

WORLD METEOROLOGICAL ORGANIZATION
COMMISSION FOR ATMOSPHERIC SCIENCES

CAS/THORPEX ICSC/
GIFS-TIGGE 11
Report of the meeting

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

Met Office, Exeter, UK
12-14 June 2013

Original: ENGLISH

REPORT OF THE MEETING

1. Organisation of the meeting

1.1. Aims of the meeting

Dale Barker welcomed members to the meeting on behalf of the Met Office. He noted that post-THORPEX arrangements are a major topic for debate and the three projects S2S, PPP and HIW all have relevance to this Working Group. It was noted that data assimilation and ensemble prediction work very closely together in the Met Office. Also important was a possible restructuring of the WWRP WGs and the formation of new groups. The Open Science Conference (OSC) coming up in 2014 was an important event to which the group should contribute and the purpose and goals need to be kept in mind.

Gilbert Brunet also welcomed the members to the Met Office. He is on secondment from Environment Canada and is currently Director of Weather Science in the Met Office and chair of the WWRP JSC. He outlined the objectives of the WWRP i.e., advancing the science of weather prediction and especially the role of bringing people together from developing countries and engaging young scientists. He briefly outlined the 2009- 2017 WWRP Strategic Plan. Noting that THORPEX will end in 2014 he noted some probable changes to the WG structure and the formation of new projects i.e. S2S, PPP and HIW. Regarding PPP he wished to see more engagement from the Southern Hemisphere community and that a number of topics should be tackled in conjunction with the WCRP. Finally he said that a main theme of the OSC in 2014 would be seamless prediction on timescales from minutes to months.

Richard Swinbank then outlined the aims of the meeting which included reviewing and consolidating current work, collaboration with the SWFDPs, participation of some TIGGE partners in GEOWOW and discussing TIGGE-LAM development. A main purpose of the meeting was also to look forward and consider issues such as continuation of the TIGGE archive and how best to support the S2S, PPP and HIW projects. In addition there was the need to discuss the formation of a proposed new group on Predictability, Dynamics and Ensemble Forecasting.

1.2 Adoption of the agenda

The agenda was discussed and agreed.

1.3 Working arrangements

The working arrangements were agreed. All presentations will be displayed on the THORPEX website.

2. Report and actions from previous meetings

2.1. Status of actions from the tenth GIFS-TIGGE meeting (R. Swinbank)

The actions were reviewed:

P1 – ECMWF, NCAR statistics were available [*post meeting note: CMA data have now been included*].

P2 – Work is continuing.

P3 – ongoing, updating is needed by several data providers

P4 – completed

9.3.4 – a link has been added to Mio Matsueda's tools – this action will be reclassified as permanent (P5)

9.4.1 – completed

10.3.1 – completed

10.3.2 – some discussions had taken place. This topic will be taken forward as a new action.

10.4.1 – completed – also on the agenda

10.5.1 – completed.

10.5.2 – completed – a proposal has been developed.

10.6.1 – completed – contact has been established.

10.6.3 – encouragement was provided but the action was not implemented. Will be retained as a new action from this meeting.

10.6.4 – ongoing, will be revised and retained as an action from this meeting

10.7.1 – not much progress to date; ongoing. [*Tiziana Pacagnella is likely to be invited to. an upcoming Workshop on La Plata Basin Project.*].

10.7.2 – completed – but not much use of the TIGGE data can be made.

10.8.1 – completed

10.9.1 – completed

10.10.1- completed

10.11.1- completed

2.2 IPO update and post –THORPEX plans (T. Nakazawa)

The main actions for the GIFS-TIGGE WG arising from ICSC10 were outlined. For ICSC 10(7) the action was ongoing and some progress was being made and the ICSC 10(8) topic was on the agenda and significant progress was being made.

The recent programme of meetings of the THORPEX Working Groups and projects was then described. Some other main actions from ICSC 10 were described including the preparation of a comprehensive review paper on the whole THORPEX programme, participation in DACA 13 and the planned HIW project.

The current and proposed new structure of the WWRP was then outlined. The new structure would comprise time limited projects (funded by Trust Funds) supported by Working Groups or Expert Teams funded by the WMO Core Budget. This included the proposed merger of the PDP and GIFS-TIGGE WGs. This would be discussed further at the ICSC 11 and JSC 6 meetings planned for July 2013. The

recommendations would then be put to CAS in November 2013 and finally a decision taken to introduce the structure by EC 66 in June 2014.

2.3 Outcome of THORPEX ICSC-10 and EC 64/65 meetings (T. Nakazawa)

EC 64 approved the S2S project in June 2012. A Trust Fund was established in August 2012 and offers to host the International Coordination Office (ICO) were received from Korea and Bhutan. Following clarification Bhutan withdrew, and so the ICO will be hosted by Korea.

EC64 also approved the PPP project and again a Trust Fund was set up in August 2012. Some offers to host the ICO have been received but no final decision has yet been taken [*post meeting note: the ICO will be hosted by Germany*].

ICSC 10 requested that a third legacy project, on high-impact weather (HIW), should be created. A Workshop was held in Karlsruhe in March 2013 and a Task Force has been set up under the leadership of Prof. Sarah Jones to prepare a draft Implementation Plan for consideration at ICSC 11.

