Atmospheric Circulation Response to Future Arctic Sea Ice Loss

Clara Deser, Michael Alexander and Robert Tomas

Future Arctic Sea Ice Loss

NCAR Coupled Model Simulation

Holland et al. (2006)

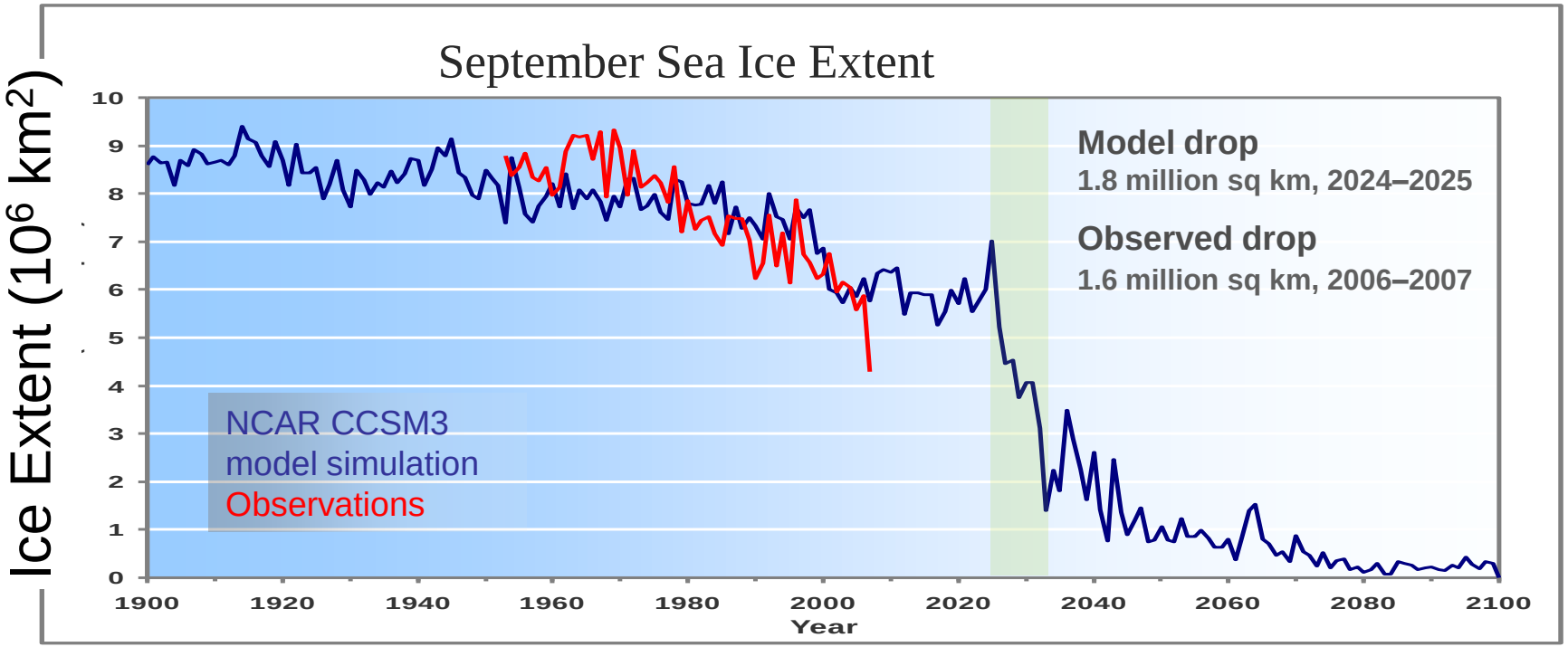

Figure courtesy of Julienne Stroeve

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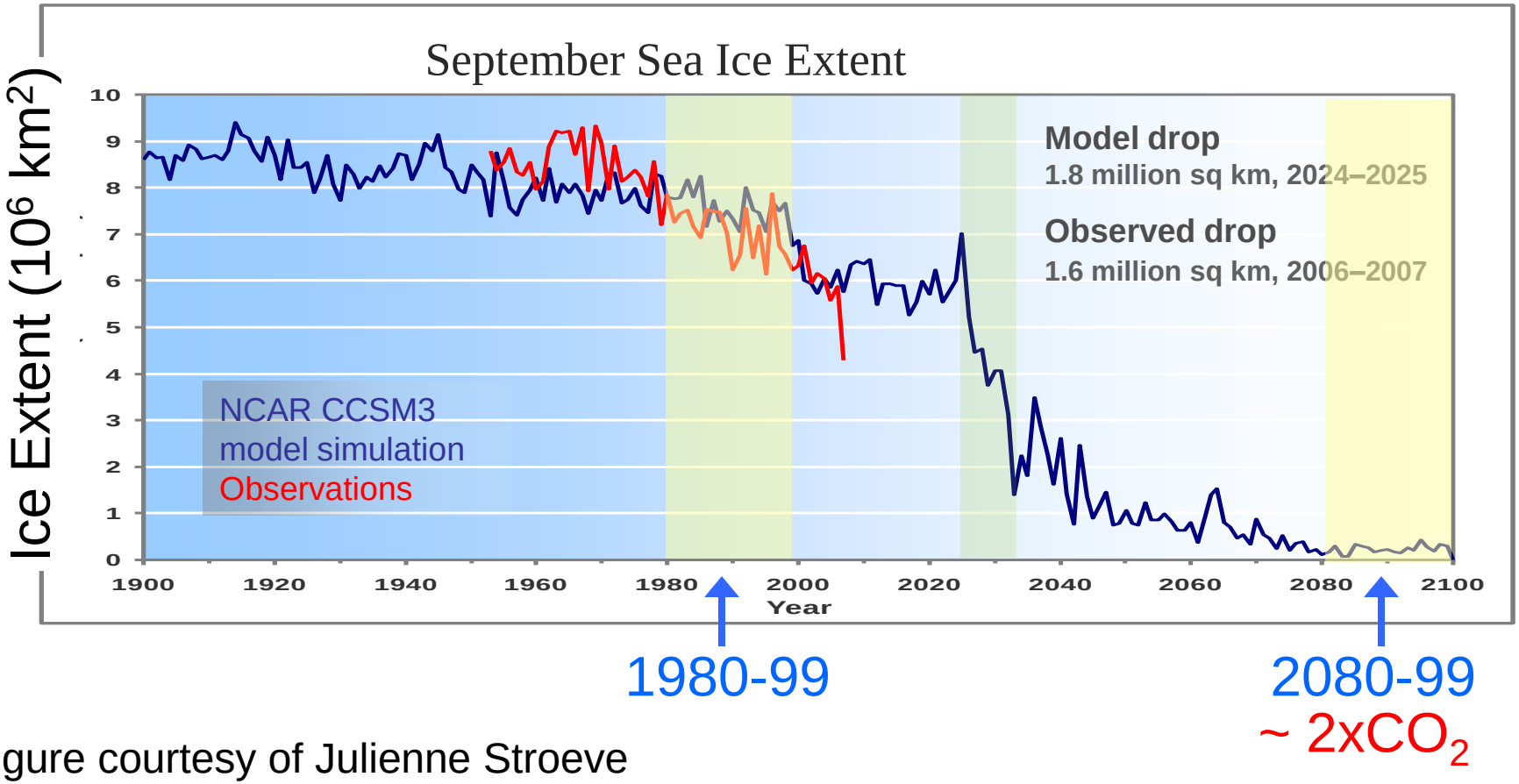
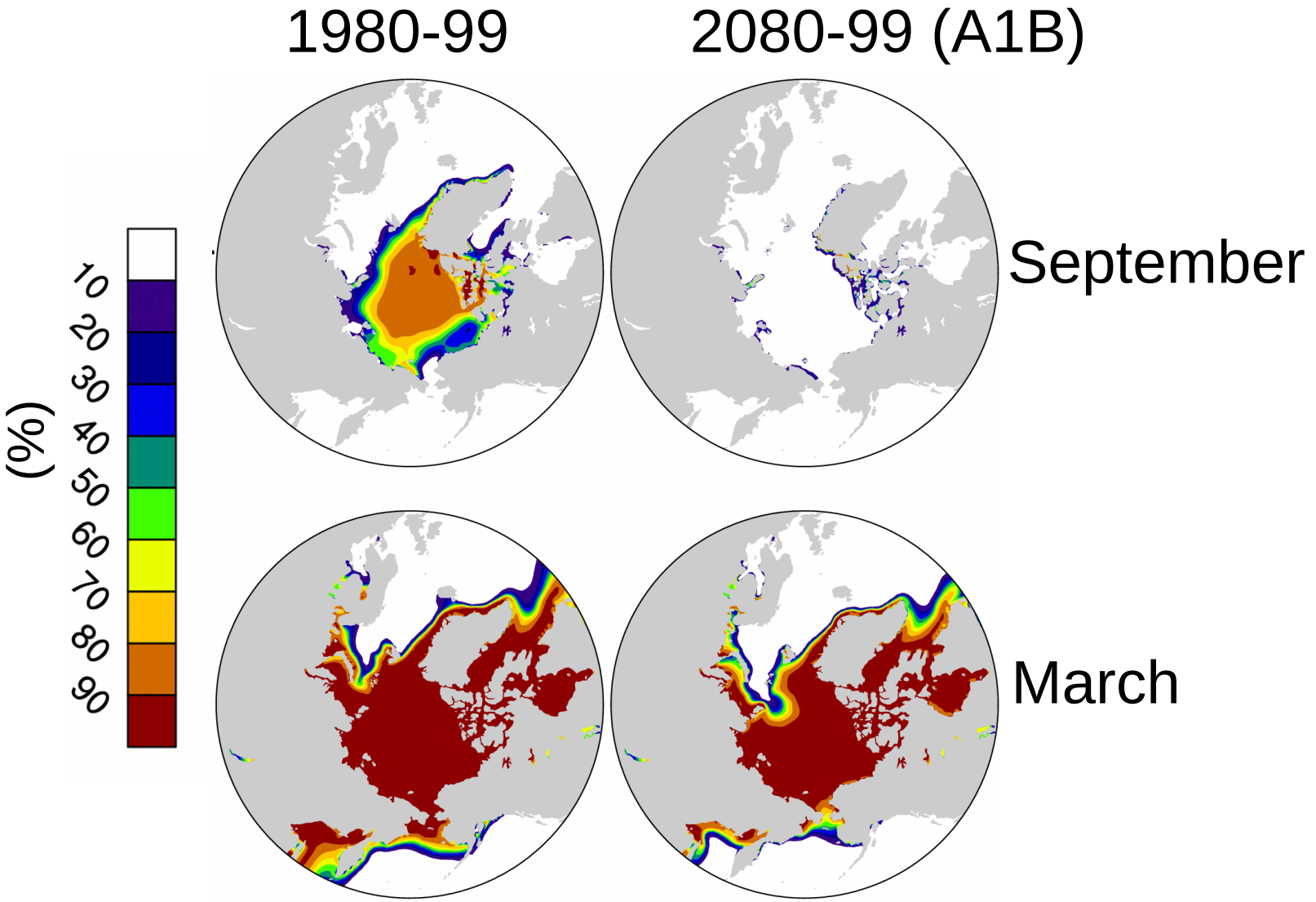


