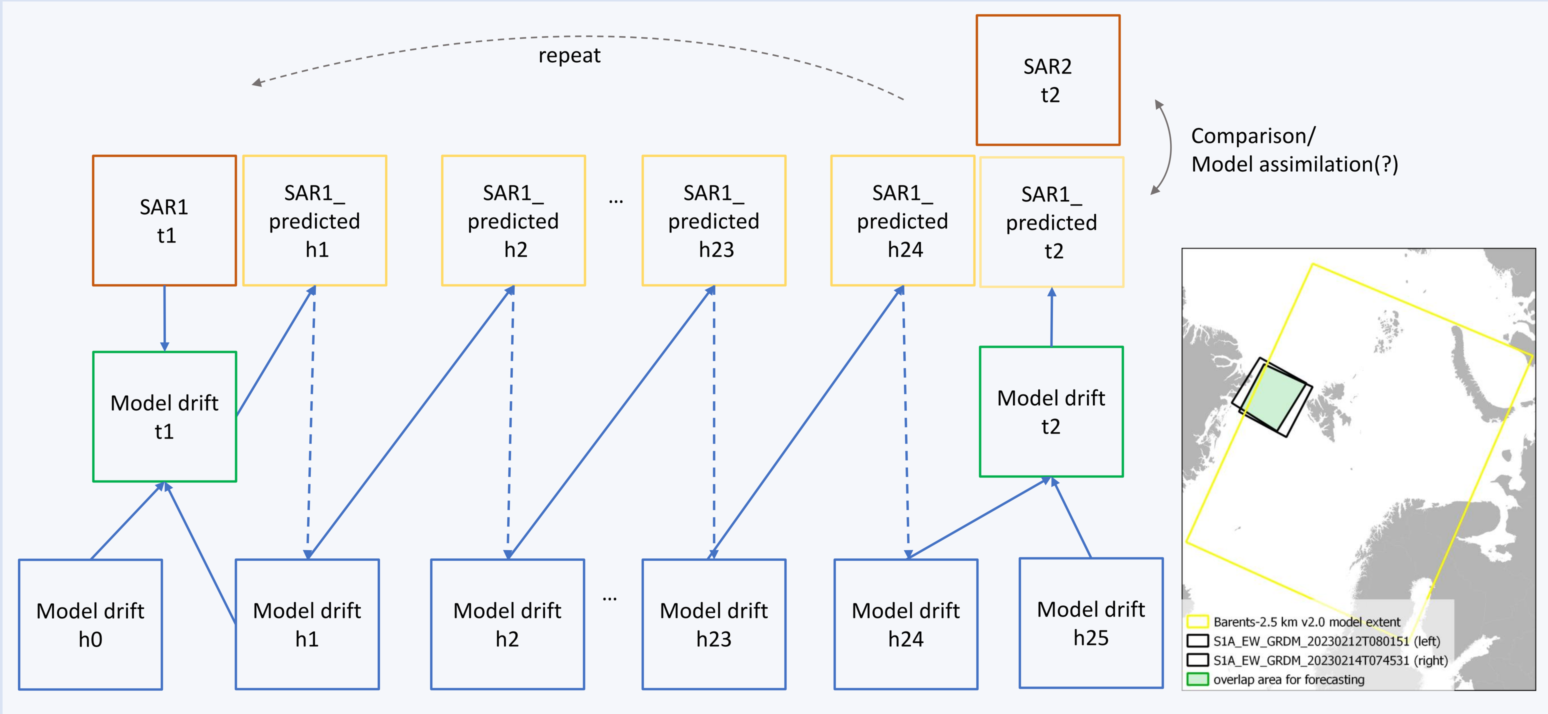
Short-term prediction of ice conditions: an integration of SAR Imagery and model-derived sea ice drift data

Anna Telegina[1], Wolfgang Dierking[1,2] , Anthony P. Doulgeris[1] , Anton Korosov[3], Denis Demchev[4]

