Evaluation of the influence of non-hydrostatic processes in development of tropical convection using Global Eta Framework (GEF)

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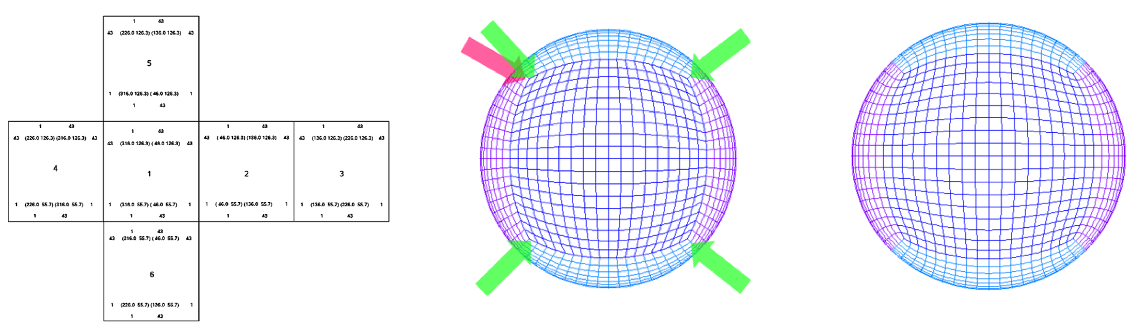
1. INTRODUCTION

Global Eta Framework (GEF) is a global atmospheric model based on quasi-uniform cubic grid, whose initial version has been developed in 2006. Its recently improved mapping method provides the end state that is perfectly “equal-area”, and therefore removes any variation in Jacobian. Following a trend in global modeling of development of non-hydrostatic dynamical cores, there is an ongoing project of addition and implementation of non-hydrostatic version of this model based on the approach of Janjić et al (2001), the same method used as in Regional Eta Model. The method consists of reformulation of governing equations in the way that they include a parameter which defines whether the set of equations will be hydrostatic, if its value is zero, or non-hydrostatic in any other case. It is expected that non-hydrostatic processes could have a significant impact in development of tropical convection in some extreme cases. The Amazon region suffered severed floods in 2009 and 2012 and these extreme events are perfect examples to evaluate how the inclusion of non-hydrostatic processes changes the simulation of total rainfall, intensity of convection, as well as the onset of rainy season and how it affects diurnal cycle of precipitation. Above mentioned method provides excellent conditions to analyze the influence of these processes, since it is possible to run the model both as hydrostatic and non-hydrostatic, which is easily defined by a switch at the beginning of calculation. A simple comparison of the outputs of both versions of the model, with horizontal resolution below 10km, will give the insight in the contribution of non-hydrostatic processes to the convection in tropical regions.

2. MATERIALS AND METHODS

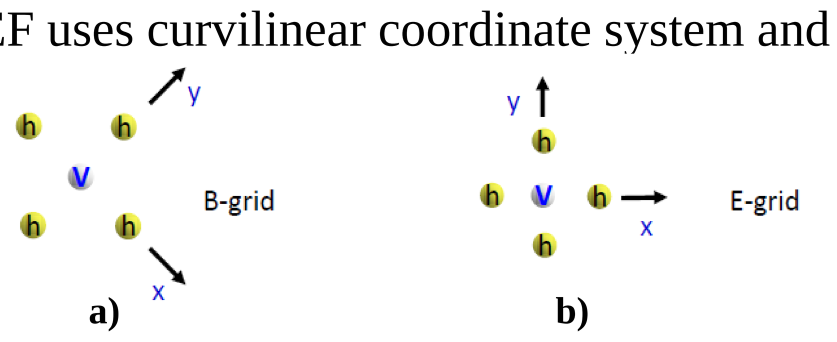
This model uses cubic grid (Fig. 1a) which consists of 6 tiles, which represent 6 sides of the cube. Applying a Regional Eta Model on each side of the cube, and allowing the interaction between them, the whole globe can be covered. In this way, a global model is obtained using regional model. This process is called “globalization” of regional models. Cubic grid allows any other regional model to be implemented on it, Regional Eta Model is taken only as a prototype. This is why this model is called Global Eta Framework, rather then Global Eta Model.



a) b) c)

Figure 1: a) cubic grid with 6 sides , **b)** evolution of cubic grid from 1972 Sadourny’s gnomonic cube (b) to 1998 Purser’s and Rančić’s smoothed conformal cube **(c)** (quasi-uniform grid)

