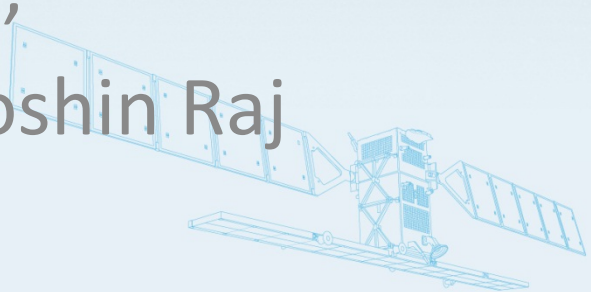
Norsk Romsenter
NORWEGIAN SPACE CENTRE
NERSC
esa
SEASAR 2012
The 4th International Workshop on Advances in SAR Oceanography

Monitoring the Nordic Seas surface velocity using Envisat ASAR

Morten W. Hansen,
Johnny A. Johannessen, Roshin Raj



18-22 June 2012 | Tromsø, Norway

Outline

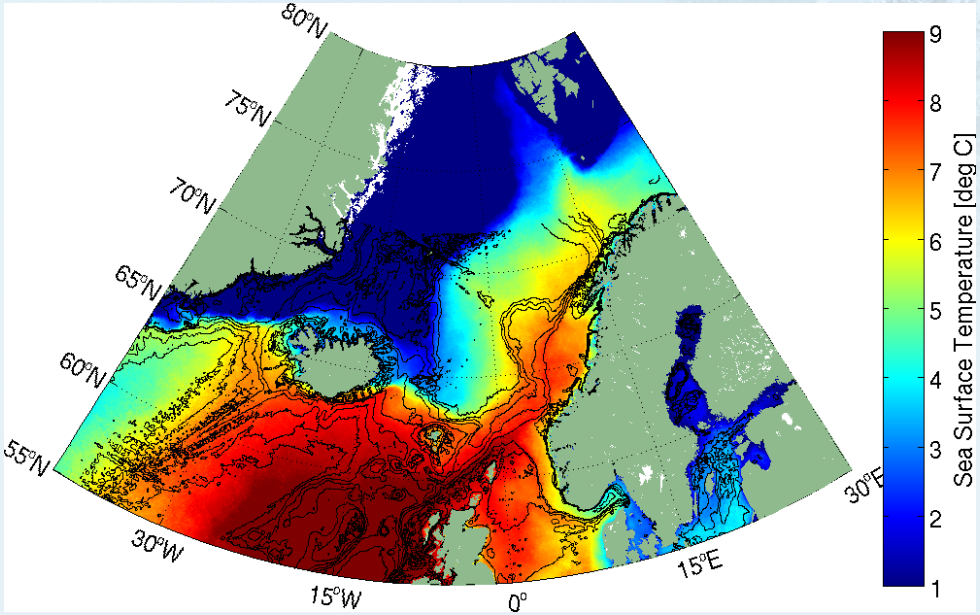
- Motivation
- The Nordic Seas circulation
- SAR range Doppler velocity
- Reconstruction of 2D current from line-of-sight components
- Mean zonal velocity from ASAR (2007-2011)
- Comparison to other data
  - Rio ‘09 Mean Dynamic Topography from CNES-CLS09
  - Current meter recordings from the University in Bergen
  - Absolute Dynamic Topography from AVISO
  - Mean Dynamic Topography from GOCE

Motivation

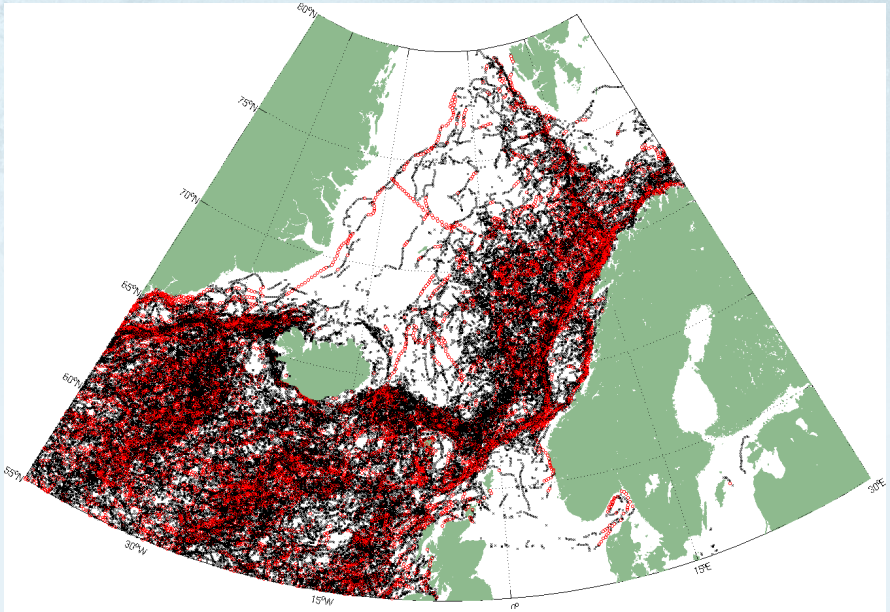
- The Nordic Seas circulation is of great importance to the high-latitude and Arctic climate and eco-system
- Mesoscale current variability on the order of 10-100 km is not adequately measured
- The range Doppler velocity product from Envisat ASAR allows to develop better methodologies for surface current estimation at these scales
- Combination with results from the GOCE mission makes promising opportunities for obtaining finer spatial resolution of the geoid, Mean Dynamic Topography (MDT), and surface current in areas of strong topographic steering

