

# CIAO: the CNR-IMAA Atmospheric Observatory and its role in the European and global scenarios

Gelsomina Pappalardo

National Research Council of Italy- Institute of Methodologies for  
Environmental Analysis, Tito (Potenza), Italy

*[gelsomina.pappalardo@imaa.cnr.it](mailto:gelsomina.pappalardo@imaa.cnr.it)*

CIAO: CNR-IMAA Atmospheric Observatory, (40.60N, 15.72E, 760 m a.s.l.)

CIAO represents a well-established ground-based remote-sensing observatory for the study of weather and climate.

The observatory consists of a combination of advanced systems able to provide high quality long-term observations of aerosol and cloud properties.

Since 2000, systematic observations of aerosol, water vapour and clouds have been collected and the acquisition of new active and passive microwave profilers has strengthened the equipment required for performing accurate aerosol and cloud observations.

Currently, CIAO represents the largest ground-based remote-sensing station in the Mediterranean Basin and is one of the first atmospheric observatories in Europe.

The main scientific objective is the long-term measurement for the climatology of aerosol and cloud properties.

The observation strategy is mainly organized in order to provide quality assured measurements for satellite validation and model evaluation and to fully exploit the synergy and integration of the active and passive sensors for the improvement of the atmospheric profiling.

CIAO provides access to data, services and to the research facility for conducting measurements campaigns and instrument testing.

CIAO staff: 6 researchers + 3 technicians + 6 PhD students and post doc

The main research lines currently active at CIAO include:

- design and implementation of lidar systems for aerosol, water vapour and cloud measurements;
- development of algorithms for the integration of lidar and microwave radiometer measurements;
- definition of measurement protocols, quality assurance programmes and data managing strategies;
- definition of a suitable strategy for the satellite CAL/VAL;
- analysis of the physical and dynamical processes related to aerosol transport, their modification and classification;
- analysis and physical interpretation of observations provided by both active and passive sensors for the study of aerosol and cloud interactions and nucleation processes;
- organization and participation in measurement campaigns;
- development of methods for the evaluation of aerosol transport and mesoscale weather prediction models;
- networking.



Instruments	Contact person	Current state
Multi-wavelength Raman lidar	Giuseppe D'Amico	Operative
Transoprtable multi-wavelength Raman lidar	Aldo Amodeo	Operative
Water vapour Raman lidar	Aldo Amodeo	Operative until 2006
UV Raman lidar (24/7)	Giuseppe D'Amico	Operative from spring 2015
Sun photometer	Lucia Mona	Operative
Ka-band Doppler radar	Fabio Madonna	Operative
Ceilometers	Aldo Giunta	Operative
Microwave profiler	Fabio Madonna	Operative
Surface radiation station	Lucia Mona	Operative
GPS antenna/receiver	Fabio Madonna	Operative
Radiosounding systems	Fabio Madonna	Operative
Meteo station	Aldo Giunta	Operative
Allsky camera	Fabio Madonna, Francesco Amato	Operative



## ➤ *Networks*

- EARLINET (European Aerosol Research Lidar NETwork)
- AERONET (Aerosol Robotic Network)
- Cloudnet (Development of a European pilot network of stations for observing cloud profiles)

## ➤ *Current EC projects (FPVII) and HORIZON 2020*

- ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) 2011-2015
- ITARS (Marie Curie - Initial Training for Atmospheric Remote Sensing) 2012-2016
- BEYOND (Building Capacity for a Centre of Excellence for EO-based monitoring of Natural Disaster) 2013- 2016
- GAIA-CLIM (Gap Analysis for Integrated Atmospheric ECV CLimate Monitoring) 2015-2018
- ACTRIS-2 (Aerosols, Clouds, and Trace gases Research InfraStructure -2) 2015 - 2019
- ENVRIPLUS (Environmental Research Infrastructures Providing Shared Solutions for Science and Society) 2015 - 2019

## ➤ *Long term strategy for Research Infrastructures in ESFRI*

## ➤ *National and Regional projects*

## ➤ *CAL/VAL programs*

- CALIPSO (NASA-CNES)
- ESA: EC-ACTS: Earlinet and Cloudnet - Aerosol and Cloud Team for Sentinel-5 Precursor Validation
- ESA: ADM-Aeolus L2A aerosol and cloud product validation using the European Aerosol Research Lidar Network EARLINET

## ➤ *WMO*

- GAW - GALION (Global Atmosphere Watch - Lidar Observation Network)
- WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)
- GRUAN – The GCOS (Global Climate Observing System) Reference Upper Air Network



# Potenza EArlinet Raman Lidar (PEARL)

## LASER: ND:YAG (Continuum Powerlite Precision II 9050)

Max. pulse energy : 1200mJ @1064nm

600mJ @532nm

350mJ @355nm

Max. repetition rate 50Hz

Beam divergence 0.25 mrad

(beam expander 2X with remixing)

## RECEIVER: Cassegrain Telescope

Diameter of the primary mirror 0.5 m

Combined focal length 5 m

Nighttime field of view 1 mrad

Achromatic lens  $\varnothing=2"$ ,  $f=50\text{cm}$

## CHANNEL SELECTION

Interference filters (FI), bandwidth 0.5 nm

Polarizer beam splitter (BK7) a 532 nm (POL)

Dichroic mirrors (DM e HT)

Selection of high and low altitude channels

## ACQUISITION

Fotomultipliers (PMT) THORN EMI

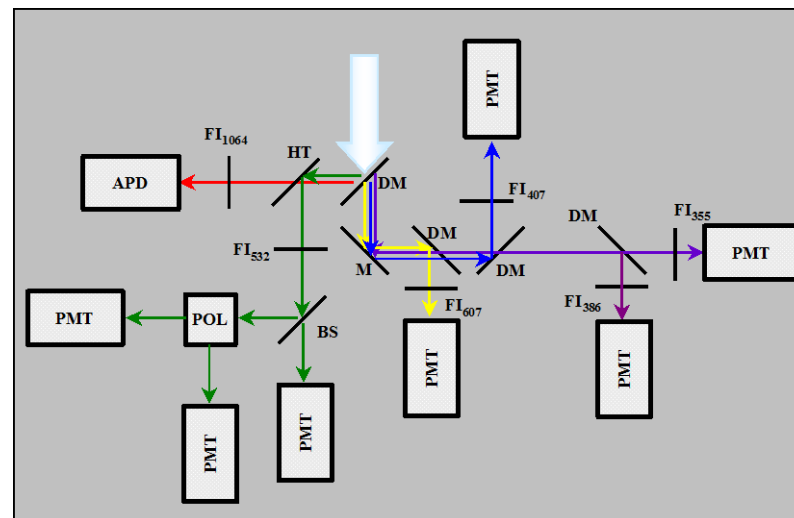
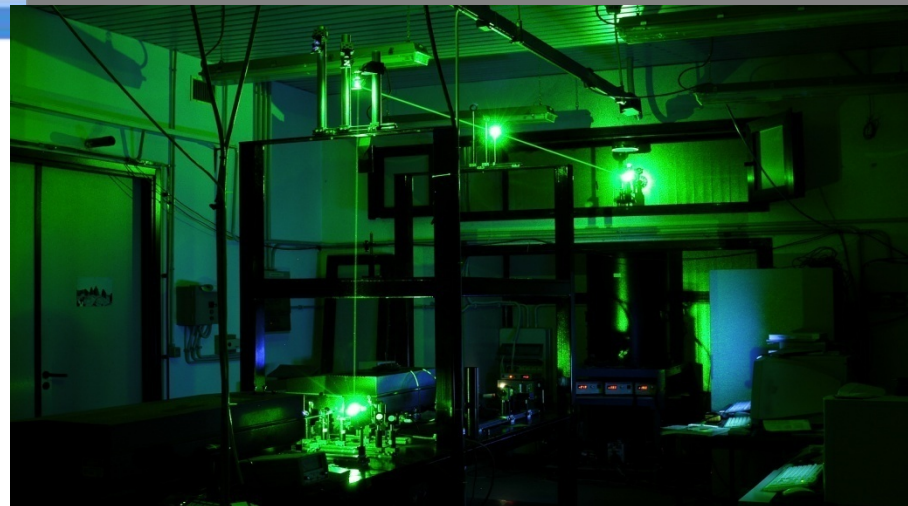
9202QA 532, 532 $\perp$ , 532 $\parallel$ , 607 nm

