Seasonality and spatial distribution of solar radiation under Arctic sea ice

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Introduction

The observed **changes of Arctic sea ice** during the last decades have a strong impact on interactions with the atmosphere and ocean. Due to a **more seasonal ice cover** the transmitted and absorbed solar radiation (light) of Arctic sea ice increases significantly. This, in turn, affects sea ice melt as well as **biological and geochemical processes** in and under Arctic sea ice.
Up to now, it is not possible to observe **light transmission** sufficiently well over large regions and during **different seasons**. Hence, to obtain **Arctic-wide** estimates of light under sea ice, it is necessary to develop new methods. Here we present an **upscaling method** based on parameterization of light transmittance and remote sensing and reanalysis data.

Data

Table 1: Description of all used data sets. Data were interpolated to a 10-km polar stereographic grid.

Data set	Source	Period
Surface solar radiation	ECMWF	1979–2012
Sea ice concentration	OSI SAF	Reproc. 1979–2007 Operat. 2008–today
Sea ice type	Maslanik et al. [2007]	1979–today
Melt/Freeze onset	Markus et al. [2009]	SSMR 1979–2005 AMSR-E 2003–2010 SSM/IS 2008–2011
Melt pond fraction	Rösel et al. [2012]	2000–2011 (09.05.–13.09.)

Table 2: Measured and calculated summer transmittances of snow-free Arctic sea ice for August 2011. Transmittance of open water for the entire year: 0.93.

Ice type		Transmittance (Nicolaus et al., 2012)	Melt pond fraction (Rösel et al., 2012)	Total trans-mittance
FYI	white	0.04	26 %	0.09
	ponded	0.22		
MYI	white	0.01	29 %	0.05
	ponded	0.15		

Method

Ice type classification

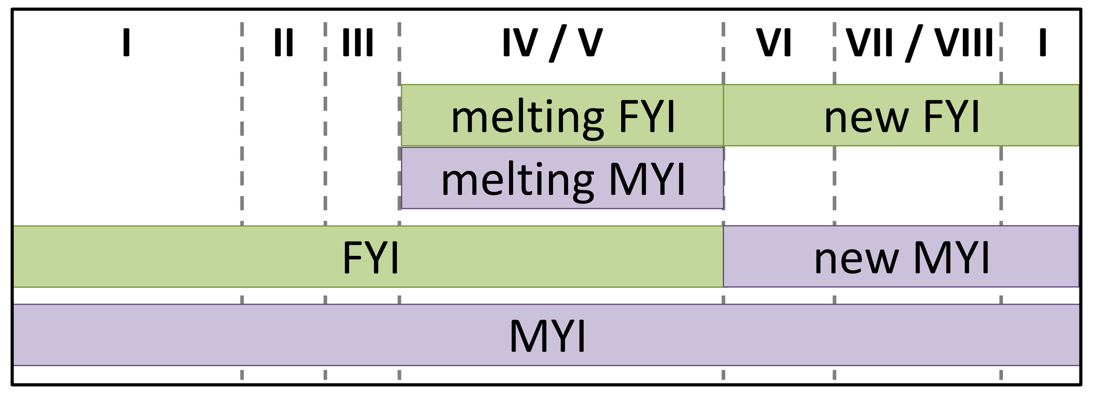

Figure 1: Extended ice type classification for an improved characterization of sea ice properties.

