Wind in the sea around Iceland

Charlotte Hasager and Nikolai Nawri

Contribution from:
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Introduction

- Previous analyses (Nawri et al, 2014: The Wind Energy Potential of Iceland, *Renewable Energy*), conducted under Work Package 2 of IceWind, have demonstrated the excellent onshore wind energy resources of Iceland, placing it into the highest category, defined in the European Wind Atlas
- In this follow-up study, the offshore wind energy resources are being evaluated based on satellite data and mesoscale numerical model simulations

Data

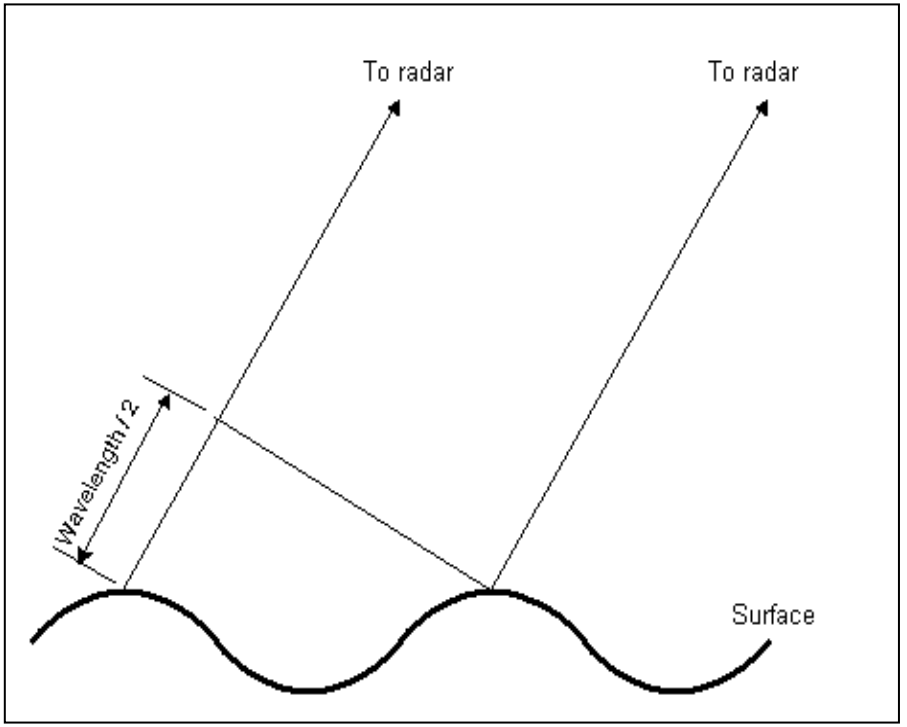
- Synthetic Aperture Radar (SAR): Envisat ASAR images for the 2005 – 2012 period
- Mesoscale model simulations produced with the IMO operational forecast model Harmonie (Version 37h1.2), with a spatial resolution of 2.5 km, using ECMWF operational analyses as boundary conditions
- Surface station measurements of wind speed and direction at 10 mAGL, at a few onshore locations near the coast or on small islands

Methodology on satellite winds

Bragg / resonance scattering:

$$\lambda_{Bragg} = \frac{\lambda_{radar}}{2\sin\theta}$$

θ = incidence angle (15-70°)
λ = wave length



Bragg waves ride on longer-period waves
Random variation occurs (speckle) → Pixel averaging is necessary

SAR backscatter to wind

Empirical geophysical model functions (GMF):

$$NRCS = U^{\gamma(\theta)} A(\theta)\left[1 + B(\theta, U)\cos\phi + C(\theta, U)\cos 2\phi\right]$$

$NRCS$ = radar backscatter [dB]

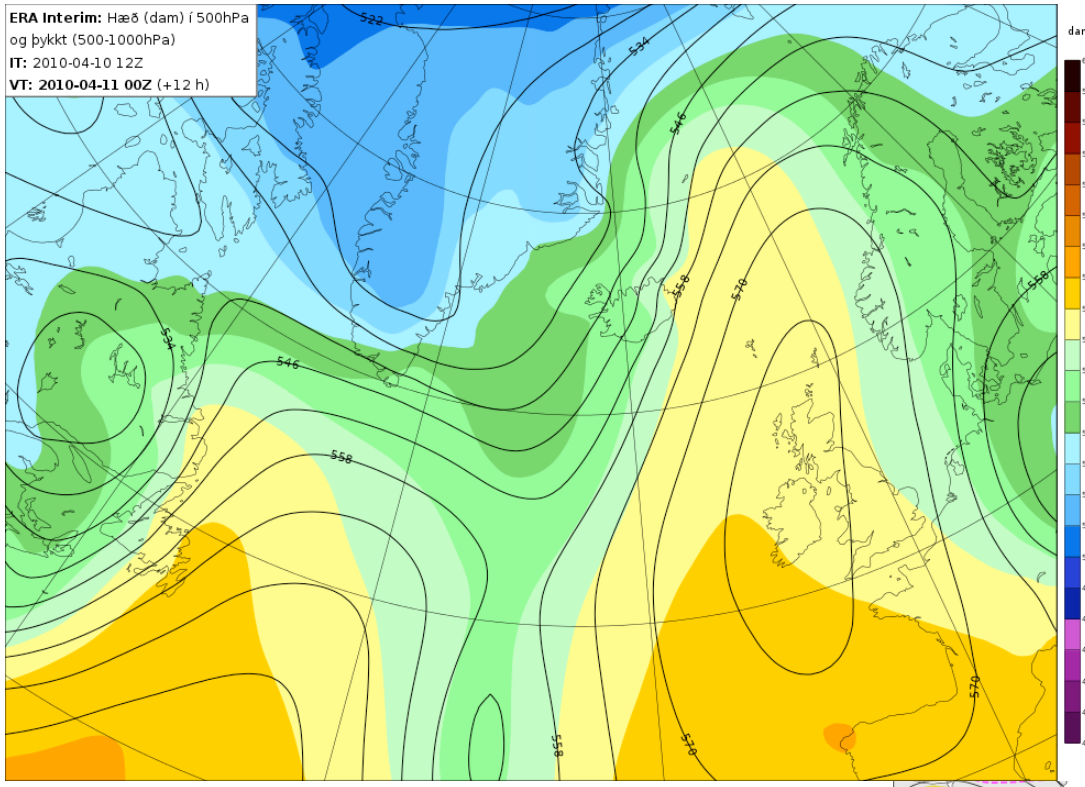
θ = incidence angle [degrees]

U = wind speed at 10 m [m/s]

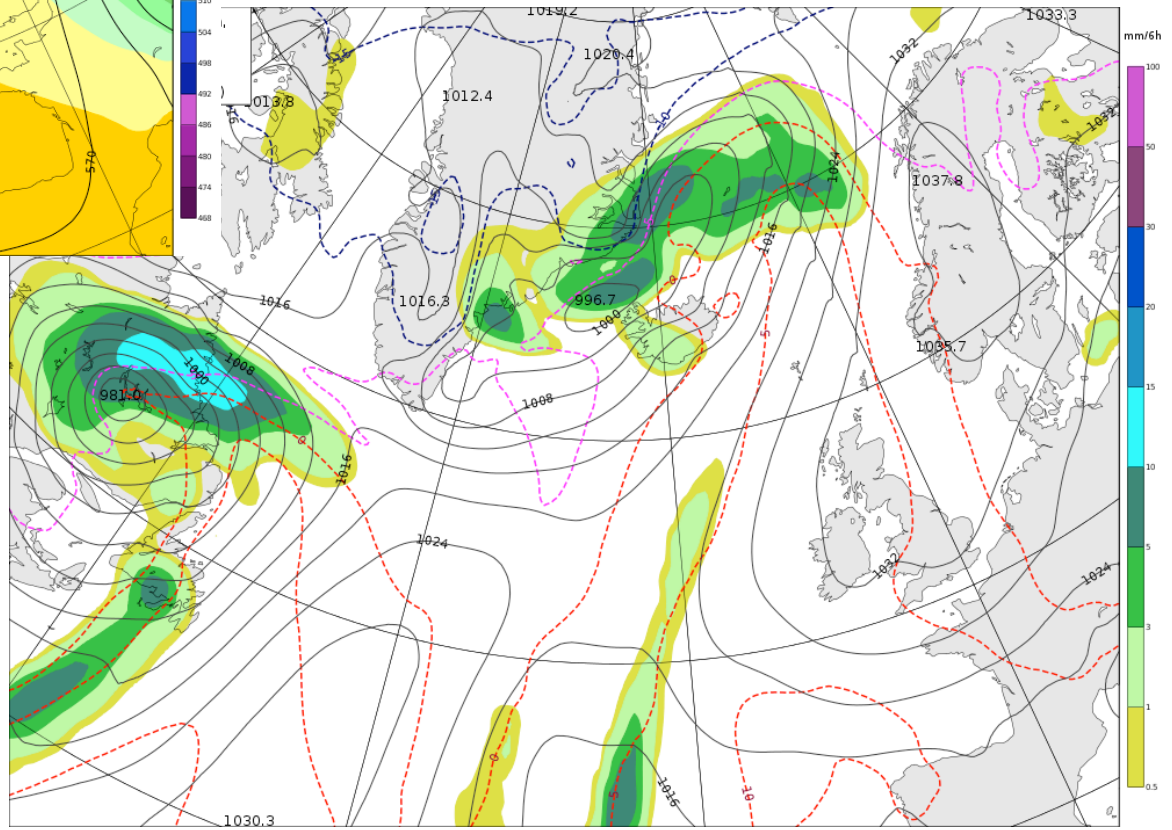
Φ = relative wind direction [degrees]

