Shifts in Seasonal Hydrology Across Eurasia:

Emerging Trends and Water Cycle Linkages

[1]Michael A. Rawlins, [2]Hengchun Ye, [4]Daqing Yang, [4]Alexander Shiklomanov

[1]Jet Propulsion Laboratory/California Institute of Technology

[2]California State University – Los Angeles

[3]University of Alaska – Fairbanks / CliC Project Office

[4]University of New Hampshire

American Geophysical Union Fall Meeting

December 19, 2008

Acknowledgements

Funding from the NASA postdoctoral program

Collaborators at the Jet Propulsion Laboratory
and the University of New Hampshire

a host of others

Outline

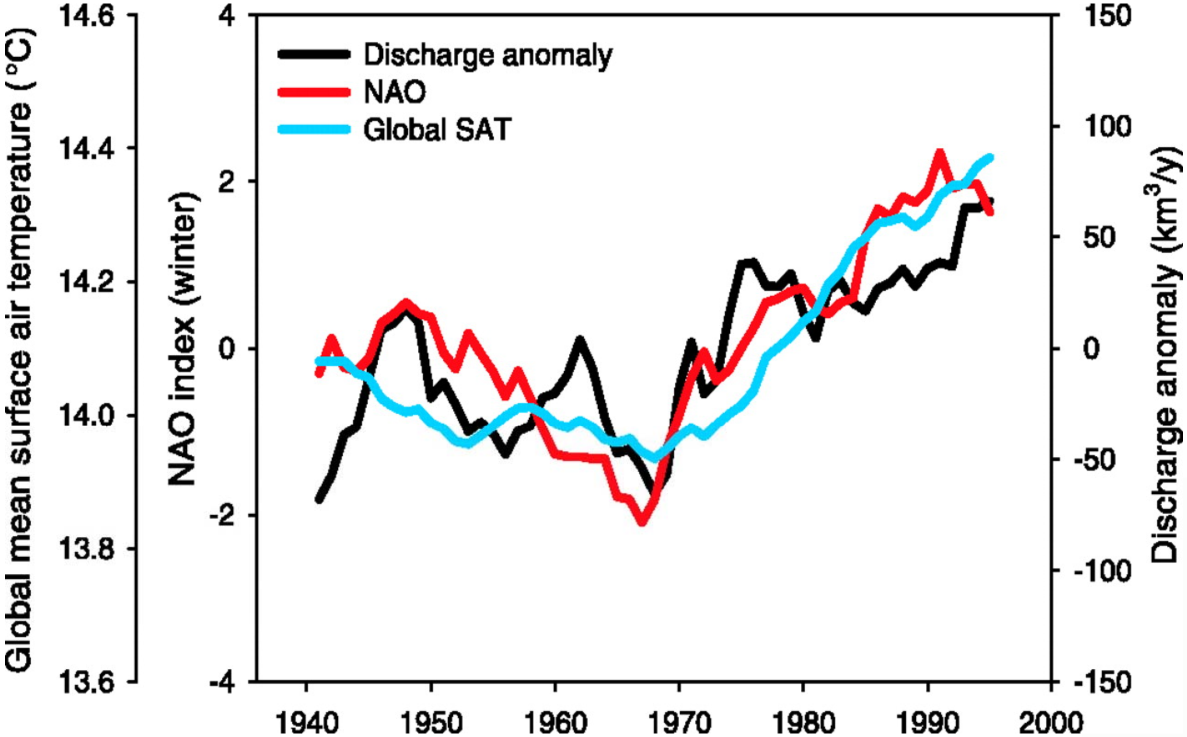
- Background / Motivation

- Changes in Seasonal River Discharge

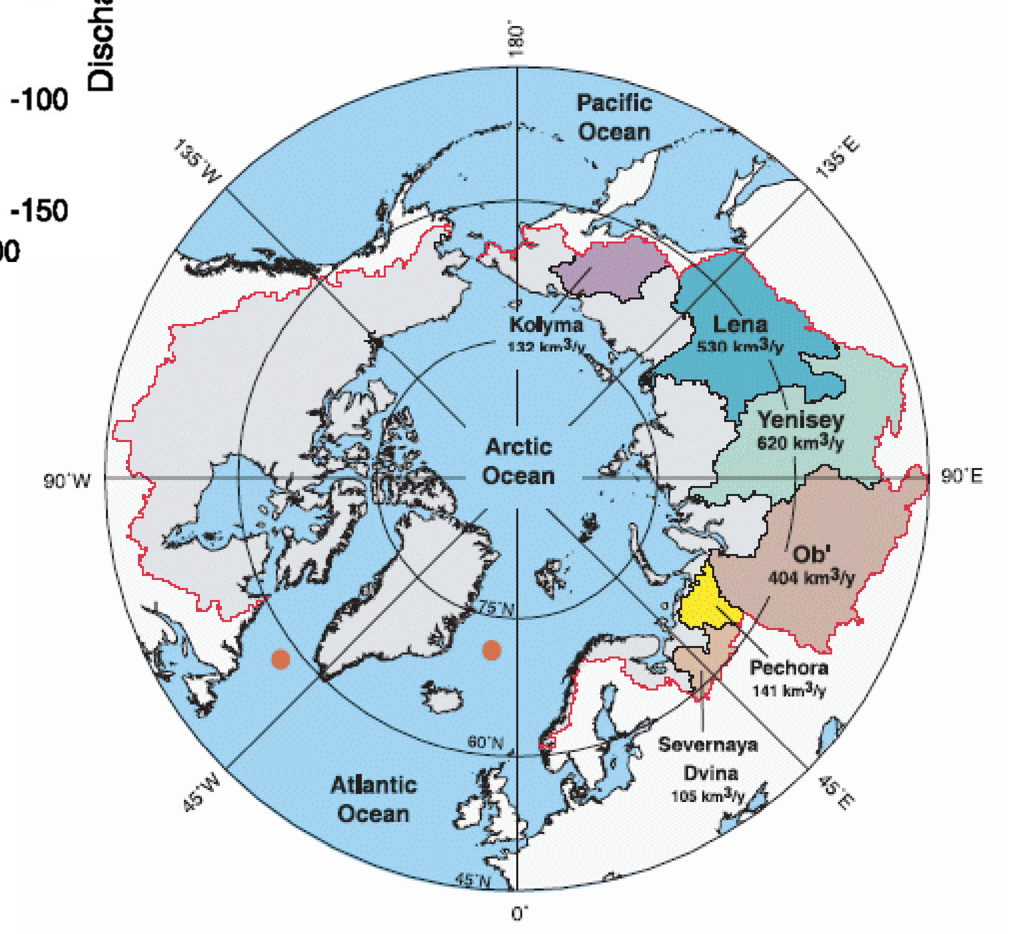
- Precipitation Trends...Spatial Analysis

- River Discharge and Precipitation Trends

A significant increase in river discharge from 6 largest Eurasian rivers 1936-1999

