



# Resolution dependency of CAM5 physics and its ramification on aerosol transport into the Arctic

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# Motivation

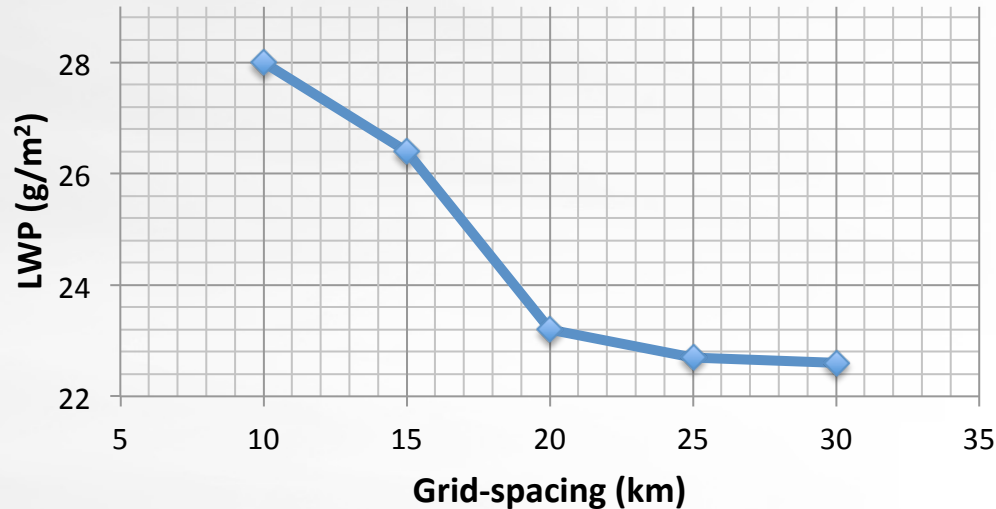
- ▶ Both dynamics and physics play a role:

$$dQ/dt_{(\text{low-res})} = \text{advection}_{\text{coarse}} + \text{parameterizations}_{\text{coarse}}$$

$$dQ/dt_{(\text{high-res})} = \text{advection}_{\text{coarse + fine}} + \text{parameterizations}_{\text{fine}}$$

$$\text{advection}_{\text{coarse}} + \text{advection}_{\text{fine}} + \text{parameterizations}_{\text{fine}}$$

- ▶ Lack of convergence in current cloud parameterization

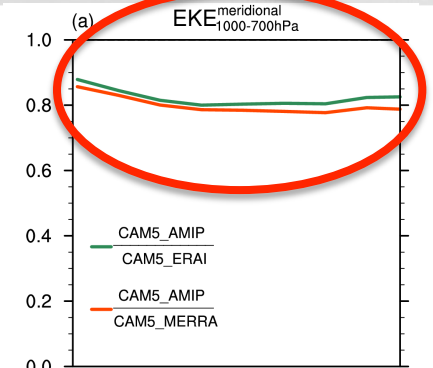
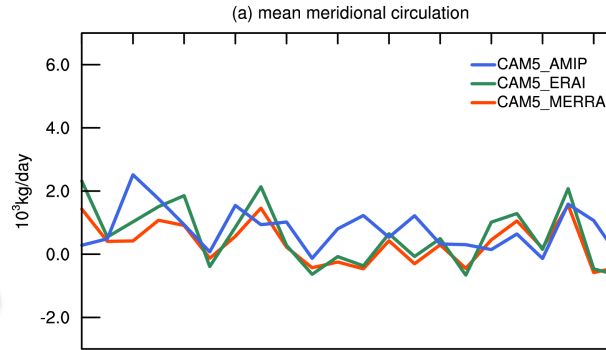
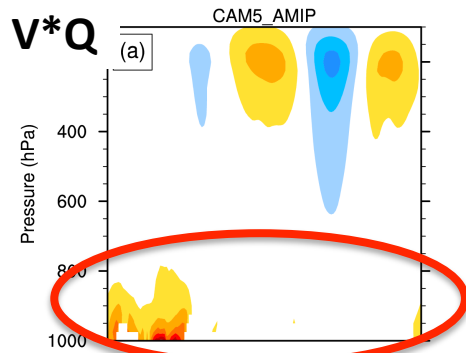


- ▶ High-resolution simulation and variable grids becomes available
- ▶ Scale-aware parameterizations are required

