The International Polar Year 2007-2008

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1. Introduction

So far, there have been two so-called Polar Years separated by a time-difference of 50 years: The First International Polar Year took place in 1882-1883 and established a precedent for international science cooperation. The Second International Polar Year took place 50 years later in 1932-1933, and investigated the global implications of the newly discovered “Jet Stream”. The International Polar Year, 2007-2008, will take place 50 years after the International Geophysical Year, 1957-1958, and is an international programme of coordinated, interdisciplinary scientific research and observations in the Earth’s polar regions.

Its main tasks are:

- to explore new scientific frontiers
- to deepen our understanding of polar processes and their global linkages
- to increase our ability to detect changes, to attract and develop the next generation of polar scientists, engineers and logistics experts
- to capture the interest of schoolchildren, the public and decision-makers.

From an enhanced observational network, sophisticated use of new observations and not at least better understanding of physical processes, it is hoped that the International Polar Year 2007 to 2008 will give a similar leap forward in predictive skill in numerical weather prediction as the FGGE year in 1979.

The IPY themes are:

To determine the present environmental status of the polar regions by quantifying their spatial and temporal variability; to quantify, and understand, past and present environmental and human change in the polar regions in order to improve predictions; to advance our understanding of polar - global interactions by studying teleconnections on all scales; to investigate the unknowns at the frontiers of science in the polar regions; to use the unique vantage point of the polar regions to develop and enhance observatories studying the Earth’s inner core, the Earth’s magnetic field, geospace, the Sun and beyond and to investigate the cultural, historical, and social processes that shape the resilience and sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.

IPY and THORPEX

THORPEX will play an important part during the IPY, and will in particular

- assess and seek to improve the quality of operational analyses and research reanalyses products in the Polar Regions
- address improving data assimilation techniques for Polar Regions
- assess the skill in the prediction of polar to global high impact weather events for different observing strategies in higher latitudes

- demonstrate the utility of improved utilization of ensemble weather forecast products for high impact weather events and for IPY operations, when applicable
- result in recommendations on the design of the Global Observing System in polar regions for weather prediction
- assist in accomplishing these research goals, THORPEX/IPY will conduct field campaigns during the IPY intensive observing period
- address two-way interactions between polar and sub-polar weather regimes

THORPEX has also a climate dimension; THORPEX will play a major role in partnering with the climate forecast community to bridge the gap between weather and climate forecasting, leading to better understanding, improved forecast techniques, and more skilful forecasts for the often neglected, 10-60 day range between the weather and climate time scales.[1]

The process towards clustering

To coordinate and cooperate ICSU and WMO established the IPY Joint Committee (JC) and issued a call for Expressions of Intent (EOI) by Nov. 2004. The response was formidable; - by14 January 2005 more than 1000 Expressions of Intent (EOI) were collected. In their first session in Paris, 7-9 March 2005, the JC identified EOI of category 1 that may become “cluster” full proposal projects for IPY, and EOI of category 2 that should be grouped around “cluster” full proposal. IPY JC and IPO then sent out letters to all proponents on 30 March 2005 with JC guidance on clustering of EOI and preparation of full proposals with three deadlines: 30 June 2005, 30 September 2005, 31January 2006. More than 400 full proposals were received at IPY IPO by the three deadlines, and JC eventually endorsed 160 IPY scientific projects proposals and 46 proposals on education and outreach.

In this paper we will first present some of the meteorological conditions which are special for Polar Regions with focus on the Arctic, challenges with regard to (numerical) weather prediction, THORPEX and IPY, the role of EUCOS, WMO Observing Systems and the IPY-THORPEX cluster project.

2. Meteorological conditions and challenges for weather prediction

The area is data sparse, at least for conventional observations. Fig. 1 shows the availability of surface and radiosonde observations between 1st and 15th October 2005. Blue dots are stations reporting more than 90% of the time while all other colours show stations with less complete reports. In the centre of the Polar basin and on the Antarctic Plateau there are virtually no conventional observations. There is no help from commercial aircrafts either (AMDAR data) as no scheduled flights cross the area. The use of satellites will therefore play an important role. This is however not straight forward as satellite retrievals in polar regions are difficult due to snow and ice covered land surface as well as cold low level clouds consisting mainly of ice crystals.

