Détection et Caractérisation de la glace de mer dans les echos SWIM

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Objective

o Feasibility to integrate a « sea ice/ water » flag at L1a level , and define/prototype an « ice product » from other levels

oWork at radar gate measurements (~20m rg x 18 km az)

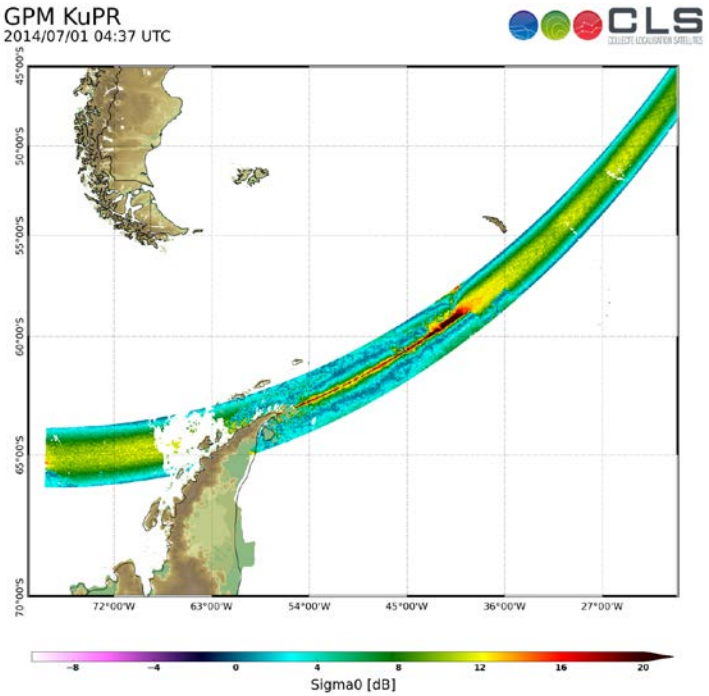
- One measurement at one given incidence angle
- Possibility to provide water/ice flag detection only

o Work at a new « Ice cell » level depending on spatial/temporal aspect and user interest

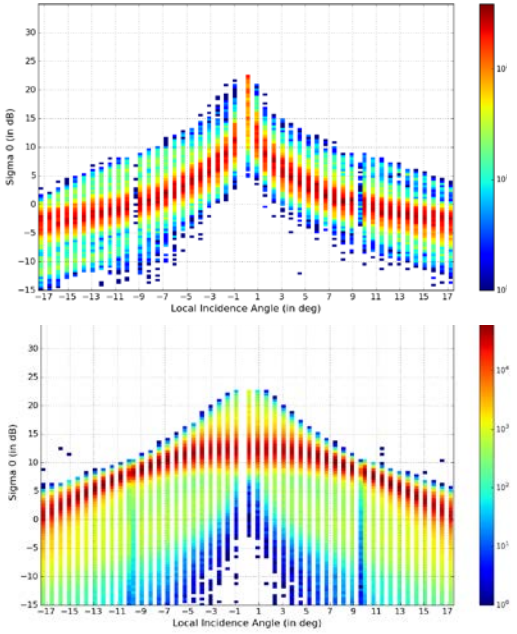
- Multi-angular approach possible either based on single data acquisition or multi-temporal data acquisitions – do we need good temporal or spatial sampling ?
- Possibility to get more than a « simple » water/ice flag and attempt to characterize sea ice

Sea Ice Flagging

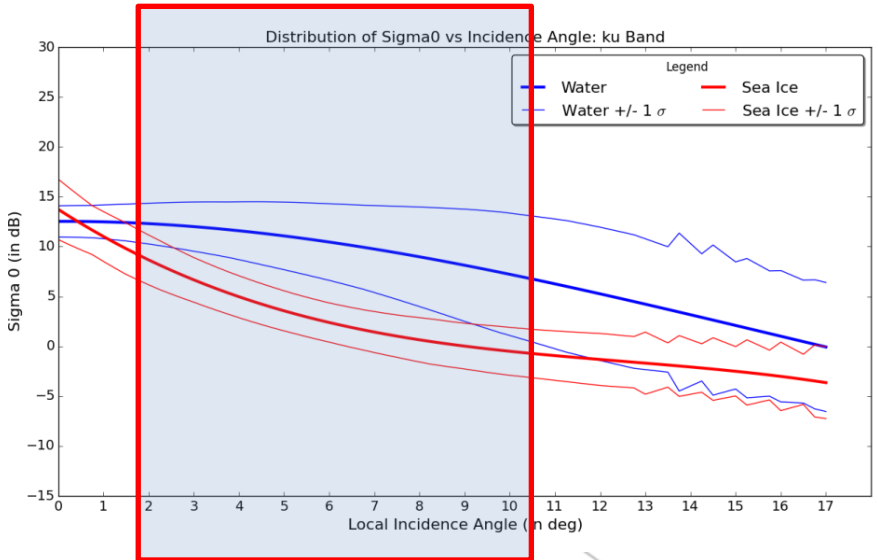
What has been already demonstrated



Massive collocation between OSISAF sea ice products and GPM KuPR



Need for improving sea ice and open water distribution with a priori information



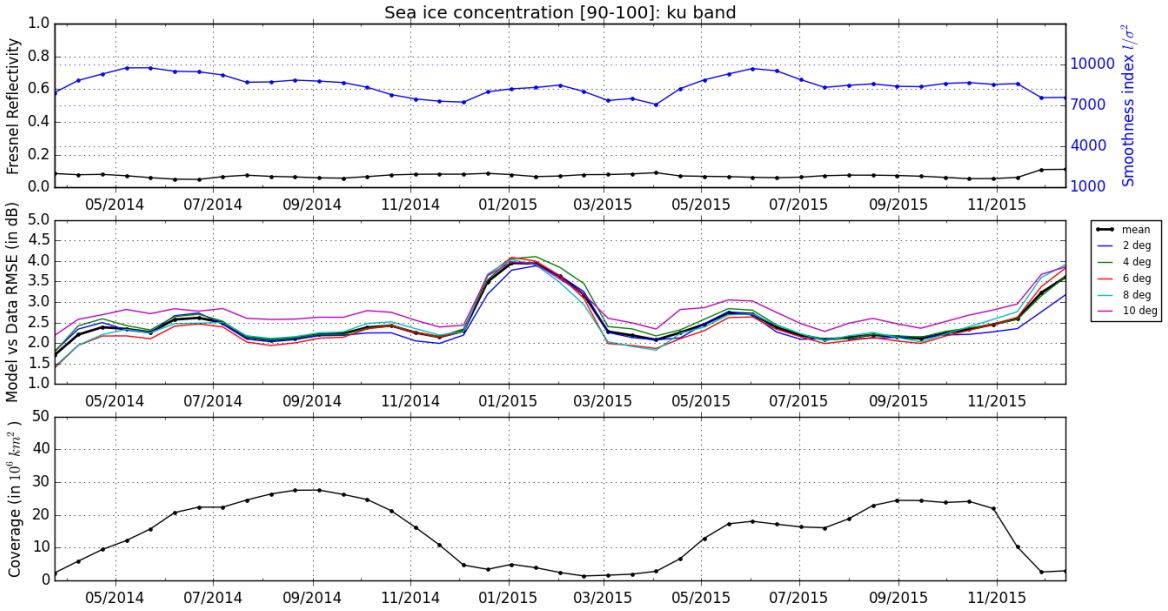
Attempt to build a SeaIce GMF

Following (Kurtz et al, 2014) (Hagfors et al. 1970), valid if:

- Correlation length larger than Electromagnetic wavelength, $l > \lambda$,
- Radius of curvature of the surface large with respect to the wavelength $\frac{l}{2h\sqrt{\pi/6}} > \lambda$

$$\sigma^0(\phi) = \left(\frac{R_0}{2cos^6(\phi)}\left(\frac{l}{2k_0h_m^2}\right)^2\right)\left[1+\left(\frac{l}{2k_0h_m^2}\right)^2 \sin^2\phi\right]^{\frac{-3}{2}}$$

