Part II

Regional Activities and Achievements

Consortia of nations have established THORPEX Regional Committees (RCs) that define regional priorities for participation in THORPEX within the framework of the THORPEX International Science and Implementation Plans. These THORPEX Regional Committees develop their own Science and Implementation Plans. They facilitate provision of funding, logistical and other support, planning, coordination and implementation of THORPEX activities conducted by the region with respect to the THORPEX International Research Implementation Plan.

1 African Regional Committee (AfRC)

1.1 Science and Implementation Plans production and dissemination

THORPEX-Africa was launched at the THORPEX Workshop held in association with the RA1-XIV session in Ouagadougou (Burkina Faso) during February 2007. Two task teams were formed, i) to revise a draft Science Plan and ii) work out the structure of the regional committee respectively. A meeting was then held in Dakar in September 2007 to improve the Science Plan, outline the Implementation Plan and prepare the terms of reference for a following planning meeting.

This planning meeting was held at the University of Karlsruhe in November 2007 jointly with the 2nd AMMA conference. The WWRP/THORPEX African Science Plan was further amended and implementation activities discussed and agreed. The structure and terms of reference of the Regional Committee (RC) was discussed during that meeting and the Regional Committee composition set up.

In mid-2008, the RC held its first meeting in South Africa to finalise the Implementation Plan. The meeting gathered the members of the RC and the WMO/WWRP Chief and representatives of THORPEX-IPO, GEO, the UCAR/Africa Initiative and ICSU-ROA also attended. The implementation tasks were discussed in detail. Other aspects such as partnerships, resource mobilization/funding opportunities, endorsement of THORPEX-Africa and dissemination of the Science and Implementation Plans were also discussed.

The Science and Implementation Plans were finalised and published in March 2009 and are available on line at www.wmo.int/thorpex in English and French versions. The Science plan describes the major concerns of Africa in terms of high-impact weather monitoring, predictability and the impact on society and the economy. The Implementation plan describes the specific activities and tasks on which THORPEX Africa will focus.

Regarding Societal and Economic Research Applications (SERA), two main tasks were identified:

i) High impact weather information system for Africa

This task aims to collect, process and archive data related to selected high-impact weather events and associated impacts in Africa, from 1990 to date. The resource will integrate existing information available from diverse sources, fill gaps using focused efforts within the African THORPEX Community (see PDP section below) and make it accessible for PDP and SERA research.

ii) User Forecast verification, cost and benefit assessments

This research aims to develop appropriate verification measures for forecasts of high impact weather events for each priority sector and provide precise estimation of high-impact weather events effect on society and the cost/impact for each application sector. This research will be carried out in close partnership with social and economic scientists.

Regarding Predictability and Dynamical Processes (PDP), two tasks were also identified:

i) Predictive skill of high-impact weather events in Africa

The main goal of this task is to improve our understanding of High Impact Weather (HIW) events, assess their predictability and eventually improve our ability to predict the events. The predictive skill of HIW in Africa will be analysed in global NWP deterministic and probabilistic models using case studies from a catalogue. The use of limited area models in deterministic and probabilistic mode (e.g. TIGGE LAMs) will be promoted to further explore the predictive skill for HIW in Africa.

ii) Development of a seamless forecast system

This task aims a) to improve our knowledge and understanding of the nature and causes of intraseasonal variability and its impacts on weather statistics and b) to provide a continuum of skilful weather/climate prediction from daily to seasonal timescales that meet societal and economical needs in Africa. Intraseasonal variability and its impacts on weather statistics will be carried out by building on the work currently being done in AMMA. The successes gained in West Africa will be replicated in other sub-regions.

Regarding Data Assimilation and Observing Systems (DAOS), THORPEX-Africa has identified the three following tasks:

i) Design an optimum observing network

The main goal of this task is to design an optimal network for Africa by assessing the performance of the current state of the observing system in Africa and conducting in collaboration with NWP centres Observing System Experiments (OSEs) in Africa such as data impact studies that are being conducted in the framework of AMMA.

ii) Enhance the use of available observing technologies

This activity aims at exploring the potential for new observing technologies and new satellite sensors to provide observations that improve the skill of high-impact weather forecasts. Platforms for receiving and processing the observations will be promoted in African meteorological services and regional centres. The first focus will be on the AMDAR system to assess its benefits in improving analyses and forecasts in Africa.

iii) Improvement of telecommunication facilities

A good telecommunication network is a prerequisite for data exchange for observational data and model outputs. In the framework of THORPEX, large data sets spanning daily to sub-seasonal timescales from (multi-model) ensemble prediction systems will be used through TIGGE. This task aims at ensuring that telecommunications plans for Africa are in

agreement with the next generation's requirements. Specifically, the opportunities offered by the WMO Information System (WIS) and GEONETCAST (Extension of EUMETCAST) in Africa will be studied and recommendations formulated to WMO/CBS.

In the THORPEX-Africa Implementation Plan emphasis is also put on Forecast and Research Demonstration Projects (FDP-RDP) and Capacity Building development. The FDP-RDP will be developed to assess the social and economic benefits that would result from the operational use of new tools and techniques in Africa.

The Science and Implementation Plans were distributed to the directors of the meteorological services of the 52 nations in Africa under cover of a letter from the WMO Secretary General asking them to help implement THORPEX in Africa and to nominate national representatives who will take part of THORPEX-Africa implementation and coordinate at national level related activities. About 25 nominations were received. The Science plan was also distributed to regional institutes and universities and to scientists who took part in THORPEX planning meetings.

From the Implementation tasks described above, it has been decided to start with a subset of feasible activities. The information system and predictability studies are seen to be the most urgent and will be useful to help develop the other tasks.

1.2 High-impact Weather Predictability and Information System workshop

A workshop was held at UNESCO/ ICTP, 5-9 October 2009, and co-funded by ICTP, THORPEX Trust Fund, GEO and RIPIECSA. It was recognised that there is a need to establish a new database of key high-impact African weather events, consisting of observations, model outputs, and event-documentation, which would be a key resource for meteorological research to contribute to improvement of daily to monthly forecasts in Africa and socio-economic research to improve use of these forecasts.

On the other hand, there are a diversity of methods and levels of expertise of forecasting in African Meteorological Services that are not harmonized or synthesized in text books. The forecasters' handbook for West Africa project, in the framework of the AMMA programme www.amma-international.org under the direction of Dr. Doug Parker (University of Leeds), includes the objectives of long-term documentation of existing forecasting methods, sharing of existing good practice, testing of existing forecasting tools, new methods and new data sources, and development of new tools for forecasters training and wider meteorological education.

The workshop, that gathered research scientists from Africa, Europe and North America and representatives of National Meteorological agencies from across the African continent, was planned with the following specific aims:

- To have a better understanding of HIW in different sub-regions of Africa and their impact
- To identify tools and products available in/for African meteorological services
- To give a momentum to THORPEX Africa planned activities, particularly those concerning the implementation of an HIW database and predictability studies.
- To present the handbook project to forecasters and academics and have interactions regarding structure, contents, support, etc.

The workshop has provided momentum to THORPEX-Africa activities related to the High-Impact Weather (HIW) Information System (IS) and assessment of forecasting system performance for African HIW. Amongst the HIW that are of concern for African Nations are : i) dry spells and late onset/early end of the rainy season; ii) Flooding/Flash floods associated sometimes to landslides iii) tropical cyclones landfall in South-eastern Africa and tropical depressions/tropical cyclones genesis in North-western Africa, iv) dust events, v) marine hazards. These high impact weather events affect livestock, agriculture, water resources, energy, and health and can cause loss of life, displacement of people and damage to infrastructure. The heterogeneity of tools available in NHMSs to forecast HIW as well as working relationships with disaster management services and relief organizations were highlighted. Also tools and methods to forecast African HIW available or in development in global and regional forecasting centres, academic institutes or within relevant programmes as well as relevant information system and database were highlighted.

For predictability studies, the workshop identified a number of target high impact events that occurred recently, such as the severe flooding that hit Burkina Faso, Senegal and other West African countries in 2009, South of Algeria in 2008, Southern Africa in 2008 and East Africa and Central Africa in 2007 and 1997. A 3-year work plan has been drawn up to undertake predictability studies with the selected case studies on a sub-regional basis. Three phases have been identified: i) analysis and documentation of the selected events by April 2010, ii) deterministic and global model assessment by April 2011; iii) modelling studies and ensemble prediction assessment by June 2012. National Met services representatives committed to gather data related to the selected cases and to provide first analysis. Representatives of major forecasting centres and academic communities will provide model data for the selected events and possibly rerun the case studies. The JWGFVR provides guidelines for model assessment.

The aim of the HIW IS is to collect HIW events in the past two decades and ongoing HIW events with a user friendly interface for analysis, processing and visualisation to facilitate integrated and multidisciplinary studies. It has been decided to start the activity with an interim prototype database with few selected case studies, the same as the ones targeted for the predictability studies. This will be regarded as a pilot demonstration project hopefully leading to a comprehensive information system given the required funding. The African RC will coordinate with African sub-regional coordinators on the progress of data collection and predictability studies by providing guidance for the analyses of the high-impact weather events related to the selected cases studies.

Regarding the ‘Forecasters’ handbook for West Africa’ project, the workshop provided the opportunity to engage the National Met. Services in the project and gain feedback on different aspects of the project and review what has been achieved in term of forecasting in the framework of the AMMA Operational Centre (AOC). The session enabled interactions between forecasters and researchers to underline known problems, to review methods/tools, and define research, modelling and forecasting perspectives for 3 elements of the handbook: intraseasonal variability, synoptic analysis and convection initiation. The target date for the first draft is December 2011.

After the ICTP October 2009 workshop, a workplan to handle HIW predictability studies has been detailed and circulated to THORPEX national focal points, coordinators of case studies and Regional Committee members. There are different phases and stages in the workplan. These include HIW event description (collection of observational data etc.,), estimates of the “extremeness” of the event, conceptual models for the event, verification

of forecast skill and assessment of the performance of deterministic and ensemble models..

The East Africa case study is the one which has progressed furthest (reported by Beatrice Morel, Université La Réunion). It concerns a severe flooding episode that hit East and Central Africa in the second half of October 1997 and caused devastating loss of life and property in some areas.

As first step to improve the synoptic description of this High Impact Weather event countries were asked to supply in-situ data. Preliminary analyses of the station rainfall indicate that East Africa received excessive precipitations during October 1997; in R.D Congo, record rainfall was observed up to December 1997. In Ethiopia, most of the rains (averaging 60 to 90 percent the monthly total rainfall) were received within 11 days over the period 18-28 October 1997. Further south, record total rainfall was observed within 7 days within the period 17-23 October 1997 (averaging 50 to 70 percent of the monthly total rainfall for much of the North-eastern Highland and the Northern Coast of Tanzania.

