LPW & SAI
Layer Precipitable Water and Lifted Index

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Madrid

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INM

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

SAFNWC

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

✓

IR SEVIRI Channels	Centred	Comments	Absorbents
WV6.2µm	6.25µm	WV channel	H20
WV 7.3µm	7.35µm	WV channel	H20,N20,CH4
IR 8.7µm	8.70µm	Window Channel (Tsfc)	H20,O3,N20, CH4
IR 9.7µm	9.66µm	Ozone channel	H20,CO2,O3
IR 10.8µm	10.8µm	Window Channel (Tsfc)	H20,CO2,O3
IR 12.0µm	12.0µm	Window Channel (Tsfc y q)	H20,CO2
IR 13.4µm	13.4µm	Air Temperature	H20,CO2,O3

✓ 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:

LPW Parameters	Bottom level	Top level
BL	P_{SFC}	840 hPa
ML	840 hPa	437 hPa
HL	437 hPa	0 hPa
TPW	P_{SFC}	0 hPa

PGE08: Stability Analysis Imagery

SAI Parameters	Bottom level	Top level
LI	P_{SFC}	500 hPa

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

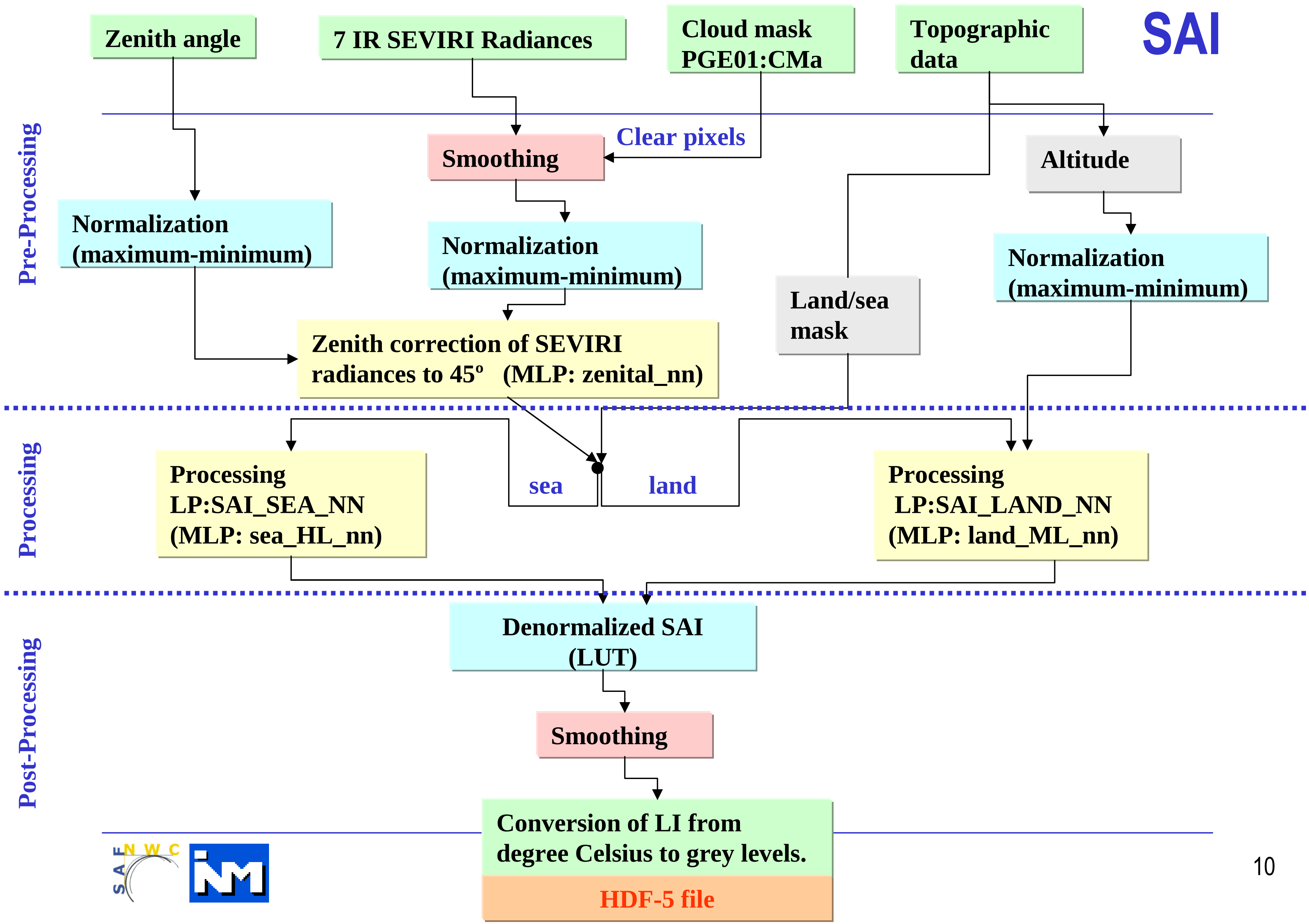
- **60L-SD database has been used.**
  - **This database is provided by NWP SAF**
  - **It is well suited for precipitable water parameters.**
  - **It is not so good for stability parameters.**

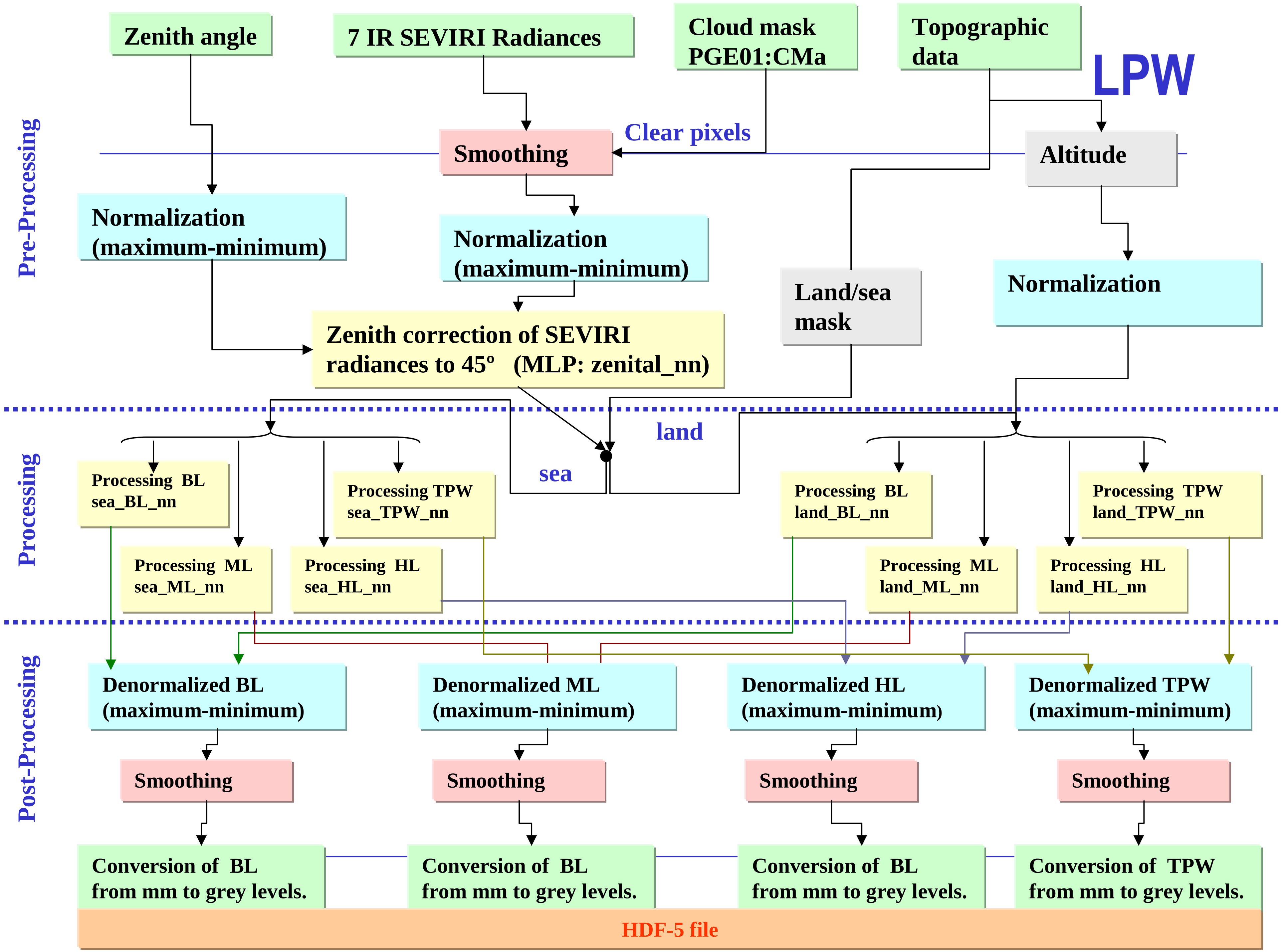
- **In order to build the training dataset for LPW sea and land neural networks, all profiles of the 60L-SD database were used as inputs to the RTTOV-7.**

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


SAI
Zenith angle
7 IR SEVIRI Radiances
Cloud mask PGE01:CMa
Topographic data
Pre-Processing
Smoothing
Clear pixels
Altitude
Normalization (maximum-minimum)
Normalization (maximum-minimum)
Normalization (maximum-minimum)
Land/sea mask
Zenith correction of SEVIRI radiances to 45º (MLP: zenital_nn)
Processing
Processing LP:SAI_SEA_NN (MLP: sea_HL_nn)
sea
land
Processing LP:SAI_LAND_NN (MLP: land_ML_nn)
Post-Processing
Denormalized SAI (LUT)
Smoothing
Conversion of LI from degree Celsius to grey levels.
HDF-5 file
SAF NWC



LPW
Zenith angle
7 IR SEVIRI Radiances
Cloud mask PGE01:CMa
Topographic data
Pre-Processing
Smoothing
Clear pixels
Altitude
Normalization (maximum-minimum)
Normalization (maximum-minimum)
Land/sea mask
Normalization
Zenith correction of SEVIRI radiances to 45º (MLP: zenital_nn)
land
sea
Processing
Processing BL sea_BL_nn
Processing ML sea_ML_nn
Processing HL sea_HL_nn
Processing TPW sea_TPW_nn
Processing BL land_BL_nn
Processing ML land_ML_nn
Processing HL land_HL_nn
Processing TPW land_TPW_nn
Post-Processing
Denormalized BL (maximum-minimum)
Denormalized ML (maximum-minimum)
Denormalized HL (maximum-minimum)
Denormalized TPW (maximum-minimum)
Smoothing
Smoothing
Smoothing
Smoothing
Conversion of BL from mm to grey levels.
Conversion of BL from mm to grey levels.
Conversion of BL from mm to grey levels.
Conversion of TPW from mm to grey levels.
HDF-5 file

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

OPTIONAL STEP (Configuration file)

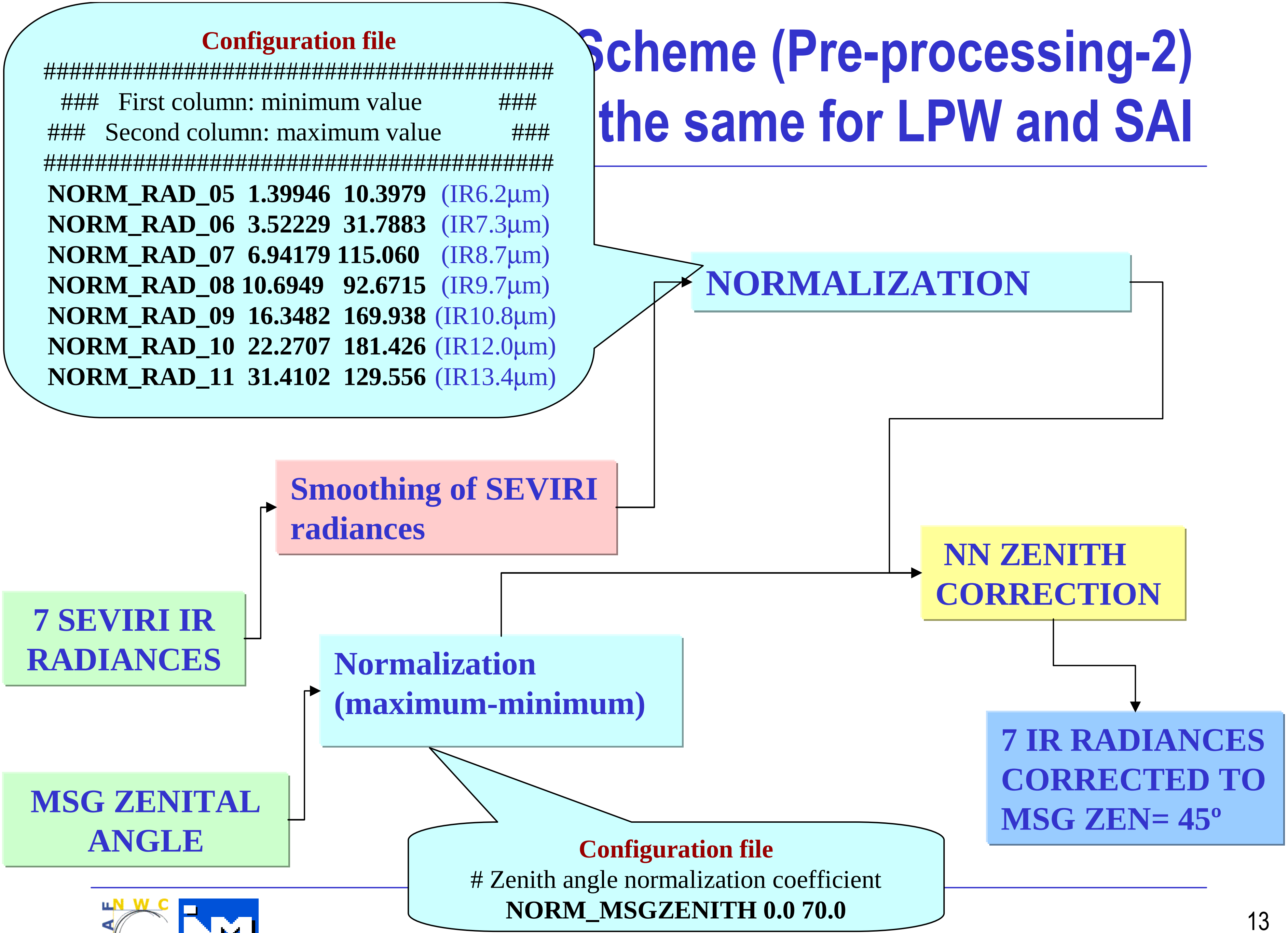
```
##########################################
### Spatial_Preprocessing_Radiance       ###
##########################################
### First field: Box length              ###
### Second field: Minimum number of      ###
###            cloudfree pixels          ###
### Third field: Method used  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

7 SEVIRI IR RADIANCES → **Smoothing of SEVIRI radiances** → **NORMALIZATION** → **NN ZENITH CORRECTION**

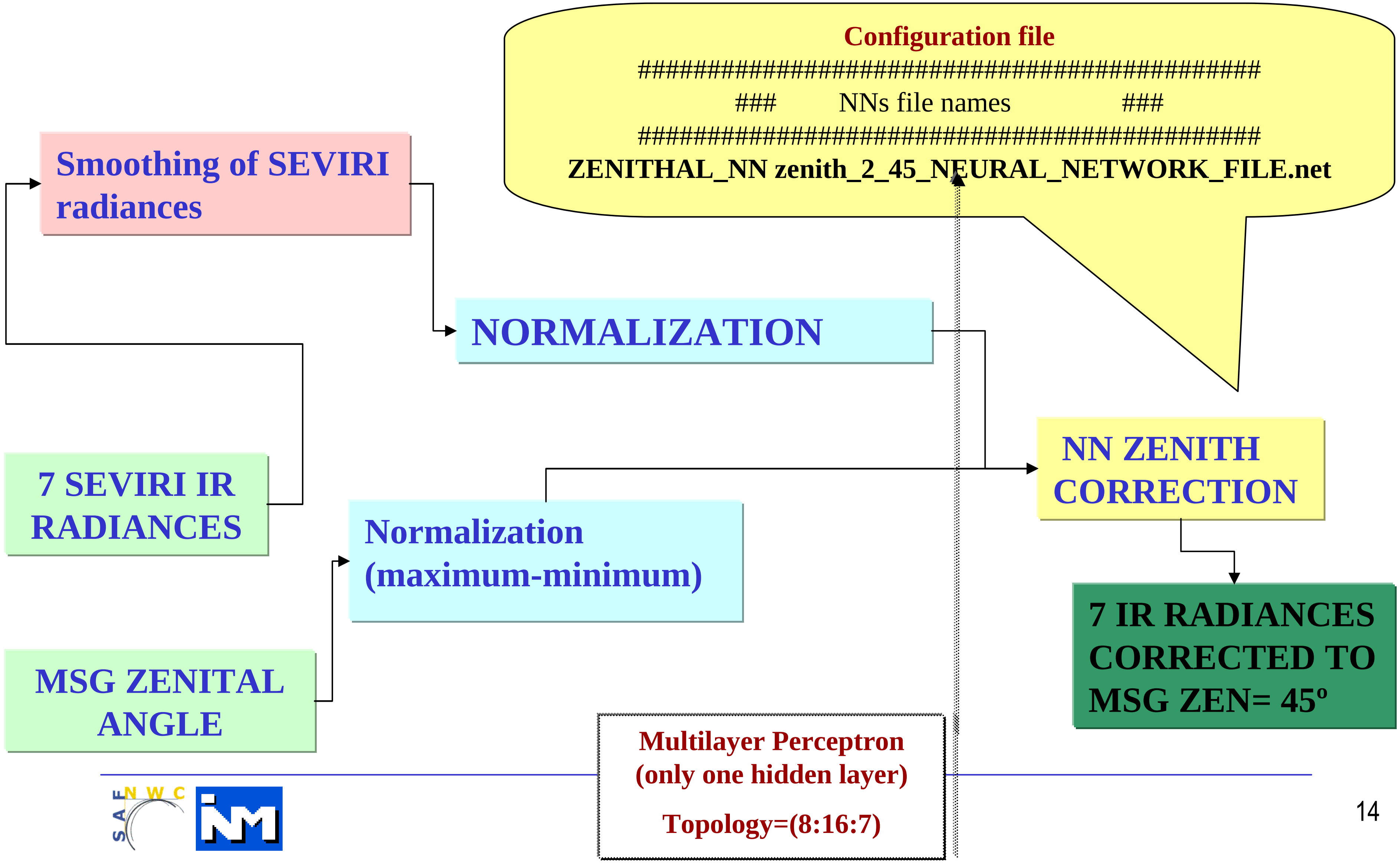
MSG ZENITAL ANGLE → **Normalization (maximum-minimum)** → **NN ZENITH CORRECTION**

NN ZENITH CORRECTION → **7 IR RADIANCES CORRECTED TO MSG ZEN= 45º**

Scheme (Pre-processing-2) the same for LPW and SAI

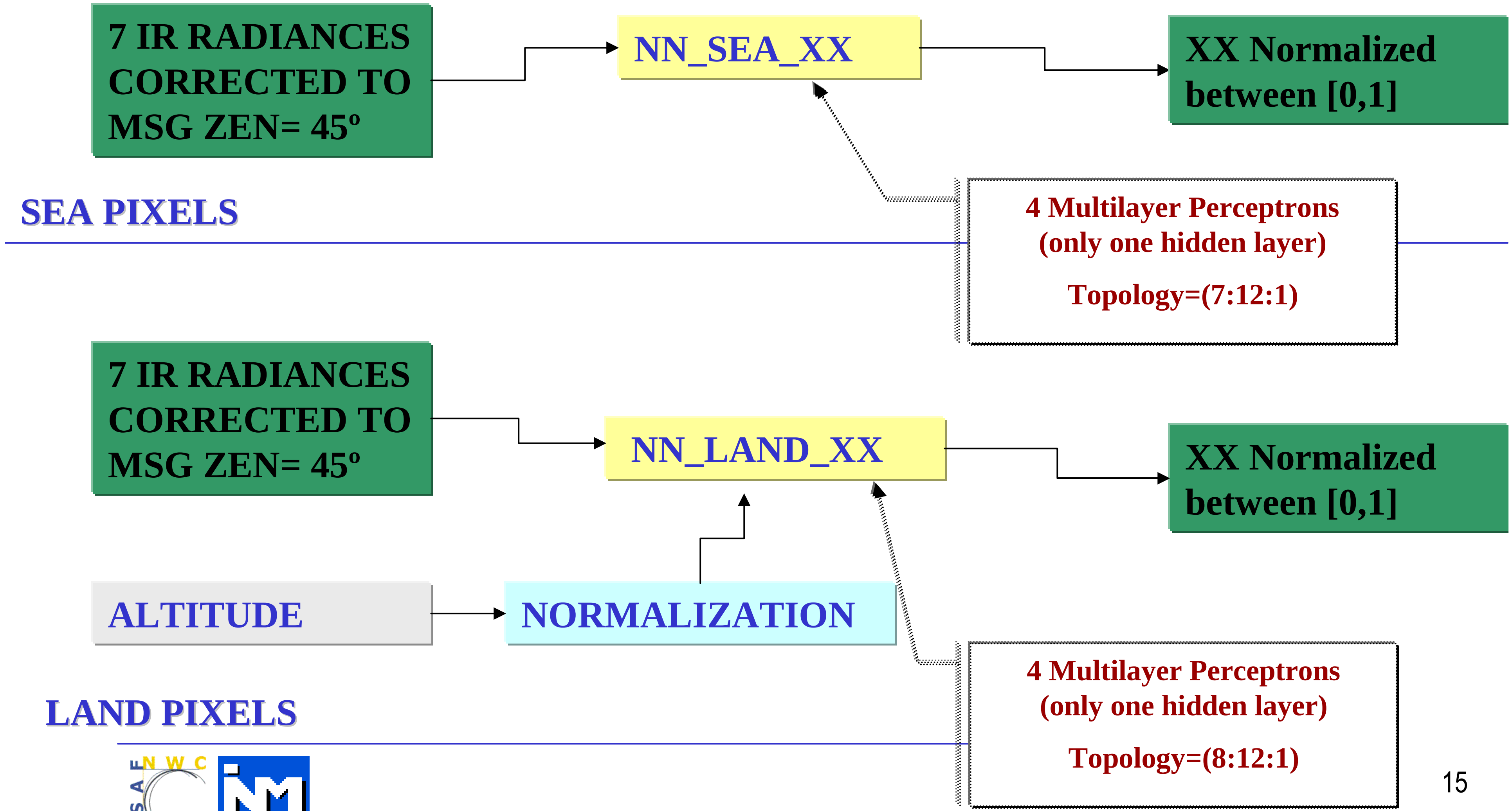


Scheme (Pre-processing-3)
It is the same for LPW and SAI



Scheme (Processing)

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



Scheme (Post-Processing) LPW

LPW (BL or ML or HL or TPWcontrol)

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
```

Smoothing of LPW parameter

Conversion of LPW parameter from mm to grey levels.

HDF-5 file

LPW parameter normalized between [0,1]

Denormalized LPW parameter(maximum-minimum)

Defined in a include file

Scheme (Post-Processing) SAI

OPTIONAL STEP (Configuration file)

```
##########################################
### Spatial_Preprocessing_Radiance       ###
##########################################
### First field: Box length              ###
### Second field: Minimum number of      ###
###              cloudfree pixels        ###
### Third field: Method used             ###
##########################################
POSTPROC_SAI   3   3  MEDIAN
```

Smoothing of LI

Conversion of LI from ºC to grey levels.

HDF-5 file

LI normalized between [0,1]

Denormalized LI LUT

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.**

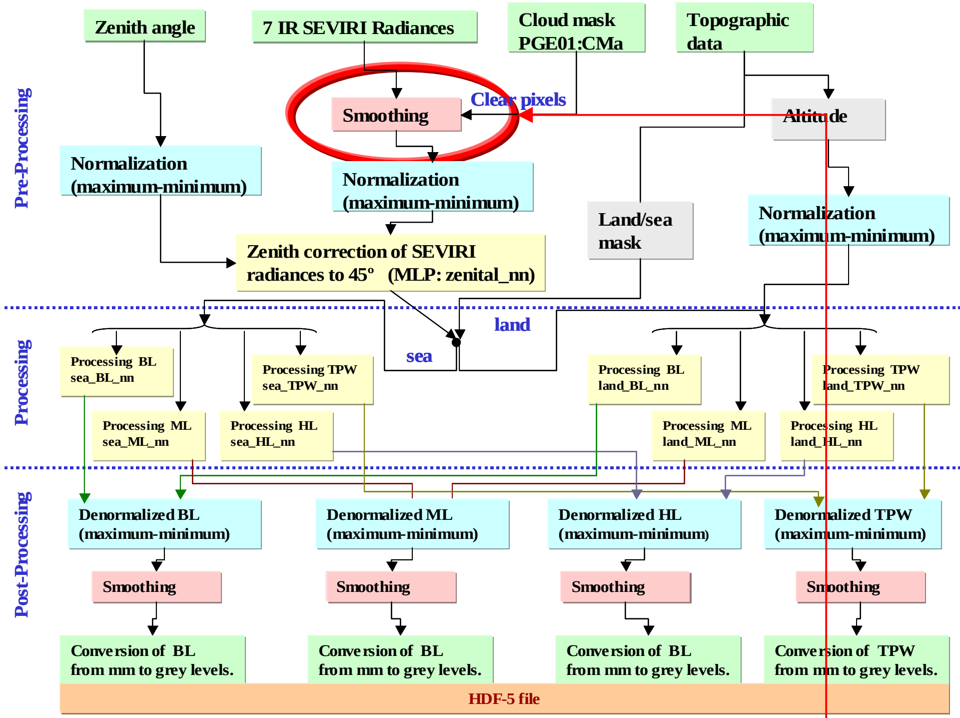
Advantages of the algorithms' design (3)

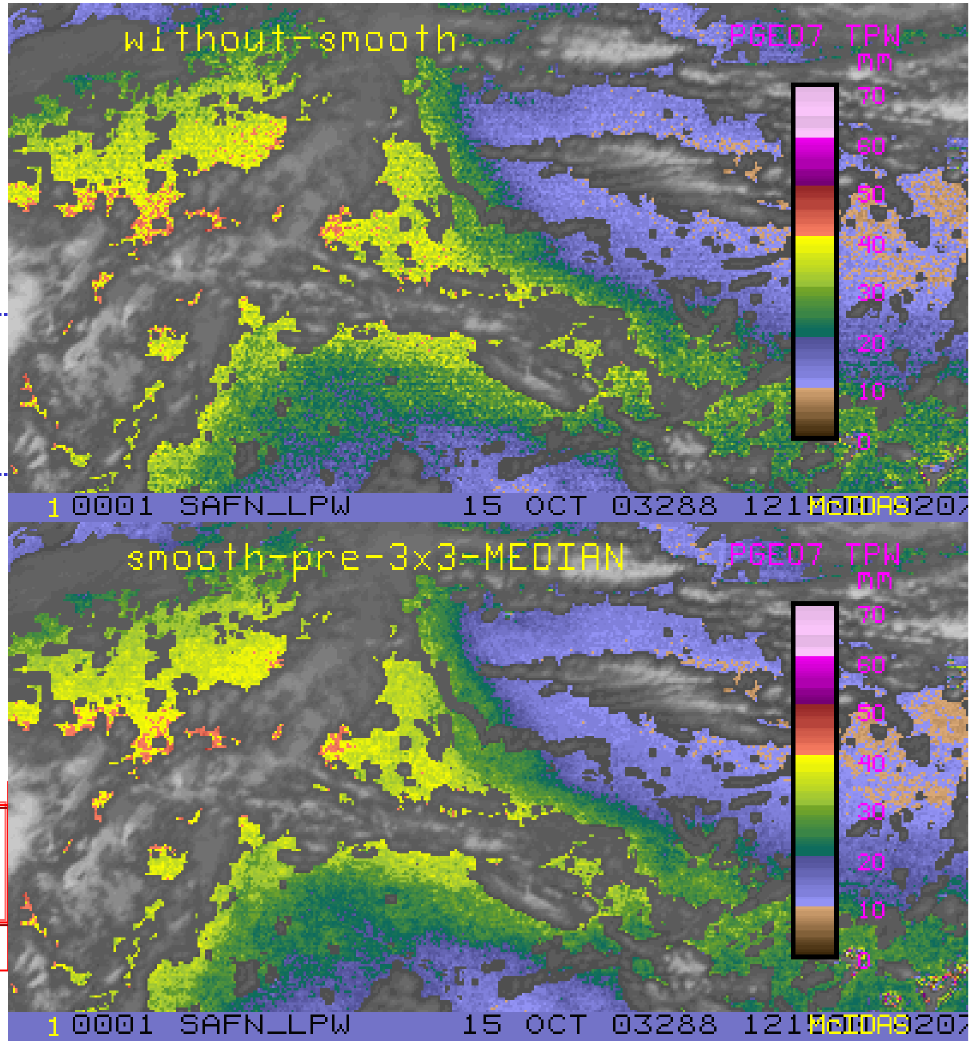
- Smoothing of SEVIRI radiances (optional and configurable in the model configuration file) and smoothing of the clear air parameter (optional and configurable in the model configuration file) will allow to obtain trends of the parameters.

- Normalization in the pre-processing step and denormalization in the post-processing step will allow to performer the tuning of the parameters

SMOOTHING

Smoothing in the Pre-processing Step



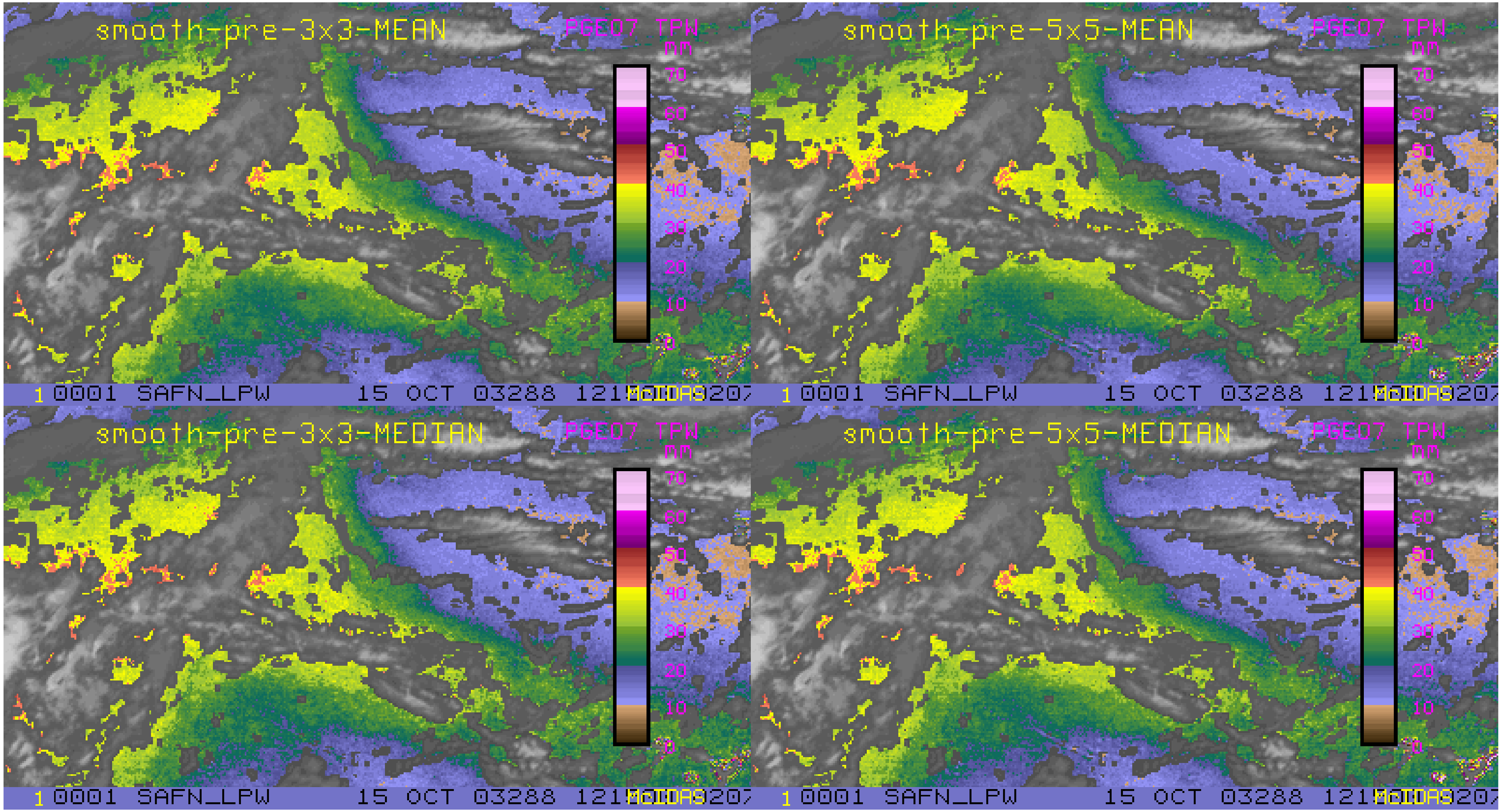


Smoothing of SEVIRI radiances (optional) performing a median o mean/average (configurable in the model configuration file) over a window centred at the processing pixel. Boundaries of the region are not considered.