9893/350B 355, 386 nm

EG&G MCS - PCI (100ns min dwell time, 150MHz photon counting)

APD 1064 nm Licel Transient recorder (12bit 20 MHz analogic, 250 MHz photoncounting)

Operational since 2000 (upgrade in 2005 of a pre-existing lidar system)







# CNR-IMAA EARLINET Mobile Reference System



## LASER: ND:YAG (Continuum Surelite II-20)

Max. pulse energy : 550mJ @1064nm  
250mJ @532nm  
120mJ @355nm

Max. repetition rate 20Hz

Beam divergence 0.6 mrad

## RECEIVER: Cassegrain Telescope

Diameter of the primary mirror 0.3 m

Combined focal length 950 mm

Nighttime field of view 1 mrad

Achromatic lens  $\varnothing=9\text{mm}$ ,  $f=100\text{mm}$

## CHANNEL SELECTION

Interference filters (FI), bandwidth 0.5 nm

Polarizer beam splitter (BK7) at 532 nm (POL)

Dichroic mirrors (DM e HT)

## ACQUISITION

Fotomultipliers (PMT), Hamamatsu

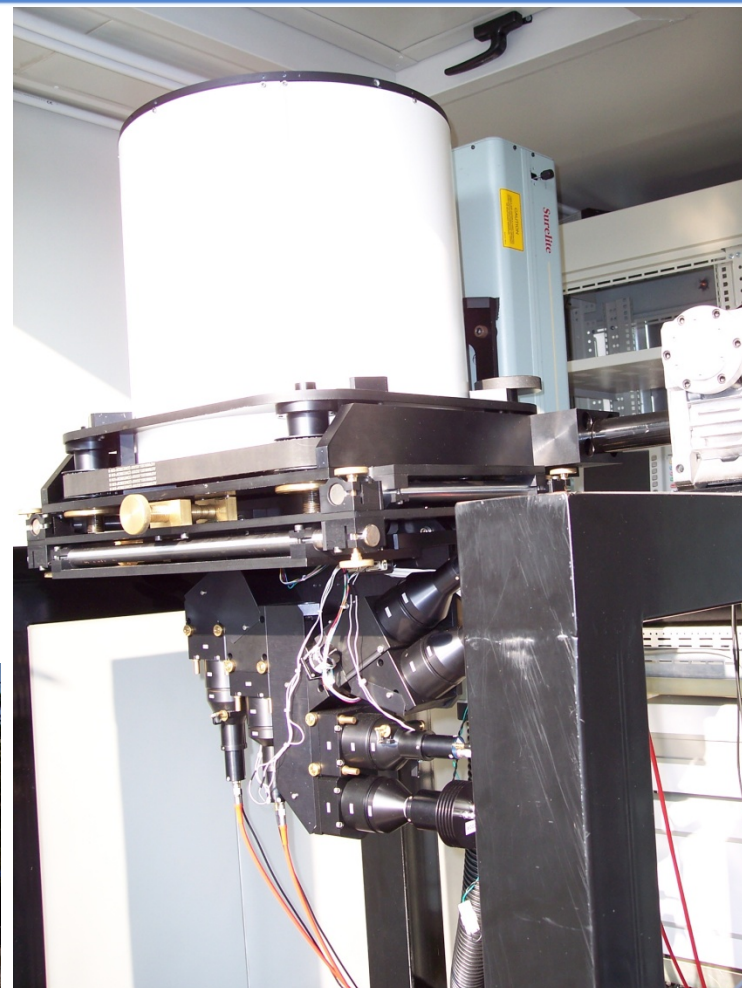
R7400P-06 355, 387, 532 $\perp$ , 532 $\parallel$  nm

R7400U-20 607nm

APD 1064nm

Licel Transient recorder (12bit 40 MHz analogic, 250 MHz photoncounting)

Operational since April 2009





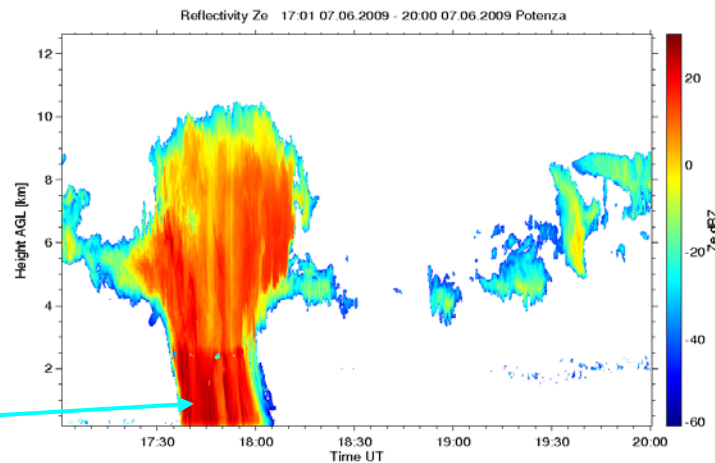
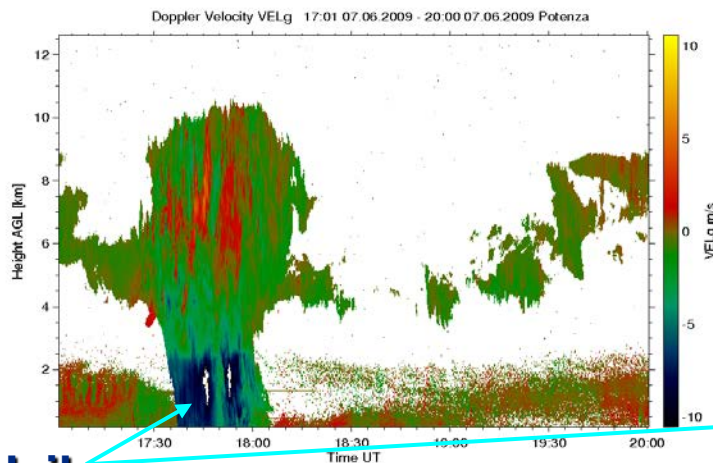


