PENNSTATE 1855

Dynamics and uncertainties of the intra-annual mid-latitude atmospheric response to reduced Arctic sea ice

Hans Chen

Department of Meteorology
The Pennsylvania State University

Santa's revenge: melting Arctic ice may be driving this winter's chill

Evidence is mounting that a warming Arctic has set the jet stream loose.

by **John Timmer** - Feb 17 2014, 7:00am EST

EARTH SCIENCE 197

Sunset in the Arctic

NASA Goddard Photo and Video

Santa's revenge: melting Arctic ice may be driving this winter's chill

Evidence is mounting that a warming Arctic has set the jet stream loose.

by **John Timmer** - Feb 17 2014, 7:00am EST

EARTH SCIENCE 197

Sunset in the Arctic

NASA Goddard Photo and Video

Climate Change Might Just Be Driving the Historic Cold Snap

Climate change skeptics are pointing to the record cold weather as evidence that the globe isn't warming. But it could be that melting Arctic ice is making sudden cold snaps more likely—not less

By Bryan Walsh @bryanrwalsh | Jan. 06, 2014 | 1029 Comments

It's polar bear weather today for much of the Midwest. Temperatures are in the -20s° F (-28° C) and -30s° F (-35° C) in eastern Montana, North Dakota, northeast South Dakota, Minnesota and northern Iowa. With the stiff wind, it's even worse—wind chills in the -40s° F (-40° C) and -50s° F (-45° C) are common across Minnesota and North Dakota, cold enough for exposed skin to suffer frostbite in just five minutes. By tonight, the freeze will reach the East Coast, where temperatures from Florida to Maine are expected to be 30° F to 40° F (16° C to 22° C) degrees below normal, extremes that haven't been seen in decades. The National Weather Service isn't kidding when it calls the cold "life-threatening."

Photo by Ronald Martinez/Getty Images

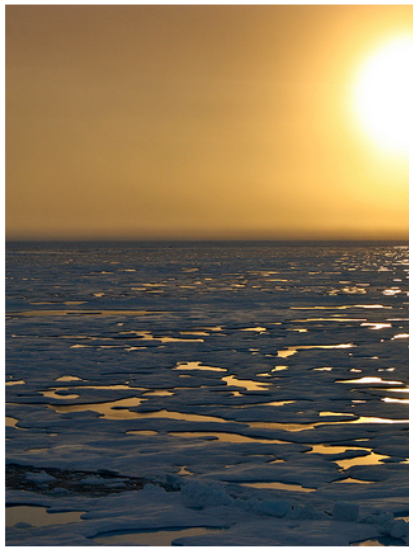
Fans in Green Bay suffered through frigid temperatures, thanks to Arctic air that has come south

Santa's revenge: melting Arctic ice may be driving this winter's chill

Evidence is mounting that a warming Arctic has set the jet stream loose.

by **John Timmer** - Feb 17 2014, 7:00am EST

EARTH SCIENCE 197



Sunset in the Arctic

NASA Goddard Photo and Video

Polar Vortex 2: The Return of Some Really Cold Weather

Tweet 101 | 8+1 7 | 51 | Text

More Than 80 Million Americans Pounded by Winter Storm

Might Just Be Driving the ap

nting to the record cold weather as evidence that the globe isn't lting Arctic ice is making sudden cold snaps more likely—not

, 2014 | 1029 Comments

1,088 | 8+1 55 | Share 27 | Pin it | Read Later

of the
° F (-28° C)
a, North
esota and
even
C) and -50s°
ota and North

Dakota, cold enough for exposed skin to suffer frostbite in just five minutes. By tonight, the freeze will reach the East Coast, where temperatures from Florida to Maine are expected to be 30° F to 40° F (16° C to 22° C) degrees below normal, extremes that haven't been seen in decades. The National Weather Service isn't kidding when it calls the cold "life-threatening."

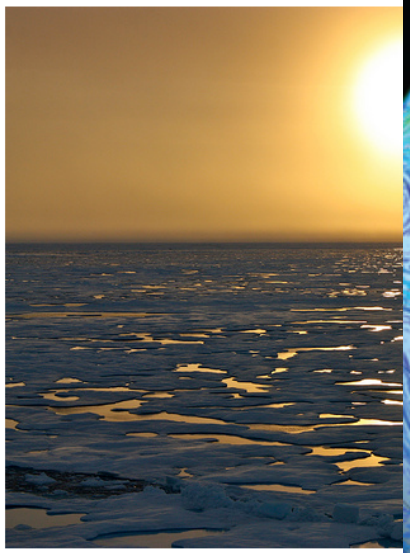
Photo by Ronald Martinez/Getty Images

Fans in Green Bay suffered through frigid temperatures, thanks to Arctic air that has come south

Santa's revenge: melt
driving this winter's c

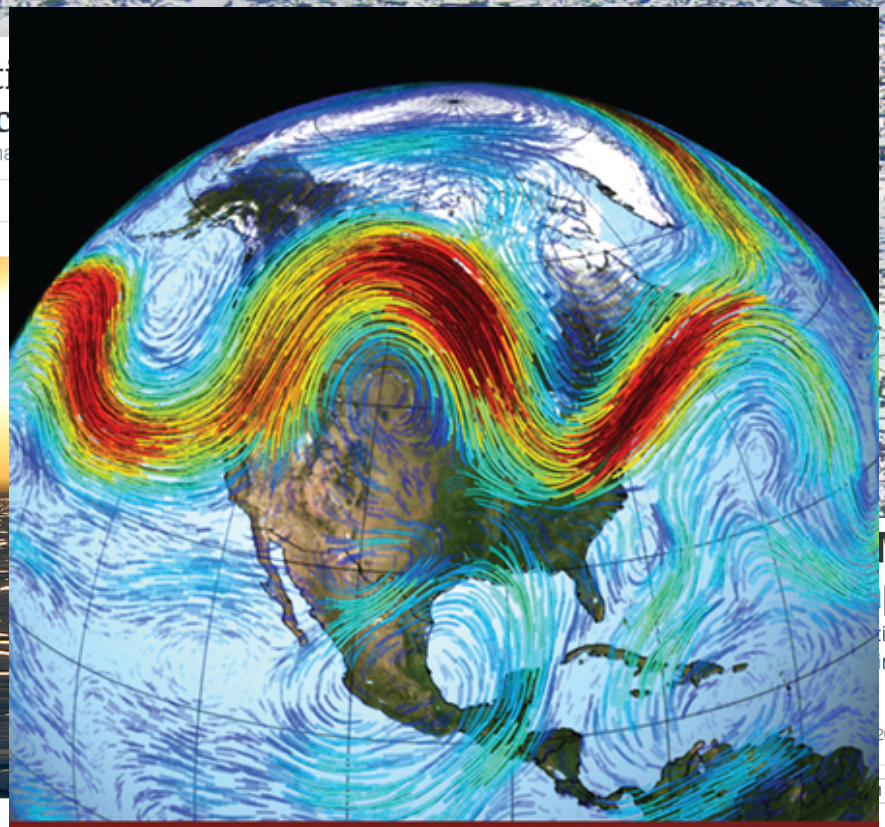
Evidence is mounting that a warming Arctic ha

by **John Timmer** - Feb 17 2014, 7:00am EST



Sunset in the Arctic

NASA Goddard Photo and Video



Linkages Between Arctic Warming and Mid-Latitude Weather Patterns

Summary of a Workshop

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Might Just Be Driving the
p

ing to the record cold weather as evidence that the globe isn't
ng Arctic ice is making sudden cold snaps more likely—not

2014 | 1029 Comments

,088 | 8+1 55 | Share 27 | Pin it | Read Later

f the
F (-28° C)
North
ota and
ren
) and -50s°
and North
suffer
the freeze
tures from
F to 40° F
xtremes
ational
ls the cold

Photo by Ronald Martinez/Getty Images

Fans in Green Bay suffered through frigid temperatures, thanks to Arctic air that has come south

Scientific question

- Does Arctic sea ice loss have a significant impact on the weather and climate conditions in the Northern Hemisphere mid-latitudes?

