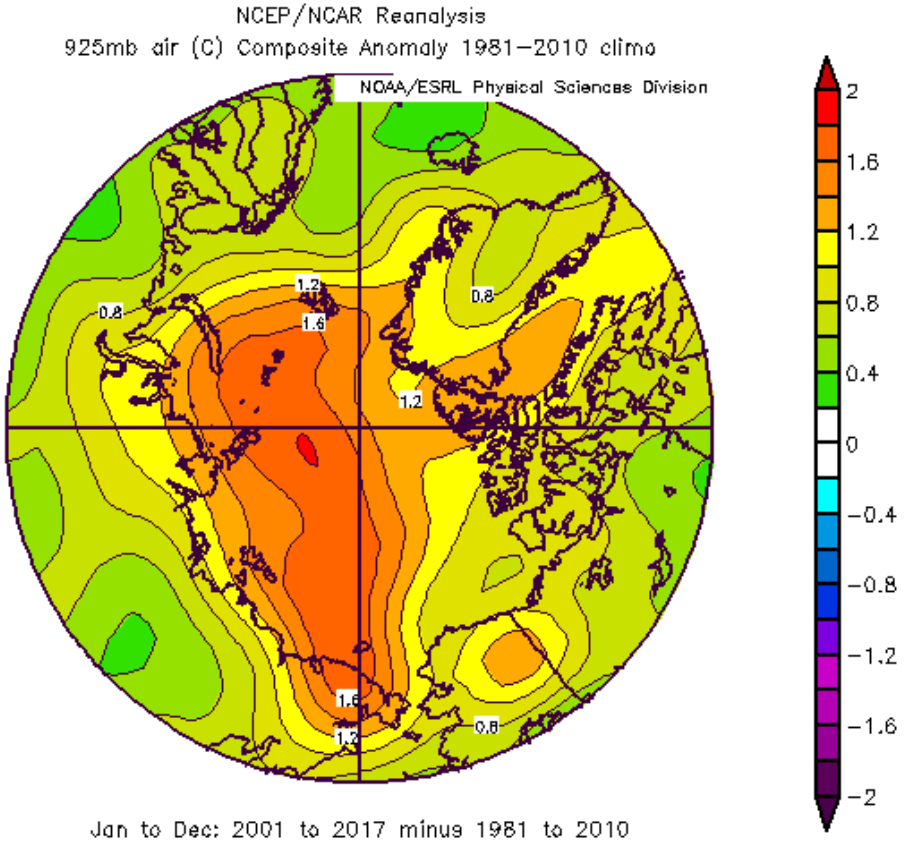
Mean Annual Precipitation (mm)

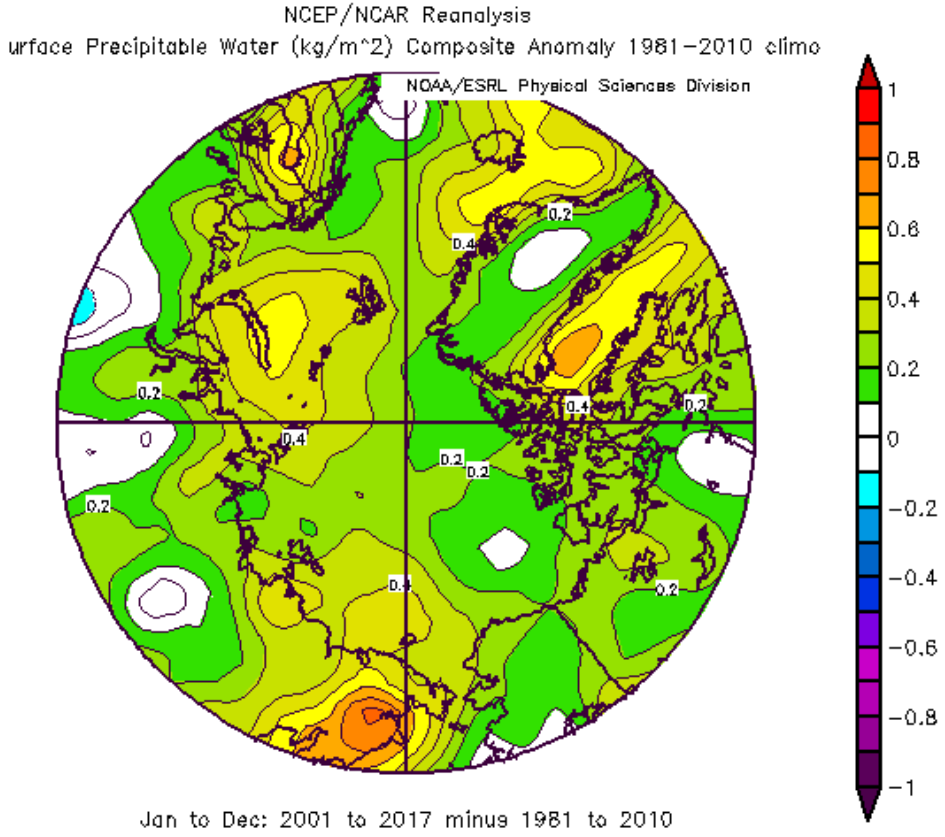


http://www.climate4you.com/Polar%20precipitation.htm

Do we have a handle on even basic statistics like average precipitation across the Arctic (let alone trends)? The gauge network has not improved and undercatch problems have never been fully resolved. Satellite retrievals don't work. Are we left with using output from reanalyses?

