GOBIERNO DE ESPAÑA
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AEMet Agencia Estatal de Meteorología

# Project 6

## Development and use of tools for quality control of radar data. Monitoring of AEMET radar data for NWP. Installation and configuration of a BALTRAD node and ROPO tools in AEMET.

**Lorenzo Rodríguez Magaz**
**Advisor: Carlos Geijo**

**Area of Modelization**

# Outline of the presentation

- **Web-site construction for support to radar data assimilation (and not only radar data assimilation!)**
- **BALTRAD, a baltic system for radar data exchange**
- **Radar QC ToolBox ROPO.**
- **Presentation of results in radar data QC (quality control).**

**Objective**: **Build a web-based system for support in radar data assimilation.**

**Technologies used:**

- **Web servers : Apache + Tomcat**
- **Web development: Joomla ( a CMS (Content Management System))**
- **Web programming: PHP 5, CGI, Javascript, XML**
- **Databases: MySQL, PostgreSQL**
- **Utilities programming: FORTRAN90, C, Python, Perl**
- **Radar Data Formats: BUFR, HDF5**
- **Graphics: GRADS, hdfview.**

# How many things are included in this Web-Site ?

**A monitoring tool to provide us with a quick and easy way of monitoring the reception, the content, eventual re-formatting and transmission (e.g. to ECMWF, HYMEX ftp server ) of the radar data received**

**It also includes monitoring of a data QC process using bROPO**

**Also monitoring of HARMONIE analyses done with radar data and other observations every 3 hours (RUC: Rapid Update Cycle)**

**The interface must provide an overview of the status and results of all these processes whenever a user makes a request from the browser**

**A BALTRAD node administration and viewer also integrated in this web-site**

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# 1st Phase

- Installing and configuring the web servers Apache and database MySQL.
- Installation of Joomla CMS (Content Management System)
- Web pages programming done in PHP and CGI
- Several shell scripts running in the background producing contents for the Web

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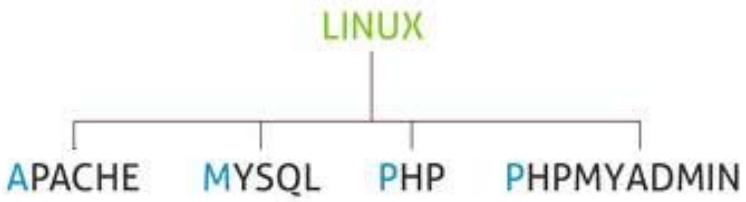
# 1st Phase

- **Installation of webserver Apache and MySQL database.**

- We chose "Apache", a well-known webserver in Linux environments

- A database manager: MySQL is fast and well tested

These elements can be downloaded and installed from a common package known as LAMPP. We need install also PHPMYADMIN.





Server selected for installation: **noreste**
**User stop lampp :** sudo /opt/lamp/lamp/stop
**User start lampp :** sudo /opt/lamp/lamp/start

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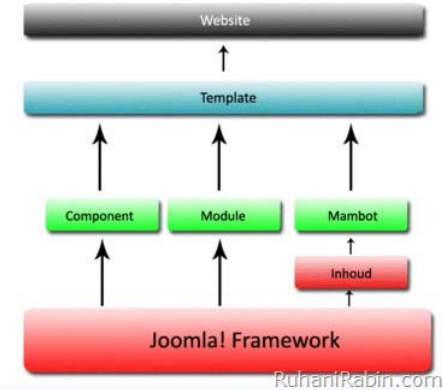
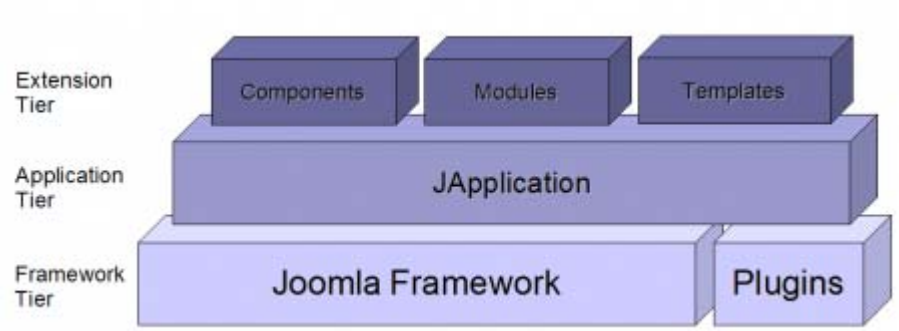
# 1st Phase

- **Installation and configuring Joomla v.1.5 .CMS**

- Installed over **lampp** in server **noreste**

We have chosen Joomla v.1.5 because is a content management system (CMS), which enables you to build Web sites and powerful online applications. It offers many features and it is ease to use and extendible. It is an open source solution that is freely available to everyone. It has thousands of extensions, most of them are free under the GPL license.



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# 1st Phase


After installation we have the backend from where we manage joomla.

We can add and configure new components and PHP modules to increase the functionality of the web in addition to many other features such as creating users and setting up his access rights, blogs, chats, etc...

**http://noreste.inm.es:81/joom1/administrator**

User : admin
Pass: ****

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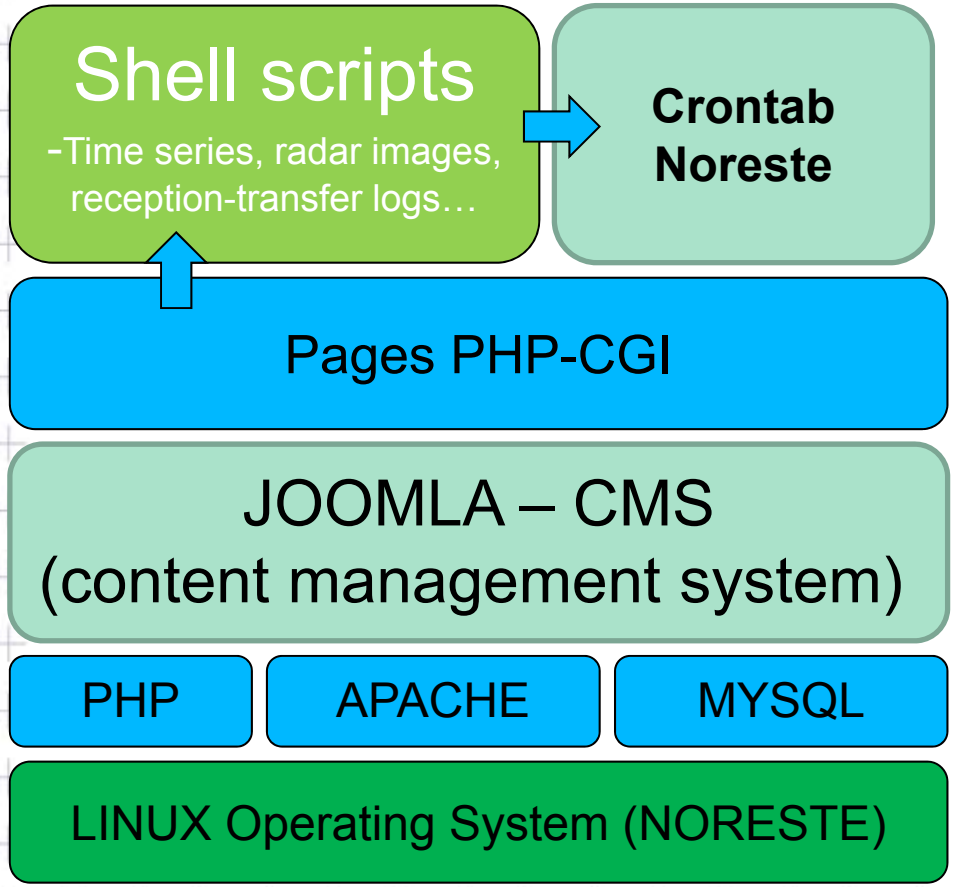
# 1st Phase

## Web pages programming done in PHP and CGI




These pages were created in php and later integrated Joomla CMS.