Figure courtesy of Julienne Stroeve

CCSM3 Arctic Sea Ice Concentration



Approach

Prescribe sea ice cover for 1980-99 and 2080-99 to Community Atmospheric Model Version 3

T85 *(1.4 latitude x 1.4 longitude); 26 levels*

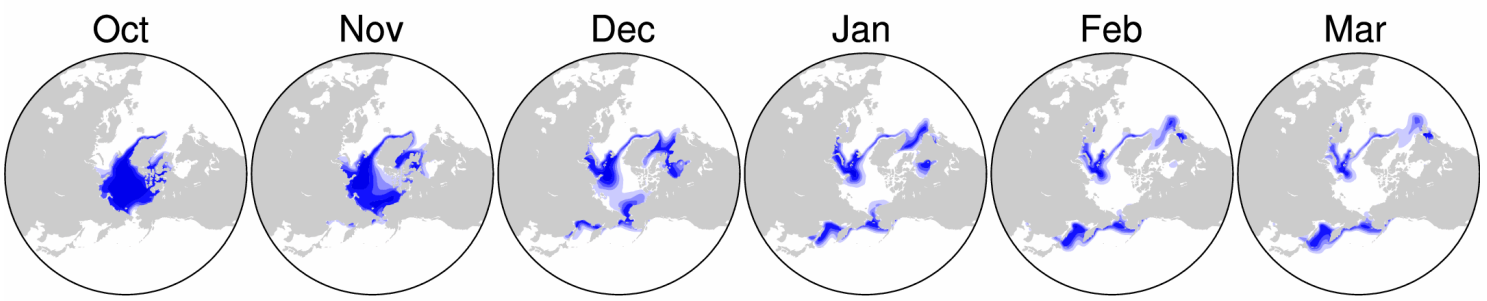
DETAILS

60 year integrations with repeating seasonal cycle of time-average sea ice concentration and thickness:

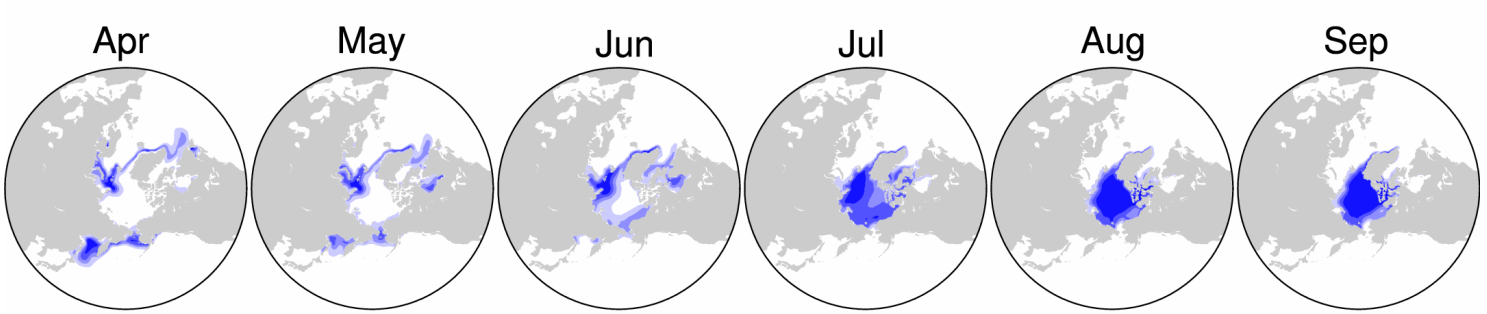
- 1980-99 (CCSM3 historical)
- 2080-99 (CCSM3 A1B)
- *SSTs fixed at 1980-99 values, and set to -1.8 C where sea ice removed*

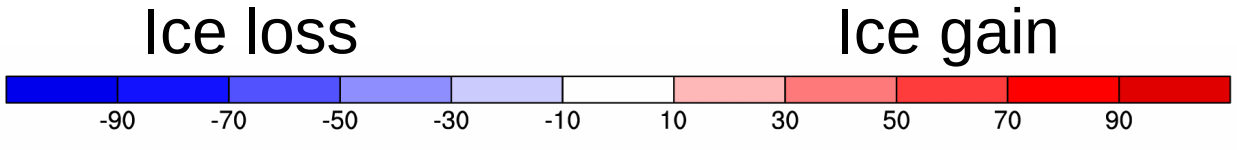
Sea Ice Change: 2080-99 minus 1980-99

Sea Ice (%)



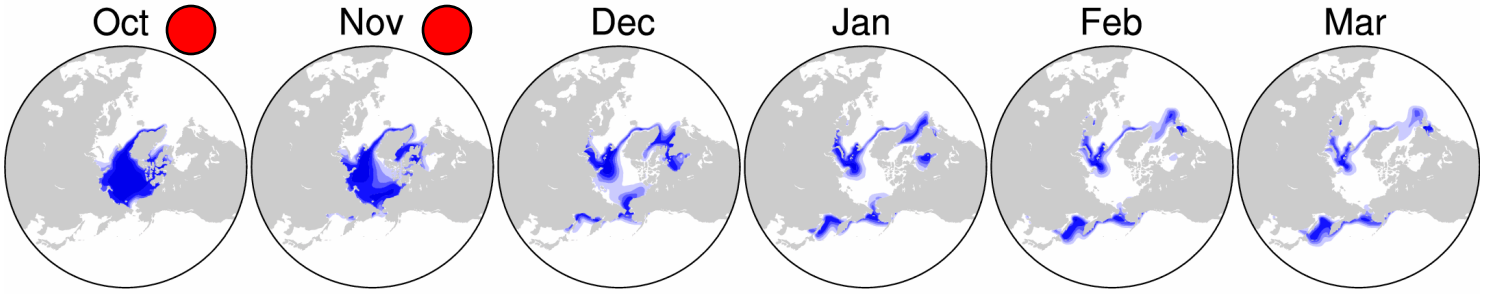
Sea Ice (%)



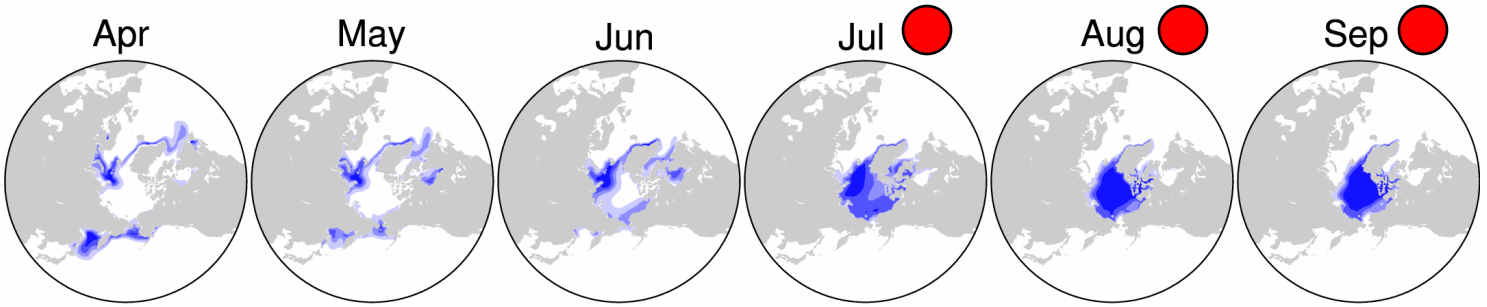


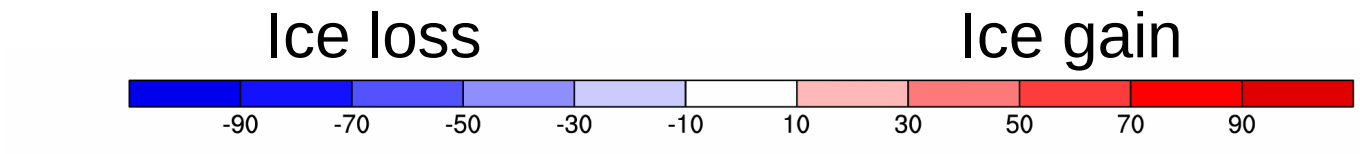
Sea Ice Change: 2080-99 minus 1980-99

Sea Ice (%)

