Scientific Potential for XOVWM

Summary of Science Studies
in Support of XOVWM in Summer 2007

Background

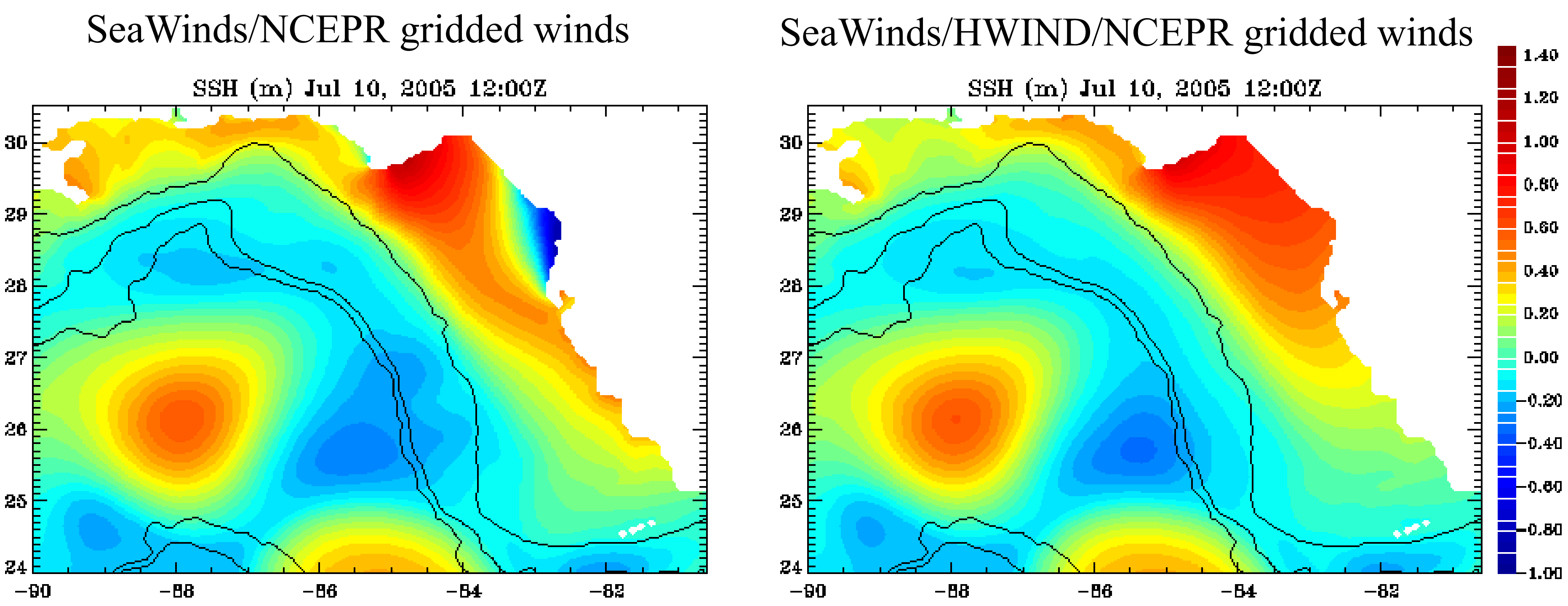
- A set of short directed studies was requested by NASA HQ in support of XOVWM
- Study teams:
  - COAPS/FSU: Bourassa, Maue, Morey
  - JPL: Chao
  - UW/JPL: Kelly, Thompson, Booth, Patoux, Veleva
  - CoRA/BYU: Milliff, Long, Morzel, Williams
  - OSU/JPL: Strub, Abbott, Bane, Barth, Chao, Freilich, Haack, Holt, James
  - Woods Hole/JPL: Yu, Jin, Veleva

COAPS Objectives

- Evaluate the advantages of 5km resolution with improved rain capabilities
- Applications:
  - Detection of Tropical Disturbances
  - Investigation of Storm Surge
  - Fine Scale Features in Atmospheric Fronts
  - Warm Core Seclusions
  - Cross Shelf Transport of Water Properties
- In each of these cases, increased spatial resolution and/or improved retrievals in rain would be beneficial to studies seeking to better understand processes in the upper ocean or lower atmosphere.

Storm Surge

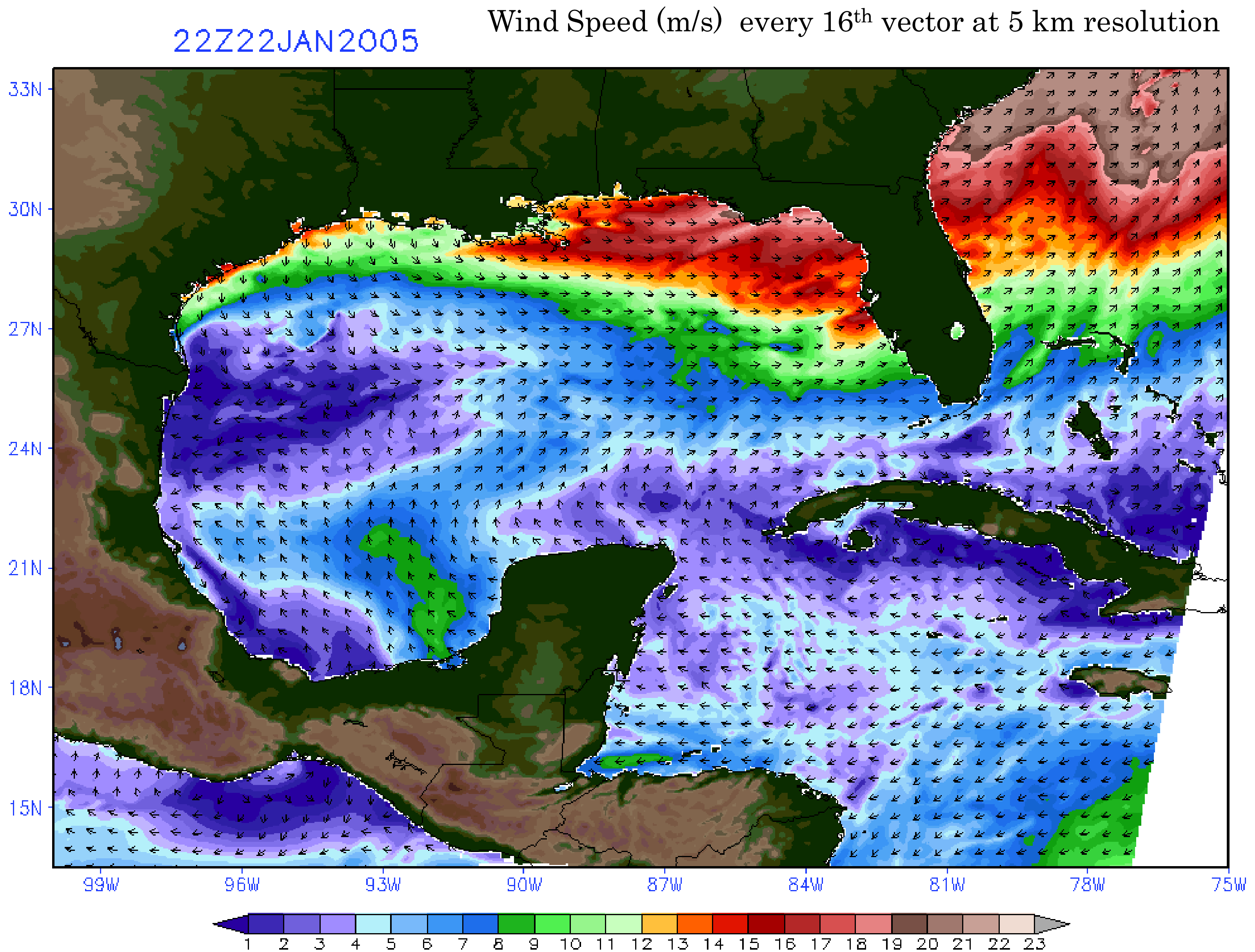
- Blending QSCAT with NCEP lacks the spatial resolution to produce realistic wind-induced changes in sea surface elevation and storm surge.
- Adding the relatively high resolution HWIND data to the blend results better representation of the winds around the core, as well as the eye wall.
  - The inclusion of the high resolution data resulted in a very accurate storm surge hindcast, and showed which part of the wind field was critical in this case



