Working Group on Numerical Experimentation Report (draft 1)

1. Highlights for JSC

The WGNE systematic errors survey results (presented at JCS-40) indicated that all modelling groups (regardless of the time-scale they were developing their model for) highlighted convective precipitation, surface fluxes, surface temperatures (incl. diurnal cycle), cloud microphysics (incl. aerosol interaction) and representing model uncertainty as key issues to be addressed. WGNE have a number of projects now active in relation to these priorities:

- WGNE MJO task force - The research activity of the group is organized around four research themes: MJO simulations and mechanisms, MJO prediction, MJO and extratropics, and MJO-Maritime Continent (MC) interactions. The group has found a robust relationship of the mean state moisture pattern with MJO simulation fidelity in climate model simulations and with MJO prediction skill in hindcast datasets. MJO-TF is collaborating with PCMDI to implement several MJO metrics into PMP. MJO prediction skill in S2S and SubX models has been assessed. A standardized set of diagnostics and metrics to evaluate MJO teleconnections is being developed and applied to model simulations. Observations collected during YMC are being used to better understand the MJO-MC interaction. Climate model sensitivity simulations suggest that MC land masses affect the propagation of the MJO by altering the mean state moisture pattern.
- WGNE-GASS 'grey-zone' project – Many weather and regional climate models are, or will be, run at resolutions in the convective 'grey zone' where convection is partially resolved. The project's deep-convection component will leverage GATE phase III field campaign observations and the shallow-convection component is based around the recently completed EUREC4A field campaign, with the goal of informing the development of grey-zone convection schemes.
- WGNE Surface fluxes project - The protocol, was disseminated in February 2019. Ten centers have participated thus far, with about 1.5 Tb of data in total being archived at Météo France. Initial analysis has been carried out with more detailed analysis to follow. Further engagement may be needed to increase climate model participation.
- WGNE-GAW-S2S Aerosols project - The final version of the project protocol has now been released. The protocol has two components. The first is regional experiments focusing on short-range, high resolution, forecasts for South America and South Africa, Egypt and East Asia considering the years 2016-2018. The second is longer timescale global 32-day ensemble experiments for a 2003-2018 hindcast period. These will be used to explore the benefits of including a representation of aerosol impacts at different levels of complexity.
- WGNE-PDEF Model uncertainty project – A draft protocol has been written for a project to evaluate and inform the development of stochastic physics schemes. The project involves running km scale simulations, coarse graining them, applying to single column models and comparing their evolution (to be launched once the lead returns from maternity leave).

Other key activities of WGNE are:

- WGNE-GASS drag project – Previous analysis has shown that many CMIP models show biases consistent with too little overall surface drag. A previous WGNE project showed that drag partitioning between different schemes differs markedly amongst models. COORDE (COnstraining Orographic DRag Effects) is focussed on understanding impacts of differences in orographic drag parametrizations for modelled circulation and quantifying small-scale orographic drag with the use of high resolution simulations. The project is focussed on two regions: the Middle East and the Himalayas. Analysis of several submitted model simulations have now begun.
- Model verification and evaluation – WGNE continues to explore process-orientated evaluation methodologies. The JMA annual tropical cyclone (TC) verification is extremely valuable and has identified a clear reduction in TC track and intensity errors over the years. Traditionally, global models have underestimated TC intensities, however several NWP centres now produce TCs that are too intense (perhaps due to a lack of ocean coupling). The WGNE-WWRP JWGFVR have developed new forecast verification metrics using non-traditional observations. They continue to promote the exchange of surface temperature scores and precipitation verification, and have undertaken processes-orientated verification work on temperature errors. A WGNE-WGCM panel has been set up to focus on the evaluation of precipitation in climate models, with groundwork planned over the next year. Potential synergies and joint work between the JWGFVR and ESM precipitation benchmarking are being considered.

2. Primary science issues (looking ahead, 3 to 5 years)

- Earth System Modelling across timescales – WGNE has always taken a leading role developing models for use across weather and climate timescales. Traditionally this has been the atmosphere and land, but increasingly other Earth System model (ESM) components are being used across timescales and hence WGNE is evolving to gain expertise in these areas. Moving forward, WGNE will focus on reducing key systematic errors in ESMs. Many efforts will still be focused on the atmosphere and work will continue on the projects listed in the previous section, however key errors in other ESM components will need to be identified and investigated with the relevant communities.
- Exascale – WGNE has undertaken reviews of exascale developments in modelling centres. Some centres are progressing well in re-writing their code for exascale architectures while others, especially centres only involved with climate simulations, are yet to start. Thus far, WGNE has focussed on atmosphere and ocean codes, but other ESM components need to be considered in the future. WGNE plans to act as a focal point for sharing information amongst modelling centres on different approaches and is also exploring how reduced precision may be useful for accelerating codes.
- Machine Learning (ML) – WGNE will continue to share information around the use of ML for model development and evaluation. Most current applications aim to emulate existing parametrizations, replace parametrizations by emulating observations/high resolution models, or emulate full GCMs. A practical common difficulty is calling ML code (in e.g. Python) from model code (often Fortran). There has been significant and promising progress in this area, but key remaining concerns include going outside of training data (especially for climate change simulations) and model stability.

3. Issues and challenges, for example:

- The expertise of WGNE needs to be expanded to cover the full Earth System (atmosphere, land, ocean, cryosphere, chemistry, hydrology, etc.). However, a strength of WGNE is that it's an expert working group which undertakes coordinated studies and experiments. A large increase in the number of members or remit would be detrimental to this strength, hence we envisage building expertise through normal membership changes at the end of terms, with possibly a small number of additional members, and links to other groups. We see an essential continuing need for groups understanding key processes in model components such as GASS, GLASS, chemistry expertise within GAW, and a cross-timescale ocean group (OMDP?).

- As WGNE becomes the focal point for model development, WGNE members are being asked to sit on the panels/steering committees of an increasing number of other groups and/or representatives from many other groups are asking to attend the WGNE meetings with a danger of making them unproductively large. An efficient means of communication and reporting to working groups within WWRP, WCRP and GAW, together with the JSC, WWRP SSC and GAW SSC and Research Board which doesn't require attendance at a large number of meetings needs to be established.
- There is a very strong argument for WGNE to act as a focal point for ESM across timescales. However, it is unclear if processes only relevant to long climate timescales (e.g. interactive ice sheets, long-timescale carbon-cycle processes) should be within the remit of WGNE or another group (e.g. WGCM where C4MIP resides).