Phenomenal sea states and swell radiation: a comprehensive analysis of the 12-16 February 2011 North Atlantic storm

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Phenomenal sea states estimated from altimeters, SAR, buoys, seismometers, and WaveWatch-III model

Abstract: Several storms with hurricane-force winds cross the North Atlantic every year. Observing the dynamics of these storms is a particular challenge because in situ observations are scarce in the middle of the ocean, and opportunities to validate remote sensing techniques are rare. As a result of sensor saturation and/or reduction in SNR, satellite observations of wind speeds above hurricane force (32.7 m/s) signiﬁcant wave heights above 15 m and wave periods above 14 s are considered to have low levels of conﬁdence. Additionally, numerical models, both of the ocean and of the atmosphere, are generally believed to underestimate the severity of such extreme events. In February 2011 the north Atlantic storm Quirin produced the largest hurricane-force wind speeds by a satellite, with a significant wave height of 20.3 m. Observations from space buoys and seismometers above swell periods of 21-25 days along the western coast of Europe, from the Canaries Islands to the Hebrides and as far west as Greenland. These exceptionally long swells were also captured by Eosat’s Synthetic Aperture Radar observations in wave mode with a peak wavelength of 700m, corresponding to a 22 s peak period.

We intend to present for this particular storm a comprehensive view of wave energy and periods using information from satellites, in situ buoys, and land-based seismometers. The relationship with the storm power can be analyzed using both the wave fields produced by the WAVEWATCH-III model. It showed that despite known limitations of both models and observations, we obtain a fairly coherent description of the wave ﬁeld that can be comprehensively related to the Quirin storm characteristics. The fact that the model is capable of reproducing the wave properties well in extreme conditions requires further validation, but also encourages us to use it as a tool to study the ocean energy ﬂows due to this particular storm, and to investigate the mechanisms leading to such conditions.

Figure 1: Average annual frequency of storms and hurricanes of hurricane force (V>32.5 m/s) and with a maximum peak period at each buoy. The circle represents the time of arrival of the maximum peak period and the color signiﬁes the value of the peak period at this time.

Figure 4: Peak periods as calculated by the WaveWatch III model: 1) from SAR, wave buoy, and seismometers observations. The background shows the model values at 1200 on the 15, as the longest swell continues making its way along the west coast of Scotland. The square symbols represent the wave buoy data, the size of the symbol signifying the SWH at the time of the maximum peak period and the color signifying the value of the peak period at this time. Beside each symbol is printed the time of arrival of the maximum peak period at each buoy. The circle gives the location of the SAR observations and the diametral symbols represent the seismic stations, also colored according to the peak periods observed.

References: