Corrupted QuikSCAT Data and Resultant Erroneous Wave Watch III Output

Robert Burke
NOAA National Weather Service
Honolulu Forecast Office
Honolulu, Hawai,
Robert.Burke@noaa.gov

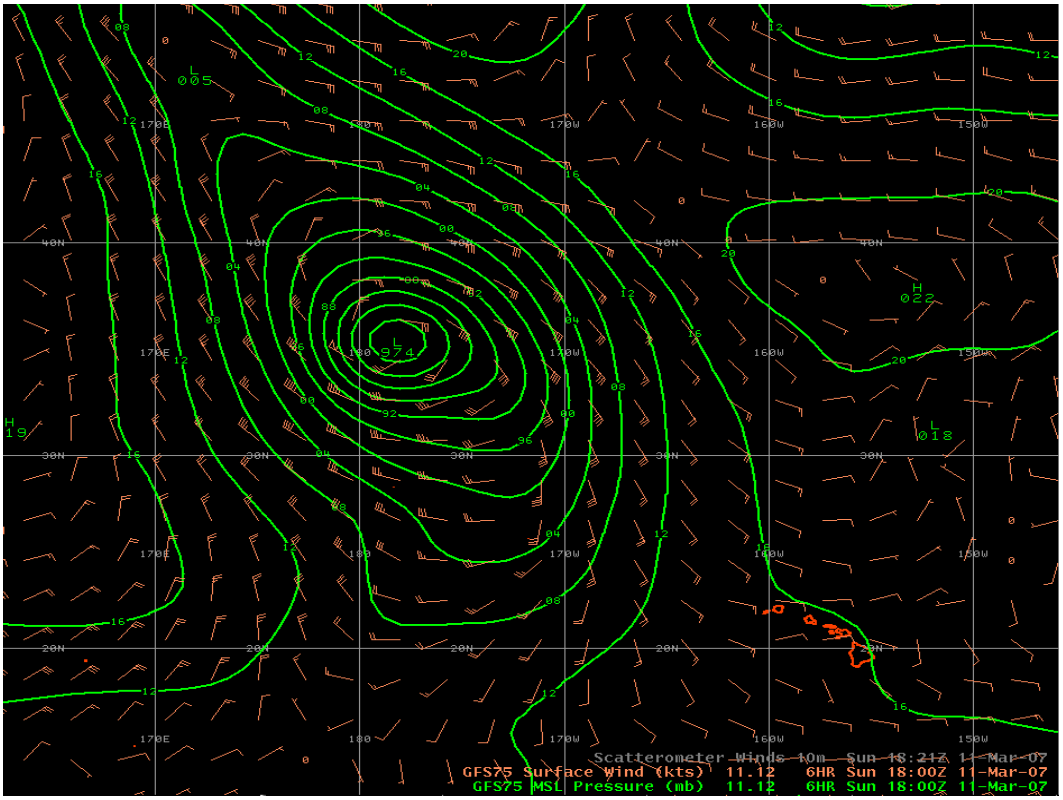
Patrick Caldwel,
NOAA Data Centers, Hawaii Liaison Office
Honolulu, Hawaii
patrick.caldwell@noaa.gov

Abstract:

