The Use of Synthetic Aperture Radar-Derived Wind Speed in Numerical Weather Prediction Error Detection

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Goals

- Determine if SAR Derived Wind Speed (SDWS) images can be used to detect errors in NWP model forecasts
  - Location errors?
  - Intensity errors?
  - Existence errors?

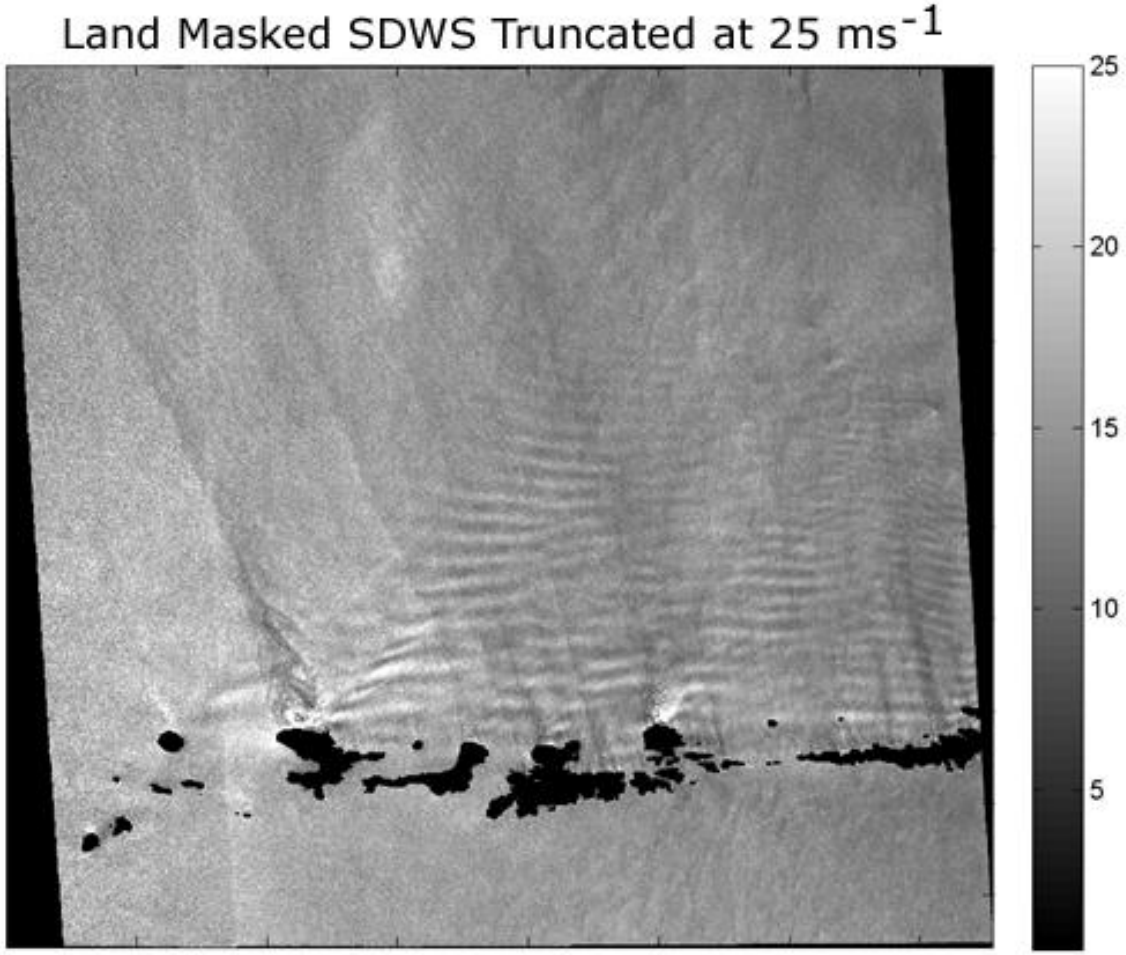
Synthetic Aperture Radar

- SAR – a single-look scatterometer
  - Wide swath modes of RADARSAT-1 and Envisat
  - SAR backscatter yields 10 m wind speed
  - Required wind direction obtained from WRF
- SAR / WRF wind speed disagreement
  - WRF wind speed errors
  - WRF wind direction errors
  - Bottom line: model wind vector is wrong
- SAR resolution: *sub-kilometer*