Investigate seasonal variation for pack ice (SIC > 90%) in the Weddell sea



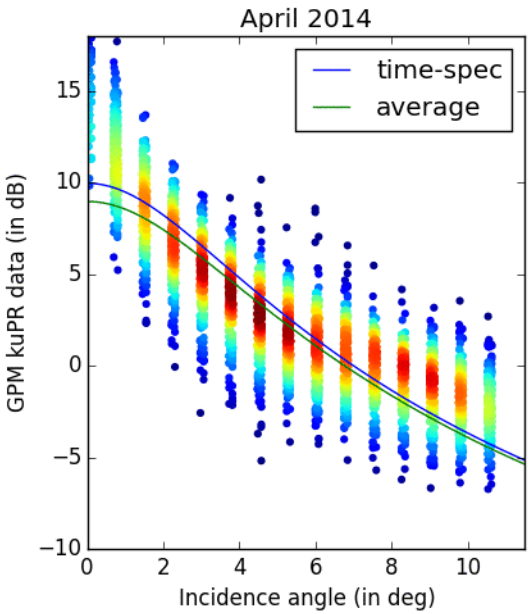
Temporal variability of retrieved parameters (Increase of roughness in winter)

Goodness of fit equivalent for all SWIM beam, except 10°

Kurtz et al, «An improved CryoSat-2 sea ice freeboard retrieval algorithm through the use of waveform fitting", The Cryosphere, 8, 1217–1237, 2014

Attempt to build a Sealce GMF

Goodness of fit of the Kutz Model
-Using a month-specific fit on R0 and smoothness parameters
-Using the average values of these fits

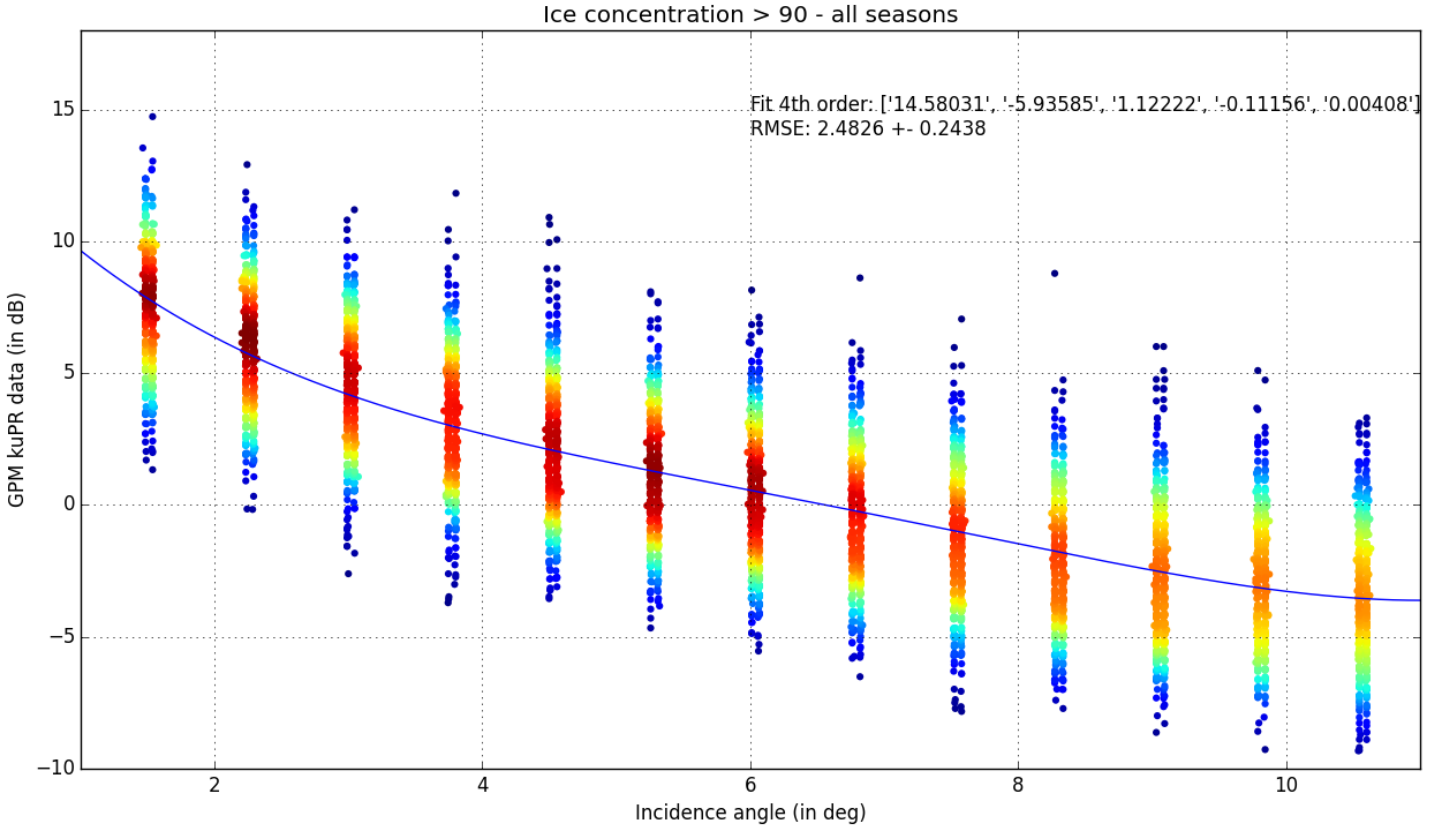


-Fits are generally good (RMSE < 3dB) even though:
- Dynamic at nadir not well represented by the model as fit is performed from 1 to 11 deg
- Goodness of fit variable at large incidence (typicall beam @ 10deg)

- Kurtz model not necessarity the best model in [1-11 deg]
- Difficulty to find robust parameters valid for all ice type/seasons
- Difficulty in terms of algorithms implementation if variable temporal/regional fit required

Attempt to build a SeaIce GMF

Dataset: all seasons evenly represented, SIC > 90%
A more pragmatic approach



-Polynomial fit 4th order is found with RMSE of about 2.5 dB (for all beams)

On a dedicated open water GMF

Need for Integrating better prior data distribution over open water
- Based on previous analysis, Ku Sigma0 depends on inc.ang. and wind speed, and on Hs for steep angle and low wind, eventually slope and/or period of swell …

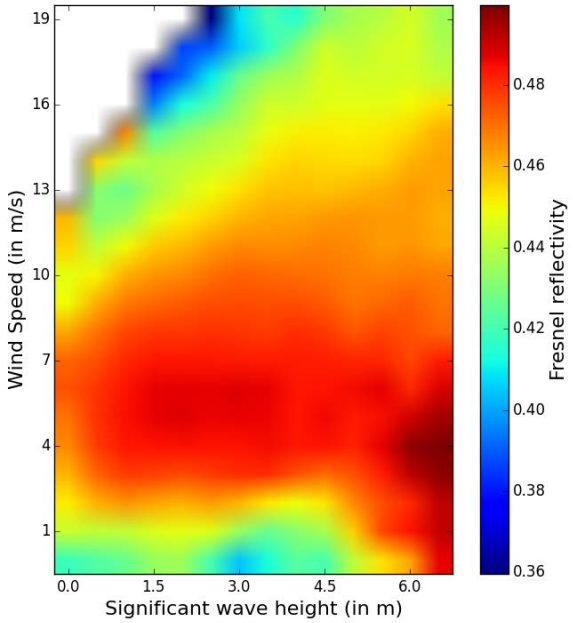
-Our approach:

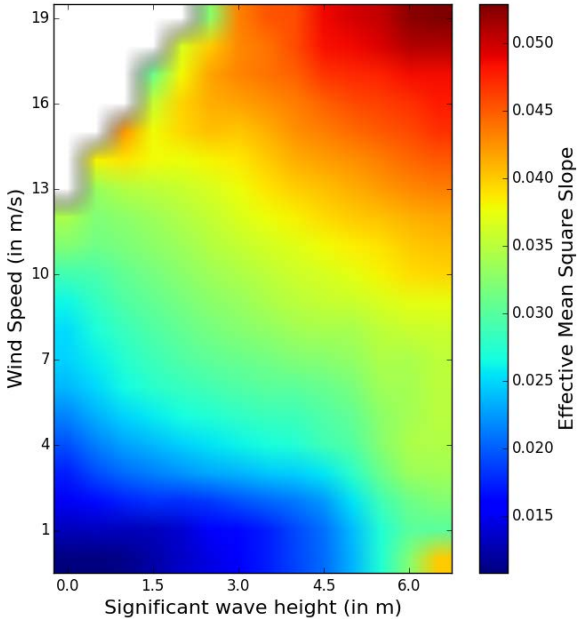
- GPM KuPR collocated with WW3 / ECMWF data
- Based on Freilich formula: find optimized R0 and « mss-related » values
- Each R0 and mss-related values emprirically model with a bicubic spline gridded 2d function
- Two variables considered: Wind speed and one sea state variable. But which one ?
  - significant wave height
  - significant wind wave height
  - significant wave height for the first swell partition
  - steepness for the first swell partition
  - peak period for the wind wave partition
  - peak period for the first swell partition

Up to now, best results if significant wave height considered togather with wind speed
-> to be further consolidated

On a dedicated open water GMF

R0 and Freilich “Mss-related” parameters fitted by bicubic spline interpolation here wind speed and Hs





Freilich et al. 2003

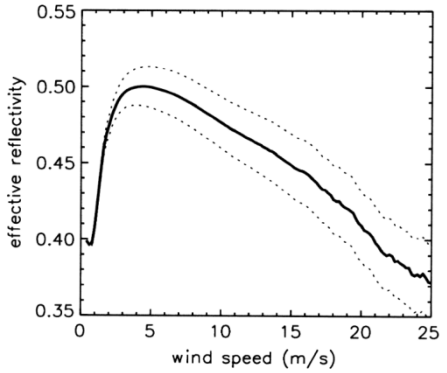


FIG. 6. Solid line: least squares solutions for $|R(0)|^2$ as a function of wind speed. Dotted lines: ± 1 standard deviation calculated from the two-parameter fit of the fully empirical model function to (3).

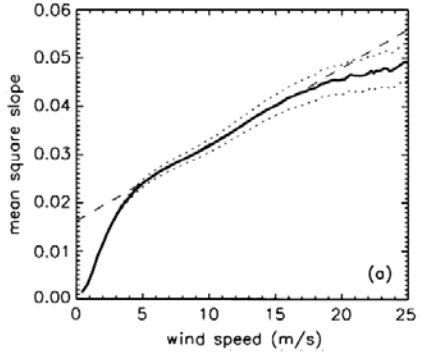
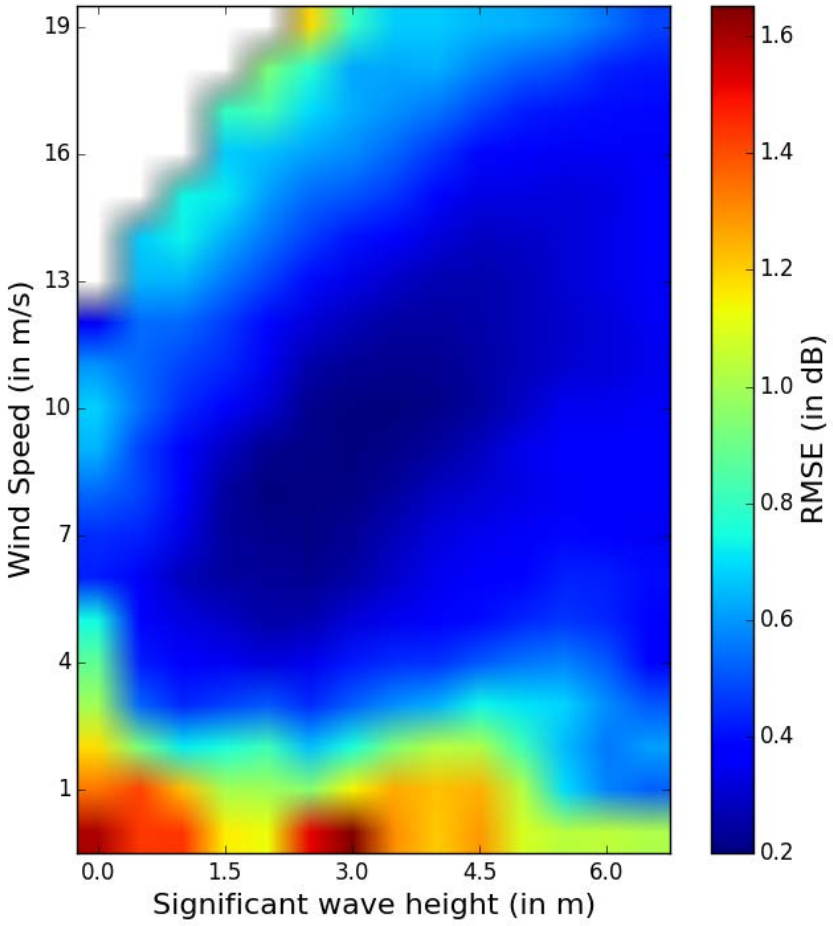
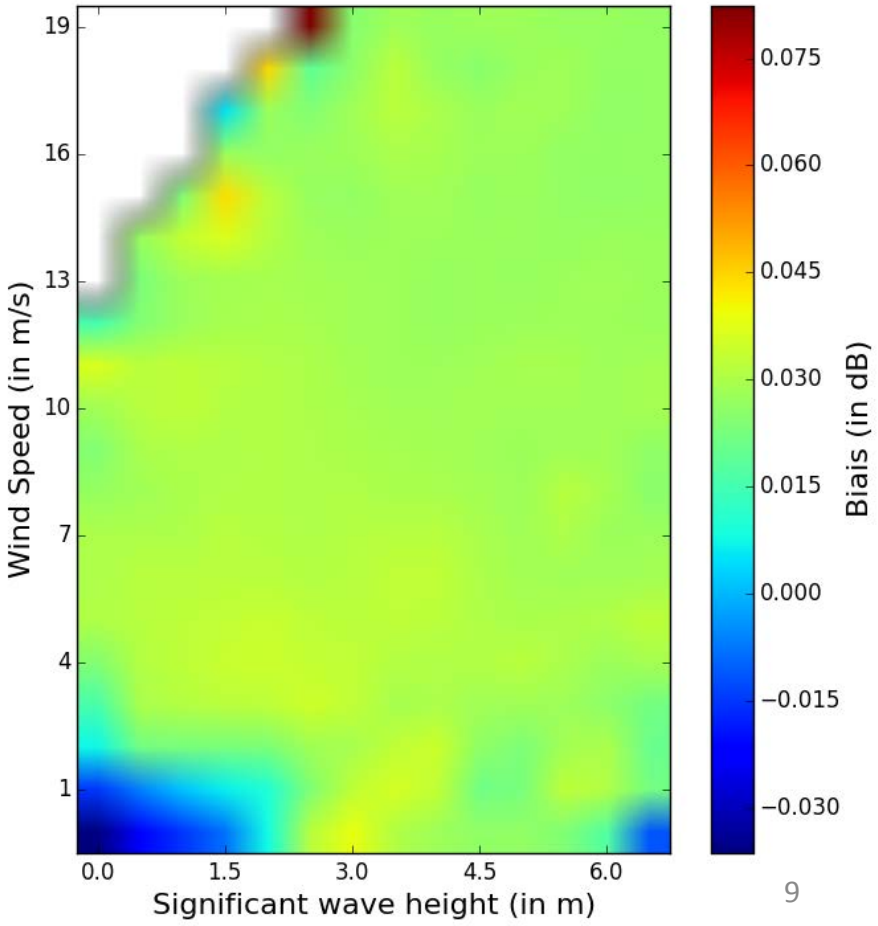


FIG. 7. Effective mean square slope $[s(u)]$ from the two-parameter fit of the fully empirical model function to (3). (a) Solid line: least squares solution for $s(u)$. Dotted lines: ± 1 std dev. Dashed line: linear (Cox and Munk–type) parameterization based on a least squares fit for $5 \leq u \leq 15$ m s^{-1}.

