

# 21st Century Polar Climate Response in CCSM4

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# Overview

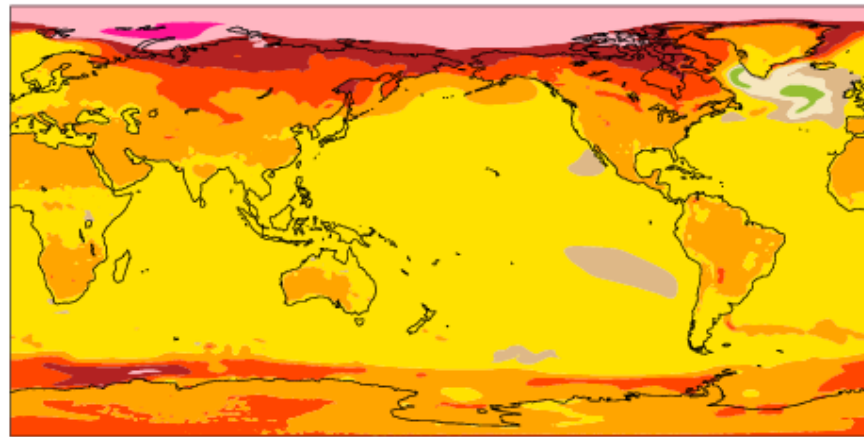
- Arctic and Antarctic changes
- Late 21st century (2080-2099) vs. Late 20th c (1980-1999), one ensemble member from each time period
- RCPs (Representative Concentration Pathways) instead of SRES emissions scenarios: **RCP8.5** (~A1F1), RCP4.5 (~B1)
- \* Surface temp., Precipitation, SLP, Clouds, Sea ice, Ocean



