Recent physics modifications and results with KFB

Eric Bazile[1], D. Banciu, F. Bouyssel, J.F. Geleyn and S. Sbii
Météo-France/CNRM

1. INTRODUCTION

During the last quarter, several modications have been done in the ARPEGE/ALADIN physical package: a reduction of noise in the vertical diffusion due to the shallow convection term, implementation of a new snow scheme, a modification of the partition between resolved and unresolved precipitation and new cloud cover formulation. All those modifications are used in operations since the 15th April 2003. The Bechtold's scheme has been tested in ARPEGE for 13 forecasts of January and in ALADIN on the 8-9 September 2002 flash flood. The snow scheme is the one described in (Bazile et al., 2002).

2. SHALLOW CONVECTION

Following the idea of (Geleyn, 1987), the modification of the Richardson Number ($R_i^* = R_i + R_i^{shallow}$) is supposed to take into account the enhanced vertical exchange at the top of the PBL with a shallow cumulus.

$$R_i^{shallow} = \frac{g}{C_p T} L \frac{min(0., \frac{\partial (q - q_{sat})}{\partial z})}{(\frac{\partial u}{\partial z})^2}$$

For 4 years ago, it is known that the scheme has a tendency to an on/off behaviour from one time step to the next. Recently, in 1D experiment, it was discovered an increasing of noise with a decrease of the time step ! In fact, the scheme mixes the water vapour in one time step whatever its value (Fig: 1). The modification consists to compute a new exchange coefficient K^* following the philosophy of the anti-fibrillation scheme (Bénard et al., 2000):

$$K^* = K_0 + \frac{K - K_0}{1 + (\beta - 1)(K - K_0)\delta t}$$

where K_0 is the exchange coefficient computed without the shallow convection correction. The β coefficient takes into account the saturation vertical gradient at the departure and after the mixing.

3. CONVECTION AND RESOLVED PRECIPITATION

The convection scheme uses a moisture convergence (CVGQ) closure: $CVGQ = -R(\vec{u}\vec{\nabla}q + \omega\frac{\partial q}{\partial P}) - g\frac{\partial J_q}{\partial P}$ with J_q the vertical diffusion flux and R a correcting factor to take into account the local resolution. R was introduced in 1995 in ARPEGE/ALADIN

[1] *Corresponding author address*: E. Bazile Météo-France, CNRM/GMAP 42 Av. Coriolis, 31057 Toulouse Cédex, France tel : (33) (0)5 61 07 84 68 - fax : (33) (0)5 61 07 84 53 email: eric.bazile@meteo.fr