Nordic Seas circulation

Mean winter SST (2002-2011)



Surface drifter tracks (1991-2007)



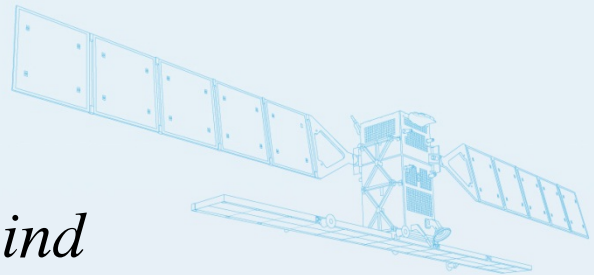
Red: |v| > 50 cm/s

- Inflow of warm and saline Atlantic water
- Production and transformation of water masses
- Outflow of cold and fresh Arctic water

SAR range Doppler velocity

- Only the velocity component along the radar look direction can be retrieved
- Results from the combined contributions from surface current and wind-driven surface waves
- The Doppler shift resulting from surface current is found by subtracting the contribution from wind-waves:

$$v_{current} = v_D - v_{wind}$$



Reconstruction of 2D current from line-of-sight components

$$v_a = u\cos\alpha + v\sin\alpha$$

$$v_d = u\cos\delta - v\sin\delta$$

➡ Expressions for the mean zonal and meridional current!

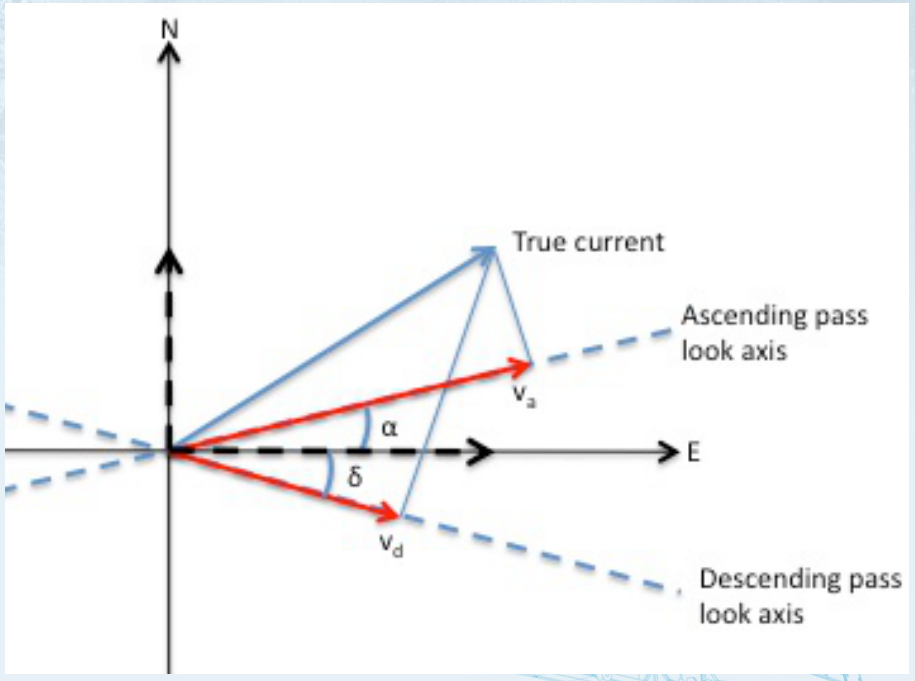


Figure from Dagestad et al. (2012)

