CIMR over sea ice

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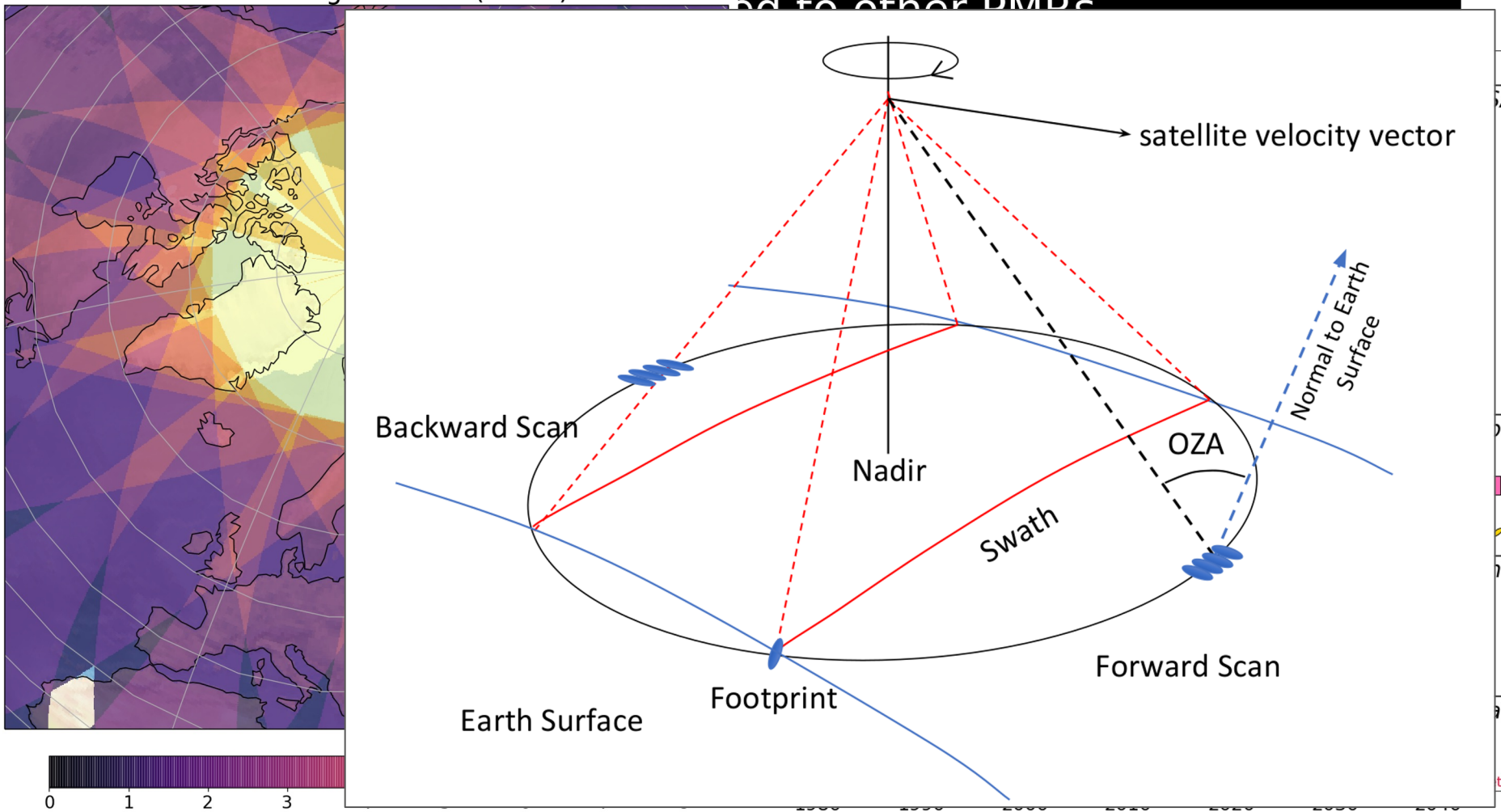
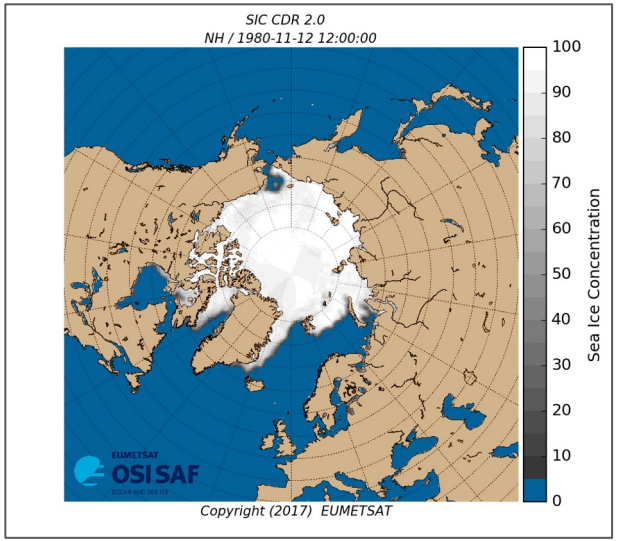
Polar coverage of CIMR (Arctic)