PENNSTATE 1855

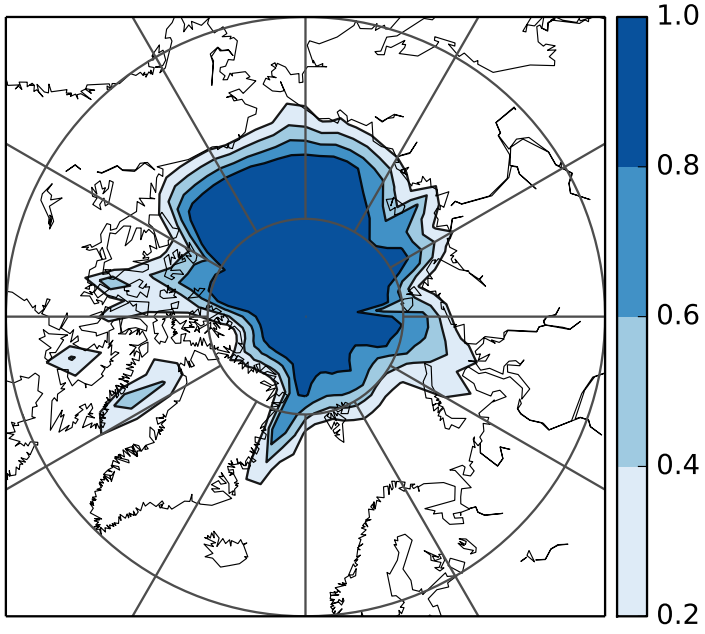
Model setup

- NCAR Community Atmosphere Model (CAM) 5.3
- Prescribed monthly sea ice and sea surface temperature
- 4° latitude by 5° longitude finite volume grid
- 30 vertical levels up to 3.6 mb
- 7 ice scenarios, each with 20 ensemble members run for 6 years

