Improvements to the surface analysis CANARI in the FP7-EURO4M project

C. Soci
GMAP: E. Bazile, F. Bouyssel, J-F. Mahfouf, F.Taillefer
DCLIM: F. Besson
GMME: E. Martin
SMHI: T. Landelius, P. Unden

OUTLINE

- EURO4M
- Objectives
- Downscaling issues
- Results
- Conclusions and Perspectives

EURO4M (www.euro4m.eu)

- EURO4M – EUropean Reanalysis and Observations For Monitoring
- 4-year Project, starting date: 1 April 2010
- Finance by the EU FP7, Theme 9 “SPACE”
- SCOPE: “To develop the capacity for, and deliver the best possible and most complete (gridded) climate change time series and monitoring services covering all of Europe.”
- 9 participant organizations:
  - KNMI (Project Leader - A. K. Tank)
  - Météo-France, Met Office, DW, SMHI, Meteo Swiss, NMA
  - Universitat Rovira i Virgili (Espagne), University of East Anglia

Objectives

- Downscaling:
  - improvement of the method to better describe the orographic effects on the screen-level and surface variables (e.g. T of the lakes surface, T2m accounting for the model actual temperature laps rate);

- 2D Analysis:
  - introduction of a new structure function to account for the land-sea mask and difference of height;
  - improved error statistics for background and the observations;
  - Development: precipitation analysis, the usage of Tmin and Tmax.

- A 2D reanalysis over Europe for surface variables will be performed at ~5 km scale in order to demonstrate the added value compared with the 3D reanalysis at 22 km done by SMHI under the framework of WP2.2 of EURO4M project.

Dynamical downscaling and reanalysis over Europe

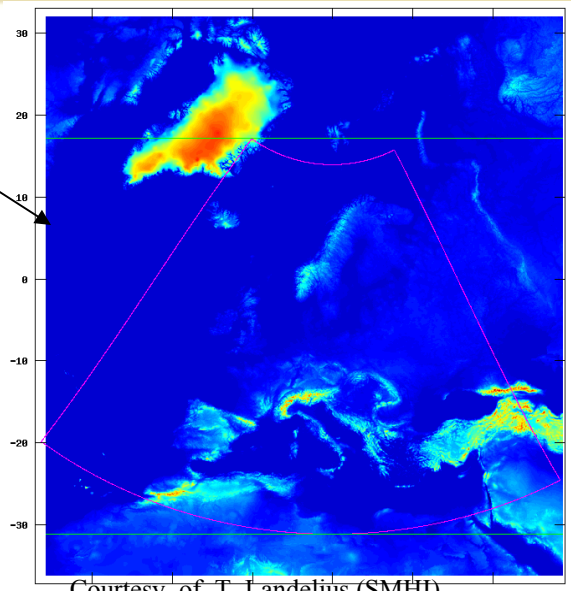
3D-Var Re-analysis at 22 km, 60Levels over Europe (SMHI)

