# Seasonal transition of sea-ice and snow properties from remote sensing and in-situ measurements

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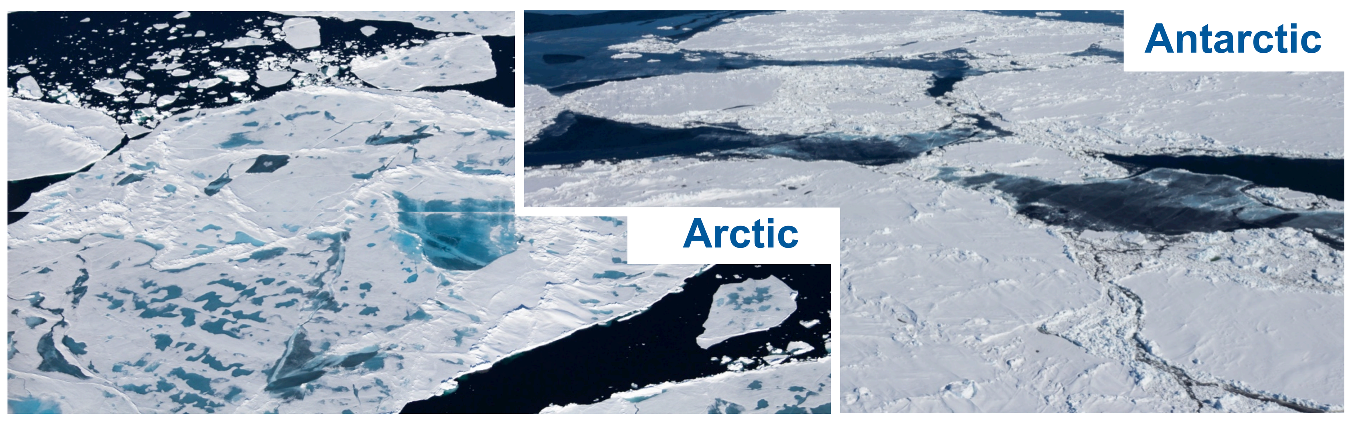
## Introduction

The surface properties of sea ice dominant key processes and drive important feedback mechanisms in the polar oceans of both hemispheres. Examining Arctic and Antarctic sea ice, the distinctly different dominant sea-ice and snow properties in spring and summer are apparent. While Arctic sea ice features a seasonal snow cover with widespread surface ponding in summer, a year-round snow cover and strong surface flooding at the snow/ice interface is observed on Antarctic sea ice.