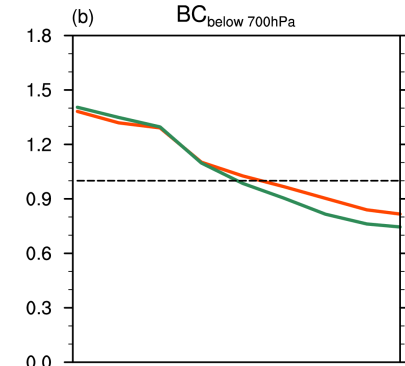
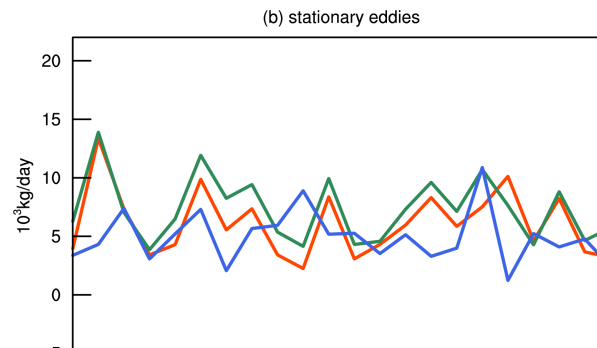
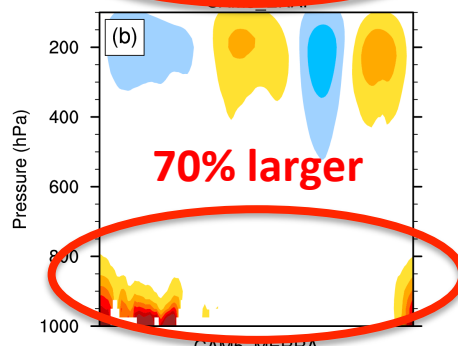
# Motivation poleward transport of aerosols



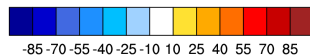
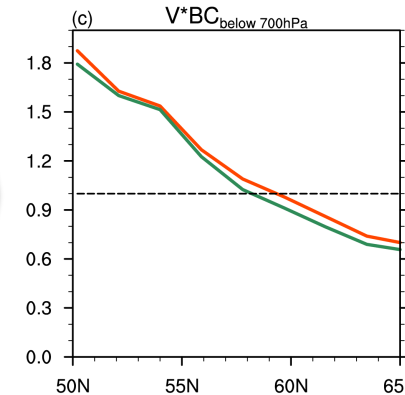
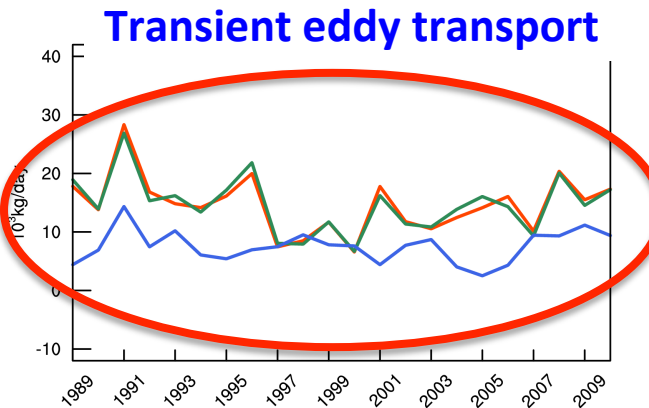
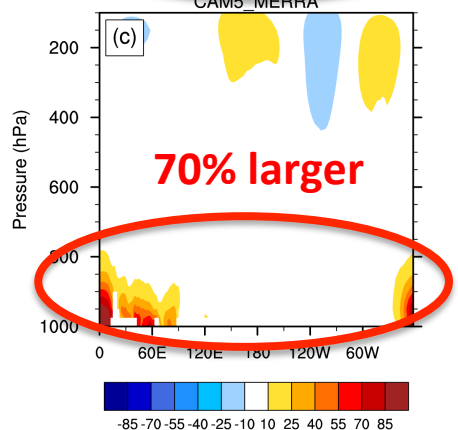
AMIP



Offline  
(ERA-Interim)