Air Temperature and Precipitable Water Anomalies (Annual Means, 2001 through 2017)





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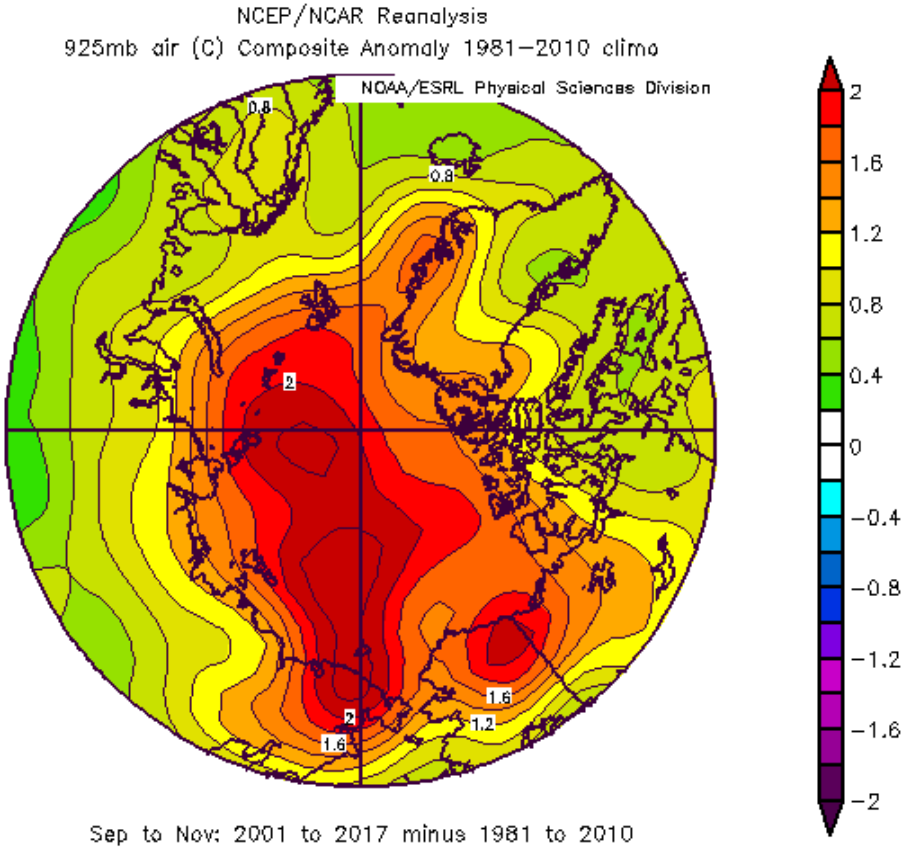
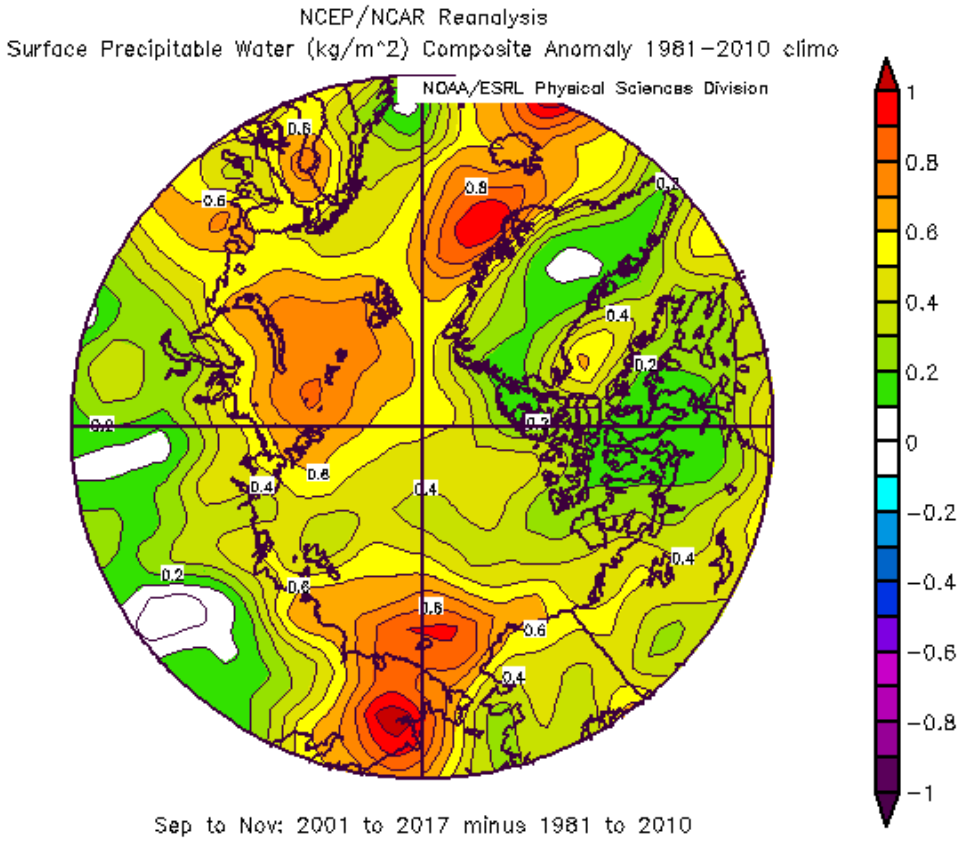
Air Temperature and Precipitable Water Anomalies (Autumn, 2001 through 2017)