Model functions apply to open oceans and neutral atmospheric stability
The nominal accuracy on wind speed is +/- 2 m/s

11 April 2010, 00 UTC (ERA-Interim)

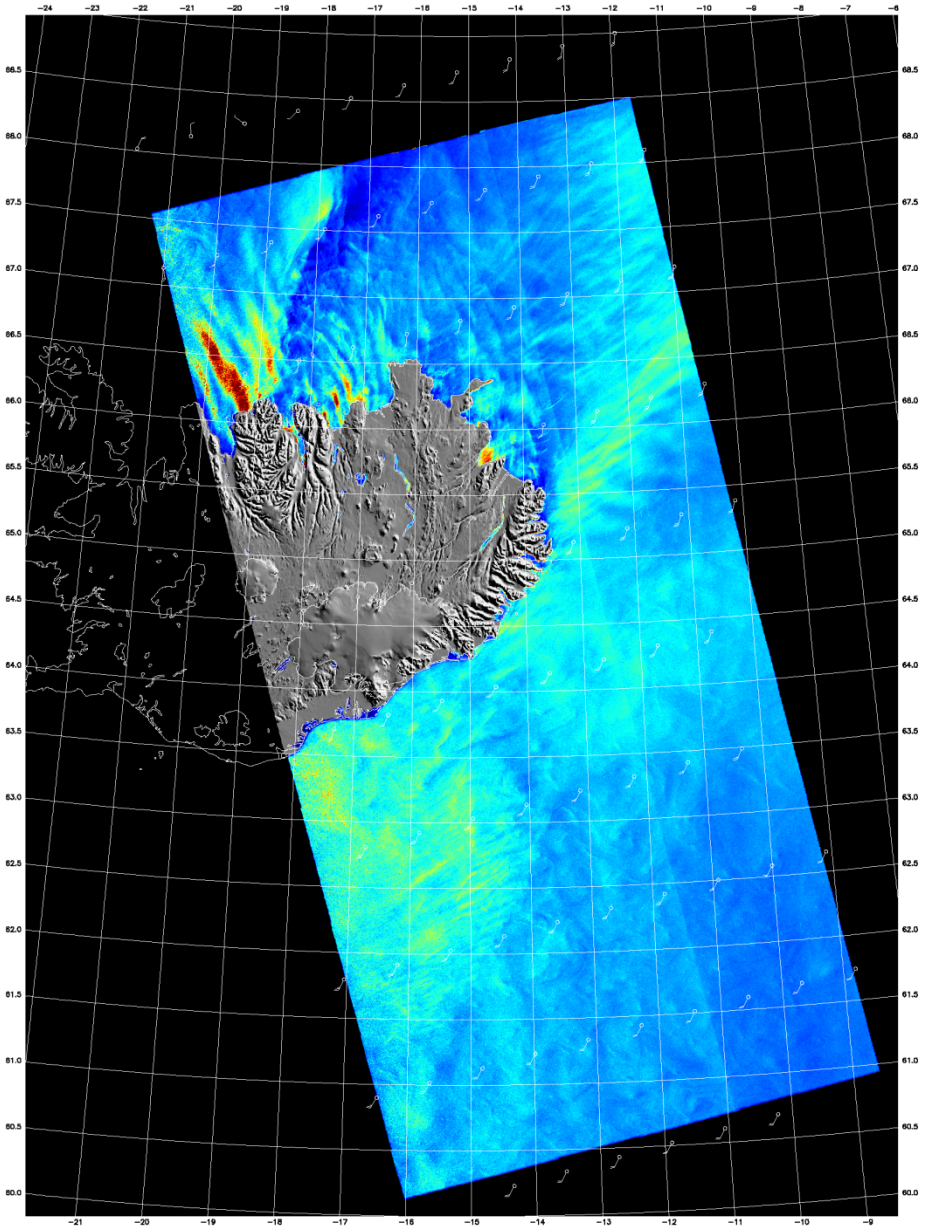


500 hPa geopotential height
1000 – 500 hPa thickness

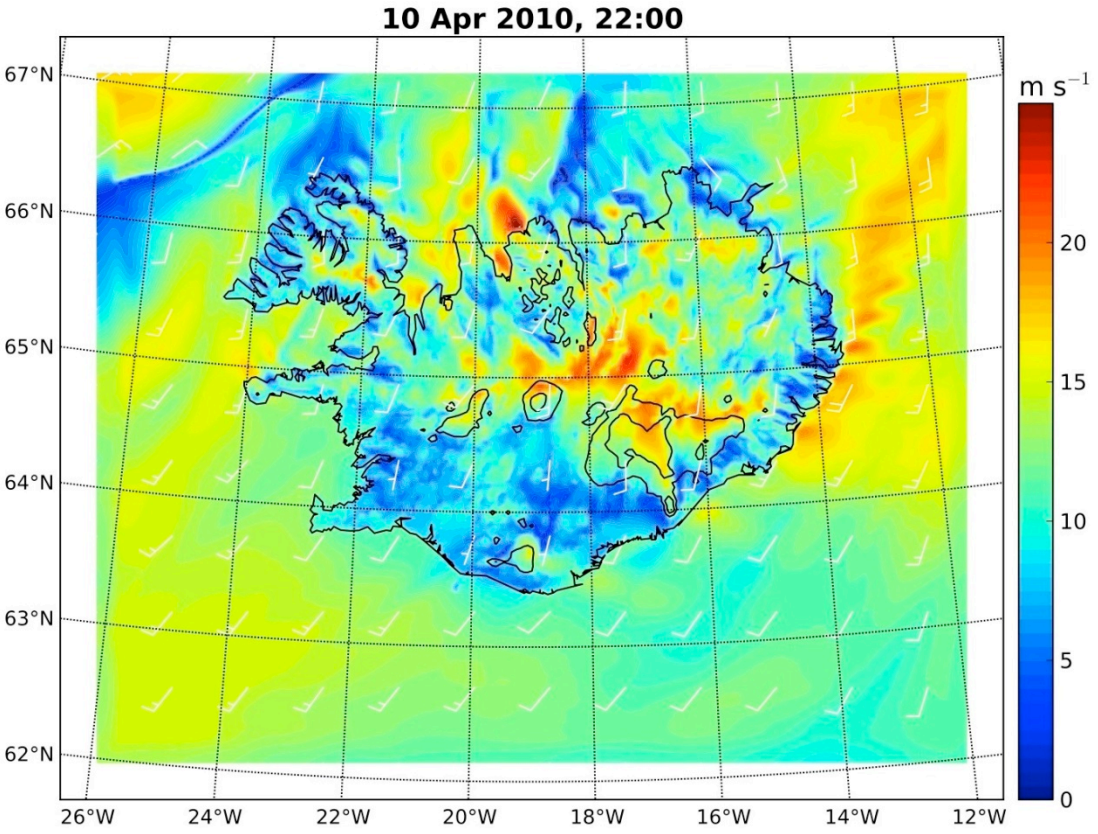


MSLP
6-hr precipitation
850 hPa temperature

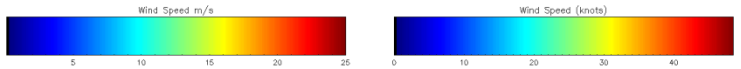
10 April 2010, ~ 22 UTC (SAR and Harmonie)



