Towards investigating the effect of modeled dust mineralogy upon heterogeneous ice nucleation in mixed-phase clouds with EC-Earth

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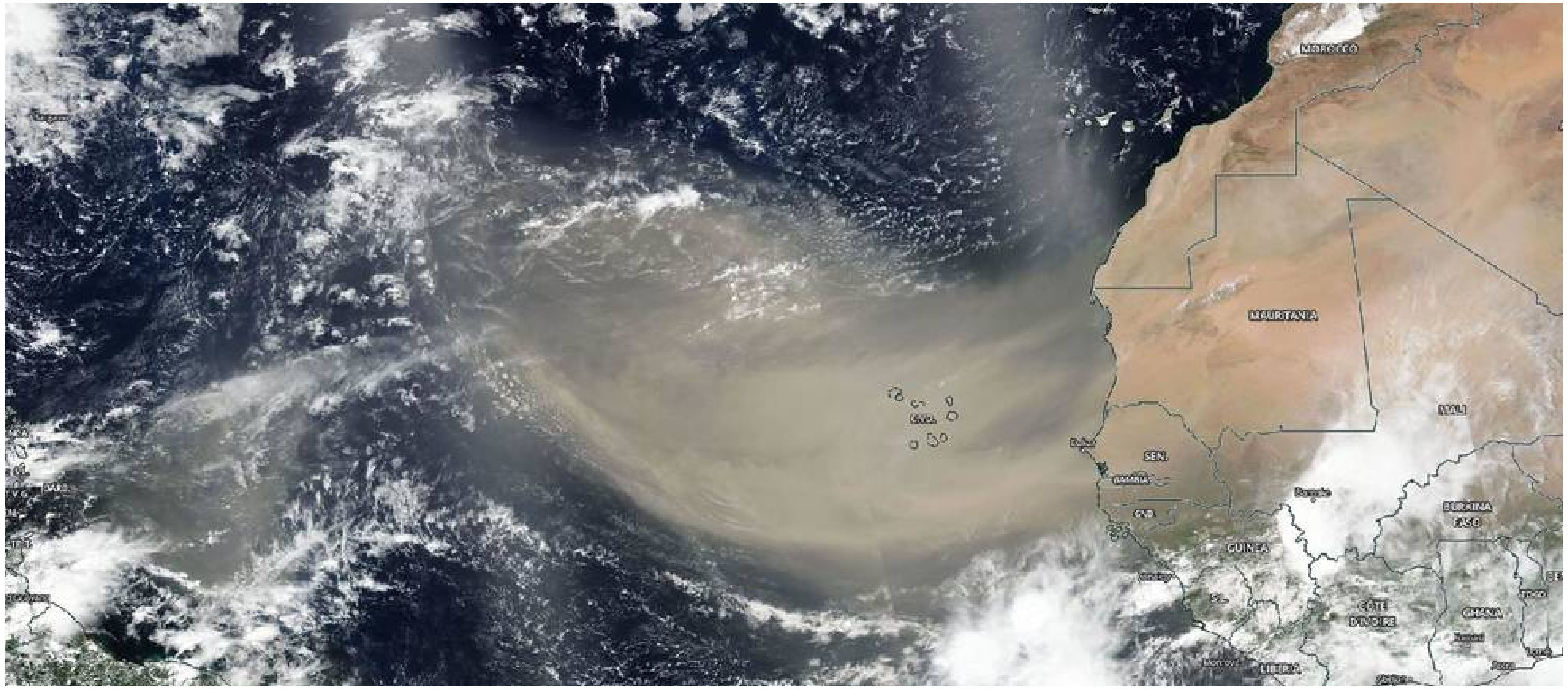
17/11/2021

Motivation

Investigate the effect of modeled dust mineralogy upon heterogeneous ice nucleation in mixed-phase clouds using EC-Earth model.

Test the hypothesis that improving IN parameterizations (e.g., with new findings from Atkinson et al., 2013; Harrison et al, 2019) will improve the MPC cloud fields produced by the model.