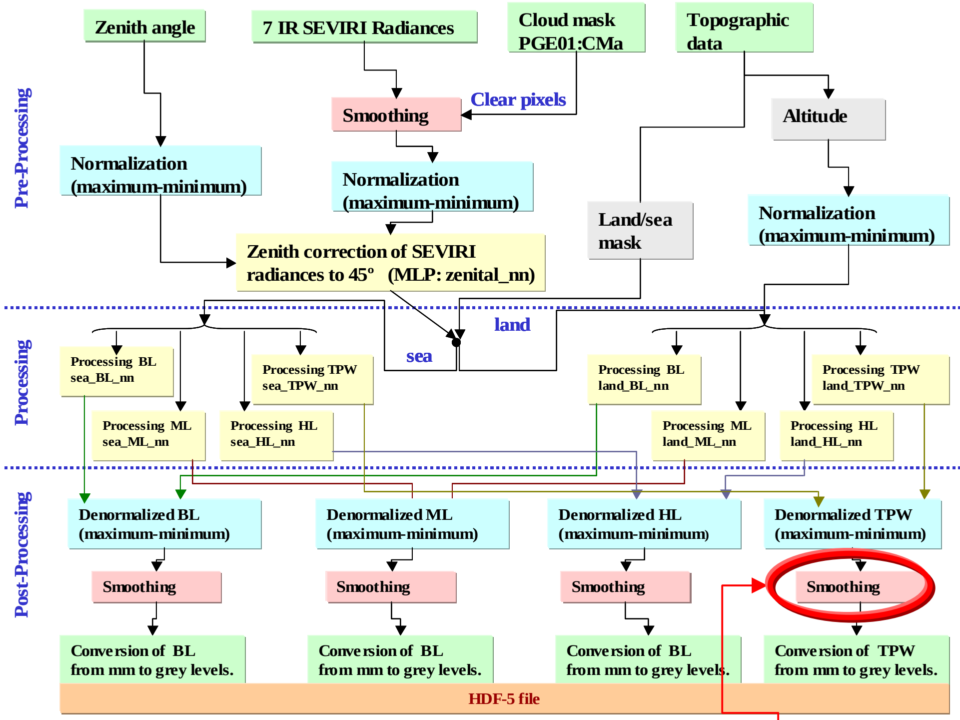
3x3 MEDIAN

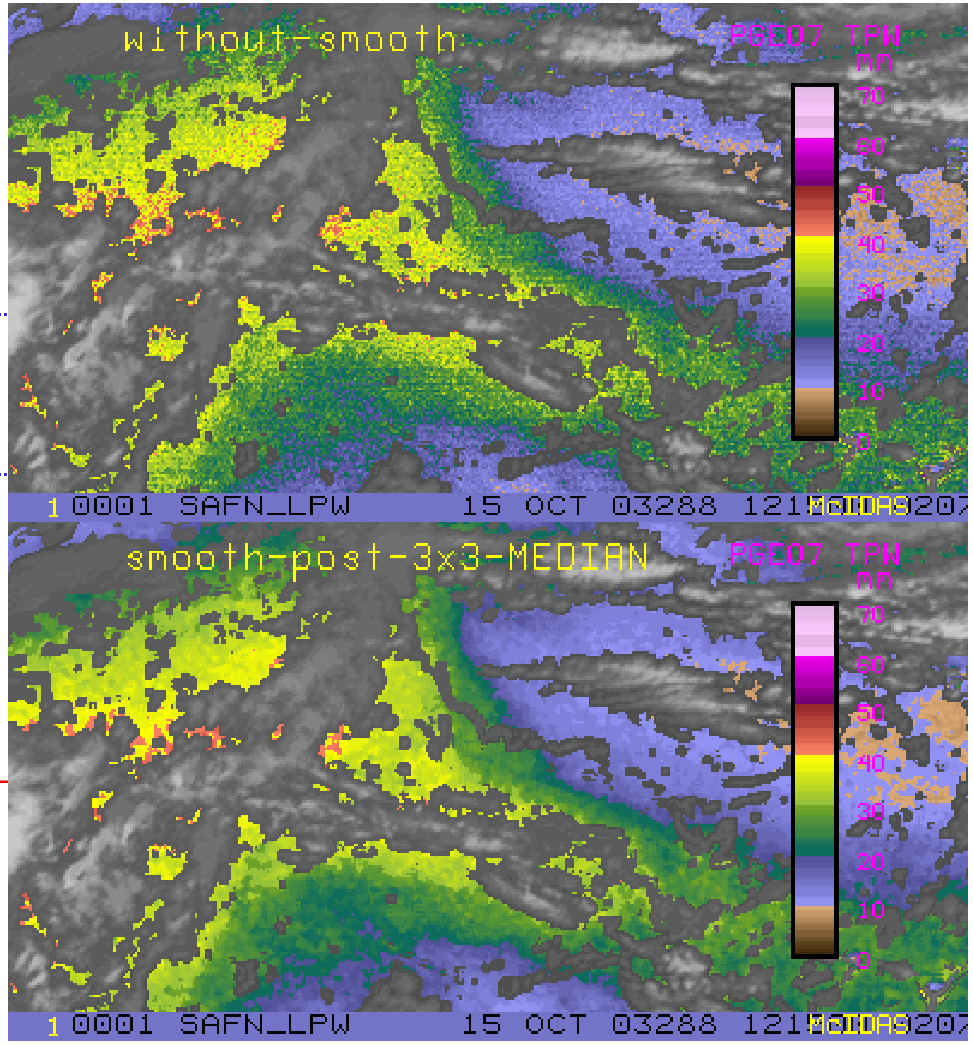
In all radiances

Comparison of the outputs with different activated smoothing in pre-processing



Smoothing in the Post-processing Step



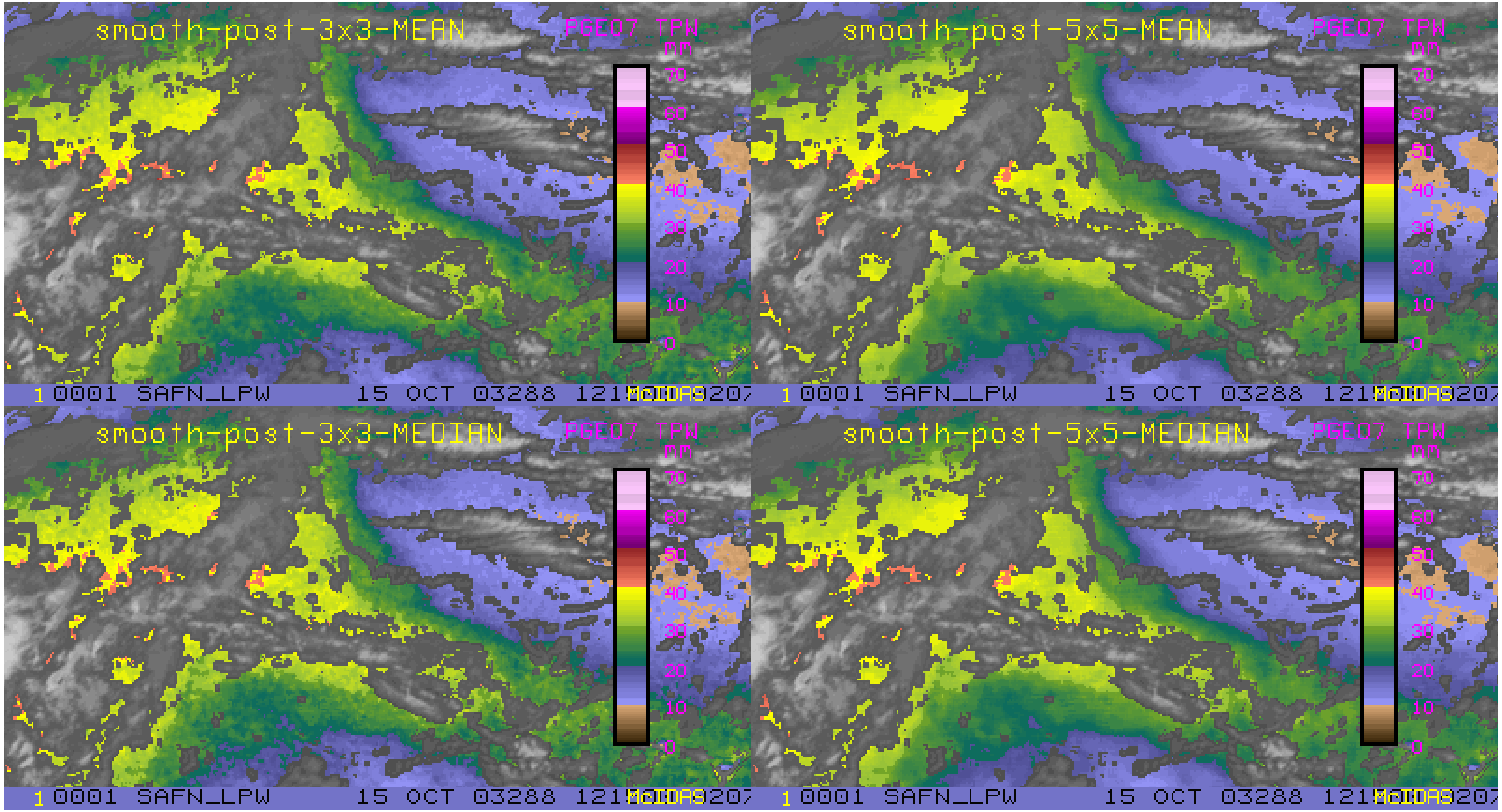


Smoothing of each layer when it is required in the model configuration file. For this case parameter TPW and method median and length of the processing box 3x3

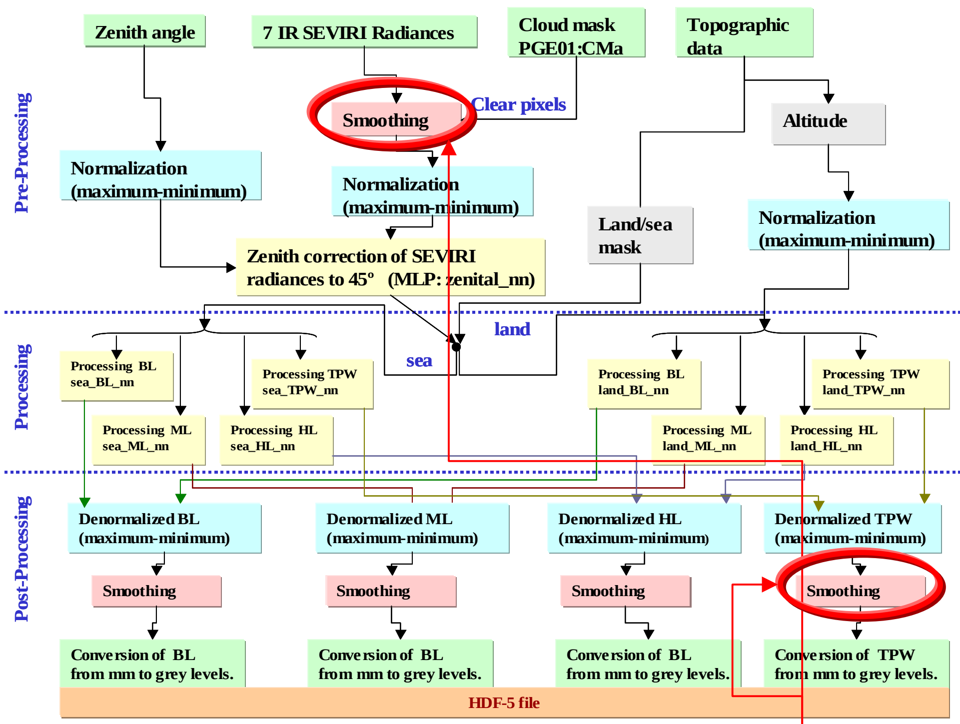
3x3 MEDIAN

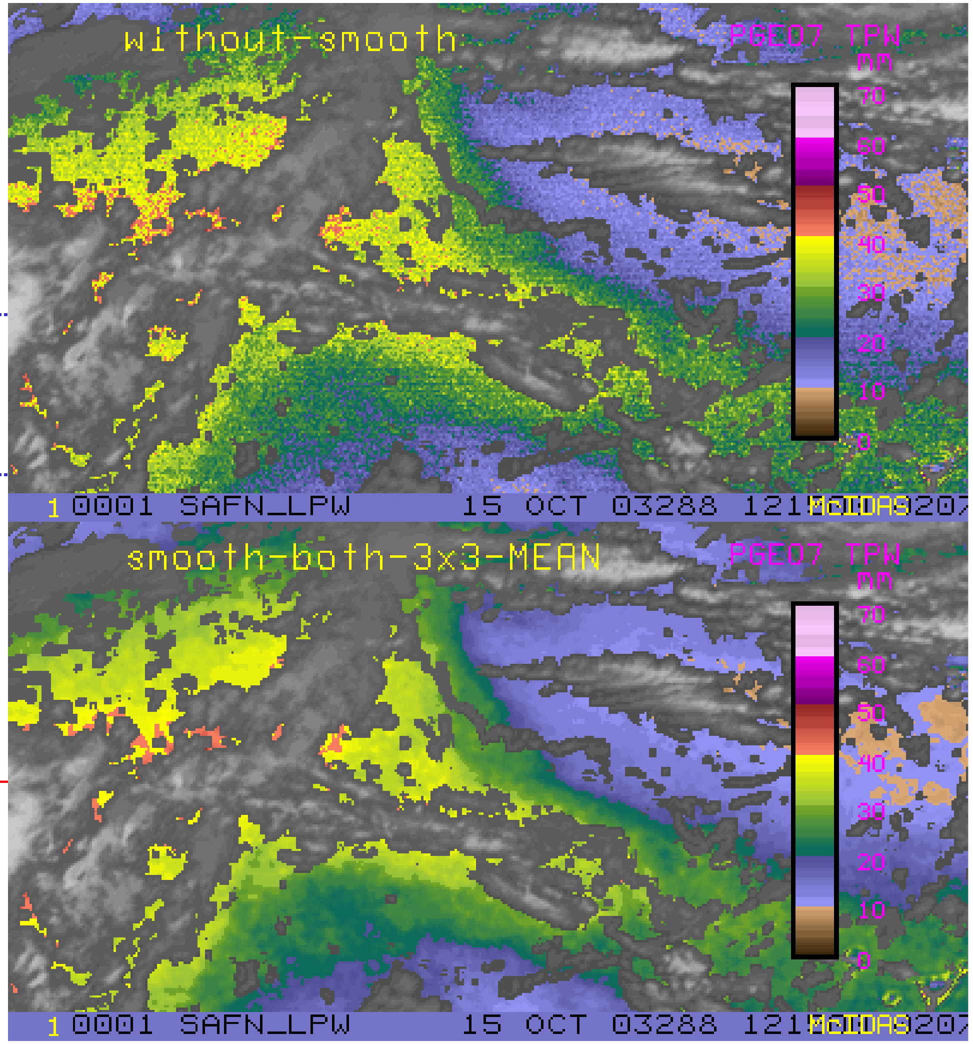
In TPW parameter

Comparison of the outputs with different activated smoothing in post-processing



Smoothing in the both Steps





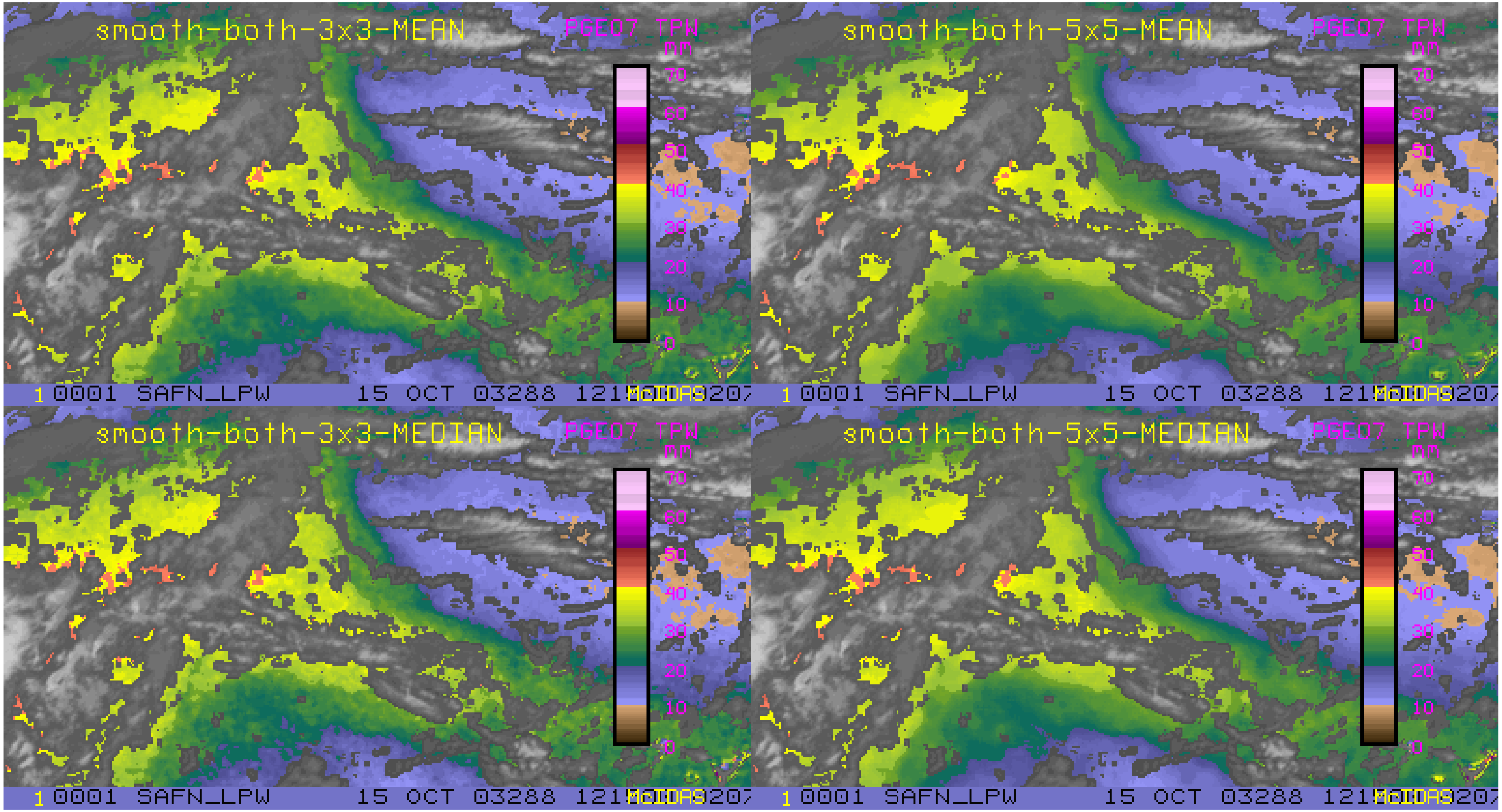
Smoothing of SEVIRI radiances (optional and configurable in the model configuration file) and smoothing of TPW (optional and configurable in the model configuration file).

3x3 MEDIAN

In all radiances

In TPW parameter

Comparison of the outputs with different activated smoothing in both



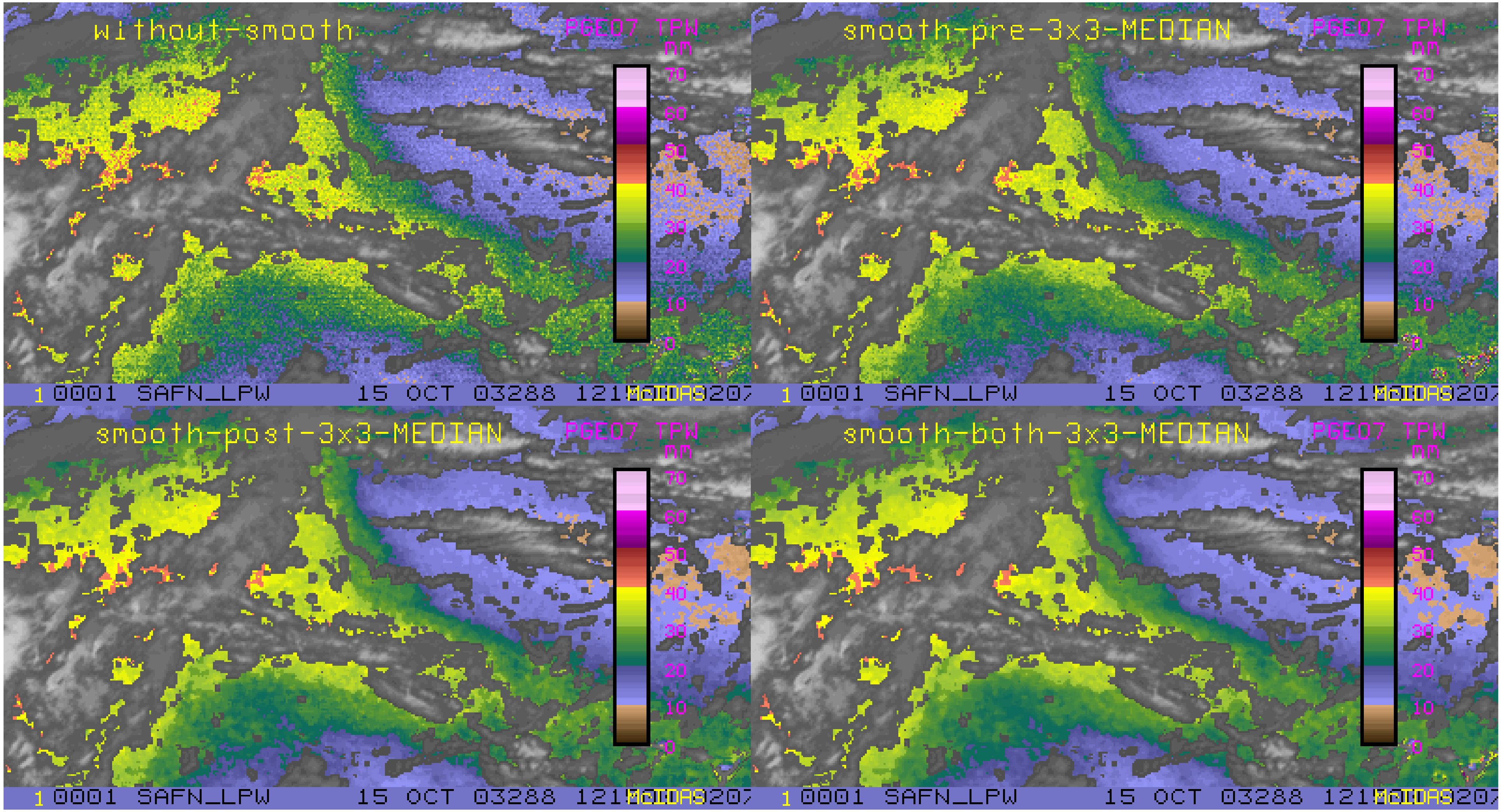
Trends

- 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

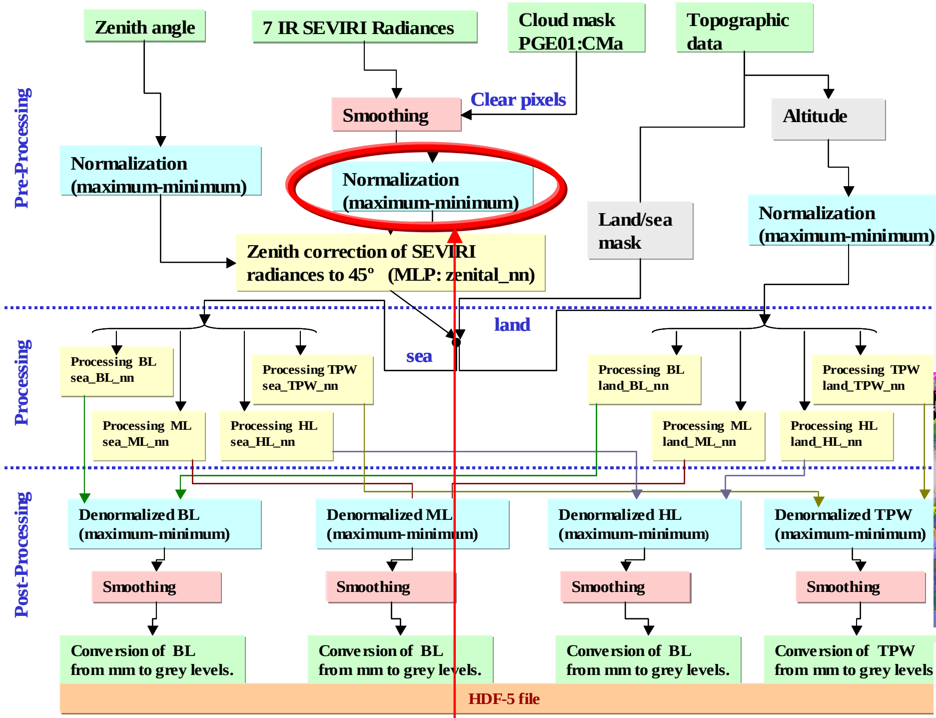


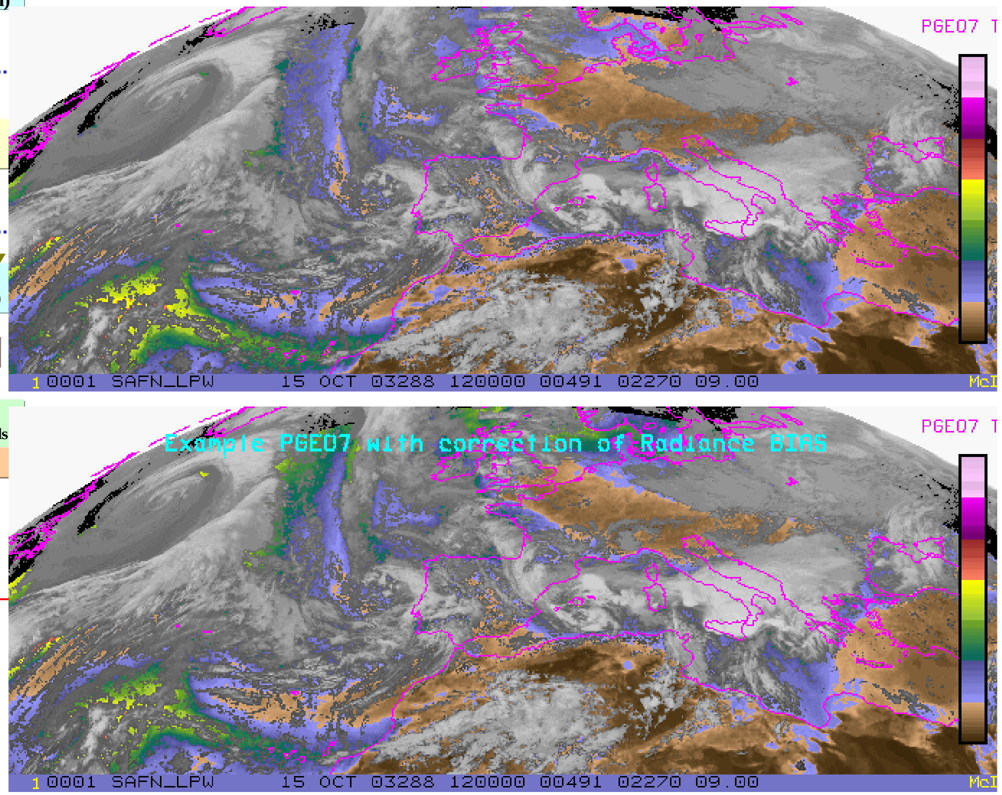
BIAS

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.

BIAS

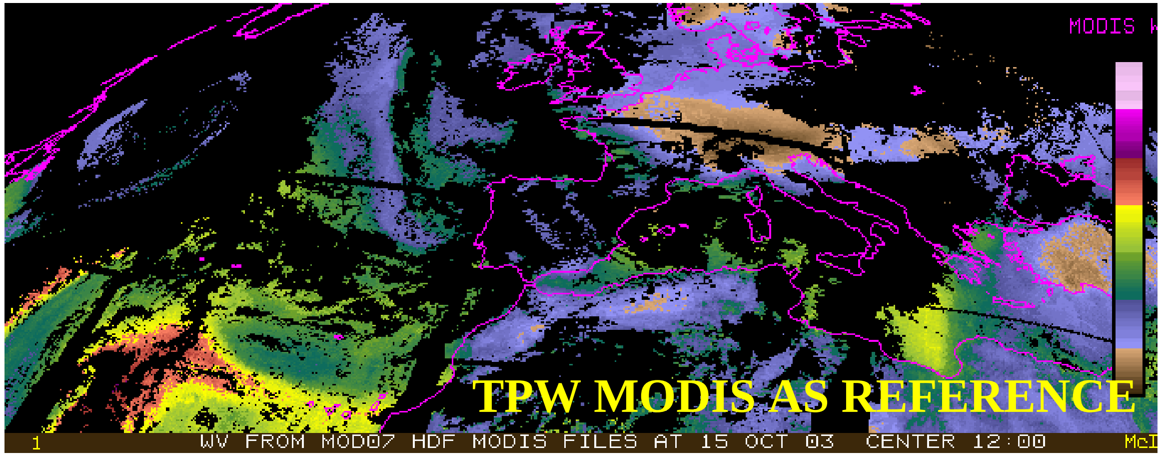


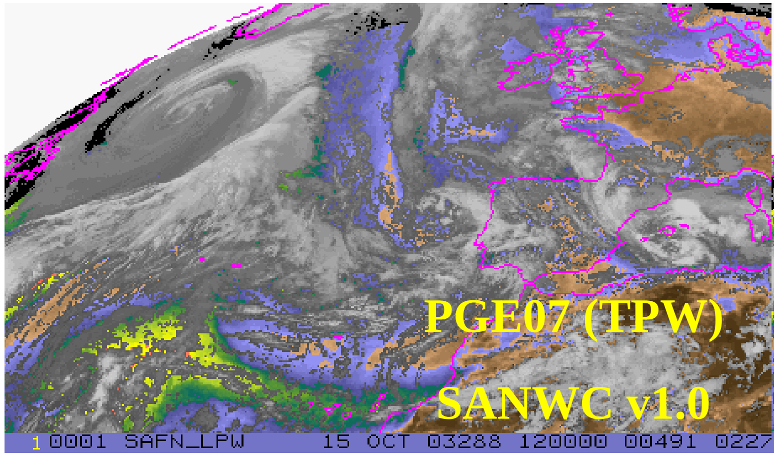


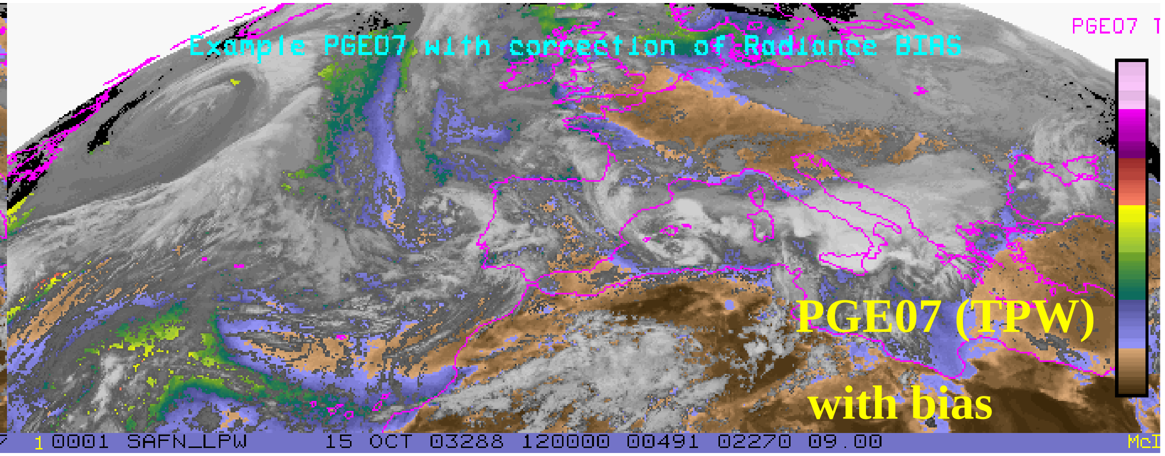
This first approach is not enough good and it was not included in the version 1.0.

