

# High Latitude Climatic Response to Vegetation Change

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# High Latitude Vegetation

Long term focus:

Investigate effect of afforestation of marginal lands  
(as opposed to PFT replacements in DGVMs)

This first study:

Concentrate on the Arctic where climate change is  
happening the fastest

# High Latitude Vegetation

experiment = all ice free bare ground assigned to Broad Leaf Deciduous Temperate (BLD)

control = present day PFT distribution

both use:

cam 3.4.0 = cam 3.0 + clm 3.5

CASA'

and either:

som = slab ocean & thermodynamic sea ice

fixed SST = fixed SST and sea ice

run for 30 years, results averaged over 20 years

plots show July mean

# Boundary Conditions

## Fixed SST

no ocean and ice feedback

forcing

+ land-atmosphere feedback

## Slab Ocean

ocean and sea ice feedback  
allowed

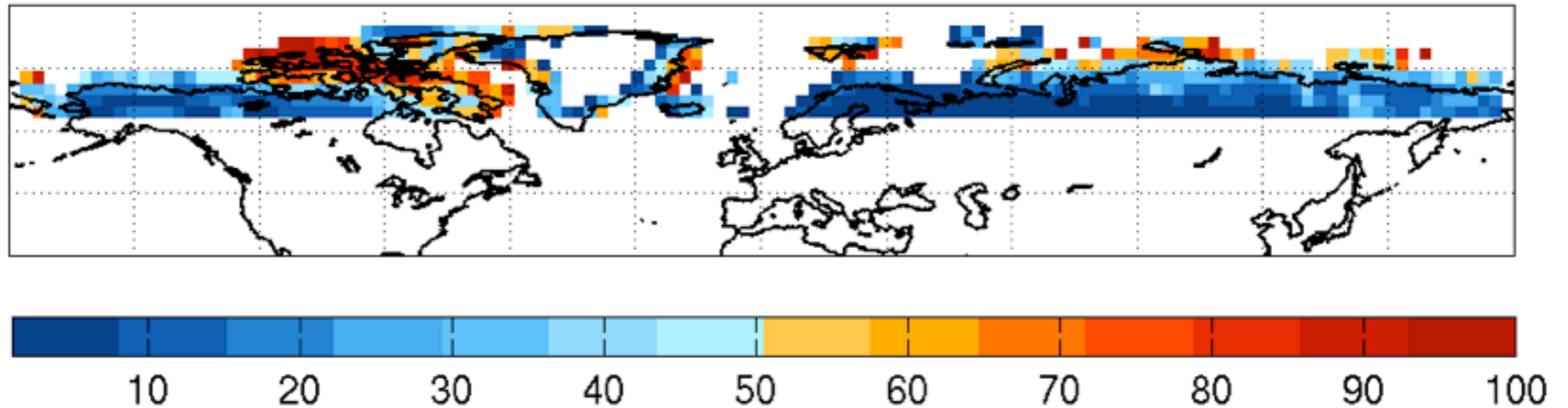
forcing

+ land-atmosphere feedback

+ sea ice and ocean feedback

# Ice free Bare Ground $\Rightarrow$ Broad Leaf Decid. Trees

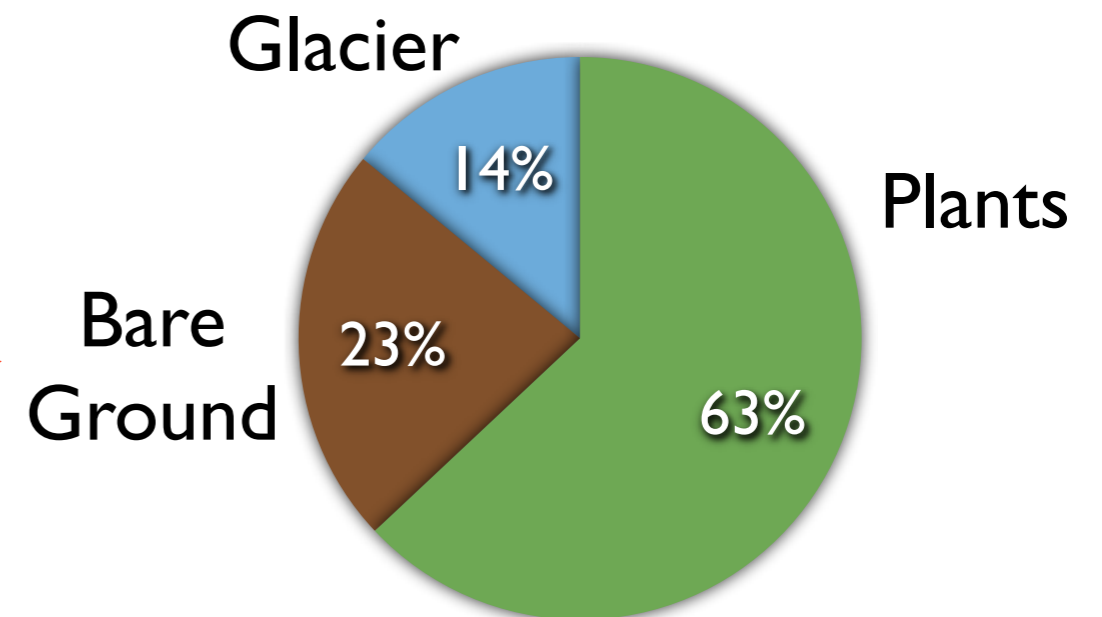
Fraction of land converted to BLD Trees



Total land area north of 60 deg  
 $= 17.5 \times 10^6 \text{ km}^2$

Area Converted to BLD Trees  
 $= 4 \times 10^6 \text{ km}^2$

Land Area North of 60 deg



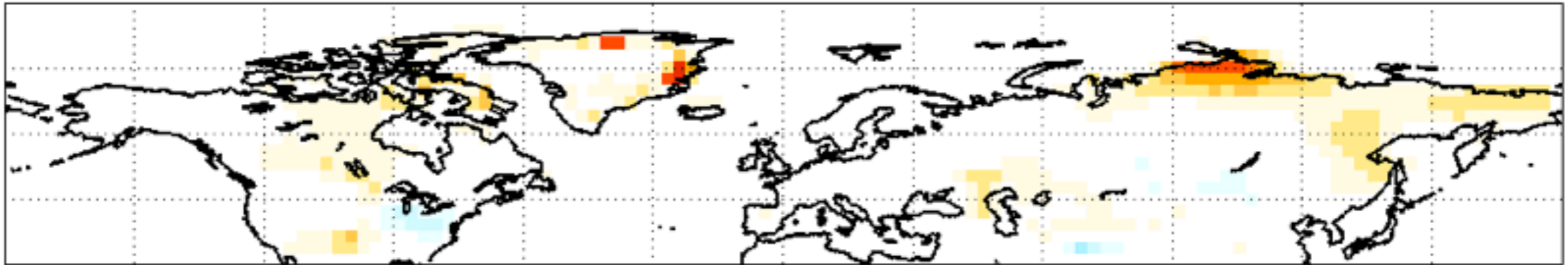
# Climate Response

# Surface Temperature Anomaly

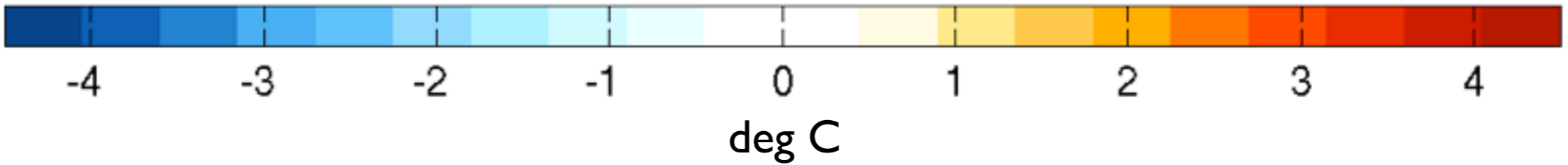
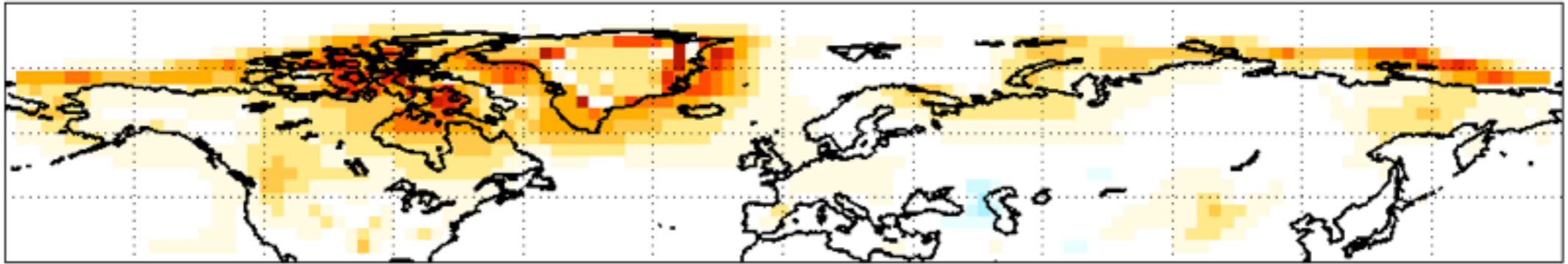
July

TS

Fixed SST



Slab Ocean



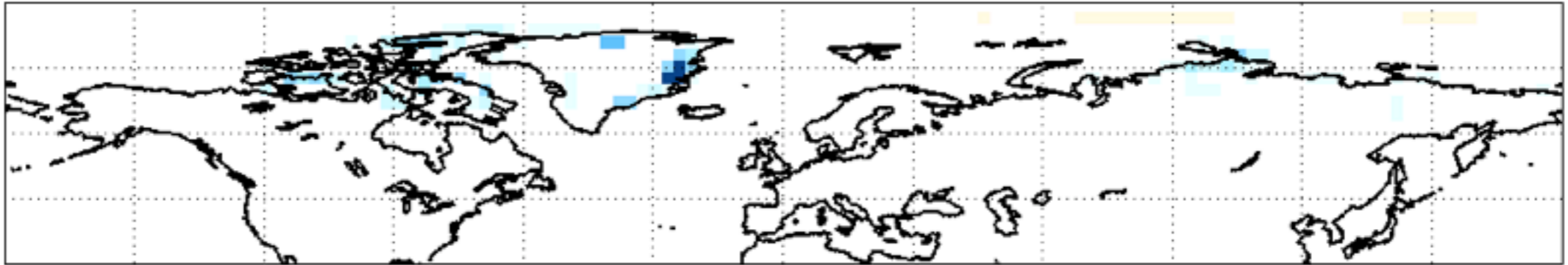
Widespread Temperature Increases across the Arctic

# Albedo Anomaly

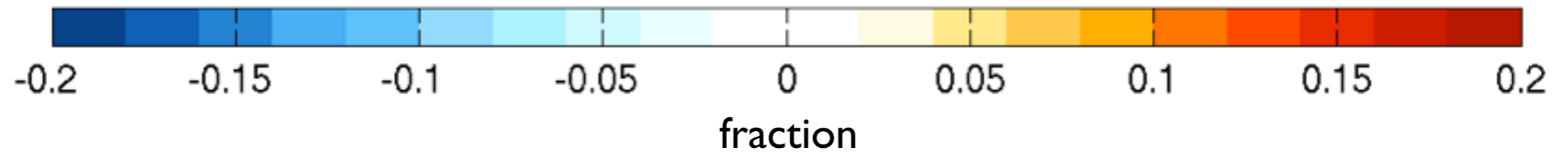
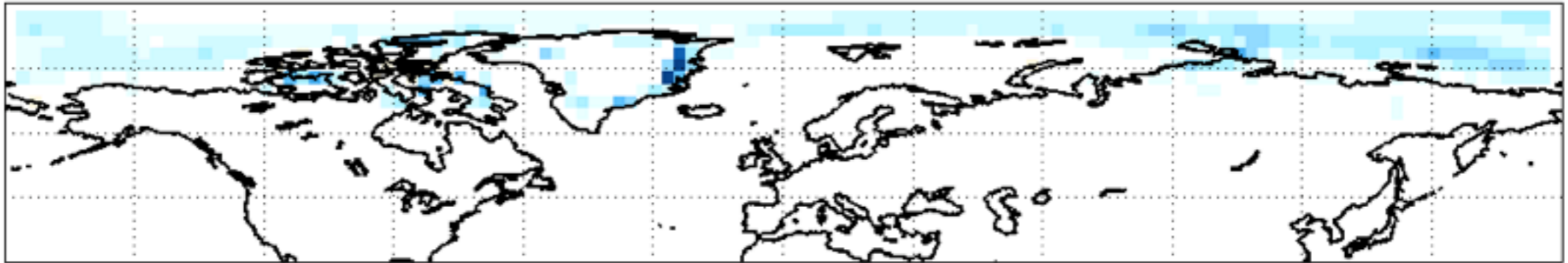
July