0 1 2 3

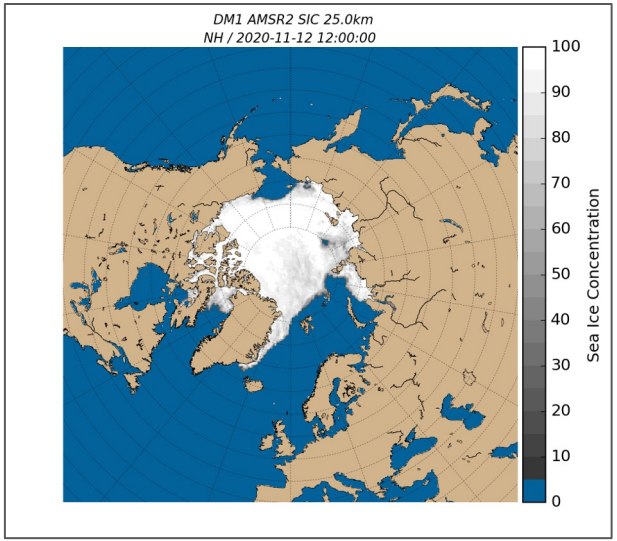
Number of revisits in 24 hours

Source: WMO OSCAR (https://www.wmo-sat.info/oscar/)



nov. 1980

Sea Ice Concentration

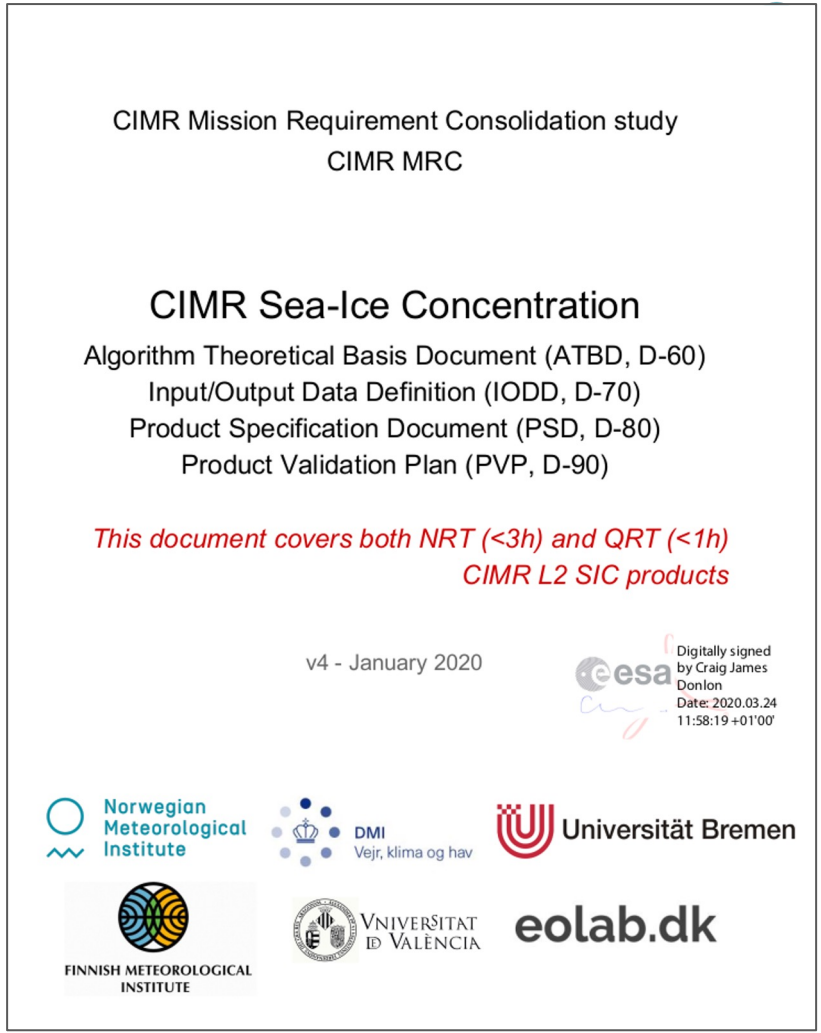


nov. 2020

CIMR L2 Sea Ice Concentration

- ATBD for L2 SIC were prepared for CIMR NRT3H product (and NRT1H).
- Several channel combinations were tested, including one based on Ku/Ka (best resolution) and one based on C,X,Ku,Ka (ok resolution, better accuracy).
- SIC algorithms further tested in CIMR End-to-Eend simulator (Jimenez et al 2021).

Jiménez, C., Tenerelli, J., Prigent, C., Kilic, L., Lavergne, T., Skarpalezos, S., et al. (2021). Ocean and sea ice retrievals from an end-to-end simulation of the Copernicus Imaging Microwave Radiometer (CIMR) 1.4–36.5 GHz measurements. JGR - Oceans, 126, e2021JC017610. https://doi.org/10.1029/2021JC017610

