Understanding Change in the Climate and Hydrology of the Arctic Land Region:

Synthesizing the Results of the ARCSS Fresh Water Initiative Projects

Eric F. Wood
John Cassano
Dennis Lettenmaier
Charles Vörösmarty

Project Science Questions

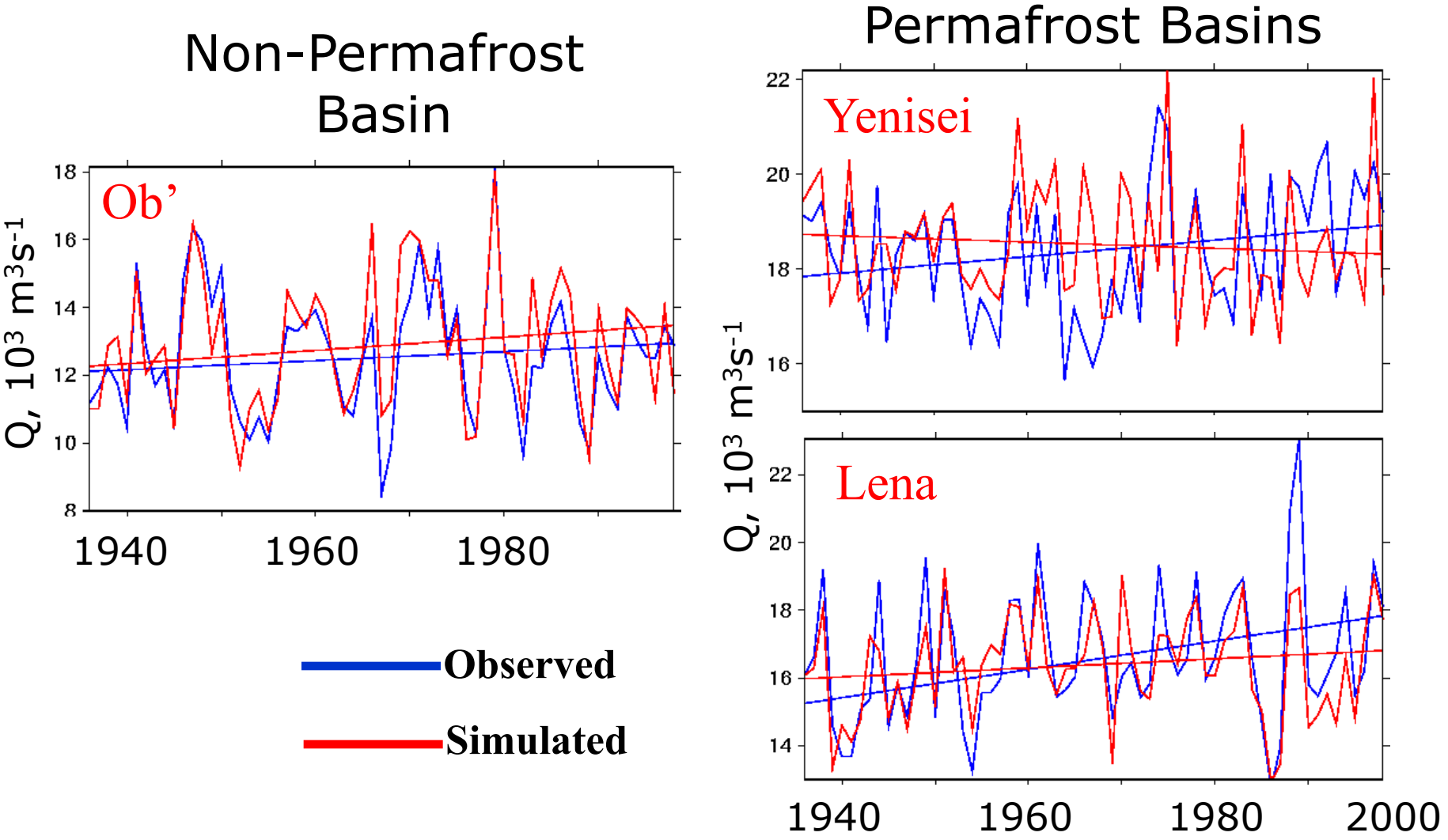
- How do changes in arctic land processes affect the hydroclimate of the region?
- What are the implications of these changes for the arctic hydrologic cycle (including coupling and feedbacks with the atmosphere)?
- What are the impacts of changes in the arctic freshwater system on global climate?

"How do changes in arctic land processes affect the hydroclimate of the region?"