In an attempt to gain insight into the atmospheric processes involved, first results show that these excessive rainfalls occurred in association with strong ENSO conditions, a positive phase Indian Ocean Dipole (not shown) as well as significant Equatorial-Rossby (ER) wave activity occurring at this time period.

The West African case is most recent. It concerns a wet spell across West Africa during the last decade of August and first decade of September 2009, marked with heavy precipitation leading to floods, particularly in Niger, Senegal and Burkina Faso. The event that occurred in Burkina Faso on September 1st 2009 has been the most extreme. In ten hours, Quagadougou, the capital city, recorded 261 mm from a quasi –stationary mesoscale convective system leading 150 000 affected people with 9 death and loss of properties and damaged roads. First analyses have shown presence of synoptic early waves but also interactions with North African and Mediterranean systems participating in a kind of blocking weather. For northern and southern Africa, some countries have proposed cases of interest, South Africa, Algeria, Tunisia.

1.3 A New way forward for THORPEX-Africa

At a meeting in WMO during July 2011 it was agreed to try and link THORPEX- Africa activities somewhat more closely to operational activities in the NMHSs. To take this approach further the following steps will be implemented

- Design a template on High Impact Weather (HIW) events and encourage and promote reporting of HIW close to near real-time and also promote close to near real-time verification of the events

- Customize TIGGE products for applications in Africa (related to temperature, wind, humidity, and rainfall) – Working with the TIGGE Working Groups and the Severe Weather Forecast Demonstration Projects (SWFDPs) where they exist for example Southern Africa and East Africa and working directly with groups of National Meteorological and Hydrological Services (NMHSs) in other cases.

- For areas without SWFDPs, develop a dedicated web page for the products

- THORPEX-Africa to add value to the raw ECMWF products for applications in Africa and to the web site.

- For both TIGGE and ECMWF products, encourage NMHSs to provide feedback on the value of these products. THORPEX-Africa should contribute to scientific evaluation of these products.

- Consider developing MOS products

Continue to follow-up the set of case studies engaging the working groups to the maximum extent and encourage universities and NMHSs to collaborate on activities related to predictability and dynamical processes.

Also proceed with the development of the HIW Information System when dedicated personnel are available (incorporating HIW reporting, case studies, socio-economic information, data related to the events, etc). The Information System will initially be hosted at the ICTP and eventually transferred to an African centre.

Were possible promote training on the use of the ensemble products (mostly for forecasters) and on the skills to enable NMHSs to add value to model products, particularly multi-model ensemble data.

1.4 Resources

A major impediment to implementation of THORPEX Africa activities is the lack of suitable resources. Previous bids for funding did not succeed. Funding is required for two individuals to implement

(i) High Impact Weather Information System,

(ii) Generate test products for (and manage) a dedicated website,

Ideally funding is also required for post-docs and graduate students to conduct predictability studies and analyses of High Impact Weather events and for supporting facilities, networking and training programmes.

Some possible funding approaches include: Working through GEO. The new GEO work plan (2012-2015) emphases the additional resources necessary for THORPEX-Africa implementation. Other possible approaches include seeking to influence the Korean NWP capacity building element of the GEO task to align it with THORPEX-Africa interests. Working with EGIDA (an EC funded initiative to identify sources of research funds for GEOSS implementation) and with the West Africa Science and Service Centre on Climate and Adapted Land Use (WASCAL) and with the African Water Cycle Coordination Initiative (AWCCI)
It is hoped that the THORPEX Trust Fund will support regular meetings of specific people to implement the activities of the new way forward and for occasional short visits by selected individuals to main operational centres (e.g. ECMWF, UKMO, Meteo-France, NCEP, etc)

Other approaches for funding include submitting a proposal to the International Centre for Theoretical Physics (ICTP) for workshop training and networking. Approaching the Meteorological Association of Southern Africa (MASA) for supporting post-docs and masters and exploring the possibility of support from the Global Change System for Analysis Research and Training (START)

2 Asian Regional Committee (ARC)

The Asian Regional Committee (ARC) was established in May 2003. There was a preparatory meeting, led by Dr. Hajime Nakamura, who was the first chair of the ARC, to discuss the objectives and structure of the ARC in February 2003 in Tokyo. ARC meetings have been held, about once each year since the first one in March 2004 in Seoul, Korea. Currently the ARC consists of five Member countries; China, India, Japan, Republic of Korea and Russia. A series of Asian THORPEX Scientific Workshops was started in June 2006 in Goyang, Korea. The second Workshop was held in February 2009 in Hangzhou, China, and the third Workshop in June 2010 in Jeju, Korea.

The main objectives of the ARC meeting and the Scientific Workshop are to;

- promote the activities of THORPEX in Asia and establish close links , with International THORPEX activities
- exchange information among the Members, related with THORPEX and the status of the activities
- discuss the latest scientific results from THORPEX
- plan, coordinate and execute THORPEX regional campaigns

The major ARC activities are therefore organised and reviewed through the Regional Committee meetings and regular Scientific Workshops.

Committee Meetings

The ARC meetings have been held about once a year to exchange information concerning the activities in Member countries and to discuss the regional THORPEX Science Plan and Implementation Plan. In the first few meetings, there was also a discussion on the main high impact weather features that should be the main focus. At the next few meetings the primary interest concerned the THORPEX Pacific Asian Regional Campaign (T-PARC) whilst in recent meetings the main theme has been the future THORPEX activities in the region.

Scientific Workshops

The ARC Workshops mainly discuss the programmatic items. Thus the Member counties agreed to hold a regional THORPEX Scientific Workshop, to discuss scientific topics and results. In the latest ARC meeting, the ARC agreed to hold the meetings about every two years.

2.1 Major accomplishments of the ARC

2.1.1 Field Experiments

THORPEX Pacific Asian Regional Campaign (T-PARC) in Summer 2008

An international scientific field campaign over the Pacific in 2008, called the THORPEX Pacific Asian Regional Campaign (T-PARC), was carried out by the international scientific community and a wide range of institutions, including the ARC, the North America Regional Committee (NARC), and the European Regional Committee (ERC). The main aim was to improve typhoon track forecasts and to study extratropical transition (ET) and downstream impacts. During T-PARC, there were several targeting guidance products available for adaptive observations taken by airplanes to improve typhoon track prediction. These products identify the "sensitive area", where the in-situ observations by airplane are expected to give a high impact for improving the forecast. There are several different methods to compute the sensitive areas, such as adjoint- versus ensemble-based methods and a moist versus dry norm. The results show that the adaptive observations on average improve the typhoon track forecast over the western North Pacific, although the amount of improvement differs between the models. Also it was learned that in some cases the forecasts were strongly degraded, mainly due to inadequate data assimilation of the additional airplane observations near the typhoon centers, suggesting that there is need to develop further not only the strategy on how we utilize the targeting guidance, but also the careful treatment of the observational data near the typhoon center.

During the field phase of T-PARC, several tropical disturbances moved poleward and underwent a transition into the mid-latitudes. The character of these disturbances included a weak circulation associated with widespread deep convection, a small tropical cyclone, a typhoon, and a super typhoon. Corresponding to the variety of tropical disturbances was a wide range of forecast and actual structural changes and downstream developments, which provided a broad spectrum of forcing and downstream impacts to be investigated.

A three-aircraft mission was conducted into what was thought to be a weakening typhoon Sinlaku. However, during the mission convection increased rapidly and the ELDORA observations identified some of the deepest convection observed during the T-PARC period. Sinlaku re-intensified to a typhoon and then began ET 24 hours later. This period represents a source of a large amount of variability in deterministic and ensemble forecast fields from a variety of operational forecast centers. The results show that the role(s) of the vertical distribution of vorticity contained in the deep convection was found to be critical to the re-organization of the tilted vortex to an upright circulation that intensified to typhoon strength. The overall combination of vertical wind shear, TC vortex, and deep convective activity resulted in a unique interaction among synoptic-scale, storm-scale, and mesoscale factors.

Typhoon Jangmi also provided a source of reduced predictability, but this was related to modification of the mid-latitude jet stream due to outflow from Jangmi rather than increased convection and downstream ridge building. Numerical simulations with a high-resolution mesoscale model have been combined with potential vorticity (PV) diagnosis to investigate the physical mechanisms responsible for the interaction between TY Jangmi and the mid-latitude flow. The analysis of the PV structure along with trajectory calculations showed that most of the lifting of tropical air to the jet level occurs in a small band at the baroclinic zone. This results in an enhanced outflow and may explain the acceleration and deflection of the jet.

The above examples represent a sample of the investigations being conducted on the variety of data obtained during the T-PARC field campaign. As indicated in these studies the results are expected to eventually lead to increased predictive skill for tropical cyclone-related weather.

THORPEX Pacific Asian Regional Campaign (T-PARC) in Winter 2008/9

Asian countries also played a major role in Winter T-PARC. For example, 37 upper-air stations of 11 Regional Roshydromet Administrations took part in the campaign during the period 07.01.2009 - 28.02.2009 and made totally 603 irregular adaptive ascents within 33 periods of intensive observations (IOPs).

In each IOP an individually selected subset of the participating stations performed additional 06 and 18 UTC ascents following special Data Targeting System observation requests.

Requests were sent by the Senior Duty Meteorologist of NCEP NOAA Central Operations to Moscow Main Radio-meteorological Centre of Roshydromet by e-mail ~30 hours prior to additional ascent 06 UTC and were promptly disseminated by MRMC to upper-air stations via Roshydromet communication channels.

Results of additional observation were transmitted operationally to the WMO GTS as conventional FM35 TEMP messages. A special e-mail feedback was organized to notify stations timely about any mistakes they were making in TEMP messages. Operational daily presentation of the status of the observations and entry of data to the WMO GTS was organized both by NCEP NOAA (http://www.nco.ncep.noaa.gov/sib/qap/realtime/thanks/index.thanktpr.shtml) and CAO (http://www.caorhms.ru/monitor/wtparc).

Campaigns in Korea

The 2010 summer intensive observation was conducted from 14 August to 4 September 2010 at three observation sites of Incheon airport, Yangpyeong, and Dongducheon that surround the Seoul metropolitan area by using instruments such as micro rain radars, radiosondes, rain gauges and so on. The micro rain radar is a vertically-pointing Doppler radar that was used for examining vertical structures of precipitation systems as it measures rainfall rate and radar reflectivity. Radiosondes were used for analyzing atmospheric physics in mid and upper levels at three sites and also used as a data source of comparison with aircraft measurements (i.e., AMDAR) near Incheon airport. The goals of the summer intensive observation are 1) to investigate relationships of frequency, amount, and intensity of rainfall with urbanization, 2) to understand physical mechanisms of severe weather accompanied by heavy rainfall, and 3) to examine effects of urbanization and topography on changes in precipitation processes.

During the observation period from 14 August to 4 September 2010, a total of 5 rainfall cases including a Typhoon “Kompasu” (September 1~2, 2010) that produced a lot of damage in the metropolitan areas during landfall were observed and investigated by using the collected data. For each rainfall case, reasons of rainfall occurrence were varied such as cold front, late Changma, urban and topographic effect, blocking, etc.

