Norwegian Meteorological Institute

10 years of global Envisat ASAR range Doppler shift retrievals

Morten W. Hansen[1], Jeong-Won Park[2], Harald Johnsen[3], Geir Engen[3]

[1] MET Norway, [2] Korea Polar Research Institute, [3] NORCE.
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Content

- Background and motivation
- Requirements
- Doppler terms and corrections
- Status and preliminary results
  - Uncertainty
  - Individual scenes
  - Wind
  - Averages

Background

Chapron et al. (2005). Direct measurements of ocean surface velocity from space: Interpretation and validation. Journal of Geophysical Research – Oceans.

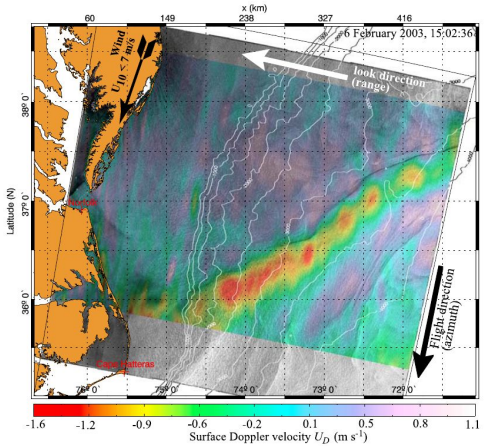

Figure 1. Normalized radar cross-section σ_0 (gray shades) and Doppler velocity U_D (colors), analyzed from a wide-swath image obtained by ENVISAT on 6 February 2003 at 1512 UTC. Oceanic fronts appear as sharp gradients of σ_0, while the surface velocity seen by the radar appears to be related to the Gulf Stream.

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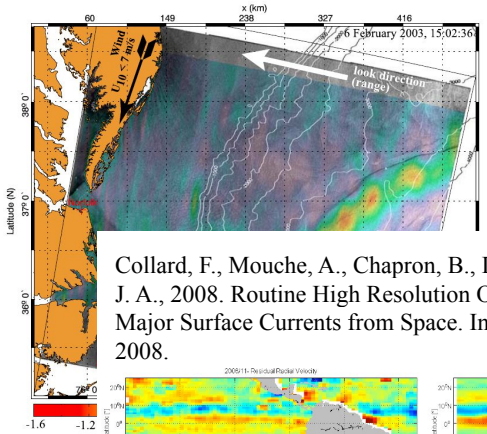

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Figure 1. Normalized r
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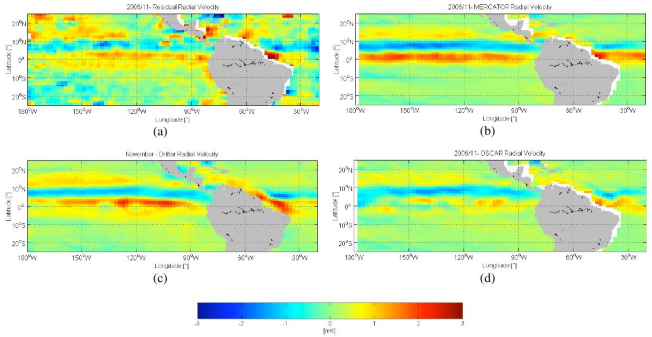

Figure 4: (a) Residual radial velocity obtained from Doppler Anomaly analysis. Radial velocity obtained using (b) MERCATOR ocean circulation model, (c) monthly climatology available from the global drifter program and (c) the ocean surface current derived from altimetry data and wind field analysis (OSCAR). November 2006 is considered here.

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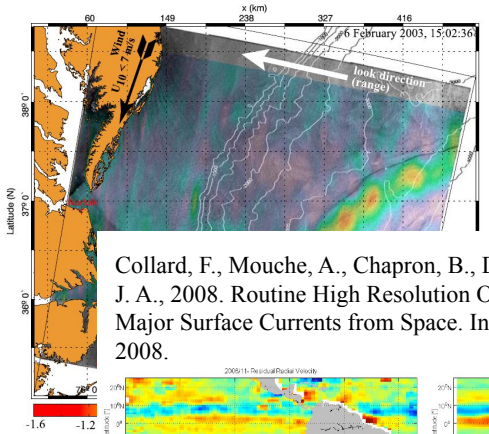

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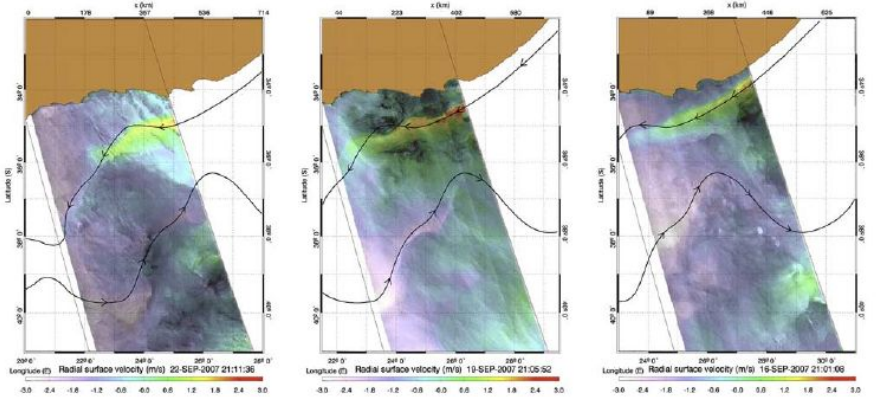
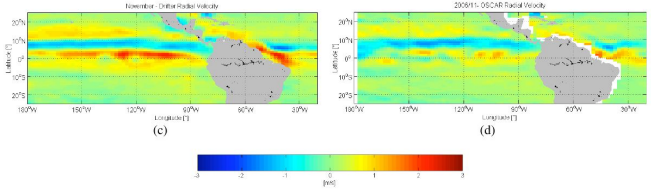


Figure 1. Time series of the Doppler velocity from the ascending ASAR wide swath (420 km) images on (right) 16, (middle) 19 and (left) 22 September 2007 covering the greater Agulhas Current region. The color bar marks the radial velocities from −3 m/s to +3 m/s. Positive speed is directed towards the SAR look direction. Black curve marks position of the maximum geostrophic current derived from altimetry 7-day mean.