ALBEDO

Fixed SST



Slab Ocean

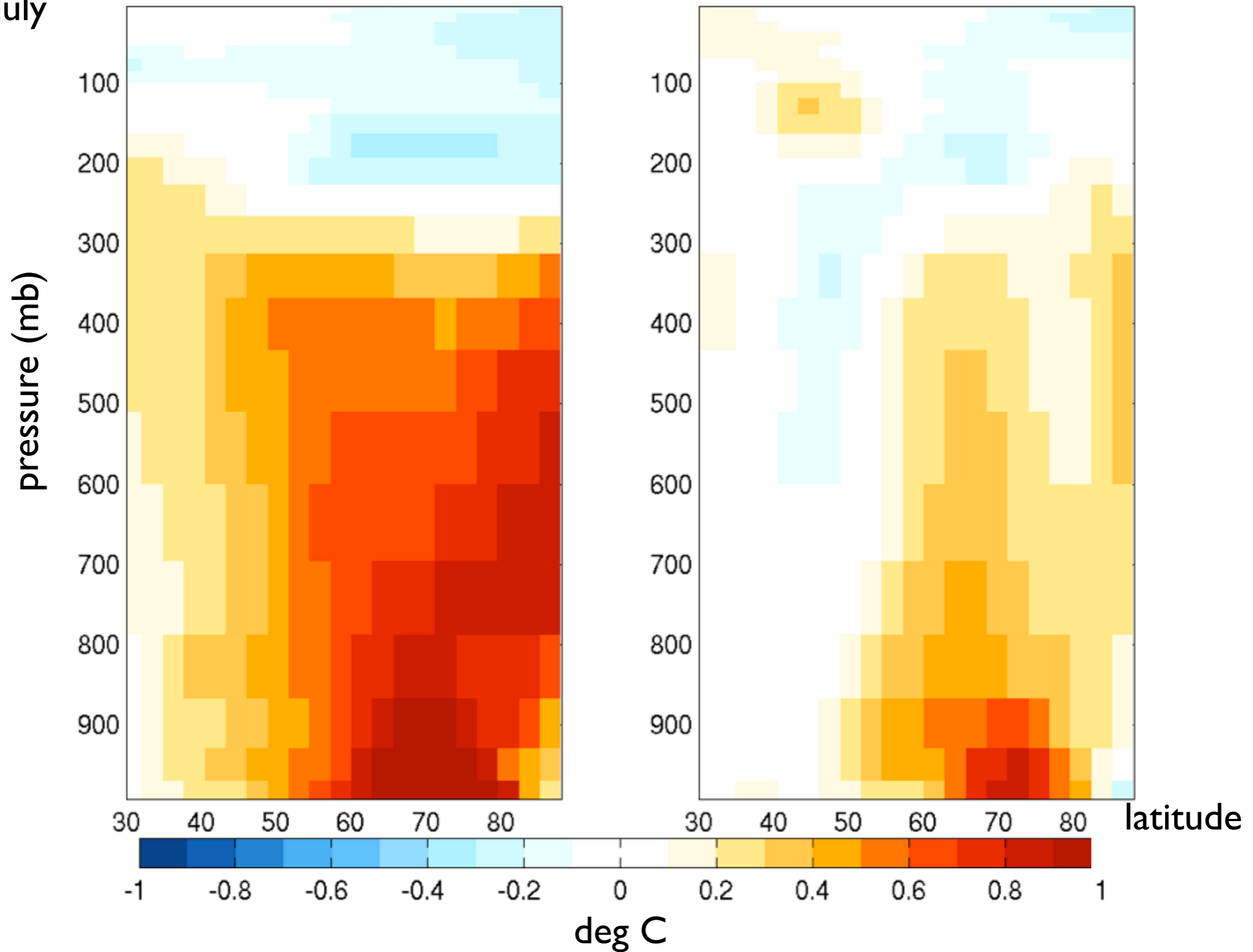


Albedo anomaly over land is negative in March-May by 0.2 in both fixed SST and Slab Ocean cases



# Vertical Temperature Anomaly Profile

July



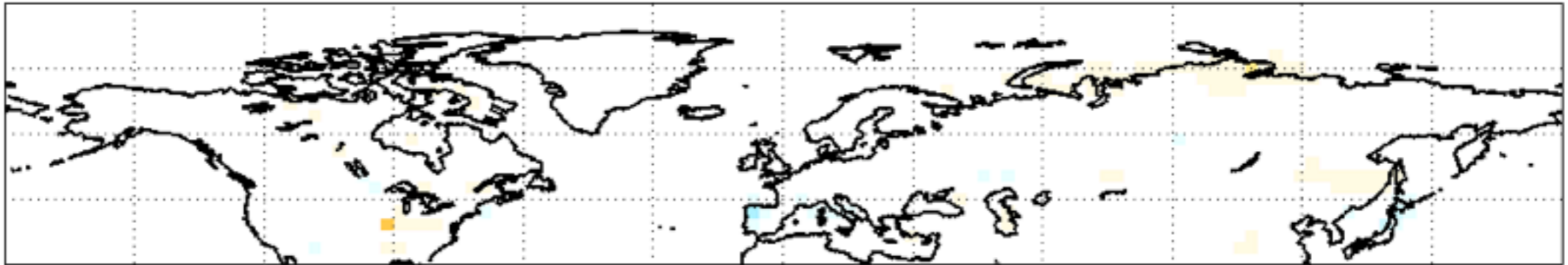
warming at height looks like greenhouse effect

