Ice nucleating particles from a large-scale sampling network: insight into geographic and temporal variability

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Introduction

- The number concentration of ice nucleating particles (INP) is an important, yet scarcely quantified atmospheric parameter. The temporal and geographic coverage by observations worldwide remains relatively small, with many regions being almost completely unrepresented.
- Measurements at pristine sites are particularly rare, but all the more valuable because such observations are necessary to estimate the pre-industrial baseline of aerosol-and cloud-related parameters that are needed to better understand the climate system and forecast future scenarios.
- However, absolutely pristine conditions appear to be hard to find on a polluted planet, especially over the continents [A] (Fig. 1).

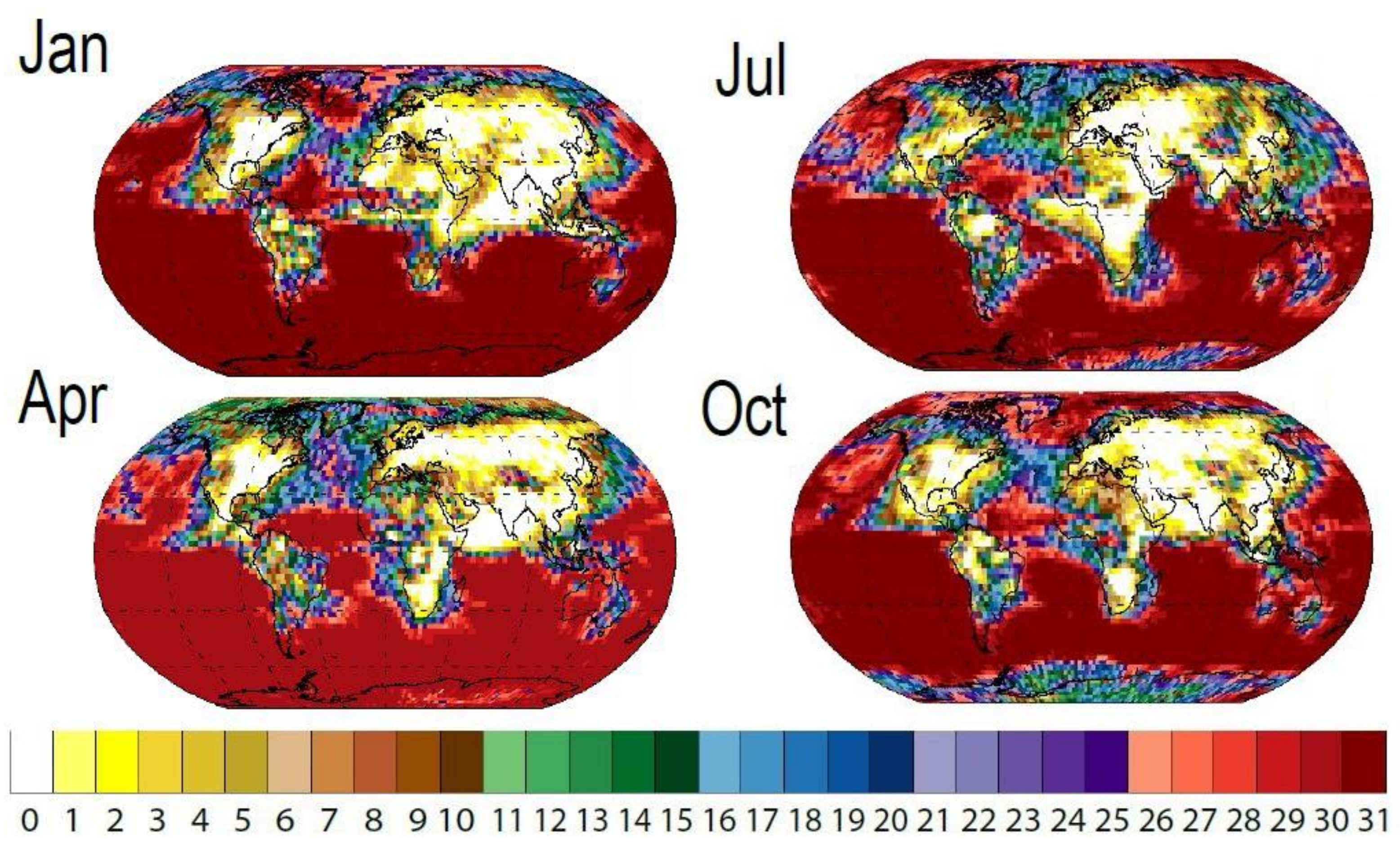

Fig. 1: Number of days per month (year 2000) with aerosol number concentrations >500nm that are within ±20% of the pre-industrial concentrations.

