

**THORPEX ICSC
GIFS TIGGE Working Group
Ninth Meeting**

WMO, Geneva
31 August to 2 September 2011

Original: ENGLISH

Draft minutes of the 9th GIFS-TIGGE WG meeting

1. Organization of the meeting

1.1. Opening and aims of the meeting

The meeting was opened by Deon Terblanche the recently appointed Director of the ARE at WMO. He said that he had spent 30 years in the South African Weather Service and had a background of research in a developing country. He noted that the TIGGE initiative was one of the real successes of the THORPEX programme and was built around exemplary international co-operation between the partners. In conclusion, he thanked all participants for their continuing strong support and said that TIGGE/GIFS would form an important legacy from THORPEX and wished the meeting every success.

Zoltan Toth then outlined his vision for the aims of the meeting. He reviewed the TIGGE data set which was available from 2006. Centres continue to add data and the archive has been shown to be of great value for EPS research. There were several open questions – not least can data providers continue to supply information and the archive centres continue to expand the data stored as model resolution increases? It seems this is likely to be the case at least until the end of the THORPEX programme in 2014.

Concerning GIFS the conceptual plan had been laid down in 2004 and a way ahead in conjunction with the SWFDPs was agreed. However, issues such as real time access to ensemble data and achieving effective international collaboration to develop new products remained. Progress with the “tool box”, rules, software exchange etc., was slow but needed to be made. Overall progress had also been slow in the focus areas of TCs and heavy precipitation mainly due to lack of commitments and failure to establish the focus groups. He saw two distinct ways ahead – either make GIFS-TIGGE primarily a scientific discussion group or assign higher priority to GIFS product development.

He then noted that it was his intention to stand down as Co-Chair but to remain a member of the WG until a new member from NOAA has been appointed. The WG thanked him for all the contributions he had made to their work over many years.

In discussion it was felt that the focus of the WG should lie between the two extremes of a discussion group or a GIFS product development group. The SWFDPs can potentially get significant benefit from state of the art multi-model EPS products.

1.2. Adoption of the Agenda

It was decided to incorporate relevant aspects of Item 6.1 within Item 6.2 and drop the former. The Symposium on Ensemble Methods planned for November 2012 would be discussed under Item 11. With these amendments the Agenda was adopted.

1.3. Working Arrangements

These were discussed and agreed. The WMO would host a WG dinner on the evening of the 1 September.

2. Reports and actions from precious meetings

2.1. Status of actions from the eighth GIFS-TIGGE meeting

The status of GIFS-TIGGE 8 actions can be summarised as follows.

8.2.1 - completed

8.4.1 - some progress made

8.4.2 - not much progress, more focussed effort needed.

8.4.3 – limited progress

8.4.4 – completed

8.4.5 – completed

8.5.1 – completed

8.5.2 – no progress to report

8.5.3 - no progress to report

8.5.4 – not done, to be discussed further under the verification agenda item

8.5.5 – will be implemented through GEOWOW project

8.6.1 – some progress, will be reviewed later in the meeting

8.6.2 – being implemented. CMA is experiencing difficulties.

8.6.3 – 5 centres had complied, the situation would be reviewed later in the meeting

8.6.4 – completed, but a volunteer was needed to continue the work

8.6.5 – completed

8.6.6 – completed

8.6.7 – would be discussed under item 3.1

8.6.8 – completed

8.7.1 – completed

8.7.2 – work underway, delayed due to difficulties with GRIB 2 but should be finished soon

8.9.1 – limited progress but some support had been given to TC RSMC New Dehli. A systemic approach was required. This topic would be discussed again later in the meeting.

8.10.1 – completed

8.10.2 – completed

8.11.1 – not done, the meeting agreed that links should be made to the new sub-seasonal to seasonal project.

8.11.2 – completed.

8.14.1 – nearly completed.

The outstanding and partially completed actions were then rationalised taking account of discussions at this meeting (an overall list of new actions is at Annex 1)

The minutes of the joint meeting with the SWFDP were then reviewed and the main points noted – closer links with the SWFDP SG and associated groups was essential and would be implemented progressively during 2012.

2.2. IPO update including an update on the THORPEX mid-term review

Jim Caughey gave a short presentation on the status of THORPEX. He covered the DAOS WG and PDP WGs noting recent activities and areas of interest for the future. The DAOS WG has prepared a comprehensive statement on the impact of targeted observations on NWP and would submit a shortened version for publication in BAMS. They had carried out inter-comparisons of observations impacts and were involved in the assessment of the highly successful ConcordIASI field campaign. The PDP WG had focussed on T-PARC, TCS 08 and Winter T-PARC and the main results related to dynamical processes were being written up. They had arranged a Workshop on "Diagnosing model errors" which had emphasised the crucial need for further research in this area to guide model development. In this regard they would focus on The Indian Summer Monsoon (ISM) and Cyclonic Systems (CS). A number of key topics would be addressed in the future including ensemble DA, diabatic processes, organised tropical convection (with YOTC) etc.,

The outcome of the Sub-seasonal to Seasonal and Polar Prediction Workshops were then outlined. In both cases WMO intended to set up new projects supported by consultants. The first step would be the production and endorsement of detailed Implementation Plans.

The YOTC initiative was outlined including the recent highly successful Science Symposium hosted in Beijing by CMA and CAS. YOTC was now well established with a small project office based at NCAR. It was expected that the data sets and the NASA Giovanni satellite system would also be of great interest for research outside the tropics. YOTC has set up an MJO task Force.

The THORPEX Regional Committees were then outlined. Europe had hosted an excellent workshop at Karlsruhe and was revising the European Plan in the light of discussions. In Asia a 7th meeting of the Committee hosted by KMA had taken place on Jeju Island and this had been preceded by a 3rd Asian THORPEX Science Symposium at which 70 researchers had been present. In North America efforts were devoted to supporting the many major field campaigns including T-PARC and in SERA studies. In the Southern Hemisphere progress was somewhat slow although the benefits of the THORPEX programme for improving collaboration and interaction amongst scientists was clear. THORPEX Africa was also making rather slow progress but at a meeting held in WMO during July a fresh approach had been discussed and it was hoped that this would stimulate further activity.

Finally, it was noted that David Burrige had retired from the IPO and that Tetsuo Nakazawa was now the IPO manager.

