



ICOS improved sensors, network and interoperability for GMES

## ICOS - greenhouse gas observations for GEO and Copernicus

ICOS-INWIRE

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Bremen



# Improving data quality and availability from ICOS stations to users

## Objectives:

- to enhance capabilities of the ICOS infrastructure for GHG monitoring,
- to meet needs of operational users in Copernicus.

## Approach:

1. Developing and testing autonomous, robust, low-maintenance stations and sensor systems for GHG concentration and fluxes.
2. Enhancing the portfolio of data processing tools and algorithms: quality NRT data, rapid TCCON, BLH from lidar, and eddy-covariance GHG fluxes
3. Developing integrated, rapid delivery data products for satellite cal/val needs
4. Improving inter-operability with other networks (standardization of protocols, metadata definition, discoverability)

## Outcome after the project life

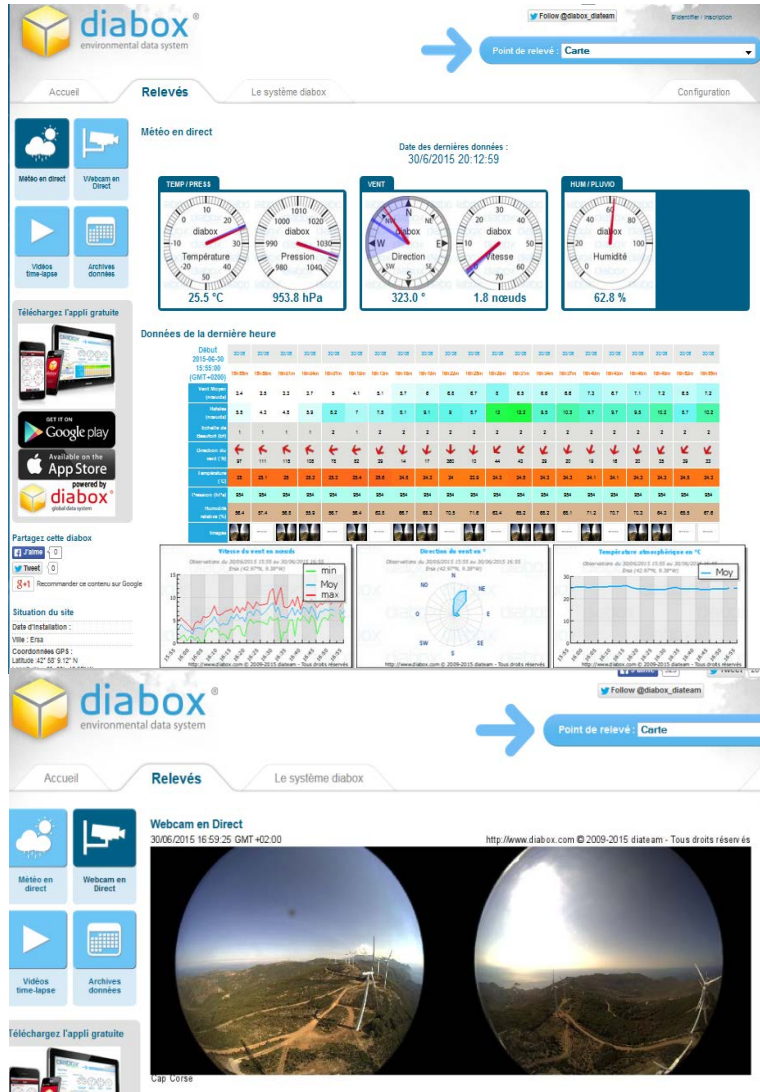
- More NRT data to Copernicus and cal/val support capability
- Less gaps in data due to robust, autonomous sensor systems
- Improved algorithms for ICOS, interoperable data and integrated datasets for users.







