Third meeting of the WWRP PDEF working group, Met Office, Bern

Minutes of meeting, 3-5 July 2017

PDEF WG attending: Craig Bishop (NRL, USA), John Methven (U Reading, UK), Judith Berner (NCAR, USA), Susanne Theis (DWD, Germany), Munehiko Yamaguchi (JMA, Japan), Oscar Alves (BoM, Australia), Olivia Romppainen-Martius (U Bern, Switzerland), Estelle de Coning (WWRP), Paolo Ruti (WWRP)

PDEF WG apologies: Mark Rodwell (ECMWF), Zhiyong Meng (U Peking, China), Manuel Fuentes (ECMW as TIGGE chair, presenting via internet)

Meeting guests: Frederic Vitart (S2S co-chair, presenting via internet), Maxi Böttcher and Hanin Binder (guests from ETH Zurich, NAWDEX/diabatic processes), Christoph Spirig (Meteo Swiss), Dan Rowlands (blending medium-range and extended range ensembles), Martin Weissmann (data denial experiments for NAWDEX period), Luca Della Monache (statistical ensemble post processing, NCAR), Aiko Voigt (convection-permitting resolution climate modelling), Lisa-Ann Quandt (KIT, ensemble sensitivity analysis/multi-model applications to heat waves), members of Olivia’s research group at University of Bern.

Actions from 2nd PDEF WG meeting and outcomes

Action 1.6.2: The working group welcomed the possibility of FNMOC ensemble prediction data to the TIGGE database. CHB, YZ to ensure necessary support is provided by NRL and NCDC, and secretariat to assist if necessary with the provision of a WMO identifier for the data.
Ongoing being carried forward by CHB together with letter to NCEI about benefits of TIGGE and the new TIGGE panel. NCEI have taken over responsibility for both the NCEP and FNMOC ensembles.

Action 2.3.1: Outcomes of model error workshop collated as a report and presented on the ECMWF website. PDEF to write an additional page explaining the value of coarse-graining [MR & JB]. Report to co-chairs including a summary of literature [JB & CB].
Done. Workshop report written by MR and JB.

Action 1.7.1 continued: Organise stochastic session in WGNE systematic error workshop [OA & JB].
Done.

Action 1.7.2 ongoing: Explore experimental design for coarse-graining studies that can be applied in a common framework across different models. Using high resolution model data to compile tendencies within larger grid boxes and compare to those from physical parameterization schemes. Using coarse-grained high resolution output as forcing for a suite of single-column models would allow to involve different modelling centers and applications. [JB & CB].
Ongoing.

Action 2.3.2: Suggest setting up some similar experiments with NICAM in Japan. To be introduced by PDEF WG. More concrete experimental design is required. [MY & MK].
Discussion initiated with Masaki Sato, Tokyo.
**Action 2.5.1:** Encourage use of the NAWDEX campaign period for the investigation of the processes in NWP models and the origins of model error [JM].
Ongoing.

**Action 2.5.2:** Output tendencies (partitioned by process) from the operational ECMWF ensemble during the NAWDEX campaign. Used for case studies looking at model error. Other potential diagnostics include analysis increments and EDA applied to NAWDEX period. Phenomenon-based composites maybe necessary to compile statistics over many similar situations. [MR]
Done? Link more with the data denial experiments being performed by SHOUT project.

**Action 2.5.3:** Investigate the possibility of data denial experiments using NAWDEX data for campaign period and who will be able to conduct those experiments. Further discussion required with DAOS, Met Office, ECMWF and Waves to Weather group [JM].
Done.

**Action 2.5.4:** Run workshop on the role of diabatic processes in weather systems at the Royal Met Soc conference on “High impact weather and climate” in Manchester, July 2016 [JM].
Done.

**Action 2.5.5:** Consider follow on meeting from blocking workshop. Strong support from participants for a repeat workshop in 2-3 years time. Also, potential to convene a session on blocking in IAMAS conference (Cape Town, Aug 2017). Decided that 2017 was too early for a repeat of this workshop.

**Action 2.6.1:** Change title and remit of this challenge to reflect the need to consider applications in order to generate meaningful probabilistic forecast products for users. The suggested title is, “Assessment of ensemble forecasts and adding value to them” [MY & co-chairs].
This challenge title was discussed at length and revised to “Spatio-temporal post-processing for ensemble applications”

**Action 2.6.2:** Write up summary of TIGGE papers and put onto TIGGE portals. This includes an annual update of publications using TIGGE [MY].
Done.

**Action 2.6.3:** PDEF to recommend to WWRP that ensemble tropical cyclone forecasts with forming tropical cyclone information be available in real-time in order to benefit operational tropical cyclone forecasting and early warning. [co-chairs]
Link in with TIGGE actions from this meeting.

