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GC21A-1055: A Variable Resolution Atmospheric General Circulation Model for a Megasite at the North Slope of Alaska

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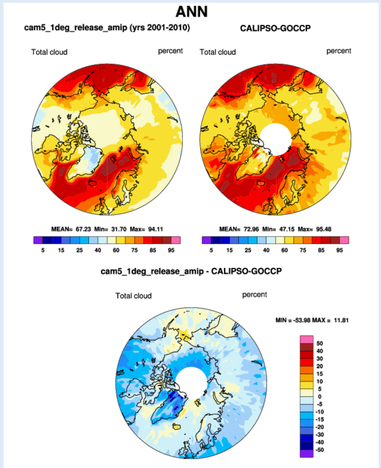
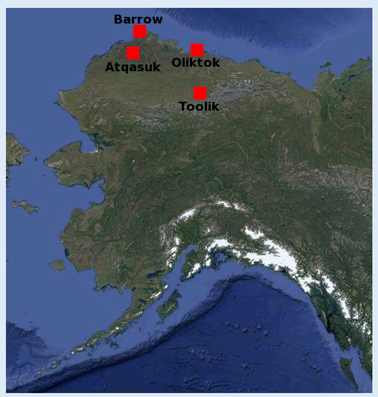
I. Motivation/Background: Cloud Representation

The Arctic is warming more than any other region, and the area is very important to global energy balance. Clouds in the Arctic, which are important to the radiative balance of the region, have been identified as an area for improvement in the current Community Atmosphere Model version 5 (e.g., Kay et al. (2016)).

Potential Solution: A variable resolution model configuration is explored as a potential alternative to a stand-alone high-resolution regional model for a study of the North Slope of Alaska. We hypothesize that increased resolution could be a pathway towards better representation of clouds, especially at low levels.



North Slope of Alaska



The North Slope of Alaska (NSA) is bounded by the Brooks Range to the south and the Arctic Ocean on all other sides. Sites at Utqiagvik (formerly Barrow), Oliktok and Atqasuk are a part of the Atmospheric Radiation Measurement (ARM) Climate Research Facility, which is "a multi-platform scientific user facility with the objective of providing a detailed and accurate description of the Earth's atmosphere in diverse climate regimes to resolve the uncertainties in climate and earth system models"[1] A research station at Toolik Lake also provides a site at which measurements may be gathered. These sites would compose a "megasite" which would combine observational data and high-resolution modeling over the area.

II. Methods

Variable refinement is performed on a cubed-sphere grid using SQuadGen, NCL, and GIMP.

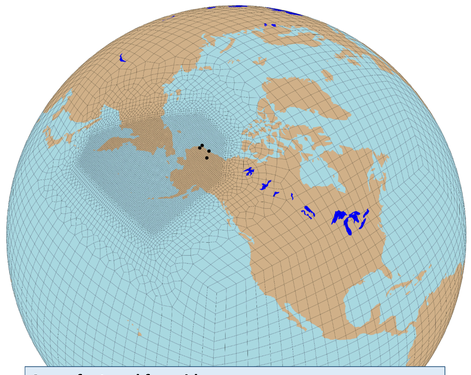
SQuadGen	→	NCL	→	GIMP	→	SQuadGen	→	NCL
Create grid		Plot grid		Specify area of refinement		Create refined grid		Plot variable resolution grid

SQuadGen
-open-source mesh generation utility which corresponds to grid of latitude and longitude

NCL
-open-source, interpreted language created by the National Center for Atmospheric Research (NCAR) which is used for visualizations

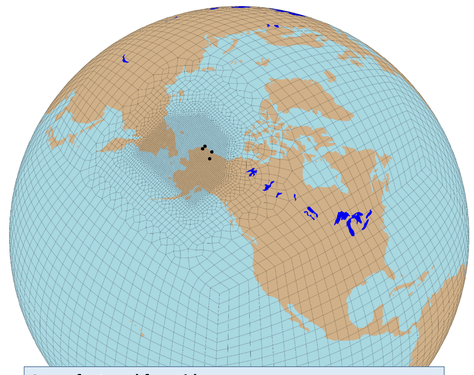
GIMP
-open-source graphics editor

Large (13,861 elements)