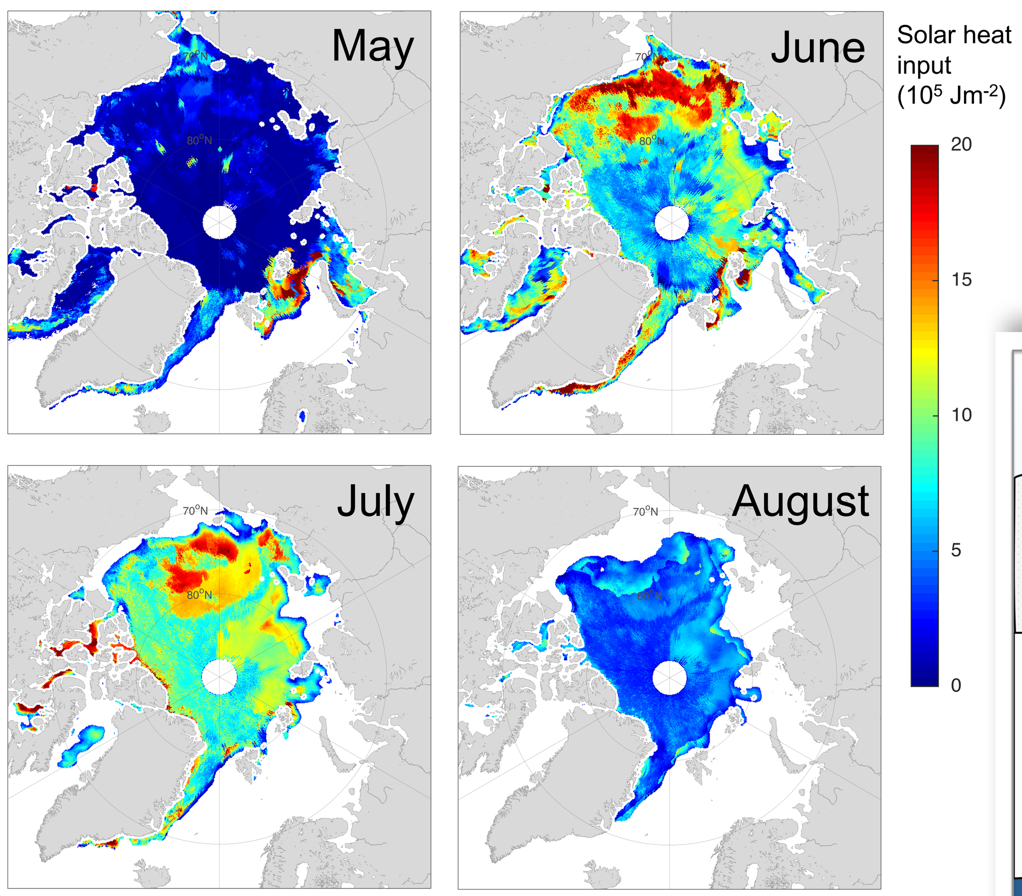
Here, we aim to outline the influence of seasonal changes of surface properties on the Arctic and Antarctic sea ice. The main focus is the analysis of the transition from spring to summer conditions, since its timing is identified as the main driver of the annual sea-ice energy and mass budgets.




## Arctic sea ice: A changing physical environment

### Method

- **Up-scaling approach** based on satellite remote sensing and reanalysis data products

