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Assessing the WRF model with the CAM5 physics suite (WRF-CAM5): model implementation, evaluation, and resolution sensitivity

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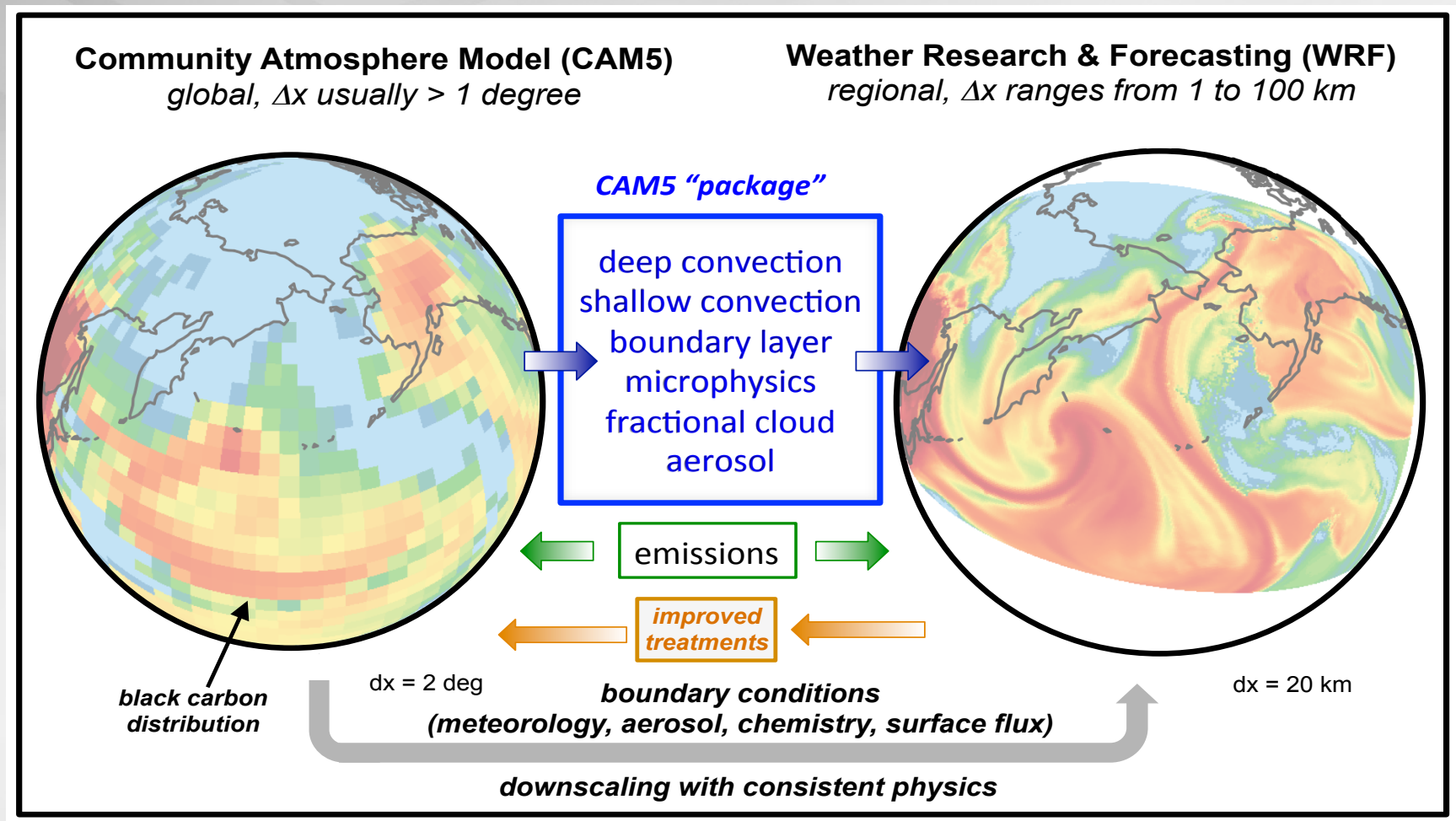
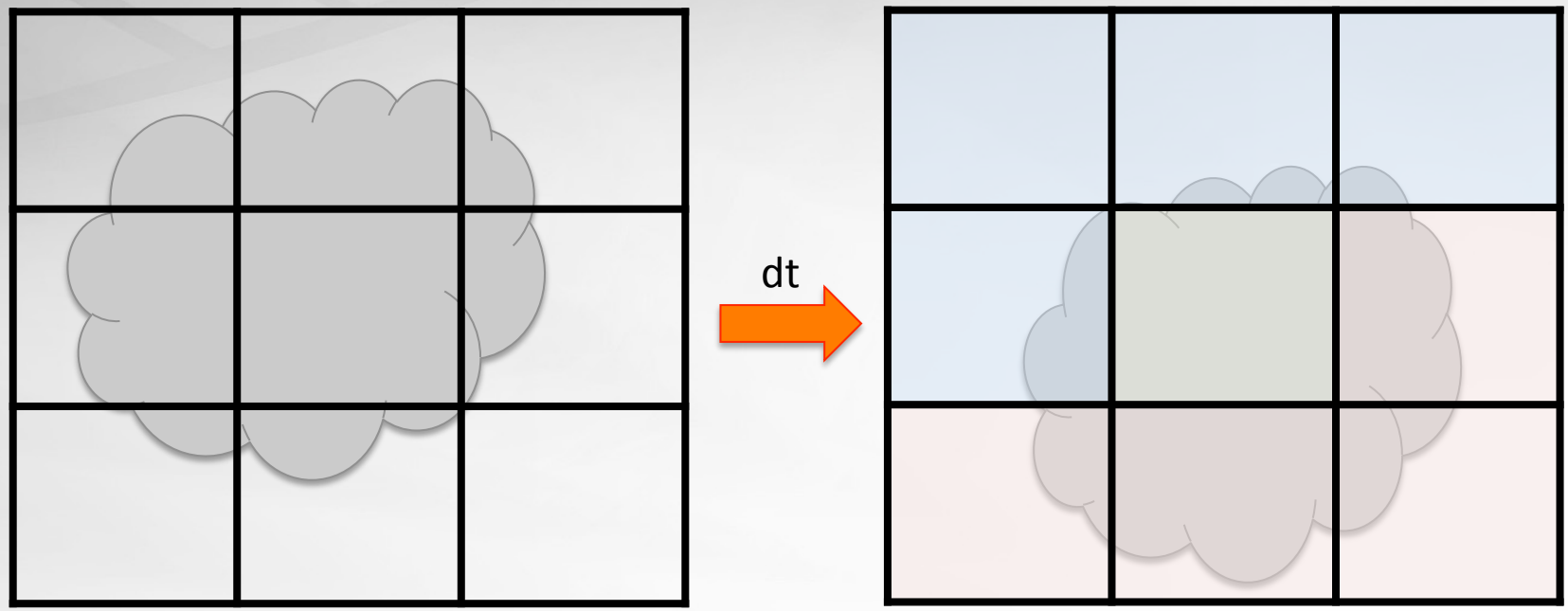
Concept

