Future benefits of high-density radiance data from MTG-IRS in the AROME fine-scale forecast model

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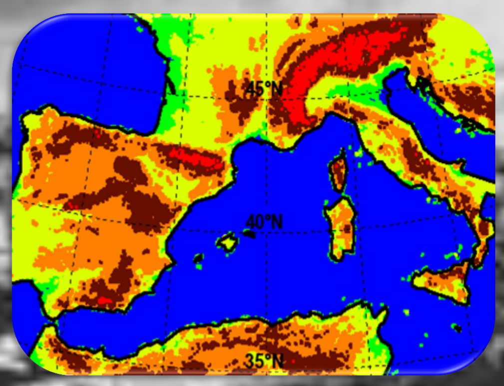


Fig 1 : AROME-WMED domain

Fig 2 : MTG –GEO coverage

INTRODUCTION

Satellite radiances from geostationary platforms currently provide a large input to meso-scale data assimilation systems for Numerical Weather Prediction (NWP) but the number of used observations is far less than the number of available data (less than 5%). In fact, assimilating high density observations may result in a degradation of the analysis if observation and background error covariances are not correctly specified.

Observation errors are supposed to account for errors in : observation operator (RTTOV), representativeness and quality control (cloud screening). Errors are likely to exhibit correlations. However, for technical and computational reasons, covariance matrices are mostly assumed to be diagonal in most NWP centers.

For high resolution satellite observation systems, such as MTG-IRS, the assumption of uncorrelated errors is questionable and can lead to sub-optimal systems if the observations are used at full resolution (Liu and Rabier, 2003). Recently, a relevant formulation for spatial error correlation has been proposed and implemented in a real size system (Bormann and Bauer, 2010, ECMWF). It was shown that correlated observations might be less informative than uncorrelated observations (even if correlations are well specified). But, is it valid for meso-scale models since background error correlation length (Lb≈20 km) is usually shorter than the one in global models (Lb≈200km) ?

<u>Objective</u> : Enhanced density of assimilated radiances using available data (SEVIRI/ IASI) and simulated data (MTG-IRS)

<u>Context</u> : International HyMeX project to improve our understanding of the water cycle, with emphasis on the predictability of intense events

2. Framework and data

A. The AROME-WMED system

- Inherited from the operational AROME/FRANCE model (Seity et al., 2011)
- Aim to support HyMeX campaigns .
- Resolutions : 60 vertical levels, Horizontal 2.5 km (fig. 1).
- 3D-Var assimilation system used to produce 8 daily analysis.
- obs.: conventional data, reflectivity, radar Doppler, GEO winds, radiances
- Bias monitoring and correction : VarBC (Variational Bias Correction)

B. Toward MTG-IRS simulation & assimilation

Since observations from MTG-IRS are not yet available, comparable instruments are used as proxy.

⇒ Impacts of neglecting obs. error correlations and diagnose R matrix…

- SEVIRI : comparable horizontal/time sample (4 km/15 min, fig. 2)
- IASI : comparable vertical sample (2km Q, 1km T)

3. Ideal 1-D study

- 1D-periodic domain (L = 2πa ≈ 8000 km)
- 10 random realizations over x_t, x_B, x_O
- config. :1) $L_B = 200\ km$ or 2) $L_B = 20\ km$ (fig.3)

Comment : Correlated observations can be informative (especially if correlations are specified)