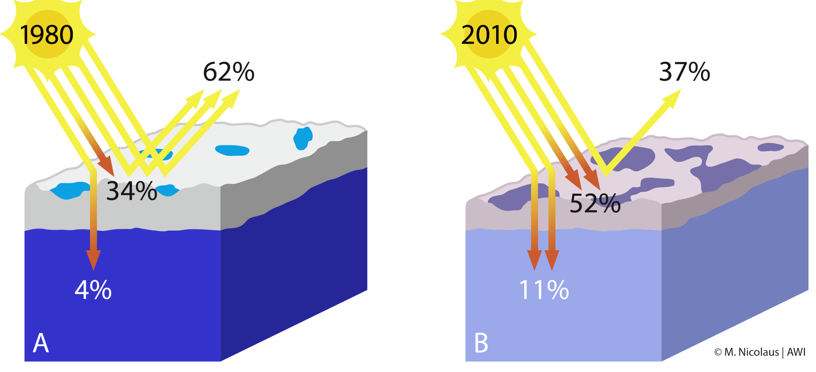


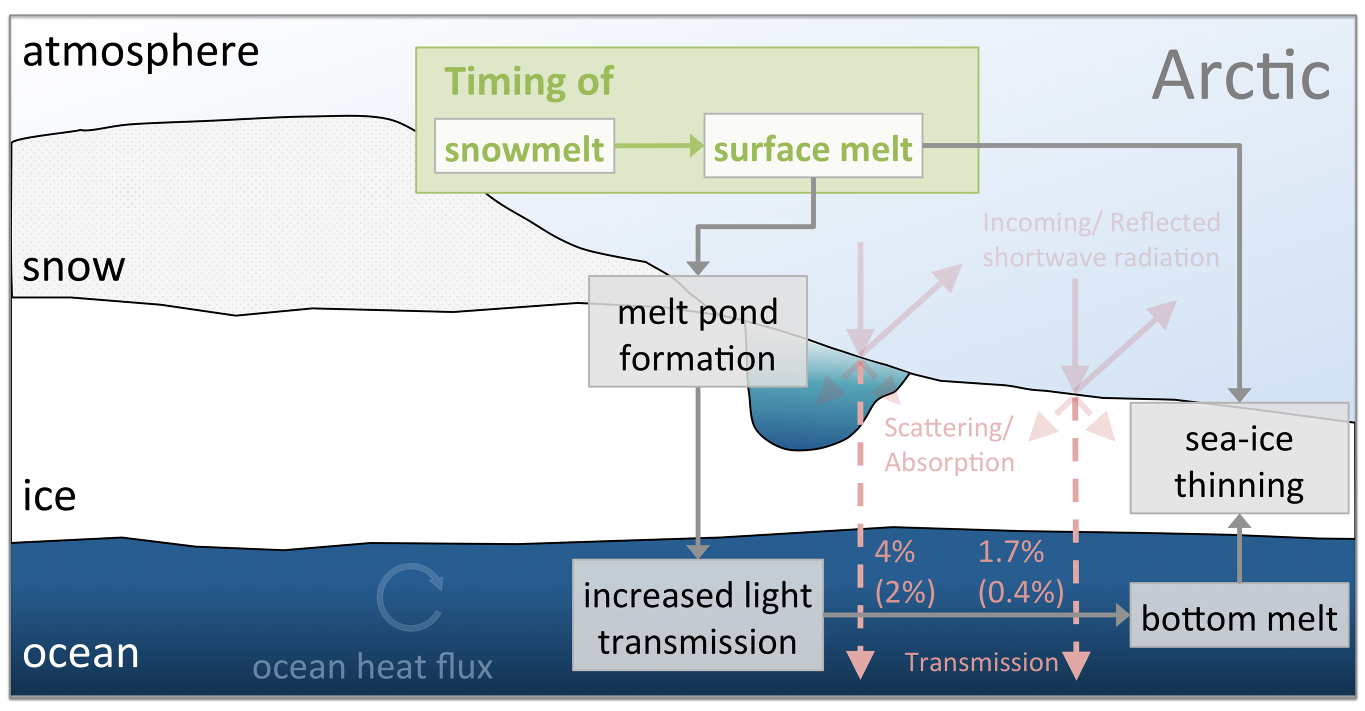

*Monthly mean of total solar heat input under Arctic sea ice for the year 2011 [Arndt & Nicolaus, 2014].*

- **Seasonal variability** in sea-ice surface properties does highly impact the **under-ice light regime**
- **96 %** of the annual under-ice radiation are transmitted in only **4 months** (May to August)
- **14 days earlier** melt onset results in an **increase of 24 %** transmitted heat flux (=melt)

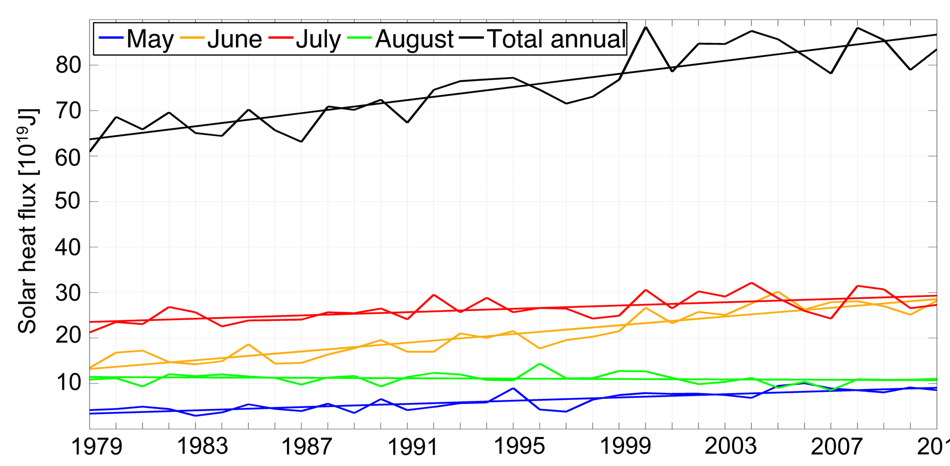
### Temporal evolution of Arctic sea ice …