Observations

- 15 cases from JHUAPL archives
- Gulf of Alaska and Bering Sea
- Mesoscale features sampled:
  - Gap flows
  - Barrier jets
  - Synoptic fronts
  - Pre-frontal jets
  - Secluded cyclones
  - Terrain-induced gravity waves

Observations



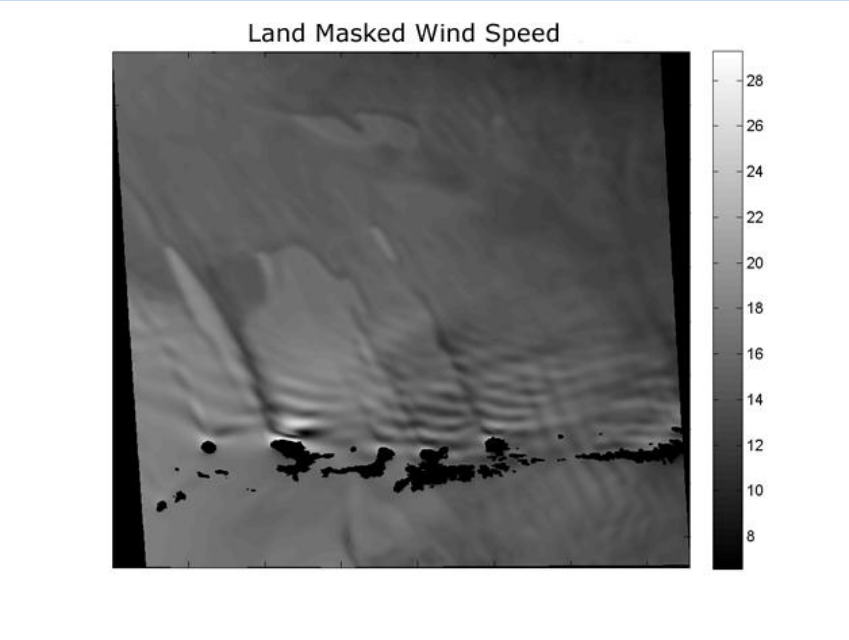
250 m pixels

Model

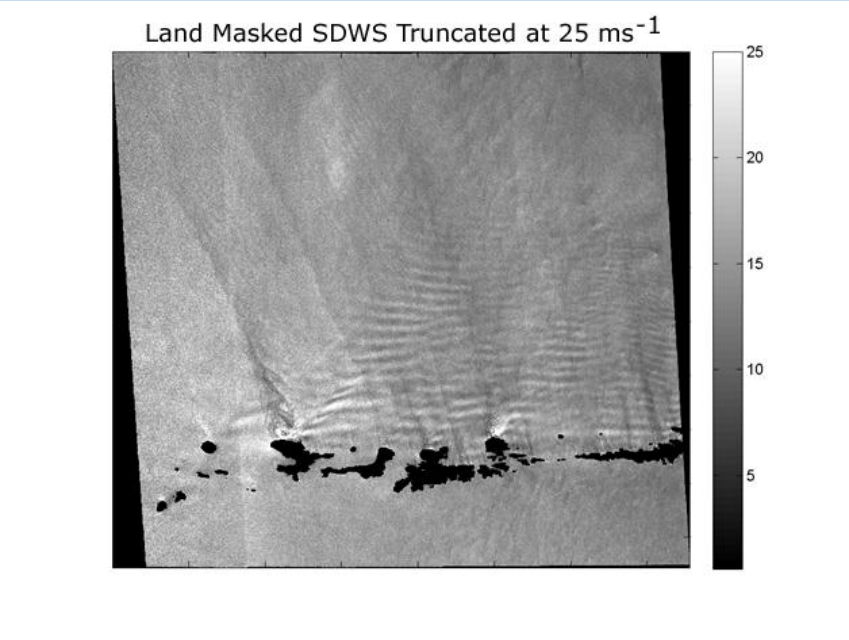
- WRF 3.2
  - Generic operational / research model
  - Allows examination of model performance at multiple resolutions
    - 54, 18, 6, and 2 km grids
    - Full spectrum from operational to research resolutions
  - GFS initial and boundary conditions
  - Parameterizations:
    - Kain-Fritch (but not on fine grid), Rapid Radiative Transfer Model, Dudhia Shortwave Radiation Parameterization, Yonsei University Boundary Layer Parameterization

