FAMOS Workshop
Poster A18

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Seasonal evolution of light transmission through Arctic sea ice

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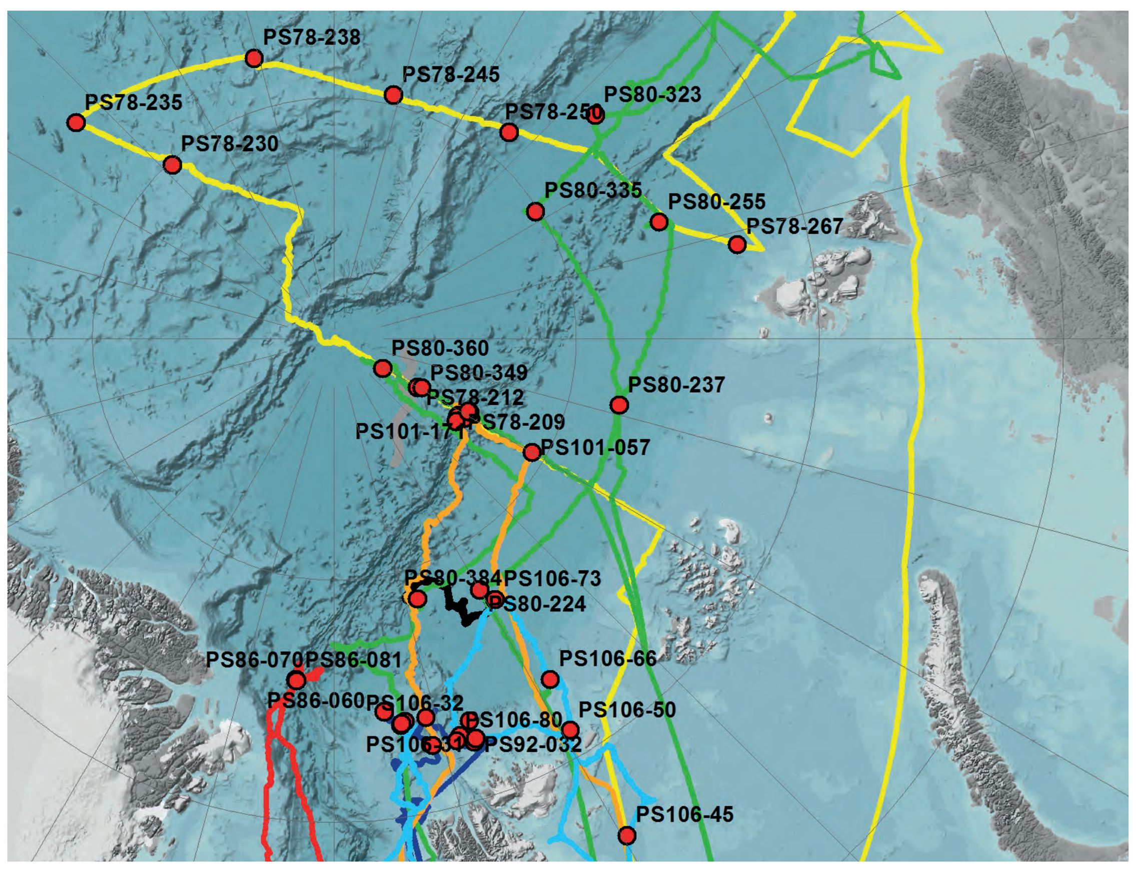
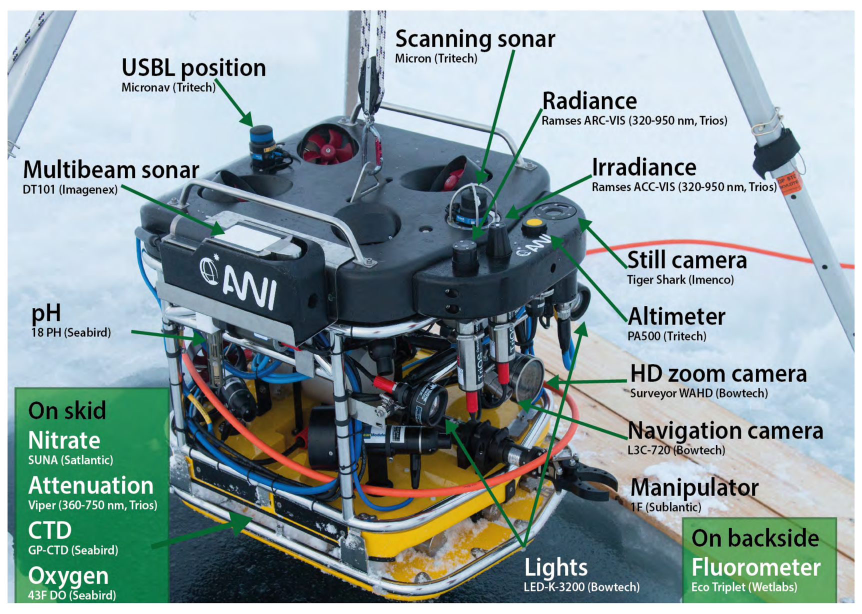
Observations

