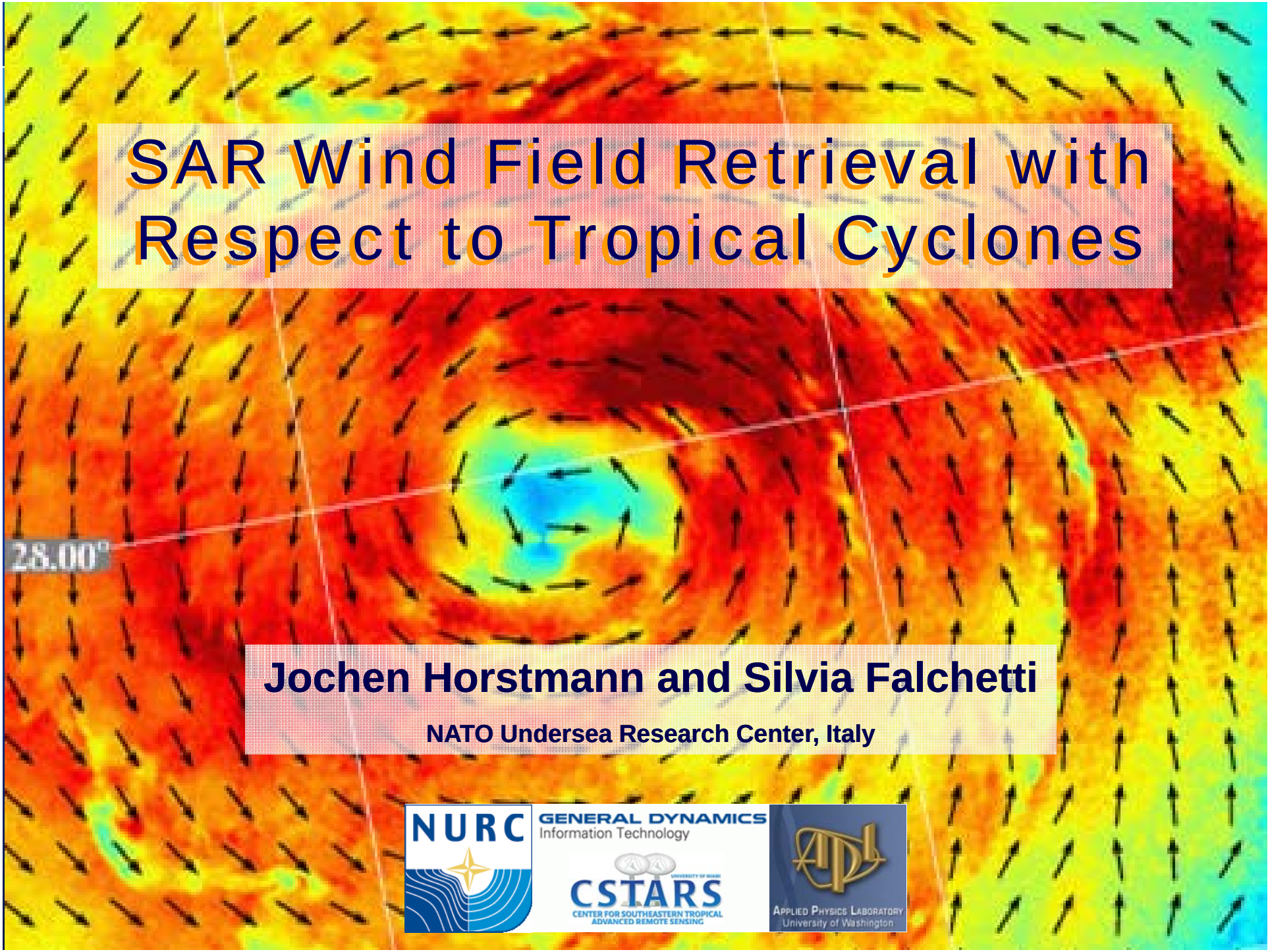


SAR Wind Field Retrieval with Respect to Tropical Cyclones

Jochen Horstmann and Silvia Falchetti

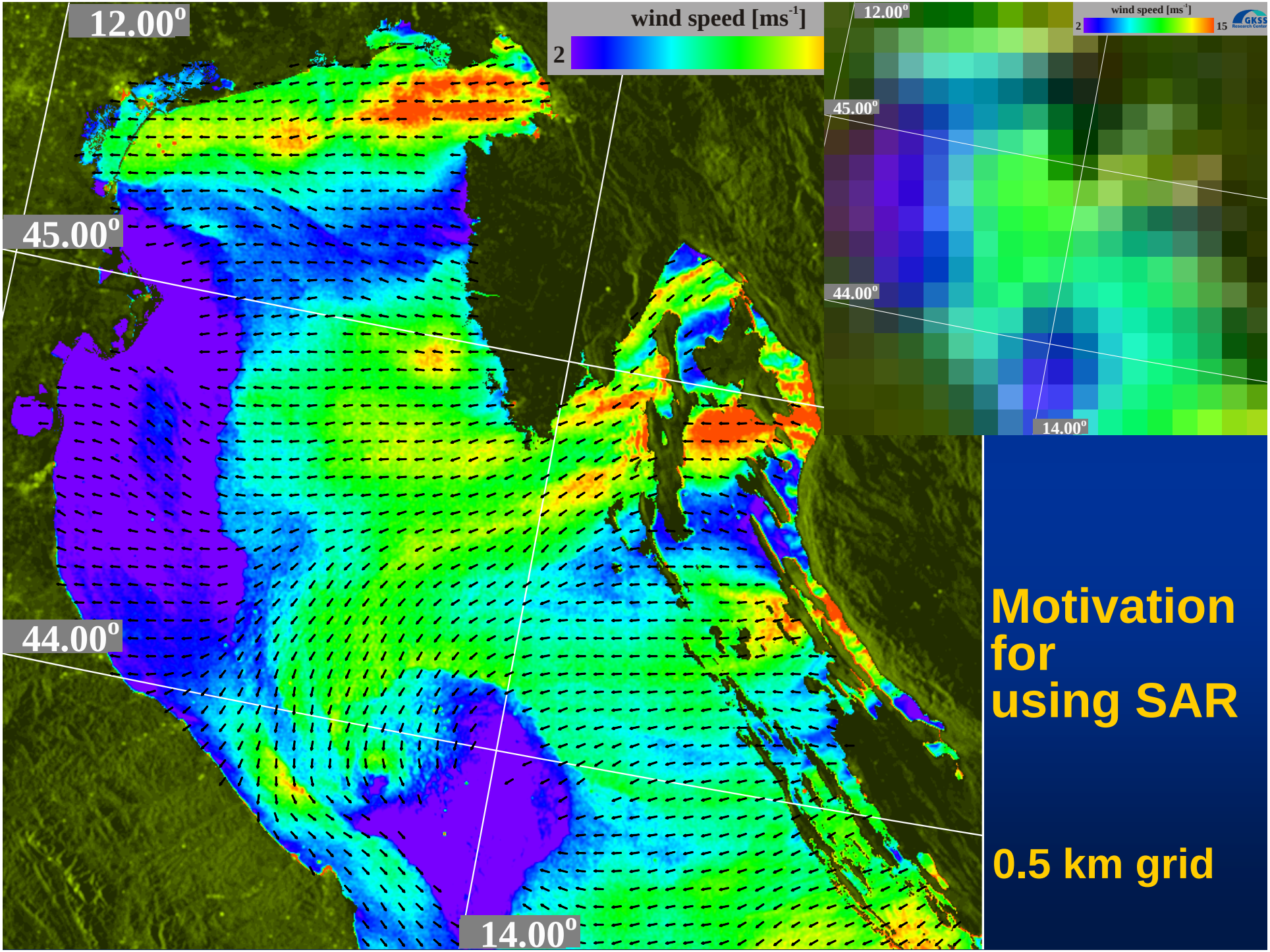
NATO Undersea Research Center, Italy

NURC

GENERAL DYNAMICS
Information Technology

CSTARS
CENTER FOR SOUTHEASTERN TROPICAL ADVANCED REMOTE SENSING

APPLIED PHYSICS LABORATORY
University of Washington


12.00°
45.00°
44.00°
14.00°
wind speed [ms-1]
2
12.00°
45.00°
44.00°
14.00°
wind speed [ms-1]
2
15
GKSS Research Center
Motivation for using SAR
0.5 km grid

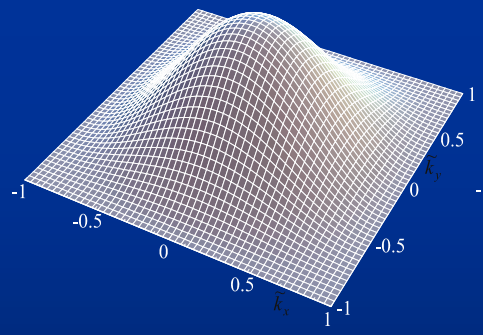
General Approach for Ocean SAR Wind Field Retrieval (WiSAR)

Local Gradient Method

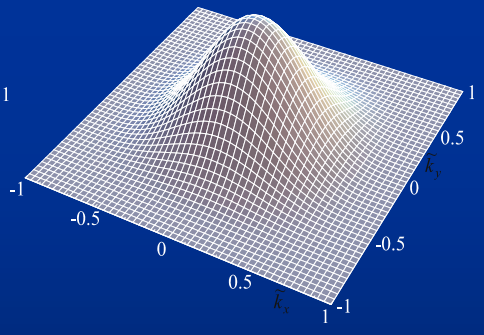
$(B^2B_{xy}^4)^3$ → Sobel → $(B^2B_{xy}^4)$ → Φ

Binomial filter

2 dim. B^2 Filter



2 dim. B^4 Filter

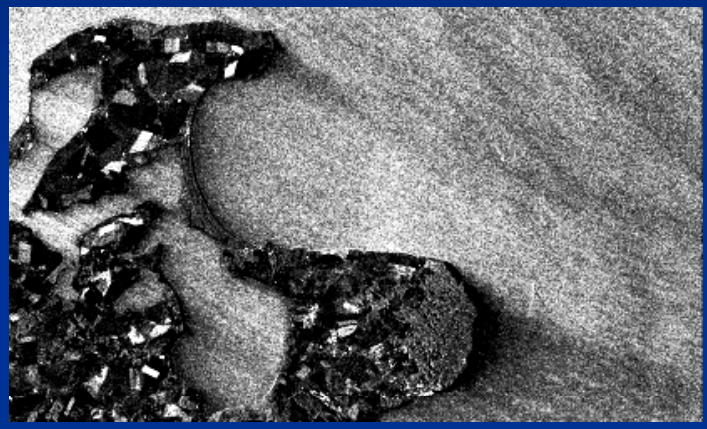


Optimized Sobel-Filter

3	0	–3
10	0	–10
3	0	–3

3	10	3
0	0	0
–3	–10	–3

Geophysical Model Function



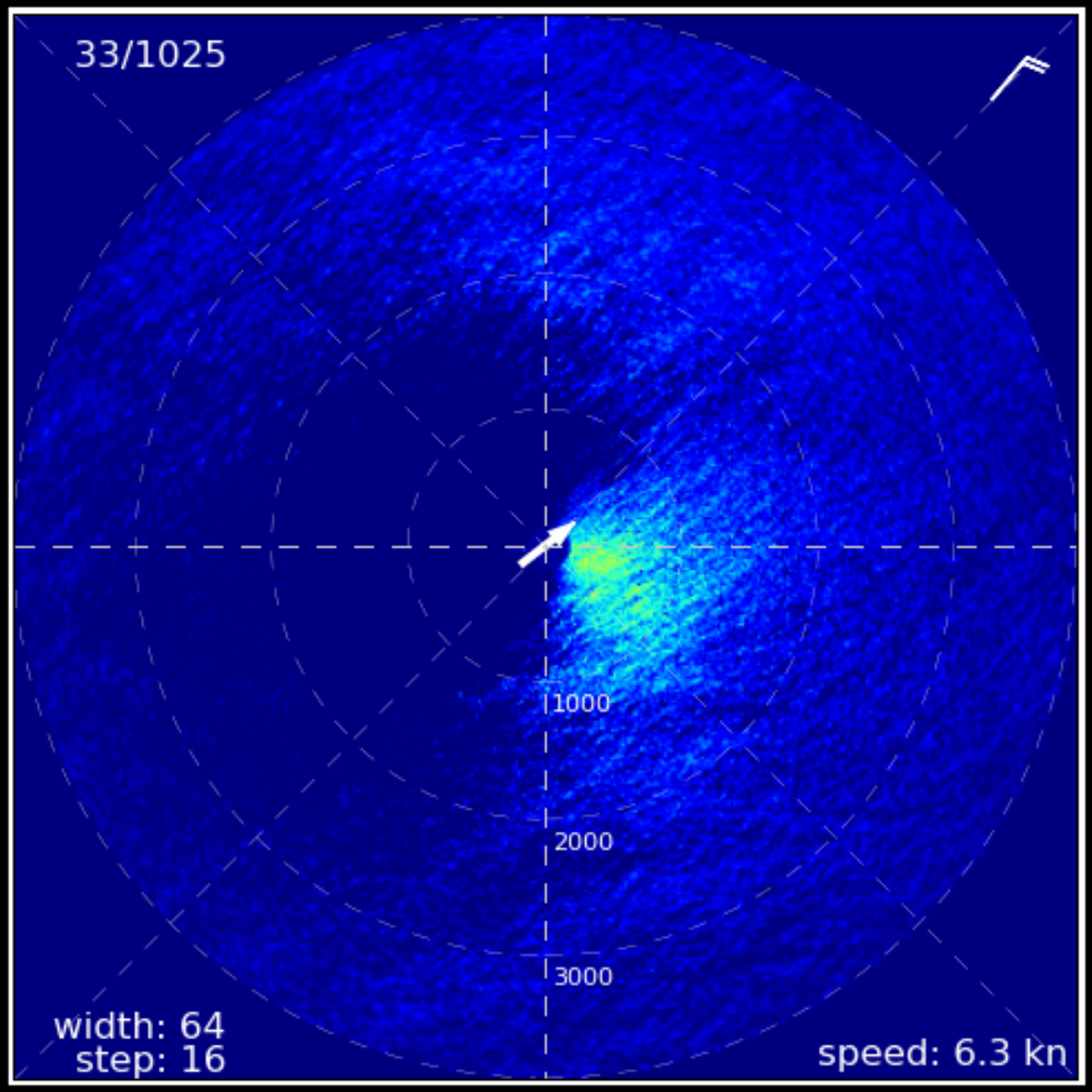
$$\sigma_0^{pol} = a(\theta)u^{\gamma(\theta)}[1 + b(\theta)\cos\phi + c(\theta)\cos(2\phi)]$$

Φ θ u_{10}

GMF for C-, X- and L-band

σ_o

Surface Streaks Imaged by X-band Marine Radar



160 sec mean NRCS with 30 sec time step

NATO UNCLASSIFIED

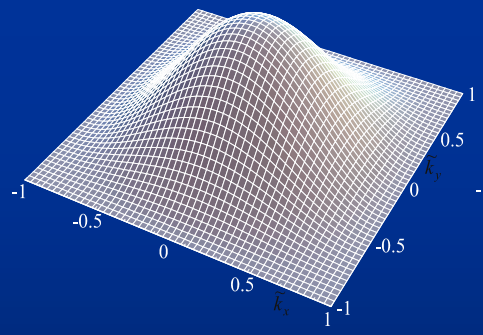
General Approach for Ocean SAR Wind Field Retrieval (WiSAR)

Local Gradient Method

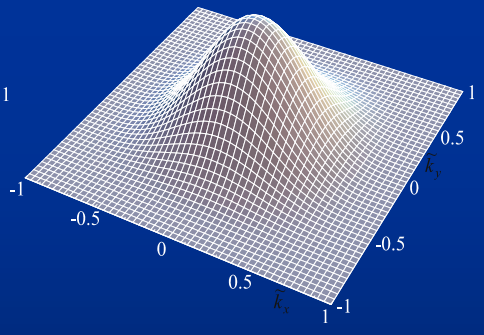
$(B^2B_{xy}^4)^3$ → Sobel → $(B^2B_{xy}^4)$ → Φ

