



<p>The EUMETSAT Network of Satellite Application Facilities</p>	 <p>NWP SAF Numerical Weather Prediction</p>	<p style="text-align: center;">NWP SAF 1D-Var Overview</p>	<p>Doc ID : NWPSAF-MO-UD-010 Version : 1.2 Date : 4th May 2012</p>
---	--	--	---

NWP SAF 1D-Var Overview

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 1 December, 2006, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, KNMI and Météo France.

Copyright 2012, EUMETSAT, All Rights Reserved.

Change record			
Version	Date	Author / changed by	Remarks
1.2	4.5.12	P. Weston	Updated for Met Office 1D-Var v3.4

<p>The EUMETSAT Network of Satellite Application Facilities</p>		<h1 style="text-align: center;">NWP SAF</h1> <h2 style="text-align: center;">1D-Var Overview</h2>	<p>Doc ID : NWPSAF-MO-UD-010 Version : 1.2 Date : 4th May 2012</p>
---	---	---	---

1. Introduction

There are still three NWPSAF 1D-Var schemes: the Met Office 1D-Var; SSMIS 1D-Var; and ECMWF 1D-Var. For more information on the three separate 1D-Var schemes see Annex A.

2. Upgrade

The Met Office 1D-Var version 3.4 enables support for RTTOV v10 and adds the capability for performing retrievals of cloud liquid water with SSMIS. This upgrade works to merge the capabilities of the SSMIS 1D-Var with the Met Office 1D-Var. This means that the SSMIS 1D-Var scheme will be retired in the near future but in the meantime support will remain for any remaining users.

3. Future Plans

The upgrade described above has been made in preparation for replacing the three current 1D-Var schemes (Met Office, ECMWF and SSMIS) with one generic NWPSAF 1D-Var scheme. This will involve a rewrite of the code and the addition of a graphical user interface to make the code easier to use and for visualisation of the inputs and outputs of the scheme. The aims of the new generic scheme are to make it easier for users to use and adapt the code for their individual needs and for it to be used in planned NWP SAF training courses.

Annex A

NWP SAF 1D-Var Overview

v1.1, 11 November 2004

NWP SAF	NWP SAF 1D-Var Overview	Doc ID : NWPSAF-MO-UD-010 Version : 1.1 Date : 11.11.04
----------------	------------------------------------	---

NWP SAF 1D-Var Overview

*Roger Saunders and Bryan Conway
Met Office, UK*

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 19 December, 2003, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, KNMI and Météo France.

Copyright 2004, EUMETSAT, All Rights Reserved.

Change record			
Version	Date	Author / changed by	Remarks
0.1	22.8.04	Bryan Conway	Initial draft based on NWPSAF-MO-TR-011 v1.5 by R.W.Saunders
0.2	2.9.04	Roger Saunders	Incorporated comments from RWS and AM
1.0	2.9.04	Bryan Conway	Minor edits. Version for distribution to SG
1.1	11.11.04	Bryan Conway	References updated

NWP SAF	NWP SAF 1D-Var Overview	Doc ID : NWPSAF-MO-UD-010 Version : 1.1 Date : 11.11.04
----------------	------------------------------------	---

1. Introduction

The NWP SAF has developed three 1D-Var software packages. This overview is intended to help prospective users decide which of these packages is the most suitable for their applications.

2. Background

One of the objectives of the NWP SAF is to provide documented software modules which can be useful to NWP centres and research institutes to develop methods to ingest, pre-process and assimilate satellite data into NWP models. In accordance with this, it was decided that the NWP SAF should develop a generic 1D-Var module as one of its deliverables, which could handle radiance data from different satellite sensors including the advanced IR sounders.

NWP SAF partners ECMWF (Chevallier, 2004) and the Met Office (Collard, 2004) have developed, in parallel, different 1D-Var codes, both of which have been made available as deliverables of the NWP SAF.

In addition to this a separate 1D-Var code for SSM/I retrievals, originally developed by Phalippou (1996) at ECMWF, was also developed into an NWP SAF deliverable. This was further developed to handle SSMIS 1D-Var by G. Deblonde during a visit to the Met Office in 2001.

3. 1D-Var Applications

One dimensional variational analysis codes can be used within NWP systems for a variety of different applications:

- To carry out idealised experiments with new satellite data types (e.g. IASI) and/or model state parameters (e.g. ozone, cloud, precipitation etc)
- To provide a q/c step in the operational satellite data pre-processing (e.g. Met Office ATOVS processing which includes a cloud detection step)
- To perform a retrieval of model state parameters prior to their assimilation in OI or 3/4Dvar (e.g. T, q profiles, surface and cloud parameters) (e.g. Met Office SSM/I surface wind and TCWV retrievals). This can also include retrieving state vector parameters not provided by the NWP model FG but required as input to the observation operator (e.g. upper stratospheric temps in Met Office model).