Light transmittance through sea ice was measured with a remotely operated vehicle (ROV) (Katlein 2016, Nicolaus 2013) during icestation work of six *RV Polarstern* expeditions: TRANSARC 2011, ICEARC 2012, AURORA 2014, TRANSSIZ 2015, KARASIK 2016, PASCAL/SIPCA 2017. These expeditions cover the entire summer melt period from end of May to beginning of October.



Spatial variability: ROV



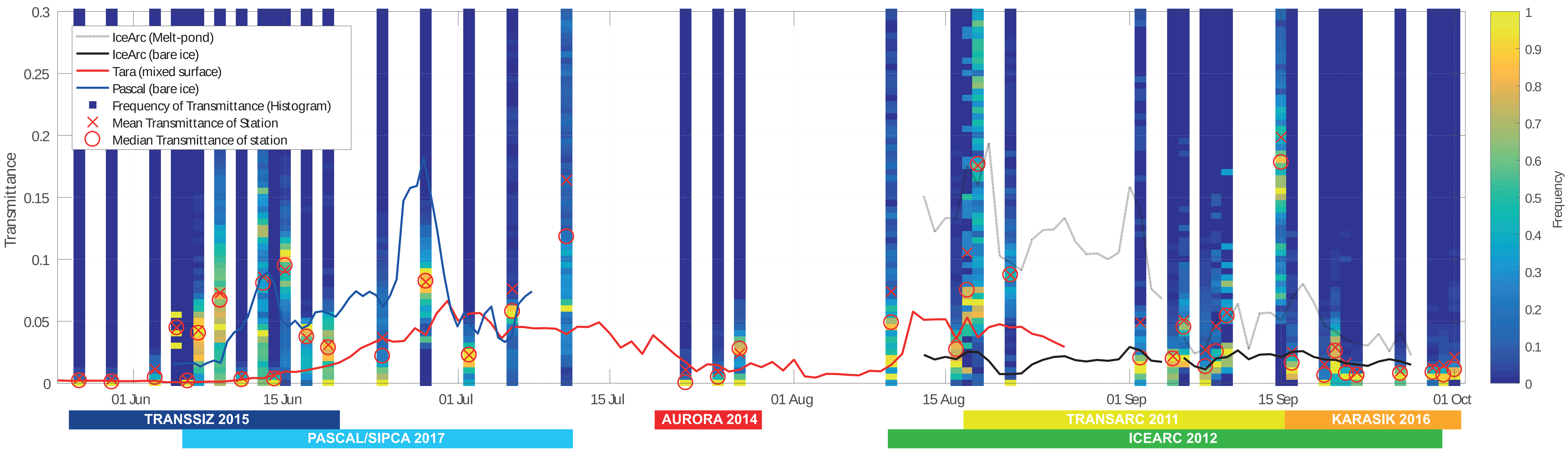
Seasonal variability: buoys

Light transmittance was measured typically under a 100x100 m survey area, covering a wide range of current ice conditions including thin ice, pressure ridges and melt ponds. Ice thickness was derived from the upward looking sonar and the vehicle's depth sensor. Ice relative position was measured with an acoustic ultra short baseline (USBL) positioning system.