During discussion it was recognised that the projects and new WG structure would need to work closely together. In essence a matrix structure is being proposed. There would probably need to be reciprocal representation from the WGs on the projects and vice versa with the WGs tackling topics of importance to the projects.

3. TIGGE archive

3.1. Brief updates from the archive centres (reps from archive centres)

NCAR: There is a gradual winding down of activity towards the end of the 2014 cessation of TIGGE archiving and NCEP data reprocessing at NCAR. No further changes are being made so the operation is in “frozen mode”. There is a willingness to help in transiting NCEP data direct to ECMWF rather than via NCAR. The validation portal will continue as will CXML archiving.

ECMWF: Data collection is generally fine with the exception of CPTEC. This data often has gaps and ECMWF has difficulty getting a response from the contact person. There also some gaps in NCEP data, the Sunday data is occasionally absent. Again there is difficulty in maintaining close and effective contact. Effective technical contact points are needed to resolve problems. Thanks were expressed to all the data suppliers for continuing to provide the TIGGE data.

Parallel archiving of European TIGGE-LAM data has been commenced under the GEOWOW programme. At present 2 EPSs are included although this will increase in future. Work on extraction of time series data will start soon and will be completed before August 2014.

ECMWF again stated that it is their firm intention to continue archiving TIGGE data after the end of the THORPEX programme and the data centres are strongly encouraged to continue to supply the data sets.

Action 11.3.1: Yuejian Zhu to inform ECMWF of the name of technical contacts at NCEP and NCDC to liaise over the practicalities of providing the NCEP data to the ECMWF archive centre, by end of July 2013. [*post meeting note: POC of NCEP and NCDC has been offered via email*]

Action 11.3.2: The working group requests **Christopher Cunningham** and **Yuejian Zhu** to ensure that missing data from CPTEC and NCEP is minimised by liaising with contact points to respond to requests from archive centres to fill any gaps.

CMA: Progress on the TIGGE archives was reviewed. About 750 TB of data was now in the archive. Around 60% of this was ECMWF. Although some aspects of the archive were updated in 2013 there is still reliance on manual tape loading. Automated loading will not be available for another 2 years. Generally upgrading the facility in the future is going to be a real challenge. Also, as resolution of the models increases so demands on the archive increase. CMA has already spent more than £0.3m on improvements and 2-3 people are needed to maintain the archive. Some way to limit the increase in data needs to be found. In addition CMA has found that only about 10% of the data in the archive is used for research purposes. A first assessment report on the future of archiving TIGGE data has been prepared but this is inconclusive and no final decision has been taken by CMA management. Further discussions are now taking place recognising the need to balance future investment and benefits.

Action 11.3.3: Archive centres are requested to investigate which types of TIGGE data are most widely used.

3.2 Brief news from the data providers, (reps from data providers)

ECMWF: There has been little change since the last meeting. The re-forecast data set has been extended. The ensemble system (now known as ENS) is unchanged from June 2012. The high resolution forecast model will be changed in a few weeks time to 137 levels and later in the year the ENS will be increased to 91 levels. The ENS will couple to the ocean from day 1 rather day 10.

Canada: The system was changed on Feb. 13 2013 to V3.00. The analysis is now at 66km (previously 100km) and has 74 levels. More observations are assimilated – especially from AMSU. A bias correction is added to input data and the time step has been reduced from 30 to 20 mins. There is also improved physics and filtered topography. This has resulted in a big improvement to the surface fields. There are plans to increase the resolution to 50km in 2014 and further improve the EPS system.

JMA: JMA is the lead centre under CBS for EPS verification and provides a comparison of EPS verification results. The forecast range has been extended from 9 to 11 days. In March 2014 it is planned to increase the resolution to about 40km and the frequency to twice per day, while reducing the ensemble size to 27 members. Gridded data to the TIGGE archive will not change. JMA recommends some common (fixed) resolution to middle and upper atmosphere data to control data volumes in the future.

Action 11.3.4: JMA and **CMA** are requested to consider extending CXML tropical cyclone forecast data to all ocean basins.

NCEP: The horizontal resolution of the model has been improved to around 50-55km. As a result hurricane forecasts were improved with a 10-20% improvement in track prediction. Initial condition improvements were responsible for another 5% improvement. The global EPS operates at 50km resolution out to 8 days and then at 70km out to 15 days. It is run 4 days each day with 20 members. Next year a unified EPS at 33km and 64 levels will be introduced. But resources are limited to increase ensemble membership, and NAEFS (combined NCEP and CMC) should have reasonable ensemble size. In 2016/7 a ten fold increase in computing power is planned and there are ambitious plans for coupled system at 15-17km resolution out to 10 days and then 35 km out to 32 days.

NAEFS was showing good promise with a gain of 1 day from the combined ensemble. However, a lot of works had been devoted to setting this up operationally although this is now regarded as justified. Bandwidth is an issue and priority for coming NAEFS half-degree data exchange in real-time.

Met Office: The 2012 upgrades to MOGREPS were outlined. A 2.2km UK ensemble with predictions to 36h is nested in a 33km global ensemble with predictions out to 72h. The North Atlantic / European regional model will cease. There are now 4 cycles each day with 12 members. The ETKF now uses 44 perturbed members. MOGREPS-15 (which is used for TIGGE) still runs 24 forecast members. The grid length is still 60km but the model now uses 85 levels.

