



Dust vertical and horizontal distributions simulated by CESM 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.

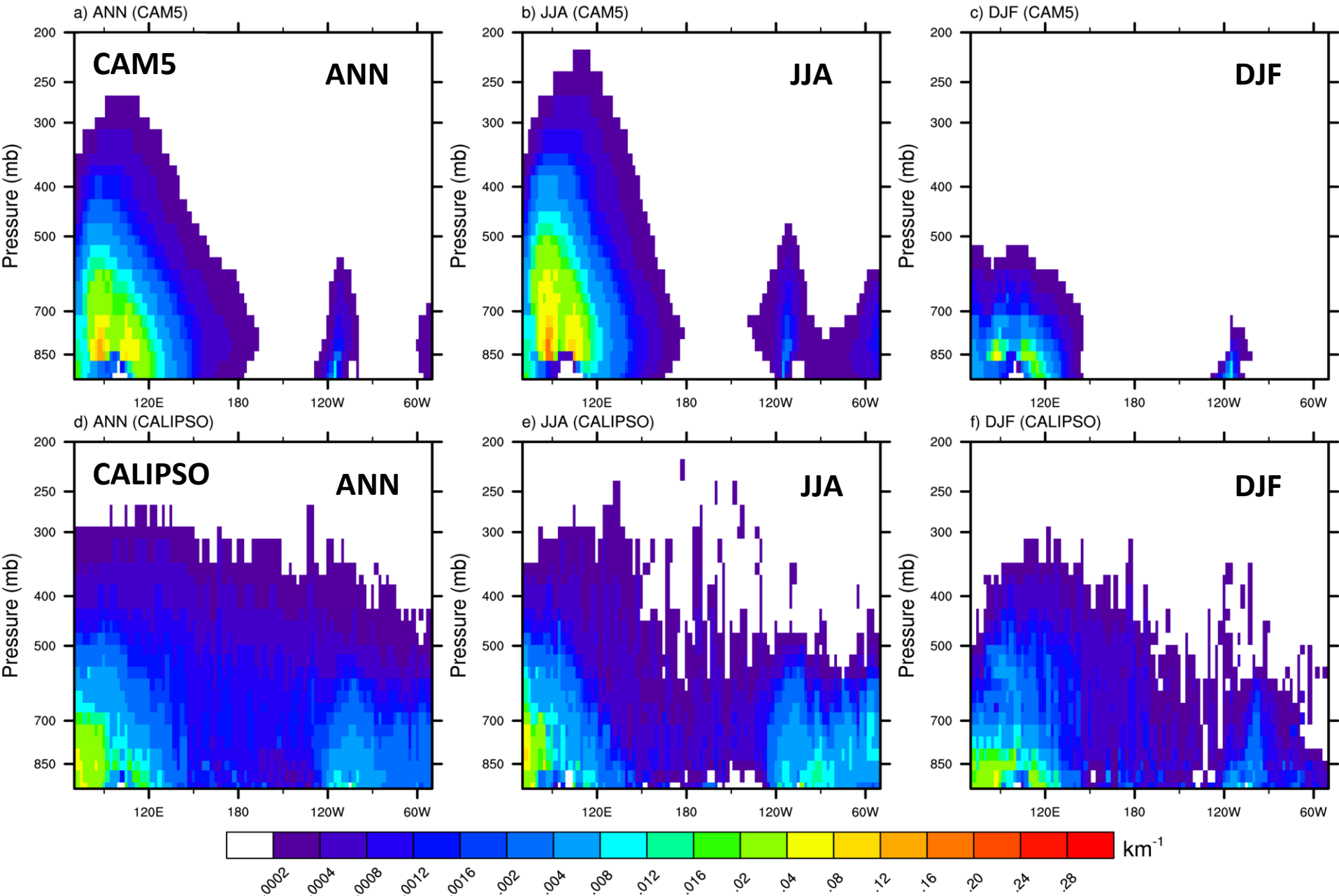


Model and Data

- ▶ **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:** $1.9^{\circ} \times 2.5^{\circ}$
- ▶ **Dust emission:** Zender et al. (2003)
 - Dust emissions were tuned so that annual mean AOD in dust source regions ($\text{DOD}/\text{AOD} > 0.5$) matches MODIS observation for 2007-2009
- ▶ **Observation data:** CALIPSO with improved thin dust layer detection (Luo et al. 2015)

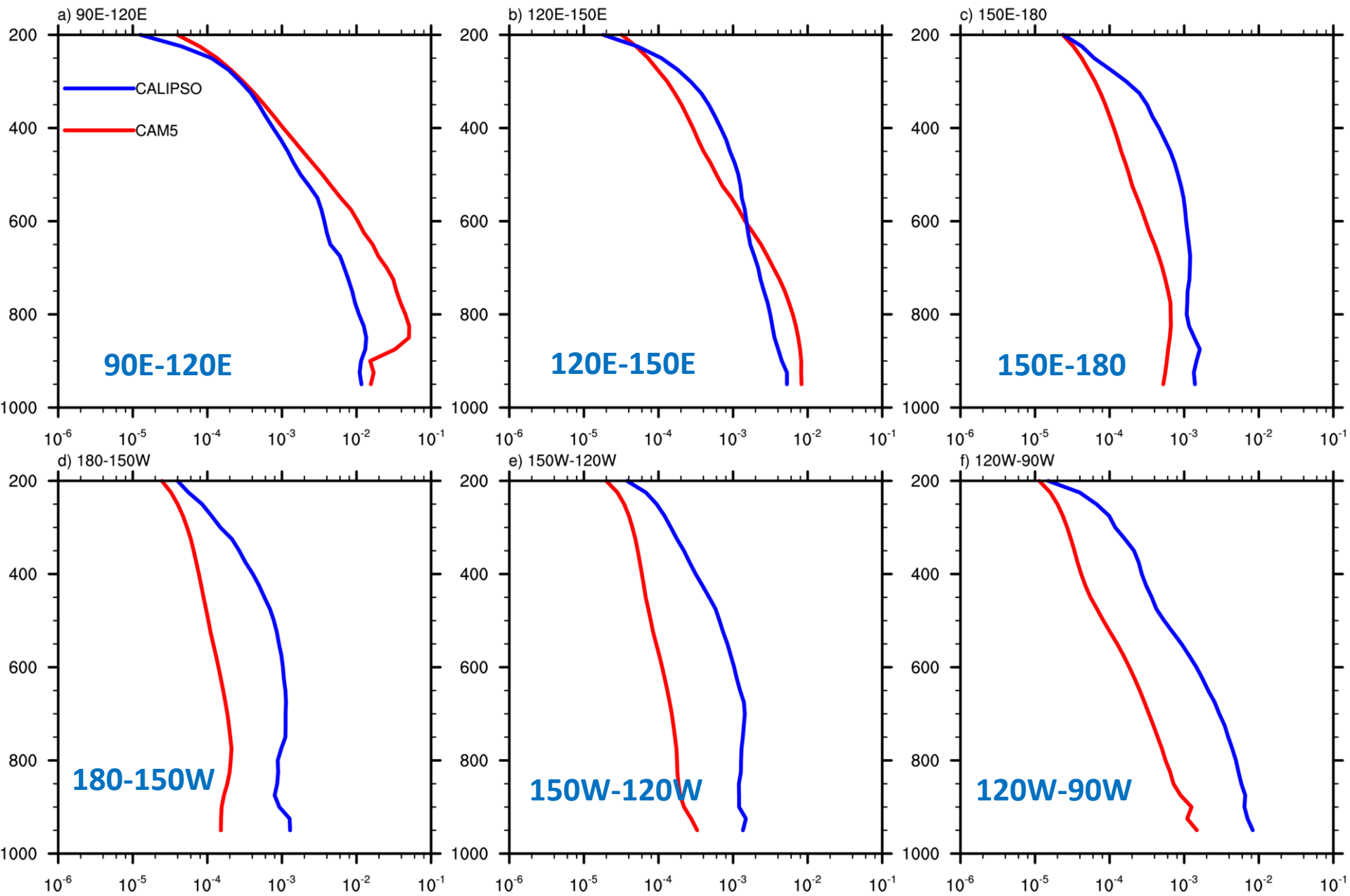
Comparison with Collocated CALIPSO observations