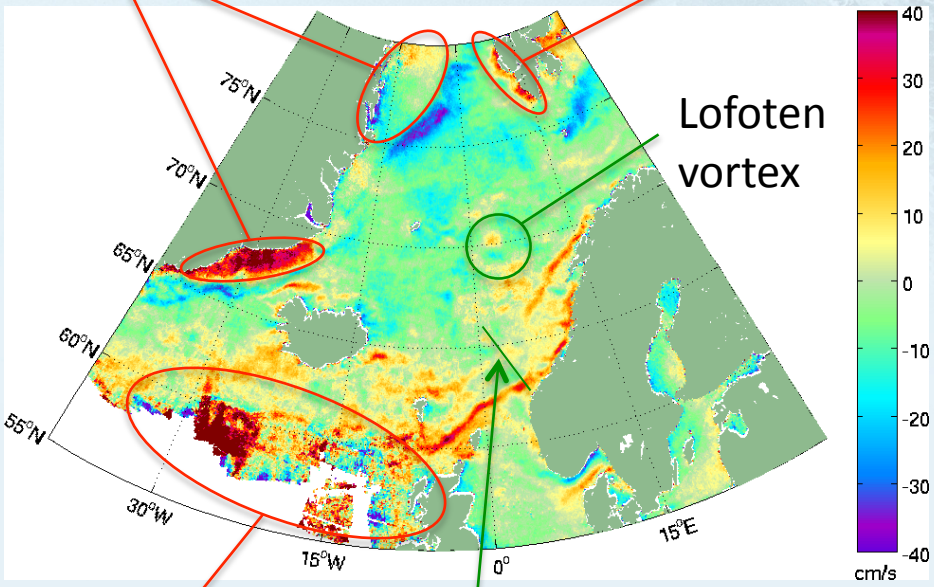
Zonal (east-west) velocity component

2007-2011

Sea ice

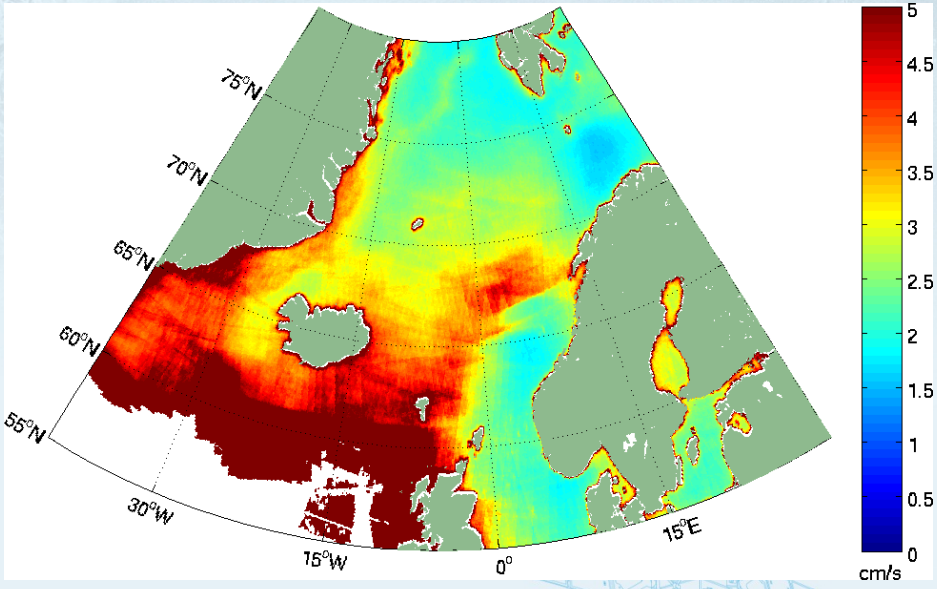
Weighted mean

Wind?