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

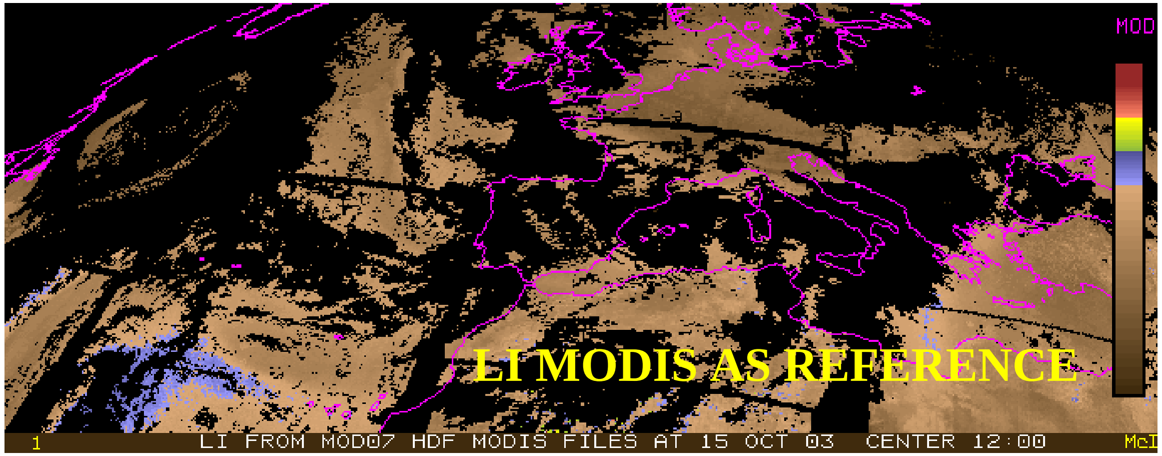
EXAMPLE: TPW

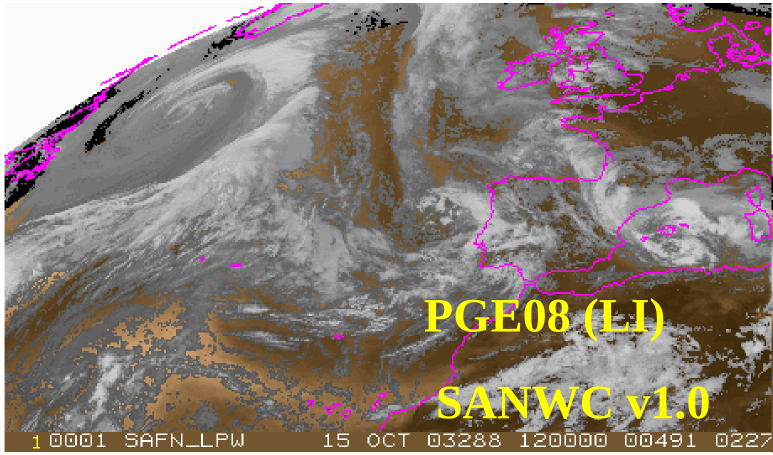

TPW MODIS AS REFERENCE
WV FROM MOD07 HDF MODIS FILES AT 15 OCT 03 CENTER 12:00

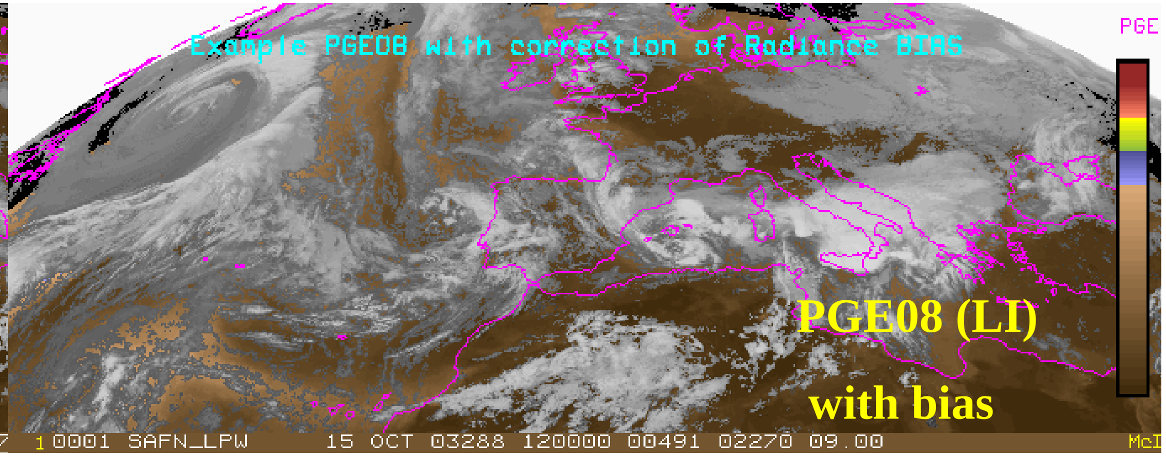

PGE07 (TPW)
SANWC v1.0
1 0001 SAFN_LPW 15 OCT 03288 120000 00491 0227


Example PGE07 with correction of Radiance BIAS
PGE07 (TPW)
with bias
1 0001 SAFN_LPW 15 OCT 03288 120000 00491 02270 09.00

EXAMPLE: LI


MOD
LI MODIS AS REFERENCE
1 LI FROM MOD07 HDF MODIS FILES AT 15 OCT 03 CENTER 12:00
McI


PGE08 (LI)
SANWC v1.0
1 0001 SAFN_LPW 15 OCT 03288 120000 00491 0227


Example PGE08 with correction of Radiance BIAS
PGE
PGE08 (LI)
with bias
1 0001 SAFN_LPW 15 OCT 03288 120000 00491 02270 09.00
McI

Variation in the channels' calibration

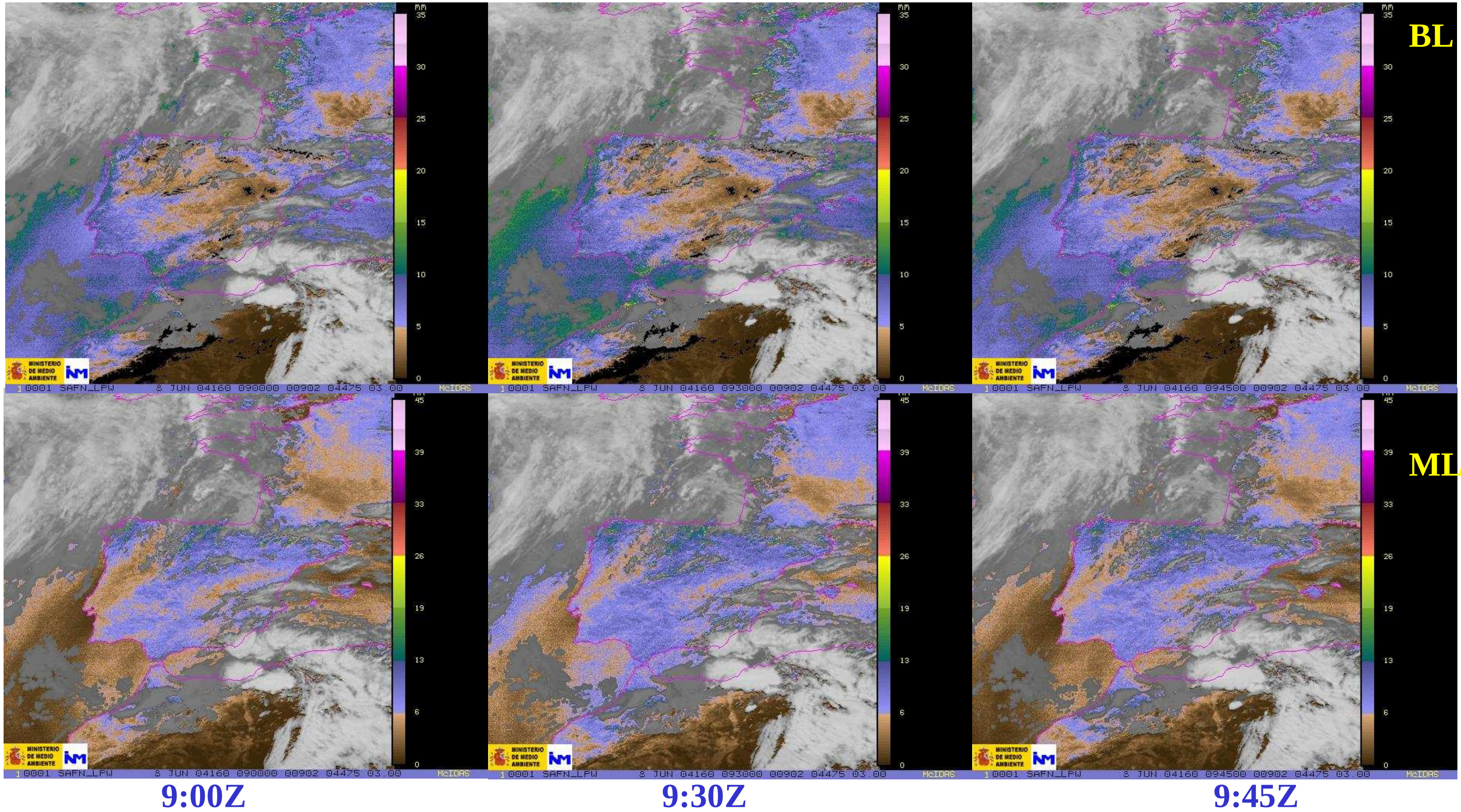
- Channels' calibration have been modified with an impact in the PGE07 and PGE08 outputs not negligible.

- 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.

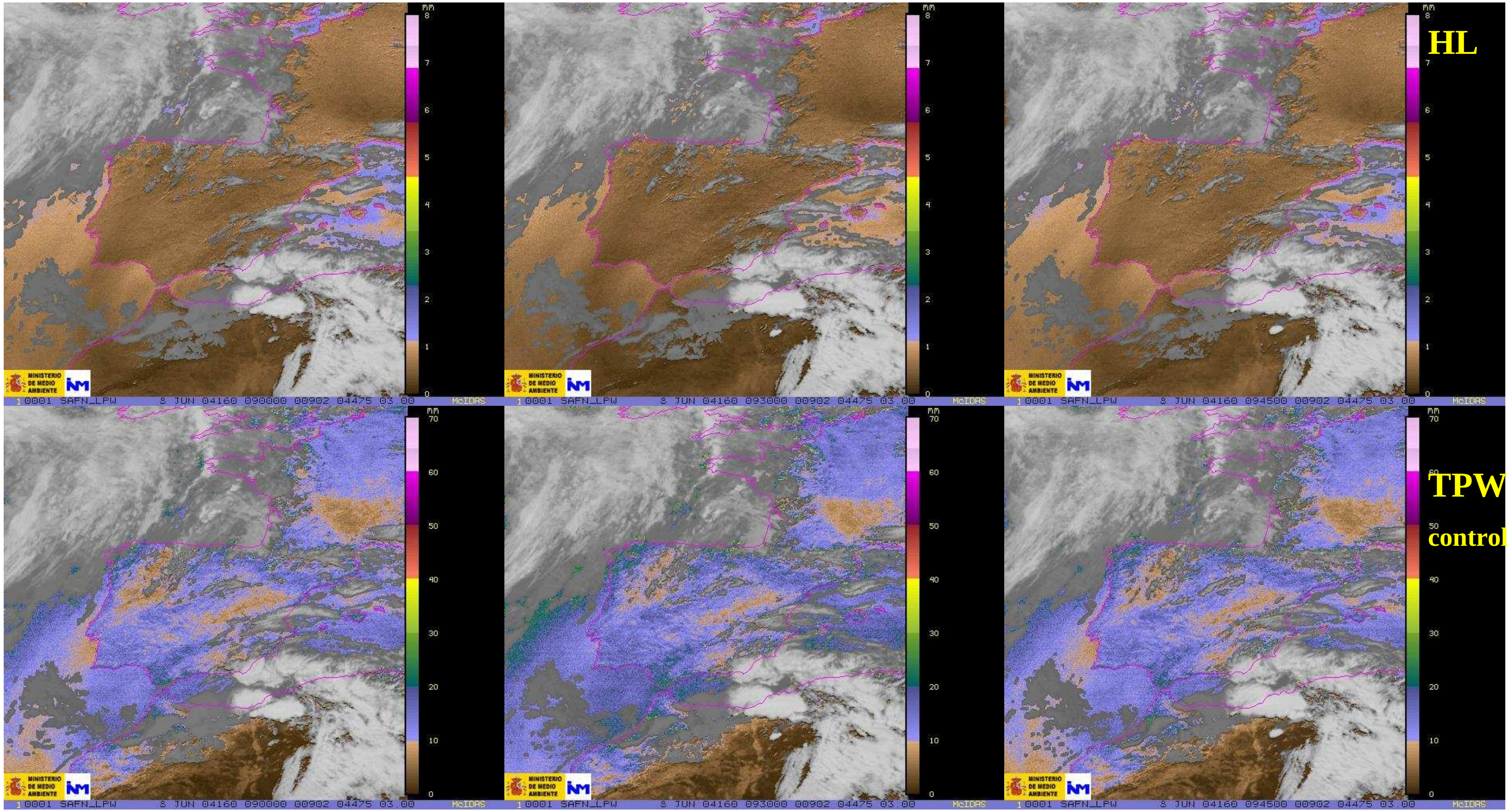
Example of the impact

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



Example of the impact (2)

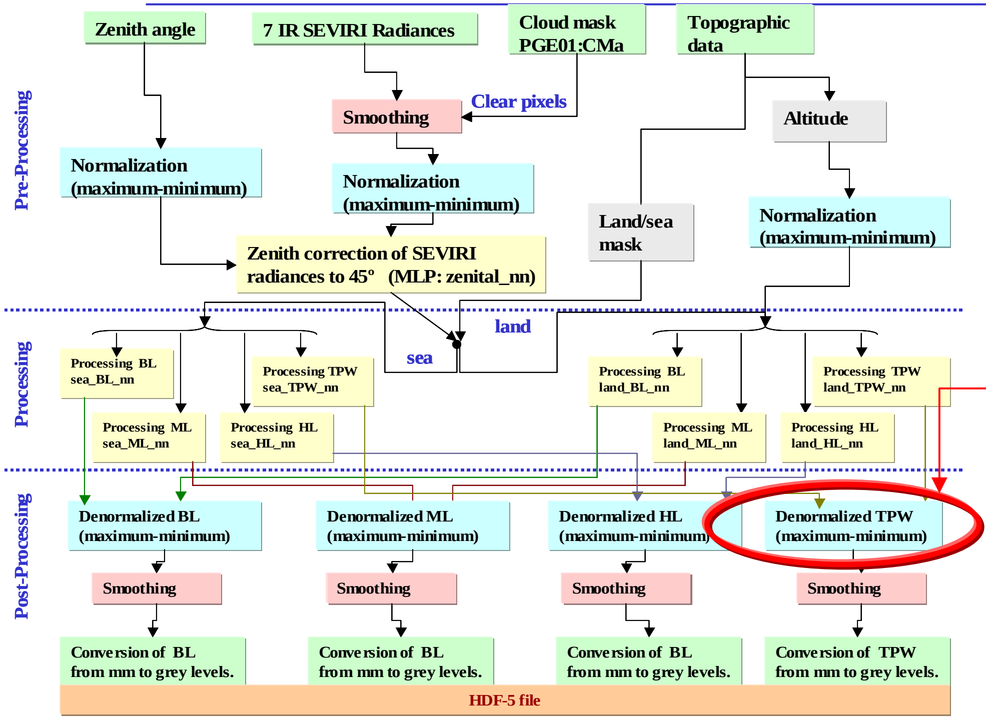
WV6.2 radiances have been increased by EUMETSAT a 10% in the 9:30Z image (8-June-04)



9:00Z **9:30Z** **9:45Z**

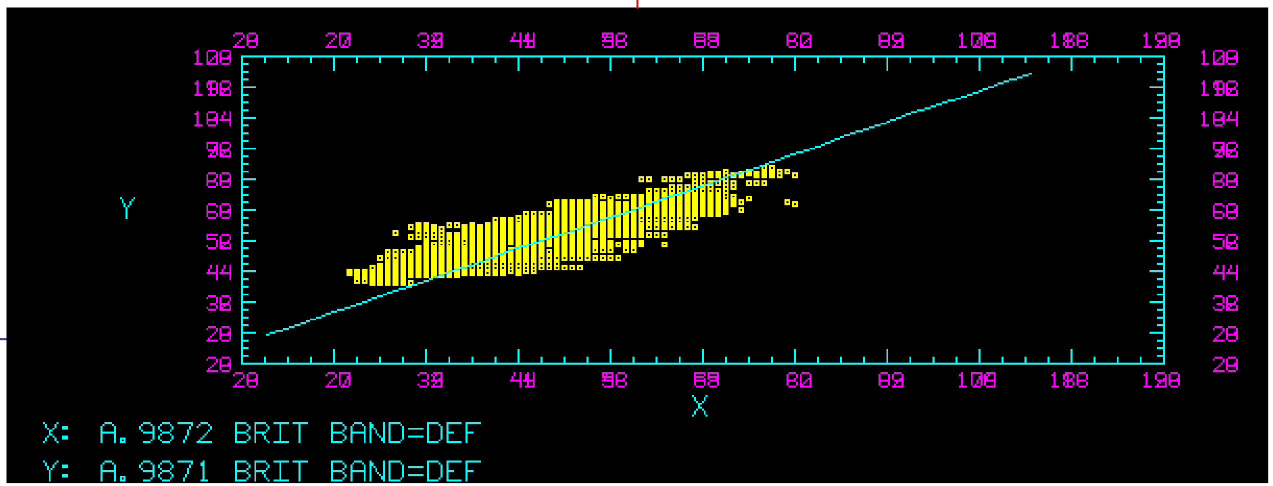
Tuning at denormalization process

Denormalization step

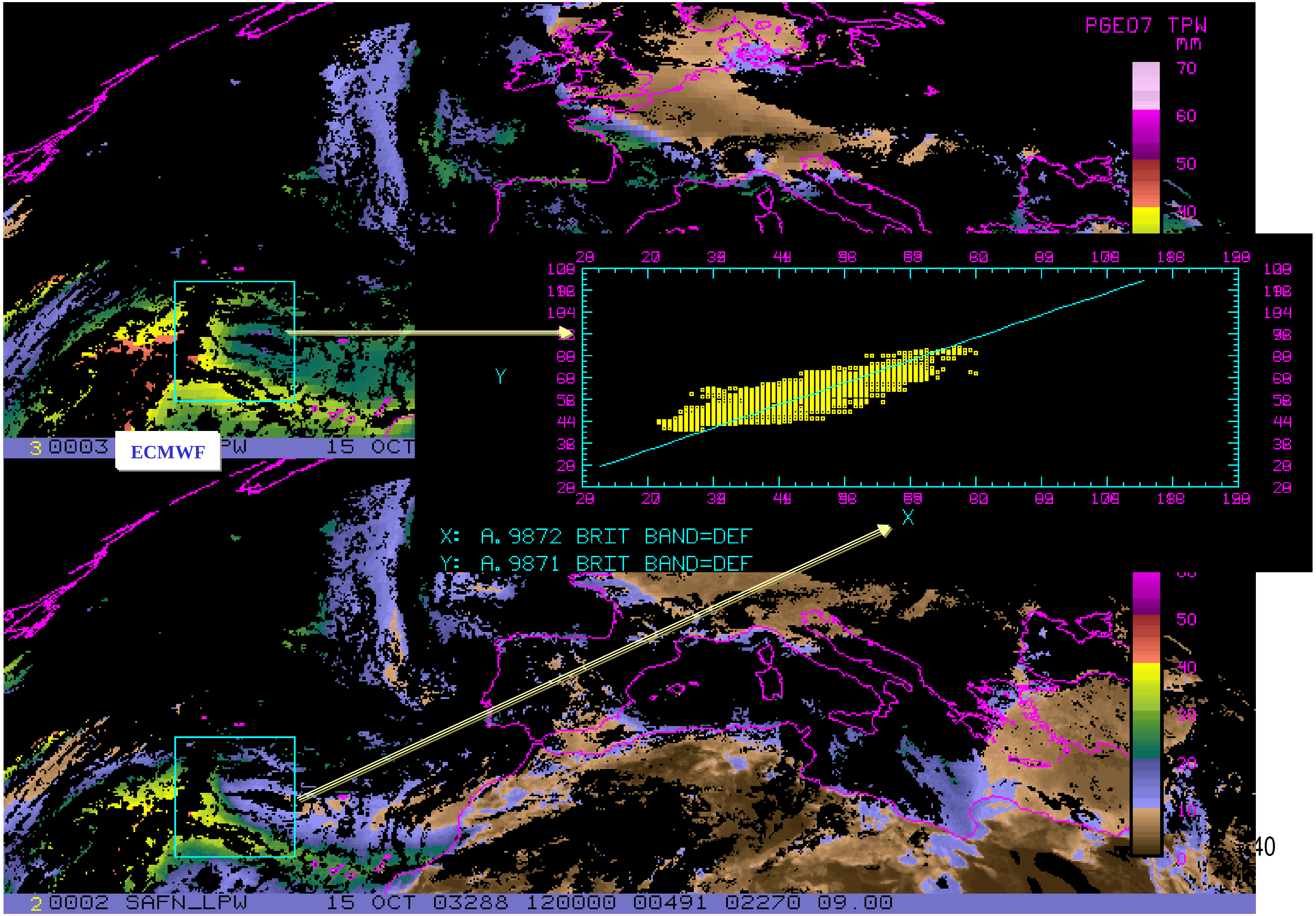


PLOT TPW ECMWF vs TPW(LPW) SAFNWC in an area of 200x200 centre at 33N, 24W

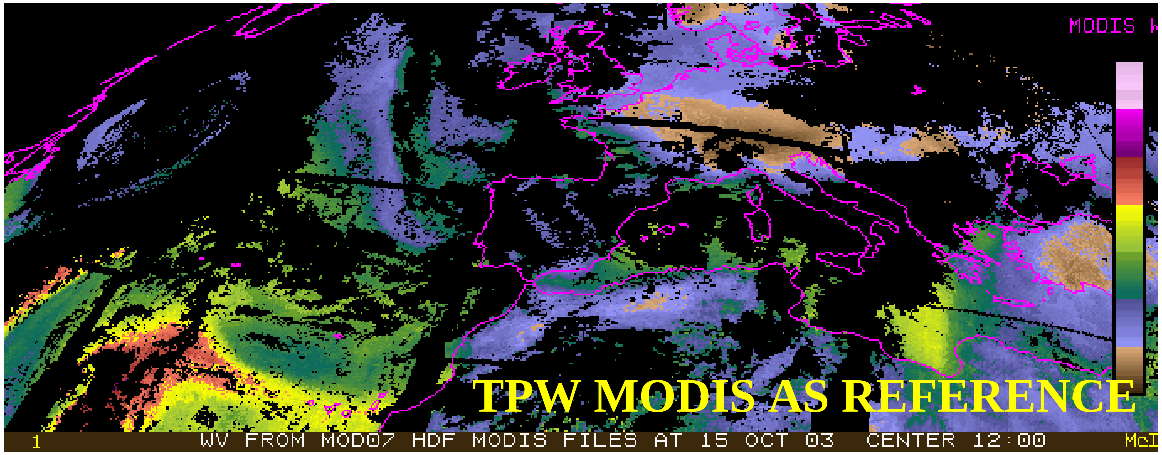
If the radiances bias correction will not produce the waited effect, we can apply the tuning at the denormalization step.

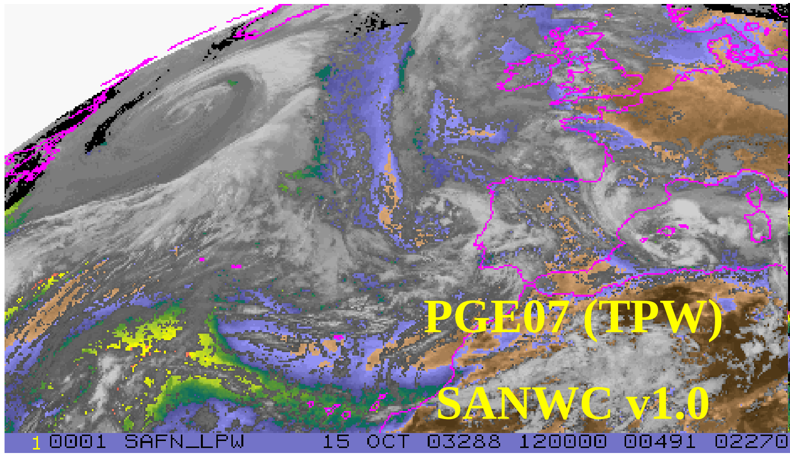


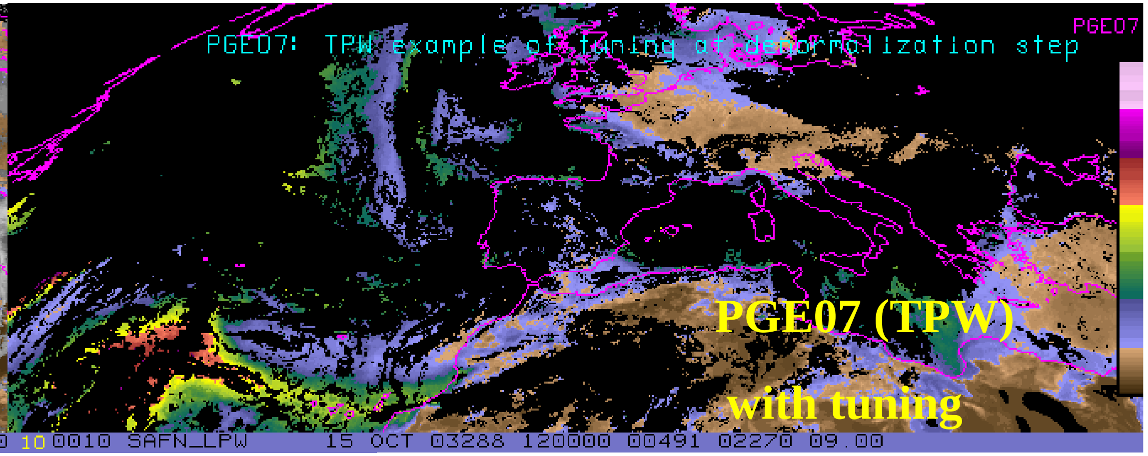
PLOT ECMWF vs SAFNWC



EXAMPLE: TPW


MODIS
TPW MODIS AS REFERENCE
WV FROM MOD07 HDF MODIS FILES AT 15 OCT 03 CENTER 12:00


PGE07 (TPW)
SANWC v1.0
0001 SAFN_LPW 15 OCT 03288 120000 00491 02270


PGE07
PGE07: TPW example of tuning of denormalization step
PGE07 (TPW)
with tuning
0010 SAFN_LPW 15 OCT 03288 120000 00491 02270 09.00

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

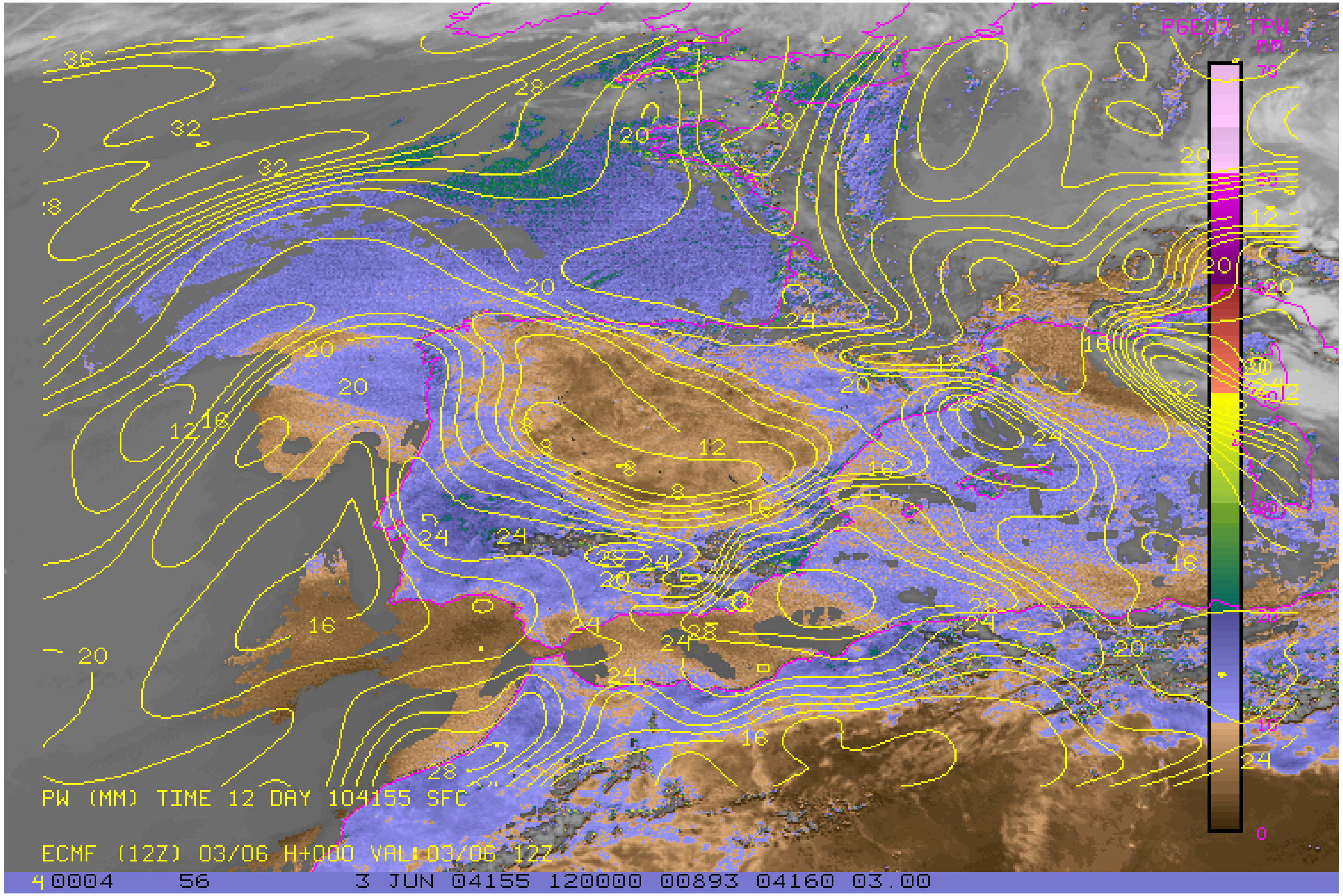
Validation

- Radiosonde and NWP analysis (From July2004 to September2004)
- MODIS (only a few study cases)

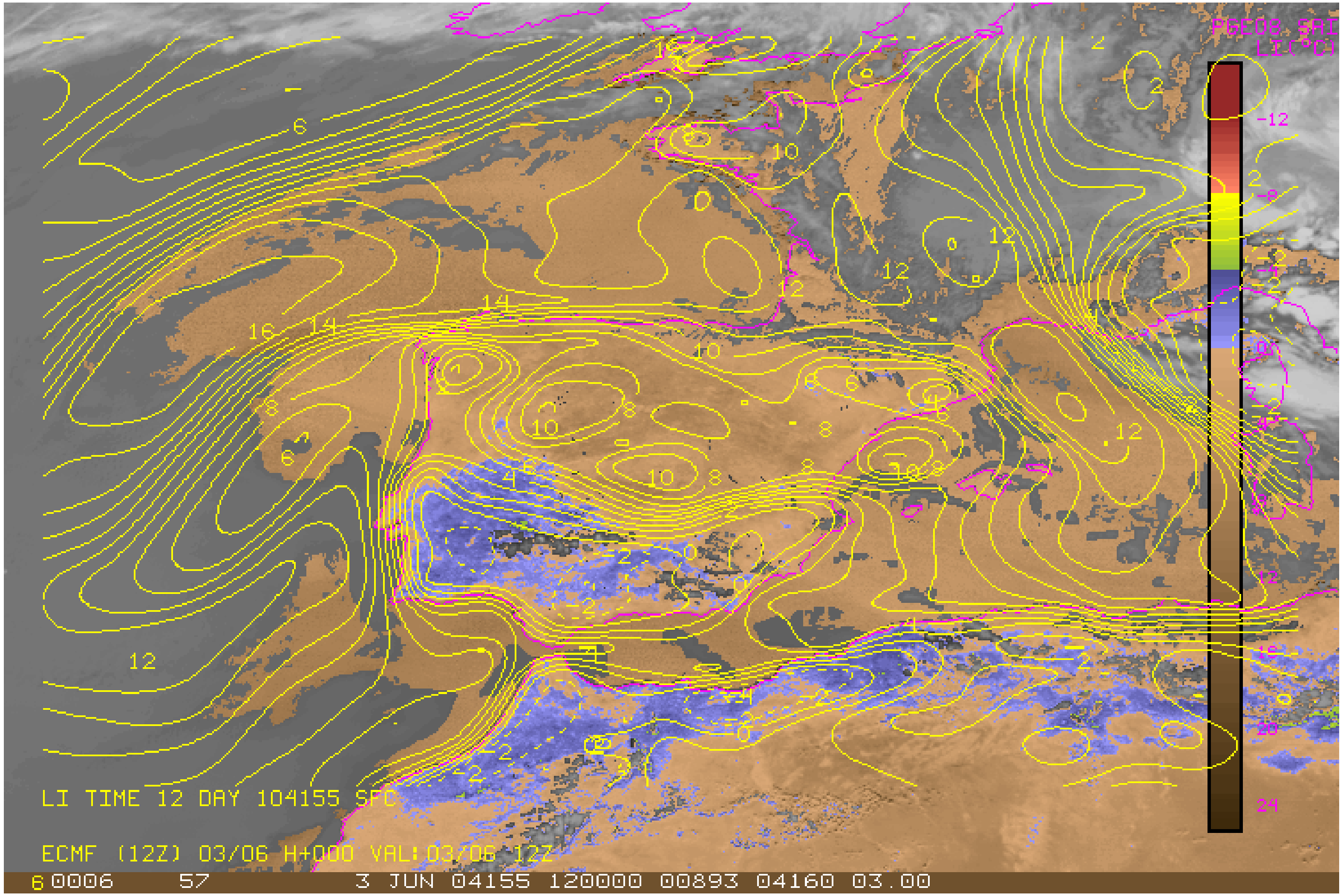
EXAMPLES

- **The spatial patterns are agree**
  (except in desert areas at nigh)
- **Quantitative values must be tuned**