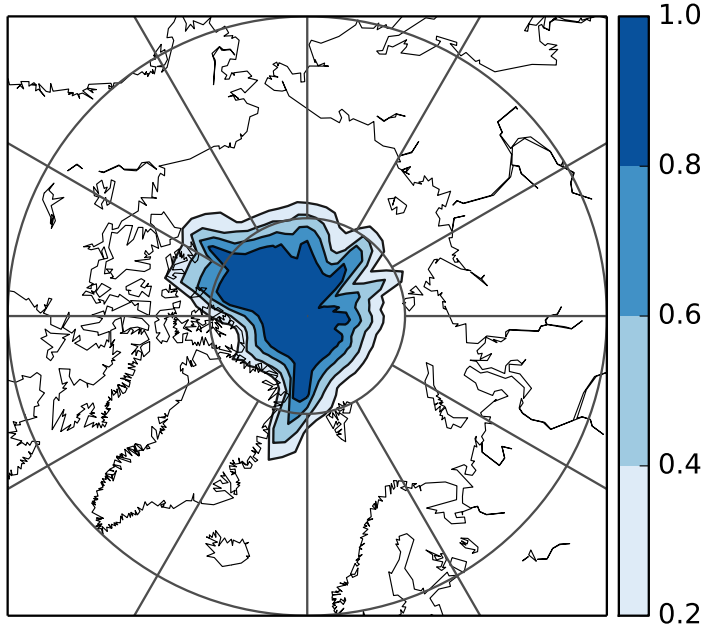
PENNSTATE 1855

Sea ice scenarios

Sea ice concentration in September



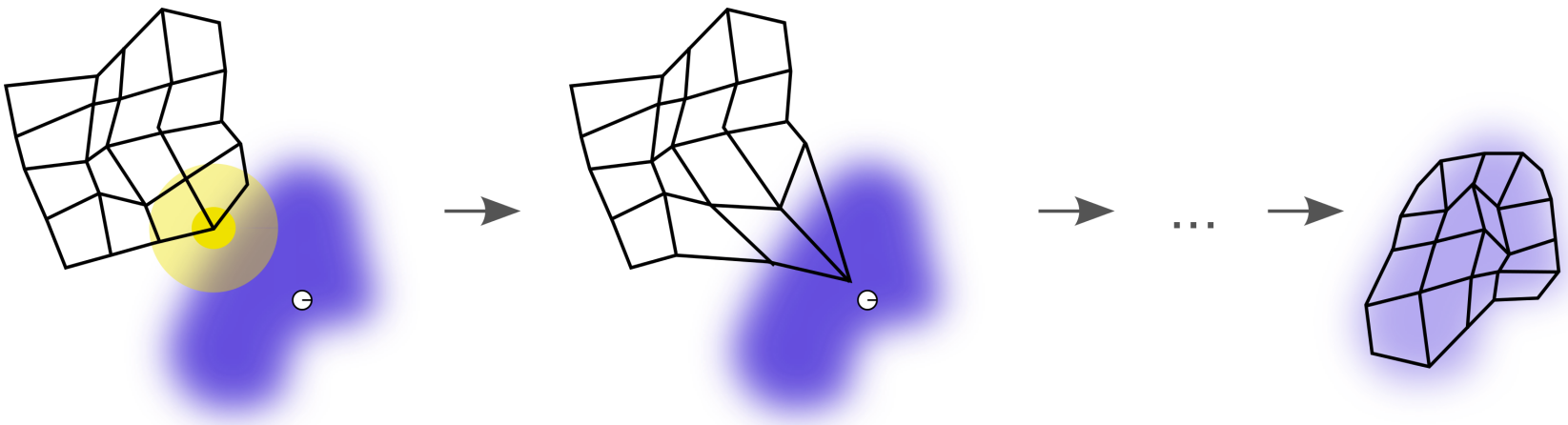
High ice scenario



Low ice scenario

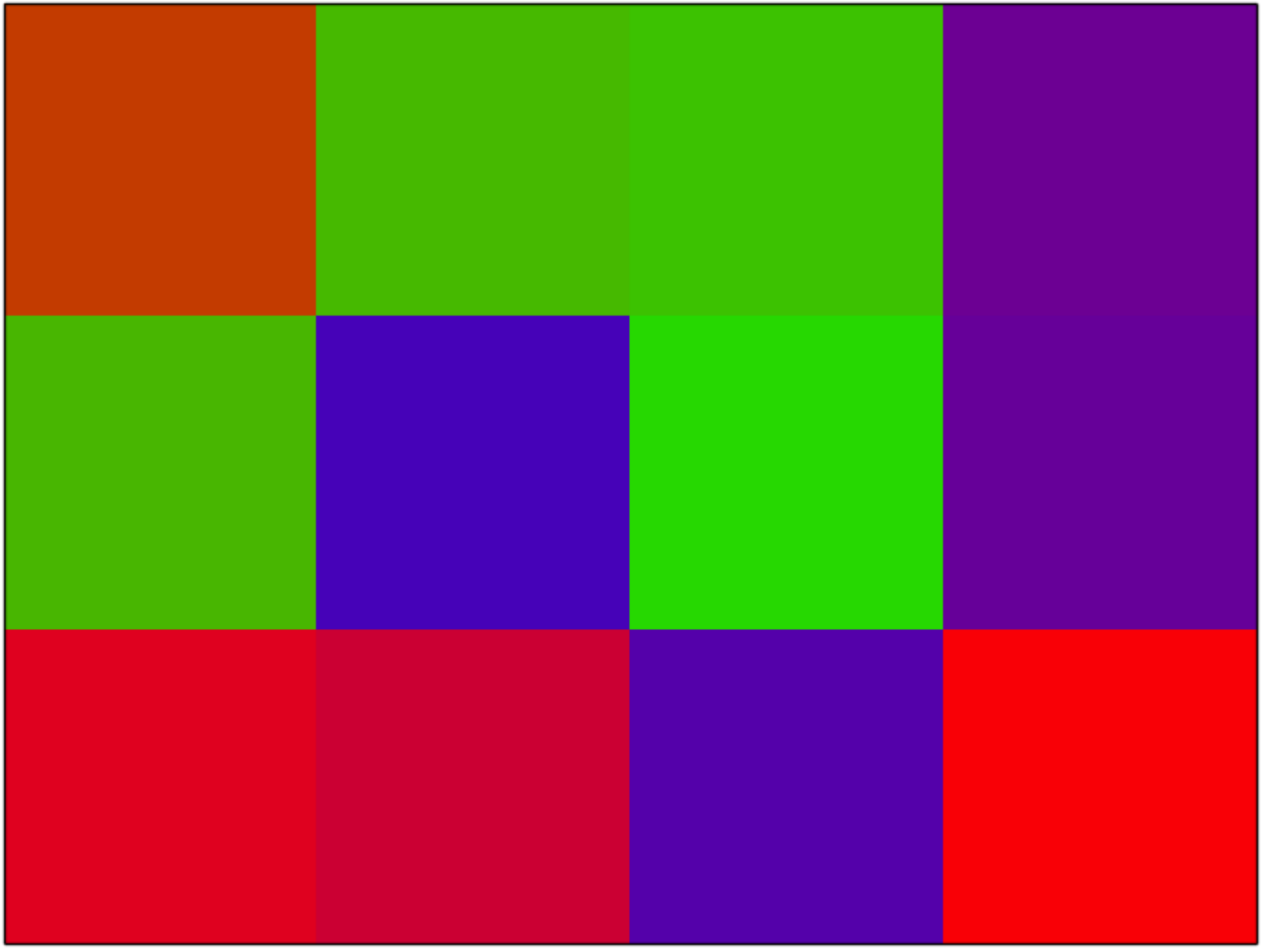
PENNSTATE 1855

Crash course on self-organizing maps



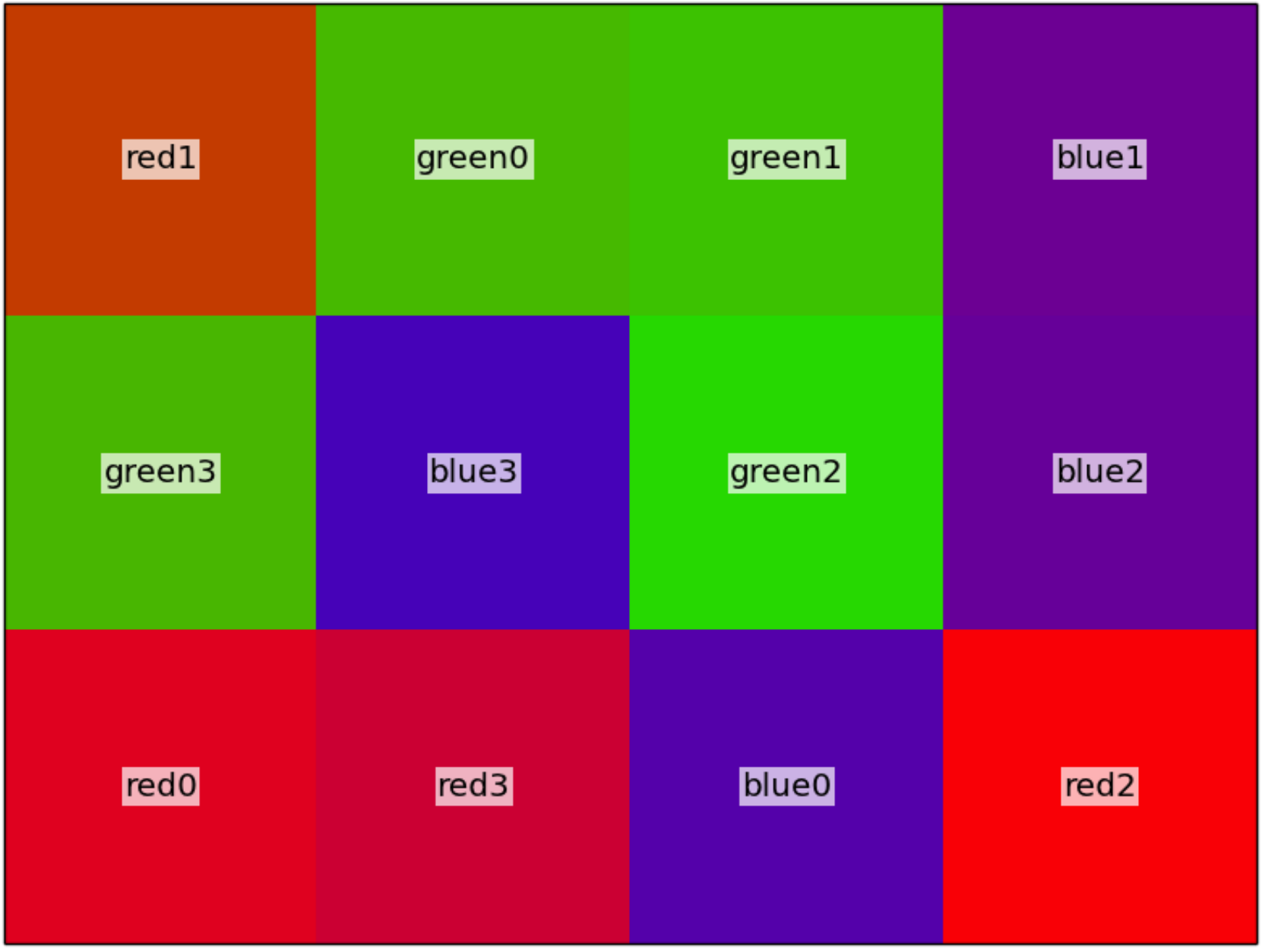
PENNSTATE 1855

Crash course on self-organizing maps



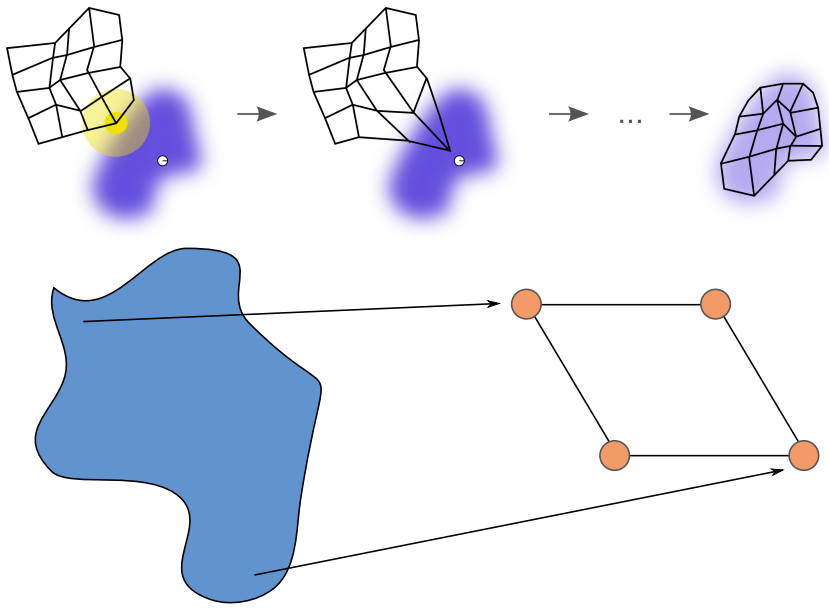
PENNSTATE 1855

Crash course on self-organizing maps



PENNSTATE 1855

Crash course on self-organizing maps



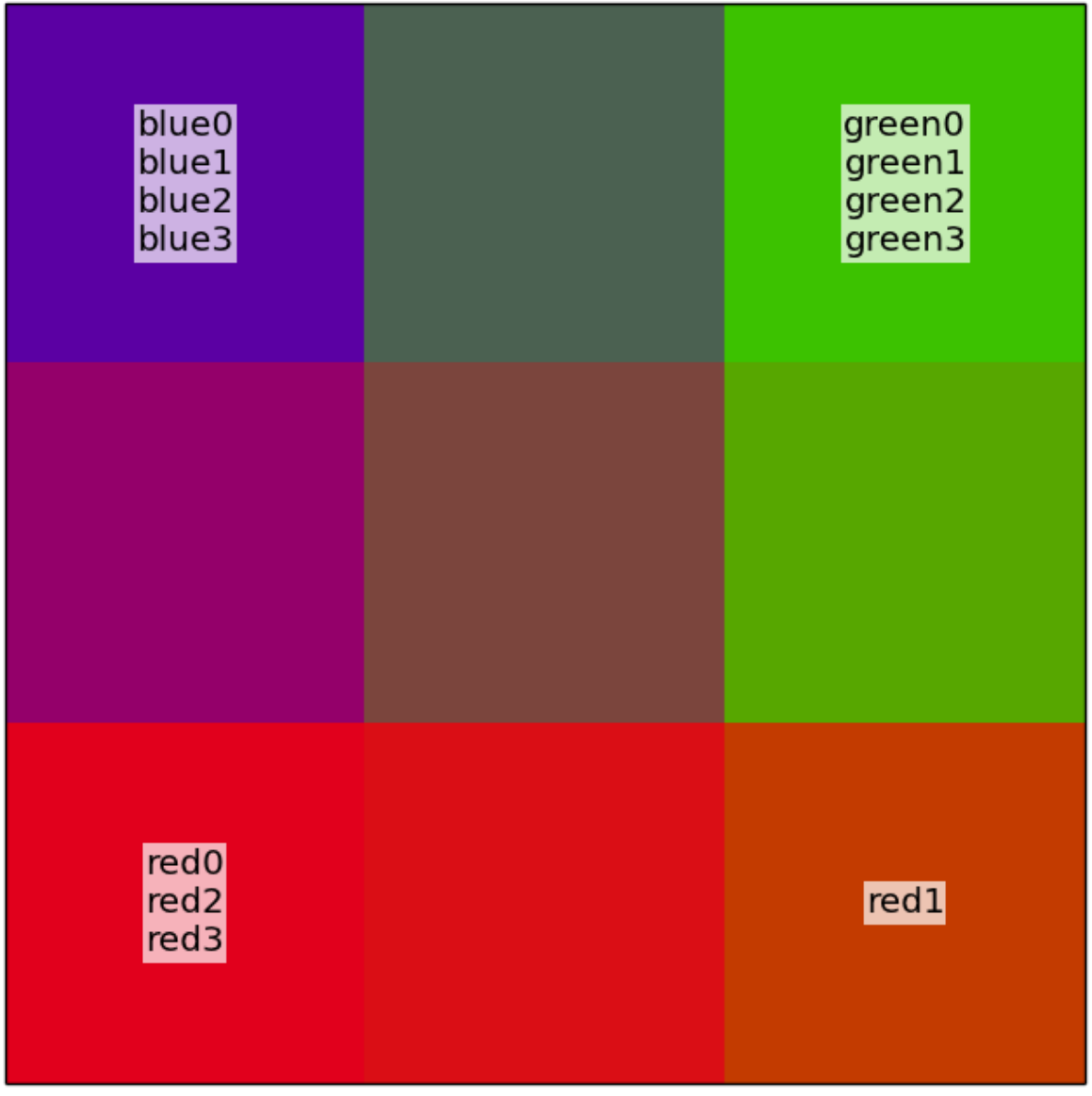
Input

$\mathbf{x} = (r, g, b)$

Output

PENNSTATE 1855

Crash course on self-organizing maps



PENNSTATE 1855

Self-organizing maps analysis

1. Obtain monthly anomalies weighted by grid cell area
   - Sea-level pressure, geopotential height at 500 mb, 2-m temperature
   - Early winter (November through January)
   - Region northward of 30°N
2. Train map using all ensemble members from both sea ice scenarios
3. Map ensemble members data from each ice scenario
4. Count the number of occurrences in each node

PENNSTATE 1855

Self-organizing maps analysis

1. Obtain monthly anomalies weighted by grid cell area
   - Sea-level pressure, geopotential height at 500 mb, 2-m temperature
   - Early winter (November through January)
   - Region northward of 30°N
2. Train map using all ensemble members from both sea ice scenarios
