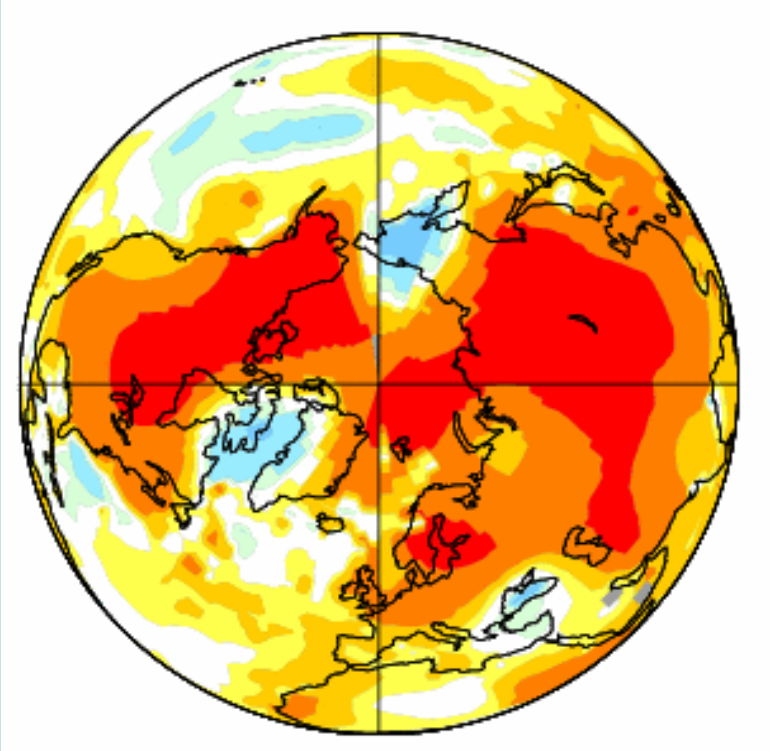
Climate Change Projections and Uncertainties for Alaska

John Walsh

International Arctic Research Center, UAF

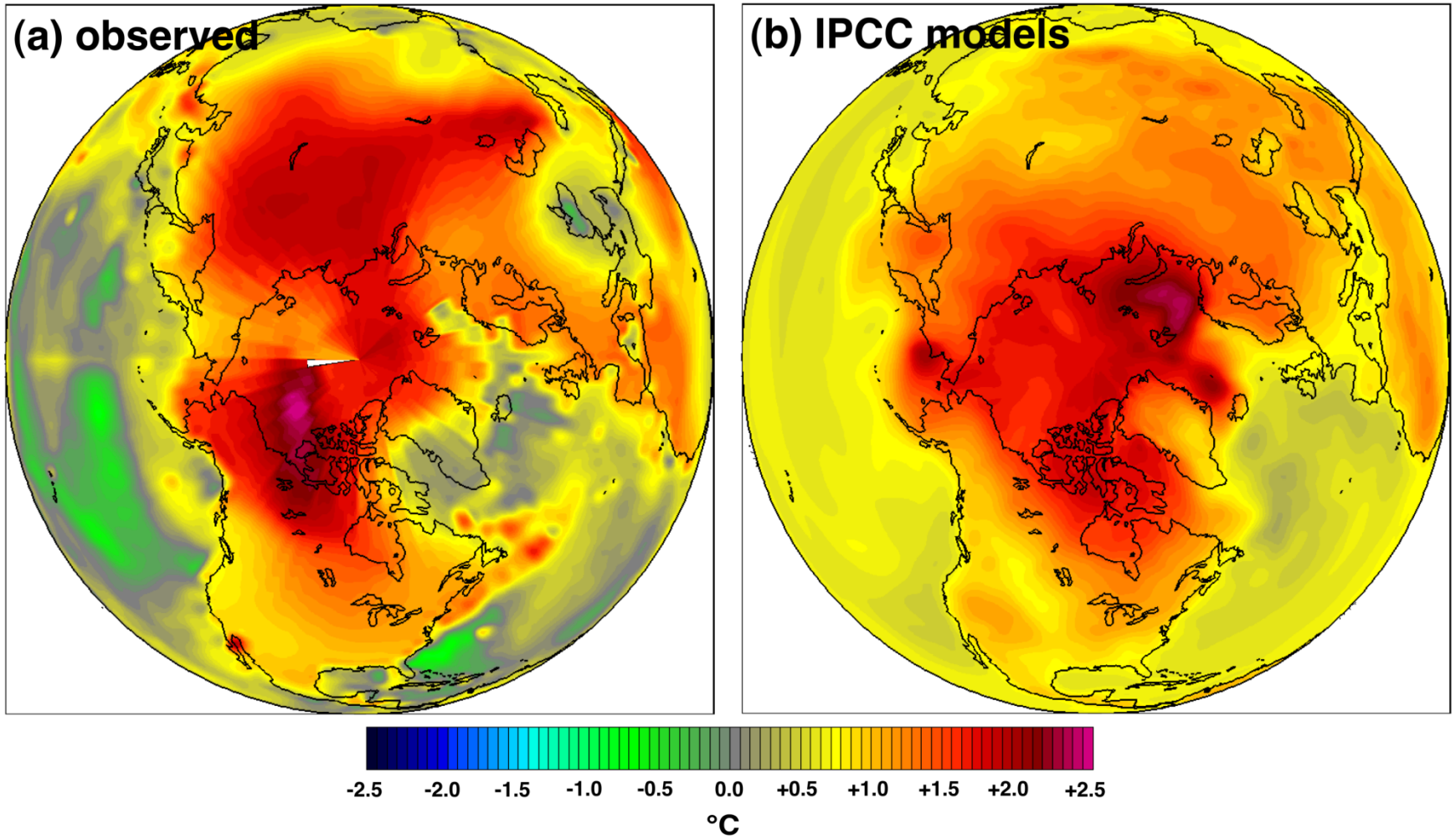


Western Alaska LCC Workshop, Anchorage, April 2011

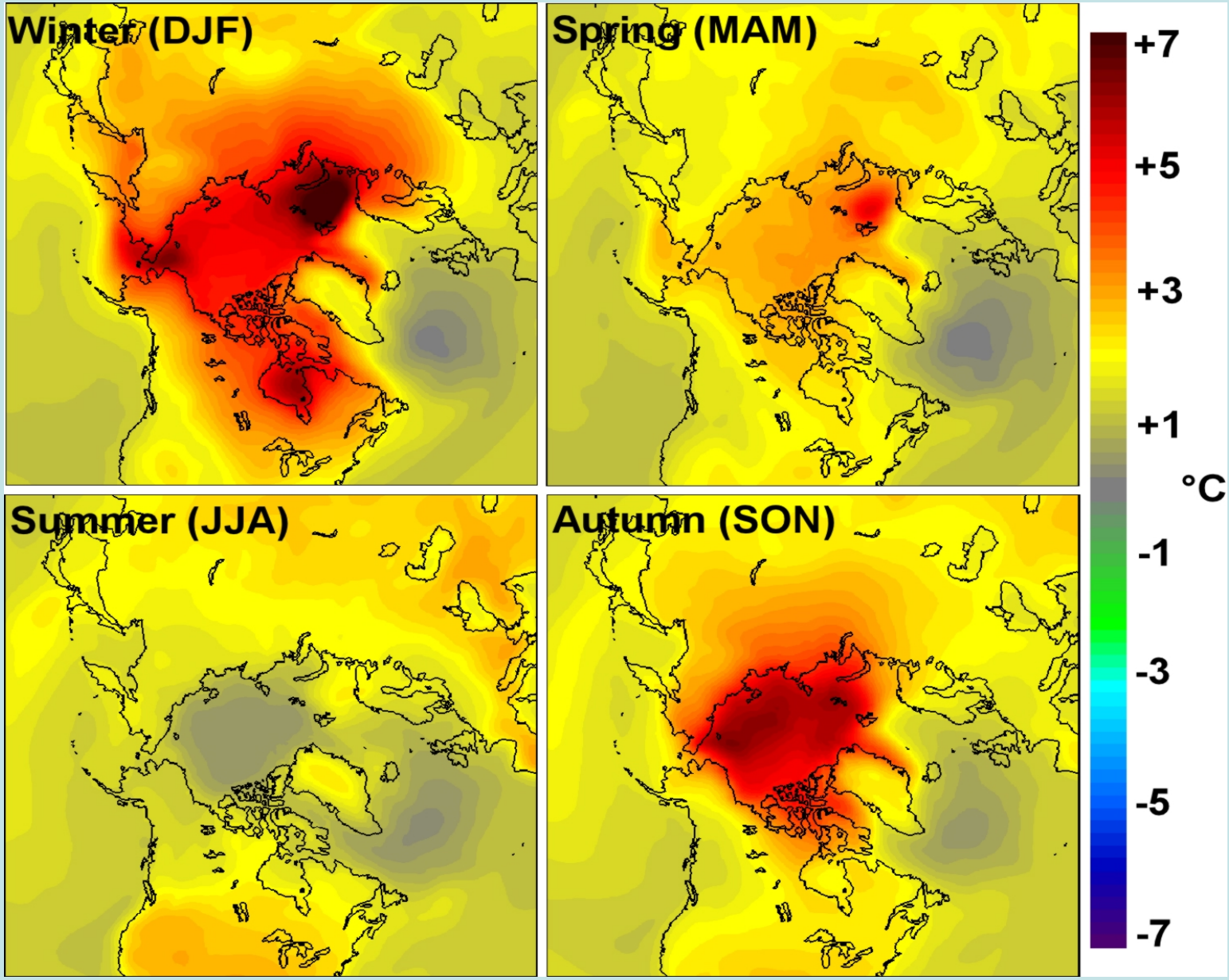
Presentation will address:

- **Model projections of change in Alaskan climate**
- **Capabilities and limitations of model projections of climate change – "sources of uncertainty"**