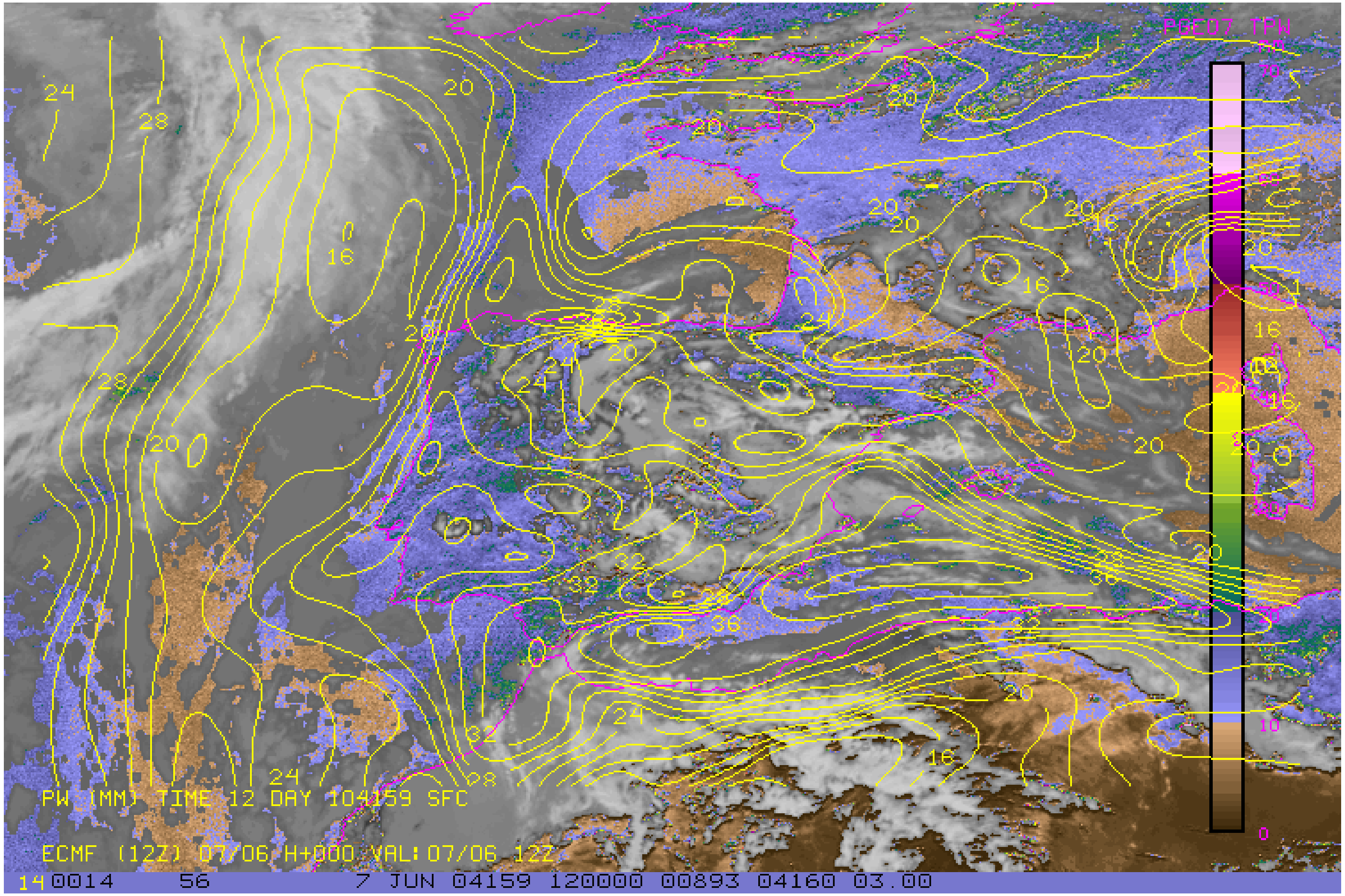
LPW: TPW control (3-6-04/12Z)



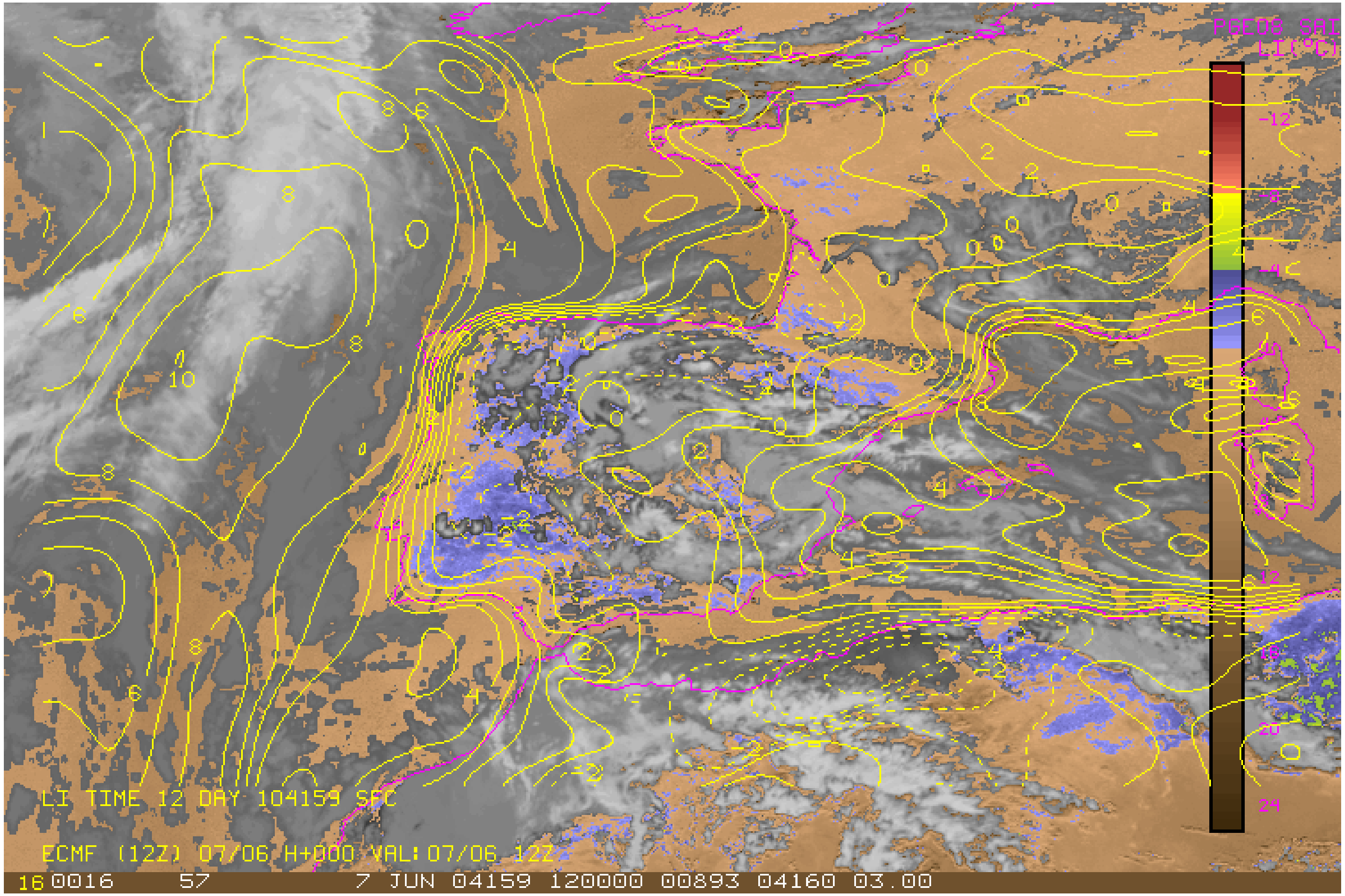
SAI: Lifted Index (3-6-04/12Z)



LPW: TPW control (7-6-04/12Z)



SAI: Lifted Index (7-6-04/12Z)



STUDY CASE

14, 15 & 16 October 2003

STUDY CASE

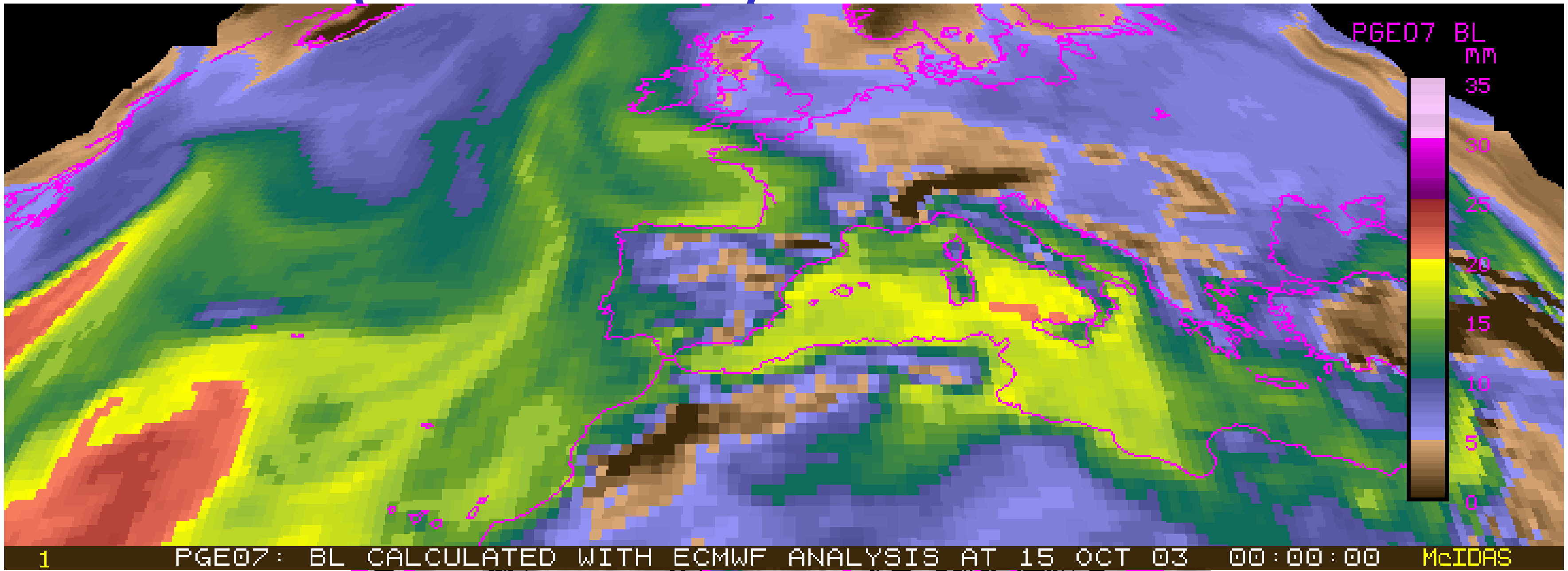
- **ECMWF analysis and SAFNWC products:**
  - BL (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  - ML (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  - HL (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  - TPW (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
  - LI (15-10-03/00Z&12Z and 16-10-03/00Z&12Z)
- **MODIS products and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

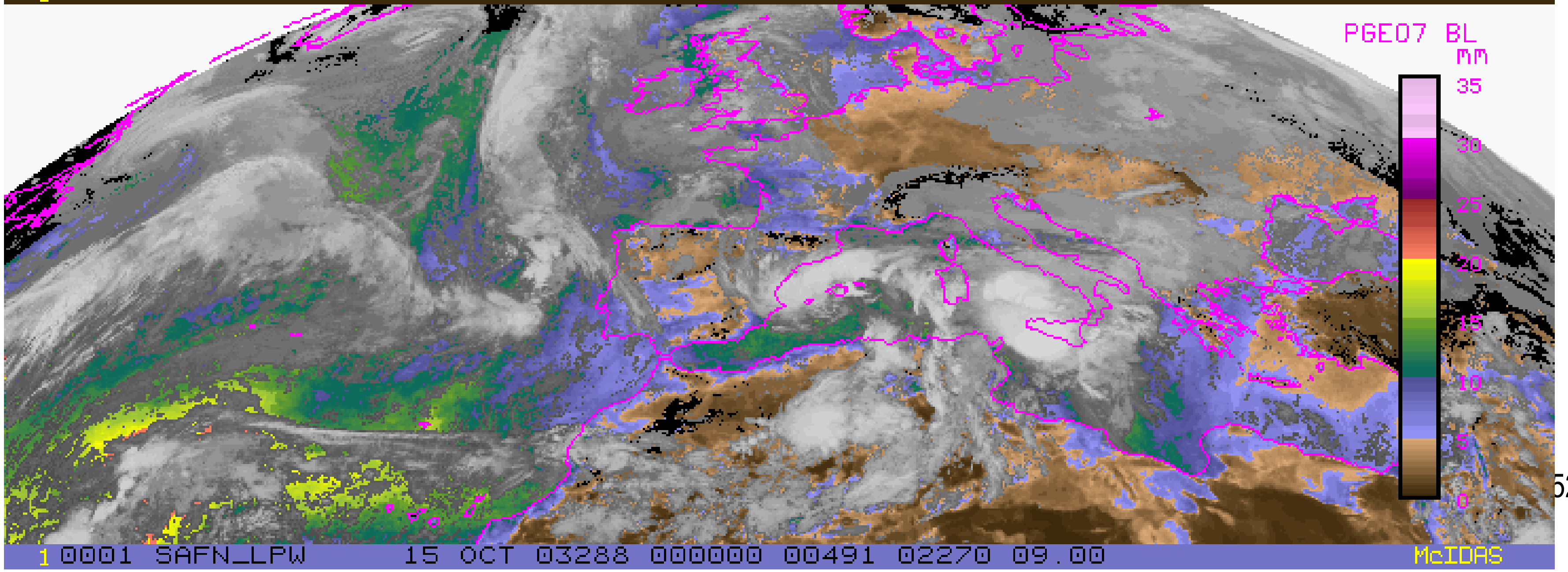
ECMWF ANALYSIS

VS

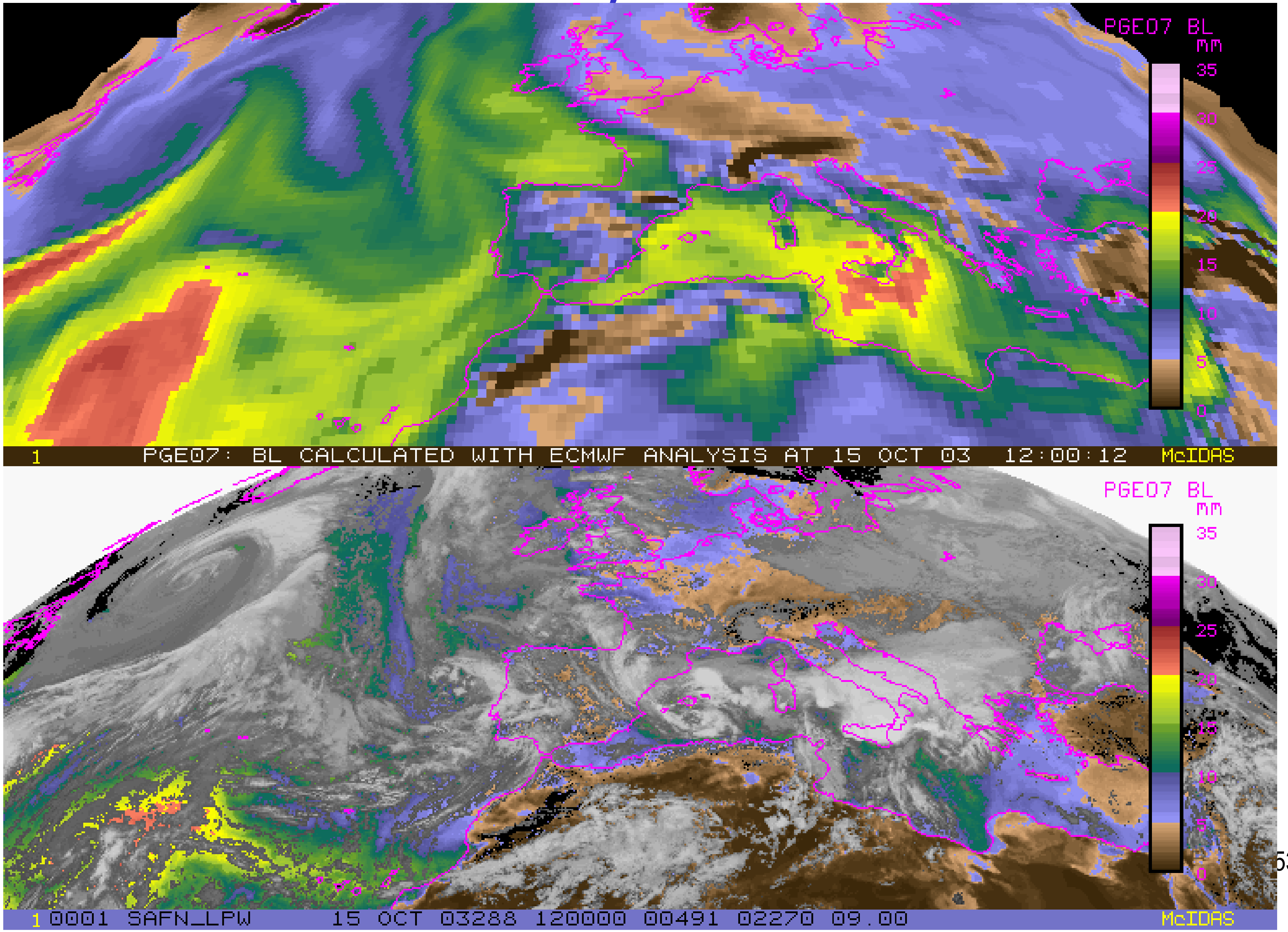
SAFNWC PRODUCTS

LPW: BL (15-10-03/00Z)

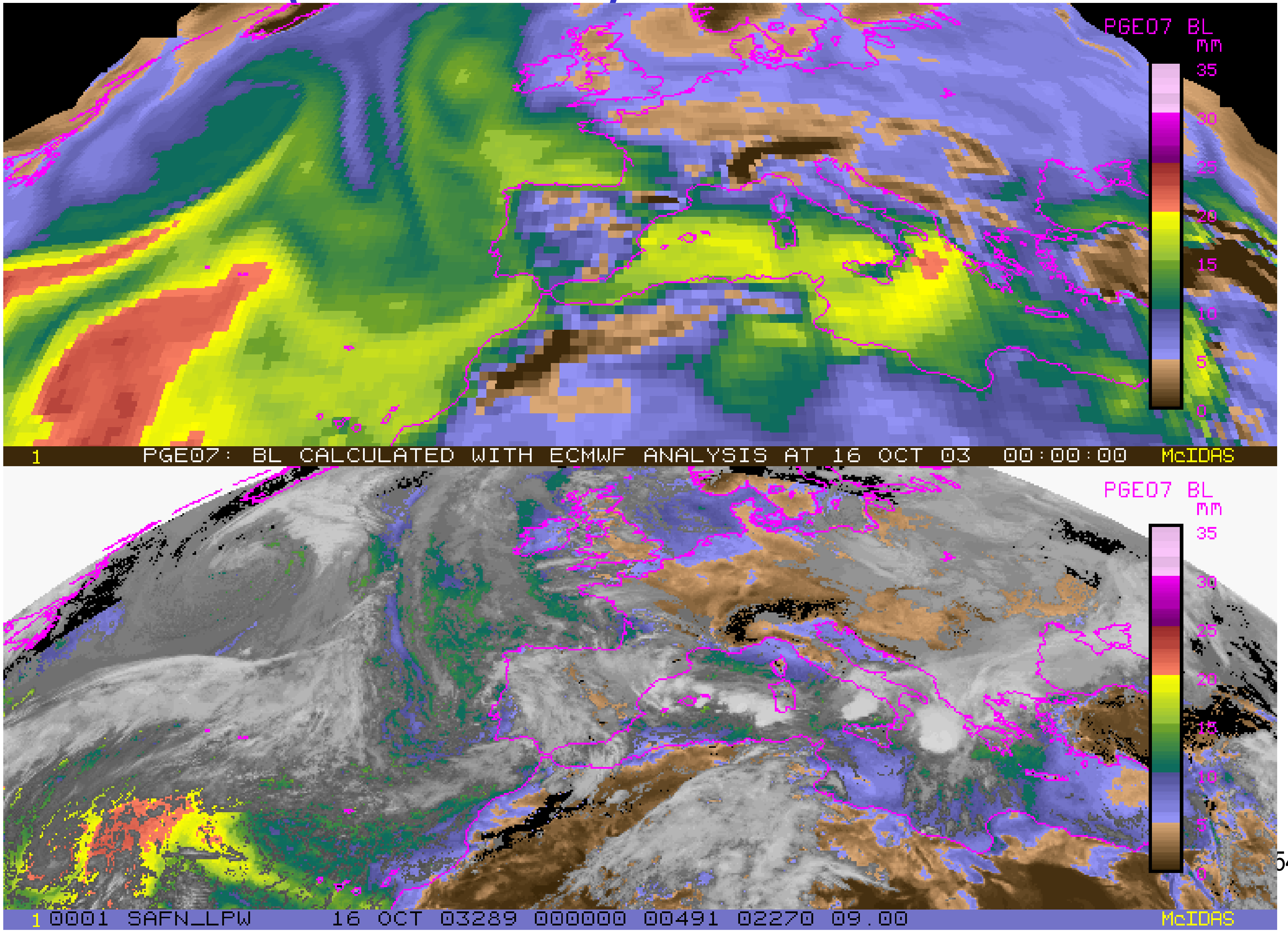




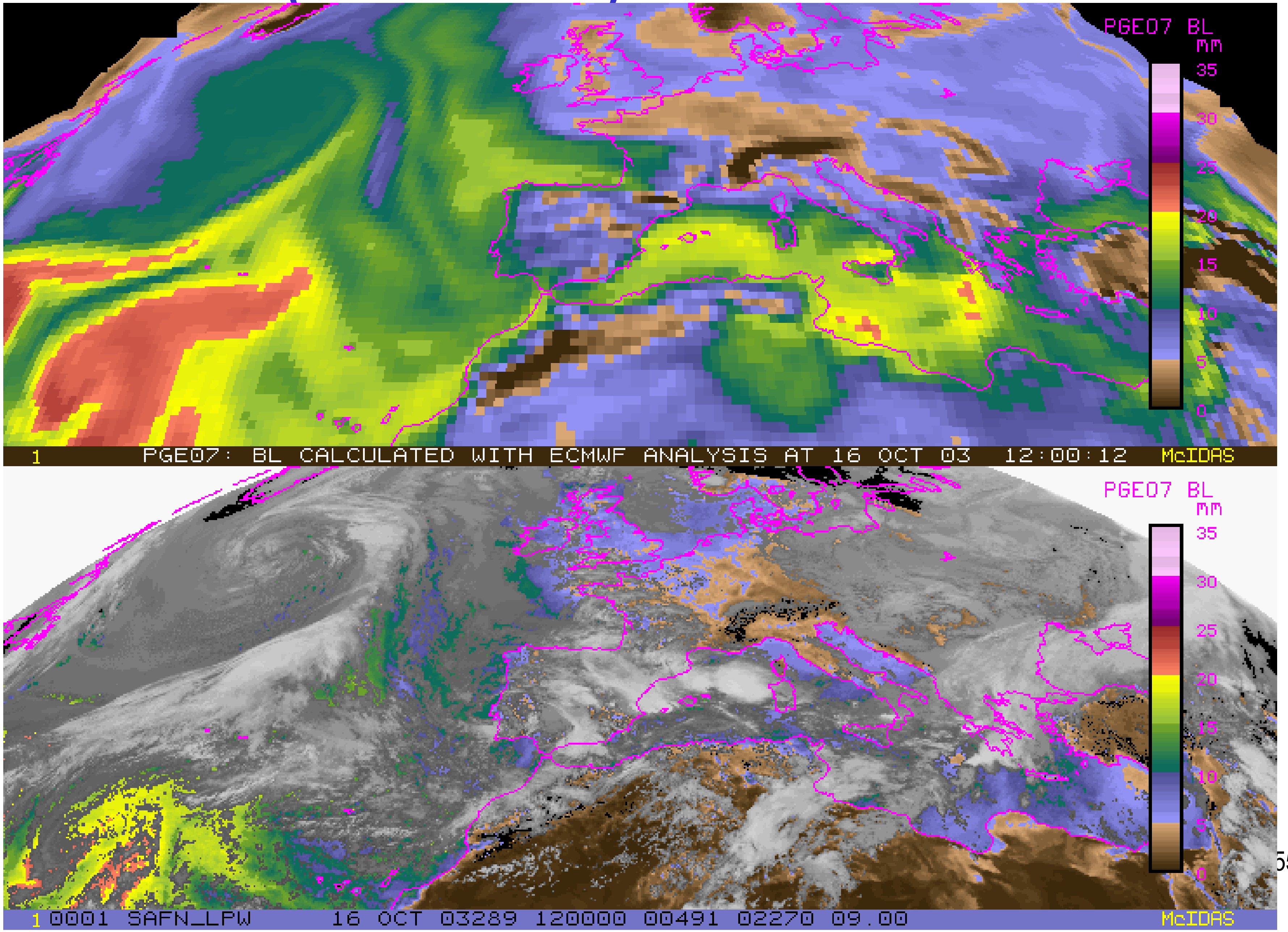
LPW: BL (15-10-03/12Z)



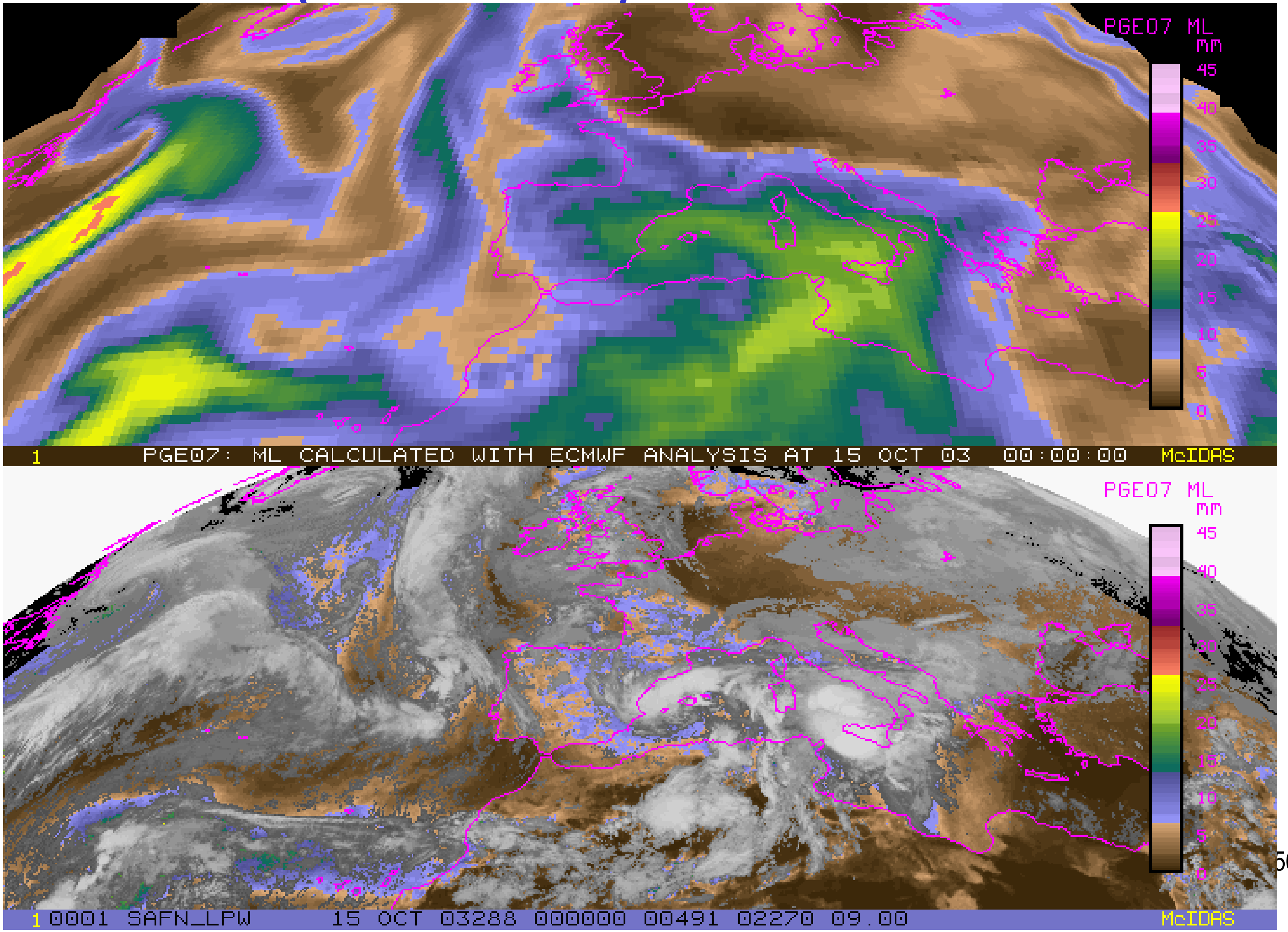
LPW: BL (16-10-03/00Z)



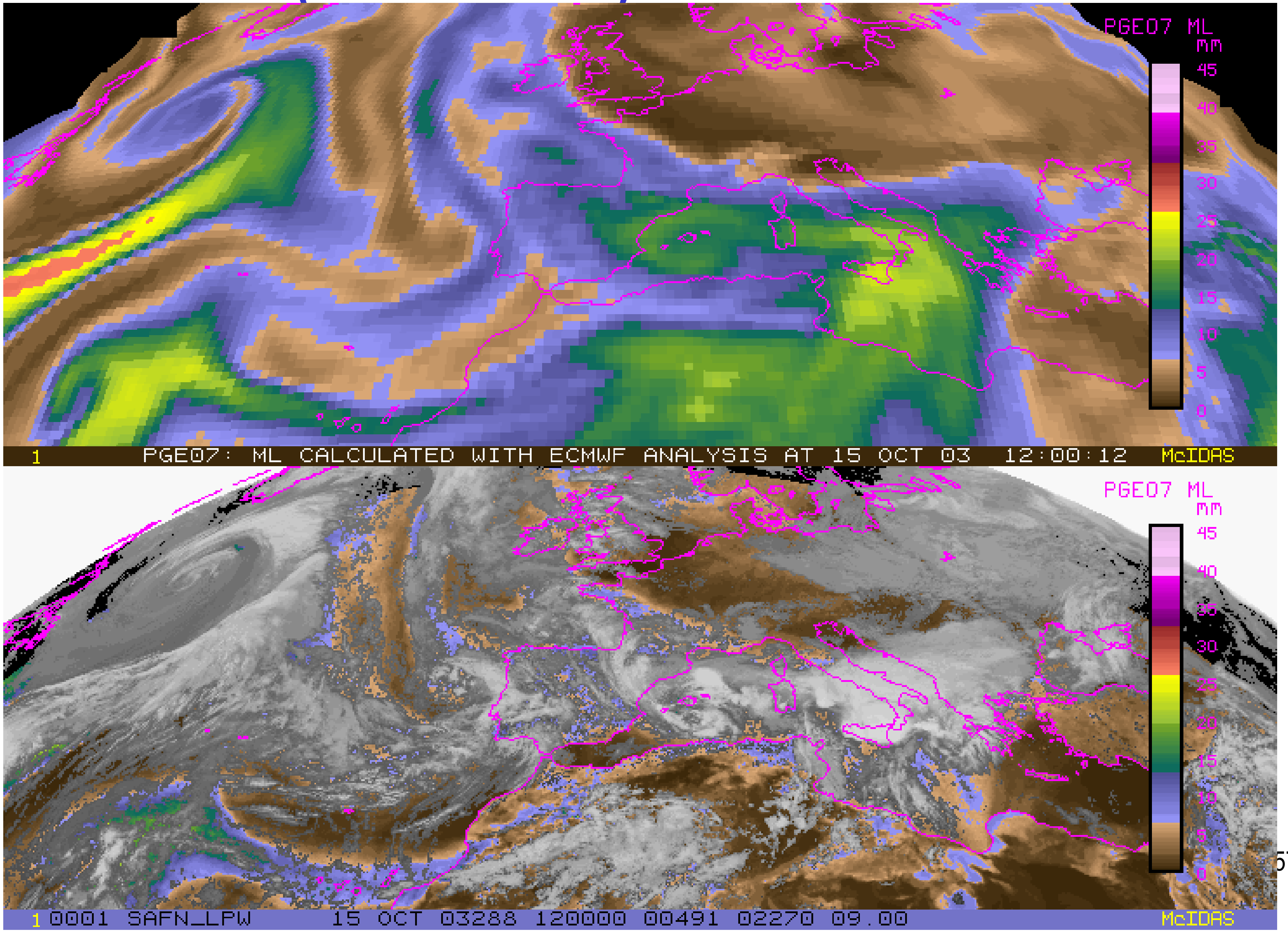
LPW: BL (16-10-03/12Z)