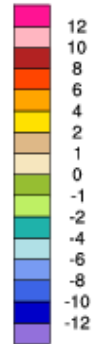
# RCP8.5

b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

mean = 3.64      rmse = 4.05      K



Min = -0.97 Max = 13.69



# Annual Change in Surface Temperature (late 21st c)

*Polar Amplification:*

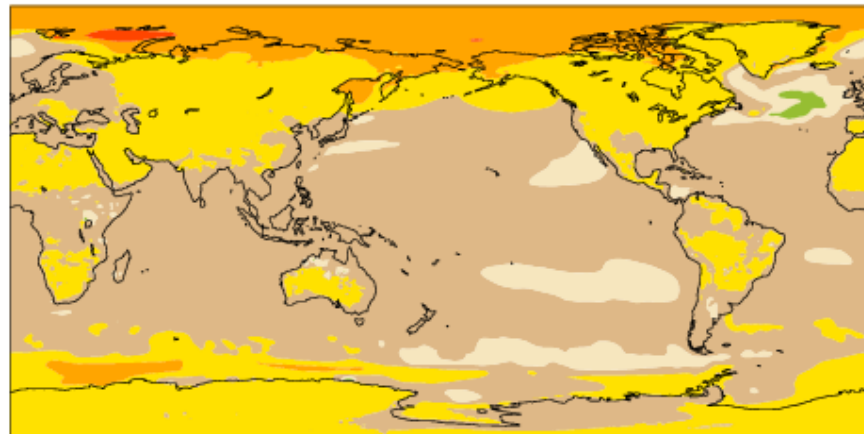
*~ 2.5 Arctic,*

*~ 1.5 Antarctic*

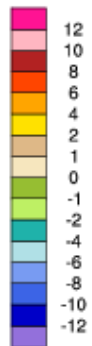
# RCP4.5

b40.rcp4\_5.1deg.001 - b40.20th.track1.1deg.005

mean = 1.73      rmse = 1.93      K



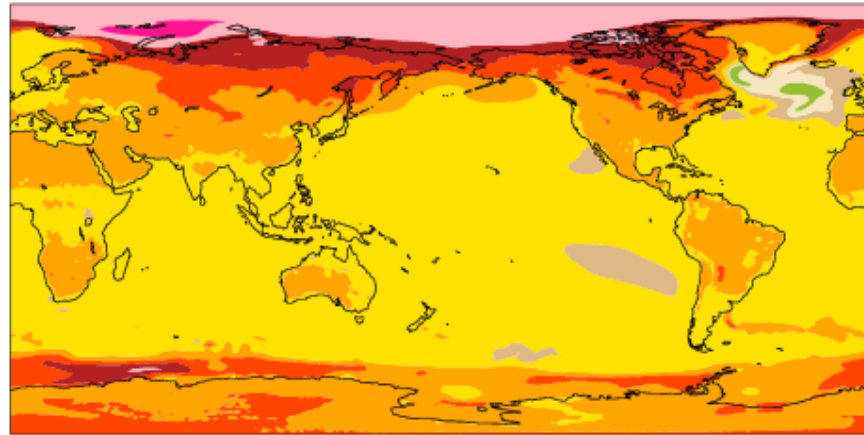
Min = -0.92 Max = 6.80



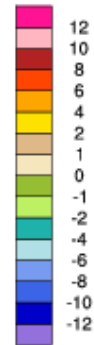
# RCP8.5

b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

mean = 3.64      rmse = 4.05      K



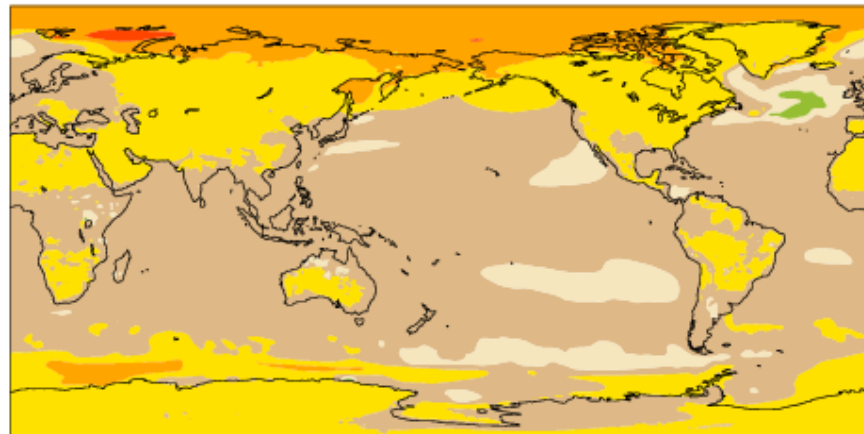
Min = -0.97 Max = 13.69



# RCP4.5

b40.rcp4\_5.1deg.001 - b40.20th.track1.1deg.005

mean = 1.73      rmse = 1.93      K



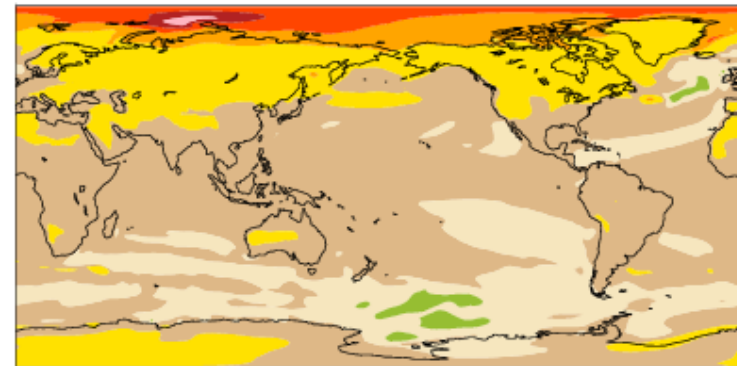
Min = -0.92 Max = 6.80



# CCSM3 B1

b30.041a - b30.030a

mean = 1.49      rmse = 1.74      K



Min = -0.81 Max = 11.24

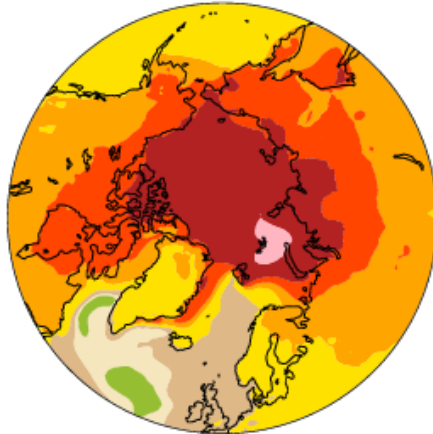


# Annual

b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

Surf Temp (radiative)

K



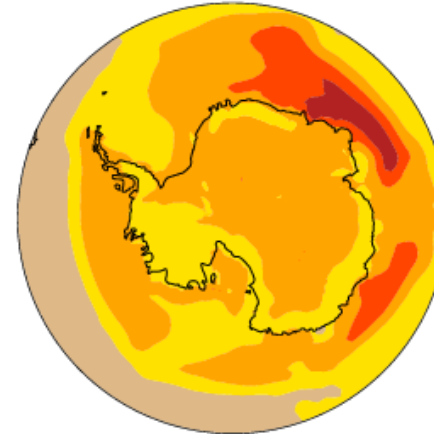
MIN = -0.97 MAX = 13.69



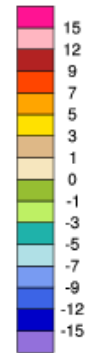
b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

Surf Temp (radiative)

K



MIN = 1.71 MAX = 10.29

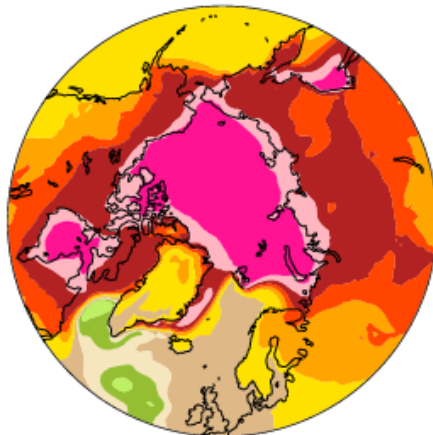


# Winter

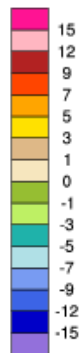
b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

Surf Temp (radiative)

K



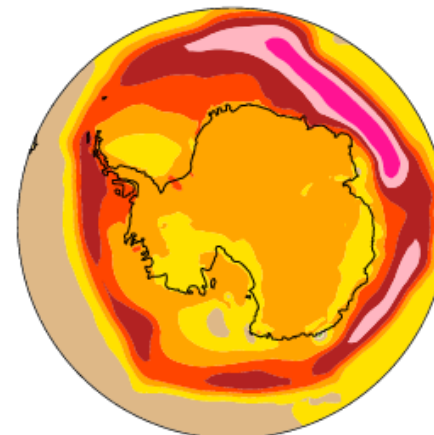
MIN = -2.43 MAX = 24.03



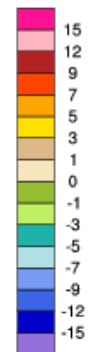
b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

Surf Temp (radiative)

K



MIN = -0.69 MAX = 18.18



# ANN

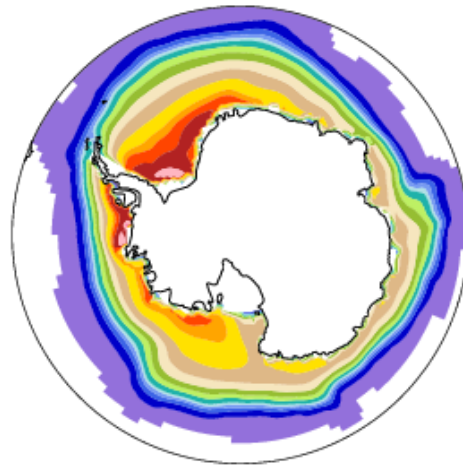
b40.rcp8\_5.1deg.001 (yrs 2080-2099) b40.20th.track1.1deg.005 (yrs 1980-1999)

