3dvar data assimilation of surface observations

Ludovic Auger

Météo-France

15th ALADIN workshop, Bratislava

- Short presentation of diagnostic analysis tool : diagpack
- Diagnostic analysis with Aladin 3dvar
- Surface observations in Aladin 3dvar cycle

Diagpack in Météo-France

- Analysis provided every hour to forecasters
- OUTPUT fileds :

-2m temperature and humidity, 10m winds

-CAPE and MOCON fields

- Assimilating all SYNOP-type observations, that is 2m temperature and relative humidity, 10m winds.
- These observations are not used by the ARPEGE model.
- The main goal is for the forecaster to have an idea of the areas where convection could develop.

Diagpack in Météo-France

- Based on the Optimal Interpolation system CANARI.
- OI is adapted to Boundary Layer fields.
- The meso-scale analysis is not meant to provide balanced fields.
- 2m fields are directly analyzed without taking into account altitude fields.
- An altitude analysis is also preformed because of the need of altitude variables for the CAPE computation.
- The error covariances have the following form :

$$< Q_1 Q_2 >= \sigma_{Q_1} \sigma_{Q_2} \Phi(\overrightarrow{R})$$

- The function Φ has an horizontal lengthscale of 50km near the ground.
- There is no correlations between different predictors.

3dvar assimilation differences with OI

- Adapted to obtain a balanced atmospheric state.
- Observation operators do not have to be linear.

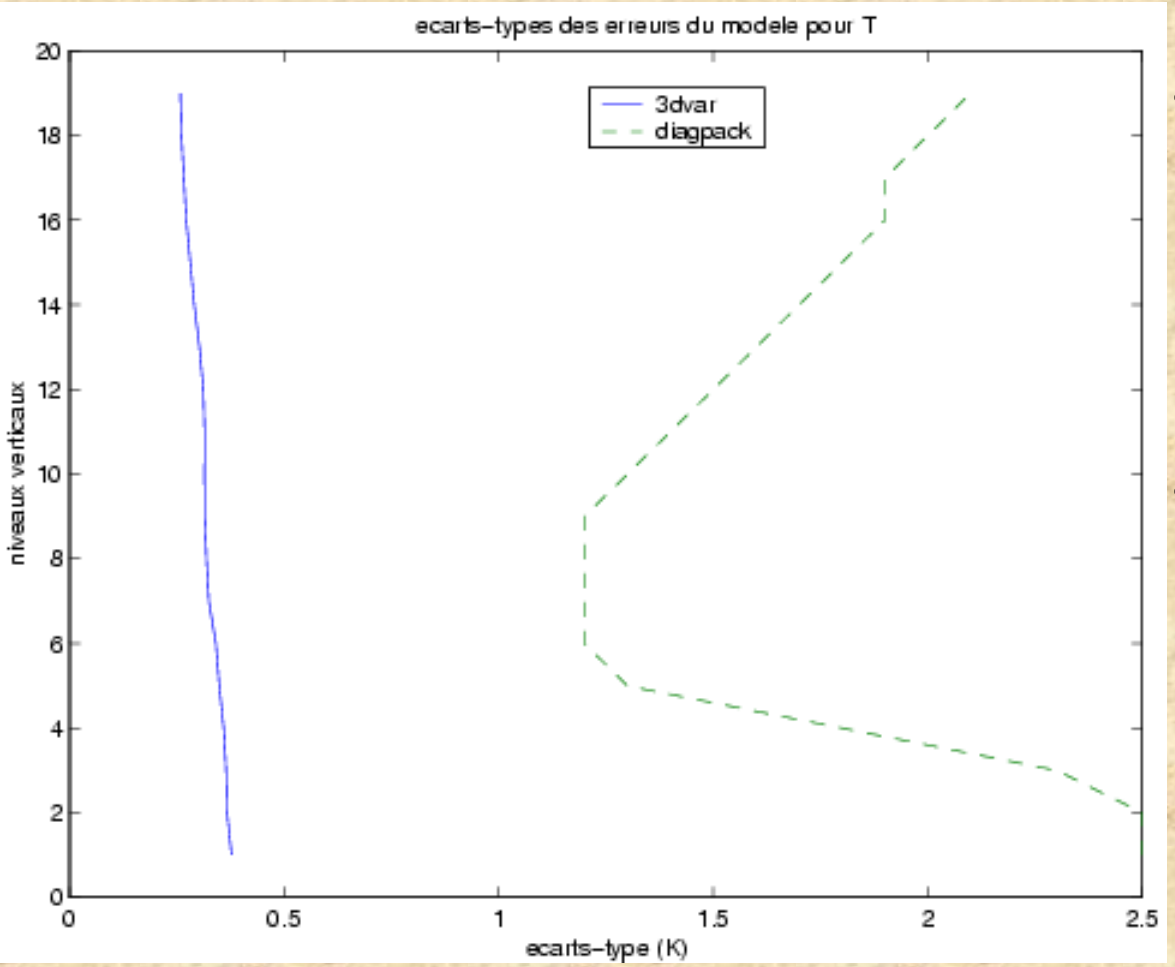
$\Rightarrow$ an highest number of observation types can be assimilated by the 3dvar.

- Algorithm based on a coast function to minimize.

=>Require to have a tangent linear of each operator and its adjoint.

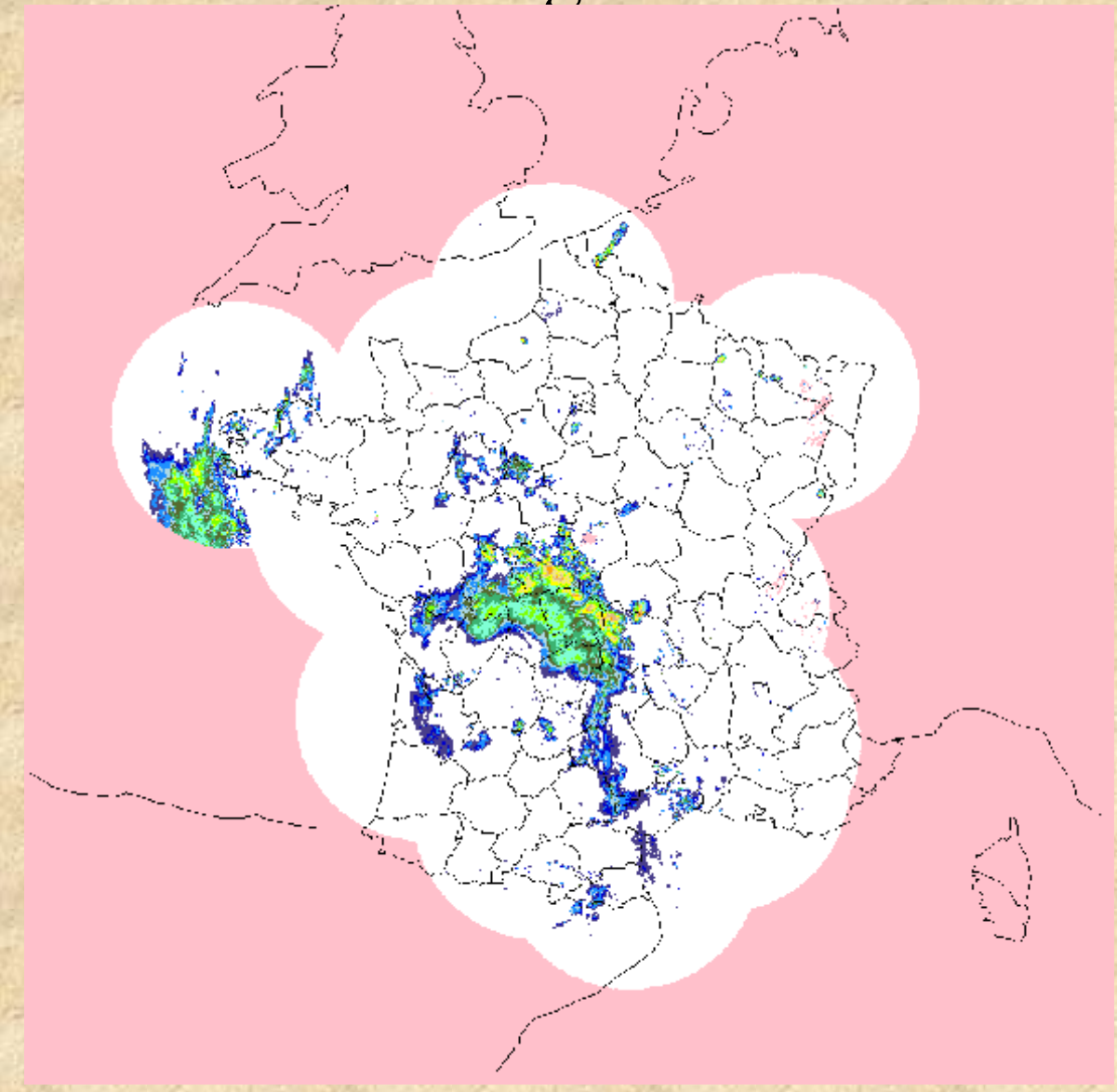
- Multivariate aspect through the B matrix.
- Screening Vs diagpack observation system rejection

