TIGGE/S2S Workshop: WG4 Dynamical Processes and Ensemble Diagnostics

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1. **Implementing diagnostics relating dynamics to predictability**

Which diagnostics could relate dynamical processes and flow dependent predictability?

- RMM indices for MJO phase – but does not reflect heating magnitude or meridional location
    - *tracking precipitation envelope*
- Rossby wave and teleconnection diagnostics (see output from YTMIT):
    - Rossby wave source
    - refractive index and permitted wavenumbers for propagation
    - wave activity flux (3-D)
    - ridge (and trough) area (Rossby waves on jet stream)
    - *ray tracing*
- Regional large-scale patterns of variability (extratropical "regimes")
    - Dynamical interpretation of patterns and transitions
    - Relation to HIW
- Conditional dependence on interannual indices: ENSO, QBO etc.
- Many aspects cannot be addressed with TIGGE/S2S due to requirements on data resolution or online calculation (e.g., trajectories, diabatic tracers, tendencies, balance). However, can advocate special forecasting periods (e.g., YOTC, YOPP, YMC, NAWDEX).

What variables could be added to facilitate new diagnostics?

- Review TIGGE and S2S user surveys for suggestions.
- Compare variables archived in re-analyses with TIGGE and S2S. Additional forecast variables with re-analyses for climatological statistics.
- Surface variables at higher frequency from S2S (diurnal cycle for increasing lead time).
- Surface fluxes relating to coupling: ocean, land, sea ice.
- "meridional eddy fluxes" such as $v'\theta'$, $u'v'$ are useful, but transient fluxes depend on frequency of output (or online calculation). Need to complete set for 3-D wave activity flux.
- $\omega'\theta'$ would be useful (baroclinic energy conversion), but vertical velocity is lacking.
- Diabatic heating (comprised of physical parameterisation tendencies).
- Column integral quantities including TCWV and IVT (vector). Capability to close budget?

How could coordination of dynamical processes and predictability studies be improved?

- Regional large-scale patterns of variability (extratropical "regimes")
    - *review* definition of patterns for each mid-latitude storm-track region
    - *define* shared diagnostics including transition rates between regimes
- Ensemble sensitivity analysis – review approaches

2. Bridging from medium range to seasonal prediction utilising both TIGGE and S2S ensembles

- Diagnostics relating to predictability at different spatial and time scales.

  e.g., spectral filter applied to ensemble members and error growth as function of scale.

- Using basic scores to compare TIGGE and S2S ensembles across week 1 (and week 2 where possible) and the role of calibration.

- Characterising systematic error in large-scale spatial structures as function of lead time in TIGGE and S2S systems across common time range (to 7 days).
  - E.g., teleconnection patterns conditional on MJO phase
  - Mid-latitude weather regime structures

3. Ensemble design

How can we use both TIGGE and S2S data sets to improve the design of ensembles in predicting uncertainty?

Includes the construction of initial perturbations, ensemble size, frequency of forecasts, model resolution and complexity.

- Compare rate of increase in spread (and error) for TIGGE and S2S ensembles.
  - A few centres continue same members into extended range. Many centres use different models and ensemble construction strategy. Subset to compare.
  - Need to assess importance of ensemble construction in S2S.
  - Compare initial perturbation statistics with uncertainty in analysis.
- Add high res forecasts from each centre to TIGGE database (on same grid)
  - Typically without perturbation – also use in multi-model ensemble.
  - Use to evaluate resolution dependence of systematic error (especially spatial)
- Does S2S ensemble spread saturate at the right lead time? Flow dependence?
- Influence of stochastic parametrization
  - PDEF/WGNE coarse-graining experiments to inform stochastic parametrization
- Learn about coupled/uncoupled prediction – or dataset unsuitable for this?
- Re-forecast datasets too short for statistics conditional on ENSO/QBO etc?
  - Suggestion – long “re-forecast” from each contributor to S2S every 5 years.

4. **How important is it *for research* to have access to the forecasts in closer to real time?** (Q.7)

Two aspects of research where access to forecasts (via TIGGE/S2S) in NRT would be beneficial are:

i) Applications of ensembles in different sectors where evaluation of uptake is only possible in real time. For example, the use of ensembles (or multi-model ensembles) in risk-based decision making.

ii) Analysis of extreme events where interest is driven by unfolding situation. “Live science” and public engagement in science.

- Noted that it is very useful for non-operational modelling groups to evaluate their ensembles continuously in near real time (e.g., SubX).
- 16 near real-time ensemble forecast pilot projects as part of S2S Project.
- Many respondents to TIGGE Users survey are using the data base and TIGGE Museum in near real time in prediction mode (despite two day delay).

5. **How can utilisation of TIGGE and S2S forecasts be improved via portals and web services?**

- Stimulate use of IRIDL for diagnostics and exploratory studies.
- Build up code repository for diagnostics – perhaps via python interface to IRIDL?
- Ability to expand web service building on S2S and TIGGE databases.
- Enable investigators to publish method and Open code using doi (visibility).
- Needs technical and scientific documentation accompanying software and QC.
- Reward community code contributors with recognition from WMO projects.