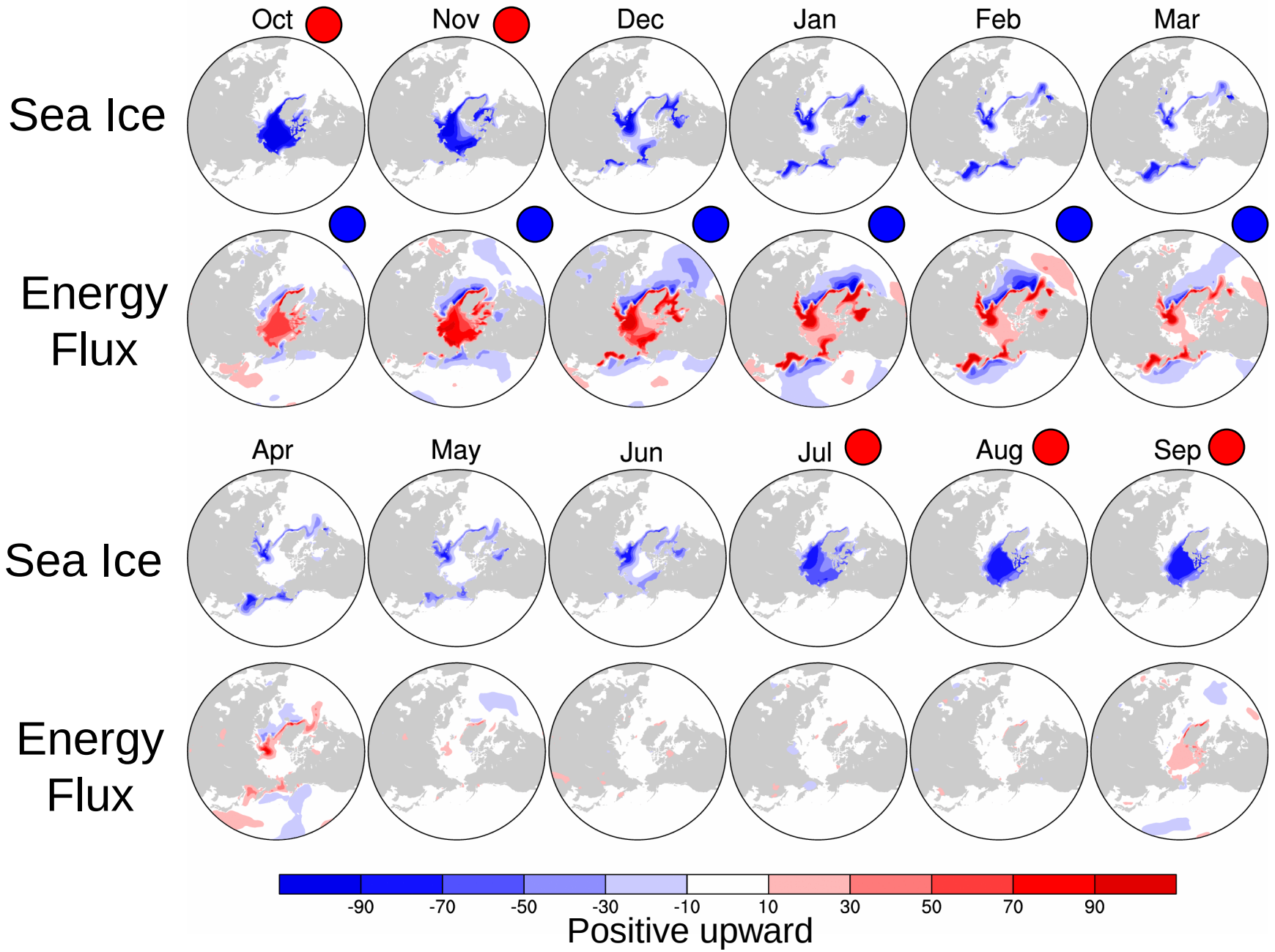


Sea Ice (%)

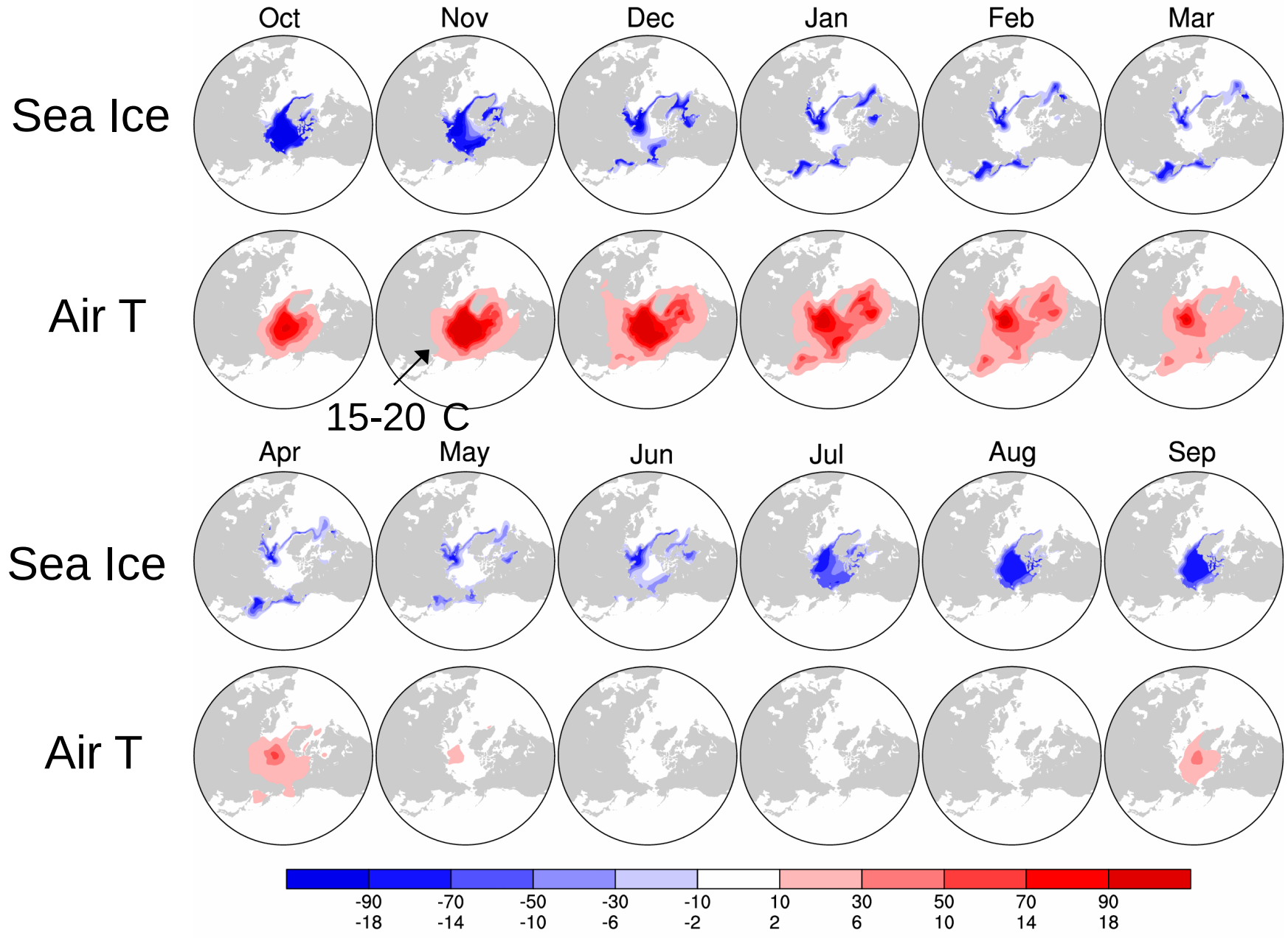




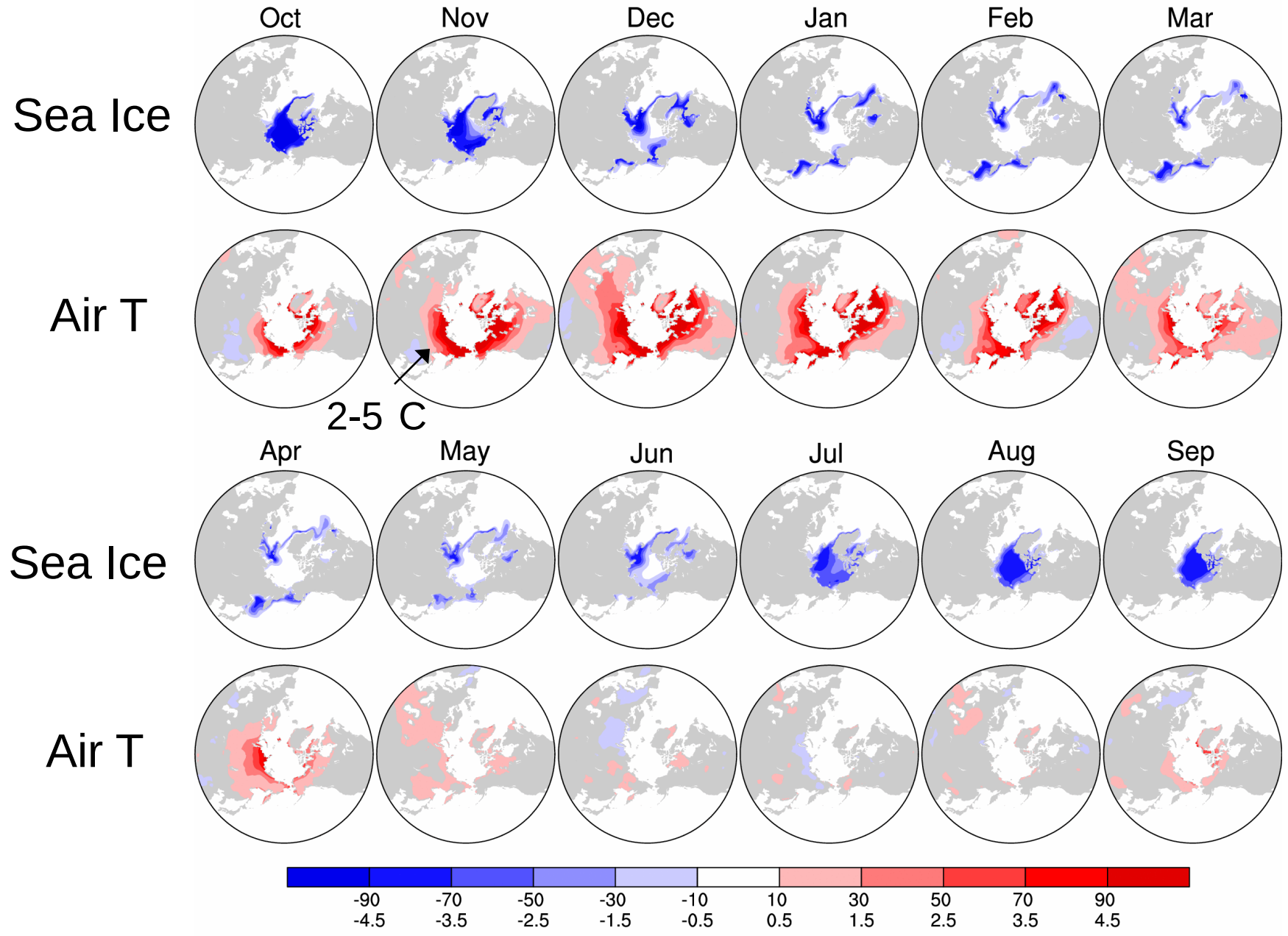
Surface Energy Flux Response (Wm^{-2})