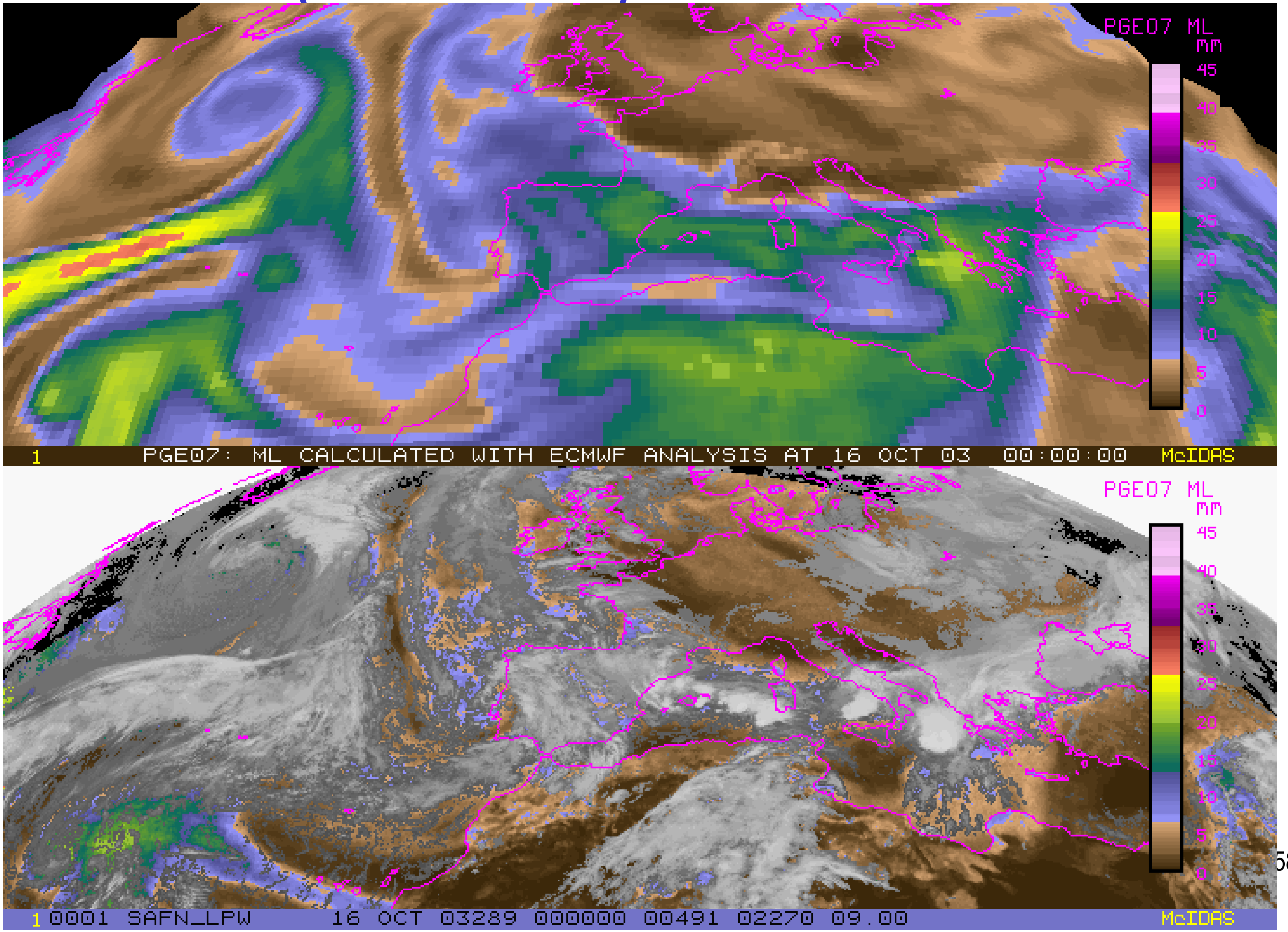
LPW: ML (15-10-03/00Z)



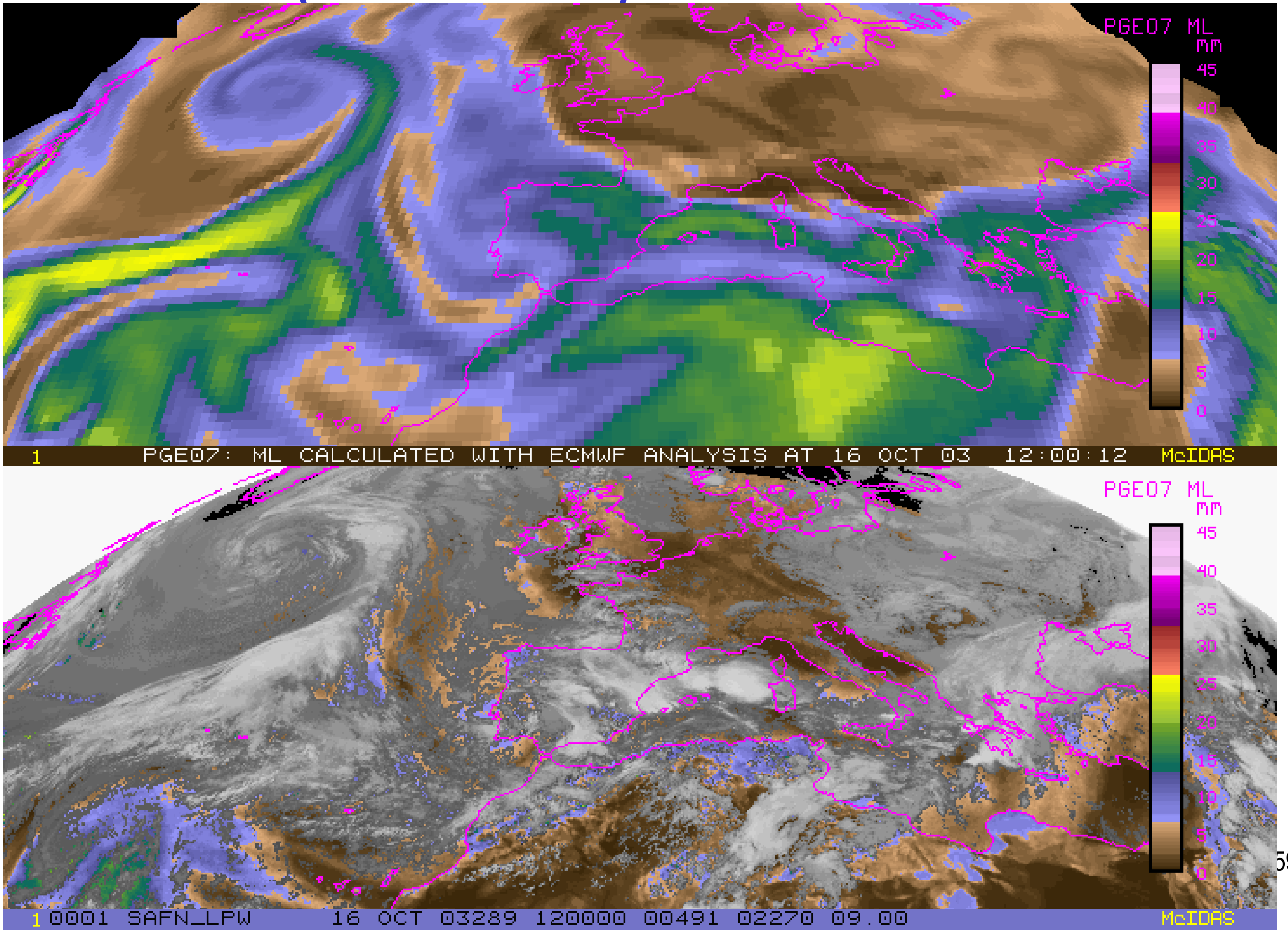
LPW: ML (15-10-03/12Z)



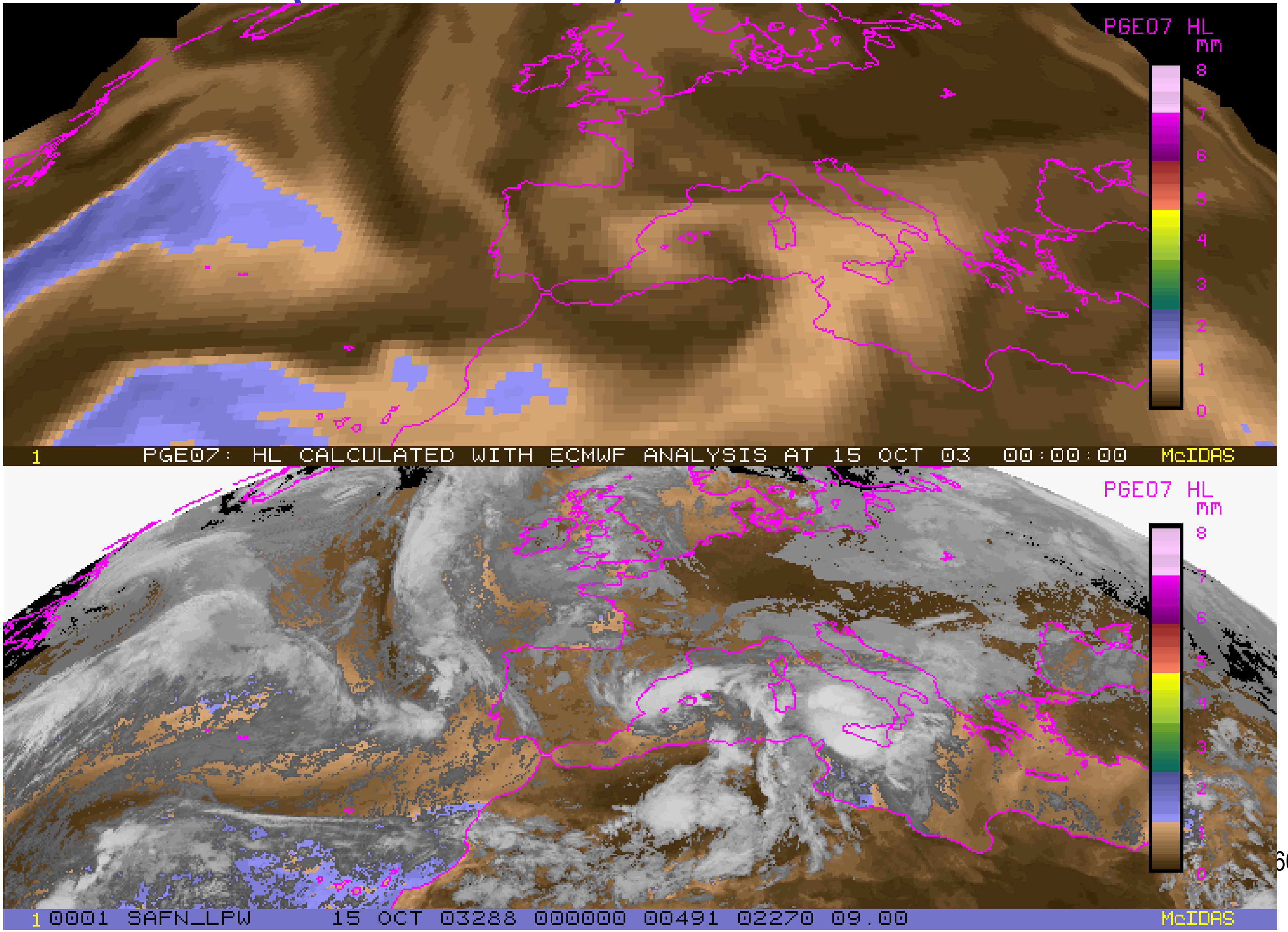
LPW: ML (16-10-03/00Z)



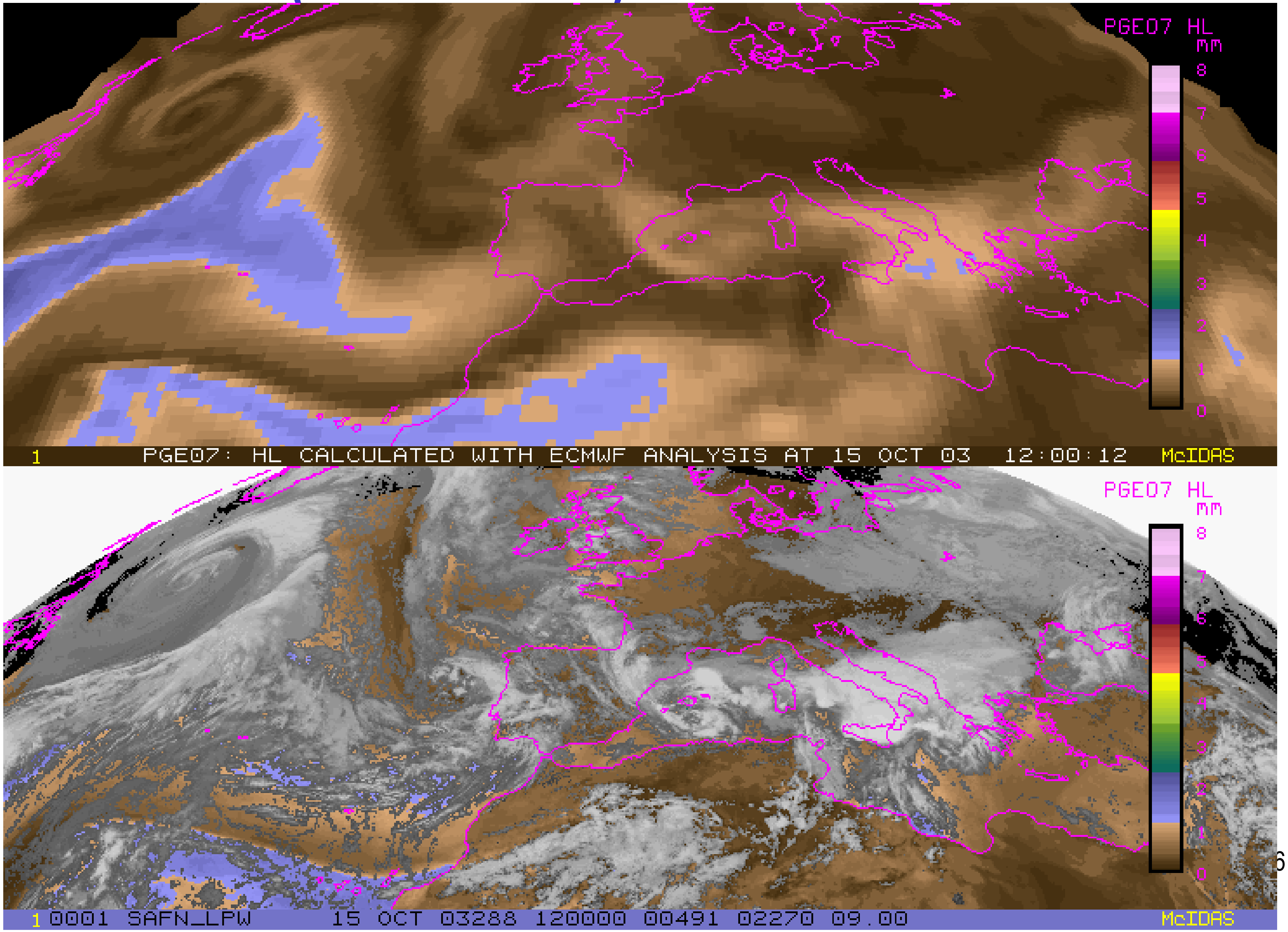
LPW: ML (16-10-03/12Z)



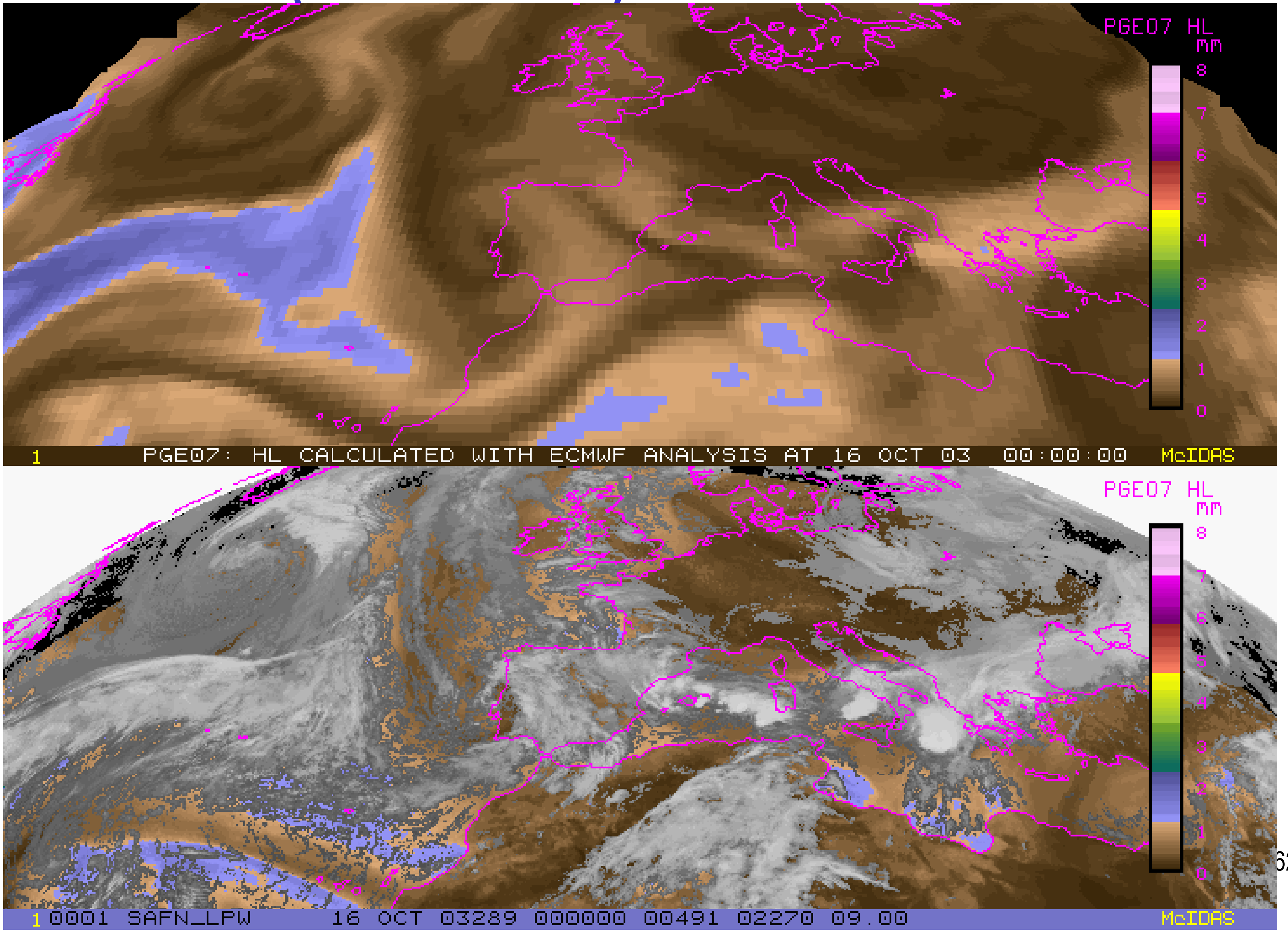
LPW: HL (15-10-03/00Z)



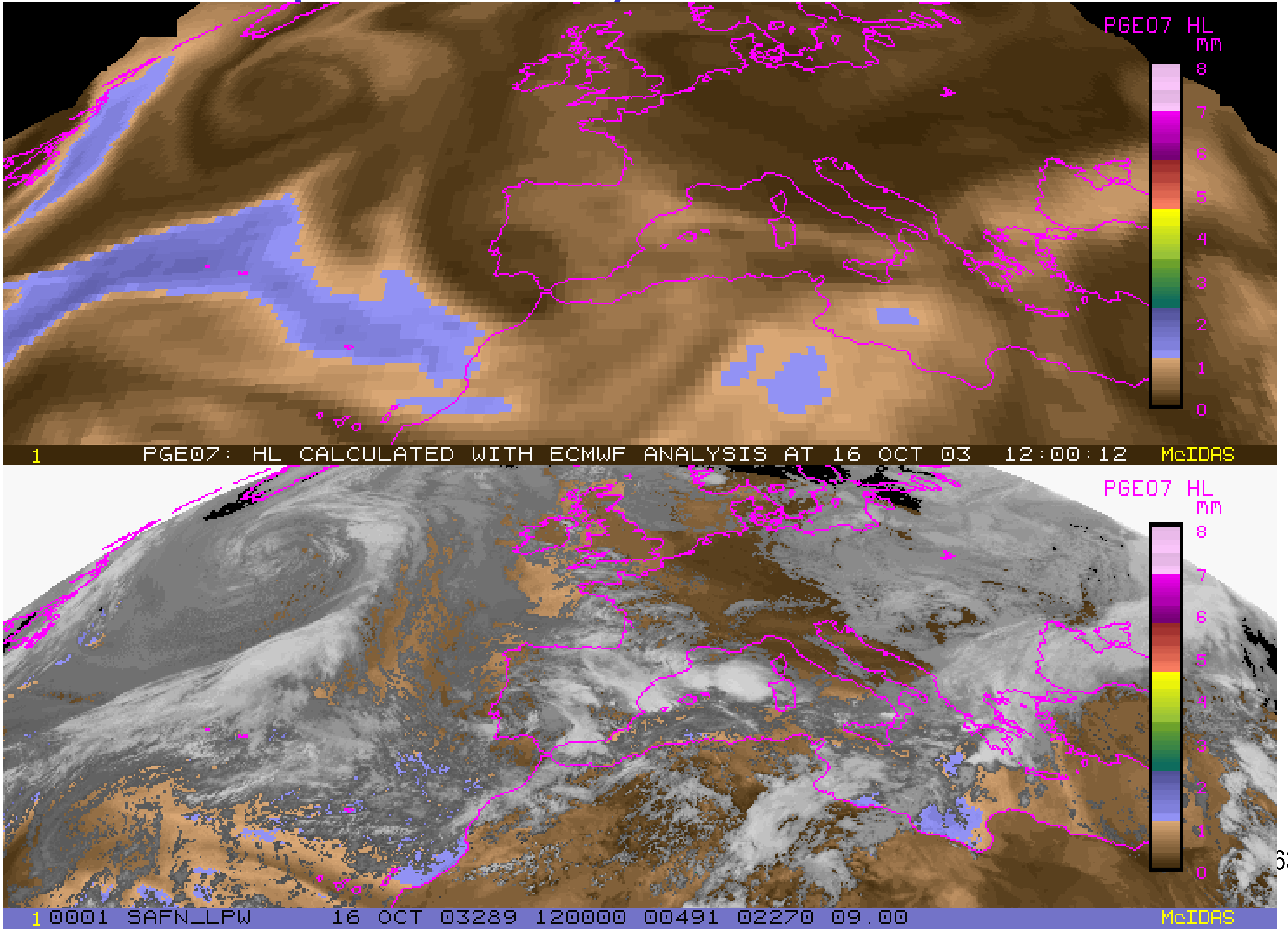
LPW: HL (15-10-03/12Z)



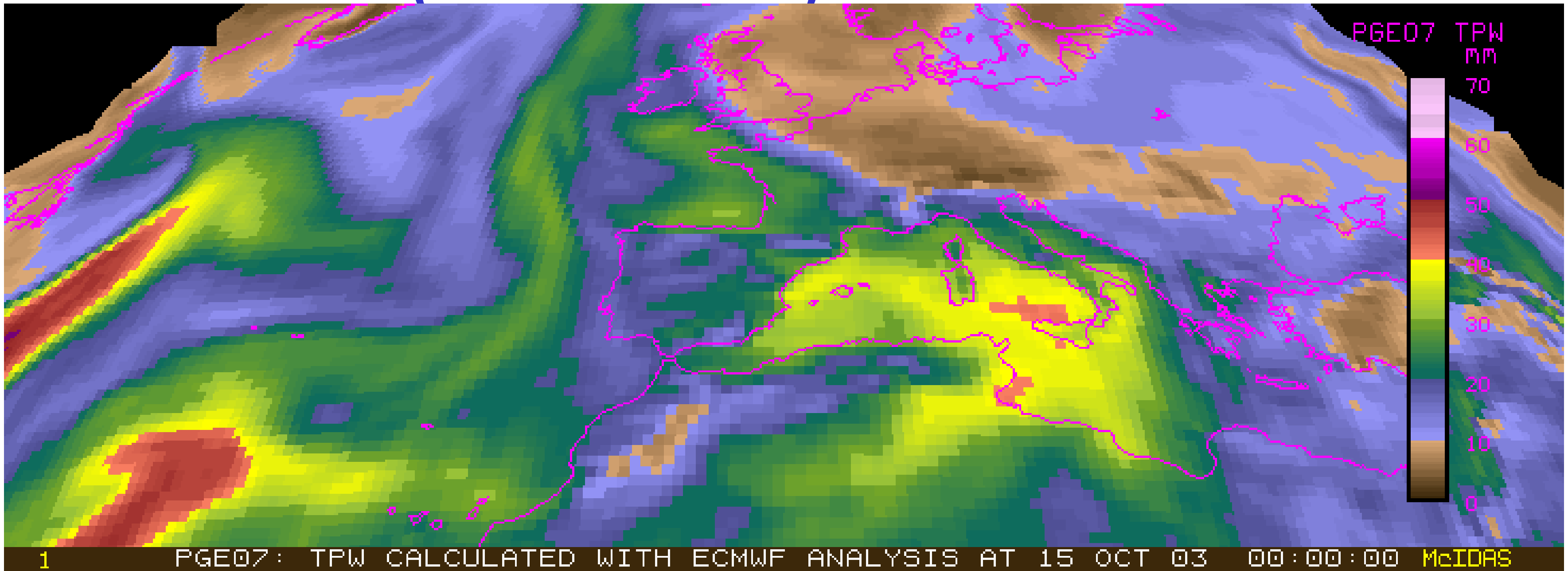
LPW: HL (16-10-03/00Z)

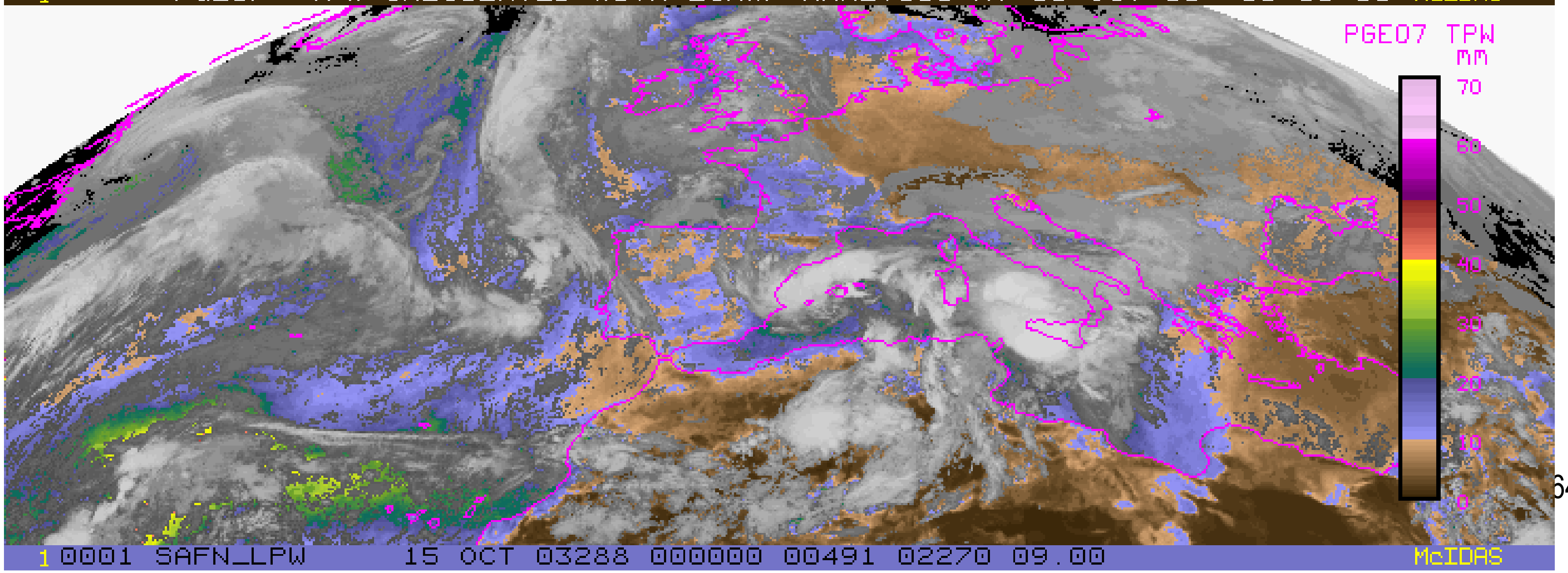


LPW: HL (16-10-03/12Z)

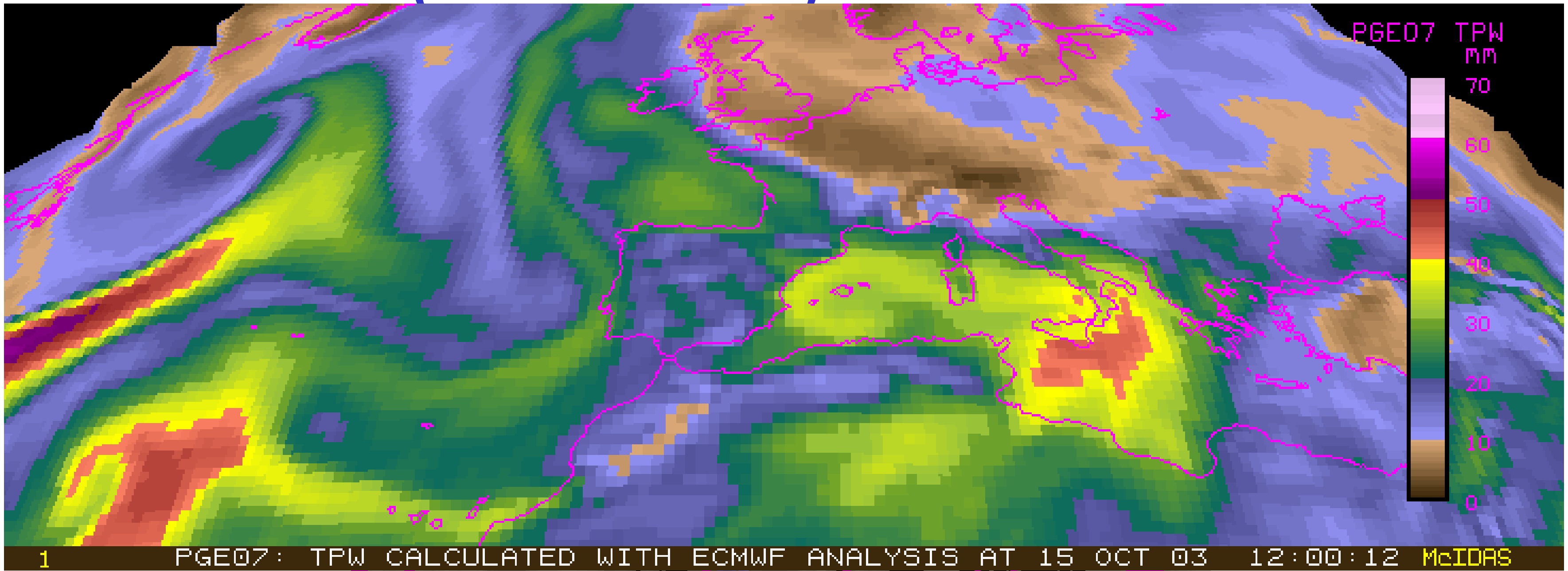


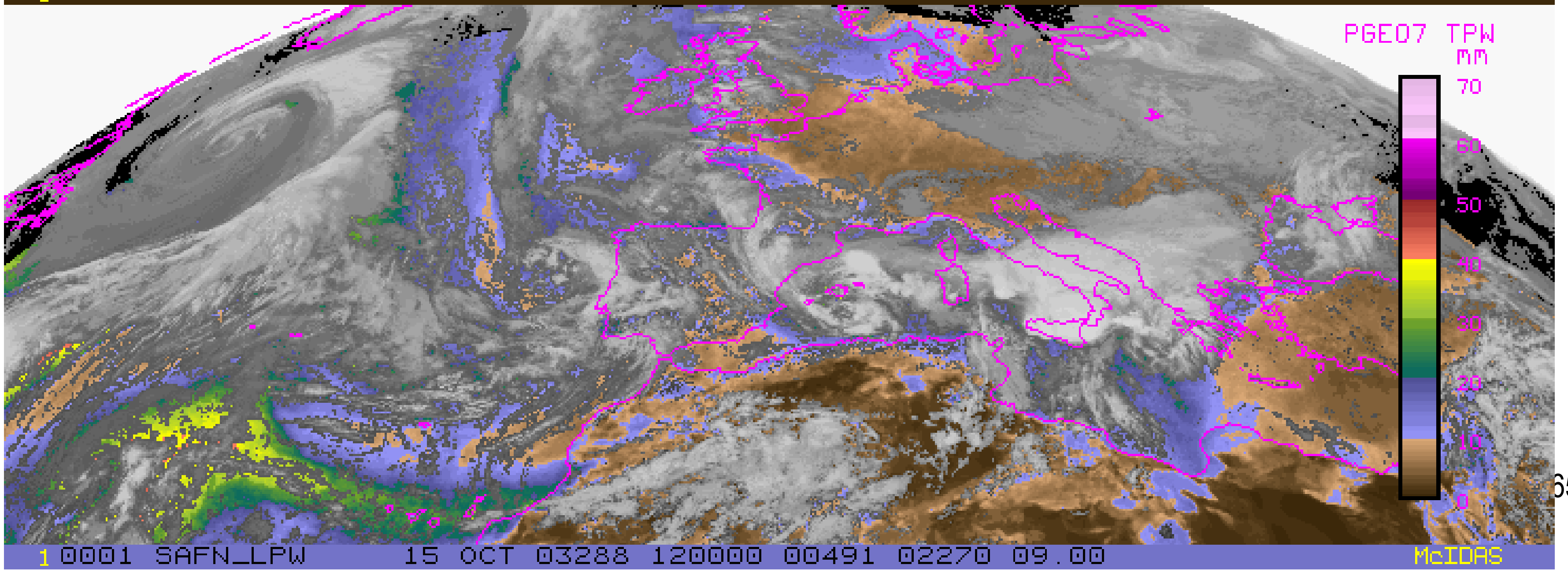
LPW: TPW (15-10-03/00Z)



