The Use of Radar Altimeter Data to Diagnose Wave Model Initialization and Improve Short Term Wave Height Forecasting

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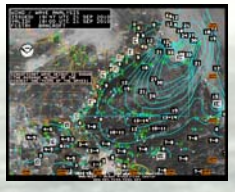
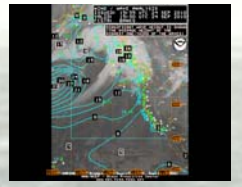
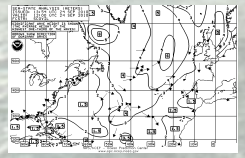
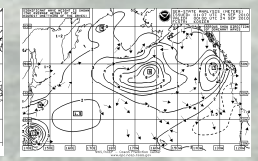
- **NCEP/OPC** – Responsible for issuance of marine warnings, forecasts, and guidance in both text and graphical formats over **Atlantic and Pacific marine areas extending from 20°N to 67°N**

- Significant wave height (SWH) analyses and forecasts to day 5
  - In situ buoy and ship observations
  - Jason-1, Jason-2, and Envisat radar altimeter
  - NOAA Wavewatch III and ECMWF wave models

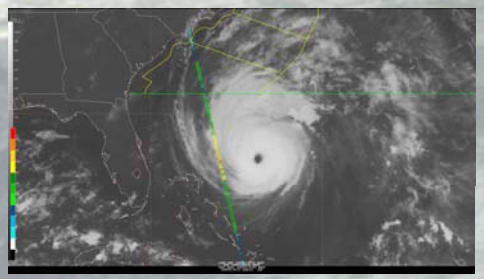








Examples of OPC Atlantic regional (upper left) and high seas (lower left), and Pacific regional (upper right) and high seas (lower right) SWH analyses. Regional analyses (ft) are issued every three hours and high seas analyses (m) once per day.



0215 UTC 02 Sep 2010 GOES infrared satellite image of Hurricane Earl with overlaid 0200 UTC Envisat altimeter SWH (ft). Altimeter data is critical in providing 12 ft seas radii to the National Hurricane Center for active tropical cyclones.

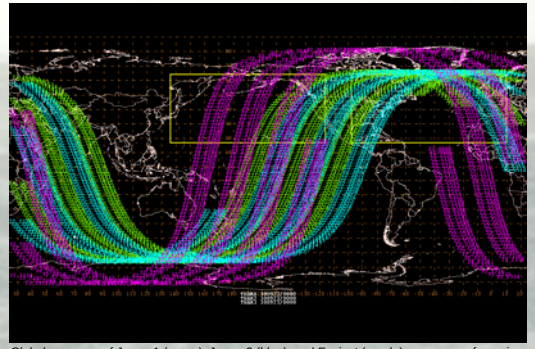
NCEP/OPC – Near real-time significant wave height (SWH) data by Jason-1 radar altimetry since June 2007 and Jason-2 and Envisat radar altimetry since August 2008

To evaluate wave model initialization/first guess:

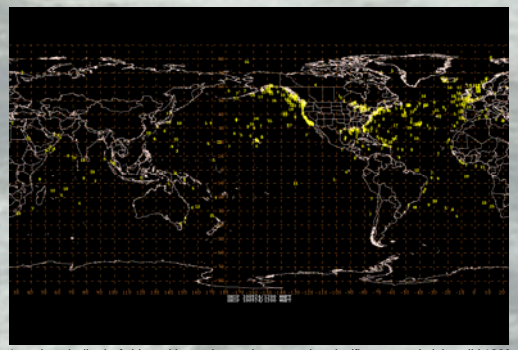
Pre altimeter: Buoy observations
- Very limited spatial resolution

Ship observations
- Subjective and inconsistent methods/means of observing

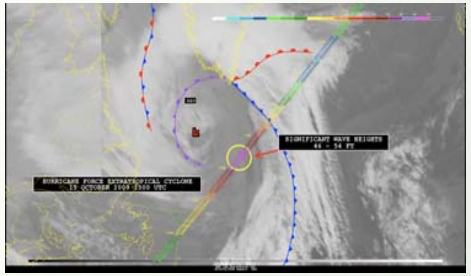
Altimeter data are accurate, consistent, uniformly distributed over all oceans and have a positive impact when assimilated into global wave models.

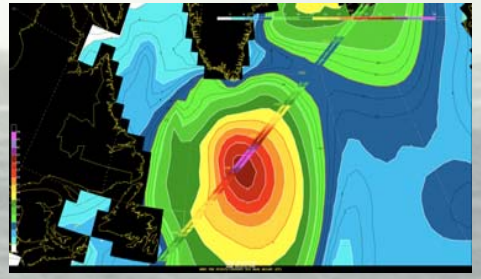


Global coverage of Jason-1 (green), Jason-2 (blue), and Envisat (purple) overpasses for a six hour period ending 0000 UTC 23 Sep 2010. The figure above does not accurately represent the swath width of the instruments which is on the order of km. In contrast to figure below, the altimeter data is uniformly distributed over the oceans.

