The assimilation of SEVIRI radiances into the COSMO Model

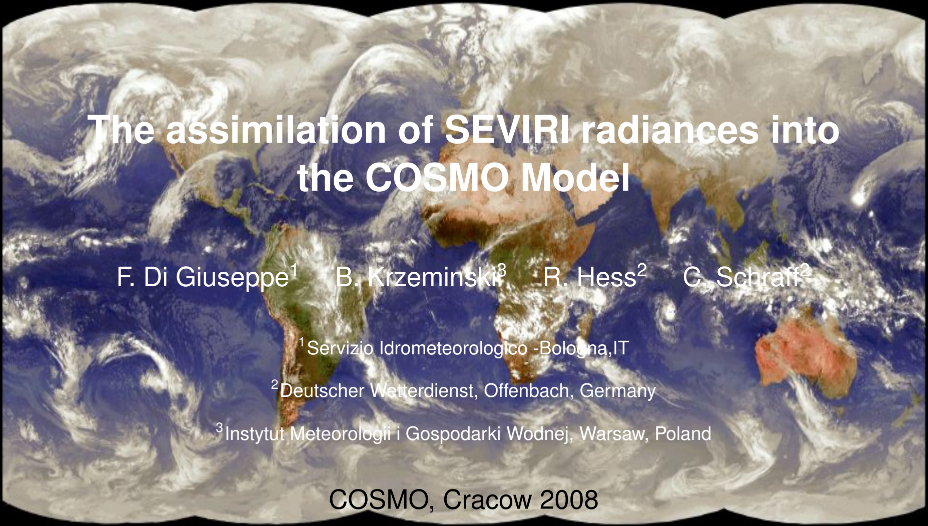
F. Di Giuseppe[1] B. Krzeminski[3] R. Hess[2] C. Schraff[2]

[1]Servizio Idrometeorologico -Bologna,IT

[2]Deutscher Wetterdienst, Offenbach, Germany

[3]Instytut Meteorologii i Gospodarki Wodnej, Warsaw, Poland

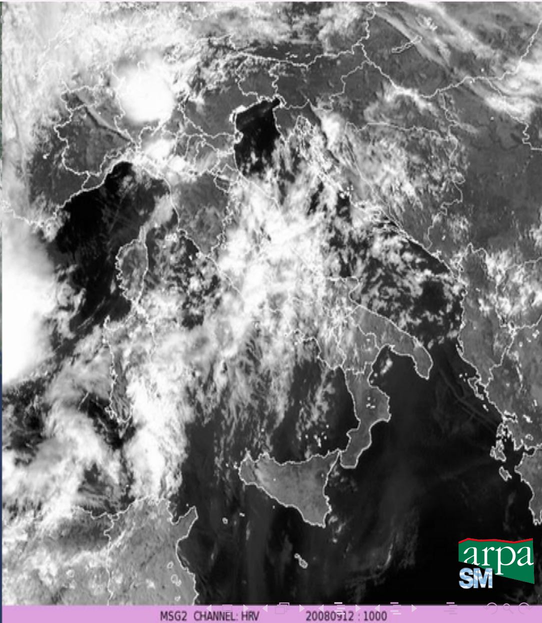
COSMO, Cracow 2008



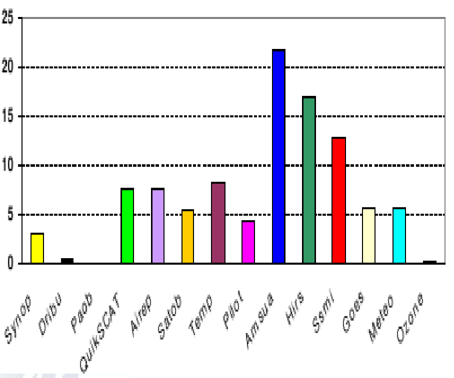
18th January 2005 at 15:00 GMT

World Cloud Map

Why bother with geostationaly satellite?