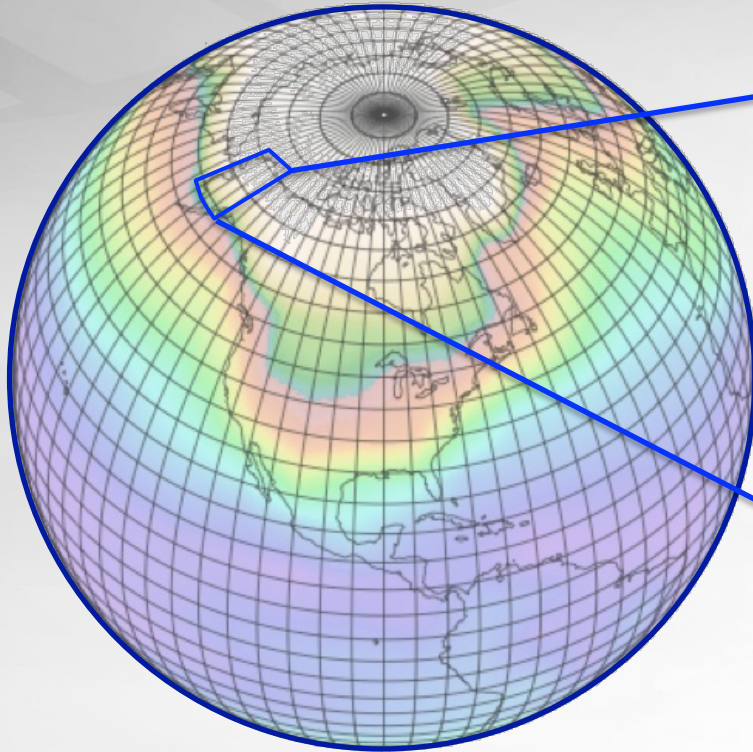
Offline  
(MERRA-2)