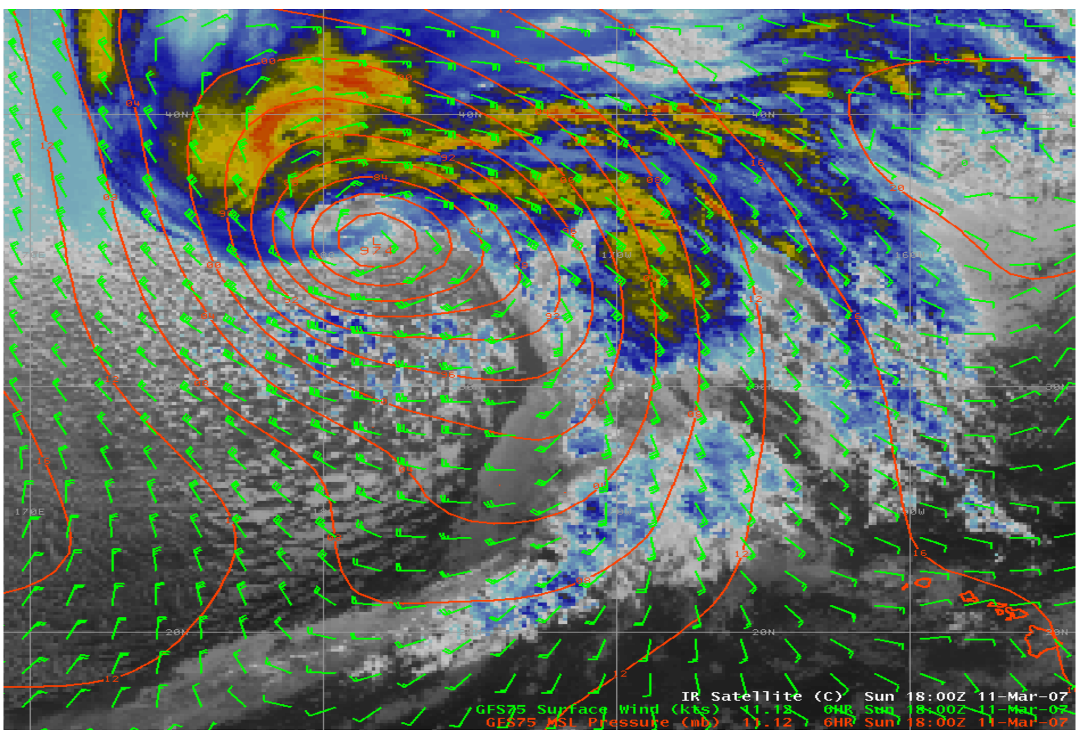
Surf is the most frequent weather-related killer in Hawaii. Surf forecasts are routinely prepared by the NOAA National Weather Service Honolulu Forecast Office (HFO) for the protection of life and property. Marine forecasters utilize meteorological and oceanographic observations as well as model output-- the most important from the Wave Watch III. This model relies on initial conditions from weather models, which in turn input various sources of observations such as QuikSCAT estimates of ocean surface winds.

On Tuesday March 13th 2007, the largest northwest swell of the season reached the Hawaiian Islands resulting in warning level surf exceeding 7.5 m (25 feet). Prior to 18Z Sunday March 11th 2007, global weather and wave models were resolving well the swell source-- an evolving storm-force, extra-tropical cyclone.

A QuikSCAT pass centered over the low pressure area around 18Z on the 11th had significant errors in the wind field, primarily with wind direction. Due to lack of any ship or surface data in the area, the QuikSCAT winds were used in the 18Z Global Forecast System (GFS) model initialization. The result was a much weaker low and an unrepresentative wind field. The GFS input to the Wave Watch III model resulted in much lower seas in the fetch area aimed at Hawaii. Forecasters at the HFO were quick to pick up on this erroneous output and reverted to previous model output for swell and surf forecasts associated with the approaching wave train. This study shows the continued need for quality control of input data into the GFS and Wave Watch III models. Introduction of erroneous data can cause significant errors in the resulting forecasts of winds and waves.



Slide 1: 12Z GFS run-- 18Z forecast with isobars and winds. Central pressure is 974 mb.



Slide 2: 12Z GFS run--18Z forecast with isobar, winds and IR satellite image

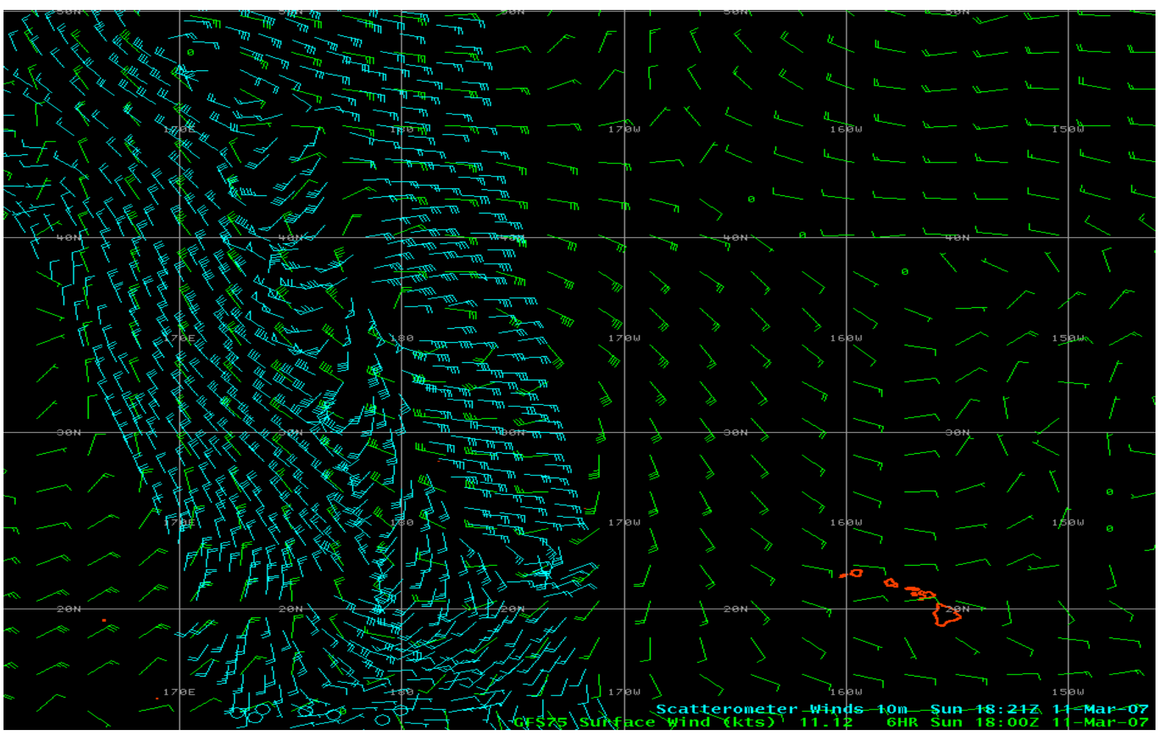
Discussion:

Large waves are common in the Hawaiian Islands. Usually a few times per year, the islands receive swell events that have the potential to cause damage to property as well as inundate coastal roads. High surf poses danger to swimmers and beachgoers. Forecasters at the HFO are responsible for issuing High Surf Advisories and Warnings. Expected surf heights, arrival time and duration of an episode can be deduced by estimating the evolving open ocean wave characteristics at the source relative to its distance from Hawaii.

More times than not, getting ground truth data around strong extra-tropical cyclones in the North Pacific is not possible because most ships avoid the system's path based on forecasts issued by the National Weather Service and the Japan Meteorological Agency. QuikSCAT data over the open waters are valuable for forecasters in analyzing a system's structure. It can then be matched up with output from weather models to fine-tune a forecast.

The last reliable GFS run was March 11th at 12Z (Slide 1) which shows a 974 mb low centered near 36N 178W at 18Z. Slide 2 shows this model output overlaid with an IR satellite image.

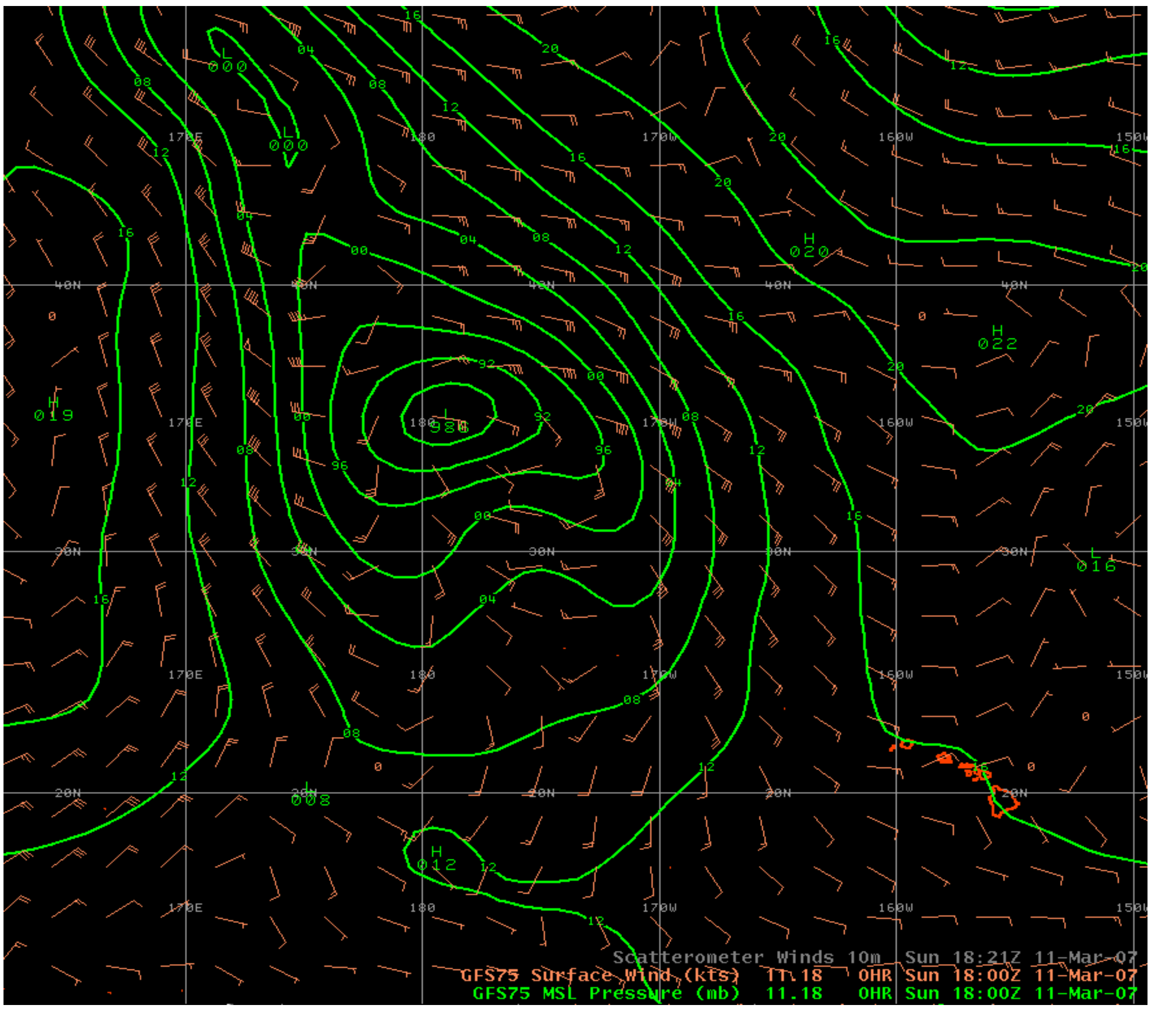
The expected wind field at 18Z from the 12Z GFS run (Slide 3) is overlaid with a QuikSCAT pass that occurred around 18Z. It is obvious that the QuikSCAT pass was in error with a very unrealistic wind field depicted.