Tunning of vertical error variances

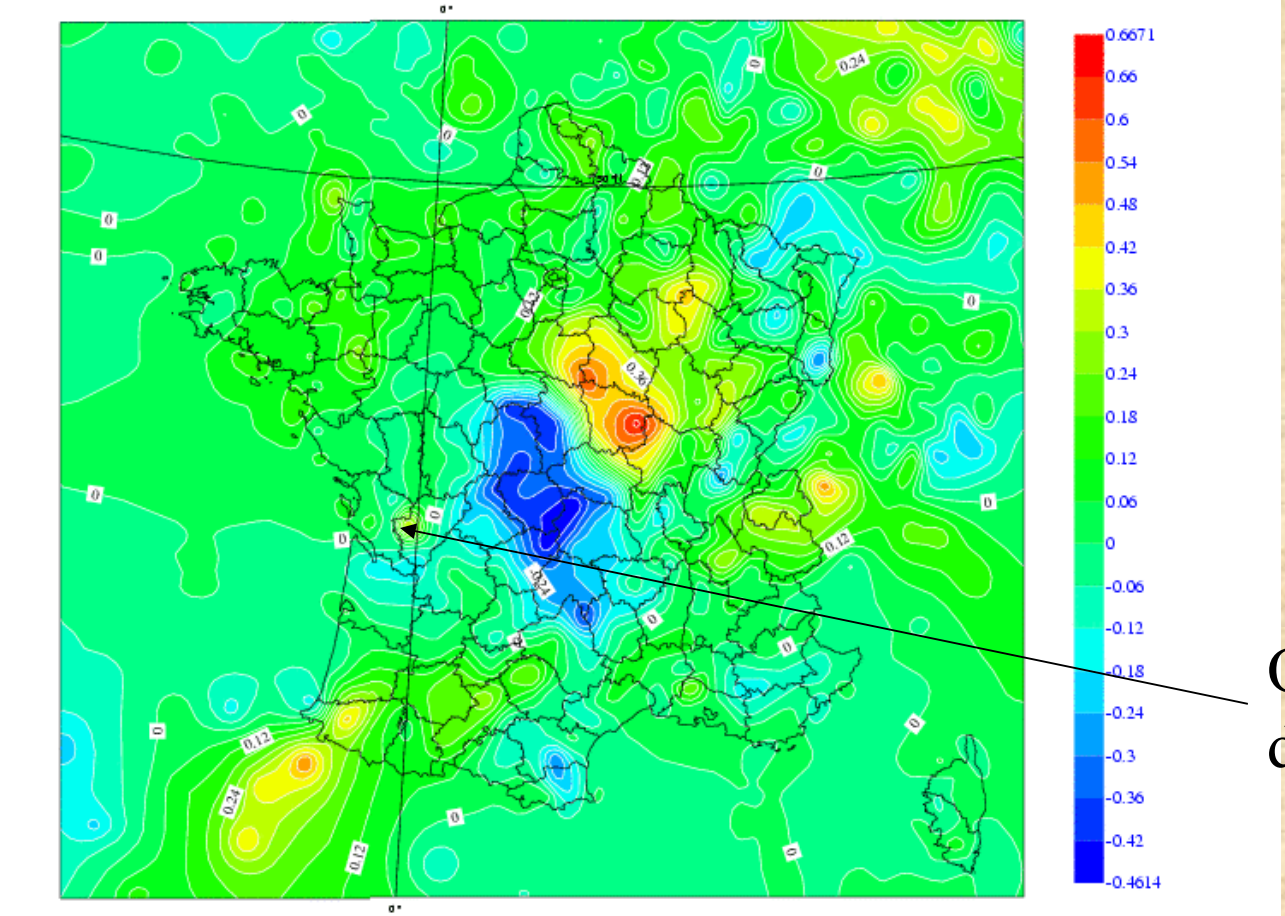


- The standard deviation model error for temperature at the ground is 0.4 K for 3dvar and 3 K for diagpack
- For diagpack a minimum can be observed around level 9, corresponding to the boundary layer top.

15/08/2001
radar images at 17H00



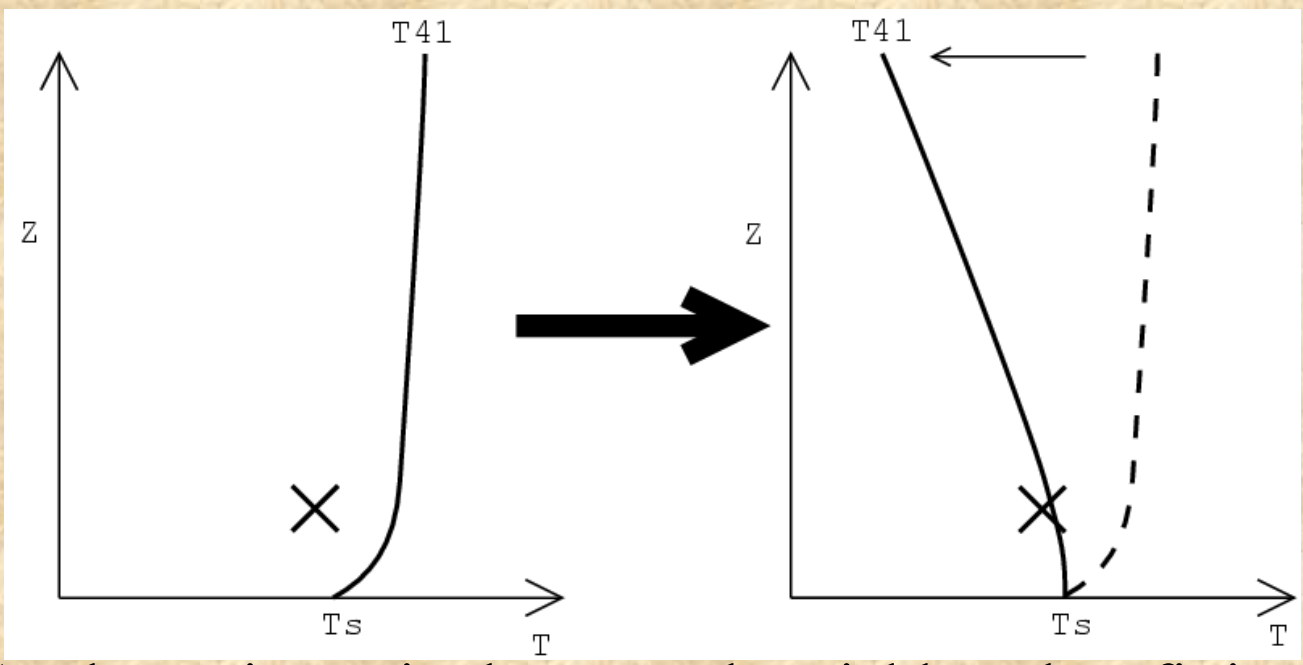
15/08/2001



- Analysis increment due to one observation
- This observation gives wrong increments, the maximum impact is far from the observation area.