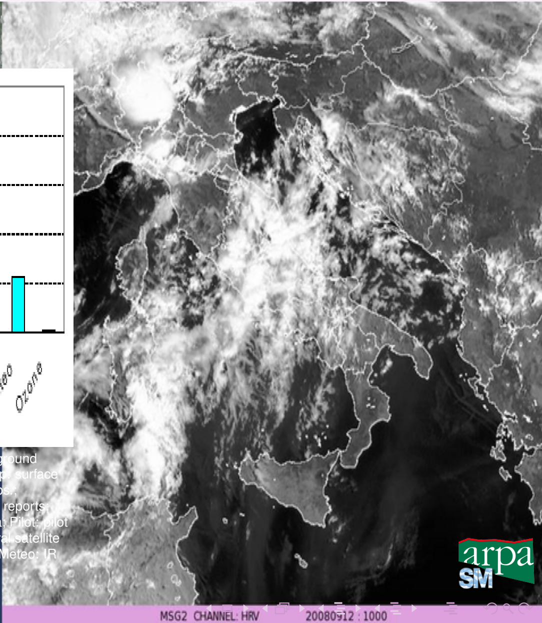


Why bother with geostationaly satellite?

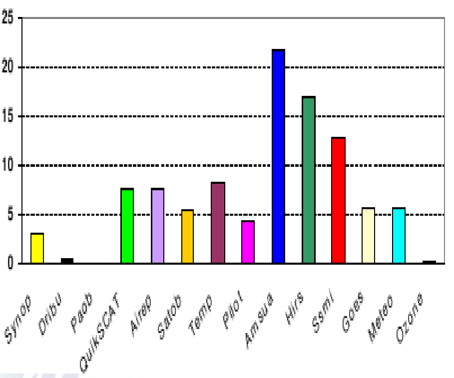


Global influence (%) of satellite and in situ observations on background analysis when assimilated by the ECMWF 4-D Var system. Synop: surface obs; Dribu: drifting buoys; Paob: Southern Hemispheric bogus obs.; QuikSCAT: scatterometer sea-surface winds; Airep: com. aircraft reports; Satob: satellite Geo./MODIS winds; Temp: radiosondes, land/sea; Pilot: pilot balloons; Amsua: AMSU temp./r.h. soundings; Hirs: hyper-spectral satellite soundings; Ssmi: microwave soundings/surface.wind; Goes and Meteo: IR soundings; Ozone: radiative characteristics

courtesyofCarlaCardinali , ECMWF



Why bother with geostationaly satellite?



Global influence (%) of satellite and in situ observations on background analysis when assimilated by the ECMWF 4-D Var system. Synop: surface obs; Dribu: drifting buoys; Paob: Southern Hemispheric bogus obs.; QuikSCAT: scatterometer sea-surface winds; Airep: com. aircraft reports; Satob: satellite Geo./MODIS winds; Temp: radiosondes, land/sea; Pilot: pilot balloons; Amsua: AMSU temp./r.h. soundings; Hirs: hyper-spectral satellite soundings; Ssmi: microwave soundings/surface.wind; Goes and Meteo: IR soundings; Ozone: radiative characteristics

courtesyofCarlaCardinali, ECMWF

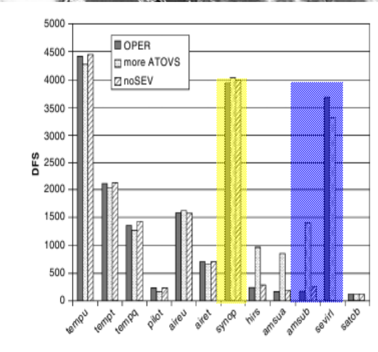


Figure 6. DFS values per observation type for *OPER*, *moreATOVS* and *noSEV*.

