Assimilation of IASI Data into the Regional NWP Model COSMO: Status and Perspectives

Marc Schwaerz, Reinhold Hess

German Weather Service (DWD), Offenbach, Germany

16th International TOVS Study Conference,
May 7 – 13, 2008

Outline

Outline

Outline

Outline

Outline

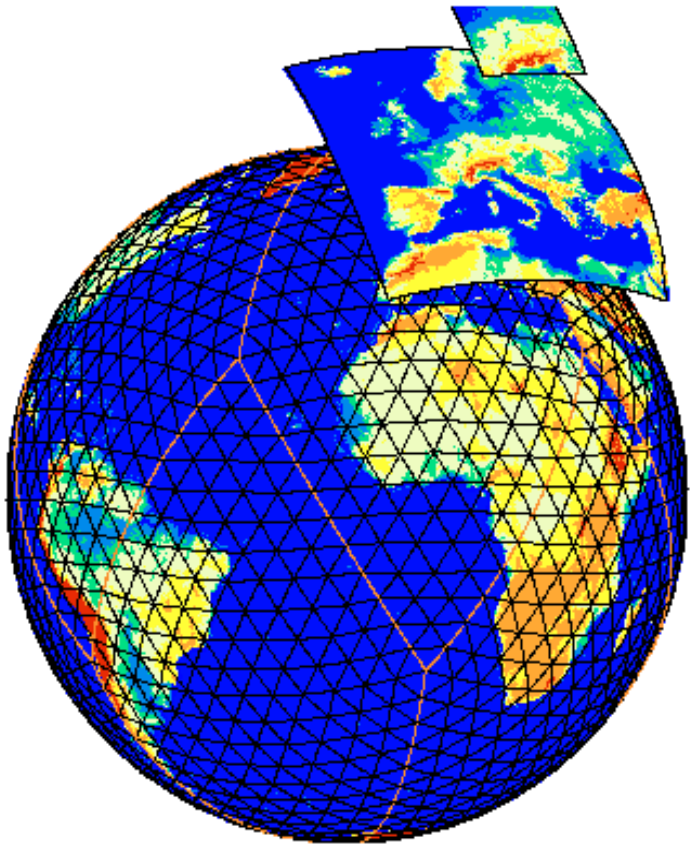
COSMO Project

COSMO Project

- **Co**nsortium for **S**mall-scale **M**odeling
- Germany*, Switzerland, Italy*, Greece, Poland*, Romania

  *: member of the project
- Work is done under the COSMO project:
  Assimilation of IASI data for the regional model COSMO with a continuous assimilation scheme
  My work is financed by a EUMETSAT fellowship and located at DWD, Offenbach, Germany.

Local Model COSMO-EU (lme)



nesting of the cosmo models into GME.

GME $\longrightarrow$ COSMO-EU $\longrightarrow$ COSMO-DE

COSMO

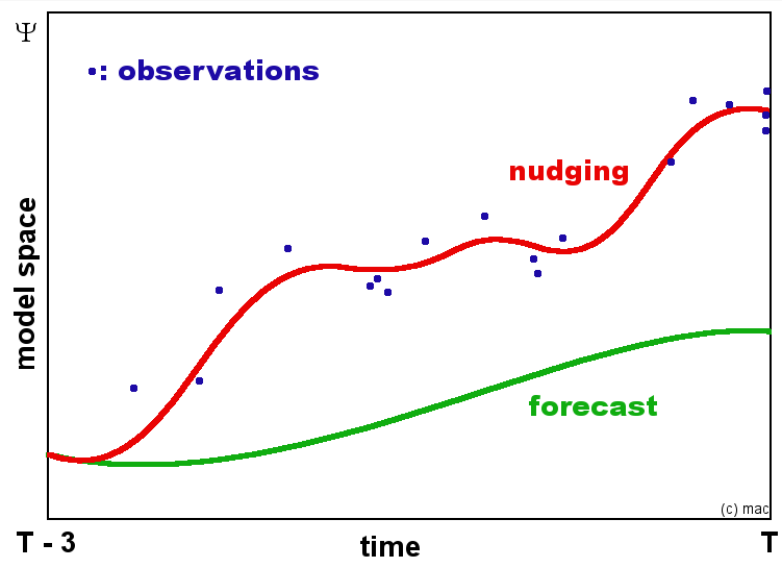
- non-hydrostatic regional model
- rotated latitude-longitude grid with mesh size 7 km
- hybrid vert. coord. grid with 40 layers up to 20 hPa
- forecast range: 78 h for inital times at 0 and 12.
- cloud ice and rain are prognostic variables
- boundary values from GME