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



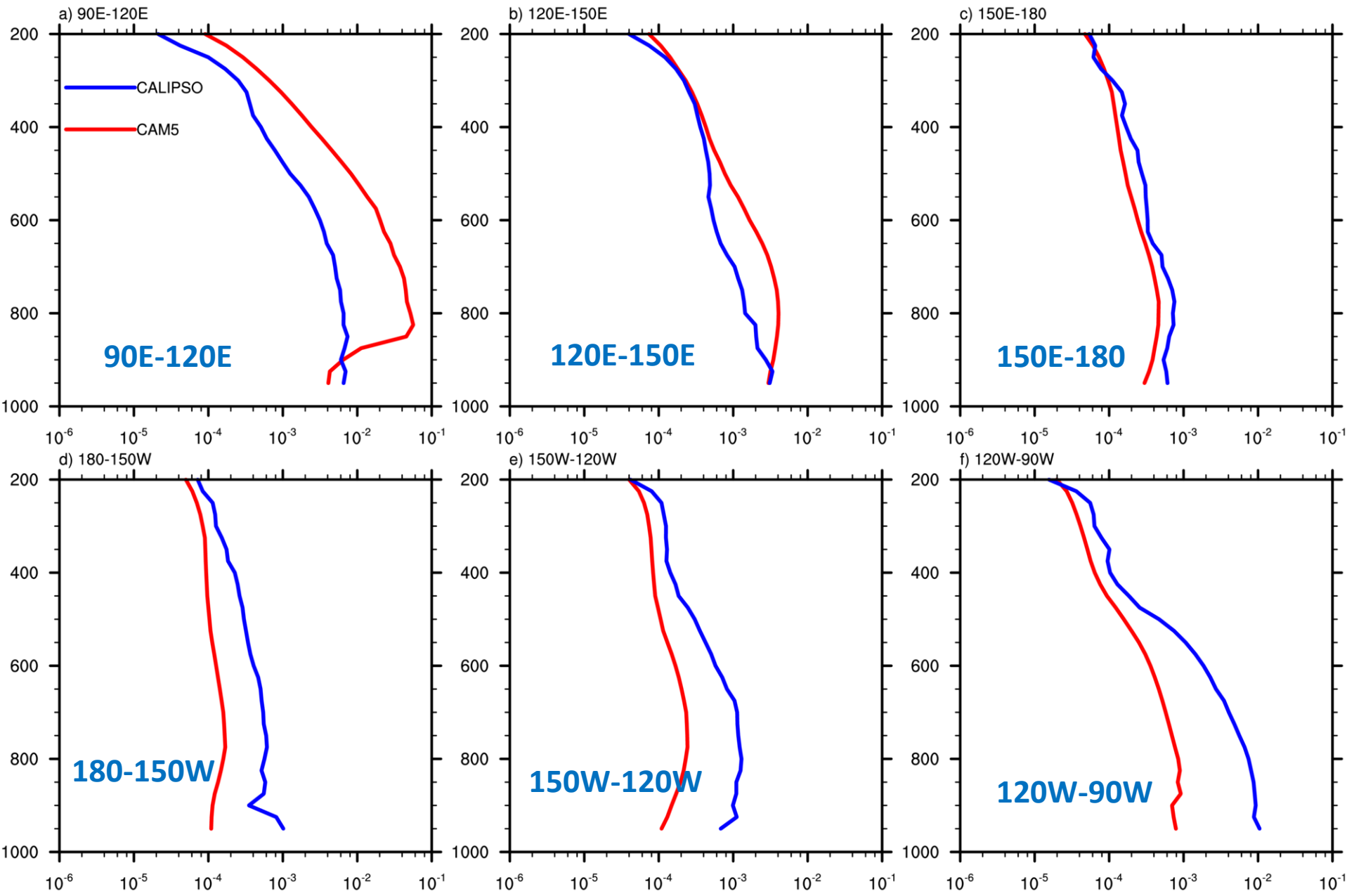
Comparison with Collocated CALIPSO observations

Dust extinction profile (annual mean)