Problem when assimilating 2m temperature.

- The equivalent model of 2m Temperature is computed through similarity relationship for which the ground temperature plays an important part



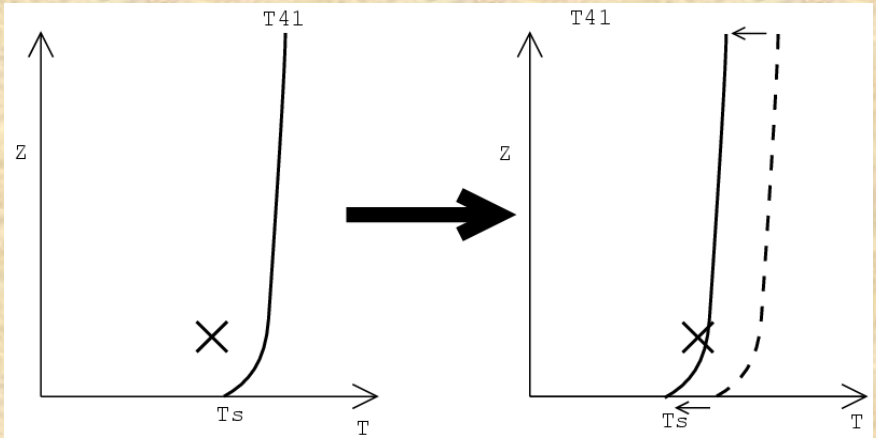
- As the Ts is not in the control variable, when fitting the observed 2m temperature, the model can only modify T on the last level (~17m) resulting in incoherent last level temperature increment.

T_S-T_N in the control variable.

- The difference T_S-T_N was introduced as a new control variable at each observation point.
- The new cost function writes :

$$J_b = \frac{1}{2}\delta x^t B^{-1}\delta x + (T_S - T_N)^t \sigma^{-2}_{T_S - T_N}(T_S - T_N)$$

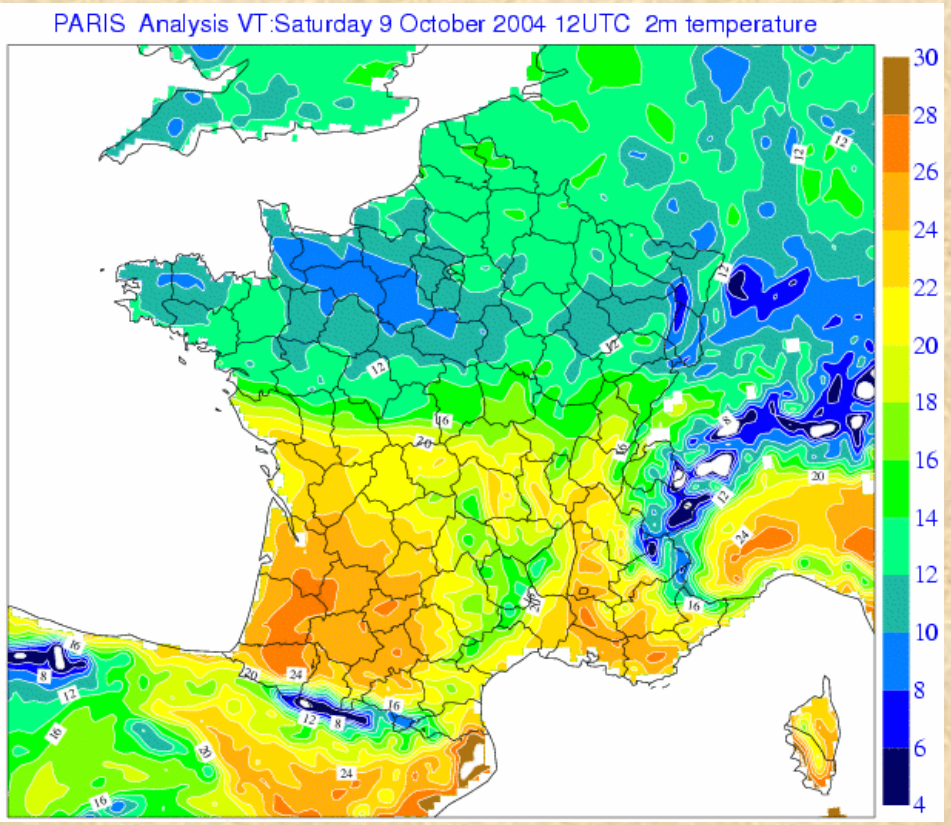
- The goal of introducing T_S-T_N instead of T_S only is to impose a correlation between T_S an T_N.
- The standard deviation of the model error for T_S-T_N is controlled through σ_{TS-TN}
- There is no direct horizontal correlation between T_S at different locations.



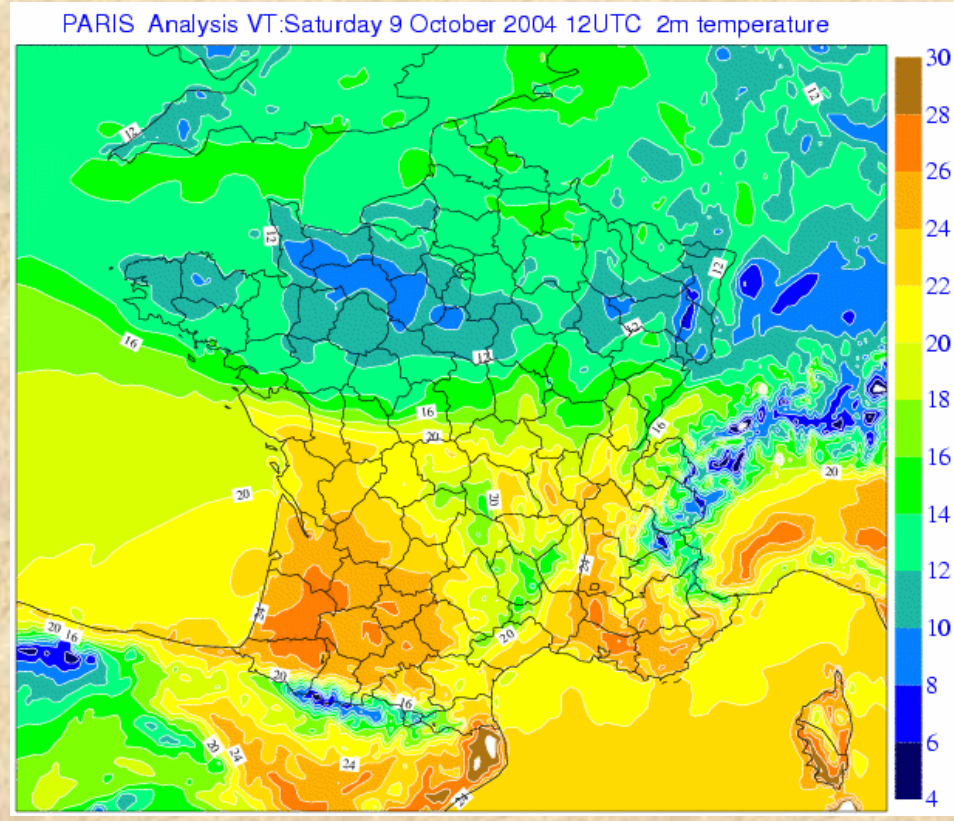
Settings of 3dvar for diagnostic purposes

- The parameter REDNMC will be set at 7 at the ground in order to fit the error variances of diagpack.
- We will also impose a vertical decrease of error variances so as 4 levels above the ground, the standard deviation of model error is the usual one used in 3dvar.
- The same number of observations than in diagpack will be used in 3dvar.
- For that we softened the rejection thresholds during the screening phase.
- In the following we call Varpack this version of 3dvar.

