

High Resolution Wind Field Retrieval Using Synthetic Aperture Radar

45.00°

44.00°

14.00°

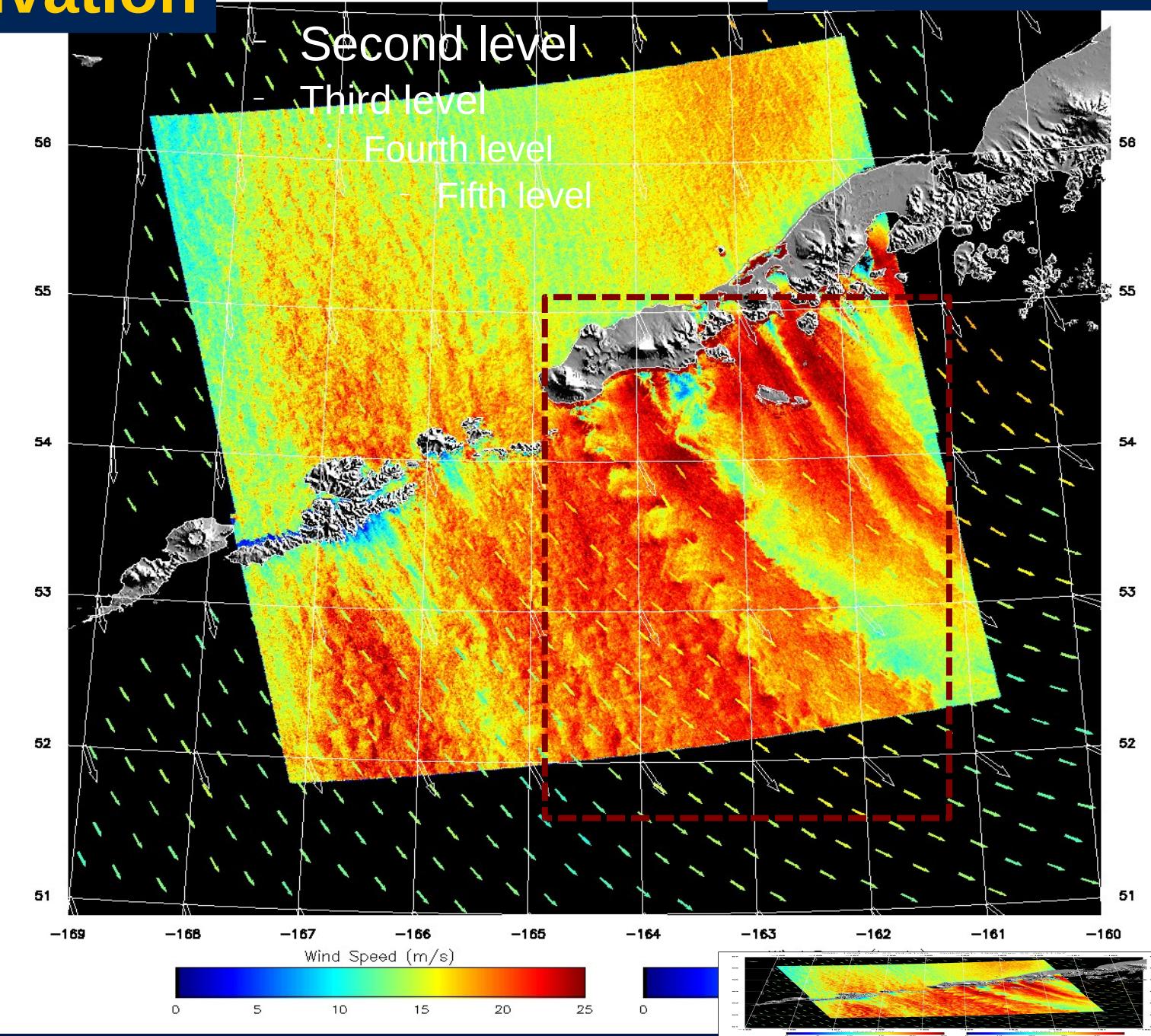
J. Horstmann, F. Monaldo, A. Mouche,
D. Thompson and C. Wackerman

NATO Undersea Research Center, Italy
Applied Physics Laboratory JHU, USA
CLS, France
General Dynamics, USA