Method

- Aerosol samples were collected regularly on-site by electrostatic precipitation of particles onto silicon substrates.
- Samples were shipped to the laboratory for analysis.
- The INP on the substrate are activated and analyzed in the isothermal static diffusion chamber FRIDGE [B] at temperatures between -20°C and -30°C and relative humidity with respect to ice from 115 to 135%.

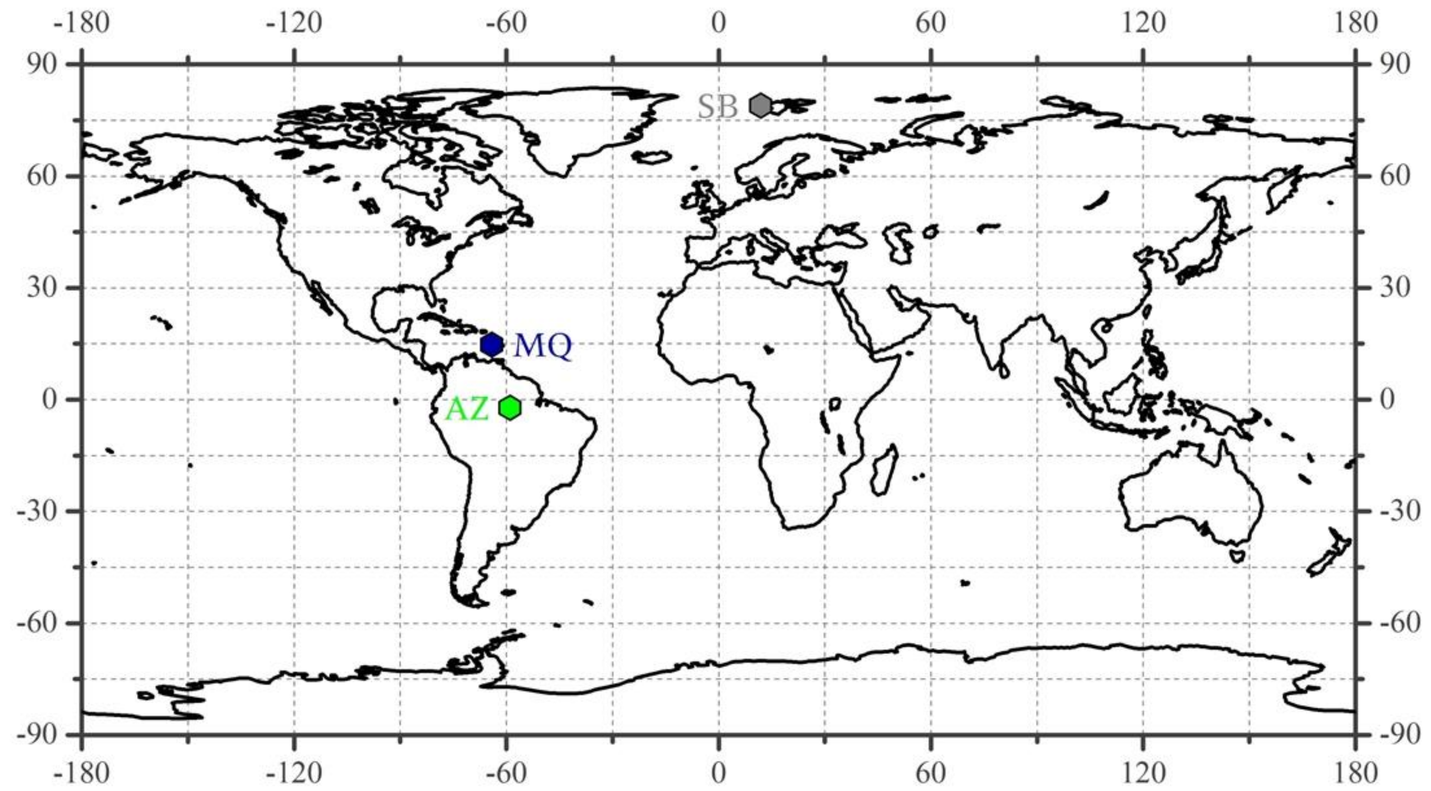

Fig. 2: Locations of the three BACCHUS sites.

