Dust vertical and horizontal distributions simulated by CESM/CAM5 and compared with CALIPSO observations

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The role of dust

- Dust is one of the most abundant aerosol species in the atmosphere in terms of emitted mass [Forster et al., 2007].

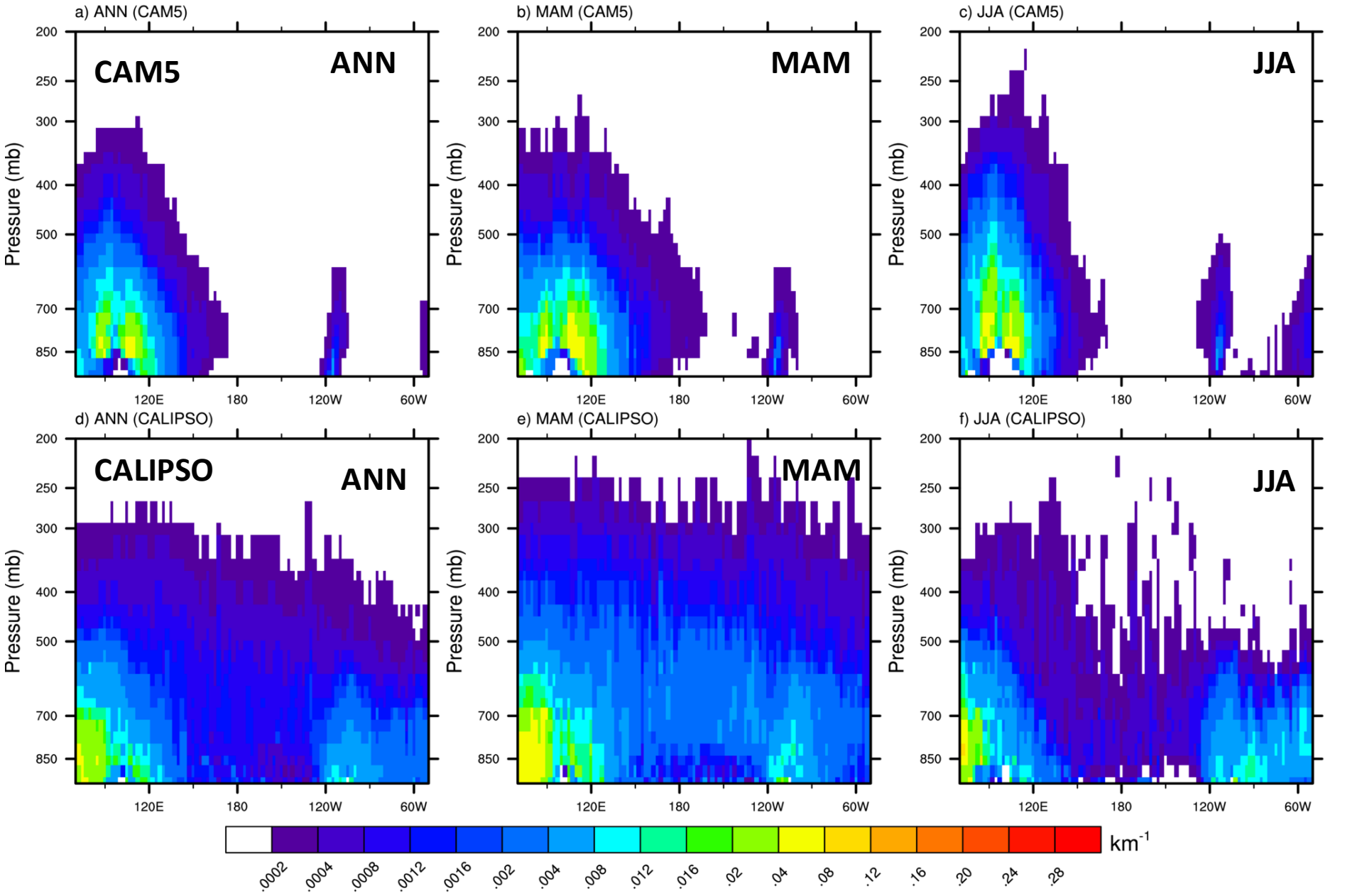
- Dust has important climatic effects
  - Scattering and absorbing solar and terrestrial radiation
  - Influencing cloud radiative and microphysical properties as CCN and IN
  - Fertilizing oceans with iron dust
  - etc.

Model and Data

- Configuration: CAM5.4, MG1.5 microphysics, MAM4 with Aitken mode dust, prescribed SST
- Simulation period: Aug. 2006 to Dec. 2009, last 36 months for analysis
- Meteorology: wind fields nudged to ERA-interim Reanalysis
- Resolution: $1.9^{o} \times 2.5^{o}$
- Dust emission: Zender et al. (2003)
  - Dust emissions were tuned so that annual mean AOD in dust source regions (DOD/AOD > 0.5) matches Terra/Aqua MODIS observation for 2007-2009
- Observation data: CALIPSO with improved thin dust layer detection (Luo et al. 2015)

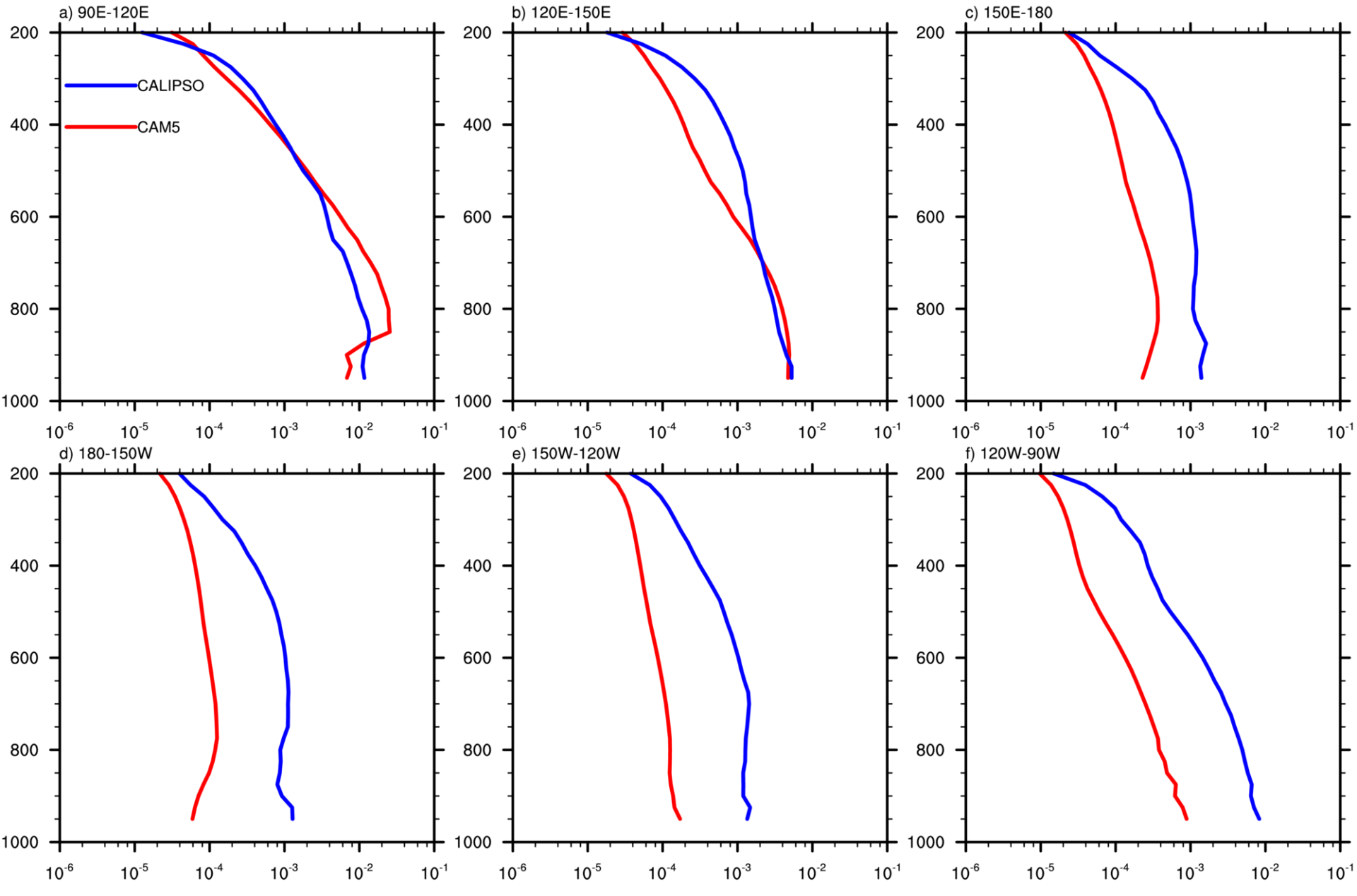
Comparison with Collocated CALIPSO observations

Dust Extinction (90E-50W, averaged over 20N-50N)



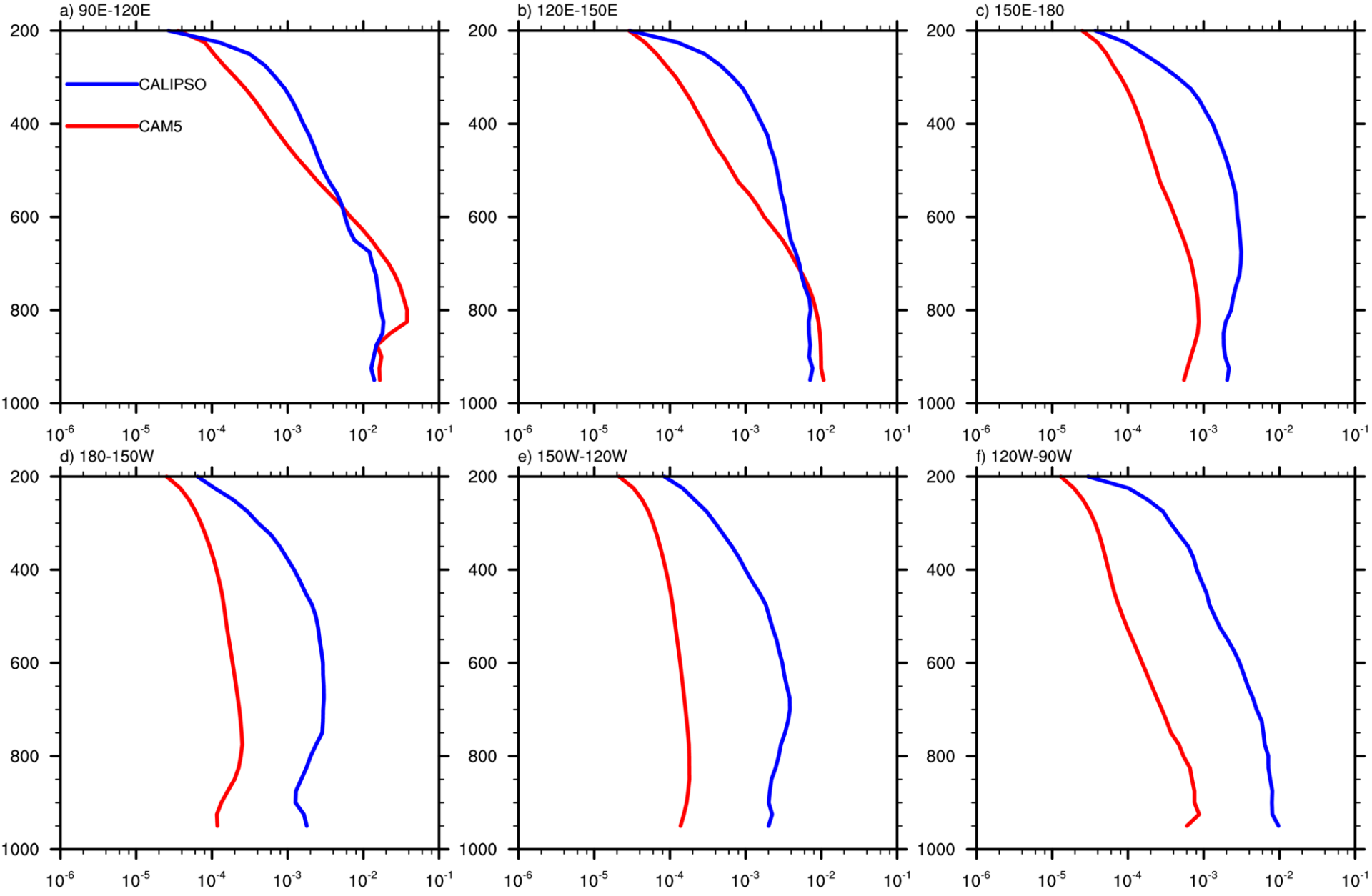
Comparison with Collocated CALIPSO observations

Dust Extinction profile (annual mean)



Comparisons with CALIPSO observations

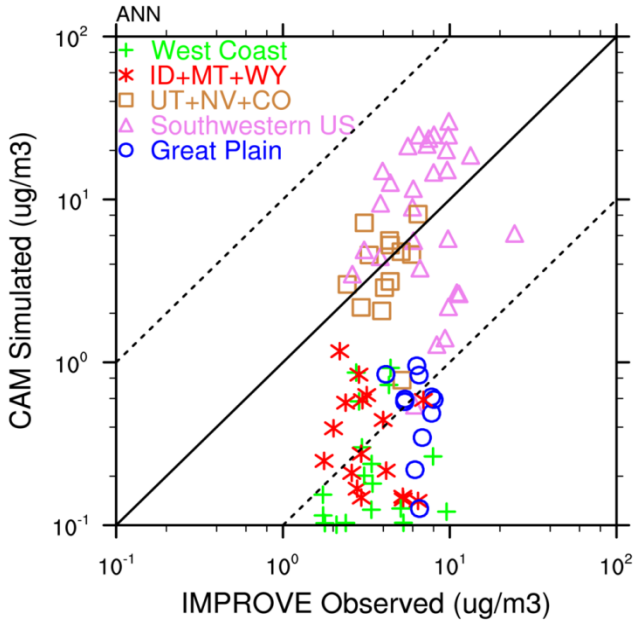
Dust Extinction profile (MAM)



