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Investigation of aerosol-cloud interactions near the North Pole

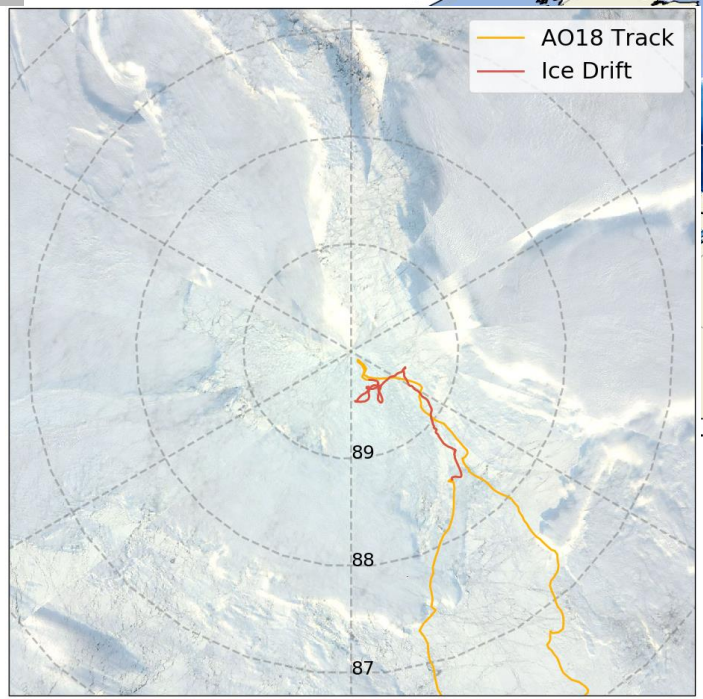
21st May 2019, Frontiers in Energy Research

