A Storm Surge Model for the West Coast of Canada

Winter storms on the west coast of Canada bring high water and waves to coastal regions. When combined with high tides, these conditions can cause widespread damage due to flooding and erosion. The damage caused by hurricane Katrina in 2005 showed the potential of storm surge damage particularly in communities constructed on flood plains which are very close to sea level and dependent on dykes or levees for flood protection. In British Columbia, the cities of Richmond and Delta are built on the Frazer River delta and are protected by a system of dykes which form a protective barrier against flooding from the Fraser River and the Strait of Georgia. The greatest test of this coastal defense system was made on December 16, 1982 during one of the 20th centuries strongest El Niños: a series of storms struck southern British Columbia with the last hitting near high tide, and drove the water level at the Point Atkinson water level gauge to reach 5.62 m. On February 4, 2006, a very intense low pressure struck at high tide to cause widespread damage in the south Delta community of Beach Grove due to flooding by over topping of the seawall. Funds up to a total of $3 million were made available through the British Columbia government's Disaster Financial Assistance program were in excess of $3 million (CBC archives).

photo: courtesy of the Corporation of Delta

The surge associated with storms is composed of two parts. The first is a large-scale response of the ocean surface to the drop in atmospheric pressure from the storm, amounting to nearly one centimeter of sea-level rise for every one millibar of pressure drop (a typical strong storm can have a minimum pressure of 30-40 millibars below normal). The second component arises from the wind stress associated with the storm. Strong winds normally approach from the south or southeast and become westerly during the passage of the storm. Over the continental shelf, such winds are associated with downwelling - a condition where shelf waters are pushed shoreward due to surface Ekman transport and cause broad-scale sea-level rise along the coast. The overall contribution to the total surge from winds is typically one-half the contribution due to low atmospheric pressure.

The Department of Fisheries and Oceans has partnered with the British Columbia Ministry of Environment to develop a storm surge prediction system based on an operational ocean model already in use at the Institute of Ocean Sciences in Sidney, BC. The program began in 2003 with an adaptation of a northeast Pacific Ocean model based on the Princeton Ocean Model coupled with atmospheric pressure and wind predictions from the US Navy's Coastal Ocean Atmosphere Prediction System (COAMPS). The current storm surge prediction system now incorporates an expanded northeast Pacific model with a nested medium resolution (4 km) coastal model for the coast of British Columbia and a further nested high-resolution (800 m) model for Juan de Fuca Strait and the Strait of Georgia. The forcing for the model now comes from both COAMPS (Pacific Ocean) and the Canadian Meteorological Centre (CMC) regional GEM 15-km resolution model (coastal regions). 48 hour predictions from the nested model are made daily. In addition to the nested model, a large scale two-dimensional north Pacific model is run three times a week and produces a 7 day forecast based on the NOAA Global Forecast System 16 day atmospheric forecasts. The output of this long-range model is used to detect possible storms that may impact our region in the coming week.

If a storm is detected with the early warning system, its timing is compared to the predicted tides in order to assess the risk of an impending high water level event. Alerts are sent directly to the Ministry of Environment who may make the information available to the Provincial Emergency Program, municipal managers in the regions impacted, and other potentially affected authorities and agencies.