On a dedicated open water GMF

Full assessment of the performance of these GMF
RMSE are evaluated, and are now estimated via a bicubic spline approach knowing the wind speed and sea state parameters





Bayesian scheme for ice flagging

-Our approach:

- For open water: sigma0 probability follows normal distribution with:
  - mean value defined by Freilich-based model and cubic spline fit on its R0 and « mss » parameters using wind speed and hs
  - Standard deviation modeled by a bicubic splie fit using wind speed and hs
- For sea ice: sigma0 probability follows normal distribution with:
  - mean value defined by a quadratic fit with incidence angle
  - Fixed standard deviation
- Prior probability of sea ice presence given by ECMWF sea ice mask (distance criteria …)

-To be implemented using radar gate input (L1a level)

Prototype to be delivered to CNES in Q2 2017

Towards Sea Ice characterization using SWIM

What has been already demonstrated

Following (Kurtz et al, 2014) (Hagfors et al. 1970), valid if:
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$$\sigma^0(\phi) = \left(\frac{R_0}{2cos^6(\phi)}\left(\frac{l}{2k_0h_m^2}\right)^2\right)\left[1+\left(\frac{l}{2k_0h_m^2}\right)^2\sin^2\phi\right]^{\frac{-3}{2}}$$

Methodology:
-Over a month, accumulate available (Sigma0 / inc angle) pairs given a geographic grid from all available GPM data
- Over each point of the grid, find optimized R0 and l/h^2 parameters
- Plot these optimized parameters

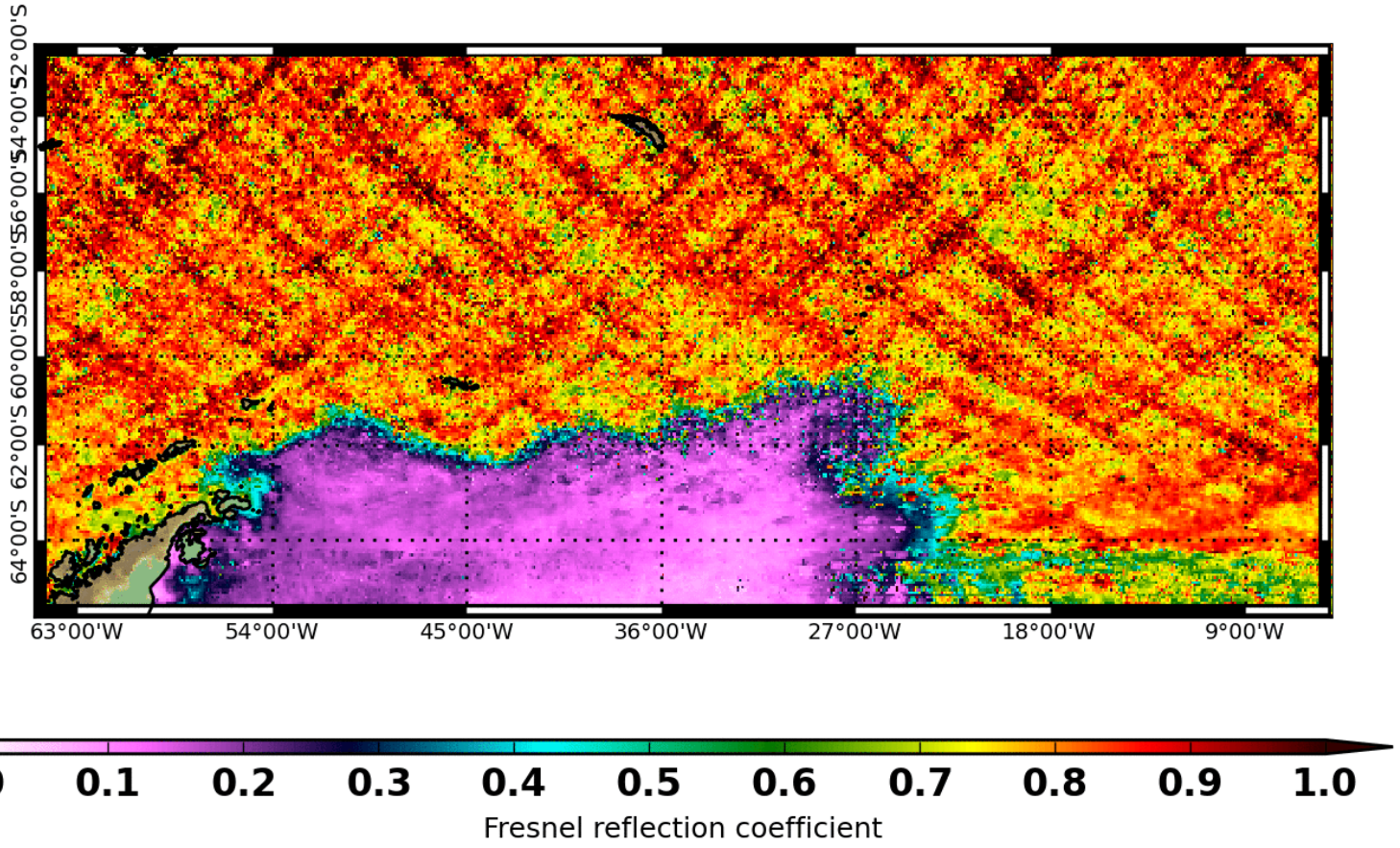
Kurtz et al, «An improved CryoSat-2 sea ice freeboard retrieval algorithm through the use of waveform fitting", The Cryosphere, 8, 1217–1237, 2014

Towards Sea Ice characterization using SWIM

What has been already demonstrated

Fresnel reflectivity ku band

April 2014



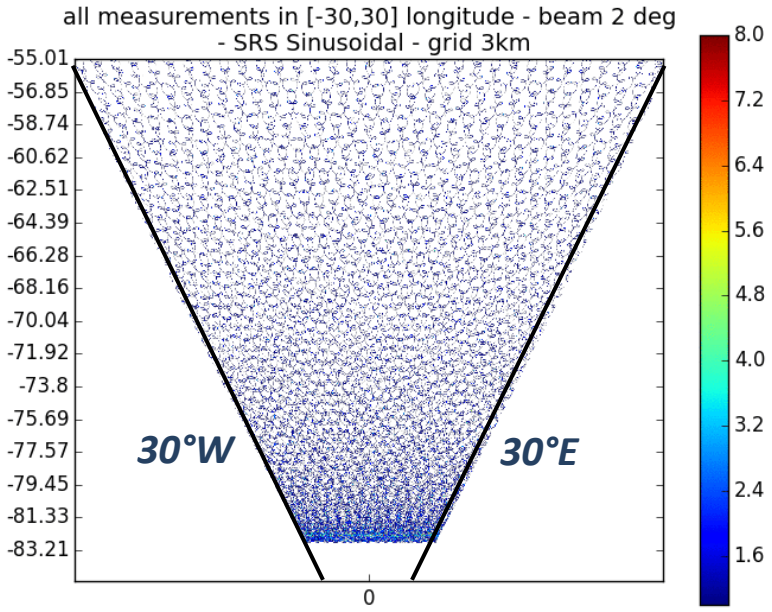
Sea ice mask can be simply derived with threshold on R0 values (R0 < 0.4)

SWIM measurements & CFOSAT orbit

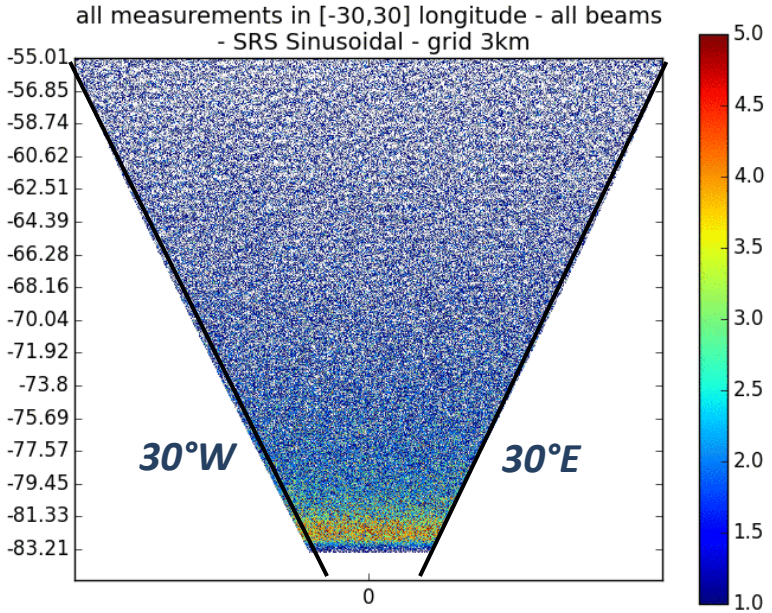
Can we define Sea Ice Cell ? In time / space