Conflicting Explanations for Discharge Trends

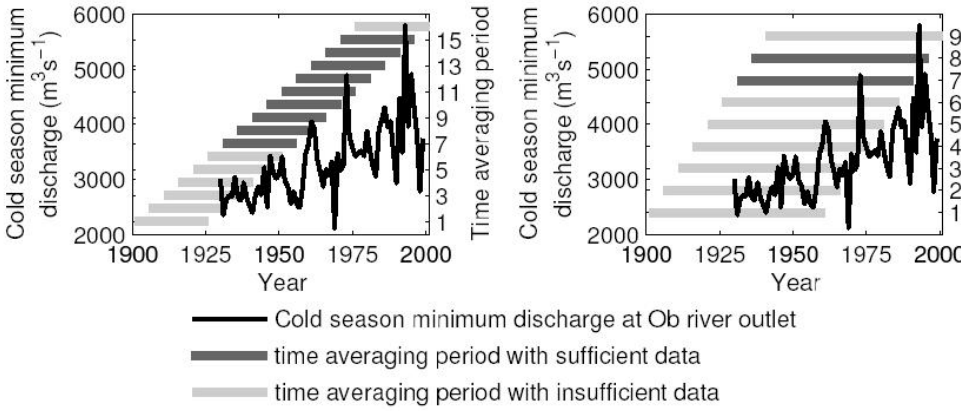
Increased northward atmospheric moisture transport	Nijssen et al. (2001), Wu et al. (2005), Arnel (2005)
Human effects (reservoir construction)	Yang et al. (2004), Ye et al. (2003), McClelland et al. (2004)
Release of water from permafrost degradation	Frauenfield et al. (2004), Zhang et al. (2003), Ye et al. (2003)
Climate-induced changes to the land surface (increased fire frequency)	McClelland et al. (2004), Conrad and Ivanova (1997)
Changes in lake areal extent and storage	Smith et al. (2005)
Change in evapotranspiration	Gedney et al. (2006)
Change in snow accumulation / ablation patterns	Brown (2000), Groisman et al. (1994), Robinson et al. (1990)

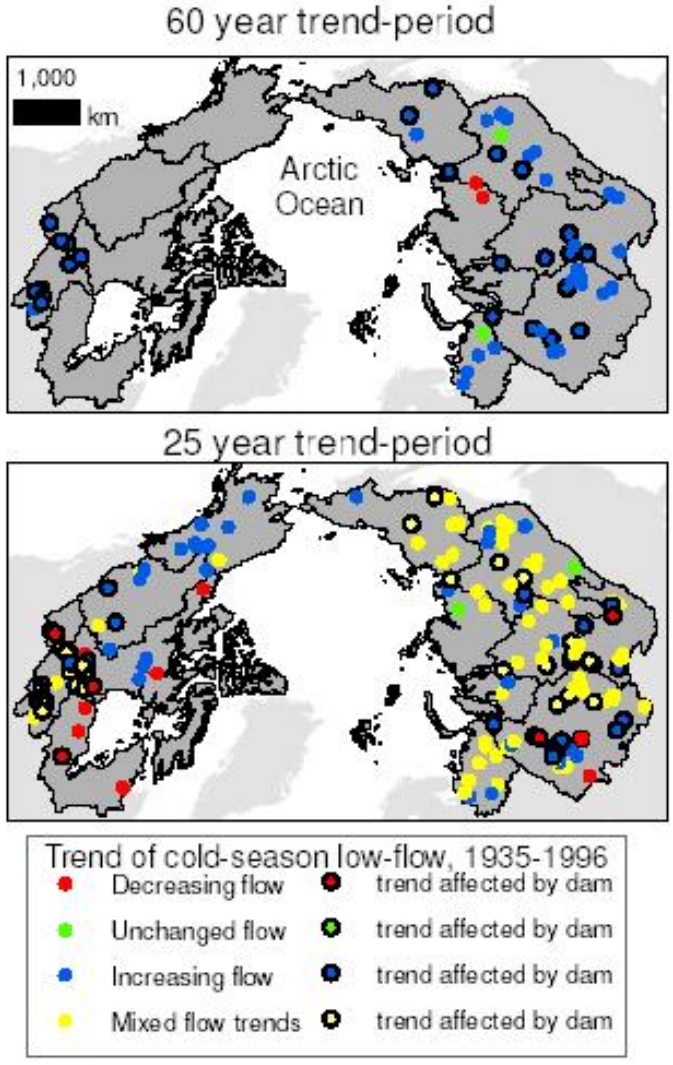
Historical Streamflow Trends Not Captured in Permafrost Basins