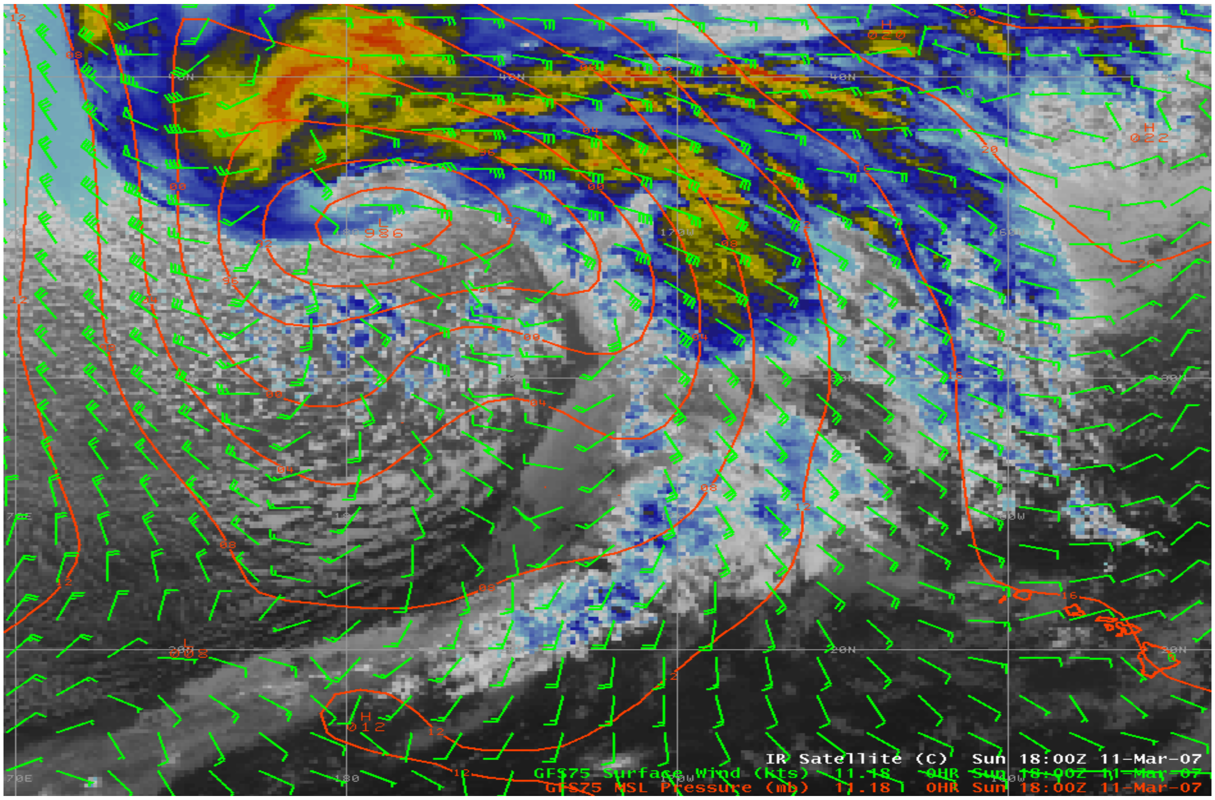
Slide 3: 12Z GFS run for 18Z winds (green) and 18Z QuikSCAT pass (blue).