Due to the low troposphere and large horizontal variability in stability and temperature, small scale systems with rapid developments are not uncommon. The most well known examples of this are polar lows but heavy precipitation (snow) from convective systems, low level fronts and corresponding jets, and mountain lee waves trapped under an inversion all cause difficult meteorological conditions.

[1] THORPEX International Research Implementation Plan, Version I, 2005

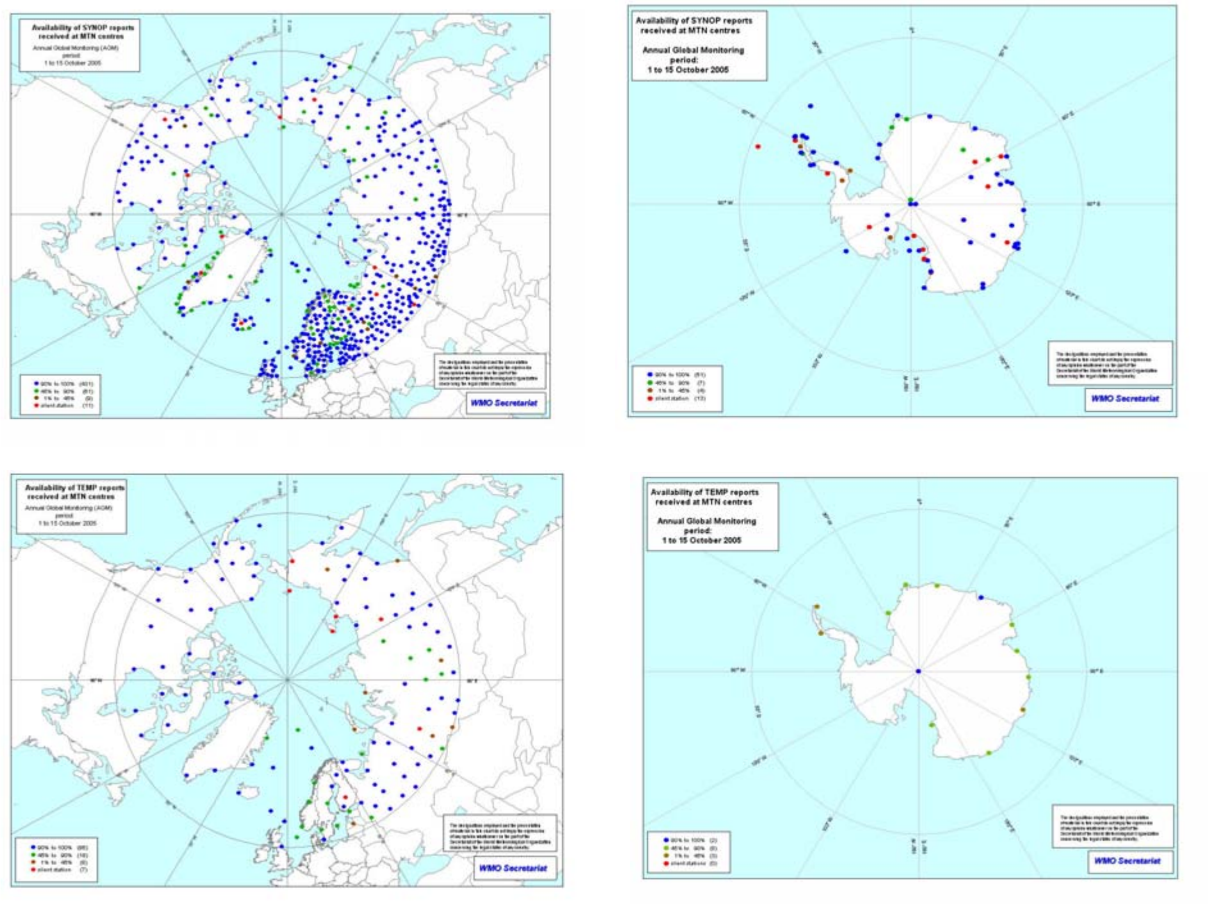

Figure 1. Synops (upper panels) and TEMPS (lower panels) received at MTN centres during the period 1st to 15th Oct. 2005 in the Arctic (left panels) and the Antarctic (right panels).

