Assimilation of Geostationary WV Radiances within the 4DVAR at ECMWF

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Assimilation of Geostationary WV Radiances within the 4DVAR at ECMWF

- Introduction
- Observation quality: METEOSAT WV radiances
  - Calibration
  - Solar stray light & Cloud contamination
- Assimilation : clear-sky water vapour radiance
  - Changes to humidity and wind fields
  - Verification
- Conclusions & future issues

Introduction: Why use geostationary WV radiances ?

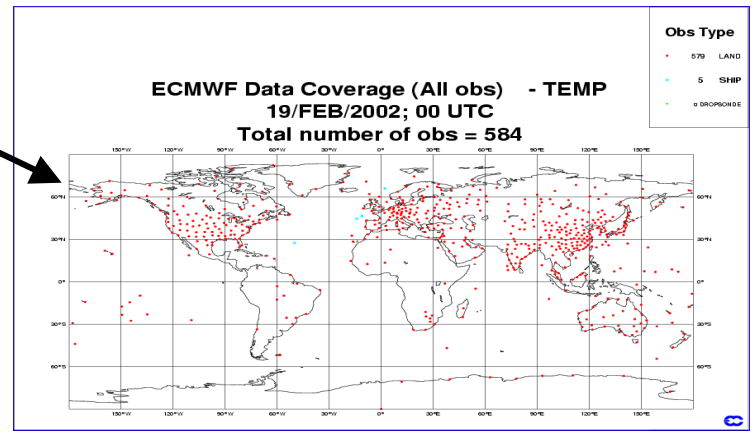
- Only few observations control upper tropospheric humidity

  Radiosondes

  HIRS-12 radiances

  (AMSU-B : not assimilated)

  (SSM/I : IWV only)



- 4DVAR can exploit information on movement of WV structures → information on wind field

→ Geostationary satellites provide UTH at high time resolution

Introduction: Why use geostationary WV radiances ?

- Preparation for future geostationary instruments :

  e.g. MSG

  GIFTS

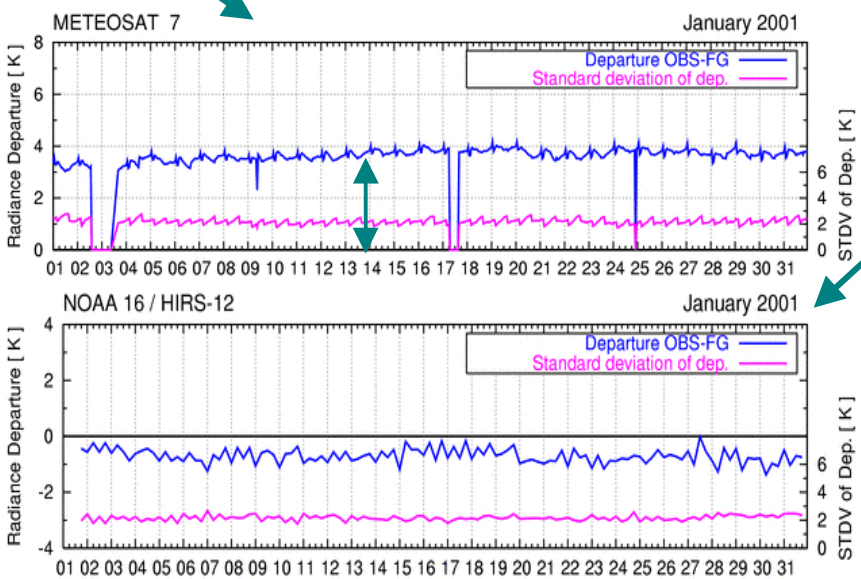
The data: Geostationary Clear - Sky Radiances (CSR)

- METEOSAT (EUMETSAT)
  GOES (currently CIMSS / soon from NESDIS)
- Hourly imager data
- Resolution (data volume !) $\rightarrow$ Area averages
  METEOSAT : $16 \cdot 16$ pixels $\approx$ $80 \cdot 80$ km^2
  GOES : $11 \cdot 17$ pixels $\approx$ $45 \cdot 45$ km^2
- Cloud detection :
  METEOSAT: Histogram analysis (IR, WV, VIS in $32 \cdot 32$ segments)
  GOES : Multispectral threshhold method (per pixel)
- CSR is a clear-sky area averaged radiance

Observation quality : 1) Calibration

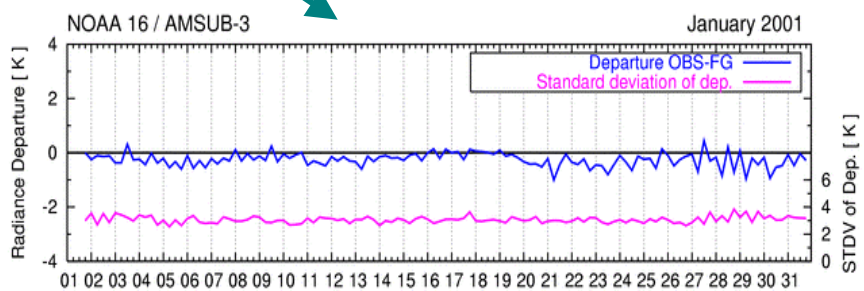
- Operational monitoring : CSR versus model First Guess
- Validation of RT - model : RTTOV Bias for MET WV ≈ -0.8 K (Matricardi et al., 2001)
- Comparison to other instruments : HIRS, AMSU

