Exceptional service in the national interest

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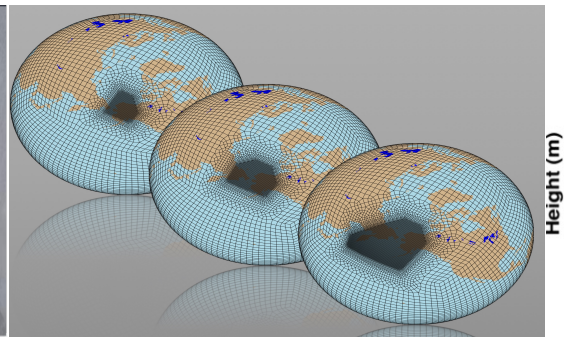

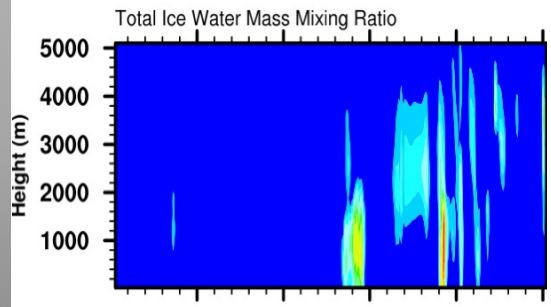

Paths Towards Routine High Resolution Atmospheric Modeling of the North Slope of Alaska

AMS Joint Session 1: Polar Clouds and Climate Part I

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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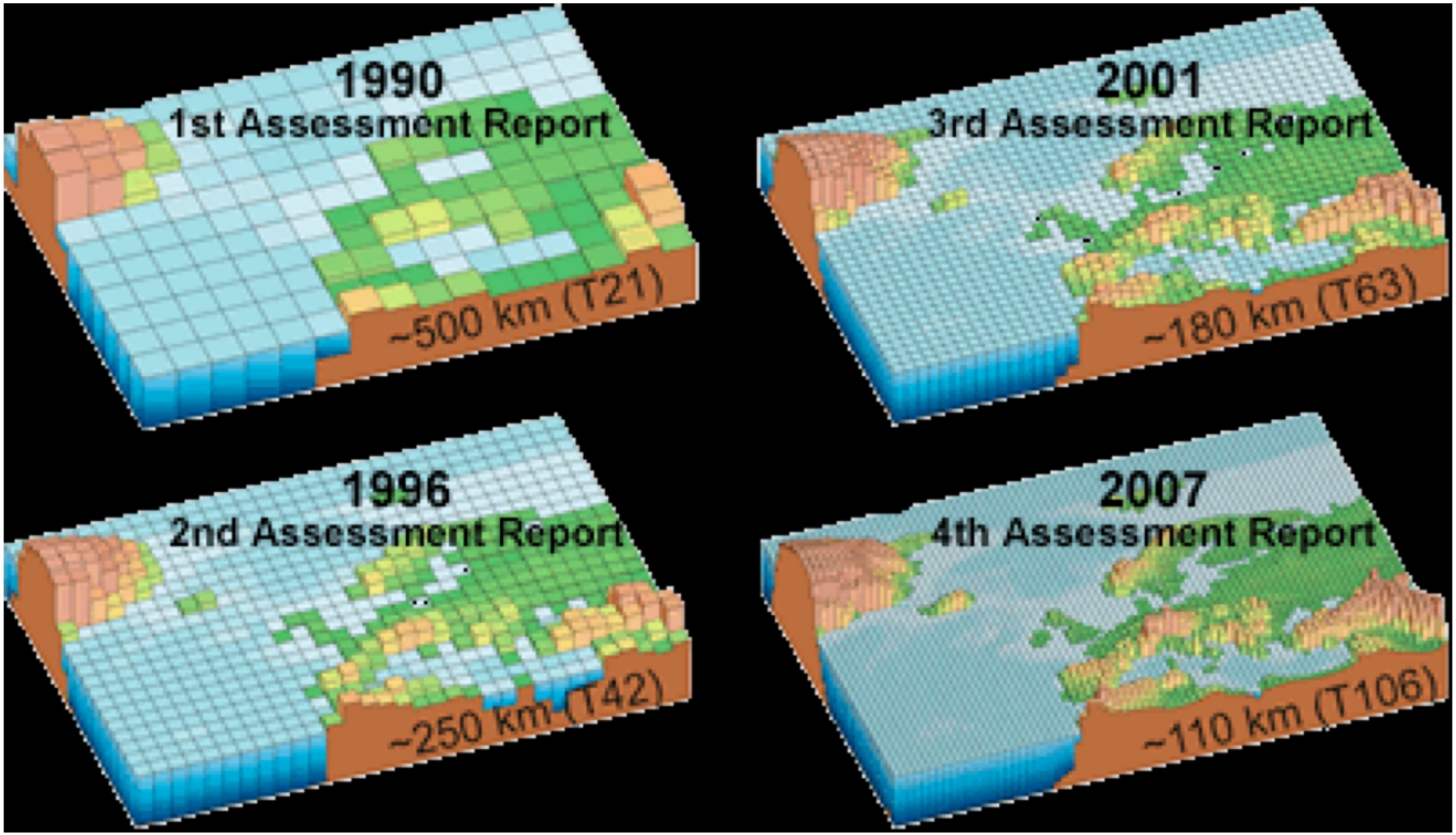
Global Model develoment is trending to higher spatial resolutions.