Downscaling

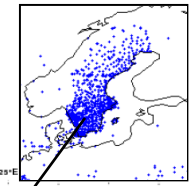
Δx ~ 5 km over Europe

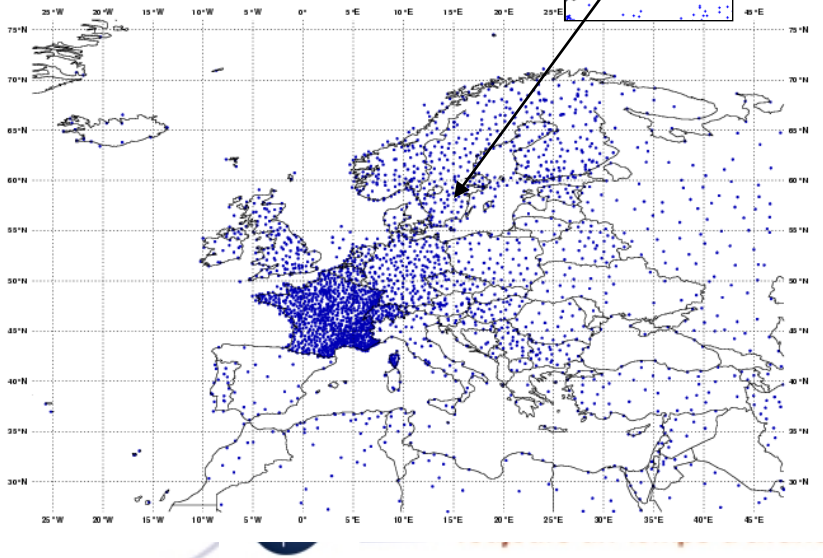
More observations

2D analysis at Δx ~5 km



Courtesy of T. Landelius (SMHI)

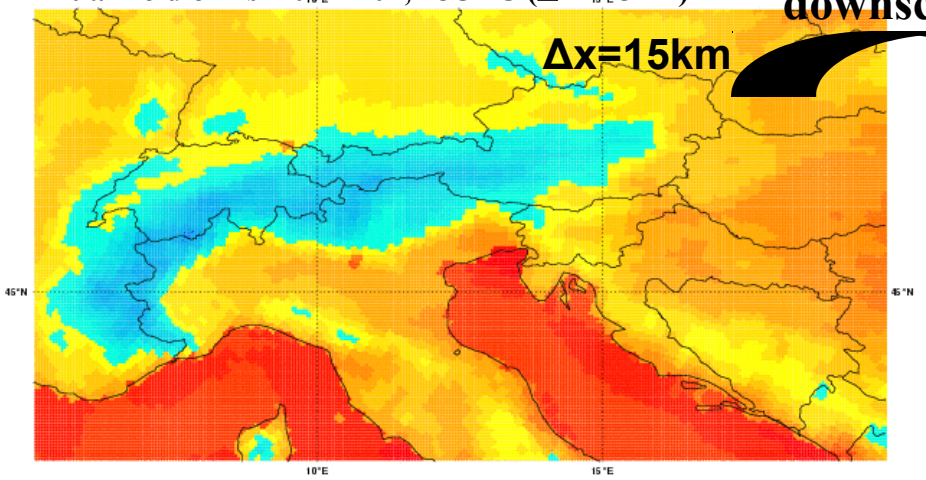




By adding details with topography and more observations, the quality of the analysis should improv
… ~ 4000 obs (1200 over France)

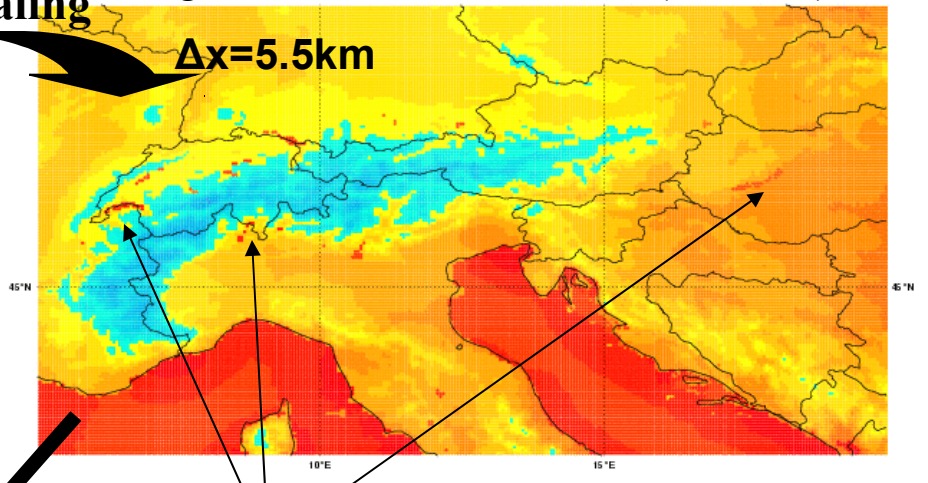
Downscaling issues

Initial field of Ts 20091201, 18UTC (Δx =15km)