3. Map ensemble members data from each ice scenario
4. Count the number of occurrences in each node

PENNSTATE 1855

Self-organizing maps analysis

1. Obtain monthly anomalies weighted by grid cell area
   - Sea-level pressure, geopotential height at 500 mb, 2-m temperature
   - Early winter (November through January)
   - Region northward of 30°N
2. Train map using all ensemble members from both sea ice scenarios
3. Map ensemble members data from each ice scenario
4. Count the number of occurrences in each node

PENNSTATE 1855

Self-organizing maps analysis

1. Obtain monthly anomalies weighted by grid cell area
   - Sea-level pressure, geopotential height at 500 mb, 2-m temperature
   - Early winter (November through January)
   - Region northward of 30°N
2. Train map using all ensemble members from both sea ice scenarios
3. Map ensemble members data from each ice scenario
4. Count the number of occurrences in each node

PENNSTATE 1855

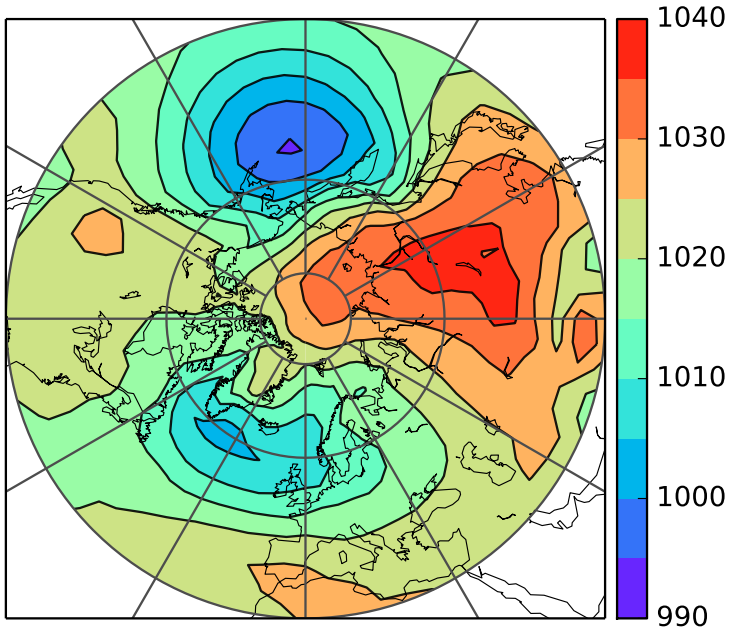
Self-organizing maps analysis

1. Obtain monthly anomalies weighted by grid cell area
   - Sea-level pressure, geopotential height at 500 mb, 2-m temperature
   - Early winter (November through January)
   - Region northward of 30°N
2. Train map using all ensemble members from both sea ice scenarios
3. Map ensemble members data from each ice scenario
4. Count the number of occurrences in each node