Lofoten vortex

Uncertainty



Poor coverage

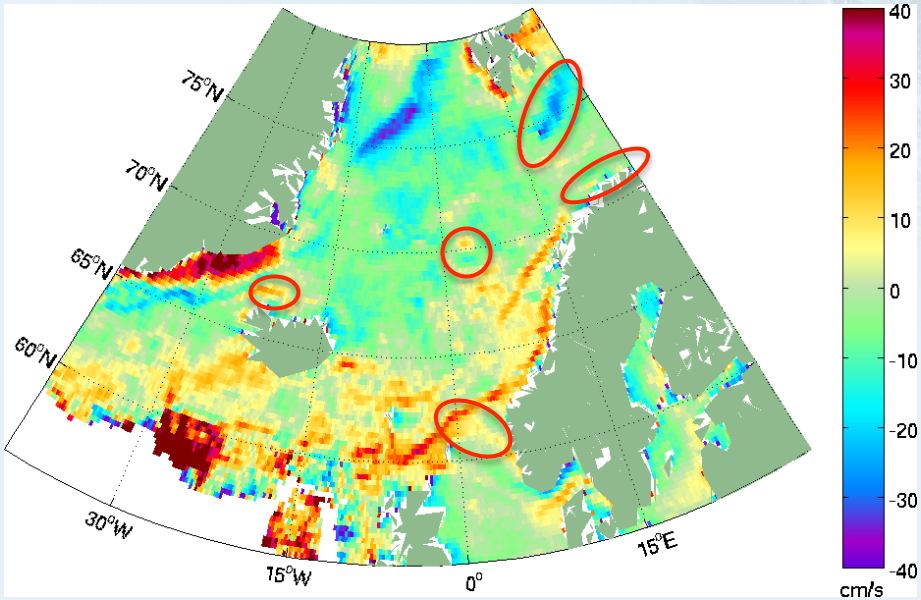
Svinøy section

RMSE: down to 2 cm/s

Spatial resolution: 10 km

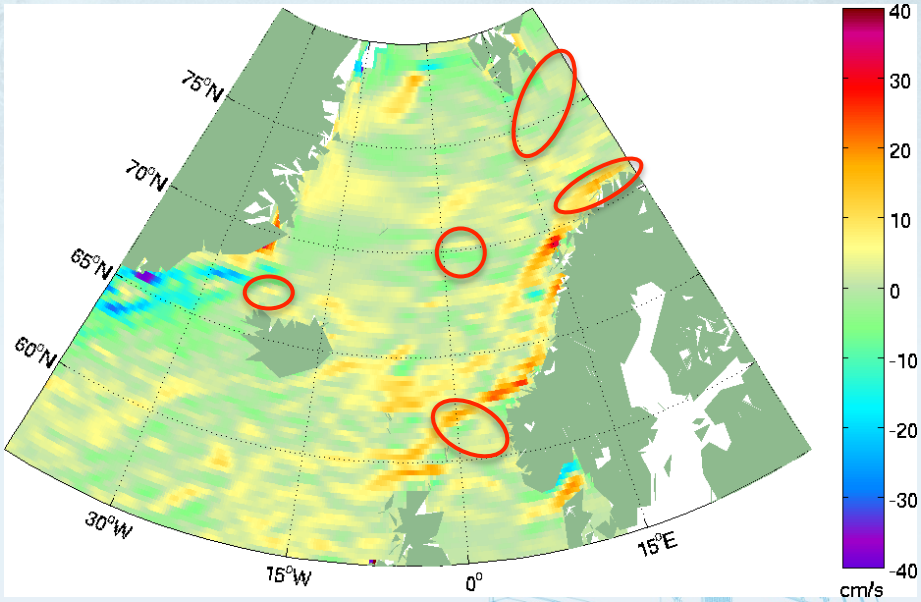
Surface geostrophic current

ASAR



2007-2011

CNES-CLS09 (Rio et al., 2011; GRACE geoid, altimetry, drifters)

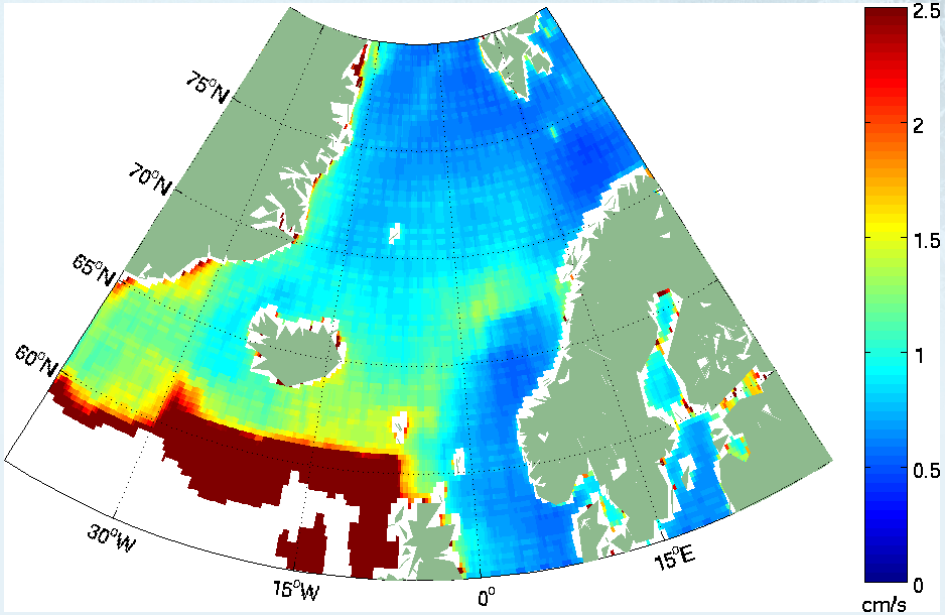


1993-2008

Spatial resolution: 50 km

Uncertainties

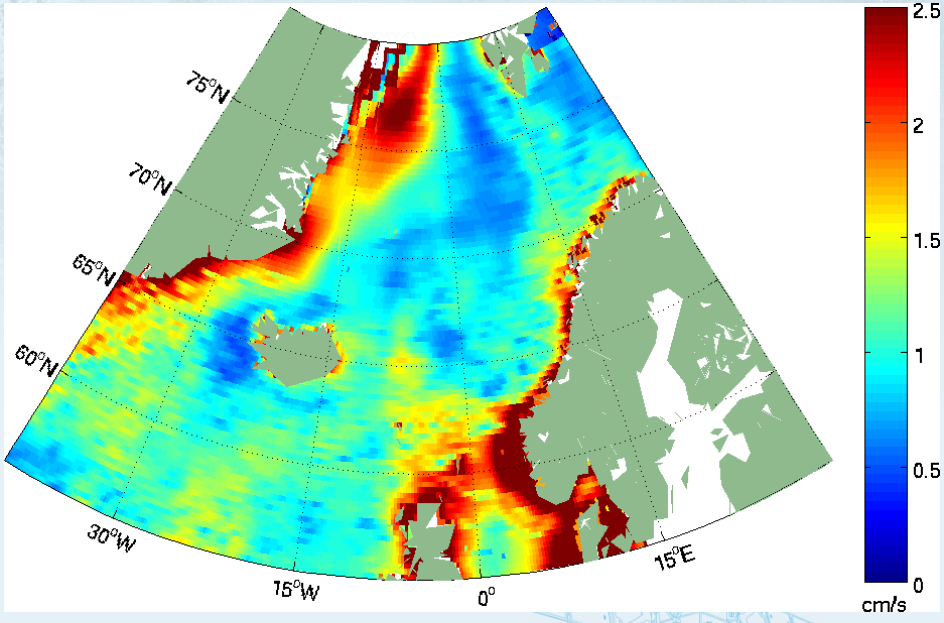
ASAR



4 years of data

RMSE approaching 0.5 cm/s

CNES-CLS09 (Rio et al., 2011)