MET-7 ≈ 3.8 K



HIRS-12 (in MET-7 area) ≈ -0.7 K

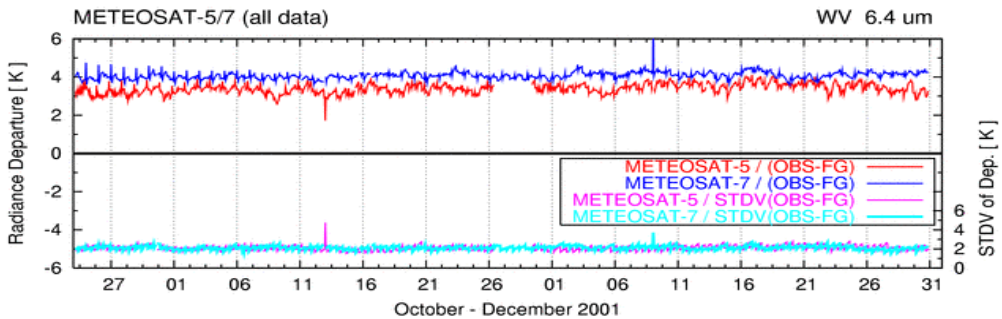
AMSUB-3 (in MET-7 area) ≈ -0.3 K



Observation quality : 1) Calibration (cont'd)

- Comparison to other instruments :

  METEOSAT ↔ GOES



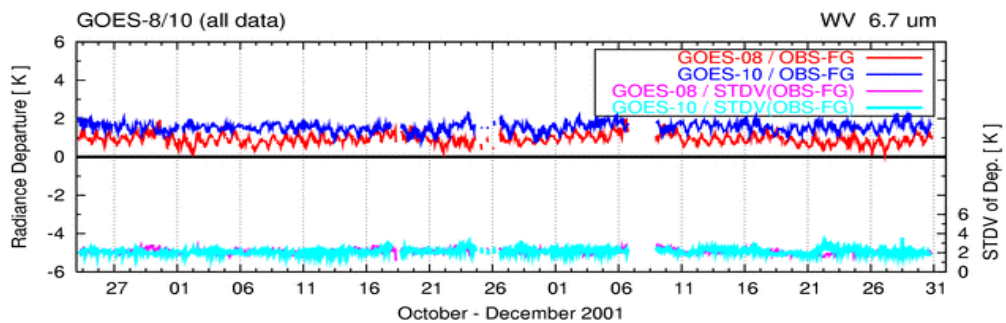
MET-7 ≈ 4 K

MET-5 ≈ 3.2 K

(RTTOV error≈ -0.8 K)

GOES-10 ≈ 1.5 K

GOES-8 ≈ 0.8 K



➡ METEOSAT WV channel probably biased warm ≈ + 2.5 - 3 K

Bias correction needed

Observation quality : 2) Solar Stray Light

- Solar stray light may intrude into radiometer

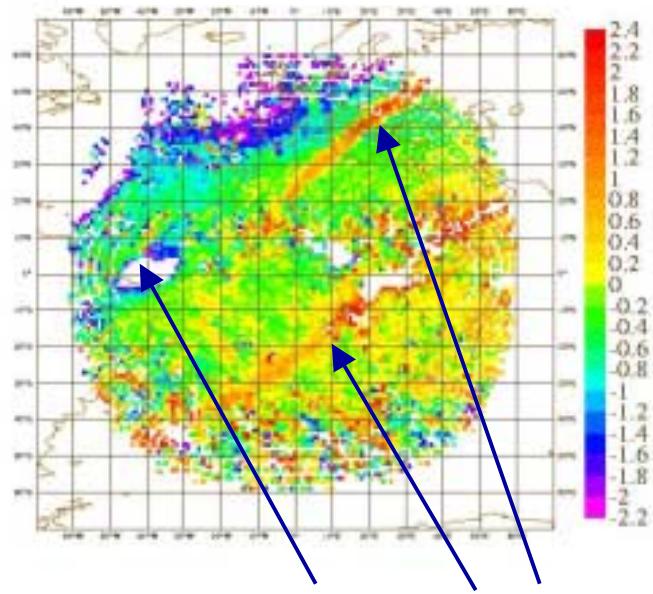
  Strongest effects during eclipse

- Monitoring shows that small effects are present throughout the year

- Local anomalies in WV channel : 2 ... 30 K

- Documented in Köpken, Fellowship Rep. 10, 2001

Example :
Mean OBS diff. 01 - 00 UTC
(Average 15-17 Aug 2000)