- Weddell and Ross Sea > -78°S, and sea ice extent up to about 55°S

Below 15 km resolution grid: sparse data coverage for a consistent sea ice monitoring in Antarctica
15 km – 20 km resolution grid : Cell with only 3-4 beams may be present in Northern parts
Over 25 km: Consistent coverage with 1 and even 3 measurements for all 5 beams



Number of measurements for one single beam (here 8 deg) during a 13-day cycle



Number of beams with at least one measurement during a 13-day cycle

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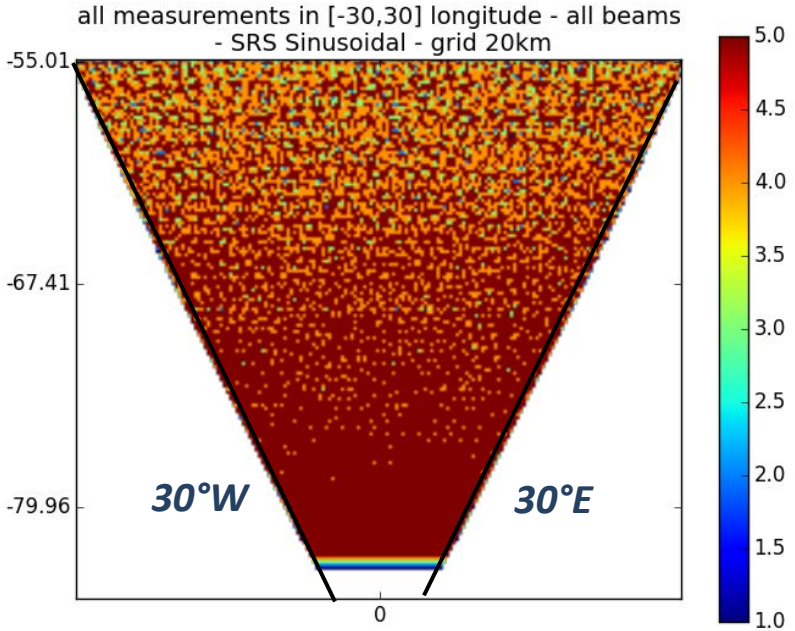
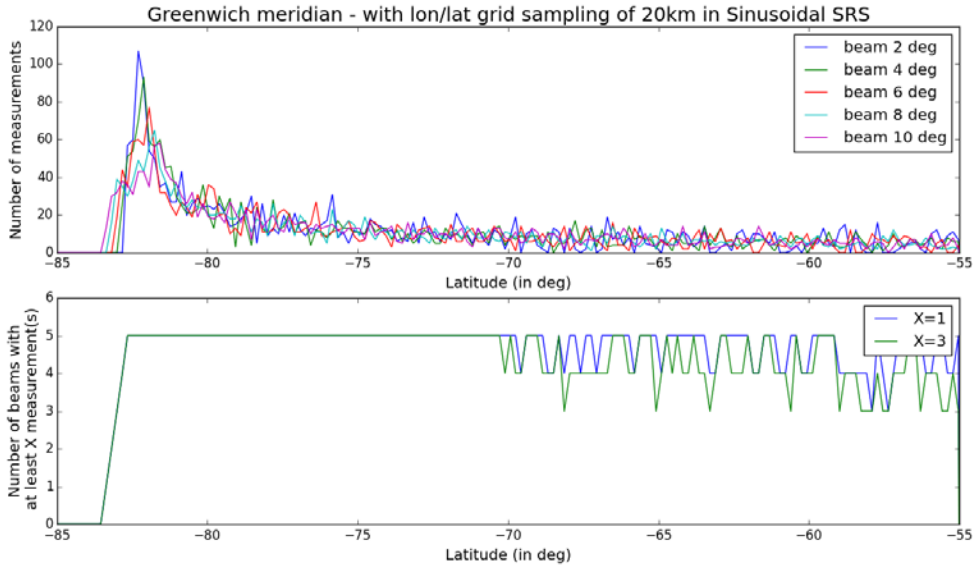


Number of beams with at least one measurement using a 20x20 km grid



SWIM measurements & CFOSAT orbit

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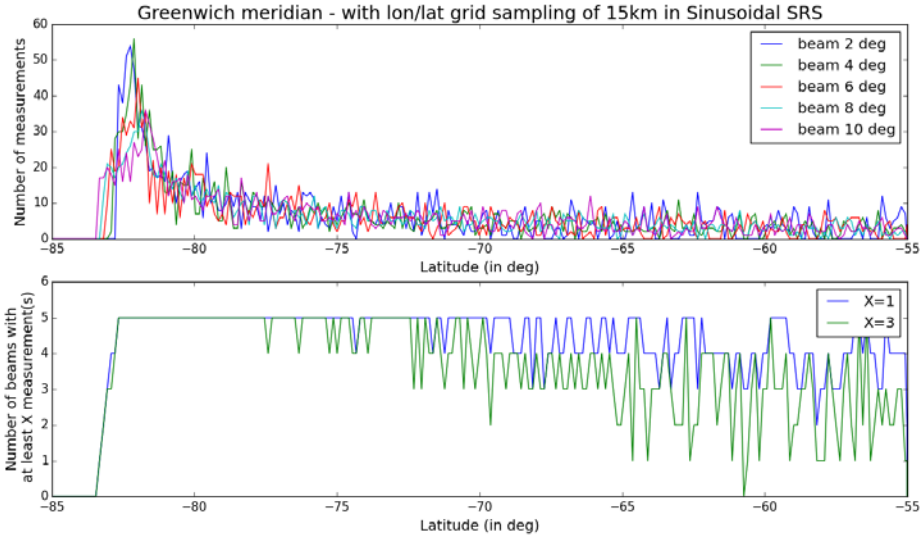
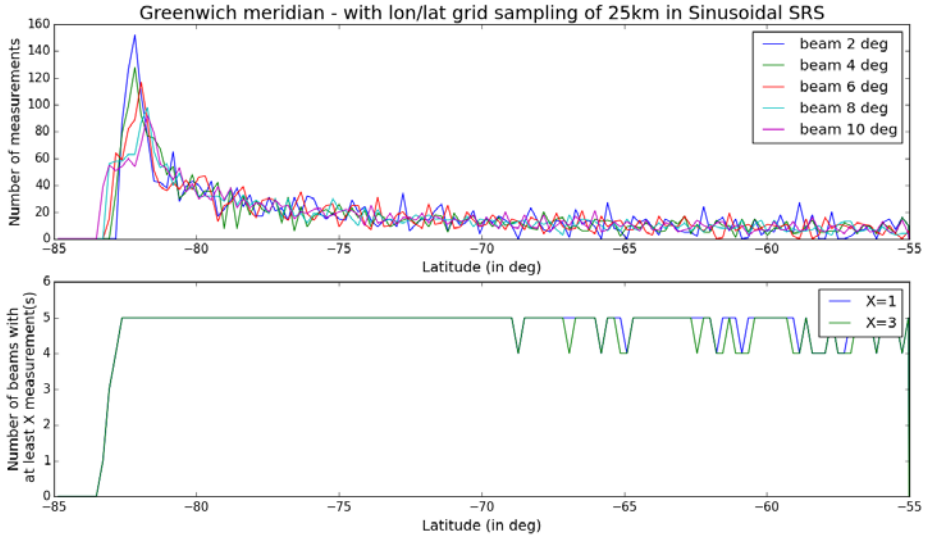
Over 25 km: Consistent coverage with 1 and even 3 measurements for all 5 beams