SeaWinds/NCEPR gridded winds

SeaWinds/HWIND/NCEPR gridded winds

Gulf of Mexico Frontal Surges



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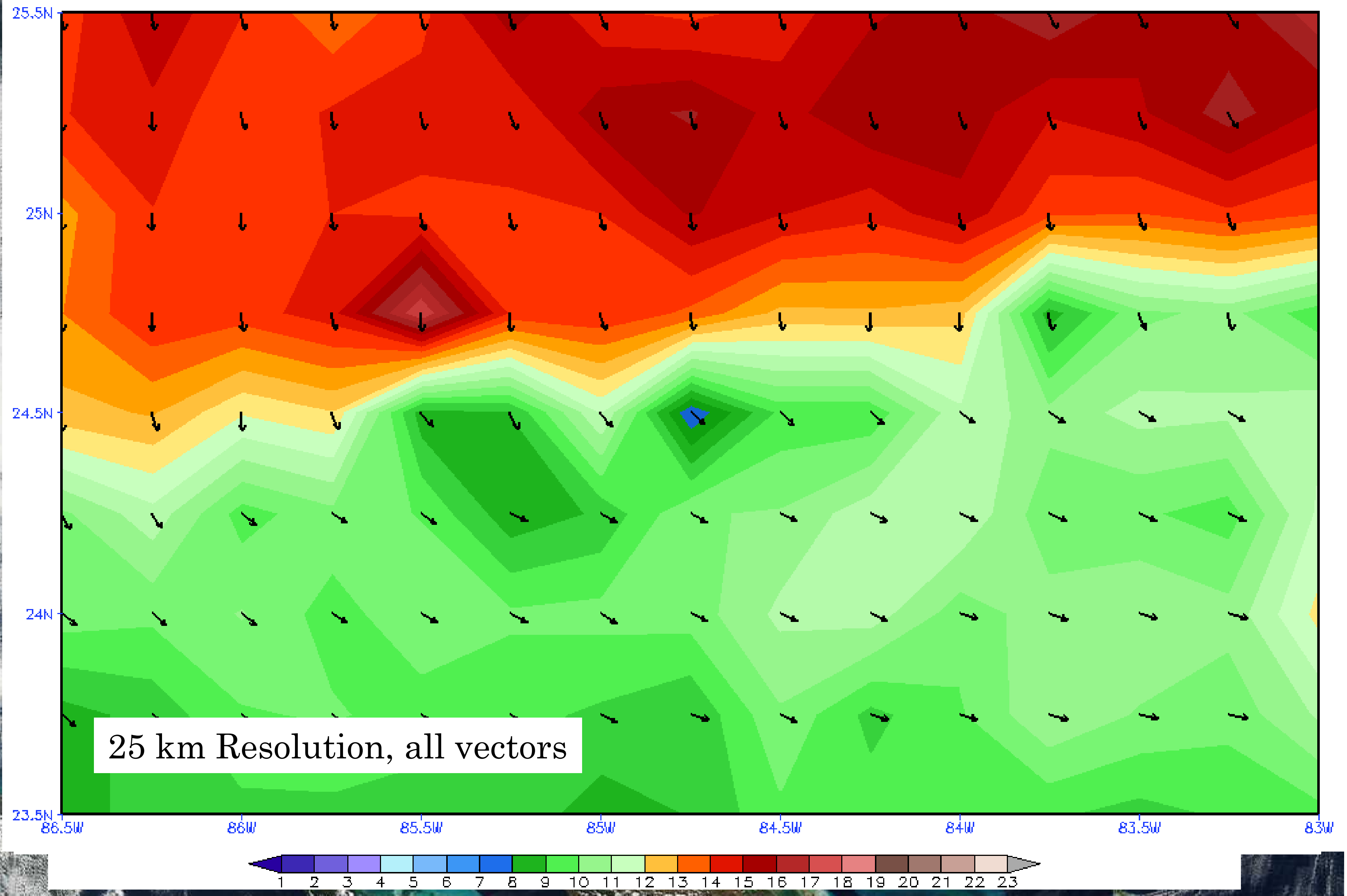
Wind Speed (m/s) every 16th vector at 5 km resolution

5 km Wind Speed (m/s)

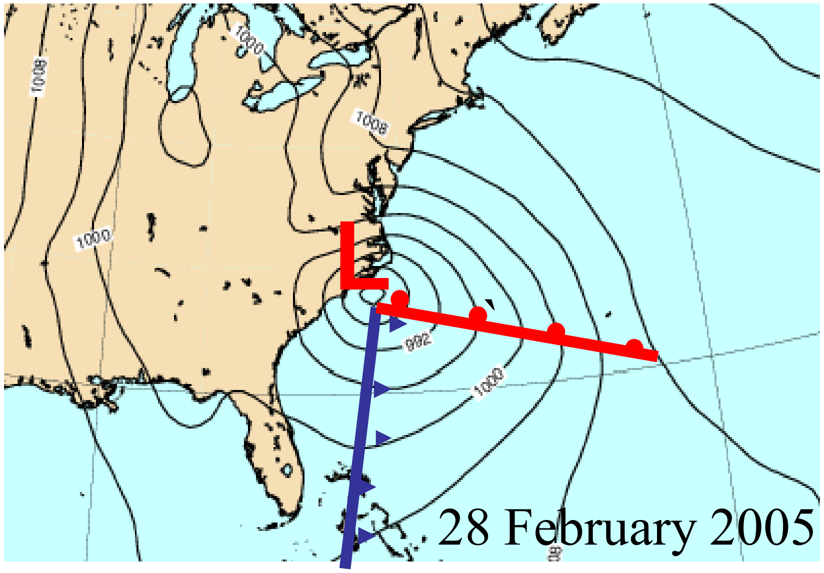
Gulf of Mexico Frontal Surges

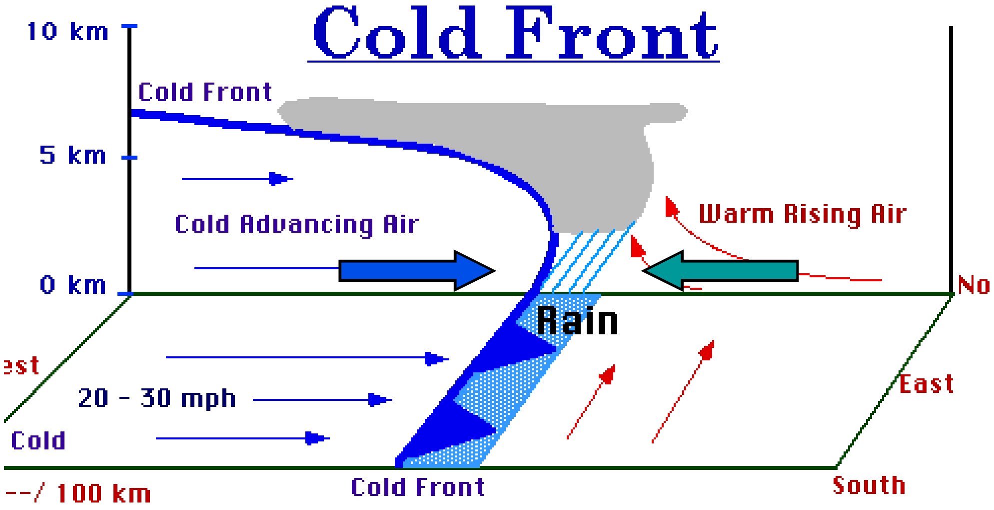


25 km Resolution, all vectors

Storm Intensification over the Gulf Stream

Kelly, Thompson, Booth, Patoux, University of Washington
Veleva, Jet Propulsion Laboratory