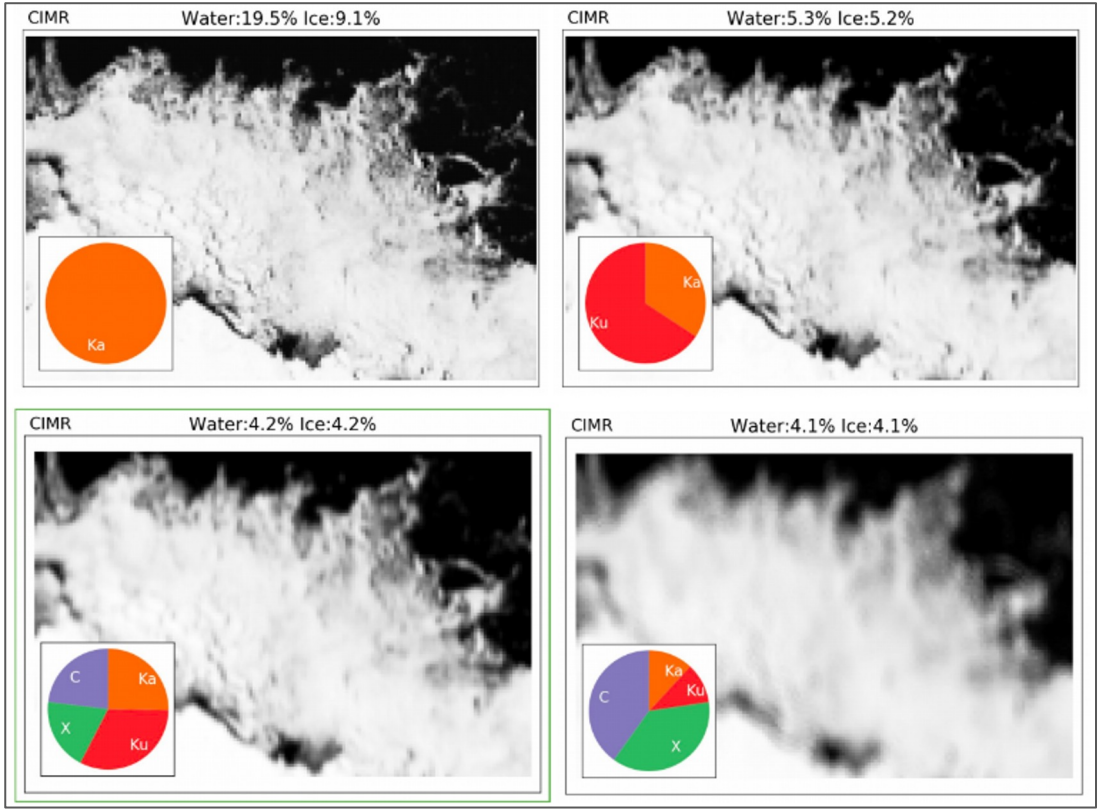


Testing channel combinations

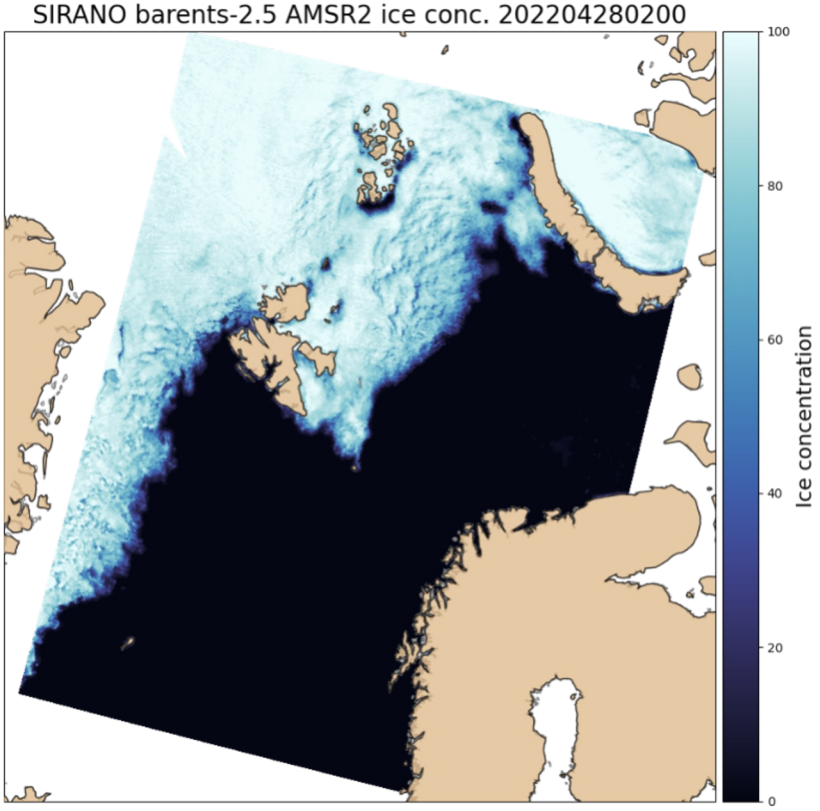
Spatial resolution degrades rapidly when using C and X band imagery.

Some algorithms with all channels are good compromise, but their resolution is coarser than the SIC algorithms based on Ku/Ka band.

Still some R&D to be performed with pan-sharperning methods (on-going in ESA CCI+ and NFR SIRANO).



A regional AMSR2 SIC product using pan-sharpening



- From R&D in ESA CCI+ and NFR SIRANO projects, MET Norway developed a regional 2.5 km SIC product for assimilation in our ocean+ice forecast model.
- The product is based on the AMSR2 mission, and uses the 89 GHz channels + a pan-sharpening algorithm.
- This is typically where CIMR would provide more accurate SICs “out-of-the-box” thanks to the 18.7 and 36.5 GHz channels.

