# TM5 in EC-Earth

## Change in aerosol burden when using online meteorology for wet deposition

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# Overview

- Procceses of aerosol wet deposition
- Current representation

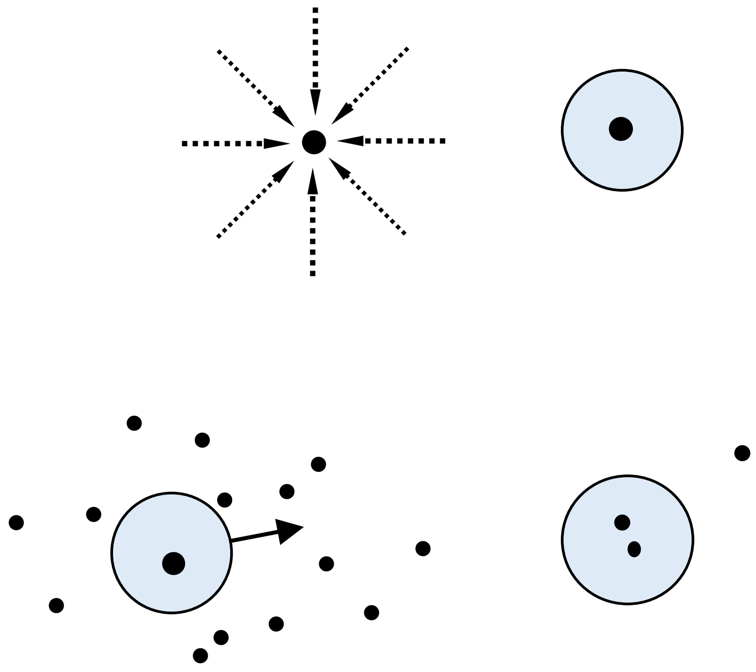
- Changes in precipitation

- Implementation of aerosol resuspension
- Analysis of changes in aerosol burden

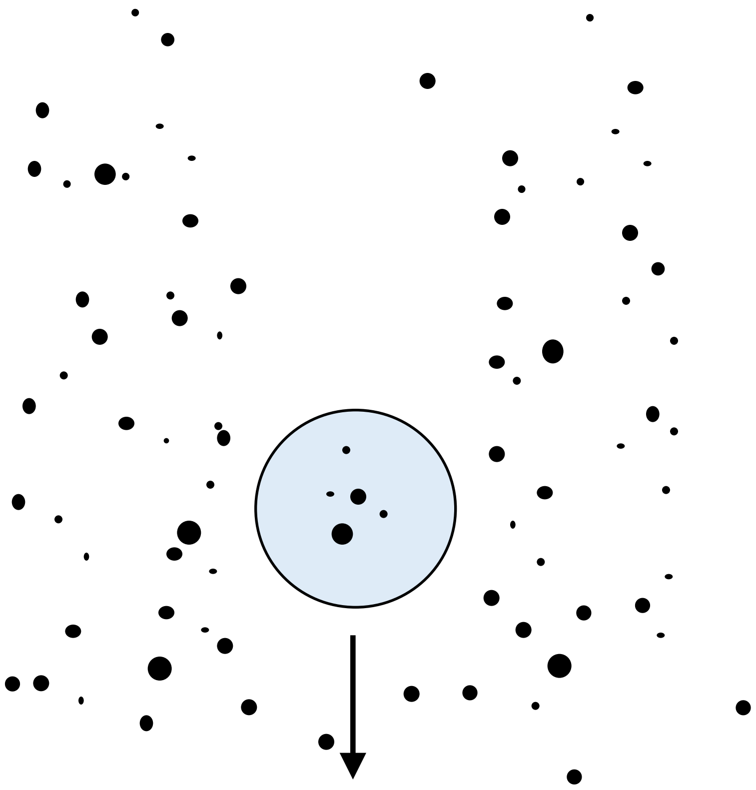
- “TO DO”

# How are aerosols removed?

- *In-cloud* scavenging by nucleation and impaction



- *Below-cloud* scavenging by falling precipitation



# Current TM5 wet scavenging scheme

- Limited meteorological fields from reanalysis

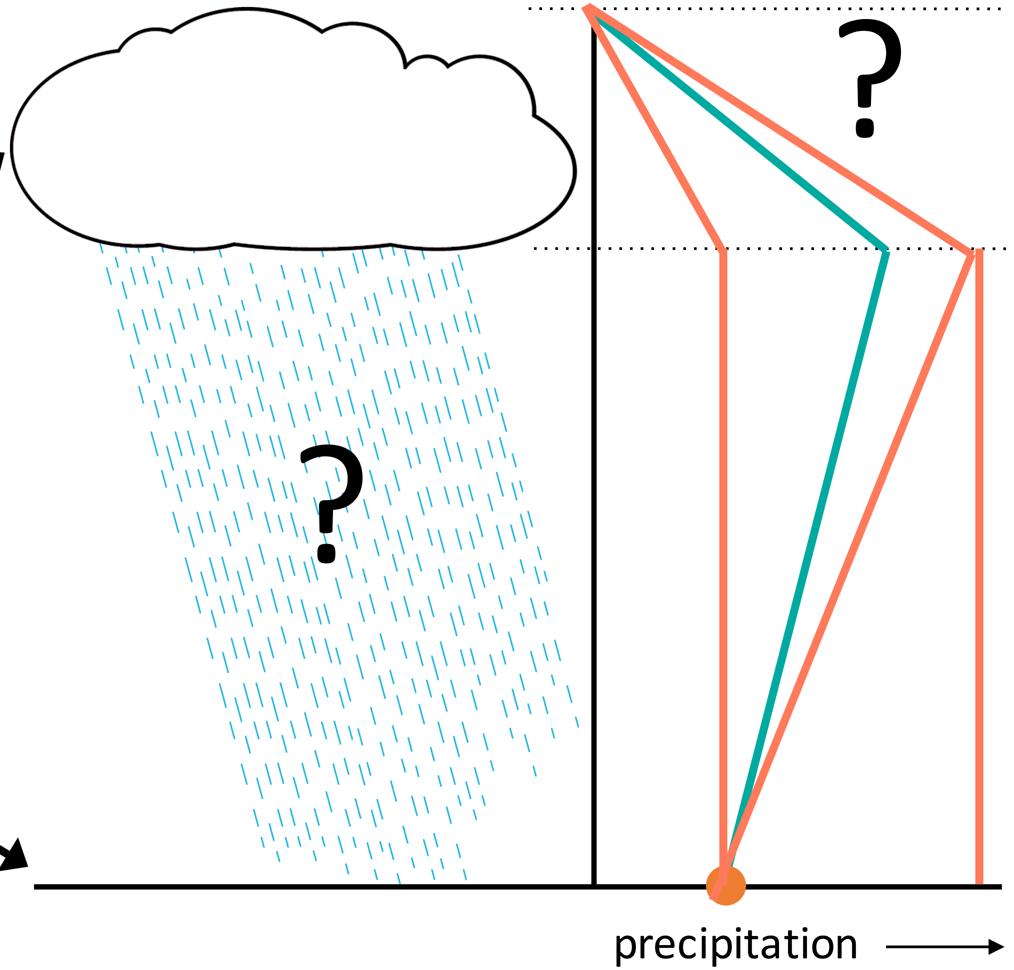
*3D*

Cloud liquid water content

Cloud ice water content

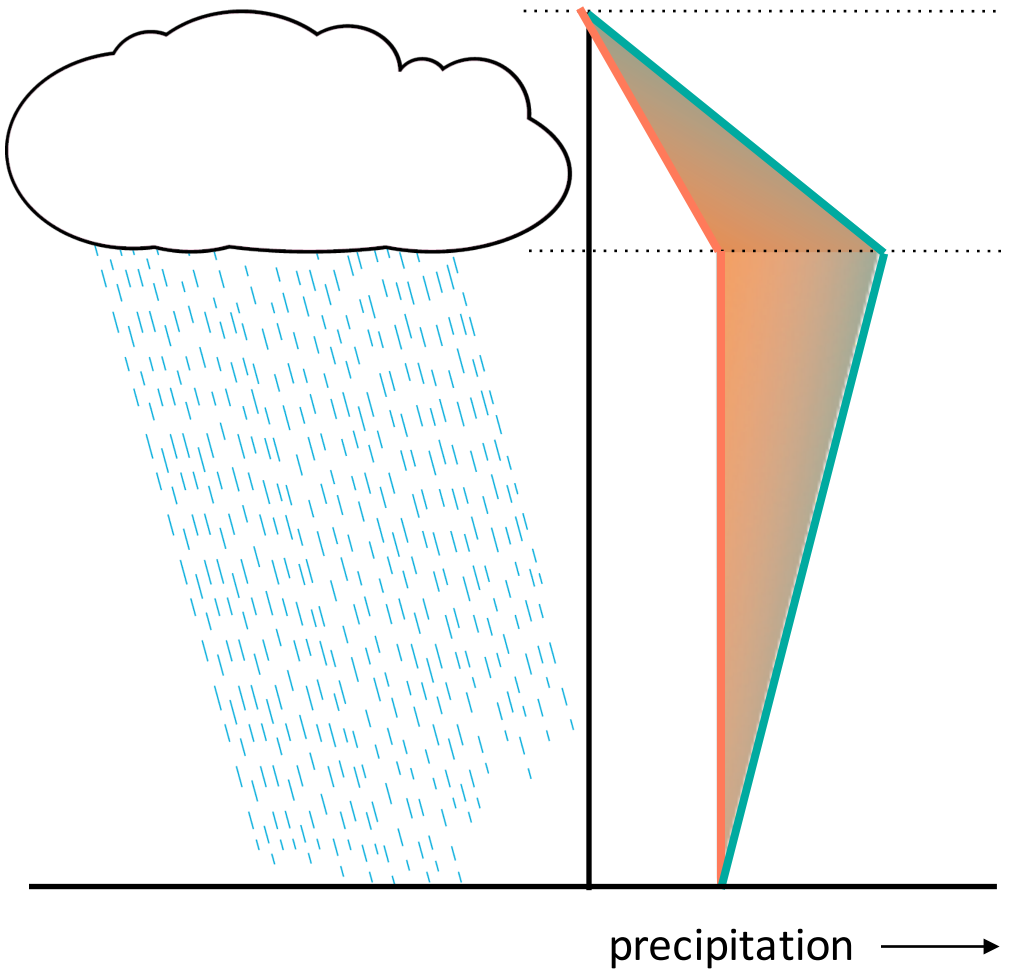
Large scale precipitation

*Surface values*



# Current TM5 wet scavenging scheme

- Precipitation formation too low: in-cloud scavenging underestimated
- Total column precipitation too low: Below-cloud scavenging underestimated (when rescaled to surface precipitation)
- No evaporation:
- Missing resuspension of aerosols
- Solution in EC-Earth, directly import 3D precipitation from IFS ☺