- Arctic sea ice has not only decreased in volume during the last decades, but has also changed in its physical properties **towards a thinner and more seasonal sea-ice cover**



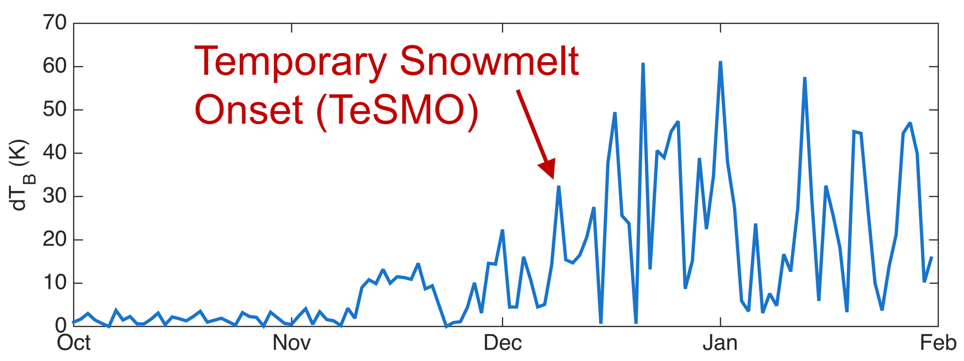

### … and its under-ice light field



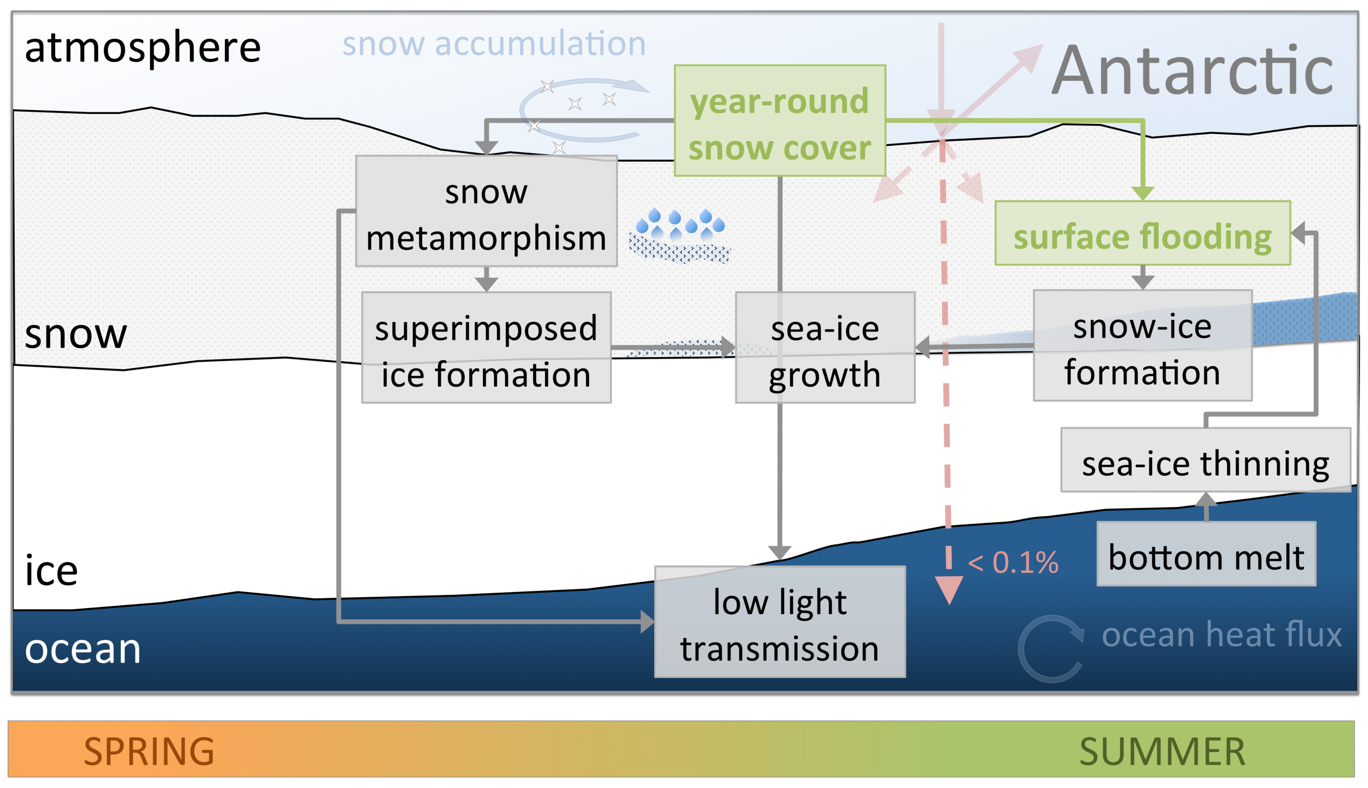

*Arctic-wide annual and monthly total solar heat input under Arctic sea ice and its trend from 1979 to 2011. The data are corrected for the trend in sea-ice concentration [Arndt & Nicolaus, 2014]*