PENNSTATE 1855

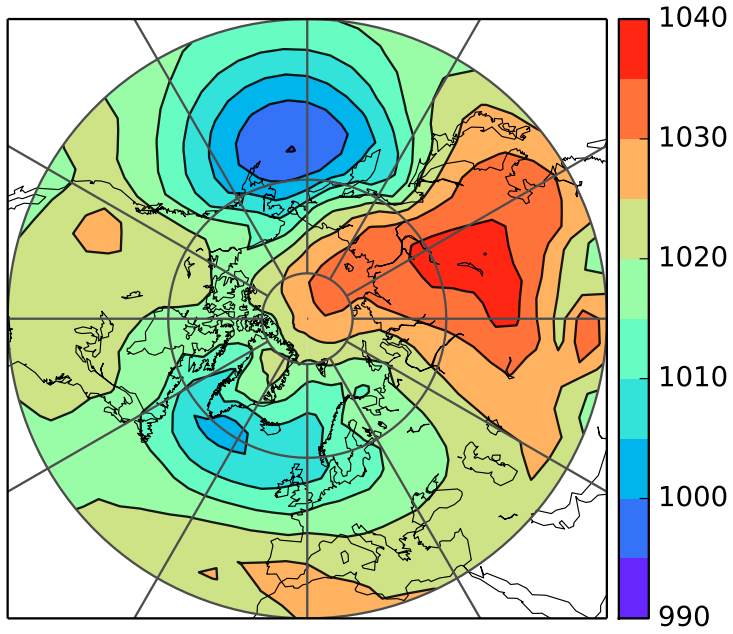
Large signal to noise ratio

Sea-level pressure during early winter (mb)



High ice scenario

Ensemble mean

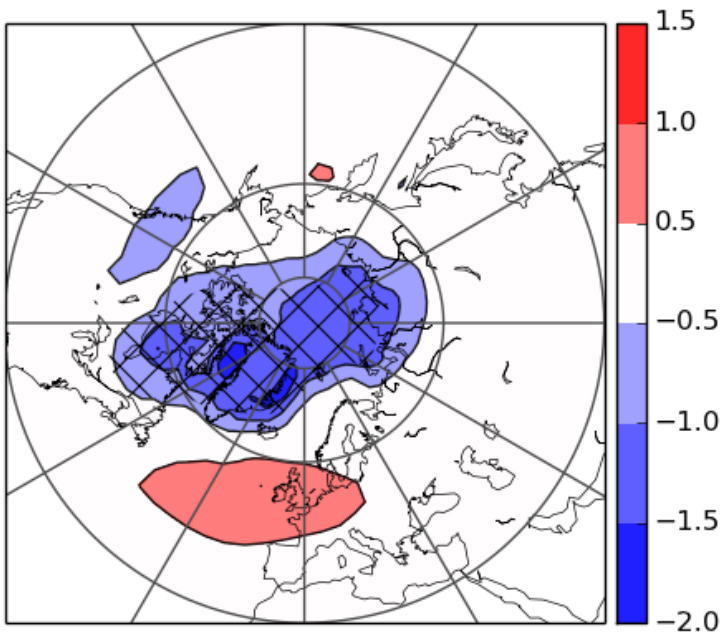


Low ice scenario

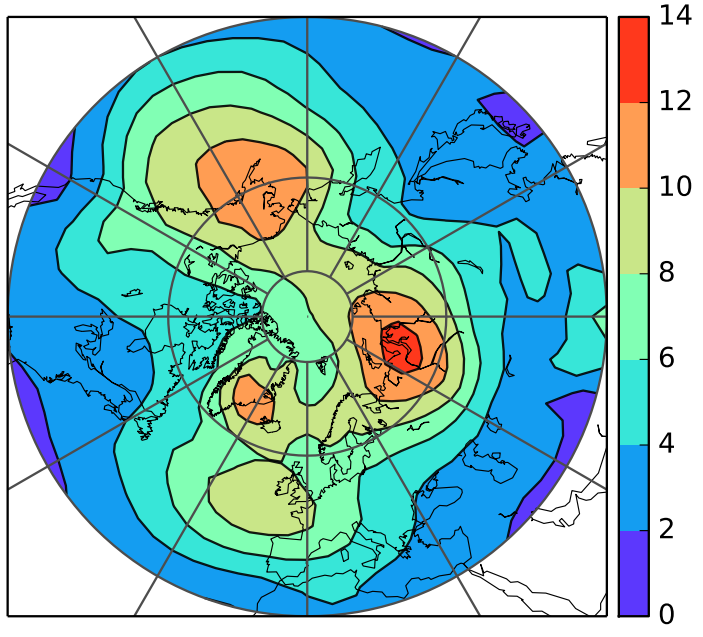
Ensemble mean

Large signal to noise ratio

Sea-level pressure during early winter (mb)



