Internal Tidal Waves under the Landfast Sea Ice in the Southeast Hudson Bay


Centre for Earth Observation Science, University of Manitoba, Winnipeg, Manitoba
Satellite Oceanography Laboratory (SOLab), Russian State Hydrometeorological University, Saint-Petersburg, Russia
Data Assimilation and Satellite Meteorology Research Section, Environment and Climate Change Canada, Ottawa, Ontario
Arctic Eider Society, St. John’s, Newfoundland

Introduction
Internal waves in the Arctic regions have been of recent scientific interest due to their role in vertical mixing, and their influence on the heat budget of the upper ocean and ice cover. Until now internal tidal waves observations in Hudson Bay have not been conducted. The Belcher Islands archipelago would be an interesting region for internal tidal waves observation in Hudson Bay due to its unique shoreline and bottom topography. Until now internal tidal waves observations in Hudson Bay have not been conducted. The Belcher Islands archipelago would be an interesting region for internal tidal waves observation in Hudson Bay due to its unique shoreline and bottom topography.

Data and Methods
- An ice-tethered mooring (SK1) consisting of eight conductivity and temperature sensors and an acoustic Doppler current profiler was deployed in January–March 2014 in a narrow channel between Broomfield and O’Leary islands located in the south-east tip of Belcher Islands group in Hudson Bay.
- The mooring data were complemented by CTD casts made at various stations (SK1, SK2, SK3, SK8, SK9 and SK10) surrounding Belcher Islands in January and February 2014.
- In October 2016, a bathymetric survey was conducted in the narrow channel between Broomfield and O’Leary islands where mooring SK1 was deployed in 2014.

Results
The mooring recorded oscillations of temperature and salinity through the whole water column, which could be attributed to the vertical displacement caused by internal tidal waves.
- During the storm event on 27-28 January 2014, the weather stations located ~100 km from the mooring site recorded significant westerly and southwesterly winds. On 27 January, the mooring recorded increased residual currents of NNW (off-shore) that was directed about 90° to the wind direction. On 28 January, direction of the residual currents shifted to NNE, i.e., aligned with the channel at SK1. This direction of currents corresponds to the Ekman’s transport. During the storm event, the mooring recorded an episode of isolating and isothermal upshift by ~10 m that was consistent with upwelling.

Conclusions
- The tidal driven oscillations of velocity, temperature and salinity through the whole water column were observed in a channel at the south-east tip of the Belcher Islands group. The tidal harmonic analysis and calculated vertical displacements of water parcels showed the pattern characteristic for internal waves generated in the presence of stratification and rough bottom topography. Most likely, the main source of such internal tidal waves was interaction of high tides typical for Hudson Bay with sill-like features located below the halocline in the narrow channel between the islands.
- Analysis of SAR data clearly showed that ISWs were present in the study region throughout the entire ice-free season, with the first (and last) manifestations of internal solitary waves were observed in May (November-December) under the presence of land fast ice, suggesting that ISW generation is also active in winter. General pattern of ISWs in SAR images expressed through high radar contrasts and relatively large spatial scales and located to the south of Belcher Islands suggests that the ISWs were similar to intense internal waves observed in other Arctic regions.
- While the tidal-driven variability in temperature and salinity recorded by the mooring was large, the high stratification to the south of Belcher Islands restricted vertical mixing. It appears to be insignificant as evidenced from the occurrences of the double diffuse staircases. The upwelling-favourable storms can be another efficient mechanism of vertical mixing; however, the land-fast ice eliminates wind stress from the water column.