Warm spots & bands
at 00 and 01 UTC

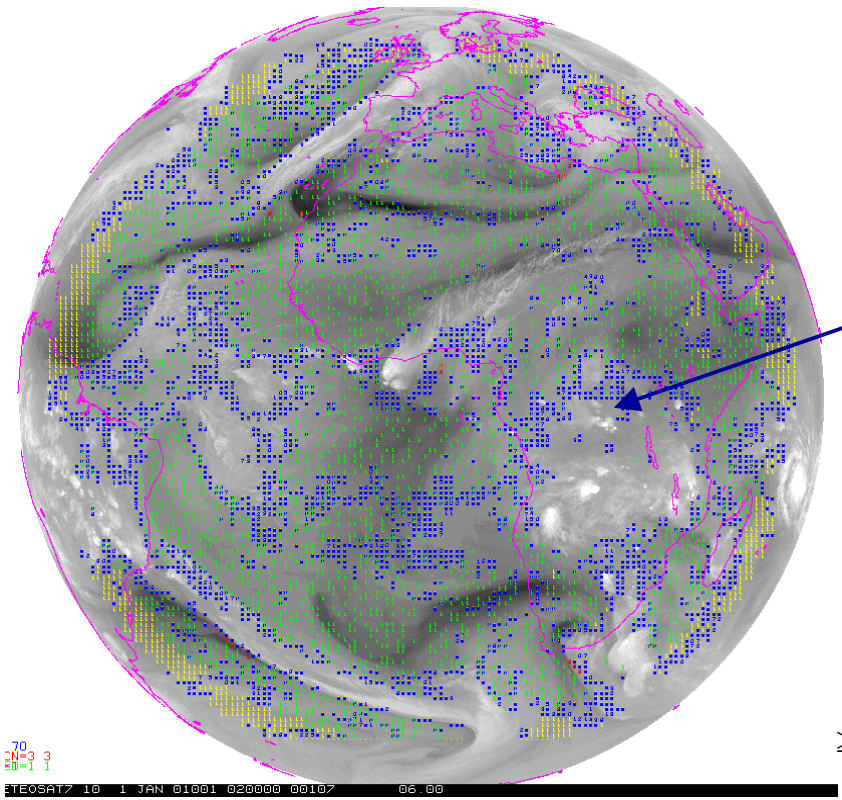
➡ Exclude contaminated data from assimilation

Observation quality : 3) Cloud contamination in CSR

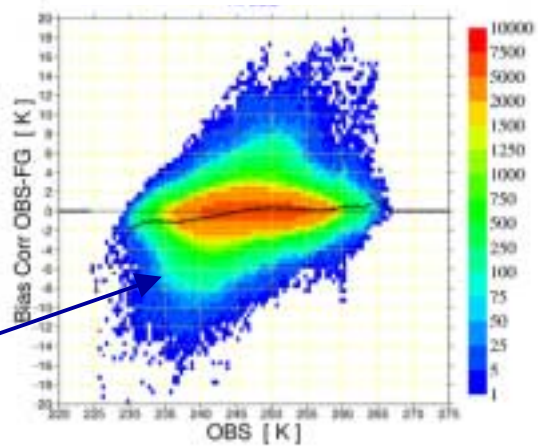
- Some cloud contamination present in clear-sky radiances

Blacklisting : Possible cloud contamination

Large viewing angles

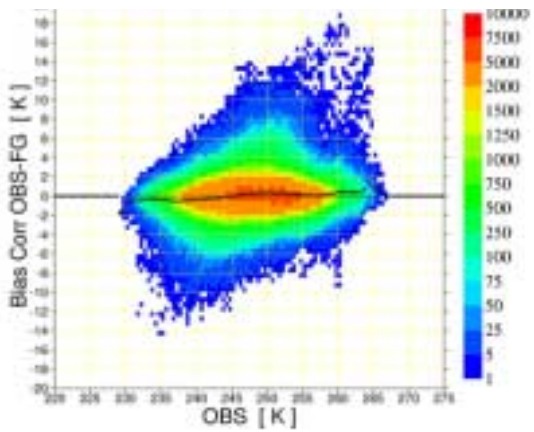


All data



Data passing blacklisting

≥ 70% clear pixels



Assimilation Experiments : Setup

Several assimilation experiments run at operational resolution :

Model / Analysis increments : T511/T159 ≈ 40 km / 125 km

- Assimilation of METEOSAT-7 water vapour radiances

  (Current experiments : MET-5, MET-7, GOES-8, and GOES-10)

- Bias correction based on statistical regression & model predictors

- Quality control :