Motivation

SAR: 1999 Dec 22 04:41:45 QuikSCAT: 1999 Dec

Radarsat-1 SAR

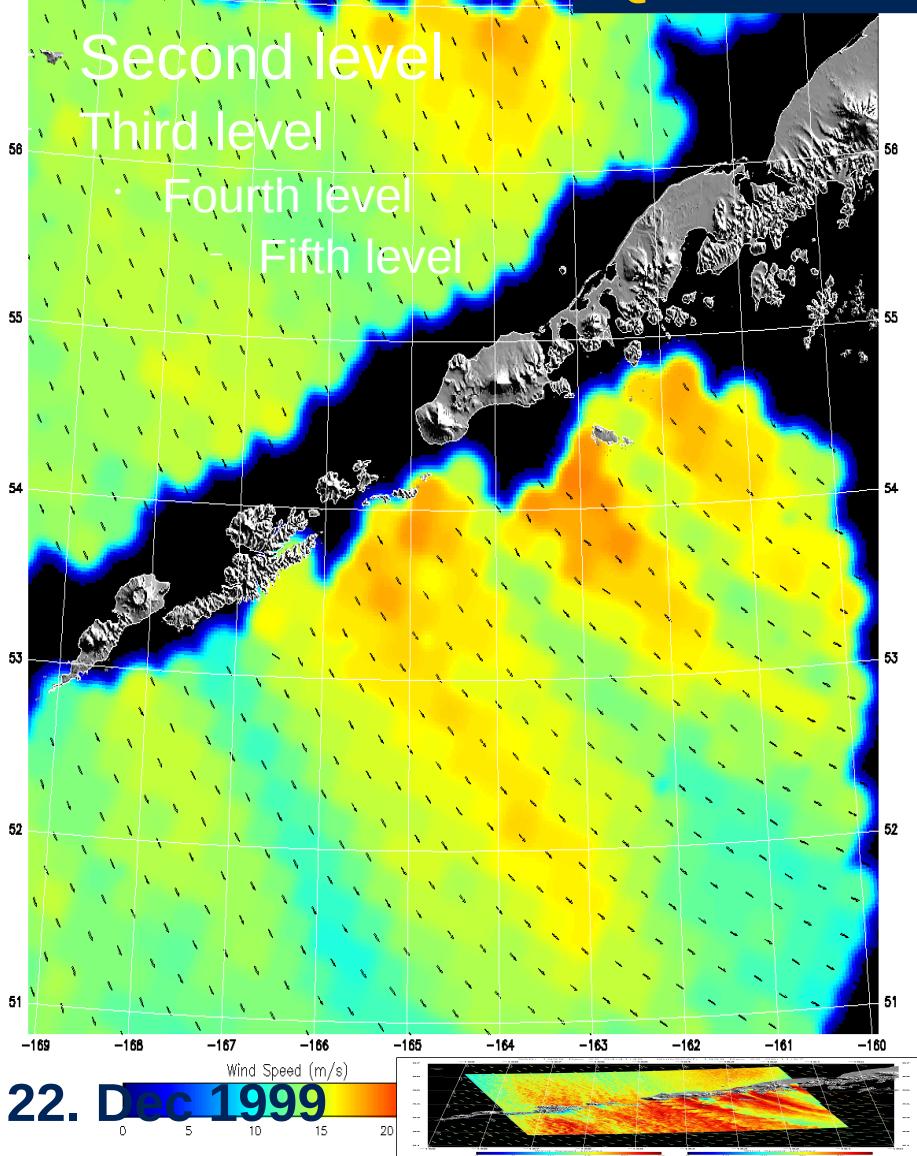




Motivation

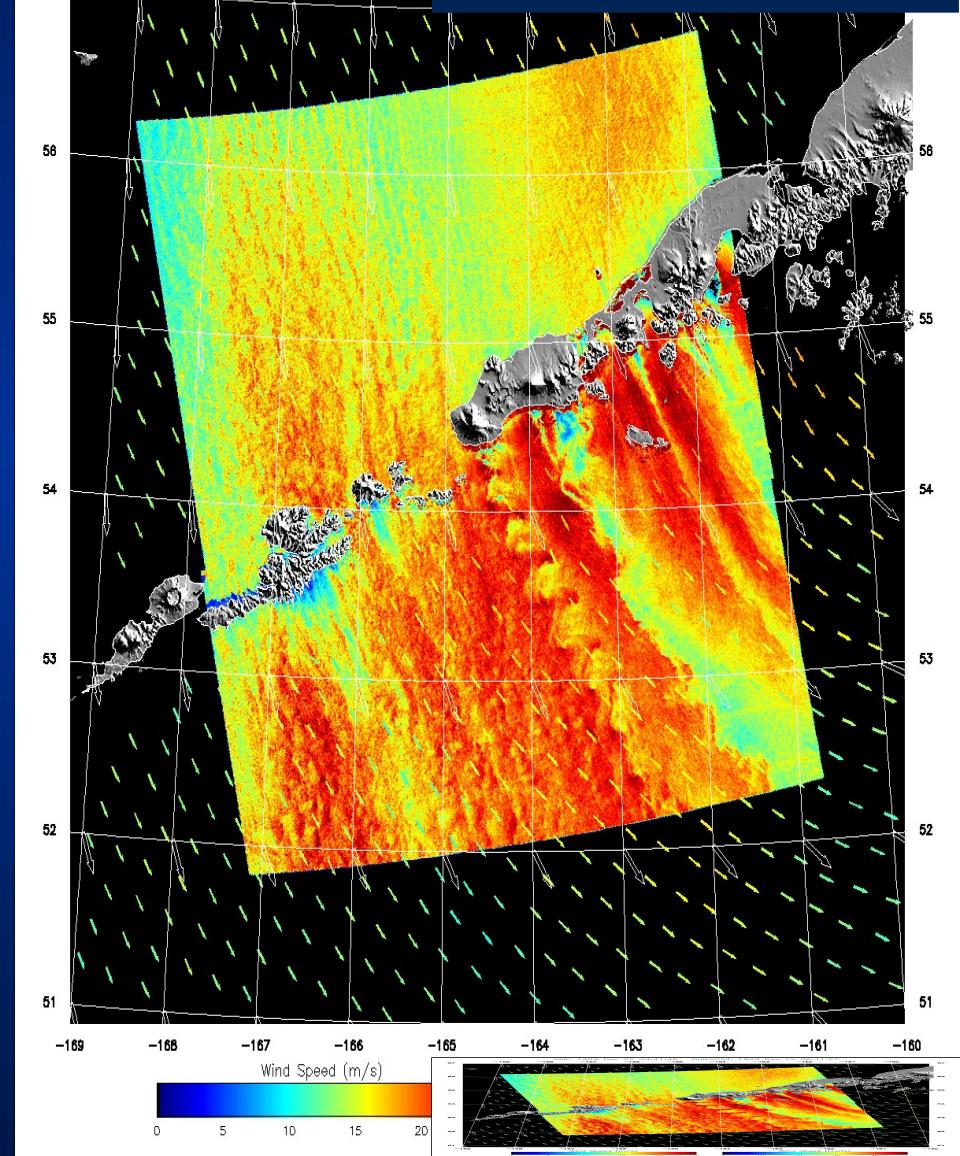


QuikSCAT
SAR: 1999 Dec 22 06:11:55



QuikSCAT

SAR: 1999 Dec 22 04:41



Radarsat-1 SAR

22. Dec 1999



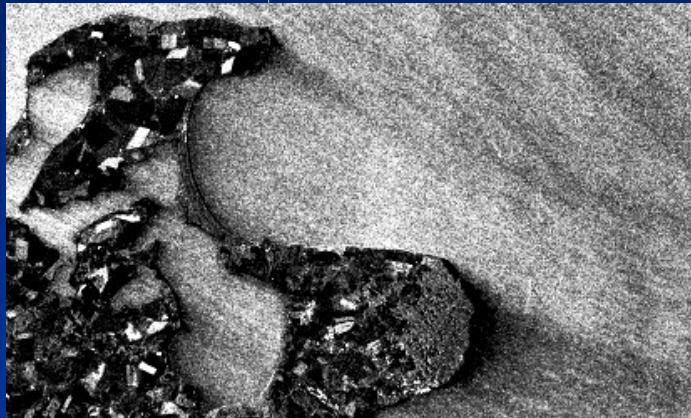
Wind artifacts in SAR imagery

ERS-1 SAR
image of
Rügen, in the
Baltic Sea
Aug. 12, 1991



SAR Wind Field Retrieval

Wind Speed



Wind Direction

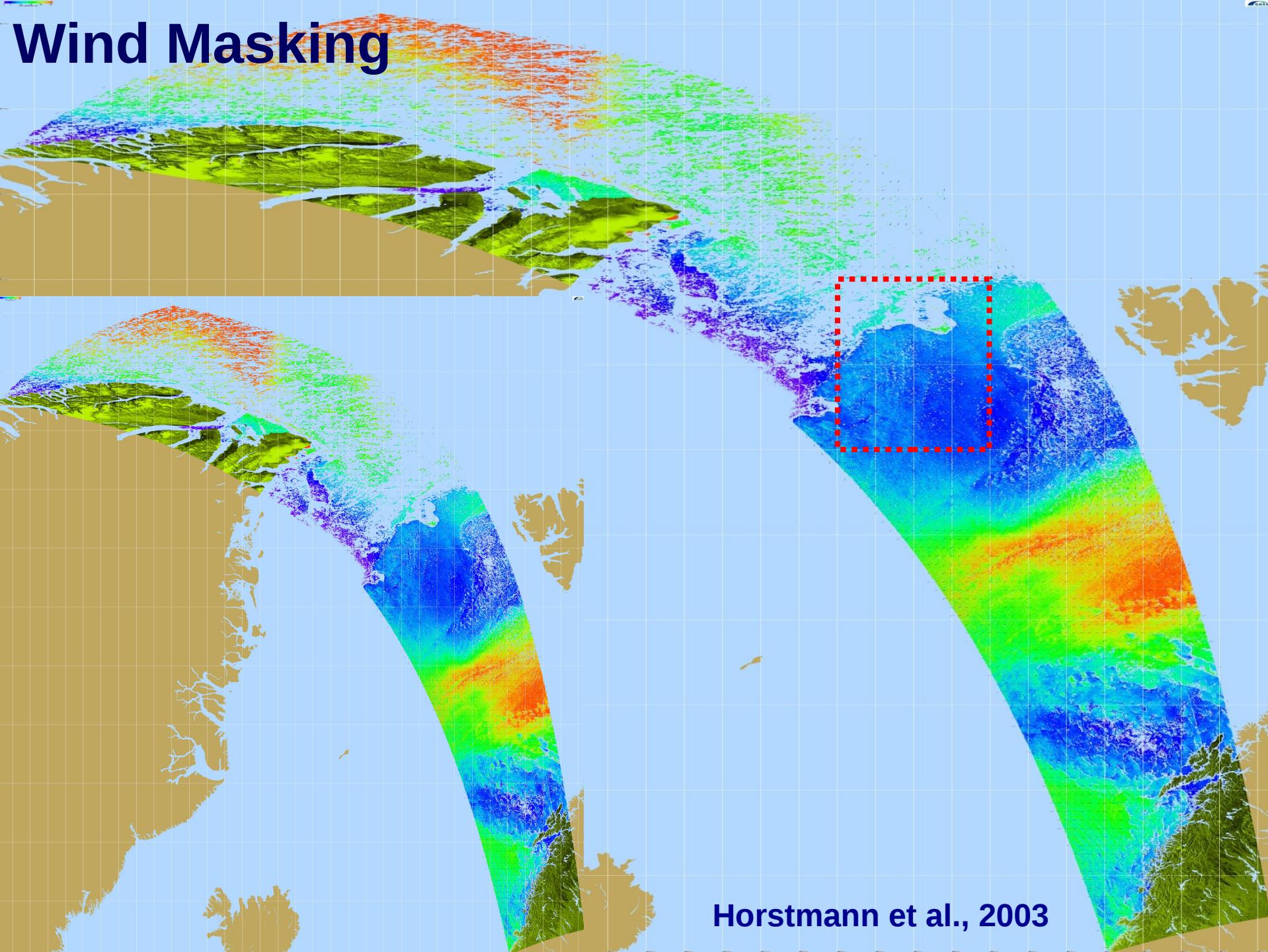
A priori information

- Numerical model results
- In situ measurements
- SCAT measurements



Linear features

- FFT Method
- Local Gradient Method
- Projection Method



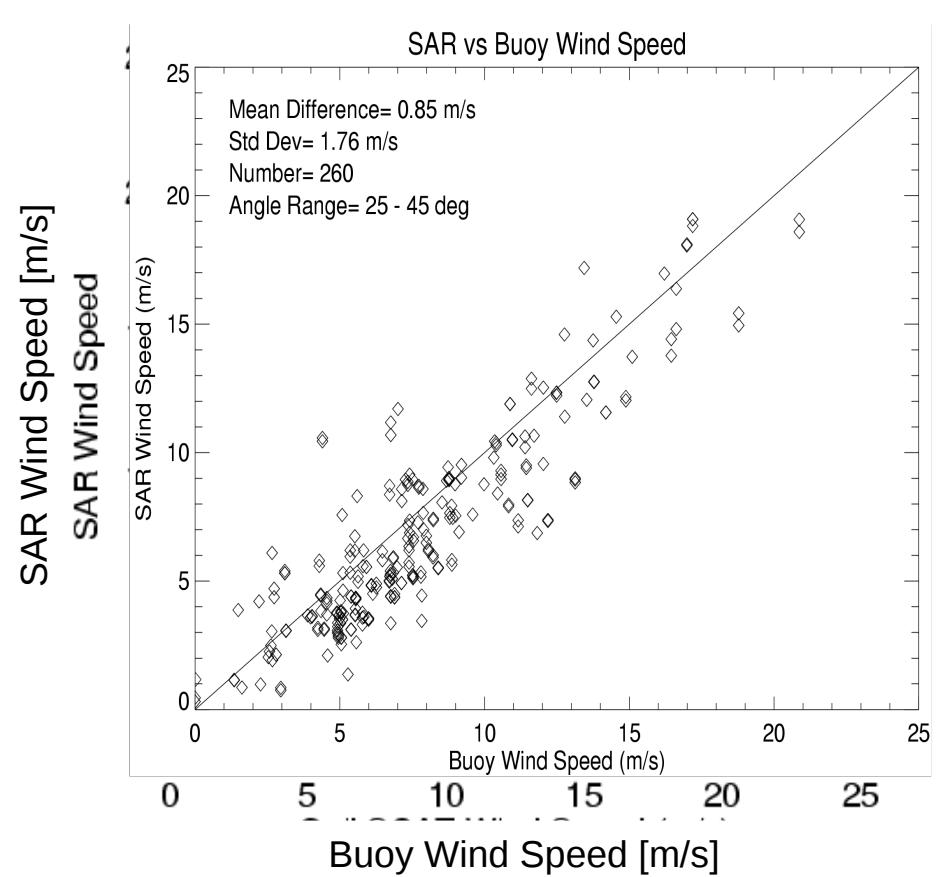
Wind Masking

Horstmann et al., 2003

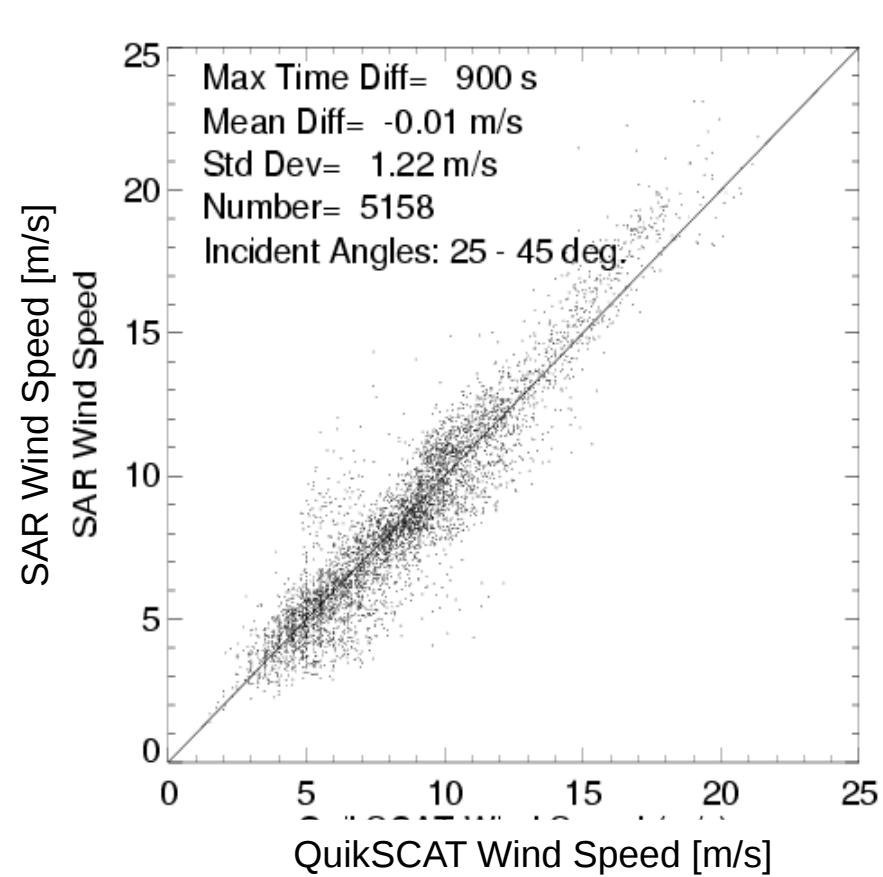
Validation Considering a priori Wind Directions



Comparison to Buoys



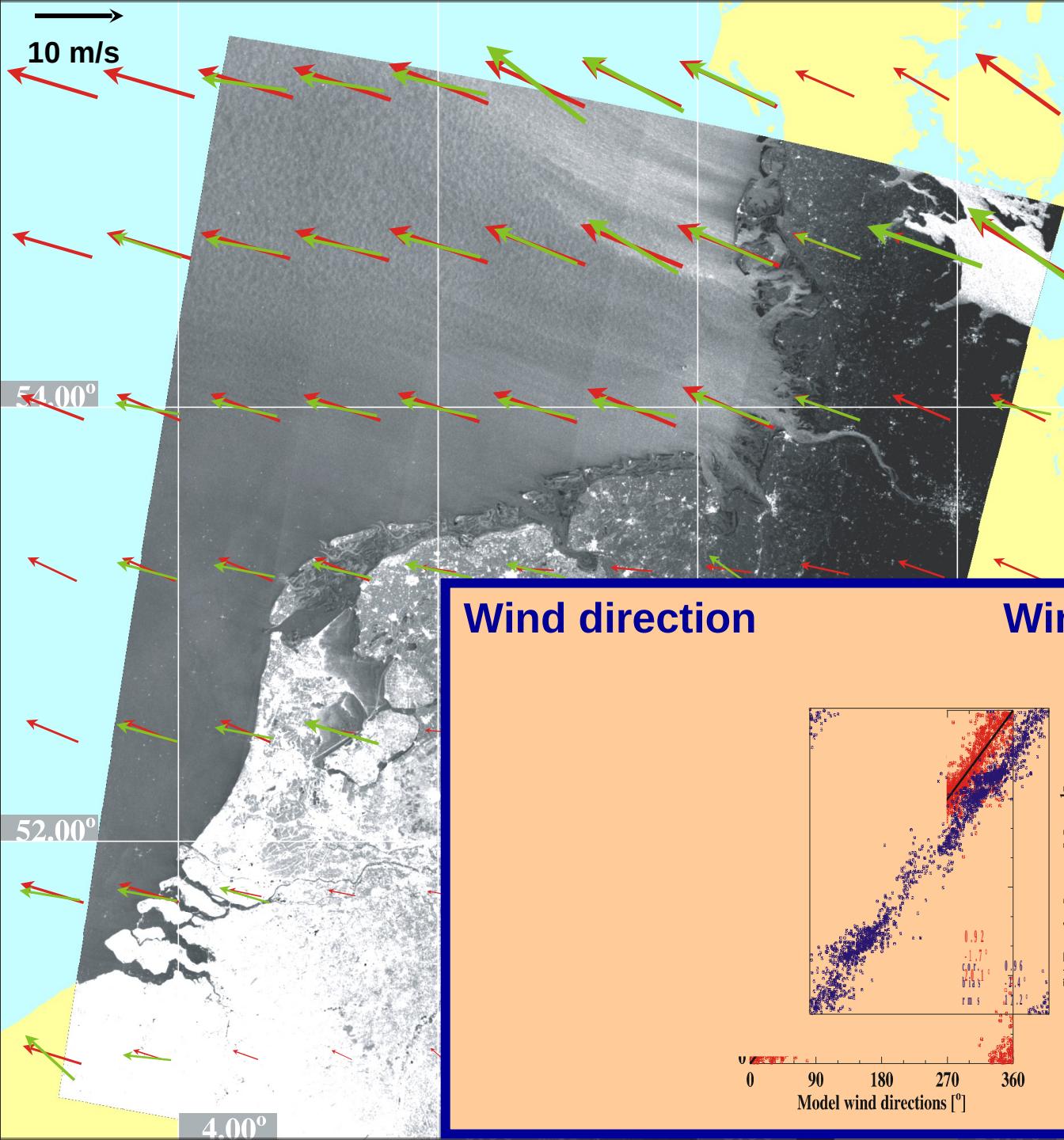
Comparison to QuikSCAT



Monaldo et al., 2002

Monaldo et al., 2003

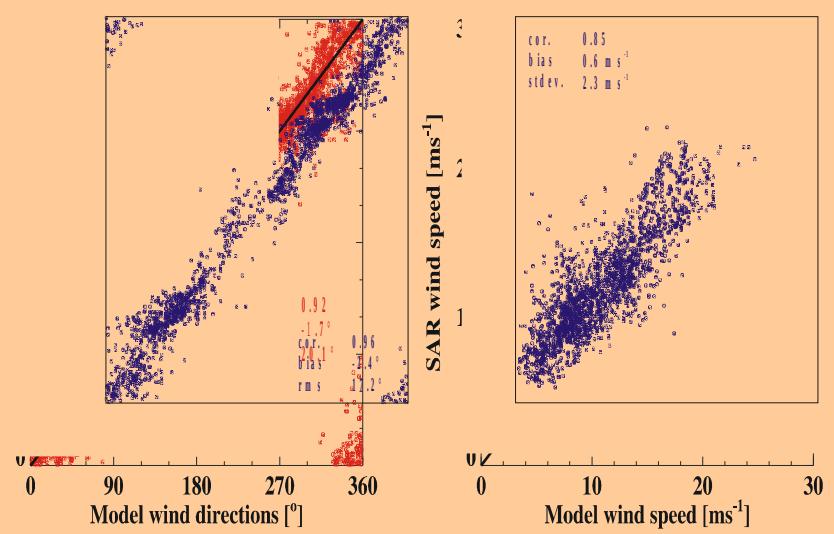
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Comparison of ASAR to the DWD model

Wind direction

Wind speed

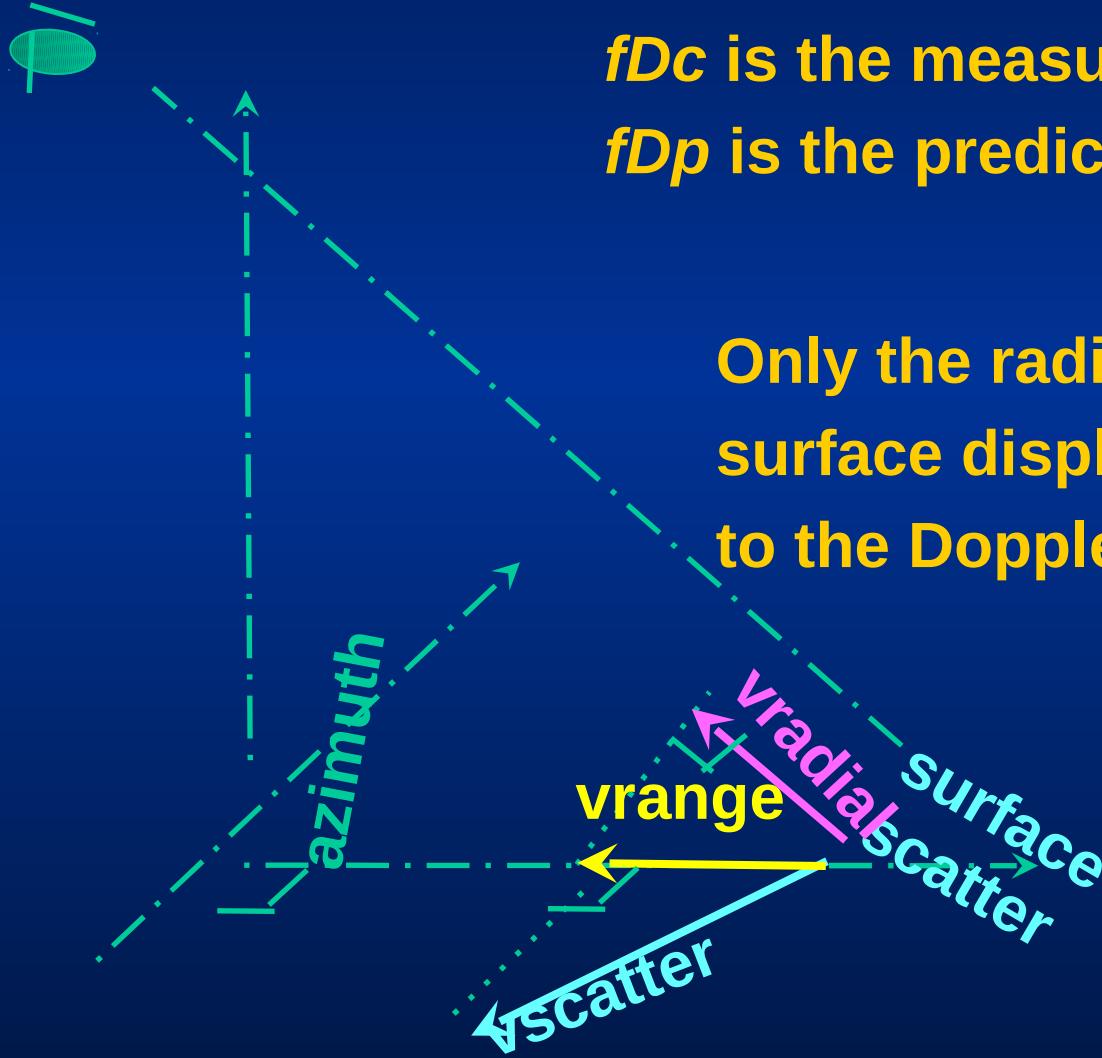




Doppler Shift for Wind Retrieval



$$fDs = fDc - fDp$$



**fDc is the measured Doppler centroid,
 fDp is the predicted Doppler shift**

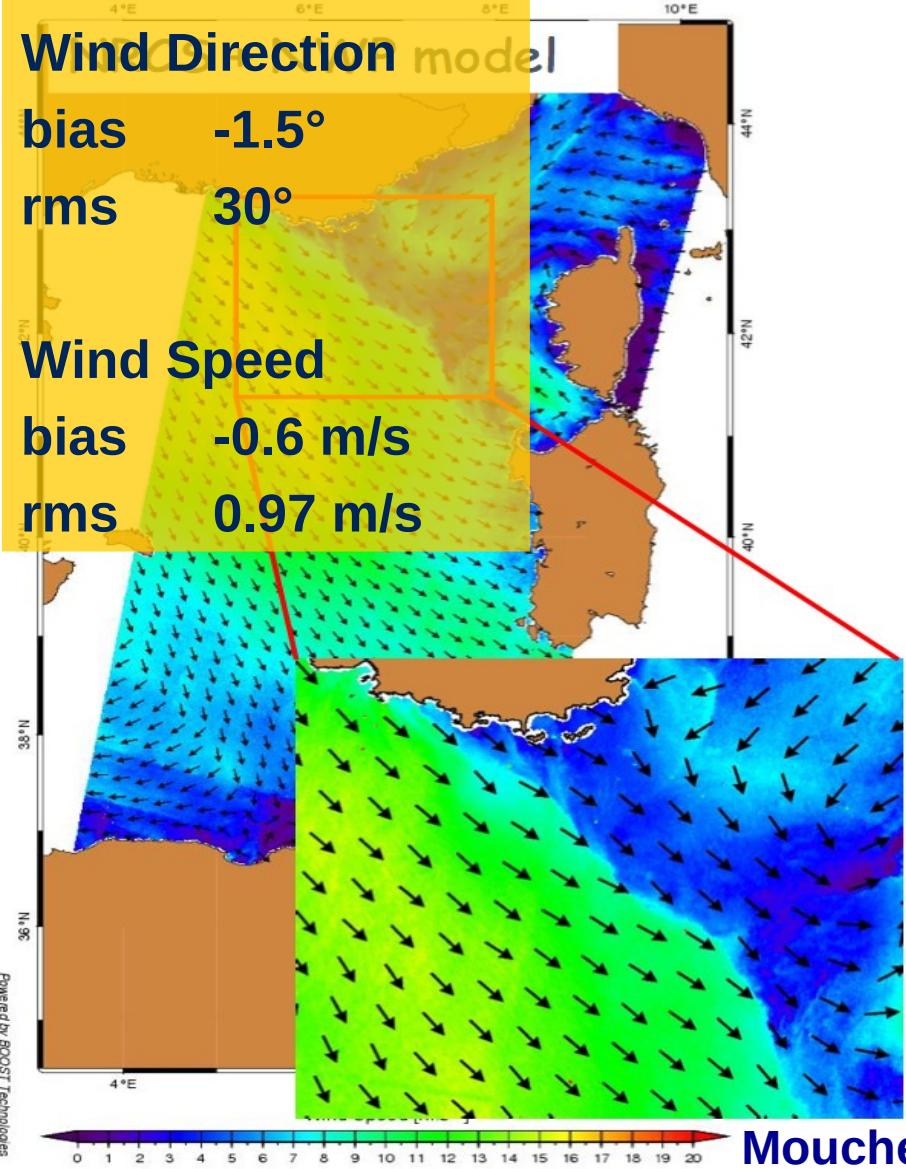
**Only the radial component of the
surface displacement contributes
to the Doppler shift**

