Numerical modeling, from weather to climate: Progress achieved, and some of the reasons promising further progress

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Abstract. Milanković's thinking is summarized, when in 2013 looking for a major "cosmic" problem to embark on using his mathematical talents, Milanković started with weather. But he eventually decided that, "at least for the time being", this was not possible, turning his attention to climate. Regarding weather, when the time did come, numerous necessary steps were taken. Some illustrations of how far this took us are given. Not only regarding the accuracy of the day to day forecasts, but eventually also finding "predictability in the midst of chaos", thereby extending lead times of obtainable skill into seasonal, annual, decadal, and even longer climate change time scales. As to the weather, an illustration of progress achieved in both the data assimilation and the predictive skill of models, often the near disappearance of skill difference between extratropical data rich northern and data poor southern hemisphere is taken. If he is looking, we are confident Milanković is pleased to see the skill achieved by a model largely from his part of the world, the Eta model. We show results showing its advantage over the ECMWF model, generally considered as "the benchmark to beat" among multitude of present-day models; and added skill it derives from two of its unique features. One is its "eta" vertical coordinate with coordinate surfaces intersecting topography, and the other finite-volume vertical advection. The vitality of the extraordinary variety of today's approaches to numerical design justifies an optimism expected of further progress. Emergence of skillful seasonal forecasts is yet another reason in that sense. We show an example of again the Eta but now in that role. In climate change area, the need to understand the reason for recent acceleration of global warming is a problem deserving full attention. This would offer a challenging test for further improvement in what is now referred to as earth system modeling.