PRELIMINARY EVALUATION OF VERTICALLY-INTEGRATED FLUXES OF MOISTURE AND ENERGY FROM ERA-40

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The primary set of new diagnostics we have committed to explore are those of the vertically integrated mass, heat and energy, and their fluxes. These allow precipitation minus evaporation to be deduced from the moisture budget, diabatic heating from the heat budget, and the divergence of the atmosphere energy transports, $\nabla \cdot \mathbf{F_A}$, from the energy budget. When the latter is combined with top-of-the-atmosphere radiation, the surface fluxes result as a residual. We have worked with Per Kålberg to implement computation of the relevant quantities as part of the post processing in ERA-40 and include them in the official archive. Preliminary evaluations have been made and adjustments made to the suite of products to make sure that all those desirable are included. There are some remaining issues to be sorted out, however.

These computations are extremely demanding and are not straightforward. Substantial adjustments are required to the energy terms to obtain sensible results by ensuring a balance in the mass budget. For ERA-15 the full resolution data four-times daily on model coordinates are used to obtain the best accuracy possible. With the ERA-40 reanalysis being at T159 resolution and 60 levels, there is interest in how well the results can be replicated with the pressure level archive. Hence we similarly processed all the NCEP and ECMWF pressure level data, which are more readily available and which constitute a much smaller processing task as they are on a 2.5°grid at 17 levels. The products can be compared with the complete results and evaluated to determine the effects of vertical interpolation to the pressure levels and degraded horizontal and vertical resolution on the results. We have also compared some results between ERA-15 and ERA-40 and the differences have led to further in-depth study. To further explore the sources of errors, we developed a post processor of the model level data to recreate the pressure level archive, and thus we have developed the capability to create a pressure level archive at much higher vertical resolution, for instance with pressure layers of 25 mb.

In comparing the ERA-15 and ERA-40, we found that we could not balance the mass budget as accurately in ERA-40. Initially we were working with the vertically integrated fluxes, as supplied by ECMWF. Subsequently, the divergences of the fluxes were also made available. This has not resolved the issues and instead has led to others. In particular, we can not reproduce the divergences from the two components although the pattern of differences is peculiar.

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In addition, in evaluating the results from the pressure archive versus the full model archive from ERA-15, we find that there are discrepancies, especially in polar regions, strongly suggestive of problems in generating the 2.5° pressure archive. Our own results from use of the NCAR post-processor are much closer to the "truth" which is the full model coordinate computation. In addition, we have found considerable benefits in going to a higher vertical resolution in pressure coordinates.

One conclusion is that there is clear evidence that the standard pressure level archive is far too coarse in terms of vertical resolution to resolve the surface and boundary layer adequately. On the other hand, for many purposes, the model coordinate is not suitable and the number of levels is more than required. We suggest that a suitable future pressure archive should contain the following 27 levels (in addition to any other levels above 10 mb): p = 1000, 975, 950, 925, 900, 875, 850, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100, 70, 50, 30, 20 and 10~mb. This increases the resolution to 25 mb below 850 mb, 50 mb through the main troposphere, and includes the 20 mb level in the stratosphere.

After considerable exploration, we conclude that there may be problems in how the postprocessing worked at ECMWF in truncating the fields at T106 and T63, and outputting values on a 2.5 degree grid. This issue has not been resolved, but we suspect that the vector fields are not truncated as a vector, but rather as two scalars.