**available with
ENVISAT ASAR
SENTINEL-1**

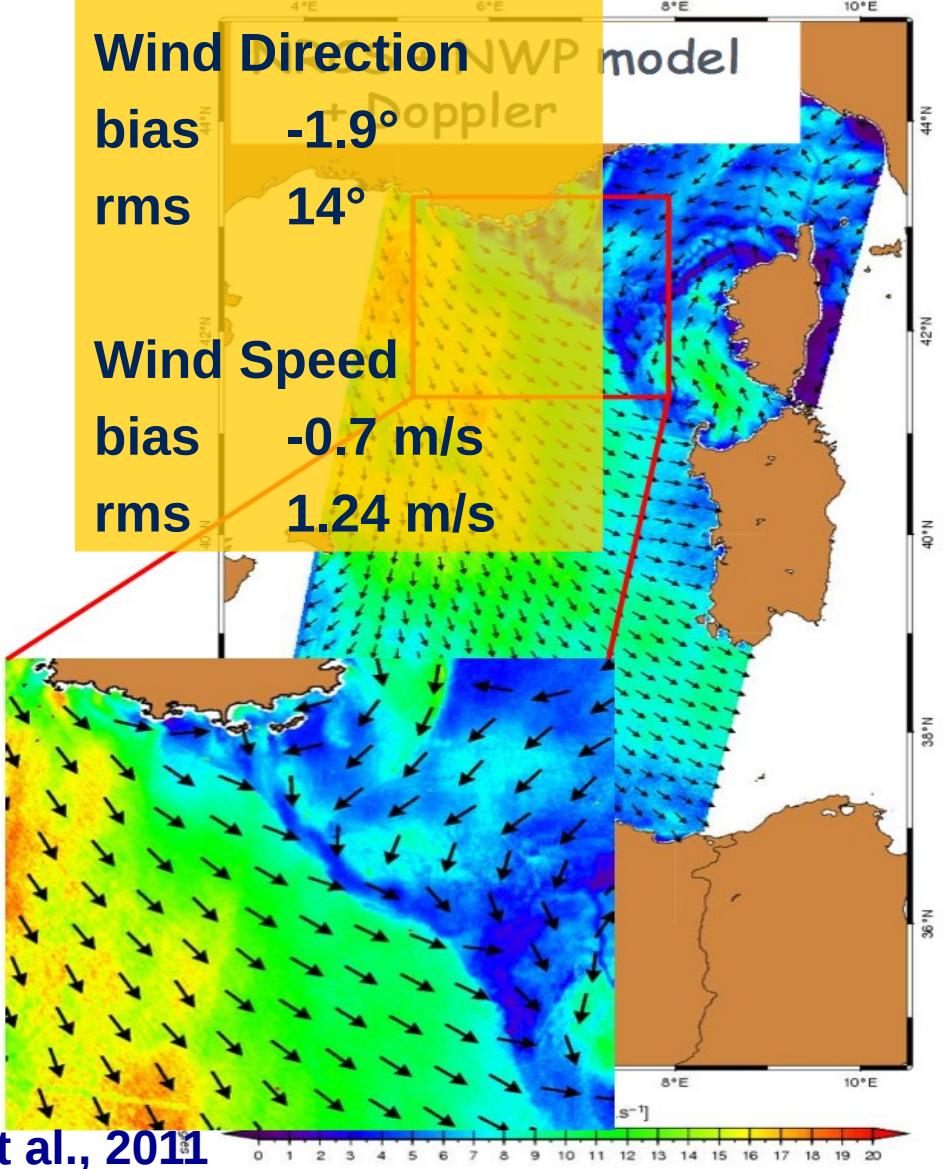


Doppler Shift for Wind Retrieval

NRCS & NWP



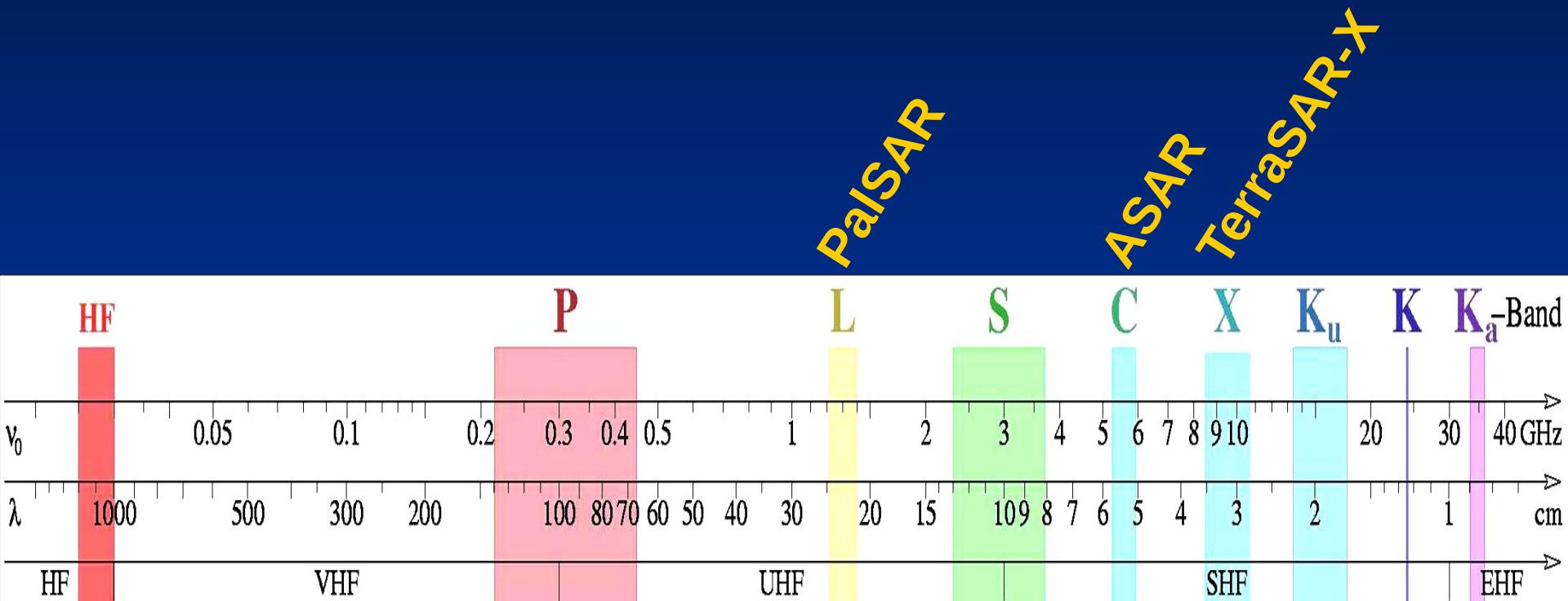
NRCS, NWP & Doppler Shift



Mouche et al., 2011



Development of an empirical GMF for X- and L-band



extrapolation

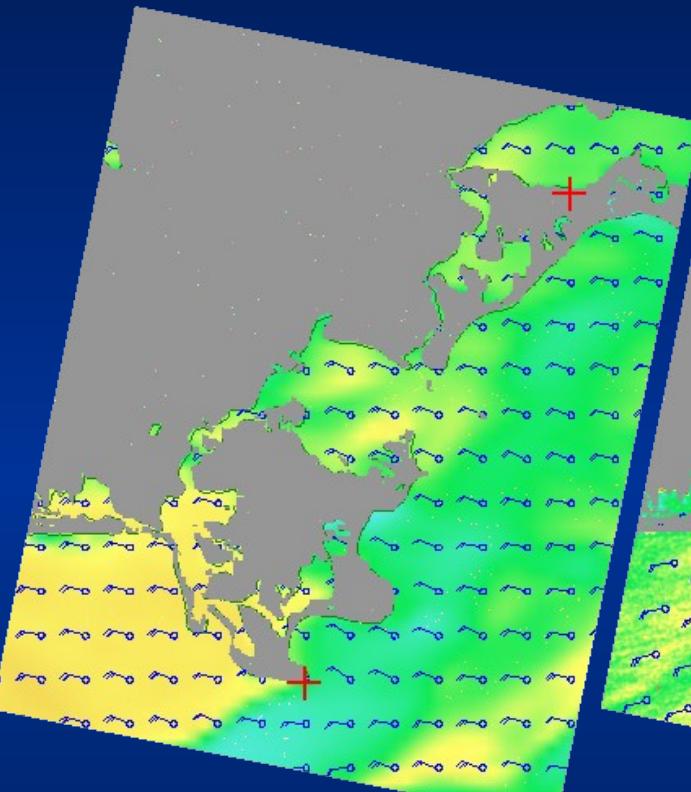
interpolation
QuikSCAT

extrapolation using a theoretical model

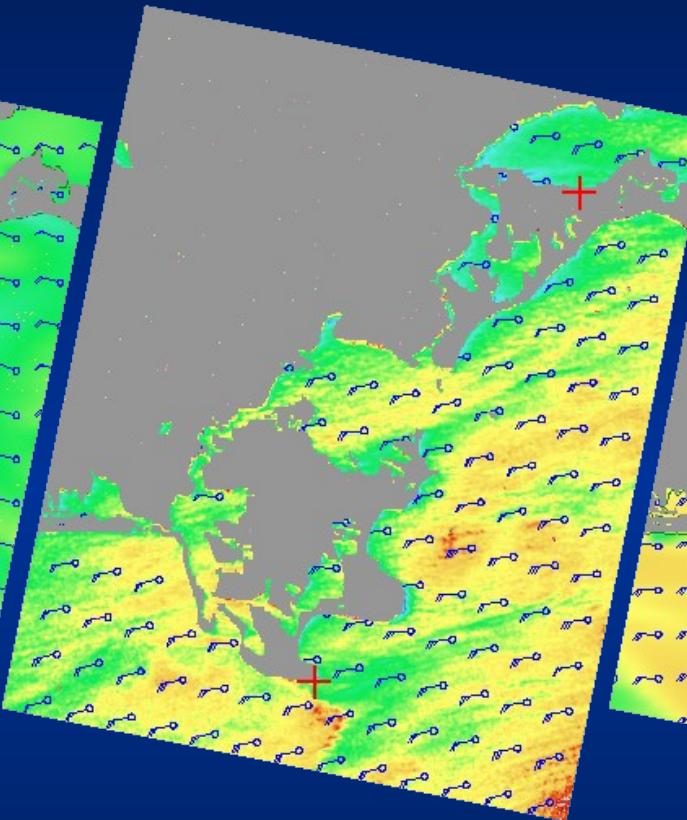
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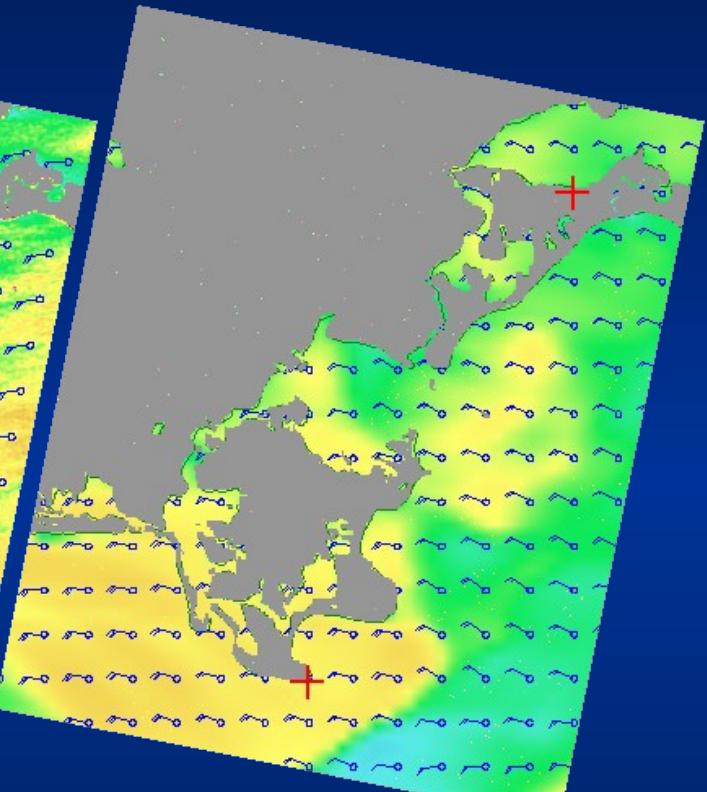
Comparison of TerraSAR-X SAR Winds to the WRF model



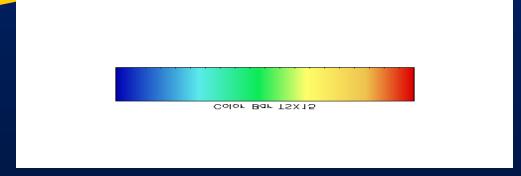
WRF model at
16:30 UTC



SAR winds
16:44 UTC



WRF model at
17:00 UTC



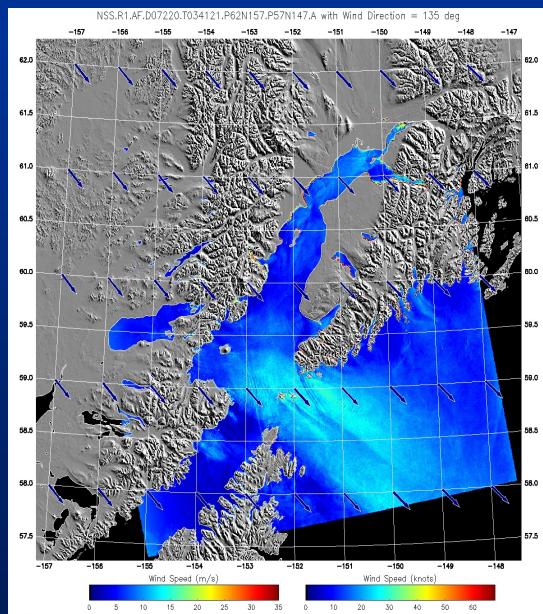


ANSWRS

JHU/APL

Input:
Wind directions
SAR data

Output:
Wind speeds



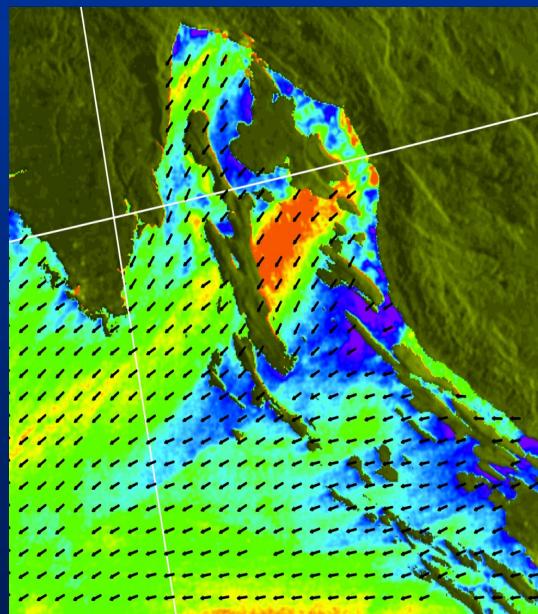
fully automated (1997)

WiSAR

HZG (GKSS)

Input:
SAR data
Wind directions (opt.)

Output:
Wind vectors
filter and error masks



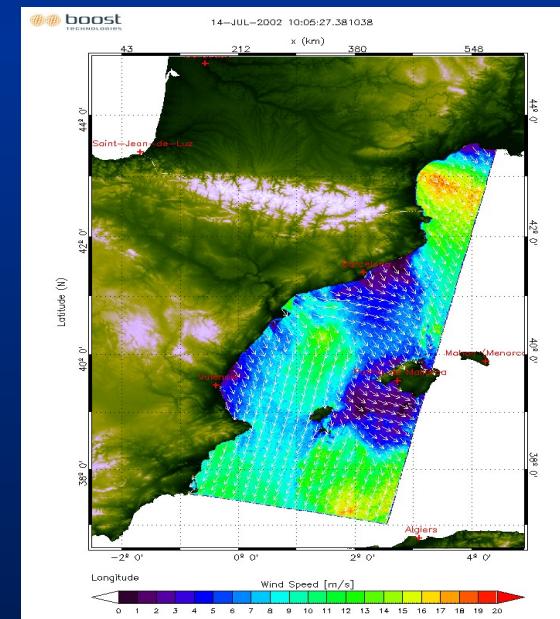
fully automated (2005)

SARTool

CLS (BOOST)

