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Development of the spectral-based dynamical core of the JMA operational global model

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Since 1988, Japan Meteorological Agency (JMA) has been operating a global spectral hydrostatic primitive equations model named Global Spectral Model (GSM). In its first implementation, GSM employed spherical harmonics transform on quadratic Gaussian grid, an Eulerian advection scheme, and a semi-implicit time integration method. These methods were chosen to take advantages of the spectral method such as accurate calculation of horizontal gradients and ease of solving a Helmholtz equation in spectral space.

Keeping in pace with the increasing computing power, GSM has steadily increased its resolution, but this was not achieved with increase in computing capacity alone. A number of improvements to numerical methods have been incorporated, keeping the advantages of the spectral method, to harness the evolving computer architecture. With successive introduction of a semi-Lagrangian advection scheme on linear grid, reduced spectral transform and speedup of spectral transforms on massively parallel computers, GSM has evolved to accommodate horizontal resolution as high as 20 km (in operation) and 13 km (planned in the next few years). The increase of horizontal resolution on the linear grid has led us to revisit the issue of spectral blocking which has been recognized early in the history of atmospheric modelling. To resolve this issue, we developed a new discretization of the pressure gradient terms which ensures their rotation-free by exploiting characteristics of the spectral discretization (Ujii and Hotta 2019). Our recent experience also highlights the importance of numerics, particularly mimetic discretization, at high-resolution modelling.

Preparing for further resolution increase and possibility of non-hydrostatic global modelling, research is ongoing on a new nestable grid system that allows for both accurate spectral transforms and multi-grid methods (Hotta and Ujii 2018), which will also foster gradual transition toward spectral-grid hybrid modelling.

The talk will present current status and future outlook of the global spectral model at JMA.

Presenter: UJII, Masashi (JMA)

Session Classification: Moderator: Inna Polichtchouk (ECMWF)