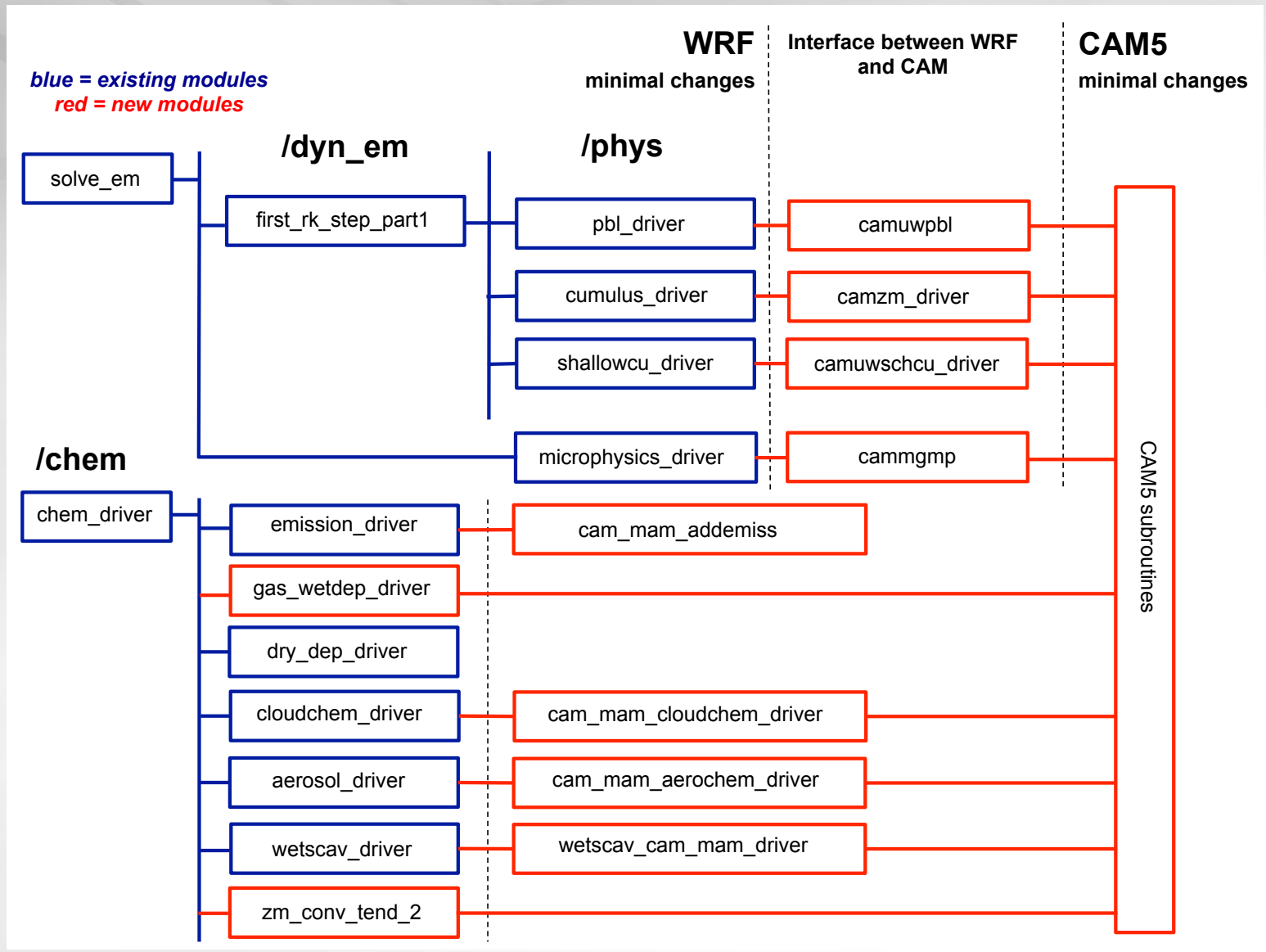


Macrophysics

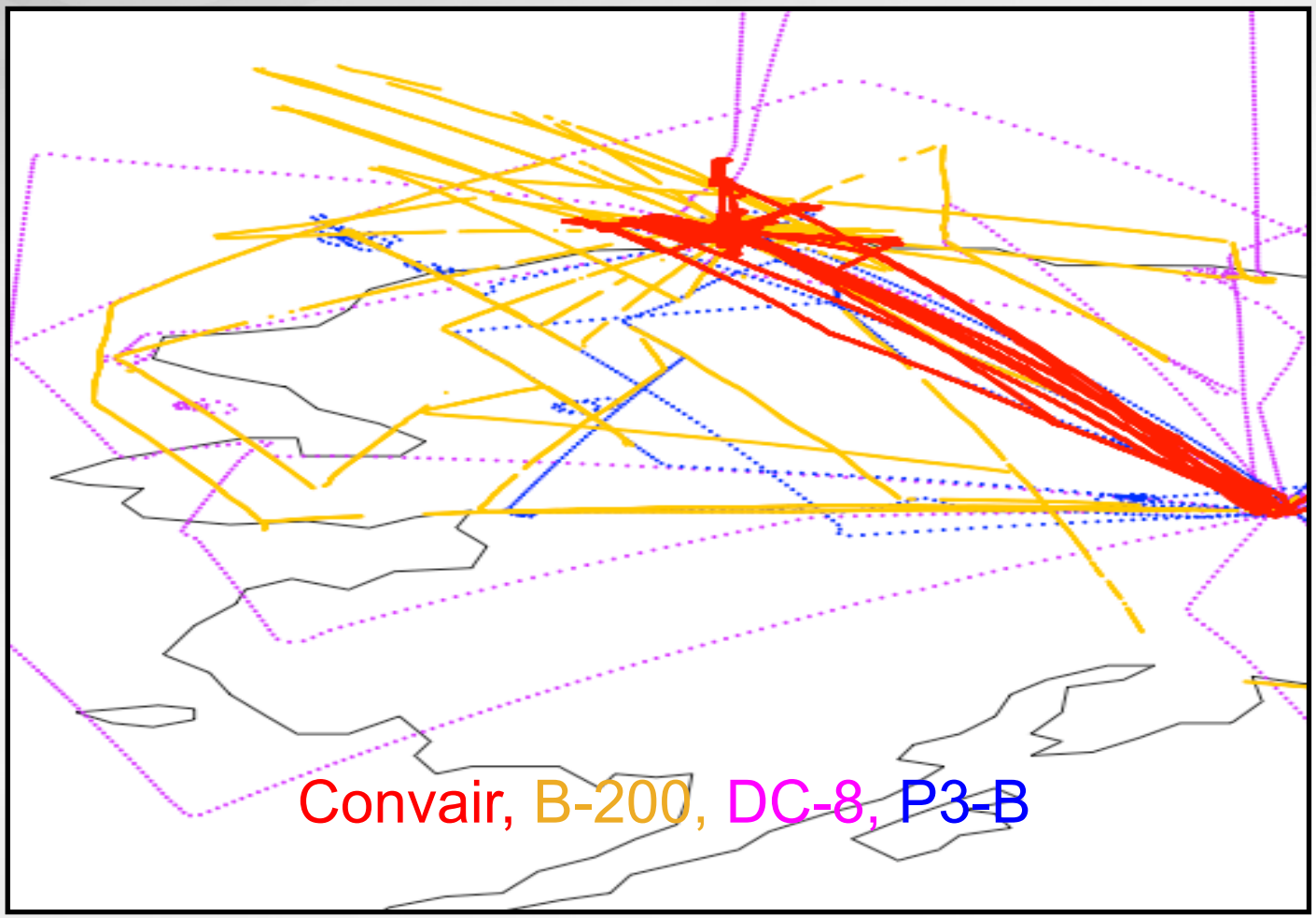


- Cloud fraction
- Large-scale condensation and evaporation
- Aerosol activation and re-suspension
- Detrainment of liquid and ice condensate (mass+number) from convections (treated in physics_addtendc)