From IPCC AR4 2007, Figure 1.4

Cloud amount in the Arctic does not look like it changes with resolution.

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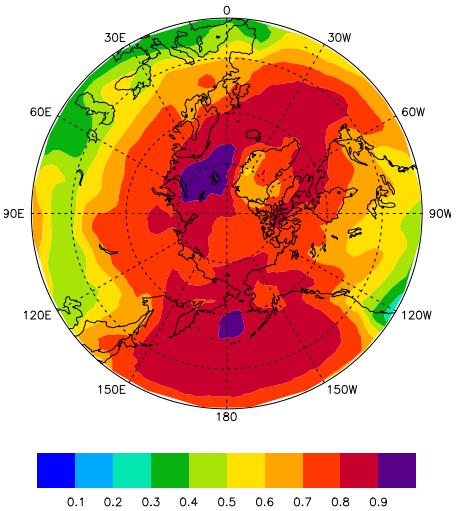
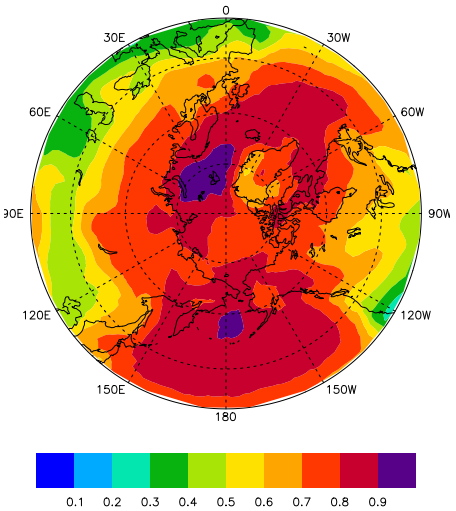
Variable Resolution is used to preview high resolution without computational expense.