To obtain the seasonal variability of the spatial distribution of the under ice light field, results from all 43 ice stations are combined into a ‚pseudo timeseries'. The 160 000 measured light transmittance spectra are quality controlled and corrected for the water layer between the sensor and the ice bottom. Regridding data in cells of 1x1m removes biases introduced from multiple sampling and leads to a remaining dataset of 35 600 datapoints.

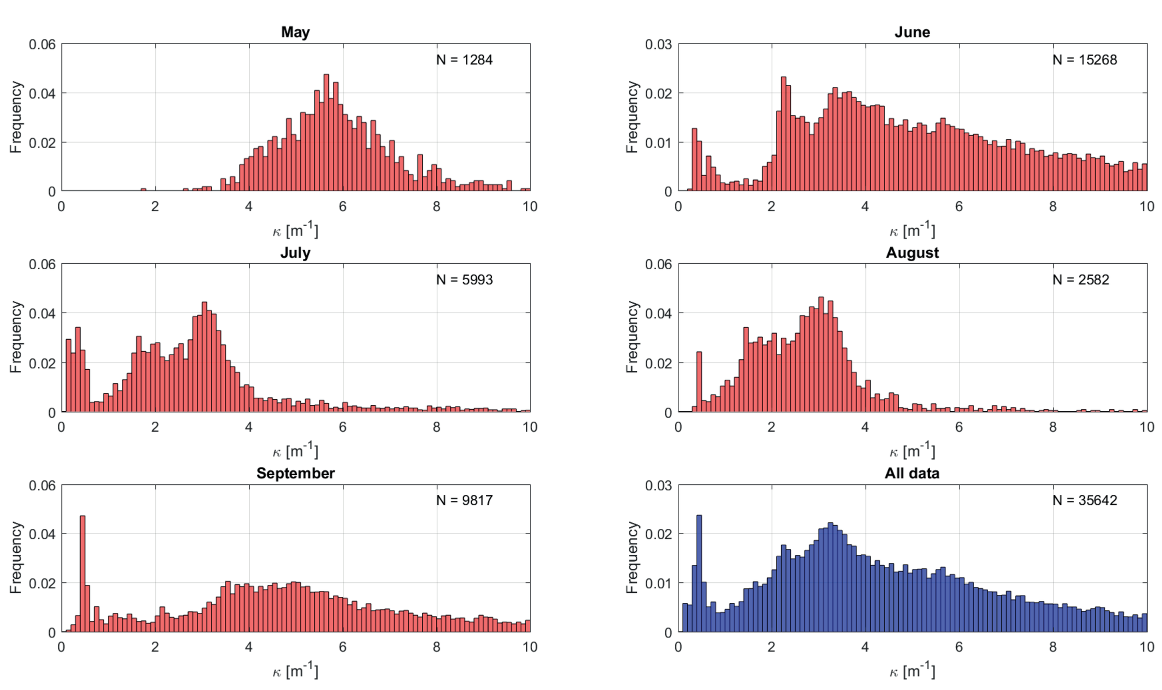
As the ice station locations vary with time and season according to the cruise schedule, this dataset does not represent a traditional timeseries in a single location, but rather describes the seasonal development of the spatially varying under ice light field.

To put these ROV observations into a context of a timeseries in a more traditional meaning, we combine them with autonomous light transmission measurements acquired from spectral radiation stations. Such stations were deployed and retrieved during the ICEARC 2012 and PASCAL/SIPCA 2017 cruise, as well as during the drift of Tara in 2008.



