Observed and Modeled Cloud Responses to Interannual Climate Variability

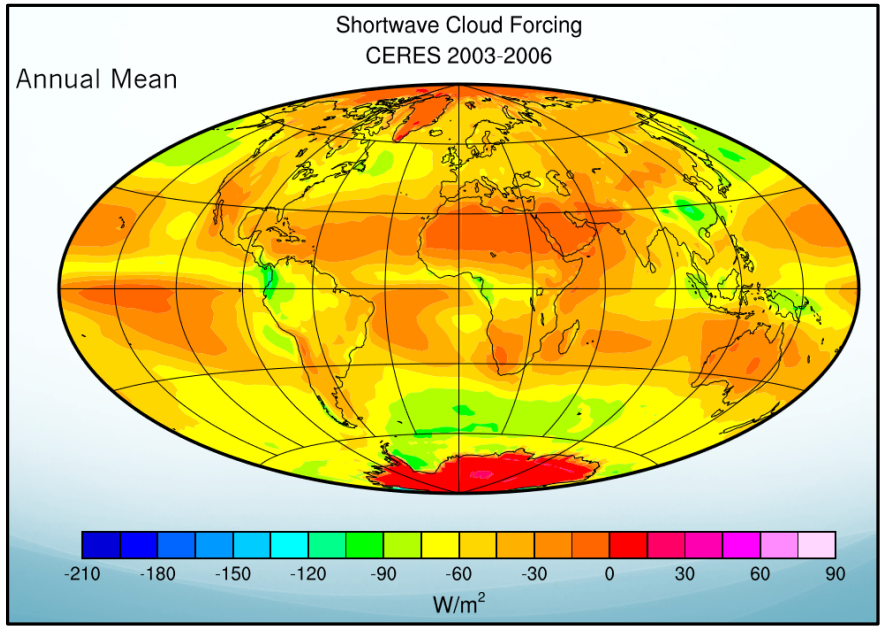
Andrew Geiss and Roger Marchand

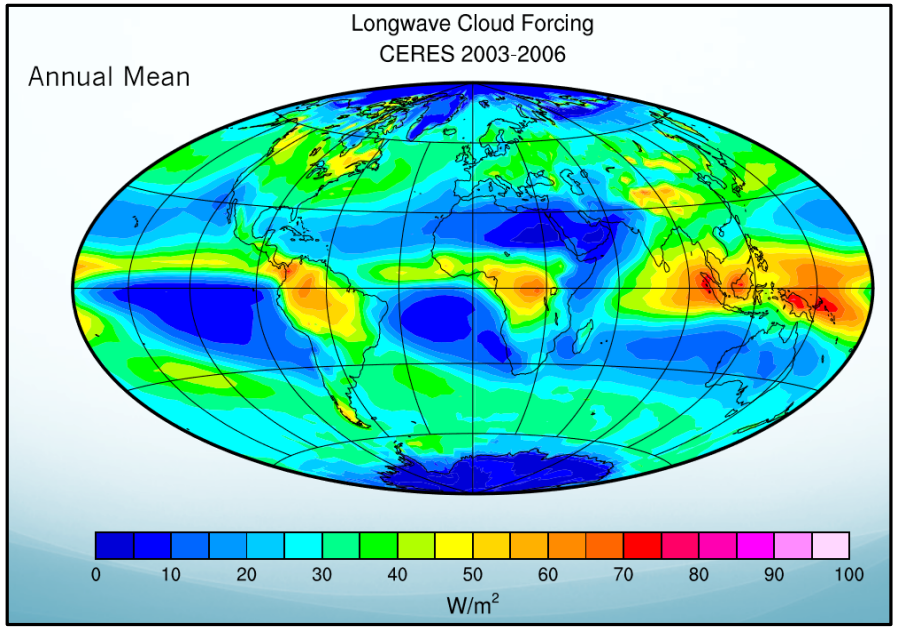
University of Washington

AMS Annual Meeting, Jan. 7th, 2019

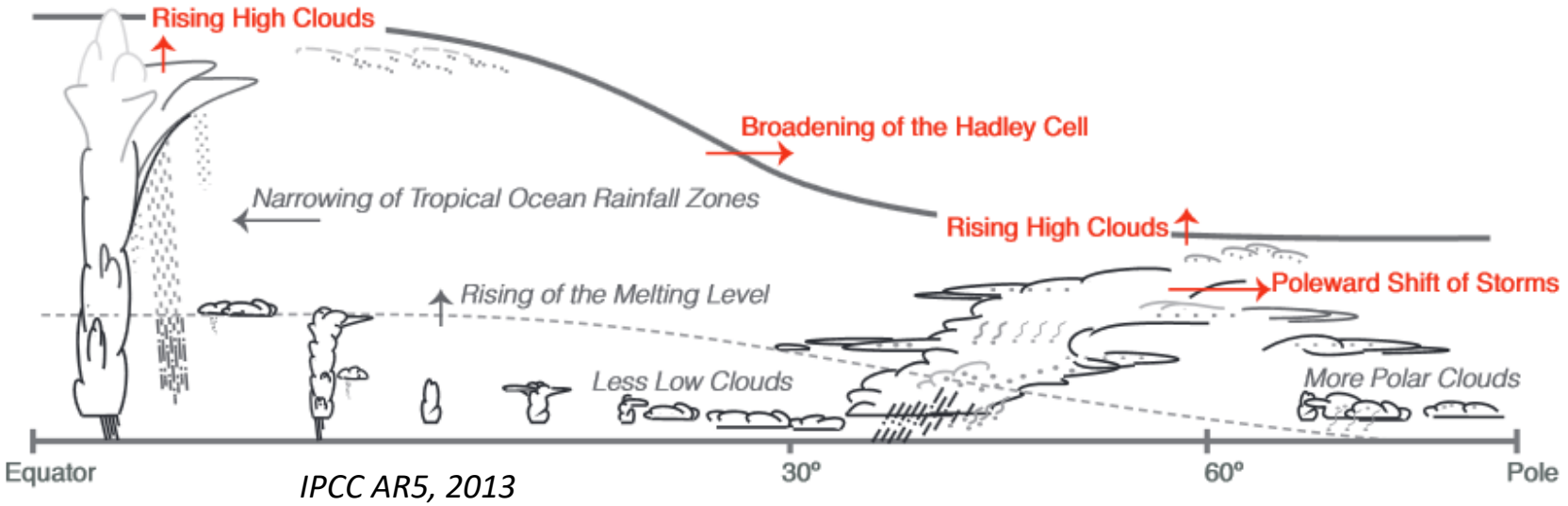
Background: Motivation

Clouds have a substantial impact on the Earth's radiative budget





Hartmann, 2014



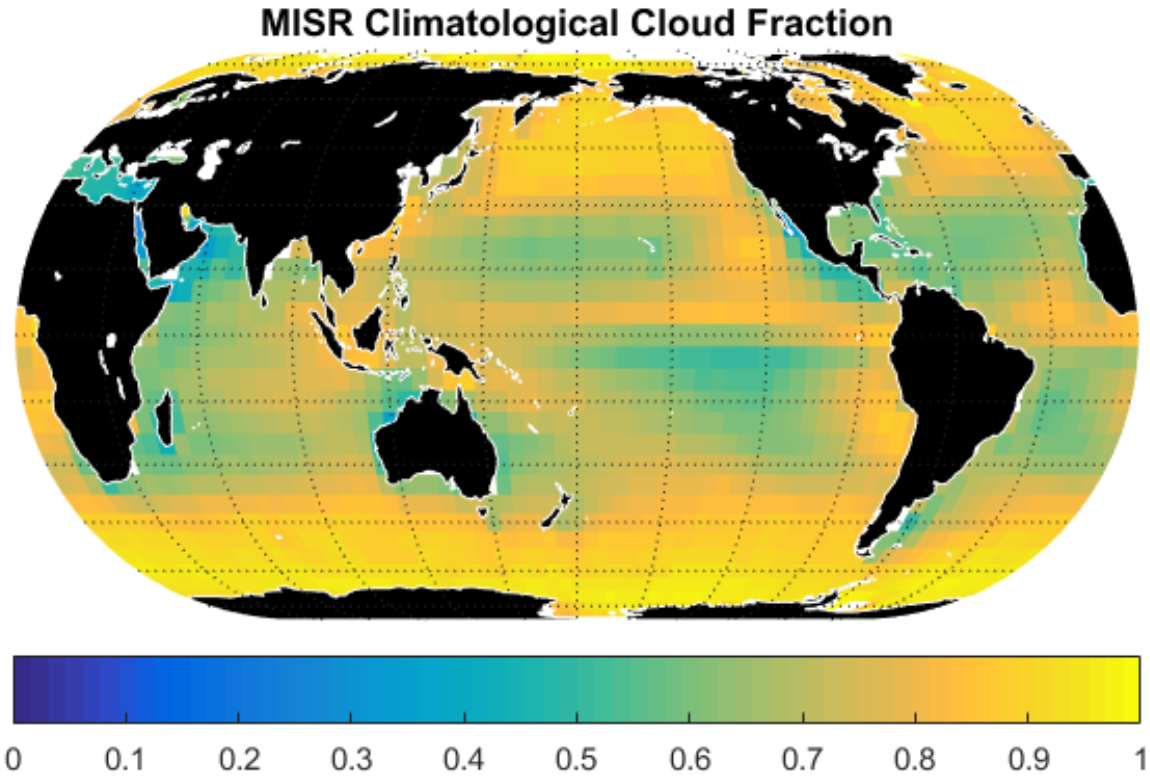
IPCC AR5, 2013

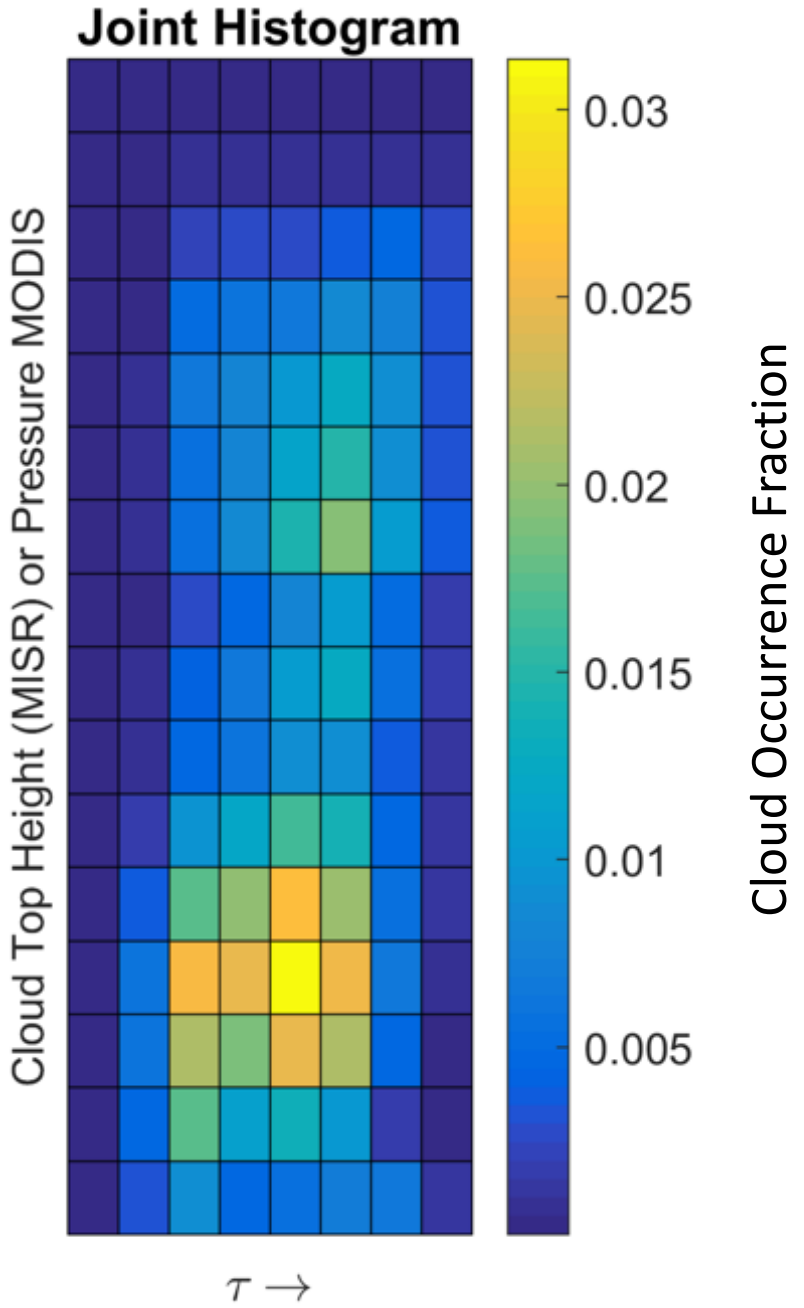
There are a several expected cloud responses to climate change