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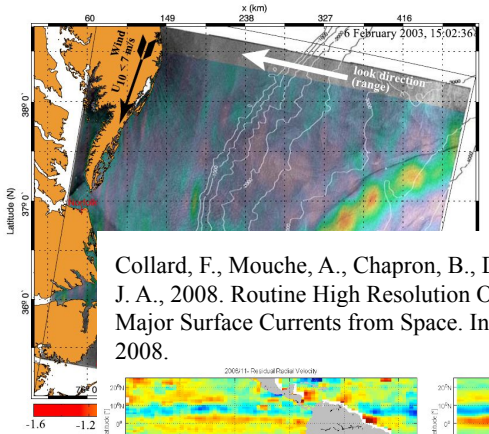

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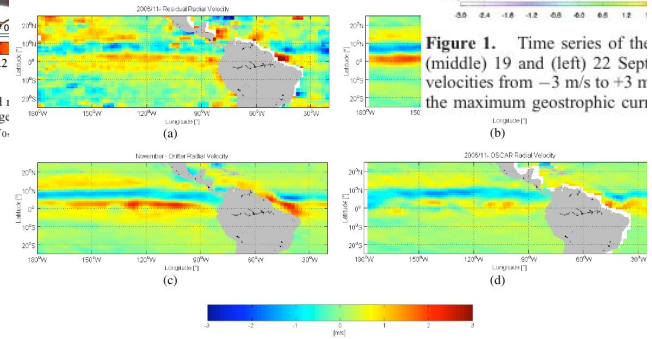

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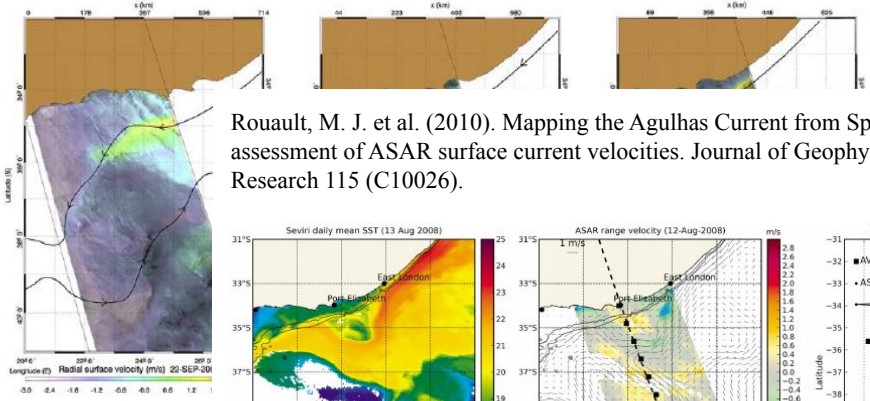

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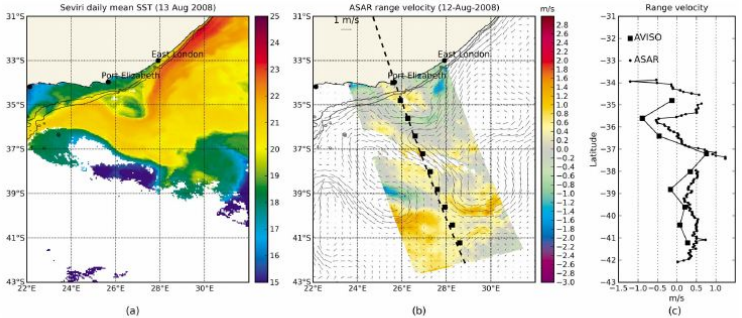

Figure 8. (a and b) Color maps of SST and ASAR range-directed surface current velocity (in m s^{-1}) during the passage of the Natal pulse. Surface temperatures from the Meteosat Second Generation sensor (Figure 8a) show the presence of a cold water core of 150 km diameter at the inshore edge of the Agulhas Current. Figure 8b shows range velocities derived from the ASAR on 12 August 2008 that are overlaid with geostrophic velocity vectors derived from AVISO. Positive values in the color scale indicate a flow toward the northeast. Negative values are associated with a southwesterly flow. (c) A transect taken across the ASAR image illustrates the ability of ASAR and AVISO to capture the presence of a cyclonic flow, with the ASAR providing additional information on the nearshore circulation. Solid black lines in Figures 8a and 8b indicate the position of the 200 m and 1000 m isobaths.

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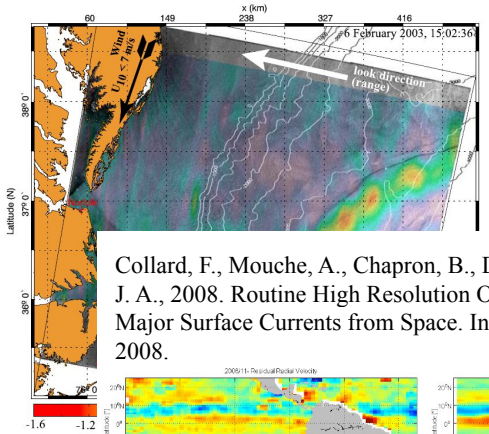

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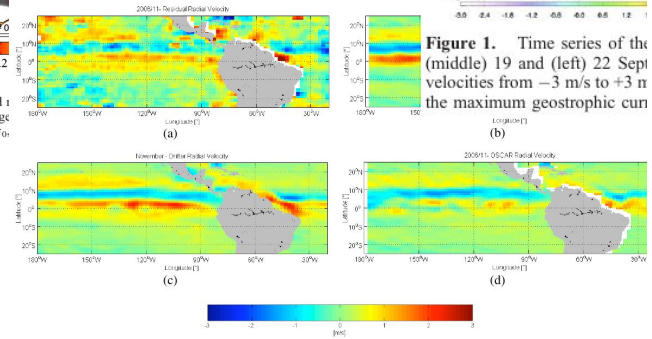

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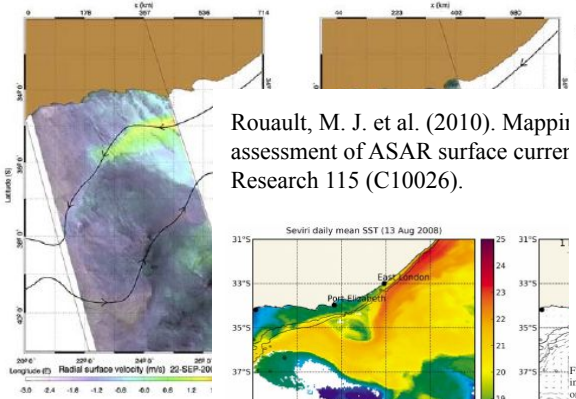