# Transpiration Anomaly

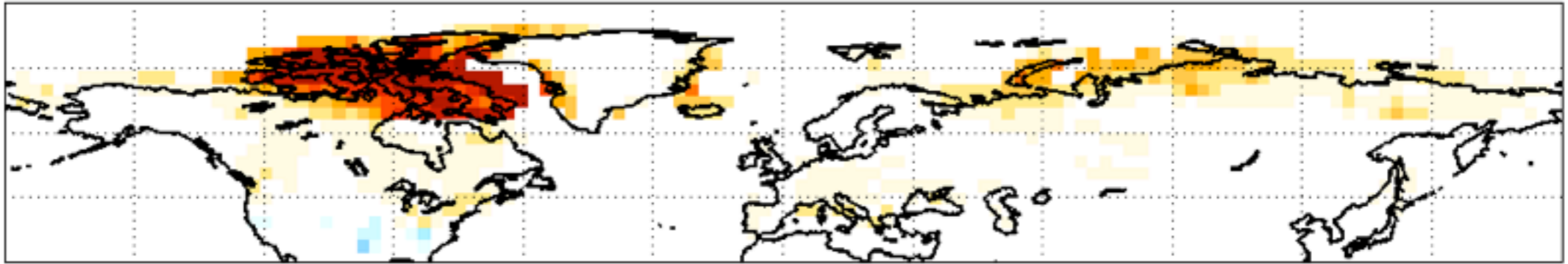
July

FCTR

Fixed SST



Slab Ocean



-30

-20

-10

0

10

20

30

W/m<sup>2</sup>

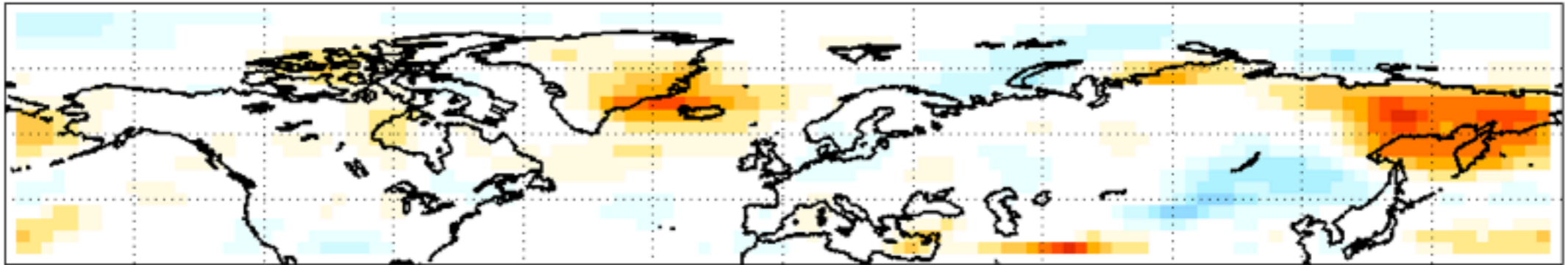
Source of water vapor to the atmosphere

# Column Water Vapor Anomaly

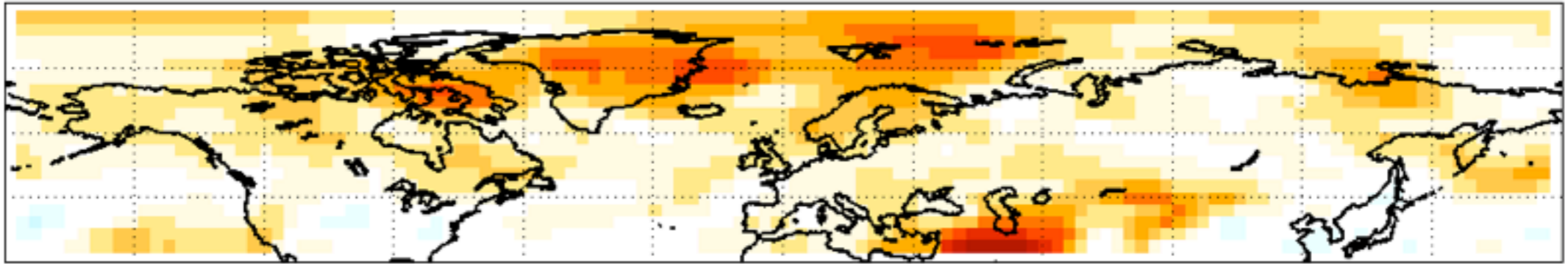
July

TMQ

Fixed SST



Slab Ocean



-0.2

-0.15

-0.1

-0.05

0

0.05

0.1

0.15

0.2

fraction

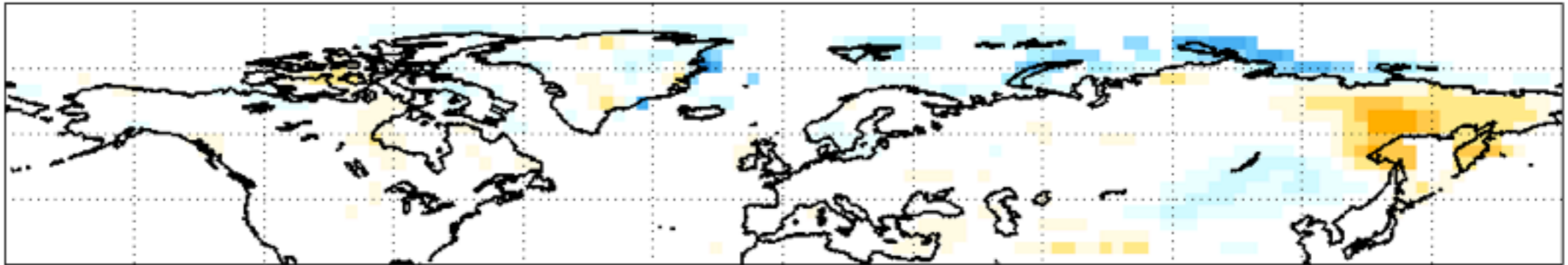
Increased column water vapor  $\Rightarrow$  greenhouse effect

# Long Wave Downwelling Anomaly

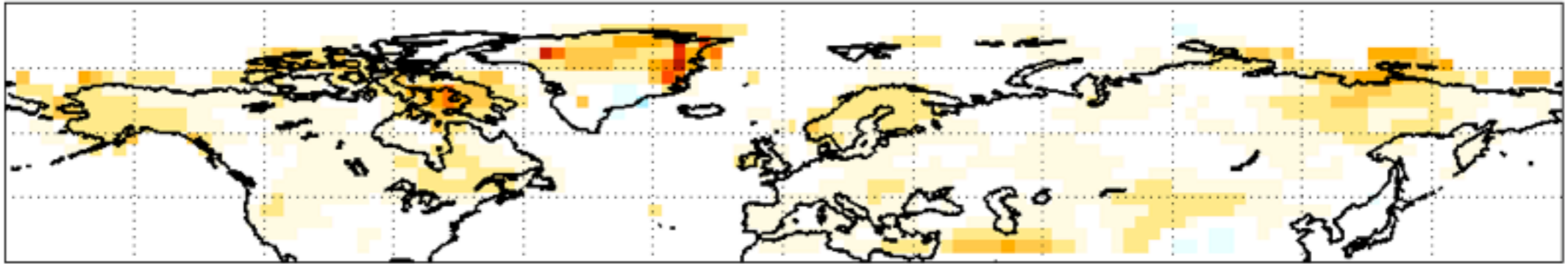
July

FLDS

Fixed SST



Slab Ocean



-25

-20

-15

-10

-5

0

5

10

15

20

25

W/m<sup>2</sup>

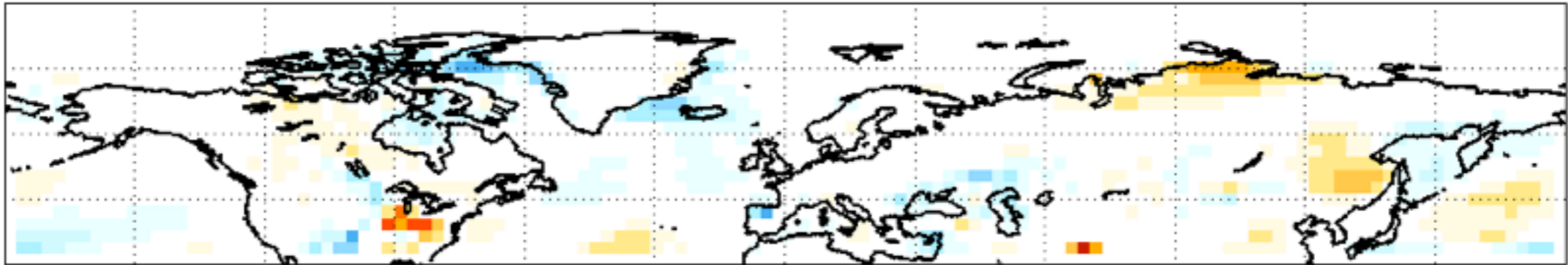
warming at the surface is forced from the atmosphere