analysis of COSMO-EU

analysis

- continuous nudging
- operational: conventional data: AIREP, AMDAR, ACARS
- variational soil moisture analysis
- cutoff: 2 h 30 min
- projects: usage of ATOVS and SEVIRI data via 1dvar scheme (by R. Hess, F. Di Giuseppe, C. Schraff, and B. Krzeminski)
- now: usage of IASI data via 1dvar scheme

assimilation scheme of COSMO-EU



influence of the observations on forecast process.

nudging approach (newtonian relaxation scheme)

- model trajectory nudged towards obs. at every time step.
- influence according to nudging weights depeding on:
- spatial distance
- temporal distance
- no direct usage of non-linear obs. possible
  $\Longrightarrow$ 1DVar scheme

nudging – pros and cons for limited area models

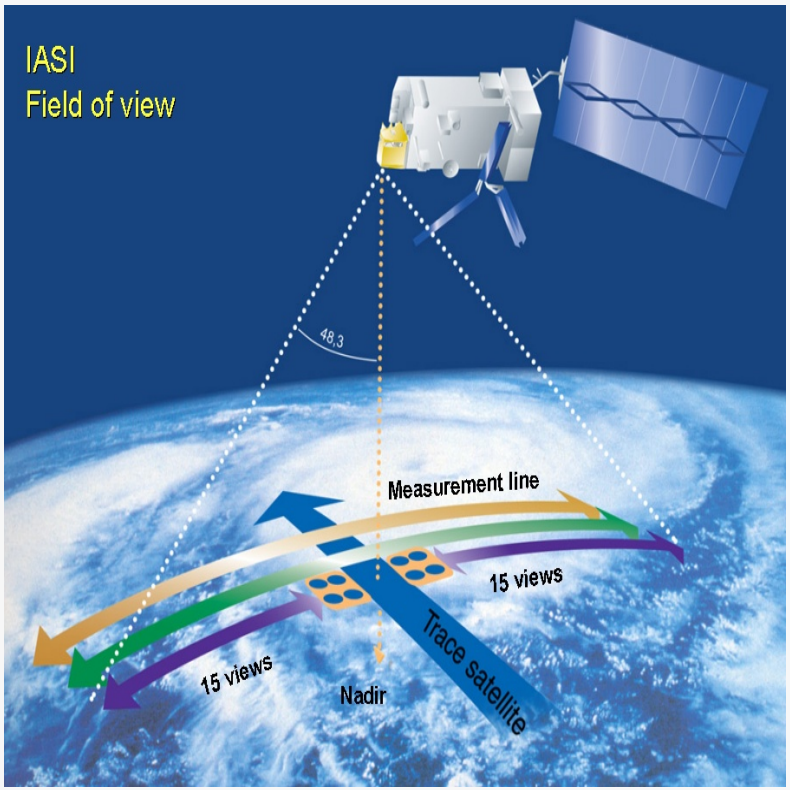
pros

- possible use of asynchronous and high frequent observations
- fast method – can provide a punctual forecast
- combination with ensemble methods is possible
- no initialisation required

cons

- no direct use of nonlinear observations (i. e., satellite obs.)
- no consistent mathematical framework why what is done
- lots of tuning is necessary