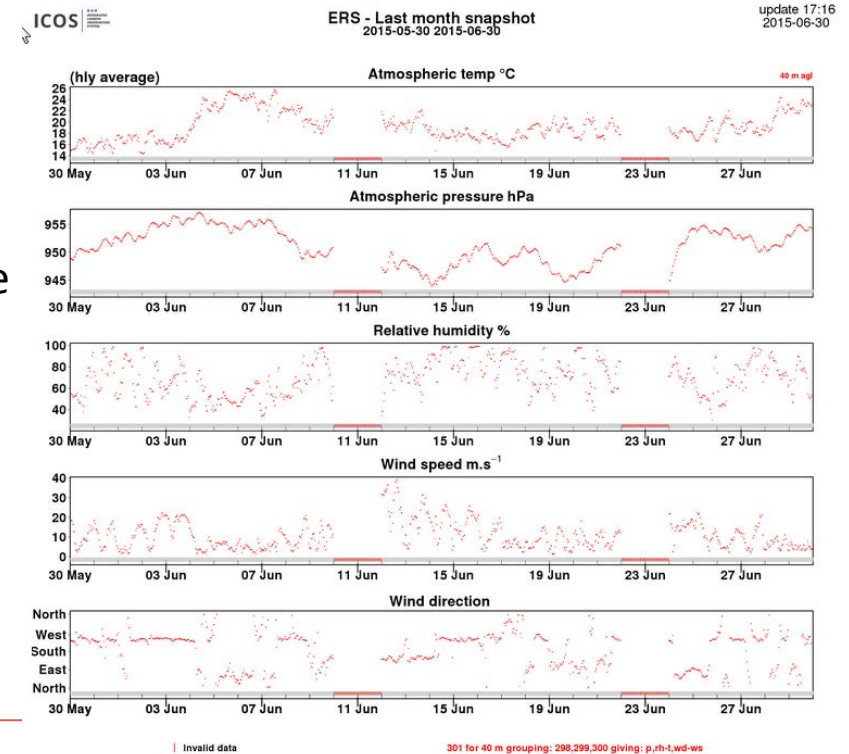
# Robust, integrated data transmission for remote sites



The information collected by the DIABOX (meteorological parameters, webcams) is available in near-real time on a web page  
Next step: all analysers interfaced




Interfaced to ICOS database



- Provide recommendations and manuals for users.
- Collaborative effort (cf. WEBOBS)
- Strong interest from manufacturers

Improvement and Failure Form

Feedback on Picarro experience  
Failures and Improvement:  
**Internal electric connectors**



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LSCE - 17/10/2014

cea CNRS Institut Pierre Simon Laplace

Improvement and Failure Form

...ates all details as much as possible (photos, references...)

...nd is slightly above the room temperature. It seems the Peltier

...n't solve the problem

...echecked on the Peltier power supply cable: (see picture below), it

...istance of the Peltier is below 10 ohms.

...the position of the resistor  
...edance measure can be very high



Improvement and Failure Form

...maly below

...n

...OPE (Andra)

...m Box present a weak connection that interfere on

...The aim of this document is to explain in detail where the

...advice to avoid this problem.

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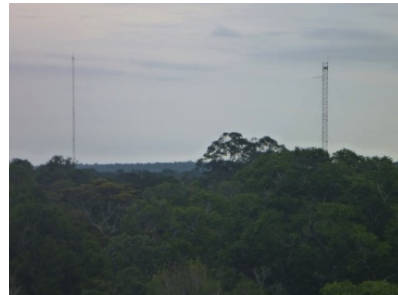
- Effect of high and variable water vapour concentration on the built-in correction to dry mole fractions
- Efficiency of Nafion dryers and functionality in combination with (dry) calibration gases
- Instrument set up and performance under high particle load (dusty environments)
- Instrument performance on mobile platform with induced vibrations and movements



# Field tests from Arctic to tropics & deserts



Norunda, Sweden



Amazonian Tall Tower Observatory (ATTO), Brazil



Las Majadas, Spain



R/V Meteor



Hyytiälä, Finland



Tropical sites Lamto (Ivory Coast) & French Guyana



Namib Desert Atmospheric Observatory (NDAO), Namibia



## CIMO arrangements

### Proposal for a WMO standard on Eddy Covariance,

First draft July 2015.