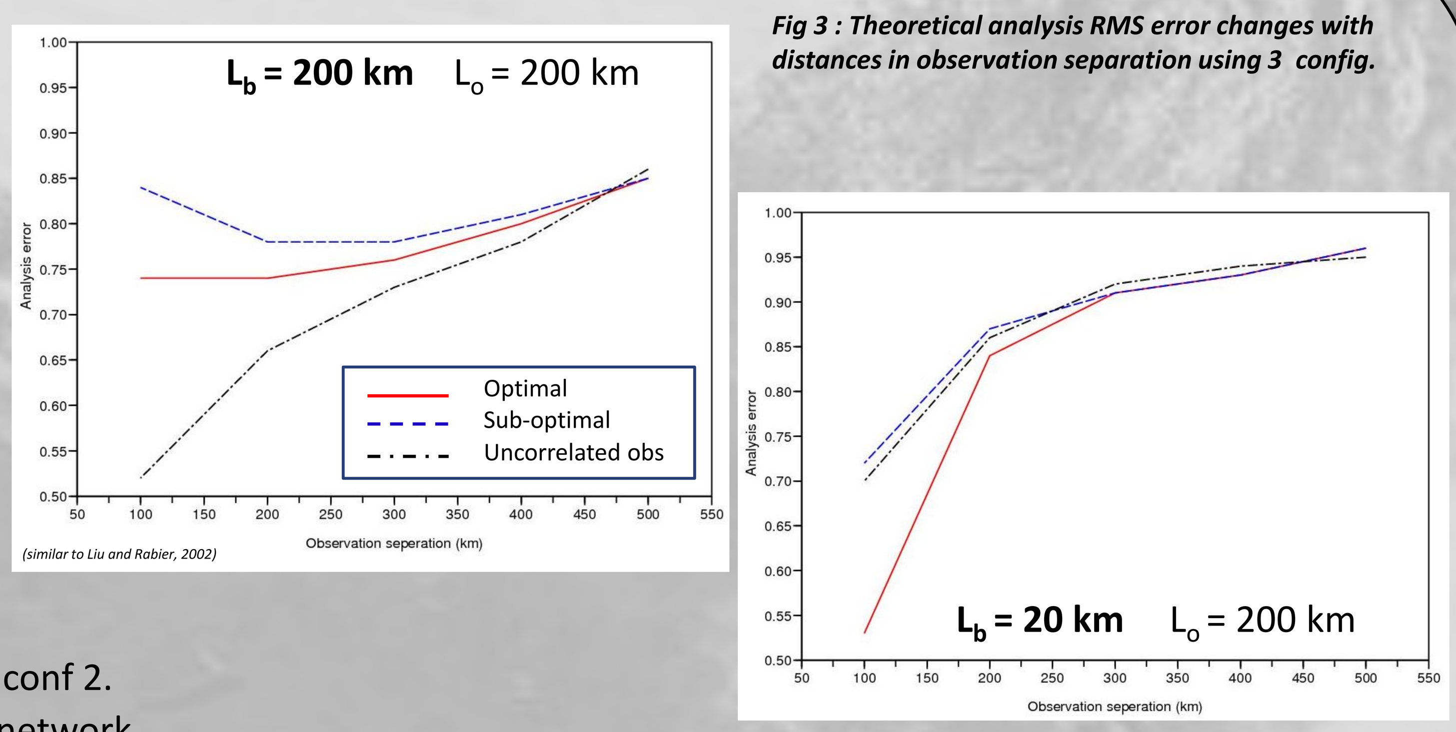


Fig 3 : Theoretical analysis RMS error changes with distances in observation separation using 3 config.

<u>Theoretical distance threshold for high density data assimilation :</u>

1D-periodic model has been run for reduced obs. interval in conf 2.

Error covariances are extracted from an equally-spaced obs. network

Comment : In meso-scale models, observation intervals could be reduced to 10 km (rp. 20 km) if correlations are specified (rp. not specified) (not shown).

4. Assimilation experiments

3D-Var experiment design

- CTL: current AROME-WMED version (without SEVIRI)
- EXPs: CTL + The density of assimilated WV SEVIRI data is increased

Obs distances separation (km)= 100, 70, 40, 20, 15, 10 and 5

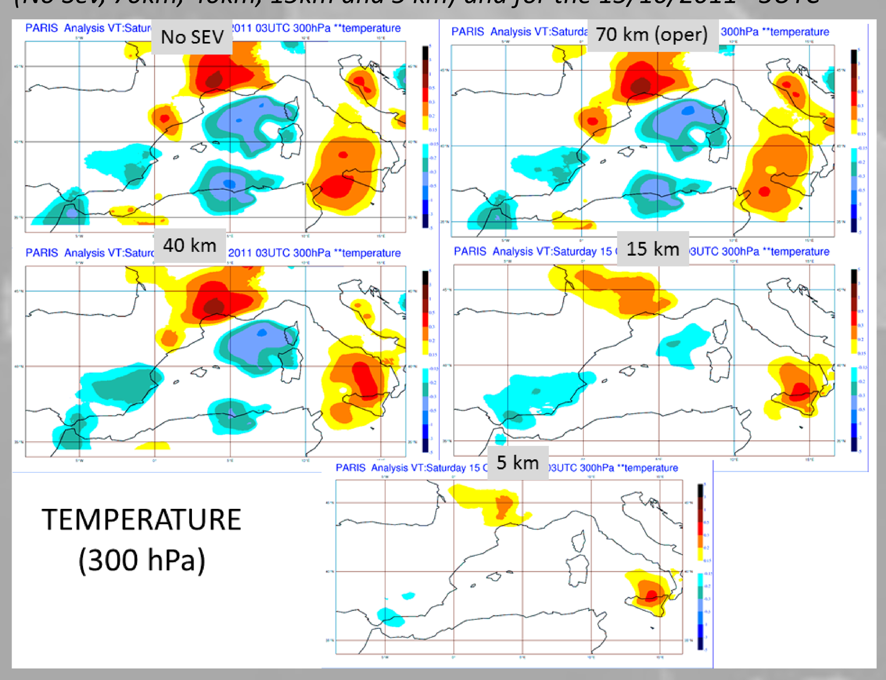
⇒ No obs. error correlation specified in the R matrix and σ_O are unchanged

<u>On the analysis increments (1st assimilation)</u>

- Computed increment analysis : T, Q, U and V (15/10/2011)

Comment : The higher the density of SEVIRI observation, the weaker the analysis increments (fig 4).

Fig 4: Analysis Increments for temperature (300hPa) in 5 experiments (No Sev, 70km, 40km, 15km and 5 km) and for the 15/10/2011 - 3UTC



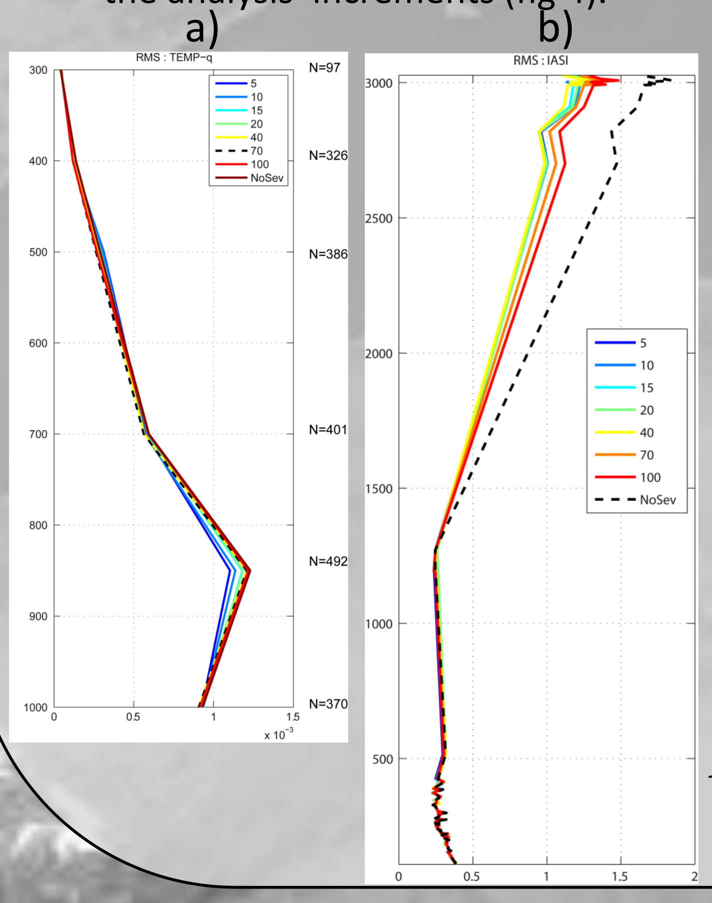


Fig 5: RMS for the first-guess departures for a) radiosounding data of humidity and b) IASI observations ty. N is the number of used observations.Results are for 2 days of assimilation (17-18th of October)

<u>On the fit to other observations</u>

- As expected, the analysis fits less the other observations.
- The impact on first-guess (FG) departures for radiosounding temperature is neutral (not shown).

However, the FG departures are improved for the wind and the humidity with regard to radiosounding wind data (fig 5) humidity data (fig 6a) and IASI water vapor channel observations (fig 6b).