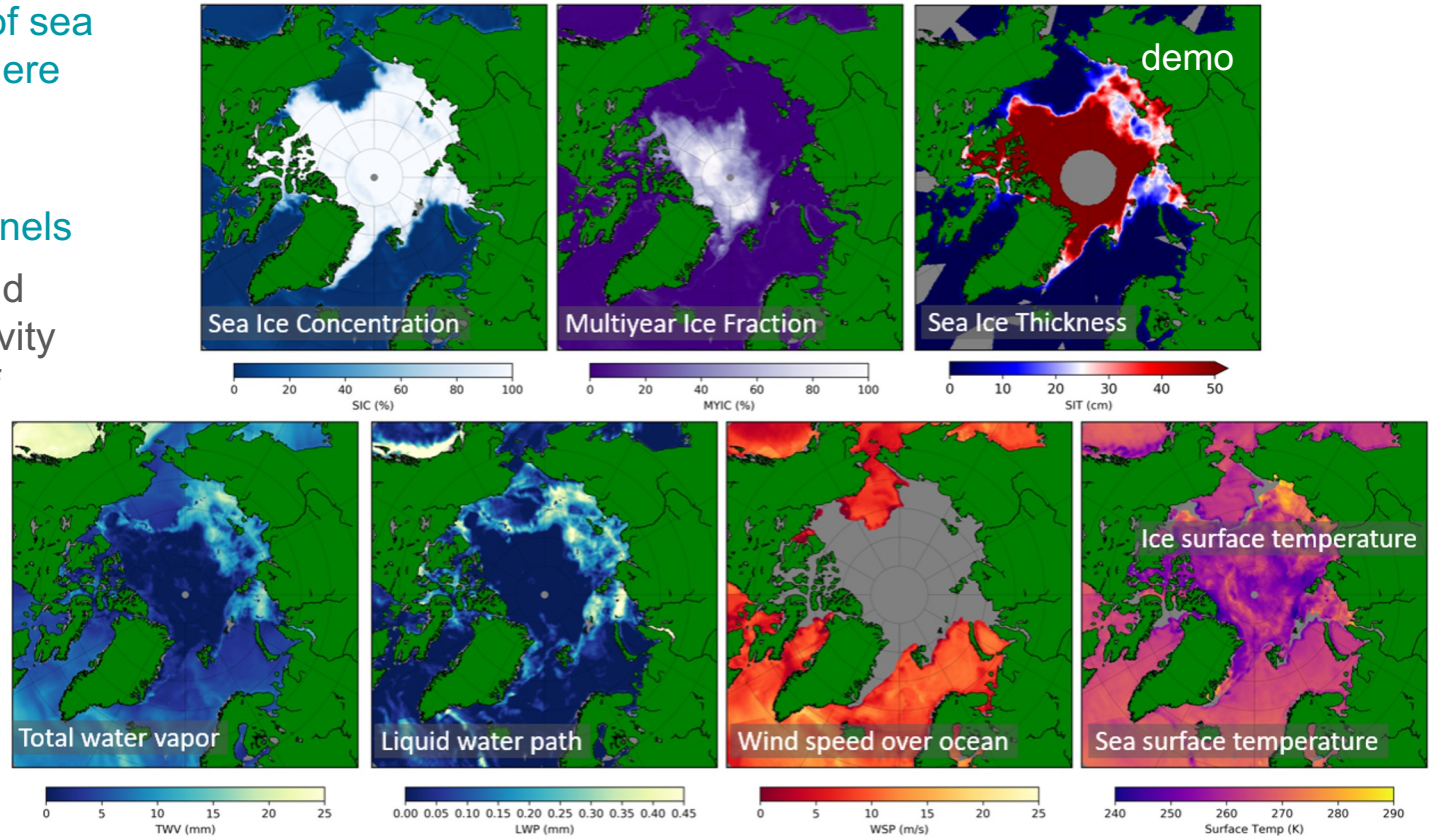
Another promising route for CIMR : OEM retrievals for sea ice

- Toudal Pedersen, PhD thesis 1991 : multi-freq retrieval of (SIC, MYIF, SST, Tair, WS, WV, TCLW) from Nimbus-7 SMMR (C -> Ka).
- IOMASA, ESA CCI Phase 1, now Scarlat et al., etc…
- They work well, and can be further refined towards CIMR :
  - better sea-ice emissivities (simplified physically-based models, e.g. based on MOSAiC)
  - handling of FoVs (resolution and pointing), 2DVar
- We will also work on combining the OEM and SIC retrieval algorithms, e.g. use the coarse-resolution OEM fields as a-priori / first-guess to the retrieval algorithms (work in the ESA DEVALGO project).

