Small scale sea ice deformation during N-ICE2015: From compact pack ice to marginal ice zone

Annu Oikkonen1, Jari Haapala1, Mikko Lensu1, Juha Karvonen1, Polona Itkin2
1) Finnish Meteorological Institute, 2) Norwegian Polar Institute

1. Data
During the N-ICE2015 campaign, R/V Lance was drifting frozen into the pack ice north of Svalbard. In this study we use:
- ship radar images (resolution 12.5 m) with interval of 1 min.
- weather observations
- ice drift (calculated from the position of R/V Lance)
- distance to ice edge determined from ice charts

2. Methods

- Sea ice motion is detected from a sequence of ship radar images by Virtual Buoy (VB) tracking algorithm.
- Deformation rates are obtained by following triangles connecting VBS.
- 10 min average position of VBs are used, larger time scales (1 h, 3 h, 6 h, 24 h) are obtained as subsampling of 10 min positions.
- Different-sized triangles are formed → 6 size groups to cover length scales from 50 m to few km

3. Deformation rate - Impact of distance to ice edge
We compare daily mean deformation rates with corresponding mean wind and drift speeds. This is done separately for the days when the distance to ice edge, \( l \), was \( l < 100 \) km, \( 100 \) km \( < l < 200 \) km and \( l > 200 \) km.

4. Length and time scale dependence of deformation rate
Sea ice deformation is a highly localized and intermittent process. The deformation rate, \( \varepsilon \), follows the power law with respect to both the length (\( L \)) and time scale (\( \tau \))

\[ \varepsilon \sim L^{-\beta} \sim \tau^{\alpha} \]

With ship radar images, we can study smaller length and time scales than previously possible.

In all the scales covered:

- Length scale dependence depends on time scale:
  \[ \beta = \beta(\tau) \]
- Time scale dependence depends on length scale:
  \[ \alpha = \alpha(L) \]
  → When comparing deformation rate values, length and time scales have to be considered
  → In agreement with Rampal et al. (2008)

5. Winter data (Floes 1 and 2) is divided into three clusters with respect to distance to ice edge: \( l < 150 \) km, \( 150 \) km \( < l < 200 \) km and \( l > 200 \) km. Then, the length scale dependence analyses are repeated.

When going deeper into the ice pack, both the level and the length scale dependence of deformation rate decrease.

- Decrease in the magnitude of \( \beta \): internal stresses are transmitted over longer distances

3) Marsan, D., H. Stern, R. Lindsay, and J. Weiss (2004), Scale dependence and localization of the deformation of Arctic Sea Ice, Phys. Lett. 93, 17, 178501.