**Action 2.6.4:** Ensure link from ECMWF TIGGE portal to NCAR portal for TC data (in CXML) [MK].
Done.

**Action 2.6.5:** Appoint Munehiko as champion of this challenge area.
Done.

**Action 2.7.1:** Input suggestion to HIW that we produce guidelines on interpretation of probabilistic forecast charts for high impact weather [ST]
Short guideline document written and provided to the verification and SERA group of the HIW project.
**Action 2.9.1:** Co-chairs to input to WWRP implementation plan (within input from WG) & provide a Gantt chart of PDEF activities on the two year time horizon [co-chairs].
Done.

**Action 2.10.1:** PDEF to provide input to PPP before their YOPP planning meeting in Reading, 5-9 Sep 2016. PPP requests recommendations from PDEF regarding the design of experiments for YOPP and also any commitment to execute relevant experiments. PPP will send PDEF some more specific ideas relating to the scientific hypotheses being tested during YOPP. JM to attend that meeting as representative of PDEF. [co-chairs]
Done.

**Action 2.10.2:** Ask S2S co-chairs to recommend that researchers use TIGGE data to complement S2S data for short-range at higher resolution. Evidence suggests that this is particularly pertinent to the emergence of systematic model error which often occurs within 3 days. The contrast between the NWP and S2S prediction systems would be informative. Moved into Action 3.6 contribution to S2S 5-year plan.

**Action 2.10.3:** S2S has requested suggestions for novel diagnostics that can be applied routinely to S2S model data. PDEF to report back to S2S [co-chairs]. CHB: Spoke to Frederick Vitart after meeting. He was very keen to have Rossby wave packet tracking diagnostics inserted into S2S. Particularly, diagnostics pertaining to interactions between the tropics and extra-tropics.
Done.

**Action 2.10.4:** PDEF to recommend to the leaders of the YTMIT initiative of S2S (Year of Tropics and Mid-Latitude Teleconnections) that they link their plans and experimental designs with the polar-low-latitude interactions activity of YOPP (under PPP) and share results. [OA & co-chairs]
To do.

**Action 2.11.0:** CB has entered into discussions with Dr Benjamin Lamptey, Deputy Director-General of the African Centre of Meteorological Applications for Development (ACMAD) on strategies for promulgating and verifying/evaluating convective scale simulations from Africa’s four regional centers. First step is to get deterministic forecasts going. Follow-on step is ensembles and the ensemble configuration.
Done.

**Action 2.11.1:** PDEF to propose scientific questions that could be used to promote the use of TIGGE and TIGGE-LAM by the scientific community (as S2S has done for their new archive). [all]
Supercended by new TIGGE actions from this meeting.

**Action 2.12.1:** Consider cross-representation between DAOS and PDEF when WG meetings are not in the same location. Exchange meeting agenda and minutes. [co-chairs]
Was not possible this year.

**Action 2.13.1:** Organise coupled model & DA workshop in South Africa as part of IAMAS conference in Cape Town, Aug 2017. Need to find co-convenor from ocean
DA. [Craig, Oscar].  CHB Update: Prof. Andrew Moore (UCSC) has agreed to co-convene the meeting – hopefully it will move forward now. Continue Action 1.7.2. Organised and happening.

1. Organisation of the meeting

2. WWRP Implementation Plan and Aims

Estelle de Conig (WMO) presented a summary of the WWRP Strategic Plan 2016-2023. The rationale behind writing the plan is that it started with end users to define the societal challenges under four headings: urbanization, weather extremes, predicting the water cycle and use of emerging technologies.

It was also noted that the Nowcasting and Mesoscale WGs of WWRP have recently merged.

3. Quick review of objectives of working group and 5 challenge areas:
   - Stochastic representation of the effect unresolved processes in numerical models
   - Construction of ensemble initial conditions
   - Role of diabatic processes in weather system dynamics
   - Spatio-temporal post-processing for ensemble applications
   - Coupled modelling & assimilation

4. Review of activities on coupled modelling and assimilation

Oscar Alves
S2S Phase 2 plans – change of start dates and lead times in the multi-model S2S database.
Why is S2S database only out to 6 weeks? Oscar argues it would be better to go to the season where possible.
Coupled DA workshop in Toulouse (Oct 2016). Very comprehensive workshop volume is close to publication.
Need services to put more of their obs on the GTS.
Gaps in observing systems – e.g., surface fluxes.
Now almost every group implementing weakly coupled DA.
Some groups now trying strongly coupled DA (BoM, ECMWF, Japan)
- Gain – obs of atm impact ocean model directly in DA and vice versa
- Drawbacks – errors in one have greater effect on the other component
- Shocks from ICs are less with coupled DA than in weakly coupled? However first day spin-up is a big issue for operational forecast.