# Research set-up

- 3 runs

  BASE: Status quo

  NOEVAP: Online meteorology

  EVAP: Online meteorology + evaporation

1 year runs, nudged for comparison/validation

# Research set-up

- 3 runs

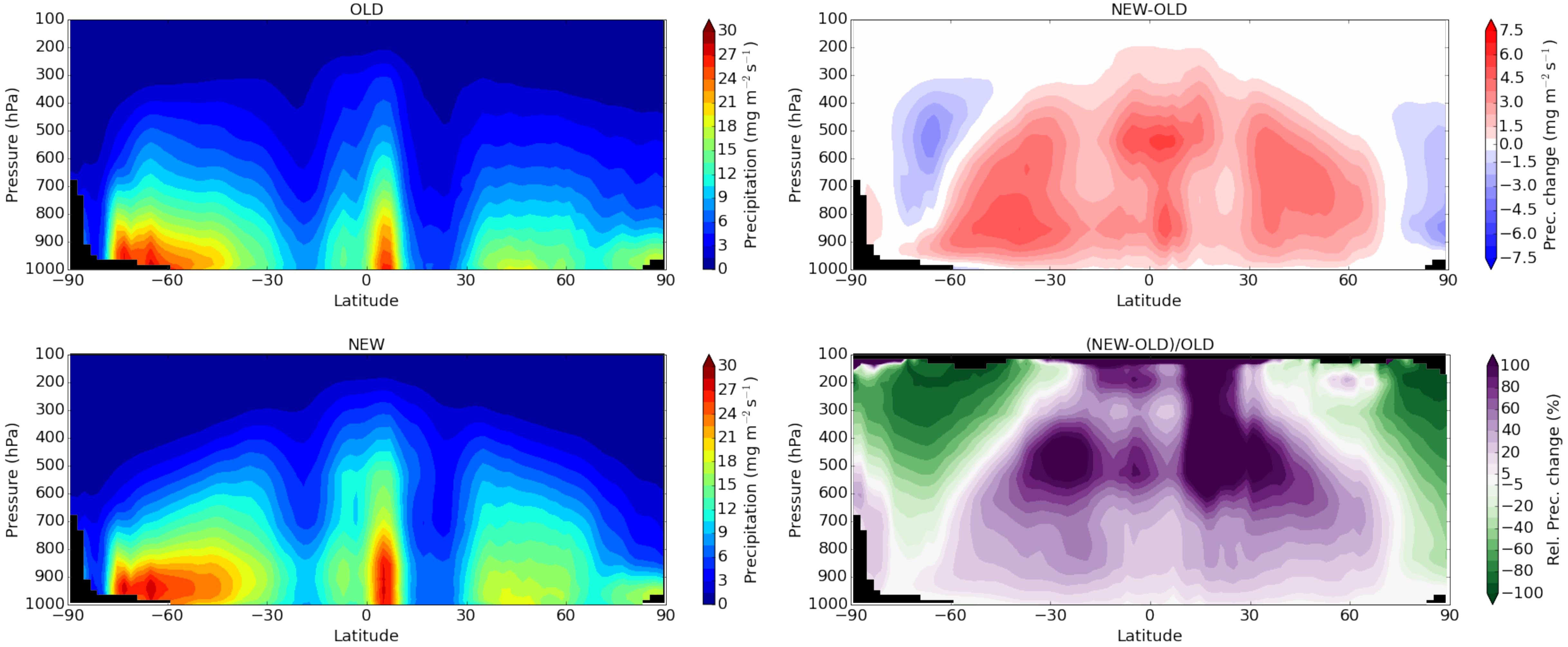
BASE: Status quo

EVAP: Online meteorology + evaporation

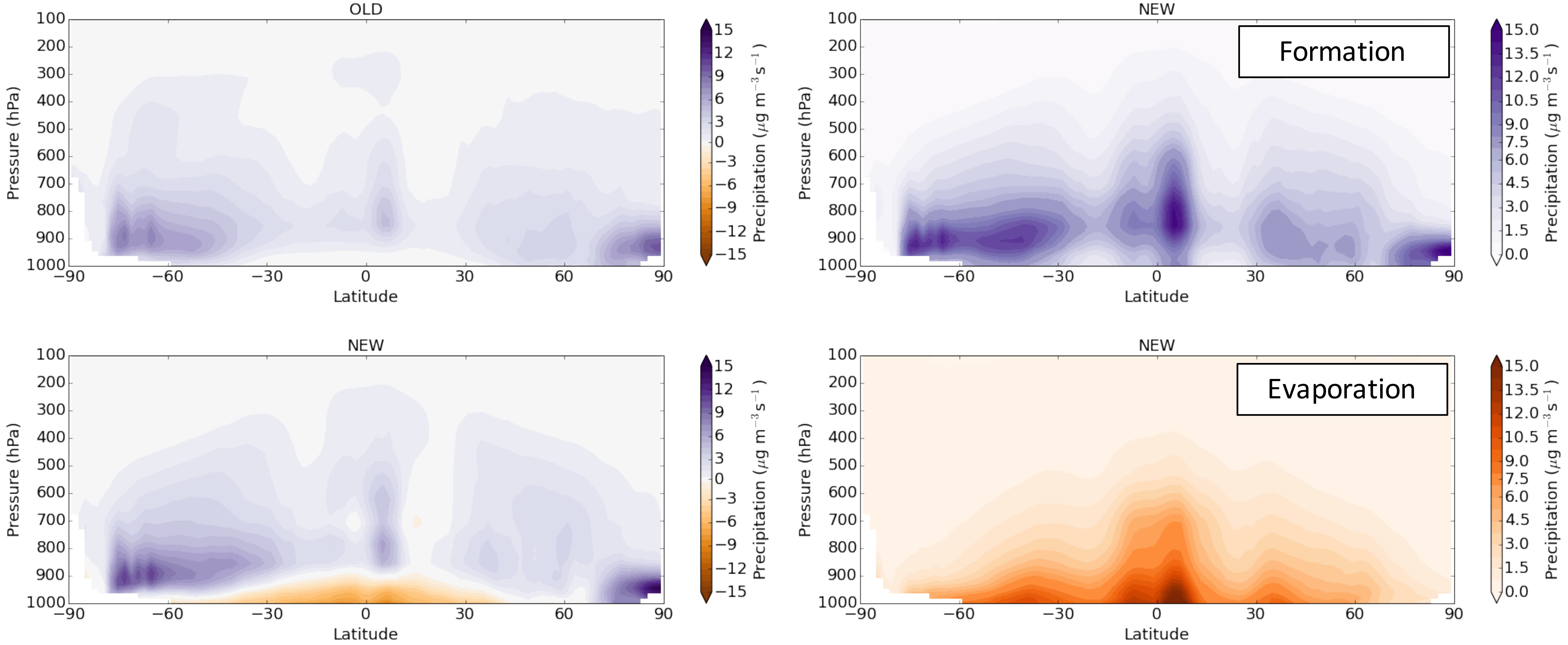
Jan-aug 2005, nudged for comparison/validation