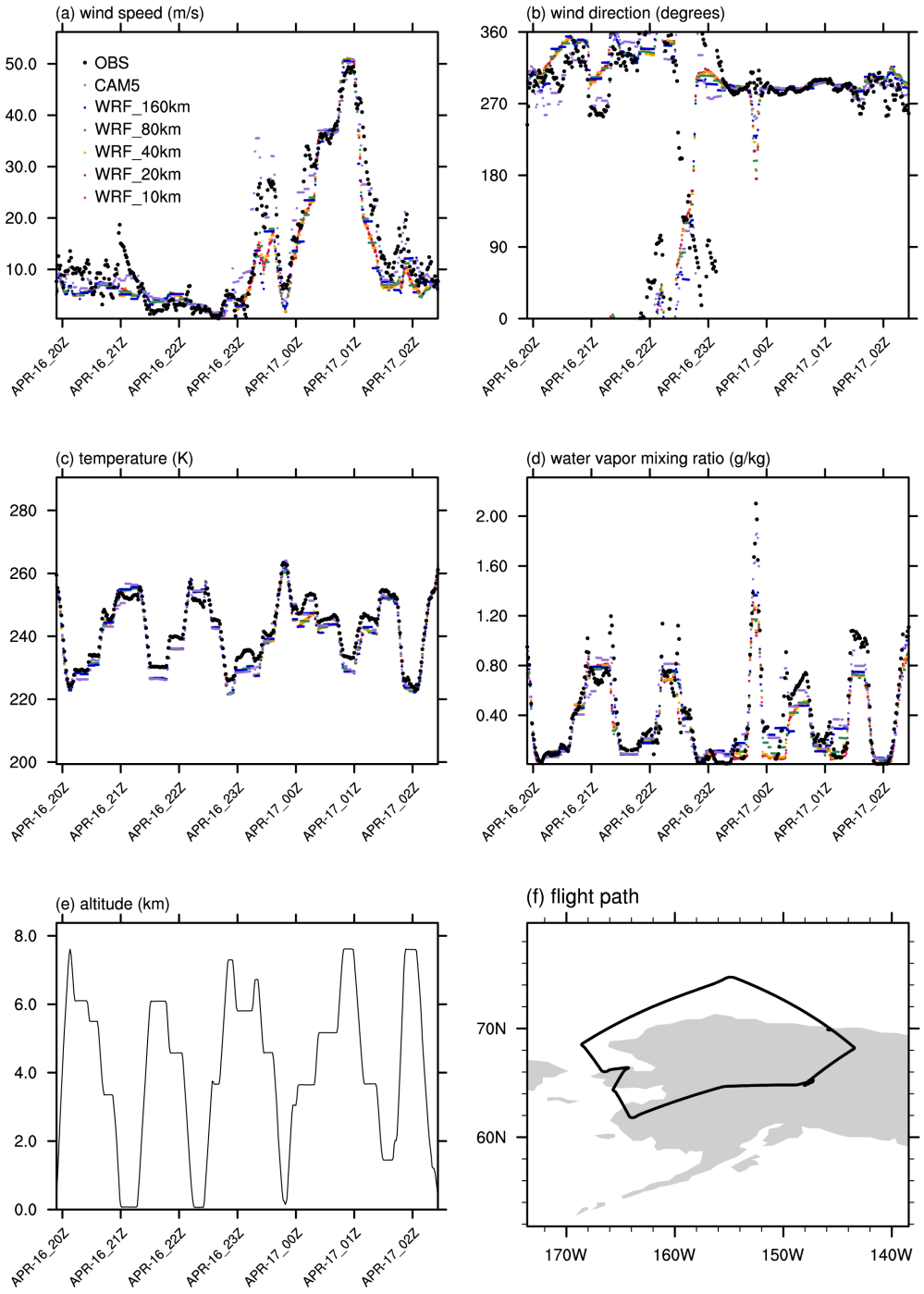
Code implementation



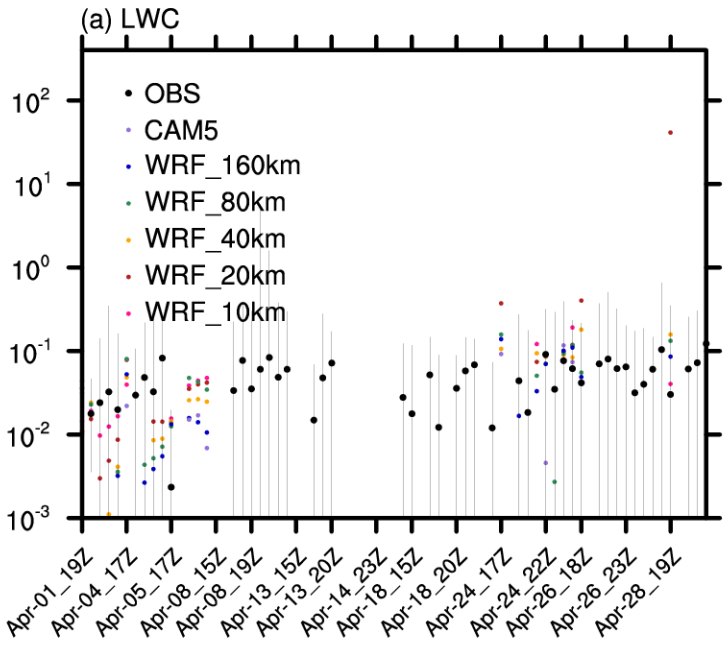
ARCTAS/ARCPAC/ISDAC (April, 2008)