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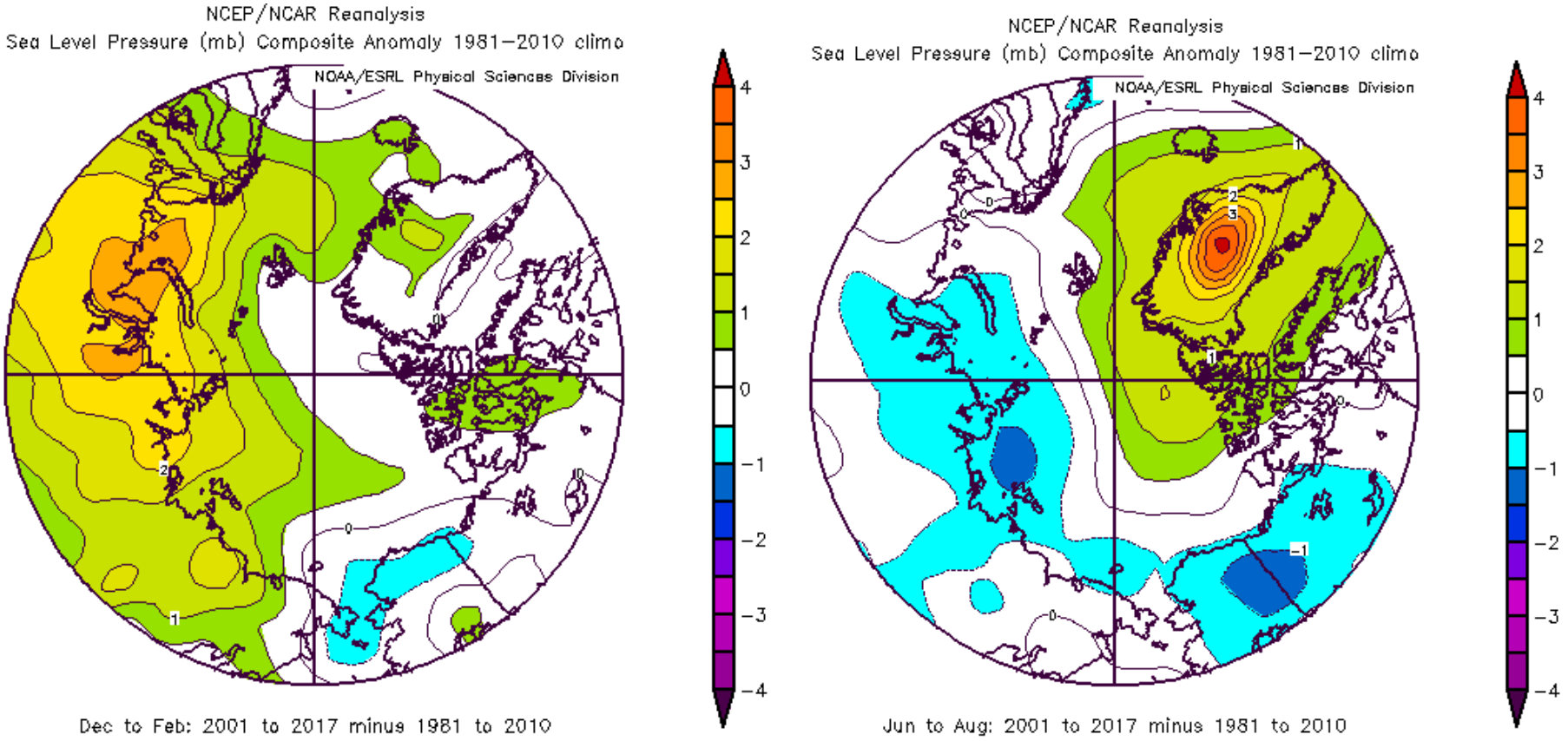
Sea Level Pressure Anomalies (Winter and Summer, 2001 through 2017)



