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IMPROVING SEA-ICE REPRESENTATION THROUGH DATA ASSIMILATION IN A GLOBAL NEMO MODEL

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ABSTRACT

- Objective 1 : to improve the estimation of **sea-ice** volume through **data assimilation**.
- Objective 2 : to develop the future **operational** multi-variate and multi-data sea ice analysis system.

- Data assimilated : **radar freeboard**.

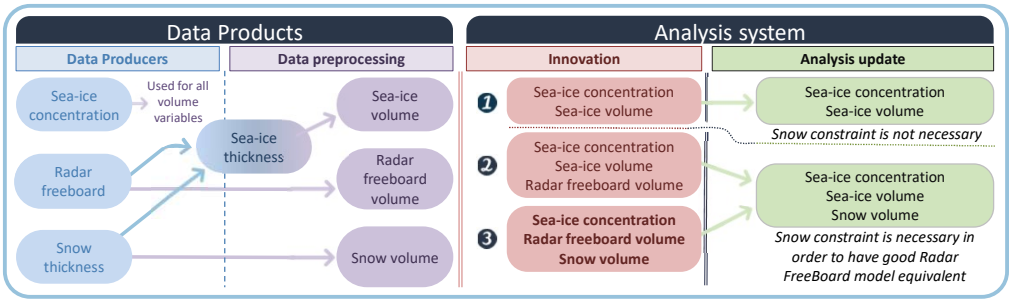
Radar freeboard is linearly dependent on sea-ice thickness and snow depth.

Different assimilation methods are described :

- Intermediate experiment (method 1) assimilating concentration and a sea-ice volume built from LEGOS radar freeboard and Warren 99 modified climatology snow depth.
  - Results show more small scale patterns;
  - Comparison with assimilated and independent datasets show better result.
- **Method 3** is favoured over methods 1 and 2
  - **Direct radar freeboard assimilation**;
  - independent datasets available in **both hemispheres**;
  - Snow constraint with new **snow depth** measurements.

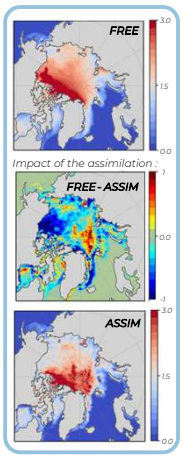
MULTIDATA ASSIMILATION METHODS

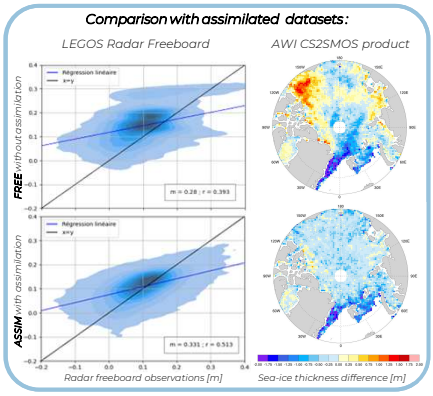
As various sets of data products are available, there are also various methods possible to constraint the sea-ice volume thanks to radar freeboard data.

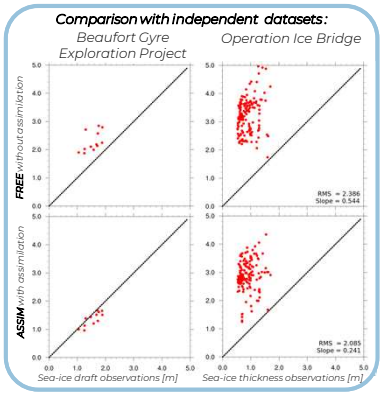


RESULTS : METHOD 1

- Short 3-month test experiment with the assimilation method 2 (Jan → March 2011).



