Sensitivity of nitrate aerosols to chemistry and emissions

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Acknowledgements:
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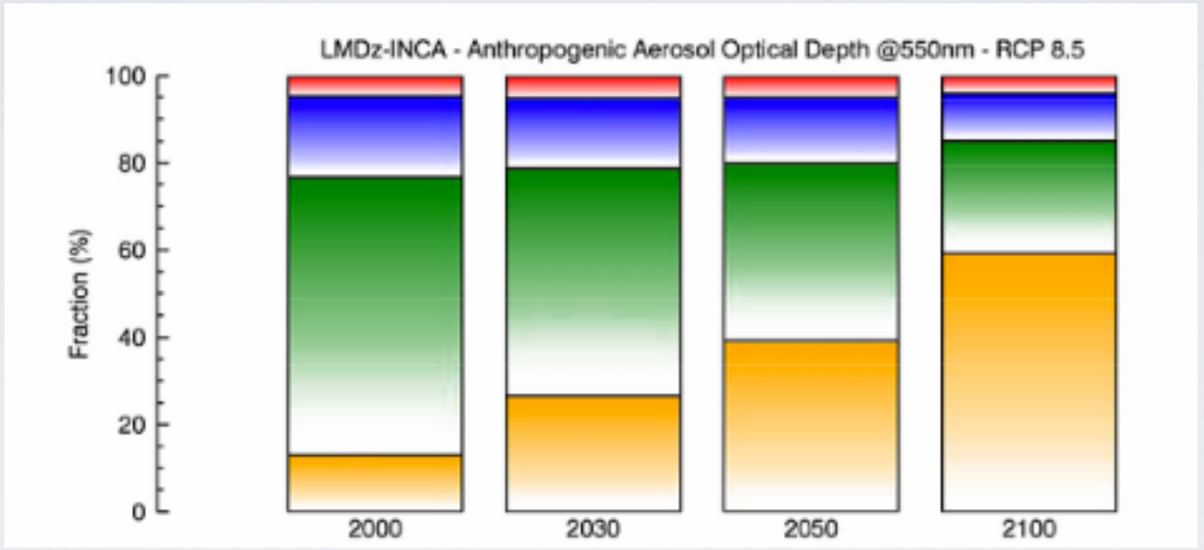
Nitrate aerosols may dominate anthropogenic aerosol AOD by the end of the century

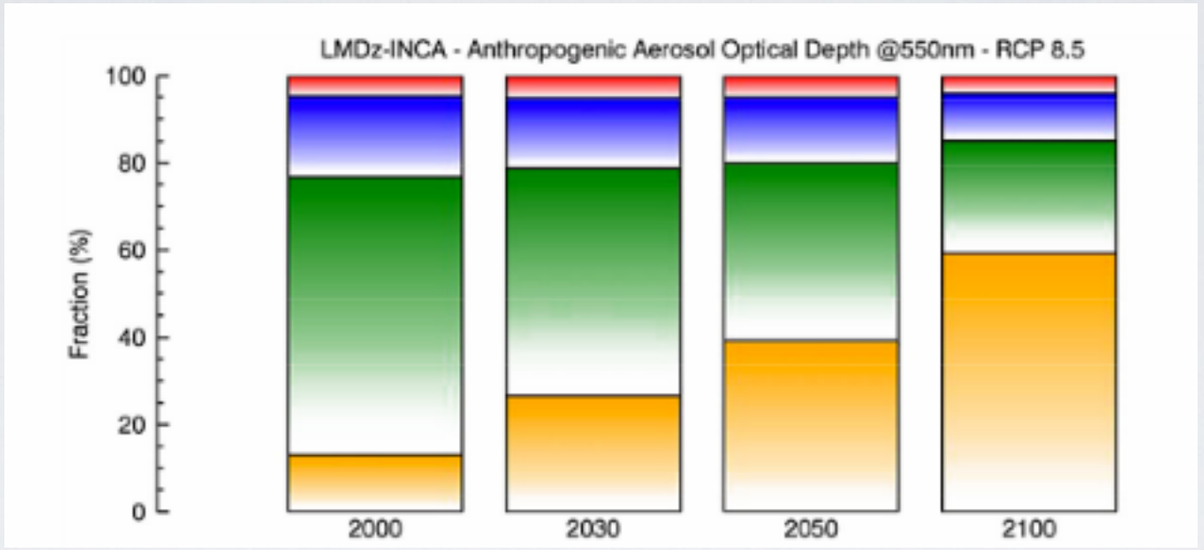


BC
OC
SO_4
NO_3

Hauglustaine et al. (2014)

but

Nitrate aerosols may dominate anthropogenic aerosol AOD by the end of the century



BC
OC
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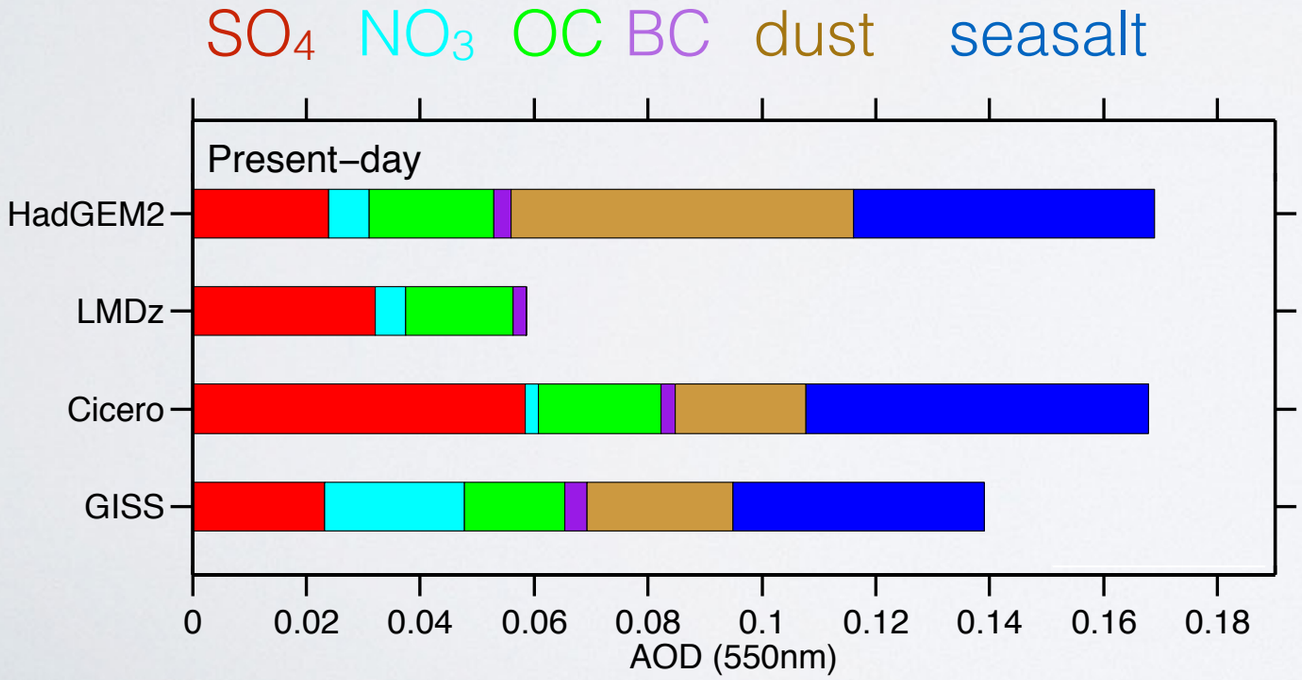
NO_3

Hauglustaine et al. (2014)