GEF has the same dynamics and physics as the Regional Eta Model, nevertheless, some changes had to be made due to implementation of a new, quasi-uniform grid. Therefore, as the most significant difference in comparison with the Regional Eta Model, GEF uses curvilinear coordinate system and Arakawa's B grid.



a) b)

Figure 2: a) Arakawa's B grid in GEF, **b)** Arakawa's E grid in Regional Eta Model

One of the first tests made with this model was to evaluate its capability to simulate extreme climate events and its stability in longer, low resolution (~230km) climate runs. For that purpose, there were 2 runs performed for a period of approximately 2 years for the cases of two extreme ENSO events, El Niño from 1997 and La Niña from 1999. Some results are presented in the Figure 3 and Table 1. With a new, “equal area” grid and increased resolution (~25km), there were new seasonal runs (90 days) performed, with the results presented in the Figure 4. These runs will be used as control runs for the next phase of the tests, which are expected to happen soon, after final development of non-hydrostatic version of the model and increase of horizontal resolution to the value of approximately 8km.

3. PRELIMINARY RESULTS

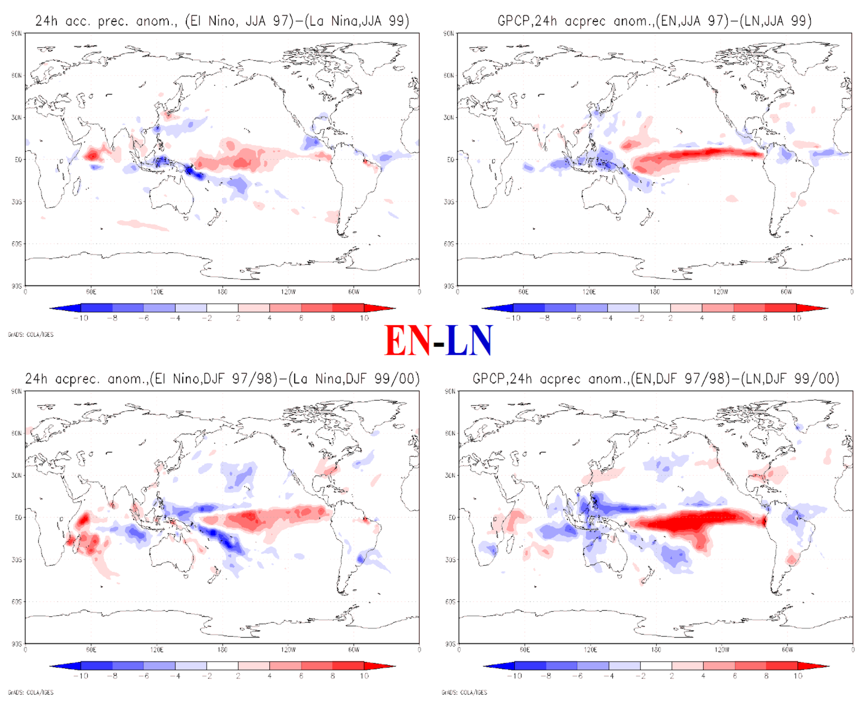


Figure 3: Comparison of 24hs accumulated precipitation anomaly obtained as a difference of the year with El Niño and the year with La Niña, with the appropriate observed anomaly (GPCP) for the periods of JJA (upper row figures) and DJF (lower row figures)

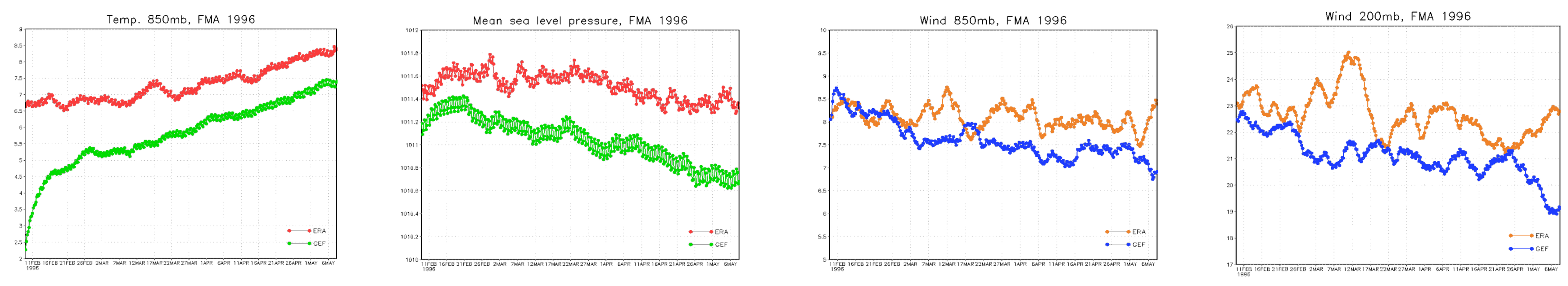
JJA ‘97	VARIABLES	SCORR
temp 850mb		0,98
wind 850mb		0,73
geopotential 500mb		0,99
wind 200mb		0,88
24h acc. precipitation		0,58