  Blacklisting : Slots affected by solar stray light

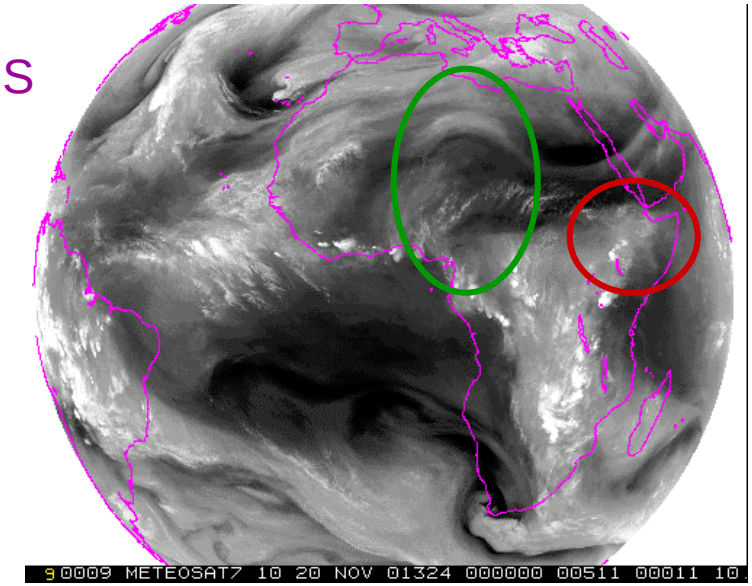
  Segments with less than 70% clear pixels

  First Guess Check

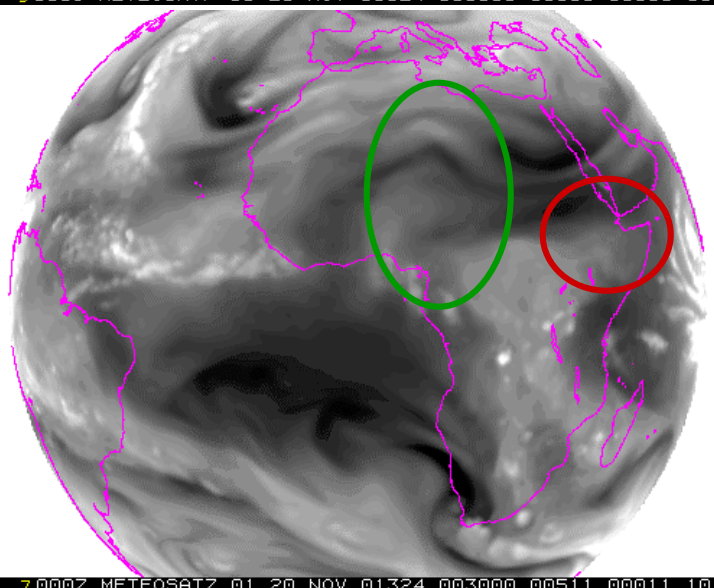
  Variational quality control

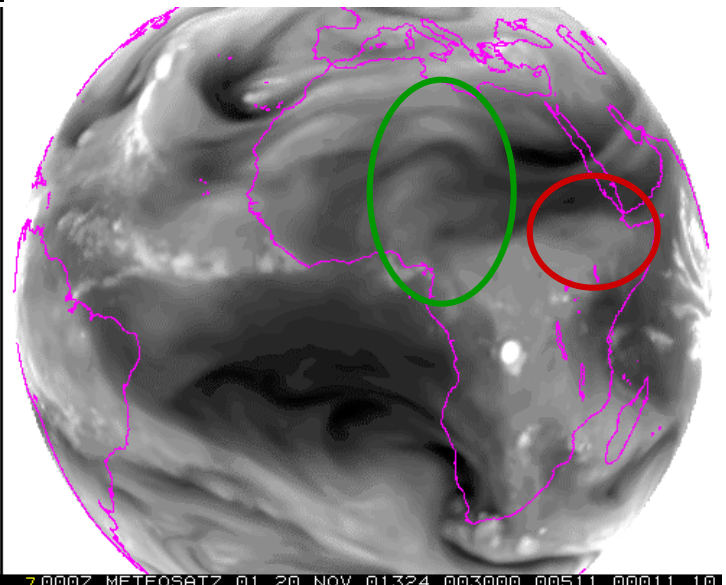
Assimilation: 1) Humidity fields as seen by METEOSAT

OBS



FG
CNTL





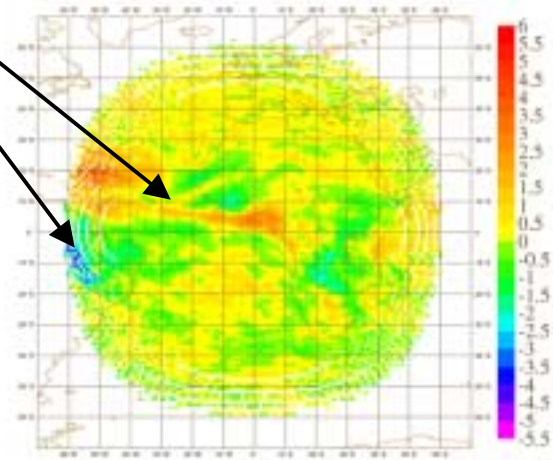
FG
MET7-WV

Assimilation : 2) Mean change in humidity field

- METEOSAT sees known model deficiencies, e.g.