SDWS vs Modeled Wind Speed

2 km WRF



SDWS

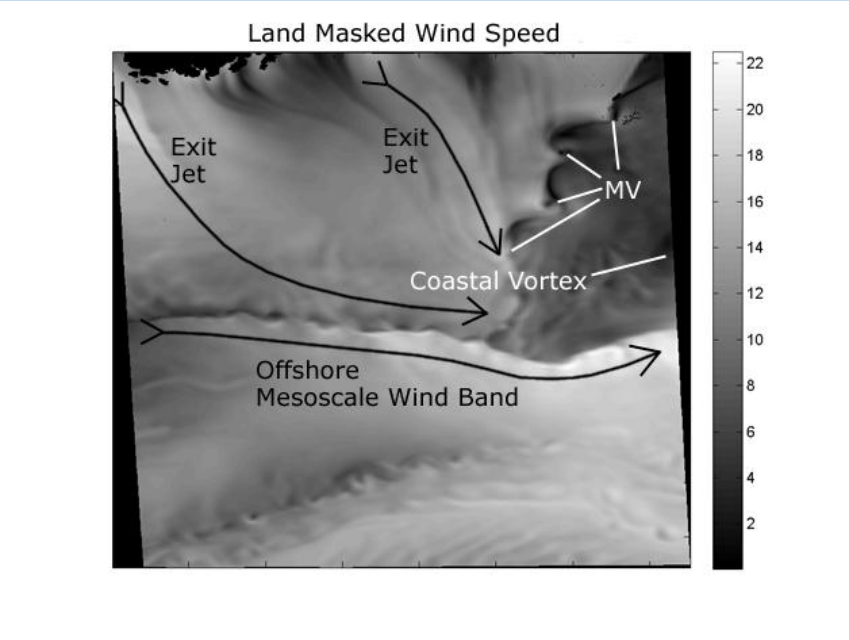


Results

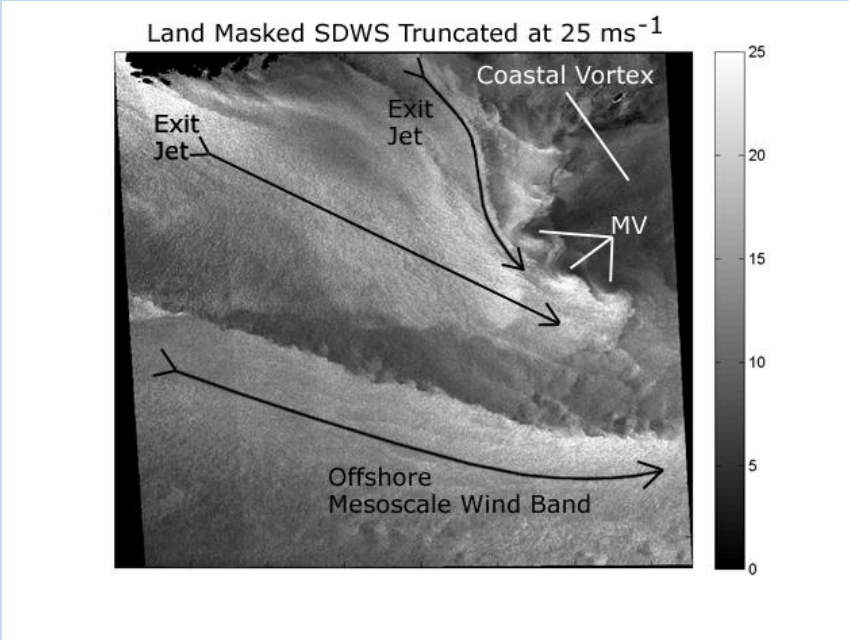
- WRF wind speed and wind direction errors result from:
  - Misplacement of synoptic and mesoscale weather features
  - Failure to resolve mesoscale structures in the boundary layer wind field
- Increased WRF resolution
  - Improved the positioning of these features
  - But not their intensity
- Two-way nesting
  - Had only minor impact on the forecasts produced on the coarse-resolution grids