OE Multiparameter Retrieval

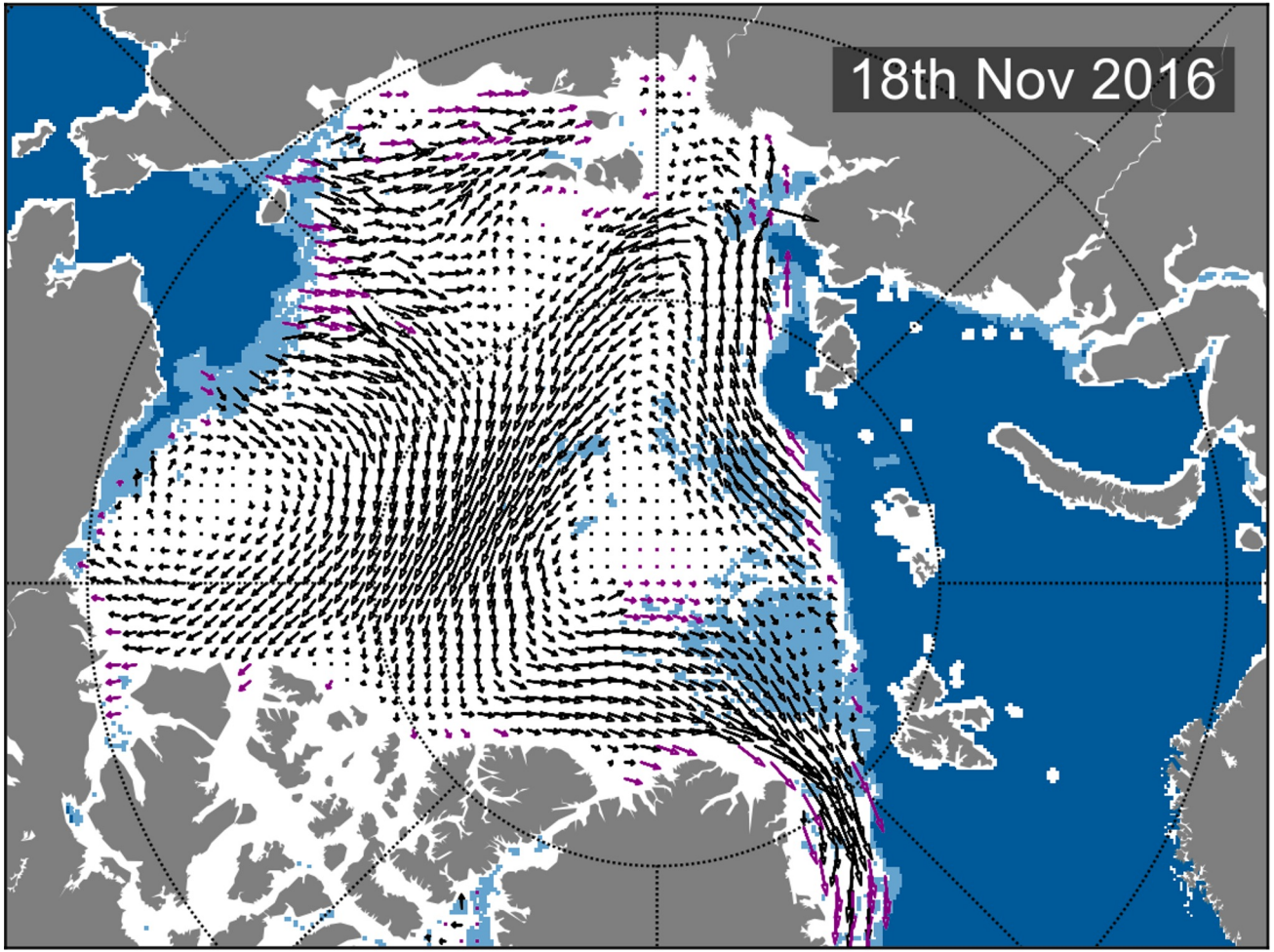
University of Bremen

- Simultaneous retrieval of sea ice, ocean and atmosphere properties using optimal estimation (OE)
- Using all available channels
- Physically consistent and adaptive surface emissivity allows better retrieval of atmospheric properties
- Here shown for JAXA's AMSR2 MW radiometer (7 – 89 GHz) + SMOS (1.4 GHz)



6 Nov 2019

Scarlat et al., JGR, 2020



Zone: Arctic Ocean / Image: Copyright (2016) EUMETSAT

Sea Ice Drift

CIMR L2 Sea Ice Drift

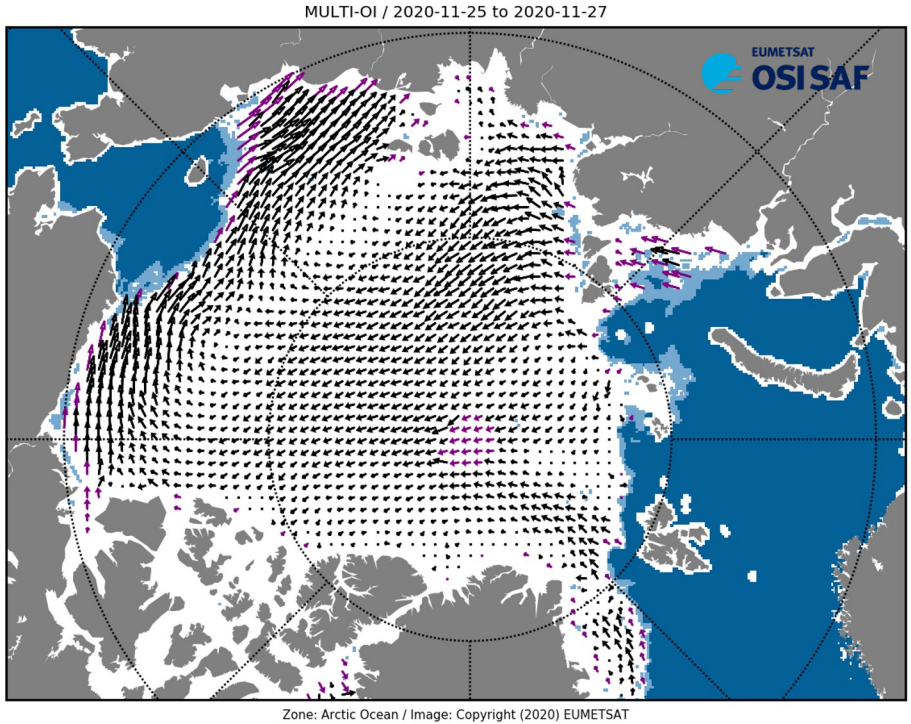
- The CIMR L2 sea-ice drift will be a game-changer thanks to:
  - The CIMR instrument itself (resolution, swath width, etc...);
  - Processing at Level-2 (similar missions have sea-ice drift only at L3);

- During the CIMR Mission Requirement Consolidation study, we developed the v0 algorithm.

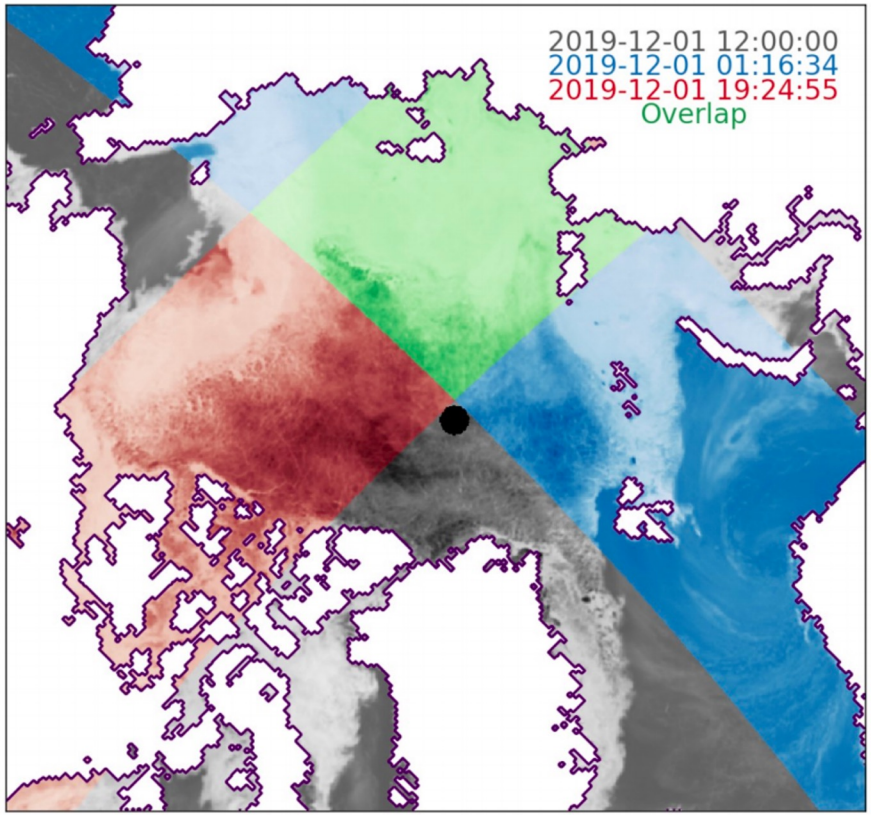
- A manuscript was published, investigating the proposed L2 approach using AMSR2 data.