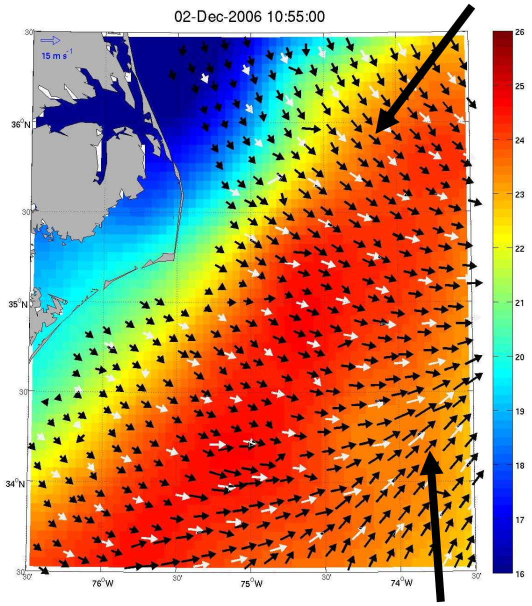


Over the Gulf Stream, cold, dry air meets warm, moist air to form a front and ideal conditions for storm formation.

Slight changes in wind direction indicate *convergence* and vertical motion (*convection*) at the front, which fluxes heat and moisture from the ocean to the atmosphere.

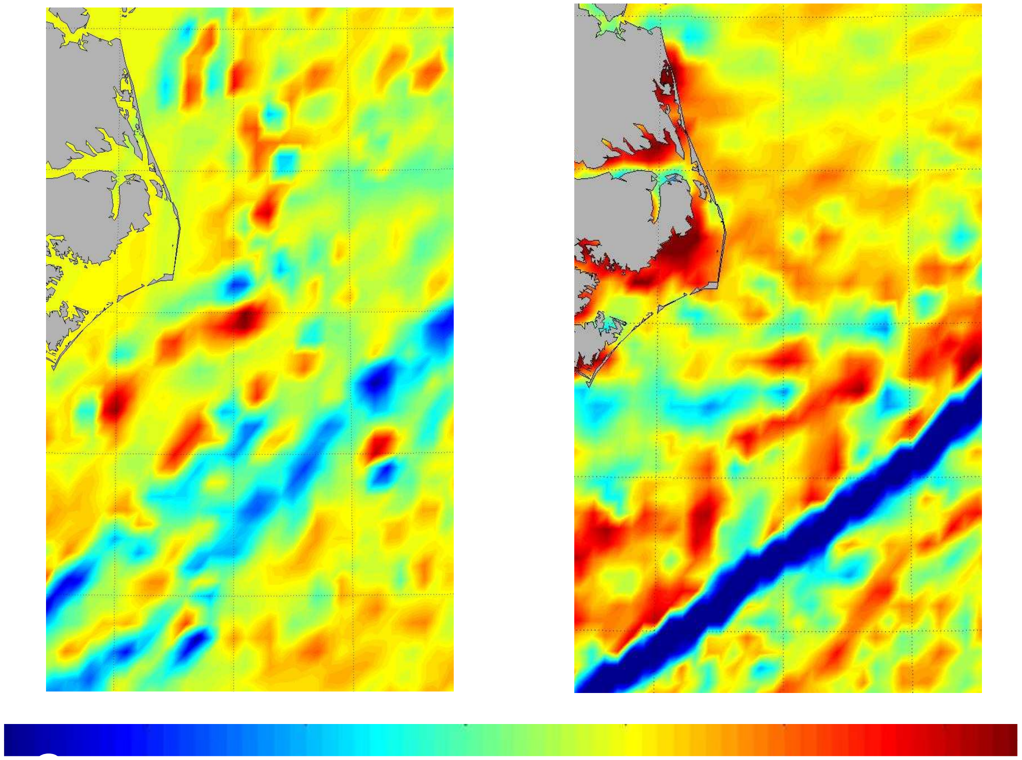
Convergence from XOVWM Wind Vectors
to distinguish effects of atmospheric versus ocean fronts

Gulf Stream front divergence



Atmospheric front convergence

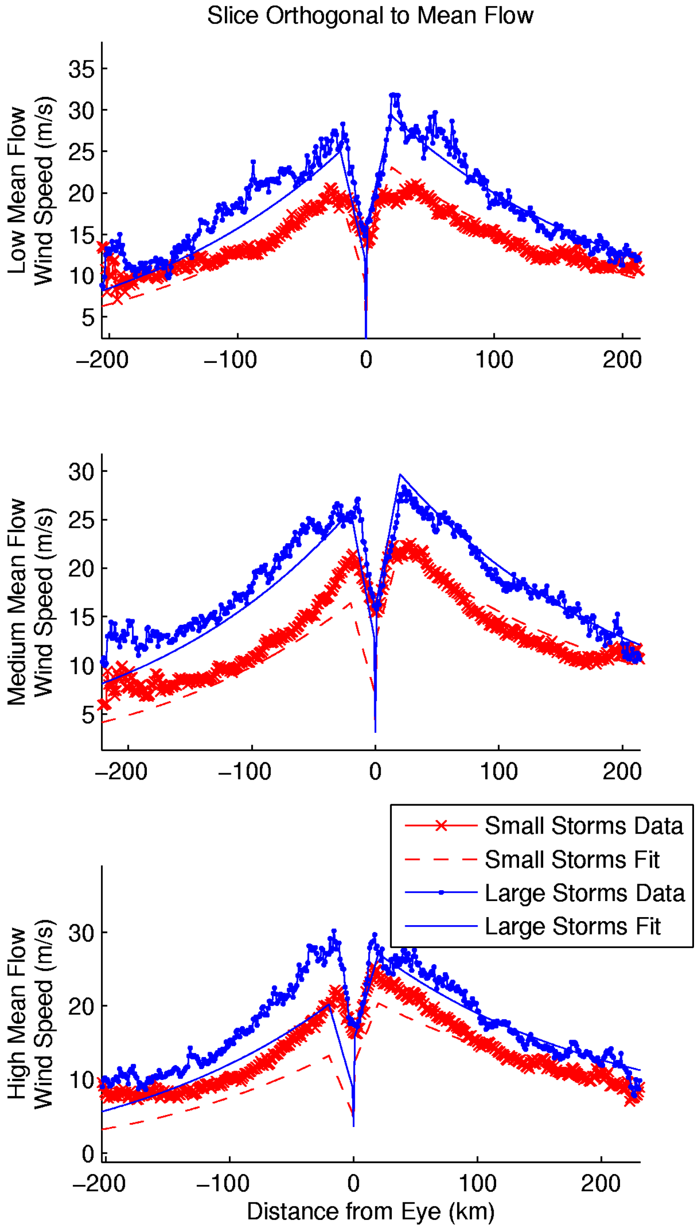
QuikSCAT **Simulated XOVWM**



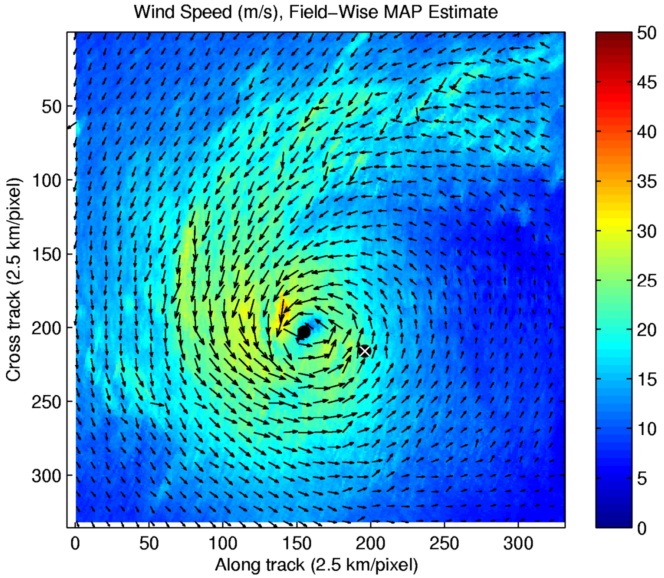
High-resolution winds can distinguish effects of ocean on atmospheric stability versus the convergence from fronts to understand and improve predictability of storms.

