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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Spatial variability and seasonality of light transmission through Arctic sea ice

Field measurements

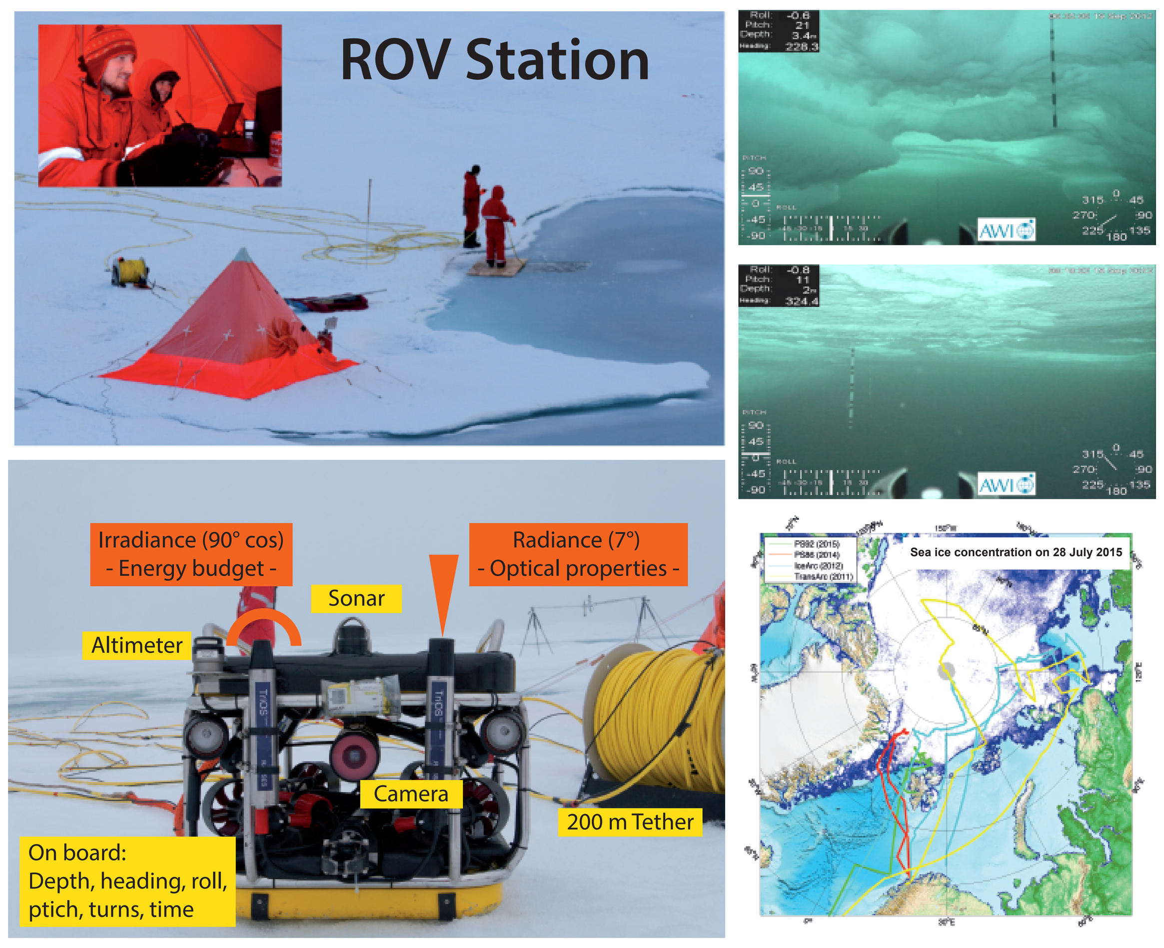


Figure 1: Left: Set up and instrumentation for under-ice transects of spectral radiation using a Remotely Operated Vehicle (ROV) operated directly from the sea ice. Right top: Impressions from under the sea ice, photographs taken by the ROV. Marker length: 1 m. Right bottom: Cruise tracks of all field measurements.