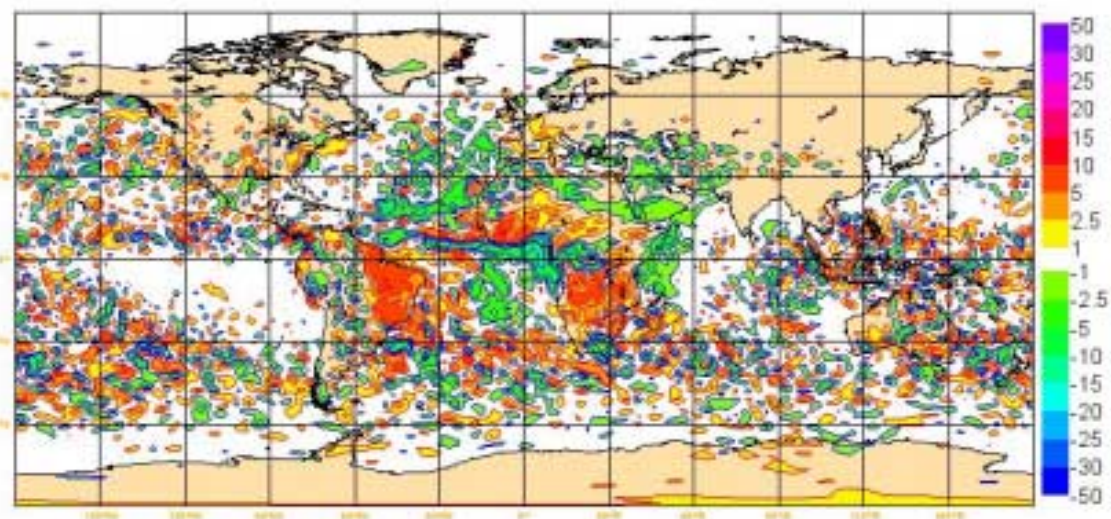
ITCZ too static (too moist)
not enough deep convection over Brasil

Mean difference
Nov / Dec 2001
OBS - FG [K]



- **Mean Analysis Difference : MET7-WV Assim - CONTROL**

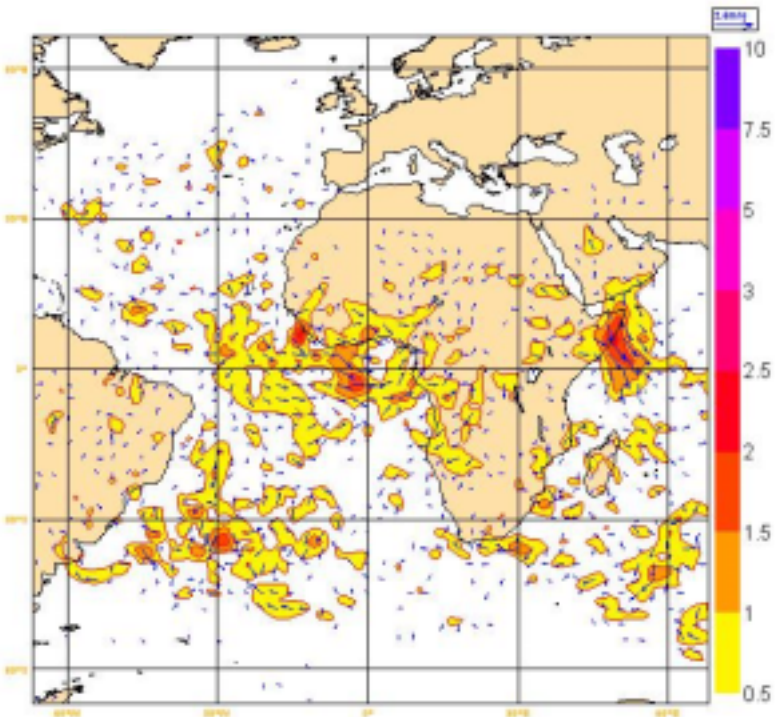
Date = 20011116 - 20011215 , 12 UTC
Par= **relative humidity, Lev=300hPa