A new dynamical core (ENDGame) is planned plus associated physics changes. It is proposed to extend the 33km short-range global ensemble from 3 days to longer range, which would support the Global Hazard Map presentation and provide global probabilistic products to complement the deterministic forecast out to 6 days. There will also be a suite of medium range and monthly/seasonal forecasts, using a coupled ocean-atmosphere ensemble.

KMA: The KMA EPS system development was outlined. As of June 2013 a hybrid ensemble/4dVar prediction system is in place. And a seamless prediction system from the medium range to sub-seasonal (3-4 weeks) will be developed by the end of this year. The model will be coupled to the ocean model. A convective scale EPS is being developed to provide short range probabilities of HIW over local areas. On the DA side the Hybrid Ensemble 4D-VAR is being further optimised. The global EPS will be at 20km resolution in accordance with new high performance computing resources.

CMA: An update of EPS plans was provided. GRAPES GEPS will provide 30 member global forecasts at 25-50 km resolution.

BOM: AGREPS (Access Global and Regional EPS) will operate to 10 days globally (at 60km and 70 levels) and 3 days regionally. The model is running daily but has not been declared operational, so the forecasts are not yet being added to the TIGGE database. Timeframe for system to be operational is still undecided.

CPTEC: A new global DA system has been introduced: the Gridpoint Statistical Interpolation (GSI) analysis scheme at T299L64 global resolution. This resulted in substantial improvements in forecast skill, especially in the tropics. A new improved EPS, which includes better perturbations and bias corrections, is being implemented operationally. There is a plan to move to perturb their own analysis rather than use the NCEP analysis.

Meteo-France: The global EPS is still based on singular vectors. It has 35 members on a stretched grid and is run at 6 and 18 UTC. A re-forecast system is being built. A new computer system is expected in about 2 years' time. A 2.5 km model EPS is planned based on the AROME system. Data will be submitted to TIGGE-LAM.

3.3 Continuation of the TIGGE archive after 2014 (R.Swinbank and M. Kyouda)

ICSC 10 invited the GIFS-TIGGE WG to consider this matter in some detail and report to ICSC 11 (see Action ICSC 10 (8)). The previous meeting concluded that at least one archive centre was needed. ECMWF has offered to continue to archive data after 2014 but a solution needs to be found so that the NCEP data can continue to be provided. NCAR will stop TIGGE archiving activities but the validation portal will be maintained and can be linked to other sites. NCAR will continue to ingest and archive CXML data after 2014. CMA is assessing the situation and carrying out internal studies to inform a decision.

There is perhaps the possibility to have complementary centres, not duplicating one another e.g. for the main global TIGGE data, CXML, observations data, reforecast datasets, regional EPSs for different regions etc., But there is then the issue of a back-up capability. It would be preferable to see two data centres in the future rather than just ECMWF.

Regarding NCEP data there will need to be some software changes to transfer direct data from NCEP and NCDC to ECMWF rather than through NCAR. It will also be necessary that NCDC has some official status as a TIGGE partner.

Action 11.3.5: WMO secretariat to send a formal letter to NCDC by end of July 2013, to convey appreciation of their work and to request continuation of the provision of NCEP data to the TIGGE archive after the end of THORPEX.

3.4 Possible changes to TIGGE fields, resolution, additional parameters.

Following THORPEX there are expected to be 3 datasets available i.e. TIGGE, TIGGE-LAM and the S2S. These are expected to be used by the WWRP projects i.e. PPP, S2S, HIW, RDPs and FDPs. There is a need to clarify future archiving requirements e.g. parameters, resolution, time delay, etc., There will also be a need to archive some RDP and FDP datasets. Some examples of new requirements coming from PPP include sea ice fields, snow cover, ocean wave data, observational data, reforecast data, short range forecast data etc., JMA again stressed the need for some common TIGGE resolution for the middle and upper atmosphere to limit future data volumes. However, full resolution is desirable for other fields (e.g. surface data and PV); it is not clear whether mixing resolutions for different parameters would lead to any technical problems. It is possible that new TIGGE data providers may be found – one possibility is The Fleet Numerical Meteorology and Oceanography Center (FNMOC) of the US Navy.

Action 11.3.6: WMO secretariat, in consultation with the **co-chairs**, to prepare letter(s) to archive centres by October 2013, with the aim of confirming their plans regarding the future of TIGGE in the post-THORPEX era.

Action 11.3.7: WMO secretariat, in consultation with **co-chairs**, to prepare a letter to current data providers by October 2013 enquiring about their willingness to continue to provide data to the TIGGE archive in the post-THORPEX era.

Action 11.3.8: Craig Bishop to approach FNMOC to sound out their willingness to provide data to the TIGGE archive in the future. [*post-meeting note – FNMOC has informally indicated a willingness to provide the data but is still assessing the internal costs of doing so*].

3.5 TIGGE-LAM progress and plans (T. Paccagnella)

LAM EPSs are contributing to many projects e.g. HyMeX, FROST etc., The EPS systems involved in FROST were outlined e.g. COSMO-LEPS, GLAMEPS, ALADIN-LAEF, and NMMB EPS. These are convective parameterised systems. Some convective permitting systems are also in use e.g. COSMO –RU-EPS, Harmon EPS (HIRLAM).