Seasonal evolution of the light transmittance distribution: Colored bars indicate the distribution function of transmittance values per station. Circles (crosses) denote the median (mean) of each station. Lines represent stationary transmittance measurements obtained by autonomous stations during different cruises.

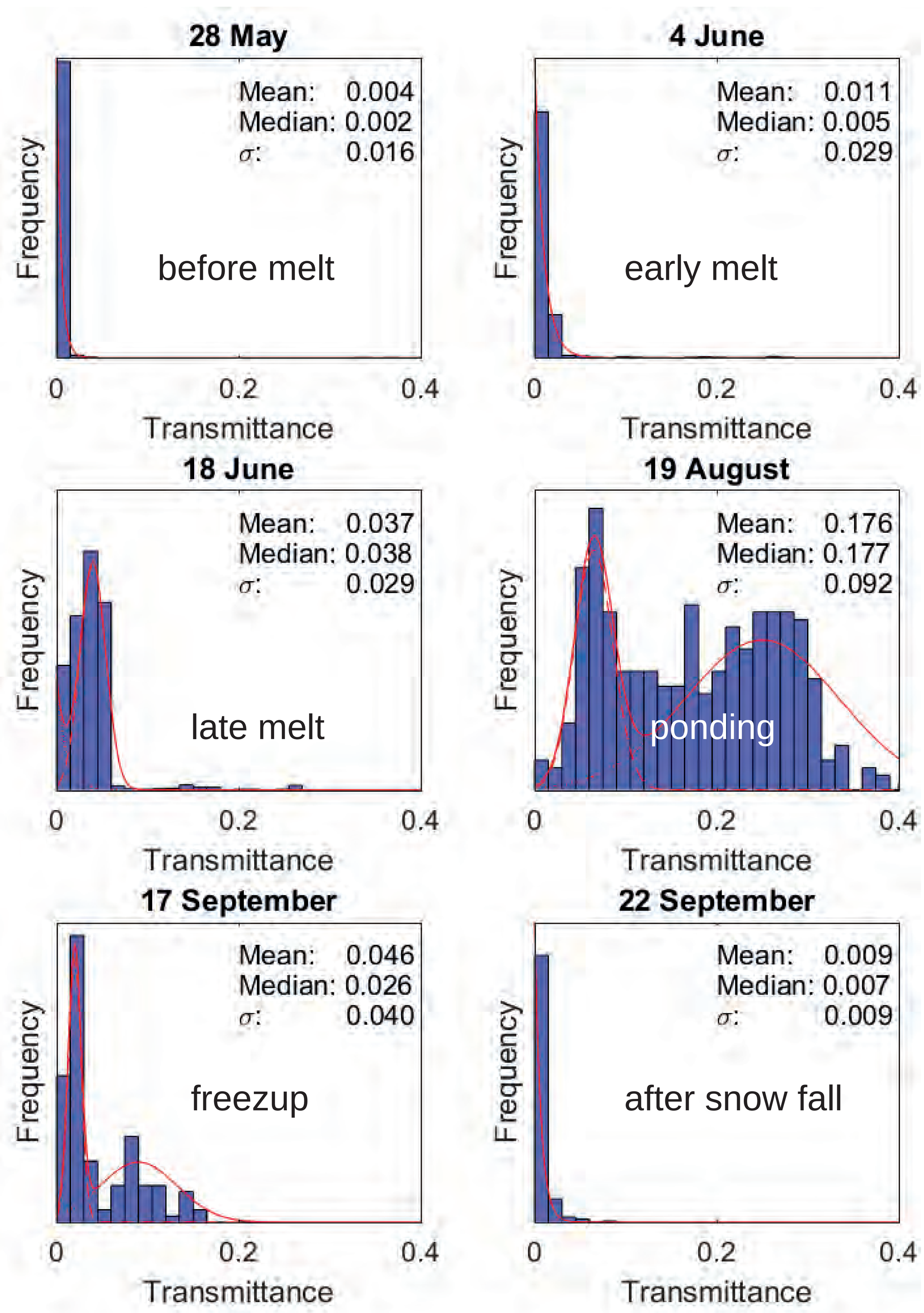
Extinction coefficients



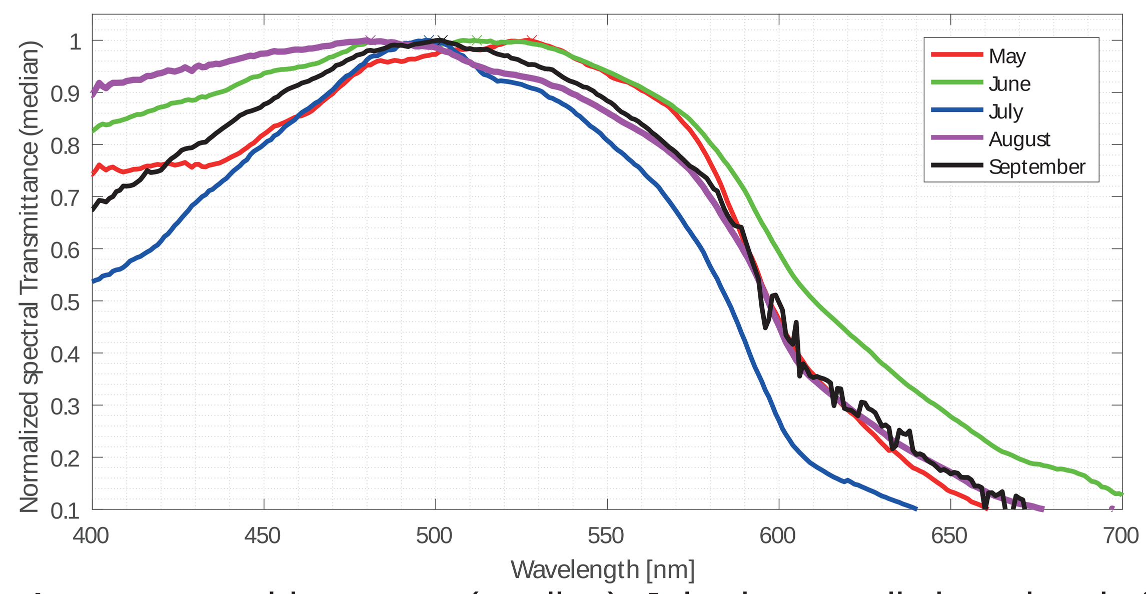
Monthly distributions of extinction coefficients (above) are indicative of the evolution of surface properties: Literature values for sea-ice (0.8-1.5 m^{-1}) are often not reached due to the effects of snow cover and underestimated ice thickness. During summer values get lower, but still deviate, likely due to the influence of a surface scattering layer.

The examplary evolution of the light transmittance distribution (right) shows a power law distribution with sea-ice winter conditions (optically thick snow cover). Transmittances then increase until a single mode is developing. With an advancing melt, a second high transmission mode associated with melt ponds develops. This bimodal structure survives freezup and the first snow falls, until the winter situation is regained.

Seasonal evolution of modes



Mean spectral transmittance



Average monthly spectra (median). July shows a distinct signal of biomass absorption indicated by the steepest spectral slope between 400 and 500nm.

Conclusions

- **First pseudo timeseries of spatially distributed under ice light measurements**
- **Light transmission increases throughout June**
- **A separated „pond mode" with high light transmittance develops over summer**
- **Bulk extinction coefficients are much higher than typical literature value**
- **Clear signal of biomass absorption in July**

References

Katlein, C. , Schiller, M., Belter, H.J., Coppolaro, V., Wenslandt, D., Nicolaus, M. (2017) A New Remotely Operated Sensor Platform for Interdisciplinary Observations under Sea Ice, Frontiers in Marine Science – Ocean Observation

Nicolaus, M. and Katlein, C. (2013) Mapping radiation transfer through sea ice using a remotely operated vehicle (ROV) , The Cryosphere, 7 , pp. 763-777

Acknowledgements

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