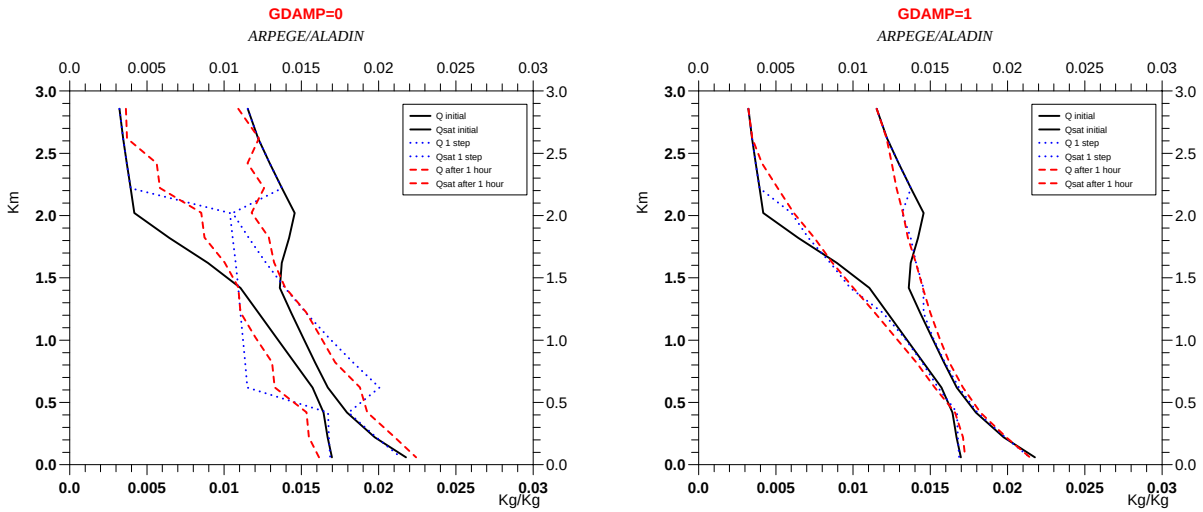

Figure 1: 1D simulation starting from the BOMEX case. Only the vertical diffusion. Black line: q and q_{sat}. Dotted line: the same but after one time step. Dashed line: the same after 4 time step. Left:Before. Right: After the modification.

to reduce the convective part when the resolution increases. In October 1999, we have added the large scale tendency to reduce automaticaly the CVGQ with the increase of the resolved precipitation and set $R = 1$: $CVGQ = -R(\vec{u}\vec{\nabla}q + \omega\frac{\partial q}{\partial P}) - g\frac{\partial J_q}{\partial P} - g\frac{\partial P_{ls}}{\partial P}$

But recently, a detailed study has shown that the evaporation of the large scale rain below the cloud can promote the convective activity with a less vertical extension of the cloud (Fig: 2). Consequently, 4 years after we take back on the modification made in 1999.

4. CLOUD COVER FORMULATION

During the winter, in stable condition with low clouds or fog, ARPEGE/ALADIN models have a tendency to underestimate the cloud cover even if the vertical profile of humidity is well predicted. Furthermore, the cloud cover zonal mean shows a general deficiency of clouds in particular for the maritime anticyclonic area compared to the climatological data or to the ARPEGE-CLIMATE version. With the cloud cover formulation proposed by Xu and Randall (2000) with a new tuning of the parameters, we improved significantly the zonal mean of clouds, but also the forecast of low clouds. On a 1D profile, extracted from the 3D model, in the tropics the time evolution of the shallow cumulus is more reasonable with a better top of the cloud (Fig: 3).

5. PRELIMINARY RESULTS WITH THE KFB SCHEME

The (Bechtold et al., 2001) scheme has been tested in ARPEGE (without 4DVAR assimilation) on the thirteen first days of January 2003. Only the deep convection was tested, because the shallow version crashes several time. The performance has been evaluated against the sounding data (Fig: 4). The scores are slightly worse (red or dotted line) but the sign of the bais changes significantly and that suggests a new experiment with a 4DVAR assimilation.

