Simulating Arctic Mixed-Phase Clouds with Aerosol-Dependent Ice Nucleation and Ice Nuclei Depletion

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Arctic stratus clouds frequently consist of long-lived supercooled liquid layers which precipitate ice. Depending on the partitioning of liquid water and ice, they modify the radiation budget at ground levels [1].

In semi-idealized simulations with a cloud-resolving model, we investigate for which concentrations of ice nucleating aerosols (here: mineral dust and ice-active bacteria) a stratiform supercooled liquid cloud remains stable, i.e. maintains an approximately constant liquid water path and ice water path over several hours. For this purpose, the ice nucleation scheme in the COSMO model has been replaced by an ice nucleation active site density approach for immersion freezing [2], relating the ice nuclei number to the temperature and to the aerosol surface area based on results from laboratory experiments. In addition, depletion of ice nuclei is taken into account, assuring that only entrainment of fresh aerosol particles or further cooling of an air parcel leads to the formation of ice crystals. The model is applied to the simulation of a cloud which was observed during the ISDAC campaign [3].

The evolution of the liquid/ice partitioning in the cloud is highly sensitive to both the vertical velocity distribution, the ice crystal growth parameterization and the ice nuclei concentration. It is found that both dust and bacteria concentrations need to be several orders of magnitude higher than our initial assumptions based on typical background values to reach the transition from the growing to the glaciating state through immersion freezing.

[1] Shupe & Intrieri (2004), *J. Clim.* **17**, 616-628. [2] Niemand *et al* (2012), *J. Atmos. Sci.* **69**, 3077-3092. [3] Ovchinnikov *et al* (2012), *ISDAC LES intercomparison*, https://engineering.arm.gov/~mikhail/ISDAC_case_description.pdf.

Annual Rainfall Proxy Records from Soda-straw Stalactites

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We present a reconnaissance study of the use of soda-straw stalactites (straws) as palaeoclimate proxies. Straws are a previously under-utilised, yet potentially promising, source of such data that may provide intra-annual rainfall records of up to 1000 years, depending on growth conditions. In this contribution we investigate the structure and formation of straws and look at some issues that may affect the reliability of these records. We use laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) trace element analysis to document surface contamination features that have the potential to obscure annual trace element variations, and discuss a simple method to reveal the underlying layering. We also use LA-ICP-MS to map the two-dimensional trace element distribution in straws. This internal structure reveals broad layers with relatively higher Sr, Mg and Ba contents, compared to narrow, trace-element-poor winter layers. These layers are widest at the outside edge of the straw, narrowing and becoming almost parallel on the interior of the straw.

Based upon these observations, we present a model for the formation of visibly layered straws, where rapid degassing of CO_2 from the drip extending below the straw forms the wider outer layers. In the example presented, summers are defined by increased layer widths and higher trace element contents relative to winter layers. In palaeoclimate studies, where such annual variations can be used to construct time-lines, we suggest that, ideally, the outer-most surface of the straw be analysed where the trace element content difference is greatest and layering is widest.

We also present the trace element profile of the terminal phase of a straw, where layer widths decrease and trace element contents increase. The features described are likely representative of soda-straw responses to drought-induced decreases in percolation water, and may be used to recognise droughts from the pre-instrumental period. We also discuss initial modelling of results from another straw that records annual layers from 1996 to 1780.

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