National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

Columbia University
In the City of New York

How the Assumed Size Distribution of Dust Minerals Affects the Predicted Ice Forming Nuclei

Jan P. Perlwitz[1,2], Ann M. Fridlind[2], Carlos Pérez García-Pando[1,2], Ron L. Miller[2,1], and Daniel A. Knopf[3]

[1] Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY, USA, Contact: jan.p.perlwitz@columbia.edu

[2] NASA Goddard Institute for Space Studies, New York, NY, USA

[3] Institute for Terrestrial and Planetary Atmospheres / School of Marine and Atmospheric Sciences, Stony Brook University, NY, USA

Stony Brook University

Motivation for the study

- New dust module in Earth System ModelE2 with prognostic mineral species (Perlwitz et al., ACP 2015a,b).
- Challenges to be addressed to achieve that.
- One big challenge came with following question:

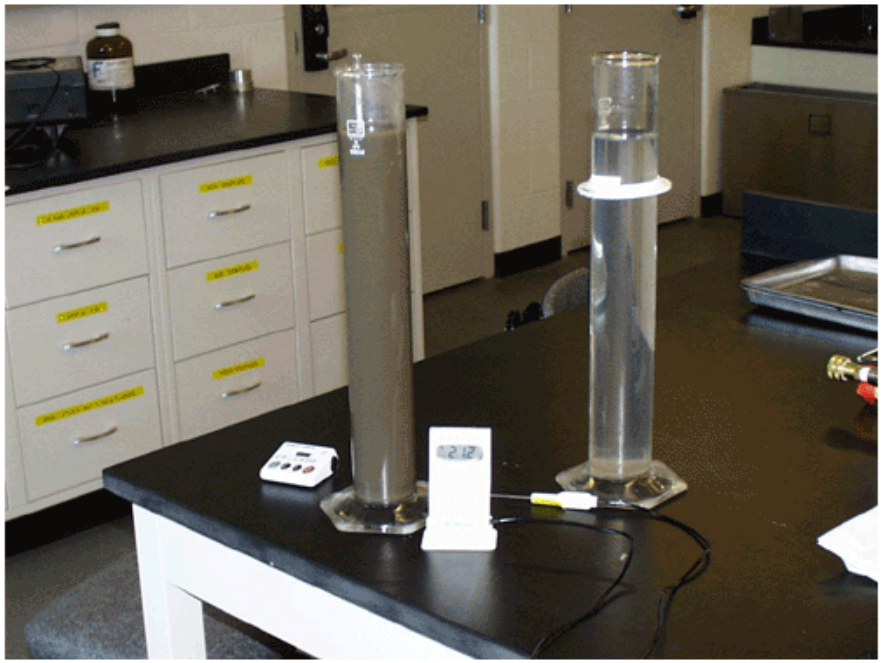
How do measured soil mineral fractions translate to the mineral fractions of the dust aerosols?

- Why is this a challenge? To a large degree because of wet sieving!
- Combining brittle fragmentation theory (Kok, PNAS 2011) with empirical mineral size distribution (Kandler et al., Tellus B 2009) to derive the mineral fractions of the emitted dust aerosol.

Soil Texture and Mineral Fractions Determined Using Techniques Leading to Nearly Full Destruction of Aggregates

Figure 5-5. Laboratory sieves for mechanical analysis of grain size distribution. Shown (right to left) are sieve Nos. 3/8-in. (9.5-mm), No. 10 (2.0-mm), No. 40 (250-µm) and No. 200 (750-µm) and example soil particle sizes including (right to left): medium gravel, fine gravel, medium-coarse sand, silt, and dry clay (kaolin).

Figure 5-6. Soil hydrometer apparatus (http://www.ce.siue.edu/).



