

Characteristics of high resolution winds from SAR

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Overview

- **Synthetic Aperture Radar**
 - Winds from Synthetic Aperture Radar
 - Strengths and weaknesses
 - Coastal winds
- **Hurricane watch program**
- **Hurricane analysis**
 - Katrina comparison with QS winds
 - Eye wall gallery
- **Future SAR**
- **Summary**

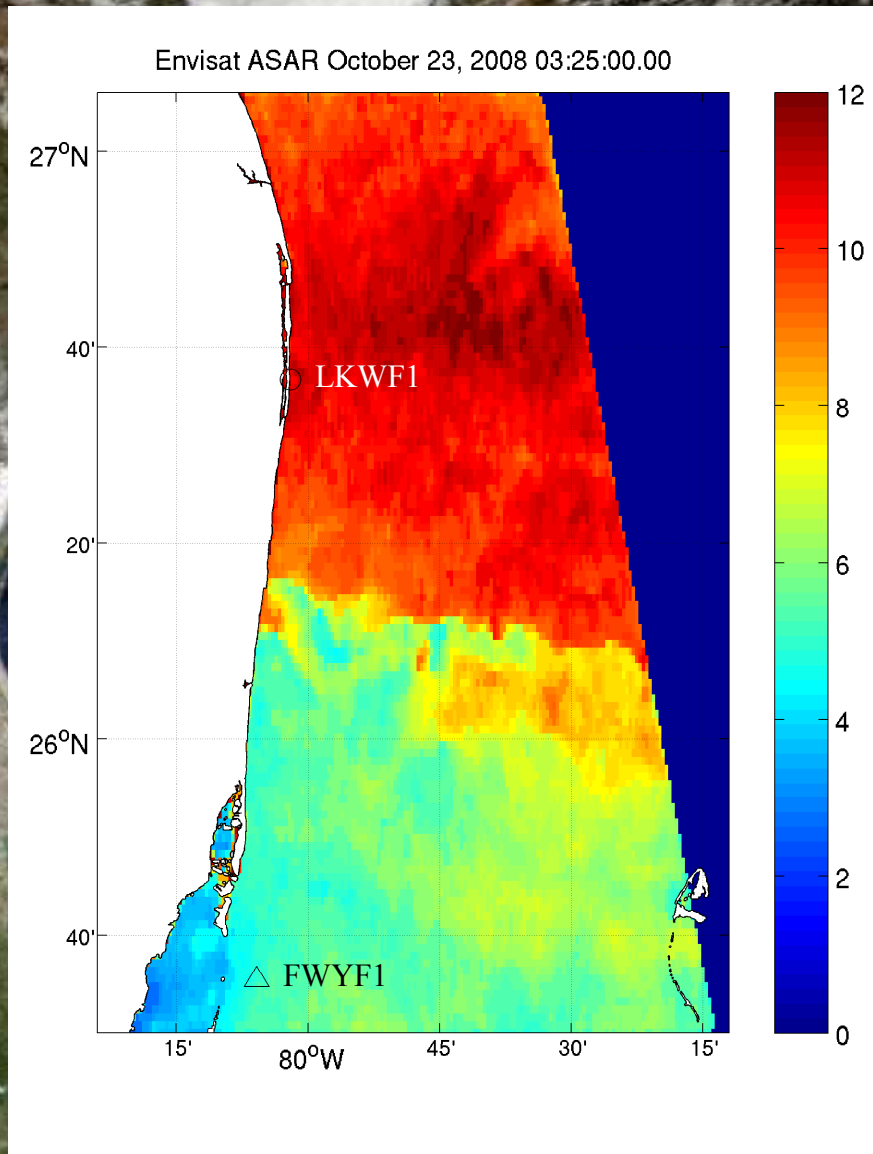
Winds from SAR

- High (300 – 500 m) Resolution Scatterometer
- CMOD 4/5
- A priori wind directions
- Local wind direction from model or wind streaks using the Local Gradient Method
- RMS 1.76 m/s (buoys), 1.24 m/s (QS), 2.8 m/s (models)

Strengths and weaknesses

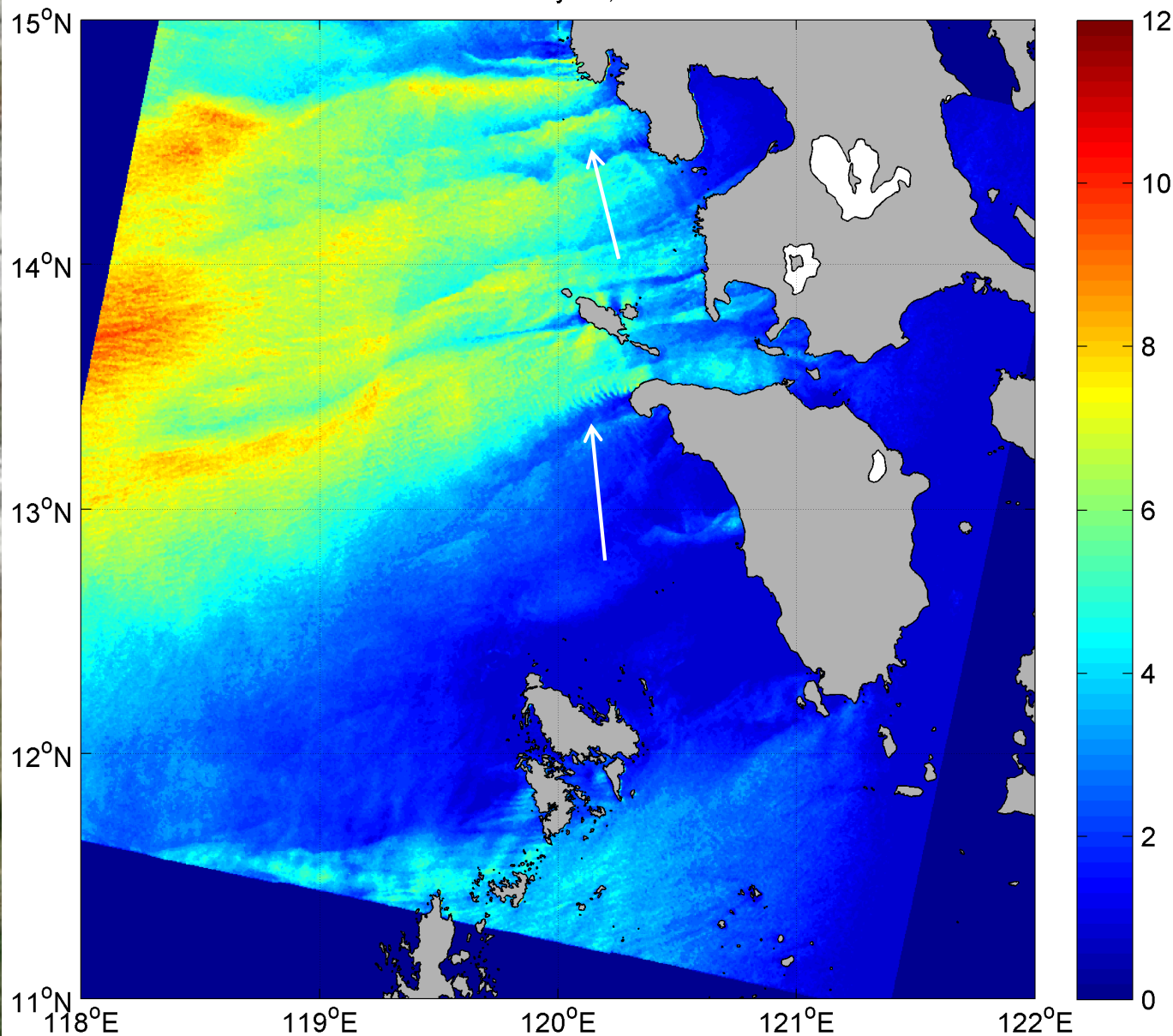
- **Strengths**
 - Accuracy comparable to scatterometry
 - Sub km resolution winds
 - Near shore measurements
- **Weaknesses**
 - Wind speed errors related to wind direction errors
 - Absolute calibration of backscatter, particularly in wide scan mode
 - Limited coverage

Fronts



- **Station LKWF1 –
8.8 m/s, gust 11.8 m/s**
- **Station FWYF1 –
6.7 m/s, gust 7.2 m/s**
- **Winds from ENE**
- **Frontal features from
2 – 7 km**