Binomial filter

2 dim. B^2 Filter



2 dim. B^4 Filter



Optimized Sobel-Filter

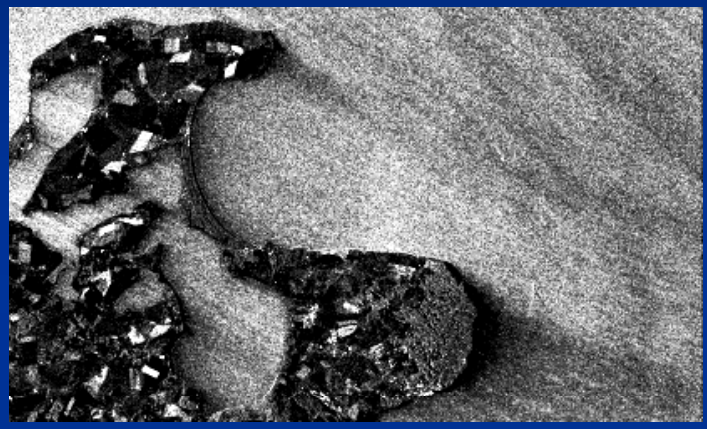
3	0	–3
10	0	–10
3	0	–3

→

3	10	3
0	0	0
–3	–10	–3

→

Geophysical Model Function



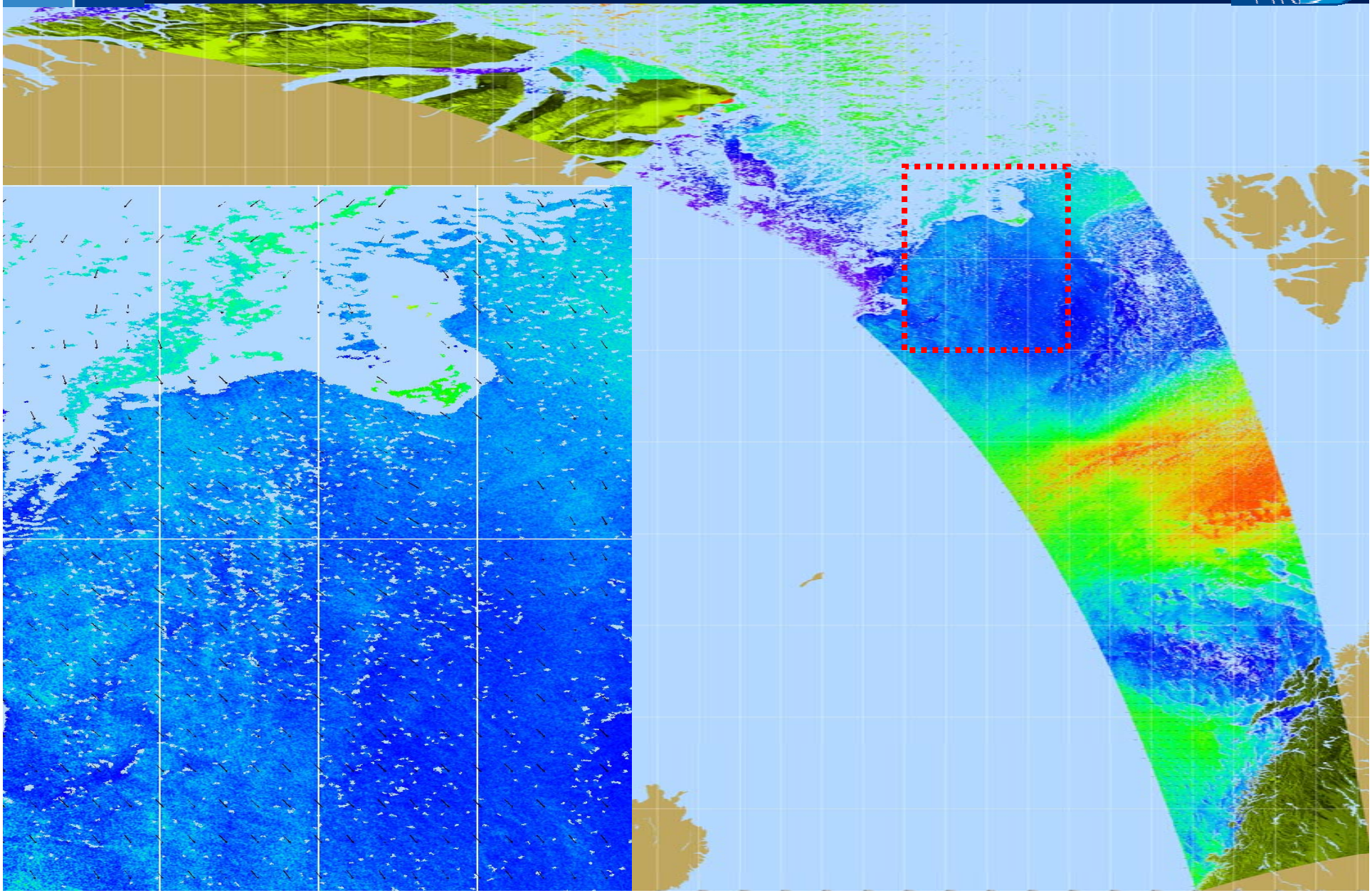
$$\sigma_0^{pol} = a(\theta)u^{\gamma(\theta)}[1 + b(\theta)\cos\phi + c(\theta)\cos(2\phi)]$$

