LPW & SAI
Layer Precipitable Water and Lifted Index

15th June 2004
Madrid

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Plan of SAI & LPW presentation

✓ Algorithms’ description
✓ Smoothing/trend parameters
✓ Tuning the algorithms:
  • Radiances bias correction
  • At denormalization process
✓ Known problems
✓ Planned activities in 2004
✓ Examples
✓ Case study
The scope of the SAFNWC activities is to deliver a software package:

- Near Real Time (NRT)
- Full resolution (3km x 3km at Nadir)
- Frequency to be selected by the user (default every repeat cycle)
- Region to be selected by the user
# PGE07&PGE08 INPUTS

<table>
<thead>
<tr>
<th>IR SEVIRI Channels</th>
<th>Centred</th>
<th>Comments</th>
<th>Absorbents</th>
</tr>
</thead>
<tbody>
<tr>
<td>WV 6.2µm</td>
<td>6.25µm</td>
<td>WV channel</td>
<td>H20</td>
</tr>
<tr>
<td>WV 7.3µm</td>
<td>7.35µm</td>
<td>WV channel</td>
<td>H20,N20,CH4</td>
</tr>
<tr>
<td>IR 8.7µm</td>
<td>8.70µm</td>
<td>Window Channel (Tsfc)</td>
<td>H20,O3,N20,CH4</td>
</tr>
<tr>
<td>IR 9.7µm</td>
<td>9.66µm</td>
<td>Ozone channel</td>
<td>H20,CO2,O3</td>
</tr>
<tr>
<td>IR 10.8µm</td>
<td>10.8µm</td>
<td>Window Channel (Tsfc)</td>
<td>H20,CO2,O3</td>
</tr>
<tr>
<td>IR 12.0µm</td>
<td>12.0µm</td>
<td>Window Channel (Tsfc y q)</td>
<td>H20,CO2</td>
</tr>
<tr>
<td>IR 13.4µm</td>
<td>13.4µm</td>
<td>Air Temperature</td>
<td>H20,CO2,O3</td>
</tr>
</tbody>
</table>

## Cloud Mask (PGE01 SAFNWC)

## TOPOGRAPHIC DATA (GTOPO 3.0, remapped to SEVIRI projection)

Total Precipitable Water (PGE06 SAFNWC). Not mandatory. Only used for validation flag on sea pixels in PGE07 (LPW)
# PGE07&PGE08 OUTPUTS

## PGE07: Layer Precipitable Water:

<table>
<thead>
<tr>
<th>LPW Parameters</th>
<th>Bottom level</th>
<th>Top level</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>P_{SFC}</td>
<td>840 hPa</td>
</tr>
<tr>
<td>ML</td>
<td>840 hPa</td>
<td>437 hPa</td>
</tr>
<tr>
<td>HL</td>
<td>437 hPa</td>
<td>0 hPa</td>
</tr>
<tr>
<td>TPW</td>
<td>P_{SFC}</td>
<td>0 hPa</td>
</tr>
</tbody>
</table>

## PGE08: Stability Analysis Imagery

<table>
<thead>
<tr>
<th>SAI Parameters</th>
<th>Bottom level</th>
<th>Top level</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>P_{SFC}</td>
<td>500 hPa</td>
</tr>
</tbody>
</table>
Selection of training dataset

• The algorithms of PGE07 and PGE08 are based on Neural Networks

• When working with neural networks the importance of the training dataset is of the outmost importance.

• All Neural Networks included in version 1.0 have been trained using only simulated radiance.
Training Database used in the implementation of the LPW algorithms: 60L-SD + RTTOV-7

- 60L-SD database has been used.
  - This database is provided by NWP SAF
  - It is well suited for precipitable water parameters.
  - It is not so good for stability parameters.

- In order to build the training dataset for LPW sea and land neural networks, all profiles of the 60L-SD database were used as inputs to the RTTOV-7.
Training Database used in the implementation of the SAI algorithms: (SSDB+60L-SD) + RTTOV-7

- A new special database well suited to represent the different stability cases (SSDB) has been built:
  - Using as support the ECMWF analysis from November 2002 to October 2003. The LI of 00 and 12 UTC analysis from days 1st, 8th, 15th and 22nd of these months were calculated for each profile.
  - The profiles were classified by month, latitude interval, sea or land and LI interval.
  - A random process of extraction was designed with the following criteria “try that all the classes were represented” and “extract more profiles of the unstable classes”.
- The SSDB has been mixed with the 60L-SD to built a new database
- In order to build the new training dataset for SAI sea and land neural networks, all profiles of the SSDB+60L-SD database were used as inputs to the RTTOV-7.
ALGORITHMS’ DESCRIPTION
Zenith angle

7 IR SEVIRI Radiances

Cloud mask PGE01:CMa

Topographic data

Clear pixels

Normalization (maximum-minimum)

Zenith correction of SEVIRI radiances to 45° (MLP: zernal_nn)

Normalization (maximum-minimum)

Land/sea mask

Normalization (maximum-minimum)

Altitude

Processing LP:SAI_SEA_NN (MLP: sea_HL_nn)

Processing LP:SAI_LAND_NN (MLP: land_ML_nn)

HDF-5 file

Processing Pre-Processing

Post-Processing

Denormalized SAI (LUT)

Conversion of LI from degree Celsius to grey levels.