# Changes in precipitation

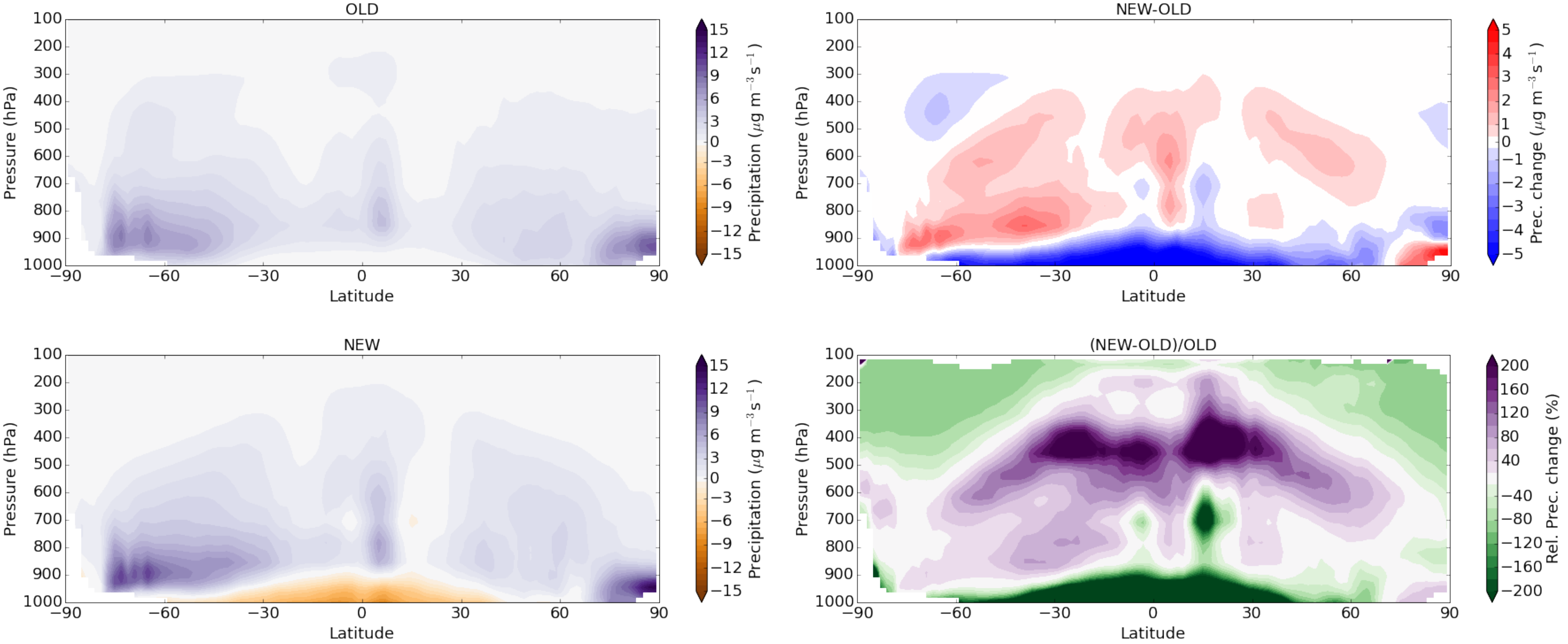
Jan-Aug 2005



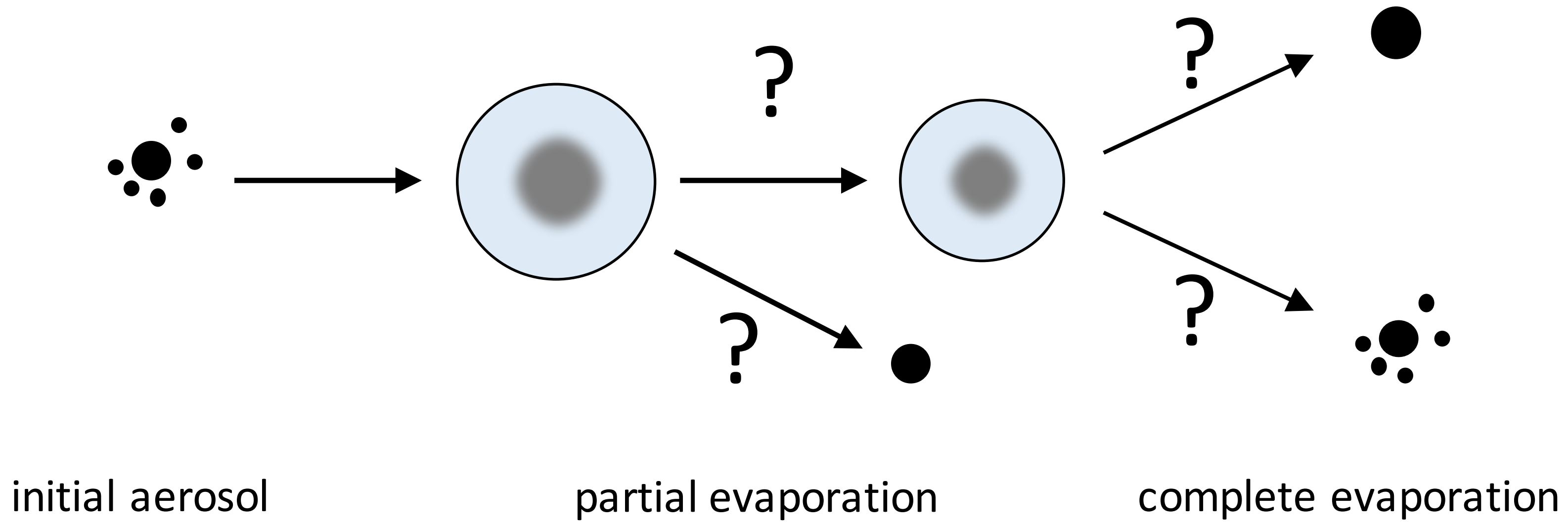
# Changes in precipitation formation



# Changes in precipitation formation

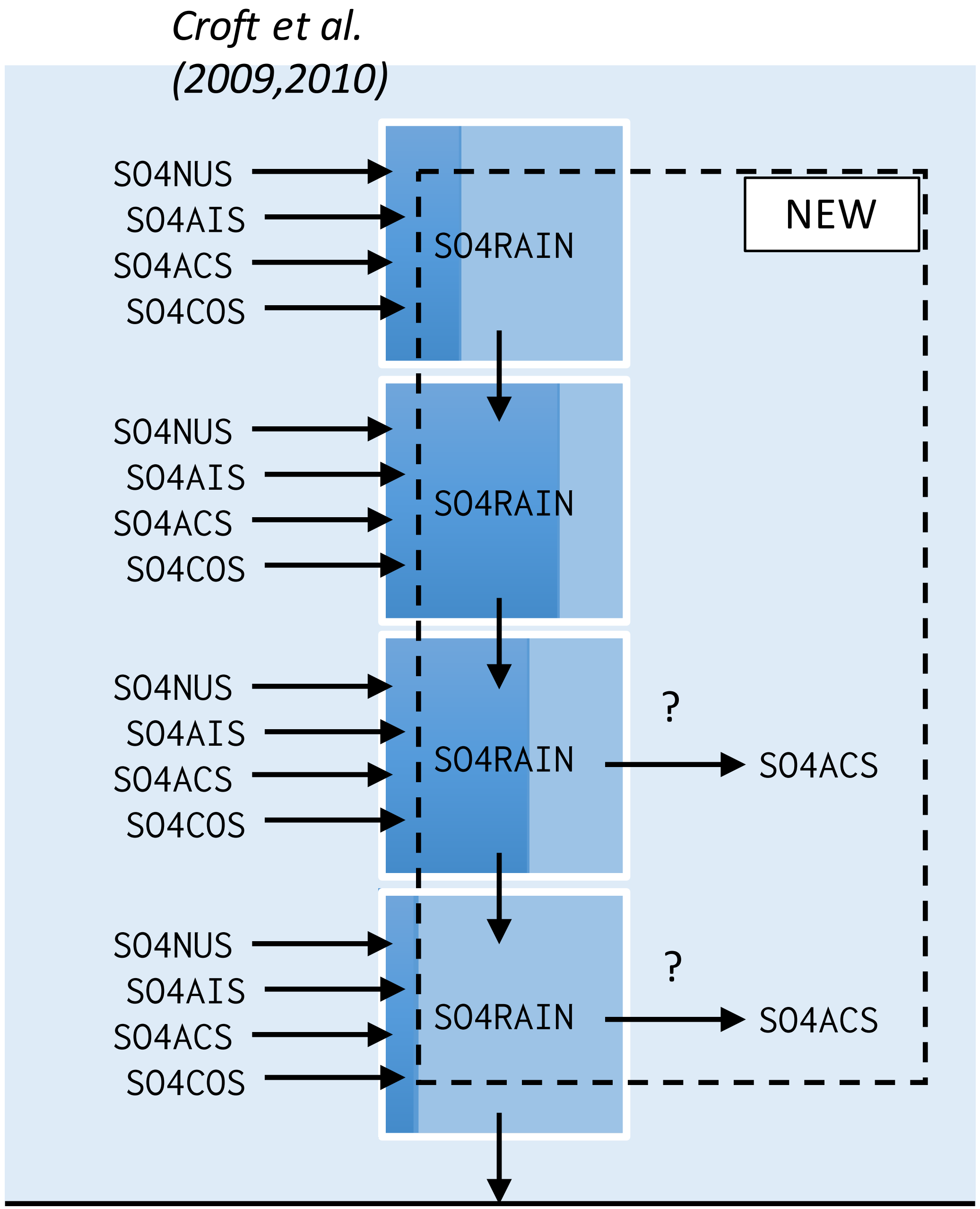


# Implementation



# Implementation

- Accumulation of different aerosol modes of 1 species in precipitation
- Transported down with falling precipitation
- (Re-)evaporated aerosol added to ACS mode



# Implementation

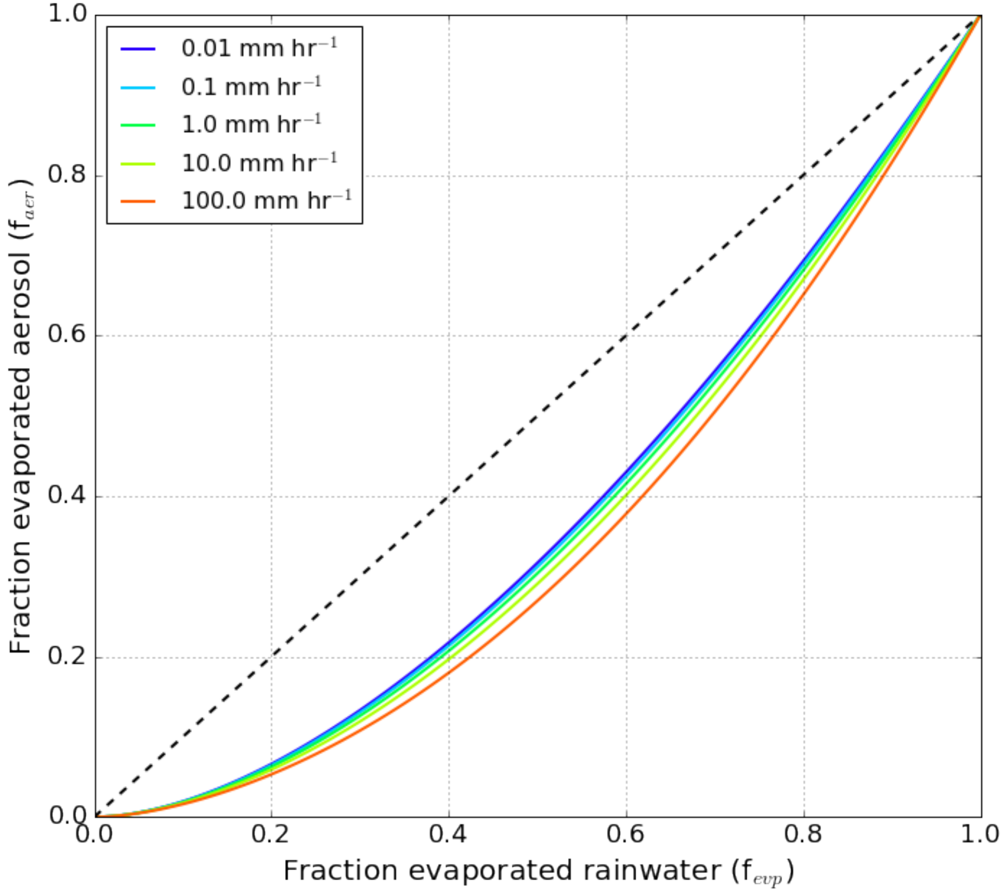
1:1 ratio of release of aerosol to evaporated fraction of rainwater ($f_{evp}$) overestimates release of aerosols ($f_{aer}$).

Release of aerosol only at complete evaporation of raindrop.

Smaller raindrops completely evaporate faster.

Efficiency factor $\boldsymbol{\varepsilon}$ (Gong et al., 2006)