1 - *Department of Physics and Technology, UiT The Arctic University of Norway, Tromsø, Norway, 2 - Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, 3 - Nansen Environmental and Remote Sensing Centre, 4 - Chalmers University of Technology, Sweden*

(anna.telegina@uit.no)

Goal – SAR forecasting algorithm



Scan for animation example

Data and methods

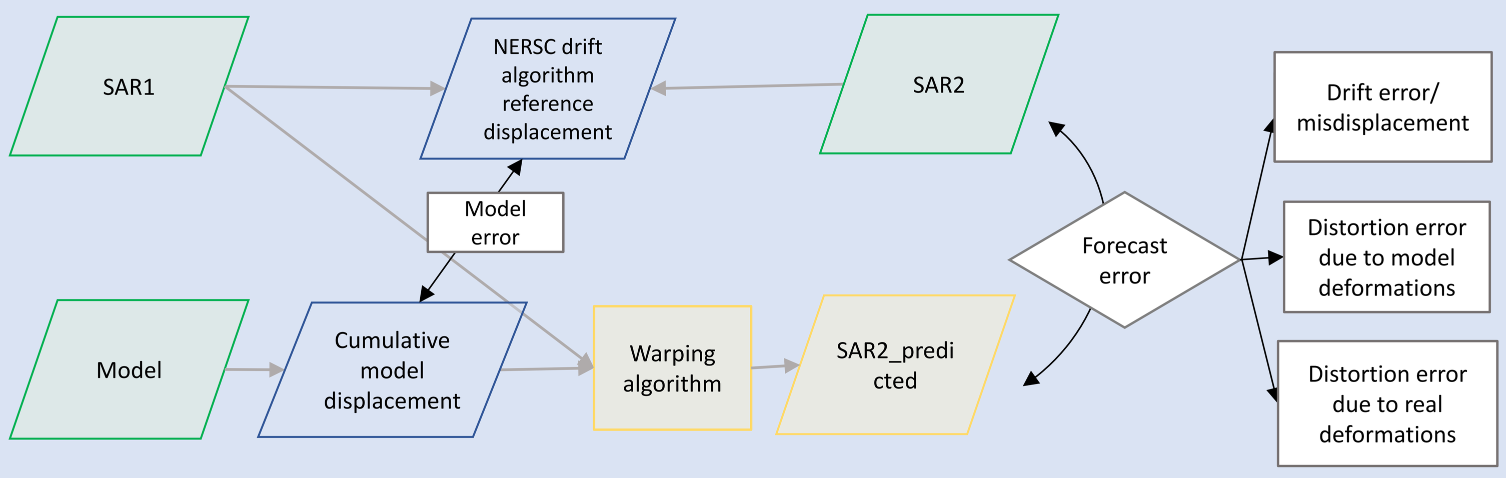
Data: Sentinel1-A
- Level-1 GRD
- EW swath mode
- HV polarization
- Subset ~200/200km
- AOI: Fram Strait