# Methodology CAM-to-WRF modeling framework

## Community Atmosphere Model (CAM5)

$\Delta x \sim 200$  km



MAM  
aerosol

UW PBL

ZM deep  
convection

UW shallow  
convection

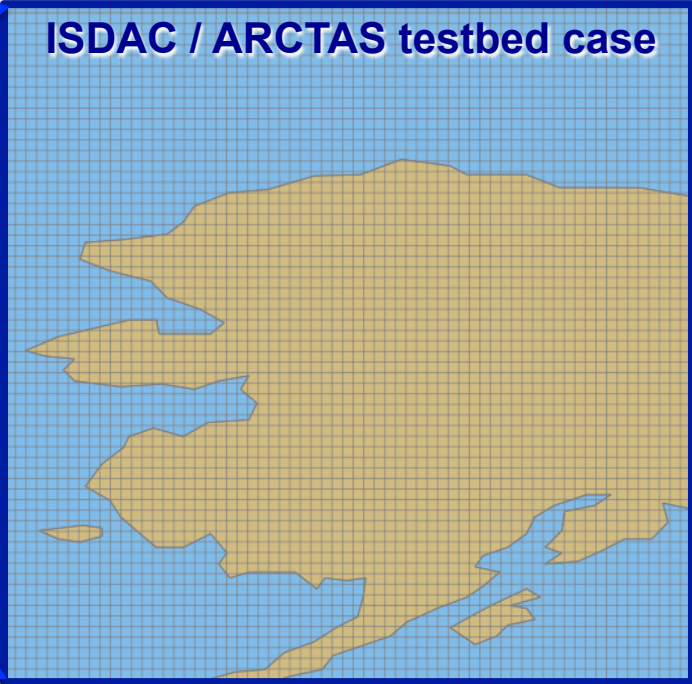
M-G  
microphysics

Initial/boundary  
condition of  
meteorology,  
aerosol, chemistry

POLMIP  
emissions

## Weather Research & Forecasting (WRF)

$\Delta x = 10$  km



400 times more grids  
(if global domain)  
30 times more time-steps



# Black carbon



Pacific Northwest  
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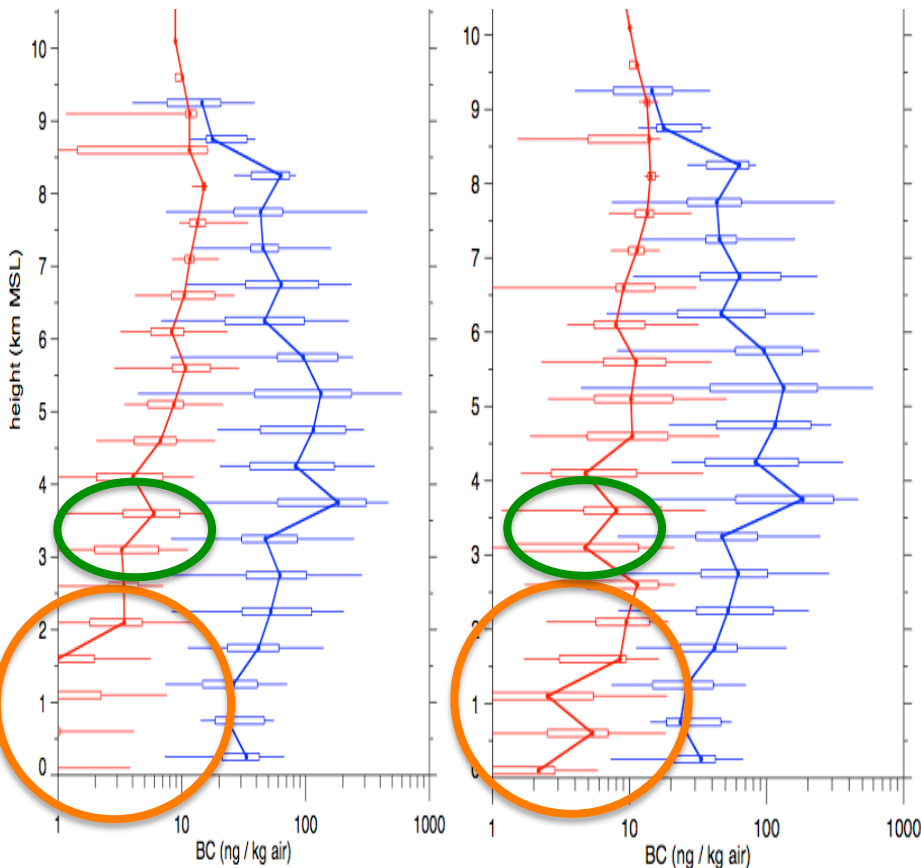
Proudly Operated by **Battelle** Since 1965