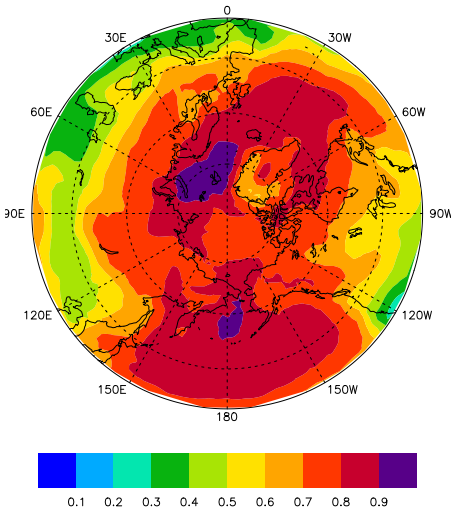
2° (~ 225 km)



1° (~ 110 km)

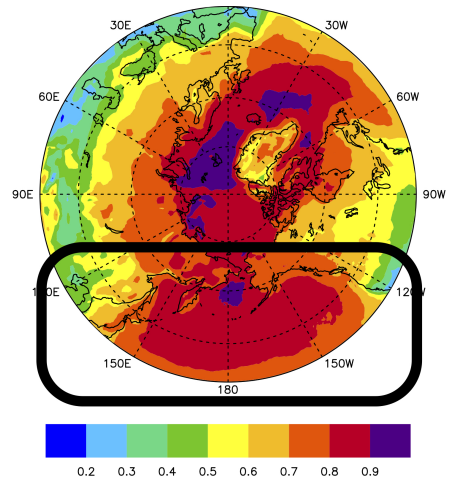


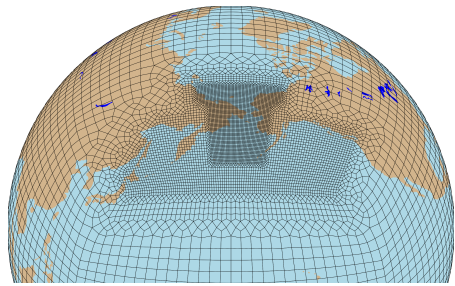
$\frac{1}{2}^\circ$ (~ 60 km)



$1^\circ \rightarrow \frac{1}{4}^\circ \rightarrow \frac{1}{8}^\circ$

(~ 110 → 25 → 14 km)