DJF ’97/98	VARIABLES	SCORR
temp 850mb		0,98
wind 850mb		0,66
geopotential 500mb		0,97
wind 200mb		0,81
24h acc. precipitation		0,69

JJA ‘99	VARIABLES	SCORR
temp 850mb		0,98
wind 850mb		0,74
geopotential 500mb		0,99
wind 200mb		0,90
24h acc. precipitation		0,63

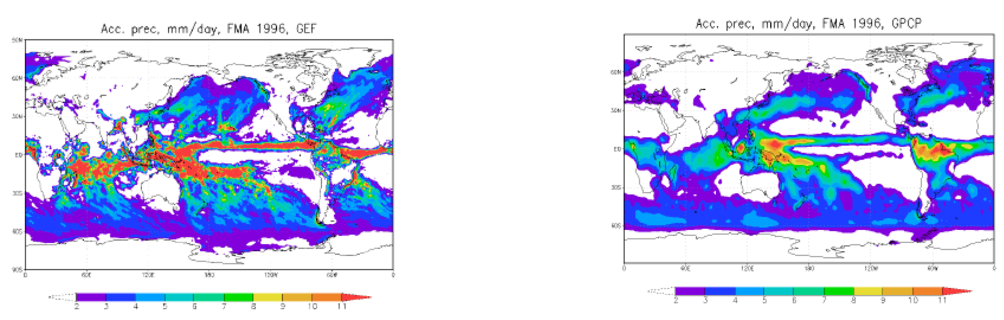
DJF ’99/00	VARIABLES	SCORR
temp 850mb		0,98
wind 850mb		0,64
geopotential 500mb		0,97
wind 200mb		0,75
24h acc. precipitation		0,70

Table 1:Spatial correlation for various atmospheric fields for the period of JJA and DJF of 1997 and 1999



a) b) c) d)

Figure 4: Global average fields for the period FMA 1996 simulated by GEF (green) compared with appropriate data from ERA Interim reanalysis (red): **a)** 850mb temperature **b)** MSLP; Global average wind for the period FMA 1996 simulated by GEF (blue) compared with appropriate data from ERA Interim reanalysis (brown): **c)** 850mb, **d)** 200mb



a) b)

Figure 5: 24hs accummulated precipitation for the period FMA 1996: **a)** GEF, **b)** GPCP

4. SOME CONCLUSIONS AND FURTHER PLANS

Preliminary results show that GEF is capable of running on a climate scale and simulating extreme climate events. It is also capable of running on higher resolution and its performance in hydrostatic mode was satisfying. All the runs were performed with a relatively modest use of computational resources. These results are encouraging and expectations are that it will perform well also in non-hydrostatic mode, as the Regional Eta Model does, and that it will be a useful tool which will contribute in understanding of the influence of non-hydrostatic processes in development of tropical convection.

The main aim of this PhD proposal is to investigate the effects of non-hydrostatic processes on tropical convection, with a focus on the Amazon region, using global model. One of the expected results of this project will be development of a global, high resolution, non-hydrostatic model.

Specific objectives:

1) To assess the model performance in simulating the beginning of the rainy season for the chosen years
2) To study the effect of small-scale processes in the development of deep convection and characterization of convection
3) To investigate the effects of non-hydrostatic processes in the simulation of diurnal cycle of precipitation
4) To investigate the convection intensity depending on use of hydrostatic or non hydrostatic version of the same model
5) Understand the role of convective parameterization schemes in simulations at "gray-zone" resolutions

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