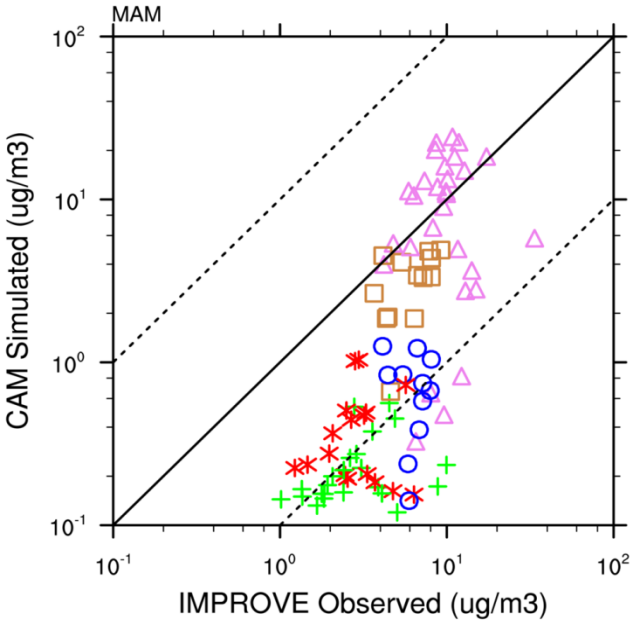
Comparison with IMPROVE observations

Dust surface concentration

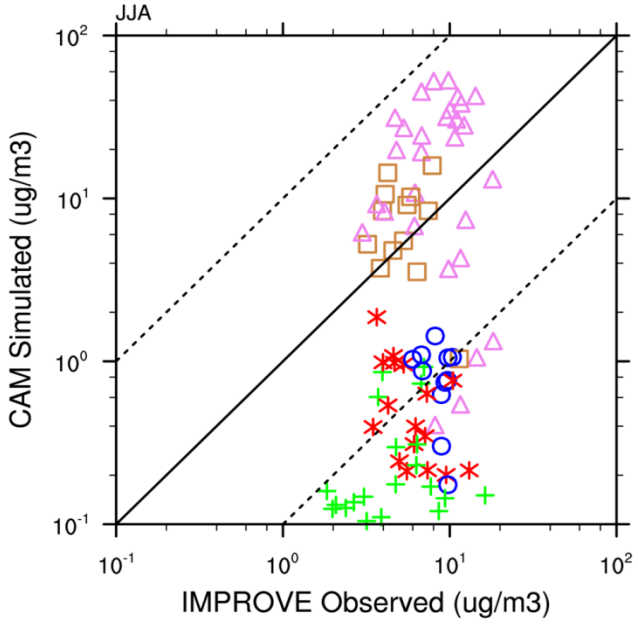
ANN

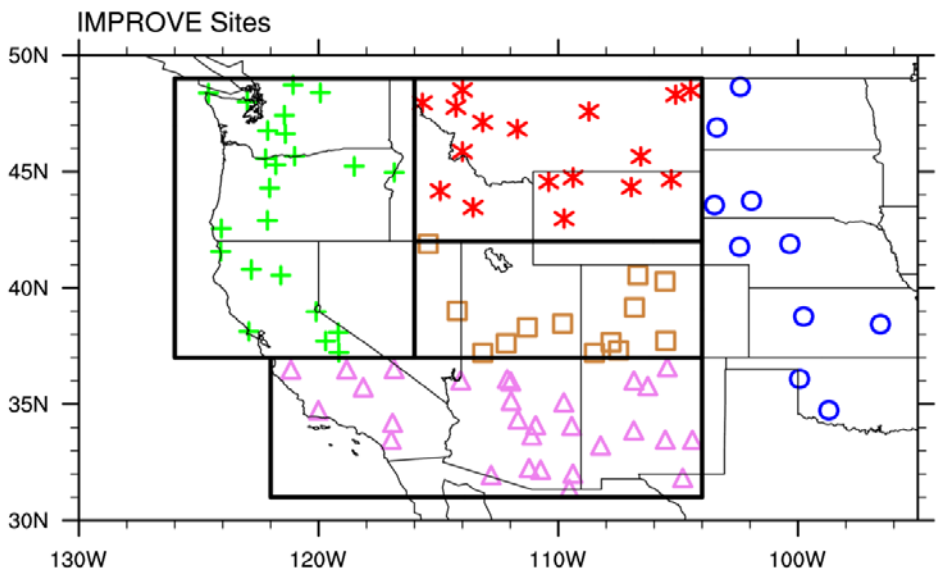


MAM



JJA





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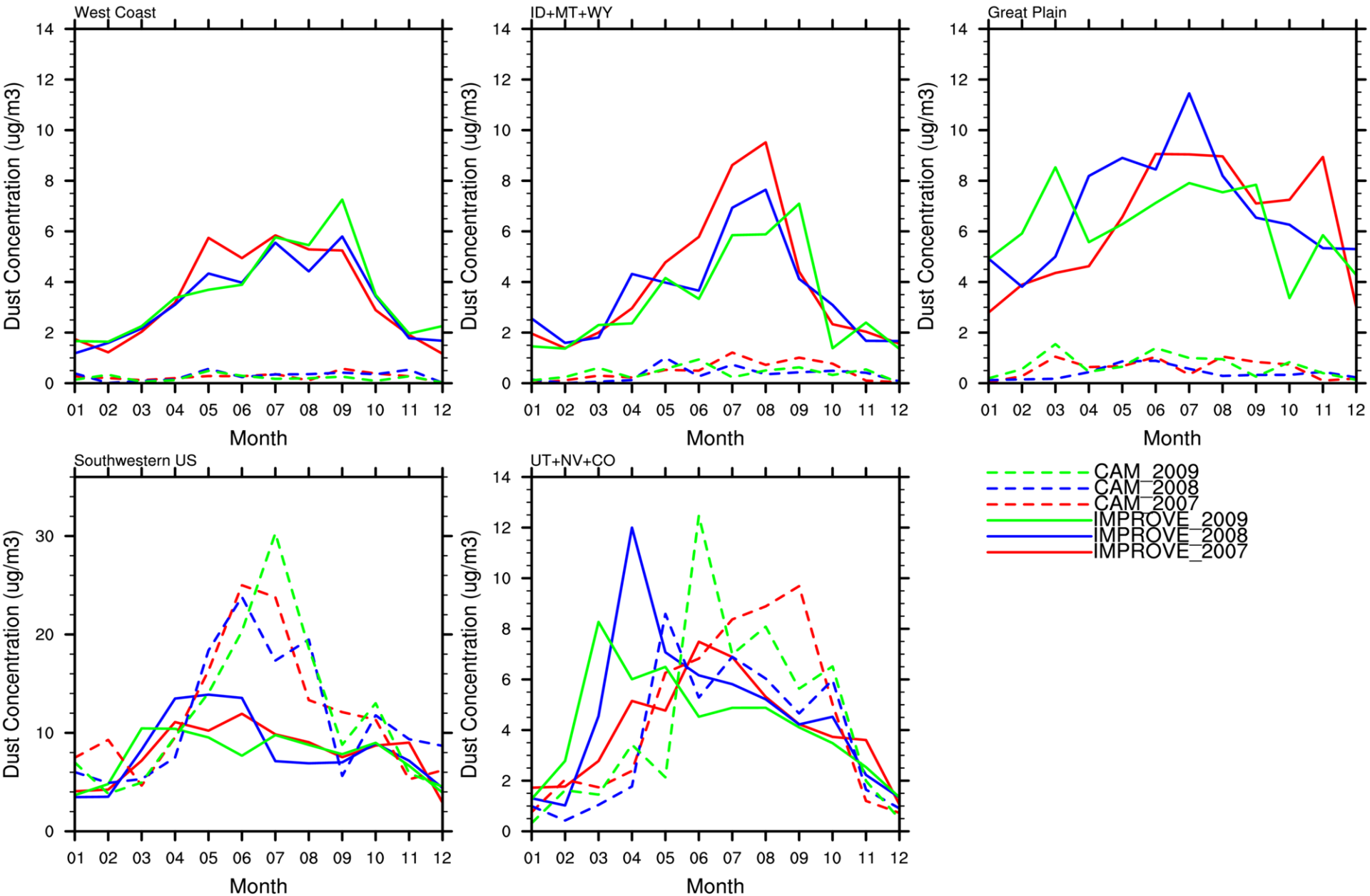


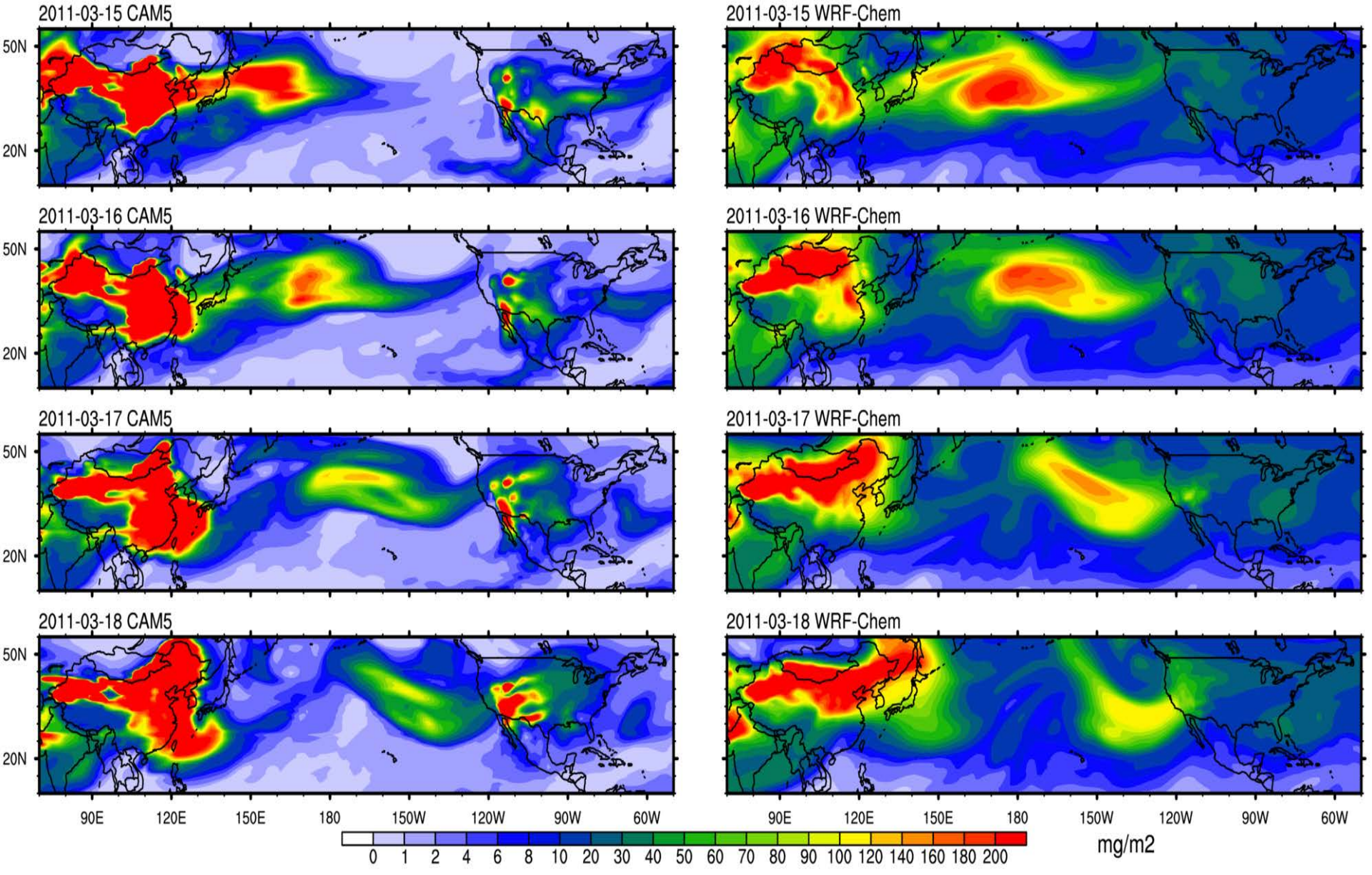
Dust transport from Asia to N. America

- Case study: March 15-18, 2011
- Configuration: CAM5.4, Specified dynamics
- Simulation period: February 1 to March 31, 2011
- Resolution: $0.9^{o} \times 1.25^{o}$
- Sensitivity tests:
  - **Dust emission schemes:** Zender et al. (2003) (Default), Kok et al. (2014)
  - **Dust dry deposition**

- WRF-Chem:
  - **Nearly global 1° simulations** (Hu et al. 2016)
  - **MOSAIC aerosol bin microphysics**
  - **Dust emission scheme:** Ginoux et al. (2001)