Routine verification at the Norwegian Meteorological Institute reveals that the overall quality of numerical weather prediction performance is not as good in these high latitudes as further south (see fig 2). This is probably caused by poorer data coverage as well as a higher percentage of small scale systems.

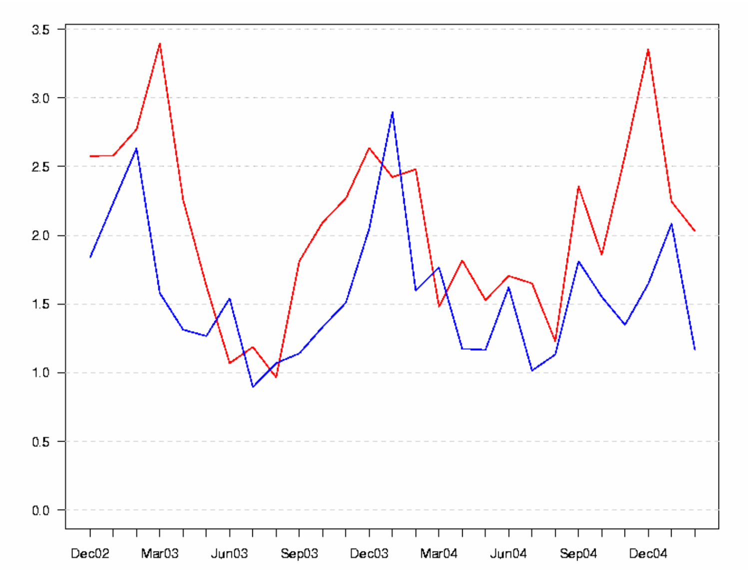

Figure 2. RMS error of mslp forecasts with the Norwegian limited area model system (HIRLAM) over a two year period; the Barents Sea in red and the North Sea in blue.

Polar processes may have significant impact on weather phenomena at high and middle latitudes in Europe. The combination of Greenland's high topography and the data sparse area of Northern Canada make the area important as an initiation place for surprise developments hitting Europe with a relatively short lead time. Klinker and Ferrant (2000) investigated the poor performance of the ECMWF model for the summer of 1999 as compared to the 1998 summer, and showed that analysis errors in the polar area can have a detrimental impact on forecast skill over Europe. The result is likely to be dependent on the flow conditions. For the period they considered, a strong baroclinic flow extended from Greenland over the North Atlantic into Europe.

Fig. 3 is a typical result from a state of the art limited area model. Superimposed on the mslp contour lines is a satellite picture showing that the central area of the synoptic scale low actually consists of a number of smaller scale vortices. The forecasting challenge in situations as these is to decide which of these local vorticity maxima will intensify, in which direction and speed they will move and how strong the corresponding winds will be.