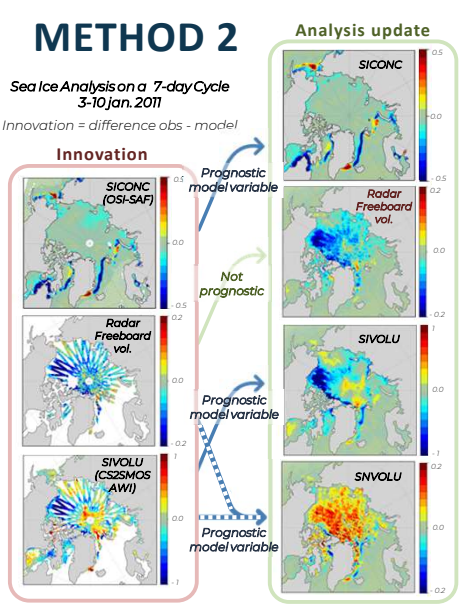




METHOD 2

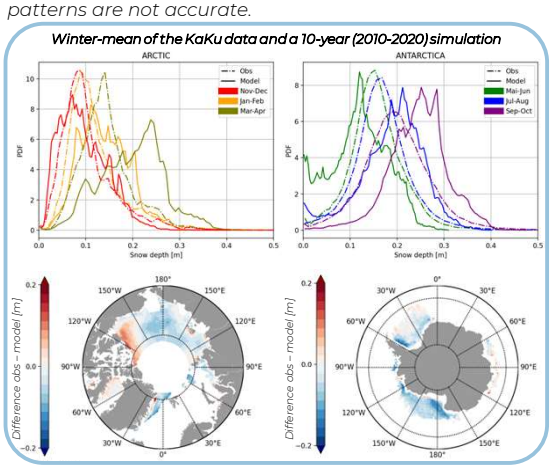
Sea Ice Analysis on a 7-day Cycle
3-10 jan. 2011

Innovation = difference obs - model



METHOD 3

- Preliminary results for the implementation of method 3.
- Snow depth data has a good consistency with the thickness distribution in the model, but the spatial patterns are not accurate.



OPERATIONAL SYSTEM

MODEL

- Ocean : NEMO 3.6
- Sea-ice : LIM3, multicategories
- Global ¼° grid
- ERA5 atmospheric forcing (1h)

ASSIMILATION

- Analysis based on a 2D local multivariate Sigular Evolutive Extended Kalman filter (SEEK).
- 7-day cycle ;
- 2 separate analysis :
  - Ocean Analysis (SLA, SST, in situ data)
  - **Ice Analysis : sea-ice concentration** from the OSISAF products (Ocean and Sea-Ice Satellite Application Facility) & **radar Freeboard**. (see beside : ongoing work)

SATELLITE DATA

SEA-ICE CONCENTRATION

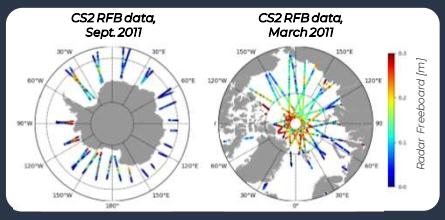
- EUMETSAT OSI-SAF OSI-401 daily product, using DMSP/SSMIS microwave measurements.
- Product used in the operational system.

RADAR FREEBOARD

- Altimetric along tracks satellite measurement, processed by LEGOS (Guerreiro et al., 2017).
- Satellite CryoSat-2 (since 2010).
- RFB = a·· Hice + b · Hsnow

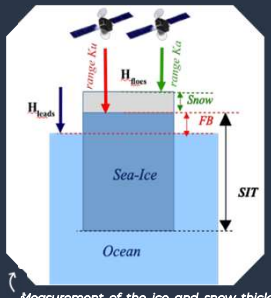
(a and b depending on the water, sea-ice and snow densities).

- Only available in winter up to now.



Snow depth KaKu

- Monthly gridded dataset, produced by LEGOS, using 2 types of altimetric measurements (Garnier et al. 2020).
- Ku band from CryoSat-2, since 2010.
- Ka band from SARAL, since 2013.



Measurement of the ice and snow thicknesses with satellite altimetry through the difference in altitude between the surfaces of the leads and the floes.

References : Garnier, F., Fleury, S., Garric, G., Bouffard, J., Tsamados, M., Laforge, A., Bocquet, M., Fredensborg Hansen, R. M., and Rémy, F.: Advances in altimetric snow depth estimates using bi-frequency SARAL/CryoSat-2 Ka/Ku measurements, The Cryosphere Discuss. [preprint], https://doi.org/10.5194/tc-2021-79, 2021. Guerreiro, K., Fleury, S., Zakharova, E., Kouraev, A., Rémy, F., Maisongrande, P., 2017. Comparison of CryoSat-2 and ENVISAT radar freeboard over Arctic sea ice: toward an improved Envisat freeboard retrieval. The Cryosphere 11, 2059–2073. https://doi.org/10.5194/tc-11-2059-2017.