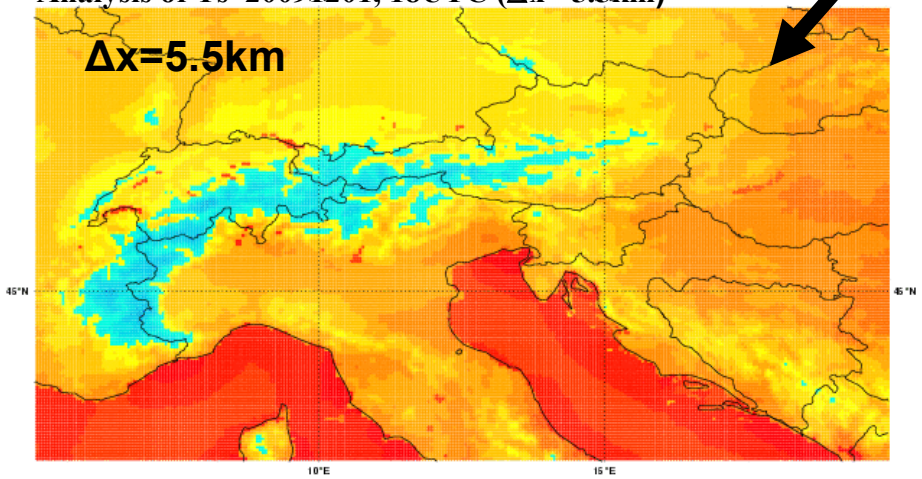
downscaling

Background field Ts 20091201, 18UTC (Δx =5.5km)



2D Analysis

Analysis of Ts 20091201, 18UTC (Δx =5.5km)

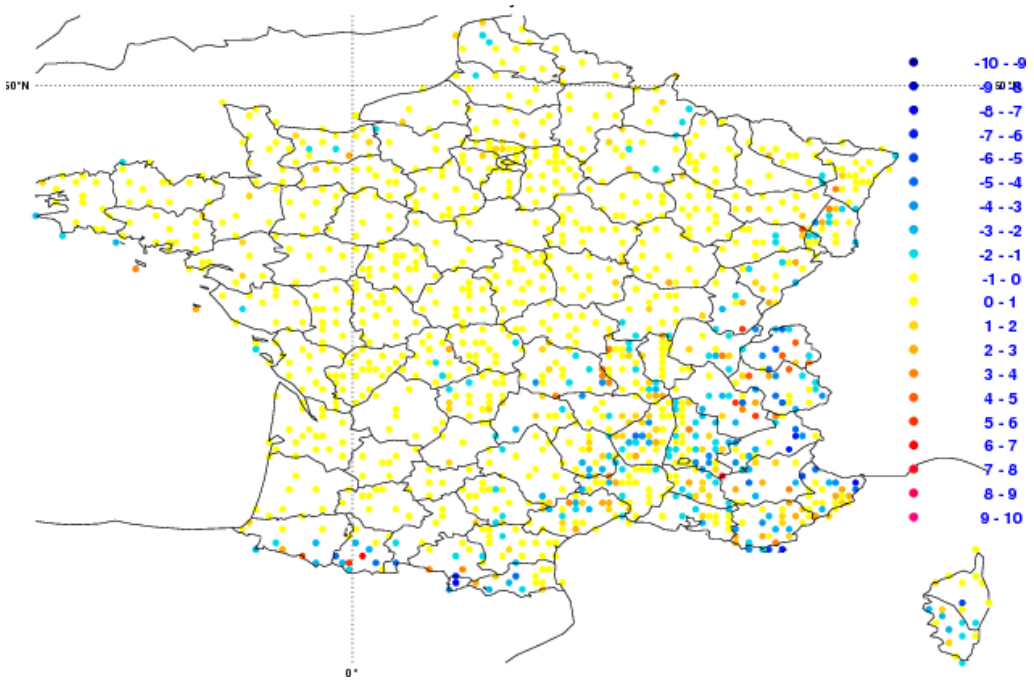


LAKES are created by downscaling but the lake temperature is not realistic especially during winter!