Source: http://www.fhwa.dot.gov/engineering/geotech/pubs/05037/05a.cfm

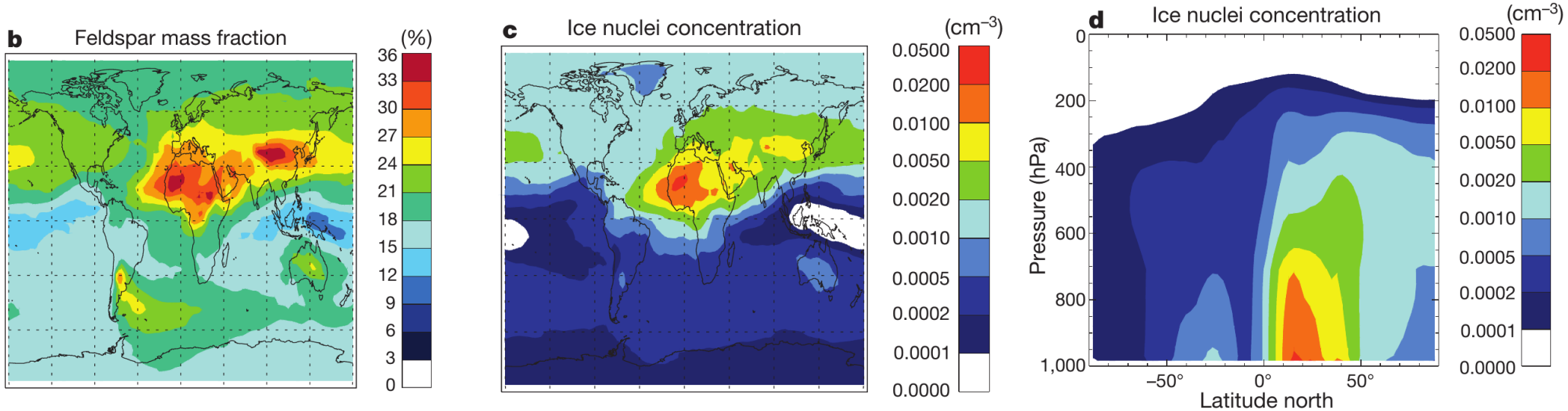
Wet Sieved Soil Texture Fractions ≠ Size Distribution of Eroded Soils