Comparison diagpack /varpack, 2m temperature

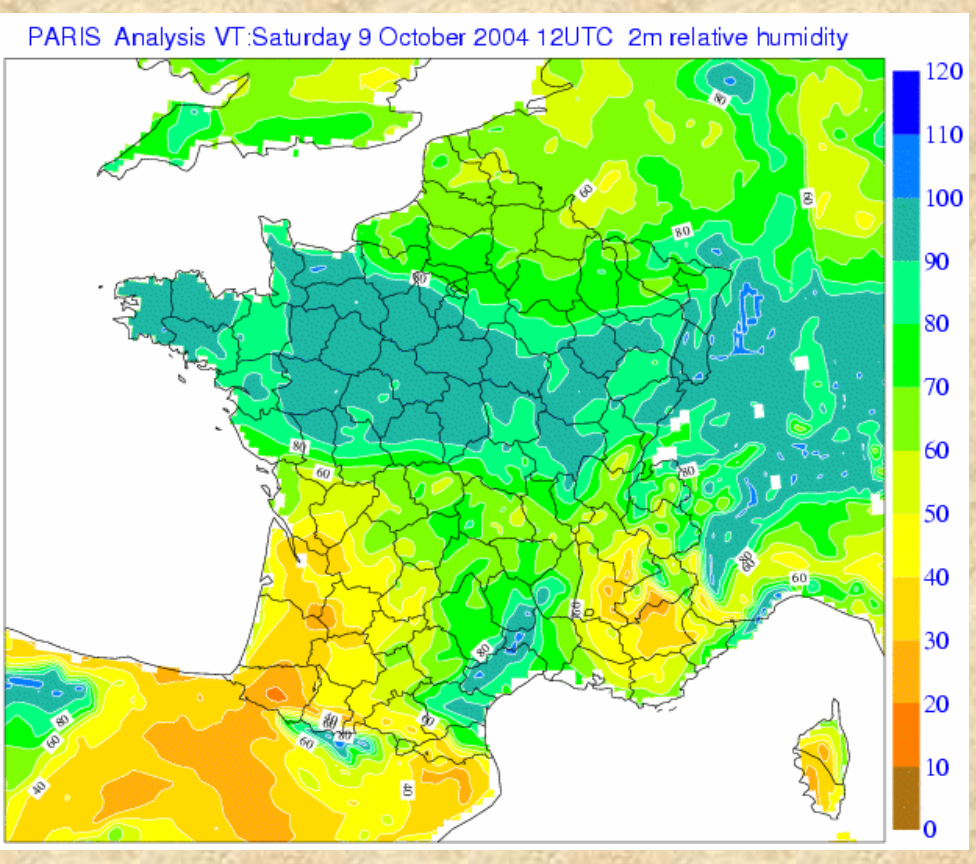


diagpack

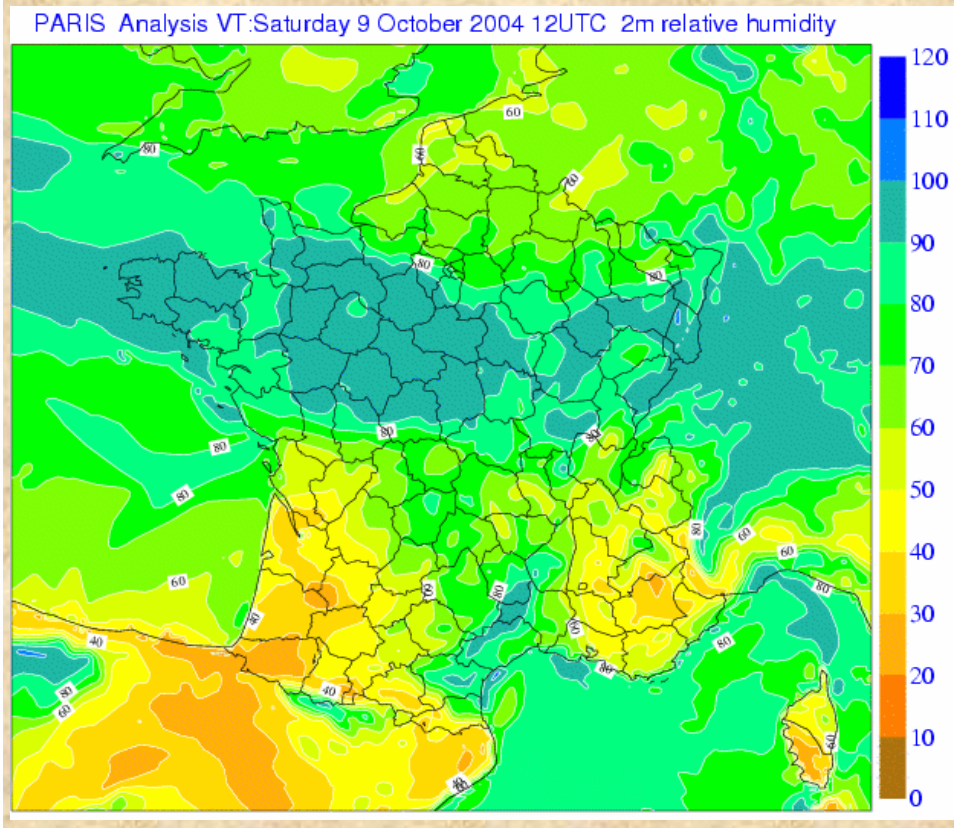


varpack

Comparison diagpack/varpack, 2m relative humidity

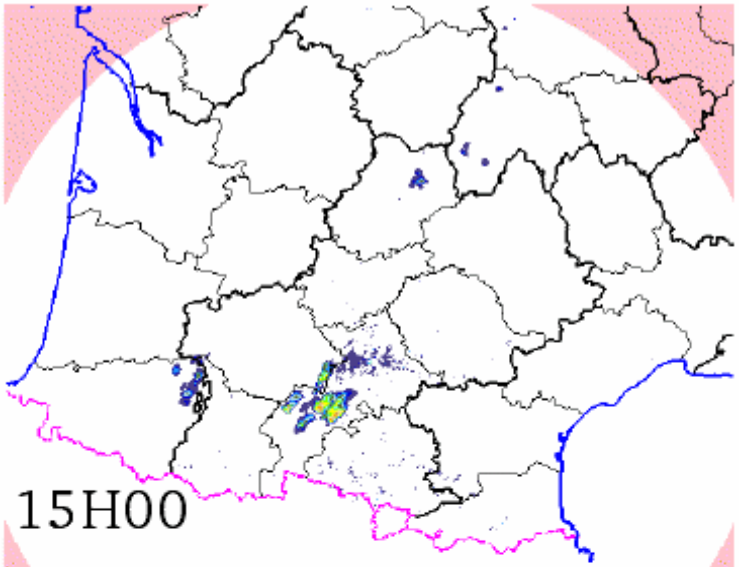


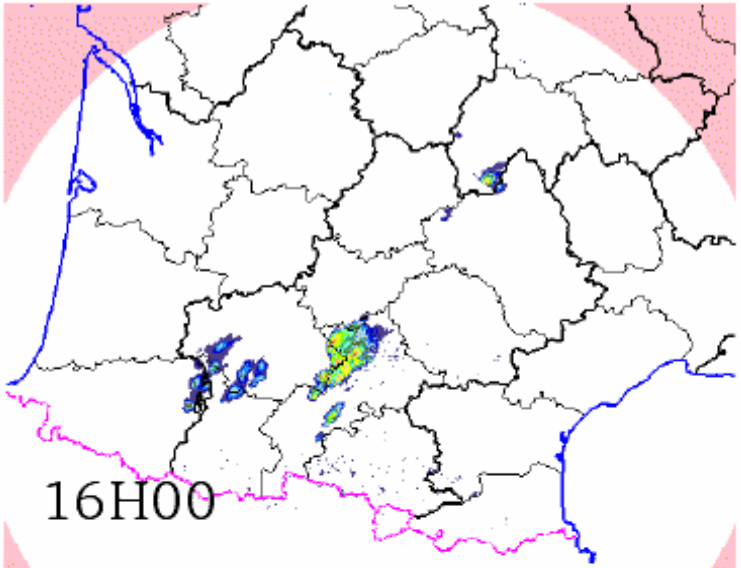
diagpack