Several shell scripts running in the background producing contents for the Web

Monitoring of the radar data reception, formatting and transfer processes. These processes are launched every hour from crontab in “noreste”.

We made adjustments to improve the correct display and operation of visualization of logs, time series and presentation of radar images.

We had to solve some problems that have been related to the visualization of the website in browsers.

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# Phases OF THE PROJECT

## 2nd Phase

- Transmission to **HyMex** ftp-server implemented using **lftp** and also to **ECMWF** using **ecput**
- Extension of the monitoring facility to include results from an experimental **RUC** installed on **c1a.**
- Installation of **BALTRAD node**
- Extension of the monitoring facility to include results from the radar data QC ToolBox **bROPO**

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# Phases OF THE PROJECT

## 2nd Phase

- Transmission to **HyMex** ftp-server implemented using **lftp** and also to **ECMWF** using **ecput**

HyMeX
HYdrological cycle in Mediterranean EXperiment

HyMex is an important ongoing European Project focused on the Hydrology of the Mediterranean basin

We were directly involved by sending in NRT radar data to the HyMex data hub during the SOP-1 (first Special Observation Period) which took place between september and november 2012

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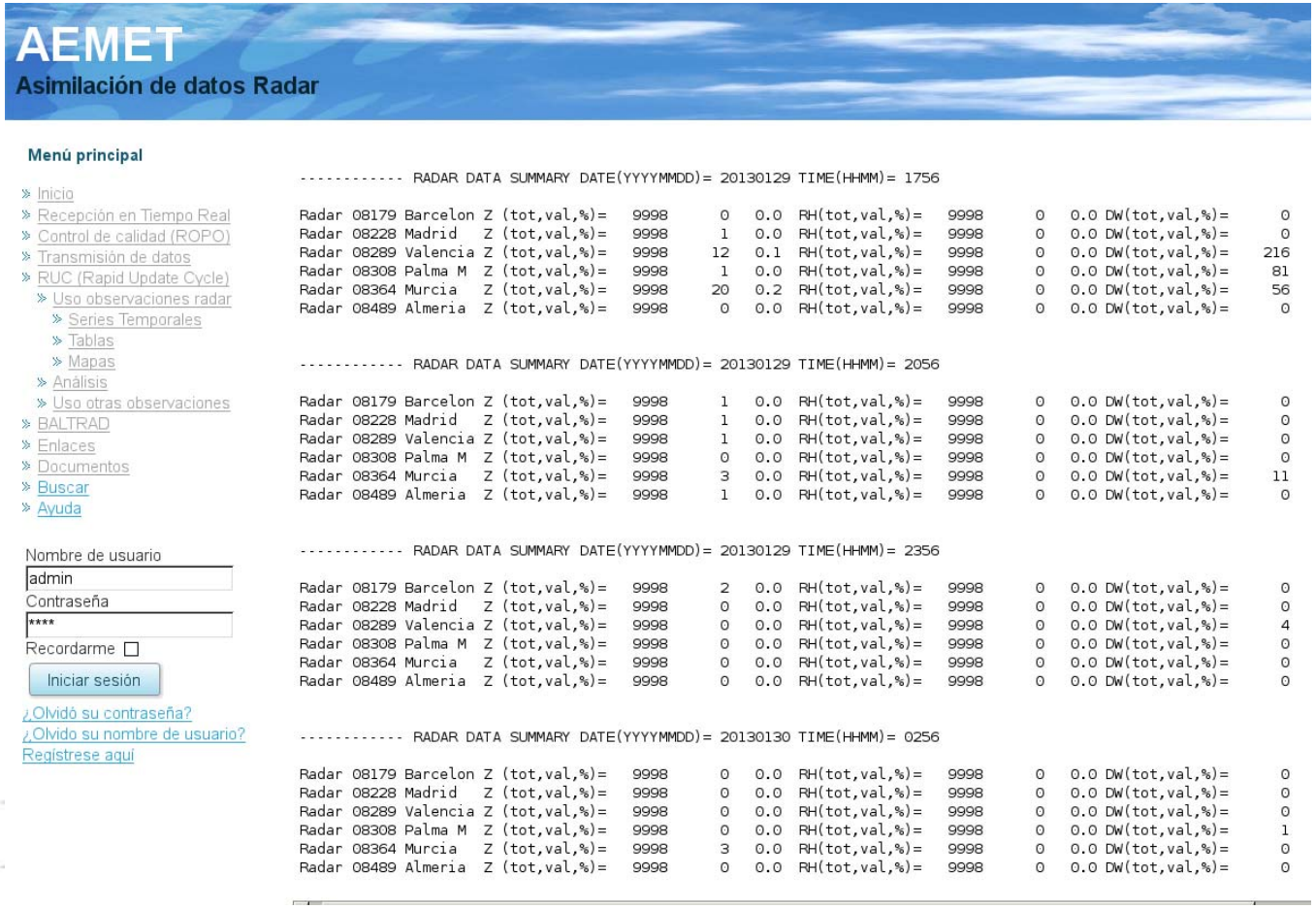
# 2nd Phase

- Extension of the monitoring facility to include results from an experimental **RUC (Rapid Update Cycle)** installed on **c1a** in **ECMWF**