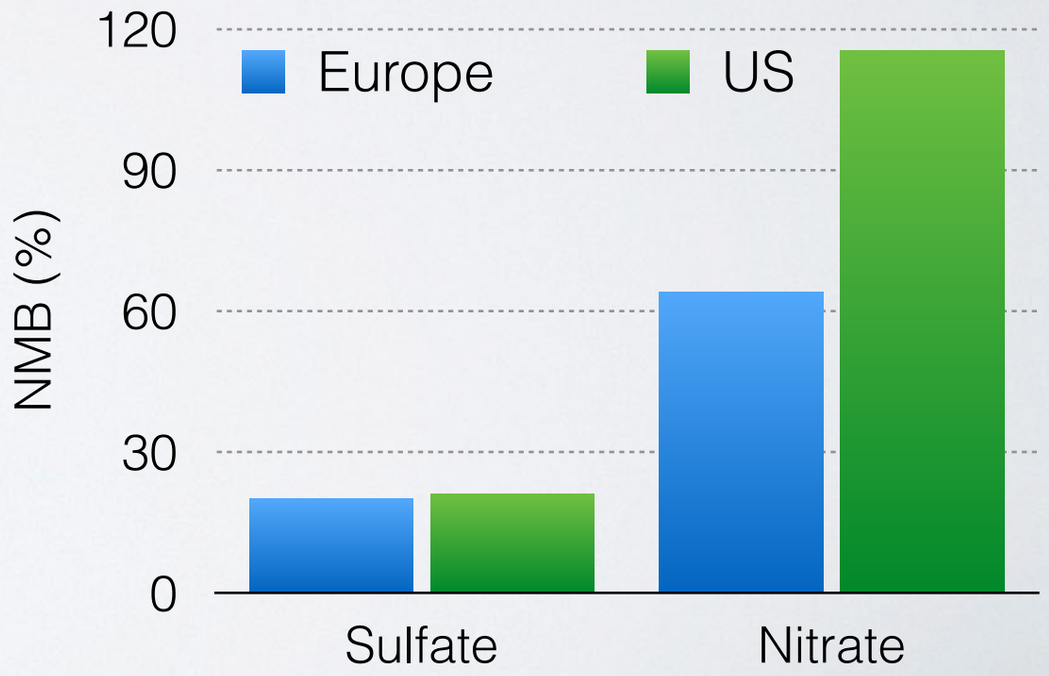
but

large variability in simulated present-day NO_3 optical depth



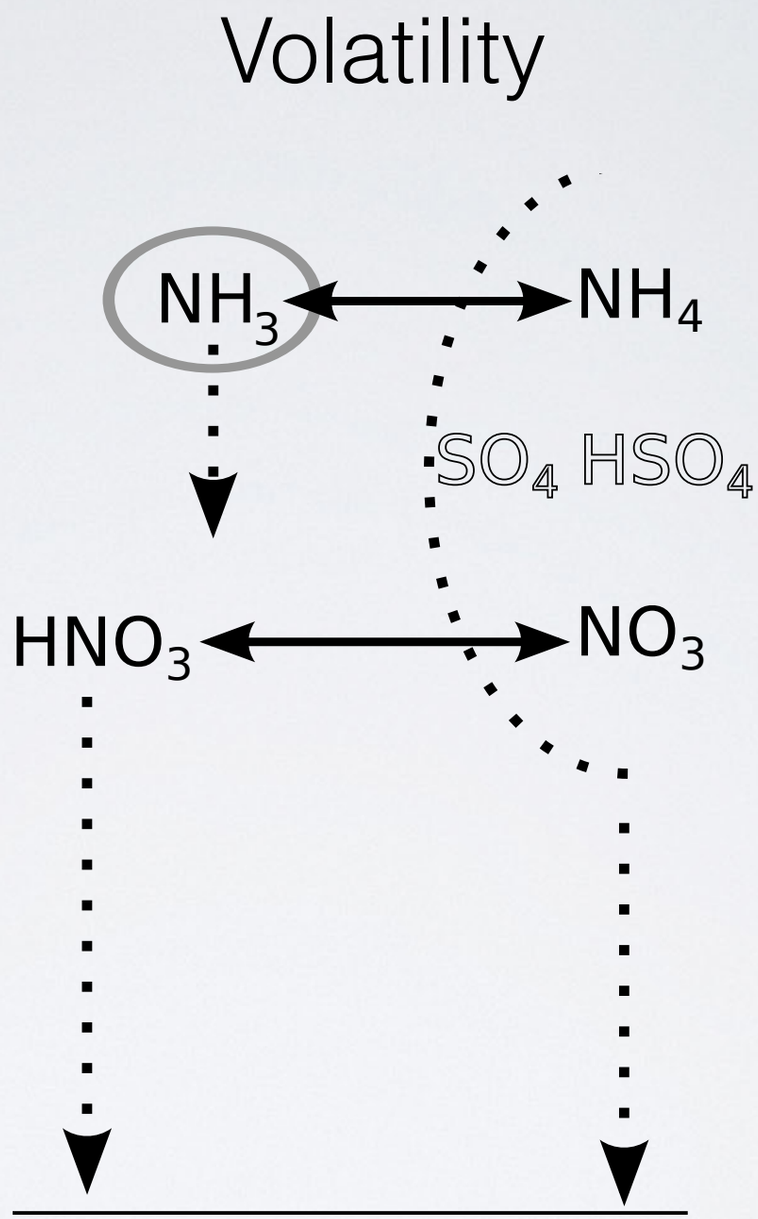
Paulot et al. (2015)

models do not capture surface NO_3



Data from Hauglustaine et al. (2014)

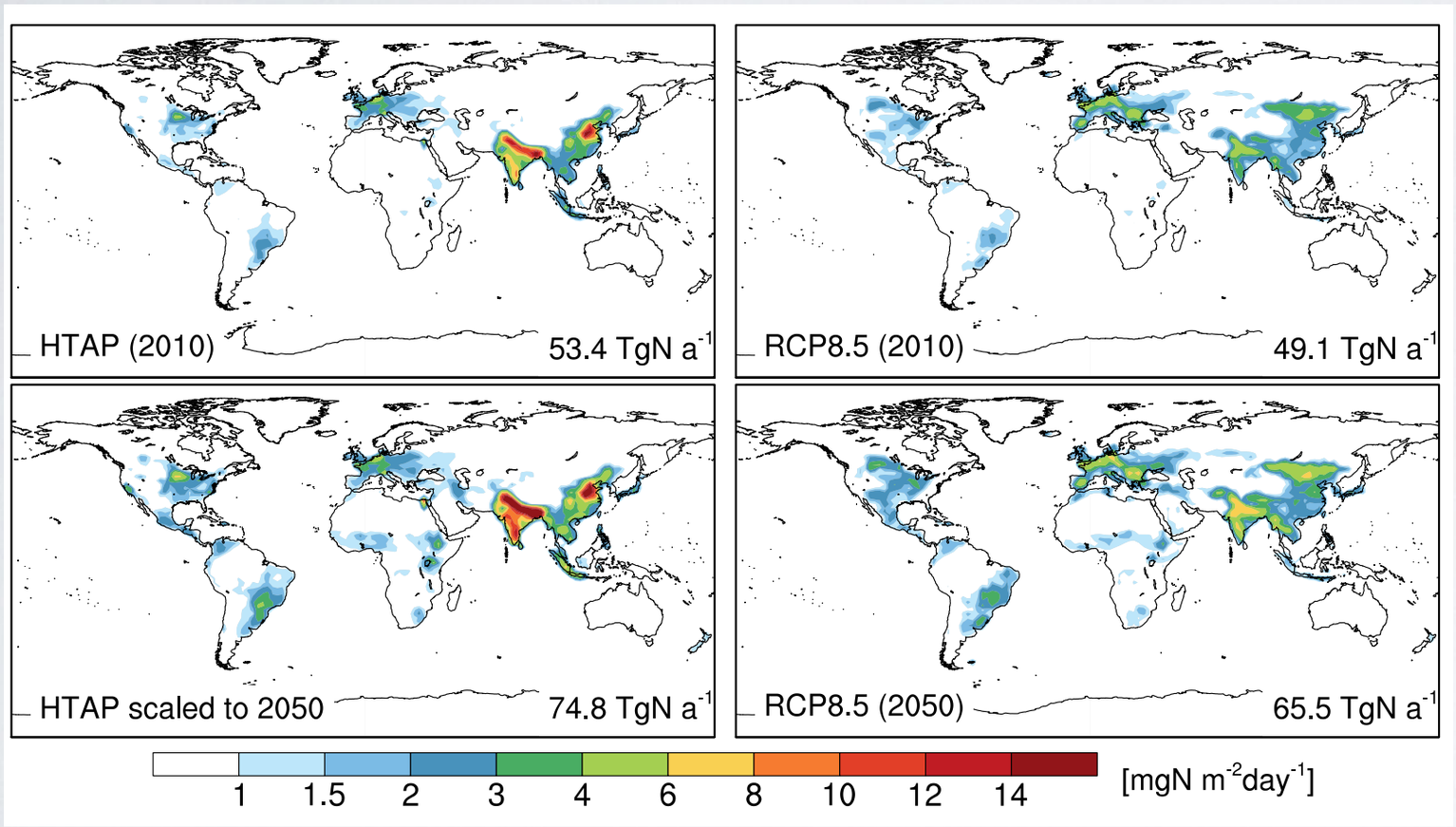
Why is NO_3 aerosol so difficult to simulate?



