Impact of GPS ZTD observations in HIRLAM 3D-Var analyses and forecasts

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Outline

1) Motivation
2) GPS ZTD Observing system
3) Experiment design
4) Verification
   • Upper air parameters
   • Categorical forecasts of accumulated precipitation
5) Conclusions
Motivation

The HIRLAM-CIS (Comprehensive Impact Study) will explore the impact of high-resolution observation types on 4D-Var analyses and forecasts of summertime convection.

The number of GPS observing sites continues to increase

- Zenith Total Delay (ZTD) data from Finnish receiver stations has become available in May 2008.

There have been improvements in GPS ZTD data assimilation code of HIRLAM.

An impact study with 3D-Var was decided to be performed as a preparation to the HIRLAM-CIS experiment.
GPS ZTD data

Observing system status in Europe

The observing system is controlled by the EUMETNET programme E-GVAP

The observing system consists of ground-based receiver networks that are specific to each country

Increasing number (>1000) of receiver stations is included in near-real-time processing

The processing is done at ~10 processing centres, including both geodetic and meteorological institutes
Experiment design

*NWP model domain and time period*

*HIRLAM 3D-Var* in a regular grid of 406 x 320 grid points

0.1° horizontal grid resolution at 60 model levels

A deterministic +48 hour forecast is produced every 6 hours

A 10-day ”warming up” period of 18—27 July 2008

A 35-day forecast period of 28 July—31 August 2008
Experiment design

Performed NWP model runs

Control run with only a few modifications on top of the HIRLAM 7.1.4 reference system:

- Horizontal domain and grid spacing are modified
- ATOVS observations are not assimilated

Regular GPS run: as control, but ZTD observations are included in data assimilation (651 receiver stations)

Thinned GPS run: as regular GPS run, but a horizontally thinned subset of ZTD observations is used (437 receiver stations)

Bias-corrected GPS run: as regular GPS run, but ZTD observation biases are corrected using a static site-dependent bias-correction algorithm
Observation selection and $\sigma_0$ specifications

Five ”most productive” GPS data processing centres are used.

Analysis-centre dependent observation error standard deviations $\sigma_0$ are determined on the basis of OmB statistics over a three-week period in July 2008:

- $\sigma_0=10$ mm for ZTD processed at METO and GFZ
- $\sigma_0=11$ mm for ZTD processed at SGN
- $\sigma_0=15$ mm for ZTD processed at NGAA and ROB

Background error standard deviation $\sigma_b$ is assumed to be 9 mm.

The OmB dataset serves as the basis for the bias-corrections as well.
Observation verification

EWGLAM radiosonde stations

Mean forecast errors show a systematic positive (negative) impact in the upper (lower) troposphere

Forecast error standard deviations show a neutral impact
Horizontal thinning

Thinning has very little impact on top of the regular GPS run
**Observation bias correction**

*Bias correction reduces the impact of GPS data*

*A positive (negative) impact in the lower (upper) troposphere*

*Impact on forecast error standard deviations remains neutral*
## Verification of categorical forecasts

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<th>$\geq 1 \text{ mm}$</th>
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24-hour forecasts of 12-hour accum. precipitation

Impact of GPS ZTD observations in HiRLAM 3D-var

EWGLAM WEST

PROBABILITY OF DETECTION

EWGLAM EAST

PROBABILITY OF DETECTION

EWGLAM WEST

FALSE ALARM RATE

EWGLAM EAST

FALSE ALARM RATE

CON
GPS
BC

THRESHOLD [mm/12h]
Conclusions

The impact of GPS ZTD data assimilation in standard verification scores is small

- specific humidity, temperature and geopotential height in the upper troposphere are systematically increased

Verification of categorical forecasts of 12-hour accumulated precipitation shows a positive impact on 12- and 24-hour forecasts in Western and Northern Europe

Horizontal thinning improves forecasts in cases of heavy precipitation

ZTD observation bias correction decreases forecast humidity and precipitation but does not provide a clear impact on verification scores