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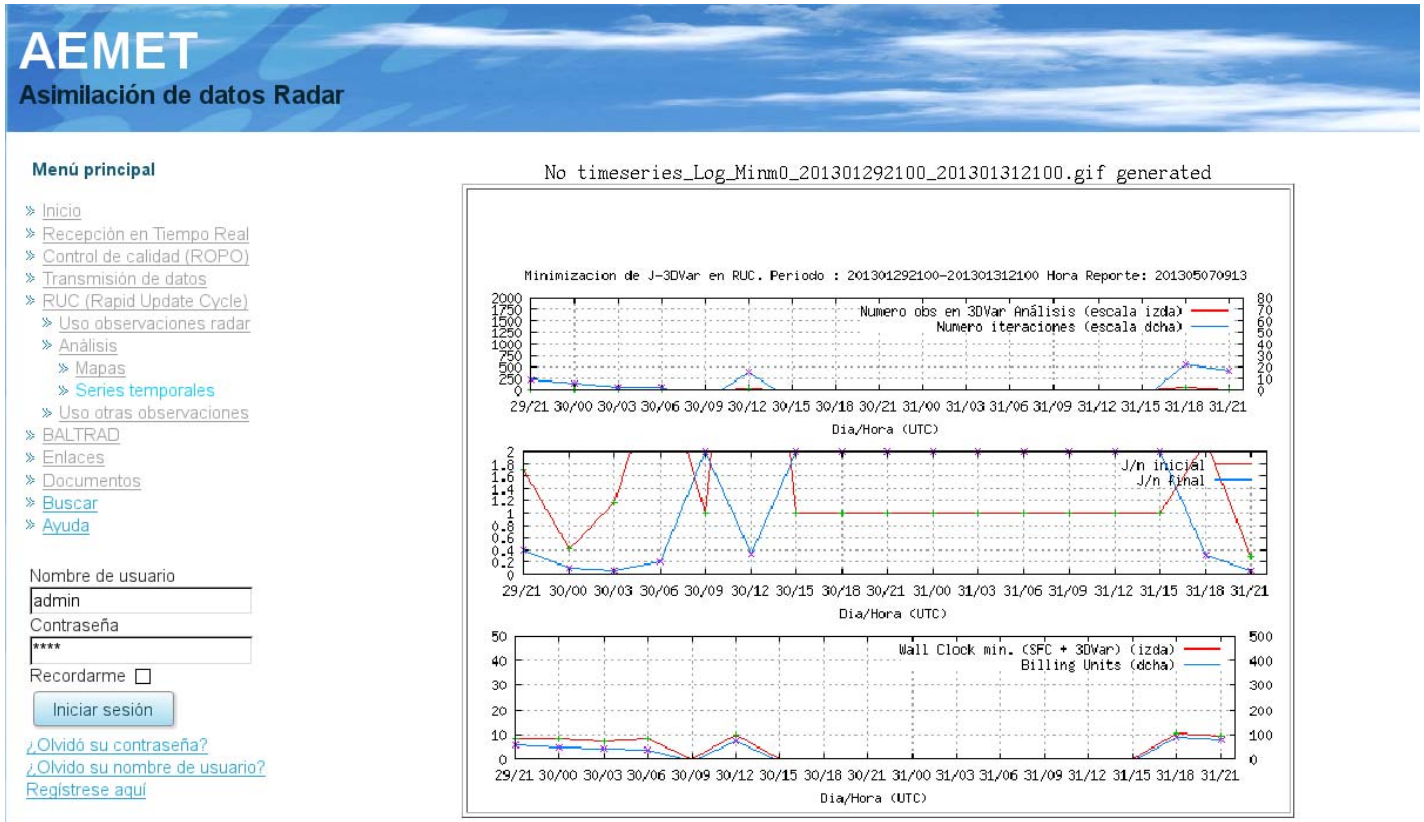

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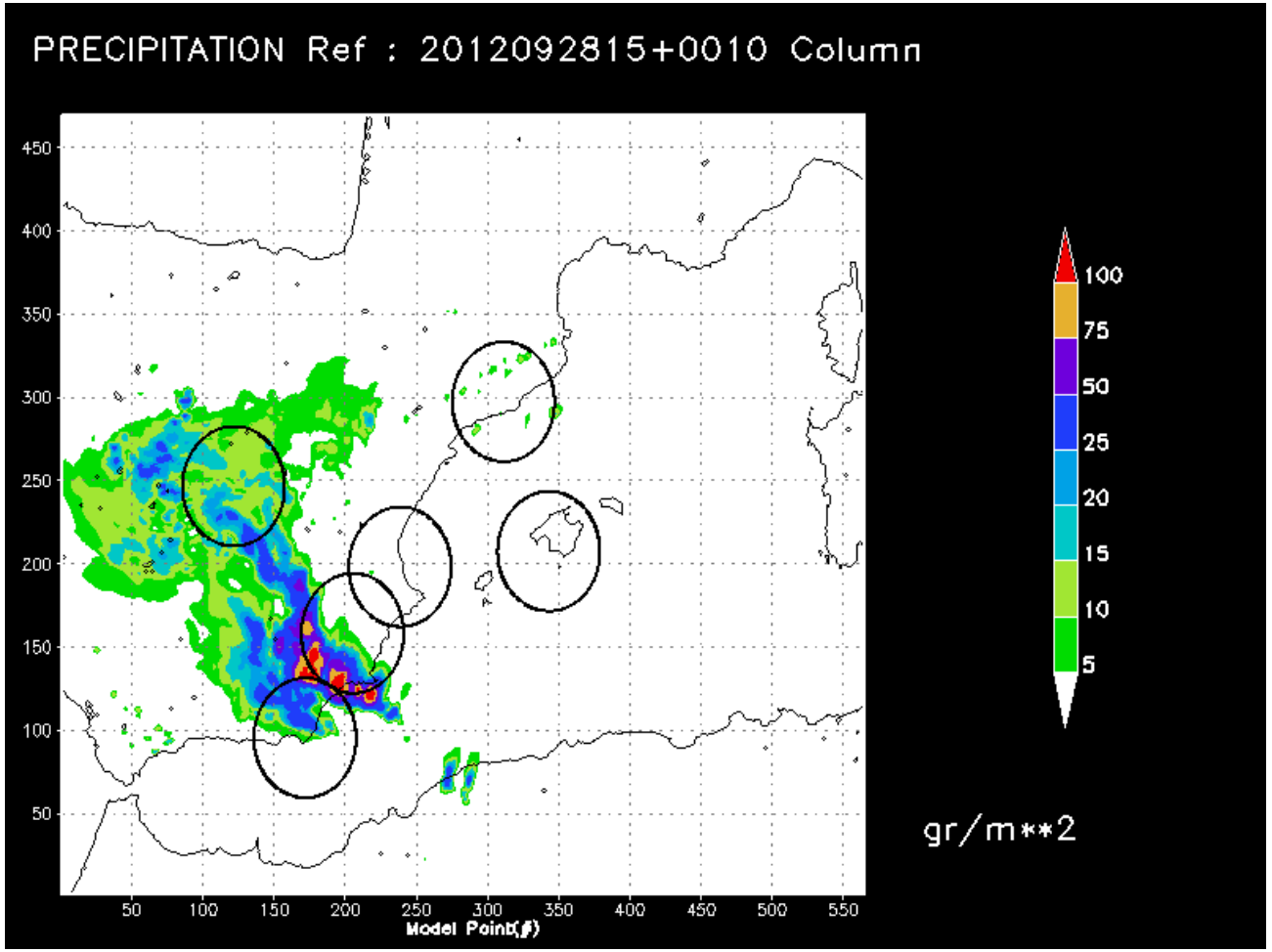

# What is BALTRAD ?

**BALTRAD** is a weather radar network, shared by the Baltic countries, operating in real-time, and exchanging data among **BALTRAD** nodes**.**

**BALTRAD** is also a radar data processing and display environment (this is what we have installed at **AEMET**)

Most **BALTRAD** members are also **OPERA** members and a strong collaboration exists between **BALTRAD** and **OPERA**.

**OPERA**. (Operational Programme for the Exchange of weather Radar information) is a EUMETNET program to stimulate the exchange of radar knowledge.

The exchange of radar data in Europe has greatly been enhanced by the adoption of a common data information model **ODIM** (OPERA Data Information Model).

Two encoded versions of **ODIM** have been developed **ODIM-HDF5** and **ODIM-BUFR**.

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## 2nd Phase

# Installation of a **BALTRAD node**

- Prepare a Linux 64-bit machine. **oceano** runs with Centos.