Wet Sieved Soil Texture Fractions ≠ Suspended Dust Size Distribution

Wet Sieved Clay/Silt Mineral Fractions ≠ Mineral Fractions of Suspended Dust

More motivation

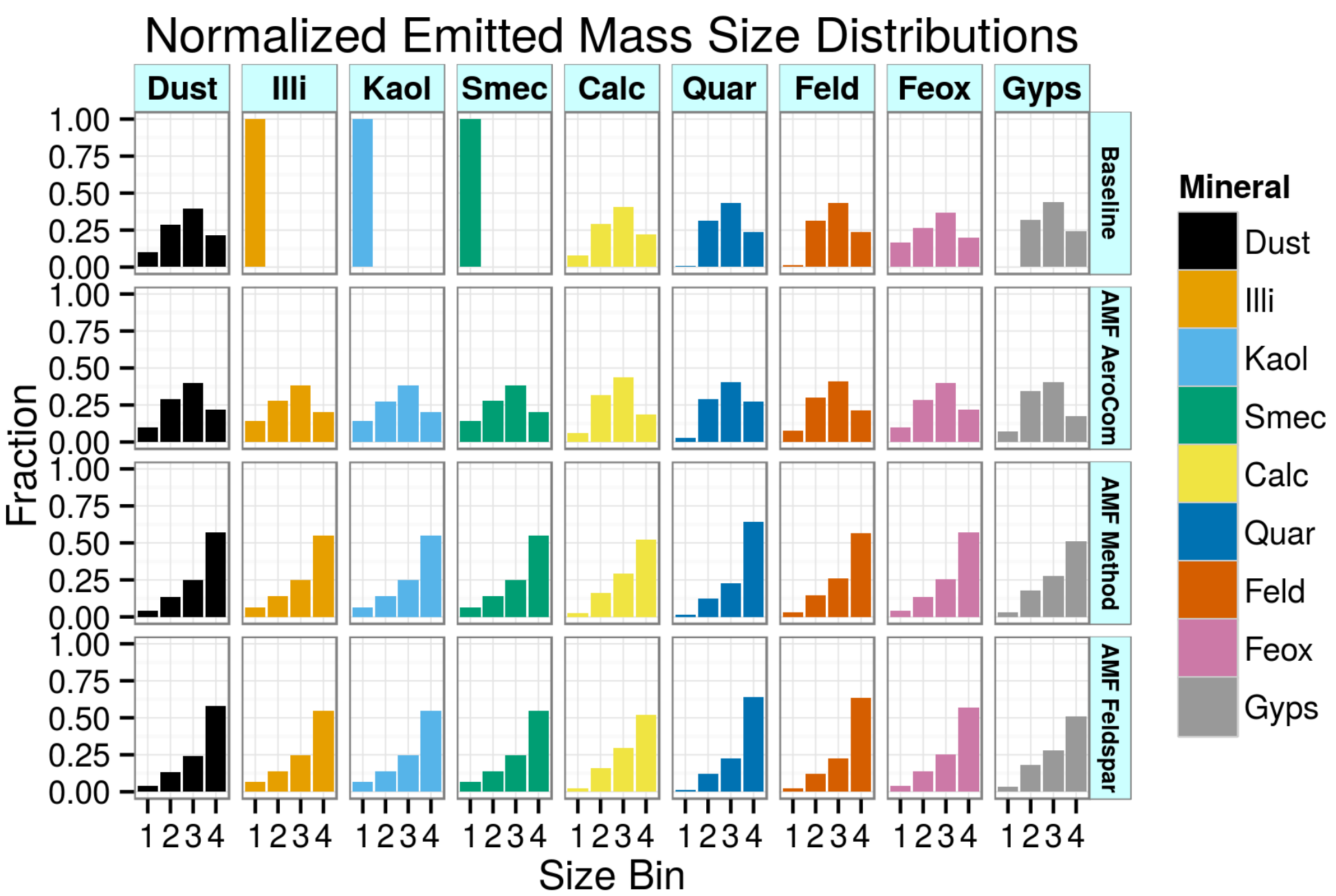
- Very few attempts to calculate ice forming nuclei (IFN) abundance from mineral species simulated with a global model.
- Kaolinite and illite/montmorillonite: Hoose et al., ERL (2008).
- Feldspar: Atkinson et al., Nature (2013)
- Approach: Using directly the mineral fractions in soils for the mineral fractions of dust aerosols