HDF-5 file
Scheme (Pre-processing-1) the same for LPW and SAI

OPTIONAL STEP (Configuration file)

12

Normalization (maximum-minimum)

BOX_05 3 3 MEDIAN
BOX_06 3 3 MEDIAN
BOX_07 3 3 MEDIAN
BOX_08 3 3 MEDIAN
BOX_09 3 3 MEDIAN
BOX_10 3 3 MEDIAN
BOX_11 3 3 MEDIAN

Smoothing of SEVIRI radiances

7 SEVIRI IR RADIANCES

MSG ZENITAL ANGLE

Normalization (maximum-minimum)

NN ZENITH CORRECTION

7 IR RADIANCES CORRECTED TO MSG ZEN= 45°

NORMALIZATION

Spatial Preprocessing Radiance

First field: Box length
Second field: Minimum number of cloudfree pixels
Third field: Method used

Spatial Preprocessing Radiance

ZENITH CORRECTION

BOX_05 3 3 MEDIAN
BOX_06 3 3 MEDIAN
BOX_07 3 3 MEDIAN
BOX_08 3 3 MEDIAN
BOX_09 3 3 MEDIAN
BOX_10 3 3 MEDIAN
BOX_11 3 3 MEDIAN

Normalization (maximum-minimum)
Scheme (Pre-processing-2)

Normalization (maximum-minimum)

7 SEVIRI IR RADIANCES

Smoothing of SEVIRI radiances

Normalization (maximum-minimum)

7 IR RADIANCES CORRECTED TO MSG ZEN= 45°

NN ZENITH CORRECTION

Configuration file

# Zenith angle normalization coefficient
NORM_MSGZENITH 0.0 70.0

Configuration file

# Zenith angle normalization coefficient
NORM_MSGZENITH 0.0 70.0

Normalizer (maximum-minimum)

7 SEVIRI IR RADIANCES

MSG ZENITAL ANGLE

Normalization (maximum-minimum)

NN ZENITH CORRECTION

7 IR RADIANCES CORRECTED TO MSG ZEN= 45°

Configuration file

# Zenith angle normalization coefficient
NORM_MSGZENITH 0.0 70.0

Normalizer (maximum-minimum)

7 SEVIRI IR RADIANCES

MSG ZENITAL ANGLE

Normalization (maximum-minimum)
Scheme (Pre-processing-3)
It is the same for LPW and SAI

- Smoothing of SEVIRI radiances
- 7 SEVIRI IR RADIANCES
- MSG ZENITAL ANGLE

Normalization
(normalization (maximum-minimum))

Configuration file

# Configuration file
### NNs file names ###
# ZENITHAL_NN zenith_2_45_NEURAL_NETWORK_FILE.net

## Multilayer Perceptron
(only one hidden layer)

Topology=(8:16:7)

### NN ZENITH CORRECTION ###

7 IR RADIANCES CORRECTED TO MSG ZEN= 45°
Scheme (Processing)

XX BL or ML or HL or TPWcontrol (PGE07)
LI (PGE08)

7 IR RADIANCES CORRECTED TO MSG ZEN = 45°

NN_SEA_XX

XX Normalized between [0,1]

SEA PIXELS

4 Multilayer Perceptrons
(only one hidden layer)
Topology=(7:12:1)

7 IR RADIANCES CORRECTED TO MSG ZEN = 45°

NN_LAND_XX

XX Normalized between [0,1]

LAND PIXELS

ALTITUDE

NORMALIZATION

4 Multilayer Perceptrons
(only one hidden layer)
Topology=(8:12:1)
Scheme (Post-Processing) LPW

LPW (BL or ML or HL or TPWcontrol)

LPW parameter normalized between [0,1]

Denormalized LPW parameter (maximum-minimum)

Smoothing of LPW parameter

Conversion of LPW parameter from mm to grey levels.