Montmerle et al., QJRMS, 2007

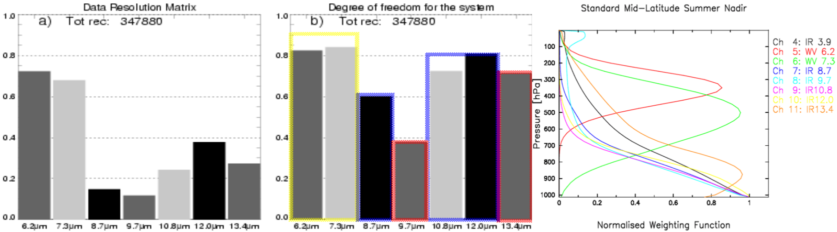
- SEVIRI has the same impact as synop
- SEVIRI has more impact than Amsu-a,b

MSG2 CHANNEL: HRV 20080912 : 1000

Outline

Channel Selection

DFS: measures how much a channel in *isolation* is able to reduce the model error defined by **B** in the observational space $DFS = \frac{\mathbf{h}^T\mathbf{B}\mathbf{h}}{1+\mathbf{h}^T\mathbf{B}\mathbf{h}}$
DRM: The DRM uses **A** to estimate which is the most useful channel in the analysis between *all* the ones used.



- The O_3 gas monitoring channels at 9.7μm blacklisted because large inaccuracies in the radiative transfer simulation are expected
- The 13.4μm blacklisted for persistent bias correction problems.

Analysis data period

1-20 September 2006

Bias Correction

Air-Mass dependent bias:

Multi-linear regression coefficients based on 4 predictors:

1. 900hPa-700hPa thickeness
2. 200hPa-50hPa thickeness
3. integrated total water mixing ratio
4. T_{2m}

Coefficients dependent on weather regimes - updated Seasonally

Bias Correction

Air-Mass dependent bias:

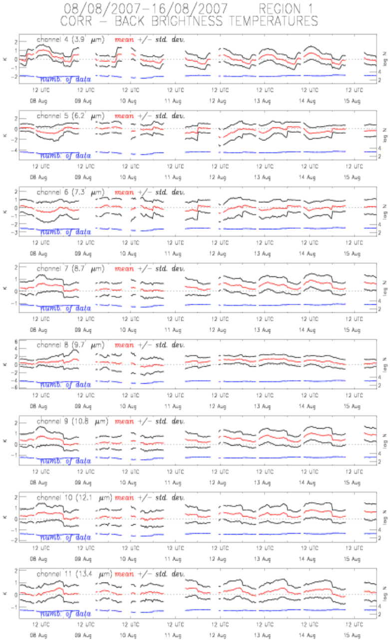
Multi-linear regression coefficients based on 4 predictors:

1. 900hPa-700hPa thickeness
2. 200hPa-50hPa thickeness
3. integrated total water mixing ratio
4. T_{2m}

Coefficients dependent on weather regimes - updated Seasonally

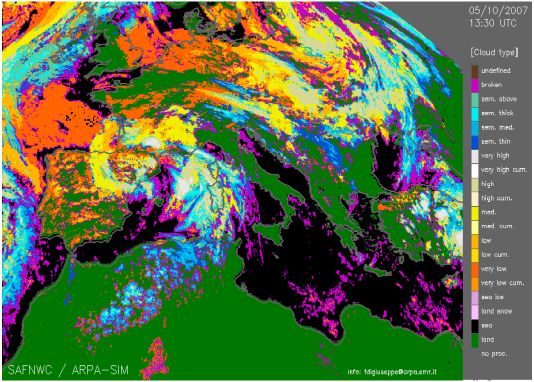
Scan-Angle dependent bias:

Negligible for geostationary satellite



Cloud detection

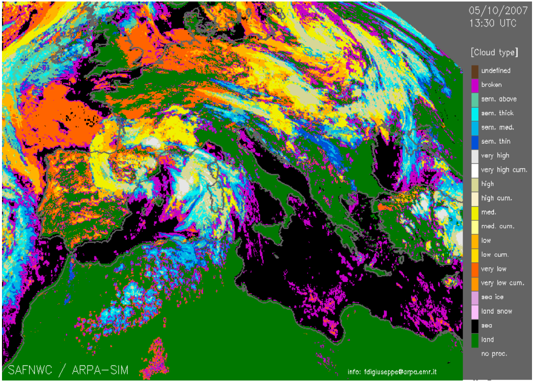
Only cloud-free observations over sea points are used.



