Further tests with 3D-FGAT in ALADIN analysis

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1 Introduction

The experiments described in this report can be seen as a sequel of those presented in the "3D-FGAT in ALADIN analysis" (stay report, May-June 2004). In the previous work, the results obtained from single-obs experiments (e.g. 2m temperature at one time slot) revealed that the values of the analysis increments issued from 3D-FGAT were larger than those from 3D-VAR. This feature was considered to be carefully investigated in the forthcoming validation.

The tests performed during the phasing stay are designed to answer to the folowing questions:

1) why for a single observation experiment the 3D-FGAT analysis increments are larger than those issued by 3DVAR ?

2) do the upper-air analysis increments from a single observation experiment have the same feature as for the surface increments, i.e. are they significantly greater when computed with 3D-FGAT?

3) which is the CPU cost of a full observation 3D-FGAT analysis if compared with 3D-VAR?

This work is based on cycle CY28T3_CY29 of ARPEGE/Aladin.

2 Experimental framework

The domains employed in the further described experiments are the same as those used in the previous work:

- a so-called FrSud domain (64x64x41, linear truncation 31) nested into the operational Aladin-France;

- the operational Aladin/France (300x300x41, linear truncation 149).

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2.1 Single observation experiments

In this section, two types of single observation experiments are discussed: TEMP and SYNOP. Both are performed using the **FrSud** domain as a test bed. The aim is to create an analysis by using 3DVAR and 3DFGAT and to compare the resulting analysis increments. In our experiments the date chosen for creating the analysis is 00 UTC 12 May 2004. In this respect, the needed ingredients are a background file and an observation. In 3DVAR the background is the +6h forecast (P6) taken from a previous Aladin forecast which was integrated starting from the initial data valid at 18 UTC 11 May 2004. During the integration (hereafter refered as the reference forecast), one obtains forecasted fields at +3, +6 and +9 hours range respectively. The +3h (P3) and +9h (P9) as well as P6 forecasts are further necessary in 3DFGAT analysis.

In the so-called TEMP experiment (see Table 1), the observation is the 500 hPa temperature located in the middle of the domain (latitude $44^o30'$ N, longitude 1^o E). The difference between the observation and the reference forecasted temperature is chosen to be $1K$. As illustrated in Fig.1, panels (a) and (b), when introducing the observation at one time slot (00 UTC), the values of the analysis increments at model level 21 ($\sim$500hPa) obtained with 3DVAR and 3DFGAT are identical. However, the identity is not retrieved on other model levels. On some levels, the increments are found to be slightly but not significantly different. For example, on the model level 20 (not shown) the increments obtained with 3DFGAT are 0.1K greater than those issued by 3DVAR.

Next, the 3DFGAT analysis is performed with the observations available at 3 time slots, at 21, 22 and 00 UTC respectively. The analysis increments for model level 21 are plotted in Fig.1c for comparison with those illustrated in the panels (a) and (b). The results obtained for the upper-air atmosphere show that the 3DVAR and 3DFGAT increments have isotropic patterns while their maximum values are about the same.

In the SYNOP experiments, a 2m temperature is used as the observation first at one time slot (00 UTC) and then at 6 time slots. The single observation analysis increments issued from 3DVAR and 3DFGAT are shown in Fig.2a-b. In both panels (a) and (b) the increments have an isotropic pattern although their maximum values are different. That difference in magnitude is due to the fact that the background fields are not the same in 3DVAR and 3DFGAT. Whereas in 3DVAR the background is the P6 issued from the reference integration, 3DFGAT uses references P3, P6 and P9 files for coupling, creating its own background during the integration process. Also the physical parametrizations used in 3DFGAT are different than in employed in the reference forecast since in the analysis proccess the old radiation scheme (LRAY=.T., LRAYFM15=.F.)

was used. Thus, the difference between the analysis increments, illustrated in Fig.2a-b, can be related to the stronger influence of the physical processes near the surface than in the free atmosphere. Actually, it was found that the reason why the results obtained in the previous tests (May-June 2004) were so different between 3DVAR and 3DFGAT regarding the increments were owing to the different physical parameterization used in the reference forecast and in the assimilation. Indeed, one shortcoming in the previous designed set of experiments was that while the reference forecast was created with cy26t1 in the analysis cycle the cy28t1 was used. However, the new SYNOP experiments emphasize once again a significat difference between the increments obtained with 3DVAR and 3DFGAT when the observations are introduced at 6 time slots. The usage of a different background and physical parametrization during the analysis may explain why near the surface the analysis increments have greater magnitudes in one analysis type than in another but it cannot explain the unisotropic pattern shown in Fig.2c. Its origin should be further investigated.