Trends in Cold Season Low Flows

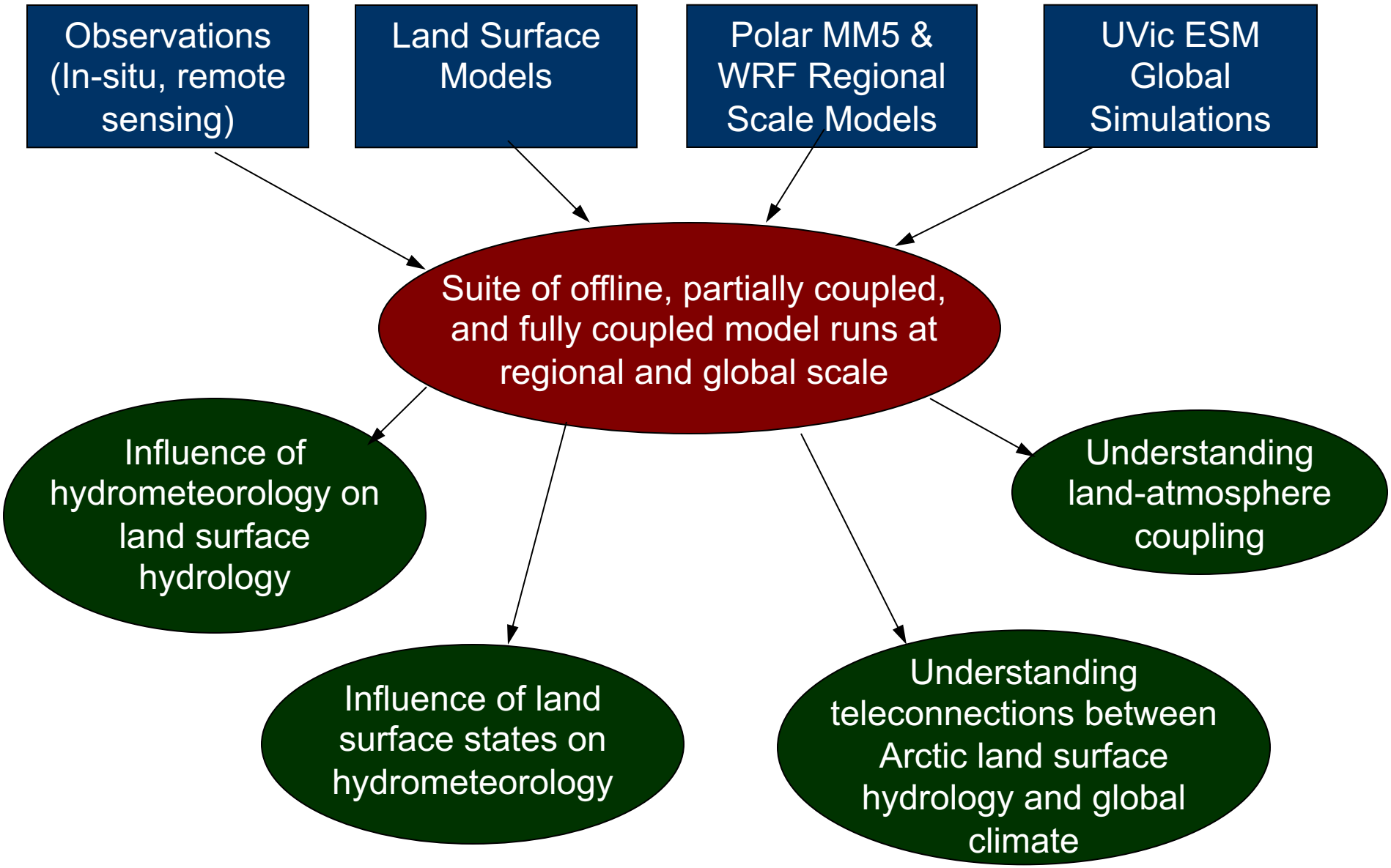
- Cold-season low flows are increasing across Northern Eurasia at large time scales (60 years) with conflicting results over smaller trend periods.
- Consistent trends between natural and managed basins
- Ob River shows a pronounced increasing trend in low flows





(Rennermalm and Wood, in preparation)