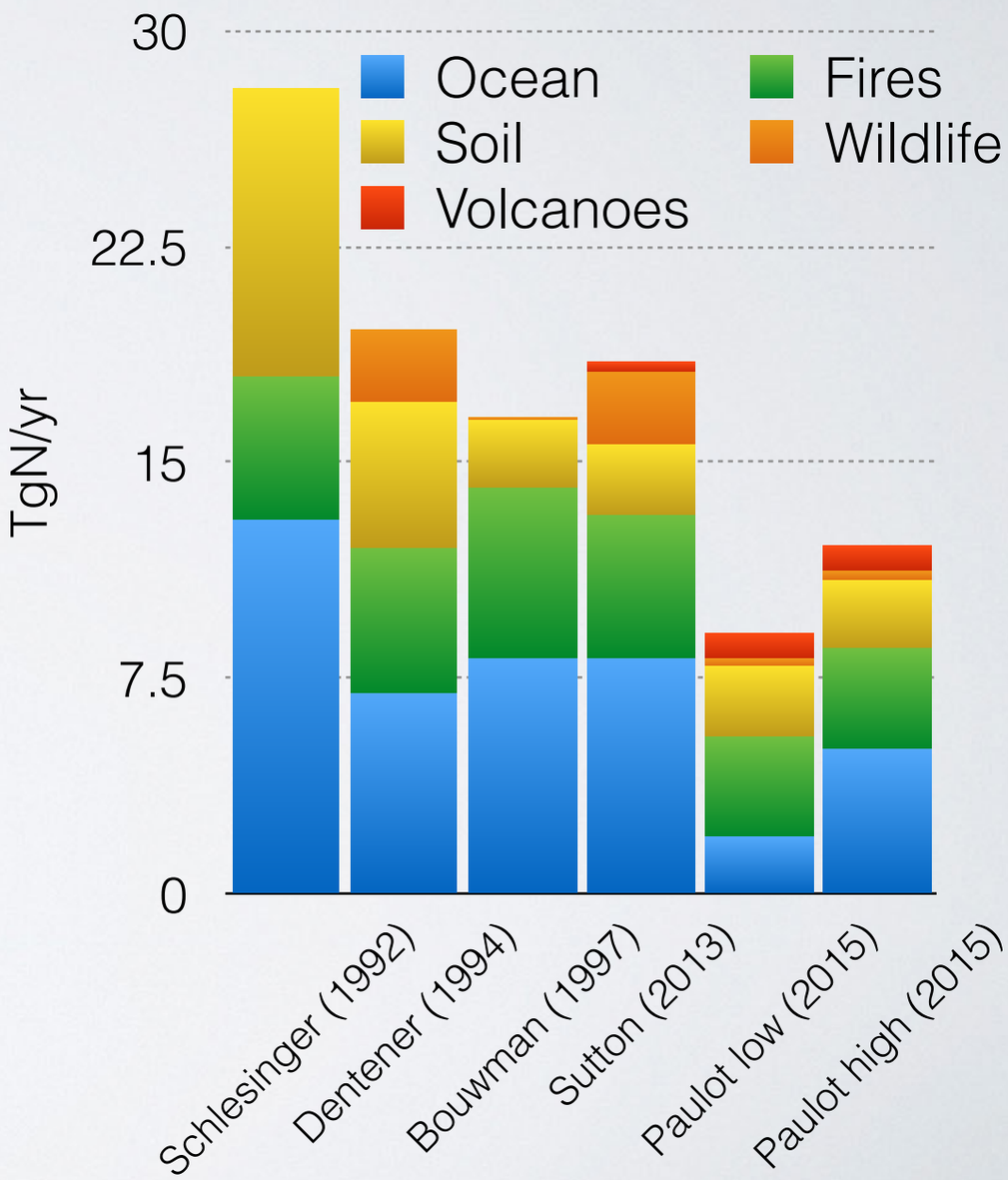
Why is NO_3 aerosol so difficult to simulate?

Ammonia Nitric acid

Global distribution



Natural NH_3

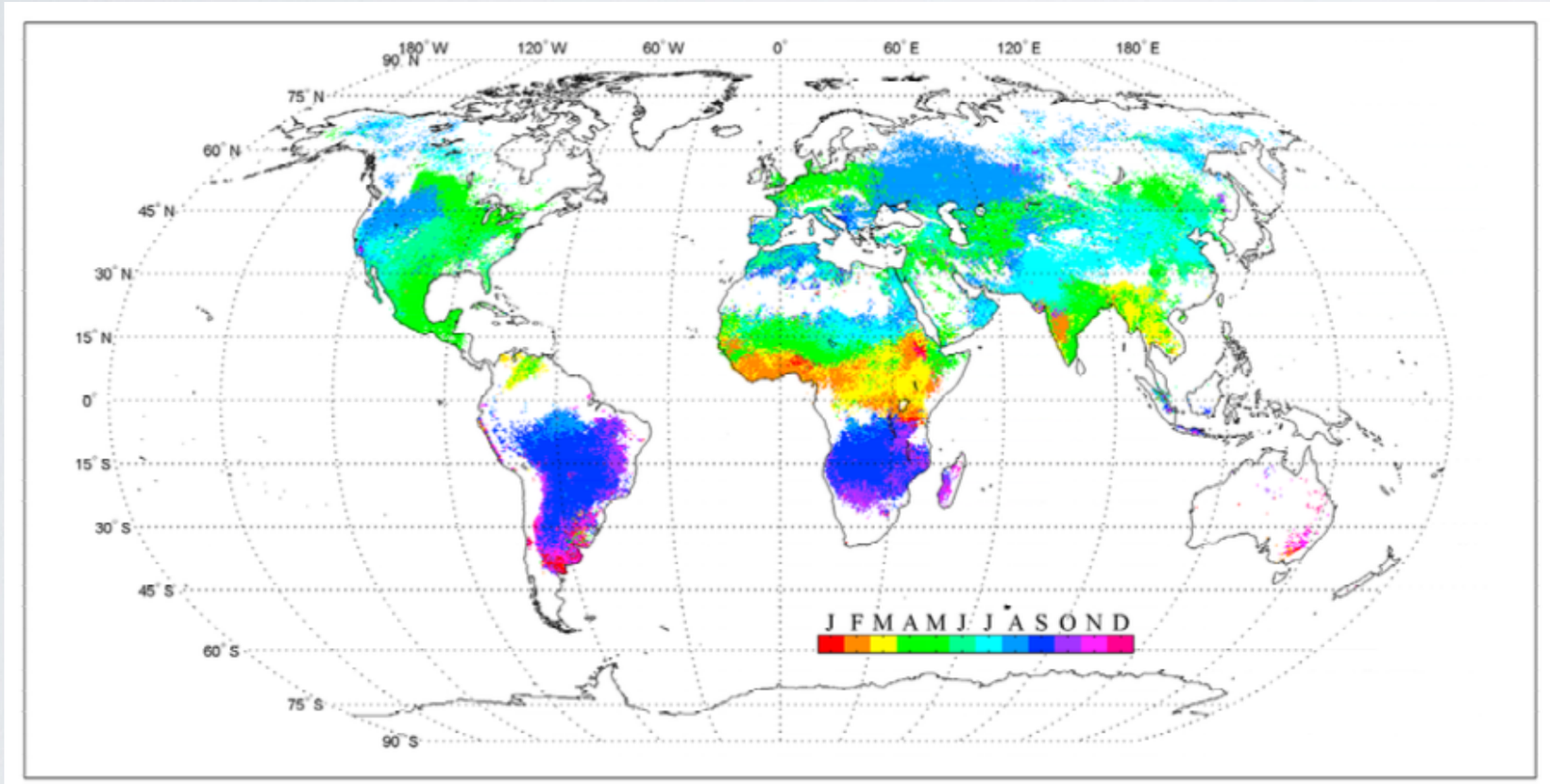


Paulot et al. (2015)

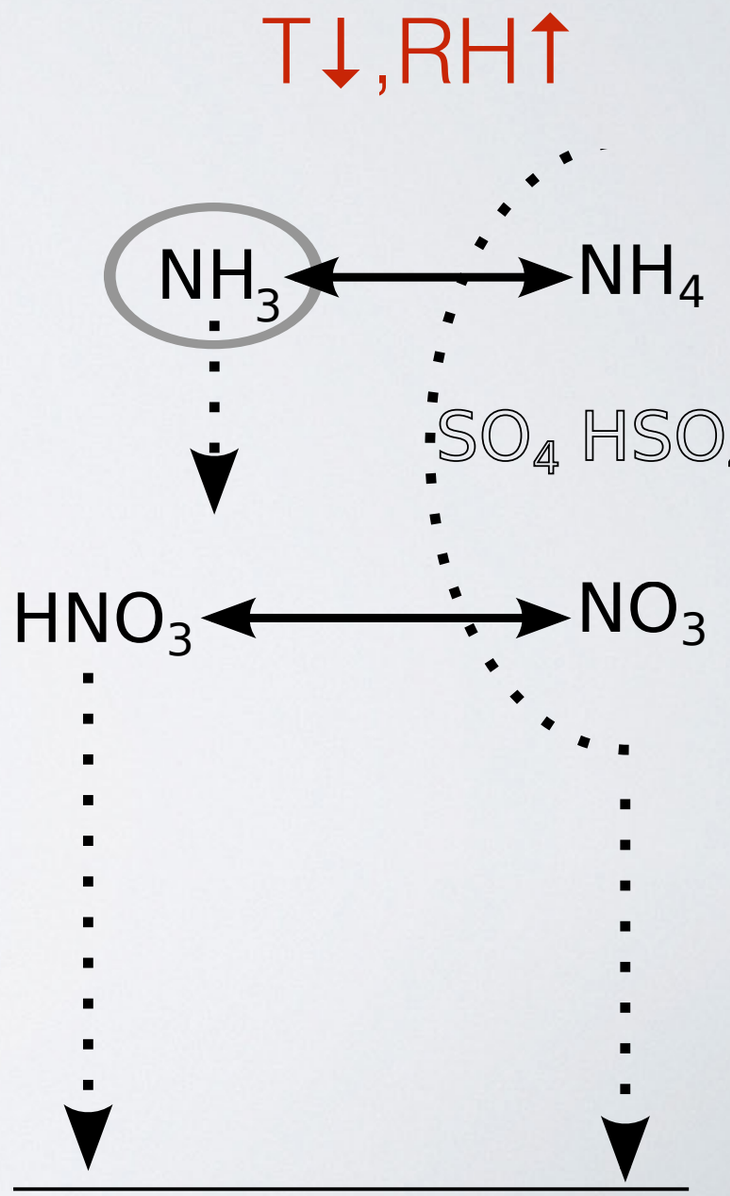
Why is NO_3 aerosol so difficult to simulate?