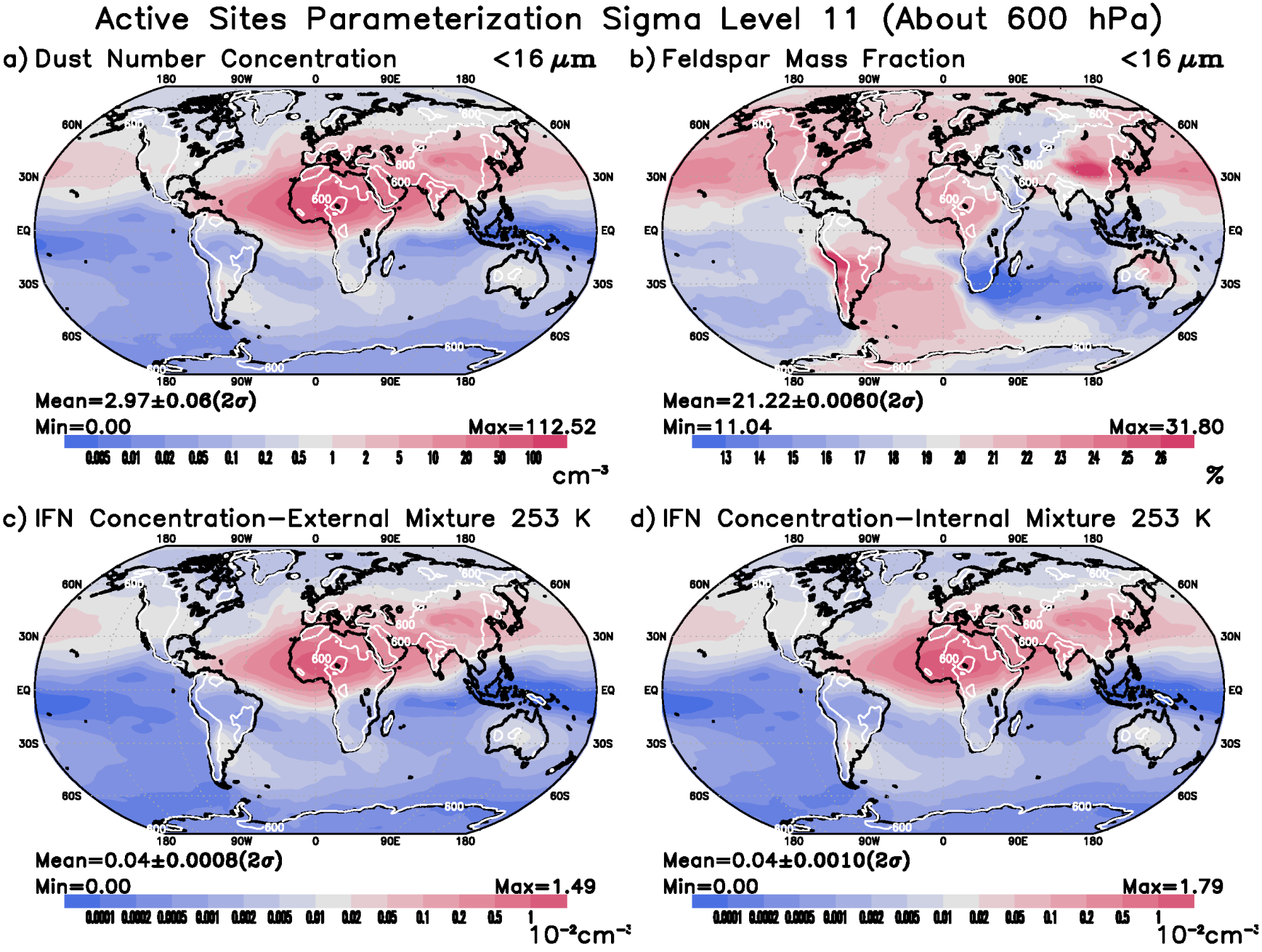
What about IFN numbers by feldspar if we use our improved dust mineral model instead?

Four experiments:

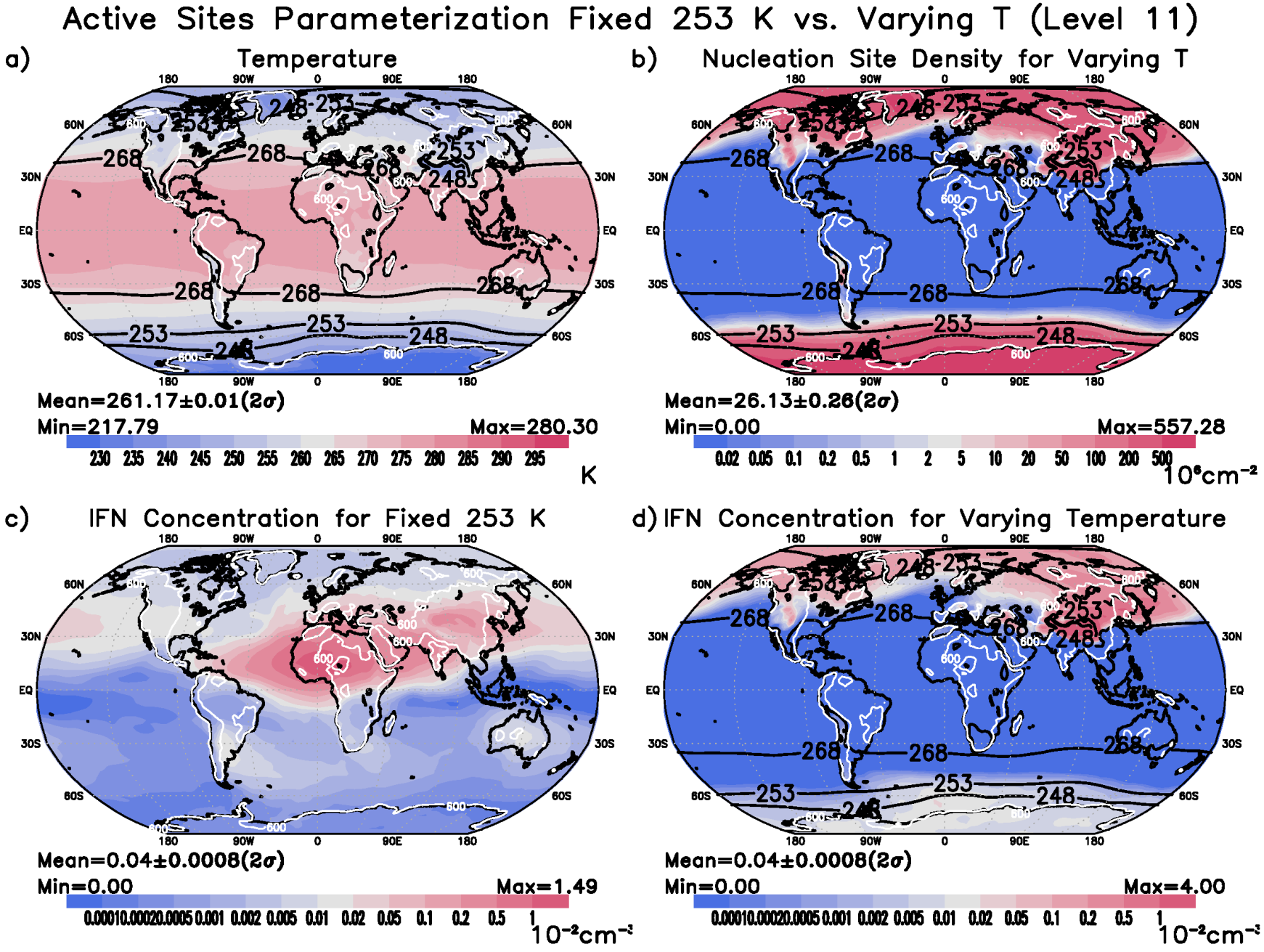
1. Baseline experiment: Same set up as by Atkinson et al. (active sites parameterization with nucleation densities at fixed temperatures), mineral fractions in soil projected onto AeroCom dust emission.
2. Aerosol mineral fraction (AMF) method: used for minerals in dust module as described in Perlwitz et al. (2015a,b).
3. AMF AeroCom: Mineral fractions from AMF method, projected onto AeroCom dust emissions.
4. AMF Feldspar: Sensitivity to a feldspar distribution that is steeper toward larger particle sizes.


Normalized Emitted Mass Size Distributions
Dust
Illi
Kaol
Smec
Calc
Quar
Feld
Feox
Gyps
Baseline
AMF AeroCom
AMF Method
AMF Feldspar
Fraction
1.00
0.75
0.50
0.25
0.00
1 2 3 4
Size Bin
Mineral
Dust
Illi
Kaol
Smec
Calc
Quar
Feld
Feox
Gyps