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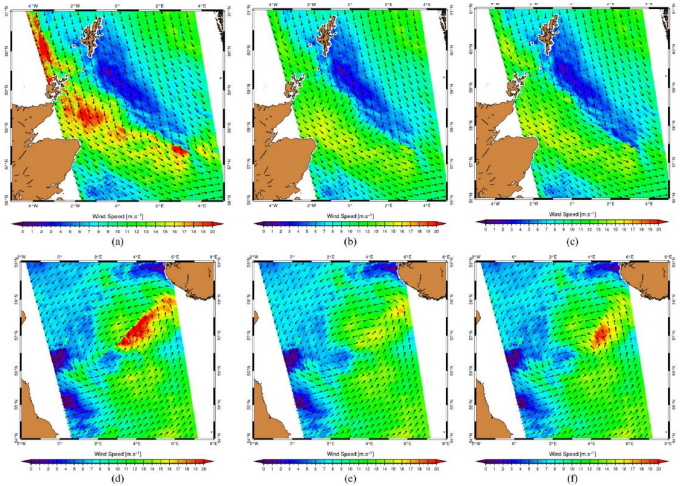

Fig. 4. (Top panel) Case of an atmospheric front on 11 June 2010 at 21:27:32 UTC. (a) Scatterometry approach, where the wind direction is given by the *a priori* information. (b) Bayesian scheme without Doppler shift, (c) Bayesian scheme including Doppler. (Bottom panel) The same for the case of a low pressure system on 11 June 2010 at 21:27:32 UTC.

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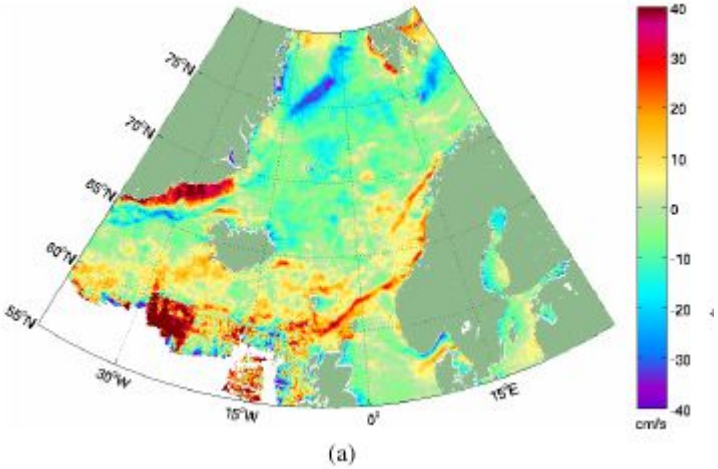


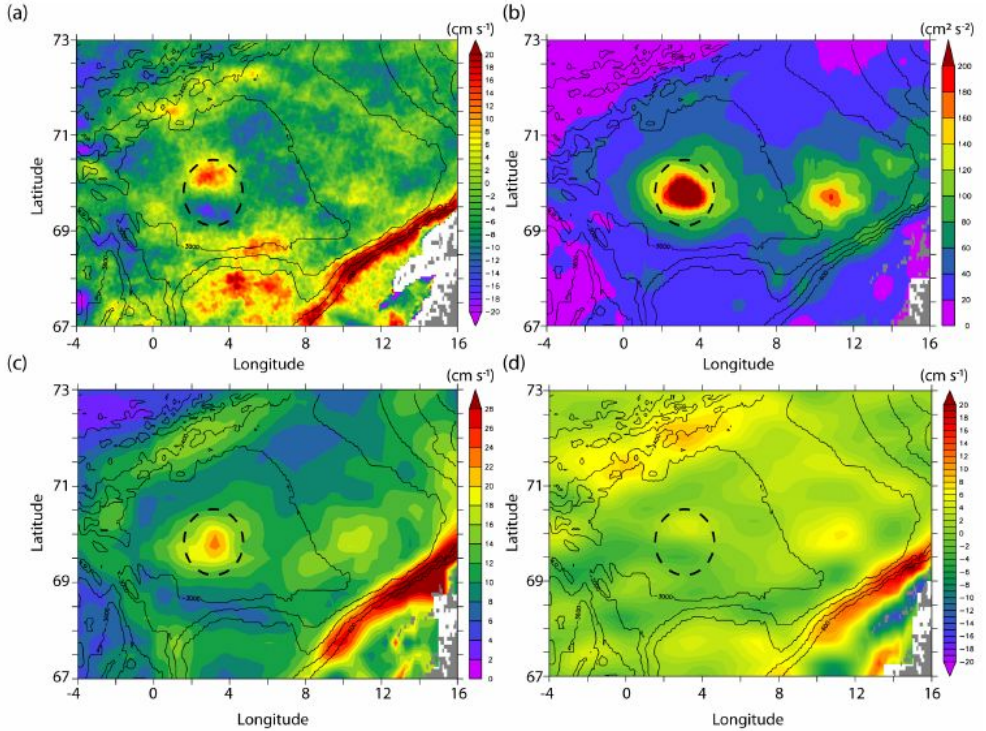


Figure 6. Time average (01/08/2007 to 31/07/2011) maps of SAR zonal velocities (a), and altimeter derived EKE (b), absolute speed (c), and zonal velocities (d). The black lines are isobaths drawn for every 600 m of depth. The dashed circle indicates the Lofoten Vortex.

The ASAR Doppler product needed optimization and extension in time

ESA GlobCurrent user survey:

- Global current data is required
- Spatial resolution of 1-2 km in coastal region, and 10-25 km for open ocean
- Temporal resolution from 1-24 hours
- Speed uncertainty between 5 and 30 cm/s
- 10-20 years timeseries
- Near real-time data access
- Quantification of Stokes and Ekman drift, and tidal currents

In addition:

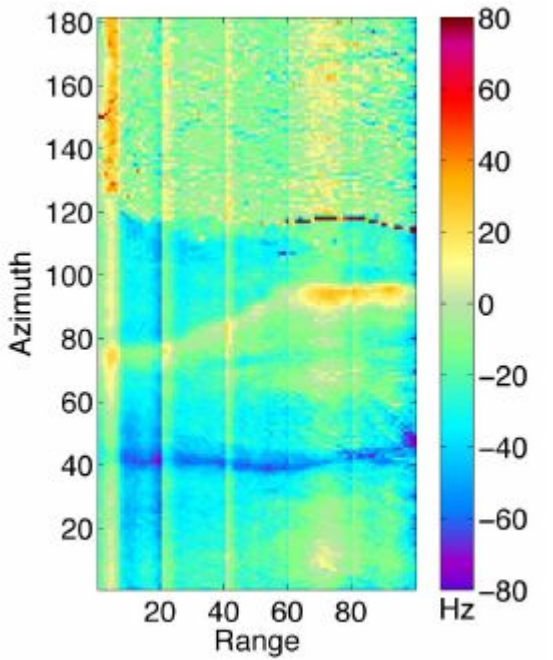
- Time coverage previously only 2007-2012
- Old data is not easily available

Contributions

… to the Doppler centroid shift

- Geophysical (wind, waves and current)
- Geometric (estimated from satellite orbit and attitude)
- Electronic (antenna mis-pointing)
- Residual error

Non-geophysical terms must be precisely estimated and removed..