15 years of data

Moored current meter in the Svinøy section

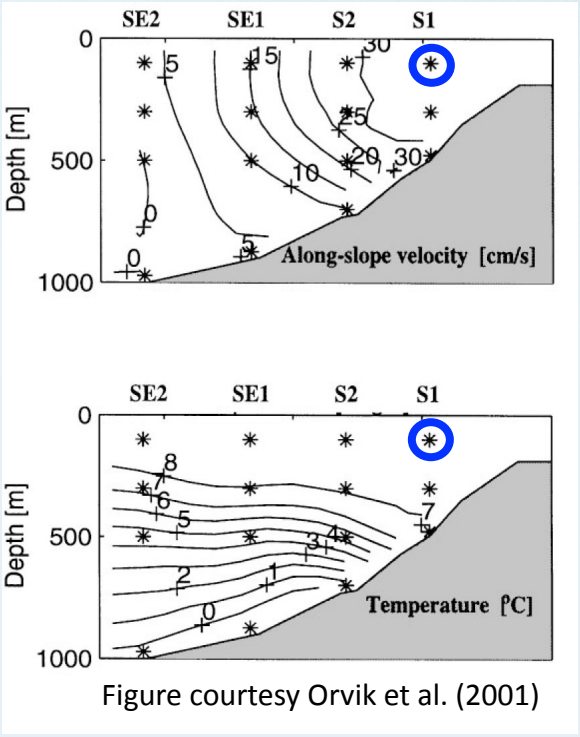
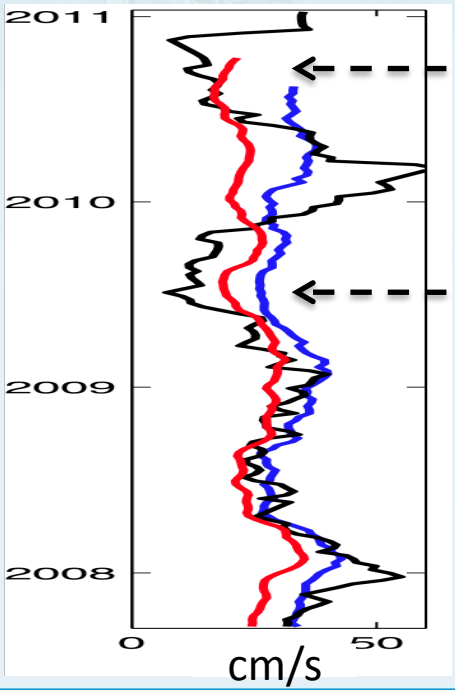
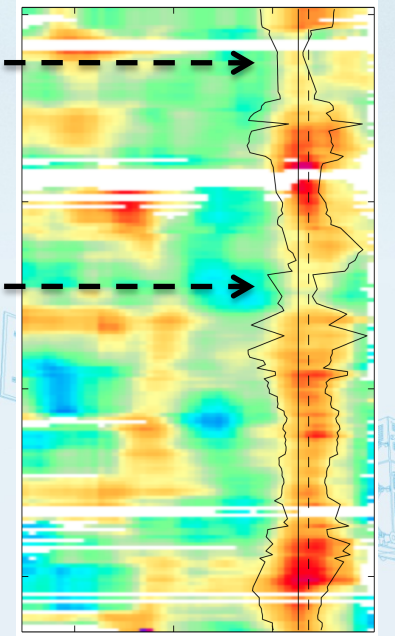


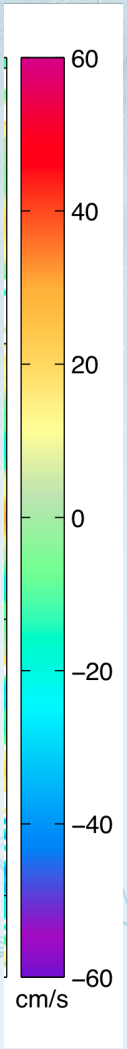
Figure courtesy Orvik et al. (2001)

