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 transmission and remote sensing and reanalysis data.

Method

Ice type classification

The transmittance of Arctic sea ice is affected by the type of ice, the melt or freeze onset, the melt pond fraction, and the concentration of sea ice. The table below provides an overview of the different ice types and their transmittance properties.

<table>
<thead>
<tr>
<th>Ice type</th>
<th>Transmittance (Nicolaus, 2012)</th>
<th>Melt pond fraction (Rösel et al., 2012)</th>
<th>Total transmittance</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYI</td>
<td>0.04 (white)</td>
<td>0.22</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>0.04 (ponded)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MYI</td>
<td>0.01 (white)</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>0.01 (ponded)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Indicated phases:
- Winter: 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

Sea ice surface properties

The surface properties of sea ice are crucial for the seasonal transmittance of Arctic sea ice. The figure below shows the annual cycle and development of surface characteristics of Arctic sea ice.

Seasonal transmittance of Arctic sea ice

The seasonal transmittance of Arctic sea ice is illustrated in the figure below. The red curve represents the positive linear trend of the summer transmittance.

Results

The monthly mean solar irradiance under Arctic sea ice is depicted in the figure below. The trend analysis indicates an increase in transmittance and solar heat input through Arctic sea ice due to changes in ice and surface properties.

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.

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.meeresportal.de.

References


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