Envisat ASAR February 22, 2008 01:53:00.00



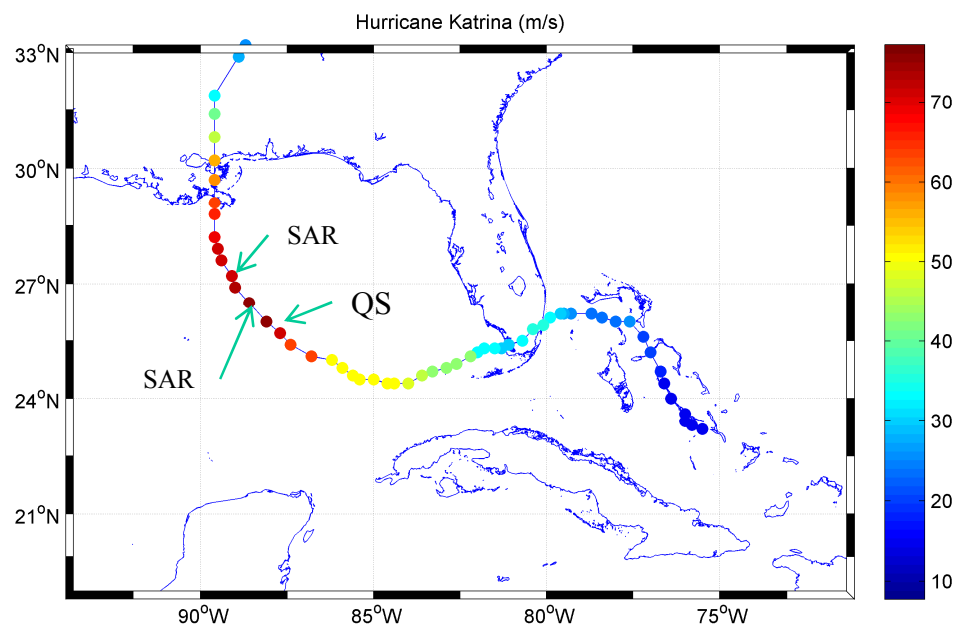
Features of SAR winds

- Mountain wakes
- Gap flows
- Lee waves
- Point wakes
- Synoptic fronts and lows

Hurricane Watch

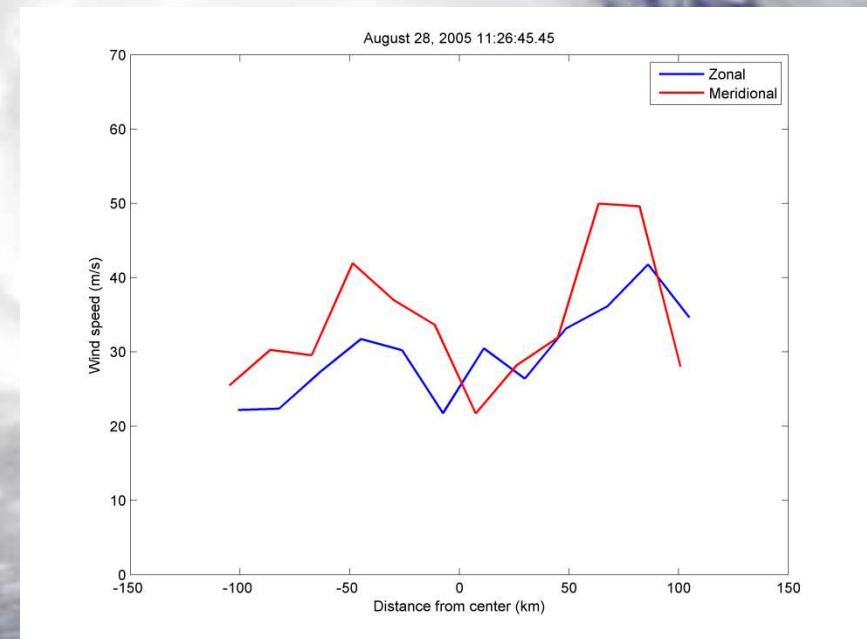
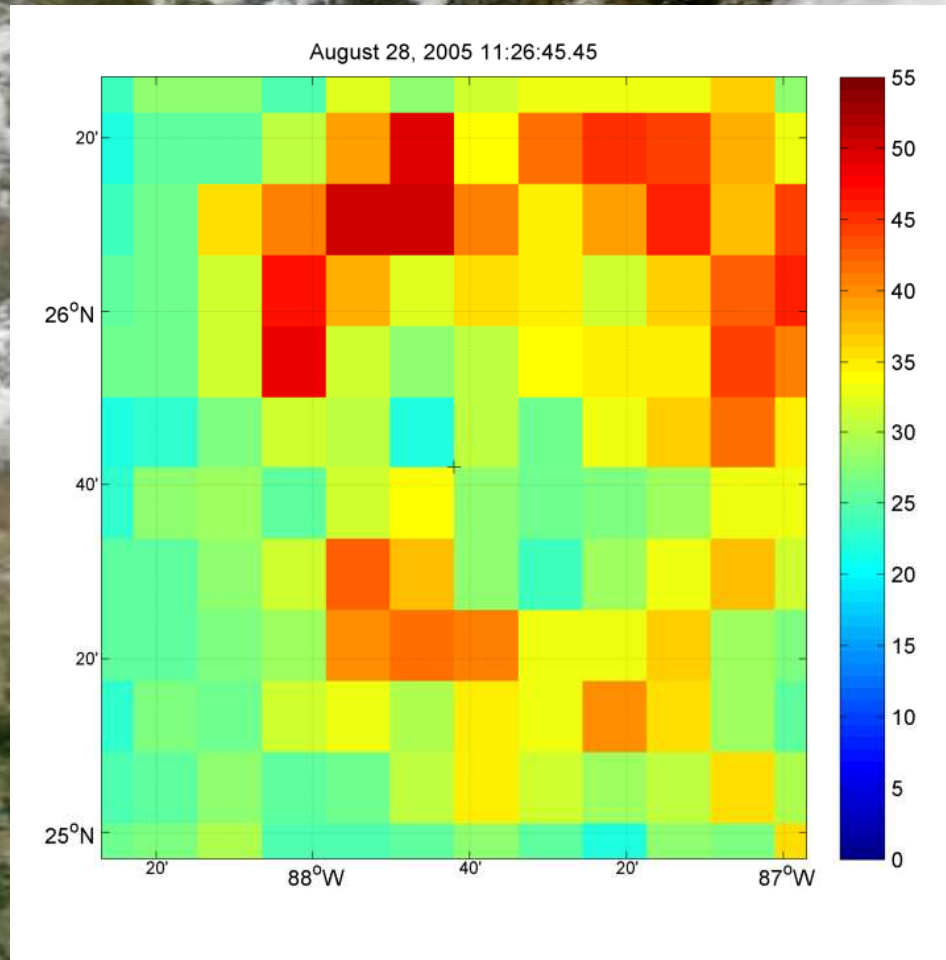
- The Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) with the Canadian Space Agency (CSA) and the U.S. National Oceanic and Atmospheric Administration / Atlantic Oceanographic and Meteorological Laboratory (NOAA/AOML)
- Analysis of C-band Synthetic Aperture Radar (SAR) data acquired over hurricanes
- Started in 1999 and has collected over 300 images of tropical cyclones