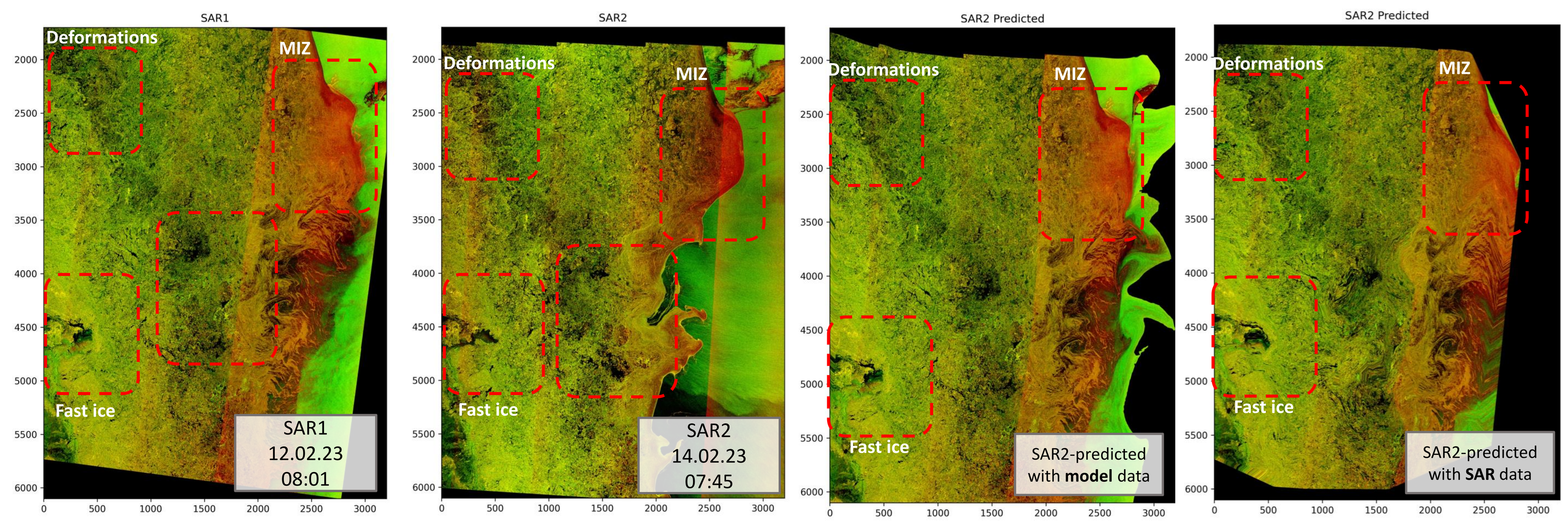
Model: Barents-2.5 v2
- Uses Los Alamos sea ice model (CICE)
- Elastic-viscous-plastic rheology
- Resolution 2.5 km
- SST/SIC assimilation
- Executed 4 times daily, spreading the 24 ensemble members into 4 sets of 6 members which executed with a 66-hour forecast range [1]