Sea ice surface properties

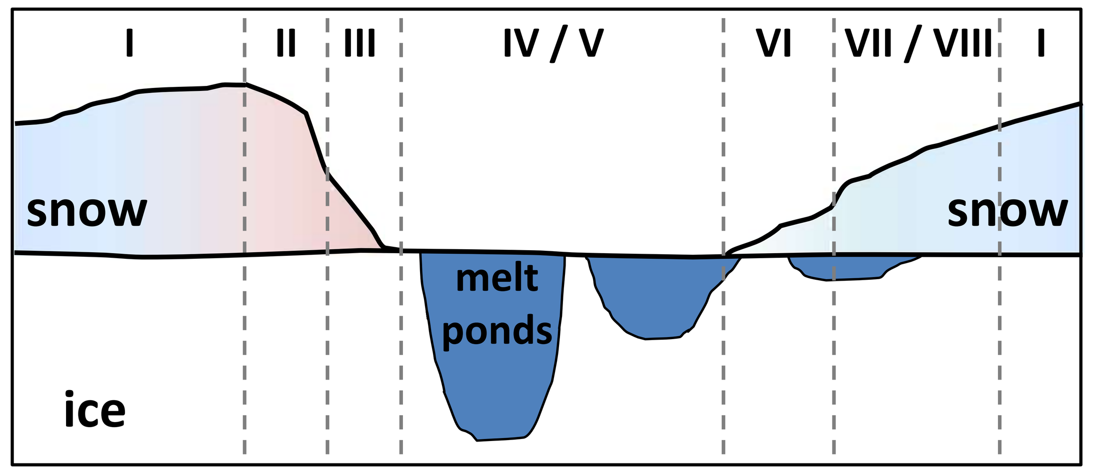

Figure 2: Annual cycle and development of surface characteristics of Arctic sea ice.

