

Experiments with the ALADIN 3D-FGAT system

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Incremental 3D-FGAT in ALADIN

First guess at appropriate time

3D-FGAT is a simplification of 4D-VAR by setting the TL and AD model operators to the identity ($\mathbf{M}=\mathbf{M}^T=\mathbf{I}$)

The innovation vector is computed the same way as in 4D-VAR along the background trajectory. This is a main advantage over 3D-VAR

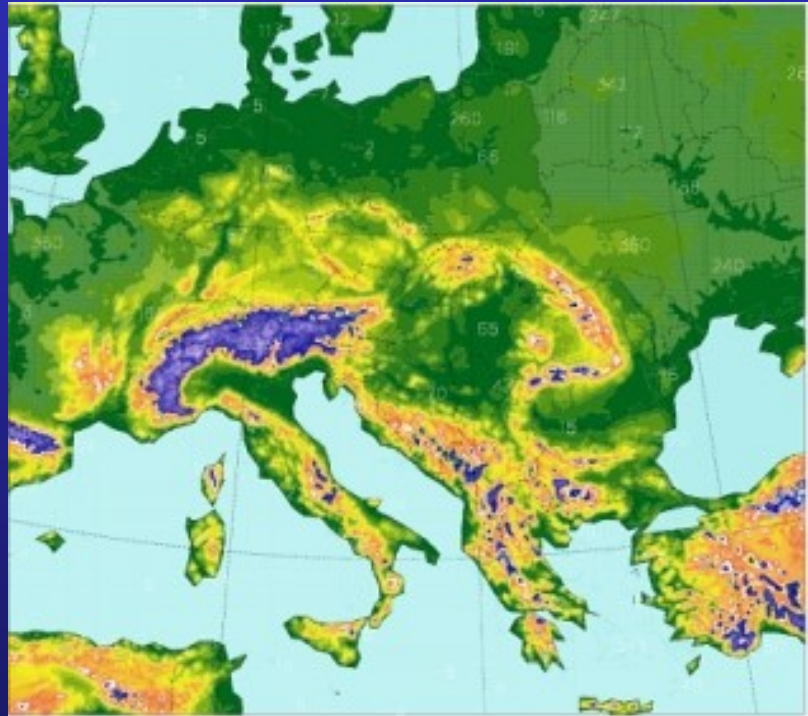
$$J(\delta x) = \delta x^T B^{-1} \delta x + \sum_{i=1}^n (d_i - H_i \delta x)^T R_{i-1}^{-1} (d_i - H_i \delta x)$$