Φ θ u_{10}

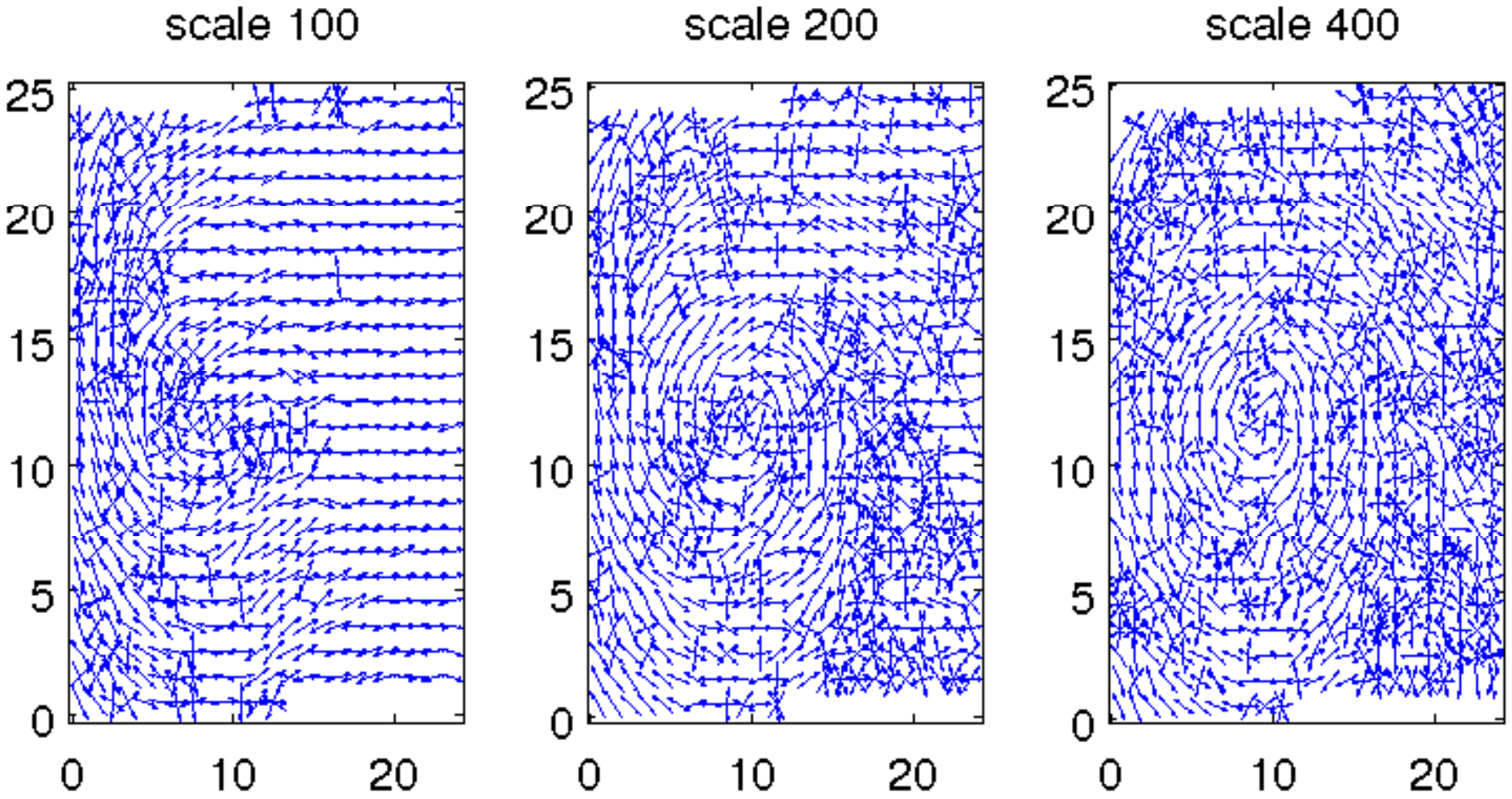
→ GMF for C-, X- and L-band →

σ_o

Flagging of Land and Non Wind Induced Areas

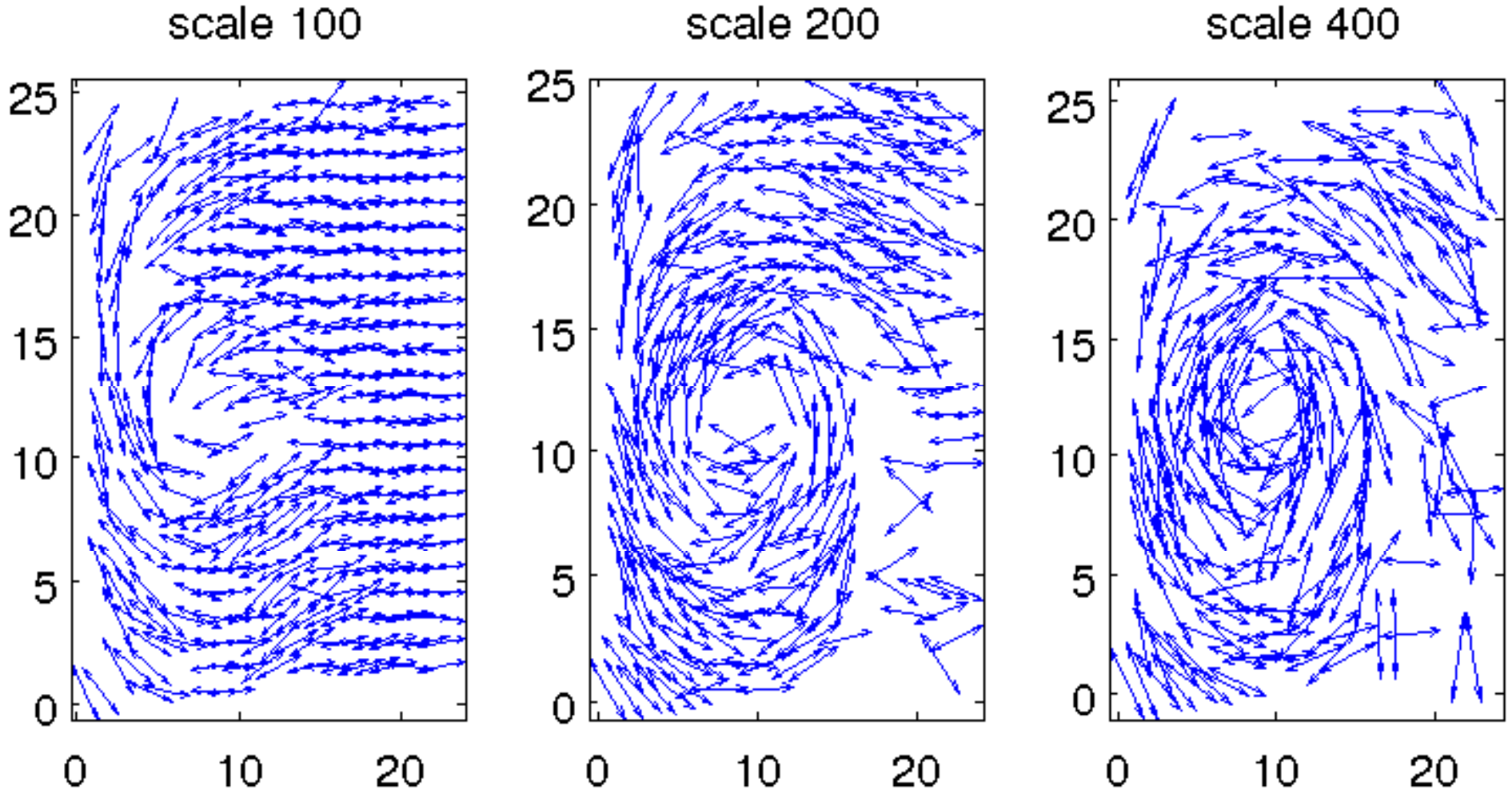


Wind Direction Ambiguity Removal



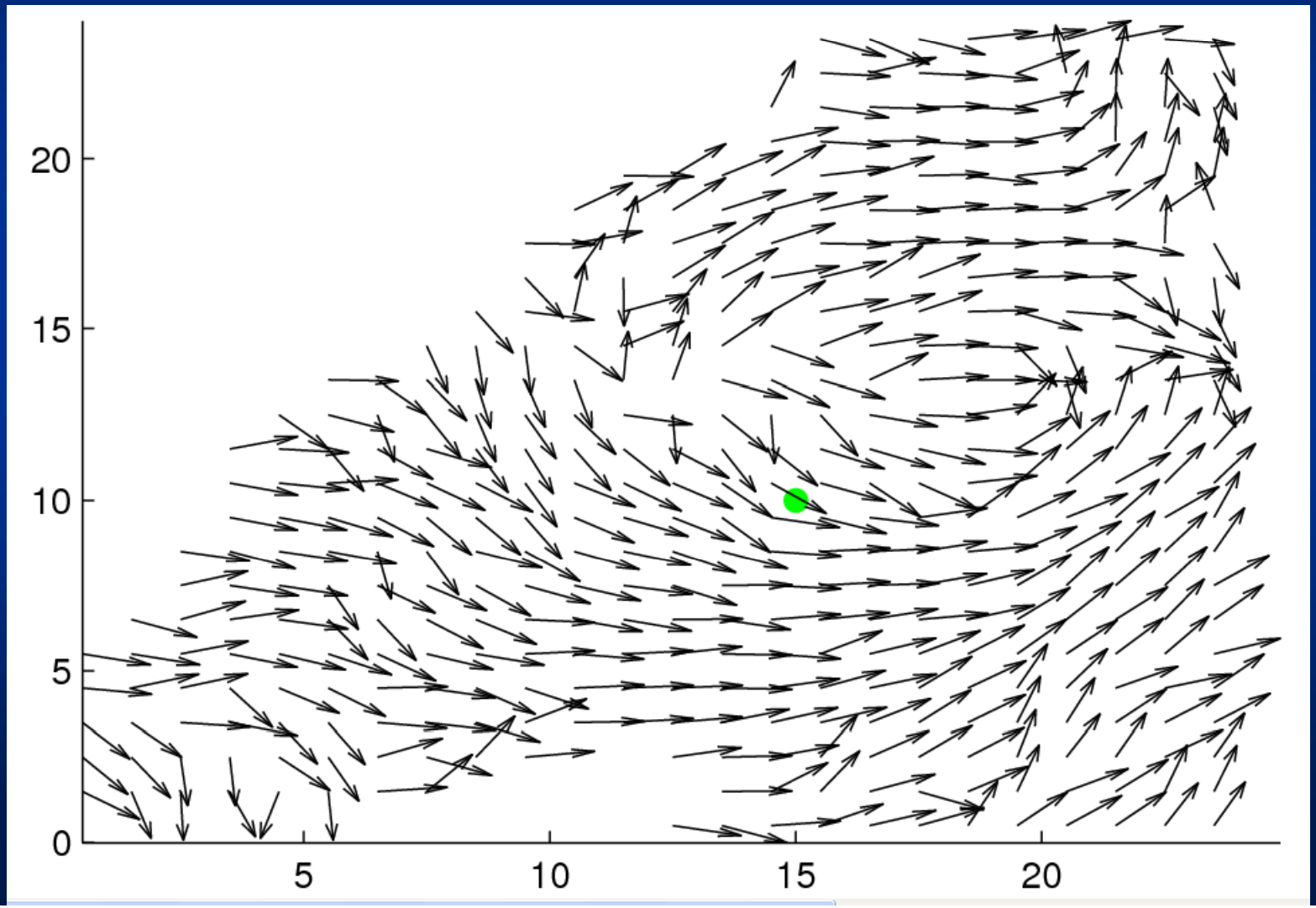
Wind Direction Ambiguity Removal

1. Select grids with only one wind direction (400m)



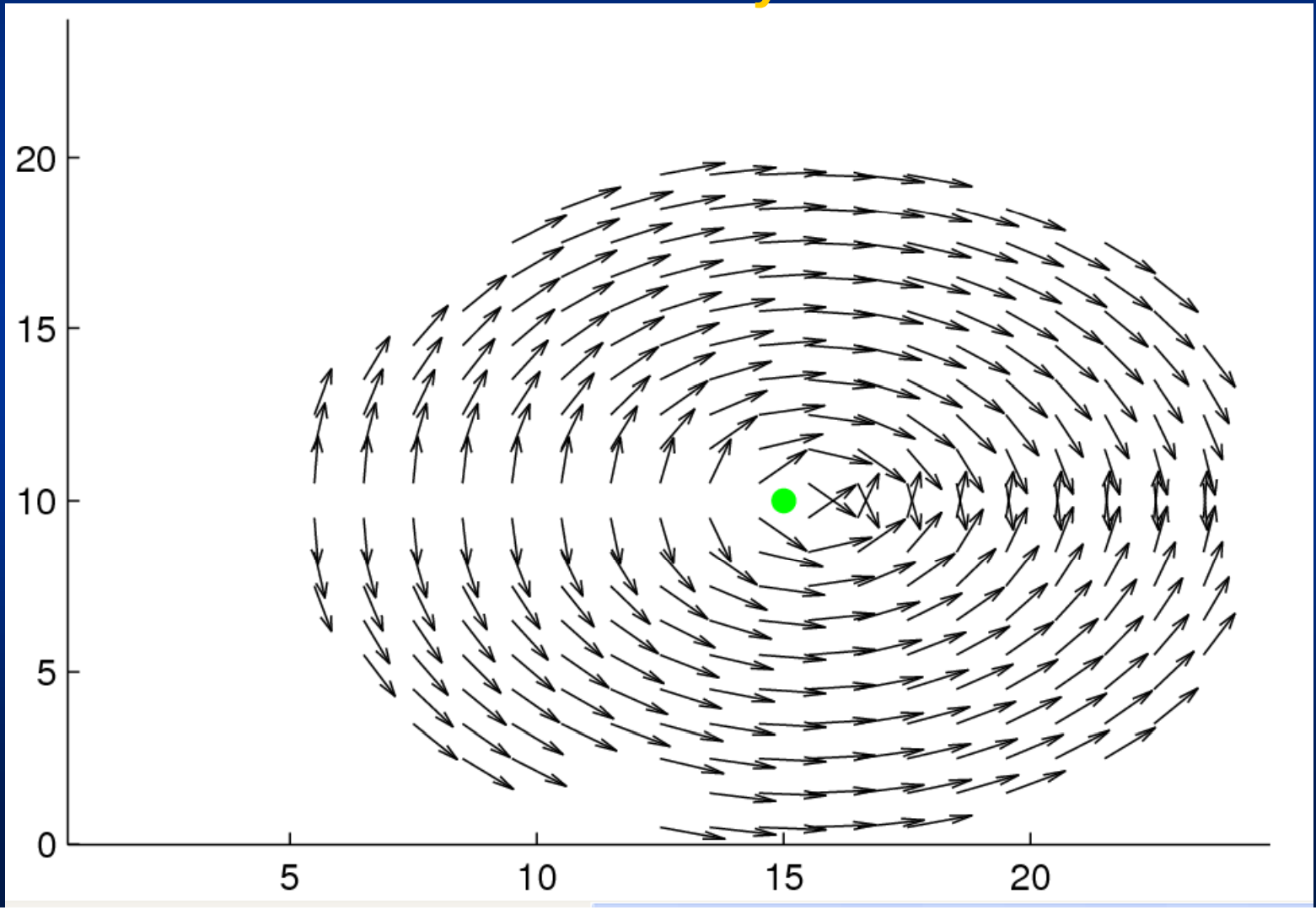
Wind Direction Ambiguity Removal

2. Select nearest neighbor for the other wind directions



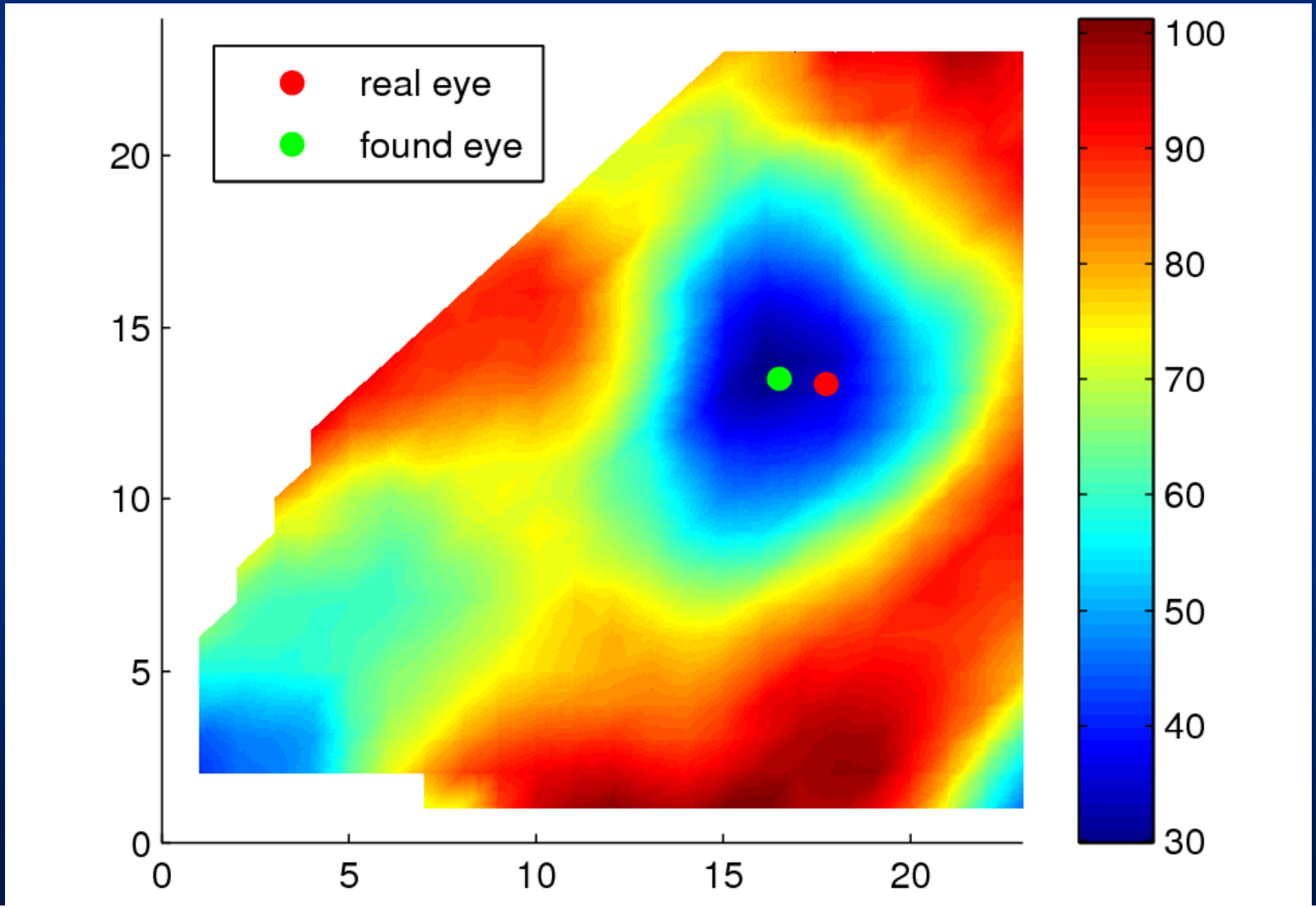
Wind Direction Ambiguity Removal

3. Polar wind directions around hypothetic eye with 180 deg ambiguity