IASI – infrared atmospheric sounding interferometer



source: http://smc.cnes.fr/IASI/

IASI specifications

- spectral range: 645-2760 cm^{-1}
  15.5-3.6 μm
- 8461 channels
  separated into 3 bands
- spectral res.: 0.35 - 0.5 cm^{-1}
- radiometric res.: 0.25 - 0.5 K
- time needed for one scanline: 8 s
- pixel/views: 4
- views/scan: 30

EUMETSAT

Outline

Offline Data Preparation and Preprocessing

no background data is needed

- rough quality control step where in a first implementation the different IASI quality flags
- region selection (COSMO-EU region)
- only measurement pixles over sea via COSMO-EU land-sea mask
- selection of optimal channel subset – currently 300 gts channels are monitored
  and 122 are used for the minimization.

Preprocessing inside COSMO-EU

background data is needed

- bias correction (scan line and air-mass correction; c. f. below)
- cloud detection: currently the IASI Level 2 cloud flags are used; will be replaced by McNally and Watts (2003).
- quality control based on simple first guess check.

the forward model and 1DVar scheme

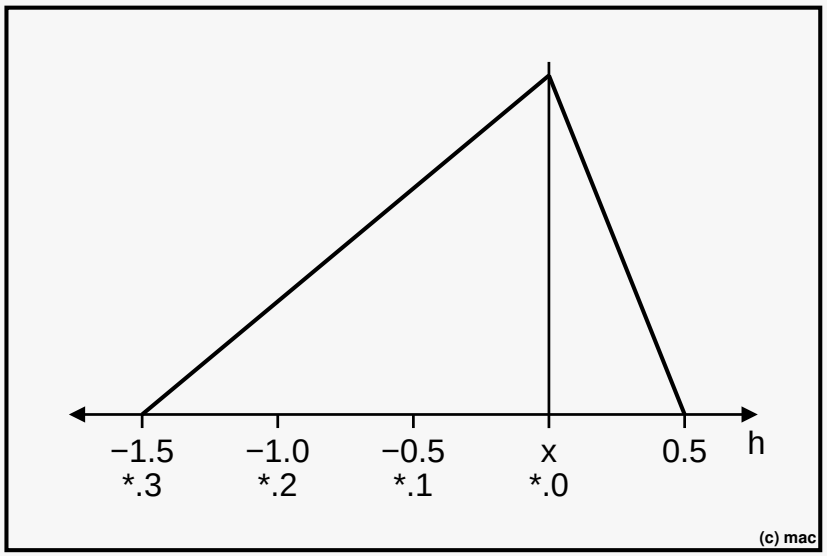
RTTOV9 - an overview

- simulation of the IASI measurements at 90 fixed pressure levels between 0.005 and 1050.00 hPa
- brightness temperatures $\mathbf{T}_B$ (or radiances, respectively).
- tangent linear and adjoint model to calculate jacobians, e.g., for $\mathbf{T}$, $\mathbf{q}$, $\mathbf{O_3}$, and SST - $\frac{\partial \mathbf{T}_B}{\partial \mathbf{T}}$, $\frac{\partial \mathbf{T}_B}{\partial \mathbf{q}}$, $\frac{\partial \mathbf{T}_B}{\partial \mathbf{O_3}}$, and $\frac{\partial \mathbf{T}_B}{\partial \mathrm{SST}}$

1-dvar algorithm

- implementation of algorithm prepared by NWP-SAF – based on Chevallier (2000).

nudging and *1DVar* – "nudgeVar"



influence of the nudging term which forces the model trajectory towards the obs.