# Surface Latent Heat Flux Anomaly

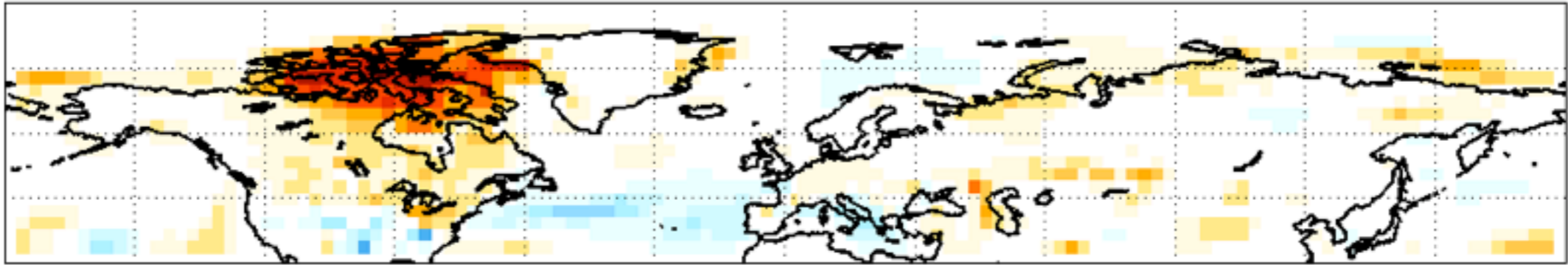
July

LHFLX

Fixed SST



Slab Ocean



-30

-20

-10

0

10

20

30

W/m<sup>2</sup>

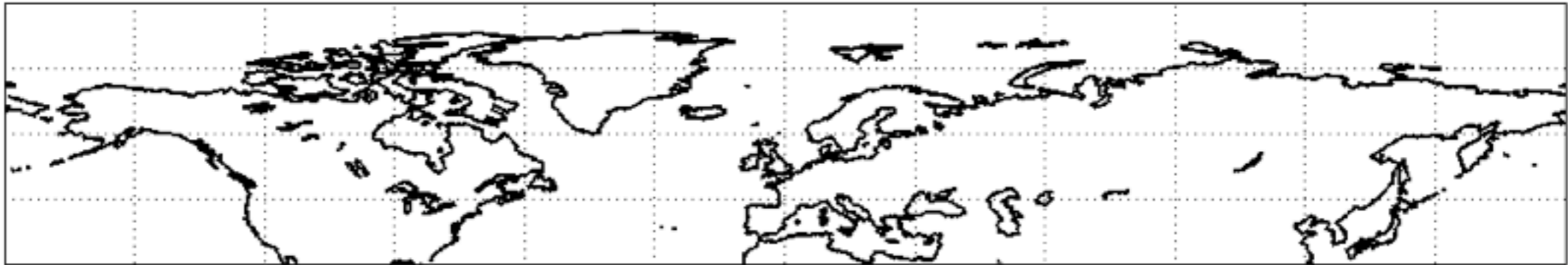
Some evaporation from the ocean but most is coming from transpiration

# Ice Fraction Anomaly

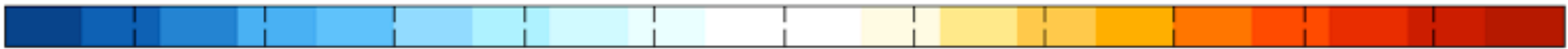
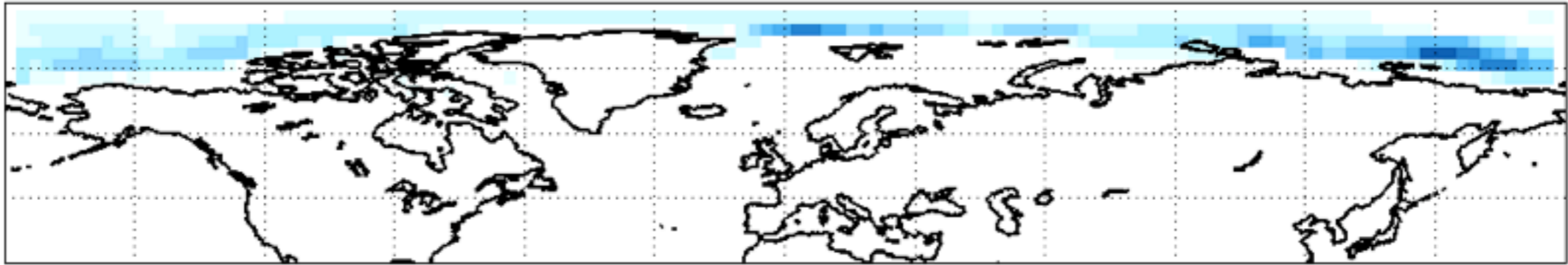
July

ICEFRAC

Fixed SST



Slab Ocean



-0.25 -0.2 -0.15 -0.1 -0.05 0 0.05 0.1 0.15 0.2 0.25  
fraction

Widespread ice melting  
more than 30% in August and Sept

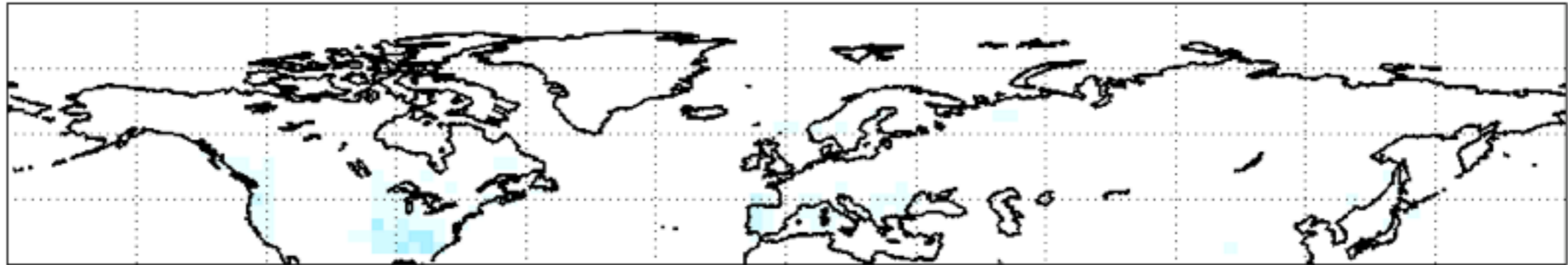
# Carbon Cycle Response

# Annual Mean Soil Respiration Anomaly

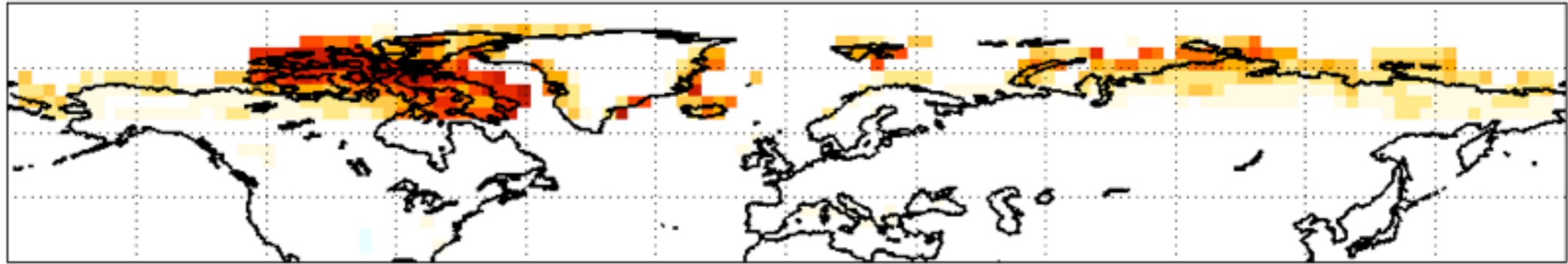
Annual Mean

RESP\_C (soil pools)