Seasonal transmittance of Arctic sea ice

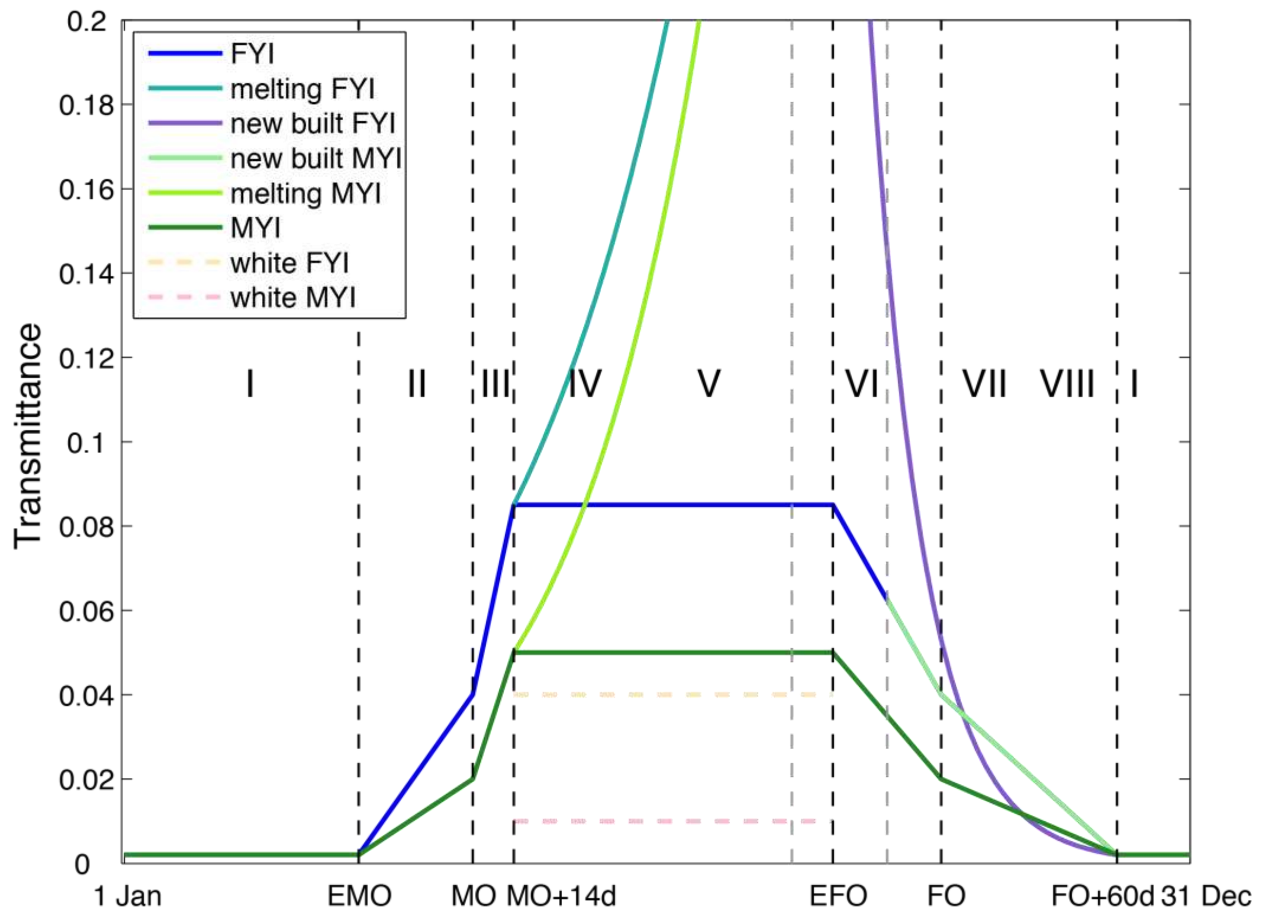

Figure 3: Total transmittance of Arctic sea ice for different ice types. Characteristic days: **EMO**: Early Melt Onset, **MO**: Melt Onset, **EFO**: Early Freeze Onset, **FO**: Freeze onset [Maslanik et al, 2007].

Indicated phases:
I: Winter, **II**: Snow melting, **III**: Pond formation/continuous melting, **IV**: Pond evolution/summer, **V**: Sea ice melting, **VI**: Fall freeze-up**,** **VII**: Continuous freezing, **VIII**: New ice growth