Input:
Wind directions
SAR data

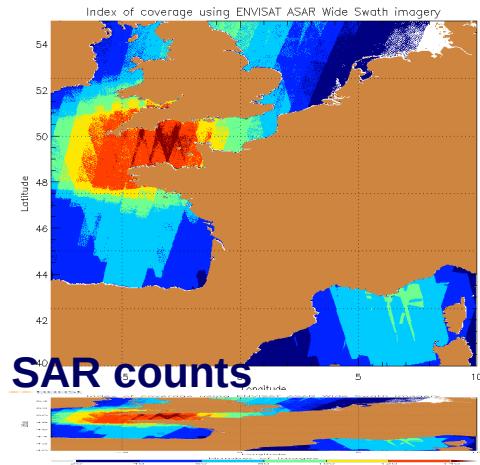
Output:
Wind vectors



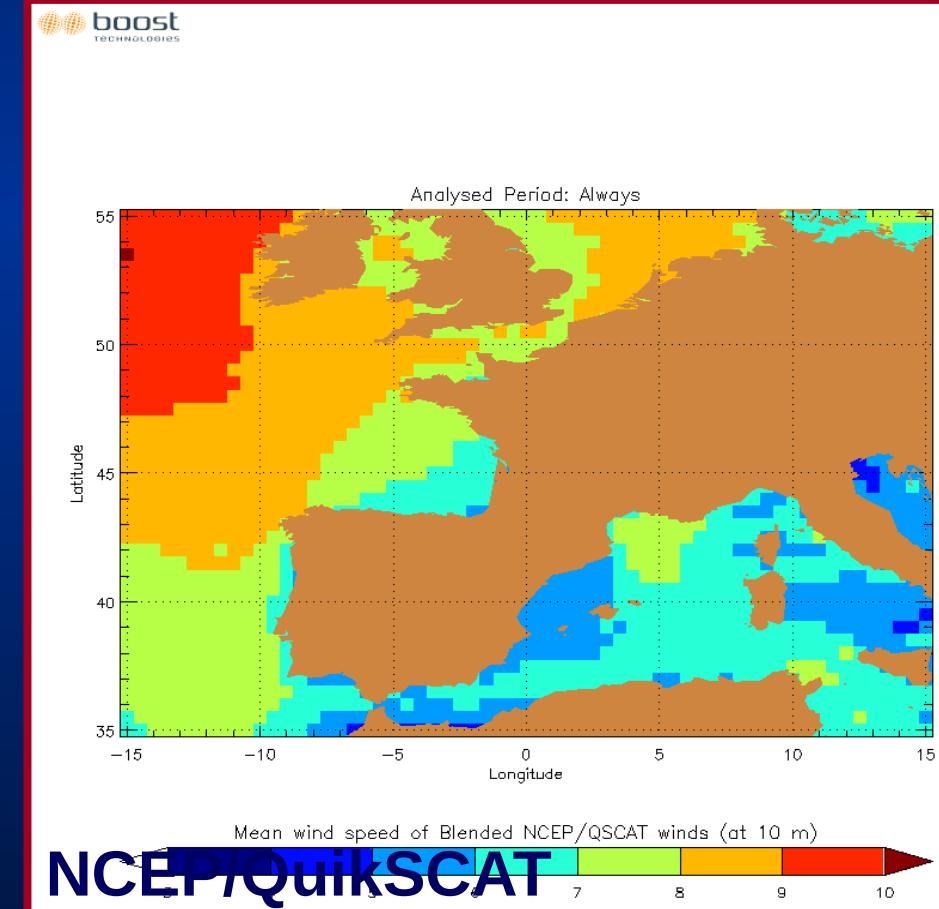
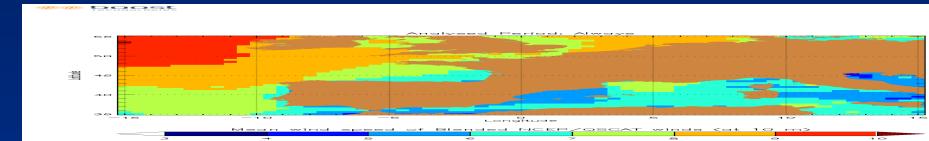
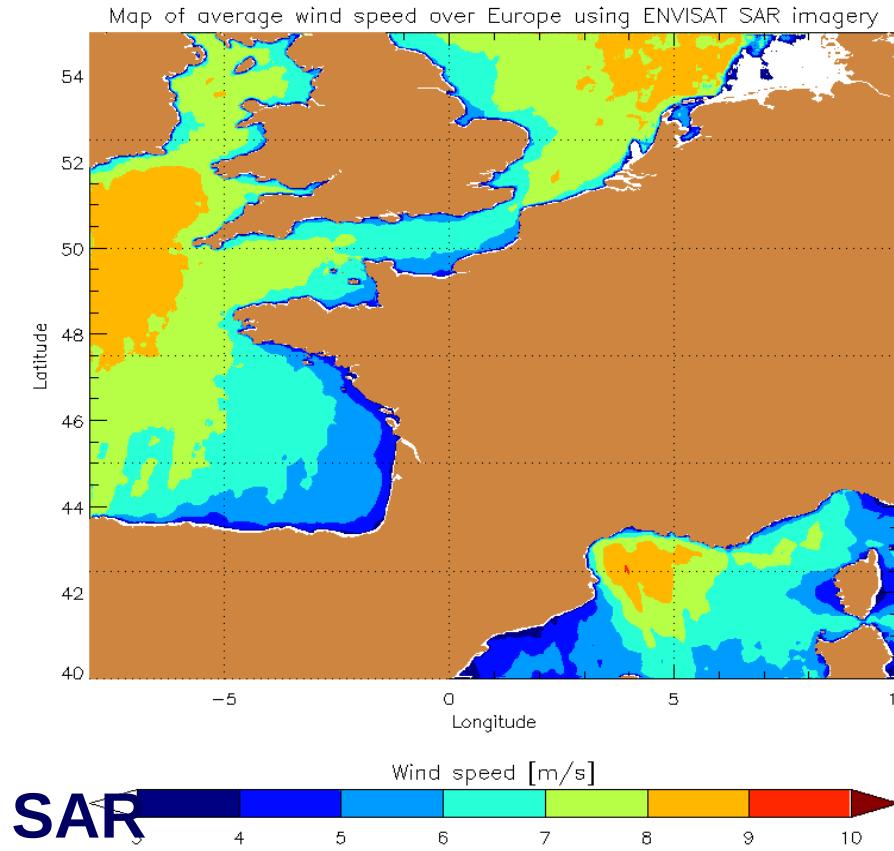
fully automated mode

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Climatology from SAR considering 450 SAR acquisitions

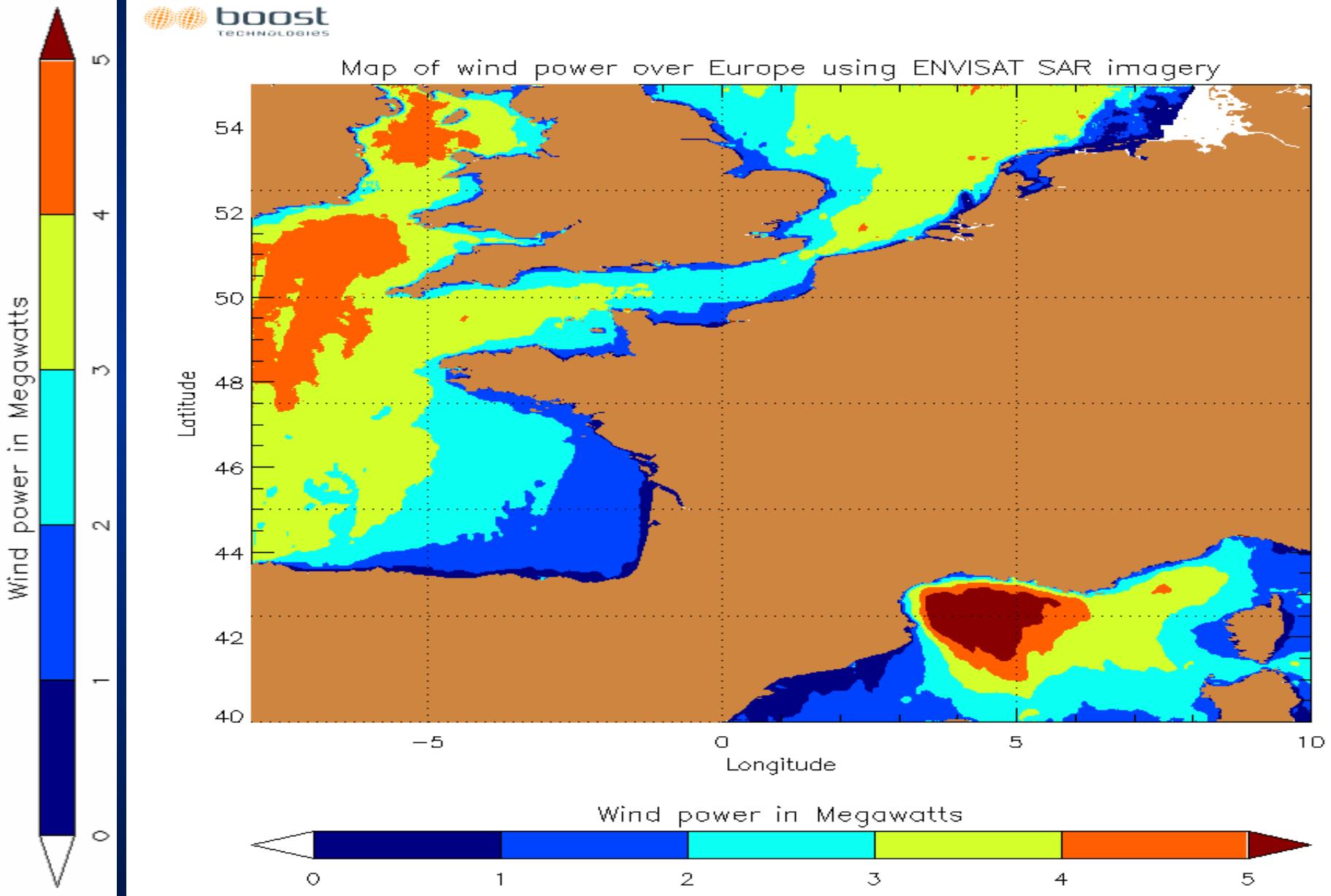


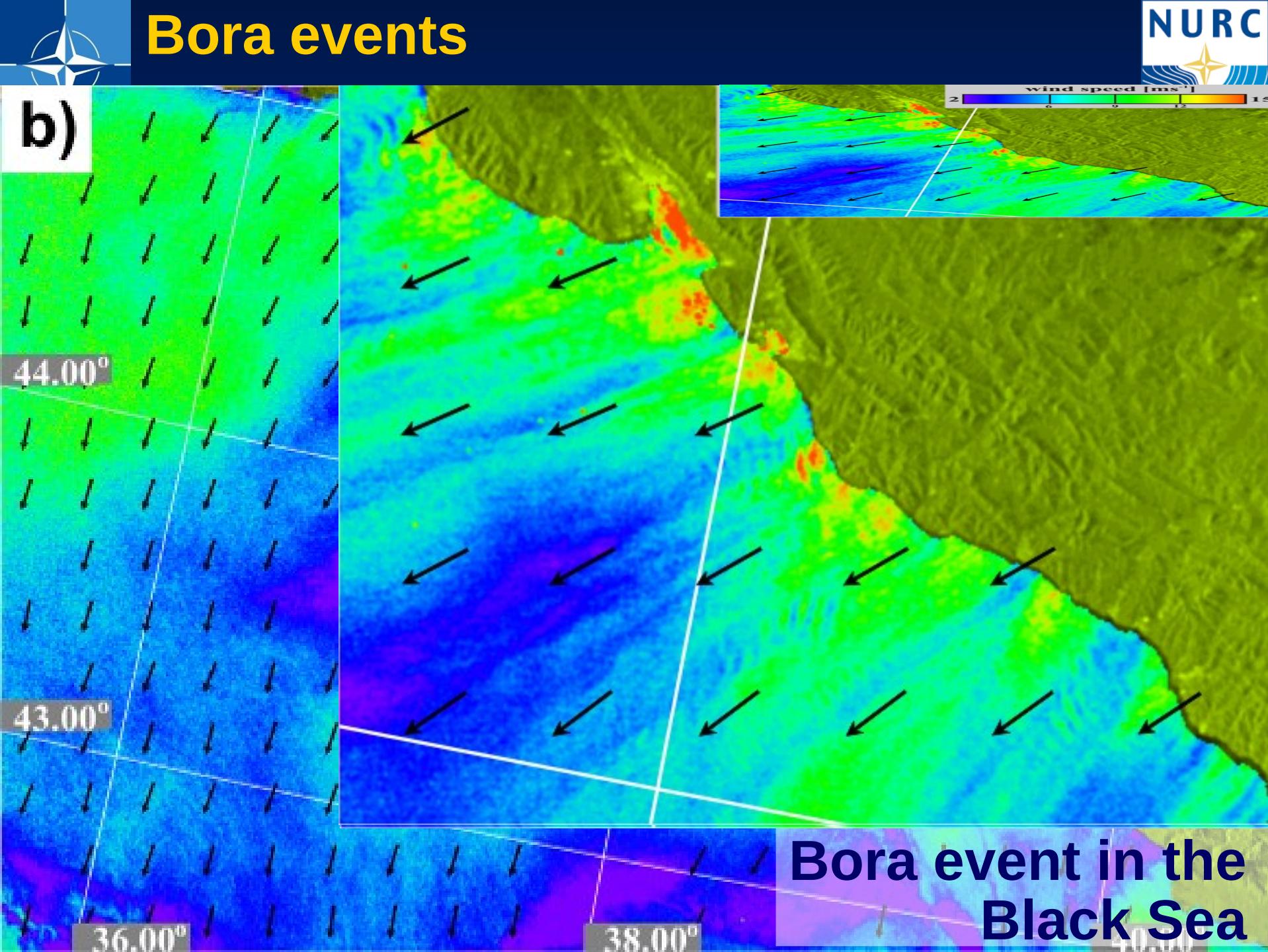


Offshore powermap

 boost
TECHNOLOGIES

Map of wind power over Europe using ENVISAT SAR imagery

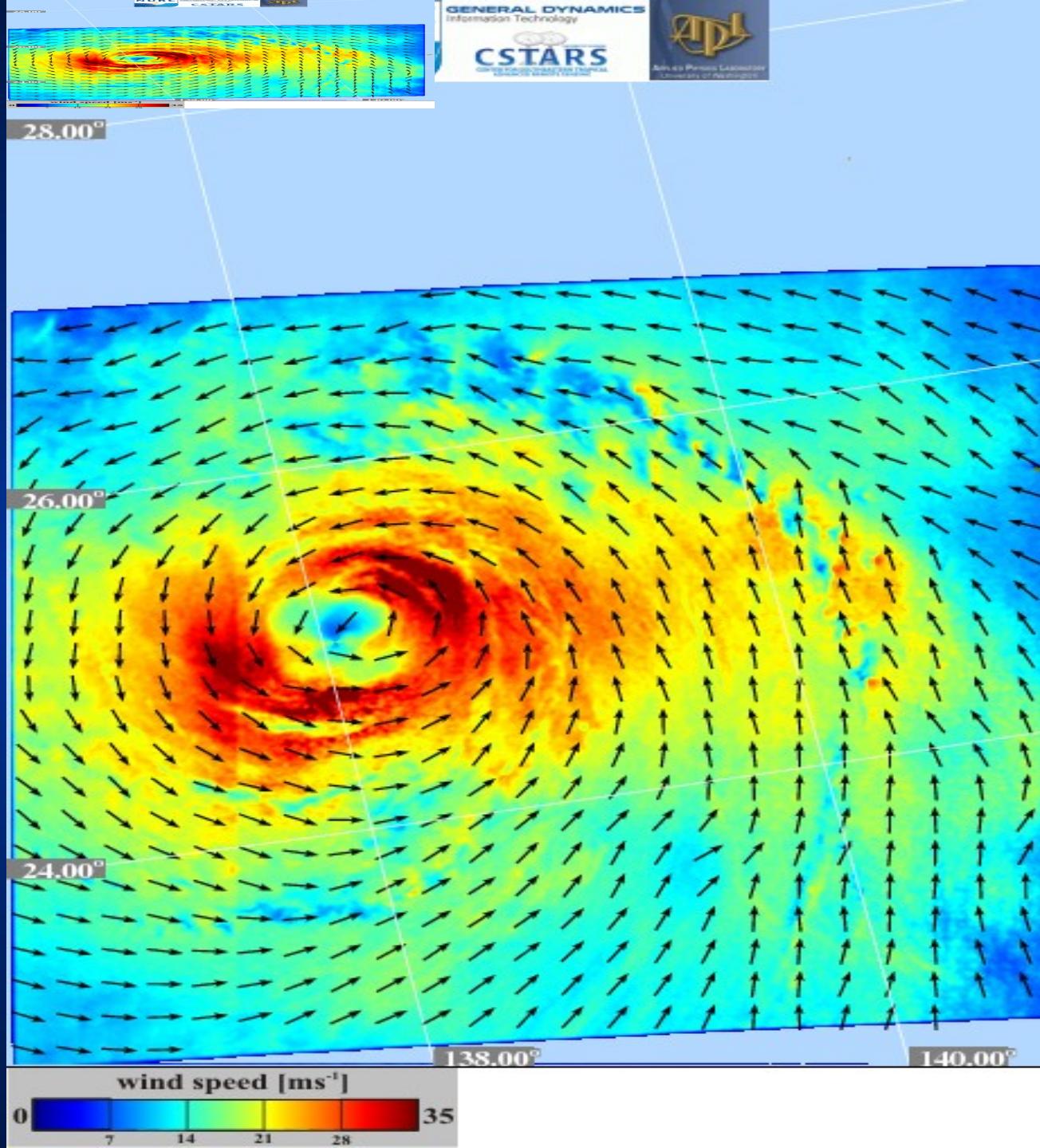




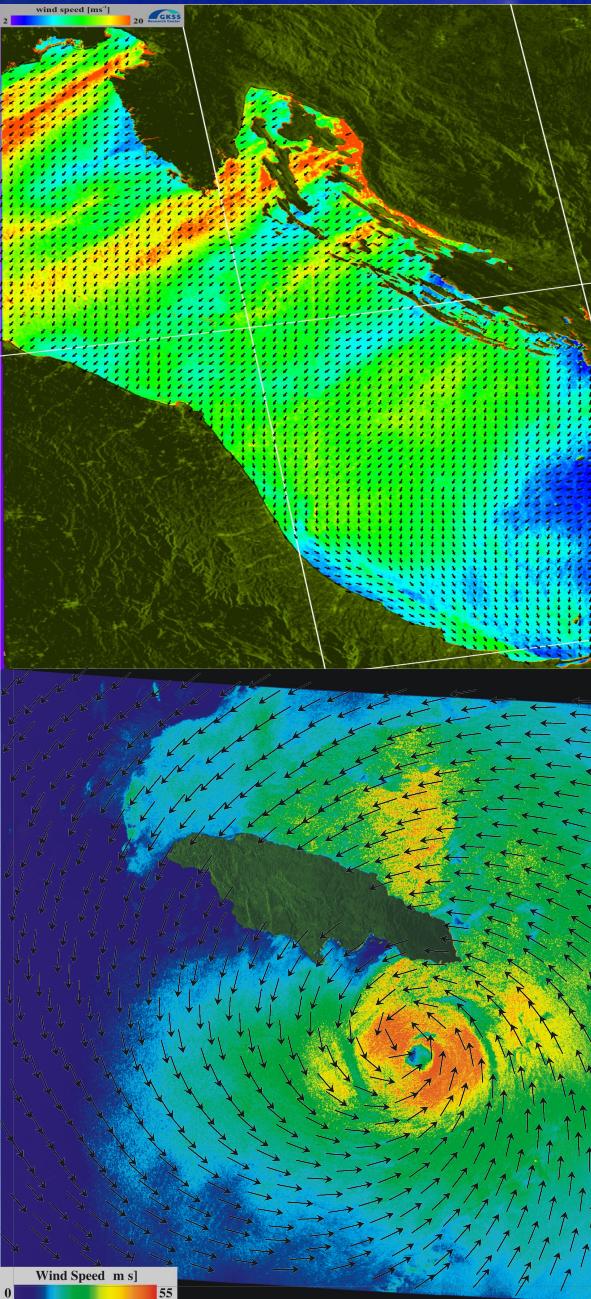


Investigations of Tropical Cyclones

Radarsat-1
22. Aug. 2007



Summary



SAR wind directions are taken fro a priori information or extracted from linear features (rms of 20°)