Warping algorithm: Chalmers alignment algorithm
- Warping based on a piecewise affine transformation [1] or spline interpolation [2]

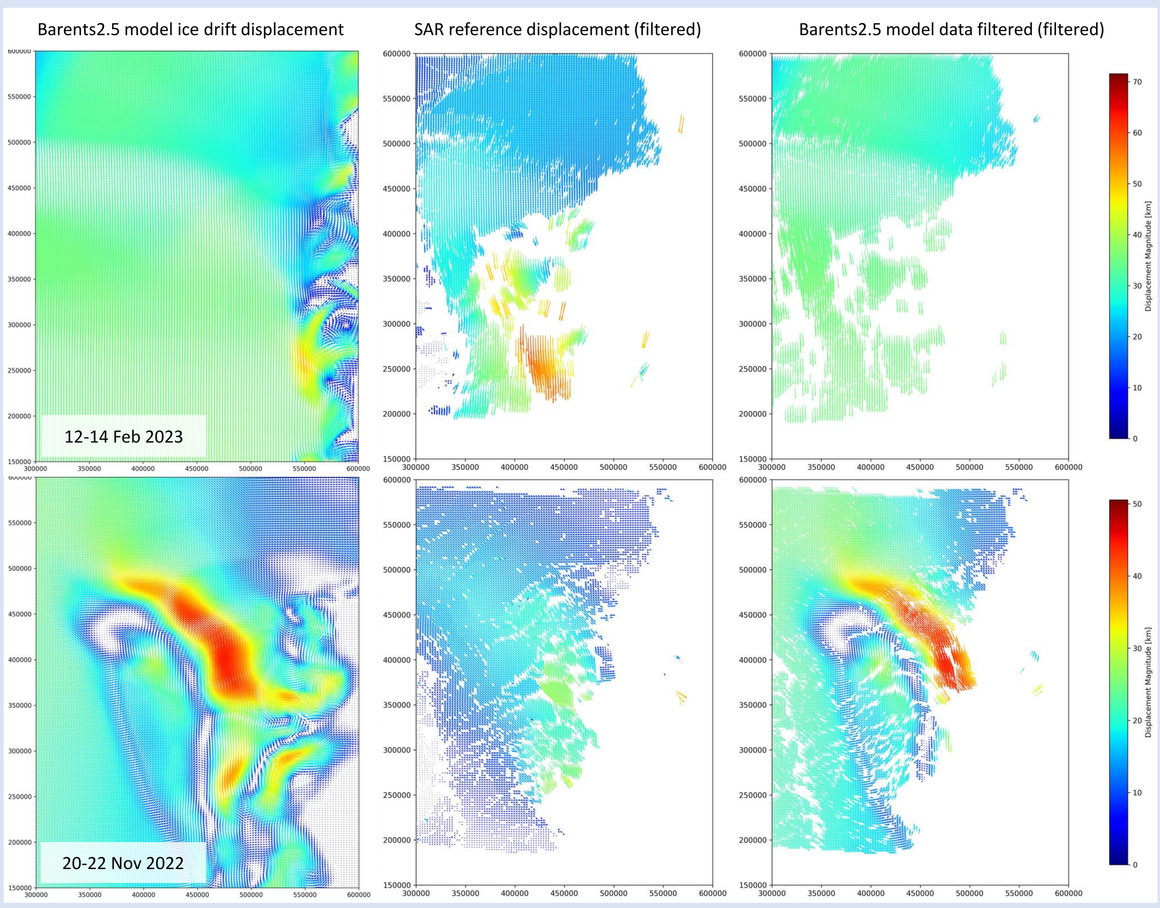
Applying model data for warping SAR data into the future