1 PAUL SCHERRER INSTITUT PSI

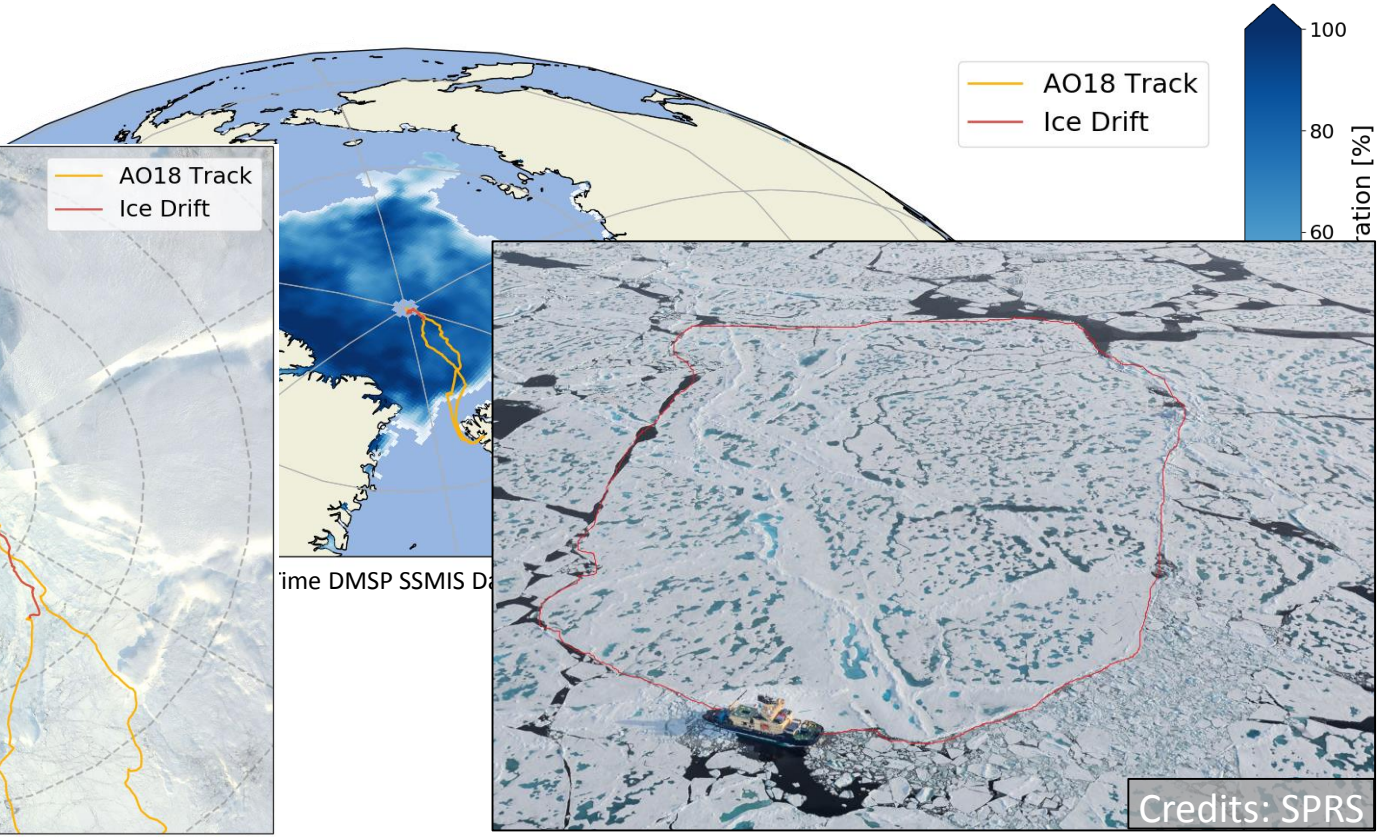
2 Stockholm University

3 DALHOUSIE UNIVERSITY

Arctic Ocean 2018 - Overview



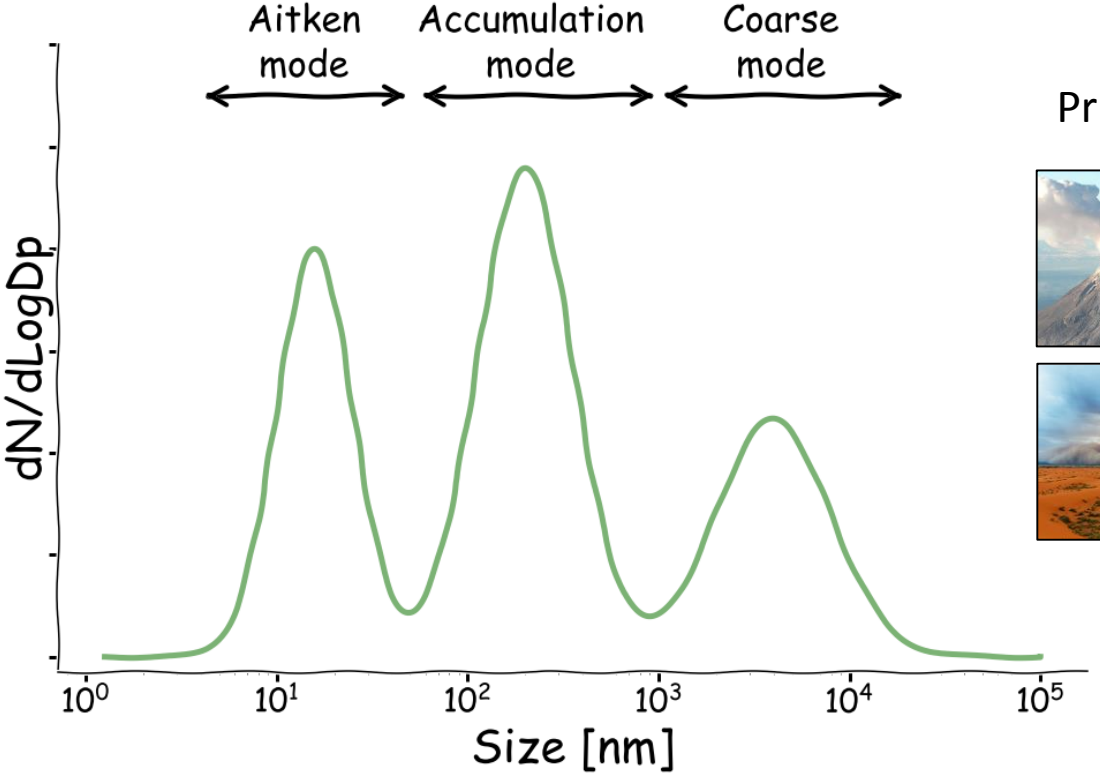
Corrected reflectance image from MODIS Terra



Aerosol particles

Aerosol are a *suspension of fine solid or liquid particles in a gas, that range in size from a few nanometer to several micrometers in diameter.* [Senfeld and Pandis 2016]