An example of a heavy precipitation event in Soichi was shown and the difficulty but importance of distinguishing rain from snow emphasised. Also local foehn wind events were important.

The EPS systems contributing to HyMeX were discussed. Several systems are running. HyMeX has a ten year timescale and wider participation is welcome.

The Typhoon landfall project was outlined and the added value from LAM EPSs concerning intensification, max. wind, central pressure etc., was noted.

The SRNWP-EPS project is an activity on convective permitting EPSs leading hopefully to a 3 year EUMETNET proposal for further work.

Regarding archiving CMA continues to archive their own data whilst at ECMWF the GEOWOW project has funded commencement of archiving data from some LAM EPSs in Europe. This is expected to expand in the coming year.

It is also recognised that there is a need to consider the future of the TIGGE LAM panel after the end of THORPEX.

Due to the poor overlapping of integration domains in the Convection Permitting LAM EPS systems, a valuable contribution to the TIGGE LAM archive would be represented by datasets collected during RDPs, FDPs and other projects. During these projects several systems are implemented *ad hoc* and run on the same region. This would also allow a wider scientific community to use these projects datasets.

Action 11.3.9: WG members to consider & clarify the future of the TIGGE-LAM panel after THORPEX and make recommendations to ICSC before EC-66.

4 Links with other THORPEX and WWRP groups

4.1 Links with PDP and proposed Predictability and Ensemble Expert team (C. Bishop, R.Swinbank)

There is a desire to carry on some of the best aspects of the THORPEX programme into the future. The TIGGE WG focus has changed from technicalities of the archives to calibration of ensembles, research on EPS products etc., The group is also now addressing more basic research issues such evaluation and diagnosis of

EPSs leading to overall improvements. Looking to post-THORPEX arrangements there is a firm proposal to create a Predictability, Dynamics and Ensemble Forecasting group which would bridge the operational and academic communities, promote archiving, focus on scientific issues such as growth of errors, consider stochastic representation of unresolved processes etc., The group would need good links to WGNE and other WWRP expert teams. It would be able to provide expert support to projects such as HIW, PPP and S2S. However, development of severe weather products could perhaps be transferred to HIW and archive management to a new liaison group.

Some transition arrangement will be needed and it would make sense to work towards a merger during 2014. It is important that the new group also helps to accelerate the take up of TIGGE research in operational centres.

The GIFS-TIGGE WG strongly supported the proposed merger with the PDP WG.

Decision: Members of the GIFS-TIGGE working group agreed in principle to the proposed merger of the current GIFS-TIGGE WG with PDP WG as outlined in the paper by the co-chairs of the two working groups.

Action 11.4.1: Co-chairs of both GIFS-TIGGE and PDP working groups to amend the paper on the proposed merger of GIFS-TIGGE and PDP groups and then submit it to the two working groups and table it for discussion at ICSC-11, in preparation for discussion by CAS.

Action 11.4.2: Co-chairs of both GIFS-TIGGE and PDP working groups to consider the advantages of convening a joint working group meeting early in 2014 to consider scientific priorities of the proposed merged group.

4.2 Update on the HIW project (J.Keller)

The background to the proposed project was outlined. With PPP and S2S there is still believed to a “gap” – global high impact weather on timescales from minutes to 2 weeks. The new project is designed to improve predictive skill on these timescales in the context of a changing climate. A Workshop was held in Karlsruhe leading to a draft project plan. This will be submitted to the ICSC and WWRP JSC in July 2013. A revised proposal will be tabled at CAS in November 2013 and finally the WMO EC asked to approve the project in June 2014.

The project is aimed at making a step change in the ability of individuals, businesses and communities to reduce the impacts of adverse weather. Some key project goals have been defined including improving understanding of the factors determining the predictability of HIW, enhancing capability to forecast impacts, producing more relevant forecasts and warnings, growing trust in forecasts and enabling more effective responses from users.

Some cross cutting activities will include the design of observational systems, field campaigns, knowledge transfer etc., The research focus will be on convection, TCs, storm surges, river floods, windstorms etc., Other research goals will address model development, observations, DA and EPSs. Evaluation, addressing uncertainty and communication of the forecast will be important elements.

The strategy to implement the project will involve developing linkages with international bodies, increasing national initiatives, strengthening inter-disciplinary

linkages between academia, research institutions and operational centres and engaging scientists with different backgrounds.

There is a strong interest in the potential contributions of TIGGE and TIGGE-LAM to the project and in other R and D efforts e.g. T-NAWDEX and HyMeX. There is also a need to consider which variables are most useful for the study of HIW and to identify large scale precursors for HIW.

Action 11.4.3: Working group members to consider how TIGGE and TIGGE-LAM should best support and contribute to the proposed High-Impact Weather project.

4.3 Links with DAOS (R. Saunders)

The role of this WG was outlined and the upcoming 6th WMO Symposium on DA was noted. Some current issues in observations were described. Metop-B provides improved coverage of IASI and ATOVS radiances. The Met Office is now assimilating both. Impact studies have demonstrated the loss of skill when various satellite data are removed. There is a distinct benefit in adding more polar orbiting data.

There is a potential gap in US polar data. NPP was launched in 2012 and the first JPSS is not due for launch until 2017. However, other data from the Chinese FY-3 and the Indian Oceansat-2 are now proving useful. Also, there is the possibility of commercial data supply in the future.

