The Synergy of Active and Passive Sensors for Arctic Sea Ice Monitoring

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The Arctic sea ice extent is one of the most striking indicator of global warming and climate change. On the long run and at polar ocean scale, climate modelers are forecasting a drastic reduction of the sea ice extent in summer. At most, some of these models even predict a complete ice free Arctic ocean by the end of the century. In fact, this indicator is a measure of the area of perennial (Multi-year - MY-) sea ice over the Arctic Ocean. This indicator varies from year to year and is time dependant during its annual cycle. The MY ice area is maximum at the end of the melting period, early autumn, when the remaining sea ice of the previous winter becomes, by definition, the MY ice for the new freezing period. All year long, a significant portion of this MY ice is exported from the Arctic Ocean to the Atlantic Ocean mainly via the Fram Strait or melts during summer.

On the short run and at local scale, multi-year sea ice is a proxy for sea ice thickness. This late parameter impacts both the heat budget balance and the fresh water flux to the ocean for ocean circulation models. It is thus important to be able to discriminate and monitor, as often as possible, MY from First Year (FY) ice and also to follow the sea ice drift.

Since the late 1970's, the brightness temperatures of microwave radiometer flown onboard polar orbiting satellites are used to produce daily sea ice extent and total sea ice concentration maps. These estimations are quite robust because, in this range of frequencies, the emissivity of sea ice is about twice that of sea water which enables the discrimination of ice covered areas from the open ocean. More controversial information about sea ice types have been made available. It follows that the discrimination of FY from MY sea ice areas and their winter evolutions, estimated only from radiometer data, are not reliable.

Scatterometer data are primarily designed for wind vector estimates over the oceans. Over sea ice areas, these radars provide bulk information on surface and volume scattering respectively related to the surface roughness, at the scale of the electromagnetic beam, and to the heterogeneity of the ice layers mainly due to air bubbles and brine pockets. These physical and electromagnetic properties are related to sea ice age.

Since the early 1990's, sea ice backscatter maps, at fixed incidence angle, are regularly produced. Given the sensor geometries, one week of ERS scatterometer data (1992-2000) was required to built such map. This time interval was reduced to three days for the NSCAT sensor (winter 1996-1997) and since 1999, QuikSCAT backscatter maps are produced daily.

As melt ponds occur, the radiative and backscattering properties are modified and the retrieval of sea ice geophysical parameters fails. Fortunately, the melt onset and, symmetrically, the refreezing period do not affect simultaneously these properties. Thus, using jointly radiometer and scatterometer information enables the computation of the initial extent of MY sea ice every year and its seasonal variations. Similarly, the ice drift estimations from radiometer and scatterometer data can be merged to provide an enhanced quality control, a longer seasonal time series and a better spatial distribution of the drift vectors. Examples of such improvements in MY ice discrimination and daily sea drift over the whole Arctic Ocean are presented for the period 1992-2005.