SAR wind speeds are retrieved from C-band models (rms of ~ 1.5 m/s)

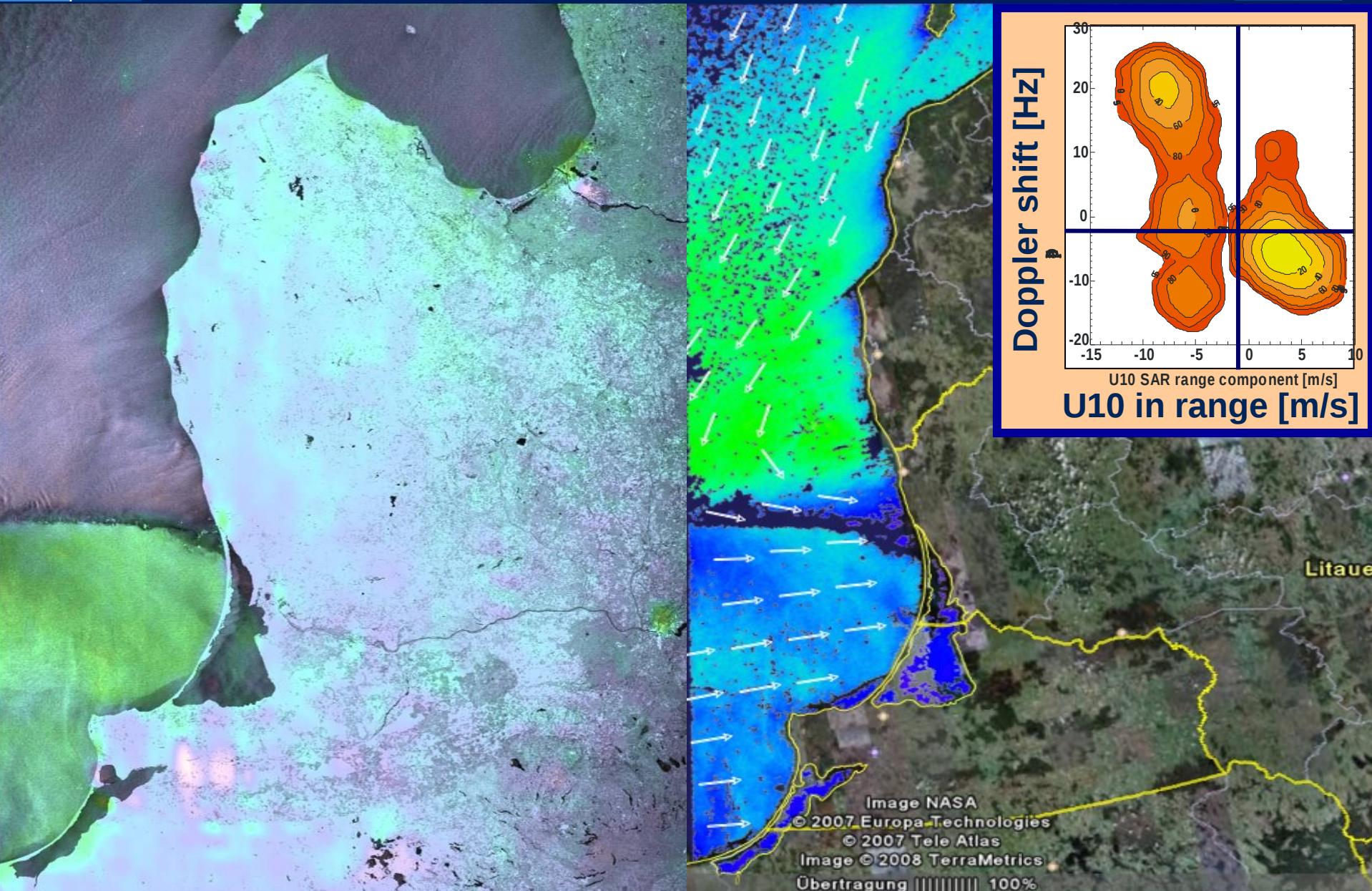
Doppler shift give additional valuable information for wind direction retrieval

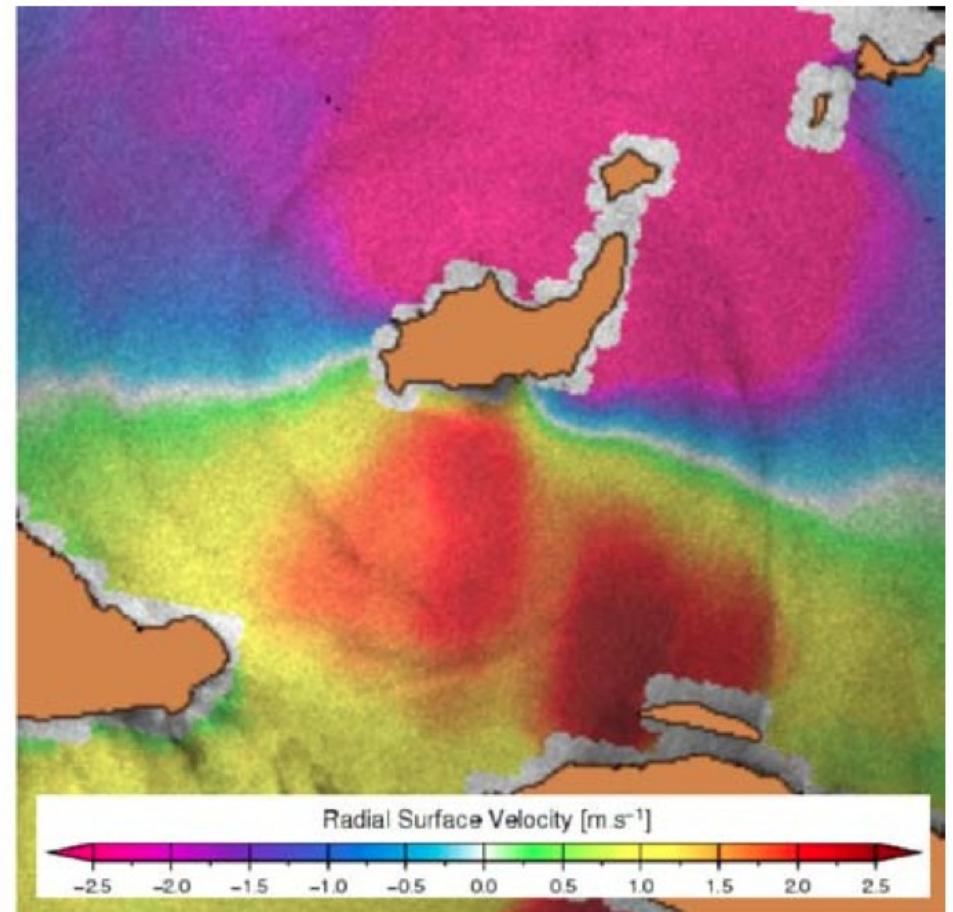
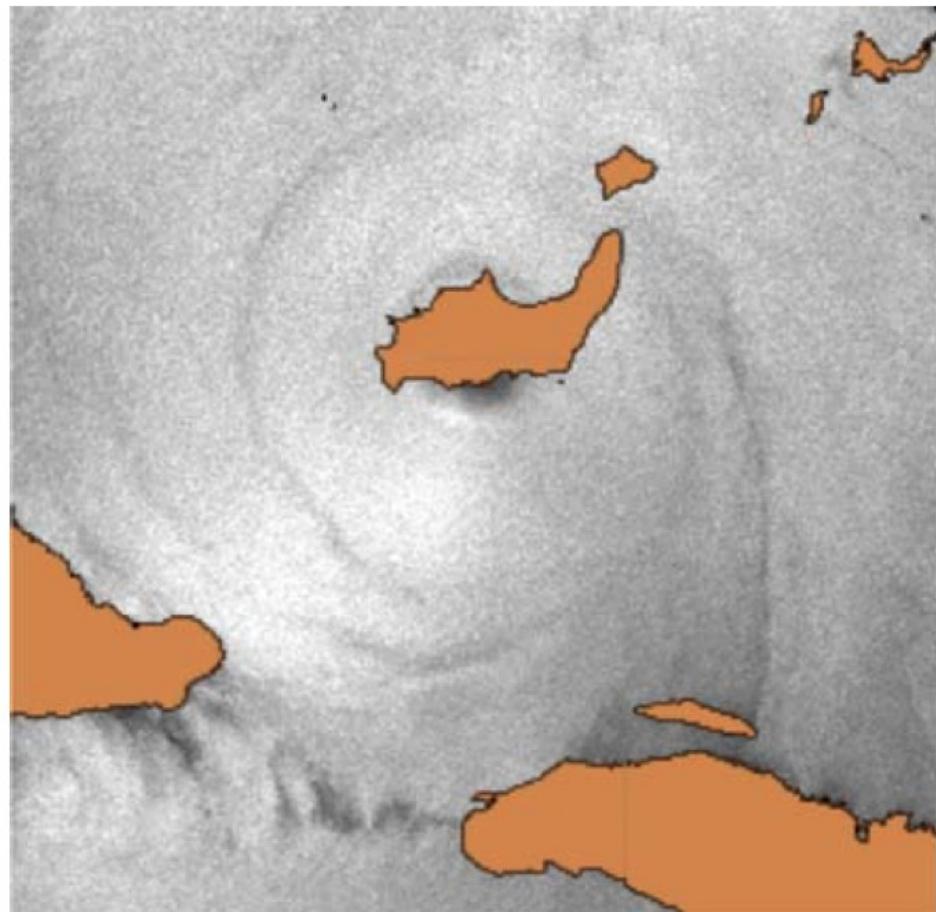
X-band GMF available

Applications:

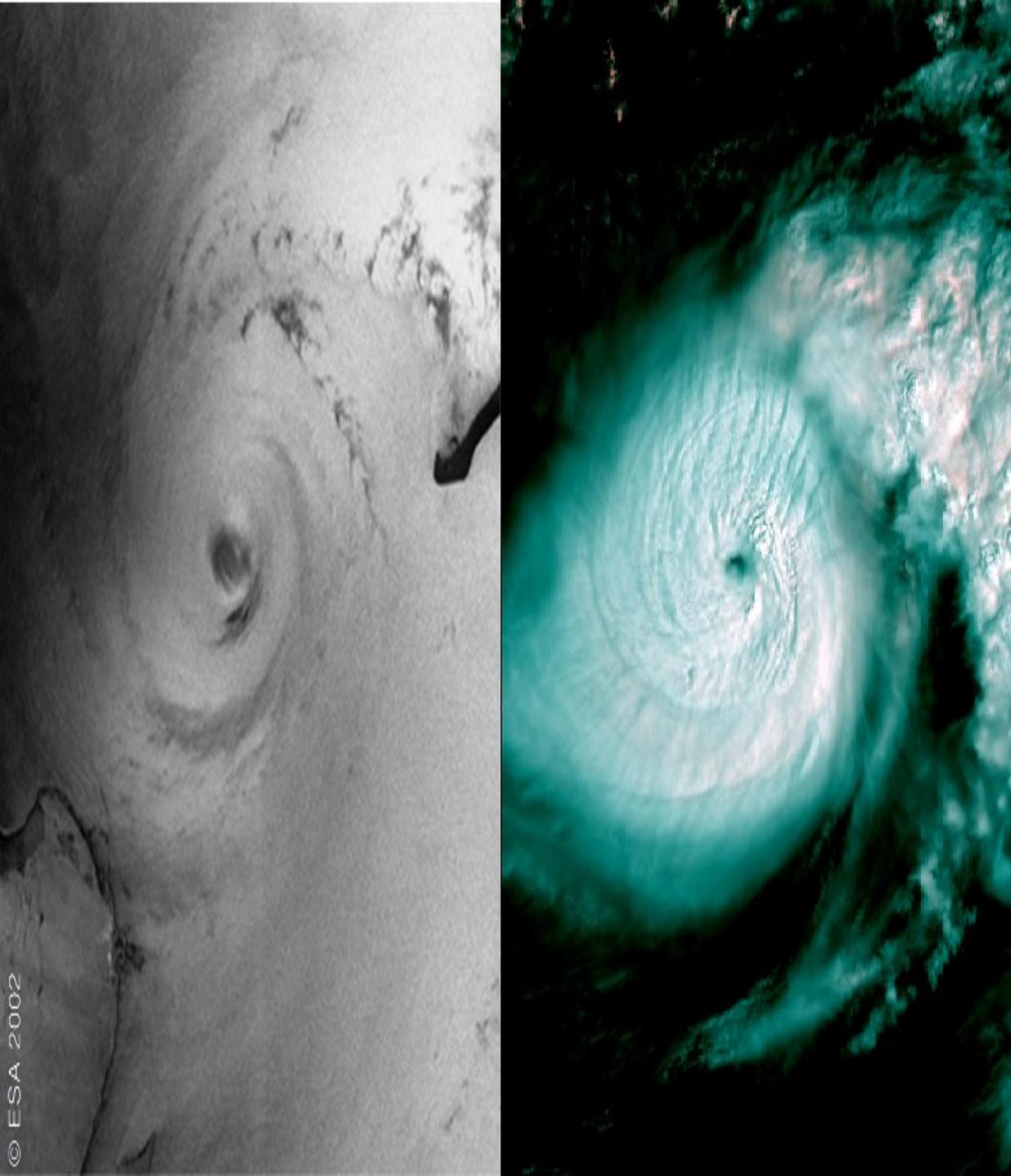
- **coastal security**
- **quantitatively characterize cyclones**
- **estimate size, location and shape of cyclone eyes**
- **offshore wind farming**