GPS-RO is proving to be a fantastic source of data with excellent coverage but COSMIC satellite failures are weakening the overall system.

The first steps are now being taken to enable exchange of weather radar data. CBS is exploring the definition of common formats. Regarding ground based GPS there is good coverage over Europe and the network in the US is now available. However data from the rest of the world is limited. There is a need to bring other countries on stream.

DAOS studies using the current ECMWF forecasting system showed virtually no impact from the US Winter Storm Reconnaissance Program (WSR). Tests performed about a decade ago using NOAA's forecasting system showed that, at this time, the WSR program had a significant positive impact on the forecasts of severe weather events. It is possible that improved modelling and improved use of satellite data has reduced the marginal gain realizable from the WSR observations over the past decade. Thus, the latest investigation of the impact of WSR data on the ECMWF system has encouraged NOAA to reevaluate the benefit of the WSR program to their current forecasting system. .

Other WG activities related to DIAMET (sting jets over Scotland), T-NAWDEX planning and HyMeX were outlined.

DA terminology has been revised by the group and will be circulated for comment.

Other interests include using the TIGGE data bases to examine forecast performance and model errors. The link with the HIW project will be important especially as regards the necessary improvements to the observations system and using OSSEs to decide future useful observation sites for extreme weather.

It is expected that after THORPEX the DAOS WG will become a WG of the WWRP funded by the WMO core budget.

4.4 Update on the S2S project and potential of cloud computing (A. Arribas)

The S2S project was outlined. There is a wide range of participants and big differences in prediction systems with little commonality and so a challenge in using the data easily and flexibly. The S2S archive will contain a large number of variables for the atmosphere and ocean, hindcast data and also sea ice data. This will be interpolated to a common 1.5 degree resolution. Data submission is expected to start early in 2014. The archive will not include all the TIGGE variables, just the more common ones.

The Met Office is investing heavily in cloud computing and the application of this facility to the S2S project was outlined. Although the main S2S archive will be at ECMWF it is proposed to offer the most commonly used data through the cloud facility. This will make it much easier for the user and will open more opportunities for application of the data by other communities. This approach has been welcomed by the WMO and IRI. A trial with the users will start by the end of next year and the Met Office is presently able to absorb the cost of this work.

Some of the main interests of the S2S project were then described including the MJO and land surface research.

4.5 Update on PPP (T. Iversen)

The background to this project was outlined. Final versions of the Science and Implementation Plans are available from the WMO website. The mission statement is "to improve weather and environmental prediction in polar regions on timescales from hourly to seasonal". Some of the research areas include forecasting system research (observations, modelling, DA and EPSs), underpinning research (predictability and diagnostics), teleconnections, SERA and verification. Because of the sparse data coverage in polar regions there are serious verification issues for e.g. TIGGE data. The large central Arctic area has few observations. However, the impact of satellite data is already large and becoming even more significant.

There are plans to do model development to resolve issues of poor predictability e.g. blocking. It is clear that coupled models are needed for polar NWP.

A Year of Polar Prediction (YOPP) involving intensive observations and modelling is planned for 2017/8. The preparatory phase has already started. It is hoped to have a consolidation and analysis phase in 2018/20.

Regarding TIGGE and the relationship with PPP there are number of interesting questions e.g. the benefits of multi-model versus single model EPSs, EPS calibration in polar regions, the paucity of LAM EPS data etc., It was hoped that the next phase of TIGGE would pay increased attention on polar issues such as mid-latitude teleconnections, verification using non-conventional data, the role of coupling and other polar scientific issues.

5 EPS research and development

5.1 Initial Conditions: 4D-En Var (N. Bowler)

The 4D-En-Var algorithm was outlined and contrasted with 4D-Var; the En-Var method uses an ensemble to propagate error covariance information, rather than the tangent-linear (and its adjoint) that are used by 4D-Var. The latter has some advantages i.e. is more parallelisable and so is able to do DA at high resolution and it can make use of larger ensembles. Since it has no tangent linear model and so there is no concern over neglected physics schemes. The disadvantages are that it requires a large memory allocation and makes significant input/output demands, and there is no propagation of static covariance information.

The mathematics of ensembles of DA was reviewed and a comparison given of the different schemes. En-4D-Var is expensive, En-4D-En-Var is much cheaper and EnKF is quickest to run but has a high maintenance cost and may need a linear operator. Currently, 4D-En-Var is found to have poorer performance than 4D-Var. This needs further investigation; there seem to be a number of factors at play. Some single observation tests are being carried out.

For ensembles in the future it will be necessary to look at inflation methods and investigate perturbed observations.

5.2 EnKF and ETR (Y. Zhu)

The characteristics of the planned improvements to the NCEP Global Ensemble Forecast System (GEFS) were outlined. It will include updated global DA and global deterministic and ensemble models.

The GFS model upgrade (V10), includes a semi-lagrangian approach, more accurate spectral grid transforms, improvements to physics. High resolution SST analysis and sea ice analyses will be used.

Meanwhile, GEFS initial and stochastic perturbations are being improved. In initial tests with hurricane Sandy, significant improvements were noted i.e. more ensemble members moved the hurricane north-west and provided better advice than the operational model which is 7-day ahead before landing.