During the observation period, total rainfall accumulation was largest in the Seoul area (most populated) and the rainfall accumulation in Incheon airport and Yangpyeong (less populated) was relatively smaller. For the case of Typhoon “Kompasu”, average wind speed was greatest at the Incheon airport site, indicating that effects of Typhoon “Kompasu” is relatively greater in coastal areas and this is probably attributed to topographic effects. In the future, precipitation mechanisms with more case studies will be investigated through surface and upper air observations and the effects of the city environment and topography on the precipitation processes will also be examined. Evaluations for these effects by using numerical models and improvements of predictability will be performed.

Campaigns in India

In recent years, India has taken a number of initiatives and planned field experiments linked to THORPEX have a better understanding of tropical weather systems and to improve forecasting skills. Some of these are

STORM (Severe Thunderstorm Observation and Regional Modelling Experiment) covering North Eastern parts of India, Bangladesh, Nepal and Bhutan

- Nowcasting Experiment for Common Wealth Games 2010 followed by Metropolitan Weather and Air Quality Forecast System for Delhi Metropolitan Region

- Bay of Bengal Land fall Cyclone Track Prediction Experiment

- Continental Monsoon Convergence (CTCZ): A Major South Asian Monsoon Experiment

Forecast Demonstration Project (FDP) of tropical cyclone over the north Indian ocean.
During the past few years huge technological advancements have been achieved elsewhere in the world to observe the inner core of the cyclone. Accordingly a programme has been evolved on prediction of track of tropical cyclone over the north Indian ocean in collaboration with the USA resulting in planning of the Forecast Demonstration Project (FDP) over the north Indian ocean.

Campaigns in China

Observation Experiment of Mesoscale Predictability on Summer Rainstorm around Beijing Area The project "The Summer Storm Observing System Research and Predictability Experiment Demonstration around Beijing Area" was launched in Oct, 2007.The field observation experiment was carried out to determine the sensitive observation area for Beijing summer rainstorm forecasting through diagnostic analysis and numerical simulation. It set up an adaptive observation system to study the impact of the observation in the sensitive areas on rainstorm forecast around Beijing area. The observation project mainly focused on intensive and enhanced temporal and spatial observation under severe rainstorm conditions using operational upper air observations, GPS radiosonde observations, wind profilers, Doppler radar and regional AWS network. The continuous observation period was from June to August and continuous intensive observation was from July 20 to August 20. With the observation dataset acquired from the field experiment, a research was carried out on Tianjin Dagang GPS radiosonde sensitivity.

*South China Heavy Rainfall Experiments (SCHeREX***)** (Zhang et al., J. Meteor. Soc. Japan, 2011) The South China Heavy Rainfall Experiments (SCHeREX) was staged during 2008 and 2009 in the southern part of China by the Chinese Academy of Meteorological Sciences under the support of the Chinese Ministry of Science and Technology and China Meteorological Administration. SCHeREX aims at obtaining abundant observational datasets at the meso- scale, better understanding of the structure and evolution of heavy precipitation systems in south China, exploring establishment of an operational platform for heavy rainfall monitoring and prediction and improving the ability of heavy rainfall monitoring and prediction. Four zones were selected in SCHeREX, namely, southern China, the middle reaches of the Yangtze River valley, the Huai River valley, and the lower reaches of the Yangtze River valley. The observation phases were May 1–June 10 in the southern China zone and June 10–July 20 in the other three zones. The efforts have led to the establishment of the meso-scale observing networks with enhanced capacity to observe precipitation systems at the meso- scale level. The collected data have been utilized in meso-scale reanalysis not only to reveal the fine structures of the precipitation systems but also to provide better initial conditions for meso-scale numerical models to make short-term forecasts. Assimilation of the dropsonde data has improved the analysis of the locations and intensities of typhoons Goni and Morakot. With the real-time field data being part of the forecast system, the experiments have allowed more efficient interactions between the observing system and the forecast system and thus improve the performance of meso-scale heavy rainfall forecasts.

The Third Tibetan Plateau Experiment for Atmospheric Sciences The Tibetan Plateau is the “third pole” of the Earth. Its unique geographical environment determines that Plateau Meteorology has long been the constraint on the development of atmospheric sciences in China. The overall objectives of this experiment are, through the third Tibetan Plateau Experiment of Atmospheric Sciences, to optimize the comprehensive meteorological observation system on and surrounding the plateau, to develop the satellite remote sensing - terrestrial integrated observations re-analysis techniques; to clarify the plateau energy cycle, the material cycle, and the water cycle, to enhance the understanding of the plateau impacts on China’s and global weather and climate; and to improve the prediction of China's disastrous high impact weather and the response capacity to the climate change.

Field experiment on Convective Clouds and Heavy Monsoon Rainfall. As a follow-up field experiment of the SCHeREX (Zhang et al., J. Meteor. Soc. Japan, 2011), it will focus on the interaction between convective clouds and heavy monsoon rainfall in South China during the onset period of the South China Sea monsoon. Its scientific gaols are understanding micro-physical processes in convective clouds, thermal and dynamic as well as hydrometeor structures and their evolution, relations of meso-scale system with synoptic and planetary systems. It aims at improving cloud model, assimilating intra-cloud parameters, and thus raising the capability for heavy rainfall forecasts in South China.

Campaigns in Japan

Support for the Severe Weather Forecast Demonstration Project (SWFDP) in Southeast Asia Southeast Asian countries (Cambodia, Lao, Thailand, and Vietnam) are implementing the SWFDP, to mitigate disasters due to high-impact weathers, such as typhoons and flooding. To support SWFDP in Southeast Asia, the MRI is preparing a website to provide the probability of extreme events such as heavy precipitation based on TIGGE data, in addition to the tropical cyclone ensemble forecast information website.

2.1.2 TIGGE related activities

CMA TIGGE Portal

CMA operates one of the three TIGGE Portal sites at http://bridge.cma.gov.cn:8080/tigge/index.jsp, where the data is available with a 48 hour delay for research purposes.

As a complement to the TIGGE archive, CMA agreed to archive Asian LAM EPS following TIGGE LAM directives.

Tropical Cyclone Research Projects

There are two on-going WWRP FDP/RDP projects on tropical cyclones over the western North Pacific. These are the Typhoon Landfall Forecast Demonstration Project (http://tlfdp.typhoon.gov.cn/) and the North Western Pacific Tropical Cyclone Ensemble Forecast Project (http://tparc.mri-jma.go.jp/cyclone/), which are jointly organized by the Tropical Cyclone Programme (TCP) and WWRP. These two projects were also related to the Shanghai EXPO 2010, and provided some operational guidance to forecasters.

TIGGE monitoring and verification website

This research website compares the ensemble forecasts produced by the TIGGE data providers. It includes a comparison of selected verification statistics for the TIGGE forecasts and a comparison of forecasts such as the Madden-Julian Oscillation. http://tparc.mri-jma.go.jp/TIGGE/index.html

TIGGE related research

Many research articles using TIGGE data have been published. The TIGGE data are used not only for the construction of the multi-model EPS (Matsueda et al. 2006; Matsueda et al. 2007; Matsueda and Tanaka 2008) but also for the predictability studies such as blocking (Matsueda 2009; Matsueda et al. 2011; Matsueda 2011) and tropical cyclone tracks (Yamaguchi and Majumdar 2010).

2.1.3 TIGGE-LAM activities

LAM EPS developments

The development of LAM EPS in Asia has been rapid over the past few years, mainly due to the WMO B08RDP project. The Asian LAM EPS systems are listed in the following table.

Table 2.1: List of LAM EPS for Asia

LAM EPS System	Status	Institute
CMA-REPS	Operational	CMA
KMA-REPS	Pre-operational	KMA
JMA-REPS	Development	JMA

CMA, China

The WRF-ARW-model-based regional ensemble prediction system (REPS) over China has been running operationally since June 2011 with the horizontal resolution of 15km and 15 members. The system uses multiple initial conditions (based on bred vector methods) and multi-physics. The lateral boundary conditions are provided by the CMA global EPS. The REPS products have been distributed to all CMA weather services, including (1) ensemble mean and ensemble spread for upper level variables (2) probabilistic products for surface parameters and two convective risk probabilistic products. The next generation of operational model GRAPES (The Global/Regional Assimilation and Prediction System) with 4D-VAR data assimilation system is being developed. Currently, work is underway on the development of a singular vector based global EPS using GRAPES.

JMA, Japan

Different initial perturbation methods have been used to construct the regional EPS at JMA, namely singular vectors and ensemble data assimilation (EnKF and En3DVar). Currently, the ensemble-related research has been focused on the effects of resolution, ensemble size, the perturbed boundary condition and model-physics perturbation.

KMA, Korea

A regional EPS based on multi-model method has been tested in real-time by NIMR (National Institute of Meteorological Research) since 2003. Six model systems (MM5, GSMM5, WRF-ARW, WRF-NMM, WRF-ARW-DA, and UM) are used to construct 16-member ensemble. The multi-physics method is used for each model system to produce its corresponding ensemble members. It is planned that the regional EPS will be operational REPS in 2013; this will include a downscaled regional EPS from based on the global ETKF EPS, and the NIMR multi model ensemble.

TIGGE LAM archive

As a complement to the TIGGE archive, CMA has agreed to archive Asian LAM EPS following TIGGE LAM standards.

2.2 Future Directions for the ARC

At the 7th ARC meeting in Jeju Island, Korea, the ARC agreed to establish two Working Groups; a Numerical Weather Prediction Working Group (NWP-WG) and a GIFS-TIGGE Working Group (GIFS-TIGGE WG). The purpose of these Working Groups is to develop more frequent and effective communication structures amongst the WG members.

Several Southeast Asian countries (Cambodia, Laos, Thailand, Vietnam) are implementing an SWFDP, to study high-impact weather over the region and to mitigate disasters due to high-impact weathers, such as typhoons or flooding. The ARC at the 7th ARC meeting in 2010, agreed to join this project. The objective of ARC participation to the project is to show the capability of the TIGGE database.

3 European Regional Committee (ERC)

The European THORPEX community is characterised by a high level of activity within both the operational and academic communities and a strong collaboration between the two communities. The role of the European Regional Committee has been defined as providing a framework within which activities can be focussed on specific THORPEX tasks within Europe and promoting communication between the different groups working on these tasks. Thus a major effort was devoted to developing the THORPEX European Plan followed by the organisation of the first THORPEX European Regional Meeting.

The European Plan builds upon the overall THORPEX Science Plan and focuses on implementation and prioritisation of the scientific issues that are specific to European interests, and recommendations for actions to be initiated within Europe. The most important links to other organisations and programmes inside and outside THORPEX, and inside and outside Europe, are documented. The plan has been published on the THORPEX website, and will be updated in conjunction with European regional meetings.