nudging

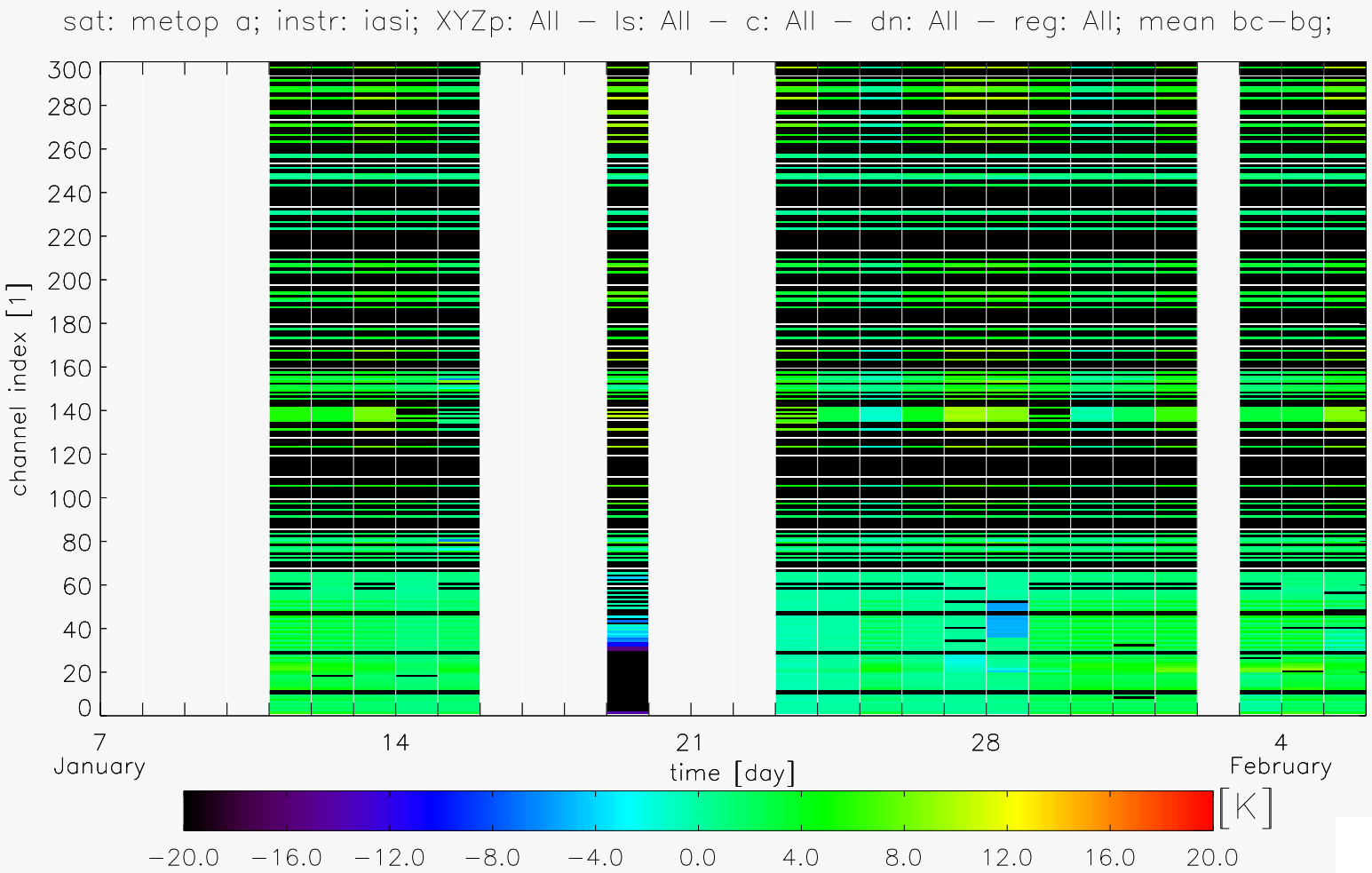
- nudging obs. 1.5 h before until 30 min after obs. time with temporal weighting depending on time difference to obs.
- preliminary retrievals are computed from 1.5 h before until 30 min after obs. time
- correlation between 1st guess and observation occures

bias correction

implementation of model dependend bias predictors after Harris and Kelly (2001)