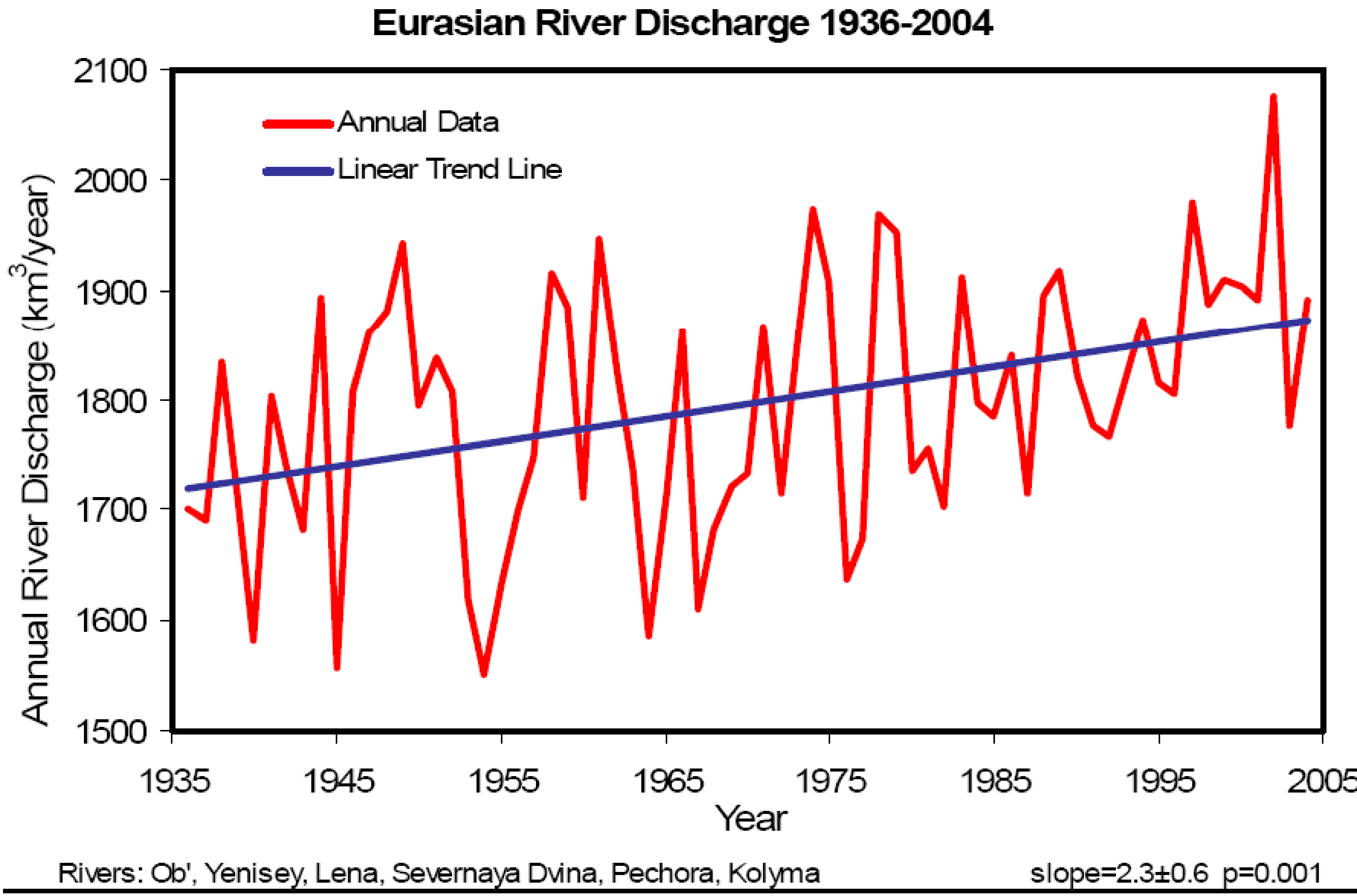


Peterson et al., 2002, Science



...the trend continues

2007



courtesy A. Shiklomanov, U. New Hampshire

Winter Precipitation over Northern Eurasia

From ***Frey and Smith, 2003: Polar Research 22(2), xx-xx 1***:

- “The most evident result from the precipitation records examined is a general increase in winter precipitation throughout West Siberia."

- “Significant precipitation trends for 12 of the 14 stations north of 60° N."

- "The increases in winter precipitation should affect the volume of freshwater input to the Arctic Ocean."

Fig. 2. West Siberia, showing locations of the ten meteorological stations used in this study.

Attribution Studies for the Discharge Trend

McClelland et al., 2002, JGR - dams, permafrost melt, fires unlikely to be primary drivers for trends. Increased northward moisture transport most likely cause.

Berezovskaya et al., 2004, GRL - no trends in annual precipitation for Ob, Yenisei, or Lena

Pavelsky and Smith, 2007, JGR – agreement in sign of trends for small basins w/o impoundments

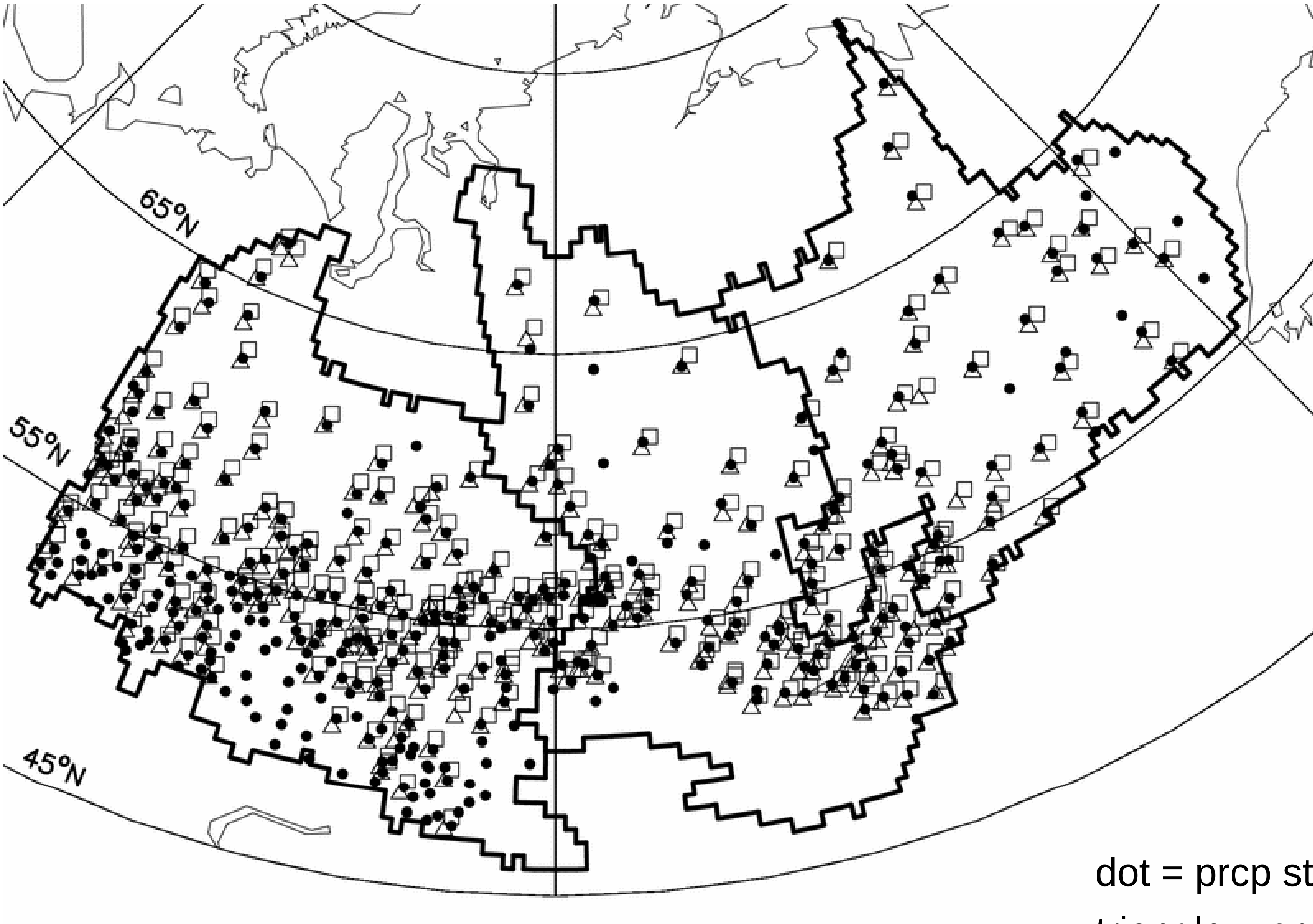
Adam and Lettenmaier, 2008, J. Climate – river discharge trends exceed precipitation trends in coldest subbasins of Yenisei and Lena basins

thesis: Increases in solid precipitation are primary agent of change for the positive river discharge trend, with the largest snow-to-discharge linkages expected for the colder regions such as the northern Yenisei and Lena basins.