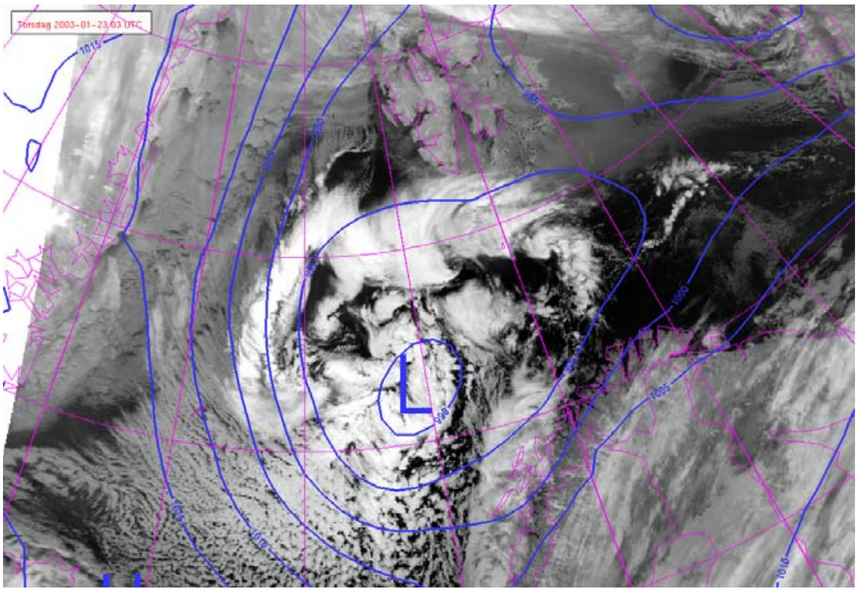

Figure 3. Forecasted mean sea level pressure from the operational HIRLAM model at the Norwegian Meteorological Institute with horizontal resolution 10 km.

Simple linear baroclinic theory (small perturbations on basic flow) shows that maximum growth in polar regions may occur for much smaller horizontal scales than at middle latitudes. This is caused by a low tropopause, small static stability and a relative large Coriolis parameter. Most polar lows will however develop as a finite disturbance mechanism (Montgomery and Farrel, 1992) where a disturbance (e.g. a potential vorticity maximum) at upper levels interacts with a low level baroclinic zone. Due to large contrasts in low level characteristics (open sea, ice covered sea, snow covered land, "warm" and cold ocean currents etc.) there are amble possibilities for interactions with transient upper level PV maxima. Release of latent heat from convection comes as an additional energy source to baroclinic instability.

It is therefore necessary to have high resolution as well as a good parameterisation of physical processes in order to simulate these phenomena properly. Unfortunately, NWP models seem to have problems at high latitudes. The ECMWF model has for instance been compared to measurements taken during the Sheba campaign and there are large differences between modelled and observed quantities (Figs. 4). This is of some concern since the transition of low level air due to strong heat and moisture fluxes in cold air outbreaks is an important factor for preconditioning the atmosphere to be favourable for polar low developments. (Nordeng and Rasmussen, 1992).