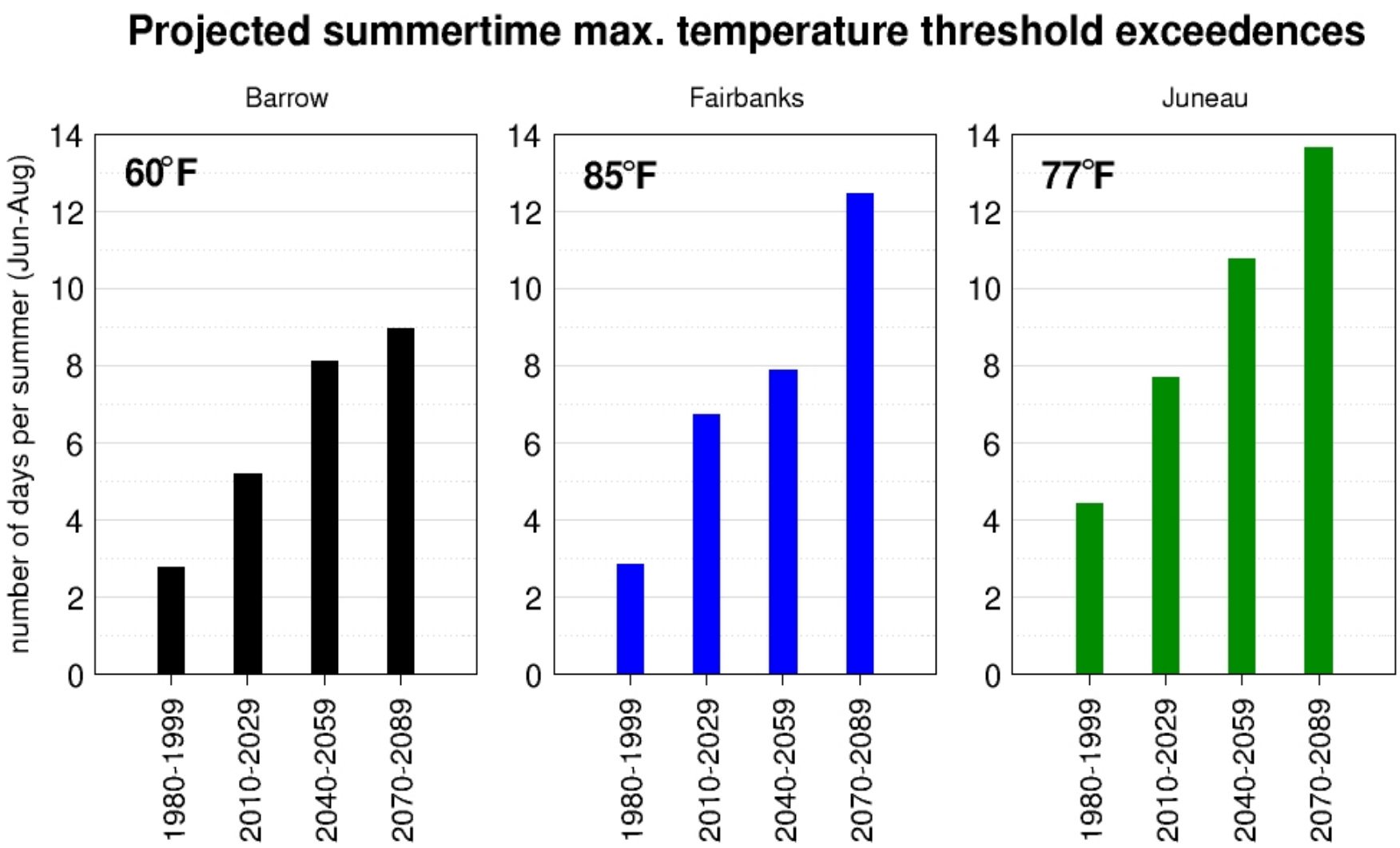
Change in *annual* surface air temperature, 1957-2006



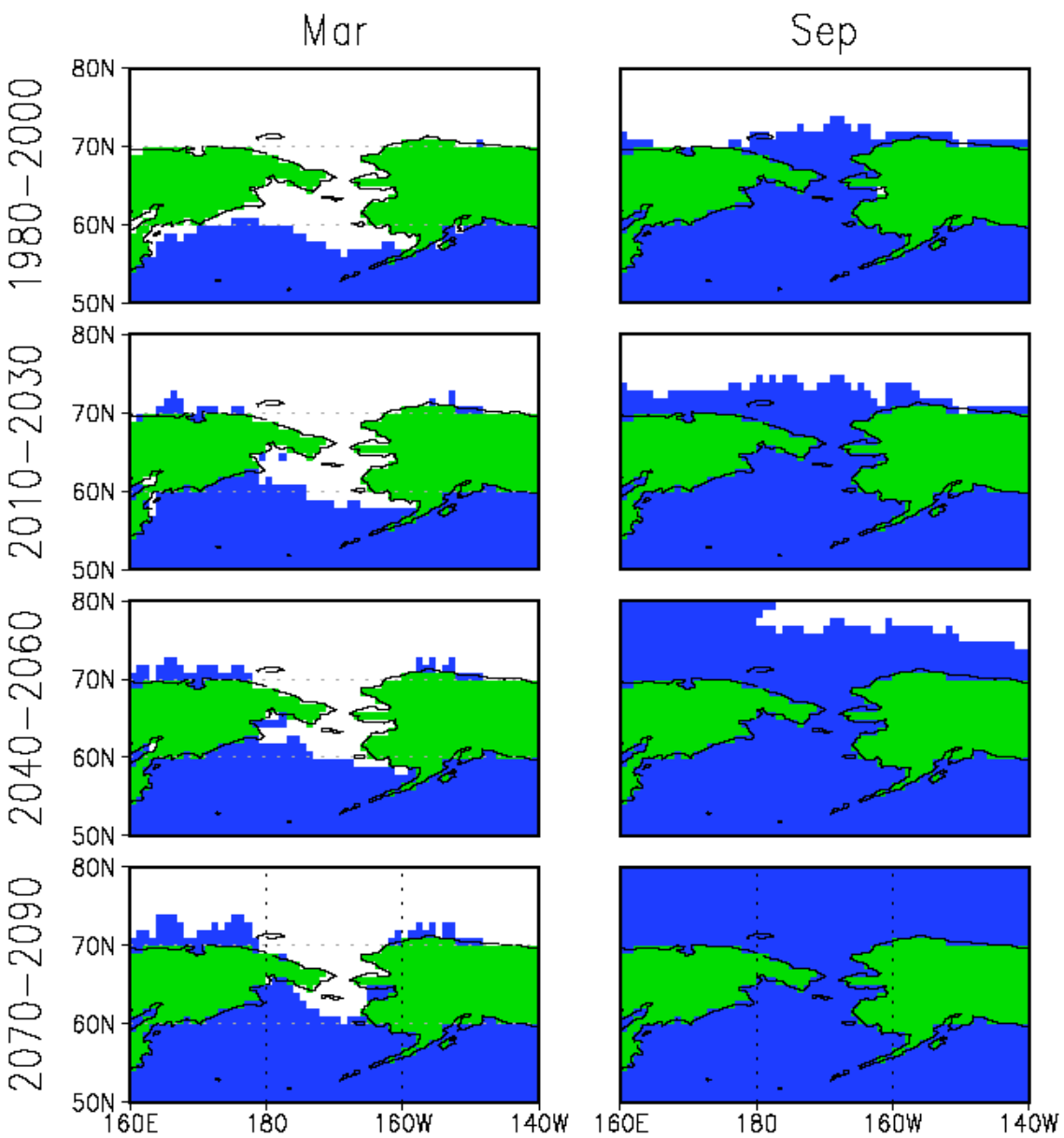
Projected changes of temperature: 2070-2090



Projected daily T_{max} exceedences



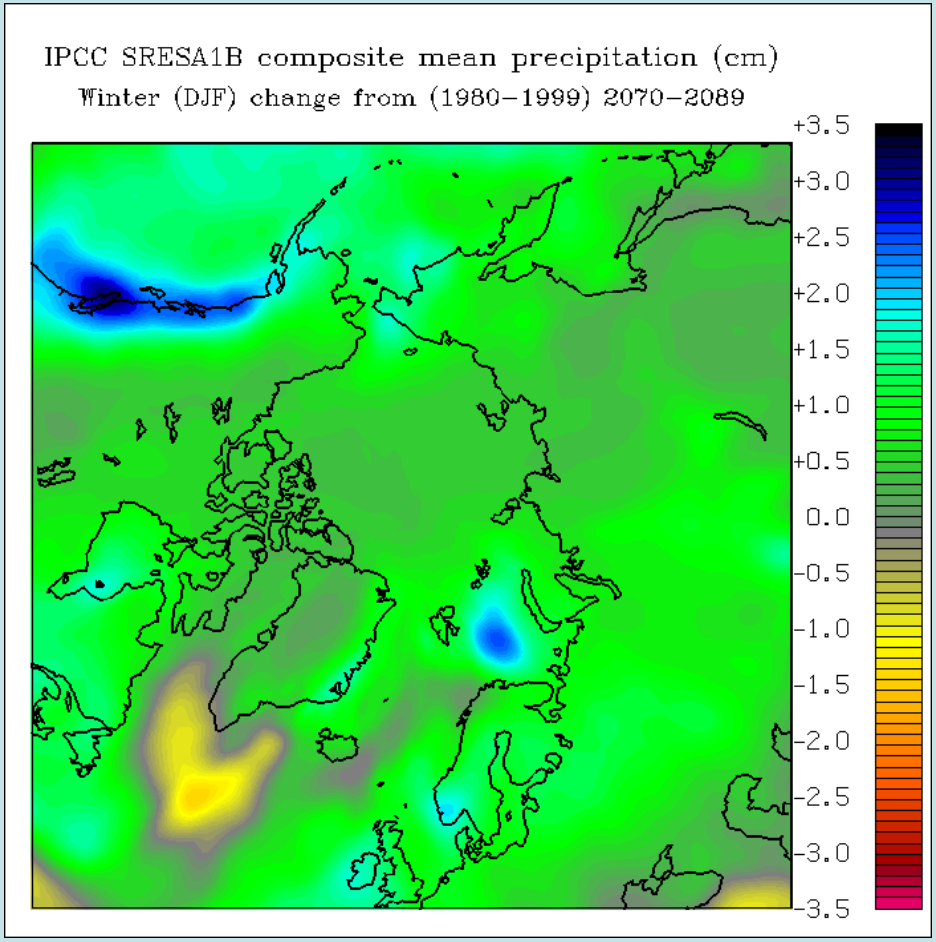
Climate model projections: Alaskan sea ice