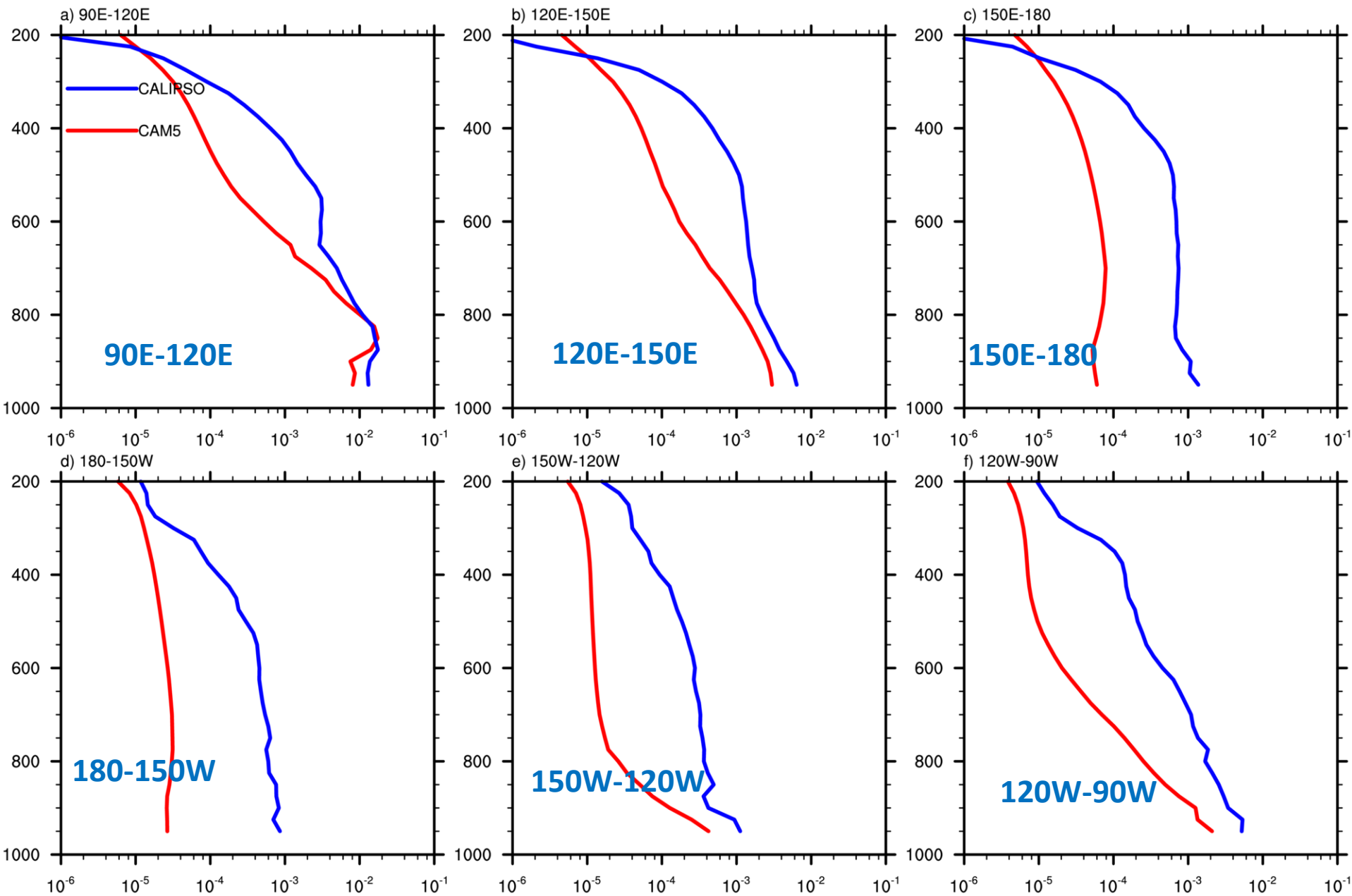
Comparison with Collocated CALIPSO observations

Dust extinction profile (JJA)



Comparisons with Collocated CALIPSO observations

Dust extinction profile (DJF)



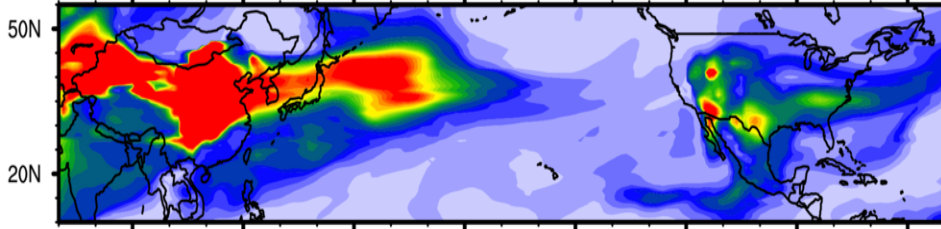
Dust Event in Asia

- ▶ **Case study:** March 15-18, 2011
- ▶ **Configuration:** CAM5.4, Specified dynamics
- ▶ **Simulation period:** February 1 to March 31, 2011
- ▶ **Resolution:** $0.9^\circ \times 1.25^\circ$
- ▶ **Sensitivity tests:**
 - **Dust emission schemes:** Zender et al. (2003) (Default), Kok et al. (2014)
 - **Dust size distributions:** Kok et al. (2011) (Default), Zender et al. (2003)
 - **Dust gravitational settling and dry deposition**
- ▶ **WRF-Chem:**
 - **Nearly global 1° simulations** (Hu et al. 2016)
 - **MOSAIC aerosol bin microphysics**
 - **Dust emission scheme:** Ginoux et al. (2001)
 - **Dust gravitational settling is neglected**