The plan reflects the special circumstances of meteorological research in Europe. Most important is the large number of nations, each with its own research funding structure, and its own national meteorological service. These are supplemented by trans-national organisations at the European level, including EUMETNET, EUMETSAT and ECMWF, as well as trans-national research and coordination agencies, such as the European Community Framework Programmes, and the Co-Operation in Science and Technology Programmes (COST).

The diversity of meteorological research in Europe influences the priorities seen in the plan, notably the significant emphasis on limited area modelling, data assimilation, multi-model ensembles, and model development.

The THORPEX European Regional Meeting was held in Karlsruhe, Germany from the 24 to 27 May 2011, hosted by the Karlsruhe Institute of Technology. The aim of this meeting was to review progress in European THORPEX research, to strengthen existing collaborations and initiate new collaborations within the European THORPEX community, to identify necessary revisions to the THORPEX European Plan, and to discuss European involvement within new THORPEX initiatives. The meeting was attended by 74 participants, many of whom presented talks or posters on THORPEX related scientific research projects.

Break-out groups made a series of recommendation in the PDP, DAOS and TIGGE areas. A number of overall recommendations emerged. These were related to cross-cutting topics between the WGs (e.g. ensemble DA and verification) and recommended that links between the WGs should be strengthened. It was recommended that a joint workshop with the Verification WG should be held. Also it was suggested that links with SERA should be improved e.g. by developing projects related to renewable energy. Overall the meeting was considered very useful and it was hoped that others would be planned.

3.1 Activities – Predictability and Dynamical Processes (PDP)

3.1.1 PANDOWAE

PANDOWAE (Predictability and Dynamics of Weather Systems in the Atlantic European Sector – www.pandowae.de) is a research unit funded from 2008-2014 by the German Science Foundation (DFG) focusing on PDP priorities but with a contribution to DAOS interests related to targeting. The partners are Karlsruhe Institute of Technology, the DLR, University of Mainz, University of Munich, Institute for Atmospheric Physics Kühlungsborn, ETH Zürich, University of Bern, DWD. PANDOWAE is defined around three research areas: a) Upper-level Rossby waves: triggering, propagation and wave-breaking, b) Moist processes and diabatic Rossby waves and c) Ensembles and Adaptivity. The group conducts basic research motivated by NWP priorities. A particular feature has been the strong collaboration with operational centres. Operational NWP models, especially the ECMWF IFS and the COSMO model are applied in research mode. PANDOWAE early career scientists have worked together with the DWD; ECMWF, MeteoFrance and NRL. In each three year phase 5 postdoctoral scientists and about 7 Ph.D. students are funded. In addition, 7 Masters students graduated during Phase 1. Key results are related to the assessment of objective techniques used to identify Rossby wave trains (Glatt et al. 2011), the role of diabatic processes in a sequence of events initiated by an extratropical transition event and culminating in a Mediterranean cyclogenesis (Grams et al. 2011), a case study of a diabatic Rossby wave (Böttcher et al. 2011), the vertical structure of Atlantic extratropical cyclones (Campa and Wernli 2011), the impact of targeted observations on typhoon track during T-PARC (Harnisch and Weissmann 2010), the assimilation of T-PARC DIAL water vapour observations (Harnisch et al. 2011) and the structure of singular vectors associated with an Atlantic extratropical transition case (Lang et al. 2011).

3.1.2 PREVASSEMBLE

The project PREVASSEMBLE, supported by the French Agence Nationale de la Recherche for a four-year period (2009-2012), focuses on all aspects of the study of ensemble methods for both assimilation and prediction in meteorology and oceanography. Three partners participate in the project : Institut Pierre Simon Laplace (IPSL, Paris, with O. Talagrand as person-in-charge), Institut National de Recherche en Informatique et en Automatique (INRIA, Rennes, F. Le Gland) and Météo-France (Toulouse, G. Desroziers).
The main results obtained so far that have relevance for THORPEX bear on the following aspects

- *Saturation of prediction ensembles*. Objective evaluation scores for ensemble prediction saturate for ensemble size 30~50. This results from the fact that only probabilities for events or probability distributions for small-dimensional variables can be objectively validated. This has significant implications for the design of ensemble prediction system
- *Quantification of model error for ensemble prediction*. Assuming that model and analysis errors are uncorrelated, the covariance matrix of the former can be obtained by appropriate subtraction from the observed covariance matrix of the total forecast error. That approach, implemented on the ensemble prediction system AEARP of Météo-France, has shown positive impact on the quality of the forecasts
- *Ensemble variational assimilation*. Ensemble variational assimilation has been implemented for defining the initial conditions of AEARP. The impact is positive

Other works are being performed on the Bayesian character of ensemble variational assimilation, on the mathematical properties of Ensemble Kalman filter and of particle filters, and on assimilation of images of the oceanic circulation.

3.1.3 DIAMET (Diabatic Influences on Mesoscale Structures in Extratropical Storms)

DIAMET is a new project that will form the focus of UK activity on mid-latitude storm dynamics and prediction for the next 3 years (http://ncasweb.leeds.ac.uk/diamet/). It is one of three projects funded through the NERC (Natural Environment Research Council) Storm Risk Mitigation programme and started in October 2010. As part of DIAMET there will be two field campaigns based across the UK and Atlantic approaches, using the FAAM aircraft and an enhanced ground-based observation network including Doppler radar coverage across the country, automatic weather stations, wind profilers and radiosondes. The first campaign in autumn 2011 (September and late November) builds on the methods from the T-NAWDEX pilot flights; the second campaign in 2012 (July/August) will examine storm systems during summer. The project will be collaborating with THORPEX partners from France, Germany and Switzerland. DIAMET will address three topics:

A. Characterisation of the effects of diabatic processes on mesoscale structures within extratropical cyclones and their subsequent evolution. Central to this activity is an attempt to derive diabatic heating rates through both detailed observations of cloud microphysics and by integrating changes in potential temperature following air masses. Heating cannot be observed directly and the use of models is essential to draw the observations together. High resolution modelling of case studies will be used to determine the effects of different processes within NWP models (such as parameterised turbulence or radiation) accumulated following air masses and their impacts on forecasts.
B. Examine the parameterisation of three key processes and ways in which it might be improved in the light of the new observations: 1) convection in the shear environment of an extratropical cyclone, 2) boundary layer fluxes at high wind speeds over ocean and 3) ice and liquid cloud microphysics, especially within warm conveyor belts.
C. Predictability of precipitation and high surface winds and its link to the predictability of mesoscale features (tracked by the Met Office within the MOGREPS ensemble) with which the weather is often associated. This element involves running ensembles of convection-resolving forecasts perturbing model parameters and exploring the sources of model error and the nature of balance at small scales using the data assimilation scheme.

DIAMET will work with the other two projects of the NERC Storm Risk Mitigation programme: TEMPEST is investigating the representation of extratropical cyclones in climate model simulations, identification of model error and its relation to processes. TEMPEST will use results from the CMIP5 multi-model dataset, as well as some multi-decadal simulations using the ECMWF model at a range of resolutions (100 down to 10km grid) that were conducted by the ATHENA project (http://wxmaps.org/athena/home/). DEMON is examining flood impact modelling, in particular the cascade of uncertainty associated with driving hydrological models with NWP model output and then using those hydrological models to provide boundary conditions for hydraulic flood inundation models.

3.2 Activities – Data Assimilation and Observing Strategies (DAOS).

3.2.1 A-TReC

The Atlantic THORPEX Regional Campaign (ATREC) was a collaborative effort between EUCOS (EUMETNET Composite Observing System) program and THORPEX to test the targeting ability of a wide range of observational platforms in a real-time quasi-operational environment. It involved a high degree of coordination and collaboration among UK Met office, ECMWF, Meteo-France, NRL, NASA, U of North Dakota, Meteorological Service of Canada, NCEP, FSL, NCAR and U of Miami. Both ETKF and SV methods were used to identify the areas where supplemental observations might help to mitigate forecast errors in regions selected for verification over Europe and the eastern US. A variety of observing platforms were deployed where data were collected from instruments aboard or released from these platforms. They included aircraft, AMDAR, ASAP ships, GOES rapid-scan winds and radiosondes to supplement the routine observational network.

In general, the assimilation of targeted observation gave little overall positive impact in terms of the number of cases with the majority of forecasts being only slightly improved or neutral although the impacts varied with NWP system considered..

3.2.2 EURORISK PREVIEW Data Targeting System

The main goal of the PREVIEW DTS project was to develop and to assess the feasibility of operational adaptive control of the operational observing system. The DTS project was led by the Met Office and co-funded by EUCOS and the European Commission (within the PREVIEW project). The main software, an interactive web-based tool, was developed by ECMWF and ran on their computer system during the trial phase which lasted from 4th February until 19th December 2008. During the trial the focus was on improving short range (1-3 days) forecasts of potentially high-impact and/or high-uncertainty weather events in Europe. Forecasters from all EUMETNET members had had the chance to submit “sensitive area prediction” requests on a daily basis. Afterwards the DTS displayed the sensitive areas calculated by ECMWF, Météo-France and Met Office and the lead user (an experienced forecaster) could then use the system to issue requests for additional, unscheduled observations. The role of the lead user was predominantly taken by a forecaster at Met Office. However, the DTS also proved to be portable in that sense that the lead user role was given for two shorter periods to Météo-France.

The DTS was developed and run according to plan and within budget. The trial has shown that a data targeting system can be routinely used. A total number of 628 cases were suggested; thereof 548 were accepted and from these 184 sets of observations were requested. Targeted observations were successfully deployed from E-ASAP units, by the E-AMDAR programme and in 21 countries (incl. Bermuda and Canada). 88% of the additionally requested radiosondes from land stations have been launched. Furthermore, the DTS has been used to support research field campaigns like THORPEX-IPY, T-PARC and MEDEX. Extensive modifications were carried out by ECMWF for T-PARC to allow the DTS to be used in the western North Pacific, to give a combination of fixed and flexible verification regions, and to incorporate products from additional operational centres. A comprehensive description of the DTS and the 2008 trial phase can be found in Prates (2008).

A subsequent evaluation of the trial will be coordinated by EUCOS.. The basic question to be answered is whether there was a beneficial impact of the extra observations on NWP forecasts.

3.2.3 E-TReC

The European THORPEX Regional Campaign 2007 took place in conjunction with the mesoscale Convection and Orographically-induced Precipitation Study (COPS: Wulfmeyer et al., QJRMS 2011), and focused on the synoptic and upstream conditions leading to summertime precipitation. An enhanced density of AMDAR reports was collected on 7 days in July of 2007, additional radiosonde launches were made on 6 days (both data sources funded by EUCOS), and flights of the DLR Falcon, equipped with wind and water vapour lidars took place on 3 days (funded jointly by DLR and DFG). Specialized guidance for planning the missions was provided in the form of sensitive area calculations from MeteoFrance, ECMWF, and the University of the Balearic Isles, which were used to identify regions of interest for subsequent precipitation events. Some preliminary analysis was carried out shortly after the field phase, including data denial experiments at ECMWF on the impact of water vapour observations and a comparison of the different sensitive region calculations, but was not continued since the number of cases was too small for convincing results. The observational data is lodged in the COPS data bank and is openly available.