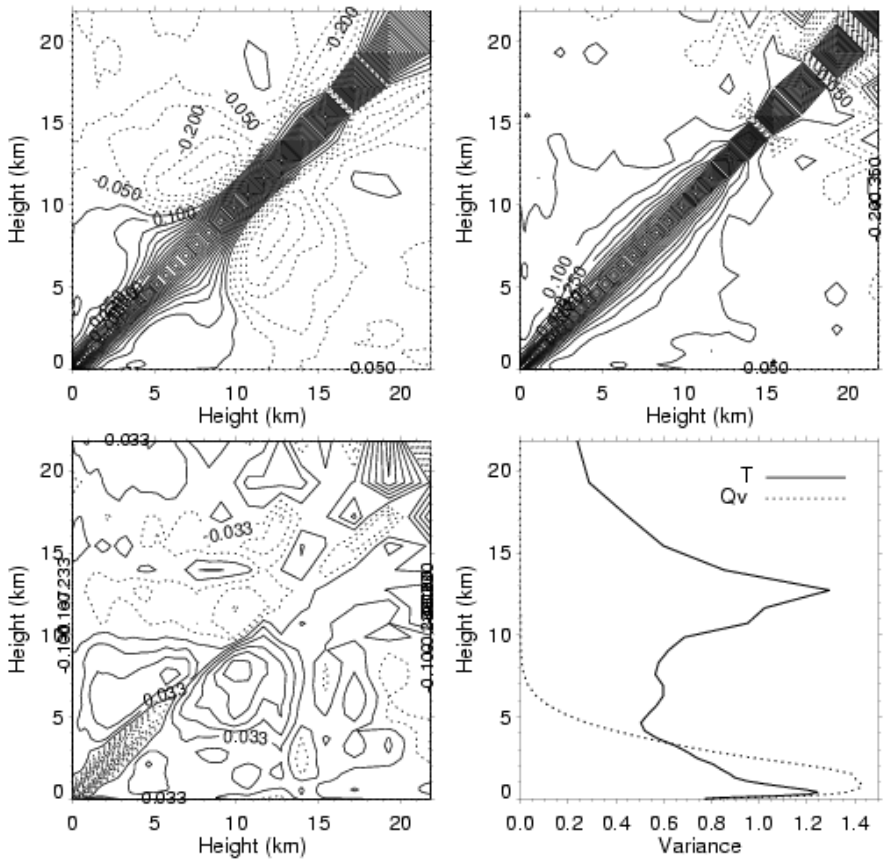
- very preliminary bias coeffs.
- cloud flagging using iasi Level 2 cloud flags at first step
- Predictors:
  - Layer thickness between 1000 hPa and 300 hPa
  - Layer thickness between 200 hPa and 50 hPa
  - surface temperature
  - total column water vapor

bias DNA plot



Observed minus bias corrected measurements for about one month of IASI data.

the *a priori* error covariance matrix



background error covariance matrices for temperature and humidity.

background error cov.

- calculated via NMC method
- using forecast comparisons between 12 h and 36 h forecast using an average over 3 month
  (by F. Di Giuseppe)