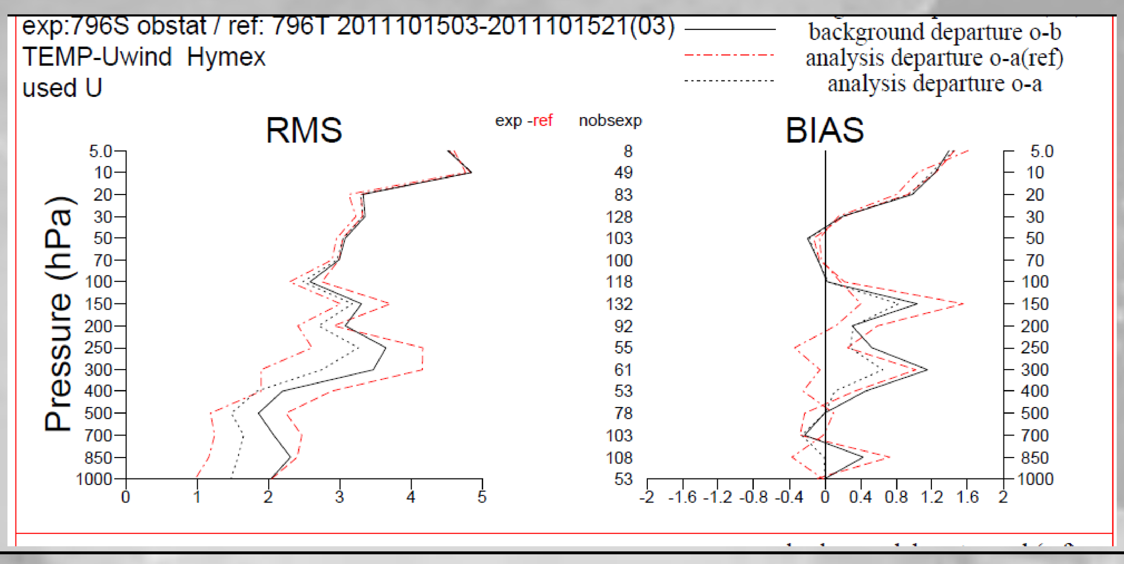


Fig 6: RMS for the first-guess and the analysis departures for used U-Wind radiosounding data in Exp 5km (796S) and Exp 15km (796T). Results are averaged over 7 cycles of assimilation.

5. Obs. Error modelisation

Error stdev estimated by Desroziers's method (2005)

Full resolution SEVIRI WV channel observations to diagnose error

Mains assumption : The weight given to the observation in the assimilation system is consistent with the true error covariances.

Comment: For SEVIRI WV channels, the method can provide full R matrix

Preliminary results:

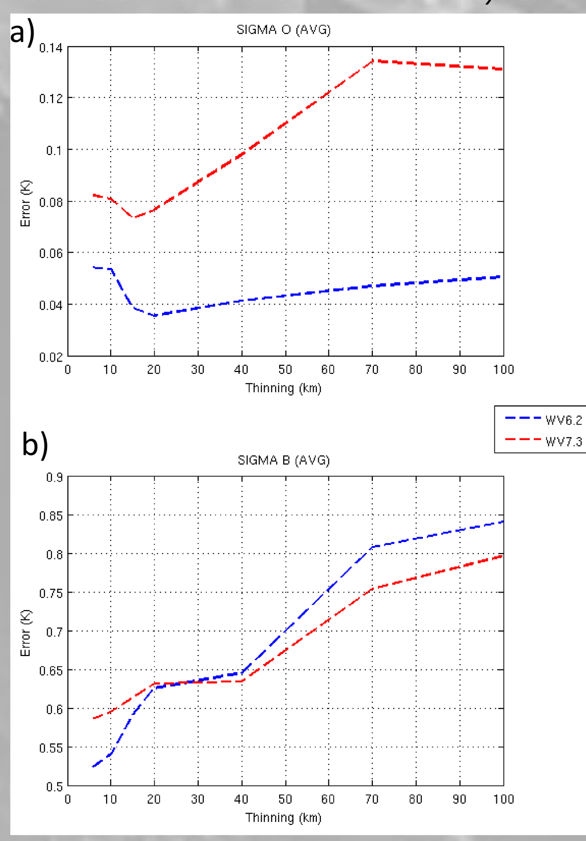
- Significant correlations in observation errors is suggested in Fig 7a for observation distances < 70 km (sigma O decrease).

BUT,

- The background errors are even reduced for observation distances < 70km (fig 7b).

⇒ This result suggests that the assimilation of correlated error obs. can improve the background (if Lb is short).

Fig 7 : Averaged estimated stdev a) observations errors (σ_o) and b) background errors (σ_b) using the Desroziers's method over 8 assimilation cycles



Other results : **Covariance estimated by Hollingsworth-Lönnberg (1986)** give misleading results for instance.

Conclusions and plans

The aim of this work was to enhance density of assimilated radiances using available data (SEVIRI/ IASI) and simulated data (MTG-IRS). Using a one-dimensional study, the interaction between observation density and analysis error has shown that in meso-scale models, observation intervals could be reduced to 10 km (20 km) if correlations are (not) specified. 2 diagnostics have been applied to better characterize observation errors. The presence of correlated observation errors was highlighted if observation are used too densely (inter-distance lower than 20 km). In the real-size system (AROME-WMED), it has been shown that, without any changes in observation error specification, the analysis is closer to the First-Guess. The fit to other observations do not indicate systematic degraded statistics even if the analysis is significantly modified.

These preliminary results are encouraging but need more diagnostics and more observations for the validation. To evaluate the future benefits of MTG-IRS, this study also needs further test to understand effects of inter-channels error correlation over the analysis (using IASI observations as proxy, Guidard et al., 2011). Following results from the one-dimensional study, some feasibility study are on the way to model a non-diagonal R matrix taking account of spatial and inter-channel correlations. Then, within the framework of an OSSE (Observing Simulated System Experiment), future benefits of simulated MTG-IRS in meso-scale model would be evaluated. Several case study of heavy precipitation events as the one of the 24th of October will be intensively studied.

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