# MIRA 36 GHz doppler radar



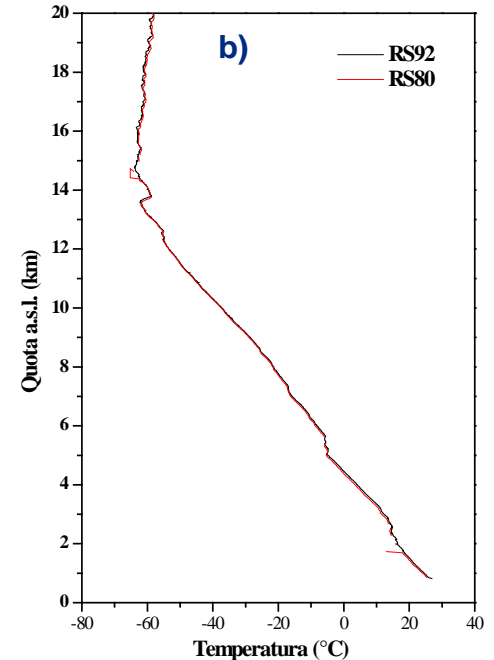
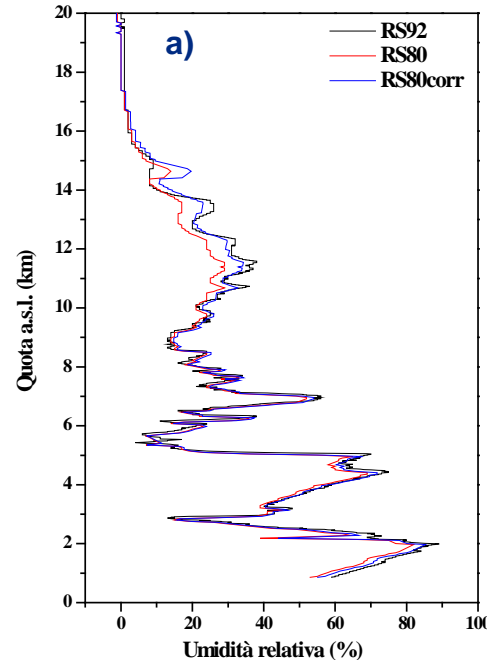
- Vertically pointing (ground based, scanning unit)
- Ka- Band 35.5 GHz  $\Leftrightarrow$  8.6 mm
- Magnetron based, 30 kW Pulse Power
- Range resolution 30 m (w.o. pulse comp.)
- Dual polarization receiver
- - 45 dBZ @ 10 km and 10 s Averaging
- PRF = 5 kHz  $\Leftrightarrow$  +/- 11 m/s

**Operational since February 2009**



**Hail**

- AS 13 Autosonde system (October 2004)
- MW 21 manual system (July 2004)
- PP15 manual system (January 1994)



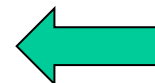
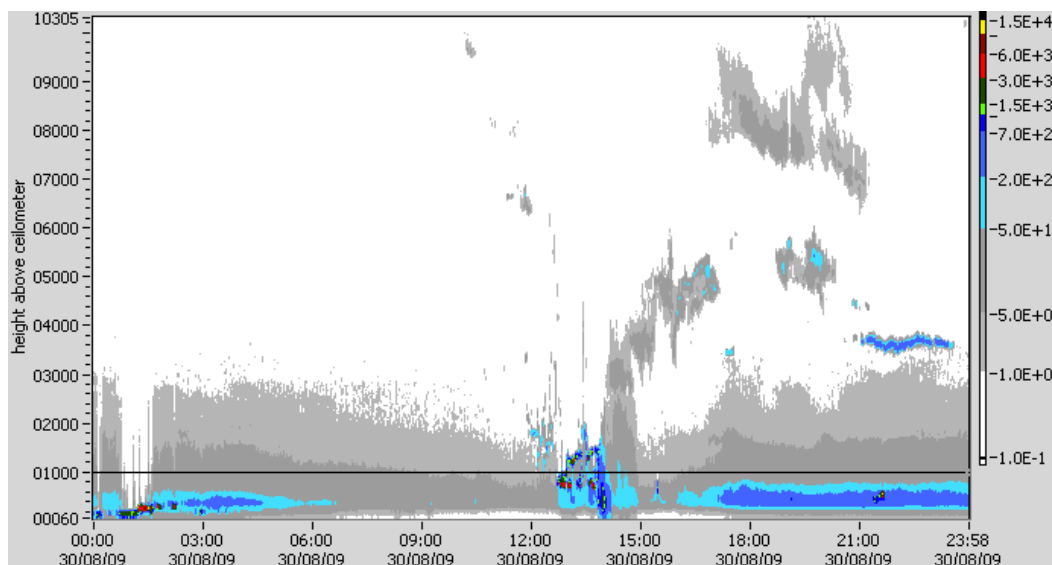
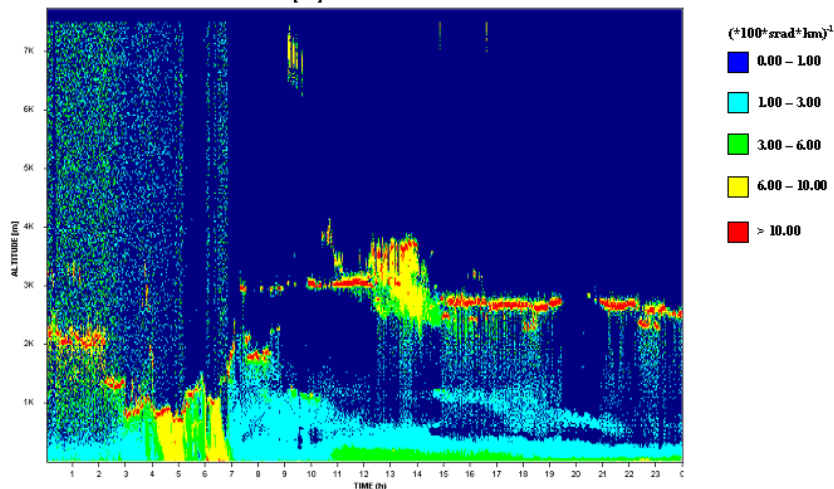


# Ceilometers



**CT25K 905 nm ceilometer**  
Operational since August 2004

C.N.R. - I.M.A.A.  
TITO SCALO (40.60N, 15.72E, 760 masl)  
Backscattering coefficient 12/10/2005 00:00 - 24:00 GMT  
Altitude [m] above lidar station



**CHM15K 1064 nm ceilometer**  
Operational since July 2009



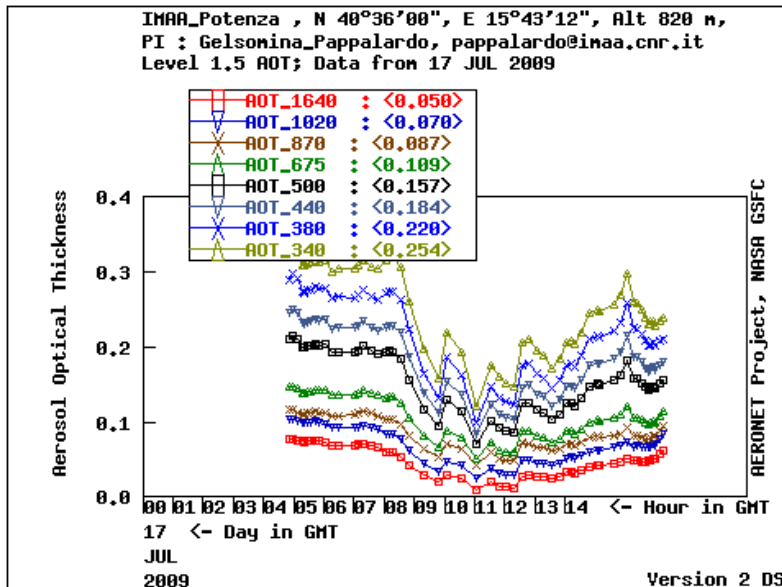


**Operational since November 2004.**

## Specifications

- Multi-channel sun photometer operating at 340, 380, 440, 675, 870, 1020, 1640 nm
- Optical head with 2 collimators
- FOV: Solar collimator: 1.2°  
Sky collimator: 1.2°
- Bandwidth: 10 nm at full width at half maximum
- Detector: UV enhanced silicon detector for the sun radiance
- Silicon detector for the sky radiance
- Automatic operations and fully autonomous (power supply from solar panels)