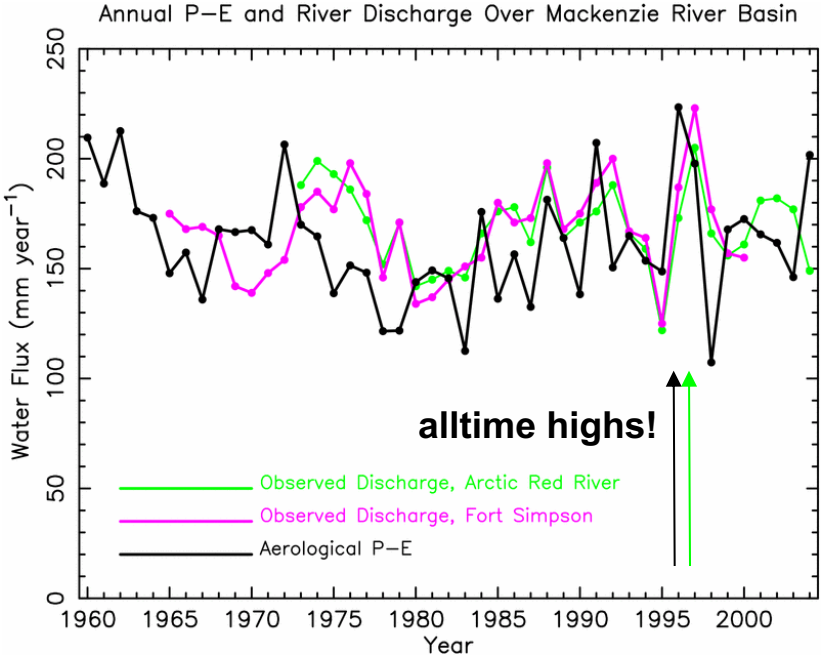
Research Approach



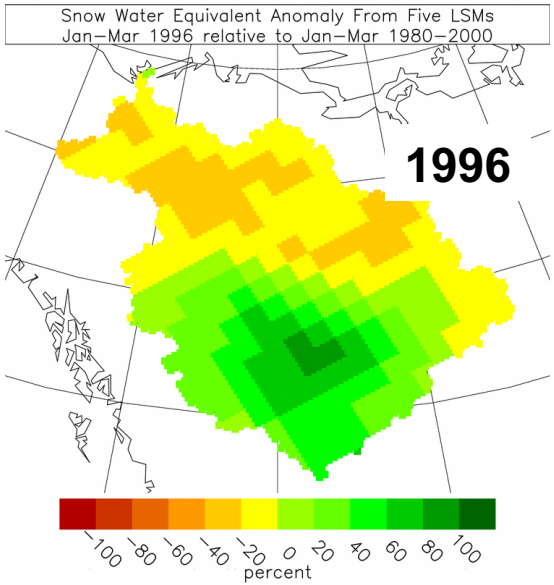
Tracing Freshwater Anomalies Through the Arctic System

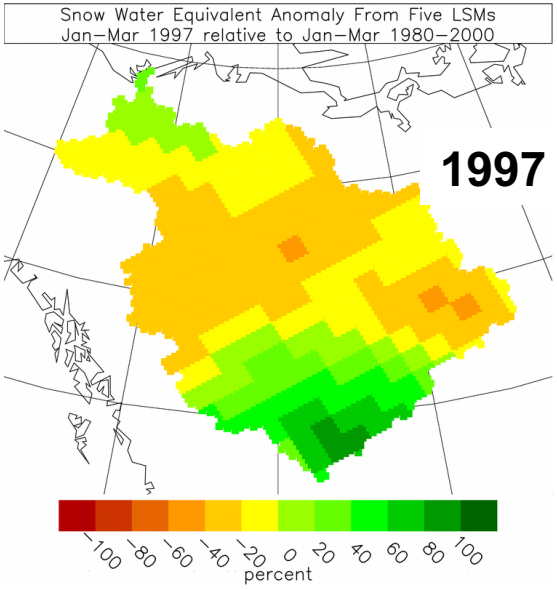
Record discharge in 1997 caused by excessive winter snowfall in 1996-1997

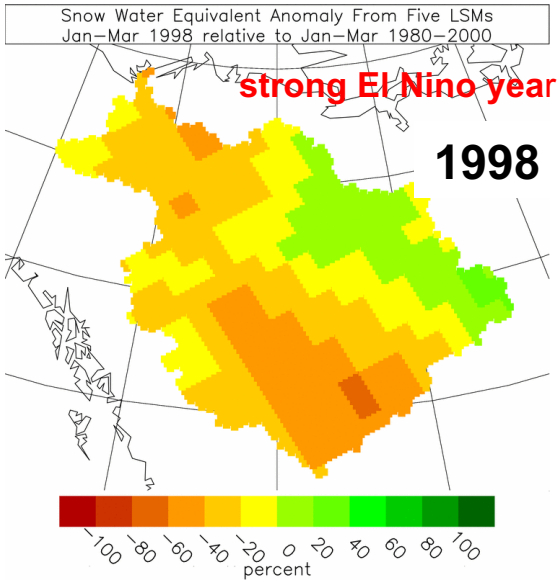
Flux from atmosphere noted in reanalysis data using aerological method for P-E