$d_i = y_i - H(M_i(x_b))$

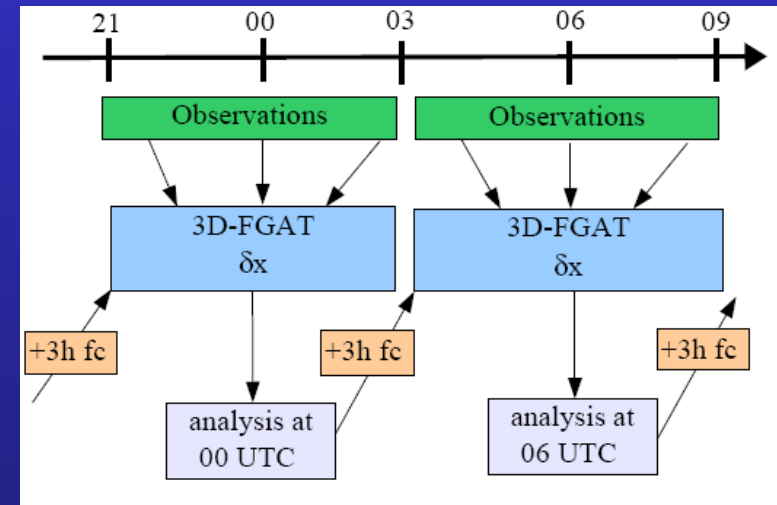
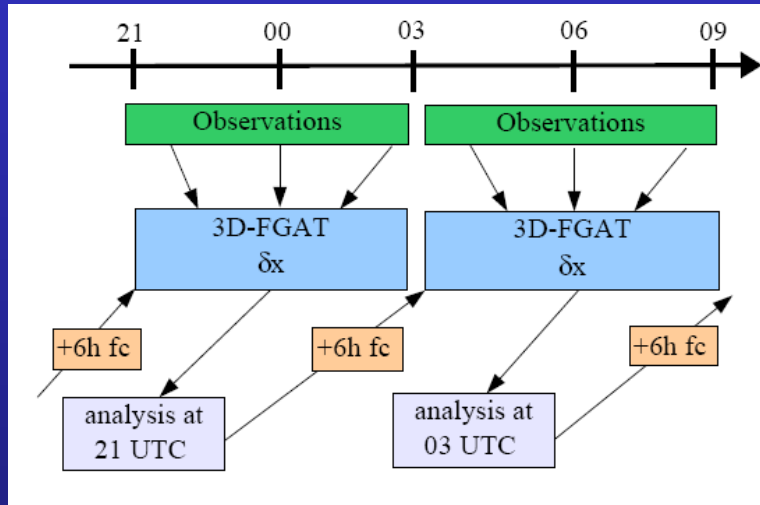
The increment in J_0 is not propagated in time with the TL. It is „static”, without having temporal information
disadvantage over 4D-VAR

Experiment set-up

- Model version: AL28T3
- Domain: 12km, 37 levels
- Period: 4-21 May, 2005
- Warm-up period: 4 days
- 48 h forecasts at 00 and 12 UTC
- 6h analysis cycling
- 7 timeslots in 3D-FGAT
- Observations available at the analysis time except AIREP and satellite radiance data



Position of the increment



Default settings:

Increment added at the beginning of the observation window (hard-coded in the model)

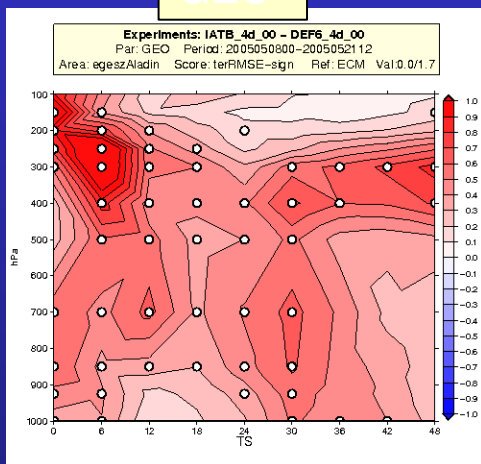
For a 48h forecast from 00 UTC a 51h integration is needed!

Modified set-up:

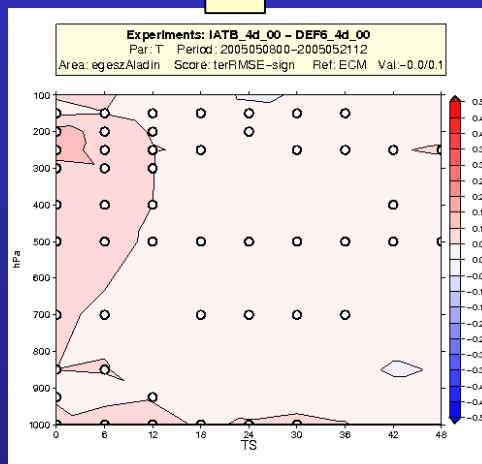
Increment is shifted by 3h to the middle of the observation window