2.3. Outcome of the IWTC

Richard Swinbank summarised the main points of relevance. Some sessions had been of particular interest. Three presentations were given. These included plans for GIFS/TIGGE including the reliability of probability products. The NW Pacific TC experiment was also described.

The TC community showed quite a lot of interest but there was much more work to do to establish effective links. There was a need to establish a good dialogue with "end" users. He subsequently visited RSMC Darwin and found that they did not use EPS products. There was a need for further interaction and education about what was already available.

2.4. Outcome of the polar workshop

Laurie Wilson outlined some the main recommendations from the meeting. Verification should be undertaken from 60 degrees poleward and EPS verification also carried out. It was felt that verification could be strengthened by using operational and research data bases such as TIGGE.

DA could be improved using new satellites including the Canadian Polar mission. Experiments were needed to determine the utility of existing and new sources data.

Additional field campaigns were recommended as was more extensive collaboration with the WCRP. The focus should be on the development of coupled models. There were great scientific and organisational issues and TIGGE was noted as a good model for effective international collaboration.

The proposed setting up of a Polar Prediction Project was noted with the first task being the appointment of a Steering Group and consultant to prepare an Implementation Plan.

Action 9.2.1: Co-chairs to establish contact with Thomas Jung (chair of polar project), establishing collaboration with polar project

2.5. Outcome of the workshop on sub-seasonal to seasonal prediction

Richard Swinbank gave a brief overview of this workshop noting that the THORPEX summary (Item 2.2) had covered the main issues. The first step would be preparation of an Implementation Plan for endorsement by the WWRP JSC and ICSC. It was expected that a draft Plan would be available by the Spring of 2012.

Action 9.2.2: Co-chairs to establish links with new sub-seasonal to seasonal prediction project especially David Anderson (consultant), and Frederic Vitart and Andrew Robertson (co-chairs) to maximize compatibility between the new project archive and the existing TIGGE archive.

2.6. Outcome of the WWRP JSC4 meeting

Jim Caughey outlined the discussions at the recent WWRP JSC 4 meeting related to TIGGE. The JSC stressed the importance of close and effective links with the SWFDP initiative and asked the GIFS- TIGGE WG to report on the status of these links at JCS 5 in the Spring of 2012. The JSC 4 also asked the WG to consider the production of a refereed paper in the open literature based upon and summarising the main areas of GIFS/TIGGE research that had appeared in the literature.

Action 9.2.3: Co-chairs to report on status of collaboration with SWFDP project at WWRP/JSC5 meeting, Spring 2012.

Action 9.2.4: WG members to consider developing an article reviewing TIGGE research in refereed literature, for discussion next WG meeting.

3. TIGGE

3.1. Updates from the archive centres

The TIGGE database now contains five years of global EPS data: more than 520 terabytes (2.6 billion fields). There are around 1300 registered users of the TIGGE data portal. The number of users and volumes of data accessed continue to increase. ECMWF has typically 60 active users each month, and NCAR 10 active users; users of the CMA archive are mainly internal. On average 25TB of data are accessed each month and 5-6TB are delivered to users. KMA and BOM have temporarily stopped contributing data to the TIGGE archive, although KMA was now conducting tests for their new data.

NCAR –50TB of data (3 months of TIGGE forecasts) and 180GB of CXML data sets are now held on-line, to provide quicker turnaround, and the full set of data is held off-line. NCAR was

implementing the first version of the TIGGE model validation data portal which contained a wide range of observations and analysis data.

Concerning archive usage about 17TB of data had been downloaded but there were not many very active users (about 10). They had seen a jump in the use of the CXML archive. Future plans included a high performance centralised disk giving better I/O and better turnaround time. The potential for subscription services is being investigated.

In discussion it was noted that single point time series could still not be easily obtained. It was also recognised that the relatively short time series of TIGGE data would limit its usefulness for some applications.

ECMWF – There was 520 TB of data and 1300 registered users. Of these only 50-60 were active each month. Data volumes were steadily increasing. A new batch access arrangement has been implemented; in discussion it was noted that this was working well. A next generation portal is under development.

The GEOWOW project was expected to start on the 1st September and would provide a single point time series for a small number of fields. TIGGE –LAM European fields would be added. Data would be provided in NetCDF as well as GRIB.

CMA - A chronology of recent advances was given including establishing a test platform (2006), using the MARS system (2007/8), updating performance and portal (2009), a system upgrade (2010) and establishing the TIGGE Data Management System (2010) to provide data directly to users. A description was then given of the TIGGE Archive Platform Infrastructure and data Processing for internet users and other users within CMA.

About 441Gb of data was archived of which ECMWF is nearly 50% following their recent model upgrade. There were developments in the data server and monitoring. There was continuous upgrading of the archive capability. In discussion it was noted that KMA is now able to send data direct to CMA.

It was noted that while the archive centres can support the current volumes of TIGGE data there were some concerns over the support for the full volume of archived data in the future. Significant increases in data volumes, as happened for example when the ECMWF EPS resolution was increased in early 2010, can put strain on the archives and require system upgrades to provide continued stable support. Several centres have increased resolution in the last year, and further increases are planned. It may be necessary to review the archiving strategy (including the retention of old data) when considering the future requirements for TIGGE data exchange.

3.2. News from the data providers

JMA - operated several EPSs for the medium range, typhoons and seasonal forecasts. The EPS for 1 week ahead has been contributed to TIGGE since Oct. 2006. Stochastic physics was introduced in Dec. 2010 and initial condition perturbations were extended in the Southern Hemisphere in March 2011. The latest model description was sent to ECMWF. Recent EPS skill has improved but is still inferior to ECMWF by about 1 day. The T+0 field is now provided at 00UTC, as requested. Incorrect "land-sea mask values" for the period 16 Dec 2010 to 28 March 2011 had been flagged.

JMA is contributing both deterministic and probabilistic products to the website for the SE Asia SWFDP.

JMA is the lead centre for verification of EPSs and hosts 2 sites (FTP and web sites) where verification reports can be accessed and comparisons for each EPS centre providing data are

available. The number of verification reports is expected to increase as more centres send in their data.

Canada – The new operational system came into use on the 17 August, and is already documented on the ECMWF website. The grid spacing is now 66km (formerly 100km), the number of levels was 40 (28) and the top level was 2 hPa (10hPa). An improved physics was employed. The ensemble had 20 forecast members plus the control.