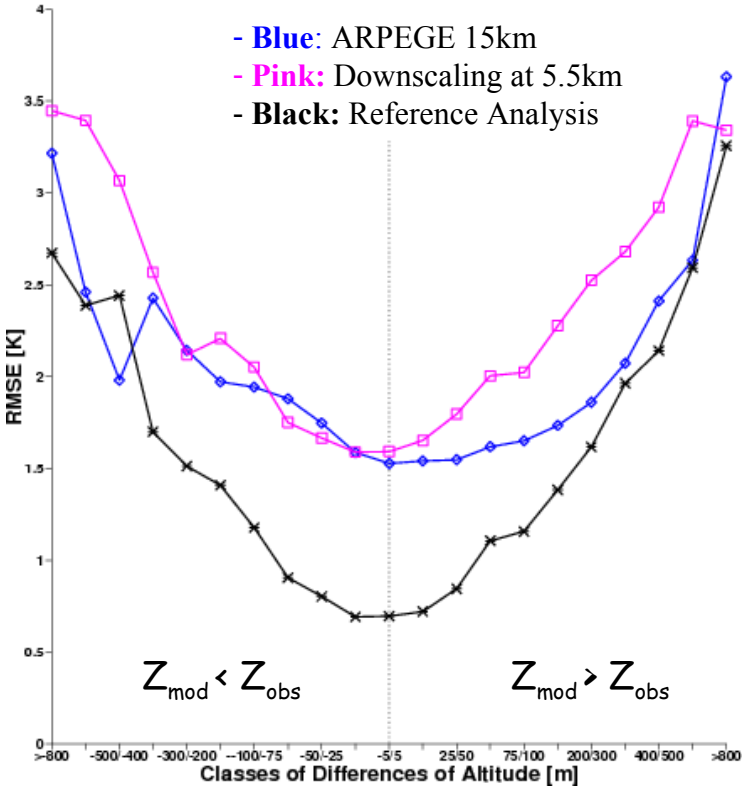
The 2D analysis improves the Ts but cannot correct the lake temperature due to the lack of measurements.

A global dataset for lake characteristics (Kourzeneva, 2009) will be used with SURFEX (see below) to improve lakes surface temperature.

Downscaling issues



RMSE of T2m for Dec09-Jan10

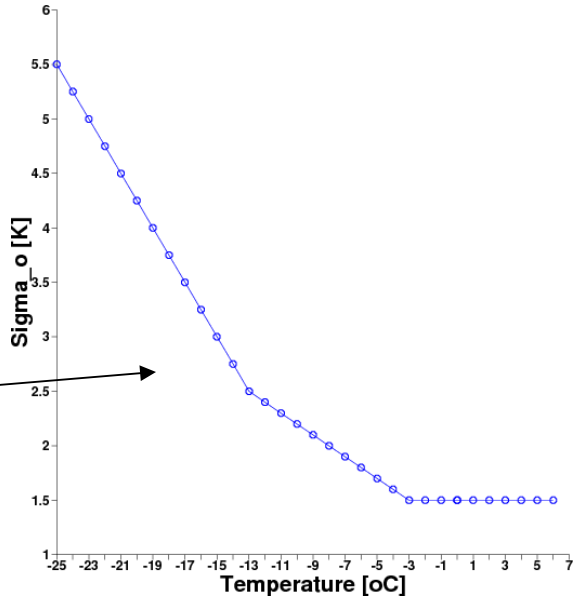


- Errors of T2m are important over high topography and along the coasts (left Figure);
- Downscaling does not necessarily improve the quality of the first guess (right Figure).

New features in CANARI (MESCAN ?)

