A Framework for Evaluating the CAM5 Physics Suite at High Spatial Resolution in WRF

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Acknowledgements

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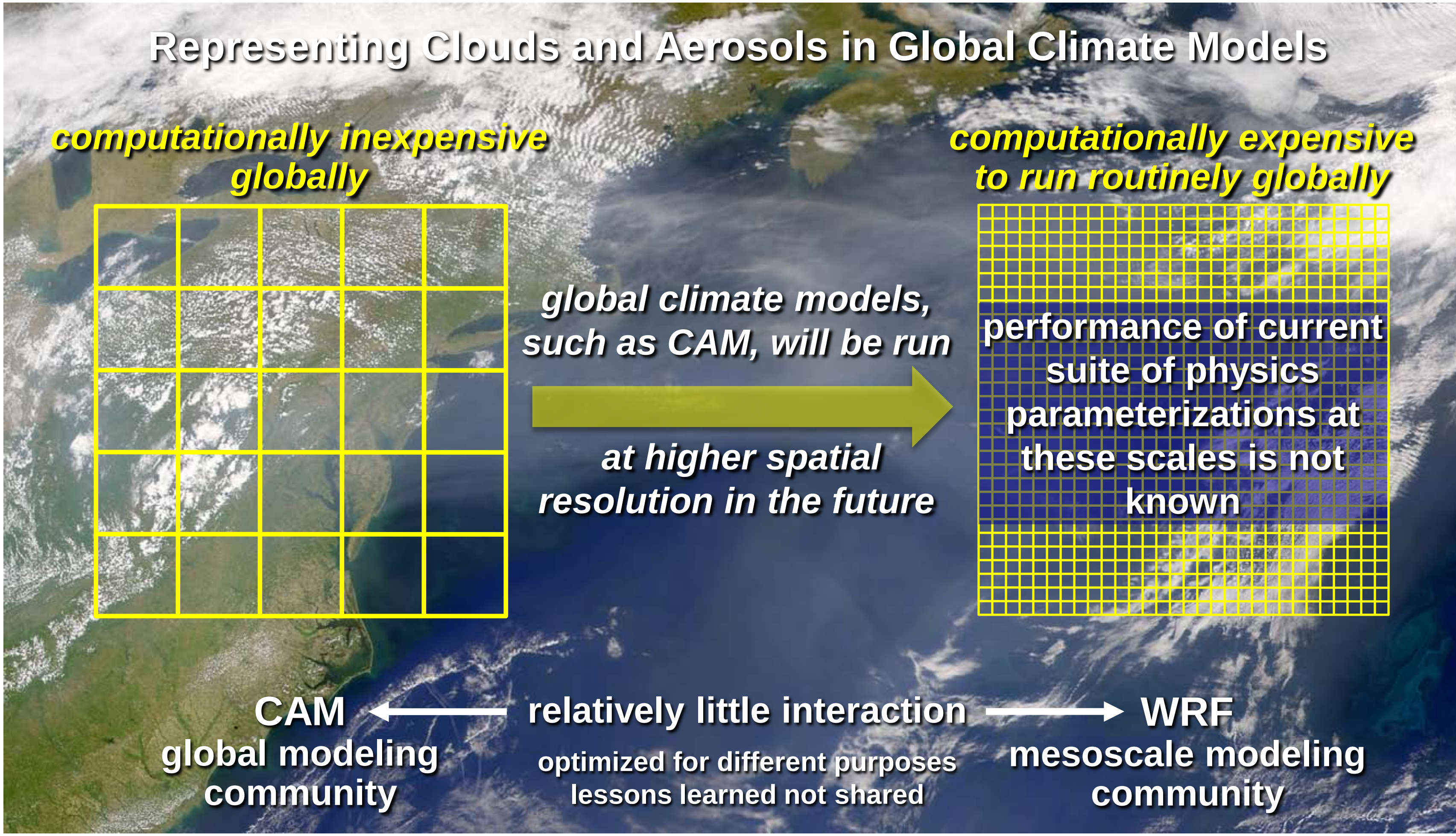
Motivation

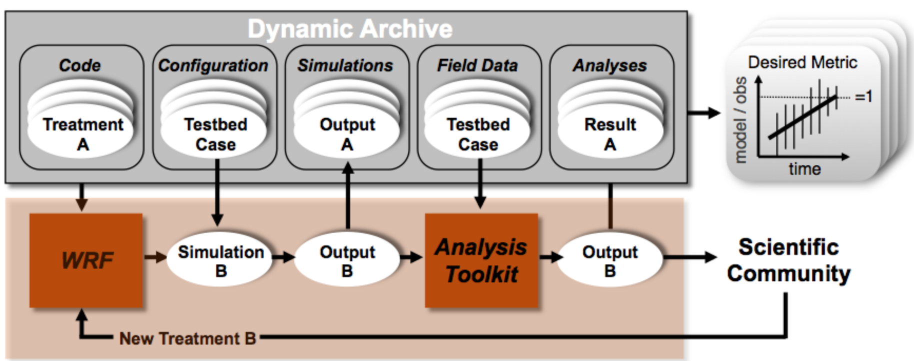


- Development of the next generation suite for CAM requires the ability to **isolate processes** and **test parameterizations** across a range of scales

Objectives

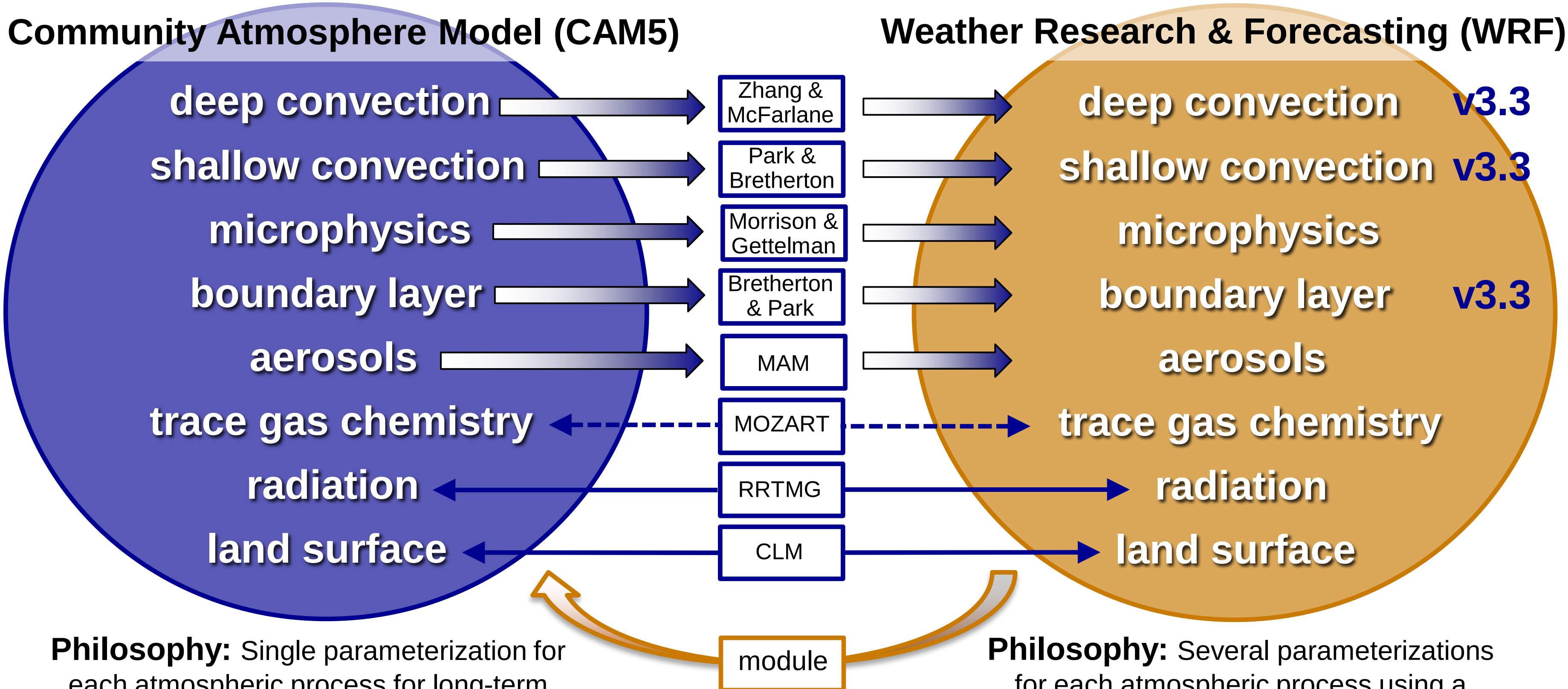
- Use WRF's framework to **test the scale dependency of the CAM5** parameterization suite and develop improved parameterizations for both models

- Use the **Aerosol Modeling Testbed** to evaluate performance of the CAM5 parameterization suite
  - Evaluate physics suite at spatial resolution more compatible with data
  - Compare simple and complex representations
  - Identify more desirable parameterization choices



- **Increase communication** between WRF (cloud-resolving / mesoscale) and CAM (global scale) modeling communities

Overall Approach



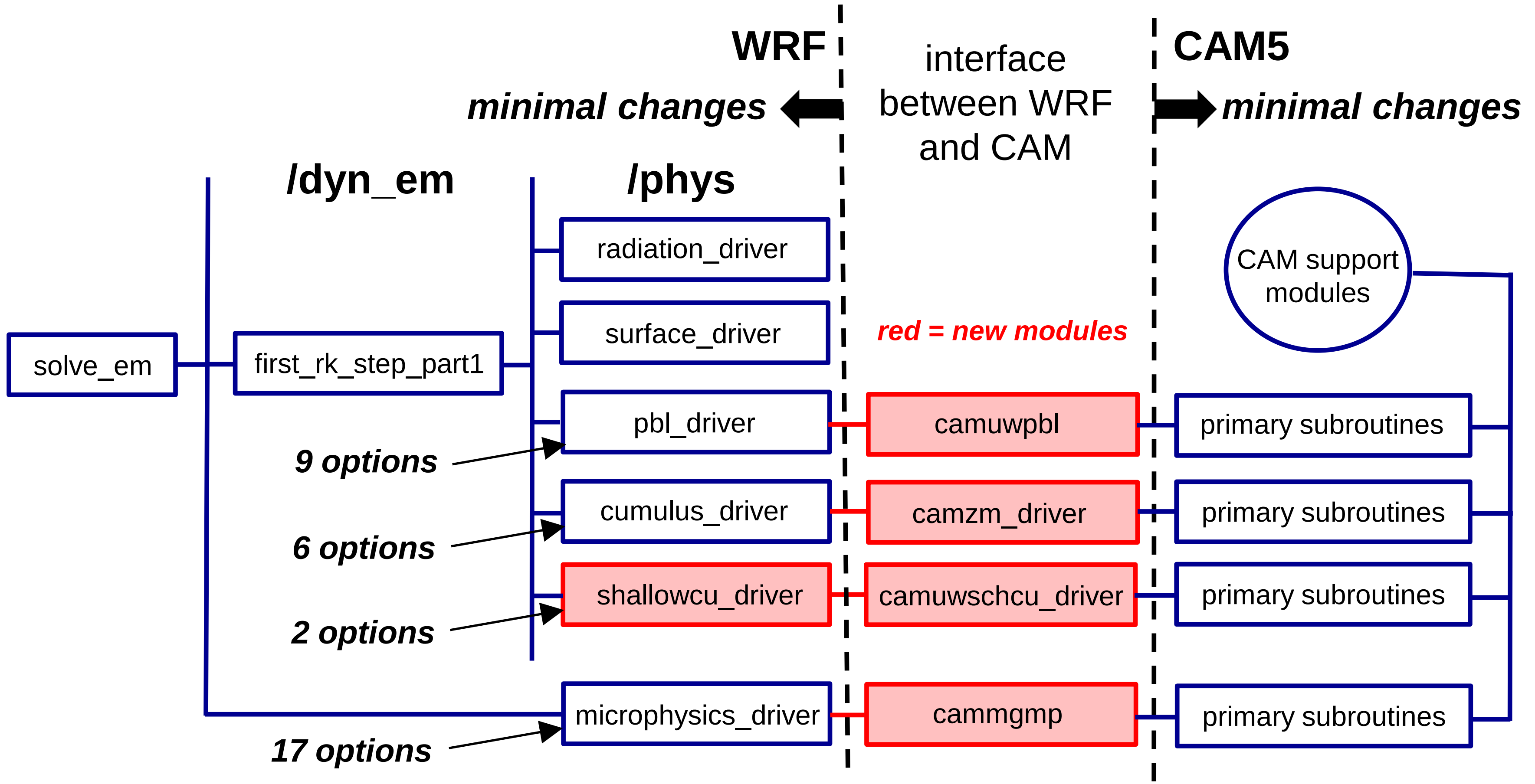
Philosophy: Single parameterization for each atmospheric process for long-term climate simulations using a coarse grid

Philosophy: Several parameterizations for each atmospheric process using a wide range of grid spacings

Engineering Component:
Merge code and ensure code inter-operability

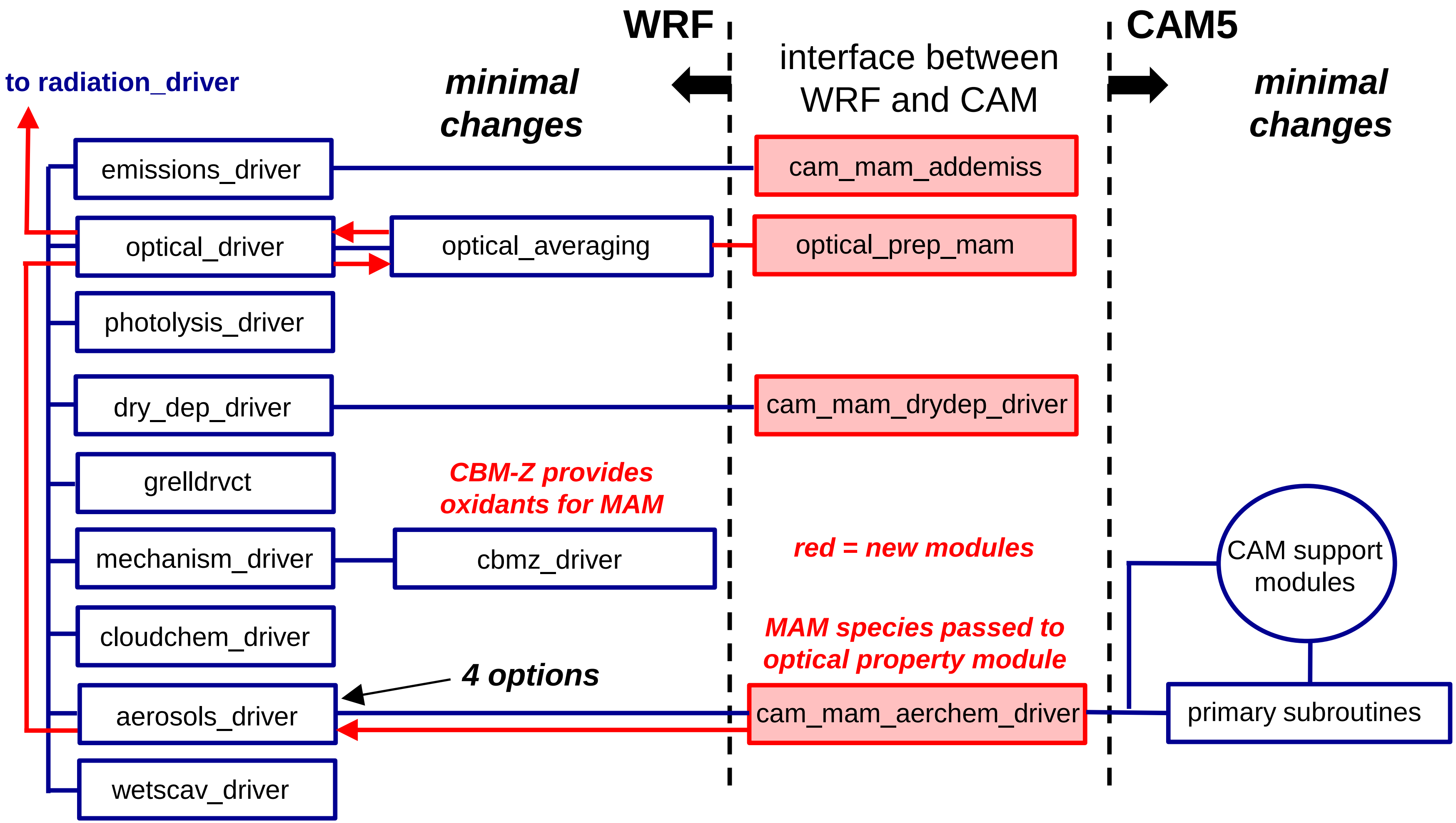
Science Component:
Evaluate performance of CAM modules at regional scales

