Recent developments at ECMWF

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1 General

Recent developments at ECMWF include:

- Revisions to the 4DVAR algorithm are motivated by the need for improved efficiency to offset the costs of higher resolution, better tangent linear physics and the increased number of satellite observations. Also the wish to assimilate radiances in cloudy and/or rainy areas will require more advanced physics in the data assimilation. The set of revisions that accommodates for these requirements consists of: quadratic inner iterations, conjugate gradient minimization, Hessian eigenvector pre-conditioning, a multi-incremental approach with resolutions T42/T95 and T159, interpolation of the trajectory from high resolution to low resolution and tangent linear physics during all iterations.

- Recent satellite operational milestones are: use of QuikScat data, modified thinning of ATOVS, new RT model which is better for water vapor channels, use of water vapor radiances from Meteosat, use of SBUV and GOME, passive monitoring of water vapor radiances of GOES-8/10, and passive monitoring of NOAA-17. Ongoing satellite work is focussing on: (i) data use from operational satellites, (ii) preparation for AIRS, ENVISAT, EOS and other research satellites, and (iii) assimilation of cloud or rain affected radiances.

- The numerics section has introduced finite elements in the vertical and is focussing now on conservation, vertical resolution around the tropopause, and the upper boundary condition. On the technical side, there is the migration to the IBM, optimization for the IBM and PrepIFS and PRISM related activities.

- A new short radiation scheme has been introduced with 6 spectral bands and revised absorption coefficients. The result is a better representation of solar absorption in the stratosphere and a slightly reduced downward solar radiation at the surface.

- Substantial changes to the cloud and convection schemes have been prepared and are currently under test. They consist of a complete rewrite of the cloud code with scientific changes to the ice settling, better numerics and many bug fixes. The convection scheme has new activation and cloud base cloud top algorithms.

- New linear and adjoint code for radiation has been introduced but will only be activated after migration to the new IBM.

- The MAP period has been re-analyzed with a recent version of the 4DVAR system at T511 resolution, making use of the additional observations during the MAP project.

2 Assimilation and modelling of the hydrological cycle

A substantial effort is currently taking place at ECMWF to improve the moisture analysis. A status report entitled "Assimilation and Modelling of the Hydrological Cycle", by Holm et al. has been published as Research Technical Memo 383, and is available from ECMWF. The abstract of this memo is reproduced here.

Several new types of satellite instrument will provide a rich source of additional humidity information in the next few years. The assimilation of cloud and rain observations from existing types of instruments will also provide important new humidity information. In an effort to make the best possible use of these data a re-formulation of the 4D-Var humidity analysis has been developed. The new formulation will better account for the wide variations in humidity in the vertical and at small scales in the horizontal, thus improving the interpretation and the spatial interpolation of humidity information from space and ground based observing systems. The theoretical basis for the new formulation, its practical implementation within the ECMWF assimilation system, and several illustrations of its performance, are presented. The status of the preparations for cloud and rain assimilation is given, including the development of linearized moist physics, the development of fast radiative transfer codes and the recent experimental results using rainfall rates from space borne microwave radiometers.

Results of model validations (against *in-situ* data) of boundary-layer moisture are presented, indicating generally good agreement, often to within the absolute calibration accuracy of the measurements. We also present evidence of shortcomings in ECMWF's current humidity analysis, from the operational data assimilation and forecasting system, and from the 40-year reanalysis project (ERA-40). Examples are shown of biases in the data and in the model that lead to biased humidity analyses. Although these biases are relatively small, they contribute to an over-prediction of precipitation in short-range forecasts and a marked spin-down in tropical rainfall.