When the 18Z GFS output became available, forecasters at HFO noticed that the storm system did not look like what was expected from the previous run (Slide 4). The central pressure was now higher by 12 mb than the previous run indicated. Also the wind field and pressure pattern did not have a realistic surface stream-flow pattern as suggested by the infrared (IR) satellite image (Slide 5).

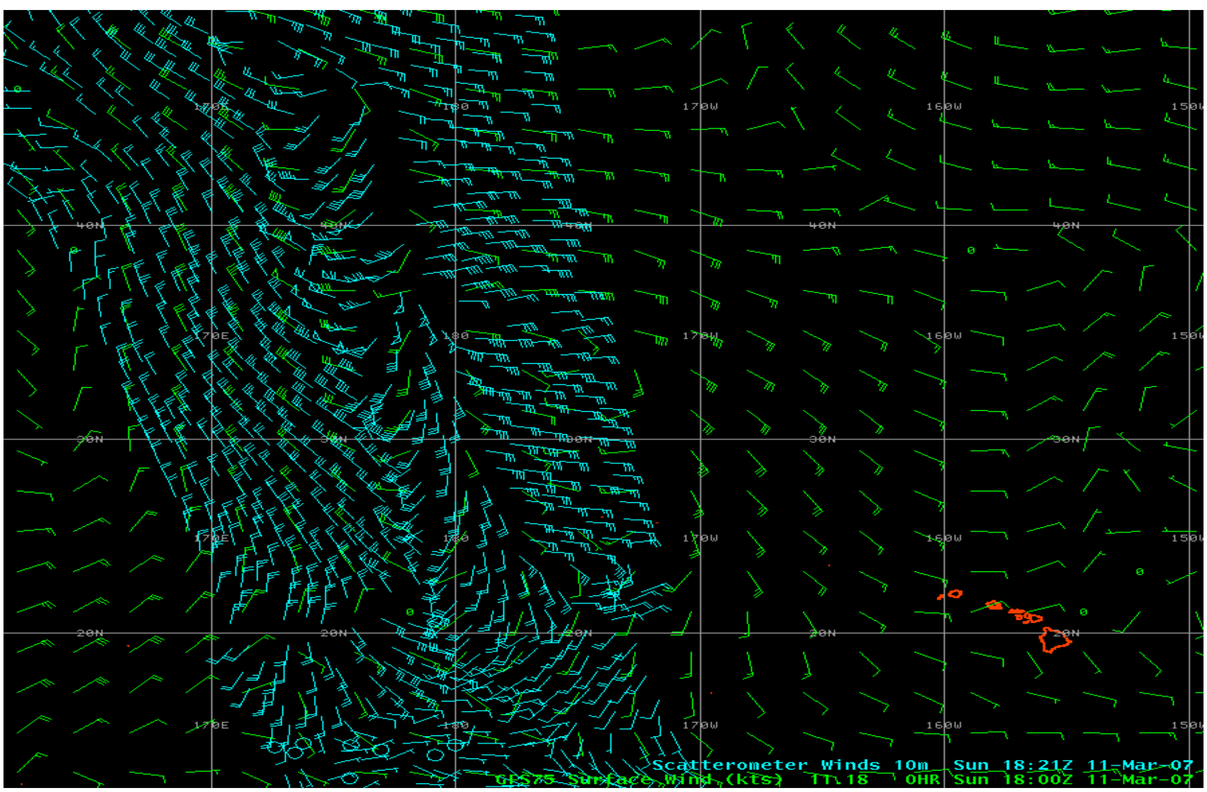
Thus the wind field was overlaid with the QuikSCAT pass (Slide 6) and it was obvious that the model had a significant error in its depiction of the low and its associated wind field. The culprit for the bad model output was the 18Z QuikSCAT pass, which was used as input to the 18Z GFS run. Slide 7 shows both the 12Z and 18Z forecasts valid at 00Z. The difference in central pressure was 21 mb.