Some are more certain than others

Data: MISR Cloud Occurrence

5-Degree gridded monthly CTH-OD joint histograms





Data: COSP

HadGEM COSP MISR Simulator:

COSP -- CFMIP Observational Simulator Package

Emulates MISR CTH-OD product directly from model cloud fields

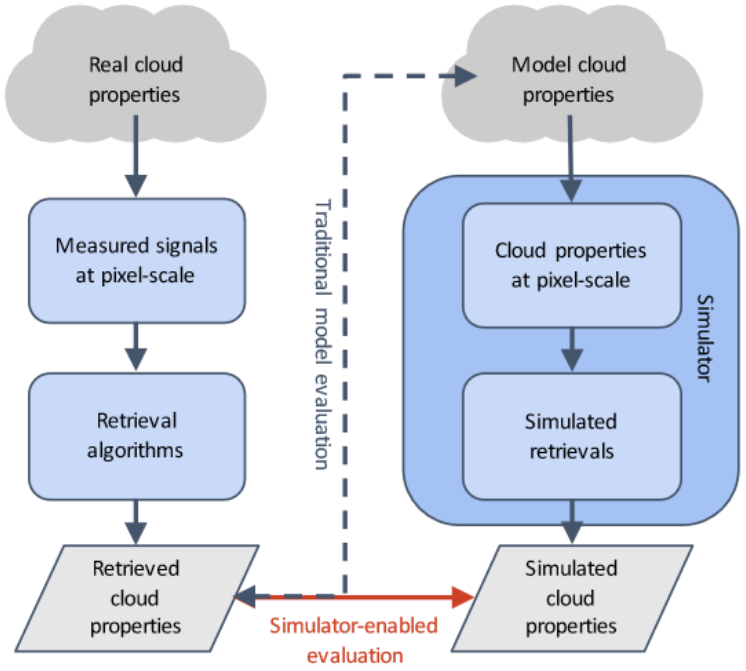
HadGEM2 CFMIP3 Experiment

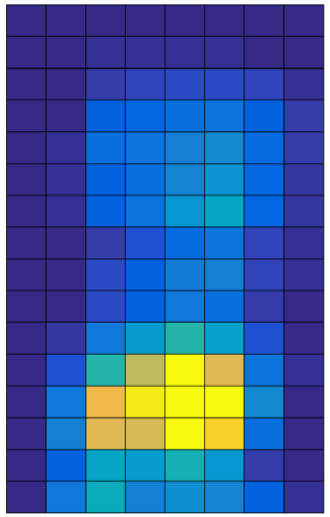
MISR cloud top height Levels,

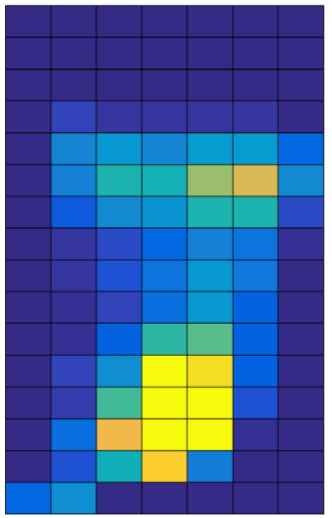
Interpolated to 5-Degree grid,

Monthly 1979-2008 historical run (prescribed SST)

