Recent activities for fixing compensating errors in parametrisation schemes of the JMA operational global model

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The Japan Meteorological Agency (JMA) has operated and constantly upgraded the Global Spectral Model (GSM) for the deterministic and ensemble global NWP systems. Particularly, in March 2014 (GSM1403) and March 2016 (GSM1603), almost all of parametrisation schemes including cloud, convection and radiation schemes were upgraded. Further upgrade is planned in this year (GSM17XX). Most of these upgrades were carried out by revising and/or overhauling of the existing schemes.

Before these upgrades, problems of error compensation (or hidden errors), in which an error in one part of the model hides in the other, and minor (but critical for model's performance) treatments in the parametrisation schemes had prevented us from improving GSM. Although physically more sensible parametrisation schemes had been tested, the new schemes often degraded the performance of GSM due to these problems.

To face the problems, we have made efforts on (1) detecting which parts of the schemes hide errors in the others, and (2) proactively overhauling parametrisation schemes, rather than just replacing schemes with something newer and/or more complex. For (1), we have carried out hierarchy of experiments building up from detailed single column models tests to understand parametrisation's behavior at source code level, NWP case studies to see impacts of the modified schemes on forecasts, data assimilation cycles to see fit of forecasts to observations, and long term integration tests to see robust biases. We also have given importance to package testing to understand interaction between processes. For (2), we have conducted detailed code-level re-examination of the model and made the formulation/discretisation (numerics) as clear as possible. This review has helped us to achieve (1).

The above approach applied to the development for GSM1403 and GSM1603 revealed, for an example, that an artificial energy correction used in the convection scheme had compensated for errors associated with lack of snow melting and insufficient precipitation generation from convective cloud condensate. Implementation of these missing processes into GSM1603 made us enable to minimize effects of the artificial correction scheme and made convective heating profiles more appropriate. We also found that inflating PDF (Probability Distribution Function) width in the cloud condensation scheme, a kind of old tuning to increase mid-level cloud, had brought severe "side effects" (e.g. distorted vertical heating profiles which had hidden a troposheric cold bias) that overweighed its intended benefit. We also found that this inflation of PDF width as a "minor" treatment was also a "major" source of a long-standing tropospheric dry bias in GSM. These inadvertent side effects of tuning / correction had been obstacles for introducing a more physically sensible scheme. Both approaches of (1) and (2) helped us to find and fix these problems. We stop the PDF inflation combined with the changes in the other parts of the model in GSM1603, and are planning to consider convective cloud fraction in the radiation scheme in GSM17XX to cope with the problems of mid-level cloud and biases in radiative fluxes in a more sensible way.

These activities of reducing the compensating errors also enable us to re-challenge introducing brand-new schemes and/or more physically sensible treatment. Now, GSM1603 becomes a new "baseline" for further improvement of GSM since the characteristics of global distribution of cloud, precipitation, convective activity and circulation have been changed in a more sensible way from the older versions. A number of further improvements in cloud, convection, radiation, surface and subgrid gravity waves schemes which were turned down by the older versions of GSM are being tested.

This talk will show these examples and discuss how we can face the error compensation problems.