$f_{aer} = \boldsymbol{\varepsilon}(f_{evp}, P) \cdot f_{evp}$

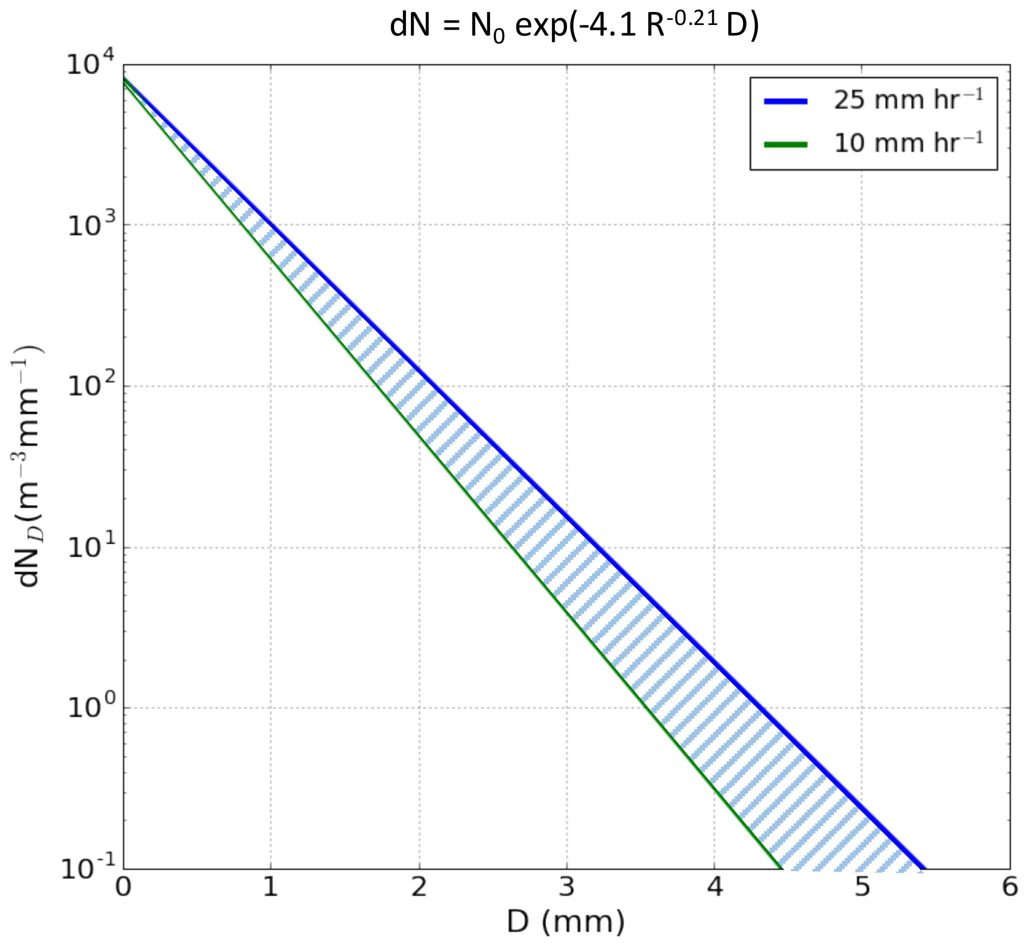


# Implementation

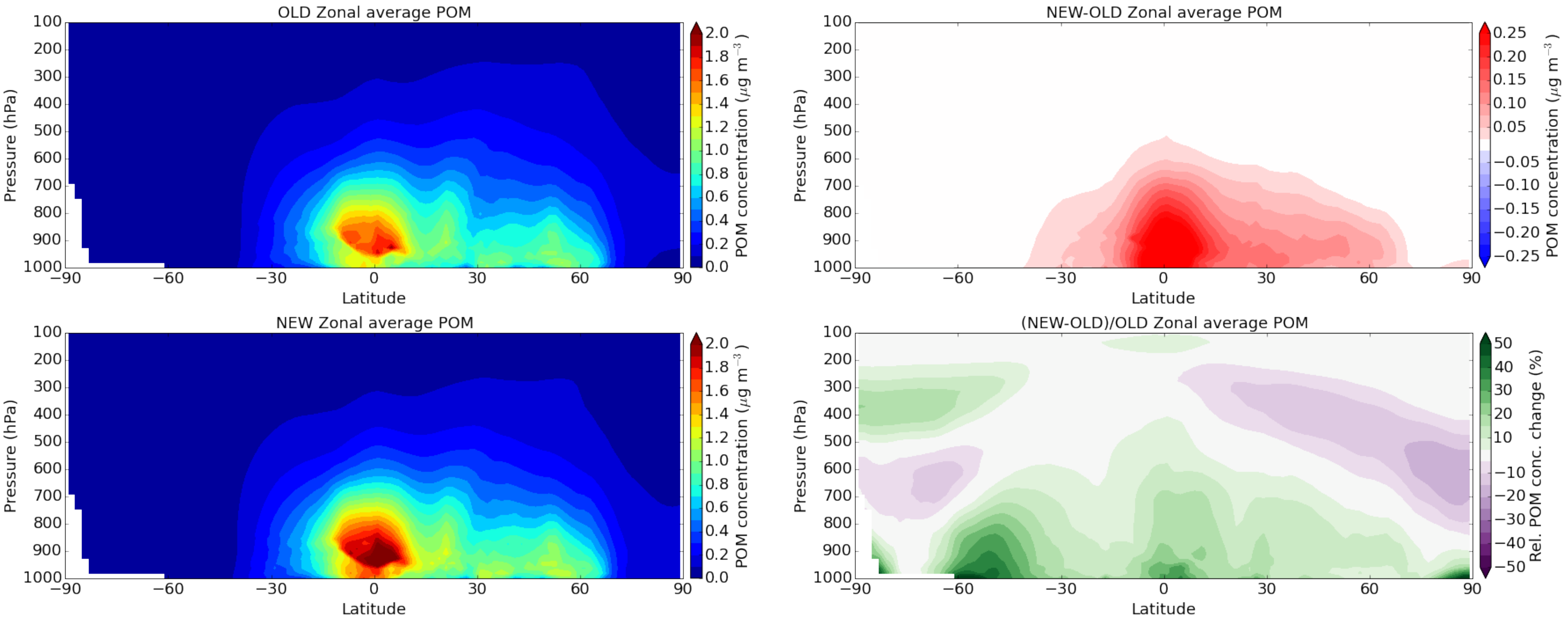
- Evaporation of aerosol number treated separately

- Based on Marshal-Palmer raindrop distribution
- 1 raindrop ⟶ 1 aerosol

- $N_{evp} = N(P) - N(f_{evp}P)$



# Changes in organic matter (+10%)



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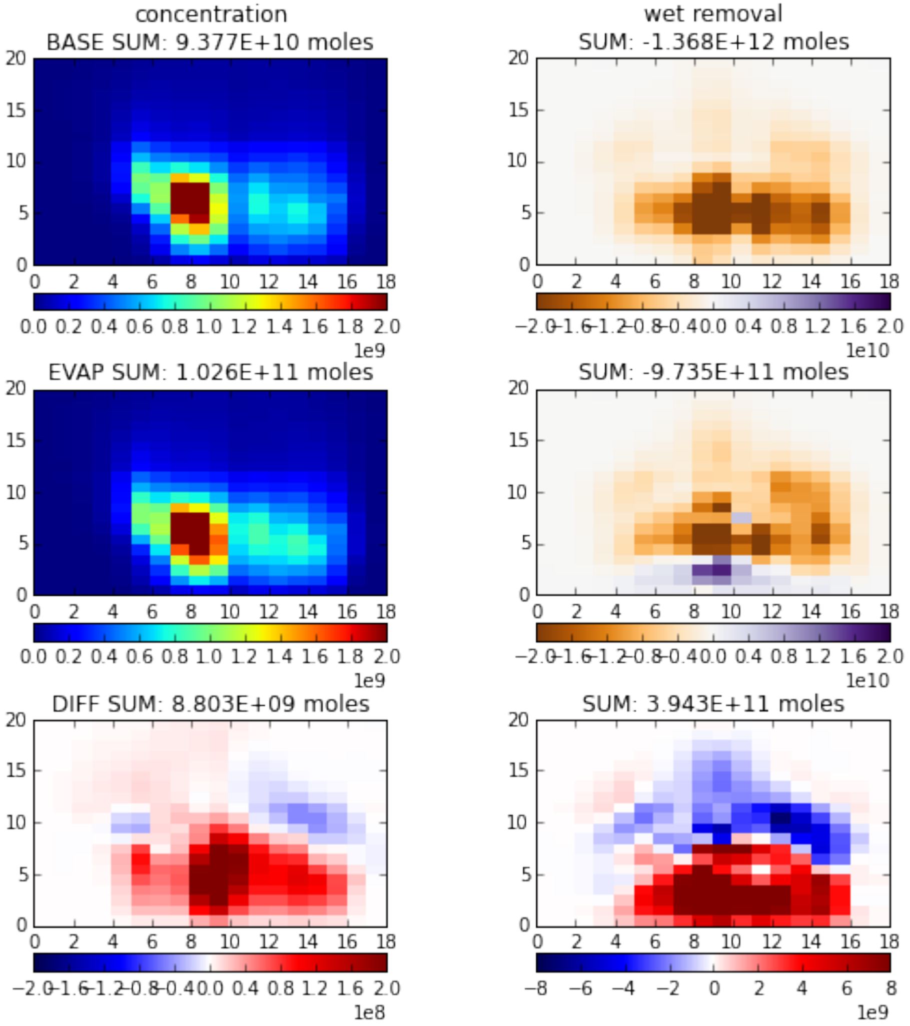
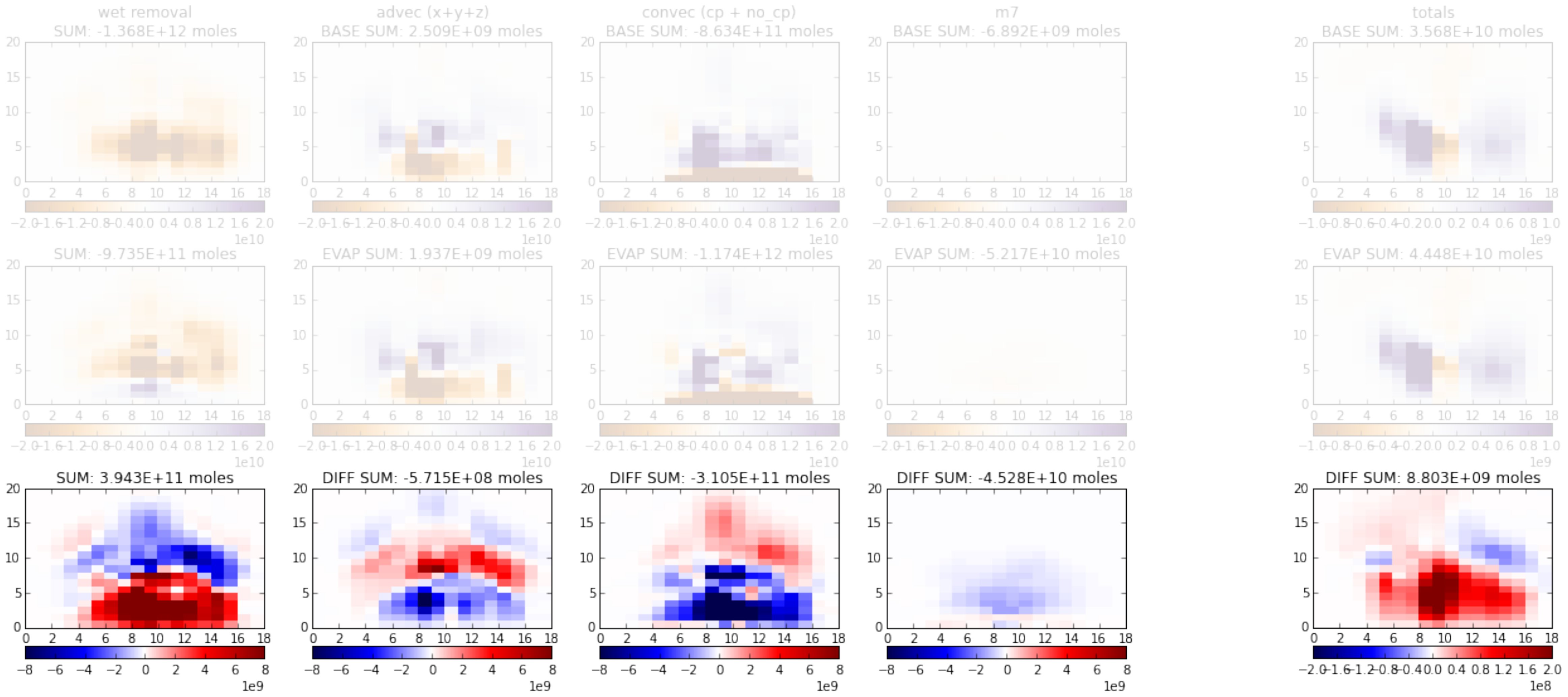