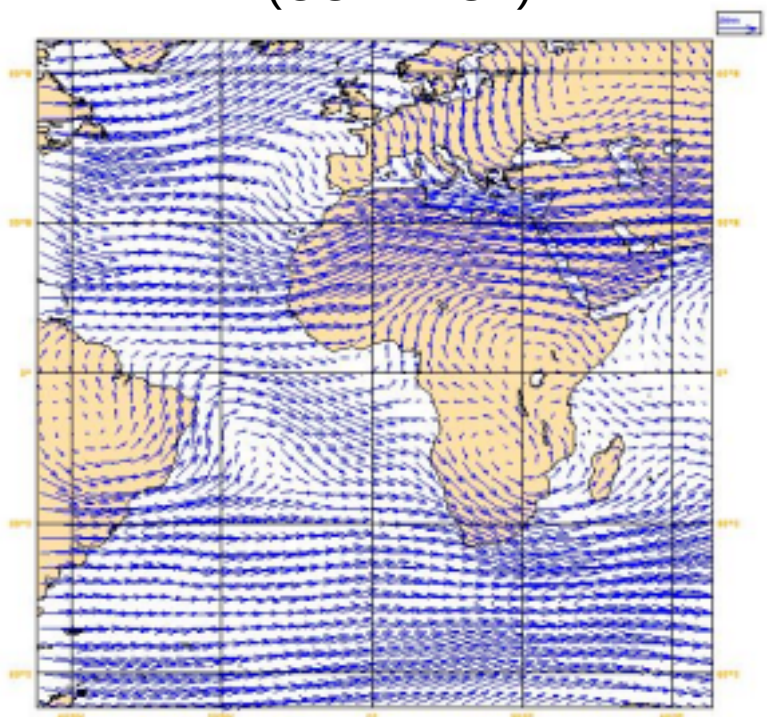
Assimilation : 3) Change in wind field

- WV - CSR assimilation feeds back on wind field in single analysis
  Small adjustments visible in mean wind field

Mean Analysis Difference
MET7-WV – CONTROL



Mean Analysis
(CONTROL)

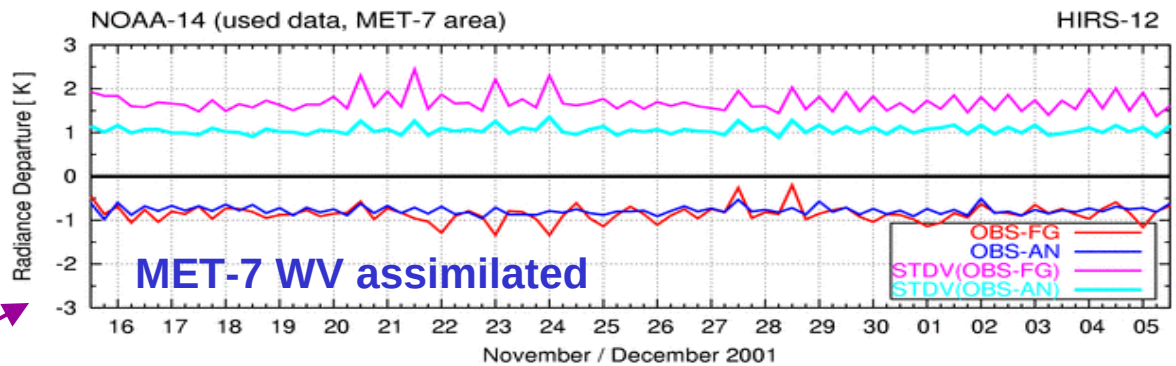


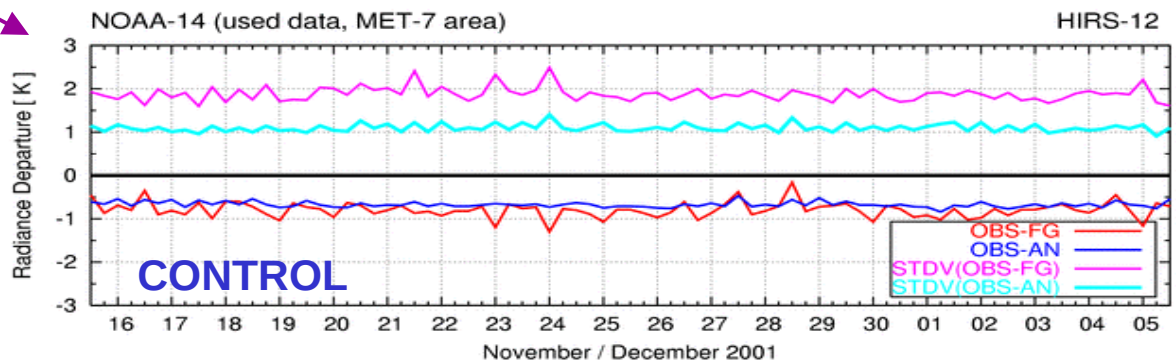
200 hPa

Assimilation verification: 1) Fit to other observations

- Mostly unchanged ✓
- Slightly improved for tropical pilots and 'aireps' (wind observations)
- Improved fit of model to HIRS-12 and AMSU-B data