SWE anomaly is average of five LSMs: CLM, NOAH, CHASM, VIC, ECMWF

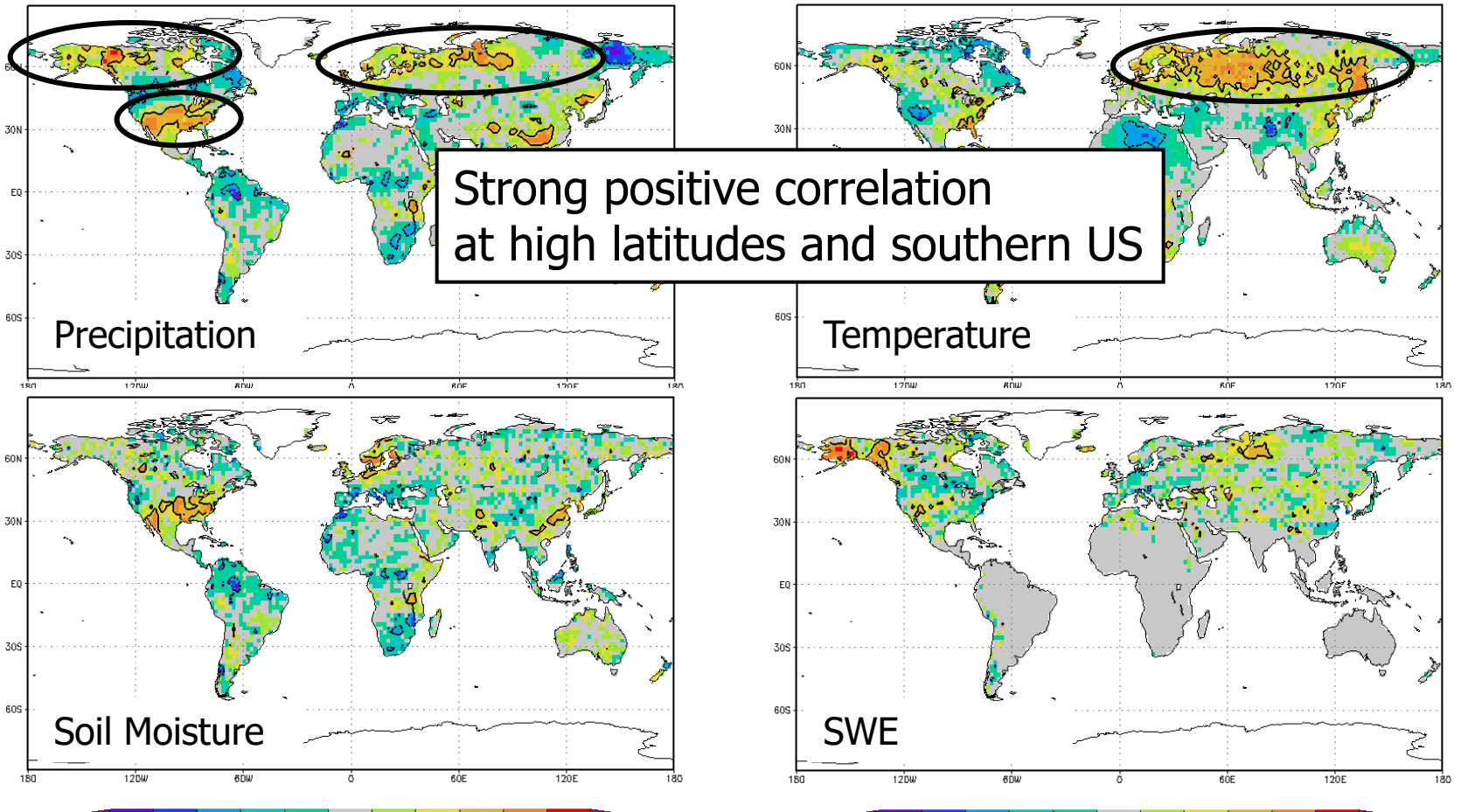






NAO Teleconnections with Surface States