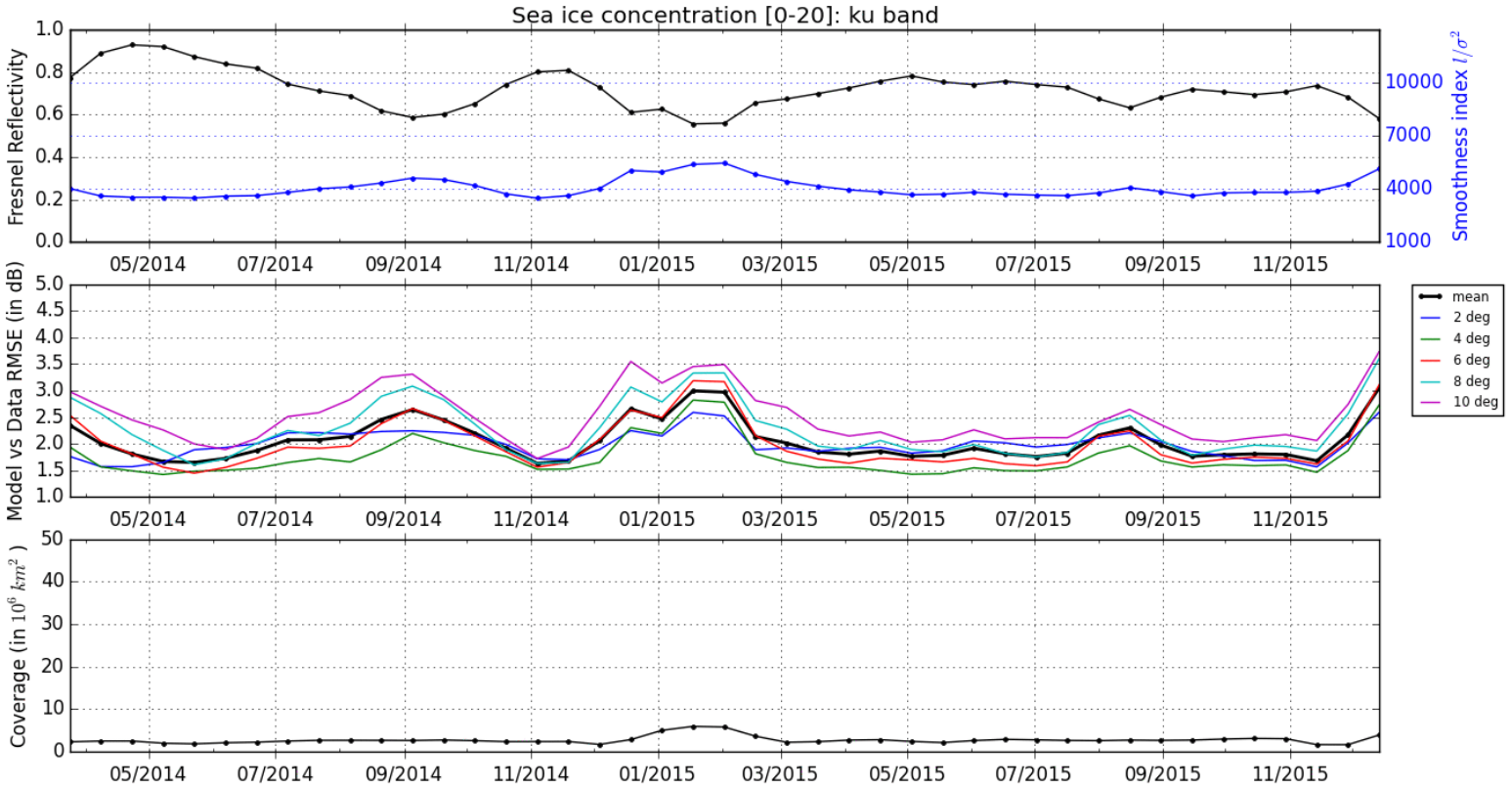
Potential for a 25 km products every 13 days, and even less (15 to 20 km with 1/2 or 1/3 repeat cycle) depending upon radiometric absolute/relative calibration…





Sea Ice concentration

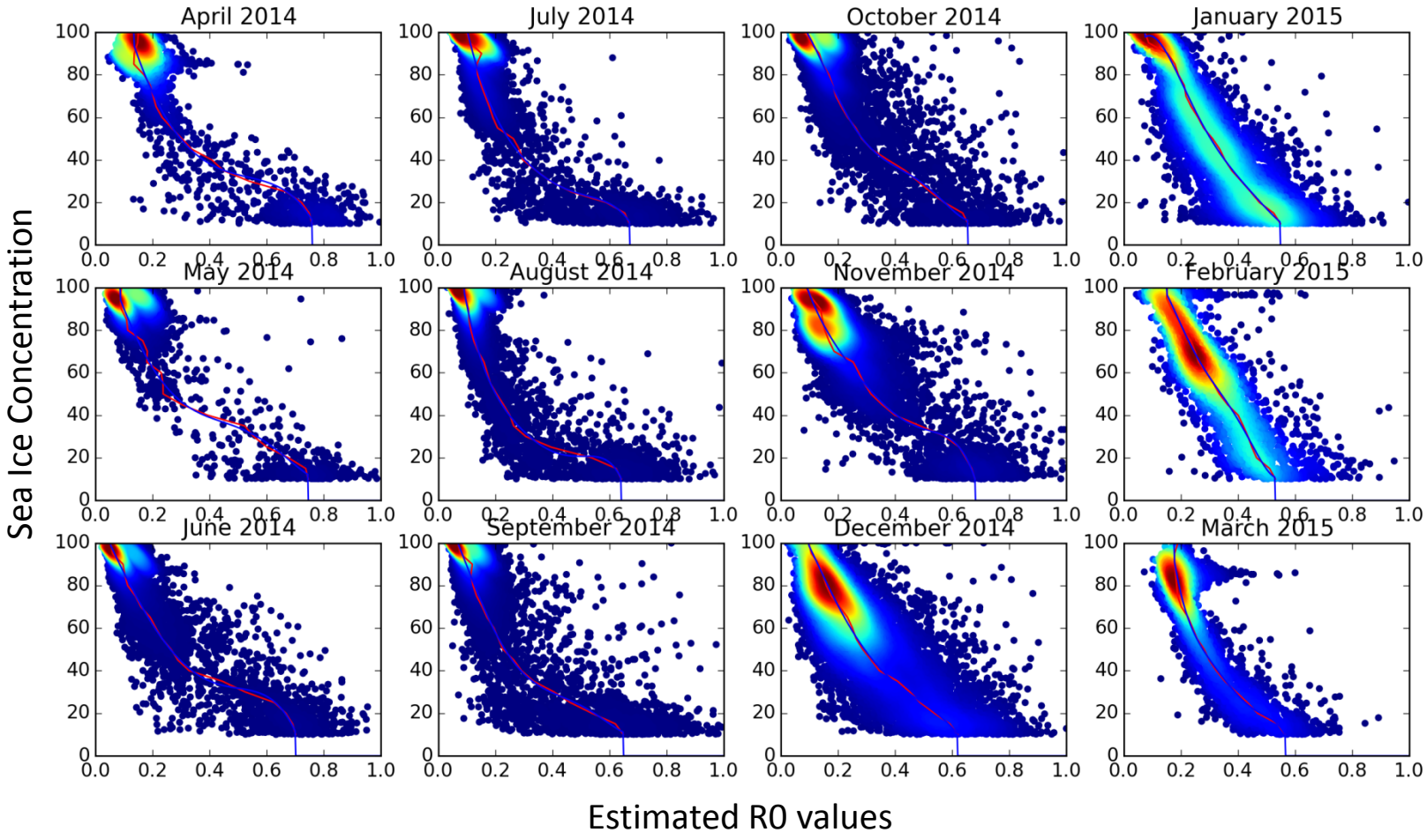
Retrieved R0 and Smoothness parameters wrt time period and SIC



Further analysis required to understand seasonal variability
But at first order link between estimated R0 and SIC