The sun photometer is operating within AERONET network and the measured radiances are processed at the NASA GSFC. All the data are available at <http://aeronet.gsfc.nasa.gov>



## Main AERONET products (quality assured lv2.0)

1. Aerosol optical depth at 340, 380, 440, 500, 675, 870, 1020, 1640 nm
2. 870-440 nm Ångström coefficient
3. Integrated water vapour
4. Single scattering albedo
5. Refractive index
6. Size distribution

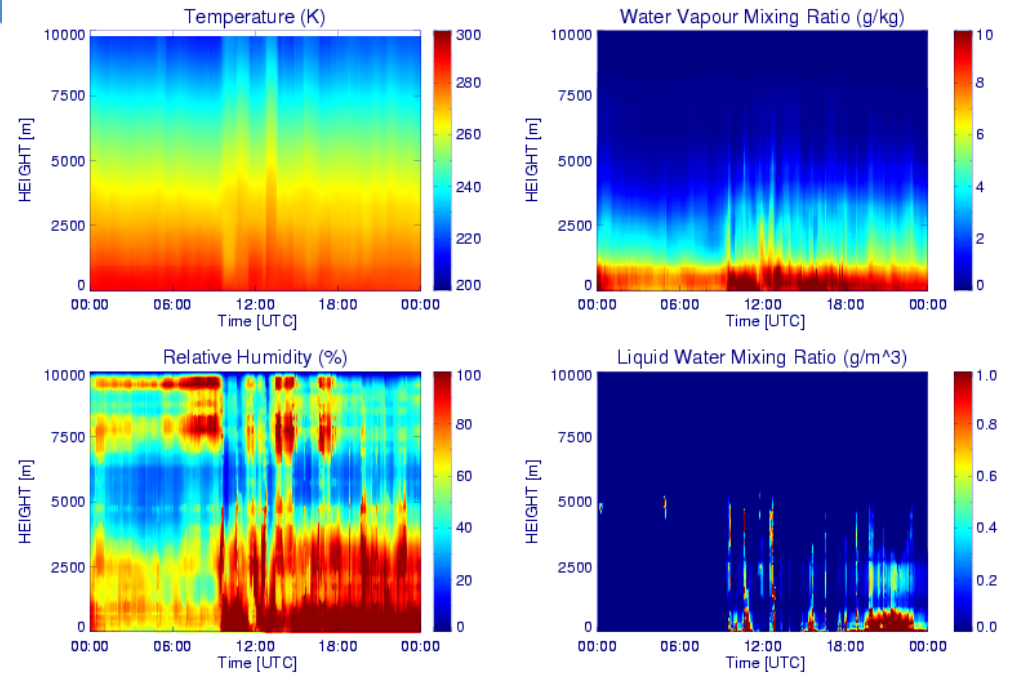




# MP3014 Microwave profiler



K-band channels = 22.235,  
23.0335,  
23.835, 26.235, 30 GHz  
V-band channels = 51.250, 52.280,  
53.850, 54.940, 56.660, 57.290,  
58.800 GHz  
Rate: > 12 s  
Accuracy: 0.5 K  
Resolution: 0.25 K



## Output products (Neural network retrieval)

Temperature, water vapour, relative humidity and cloud liquid water profiles up to 10 km above the ground

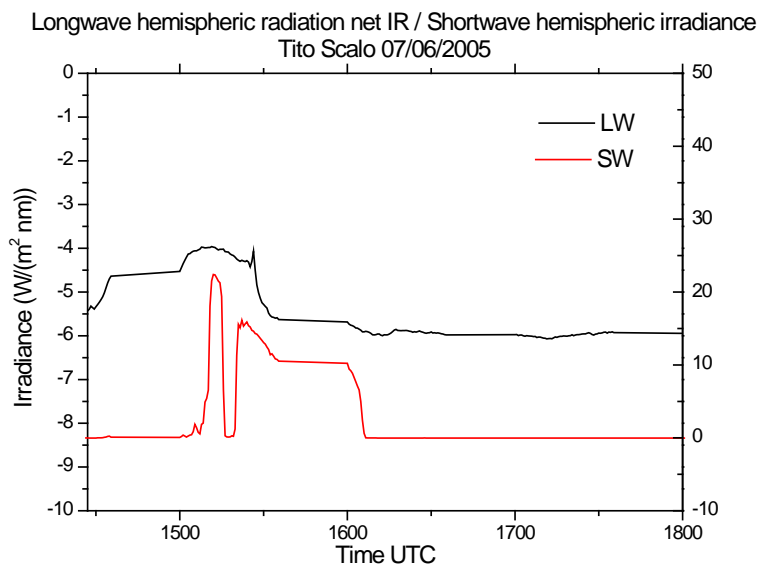
Operational since February 2004

Automatic surface radiation station. The station is designed according to the BSRN requirements and it is equipped with the following sensors:

Instrument	Spectral Range	Sensitivity
Pyrheliometer CH1	200 - 4000 nm (50 % points)	11 $\mu\text{V/W/ m}^2$
Pyrgeometer CG4	4.5 - 42 $\mu\text{m}$	10 $\mu\text{V/W/ m}^2$
2 Pyranometer CM22	200 - 3600 nm (50% points)	10 $\mu\text{V/W/m}^2$

The sensors are automatically managed by a sun tracker.

Operational since May 2005.

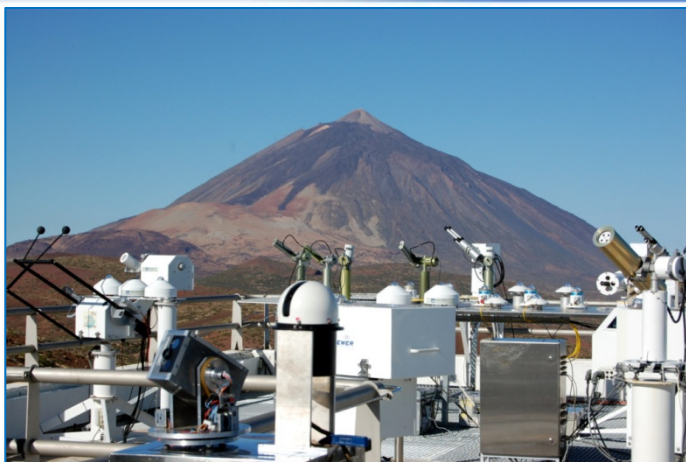




## **Sustainable research infrastructure network of coordinated long-term atmospheric observations in Europe**

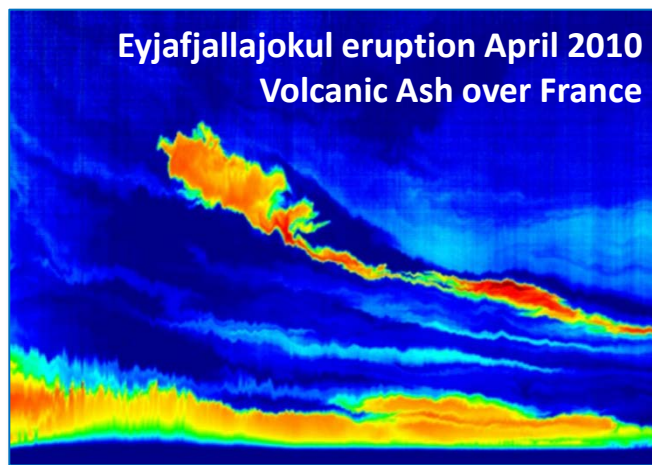
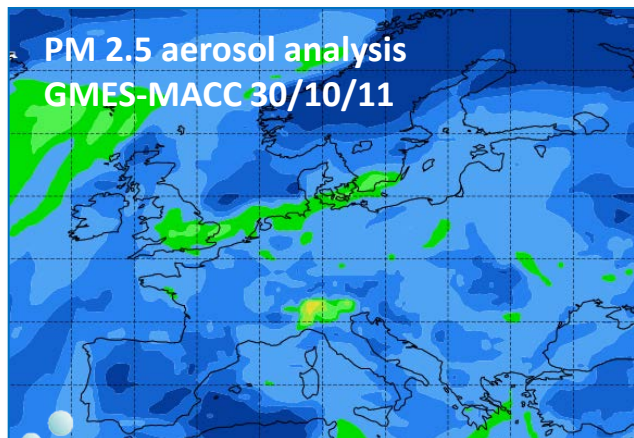
- ❖ **High-quality data relevant to climate and air quality research on the regional scale**
- ❖ **Centralised data centre**
- ❖ **Access to world-class research infrastructures and advanced instrumentation**
- ❖ **Training of researchers and young scientists**
- ❖ **New technologies and integration tools for ground-based observations of relevant atmospheric parameters**





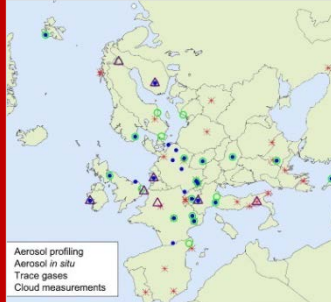
**Long-term observations of key atmospheric parameters and environmental assessments related to climate, air quality, and long-range transport**

**Direct observation of atmospheric hazards: forest fires, dust storms and volcanic eruptions**



**Improved regional forecasts of both weather and air quality**

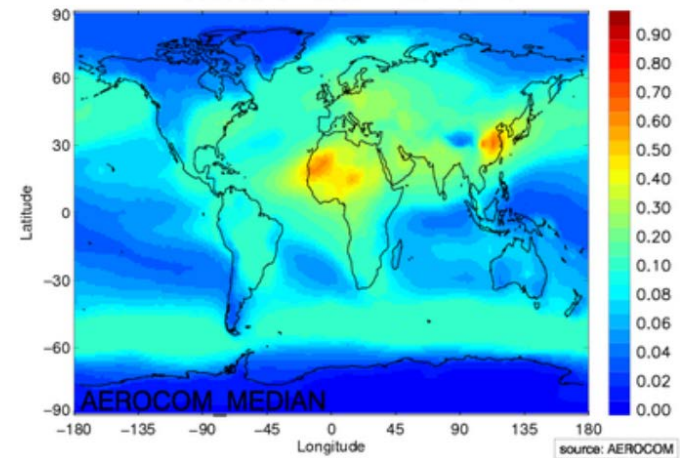
## Ground-based OBSERVATIONS



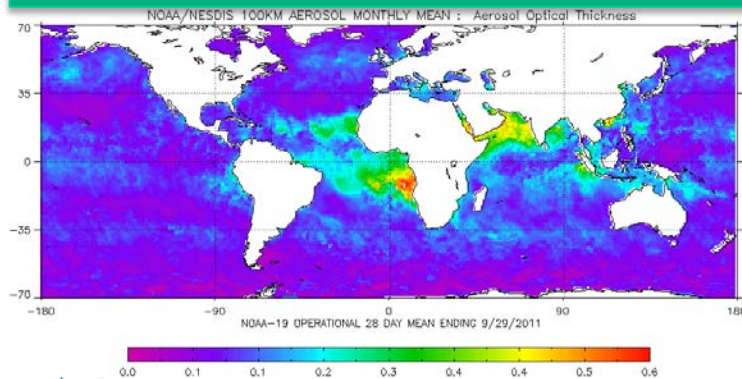
- Aerosol in-situ and profiling
- Clouds profiling
- Trace gases NO<sub>x</sub>y and VOC