INP network

- As a partner of BACCHUS we began in September 2014 to operate an INP measurement network of three sampling stations, with a global geographic distribution (Fig. 2). The stations are located at unique sites reaching from the equator to the Arctic:
  - **AZ** The Amazonian Tall Tower Observatory ATTO in Brazil
  - **MQ** The Observatoire Volcanologique et Sismologique on the island of Martinique in the Caribbean Sea
  - **SB** The Zeppelin Observatory at Svalbard in the Norwegian Arctic
- The marine sites of SB and MQ can still be considered as pristine environments for most of the year. At the continental site AZ the number of pristine days per moths is considerably more variable (Fig. 3).

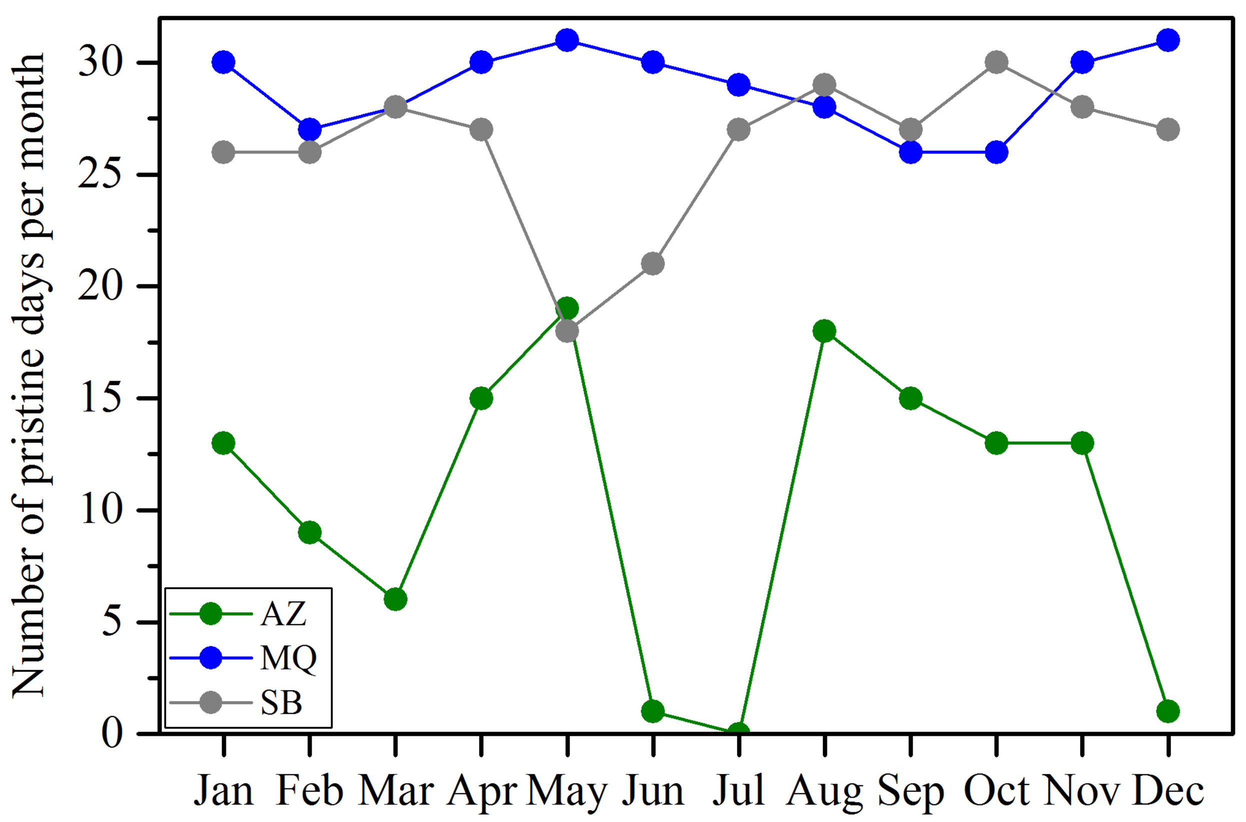

Fig. 3: Number of pristine days per month for the three sites.

Results

- Figure 4 shows the INP concentration in samples of the years 2015 and 2016 (shaded areas: samples not yet analyzed).
- On average, samples from MQ showed the highest ice activity, followed by AZ and SB (Fig. 5).
- SB samples had the fewest INP (factor 2-3 lower) and little seasonal variability (Fig. 6).
- In AZ the highest INP concentrations were found in April and March, when Saharan dust is transported to the Amazon.
- MQ concentrations peaked in summer, concomitant with the seasonal variation of transported dust [C]. INP concentrations in 2016 from MQ were a factor of 2-3 lower than from 2015.