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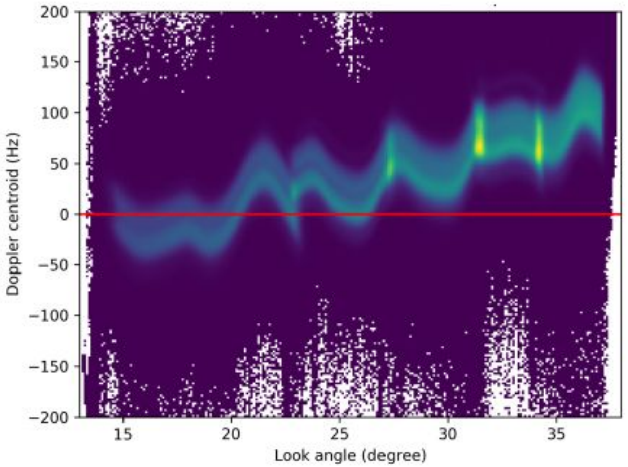
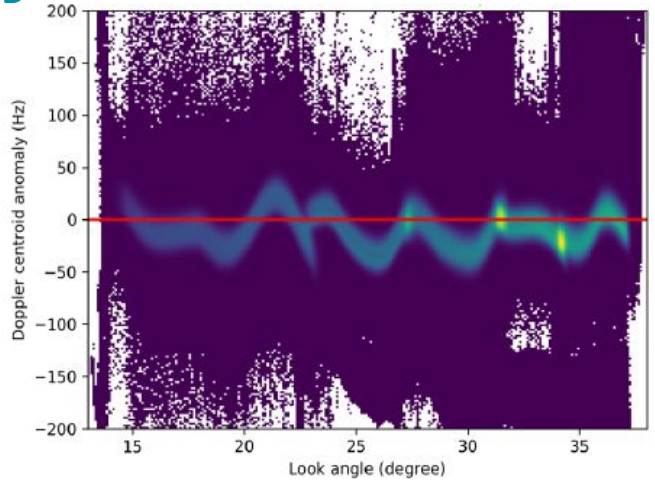
Doppler centroid anomaly distributions over land

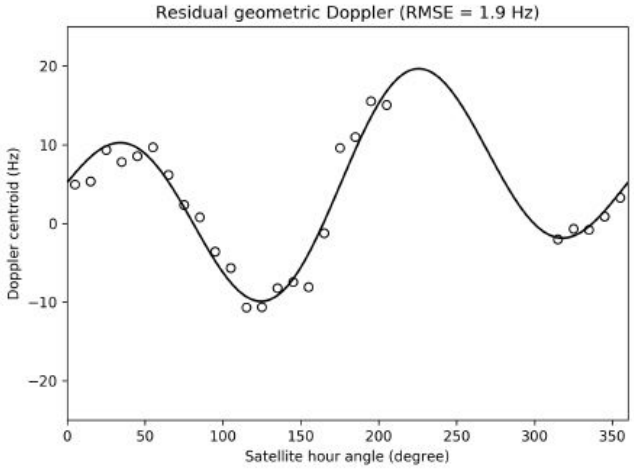
Before attitude correction

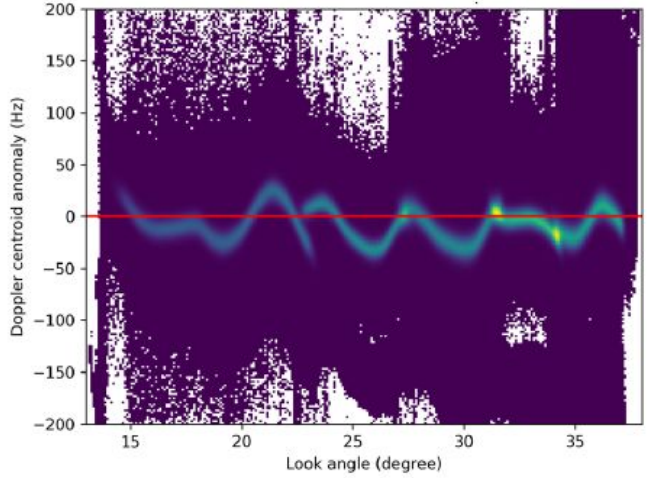




Following empirical attitude correction

Residual orbit dependent Doppler variation





Following orbit correction

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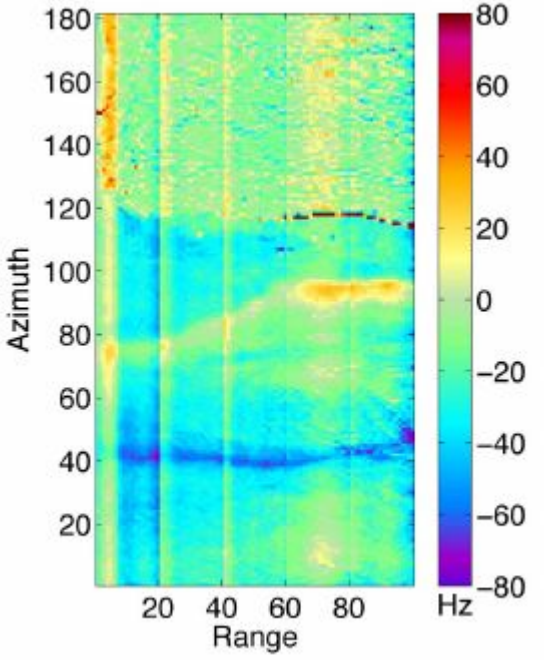
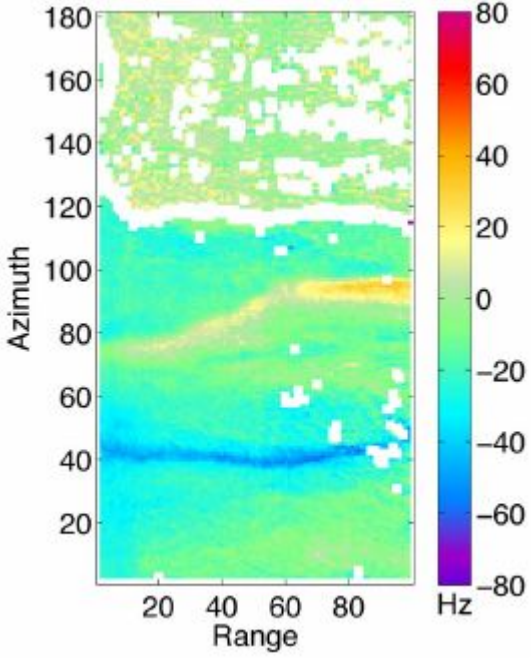
Before and after correction of antenna mis-pointing