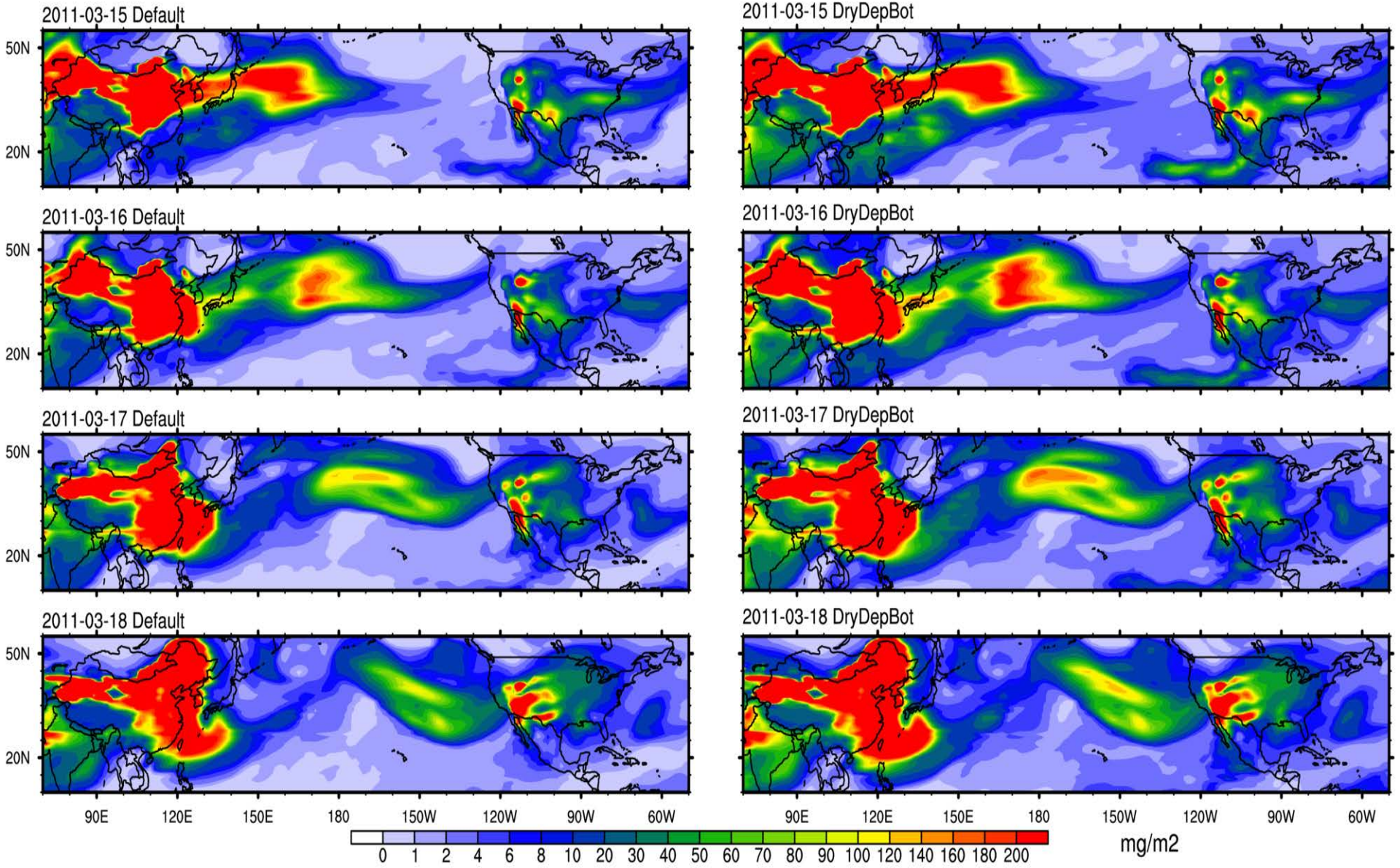
Dust event on March 15-18, 2011

Daily mean dust column burden *(CAM5, Left vs WRF-Chem, Right)*



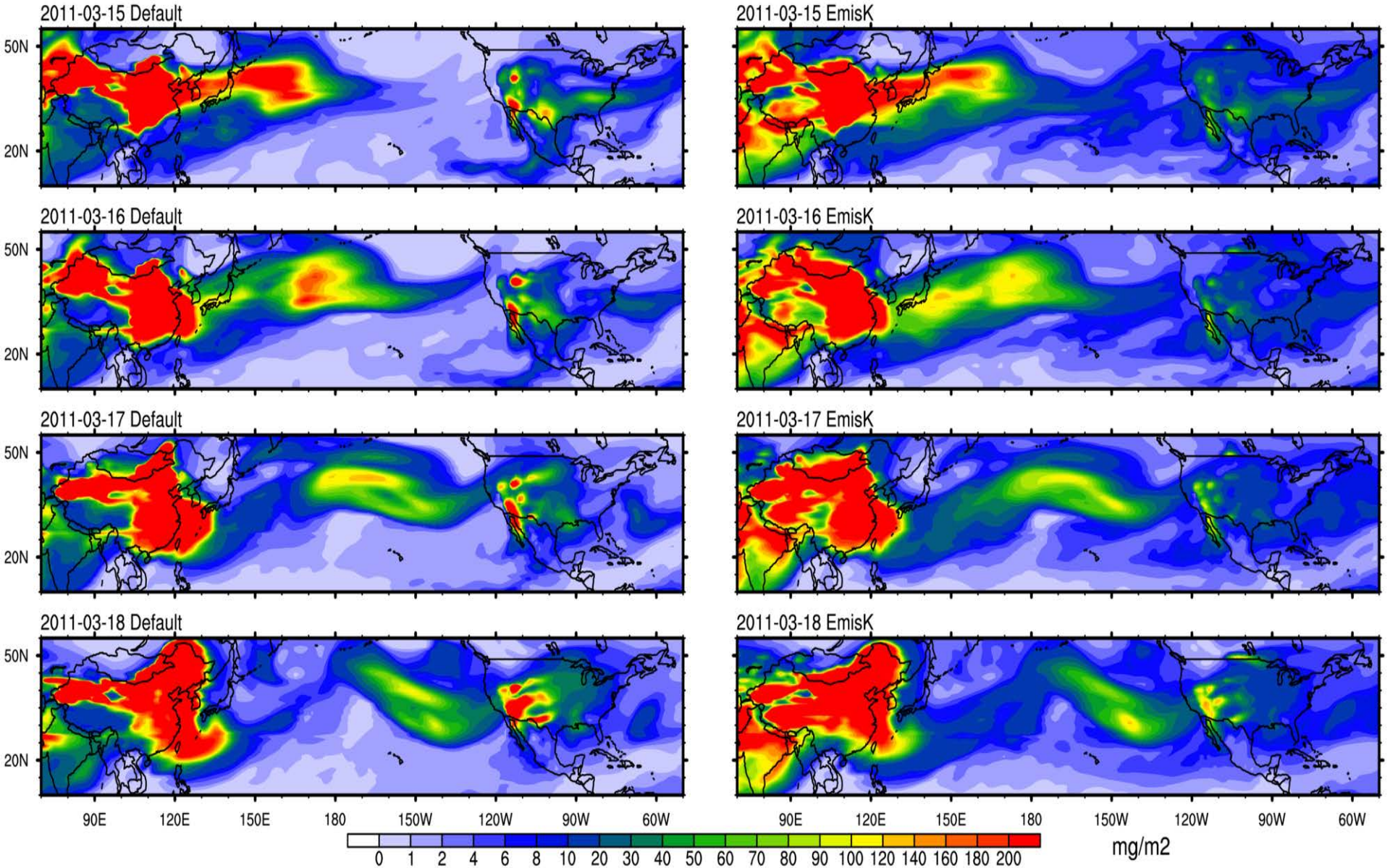
Dust event on March 15-18, 2011

Dust column burden *(Default-left vs DryDepBot-Right, dry deposition velocity in bottom layer reduced to 10% on non-vegetated surface)*



Dust event on March 15-18, 2011

Dust column burden *(Default-left vs EmisK-Right, dust emission scheme from Kok et al. (2014))*