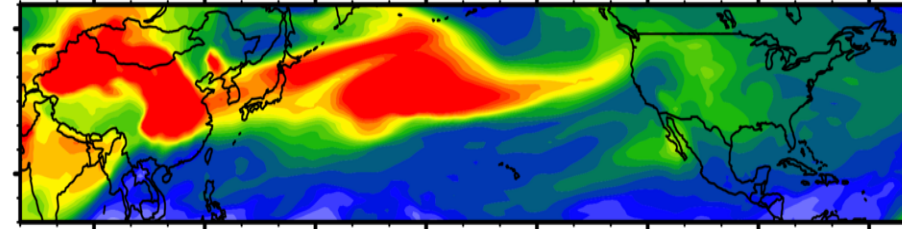
Dust event on March 15-18, 2011

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

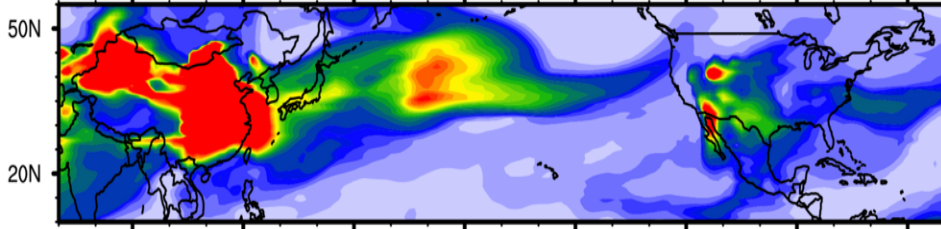
2011-03-15 CAM5



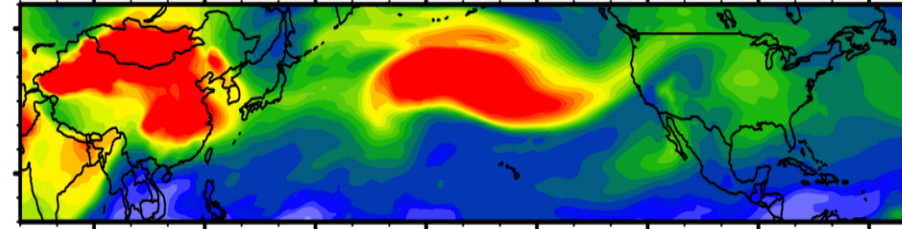
2011-03-15 WRF-Chem



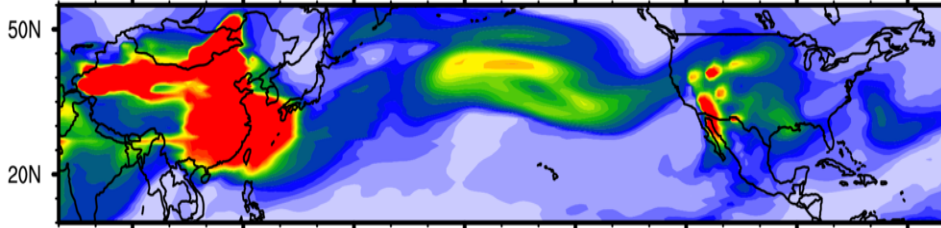
2011-03-16 CAM5



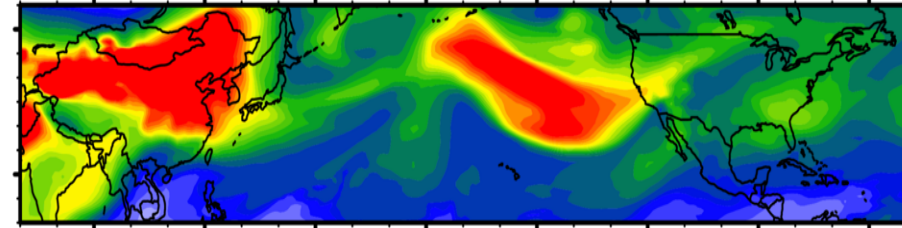
2011-03-16 WRF-Chem



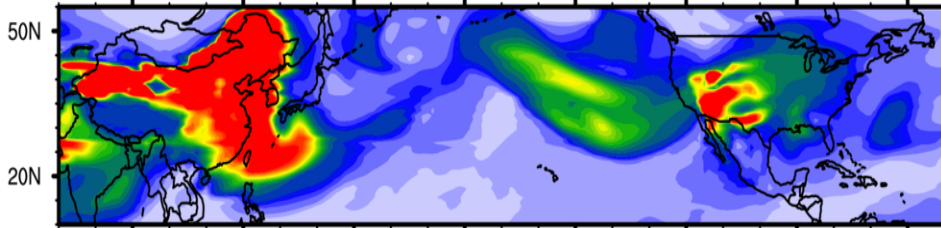
2011-03-17 CAM5



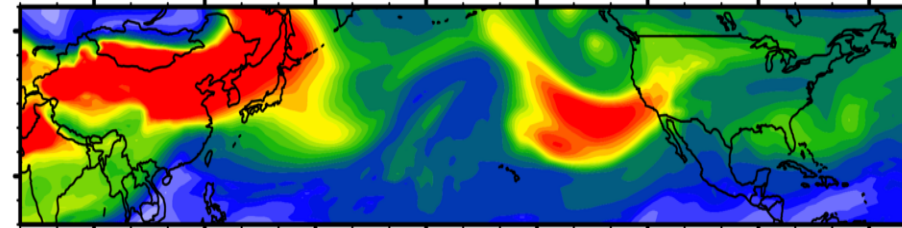
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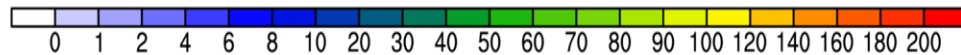
2011-03-18 CAM5



2011-03-18 WRF-Chem



90E 120E 150E 180 150W 120W 90W 60W

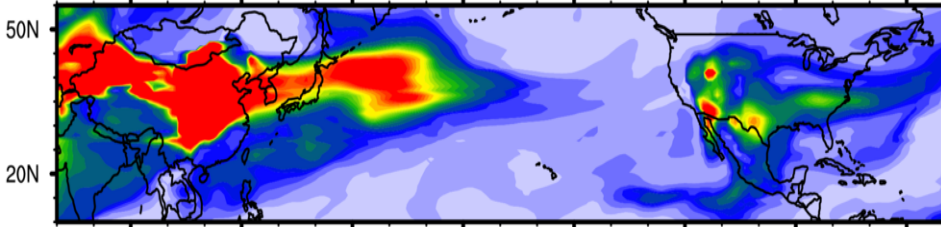


mg/m²

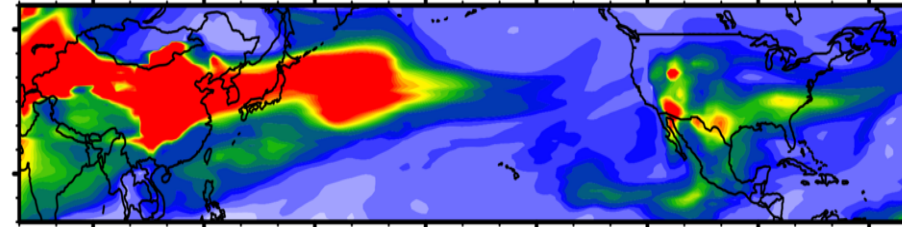
Dust event on March 15-18, 2011

Daily mean dust column burden (*CAM5 Default-left vs no gravitational settling-right*)

