NWS Gridded Marine Verification-- Derivation of 'True' Wind/Wave Fields at NDFD Grids Using A Geostatistical Approach

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Outline

- NWS National Digital Forecast Database (NDFD) marine forecast
- NWS gridded marine verification
- QuikSCAT wind data
- Derivation of truth via a geostatistical approach of Kriging using multiple sources of observations
- Future work

NWS NDFD Marine Forecast

- 10m level wind speed and direction, significant wave height
- Grid sectors: US CONUS, Guam, Alaska*, Puerto Rico, Guam, and Hawaii
- Spatial resolution at 5km
- Temporal resolution: 3 hours for days 1-3 and 6 hours for days 4-7 for wind; 12 hours for days 1- 5 for wave
- All products are currently in experimental stage and are in GRIB2 format (with some soon to be operational)

*** Experimental gridded forecast not available until 2005**

NWS Gridded Marine Verification

- Goal
  - *to develop a stat-on-demand, web-based, and database-driven gridded marine verification system*
  - *To help filed forecasters identify strength and weaknesses in forecast skills*
  - *To assist managers to identify strengths and weaknesses in marine services*

NWS Gridded Marine Verification (cont'd)

- What to verify
  - *NDFD forecasts of wind speed, wind direction, and significant wave height at grids (for desired cycles and projections)*
  - *Wind/wave guidance/model forecasts: interpolated to grids (through bilinear interpolation in 2D x-y directions)*
    - Wind models: GFS, NGM, ETA
    - Wave models: AKW, WNA, NWW3, NAH

NWS Gridded Marine Verification (cont'd)

- How
  - *Wind speed, wind direction and wave height are classified into multiple categories*
  - *A contingency table is computed for each truth – forecast/guidance pair*
  - *Verification statistics/skill scores are computed based on contingency table*
  - *Verification statistics compiled and summarized for marine zones, regions, and WFO's area of responsibility*
  - *Everything implemented so that the system is database-driven and web-based*

NWS Gridded Marine Verification (cont'd)

- Truth?
  - *No observations are available at desired forecast times at every grid point*
  - *Has to be estimated from observations collected at locations in the neighborhood of the NDFD grids.*

NWS Gridded Marine Verification (cont'd)

- Available nearby observations
  - *Fixed buoys/C-MANs data*
  - *Drift buoy, ship data*
  - *Quick Scatterometer Satellite (QuikSCAT) wind data*

QuikSCAT Wind Data

- SeaWinds scatterometer launched in June 1999
- Microwave radar sensors to measure wind indirectly from sea surface roughness
- Rotating dish antenna; one swath, 1800 km wide
- 1.1 million measurements a day; maps 90% of World's oceans every day
- Found to have an impact on the issuance of Marine Wind Warnings by Ocean Prediction Center (OPC).
- Original measurements have been interpolated by OPC to grids of resolution 1/3 degree by 1/3 degree
- Supplement data collected by buoys/C-MANs, especially at areas where such buoy/C-MAN stations are absent

Derivation of Truth Estimation via Geostatistical Approach of Kriging

- **To make maximum use of all kinds of data we adopt Geostatistical approach of Kriging**
- **Key ideas**
  - *Variable of interest is modeled as spatially and temporally random variable whose variability is characterized by its variogram*
  - *Estimate of the variable at any specified location and time is based on a linearly weighted average of the variable at neighborhood locations where observations are available.*
  - *The weights are determined by minimizing the estimation error variance*
  - *Depending on whether the trend is know a prior, whether the estimation is point-wise or block-wise, whether the variable is a continuous or a categorical one, and whether a trend is present, kriging is further classified into simple, ordinary, block, indicator, and universal kriging*

Truth Estimation via Geostatistical Approach of Kriging (cont'd)

- **Desirable properties**
  - *It is the best linear unbiased estimator*
  - *At a location where observation is available, the kriging estimate reduces to the observed or sample value (in the absence of any observation error)*
  - *Kriging smoothes estimates based on the proportion of total variability accounted for by random noise and/or measurement errors.*
  - *Clustered points that are highly correlated in space and time carry less weight than isolated ones at the same distance*
  - *If observations are more highly correlated in a particular direction/dimension, kriging weights will be greater for observations in that direction/dimension).*
  - Kriging will yield estimation error variance as well as the estimate itself

Truth Estimation via Geostatistical Approach of Kriging (cont'd)

- **Modeling of different types of observations**
  - *Presence of observation bias as well as errors are assumed*
  - *Two different measurement instruments (e.g., buoy and satellite) are assumed to have distinct biases and errors*

Truth Estimation via Geostatistical Approach of Kriging (cont'd)

- **Computational effort**
  - *Number of potential NDFD grid sectors: 5*
  - *Each NDFD sector consists of 20,000-50,000 grid points for which estimation of truth is required for all forecast times*
  - *For each grid point, an kriging estimate requires the solution of a kriging system of equations (whose rank equals to the number of observations in the neighborhood of the grid)*

Future Investigation

- Upon availability of more gridded satellite wind data, evaluate performance of the geostatistical approach via cross-validation
- To implementation parallel computation

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