Interfaces in /phys Directory



- Can now compare CAM5 parameterizations with many alternative methods
- With the “interfaces”, updates to CAM5 code can be easily added to WRF

Interfaces in /chem Directory



- Can now compare MAM with other aerosol treatments
- 3-mode and 7-mode version of MAM implemented

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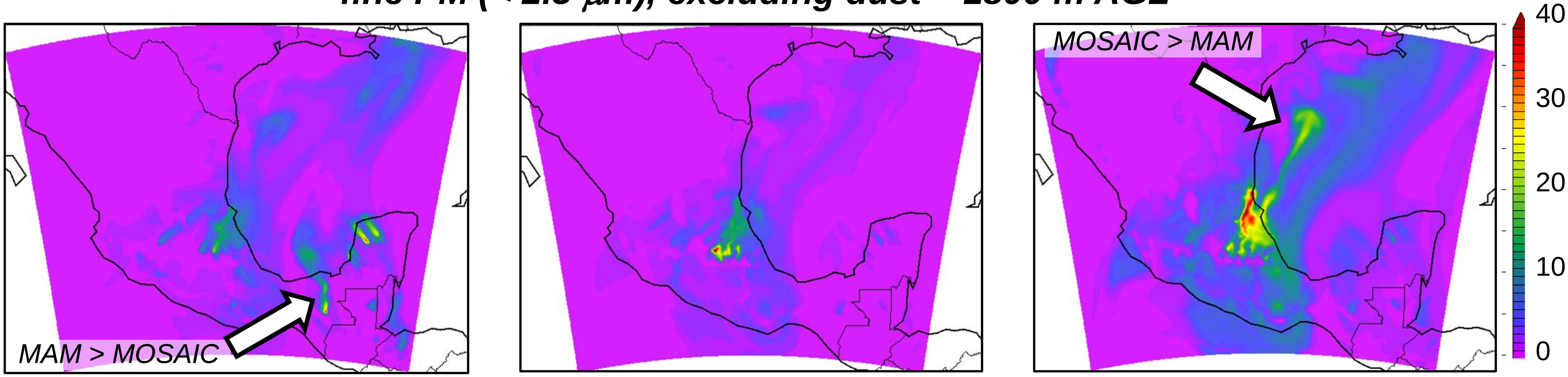
Aerosols: Comparing with Other Models

- **AMT methodology:** identical emissions, meteorology (aerosol-radiation-cloud feedbacks turned off), chemistry, dry deposition, boundary conditions

MAM (from CAM5)	MADE/SORGAM	MOSAIC
modal – 3 modes, **18** species	modal – 3 modes, **38** species	sectional – 4 bins, **164** species
'simple'	*9 times more species*	**'complex'**
total CPU time = 1	*1.14*	*2.85*

fine PM (< 2.5 μm), excluding dust ~1800 m AGL

μg m^{-3}



- Differences due to secondary aerosols (SO_4, NO_3, NH_4, organics)
- Treatment of organics:

  MAM: POA - non-volatile, SOA – simple yields

  MADE/SORGAM: POA - non-volatile, SOA - 2-product approach

  MOSAIC: volatility basis set, non-volatile POA & SOA

Aerosols: Comparing with Other Models

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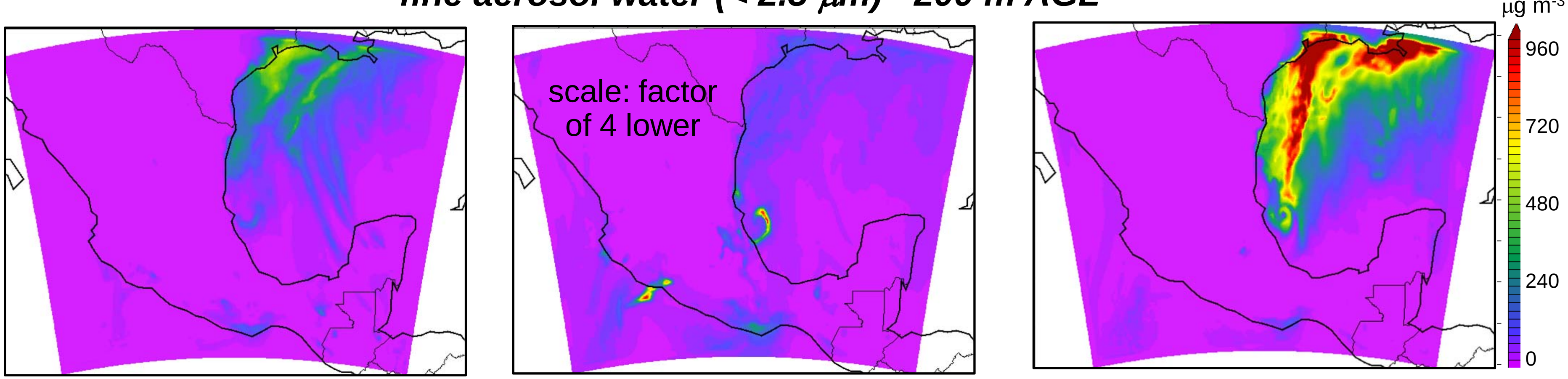
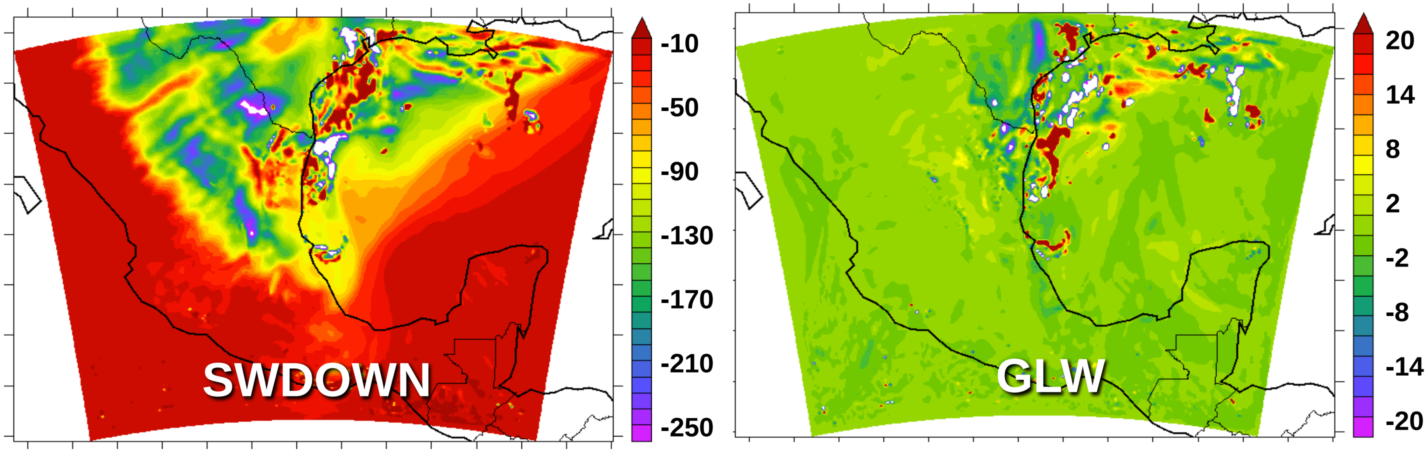
fine aerosol water (< 2.5 μm) ~200 m AGL