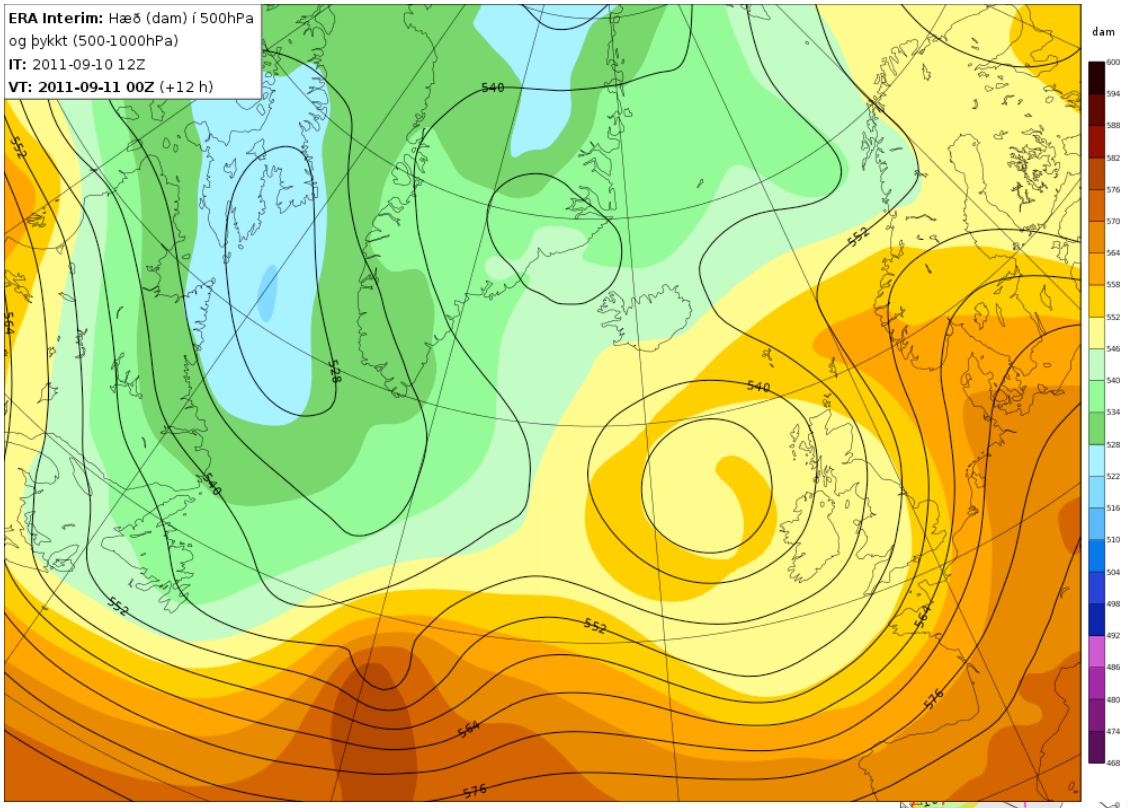
SAR (22:20 UTC)



Harmonie (22:00 UTC)