Sea ice concentration

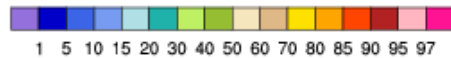
% Sea ice concentration

%

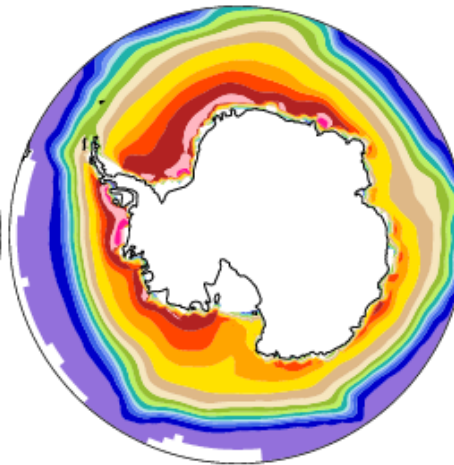
Late 21st Century



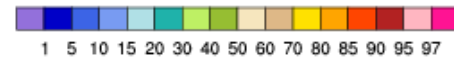
MEAN= 31.05 Min= 0.00 Max= 97.61



Late 20th Century



MEAN= 45.72 Min= 0.00 Max= 98.87

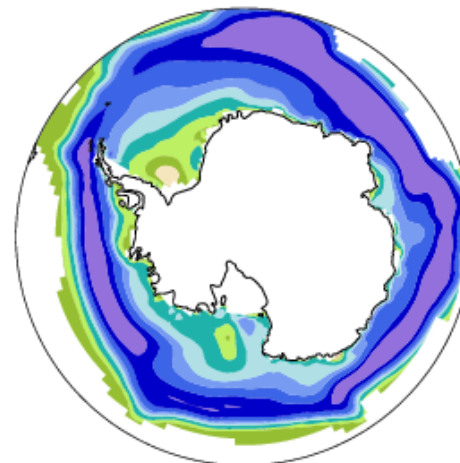


b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

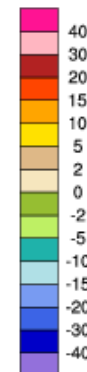
Sea ice concentration

%

Change



MIN = -62.69 MAX = 4.41



# ANN

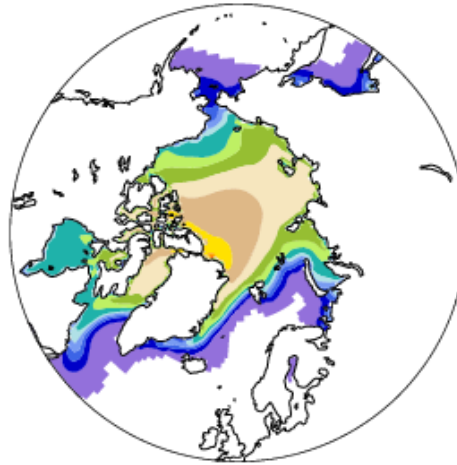
b40.rcp8\_5.1deg.001 (yrs 2080-2099) b40.20th.track1.1deg.005 (yrs 1980-1999)

Sea ice concentration

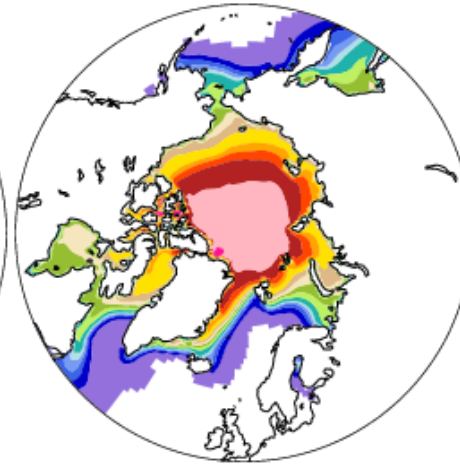
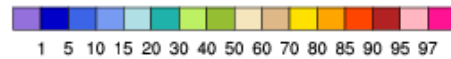
% Sea ice concentration

%

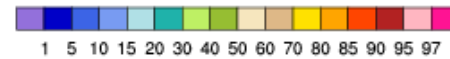
Late 21st Century



MEAN= 27.58 Min= 0.00 Max= 87.79



MEAN= 44.66 Min= 0.00 Max= 99.17



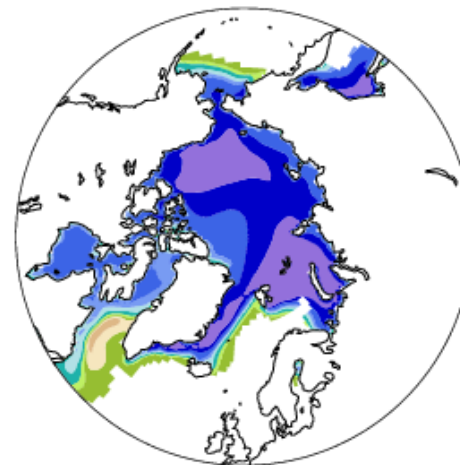
Late 20th Century

b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

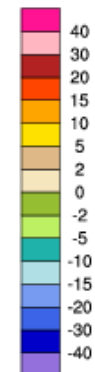
Sea ice concentration

%

Change

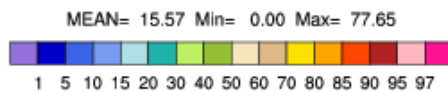
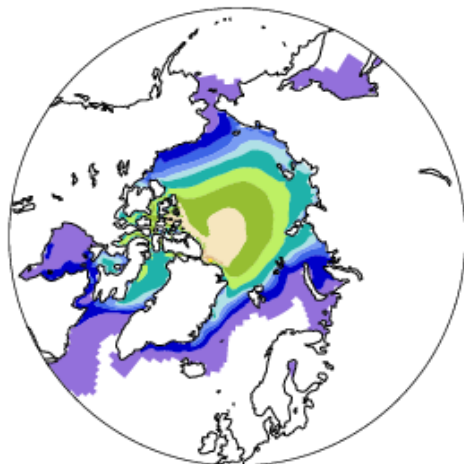


MIN = -75.93 MAX = 4.82

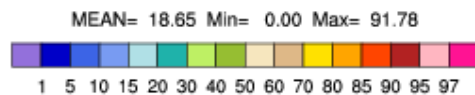
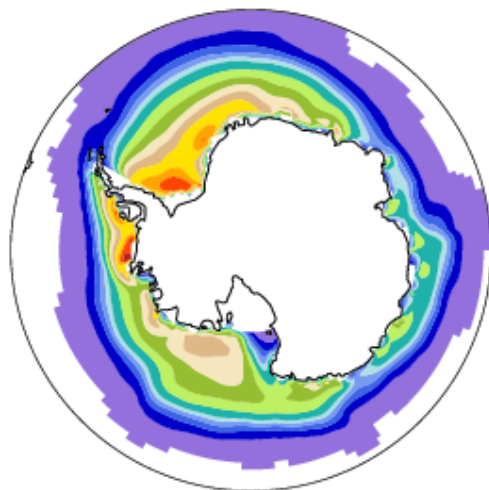