5.3 Stochastic physics (W. Tennant)

Various aspects were outlined including a random parameter scheme, stochastic KE backscatter (SKEB), stochastic perturbed physics tendencies, vorticity confinement, stochastic convection parameterisation, and surface perturbations.

The SKEB scheme was considered in some detail. Tracked storms are more intense with SKEB2 but have slightly better position without the scheme. In the tropics the scheme improves the divergence field and the precipitation rate. It also provides a better wind field over the Arabian sea and over India. However, the scheme needs to be retuned to compensate for the more active dynamical core of ENDGame.

5.4 Stochastic convective trigger for HWRF (Y.Zhu)

Storm intensity has been found to be very sensitive to the convective trigger but the intensities do not respond linearly to the trigger function. The latest version of HWRF ensemble has been tested for past two seasons, the improvements of intensity and track errors are encouraged. But, some important questions need to be answered e.g. the reason for large intensity variations. These will form the basis for future work.

5.5 Canadian GEPS (L. Wilson)

Details of some experiments with the old and new systems were outlined. The latest version of GEPS is V3.0. Improvements in the upper air have been noted as have the NAEFS forecasts. The ensemble is more stable computationally (by limiting physics perturbations in high CAPE areas, shorter time steps and filtering). The Canadian centre is now in the TIGGE data set for 2m temperature.

Big differences in verification scores have been noted, depending on whether own or ERA interim analysis data are used.

5.6 PDP working group and EPSs (C. Bishop)

The PDP WG topics of interest were outlined including the experimental field campaigns T-NAWDEX/DOWNSTREAM, DIAMET, HYMeX and T-PARC. Some of the WG members are active participants in these programs. In the area of EPSs, recent work on measuring the ability of ensemble variances to track true flow dependent error variance was described as was a new approach for post-processing multi-model ensembles.

Measures of the ability of ensemble variance to track true flow dependent error variance may prove useful in the development of stochastic representations of sub-grid scale processes. Ideally, the inclusion of stochasticity in such schemes should increase the ability of the ensemble variance to track true flow dependent error variance. New PDP work on the “relative error variance of variance prediction” or “effective ensemble size” measure of ensemble performance described in Bishop et al's (2013, MWR) papers on hidden error variance theory provide a promising means of testing whether stochastic physics schemes are increasing or decreasing the ability of ensemble variance to track true error variance.

The TIGGE ensemble archive is similar to the ensemble archives associated with those constructed as part of the Coupled (climate) Model Inter-comparison Project (CMIP) in that it is constructed from ensemble forecasts contributed from a variety of agencies. Undoubtedly, some models are more skilful than others and some of the ensembles have been more accurately constructed than others. How then should the information from all of these sub-ensembles be optimally combined? Other recently published PDP work shows that one way of dealing with this problem is to mathematically transform the multi-model ensemble of ensembles so that it is similar to ensemble of perfect models in that (i) the transformed ensemble mean is the linear combination of transformed ensemble members that minimizes the distance from observations in both in-sample and out-of-sample tests, and (ii) the mean square distance of the transformed ensemble from observations is equal to the variance of the transformed ensemble. In tests, this new approach outperformed existing approaches. It is hoped that funding will be obtained to apply this new approach to the TIGGE ensemble in addition to the CMIP ensembles.

6 Applications of TIGGE data

6.1 Status and plans of the SWFDP (K.Mylne)

An update was provided of the SWFDPs. The main objective is to improve warning services of severe weather in developing countries. A cascade process is operated from the global centres to a regional centre and then down to the individual NMHS

which retain their national responsibilities for issuing advice. All information is sent as charts. New satellite and imaging tools are being brought in to aid nowcasting. There are a number of SWFDP regional projects. In East Africa, a regional project has recently been started, centred around Lake Victoria. A specific focus is on storms on the lake, considering strong winds, heavy precipitation and hazardous waves. More than 3000 people die each year in boating accidents. However, verification is difficult due to lack of observations.

The Southern Africa SWFDP is progressing well and good progress is being made with the other initiatives in the South Pacific Islands, Eastern Africa, Southeast Asia and the Bay of Bengal. Whilst the SWFDPs are keen to engage and support new prototype products they do not wish to make big demands locally or form a distraction from the main work.

There is a real need to improve forecasts of tropical convection and localised events and to improve forecasting tools for the very short range i.e. less than 12h ahead. On the TIGGE side moving the multi-model tropical precipitation forecasts to near real time will be very important. Developments to visualise hazards are also desirable e.g. the Met office global hazards map and overlays showing roads, population density etc. The SWFDP program is run based on voluntary contributions. Further funding is needed so an approach to the World Bank is being made.

6.2 Progress in SWFDP/GIFS-TIGGE collaboration (R.Swinbank, M. Matsueda)

The "TIGGE Museum" web pages were outlined. These relate to probabilistic extreme weather. Maps covering the polar regions have now been added for the PPP project. Summaries of extreme weather over the whole globe are also now presented. People in developing countries are able to access the website. Some examples were shown e.g. of the 2010 Russian heatwave (all the models showed good performance), the Pakistan Floods (NCEP was much better), Hurricane Irene (JMA was better) and Hurricane Sandy (ECMWF had much better performance). Thus it is clear that the best performance varies from centre to centre in different forecast cases.

Objective verification of the severe weather products demonstrated that the grand ensemble forecasts are better than those from ECMWF or any other single-model ensemble.