Maximum Aposteriori Probability (MAP) *Hurricane Model:*

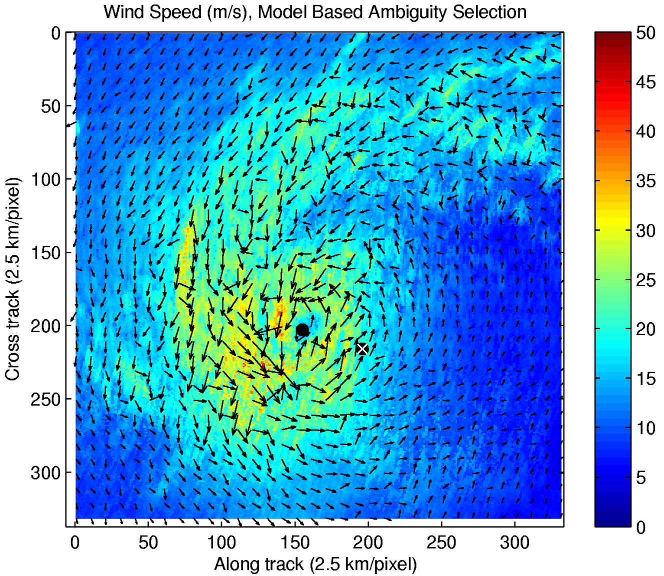
Hurricane Model Prior



MAP Field Estimate

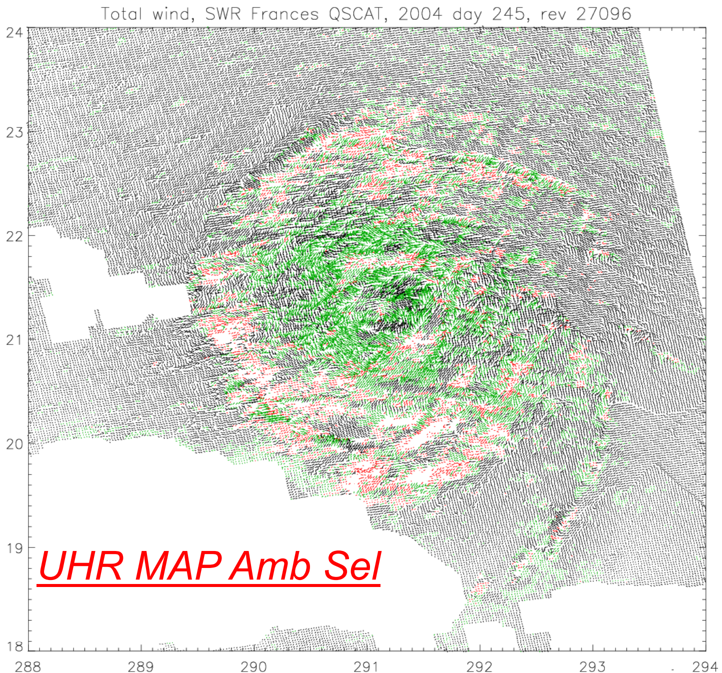


MAP Ambiguity Selection

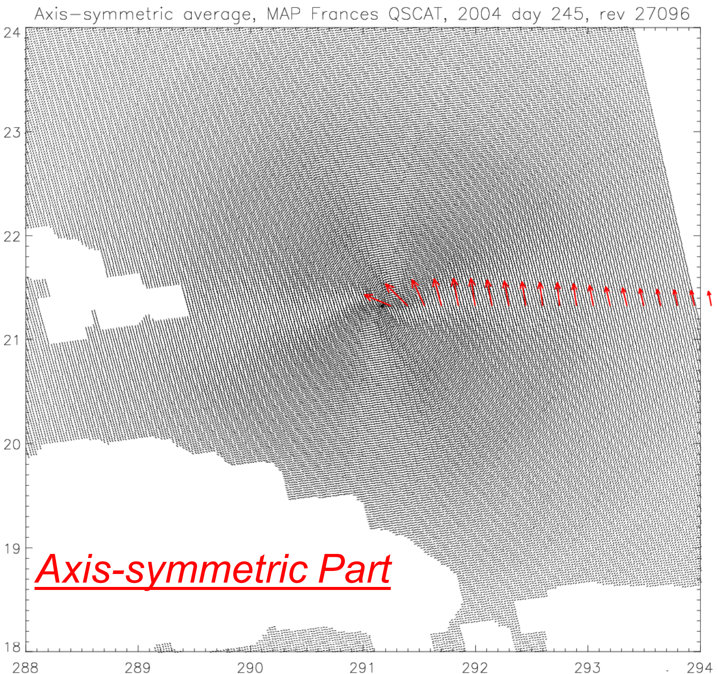


Hurricane Floyd (1999)

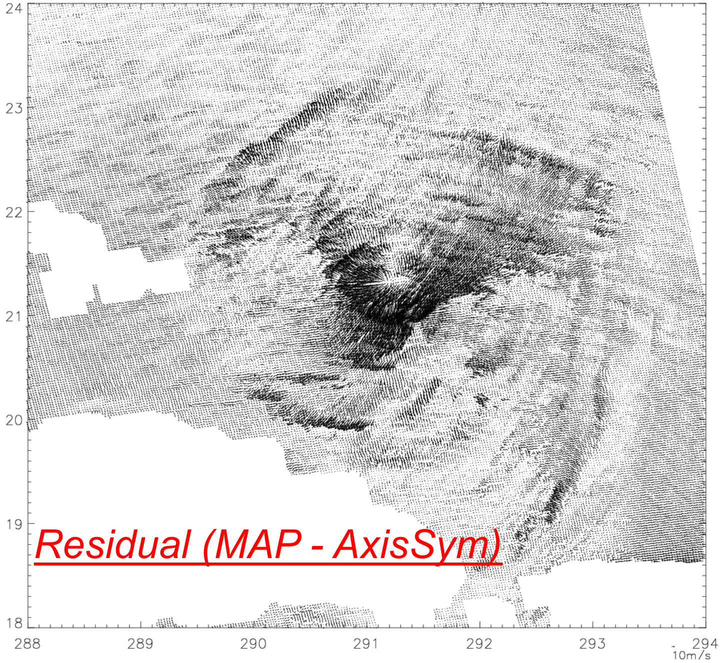
3-Step Process to Identify ***"Surrogate Mesoscale"***