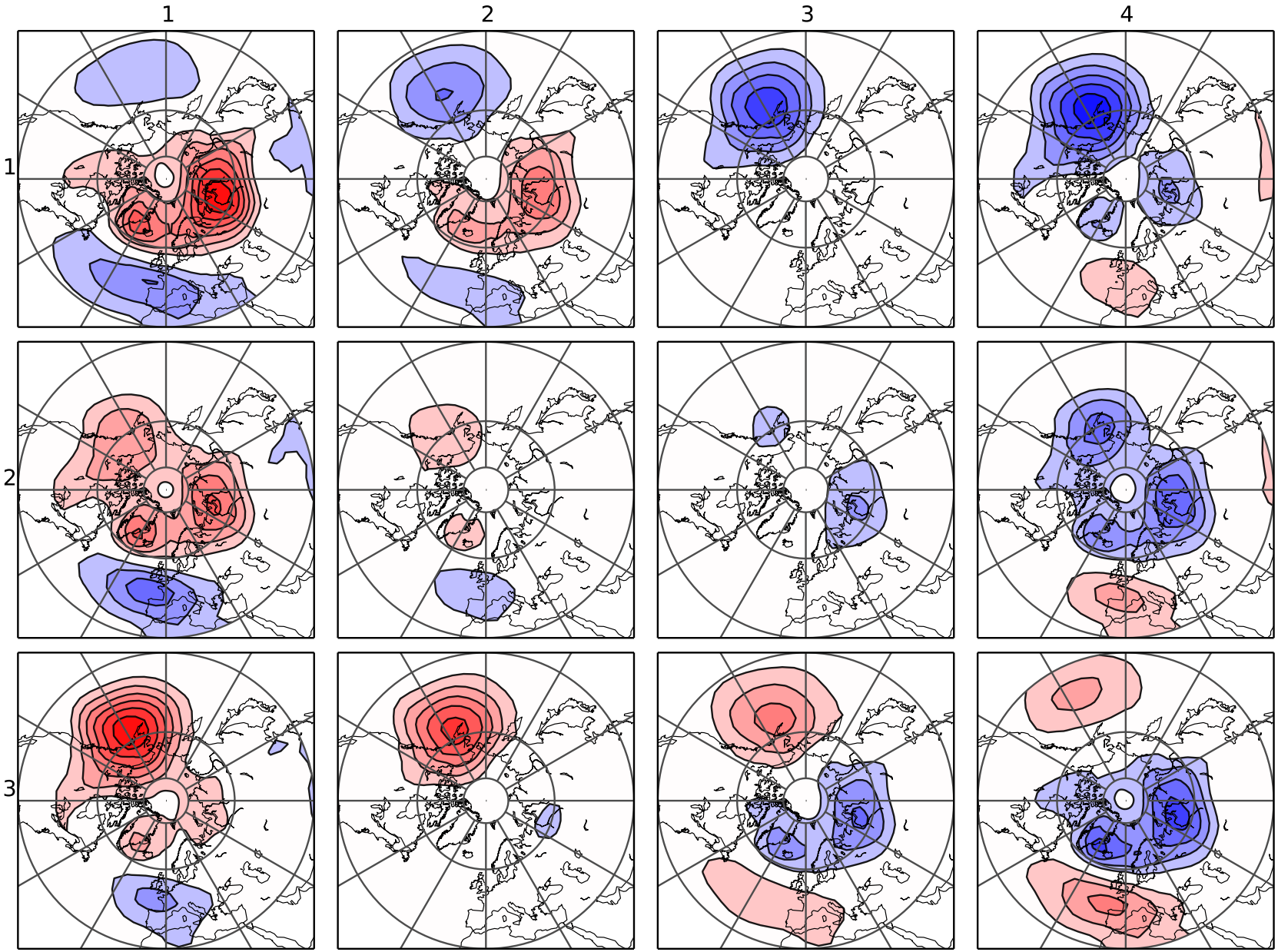
Low ice – High ice
Difference



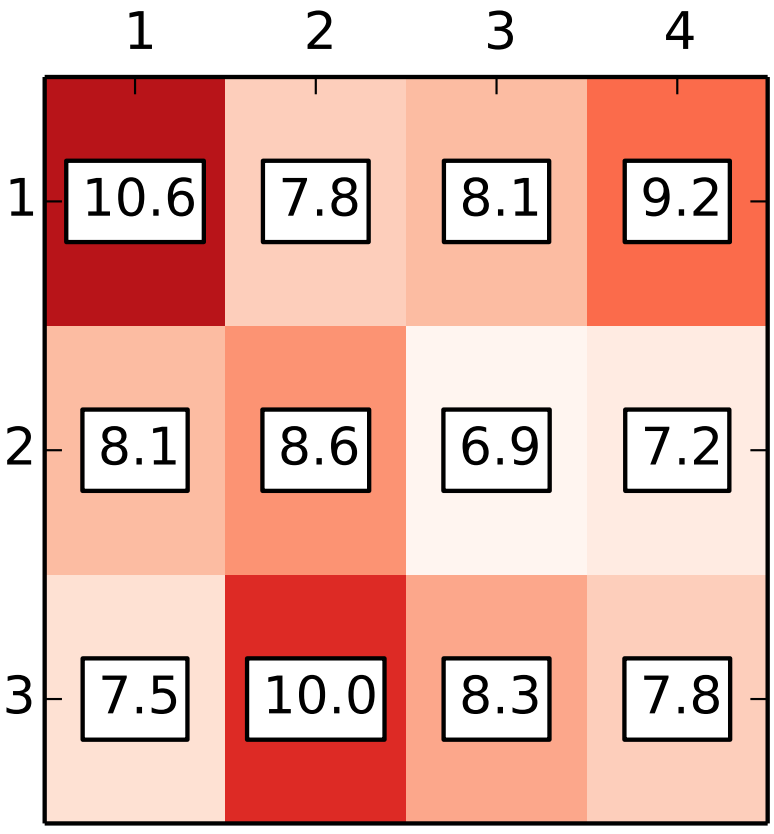
Low ice – High ice
Spread

PENNSTATE 1855

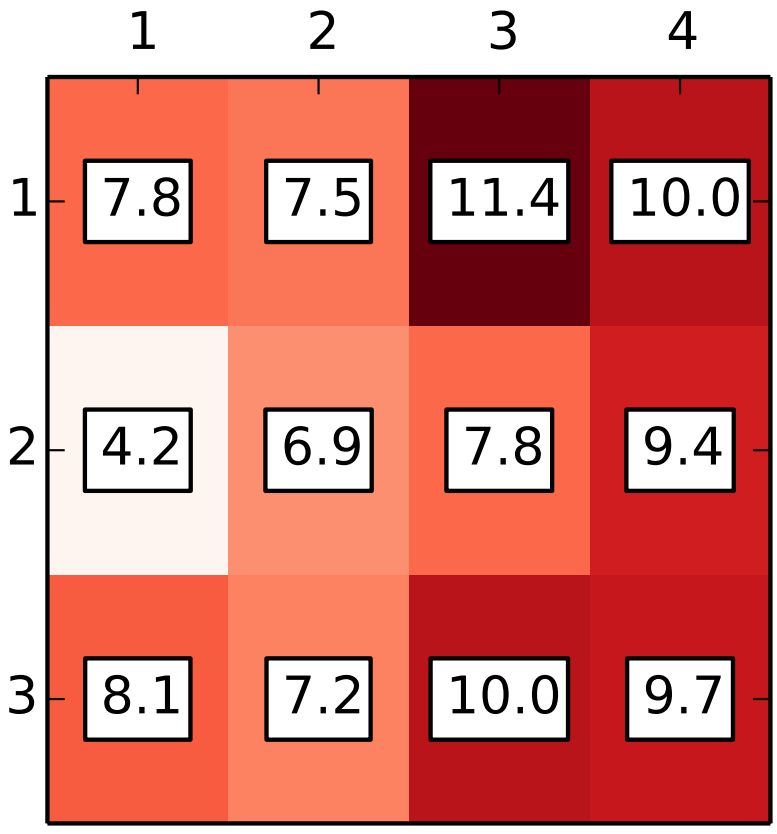
Trained self-organizing map



Frequency of nodes

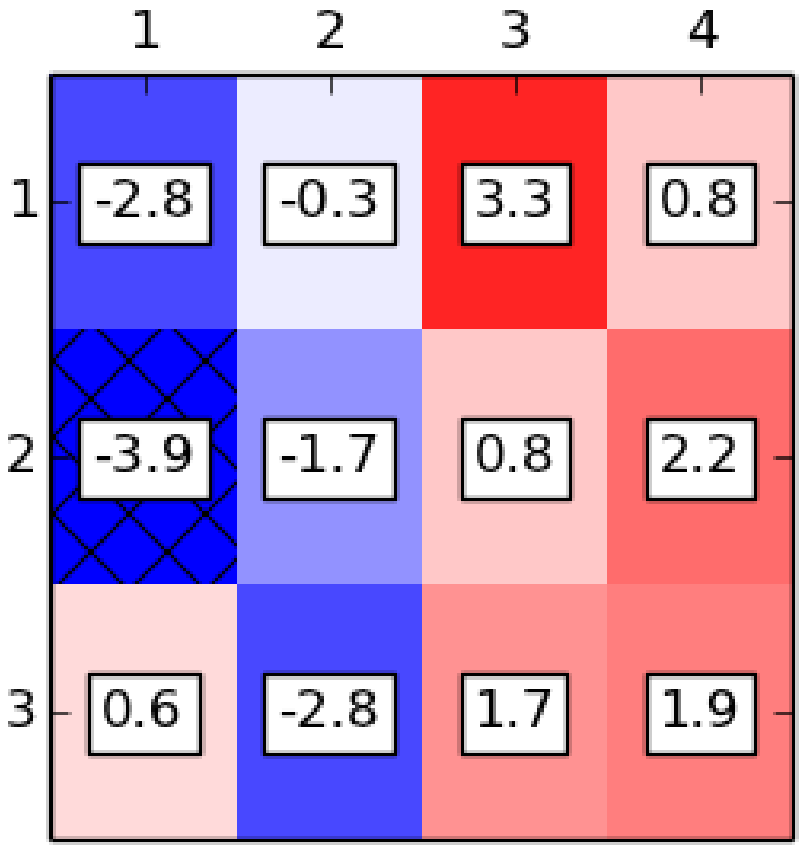


High ice scenario (%)



Low ice scenario (%)