Data:

- Daily Precipitation data (TD9813) for over 2000 stations across the FSU. Undercatch adjusted.
- Snow depth data for FSU (1966-1995). Approximately 238 stations with data through 1995.
- Snow water equivalent data for same stations.
- Monthly river discharge data for subbasins across Eurasia. 'Naturalized' for Yenisei basin

Study focus on Ob, Yenisei, and Lena basins



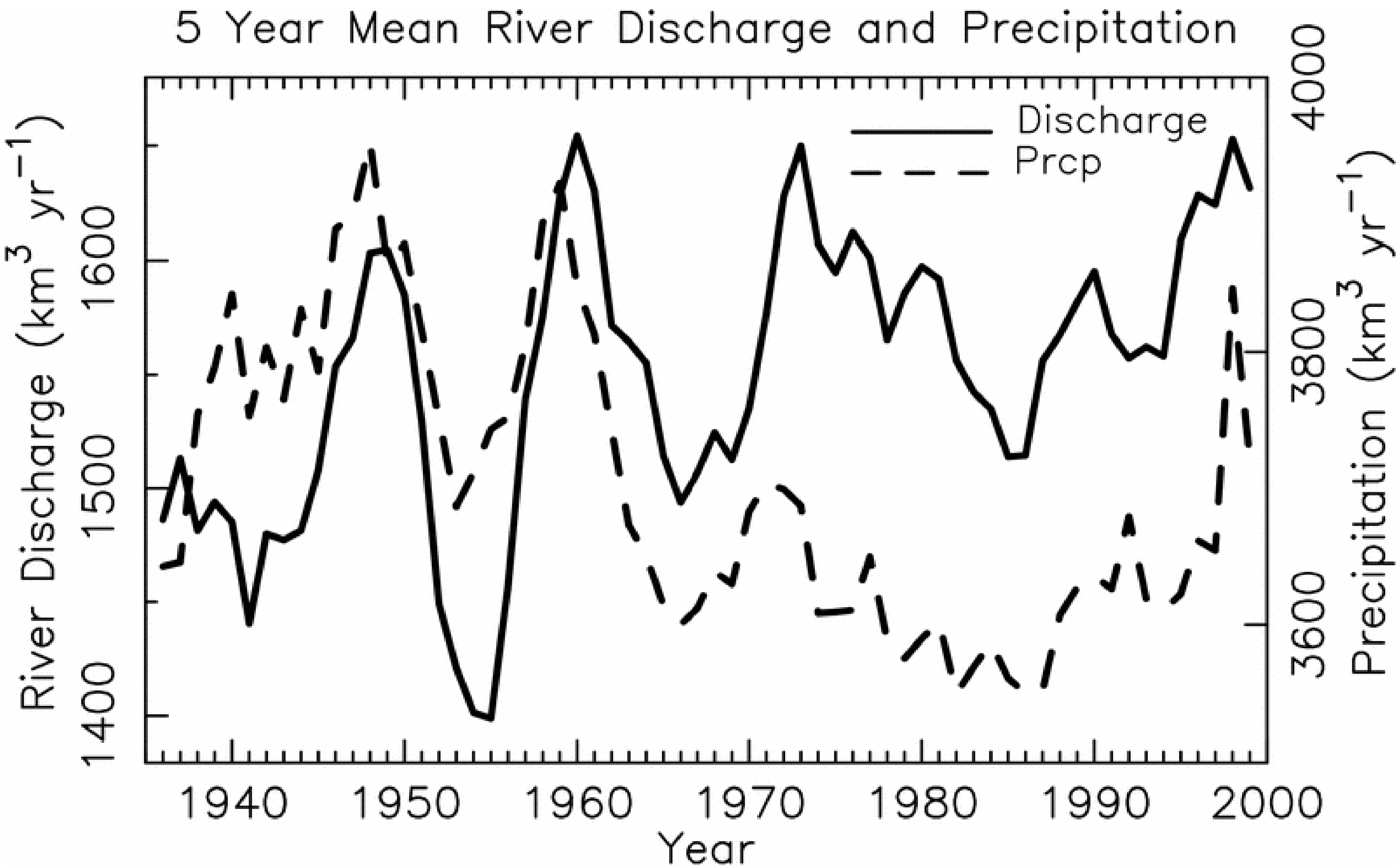
9.31 million km^2

dot = prcp station

triangle = snow depth station

square = SWE station

Annual and Seasonal River Discharge

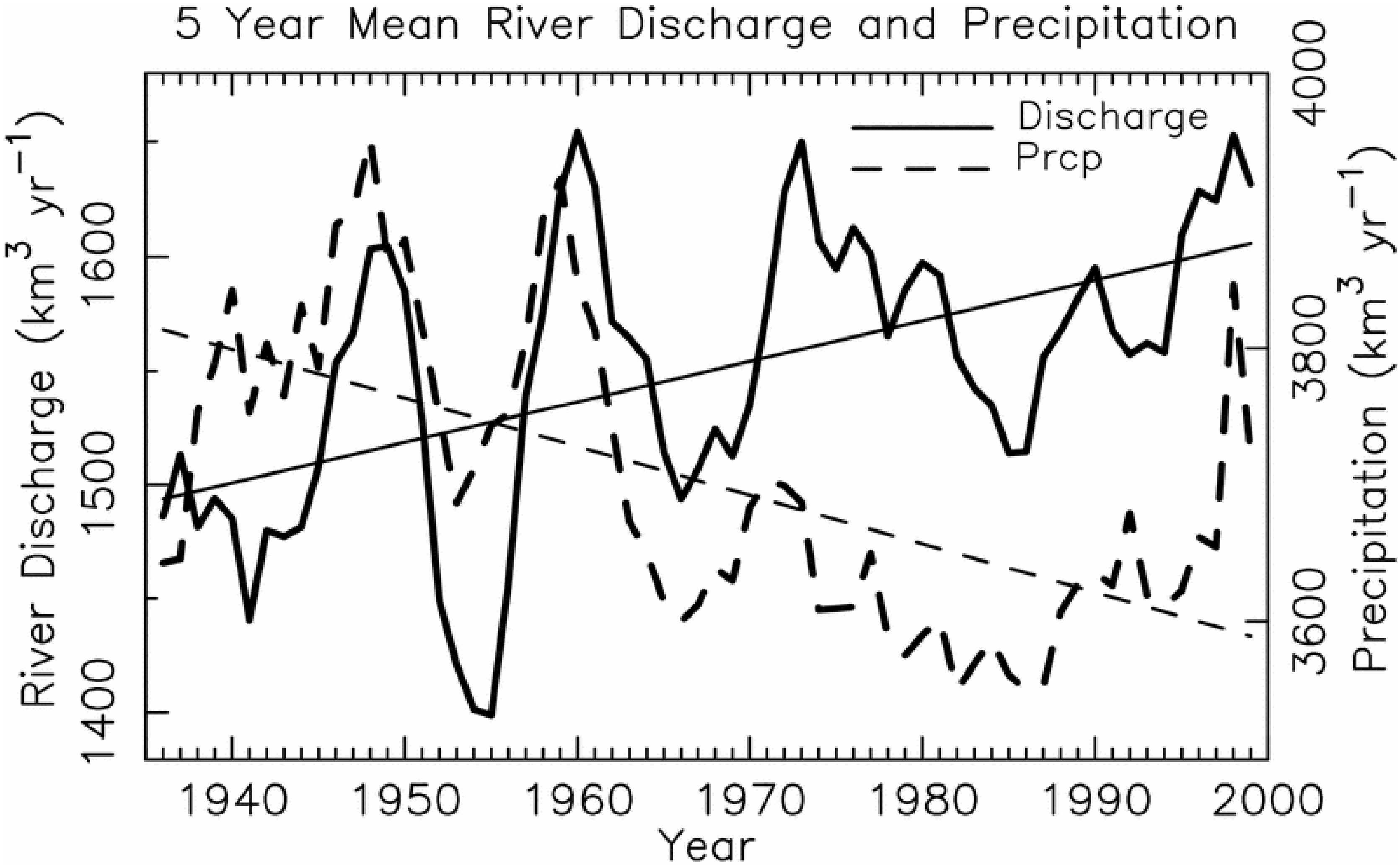


- River Discharge from RArctic-Net

www.r-arcticnet.sr.unh.edu/v4.0/index.html

- Precipitation from TD9813

www.ncdc.noaa.gov/oa/documentlibrary/surface-doc.html9813

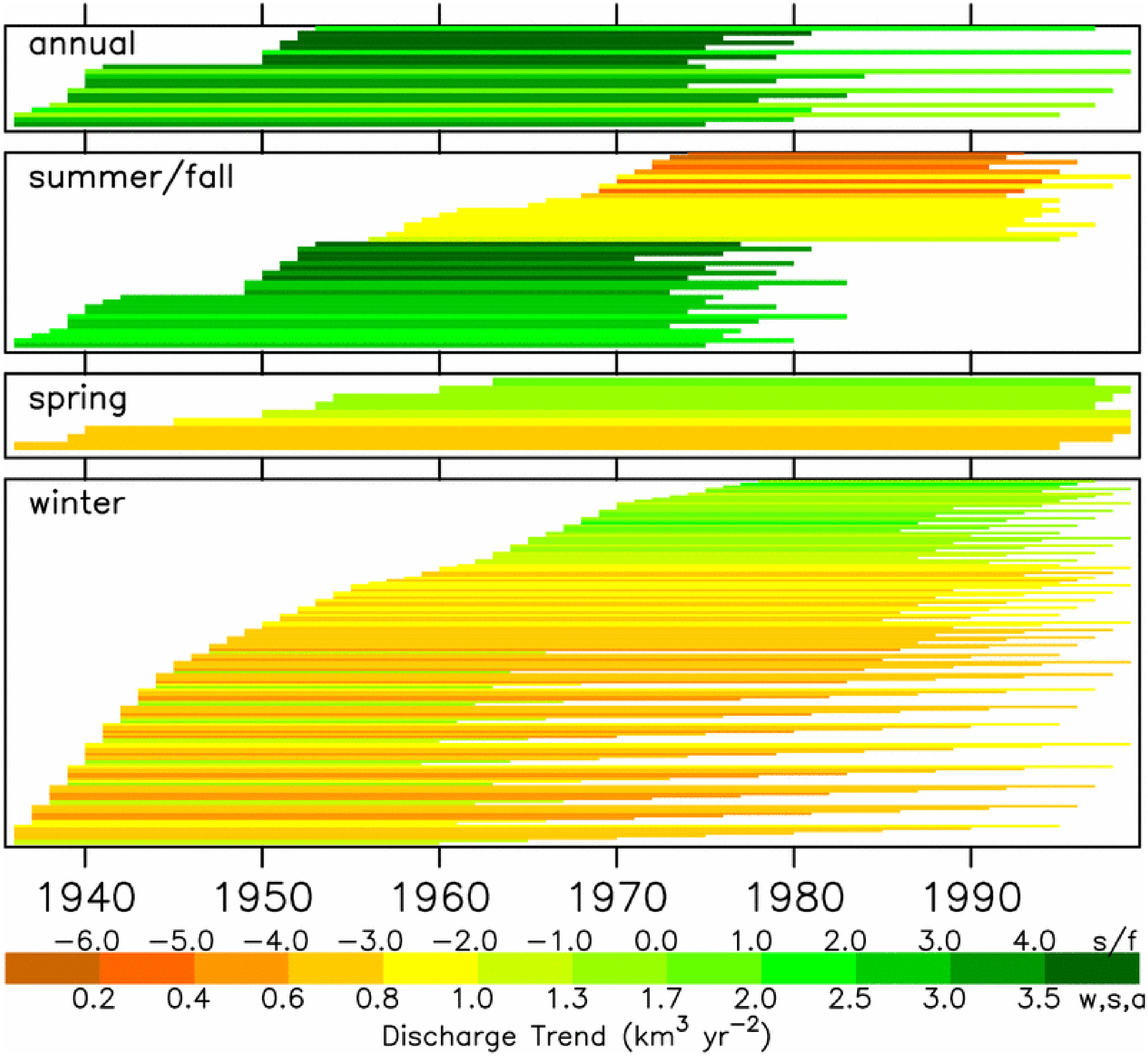