The input radiance vector can be from 1 to more than 8000 individual channels. The atmospheric state variables must include any variable required for the observation operators in 3/4Dvar. The NWP SAF 1D-Var code must meet all of these needs. This has implications for the minimisation options employed.

Over the past few years 1D-Var codes have been used for various applications:

- investigating the assimilation of precipitation from TMI in the ECMWF model
- investigating the assimilation of cloudy ATOVS radiances at ECMWF
- retrieving cloud parameters for input to the Met Office mesoscale model

NWP SAF	NWP SAF 1D-Var Overview	Doc ID : NWPSAF-MO-UD-010 Version : 1.1 Date : 11.11.04
----------------	------------------------------------	---

- investigating the information content of AIRS, SSMIS and IASI radiances
- verifying the impact of revised background errors in the Met Office 1D-Var pre-processing
- investigating the assimilation of ozone using HIRS
- development of AIRS variational cloud detection

4. Comparison of NWP SAF 1D-Var products

A report by Hess (2002) highlights the differences between the Met Office and ECMWF 1D-Var codes to which the interested reader is referred for more details. The main differences between the 1D-Var codes are summarised below.

The ECMWF 1D-Var package is a generalised minimisation code applicable to a wide range of inversion problems for satellite data. It does not provide all the components necessary for a 1D-Var retrieval (e.g. fast radiative transfer model). It makes use of the *MIQN3* software from INRIA (quasi-Newton method) and preconditions the state vector with the eigenvectors of the background error covariance. The code is in Fortran and documented. It has been available for distribution to users since 2001. It cannot be treated as a ‘black box’ as various additional modules have to be interfaced to the ECMWF 1D-Var package before it will work.

The Met Office 1D-Var code in contrast provides a stand-alone system for doing 1D-Var retrievals with user-provided files of observation and background error covariances. This code is currently configured with RTTOV-7 and RTIASI-2 as possible observation operators at present, providing a capability for any sensors supported by these RT codes. The Met Office 1D-Var code is tailored to be flexible for research purposes and for portability rather than streamlined for operational running within an NWP model. Users who require the code to run efficiently within their NWP systems should expect to do some optimisation of the code for their platform. Several minimisation options are provided within the code, tailored for 1D-Var applications, which include Newtonian with two configurations, depending on number of channels, and Marquardt-Levenberg. Also, the possibility of non-diagonal observation and forward model error correlations is catered for. This code is written in Fortran-90, using many of the intrinsic features and is documented in Collard (2004). The package currently supports ATOVS, AIRS and IASI sensors. There are plans to add SEVIRI. Also note that the ECMWF code has been incorporated within the Met Office 1D-Var code as an alternate minimisation option.

G. Deblonde has further developed the SSM/I 1D-Var code, originally developed at ECMWF by Phalippou (1996), for the SSMIS microwave imager/sounder and AMSU. This is tailored to retrievals of temperature, water vapour, surface wind speed and cloud liquid water using microwave radiances. The various components of the state vector can be configured by the user. As with the Met Office code described above this is a complete package. RTTOV-7 is the RT model used in this case.

5. Future plans for NWP SAF 1D-Var codes

The NWP SAF intends to avoid further proliferation of different specialised 1D-Var codes, so any further developments will be based on the existing products. In the long term it is possible that the

NWP SAF	NWP SAF 1D-Var Overview	Doc ID : NWPSAF-MO-UD-010 Version : 1.1 Date : 11.11.04
----------------	------------------------------------	---

NWP SAF will combine at least two of its 1D-Var products so as to reduce the number of products it has to maintain, but without reducing the range of instruments supported. However, there are no immediate plans to withdraw any of the existing products, and further developments will be driven by user-requirements.

6. Further information

The references listed below provide further technical details. If you have specific questions that are still not answered, please contact the NWP SAF Helpdesk. (Click on the “Contact us” link on the NWP SAF website at <http://www.metoffice.gov.uk/research/interproj/nwpsaf/>).

7. References

Chevallier, F. 2004 A one dimensional variational analysis package. *NWP SAF report NWPSAF-EC-UD-001, Jan 2000. (Latest version available at the 1D-Var user-guide link at http://www.metoffice.gov.uk/research/interproj/nwpsaf/ecmwf_1dvar/index.html)*

Collard, A. 2004 NWP SAF 1D-Var User Manual at: http://www.metoffice.gov.uk/research/interproj/nwpsaf/metoffice_1dvar/nwpsaf-mo-ud-006_NWPSAF_1DVar_Manual.html

Hess, R. 2002 Comparison of 1D-Var codes and impact of background error covariances. *NWP SAF: Visiting scientist report NWPSAF-MO-VS-006, April 2002 (available from <http://www.eumetsat.de> >>Satellite Application Facilities >> SAF Network >>SAF Visiting Scientists >>Visiting Scientist Reports)*

Phalippou, L. 1996 Variational retrieval of humidity profile, wind speed and cloud liquid water path with the SSM/I: Potential for numerical weather prediction. *Q.J. Roy. Meteorol. Soc.* **122** 327-355.