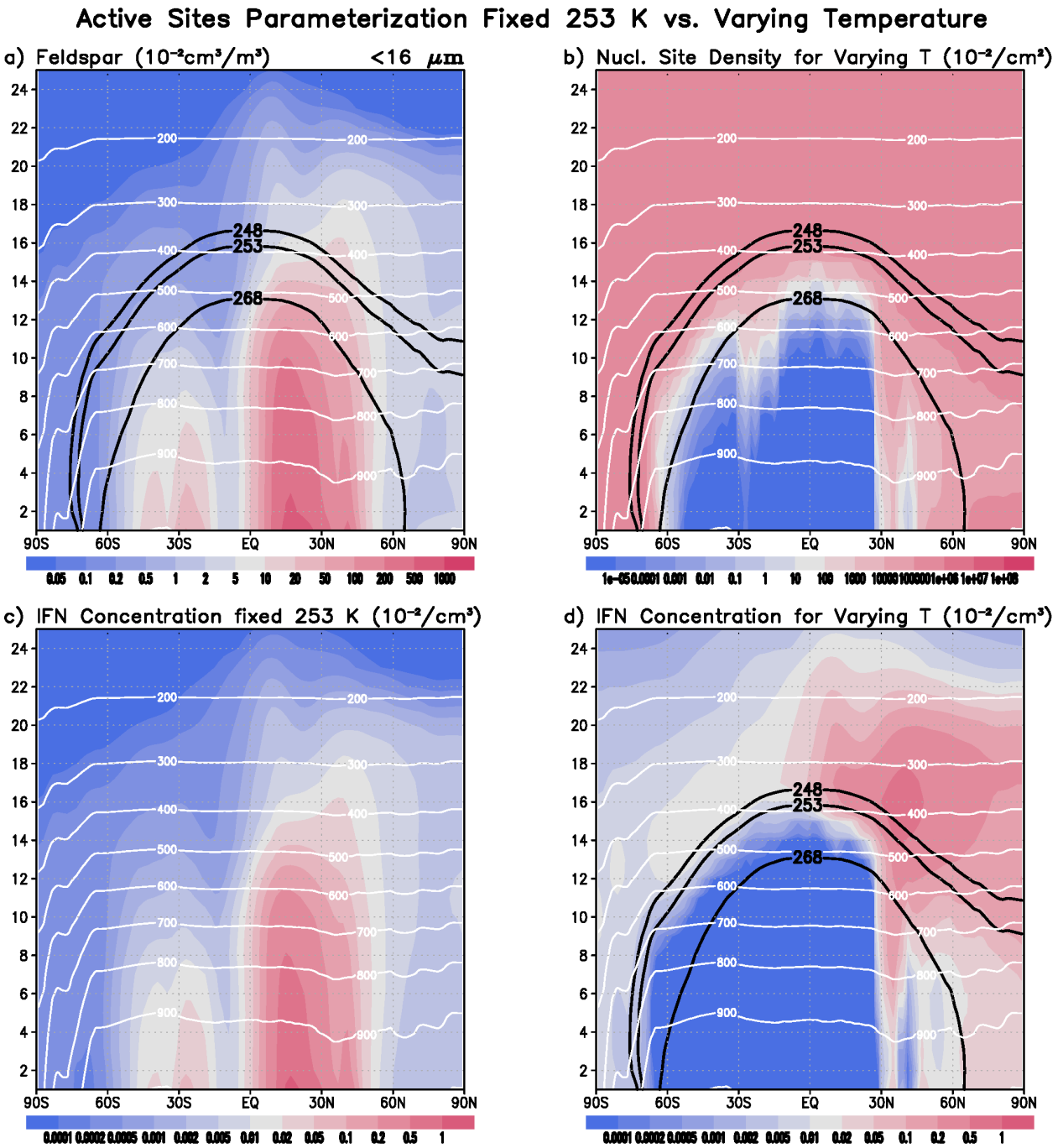
Can we reproduce the previous study?