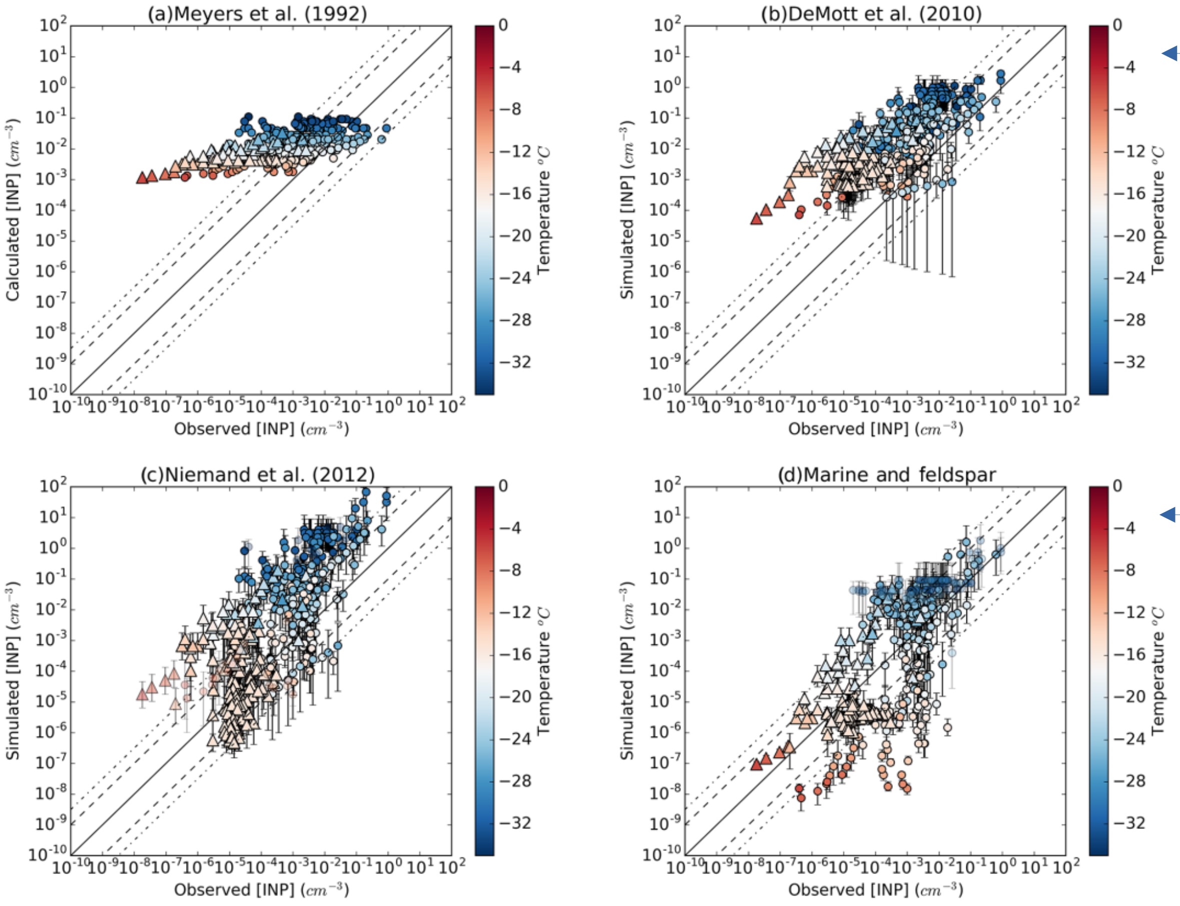
Credits: NASA Worldview

Importance of the aerosol mineralogy on ice nucleation

Comparison of the performance of a variety of INP parameterizations tested against field measurements

Depends only on the temperature (independent of aerosol properties) → poor representation

Parametrization based on desert dust aerosols → overestimation



Based in empirical evidence from atmospheric measurements to define INP concentrations → better correlation but INP overprediction

Two-species representation (mineralogy-dependent) based on feldspar (Atkinson et al., 2013) and marine organic aerosols (Wilson et al., 2015) → better representation

Vergara-Temprado et al., 2017

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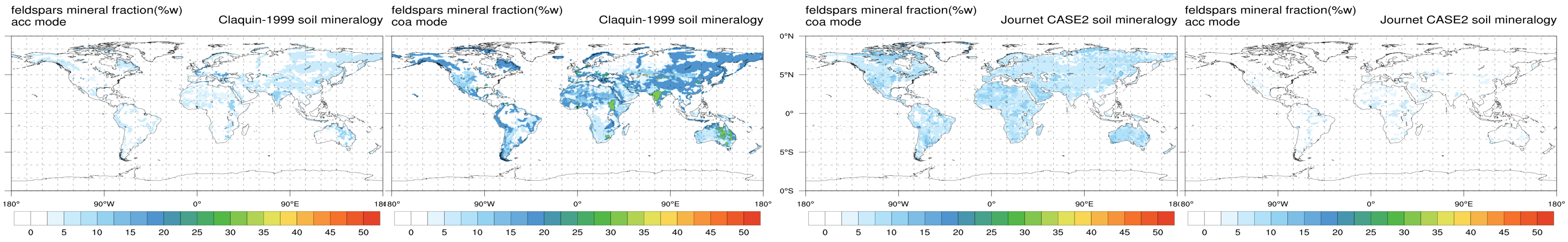
Global mineralogy datasets