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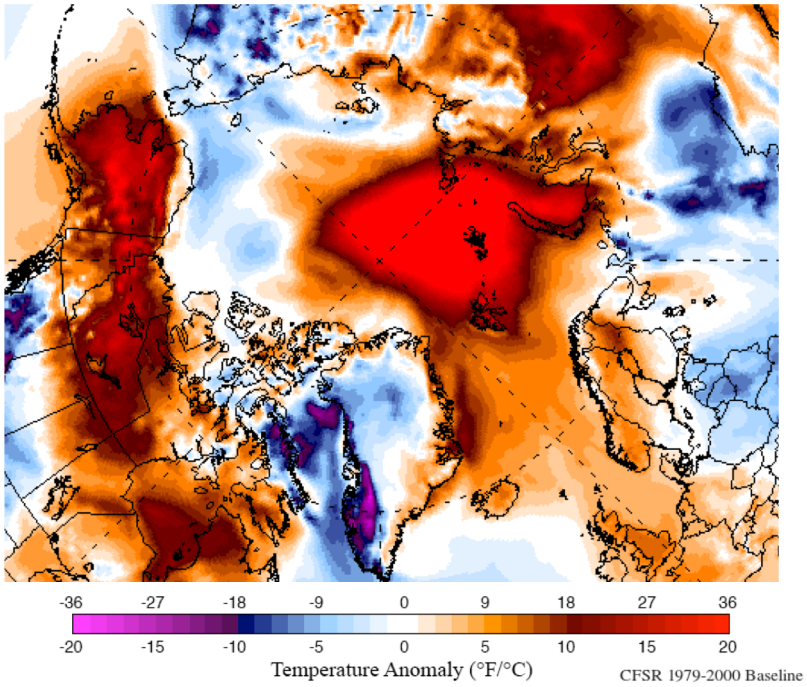
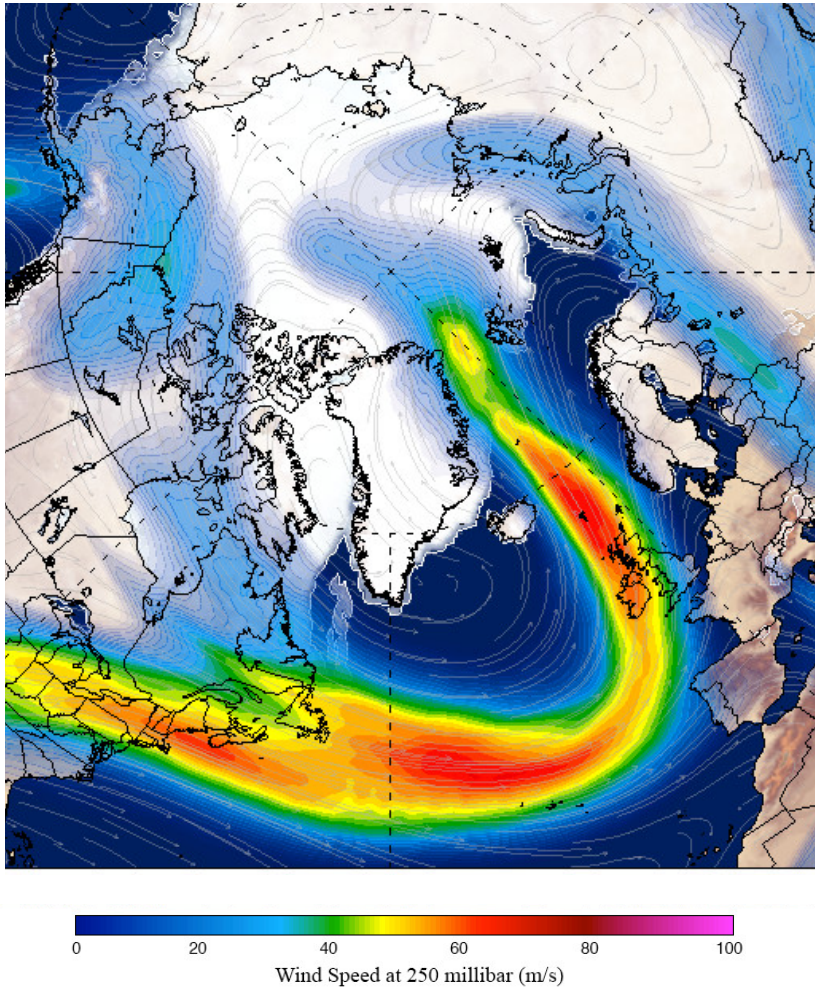
Extreme Arctic Weather Events

Temperatures above the freezing point recorded near the North Pole on December 30, 2015, associated with a contorted jet stream drawing heat and moisture far into the Arctic Ocean. As the jet stream and atmospheric river passed over England, it brought intense rainfall and flooding.