- Enhanced downward transport of aerosol

# Changes in organic matter



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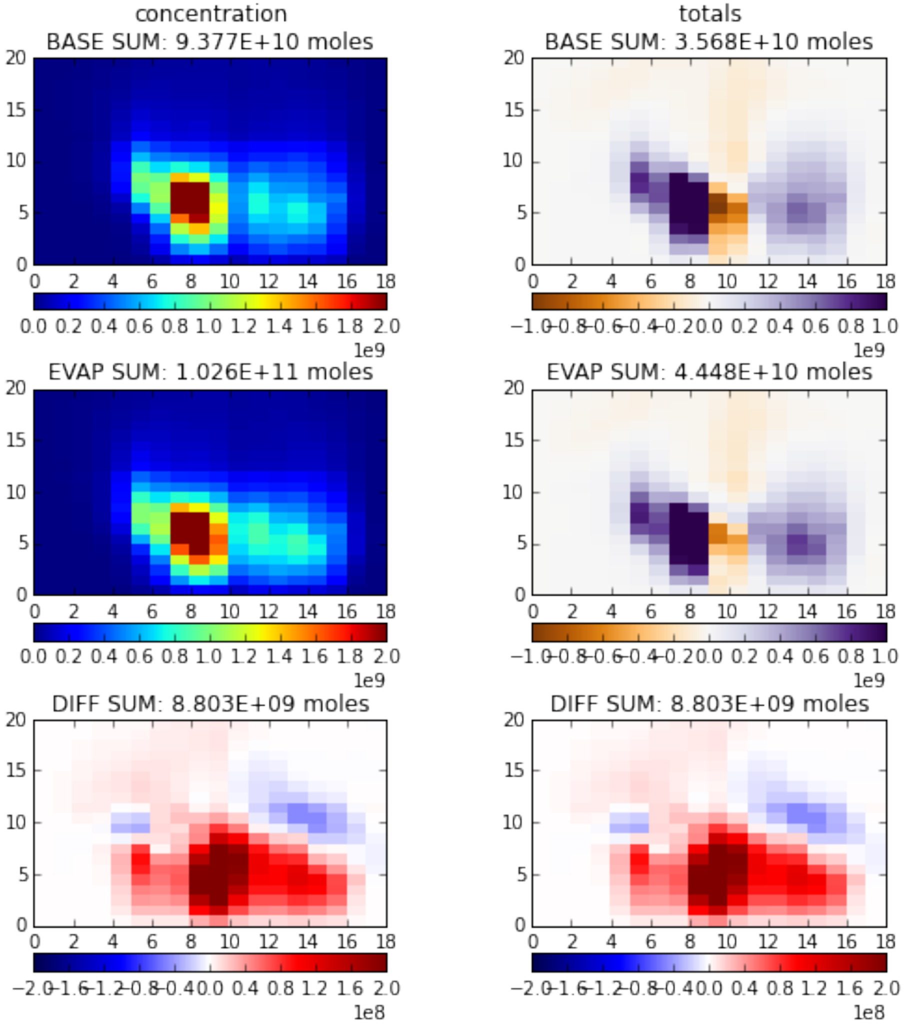
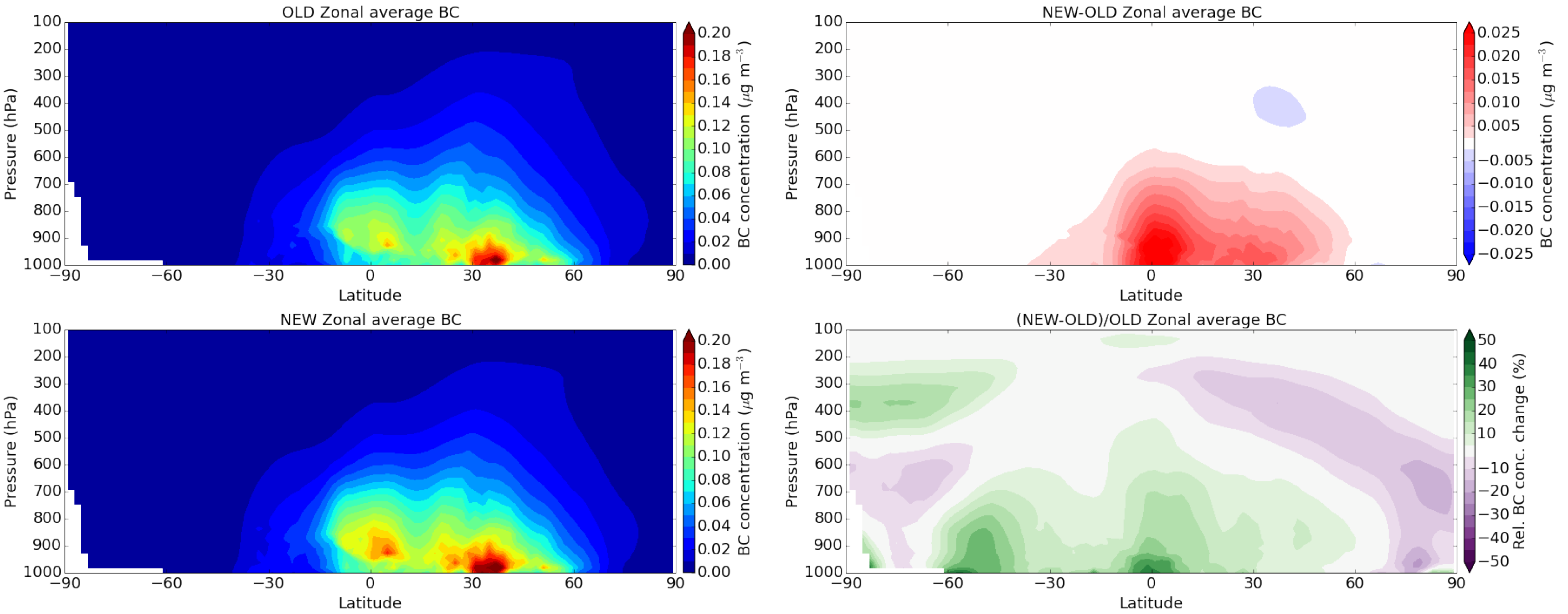
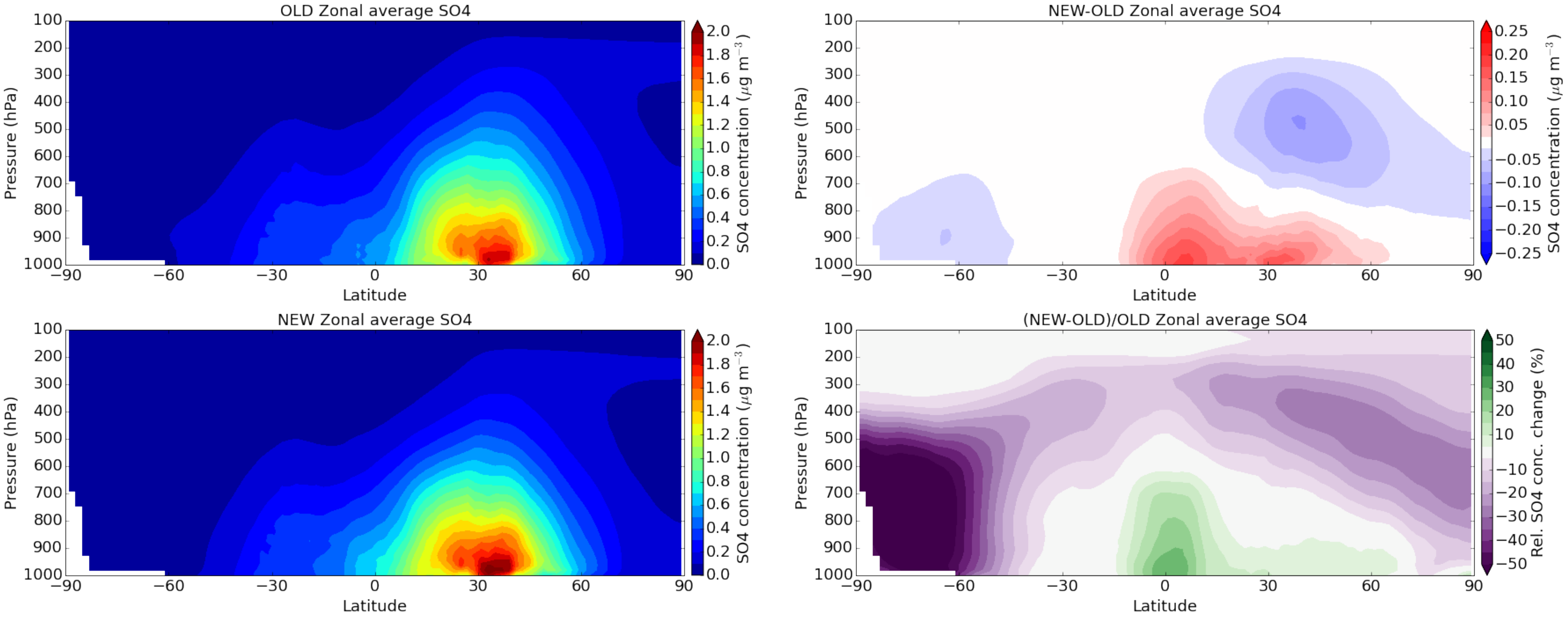



- Enhanced downward transport of aerosol
- (Partly) counteracted by advection, convection, sedimentation

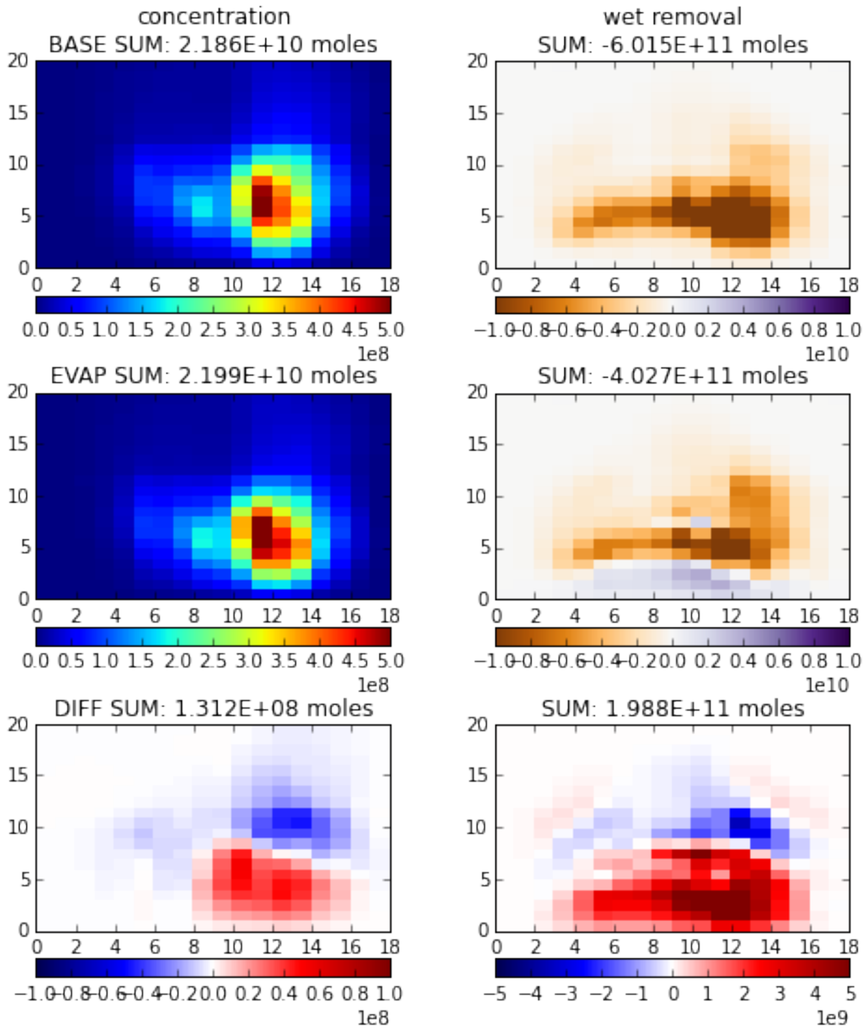
# Changes in black carbon (+10%)