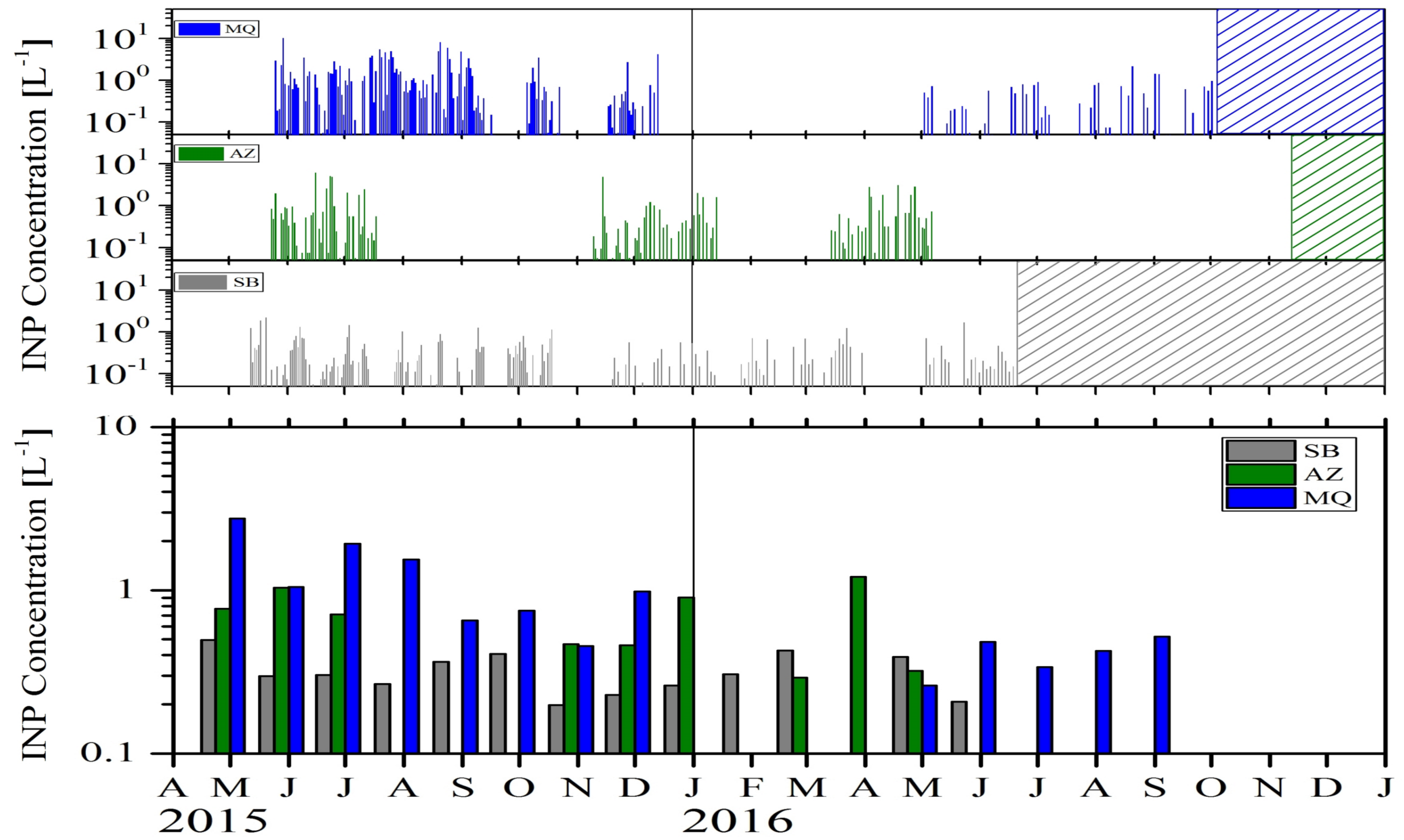

Fig. 4: Top: INP conc. ($T = -25°C$, $RH_I = 1.29$). Bottom: Monthly means.