Ammonia Nitric acid

Seasonality
driven by farming + weather

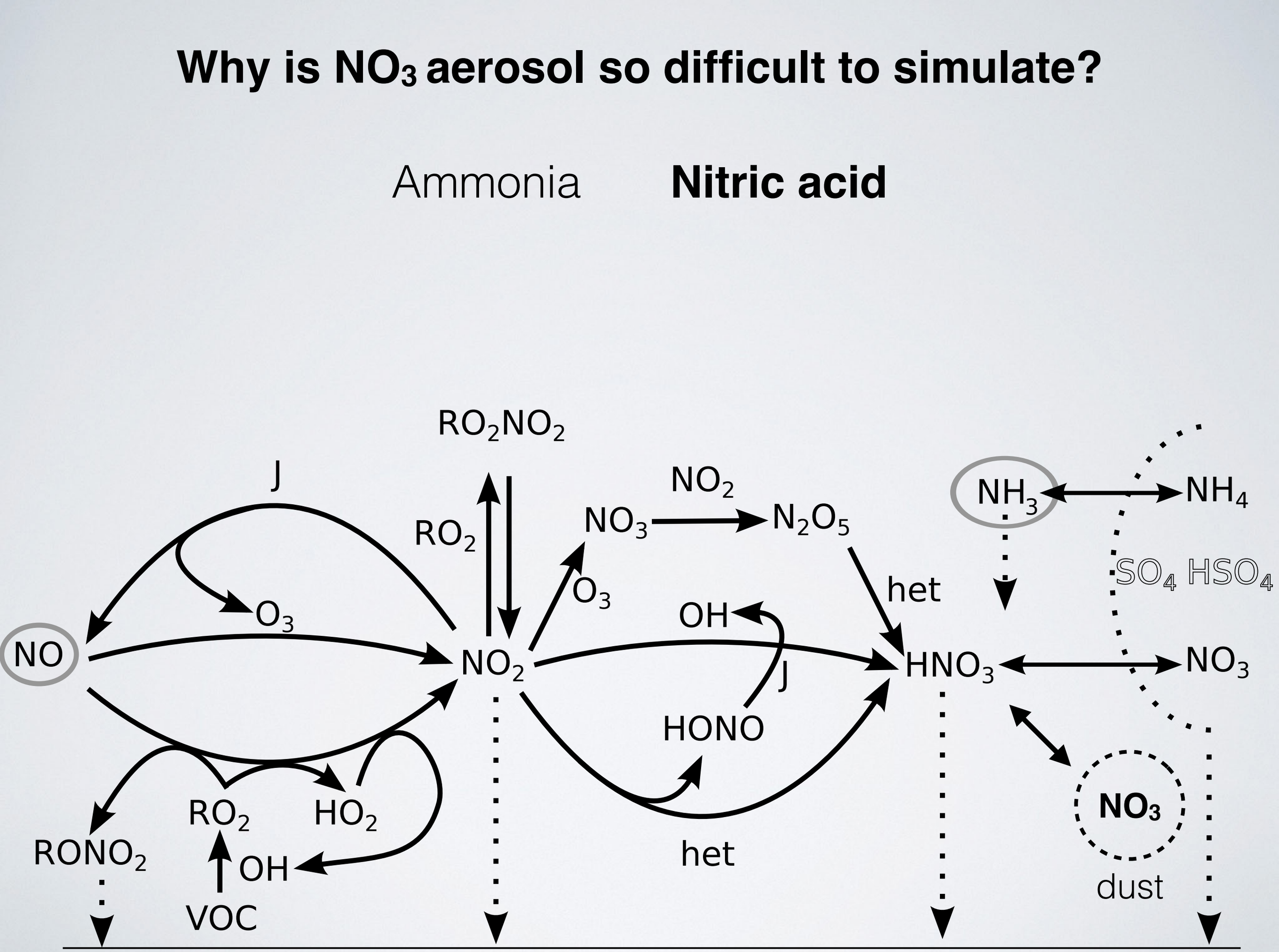


Van Damme et al. (2015)



Why is NO_3 aerosol so difficult to simulate?

Ammonia **Nitric acid**



Why is NO_3 aerosol so difficult to simulate?