Katrina

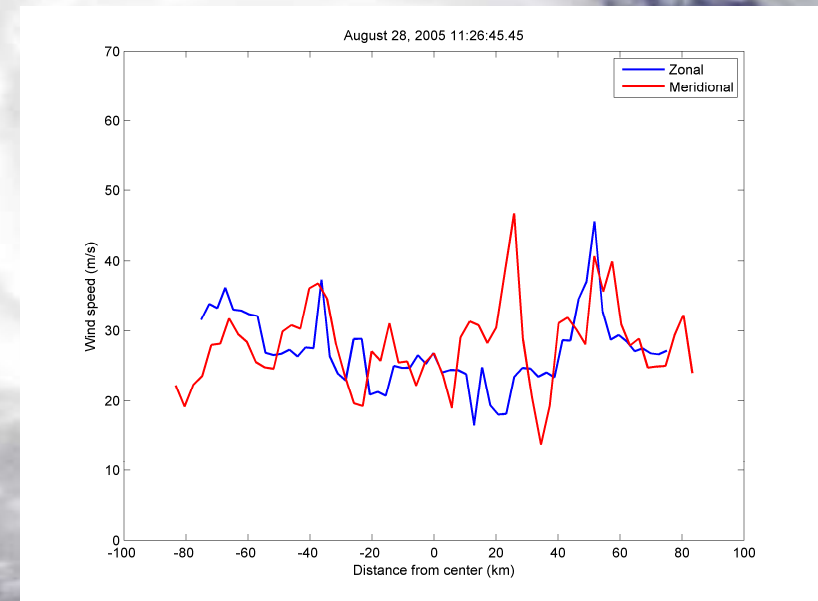
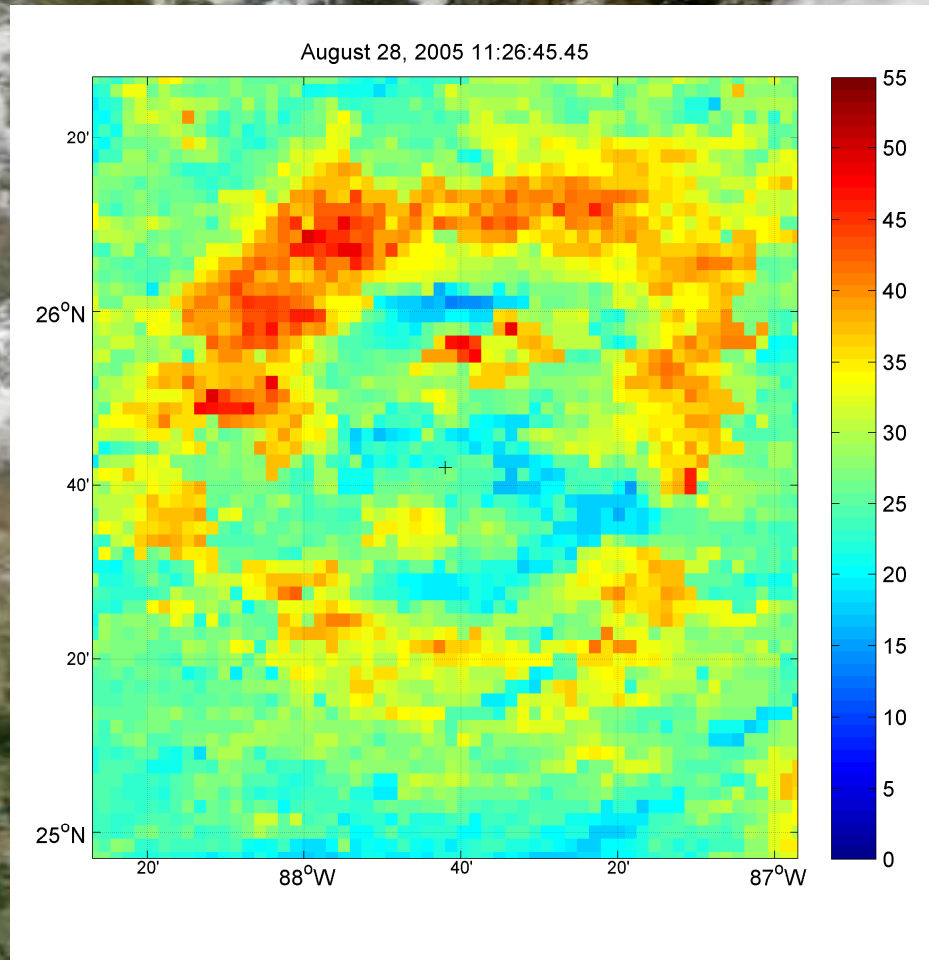


- Max wind speed 150 kts
- Cat 1 landfall at Miami
- Aug 27 – Doubled in size
- Cat 5 Aug 28 1200 GMT
- Cat 3 landfall Aug 29 1100

QuikSCAT 12.5 km

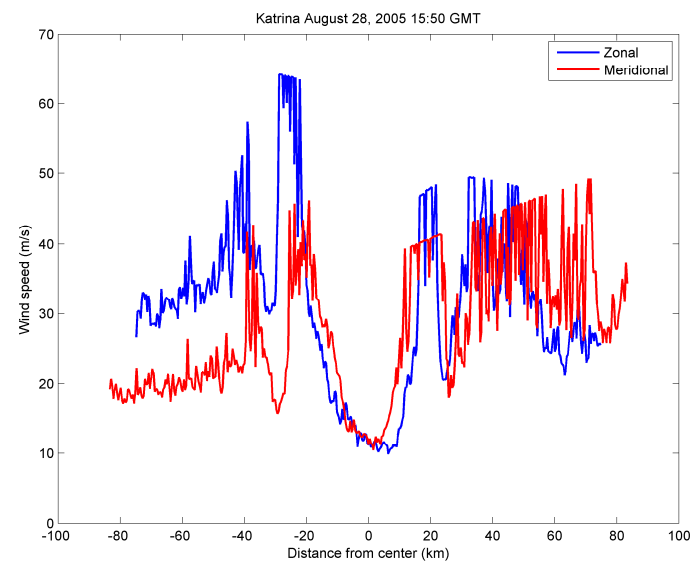
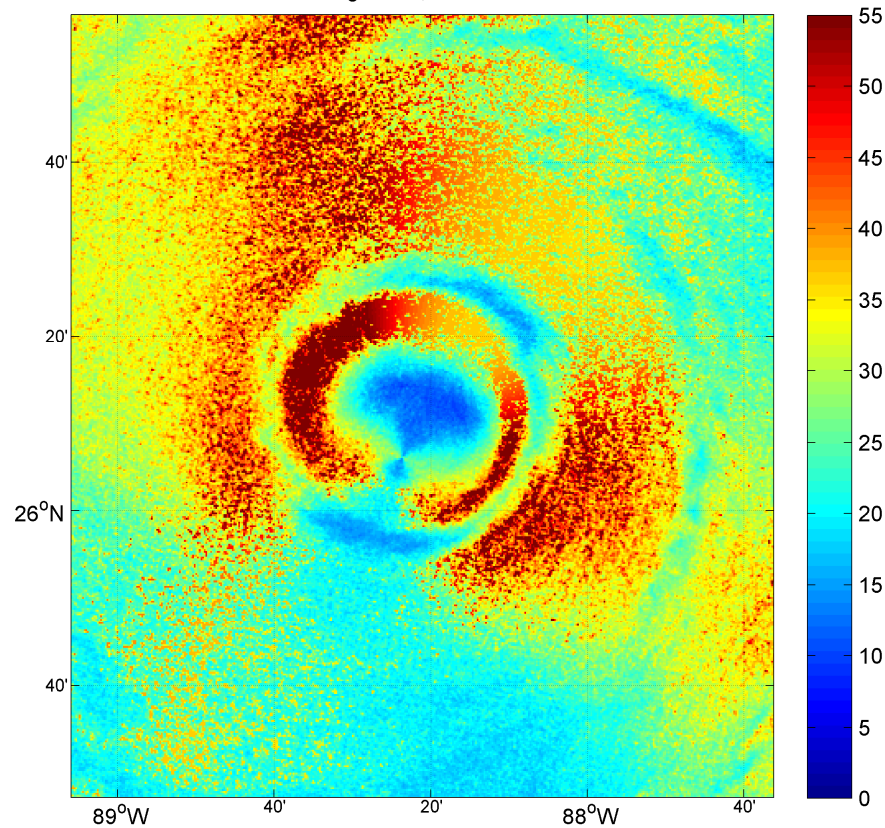