Dust event on March 15-18, 2011

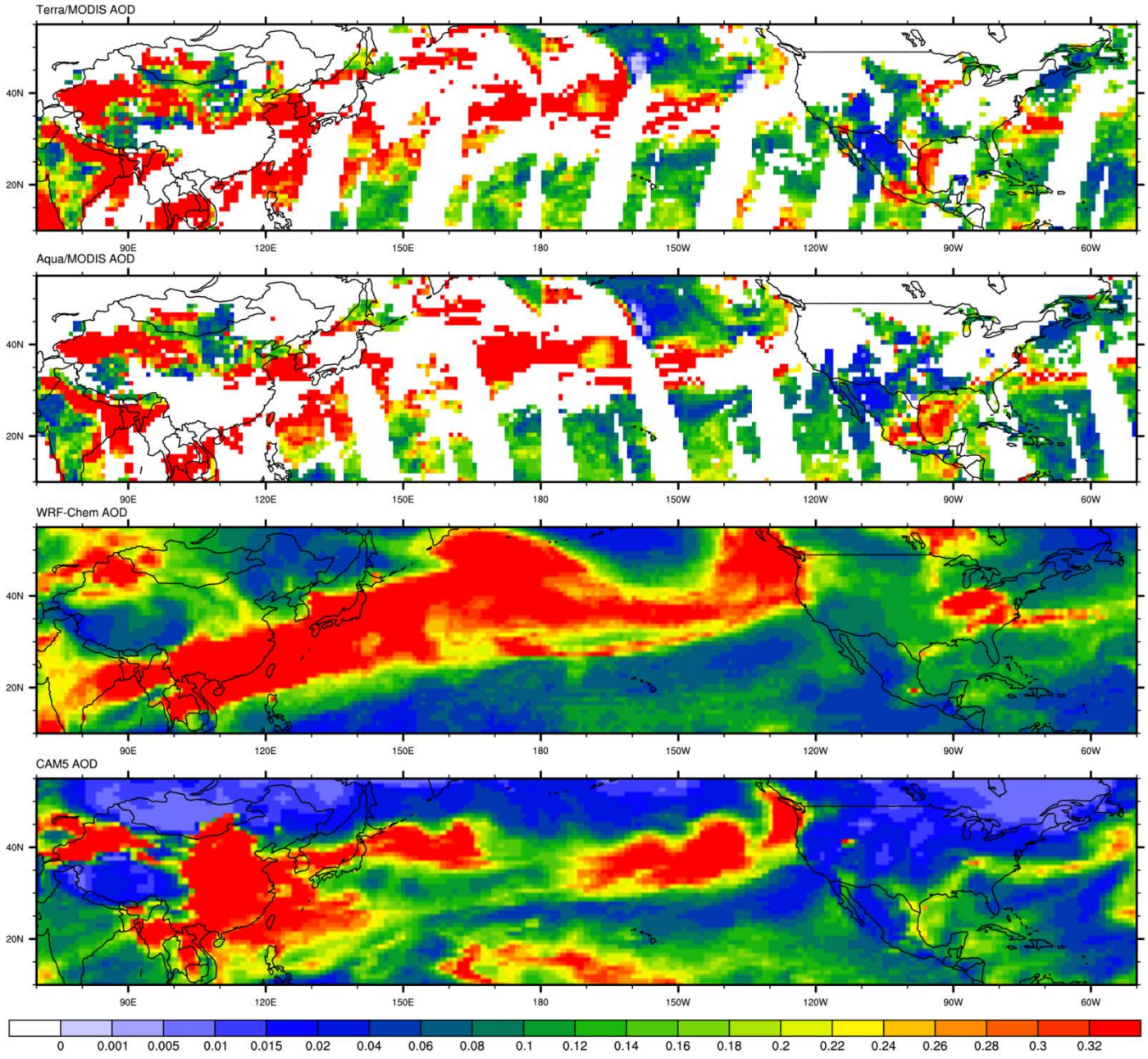
AOD on March 15

Terra/MODIS

Aqua/MODIS

WRF-Chem

CAM5



Dust event on March 15-18, 2011

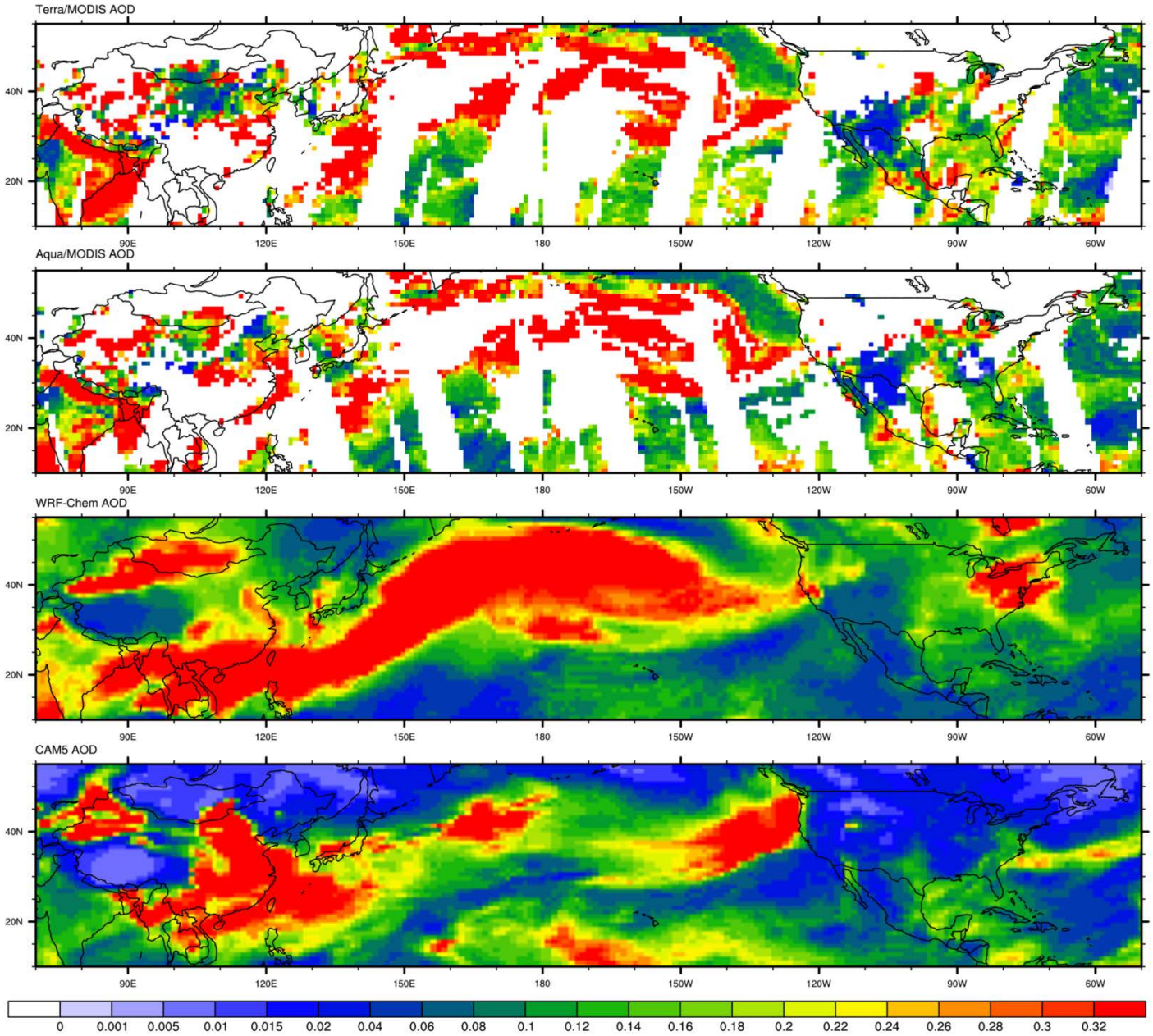
AOD on March 16

Terra/MODIS

Aqua/MODIS

WRF-Chem

CAM5



Dust event on March 15-18, 2011

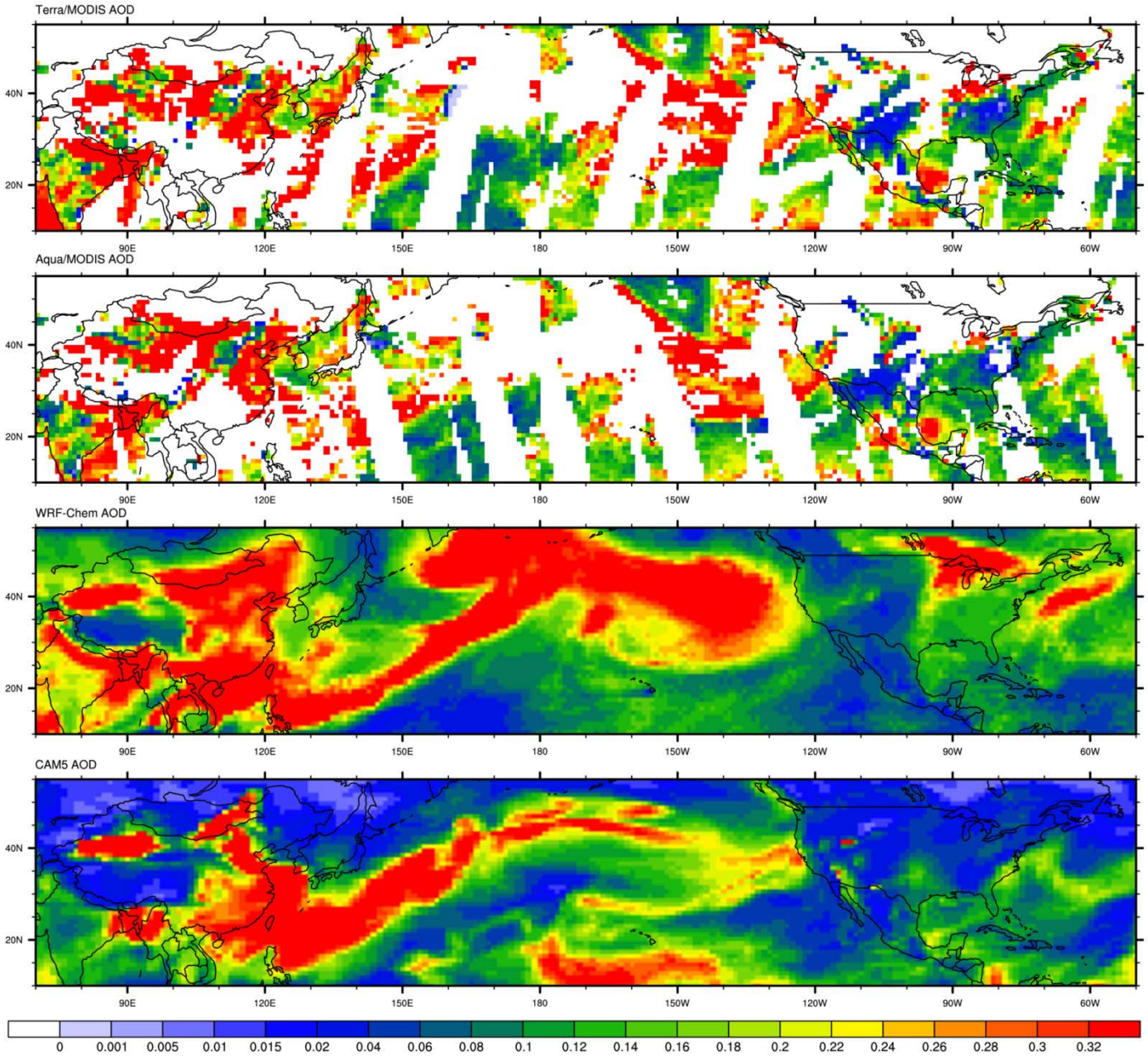
AOD on March 17

Terra/MODIS

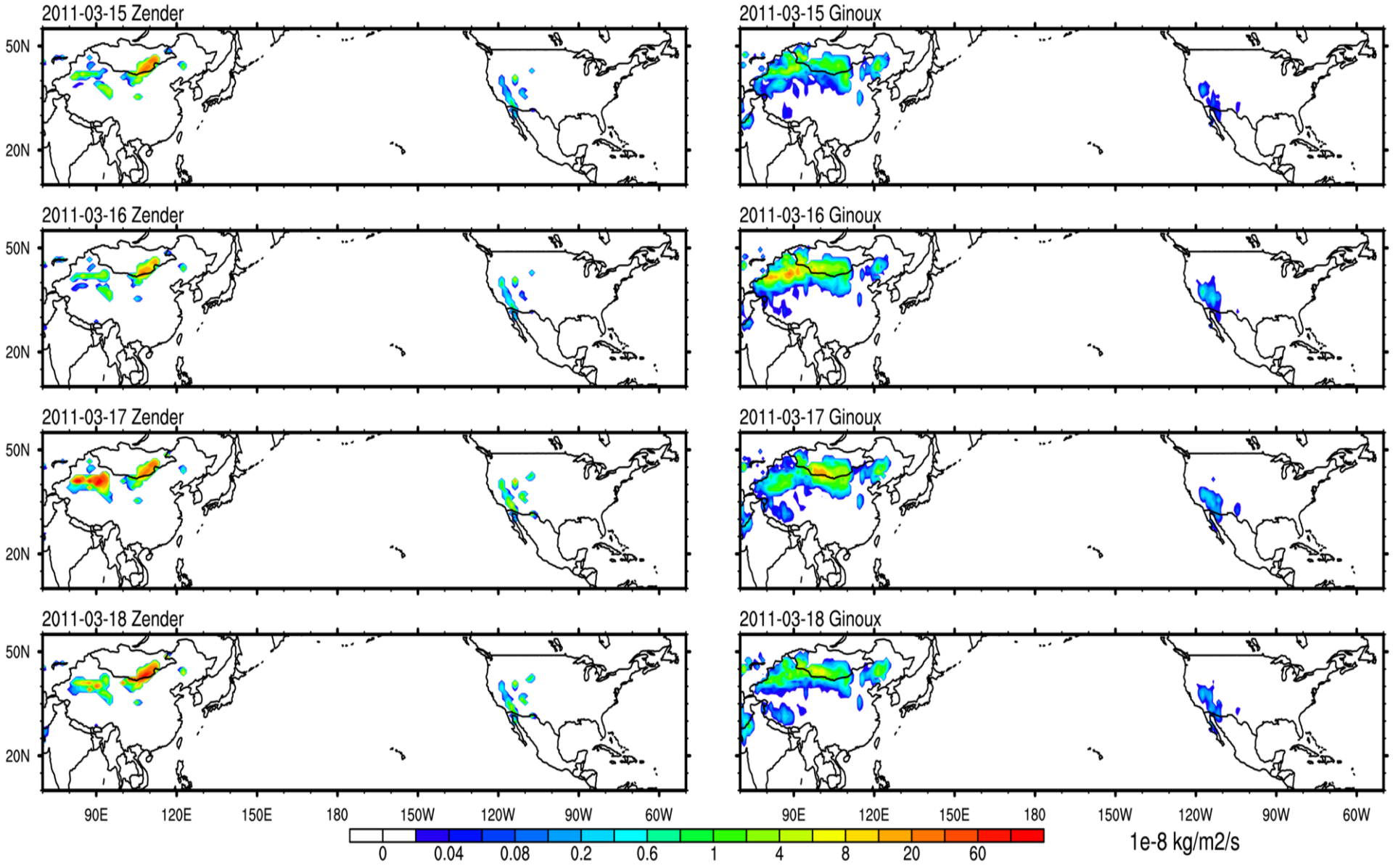
Aqua/MODIS

WRF-Chem

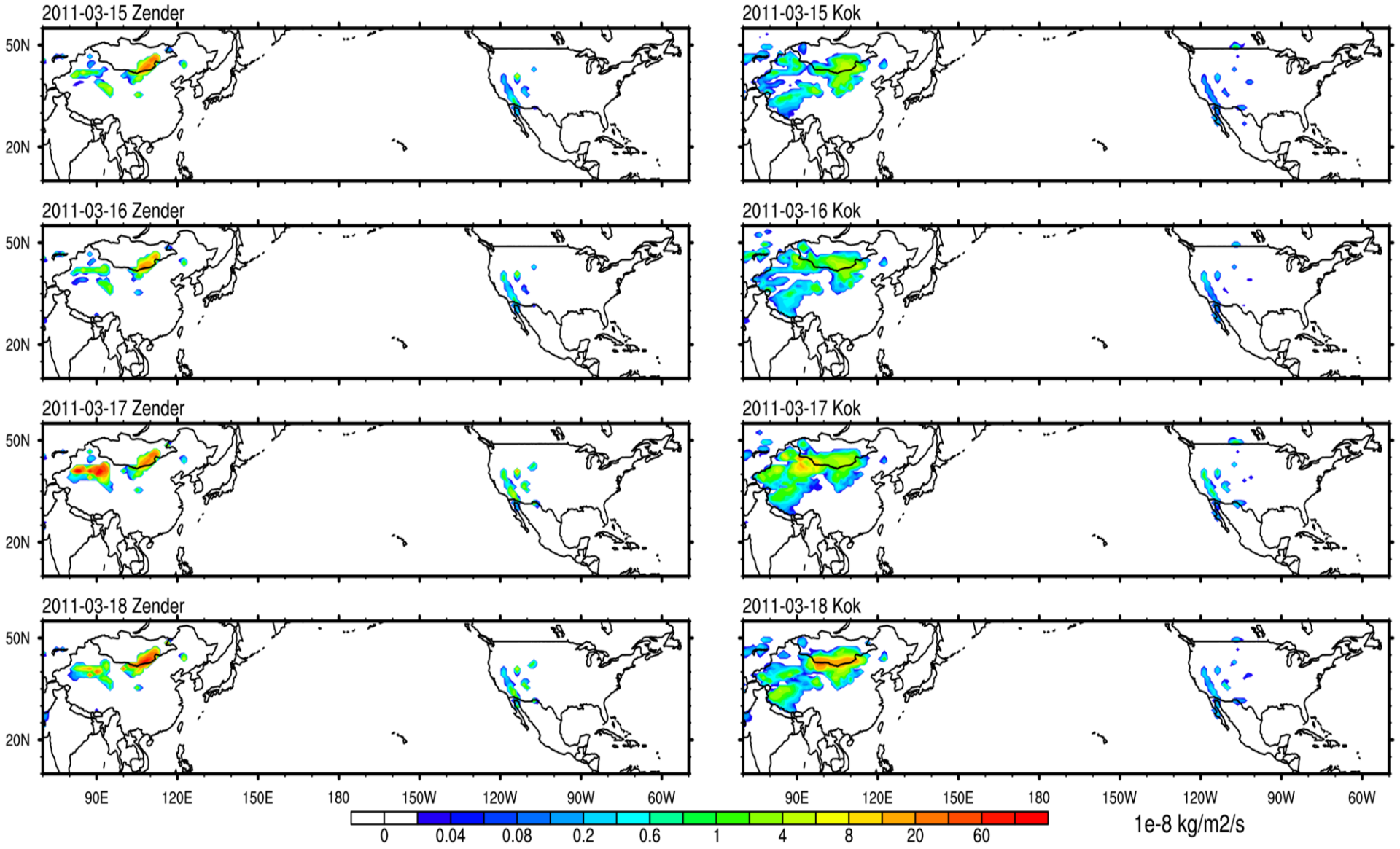
CAM5



Dust emissions March 15-18 *(CAM5-Left vs WRFChem-Right, Zender et al. (2003) vs Ginoux et al. (2001)*



Dust emissions March 15-18 *(Zender-Left vs Kok-Right, Zender et al. (2003) vs Kok et al. (2014)*