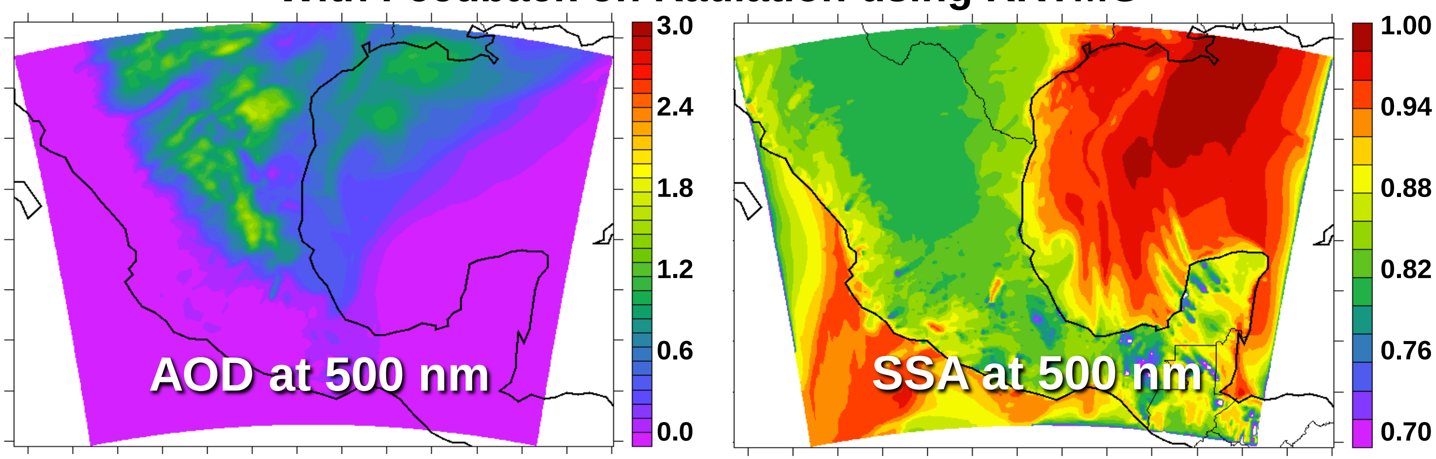
- Differences in secondary aerosols and thermodynamic modules leads to large variations in uptake of water on aerosols
- These differences will influence aerosol direct effect

Aerosols: Impact on Radiation

Differences using MAM, Feedback – No Feedback on Radiation, using RRTMG

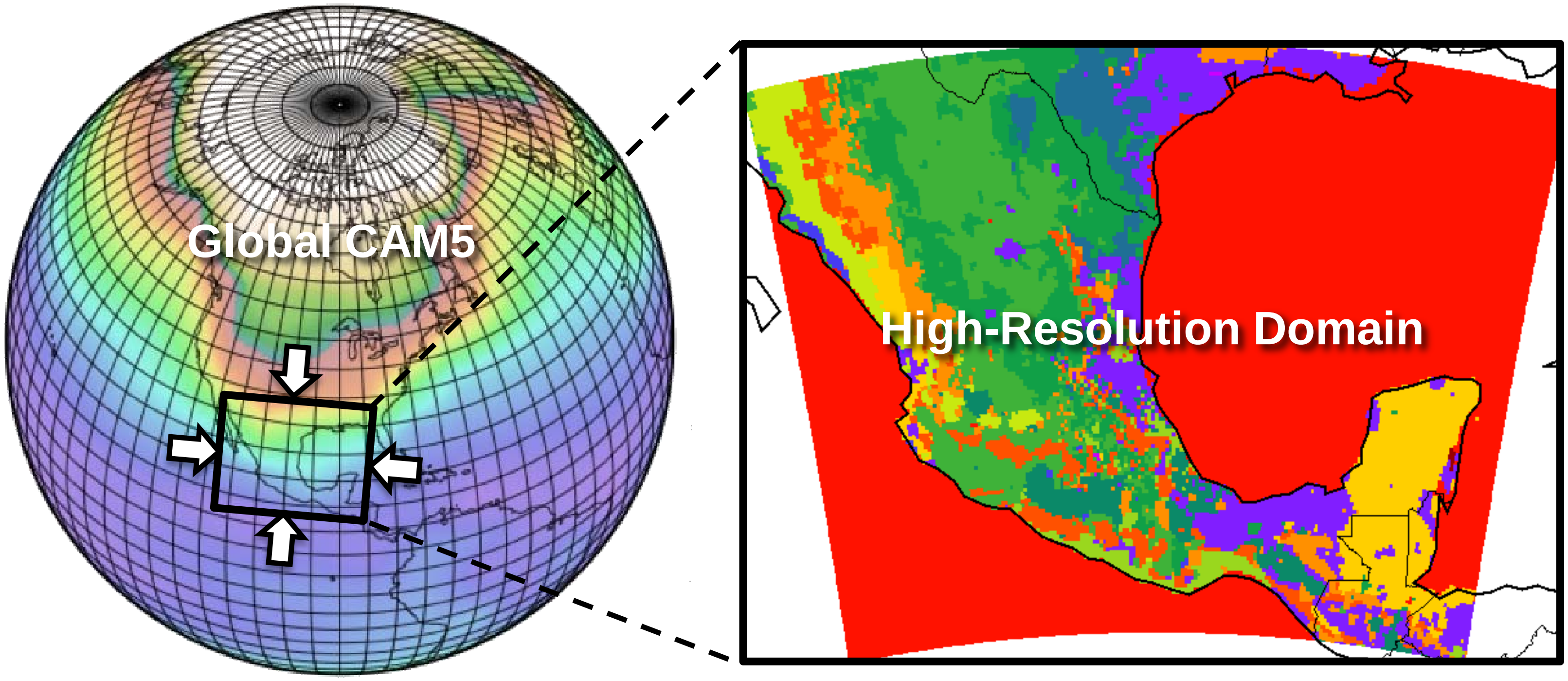


With Feedback on Radiation using RRTMG



- Behavior of MAM and MADE/SORGAM somewhat different, especially for SSA, due to size distribution assumptions