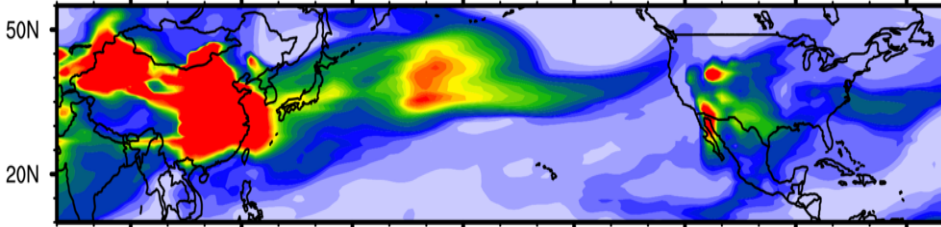
2011-03-15 Default



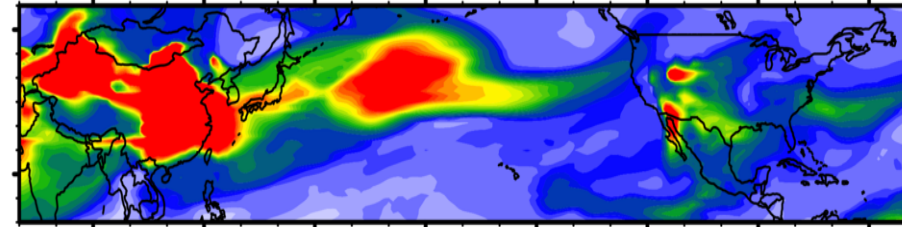
2011-03-15 GrvSetVel



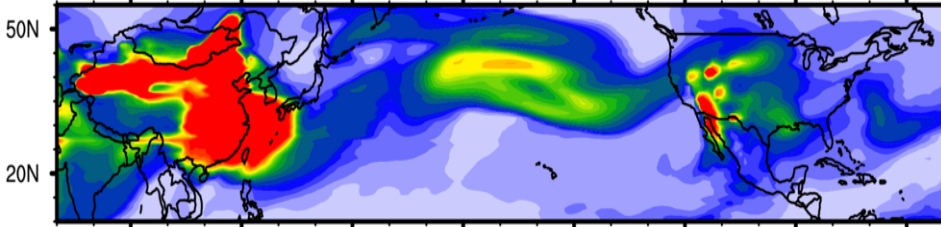
2011-03-16 Default



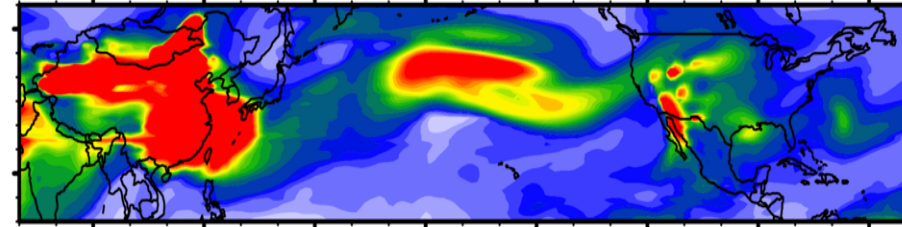
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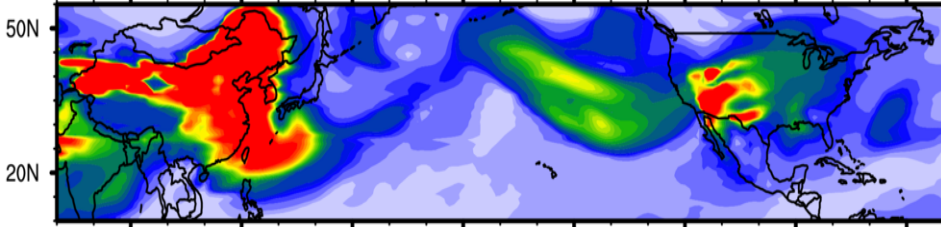
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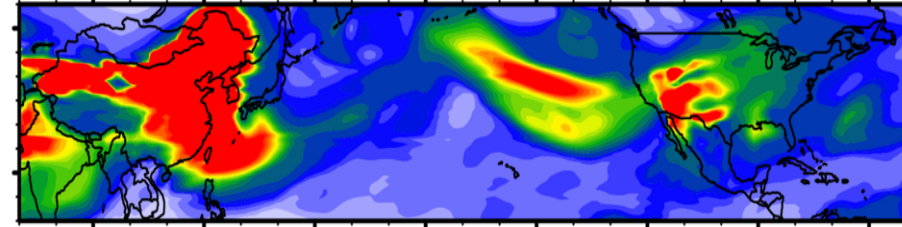
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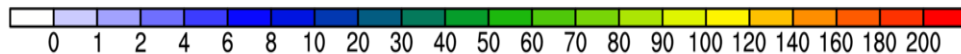
2011-03-18 Default



2011-03-18 GrvSetVel



90E 120E 150E 180 150W 120W 90W 60W 90E 120E 150E 180 150W 120W 90W 60W

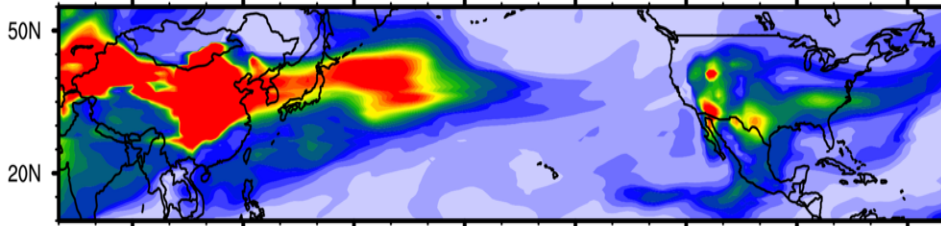


mg/m²

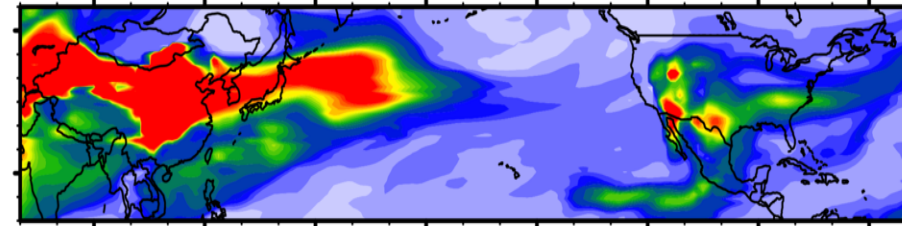
Dust event on March 15-18, 2011

Daily mean dust column burden (*CAM5 Default-left vs DryDepBot-Right, dry deposition velocity in bottom layer reduced to 1% on non-vegetated surface*)