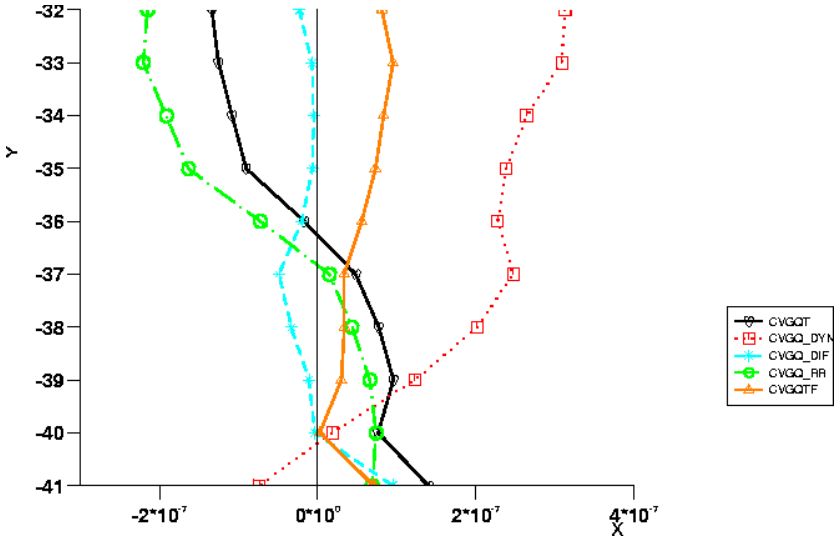

Figure 2: Vertical profil of the various term for the moisture convergence: CVGQ_RR: large scale rain contribution, CVGQ_DYN: dynamical part, CVGQ_DIF: vertical diffusion term, CVGQTF: R*CVGQ_DYN + CVGQ_DIF and CVGQT: CVGQTF + CVGQ_RR.

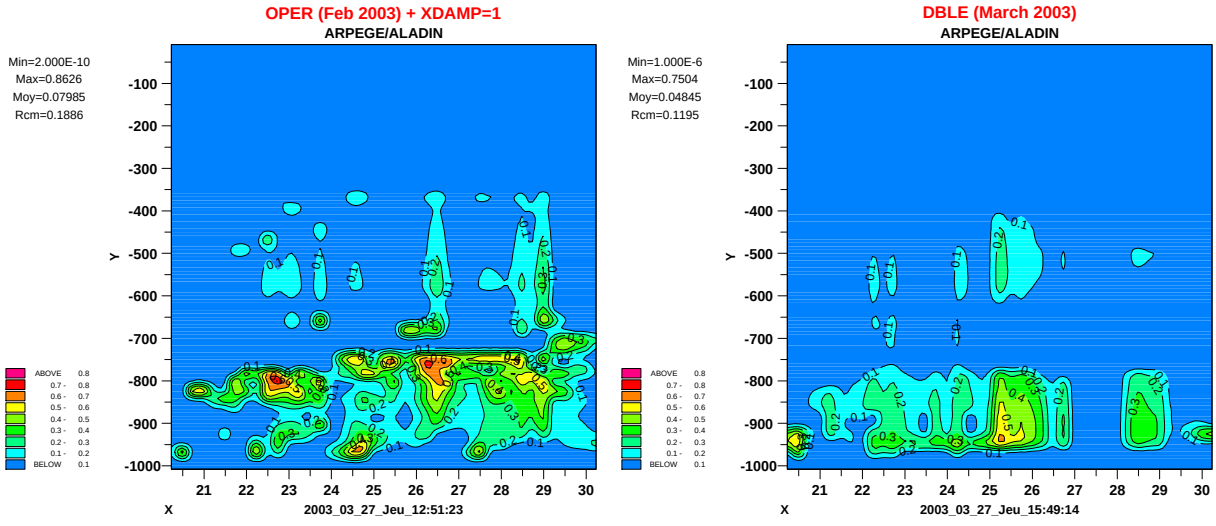

Figure 3: 12 hour forecast. Left: old cloud cover formulation, right: new formulation