- The Linux machine must run an servlet container (**Tomcat**), a database
- ( **Postgre SQL** ) , a **Java virtual machine**, a **Python interpreter**, etc …

- Download the BALTRAD node software with **git** from the BALTRAD hub

- Installing the node software .There is a long list of installation parameters

- The BALTRAD node is built with a variety of programming languages, mainly OO programming languages like **java** and **Python**

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# 2nd Phase

## Installation of a **BALTRAD node**

The command to use is setup, but it comes with a lot of arguments and options

```
$ ./setup --nodename=baltrad.aemet.es --
prefix=/opt/baltrad \ --jdkhome=/usr/java/jdk1.6.0_16 \ --
with-psql=/usr/include/pgsql,/usr/lib64/pgsql --dbpwd=<> --
excludedb \ --with-rave --rave-dex-spoe=localhost:8080 --
rave-center-id=82 \ --with-rave-gmap --with-bropo --with-
beamb --with-bufr install
```

The nodename is unique. This command specifies also where to locate jdkhome directory and the postgresql.. Also Install the google map plugin, BUFR, bROPO Tools, rave module, e. g.

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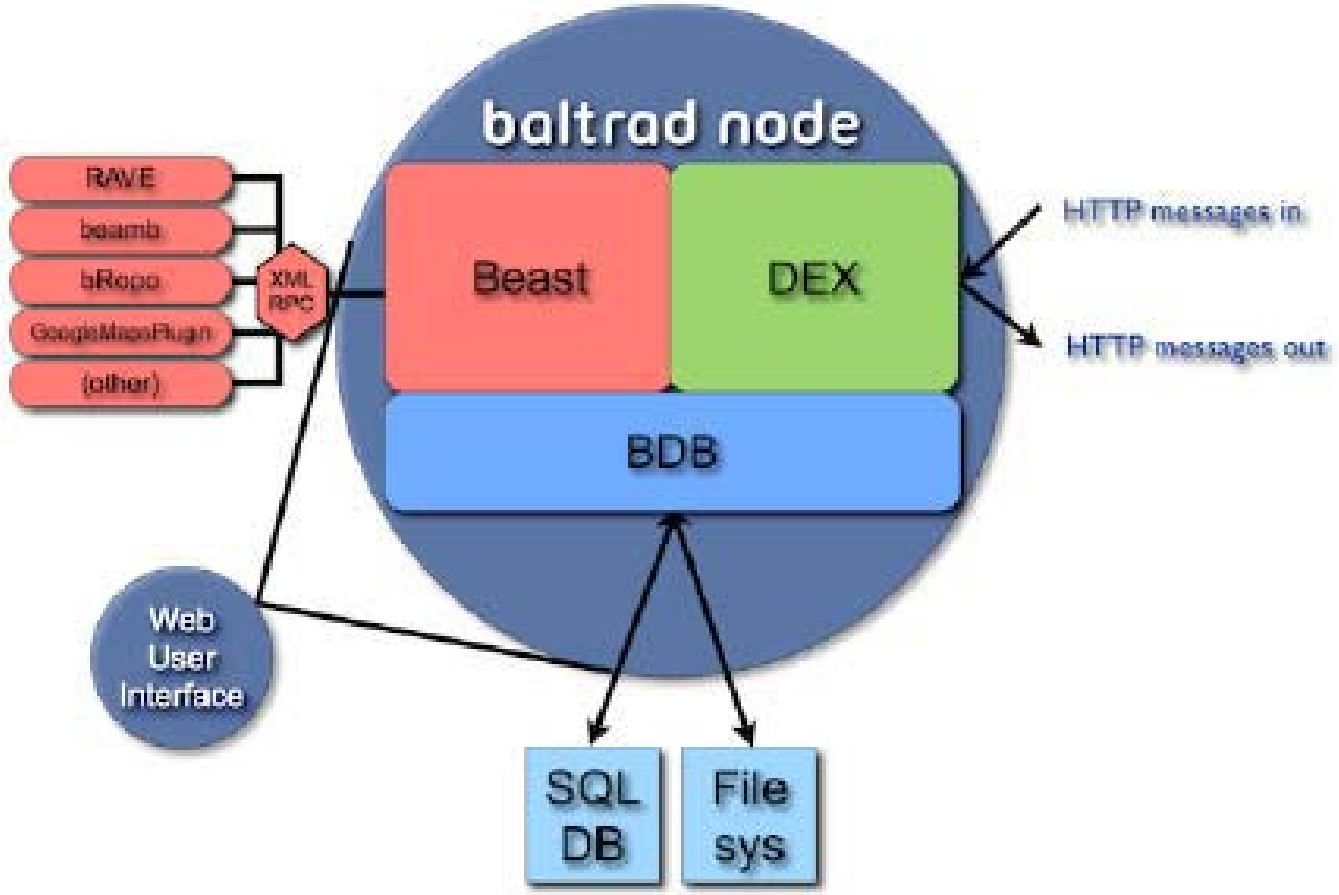
# 2nd Phase

## SCHEME OF A BALTRAD-node



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# 2nd Phase

## SCHEME OF A BALTRAD-node

```
oceano:/opt/baltrad/1.2.0

11 baltrad baltrad   4096 may 10  2013 third_party
 5 baltrad baltrad   4096 dic 13  2012 rave_gmap
18 baltrad baltrad   4096 may 27  2013 rave
 3 baltrad baltrad   4096 nov 28  2012 hlhdf
 3 baltrad baltrad   4096 oct 30 10:39 etc
 6 baltrad baltrad   4096 nov 28  2012 doc
 6 baltrad baltrad   4096 nov 28  2012 bropo
13 baltrad baltrad   4096 mar 22  2013 brack
 2 baltrad baltrad   4096 dic 10  2012 bin
 8 baltrad baltrad   4096 nov 28  2012 beast
 6 baltrad baltrad   4096 nov 28  2012 beamb
 2 baltrad baltrad 630784 nov 14  2013 bdb_storage
 5 baltrad baltrad   4096 nov 28  2012 bbufr
 4 baltrad baltrad   4096 nov 28  2012 BaltradDex
 6 baltrad baltrad   4096 nov 28  2012 baltrad-db
```

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# 2nd Phase

| | | |
|---|---|---|
| baltrad-db | Python, Java | Database manager subsystem |
| BaltradDex | Java | Distribution and Exchange subsystem |
| baltrad_wms | OGC Map Server | Web map services |
| bbufr | C, Python | BALTRAD interface to EUMETNET OPERA's BUFR software |
| beamb | C, Python | Determination of, and correction for, beam blockage caused by topography |
| beast | Java | Task manager/scheduler subsystem |
| bRopo | C, Python | Anomaly (non-precipitation echo) detection and removal |
| GoogleMapsPlugin | Python | Creates PNG images for use with Google Maps |
| node-installer | Python | Installation wizard |
| OdimH5 | Java | Data injector using ODIM_H5 and Rainbow file formats |
| RAVE | C, Python | Product generation framework and toolbox. Injector using ODIM_H5 files. |

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## 2nd Phase

# Installing a **BALTRAD node**

- The utility **bltnode** starts up, shuts down, and reports back the status of the node. If the installation is not done with *root*, we need *sudo*:

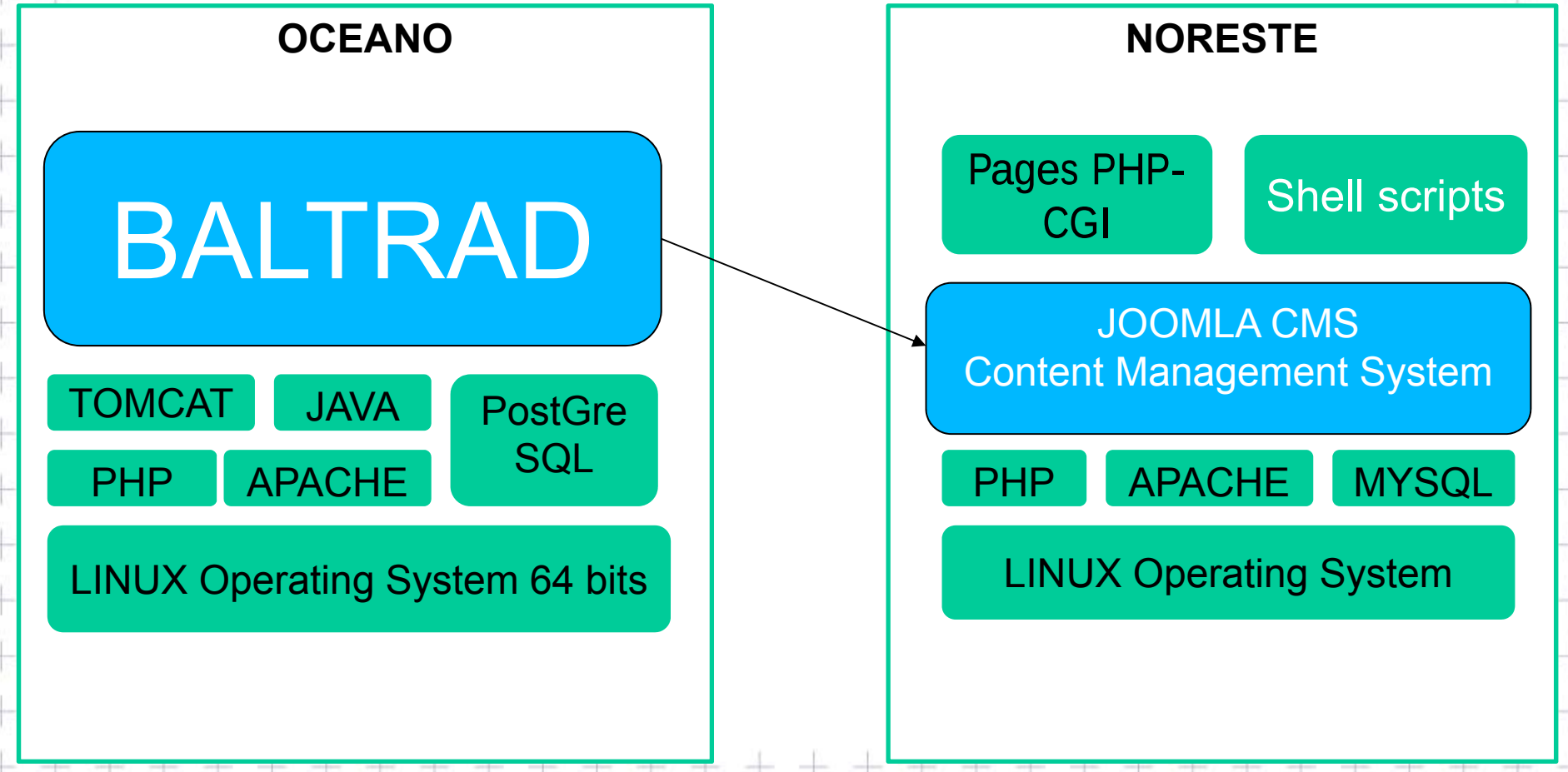
```
sudo /opt/baltrad/1.2.0/bin/bltnode –all start
sudo /opt/baltrad/1.2.0/bin/bltnode –all stop
sudo /opt/baltrad/1.2.0/bin/bltnode –all status
```

- We access and work with BALTRAD with a browser:

**http://noreste.inm.es:81/joom1/administrator**

## 2nd Phase

- **The BALTRAD node is integrated in the Radar Website**



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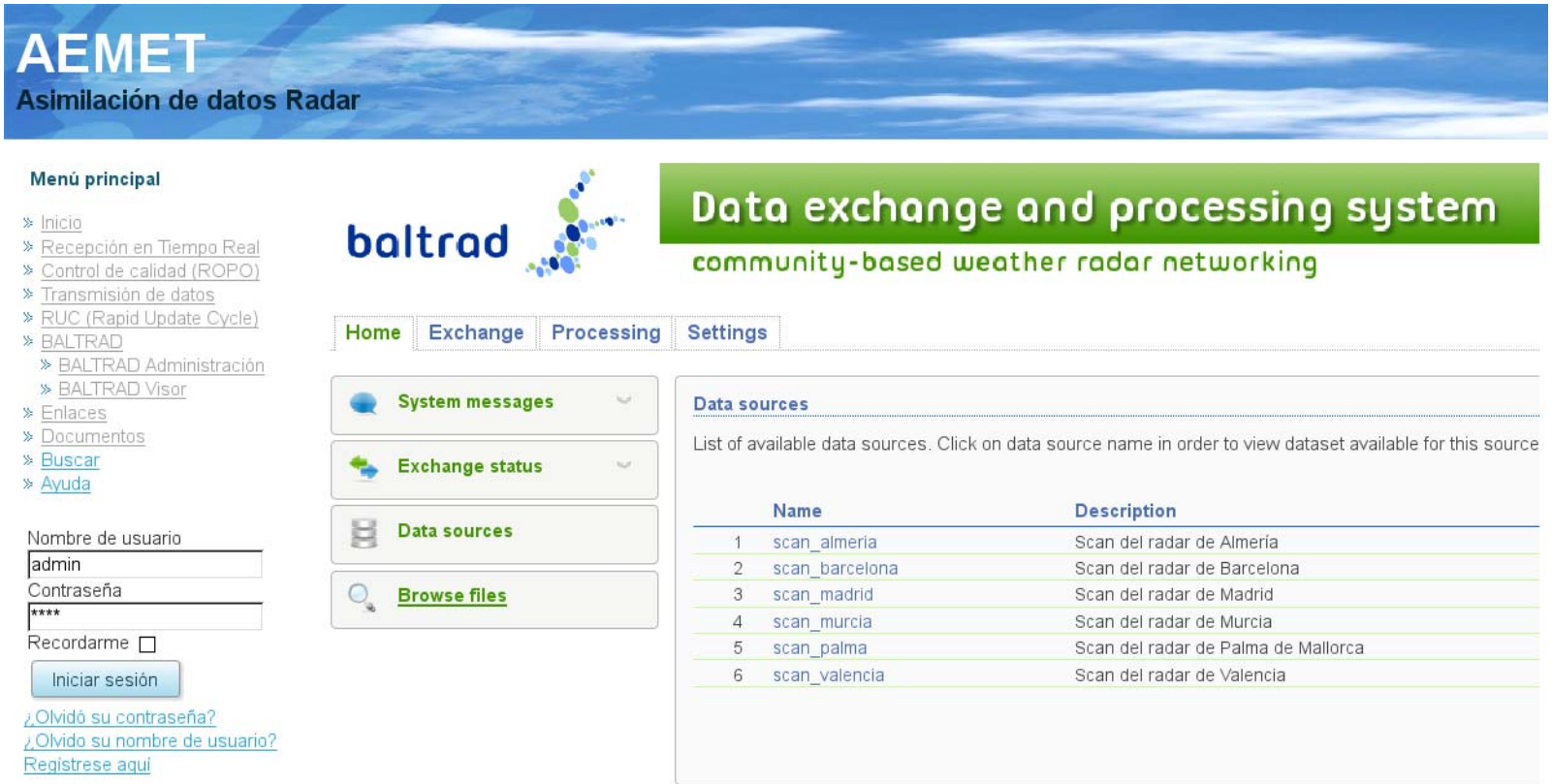
# 2nd Phase