Used HIRS-12 data in MET-7 area



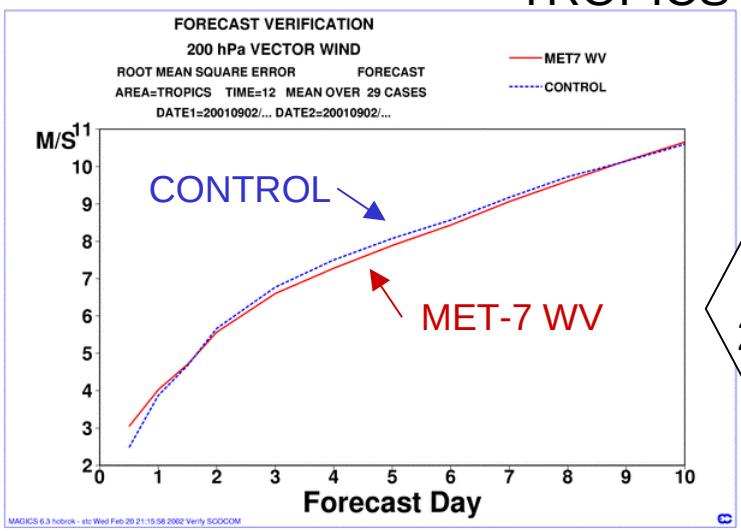


Assimilation verification : 2) Forecast quality

- Neutral in forecast verification versus observations

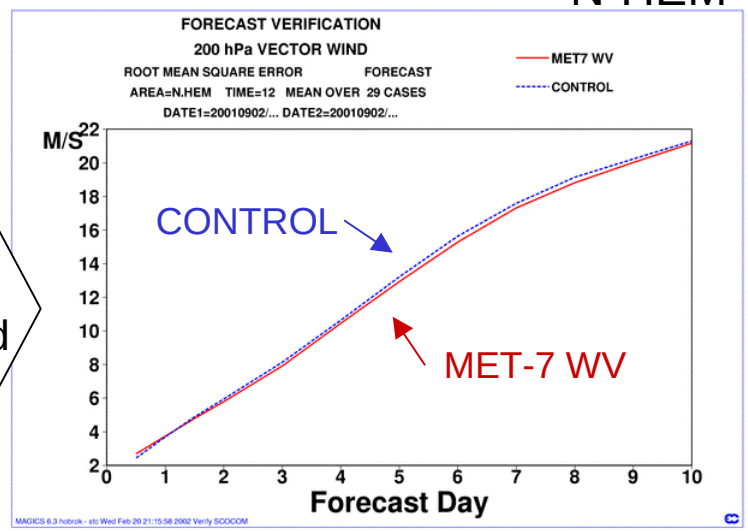
- Positive to neutral in verification versus analyses for geopotential and (upper level) wind fields

TROPICS



RMS
200 hPa wind

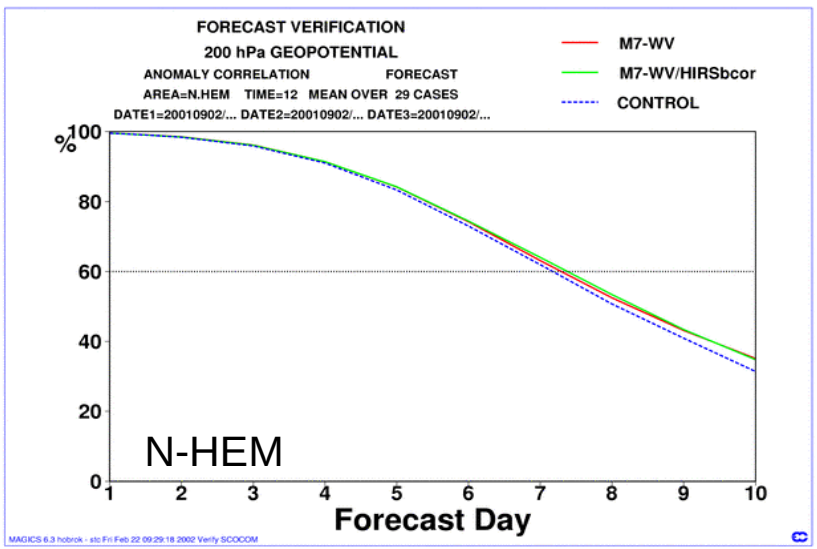
N-HEM

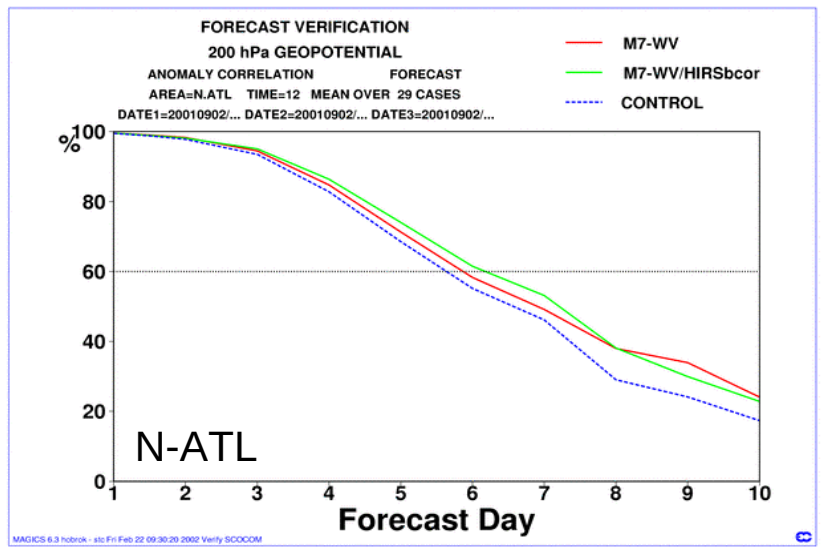


Assimilation : Influence of bias correction

Example : MET-7 WV assimilation in combination with slightly different HIRS-12 bias corrections