### Method

- Analysis of **diurnal variations in brightness temperature** (passive microwave, 37 GHz, vert. pol., $dT_B$) to derive the onset of diurnal thawing and refreezing

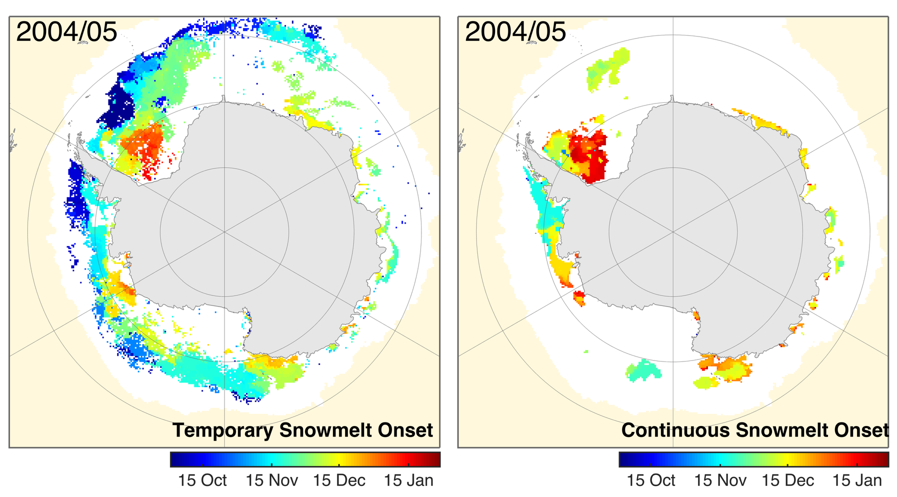



*Diurnal variations of 37 GHz vertical polarized brightness temperature ($dT_B$) for one exemplary grid cell.*




[Arndt, 2016: PhD thesis]

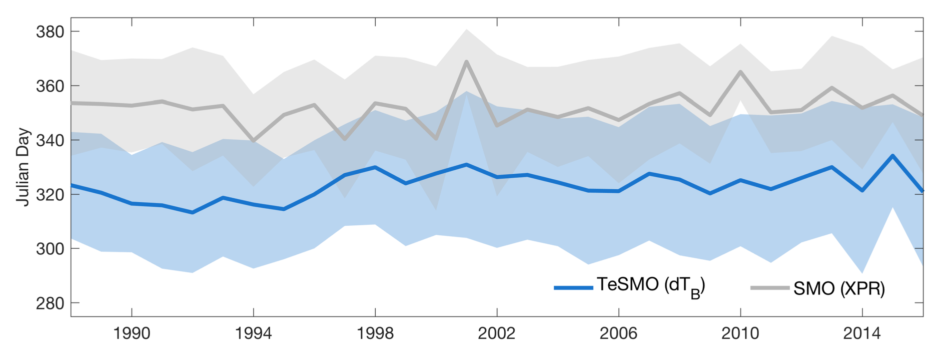
### Snowmelt onset on Antarctic sea ice …