Doppler Shift for Wind Direction Ambiguity Removal

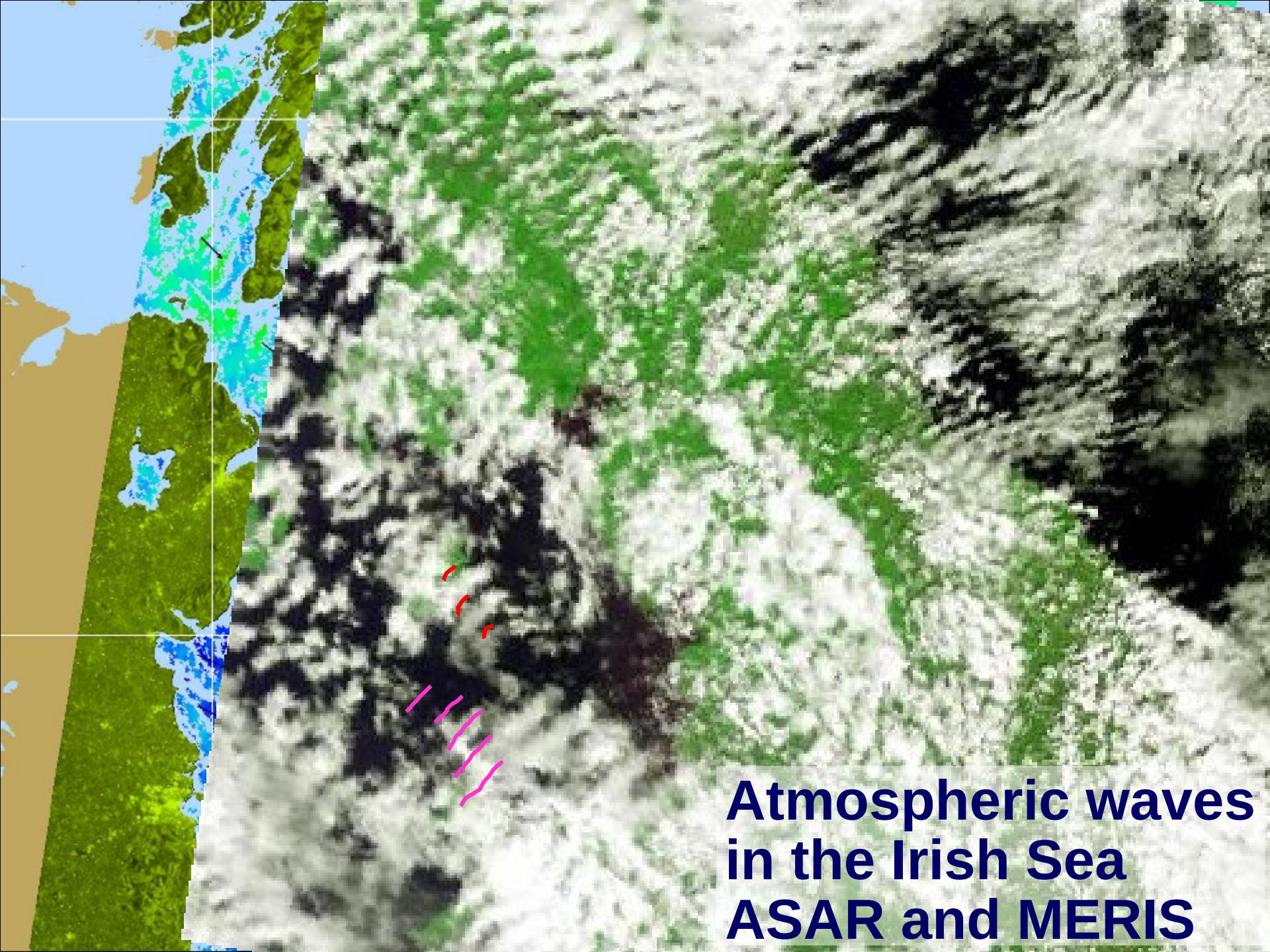




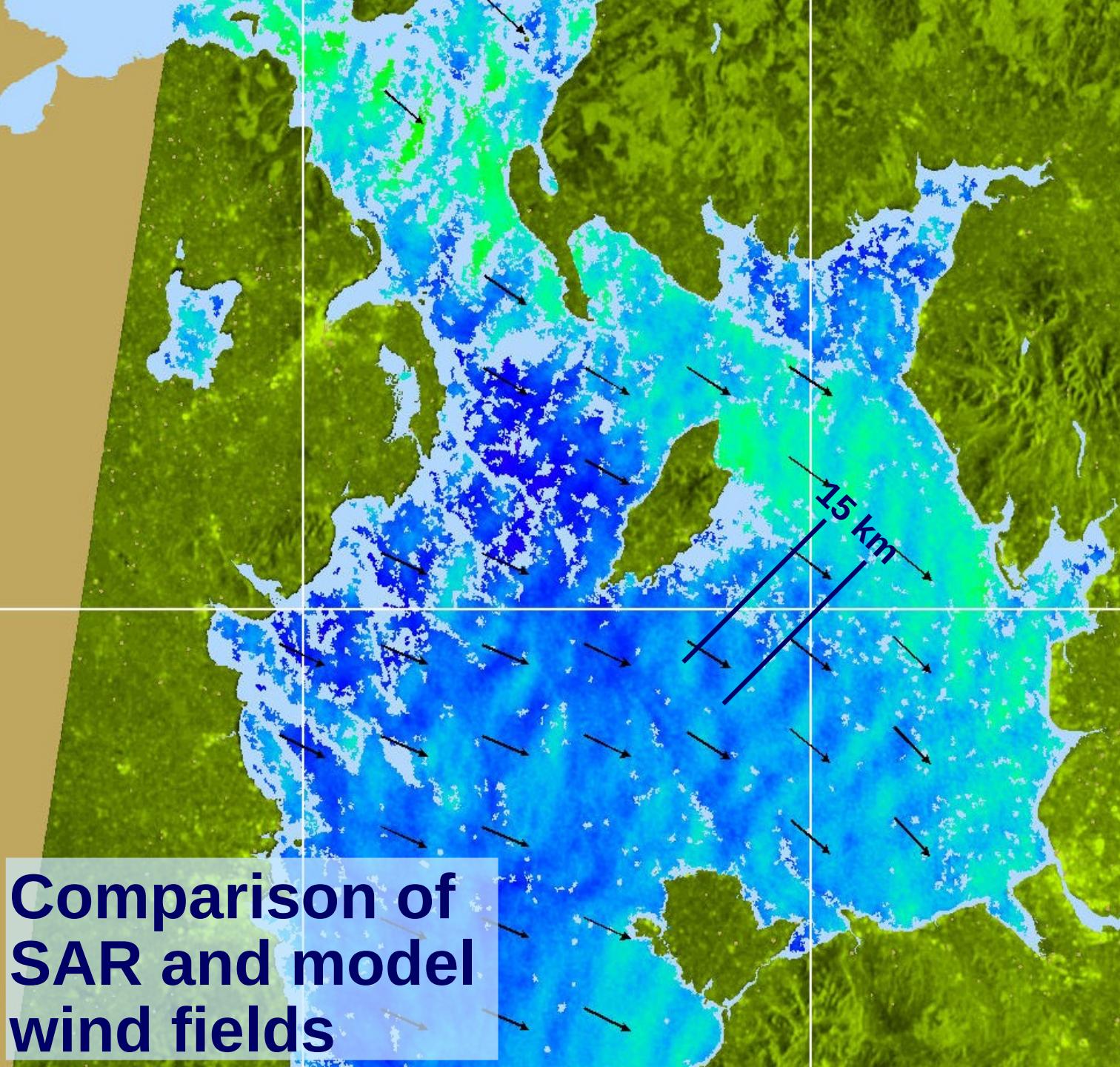
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Investigation of Extreme Winds

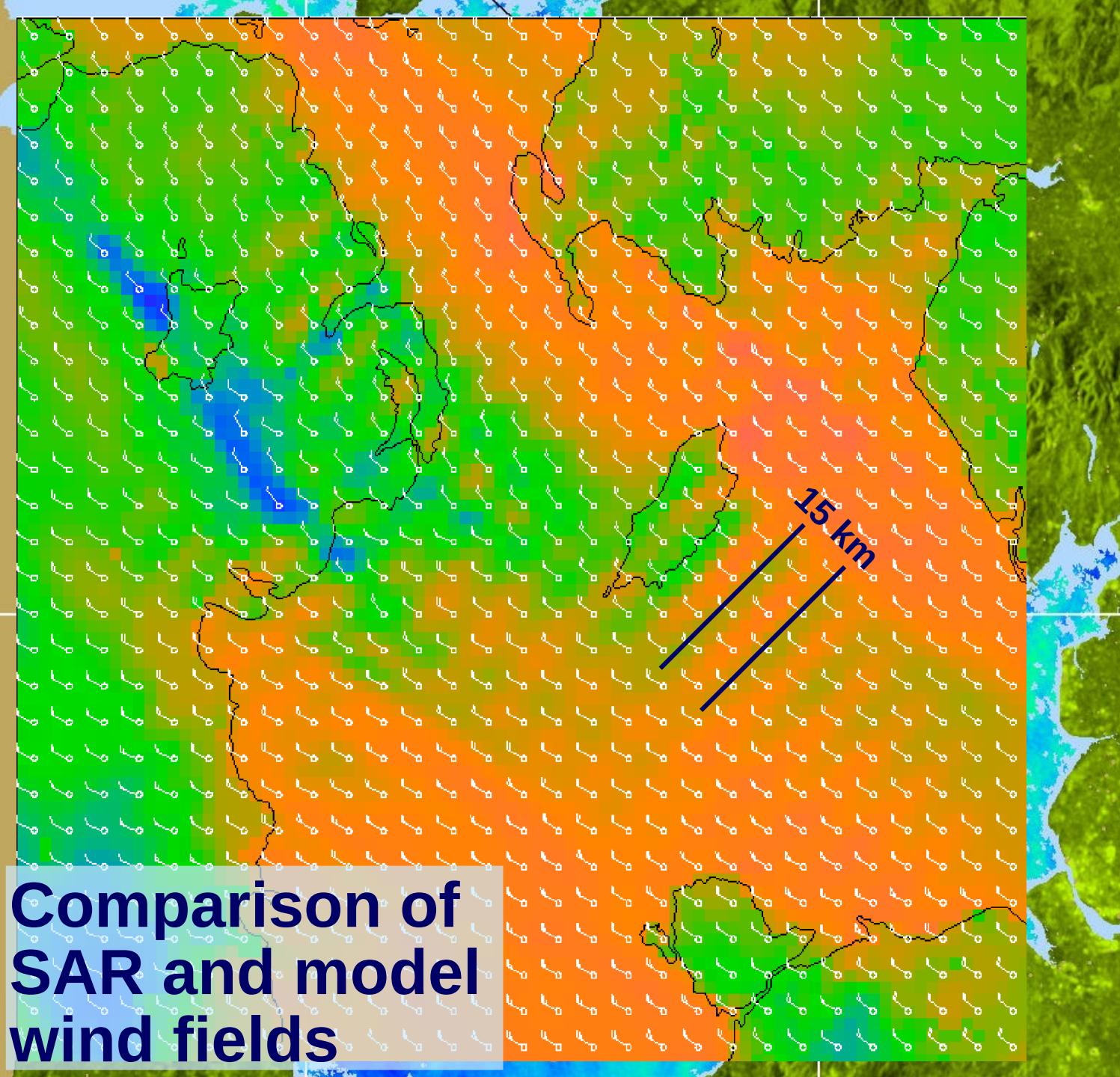


**Atmospheric waves
in the Irish Sea
ASAR and MERIS**



**Comparison of
SAR and model
wind fields**

wind speed [ms^{-1}]
 2 25

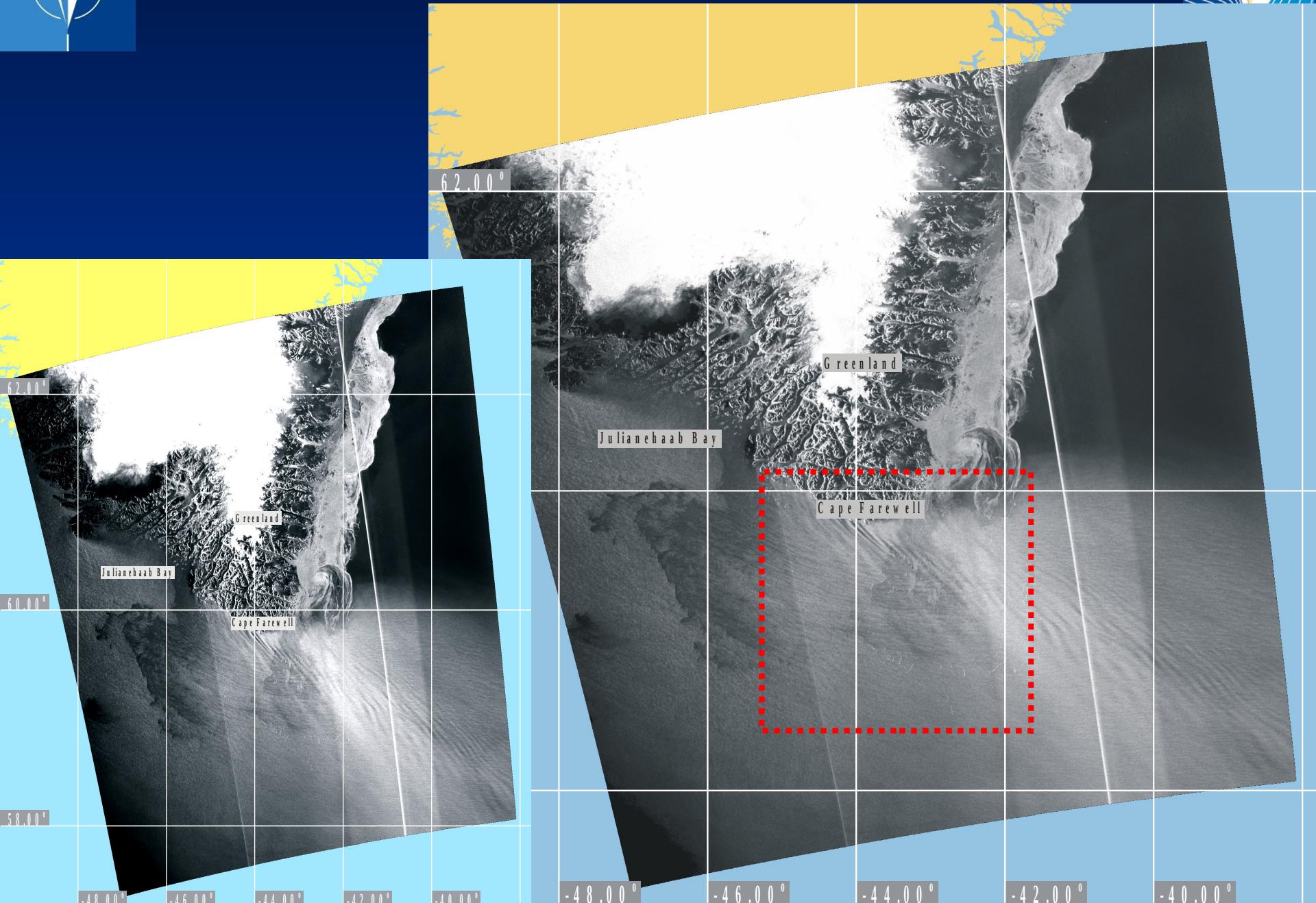


Comparison of
SAR and model
wind fields

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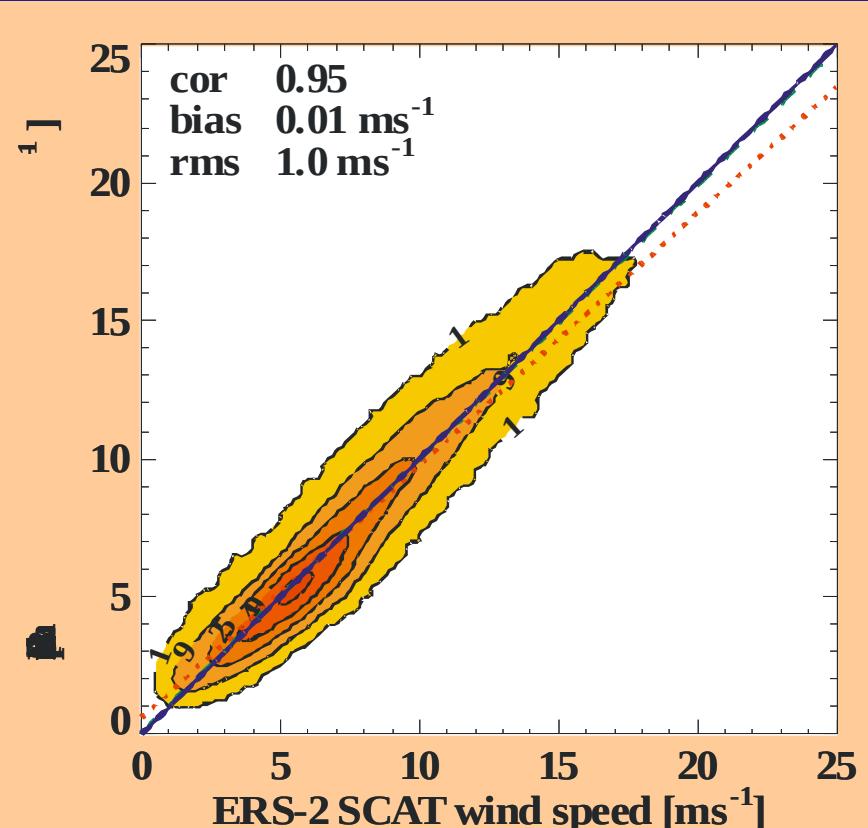
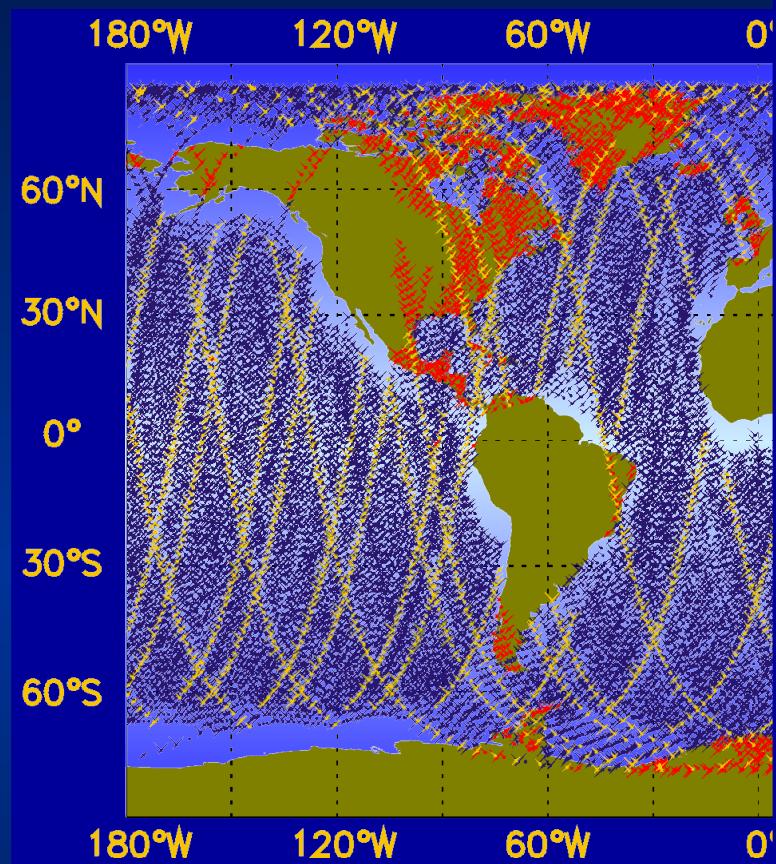