**CAM5,  $\Delta x = 1.9 \times 2.5$  deg**

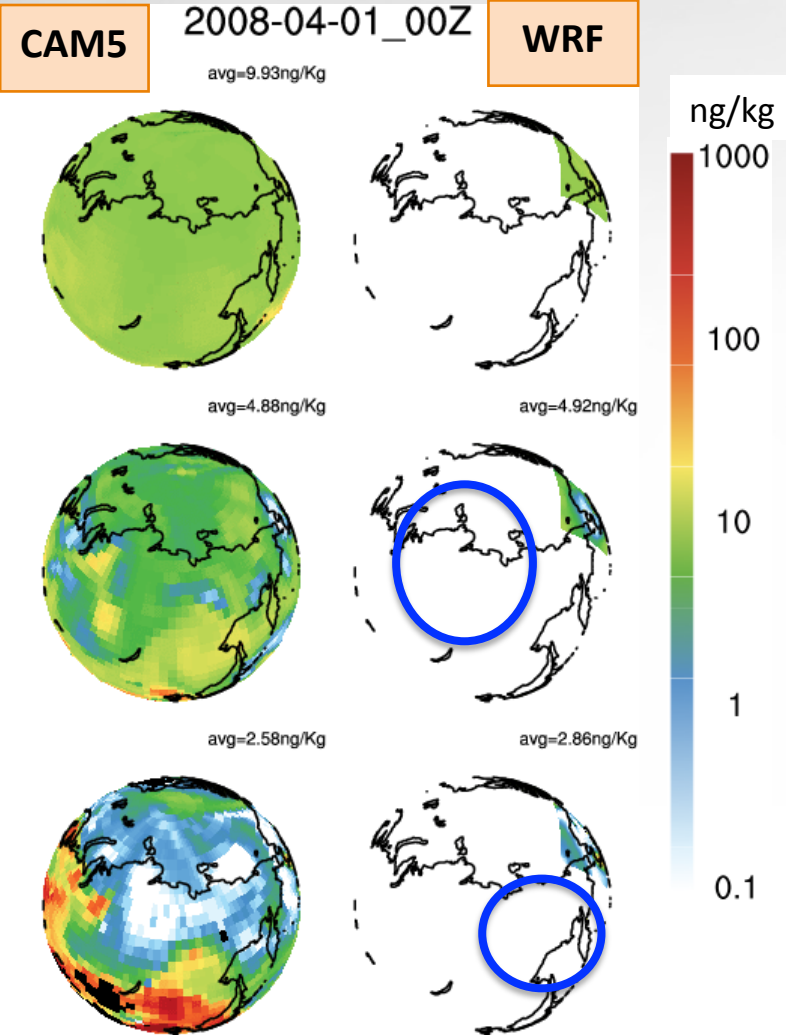
**WRF,  $\Delta x = 10$  km**

CAM5 simulation  
Aircraft measurement

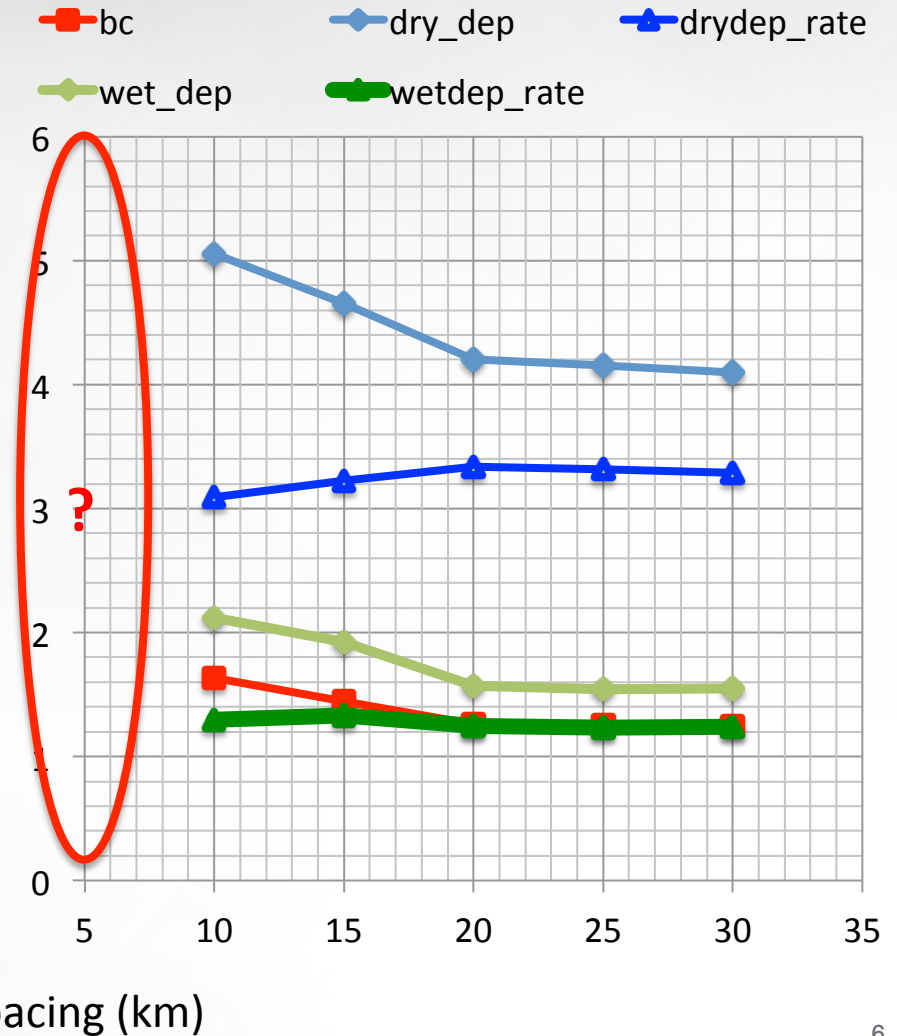
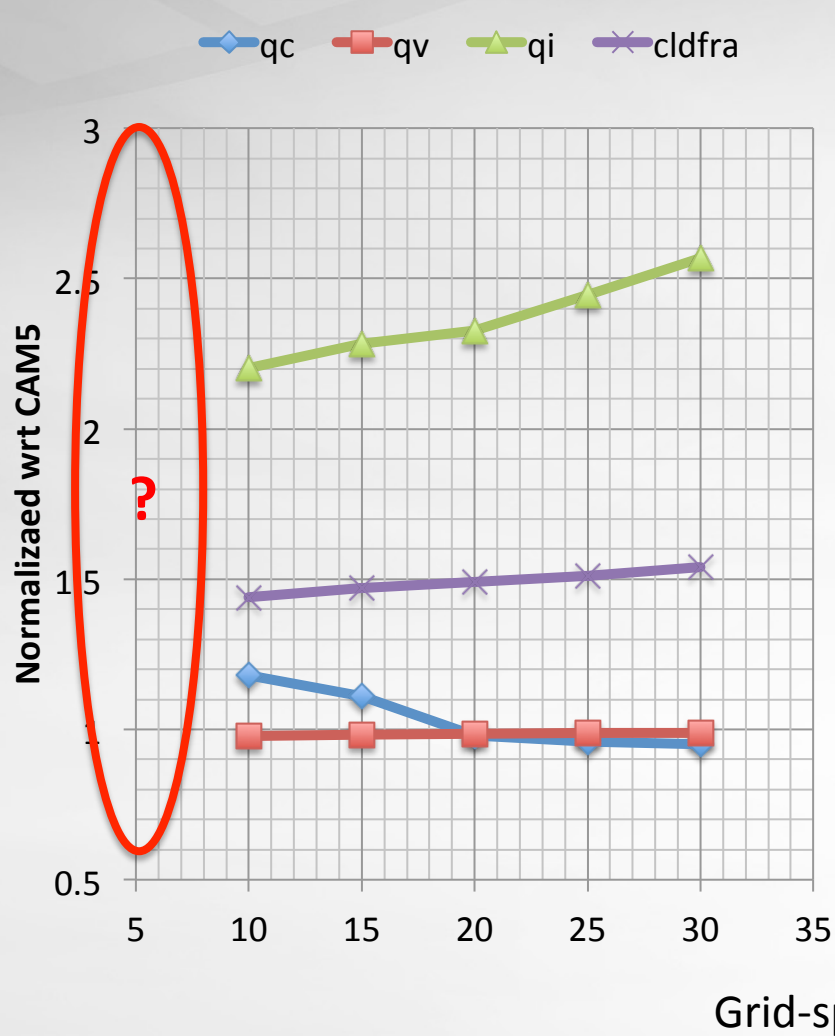
WRF simulation  
Aircraft measurement