2.2 Technical notes - CPU cost

For assessing the CPU cost in 3DFGAT, a complete set of observations (including synop, temp, airep, satob, radiances etc) were taken into account when creating the analysis. The operational Aladin-France domain was employed in the tests. The results obtained for screening and minimization were compared with their equivalent from 3DVAR (see the Annex). During the analysis, 6 processors were used.

As a summary, 3DFGAT minimization is about 8 times more costly in terms of CPU than 3DVAR, while it might be of about 1.3 times more expensive in terms of memory, provided that the trajectory is saved hourly, that is tstep_traj is a multiple of tstep. In our tests, tstep_traj=3600s whereas tstep=400s. After investigations, it was reavealed that the significat difference in CPU is mainly due to the call of the physical parametrizations routines, especially acraneb (under LRAY=T switch). There is a hope that by using the new radiation scheme under LRAYFM15=.T., the CPU might decrease since the scheme can be employed hourly, although the usage of the new radiation scheme in ARPEGE was found to be more costly than the old one (Y. Bouteloup personal communication).

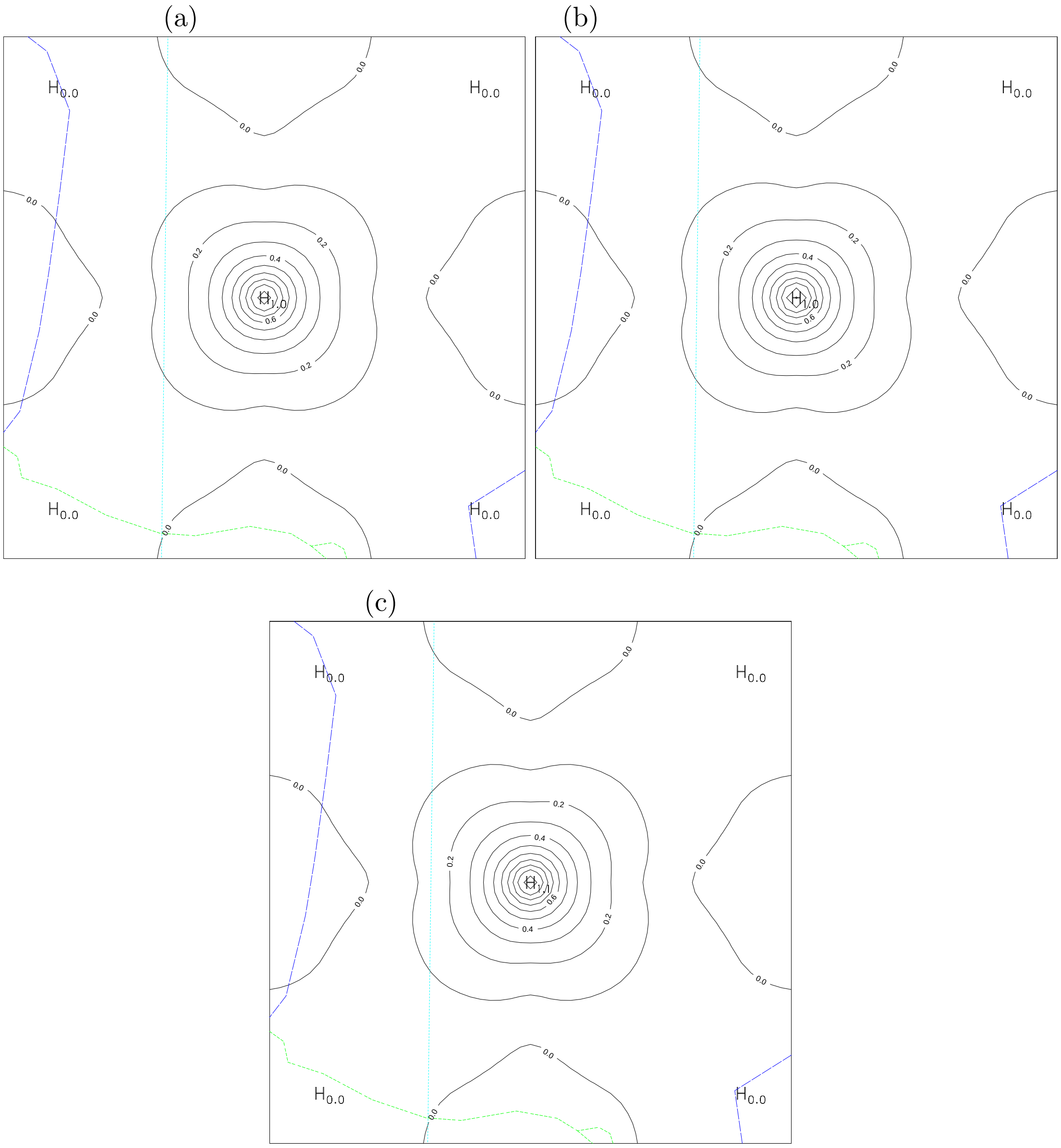

Figure 1: Temperature increments at model level 21 ($\sim$500hPa) issued from a single-obs experiment (a) 3DVAR (exp label a000/TEMP in Table 1), (b) 3DFGAT, experiment labelled a001/TEMP (see Table 1), (c) 3DFGAT, exp labelled a012/TEMP 1. Contour isolines every 0.1K.

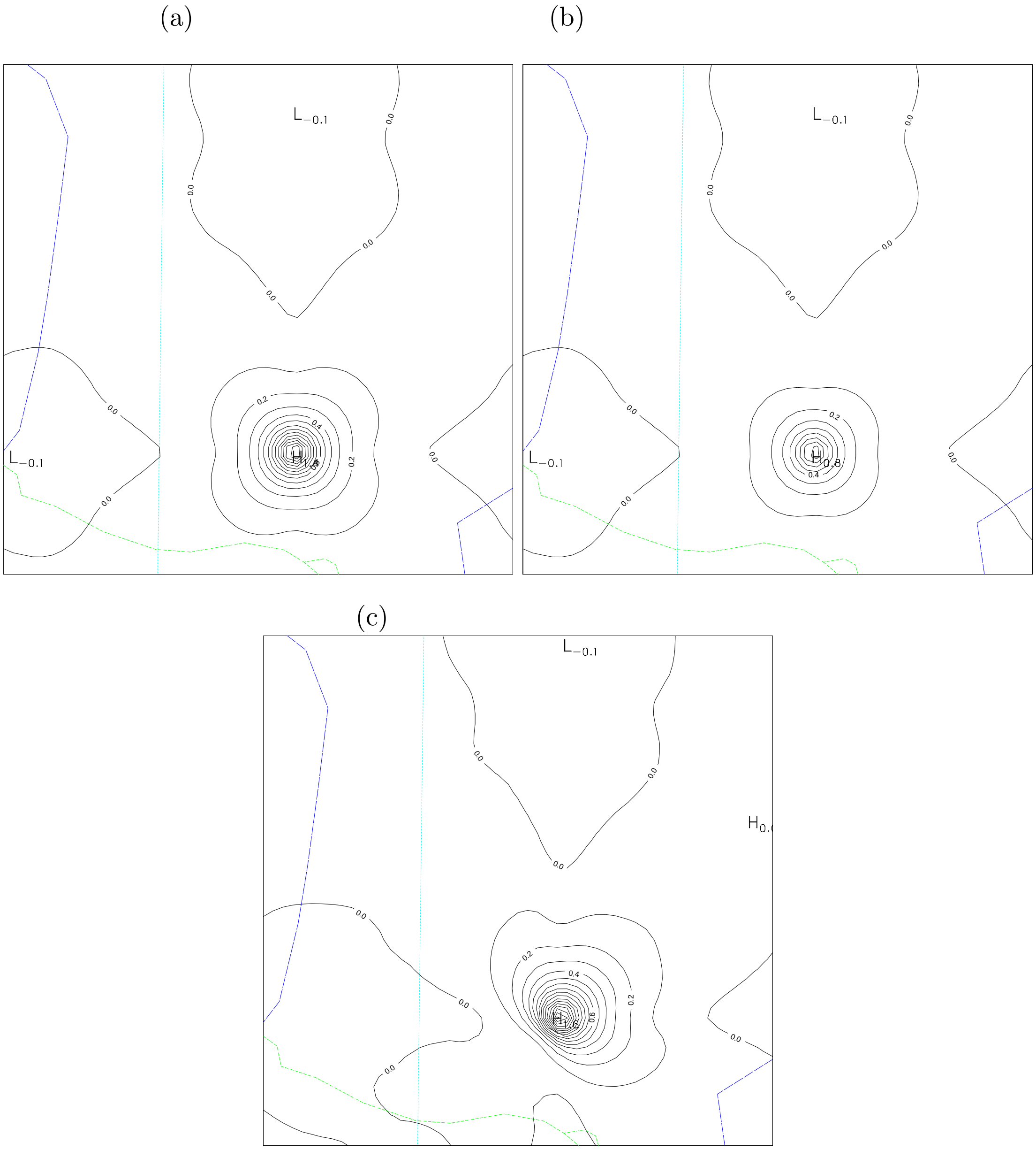

Figure 2: Temperature increments at model level 41 issued from SYNOP experiments (a) 3DVAR (label a004 in Table 1), (b) 3DFGAT (label a005 (Table 1), and (c) 3DFGAT (label a006 in Table 1). Contour isolines every 0.1K.