## MODELLING

OD550\_AER 2000 mean 0.112



## SATELLITE



**Model evaluation**  
**Data assimilation**  
**Satellite validation**

**Harmonized measurements  
of physical, chemical and  
optical aerosol properties**

**CREATE  
FP5 -  
EUSAAR  
FP6**

**Long-range transport**

**Advanced laser remote  
sensing for 4-D  
spatio-temporal  
distribution of  
aerosols**

**Air Quality &  
Health**

**Measurement of  
atmospheric precursor  
compounds**

**Radiative Forcing**

**Observation of  
vertical profiles of  
important cloud  
parameters**

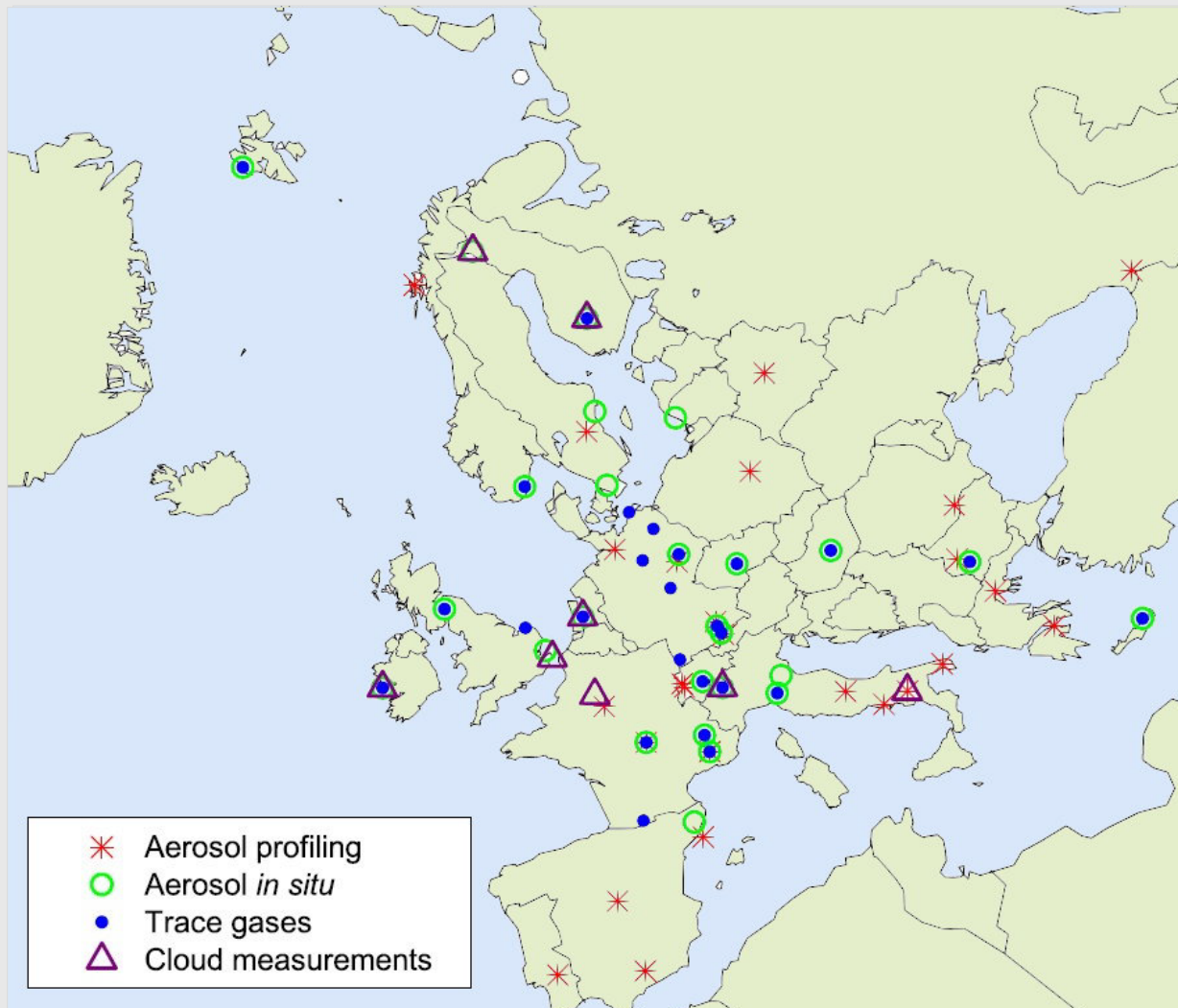
**CLOUDNET  
FP5**

**EARLINET  
FP5+6**

**APRIORI**







- ✓ Ground-based component of global Earth Observation System
- ✓ Provision of advanced data products and services
- ✓ Response to user needs (AEROCOM, COPERNICUS, ECMWF, research, policy-driven networks, natural hazards)
- ✓ Support policy issues on climate change, air quality, and health

**ACTRIS is a network of networks / Federation of existing networks**

**Each network operates with a rigorous QA program for both instrument and data processing**

**Observation strategy**

**Standardization of data and metadata**

**Integration is the added value**

- at instrument level: exploiting the synergies among different sensors and providing integrated advanced products**
- at data base level: providing open access to a central data portal**





**Opportunities for world-class research and international collaboration at its unique infrastructures and advanced instrumentation**

**Training of researchers and young scientists to become future leaders in the field and promote scientific excellence in less-favoured regions in Europe**

**New technologies and algorithms for monitoring activities relevant for climate and air quality models, satellite retrievals, and forecast systems.**



# ACTRIS sites offering Trans National Access



<b>AMO</b>	Auchencorth Moss	Penicuik, United Kingdom
<b>CESAR</b>	Cabauw Experimental Site for Atmospheric Research	Lopik, The Netherlands
<b>CIAO</b>	CNR-IMAA Atmospheric Observatory	Potenza, Italy
<b>FKL</b>	Finokalia	Crete, Greece
<b>HPB</b>	Hohenpeissenberg Meteorological Observatory	Hohenpeissenberg, Germany
<b>JFJ</b>	High Altitude Research Station Jungfrauoch	Switzerland
<b>MAIDO</b>	Observatory of Atmospheric Physics of Reunion Island - Maïdo Station	Reunion Island, France (at 20°60'S, 55°30'E)
<b>MHD</b>	Mace Head Atmospheric Research Station	Carna, Ireland
<b>PAL</b>	SIRTA Atmospheric Observatory	Palaiseau, France
<b>SMR</b>	Station for Measuring Forest Ecosystem-Atmosphere Relations - SMEAR II	Hyytiälä, Finland
<b>RADO</b>	Romanian Atmospheric research 3D Observatory	Magurele, Romania