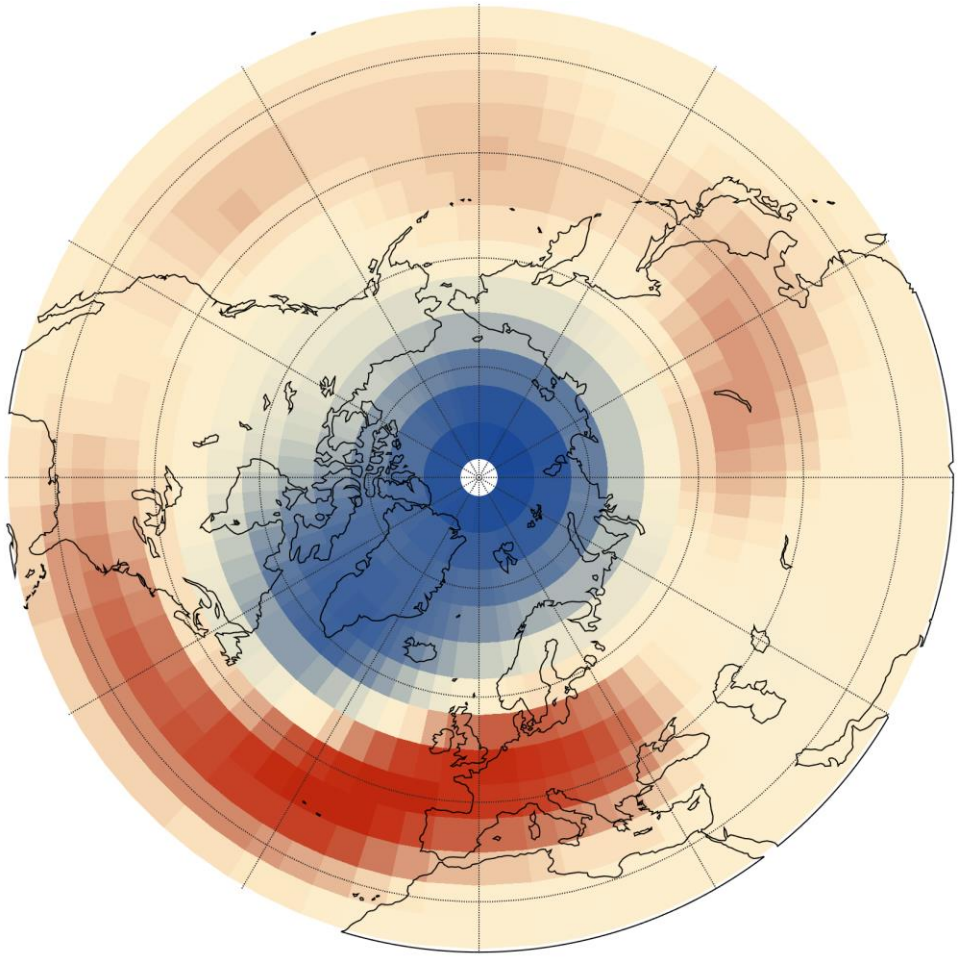
ECMWF ERA-Interim Reanalysis







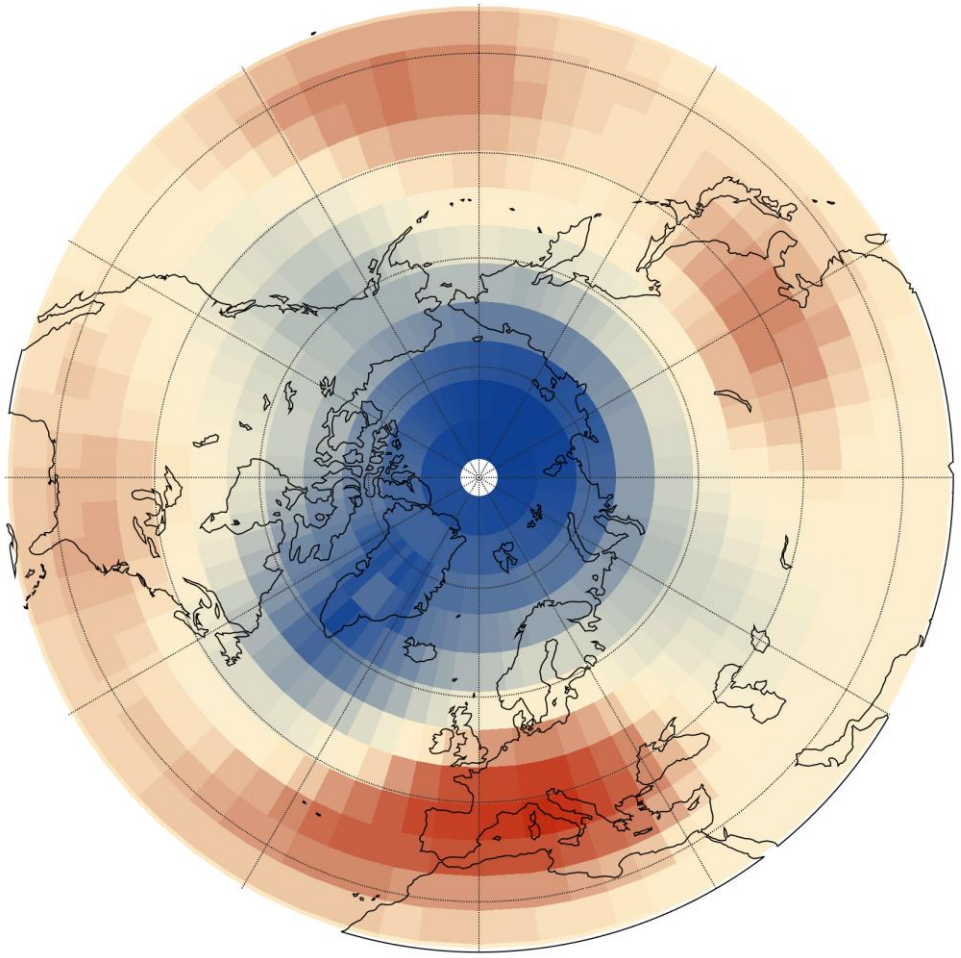
NAO: Loading Patterns



ERA-Interim NAO (10%)

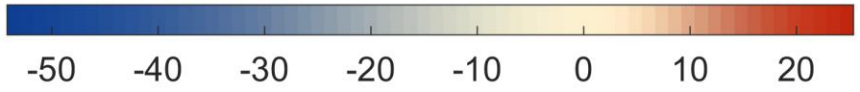
700hPa Height Anomaly ($m\sigma^{-1}$)

ρ = 0.97

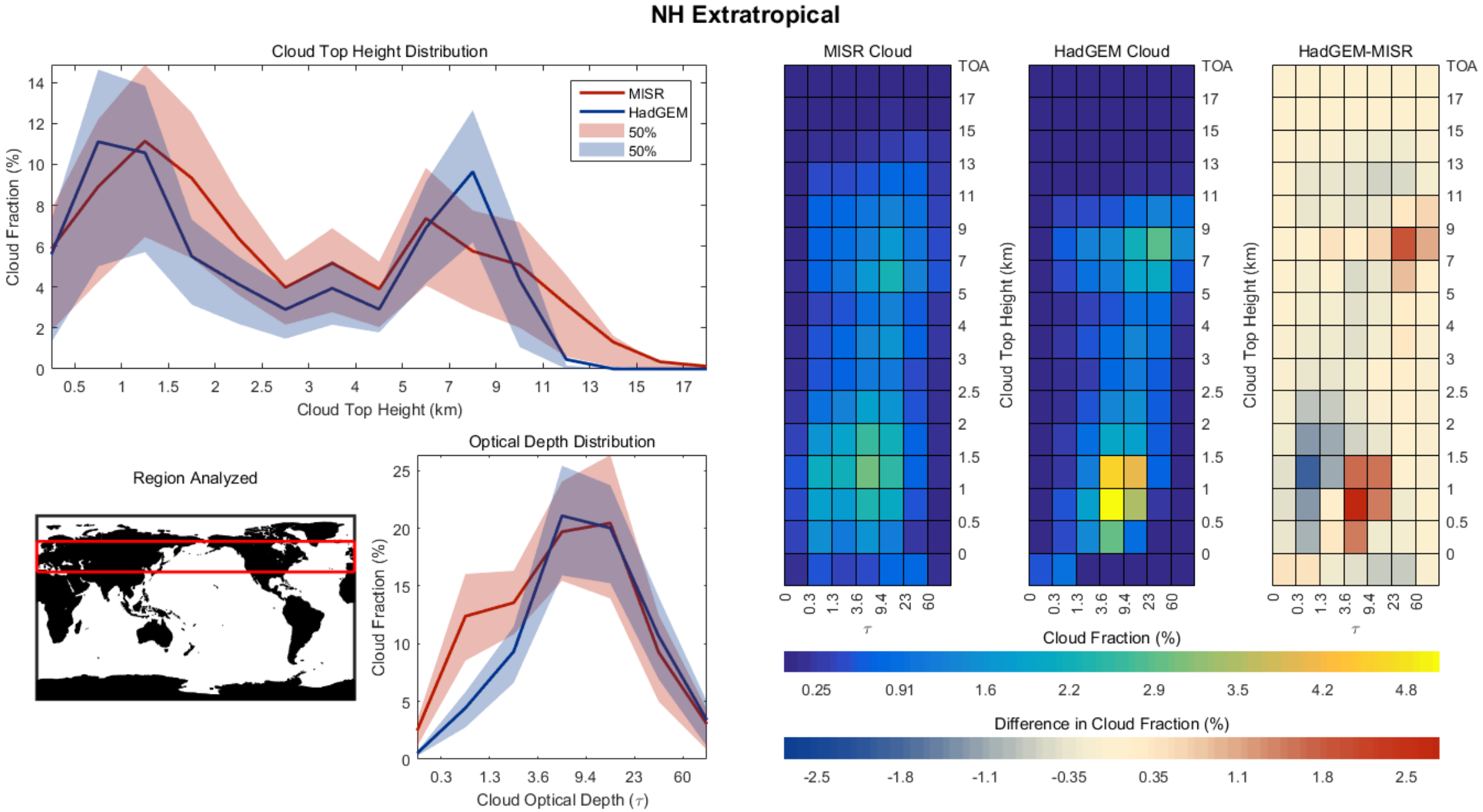


HadGEM NAO (9%)

