Variational Bias Correction for GNSS ZTD

RCLACE stay report

Budapest, from 1st to 14th of August, 2014.

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1. Introduction

By the GNSS (Global Navigation Satellite System) constellation, the tropospheric delay of the transmitted satellite signals can provide useful atmospheric information (especially for water vapour content) to the initial conditions of the numerical weather prediction models (see e.g., *Yan et al,* 2008; *Poli et al,* 2007; *Storto and Randriamampianina,* 2010). The Zenith Total Delay (ZTD) is an estimate of this time delay (expressed in lenght unit) along the zenithal path above the ground-based GNSS receiver stations. With the use of ZTD in data assimilation, it is well known that efficient bias correction is needed and recently a constant site-dependent bias correction is used widely at several centres which has many drawbacks. In newer ARPEGE/IFS common cycles the variational bias correction approach for ZTD has been implemented and the goal of this stay was to make first tests with this advanced method in cy38t1.

2. Technical part of the work: Phasing exercises

Necessary source code modifications of VARBC for ZTD (which are not already included in cy38t1_bf03) were kindly provided by Meteo-France (Patrik Moll) and HIRLAM (Magnus Lindskog, Jana Sanchez) colleagues, however, the MF's modset was built for cy40 and HIRLAM's modset was for cy38h1. Therefore phasing (backphasing) exercises have to be done in order to harmonize the modsets with cy38t1_bf03 and to apply the fixes in new userpack(s) on the top of cy38t1_bf03 mainpack. Finally two new userpacks have been made with backphased MF and with HIRLAM modifications which contain the following modified subroutines:

cy38t1_gpsvarbcmfcy40.01.INTEL111059.x.pack (based on Meteo-France modset)

arpifs/obs_preproc/upecma.F90
arpifs/obs_preproc/defrun.F90
arpifs/op_obs/hopad.F90
arpifs/op_obs/gpszen_delay.F90
arpifs/op_obs/gpszen_delayad.F90
arpifs/op_obs/gpszen_delaytl.F90
arpifs/op_obs/hoptl.F90
arpifs/op_obs/hop.F90
arpifs/module/varbc_pred.F90
arpifs/module/varbc_table.F90
arpifs/module/varbc_setup.F90
arpifs/module/yomobs.F90

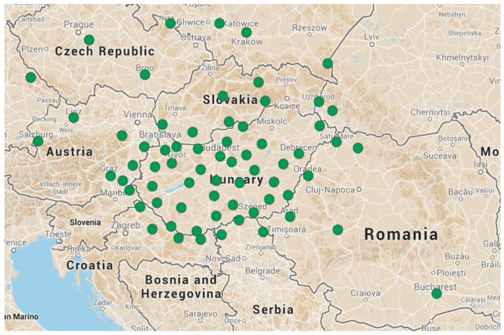
cy38t1_gpsvarbchirlam38.01.INTEL111059.x.pack (based on HIRLAM modset)

arpifs/op_obs/hopad.F90
arpifs/op_obs/gpszen_delay.F90
arpifs/op_obs/gpszen_delayad.F90
arpifs/op_obs/gpszen_delaytl.F90
arpifs/op_obs/hoptl.F90
arpifs/op_obs/hop.F90
arpifs/module/varbc_sfcobs.F90
arpifs/module/varbc_pred.F90
arpifs/module/varbc_setup.F90
odb/ddl/getsfcobsid.sql
odb/ddl/varbc_sfcobs_robhdr.sql
odb/ddl.ECMA/getsfcobsid.sql
odb/ddl.ECMA/varbc_sfcobs_robhdr.sql
odb/ddl.CCMA/getsfcobsid.sql
odb/ddl.CCMA/varbc_sfcobs_robhdr.sql

3. Preliminary runs to validate userpacks

After the successful compilation of the above mentioned two userpacks, assimilation runs were executed to verify the correctness of the VARBC for ZTD with the new binaries. For the preliminary runs and for the longer passive assimilation experiments as well, Hungarian AROME configuration and GNSS ZTD observations from E-GVAP SGOB network were used (ZTDs from SGOB network were tested also with static bias correction approach in previous Hungarian impact studies). At first only one predictor has been set for ZTD observations which was the predictor 0. The modifications were validated through one or two updates of the VARBC parameters where VARBC ASCII files and diagnostics in NODE files were checked. It is worth mentioning that cycling of VARBC parameters can be done by daily update (24 hours) and also it is possible to make update by every analysis steps (e.g. with 3h RUC, 3 hours cycling of VARBC parameters).