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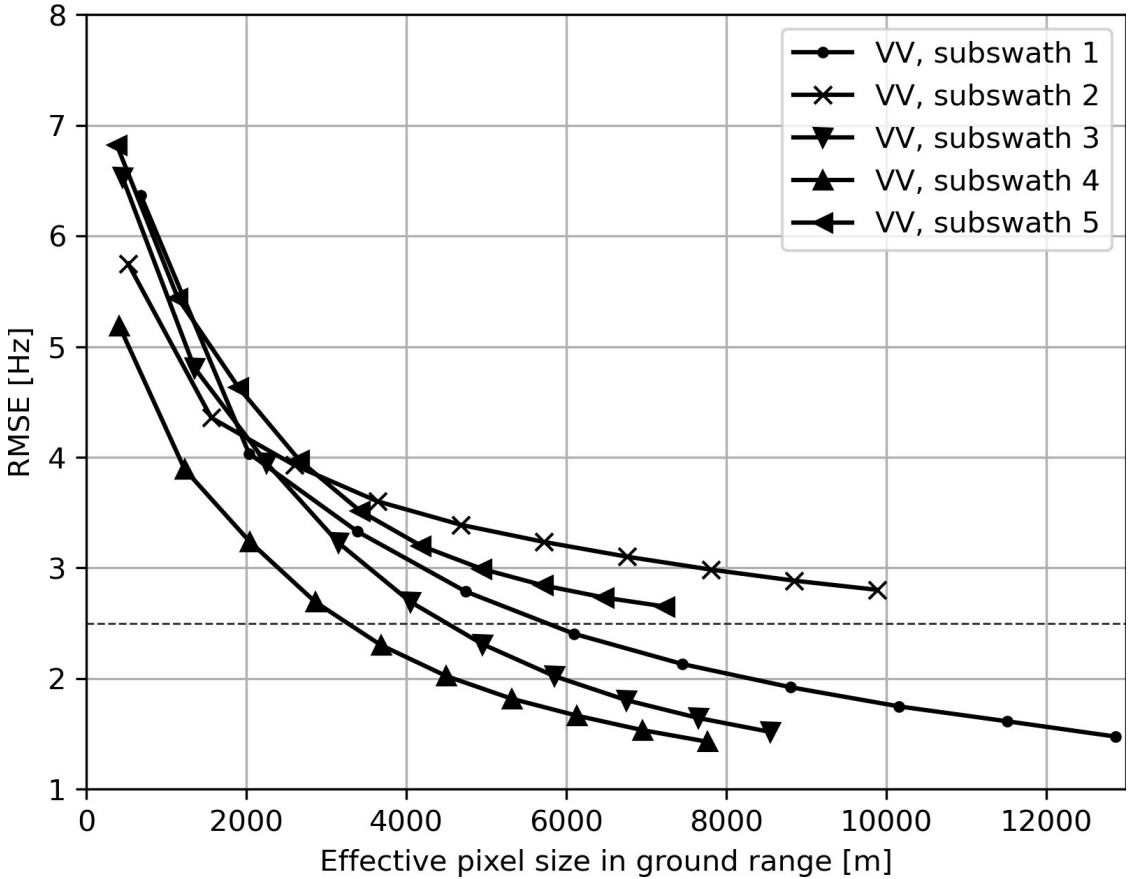
RMSE as a function of pixel size



