Assimilation of Geostationary WV Radiance within the 4DVAR at ECMWF

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• 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 !) → Area averages
  - METEOSAT: \(16 \times 16\) pixels \(\approx 80 \times 80\) km\(^2\)
  - GOES: \(11 \times 17\) pixels \(\approx 45 \times 45\) km\(^2\)

- Cloud detection:
  - METEOSAT: Histogram analysis (IR, WV, VIS in 32×32 segments)
  - GOES: Multispectral threshold 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 \(\approx -0.8\) K (Matricardi et al., 2001)
- Comparison to other instruments: HIRS, AMSU

MET-7 \(\approx 3.8\) K

HIRS-12 (in MET-7 area) \(\approx -0.7\) K
AMSUB-3 (in MET-7 area) \(\approx -0.3\) 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)

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

- Data passing blacklisting
  > 70% clear pixels
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
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 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
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
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 → Near global coverage

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

- Enhancement of quality indicator for clear-sky radiances → 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)