Position of the increment

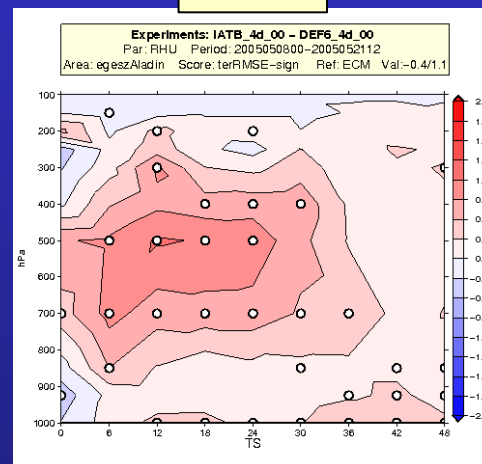
GEO



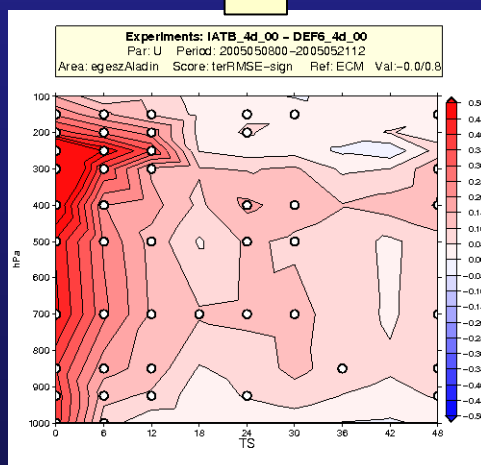
T



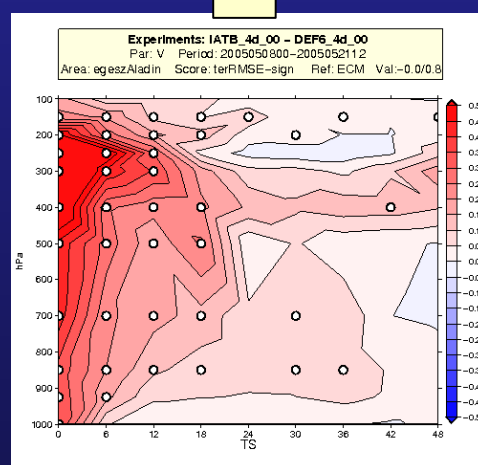
RHU



U



V



00 UTC scores:

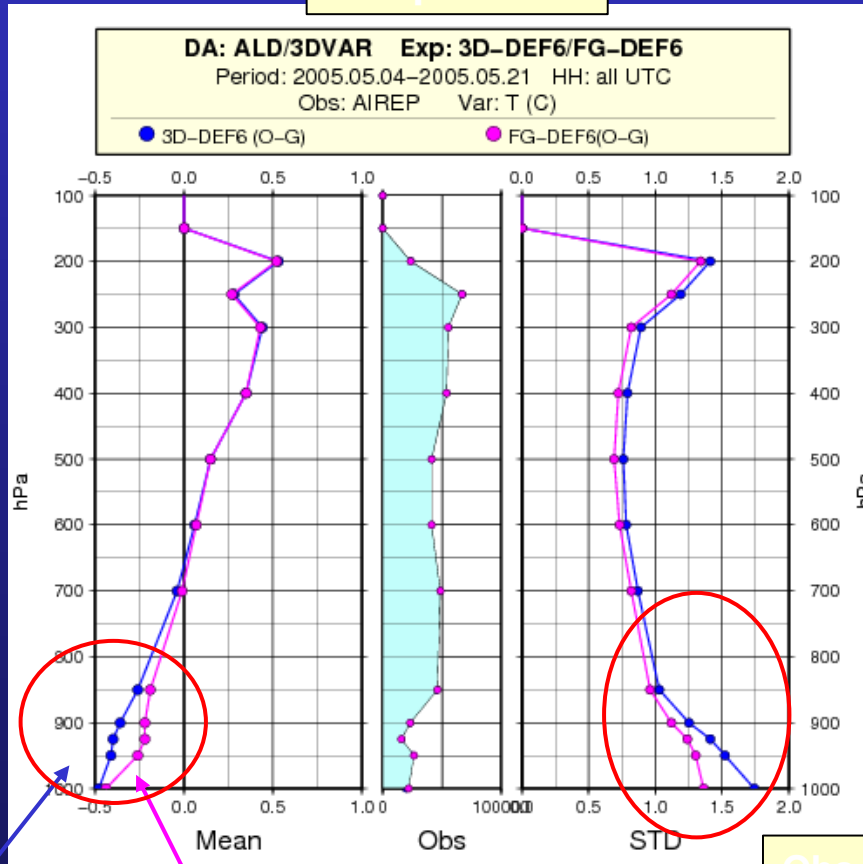
RMSE differences.
Verification against ECMWF
analyses. Red shades
indicate that increment shift is
better.