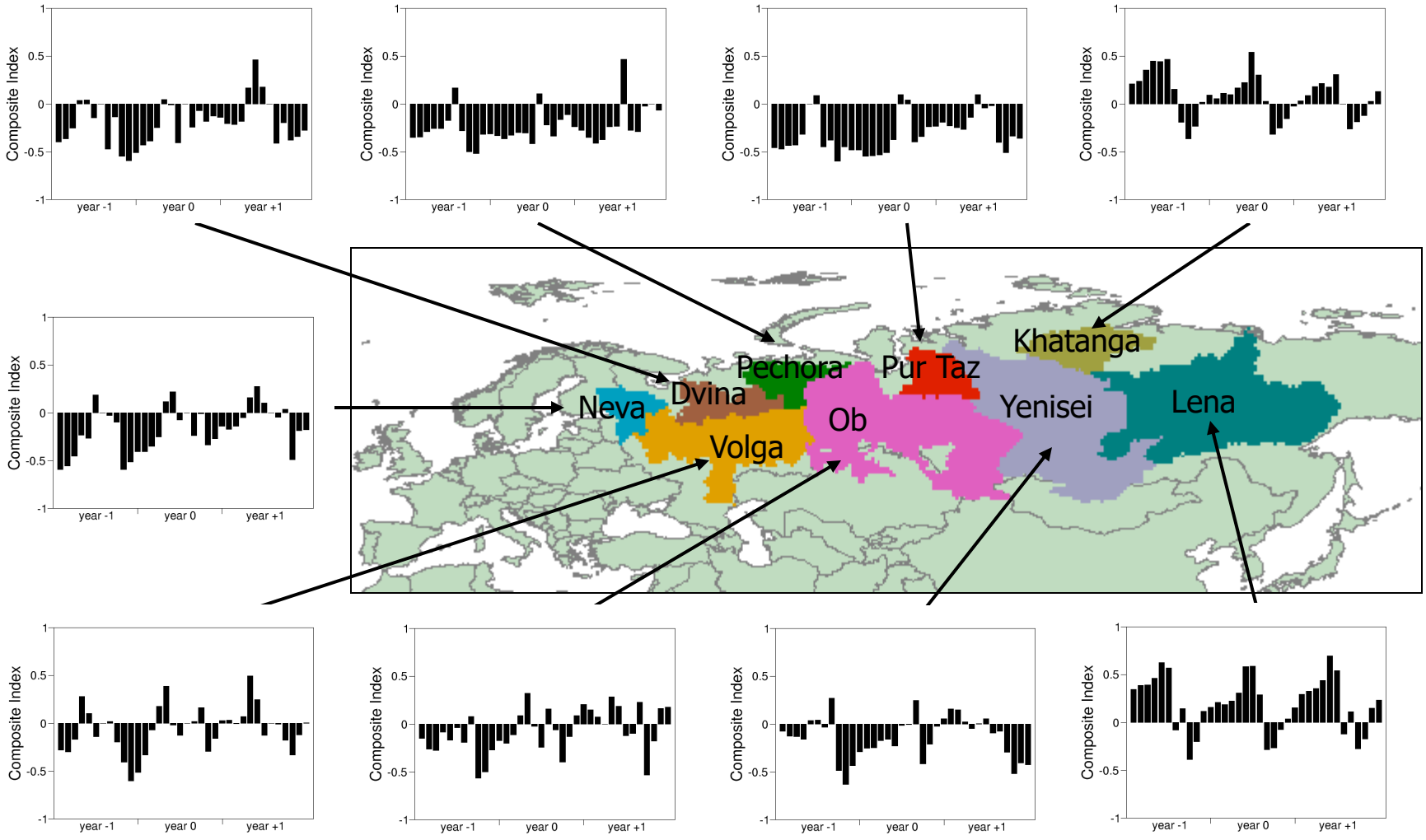
Correlation of DJF average states with CRU NAO index



Correlation (95% significance)