*Temporary Snowmelt Onset (TeSMO) and Continuous Snowmelt Onset (SMO) for the melt season 2004/05 [Arndt et al., 2016].*

- **Diurnal thawing and refreezing dominates** the Antarctic summer snowmelt
- Temporary snowmelt shows a **latitudinal dependence**
- Snowmelt on Antarctic sea ice **does not show a significant trend** in the last decades

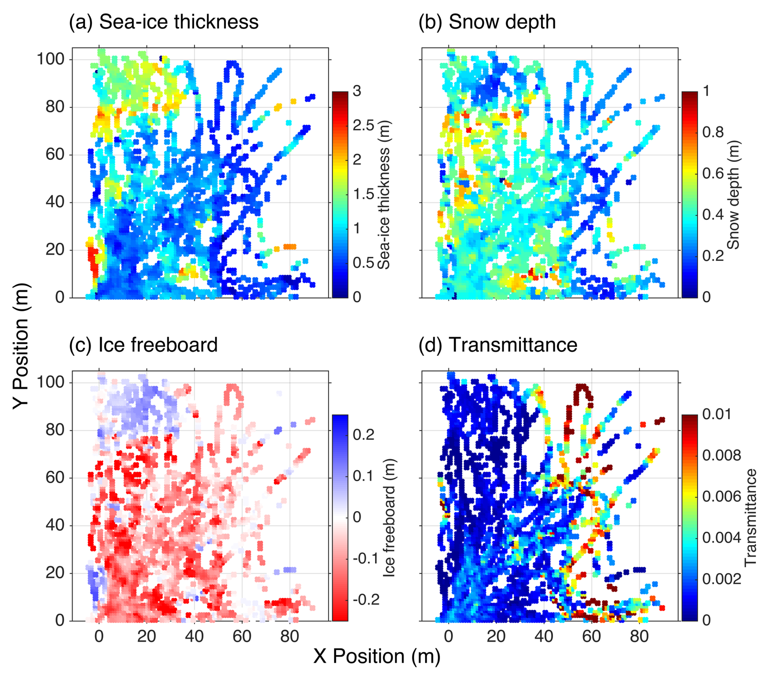
### … and its decadal variability




*Temporal evolution of TeSMO and SMO. Solid lines: Antarctic-wide mean, shaded area: standard deviation [Arndt et al., 2016].*

### The impact of snow on the under-ice light field

- **Field study** in Sep. 2013 in the Antarctic pack ice with a Remotely Operated Vehicle (ROV)




*Physical properties of the ice floe within the ROV survey area [Arndt et al., 2017].*

- **Freeboard and flooding dominate** the spatial variability of the under-ice light regime
- The **heterogeneous Antarctic** snowpack **obscures a direct correlation** between the under-ice light field and snow depth

## Antarctic sea ice: A polar opposite

**Arctic:** Direct dependency of seasonal and inter-annual changes of sea-ice surface properties and the Arctic energy and mass budgets

**Antarctic:** Heterogeneous and metamorphous snow obscures a direct correlation between Antarctic energy budget and snow depth only


Contrasting processes controlling the sea-ice energy and mass budgets of the Arctic and Southern Oceans

**Needs for future studies:**

- Comprehensive description of snow stratigraphy and properties (small scale)
- Temporal evolution of snow properties for the entire snow column from satellite remote sensing (large scale)

## Conclusions