Introduction

Clouds impact Arctic surfaces

- Studies illustrate that for much of the year clouds have a net warming effect on the surface[1]
- Low optical depth clouds have been shown to enhance melting at the surface[2]
- Changes in Arctic cloud properties with increasing greenhouse gases may influence radiative fluxes at the surface and affect the relative importance of albedo feedbacks[3]

Goal: Use CESM to assess how modification of cloud optical depth (COD) impact Arctic surfaces, specifically:

- Examine **downwelling radiation changes** as a function of COD of Arctic clouds
- How different CODs impact the **sea ice extent** and **thickness**, and **surface temperatures** in the Arctic
- How different CODs impact the same features plus **surface albedo feedback** in a **doubled-CO2 climate scenario**

1 Curry et al., 2000; Intrieri et al., 2002; Shupe and Intrieri, 2003

2 Bennartz et al., 2013; Van Tricht et al., 2016

3 ; Kay et al, 2008; Pithan and Mauritsen, 2014

Experiment Outline – 1

1: Sensitivity Study

- Use CESM with active atmosphere and land models (F1850) and prescribed sea ice and SSTs to assess the downwelling radiation
- In addition to a control run, we examine the radiative impact of changing the cloud optical depth in the model for the Arctic region (60° – 90°N) only:
  - Fractions: 50%, 75%, 150%, 200%, and 500% COD
- Compare the results to the control and assess if more sensitivity studies are warranted
- Use the COD fractions with the highest potential increase in downwelling radiation when compared to control in Part 2

Experiment Outline – 2

2a: COD and Sea Ice Study

- Use CESM with active atmosphere, land, and sea ice components and slab ocean (E1850) to assess radiative impact of COD on sea ice extent, thickness, and surface temperature
  - In the absence of ocean dynamics
  - Using slab ocean for assessment of surface temperatures and sea ice extent (Kay et al., 2012)

2b: Double CO2, COD, and Sea Ice Study

- Use CESM with active atmosphere, land, and sea ice components and slab ocean (E1850) and abrupt doubling of CO_2 to assess radiative impact of COD on sea ice extent, thickness, surface temperature, and surface albedo feedback
  - Assess the impact of the COD changes under a climate change scenario forced by increases in greenhouse gas emissions

Experiment Outline

Experiment	Model Components	Number of Years
Sensitivity Study: Radiative impact due to changes in COD in Arctic clouds (.5, .75, 1.5, 2, and 5 times)	**Active** CAM6; CLM5 **Prescribed** CICE; OCN F1850	**35** (throw out years <5)
Sea Ice Study: Based on sensitivity study, change the COD of Arctic clouds	**Active** CAM6; CLM5 CICE; SOM E1850	**250** (throw out years <50)
Sea Ice+2XCO_2 Study: Based on sensitivity study, change the COD of Arctic clouds, and abrupt doubling of CO_2	**Active** CAM6; CLM5 CICE; SOM E1850 *co2vmr = doubled*	**250** (throw out years <50)

Timing/Cost Table/Output

Configuration	Resolution	Number of Runs	Number of years per run	Cheyenne core hours per simulated year	Total core hours (in thousands)	Total data volume
F1850	f09_g17	10	35	400	140	550GB
E1850	f09_g17	8	250	1700	3400	2.2TB

Monthly means 1850 runs:

- Sea ice extent/thickness
- Surface temperature
- Surface/TOA radiative fluxes
- Cloud variables
- Temperature Profile
- Specific Humidity Profile
- Surface air temperature

Analyses:

- Relationship between radiative fluxes and COD
- Impacts of COD on sea ice properties
- Response to GHG forcing, including surface albedo feedback (radiative kernel)