# Summer Sea Ice Concentration (Late 21st c)

Sea ice concentration %

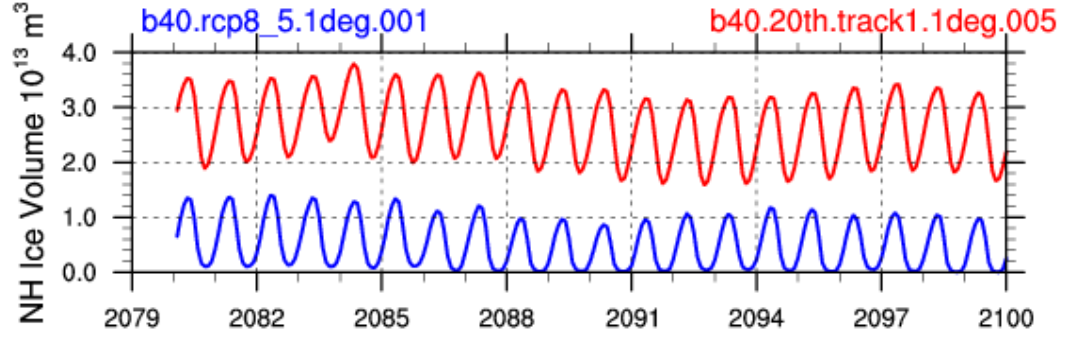
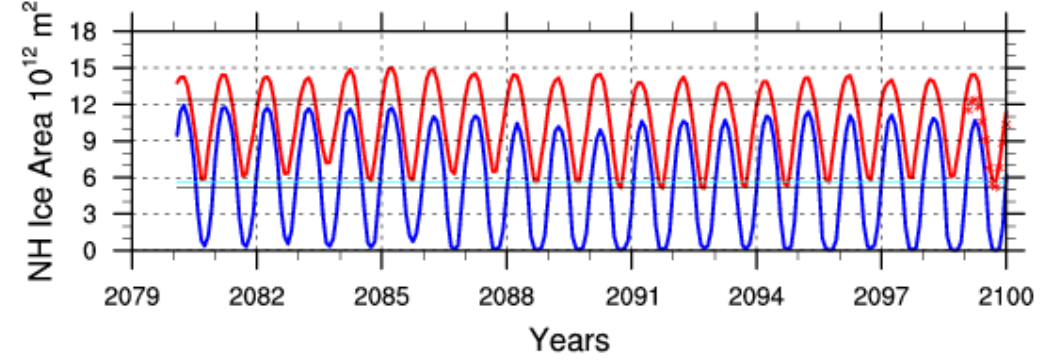
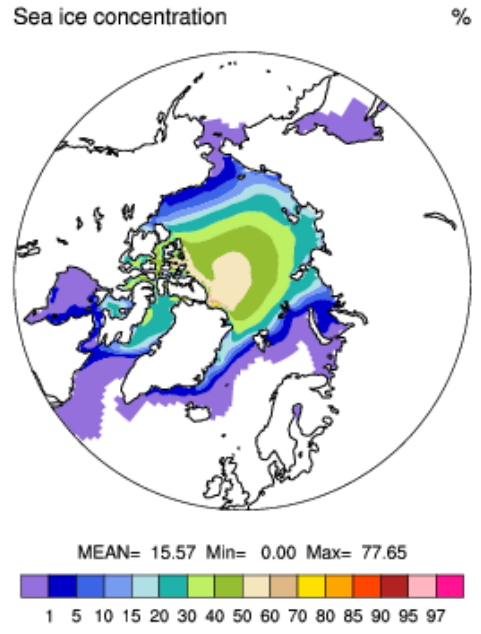


Sea ice concentration %



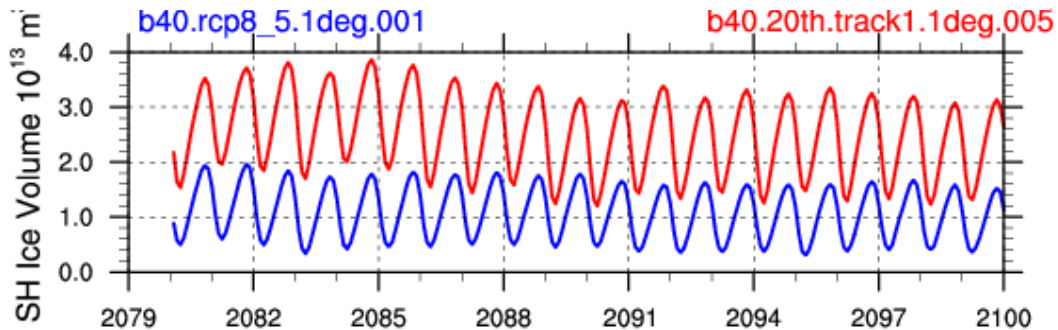
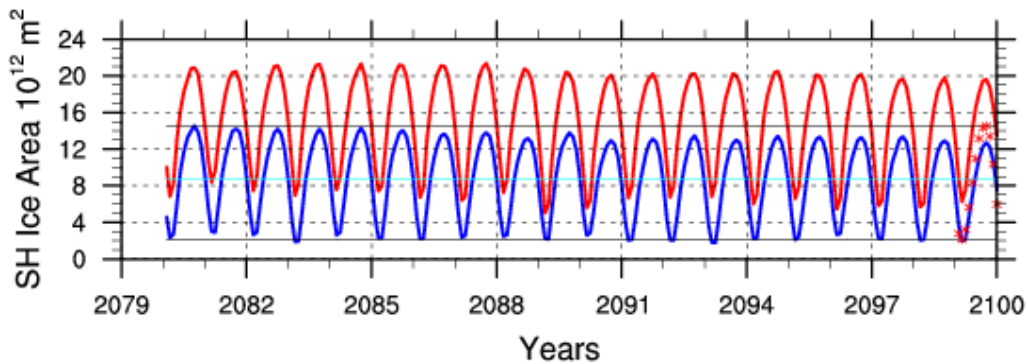
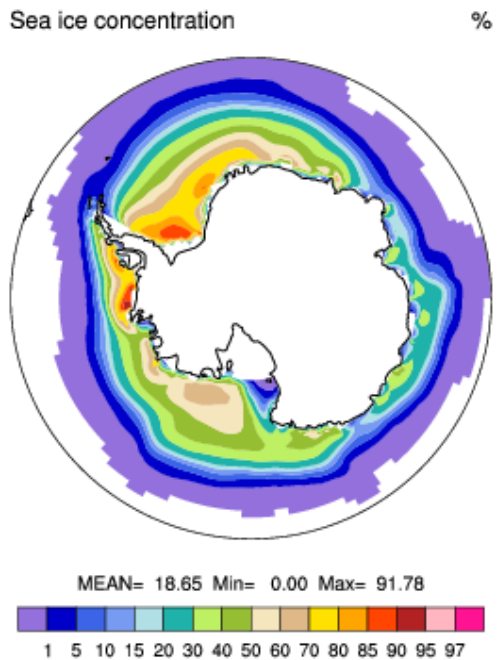