The GEOWOW project will allow these probabilistic products to be generated in real time and supplied to SWFDP forecasters for evaluation.

6.3 GEOWOW project and hydrological applications (F. Pappenberger)

The TIGGE hydrological EPS, TIGGE-HEPS was described. The active hydrometeorological community is mainly in HEPEX. This project is very end-user focused. A new science plan is currently being written. The European Flood Awareness System (EFAS) was outlined. The major floods in central Europe in June 2013 were well forecast with a lead time of 4-5 days.

At least 12 publications using TIGGE data in hydrology have appeared in the literature. Flooding is expected to be a good application area in the HIW project.

Some aspects of the GEOWOW project were described especially the work related to global river run off and comparison with observations.

6.4 NW Pacific TC Intercomparison (M. Yamaguchi)

Studies of TC forecasting using TIGGE data were outlined. There are 14 papers in the literature, 2 were application orientated, 6 looked at benefits of the grand ensemble approach and 6 considered dynamics and predictability.

Some inter-comparison verification results were shown for TC track predictions in the western North Pacific. The ensemble mean was shown to perform better than the control. Combining 3 ensemble centres improves the Brier skill score of TC strike probability forecasts with respect to the best single model ensemble.

Verification of TC genesis in the North Indian Ocean and the western North Pacific was described. Probabilistic forecasts of TC activity are skilful compared to climatological forecasts in week 1. For the ECMWF one month EPS, in the western North Pacific, it was shown that the hit rate was high, miss rate small but the false alarm rate was also high.

The status of the CXML data exchange was reviewed. Nine centres providing data are listed. However, China and JMA only provide data for the western North Pacific.

Extension of the CXML messages may be beneficial to advance studies and improve TC genesis and intensity forecasts.

6.5 Progress with the TIGGE review paper (R. Swinbank)

Limited progress had been made on this topic. A proposal for the content of the paper was reviewed and further contributors indentified.

Action 11.6.1: Co-chairs & other co-authors to prepare a draft TIGGE review paper within the next 6 months with intention of publishing it in BAMS.

7 Membership

Anticipated changes were reviewed. It is expected that a replacement for Laurie Wilson will be announced in a few weeks time. The co-chairs thanked Laurie for his excellent contributions to the WG over a number of years.

8 Any other business

There was no additional business.

9 Review of meeting outcomes, decisions and actions, next meeting

9.1 Discuss ICSC report

It was agreed that the paper to ICSC would include an update of the status of TIGGE, recent scientific papers, a section on the future of the archive, a note the CXML requests and also discussion of the future arrangements for the working group.

9.2 Review of decisions and actions

The actions and decisions were reviewed and agreed

9.3 Next meeting

The next meeting is likely to be held in conjunction with the PDP WG in early 2014 and will discuss a road map to merger of the two groups.

PARTICIPANTS

1) GIFS-TIGGE WORKING GROUP

Richard Swinbank (Co-chair)
Masayuki Kyouda (Co-chair)
David Richardson
Gong Jiandong
Mike Naughton
Seung-Woo Lee
Christopher Cunningham (for Osvaldo Moraes)
Laurie Wilson
Doug Schuster
Yuejian Zhu
Tiziana Paccagnella

3) WWRP / THORPEX WG REPRESENTATIVES

Allberto Arribas (Met Office) – S2S project
Craig Bishop (NRL) – PDP
Roger Saunders (Met Office) – DAOS
Trond Iversen (NMI) – PPP
Julia Keller (KIT) – HIW project

4) INVITED EXPERTS

Munehiko Yamaguchi (JMA/MRI, visiting ECMWF) – TC forecast inter-comparison
Florian Pappenberger (ECMWF) – hydrological apps: GEOWOW
Warren Tennant (Met Office) – Stochastic physics
Neill Bowler (Met Office) - 4D-Ensemble-Var
Mio Matsueda (Oxford) – severe weather products
Ken Mylne (Met Office) – SWFDP

5) WMO SECRETARIAT

Jim Caughey
Tetsuo Nakazawa

Actions and Decisions GIFS-TIGGE WG 11

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, active users, etc. Doug Schuster to coordinate.

Action P.2: **Yuejian Zhu** to carry out literature search for papers based on TIGGE data on an annual basis (end of each year), 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.

Action P.5: **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.

Actions & Decisions

Action 10.6.3 The WG encourages **providing centres** to include information on forming tropical storms in CXML messages (initially using location / time as identification and subsequently discuss a naming convention).

Action 10.7.1 **Christopher Cunningham** to consult with **Tiziana Paccagnella** to ensure transfer of benefits from the TIGGE-LAM work to the La Plata Basin Project

Action 11.3.1: **Yuejian Zhu** to inform ECMWF of the name of technical contacts at NCEP and NCDC to liaise over the practicalities of providing the NCEP data to the ECMWF archive centre, by end of July 2013.

Actions 11.3.2: The working group requests **Christopher Cunningham** and **Yuejian Zhu** to ensure that missing data from CPTEC and NCEP is minimised by liaising with contact points to respond to requests from archive centres to fill any gaps.

Action 11.3.3: **Archive centres** are requested to investigate which types of TIGGE data are most widely used.

Action 11.3.4: **JMA** and **CMA** are requested to consider extending CXML tropical cyclone forecast data to all ocean basins.

