Arctic ocean-sea ice-atmosphere exchange of climate-active trace gases

A multi-scale modelling contribution to MOSAiC

J.G.M. Barten; L.N. Ganzeveld; G.J. Steeneveld; M.C. Krol
Meteorology and Air Quality, Wageningen University

Background

The **opening of the Arctic ocean** leads to substantial changes in ocean-sea ice-atmosphere exchange and, consequently, concentrations of **carbon dioxide** (CO_2), and other gases affecting climate like **methane** (CH_4) and **ozone** (O_3). Also, we expect a change in emissions of **dimethylsulfide** (C_2H_6S / DMS), produced by **plankton**, that plays a role in **cloud formation**.
In this research we integrate MOSAiC experimental activities into a different set of models to **understand local processes**, but also to assess the impact on **larger spatial and temporal scales**.

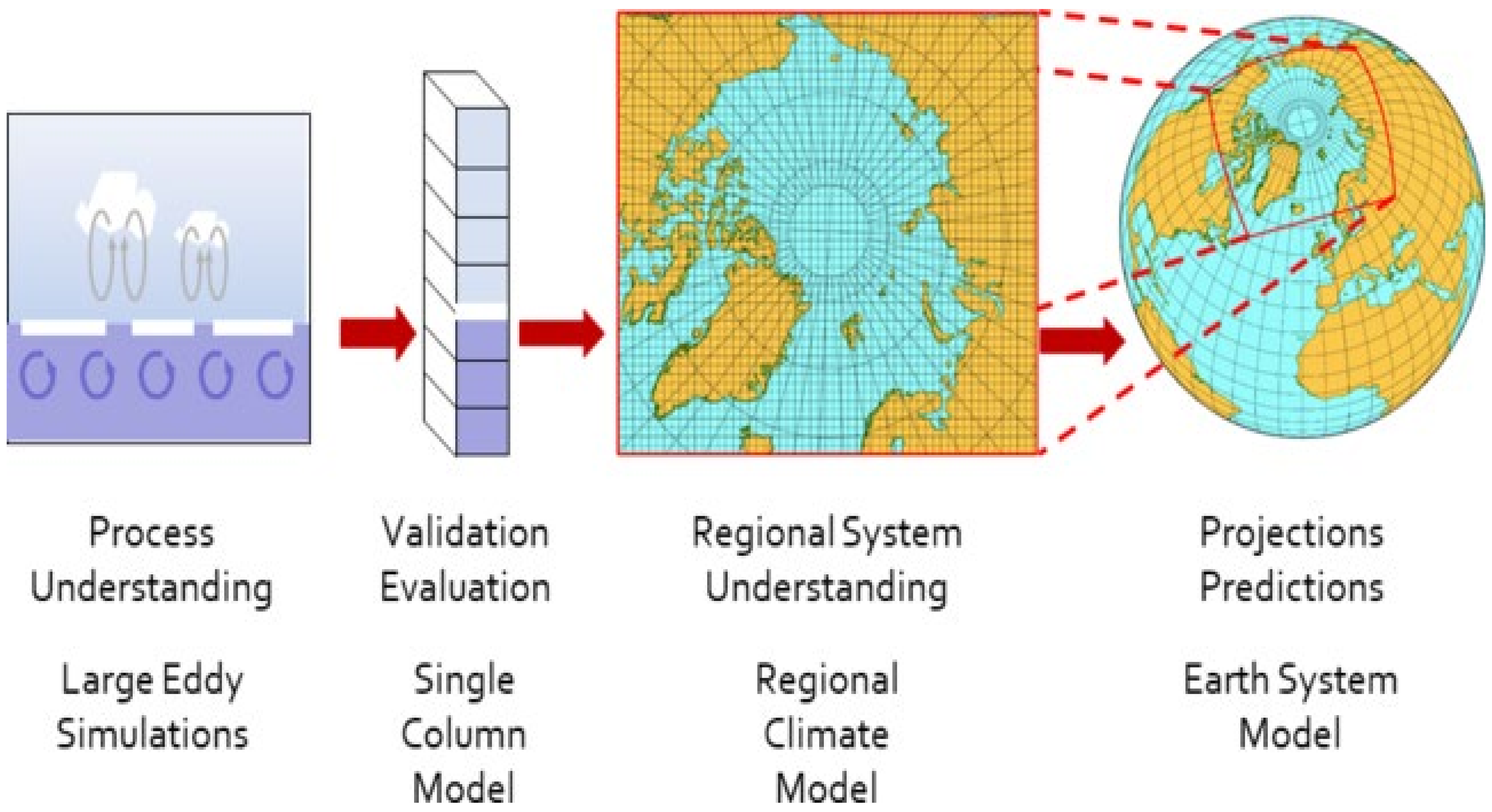

Figure 1. Conceptual image of multi-scale modelling and 'upscaling'. From the understanding of local processes to the evaluation of larger spatial domains.