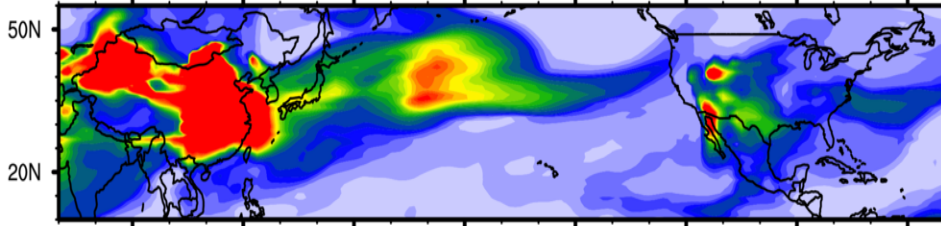
2011-03-15 Default



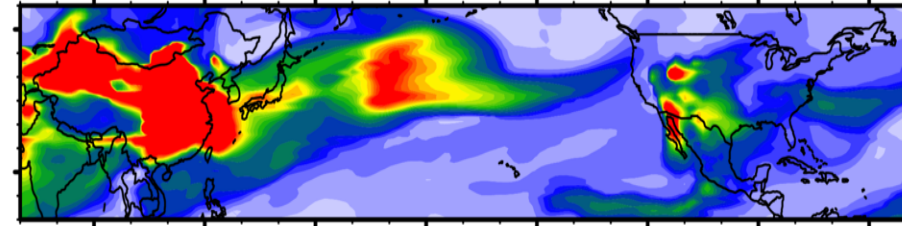
2011-03-15 DryDepBot



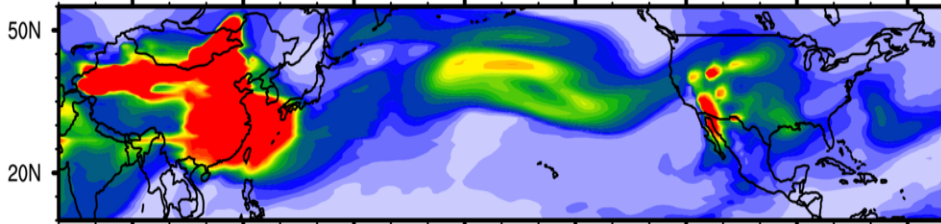
2011-03-16 Default



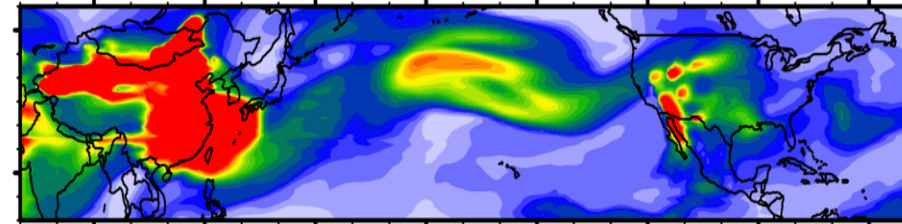
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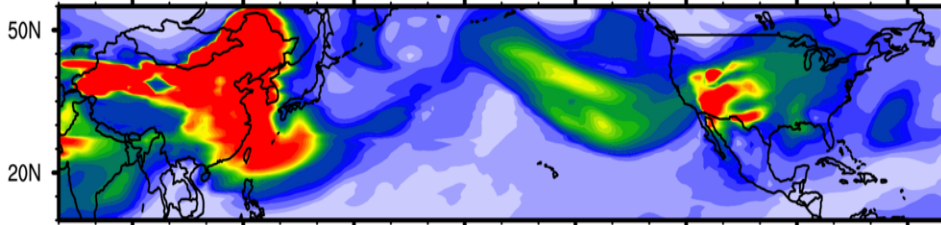
2011-03-17 Default



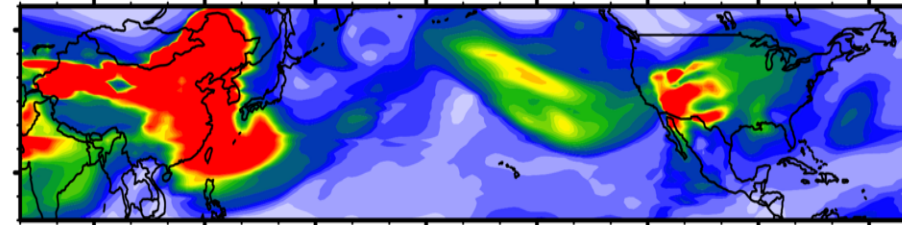
2011-03-17 DryDepBot



2011-03-18 Default



2011-03-18 DryDepBot



90E 120E 150E 180 150W 120W 90W 60W

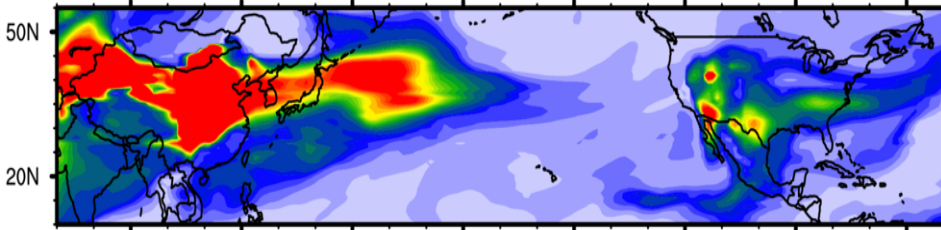


mg/m²

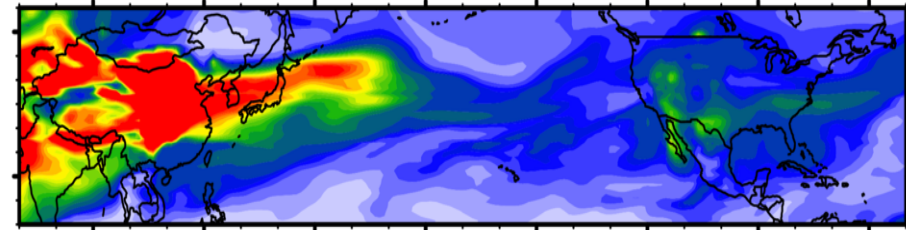
Dust event on March 15-18, 2011

Daily mean dust column burden (*CAM5 Default Zender-Left vs Kok Emission-Right*)