Issues with disparate ENSO forecasts from different centres (e.g., El Nino 2017)
- Bad news for users and loss of confidence unless explained.
- Winter 2016/17 was the least predictable in long range hindcasts for the last 20 years (Dan Rowlands)
- Different ensemble spread as well as central outcome
- Why does ECMWF have more spread? Over-sensitive, too strong stochastic param?
- The major challenge is onset of a new ENSO phase (before it has started) All models grow seasonal system bias in ~5 days (in atm models).
In ocean models (decadal prediction) the first year bias is very different from subsequent years.
Craig Bishop
Key issue is location of cloud belts (shading ocean) for coupled forecasts.
Interface solver approach to coupled DA
- V. good prelim results for strongly coupled DA
- Mixed time window approach
- Need to retain cross-fluid correlations that are missed in weakly coupled DA
High risk to throw out existing DA schemes for atm and ocean which are evaluated
- **Extend** ocean DA system to include atm BL and atm DA system to include ocean mixed layer. Then couple these two systems weakly. E.g., TC cold wake.
- What happens when the two analyses in the BLs disagree?
- A little like strongly coupled DA for full problem but with localization?
- **Main** issue is synchronization for DA windows in the two components. Feed analyses for the BLs into interior ocean DA scheme (24 hour window)

5. **Review of activities on role of diabatic processes in weather system dynamics**

John Methven
Main activities since last PDEF meeting are:
- Blocking workshop joint with SPARC in Reading, April 2016
- Ran workshop with challenge title within the Royal Met. S. conference, Manchester, July 2016
- North Atlantic Waveguide and Downstream Impacts Experiment (NAWDEX) went ahead Sept-Oct 2016. Successful aircraft and ground-based observational campaign in very favourable situation with active waveguide, HIW and periods with notably low predictability associated with triggers to the waveguide and uncertainties in the downstream evolution towards Europe.
- First NAWDEX workshop in Munich, March 2017.
- Joint workshop featuring NAWDEX and WWRP Challenge on Clouds, Circulation and Climate Sensitivity at the EGU 2017.

Six golden case studies identified and the focus of small teams.
Separate research related to impact of data and whether the ensembles capture the flow dependence in predictability?

Maxi Boettcher and Hanin Binder
Presented the scientific objectives of the NAWDEX campaign, focusing on those related to diabatic processes within warm conveyor belts and their downstream influence. Showed some observational highlights, especially the LIDAR and RADAR observations from the HALO aircraft. Discussion included the following aspects:
Q. Were DIAL WV obs assimilated?
A. Andreas Schaeffler will be investigating this as for T-PARC
Q. Are the observable quantities, such as ice and liquid water content being used to evaluate forecast models in these cases?
A. Yes, but very early stages in this work.
Q. Ask Mark Rodwell about physical tendency output from ECMWF forecasts for NAWDEX and potential for investigation of diabatic processes in the IOPs.

6. **Review of activities on construction of ensemble initial conditions**

Craig Bishop
Still major variation on construction of ensemble initial conditions between global forecast centres.
Still use of ad-hoc adjustments including inflation of ensemble perturbations, relaxation to prior perturbations and additive noise such as random draws from climatology.

No qualitatively correct assimilation procedures for non-Gaussian variables such as water vapour, cloud, precipitation.

Other challenges include:

- Positive definite quantities
- Multi-scale covariance models
- Nonlinear evolution of perturbations
- Nonlinear Observation operators

**Martin Weissmann**

New data denial experiments for the NAWDEX campaign were discussed (more in the domain of DAOS, but of direct relevance for PDEF). The key aim is to improve dynamical understanding of observation impact.

Using ECMWF IFS system to re-run two parallel forecasting suites throughout the entire campaign: one with all obs on the GTS and one excluding the dropsondes and radiosondes associated with NAWDEX. This set included the more northern dropsondes released by the Global Hawk during the SHOUT campaign, but does not deny the releases in the subtropical region that is the focus of the TC reconnaissance flights.

This is the first time that the ensemble of data assimilations has been re-run in this way and will hopefully enable investigation in the uncertainty of the analysis and influence of sondes.

Forecast improvement was found on average and the impacts accumulated through multiple DA-forecast cycles and were greatest over Europe (rather than the Atlantic).

Two events stood out where NAWDEX sondes had a much bigger than average impact on forecast error. Appear to be related to extratropical transition of TCs (Karl and Nicole).

Q. Do the additional sondes reduce ensemble spread in times of lower predictability?

The subtropical dropsondes from the TC reconnaissance flight region are detrimental to the forecasts on average.

7. **Review of activities on stochastic representation of the effect unresolved processes in numerical models**

**Judith Berner**

Summarised discussion at WGNE meeting in Montreal, particularly PDEF session on model error in ensembles. Many talks from “climate community” diagnosing ensemble spread and mean bias in multi-model ensembles (e.g., CMIP) without exploring why or linking with model error. This work cannot feed back on model development. Other topics included hierarchies of models for investigating model error, including role of mesoscale variance missing through model truncation.