Comparative verification of the old and new systems shows that the new one is better at 500mb but less so at 850mb and there was much less impact near the surface. The stratosphere was also improved as was the spread and RSME. However, surface temperature and wind were not as good as in the old system. Some verification results were now being sent to JMA – this should happen routinely from October.

In discussion it was noted that the 20 forecast members were selected randomly from the 192 available from the ensemble data assimilation system. The physics package was also being further reviewed.

KMA – Since Dec 2010 KMA have been using a new 24-member EPS, forecasting to 10 days ahead. This is based on the UK Met Office model, with resolution N320 (40km) and 70 levels. The data volumes, initially 64GB, later 84GB, proved too large to send – the lines were too slow. Test data is now being sent using LDM; 32 GB can now be sent in 80 mins. Provided tests continue to be successful, a routine service will be started soon. The CXML cyclone data is not working after the changeover; it will resume later. The model description is ready to be updated. At the moment verification data is not being sent to JMA. The new system was performing better than the old system.

In discussion it was noted that it would be interesting to consider how best to combine EPSs from 3 different versions of the Unified Model now being run.

BOM - The Australian version of MOGREPS known as AGREPS was being implemented, and replaces the BOM global EPS that had been run between 2001 and 2010. AGREPS is currently run in research mode using a 24-member, 37.5-km 70-level regional ensemble for short range forecasting nested in a 90-km global ensemble. It is expected to become operational at higher resolution (24km regional & 60km global) in 2012 or 2013 depending on the available supercomputing capacity. Some verification was underway and the new EPS was proving to be much superior to the old. The spread skill was just a little below ECMWF.

ECMWF – The resolution of the EPS has been increased and as a result the amount of archive data had increased significantly. Initial perturbations are now derived from a combination of singular vectors with optimised energy growth over 48 hours and perturbations from the new ensemble data assimilation system. By the end of 2010 stochastic physics backscatter had been introduced. The skill was improving and it remains the case that the ECMWF EPS performs better than the others.

Meteo-France – There were no significant changes to describe. The EPS has 35 members and is run twice a day at 06 and 18 UTC out to 120h ahead. Initial perturbations are from 6 member SVs. For TC areas there is specific optimisation and a model error component included. During 2012 it was hoped to implement stochastic KE backscatter developed at ECMWF.

CPTEC - CPTEC is working to migrate to an EPS based on the Local Ensemble Transform KF (LETKF) in the next two years. They have recently installed a massively parallel Cray XTC with 30,000 cores however only 5000 are currently being used due to power supply issues. Various improvements are being implemented in the EPS: initial EOF-based perturbations are now

added to the extra-tropics and for new variables (Sea Level Pressure and Humidity). It is also planned to introduce representation of model uncertainties. An Extreme Forecast Index (EFI) has been developed, using three years of reforecasts to provide a climatology, with the aim of indicating potential zones of very high winds. The potential of an extended 30-day ensemble forecast has been studied. The preliminary results indicated some potential to increase skill above deterministic forecasts after day 5.

CMA – Considerable effort has been devoted to updating global/regional EPS at CMA between 2006 and 2011. The regional (REPS) ensemble has 15 members at a resolution of 15km and forecasts to 60 hours ahead. They plan to upgrade the initial perturbations from error-breeding to ETKF in 2012.

UK Met Office – Recent and planned developments were described. Following upgrades in 2010, the model now had an 18km European grid nested in a 60km global grid with 70 levels. Hybrid DA (introducing flow-dependent error from MOGREPS into operational DA) went live in July 2011. Further major changes are in the pipeline, in conjunction with a supercomputer upgrade. A new UK EPS will be introduced, with resolution changes to Global and European short-range versions of MOGREPS. Four runs a day of each EPS were planned. Phased implementation would take place in 2012.

They were also considering “seamless” ensemble forecasting system by running different numbers of ensemble members out to as far as 7 months ahead.

USA NOAA – The work of the ensemble team at NCEP was described. Verification scores are being produced and will be sent to JMA within the next 12 months. The global EPS system had been upgraded in 2010. The resolution at T190 was being run to 16 days with a frequency of 4 times each day. They included both ETKF and stochastic perturbations. A new precipitation analysis was being introduced but only for the continental US at a resolution of 4km. Statistical downscaling was being performed for the Alaska area on a 6km grid. Some further work was ongoing to run a high resolution T190 for the first week and then lower resolution T 154 much further ahead.

During discussion it was noted that WG members should all update the Excel Table and add new information. Data providers are also encouraged to provide initial conditions for verification purposes; for compatibility with other fields in the TIGGE archive, they should be labelled as T+0 control forecasts. They should also inform JMA when they expected to deliver verification data.

Action 9.3.1: All data providers are encouraged to provide T+0 data at 0 and 12 UT at least, 6 hourly if available, in consultation with archive centres.

Action 9.3.2: WG members to inform JMA by Nov 11 (ET-EPS meeting) what they propose to supply to WMO Lead Centre on EPS verification, and when.

3.3. Status of scientific results

Richard Swinbank highlighted recent developments. The focus was now on calibration of EPSs, combination of multi-models and research related to the development of probabilistic forecasts. Up to end of 2010 43 publications had been identified, a few more had since been added to the website, but our records are incomplete. Some examples of research studies were given. Examples included: Hamill, 2011 (multi-model ensemble precipitation forecasts); Froude, 2010,

(propagation of extra-tropical cyclones; Kipling et. al., 2011 (evolution of perturbation structure), Matsueda and Endo 2011 (skill of MJO forecasts); Frame and Methven 2011 (how different TIGGE models capture regime change in the medium range); Hamill 2011 (comparison of TC track forecasts).

In discussion it was noted further impact of TIGGE data on research activities was desired and that perhaps Universities were not fully aware of the possibilities. It was noted that the tigde-users mailing list had not taken off. Should new social media be used to raise visibility?

Richard Swinbank also drew the WG's attention to a new project led by Andrew Charlton-Perez. He is inviting TIGGE data providers to join a new project, SNAP (Stratospheric Network on Assessment of Predictability), and provide additional stratospheric output to help research stratospheric influences on predictability.

Action 9.3.3: WG members to consider joining SNAP project and contribute ensemble forecast output fields to the SNAP project archive.