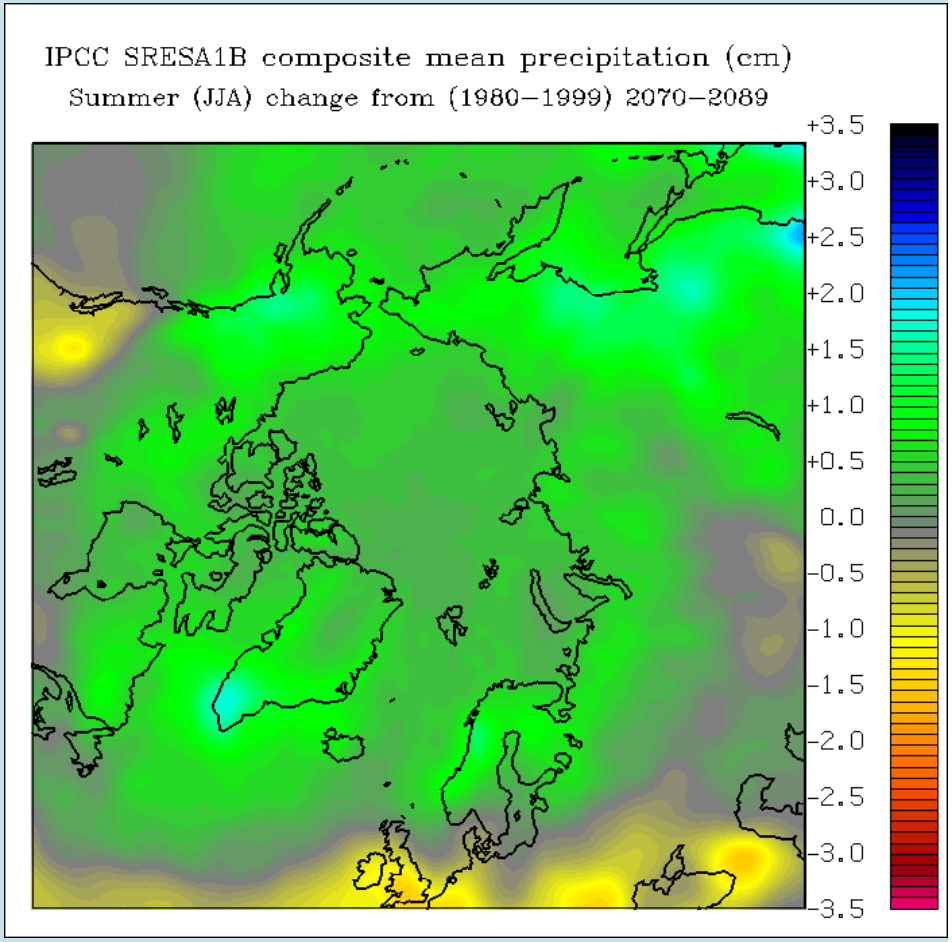
Projected changes of precipitation for 2070-2090

(models used by IPCC, 2007)

winter



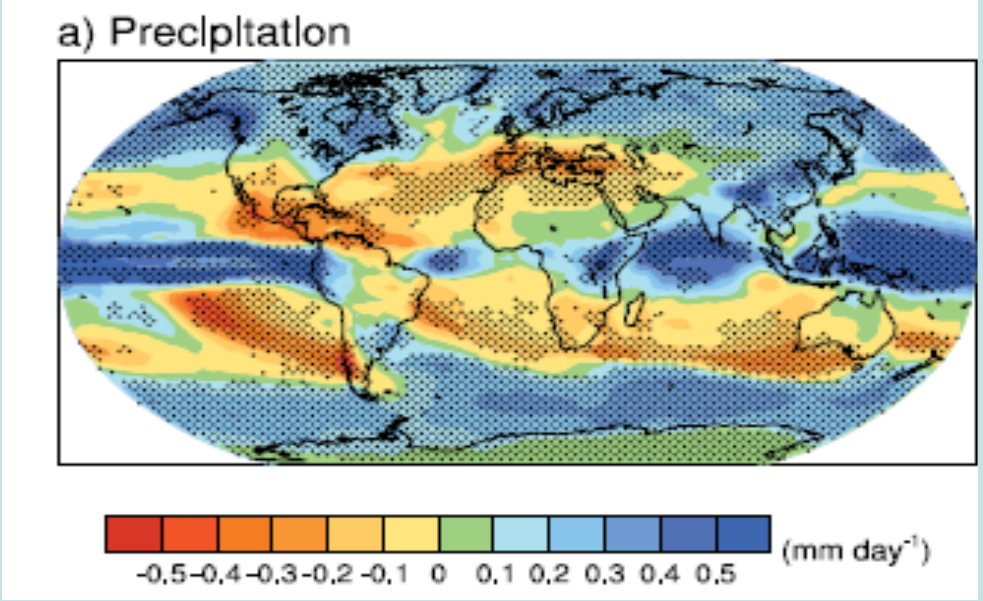
summer

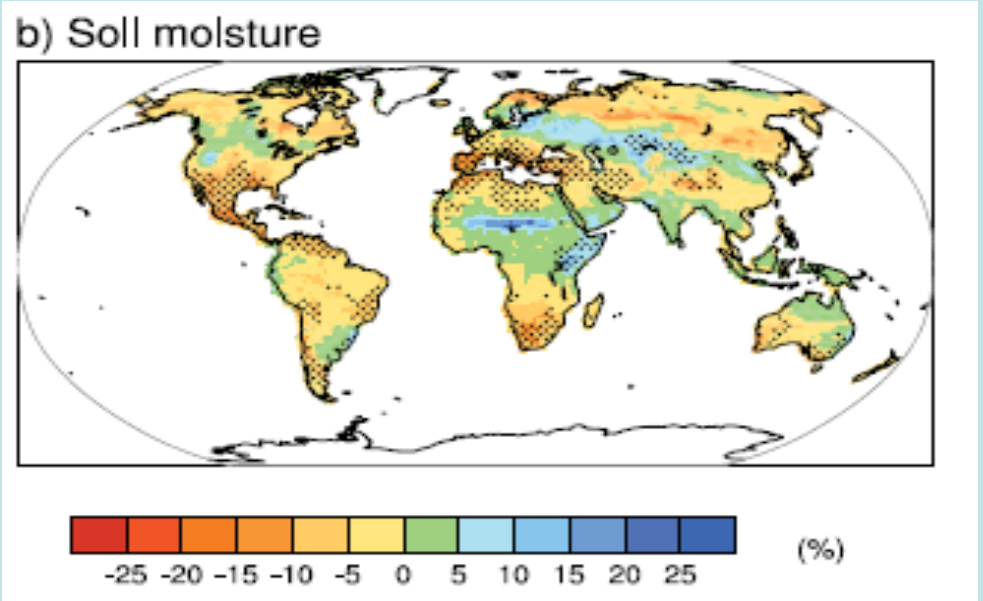


How will Alaska's hydrologic cycle change?

IPCC, 2007: projected hydrologic changes, 2080-2099:

In Alaska: Precip. ↑, Evap. ↑, Runoff ↑ (10-30%), Soil moisture ↓





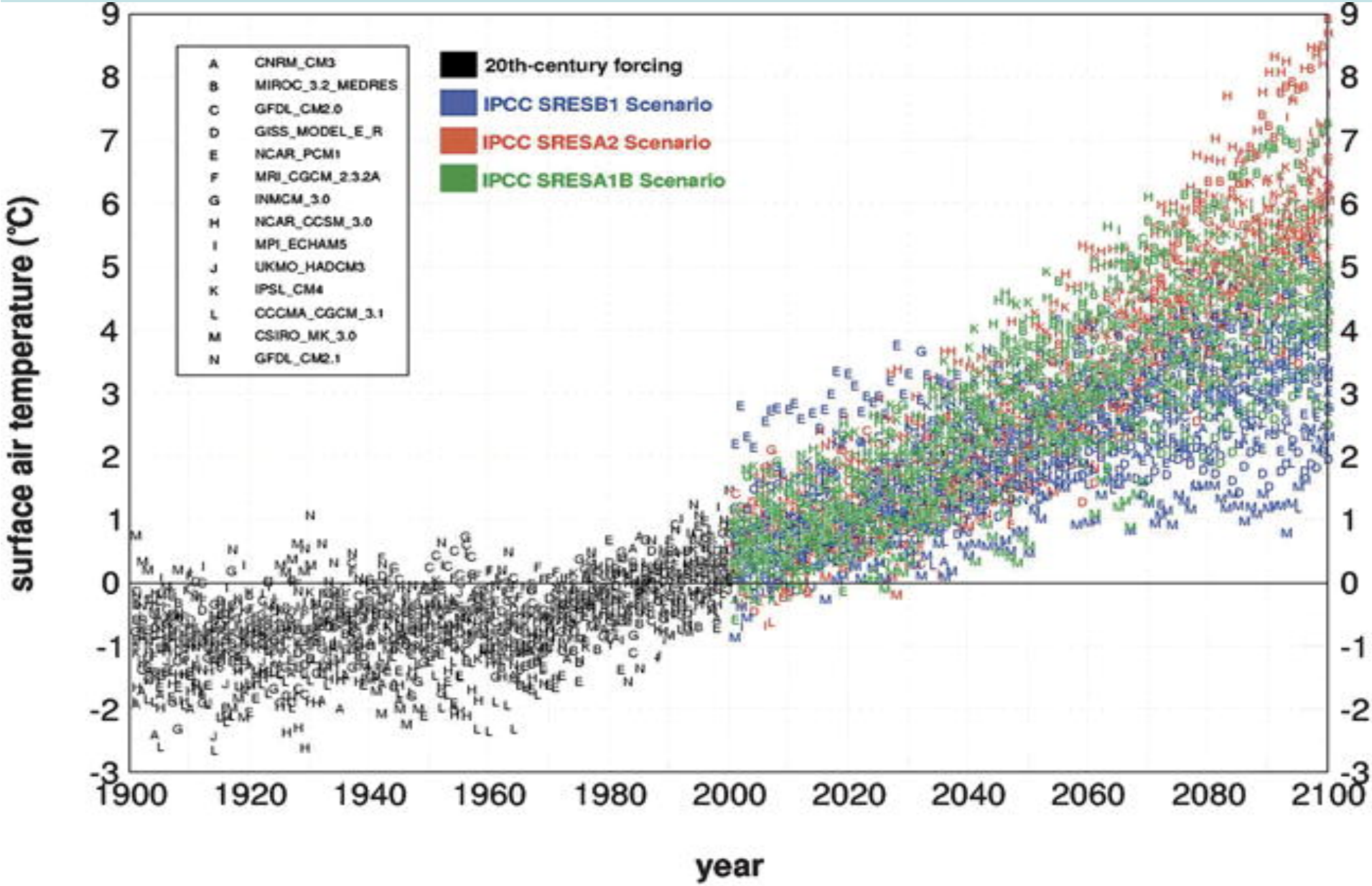
Do these models have sufficient credibility to be used in planning?