- River Discharge from RArctic-Net

www.r-arcticnet.sr.unh.edu/v4.0/index.html

- Precipitation from TD9813

www.ncdc.noaa.gov/oa/documentlibrary/surface-doc.html9813

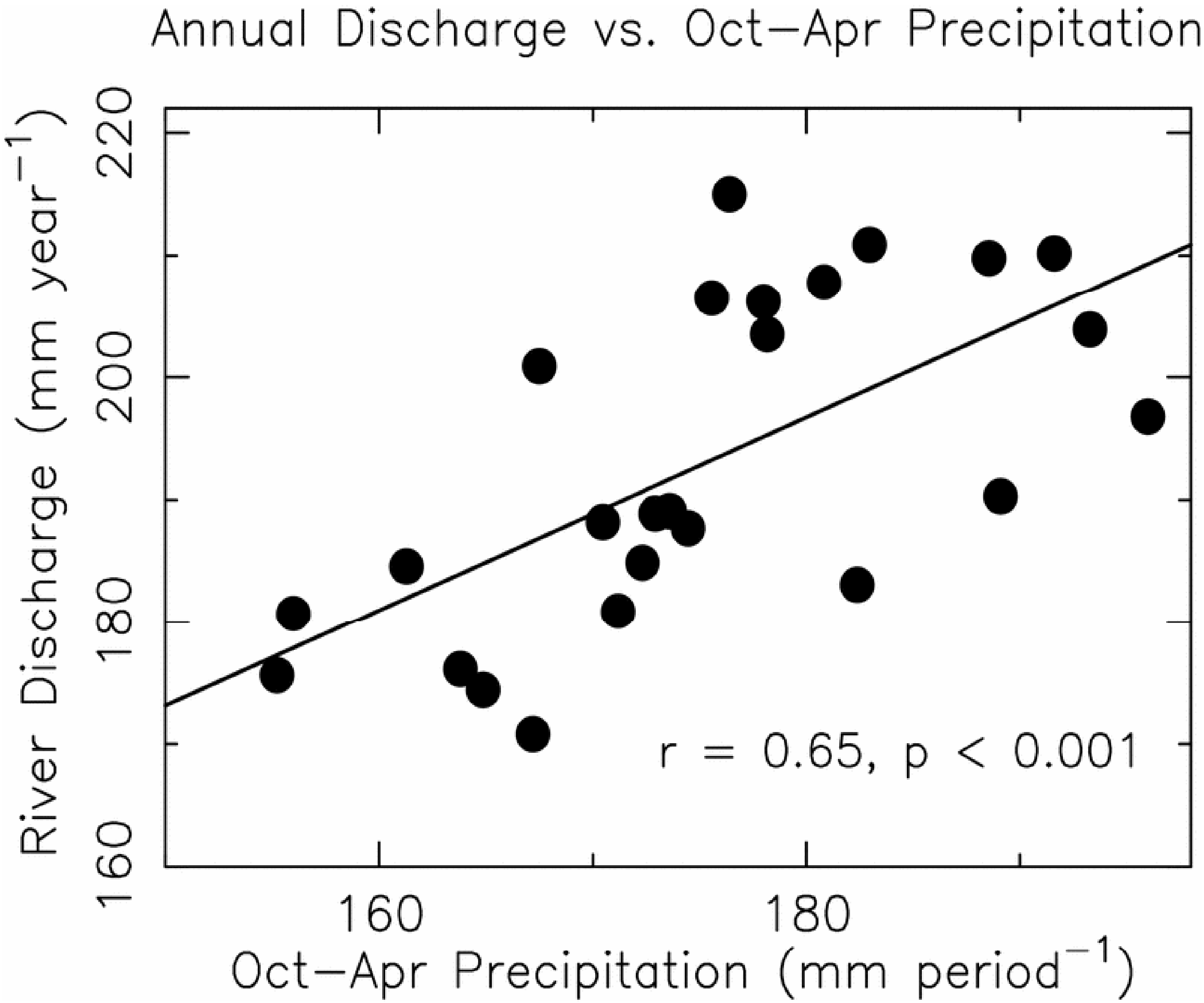


deceleration

acceleration

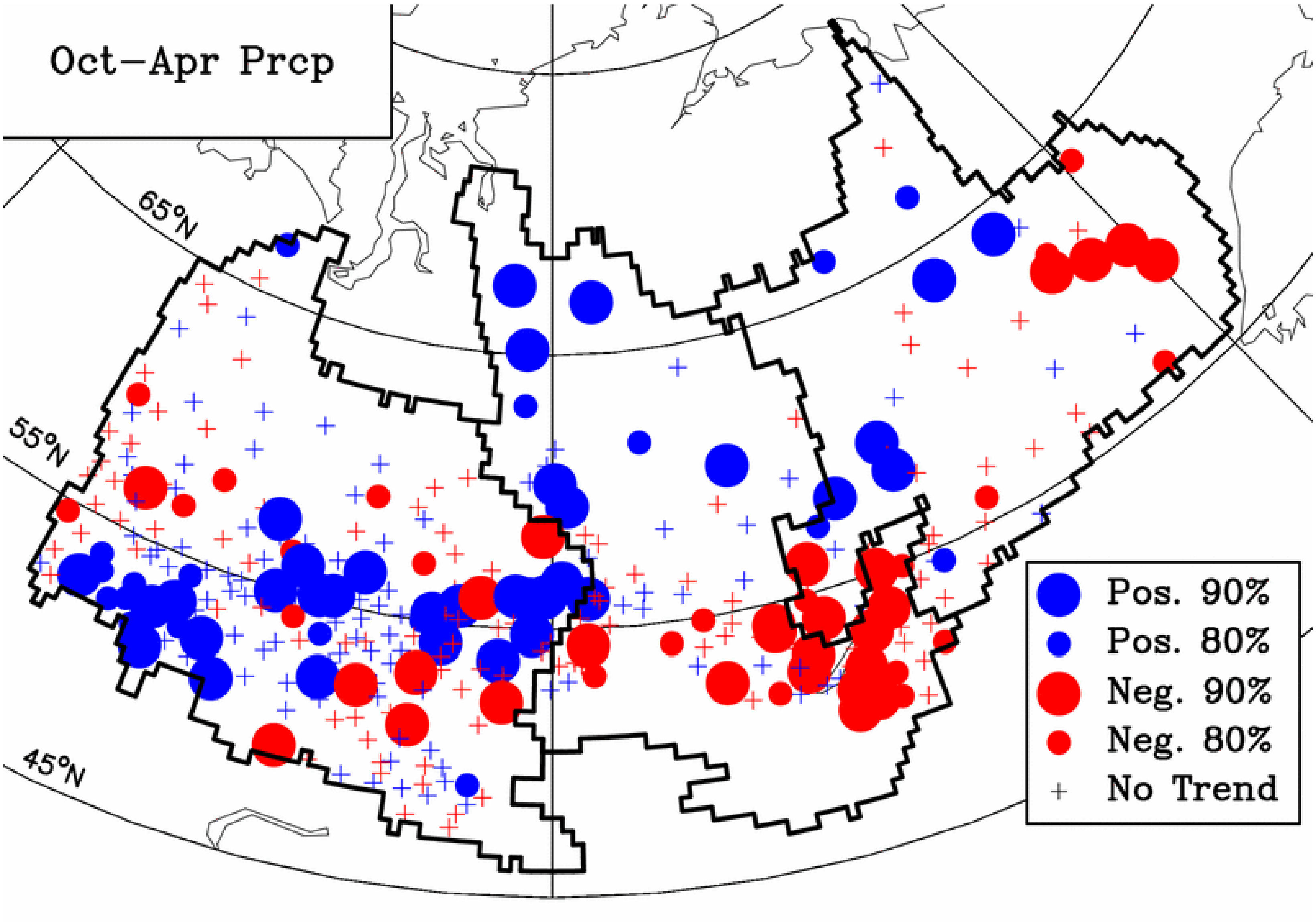
acceleration

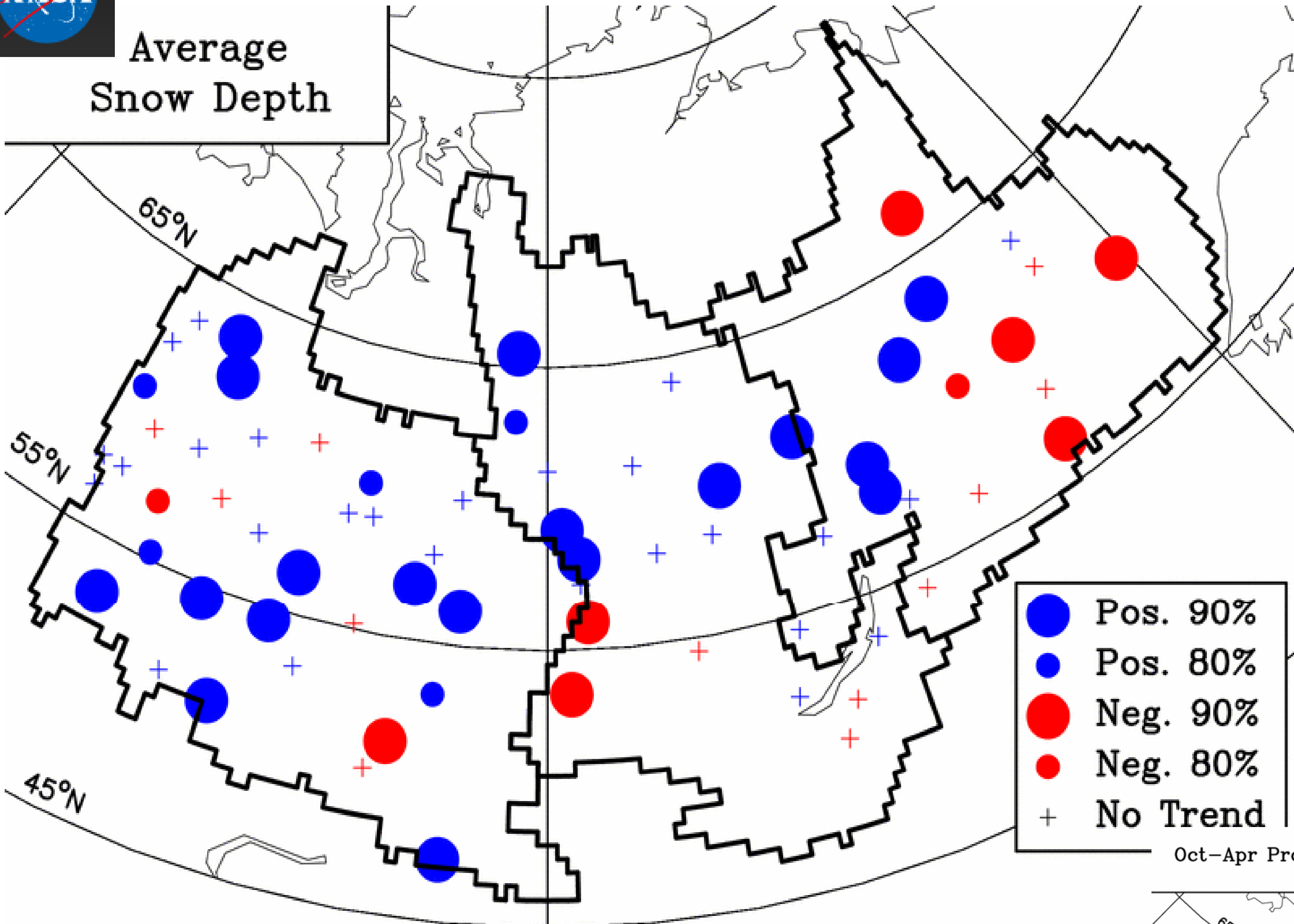
Winter Precipitation, Snow Depth, and SWE