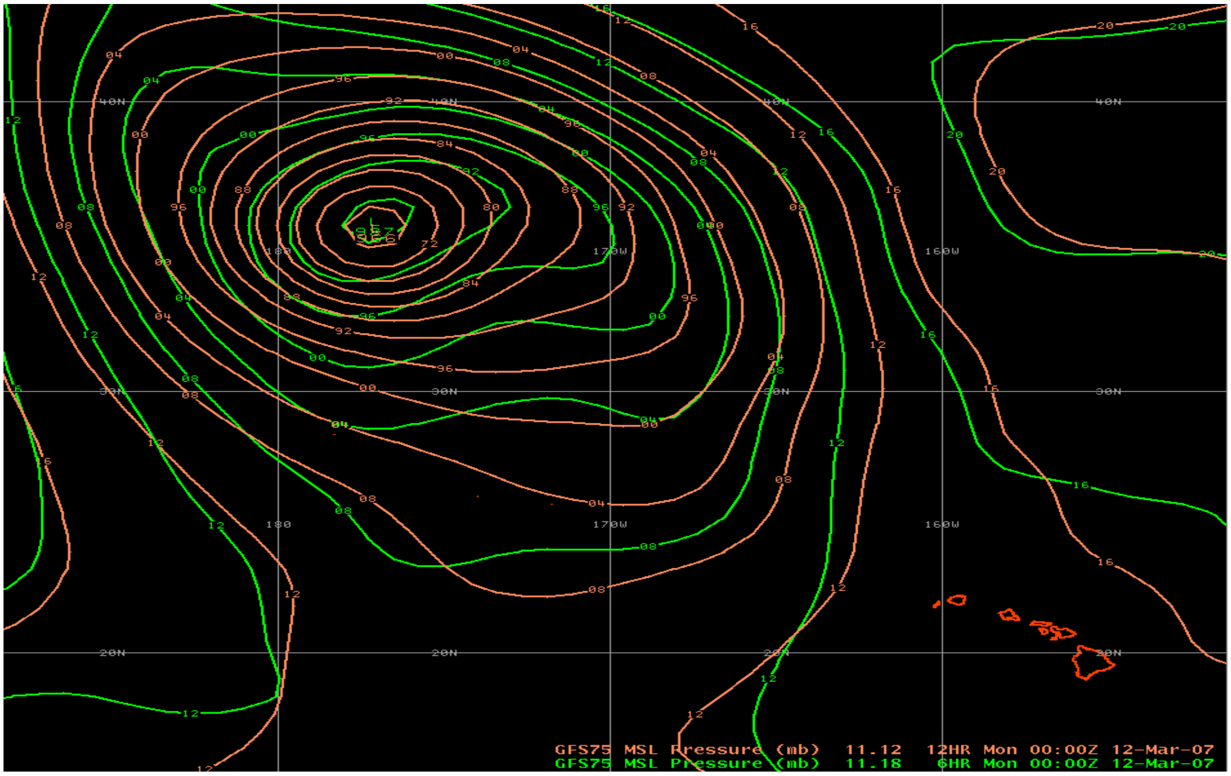
Slide 4: 18Z GFS Run with 18Z initialization for isobars and winds. Central pressure is 986 mb.



Slide 5: 18Z GFS run for 18Z isobars and winds. IR satellite image for 18Z is overlaid.



Slide 6: 18Z GFS run for 18Z winds (green) and 18Z QuikSCAT (blue) pass.