We have used 2 soil mineralogy atlases to derive the emitted mineral's size distribution (i.e. mass fraction in the accumulation and coarse modes) of TM5 from dust sources. With such information we can estimate cell-dependent emissions of key minerals for ice nuclei (i.e. Feldspars and Quartz).

Claquin et al. (1999) Journet et al. (2014)



Feldspars mineral fraction in the accumulation and coarse mode at emission (Gonçalves et al.)

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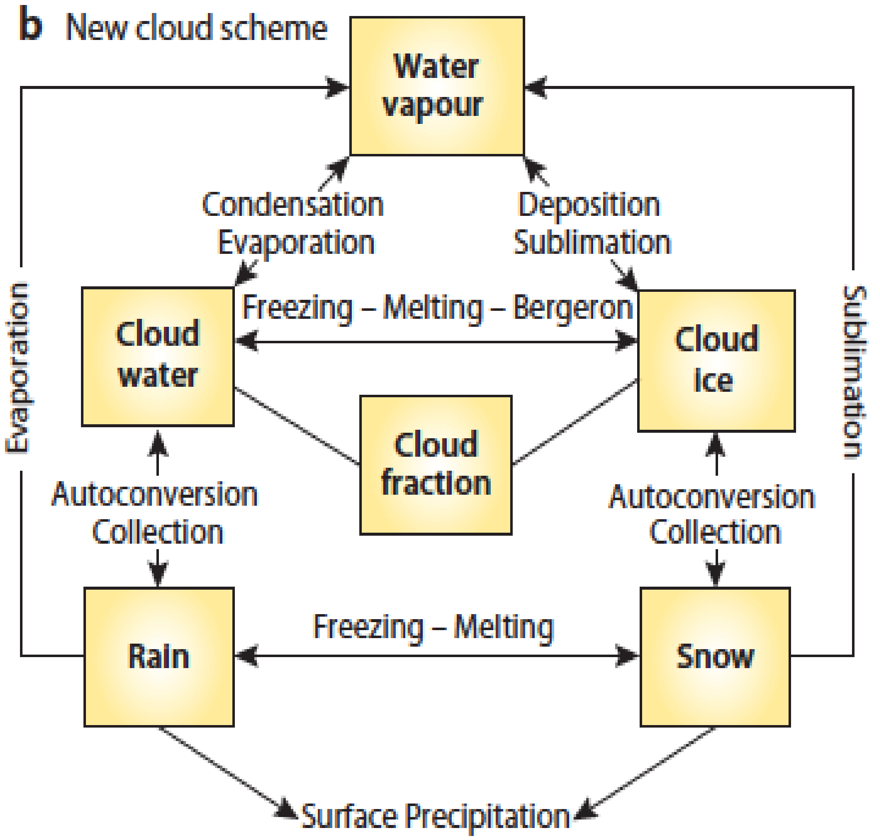
Implement aerosol mineralogy from TM5 interactively with IFS



Forbes et al., 2011

Meyers et al. (1992) deposition-condensation freezing nucleation parametrization in IFS:

$$N_i = 1000exp[12.96(e_{sl} - e_{si})/e_{si} - 0.639]$$

Bug reported in the EC-Earth dev. portal: https://dev.ec-earth.org/issues/971

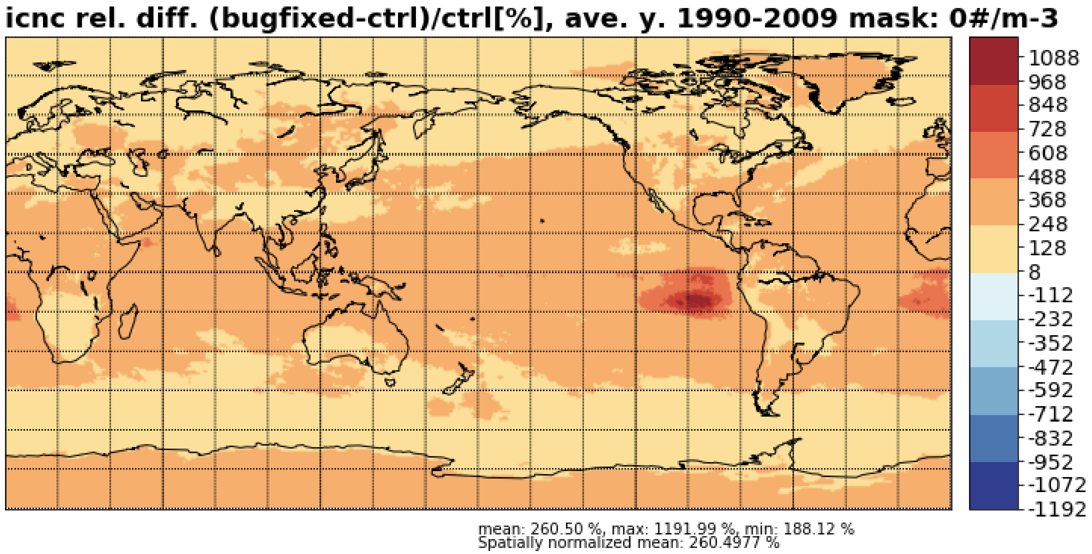
N_i: ice crystal number concentration
e_{sl}: saturation vapor pressure with respect to liquid water
e_{si}: saturation vapor pressure with respect to ice
(Considering air is at water saturation)

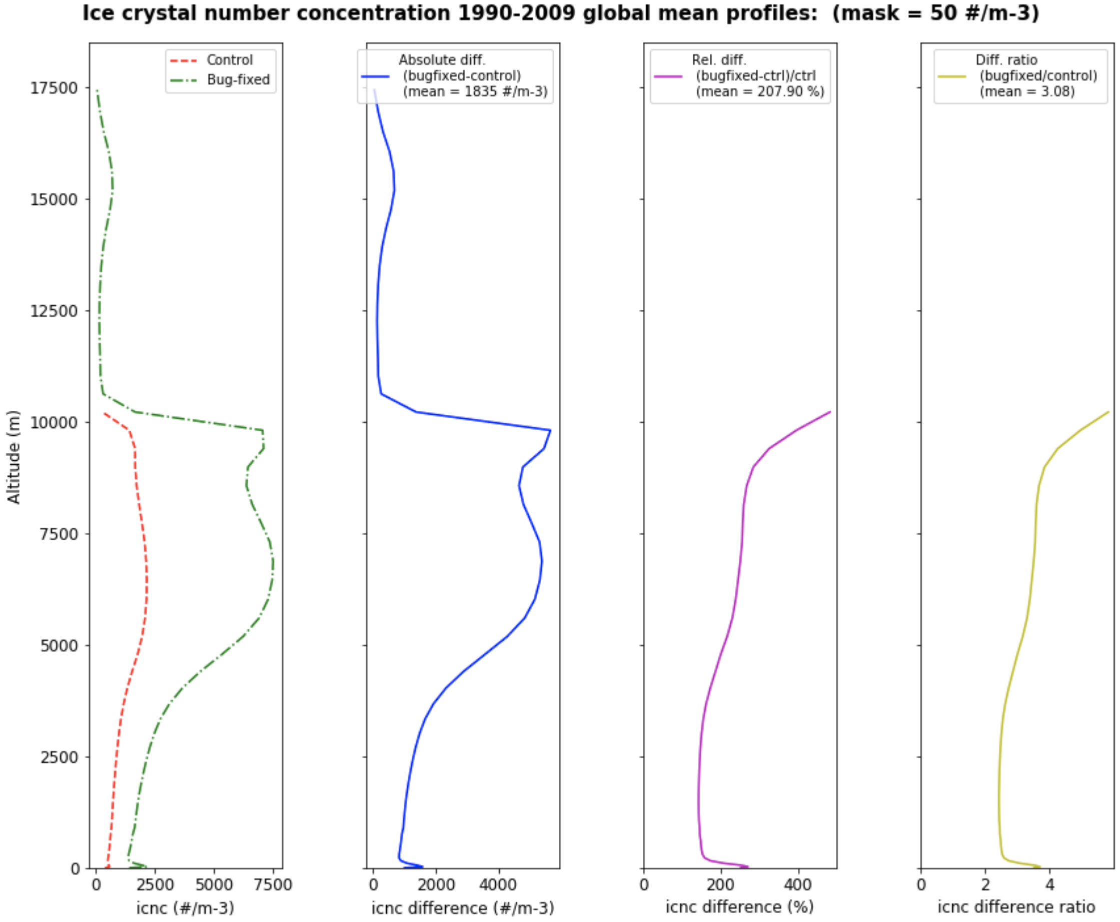
Since e_{si} < e_{sl} at the same temperature → an increase in the ice crystal number concentration is expected