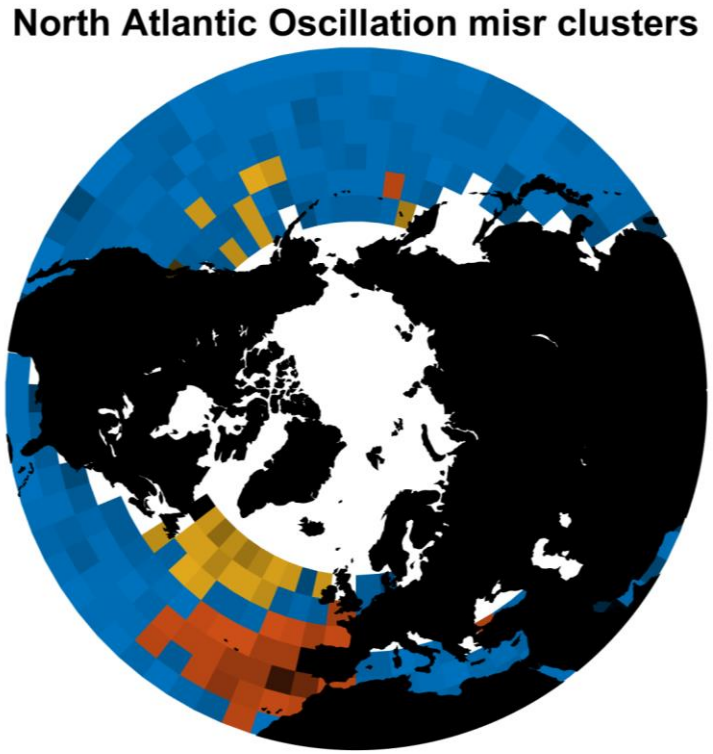
700hPa Height Anomaly ($m\sigma^{-1}$)