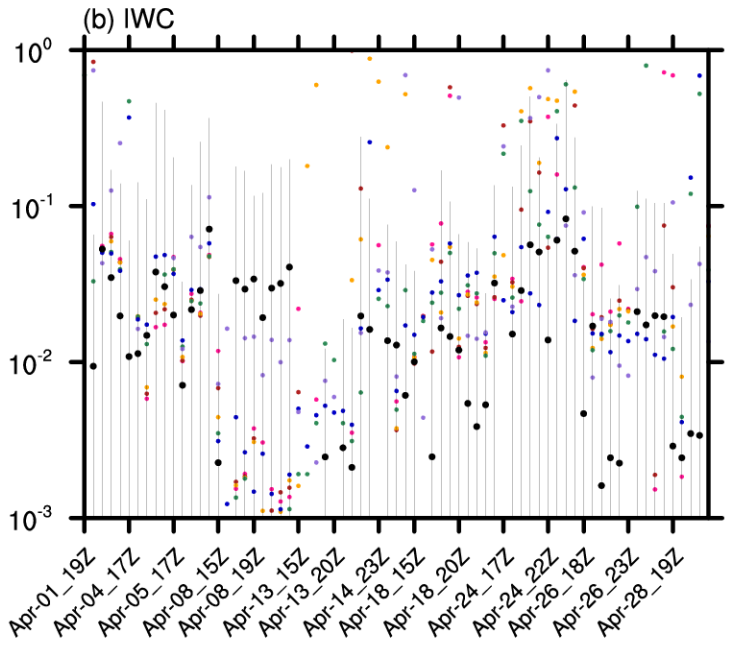


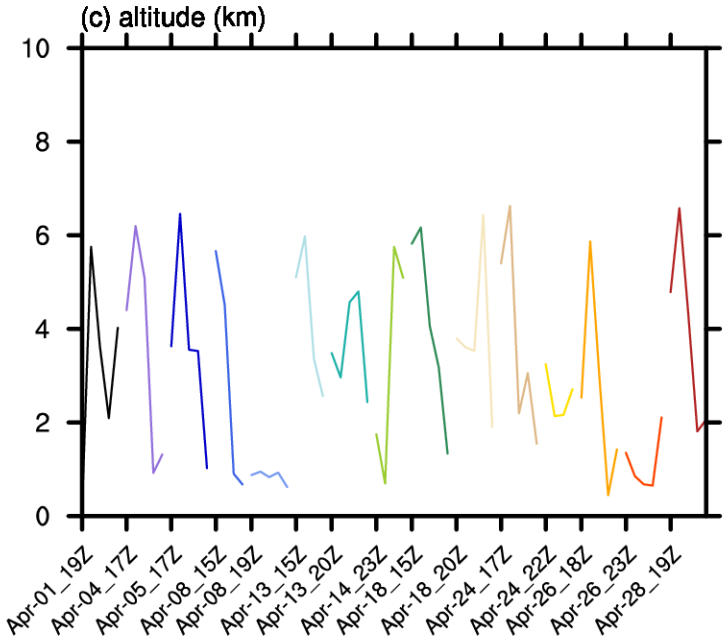
Meteorology

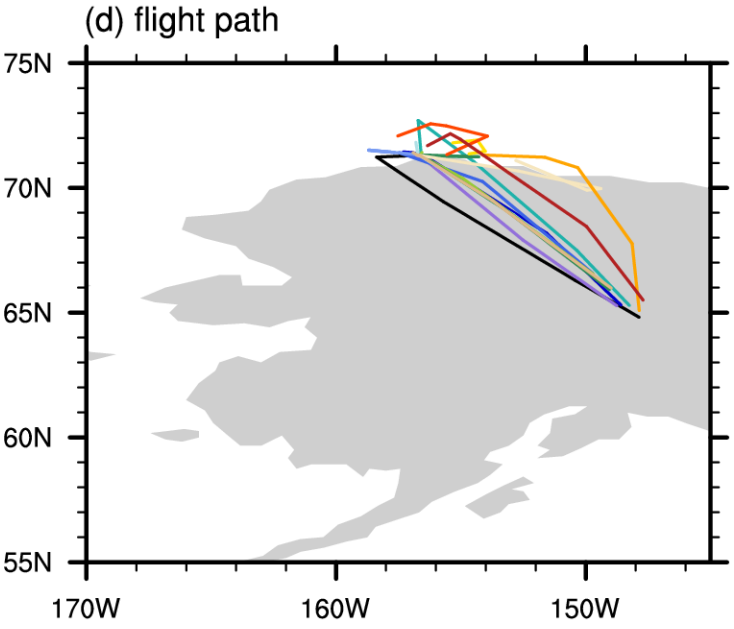


Clouds

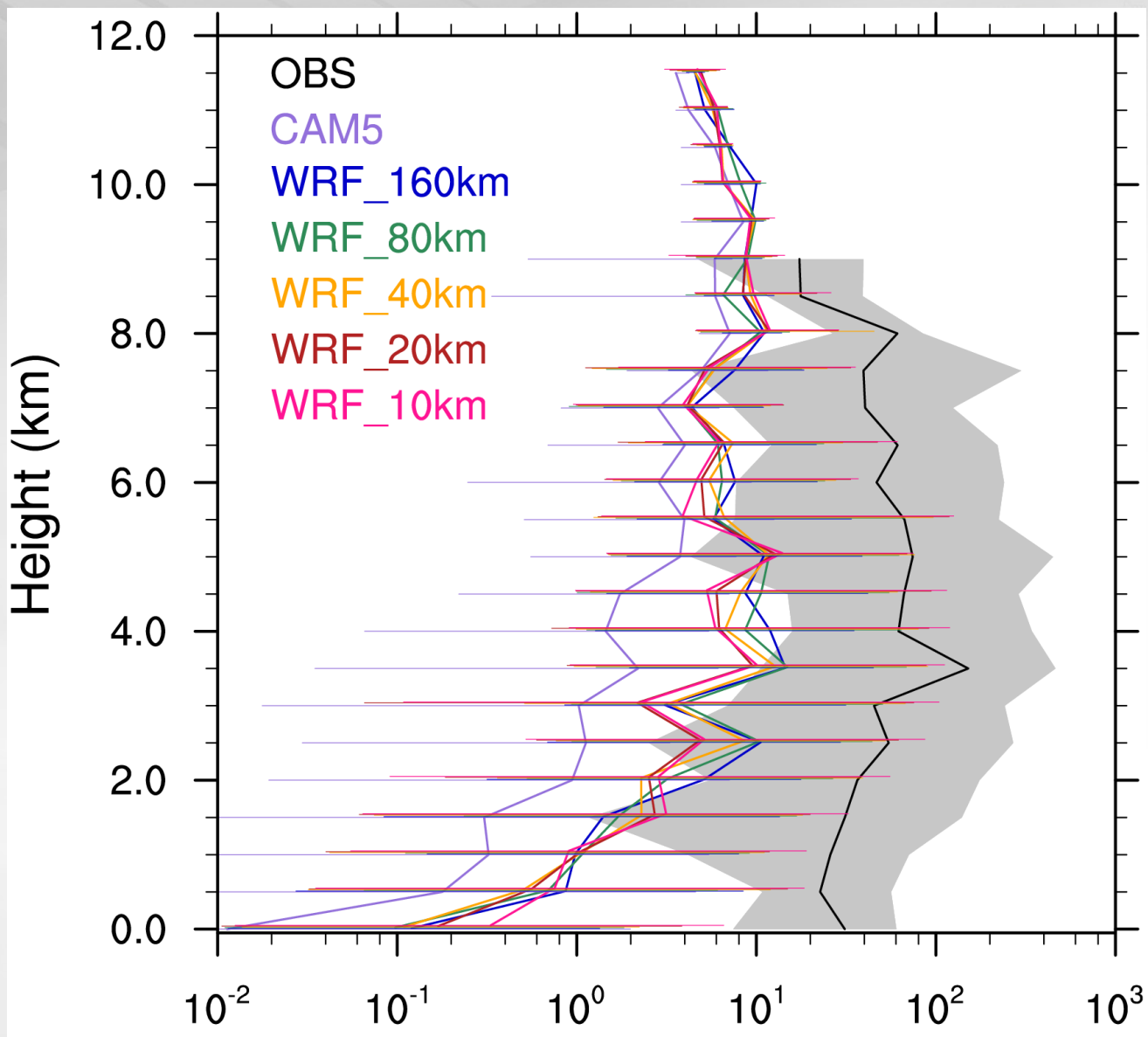

(a) LWC
OBS
CAM5
WRF_160km
WRF_80km
WRF_40km
WRF_20km
WRF_10km
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
Apr-01_19Z
Apr-04_17Z
Apr-05_17Z
Apr-08_15Z
Apr-08_19Z
Apr-13_15Z
Apr-13_20Z
Apr-14_23Z
Apr-18_15Z
Apr-18_20Z
Apr-24_17Z
Apr-24_22Z
Apr-26_18Z
Apr-26_23Z
Apr-28_19Z