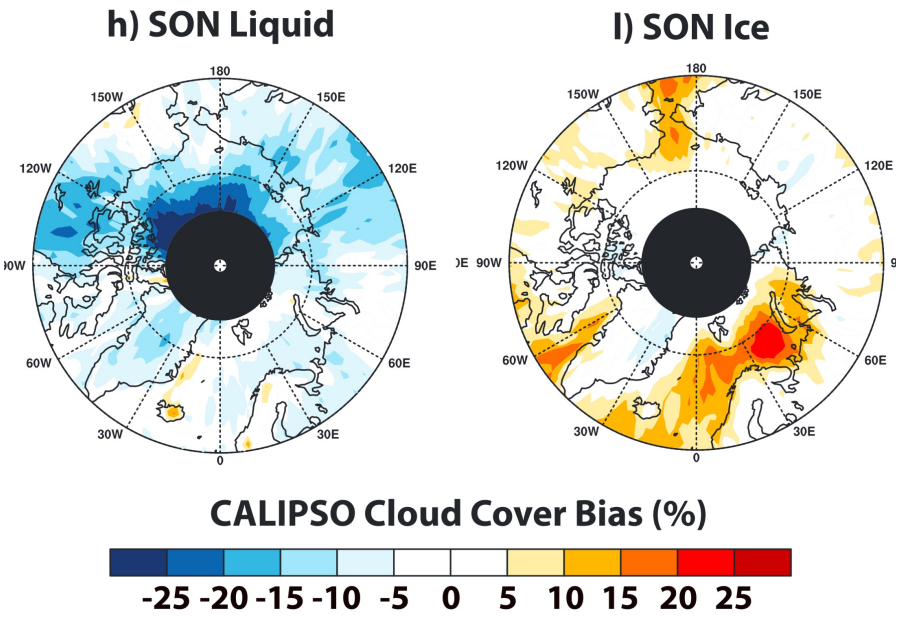


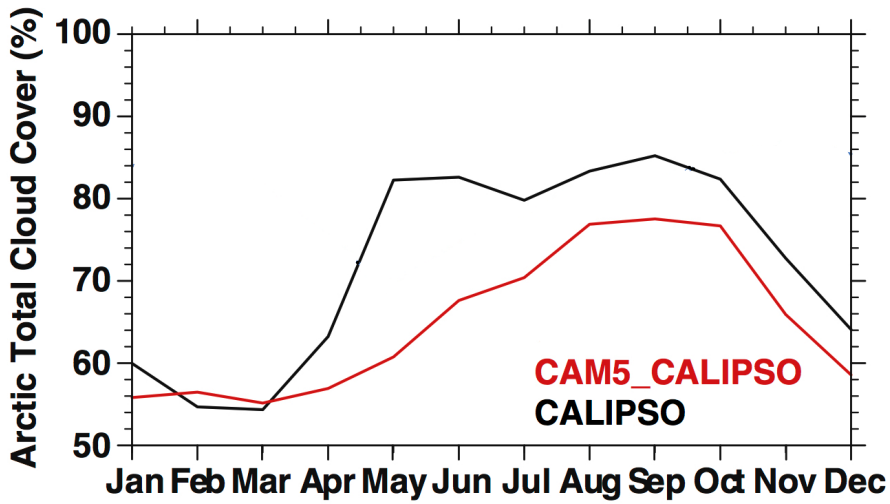


Annual Average of vertically integrated total cloud fraction from CESMv1.2. Cloud fraction slightly decreasing in variable resolution grid.

What will clouds look like in the future Arctic climate?

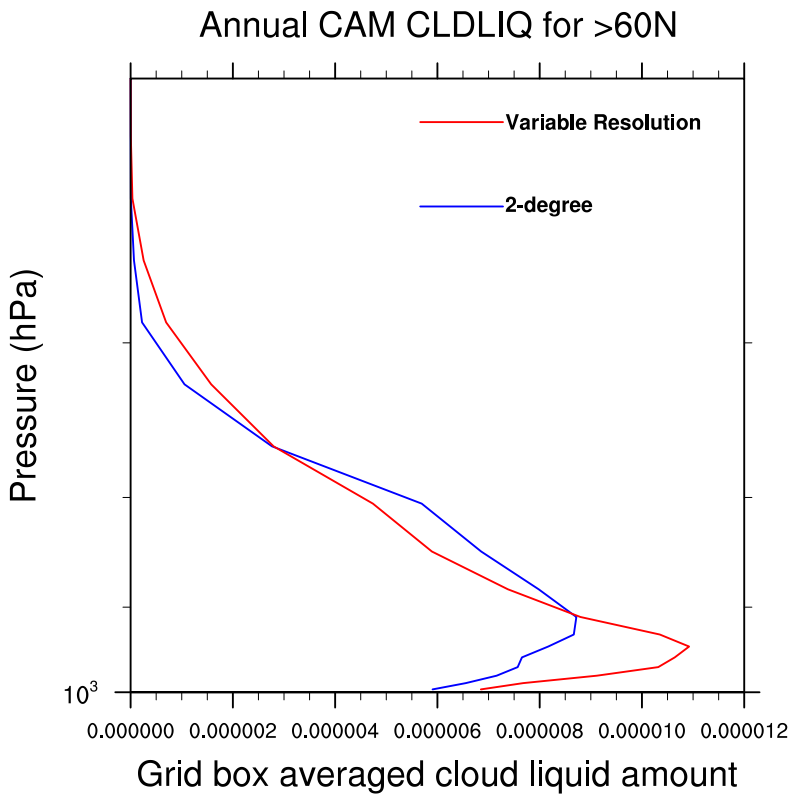
- Nonhydrostatic Atmospheric General Circulation Models (AGCMs) are under development.
  - Uncertain how (if) resolution will change Arctic clouds
- Model's phase and cloud amount do not agree with observations

