Ian Turnbull confers with one of the pilots of the Innu Mikun Airlines Twin Otter airplane, prior to embarking on the buoy deployment flight

FORECASTING
ICE BREAK-UP AND DRIFT

Forecasting ice break-up and drift can reduce uncertainty. Here, FE talks to Dr. Ian Turnbull, an ice researcher in ice mechanics at the Centre for Arctic Resource Development (CARD) in St. John's, Newfoundland. By Andrew Safer

Dr. Ian Turnbull is busy tuning up the one-of-a-kind thermodynamic-dynamic model he has been developing for nearly two years, to forecast the melt and break-up of land-fast ice off the coast of central Labrador. "This should make offshore activity safer and more efficient," explains the 33-year old ice researcher in ice mechanics at the Centre for Arctic Resource Development (CARD) in St. John's, Newfoundland. "When planning seasonal operations, this will give a better idea of how ice conditions evolve." The potential end-users for this site-specific model are shipping operators and planners at the Voiseys Bay nickel mine, oil and gas companies with an interest in exploration offshore Labrador, shipping companies that deliver goods to the coastal communities, and the seasonal ferry service. Dr. Turnbull says that the ability to accurately predict the break-up of land-fast ice – which can extend several nautical miles offshore – should translate into less operational downtime and more accurate decisions regarding long-term planning for the season. It should also enable operators to reduce their conservatism in offshore industrial planning, and the loss of revenue that goes along with it.

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Dr. Turnbull, who holds a PhD in Geophysics, has forecast the movement of individual ice floes from an icebreaker in the Beaufort Sea, and iceberg drift off Greenland for an oil company consortium. In order to maximise the model's accuracy, he included a wide-ranging selection of atmospheric and ocean parameters – considerably more than the number of inputs that are used in some other models that forecast ice events, typically over much greater distances. The following 21 inputs are included in this model: surface air temperature, surface pressure, wind speed and direction, humidity, cloud cover, ocean currents' surface speed and direction, sea surface height, snowfall, rainfall, sea surface temperature, salinity, time of day, latitude, time of season, and reflectivity of the ocean, ice, melt ponds, snow, and clouds.

The model accounts for snow cover on sea ice, the development of melt ponds on sea ice, and the development of leads and cracks. "I tried to build an extremely complex model that accounts for as many natural processes as possible," Dr. Turnbull reports.

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Site-specific forecasting supports the development of detailed knowledge of the ice in the region. Dr. Turnbull notes that extremely large deformations and keels are not generally found offshore Labrador, where first-year ice predominates. At the end of the winter, he notes that the land-fast ice offshore Makkovik and Nain is between 70 centimetres and 1.2 metres thick. Later in the season, as ice breaks up in Baffin Bay, ice up to

The shadow of the Twin Otter can be seen as it flies about 500 feet above the land-fast ice offshore Labrador during the ice tracking buoys deployment flight. The land-fast ice is relatively level first-year ice, generally 70-120cm thick by springtime, and covered in drifted snow. The land-fast ice stretches for miles from the shoreline, to the open water break which can be seen in the distance

1.5 to 2.0 metres thick – typically the thickest first-year ice – drifts down the Labrador coast, creating a narrow "shear zone" where the drifting ice floats by. Ridging can result from the two types of ice scraping against each other, with the floes forming ridges often about one metre high. In this zone just beyond the land-fast ice, ice concentration ranges between 8/10ths and 9/10ths for much of the spring.

In early April 2014 and 2015, Dr. Turnbull and his field assistant, Dr. Rocky Taylor (CARD Chair in Ice Mechanics at Memorial University), flew to pre-determined points above the land-fast ice offshore Makkovik (215 kilometres northeast of Happy Valley-Goose Bay) and Nain (370 kilometres north of Happy Valley-Goose Bay), and deployed ice-tracking buoys from the airplane. (Makkovik has been identified as a potential landing site for an offshore oil and gas pipeline.) They programmed the buoys to report their position every 30 minutes – with a change in position indicating the beginning of ice break-up – as well as track the local drift of pieces of ice.

> The model can also simulate the drift of the broken pieces of land-fast ice

In 2014, Dr. Turnbull input the model with the most recent observed and hindcast weather data – high-resolution in space and time – and began the model run on May 1st. The prediction was for ice break-up to begin on May 30th or June 1st. The beacons indicated that the break-up occurred on June 2nd. The accurate prediction of the break-up of land-fast ice to within one or two days, a month in advance, is precise enough for operational use, advises Dr. Turnbull.

In 2015, the break-up occurred in late April offshore Makkovik, and offshore Nain it was in early May. The modelling was initiated almost a month before the break-up was expected to occur, and it continued almost a month after the actual event. This simulated the retreat of ice over a two-month time horizon. Dr. Turnbull is currently analysing these results.

When the model is run only in thermodynamic mode, it simulates the seasonal melt of the stationary land-fast ice. The dynamic part of the model simulates drift and deformation (e.g., ridge building, divergence of ice, etc.) of the ice cover.

Adding the dynamic mode simulates the drift of the ice in the drifting Marginal Ice Zone (MIZ) further offshore. Once the break-up is underway, the model can also simulate the drift of the broken pieces of land-fast ice.

Asked how soon after the ice break-up a vessel can begin to operate in the water, Dr. Turnbull explains that the amount of time depends on the ice class of the vessel. An icebreaker could begin right away. For an ice-class vessel, since the captain knows the maximum ice thickness and concentration in which the vessel can operate, he/she can make the decision once the model indicates these levels have been reached. A non-ice class vessel requires that the ice concentration must be reduced from 10/10ths to about 1/10th. The model forecasts the date this is expected to occur.

While the current model is specific to the identified region offshore Makkovik and Nain, "the physics of ice break-up and drift are universal if applied to a different environment," says Dr. Turnbull. To customise the model for a particular Arctic region, he would reconfigure the geometry of the coastline and input the site-specific data acquired from that area.

He expects the model to be validated and ready for operational use by the start of the 2016 ice break-up season. FE