(b) IWC
10^{0}
10^{-1}
10^{-2}
10^{-3}
Apr-01_19Z
Apr-04_17Z
Apr-05_17Z
Apr-08_15Z
Apr-08_19Z
Apr-13_15Z
Apr-13_20Z
Apr-14_23Z
Apr-18_15Z
Apr-18_20Z
Apr-24_17Z
Apr-24_22Z
Apr-26_18Z
Apr-26_23Z
Apr-28_19Z

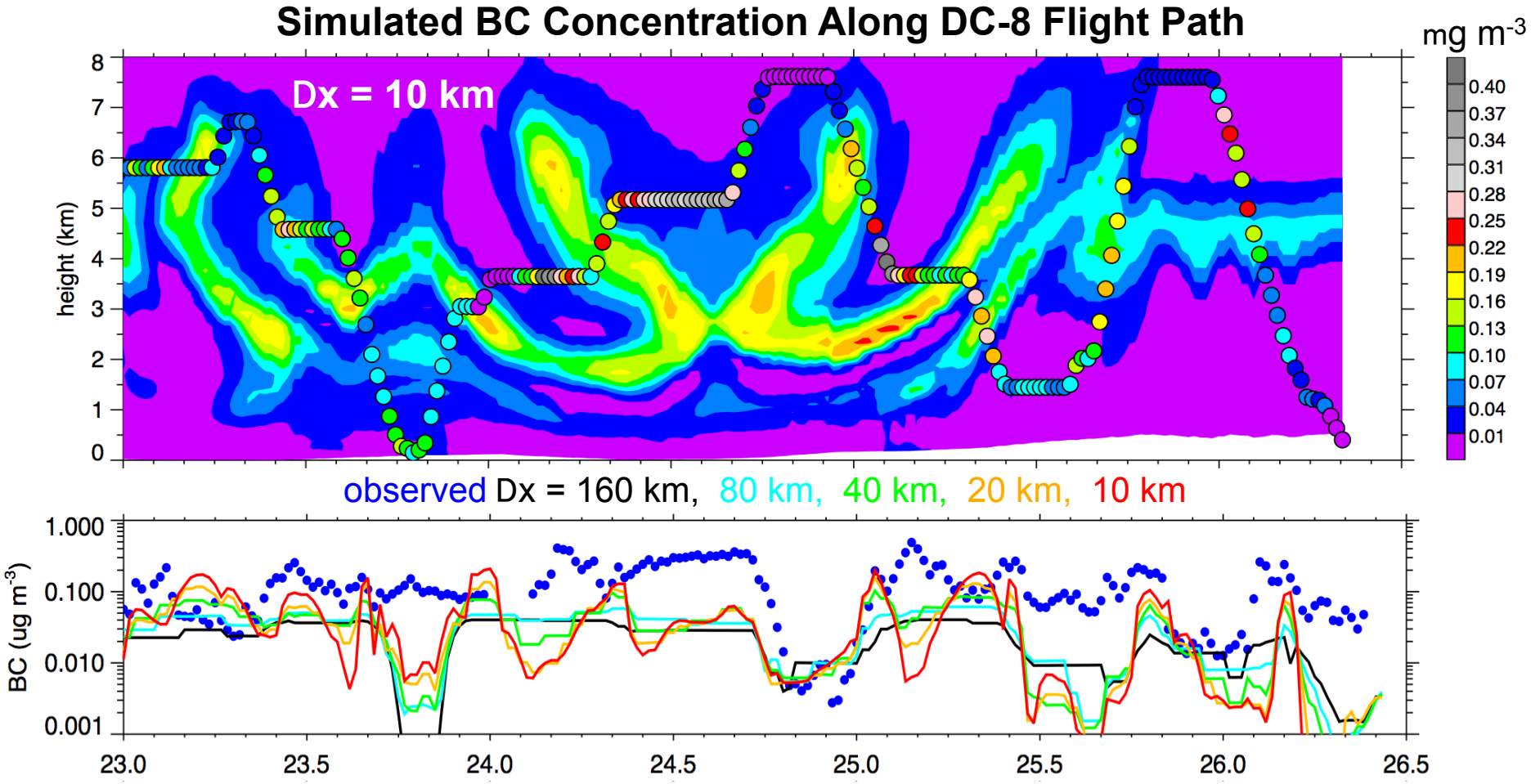

(c) altitude (km)
10
8
6
4
2
0
Apr-01_19Z
Apr-04_17Z
Apr-05_17Z
Apr-08_15Z
Apr-08_19Z
Apr-13_15Z
Apr-13_20Z
Apr-14_23Z
Apr-18_15Z
Apr-18_20Z
Apr-24_17Z
Apr-24_22Z
Apr-26_18Z
Apr-26_23Z
Apr-28_19Z