Misplacement of Mesoscale Features

2 km WRF

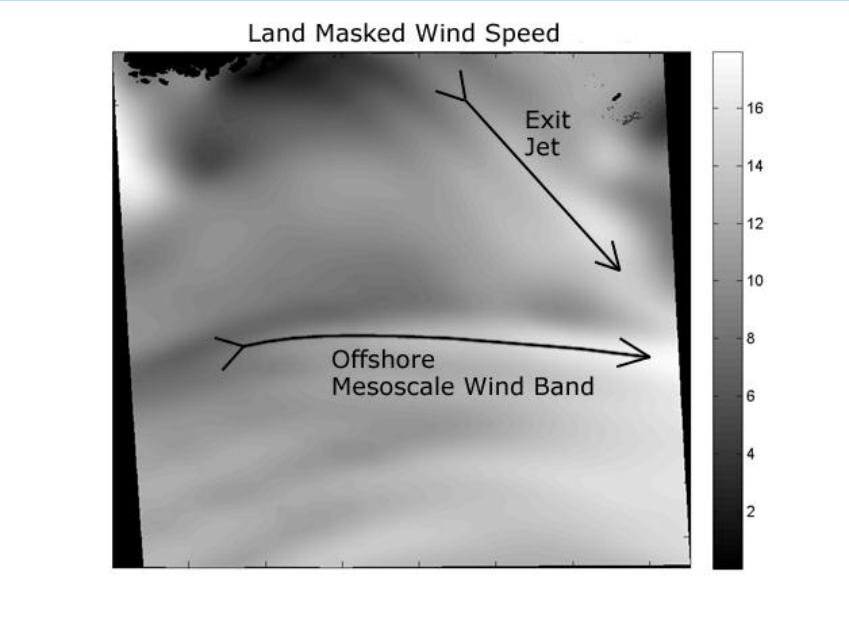


SDWS

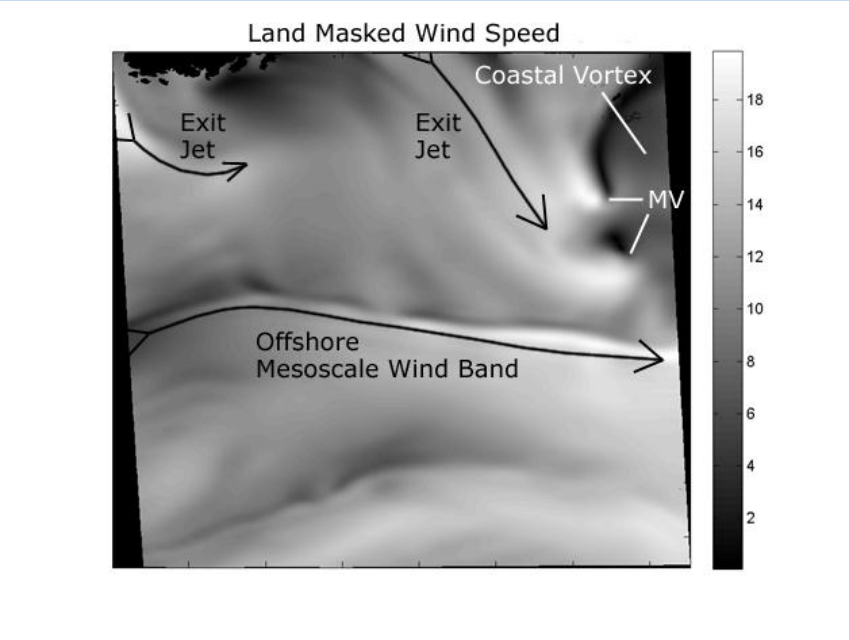


Failure to Resolve Mesoscale Features

18 km WRF

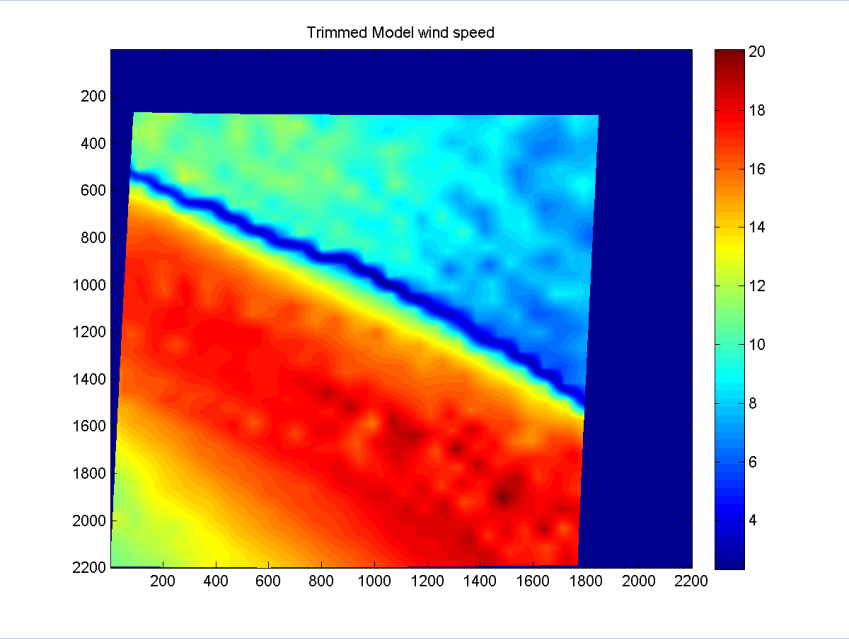


6 km WRF

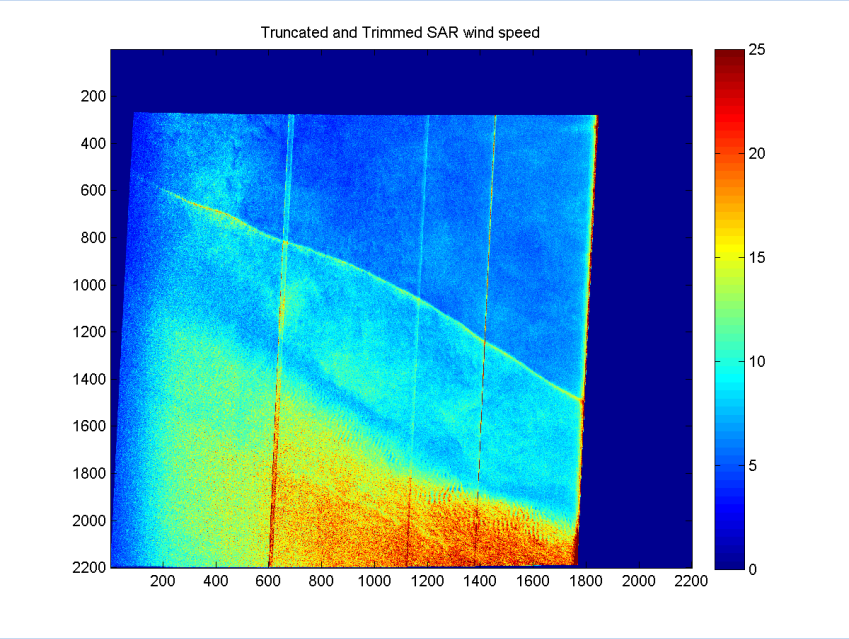


Misplacement of Synoptic Features

WRF



SDWS



Conclusions

- These results confirm the hypothesis that SDWS can be used for both quantitative and qualitative analysis of the scale- and resolution-dependence of NWP model boundary layer wind forecast errors over the ocean
- Moreover, SDWS images can be used to:
  - Alert forecasters to feature misplacement in the early lead times of an NWP model run
  - Enhance forecaster understanding of which mesoscale phenomena remain unresolved by the NWP model and the synoptic settings under which those phenomena occur