Ultra High Resolution Winds

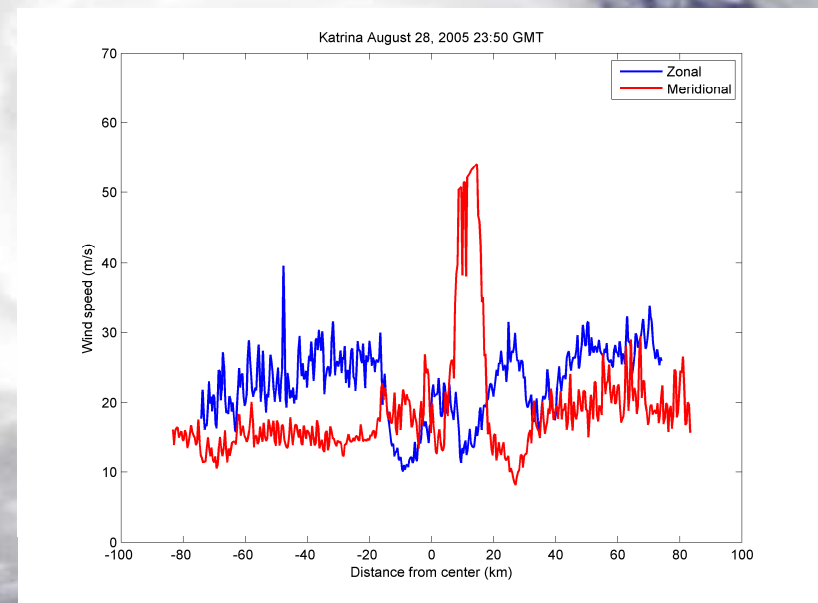
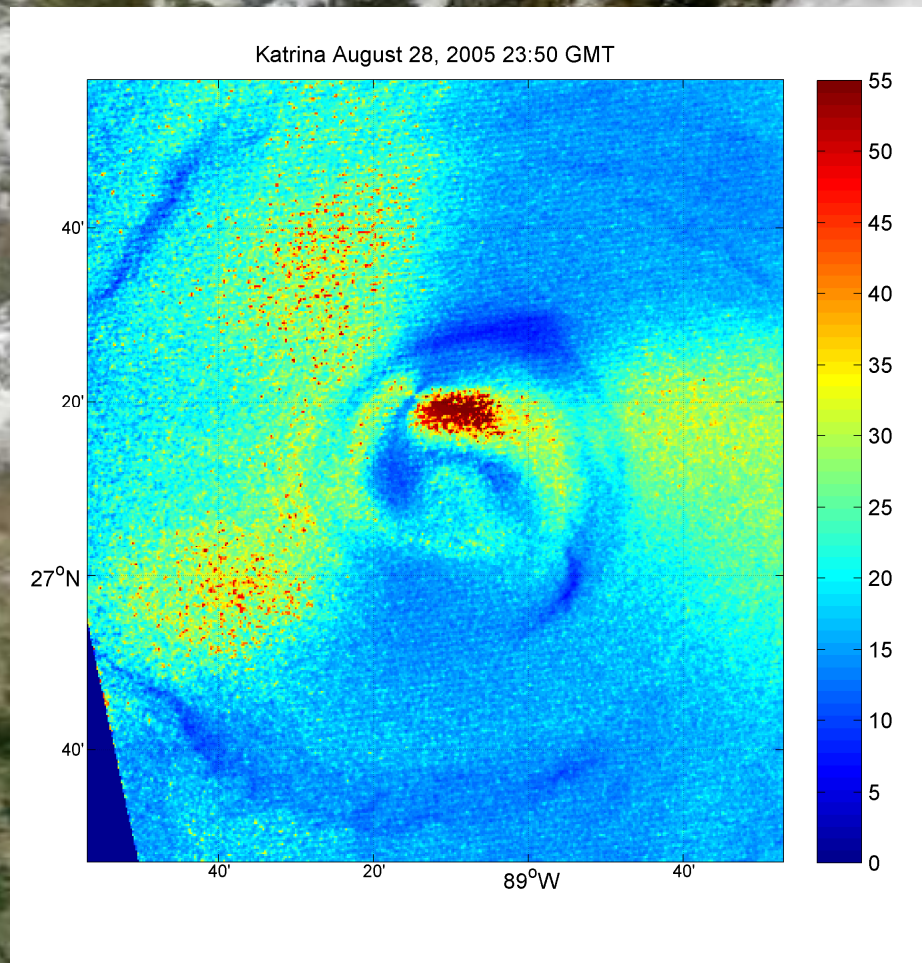


Envisat ASAR

Katrina August 28, 2005 15:50 GMT

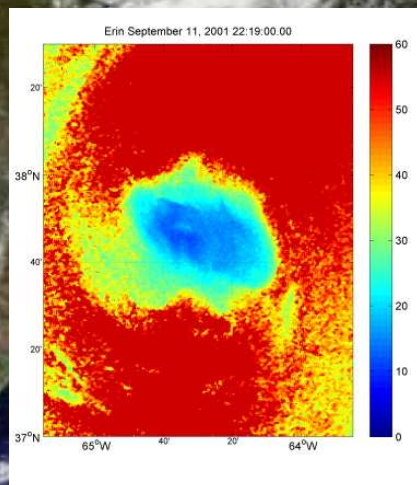


Radarsat-1 SAR

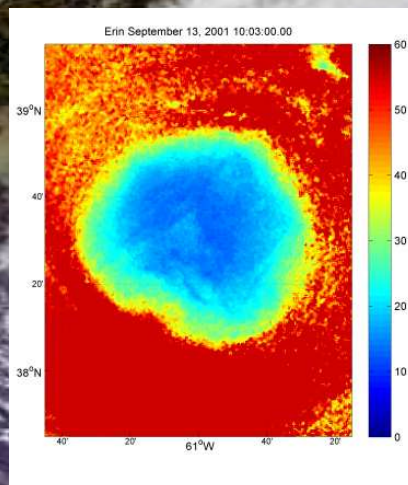


Eye Wall Gallery

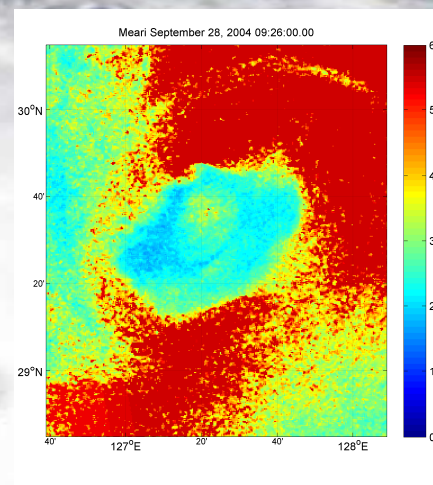
Erin



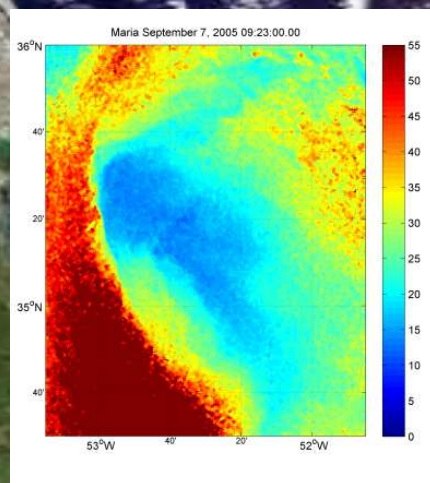
Erin



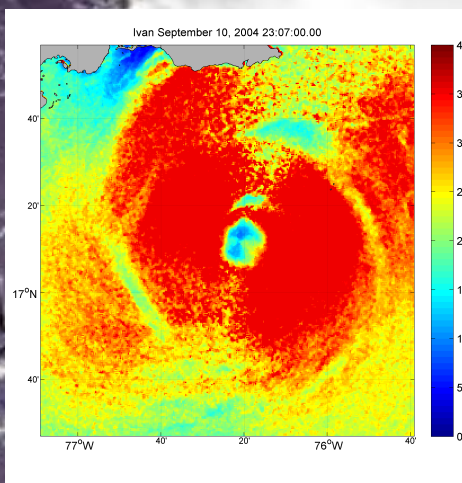
Meari



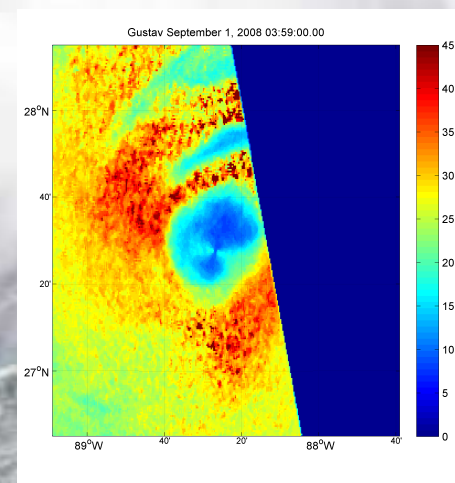
Maria



Ivan



Gustav



Future SAR

- **Radarsat 2**

- 2007 launch
- HH, VV, HV, VH
- Global, 1 – 3 days revisit time
- 20° - 60° incidence angle
- 3 – 100 m resolution; 20 – 500 km swath