Cloud detection scheme based on a multi-spectral threshold technique
SW from SAFNWC (Satellite Application Facility to support NoWCasting and very short range forecast)

Cloud detection

Only cloud-free observations over sea points are used.

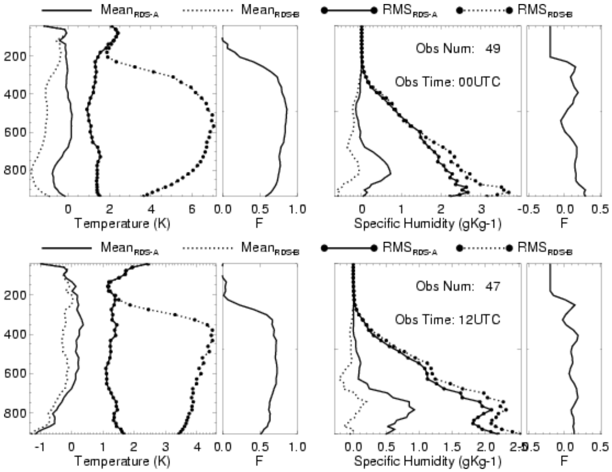


Cloud detection scheme based on a multi-spectral threshold technique
SW from SAFNWC (Satellite Application Facility to support NoWCasting and very short range forecast)

Extra quality checks: Pixels discarded:

- Pixels whose background profiles possess saturated mixing ratio values
- $BT^{obs}_{10.8\mu m} - BT^{bg}_{10.8\mu m} < 3K$

Radiosound Comparison



$$F=(RMS_{RDS-B} - RMS_{RDS-A})/RMS_{RDS-B}$$

Analysis data period

(1- 20 September 2006)

Case Study

1. *False allarm case:* 8th of July 2004
False alarm occurred in North North-Eastern Italy, Trentino Alto Adige and Friuli-Venezia-Giulia. A risk scenario was diagnosed by LM outputs. In particular a large atmpspheric instability and convection events were forecasted. In reality the event was of minor intensity and drier winds with associated scattered thunderstorms were recorded only on the early morning of the 9th July.
2. *Heavy precipitation case:* 9th April 2005
Missed forecast of heavy precipitation in the liguria region. Typically produced by south-westerly up-stream flow due to orographic forcing

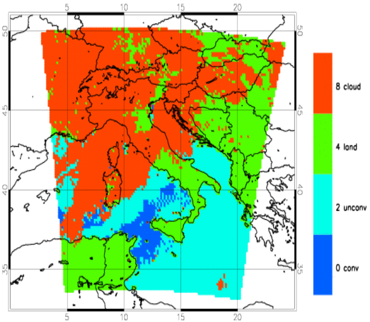
Flag Processing

MSG1 field : flg_prc

number of points : 13380

number of good points (i.e. where flg_prc has value 0): 466

date : 20040708 11:30 UTC



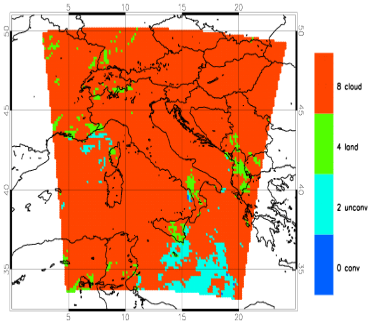
ASSIMILATION CYCLE : +11 hrs and 30 mins