4. Limit radius around the eye



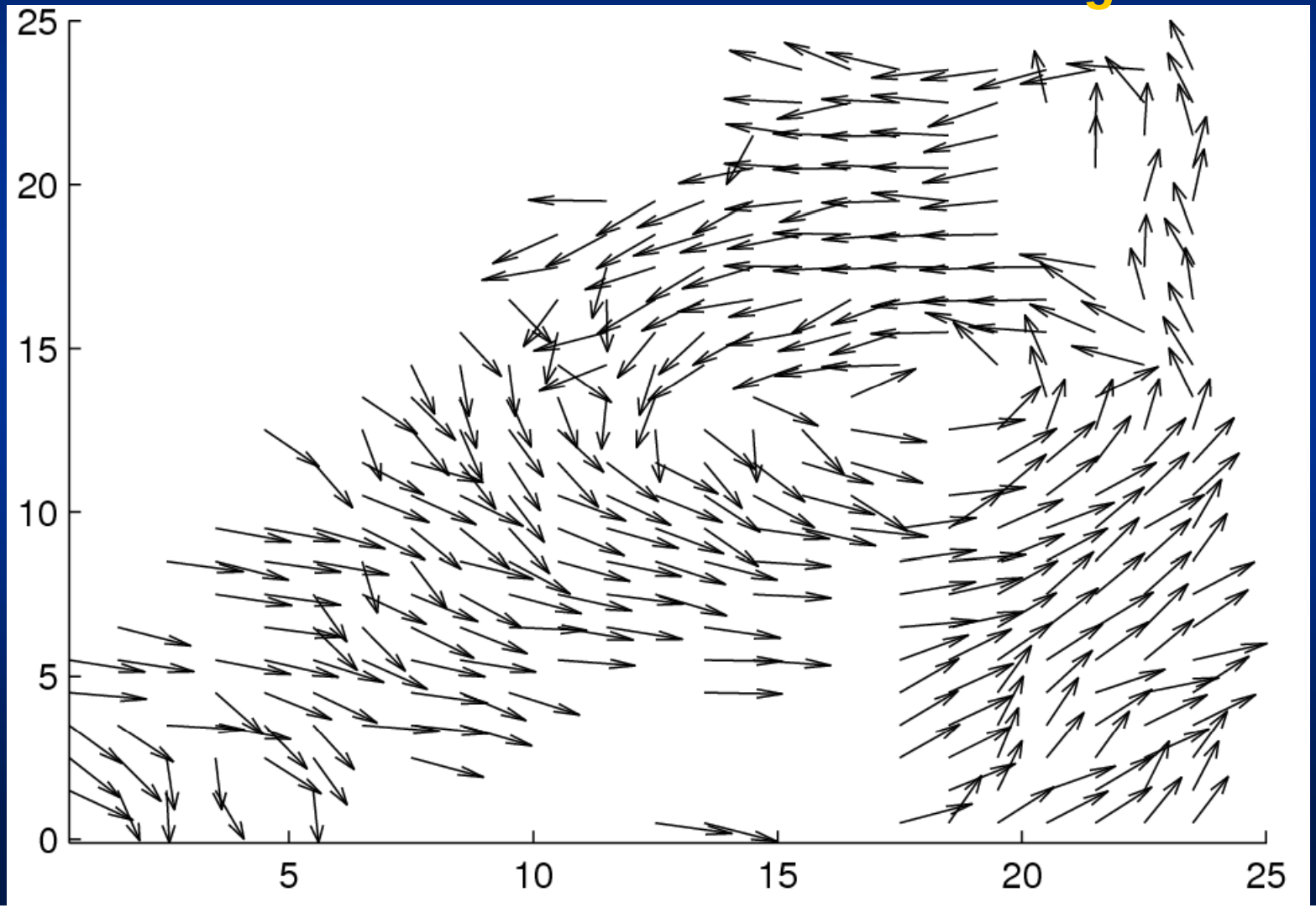
Wind Direction Ambiguity Removal

5. Retrieve 60% quantile of simulated polar wind - 400 m grid wind



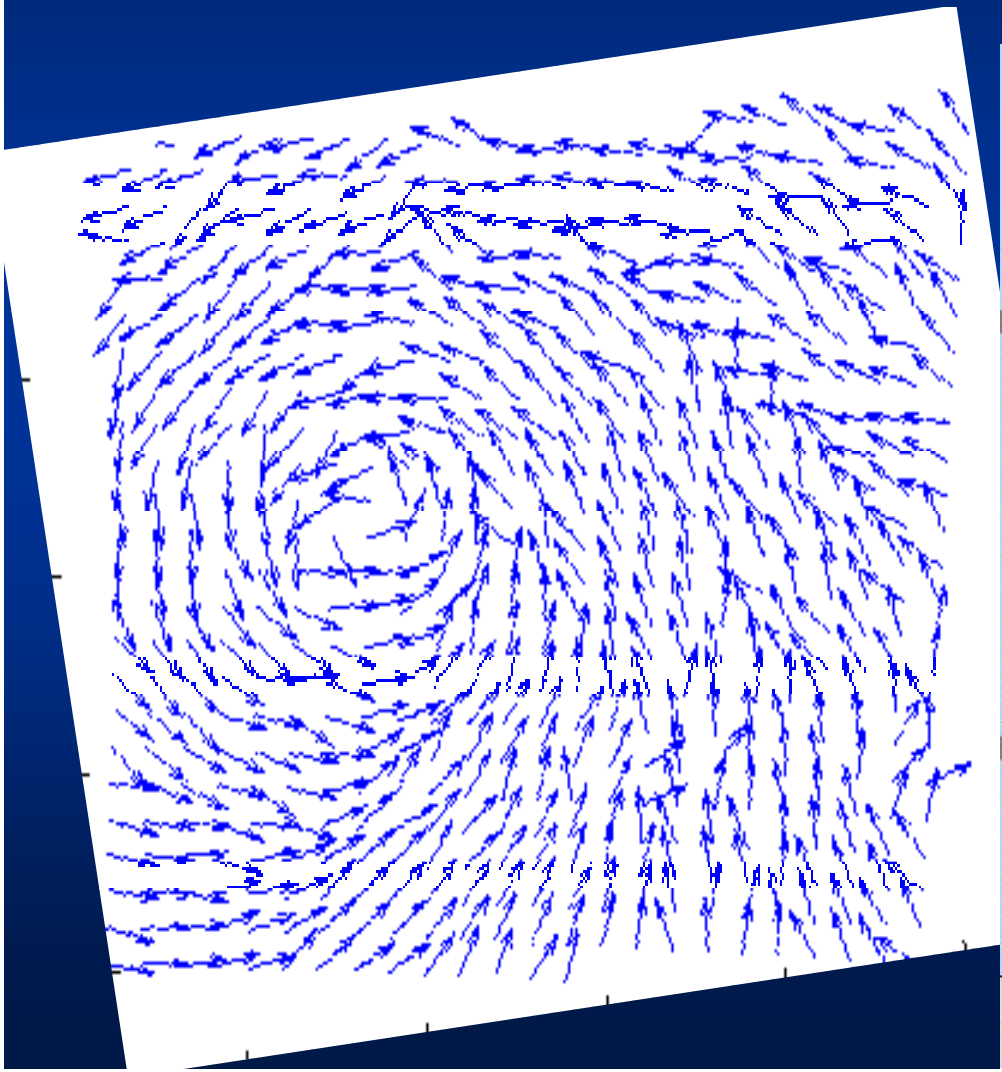
Wind Direction Ambiguity Removal

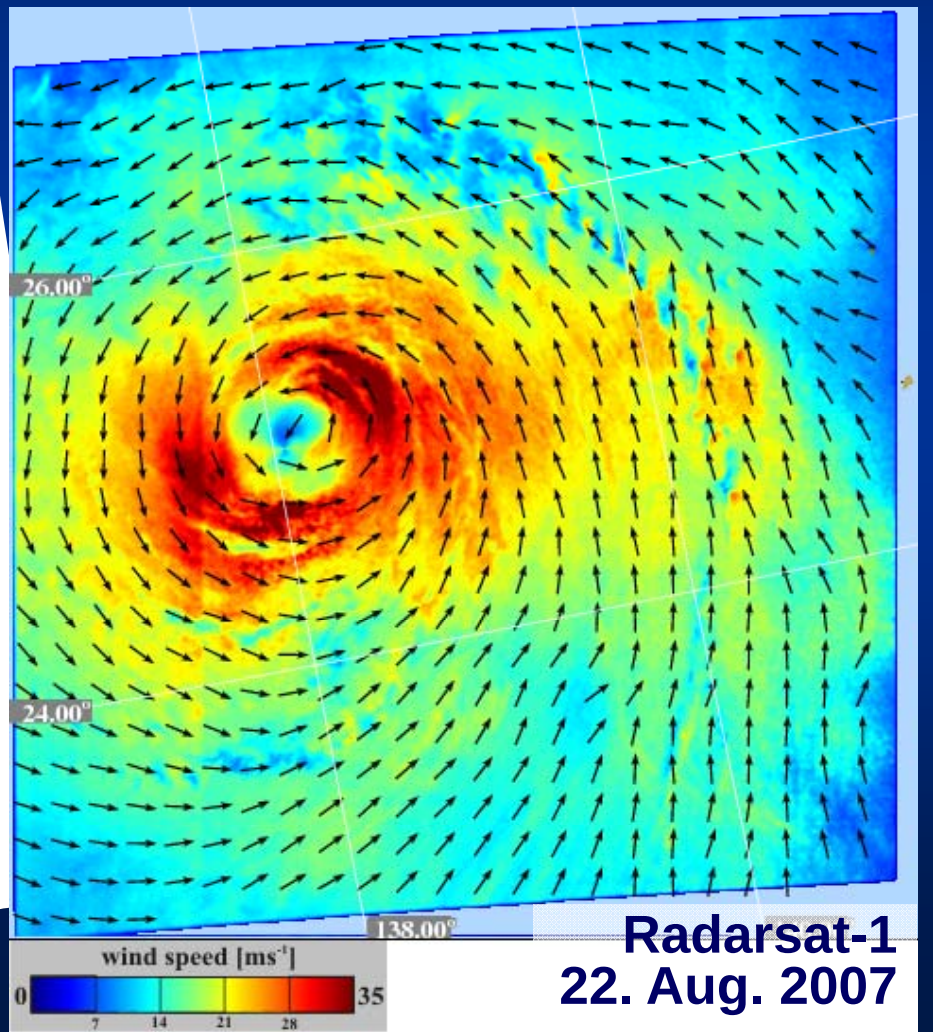
6. Use eye location and polar wind to remove 180 deg ambiguity and wind directions with difference above 60 deg



Wind Direction Ambiguity Removal

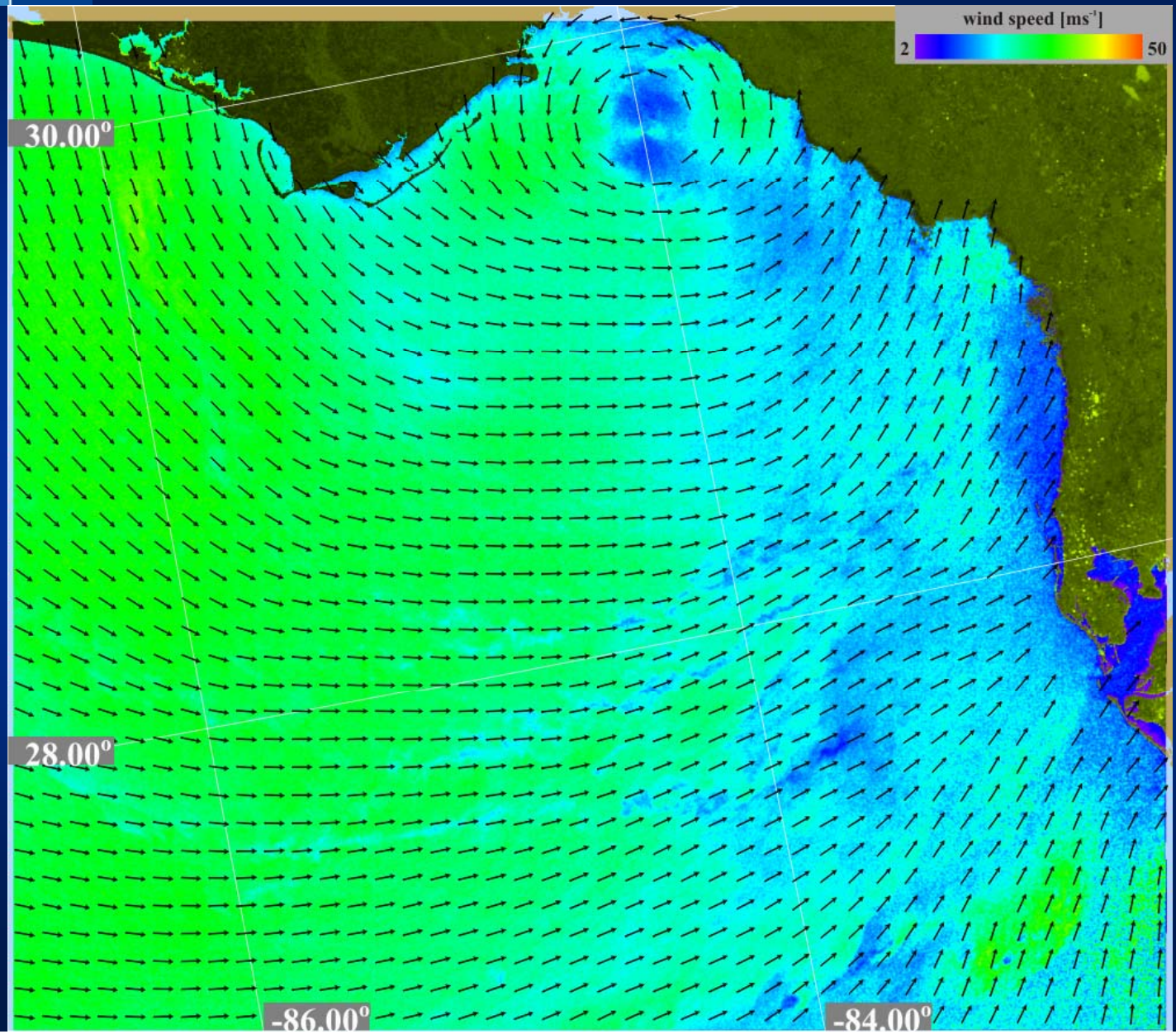
7. Select nearest neighbor of all scales to previously selected wind directions
8. Smooth wind directions