OPTIONAL STEP (Configuration file)

******************************************************************************
### Spatial_Preprocessing_Radiance ###
******************************************************************************
### First field: Box length ###
### Second field: Minimum number of ###
###  cloudfree pixels ###
### Third field: Method used ###
******************************************************************************
POSTPROC_BL 3 3 MEDIAN
POSTPROC_ML 3 3 MEDIAN
POSTPROC_HL 3 3 MEDIAN
POSTPROC_TPW 3 3 MEDIAN

HDF-5 file

Defined in a include file
Scheme (Post-Processing) SAI

OPTIONAL STEP (Configuration file)

LI normalized between [0,1]

Conversion of LI from °C to grey levels.

Configuration file.
Advantages of the algorithms’ design (1)

- The software has been structured in order to easily introduce other stability indexes.

- Other stability index can be obtained, just by changing the sea and land neural network files, the Look Up Table (LUT) used in the denormalization process, and the thresholds used in the conversion to grey levels or counts.
Advantages of the algorithms’ design (2)

• SAI's and LPW’s main algorithms have been devised as a neural network with a resulting topology. It is possible that during future developments, other topologies present better performances.
• The software has been designed to change the topology and weights only changing the name of the new neural networks in the configuration file.
• When the PGE08 or PGE07 is started, all the names of the files with the neural networks are read from the configuration file and the topology and weights are allocated and loaded.
Advantages of the algorithms’ design (3)

• Smoothing of SEVIRI radiances (optional and configurable in the model configuration file) and smoothing of the clear air parameter (optional and configurable in the model configuration file) will allow to obtain trends of the parameters.

• Normalization in the pre-processing step and denormalization in the post-processing step will allow to perform the tuning of the parameters.
Smoothing of SEVIRI radiances (optional) performing a median or mean/average (configurable in the model configuration file) over a window centred at the processing pixel. Boundaries of the region are not considered.
Comparison of the outputs with different activated smoothing in pre-processing
Smoothing in the Post-processing Step

3x3 MEDIAN In TPW parameter

Smoothing of each layer when it is required in the model configuration file. For this case parameter TPW and method median and length of the processing box 3x3
Comparison of the outputs with different activated smoothing in post-processing
Smoothing in the both Steps

Smoothing of SEVIRI radiances (optional and configurable in the model configuration file) and smoothing of TPW (optional and configurable in the model configuration file).
Comparison of the outputs with different activated smoothing in both
**Trends**

- The smoothing is necessary to exploit the trends of the clear air parameters including in PGE07 and PGE08.

- The differences between images are less noisy when a smoothing is applied.

- It is better use the smoothing is the post-processing that in the pre-processing for trends, in the five clear air parameter (BL, ML, HL, TPW-control and LI).
Comparison of the outputs with smoothing activated in different places
BIAS
BIAS

- In order to evaluate how much representative is the training dataset, the simulated radiances must be compared with co-located real SEVIRI radiances.
- It can be observed a bias between both and it is probably the most important source of error in the LPW and SAI final results.
- In a first evaluation CMa (v0.1) was used but it was not so good, and not all cases classified as "clear air" were really cloud-free. Therefore, the biases were contaminated and it makes difficult their inclusion in the algorithm version 1.0. (Two examples are shown)
- We will repeat the study using CMa (v1.0) significantly better than the older and the results will be introduced in future versions.
This first approach is not enough good and it was not included in the version 1.0.

We will repeat the study using CMa (v1.0) significantly better than CMa (v0.1) and the results will be introduced in future versions.
EXAMPLE: TPW

TPW MODIS AS REFERENCE

PGE07 (TPW) with bias

SANWC v1.0
EXAMPLE: LI

LI MODIS AS REFERENCE

PGE08 (LI)
SANWC v1.0

PGE08 (LI)
with bias
Variation in the channels’ calibration

- Channels’ calibration have been modified with an impact in the PGE07 and PGE08 outputs not negligible.

- The impact of the last modification (8-6-04) is shown:
  - BL, ML and TPW control parameters increase the Precipitable Water.
  - HL parameter decrease the Precipitable Water.
  - The Middle Levels parameter recovers the continuity between land-sea.

- This modification was reported as a error by Eumetsat, but it has shown that the bias correction can improve the outputs.
Example of the impact

WV6.2 radiances have been increased by EUMETSAT a 10% in the 9:30Z image (8-June-04)
Example of the impact (2)

WV6.2 radiances have been increased by EUMETSAT a 10% in the 9:30Z image (8-June-04)
Tuning at denormalization process
Denormalization step

If the radiances bias correction will not produce the waited effect, we can apply the tuning at the denormalization step.

PLOT TPW ECMWF vs TPW(LPW) SAFNWC in an area of 200x200 centre at 33N, 24W
PLOT ECMWF vs SAFNWC

X: A, 9872 BRIT BAND=DEF
Y: A, 9871 BRIT BAND=DEF
EXAMPLE: TPW
Known problems

✓ Desert areas:
  • No realistic LI values especially at night.
  • Underestimation in the LPW parameters.