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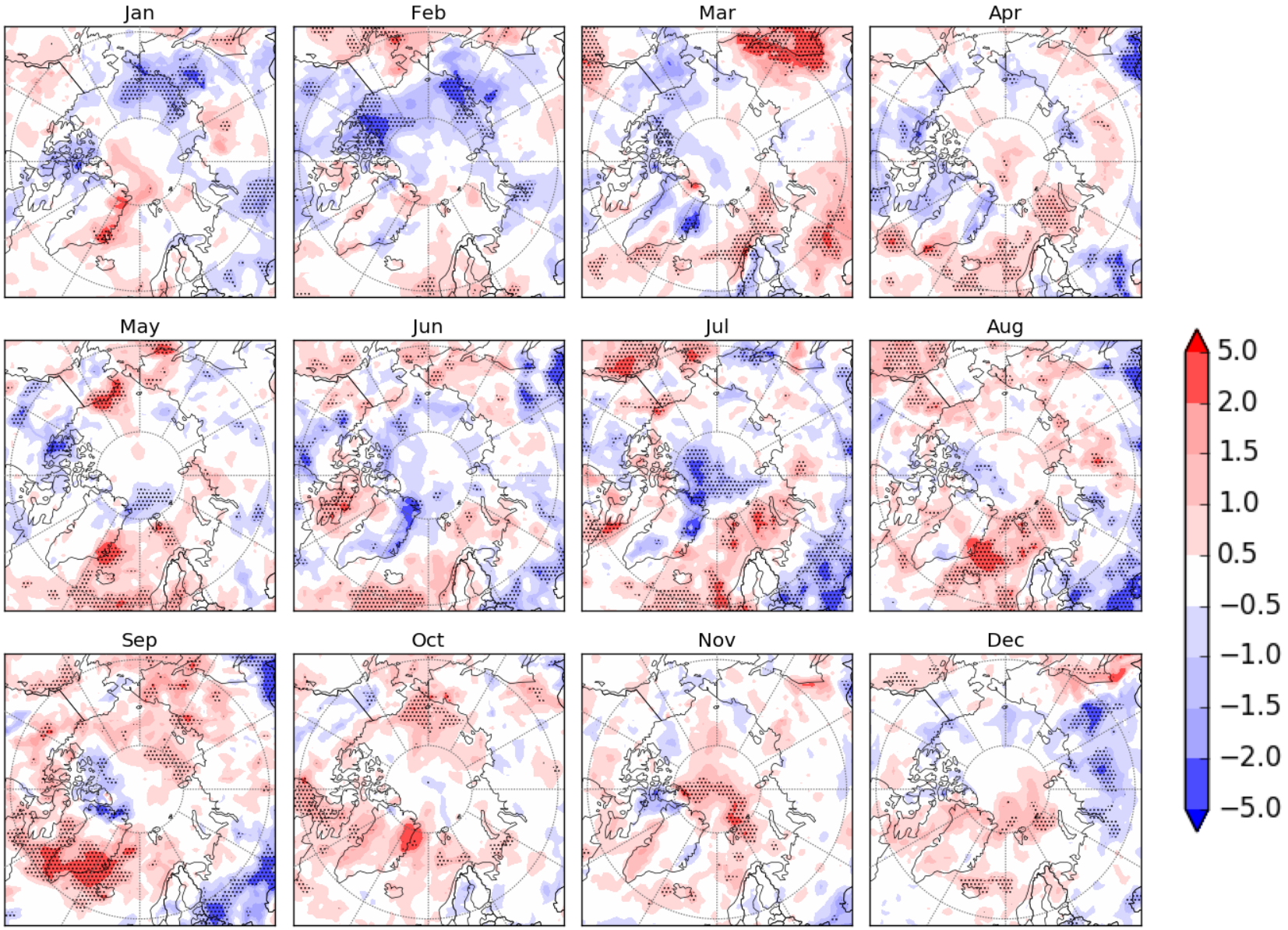
MERRA: Precipitation Trends (% Change, 1979-2015)



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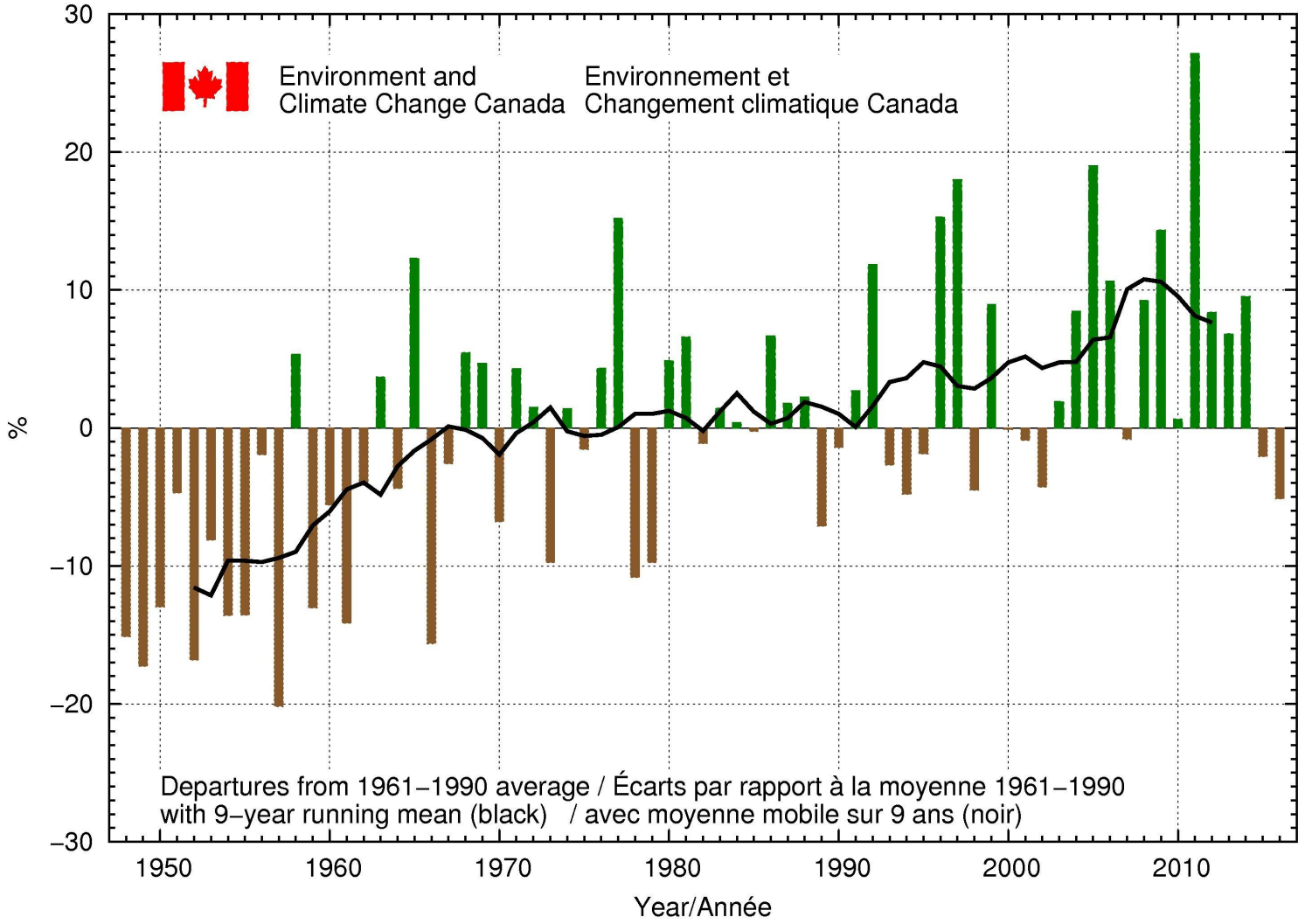
Winter Precipitation Departures in Canada