- Error statistics:

CANARI (reference: oper settings)		MESAN (+ experiments in CANARI)	
σ_b	σ_o	σ_b	σ_o
1.6K	1.4K	winter: 8K summer: 5K	1.5K+ $f(T_{2m})$



- Correlation functions:

Old:

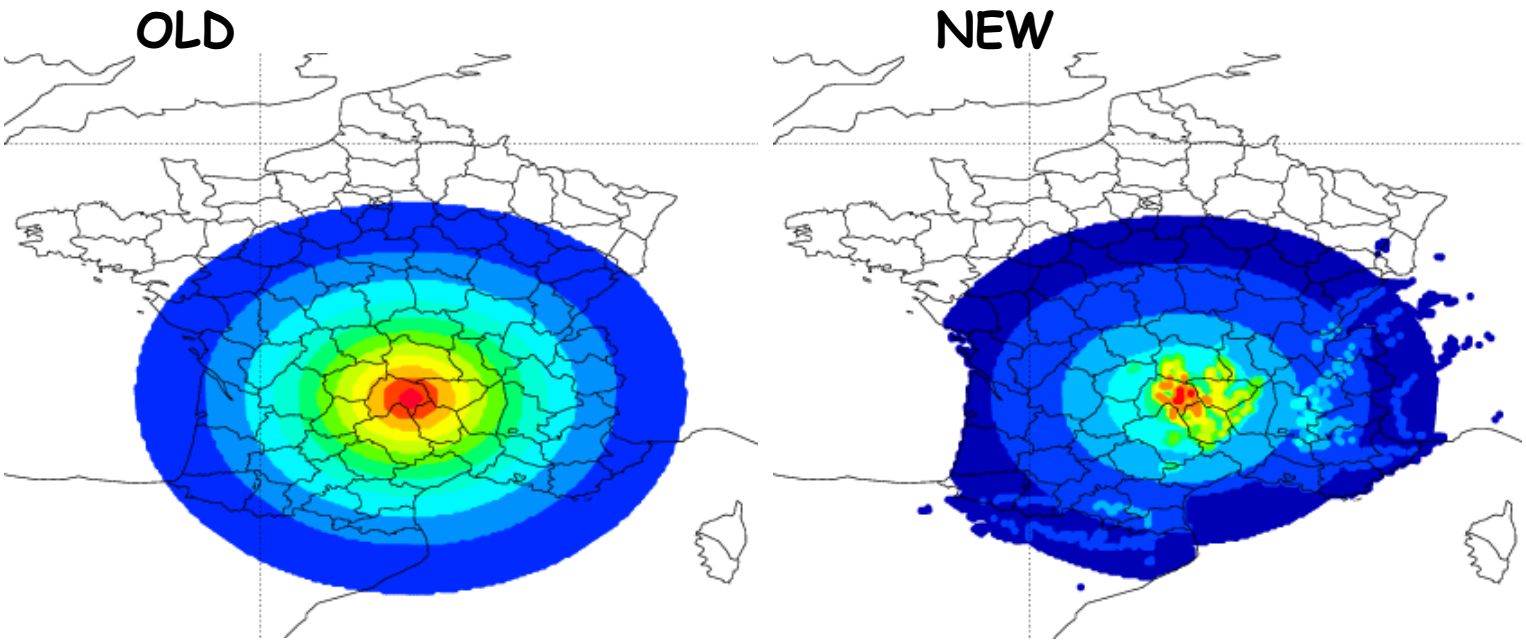
$$Corr_{CAN}(r) = e^{-0.5\frac{r}{d_1}}$$

New:

$$Corr_{MES}(r, d_p, d_z) = 0.5\left[e^{-\frac{r}{d_2}} + \left(1+\frac{2r}{d_2}\right)e^{-2\frac{r}{d_2}}\right]\cdot F_p(d_p)F_z(d_z)$$

after Häggmark et al, 2000, Tellus, 52A, 2-20.

T2m analysis increments for a single obs experiment



The new anisotropic correlation function creates more realistic analysis increments (right Figure) by accounting for height difference and land-sea mask.

Evaluation and improvements of CANARI

- Available tools:
  - M-F: **CANARI** (OI) – used in ARPEGE/ALADIN/AROME for surface analysis (**T2m, RH2m**, SST; 10-m wind, snow height not in oper).