Judith’s work and others in the area have established that stochastic parameterizations on climatic timescales often act as some form of damping, reducing variance in the resolved flow and often reducing bias for specific processes. For example, adding a stochastic parameterization to the atmospheric component of CESM improves ENSO spectra by reducing SST variability.
Judith proposes as a novel approach to investigate model error to fit a “linear inverse model” (LIM) to model simulations and look at the difference in the LIM operators. Results for the ENSO example above were shown, but the application of this method to a wider class of problems is necessary to prove the generality of its usefulness.

Hannah Christiansen has proposed the use of single column models forced by coarse-grained high-resolution output as a way to compare the tendency distribution of high resolution simulations to those from the physical parameterization schemes. The first paper has been submitted to QJRMS, a second one in preparation.

**Aiko Voigt**

Leading a high resolution modelling activity as part of the HD(CP)² project in Germany. There are six science topics and Aiko leads on the storm tracks and cloud processes one (S6). Key questions include:

Q1. What difference would it make if we could simulate global climate at 100m resolution?
Q2. How would be know if it were better?
Q3. How could we learn from the model?

Using ICON to nest down from global to 100-300m grid spacing. Has just started to simulate NAWDEX IOP3 (a case focus on cloud processes within a warm conveyor belt discussed by Maxi). There is a strong dependence on resolution for the partition between cloud ice and liquid and this appears to be important on the large-scale due to the change in the vertical heating profile.

8. **Summaries of PDEF-related research from other WG members**

**Zhiyong Meng**

Zhiyong could not attend in person (due to visa issue) but prepared a recorded presentation focusing on the predictability of high impact weather in 3 cases. Case 1 – extreme precipitation to SE of Beijing (21/7/2012) illustrated the importance of representation of short-wave trough on the tropopause in ensembles. Members with low level cyclone development closer to observed were those with closer short-wave trough representation – and some ensembles in TIGGE did not have the spread at tropopause level to capture the possible situation. In high resolution downscaling, the total rainfall accumulation was found to scale with domain size which is an undesirable model dependence.

Case 2 – one where low level jet structure was important to predictability.

Case 3 – Tornadic supercell simulation in the Moore case (20/5/2013). A case study activity on predictability of severe weather that links several groups with convective scale forecast models. The very rapid error growth is a major challenge with effects of reducing IC perturbations swamped within 3 hours. Many outstanding challenges, such as why some members develop intense supercells from very similar ICs.

**Olivia Rompainen-Martius**

Olivia was the local organiser for this PDEF meeting and introduced her research group, which includes people in the Mobiliar Lab working on high impact weather. Major topics of interest to the insurance sector especially, include hail observation and early warning, and also flood risk. The flood work focused on the role of tropopause-level disturbances for extreme precipitation events, their predictability and potential for medium-range advisories.

The challenges of representative observations of precipitation in general, but also hail, were discussed. The mountainous nature of Switzerland presents particular challenges in surface precipitation estimates from the radar network. It was noted that in Switzerland hail storms have clearly defined hot spots and do not propagate – in contrast to the mid-West USA.
Olivia described the international workshop on hail that she hosted in Bern during May.

9. Advancing research on PDEF foci

There had been much discussion during each session, so this session was kept short discussing two topics:

a. Coupled model drift. It was suggested that LIM methods could be useful to predict errors in S2S prediction systems. In some predictands, LIM models beat dynamical models after week 2 so there must be information contained on the evolution and structure of model error.

b. So far NAWDEX observations have not been used for quantitative cloud ice/water comparisons. However, this is work in progress involving collaboration between the HALO team, ETH and Manchester especially. Moving forward it would be good to link this with other modelling activities such as HC(CP)^2.

10. Links with WWRP projects (Tuesday morning)

Olivia Rompainen-Martius (HIW link)

HIW meetings:
- IAMAS session 17 on HIW – Capetown August 2017
- Landshut conference on Predictability and Multi-Scale Prediction – Oct 2017

Report on Waves to Weather project:
- A – upscale error growth (Q. rate of growth via heating and circulation?)
- B – cloud scale uncertainties
- C – predictability of local weather

New technologies angle – visualization of NWP data & ensemble forecasts (Met3D)

John Methven (PPP link)

Now YOPP is moving into its core phase (mid-2017 to mid-2019). Many major projects have been funded and are underway. For example, 3 projects funded by an additional EU call are: APPLICATE, Blue Action and INTAROS. Both APPLICATE and Blue Action focus on modelling, both in terms of NWP for the Arctic and modelling climate processes in polar regions. INTAROS focuses on observations, mainly in terms of enhancing the operational network across the Arctic rather than process-oriented campaigns during YOPP.

In the Arctic there will be two SOPs in Feb-Mar 2018 and Jul-Sep 2018. A third SOP will take place in the Antarctic Nov 2018 – Feb 2019.