# Summer Sea Ice Concentration (Late 21st c)



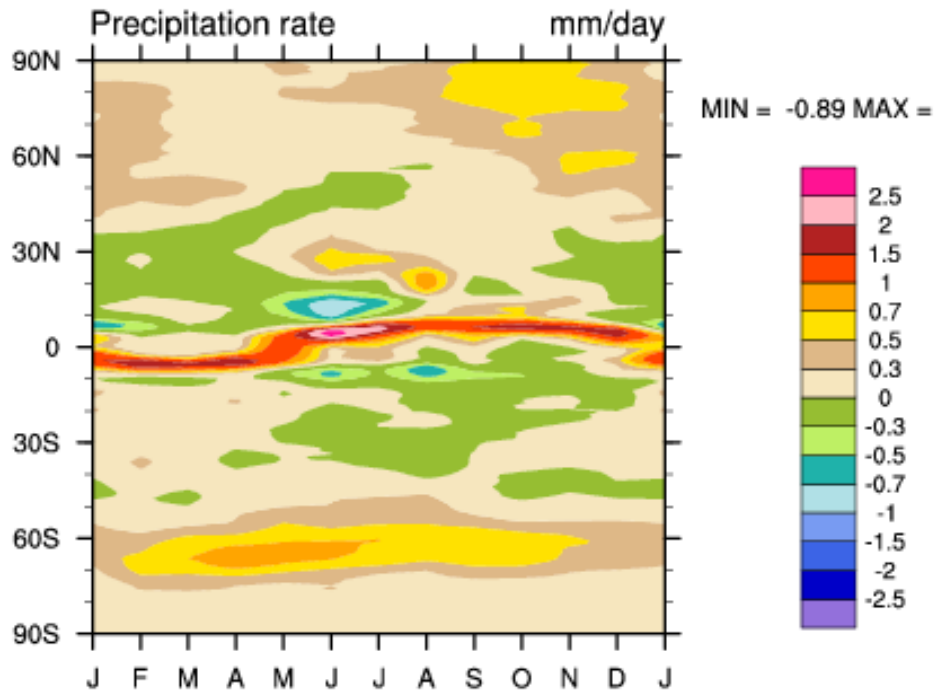
*Ice-free summers by late 21st century*

# Summer Sea Ice Concentration (Late 21st c)



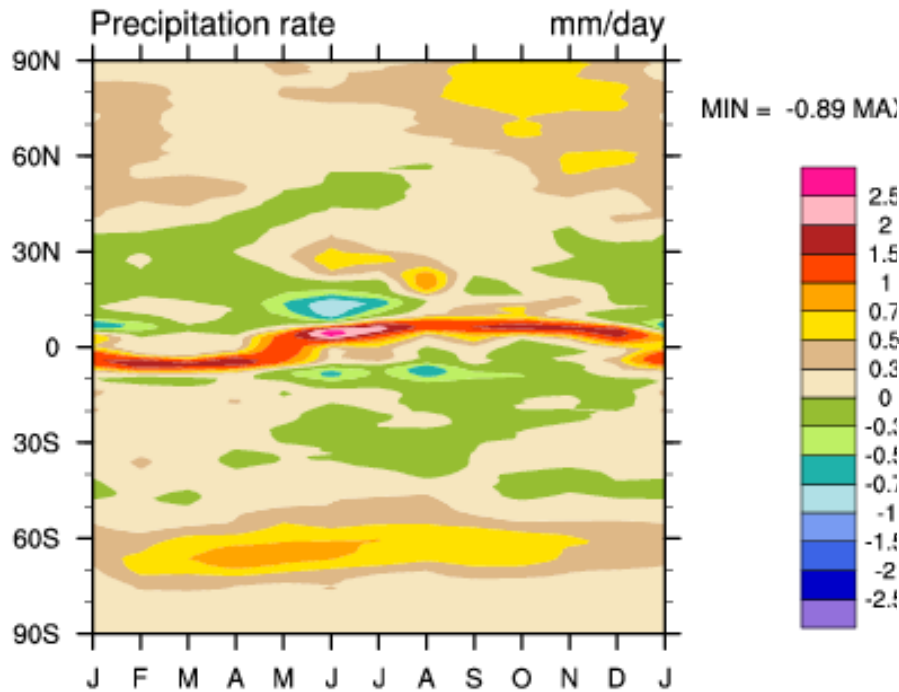
# Change in Precipitation (late 21st c)

b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005

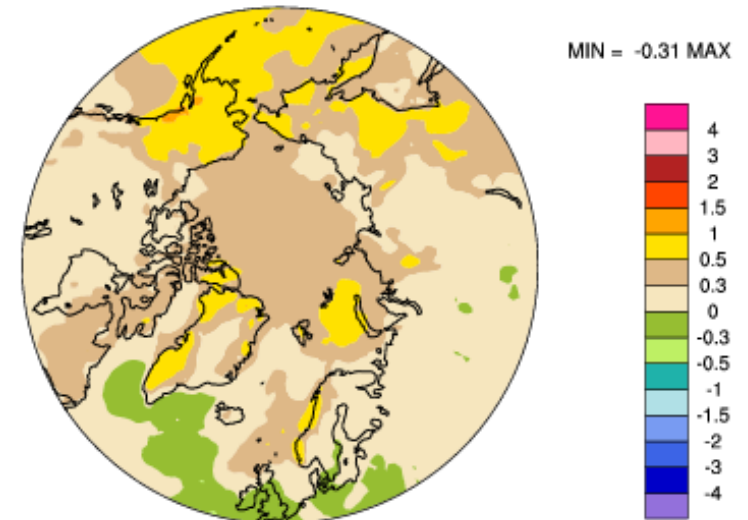


# Change in Precipitation (late 21st c)

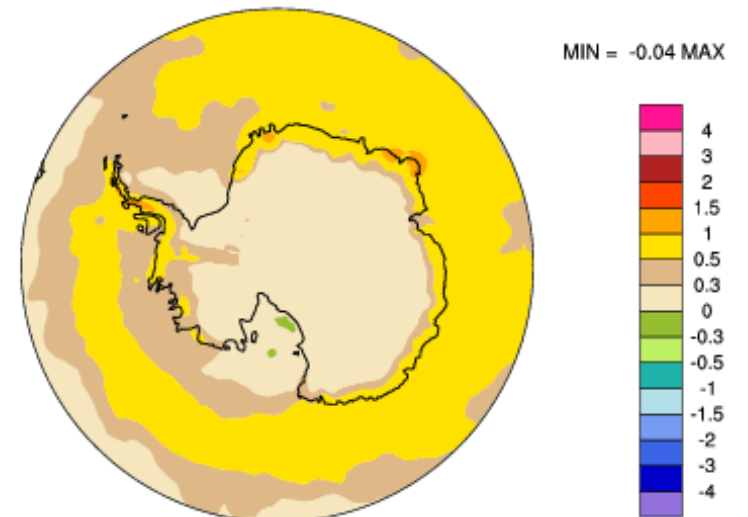
b40.rcp8\_5.1deg.001 - b40.20th.track1.1deg.005