    SAFRAN (OI) uses climatologically homogenous zones over France. System developed for relevant variables affecting snow pack evolution (**T2m, RH2m**, 10-m wind, RR, cloudiness, radiation). Not easy portable for other domains.
  - SMHI: **MESAN** (OI) – used at SMHI for operational analysis (**T2m, RH2m,** 10-m wind, RR, cloudiness, visibility, and has more elaborated structure functions)
- An inter-comparison of the 3 analysis systems was performed over France.

General conclusion: SAFRAN provides good results over complex terrain, but in average over France, MESAN is slightly better.

Inter-comparison of SAFRAN, MESAN, CANARI

T2m: Bias and RMSD computed for 3 months (Dec 2009-Jan2010, June 2010)

	BIAS [K]	RMSD [K]	Remarks
CANARI reference	**-0.01**	**1.08**	σ_b=1.6K and σ_o=1.4K (operational settings)
CANARI	**0.03**	**0.67**	modified σ_o and σ_b + old corr fct
SAFRAN (projected on 5.5 km grid)	**0.03**	**1.17**	σ_b=3.5K σ_o=1.5K
SAFRAN (projected on the obs.)	**0.001**	**0.84**	
MES1c	**0.07**	**0.87**	σ_b=8K (5K), σ_o =1.5K+ f(T_{2m})

- analyses performed with 1300 observations.

Inter-comparison of SAFRAN, MESAN, CANARI

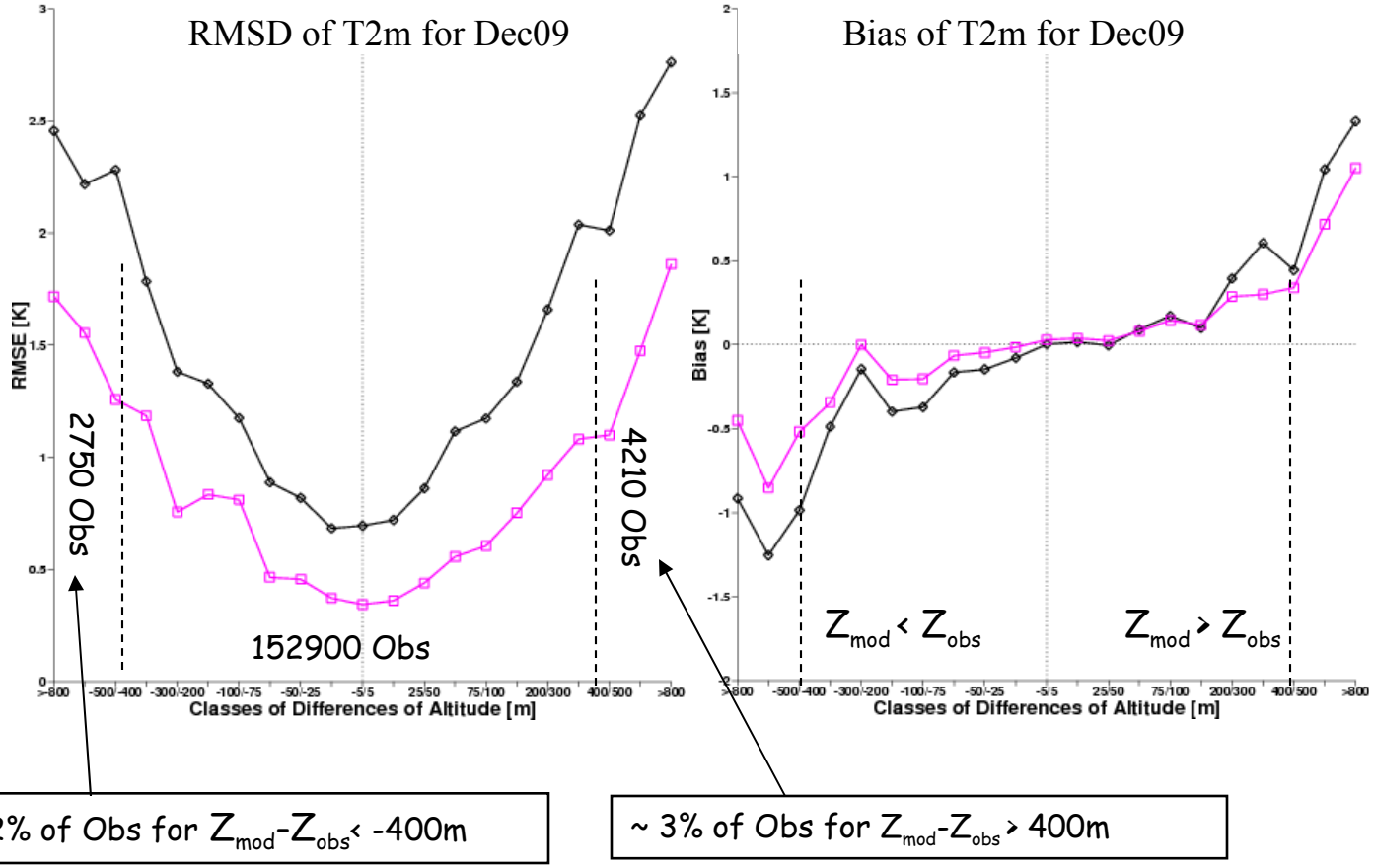
RH2m: Bias and RMSD computed for 3 months (Dec 2009-Jan2010, June 2010)