Comparison with 3D-VAR

- Only the handling of AIREP and satellite radiance data is different in the applied 3D-VAR and 3D-FGAT systems
- 3 configuration for both 3D-VAR and 3D-FGAT
 - AIRN: no AIREP was used (impact of satellite radiances)
 - AIR-1: AIREP data was used with a ± 1 h window
 - AIR-all: AIREP data was used with a ± 3 h window (all data was used!)
- The cycling in 3D-VAR and 3D-FGAT was started from the same background

3D-VAR/3D-FGAT: AIREP statistics

Temperature



- For experiment AIR-all (using all AIREPS)
 - Observations are closer to the background in 3D-FGAT for T, U and V
 - Both mean and STD of departures are smaller
 - By 5% less AIREP data rejected in 3D-FGAT

3D-VAR

3D-FGAT

Obs-Bg departures for all the analysis dates for the whole period

3D-VAR/3D-FGAT: Satellite radiance statistics

T_b statistics for all the analysis dates
for the whole period

	Rejected data	Obs-Bg Mean		Obs-Bg STD	
		3D-VAR	3DFGAT	3D-VAR	3DFGAT
NOAA15 AMSU-A	-1.3%	-0.05	-0.12	0.37	0.34
NOAA16 AMSU-A	-0.3%	-0.13	0.22	0.35	0.36
NOAA16 AMSU-B	-0.9%	0.04	0.01	2.95	2.89
NOAA17 AMSU-B	+0.02%	-0.49	-0.7	2.96	2.81

A slightly less observations are rejected in 3D-FGAT

The departure mean is mostly smaller in 3D-VAR

The departure STD is mostly smaller in 3D-FGAT

The possible reason: the bias correction coefficients were computed by 3D-VAR using wrong timing information!

3D-VAR/3D-FGAT: Verification results

- The overall differences are rather small
- Very small differences on the surface (verification against SYNOP + subjective evaluation)
- A bit larger differences in the upper air parameters for the 00 UTC runs, while little impact was found in the 12 UTC runs

3D-VAR/3D-FGAT: V

No-AIR

AIR-1

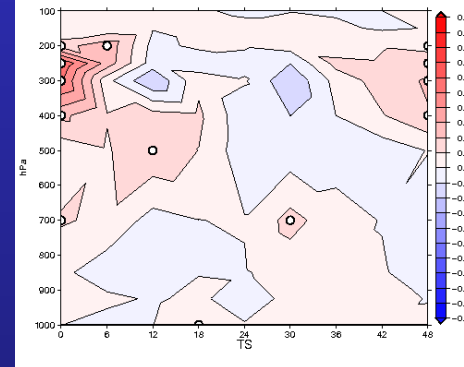
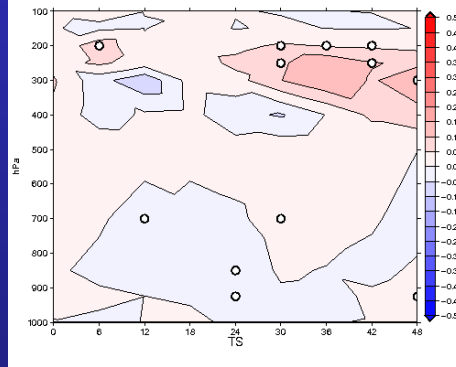
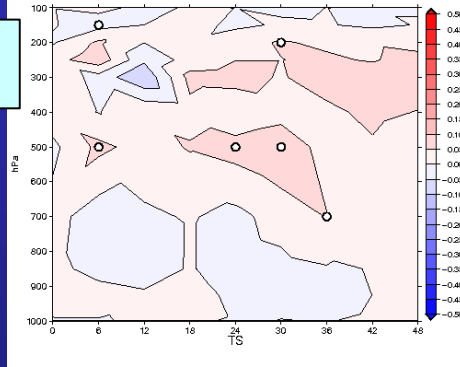
AIR-all