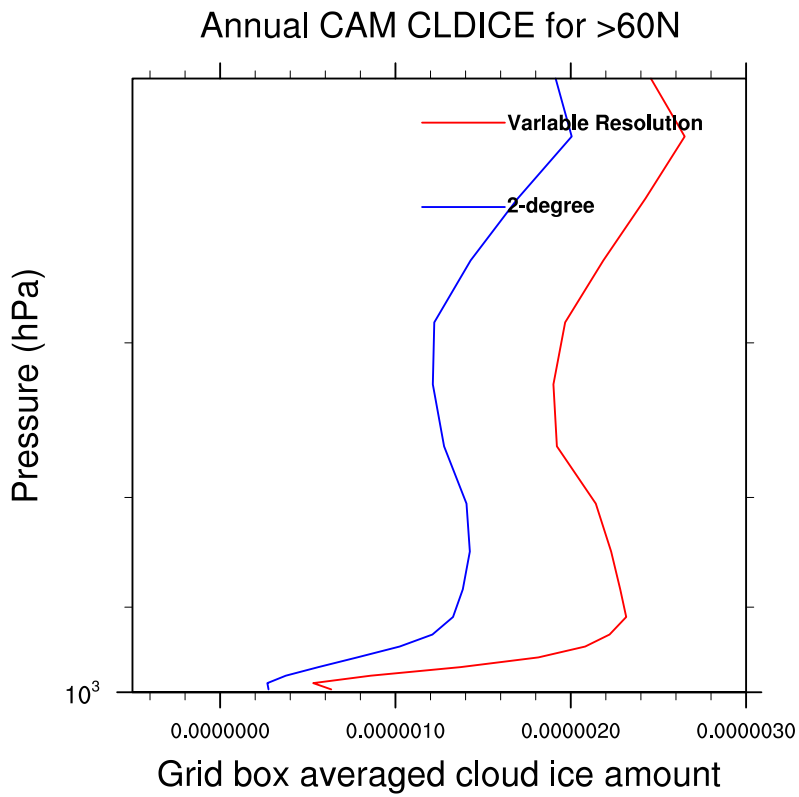




Figures adapted from Kay et al 2016 a,b comparing Community Atmosphere Model (CAM) with CALIPSO satellite observations

Resolution Dependence of Clouds > 60N





We see our resolution destination ... What might it look like?

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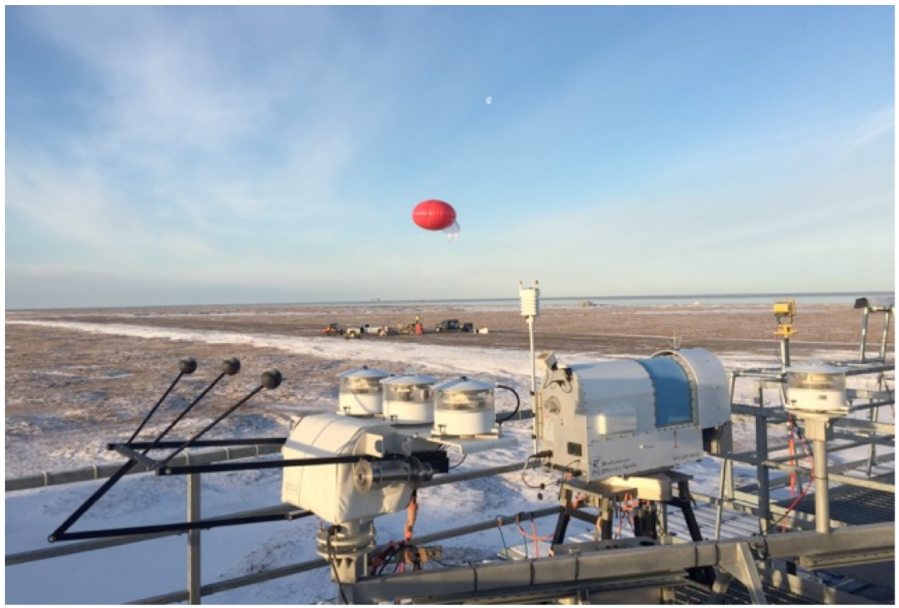
Focusing on the Department of Energy's Atmospheric Radiaion Measurement (ARM) North Slope of Alaska (NSA) Facilities at Oliktok Point, near Prudhoe Bay