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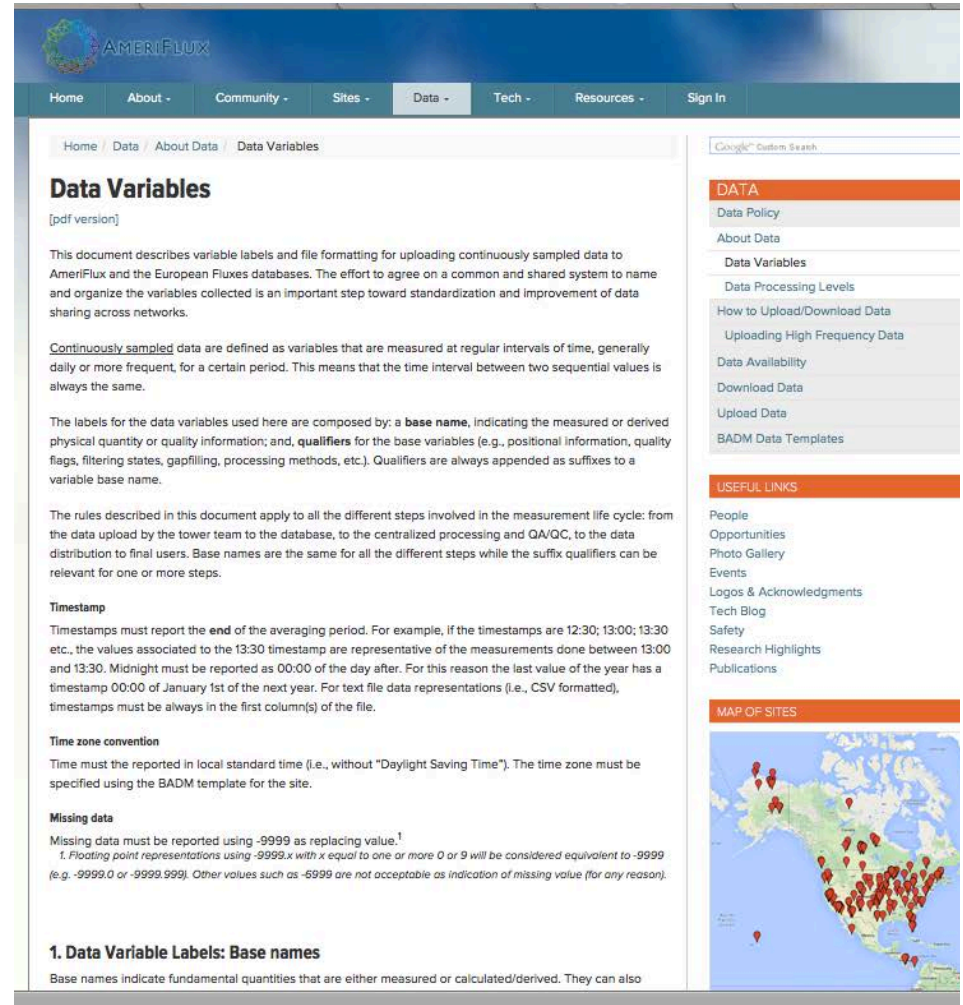
#### Background

The exchange of momentum, heat, water vapor, CO<sub>2</sub> and other scalars between the earth's surface and the atmosphere is mainly governed by turbulent transport. Buoyancy forces as well as shear stresses form turbulent motions for most of the day. *The eddy-covariance* (EC) technique directly measures these properties turbulent motions at the same time measuring the scalars (CO<sub>2</sub>, H<sub>2</sub>O, Temperature, CH<sub>4</sub>, etc.) being transported by these motions. This makes it the least invasive method currently available for direct, real-time, and continuous observations of the net scalar surface-air exchange, i.e., net ecosystem exchanges, net fluxes.