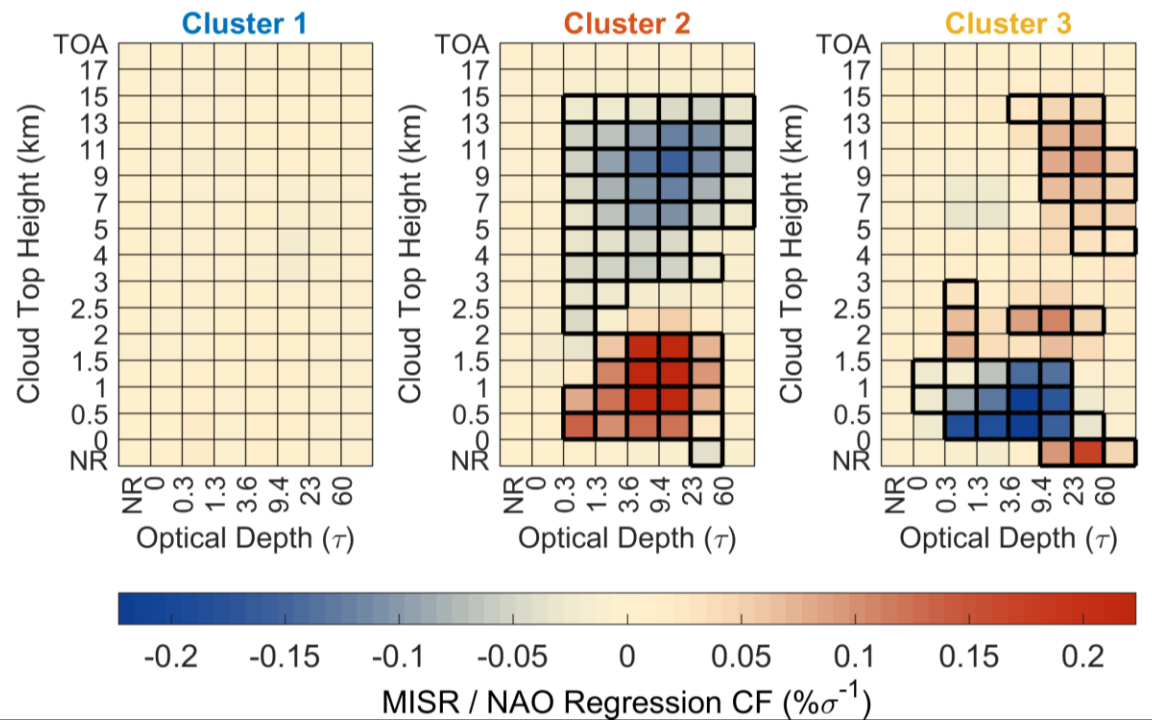


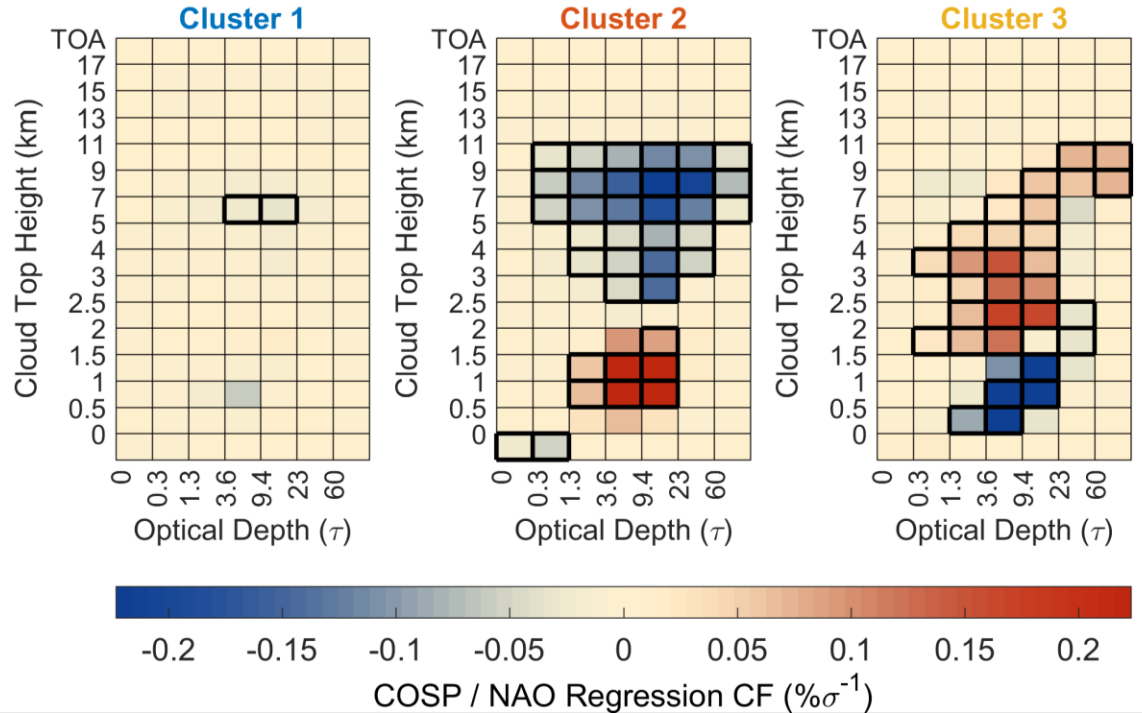
NAO: Modeled Cloud

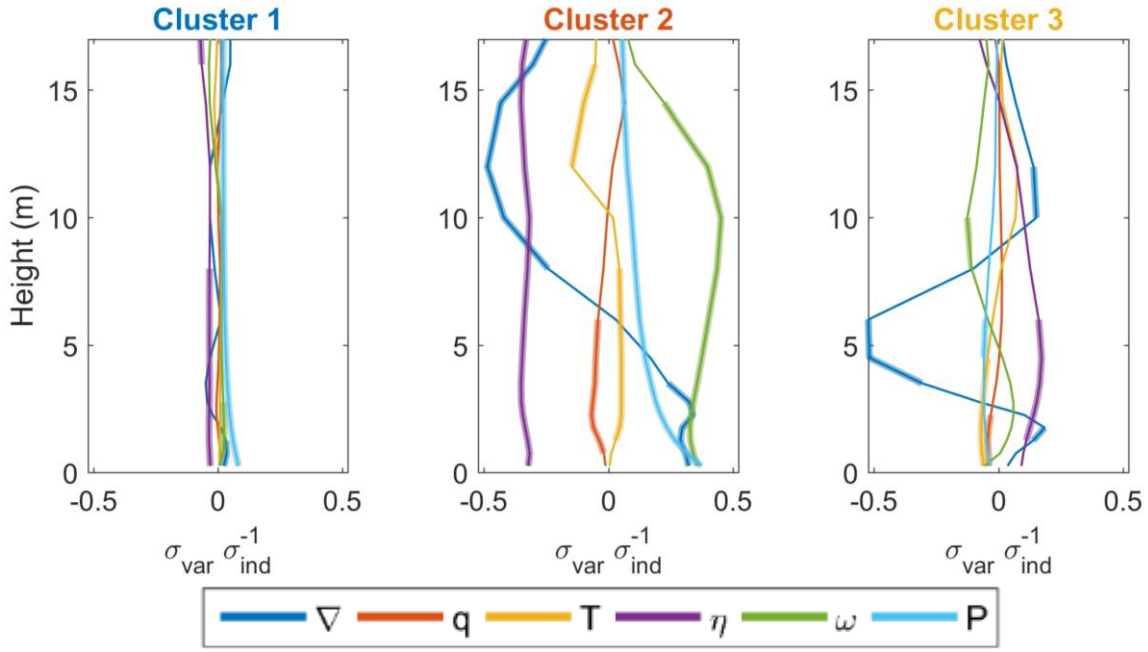


NAO: Cloud Variability

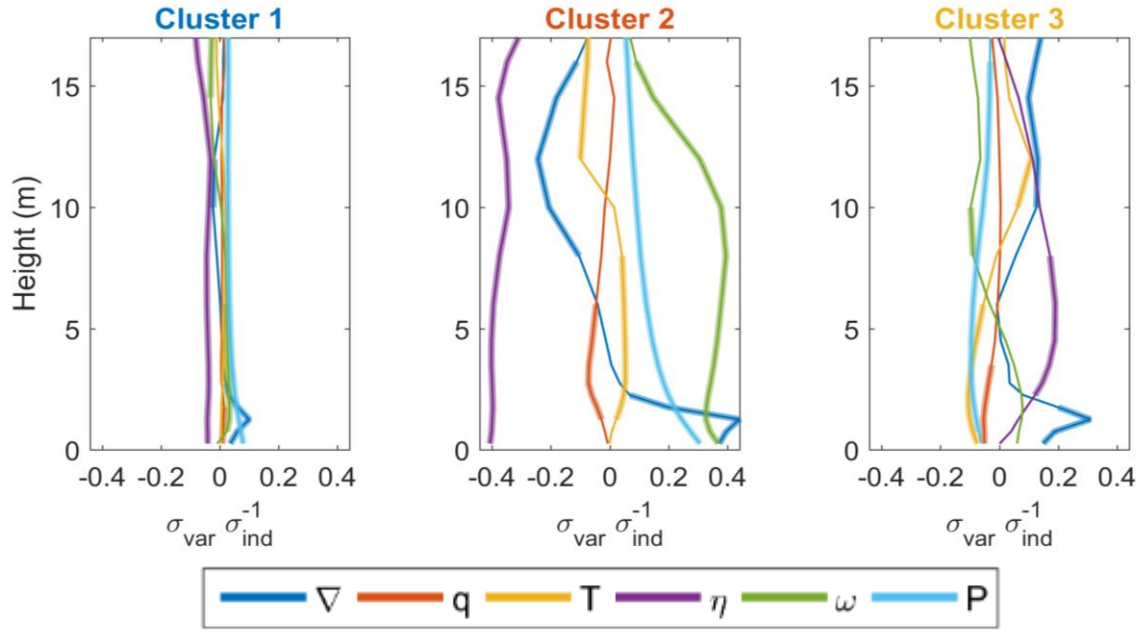




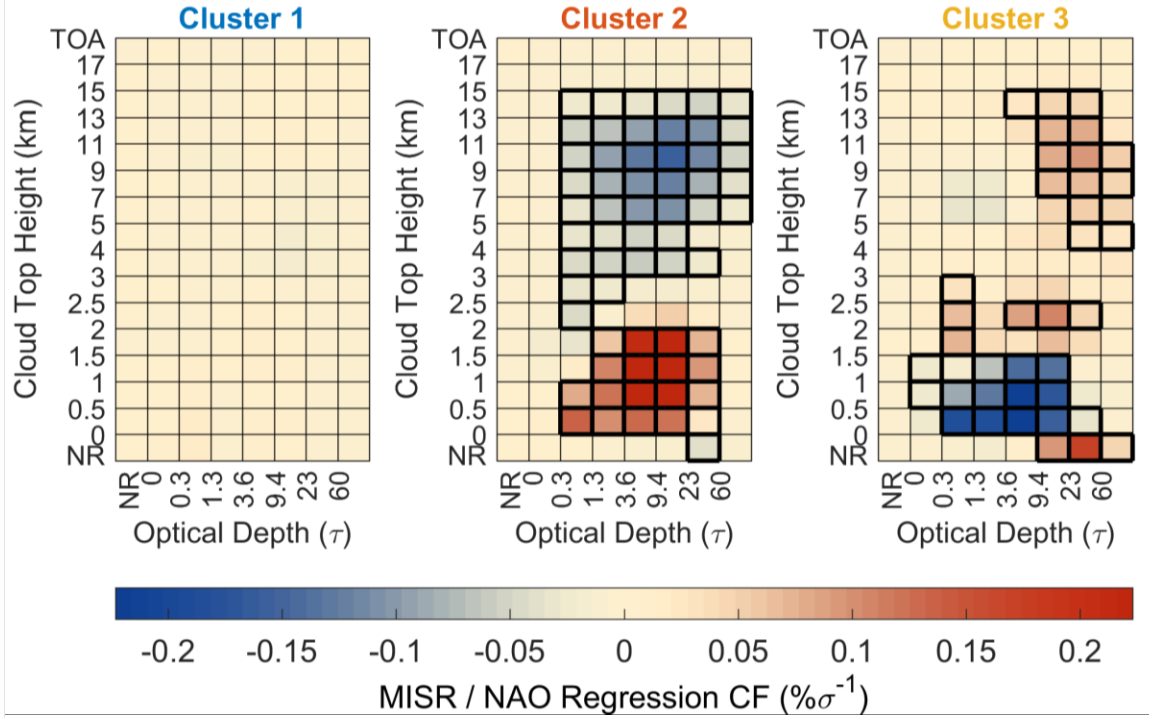


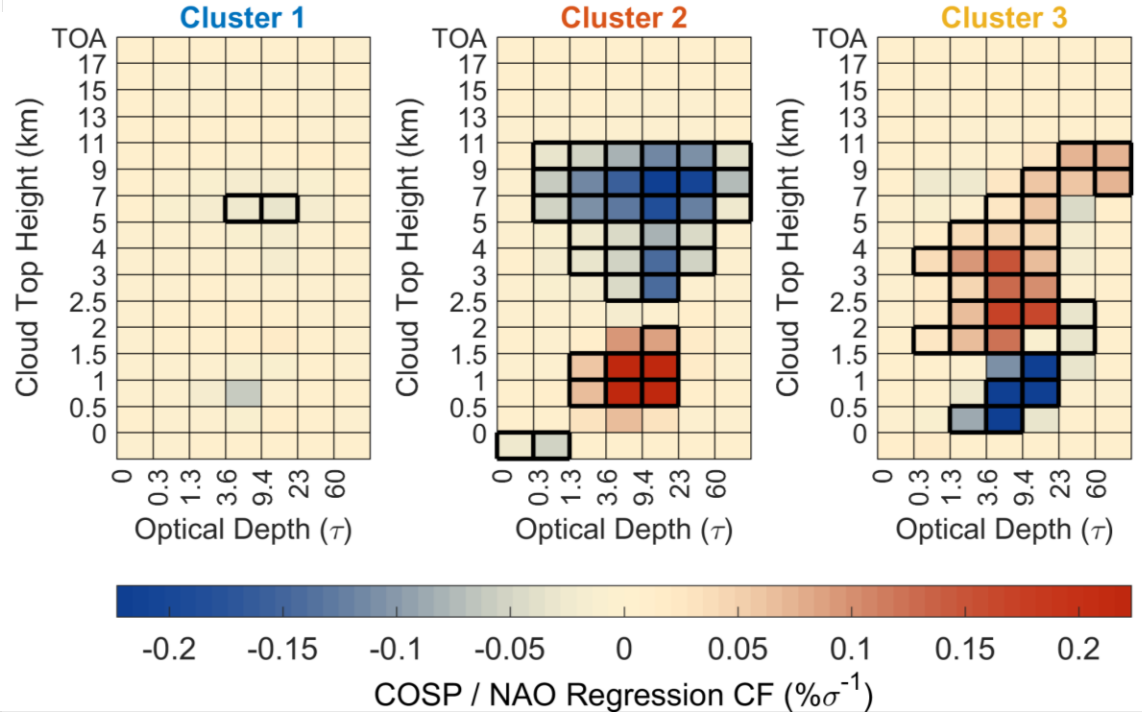


ERA-Interim / NAO Regression Coefficients

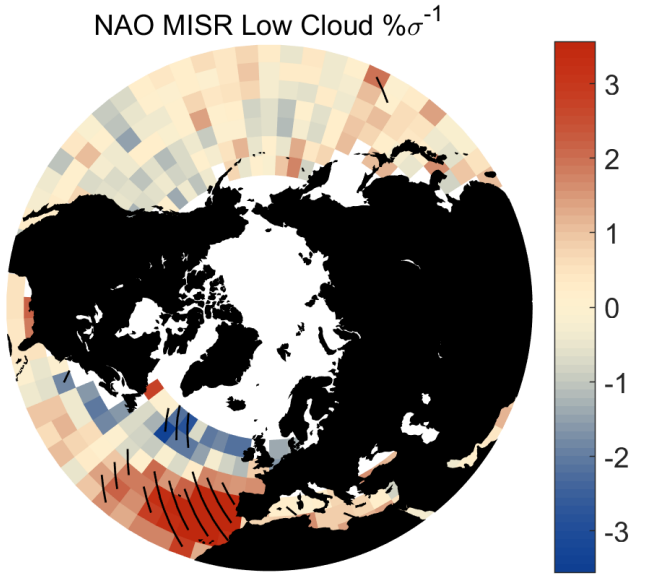


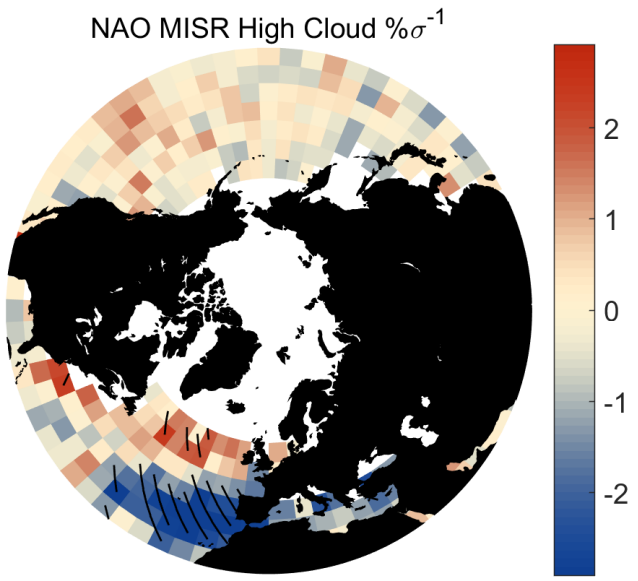
HadGEM / NAO Regression Coefficients

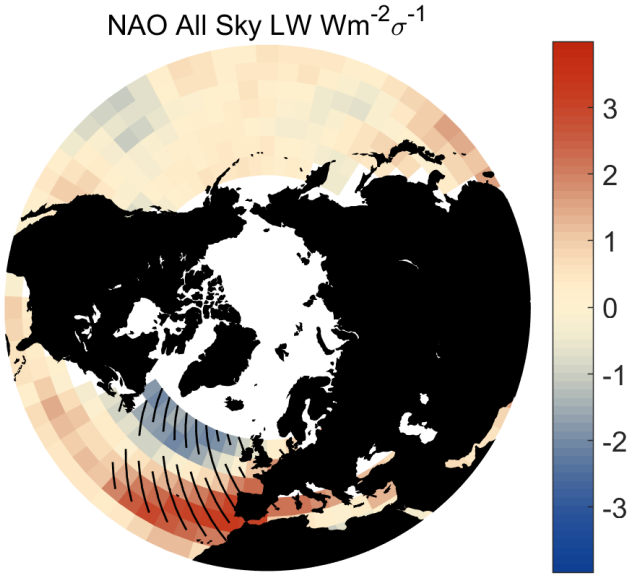


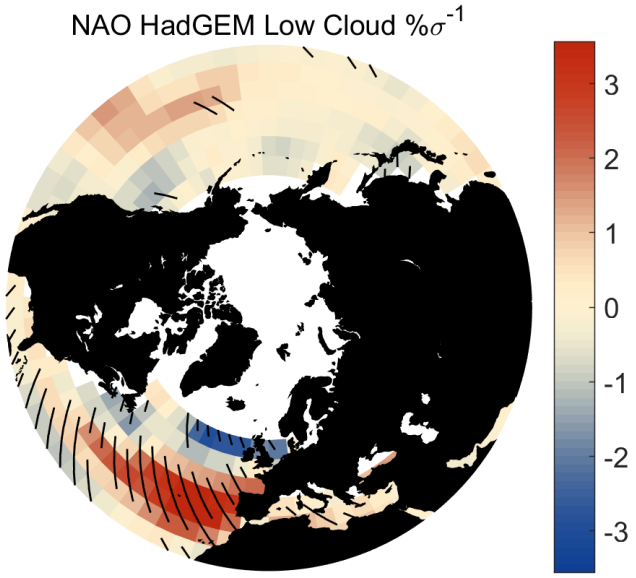