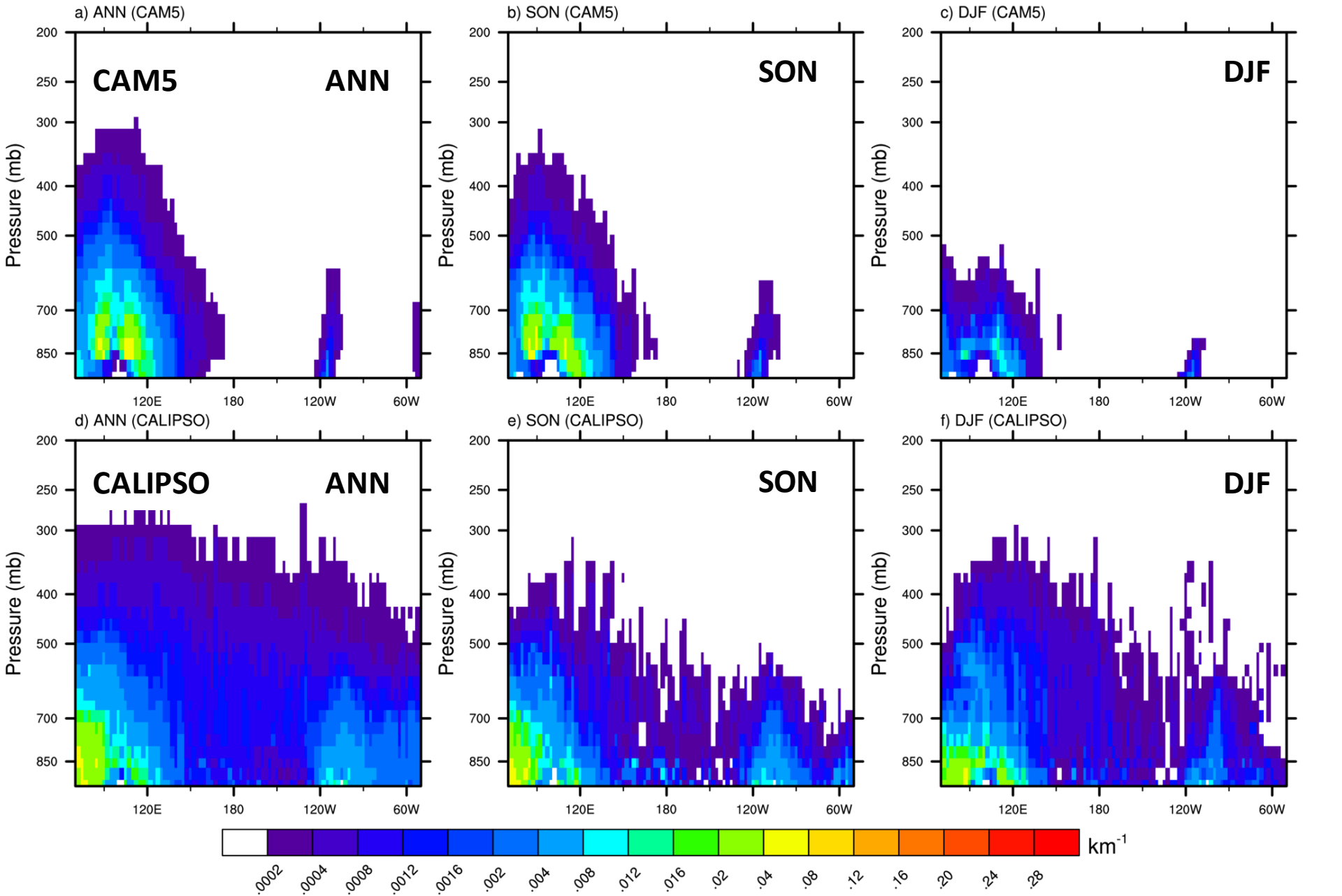


Summary

- Dust decays too fast simulated in CAM5 when transported from Asia to N. America, compared with the collocated CALIPSO data
- The too fast decay may be due to the gravitational settling related to dust size distribution in MAM/CAM5
  - WRF-Chem with a bin aerosol scheme has better simulations
- Cloud/precipitation scavenging may also play a role
- Large uncertainty in dust emissions (spatial pattern and flux) in Asia and N. America

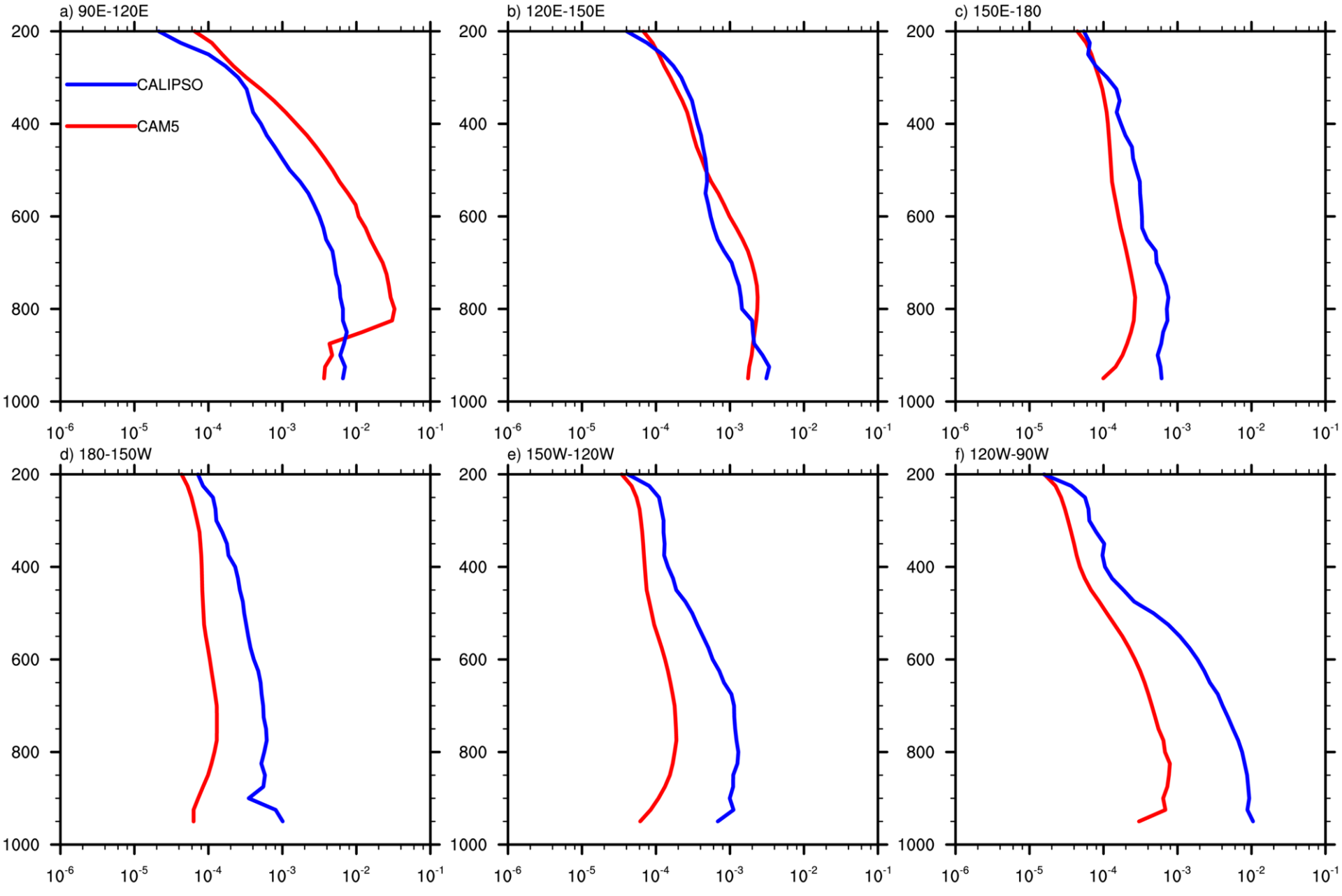
Comparison with Collocated CALIPSO observations

Dust Extinction (90E-50W, averaged over 20N-50N)



Comparison with CALIPSO observations

Dust Extinction profile (JJA)



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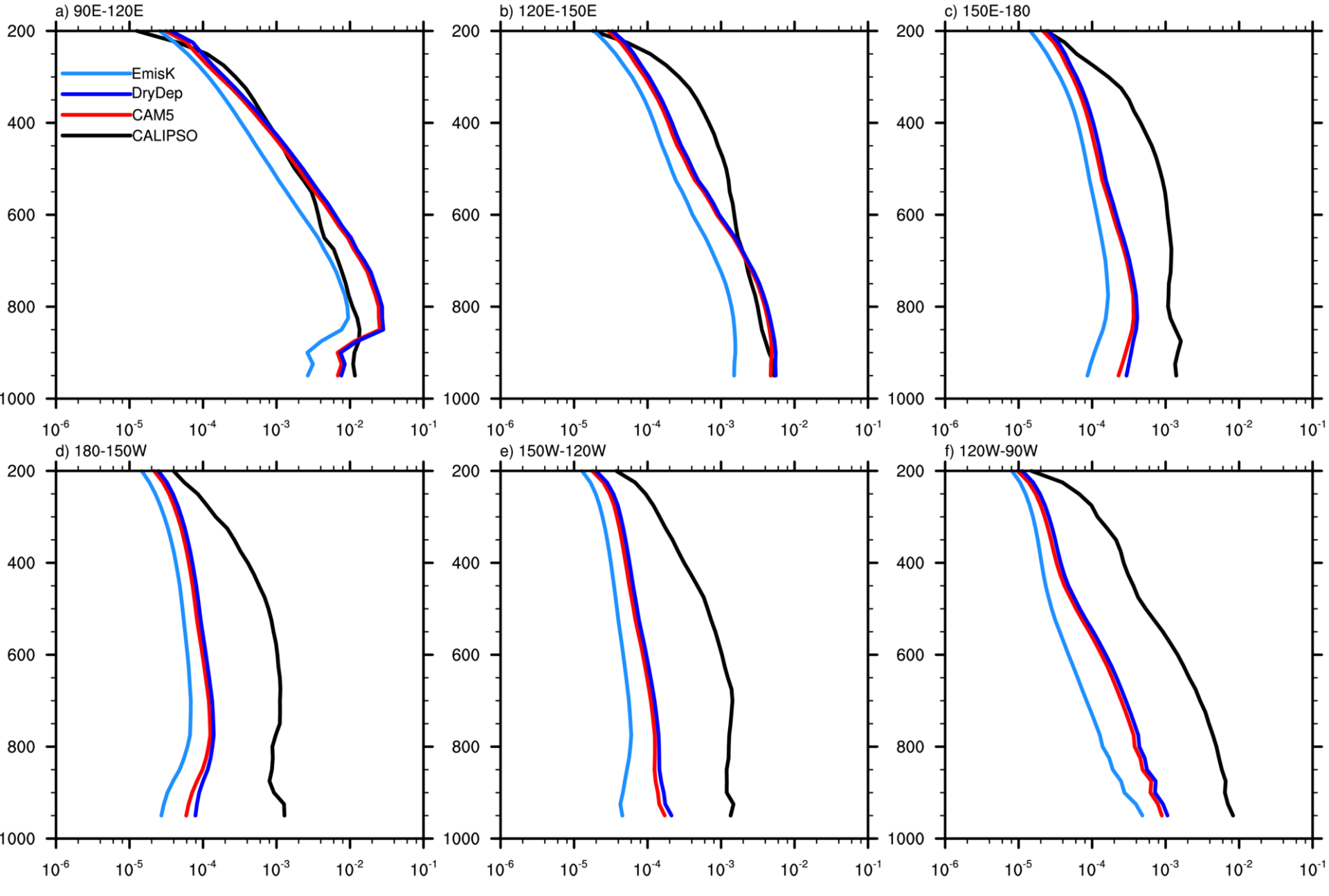
Dust Extinction profile (annual mean)



Comparison with CALIPSO observations

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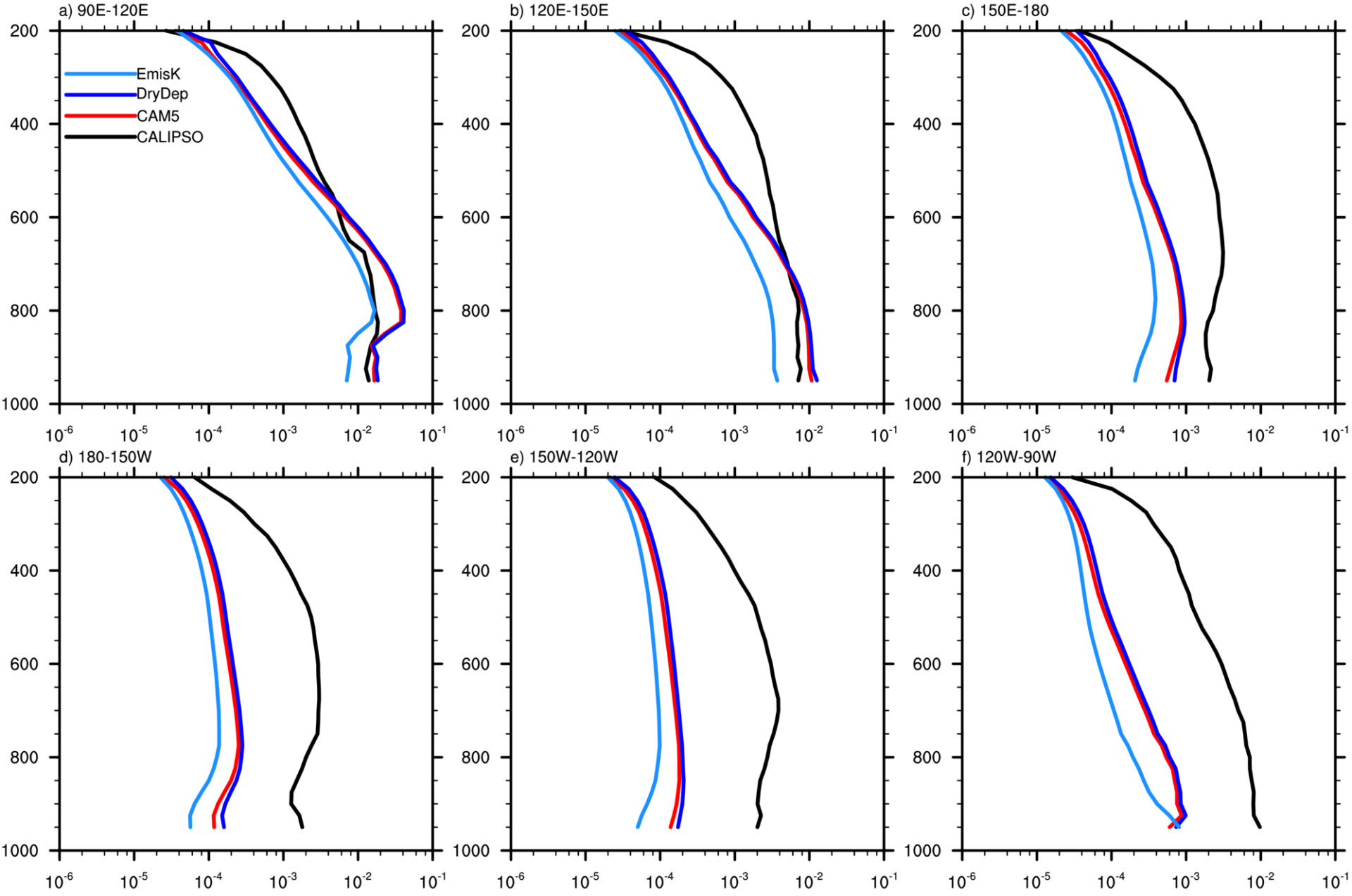