The ECMWF are storing process tendencies from the operational forecast throughout YOPP (extending the approach taken for YOTC). This started in June 2017. [http://apps.ecmwf.int/datasets/data/yopp/](http://apps.ecmwf.int/datasets/data/yopp/)

ECCC are creating several major YOPP datasets, including the GDPS global high resolution forecast, GIOPS global ensemble (10 days) and CAPS-RIOPS high resolution (3-8km) regional ensemble (out to 2 days). This is the only convective-permitting forecast spanning the Arctic and has been set up for YOPP. The YOPP data portal is hosted by Met Norway ([https://yopp.met.no](https://yopp.met.no)).

- The SERA WG have produced a new report called “Navigating Weather, Water, Ice and Climate Information for Safe Polar Mobilities”.
- The Verification WG have produced a report on forecast verification for the Arctic.
The Arctic Frontiers 2018 conference will be 21-26 January in Norway.

**Frederic Vitart (S2S co-chair) – presenting via webex**

**S2S database:**
- Daily real-time forecasts + re-forecasts, 3 weeks behind real time.
- 1.5 deg grid, 80 variables, 11 data providers.
- Same archive centres as for TIGGE (ECMWF and CMA).
- Adding new ocean sub-surface and sea-ice vars.
- Moving to netCDF.
- Number of new users per month increasing linearly.
- Support CBS (Commission for Basic Systems) sub-season activities (operational).

**Research:**
- Laura Ferranti/ Linus Magnusson – predictability of NAO to about 20 days, but Atl Ridge and Scand Blocking to about 14 days. Skill in trajectories in 2D EOF space to about 15 days.
- Modulation of RW frequency by MJO (Julian Quinting & Frederic Vitart) – via PDEF RW onset and decay. Probabilistic skill? Need at least 100km resolution to capture this behaviour.
- Representation of teleconnections from tropics to extratropics (on MJO phase).
- Underestimate N Atl teleconnection, overestimate Pacific.

**Meetings:**
- Oct 2017 – ICTP Trieste workshop
- Dec 2017 – S2S session at AGU
- Sep 2018 – 2nd S2S conference

Phase 1 ends Nov 2018. Writing proposal for Phase 2.
New sub-project could be ensemble generation (for S2S prediction) – tend to be under-dispersive for MJO.

**Could be rationalize governance of TIGGE and S2S databases? How?**
- Manuel – in principal it is fine but struggling with human resources side – need funding (same person working on both at ECMWF).

Want to move more towards science and less emphasis on S2S database development.
New sub-project on tropical/extratropical interactions +WCBs/ARs.
S2S stops at day 60. Didn’t go to seasonal because of cost and focus is on weeks 3-4 and month 2.
Will be a new Copernicus database for seasonal forecasts (in about 1 year).

11. **TIGGE and TIGGE-LAM**

**Manuel Fuentes (TIGGE coordinator) – presenting via webex**

TIGGE Global data portal – 2.0 PiB, 5.9 billion fields, growing 1.6Tb per day.
- Sept 2014 – new infrastructure for TIGGE Data Portal. Had 3000 users at this point but could not carry across registrations.
- S2S and TIGGE on same server using same infrastructure.
- Number of users per month is still growing.
- Massive increase in data retrieved from Aug 2016.
- Most users make use of the interpolation and sub-setting functions.

*No contact with CMA. Why?*
Staff changes at data providers can cause discontinuation of data (e.g., ECCC since Jan 2017, NCEP since April 2017). Taking a lot of time. Need to re-iterate that this is a WMO activity and the global centres are contributing. Need resource for 0.25FTE to continue coordination of the TIGGE and S2S databases. Also, hardware is out of warranty – but ECMWF can resource this.

TIGGE-LAM
Data since 1/1/2013. 20Tb for 80 million fields.
Rotated output but no interpolation.
Number of active users per month <10. Recently only 2 users per month.
What to do about it?

NCMWRF would like to add data to TIGGE – work is underway to adapt GRIB_API to handle their data.
FNMOC expressed interest.
MeteoSwiss would like to add COSMO-E to TIGGE-LAM.

Craig will email NCEP and NCEI (change in name from NCDC).

Craig contacted FNMOC and they are not yet ready to release their ensemble due to the continuing poor quality of the control analysis about which it is initialized. However, I still think it would be a good idea to have a FNMOC person on the TIGGE panel.

Action needed: Reactivate TIGGE panel & have telecon – sep 2017.
Similarly need an S2S provider panel to motivate contributions.
Run a joint workshop involving the people responsible for data provision?

Munehiko Yamaguchi (Review of research using TIGGE)

Has issued a 4 page report to PDEF WG. Will use to motivate TIGGE data providers.
- Number of papers per year in AMS is very constant ~9. Mainly MWR and WF.
- Wiley ~6 per year. QJRMS, GRL.
- Other journals have not been searched (e.g., journals published in Asia).

Tropical cyclone papers are very dominant, then heavy precip.
Missing use in energy meteorology and other applications?
Citation numbers on this set of papers.

ACTION: JM write a statement for citation of TIGGE in papers.
Also a terms of use statement that they must send paper reference to the portal.
Need to request a statement on use by person downloading. Radio buttons to indicate science topic for usage.
Survey existing users via email addresses. Need to write questions to ask.