✓ Other places:
  • LI SAFNWC tends to be more unstable than the LI computed from radio-soundings.
  • The LPW products tend to underestimate the precipitable water.
Planned activities in 2004

Improvements to be included in SAFNWC (v1.2)

• Additional tuning where needed, following the way described in this presentation

Validation

• Radiosonde and NWP analysis (From July 2004 to September 2004)
• MODIS (only a few study cases)
EXAMPLES

• The spatial patterns are agree
  (except in desert areas at night)

• Quantitative values must be tuned
LPW: TPW control (3-6-04/12Z)
SAI: Lifted Index (3-6-04/12Z)
LPW: TPW control (7-6-04/12Z)
SAI: Lifted Index (7-6-04/12Z)
STUDY CASE
14, 15 & 16 October 2003
STUDY CASE

• ECMWF analysis and SAFNWC products:
  • BL (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  • ML (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  • HL (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  • TPW (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  • LI (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)

• MODIS products and SAFNWC products:
  • BL (15-10-03/12Z and 16-10-03/12Z)
  • ML (15-10-03/12Z and 16-10-03/12Z)
  • HL (15-10-03/12Z and 16-10-03/12Z)
  • TPW (15-10-03/12Z and 16-10-03/12Z)
  • LI (15-10-03/12Z and 16-10-03/12Z)

• Trends ECMWF and SAFNWC products:
  • BL (15-10-03/12Z and 16-10-03/12Z)
  • ML (15-10-03/12Z and 16-10-03/12Z)
  • HL (15-10-03/12Z and 16-10-03/12Z)
  • TPW (15-10-03/12Z and 16-10-03/12Z)
ECMWF ANALYSIS VS SAFNWC PRODUCTS
LPW: BL (15-10-03/12Z)
LPW: BL (16-10-03/12Z)
LPW: ML (15-10-03/00Z)
LPW: ML (15-10-03/12Z)
LPW: ML (16-10-03/12Z)
LPW: HL (15-10-03/00Z)
LPW: HL (15-10-03/12Z)
LPW: HL (16-10-03/12Z)
LPW: TPW (15-10-03/12Z)
LPW: TPW (16-10-03/12Z)
MODIS SCIENTIFIC PRODUCTS
VS
SAFNWC PRODUCTS
MODIS SCIENTIFIC PRODUCTS

- MODIS TPW can be used as reference

- The other two water vapor data fields supplied by GSFC (not equivalent to LPW parameters because the layer are different) are:
  - Water vapor low: water vapor integrated from surface to 920 hPa
  - Water vapor high: water vapor integrated from 700hPa to 300 hPa

- The science MODIS LI is calculated using the retrieved profile and the air parcel always start the ascent at 1000hPa. While in the SAFNWC LI and in the ECMWF LI the air parcel starts the ascent at 2 meter of surface level (the colour scale reflects this different).

NOTE: Water vapor low and water vapor high can only used to compare patterns.
MODIS MOD07 FILE: TPW (15-10-03/12Z)
MODIS MOD07 FILE: TPW DIRECT (15-10-03/12Z)
MODIS MOD07 FILE: WV LOW (15-10-03/12Z)
MODIS MOD07 FILE: WV LOW (16-10-03/12Z)
MODIS MOD07 FILE: WV HIGH (15-10-03/12Z)
TREND ECMWF ANALYSIS LPW PRODUCTS

VS

TREND SAFNWC LPW PRODUCTS
TREND LPW: BL (15-10-03, 12Z-00Z)

PGE07: Trend of BL calculated with ECMWF at 03288 (12-00Z)

PGE07: Trend of BL with SAFNWC at 03288 (12-00Z)
TREND LPW: BL (16-10-03, 12Z-00Z)
TREND LPW: ML (15-10-03, 12Z-00Z)
TREND LPW: ML (16-10-03, 12Z-00Z)
TREND LPW: HL (15-10-03, 12Z-00Z)

PGE07: Trend of HL calculated with ECMWF at 0328B (12-00)Z

10001 HL_ECMWF  15 OCT 03288 120000 00491 02270 09 00  McIDAS

PGE07: Trend of HL with SAFNWC at 0328B (12-00)Z

10001 SAFN_LPW  15 OCT 03288 120000 00491 02270 09 00  McIDAS
TREND LPW: HL (16-10-03, 12Z-00Z)

PGE071 Trend of HL calculated with ECMWF at 03289 (12-00)Z

PGE071 Trend of HL with SAFNWC at 03289 (12-00)Z
TREND LPW: TPW (15-10-03, 12Z-00Z)