- **TerraSAR-X**

- X-band, 2007 launch
- HH, VV, HV, VH
- Global, 1 – 3 days revisit time
- 20° - 60° incidence angle
- 1 – 16 m resolution; 10 – 100 km swath x (up to 1,500 km)

Future SAR

- **COSMO-SkyMed**

- 4 satellites equipped with X-band multipolarimetric SAR
 - 2 in 2007, 1 in 2008, 1 in 2010
- 90° phased sun-synchronous
- Global, < 12 hr revisit time
- HH, VV, HV, VH
- 20° - 59° incidence angle
- ~1 – 100 m resolution; 10 – 200 km swath

Summary

- SAR winds show mountain wakes, lee waves point wakes, frontal instabilities and near coastal winds.
- Hurricane eye wall structures vary in size and shape and are clearly identified by SAR
- Wind fields derived from SAR good accuracy at moderate winds
- The RMS is significantly larger For hurricane winds and more work is required
- The next generation of SAR are orbiting



CSTARS
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Supporting slides



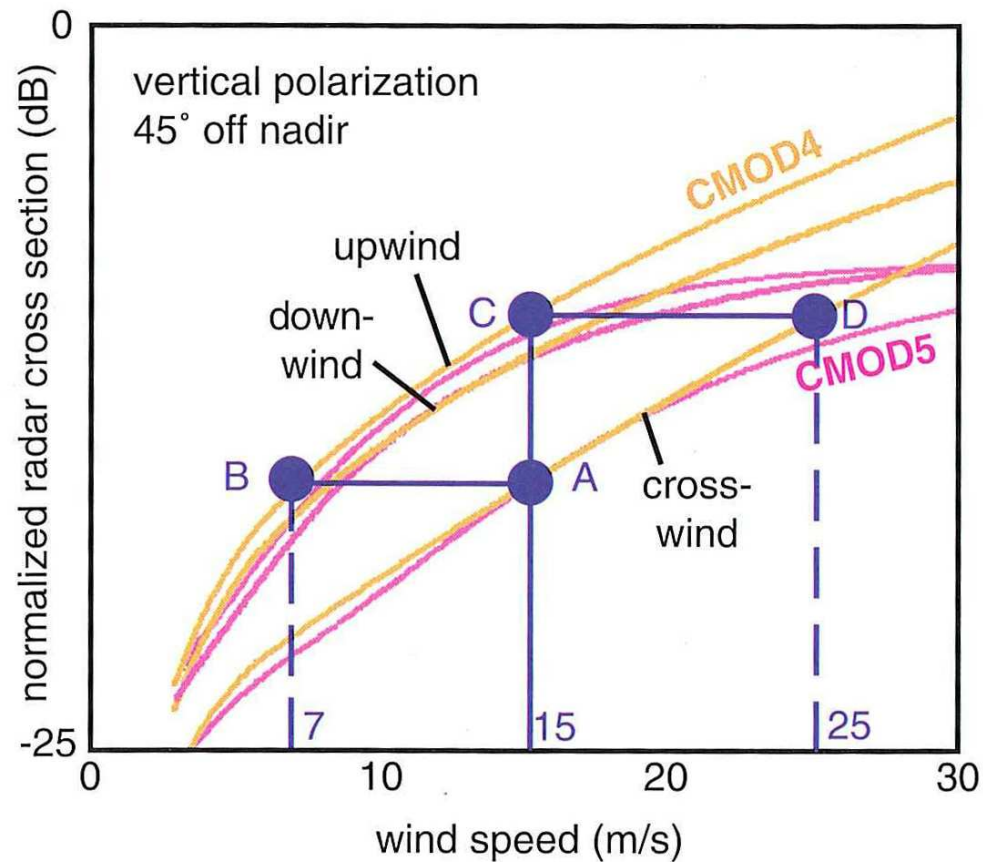
HH Polarization

$$\sigma_H^o = \sigma_V^o \left[\frac{1 + \alpha \tan^2 \theta}{1 + 2 \tan^2 \theta} \right]^2$$

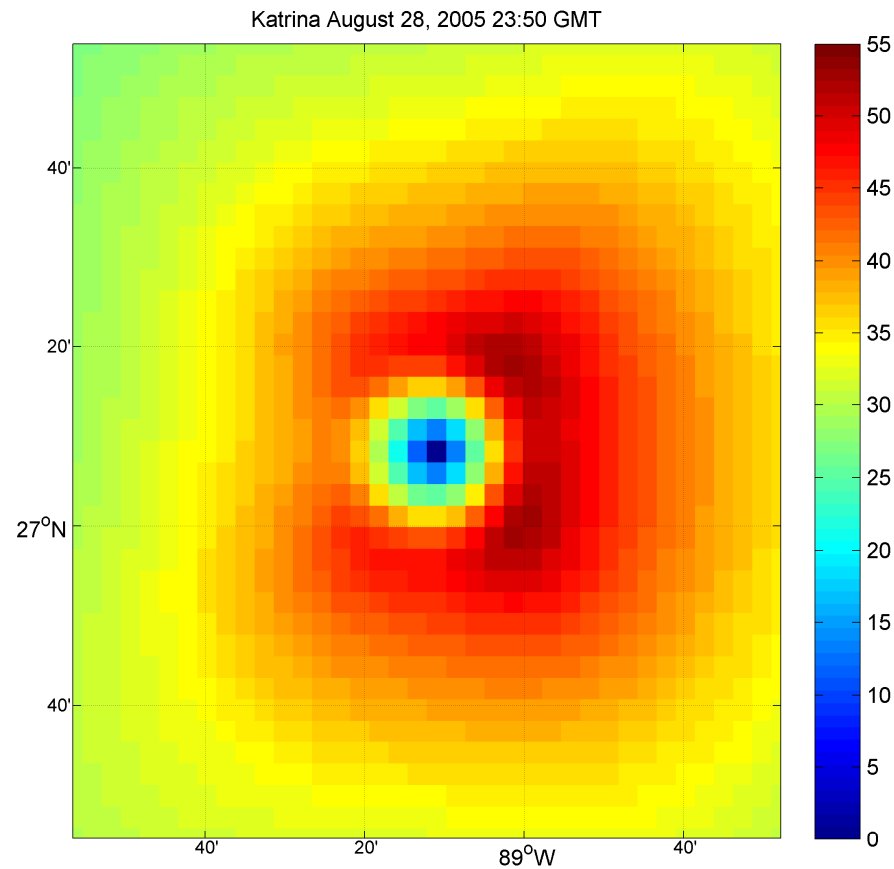
α Dependent on nature of scattering

θ Nadir incidence angle

Wind direction sensitivity



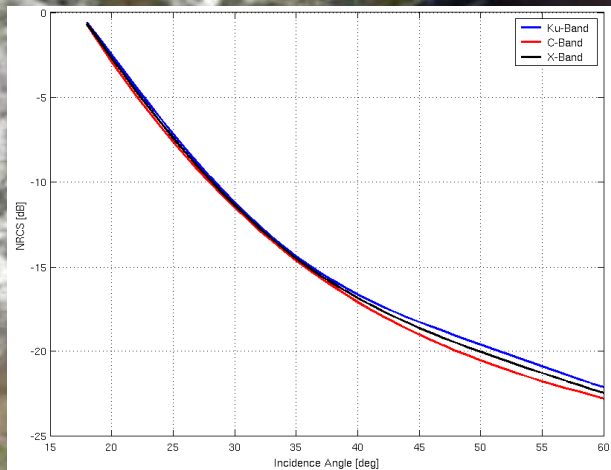
Model Comparison (Katrina)



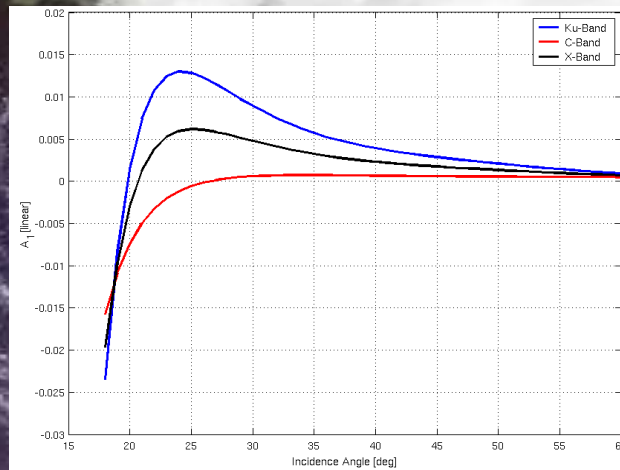
Development of an empirical XMOD using the GMFs of C- and Ku-band

$$\sigma_0^{pol} = a_0(U, \theta)u^{r(\theta)} + a_1(U, \theta)\cos\phi + a_2(U, \theta)\cos(2\phi)$$