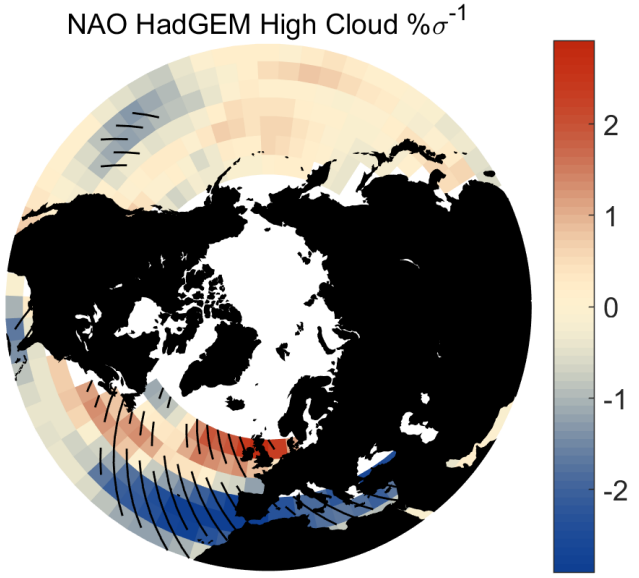
NAO: Radiative Fluxes

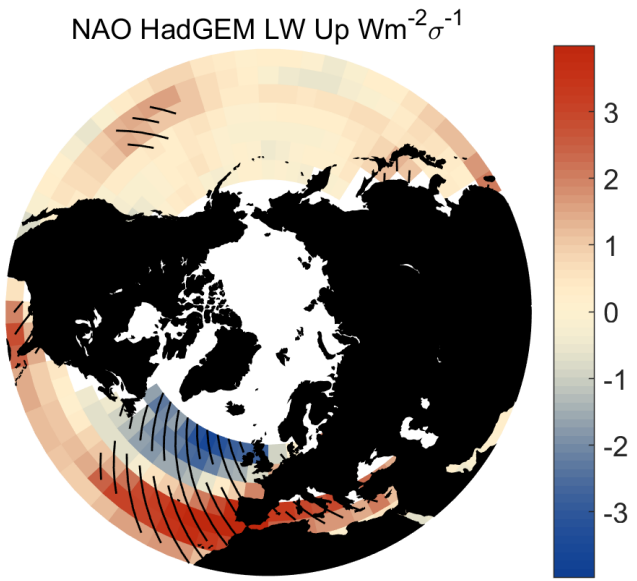






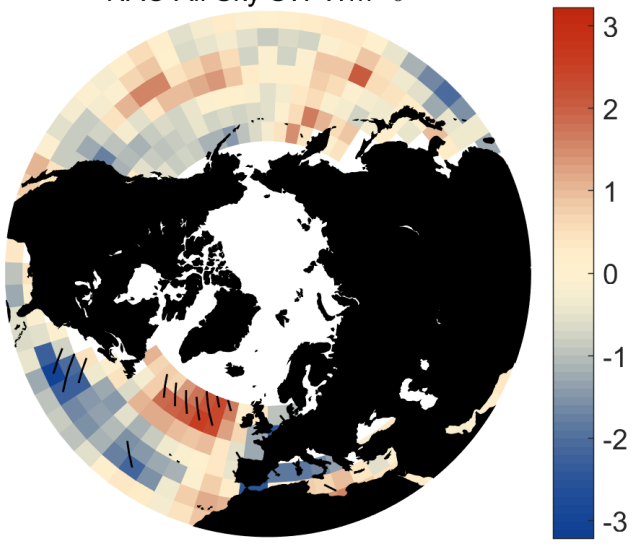




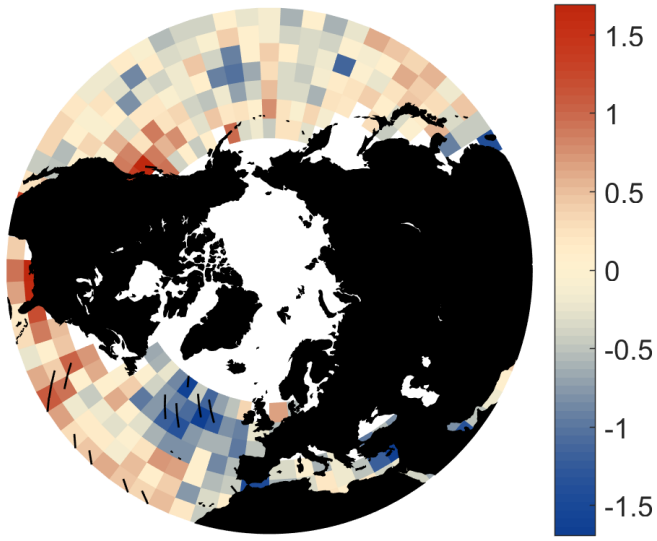


NAO: Radiative Fluxes

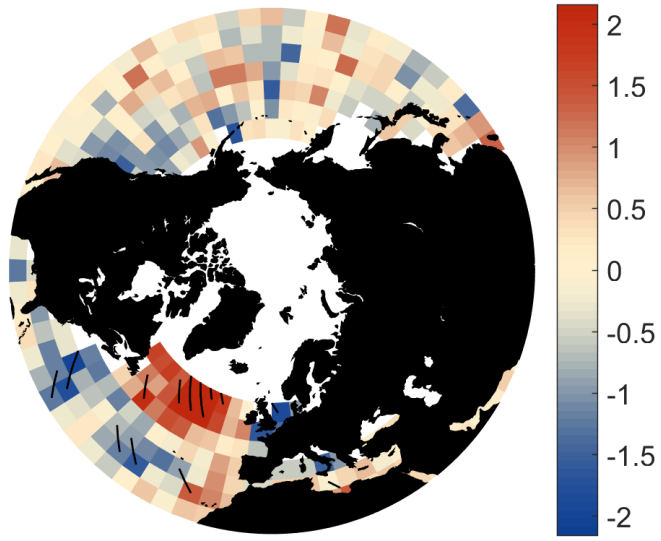
NAO All Sky SW $Wm^{-2}\sigma^{-1}$



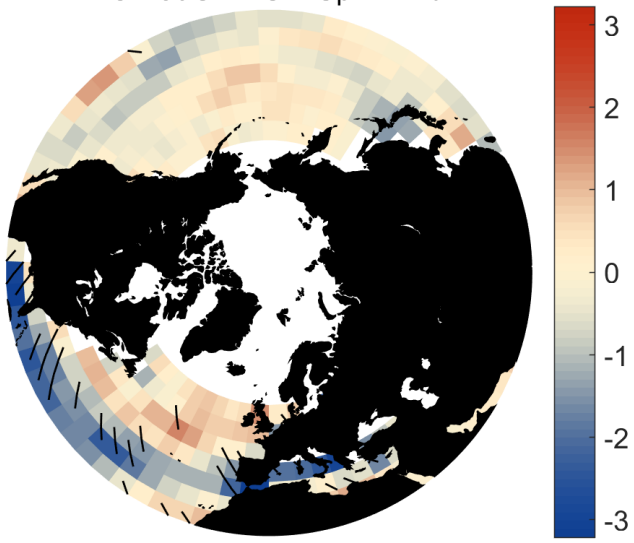
NAO MISR Thin Cloud $\%\sigma^{-1}$



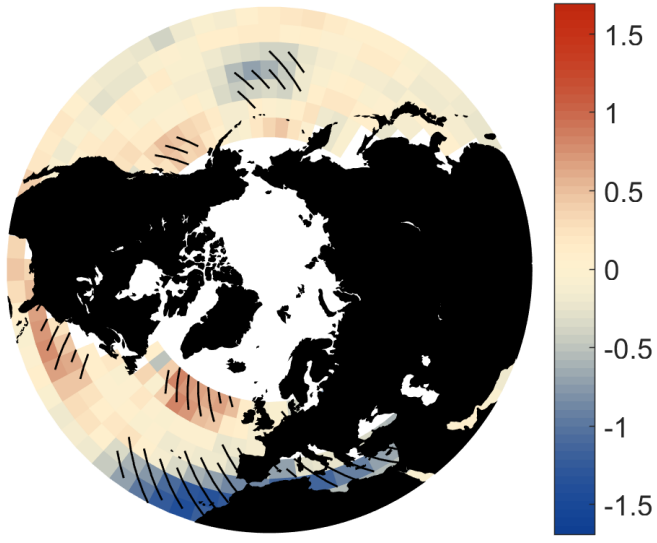
NAO MISR Thick Cloud $\%\sigma^{-1}$



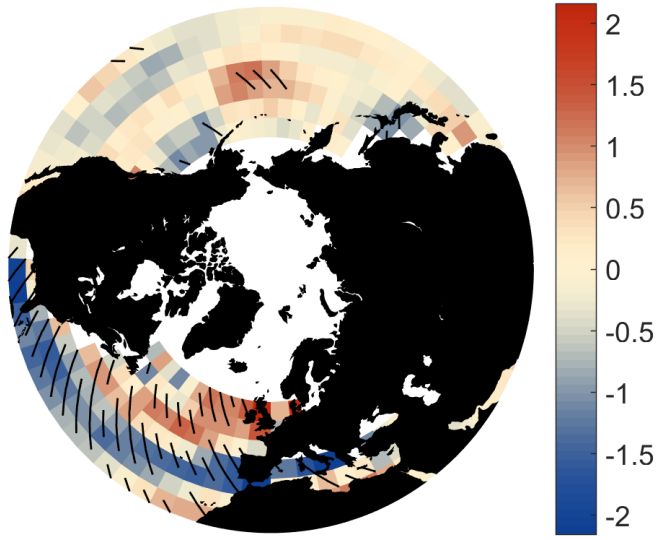
NAO HadGEM SW Up $Wm^{-2}\sigma^{-1}$