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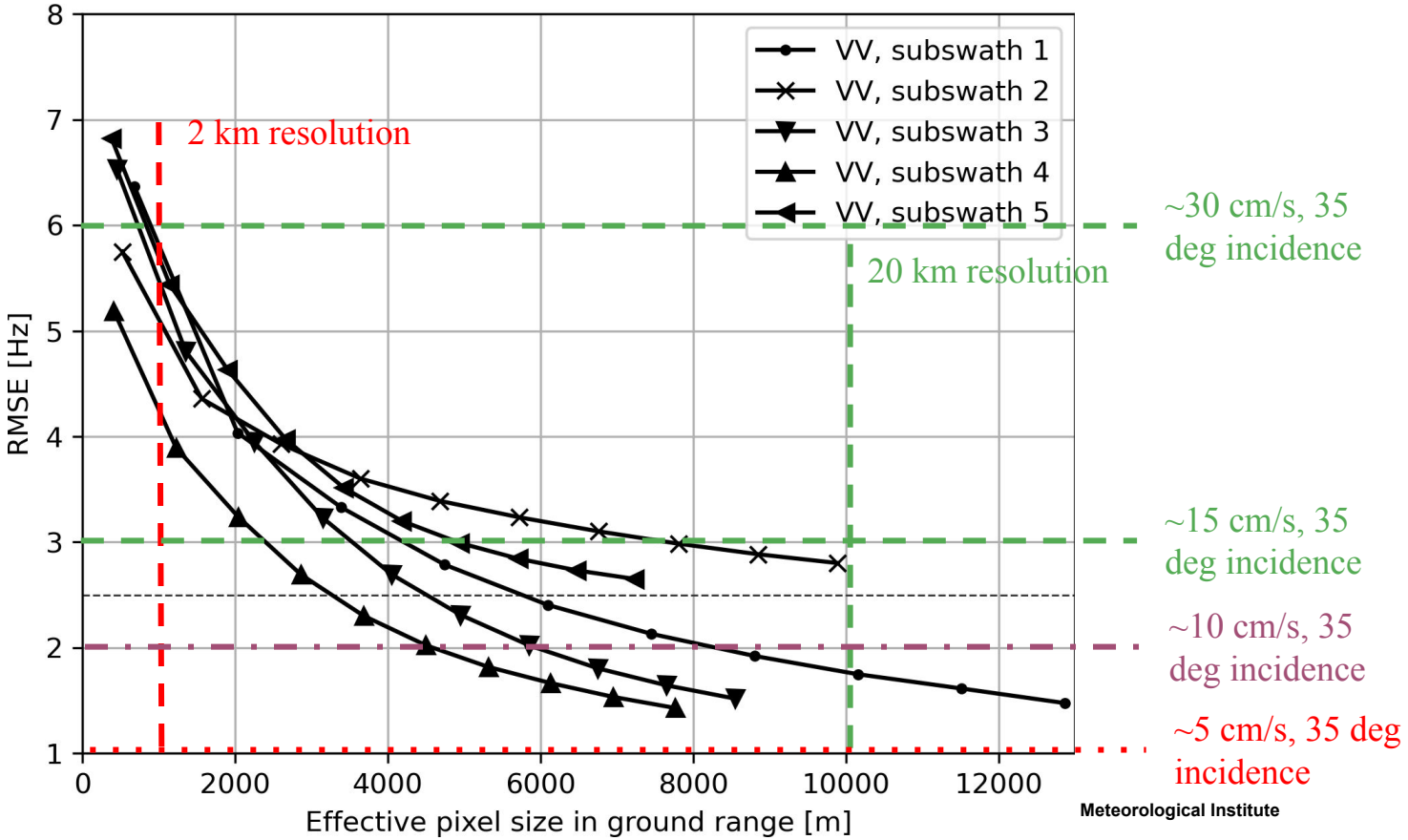
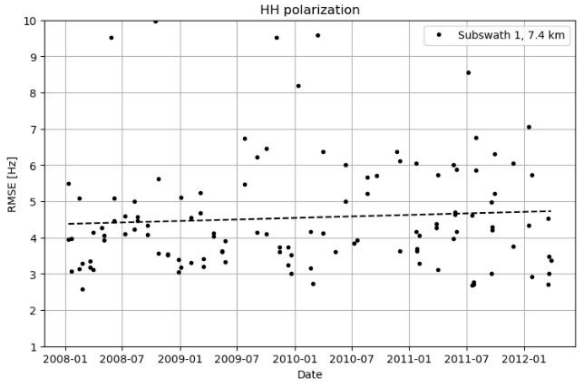
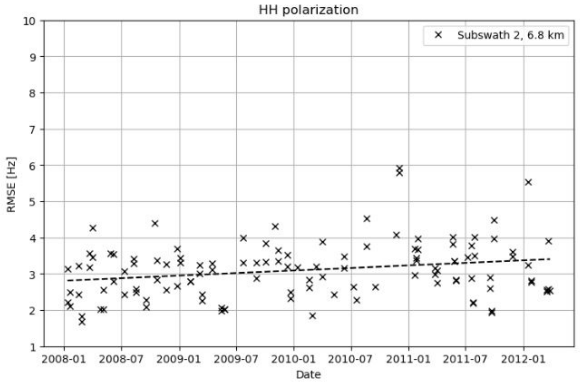
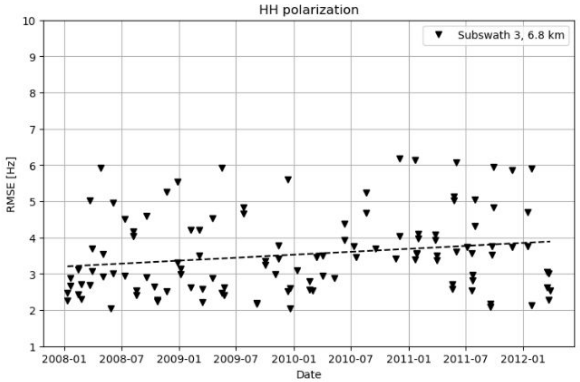
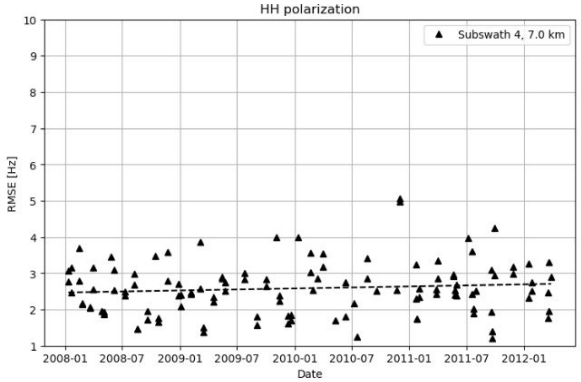


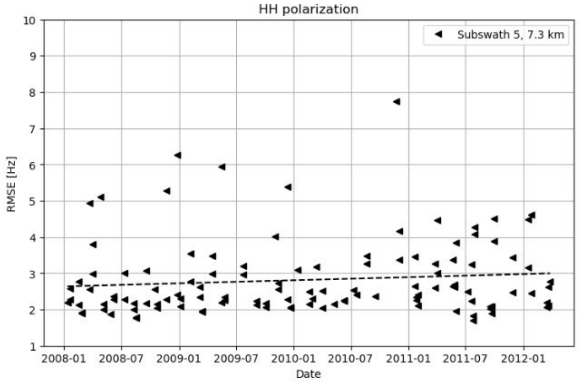
RMSE - temporal evolution









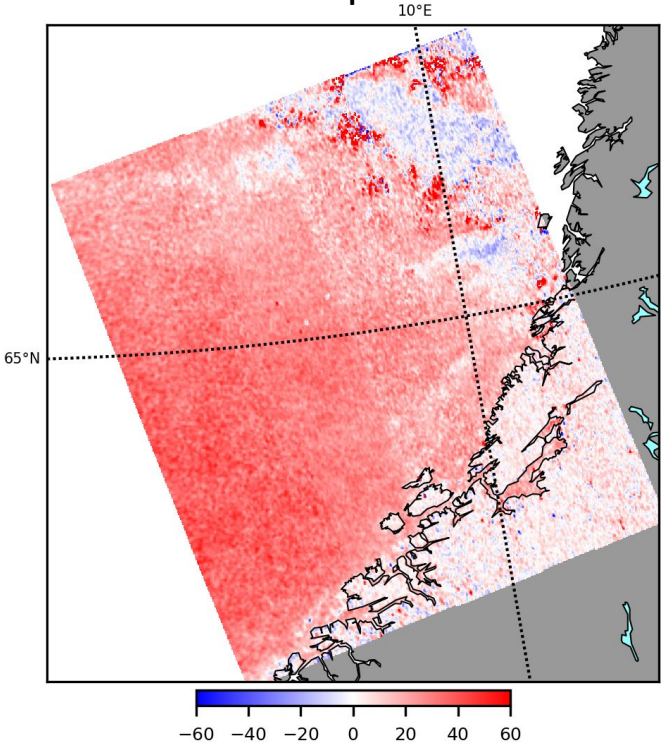


Status of the processing

- 2008 to 2012
  - Pre-processing at ESA is done
  - Look-up-tables are done
  - Final processing is ongoing in selected geographical regions
- 2005 to 2007
  - Pre-processing is ongoing at the ESA EarthConsole P-PRO service
  - Processing of Look-Up-Tables TBD at MET Norway
  - Extension of timeseries TBD at MET Norway
- 2002 to 2004
  - An issue with the Envisat attitude files is currently blocking the post-processing