Volatility

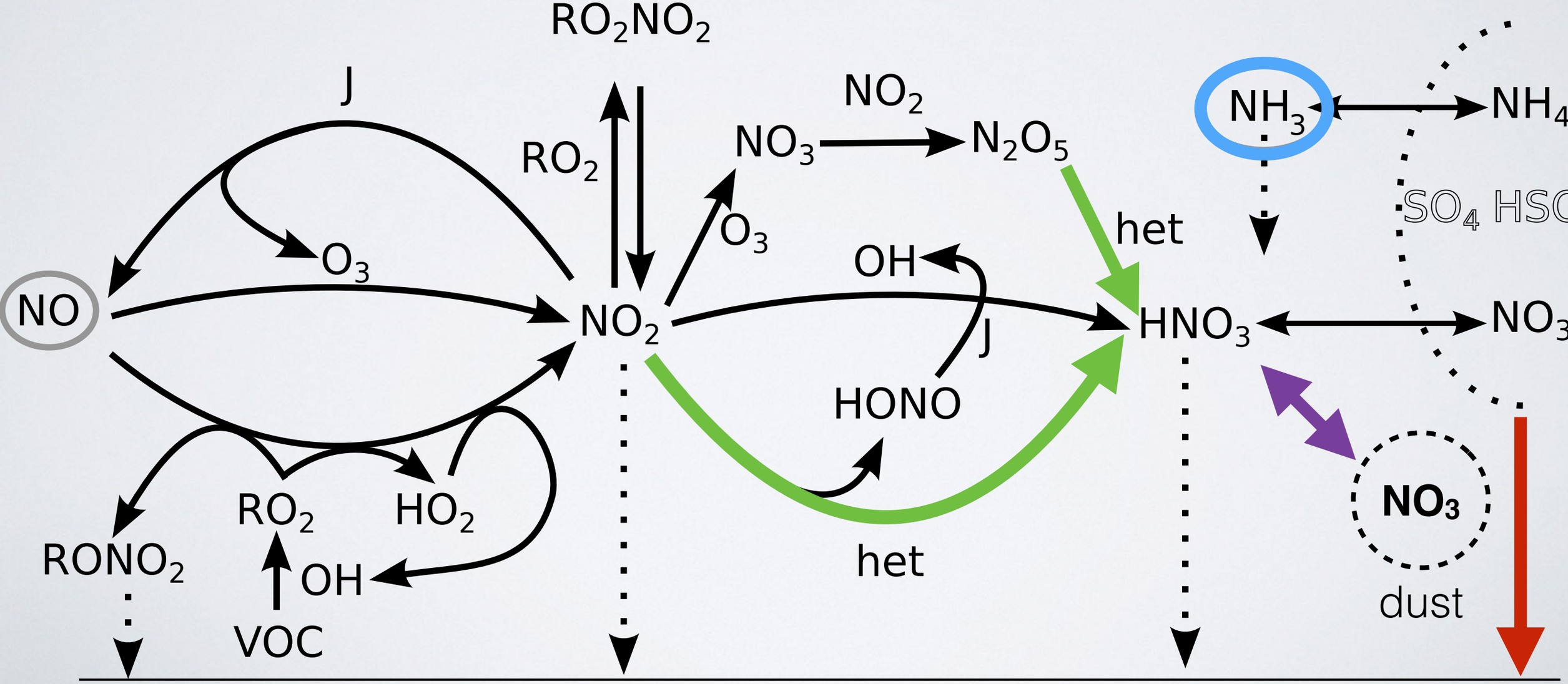
dry deposition of NH_4NO_3

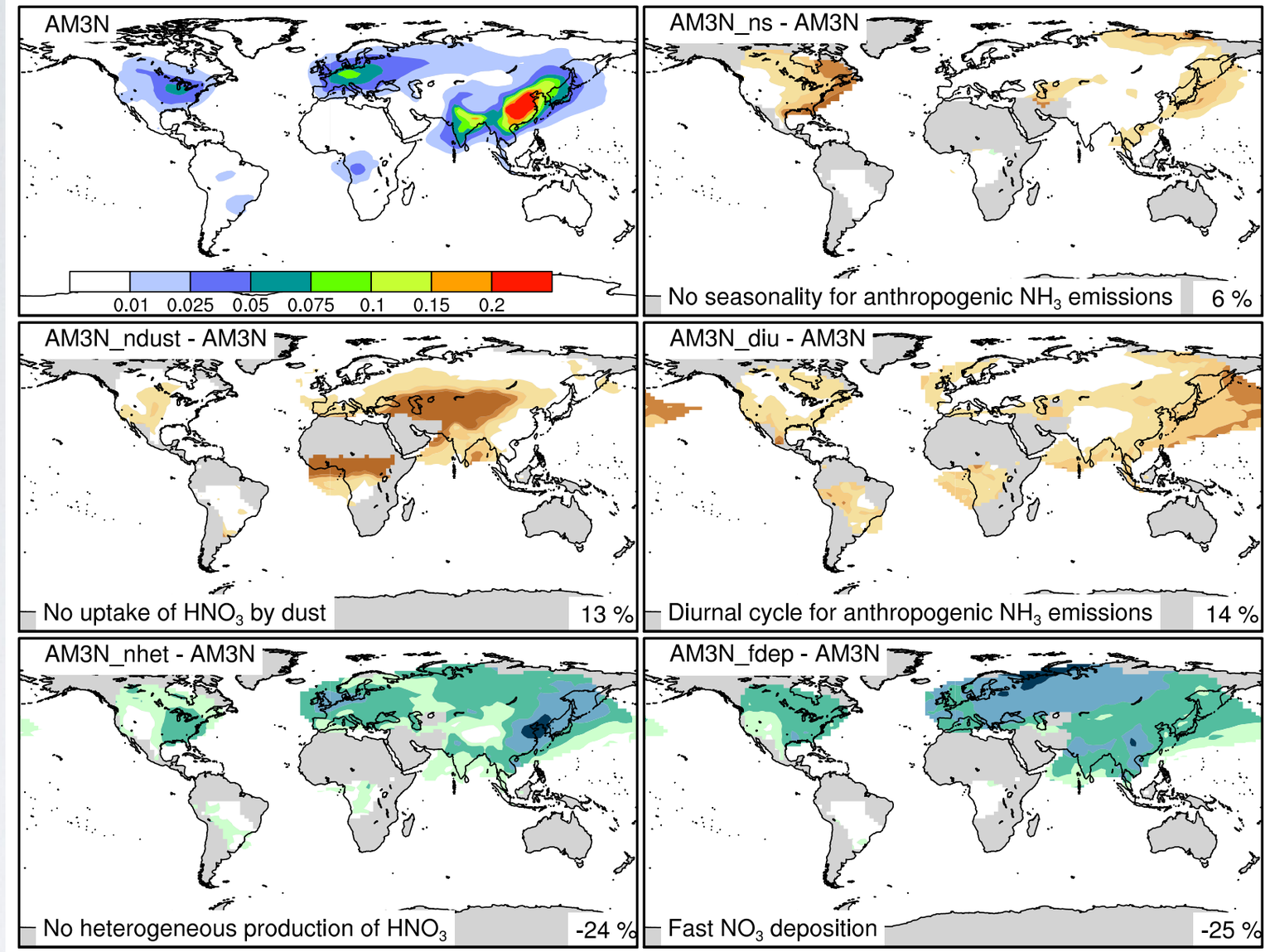
Ammonia

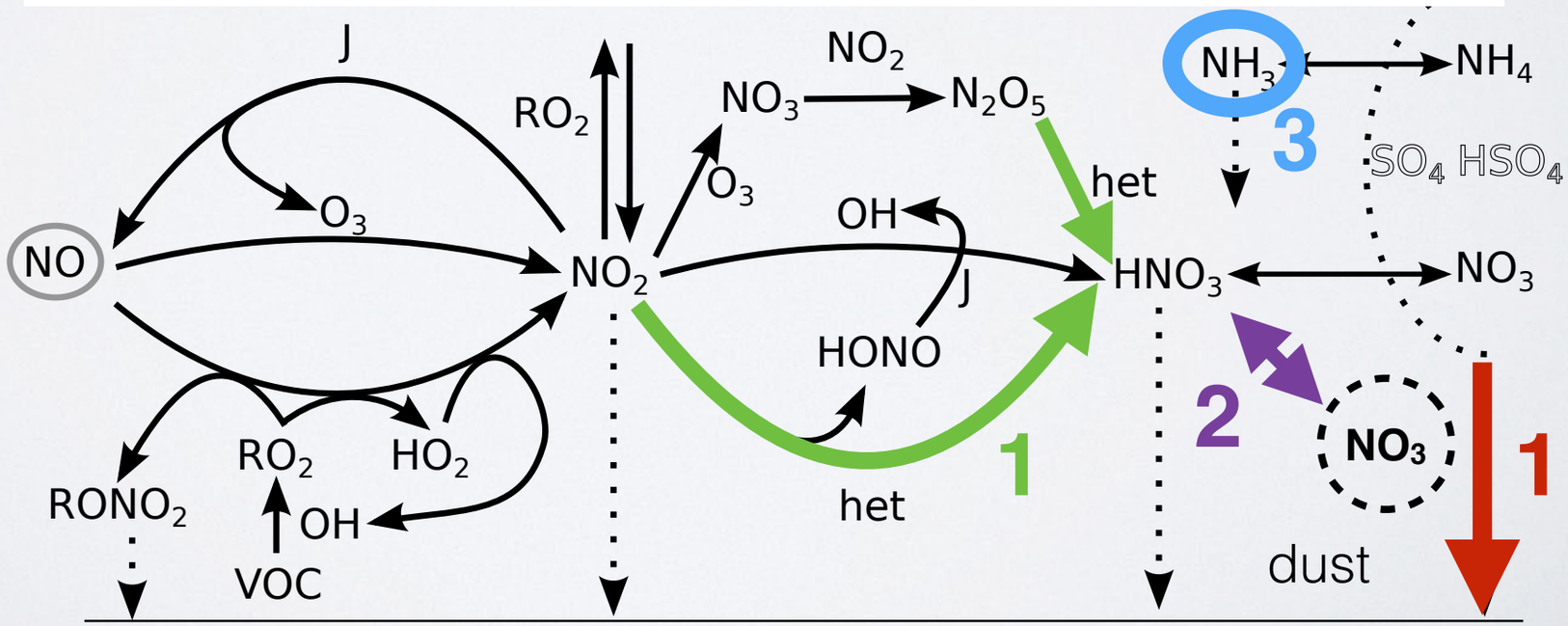
seasonality
diurnal cycles
spatial distribution

Nitric acid

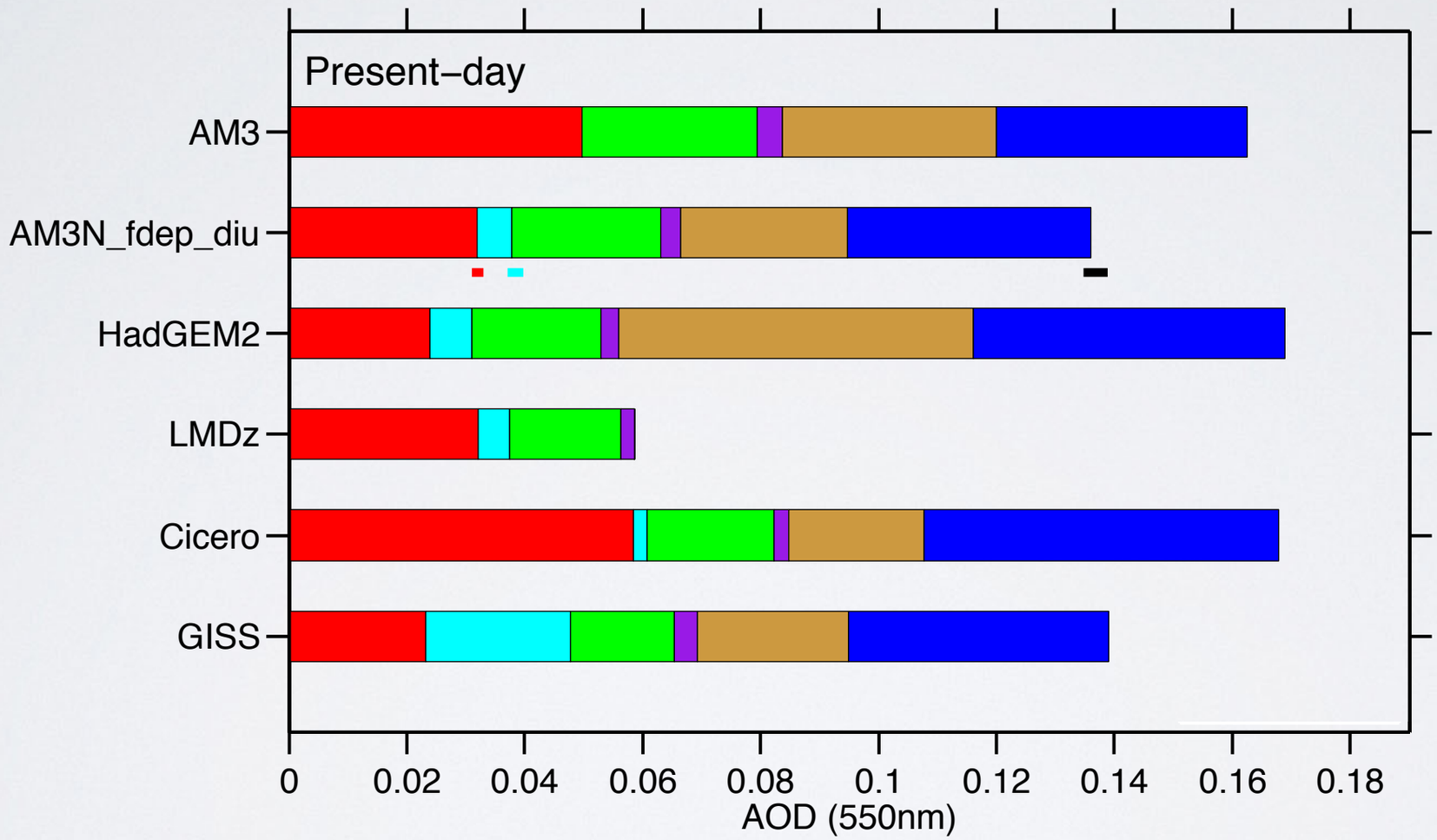
heterogeneous production
heterogeneous chemistry on dust




