Alternative Modelling Approaches

Modelling Breakout Groups Brainstorming

This breakout group aims to develop and improve climate modelling methods. We further plan to divide into two sub-groups aiming to work (i) on alternative climate modelling approaches, i.e. outside of the usual general circulation models such as energy-balance and stochastic models, and (ii) on model 'detuning', i.e. to explore a wider parameter space in climate models with a focus on identifying parameters that would be linked to low-frequency variability. In both cases, we aim to achieve climate modelling in line with evidence derived from the paleoclimate records, in particular with respect to variability at different timescales.

The (i) alternative modelling sub-group will bring together experts using different strategies for climate related predictions/projections in order to discuss the role of scaling and statistical models for predictions/projections and decision making. The group aims to review the role of stochastic versus deterministic modelling, and how to best utilize together global climate models, simple climate models and energy balance models, including regional and stochastic updates of Budyko-Sellers type models. The end goal is to improve confidence in climate predictions/projections, and perform probabilistic predictions of extreme events and changes in their distribution.

The (ii) model detuning sub-group will consider the possibility of scanning a larger parameter space in climate models in order to overcome model limitations, which some have argued were "built for stability". This would allow us to investigate a broader range of possible model sensitivities and model behaviors in terms of climate variability at various scales. By using additional climate model tuning targets next to present-day observations, the aim is to achieve simulations with greater natural variability in line with palaeoproxy evidence. First results achieved with an intermediate complexity model will be shown. The aim will be to develop strategies for parameter exploration and identify alternative tuning targets that can be derived from the palaeorecord, including spectral targets derived from the variability mapping breakout group working in parallel.

With the present document, we would thus like to collect input from you so that we can optimize the orientation of the working group based on the available expertise and scientific goals of everybody. The outline above is only indicative of promising orientations identified by the workshop organizers and subject to revision based on input from you. So please contribute your ideas and questions below, and add in references of relevant literature in the table (with the DOI if possible so we can gather them easily).

Please put you name and email address here if you are interested in joining the group or keeping updated

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What variables do we want to model/predict:

- Regional temperature projections (i.e. climatologies) until 2100 (deterministic)
- Mega climate models of macro-evolution
- Near-term predictions on seasonal to interannual to decadal lead times (stochastic)
- Point predictions / pdf
- Return times for extreme events, extreme value distributions

What model types and concepts could be used?

- Energy-balance models (both deterministic and stochastic are possible)
- Stochastic Models
- Emulators
- Hybrid models

Literature Review:

Lovejoy, S. 2022: The Future of Climate Modelling: Weather Details, Macroweather stochastics – or both? **Meteorology**, **1**, 414–449. https://doi.org/10.3390/meteorology1040027. Online version.

Lovejoy, S., R. Procyk, R. Hebert, L. Del Rio Amador, 2021: Lovejoy S, Procyk R, Hébert R, Rio Amador L. The fractional energy balance equation. **Q J R Meteorol Soc**. 2021;1–25, https://doi.org/10.1002/qj.4005.

Del Rio Amador, L., and Lovejoy, S., 2021: Long-range Forecasting as a Past Value Problem: Using Scaling to Untangle Correlations and Causality **Geophys. Res. Lett.**, doi: 10.1029/2020GL092147. Supplementary material.

Del Rio Amador, L., and Lovejoy, S., 2021: Using regional scaling for temperature forecasts with the Stochastic Seasonal to Interannual Prediction System (StocSIPS), **Clim. Dyn.,** 1432-0894, doi: 10.1007/s00382-021-05737-5.

Lovejoy, S., 2021: The Half-order Energy Balance Equation, Part 1: The homogeneous HEBE and long memories, **Earth Syst. Dyn. 12,** 1–18, https://doi.org/10.5194/esd-2020-12..

Lovejoy, S., 2021: The Half-order Energy Balance Equation, Part 2: The inhomogeneous HEBE and 2D energy balance models, **Earth Syst. Dyn., 12,** 1–23, https://doi.org/10.5194/esd-2020-13.

Paper	Model	Variables	Statistical/Deterministic	
Lovejoy et al.	HEBE/FEBE	Temperature		

Lovejoy and Spiridinov 2023	Fractional Macroevolution Model	temperature, extinction, origination rates, biodiversity	Statistical/deterministic	