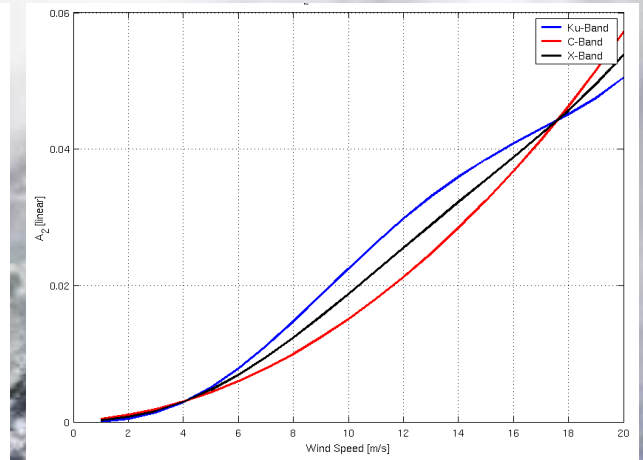
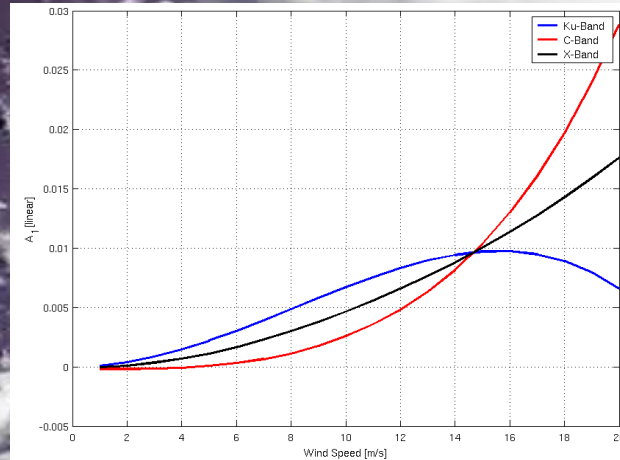
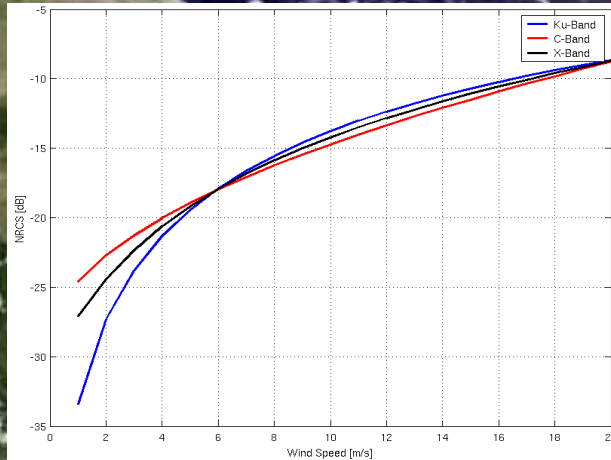
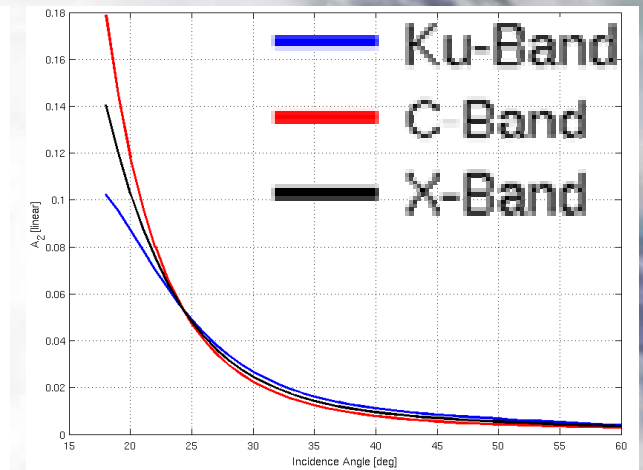
a_0 VV