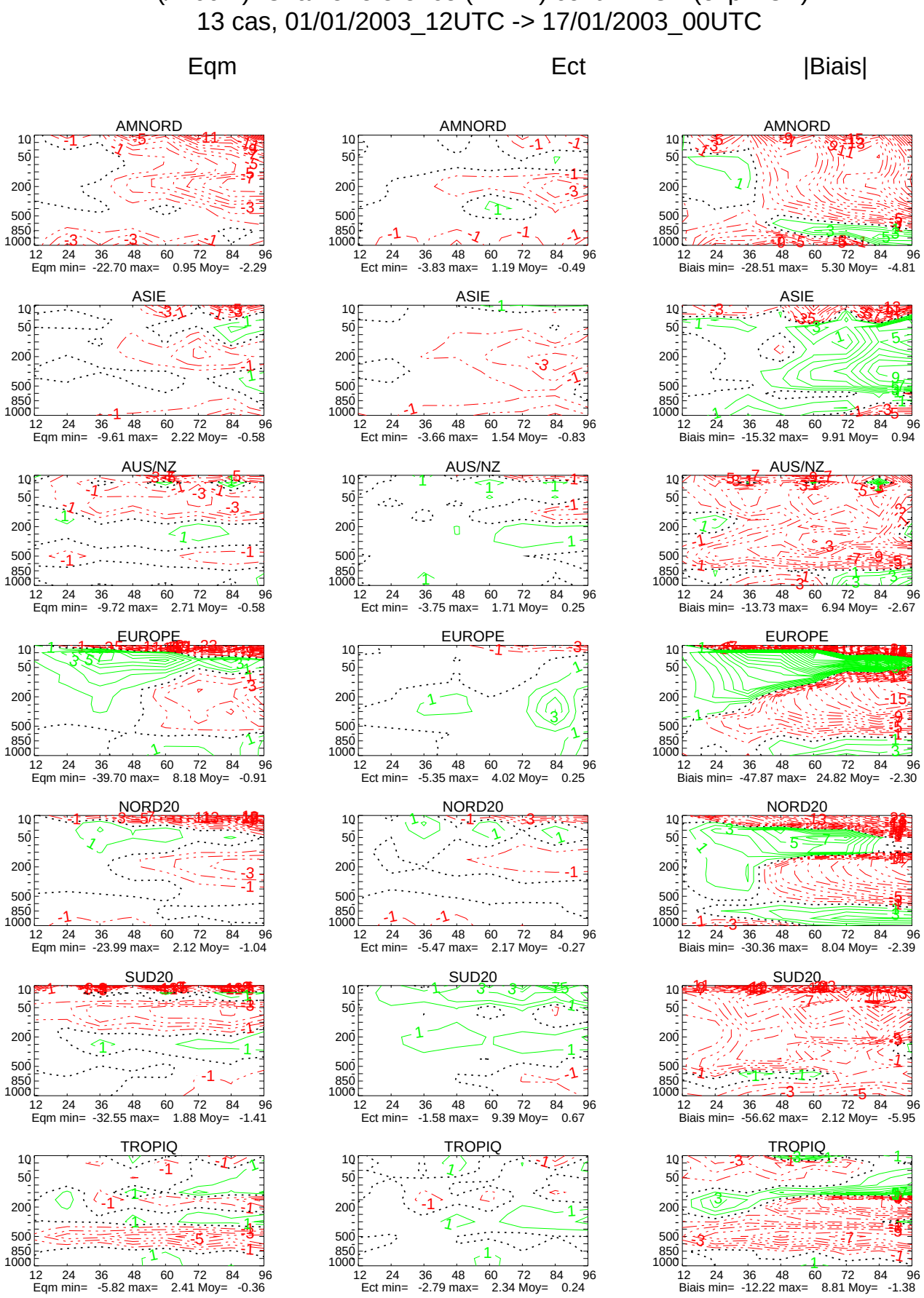

Figure 4: Difference of score against TEMP, full line or green: KFB better, red line or dashed: KFB worse

In ALADIN, the scheme has been compared on the flash flood occured the 8-9 September 2002 in the south of France. The maximum of rain with KFB is 144mm, 222mm for the reference and around 750mm according to the radar observation (the localization of the maximum does not change). A positive impact with the KFB scheme is the reduction of the area with small precipitation and, a negative one is the missing, over the Mediterranean sea, of a convective cell very active.

In ARPEGE the increase of the time computation is arround 19% and for ALADIN about +47%.

6. CONCLUSIONS

The new physical package (the new shallow convection formulation, the snow scheme, the cloud cover and the partition between the resolved and the un-resolved precipitation) improves significantly the cloud evolution and the low cloud forecast, reduces the "noise" and the relative humidity in the tropics (not shown). Concerning the KFB scheme, a 4DVAR experiment could be very relevant to estimate correctly the potential of the scheme in the global model, and in ALADIN the study of more severe events is really essential to be able to conclude correctly.

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