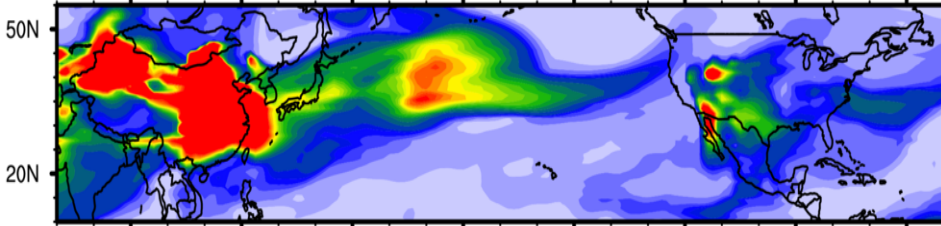
2011-03-15 Default



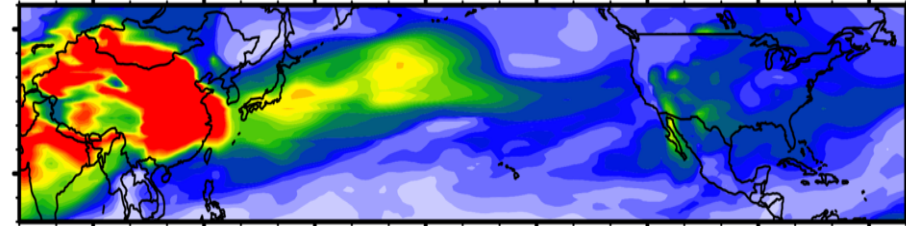
2011-03-15 EmisK



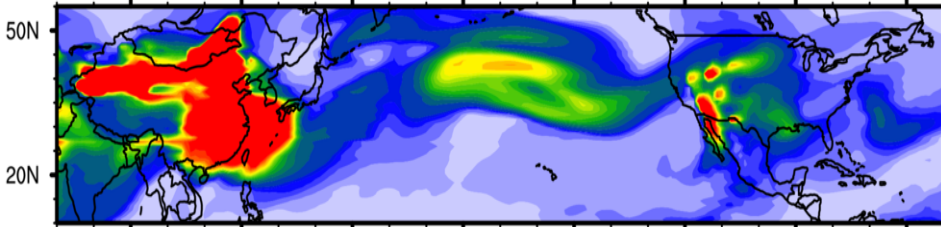
2011-03-16 Default



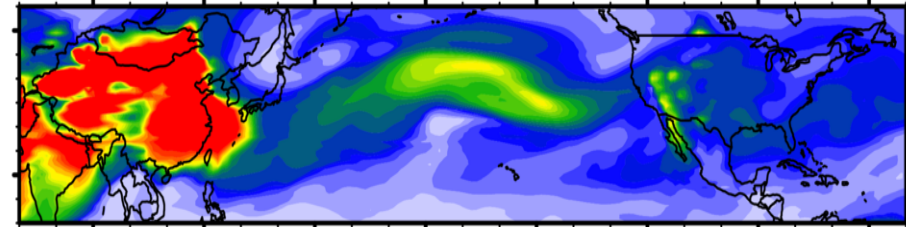
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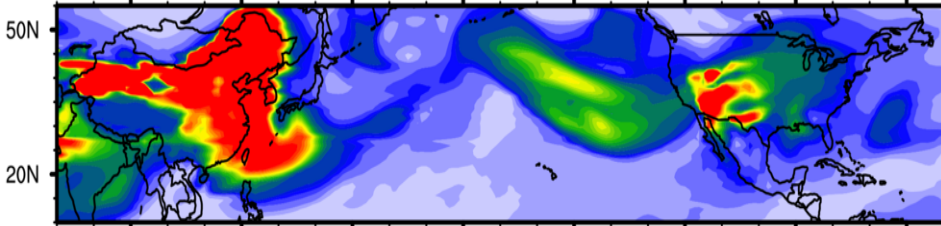
2011-03-17 Default



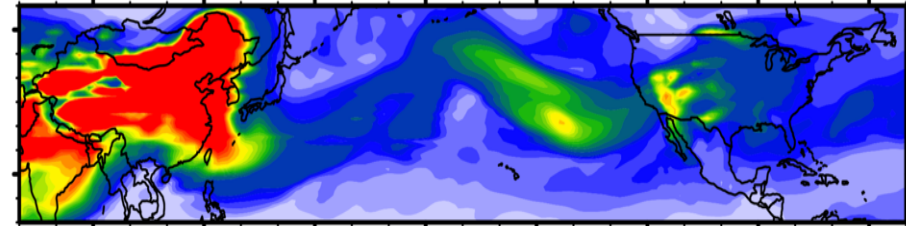
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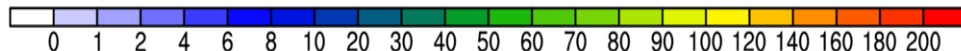
2011-03-18 Default



2011-03-18 EmisK



90E 120E 150E 180 150W 120W 90W 60W



mg/m²

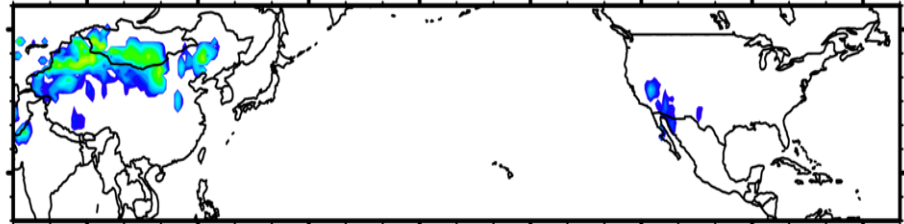
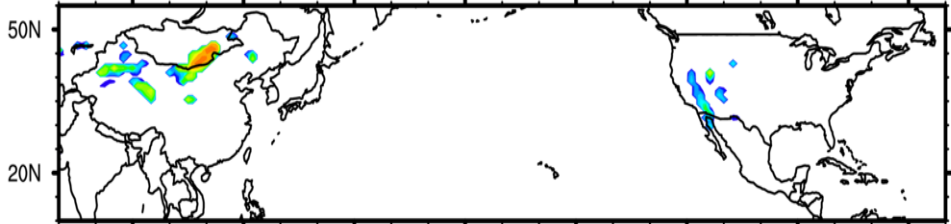
Dust emissions March 15-18 (CAM5-Left vs WRF-Chem-Right, Zender et al. (2003) vs Ginoux et al. (2001))

Zender

Ginoux

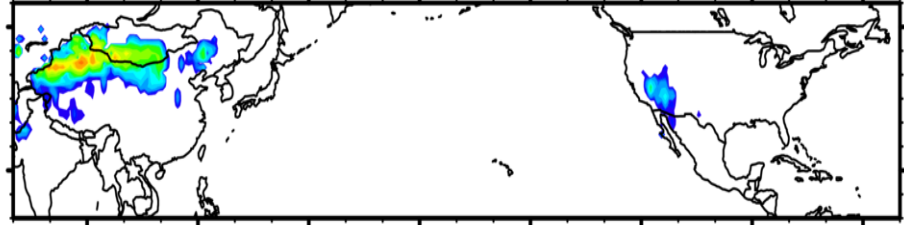
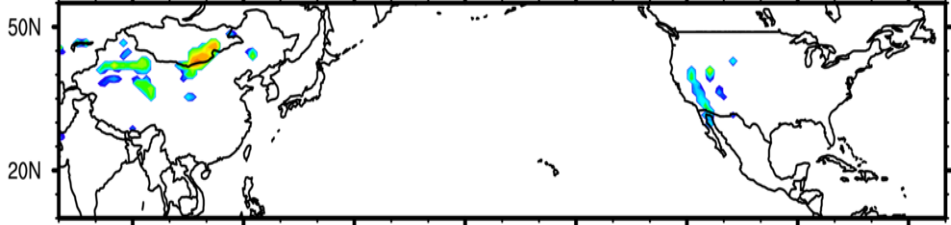
2011-03-15 Zender

2011-03-15 Ginoux



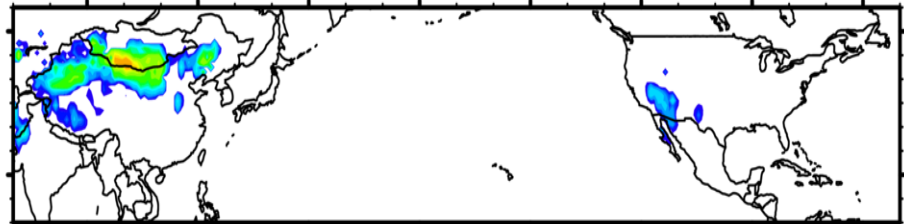
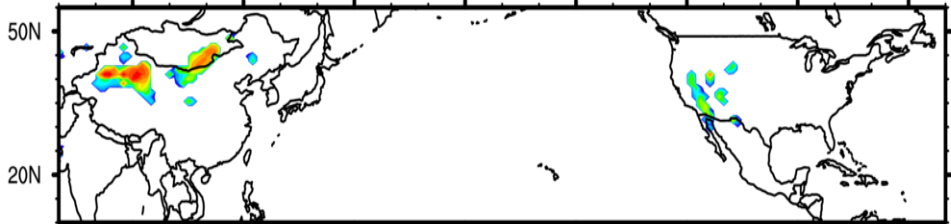
2011-03-16 Zender