12. Review of activities on spatio-temporal post-processing for ensemble applications

Munehiko Yamaguchi
“Ensemble forecasting is a contribution to disaster risk reduction but not sufficient on its own”. Munehiko described the new framework for disaster risk reduction that is being adopted in Japan. The aim is to provide spatially and temporally specific disaster risk information in an easy to understand format. It should also convey probabilistic information on disaster risk.
A particular example was given relating to the risk of flood and landslides associated with tropical cyclone landfall in Japan. Includes the use of simple hydrological models to forecast a "landslide potential index" and relate this to early warning levels up to 5 days ahead. The approach also includes expert support for emergency managers.

Susanne Theis
Susanne presented a review of current progress in ensemble postprocessing based around a workshop in Paris, May 2017. This included a review of methods. The research area on predictors and predictands is large and can be approached with "deterministic models". Therefore the scope is too wide for PDEF. PDEF should concentrate on the ensemble-specific challenge, particularly relating to the identification of prediction scenarios (or storylines) from the trajectories of ensemble members in the forecast. This is highly challenging due to the need for coherence in time and the multi-scale and multi-variate nature of the problem. For example, many forecast re-calibration techniques have focused on one variable at a single location. These are unlikely to improve forecasts of many coupled variables across a region.

A need was identified for a database for the post-processing research community:
- Common data repository for forecasts and observations
- Software exchange for postprocessing methods
- Relevance to interdisciplinary problems and users

13. Workshop on improving the societal impact of ensemble forecasts

Christoph Spirig (Meteo Swiss)
Examples of monthly forecasts:
Tercile forecasts for weeks 3-4 (high hit rate, but not sure who users are). Feedback is that general public do not understand them.
Tercile forecasts of 3-monthly means for months 1-7.
All achieved by counting ensemble members in each tercile (after recalibration)

Ongoing R&D in terms of:
- tailoring (indices and coupled impact models – want to avoid complex ones)
- dialogue with users (relevance)
exploit aggregation when calculating skill of indices
Q. how much of seasonal forecast skill cf climatology is related to long-term warming?
- Better to exploit skill for systems with memory (e.g., hydropower operations by feeding ensemble into hydrological model, or river flow).
- Heat stress predictions (multi-variate index) – more skill than single var forecasts (because depends on physical model).
- Ideas presenting skill (situation dependent) together with tercile forecasts. Skill should be conditional on weather regime for example.

User surveys:
- Operational forecasters are only considering ensemble qualitatively so far.
- A good option is layered information. Simplest on top and dig deeper if interested.
- Found that map products are preferred to other communications (contrasts with Met Office findings that public did not use maps for weather forecasts).
• Seasonal forecasts. No point in running entire ensemble infrequently (e.g., first of month). Better to run a few ensemble members every day and update ensemble by lagging. But need hindcasts in the same way.

Dan Rowlands (Cumulus Trading)
Focus on energy trading. Did try agriculture and retail but transfer function from weather forecast variables to “impacts” are too uncertain.

Example – Spain spot prices for electricity. Very strong influence of large-scale weather systems. Taking on weather risk for utilities (smoothing out impacts of price volatility. Very nonlinear price versus demand curve, so greatest penalties for poor forecasts at high demand.

Blending ensembles crudely by matching members most similar in terms of large-scale pattern and T_s. In this way latest medium-range forecasts are used to re-weight monthly forecasts (issued only twice per week).

Acting as story tellers. Persuading someone to take a risk but communicating way in which predictive skill arises (attribution of signals). For example chain of predictability from tropical low freq anomalies, teleconnections and regional weather patterns.

Weather patterns for Euro-Atlantic (using 5 including UK ridge). Look at signal:noise conditional on pattern type in terms of country-wide power production for example (combined power net demand). So although most long-range skill is in large-scale regime, the range of possible outcomes in generation net demand is very large. So convolve pattern probabilistic forecast with climatological PDF for that regime.

More skill by projecting onto weather regimes and then convolving than using ensemble forecast of surface wind directly. Because more predictability in large-scale than in the elements that do not predict onto those patterns?

Model is not sufficiently confident in NAO forecasts, so 3-week ensemble mean signal in NAO should be scaled up by x1.5. Issue is that teleconnection structure is wrong and drifts with lead time (weaker). Due to Pacific Jet being too weak (week 3).

Luca Della Monache (NCAR)
Discussed the use of analog ensembles for probabilistic prediction of renewable energy.

Although the length of record required to find an analogue situation for a large-scale (or hemispheric) forecasts is prohibitively large (Lorenz, 1969; Van den Dool, 1994) the approach does have utility for small areas focusing on only 2-3 degrees of freedom. Examples were given for 24 hour forecasts where the predictors are wind speed and surface pressure.