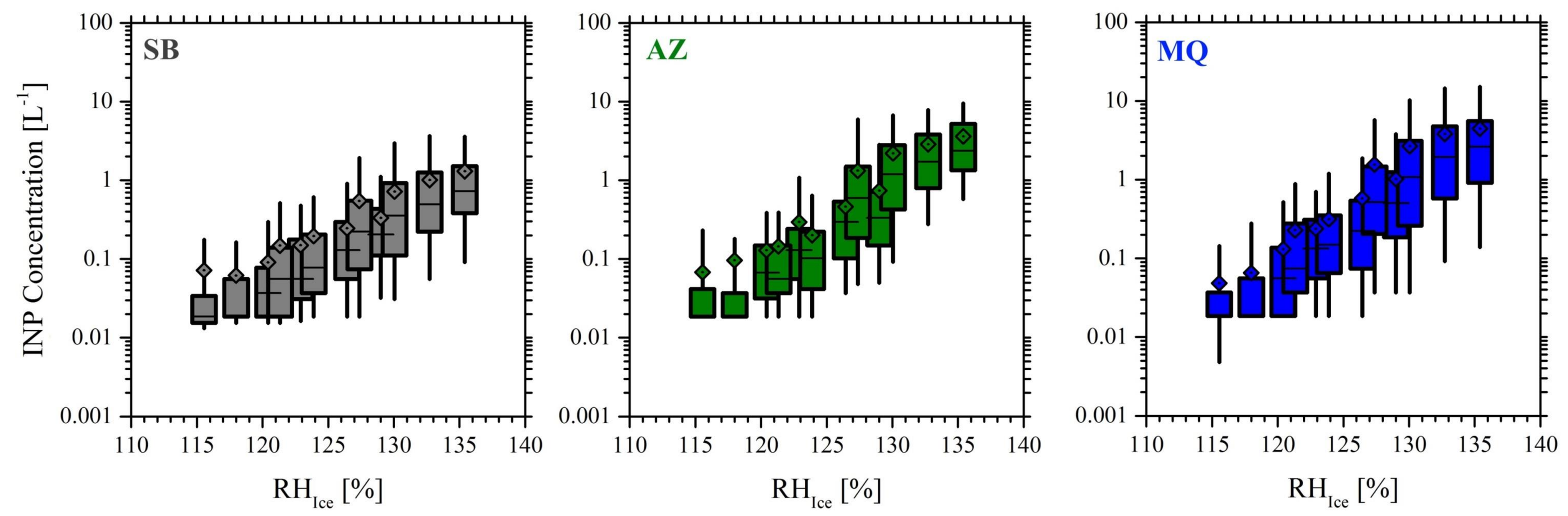

Fig. 5: Average INP concentration vs. supersaturation.

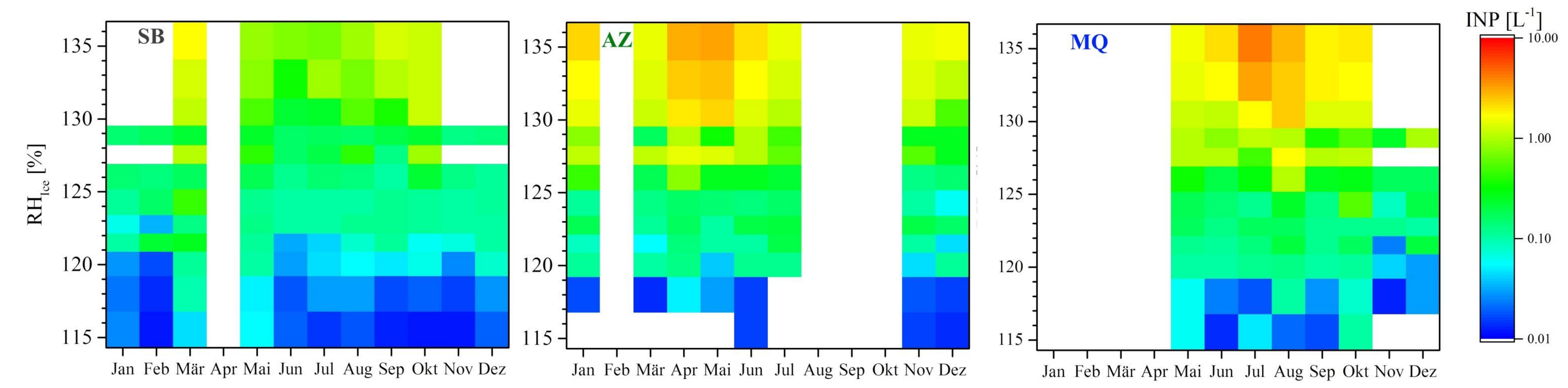

Fig. 6: Seasonal variation of INP conc.

References

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[C] Prospero, Joseph M.: Characterizing the temporal and spatial variability of African dust over the Atlantic, PAGES Magazine articles, 22, 2, 68–69, 2014.

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