NAO Composites – SWE

NAO negative phase composites for snow water equivalent

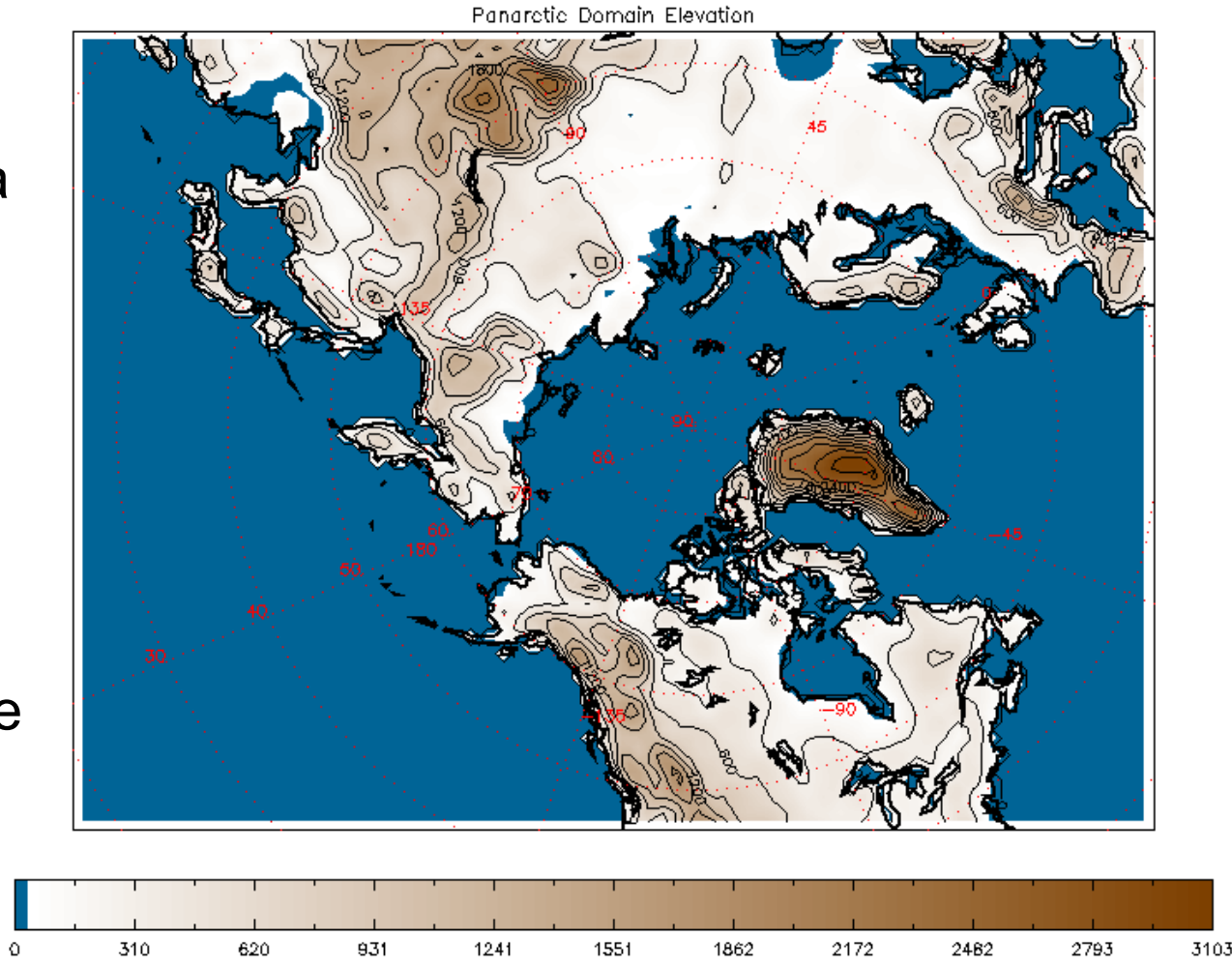


Year: -1 0 +1

Princeton University

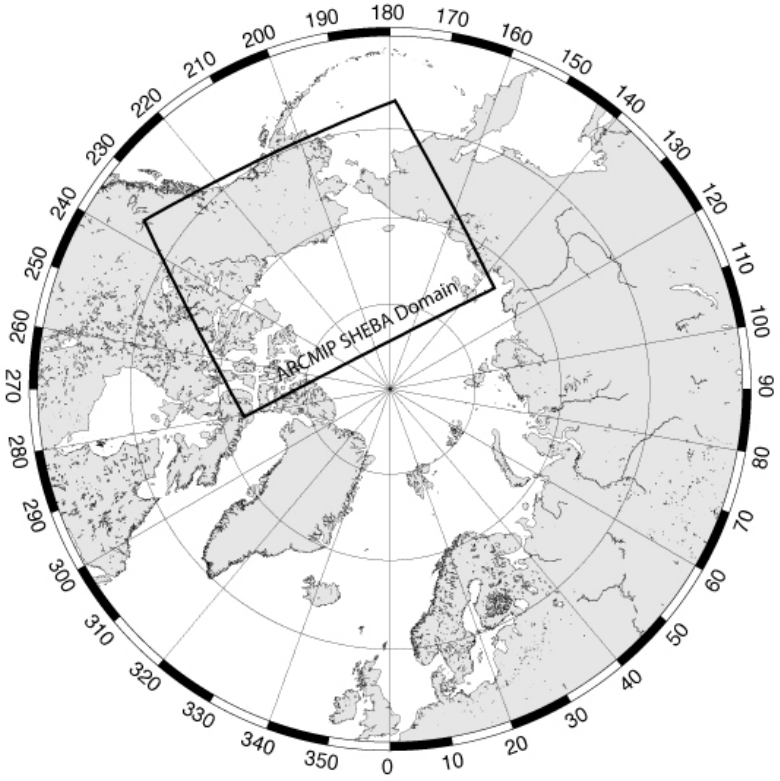
Atmospheric Modeling

- Pan-arctic simulations with Polar MM5 coupled to Noah LSM
- 1979-2002
- With and without data assimilation (FDDA)
- Large biases in non-FDDA simulations
- Source of model error is still being investigated
- Plan to explore atmospheric response to changing permafrost extent

