Applications and Future Requirements of Satellite Vector Winds for Coastal and Shelf Studies

Steve Morey, Dmitry Dukhovskoy, Austin Todd, Mark Bourassa

COAPS-FSU
Scales of Variability

- Inertial to atmospheric synoptic time scales important to shelf dynamics

- Tropical cyclones – Storm surges, and modification of shelf thermal structure and currents

- Diurnal variability strong in coastal areas

- Potentially large wind gradients in coastal areas due to SST gradients, orography, land/sea breeze
QuikSCAT Temporal Sampling

Mean Time between Scatterometer Overpasses

Maximum Time between Scatterometer Overpasses
Synoptic Scale Variability of Forcing on the Shelf

- The 3-10 day weather band (sub-inertial frequencies) dominates variability on mid-latitude shelves.

- Responses include
  - Upwelling/Downwelling
  - Shelf Waves
  - Coastal Jets
Wind \((u,v)\) components are rotated 35° to the \((u',v')\) axes, roughly along local isobaths. Winds are defined as upwelling when the rotated \(v'\) component is negative.
NARR wind – upwelling component
vs. spline interpolated QuikSCAT wind vs. K-Tower observations

NARR rotated 10m wind (black) vs interp QuikSCAT (green) vs N7 (red)
NARR wind – upwelling component

vs. subsampled and spline interpolated NARR wind

NARR rotated 10m wind (black) vs subsampled (red) and interpolated (green)
Differences between NARR wind (low-pass filtered) and subsampled/interpolated NARR wind – rotated $v'$ component

Errors due to temporal sampling pattern: RMSE = 1.89 m/s or 55.6% of stdev of $v' = 3.40$ m/s

Aliases of diurnal cycle could be an issue near coastal regions
NARR has a low wind speed bias compared to QuikSCAT

\[
m = 1.08
\]
Decrease in NARR bias over time produces a non-stationary time series.
Tropical Cyclones and Storm Surge

- Storm surge popularly considered to occur on the scale of storm size, but significant localization occurs due to:
  - Coastline geometry
  - Storm spatial structure
  - Storm track
  - Incidence angle
Hurricane Dennis, 2005
Hurricane Wind Fields for Storm Surge Simulation and Prediction

• QuikSCAT samples winds too coarsely in time to capture the storm’s movement when nearing the coast.

• Rain contamination and high wind speed retrieval issues cause difficulties in resolving the storm’s structure near the core

• NOAA HRD H*WIND surface wind analyses are widely used for storm surge simulations
H*WIND Surface Wind Analyses

• Accumulates all available surface weather observations within the region (8° x 8°)
  – Ships, buoys, coastal platforms, surface aviation reports, reconnaissance aircraft data, and satellite data

• Data composited over a 4-hour period, height adjusted, and converted to a maximum sustained 1-minute wind speed

• Data are assimilated into a surface wind field model

M. Powell, NOAA AOML HRD
Hurricane Rita H*Wind Fields

09/19/2005 2236Z

→ 10 m/s
From 19 Sep 22:30 to 24 Sep 10:30, 22% of H*Wind Analyses for Rita contained QuikSCAT data.
Summary and Conclusions

- Shelf and coastal circulation and sea level have a strong response to inertial through synoptic period atmospheric forcing.

- QuikSCAT temporal sampling pattern marginally adequate for sampling the synoptic variability at lower subtropical latitudes.
  - In the northern Gulf of Mexico shelf region, the sparse sampling leads to RMS error of about 1.9 m/s (aliasing of diurnal variability?)
  - Study of climate variability (interannual variability or trends) of “storminess” could potentially benefit from the stationarity of the scatterometer record compared to trends in the reanalysis products. But do the errors arising from sparse temporal sampling mask the trends?

- Scatterometer data are potentially valuable for tropical cyclone surface wind field analyses for storm surge modeling and prediction.
  - Rain contamination and high wind speed issues limit usefulness of data near the storm center
  - For Hurricane Rita (2005), only about 22% of H*WIND analyses contained scatterometer data
  - What is the value added by the scatterometer data?