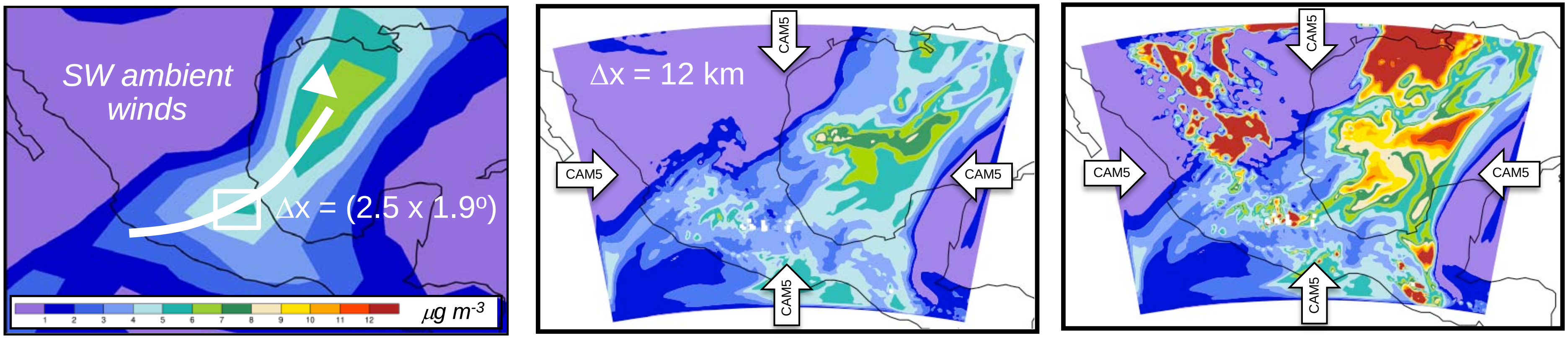
Aerosols: Downscaling



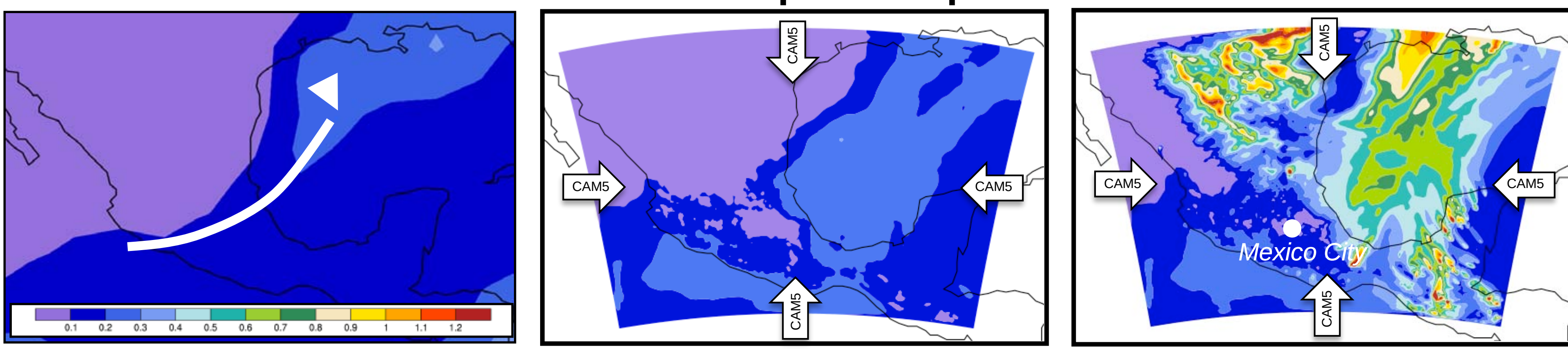
- What's different from previous coupling of models? Answer: ***Consistent physics from global to regional scale***
- Differences in predictions between the models due to resolving atmospheric processes, and not the physics parameterizations

Aerosols: MILAGRO Test

PM2.5 at 700 hPa, 18 UTC 19 March 2006



Aerosol Optical Depth



CAM5 + IPCC AR5 emissions

WRF + CAM5 Physics + (IPCC AR5) emissions

WRF + CAM5 Physics + local emissions

- Magnitude similar, but small grid spacing add details
- Differences mostly due to on-line dust calculations

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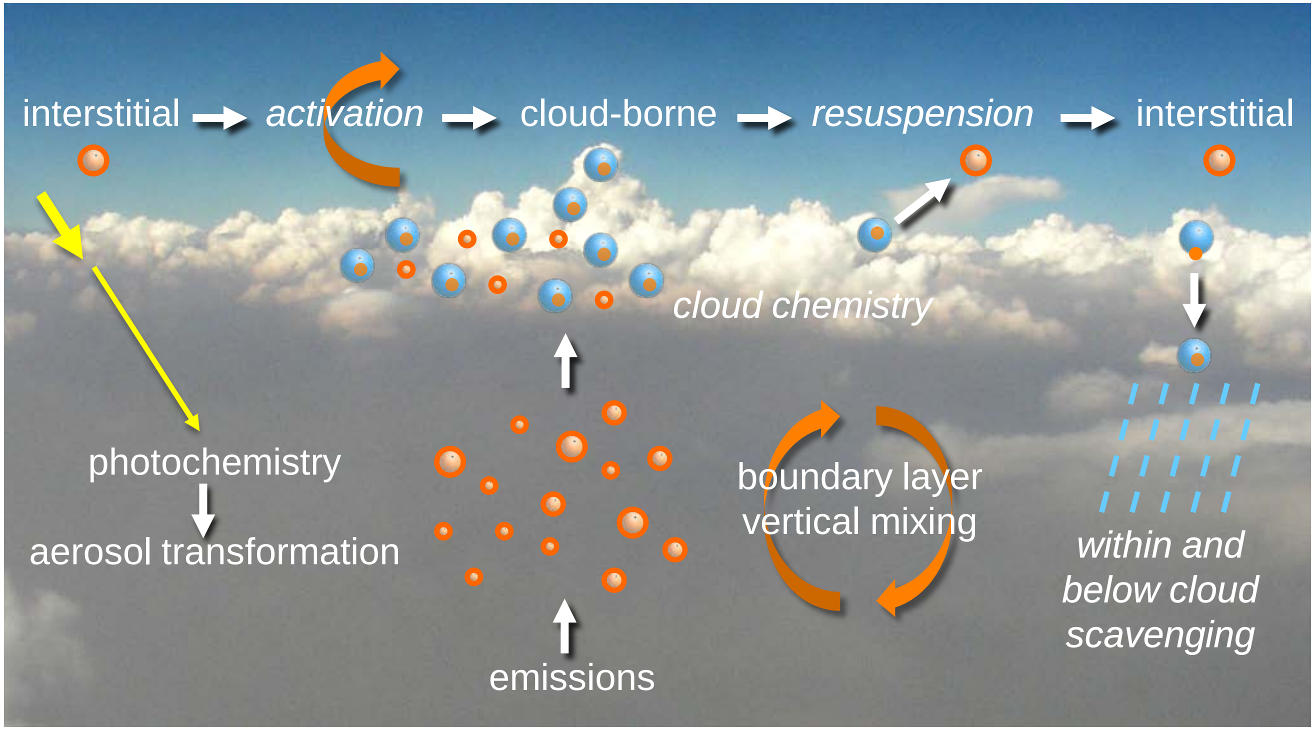
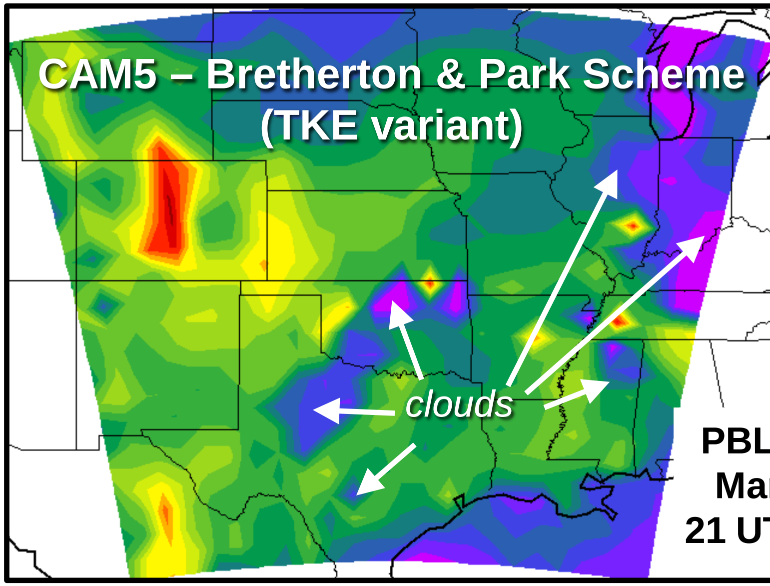
Aerosols: Summary