Fixed SST



Slab Ocean



-50

-40

-30

-20

-10

0

10

20

30

40

50

gC/m<sup>2</sup>/yr

total flux = 0.16 Pg C/yr  
overpowered by increased productivity

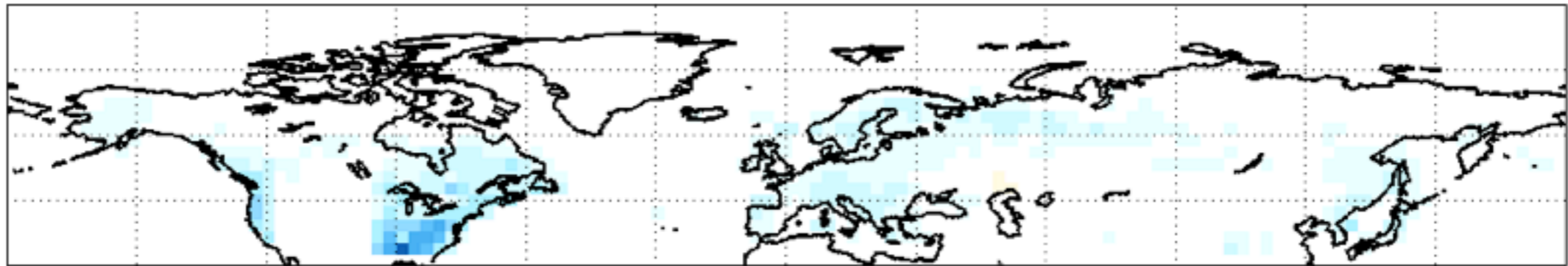


# Annual Mean Net Carbon Flux Anomaly

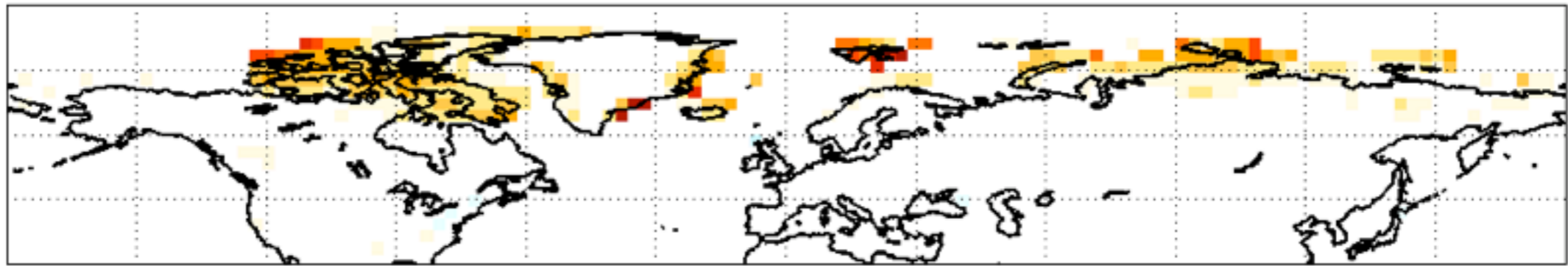
Annual Mean

CO2FLUX

Fixed SST



Slab Ocean



-200

-150

-100

-50

0

50

100

150

200

gC/m2/yr

Small carbon sink = 0.3Pg C/yr

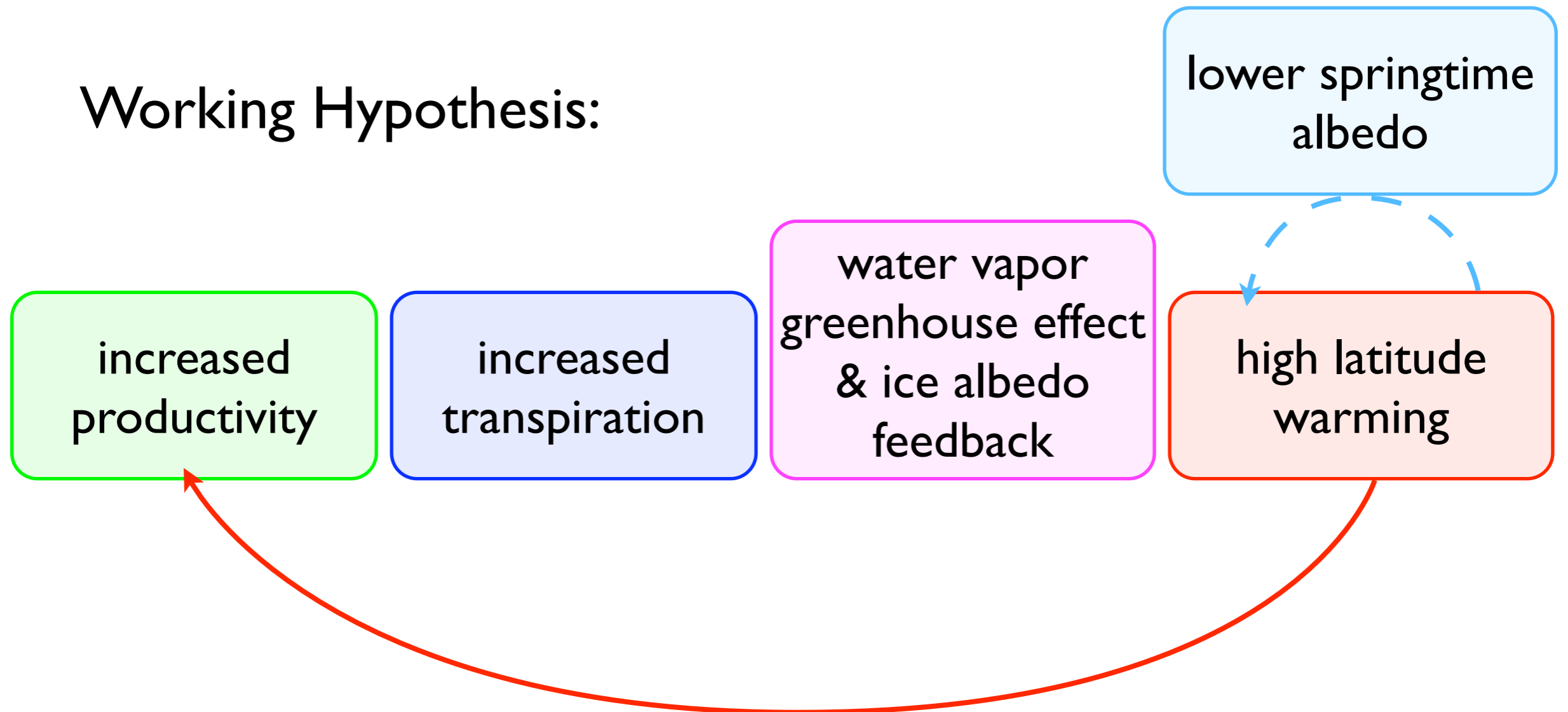
# High Latitude Vegetation Change

## Initial Observations:

high northern latitude temperature increases  $>4$  deg C

land albedo not effected by additional warming with interactive sea ice

## Working Hypothesis:



# Next Questions:

Is there a PFT dependent transpiration threshold for triggering ice albedo feedback?