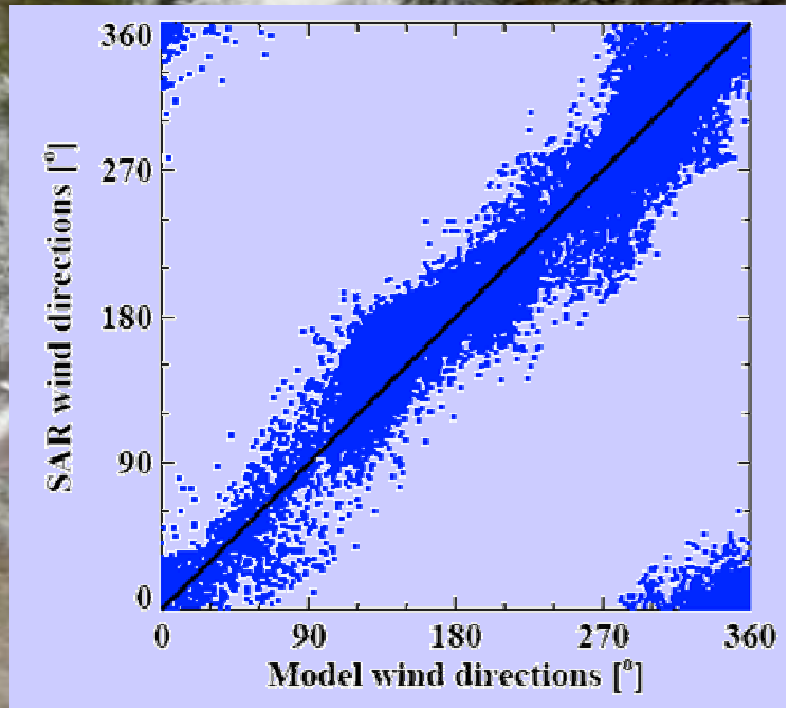
a_1 VV



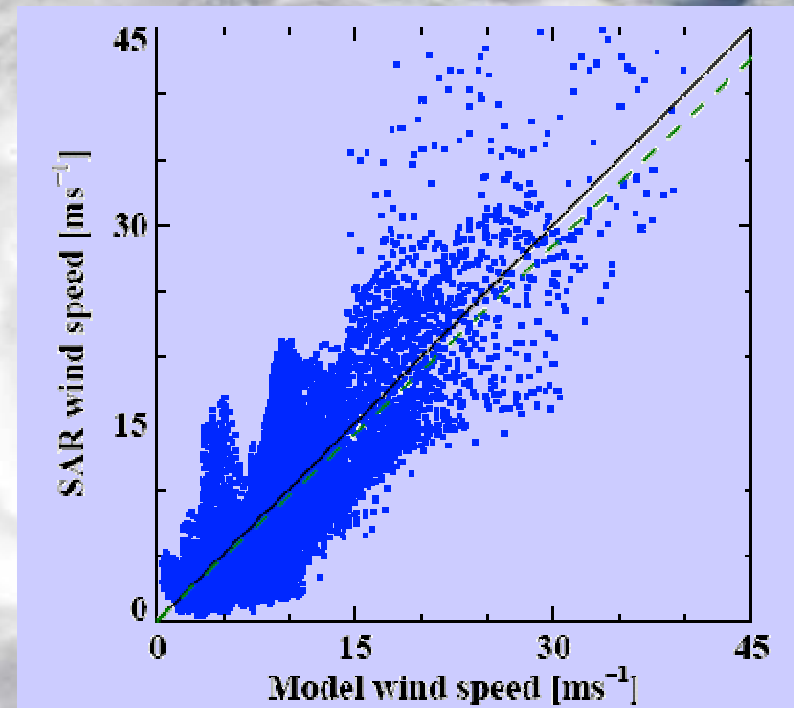
a_2 VV



Comparison of wind speeds to numerical model results

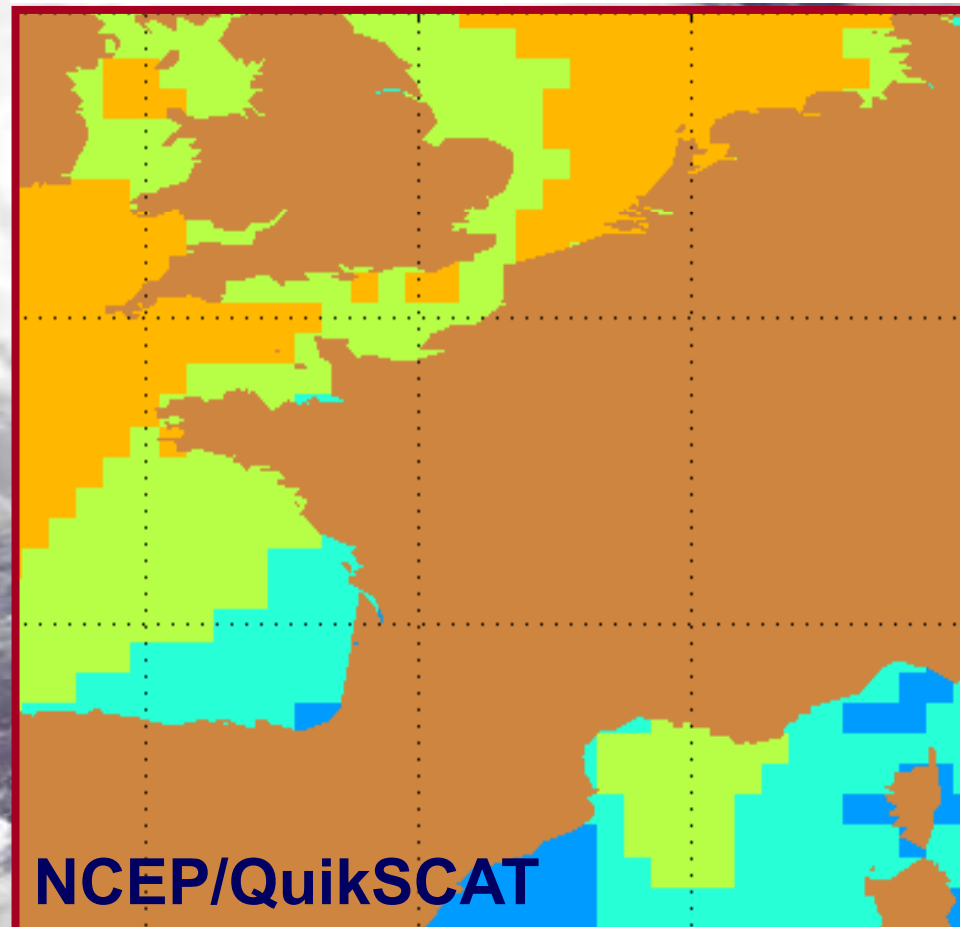
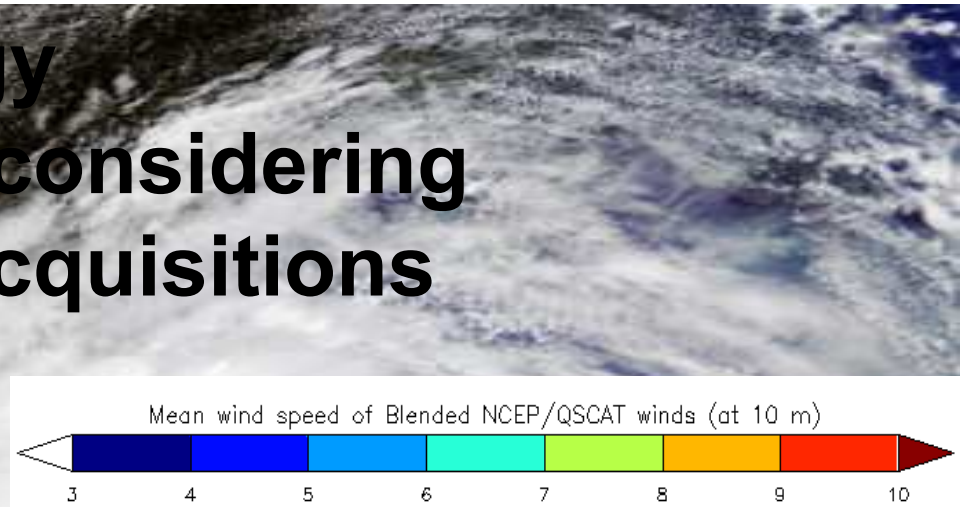
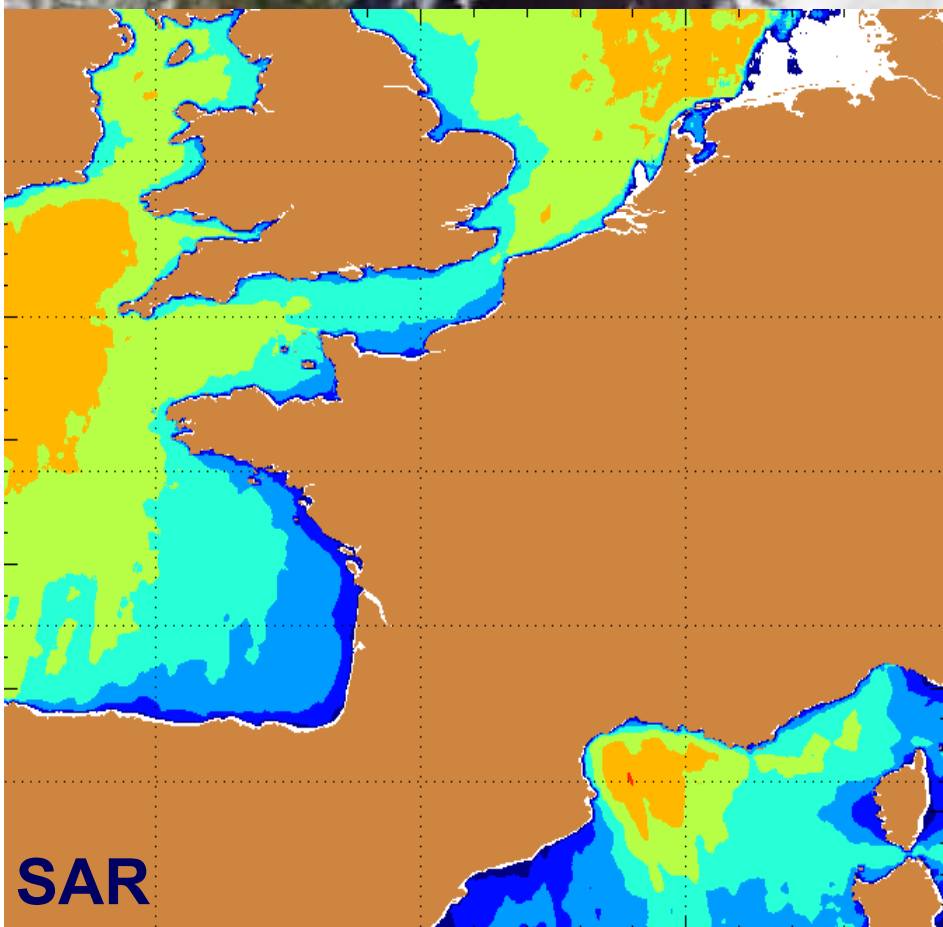
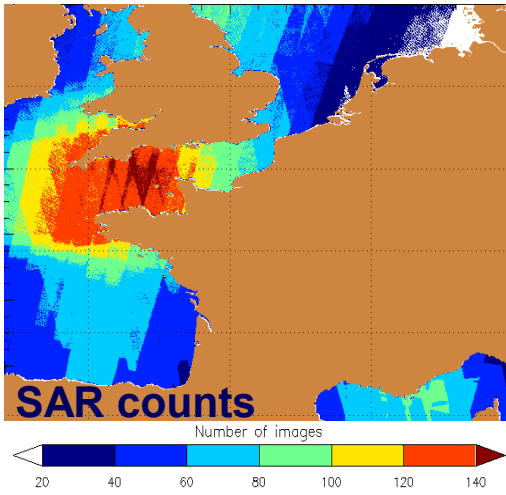