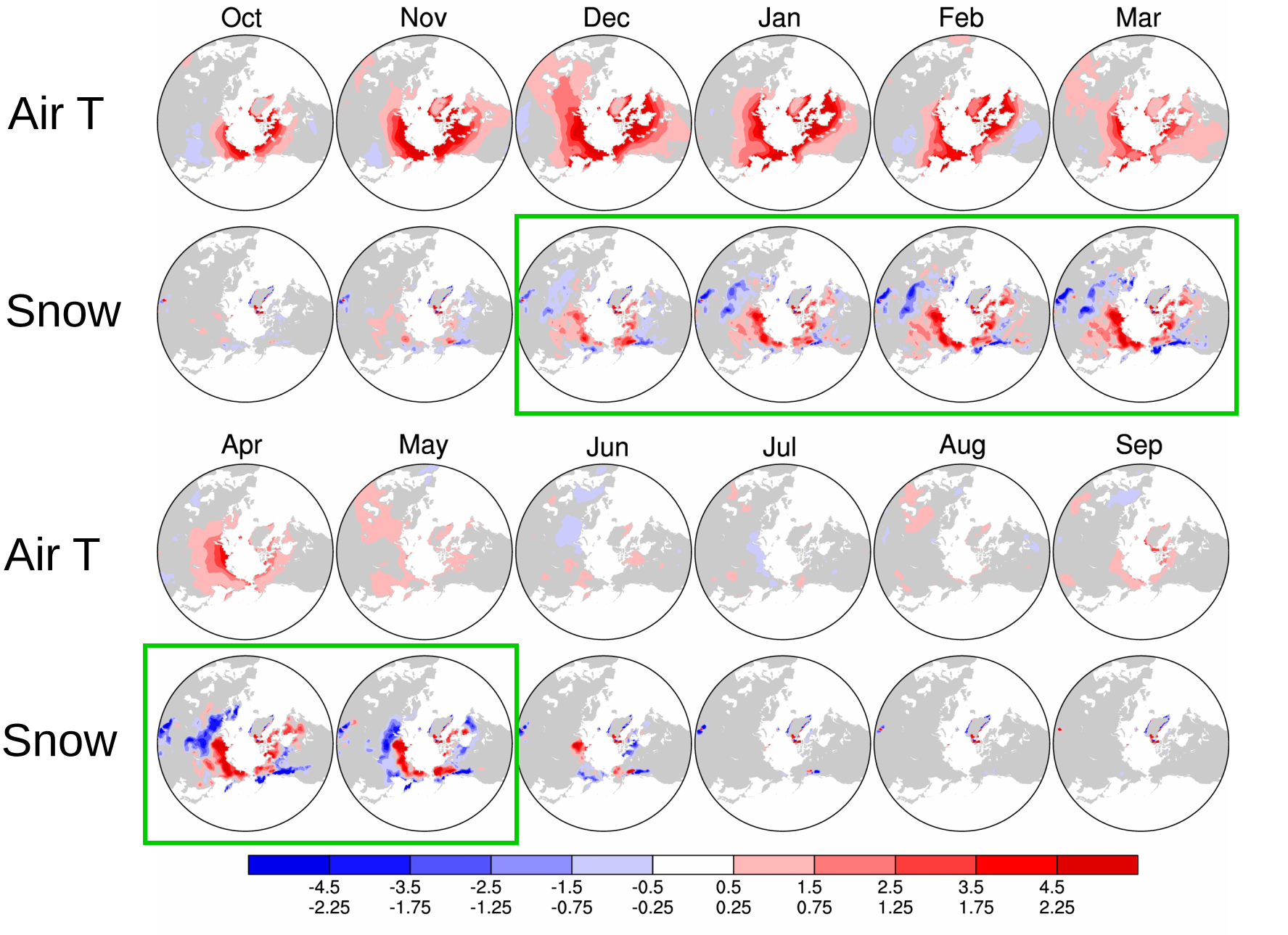
Air Temperature Response (°C)



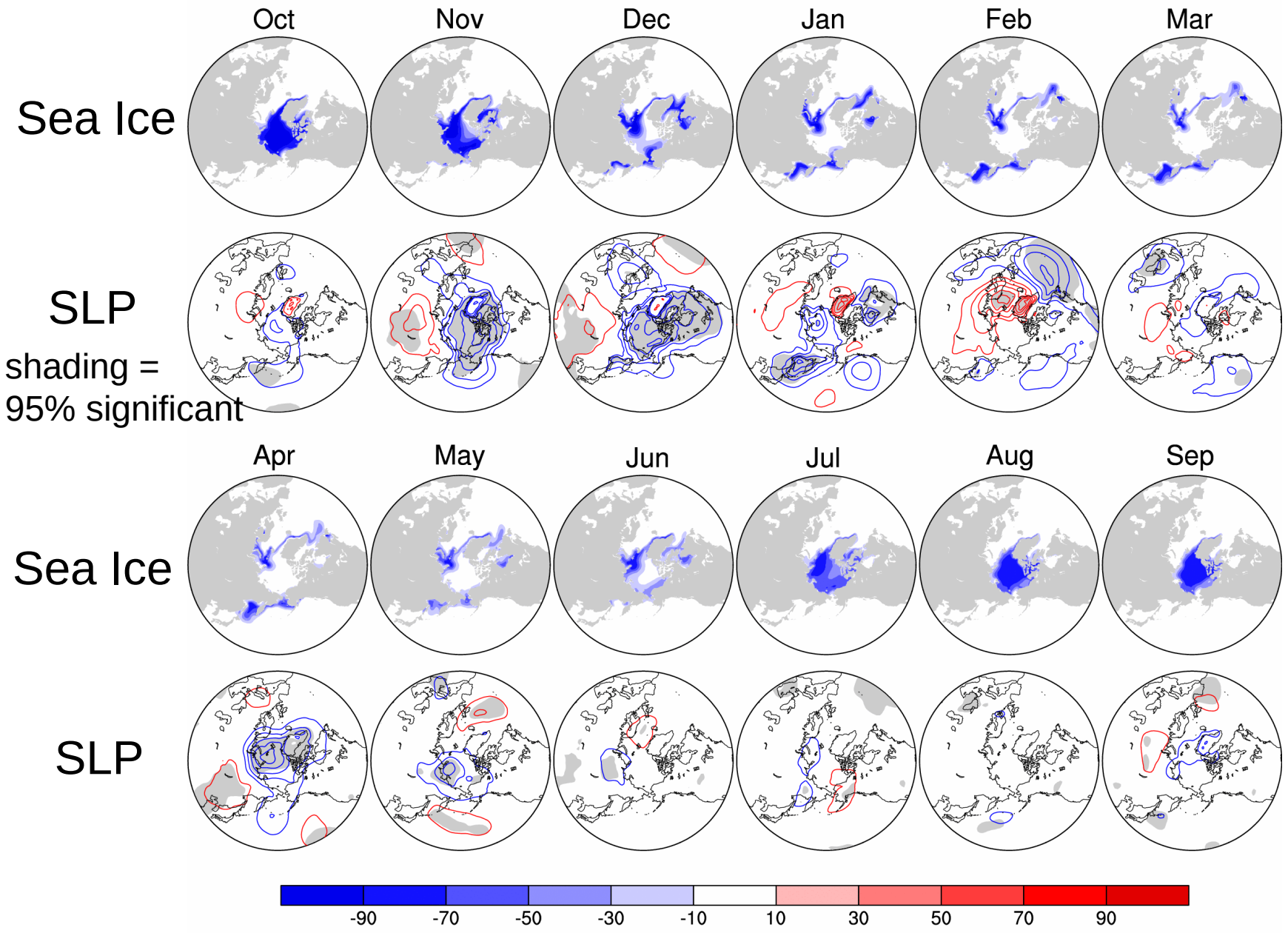
Air Temperature Response (°C): Land Only