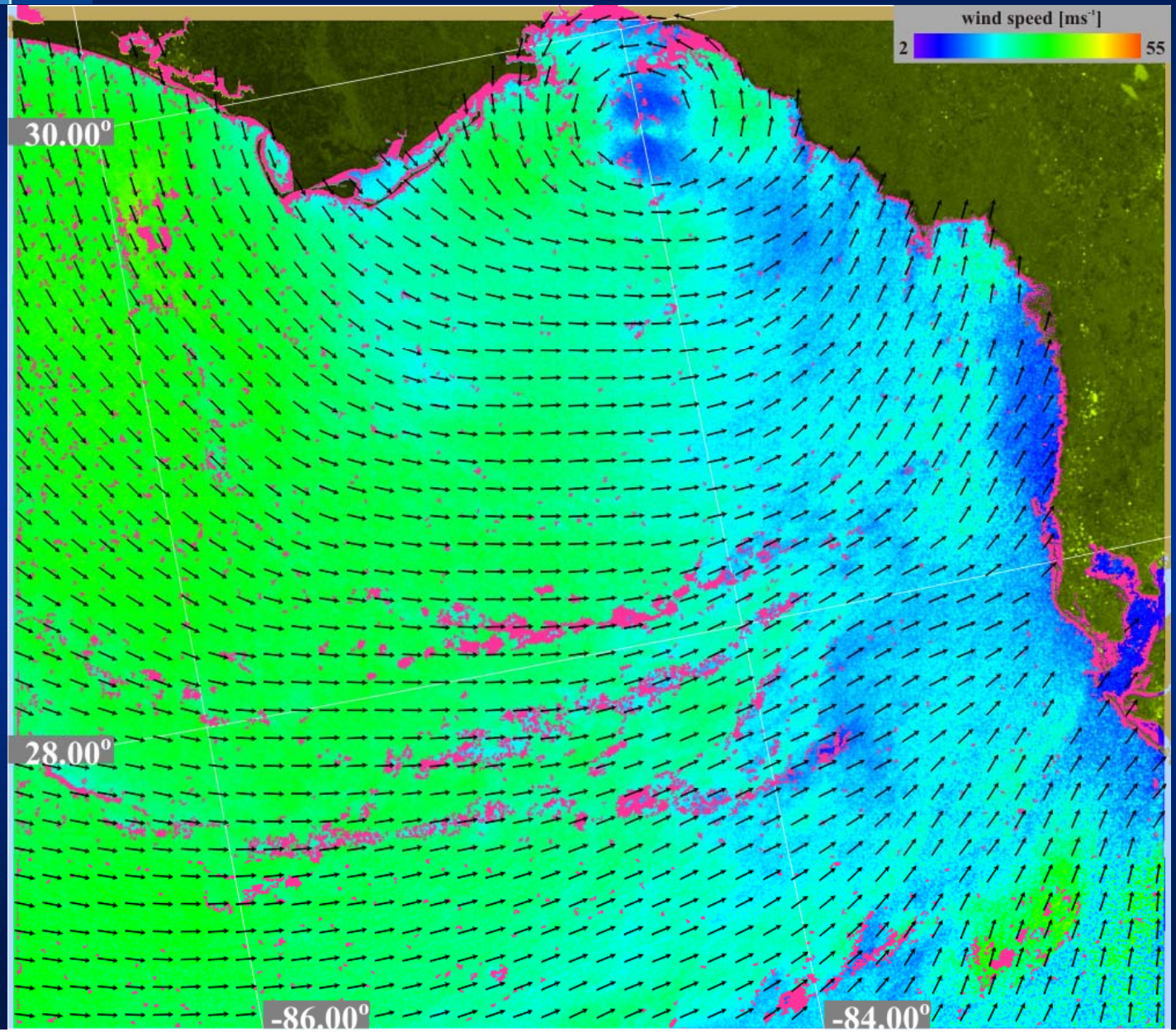
Radarsat-1
22. Aug. 2007

Flagging



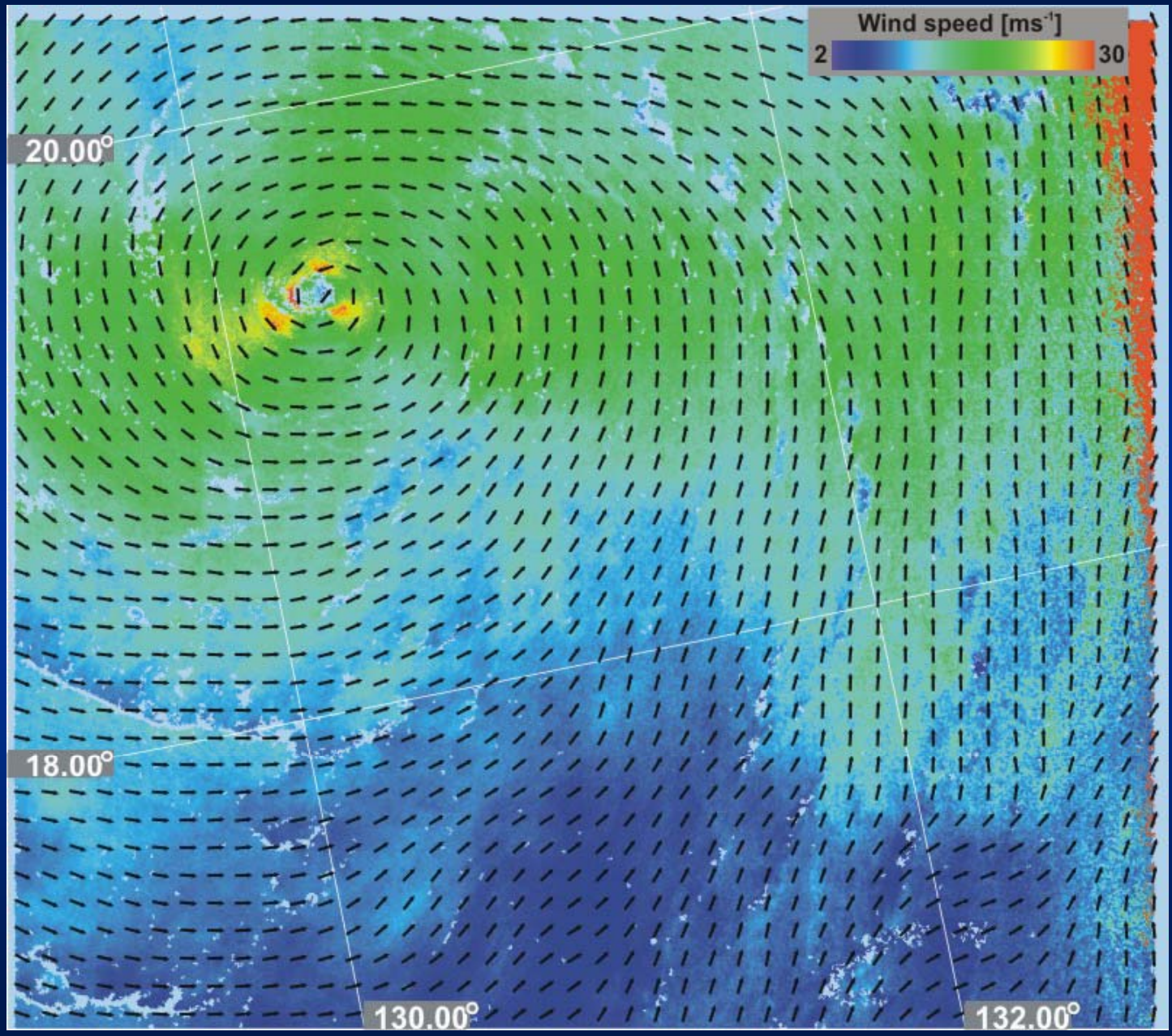
ENVISAT ASAR
6. Sep. 2004

Flagging

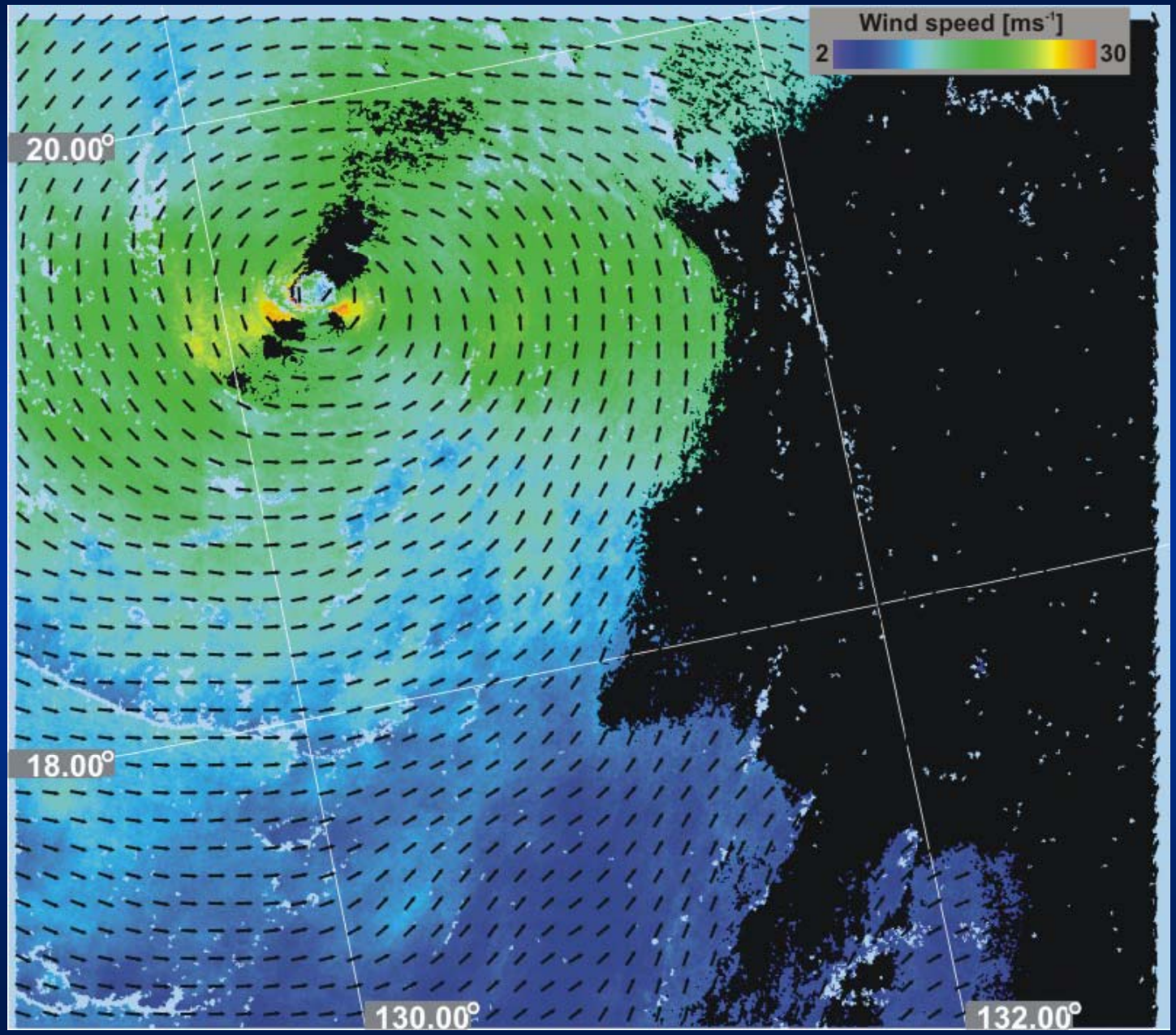


ENVISAT ASAR
6. Sep. 2004

Estimation of uncertainties



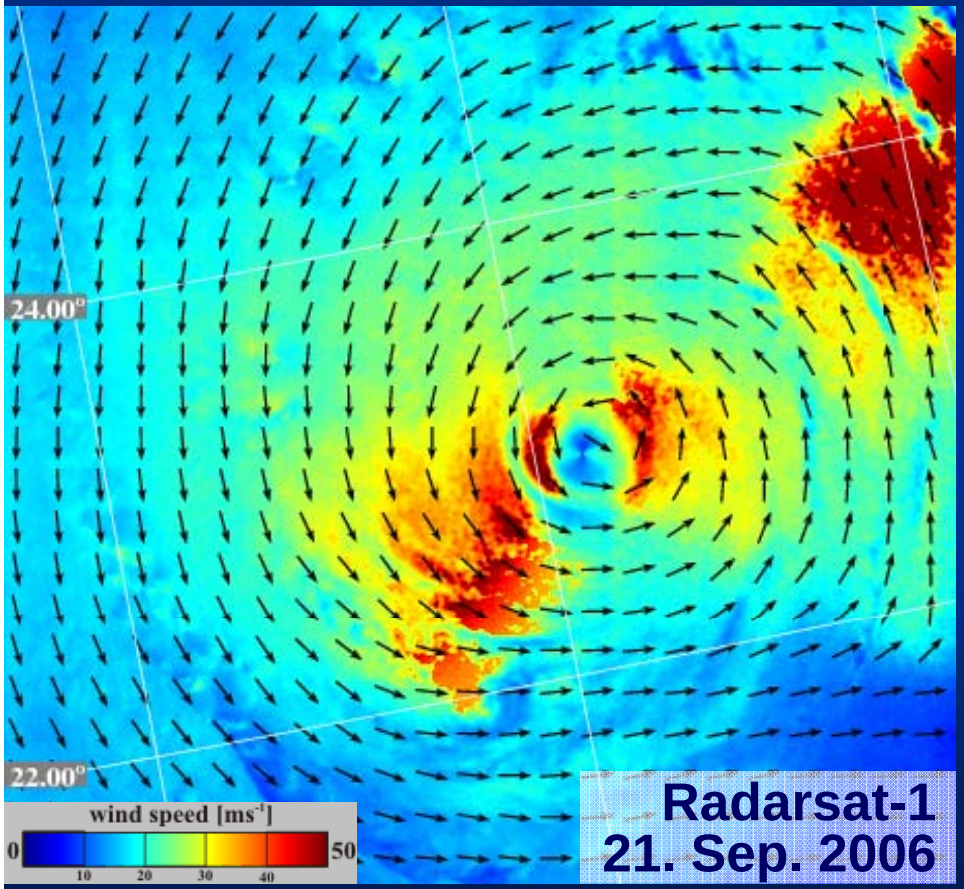
Estimation of uncertainties



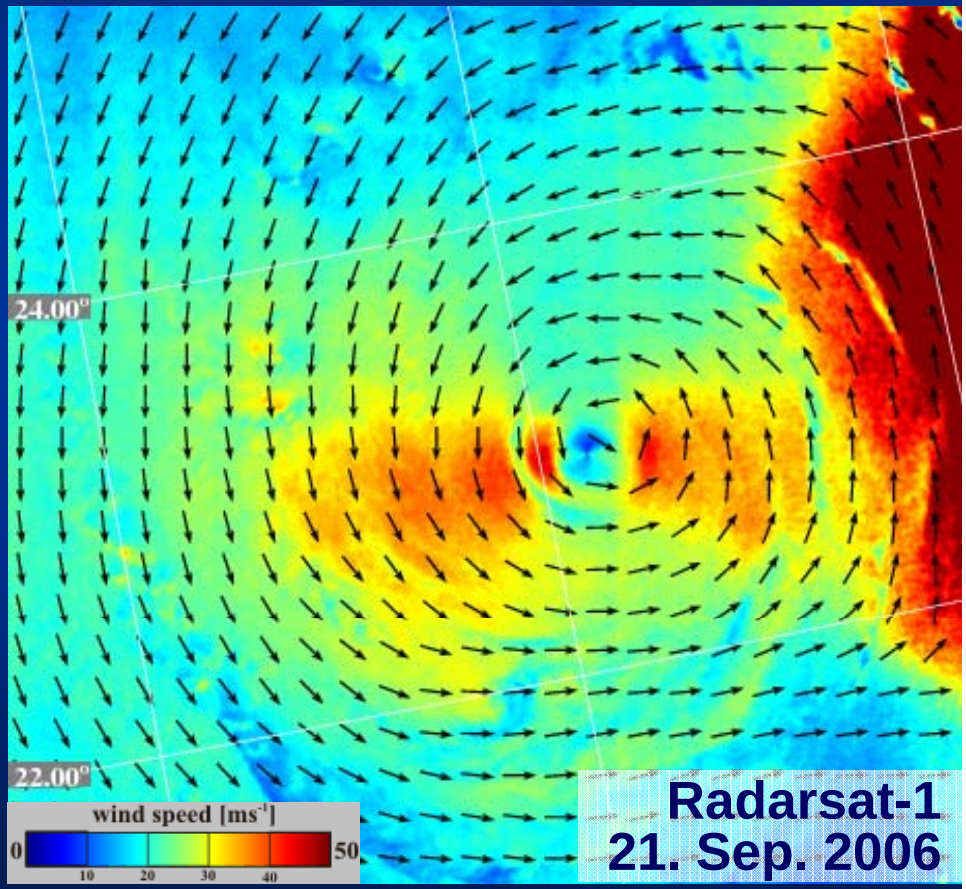
uncertainty of NRCS (0.5 dB) > 2 m/s or 20%

Different C-band GMF

CMOD5
(empirical + polarization ratio)



CWaR
(scattering model + fit to data)



Different C-band GMF

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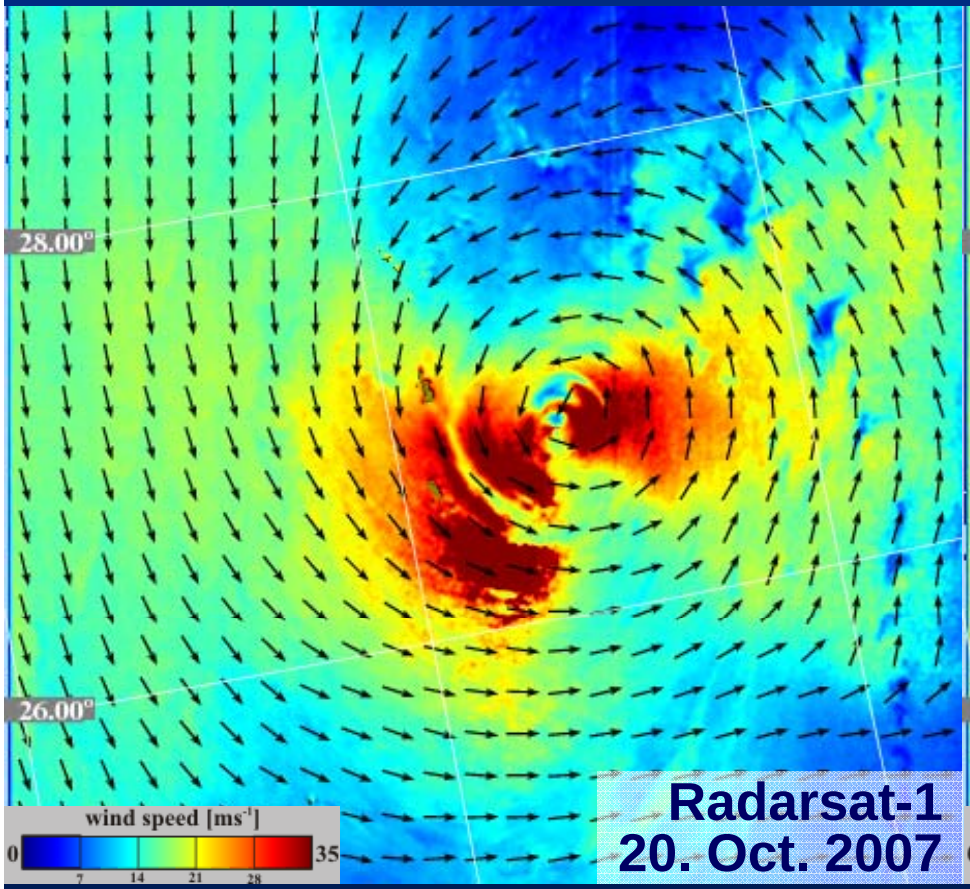

CWaR
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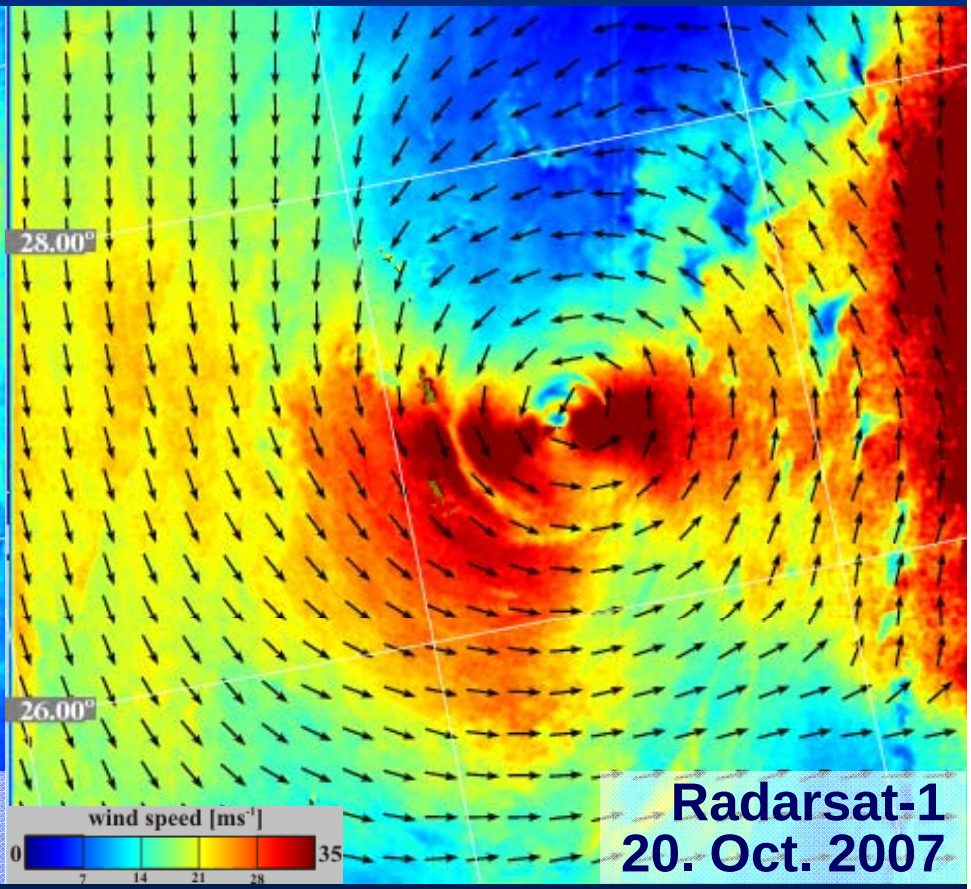
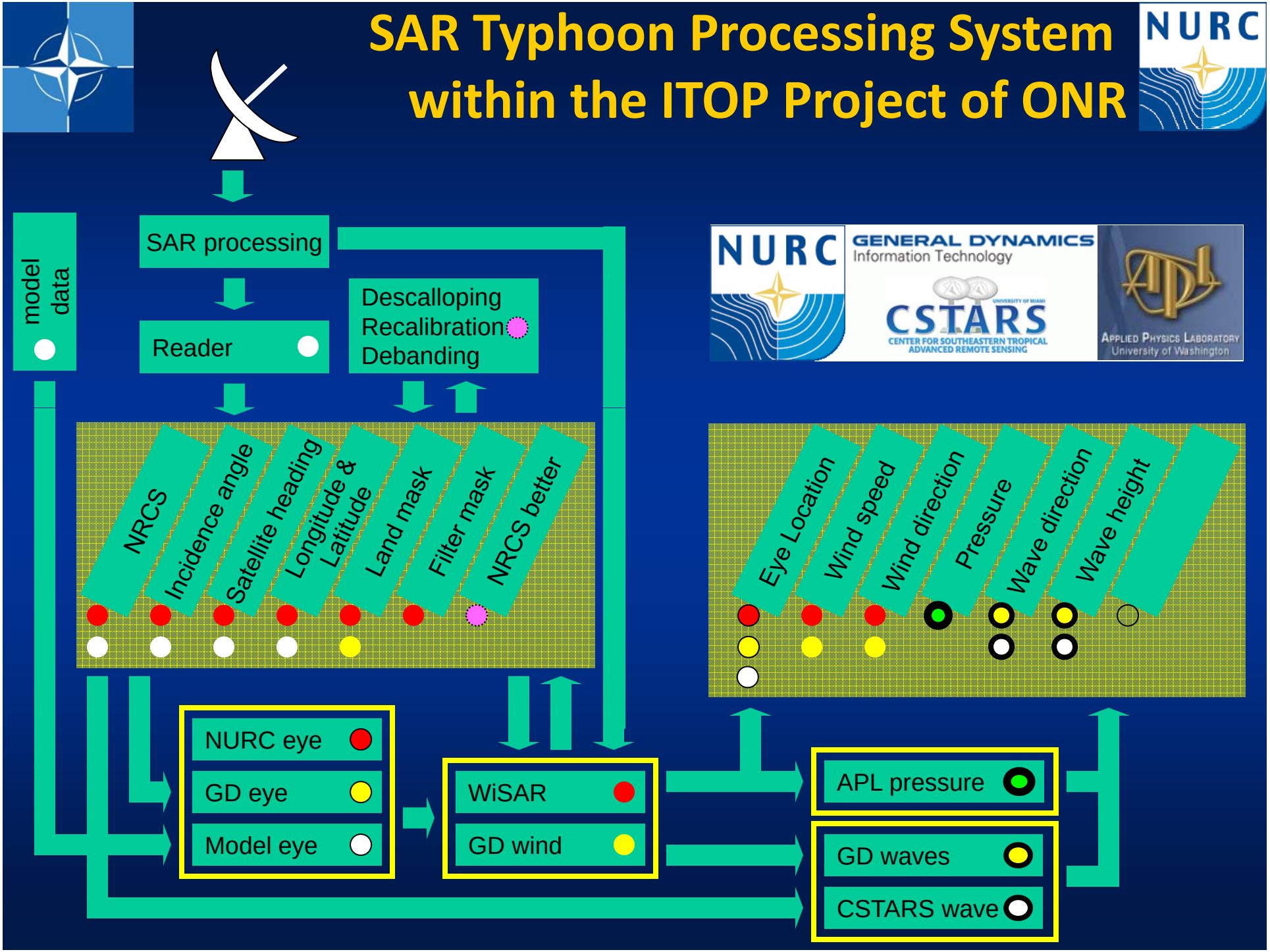
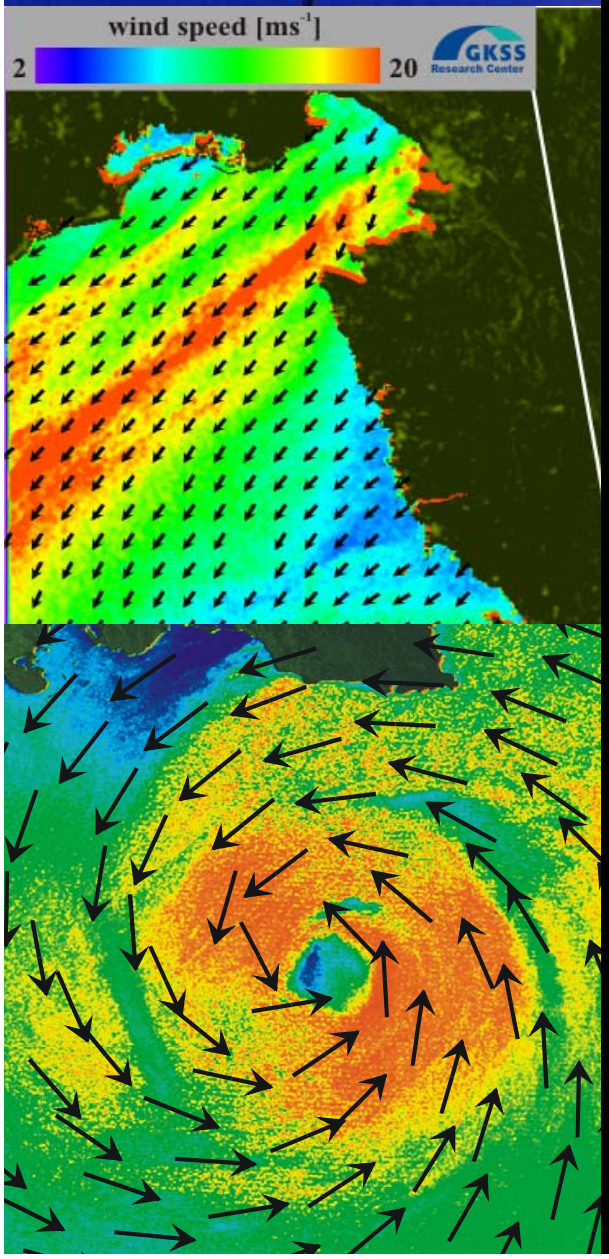