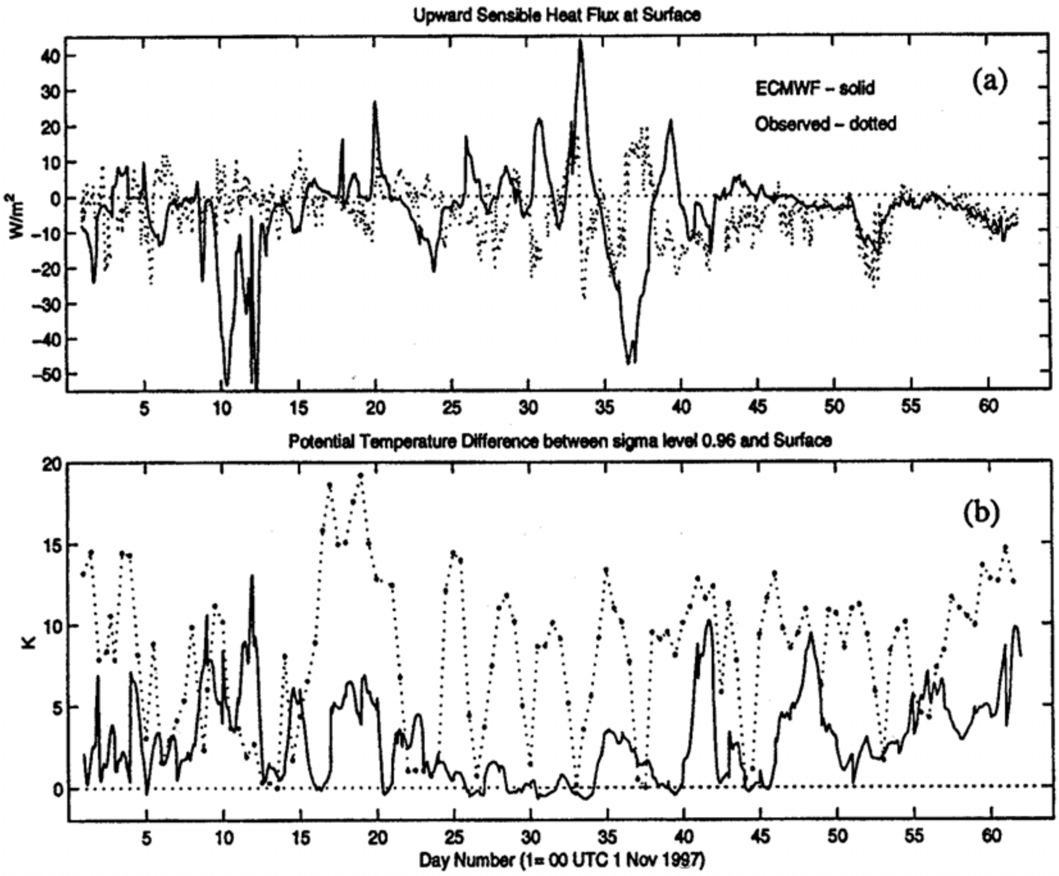

Figure 4. Modelled and observed heat flux (a) and stability (b) in Nov-Des 1997 from the SHEBA-program. Stability is defined as difference in potential temperature between 300m and 2m. From Beesley et al. 2000.

For a correct description of radiative properties schemes and for the parameterisation of microphysics one needs to describe the fraction of cloud water content at its various phases. Present schemes seem to have problems in describing the (surprisingly) high liquid water content found even at low temperatures.

A correct description of cloud properties is equally important in order to assimilate satellite radiances by variational methods into NWP models. Polar regions are data sparse in terms of conventional observations but data rich for polar orbiting satellites and one will have to rely on satellite data. Typical for the areas is however that they are cloud covered (in particular the Arctic). Another challenging task is the difficulty (for the radiation schemes) in distinguishing between cold surfaces (ice and snow) and clouds.