# Changes in sulfate (+0%)

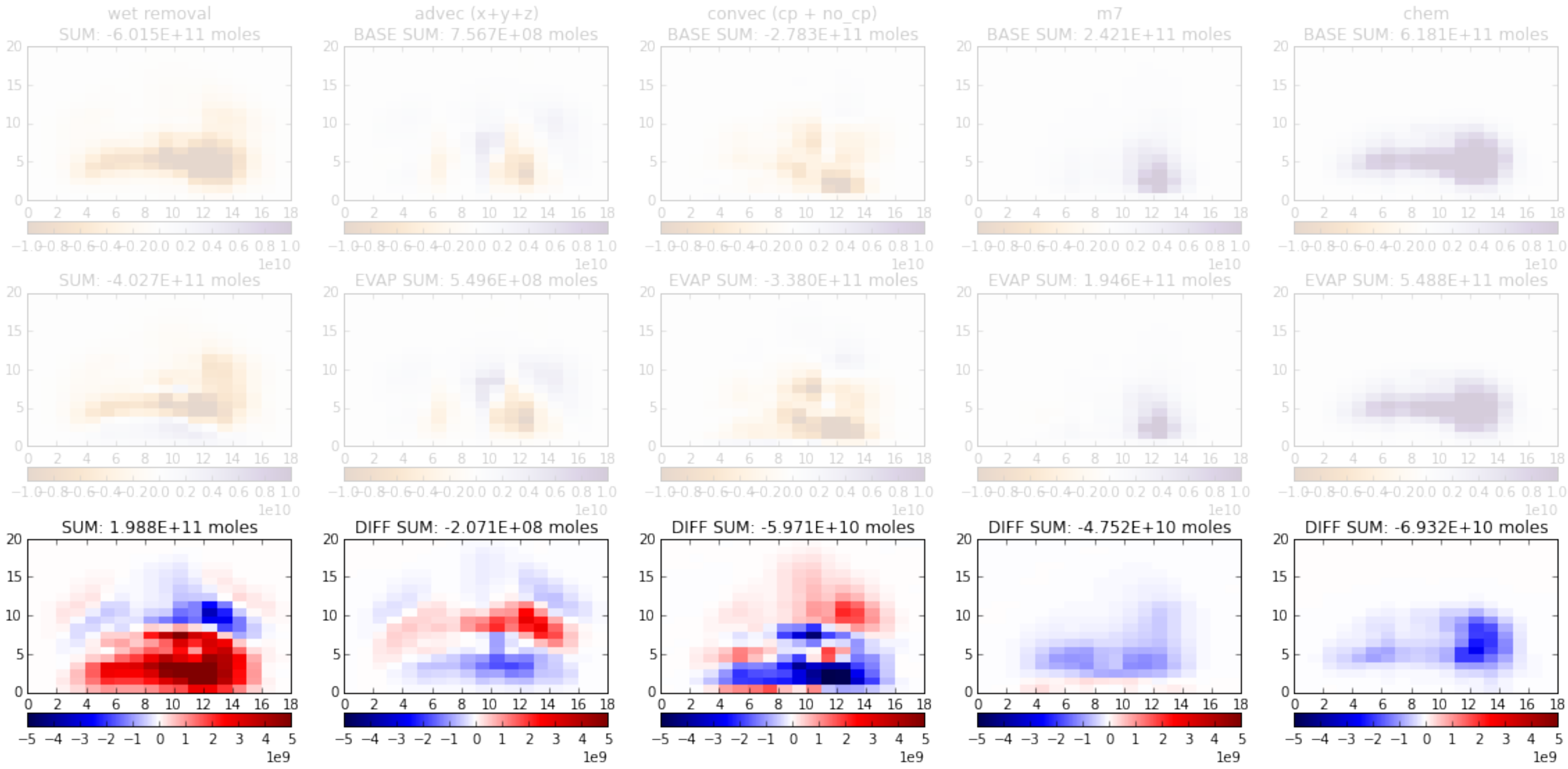


# Changes in sulfate

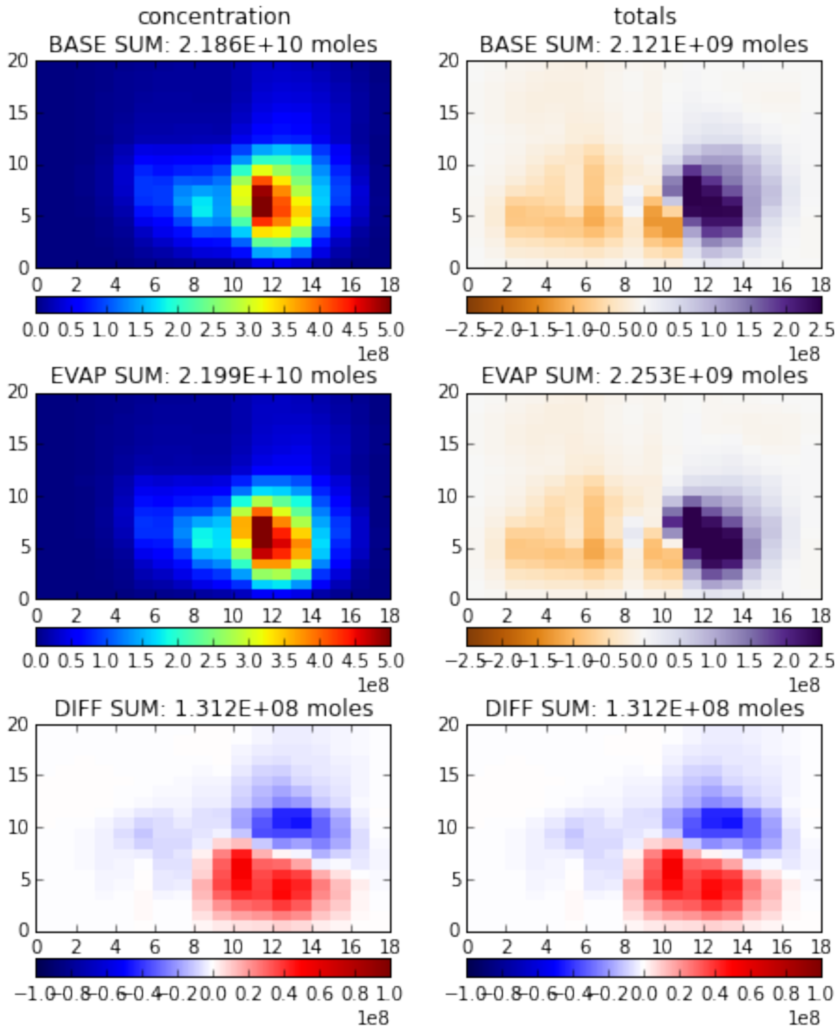



- Enhanced downward transport of aerosol

# Changes in sulfate

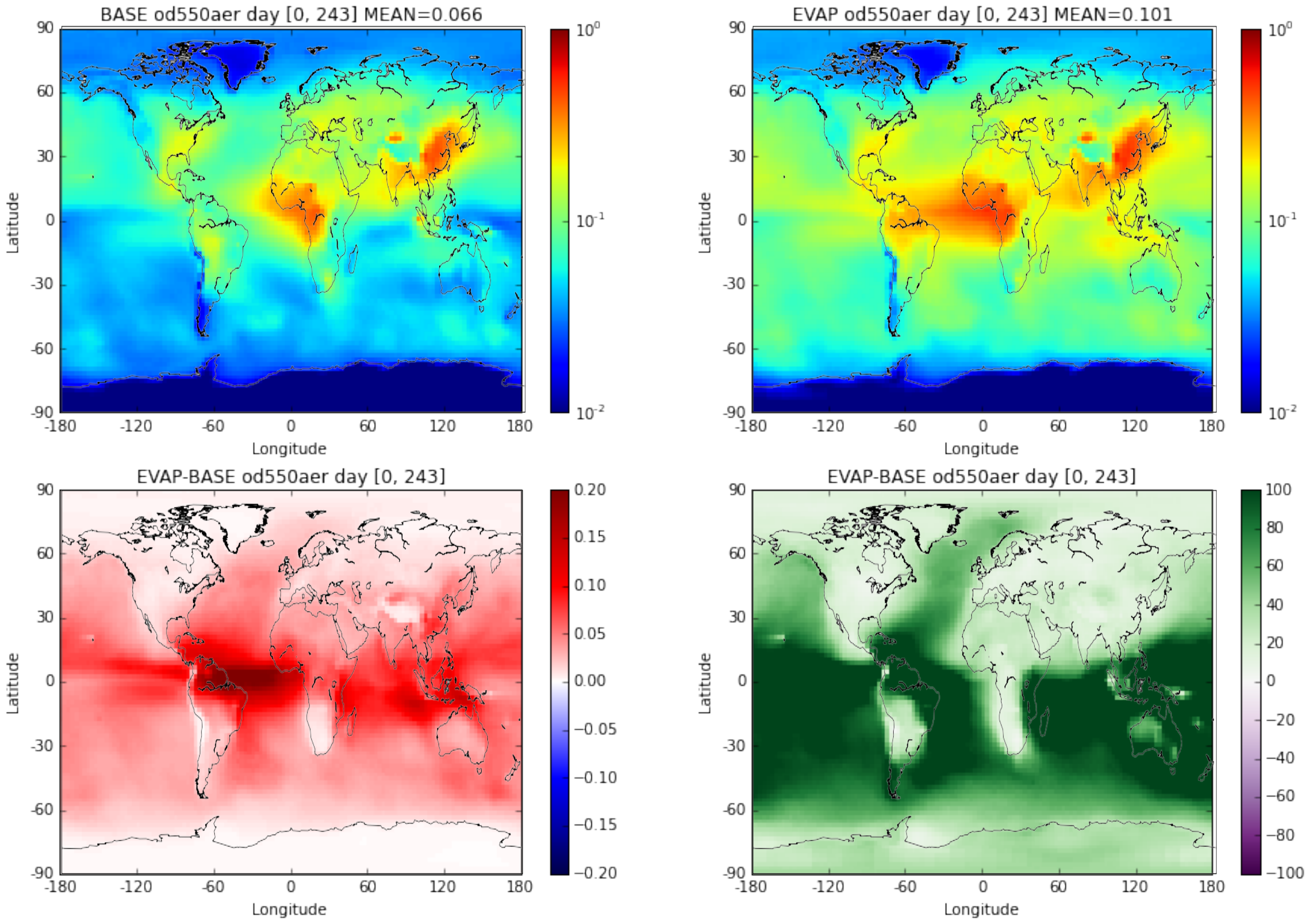


# Changes in sulfate




- Enhanced downward transport of aerosol
- (Partly) counteracted by advection, convection, sedimentation
- Reduced chemical production