2011-03-16 Ginoux



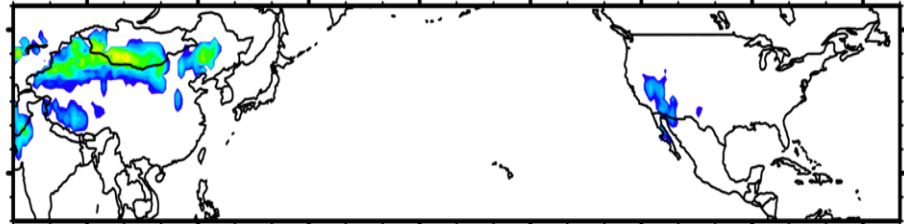
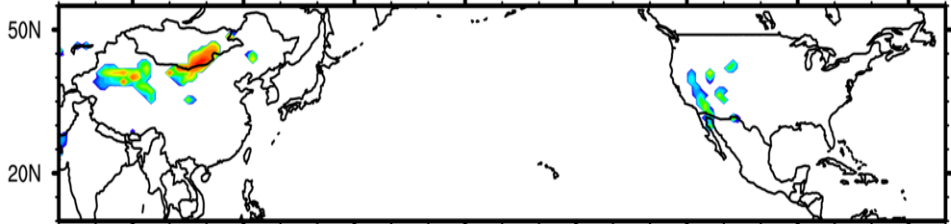
2011-03-17 Zender

2011-03-17 Ginoux



2011-03-18 Zender

2011-03-18 Ginoux



90E 120E 150E 180 150W 120W 90W 60W



1e-8 kg/m2/s

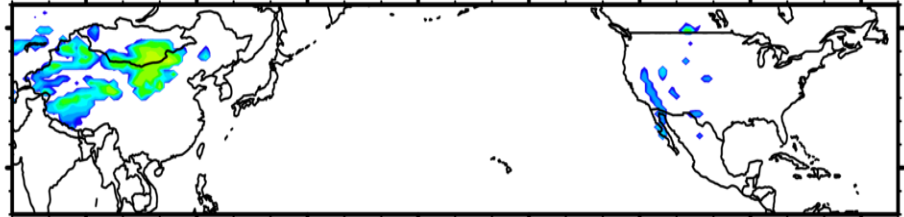
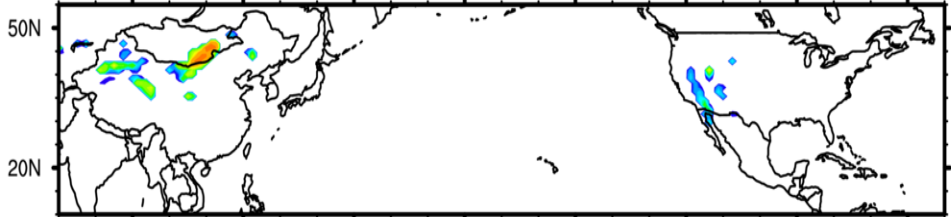
Dust emissions March 15-18 (Zender-Left vs Kok-Right, Zender et al. (2003) vs Kok et al. (2014))

Zender

Kok

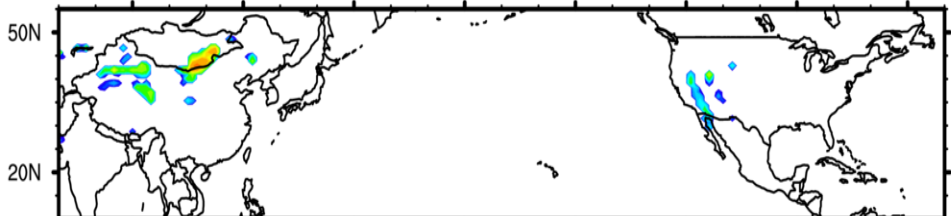
2011-03-15 Zender

2011-03-15 Kok



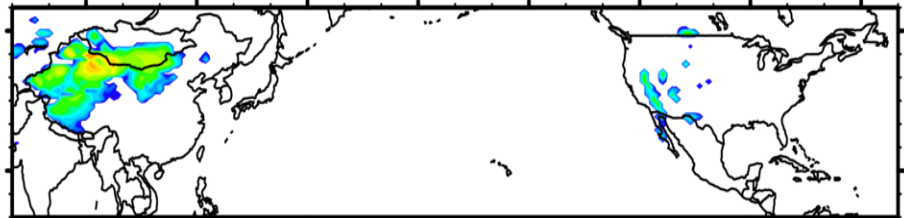
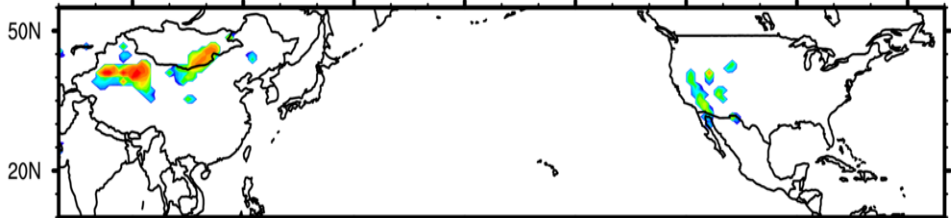
2011-03-16 Zender

2011-03-16 Kok



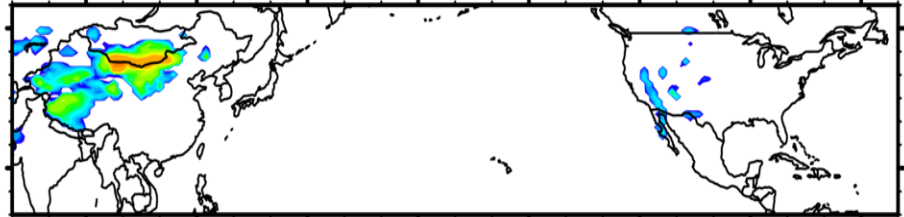
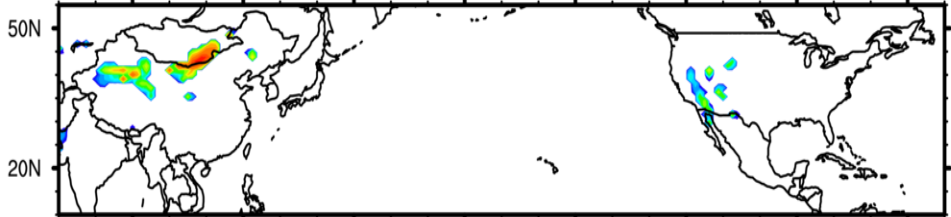
2011-03-17 Zender

2011-03-17 Kok



2011-03-18 Zender

2011-03-18 Kok



90E 120E 150E 180 150W 120W 90W 60W



1e-8 kg/m2/s

Summary

- ❑ Dust decays too fast simulated in CESM-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
 - Bin aerosol scheme can provide a benchmark
- ❑ Large uncertainty in dust emissions (spatial pattern and flux) in Asia and N. America