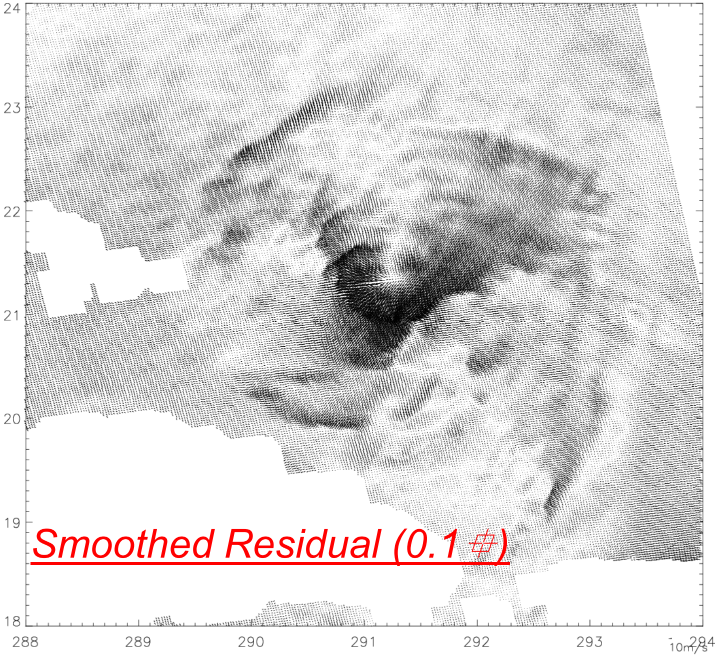
UHR MAP Amb Sel



Axis-symmetric Part



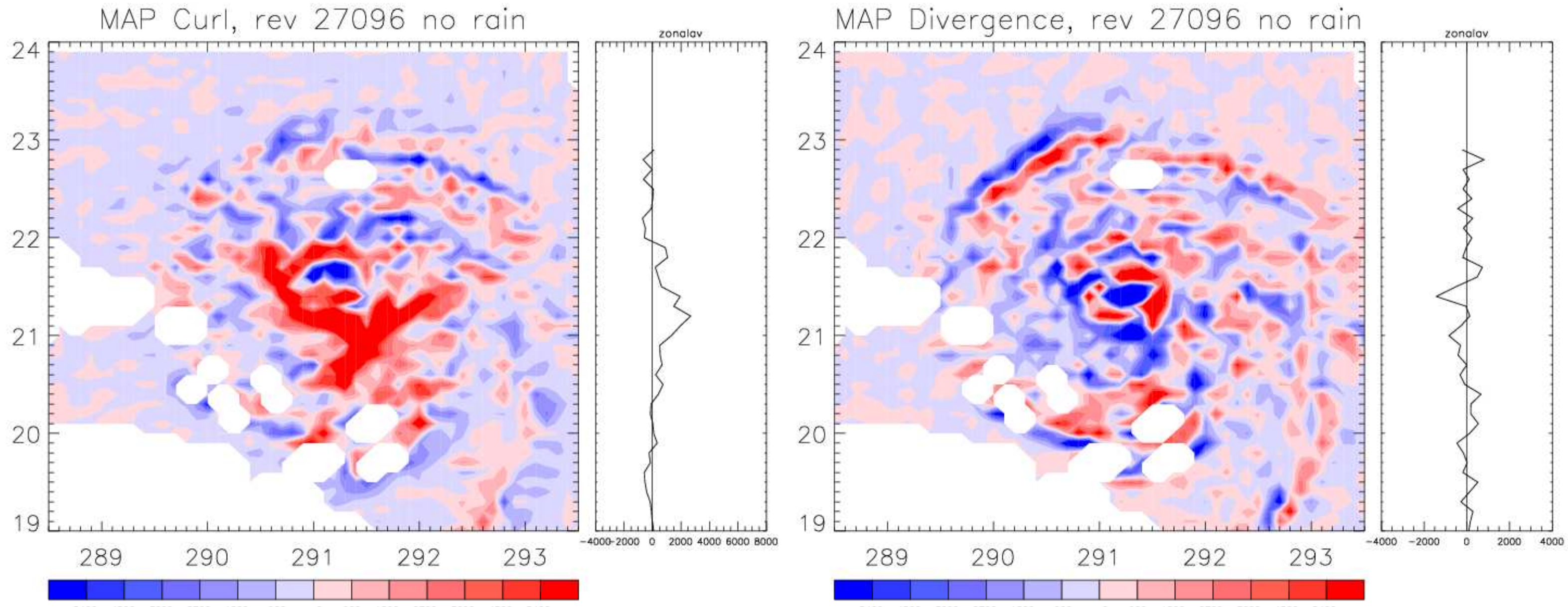
Residual (MAP - AxisSym)



Smoothed Residual (0.1 #)

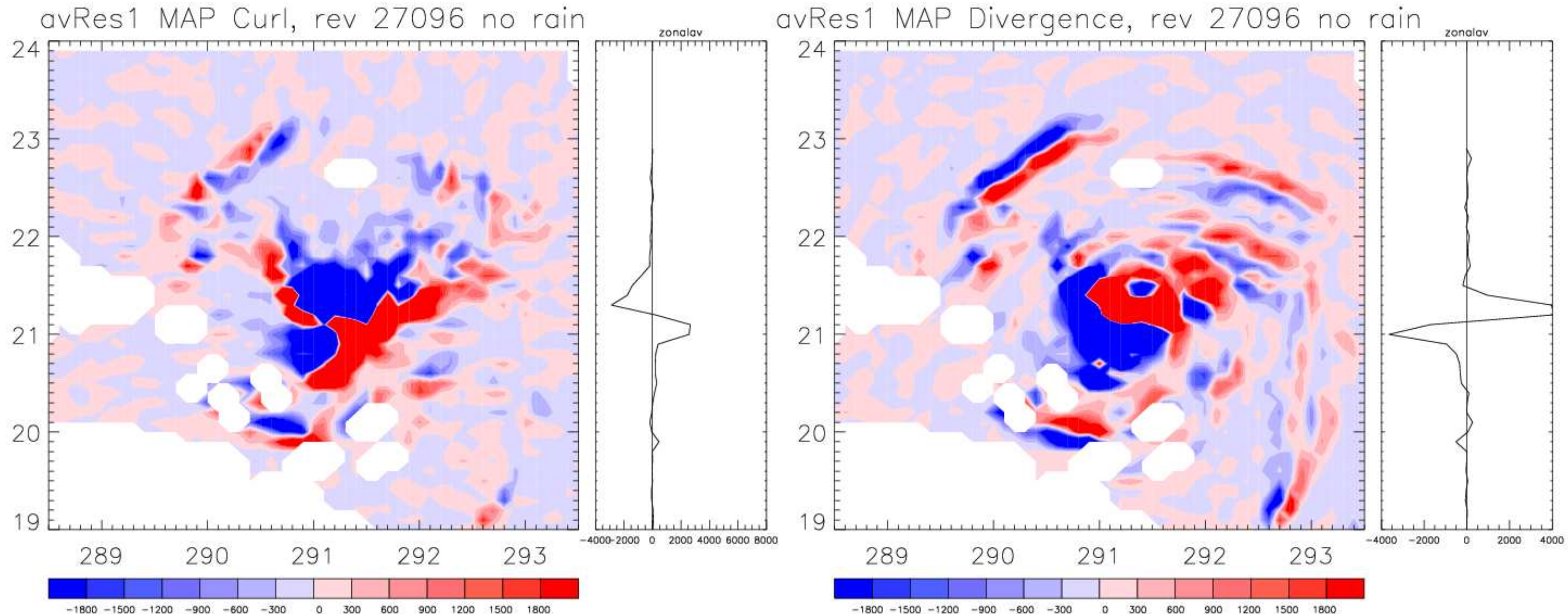
Surrogate Mesoscale is O(30%) total storm signal in WSC, WSD