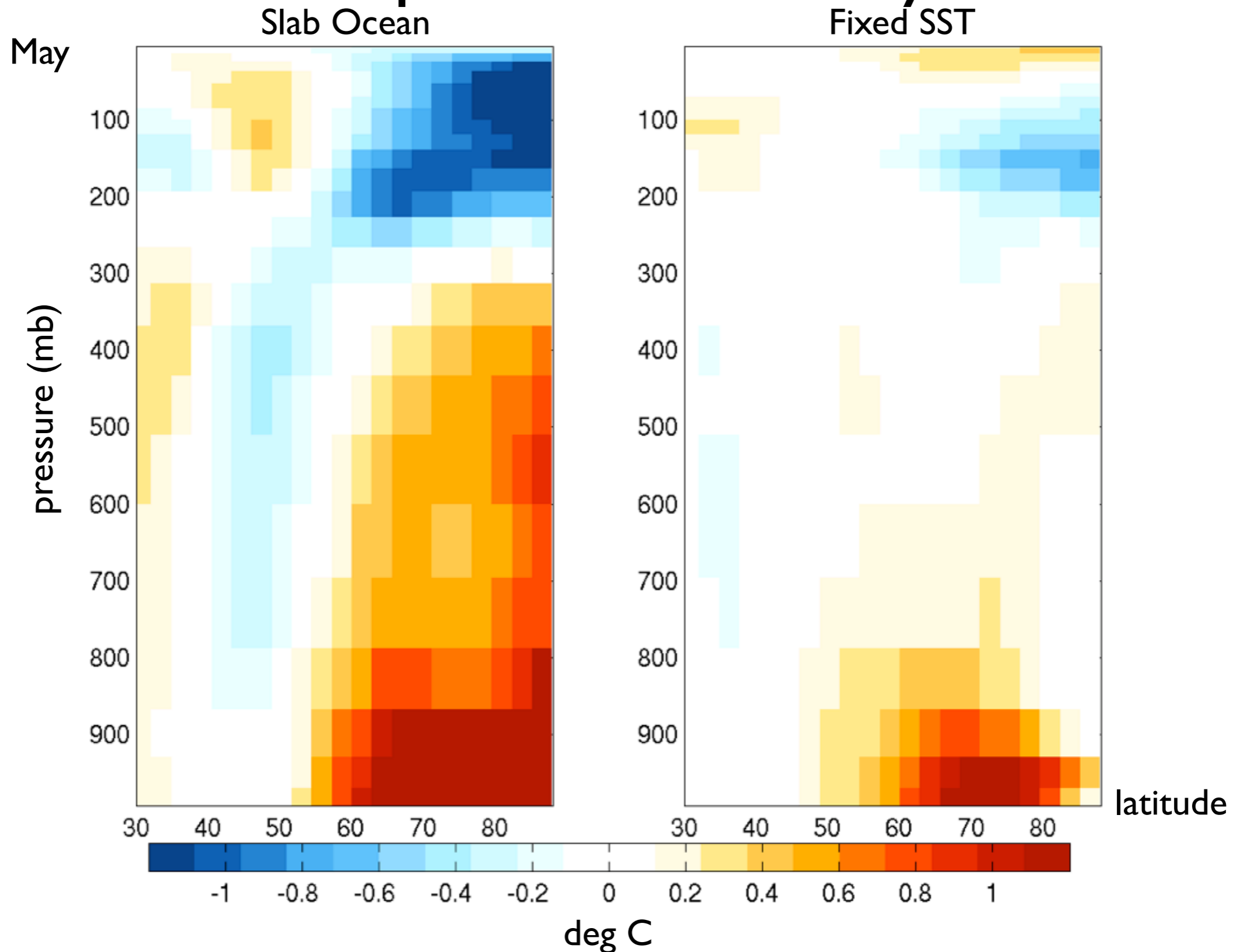
How does the competition between feedbacks play out at other latitudes?