Experiment 1 for quality assessment (48 hours forecast)

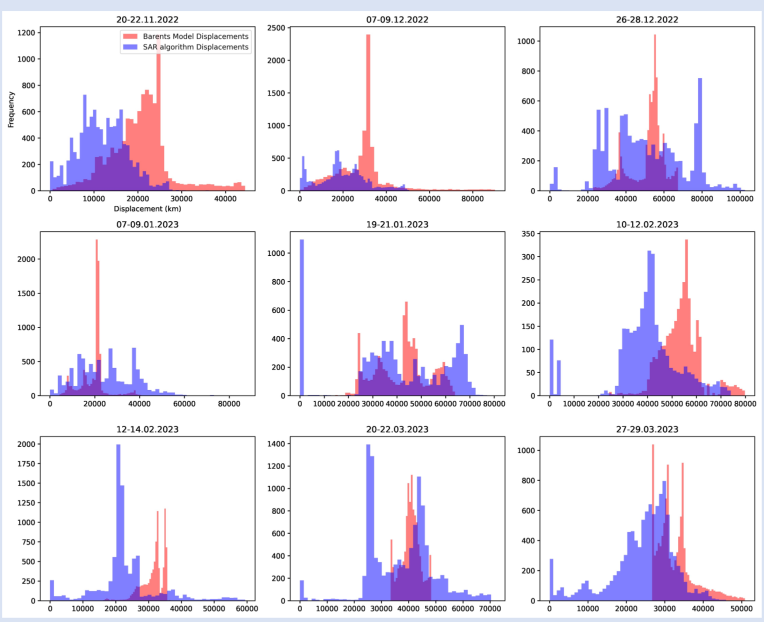




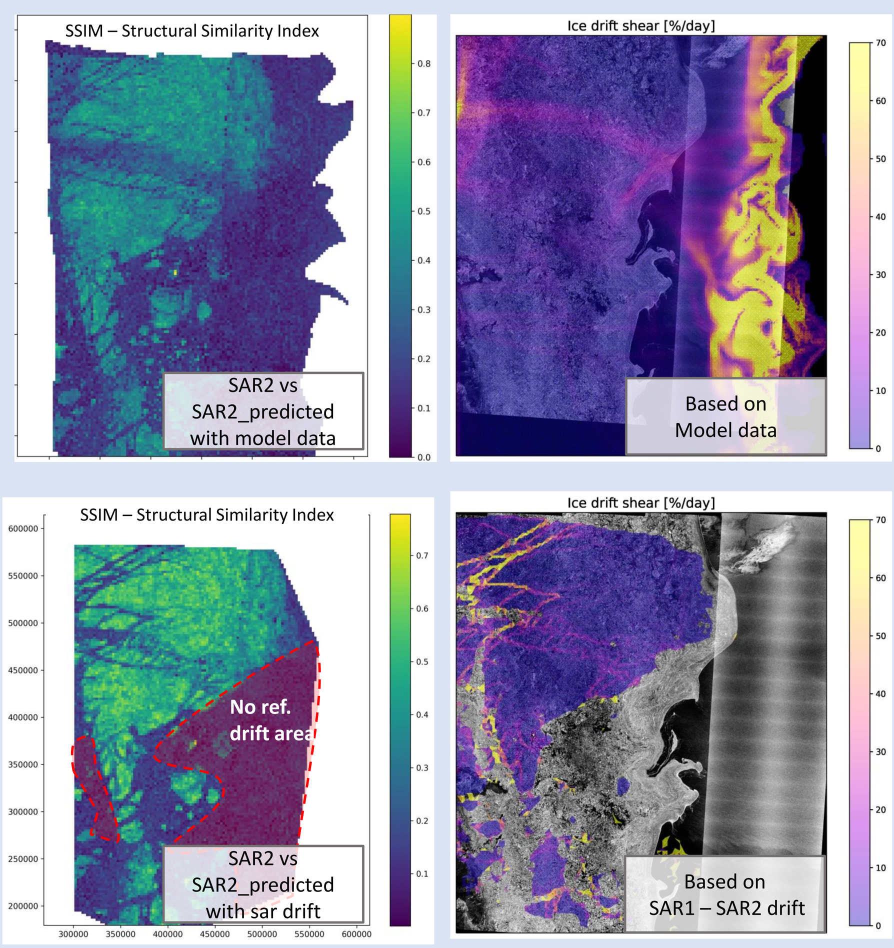
Errors1 - drift errors:



- Overestimates drift velocities
- Does not consider fast ice
- Strong effect of vortices in autumn months



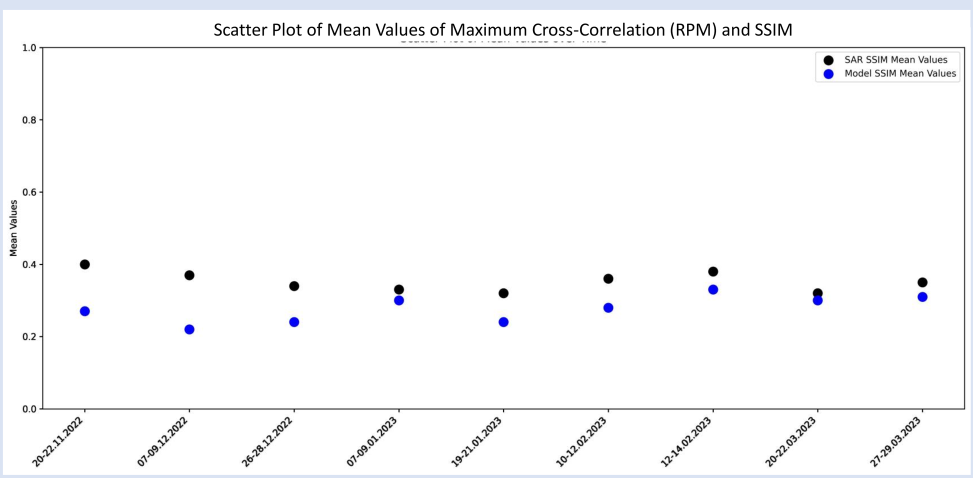
Errors 2 - distortions errors:



SSIM (Structural Similarity Index)