MOSAiC expedition

Multidisciplinary drifting **O**bservatory for the **S**tudy of **A**rct**i**c **C**limate

"*The ultimate goal of the initiative is to enhance understanding of central Arctic coupled atmosphere-ice-ocean-ecosystem processes to improve numerical models for sea ice forecasting, extended-range weather forecasting, climate projections, and climate change assessment.*"

Measurement campaign (Sept 2019 – Sept 2020):

- Ship drifting with ice
- Distributed network
- Aircrafts
- Drones
- Buoys
- Balloons
- Towers
- And many more...

Follow the expedition live!
follow.mosaic-expedition.org

Figure 2. Illustration of MOSAiC experimental activities. Graphic by Alfred Wegener Institute.

Research objectives & Methods

- Further development and evaluation of process-based model representations of surface-atmosphere exchange of climate-active trace gases.
- **Upscaling the local-scale measurements to large-scale model representations.**
- Assessing the large-scale and long-term implications of surface-atmosphere exchange processes, interactions and resulting feedback mechanisms on Arctic climate and atmospheric composition.

Preliminary results: Upscaling from local- to regional scale

Dimethylsulfide (DMS) is produced by **plankton** (Figure 3) and emitted to the atmosphere where it can form **clouds**. In the Arctic, DMS can **build-up under the sea ice** and is emitted in large quantities when sea ice melts, consequently enhancing **cloud formation**, a major **uncertainty in regional weather models**.

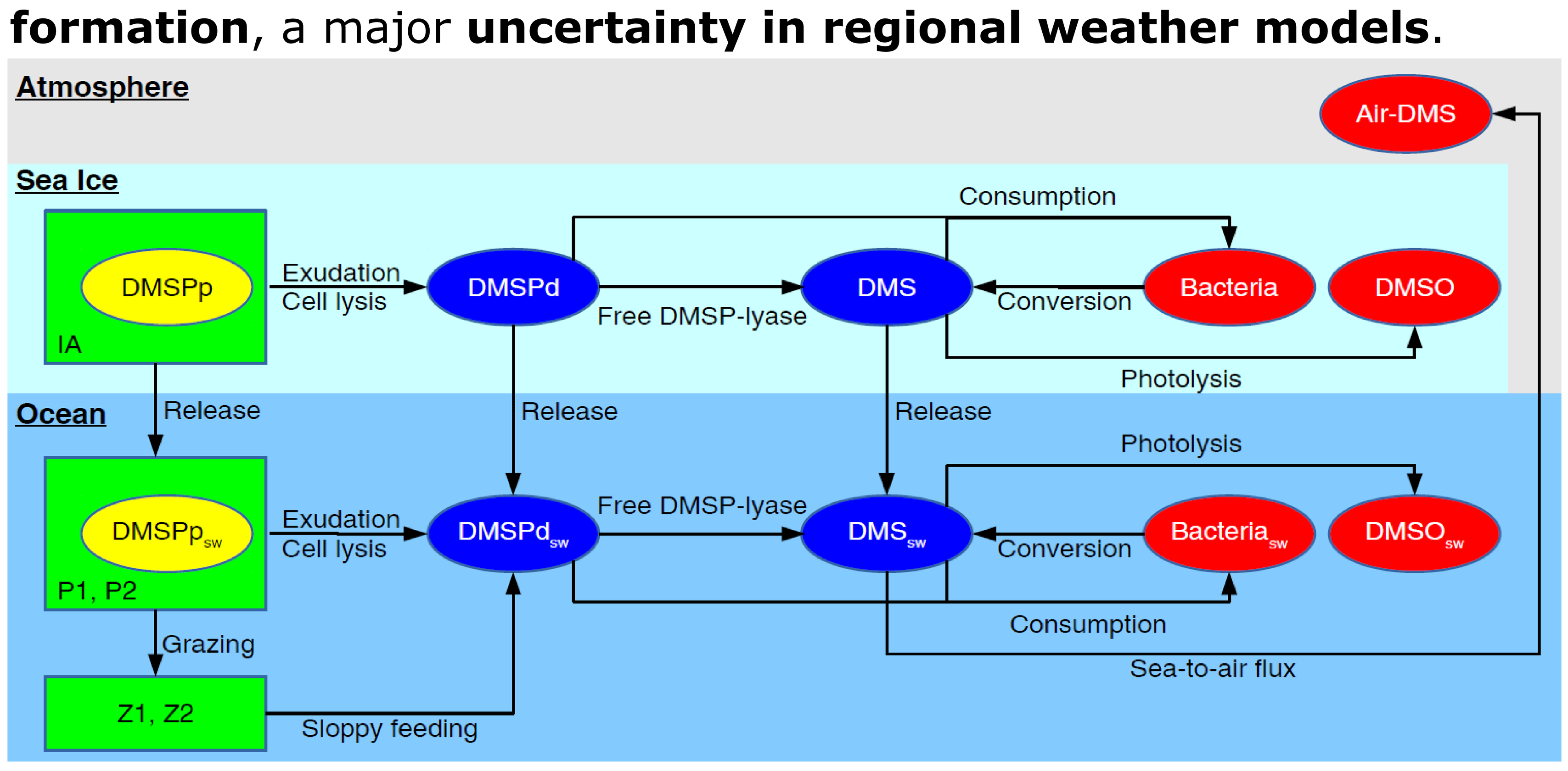

Figure 3. Schematic of DMS production in the sea ice and ocean (Hayashida et al. (2017)).