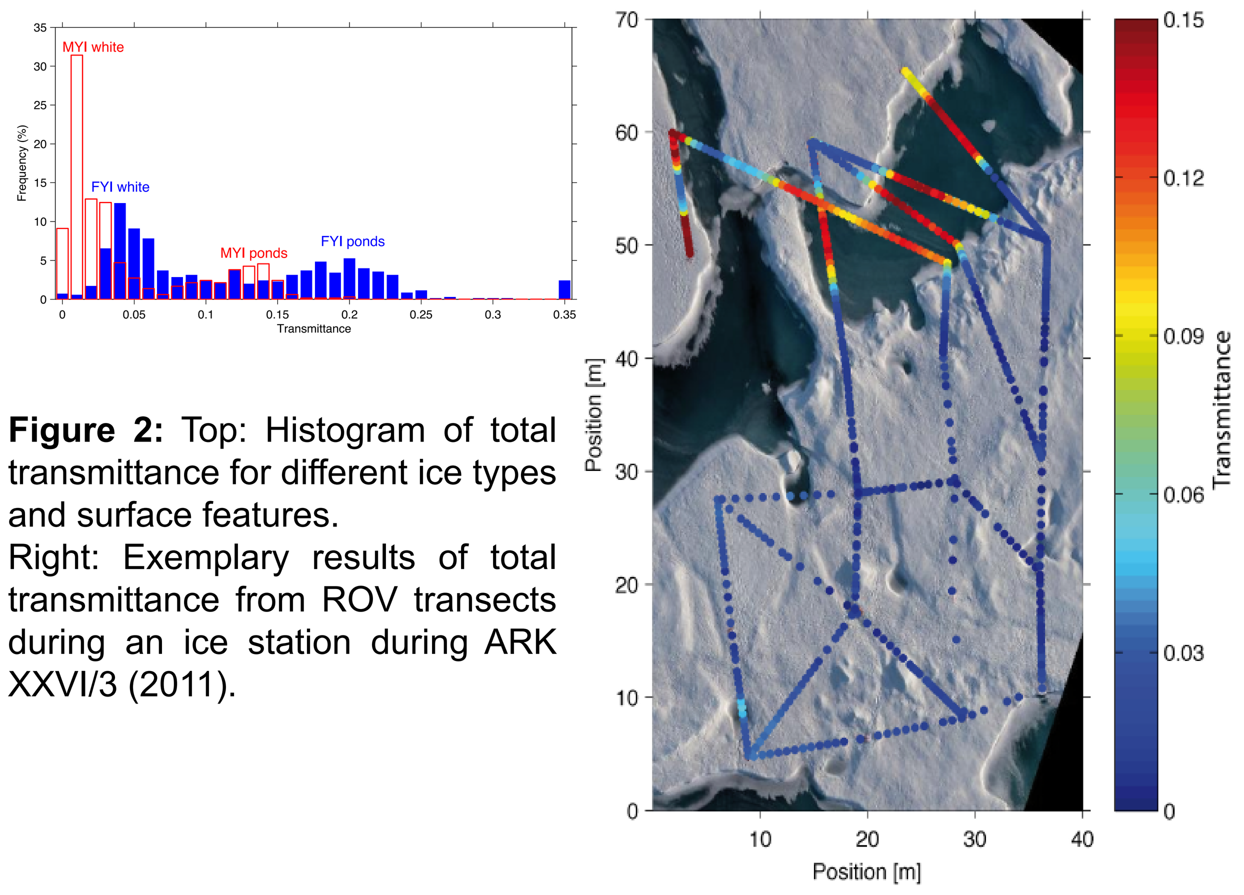


Figure 2: Top: Histogram of total transmittance for different ice types and surface features.
Right: Exemplary results of total transmittance from ROV transects during an ice station during ARK XXVI/3 (2011).