# Changes in AOD

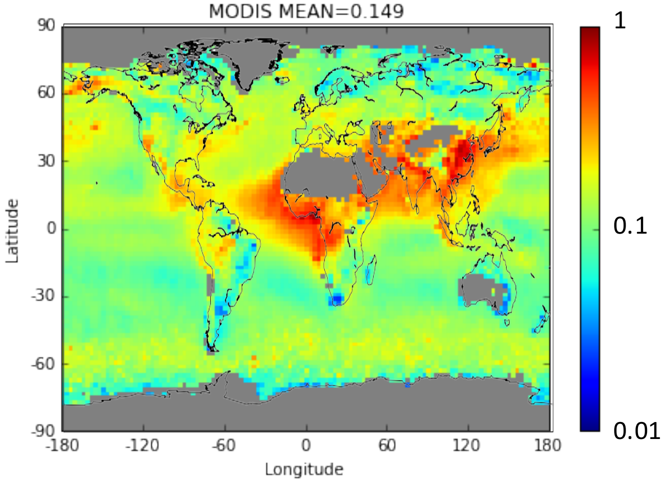


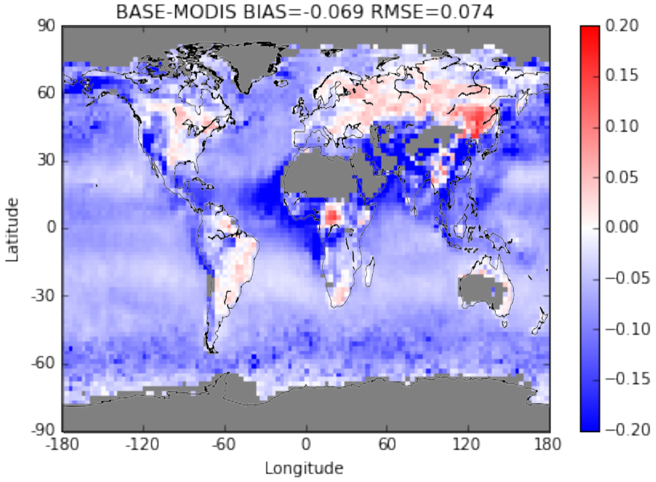

Mean AOD 0.066 ⟶ 0.101

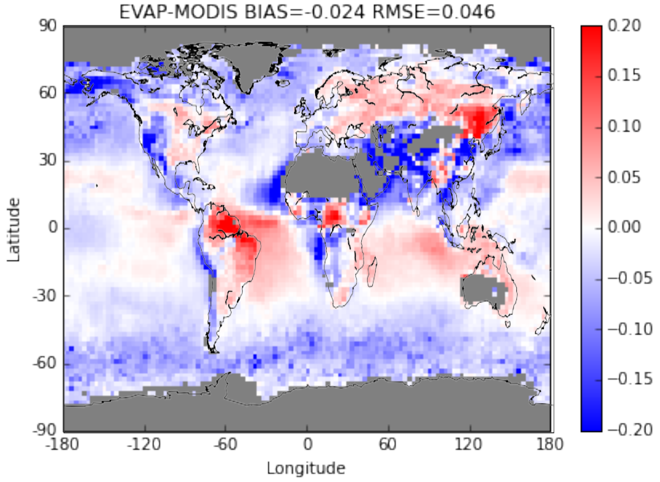
*(not weighted for gridbox area)*

Largest influence by sea salt

# Changes in AOD



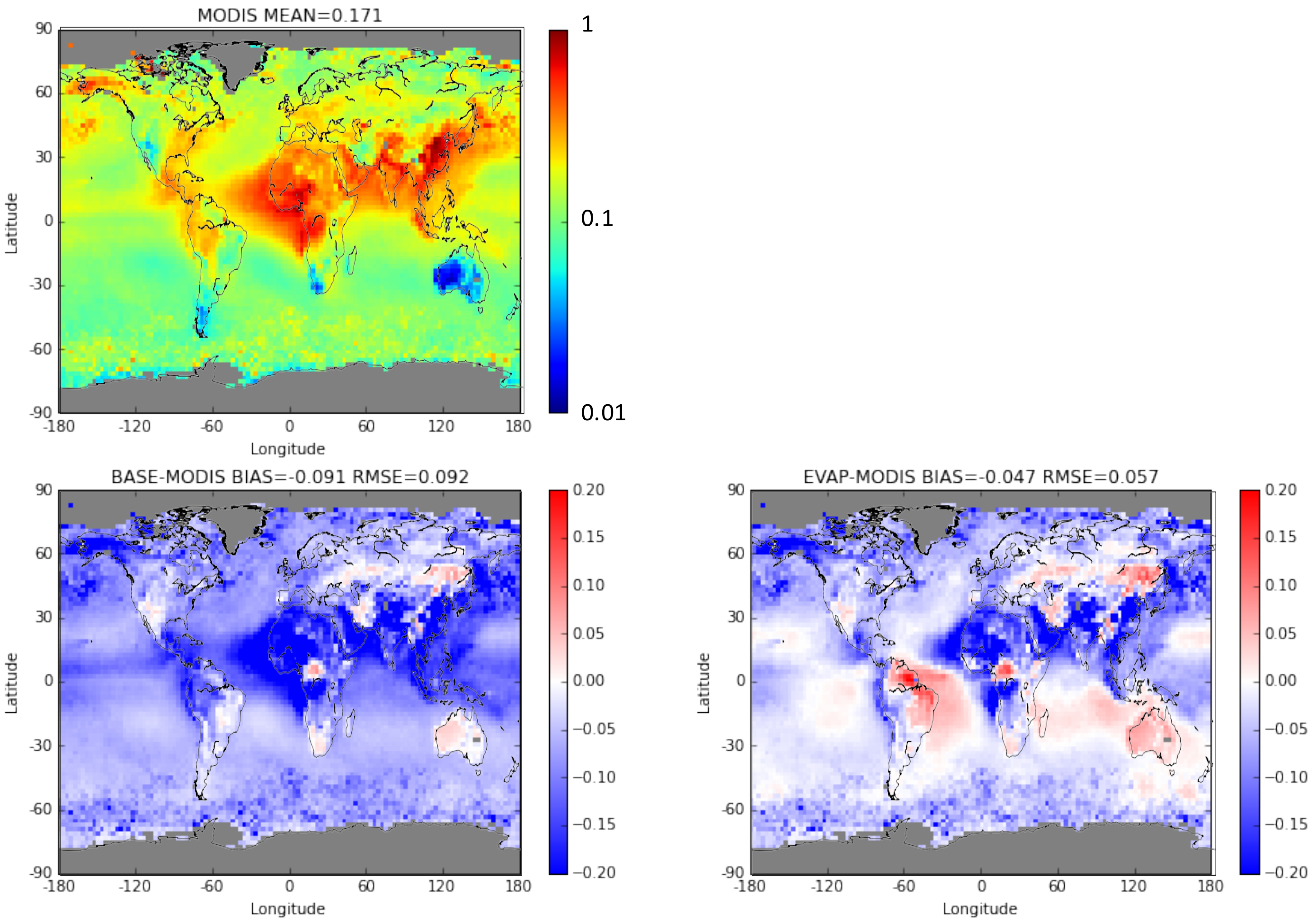

Comparison against MODIS monthly avg AOD (C5.1)

Mean bias
-0.069 ⟶ -0.024

RMSE
0.074 ⟶ 0.046

Overshoot in tropics

# Changes in AOD




Comparison against MODIS monthly avg AOD (C6)

Mean bias

-0.091 ⟶ -0.057

RMSE

0.092 ⟶ 0.057

# Remaining…

- Validity of (re-)evaporation of aerosol into accumulation mode
- Consequences for treatment of sedimentation

- Evaporation applied to aerosol only, but wet removal influences gas phase species leading to possible inconstistent changes to aerosol
  - e.g. $H_2SO_4(g) \longrightarrow SO_4(s)$

- Sensitivity study: Number (re-)evaporation

# Wrap-up

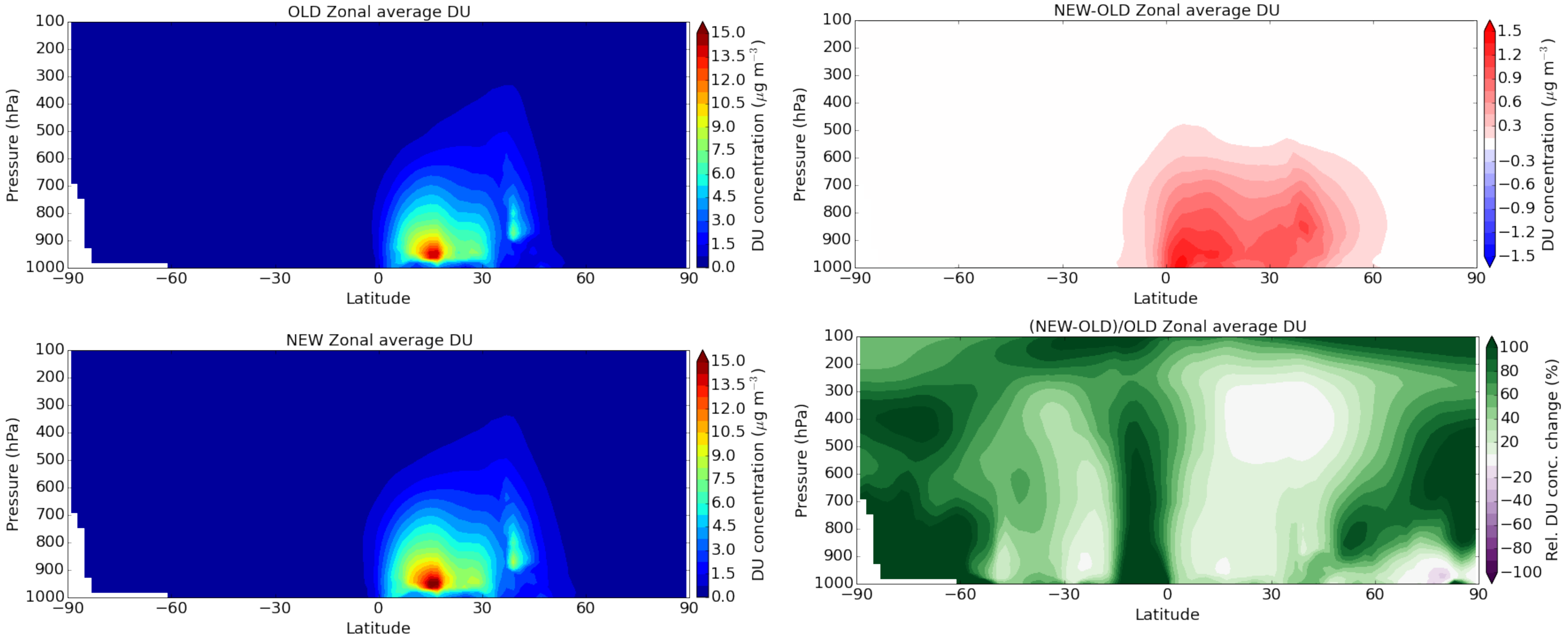
- Implementation of IFS precipitation fields
- Introduction of aerosol (re-)evaporation