Experiments: AIRN_3d_00 - AIRN_4d_00
Par: V Period: 2005050800-2005052112
Area: egeszAladin Score: terRMSE-sign Ref: ECM Val: -0.1/0.1

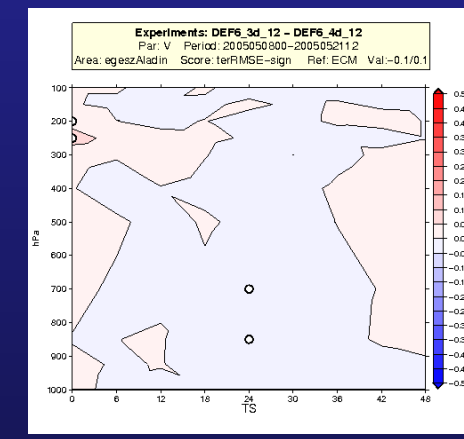
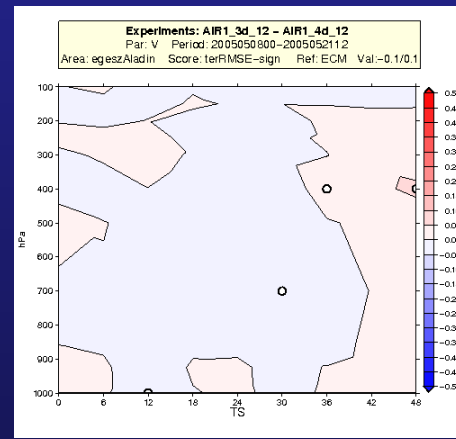
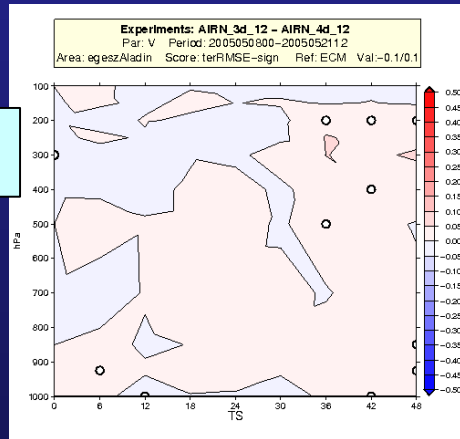
Experiments: AIR1_3d_00 - AIR1_4d_00
Par: V Period: 2005050800-2005052112
Area: egeszAladin Score: terRMSE-sign Ref: ECM Val: -0.1/0.1

Experiments: DEF6_3d_00 - DEF6_4d_00
Par: V Period: 2005050800-2005052112
Area: egeszAladin Score: terRMSE-sign Ref: ECM Val: -0.1/0.3