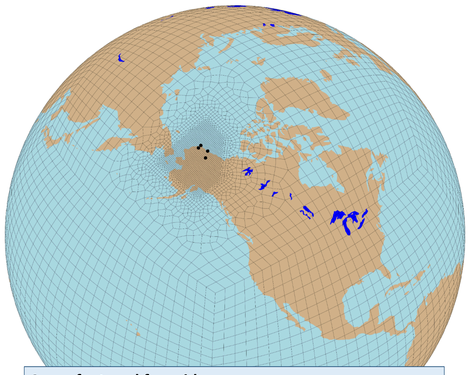
Areas featured for grid
- Kamchatka Peninsula
- Russian coast
- Aleutian Islands
- Entirety of Alaska and Brooks Range
- Chukchi and Beaufort Seas, Bering Strait

Medium (9,439 elements)



Areas featured for grid
- Russian coast
- Limited area of Aleutian Islands
- Entirety of Alaska and Brooks Range
- Chukchi and Beaufort Seas, Bering Strait

Small (7,754 elements)

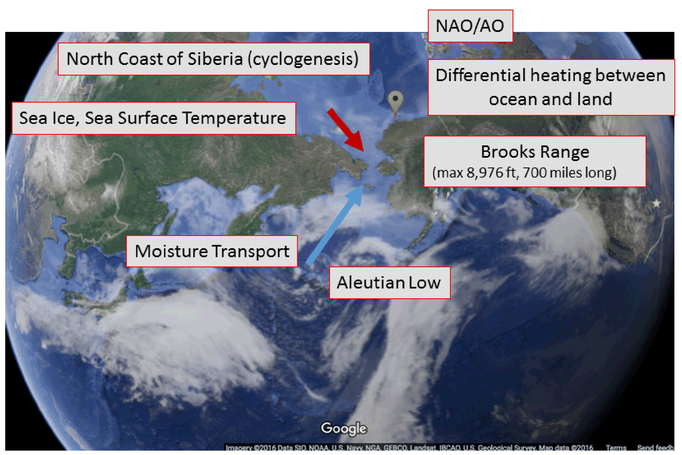


Areas featured for grid
- Entirety of Alaska and Brooks Range
- Chukchi and Beaufort Seas, Bering Strait

Grid resolution ranges from about ne30 (about 111km) to ne240 (about 14km). Using a variable resolution grid instead of a uniform high resolution grid reduces computing time. The larger the number of grid elements, the higher the computational cost; so a smaller number of grid elements is preferred. However, smaller areas of refinement may not capture weather and climate processes that are important to resolve before they reach the North Slope of Alaska. Testing grids with varying sized areas of refinement gives us information about areas which may be important to resolve.

III. Controls on North Slope Climate

- Brooks Range
  - Enhances Arctic Frontal Zone (Crawford and Serreze 2014)
- Coasts
  - Northern coast of Siberia (cyclogenesis) (Crawford and Serreze 2014)
  - Areas of differential heating between Arctic Ocean and snow-free land, influenced by topography (Crawford and Serreze 2014)
- Aleutian Islands-Bering Strait
  - Aleutian semipermanent low
  - Cyclones through Bering Sea-Aleutian Islands (Vavrus 2013), moisture transport, Rossby waves breaking (Liu and Barnes 2015)
  - Loss of sea ice, change in SST, seasonal cycle of SST (Carton et al. 2015)



(Serreze et al. 2001, Vavrus 2013, Crawford and Serreze 2014, Carton et al. 2015, Liu and Barnes 2015, F. Krikken and W. Hazeleger 2015)

IV. Next Steps

The three different variable resolution grid configurations will be used in an atmospheric general circulation model (most likely CAM5.3) in an AMIP-style simulation. Simulation output will be compared with data from the Atmospheric Radiation Measurement (ARM) sites located at the North Slope of Alaska and with satellite simulations to see how horizontal resolution changes cloud amount.

Acknowledgements

Simulations for CAM5 run at NCAR in 2011. SQuadGen was created by Paul Ullrich. For more information, visit https://github.com/ClimateGlobalChange/squadgen.

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