Anomaly correlation of forecast compared to analysis
200 hPa Geopotential





➡ Bias correction can have a big impact

Conclusions : Assimilation of geostationary WV CSR

- ✓ Adjustment of humidity fields in areas of known model deficiencies
- ✓ Improved fit of HIRS-12 and AMSU-B data
- ✓ Improved fit to tropical pilots
- ✓ Positive to neutral forecast impact

  Noticeable impact on upper level winds / geopotential

- ➢ Large sensitivity to bias correction
  - → Accuracy of calibration is an important issue
  - → HIRS and AMSU-B essential to diagnose bias and verify assimilation impact

Current and future issues ...

- Introduction of MET-7 WV-CSR into operations planned for March/April 2002

- Assimilation experiments using also MET-5, GOES-8, and GOES-10 ongoing $\rightarrow$ Near global coverage

- Preparation for future geostationary instruments, e.g. MSG, GIFTS

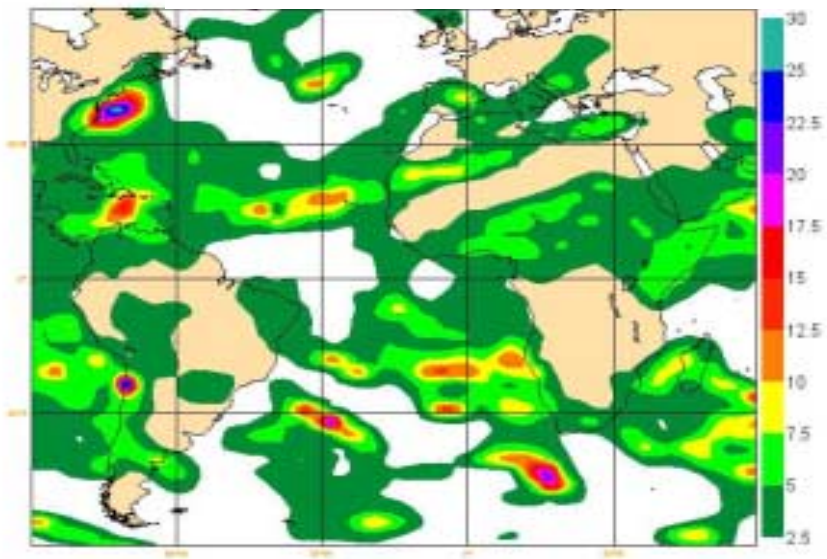
- Enhancement of quality indicator for clear-sky radiances

  $\rightarrow$ Use information from cloud detection algorithm ?

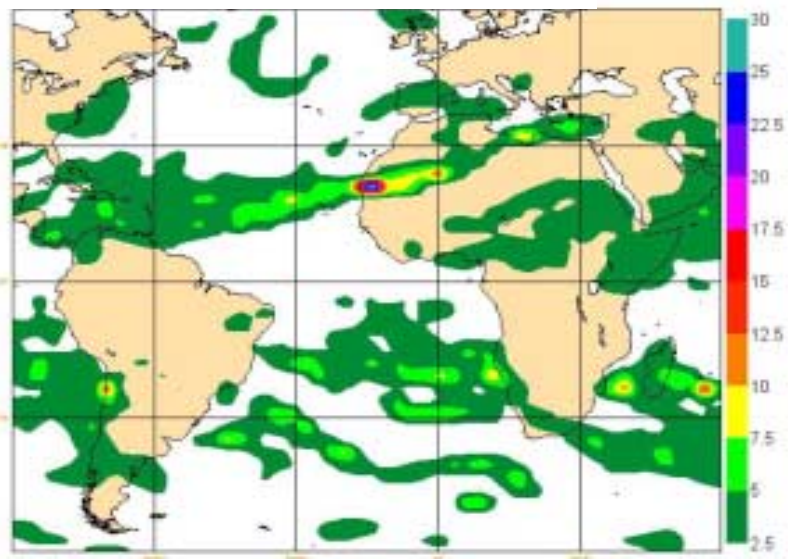
… current and future issues

- Modified humidity analysis variable in preparation
  → Retune First Guess & Variational QC checks

First Guess Error for Water Vapour Channel [K]



Current operational version



New humidity analysis variable (E. Holm)