00 UTC



12 UTC

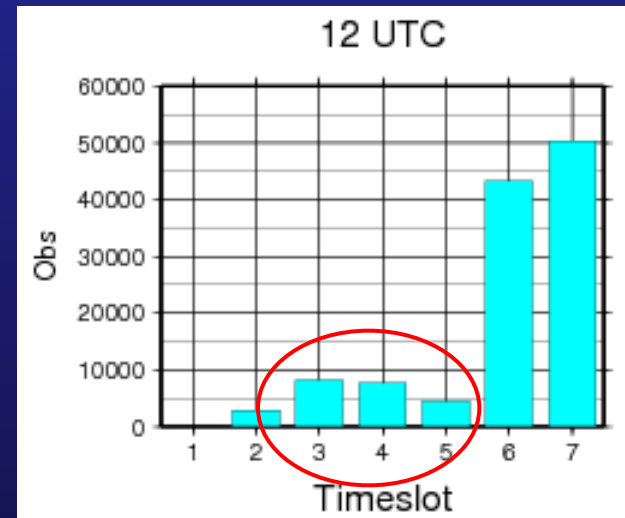
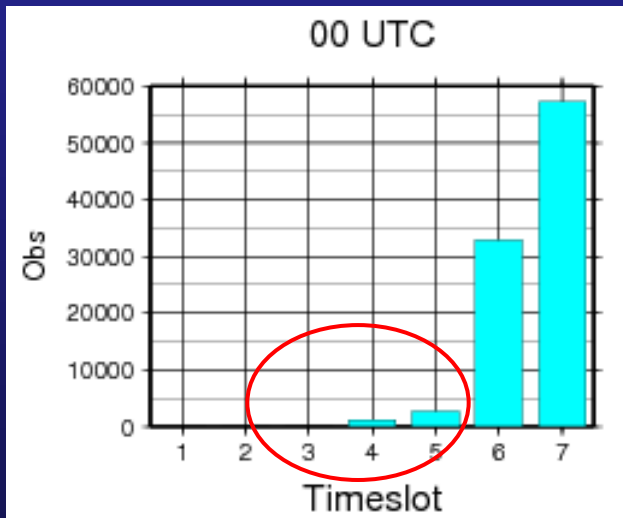


RMSE differences. Verification against ECMWF analyses. Red shades indicate that FGAT is better

Small differences: between -0.1 and +0.3

3D-VAR/3D-FGAT: Why do they differ only at 00 UTC?

- There is little difference at 12 UTC even if AIREPs are not used at all
- The impact of satellite radiances
- The temporal distribution of satellite radiance data differs at 00 and 12 UTC
- At 12 UTC there are more data closer to the observation time, 3D-FGAT is closer to 3D-VAR



3D-VAR/3D-FGAT: Why do they differ only at 00 UTC?

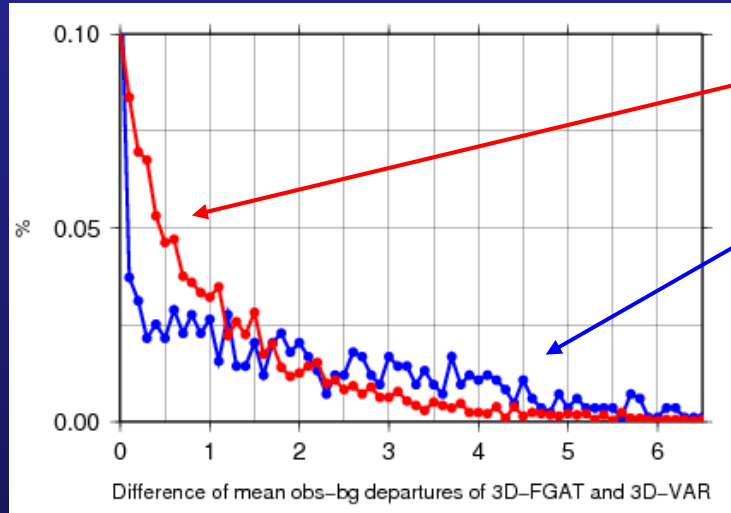
- Several AIREP observations nearly at the same location but with different times
- Simplified approach: let's suppose there is only one observation location with n observations of the same type
 - the resulting analysis increment in 3D-VAR and 3D-FGAT:

$$(\delta \mathbf{x})_k = \frac{\sigma_{bk}^2}{\frac{\sigma_o^2}{n} + \sigma_{bk}^2} \frac{1}{n} \sum_{i=1}^n d_i$$

- the analysis increment is directly related to the mean innovation (background departure)
- 3D-FGAT differs from 3D-VAR if this mean is different

3D-VAR/3D-FGAT: Why do they differ only at 00 UTC?