SAR Typhoon Processing System within the ITOP Project of ONR

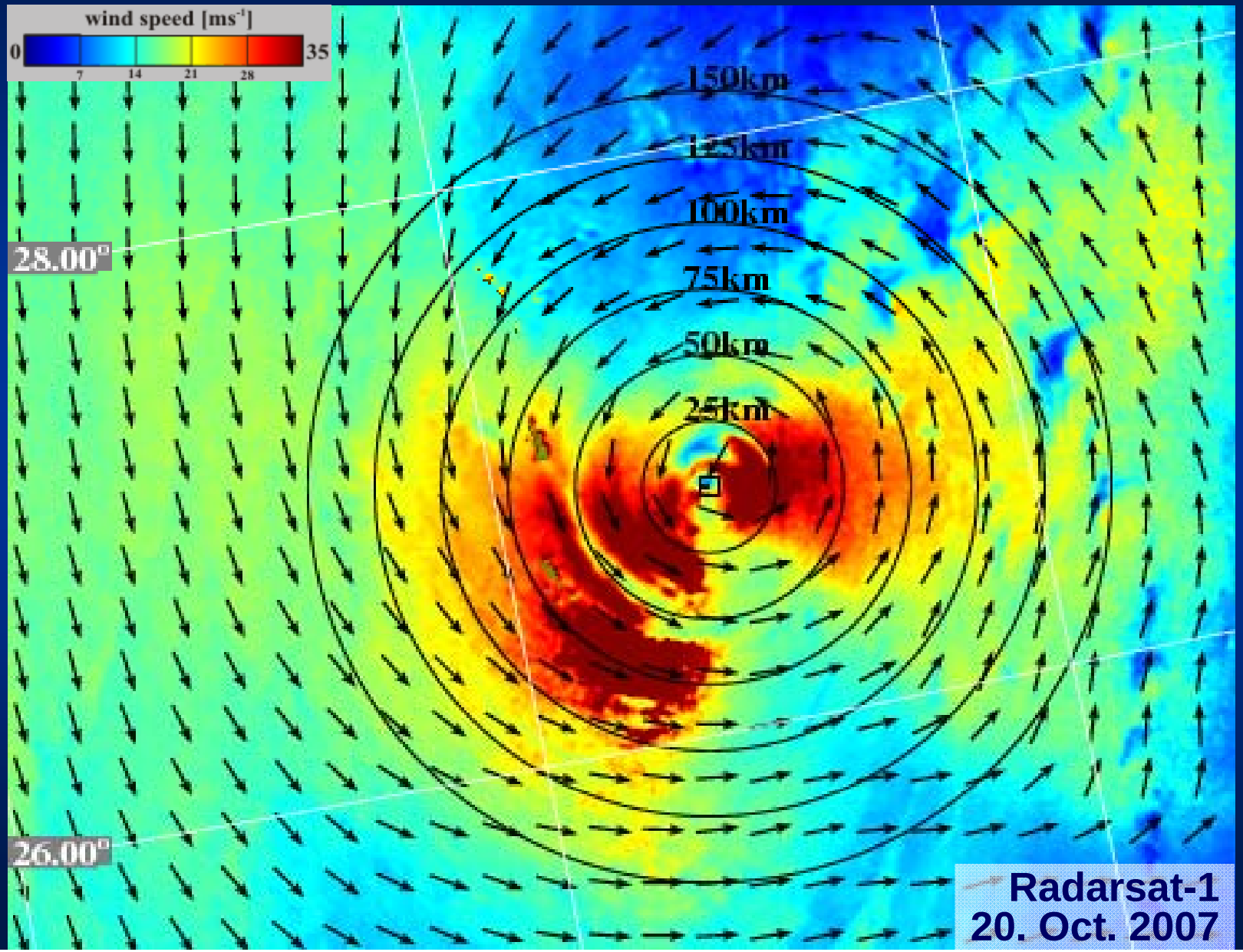


Summary and Outlook

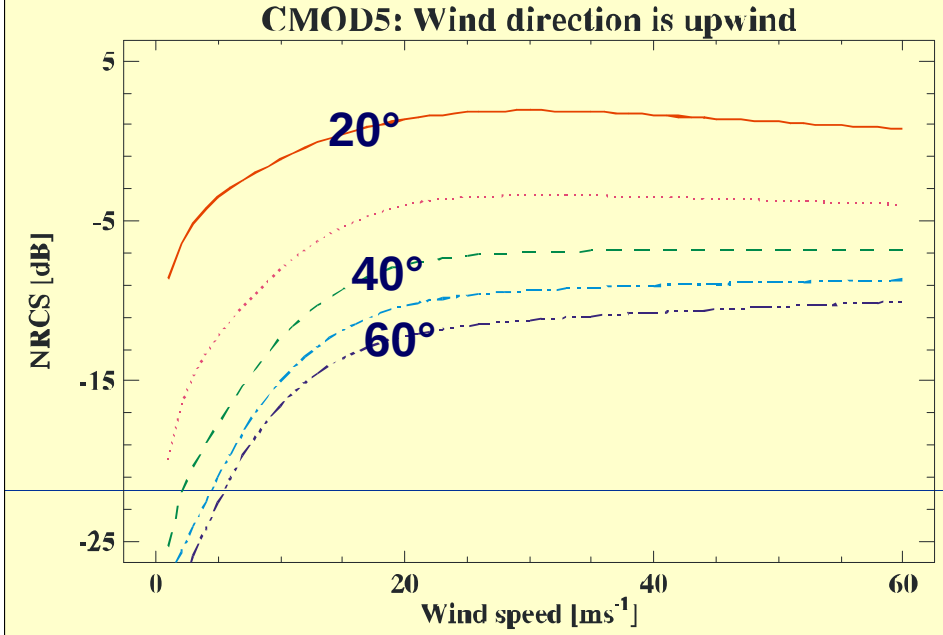


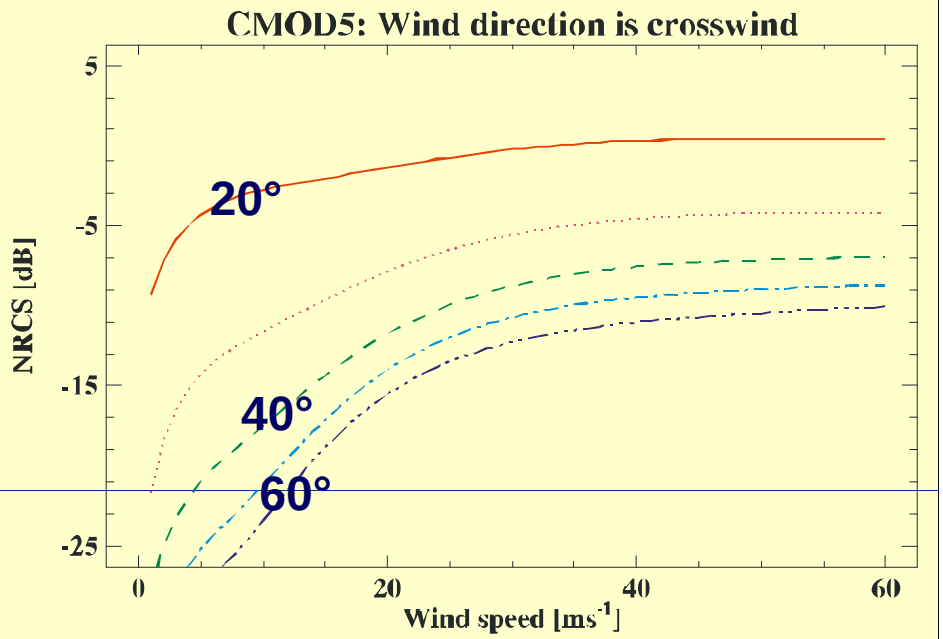
- corrections schemes for:
  - Recalibration
  - banding
  - scalloping
- Typhoon eye detection via
  - wind directions
  - wind speeds
  - correlation
  - wind direction
- choice of Polratio is still an open question
- Correction of areas with NRCS beyond definition of Cmod5
- Removal of wind speed ambiguities (Cmod5)
- Uncertainty estimates with respect to NRCS