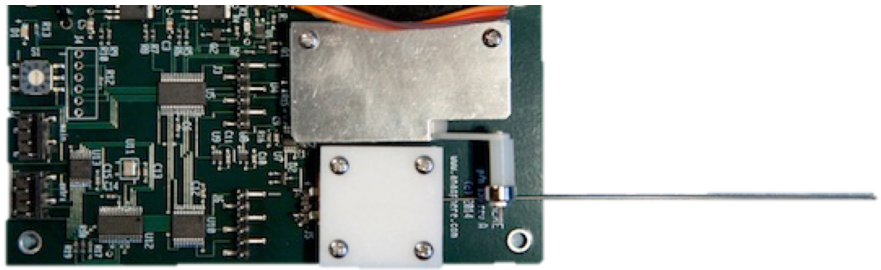
- System for Atmospheric Modeling (SAM), v 6.10.10 (courtesy of Marat Khairoutdinov)
- Configuration, Initialization, and Boundary Conditions
  - ARM's Single Column Model (SCM) ECMWF Reanalysis
  - Resolution: Δ x = Δ y = 100 m; Δ z = 40 m
  - Domain size: 12.8 km x 12.8 km (horizontal); 5.1 km (vertical)
  - October, 2016 at Oliktok Point, Alaska
  - 2-moment Bulk Morrison Microphysics with assumptions made regarding Ice Concentration following Ovchinnikov et al 2010.

In Situ Cloud Measurements at Oliktok in October, 2016



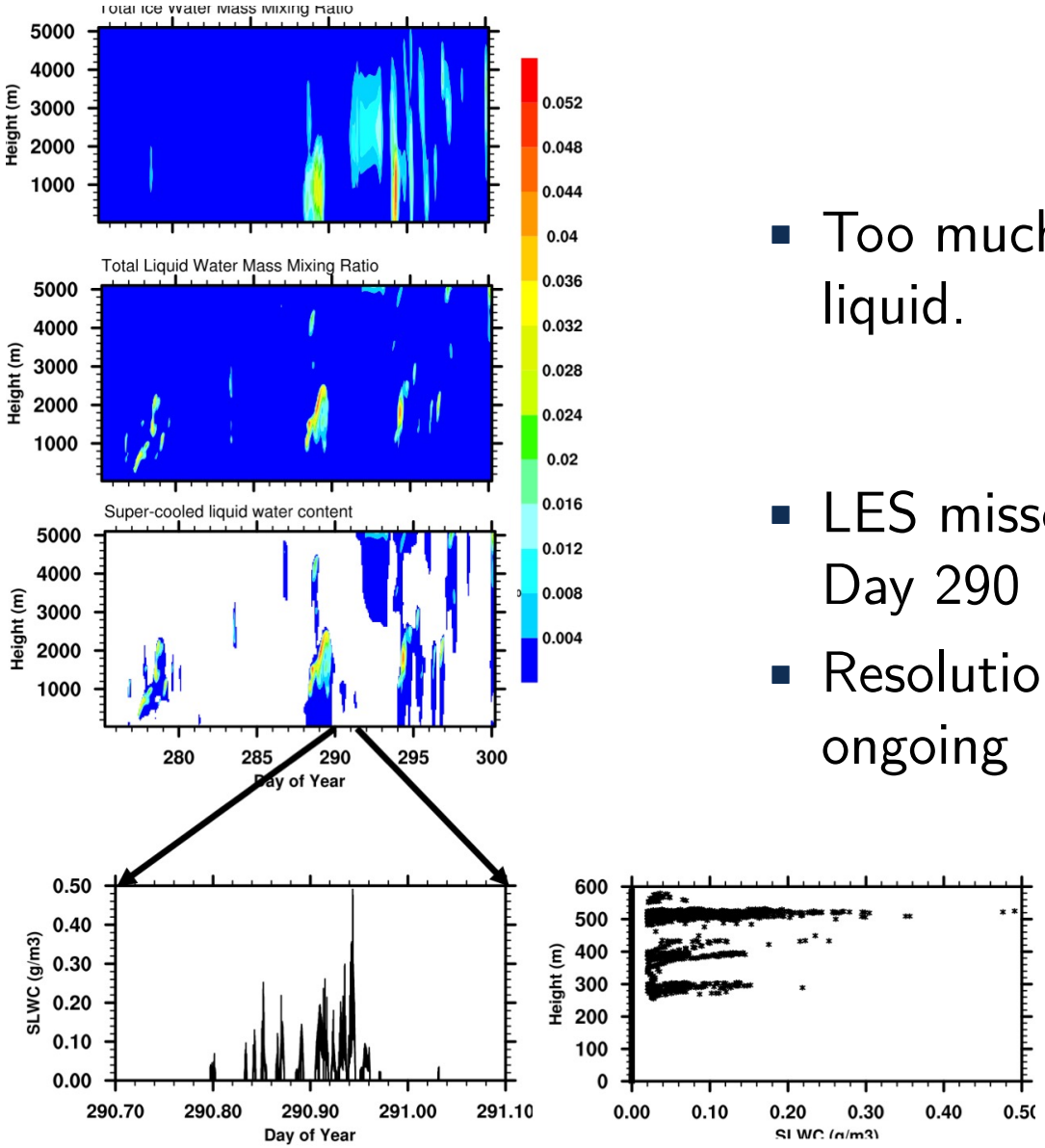
The AMF-3 and ARM tethered balloon, as seen by a DataHawk in October 2016