Figure 4 shows the modelled DMS flux to the atmosphere forced with local measurements (~20x20 m) and with ECMWF data (~20x20 km). The simulation using local measurements indicates a sudden removal of sea ice and a strong DMS flux when the ocean is ice free. The simulation using ECMWF data shows a much more gradual decrease in sea ice fraction and a smaller total DMS flux. Also the timing of the first DMS emissions has shifted ~1 month.

Question to be answered: How will this affect cloud formation?

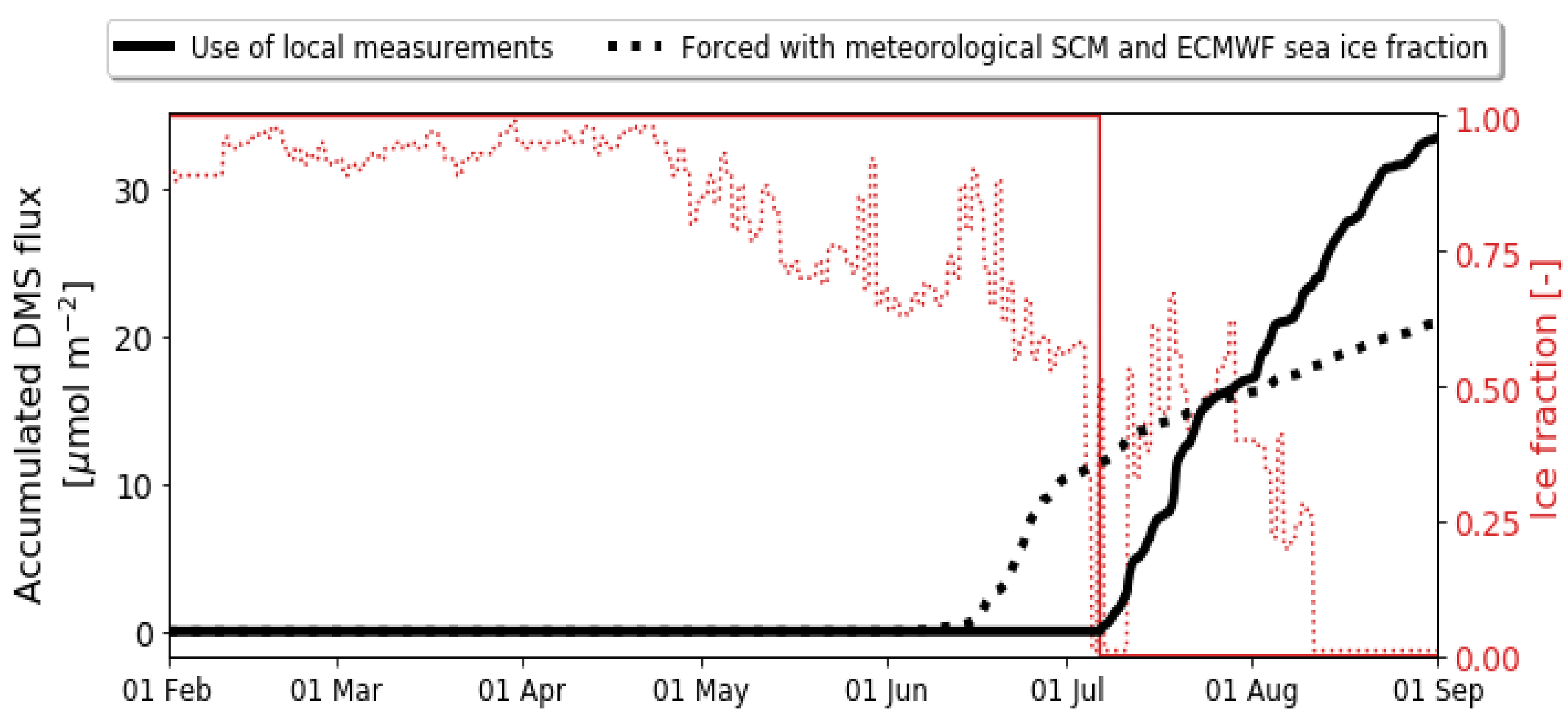

Figure 4. Timeseries of modeled DMS flux (black) and sea ice fracion (red) forced with local measurements (solid line) and ECMWF data (dashed line).

Wageningen University & Research
P.O. Box 47, 6700 AA Wageningen
Contact: sjoerd.barten@wur.nl
www.wur.nl/maq