	BIAS [%]	RMSD [%]	Remarks
CANARI reference	**0.09**	**5.94**	σ_b=18% and σ_o=10% (operational settings)
SAFRAN (projected on 5.5 km grid)	**0.27**	**6.58**	σ_b=20% σ_o=15%
MESAN	**0.02**	**5.65**	σ_b=30% σ_o =20%

- analyses performed with 930 observations.

Impact of σ_b and σ_o on the T2m analysis

-Black: Reference Analysis (oper settings)
-Pink: Analysis with modified σ_o and σ_b.

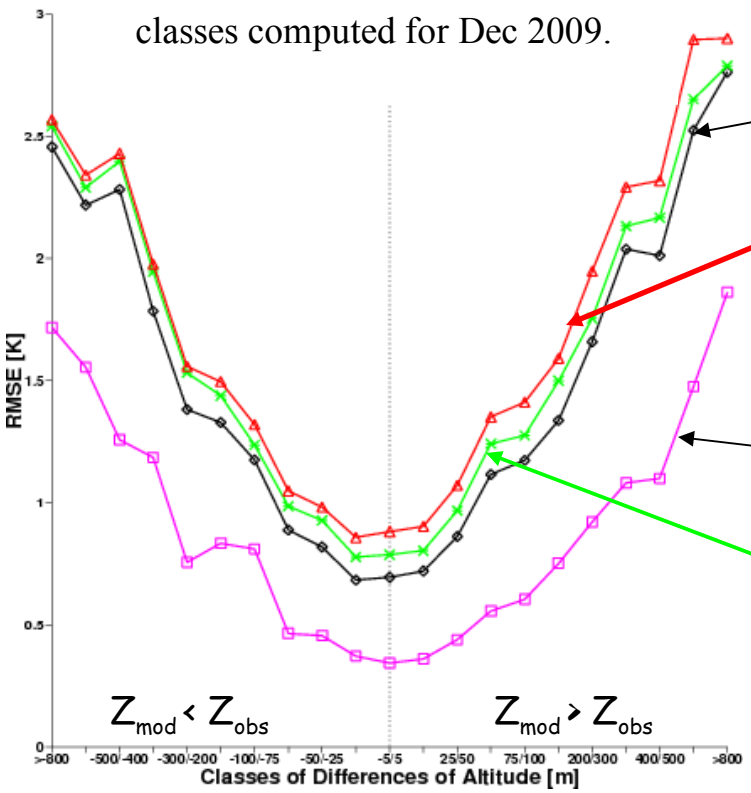


~2% of Obs for $Z_{mod}-Z_{obs} < -400m$

~ 3% of Obs for $Z_{mod}-Z_{obs} > 400m$

The impact of the observations number on analysis

RMSD of T2m as a function of classes computed for Dec 2009.