Lavergne, T., Piñol Solé, M., Down, E., and Donlon, C.: Towards a swath-to-swath sea-ice drift product for the Copernicus Imaging Microwave Radiometer mission, The Cryosphere, 15, 3681–3698, https://doi.org/10.5194/tc-15-3681-2021, 2021.

Sea-ice drift : L2 vs L3



Everyone (OSI SAF, IFREMER, JAXA, NSIDC) does **L3** drift from PMRs : daily Tb maps, then daily drift vectors.



With CIMR we want to do **L2**: drift at the overlap of two swaths (green).

Sea-ice drift : advantages of L2

1) **Timeliness** : process and distribute a new product as soon as a L1 file is available (instead of once a day).

2) **Number of vectors**:

~50,000 vectors / day for L2, instead of ~1000 for L3.

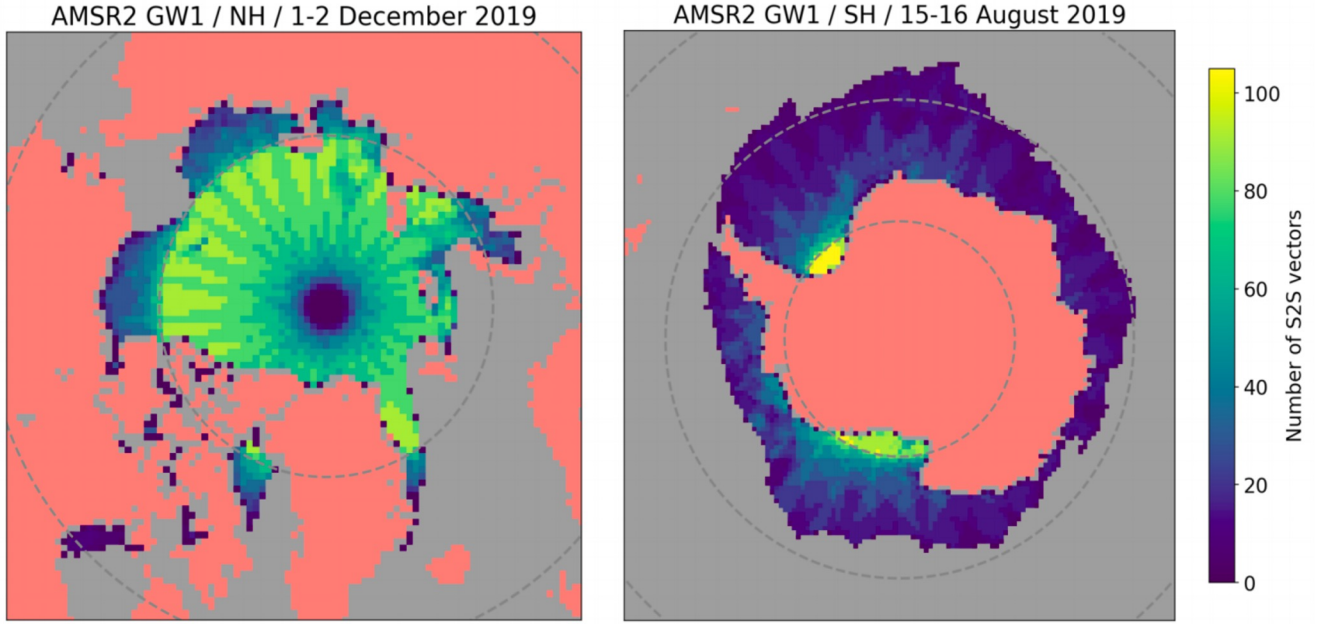
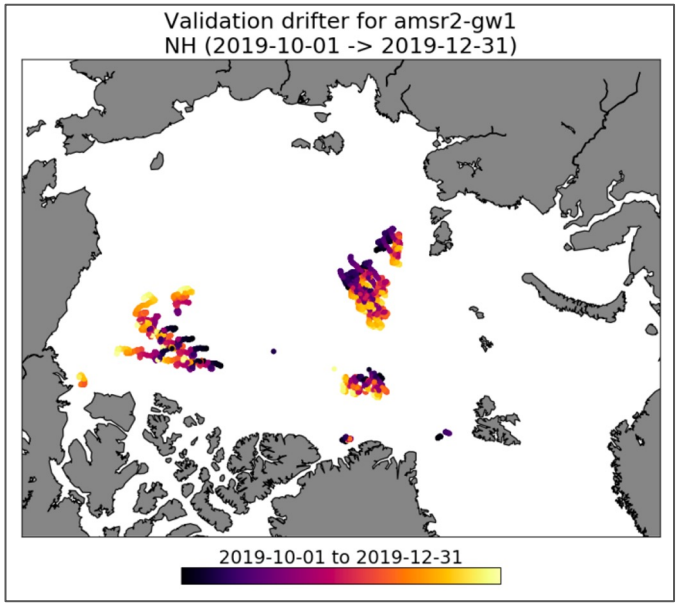


Figure 3: Left: number of S2S vectors per grid cell in the Northern Hemisphere for the period 1-2 December 2019 and GCOM-W1 AMSR2 mission. Right: same quantity but for the Southern Hemisphere and for the period 15-16 August 2019. Parallels at +/- 75 and +/-60 are drawn.

