
Editorial

The Greenland Flow Distortion Experiment

The fourth International Polar Year (IPY) – co-sponsored by the International Council for Scientific Unions (ICSU) and the World Meteorological Organisation (WMO) – ran from March 2007 to March 2009, involved over 50 000 scientists and thousands of projects. This special issue encompasses ten articles from just one IPY project: *The Greenland Flow Distortion Experiment*. The science of meteorology has had a long association with these multidisciplinary polar years – perhaps the requirement to share geographically dispersed observations in order to make progress is more pressing in meteorology and climate? The first IPY (1882–1883) in some ways pioneered the concept of major international scientific cooperation; twelve nations participated and 13 expeditions to the polar regions took place. Fifty years later the second IPY (1932–1933) was proposed and promoted by the WMO's forerunner – the International Meteorological Organization – partly with the aim of investigating the newly discovered 'jet stream'. Over forty nations participated and a similar number of permanent Arctic research bases were established.

Twenty-five years later the third IPY grew into the IGY – the International Geophysical Year (1957–1958). Making the most of new technologies, there was a focus on the upper atmosphere, continental drift and glaciology; while logistically the Antarctic continent was a major focus, with the first crossing of the continent taking place and the first permanent research bases being established. The IGY coincided with the dawn of the satellite era and provided a kick-start for international scientific cooperation across the geophysical sciences; it is no coincidence that the first long meteorological reanalyses were started in 1957. The IGY led to a number of contributions to the *Quarterly Journal* in subsequent years (e.g. Wilson and Godson, 1963), in particular with the UK's involvement in the exploration and science of the Antarctic continent (e.g. Stewart, 1958; Wexler, 1959; Dobson, 1966; Loewe, 1967). It is sobering to reflect that, fifty years ago, concerns over global climate change were very much on the scientific margins. For this fourth IPY they are a central theme.

To mark the fourth IPY (2007–2009), *Quarterly Journal's* Editorial Board agreed to publish this special issue focused on one particular IPY project: the *Greenland Flow Distortion experiment (GFDex)*. GFDex has been investigating the role that Greenland plays in generating and developing weather systems and their effects on the coupled atmosphere–ocean climate system. The genesis of GFDex was a long-term collaboration between like-minded meteorologists and oceanographers that started

during the *Labrador Sea Deep Convection Experiment* in the 1990s. In the intervening years a series of studies – using numerical models and satellite observations – had shown that the sub-polar seas around Greenland and Iceland were replete with little-understood topographic flows and mesoscale cyclones that were associated with high winds and a strong atmospheric forcing of the ocean. It was clear that a successful aircraft-based field campaign could bring a step-change in our understanding of these weather systems: providing the first comprehensive *in situ* observations and thus unique validation for numerical models and meteorological analyses (see Renfrew *et al.* (2008) for further motivation and background for GFDex).

Funding for GFDex was initially secured from a Natural Environment Research Council grant which brought with it time on the UK's BAE-146 instrumented aircraft operated by the Facility for Airborne Atmospheric Measurement (FAAM). Further staff and dropsonde funding was granted by the Canadian Foundation for Climate and Atmospheric Sciences, while funding for allied oceanographic observations and modelling work was secured from the Woods Hole Oceanographic Institution and the USA's National Science Foundation. Note that most of this allied work will be reported on later.

An expansion of the GFDex project was greatly aided by its opportune timing at the start of the IPY. A novel database of imminent projects was developed by the IPY office and this enabled Norwegian and Icelandic scientists to become involved in the project – with some further funding from the Norwegian Research Council. Through these collaborations funding from the European Union scheme EUFAR (European Fleet for Airborne Research) brought additional aircraft hours and dropsondes. This also meant all the lead scientists brought something to the table – perhaps helping the smooth running of the field campaign. The IPY also leveraged funding for additional observations from EUCOS (European Coordinated Observing System) with further dropsondes and additional radiosonde launches from Iceland, Greenland, Jan Mayen and some EU-ASAP (European Union – Automated Shipboard Aerological Programme) ships. As well as these observational enhancements, GFDex has benefited from being part of a wider weather-focused IPY project cluster (the IPY-THORPEX cluster). This has led to workshops, conference sessions and targeted scientific dissemination between like-minded researchers.

As outlined above, the high topography of Greenland distorts the atmospheric flow leading to a variety of local mesoscale weather systems – such as orographic tip jets,

barrier flows, lee cyclones and polar lows – phenomena that have rarely been directly observed. Indeed the articles in this special section – by Renfrew *et al.* and Outten *et al.* focusing on an easterly tip jet event, by Petersen *et al.* with an overview of several days of barrier flow off the southeast coast of Greenland, and by McInnes *et al.* and Kristjánsson *et al.* on a dramatic lee cyclogenesis event – present the first comprehensive observations of such systems, as well as detailed analyses of their evolution and dynamics with the aid of numerical simulations. Complementing these case-studies, Våge *et al.* present a multi-event examination of westerly tip jets off Cape Farewell, Greenland.

It has been suggested that Greenland's presence influences weather systems further afield, e.g. downstream over Europe, and partly to address this topic a 'targeted observations' programme formed part of GFDex. For this, 'sensitive area predictions' – where additional observations were predicted to improve subsequent forecasts – were targeted with dropsondes, with the resulting soundings being transmitted in real time to the Global Telecommunication System for inclusion in the next operational forecast cycle. Irvine *et al.* examine the impact of these targeted observations on operational forecasts.

The coastal seas around Greenland are now known to be the windiest in the world ocean (Sampe and Xie, 2007). They are home to frequent strong winds which are associated with high surface turbulent fluxes of momentum, heat and moisture that provide a strong atmospheric forcing of the ocean. All the low-level aircraft observations from the GFDex campaign have been carefully analysed – by Petersen and Renfrew – to provide direct estimates of these turbulent fluxes during the prevailing high wind-speed cold-air outbreak conditions of GFDex. An expanded compilation of this rare marine surface-layer dataset has been used to assess surface-layer representation in numerical weather prediction analyses and reanalyses in Renfrew *et al.*, where a number of systematic weaknesses are pinpointed. The impact of frequent strong atmospheric forcing on a high-resolution ocean model is examined in Haine *et al.*, where some interesting experiments make use of different resolutions of forcing fields to examine what factors are crucial for obtaining an accurate simulation of the sub-polar seas of this region.

It should be clear that the GFDex project included a wide variety of meteorological, oceanographic and climate studies. It was this wide variety, along with a highly respected reputation and something of a polar tradition in publishing, that led us to approach the *Quarterly Journal* for publication of this special issue. It has been a pleasure working with the editors and staff at *QJ*, the *Royal Meteorological Society* and Wiley, in particular we would like to thank John Thurnburn, Alison Hunter and Kim Paterson for their careful shepherding of this work into print.

We would also like to take this opportunity to thank the aforementioned agencies for funding GFDex, and the Met

Office, the European Centre for Medium-Range Weather Forecasts (ECMWF), Veðurstofa Islands (the Icelandic Meteorological Service), the STORM Weather Centre, the Norwegian Meteorological Institute, the Dundee Satellite Receiving Station, and the British Atmospheric Data Centre for operational support during the field campaign. In particular we would like to thank the Met Office and ECMWF for the considerable work involved in generating the tailored real-time sensitive area predictions needed for the targeted observations aims. Our heartfelt thanks go to all at FAAM, DirectFlight and Avalon for enabling such a successful detachment and flight series. We hope this special issue makes a worthy contribution to the aims of the fourth International Polar Year.

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