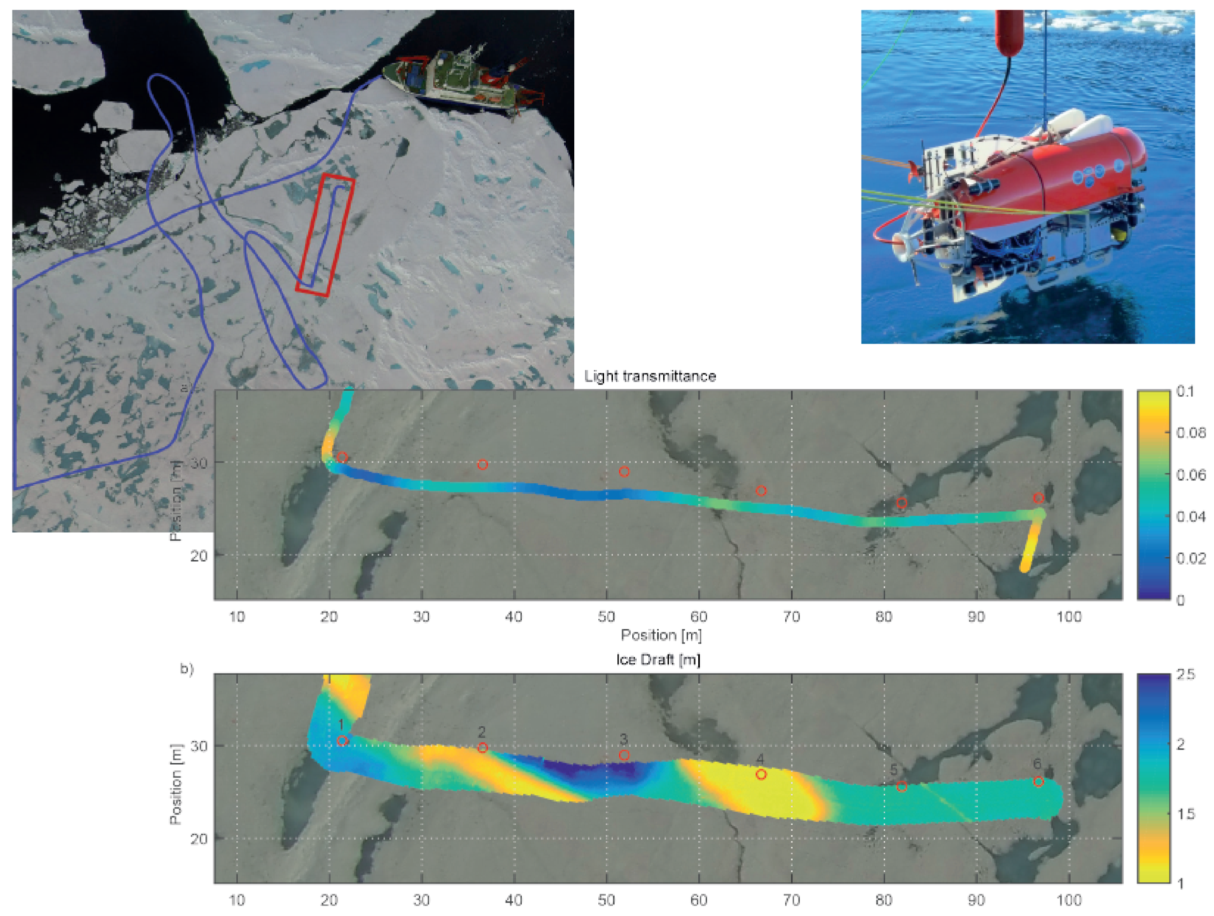


Figure 3: Top left: Aerial photograph with the dive track (red box). Polarstern is anchored to the ice floe (top right corner). Top right: Photograph of the NUI hybrid-ROV, which was used to obtain these results.
Bottom: Exemplary light transmittance and sea ice thickness along the dive track (PS92, 2015).

Introduction

Arctic sea ice has declined and become thinner and more seasonal during the last decade. One consequence of this is that the surface energy budget of the Arctic Ocean is changing.
Solar light transmitting into and through sea ice is of critical importance for the state of sea-ice and the timing and amount of primary production.
The light field in and under sea ice is highly variable: horizontally, vertically, and over seasons.
At the same time, observations of light transmittance through sea ice are still sparse, because the under-ice environment is difficult to access and high quality measurements are challenging.
Furthermore, it is necessary to generalize measurements in order to obtain Arctic-wide estimates of light conditions and energy budgets.

Summary and Results

ROV-based spectral radiation measurements give insight into the spatial variability and seasonal evolution of light transmission through Arctic sea ice.

We derived a simple parameterization for light transmission through different sea-ice and surface types.

During summer, light transmission through First Year Ice (FYI) is almost three-times larger than through Multi Year Ice (MYI).

Absorption is 50% larger in FYI than in MYI.

Light transmission though summer sea ice is dominated by 1) the distribution of melt ponds on floe scales, and 2) the sea ice thickness distribution on regional scales.