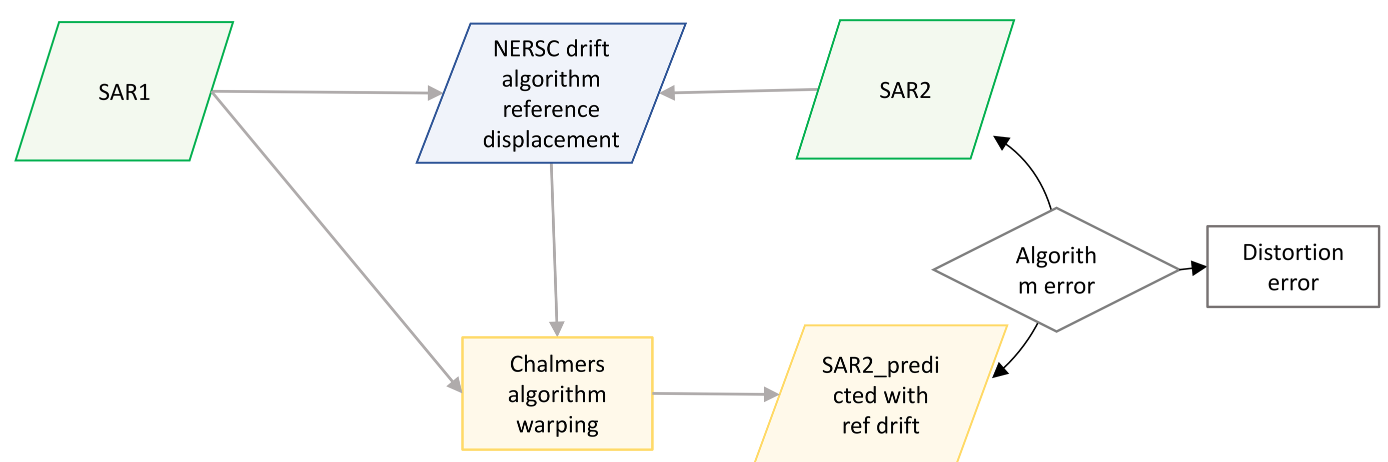
Purpose: assesses the perceived quality of images by comparing structural, luminance, and contrast differences.

Parameters: Employs mean, variance, and cross-covariance of pixel intensities within the images. [4]