Total Storm



-5400 0 5400 $x10^{-8}$ Nm^{-3}

Smoothed Residual

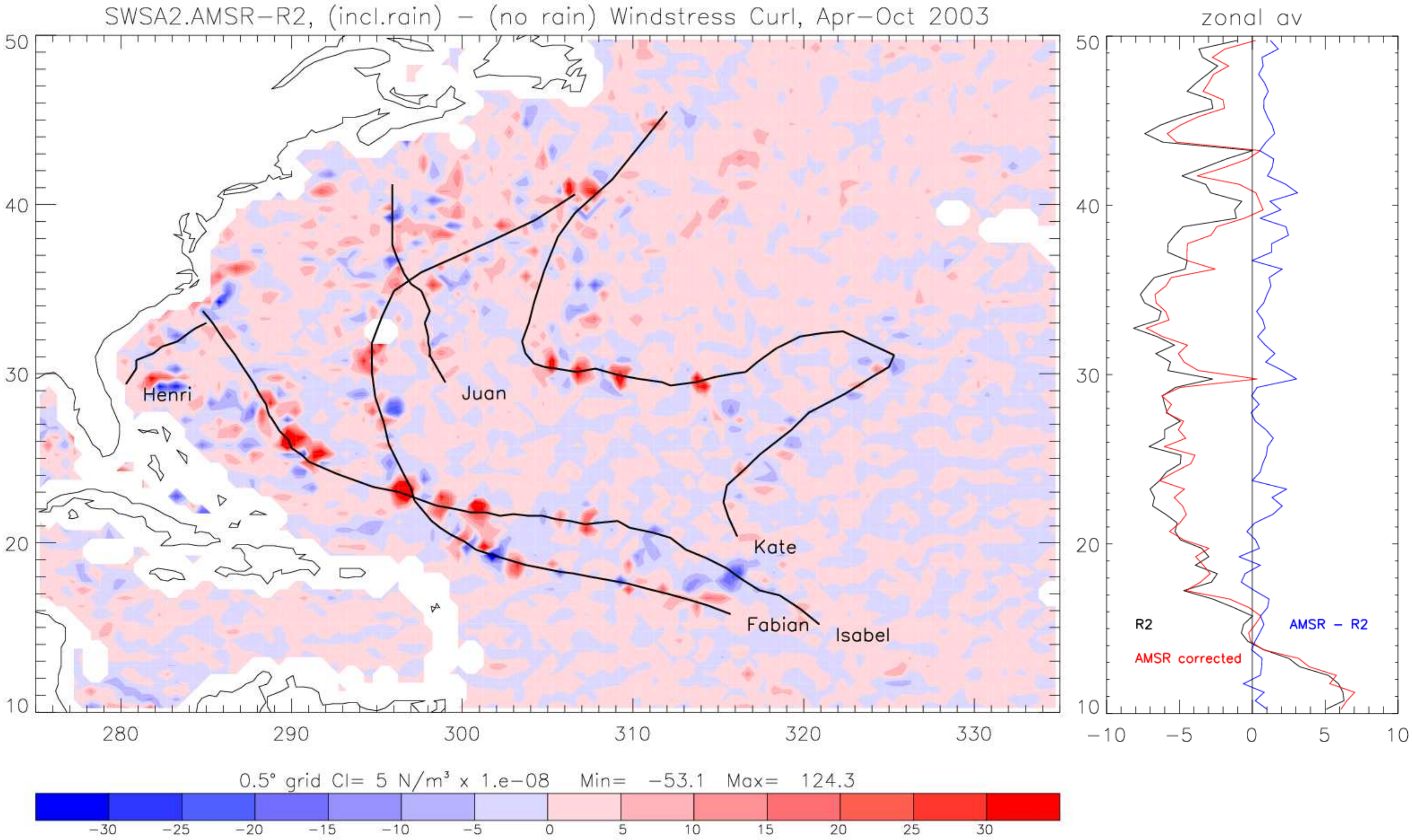


-1800 0 1800 $x10^{-8}$ Nm^{-3}

Storm dependent result; not true mesoscale

Polar-Orbiting Scatterometer Coverage of N. Atlantic Hurricanes: ***2003 Season***

- *Average WSC differences; AMSR-corrected – Std Product (R2)*
- *Typical coverage in sub-cycle; 2x/day for 2 days, 1x/day for 1 day, total miss 1 day*

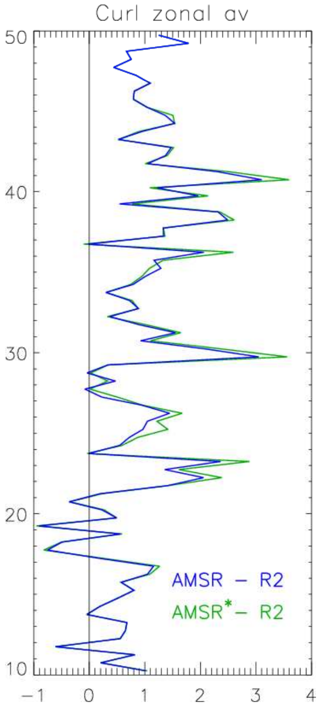


Zonal-Average, Seasonal-Average, Atlantic Basin-Scale WSC

Estimate 1. *Use AMSR-R2 zonal average WSC directly*

- AMSR-R2 difference is concentrated on hurricanes where largest rain flag errors occur in R2
- AMSR corrections represent an aggregate of hurricane mesoscale
- zonal-average WSC difference in band 15°-35°N is 0 - 2 x 10^{-8} Nm^{-3}
- this is about a 30% increase, in each latitude band, over R2
- (linearly) consistent with value-added estimate for single storm snapshots using UHR/MAP

Estimate 2. *Use AMSR-R2 map to locate hurricane samples*



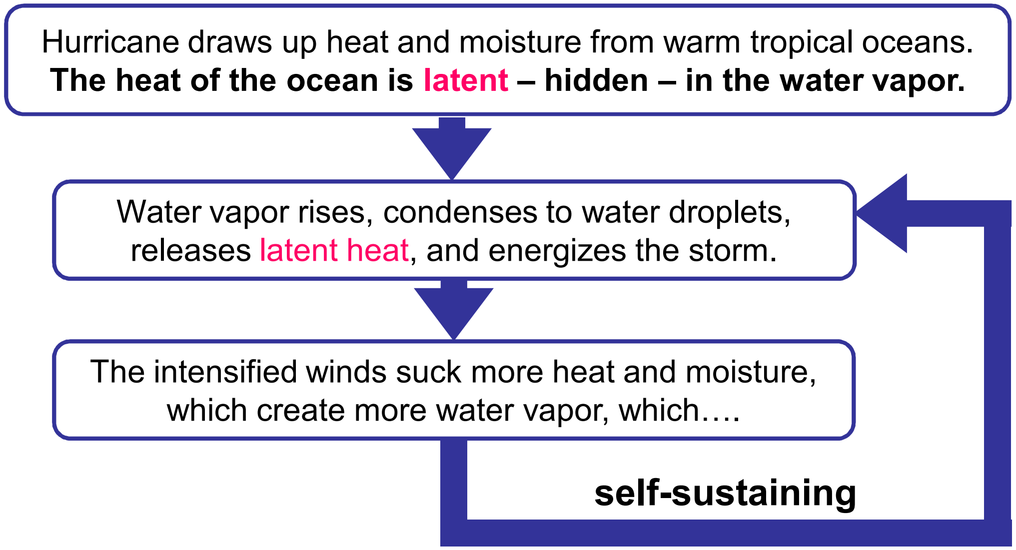
- AMSR-R2 difference map identifies hurricane signals surviving seasonal average
- augment positive and negative WSC anomalies by 30% (from UHR/MAP analysis) i.e. for each latitude band, value-added = 0.3x “red bullets” – 0.3x “blue bullets”
- accumulate new zonal average (green profile)
- zonal-average difference is about 20% (0.5 x 10^{-8} Nm^{-3}) in latitude bands containing hurricane WSC anomalies

Understanding the Hurricane Heat Engine

Lisan Yu, Xiangze Jin, Woods Hole Oceanographic Institution
Svetla Veleva, Jet Propulsion Laboratory

High-resolution, rain-corrected winds from XOVWM can improve the estimates of hurricane-induced latent heat energy, leading to a better understanding of the self-sustaining intensification mechanism and better prediction of the hurricane intensity.