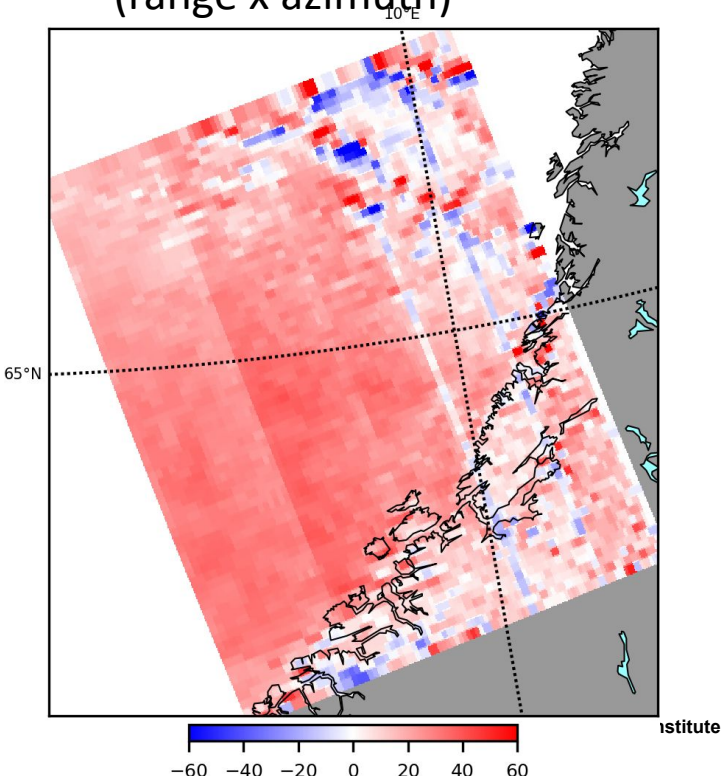
New versus old product

Grid: 1 km pixels



Wind direction

Grid: 4-9 km x 8 km (range x azimuth)



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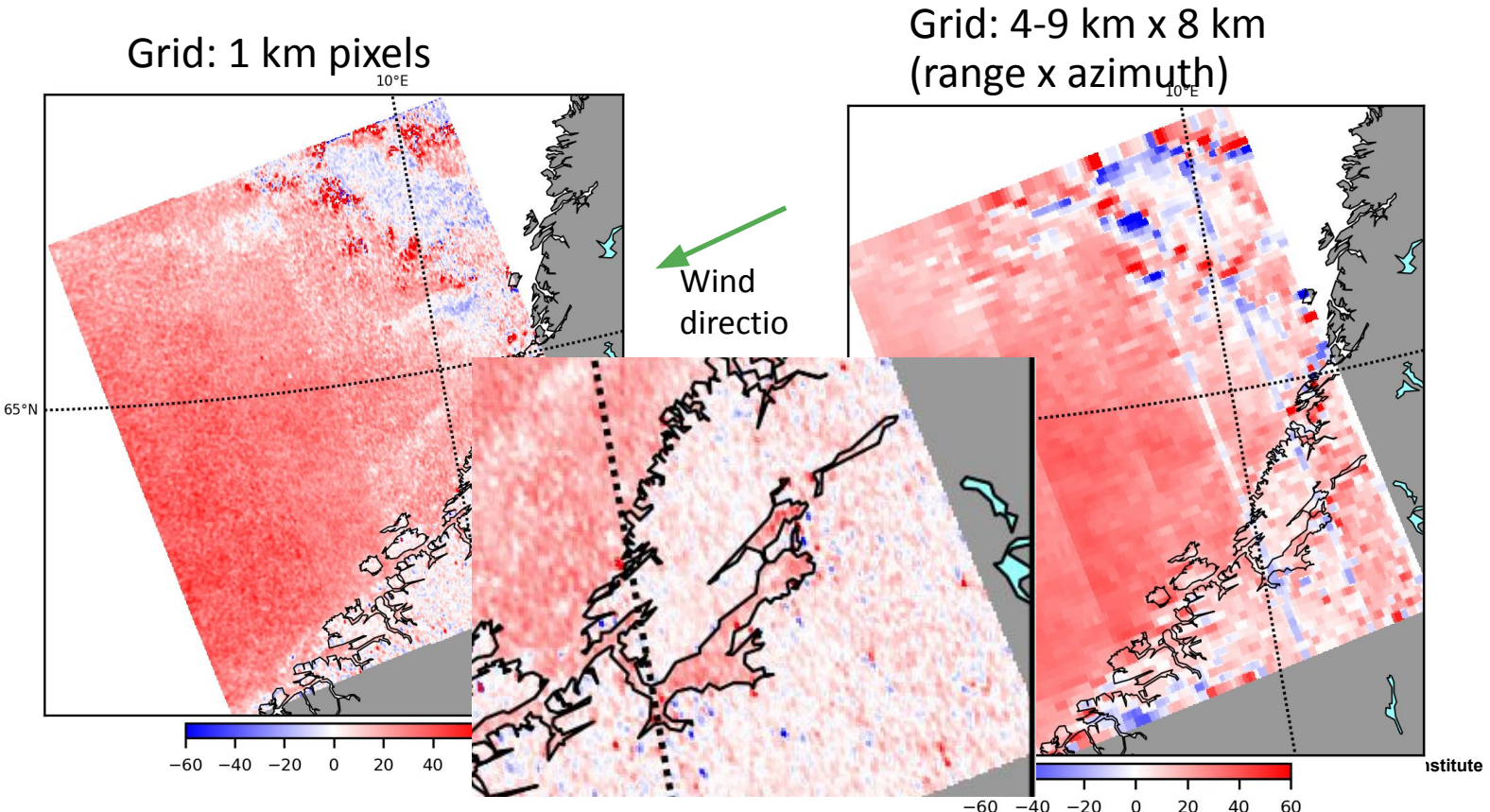
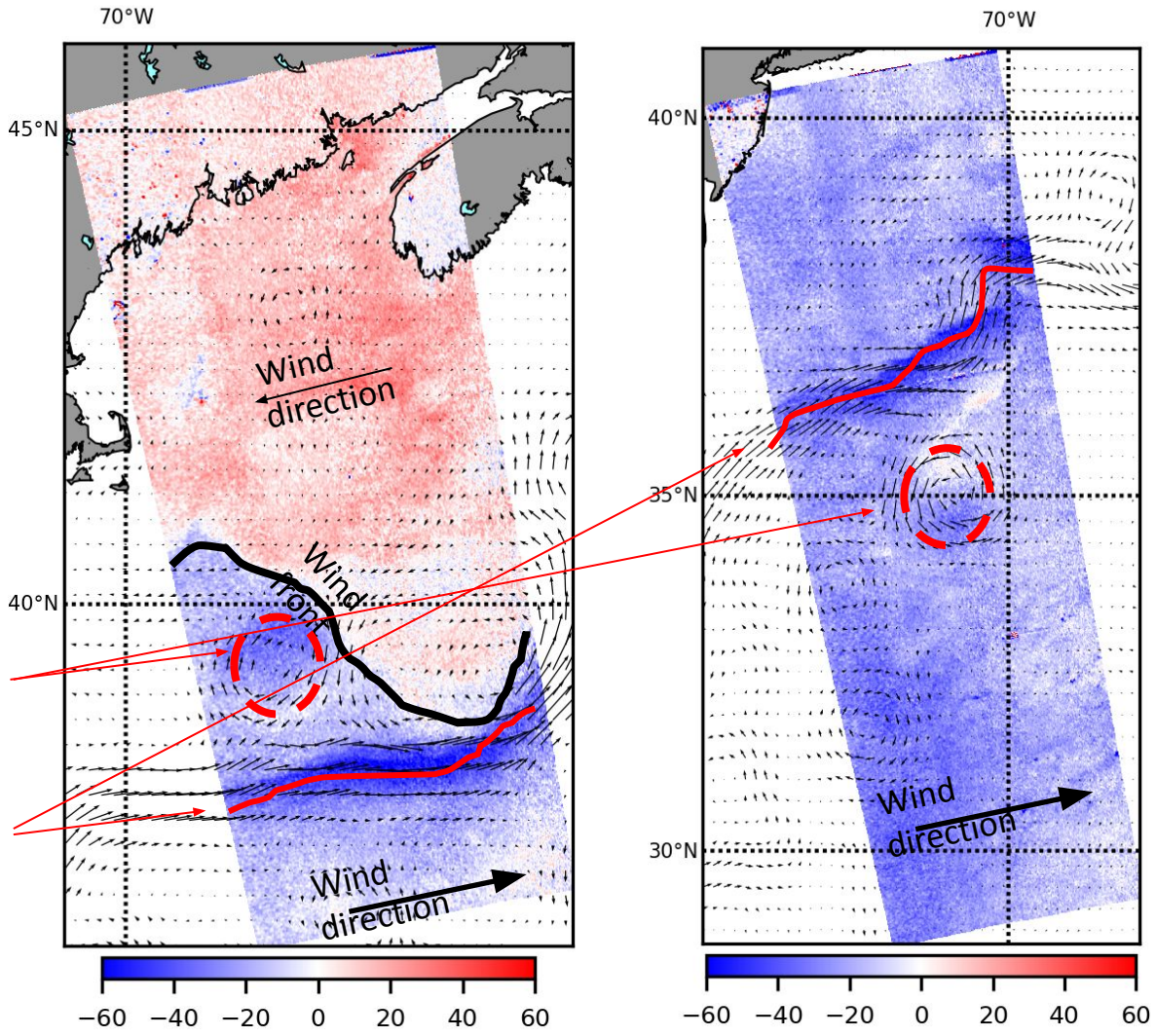
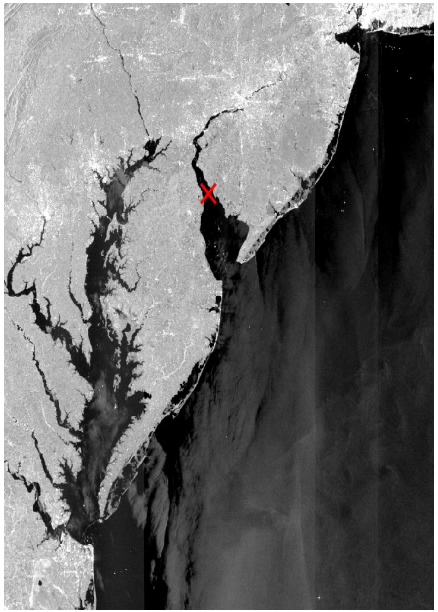