the measurement error covariance matrix

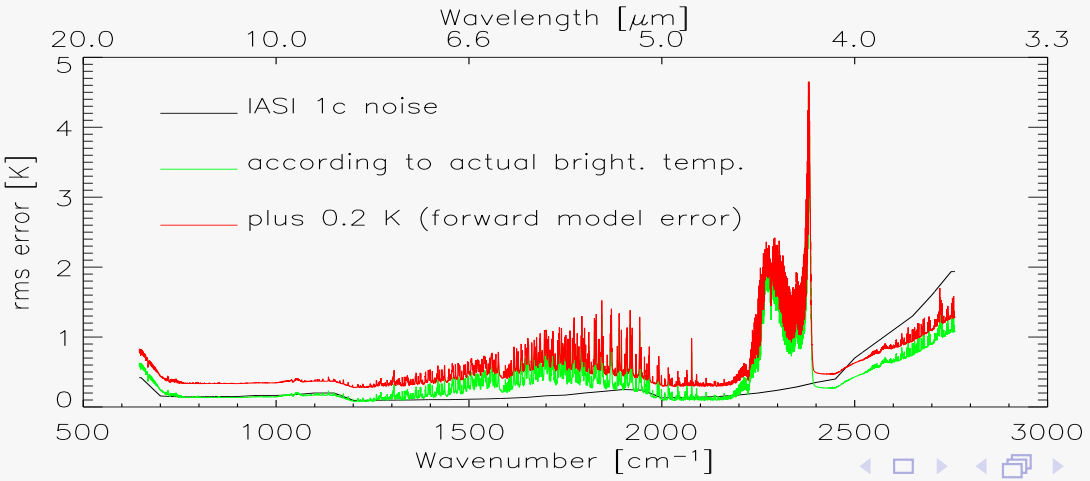
diagonal elements

- IASI level 1c noise values
- adapted to the actual brightness temperature
- +2 K forward model error + representativeness error

off diagonal elements

correlation of the three nearest neighbor channels:

1	0.75
2	0.25
3	0.04



the measurement error covariance matrix

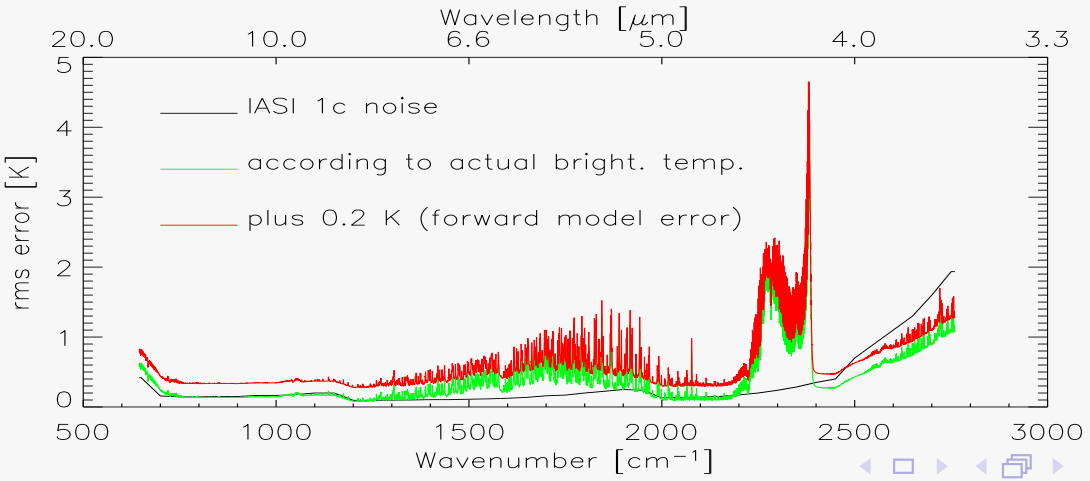
diagonal elements

- IASI level 1c noise values
- adapted to the actual brightness temperature
- +2 K forward model error + representativeness error