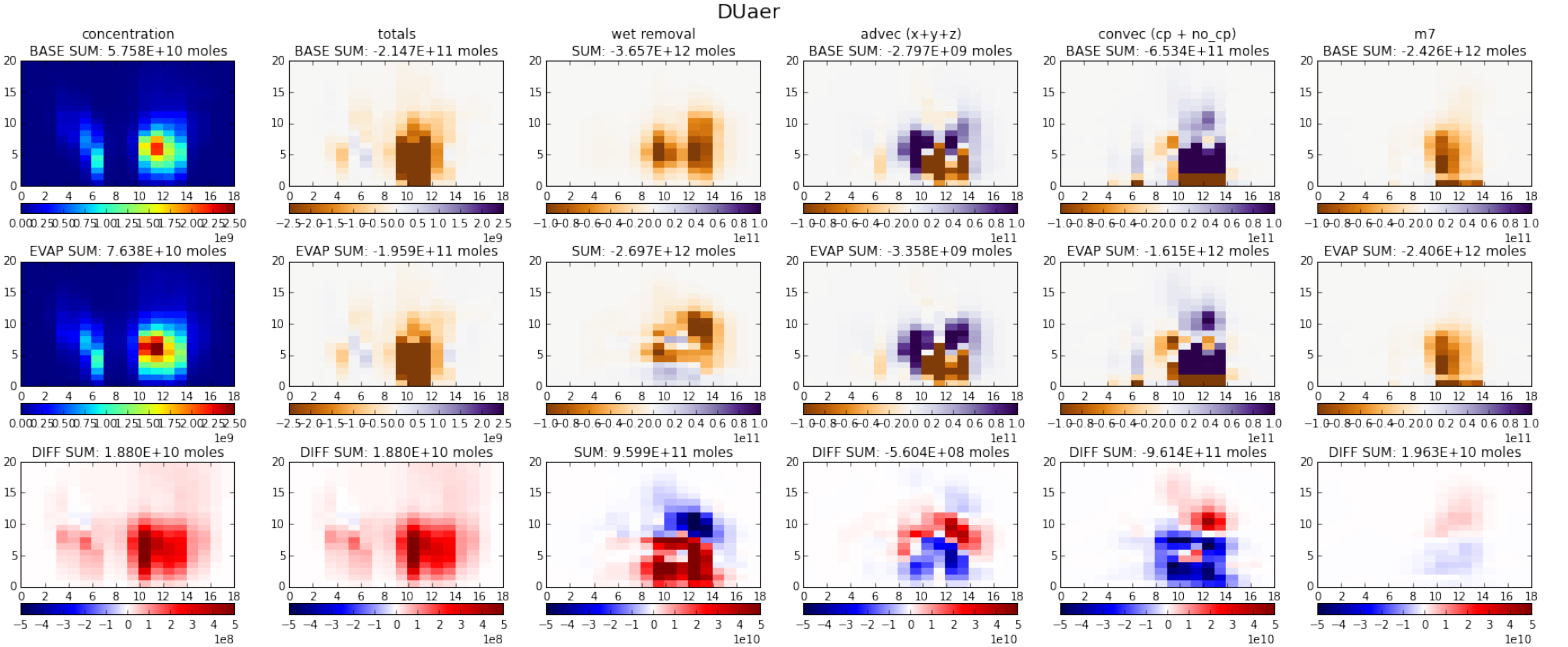
- Additional downward transport by wet deposition
(partly counteracted by advection, convection, sedimentation)
- Aerosol burden generally increases
  POM +10%, BC +10%, $SO_4$ 0%, Salt +60%, Dust +25%

- Simulated AOD increases
  TM5 vs. Collection 5.1: RMSE: 0.074 ⟶ 0.046
  TM5 vs. Collection 6: RMSE: 0.092 ⟶ 0.057

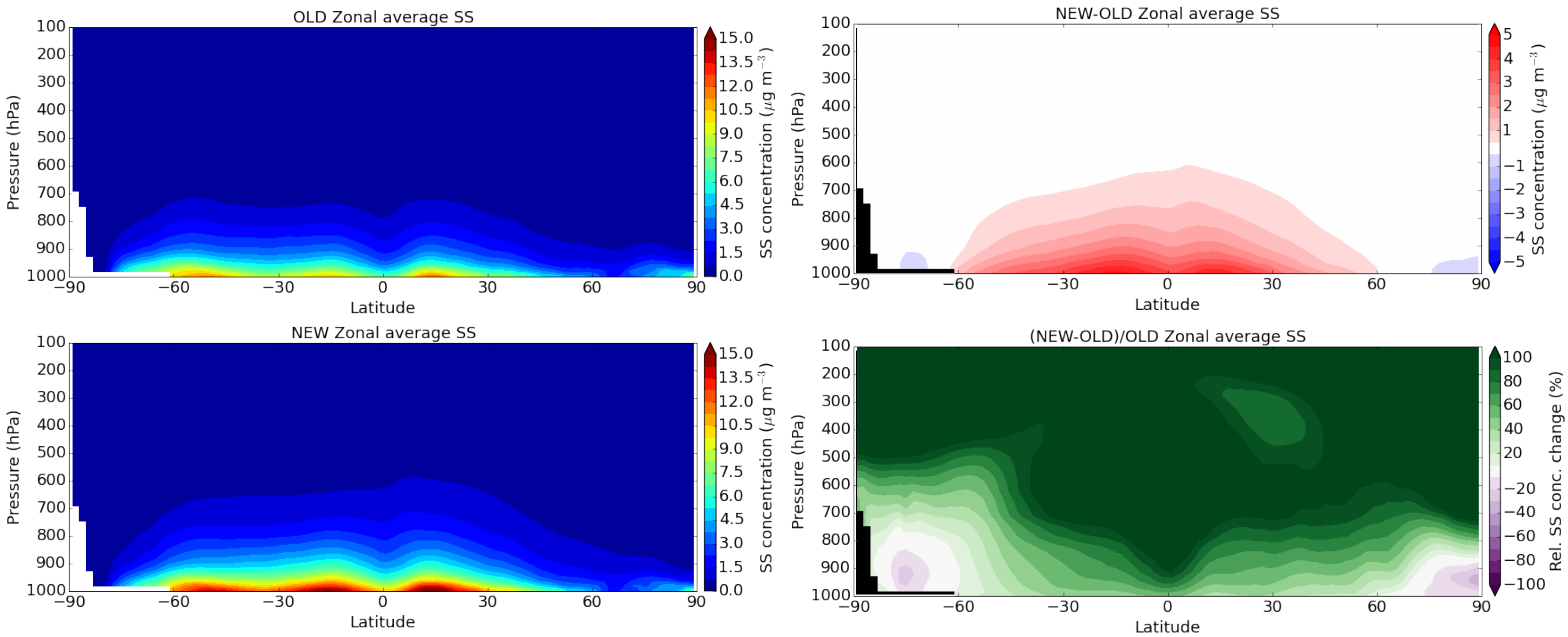
# Additional slides

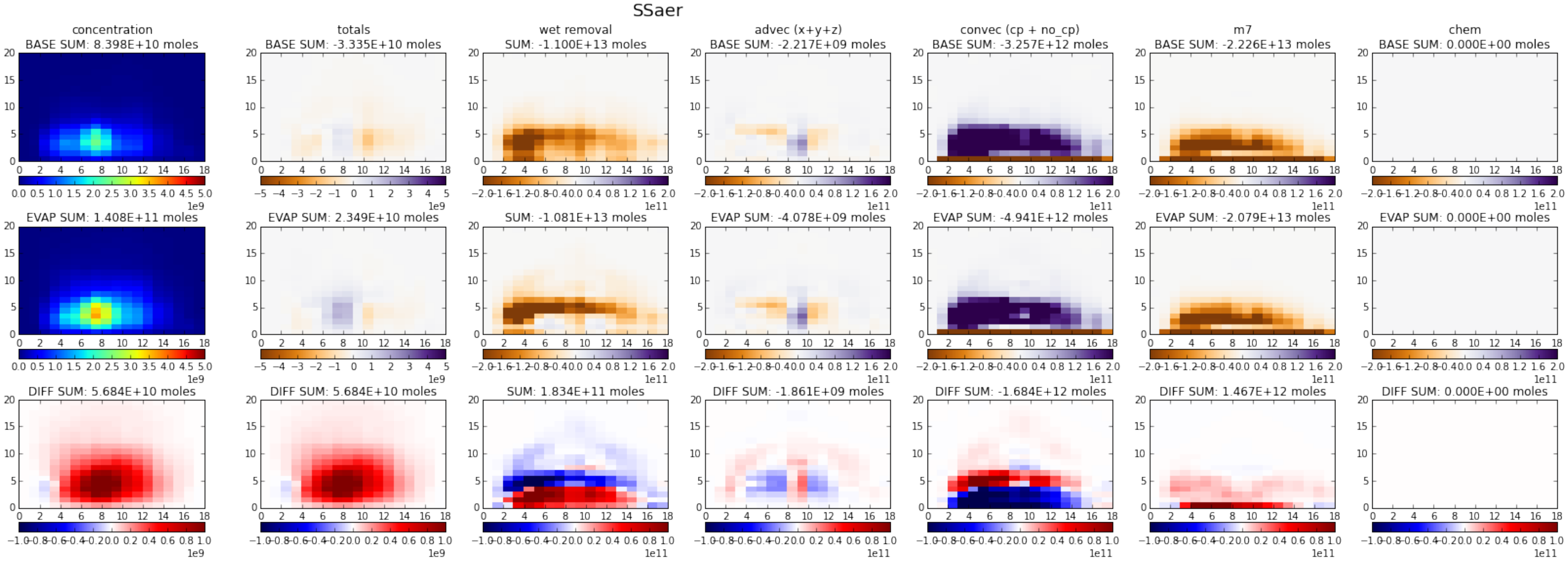
# Changes in mineral dust (+25%)




DUaer
concentration
BASE SUM: 5.758E+10 moles
totals
BASE SUM: -2.147E+11 moles
wet removal
SUM: -3.657E+12 moles
advec (x+y+z)
BASE SUM: -2.797E+09 moles
convec (cp + no_cp)
BASE SUM: -6.534E+11 moles
m7
BASE SUM: -2.426E+12 moles
EVAP SUM: 7.638E+10 moles
EVAP SUM: -1.959E+11 moles
SUM: -2.697E+12 moles
EVAP SUM: -3.358E+09 moles
EVAP SUM: -1.615E+12 moles
EVAP SUM: -2.406E+12 moles
DIFF SUM: 1.880E+10 moles
DIFF SUM: 1.880E+10 moles
SUM: 9.599E+11 moles
DIFF SUM: -5.604E+08 moles
DIFF SUM: -9.614E+11 moles
DIFF SUM: 1.963E+10 moles
1e9
1e11
1e8
1e10

# Changes in sea salt (+60%)





SSaer
concentration
BASE SUM: 8.398E+10 moles
totals
BASE SUM: -3.335E+10 moles
wet removal
SUM: -1.100E+13 moles
advec (x+y+z)
BASE SUM: -2.217E+09 moles
convec (cp + no_cp)
BASE SUM: -3.257E+12 moles
m7
BASE SUM: -2.226E+13 moles
chem
BASE SUM: 0.000E+00 moles
EVAP SUM: 1.408E+11 moles
EVAP SUM: 2.349E+10 moles
SUM: -1.081E+13 moles
EVAP SUM: -4.078E+09 moles
EVAP SUM: -4.941E+12 moles
EVAP SUM: -2.079E+13 moles
EVAP SUM: 0.000E+00 moles
DIFF SUM: 5.684E+10 moles
DIFF SUM: 5.684E+10 moles
SUM: 1.834E+11 moles
DIFF SUM: -1.861E+09 moles
DIFF SUM: -1.684E+12 moles
DIFF SUM: 1.467E+12 moles
DIFF SUM: 0.000E+00 moles

# Dominant species for AOD change