https://www.canada.ca/en/environment-climate-change/services/climate-change/trends-variations/bulletin-winter-2015-2016.html

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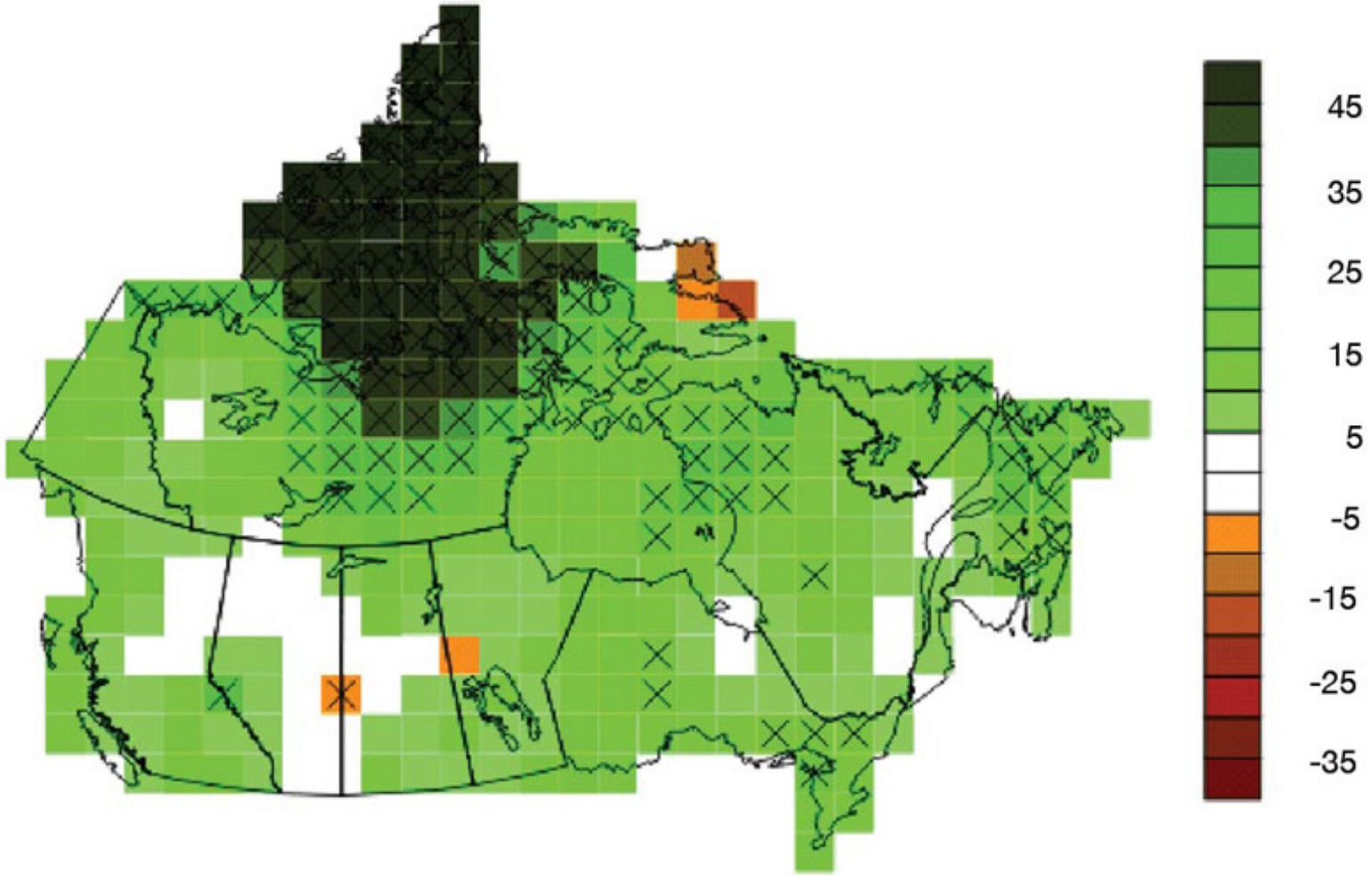
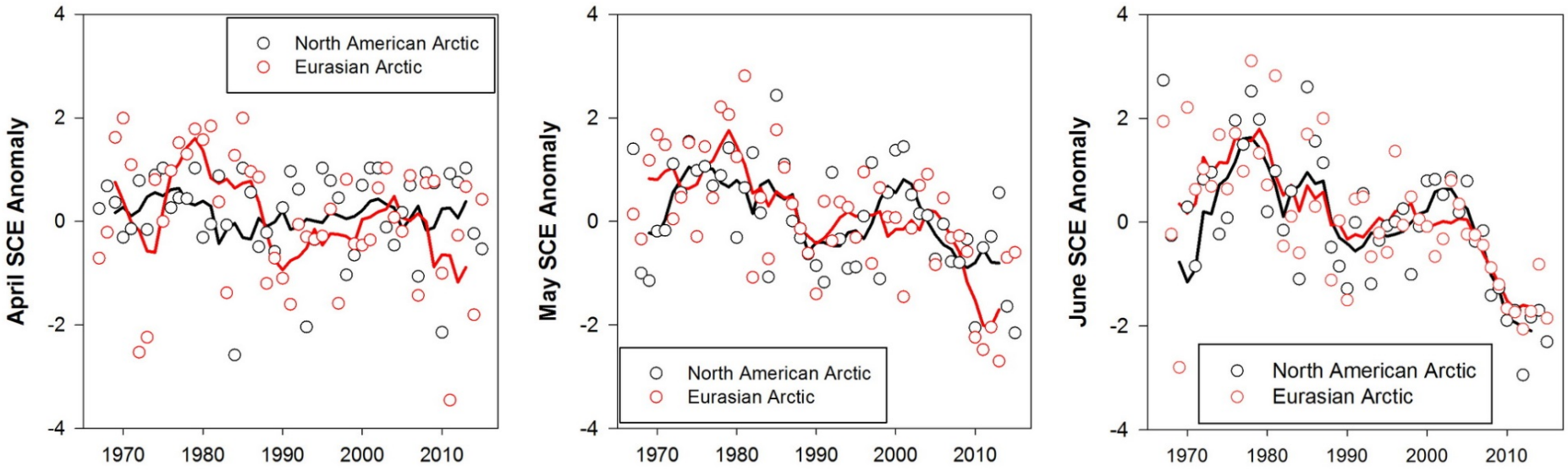
Trends in precipitation (%) over Canada, 1948-2003