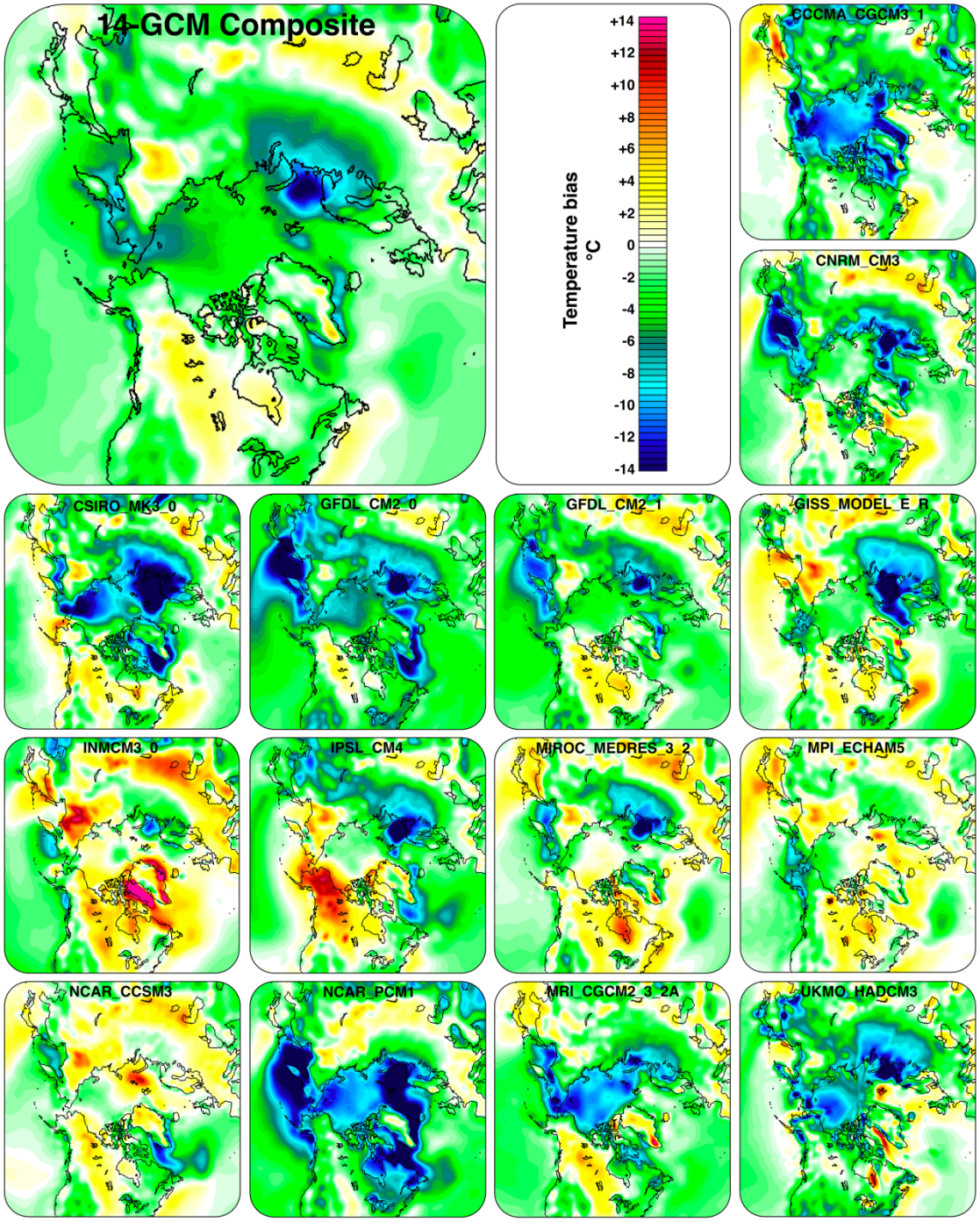
Three major sources of uncertainty:

- **Uncertainties in scenarios of greenhouse forcing**
- **Formulational differences among models**
- **Low-frequency variability in data and models**

Simulated temperatures, relative to 1971-2000, for 60°-90°N :

3 greenhouse scenarios (colors), 14 models (symbols)



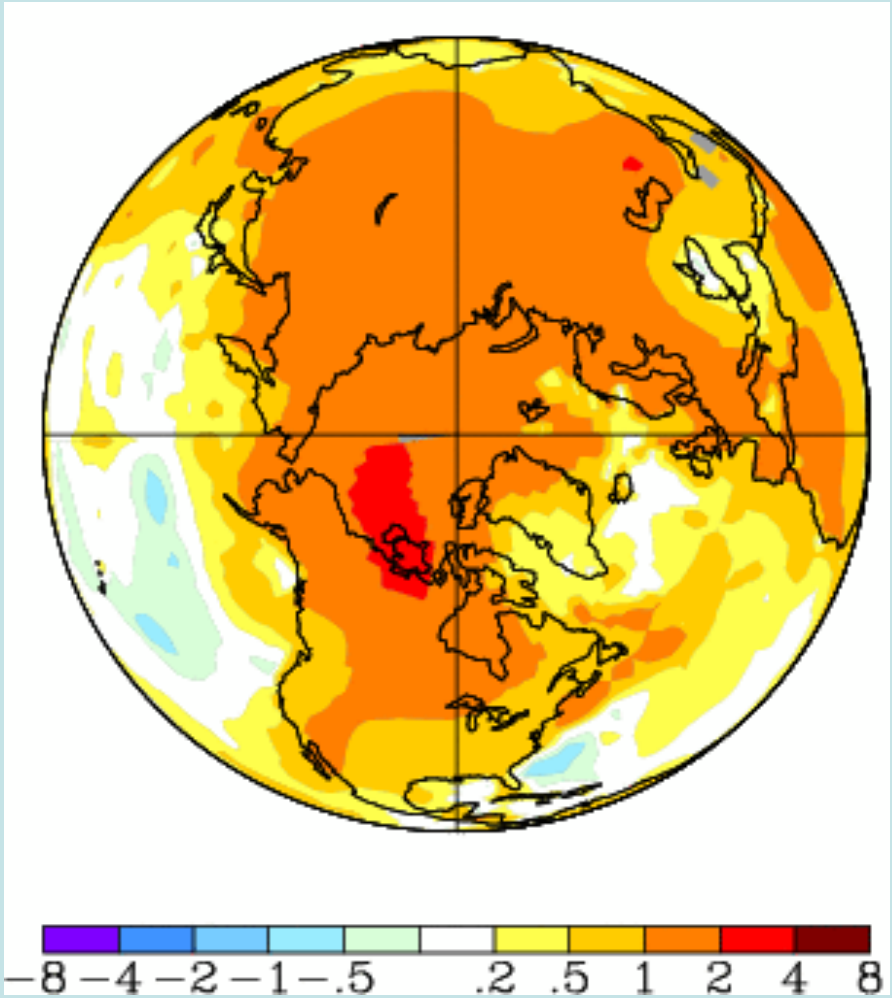


Temperature biases (winter) of IPCC AR4 models

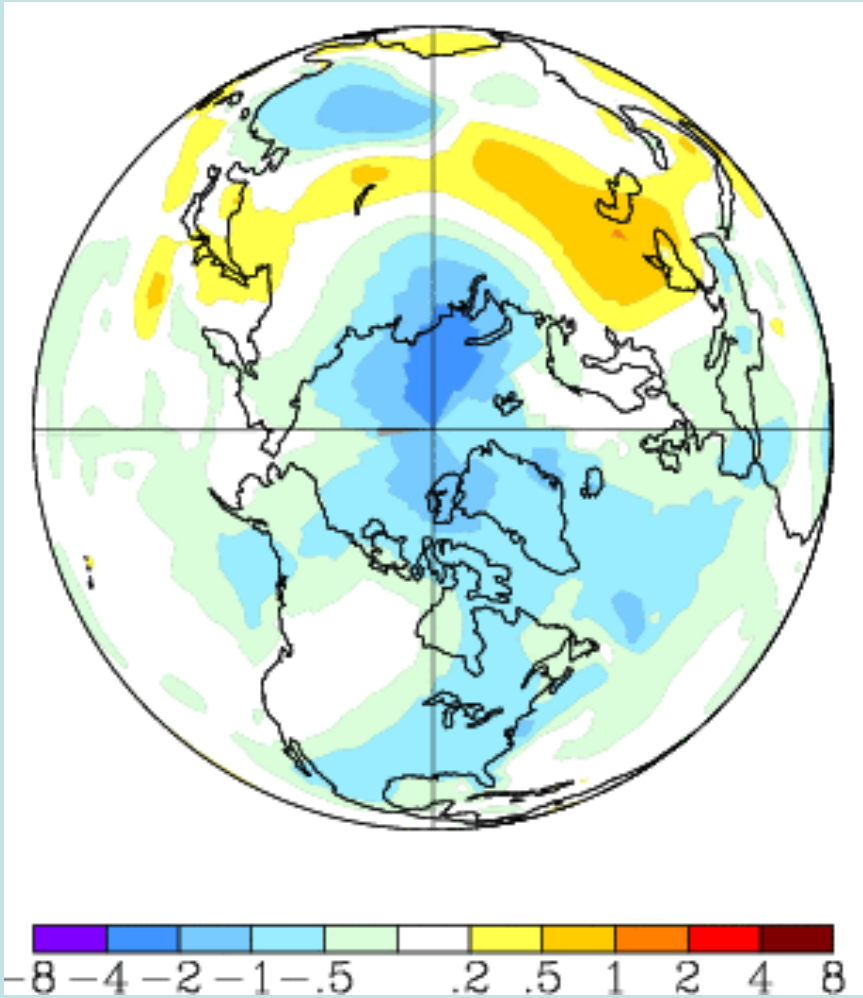
Change in surface air temperature (annual)