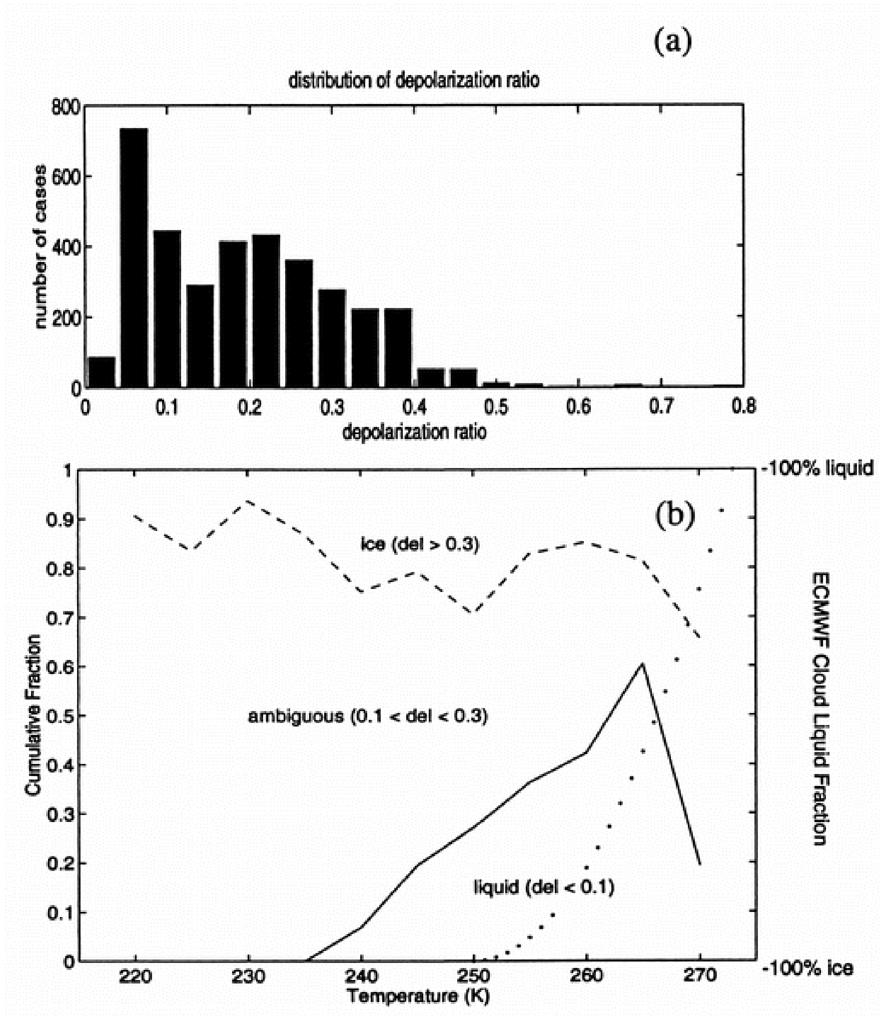

Figure 5. Depolarization ratio statistics for lidar measurements during November and December 1997. (a) The depolarization ratio frequency distribution and (b) the relationship between cloud base temperature and condensate phase as inferred from the depolarization ratio ("del"). Reading vertically from a given temperature on the horizontal axis, the distance to the solid line is the fraction of clouds that are liquid, the distance between the solid line and the dashed line is the fraction of clouds whose phase is ambiguous, and the remainder are ice clouds. The dotted line in Figure 5b represents how cloud condensate is partitioned between liquid and ice as a function of temperature in the ECMWF model (scale on right). From Beesley et al., 2000.

3. EUCOS

EUCOS will be an important element during the IPY and is involved in a number of ways. In general EUMETNET Council have approved the involvement of EUCOS and its operational programmes to support IPY activities. The involvement will support the goals of EUCOS in terms of improving regional NWP in the European domain and by implication information on how to improve observing networks so that regional NWP can be improved. Approximately 120k€ of additional money has been allocated to support observing related activities over and above the continued operational delivery of observations from the EUCOS Programme in the northern IPY region. The nature of the EUCOS Programme is such that the infrastructure of the operational observing programmes can be used to support IPY.

This include, additional AMDAR data from E-AMDAR aircraft crossing the IPY region; additional radiosonde ascents from the E-ASAP fleet in the area, predominately from the Danish and Icelandic ships; additional radiosondes from the land based radiosonde networks of the Members of EUMETNET; data quality monitoring services; To develop a data targeting service within the framework of the EC sponsored

EURORISK PREVIEW Programme to deliver additional meteorological observations over key sensitive regions to better understand issues surrounding data targeting and facilitate future services that might aid to accurate prediction and early warning of high impact weather events over Europe and reduce forecast uncertainties.

4. The Global Observing Systems

At present WMO is operating or co-sponsoring the following observing systems:

- Global Observing System of the World Weather Watch (GOS/WWW) - physical parameters of the atmosphere;
- Global Atmosphere Watch (GAW) - chemical parameters of atmosphere, including ozone;
- Global Ocean Observing System (GOOS) - physical, chemical and biological parameters of the ocean;
- World Hydrological Cycle Observing System (WHYCOS) as part of Global Terrestrial Observing System (GTOS) - hydrological cycle parameters;
- GCOS Terrestrial Network for Permafrost (GTN-P) and GCOS Terrestrial Network for Glaciers (GTN-G) – parameters of cryosphere

They will all contribute in a significant way during the IPY. The *WWW Global Observing System* during the IPY will in particular: re-activate existing and establish new surface and upper-air stations; increase the number of drifting buoys (see Fig. 6), Voluntary Observing Ships and Aircraft Meteorological Data Relay flights; use existing and new operational polar-orbiting satellite series, especially satellites with capabilities for polar regions.