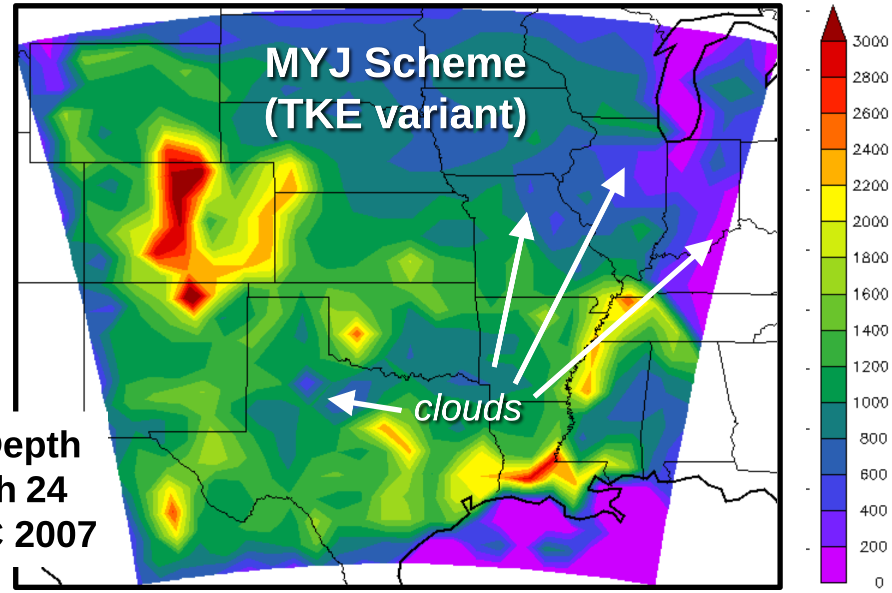
- With our new tool, we now have opportunities to:
  - Examine performance of MAM at local to regional scales, and
  - Explore alternative treatments of organics for the next version of MAM
  - See **poster P80** for more details on MAM and its evaluation
- Next, provide examples boundary layer and microphysics schemes



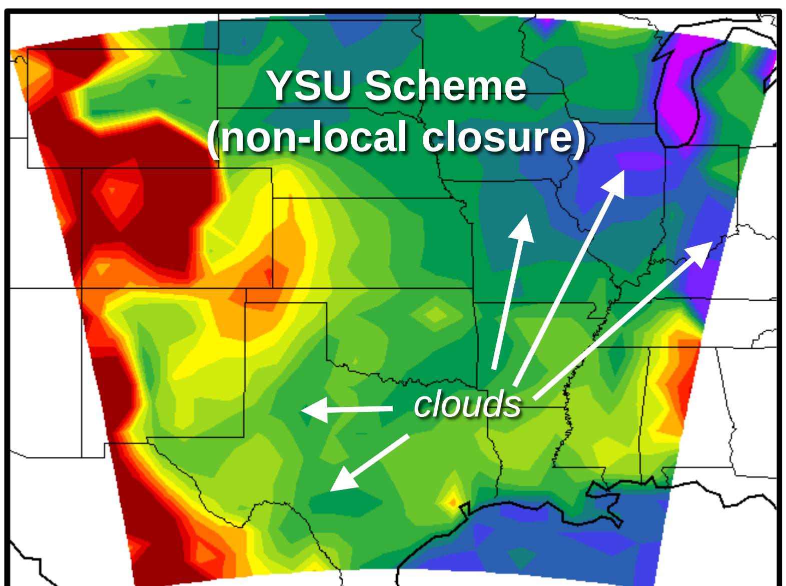
boundary layer and cloud microphysics processes have a profound effect on aerosols

Boundary Layer: Central U.S. Test





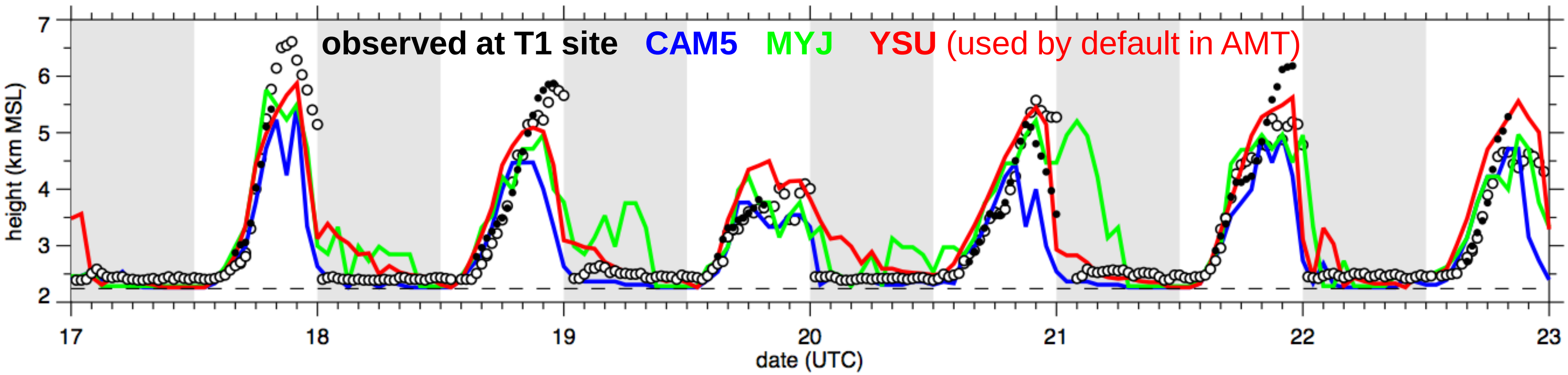
PBL Depth
March 24
21 UTC 2007



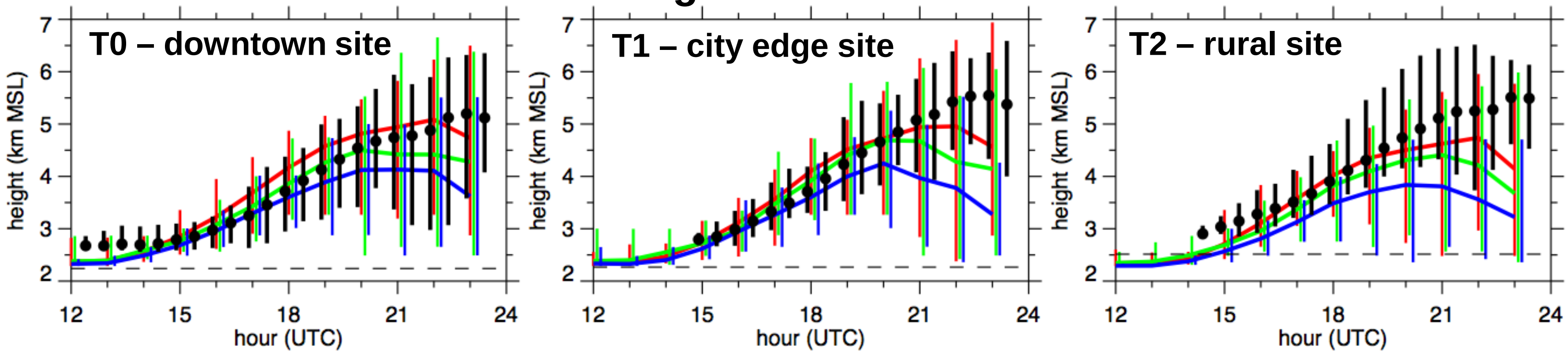
- PBL depths from CAM5 scheme qualitatively similar to MYJ scheme
- PBL from YSU scheme > MYJ (consistent with previous testing)
- Choice of PBL scheme led to somewhat different cloud distributions