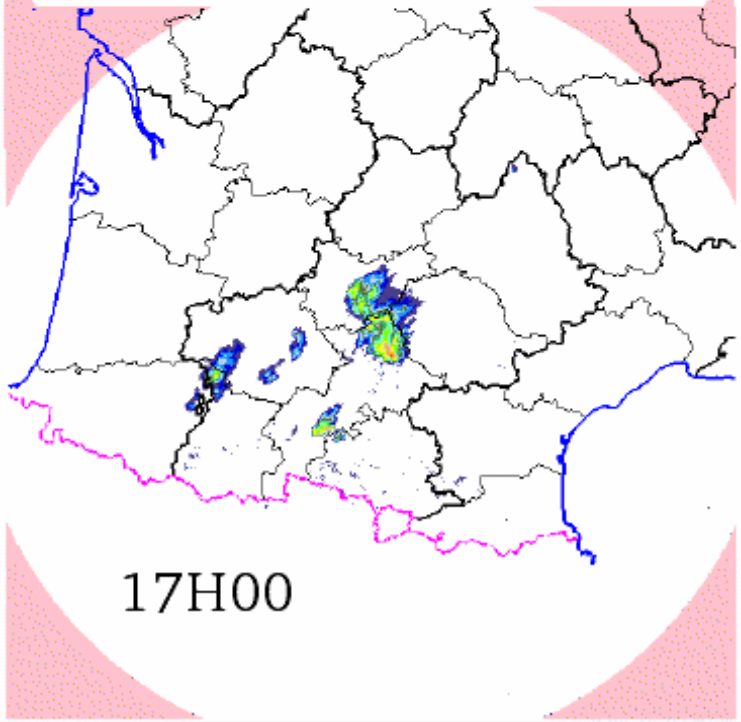


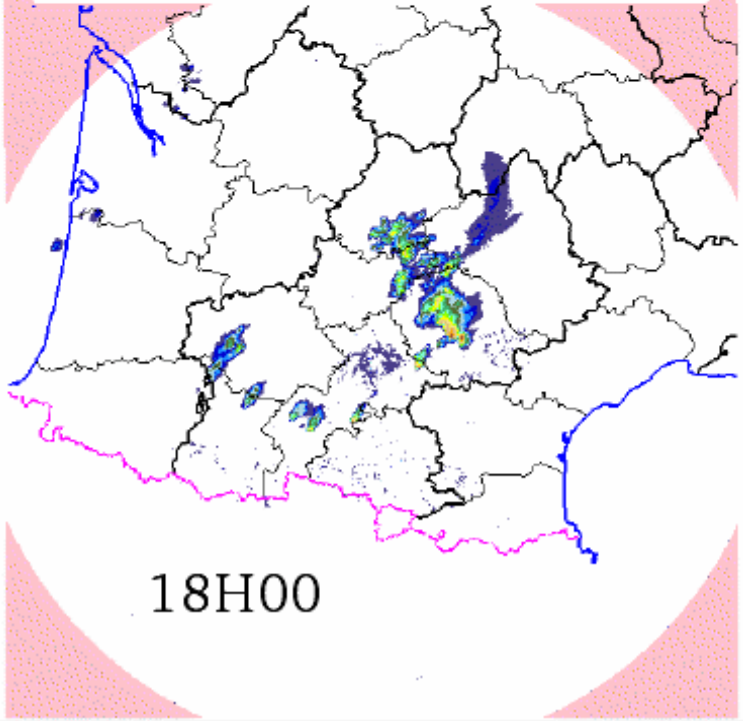
varpack

09/10/2004

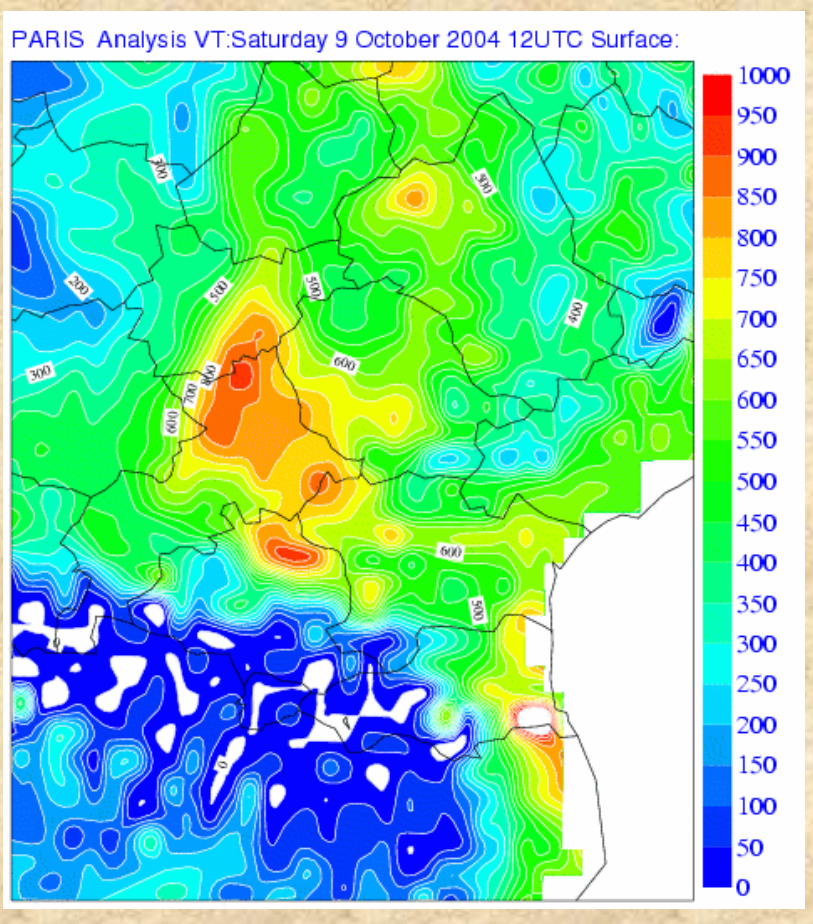




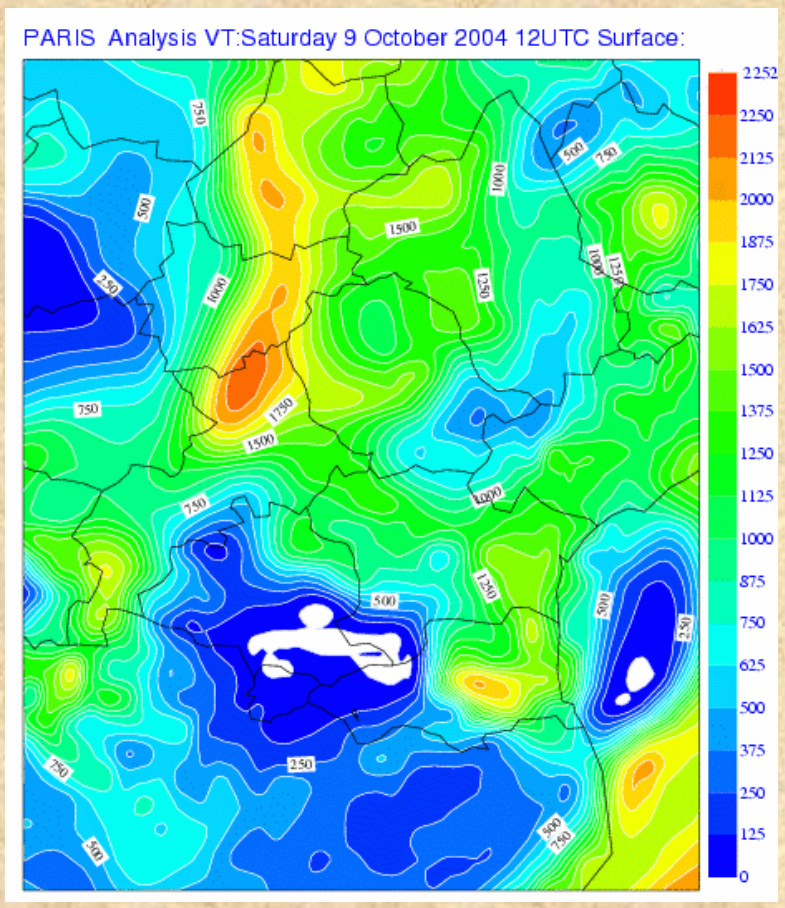




Comparison Diagpack/Varpack, CAPE at 12H00



diagpack



varpack

Advantages/drawbacks of varpack compared to diagpack

Advantages :