MSG1 field : flg_prc

number of points : 13380

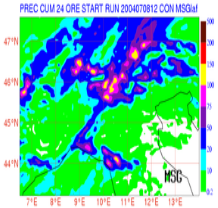
number of good points (i.e. where flg_prc has value 0): 6

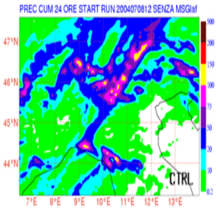
date : 20050409 20:45 UTC

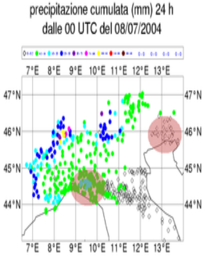


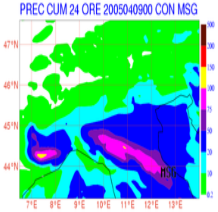
ASSIMILATION CYCLE : +8 hrs and 45 mins

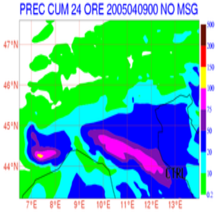
Precipitation forecast

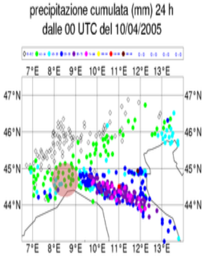






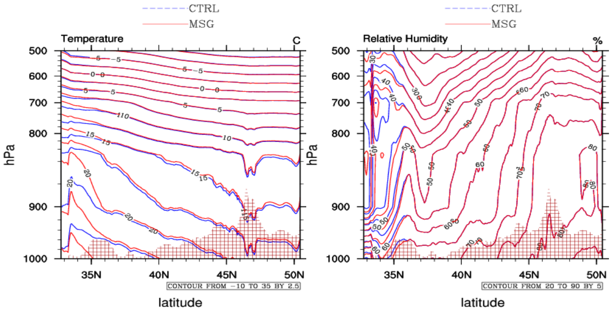






Zonal Mean Temperature and Humidity

8 days zonal mean at +24 fc time



- Very smooth increments (mostly due to smooth error covariance matrix) $->$Better model error specification required !!!
- effect only over sea (radious of influence set to around 50 km)
- increase in temperature and decrease in relative humidity should be only for non cloudy pixels. Dry increments can be spread over cloudy region. Nudging lacks a safety switch for this.

Model error specificaion: some step forward

To improve the convergency rate of 1DVAR profiles and the realism of the retrieved profiles, **B** should:

- depend on weather regimes
- be scale-dependent

In regional models we could separate:

Large scale errors (at driving model resolution) due to uncertainties in initial and boundary conditions;

Small scale errors (at model resolution) due to regional model errors.

B matrix calculations

Traditional approaches for estimating the background error covariance are built on background climatology (flow-independent)

- The Hollingsworth and Lönnberg (1986) method. Calculates the spatial covariance of differences between observations and the background.
  - (+) it is a direct diagnosis of background error covariance.
  - (-) it requires a uniform set of unbiased observations with spatially uncorrelated error.
  - (-) it only produces statistics for observable
- The NMC method (Parrish and Derber,1992). Calculates the spatial covariance of differences between 48h and 24h forecasts verifying at the same time.
  - (+) it is straightforward to calculate the required global statistics.
  - (-) it assumes that the statistical structure of 48h forecast error is similar to that of background error.
- The analysis–ensemble method.