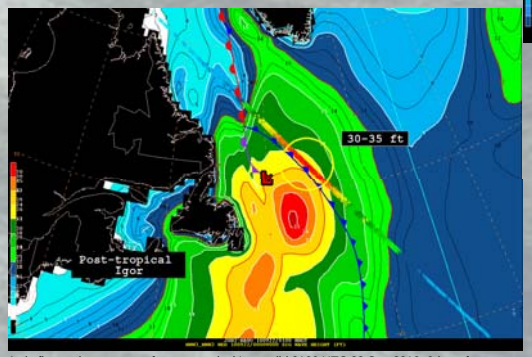


Locations (yellow) of ship and buoy observations reporting significant wave height valid 1200 UTC 24 Sep 2010. Observations are concentrated along the North American and European coasts and over the North Atlantic, but data are sparsely populated elsewhere.



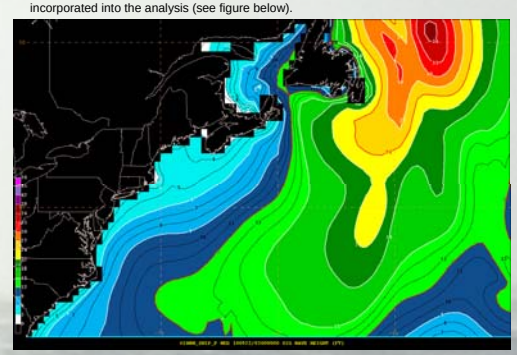


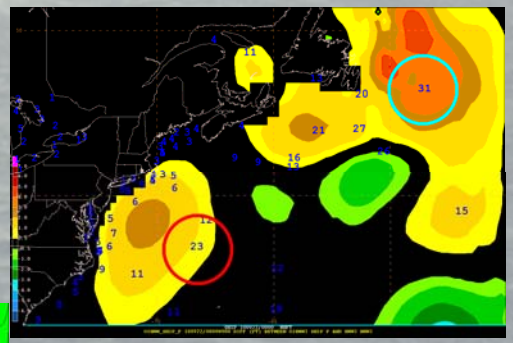
Example of a visualization technique (lower panel) used at OPC to determine initial SWH errors in wave models. Jason-1 altimeter SWHs (ft) are overlaid on the NOAA Wavewatch III SWHs (color filled contours) 9 hour forecast valid 1500 UTC 15 Oct 2009. Using the same color intervals in each data set allows forecasters to rapidly identify model errors. In this case the model is (1) depicting a smaller areal extent of SWH 30 ft or greater, (2) 30% - 40% underdone with the maximum SWHs, and (3) incorrectly placing the maximum SWHs 2-3 degrees South of the maximum indicated by the altimeter data.



As in figure above, except for post-tropical Igor valid 0100 UTC 22 Sep 2010. 6-hour forecast from 1800 UTC 21 Sep 2010 run of NOAA Wavewatch III SWH (color filled contours). Model is significantly underdone with SWH Northeast of low center where altimeter data indicate 30-35 ft and model shows 21-24 ft.

OPC Optimal Interpolation (OI) SWH analysis valid 0000 UTC 22 Sep 2010 (ft). OI uses radar altimeter, NOAA Wavewatch III, ship and buoy observations, and also allows the forecaster to interactively delete suspect ship observations from being incorporated into the analysis (see figure below).





Difference between 0000 UTC 22 Sep 2010 OI SWH analysis and the 1800 UTC NOAA Wavewatch III 6-hour forecast (ft). 0000 UTC buoy and ship observations are overlaid in blue. The radar altimeter data incorporated into the OI analysis is not shown. The 31 ft and 21 ft observations East and Southwest of Cape Race, Newfoundland, respectively resulted in higher SWH values in the OI analysis. The spurious 23 ft ship observation (circled in red) was manually deleted from the OI resulting in only a 1 ft difference in the OI analysis.

Summary

- Near-real time altimeter data have improved OPC sea state analyses and short term SWH forecasting. Multisatellite altimeter data has been shown to have a positive impact when assimilated into wave models at a global scale (Skandrani et al 2004)
- From an operational wave forecasting perspective, visualization techniques developed at OPC allow forecasters to rapidly initial wave model errors under tight time constraints over extensive forecast areas
- Altimeter data from multiple satellites are allowing for the development of wave climatology
- Altimeter SWH under investigation to be added to the NWS National Marine Verification Program for high seas SWH verification