- Multivariate aspect
- Possibility to use other kind of observations such as satellite, radar, those are high density datas
- Code common with ALADIN 3dvar => easiest maintenance

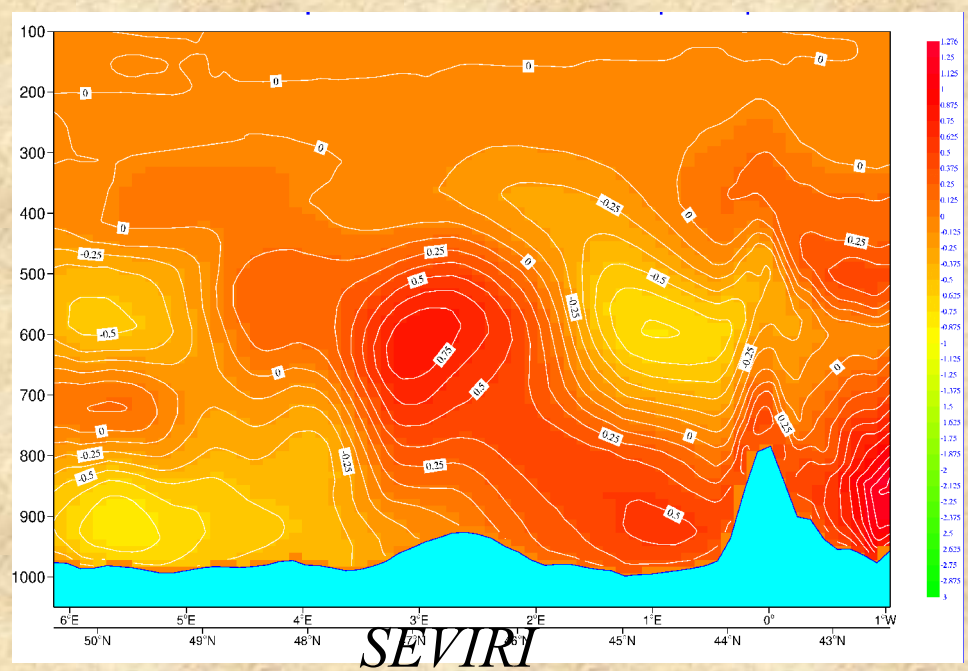
Drawbacks :

- Higher cost in term of computation time and memory
- No surface analysis
- Screening less sophisticated than OI observation rejection system ?

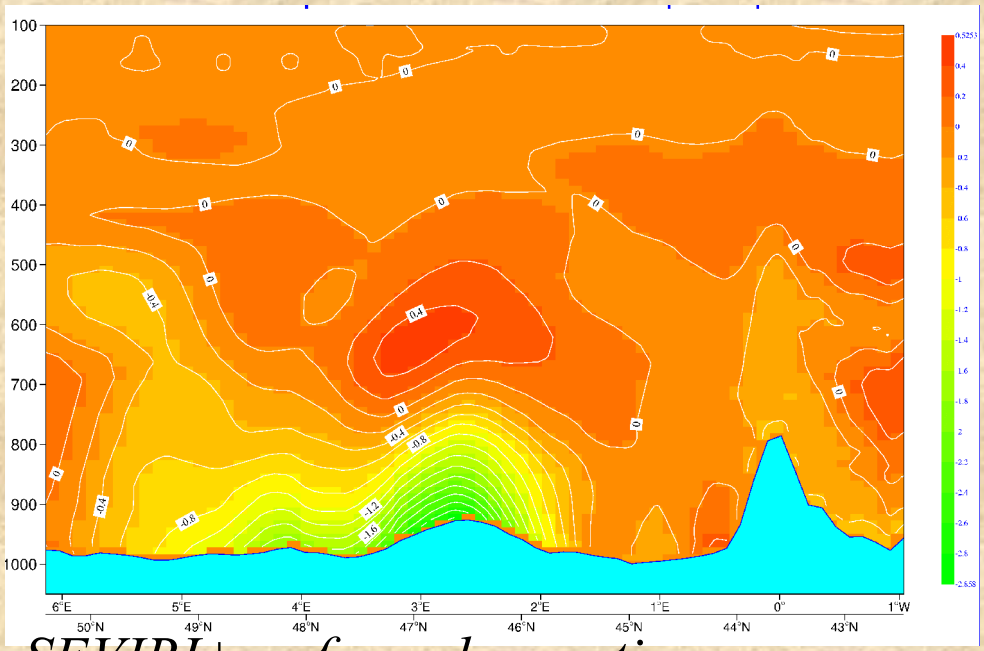
Surface observations in the ALADIN 3dvar

- We ran a test period over the month of July 2004 with surface observations.
- We took into account only temperature and humidity.
- We compared this experiment with one experiment containing all conventional observations plus SEVIRI radiances.

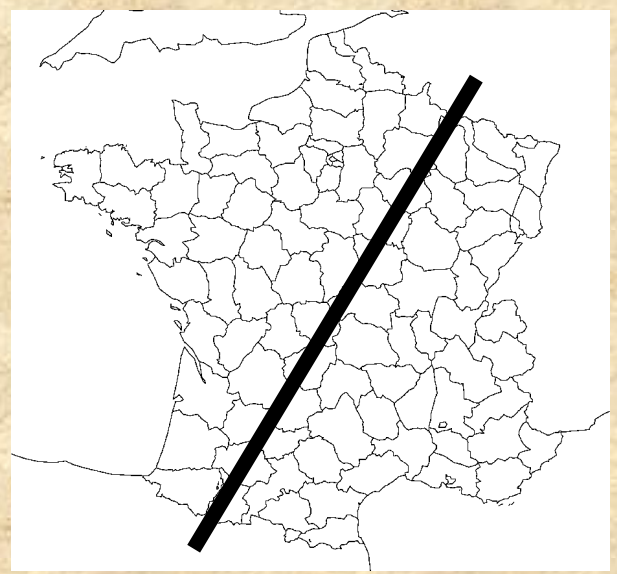
Vertical cross section of de HU increment