Console configuration of the node Baltrad (v.1.0.2). **User**:admin **Pass**:*****



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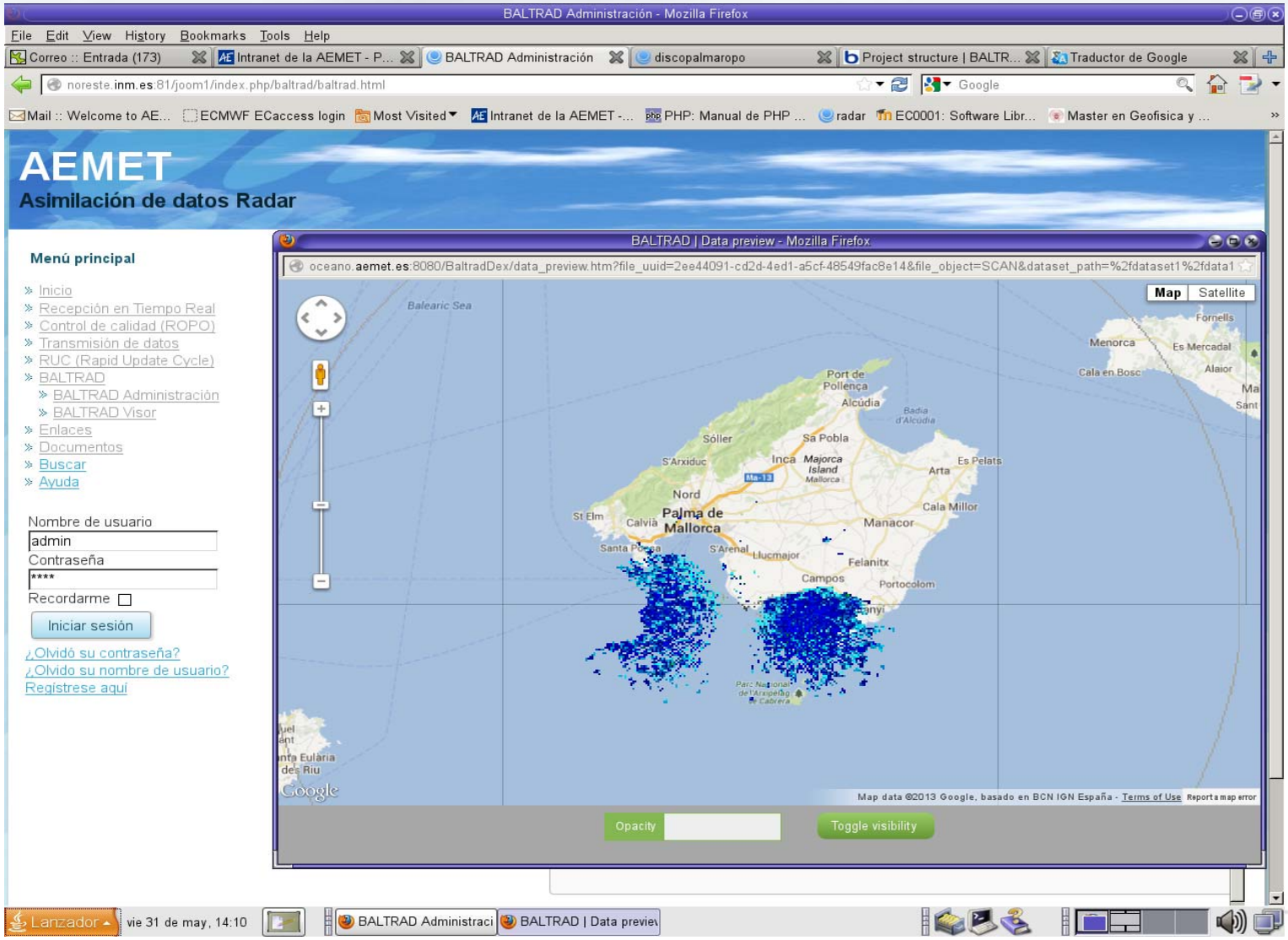
# 2nd Phase

## Viewer BALTRAD



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# 2nd Phase

**Quality improvement of radar data using BALTRAD QC ToolBox bROPO**

- Quality control in DA is very important. We have more to loose than to win
- **bROPO** comes in the git package but can also be installed as a stand-alone utility
- **bROPO** works with ODIM HDF5. We had to build a converter between two implementations of ODIM : BUFR and HDF5.
- **bROPO** has been updated several times, versions 1.0.0, 1.1.0 and 1.2.0
- **bROPO** applied to some AEMET radar data (Reflectivity) in real-time since 2013

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# 2nd Phase

**ROPO** filters and conversión tools (BUFR to HDF5, HDF5 to BUFR)

```
oceano:/opt/baltrad/1.2.0/bropo > tree
.
|-- bin
|   `-- ropo
|-- include
|   |-- fmi_image.h
|   |-- fmi_image_arith.h
|   |-- fmi_image_filter.h
|   |-- fmi_image_filter_line.h
|   |-- fmi_image_filter_morpho.h
|   |-- fmi_image_filter_speck.h
|   |-- fmi_image_filter_texture.h
|   |-- fmi_image_histogram.h
|   |-- fmi_image_restore.h
|   |-- fmi_meteosat.h
|   |-- fmi_radar_codes.h
|   |-- fmi_radar_image.h
|   |-- fmi_sunpos.h
|   |-- fmi_util.h
|   |-- rave_fmi_image.h
|   |-- rave_fmi_volume.h
|   |-- rave_ropo_generator.h
|   `-- ropo_hdf.h
|-- lib
|   `-- libbropo.so
`-- share
    `-- bropo
        |-- config
        |   `-- ropo_options.xml
        `-- pyropo
            |-- _fmiimage.so
            |-- _ropogenerator.so
            |-- ropo_quality_plugin.py
            |-- ropo_quality_plugin.pyc
            |-- ropo_realtime.py
            `-- ropo_realtime.pyc
```

```
-- bufr2hdf5
   |-- Makefile
   |-- Makefile.am
   |-- Makefile.in
   |-- Makefile.original
   |-- aemettemplatel2.h
   |-- bufr2hdf5
   |-- bufr2hdf5.c
   |-- bufr2hdf5.c.original
   |-- bufr2hdf5.o
   |-- build-antilles.c
   |-- build-compo-cumul.c
   |-- build-composite.c
   |-- build-cumul.c
   |-- build-local.c
   |-- build-odim-compo.c
   |-- build-odim-polar.c
   |-- build-odim-polar.o
   |-- build-polar.c
   |-- build-wrwp-OMM.c
   |-- build-wrwp.c
   |-- comp2hdf5.c
   |-- compo.h
   |-- decbufr
   |-- decbufr.c
   |-- decbufr.o
   |-- encbufr
   |-- encbufr.c
   |-- encbufr.o
   |-- hdf2bufr
   |-- hdf2bufr.c
   |-- hdf2bufr.c.original
   |-- hdf2bufr.c.v1
   |-- hdf2bufr.o
```

# 2nd Phase

**ROPO** filters and conversión tools (BUFR to HDF5, HDF5 to BUFR)

**$ ropo –i  radardata.h5 –o radardata-ropo.h5 –clutter -5,5**

**ROPO** working with data in hdf5 format. therefore it is necessary to convert **BUFR** to **HDF5** (Hierarchical Data Format).