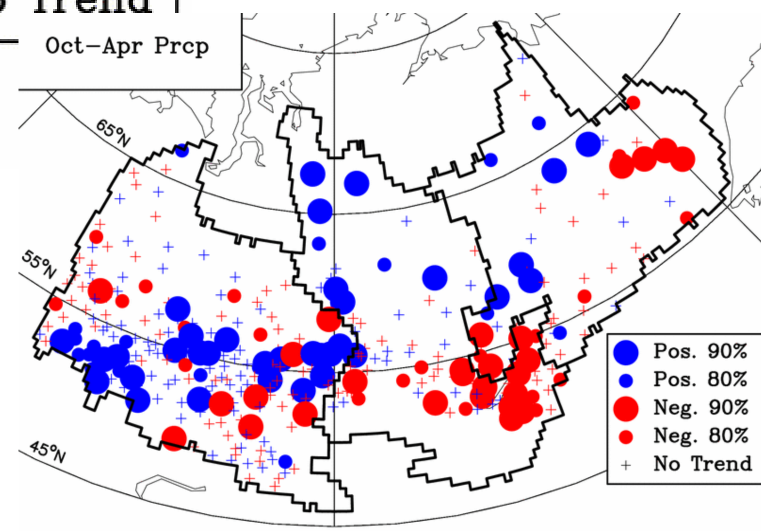
Seasonal snow accumulation strongly influences annual river discharge, not just the snowmelt period

A nearly equal number of stations with positive vs. negative trends (16% and 15%), ***but a strong spatial gradient is present, particular across the Yenisei basin***

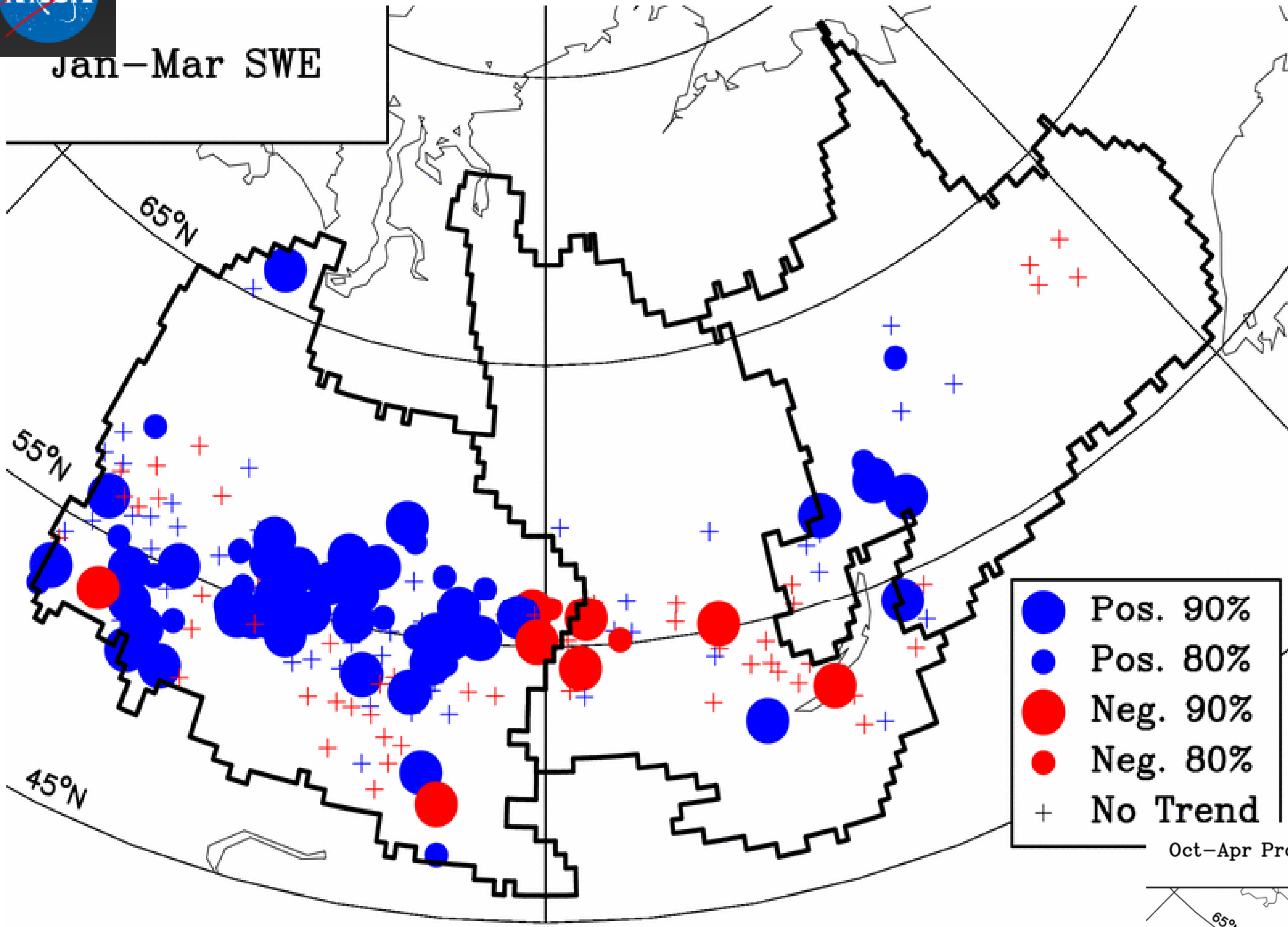




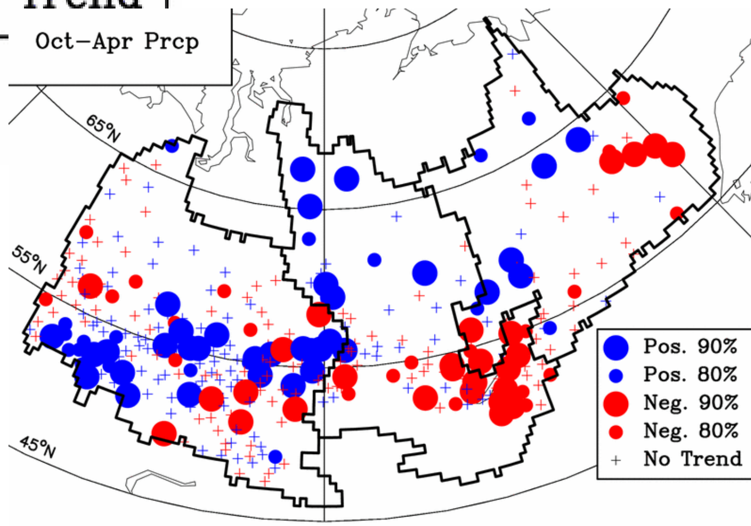
Average
Snow Depth
65°N
55°N
45°N
Pos. 90%
Pos. 80%
Neg. 90%
Neg. 80%
No Trend