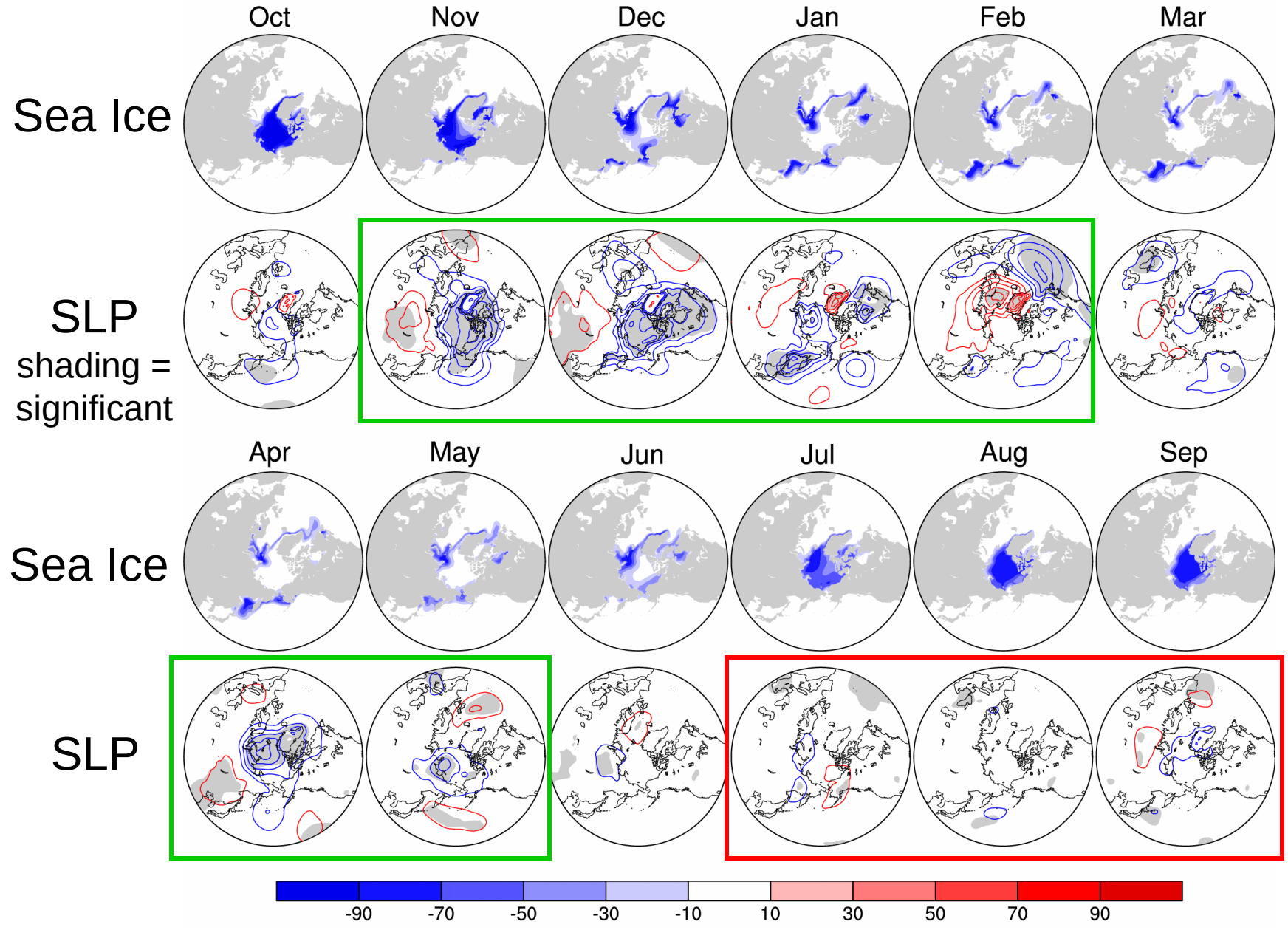
Snow Depth Response (cm liquid water equivalent)