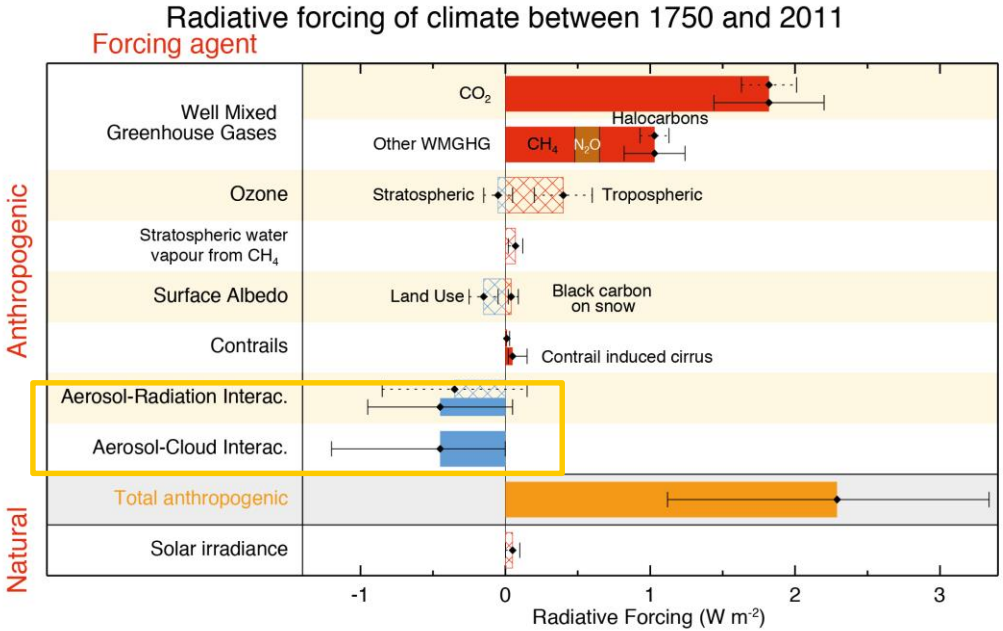
Secondary sources

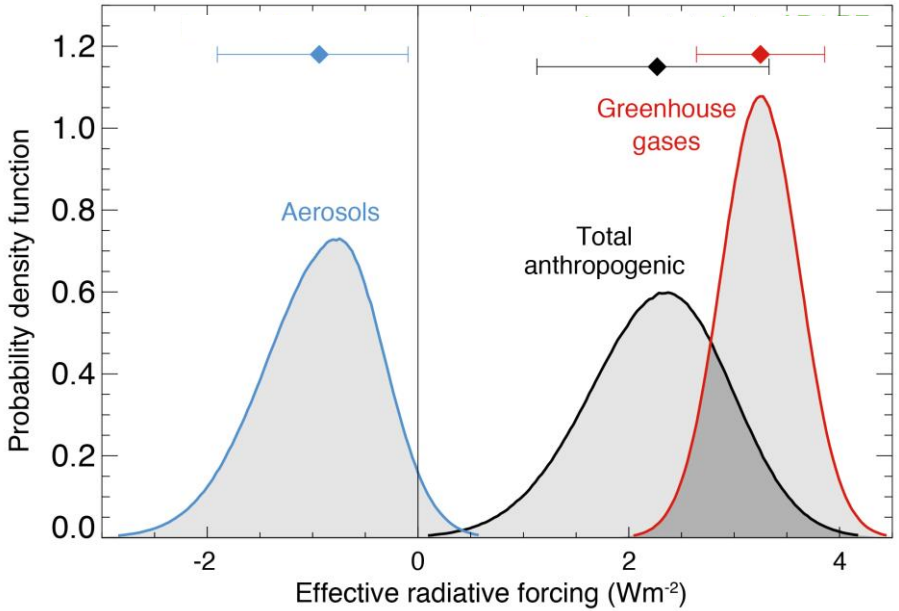


Primary sources

Aerosol and climate

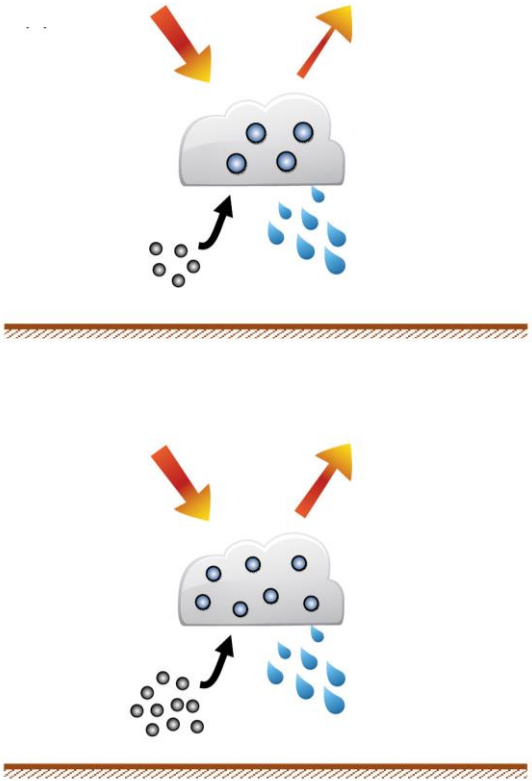
Intergovernmental Panel on Climate Change, IPCC 2013





Aerosol account for the **largest uncertainty** among all the climate forcing agents.

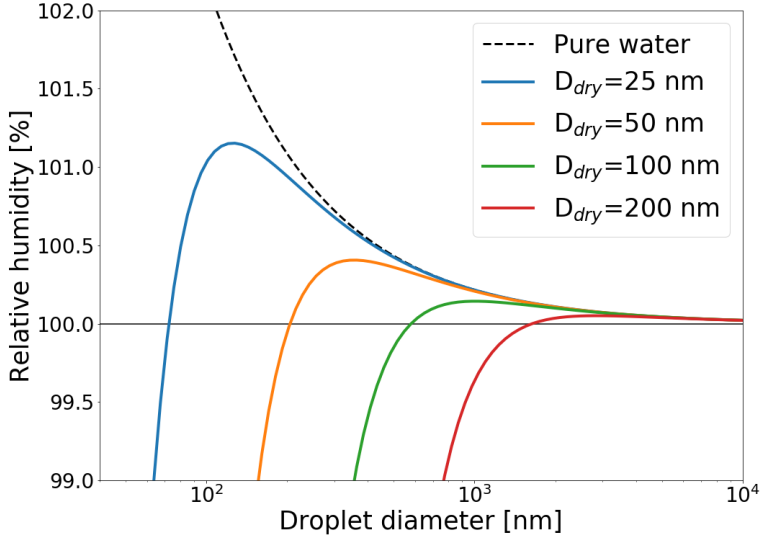
Aerosol-cloud interactions



IPCC 2013

Aerosols serve as **cloud condensation nuclei (CCN)** upon which liquid droplets can form.

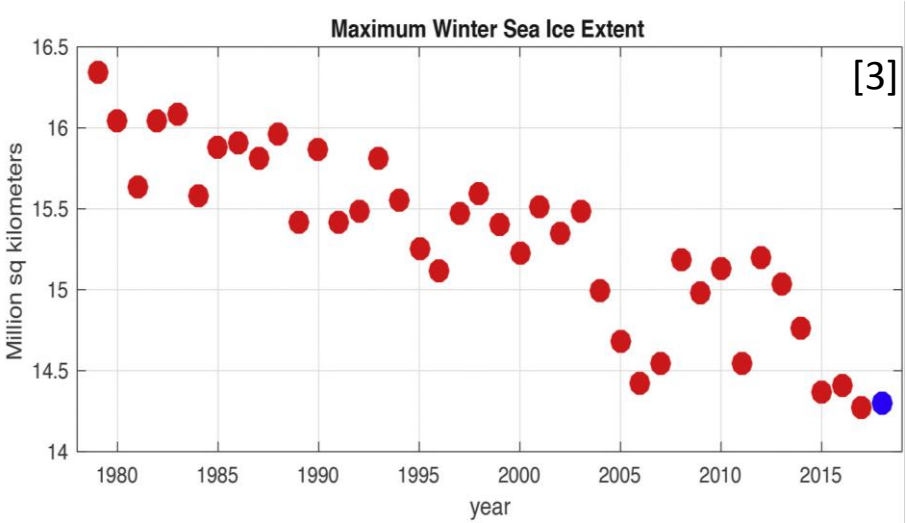
More CCNs leads to the formation of more and smaller droplets that make clouds brighter (Twomey effect).



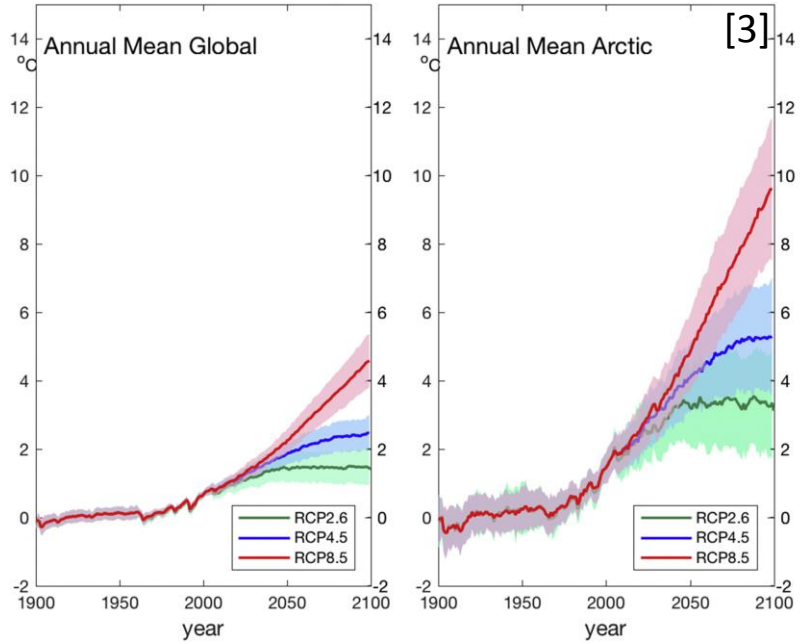
Size and chemical composition determine aerosol activation properties

Arctic amplification

The Arctic is warming twice as fast as the global average (**Arctic amplification**)[1] and the Sea Ice coverage is constantly decreasing. [2]