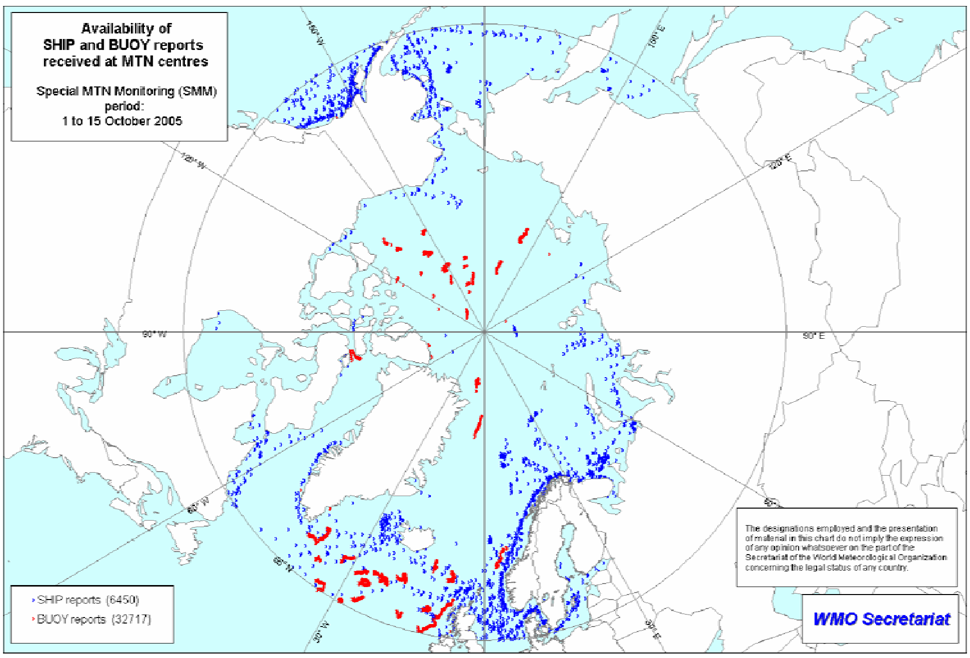

Figure 6. Availability of SHIP (blue) and BOUY (red) reports received at MTN centres during the Special MTN Monitoring period 1 to 15 October 2005.

5. The IPY-THORPEX Cluster

The IPY-THORPEX Cluster consists of a number of individual projects and the main objectives are:

- Explore use of satellite data and optimised observations to improve high impact weather forecasts (form a Polar Trec and/or provide additional observations in real time to the WMO GTS)
- Better understand physical/dynamical processes in polar regions
- Achieve a better understanding of small scale weather phenomena
- Utilise improved forecasts to the benefit of society, the economy and the environment
- Utilise of TIGGE for polar prediction

The projects span a number of scientific issues from climate research to weather prediction. They are mainly focused on the Arctic region. One of them has, however, focus on Antarctica and aims at validating and improving the assimilation of AIRS/IASI satellite data in numerical models with emphasis on polar latitudes. Other important issues that will be investigated is the role of Greenland in terms of flow distortion and its effect on local and middle latitude weather prediction as well as the thermohaline circulation; comparison of Arctic Regional Climate Models; exploration of the use of satellite data and optimised observations to improve high impact weather forecasts and improved understanding of physical/dynamical processes in polar regions with emphasis on small scale weather phenomena.

6. Summary

The IPY is expected to bring new knowledge in understanding meteorological conditions and processes at high latitudes. This includes understanding the physics of small scale systems (e.g. polar lows) and the role of Arctic mountain ranges like Greenland as well as the role of high latitudes for the climate.

Dedicated in situ observations will be limited to the IPY period; in the future observations to be used by NWP will have to rely on satellites. By the combined use of in-situ observations taken during the IPY with remotely sensed observations and better parameterisation schemes it is expected that NWP will be strongly improved.

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