(d) flight path
75N
70N
65N
60N
55N
170W
160W
150W

Vertical profile of BC

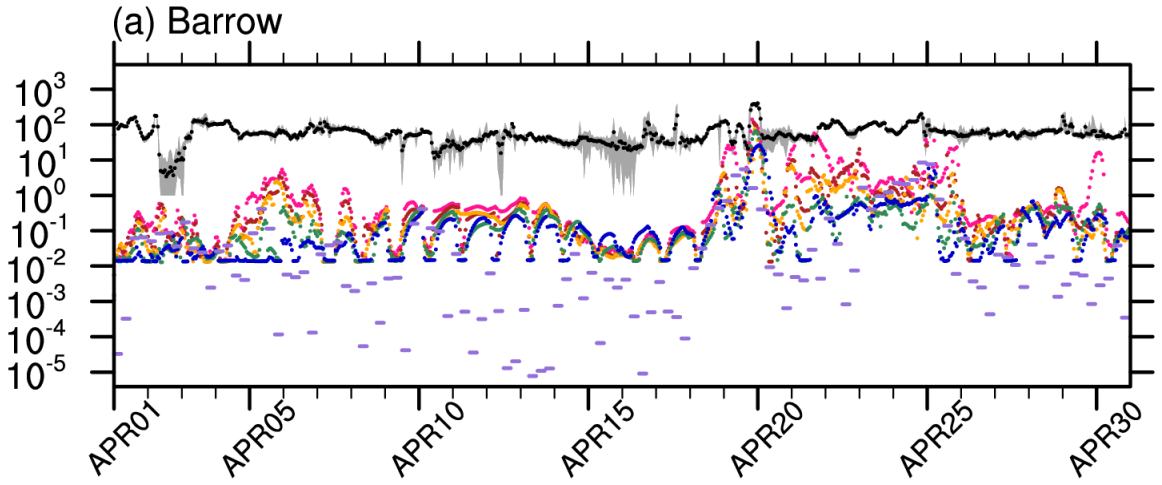


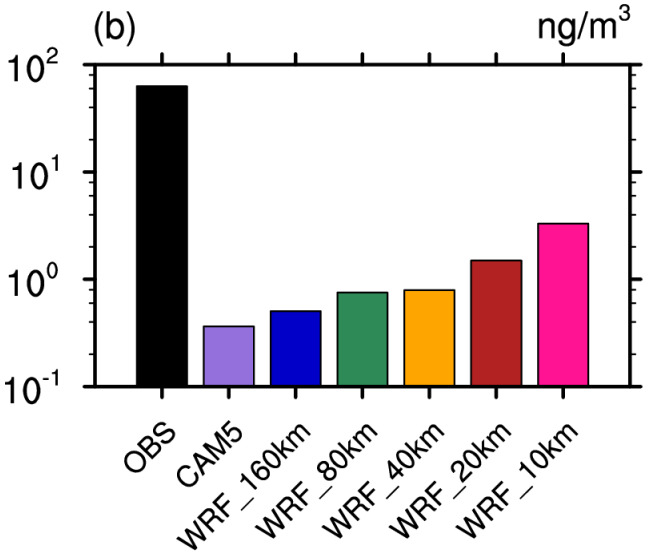
Vertical BC Distributions



- Complex layers produced by Dx = 10km simulation
- Simulated peak concentrations factor of ~2 too low