SEVIRI

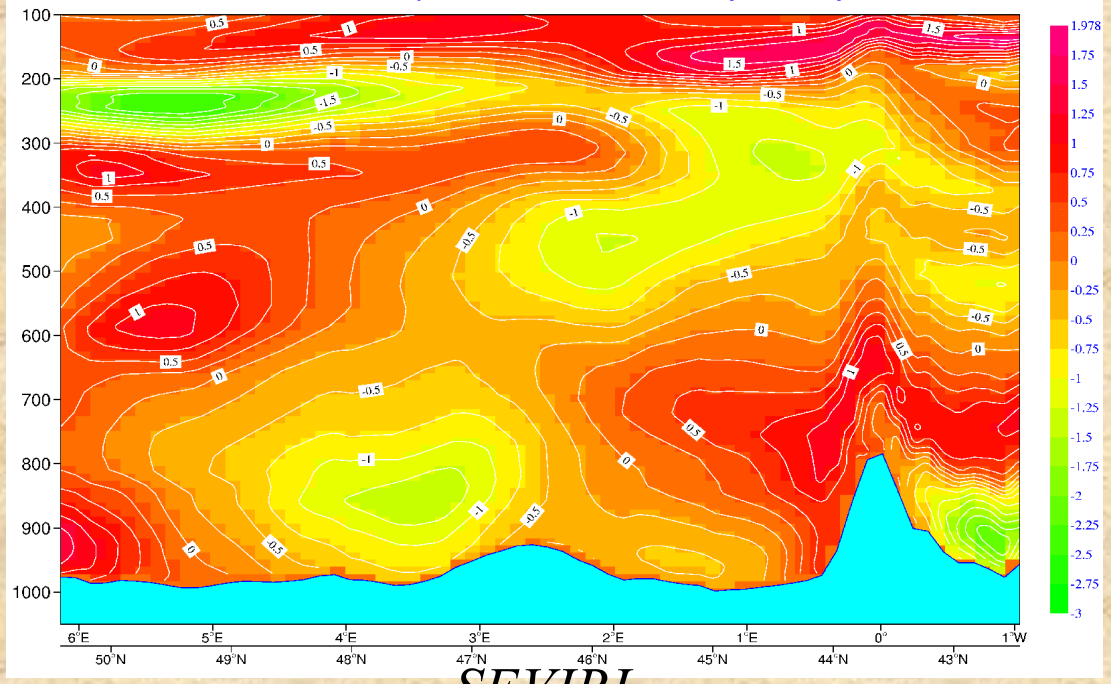


SEVIRI+surface observations

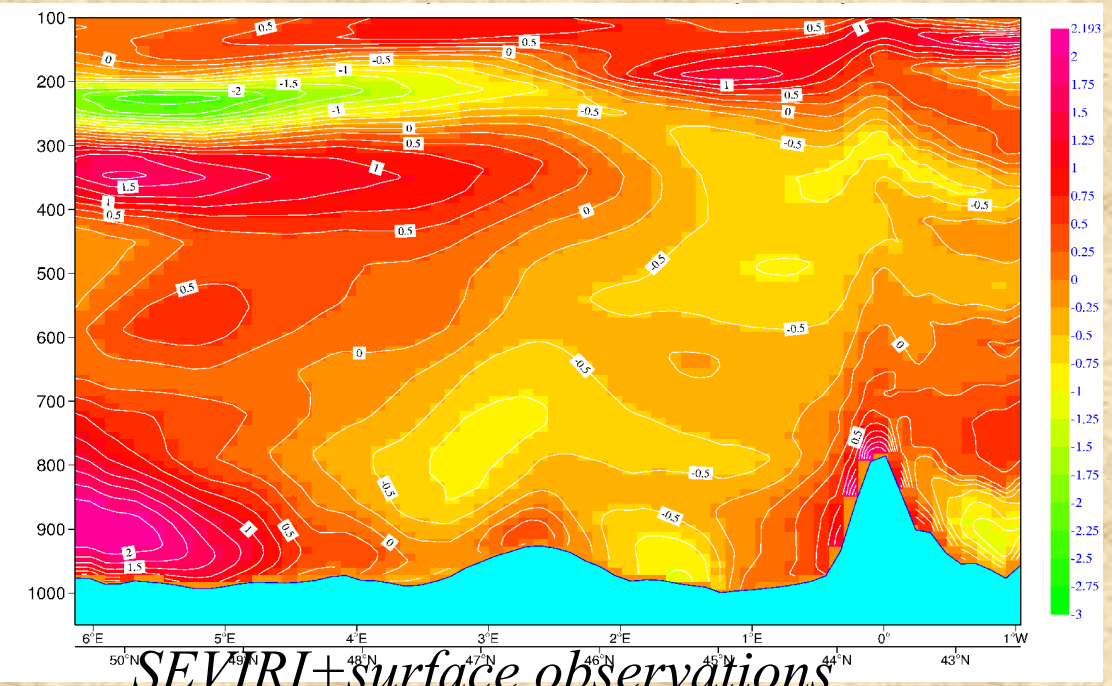


The influence of 2 m observations stays close to the ground.

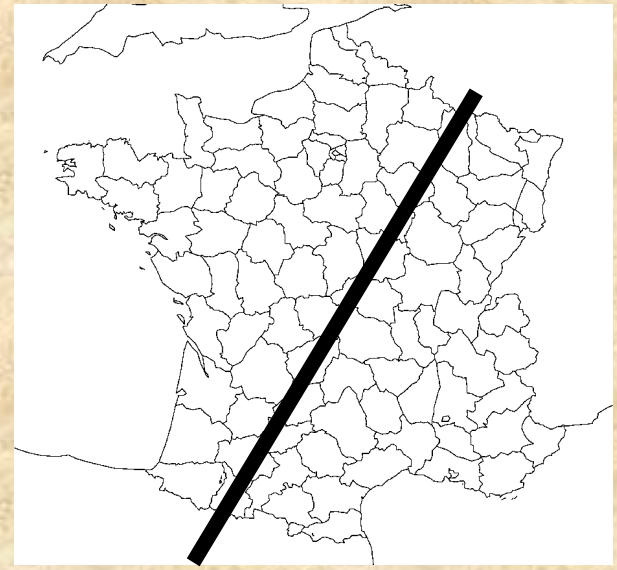
Vertical cross section of temperature increment