Photo Credit: http://ciresblogs.colorado.edu/alaska-unmanned-3/2016/10/19/more-good-weather/
http://ciresblogs.colorado.edu/alaska-unmanned-3/2016/10/20/beginning-to-feel-like-the-arctic/



Supercooled Liquid Water Sensor from Anasphere

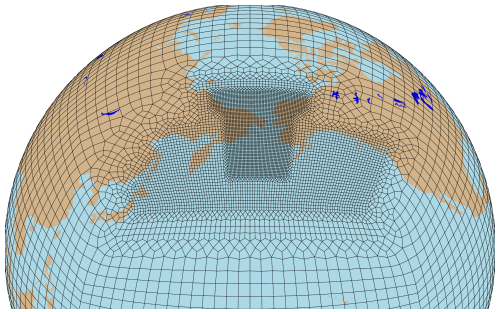
Clouds at Oliktok in October, 2016



- Too much ice, not enough liquid.
- LES misses cloudy event on Day 290
- Resolution sensitivity tests are ongoing

Summary

- Global models have increasing resolution, prompting use of variable resolution to identify resolution sensitivities
- Large Eddy Simulations (LES) for October, 2016, at Oliktok, Alaska recreate cloud occurance
- LES, similar to global models, have smaller supercooled liquid water content compared to in situ measurements from tethered balloons



Truck and Tether

Conclusions – Observations Lead the Way

- Observations that are needed to benefit future research
  1. Satellite measurements that can discern phase of cloud
  2. Ground-based measurements that can discern phase of cloud
  3. In situ aerial measuerments to validate retrieval algorithms
  4. 10-30 years of data
  5. High resolution modeling to put pieces together
- Recommended instruments that are needed to make these observations
  - MWR, Radar, Lidar, Tethered Balloon System, and Unmanned Aircraft
- Greatest observational needs this discipline
  1. Comprehensive 24/7 coverage of Arctic
  2. High resolution global earth system model to help us understand the observations