Opportunity for field campaigns, specific observations, training

*Info how to apply at [www.actris.eu](http://www.actris.eu)*





# ACTRIS-2 (2015-2019)



**WP1/  
NA1**

*Management of the project, including management of TNA*

**WP6/  
TNA1**

*Lidar Calibration Centre (LiCal)*

**WP11/  
JRA1**

*Improving the accuracy of aerosol light absorption determinations*

**WP2/  
NA2**

*Profiling of aerosols and clouds*

**WP7/  
TNA2**

*AERONET-Europe Calibration Centre*

**WP12/  
JRA2**

*The surface exchange and vertical transport of aerosols*

**WP3/  
NA3**

*Near-surface measurements of aerosols, clouds and trace gases*

**WP8/  
TNA3**

*European Centre for Aerosol Calibration (ECAC)*

**WP13/  
JRA2**

*Model evaluation, assimilation and trend studies*

**WP4/  
NA4**

*ACTRIS Innovation Platform*

**WP9/  
TNA4**

*Physical access to advanced ACTRIS stations*

**WP5/  
NA5**

*ACTRIS-2 training, outreach and sustainability actions*

**WP10/  
VA1**

*ACTRIS Data Centre*



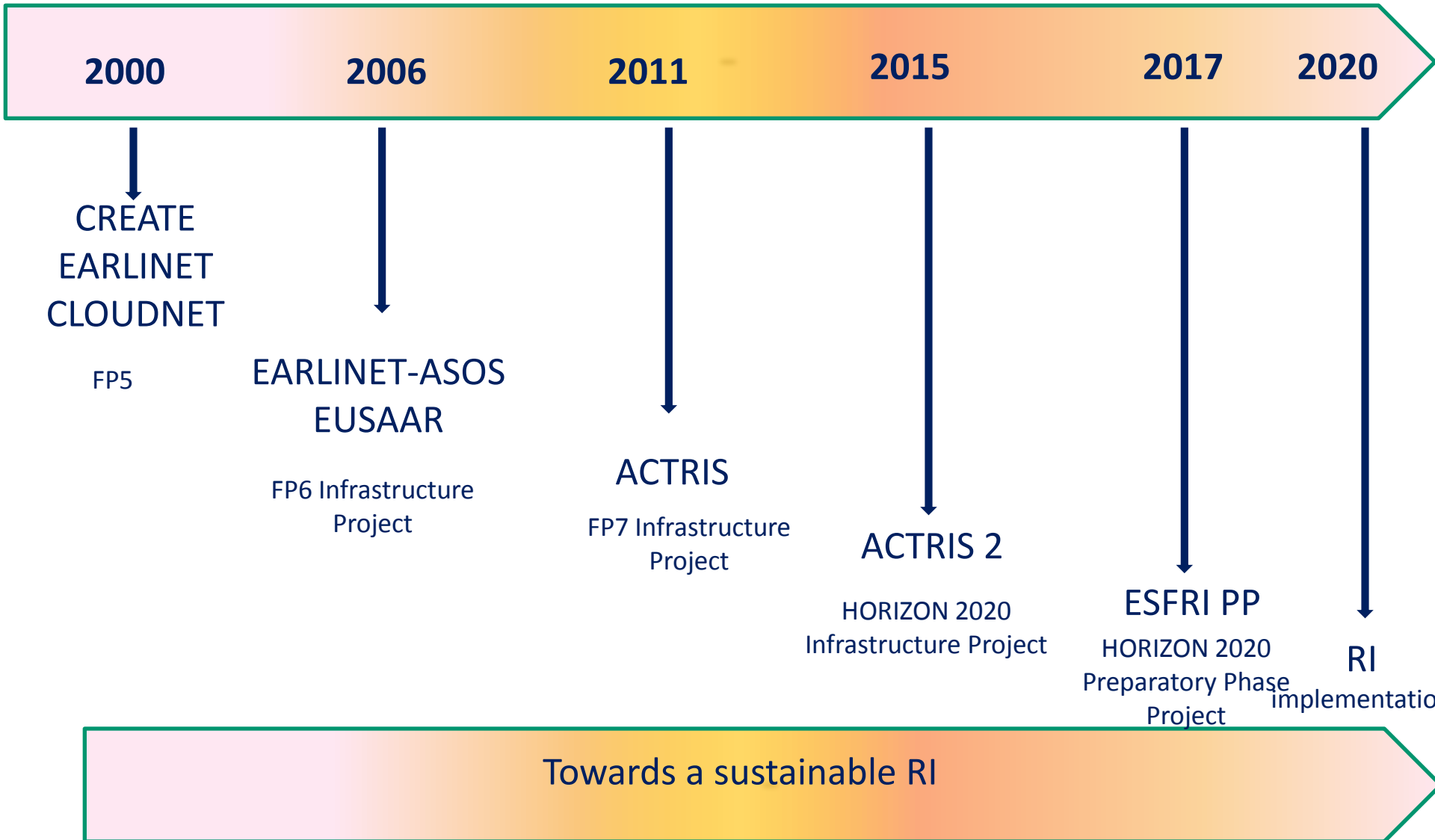


## CNR-IMAA

- coordinates the project
- handles the EARLINET database
- handles the EARLINET Single CalculusChain
- contributes to the Lidar Calibration Central Facility (Italy, Romania, Germany)
- contributes to the development of advanced data products for satellite cal/val and for model evaluation and data assimilation
- provides access to CIAO
- contributes to the activity “Profiling of aerosols and clouds”
- coordinates the cooperation with industry