Sea Ice characterization

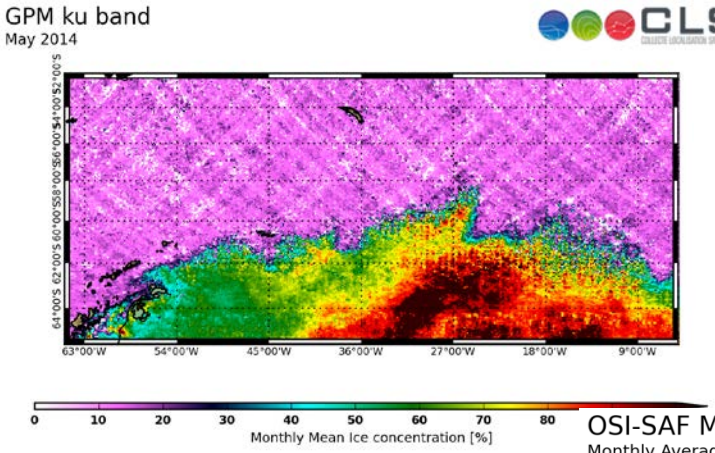
Database: Estimated Monthly R0 values + Average OSISAF monthly SIC (large std are removed)

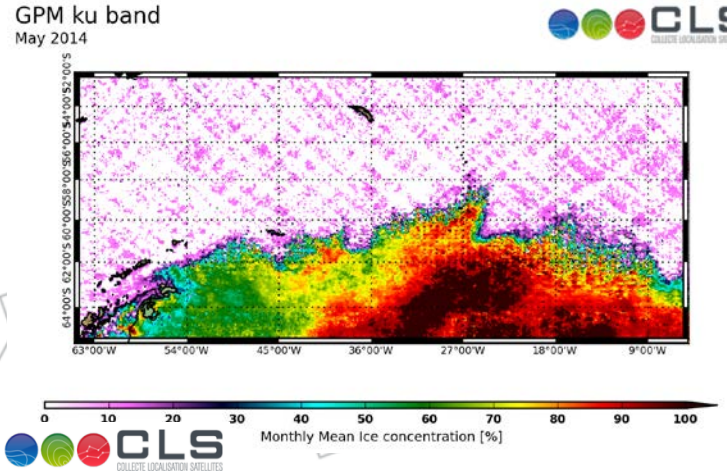


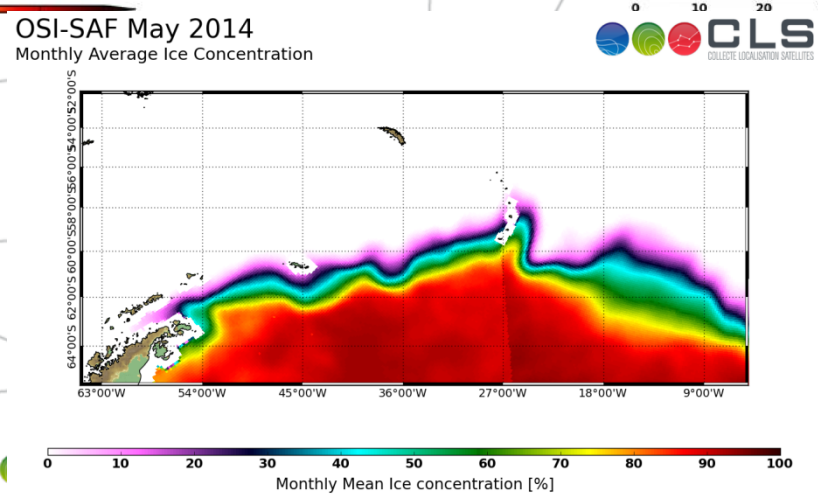
Trends depend on the selected period (and seasonality)
Small sensitivity for high SIC concentration

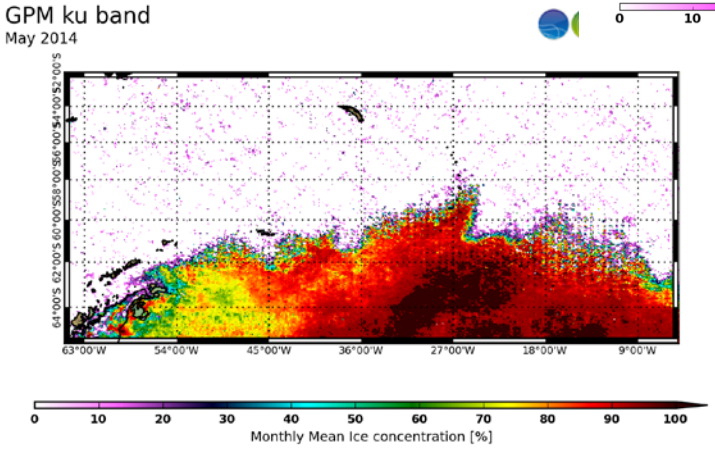
-> different approach tested for SIC retrievals (time specific, global, curve fitting)

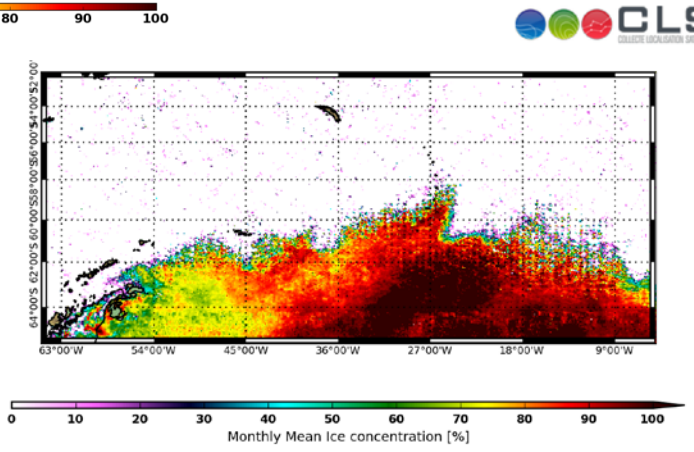
SIC retrieval (different versions – ongoing)





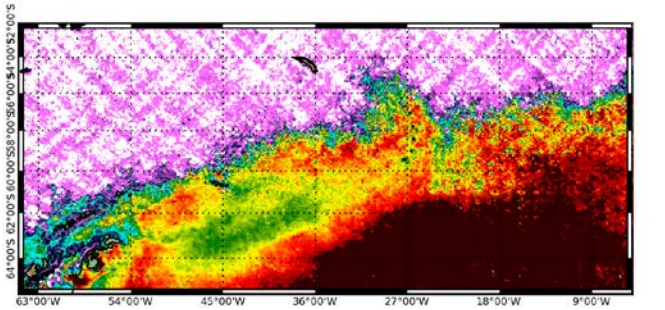


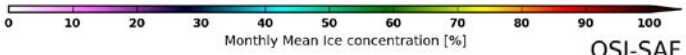




SIC retrieval (different versions – ongoing)

GPM ku band
September 2014





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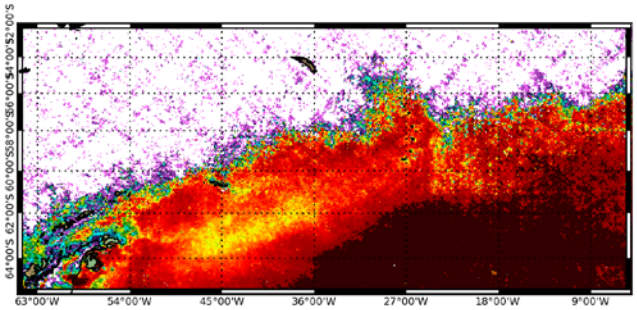
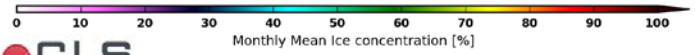
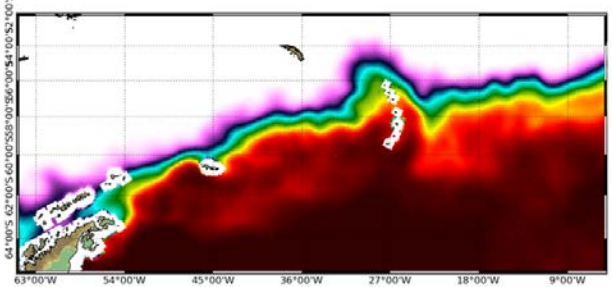
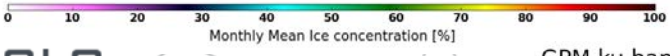