AM3N
AM3N_ns - AM3N
No seasonality for anthropogenic NH_3 emissions
6 %
0.01 0.025 0.05 0.075 0.1 0.15 0.2
AM3N_ndust - AM3N
No uptake of HNO_3 by dust
13 %
AM3N_diu - AM3N
Diurnal cycle for anthropogenic NH_3 emissions
14 %
AM3N_nhet - AM3N
No heterogeneous production of HNO_3
-24 %
AM3N_fdep - AM3N
Fast NO_3 deposition
-25 %
-40 -30 -20 -10 10 20 30 40


J
RO_2
NO_2
NO_3
N_2O_5
O_3
OH
het
NH_3
NH_4
3
SO_4 HSO_4
NO
NO_2
HNO_3
NO_3
J
HONO
2
NO_3
1
RO_2
HO_2
$RONO_2$
OH
het
1
dust
VOC

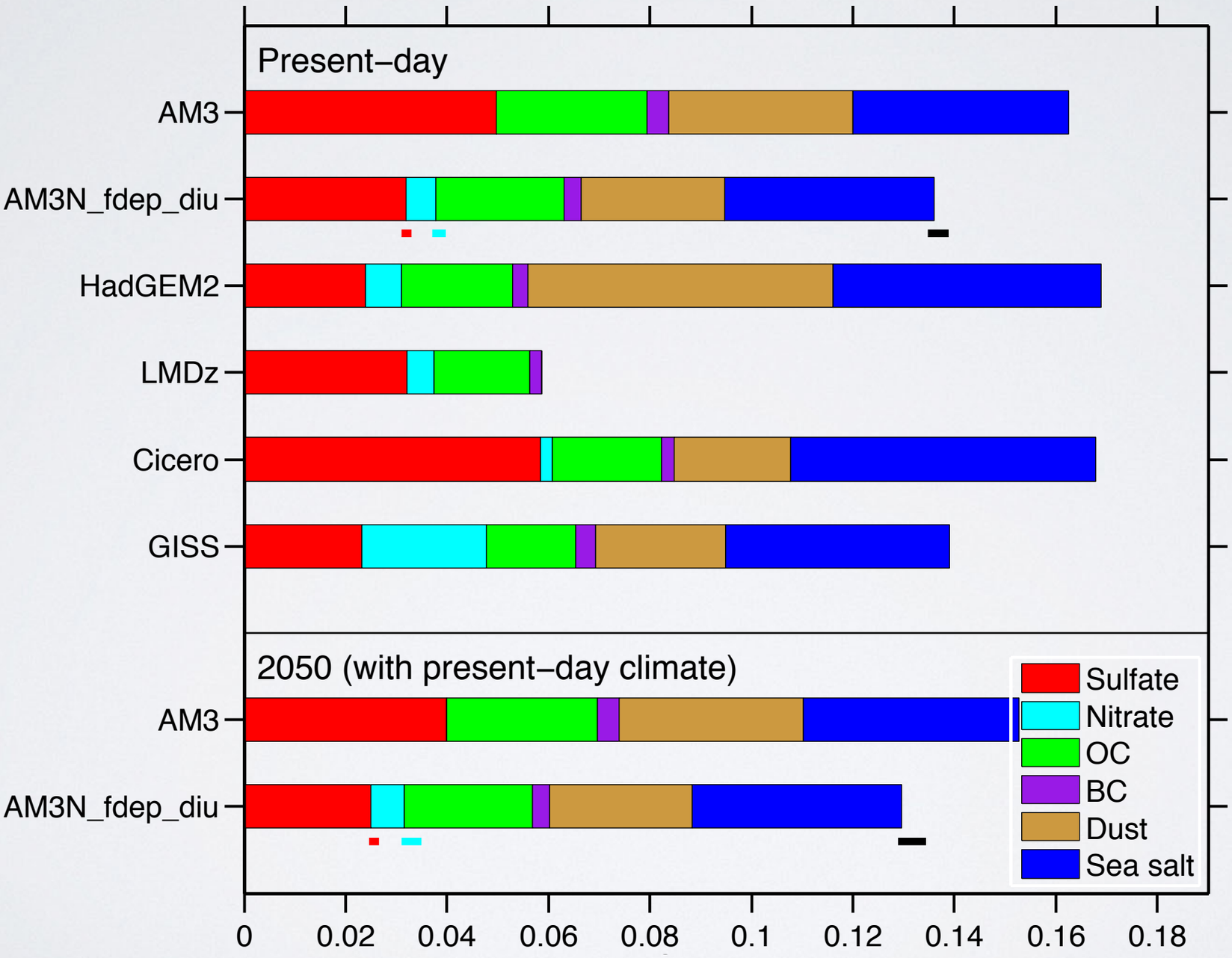
Globally differences in chemistry can change NO_3 optical depth by ~30%



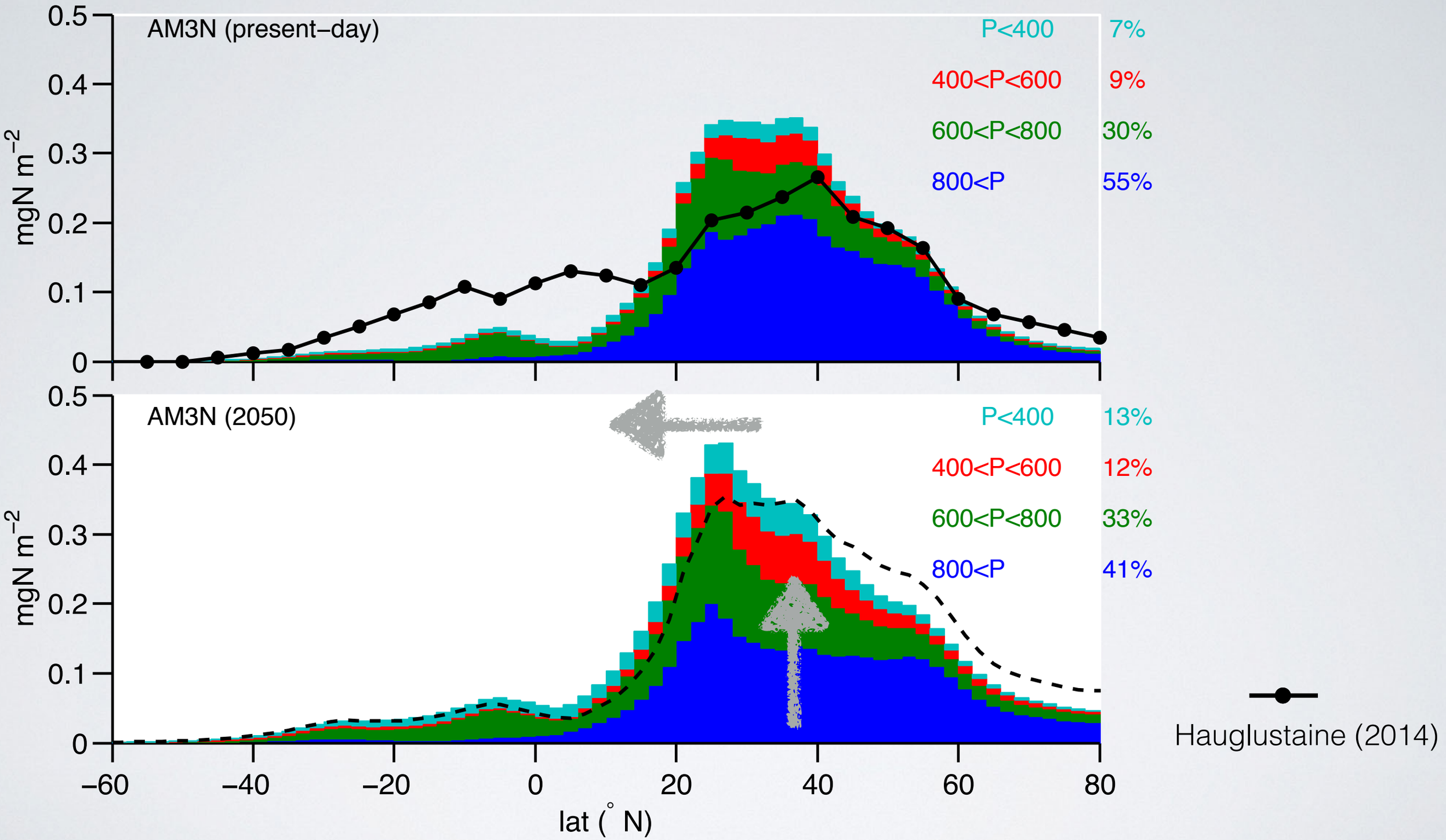
Cannot account for some of the model differences