PSAP surface measurement of BC





Resolution dependence of BC transport

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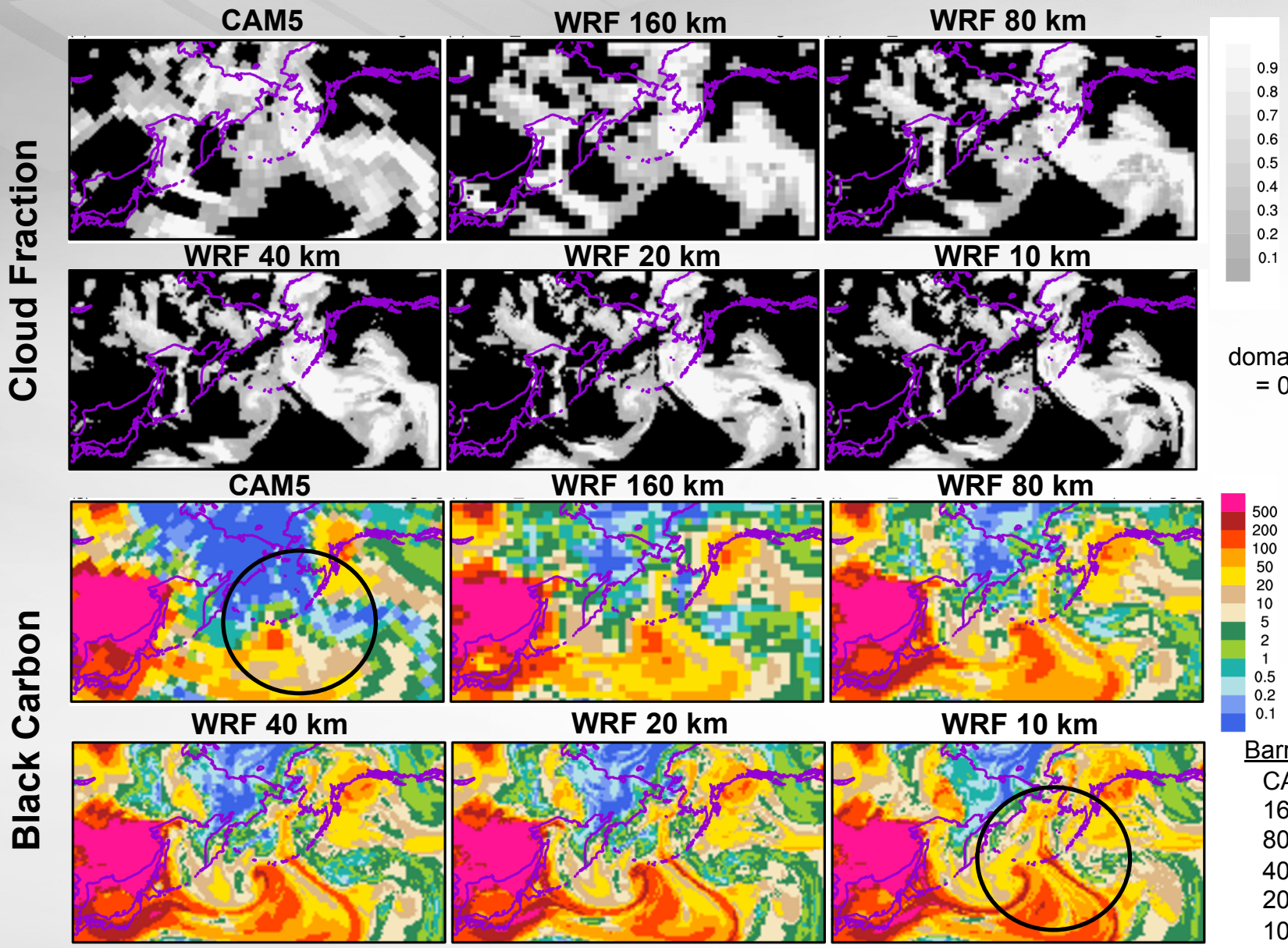
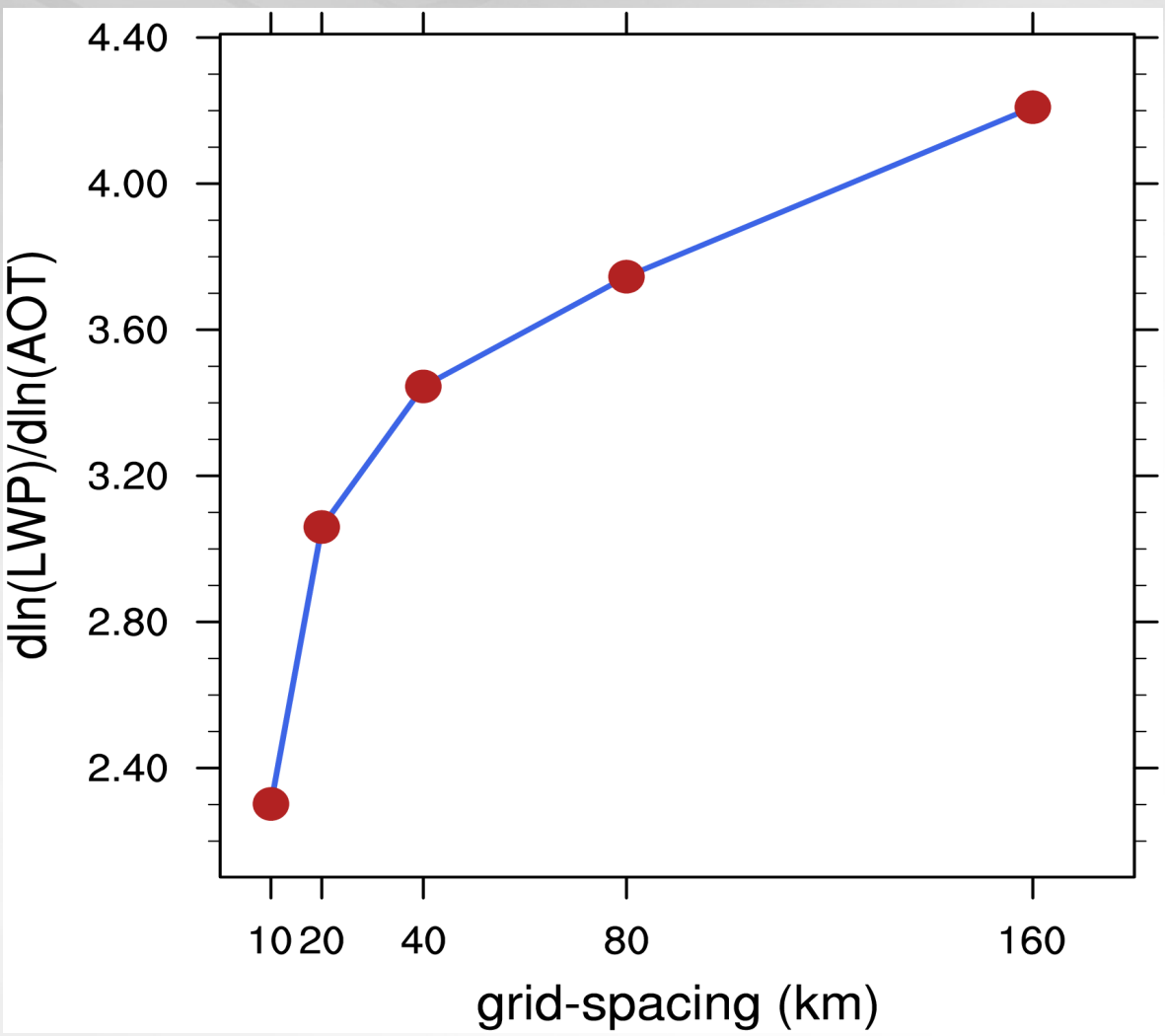
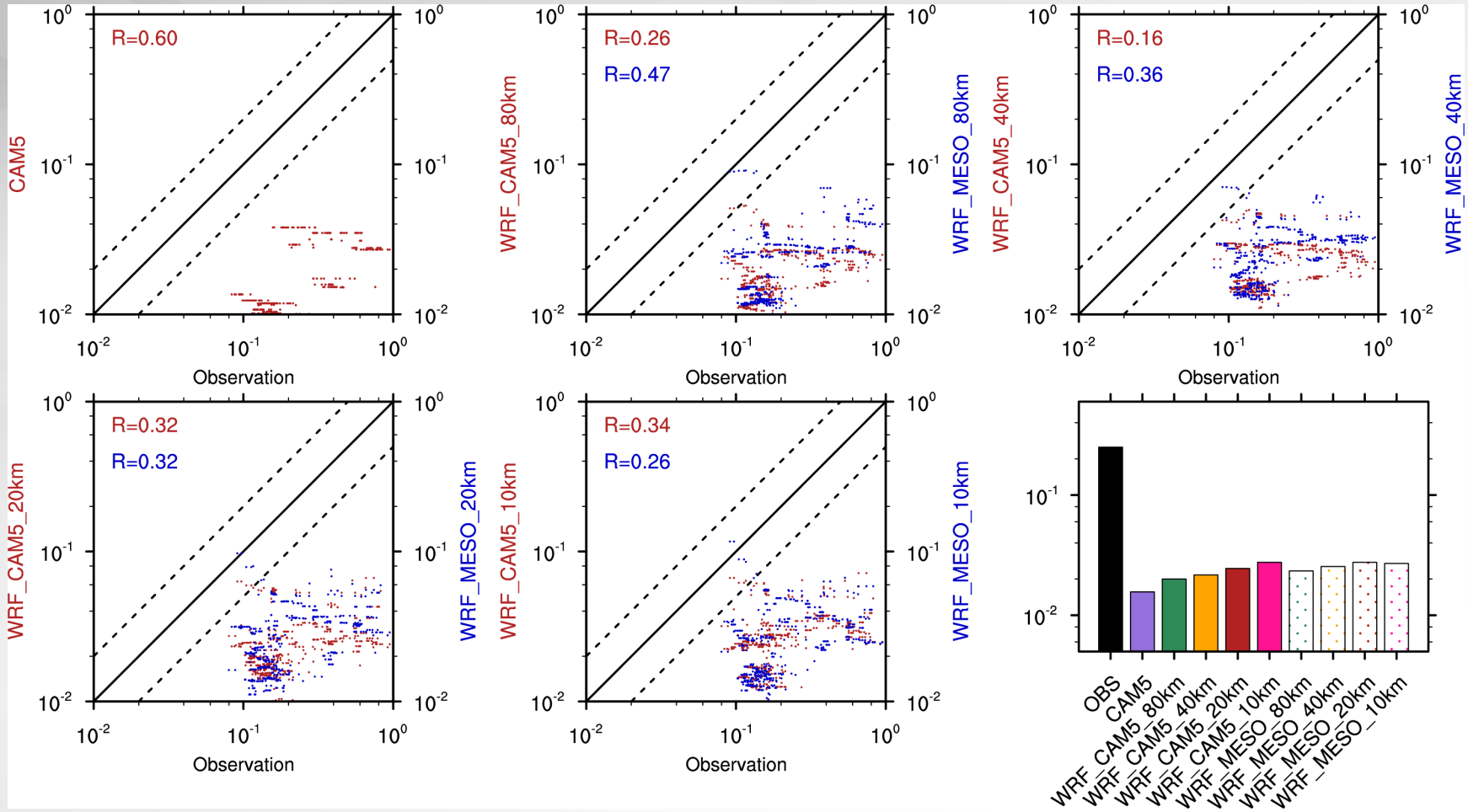