ETReC 2007 data has been used to quantitatively analyze moisture transport. This has enabled a unique evaluation of the ECMWF analysis fields, identifying a wet bias in the boundary layer and tropospheric dry layers, leading to an overestimate of moisture advection into the precipitation region (Schäfler, Dörnbrack, Kiemle, Rahm and Wirth, *J. Atm. Oc. Tech.* 2010). These errors have been confirmed in a second ETReC case, and trajectory analysis has been used to trace the moist bias to incorrect evapotranspiration over upstream land regions (Schäfler, Dörnbrack, Wernli, Kiemle and Pfahl, *Q. J. R. Met. S.* 2011). These results have led to ongoing research in the British T-NAWDEX experiment and the German PANDOWAE project.

A second use of ETReC 2007 data has been the statistical characterization of water vapour variability on scales from 1-300 km, which is required for development of future parameterizations such as stochastic convection schemes. Scaling behaviour has been identified, with high intermittency in air masses influenced by convection and steeper spectral slopes where large scale stirring dominates the variability (Fischer, Kiemle and Craig, personal communication). The European data is now being compared with similar observations from T-PARC and IPY-THORPEX.

3.3 Activities - GIFS-TIGGE

3.3.1 Global GIFS-TIGGE Project

Europe plays a major role in the GIFS-TIGGE initiative. ECMWF provides the European TIGGE archive centre, one of the three centres that make the TIGGE data available to the international research community. The ECMWF TIGGE portal is at http://tigge-portal.ecmwf.int/. ECMWF also hosts the main TIGGE website (http://tigge.ecmwf.int/) which contains general information about TIGGE and GIFS. Météo-France, the UK Met Office and ECMWF all provide regular, twice-daily, global ensemble forecasts to the TIGGE base. They are also active in the development of prototype ensemble products. For fuller details see the TIGGE section (2.1) of the main report.

The GEOWOW project (GEOSS interoperability for Weather, Ocean and Water) is an EU-funded FP7 project that began in September 2011. GEOWOW will make a significant European contribution to the Global Earth Observation System of Systems (GEOSS) by improving the overall quality of the current GEOSS Common Infrastructure (GCI), addressing access to data, usability and interoperability. GEOWOW will significantly enhance the accessibility of the TIGGE archive at ECMWF for the wider user community, in particular the ability to efficiently access long time series of forecast data at user-specified locations. GEOWOW will promote the wider use of TIGGE data for research across a range of GEO Societal Benefit Areas and show how the TIGGE archive can be used to develop ensemble products for different applications. GEOWOW will demonstrate the potential use of such ensemble products, with a focus on severe weather, in close liaison with the WMO SWFDPs. ECMWF, the Met Office, Météo-France and Karlsruhe Institute of Technology are partners in GEOWOW."

3.3.2 TIGGE-LAM related activities: LAM EPS developments

During the last five years, LAM EPS activity in Europe has been very intense. The LAM EPS systems have gained a remarkable role in terms of research priorities and in their contribution to operational weather forecasting. In recent years, operational LAM EPS systems have focused on numerical forecasting at the “regional scale”, with grid lengths typically between 7 and 25 km. European LAM EPS systems are listed in **Table 3.1**.

Table 3.1: List of LAM EPS for Europe

LAM EPS System	**Status**	**Institute -Consortium**
OMSZ LAMEPS	Operational	Hungary
ALADIN LAEF	Operational	ZAMG / Austria
AEMET-SREPS	Operational	AEMET/Spain - HIRLAM
NORLAMEPS	Operational	Met.NO
MOGREPS	Operational	Met Office/UK
SRNWP PEPS	Operational	DWD /Germany - SRNWP
COSMO-LEPS	Operational	ARPA-SIMC/Italy - COSMO
COSMO-SREPS	Preoperational	ARPA-SIMC/Italy - COSMO
GLAMEPS	Dev/ Preoperational	DNMI-Univ Oslo/ - HIRLAM ALADIN
PEARCE	Operational	Meteo-France / France
COSMO DE EPS	Pre-operational	DWD COSMO
AROME EPS	Research	Meteo-France / France
DMI - HIRLAM	Development	DMI
USAM LETKF	Development	USAM/Italy

There are several scientific and technical challenges for the further development of LAM EPS systems:

- **Perturbation of the Initial Conditions.**

Error Breeding and Singular Vectors techniques have been widely implemented. The Ensemble Transform Kalman Filter (ETKF) technique is used at the Met Office, currently it is operational at the global scale and regional perturbations are downscaled from the global ensemble (Bowler et al, 2009). DWD is developing ETKF in the framework of the KENDA (Kilometer scale Ensemble Data Assimilation) project. MeteoFrance is evaluating the ETKF as an option for the AROME ensemble. In the HIRLAM consortium, SMHI is developing ETKF both for Hybrid variational data assimilation and for EPS purposes.

- **Model perturbations**
  Model perturbations are generated by adopting three different approaches: changing parameter settings in physical parameterizations, use of multiple versions of model physics and stochastic physics schemes. The multi-physics and change in parameter approaches are widely applied. Stochastic physics are used or under further development for MOGREPS, COSMO LEPS/SREPS, and AROME.

  The multi-model approach can also be included among the methodologies to account for model errors. A multi-model / multi-boundary approach is being exploited in several implementations, notably:
  - AEMET SREPS, a multi-model multi-boundaries system, based on several LAMs nested in different deterministic global model runs.
  - COSMO SREPS, a multi boundary system where the COSMO model is run at 7 km resolution using boundary conditions extracted from four global models.
  - NORLAMEPS (Frogner and Iversen 2011), based on 21 members of TEPS (the Targeted version of ECMWF EPS) + 21 members of Hirlam LAMEPS.
  - GLAMEPS, a 52 member ensemble (13 per model) based on HIRLAM in two different configurations, Aladin and EuroTEPS.

  Results from pre-operational testing are very positive(Iversen...)

  Techniques to introduce perturbations in soil parameters have been recently developed in the Aladin consortium for Aladin CANARI and Aladin LAEF (Wang et al 2010 (d)). Direct soil moisture perturbations will be tested in COSMO-SREPS (Goufa and Petrula 2010). Soil perturbations are also included in the development plan of MOGREPS.

- **Convective-scale EPS**
  In the future, the main added value from LAM EPS will be in improved representation of high-impact and severe events that is possible using higher-resolution models, at the convective scale. A lot of activity in Europe is directed at the development of LAM EPS systems to be operated at the km scale:

  - The German weather service, DWD, is developing a convection-permitting ensemble named COSMO DE EPS (Gebhardt et al. 2008). COSMO DE uses a 2.8km grid nested in a 7km COSMO regional ensemble. The start of the operational phase is scheduled for 2012.

  - The Met Office is developing a 2.2 km ensemble (MOGREPS-UK). The ensemble will be post-processed using neighbourhood methods to generate probabilistic forecasts. Initially MOGREPS-UK will be based on pure downscaling of the

regional ensemble (MOGREPS-R), but there is also research going on in collaboration with Reading University on convective scale ensemble perturbations (linked with ensemble DA).

- Météo- France is developing a 2.5 km ensemble based on AROME. In a first approach, the PEARP short-range ensemble is downscaled via the ALADIN model, followed by data assimilation performed with AROME for each member (AROME-PEARP ensemble). In a second approach, randomly perturbed observations are assimilated to generate a set of initial conditions for the AROME model (AROME-PERTOBS ensemble). Results obtained so far show that combining both systems improves underdispersion throughout the forecast range, and improves agreement between RMS errors and spread.

- **Other research priorities**
  Some activity is also being directed at calibrating model output, both precipitation and other surface parameters. (Fundel et al. 2010 and Kann et al. 2009). The intense activity on LAM EPS in Europe offers a unique opportunity to compare the benefits of multi-model ensembles with the calibration of a single model using the reforecast data.

  The coupling of LAM EPS with other applications, notably hydrological models (e.g. Thielen-del Pozo et al. 2009) is of utmost importance. This includes propagation of uncertainty information from NWP to other modelling systems.

  Ensemble Based data assimilation is a young and rapidly developing field. The impact of ensemble based techniques is yet to be fully realised. Both Hybrid techniques and fully Ensemble Based systems are under development at several European centres, including Meteo-France, DWD, Met Office and the HIRLAM consortium.

3.3.2 TIGGE-LAM archiving

A list of TIGGE LAM output parameters has been defined, following the standards agreed for the TIGGE project. It has been agreed that ECMWF will archive a sub-set of High Priority parameters produced by the European LAM EPS data providers. This work will be carried out with the help of funding from the GEOWOW project. The TIGGE LAM archive at ECMWF will be populated with data on the original model grids; software to manage and retrieve LAM EPS products from the different grids will be developed.

A good link with the SRNWP Interoperability programme has been established. The outcome of this programme will naturally be accepted and adopted by the European LAM EPS community. TIGGE LAM groups outside Europe will also be encouraged to follow those standards.

The possibility of implementing a European archive of high resolution precipitation analyses is being explored. This would be based on observations from a high density network. Contacts have been established with ECMWF and with other European groups and initiatives with the same objective.

European LAM EPS groups are participating in several RDPs and FDPs, including Beijing 2008 RDP and FDP, MAP D Phase, HyMeX and Sochi 2014.

The North-American TIGGE-LAM group is exploring the possibility of coordinating archival efforts, following operational deployment of the CMC-REPS and in advance of the regional North-American Ensemble Forecast System (NAEFS) implementation in 2015.

3.4 European Participation in Field campaigns

3.4.1 IPY THORPEX Cluster of projects

The Greenland Flow Distortion Experiment (GFDex) has been a highly successful research project: growing from a UK-funded grant into a major international experiment with project partners in Canada, Norway, Iceland, and the USA. The research is ongoing, but at this stage there are over 20 publications, including 10 in a recent special issue of the well-respected *Quarterly Journal of the Royal Meteorological Society*. GFDex has involved collaboration with a number of Meteorological Agencies, including co-authorship with scientists at the UK Met Office, met.no and the Icelandic Met Service, and the testing of parameterization changes in the Met Office's operational forecasting models.

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 (Renfrew et al., 2008) and was greatly aided by its opportune timing at the start of the International Polar Year (IPY). A novel database of imminent projects, developed by the IPY office, enabled Norwegian and Icelandic scientists to become involved – 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. 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 ships. As well as these observational enhancements, GFDex has benefitted greatly from being part of a wider weather-focused IPY project cluster (the IPY-THORPEX cluster).