Impact of correcting Meyers formula (IFS)

<u>Sensitivity tests with 20-year (1990-2009) free run experiments:</u>

- As expected, the ice crystal number concentration increase ~ 260 % 20-year global average





Impact of correcting Meyers formula (IFS)

<u>Sensitivity tests with 20-year (1990-2009) free run experiments:</u>

- global cloud cover (clt): -0.02 [-3.89, 3.20] %.

- surface downward

    LW flux (rlds): -0.0075 [-6.27, 6.64] W/m^2

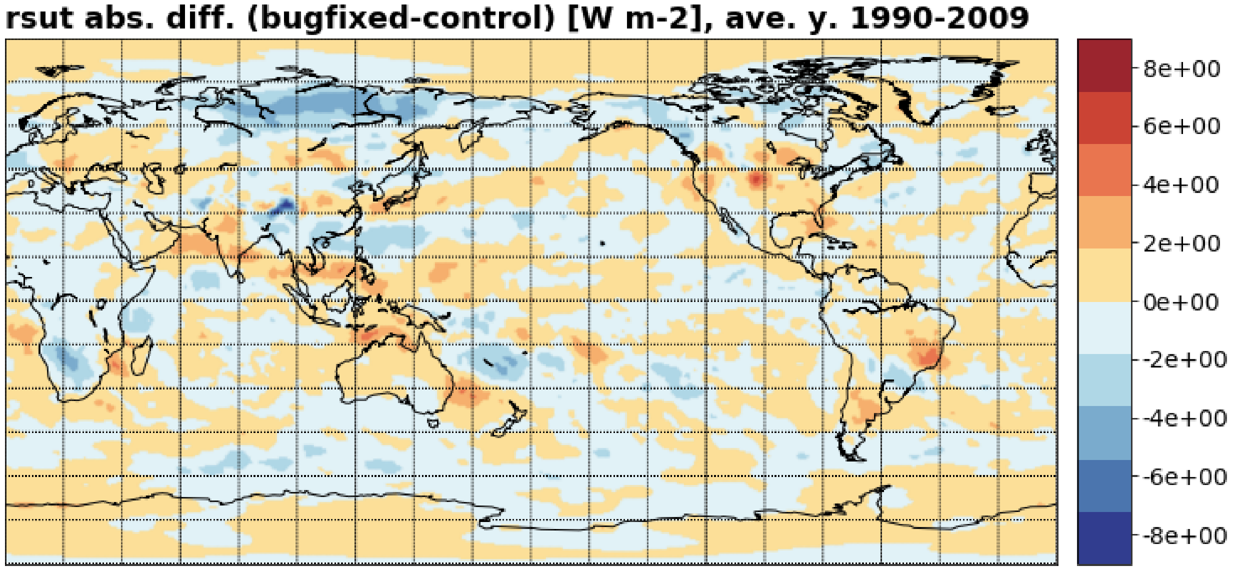
    - SW flux (rsds): 0,0312 [-7.28, 6.53] W/m^2

- TOA outgoing

    SW flux (rsut): -0.11 [-8.84, 6.19] W/m^2 →

    LW flux (rlut): 0.047 [-3.71, 4.19] W/m^2

- Near-surface air temperature (tas): 0.009 [-0.86, 1.21] K



Work in progress:

- Coupling of TM5 new mineral tracers (quartz and feldspars) with IFS (through OASIS) to implement and test if new IN parameterizations (e.g. based on Atkinson et al., 2013; Harrison et al., 2019) improve the representation of MPC.

- Validation of the IFS cloud microphysics parameterization (Meyers et al., 1992) with BACCHUS database observations (colab. with M. Chatziparaschos and Prof. Dr. M. Kanakidou (Univ. of Crete), and S. Myriokefalitakis (National Observatory of Athens)).

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