Changes in frequency

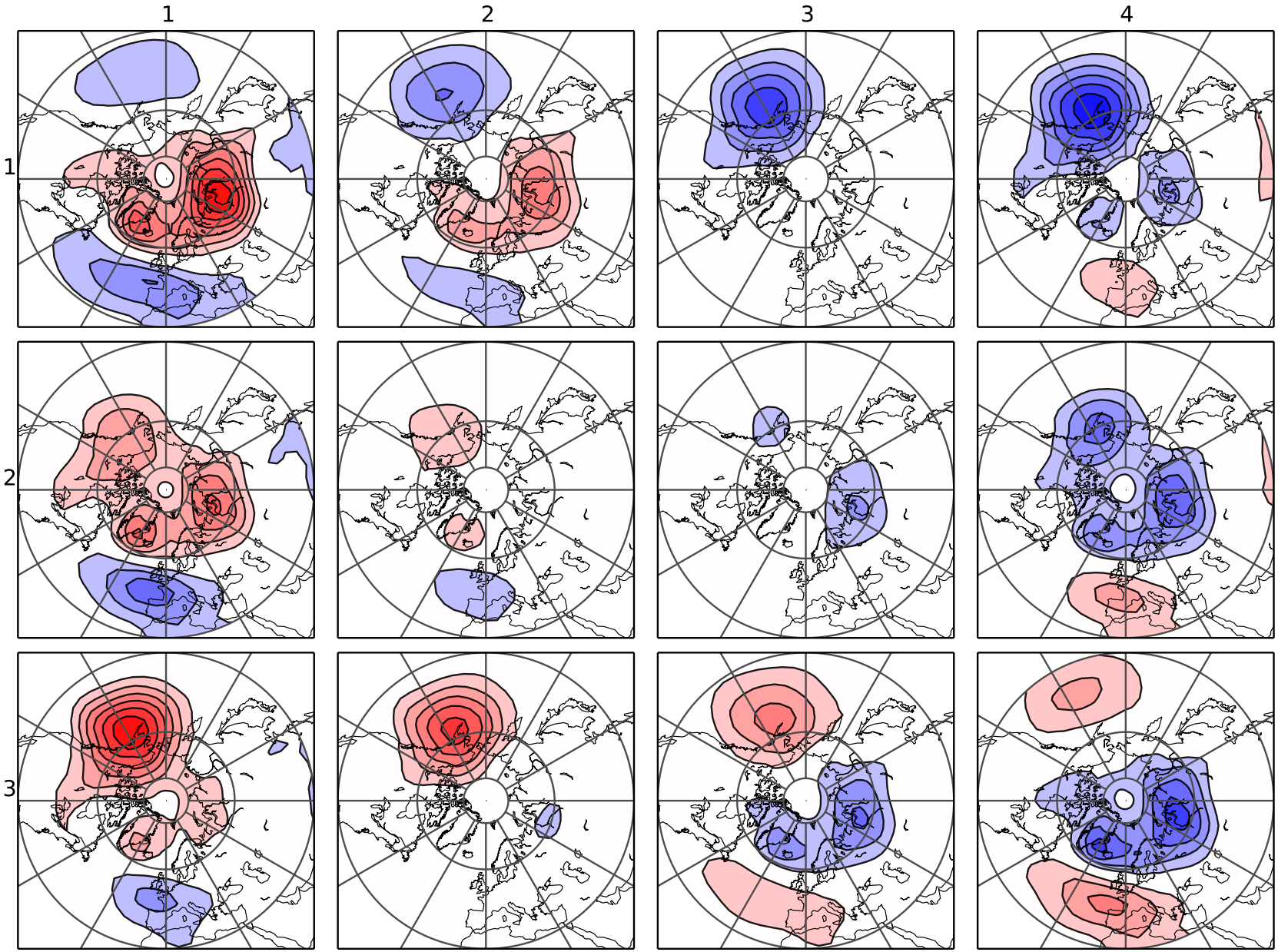


Low ice – High ice

(percentage point)

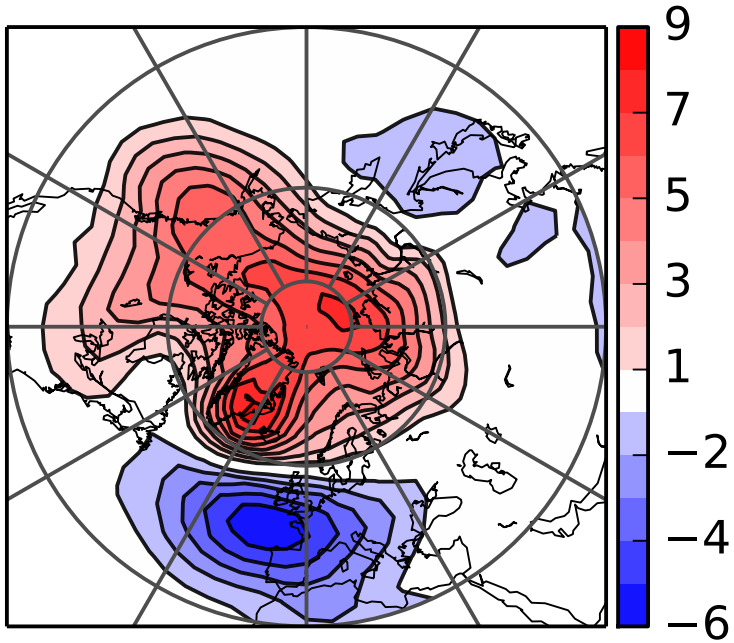
PENNSTATE 1855

Trained self-organizing map

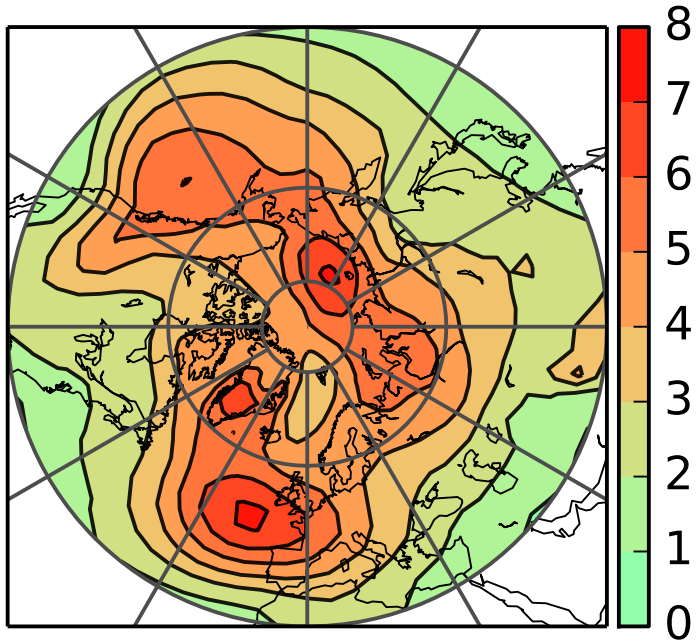


PENNSTATE 1855

Composites show good agreement



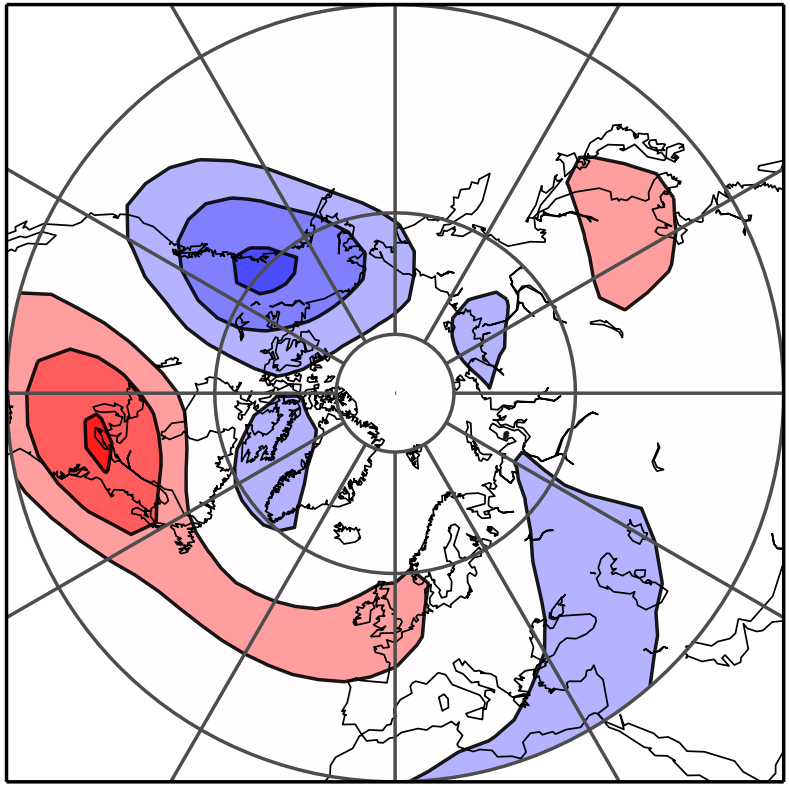
Composite of node (2, 1) (mb)