sensible vs. latent heat partitioning

short wave vs. long wave

end

# Vertical Temperature Anomaly Profile



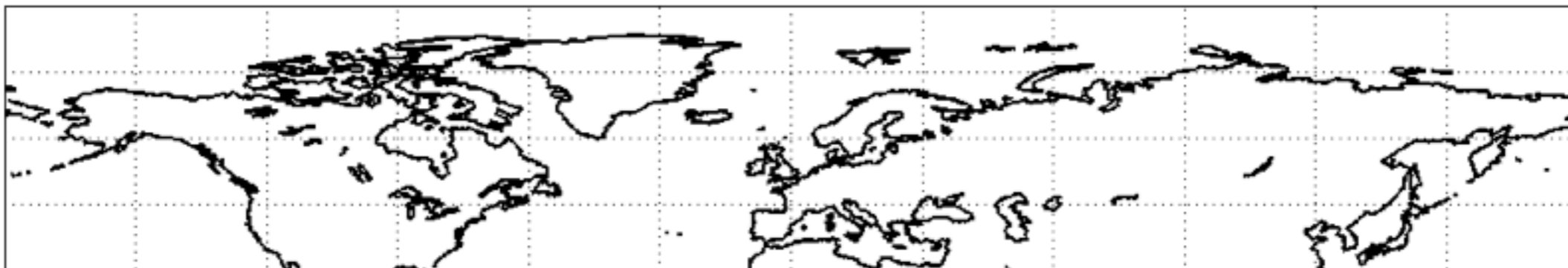
looks like greenhouse effect

# Ice Fraction (september)

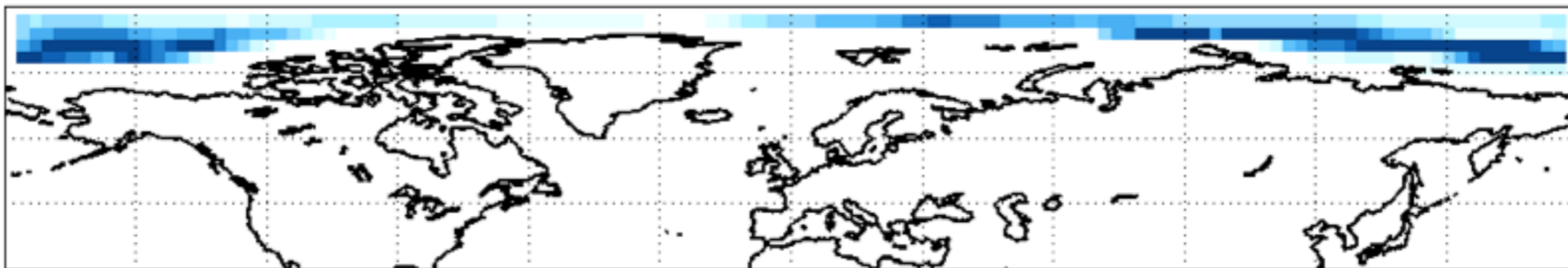
September

ICEFRAC

Fixed SST



Slab Ocean



-0.25 -0.2 -0.15 -0.1 -0.05 0 0.05 0.1 0.15 0.2 0.25

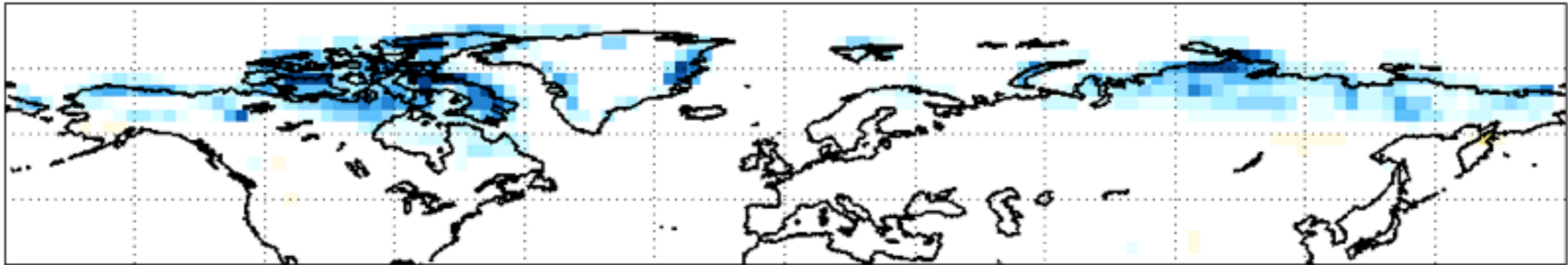
fraction

# Albedo Anomaly

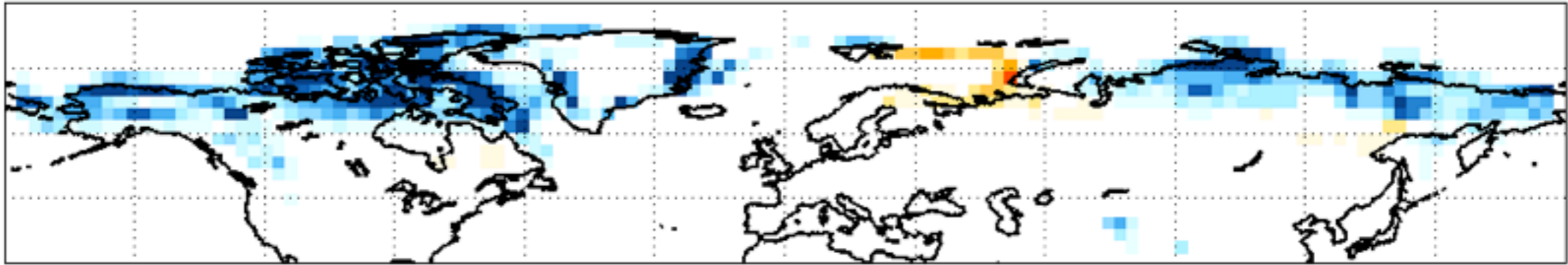
April

ALBEDO

Fixed SST



Slab Ocean



-0.2

-0.15

-0.1

-0.05

0

0.05

0.1

0.15

0.2

fraction

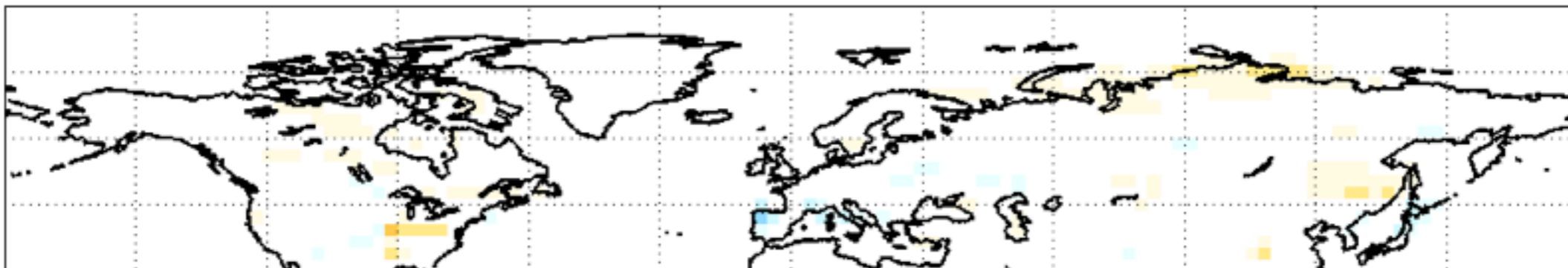
Land albedo is similar for both fixed and som  
not participating in feedback

# Transpiration

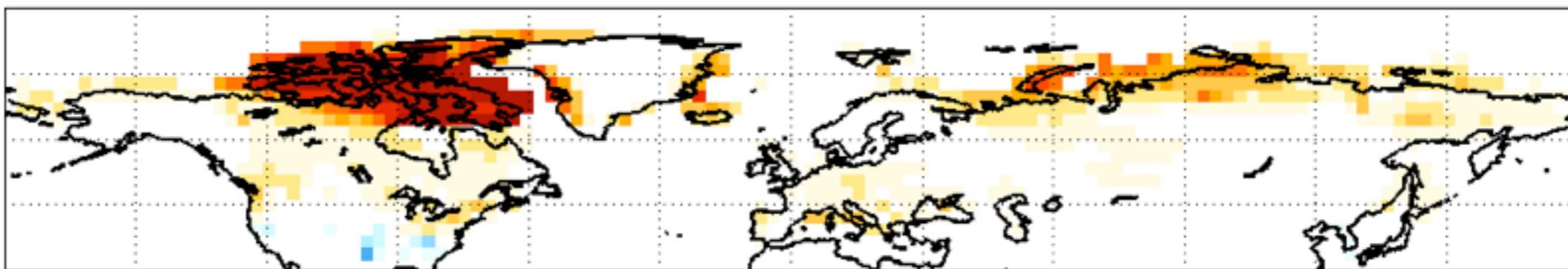
July

QVEGT

Fixed SST



Slab Ocean



-300

-200

-100

0

100

200

300

mm/yr