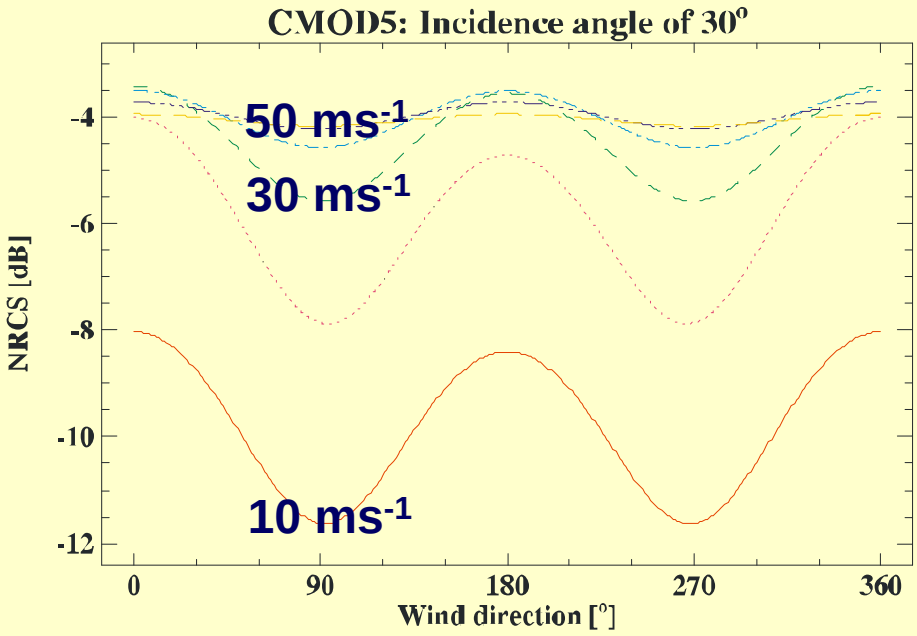
Wind Speed Ambiguities in CMOD5

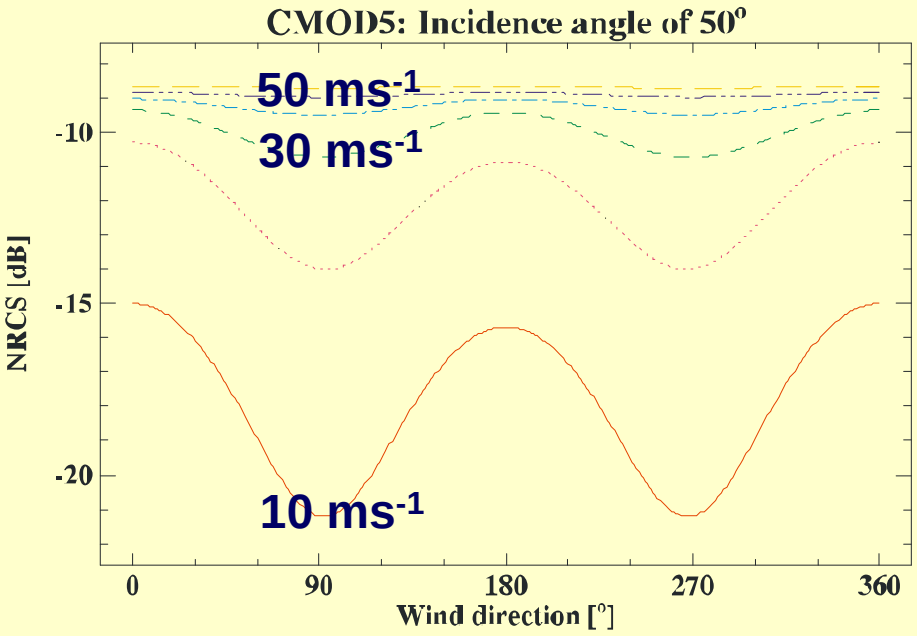


Wind Speed Ambiguities in CMOD5



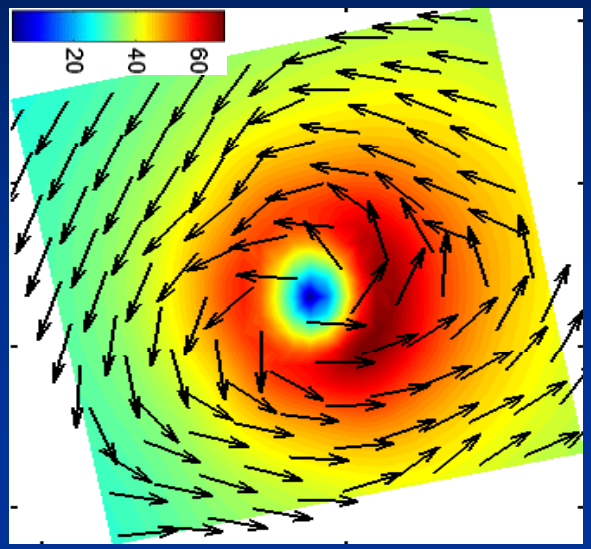




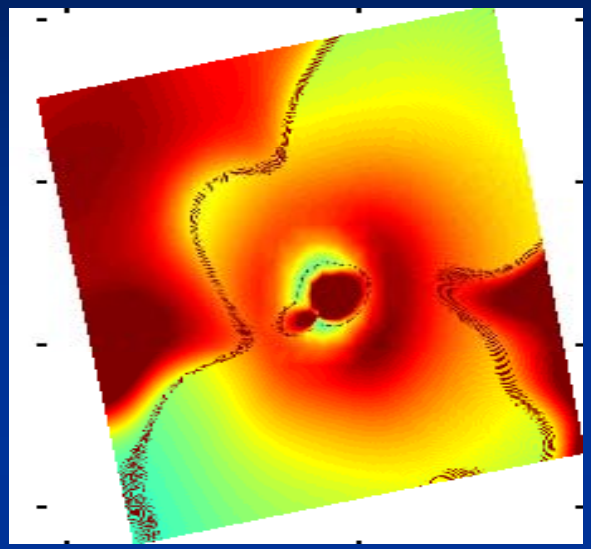


Simulated Effect of Wind Speed Ambiguities

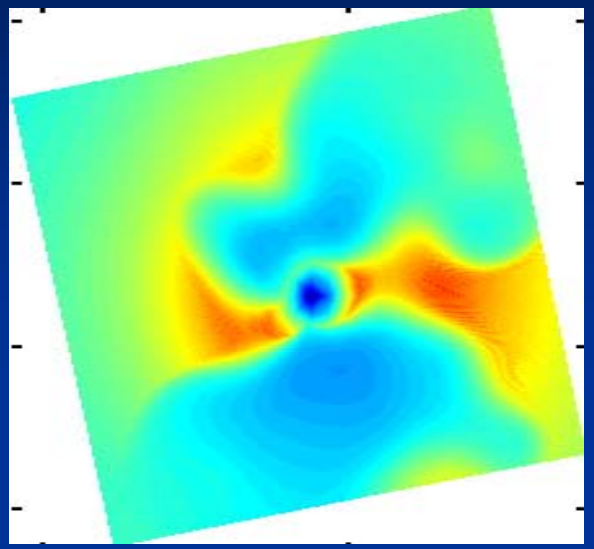
Hwind + SAR



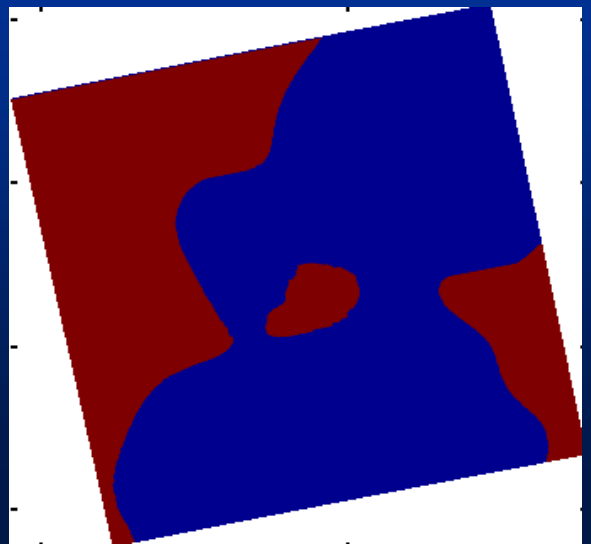
Upper solution



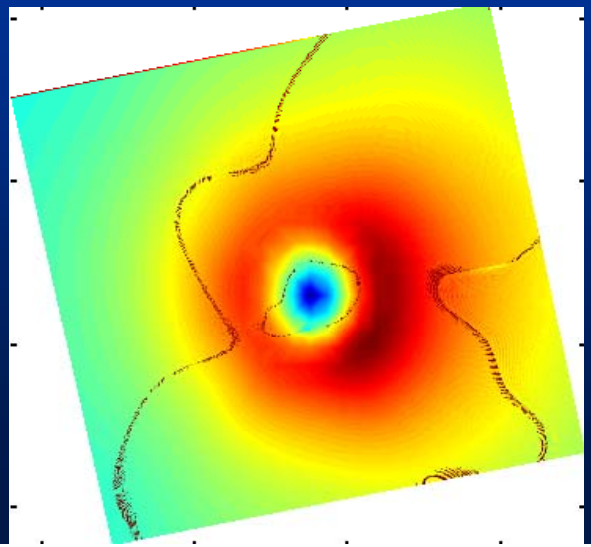
Lower solution



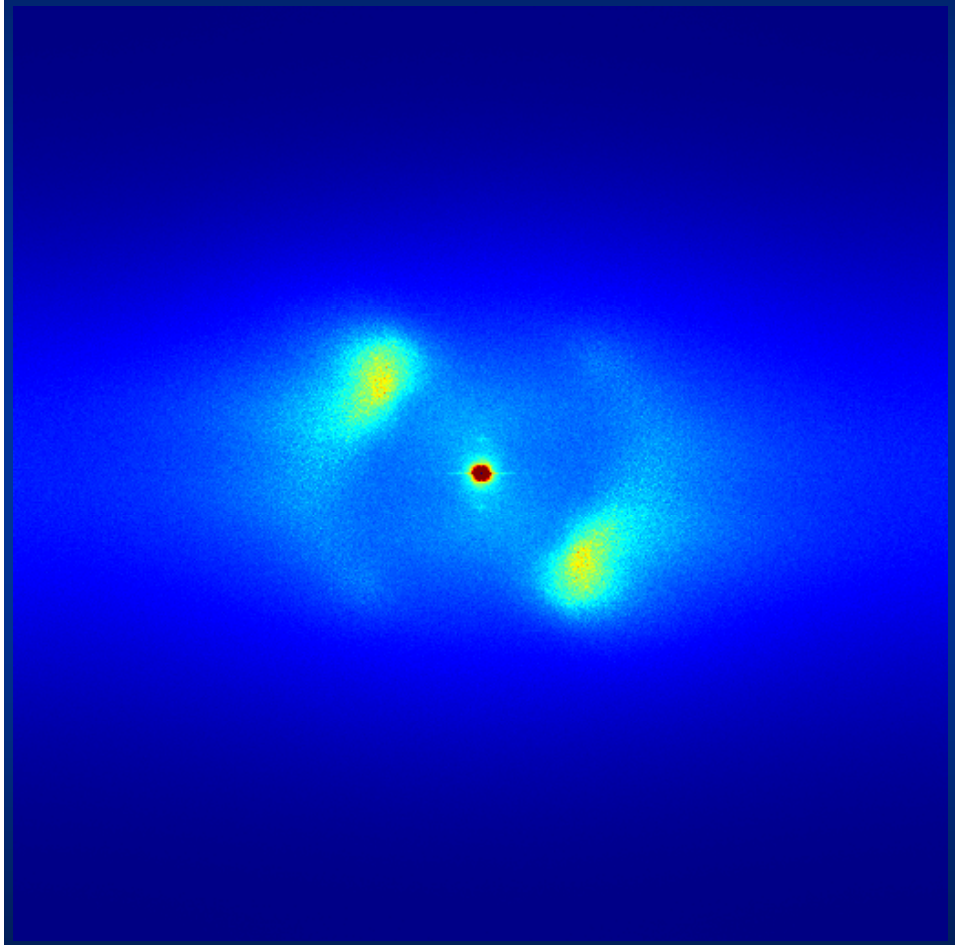
Cluster-Mask

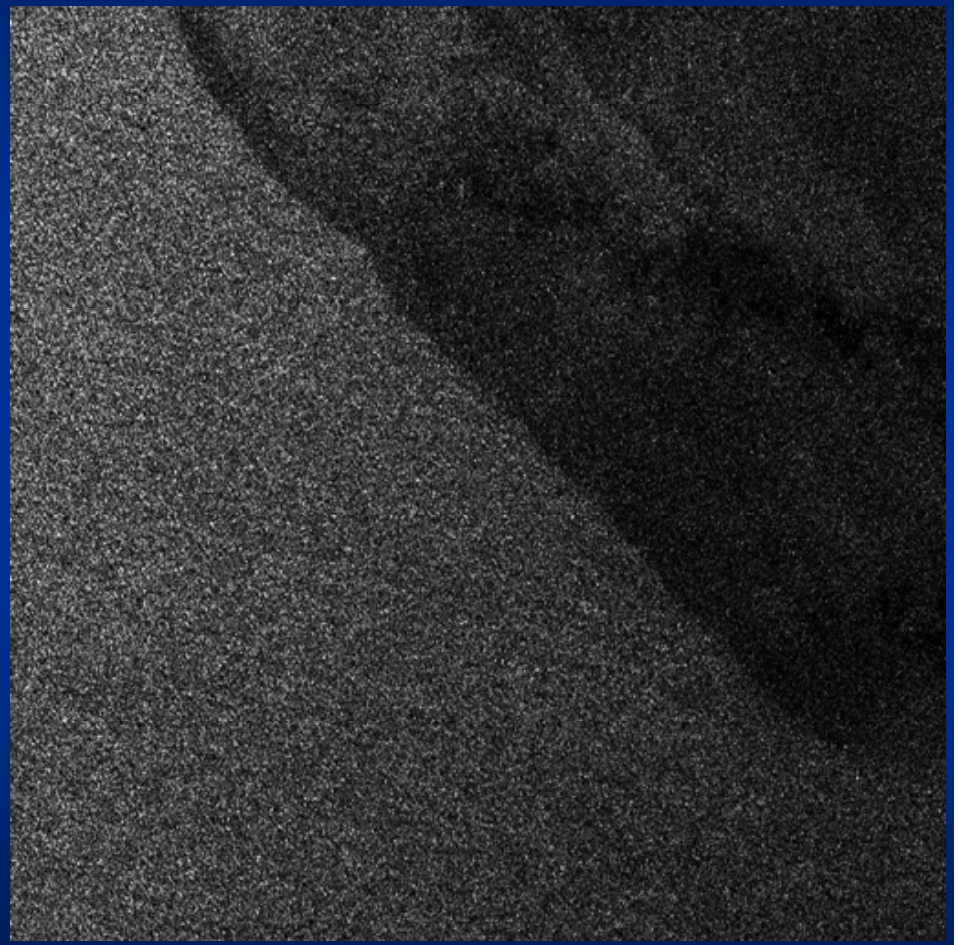


Rebuilt Wind



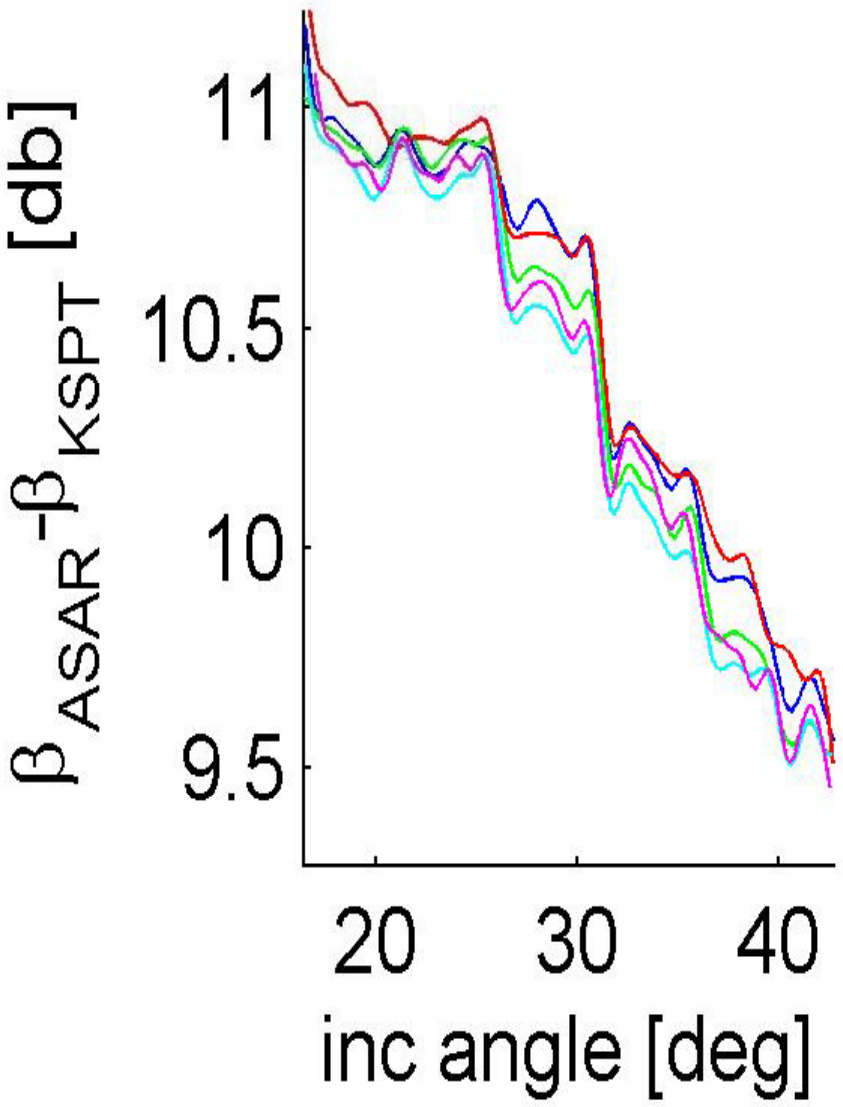
Scalloping Removal in the Spectral Domain