Reference Analysis (1300 obs)

Reference Analysis (430 obs)

Analysis with modified σ_o and σ_b. (1300 obs)

Analysis with modified σ_o and σ_b (~430 observations)

- the quality of the analysis depends on both the density of observations and the settings of the background and observation error statistics.
- the errors are larger over complex topography

Conclusions

- The new anisotropic correlation function gives more realistic analysis increments, and
  the subsequent analyses have better scores than those performed with CANARI operational settings.

- A proper tuning of error statistics is important and necessary for reanalysis, taking into account that there are more observations and already validated compared to an operational NWP data assimilation system.

- It is therefore possible to have a CANARI producing a better surface analysis over France than CANARI oper, SAFRAN, and MESAN.

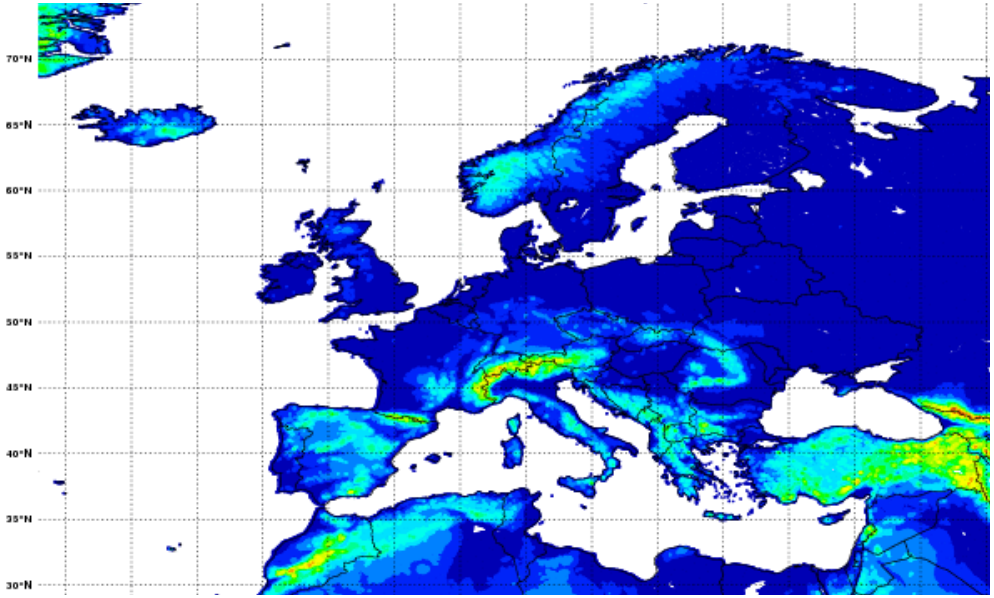
- Preliminary tests performed (by F. Besson) with (S)IM and the hydrological model using reanalyses data from MESAN (RR24h) and CANARI (T2m, Rh2m), and ALADIN forecasted fields of radiation and 10-m wind are encouraging. The objective is to propose a system to replace SAFRAN at MF, and MESAN at SMHI.

Perspectives

- Improvement of the downscaling method:
  - vertical interpolation of T2m particularly over the mountainous areas;
  - usage of a lake climatology.

- Work on the development of precipitation analysis in CANARI and the usage of Tmin and Tmax for reanalysis.

- Before April 2014 we must deliver in EURO4M surface analyses over EUROPE at ~ 5km grid and for 5 years.
  - some technical problems to be worked out:
    - To create a reanalysis domain (Lambert conformal) that best fit SMHI domain (rotated lat-lon);
    - GRIB reanalysis from SMHI converted to FA files (use of GL or c903);
    - implementation of CANARI at ECMWF;
    - Usage of additional observations not available in the classical observations files (e.g. OBSOUL), in GTS etc.



Thank you for your attention!