

Too close to the wind

The massive Greenland icesheet blocks and deflects atmospheric flow affecting the weather as far away as the UK and northern Europe. Ian Renfrew wants to know more.



Three camera crews filmed the team at work.

The Icelandic Sagas blame fierce winds around the coastal seas of Greenland for dragging Leif Eiriksson away from his home on the south-west coast of Greenland towards Vinland – heralding the first discovery of North America by Europeans. A little over a millennium later these fierce winds are a focus of attention again, but for quite different reasons: they are thought to influence the global climate system.

This spring, as the International Polar Year slipped into gear with launch events in major cities across the world, we took to the skies for one of the first projects – the Greenland Flow Distortion experiment – to sample the atmosphere over the seas around Greenland and Iceland.

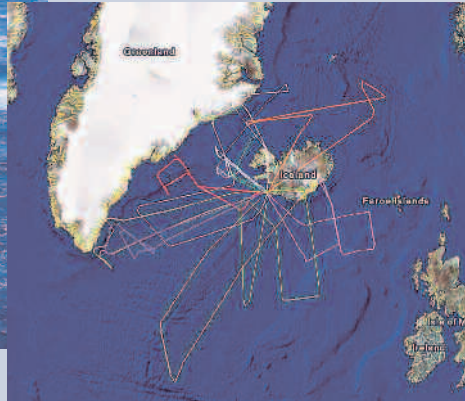
Greenland's massive mountain ranges and towering ice sheet stand over two kilometres high and stretch for thousands of kilometres. These pose a formidable barrier to the mainly westerly winds, causing a myriad of flow distortion effects: intense low-level jets around the coast; 'lee cyclones' that develop on the leeward side of the mountain; and the triggering of planetary-scale waves in the upper troposphere which can affect the atmospheric flow downstream as far as Europe and Africa. We wanted to make the first ever measurements of these flow-distortion features where they actually occur.

Running an aircraft-based field campaign out of the icy wastes of south-west Iceland at the dawn of the International Polar Year proved to be a major draw for the world's media. I suppose flying at 100 feet over churning seas and dazzling jigsaw-like plates of sea ice does make fantastic television, but we were surprised to end up hosting a Canadian reporter and three camera crews: Sky News, the Discovery Channel and the Norwegian national broadcaster. All this media attention gave the whole campaign a real sense of urgency. We really felt part of the narrative of global warming and shrinking Arctic sea ice.

Our areas of interest, the Nordic and Irminger Seas, are a key part of the thermohaline circulation; the overturning ocean circulation partly responsible for Europe's temperate climate. Temperature and salinity drive this giant circulation, making it almost entirely horizontal.



“ You could literally feel the ocean’s swell as we flew across the waves.



Vertical overturning is restricted to a few special locations where there is a cyclonic gyre and cold, strong winds sucking heat and moisture out of the ocean. When these conditions are met, open-ocean convection can occur and dense water parcels sink down to the ocean bed. Oceanographers have documented this open-ocean convection relatively well in the Nordic and Labrador Seas. In recent years a hypothesis that the Irminger Sea, to the south-east of Greenland, is also an area of open-ocean convection has gained credence. Here there is a cyclonic Irminger gyre and we think the all-important cold, strong winds may be the low-level jets caused by Greenland’s flow distortion effects.

As well as our climate interests we also wanted to improve local weather forecasts over Iceland and, by more convoluted means, downstream over the UK and mainland Europe. Working in partnership with the UK Met Office and the European Centre for Medium-range Weather Forecasts, we carried out several flights to areas predicted to be particularly sensitive to error in the forecast models.

Weather forecasts rely heavily on instruments that take vertical profiles of the atmosphere known as radiosondes – small packages of instruments which record pressure, temperature, humidity and winds as they rise attached to a helium balloon. From an aircraft we use the

evocatively named cousin – the dropsonde – a similar disposable package of instruments which falls, attached to a parachute, radioing its observations back to the aircraft. We were releasing dropsondes between breakfast and lunch (9.30-13.30) transmitting the observations immediately by satellite to the UK, and then worldwide, where they were fed straight into the operational forecasts. In our case we were hoping to improve forecasts over the British Isles and Scandinavia between 24 and 48 hours later. This concept of targeting, or adapting, the meteorological observing network on a day-to-day basis is currently a hot topic in operational weather forecasting, especially with the prospect of autonomous vehicles or drifting balloons able to deliver additional soundings into remote areas. We are now urgently assessing whether our targeting worked or not.

Our first flight will give you a taster of the flow distortion missions. After a frantic day setting up we had a prize objective: to fly through and capture a ‘tip jet’ event. These are hurricane-strength low-level jets that emanate from Cape Farewell on the southern tip of Greenland. Our flight plan plotted a long transit to the south-east Greenland coast, followed by three high-level legs – across, down and back across the jet – releasing dropsondes as quickly as possible (up to four can be monitored in

the air at any one time) to capture the vertical structure of the jet. The suspense was palpable as we waited for the dropsonde observations to come through. Initial success: a clearly defined jet, with the strongest winds nearest the coast and an acceleration as the jet reached the tip of Cape Farewell.

Our mood changed to one of trepidation when we looked at the strength of the winds – up to 49 metres per second, or 110 miles per hour – in the jet core. This was where we were heading! The third high-level leg finished and we were now descending through cloud and rain into hurricane-strength winds to fly 100 feet from the ocean’s surface and sample the large air-sea fluxes that are key to the climate system. As we burst through the cloud base around 1000 feet the turbulence picked up. Although assured afterwards by the highly-experienced pilots that it was only ‘moderate’ it certainly felt pretty vigorous to me and the sea was raging – strong winds ripping the tops of the white caps off and hurling them downwind.

If our 100ft leg across the jet was turbulent, when we turned into the jet and headed upwind, into the 10-20ft waves, it was more like a rollercoaster – you could literally feel the ocean’s swell as we flew across the waves. We managed a second 100ft leg across the jet before, stomachs churning, we climbed and headed back to our base in Keflavik, Iceland. A dramatic start to what turned out to be a very successful field campaign. Twelve flights over the three weeks with an excellent mixture of high-impact weather events: tip jets, ‘barrier flows’ parallel to the Greenland coast with high air-sea heat exchanges, lee cyclones and ‘polar lows’; plus several flights targeting areas of forecast sensitivity. Now comes the analysis. ❖

Ian Renfrew is a Reader in the School of Environmental Sciences at the University of East Anglia. The Greenland Flow Distortion experiment was funded by NERC, the Canadian Fund for Climate and Atmospheric Sciences, and by two European Union schemes; and was supported by the UK Met Office, the European Centre for Medium-range Weather Forecasts and the Icelandic Meteorological Service. More stories, photos and information can be found on the GFD website at <http://lgmacweb.env.uea.ac.uk/e046/research/gfdex/index.htm>.