Spread of node (2, 1) (mb)

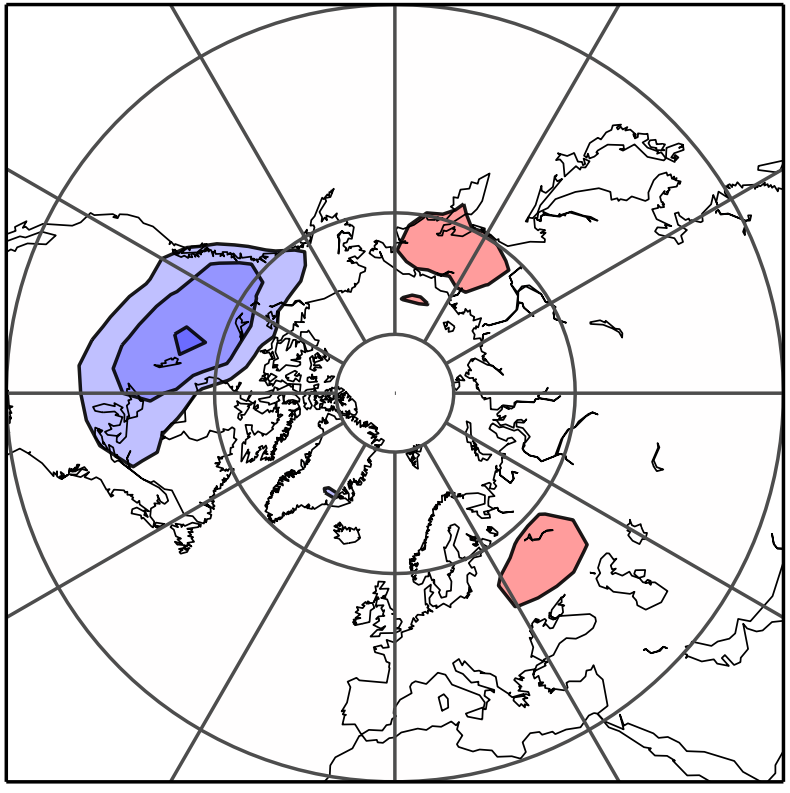
PENNSTATE 1855

500 mb height and 2-m temperature



500 mb height

+5.0 percentage point



2-m temperature (°C)

+3.9 percentage point

PENNSTATE 1855

Conclusions

- We examined the impact of Arctic sea ice loss on the mid-latitude winter conditions using CAM
- The following significant changes were found during early winter using self-organizing maps:
  - A significant decrease in the frequency of a sea-level pressure pattern that resembles the negative AO
  - An increase in a PNA-like pattern in 500 mb height
  - Cooler early winter conditions over northern North America

Conclusions

- We examined the impact of Arctic sea ice loss on the mid-latitude winter conditions using CAM
- The following significant changes were found during early winter using self-organizing maps:
  - A significant decrease in the frequency of a sea-level pressure pattern that resembles the negative AO
  - An increase in a PNA-like pattern in 500 mb height
  - Cooler early winter conditions over northern North America

PENNSTATE 1855

Conclusions

- We examined the impact of Arctic sea ice loss on the mid-latitude winter conditions using CAM
- The following significant changes were found during early winter using self-organizing maps:
  - A significant decrease in the frequency of a sea-level pressure pattern that resembles the negative AO
  - An increase in a PNA-like pattern in 500 mb height
  - Cooler early winter conditions over northern North America

PENNSTATE 1855

Conclusions

- We examined the impact of Arctic sea ice loss on the mid-latitude winter conditions using CAM
- The following significant changes were found during early winter using self-organizing maps:
  - A significant decrease in the frequency of a sea-level pressure pattern that resembles the negative AO
  - An increase in a PNA-like pattern in 500 mb height
  - Cooler early winter conditions over northern North America

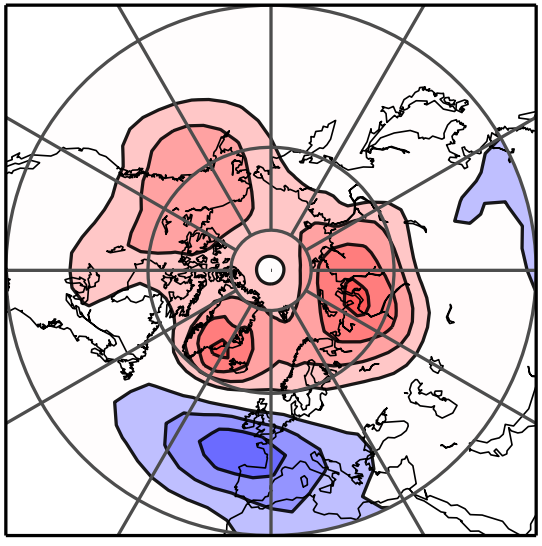
PENNSTATE 1855

Conclusions

- We examined the impact of Arctic sea ice loss on the mid-latitude winter conditions using CAM
- The following significant changes were found during early winter using self-organizing maps:
  - A significant decrease in the frequency of a sea-level pressure pattern that resembles the negative AO
  - An increase in a PNA-like pattern in 500 mb height
  - Cooler early winter conditions over northern North America

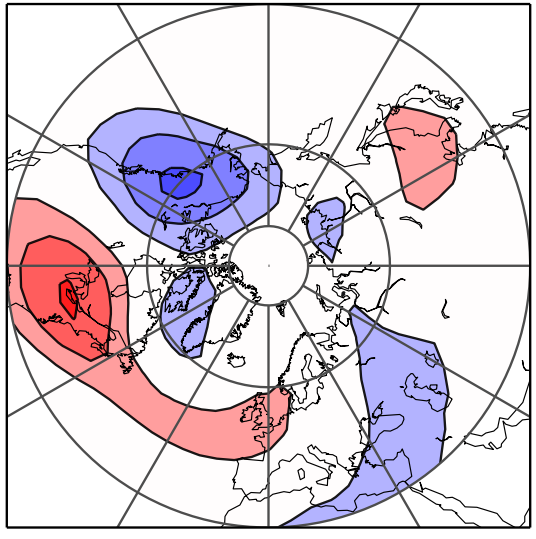
PENNSTATE 1855

Questions?



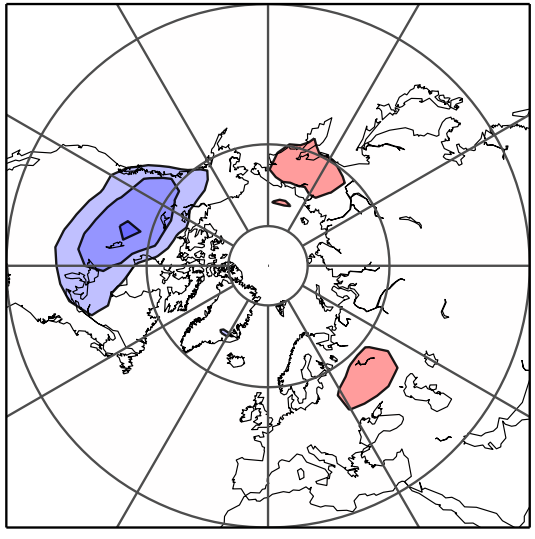
Sea-level pressure

−3.9 percentage point



500 mb height

+5.0 percentage point



2-m temperature (°C)

+3.9 percentage point