Estimating offshore wind fields using synthetic aperture radar and meteorological model data

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Synthetic aperture radar (SAR) provides a promising method for offshore wind field estimation, particularly in the context of offshore wind farm development. This poster outlines an iterative maximum a posteriori probability (MAP) method for combining meteorological model output with synthetic aperture radar data for offshore wind field estimation.

The MAP approach is demonstrated for 40 ENVISAT ASAR scenes collected for 2004-2006 over the UK Irish Sea. Retrieval using the CMOD5 geophysical model functions are presented and retrievals using MAP and a simpler direction based windspeed algorithm are validated against insitu mast observations. The CMOD5 MAP algorithm shows promising results with an estimates on average within 2 ms of the insitu observations.

- Developed by ECMWF and KNMI
- Empirical backscatter model
- Improved estimation of backscatter saturation effects at high wind speeds

Overview

Numerical Weather Prediction (NWP) Data
- UKMO Unified Mesoscale Model (UMM)
  - 6 hourly analysis levels
  - ~10 km cell size
  - To SAR acquisition time
  - To ~2.5 km grid

SAR Wind Inversion

1) Directional Wind Speed Algorithm (DWSA)
- Retrives wind speed assuming NWP wind direction is true
- Problems
  - Assumes SAR variation only due to wind speed changes
  - Doesn’t account for known retrieval errors

2) Maximum Aposteriori Probability (MAP)
- Developed from Bayesian theory
- Estimates optimal wind vector given the SAR observation and apriori (NWP) wind vector weighted by respective covariances
- Solved using iterative Gauss-Newton approach

Sensitivity Analysis
- Backscatter values simulated from CMOD5 for an incidence angle of 20° wind speeds of 5-25 ms⁻¹ and directions of 0° - 180°
- Gaussian error of ±5° applied to true wind direction and winds retrieved for 1000 iterations
- Major errors for both retrievals at moderate wind speeds around 45° and 135°

Example Retrieval
- Retrivals for 51 dates compared against insitu data from Hilbre Island
- MAP provides improved RMSE and correlation with insitu data

Validation
- Percentage Error Plots
  - Backscatter values simulated from CMOD5 for an incidence angle of 20° wind speeds of 5-25 ms⁻¹ and directions of 0° - 180°

- Gaussian error of ±5° applied to true wind direction and winds retrieved for 1000 iterations
- Major errors for both retrievals at moderate wind speeds around 45° and 135°

- SAR Image
- DWSA wind speed
- Apriori wind speed
- MAP wind speed

- CMOD5 DWSA
- CMOD5 MAP
- Hilbre Island