The maximum solar heat flux through sea ice occurs in June. 96% of the annual flux occur from May to August, in 4 months only.

Highest uncertainty and greatest importance for the annual heat budget are fluxes in late spring (melt onset).

We find an Arctic-wide increase of light transmission of 1.5% / year (1979 to 2011).

Light scattering in sea ice is anisotropic and has to be considered for any modelling approaches.

Outlook / needs: 1) Multi-seasonal time series under various sea ice and snow conditions, 2) direct connection of biological and physical data sets, e.g. from common sensor suites on ROVs and autonomous platforms.

Arctic-wide Estimates

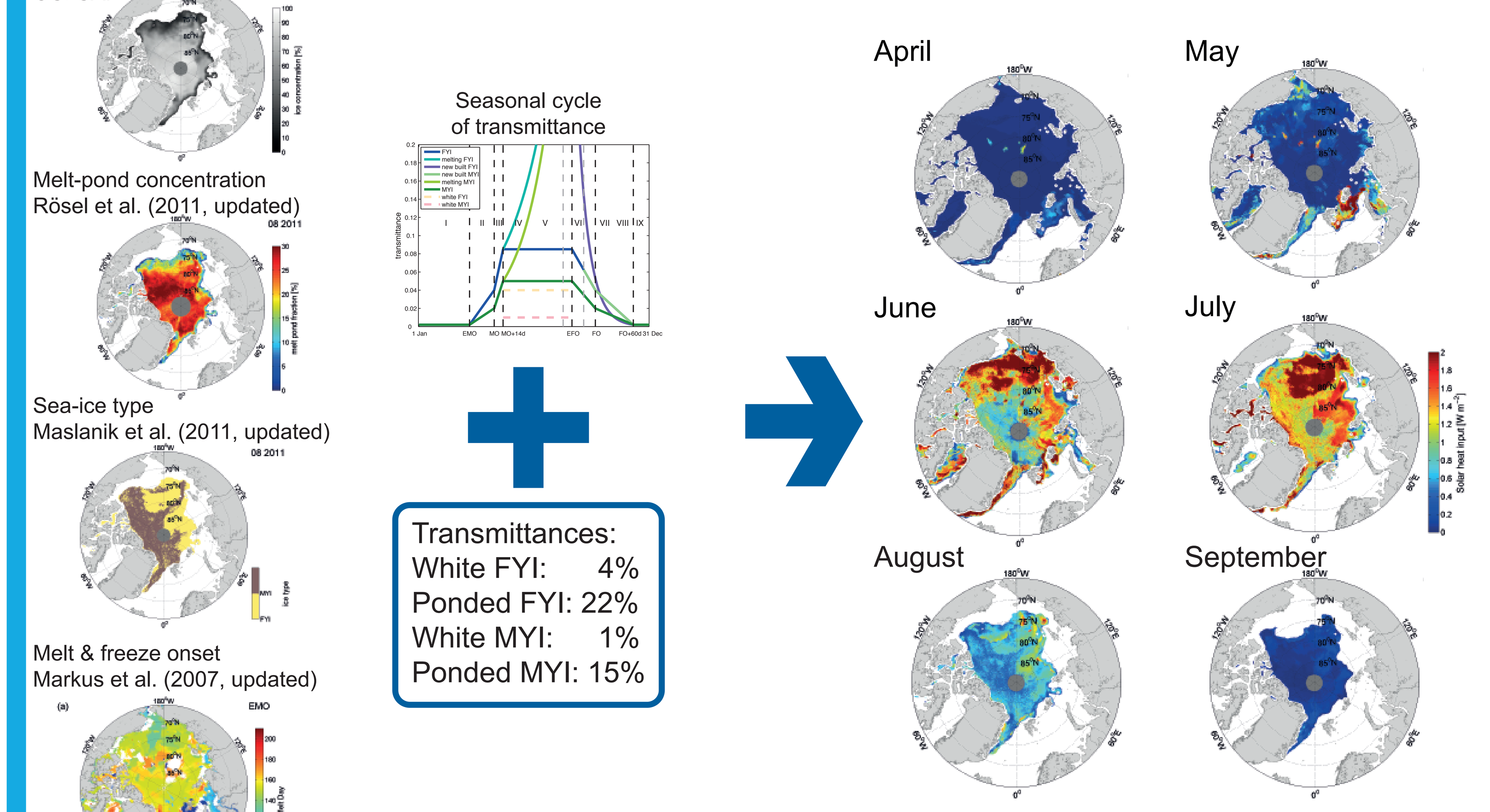
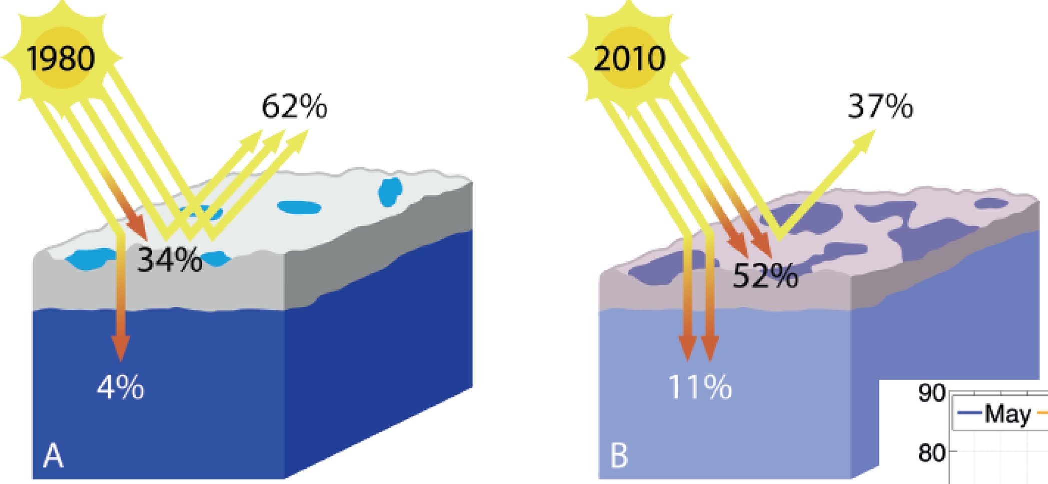