Boundary Layer: MILAGRO Test

Using AMT to Evaluate PBL Implementation (all other modules identical)

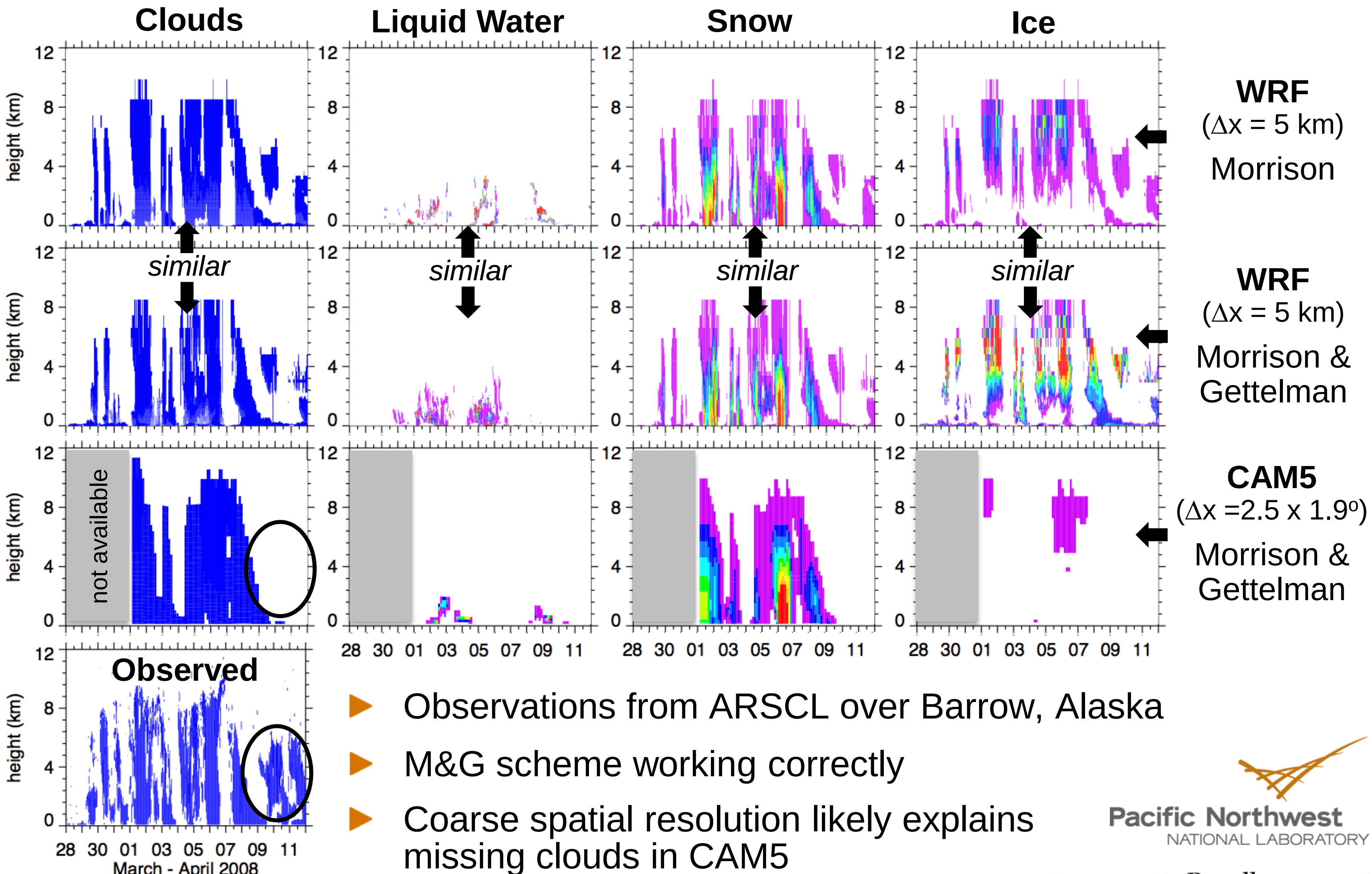


Average Diurnal Variation



- As with central U.S. test, CAM5 scheme more similar to MYJ scheme
- PBL depths from CAM5 too low during afternoon
- Performance likely to vary from location to location

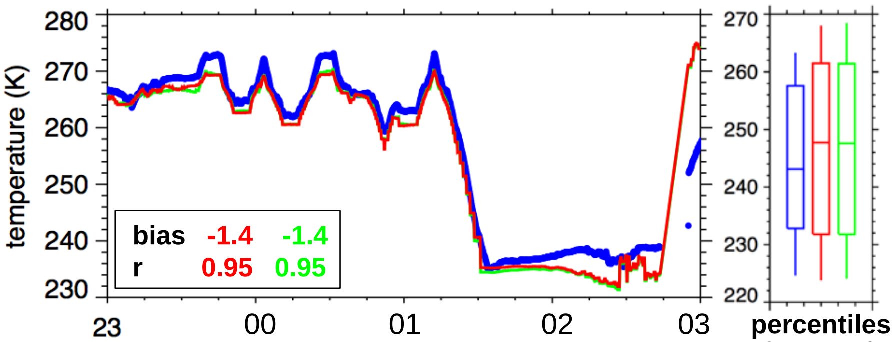
Microphysics: ISDAC Test

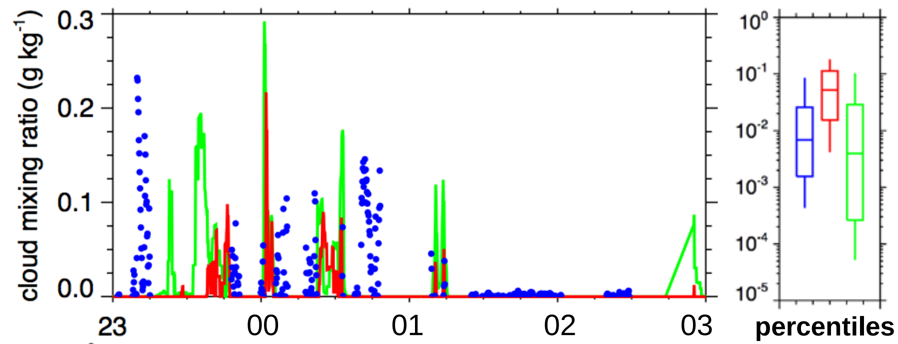


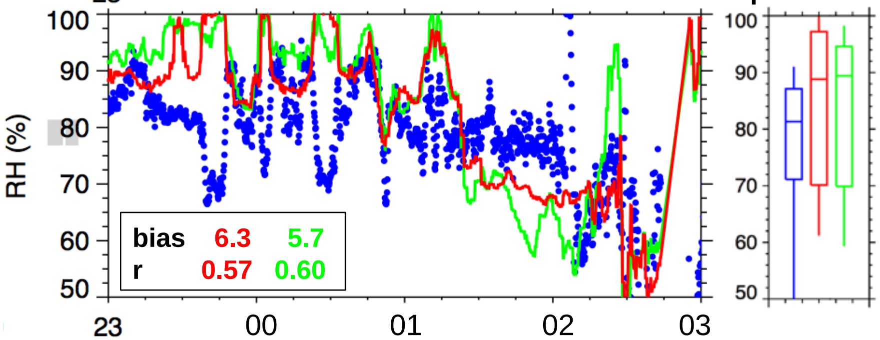
- Observations from ARSCL over Barrow, Alaska
- M&G scheme working correctly
- Coarse spatial resolution likely explains missing clouds in CAM5