(5 DC-8 and 3 P3-B flights)

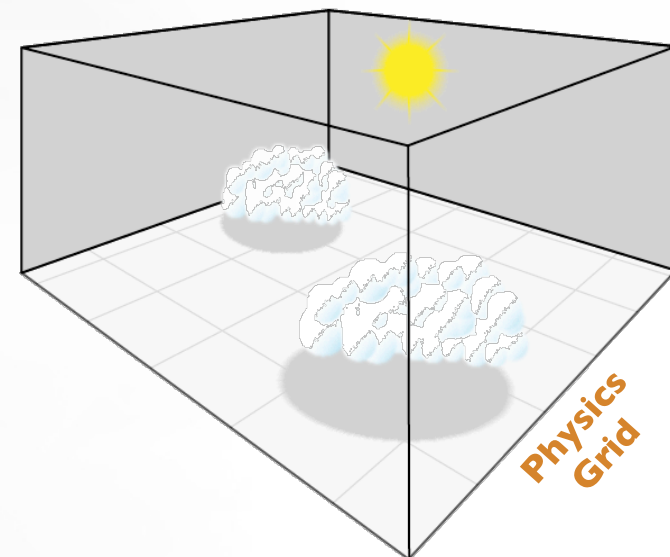
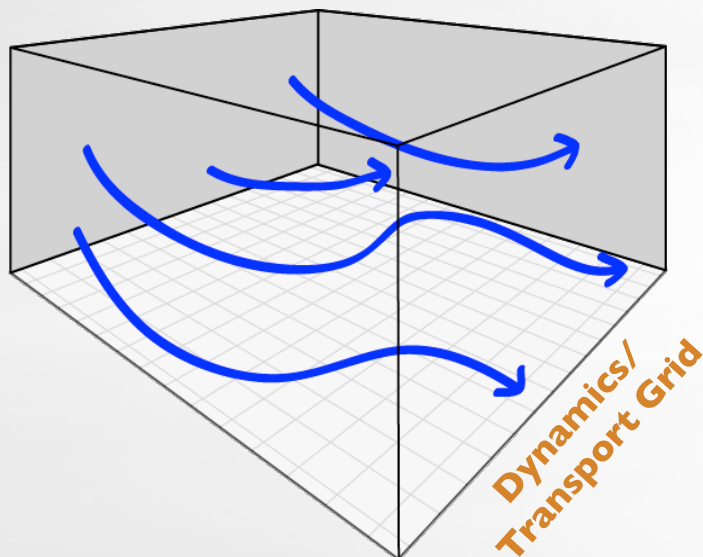