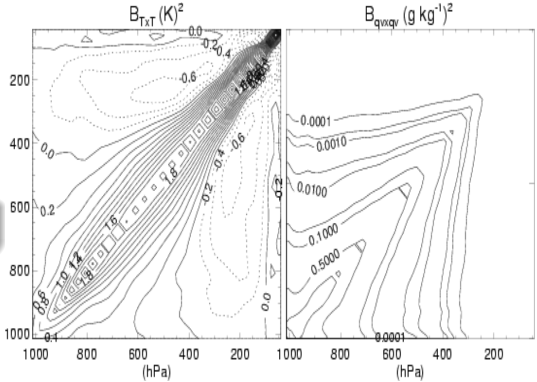
  Calculates statistics from pairs of backgrounds generated from perturbed analysis after few days from the initialisation.
  - (+) the effect of model error may be represented by introducing random perturbations to the physical parameterisations used in the assimilating model

Climatological B calculation

B: NMC method forecast comparisons at +12h and +36h averaged over four months worth of data

Analysis data period

(1 June -30 September 2006)



B dependent on weather regimes - Now it is updated seasonally but ideally should be Flow-dependednt

Road-map for a new approach using COSMO-SREPS

WHAT: Develop a simple technique to account both for the **time-dependent** and **space-dependent** components of the model error.

Road-map for a new approach using COSMO-SREPS

WHAT: Develop a simple technique to account both for the **time-dependent** and **space-dependent** components of the model error.

- The **time-dependency** is accounted for by calculating **B** at the beginning of each assimilation cycle
- The **space-dependency** is accounted for by a localization procedure

HOW:

Road-map for a new approach using COSMO-SREPS

WHAT: Develop a simple technique to account both for the **time-dependent** and **space-dependent** components of the model error.

- The **time-dependency** is accounted for by calculating **B** at the beginning of each assimilation cycle
- The **space-dependency** is accounted for by a localization procedure

HOW:

- Use a multi-analysis model-perturbed ensemble system to identify areas of homogeneous spread ("island") where model errors are likely to be homogeneous.
- Calculate flow-dependent **B** matrices inside the selected islands.

Road-map for a new approach using COSMO-SREPS

WHAT: Develop a simple technique to account both for the **time-dependent** and **space-dependent** components of the model error.

- The **time-dependency** is accounted for by calculating **B** at the beginning of each assimilation cycle
- The **space-dependency** is accounted for by a localization procedure

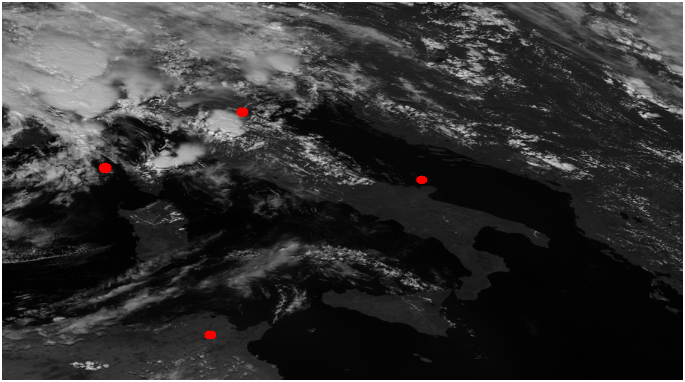
HOW:

- Use a multi-analysis model-perturbed ensemble system to identify areas of homogeneous spread ("island") where model errors are likely to be homogeneous.
- Calculate flow-dependent **B** matrices inside the selected islands.

WHERE:

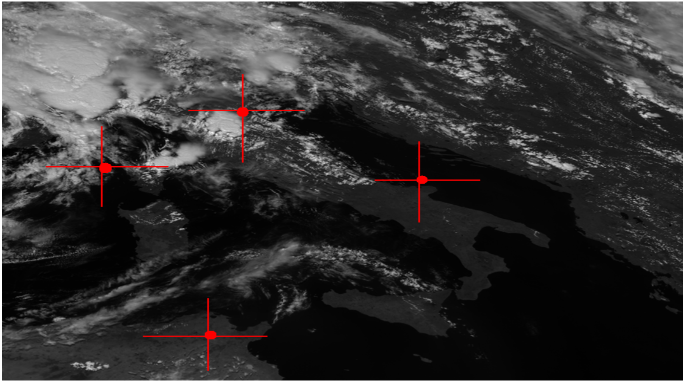
The new estimation of error covariance matrices are used to improve 1D variational retrieval of temperature and humidity profiles from MSG-SEVIRI radiances which are then assimilated into the nudging scheme of the regional model COSMO