The GFDex project has included a wide variety of meteorological, oceanographic and climate studies. 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 never or rarely been directly observed prior to GFDex. 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 GTS for inclusion in the next operational forecast cycle. Subsequently error covariance sensitivities to steep topography and model simulation of singular vector structures were examined. The coastal seas around Greenland are now known to be the windiest in the world ocean, so 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. This strong forcing has been observed, compared to models and used to simulate a high-resolution ocean model in a series of papers. The above summary illustrates that all of the original project objectives have been met and, indeed, the project has gone beyond these in scope. Further information and a list of GFDex publications can be found here:
http://lgmacweb.env.uea.ac.uk/e046/research/gfdex/index.htm

The DLR Institut für Physik der Atmosphäre deployed the DLR Falcon 20 during the IPY-THORPEX Campaign in March 2008. The mission was based in Andenes, Norway. During IPY-THORPEX airborne in-situ and remote-sensing observations of atmospheric wind, temperature and water vapour over the Norwegian and Barents Seas. Special focus was on Arctic fronts, polar lows and terrain-induced flow disturbances. The DLR participitation in IPY-THORPEX continued the airborne targeted observations during ATReC 2003 and during the European THORPEX Regional Campaign (E-TREC 2007) which was part of the COPS field experiment in summer 2007. First results of the impact of targeted observations are being published (e.g. Wagner et al. 2010)

3.4.2 T-PARC

The THORPEX Pacific Asian Regional Campaign (T-PARC) was carried out in 2008 in conjunction with Tropical Cyclone Structure (TCS08). The European contributions were the provision of the Data Targeting System by ECMWF, the CNES involvement in the driftsonde, and the leadership of the Falcon mission by the DLR along with support from Karlsruhe Institue for Technology and EUCOS. Of special interest was extra-tropical transition of storms and the downstream impact on predictability.

3.4.3 CONCORDIASI

The CONCORDIASI field experiment in 2010 over Antarctica was a major international field experiment initiated by the French and the US. It involved 19 stratospheric balloons from the French space agency CNES, 13 of which carried dropsondes with the NCAR driftsonde system. More than 600 dropsondes were released from 23 September to 30 November, and transmitted on the GTS. Some wind and temperature data from the gondolas at 17km altitude were also provided in real-time to NWP users. Furthermore, there were additional radiosonde ascents in Antarctica. The European collaboration has been an important factor in the success of this field experiment. The additional radiosonde ascents were organised at Concordia (French-Italian station), Dumont d'Urville (French station) and Rothera (UK station). ECMWF forecasts were used for the prediction of the driftsonde trajectories, together with predictions of satellite trajectories produced by Météo-France and singular vectors over the southern pole computed in real-time by ECMWF to assist the decisions in releasing sondes synchronised with satellite overpasses or in sensitive areas. The balloon and sonde data were used in real-time in European NWP centres, and coordination will continue for exploiting the data in research mode now that the field campaign is over. Concordiasi provided an unprecedented data coverage of meteorological observations over Antarctica. Preliminary results from NRL, DWD and MF indicate that both dropsonde and gondola information have a positive impact on forecast performance. The gondola temperature data at 60hPa shows the largest model errors in areas of strong gravity-wave activity. Furthermore, most models have problems predicting the lowest level temperatures. Dropsonde information confirms statistics obtained with radiosondes and provide a more global view.

3.4.4 AMMA

Collaboration took place between Météo-France and ECMWF in the context of the AMMA-THORPEX WG (exchanging data files and comparing impact of both radiosonde and satellite data over land).

Observation impact related activities were carried out concerning coordinated data impact experiments performed at ECMWF and Meteo-France on the use of bias-corrected radiosonde data (Agusti-Panareda et al. Nuret et al. 2008). A major series of data assimilation experiments performed at Météo-France on the use of microwave radiance data over land (Karbou et al., 2010a, 2010b, Gerard et al. 2011) , and a comparison with the use of MERIS data at ECMWF (by Karbou and Bauer, personal communication).

3.4.5 T-NAWDEX

T-NAWDEX (the THORPEX North Atlantic Waveguide and Downstream Impact Experiment) has been proposed by the THORPEX working group on Predictability and Dynamical Processes (PDP) and constitutes a key element of the European THORPEX Science Plan. During the first planning meeting in Erding in February 2008[1], the scientific goals were discussed with partners from UK, France, Switzerland and the USA. The overarching scientific goal of T-NAWDEX was defined to investigate in detail the link between skill in forecasts on the 1-7 days range, systematic model errors and the representation of physical processes that contribute most to model error. The focus will be on the diabatic modification of air masses, the influence this has on the development of Rossby waves as they propagate across the North Atlantic and the subsequent effects on high impact weather forecasts for Europe. Although regional in experimental focus, the results and conclusions will be pertinent to the extratropics world wide.

T-NAWDEX will focus on three stages:

1) Triggering of wave guide disturbances by different dynamic features, with a focus on the role of diabatic processes.
2) Propagation of wave activity along the waveguide and further diabatic modification of PV anomalies across the Atlantic,
3) Downstream impact of diabatically-modified PV anomalies, propagating along the jet or developing below it, on precipitation and high winds over western and southern Europe.

The original idea was to conduct the international field phase of T-NAWDEX in the time period of the 2nd PANDOWAE phase in the framework of the demonstration mission HALO-THORPEX which was jointly proposed by DLR, KIT and University of Hohenheim. HALO-THORPEX was selected by the HALO Scientific Steering Committee (HALO-WLA) as one of 8 first missions. This field phase would be ideally combined with HYMEX in autumn 2012.

However, there is significant delay in instrumentation of the German research aircraft HALO due to difficult certification issues. Therefore, the series of HALO demonstration missions has had to be postponed by 2 years (the very first demonstration mission is expected to be conducted in 2011). Currently, the selection of demonstration missions is made on a case-by-case basis by the HALO-WLA. We cannot expect HALO to be reliably available for international research missions in 2012. This has hindered the advance of the T-NAWDEX project.

As a result of the workshop, an opportunity arose to conduct several flights with the FAAM aircraft (funded by NCAS) to trial flight plans and ideas in preparation for the T-NAWDEX experiment. A consortium drawn from 4 UK Universities and led by Ian Renfrew conducted three flights through different frontal systems in November 2009 and these cases have

[1] http://www.pandowae.de/en/newsevents/t-nawdex-workshop

been studied in detail using simulations at varying resolution using the Met Office Unified Model.

3.5 Other European Meetings

Europe hosted the Second THORPEX International Science Symposium in Landshut, Germany (organised by Hans Volkert and DLR). The Met Office hosted a workshop in Exeter in October 2006, to discuss the scientific challenges facing THORPEX in Europe; the main outcome was a first draft of the European plan. THORPEX activities across the UK, involving collaboration between universities, the Met Office and ECMWF, were invigorated by a workshop hosted in Cambridge, October 2008, by the National Centre for Atmospheric Research (NCAS) and the National Centre for Earth Observation (NCEO). The successful meeting on Subseasonal – seasonal prediction was hosted by the Met Office in Exeter during December 2010.

References

Agusti-Panareda, A., Jean-Blaise N'Gamini, 2008: Correction of Humidity Bias for Vaisala RS80-A Sondes during the AMMA 2006 Observing Period. *J. Atmos. Oceanic Technol.*, **25**, 2152–2158.

Agusti-Panareda, A., Vasiljevic, D., Beljaars, A., Bock, O., Guichard, F., Nuret, M., Garcia Mendez, A., Anderson, B. E., Bechtold, P., Fink, A. H., Hersbach, H., Lafore, J.-P., Ngamini, J.-B., Parker, D. J., Redelsperger, J.-L. & Tompkins, A. M., 2009: Radiosonde humidity bias correction over the West African region for the special AMMA reanalysis at ECMWF. Quart. J. Roy. Meteorol. Soc., 135. 595–617.

Boettcher, M., and H. Wernli, 2011. Life cycle study of a diabatic Rossby wave as a precursor to rapid cyclogenesis in the North Atlantic – dynamics and forecast performance. Mon. Wea. Rev., 139, 1861-1878.

Bowler N. E., A. Arribas, S. E. Beare, K.R. Mylne and G. J. Shutts, 2009: The local ETKF and SKEB: Upgrades to the MOGREPS short-range ensemble prediction system *Q. J. R. Meteorol. Soc.* **135**: 767–776

Campa, J., and H. Wernli, 2011. A potential vorticity perspective on the vertical structure of mid-latitude cyclones. J. Atmos. Sci., in press.

Frogner, I-L. and T. Iversen, 2011. EuroTEPS –A targeted version of ECMWF EPS for the European area. *Tellus A*, **63**, 415-428.

Fundel, F., Walser, A., Liniger, M. A., Frei, C., and Appenzeller, C., 2010: Calibrated Precipitation Forecasts for a Limited-Area Ensemble Forecast System Using Reforecasts*. Mon. Weather Rev.*, **131**, 176-189.

Gebhardt, C., S.E. Theis, P. Krahe, V. Renner, 2008: Experimental ensemble forecasts of precipitation based on a convection-resolving model. Atmospheric Science Letters 9, 67-72.

Gérard É., F. Karbou, F. Rabier, 2011: Land sensitivity studies towards a potential use of surface sensitive microwave observations over land. Accepté à TGRS-IEEE.

Glatt, I., Dörnbrack, A., Jones, S. C., Keller, J., Martius, O., Müller, A., Peters, D. H.W.: Utility of Hovmöller diagrams to diagnose Rossby wave trainsTellus A (2011), 991-1006

Grams, C. M., H. Wernli, S. C. Jones, M. Boettcher, J. Campa, U. Corsmeier, J. H. Keller, C.-J. Lenz, and L. Wiegand, 2011. The key role of diabatic processes in modifying the upper-tropospheric wave guide: a North Atlantic case study. Quart. J. Roy. Meteorol. Soc., in press;

Harnisch, F and M. Weissmann, 2010: Sensitivity of typhoon forecasts to different subsets of targeted dropsonde observations. Mon.Wea.Rev., 138,2664-2680.

Harnisch, F., Weissmann, M., Cardinali, C. and Wirth, M. (2011), Experimental assimilation of DIAL water vapour observations in the ECMWF global model. Quart. J. Roy. Meteorol. Soc., 137: 1532–1546.

Kann A, Wittmann C, Wang Y, Ma X, 2009: Calibrating 2-m Temperature of Limited-Area Ensemble Forecasts Using High-Resolution Analysis. Mon. Wea. Rev., 137, 3373-3387.

Karbou, F., E. Gérard and F. Rabier, 2010a: Global 4D-Var assimilation and forecast experiments using land surface emissivities from AMSU-A and AMSU-B observations. Part I: Impact on sounding channels. Weather and Forecasting, 25, 5-19.

Karbou, F., F. Rabier, J-P Lafore, J-L Redelsperger, and O. Bock, 2010b: Global 4D-Var assimilation and forecast experiments using land surface emissivities from AMSU-A and AMSU-B observations. Part II: Impact of adding surface channels on the African monsoon during AMMA. Weather and Forecasting, 25, 20-36.