- Testing 00 UTC and 12 UTC AIREP usage
 - Boxes with the size of $\sim 2\text{km} \times 2\text{km} \times 10\text{hPa}$
 - For each box the mean of the innovations are computed both for 3D-FGAT (M_{fg}) and 3D-VAR (M_{3d})
 - Then the absolute value of the $M_{fg} - M_{3d}$ difference is computed



Relative frequency

12 UTC

00 UTC

Larger departure between innovation means at 00 UTC

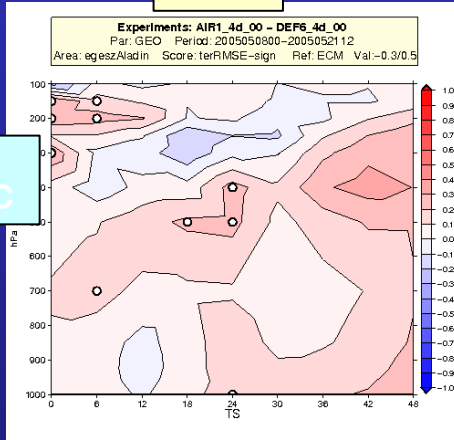
Abs ($M_{fg} - M_{3d}$) for V

The difference is larger between the two analysis system at 00 UTC

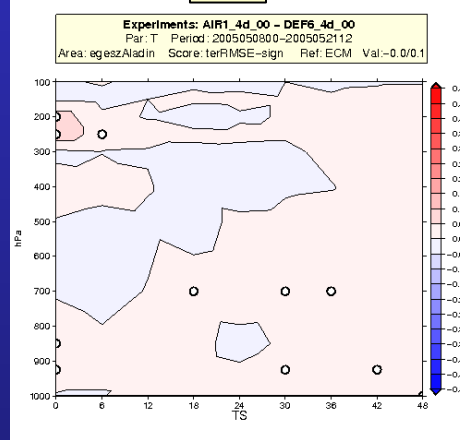
AIREP usage in 3D-FGAT

AIR-all vs. AIR-1

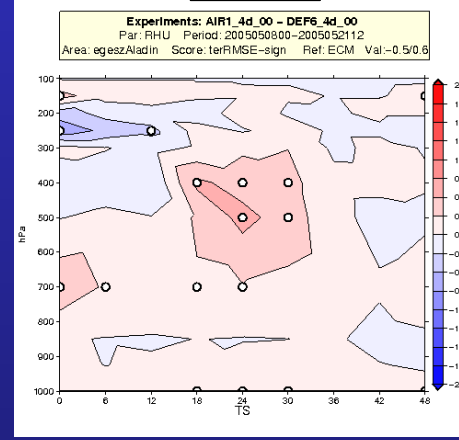
GEO



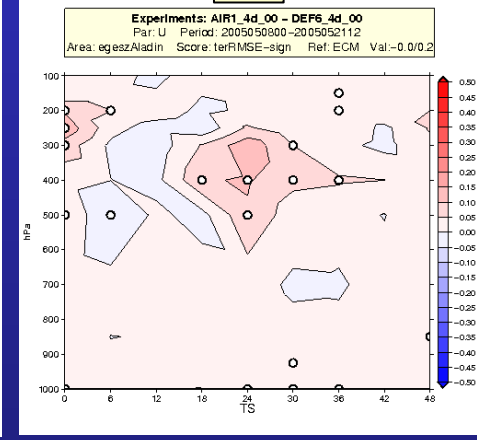
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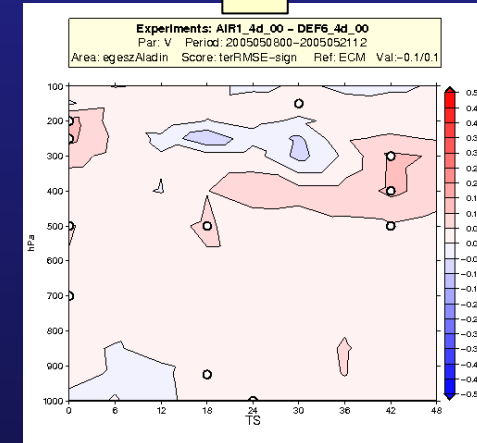
RHU



U



V



- RMSE differences for the 00 UTC runs.
- Red shades indicate that AIR-all is better
- The difference between the 12 UTC runs are very small in terms of RMSE



Conclusion: the longer AIREP window is better for 3D-FGAT

Using all the SYNOP reports

- In the former experiments only one SYNOP report per station (the closest one to the analysis time) was used in 3D-FGAT