Table 1: Description of the TEMP and SYNOP experiments.

Experiment label	Analysis type	
a000/TEMP	3DVAR	single-obs; T at 500 hPa; 1 time slot (00 UTC)
a001/TEMP	3DFGAT	Idem
a012/TEMP	3DFGAT	single-obs; T at 500 hPa; 3 time slots (21, 22 and 00 UTC)
a004/SYNOP	3DVAR	single-obs; T2m; 1 time slot (00 UTC)
a005/SYNOP	3DFGAT	idem
a006/SYNOP	3DFGAT	single-obs; T2m; 6 time slots (21-02 UTC)

3 ANNEX

```
  Screening 3D  -- RUN INFORMATIONS
 ==================================

 Binary File was <./MASTER> on processor 0 [1]

  Hits %Total %Vector %Mixed %Scalar %Unknow Vlen %Cumul Subroutine
------------------------------------------------------------------------------
    58   11.4    27.6    0.0    72.4     0.0    0   11.4 suadvar_
    38    7.5   100.0    0.0     0.0     0.0  172   18.8 rttov_transmit_
    25    4.9     0.0    0.0   100.0     0.0    0   23.7 redrp_no_sq_
    24    4.7     0.0    0.0   100.0     0.0    0   28.4 rttov_readcoeffs_ascii_
    18    3.5     0.0    0.0     0.0   100.0    0   32.0 _VPP_NodesReady
    18    3.5    22.2    0.0    77.8     0.0 1536   35.5 eggpack.makdo_
    15    2.9   100.0    0.0     0.0     0.0  889   38.4 rpassf_
    14    2.7     0.0    0.0   100.0     0.0    0   41.2 posnam_
    13    2.5    92.3    0.0    15.4    -7.7 1767   43.7 rsort32_
    12    2.4    75.0    0.0    25.0     0.0 1366   46.1 espareord_
------------------------------------------------------------------------------

VP Usage Report
===================
ID PEID T System CPU(Vector)    User CPU(Vector)       Total CPU   MEM I/O Chars
== ==== = ================== ======================== =========== ==== =========
 0  5.2 s       8.911( 0.00)     151.341(     82.337)     160.253 1920  1324573k
 1  6.2 s       2.220( 0.00)     144.692(     80.509)     146.913 1920 84052181
 2  7.2 s       2.229( 0.00)     144.262(     80.622)     146.491 1920 86623878
 3  9.2 s       2.274( 0.00)     145.428(     80.772)     147.702 1920 86028686
 4  b.2 s       2.163( 0.00)     143.883(     80.841)     146.047 1920 85809556
 5 10.2 s       2.246( 0.00)     149.419(     84.710)     151.665 1920 83895888
```

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  Screening 4D  -- RUN INFORMATIONS
  =================================

 Binary File was <./MASTER> on processor 0 [1]

  Hits %Total %Vector %Mixed %Scalar %Unknow Vlen %Cumul Subroutine
------------------------------------------------------------------------------
  1167   12.0    96.8    0.0     3.2     0.0  913   12.0 acraneb_
   814    8.4    99.9    0.0     0.1     0.0  132   20.4 accoefk_
   809    8.3    97.2    0.0     2.8     0.0  563   28.8 accvimp_
   575    5.9    95.0    0.0     5.0     0.0  547   34.7 accvimpd_
   433    4.5    97.7    0.0     2.3     0.0  806   39.2 rpassf_
   369    3.8   100.0    0.0     0.0     0.0  250   43.0 laitqmh_
   296    3.1    59.5    6.4    34.1     0.0   19   46.1 dluiv_
   242    2.5    99.2    0.0     0.8     0.0  773   48.6 acnebn_
   227    2.3   100.0    0.0     0.0     0.0  614   50.9 actqsat_
   226    2.3    75.2    0.0    24.8     0.0  843   53.2 acdrag_
   ---
    53    0.5    24.5    0.0    75.5     0.0    0   81.8 suadvar_
------------------------------------------------------------------------------