Precipitation rate mm/day



Precipitation rate mm/day

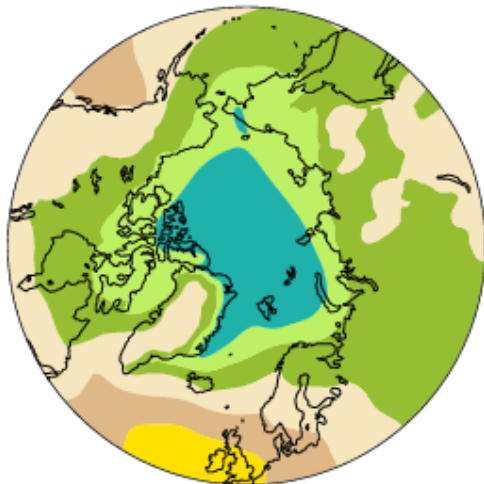


# Change in Sea Level Pressure (late 21st c)

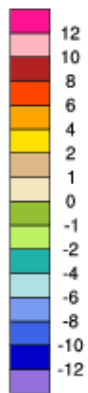
Annual

Sea-level pressure

millibars



MIN = -3.39 MAX = 2.84



Sea-level pressure

millibars



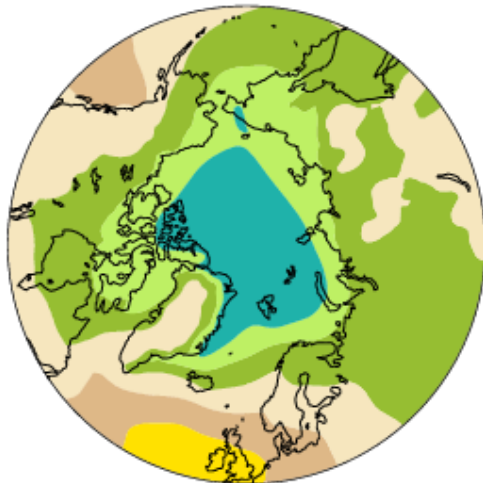
MIN = -3.05 MAX = 3.88



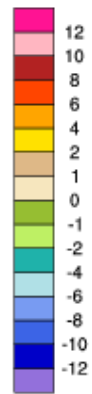
# Change in Sea Level Pressure (late 21st c)

Annual

Sea-level pressure millibars

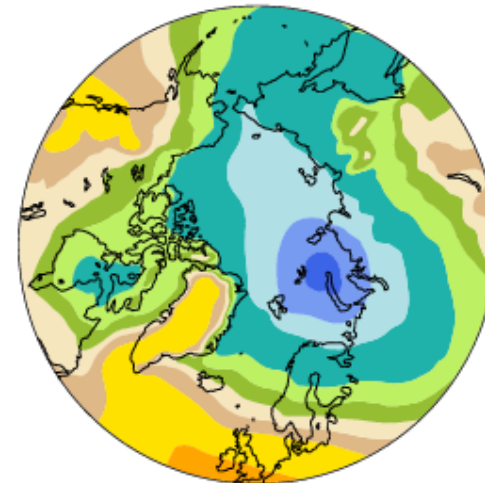


MIN = -3.39 MAX = 2.84



Winter

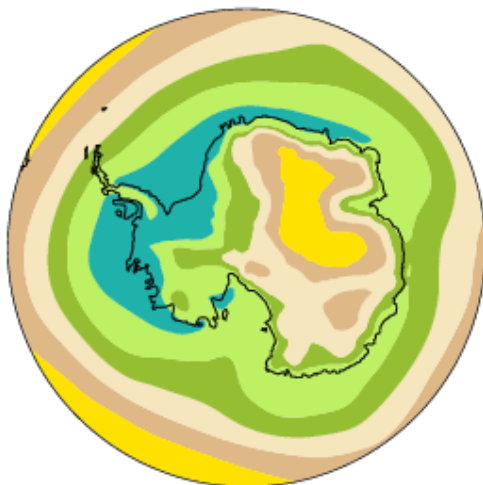
Sea-level pressure millibars



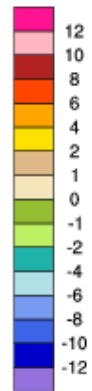
MIN = -8.67 MAX = 4.63



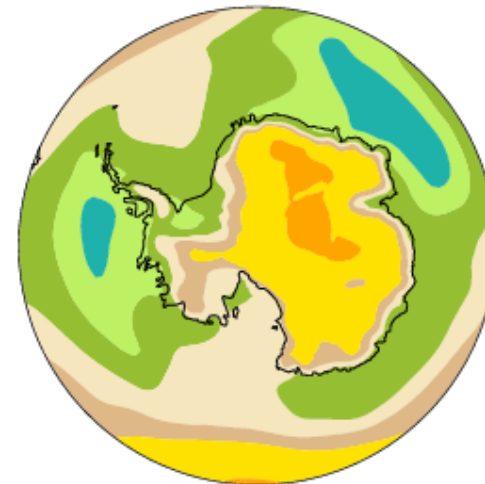
Sea-level pressure millibars



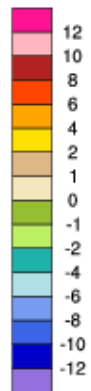
MIN = -3.05 MAX = 3.88



Sea-level pressure millibars



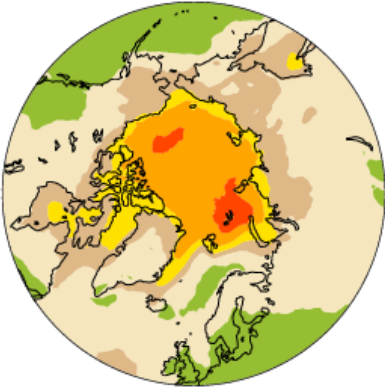
MIN = -3.12 MAX = 5.64



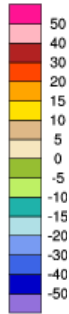
# Change in Cloud Amount (late 21st c)

## ANNUAL

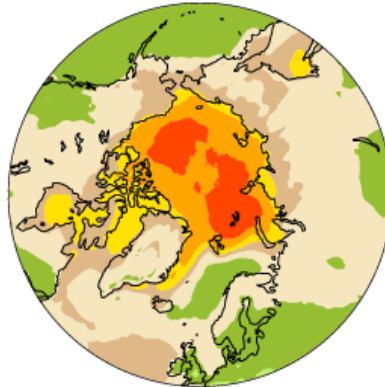
Total Cloud



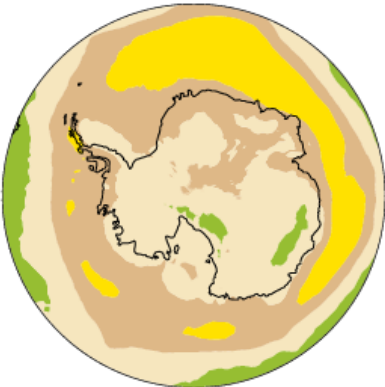
MIN = -4.66 MAX



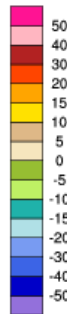
Low Cloud



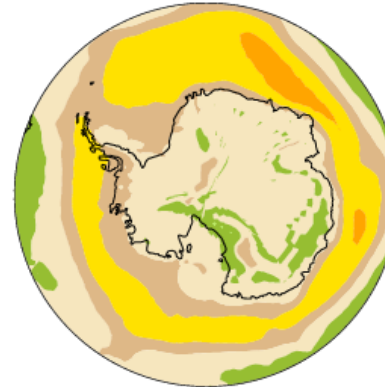
Total Cloud



MIN = -3.41 MAX



Low Cloud



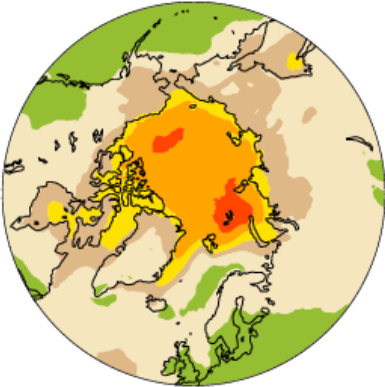
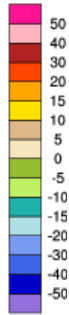
# Change in Cloud Amount (late 21st c)

