IMPROVING OUR CRAFTMANSHIP OF MARS GLOBAL CLIMATE MODEL TUNING : FUTURE DIRECTIONS ?

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Introduction: As our Mars Global Climate Models (GCMs) become increasingly more complex (because including and accounting for more physical processes) to represent as wholly and truthfully as possible the entire Mars climate system, we face a challenge that Earth GCMs experience and have begun to reflect upon [1] : the difficulty of assessing that the best model tuning strategy has been employed.

The craftsmanship, or art, of (complex) model tuning: While the fundamental physics of climate is generally well established, sub-models or parameterizations are approximate, either because of numerical cost issues (limitations in grid resolution, acceleration of radiative transfer computation) or more fundamentally because they try to summarize complex and multi-scale processes through an idealized and approximate representation. Each parameterization relies on a set of internal equations and often depends on parameters, the values of which are often poorly constrained by observations. The process of estimating these uncertain parameters in order to reduce the mismatch between specific observations and model results is usually referred to as tuning in the climate modelling community.

A difficulty arises in the fact that tuning of a given parametrization will rely on some choices (and compromises) made by the authors with respect to some target (e.g. a set of observations, or of results from a more complex and complete model); but this is usually reasonably documented in corresponding articles, although in many cases the general concept and validity of the scheme given in the paper may slightly differ from the actual coding in the GCM, once the scheme is coupled to all others (this is rarely documented). Of course, the full GCM's capability to reproduce observations is documented and presented in articles, but the strategy and subtleties of how the global tuning of the model was achieved is most often not. And also one may wonder about possible error compensations when schemes are separately tuned.

We believe, as advocated in [1] that the tuning process of any GCM is a fundamental aspect that should be documented and that new approaches for tuning (e.g. based on global uncertainty quantification, UQ, as illustrated in [2]) should be investigated.

Ideas for discussions to have at the MADA 2018 workshop: For this topic, an instructive preliminary discussion among contributors could be to survey what each GCM modelling team's strategy (if any) is in term of tuning.

A foreseen follow-up discussion could be on evaluating the pros and cons of available options for more transparent and efficient model tuning, which could include sub-topics such as:

- Can we (should we?) agree on the decisive metrics which should clearly be used when tuning a GCM?
- Should the goal be to reach only one set of optimal values for parameters? Or can we foresee that there will be multiple sets (e.g. depending on the GCM resolution, or choice of parametrizations), and how should one investigate and document this?
- Rather than tuning one parametrization at a time, what strategy should be employed for a better "global" tuning of a GCM? Old-school iterative tuning of individual parametrizations? Global Uncertainly Quantification methods? Can data assimilation also be successfully used to constrain unknown parameters?

References: [1] Hourdin F. et al. (2016) *BAMS.* [2] Williamson D. et al. (2013) *Climate Dynamics*, *41*, *1703-1729*.