From Zhang et al., 2000, updated 2005

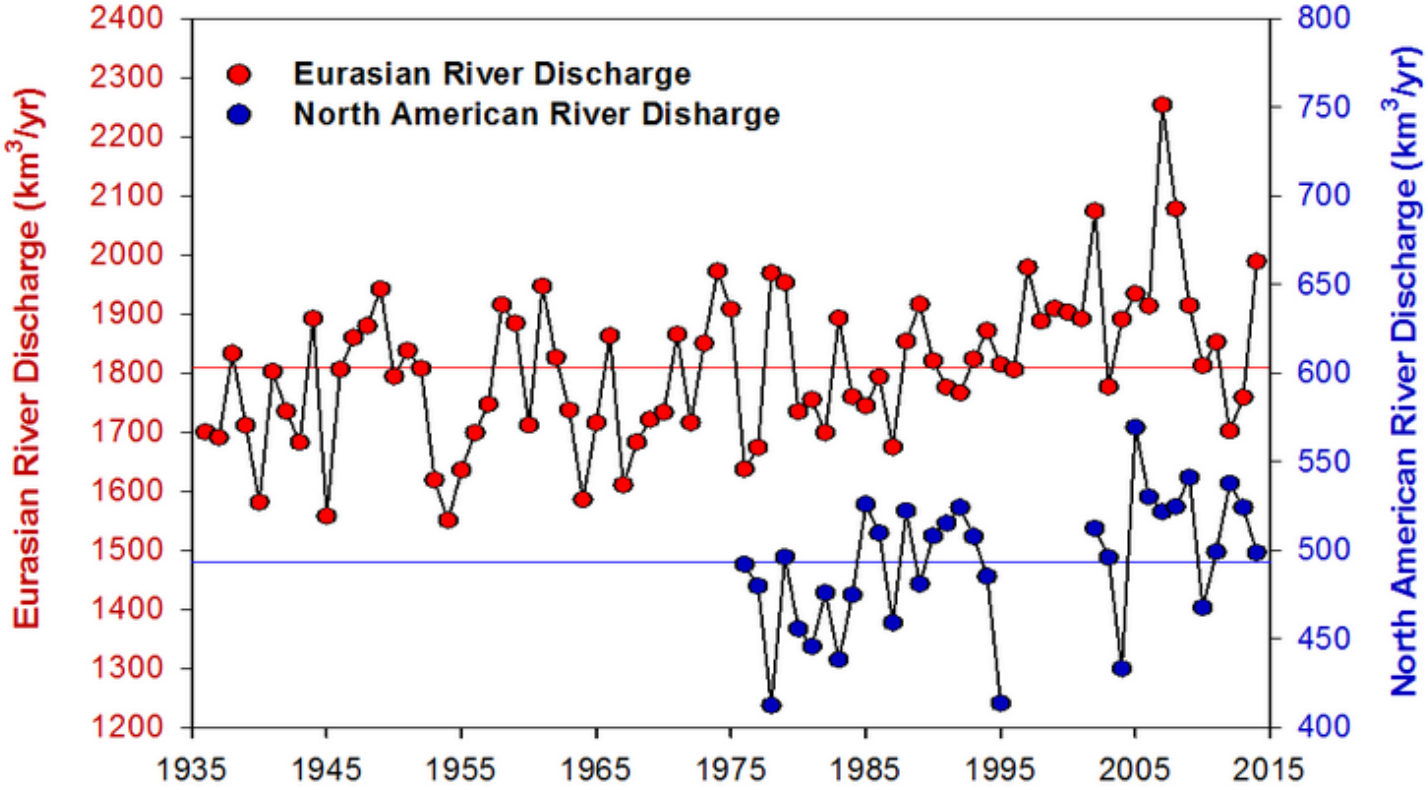
Spring snow cover



Monthly snow cover extent (SCE) for land areas >60°N) for (a, left) April (b, center) May and (c, right) June from 1967 to 2015. Anomalies are relative to the average for 1981-2010 and standardized. Solid black and red lines depict 5-year running means. The loss of spring snow cover is consistent with observations of hydrograph shifts towards more spring discharge