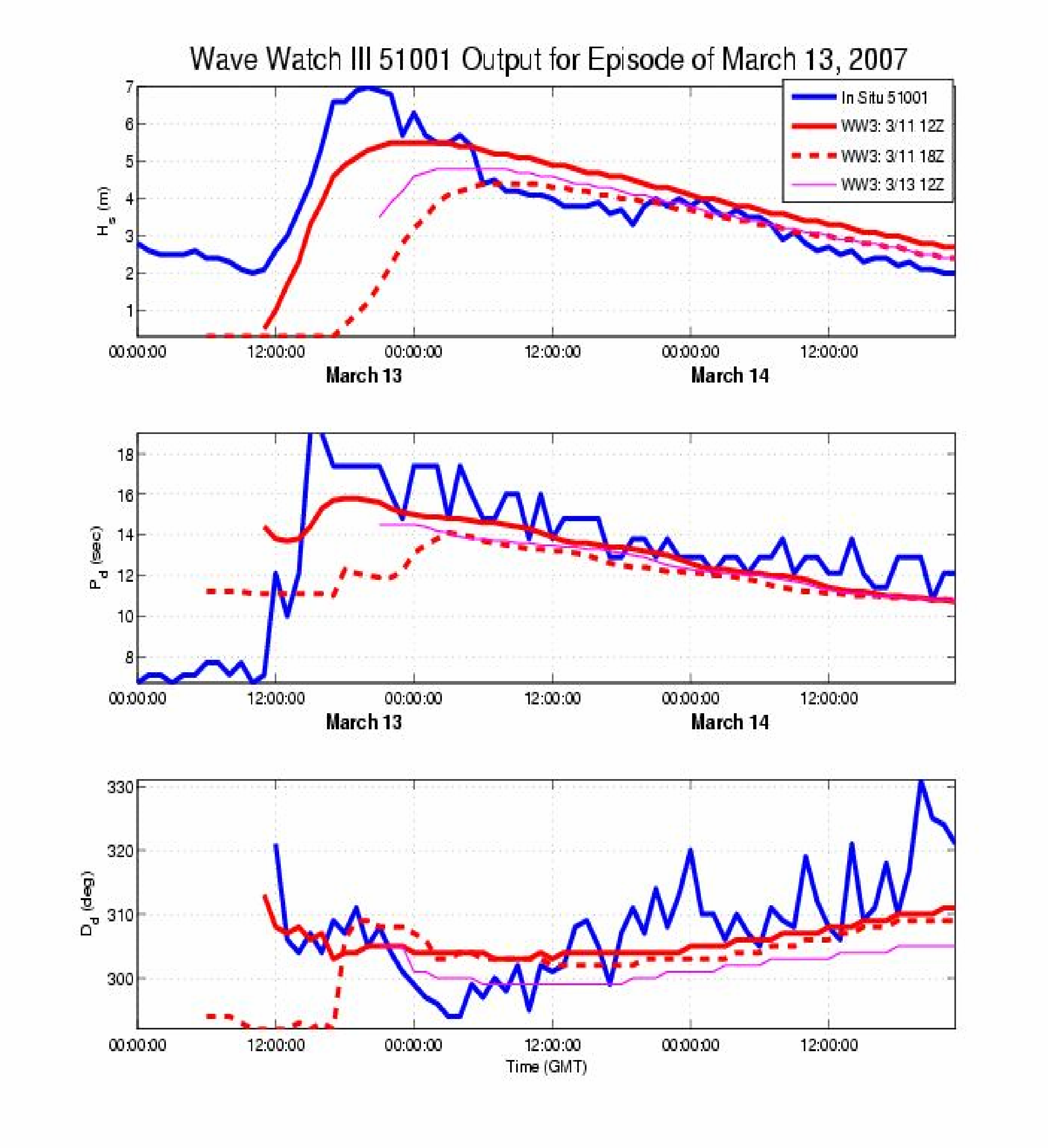


Slide 7: Isobars-- 12Z (red) and 18Z (green) GFS run for the 12 March 00Z forecast.