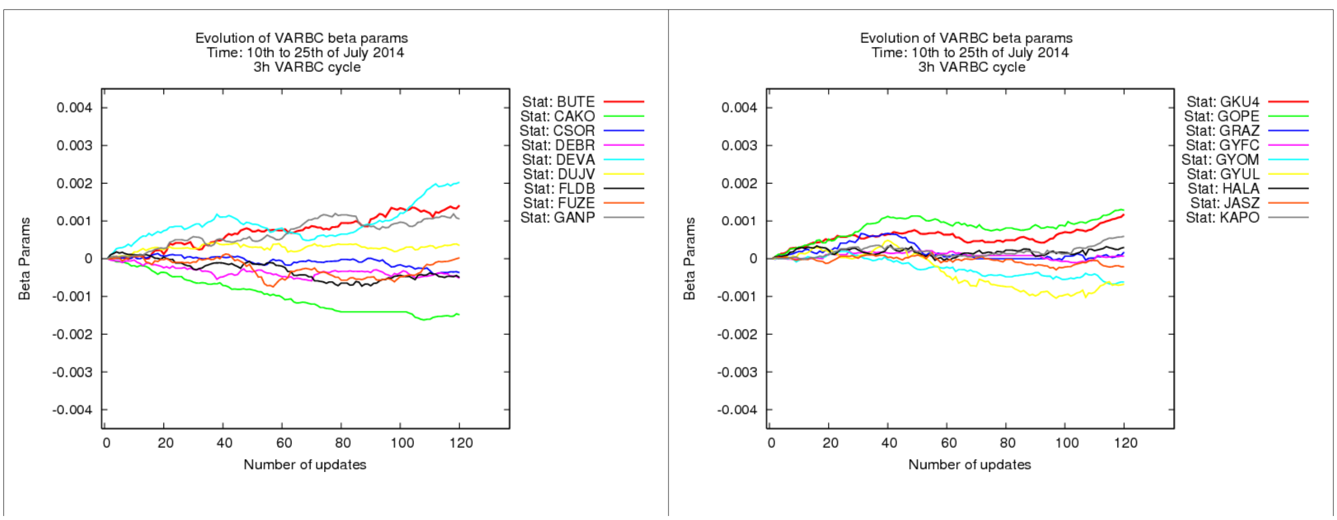
Hungarian so called SGOB GNSS ground-based receiver station network used in VARBC study



Selected stations inside AROME-Hungary domain by whitelist procedure
(similarly as previous static bias correction study)

4. Running AROME 3DVAR with GNSS ZTD using VARBC

At the very end of the two weeks stay, a longer passive assimilation experiment was started to make coldstart initialization of VARBC coefficients for the selected ZTD stations. For VARBC cycling, 3 hours frequency was used in 3h RUC system of AROME/Hungary instead of daily cycling. As a preliminary results, the evolution of VARBC parameters was plotted for GNSS ground-based stations for predictor 0.



The evolution of VARBC parameters during the period of 10.07.2014. - 25.07.2015.
(9-9 GNSS stations from SGOB network)

5. Conclusion

In conclusion the modifications to apply VARBC for ZTD observations have been installed successfully for cy38t1_bf03. Furthermore very first tests were also run in order to verify the correctness of the VARBC approach, but further investigations are needed with respect to the selection of the predictors and to the data assimilation diagnostics. For more information please contact with Xin Yan (<xin.yan@zamg.ac.at>) or Mate Mile (<mile.m@met.hu>).

6. References

Storto, A. and *Randriamampianina, R.,* 2010: A new bias correction scheme for assimilating GPS zenith tropospheric delay estimates, *Időjárás 114,* 237–250.

Yan, X., Ducrocq, V., Poli, P., Jaubert, G., and *Walpersdor,f A.,* 2008: Mesoscale GPS Zenith Delay assimilation during a Mediterranean heavy precipitation event, *Adv. Geosci.* 17, 71–77.

Poli, P., Moll, P., Rabier, F., Desroziers, G., Chapnik, B., Berre, L., Healy, S. B., Andersson, E., and *EI Guelai, F.-Z.* 2007: Forecast impact studies of zenith total delay data from European near realtime GPS stations in Meteo France 4DVAR, *J. Geophys. Res. 112*, D06114.