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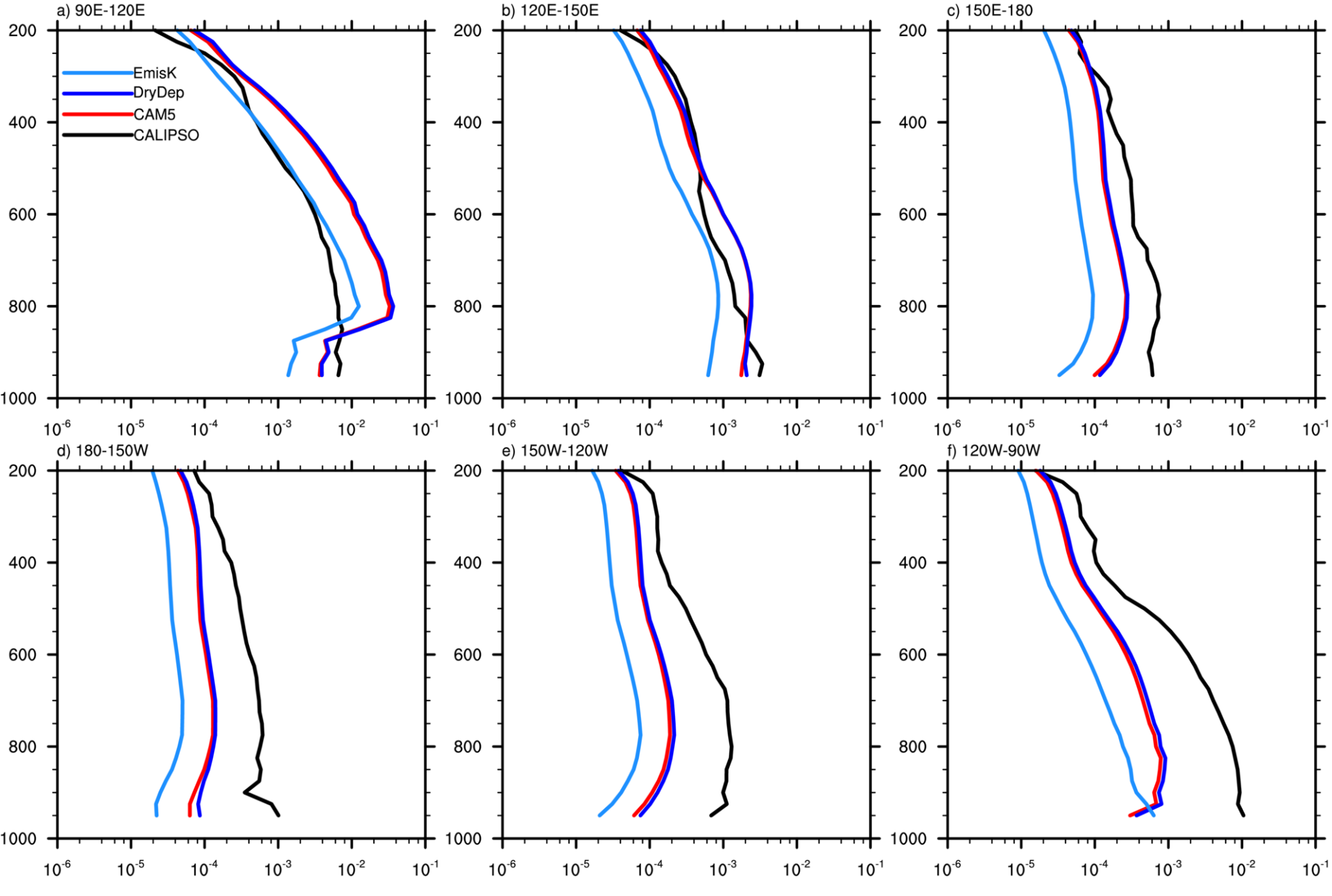
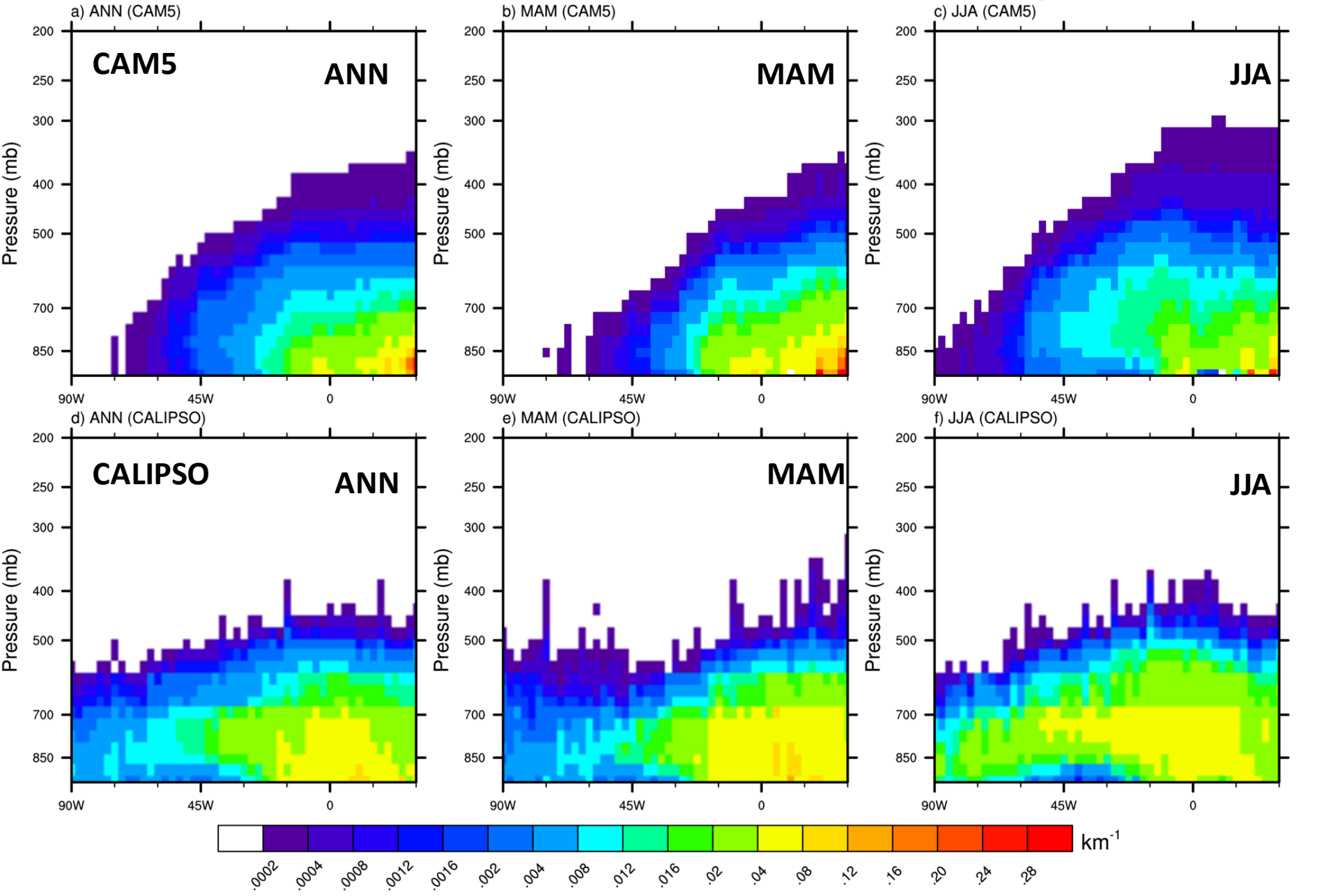


Comparison with CALIPSO observations

Dust Extinction (90W-30E, averaged over 10N-30N)



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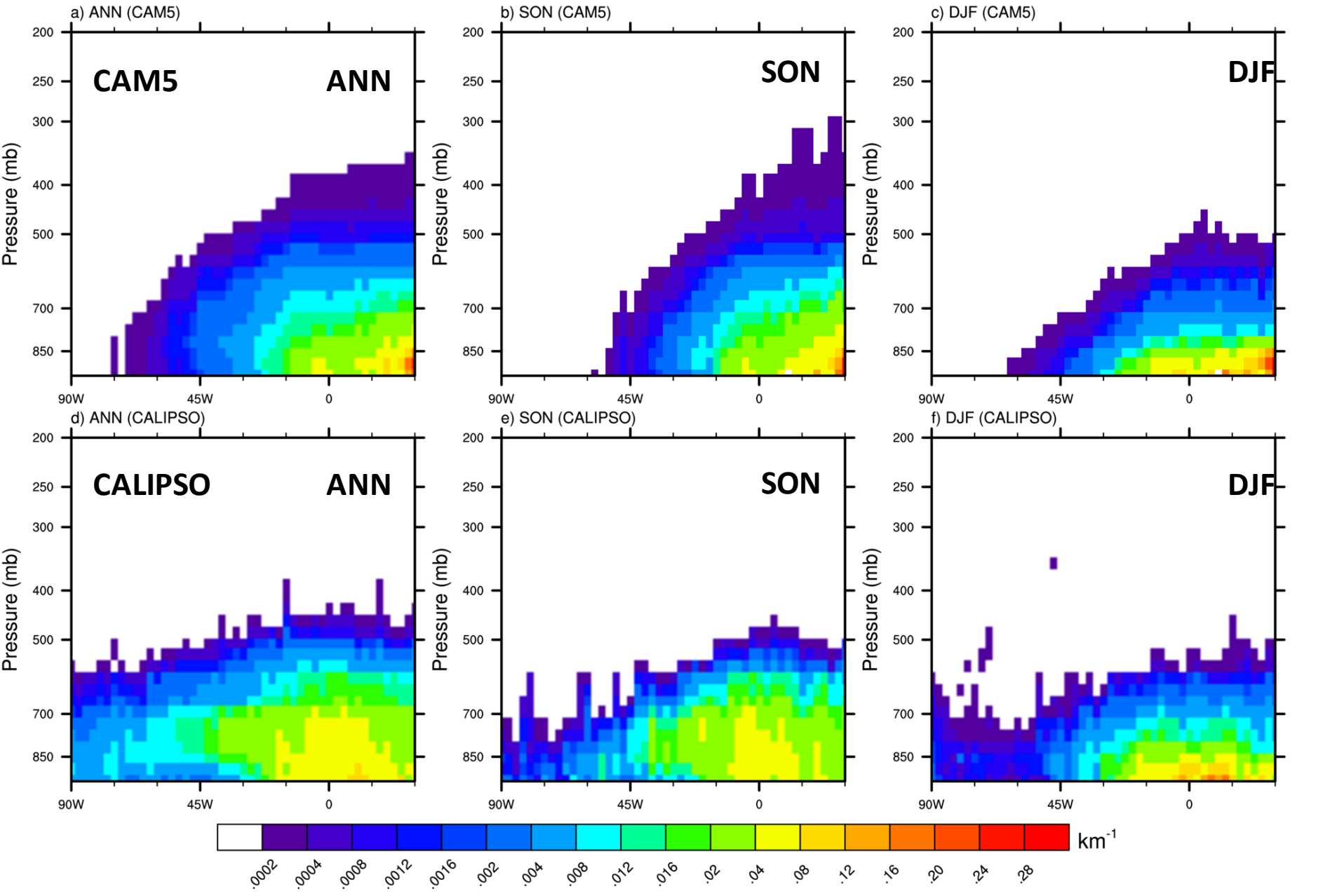
Dust Extinction (90W-30E, averaged over 10N-30N)