[from NASA GISS]

1957-2006



1941-1980

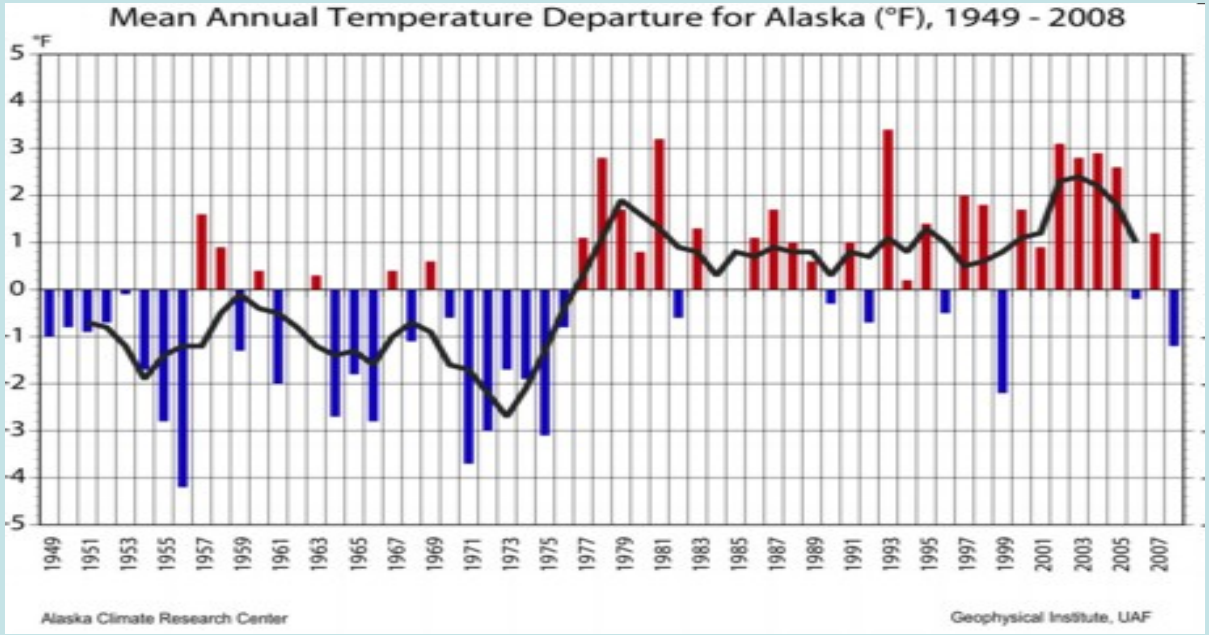


Temperature changes (°F) in Alaska: 1949-2009

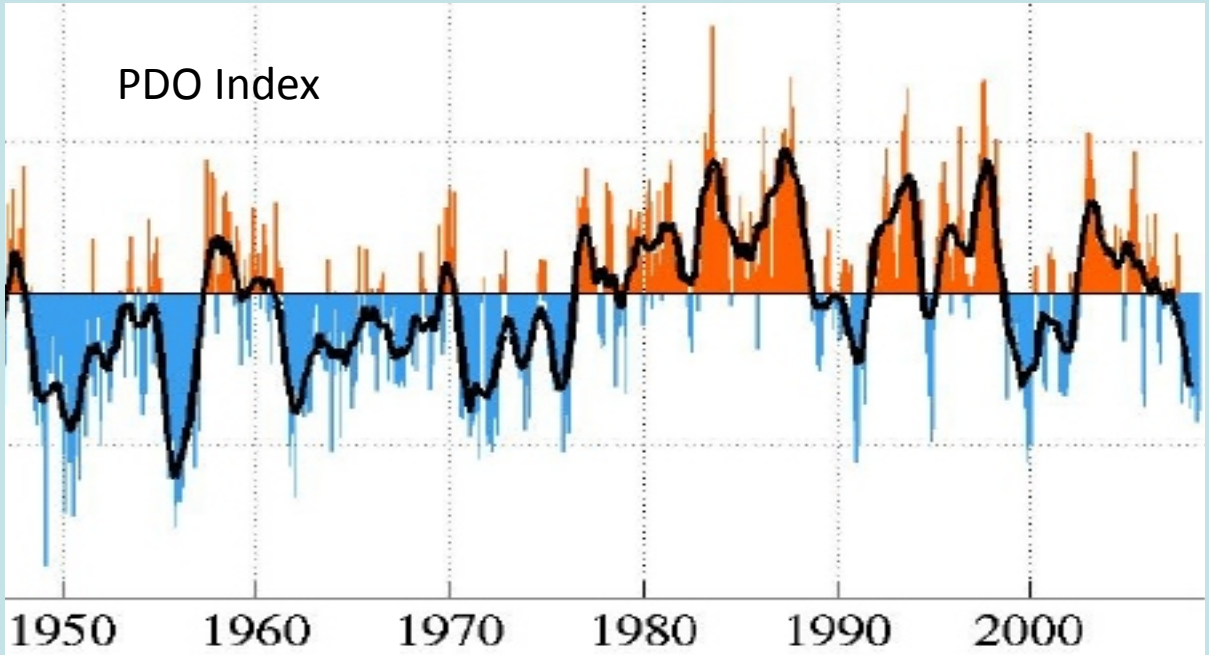
Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2009

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	6.7	4.5	3.0	3.7	4.5
Interior	Bettles	8.1	4.3	1.8	1.1	3.8
	Big Delta	8.9	3.4	1.2	0.0	3.4
	Fairbanks	7.4	3.6	2.3	-0.2	3.3
	McGrath	7.4	4.6	2.7	0.8	3.9
West Coast	Kotzebue	6.3	1.8	2.6	1.4	3.1
	Nome	4.2	3.3	2.5	0.4	2.6
	Bethel	6.6	4.8	2.3	0.0	3.5
	King Salmon	7.9	4.5	1.7	0.6	3.7
	Cold Bay	1.5	1.6	1.7	0.8	1.4
	St Paul	0.8	2.1	2.6	1.1	1.6
Southcentral	Anchorage	5.8	3.3	1.6	1.5	3.0
	Talkeetna	8.4	5.2	3.1	2.4	4.9
	Gulkana	7.7	2.4	1.0	0.1	2.8
	Homer	5.9	3.8	3.3	1.8	3.8
	Kodiak	0.7	2.1	1.2	-0.4	0.9
Southeast	Yakutat	4.6	2.8	1.8	0.4	2.5
	Juneau	6.2	2.9	2.2	1.4	3.2
	Annette	3.4	2.3	1.8	0.3	2.0
	Average	5.7	3.3	2.1	0.9	3.0

Alaska Climate Research Center — Geophysical Institute, University of Alaska Fairbanks