+

weak response to changes in anthropogenic emissions



Vertical and meridional distribution of NO_3



NO_3 in the free troposphere is longer-lived than near the surface

Experiment:

characterize the meridional and vertical budgets of NH_3 and HNO_3 and the sensitivity of NO_3 aerosols

Emissions:

HTAPv2 anthropogenic emissions, natural emissions (GEIA, Paulot 2015?), GFED4 daily
-> 2008—2010

Output:

static, vertical coordinate system, altitude above sea level

2d fields (daily):

surface pressure, NO_3 and SO_4 optical depth, wet+dry deposition (NH_3, NH_4, HNO_3, NO_3, SO_4). Separate convection from stratiform, precipitation

3D fields (daily):

temperature, specific humidity, NH_3, NO_3 (fine, coarse), SO_4 (fine, coarse), NH_4, HNO_3, SO_2, dust, N_2O_5, gamma N_2O_5 (if dynamic) sea salt,OH, NO_2,lightning NO, **snow, rain**

chemical production and loss (3D)

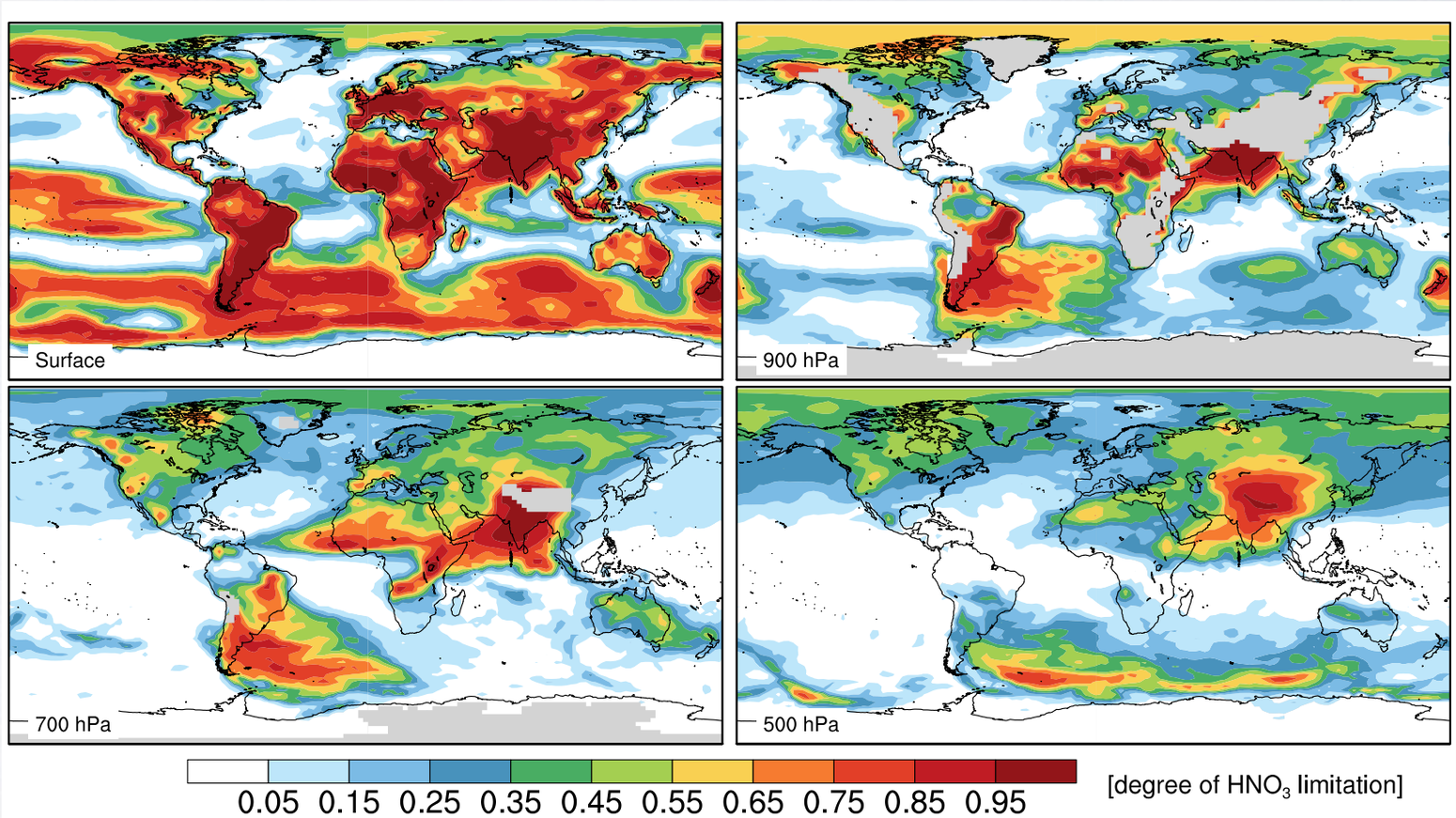
HNO_3: OH+NO2,
heterogeneous prod and loss
SO_4: SO_2 (OH, cloud)

wet removal frequency

separate stratiform and convective precipitation

dry deposition

velocity



Experiment:

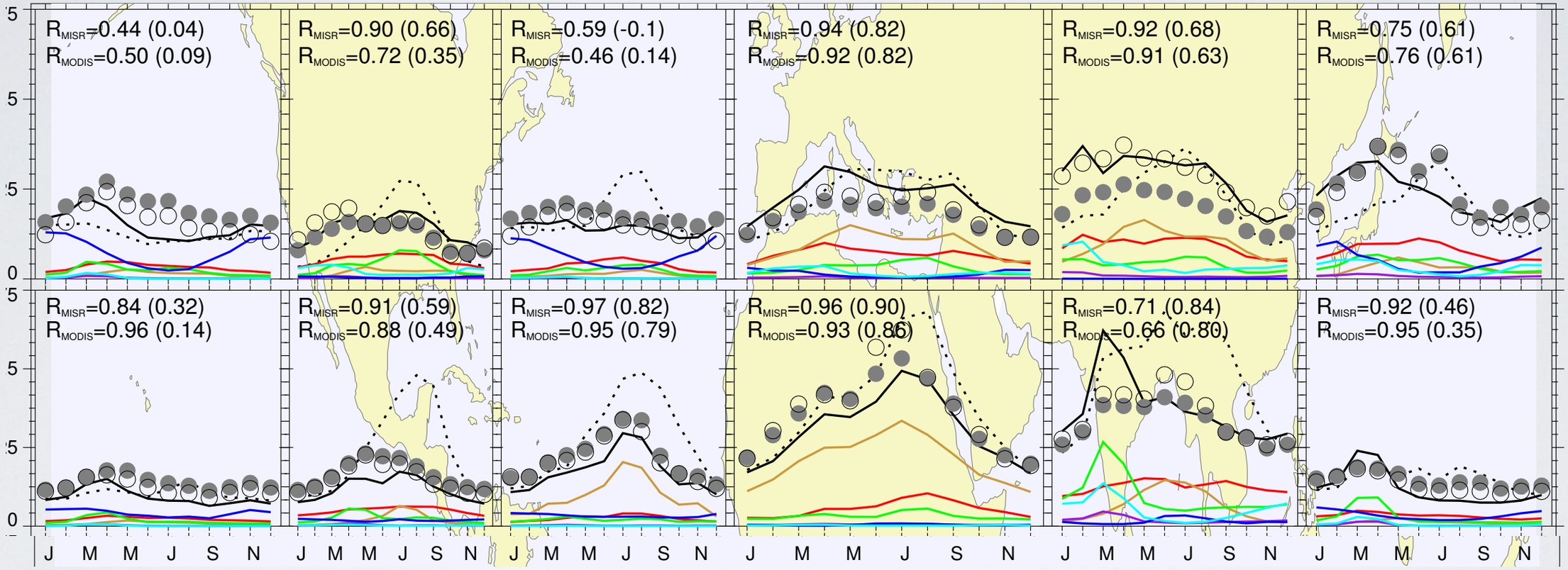
elucidate the mechanism controlling the NO_3 vertical distribution in tropical and subtropical regions

