Fine scale motion tracking of sea ice over central Arctic using TerraSAR-X data

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MOSAiC: Multidisciplinary drifting Observatory for the Study of Arctic Climate

In recent years, sea ice in the Arctic Ocean has undergone significant changes. Multiyear ice has been replaced by seasonal ice, and ice covered areas have been replaced by lead areas, partially [1].

To better understand the impact of the Arctic to the global climate, Alfred Wegener Institute (AWI) initialized the MOSAiC expedition. On 20 Sept 2019, the research icebreaker Polarstern departed from Tromsø in Norway to spend a year drifting with the sea ice across the central Arctic. To support the expedition, the DLR provides space borne Synthetic Aperture Radar (SAR) images acquired by the satellite TerraSAR-X over the study area around Polarstern [2].


TerraSAR-X radar satellite image from 17 Nov 2019, showing a major fracture zone after a major storm event
Basic principle of sea ice motion tracking

- **Aim**: Observe fine scale discontinuities in sea ice motion fields, i.e. convergence and divergence zones
- **Apply** phase correlation within a resolution pyramid\(^3\):

```
\[\text{Co-registered TS-X ScanSAR} \\
24.03.2018 17:11 UTC \]
\[\text{TerraSAR-X ScanSAR} \\
26.03.2018 16:36 UTC \]
```

```
\text{Co-registration} \\
\downarrow \\
\downarrow \\
\text{Downscaling} \\
\downarrow \\
\text{Create patch } g(x, y) \\
\downarrow \\
\text{Hann filter} \\
\downarrow \\
\text{FFT} \\
\downarrow \\
\text{Phase correlation} \\
\downarrow \\
\begin{cases} 
\text{Drift vector update } (u' + u, v' + v) \\
\text{no} \\
\text{yes} \\
\text{Last resolution level?} \\
\end{cases} \\
\downarrow \\
\text{Half scaling factor} \\
\downarrow \\
\begin{cases} 
\text{no} \\
\text{yes} \\
\text{Drift vector} \\
\end{cases} \\
```

Basic principle of sea ice motion tracking

Co-registered TS-X ScanSAR
24.03.2018 17:11 UTC

TerraSAR-X ScanSAR
26.03.2018 16:36 UTC

patch g(x, y) after Hann filter

patch h(x-u, y-v) after Hann filter

MOTION ESTIMATION

1\textsuperscript{st} res. level:
24 km x 24 km

2\textsuperscript{nd} res. level:
12 km x 12 km

3\textsuperscript{rd} res. level:
6 km x 6 km

4\textsuperscript{th} res. level:
3 km x 3 km

~48 hours later
Basic principle of sea ice motion tracking

The analysis of drift fields allows to assist navigation in polar waters by:

- Localizing converging and diverging ice areas,
- Identifying regions of compressing ice, which might form ice ridges,
- Identifying open water leads that are likely to open up or close.
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On the first view:
- Approx. 100% ice coverage
- Homogeneous drift of homogeneous ice
- Average sea ice drift: 400 m/h

Looking more detailed into it:
- Multiple small scale discontinuities i.e. convergence and divergence zones
- These discontinuities become visible due to the high resolution of the underlying image (17 m) and the drift field (250 m)

The authors would like to thank to the MOSAiC Remote Sensing team. Data were acquired through TerraSAR-X data account suman_OCE3562.