Cloud susceptibility to aerosol forcing

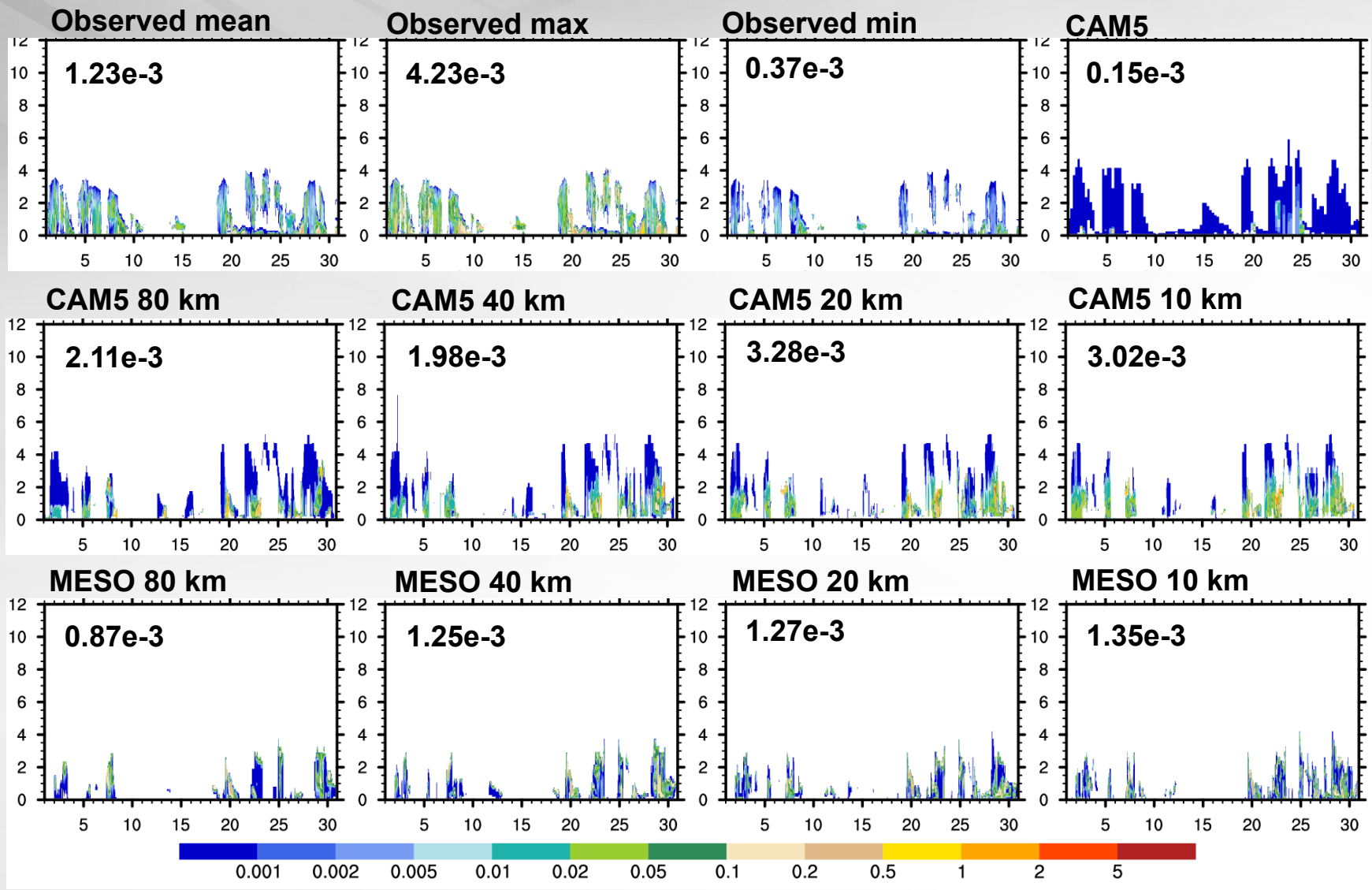


Implication: aerosol indirect forcing decreases with increasing resolution

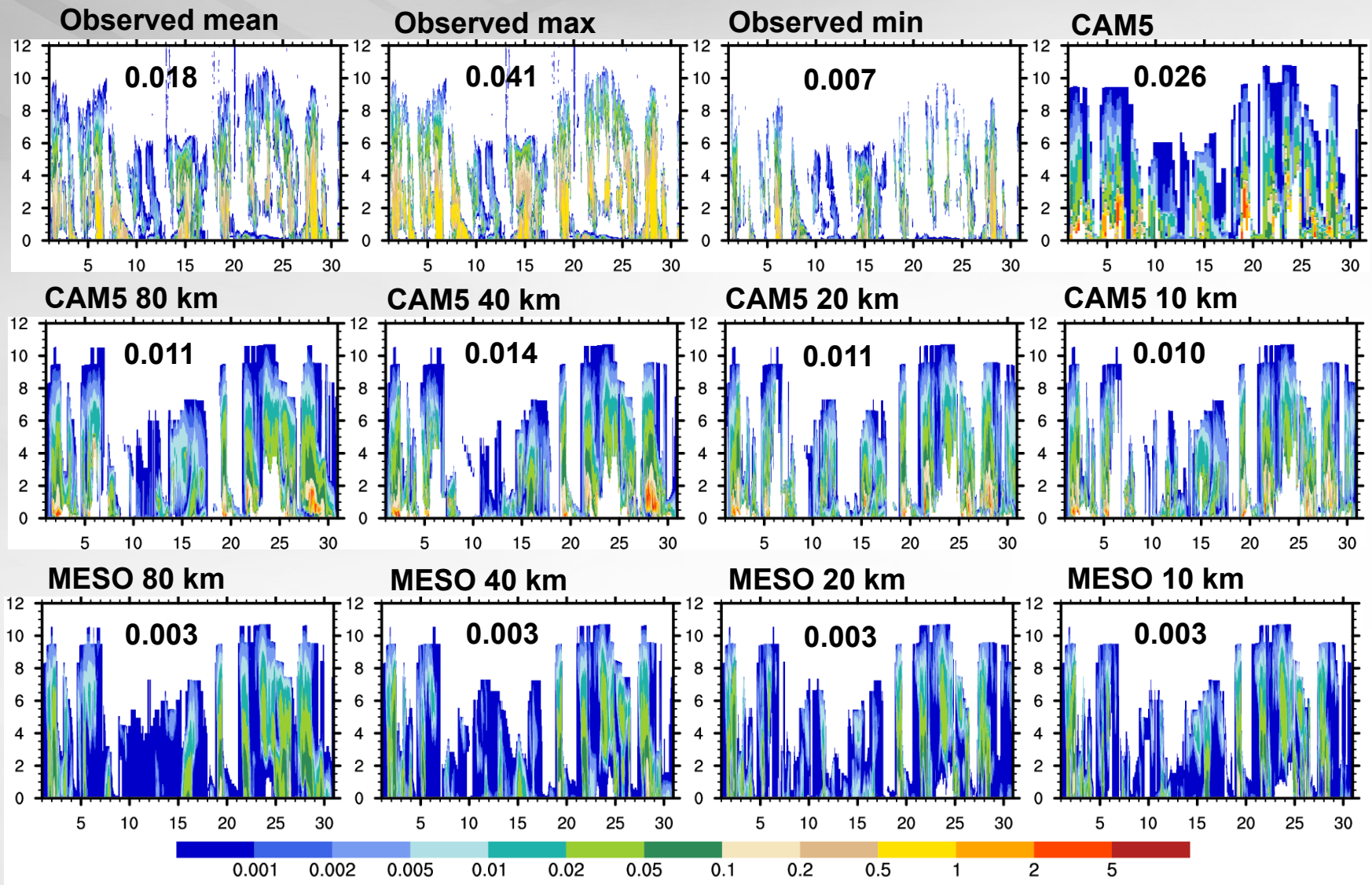
AOT over Barrow and Bonanza Creek (AERONET sites)



LWC at Barrow (ARM-NSA)



IWC at Barrow (ARM-NSA)



Summary

- CAM5 physics suite (aerosol, cloud, deep and shallow convections, turbulence) has been implemented in WRF (and WRF-Chem)
- CAM5 physics show some **resolution dependency** on long-range **aerosols transport** and **aerosol-cloud interactions**, but large bias still remains
- WRF with a **typical set of WRF physics** does not reduce the model bias when the model is driven by the same initial and boundary conditions
- Allowing **fractional clouds** produces more clouds—results better-agreed with observations
- WRF-CAM5 (**Ma et al**) has been applied to study pollutions in Mexico (**Fast et al**), marine stratocumulus clouds off the coast of South America (**Burrows et al**), clouds and precipitation in the continental US (**Gustafson et al**), aerosol effects on convections (**Lim et al**), long-range transport of aerosols (**Fast et al**), etc., and we welcome collaborations!!