Olivier Talagrand then raised the issue of the impact of ensemble size on skill; scores saturate at between 30 and 50 members. Others noted that the number of members required depends on what is being estimated; the ensemble mean could be estimated with fewer members, but more would be needed to represent error covariance structures. There was general justification for the multi-model approach from purely theoretical considerations. It was noted that using multi-model products for operations would need real time access to and there were very real technical challenges.

3.4. Publicising TIGGE

A new leaflet had been produced and distributed. WG members were asked to draw attention to it in their own countries. The availability and possible uses of the TIGGE data should continue to be publicised (at major conferences, to the academic community, etc.). In addition high level visibility had been given to GIFS-TIGGE at the recent GEO Ministerial and TIGGE had appeared as a chapter in the book presented to all Ministers at the meeting.

It was also recognised that research publications helped in raising awareness of the archives and available data. The possible WG review paper would help further and plans should be taken forward to make this a reality.

3.5. Website development

Additional material had been added to the TIGGE website hosted by ECMWF during 2010. There was appreciation for the help of ECMWF to implement these improvements.

It was recognised that more HELP pages on the various websites could assist in achieving greater and more effective use of the data. A brief introductory user guide or manual to show how to download and use data may be helpful.

Action 9.3.4: WG members to consider adding to training material on the TIGGE data portals, including data access and manipulation examples, to help potential users of the TIGGE archive.

3.6. GEOWOW

GEOWOW (GEOSS interoperability for Weather, Ocean and Water) is an EU-funded FP7 3-year project beginning 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. Total funding from the EU will be around 6.6Meuros. The weather component (participants are ECMWF, Met Office, Meteo-France and KIT) will receive around 1.1 M euros. The project will 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

4. TIGGE-LAM

4.1. Status and plans of TIGGE-LAM

Tiziana Paccagnella gave an overview of recent developments. It had been decided to pursue a Regional structure. There were 6 areas: N. America – J. Hacker, Asia – J. Chen, Europe – T. Paccagnella, S. America – C. Saulo and Africa – S. Landman. As yet there was no co-ordinator for the Australia/New Zealand region.

The TIGGE LAM Plan was almost ready but a bit more work was needed on some scientific issues. It will be revised at the SRNWP meeting in Tallin in October and it is planned to put it on the web in November. TIGGE-LAM maintained good links with RDPs and FDPs and HYMEX as well as close collaboration with Mesoscale Working Group

CMA is now archiving high priority parameters from the CMA Regional EPS System. ECMWF will archive European products as part of GEOWOW. Efforts were being made to get similar archiving going in other parts of the world. It is recommended that TIGGE-LAM products should be archived on their native grids and appropriate tools to manage these should be developed.

In Europe TIGGE-LAM is closely involved in the Sochi Olympic test bed (FROST). It would exploit convective scale multi-model ensembles. Four WGs had been established. These were WG1 – observations, WG 2 – NWP ensembles, WG 3 – IT and WG 4 – user interface. There were many potential contributors to WG 2. Wind gusts were a real issue at the Sochi site and this topic was being widely discussed. Relocation of COSMO-LEPS was planned to the Sochi region with a 7km resolution and a well trained product. TIGGE-LAM would be represented at the WWRP MWFR WG to be held in Berlin. Also co-operation was in place with the European Limited area EPS (EurEPS) a project within Eumetnet. A LAM-EPS community paper for BAMS is planned. For verification there was a continuing need to get access to high resolution precipitation fields. The SRNWP inter-operability programme was then briefly outlined.

Action 9.4.1: Tiziana Paccagnella to arrange for report on European TIGGE-LAM interoperability to be circulated for the benefit of related activities in other regions by Dec 11.

In N. America the Panel consists of mainly USA and Canadian people. Joshua Hacker is trying to encourage co-operation between these countries and to co-ordinate with other N. American efforts and activities.

Asia – Jing Chen had organised a workshop on NWP involving KMA, Japan and Korea. Developments at CMA (the CMA REPS system – 15km resolution and 15 members) and at KMA (planning for a LAM-EPS) were discussed as well as the JMA Mesoscale EPS system (MEPS).

S. America – A super model EPS (SMES) has been formed by collecting 54 models. Point meteograms were a popular display format. This was seen as a very good example of a multi-model approach.

In discussion it was noted that there was no plan to implement the original GIFS concept of real time system customization, including on-demand LAM EPS runs. Instead, TIGGE LAM should focus on implementing regional archives, stimulating research and discussions of scientific issues, supporting coordinated initiatives among LAM EPS groups and fostering communication. For GIFS, the priority is the development on LAM EPS products to complement those based on global EPS.

4.2. Links with the WWRP MWFR

There were many common issues such as the Sochi test bed and HYMEX. TIGGE-LAM would make a presentation at the next MWFR. Also the Joint Verification Working Group will be meeting at the same time which will enable useful liaison.

5. GIFS developments

5.1. Review of status of GIFS developments

Richard Swinbank gave an update of the current position. The exchange of TC forecasts using CXML started during T-PARC was continuing in near real time. Some work was progressing on TC products using CXML at MRI/JMA, ESRL, UKMO and Meteo-France/La Reunion but it was not well co-ordinated. The technical focus groups on TC products and heavy rainfall had not really got going on.

GEOOW was noted. It would focus on products for forecasting high impact weather for evaluation within the SWFDPs. Detailed plans were in the process of being put together. The project plan could be extended to involve other TIGGE partners. There were a number of issues. Real time access needed to be considered and might best be achieved by extending existing SWFDP agreements. Evaluation and verification remains a concern.

Tropical cyclone forecast products had been developed for NW Pacific and the RSMC La Reunion websites. This work could potentially be adapted for other regional projects. The current CXML products could also be developed further, likely needing an extension to the content of CXML files. A WIS metadata definition for CXML files should be developed.

To progress GIFS, gridded fields needed to be considered. In order to support particular products, a basic sub-set of rainfall forecast fields would need to be exchanged. Ideas for wind products also needed to be taken forward. It was emphasised that the TIGGE role must include evaluation of prototype products.

5.2. Technical focus groups

While a number of prototype products had been developed, the technical focus groups intended to help coordinate these developments had not really got off the ground.

5.3. Status of the SWFDPs and links with GIFS

Peter Chen in his presentation noted that the principles of co-operation between GIFS-TIGGE and the SWFDPs had been agreed. This would involve pre-operational testing of prototype products. Not very much progress had been made since the joint meeting held in February 2010 and there was a need to now enter a concrete development phase.

The SWFDPs were progressing very well. The WMO congress in 2007 had endorsed the vision for improving services in developing countries. It fits well with the WMO Strategic Thrusts – Improved Service Delivery/Quality and Strengthening Capacity Building. Many developing countries have little access or knowledge concerning advanced products – maybe as many as half the members of the WMO. The main emphasis was on improving forecasts of severe weather, improving lead times and improving interactions between NMHSs and the end users. The current and planned SWFDP regional projects are:

- Southern Africa – now involved 16 countries and would now to be taken forward by the partner countries coordinated by RSMC Pretoria.
- South Pacific Islands – underway with 9 island states led by RSMC Wellington
- S.E. Asia – possibly starting later in 2011 – an Implementation plan is available. A number of weather radars are available and an RSMC will be set up at Hanoi.
- E. Africa - starting on 1 Sept. 2011. It is focussed on Lake Victoria - some external funding was available. It will consider heavy precipitation and winds and aspects relevant to agriculture including fisheries.
- Bay of Bengal – in development. It will be directed at coastal safety and initially involve 6 countries.

All the SWFDPs will have a well defined forecast cascade from global to regional centres and then to NMSs responsible for the delivery of products to local disaster management centres. The website set up by RSMC Pretoria is accessed by 15 countries.

The SWFDPs are especially interested in products that have been well developed and are likely to be stable i.e. will not be constantly changing. They particularly require products related to heavy rainfall, strong winds etc., out to 5 days ahead.

The links between the SWFDPs and TIGGE were then discussed in some detail. It was noted that these still needed to be formalised and that only an early stage had been reached. Four TIGGE data providers were sending EPS data to the SWFDPs in real time, as part of the SWFDP project. Some multi-model EPS products could be prepared to synthesise information currently presented separately for each EPS. Prototype products based on TIGGE data suffer from a 2-day delay which is a barrier to operational use, but are useful examples of what could be done. New products would need dialogues between users and product developers. There was also some discussion of including data from wave models in the archive but it was thought that this was not the right time to start archiving new data. The SWFDPs can offer useful manual assessment of multi-model products that would complement the TIGGE objective automated approach.

It was agreed that the Regional Centres should be the main point of interaction for GIFS-TIGGE. They will be investing in verification and developing new tools for assessment. In this regard it was recommended that the GIFS-TIGGE WG be represented at the SWFDP SG which will meet early next year and at which the Pretoria, Wellington and Nairobi Regional Centres will be present.

The GEOWOW project should also help improve links and communications with the SWFDPs since this will proceed under formal project management methods and to strict timelines.

Action 9.5.1: Co-chairs to arrange representation at the SWFDP SG meeting in early 2012 and use this meeting to establish links with RSMCs Pretoria, Wellington & Nairobi

6. Tropical Cyclones

6.1. Lessons from T-PARC

Relevant aspects were included under item 6.2.

6.2. NW Pacific TC experiment

Tetsuo Nakazawa gave a presentation and noted that the WWRP and the TCP in the WMO were jointly managing this project. The cyclone homepage was discussed. An example of in CXML data from ECMWF was shown, including position, central pressure and wind speed at specified locations. Other providers included CMA, MSC, KMA, STI, UKMO, JMA, and NCEP. The project offered a flexible framework and encompassed analyses, deterministic forecasts and ensembles. All the data comparisons are available on the webpage (which is ID and password protected) e.g. EPS vs deterministic, all centres vs each centre, track vs strike probability, different ways of presenting strike probability etc.,

A large number of people used the site. Future improvements included extending to include surface wind speed and precipitation, considering regional data rather than global and looking at the SWFDP areas. User feedback would be encouraged.

As a contribution to the SWFDPs extreme rainfall was now being considered. The TIGGE data base would be used for detecting the high risk areas for high impact weather events. Several people were working on these topics at MRI. The site software was portable to other regions and was freely available. It could be the basis for handling gridded data and should be seen as a community asset.

Action 9.6.1: Tetsuo Nakazawa to request MRI to prepare questionnaire to obtain feedback from users of websites, including suggestions for improvement

Action 9.6.2: WG members encouraged to contribute additional products to the MRI TC website.

KMA was using a similar system for CXML data and using Google Earth for presentation. The meeting felt that an exchange of information on employing Google Earth might be useful since ECMWF had decided not to proceed in that direction.

6.3. Southern Africa – SWFDP and RSMC La Reunion activities.

Philippe Arbogast gave a presentation that had been prepared by Matthieu Plu. La Reunion had been the RSMC for the SW Pacific Ocean since 1993. It provides guidance forecasts. The LAM is Aladin (Reunion) and runs at 8km resolution with 3D VAR twice a day out to 3 days ahead. The model is much the same as that run in W. Europe. Results are sent to Pretoria and are available on the SWFDP website. For TC tracks several deterministic models and EPSs are used. The RSMC provides the official track forecast including information on uncertainty.

Planned improvements to Aladin include better DA and physics and the generation of uncertainty cones. Meteo-France will be a partner in the GEOWOW project developing multi-model calibration products.

6.4. SW Pacific - SWFDDP

Steve Ready noted that there were 9 countries and 4 independent forecasting services involved in this SWFDP. The region was oceanic and data sparse. The RSMC was Wellington which had access to forecasts from a number of global centres including ECMWF, NCEP and JMA. They were using the MOGREPS 15 day ensemble. Of particular interest was heavy rainfall prediction – they get a good signal for amounts of about 50mm but not so good at higher levels. The UKMO provides TC data – e.g. tracks and TC genesis probability. The ECMWF maintains a special web page providing the probability of extreme events e.g. for rainfall, wind and waves. They also offer EPS grams of swell height and direction which are proving useful. JMA also maintains a web page for this SWFDP which includes ensemble forecasts of precipitation >50mm. Data are also available for the NOAA GFS and Australian Access-TC model. South Pacific guidance charts are produced. However, important issues remain to be resolved. These include poor internet connectivity, the lack of qualified meteorologists in the region and too much dependency – 5 of the 9 countries rely entirely on the RSMC.

6.5. US Hurricane Forecast Improvement Program

Zoltan Toth said that this is an R and D program led by NOAA. Annual expenditure is roughly 15M\$. The main objective is to improve TC forecasts over the Atlantic. NRL and Universities are also taking part. EPS work is included with an emphasis on improving initialisation and the quality of derived products. There is the important question of how to better to connect with the TIGGE community and an open invitation to WG members to establish links. There is an interest for example concerning product development to link to KMA activities and feed into the NW Pacific Project webpage. A considerable amount of the available resources (6M\$) is devoted to observational programmes. Google Earth is used for visualisation.

6.6. New product development work in progress

ECMWF was starting to look at TC genesis in an attempt to forecast where and when storms might begin to form. The Met Office also has some products in this area. The main problem of forecasting the evolution of the intensity of TCs remains. It was felt that not much progress would be made with the current generation of models since the resolution is simply not good enough.

6.7. Product development needs for warnings of track and intensity

The poor performance of current models in forecasting intensity was again noted. However, some wind products could be considered. There was a need to use gridded 2D fields but it might be possible to extend CXML to include some useful information on the wind field. There was a need to establish from “end” users the sort of information that might be useful. For example, the radial distance for gales might be helpful (size may be more predictable than intensity), as would some information on the spatial structures of the wind and precipitation fields..

6.8. Statistical post-processing for improved TC predictions

It was noted that statistical post-processing could be in principle used to correct biases in intensity forecasts. However, the lack of good observational data over the oceans would be a

major hindrance. It was noted that forecasters have pressure on them to provide TC threat forecasts, so we should consider what could be done to address intensity forecasts. Zoltan Toth suggested inviting someone from HFIP to the next meeting.

Action 9.6.3: Co-chairs to consider inviting an expert from HFIP to next WG meeting.

Action 9.6.4: TIGGE-LAM panel is encouraged to assess skill of TC intensity forecasts in high-resolution models.

6.9. Enhancements to CXML content and data exchange

It was suggested that extra information should be added to CXML messages where possible and that this might include the size of the area of gales, better definition of landfall and central pressure. Maximum wind could also be considered and would be useful for research purposes.

Action 9.6.5: All data providers are invited to add central pressure information and max wind information to CXML, using conventions to be agreed, based on current practices.

6.10. Verification

The verification of TC products was seen as a very important but difficult task. More effort was needed and the WG members were encouraged to become more active in this area. The JWVG is tasked with putting together a document on this subject. There should be a draft available by the end of the year. There is a pressing need for verification of ensemble TC forecasts. ECMWF was doing some work on this issue.

It might be useful to add the actual TC track to CXML files. All tracks are stored in the National Data Centre N. Carolina and are readily available for assessment purposes.

It might be useful to look at the probability of a particular storm being in a specific Category – if this did not look reasonable there would be no point in going further.

Action 9.6.6: All data providers are encouraged to carry out TC forecast verification

6.11. Interfacing with the user community

This topic was considered together with Item 7.11.

7. Heavy Precipitation

7.1. SWFDP regional subprojects in S. Africa and SW Pacific

These aspects were covered in previous sections.

7.2. La Plata Basin project and links to GEWEX efforts

This project links to GEWEX hydrological activities. It fits well with the SWFDP concept but also contains a strong research element. The La Plata basin is a very important area and home to more than 200 million people. It contains several large rivers and is affected by fronts, mesoscale systems, etc. It has similarities to the central USA and is in a convergence zone between moist tropical air and polar air masses. This can create the conditions for explosive development of convective systems. There are also important variations on longer time scales.

It was suggested that a “GIFS-TIGGE FDP” would be appropriate and provide a suitable test bed for model development and performance assessment. It would promote evaluation of TIGGE products in a key region of S. America, help capacity building, focus on heavy rain, and align with the CHUVA field experiment. The impact of extra data on forecasts quality would also be considered. The early detection (out to 5 days ahead) of the possibility of extreme events would be a high priority. Similarly building closer links with the “end users” would be important.

In discussion it was noted that, at the last meeting it was agreed that the WG would engage with other RDPs and FDPs, rather than run a specific GIFS-TIGGE FDP. There are well defined criteria which a project must meet for it to be considered a WWRP RDP or FDP. The appropriate forms can be downloaded from the WMO website. Since this project contains a number of elements outside the meteorological area it would be better to define a sub-project devoted to the weather aspects and apply for RDP or FDP status for that element alone.

Action 9.7.1: Co-chairs to invite Celeste Saulo to submit a formal application for a WWRP FDP/RDP based on weather elements of La Plata Basin project, in order to formalize links with GIFS-TIGGE.

7.3. HEPEX

This was seen as an “umbrella” for a number of hydrological projects. There was little information available on the current status of HEPEX; the information on the project website was quite old. There has been little progress on THORPEX / HEPEX joint activities (THEPS). A number of issues remain such as understanding the data requirements for hydrological EPSs and the importance of feedback from the hydrological to the meteorological community on this and other matters. There was also a need to look at downscaling and whether grid point or catchment area approaches would be appropriate.

David Richardson volunteered to follow this up with a colleague at ECMWF to assess the current status of the HEPEX project and hydrological applications of EPS, to help ascertain the best way forward.

Action 9.7.2: David Richardson to provide a report regarding application of EPS to hydrology.

7.4. HYMEX

An overview of this long term (10 year) and ambitious project focused on the hydro-meteorological cycle was provided by Philippe Arbogast. Various Enhanced and Special Operational Periods were planned. The impact of adaptive observations would be assessed. An important meteorological focus would be on mesoscale convective systems and looking at convective scale predictability. High –resolution ensemble meteorological modelling would be used and the added value of convection permitting system assessed (two real time LAM EPSs would be available – COSMO LEPS and the AROME EPS). Verification was an integral part of the programme.

7.5. Prototype Heavy rainfall products

Mio Matsueda (JAMSTEC) gave an overview of the website he had recently developed which displays risks of heavy rainfall predicted from ensembles. The site also includes forecasts for strong wind and extreme temperature. It is automatically updated each day and includes forecasts out to 15 days ahead. The calculation of occurrence probability was outlined;

probabilities are calculated by comparing forecasts with climatological PDFs calculated from each of the 4 TIGGE models being used (ECMWF, JMA NCEP and UKMO). Extreme events warnings were typically based on 95 percentile of the climatological PDF.