The technique was first developed in the 1960's and reached maturity through field campaigns in the middle 1990's. Towards the end of the 1990's, a series of long term monitoring stations was established world-wide, some of which have been operating continuously and have a record of almost 20 years. First coordinated by continental networks such Ameriflux (Baldocchi et al., 2002) and Euroflux (Valentini et al., 2000) in the 90s and later by a suite of regional networks worldwide, now a the volunteer network has developed. This research community has initiated algorithm comparisons, later multi site comparisons (i.e. Fluxnet Activities, [www.fluxnet.org](http://www.fluxnet.org)). Currently, there are over 400 sites globally under various continental scale organizations that have a mandate for sustained long term observations: Asiaflux, Chinaflux, ICOS, NEON Ameriflux. This calls for the establishment of a global standard that can be adopted and sustained by these collective organizations and their associated governance structures. Several textbooks or advanced textbooks exist that describe the technique (e.g. Aubinet et al., 2012).

#### Site selection

While there are no uniformly accepted criteria, a general guideline to site a tower is to have adequate fetch to measure the ecosystem scale flux among the expected environmental conditions, that is, 80% contribution by the representative ecosystem with the design goal of 90% contribution (Munger et al., 2012). Footprint (see ...) and directional analyses, topography, and vegetative mapping can be used in to diagnose data quality and fetch. For eddy covariance measurements to take place in the equilibrium layer the tower shall be high enough to place the sensors at top layer well above the surrounding plant canopy in the well mixed surface layer, but not so high that the footprint during stable night time