There are two programs:

1. **'bufr2hdf5'** converts from the BUFR format to HDF5
2. **'hdf2bufr'** converts HDF5 to the BUFR format

**$ bufr2hdf5 –d /tablasbufr  datos1.bfr  datos1.hdf5**

The **B**inary **U**niversal **F**orm for the **R**epresentation of meteorological data (**BUFR**) is a binary data format and the meaning of data elements is determined by referring to a set of tables(with descriptors)

# 2nd Phase

## Results of radar data filtering, with ROPO

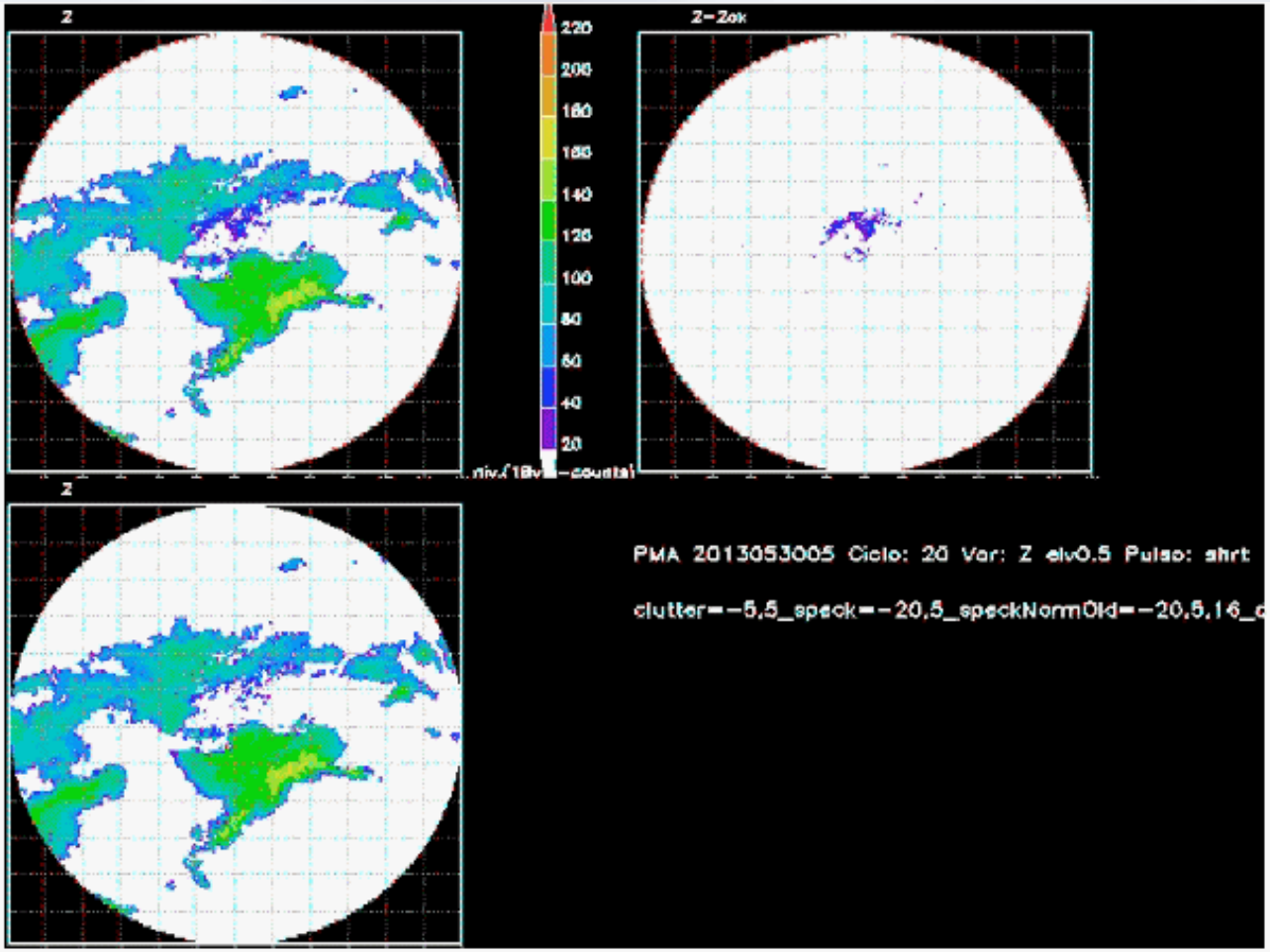
```
-o OUTFILE, --output=OUTFILE
                      Name of output file to write. If not given, input file
                      will be over-written.
--parameters=PARAMS   Which radar parameter to process. Defaults to DBZH,
                      but several can be comma-separated.
--highest-elev=ELEV   Data from elevation angles under this value will be
                      processed. Defaults to 2.0 degrees.
--separate-probabilities=SEPPROB
                      True or False. Denotes whether to accumulate all
                      detectors' probability fields into a maximum field, or
                      keep them separate. Defaults to False.
--threshold=THRESHOLD
                      dBZ threshold prior to processing. Defaults to -24
                      dBZ.
--restore-thresh=RESTORE_THRESH
                      Threshold raw value when applying probability
                      classification to remove anomalies. Defaults to 108.
--restore=RESTORE     Uses the anomaly probability field to delete anomalies
                      without filling holes. Defaults to True.
--restore-fill=RESTORE2
                      Uses the anomaly probability field to delete anomalies
                      AND fill in holes. Defaults to False.
--biomet=BIOMET       <dbz_max> <dbz_delta> <alt_max in meters> <alt_delta
                      in km> Remove insect band e.g. -10,5,5000,1
--clutter=CLUTTER     <MIN_DBZ> <max_incomp> Remove specks under
                      incompactness A, e.g. -5,5
--clutter2=CLUTTER2   <MIN_DBZ> <max_smooth> Remove specks under smoothness,
                      e.g. -5,60
--emitter=EMITTER     <MIN_DBZ> <LENGTH> Filter unity-width emitter lines,
                      e.g. 10,4
--emitter2=EMITTER2   <MIN_DBZ> <LENGTH in bins> <width in degrees> Filter
                      emitter lines e.g. -10,3,3.
--ship=SHIP           <min rel DBZ> <min A> Remove ships, e.g. 50,20
--softcut=SOFTCUT     <max_dbz> <r in km> <r2 in km> Remove insect band,
                      e.g. -10,250,100
--speck=SPECK         <MIN_DBZ> <max_a in pixels> Threshold by min dBz,
                      detect specks < A, e.g. -20,5
--speckNormOld=SPECKNORMOLD
                      <MIN_DBZ> <max_a> <max_n> Threshold by min dBz, then
                      detect specks, size A_max_range <=> size N*A A, e.g.
                      -20,5,16
--sun=SUN             <MIN_DBZ>  <min_length> <max_thickness> Remove sun,
                      e.g. -20,100,3
--sun2=SUN2           <MIN_DBZ>  <min_length> <max_thickness> <azimuth in
                      degrees> <elevation in degrees> Remove sun, e.g.
                      -20,100,3,45,2
--lookup=LOOKUP       Looks up which detectors to run, along with their
                      arguments, from XML file. Useful for automated
                      processing or just convenience. The NOD identifier of
                      the /what/source attribute is used as the look-up key.
                      If NOD doesn't exist, WMO is used to look up NOD. If
                      no look-up exists for that radar, a default set of
                      arguments is used. Using --lookup=True overrides all
                      other detector-specific arguments.
```