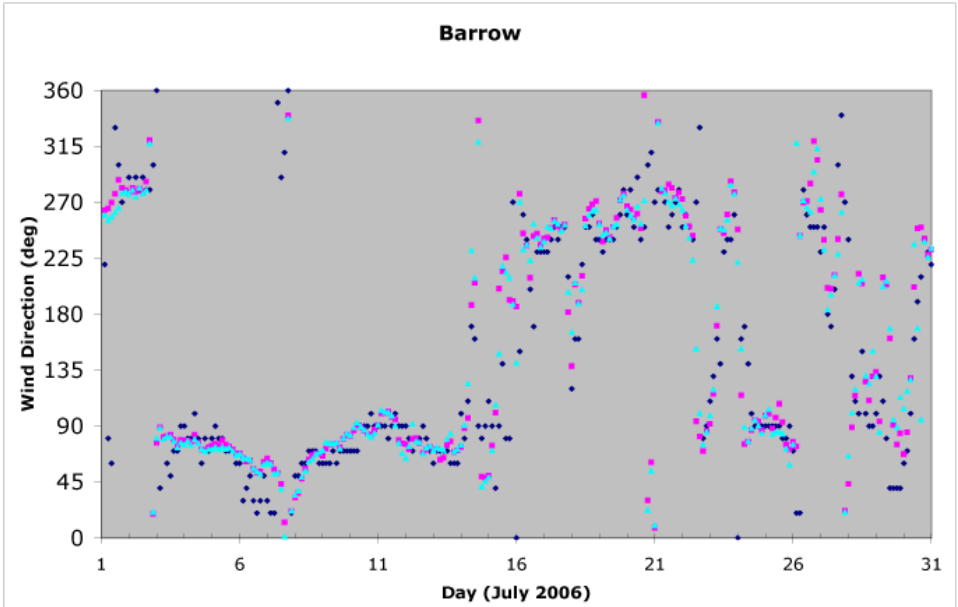


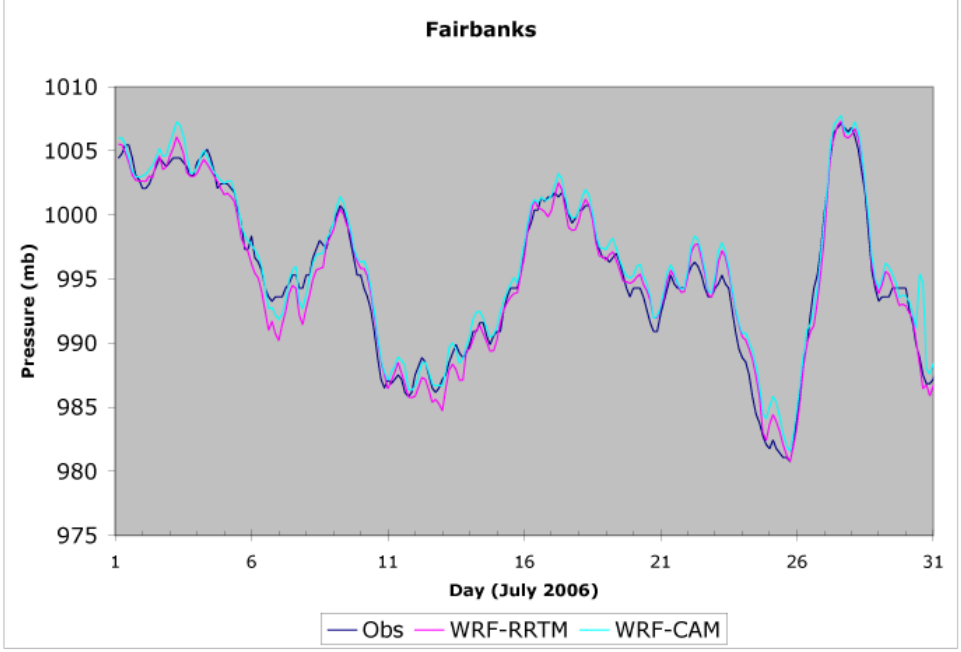
Atmospheric Modeling

- Development of Polar WRF
- Evaluation for ARCMIP domain simulations



- Initial results indicate that WRF has similar skill to Polar MM5
- Next steps: Coupling of WRF and VIC





Moving Forward – some current steps

- Implementation of VIC as land surface scheme in WRF
- Evaluation of the mesoscale model's sensitivity to land surface parameterizations
- Using the range of models, with their individual strengths, to come to an understanding of the feedbacks and connections between land, atmosphere and ocean
- Synthesizing model output with observations to understand the sensitivity of the system to changes in climate, both experienced and projected