Alaska annual temperature anomalies

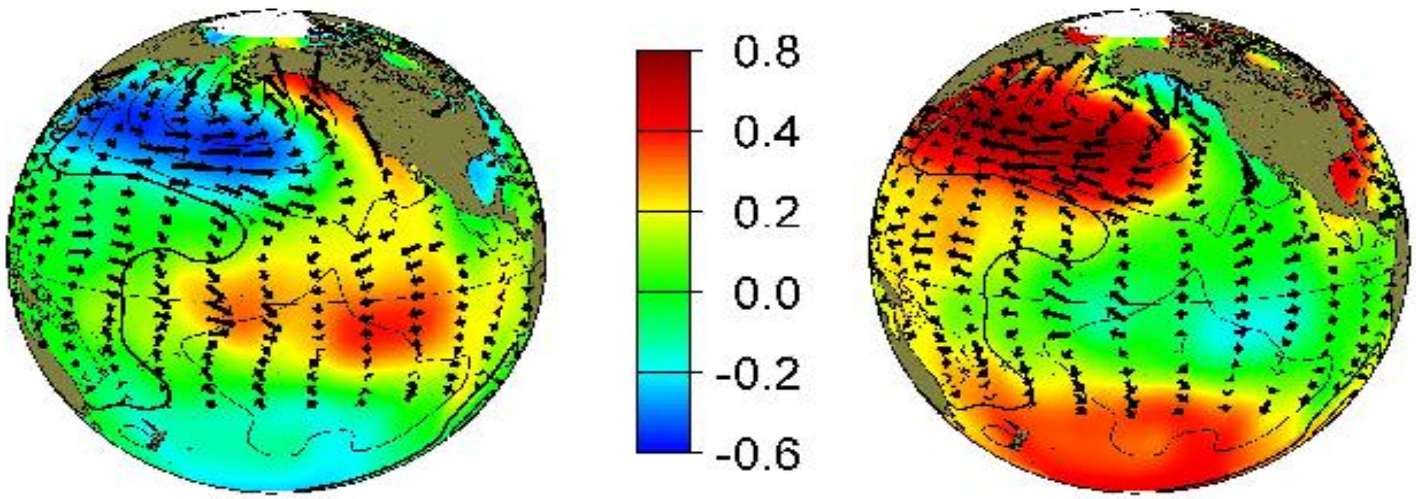


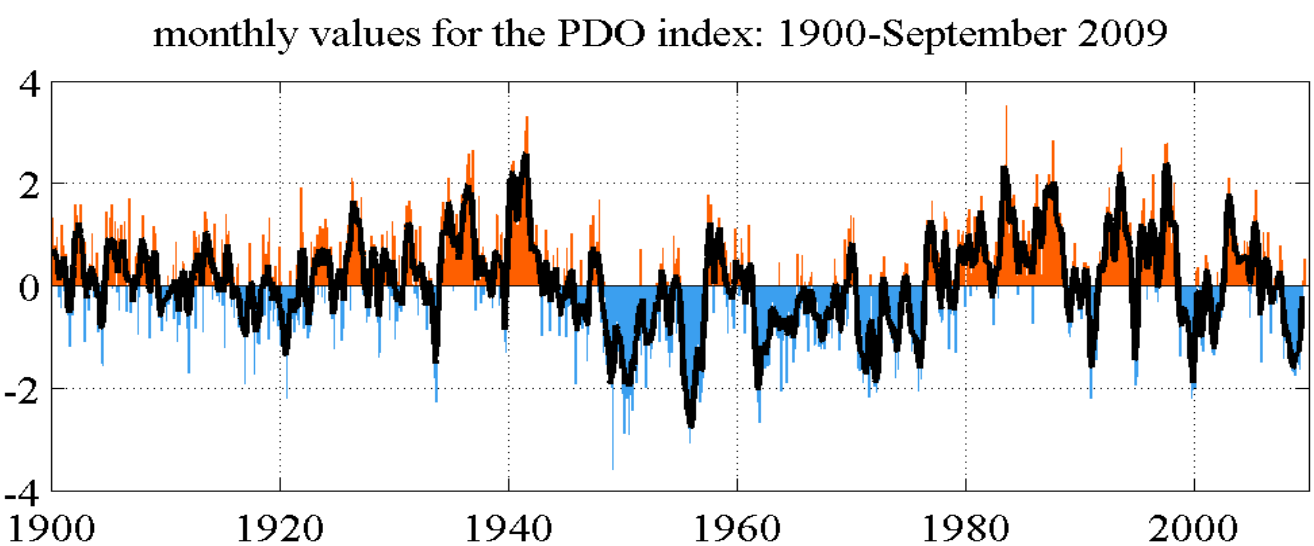
Pacific Decadal Oscillation Index

The Pacific Decadal Oscillation

[from JISAO, Univ. Of Washington]