# Resolution dependency of clouds and its effect on aerosols



# Methodology **Separate Physics And Dynamics Setup (SPADS)**

- ▶ Model after Williamson's (1999) dual-resolution model technique, using a regional scale model (WRF).
  - Separate the physics and dynamics so that they operate on independent grids.
  - Keep dynamics grid spacing constant and vary physics resolution for selected parameterizations.
  - Physics tendencies used to update state can come from either grid.

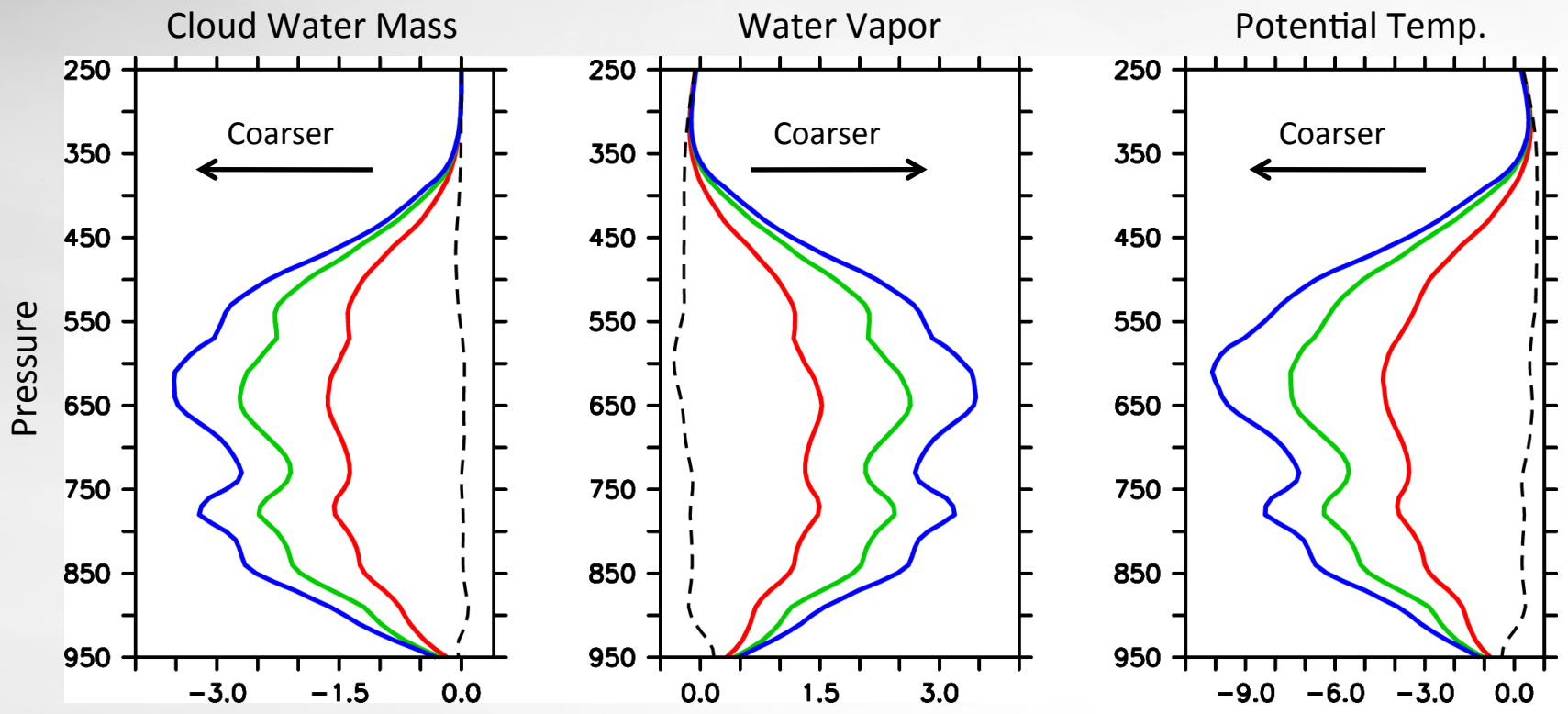




# Resolution-dependency of cloud parameterizations

- ▶ Scale dependency of microphysics would result in very different cloud state if allowed to feed back to model state.