Projections of annual mean surface air temperatures



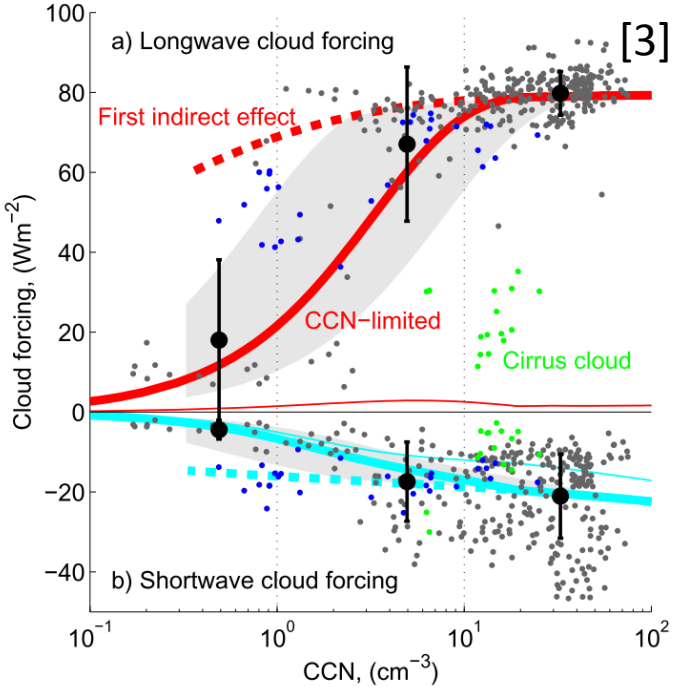
[1] Serreze, M. C. & Barry, R. G. (2011)
[2] Screen, J. A. & Simmonds, I. (2010)
[3] Overland J. et al. (2018)

Arctic Clouds

Arctic clouds have a **net warming effect on the surface**[1] and influence Arctic sea ice extent and thickness.[2]

In the Central Arctic Ocean aerosol concentration are often so low that clouds are limited by the availability of CCNs (**CCN limited regime**).[3]

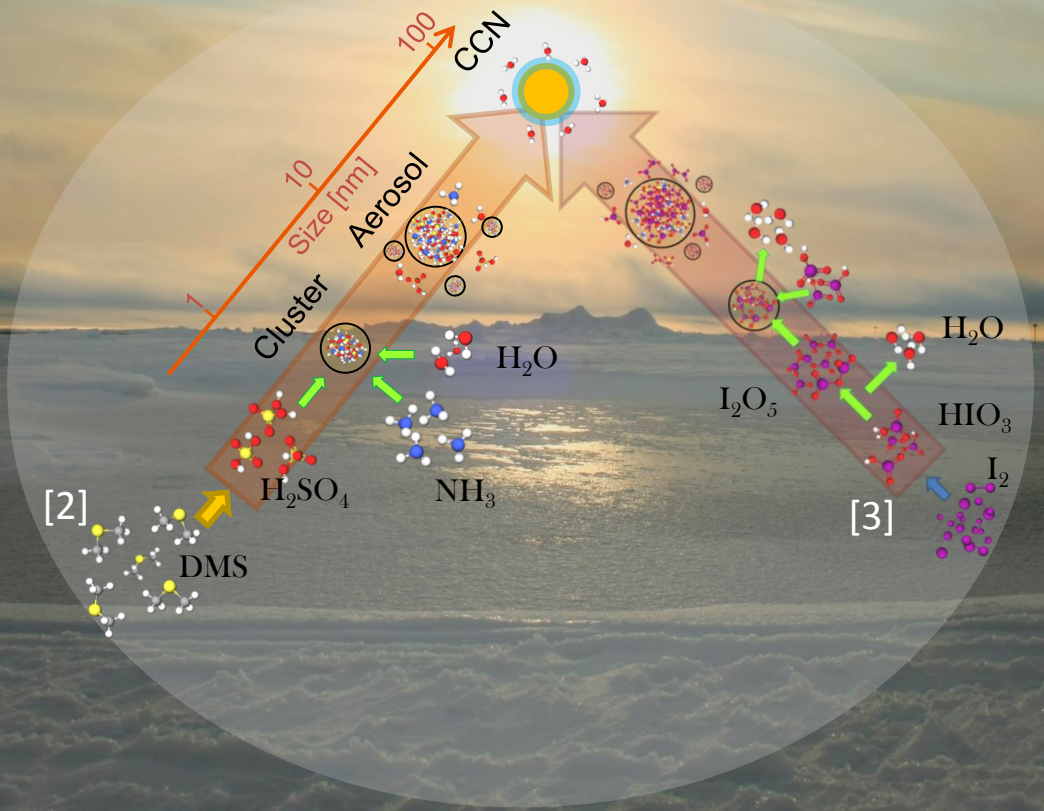
Numerical models fail in representing Arctic clouds,[4] largely because we are lacking a proper understanding of **aerosol sources and processes**.[5]



[1] Intrieri, J. M., et al. (2002) [2] Kapsch, M. L., et al. (2016) [3] Mauritsen T., et al. (2011) [4] Tjernström M., et al. (2008) [5] Sotiropoulou G., et al. (2015)

New particle formation mechanism(s)

Models estimate that 38-66% of the CCN by number are coming from NPF [1]



[1] Gordon H. et al. 2017

[2] Kirkby J. et al 2011

[3] Sipilä M. et al 2016

Research questions

1. What are the **properties of CCNs** in low level clouds or fog in the High Arctic?
2. What are the **main sources** of CCN in the High Arctic? How important are **local sources** compared to **long-range** transported aerosols?
3. How are **new particles** formed and are they a source of CCN in the High Arctic?