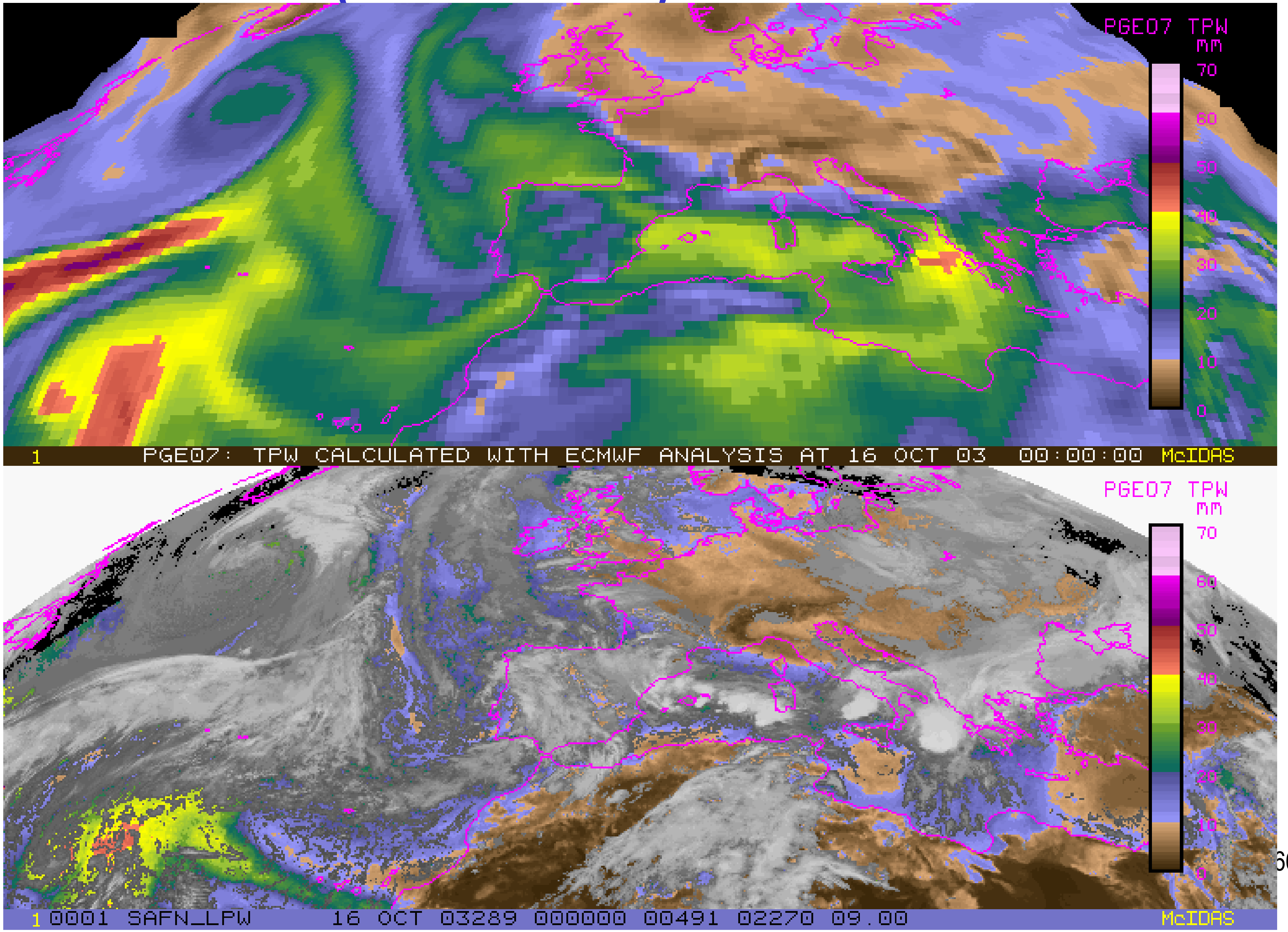


LPW: TPW (15-10-03/12Z)

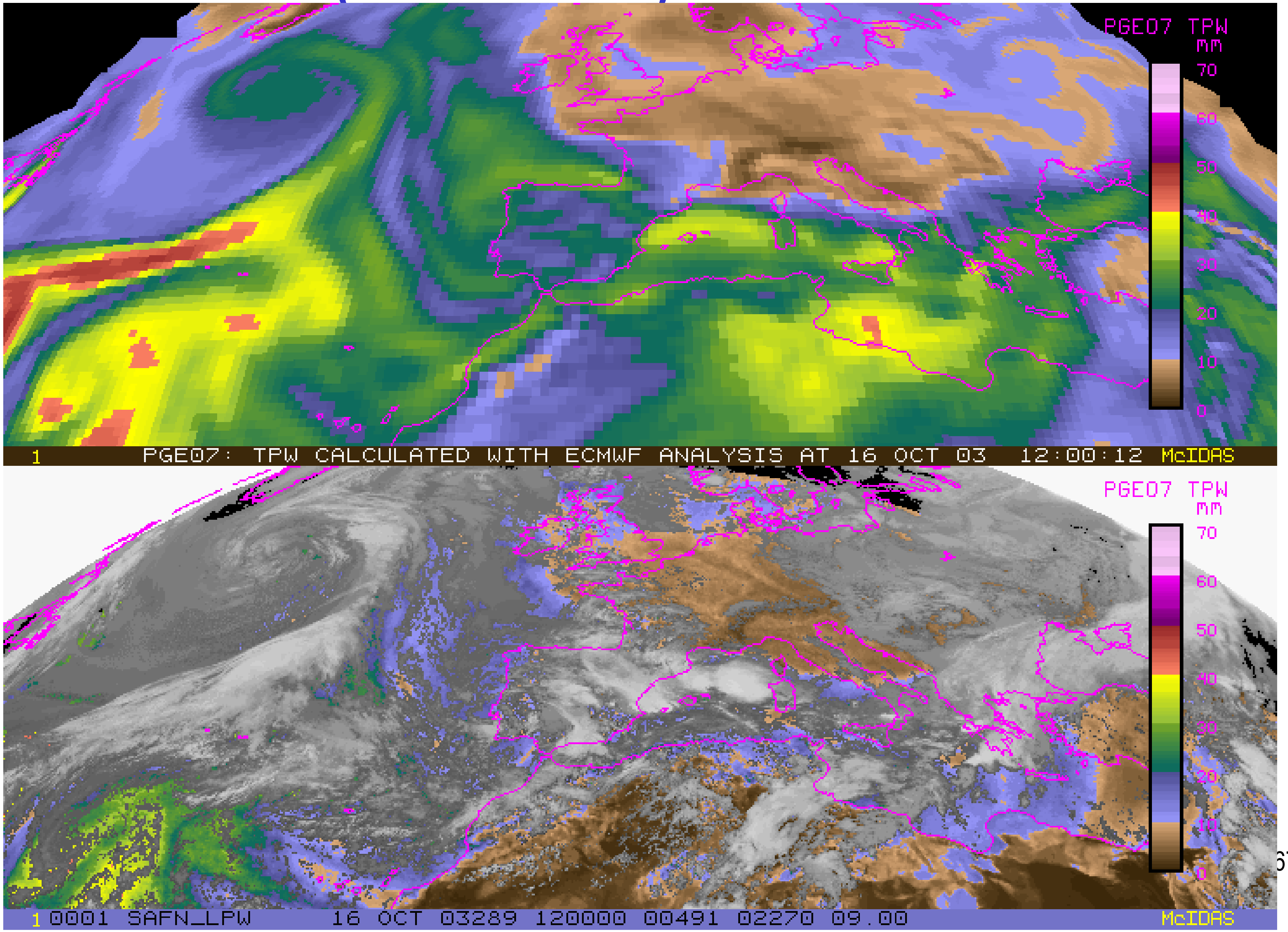




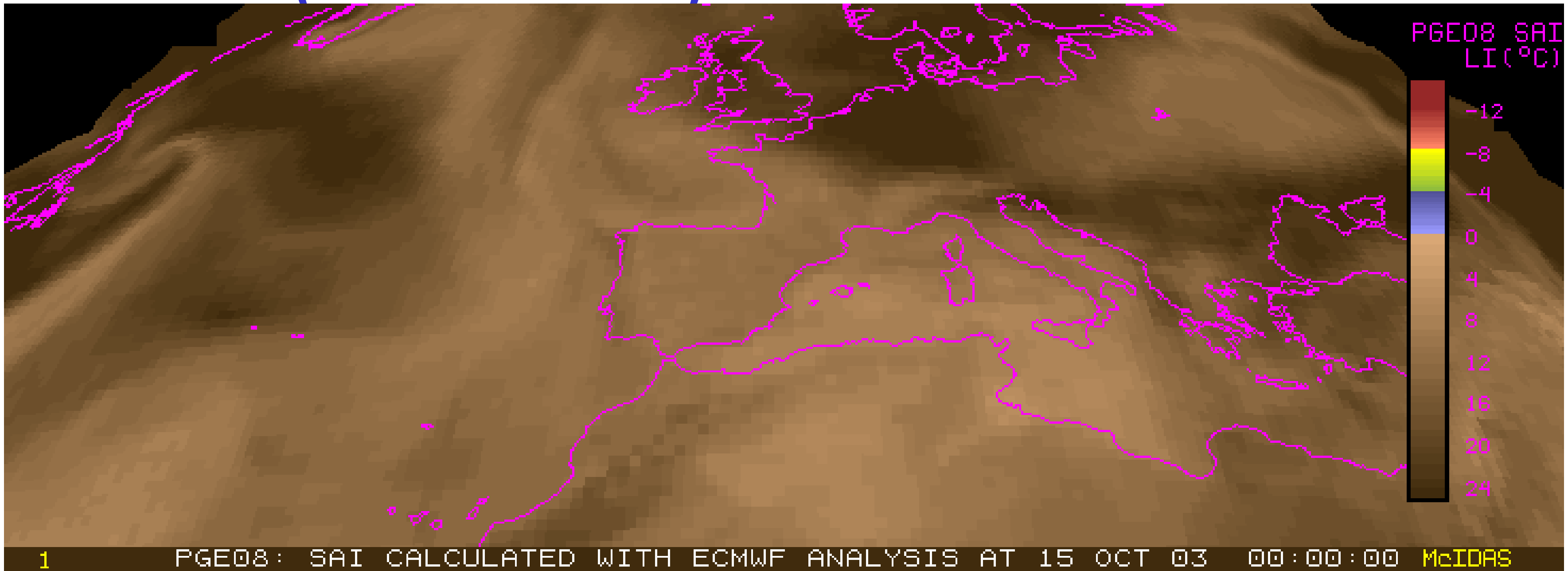
LPW: TPW (16-10-03/00Z)

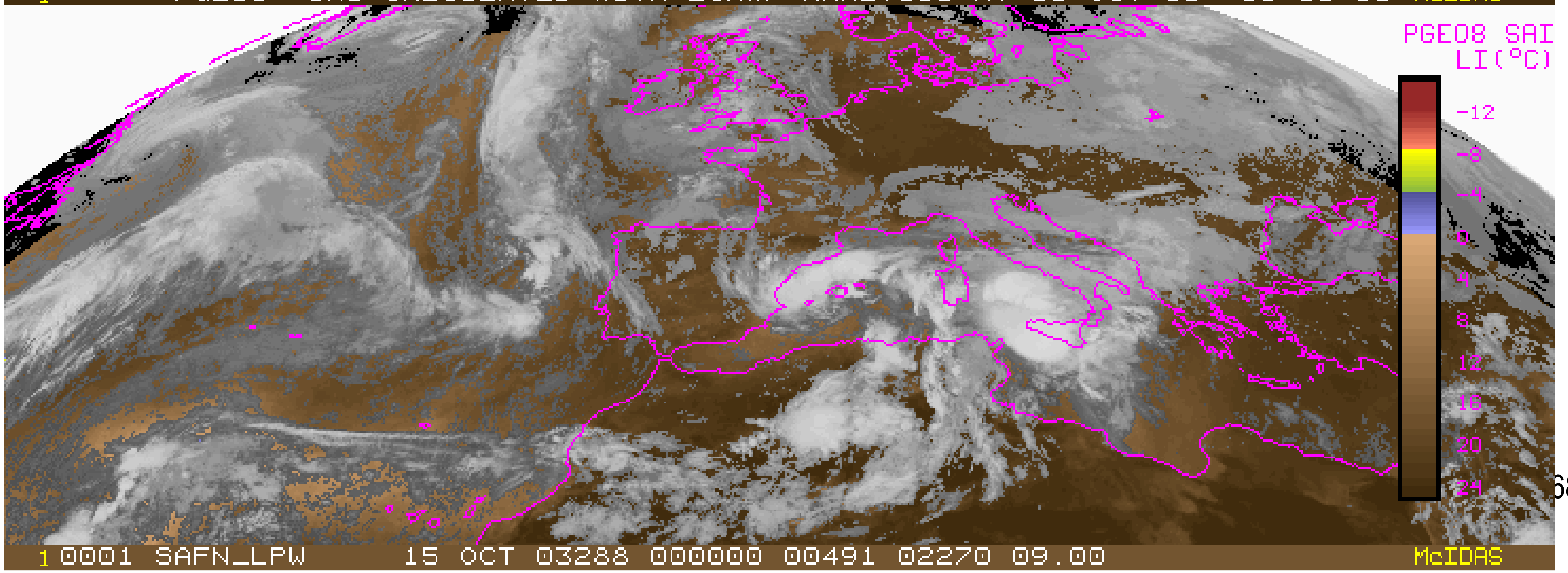


LPW: TPW (16-10-03/12Z)

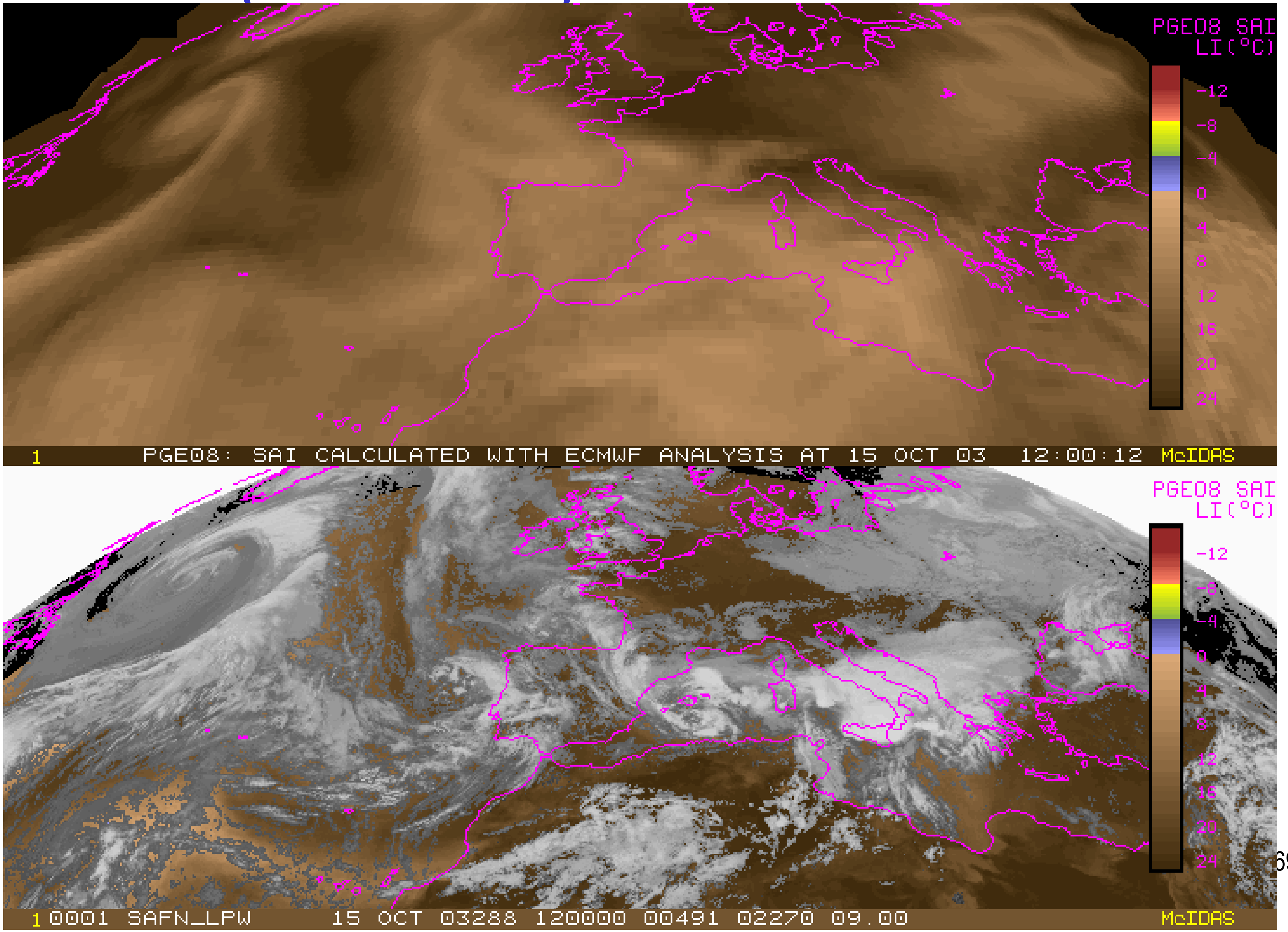


SAI: LI (15-10-03/00Z)

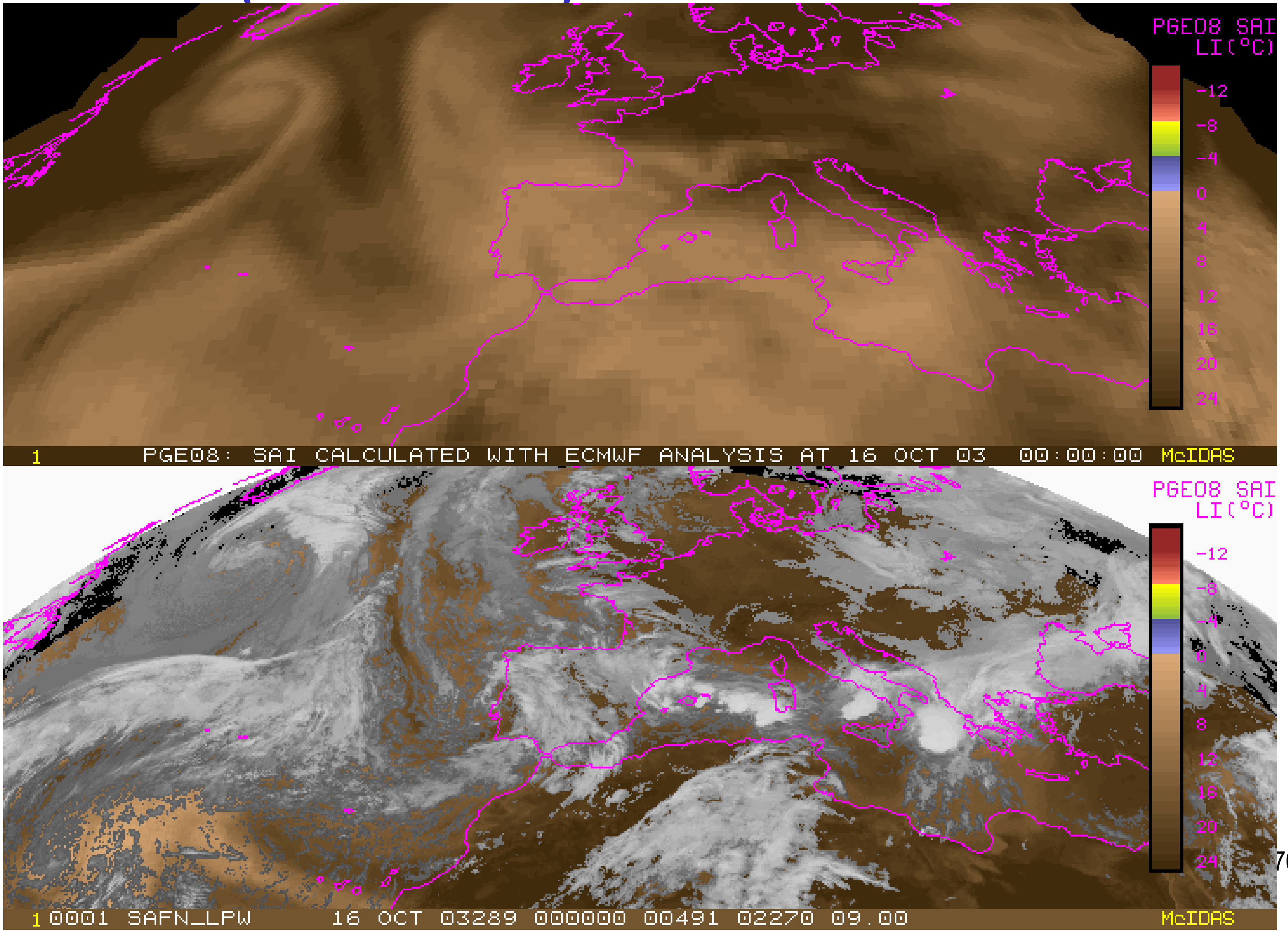




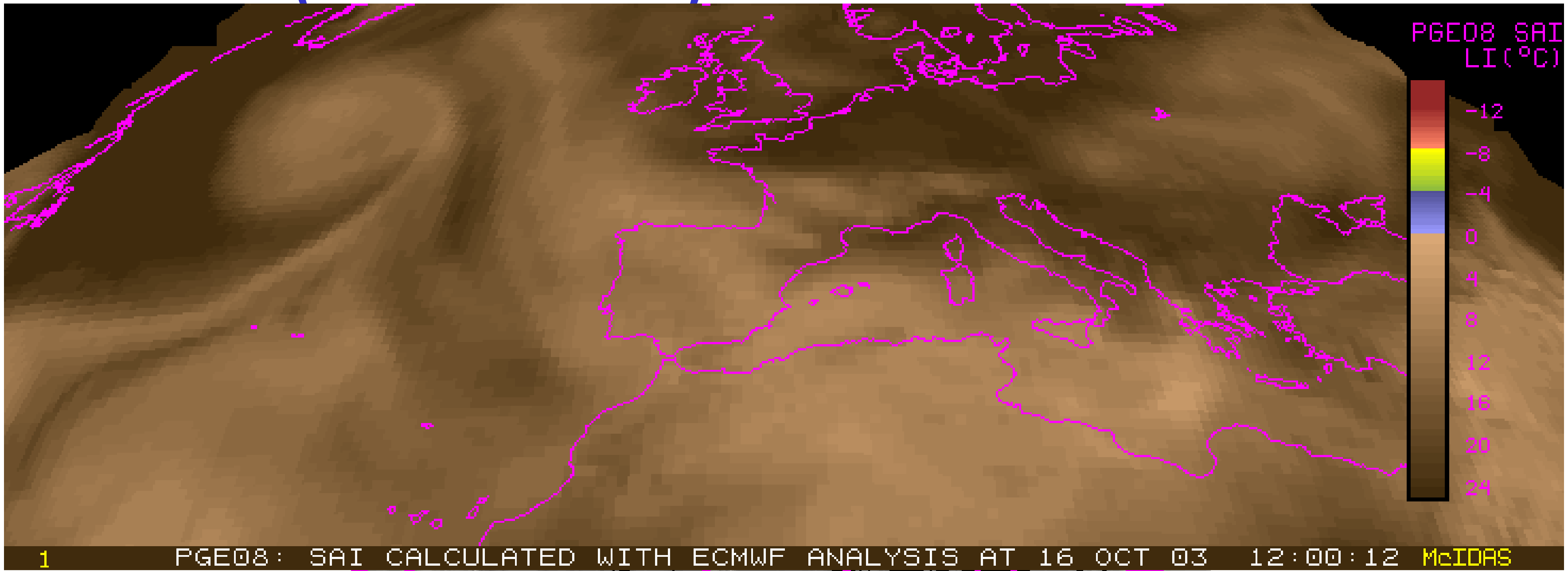
SAI: LI (15-10-03/12Z)

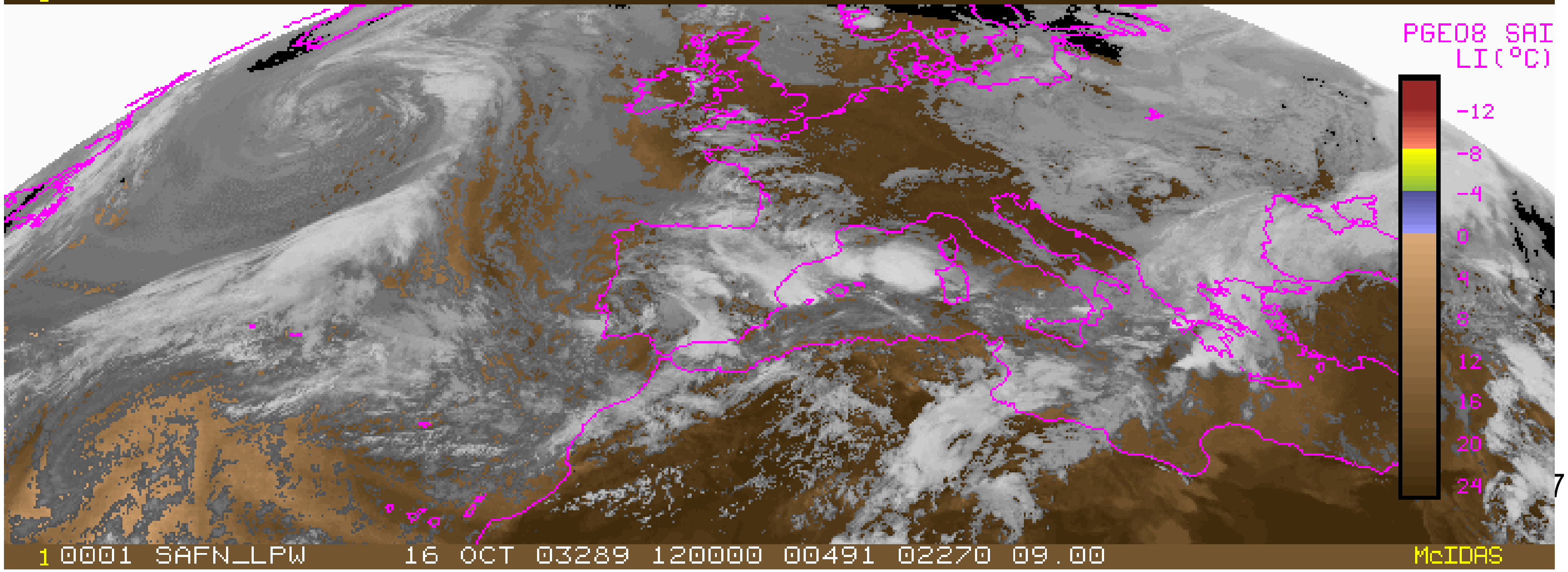


SAI: LI (16-10-03/00Z)



SAI: LI (16-10-03/12Z)





MODIS SCIENTIFIC PRODUCTS

VS

SAFNWC PRODUCTS

MODIS SCIENTIFIC PRODUCTS

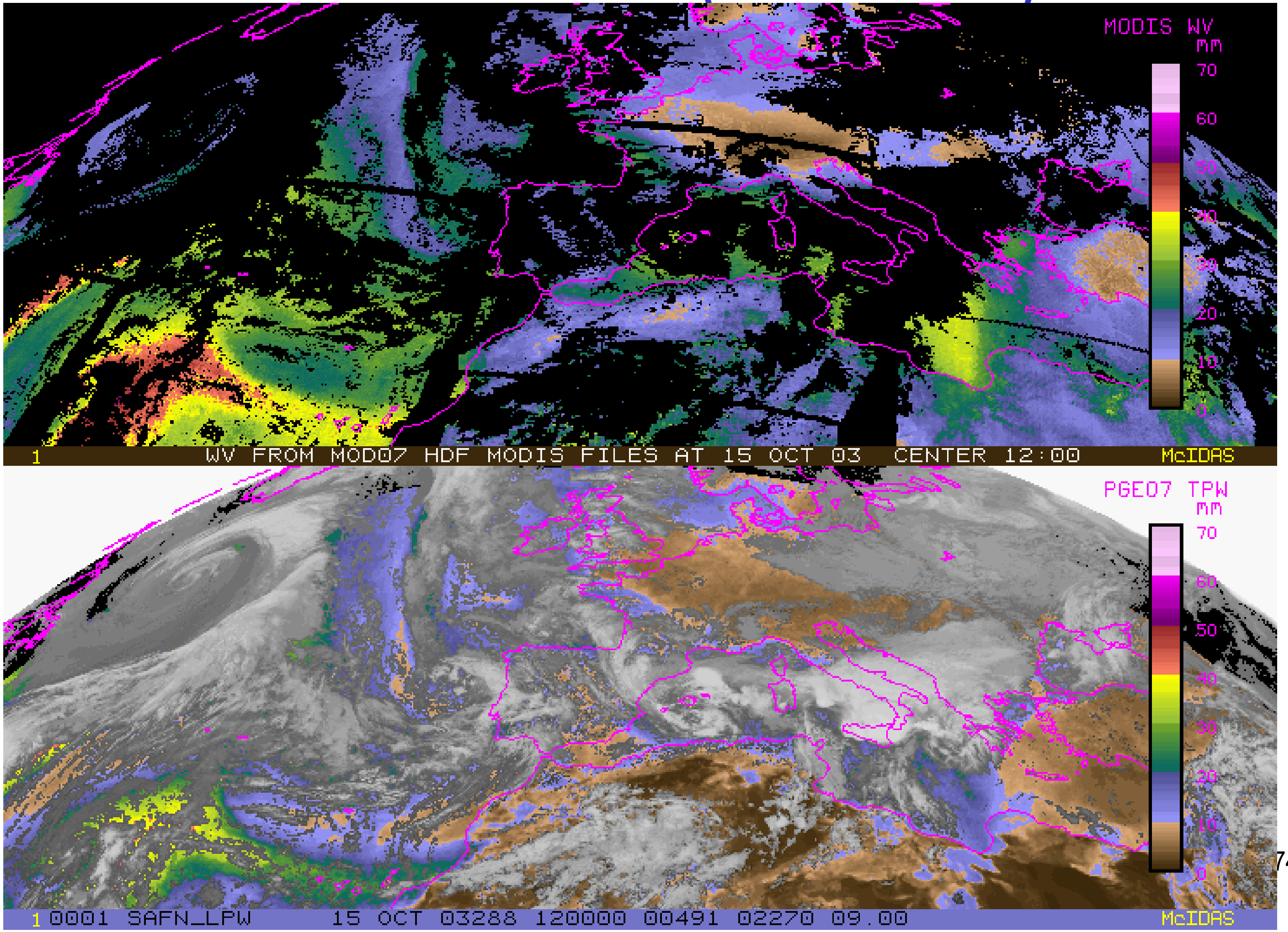
- **MODIS TPW can be used as reference**

- **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**

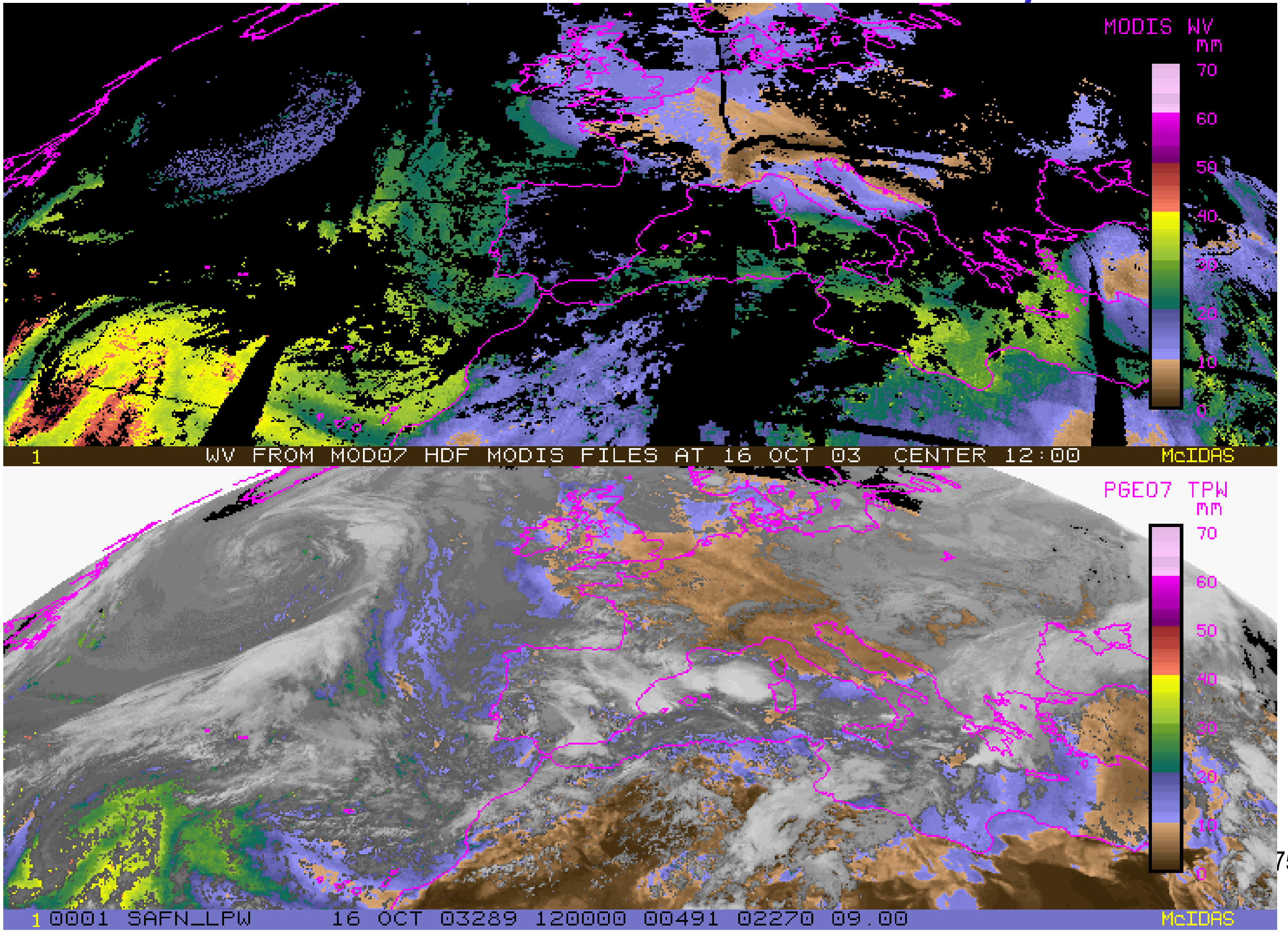
- **The science MODIS LI is calculated using the retrieved profile and the air parcel always start the ascent at 1000hPa. While in the SAFNWC LI and in the ECMWF LI the air parcel starts the ascent at 2 meter of surface level (the colour scale reflects this different).**

NOTE: Water vapor low and water vapor high can only used to compare patterns.