Geostrophic current (AVISO)
Current meter (at 100 m depth)
ASAR



ASAR

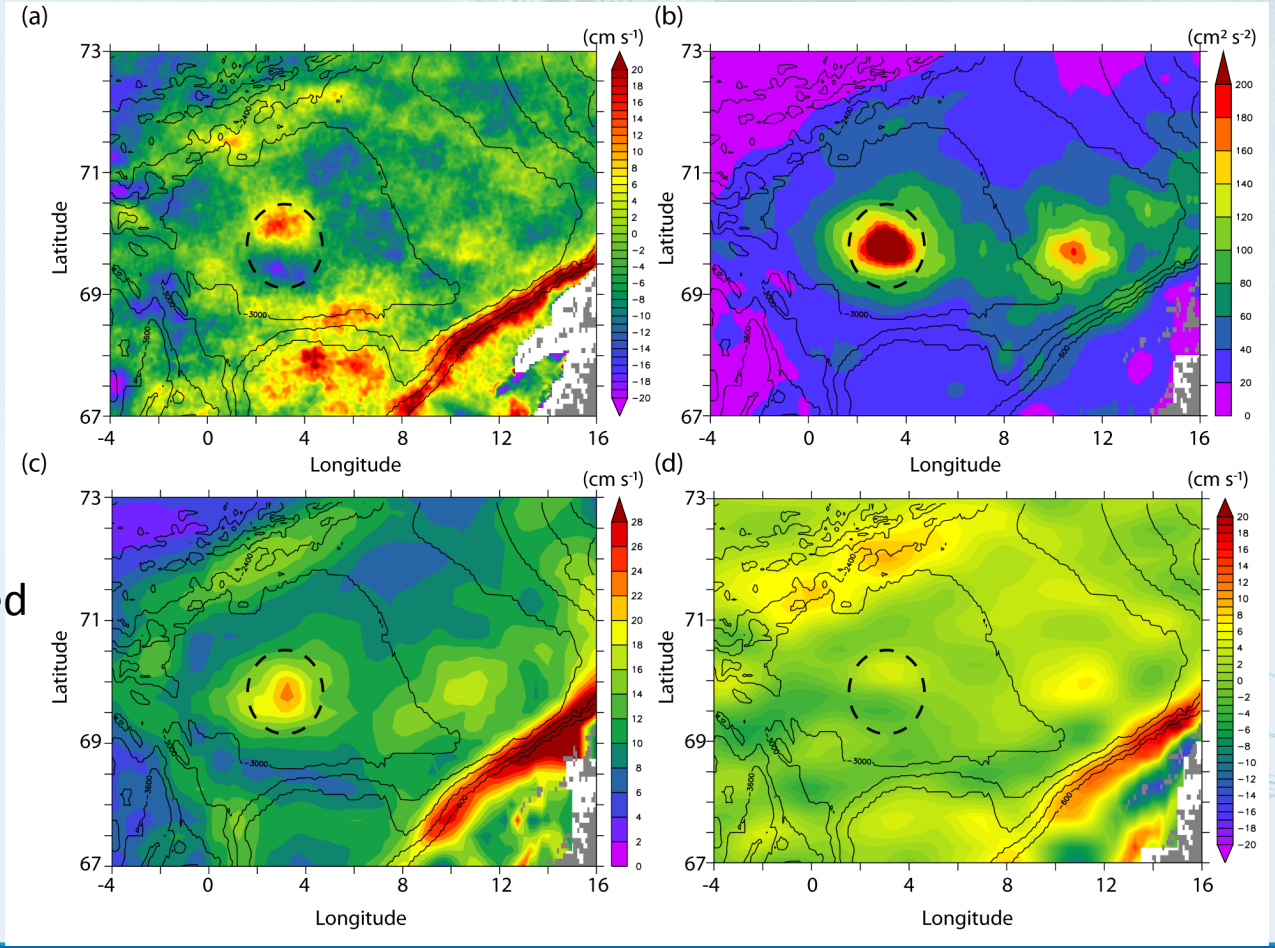




Lofoten vortex (2007-2011)

ASAR zonal velocity

ADT derived absolute speed



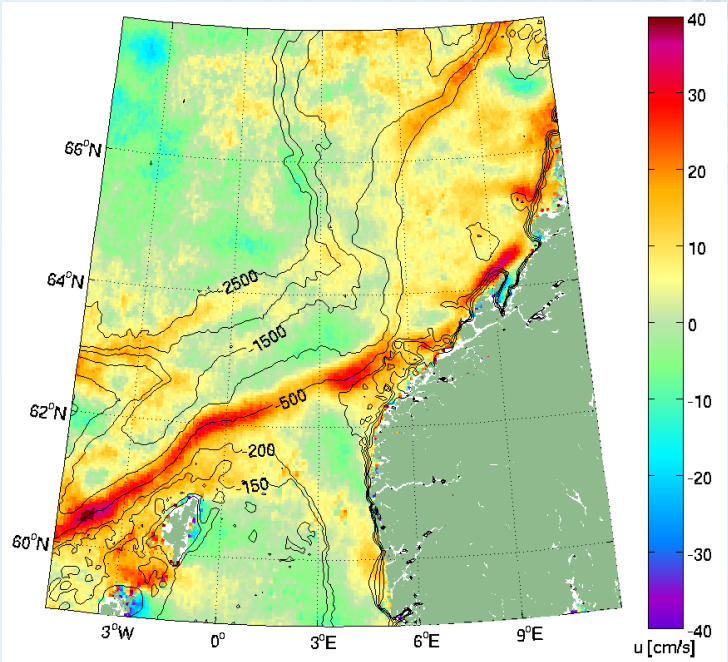
ADT derived Eddy Kinetic Energy

ADT derived zonal velocity

ADT: Absolute Dynamic Topography (AVISO)