11 September 2011, 00 UTC (ERA-Interim)



500 hPa geopotential height
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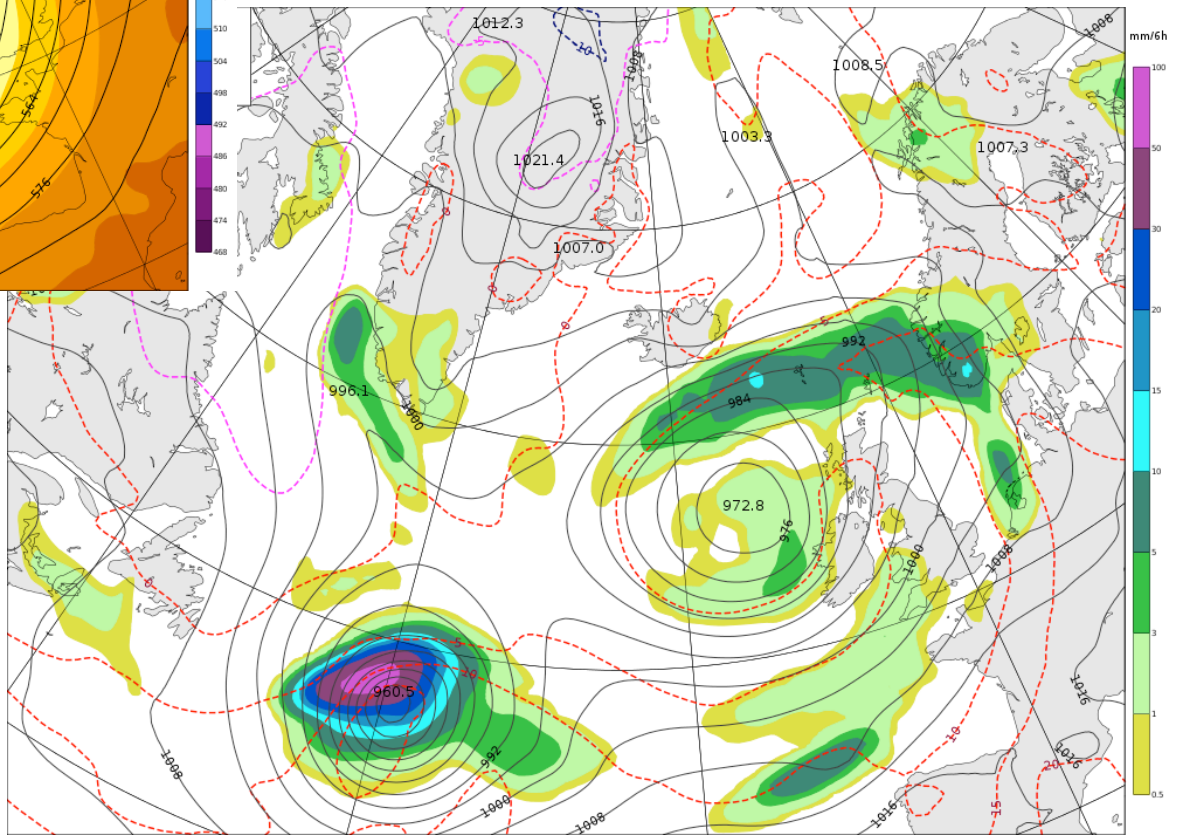
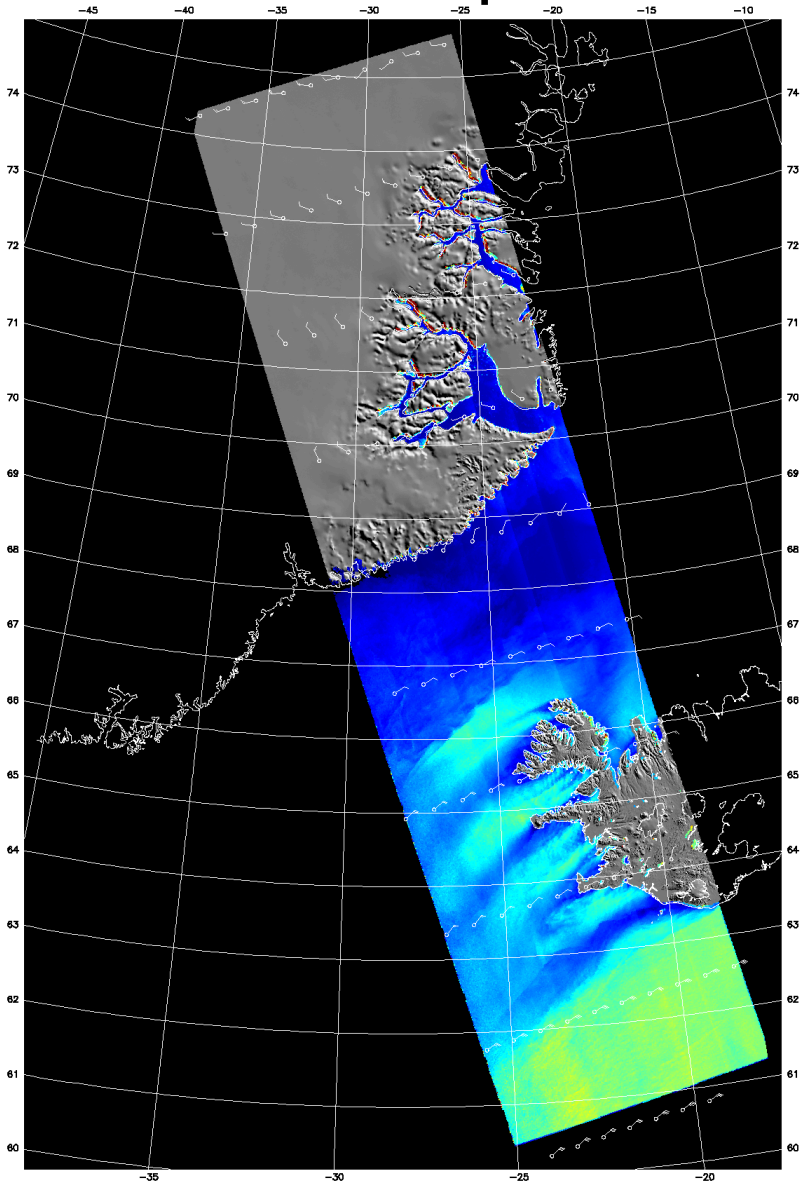
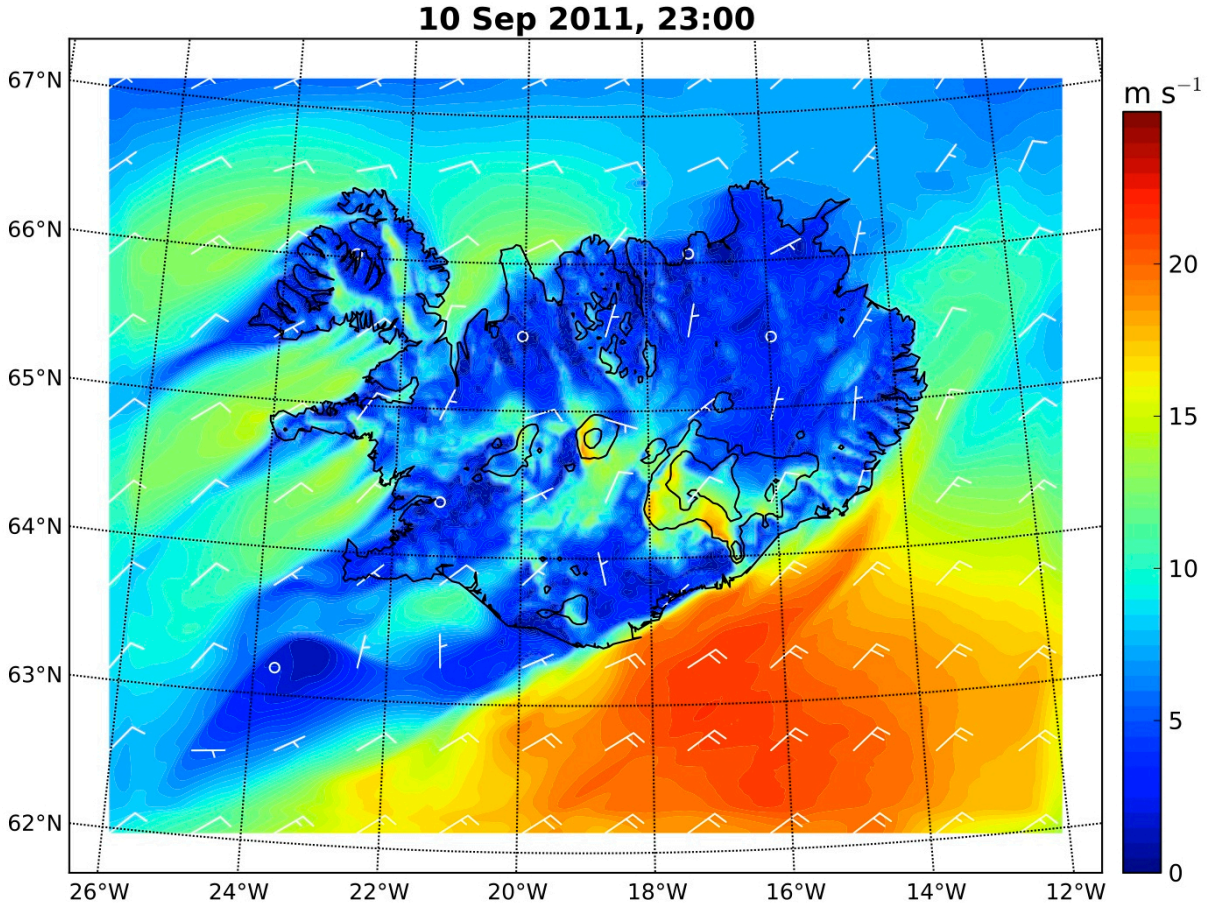


MSLP
6-hr precipitation
850 hPa temperature

10 September 2011, 23 UTC (SAR and Harmonie)

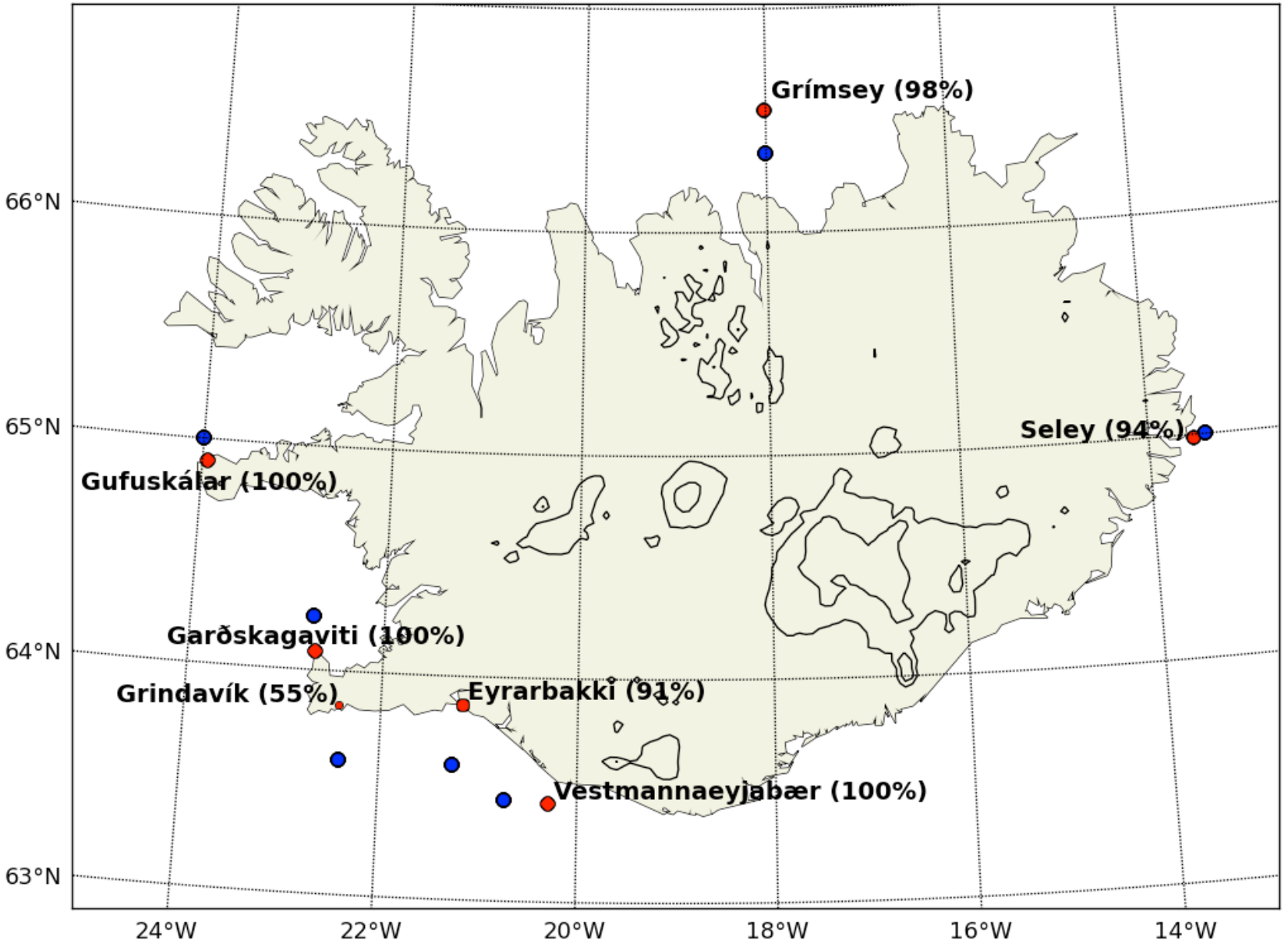


SAR (23:03 UTC)