Some examples were shown. The first was the probability of occurrence of extreme 24 rainfall for Cyclone YASI (3 Feb 2011) for each centre. The consistency improved greatly with timescales down to a few days ahead and correlated well with TRMM data (the probability that TRMM daily precipitation exceeds the 95th percentile). Case 2 considered flash flooding in S. Africa (June 2011) – in this case even the 6 day forecast showed a clear signal for the event. Case 3 was heavy rainfall in Japan (July 2011) again the event was highly predictable even at the 6 day range even though the area affected was quite small scale. Finally Case 4 looked at the Pakistan flood of July 2010. This was also picked up in the 6 day forecast.

The WG was impressed by the work done and the JMA website is considered a major achievement amongst developments to support the SWFDPs. In discussion it was noted that more user orientated products needed to be developed and that verification was crucial. Also a threshold of 50% was used in the plots but the significance was not clear nor how appropriate this value was. Also there was no information on how often “false alarms” were generated. Verification was required and it was thought that the Verification WG could help with this. The work was highly regarded and it agreed to encourage SWFDP participants to look at the products and do basic assessments and provide some feedback. However, before that, good documentation was needed to help users at the relevant RSMCs understand and use the products.

Action 9.7.3: Mio Matsueda to draft brief documentation , including health warnings, of extreme weather products and work with co-chairs to finalise by Feb 2012

Action 9.7.4: SWFDP RSMCs invited to evaluate prototype products on Mio Matsueda’s website and report back to next GIFS-TIGGE WG meeting, to assess requirements for near real-time versions of the products.

7.6. Product development needs

There was some further discussion of TIGGE products applied to hydrology. Also it was suggested that once an extreme event is detected it might be possible to run some LAM-EPS models “on demand” for the area at risk. This was regarded as impractical at the present time but that it might be reasonable to explore organisational links that could make it possible at least for some regions.

Zoltan Toth showed some examples of bias-corrected NAEFS products similar to those on the Matsueda website. These included 2m temperature out to 120h ahead from a 60 member ensemble. The 10%, 50% and 90% percentile areas were considered showing areas in which the likelihood was for relatively warmer or colder conditions.

7.7. Logistics of data exchange

There was then a general discussion on real time data exchange but it was recognised that the SWFDPs would probably implement generation of real time multi-model EPS products from operational data feeds. Although these products would be based on TIGGE research, the TIGGE data bases were not suitable for real-time data exchange. It was also recognised that data exchange should take place according to WIS directives. The importance of input from forecasters for the development of new products for the SWFDP was again stressed.

7.8. Bias correction, multi-centre ensembles and down-scaling

This was regarded as a very important topic, but which requires more work. Masa Kyouda presented some work related to storms and heavy rain, based on the JMA EPS output and using other centres data for reference. Results were shown for typhoon Fitow – 3-day accumulated rainfall reached 690mm and rivers were at danger level. Various scenarios had been run looking at the worst cases. The impact was shown to depend strongly on the reliability of the TC track forecast.

7.9. Observationally based fine resolution regional/global analyses

Some examples of precipitation analyses compiled by NCEP were shown. These were observationally based and included data from more than 100 weather radars and many thousands of rain gauges. Significant efforts had been devoted to the combination of the types of data. The analyses were in 5 by 5 km cells and are updated every 6 hours. . Verification of an E. Coast snowstorm event was discussed. It was also recognised that similar high-resolution analyses would also be valuable in Europe but, so far, progress has been limited.

7.10. Verification and evaluation

Laurie Wilson noted that verification was proceeding rather slowly and the situation was not satisfactory. For the SWFDP, quarterly reports had been compiled but there has been little evaluation of EPS data. For Southern Africa some progress is being made and the national centres are doing the best job at the moment. The same situation seems to exist with the TIGGE database –verification is mainly focused on upper air, with limited progress on surface variables such as precipitation.

The GEOWOW project will provide time series which will help with site-specific verification, but these will not be available for another year or so. Little substantive progress has been made since the last report.

7.11. Training and interfacing with users.

It was recognised that the CBS ET on EPS matters conducts training and capacity building activities in this area and it was agreed that training on new GIFS products should be integrated with those activities. Our focus should be on training the trainers. It was re-iterated that good documentation was needed to support the interpretation and use of novel products.

7.12. Products based on other gridded fields

Examples of products on wind and 2m temperature had been briefly covered in earlier agenda items (7.5, 7.6).

8. Longer term plans

8.1. Review of TIGGE-GIFS research needs and priorities

Richard Swinbank presented some thoughts and ideas on this topic. There were several research priorities that the WG presently considered. These included calibration and combination methods, bias-correction, downscaling multi-model ensembles, re-forecasts and generation of reliable probabilistic products. However, other aspects should perhaps be added. These might include: initial conditions – linking with ensemble DA and the DAOS WG; representing model errors using stochastic physics – linking with the PDP WG and WGNE; seamless forecasting – linking with the new sub-seasonal to seasonal prediction project; and convective scale ensembles – linking to TIGGE LAM and the MWFR. The first two were very

important for improving EPS skill. A virtuous circle can be considered EPSs > Evaluation/Diagnosis > Develop/improve > EPSs. The WG agreed to add a new topic on EPS improvement to the agenda. It was also agreed that verification of ensemble forecasts should be considered. By analogy with other aspects mentioned, the WG needs to take an interest on verification, while the JWGFVR takes a lead on verification research.

Action 9.8.1: Co-chairs to create new agenda item on EPS improvement for next WG meeting.

Richard Swinbank then turned to how to take forward GIFS developments. A survey of WG members showed that work on development of TC-related products was going on at 8 TIGGE partner institutions. It was suggested that people working on those developments should form the basis of the TC focus group. Similarly, all TIGGE partners have people working on developing products based on precipitation and other gridded data. The initial priority should be to improve communications between people working in those two areas, to exchange information about the work being done. The meeting then sought nominations for the formation of the 2 focus discussed earlier. Members agreed to provide suitable nominations of individuals for these groups in the next few months.

Action 9.8.2: KMA, NCEP, MO, MF, ECMWF, JMA, CMA, BOM to nominate people to form a TC focus group which will prepare a report on TC forecast product developments for next WG meeting. Names to be sent to co-chairs, by end Oct 2011. The WG seeks a volunteer to act as focal point for this group.

Action 9.8.3: All data providers to nominate people to form a precipitation focus group which will prepare a report on precipitation forecast product developments for next WG meeting. Names to be sent to co-chairs, by end Oct 2011. The WG seeks a volunteer to act as focal point for this group.