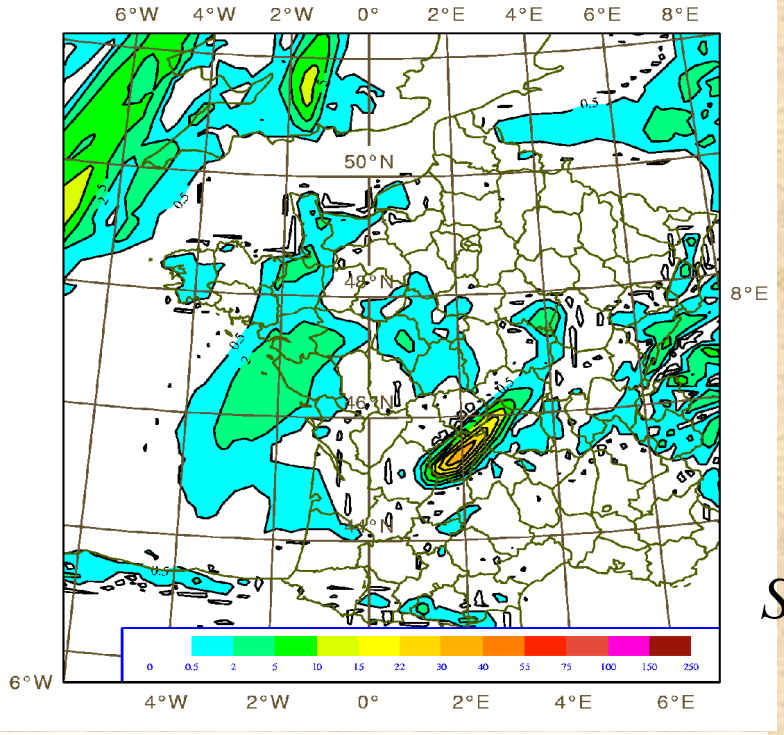
SEVIRI



SEVIRI+surface observations

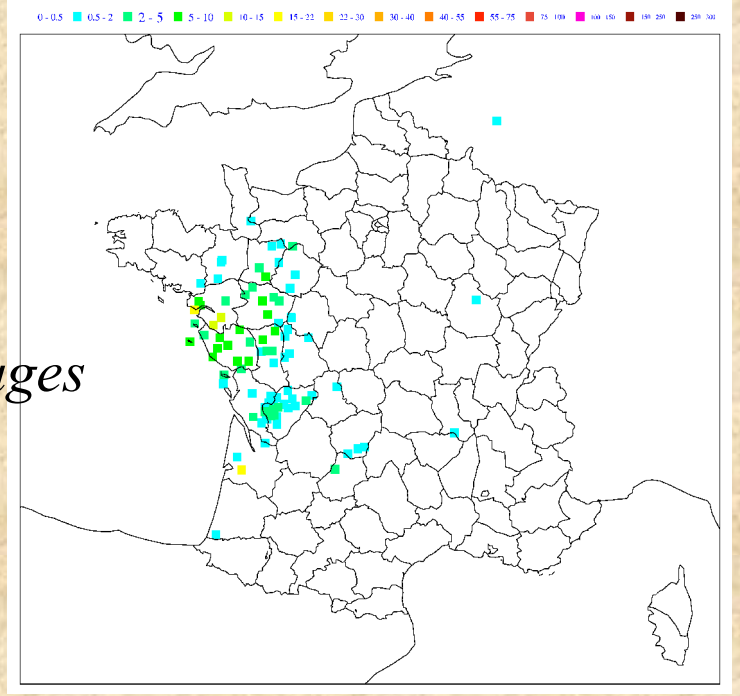


The 2m observations influence stays close to the ground



SEVIRI

rain gauges

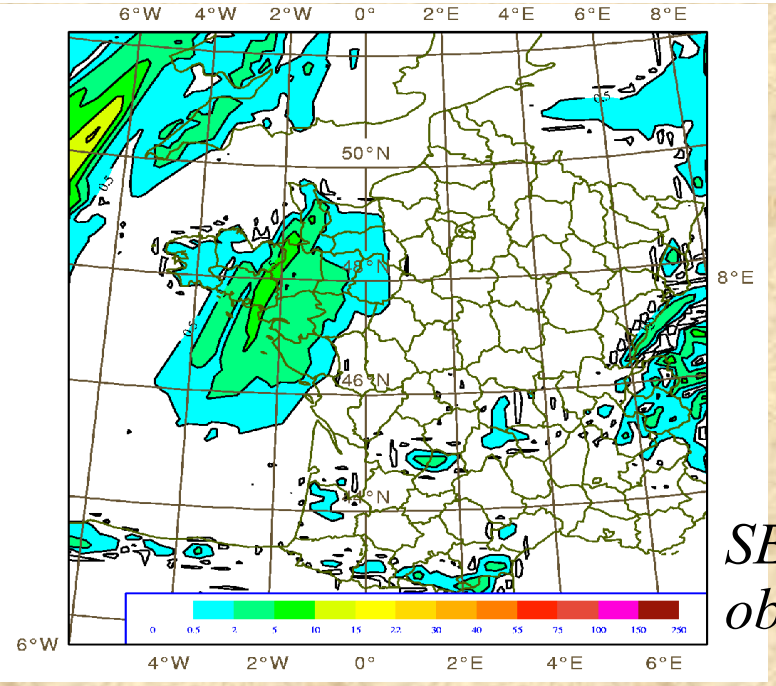


22/07/2004

For that case :

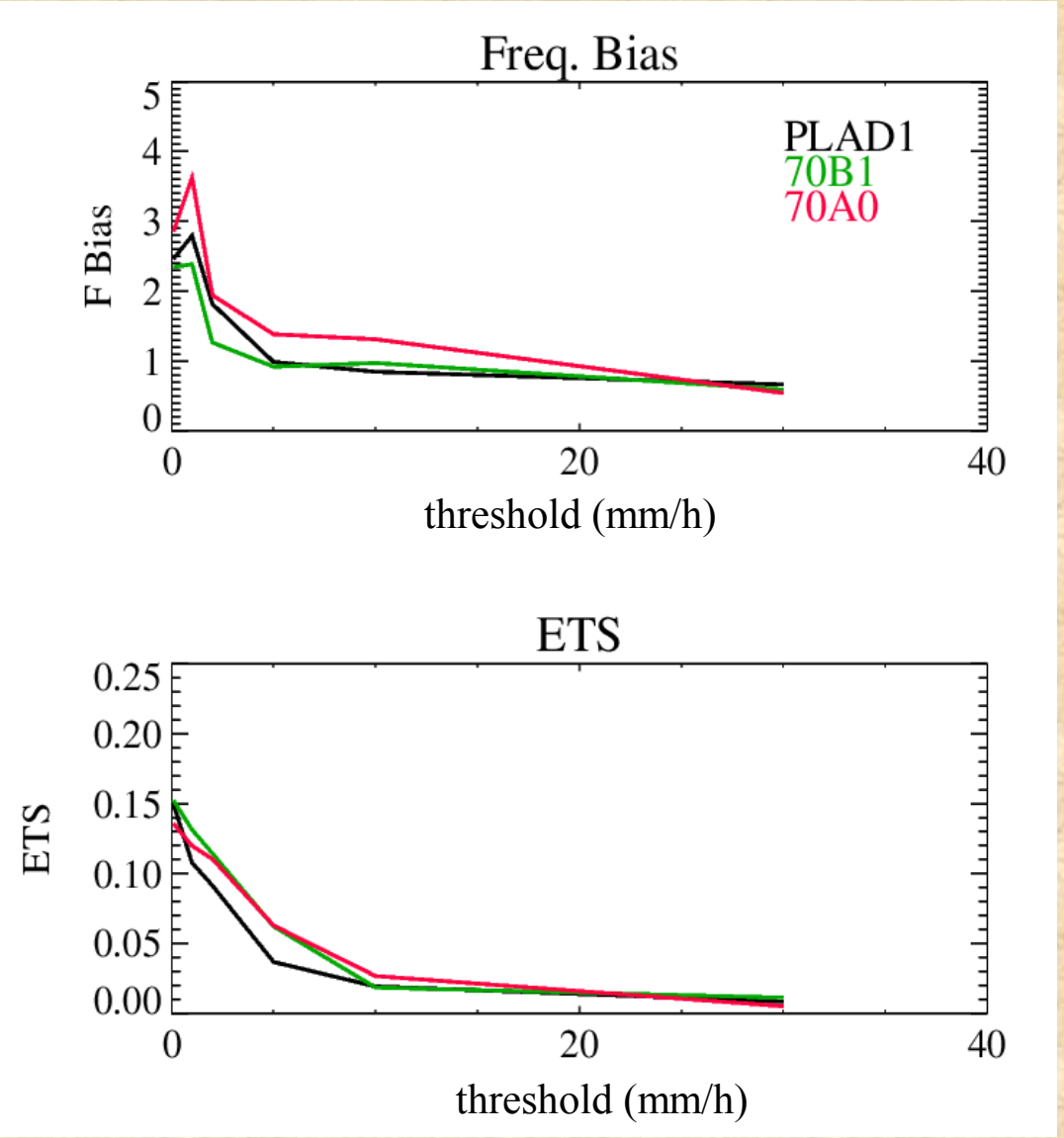
-The non-existing heavy rain spot was corrected.

-large areas of wrong predicted light rain was corrected.



SEVIRI+surface observations

Precipitations scores



The frequency bias is better for low thresholds, that means we improved light rain prediction.

70B1=SURFACE

70A0=SEVIRI

PLAD1=Operational

ETS score is also better.

B matrix in ALADIN

- The main difference with diagpack is the multivariate aspect through the B matrix.
- For the NMC technique B is represented by 36H minus 12H forecasts valid for the same time, statistics are computed on a 3 month period.
- The global variance is computed a posteriori.
- B represents a temporal averaged model error matrix and it is not adapted for extreme situations where the model is far from the observations.

Error covariances in Canari

- The variance of the different predictors have been tuned to enable an analysis close to the observations.
- The error covariances have the following form :

$$< Q_1 Q_2 >= \sigma_{Q_1} \sigma_{Q_2} \Phi(\overrightarrow{R})$$

- The function Φ has an horizontal lengthscale of 50km near the ground.
- There is no correlations between different predictors.

Cape diagnostic

- With diagpack Cape is computed from the 2m analysis fields => there is no dependance on the ground variable.
- The Cape diagnostic essentially rely on the temperature and humidity of the starting particle, not on the vertical profile.
- In the 3dvar the 2m humidity strongly depends on humidity in the ground :

$$q_{2m} = q_S + \alpha_h(z)(q_L - q_S)$$

•For cape diagnostic we assimilated humidity as if it was an observation on the last model level.