Hurricanes are giant heat engines:
they convert latent heat from tropical oceans into the energy of the storm



Hurricane draws up heat and moisture from warm tropical oceans. **The heat of the ocean is latent – hidden – in the water vapor.**

Water vapor rises, condenses to water droplets, releases latent heat, and energizes the storm.

The intensified winds suck more heat and moisture, which create more water vapor, which….

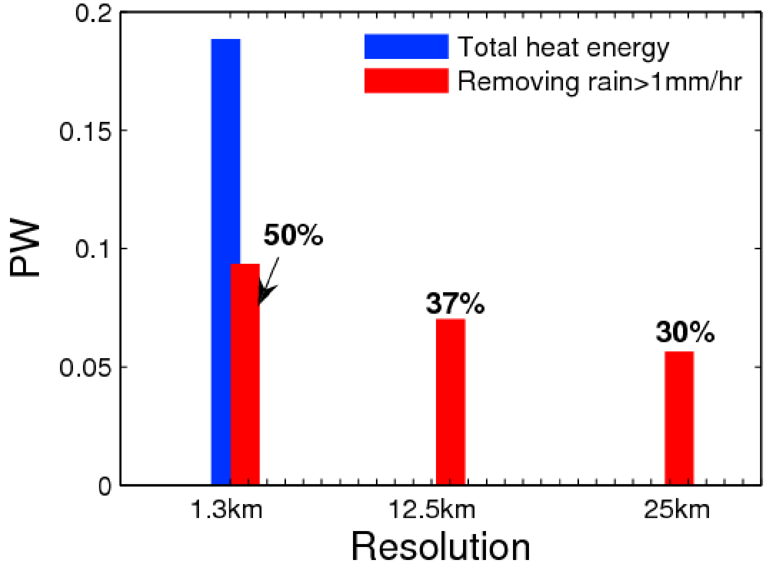
self-sustaining

(From http://visibleearth.nasa.gov/)

Hurricane-extracted oceanic latent heat energy Estimated from XOVWM and QuikSCAT winds

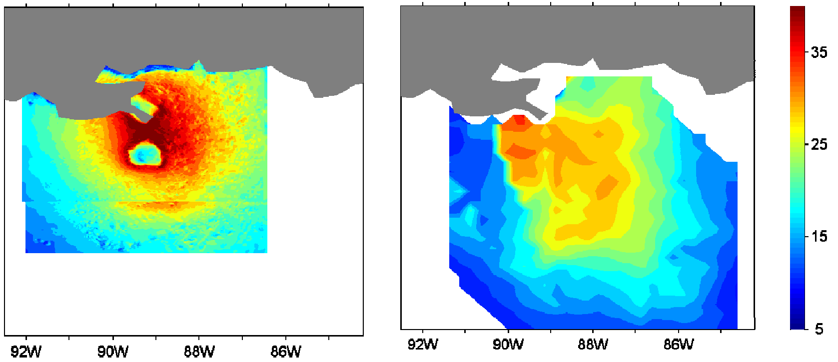
- Hurricane Katrina extracts ~0.18PW latent heat energy from the tropical ocean
- Removing rain-affected winds reduces the estimate of total heat energy by more than 50%.

Total latent heat energy extracted by Katrina during Aug28-29,2005

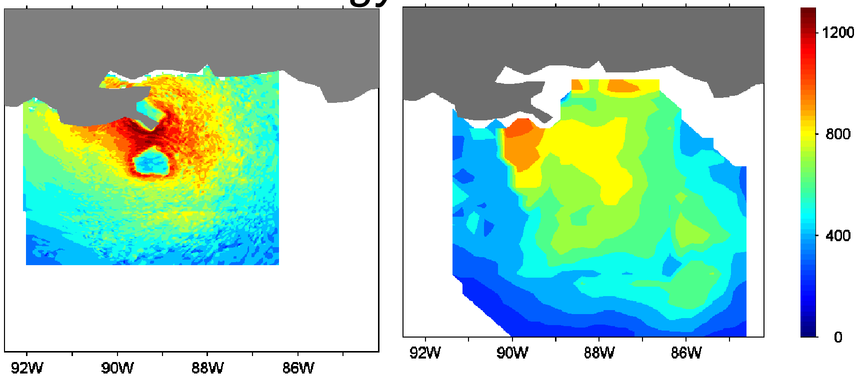


XOVWM Simulation **QuikSCAT 25km**

Wind Speed

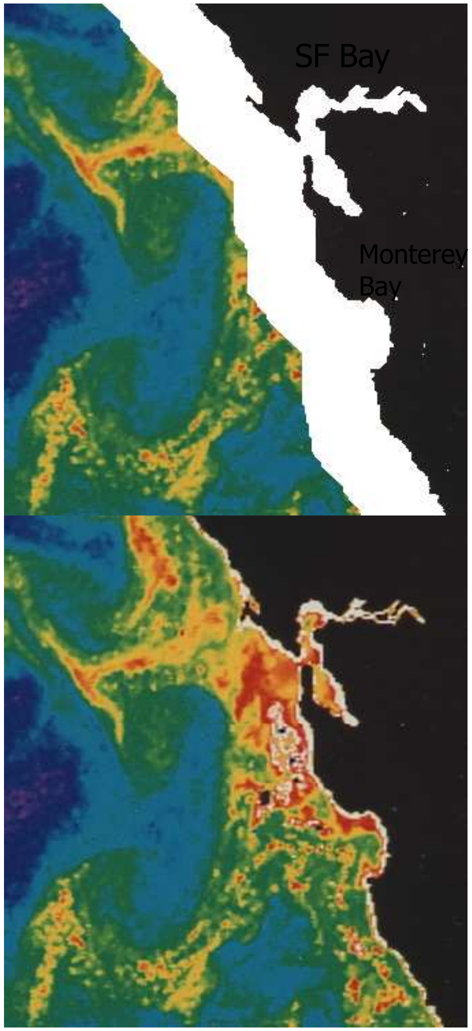


Latent heat energy from the ocean



Sensor resolution affects the magnitude and distribution of latent heat energy from the ocean.

High-Resolution Coastal Winds



Patterns of phytoplankton, created by coastal winds and currents, as seen with ~1-3km resolution (bottom) and what is lost if we can't see within 30km of the coast (top)

