The use of NWP-SAF - 1D-Var as pre-processor of the radiances: CPTEC Pre-operational results

Simone Sievert Costa*, simone.sievert@cptec.inpe.br, Stephen English**,
J. Rodrigues*, L. Barbedo*, S. Pereira* - * CPTEC/INPE, Brazil ** ECMWF, UK

This study aims to present the adapted approach on the use of the One-Dimensional Variational Analysis (1D-Var) scheme as pre-processor of radiances to NWP data assimilation system. Initial tests on the use of 1D-Var have been performed based on the background information from CPTEC global NWP model and observation from ATOVS.

Motivation

Assimilation of infrared and microwave satellite data, mainly radiances, have a dominant impact on NWP forecast accuracy. In this context, the Centre for Weather Forecast and Climate Studies of the National Institute for Space Research (CPTEC/INPE) is implementing a new assimilation system that includes radiances[1] (see poster 4.23). There are some challenges in order to maximize the use of the observed radiances into the CPTEC assimilation system, therefore the use of 1D-Var is proposed to be part of the system (Fig 1).

MetOffice NWPSAF 1D-Var

It is a stand-alone retrieval package[2] for nadir viewing passive satellite instruments, based on the Bayesian optimal estimation technique, in which the statistically optimal estimate of the atmospheric state vector **x** consistent with observations **y**, and any prior background state $\mathbf{x}_0$, is obtained by minimizing the cost function[3]:

$$J(\mathbf{x}) = (\mathbf{x} - \mathbf{x}_0)^{\mathrm{T}}\mathbf{B}^{-1}(\mathbf{x} - \mathbf{x}_0)+\{\mathbf{y} - \mathbf{y}(\mathbf{x})\}^{\mathrm{T}}\,\mathbf{R}^{-1}\,\{\mathbf{y} - \mathbf{y}(\mathbf{x})\},$$

where **R** and **B** are respectively the measurement and background error covariance matrices, and **y**(**x**) represents the forward-modeled radiances corresponding **x**. The forward model used is the RTTOV[3,4] (v. 9.3).

A Proposed Framework for the CPTEC Assimilation System

The proposed practical technique for the assimilation of IR and MW radiances (Fig.1) is based on the ITWG available tools and observations data at CPTEC/INPE. In this framework, regional real-time (Fig. 2, through HRPT system) and globally (through RARS via GTS) observed radiances are processed using AAPP (Box 2). Observed radiances and CPTEC (T213L42) model variables (background) are used as inputs to 1D-Var scheme (version 3.3). Retrieved variables together with the statistics of "model to fit observation" are passed to the assimilation system, in which produces an ensemble of analysis to the NWP model.

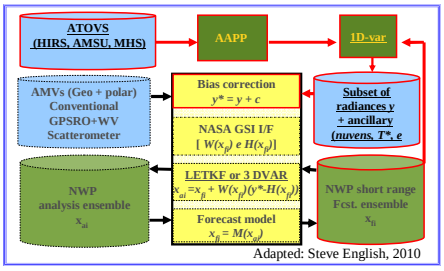


Fig. 1 – A proposed framework for the assimilation system, using 1- DVAR as pre-processor

Fig. 2 – NOAA Satellite Stations System from RARS (INPE) and coverage area.

Box 1

Advantages of the use of 1D-Var as pre-processor[2]:

✓Analyze quantities needed for direct radiance assimilation into assimilation system (Temp. above model top, T_{sfc}, etc).
✓ exclude obs. unlikely to converge in the assimilation;
✓ *data monitoring – obtain detailed statistics of model fit to observations;*
✓ *generate databases for observations bias correction.*

Box 2

ATOVS data - INPE operates NOAA polar-orbiting satellites data reception, in which covers a wide region over South America and Atlantic Ocean (Fig. 2). The ATOVS local data from NOAA satellites are acquired in real-time via the satellite's digital High Resolution Picture Transmission broadcast. In order to complete global coverage, RARS from GTS is used on the proposed framework. ATOVS data (regional and RARS) is processed through AAPP scheme, and then used as input data (level 1d) into 1D-Var.

Operational:
1 – Cachoeira Paulista (INPE)*
2 – Brasilia (INMET)**
3 – Cuibá (INPE)*
4 – Natal (INPE) *
5 – Fortaleza (FUNCEME)***

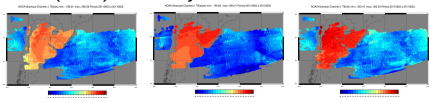
Planned 2012:
6 – Belém (INPE)
7 – Manaus (SIVAM)

Potential:
8 – Sta Maria (Potential)
9 – Boa Vista (Potential)

AAPP - versions: * 7.1 | ** 6.12 (but upgrading to 7.1) | *** 6.14

Results

AMSU-B (Ch. 1) – humidity channel



AMSU-A (Ch. 14) – stratospheric channel

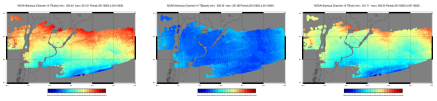
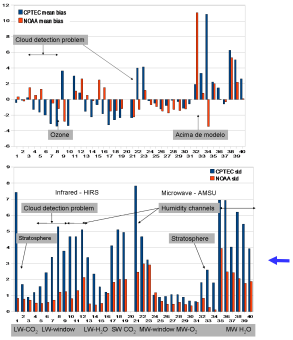


Fig 3. The brightness temperature (in Kelvin) observed (left panel), estimated using CPTEC global model variables as background (middle), and using retrieved profile from 1DVAR (right panel) for channels 1 (AMSU-B) and 14 (AMSU-A).



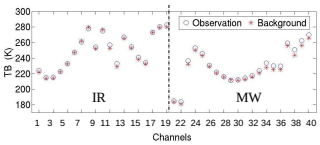


Fig. 4 - Global monthly mean of observed ATOVS radiances and simulated brightness temperature using CPTEC (T213L42) model variables as background.

Fig 5. Tb observed minus Tb (background) from CPTEC (with bias) and NCEP global monthly Sept. 2011(top panel) and standard-deviation (lower panel)..

References: 1) Silveira et al - Recent developments on inclusion of radiances in the CPTEC/INPE data assimilation systems.
2) Pavelin, E. and Collard, A. 2009 NWP SAF 1D-Var User Manual ttp://research.metoffice.gov.uk/research/interproj/nwpsaf/metoffice_1dvar/nwpsaf-mo-ud-006_NWPSAF_1DVar_Manual.html
3) Rodgers CD., 2000: *Inverse Methods for Atmospheric Sounding: Theory and Practice*. World Scientific, 238 pp.
4) Eyre J. R. 1991 A fast radiative transfer model for satellite sounding systems. ECMWF Research Dept. Tech. Memo. 176 (available from the librarian at ECMWF).
5) Saunders R.W., M. Matricardi and P. Brunel 1999 An Improved Fast Radiative Transfer Model for Assimilation of Satellite Radiance Observations. *Q.J.Royal Meteorol. .Soc.* , **125**, *1407-1425.*

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