Importants of the Short Scales

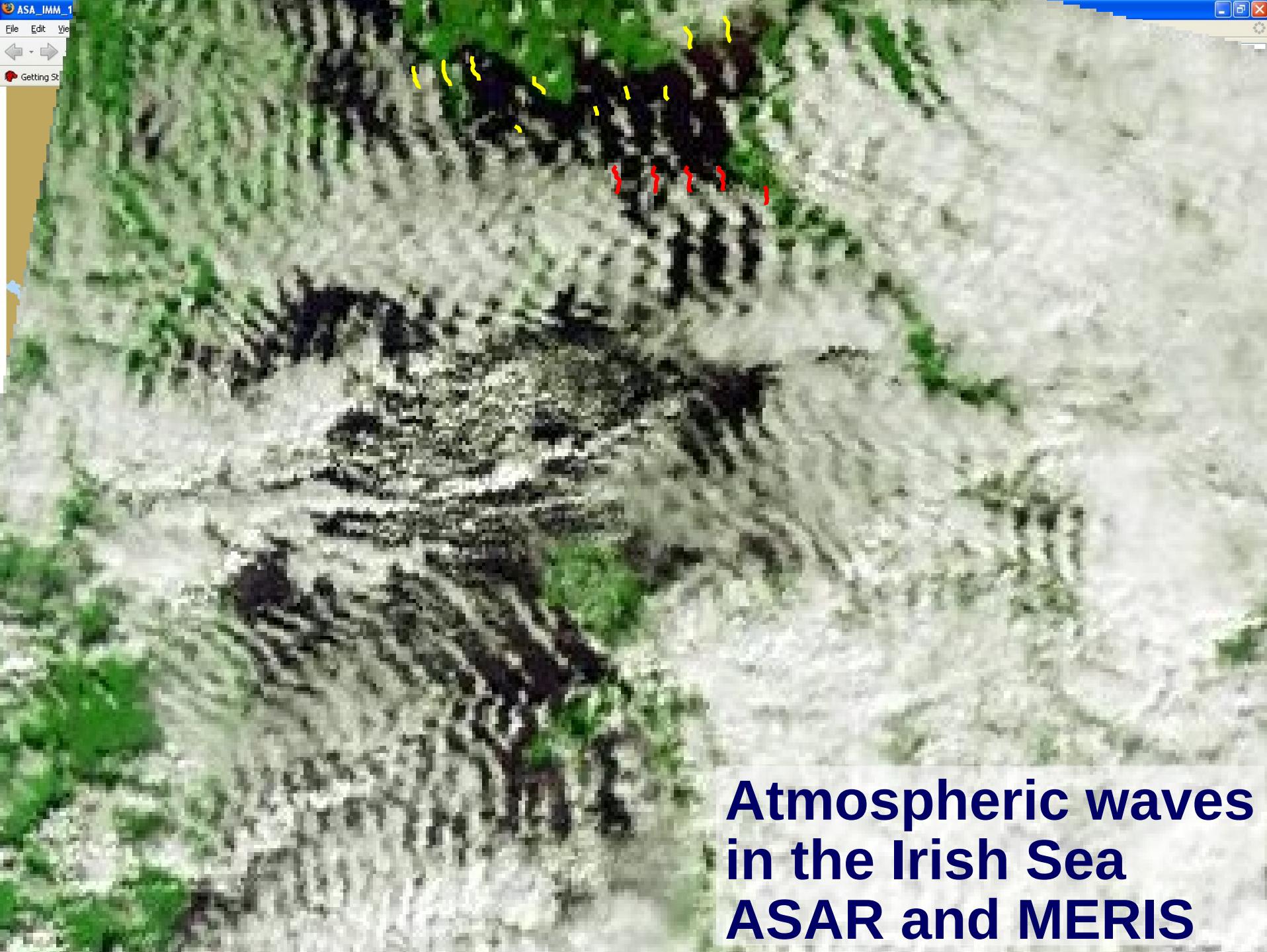




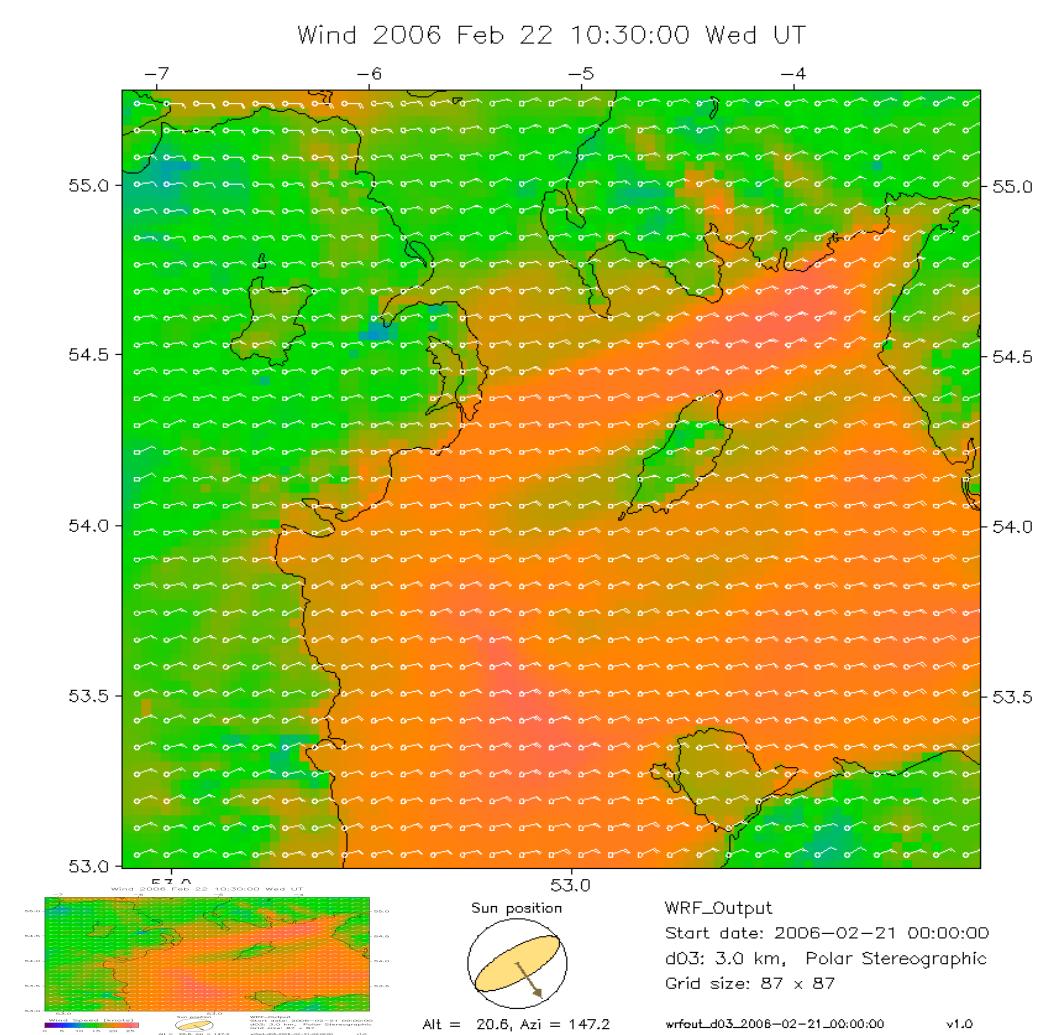
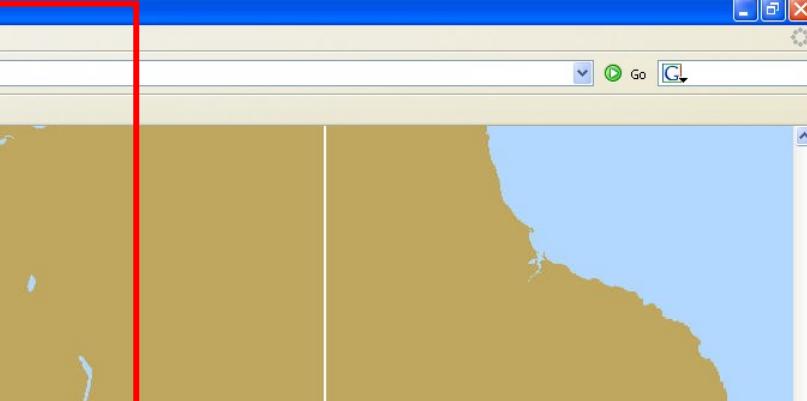
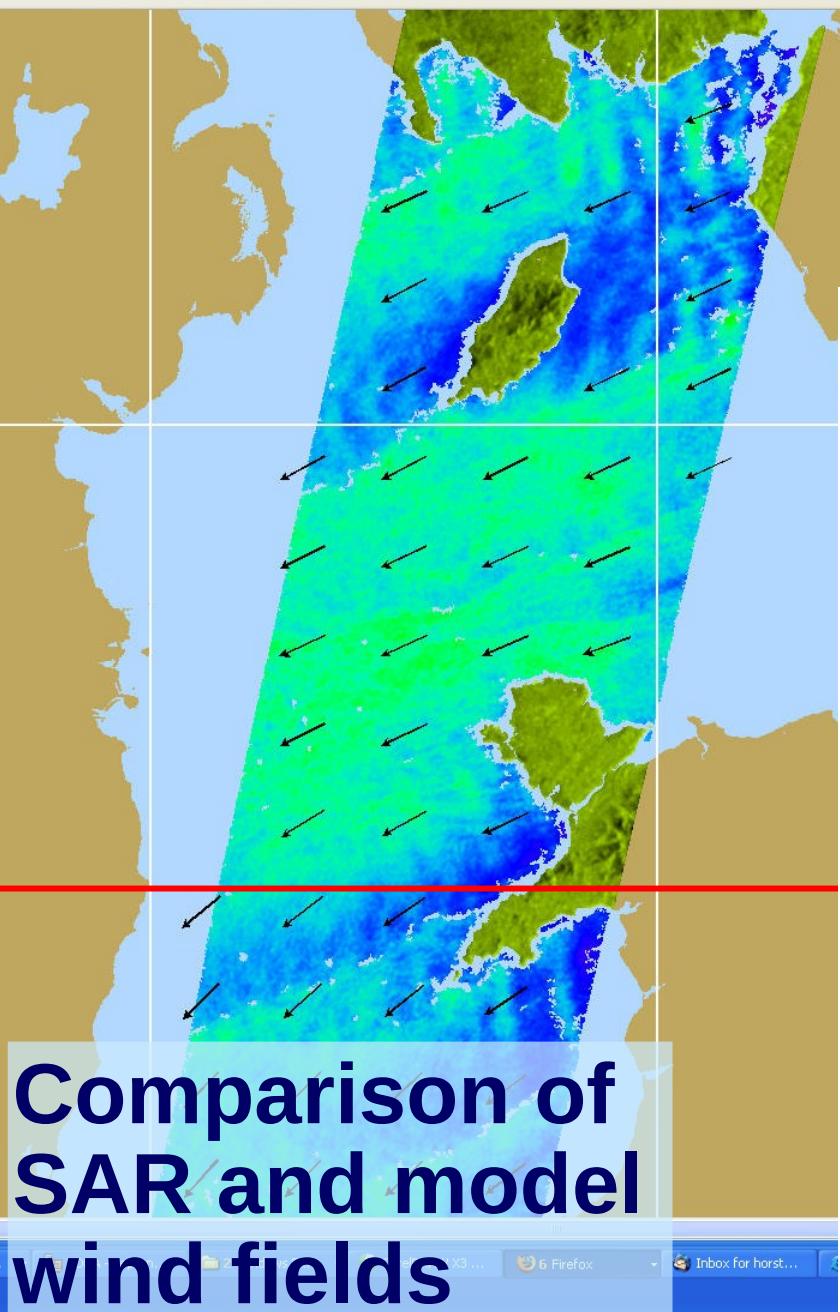
Comparison of SAR wind speeds



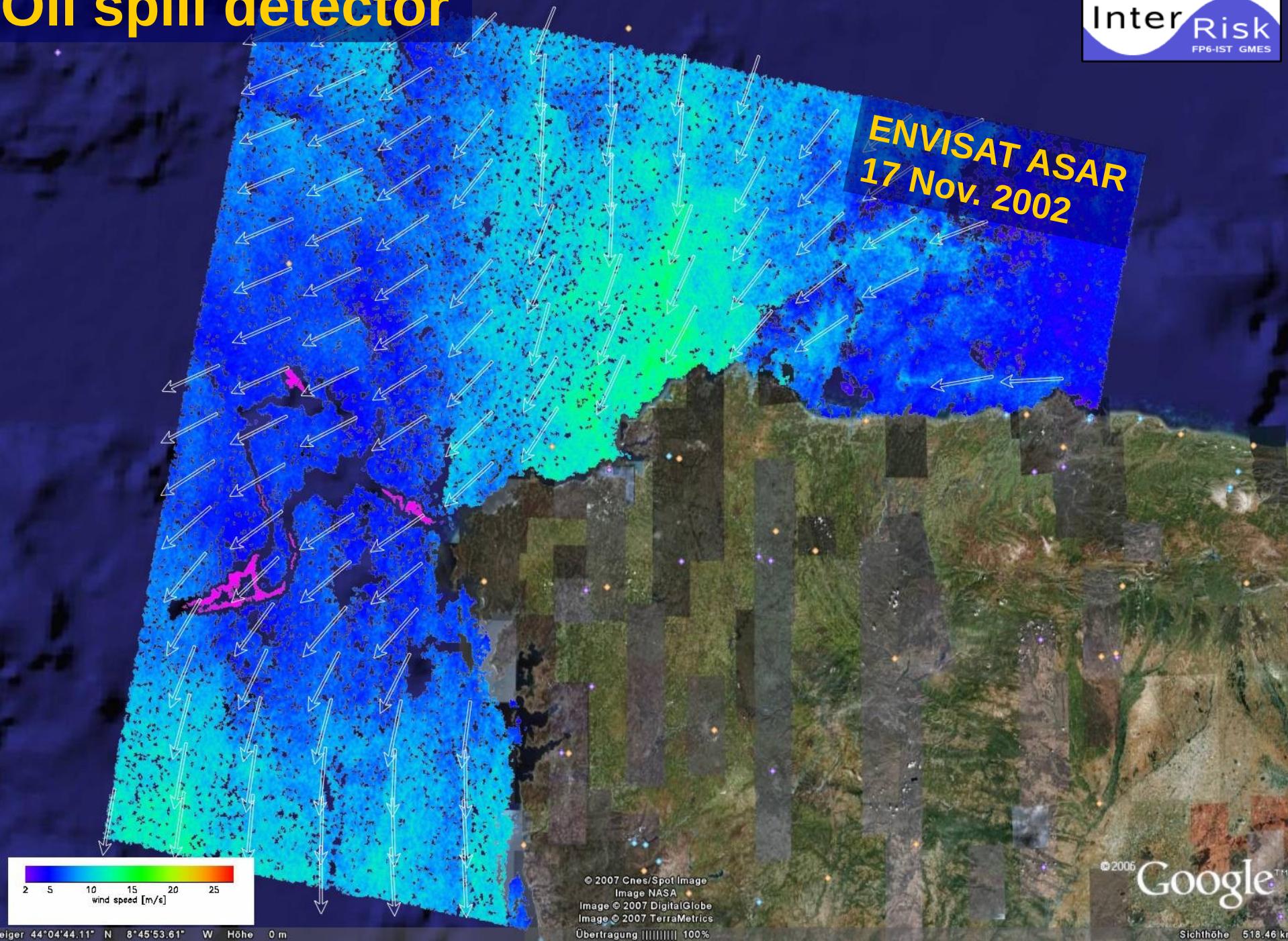
- 27 days of ERS-2 SAR imagettes (34 310)
- Co-located to ERS-2 SCAT wind data
- Co-located to ECMWF Wind forecasts
- Co-located to ECMWF Wind analysis