# of Points	23467
Cor.	0.98
Bias	-1.9 °
Rms	16.6°



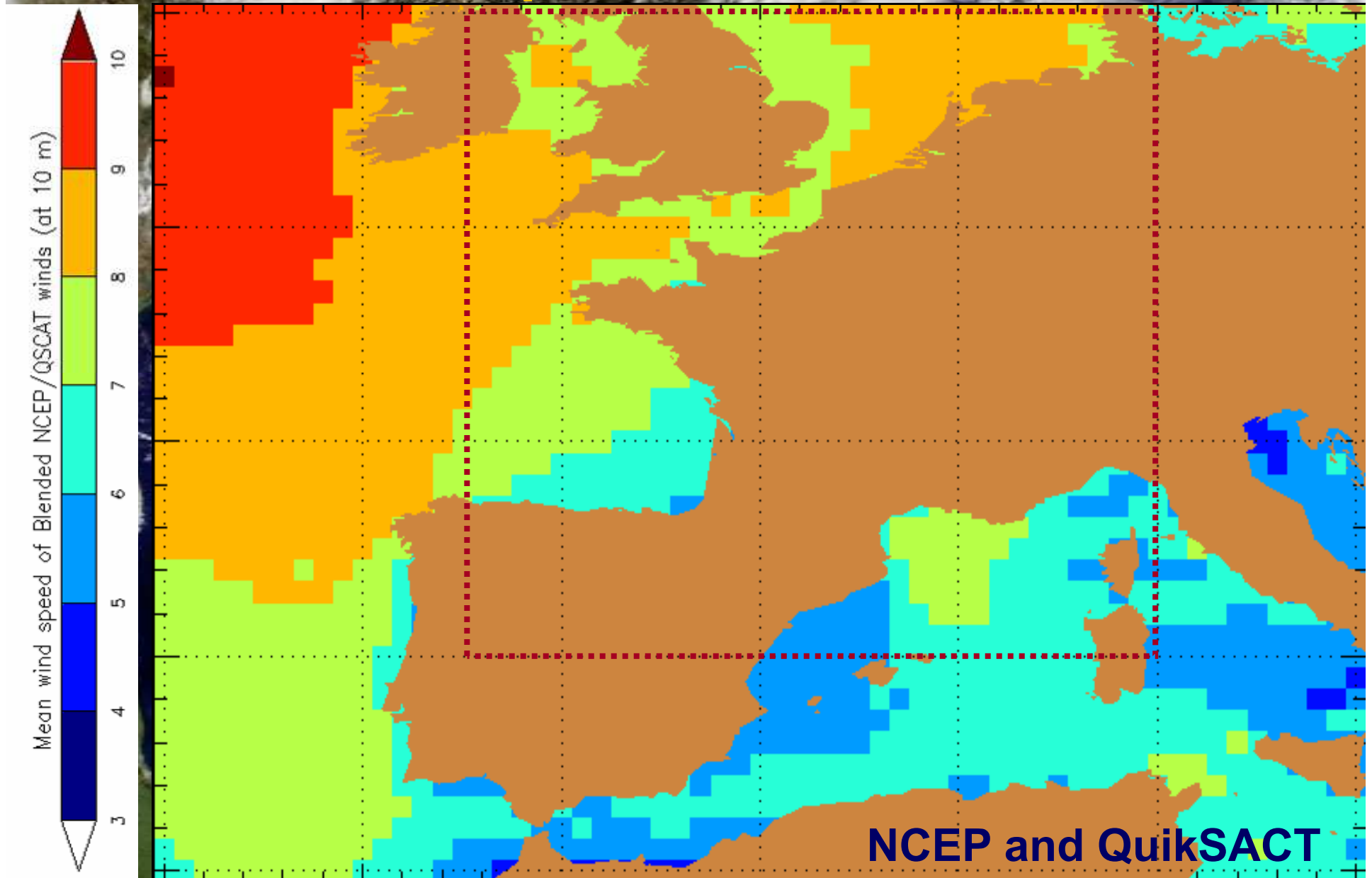
# of points	23467
Cor.	0.83
Bias	0.4 m/s
Rms	2.8 m/s

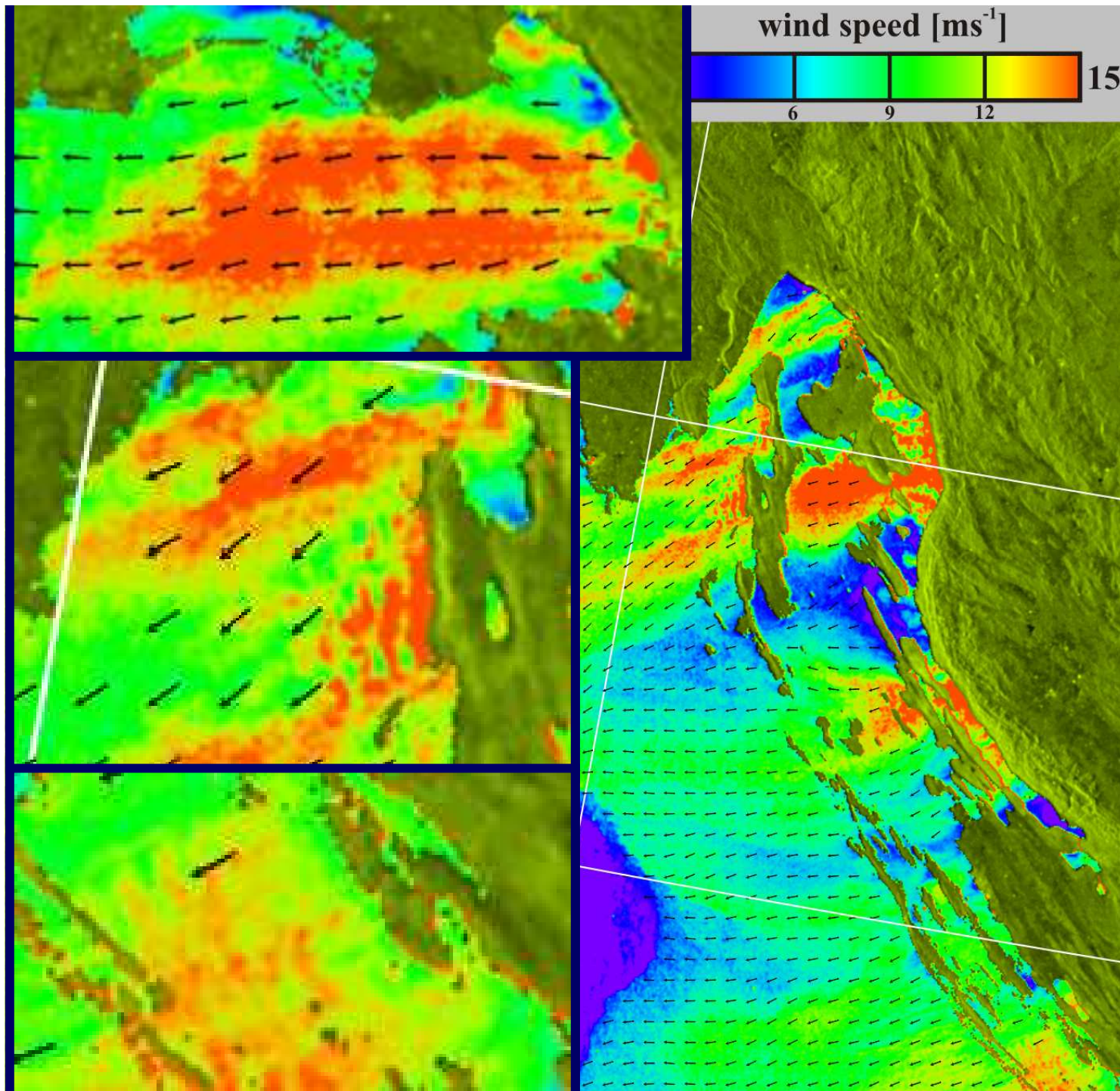
Climatology from SAR considering 450 SAR acquisitions



Applications: Climatology

Mean wind speed





**Motivation
for
High
Resolution
Winds**

0.5 km grid



Synthetic Aperture Radars

Launched	Satellite	Band	Resolution	Swath
1978	Seasat	L	25 m	100 km
1991	ERS-1	C	25 m	100 km
1991	JERS-1	L	< 25 m	75 km
1995	ERS-2	C	25 m	100 km
1995	Radarsat	C	25 – 100 m	400 km
2002	Envisat	C	25 – 100 m	400 km