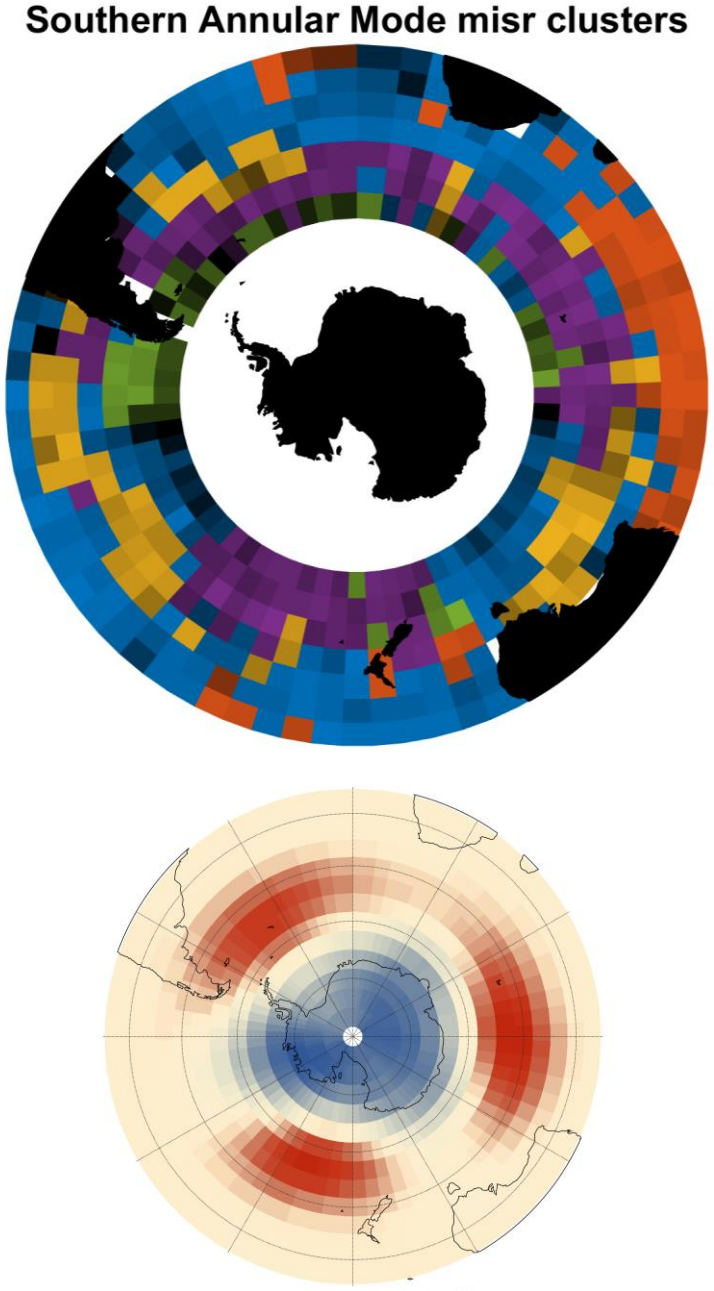
NAO HadGEM Thin Cloud $\%\sigma^{-1}$

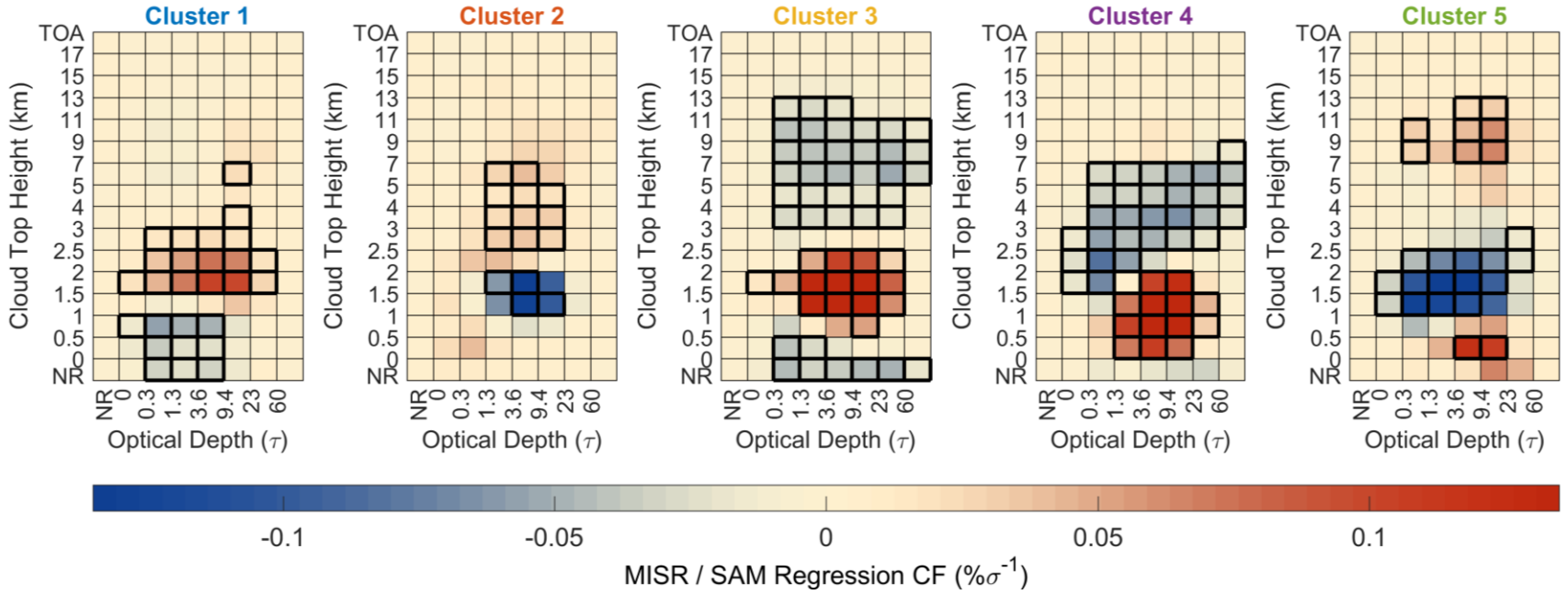


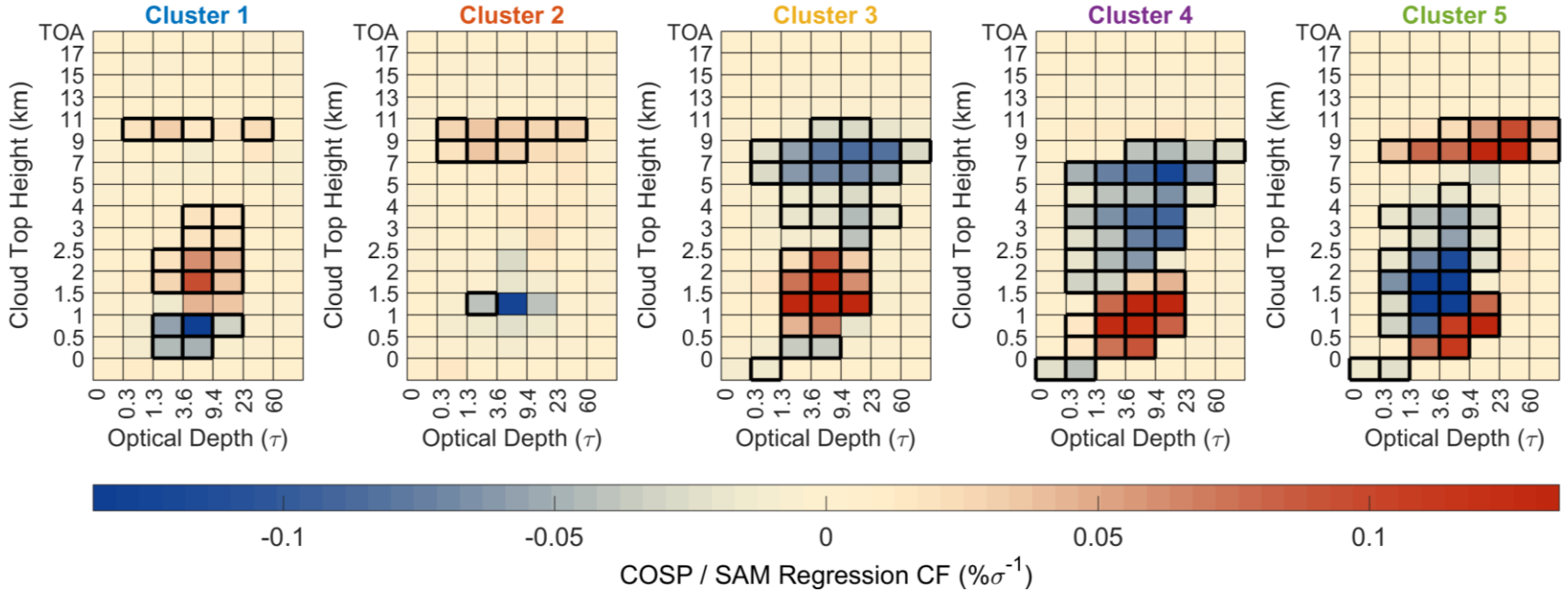
NAO HadGEM Thick Cloud $\%\sigma^{-1}$



SAM: Clouds


Southern Annular Mode misr clusters


Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cloud Top Height (km)
TOA
17
15
13
11
9
7
5
4
3
2.5
2
1.5
1
0.5
0
NR
0
0.3
1.3
3.6
9.4
23
60
Optical Depth (τ)
-0.1
-0.05
0
0.05
0.1
MISR / SAM Regression CF (%σ-1)


Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cloud Top Height (km)
TOA
17
15
13
11
9
7
5
4
3
2.5
2
1.5
1
0.5
0
0
0.3
1.3
3.6
9.4
23
60
Optical Depth (τ)
-0.1
-0.05
0
0.05
0.1
COSP / SAM Regression CF (%σ-1)

SUMMARY

-Primary cloud response to annular modes is increased low cloud and reduced high (NAO) or mid-level (SAM) cloud at high pressure centers

-Associated with increased anticyclonicity, pressure, subsidence, etc.

-Causes increased upwelling longwave

-HadGEM2 captures all of this well, but struggles with upwelling shortwave changes due to cloud optical thickness or total cloud amount changes