Arctic Ocean 2018 - Overview

Some numbers:

23 crew members 41 scientists

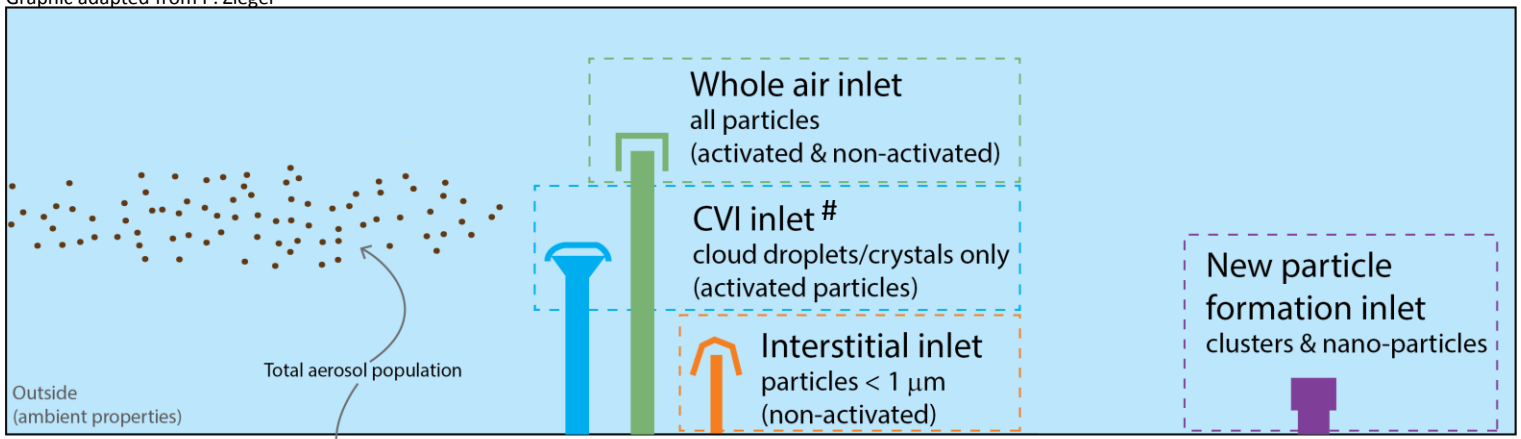
10 SPRS* staff 14 scientific projects

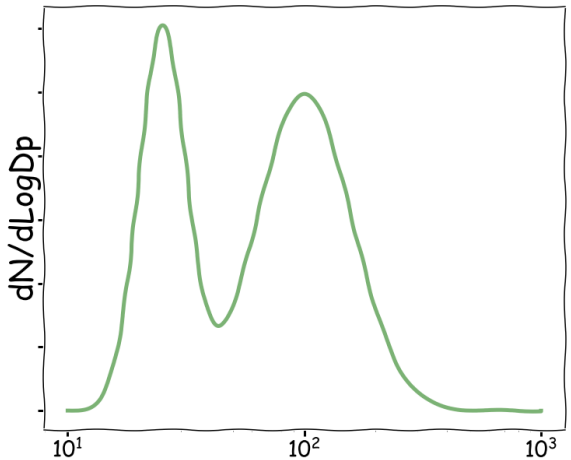
Credits:
Mario Hoppmann

*SPRS=Swedish Polar Research Secretariat

MOCCHA* – Experimental Setup

Graphic adapted from P. Zieger



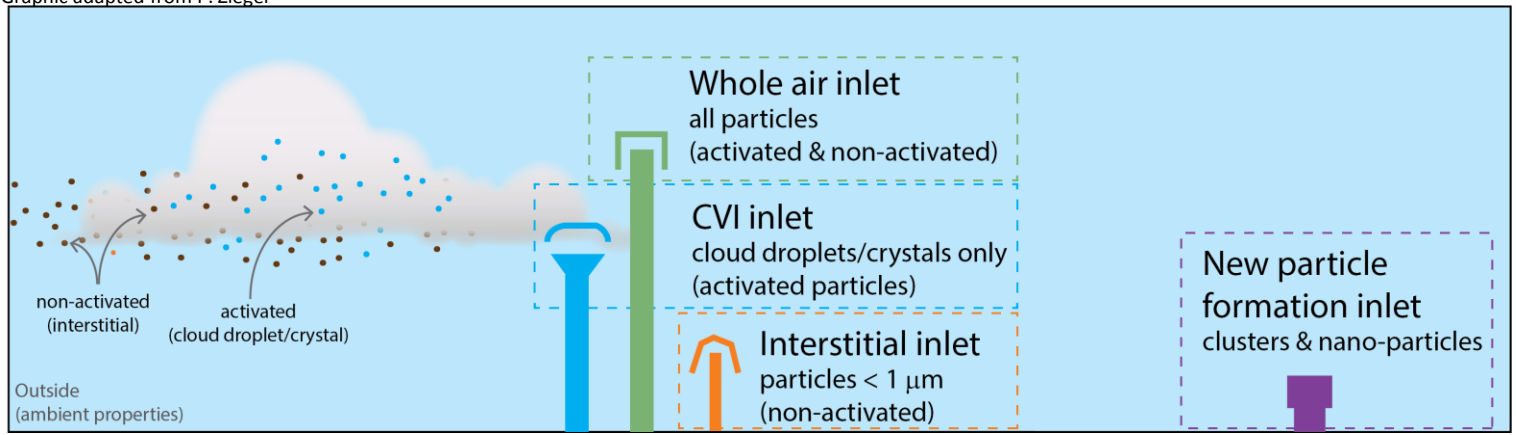


CVI: Counterflow virtual impactor, aka cloud hoover

*MOCCHA:
Microbiology-Ocean-Cloud-Coupling in the High Arctic

MOCCHA – Experimental Setup

Graphic adapted from P. Zieger



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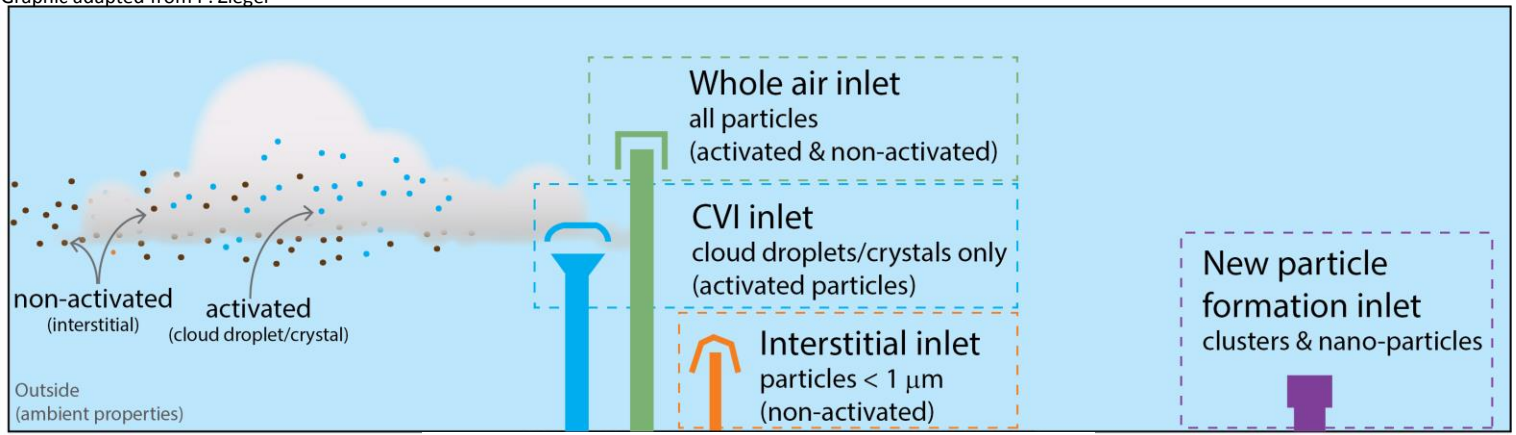