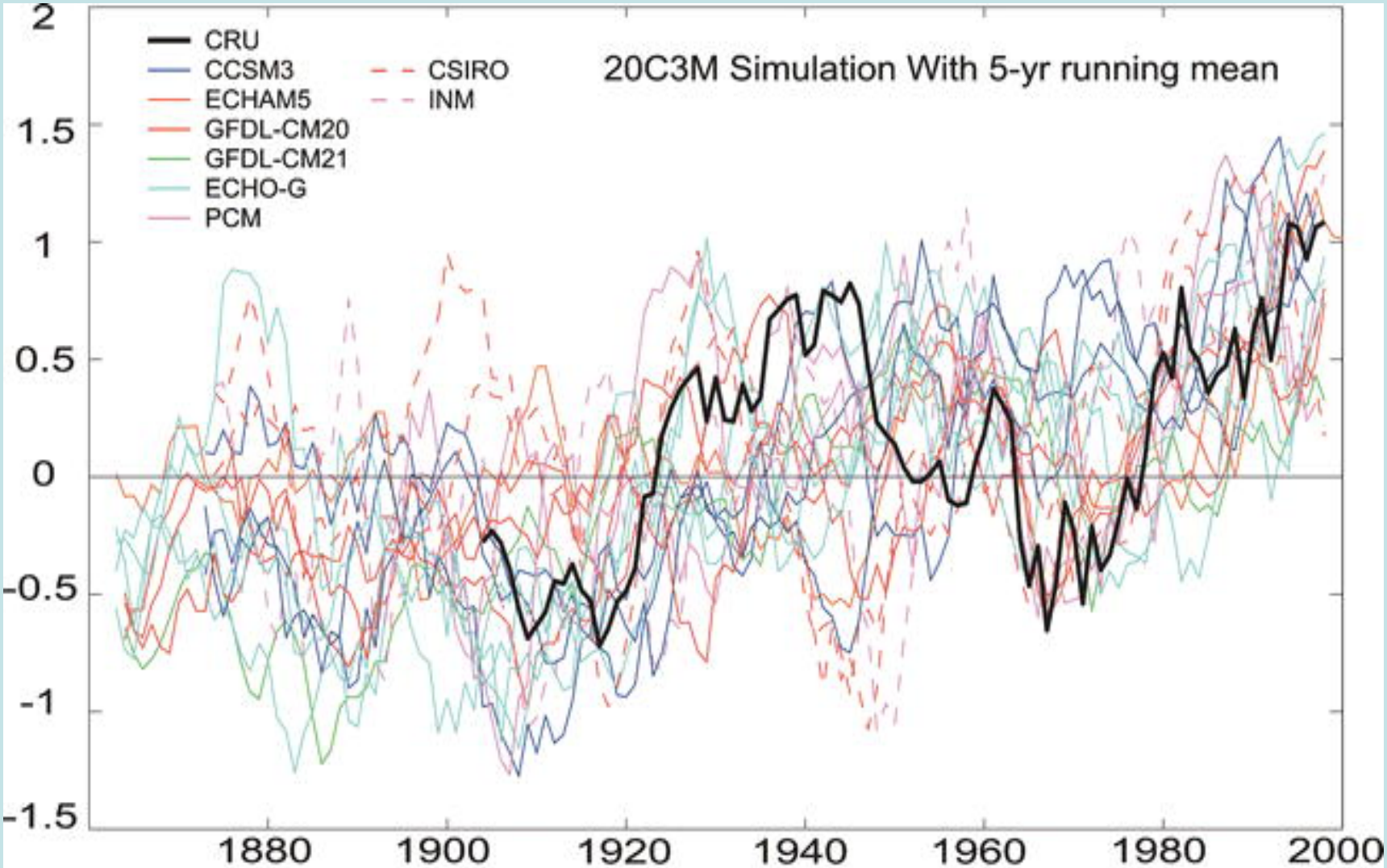
Alaska warm phase **Alaska cold phase**



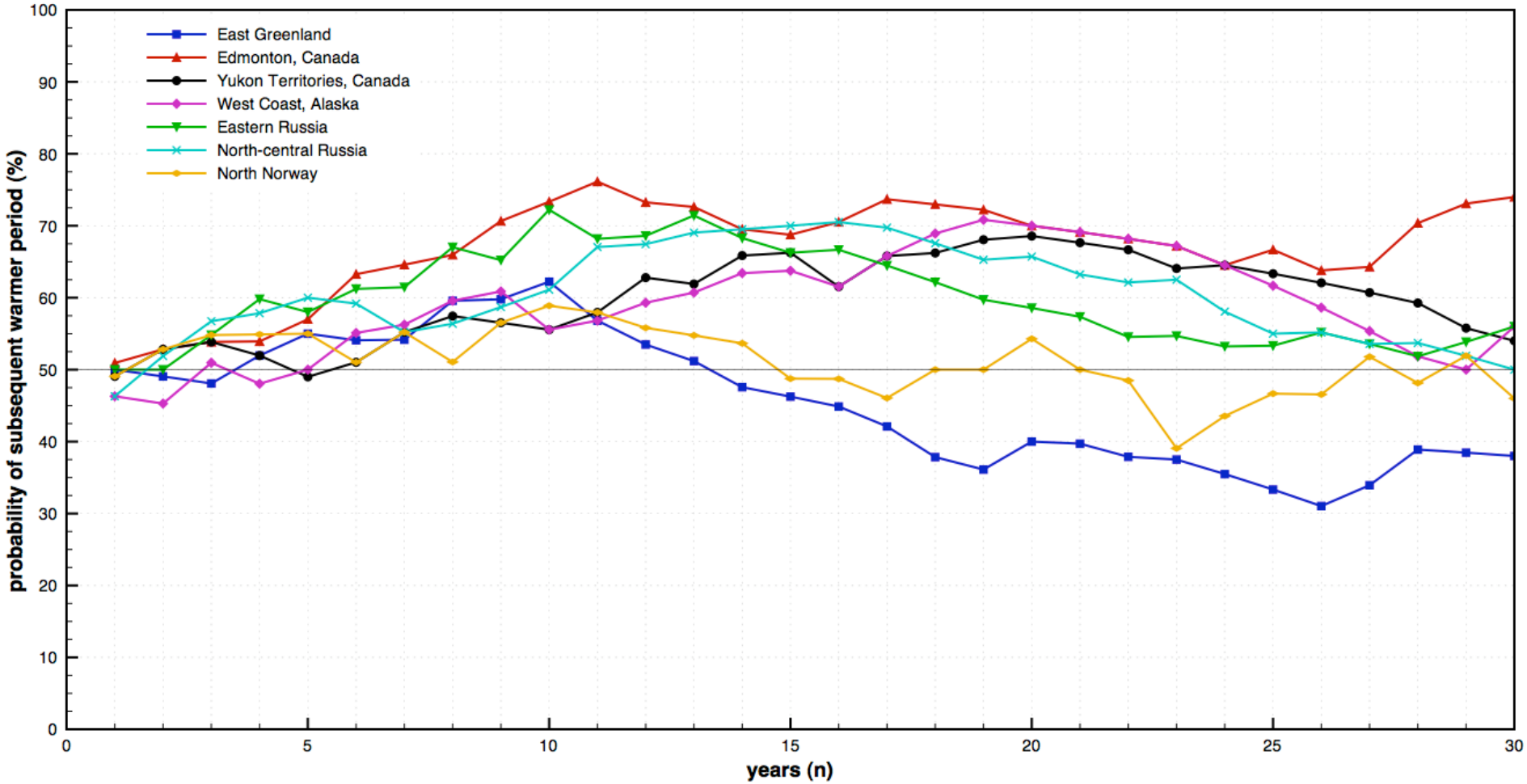


20th-century Arctic (60-90°N) temperatures simulated by individual IPCC models

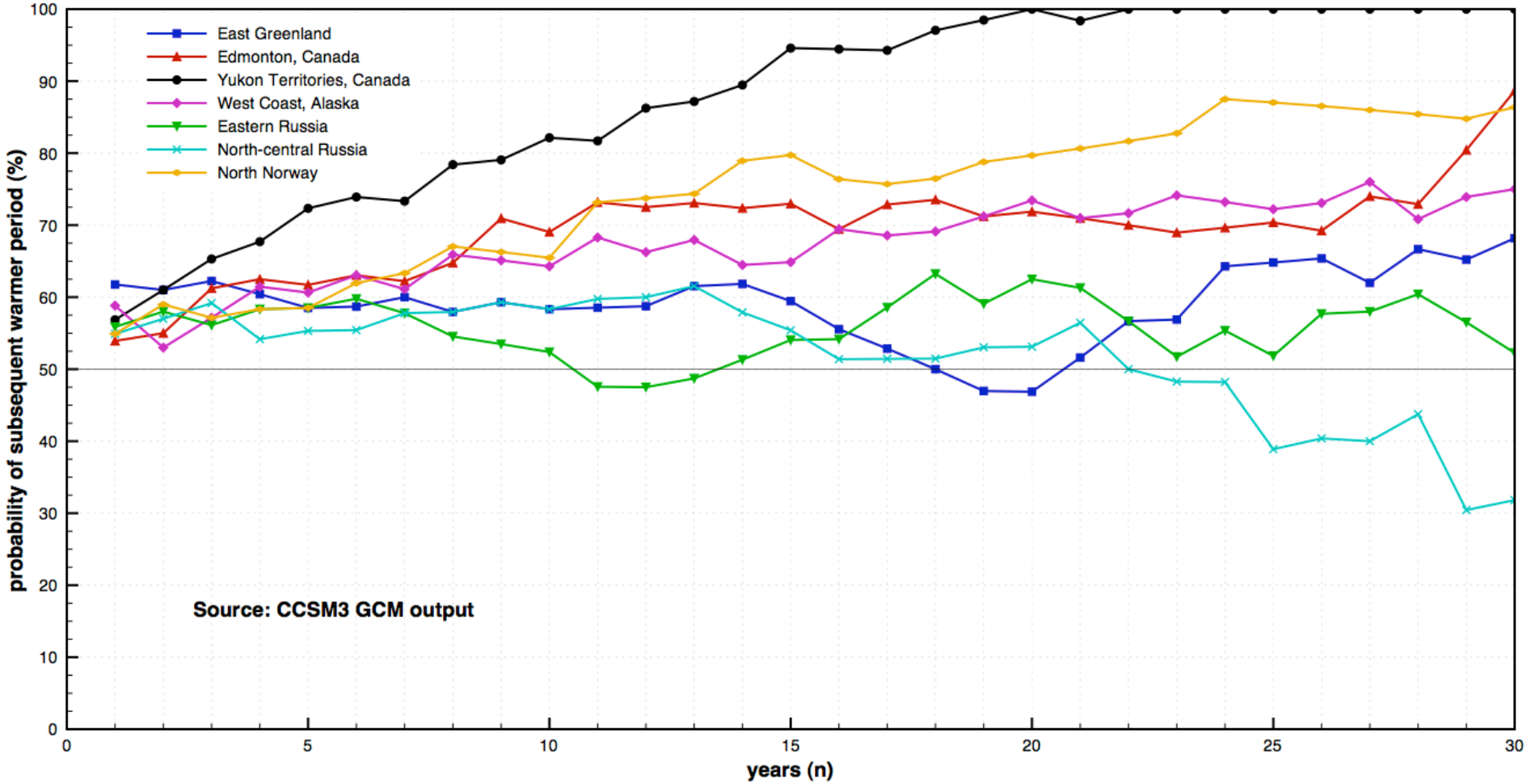
[from M. Wang et al., 2007, J. Climate]



What is the probability that the subsequent n-year period will be warmer than the preceding n years – based on observational data?



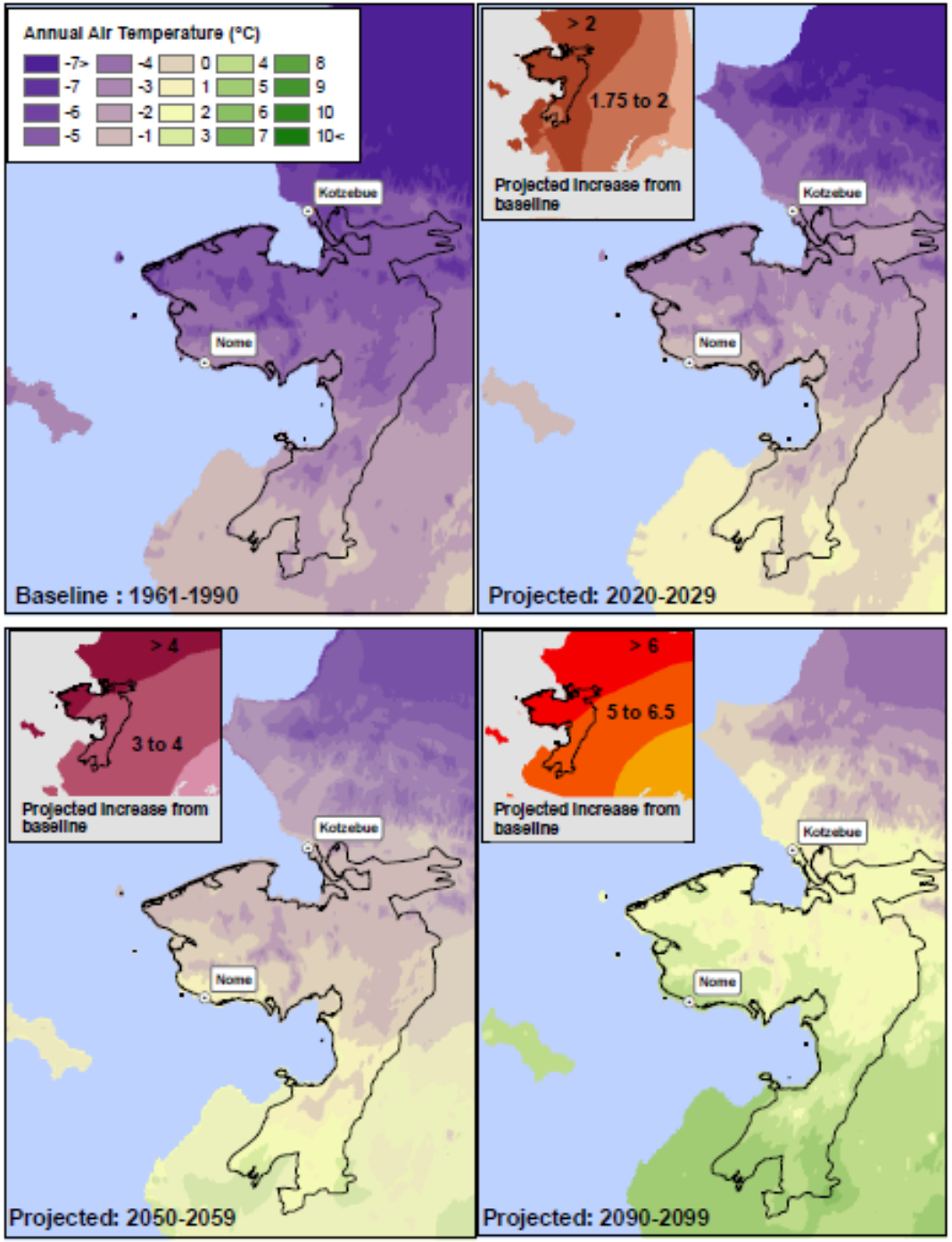
What is the probability that the subsequent n-year period will be warmer than the preceding n years – based on CCSM3 model output for 20th century?



Compositing of simulations from different models "averages out" many of the natural variations in climate model simulations

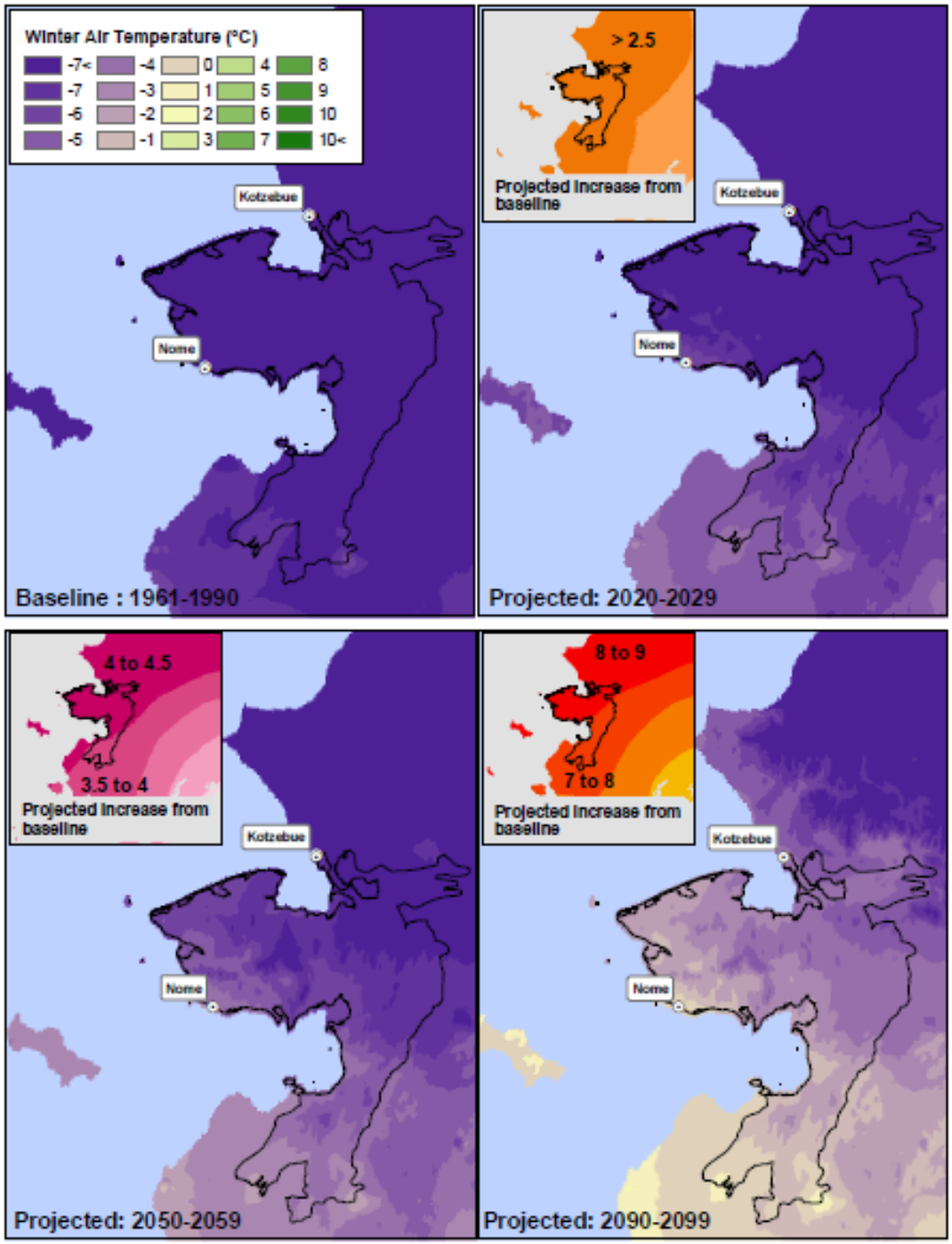
Compositing also tends to reduce the systematic error