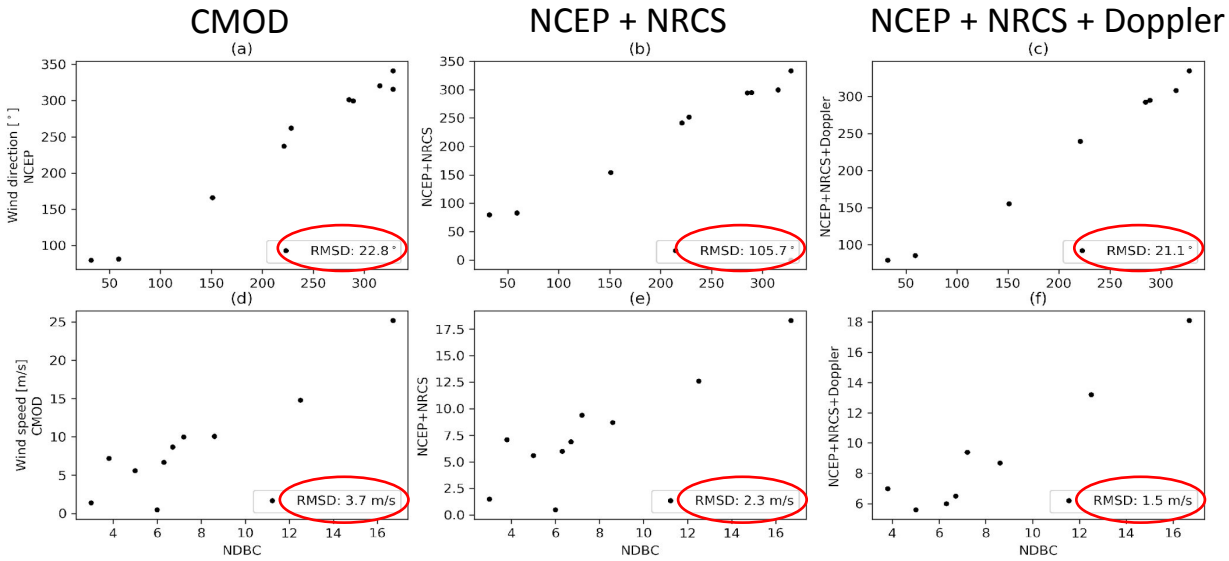
Gulf Stream

- Both wind and current contribute to the geophysical Doppler shift
- Altimetry based geostrophic current coincides with Doppler measurements



Improved wind field retrieval





Conclusion

- Full reprocessing of the Envisat ASAR wide swath archive is ongoing
- The error sources are fairly well understood
- Uncertainties are within the requirements for open ocean applications - provided sufficiently accurate correction of wind-wave effects
- The resolution is much better than before
  - e.g., allowing Doppler measurements much closer to land and in fjords
- High potential for many new and interesting studies;
  - mesoscale circulation, wind retrieval, sea ice drift, etc.!

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Thank you!

E-mail: mortenwh@met.no