## ANNUAL

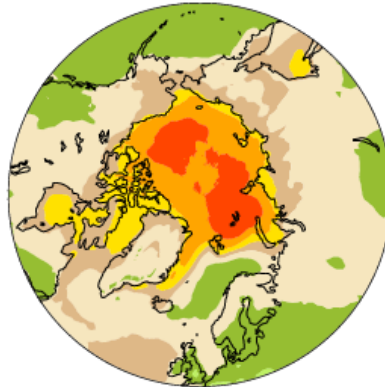
## WINTER

Total Cloud

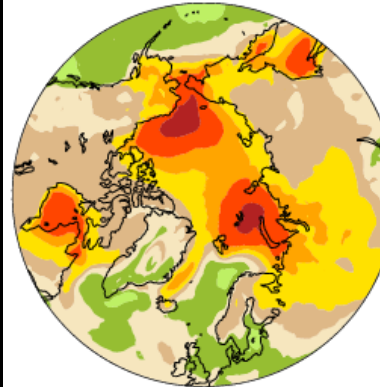
MIN = -4.66 MAX =



Low Cloud

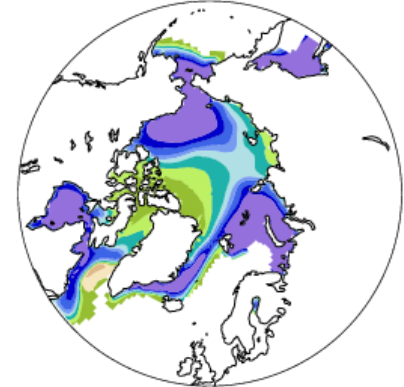
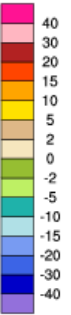


Low Cloud



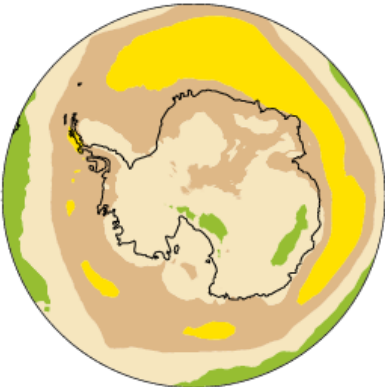
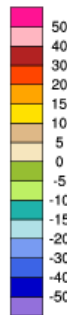
Ice Fraction

MIN = -94.59 MAX =

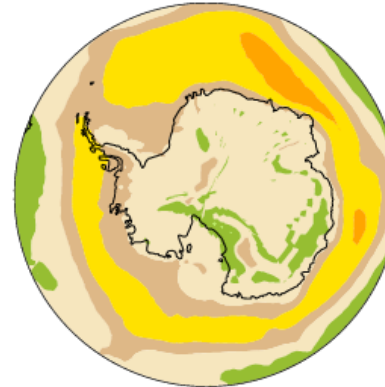


Total Cloud

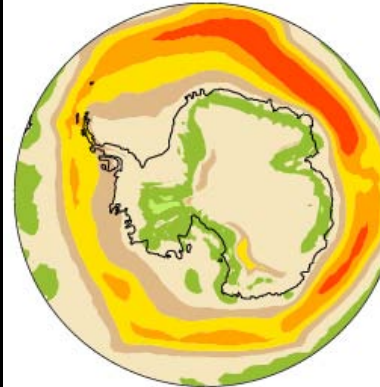
MIN = -3.41 MAX =



Low Cloud

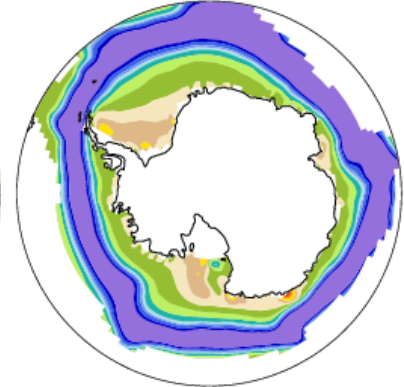
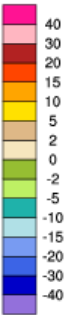