Sketch of the methodology



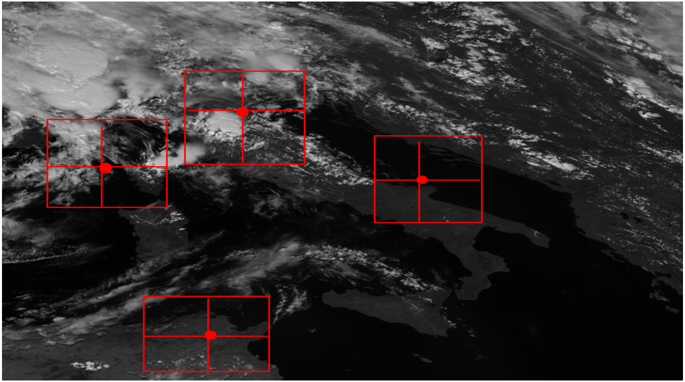
A two dimensional input spread field is computed: points with *spread* $>$ *percmax* are identified as central points for possible islands.

Sketch of the methodology



Then, the search for the island borders proceeds from this point in each of the four cardinal directions until the spread field reaches a value lower than *percmin*

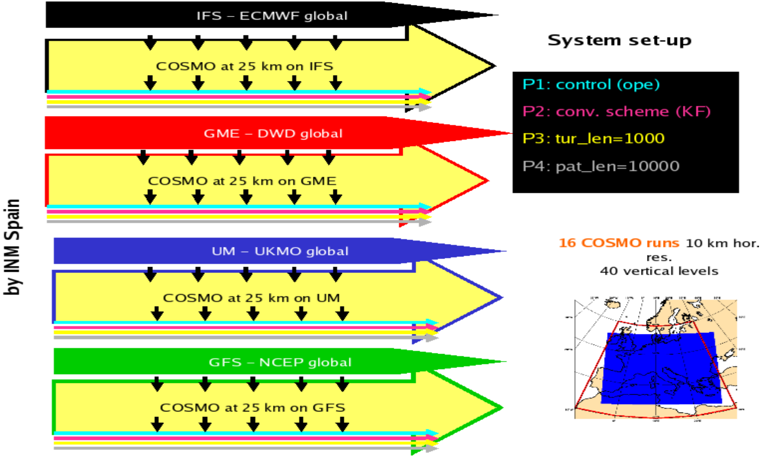
Sketch of the methodology



... the island is completed by filling a rectangular shape

COSMO-SRPES

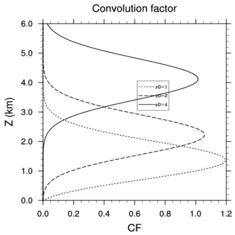
4 Global models drive 4 configuration of the regional model COSMO
→ both errors in BC/IC and in the regional model are considered



The ensemble spread index (ESI)

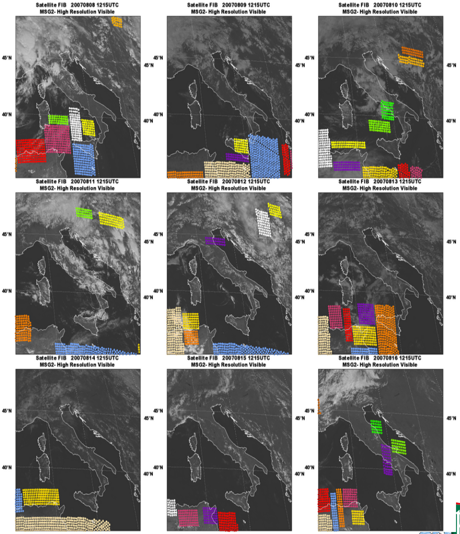
The ensemble spread index (ESI) is computed in terms of temperature and specific humidity on model levels (80 fields) by

1. calculating the departure of each ensemble member from the ensemble mean
2. normalising the departures of the different variables
3. convolving the departures with a vertical weighting function to obtain a unique integrated spread field.