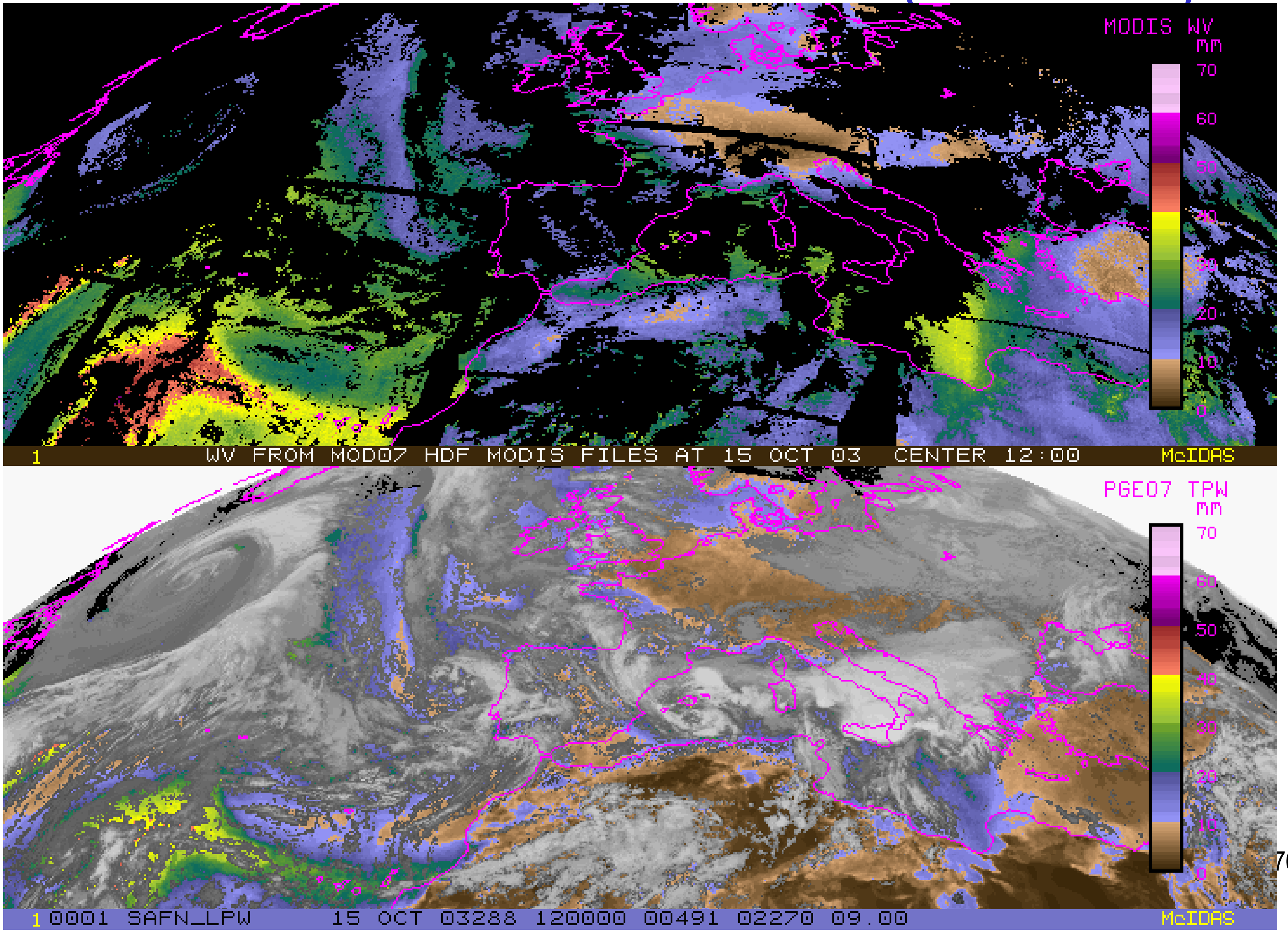
MODIS MOD07 FILE: TPW (15-10-03/12Z)



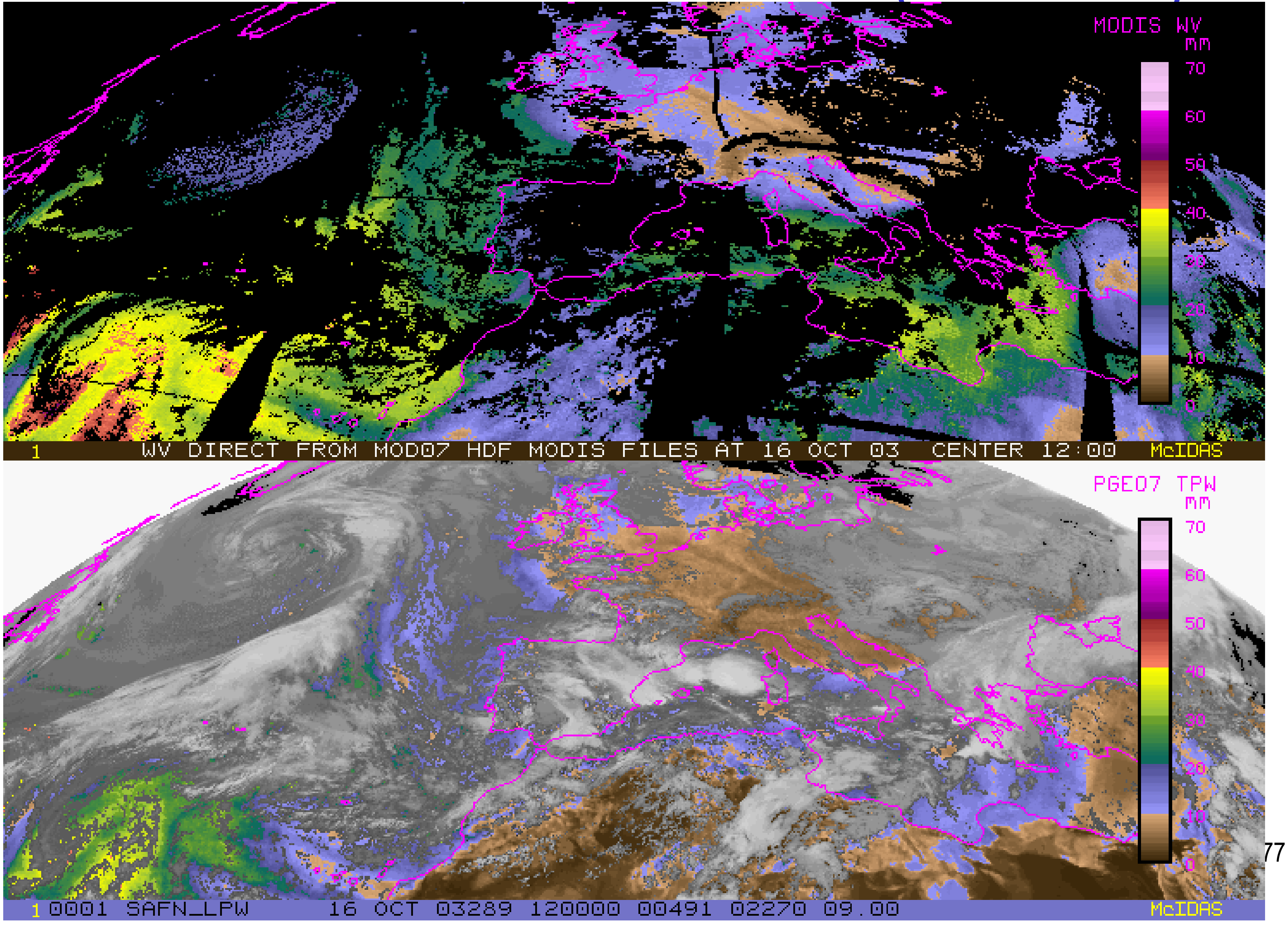
MODIS MOD07 FILE: TPW (16-10-03/12Z)



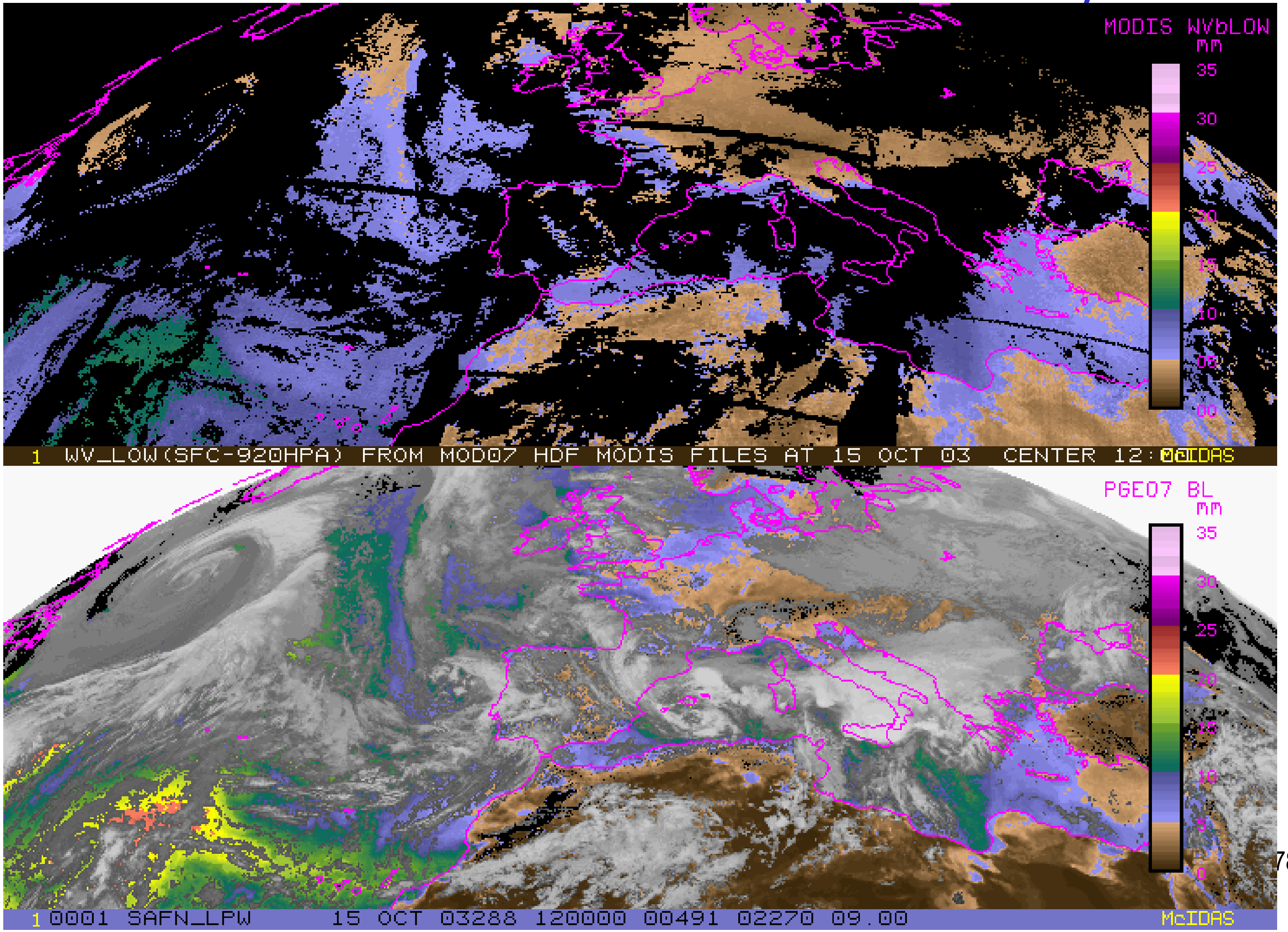
MODIS MOD07 FILE: TPW DIRECT (15-10-03/12Z)



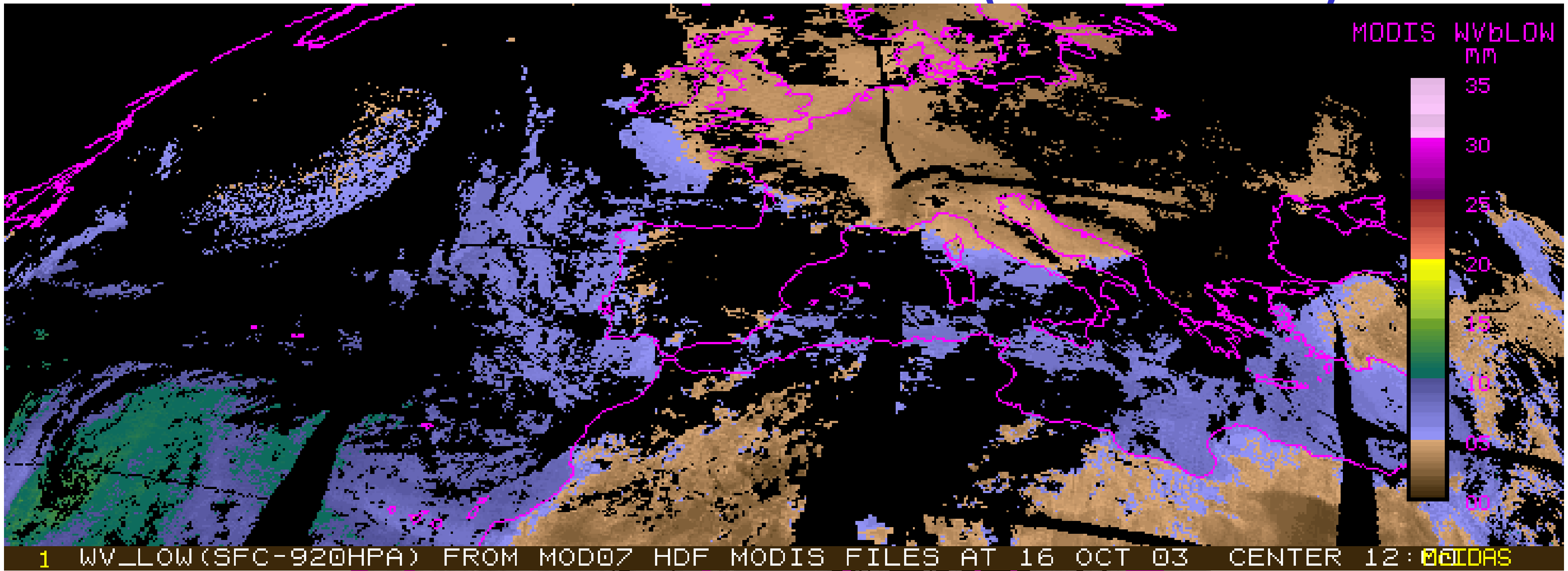
MODIS MOD07 FILE: TPW DIRECT (16-10-03/12Z)

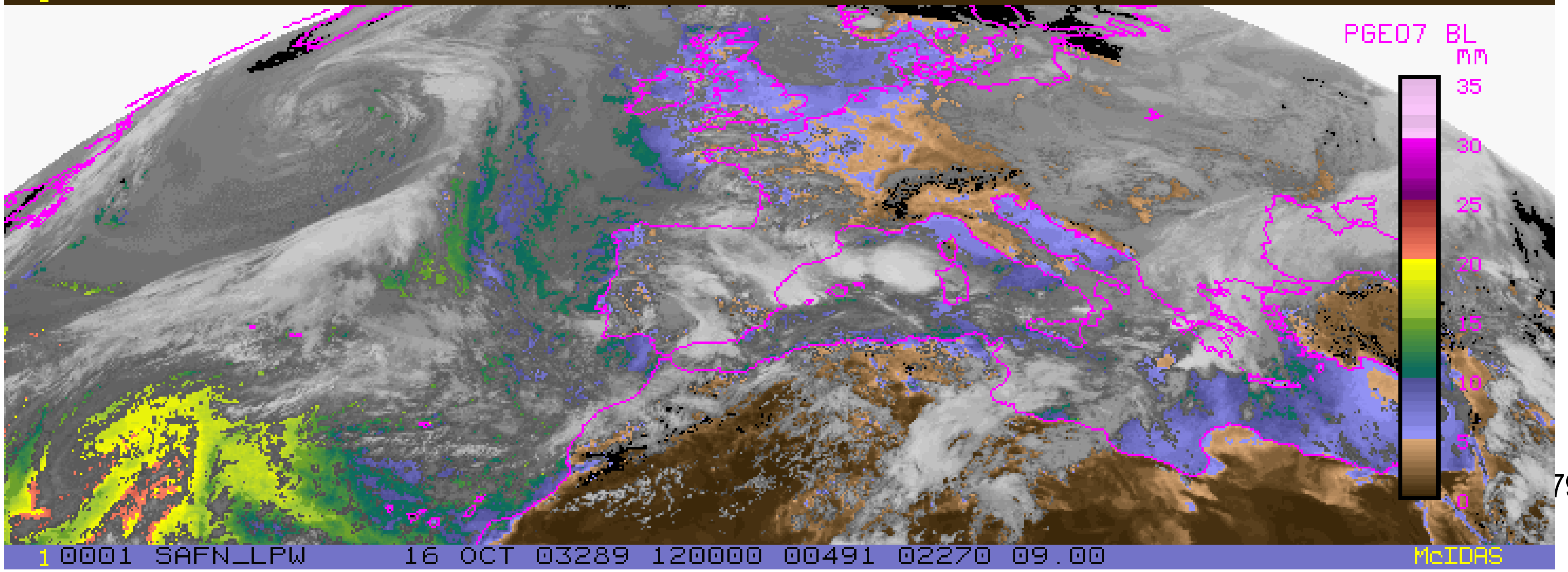


MODIS MOD07 FILE: WV LOW (15-10-03/12Z)

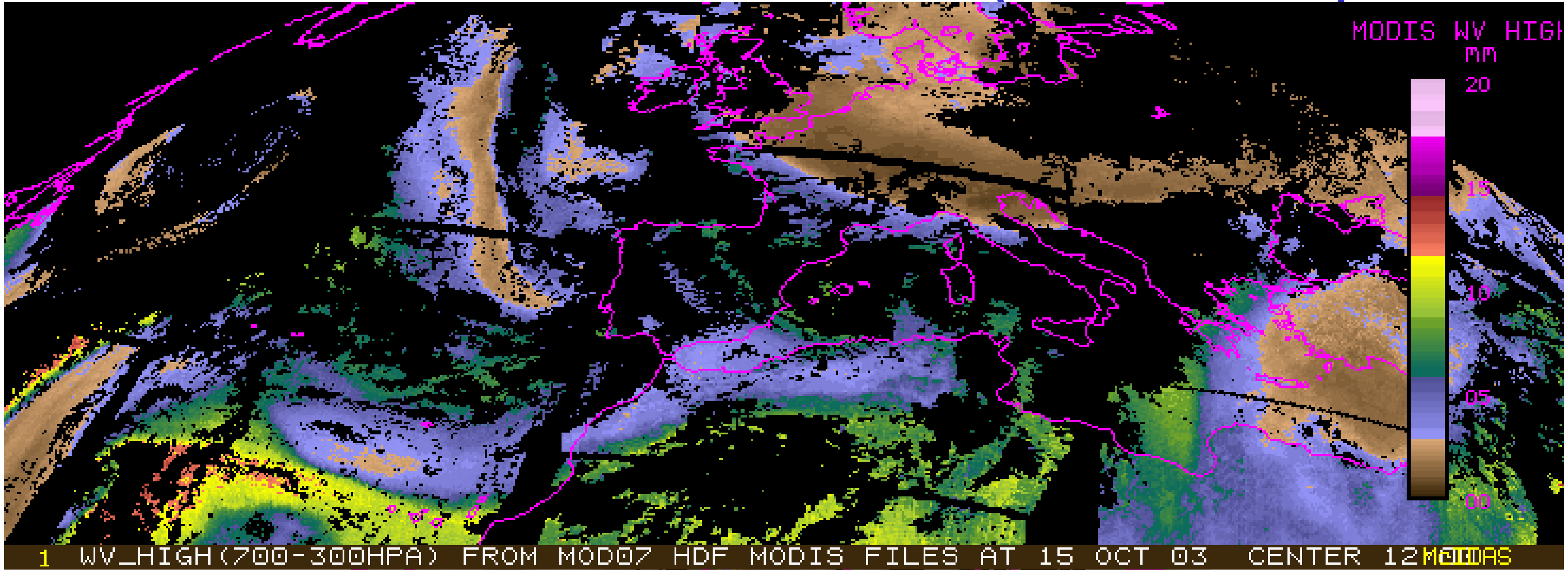


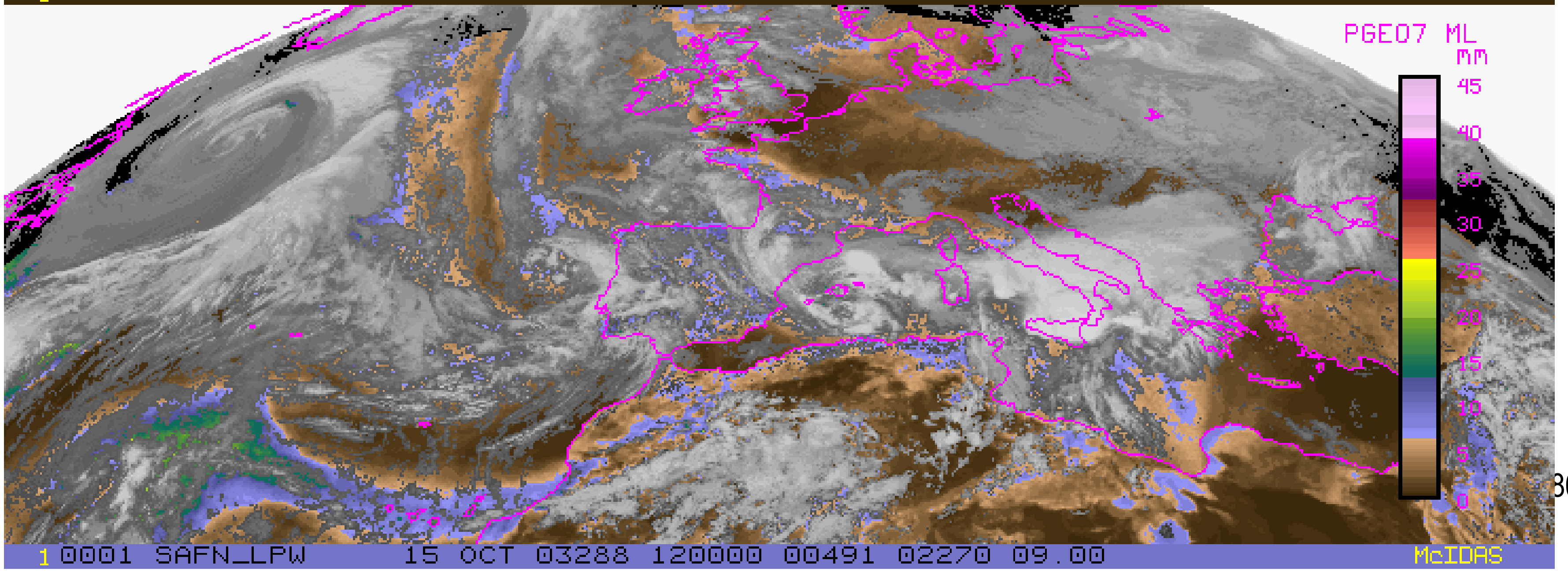
MODIS MOD07 FILE: WV LOW (16-10-03/12Z)



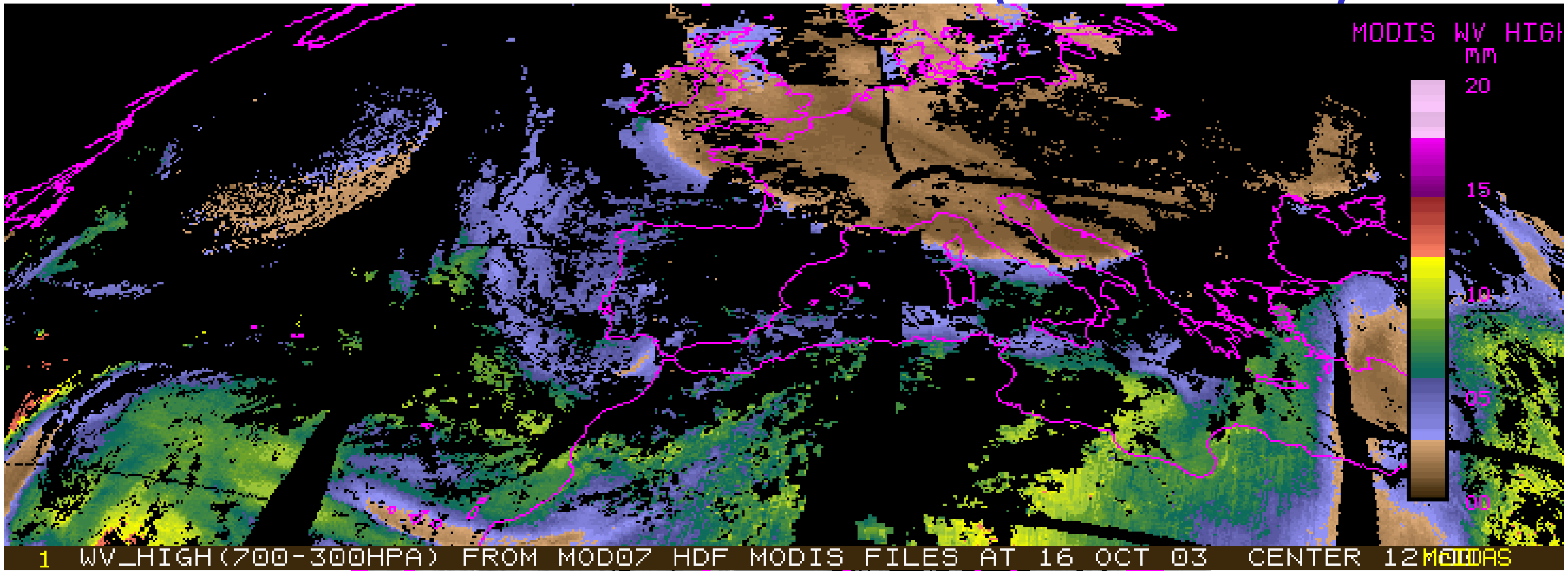


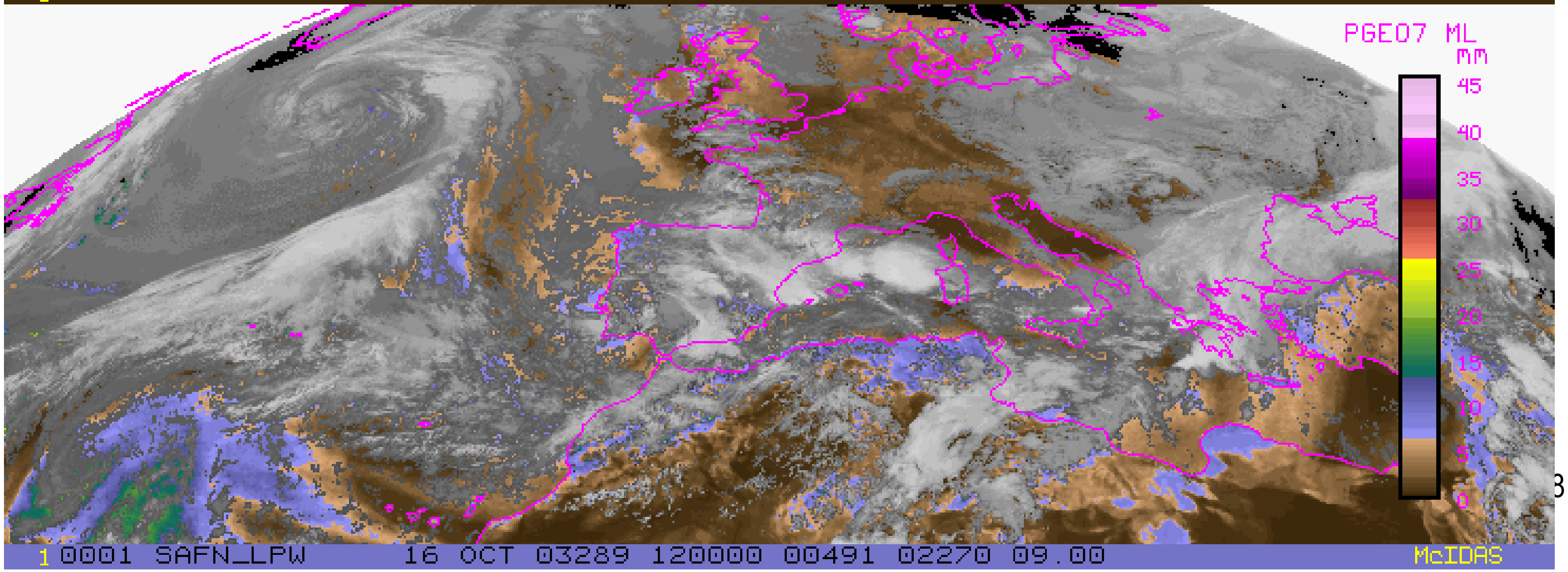
MODIS MOD07 FILE: WV HIGH (15-10-03/12Z)