Oct-Apr Prcp
65°N
55°N
45°N
Pos. 90%
Pos. 80%
Neg. 90%
Neg. 80%
No Trend

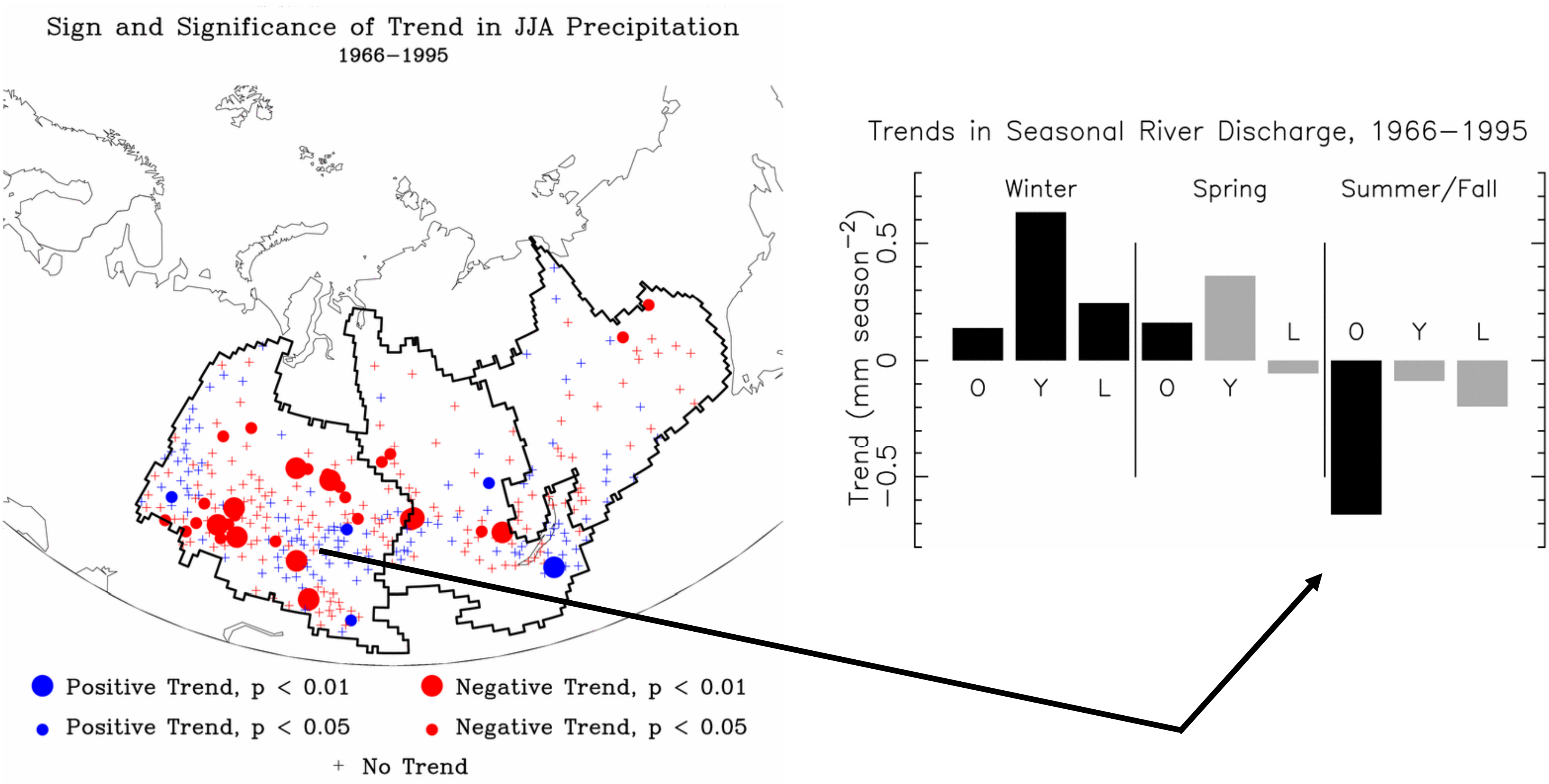


Missing observation plague SWE records across northern Eurasia.



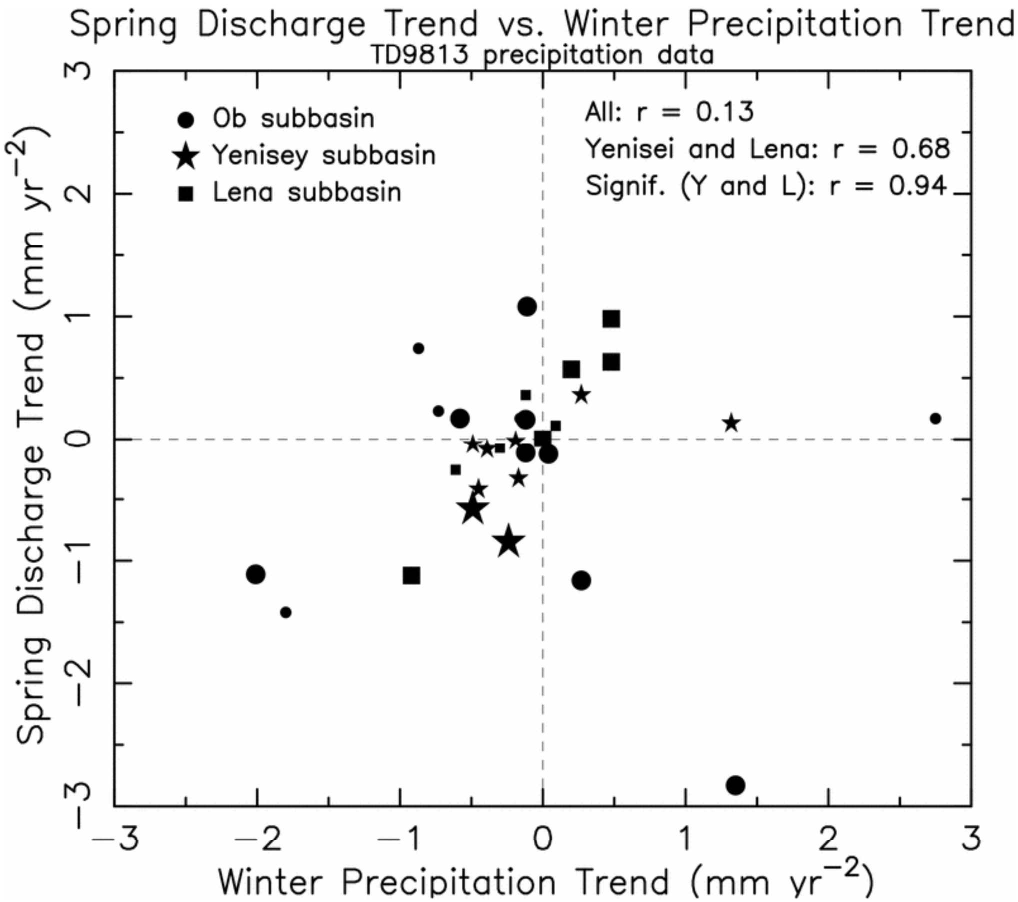
Linking Changes in Seasonal Precipitation and River Discharge