Results

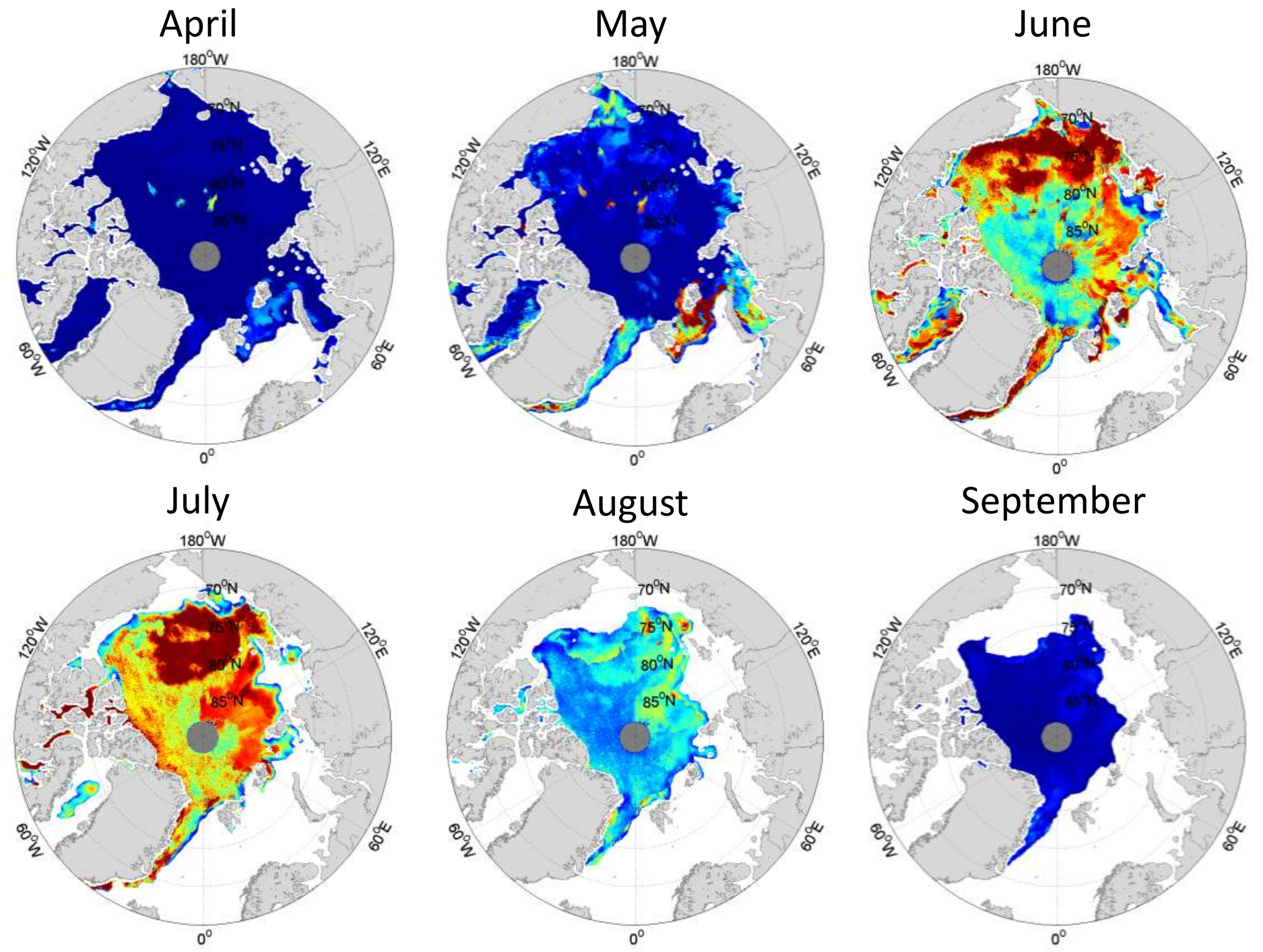

Figure 4: Monthly mean solar irradiance under Arctic sea ice (ice covered areas only) for April to September 2011. The solar heat input from October to March is not shown for its negligible impact.

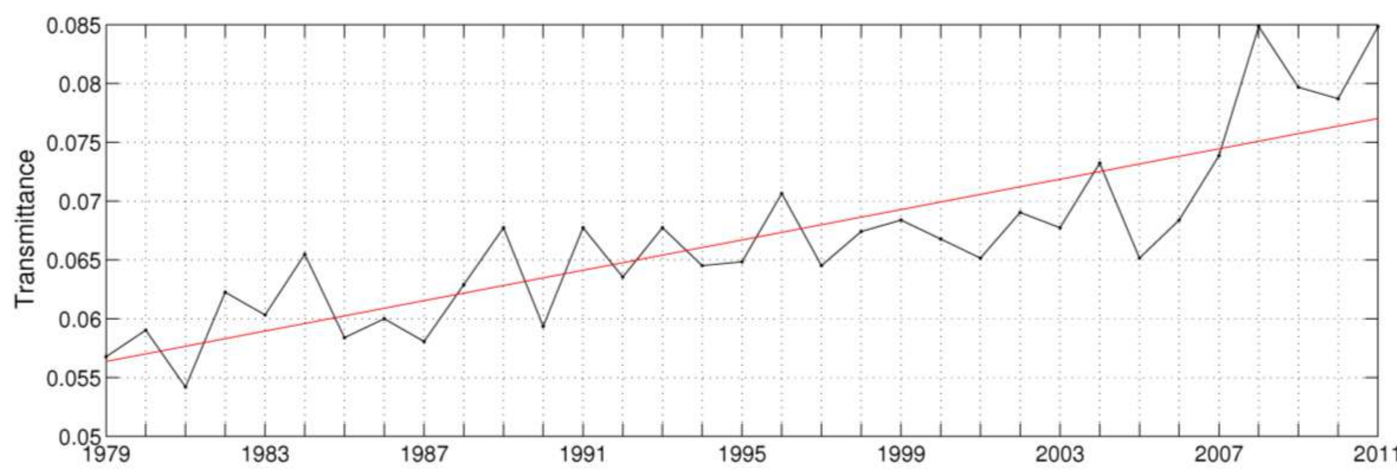

Figure 5: Monthly mean of August transmittances from 1979 to 2011. The red curve represents the positive linear trend of the summer transmittance.