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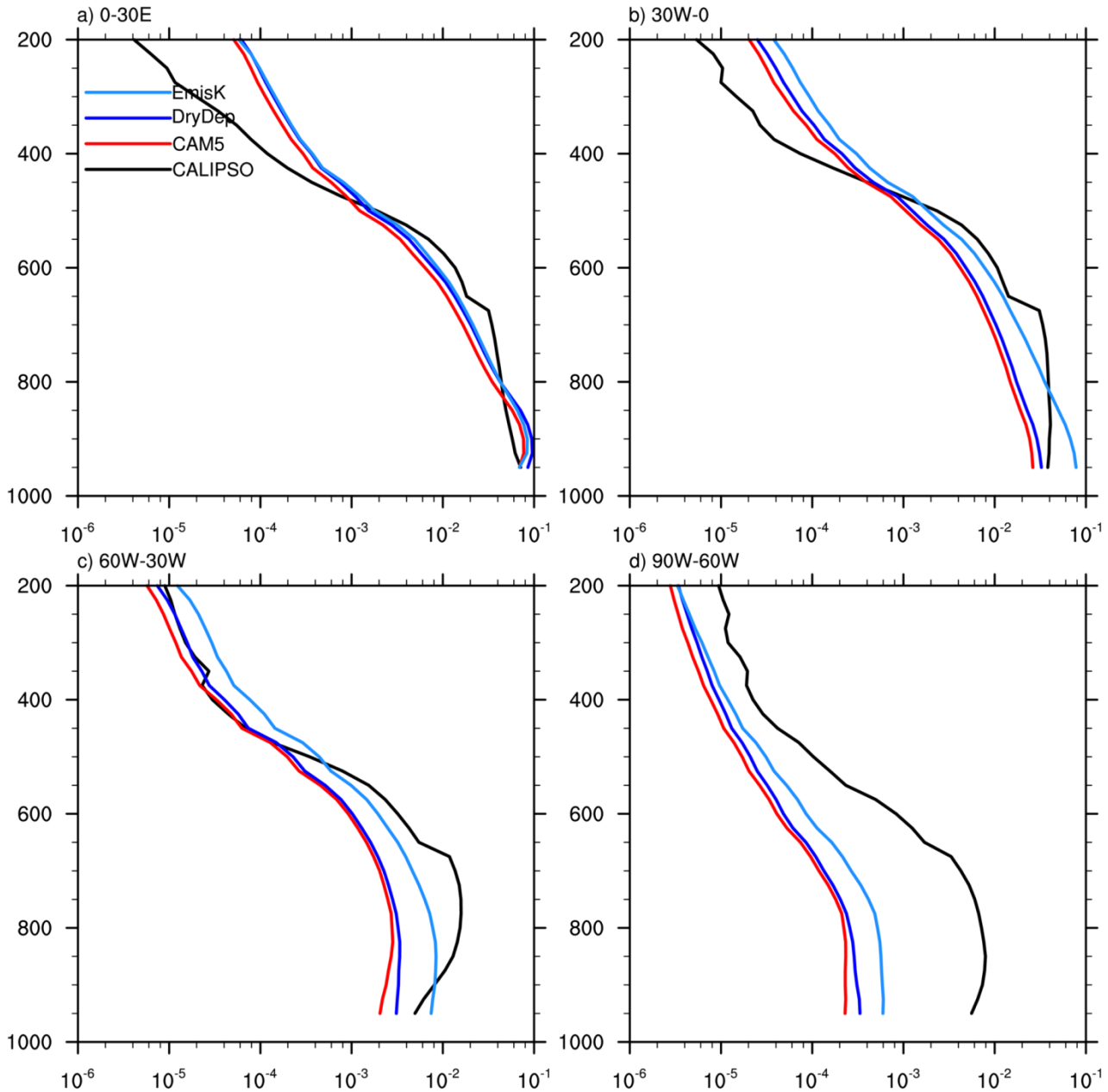
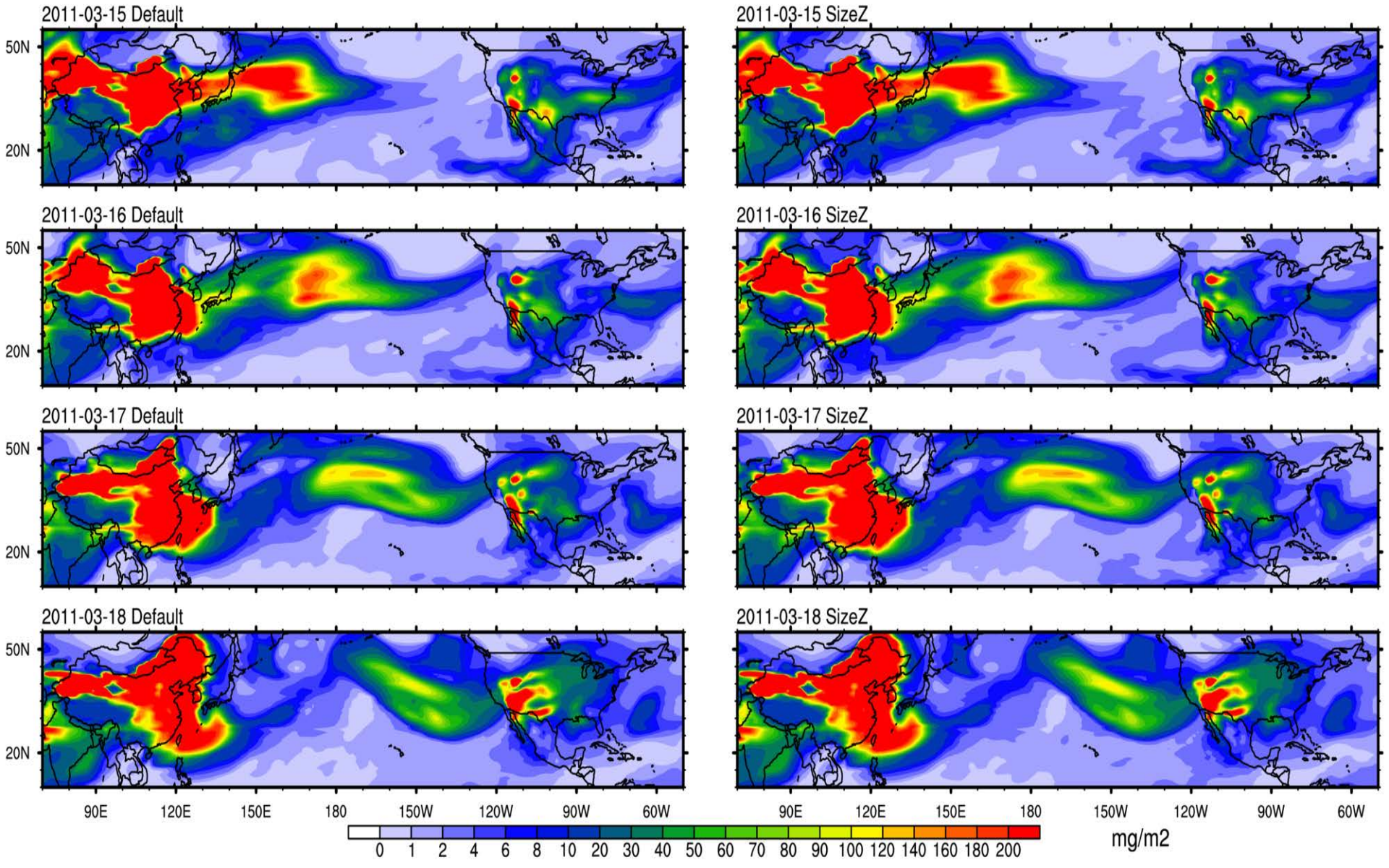


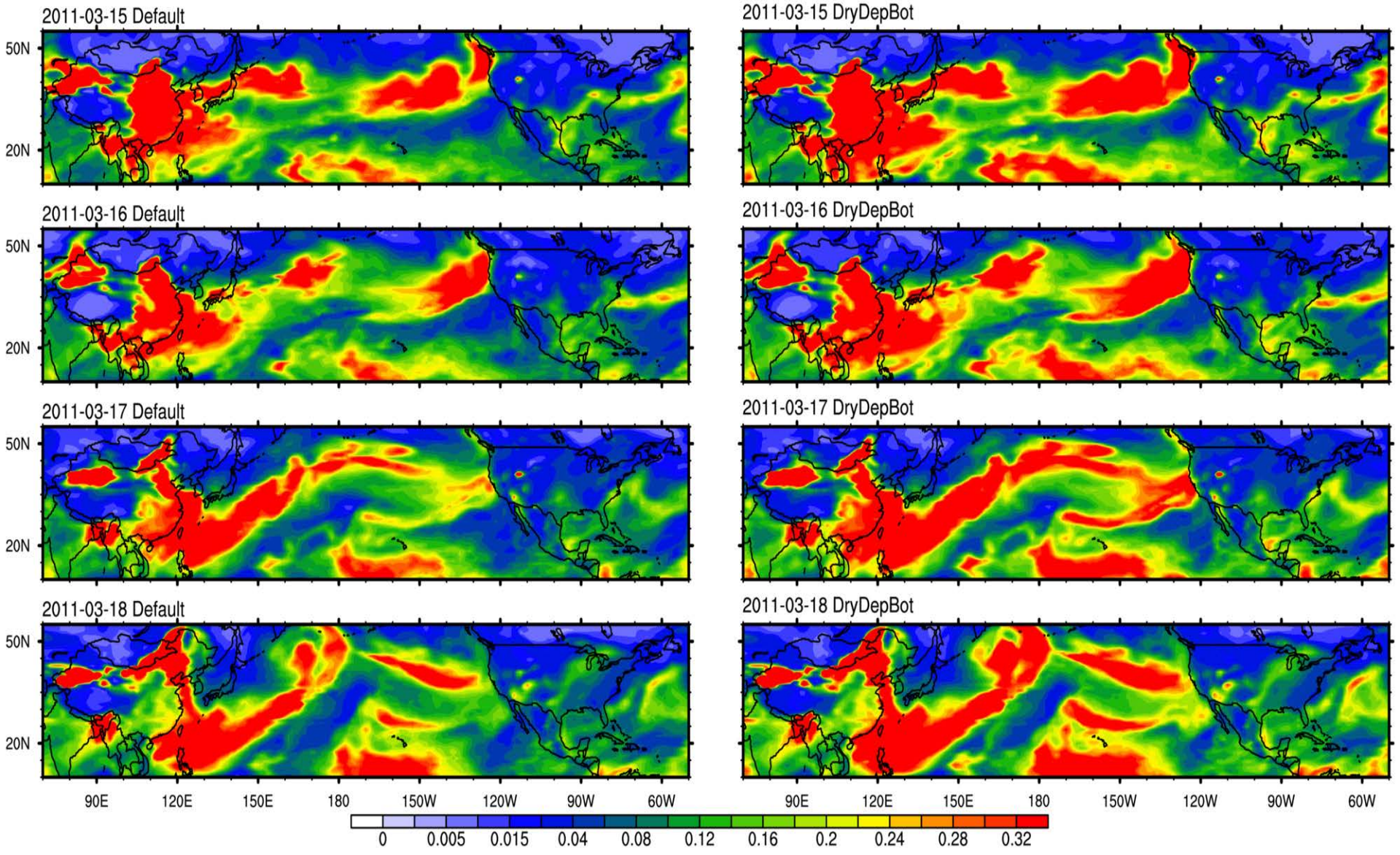
Dust event on March 15-18, 2011

Dust column burden *(Default-left vs SizeZ-Right, dust size distribution from Zender et al. (2003))*



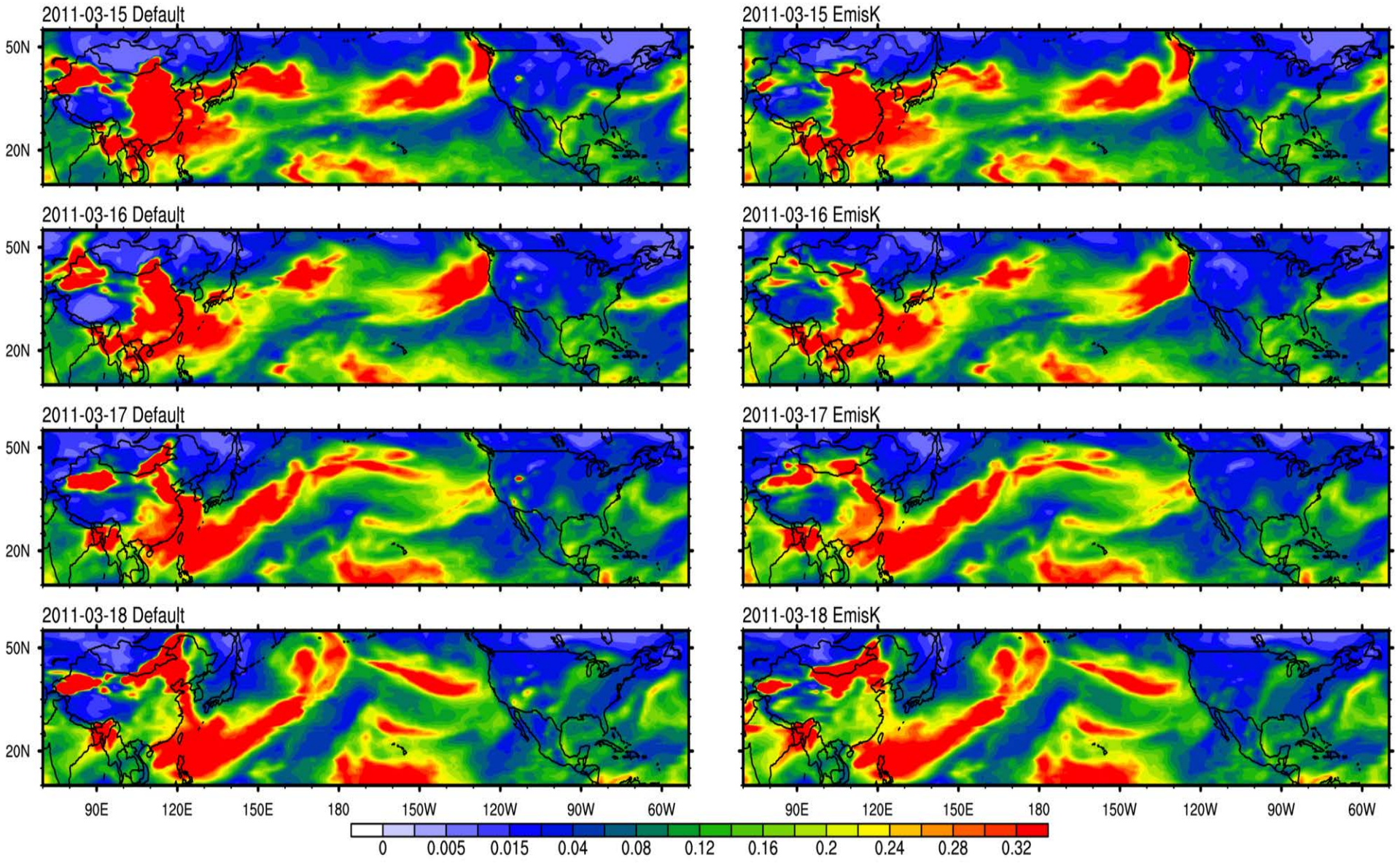
Dust event on March 15-18, 2011

AOD *(Default-Left vs DryDepBot-Right, dry deposition velocity in bottom layer reduced to 10% on non-vegetated surface)*