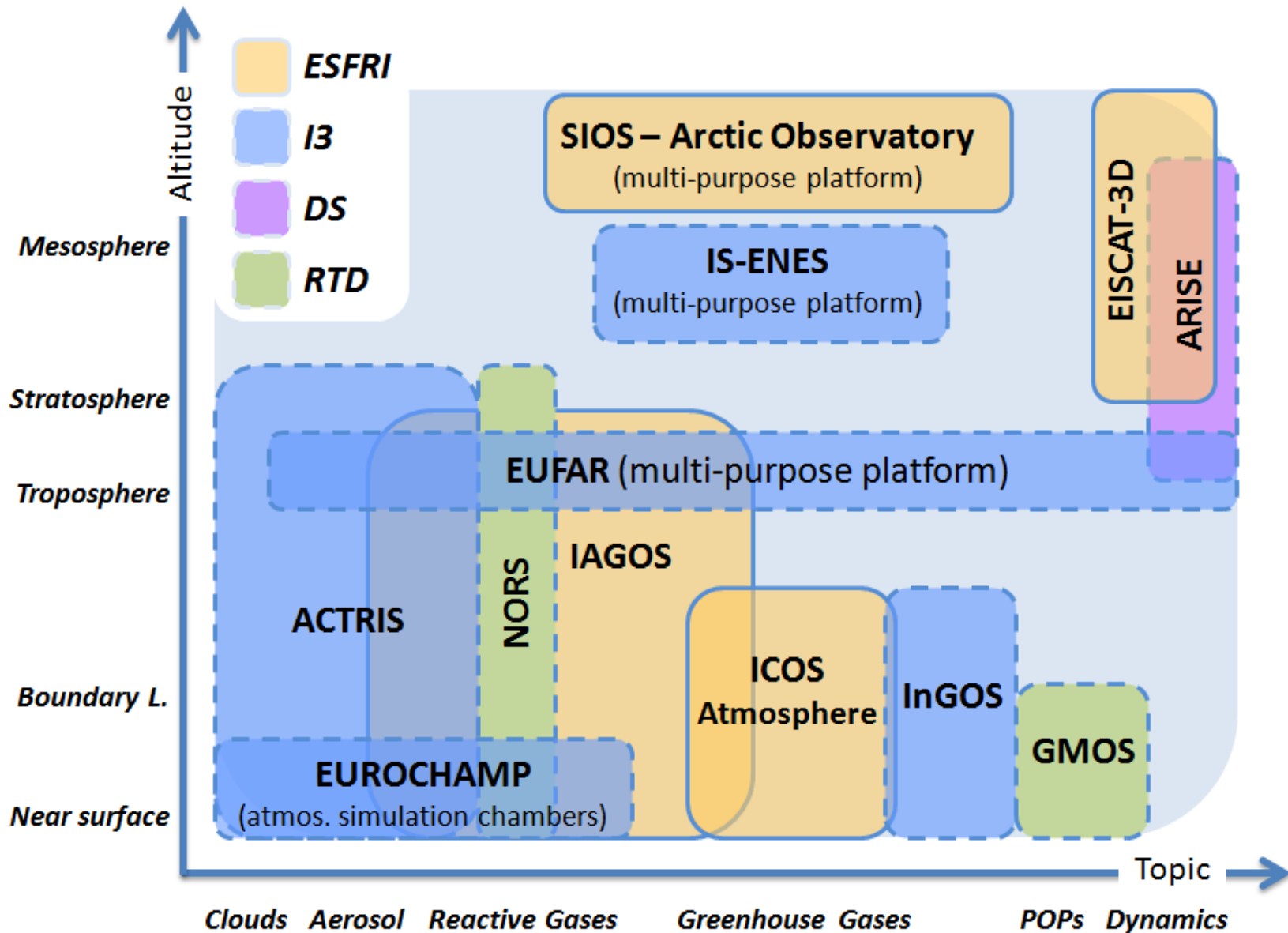


# Long term strategy



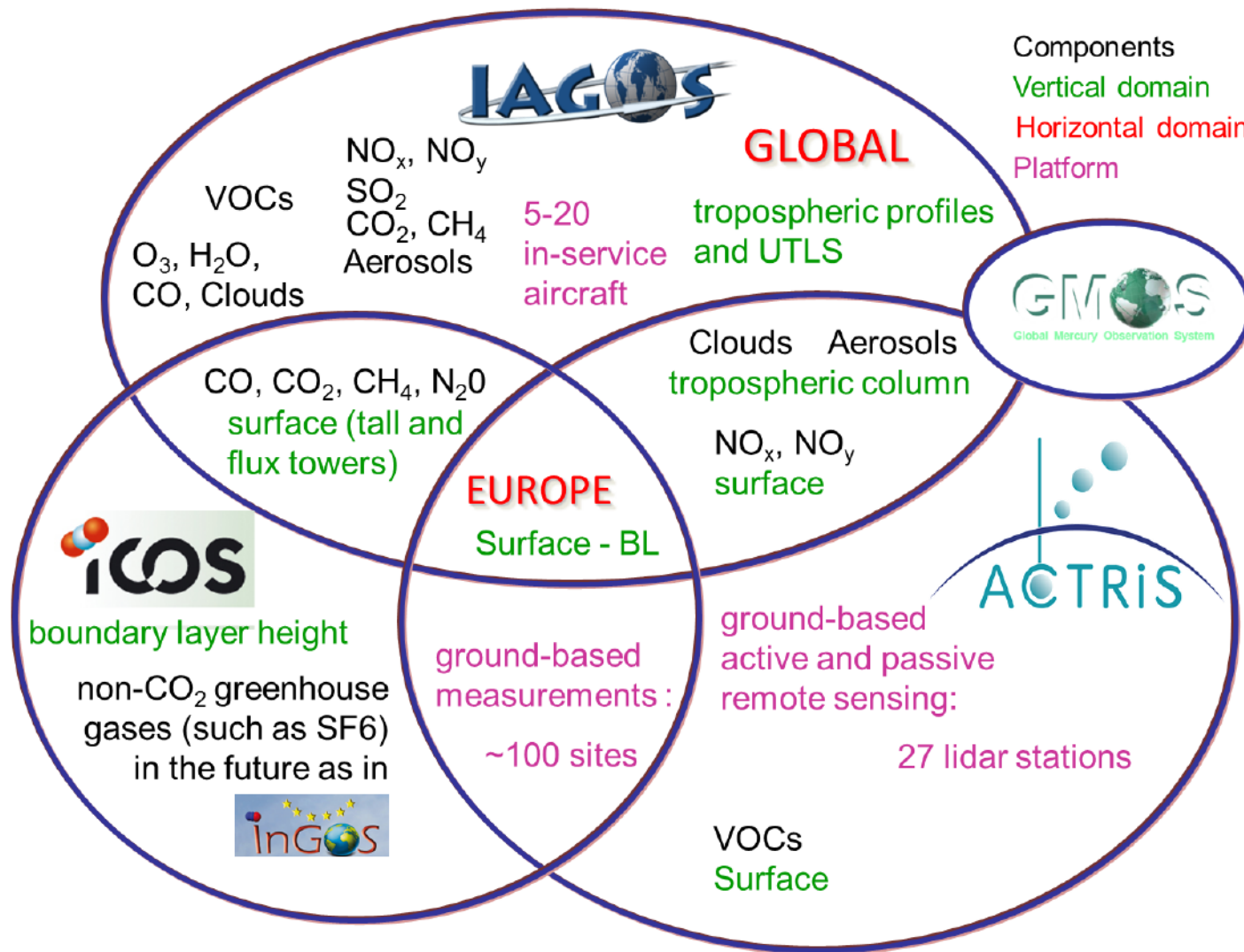


# The atmospheric subdomain RI landscape



# The Atmospheric Subdomain Landscape

## Atmospheric Composition





Satellites

Buoy

Radio  
Sondes

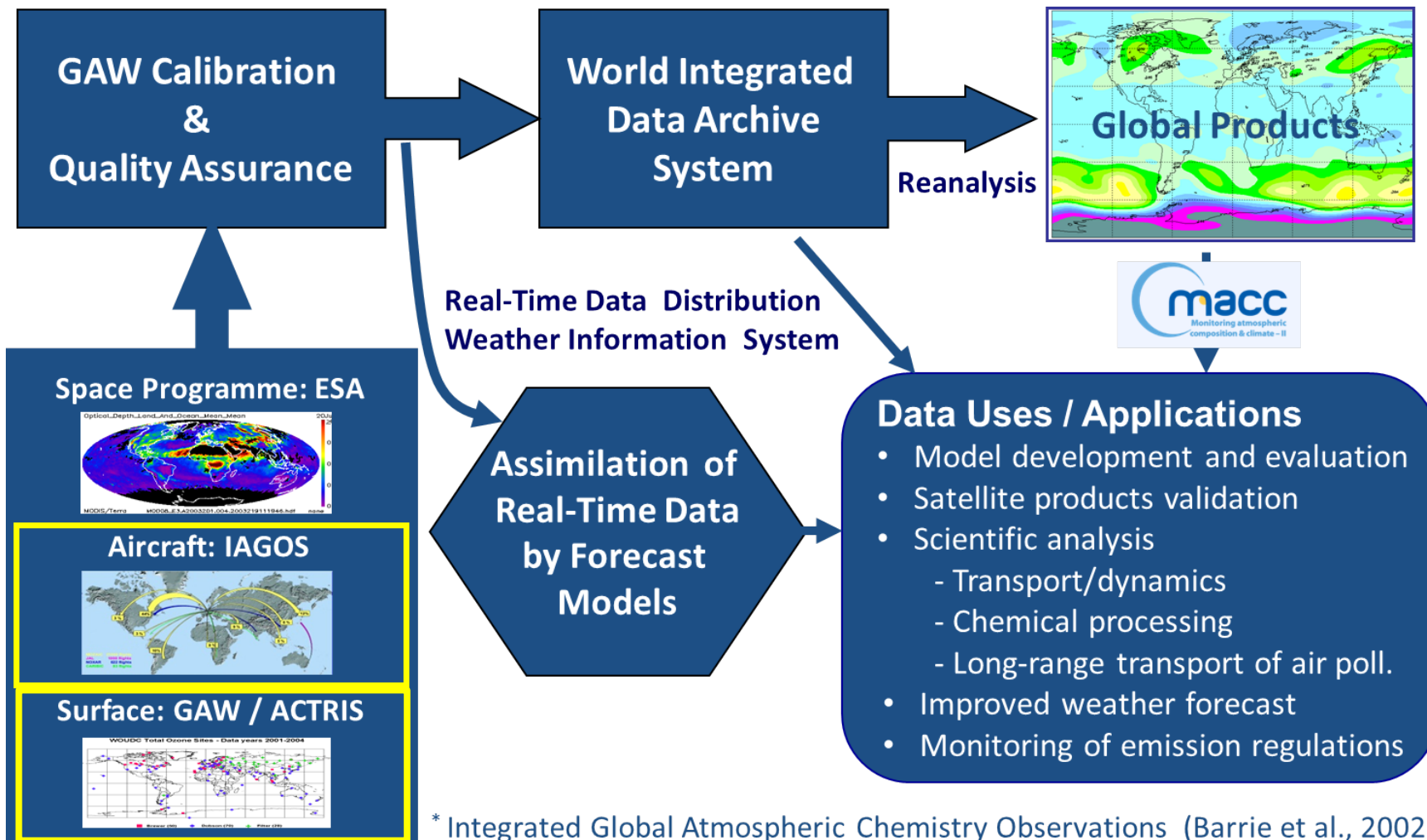
## The European Way Towards an Integrated Observing System for the Atmosphere



To develop synergies between

- existing programs and projects in the atmospheric field
- atmospheric research infrastructures (RIs)





\* Integrated Global Atmospheric Chemistry Observations (Barrie et al., 2002)