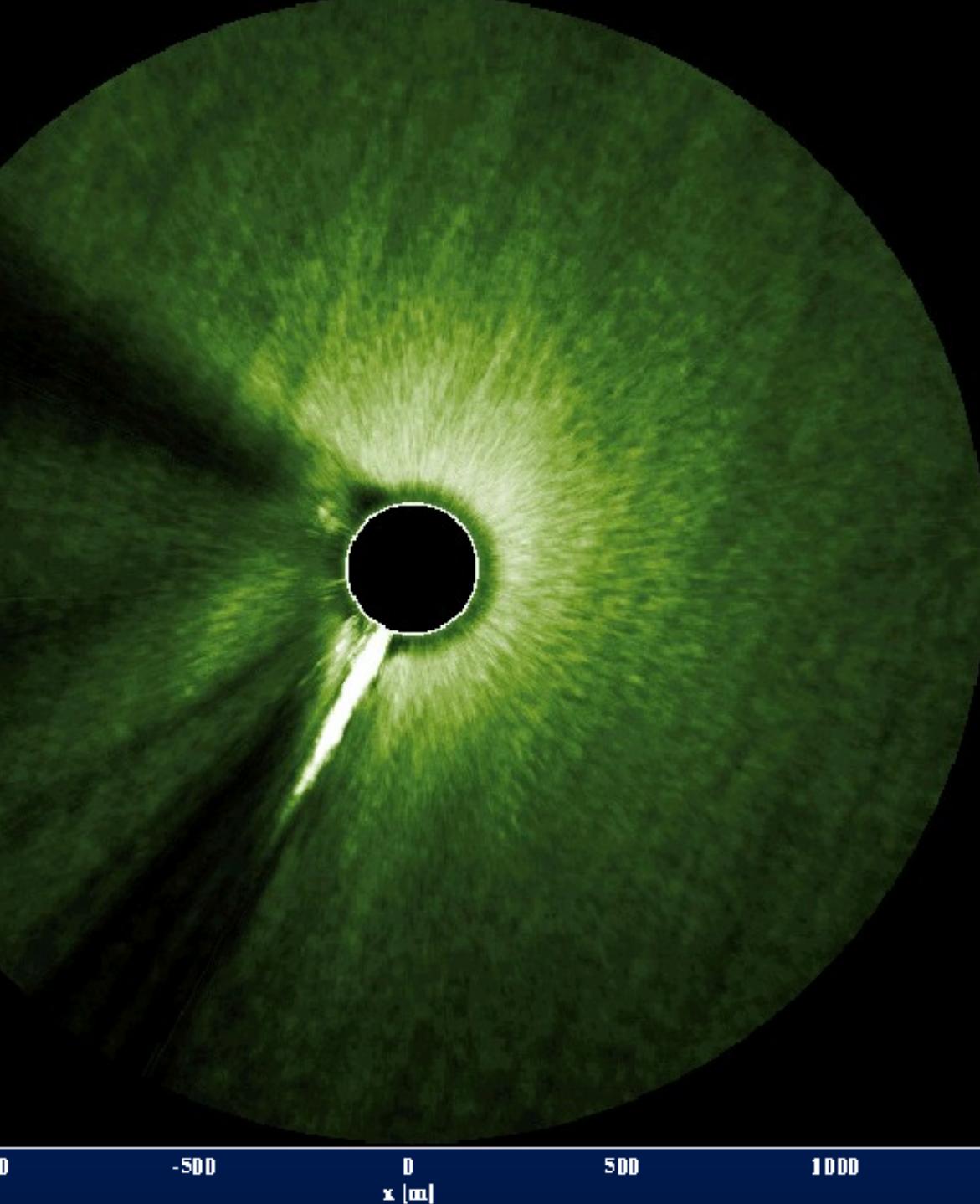
**Atmospheric waves
in the Irish Sea
ASAR and MERIS**



Oil spill detector



Oil spill detector

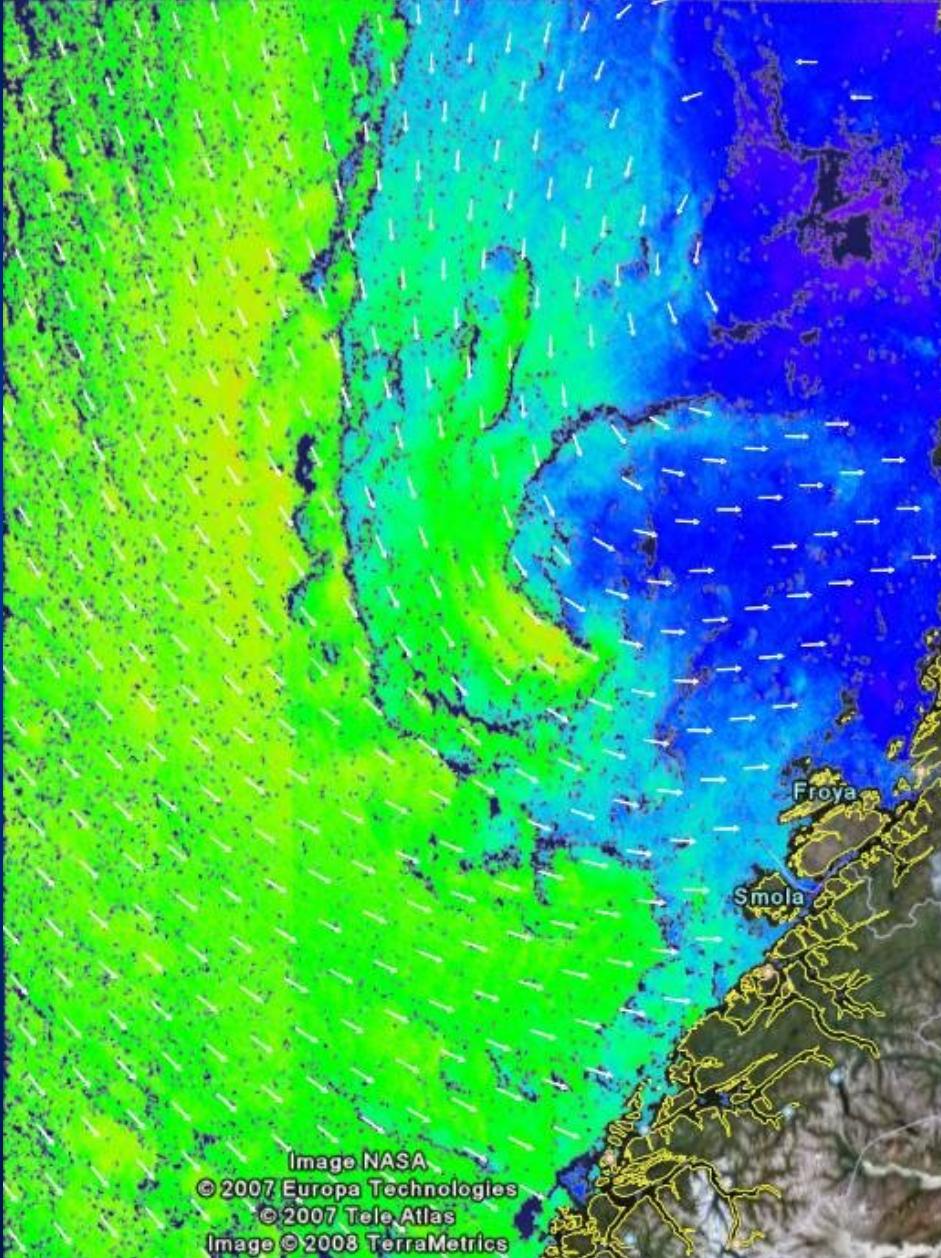
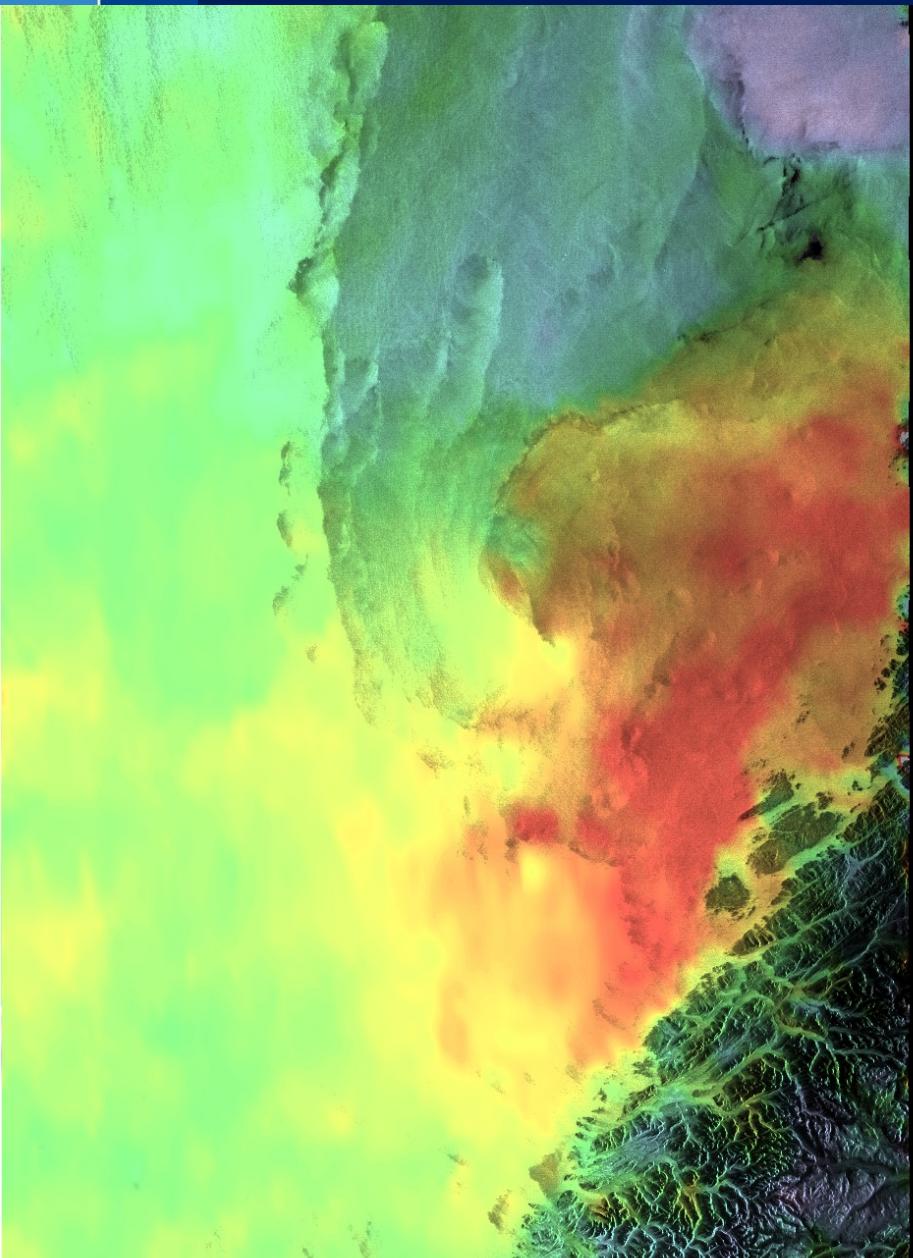


Ocean Surface Streaks

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Doppler Shift for Wind Direction Ambiguity Removal



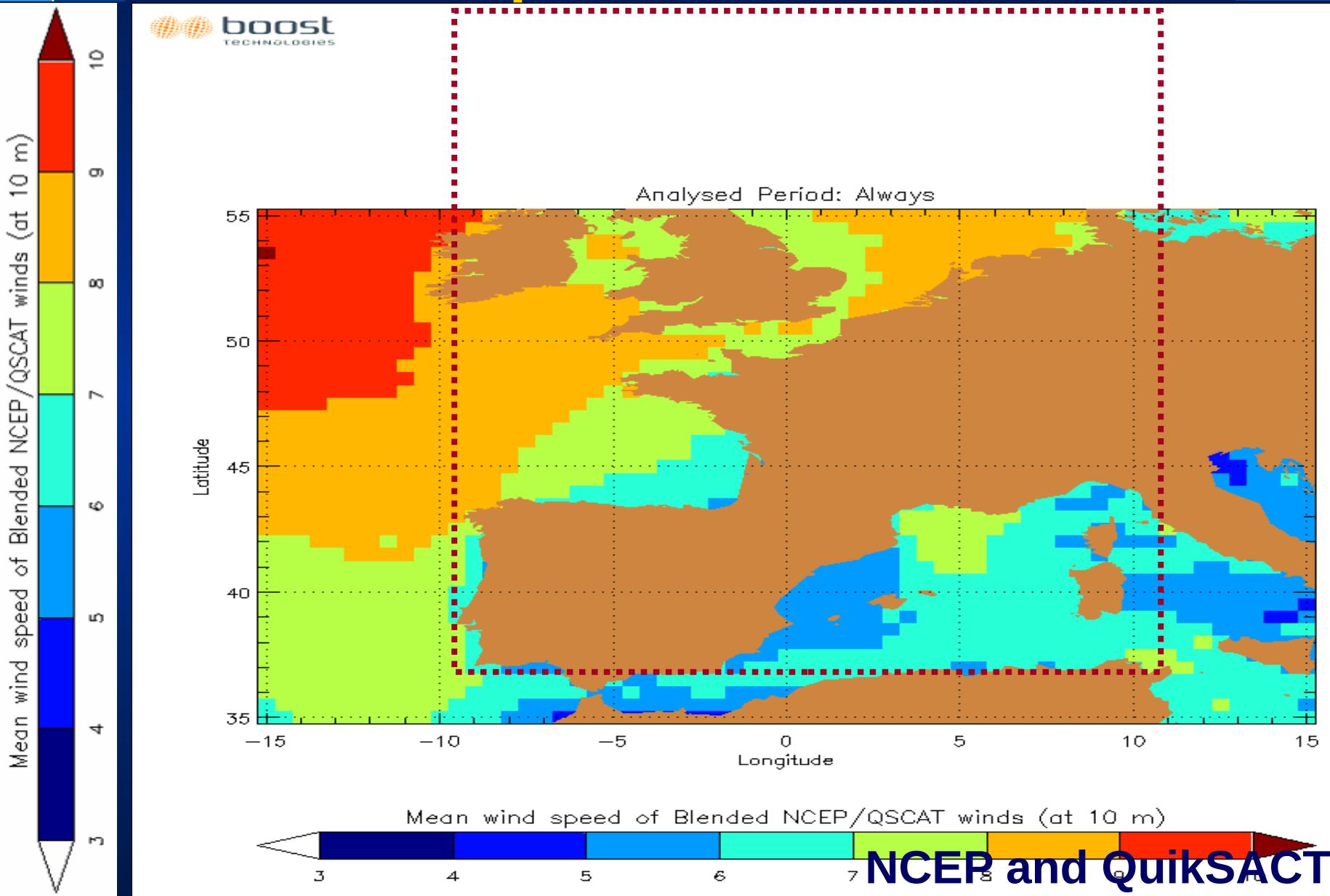


Applications: Climatology

Mean wind speed

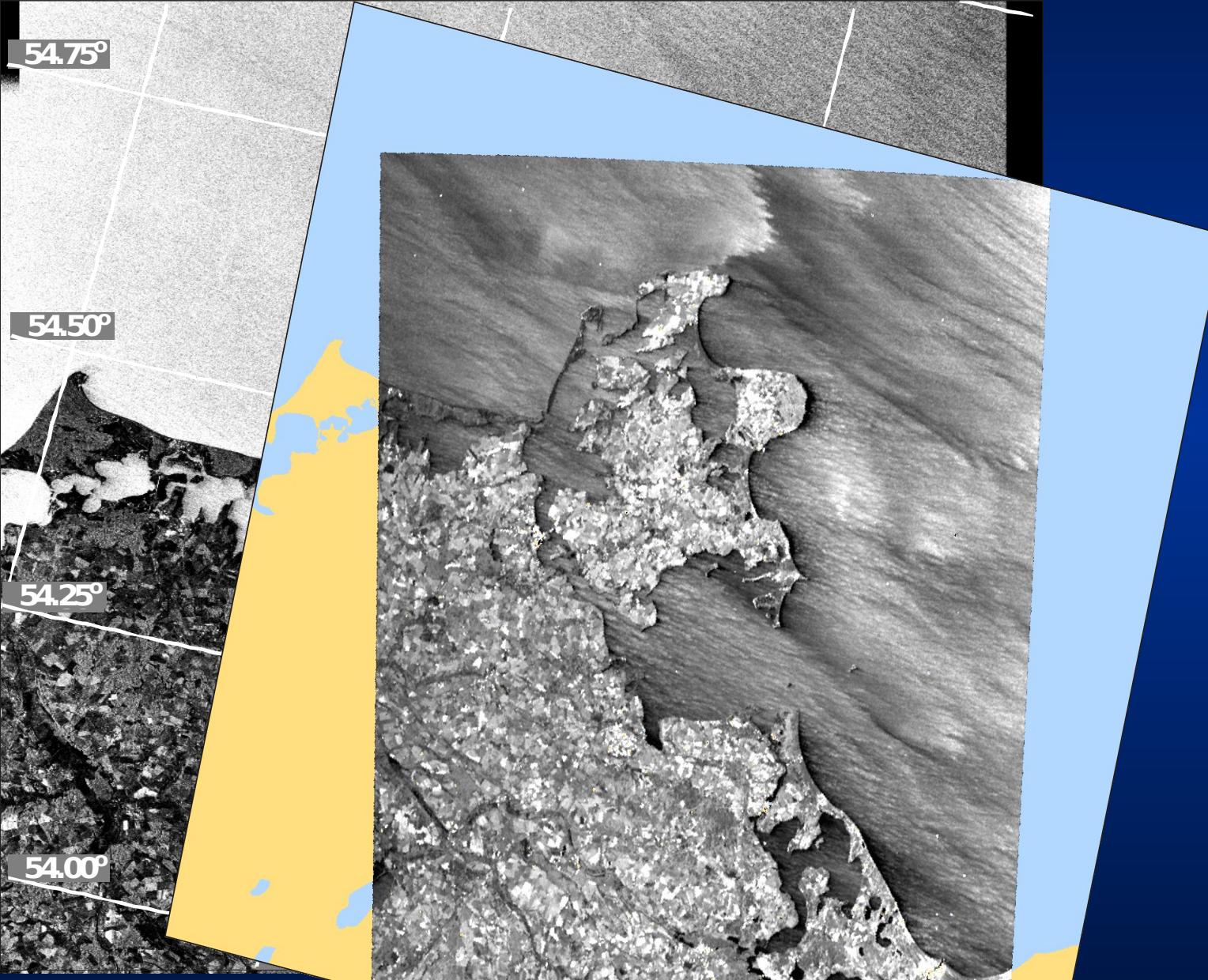


boost
TECHNOLOGIES





Development of an empirical GMF for X- and L-band



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