Sea Level Pressure Response (hPa) ci=1hPa

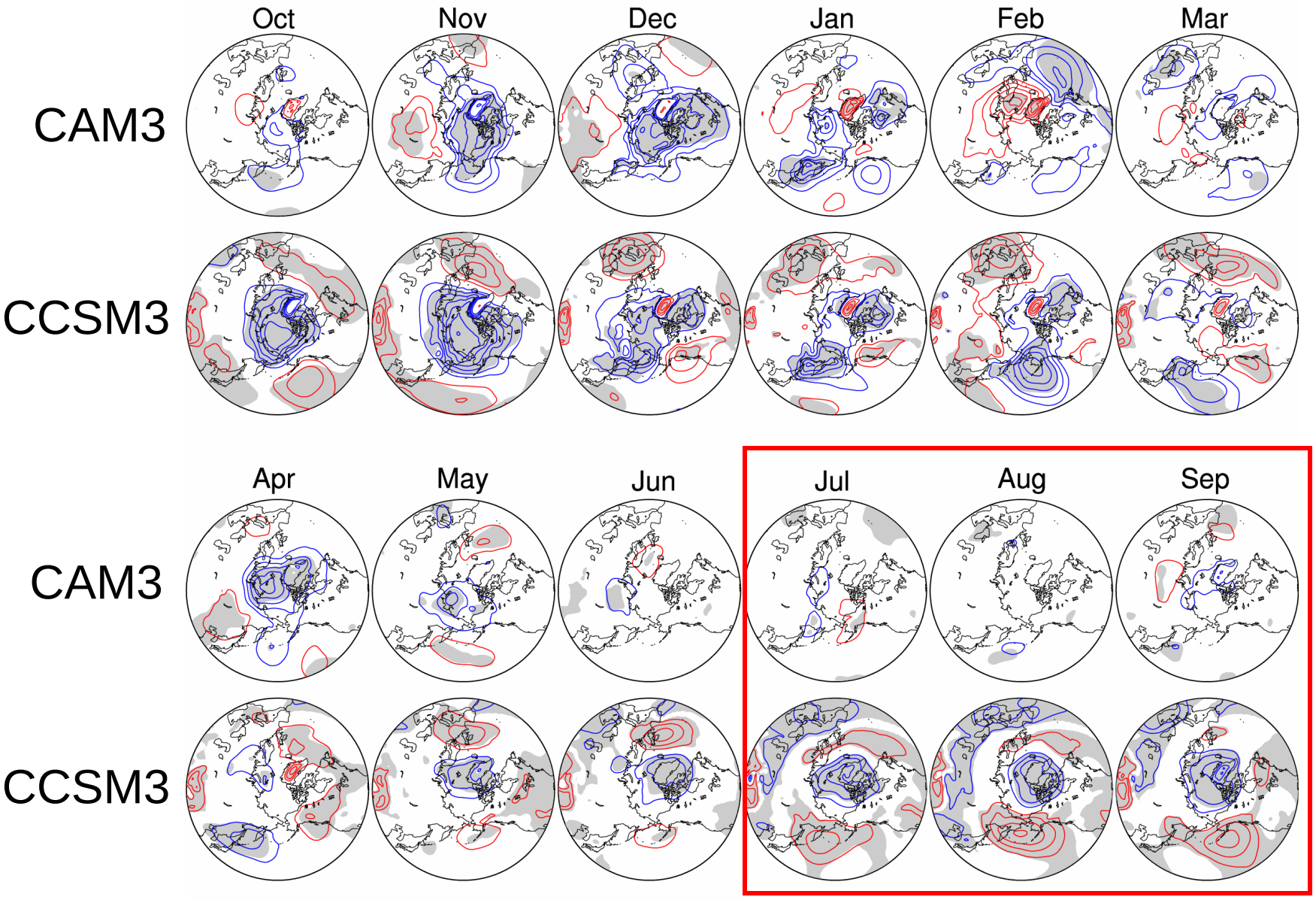


Sea Level Pressure Response (hPa) ci=1hPa

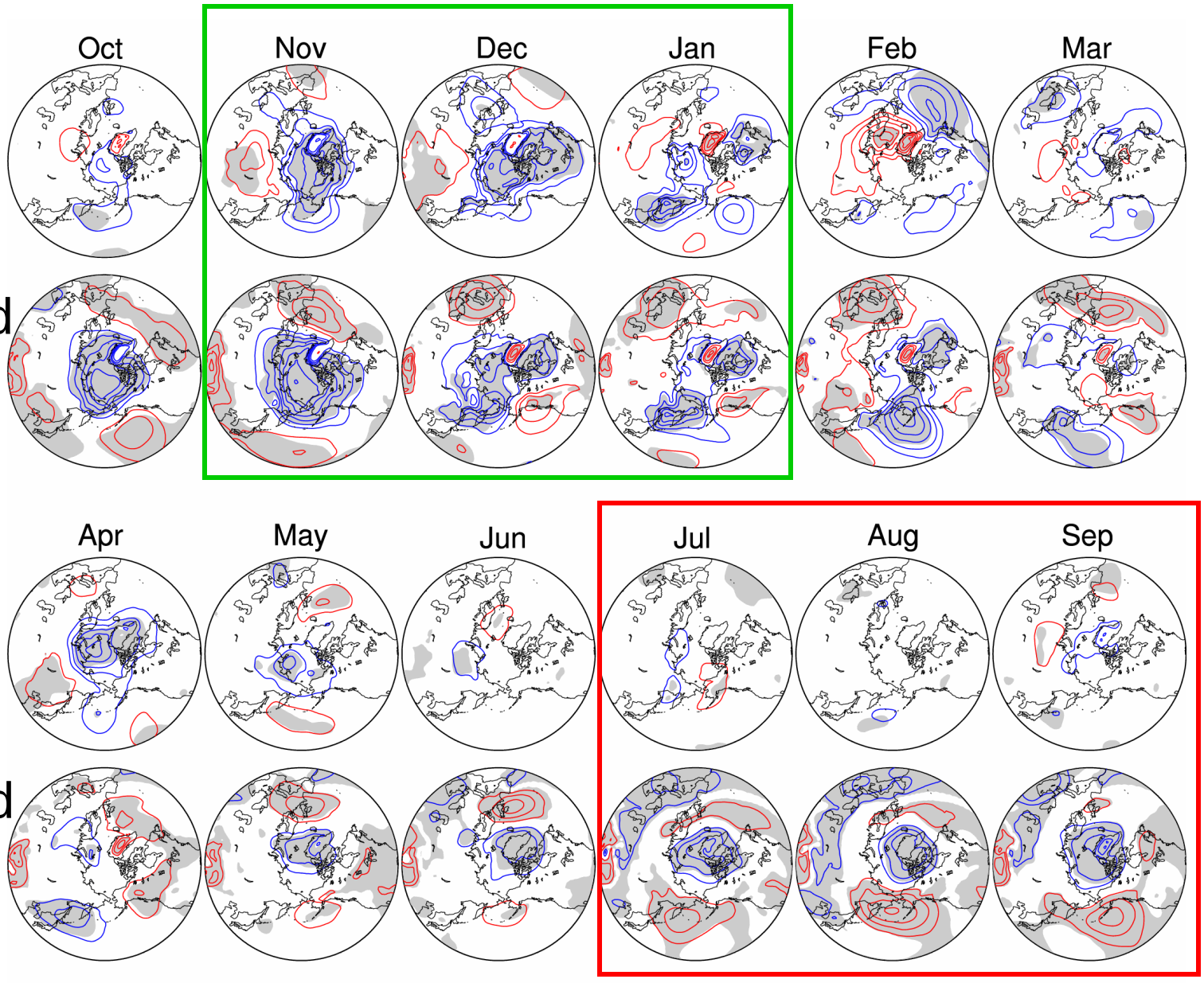


How does the atmospheric circulation response to Arctic sea ice loss compare with the response to doubled CO_2 in the fully coupled CCSM3?

Sea Level Pressure Response (hPa) ci=1hPa



Sea Level Pressure Response (hPa) ci=1hPa



SUMMARY
Atmospheric Circulation Response to Future Arctic Sea Ice Loss

- Largest sea ice loss in summer-fall (July-Nov), but largest surface energy flux response (which forces the atmosphere) in fall-winter (Oct-Mar)
- *Thermodynamic response*: warming (and moistening) of the boundary layer especially in fall-winter (2-5K over land and 15-20K over the Arctic ocean); increased snow cover over Siberia and northern Alaska
- *Dynamic response*: SLP response largest in fall-winter when it accounts for some of the response to 2xCO_2 in the coupled model; negligible in summer

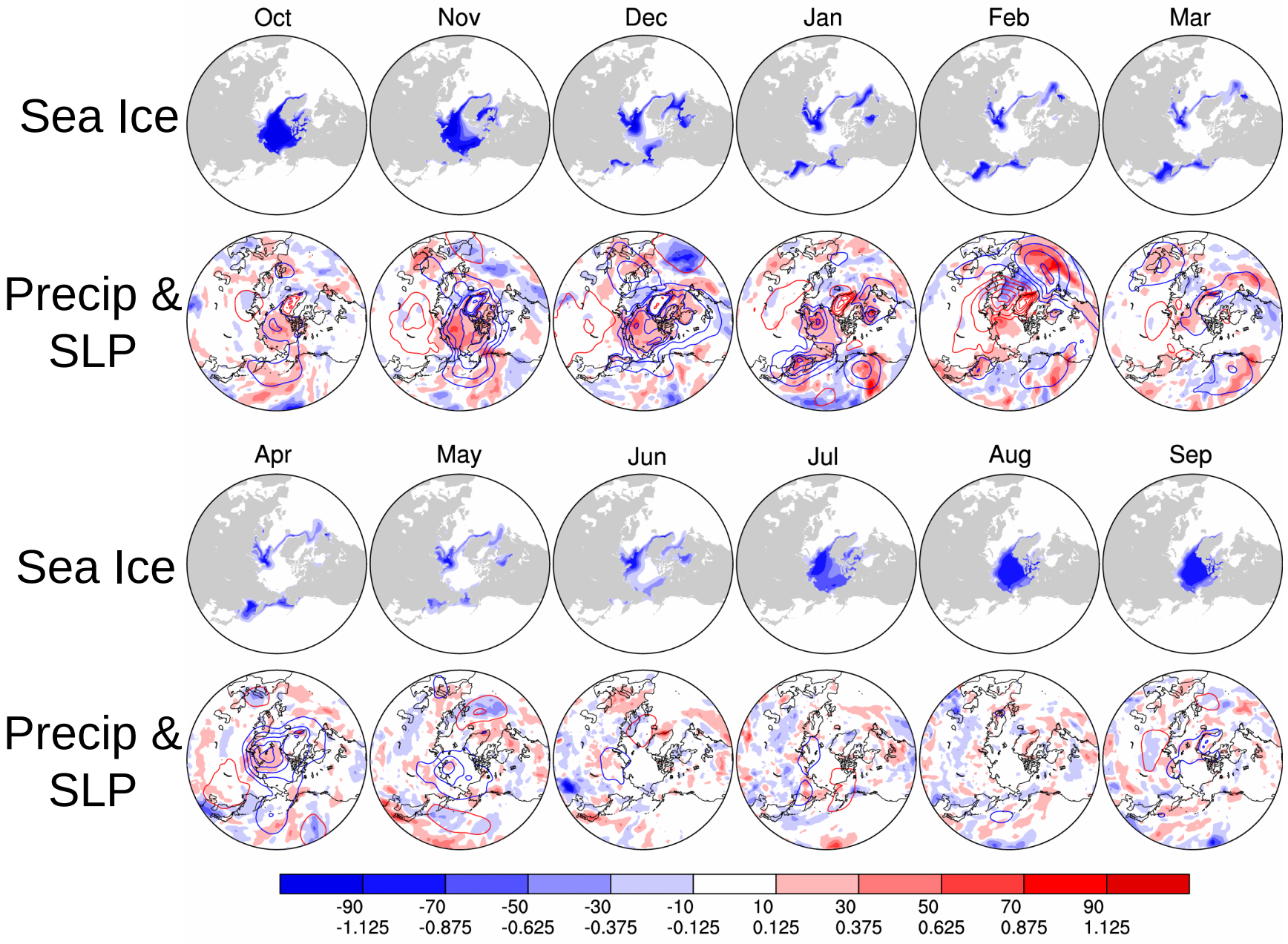
Next Steps
Atmospheric Circulation Response to Future Arctic Sea Ice Loss

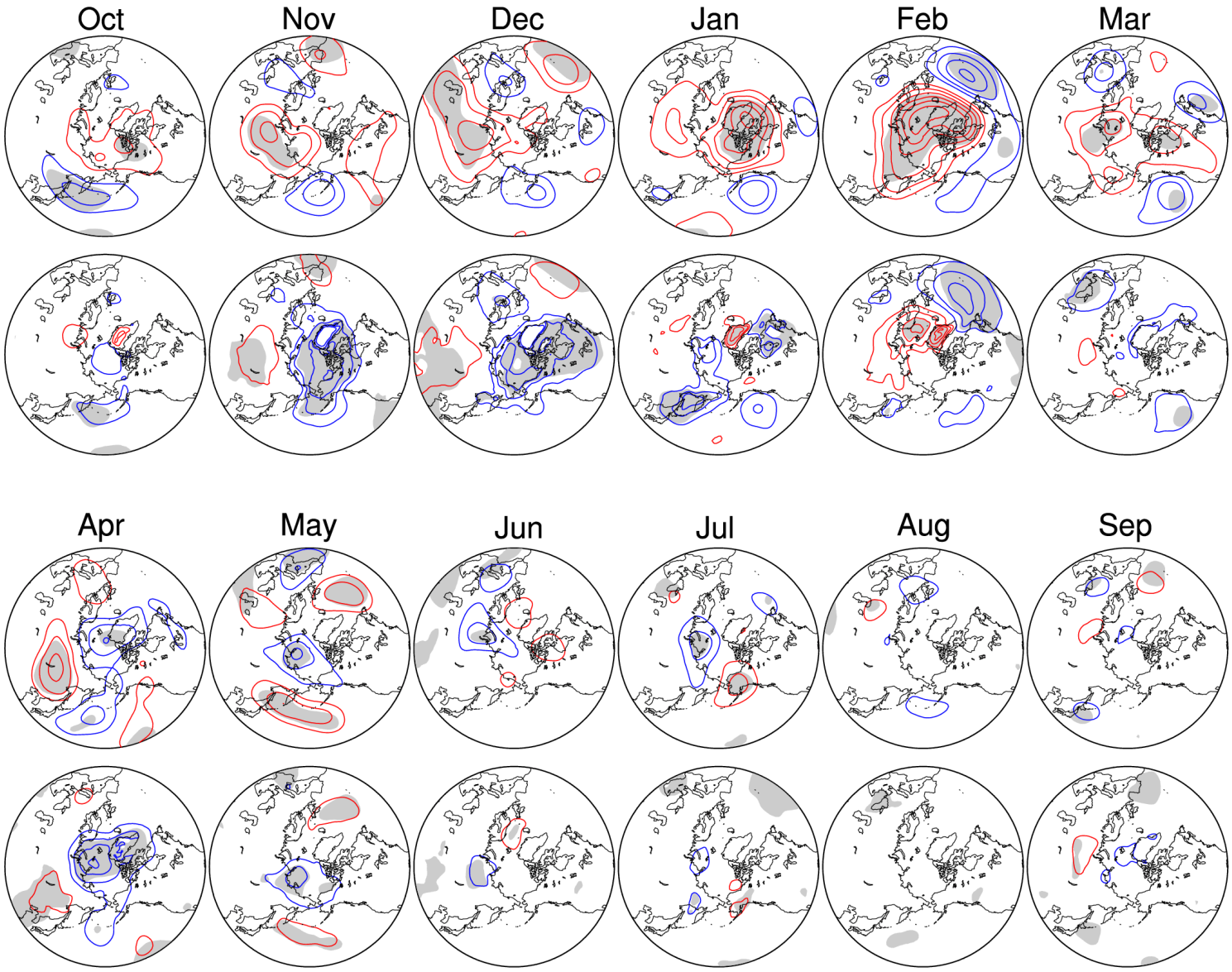
- Allow sea surface temperatures to respond to sea ice loss
- Similar experiments with a regional high resolution atmospheric model (Cassano et al.) and an AGCM with a resolved stratosphere
- Similar experiments for snow cover (Tomas et al.)