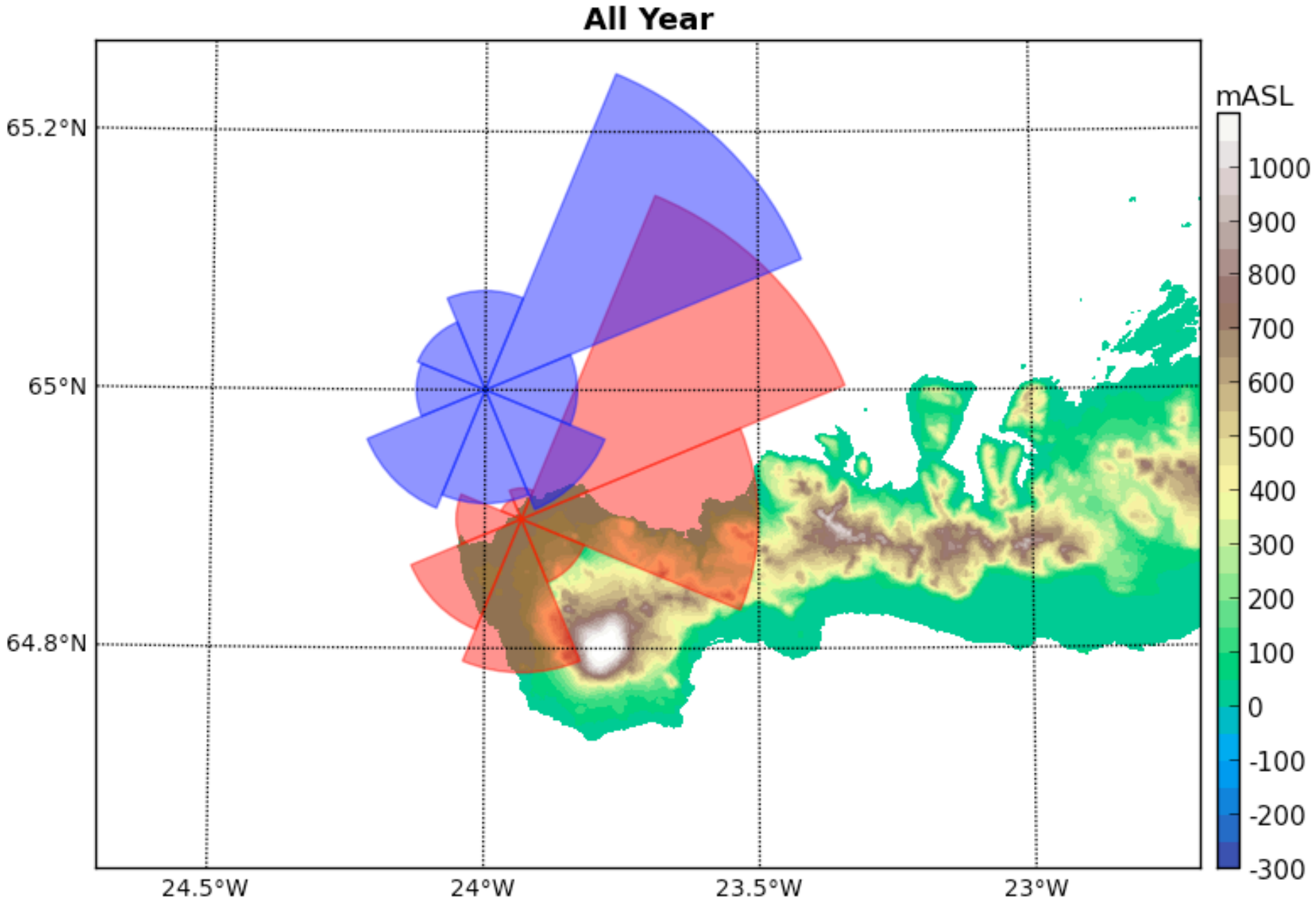


Harmonie (23:00 UTC)

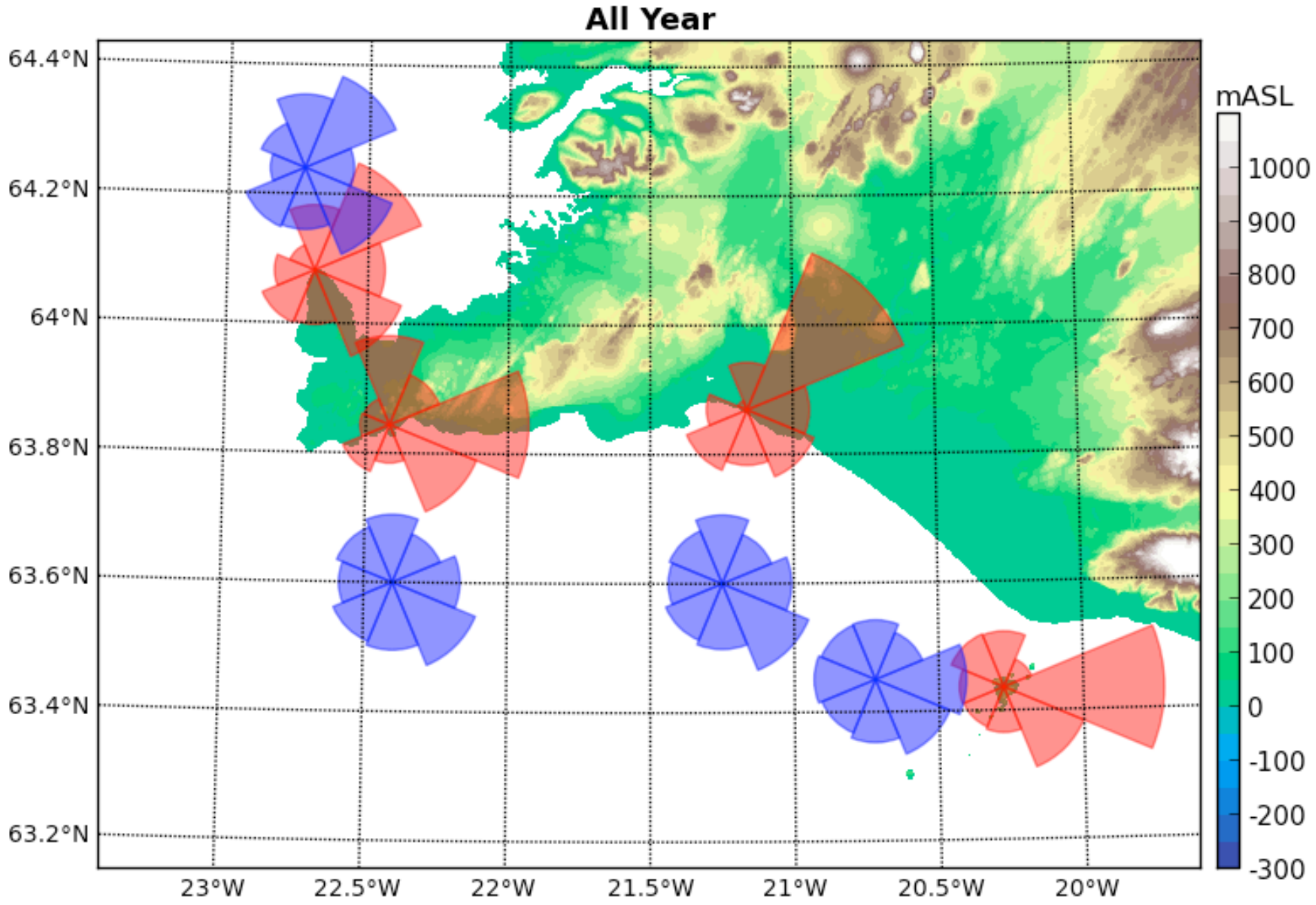
Weather Stations and SAR Reference Points