Sea-ice drift : advantage

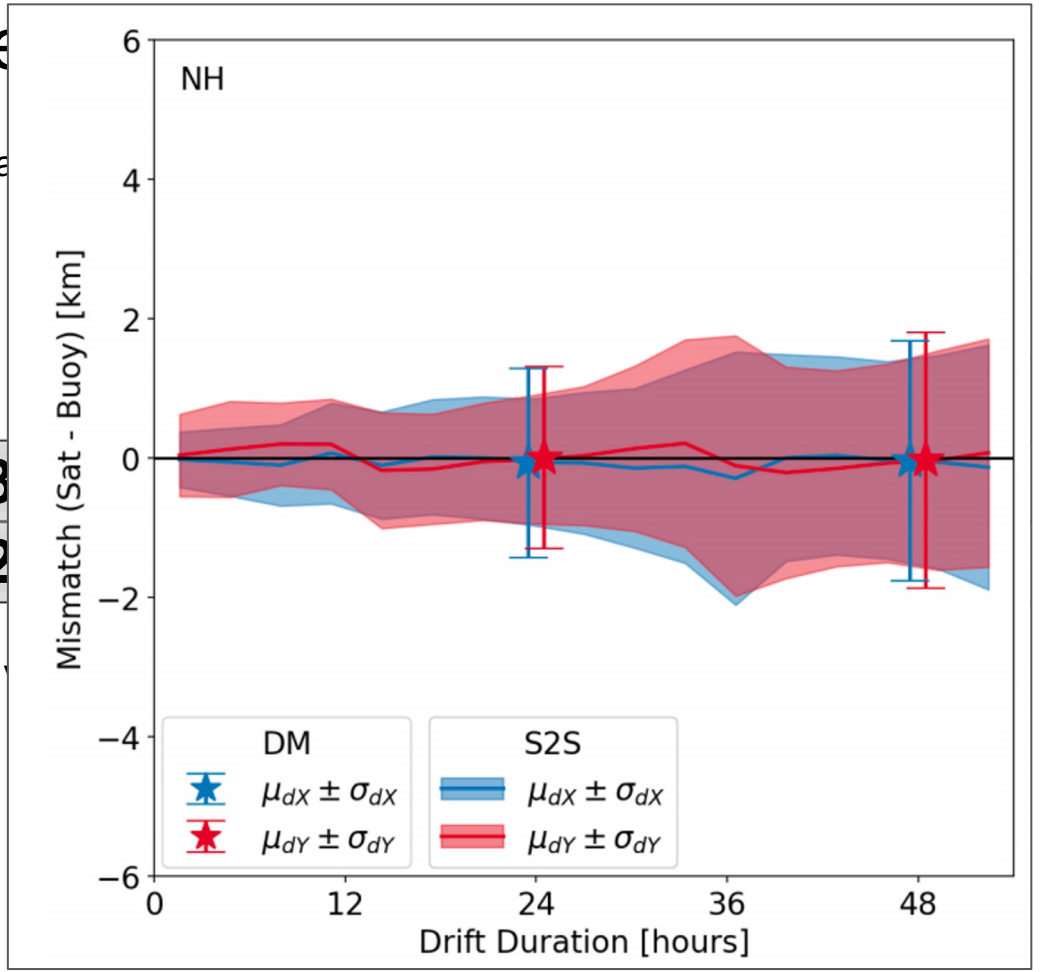
3) Accuracy : the L2 vectors have better accura



L3

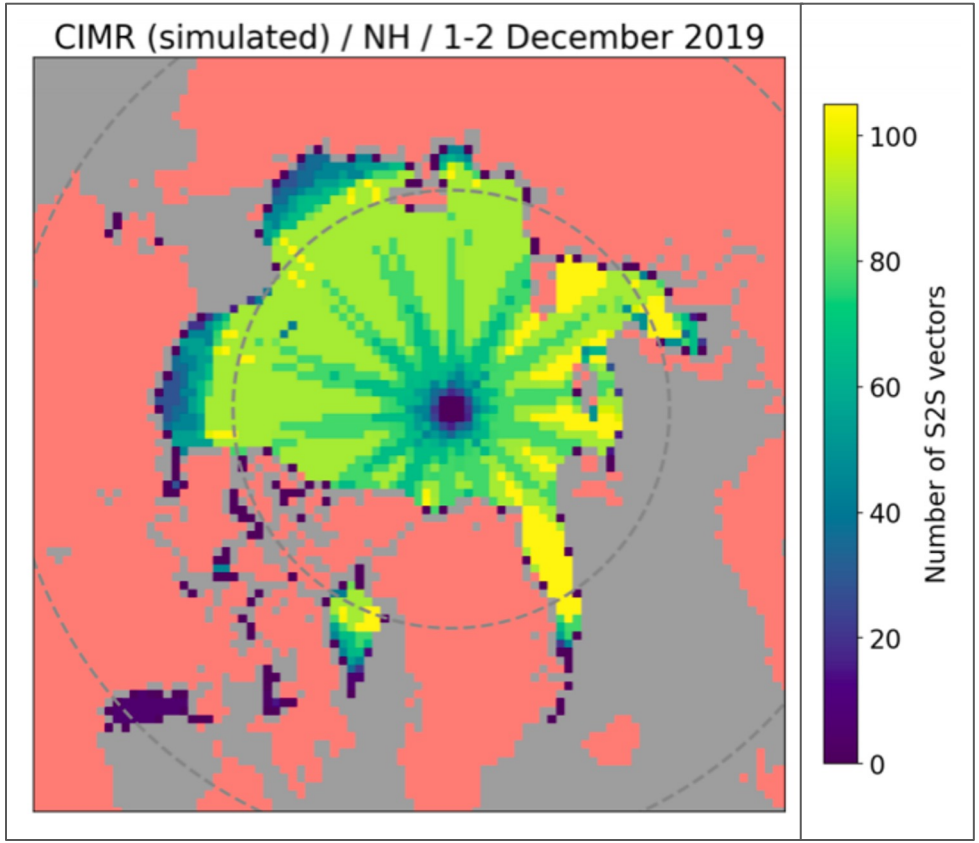
L2

L2 v



L2 vectors are more accurate across all drift durations (100 min to 52 hours).

