Impacts of Hurricane Igor on Ocean Environments off Newfoundland

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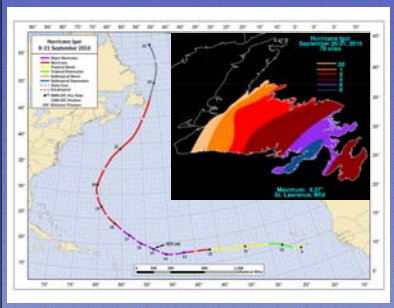
Objectives

Hurricane Igor hit Newfoundland on Sept. 21-22, 2010 and brought in heavy rainfall (Fig. 1). It caused huge damage to roads and properties. Here we use satellite altimetry, thermal imagery and ocean color data to examine the impacts of Igor on the ocean environment over the Grand Banks of Newfoundland.



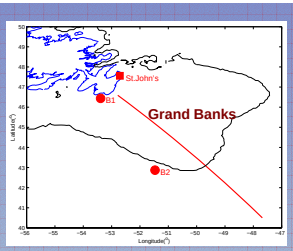


Fig. 1Hurricane Igor track (upper left) and precipitation (upper right) over Newfoundland (from Pasch and Kimberlain, 2010). In the lower panel, the red line is an altimtery ground track across the Grand Banks of Newfoundland, the square is St. John's tide-gauge site, and the red dots are buoy locations. The 200-m isobath is also depicted (black line).

Data

Satellite Altimetry Data

We have used RADS-based Jason-2 sea level and significant wave height data on a track across the southeast Grand Bank. The satellite passed over the region around 2:40 am, September 22, 2010.

Hourly sea level data at St. John's tide-gauge station are from the Canadian Hydrographic Service. The tide-gauge data were detided to produce residual sea level relative to the long-term mean sea level. The buoy (see Fig. 1 for location) data (significant wave height and sea surface temperature) are from Environment Canada.

AVHRR Data

Daily AVHRR SST data from NOAA are averaged to produce 8-d means. The spatial resolution is 4 km.

MERIS and MODIS Data

We used 8-d merged chlorophyll data based on MERIS and MODIS from the ACRI-ST GlobColour Service. The spatial resolution is 4 km.

Total Sea Level

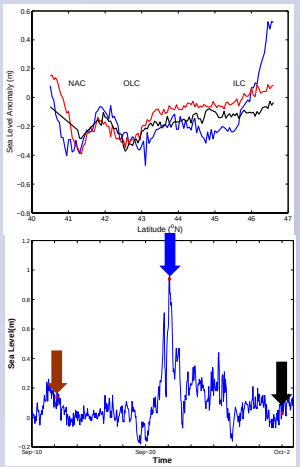


Figure 2. Sea level profiles along the satellite track (see Fig. 1 for location) before (red), during (blue) and after (black) Hurricane Igor are shown. During the storm, there are significant sea level change, characterized by a surge near the coast and a depression over the mid Bank. The lower panel shows the residual sea level at nearby St. John's tide-gauge station. The red squares indicate the sea level anomalies at the times of the satellite passing. NAC: North Atlantic Current; OLC:, Offshore Labrador Current; ILC: Inshore Labrador Current.

Sea Level (IB Effect Corrected)

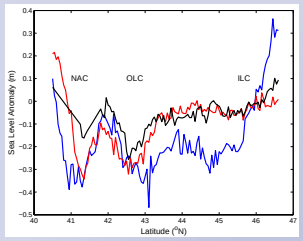


Figure 3. Sea level profiles along the satellite track (see Fig. 1 for location) before (red), during (blue) and after (black) Igor The sea level patterns suggest that the inshore Labrador Current was significantly enhanced and the Gulf Stream moved offshore. It is of interest to find out how much the enhancement of the inshore Labrador Current at this location is propagated from the upstream.

Significant Wave Height

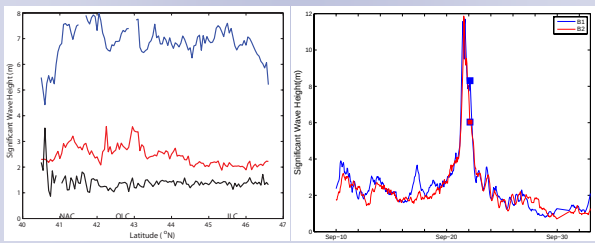


Figure 4. Altimetry-observed significant wave height along the satellite track before (red), during (blue) and after (black) Igor (left panel). The significant wave height near the coast is around 6 m at 2:40 am, Sept. 22, 2010, consistent with nearby buoy observations (right panel, see Fig. 1 for location).

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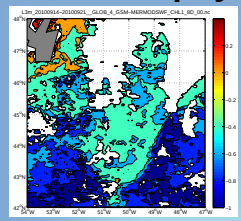
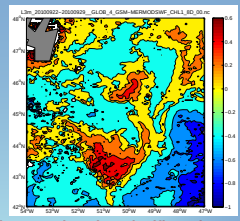
References

Richard J. Pasch and Todd B. Kimberlain, 2010: Tropical Cyclone Report Hurricane Igor (AL112010) 8-21 September 2010, National Hurricane Center. http://www.nhc.noaa.gov/pdf/TCR-AL112010_Igor.pdf

Chlorophyll Concentration





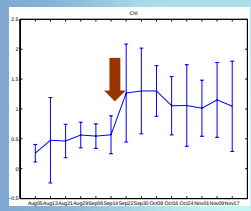


Figure 5. There is a significant increase of the chlorophyll concentration (log scale, mg/m^3) from the prior- (upper left) to post-Igor (upper right) 8-d period. The mixing due to the strong wind and upwelling associated with the cyclonic wind stress curl brought the nutrient to the surface , triggering phytoplankton bloom. The time series (averaged for the area shallower than 200 m and with the standard deviation indicated as the vertical bar) indicate that the bloom lasted for a few weeks or longer (left panel). It is of interest to find out if the persistence is due to the horizontal advection or the general increase of the wind mixing in fall.

Sea Surface Temperature

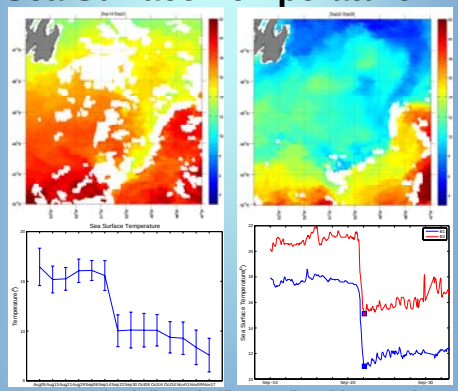


Figure 6. AVHRR data indicate significant cooling of the sea surface temperature from the prior- (upper left) to post-Igor (upper right) period. The mixing due to the strong wind and upwelling associated with the cyclonic wind stress curl brought the cold subsurface water into the near surface layer. The satellite temperature time series (lower left, averaged for the area shallower than 200 m and with the standard deviation indicated as the vertical bar) shows a decrease of 6 °C, consistent with buoy data (lower right, see Fig. 1 for location).

Conclusions

- **There are significant coastal sea level increase. The altimeter measurements are consistent with tide-gauge data. The mid-Bank sea level was lower.**
- **The altimetric significant wave height was about 5-8 m during the storm, consistent with buoy observations.**
- **Altimetry data suggest the inshore Labrador Current was intensified and the NAC moved offshore during the storm.**
- **The sea surface temperature decreased by 6 °C and Chlorophyll concentration increased by about 1 mg/m^3 , due to wind mixing and upwelling associated with the cyclone.**