Application to wind power generation across Italy was presented. Discussion included difference between point-wide (wind farm scale) verification and evaluation of regionally-aggregated generation. A key issue is spatial coherence if analog matching is done on a site-wise basis. Also, the cross-over at about 48 hours between the skill of the analog ensemble (short time-scales) and generation inferred from the COSMO-LEPS dynamical downscaling ensemble points to the importance of temporal coherence.

Lisa Quandt (Germany)
Presented research on the predictability of impacts associated with regional heat waves. Major case study was the heatwave in Russia, 2010.
Approached problem using TIGGE and S2S ensembles out to 10 and 45 days respectively. Issues discussed included the appropriateness of different impacts indices and methods of clustering ensemble forecasts. It was noted that the largest ensemble spread is typically just before block onset and the decay phase is almost always too early in the subseasonal forecasts.

14. Proposals and plans for useful PDEF activities

**John**
HIW workshop, Landshut Oct 2017. JM and ST attending. ST to make contact with ensemble post-processing group in HIW and the application side of this topic. JM diabatic processes in weather systems.

**Martin**
DA workshop in Munich, 5-9 March 2018. International Symposium for DA. Could have a session related to stochastic physics. Model error. Also ensemble design. CB to discuss with Martin on sessions for programme.

**Olivia**
SPARC General Assembly 1-6 Oct 2018 (Kyoto, Japan). Propose a workshop on Rossby waves – OM is on the programme committee. Moving towards stratosphere-troposphere processes and their role in climate. Climate dynamics and wave-mean flow interaction.

**John**
Joint workshop on diabatic processes in mid-latitude stormtracks (with SPARC and WCRP Grand Challenge). Discuss this first with SB and BS. By end of July. Propose as a session within SPARC GA? Bring in with stochastic representation of sub-grid physical processes.

**Munehiko**
NWP-TCEFP. Exploring utility of ensemble forecast products based on TIGGE data. Uncertainty representation on TC tracks from regional centres is based on historical stats and not on ensemble forecast data. Ask centres why this is not used for intensity and so on. Survey feeding into next IWTC-9 conference planned in 2018 (date undecided). First step to talk with Nannette about communication channels to the regional centres RSMC.

**ECMWF Annual Seminar** 11-14 Sept 2017 – on ensemble forecasts this year. PDEF would write a document on history of global ensembles (history of configurations). MY to contact MR and Roberto Buizza and Mio Matsueda about tabulating the information as a contribution to the Annual Seminar Proceedings.

**Craig**
JB will talk with people conducting grey zone parameterization research (e.g., George Craig, Bob Plant, Peter Clark) and link with stochastic process schemes designed to improve spread-skill relationships in ensembles. With a view to writing a white paper on motivation to use high res global simulations to facilitate improvements in stochastic representations of sub-grid scale processes.

What information from high resolution simulations is required to inform stochastic parameterization development via coarse-graining approach?

One proposed approach is the use of single column approach for coarse-graining experiments and development of stochastic parameterization. PDEF initiative would require multiple groups to commit to experiments to do this. Design protocol of technique to do it.

Oscar also discussed this at WGNE meeting. Message is that there is a lot of enthusiasm in this area.

**Craig**

Climate ensemble post-processing technique website. Benchmark approaches. Pitfalls? Related publications. ACTION – speak with Retto and WGNE/WCRP. Oscar discussed it at WGNE meeting – seemed like WCRP connection would be better.

**Craig & John**

Increasing engagement with industrial sectors, especially those relating to WWRP Implementation Plan. Eg., aviation, energy, water supply.

e.g., 100m wind and solar rad becoming part of NWP model scores, as well as output.

Should be evaluating nonlinear transformation of wind in design of ensembles. Integrated fuel burn for aviation (nonlinear function) sensitive to error correlations used in design of ensembles. (e.g., Oldenberg, SAFEWIND, ANEMOS-EU). Mean of ensemble will not minimise error variance. Design of ensembles of relevance to industrial sectors.

Agriculture has very high expectations on subseasonal forecasts and skill. Big gap between expectations/needs and what can be delivered.

Hypothetical users (e.g., farmers) so you can work out value for users of changing the forecast system. What *hypothetical users* should we construct? Need some dialogue with users. OM.

JM: What are hypothetical user functions for aviation (from workshop). OM: programme working with agriculture in Australia – coming back to hypothetical users as a synthesis.

Ideas on users sensitive to threshold. E.g., icing on roads. Diurnal range sensitivity: e.g., farm animals, plants. Min/max metric. Pull through into ensemble evaluation.

**15. Review of actions and decisions**

**Action 3.1:** Need to map from PDEF activities to WWRP, 4 societal challenges and the 18 action areas and send to Paolo Ruti.  
**WHO:** Co-chairs. **DEADLINE:** October 2017.

**Action 1.7.2:** Explore experimental design for coarse-graining studies that can be applied in a common framework across different models. Using high resolution model data to compile tendencies within larger grid boxes and compare to those from physical parameterization schemes. Using coarse-grained high resolution output as forcing for a suite of single-column models would allow to involve different modelling centers and applications.
Ongoing.
WHO: JB and CB.