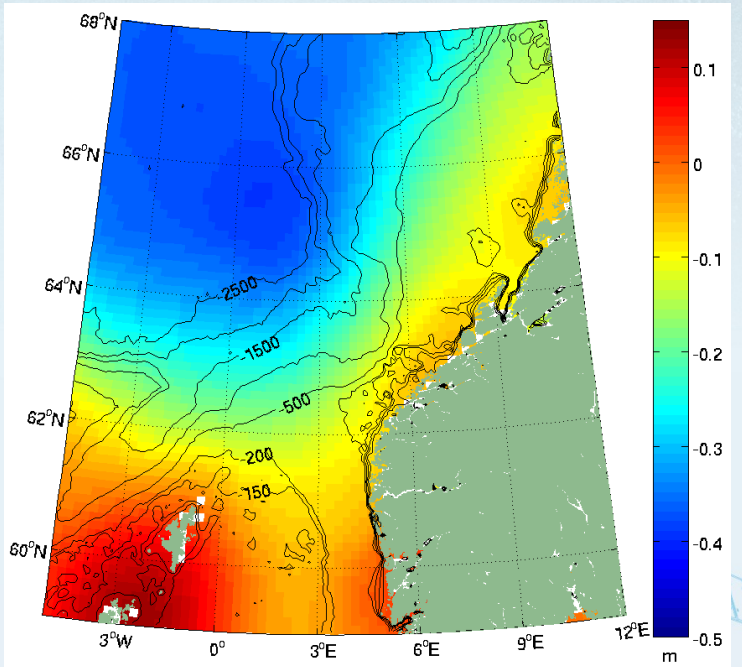
Evaluation of GOCE results with ASAR

ASAR zonal velocity



2007-2011

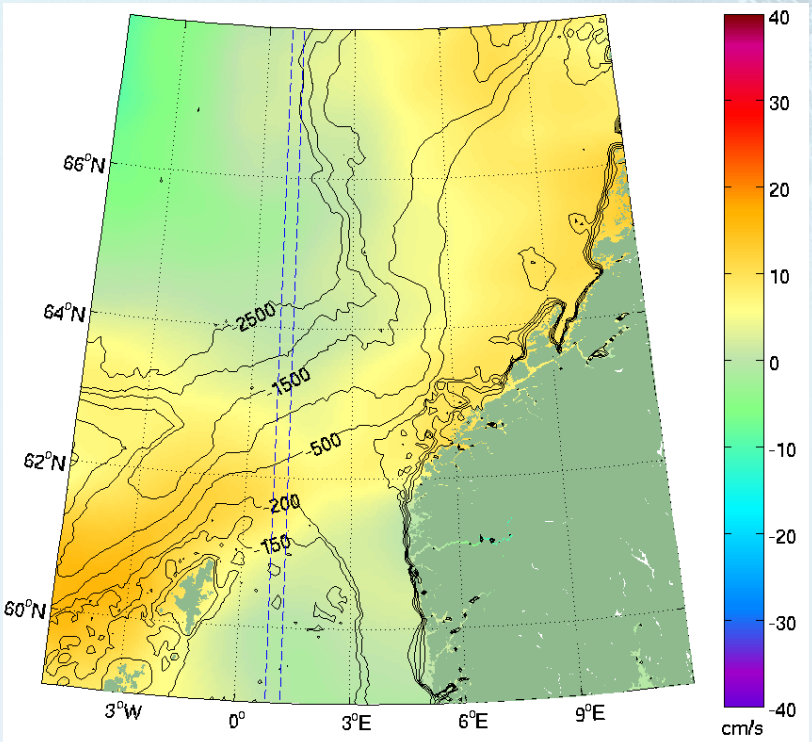
MDT based on GOCE geoid (Knudsen et al., 2011)