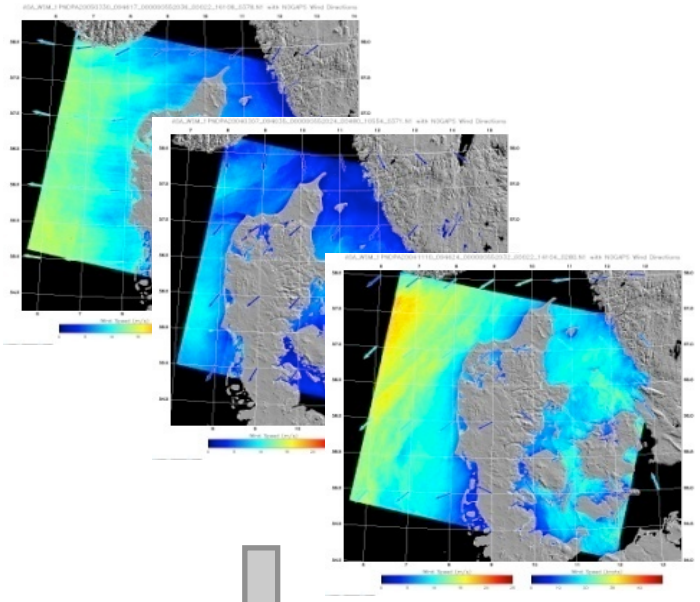
Wind Direction Histograms

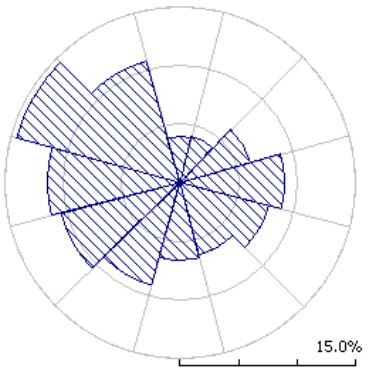


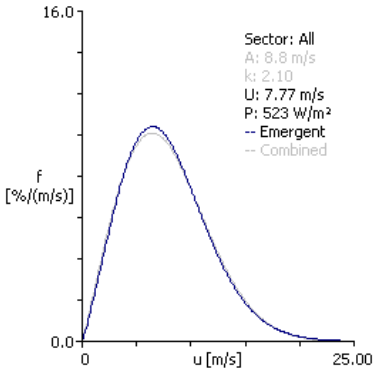
Wind Direction Histograms

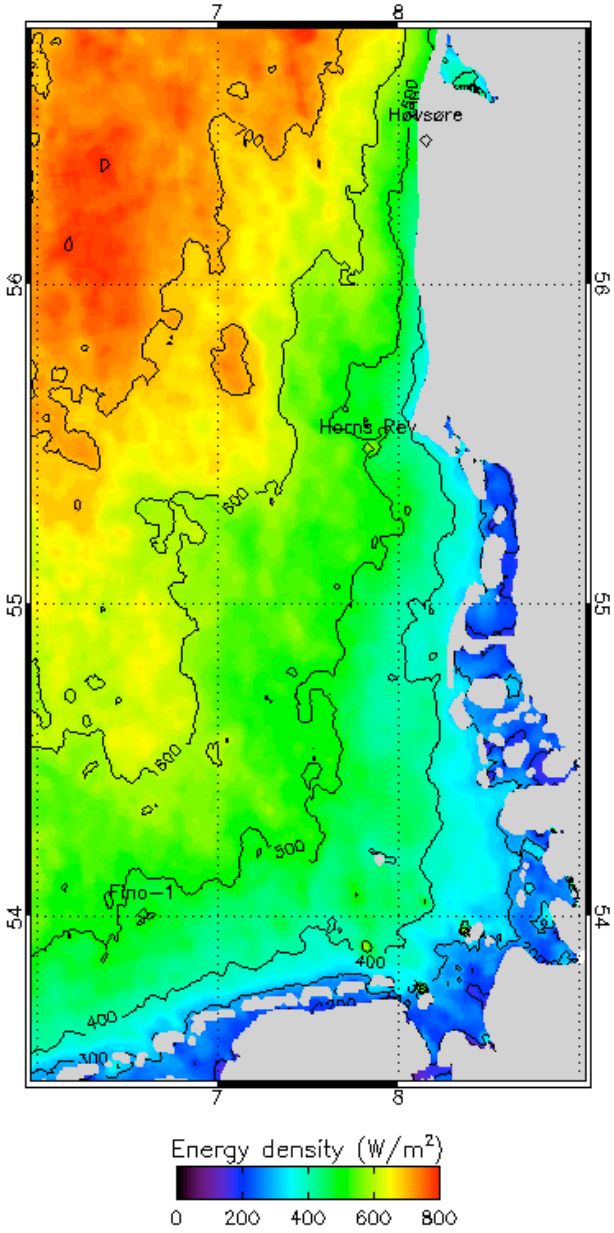


