Mapping Arctic Sea Ice Surface Roughness with Multi-angle Imaging SpectroRadiometry

Thomas Johnson\textsuperscript{1}, Michel Tsamados\textsuperscript{1}, Jan-Peter Muller\textsuperscript{2}, and Julienne Stroeve\textsuperscript{1}

\textsuperscript{1}Centre for Polar Observation and Modelling, University College London, London, United Kingdom
\textsuperscript{2}Mullard Space Science Laboratory, University College London, London, United Kingdom

Surface roughness is a crucial parameter in climate and oceanographic studies, constraining momentum transfer between the atmosphere and ocean, providing preconditioning for summer melt pond extent, while also closely related to ice age. High resolution roughness estimates from airborne laser measurements are limited in spatial and temporal coverage while pan-Arctic satellite roughness have remained elusive and do not extended over multi-decadal time-scales. The MISR (Multi-angle Imaging SpectroRadiometer) instrument acquires optical imagery at 275m (red channel) and 1.1 km (all channels) resolutions from nine near-simultaneous camera view zenith angles sampling specular anisotropy, since 1999. Extending on previous work to model sea ice surface roughness from MISR angular reflectance signatures, a training dataset of cloud-free pixels and coincident roughness is generated. Surface roughness, defined as the standard deviation of the within-pixel elevations to a best-fit plane, is modelled using several techniques and Support Vector Regression with a Radial Basis Function kernel selected. Hyperparameters are tuned using grid optimisation, model performance is assessed using nested cross-validation, and product performance is assessed with independent validation. We present a derived sea ice roughness product at 1.1km resolution over a two-decade timespan (1999 – 2020) and a corresponding time series analysis by region. These show considerable promise in detecting newly formed smooth ice from polynyas, and detailed surface features such as ridges and leads.