12 months integration

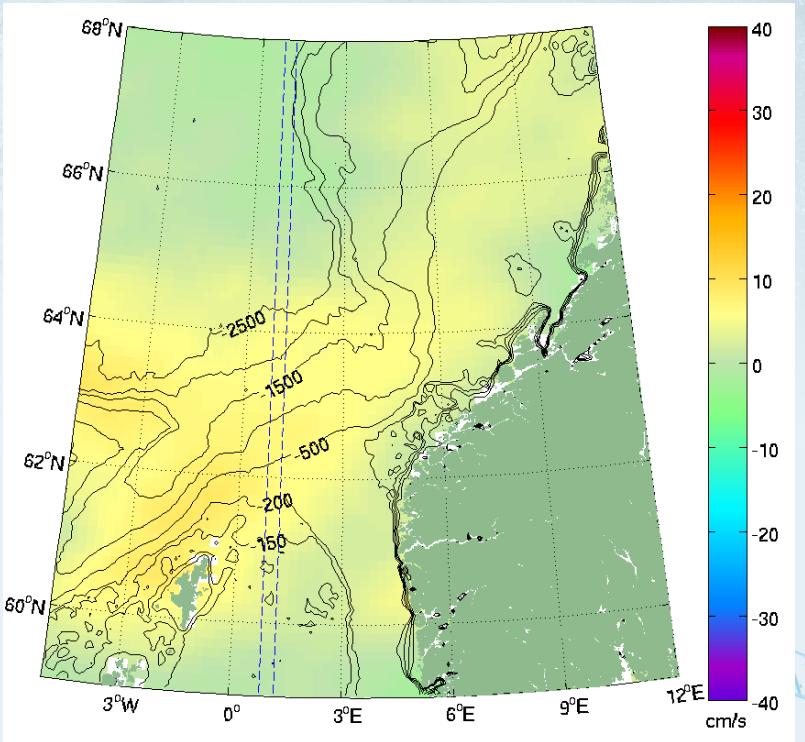
Evaluation of GOCE results with ASAR

ASAR at GOCE grid (200 km)



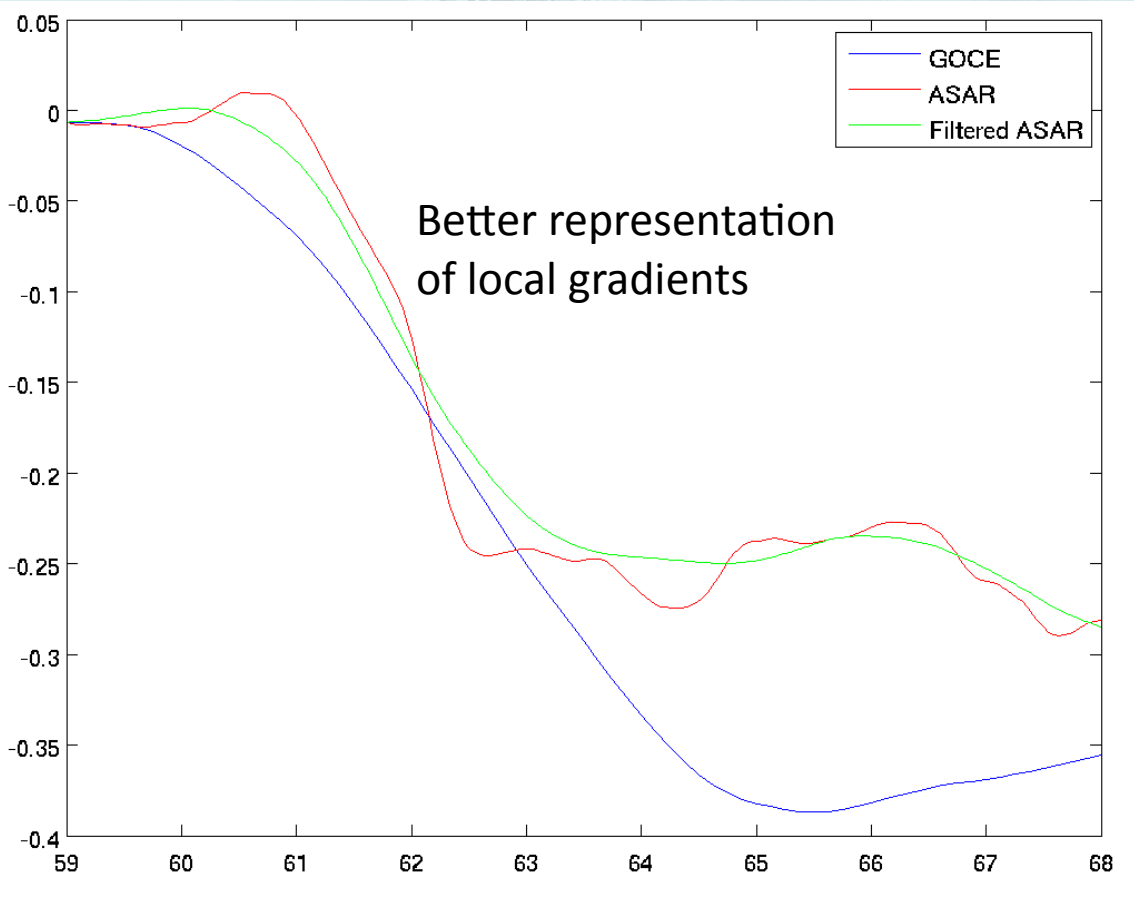
2007-2011

GOCE (Knudsen et al., 2011)



12 months integration

Mean Dynamic Topography along the meridian at 2°E



MDT from SAR calculated with geostrophic equations

Conclusion

- Mean zonal velocity from 4 years of ASAR measurements over the Nordic Seas has been presented
  - Accuracy approaches 2 cm/s at 10 km spatial resolution
  - Results are promising in the southeastern domain including the Lofoten Basin
  - Challenges exist in the northern and western domains due to sea ice and wind
- A clear seasonal signal is observed in the Svinøy section
- The Lofoten vortex is observed with a very clear signal in ASAR
- Combination with GOCE is promising for deriving higher resolution MDT and geoid in areas of strong topographic steering

To improve accuracy also in the north-south current component

- Is it feasible for ESA to reprocess data from 2002-2007 to include the Doppler centroid in the wide swath products from that period?
- Can this be done also for Radarsat-2 wide swath mode?