off diagonal elements

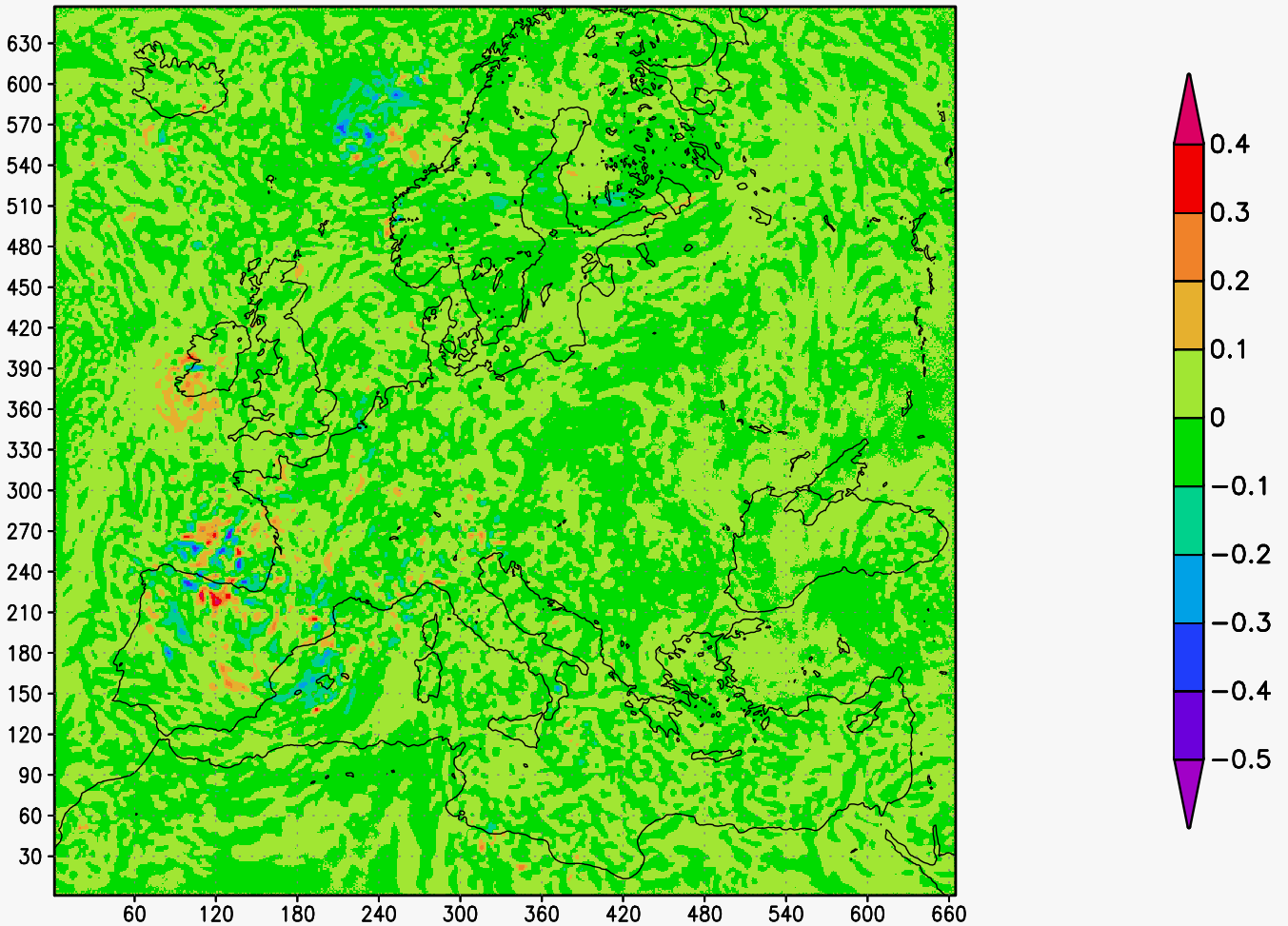
correlation of the three nearest neighbor channels:

1	0.75
2	0.25
3	0.04



Outline

analysis difference

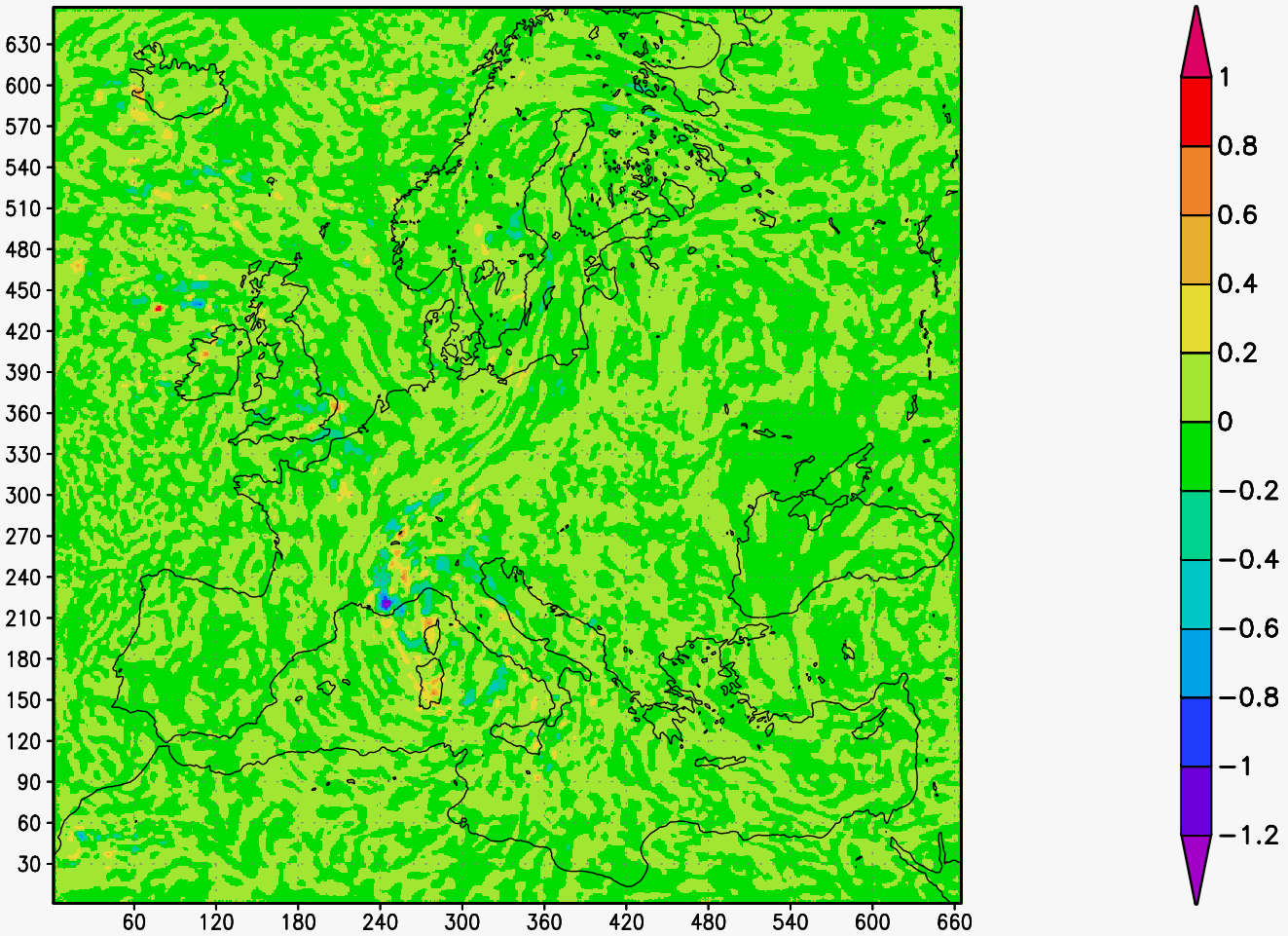


Analysis difference of 500 hPa temperature of the routine-run of COSMO-EU at DWD and the experiment where the IASI data were assimilated.

GrADS: COLA/IGES

2008-05-02-11:48

24 h forecast difference



24 h forecast difference of 500 hPa temperature of the routine-run of COSMO-EU at DWD and the experiment where the IASI data were assimilated.

GrADS: COLA/IGES

2008−05−02−14:50

Outline

Summary

Summary

- preprocessing has been implemented
- implementation of bias correction
- implementation of cloud detection
- implementation of RTTOV-9.0 beta
- start of preliminary experiment

Next Steps

Next Steps

- **Improvements:**
  - tuning of the error model
  - optimal setup for the profiles added at the top of COSMO-EU
  - investigation for an optimal subset of channels of the IASI spectrum
  - turning on of cloud detection scheme of McNally and Watts (2003)
- **next steps:**
  - comparison between *1DVar* scheme and IASI Level2 Product in the assimilation process.
  - inclusion of cloudy observations
  - testing the applicability of IASI measurements over land

Thank You!

International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.