Action 11.3.5: **WMO secretariat** to send a formal letter to NCDC by end of July 2013, to convey appreciation of their work and to request continuation of the provision of NCEP data to the TIGGE archive after the end of THORPEX.

Action 11.3.6: WMO secretariat, in consultation with the **co-chairs**, to prepare letter(s) to archive centres by October 2013, with the aim of confirming their plans regarding the future of TIGGE in the post-THORPEX era.

Action 11.3.7: WMO secretariat, in consultation with **co-chairs**, to prepare a letter to current data providers by October 2013 enquiring about their willingness to continue to provide data to the TIGGE archive in the post-THORPEX era.

Action 11.3.8: Craig Bishop to approach FNMOC to sound out their willingness to provide data to the TIGGE archive in the future.

Action 11.3.9: WG members to consider & clarify the future of the TIGGE-LAM panel after THORPEX and make recommendations to ICSC before EC-66.

Decision: Members of the GIFS-TIGGE working group agreed in principle to the proposed merger of the current GIFS-TIGGE WG with PDP WG as outlined in the paper by the co-chairs of the two working groups.

Action 11.4.1: Co-chairs of both GIFS-TIGGE and PDP working groups to amend the paper on the proposed merger of GIFS-TIGGE and PDP groups and then submit it to the two working groups and table it for discussion at ICSC-11, in preparation for discussion by CAS.

Action 11.4.2: Co-chairs of both GIFS-TIGGE and PDP working groups to consider the advantages of convening a joint working group meeting early in 2014 to consider scientific priorities of the proposed merged group.

Action 11.4.3: Working group members to consider how TIGGE and TIGGE-LAM should best support and contribute to the proposed High-Impact Weather project.

Action 11.6.1: Co-chairs & other co-authors to prepare a draft TIGGE review paper within the next 6 months with intention of publishing it in BAMS.

Abbreviations and acronyms

Acronyms	Full spelling
BOM	Bureau of Meteorology (Australia)
CXML	Cyclone XML
CAS	Commission for Atmospheric Sciences
CMA	China Meteorological Administration
CMIP	Coupled (climate) Model Inter-comparison Project
COSMO	COnsortium for Small-scale MOdelling
CPTEC	Centro de Previsao de Tempo e Estudos Climaticos (in Portuguese)
DA	Data Assimilation
DACA 13	Davos Atmosphere and Cryosphere Assembly 2013
DAOS WG	(THORPEX) Data Assimilation and Observing Systems Working Group
DIAMET	DIAbatic influences on Mesoscale structures in Extratropical sTorms
EC	(WMO) Executive Council
ECMWF	European Centre for Medium-Range Weather Forecasts
ENDGame	Even Newer Dynamics for General atmospheric modelling of the environment
EFAS	European Flood Awareness System
EPS	Ensemble Prediction System
ERA	ECMWF Re-Analysis
FDP	Forecast Demonstration Project
FNMOCC	Fleet Numerical Meteorology and Oceanography Center
FROST	Forecasting and Research: the Olympic Sochi Testbed
GDPFS	Global Data-processing and Forecasting System
GEFS	Global Ensemble Forecast System
GEOSS	Global Earth Observation System of Systems
GEOWOW	GEOSS Interoperability for Weather, Ocean and Water
GIFS	Global Interactive Forecasting System
GIFS-TIGGE WG	(THORPEX) GIFS-TIGGE Working Group
GLAEPS	Grand Limited Area EPS
GSI	Gridpoint Statistical Interpolation
HEPEX	Hydrologic Ensemble Prediction EXperiment
HIW	High-Impact Weather
HyMeX	Hydrological Cycle in Mediterranean Experiment
ICO	International Coordination Office (of WMO project)
ICSC	(THORPEX) International Core Steering Committee
IPO	(THORPEX) International Program Office
JSC	Joint Scientific Committee
JMA	Japan Meteorological Agency
KMA	Korea Meteorological Administration
MJO	Madden Julian Oscillation

MOGREPS	Met Office Global and Regional Ensemble Prediction System
NAEFS	North American Ensemble Forecast System
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NMHS	National Meteorological and Hydrological Service
NRL	U.S. Naval Research Laboratory
NWP-TCEFP	North Western Pacific Tropical Cyclone Ensemble Forecast Project
OSC	Open Science Conference
PDP WG	(THORPEX) Predictability and Dynamical Processes Working Group
PPP	Polar Prediction Project
RDP	Research and Development Project
S2S	Sub-seasonal to Seasonal Prediction Project
SERA	Societal and Economic Research Applications
SKEB	Stochastic Kinetic Energy Backscatter
SRNWP-EPS	Short Range Numerical Weather Prediction EPS
SWFDP	Severe Weather Forecasting Demonstration Project
T-PARC	THORPEX Pacific Asian Regional Campaign
T-NAWDEX	THORPEX - North Atlantic Waveguide and Downstream Impact Experiment
TC	Tropical Cyclone
THORPEX	THE Observing system Research and Predictability EXperiment
TIGGE	THORPEX Interactive Grand Global Ensemble
TIGGE-LAM	Limited Area Model component of TIGGE
Var or VAR	VARiational (assimilation)
WSR program	US Winter Storm Reconnaissance Program
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
YOPP	Year of Polar Prediction