Wind statistics from SAR

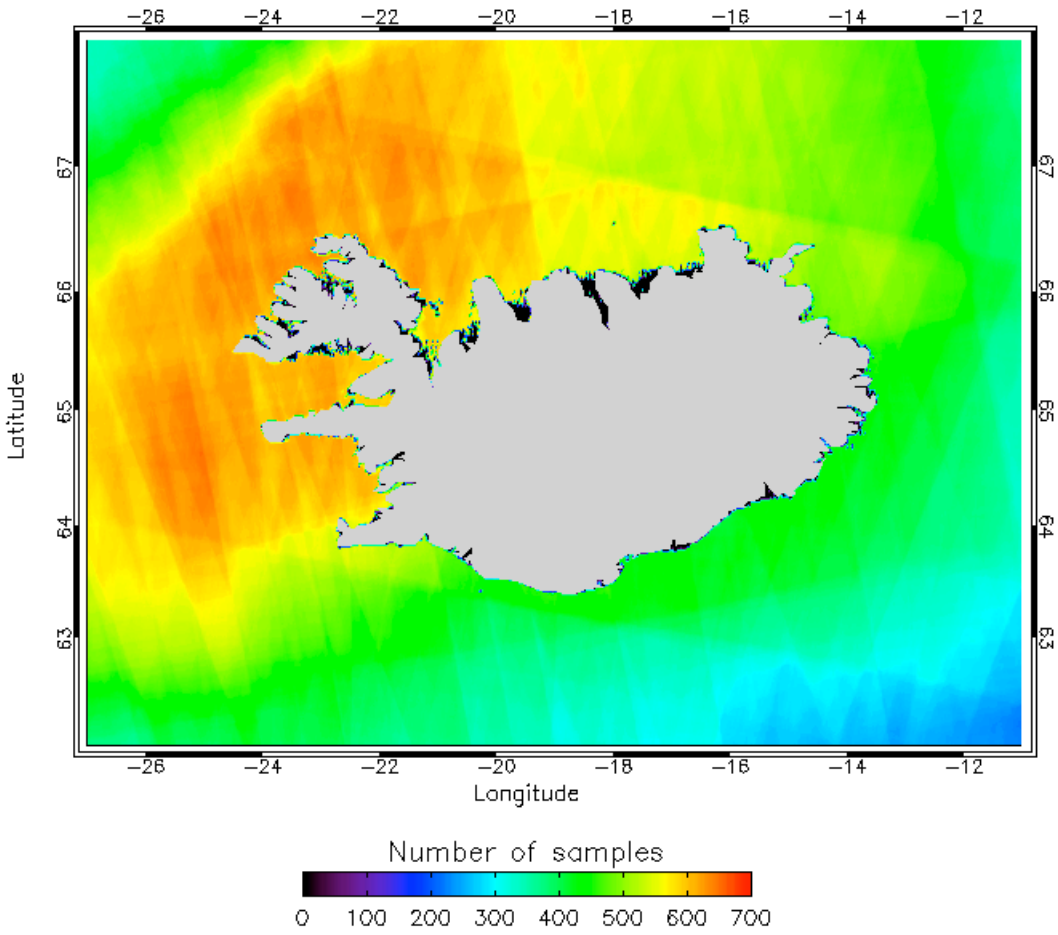




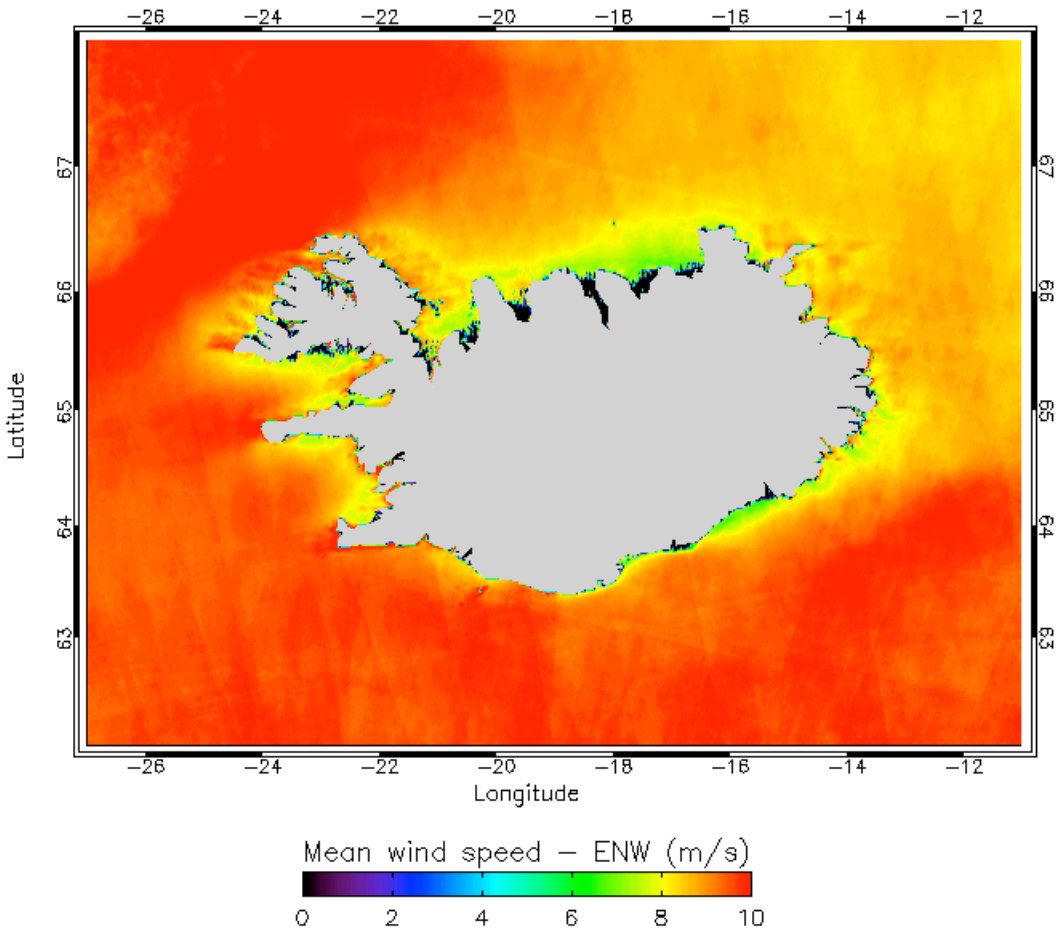




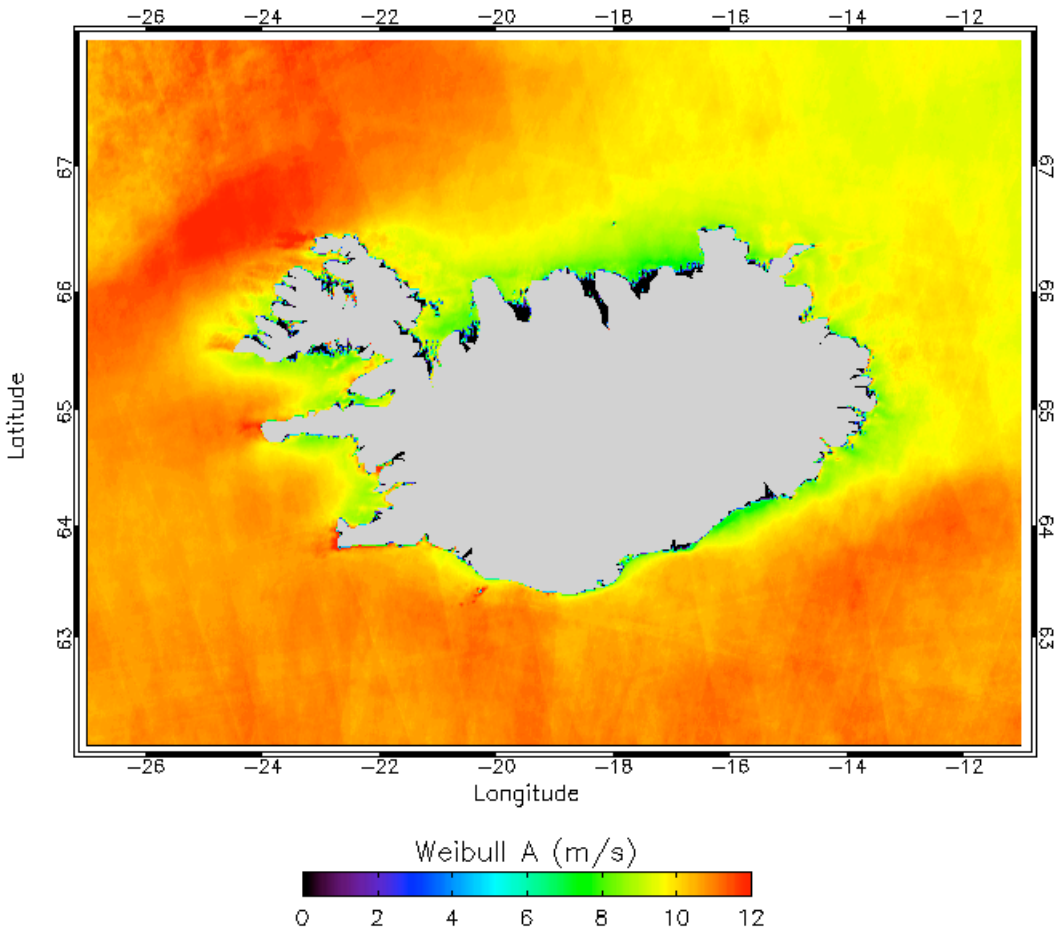
Number of overlapping Envisat ASAR images