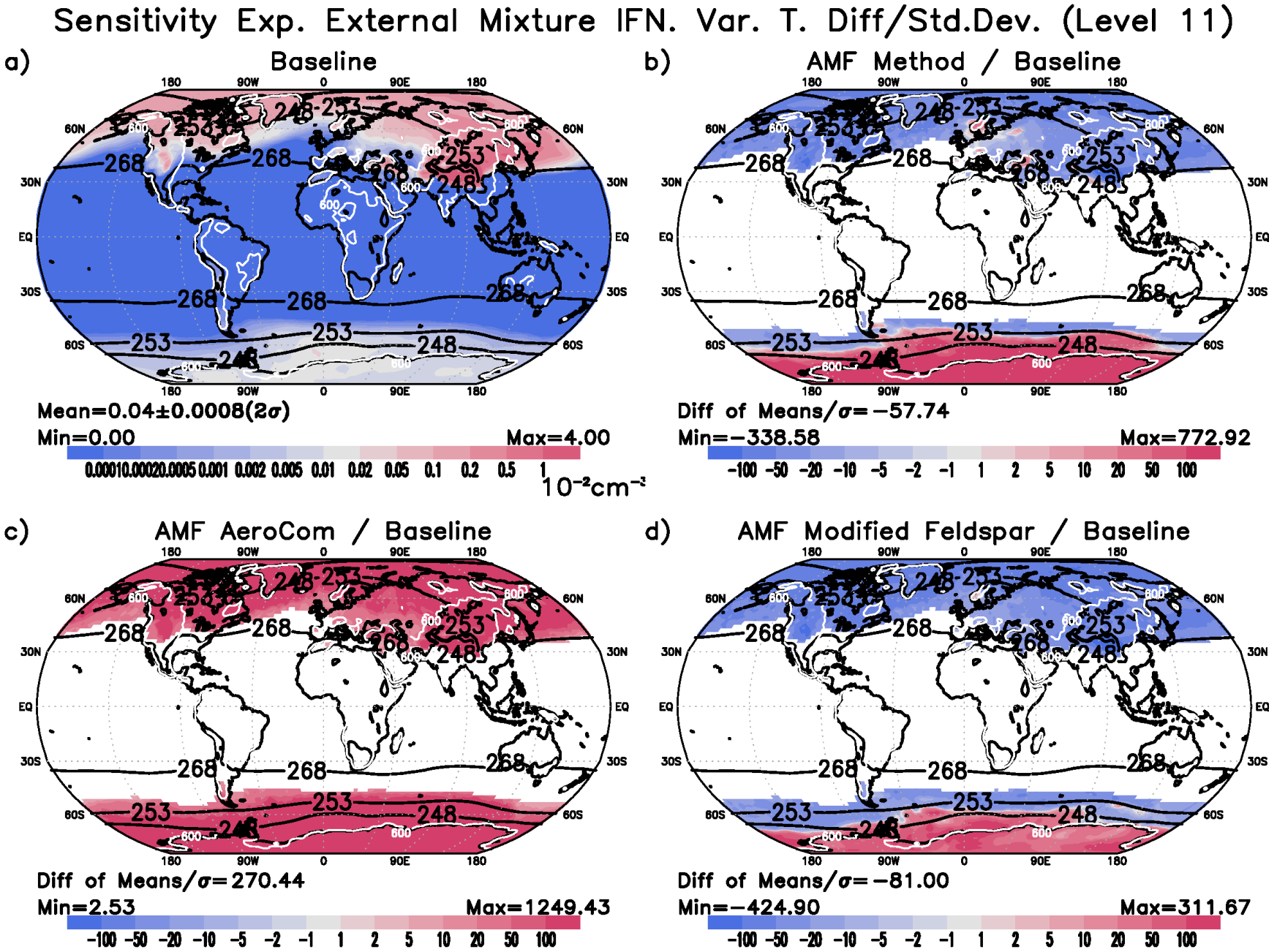
Fixed 253 K vs. more realistic temperature