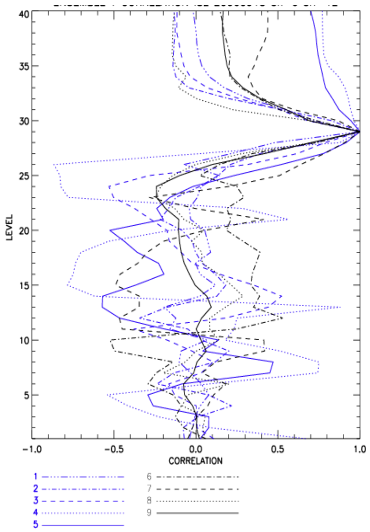


Validation framework

- Period: 9 days 8 – 16 of August 2007
- Two **B** calculations:
  - CFIX: NMC methods for the JJA period
  - EISL: island method using +12h FC time ensemble outputs
- only observations inside the island are retrieved to maximise the impact on the retrieved profiles

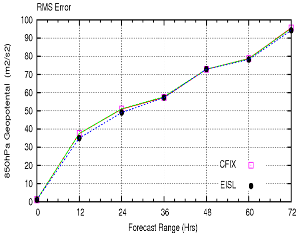


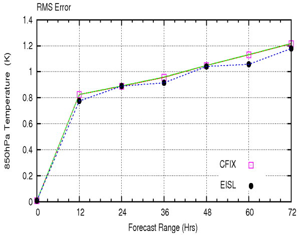
B matrix columns



Ensemble error matrix correlation at around 850 hPa height for a sample of islands compared to the climatological calculation.
Sharper features are clearly visible in the EISL experiment.

Impact on forecast





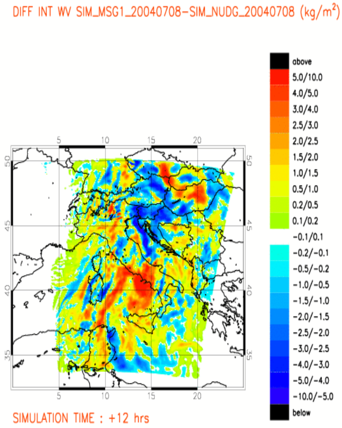
Geopotential height and temperature scores at 850 hPa
Forecast scores (forecast vs analysis) for the two experiments at different forecast time.
Slight improvements in the forecast scores

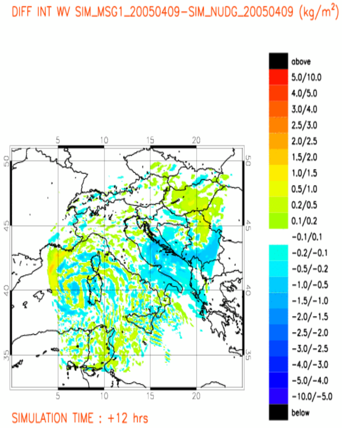
Conclusion

- *On the system set-up :*
  1. Large inpact provided by the WV channels
  2. IR window channels can be used (all of them for robusteness of the system) if good knowledge of ground temperarure.
  3. Preliminary test have shown positive inpact in precipitation forecast
  4. Still needed some sensitivity tests to optimise the nudging coefficients
- *In general...* Expecially in regional model needs for assimilation over LAND and in CLOUDY conditions

Forecast increments

EXP-CTRL in column integrated water vapour at +12 hr FORECAST





Forecast increments

EXP-CTRL in column integrated water vapour at +36 hr FORECAST