Dust event on March 15-18, 2011

AOD *(Default-left vs EmisK-Right, dust emission scheme from Kok et al. (2014))*



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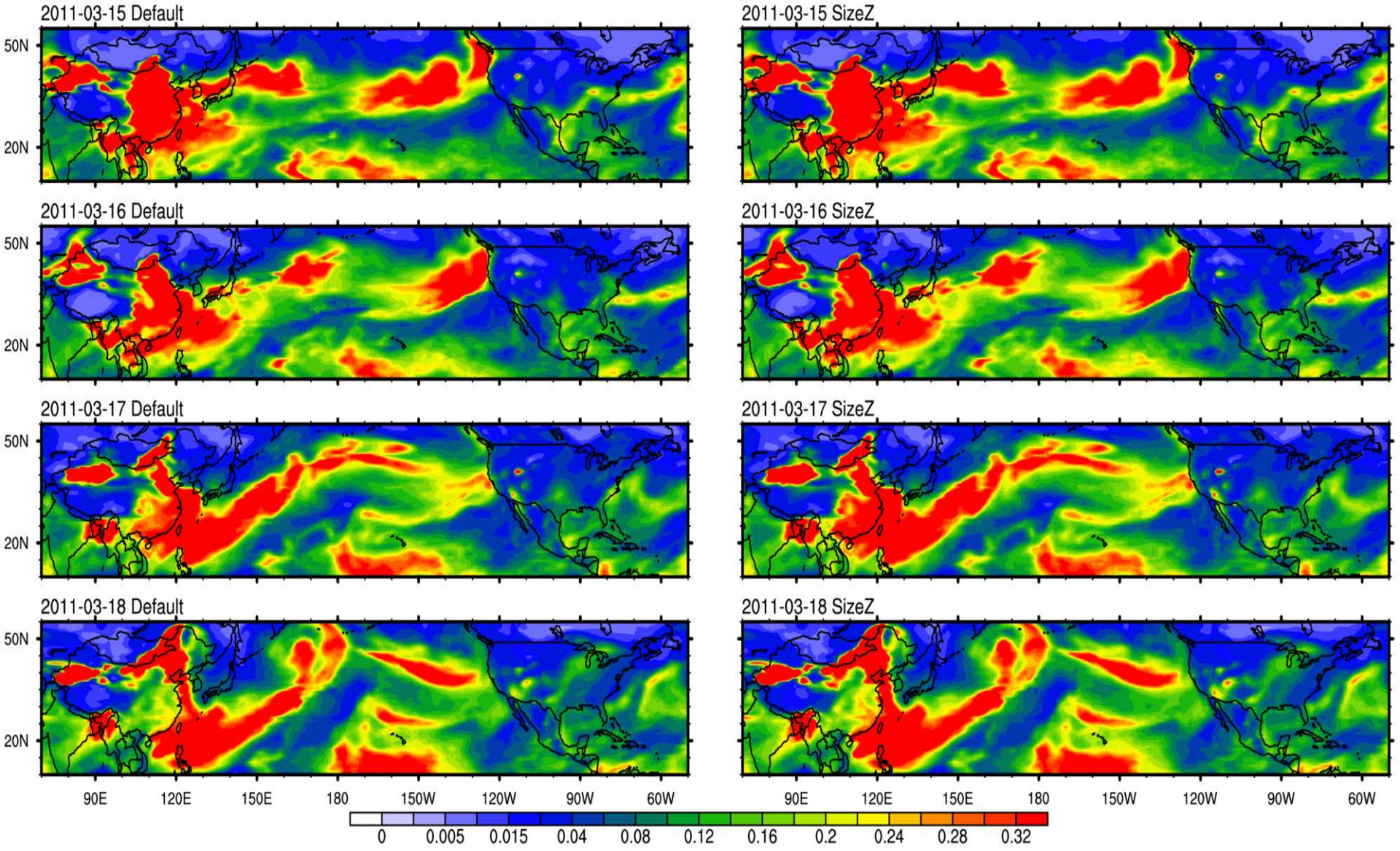
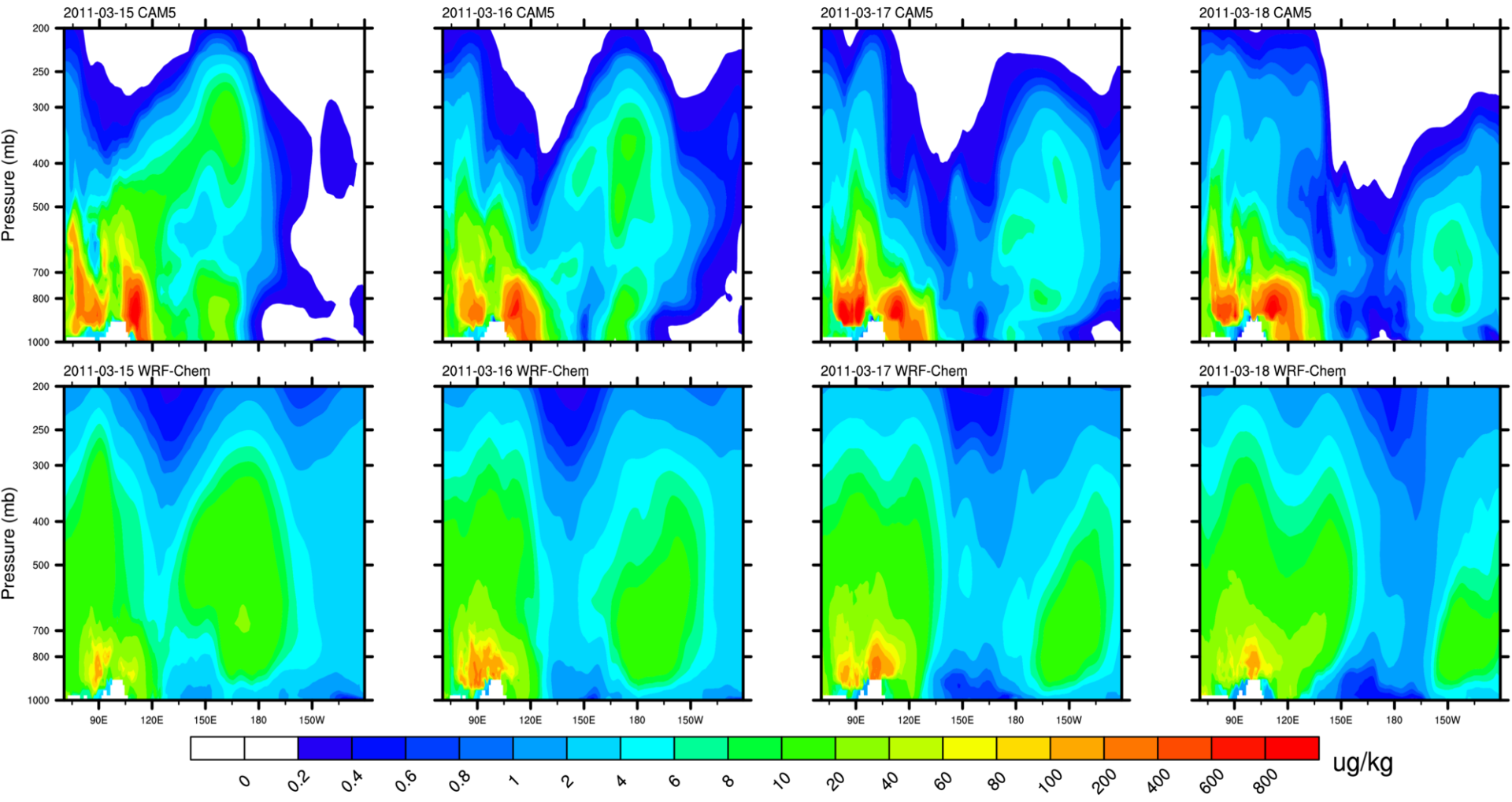


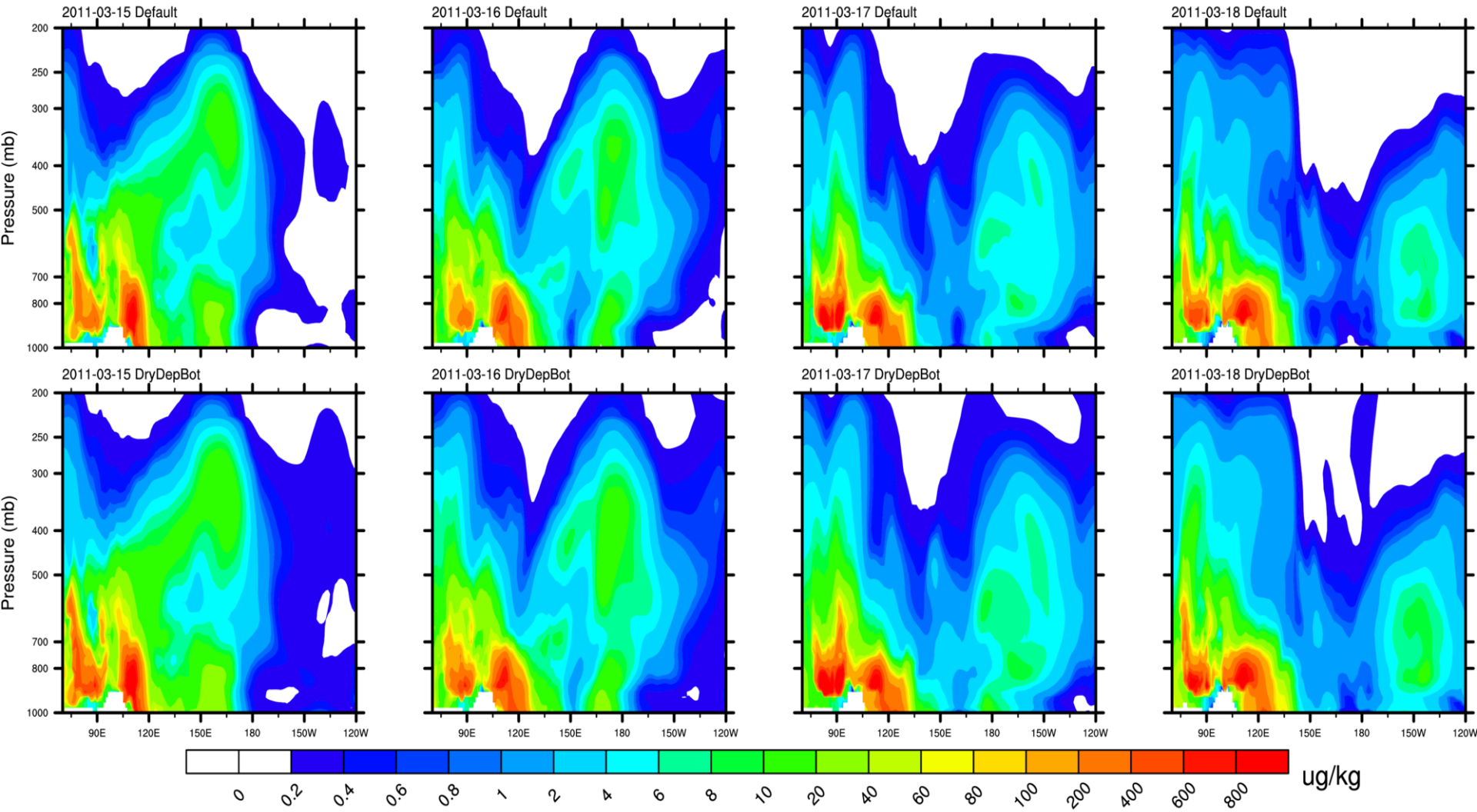
Dust event on March 15-18, 2011

Dust concentrations March 15-18 *(CAM5-Top vs WRFChem-Bottom)*



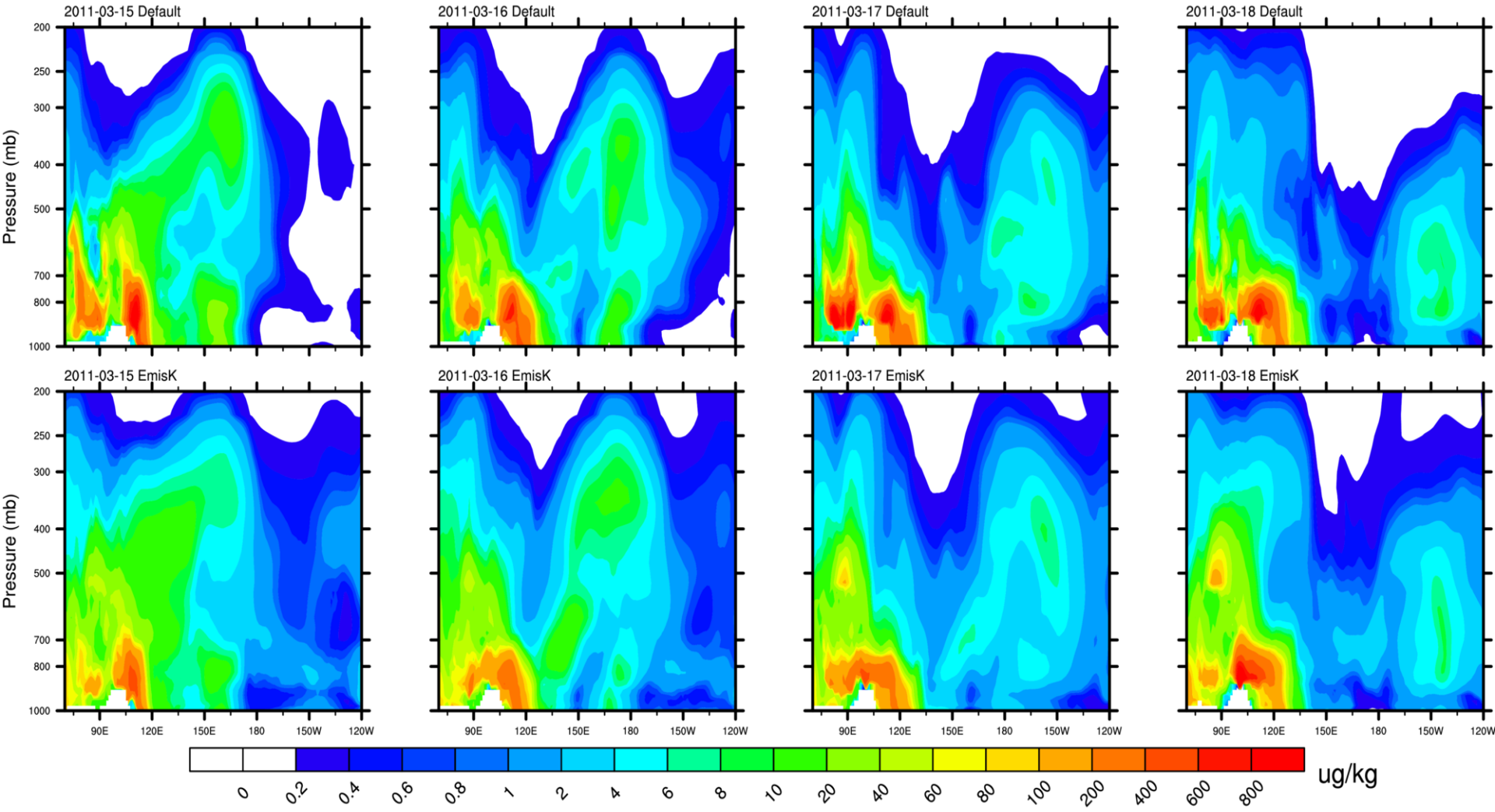
Dust event on March 15-18

Dust concentrations *(Default-Top vs DryDepBot-Bottom, dry deposition velocity in bottom layer reduced to 10% on non-vegetated surface)*



Dust event on March 15-18, 2011

Dust concentrations *(Default-Top vs EmisK-Bottom, dust emission scheme from Kok et al. (2014))*



Dust event on March 15-18

Dust concentrations *(Default-left vs SizeZ-Right, dust size distribution from Zender et al. (2003))*