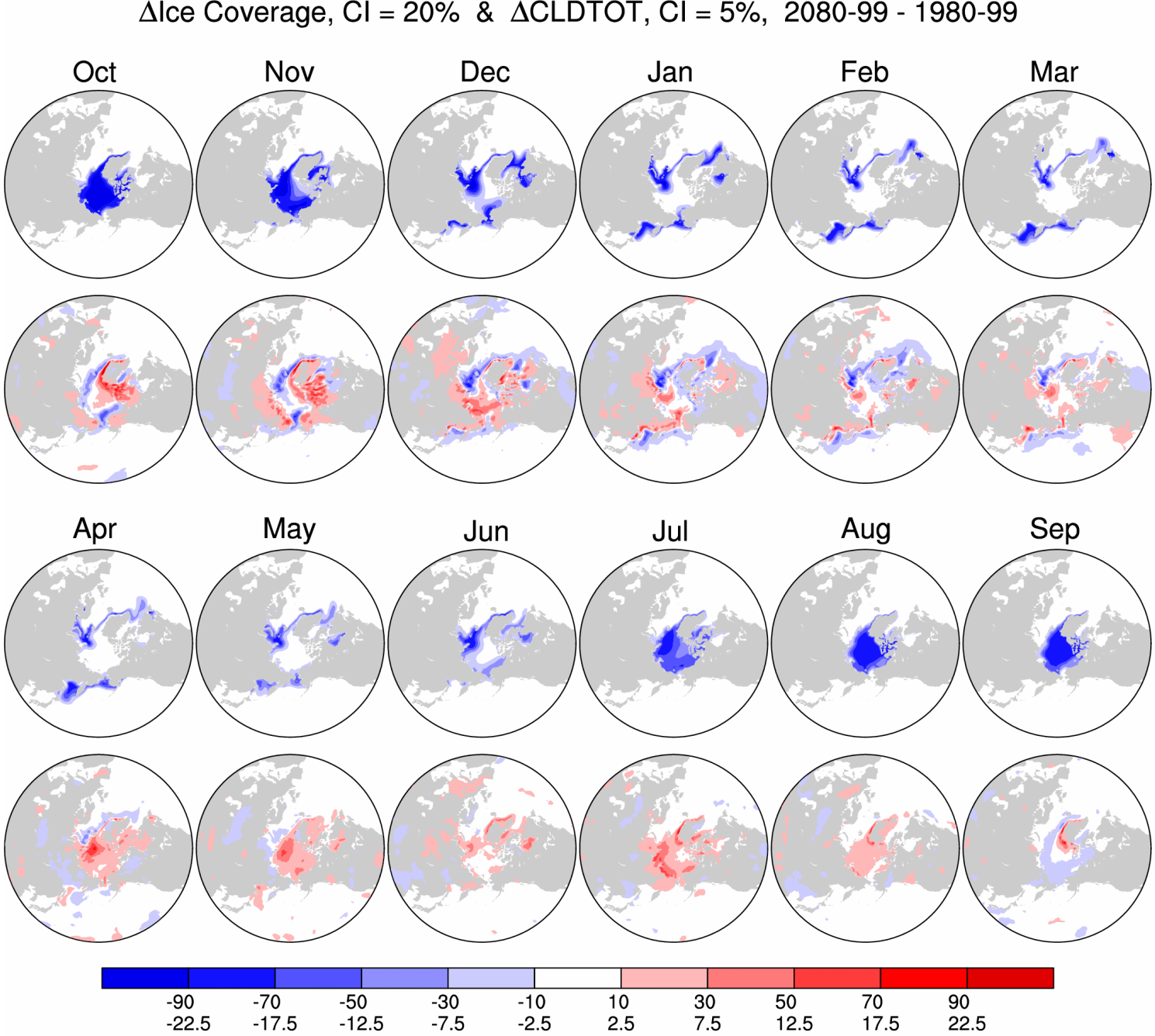
Thank You

Extra Slides

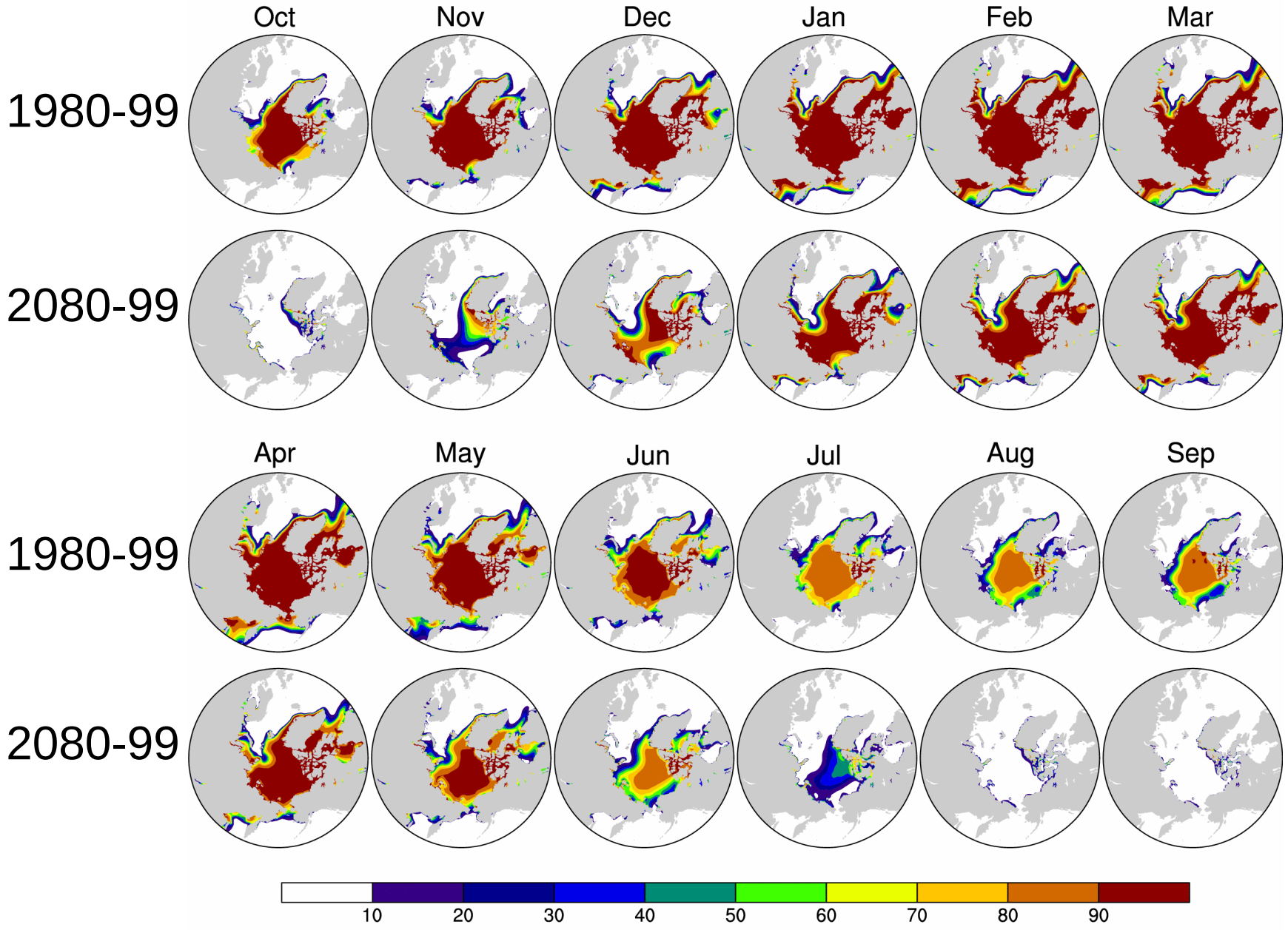
Precipitation Response (mm day^{-1})




ΔZ3 500mb, CI = 10m & ΔZ3 1000mb, CI = 10m 2080-99 - 1980-99
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