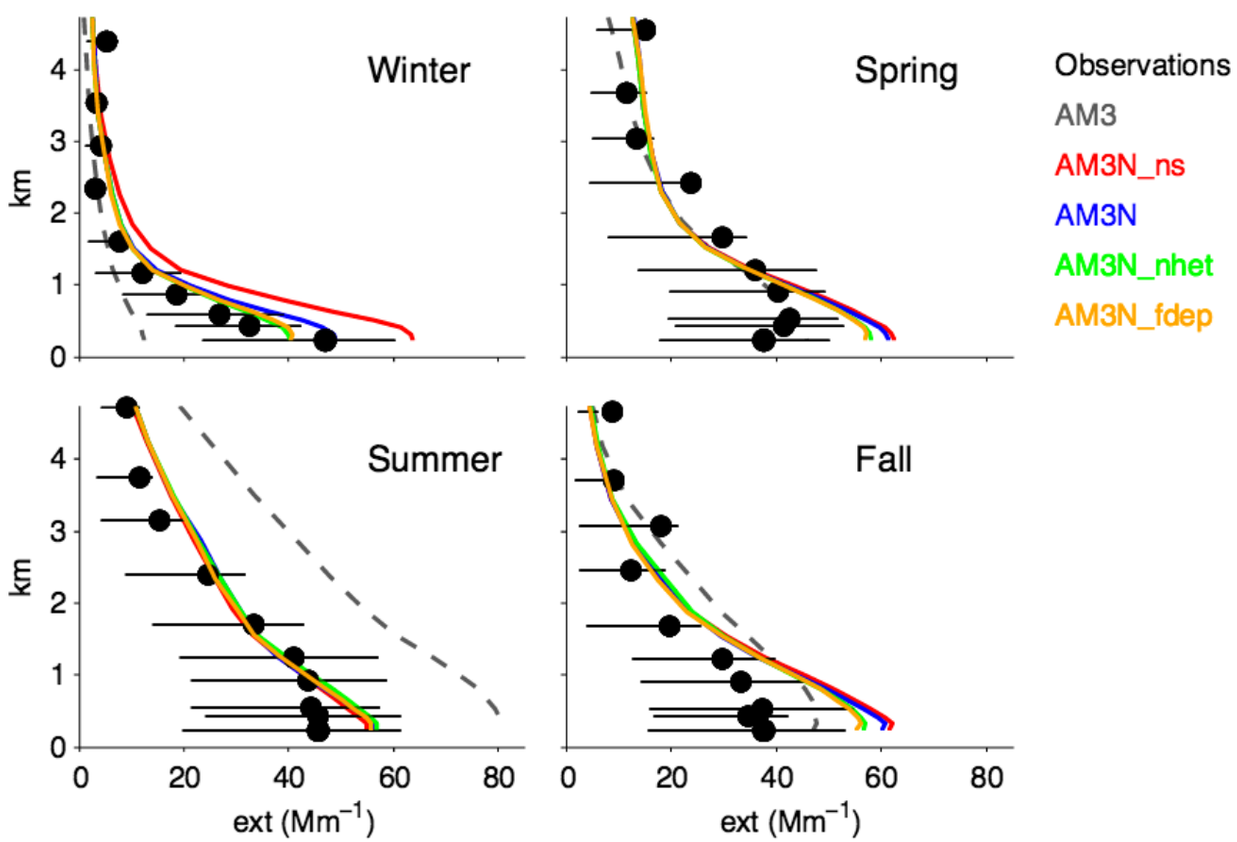
1) reduce convective removal of NH_3 (change effective Henry's constant)
2) scavenge/do not scavenge HNO_3 by snow
3) increase biomass burning emissions based on IASI (Whitburn 2015)
4) biomass burning emission at the surface/AEROCOM vertical distribution
5) turn off dust uptake of HNO_3, sensitivity to anthropogenic dust

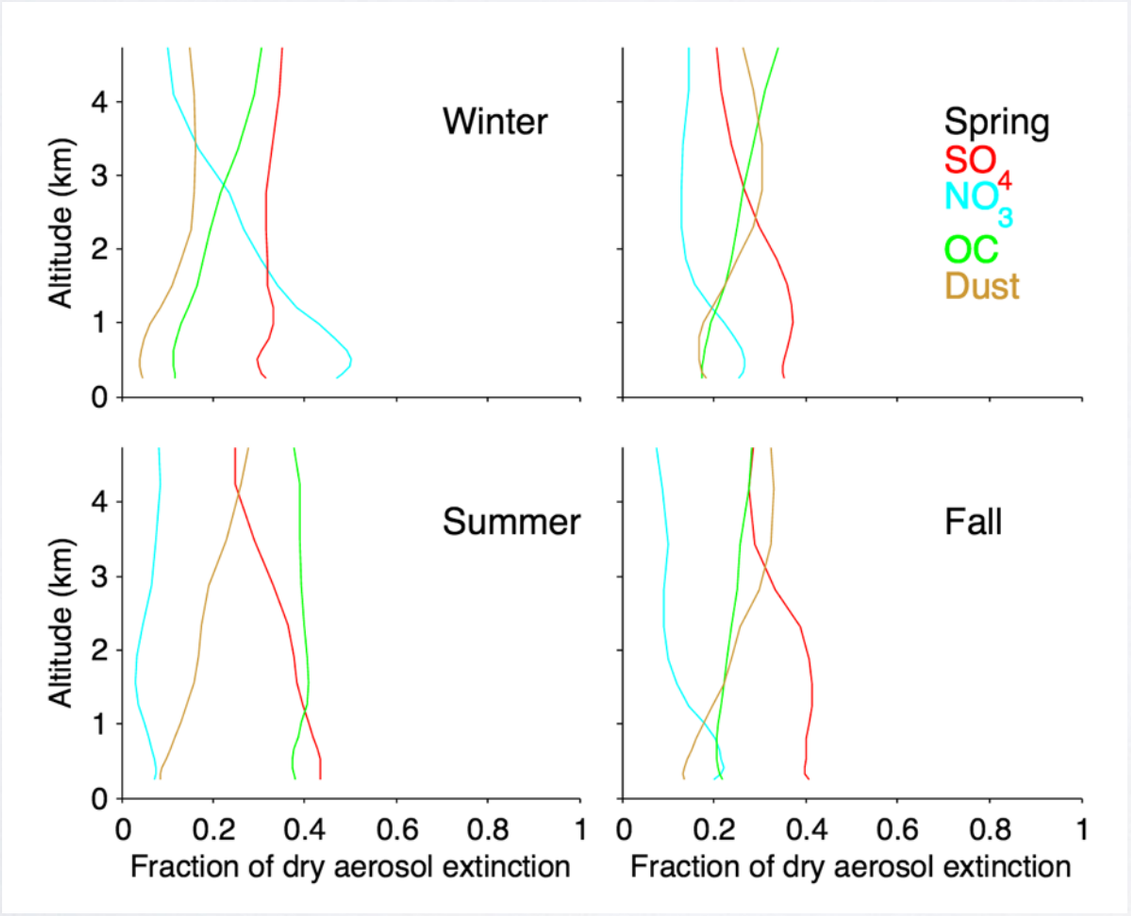
Observations (vertical profiles of NH_3, HNO_3, NO_3)?

Possible collaborations with biomass burning injection height (Val Martin)/ anthropogenic dust experiments (Ginoux)

Backup


R_MISR=0.44 (0.04)
R_MODIS=0.50 (0.09)
R_MISR=0.90 (0.66)
R_MODIS=0.72 (0.35)
R_MISR=0.59 (-0.1)
R_MODIS=0.46 (0.14)
R_MISR=0.94 (0.82)
R_MODIS=0.92 (0.82)
R_MISR=0.92 (0.68)
R_MODIS=0.91 (0.63)
R_MISR=0.75 (0.61)
R_MODIS=0.76 (0.61)
R_MISR=0.84 (0.32)
R_MODIS=0.96 (0.14)
R_MISR=0.91 (0.59)
R_MODIS=0.88 (0.49)
R_MISR=0.97 (0.82)
R_MODIS=0.95 (0.79)
R_MISR=0.96 (0.90)
R_MODIS=0.93 (0.86)
R_MISR=0.71 (0.84)
R_MODIS=0.66 (0.80)
R_MISR=0.92 (0.46)
R_MODIS=0.95 (0.35)
J M M J S N


Winter
Spring
Summer
Fall
km
ext (Mm^{-1})
Observations
AM3
AM3N_ns
AM3N
AM3N_nhet
AM3N_fdep


Winter
Spring
Summer
Fall
Altitude (km)
Fraction of dry aerosol extinction
SO_4
NO_3
OC
Dust