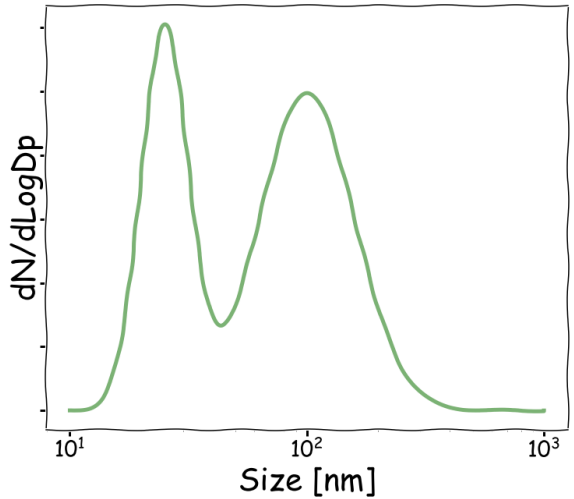

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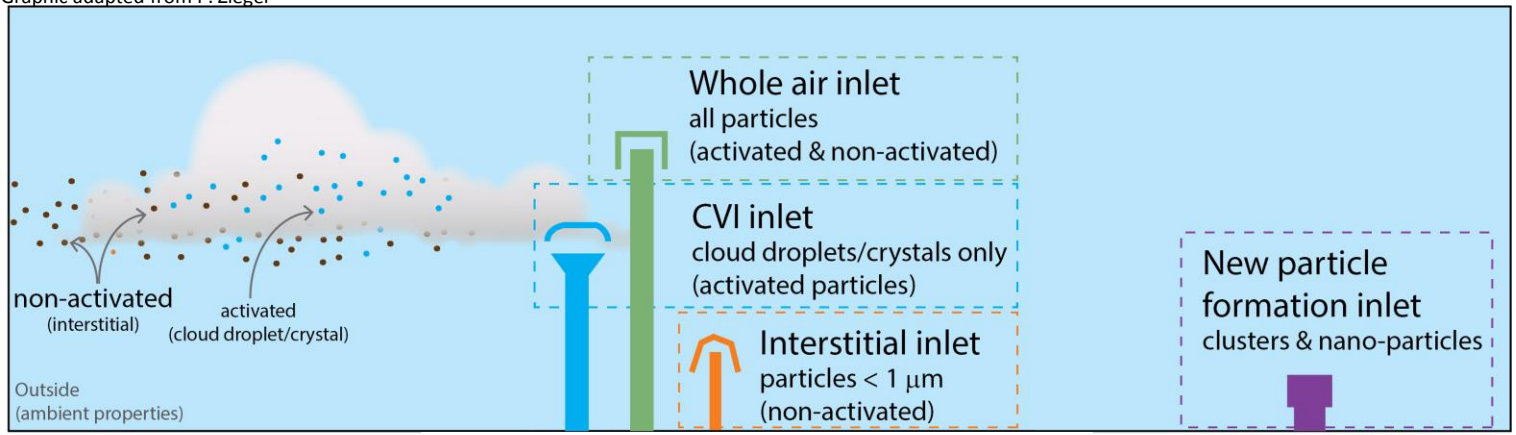

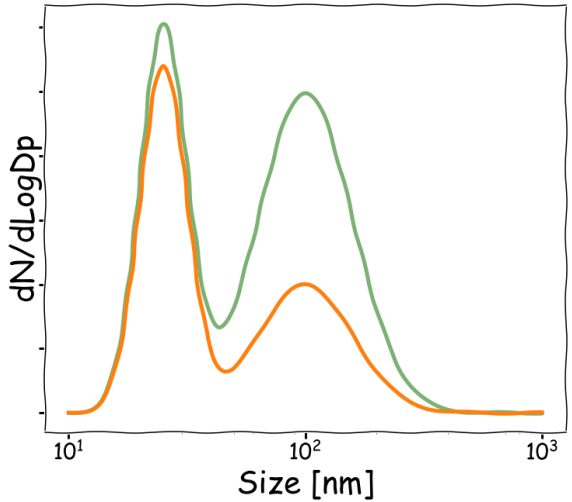

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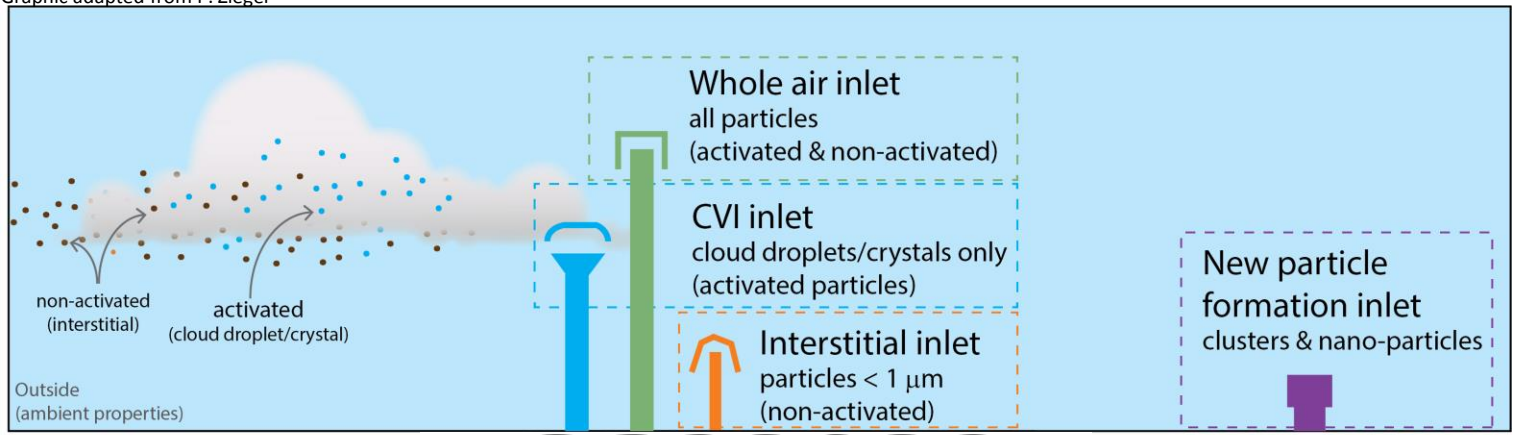