Low Cloud



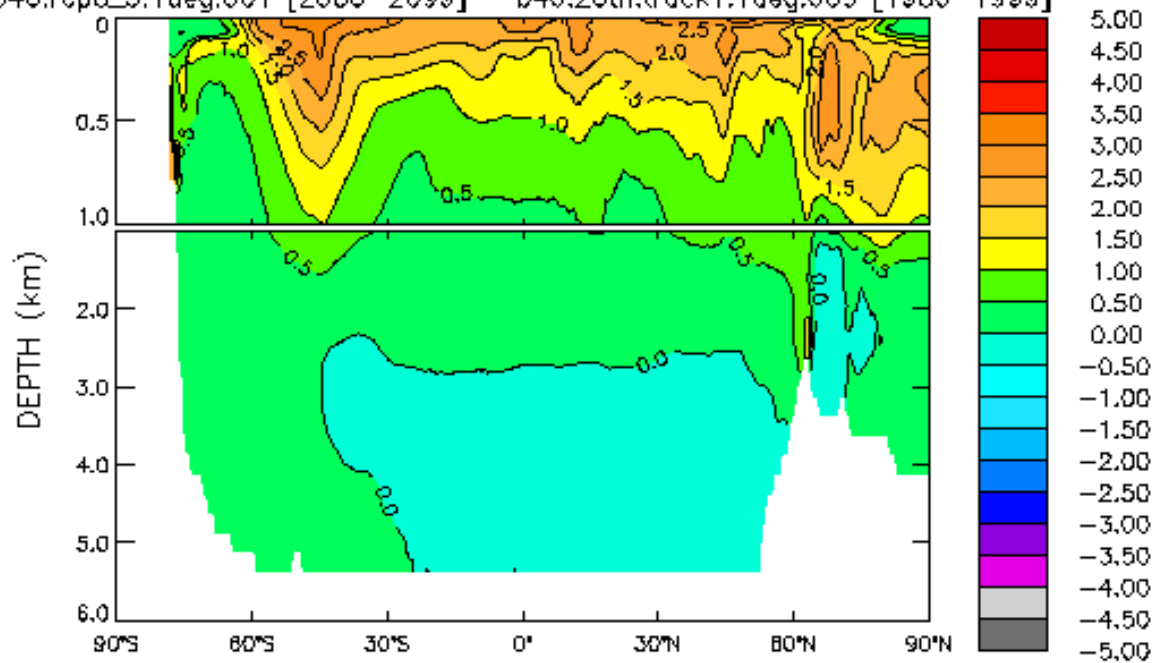
Ice Fraction

MIN = -92.00 MAX =

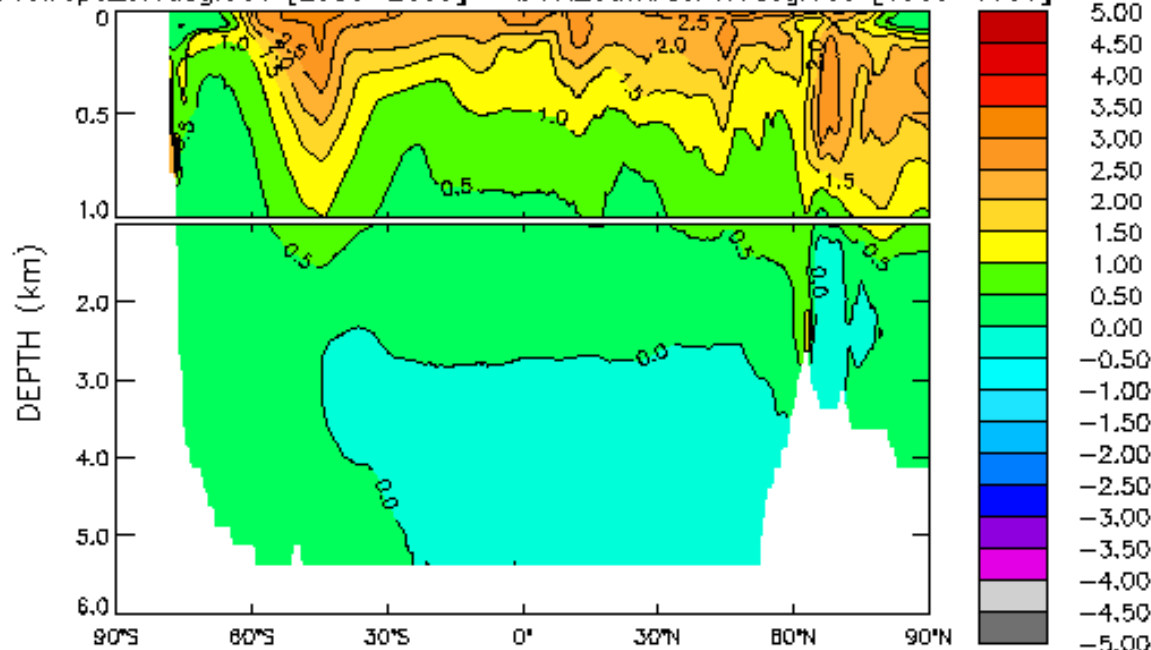




b40.rcp8\_5.1deg.001 [2080-2099] - b40.20th.track1.1deg.005 [1980-1999]



b40.rcp8\_5.1deg.001 [2080-2099] - b40.20th.track1.1deg.005 [1980-1999]

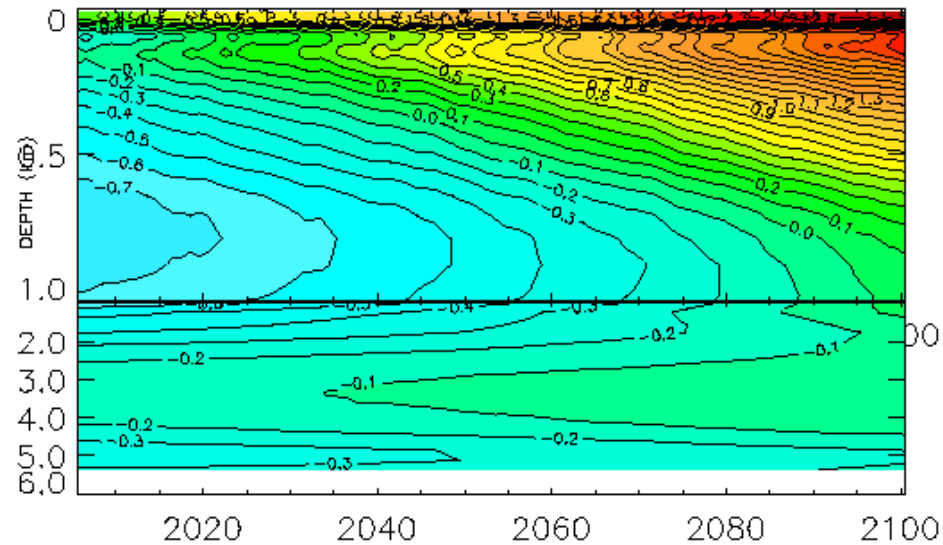
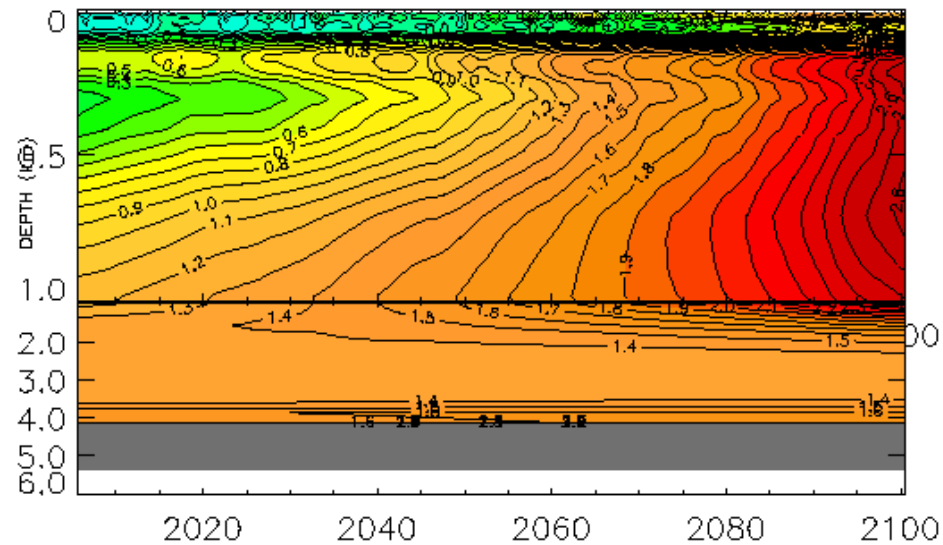


## Arctic

## Southern Ocean

MODEL - OBS

MODEL - OBS



## Summary of Polar Climate Response in CCSM4

- *No surprises*. . . .polar regions become a lot warmer, wetter, cloudier, stormier, and “waterier”
- Relative to CCSM3’s B1 simulation, CCSM4 simulates more (less) warming in South (North) polar region
- Polar amplification in CCSM4 ~2.5 (Arctic) and 1.5 (Antarctic)
- Arctic ice pack becomes seasonal by end of century
- Precipitation increases maximize in autumn
- SLP decreases and cloud increases tied to sea ice loss
- Warming of Atlantic layer in Arctic Ocean---bottom ice melt?