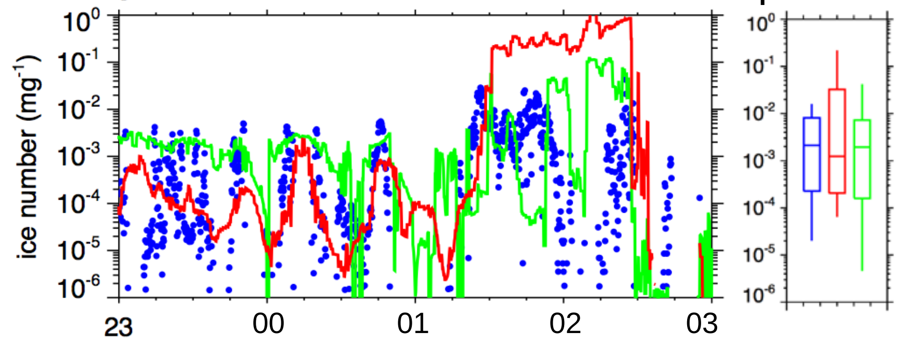
Microphysics: ISDAC Test

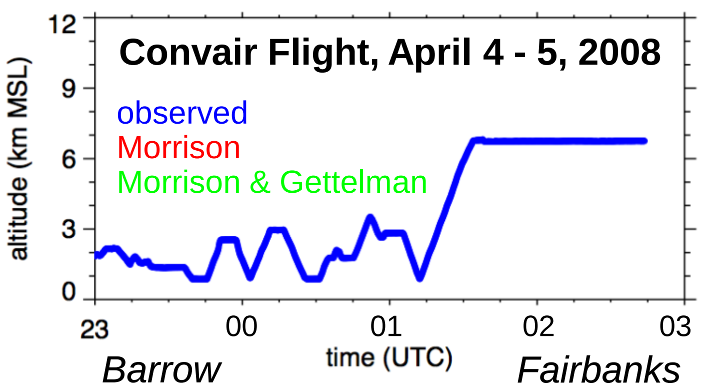
Using AMT to Evaluate Microphysics Implementation

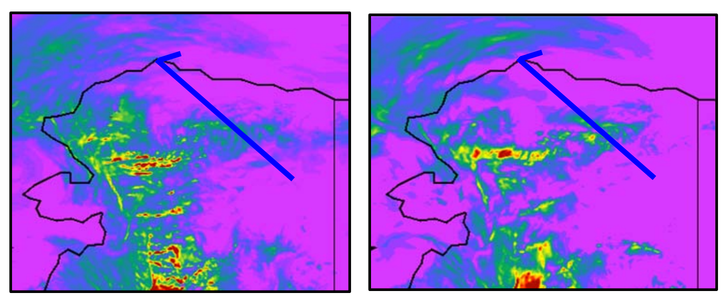












Morrison & Gettelman *Morrison*

Cloud Distribution 00 UTC. April 5

statistics from all aircraft flights

Summary

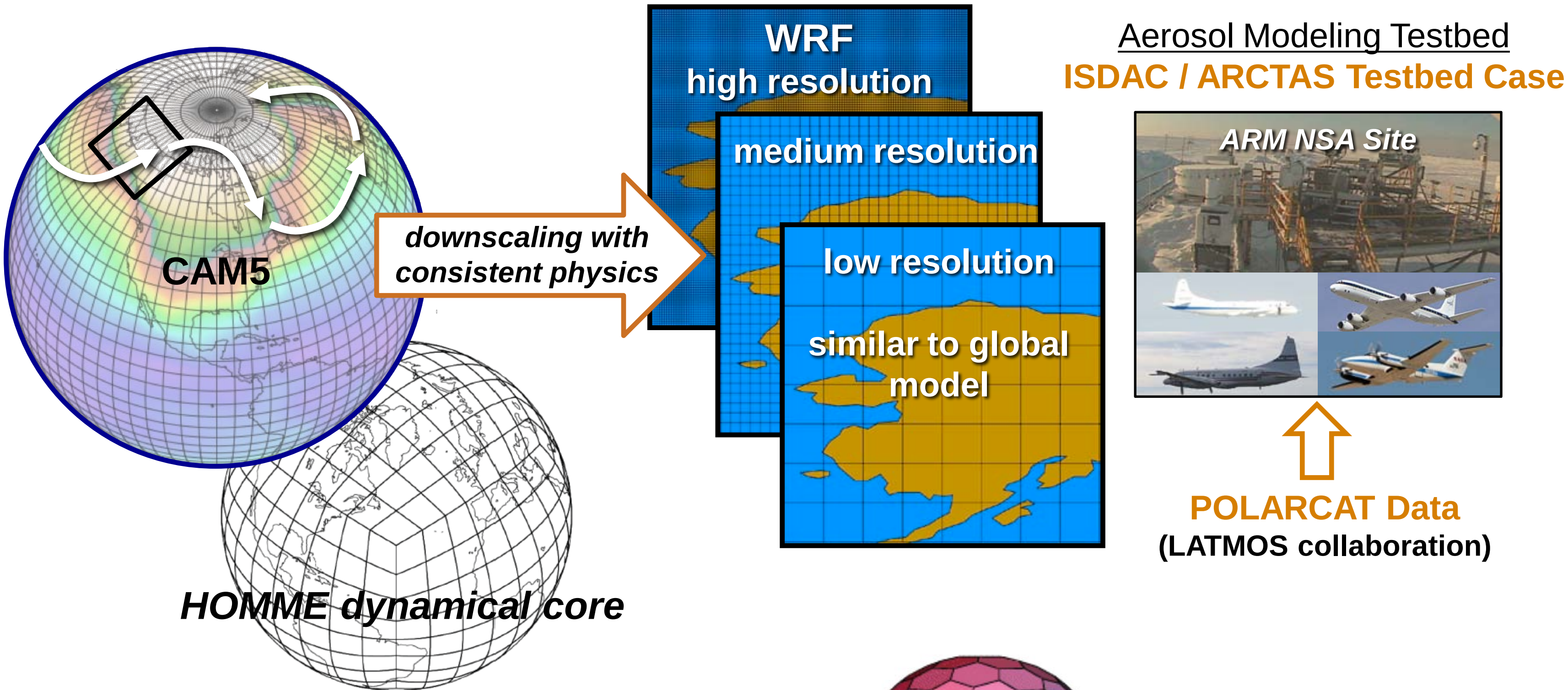
- Most of the CAM5 physics suite is now functional in WRF
  - 3 schemes made available in v3.3, others in next release?
  - Users should be aware there may still be bugs
- Behavior of CAM5 parameterizations similar to other parameterizations
  - MAM performs as well as other aerosol models in many respects, but the AMT suggests there areas of improvement
  - Computational efficiency of 3-mode version could be attractive to other applications besides its use for climate applications
- Tested functionality of downscaling CAM5 to WRF using same physics

Remaining Tasks (to be completed this summer):

- Couple MAM aerosols with cloud-aerosol interactions in Morrison & Gettelman scheme and add wet removal
- Couple MAM with MOZART and “fast” MOZART
- Perform final simulations and publish results

Next Steps

- Assess performance of CAM5 physics suite at low and high spatial resolution for simulations aerosols and clouds in the Arctic



- Move CAM5 physics into Model for Prediction Across Scales?