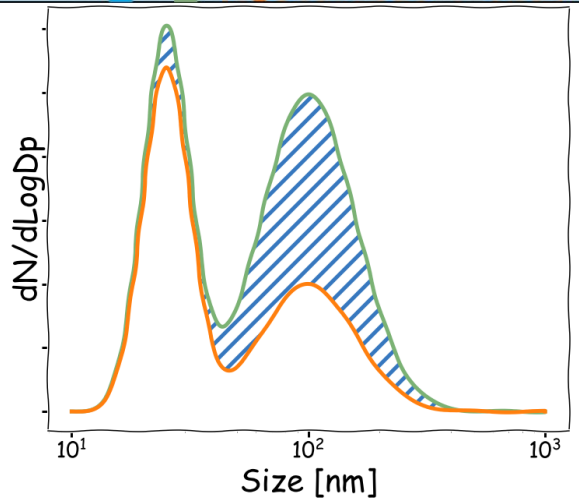

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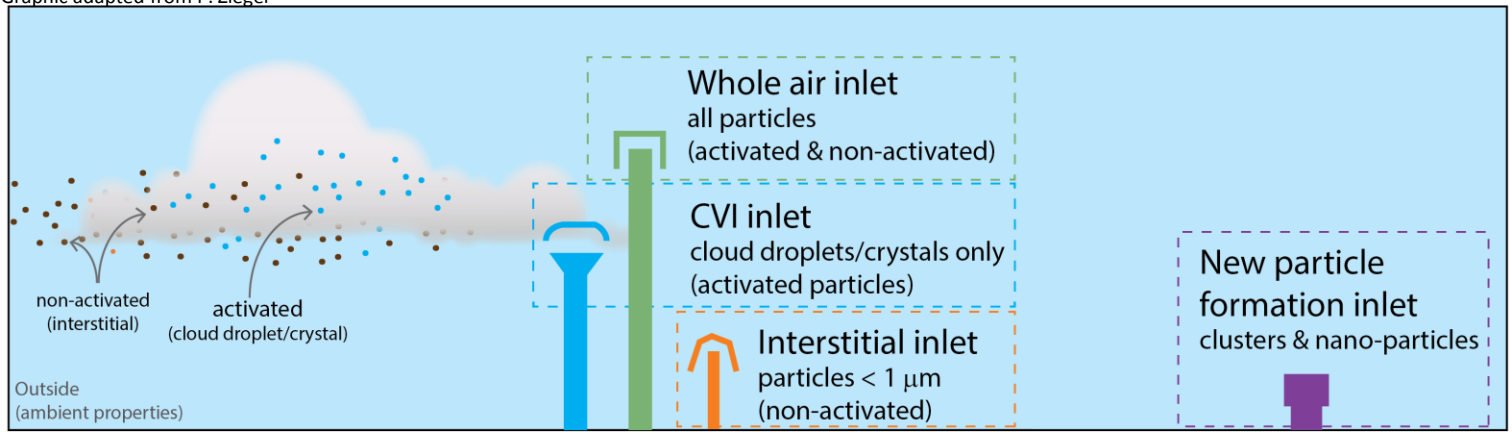