- 3D-FGAT is able to take into account one SYNOP report in each time-slot for a station
- Using 7 one-hour-long time-slots even 7 SYNOP reports can be used for a given station
- In the presented experiments only surface pressure was assimilated from SYNOP (experiment SYNG)

Using all SYNOP reports

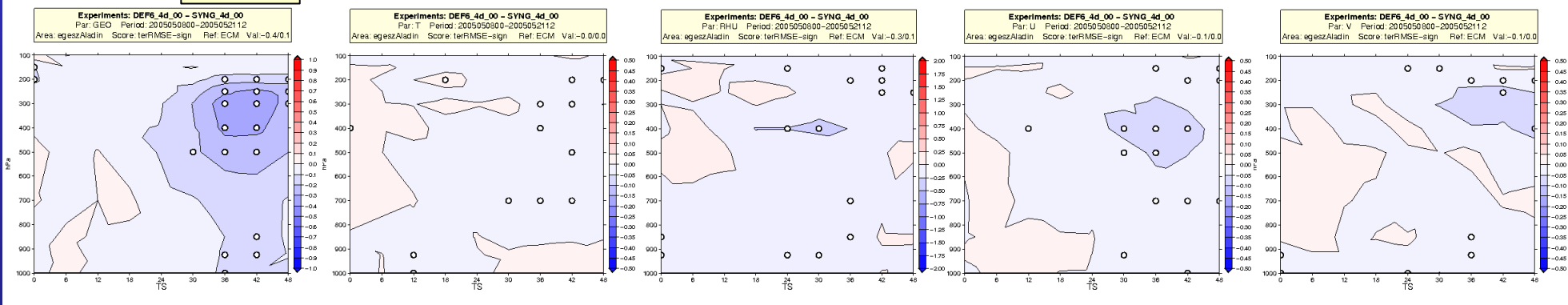
GEO

T

RHU

U

V



00 UTC scores:

- RMSE differences between AIR-all and SYNG.
- Verification against ECMWF analyses.
- Blue shades indicate that SYNG is worse.

- The same near neutral or negative impact was found for 12 UTC and for the surface parameters
- This approach should be possibly applied only in 4D-VAR

Conclusions

- 3D-FGAT in ALADIN was investigated
- It was verified that the 3D-FGAT analysis increment should be added to the background trajectory at the middle point
- 3D-VAR and 3D-FGAT were compared,
 - Little difference was found
 - Some improvement in wind for the 00 UTC runs
- Using all the SYNOP reports in 3D-FGAT is not beneficial
- 3D-FGAT may not be optimal if there are more observations nearly at the same location with different times