⇒ ***SNAP (Scenarios Network for Alaska Planning) downscaling has utilized composites based on a subset (5) of models that have best simulated Alaskan climate over the recent decades.***



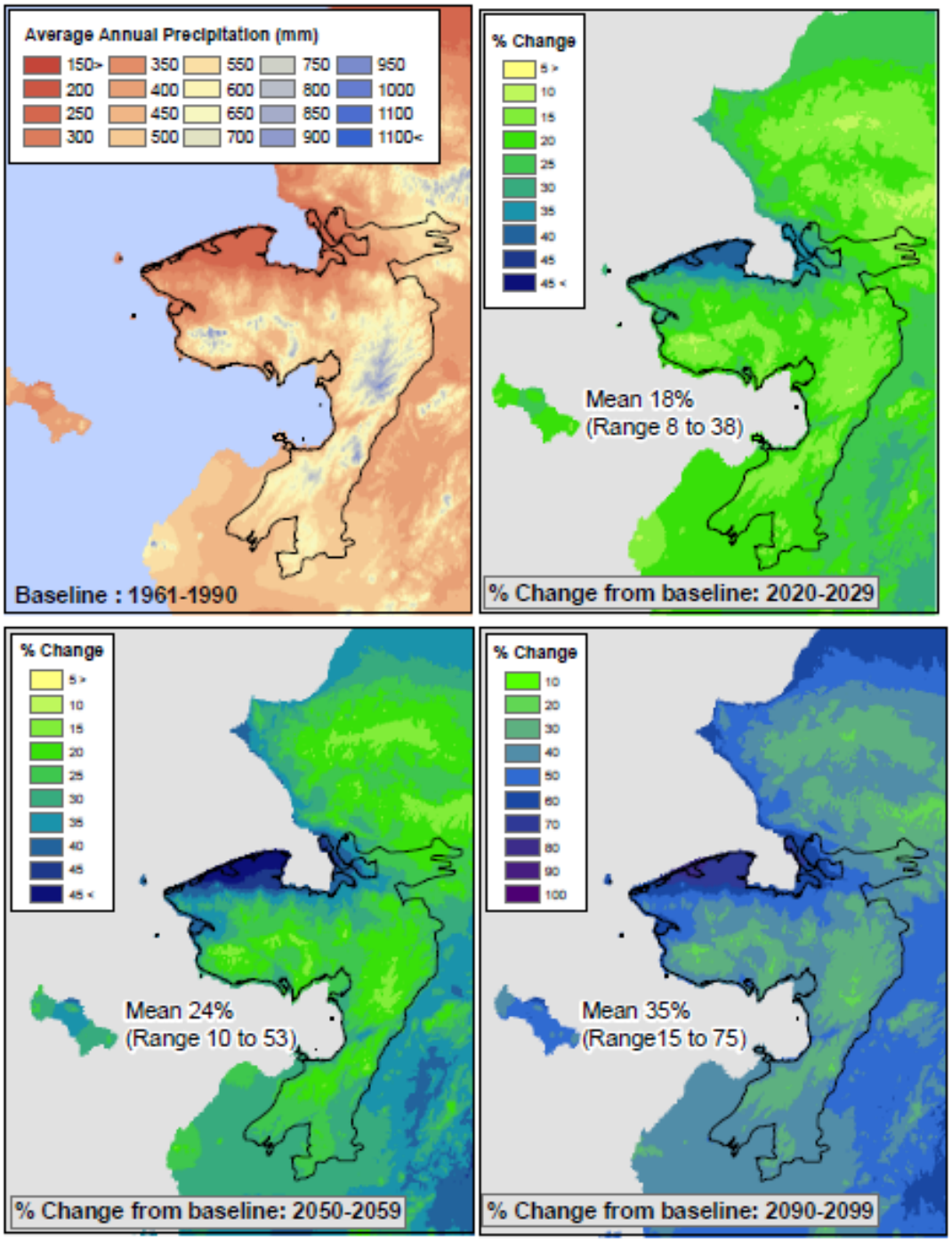
Historical (upper left) and projected changes of annual air temperature (°C)

[from UAF/SNAP and Jennifer Jenkins]



Historical (upper left) and projected changes of *winter* air temperature (°C)

[from UAF/SNAP and Jennifer Jenkins]

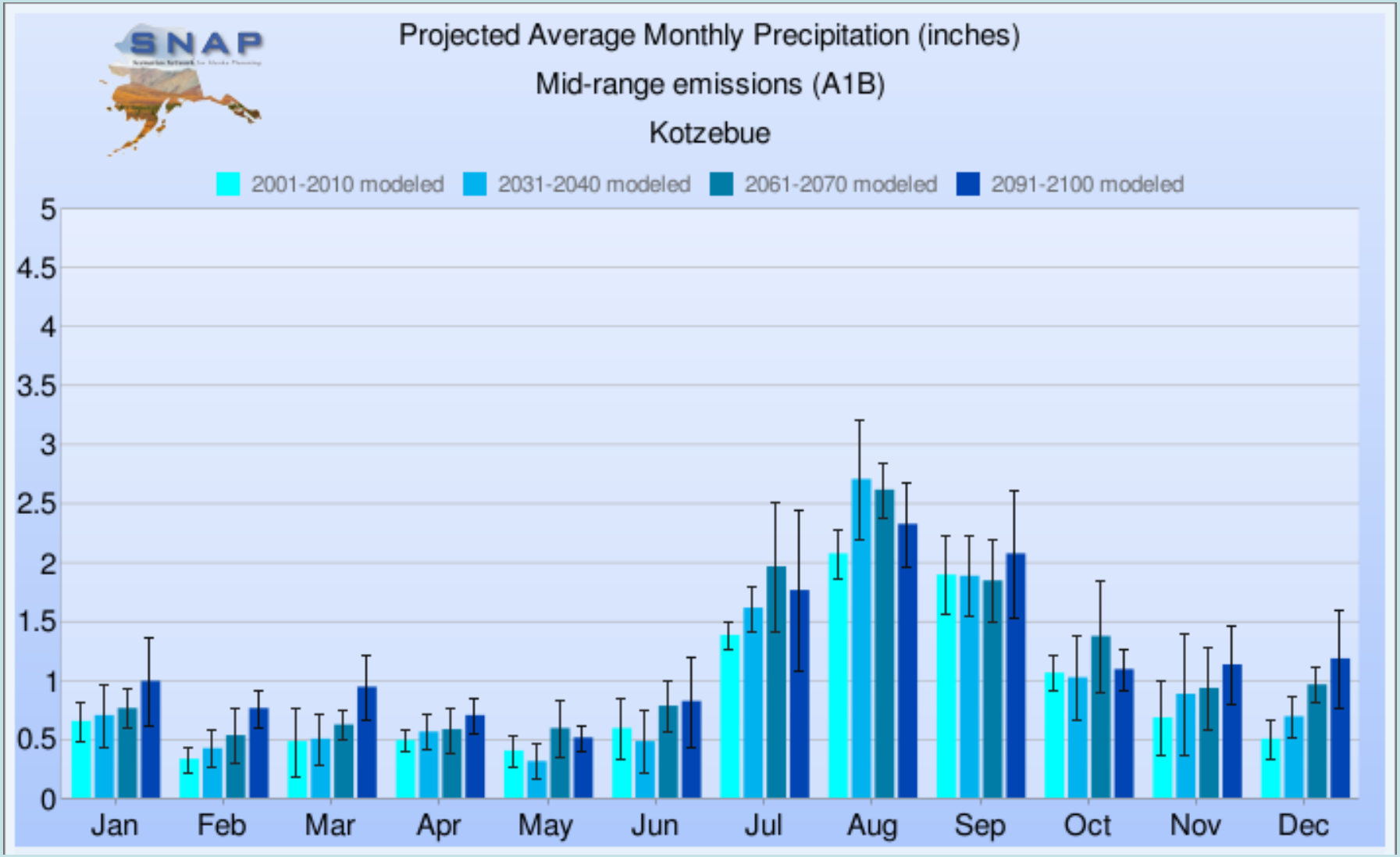


Historical (upper left) and projected change (%) of annual precipitation

[from UAF/SNAP and Jennifer Jenkins]

Precipitation projections for Kotzebue

-- illustrating across-model spread; natural variability (decadal)



Conclusions

- **A wealth of climate model output is available, and initial downscaling activities have been undertaken.**

- **Uncertainties inherent in model results point to the need for presenting model projections in a probabilistic framework, providing planners with likelihoods and/or different scenarios**

- **Low-frequency variability can be a source of modest predictability over short climatic timescales (1-10 years)**

  -- but, models may over- or under-represent this predictability