Sea-ice drift : CIMR vs AMSR2



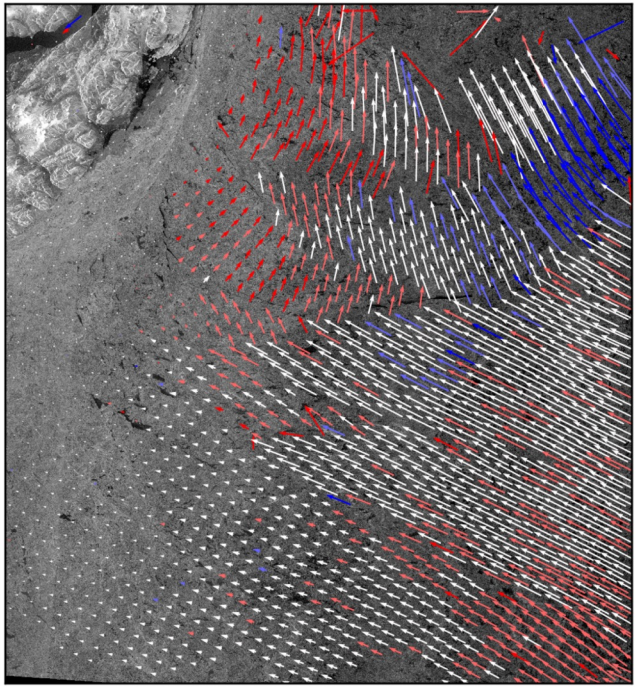
<= We simulated CIMR swath coverage to document the increase in number of L2 vectors for CIMR, e.g. impact of “no hole at the pole”.

Key advantages of the CIMR mission :

- swath width (see Fig.)
- 5 km at Ku and Ka:
  - Ka much better than 89 GHz (AMSR2);
  - Ku will help during summer melt;
- backward scan will be used to QC the vector field (four independent quasi-simulateous drift vectors).

Sea-ice drift : way forward and R&D needs

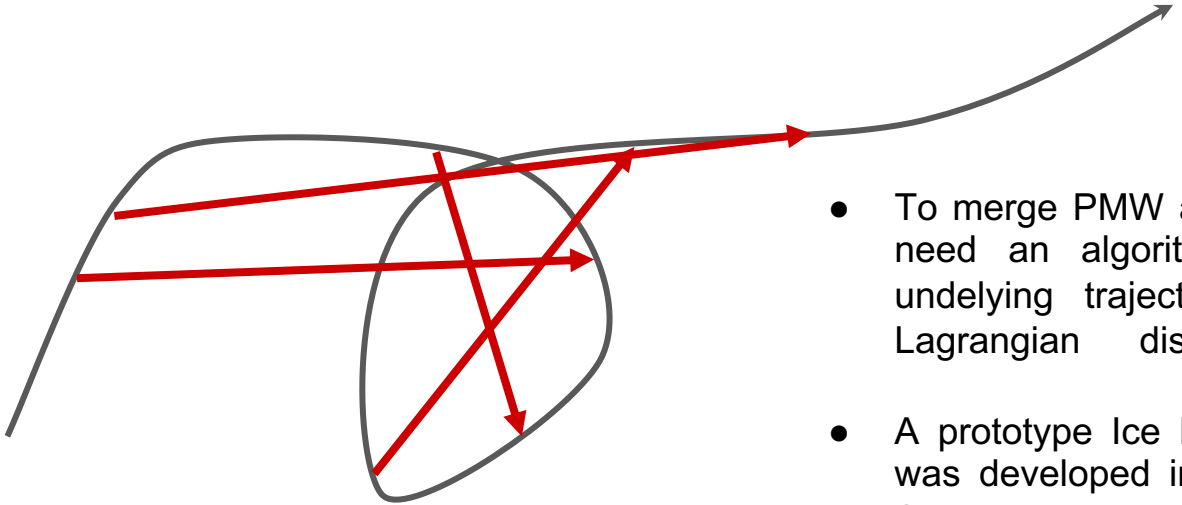
- We are developing next version of the CIMR algorithms in the ESA DEVALGO project (2022-2024).
- Uncertainties : today's uncertainty propagation for sea-ice drift (whether L3 or L2) is in its infancy.
- How to use of CIMR backward view for QC.
- Trade-off between number of vectors and timeliness of the product => dimensioning ground segment.
- In the Copernicus Services (CMEMS):
    - develop daily L3 mosaics from CIMR L2 products;
    - develop synergy mosaic (CIMR, S1, ROSE-L).



Example high-resolution sea-ice drift field from Sentinel-1 SAR (Korosov and Rampal, 2017)

Sea-ice drift : merging PMW and SAR

- Merging sea-ice drift vectors from PMW and SAR is not straightforward:
  - Spatial resolution aspects;
  - Temporal aspects.



- To merge PMW and SAR vectors together we need an algorithm that can re-create the undelying trajectory from a series of (net Lagrangian displacement) drift vectors.
- A prototype Ice Drift Analysis (IDA) algorithm was developed in ESA CCI with the German SME iLab, but would need to be revisited for PMW + SAR.

Conclusions

- The Copernicus Imaging Microwave Radiometer (CIMR) mission will be a game-changer for sea-ice remote sensing.

- It will bring the legacy passive-microwave L2 products to a much increased spatial resolution and revisit time. Here illustrated with Sea Ice Concentration and Drift variables.

- Synergy with other missions (incl. Sentinel-1 SAR and ROSE-L) must be developed.

- MET Norway, together with partner institutions in Europe, are now developing open source ATBDs for key CIMR products (CIMR DEVALGO, 2022 - 2024).