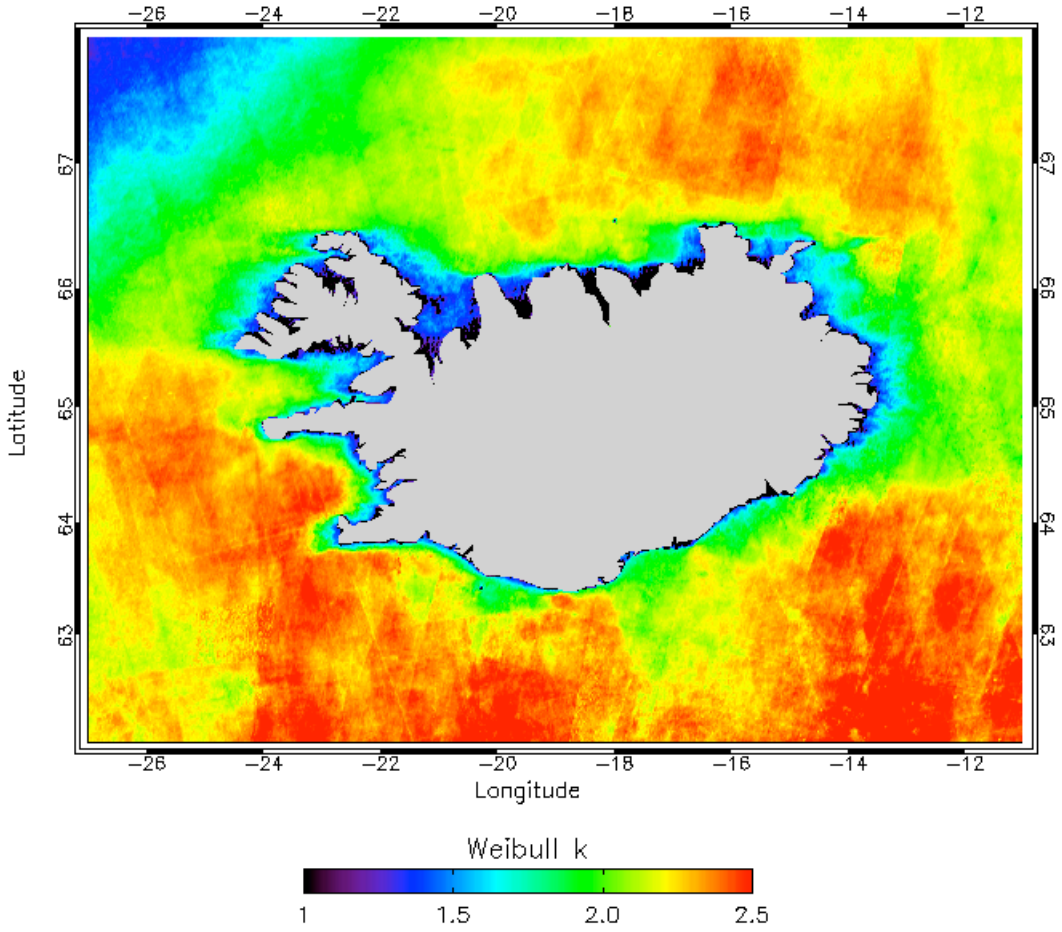
Mean wind speed from Envisat ASAR



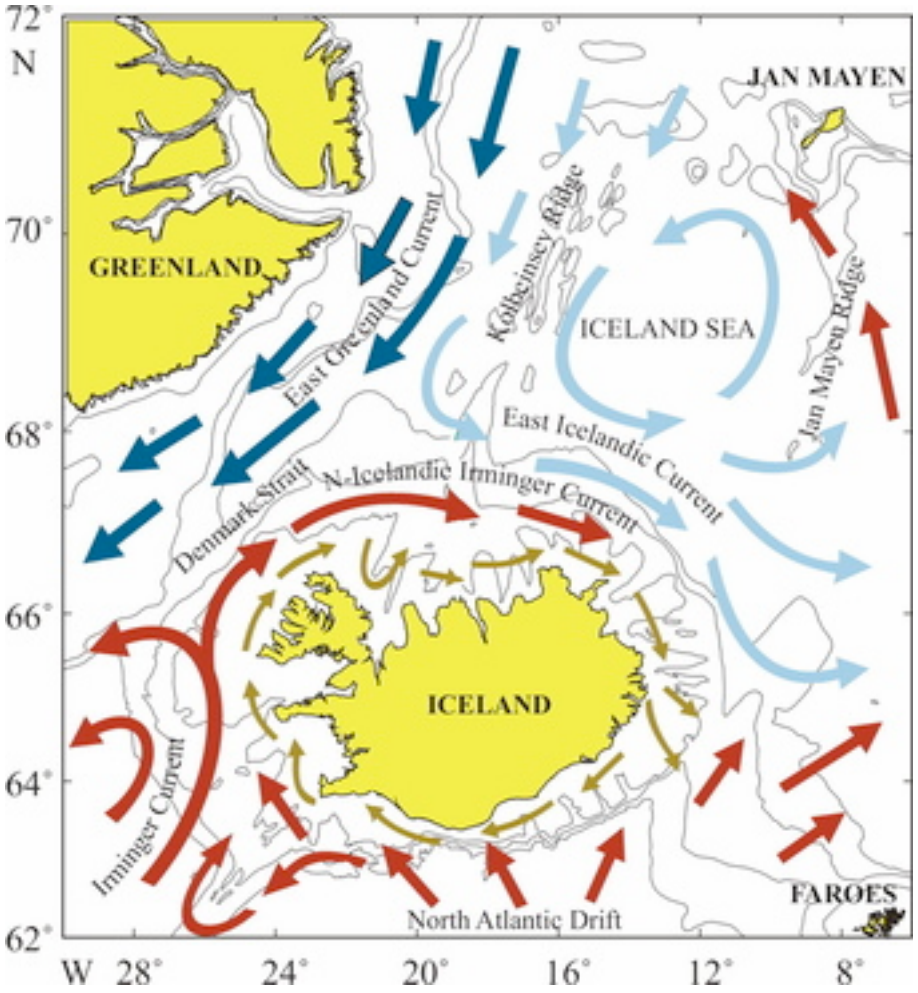
Weibull A from Envisat ASAR

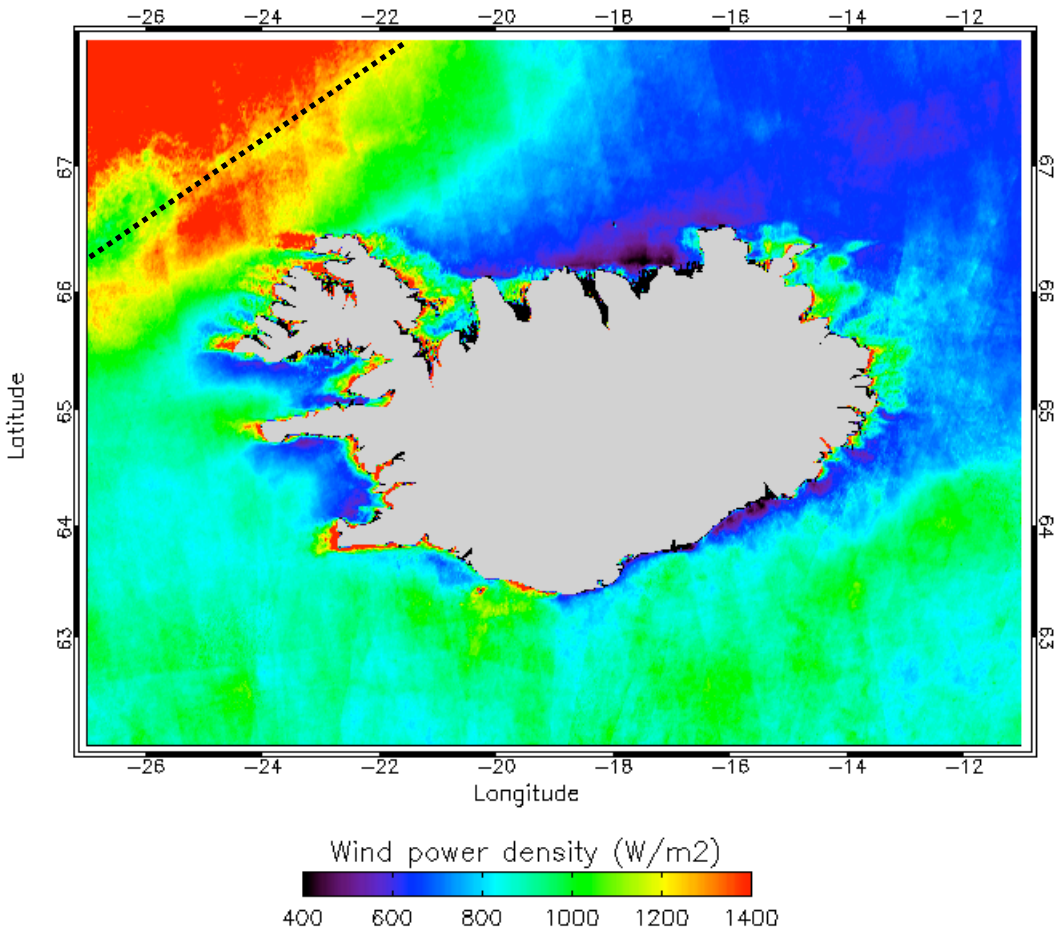


Weibull k from Envisat ASAR



Wind energy density from Envisat ASAR





Conclusions

- The spatial variability of SAR offshore winds in the vicinity of Iceland is consistent with mesoscale model simulations, including wave and wake effects from the elevated terrain
- At specific locations, differences between wind statistics determined either from SAR or nearby station measurements are consistent with orographic influences on the onshore station data
- The offshore wind energy potential for Iceland is in the highest European category

Future Projects

- Continuing collection of SAR data to build up longer climatology
- Continuing comparison between SAR data, Harmonie model simulations, and onshore station measurements
- Making SAR data available to forecasters
- Assimilating SAR into operational model forecasts