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Improved method for sea ice age computation based on combination of sea ice drift and concentration

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Sea Ice Age is one of the components of the Sea Ice ECV as defined by the Global Climate Observing System (GCOS) [WMO, 2015]. It is an important climate indicator describing the sea ice state in addition to sea ice concentration (SIC) and thickness (SIT). The amount of old/thick ice in the Arctic Ocean has been decreasing dramatically [Perovich et al. 2015]. Kwok et al. [2009] reported significant decline in the MYI share and consequent loss of thickness and therefore volume.

Today, there is only one acknowledged sea ice age climate data record [Tschudi, et al. 2015], based on Maslanik et al. [2011] provided by National Snow and Ice Data Center (NSIDC) [http://nsidc.org/data/docs/daac/nsidc0611-sea-ice-age/]. The sea ice age algorithm [Fowler et al., 2004] is using satellite-derived ice drift for Lagrangian tracking of individual ice parcels (12-km grid cells) defined by areas of sea ice concentration > 15% [Maslanik et al., 2011], i.e. sea ice extent, according to the NASA Team algorithm [Cavalieri et al., 1984]. This approach has several drawbacks. (1) Using sea ice extent instead of sea ice concentration leads to overestimation of the amount of older ice. (2) The individual ice parcels are not advected uniformly over (long) time. This leads to undersampling in areas of consistent ice divergence. (3) The end product grid cells are assigned the age of the oldest ice parcel within that cell, and the frequency distribution of the ice age is not taken into account. In addition, the base sea ice drift product (https://nsidc.org/data/docs/daac/nsidc0116_icemotion.gd.html) is known to exhibit greatly reduced accuracy during the summer season [Sumata et al 2014, Szanyi, 2016] as it only relies on a combination of sea ice drifter trajectories and wind-driven “free-drift” motion during summer. This results in a significant overestimate of old-ice content, incorrect shape of the old-ice pack, and lack of information about the ice age distribution within the grid cells.

We propose an improved algorithm for sea ice age computation based on combination of sea ice drift and concentration, both derived from satellite measurements. The base sea ice drift product is from the Ocean and Sea Ice Satellite Application Facility (EUMETSAT OSI-SAF, Lavergne et al., 2011). This operational product was recently upgraded to also process ice drift during the summer season [http://osisaf.met.no/]. . The Sea Ice Concentration product from the ESA Sea Ice Climate Change Initiative (ESA SI CCI) project is used to adjust the partial concentrations at every advection step [http://esa-cci.nersc.no/]. Each grid cell is characterised by its partial concentration of water and ice of different ages. Also, sea ice convergence and divergence are used to realistically adjust the ratio of young ice / multi year ice.

Comparison of results from this new algorithm with results derived from drifting ice buoys deployed in 2013 - 2016 demonstrates clear improvement in the ice age estimation. The spatial distribution of sea ice age in the new product compares better to the Sea Ice Type derived from satellite passive microwave and scatterometer measurements, both with regard to the decreased patchiness and the shape. The new ice age algorithm is developed in the context of the ESA CCI, and is designed for production of more accurate sea ice age climate data records in the future.