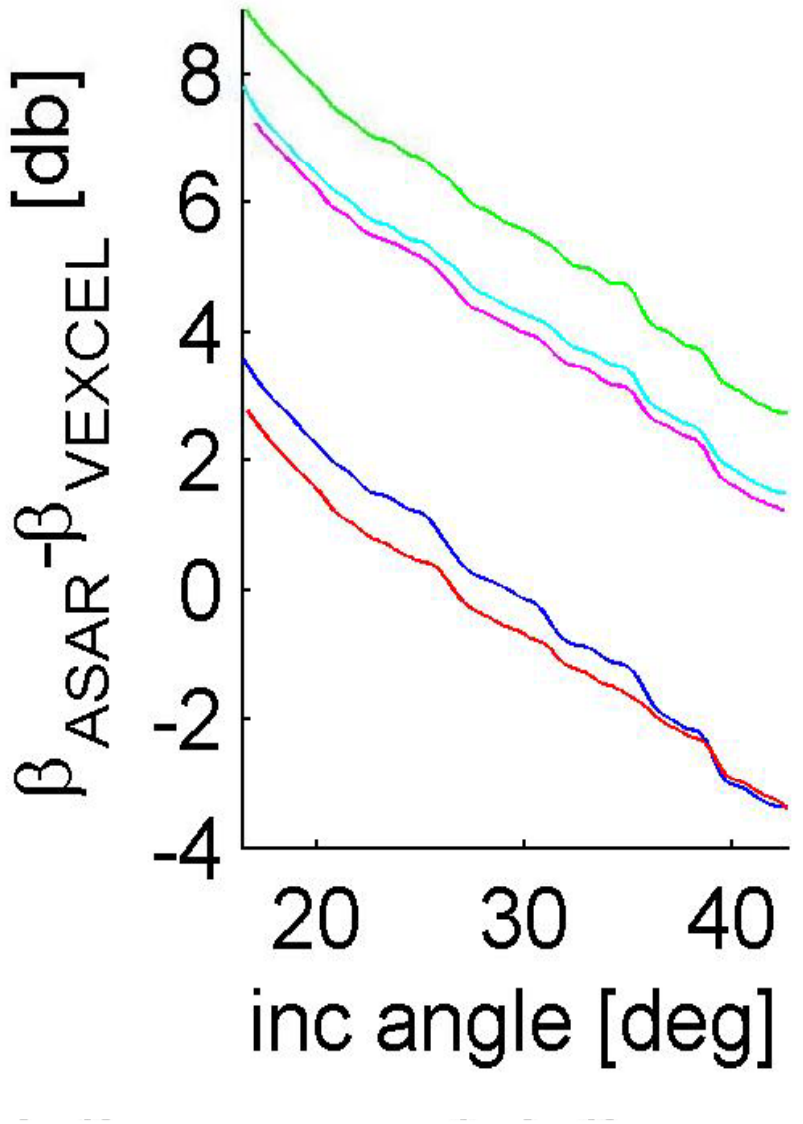




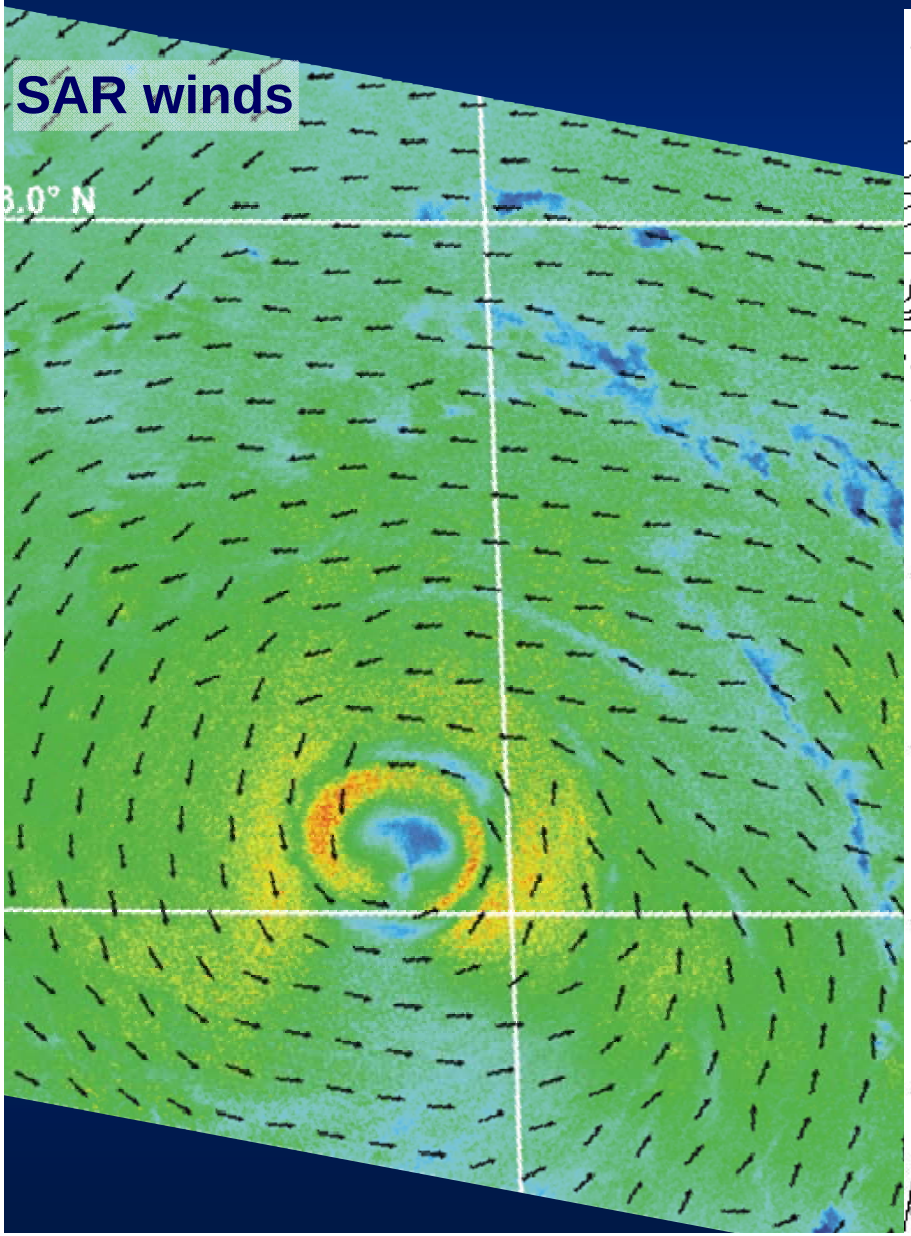
Romeiser et al., 2010

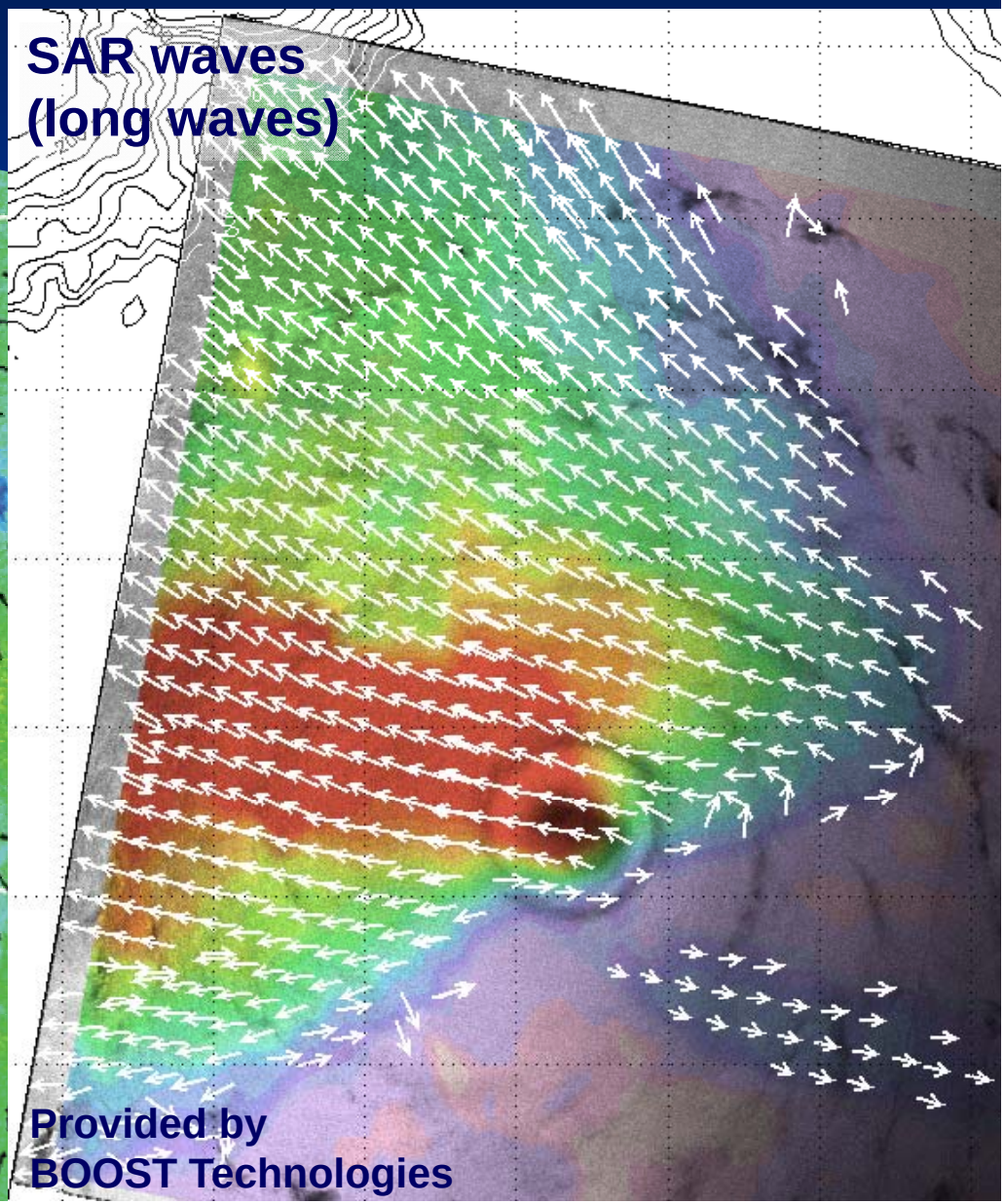
NRCS Recalibration of Different SAR Processors (e.g. Envisat ASAR)



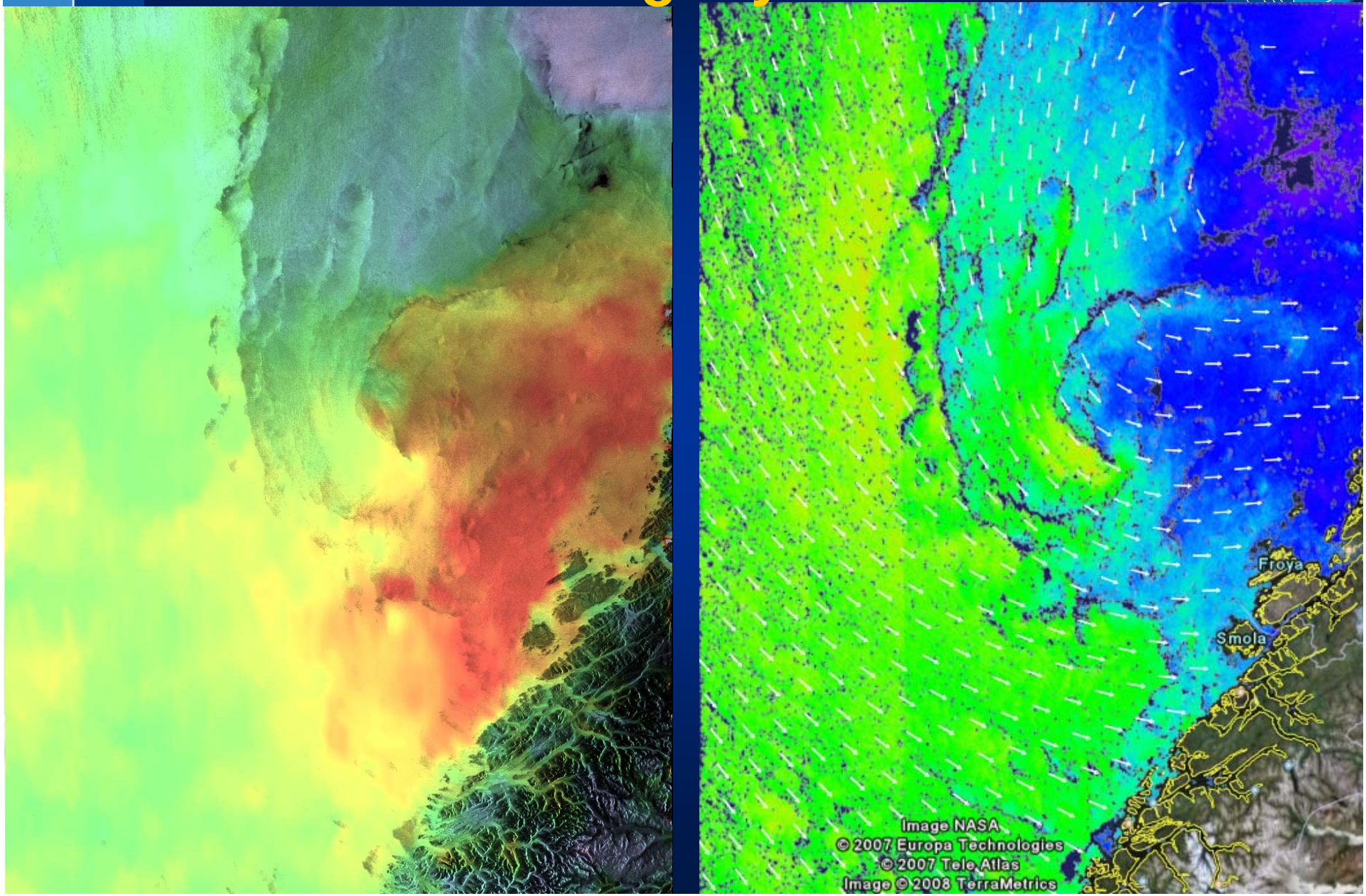


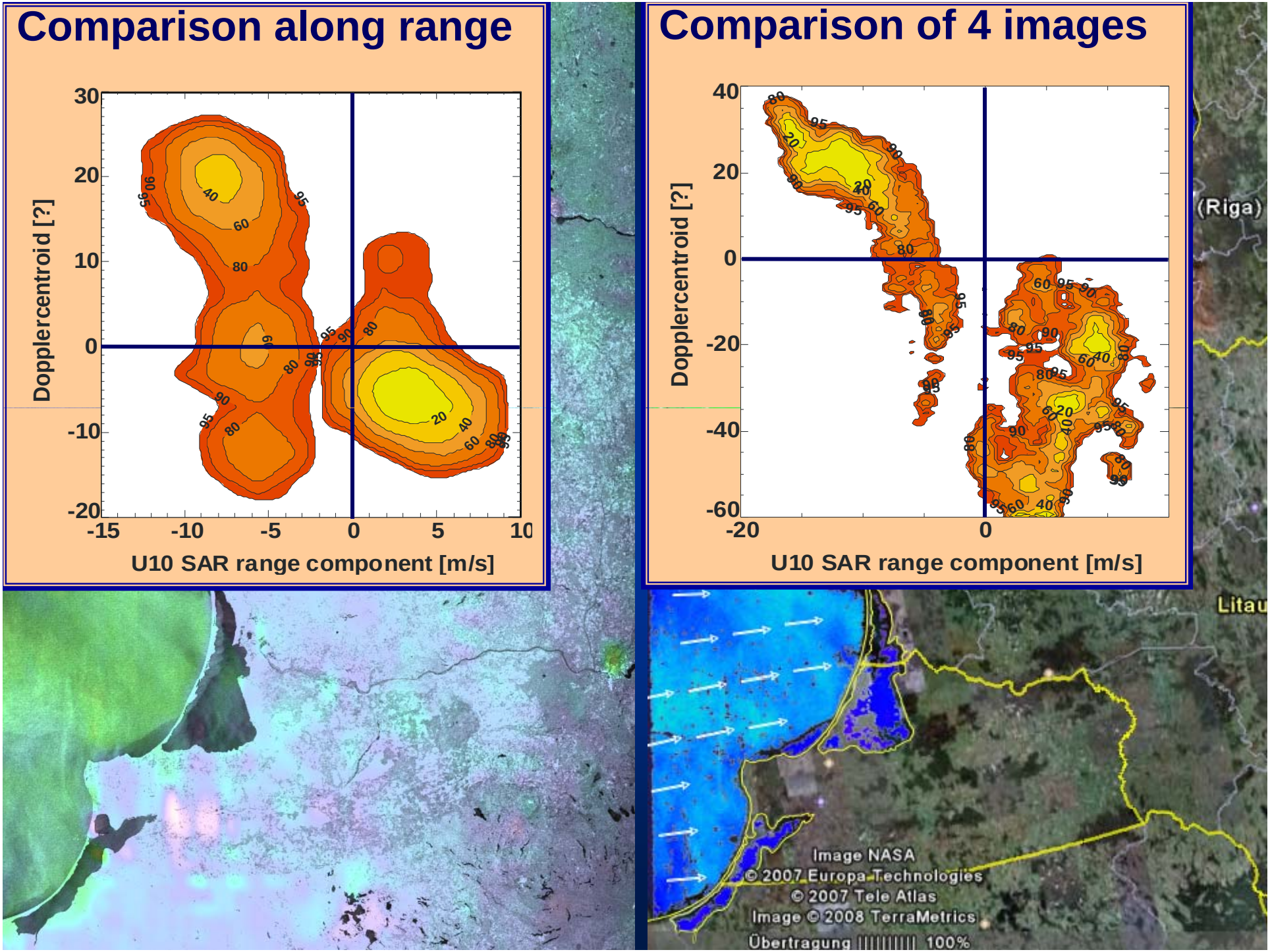
Possible wave effects on SAR wind retrieval





Doppler Centroid Estimates for Directional Ambiguity Removal



Comparison along range

Comparison of 4 images