Lang, S. T. K., Jones, S. C., Leutbecher, M., Peng, M. S., Reynolds, C. A. (2011): Sensitivity, structure and dynamics of singular vectors associated with Hurricane Helene (2006). J. Atmos. Sci. In press

Nuret, Mathieu, Jean-Philippe Lafore, Françoise Guichard, Jean-Luc Redelsperger, Olivier Bock,

Prates, C., C. Sahin, D. Richardson: Report on PREVIEW Data Targeting System, 15.12.2008, *ECMWF Technical Memorandum 581*, Reading. http://www.ecmwf.int/publications/library/ ecpublications/_pdf/tm/501-600/tm581.pdf

Renfrew, I.A., G. W. K. Moore, J. E. Kristjánsson, H. Ólafsson, S. L. Gray, G. N. Petersen, K. Bovis, P.R.A. Brown, I. Føre, T. Haine, C. Hay, E. A. Irvine, A. Lawrence, T. Ohigashi, S. Outten, R. S. Pickart, M. Shapiro, D. Sproson, R. Swinbank, A. Woolley, S. Zhang, 2008: The Greenland Flow Distortion experiment, *Bull. Amer. Meteorol. Soc.,* **89**, 1307-1324.

Thielen-del Pozo, J., J. Bartholmes, M.-H. Ramos, and A. de Roo (2009) The European Flood Alert System. Part 1: Concept and development, *Hydrology and Earth System Sciences*, **13**, 125-140, 2009.

Wagner et al, 2010 (COPS ob targeting)

Wang Y, Kann A, Bellus M, Pailleux J, Wittmann C. 2010 (d) . A strategy for perturbing surface initial conditions in LAMEPS. *Atmospheric Science Letters* **11**: 108-113, DOI: 10.1002/asl.260.

4 North American Regional Committee (NARC)

The following highlights the activities of the North American THORPEX Regional Committee. The report discusses the contribution of regional efforts to the themes and priority areas of THORPEX with strong contributions to the multinational T-PARC and YOTC campaigns, the efforts towards the development and use of a multi-institutional ensemble database for research (TIGGE) and multi-institutional operational ensemble forecast systems (NAEFS and GIFS). The report also includes a follow up of the activities of the THORPEX-IPY cluster of projects and SERA activities as well outlining the changes in the governance of THORPEX at the regional and national levels.

4.1 Contribution of the region to the Themes and Major Activities of THORPEX

4.1.1 Regional Campaigns – T-PARC

The US THORPEX Project Office continued to provide the lead in meetings on refining the scientific objectives, attempting to improve the link between research and operational activities and to further the planning of the field phase logistics. After the field campaign, the T-PARC steering committee convened several meetings in both data management and science. The summary of T-PARC and the regional contribution to the programme will be brief and limited to a few important points. The Office of Naval Research (ONR) and the National Science Foundation (NSF) funded nearly 20 research teams addressing the tropical cyclone and ET/downstream components of the experiment. The majority of these research teams are funded by ONR and focus on aspects of tropical cyclone research through the TCS-08 (Tropical Cyclone Structure) programme which took place between 27 August and 21 September 2008. The tropical cyclone and ET phases are really crosscutting activities within the WWRP between THORPEX and Tropical Meteorology. Additional proposals relating to the ET/downstream component of T-PARC were funded by NSF. The winter component of T-PARC was led by NOAA to investigate adaptive measurement strategies within the context of propagating Rossby waves. NOAA funded the measurements.

Canada also participated in T-PARC both in terms of research and a modest contribution to the field phase. The main programmatic interest in Canada is in the winter and ET/downstream phases with a focus on the impact of adaptive in-situ and remote sensing (satellite and airborne) observations on forecast skill over Canada. One SERA project has been planned for T-PARC within Canada. It will examine the relative impact of adaptive measurements on forecast skill for weather situations likely to be encountered during the operations of the 2010 BC Winter Olympics. Progress on this project has been dependent on obtaining 2 sets of winter phase GFS runs; one inclusive of the T-PARC data set and one with the T-PARC data extracted. This work was completed by Yucheng Song of NCEP. Case studies for Olympic –period weather events concurrent with T-PARC missions are now being selected. The Winter T-PARC effort in NOAA intends to examine the implication of improved skill from targeting on societal and economic activities within the Arctic. The international desks at US/NOAA's National Centres for Environmental Prediction (NCEP) have links to the needs of Mexico (and those of other Latin America and Caribbean countries) and the potential users of NAEFS. These international desks at NCEP are an effective use of resources for focused SERA activities. Maintaining stronger links between the THORPEX and the international desks at NCEP is be encouraged.

4.1.2 GIFS- TIGGE and NAEFS

NCAR is one of three official TIGGE archive centres and was the first to make TIGGE data available to the user community. The collaboration between the three archive centres has been excellent. NCEP and the Canadian Meteorological Centre provide ensemble data to the TIGGE database routinely. Significant progress toward the overall TIGGE vision has been made in the US despite the lack of “new” funding for the effort at NCEP and NCAR. Progress was made at NCAR in providing a wide range of user tools and in getting all the NCEP fields to be TIGGE-compliant. NCDC helped to convert non-compliant fields. Also, NCAR has established an on-line toolbox for analysis and access so that as software is created it is shared with the community. Although there is no current funding announcement for using the TIGGE archive, users are actively accessing TIGGE data. NOAA THORPEX is supporting an effort by Tom Hamill of NOAA to evaluate TIGGE skill for the depiction of the tropospheric moisture fields (e.g., atmospheric rivers, warm conveyer belts). NOAA continues to fund a few EMC-ESRL collaborative research projects on issues related to THORPEX. The projects are aimed at improving capabilities of the NAEFS system such as bias corrections and downscalling, T-PARC activities at NOAA, Ensemble Data Assimilation evaluations, and studies on the weather to climate link. No TIGGE or general THORPEX proposals were funded by NASA last year, although they did reference them in their AO. They plan on doing the same this year.
Finally, the North American Ensemble Forecast System (NAEFS), which is the operational counterpart to TIGGE and a prototype for GIFS, is in the process of improving its forecast system. The upgrades include incorporation of new variables, testing and implementation of a downscaling procedure and the expansion of the NAEFS membership to include the NOGAPS ensembles. Despite this progress, there is a need to extend applications and experiments to the weather-sensitive user and social science research communities. In the past year, GIFS-TIGGE has established links with CBS, developed a plan for testing and evaluating prototype probabilistic products within the context of the CBS Severe Weather Forecast Demonstration Projects, and has formed focus groups to address technical development issues.

4.1.3 TIGGE-LAM related activities: LAM EPS developments in North America

LAM EPS research and development has continued at an active pace during the last five years. Operational LAM EPS systems have focused on the scale of North America, the continental U.S., or sub-regions within the U.S. Grid lengths range from 4-20 km. A non-exhaustive list of North American LAM EPS systems is in **Table 4.1**.

Table 4.1: List of North American LAM EPS

LAM EPS System	**Status**	**Institute -Consortium**
CMC-REPS	Operational	CMC/Canada
NCEP-SREF	Operational	NCEP/USA
AFWA-MEPS	Preoperational	AFWA/USA
CAPS Spring Forecast	Research	CAPS-Oklahoma U./USA
UWME	Research	U. Washington/USA

There are several scientific and technical challenges for the further development of LAM EPS systems:

- **Perturbation of the Initial Conditions.**
  AFWA has experimented with the ETKF and hybrid methods for generation of initial perturbations. CMC is using direct downscaling from the global CMC ensemble based on an EnKF data assimilation system.

- **Model perturbations**
  Model perturbations are generated by adopting three different approaches: changing parameter settings in physical parameterizations, use of multiple versions of model physics and stochastic physics schemes. The multi-physics and change in parameter approaches are widely applied. Stochastic physics are used or under further development for CMC-REPS, NCEP-SREF, and AFWA-MEPS.

  The multi-model approach can also be included among the methodologies to account for model errors. A multi-model / multi-boundary approach is being exploited in several implementations, notably:
  - AFWA-MEPS is a 10-member ensemble using multiple physics suites in the Advanced Research version of the Weather Research and Forecast (WRF-ARW). Typically run down to grid lengths of 4 km, is uses global deterministic forecasts from NCEP-GFS, the Met Office-UM, CMC-GEM, and the U.S. Navy-NOGAPS for initial and boundary conditions.
  - The UWME uses initial and boundary conditions from eight different operational forecasts, combined with multiple physics suites within the WRF-ARW.

- **Convective-scale EPS**
  In the future, the main added value from LAM EPS will be in improved representation of high-impact and severe events that is possible using higher-resolution models, at the convective scale. A lot of activity in Europe is directed at the development of LAM EPS systems to be operated at the km scale:

  - The Center for Analysis and Prediction of Storms (CAPS) at Oklahoma University has experimented annually with storm-scale ensembles, and in 2011 ran a 50-member ensemble with 4-km grid length as part of the Spring Experiment. The Experiment is a period of intense interaction between developers and forecasters at the Storm Prediction Center. The ensemble uses a combination of multiple models, multiple physics schemes, and multiple initial conditions from operational centers and local data assimilation.

- **Other research priorities**
  NCEP and AFWA are investing considerable resources into probabilistic products in support of aviation, including visibility, lightning, and turbulence.

  Research toward regional ensemble-based data assimilation is ongoing at many universities, including University of Oklahoma, University of Washington, and State University of New York – Albany. NOAA's Hurricane Research Division, the Naval Research Lab, and the National Center for Atmospheric Research also have significant experimental efforts underway.

4.1.4 The THORPEX-IPY Cluster

Canada has been active in the THORPEX-IPY cluster of experiments and currently supports two large efforts: STAR (Storm Studies of the Arctic) and TAWEPI (Thorpex

Arctic Weather and Environmental Prediction Initiative). TAWEPI is led by Ayrton Zadra of Environmental Canada and investigates various aspects of Arctic weather and the Arctic climate system (e.g., snow processes, polar clouds, sea-ice and the ozone layer). TAWEPI is in the final year of its research activities. Three of the 6 subprojects were finished or nearly completed as of April 2009: 1) stratospheric analysis, 2) sensitivity studies in the Arctic using singular vectors, and 3) sea-ice model development. The stratospheric project involved development and analysis of dynamics and chemistry fields over the entire IPY period (2007-2009). Data have been archived on the SPARC website, several publications are in preparation, and one of the project post-docs was recently hired by Environment Canada (CMC). Another post-doc was hired by Environment Canada after completing work on the singular vector (SV) project. Daily data sets of SVs computed for the 2007-2008 period have been archived at CMC; results are being analysed for publication. Finally, CICE code has been imported and preliminary tests performed at CCC ma (Canadian Centre for Climate modelling and analysis) for the sea-ice model project. The remaining aspects of the project will be pursued in collaboration with DFO (Fisheries and Oceans) who has hired a post-doc using resources outside of TAWEPI. Three additional sub-projects are ongoing and a final report is scheduled for preparation in May 2010. The collaboration with the CMC has been one of the most important aspects of TAWEPI. In March 2009, a new version of the CMC's regional model became operational. One of the main changes in this model was a northward extension of its high-resolution core, which now covers most of the Arctic basin. This provides an ideal platform for future transfer of research findings and improvements proposed by TAWEPI researchers.