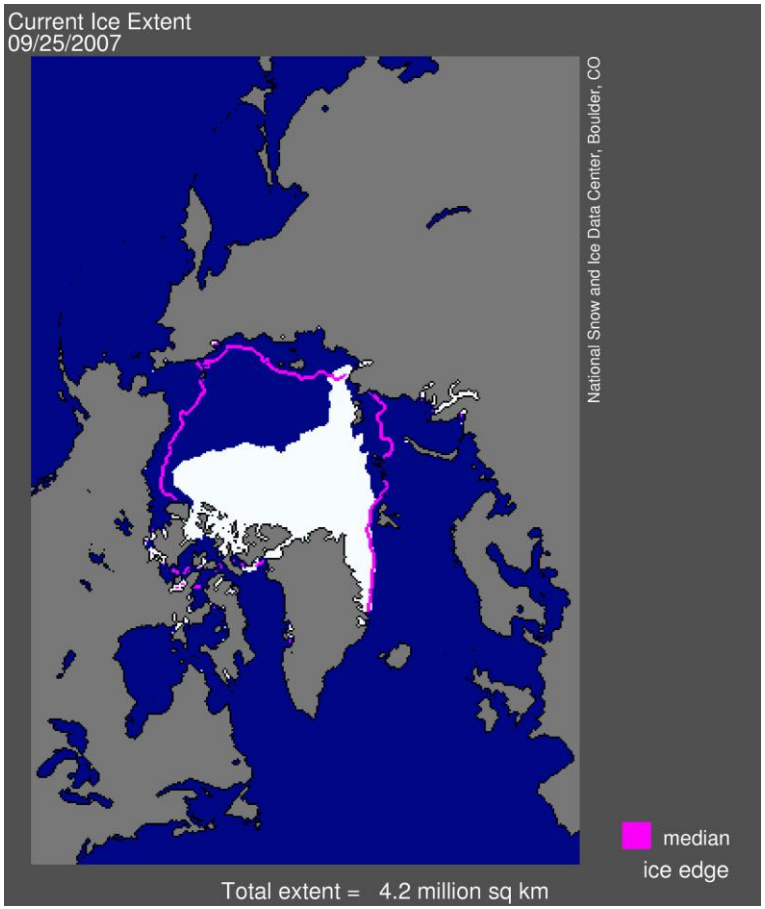

ΔIce Coverage, CI = 20% & ΔCLDTOT, CI = 5%, 2080-99 - 1980-99
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
-90
-22.5
-70
-17.5
-50
-12.5
-30
-7.5
-10
-2.5
10
2.5
30
7.5
50
12.5
70
17.5
90
22.5
Thu May 29 11:38:30 MDT 2008
p_12months_ice_cldtot

Sea Ice Concentration (%)

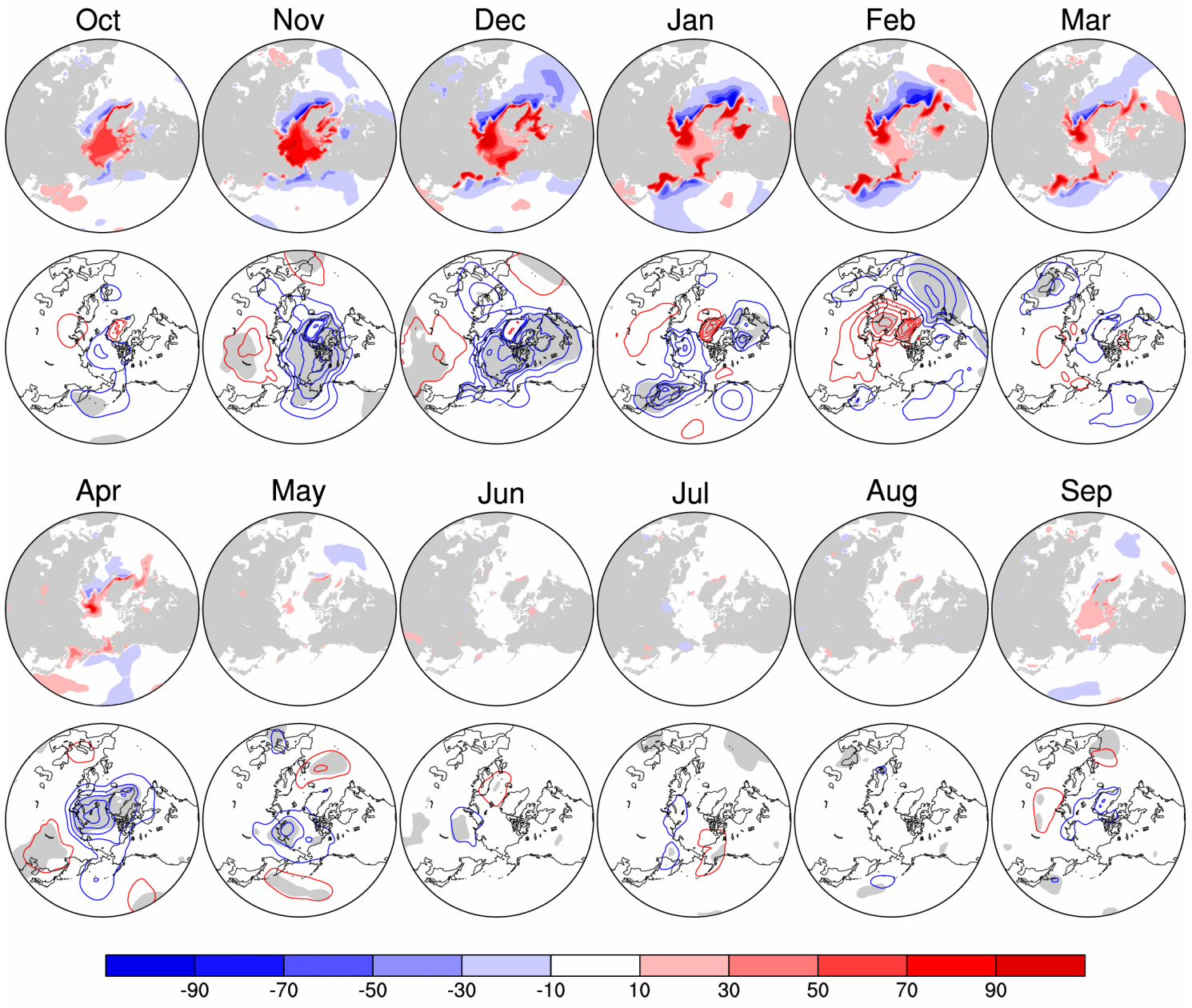


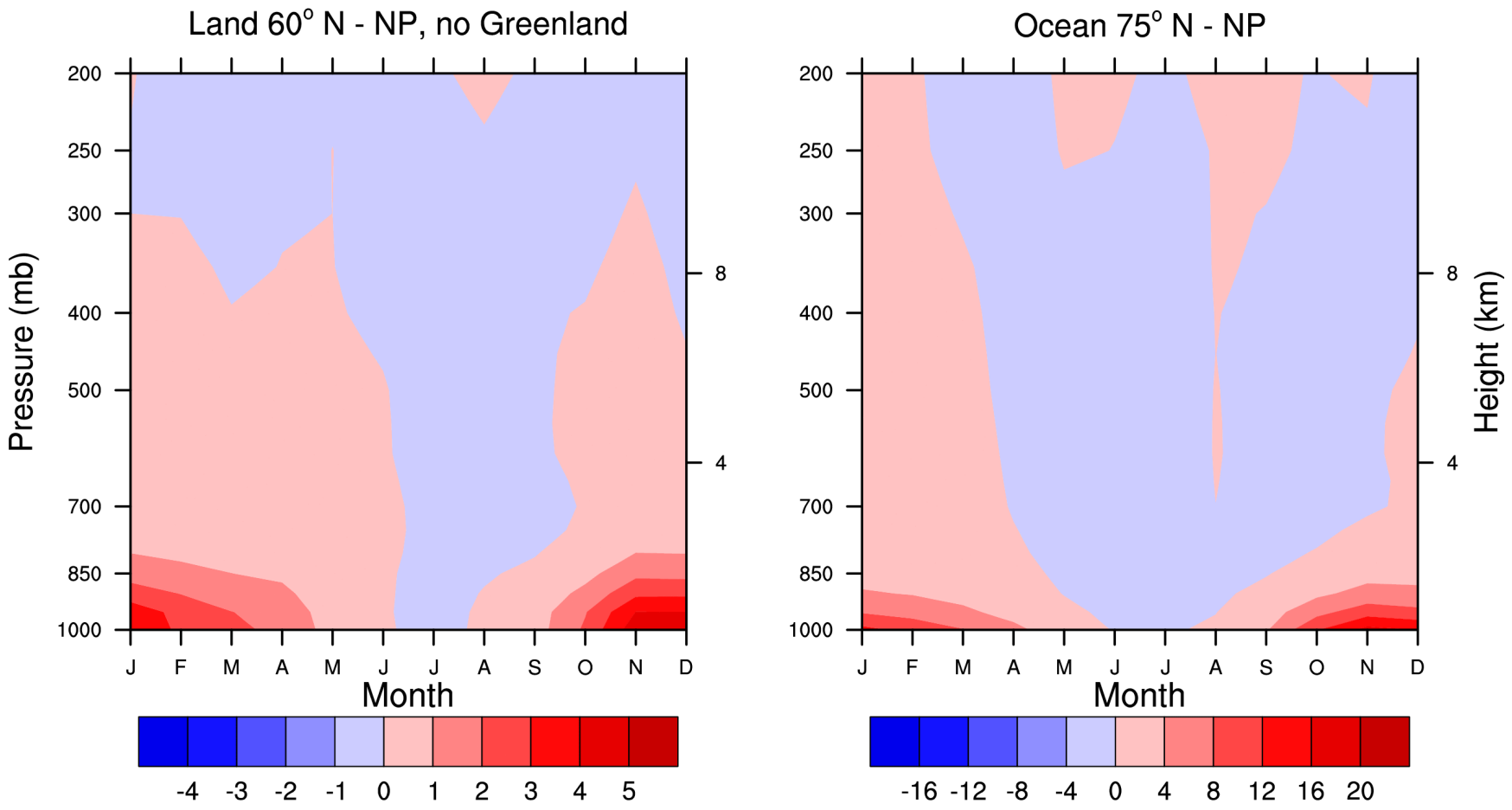
Summer 2007 Arctic Sea Ice Loss

September 2007 sea ice (white area)
vs. September long term mean (pink line)



2080-99 minus 1980-99




Land 60° N - NP, no Greenland
Pressure (mb)
200
250
300
400
500
700
850
1000
8
4
J F M A M J J A S O N D
Month
-4 -3 -2 -1 0 1 2 3 4 5
Ocean 75° N - NP
Height (km)
-16 -12 -8 -4 0 4 8 12 16 20

Surface Energy Flux Response (Wm^{-2})