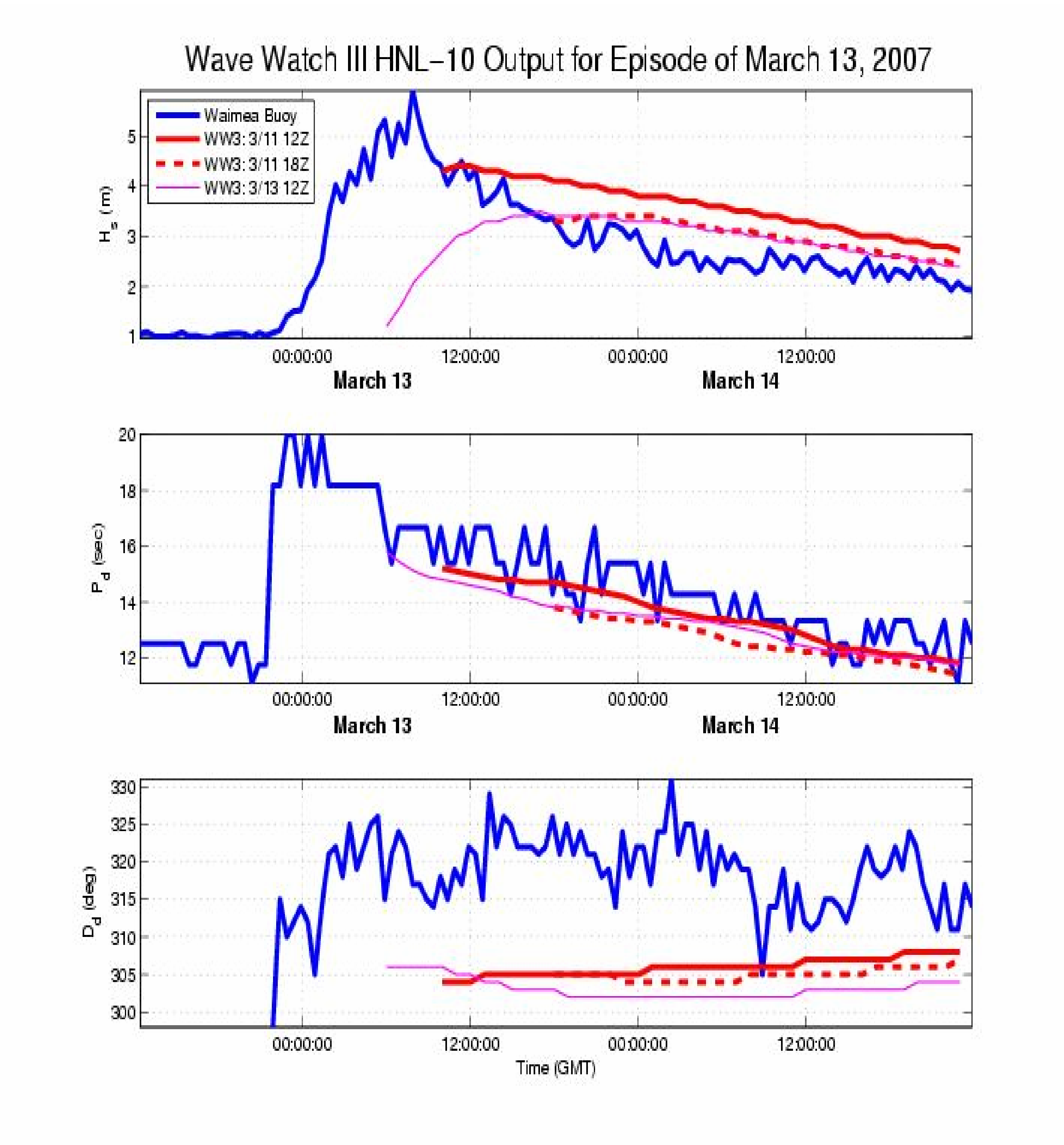
The Wave Watch III (WW3) model uses GFS winds as an optional input. Forecasters at HFO knew days in advance of this potentially large swell episode. Before 18Z on the 11th, output from WW3 had been showing deep water wave heights of over 5 m (16 feet) over the coastal waters just west of Kauai. However when the 18Z WW3 model output was available, it was quite obvious that the numbers were wrong. The resultant output had much lower wave heights, shorter periods and a much later arrival time.

When the swell finally arrived on the 13th at buoy 51001, which is located to the northwest of Kauai, it ended up being bigger, had longer periods and had a much earlier arrival time than even the non-corrupted WW3 model output was showing. Slide 8 shows the data from buoy 51001 as well as the WW3 output from 12Z and 18Z on the 11th and from 12Z on the 13th. Even the direction of the swell had a more westerly component to it for a period of time, which can have a significant impact on shores exposed to the west-- especially the Kona side of the Big Island. Slide 9 shows the data from the Waimea buoy and the WW3 model output from a nearby data point (HNL10), with similar results.

Surf reports from the 13th were reported to be 7.5-9 m (25 to 30 feet) with some waves as high as 12 m (40 feet) on outer reefs. Slides 9 and 10 are photos from the North Shore of Oahu on the March 13, 2007. Slide 10 was taken at Waimea Bay while slide 11 was taken at an outer reef know as Outer Log Cabins.



Slide 8: Data from buoy 51001 and 3 runs of Wave Watch III.



Slide 9: Data from Waimea Buoy and nearby Wave Watch III output.

Slide 10: Waimea Bay: Photo: Jamie Ballenger, HawaiianWatershots.com

Slide 11: Outer Log Cabins: Photo: Allen Mozo, BillabongXXL.com

Conclusion:

QuikSCAT has been a very important tool in helping marine forecasters, especially when ship observations are few or absent. QuikSCAT is also a source for initializing global weather models, which in turn feed global wave models. Marine forecasters pay close attention to all available observations and model products, take note when discrepancies unfold, and thus are a critical element in the quality control process. It is recommended that marine forecasters stay attentive to potentially erroneous data and notify data sources and weather model groups as soon as an error is identified, such as in this case with corrupted QuikSCAT data.

Acknowledgments:

Wes Browning, the Director of Operations at the HFO is acknowledged for his help in acquiring the weather slides. Degui Cao of the NOAA National Center for Environmental Prediction is thanked for access to the historic tabular WWIII output. Buoy 51001 data are courtesy of the NOAA National Data Buoy Center and the Waimea buoy data from the Department of Oceanography of the University of Hawaii and the Coastal Data information Program of Scripps Institute of Oceanography. The HFO is appreciated for support to Mr. Burke and the National Coastal Data Development Center is recognized for support of Mr. Caldwell.