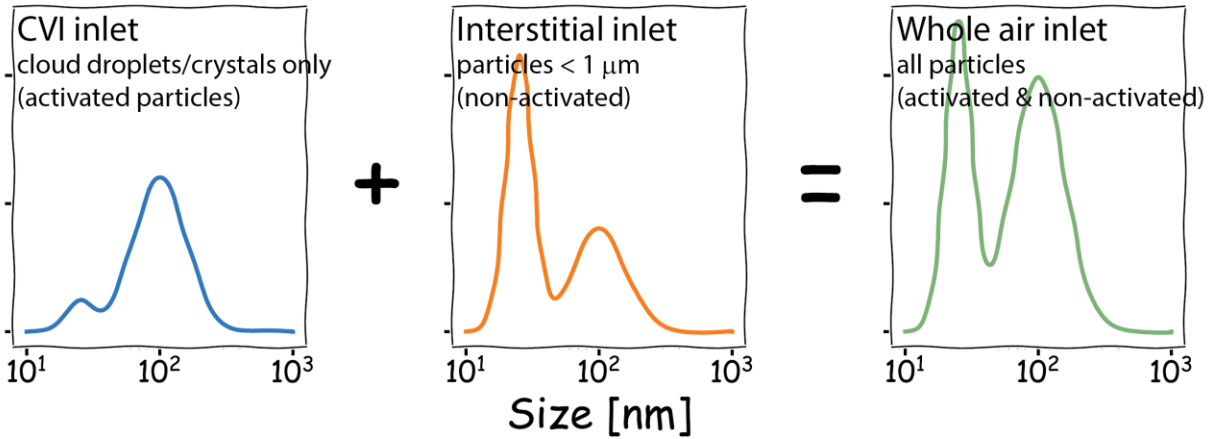

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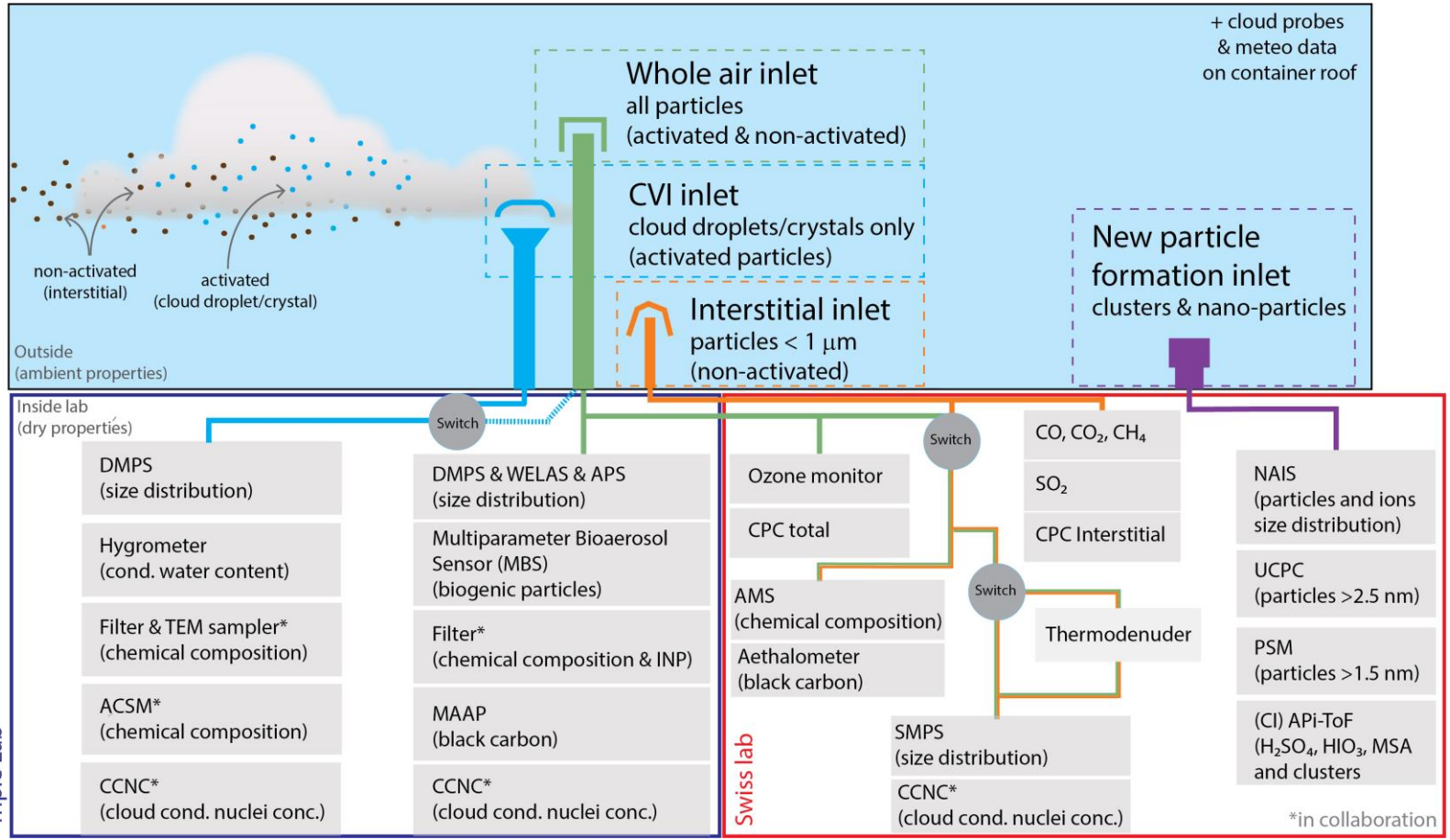
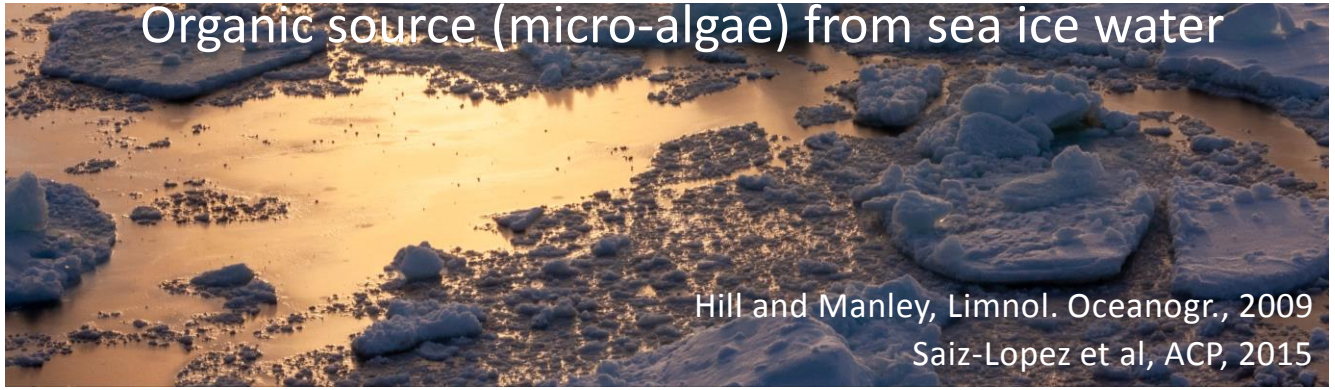


Results

Result slides have been removed because they contain unpublished material. They will be eventually updated after publication.

Iodine sources, an open question.

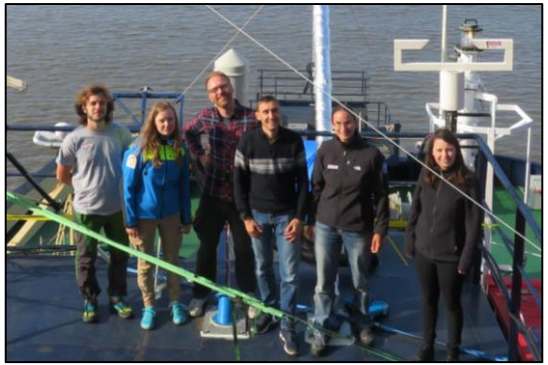


AO18 – Conclusions*

AO18 expedition was a unique opportunity to investigate aerosol cloud interactions in the central Arctic Ocean. Using different inlet systems we were able to characterize both **interstitial and activated aerosols.** Preliminary results show:

- Clear difference in aerosol properties between the marginal ice zone and the pack-ice.
- **Small particles** have the potential to **act as CCNs** under the right conditions.
- We were able to **identify the mechanism behind new particle formation** in the central Arctic Ocean and assess the role of iodine compared to sulfuric acid.

** Conclusions have been rephrased because results are not published yet.*



Supplementary slides

MOCCHA – Experimental Setup