Tendencies from Microphysics (dx = 4 km, 16 km, 25 km, 32 km)

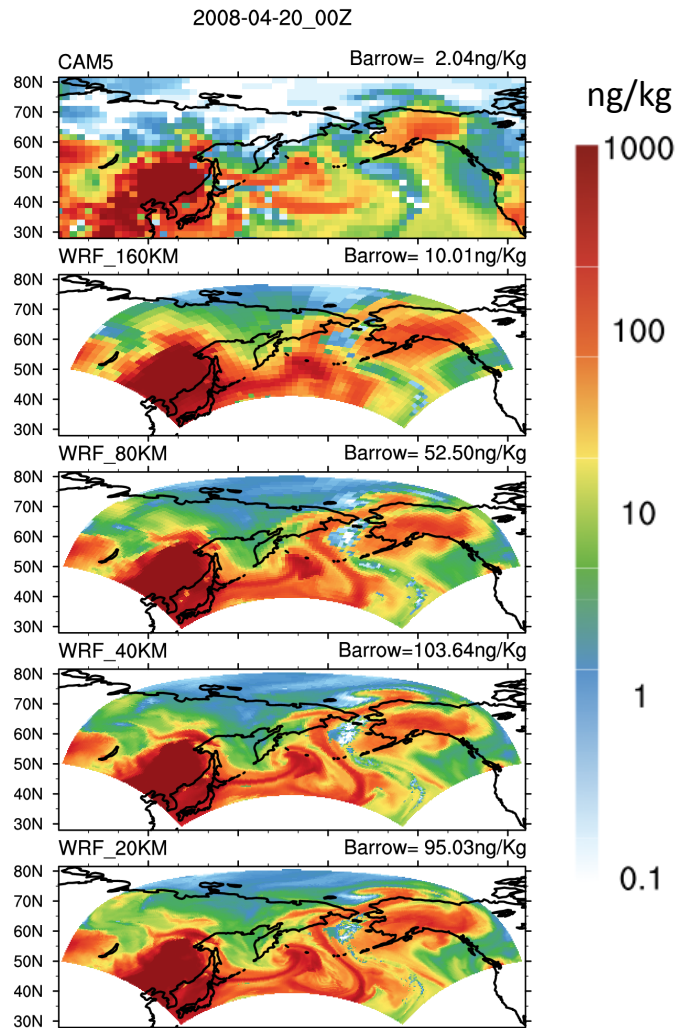


Evaporation →

KF cumulus scheme is insensitive to resolution  
ZM cumulus scheme has some sensitivity



# Long-range transport of black carbon



- ▶ Though topography effect is excluded, aerosol transport associated with meso-scale circulations are better resolved in high-resolution simulations
- ▶ High-resolution simulations show that filamentary structure of transport appears to dominate BC transport into the Arctic (advection<sub>fine</sub>), resulting in significantly higher BC mixing ratio over Barrow at “golden pollution date” (04/20/2008).
- ▶ Local circulation tends to retain BC in the WRF domain

# Summary

- ▶ CAM5-to-WRF framework has been established for dynamical downscaling with consistent physics
- ▶ SPADS has been coded to investigate resolution dependency of physical parameterizations (CAM5 physics on the way!)
- ▶ Current physical parameterizations are found not scale-independent
  - Small eddies increase as resolution increases
  - Small clouds and small aerosol plumes are observed in high-resolution runs
  - High-resolution runs tend to form more clouds and reduce water vapor
  - Filamentary structure of aerosol transport into the Arctic is evident in high-resolution runs
  - Combination of (advection<sub>fine</sub> + parameterizations<sub>fine</sub>) in high-resolution runs differs from (parameterizations<sub>coarse</sub>) effect in low-resolution runs



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**Thank you!**