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

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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

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

Source: http://www.fhwa.dot.gov/engineering/geotech/pubs/05037/05a.cfm
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).
- 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.
Can we reproduce the previous study?
Fixed 253 K vs. more realistic temperature

Active Sites Parameterization Fixed 253 K vs. Varying T (Level 11)

a) Temperature

b) Nucleation Site Density for Varying T

Mean=261.17±0.01(2σ)
Min=217.79
Max=280.30

K

Mean=26.13±0.26(2σ)
Min=0.00
Max=557.28

10⁶ cm⁻²

c) IFN Concentration for Fixed 253 K

d) IFN Concentration for Varying Temperature

Mean=0.04±0.0008(2σ)
Min=0.00
Max=1.49

10⁻² cm⁻²

Mean=0.04±0.0008(2σ)
Min=0.00
Max=4.00

10⁻² cm⁻²
Fixed 253 K vs. more realistic temperature
Sensitivity to size distribution

Sensitivity Exp. External Mixture IFN. Var. T. Diff/Std.Dev. (Level 11)

a) Baseline

Mean = 0.04 ± 0.0008 (2σ)
Min = 0.00
Max = 4.00

b) AMF Method / Baseline

Diff of Means/σ = -57.74
Min = -338.58
Max = 772.92

c) AMF AeroCom / Baseline

Diff of Means/σ = 270.44
Min = -2.53
Max = 1249.43

d) AMF Modified Feldspar / Baseline

Diff of Means/σ = -81.00
Min = -424.90
Max = 311.67
Sensitivity to size distribution


Panel a: IFN Conc. for Var. T (10^4/cm³) Baseline

Panel b: AMF Method / Baseline

Panel c: AMF AeroCom / Baseline

Panel d: AMF Modified Feldspar / Baseline
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.