VP Usage Report
===================
ID PEID T System CPU(Vector)    User CPU(Vector)       Total CPU   MEM I/O Chars
== ==== = ================== ======================== =========== ==== =========
 0  1.2 s       6.267( 0.00)      52.534(      1.484)      58.802 1408   277959k
 1  a.2 s       0.932( 0.00)      51.583(      1.495)      52.515 1376 35040896
 2  d.2 s       0.862( 0.00)      51.218(      1.531)      52.080 1376 37694020
 3  f.2 s       0.853( 0.00)      50.970(      1.604)      51.823 1376 37150278
 4 10.2 s       0.793( 0.00)      50.892(      1.563)      51.685 1376 37053650
 5 16.2 s       0.682( 0.00)      51.001(      1.508)      51.684 1408 34709914

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```

```
  Minim 3DVAR  -- RUN INFORMATIONS
  =================================

 Binary File was <./MASTER> on processor 0 [1]

  Hits %Total %Vector %Mixed %Scalar %Unknow Vlen %Cumul Subroutine
------------------------------------------------------------------------------
    58   11.4    27.6    0.0    72.4     0.0    0   11.4 suadvar_
    38    7.5   100.0    0.0     0.0     0.0  172   18.8 rttov_transmit_
    25    4.9     0.0    0.0   100.0     0.0    0   23.7 redrp_no_sq_
    24    4.7     0.0    0.0   100.0     0.0    0   28.4 rttov_readcoeffs_ascii_
    18    3.5     0.0    0.0     0.0   100.0    0   32.0 _VPP_NodesReady
    18    3.5    22.2    0.0    77.8     0.0 1536   35.5 eggpack.makdo_
    15    2.9   100.0    0.0     0.0     0.0  889   38.4 rpassf_
    14    2.7     0.0    0.0   100.0     0.0    0   41.2 posnam_
    13    2.5    92.3    0.0    15.4    -7.7 1767   43.7 rsort32_
    12    2.4    75.0    0.0    25.0     0.0 1366   46.1 espareord_
------------------------------------------------------------------------------
```

```
VP Usage Report
===================
ID PEID T System CPU(Vector)    User CPU(Vector)       Total CPU   MEM I/O Chars
== ==== = ================== ======================== =========== ==== =========
 0  1.2 s      13.300( 0.00)     272.194(     99.791)     285.495 1984   772201k
 1  a.2 s       3.149( 0.00)     264.396(     99.895)     267.545 1984 89183611
 2  d.2 s       3.169( 0.00)     264.239(     99.810)     267.409 1984 96696525
 3  f.2 s       3.068( 0.00)     263.426(    100.107)     266.494 1984 96141879
 4 10.2 s       2.967( 0.00)     262.861(     99.635)     265.828 1984 95989007
 5 16.2 s       2.715( 0.00)     261.151(     98.782)     263.866 2016 88983961
```

```
   Minim 3DFGAT -- RUN INFORMATIONS
   ================================

 Binary File was <./MASTER> on processor 0 [1]

  Hits %Total %Vector %Mixed %Scalar %Unknow Vlen %Cumul Subroutine
------------------------------------------------------------------------------
  1167   12.0    96.8    0.0     3.2     0.0  913   12.0 acraneb_
   814    8.4    99.9    0.0     0.1     0.0  132   20.4 accoefk_
   809    8.3    97.2    0.0     2.8     0.0  563   28.8 accvimp_
   575    5.9    95.0    0.0     5.0     0.0  547   34.7 accvimpd_
   433    4.5    97.7    0.0     2.3     0.0  806   39.2 rpassf_
   369    3.8   100.0    0.0     0.0     0.0  250   43.0 laitqmh_
   296    3.1    59.5    6.4    34.1     0.0   19   46.1 dluiv_
   242    2.5    99.2    0.0     0.8     0.0  773   48.6 acnebn_
   227    2.3   100.0    0.0     0.0     0.0  614   50.9 actqsat_
   226    2.3    75.2    0.0    24.8     0.0  843   53.2 acdrag_
    ---
    53    0.5    24.5    0.0    75.5     0.0    0   81.8 suadvar_
------------------------------------------------------------------------------
```

```
VP Usage Report
===================
ID PEID T System CPU(Vector)    User CPU(Vector)       Total CPU   MEM I/O Chars
== ==== = ================== ======================== =========== ==== =========
 0  5.2 s      40.942( 0.00)    1920.196(   1271.383)    1961.138 2496  2428868k
 1  6.2 s      20.332( 0.00)    1861.886(   1270.627)    1882.219 2464   152585k
 2  7.2 s      20.283( 0.00)    1848.524(   1268.965)    1868.807 2464   155441k
 3  9.2 s      20.637( 0.00)    1924.152(   1277.442)    1944.790 2464   154261k
 4  b.2 s      19.819( 0.00)    1850.011(   1275.141)    1869.831 2464   152498k
 5 10.2 s      20.531( 0.00)    1922.634(   1280.337)    1943.165 2496   153884k
```