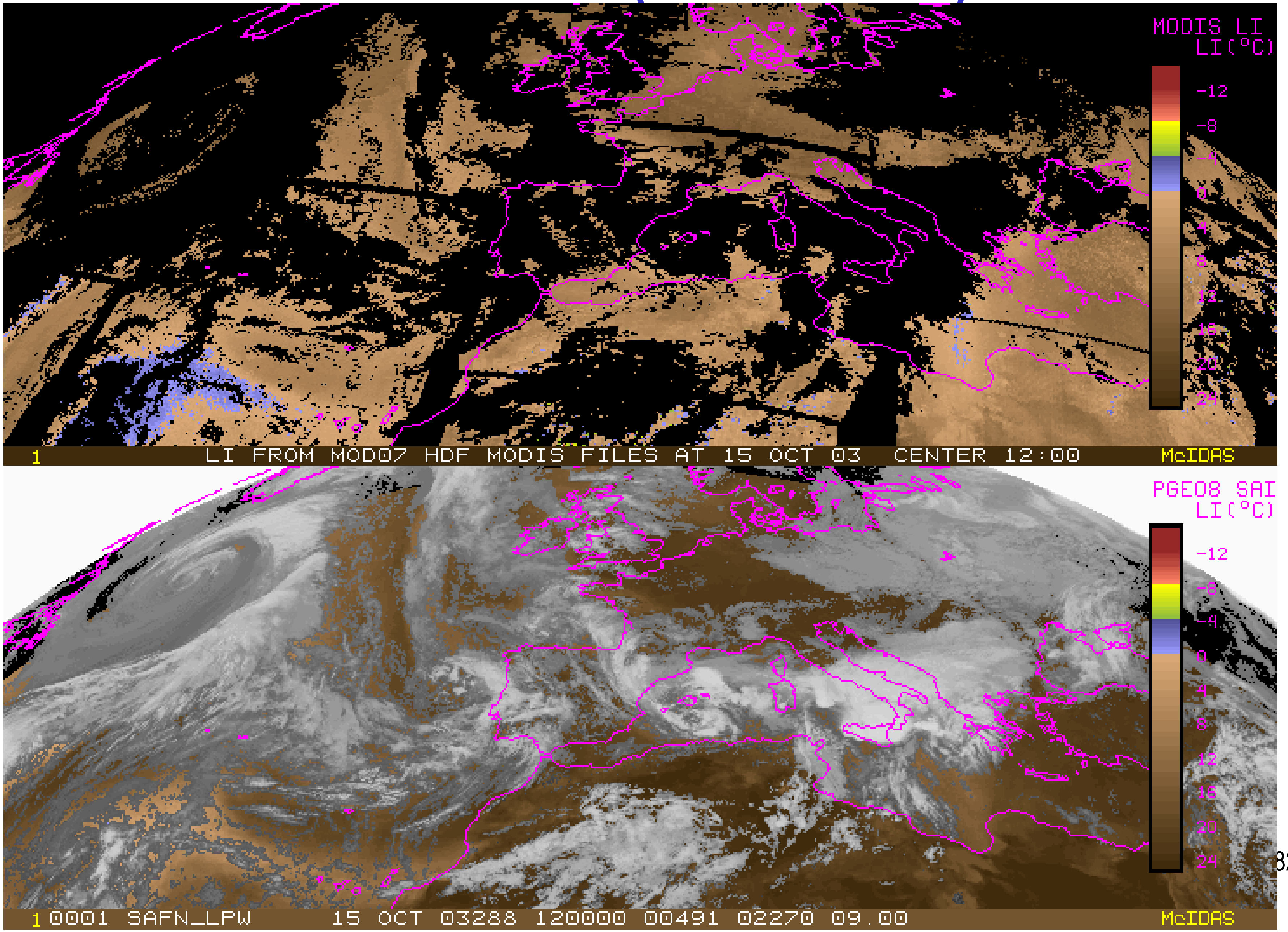


MODIS MOD07 FILE: WV HIGH (16-10-03/12Z)

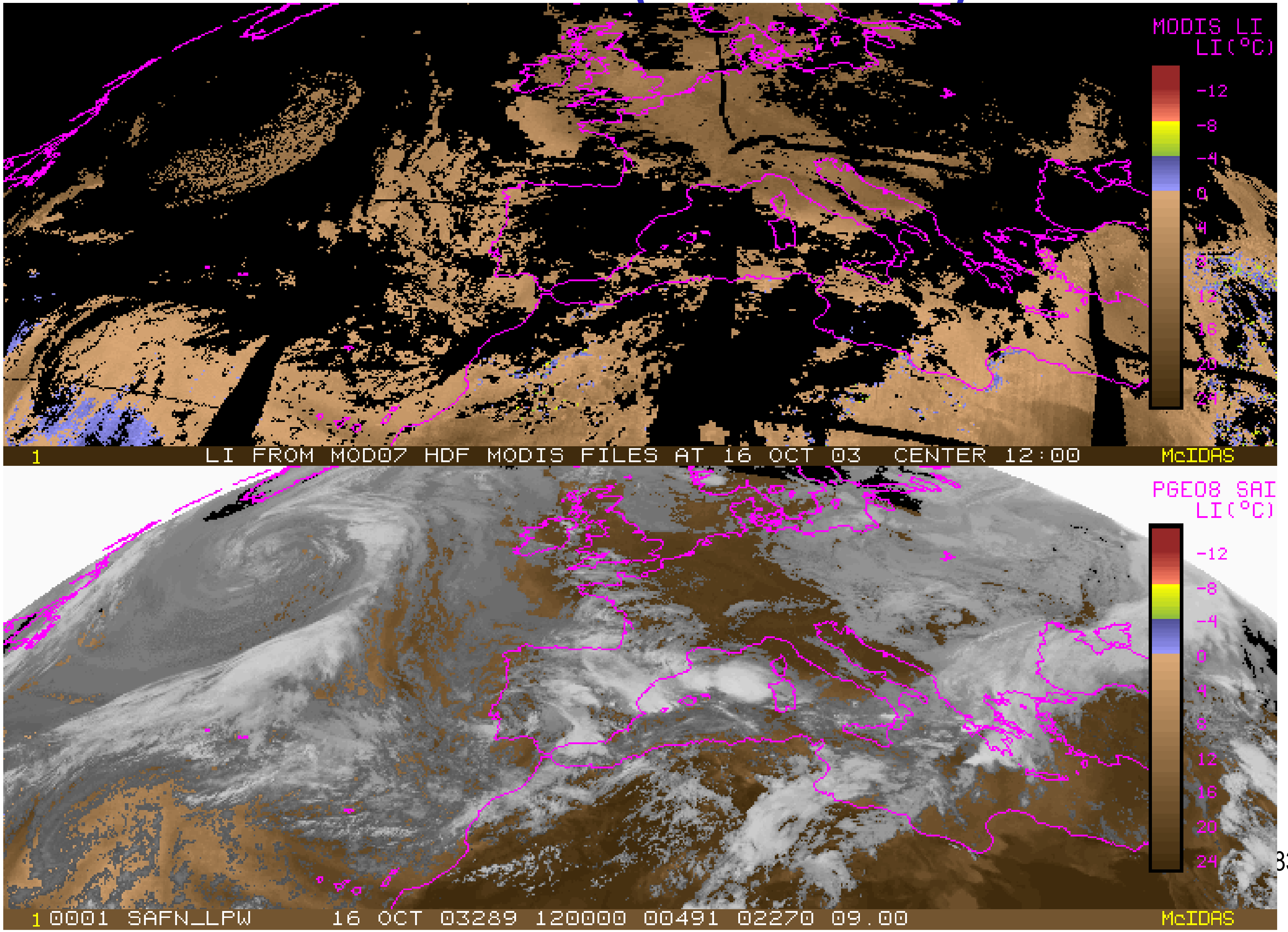




MODIS MOD07 FILE: LI (15-10-03/12Z)



MODIS MOD07 FILE: LI (16-10-03/12Z)

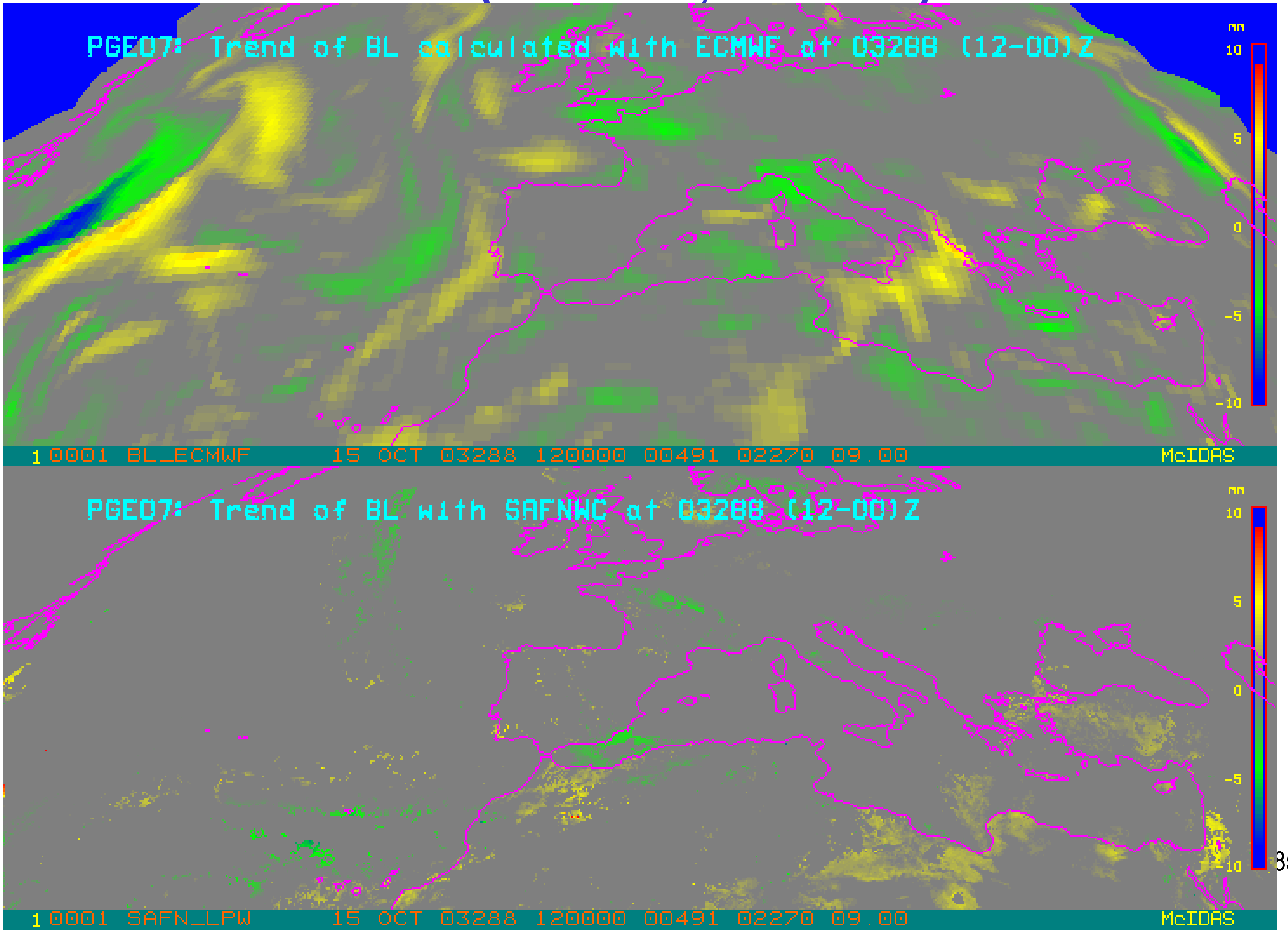


TREND ECMWF ANALYSIS LPW PRODUCTS

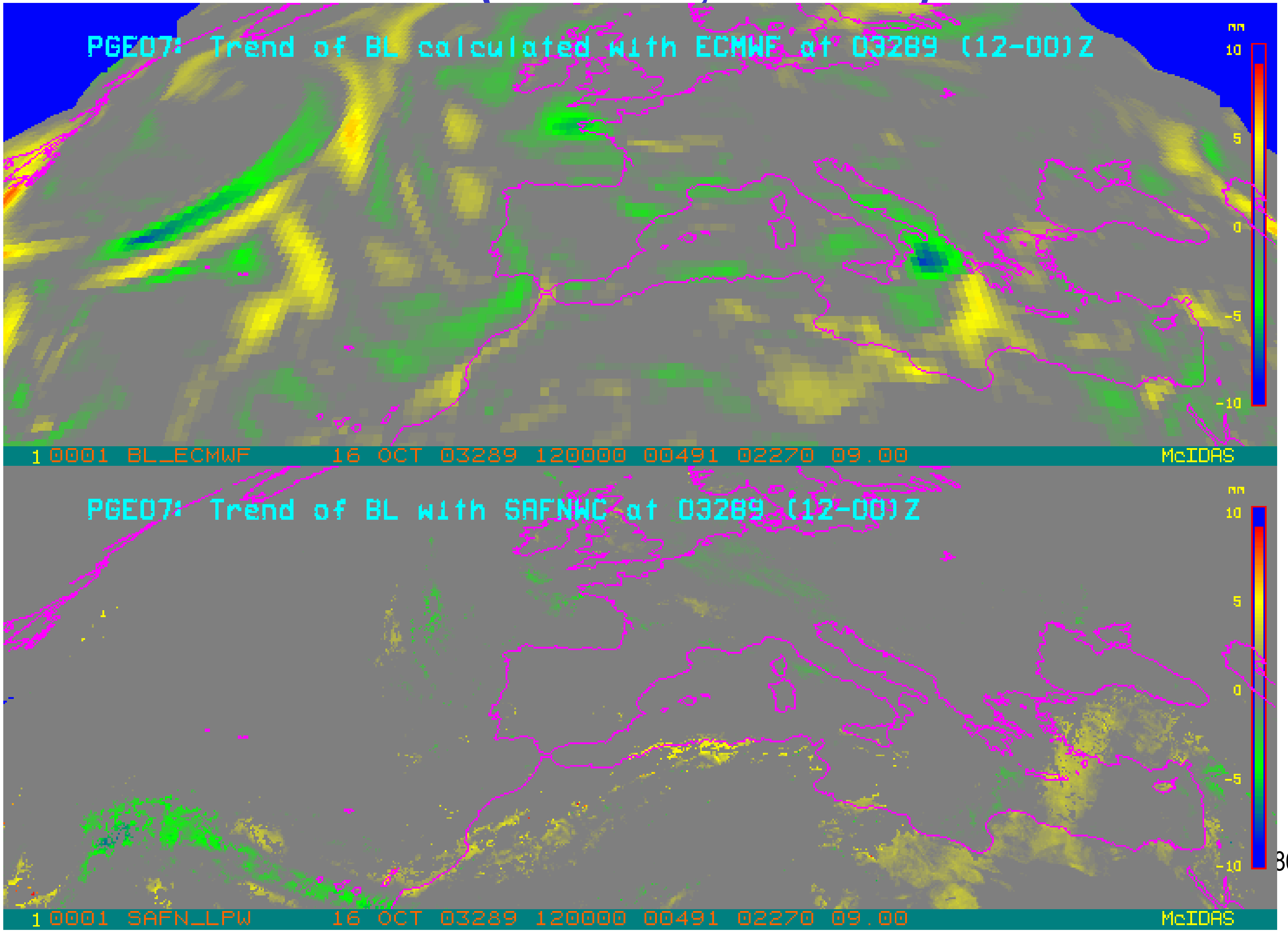
VS

TREND SAFNWC LPW PRODUCTS

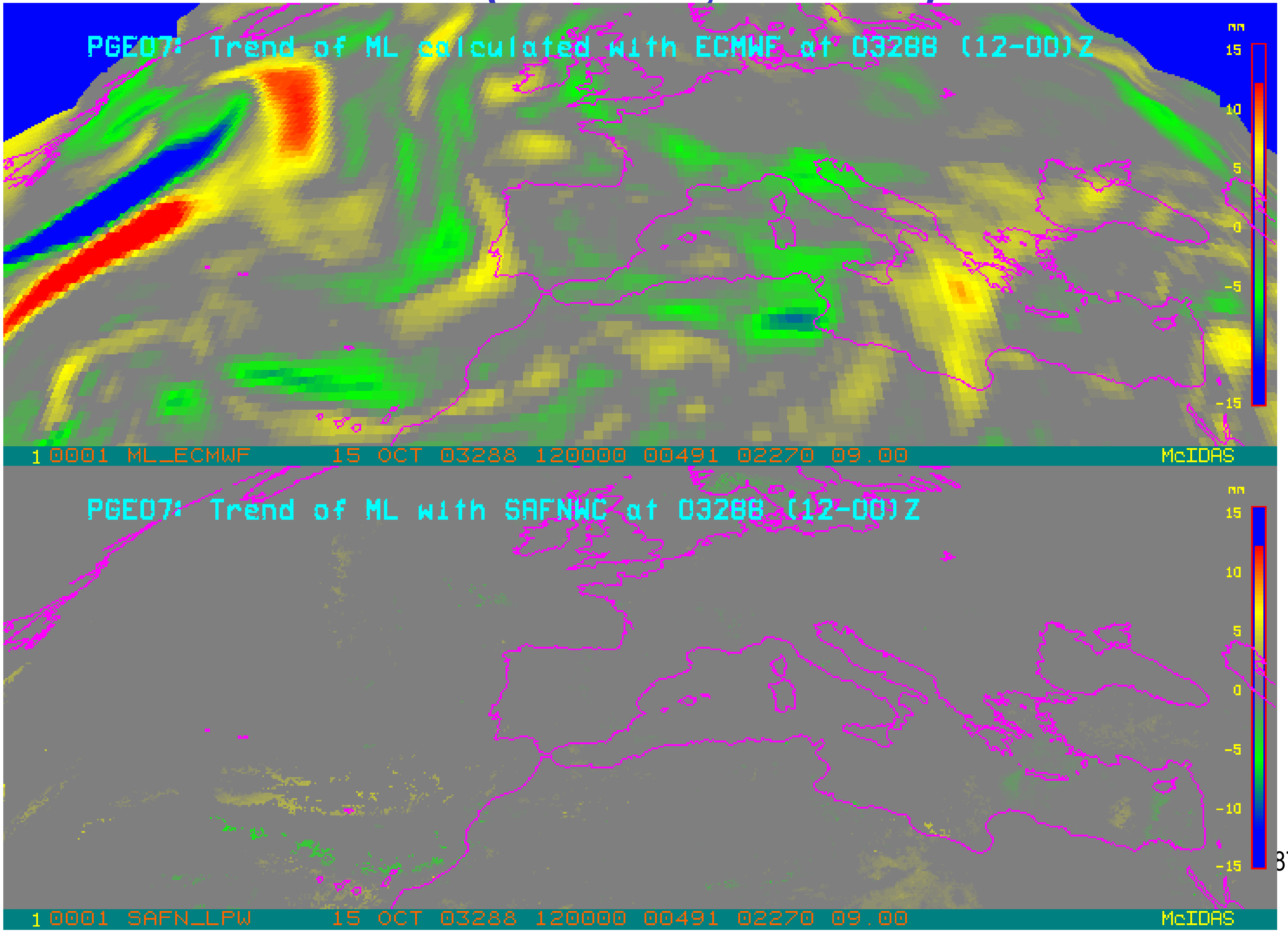
TREND LPW: BL (15-10-03, 12Z-00Z)



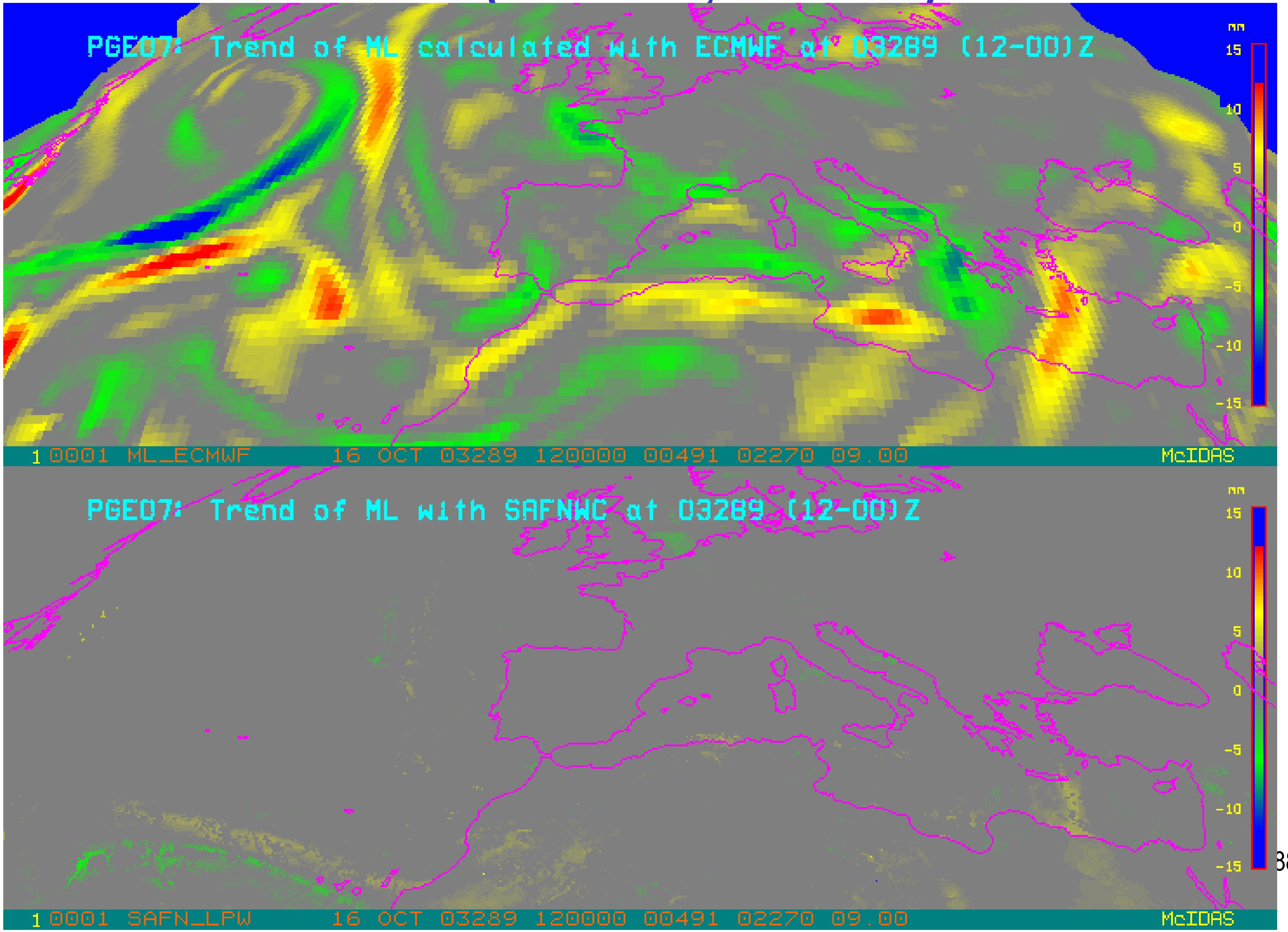
TREND LPW: BL (16-10-03, 12Z-00Z)



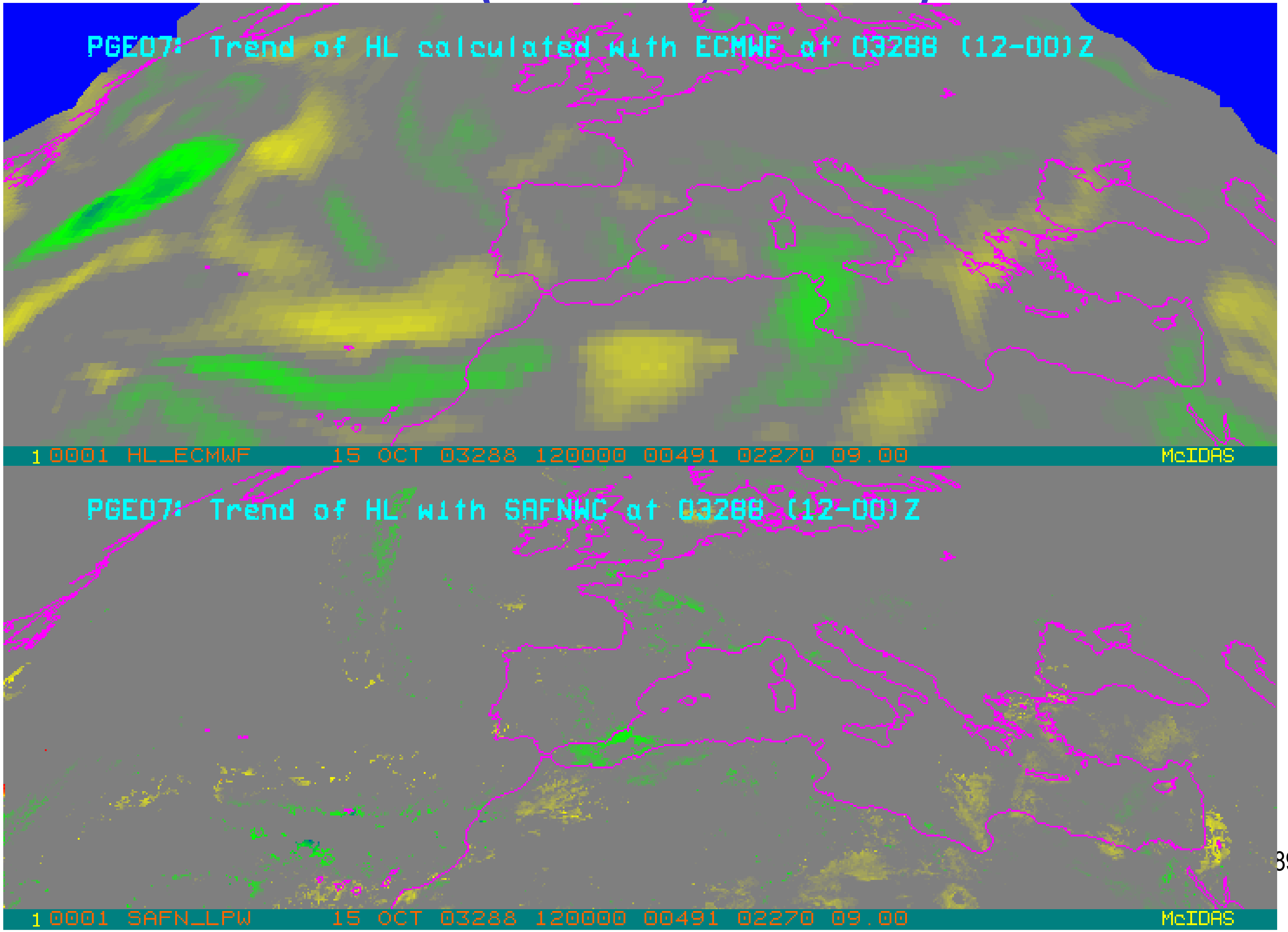
TREND LPW: ML (15-10-03, 12Z-00Z)



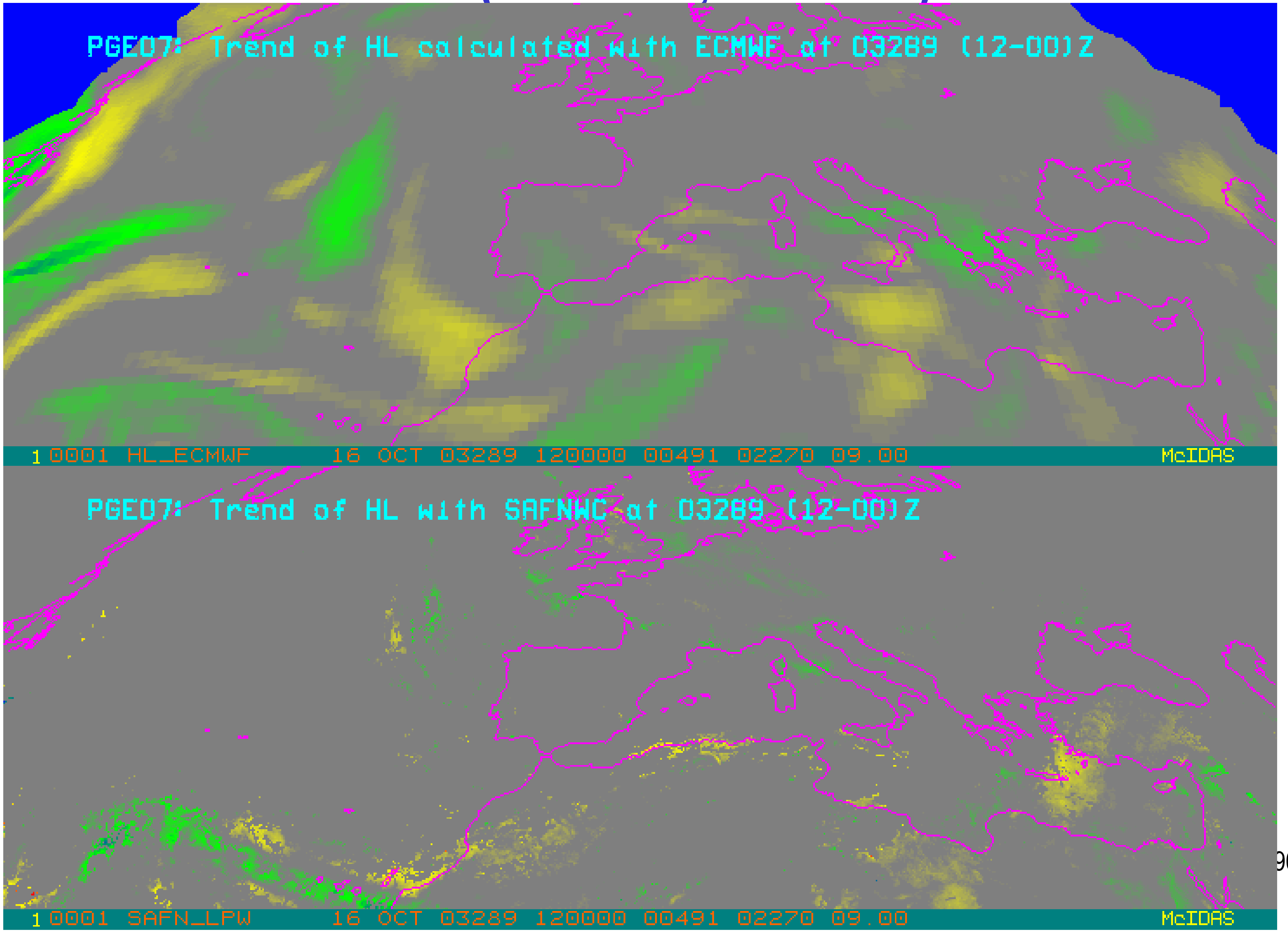
TREND LPW: ML (16-10-03, 12Z-00Z)



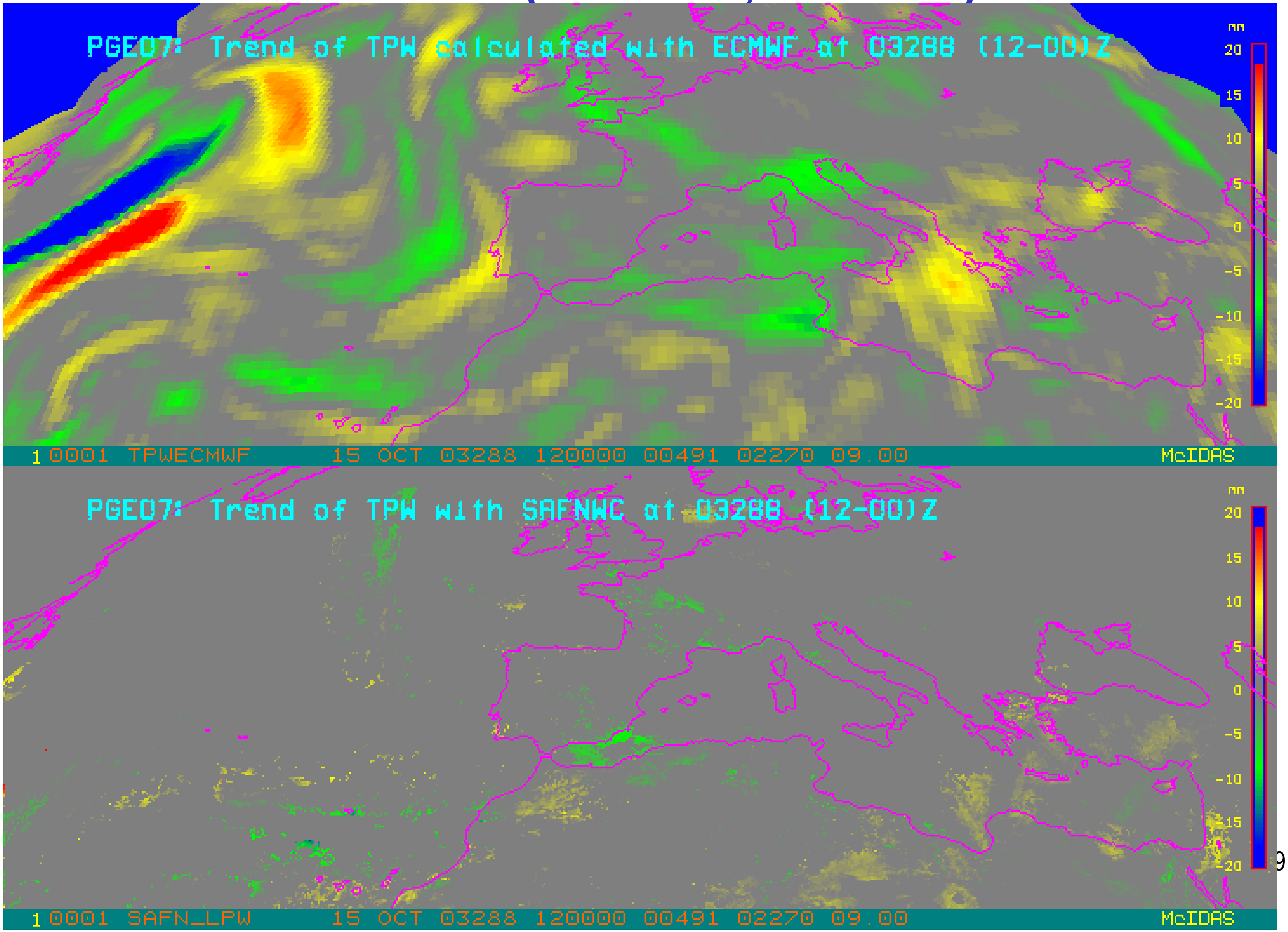
TREND LPW: HL (15-10-03, 12Z-00Z)



TREND LPW: HL (16-10-03, 12Z-00Z)



TREND LPW: TPW (15-10-03, 12Z-00Z)



TREND LPW: TPW (16-10-03, 12Z-00Z)