Figure 4: Input data sets and parameterization for the Arctic-wide upscaling and resulting. monthly mean solar irradiance under sea ice (ice covered area only) for August 2011.

Decadal Changes and Trends



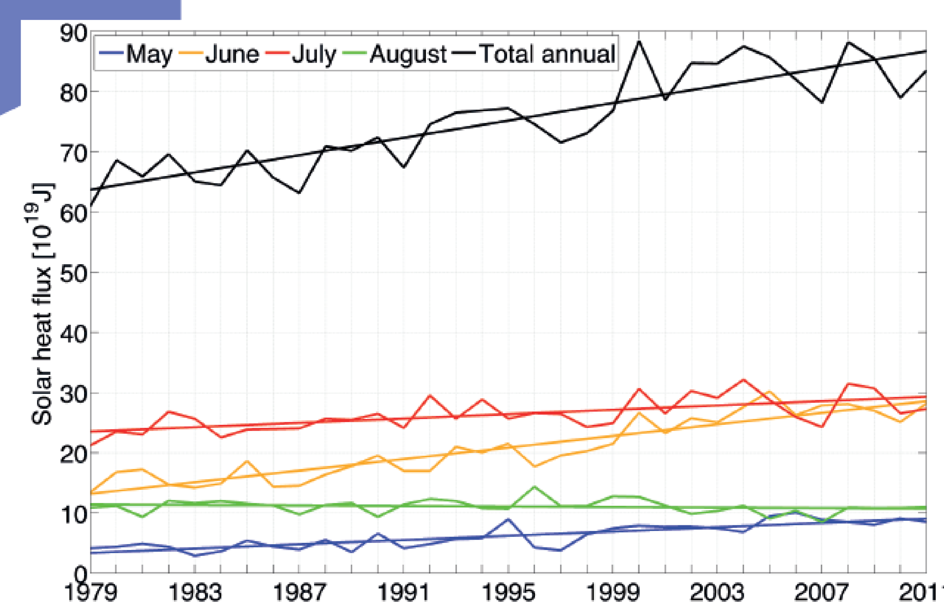


Figure 5: Top: Schematic of radiation fluxes through sea ice in a MYI dominated regime (1980) and a FYI dominated regime (2010). Right: Changes of the annual solar heat flux through Arctic sea ice for the years 1979 to 2011.

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