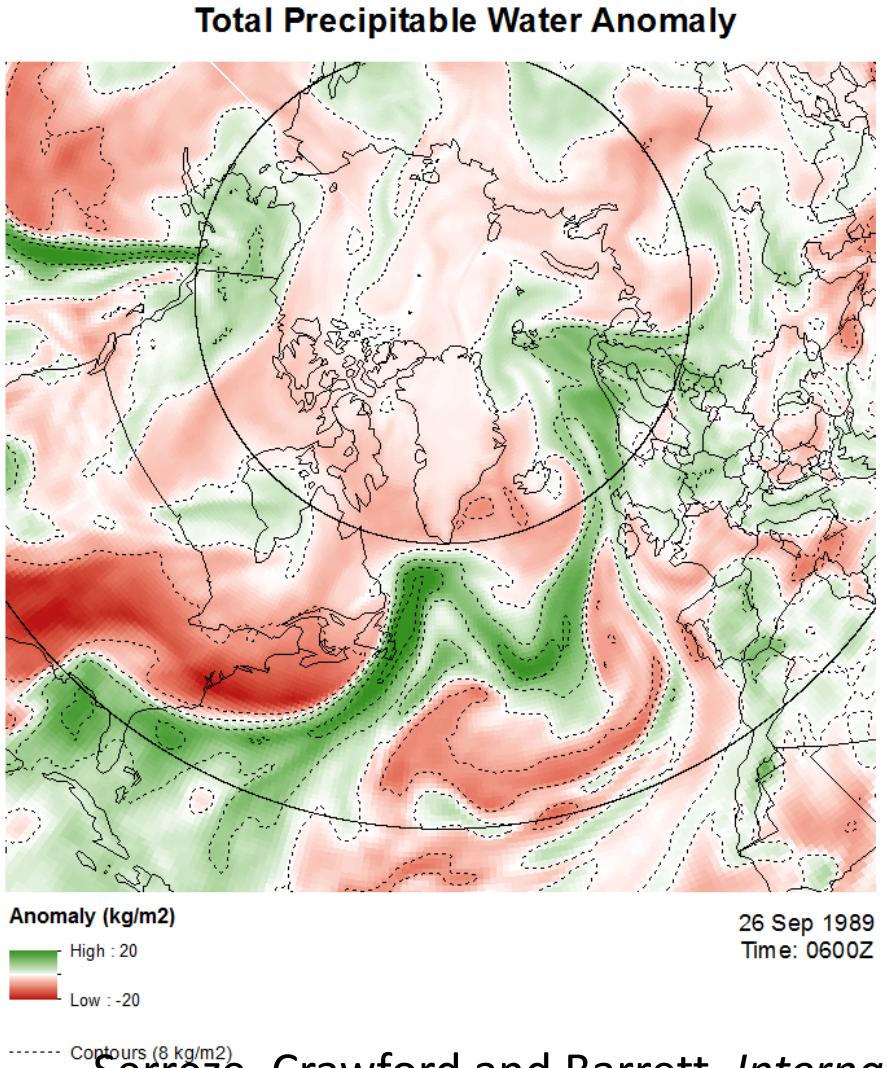
Derksen et al. (2015)

River Discharge



Annual discharge for Eurasian and North American Arctic rivers. The Eurasian rivers are the Severnaya Dvina, Pechora, Ob', Yenisey, Lena, and Kolyma. The North American rivers are the Yukon and Mackenzie. The horizontal lines show long-term mean discharge values for the Eurasian (1,809 $km^3\ y^{-1}$) and North American (493 $km^3\ y^{-1}$) rivers (2015 NOAA Arctic Report Card).

Rain on Snow and Extreme Precipitation Events



Anomaly field of column integrated atmospheric water vapor at 0600Z, September 26 1989, showing an atmospheric river extending from the tropical Atlantic into the Arctic (green shading), linked to an extreme precipitation (and Rain on Snow) event over the island of Spitsbergen. Spitsbergen is located east of Greenland between about 77°N to 80°N.

Serreze, Crawford and Barrett, *International Journal of Climatology,* 2015

Questions and Issues

- Can we measure precipitation across the Arctic with sufficient accuracy to assess trends? Questionable.
- Is there more water vapor in the Arctic atmosphere? Yes, most pronounced in autumn, especially over areas of open water, but overall the changes are not that big.
- Based on the evidence at hand, has precipitation increased? Yes in some areas, apparently not in others.
- Have rain on snow events increased? Perhaps.
- Has river discharge increased? Yes, but the time series is characterized by high interannual variability.
- Recent winters have seen extreme warm air incursions over the Arctic Ocean

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