Action 2.3.2: Suggest setting up some similar experiments (1.7.2) with NICAM in Japan. More concrete experimental design is required. Discussion initiated with Masaki Sato, Tokyo.
WHO: MY.

Action 2.5.1: Encourage use of the NAWDEX campaign period for the investigation of the processes in NWP models and the origins of model error. Ongoing.
WHO: JM.

Action 2.10.4: PDEF to recommend to the leaders of the YTMIT initiative of S2S (Year of Tropics and Mid-Latitude Teleconnections) that they link their plans and experimental designs with the polar-low-latitude interactions activity of YOPP (under PPP) and share results.
WHO: OA and co-chairs. DEADLINE: December 2017.

Action 3.2: TIGGE – a number of actions are required to ensure the successful continuation of the TIGGE data base and its utilisation in global research. These are detailed in a separate document, but are summarized here:

3.2.1: Instate the TIGGE Panel Chair as a formal member of the PDEF WG. Some part-funding is likely required to ensure that the coordination required can be delivered. Value for WMO is achieved through having one person coordinating both the TIGGE and S2S data base contributions.

3.2.2: Write a letter from WWRP to operational centres contributing to TIGGE which re-iterates the ongoing value of the TIGGE dataset in research.

3.2.3: Re-instate a person responsible for transferring data to the TIGGE portal from both CMC and NCEP.

3.2.4: Write to the new body NCEI to request transfer of both NCEP (re-instate transmission) and FNMOC ensembles (new activity) to TIGGE.

3.2.5: Re-instate the TIGGE Panel with a chair (a member of PDEF WG) and one person from each contributing operational centre who is responsible for data transfer.
WHO: TIGGE Panel Chair, Co-chairs, WWRP. DEADLINE: October 2017.

3.2.6: Re-establish contact with the person responsible for the TIGGE portal at CMA.

3.2.7: Write a clear statement to be quoted verbatim in acknowledgments of papers using TIGGE data.

3.2.8: Modify the terms of use of TIGGE data on the portal.

3.2.9: Modify the CMA portal website in a consistent way with translation into Mandarin.

3.2.10: Send an electronic survey to existing TIGGE users.
WHO: TIGGE Panel Chair and co-chairs. DEADLINE: end of 2017.

3.2.11: Work with NCMWRF to enable them to join as TIGGE contributors.

Action 3.3: TIGGE-LAM
There is very low usage of TIGGE-LAM and it is important to increase usage or discontinue. PDEF WG recommend the following actions:

a) Promote the use of TIGGE-LAM through the new mailing lists associated with the HIW Project. Emphasise ensemble applications and the possibility of multi-model use in the overlap regions in Europe.

b) Ensure that the data is as easy to use as possible for those less familiar with NWP. For example, GRIB to netCDF conversion on download from the portal and interpolation onto common grids if required.

c) Survey the existing users as for TIGGE including the question relating to obstacles to use it in scientific investigations.


**Action 3.4:** S2S database provider panel

PDEF discuss with S2S and the data portal manager, the need for a database panel, for the same reasons as the TIGGE Panel. In some instances the person responsible for data transfer is the same for TIGGE and S2S, so perhaps a single panel for both datasets would be appropriate?

The aims for both portals are similar:

a) Ensure continuity of data transfer and the engagement of the data providers.

b) Ensure that WWRP has information on the use of the datasets and their impact on research by including the statement of use in paper acknowledgements, maintaining a record of publications and surveying users on their use of the data and any obstacles to using it.

WHO: Co-chairs and TIGGE Panel Chair. DEADLINE: October 2017.

**Action 3.5:** WGNE meeting 9-13 Oct, Exeter – cross-representation with PDEF.

Processing climate ensembles. Design of stochastic parameterisations.


**Action 3.6:** Provide guidance on the S2S 5-year plan. Topics include:

- Database link with TIGGE.
- Project on analyzing ensemble characteristics of different forecast systems.
- Role of systematic error and random error.
- Rossby waves and teleconnections.
- “Rossby wave triggers”: MJO, TCs, diabatic processes.


**Action 3.7:** Proposal to the S2S 5-year plan. *Hypothetical users* as a way to evaluate and improve S2S ensemble forecast systems.


**Action 3.8:** Develop other verification metrics in relation to evaluation of additional observations during NAWDEX. E.g., high latitude Atlantic and Arctic.

Feed through findings to PPP (in time for YOPP). Take into account Verification WG report to PPP on Arctic verification.


16. Next meeting

Options discussed.

- SPARC – Kyoto, Japan – first week Oct 2018. WGNE in 2018? Also in Japan?
- EnKF conference – USA (Penn State?) – late May
- Melbourne – Nov 2018 – seasonal prediction meeting? Too late?
- S2S? S2D meeting, 17-21 Sept 2018, USA (NCAR, Boulder).