How should it be applied? is necessary to know how it affects the work of cleaning algorithms . ¿How work with the separate probabilities?

How work the clutter and the emitter ?, What exactly are the arguments that we pass?. Why does it seem that reverses the results of cleaning the clutter?

How work the speck and the speckNormhold?, What exactly are the arguments that we pass?

# 2nd Phase

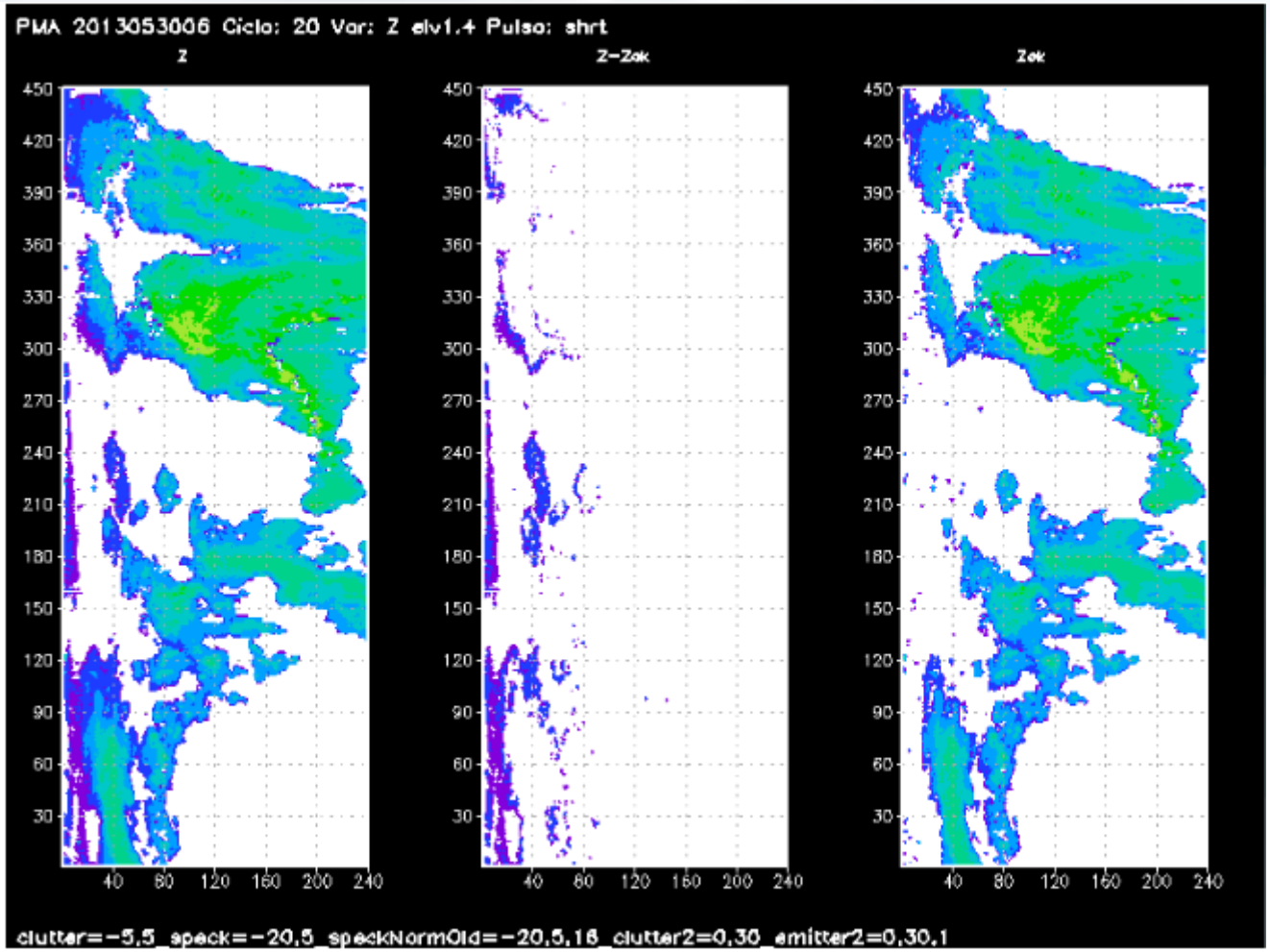



**Results of radar data filtering in real time, with ROPO**

Radar of Palma 30-05-2013.
**Left:** Polar Scan without filters. **Center:** Filtered data **Right:** Polar Scan with filters

# 2nd Phase

## ROPO filters




Ropo filters applied : clutter, speck, speckNormOld, emitter

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## Conclusions with BALTRAD QC ToolBox

- The number of different combinations with **bROPO** filters and corresponding thresholds is large.
- Results achieved are only partially satisfactory. Finding the optimum combination for all possible cases is difficult
- Currently the Ropo documentation is scarce, scattered and not very clear
- More work is necessary in this area

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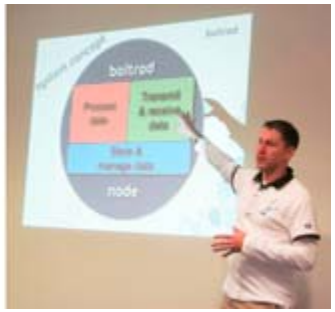
AEMet Agencia Estatal de Meteorología

- Participating in the Wokshop **BALTRAD+ User Forum IV in Berlín.**


- Installation of new versions of components in **BALTRAD node.**

- Installation and configuration of a new plugin for improving web monitoring (simple picture slideshow).

- Extension of the monitoring facility to include results from the radar data QC ToolBox **bROPO.**

- Documentation with guidelines for administration of the web portal and node BALTRAD.

# Conclusions:

- We succeeded in building a convenient web-based system for radar data monitoring

- We installed in AEMET a BALTRAD node for processing radar data, although not with all functionalities (radar exchange)

- We have thoroughly tested the performance of the bROPO QC tool

- All this work has been very useful for moving forwards in the assimilation of radar data in the HARMONIE NWP model

# Thanks for your attention