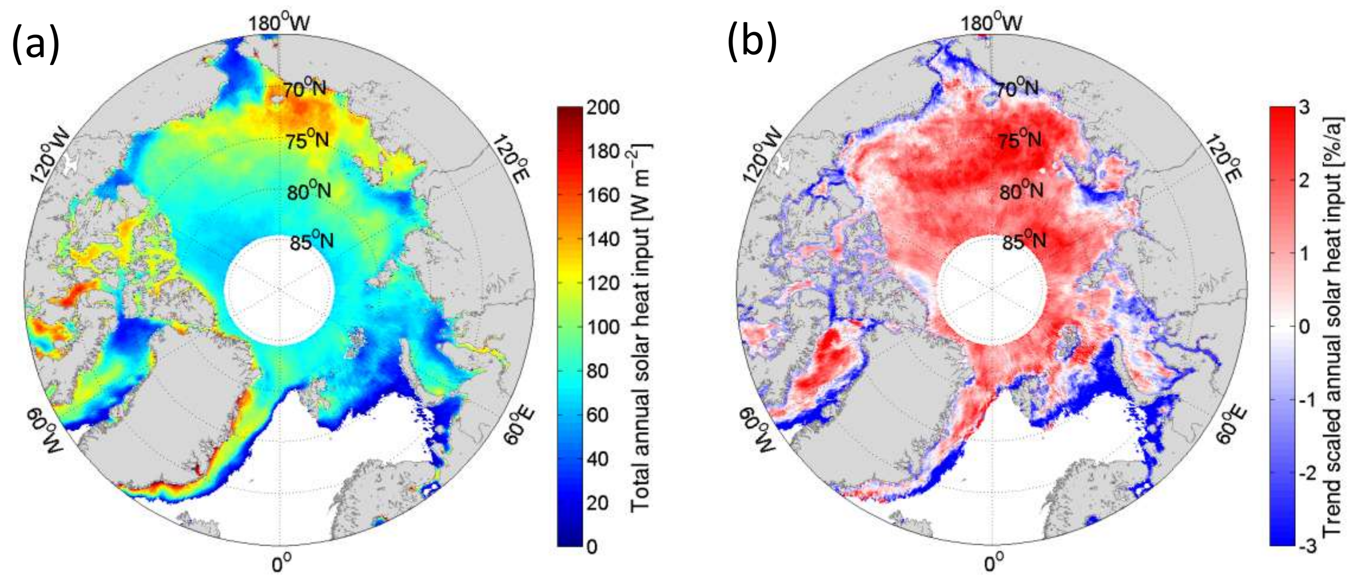

Figure 6: **(a)** Mean value of total annual solar heat input through the ice within a grid cell for 1979 to 2011. **(b)** Trend in total annual solar heat input through the ice within a grid cell for 1979 to 2011. The trend is rescaled with the sea ice concentration for results independent of the trend in sea ice concentration.

Summary

Improvement of parameterization for light transmission through Arctic sea ice including melt pond distribution and melt season durations.

Inclusion of ice type classification and **seasonality** to enable all-season estimates.

Four months (May to August) account for **96 % of the total annual solar heat input** through sea ice.

Trend analysis indicates an **increase in transmittance and solar heat input** through Arctic sea ice due to changes in ice and surface properties.

Perspectives

Sensitivity studies regarding the influence of timing and length of melting season.

Product **validation** using additional field data (e.g. Tara drift in 2007).

Classification of light availability under Arctic sea ice with respect to **biological applications** (e.g. onset and length of productive season).

Include **ice thickness** as a new parameter, e.g. from CryoSat-2 data.

Data provision through **http://www.meereisportal.de**.

References

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