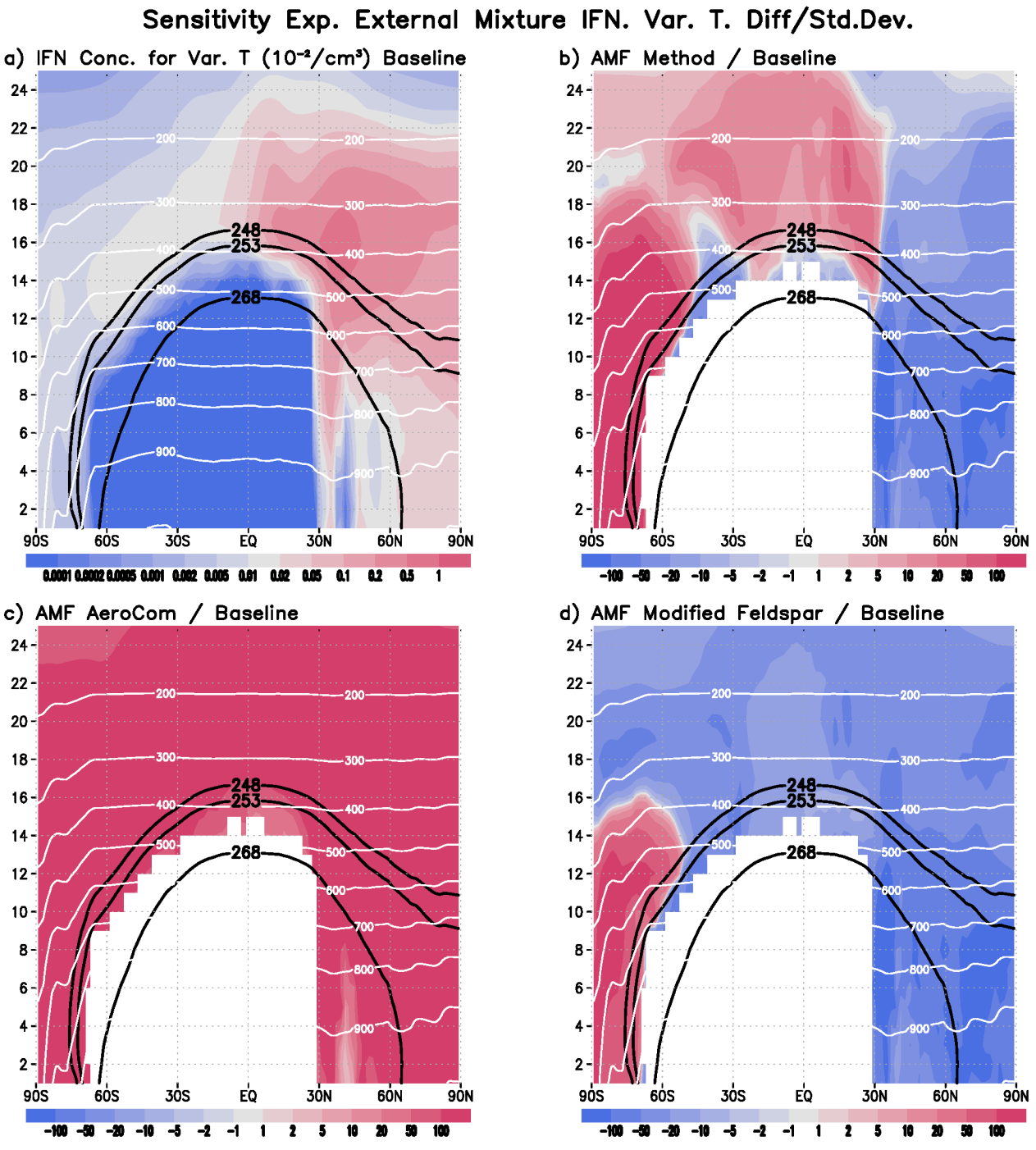
Fixed 253 K vs. more realistic temperature



Sensitivity to size distribution



Sensitivity to size distribution



Conclusions

- We can principally reproduce the IFN of the Atkinson et al. study.
- A physically more realistic temperature assumption, compared to a highly idealized one, leads to drastically different results, though. This is important for drawing correct conclusions about IFN in the atmosphere!
- Results are sensitive to the size distribution of feldspar.
- Feldspar distributed toward larger sizes decreases IFN. This is an additional source of uncertainty!
- Sensitivity to the assumption about feldspar in clay sizes.
- Preliminary results, more thorough studying needed.
- The testing of other parameterizations is also planned.