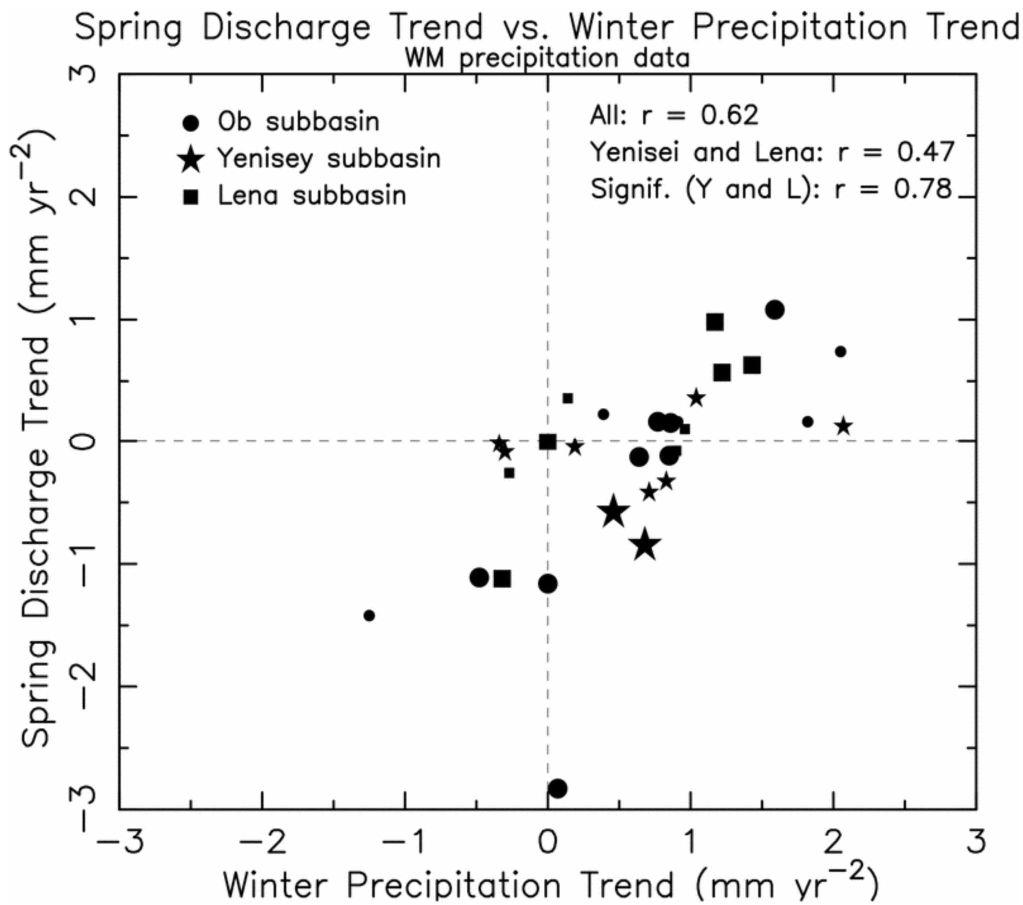
Drying in summer, particularly for Ob basin. Trends in 500 hPa heights described by *Serreze et al., 2003, JGR*

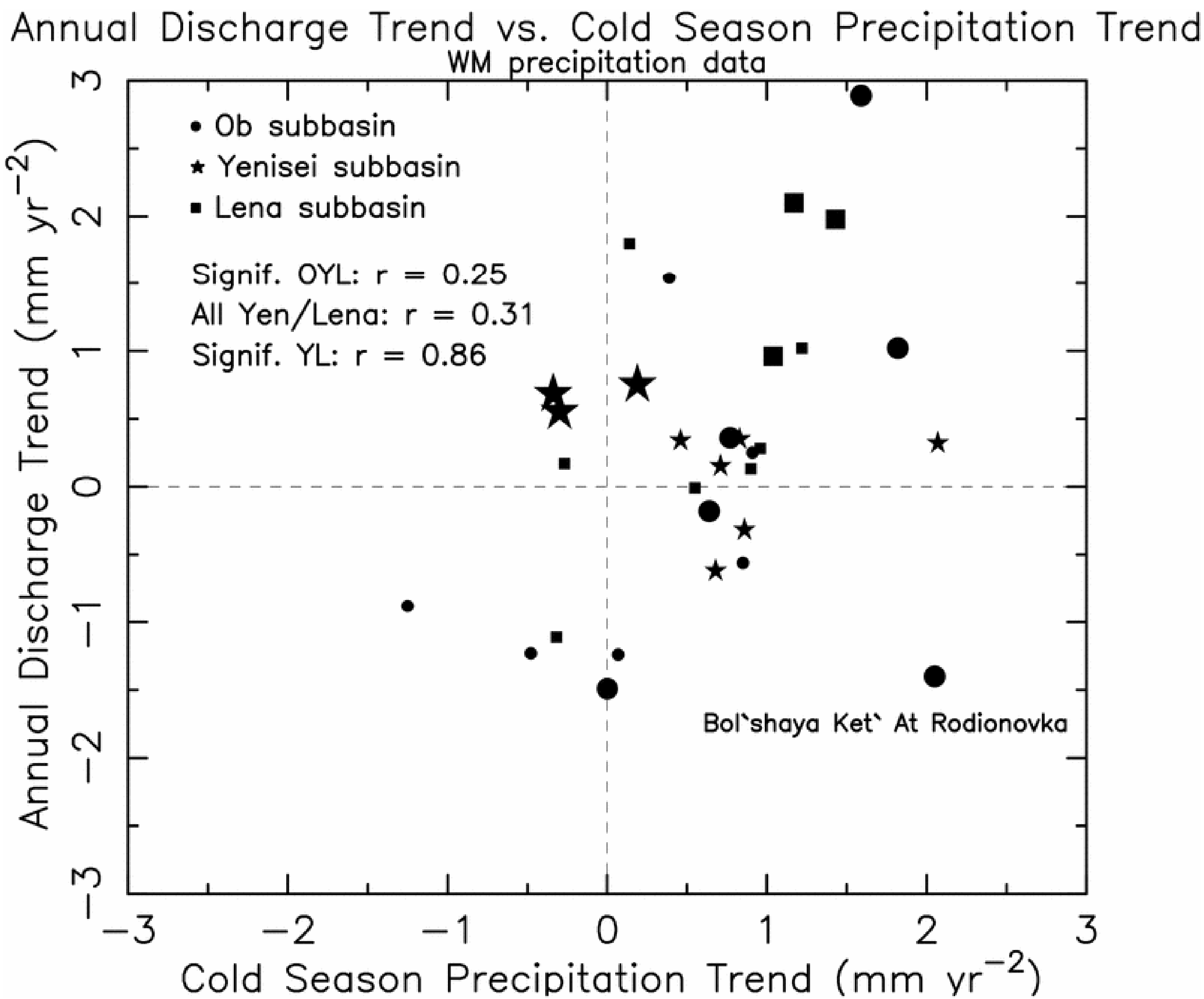


- Winter (Oct-Apr) precipitation trends explain most of spring discharge trend for subbasins with a significant trend in spring discharge

- Subbasins are nested...negative trends in south carried northward to influence downstream discharge







For annual discharge, cold season precipitation explains ~75% of trend in annual discharge for subbasins with a significant discharge trend

Summary:

- Cold season precipitation strongly influences annual total discharge from central Eurasia

- A divergence between winter and spring (increasingly positive) and summer/fall (increasingly negative) apparent in latter decades of the 1936-1999 period

- cold season precipitation trends explain a large fraction of spring and annual discharge trends for nested subbasins of Yenisei and Lena w/ significant discharge trend

- research should focus on upstream forcings and downstream implications for seasonal changes