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Long-term statistics of continuous single column model simulations at Cabauw

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Single column model (SCM) simulation has become a valuable and relied-upon tool in the development and evaluation of parameterizations for general circulation models (GCM). In this method, the sub-grid model of a GCM is independently integrated in time, using prescribed large-scale forcings and boundary conditions. Typically, an idealized case is constructed based on observational data from a field experiment. An advantage of the SCM technique is that the model physics is studied in controlled conditions, in an isolated mode from the larger-scale circulation. Combined with the low computational cost involved, this serves to enhance model transparency and facilitates getting insight into the simulated system. A drawback of the SCM as a development tool is that relatively few cases have yet been formulated. Often these idealized cases represent so-called 'golden days', reflecting observed situations thought prototypical for a specific weather regime. One could question the representativeness of such idealized cases; i) they might actually reflect unique situations that rarely occur, and ii) they do not necessarily represent those regimes that cause the most problems in GCMs. As a result, parameterizations might get optimized for rare situations, while their performance for the most 'troublesome' regimes remains unassessed.
These issues have inspired efforts to perform SCM evaluations on a more continuous basis, thus automatically covering many different weather regimes. One such project is the recently initiated Cabauw Parameterization Testbed. Short-range (3-day) SCM simulations are performed daily for the Cabauw meteorological site in the Netherlands, operated by the Royal Netherlands Meteorological Institute (KNMI). The multi-year archive of SCM simulations thus generated is evaluated against the wealth of continuous observational datastreams measured at Cabauw, which cover the thermodynamic, kinematic and cloudy state of the atmosphere. The method of investigation consists of the following steps;

1. Statistically identify a problem in a 3D GCM;
2. Assess if the problem is reproduced by the corresponding 1D SCM;
3. If so, identify which individual days contribute most to the error;
4. Study those days in great detail, using a variety of statistical tools;
5. When the cause is identified and understood, formulate a solution;
6. Re-simulate and re-evaluate the modified 1D SCMs, hopefully diagnosing improvement;
7. Rerun the 3D GCMs including the improved physics.

A benefit of this method is that GCM statistics guide the evaluation and improvement of parameterizations. At each step in this sequence, model evaluation against observational datasets is essential.
In this presentation the merit of an SCM Testbed will be demonstrated using three examples of problems in a GCM that have successfully been addressed using the method described above. All are actual problems recently encountered during the implementation of the new EDMF-DualM shallow cumulus scheme (Neggers et al., JAS, in press) into the ECMWF Integrated Forecasting System (IFS). The problems concern i) the diurnal cycle of summertime low-level cloudiness over land, ii) low-level wind scores in the mid-latitude storm tracks, and iii) momentum transport in the stable nocturnal boundary layer. Model performance will be assessed through statistics on both short time-scales (individual forecasts) and long time-scales (monthly and yearly), including standard model-obs differences but also more advanced statistical score techniques.