8.2. Longer term outlook for TIGGE and GIFS

It was necessary to retain the support of the 3 archive centres and the data providers. This seemed assured at least in the short term. However, for the longer term continuation of the TIGGE archive, it was essential that the data was well used and that the products generated were seen to be useful by users.

Increasing resolutions of models will put pressure on the archives as time goes on. Major system changes may make the older data gradually less useful.

Beyond the end of the THORPEX programme there is a need to discuss and agree an appropriate "home" for this work.

9. GEO

Jim Caughey introduced this topic and said that GIFS-TIGGE remained an important part of the GEO Work Plan within the Weather Societal Benefit Area (SBA). A new GEO Plan for the period 2010- 2015 was being developed and this would introduce a revised Task structure with fewer Tasks and streamlined management arrangements. It was expected that TIGGE would figure prominently in the presentation to the GEO Plenary scheduled for November 2011.

The funding obtained through the GEOWOW project should be useful in moving TIGGE forward and it was important to look for other funding opportunities within the GEO framework. GEO would be engaging with a range Funding Agencies to highlight those areas of the Work Plan

that still needed to be resourced. It was essential to make sure that visibility for GIFS-TIGGE remained high.

10. Membership

The WG expressed its appreciation to Zoltan Toth for the many years service he had given as a Co-Chair. The appropriate representation from CPTEC, Brazil needed to be clarified. It was agreed that the revised membership list would be added as an Annex to the report of the group to ICSC 9. This would include nomination of a new Co-Chair.

Action 9.10.1: Co-chairs to contact Pedro Silva Dias to request a nomination of a new representative from CPTEC, before ICSC-9 meeting.

11. Any other business

Olivier Talagrand gave a short presentation on the Ensembles conference being planned for Nov. 2012. The group endorsed the conference and agreed to give it full support. WMO was asked to co-sponsor the event.

12. Review of outcomes, actions and next meeting

The WG reviewed and finalised the list of actions. In addition to those noted in these minutes, four permanent actions were agreed.

Zoltan Toth invited the WG to meet in Boulder in 2012 the exact date and venue to be decided. The meeting was pleased to accept this invitation and looked forward to finalising arrangements.

Richard Swinbank closed the meeting by thanking the THORPEX IPO and WWRP for kindly hosting the meeting.

Annex 1

Consolidated list of Actions

Permanent Actions

Action P.1: All archive centres to update statistics on TIGGE data users on an annual basis (end of each year), using similar statistics for users, actives users, etc. Doug Schuster to coordinate.

Action P.2: Young-youn Park and Mio Matsueda to carry out literature search for papers based on TIGGE data, and summarise results. Archive centres to ask users to inform them when TIGGE papers are written, to enable the list of TIGGE publications to be kept up to date.

Action P.3: All data providers to provide model descriptions in agreed Excel format and to update the files after significant changes and send to ECMWF.

Action P.4: Co-chairs to request reports before each WG meeting on all actions, plus relevant progress reports.

New & amended Actions

Action 9.2.1: Co-chairs to establish contact with Thomas Jung (chair of polar project), establishing collaboration with polar project

Action 9.2.2: Co-chairs to establish links with new sub-seasonal to seasonal prediction project especially David Anderson (consultant), and Frederic Vitart and Andrew Robertson (co-chairs) to maximise compatibility between the new project archive and the existing TIGGE archive.

Action 9.2.3: Co-chairs to report on status of collaboration with SWFDP project at WWRP/JSC5 meeting, Spring 2012.

Action 9.2.4: WG members to consider developing an article reviewing TIGGE research in refereed literature, for discussion next WG meeting.

Action 9.3.1: All data providers are encouraged to provide T+0 data at 0 and 12 UT at least, 6 hourly if available, in consultation with archive centres.

Action 9.3.2: WG members to inform JMA by Nov 11 (ET-EPS meeting) what they propose to supply to WMO Lead Centre on EPS verification, and when.

Action 9.3.3: WG members to consider joining SNAP (Stratospheric Network on Assessment of Predictability) project and contribute ensemble forecast output fields to the SNAP project archive.

Action 9.3.4: WG members to consider adding to training material on the TIGGE data portals, including data access and manipulation examples, to help potential users of the TIGGE archive.

Action 9.4.1: Tiziana Paccagnella to arrange for report on European TIGGE-LAM interoperability to be circulated for the benefit of related activities in other regions by Dec 11.

Action 9.5.1: Co-chairs to arrange representation at the SWFDP SG meeting in early 2012 and use this meeting to establish links with RSMCs Pretoria, Wellington & Nairobi

Action 9.6.1: Tetsuo Nakazawa to request MRI to prepare questionnaire to obtain feedback from users of websites, including suggestions for improvement

Action 9.6.2: WG members encouraged to contribute additional products to the MRI TC website.

Action 9.6.3: Co-chairs to consider inviting an expert from HFIP to next WG meeting.

Action 9.6.4: TIGGE-LAM panel is encouraged to assess skill of TC intensity forecasts in high-resolution models.

Action 9.6.5: All data providers are invited to add central pressure information and max wind information to CXML, using conventions to be agreed, based on current practices.

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Action 9.7.1: Co-chairs to invite Celeste Saulo to submit a formal application for a WWRP FDP/RDP based on weather elements of La Plata Basin project, in order to formalise links with GIFS-TIGGE.

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Action 9.10.1: Co-chairs to contact Pedro Silva Dias to request a nomination of a new representative from CPTEC, before ICSC-9 meeting.

Annex 2
Participants

GIFS-TIGGE WORKING GROUP

Zoltan Toth (NOAA/ESRL; Co-chair)
Richard Swinbank (Met Office; Co-chair)
David Richardson (ECMWF)
Gong Jiandong (CMA)
Mike Naughton (BoM)
Young-Youn Park (KMA)
Christopher Cunningham (CPTEC)
Osvaldo Moraes (CPTEC)
Laurie Wilson (EC)
Masayuki Kyouda (JMA)
Doug Schuster (NCAR)
Philippe Arbogast (Météo-France)
Tiziana Paccagnella (ARPA-SIM)

INVITED EXPERTS

Bernard Strauss (Météo-France; chair SWFDP SG)
Steve Ready (NZ Met service; SWFDDP)
Olivier Talagrand (LMD; PDP Working Group)
Mio Matsueda (JAMSTEC)

WMO SECRETARIAT

Tetsuo Nakazawa
Jim Caughey
Peter Chen