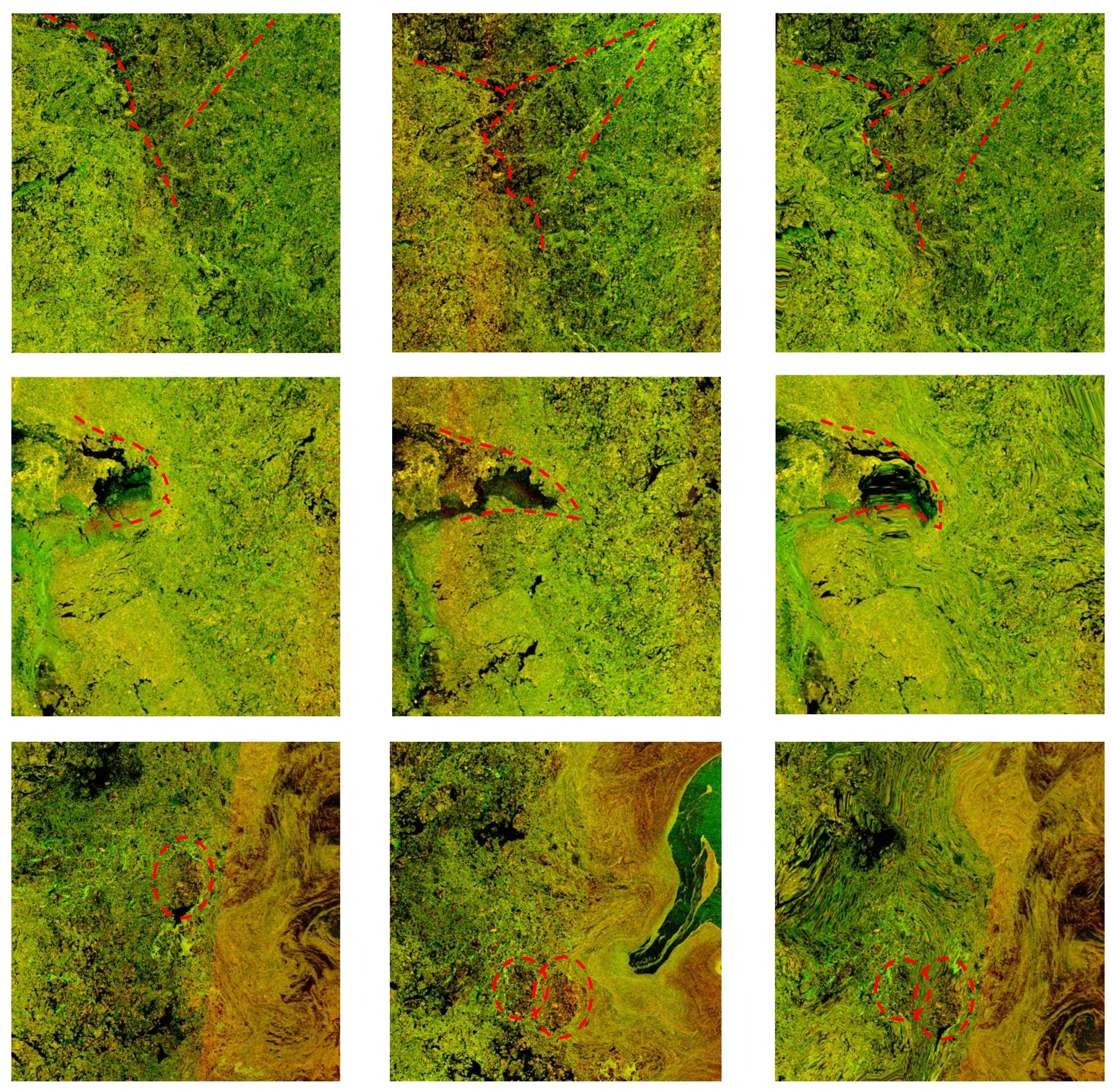


Using reference ("real drift") data

Experiment 2 for quality assessment (48 hours forecast)



SAR1 **SAR2** **SAR2_predicted**



Examples of results for different ice regimes.

Changes in the shapes of the deformation zone were reconstructed well. There are blurred linear-shaped objects corresponding to new cracks but there is no increase in brightness due to its absence on SAR1

Changes in the shapes of polynya were reconstructed realistically due to the presence of enough dark pixels on the original SAR1 scene (new ice formation is missed, of course)

Such warping can potentially create new objects like in the case of the consolidated floe to the left which is not detected on SAR1 but appears on SAR2 and SAR2_predicted with SAR data.

Results:

Barents2.5 model (advantages +)
- Works well with homogeneous drift
- The deformation pattern for February 12-14 looks similar to the reference drift data deformations.

SAR retrieved reference data (with NERSC algorithm)
- Shows the capability of the forecast with drift field improvements (by using "real" drift).
- Shows that when having realistic drift and deformations, such "difficult" ductile ice areas as polynyas, compression zones, and MIZ brash ice areas can be predicted realistically.

SSMI
- Convenient parameter for assessing errors of forecasting related to the textural distortions.

Barents2.5 (disadvantages -)
- Often overestimates drift velocities
- Autumn data are affected a lot by vortices

SAR retrieved reference data (with NERSC algorithm)
- Ice areas lacking features and patterns are not represented for comparison and forecast quality assessment.

SSMI
- Just as drift algorithm – not applicable for assessing ice types without strong patterns (MIZ, brash ice, etc.)
- Does it address distortions connected with floes size changes?

Questions to address:
- Deeper analysis of changes through the seasons?
- Compare with other models (first, will run the same experiment with the neXtSIM model
- What would be the combined parameter for the accuracy assessment of forecasted products? How to incorporate information on deformations and reliability of areas in the final product?
- How to evaluate areas where the drift algorithm and SSIM estimation don't work (compression zones, marginal ice zones etc.) -> Would more object-based approach with evaluating shapes/area/form help?
- Can it be applied for ice charts?

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