OSI-SAF September 2014
Monthly Average Ice Concentration





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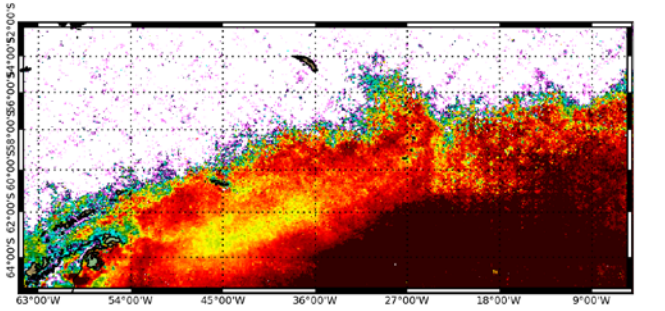

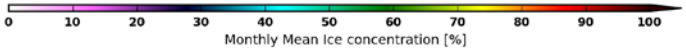

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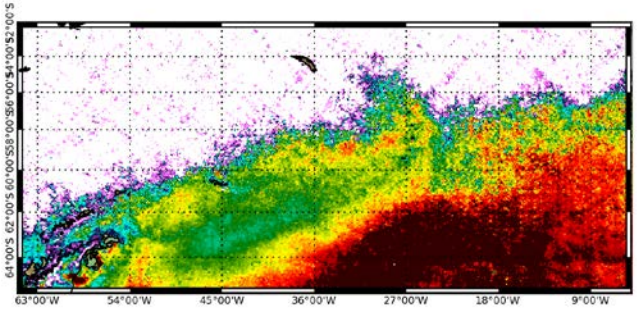
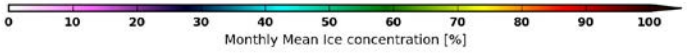
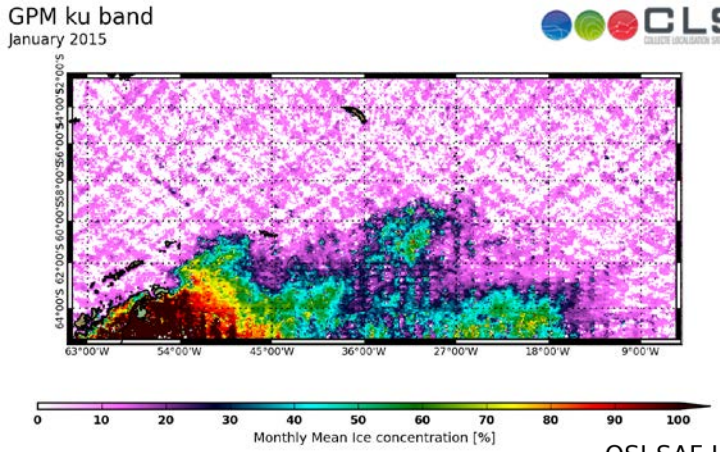
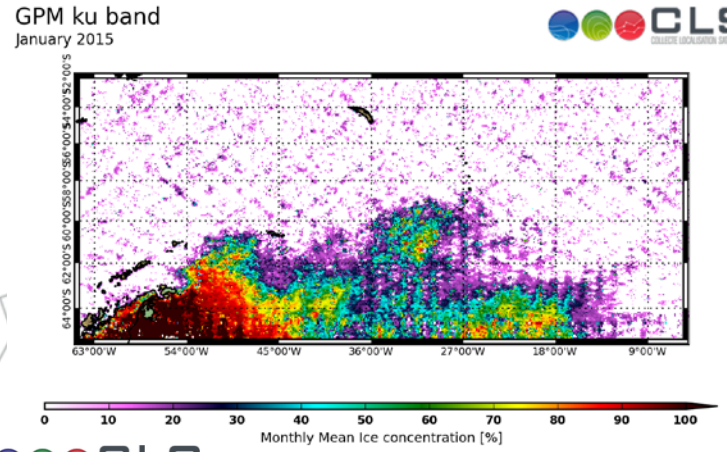
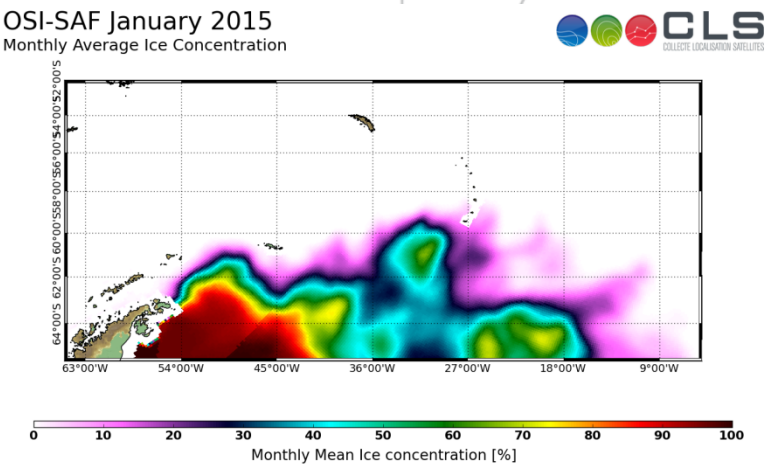


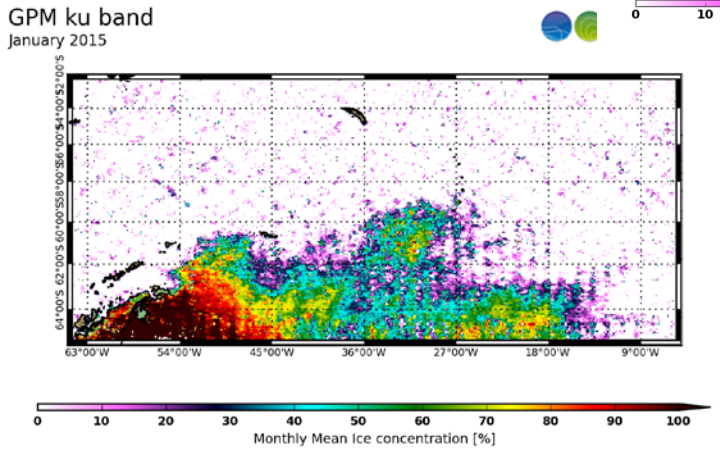


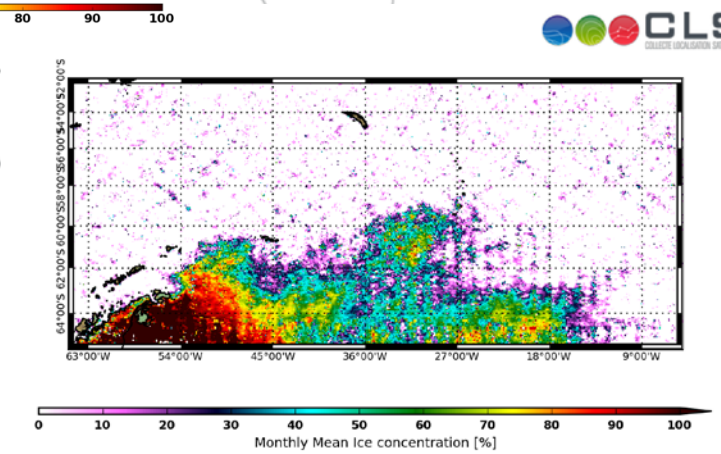
SIC retrieval (different versions – ongoing)











Future developments

To be done
Done
To be improved

- Need for:
  - Taking into account other SWIM characteristics
    - Expected inter-beam and absolute calibrations
    - SNR
    - Spatial resolution
  - Improve Model inversion (Kutz being not necessarily the best model to consider)
  - Link with SCAT over sea ice

Merci

Questions, remarques ?

This work has been funded by CNES
via the SWIM-SID project