The STAR Project, led by (John Hanesiak, University of Manitoba) is concerned with the documentation, better understanding and prediction of meteorological and related hazards in the Arctic including their modification by local topography and land-sea-ice-ocean transitions, their impact on the local communities, and information that may lead to an assessment of hazard frequency assessment relative to a changing climate. A combination of field measurements, high-resolution modelling and remote sensing (including CloudSat) will be utilized. To make progress on these critical issues, the project will focus on extreme weather events in south-eastern Nunavut. STAR includes collaboration with a French Arctic effort. USA and Canadian researchers are also involved at the PI level in other THORPEX-IPY efforts such as the Greenland Flow Distortion Experiment, Regional Climate Model Intercomparisons and Arctic surface flux studies.

In the US, the largest THORPEX-IPY effort is the US contribution to the CONCORDIASI program. The effort is co-led by Florence Rabier (Meteo France). The goals of CONCORDIASI include advancing satellite data assimilation in Antarctica, ozone, stratospheric microphysics and ozone depletion, targeting for high impact weather and the interaction of gravity waves with the dynamics of the Antarctic vortex. The observational centrepieces of the project are the new IASI satellite sounder, surface and upper-air measurements on the continent of Antarctica and dropsondes and flight level provided from long duration French CNES stratospheric balloons. An NCAR/NSF funding permitted the deployment of a driftsonde facility in McMurdo Station, Antartica. A “pre-Concordiasi” flight campaign was carried out from the Seychelles Islands. The goal for this test campaign was to verify proper operation of the driftsonde system, web interface, scheduling and other components of the system. The CONCORDIASI programme has proved to be a great success yielding many new and unique data sets.

4.1.5 Year of Tropical Convection (YOTC)

Numerous developments in YOTC have taken place recently and this report will only highlight its more important achievements. The YOTC Science Plan has been completed and the Implementation Plan (IP) was completed and approved at the Implementation Planning meeting held in Honolulu in July, 2009. The YOTC Project Office has been set up at NCAR funded jointly by NSF, NOAA, NASA via coordination by the US THORPEX Executive Committee. This project office support has provided for the development of the YOTC web site: www.ucar.edu/yotc that includes links to data, news, documents and meeting information. Science sessions at the fall AGU'08, spring AGU'09, AMS'09 etc., have been held. In addition, recent YOTC presentations were made at the Third THORPEX Science Symposium, the 13th Session of the Working Group on Coupled Modeling (WGCM), and the 2009 VAMOS Science Team meeting. In addition, a YOTC paper was included in a Compendium circulated at the World Climate Conference - 3 (WCC- 3), and a YOTC paper is part of a coordinated set of 5 papers for BAMS. High resolution analyses and forecasts, with diabatic and other process-oriented fields, are being archived; this includes ECMWF at T799 (~25km), NASA/GMAO GEOS5 at 25km, and NCEP at about 35km. The most essential satellite data sets and associated archiving and dissemination system have been identified, with funding secured from NASA to implement the GIOVANNI system. The YOTC IP and associated meeting led to the identification of a number of periods of interest for focused modeling and analysis work and the decision to extend the YOTC period from May 2008-April 2010 in order to capture the expected and upcoming El Niño winter. Finally, the IP meeting led to the identification of a number of exciting and promising modeling and analysis activities.
The First YOTC International Science Symposium was held in Beijing fro he 16-19th May 2011 and proved to be a major success.

4.1.6 Societal and Economic Research and Applications (SERA)

The THORPEX planning documents note that SERA activities are a critical component of the program. Lack of new funding opportunities has limited progress on North American SERA activities within the THORPEX programme. The priorities defined in the 2006 North American THORPEX SERA workshop (Morss et al., 2008; Bull. Amer. Meteor. Soc.) and recommendations made during the meeting of the North America THORPEX Committee in 2007 on proposing strategies for technology transfers and capacity building efforts between Canada and the US and Mexico and other central American/Caribbean partners— remain valid. Rejuvenation of the WWRP WG SERA will also likely help to support regional efforts and integrate research that is being pursued outside of the THORPEX programme (e.g., various natural hazard and disaster studies).

4.2 North American THORPEX Committee Activities and Issues

The last NARC meeting was convened in Cuernavaca, Mexico in May 2010 with an extensive participation from a number of institutions in Mexico, Central America and the Caribbean. The meeting followed the 5th North American Ensemble Forecast System (NAEFS), which is an operational outlet of THORPEX, where two operational centers (CMC and NWS) share their ensemble forecasts in real time. A third operational institution, the FNMOC, will soon join the other two and will provide the NOGAPS ensemble, to make up a 60 member multi-model ensemble every 6hrs cycle.

In addition to the NAEFS workshop, a training course on ensemble forecasting was provided by CMC experts, and two evening lectures on data assimilation and high impact tropical weather were provided. An important outcome of the meeting is the formation of a new national committee. Consensus remains the same from past year with the following

themes, all of which require interactions among the member countries; research, operations and users; and physical and social science disciplines:

- TIGGE and NAEFS
- Prediction and prediction science --- improving links between the research and academic community
- Evaluation of data produced during the T-PARC campaign
- The THORPEX-IPY Cluster of Programmes -- High impact weather in the Arctic and the link between the Arctic and high impact weather over other locations in North America
- YOTC and The Interface Between Weather and Climate – Tropical convection and two-way scale interaction
- SERA

The next meeting of the NARC has been scheduled to occur in Spring 2012 to coincide with the 6th NAEFS Workshop.

4.3 National and Regional Planning Documents

Mexico and the US have drafts of national THORPEX Plans that are readily available. A final version of the US plan has now been completed. The North American Plan is in a rough draft form with input received from a large number of authors. Work on the Plan is continuing.

4.4 Other activities

With support of the Servicio Meteorologico Nacional in Mexico an intercomparison experiment of regional models is underway. The purpose is to determine suitable configurations to predict high impact weather systems which affect Mexico and Central America. Several institutions in Mexico and a few from the U.S. and Canada are involved

5. Southern Hemisphere Regional Committee (SHRC)

The SHRC was established in 2006. To work on an Implementation Plan, three sub-programmes and teams were set up in the areas of Societal and Economics Research and Applications; Data Assimilation and Observing Strategies; and Predictability and Dynamical Processes.

The Southern Hemisphere Science Plan (http://www.wmo.int/pages/prog/arep/thorpex/plans.html) developed a rationale for a Southern Hemisphere regional focus for THORPEX that emphasises a number of features that are unique to the hemisphere. An Implementation Plan was subsequently developed and finalised at a three-day workshop held in Melbourne, Australia, in May 2007.

Since the activities outlined in this plan essentially relied on the good-will of the participants, the outcomes were very vulnerable to changes in priorities within the collaborating organizations. A refreshing of the Committee has been completed, and a revised plan is under development.

5.1 10th International Conference on Southern Hemisphere Meteorology and Oceanography, New Caledonia 23-27 April 2012.

The 10th International Conference on Southern Hemisphere Meteorology and Oceanography is a joint conference of the American Meteorological Society (AMS) and Australian Meteorological and Oceanographic Society (AMOS). The Southern Hemisphere THORPEX activities had a strong presence at the previous meeting in Melbourne in 2009 and it is hoped a similar presence will be possible in New Caledonia.

5.2 Severe Weather Forecast and Disaster Risk Reduction Demonstration Project (SWFDDP) for the South Pacific

The Severe Weather Forecasting Demonstration Projects (SWFDPs) are regarded by the SHRC as good platforms to operationally test developments in forecasting systems in the 1-14 day timescale in developing countries. Two of these regional sub-projects reside in the Southern Hemisphere, namely the Southern African SWFDP (the first regional sub-project) and the South Pacific SWFDP. Good links have been established with both of these regional sub-projects, where numerous meteorological services are participating either as regional centres (South Africa and Reunion for Southern Africa, and Australia and New Zealand for South Pacific) or as participating national centres. Specialized targeted products from ensemble prediction systems (EPS) and NWP are disseminated from participating global and regional centers to the national centres, with additional guidance products prepared by the regional centres. Training of forecasters of these developing countries are conducted annually on EPS and NWP products. A number of test products have been developed by the TIGGE WG that are being tested by these two SWFDP sub-projects, and representatives of these sub-projects have participated in a number of TIGGE and SERA meetings already. This testing mechanism has proved itself to be extremely useful.

The South Pacific Regional subproject has moved from a pilot demonstration in 2009-10 involving 4 countries, to a 'full demonstration' in 2010-11 involving 9 Pacific island countries. RSMC Wellington, as the lead regional centre for the project is producing daily South Pacific Guidance (SPG) charts for a five day forecast period, showing areas at risk of severe weather. Participating meteorological services are using the SPG charts as well as ensemble-based probabilistic output from global producing centres (ECMWF, UKMO, NCEP, JMA).

The second meeting of the SWFDDP Regional Subproject Management Team (RSMT) was held in Wellington NZ, November, 2010. The Document Planning is available from:
http://www.wmo.int/pages/prog/www/DPFS/Meetings/RAV-SWFDDP-RSMT_Wellington2010/DocPlan.html
and the final report of the meeting is available via:
http://www.wmo.int/pages/prog/www/CBS-Reports/DPFS-index.html.

Through Eugene Poolman there is a active engagement in the Southern African SWFDP, although involvement by the SHRC in the SW Pacific SWFDDP activity is mainly in a support role.

5.3 SHRC Membership

A new SHRC has been established in consultation with the ICSC Chair and the IPO by the time of ICSC-8. A review of implementation plans is scheduled over August-September 2011.

5.4 CONCORDIASI

As part of the CONCORDIASI project, a number of stratospheric balloons drifted over the Southern Ocean from 20 September to 20 December 2011 deploying dropsondes. An assessment of the impact of these dropsondes and the impact of IASI data is underway now that the relevant staff have commenced work at the Australian Bureau of Meteorology.

5.5 Concluding comments

Benefits of THORPEX in terms of scientific interaction and collaboration amongst Southern Hemisphere scientists continue. However, even with a relatively modest plan, progress has been very slow. It is intended that a refreshed SHRC should take the opportunity to rethink and revitalize the current Implementation Plan and be even more focussed on what can be achieved in future, with perhaps the best opportunities lying in leveraging regional SWFDP subprojects including the new pilot in the South Pacific, and scientific collaboration around the Met Office Unified Model.