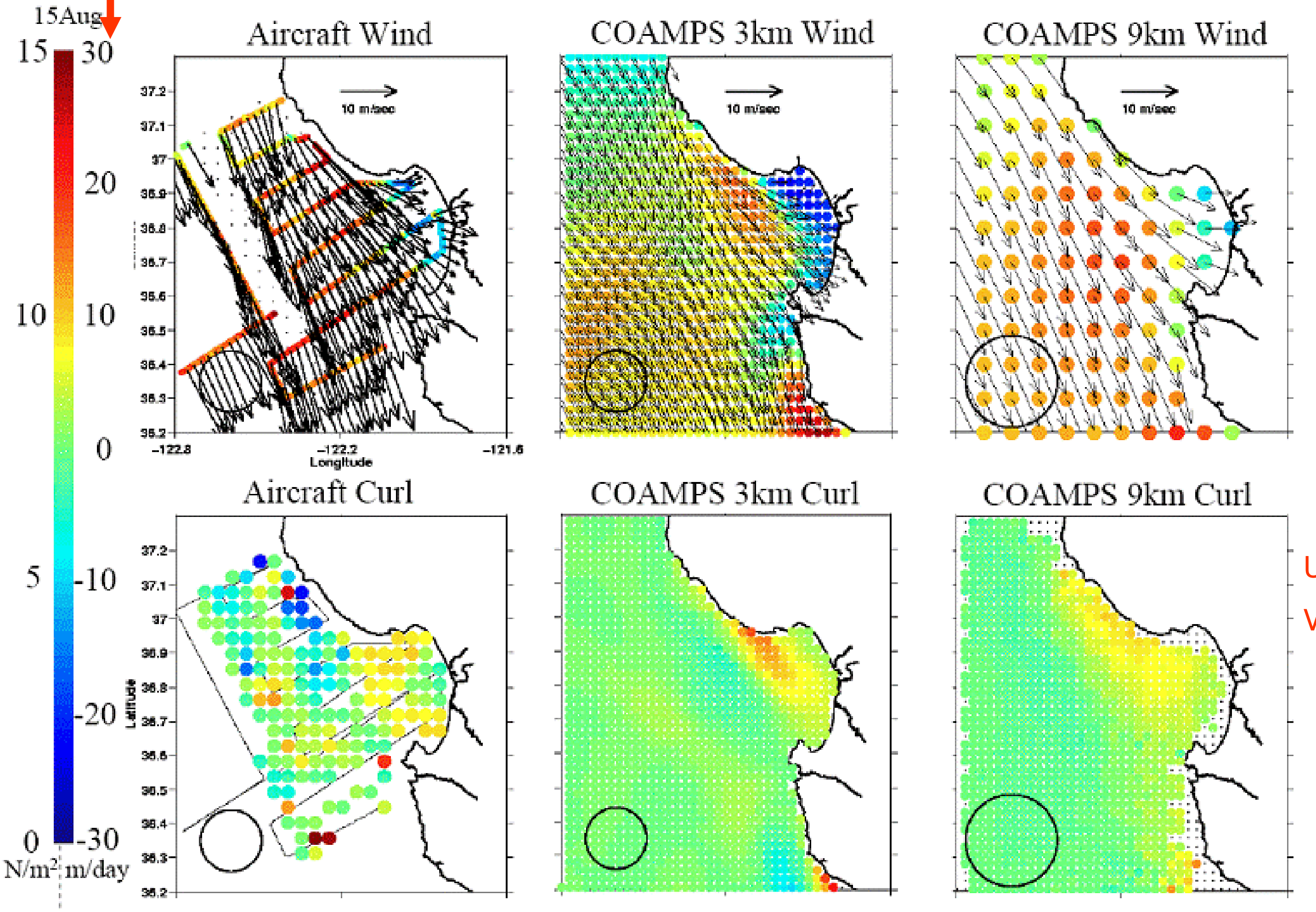
Complex windfields in the 20-30km next to the coast create patterns of currents, temperatures & plankton that fuel the rich coastal ecosystem. With present resolution, we are blind to coastal and detailed offshore wind structure, which may be as complex as phytoplankton fields (left). These winds:

- Are not resolved by our best coastal atmospheric models;
- Interact with surface water temperatures, coastal capes and bays to create both wind shadows and intense narrow jets, which may extend far offshore and are poorly understood;
- Create "centers" of upwelling at coastal and offshore locations;
- Create conditions favorable for productive ecosystems, as well as harmful algal blooms and hypoxia ("dead zones");
- Create currents that advect marine ecosystems, toxic blooms, hypoxic patches of water, disabled ships and the larvae of coastal fish and shellfish into favorable or unfavorable regions for survival;
- Create updrafts and downdrafts that create patterns of clouds and fog.

Images courtesy of Tracy Haack

AOSN Aircraft Observations, August 2003

Upwelling Velocity (m/day)

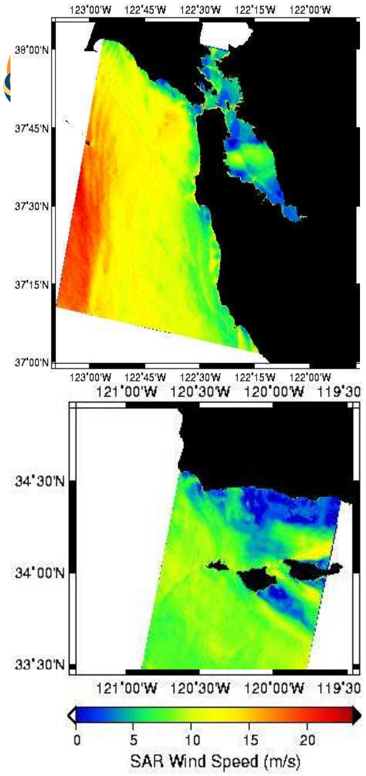


Upwelling

Velocity (m/day)

Jeff Paduan (NPS)

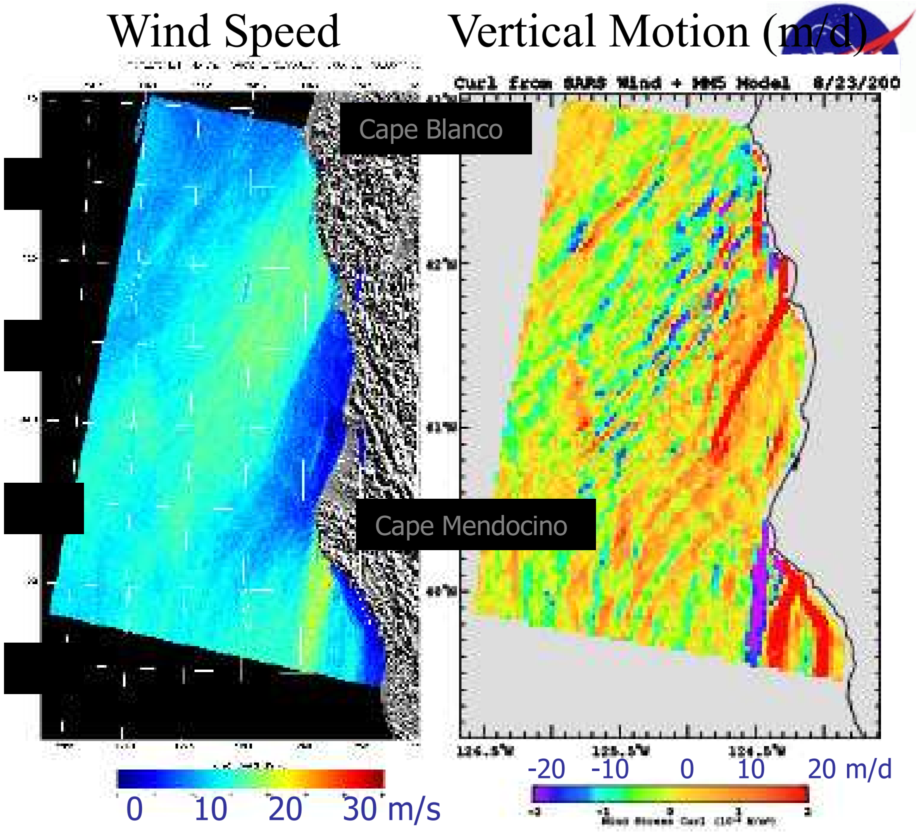
Strub



Detailed Wind Fields

Estimates of wind speed are made from the SAR sensor. Wind direction are estimated from models, allowing calculation of wind stress curl and vertical motion in the ocean. Fields of wind speed and vertical motion (**right**) off California and Oregon capes, with sharp changes in winds (5 m/s to 22 m/s over short distances) and vertical motions of 20-30 m/day.

Similar wind speed fields around SF Bay and the Channel Islands (**left**).


Wind Speed

Vertical Motion (m/d)