CIMR: a new low frequency microwave radiometer for an all-weather, high spatial resolution, and accurate estimation of ocean and sea-ice parameters.

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CIMR is a High Priority Candidate Mission for Copernicus expansion designed to respond directly to the Integrated EU Arctic Policy.

- **CIMR** will provide:
  
  **First priority**
  - Sea Surface Temperature (SST)
  - Sea Ice Concentration (SIC)
  
  **Second priority**
  - Sea Surface Salinity (SSS)
  - Ocean Wind Speed (OWS)
  - High Ocean Wind Speed (HOWS)
  - Sea Ice Thickness (SIT) (below 0.8 m)

And many other parameters...
Motivation

Current situation
- SST derived from IR under clear sky (<40% globally)
- SIC derived from VIS under clear sky and daylight only
- SST, and SIC derived from microwave sensors under cloudy condition and at night (e.g., AMSR2)
- SSS, HOWS and SIT derived from SMOS and SMAP

Limitations so far
- Microwave SST and SIC at low spatial resolution (~50 km using 6 GHz) and limited accuracy.
- No guarantee of continuation of the measurements for any of these products, with 6 and 1.4 GHz.
Applications of the CIMR mission

Numerical Weather Prediction

Climate models

Study mesoscale variability heat, and energy transport

Ship and offshore operations

Understanding marine ecosystem variability

Air/sea interaction Physical and biogeochemical
CIMR instrument concept

- Passive microwave conically scanning imager ($55^\circ$)
- **5 channels** with dual polar (full polar?) receivers and RFI mitigation
- Very low noise receivers
- ~7 m mesh Large Deployable Reflector
- Full coverage of the poles (no hole)
- Sun synchronous polar orbit (close to MetOp-SG B)

<table>
<thead>
<tr>
<th>Priority</th>
<th>secondary</th>
<th>primary</th>
<th>primary</th>
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<tbody>
<tr>
<td>Frequency (GHz)</td>
<td>1.4</td>
<td>6.9</td>
<td>10.65</td>
<td>18.7</td>
<td>36.5</td>
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<tr>
<td>Footprint (km)</td>
<td>$\leq 55$</td>
<td>$\leq 15$</td>
<td>$\leq 15$</td>
<td>$\leq 5$</td>
<td>$\leq 5$</td>
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<tr>
<td>NeDT (K)</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.7</td>
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</tbody>
</table>

*Figures from CIMR mission requirements document*
Sea Surface Parameter Retrieval

Sea Surface Temperature
- Better spatial resolution (from 48 to \(\leq 15\) km)
- Better cover of coastal areas (down to 20 km)
- Higher retrieval precision (around 0.2 K)
- Account for the wind speed from MetOp-SG B

Sea Surface Salinity
- High radiometric sensitivity to provide a theoretical precision of \(~0.3\) psu instantaneously
- Coincident analysis of the SST, OWS, SIC, and SSS
- Spatial resolution of \(\leq 55\) km but possibility to benefit from the oversampling at 1.4 GHz.

High Ocean Surface Wind Speed
- Unique estimation of the high surface wind speed with the 1.4 GHz (in addition to regular OWS...).
Sea Surface Temperature Retrieval

- The spatial resolution and the precision of the SST retrieval are largely improved with CIMR ($\leq 15$ km and 0.2 K) compared to AMSR2 (48 km and 0.35 K)

From careful information content analysis built upon up-to-date radiative transfer and realistic hypothesis
• SST retrieval precision is improved especially for cold water where the retrieval is difficult.
• Improvement close to the coasts and sea ice margins.
• SSS precision is improved (0.3 psu) due to the CIMR low noise receivers and to the better sensitivity to SSS at 55° incidence angle.
• The spatial resolution is large (≤55 km) due to the incidence angle of 55° needed to cover entirely the poles.
Sea Ice Parameter Retrieval

19 + 37 GHz

6 GHz V

Sea Ice Concentration

- Retrieval with 18 GHz and 36 GHz combination at better spatial resolution.
- Retrieval including the 6 GHz performs best with less atmospheric contamination.
- Better coverage of coastal areas

Thickness of thin sea ice

- at 1.4 GHz
- Demonstrated with SMOS and SMAP
Sea Ice Concentration Retrieval

- Improved spatial resolution (≤5 km) and possibility to analyse the ice margin
- SIC retrieval precision is around 5 % when including the low frequencies
- Refinement of the retrieval under way to benefit from:
  1. the high sensitivity of the low frequencies
  2. the high spatial resolution of the high frequencies
CIMR products

- All-weather global retrievals, twice daily
- SST with 0.2 K precision at \( \leq 15 \) km spatial resolution
- SSS with a precision of 0.3 psu instantaneously at \( \leq 55 \) km spatial resolution
- SIC with 5% precision at \( \leq 5 \) km spatial resolution
- Coincident SST, SSS, OWS, HOWS, SIC, and SIT

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Spatial resolution (km)</th>
<th>Precision (instantaneously)</th>
<th>Time sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Surface Temperature</td>
<td>( \leq 15 )</td>
<td>0.2 K</td>
<td>Twice daily</td>
</tr>
<tr>
<td>Sea Surface Salinity</td>
<td>( \leq 55 )</td>
<td>0.3 psu</td>
<td>Twice daily</td>
</tr>
<tr>
<td>Sea Ice Concentration</td>
<td>( \leq 5 )</td>
<td>5 %</td>
<td>Twice daily</td>
</tr>
</tbody>
</table>
CIMR: Conclusion

- Measurements of key oceanic variables for meteorology, oceanography, and climate analysis, with unique synergies.

- A design for the observations of polar regions.

- All weather products, with better quality and/or spatial resolution, and available close to the coasts.

- With no guarantee of continuation of low frequency measurements (after AMSR2, SMOS, and SMAP), it will insure continuity, with much improved products.

- An innovative instrument with low noise radiometers and a large deployable antenna.

- Publication
Thank you for your attention!