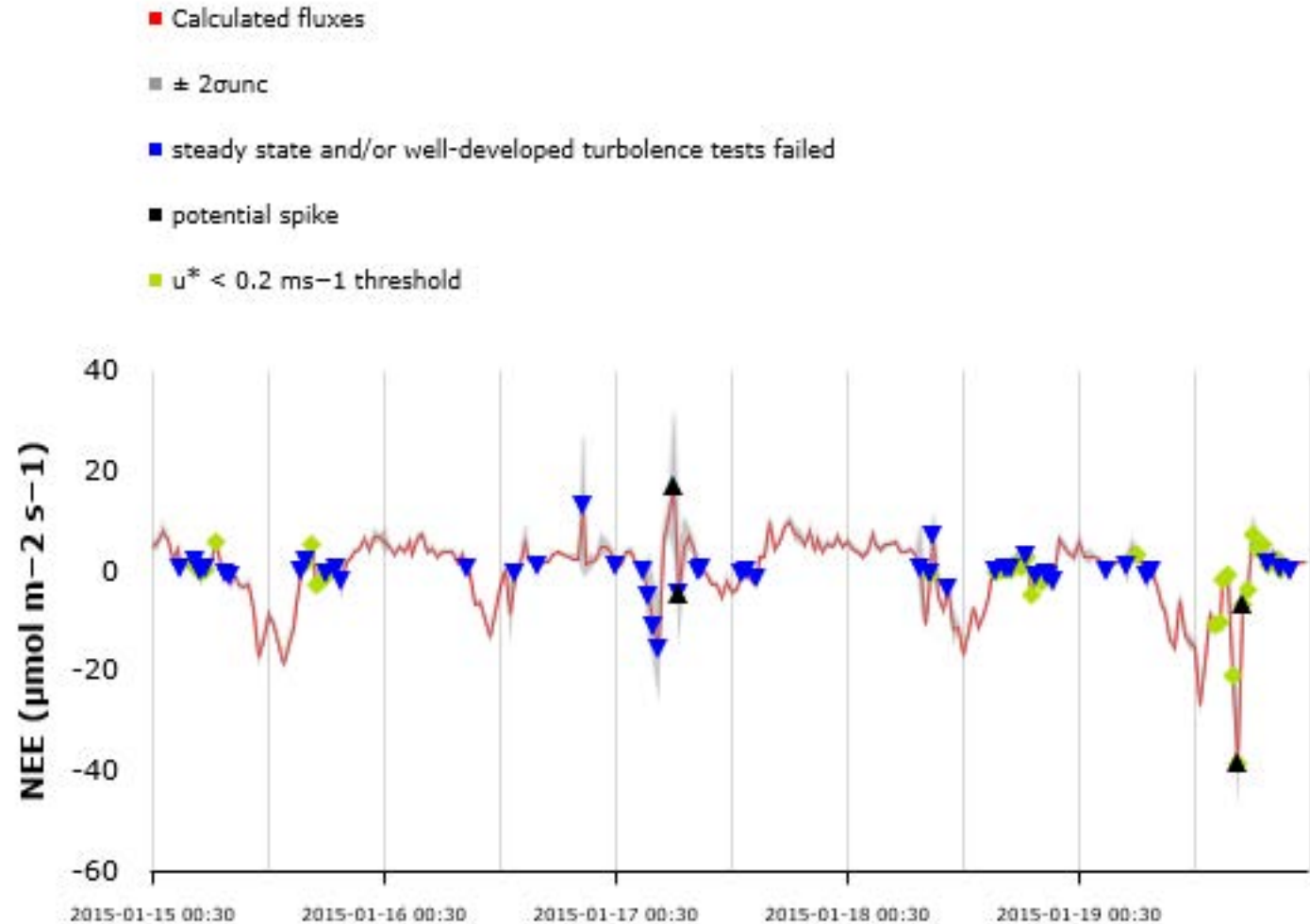


The screenshot shows the AMERIFLUX website's 'Data Variables' page. The page has a blue header with navigation tabs: Home, About, Community, Sites, Data (selected), Tech, Resources, and Sign In. Below the header, there's a breadcrumb trail: Home / Data / About Data / Data Variables. The main content area is titled 'Data Variables' and includes a '[pdf version]' link. The text describes the purpose of the document: to define variable labels and file formatting for uploading data to AmeriFlux and the European Fluxes databases. It defines 'Continuously sampled data' as measurements at regular intervals. It also explains the naming convention for data variables, consisting of a 'base name' and 'qualifiers'. The page lists rules for timestamps, time zone conventions, and missing data representations. A sidebar on the right contains 'DATA' links (Data Policy, About Data, Data Variables, etc.), 'USEFUL LINKS' (People, Opportunities, etc.), and a 'MAP OF SITES' showing a map of North America with red location markers.



# Improved data processing at ETC: Eddy covariance flux in near real time

The processing developed and implemented, that includes a complete QAQC procedure and uncertainty estimation, has been a real advancement in the NRT data production (Deliverable 5.2).



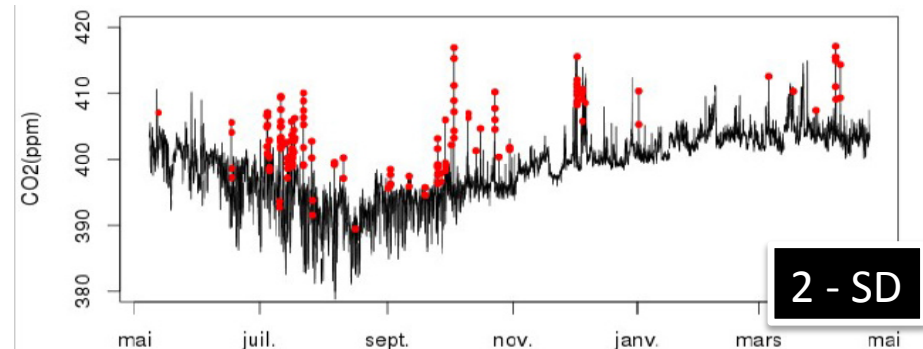
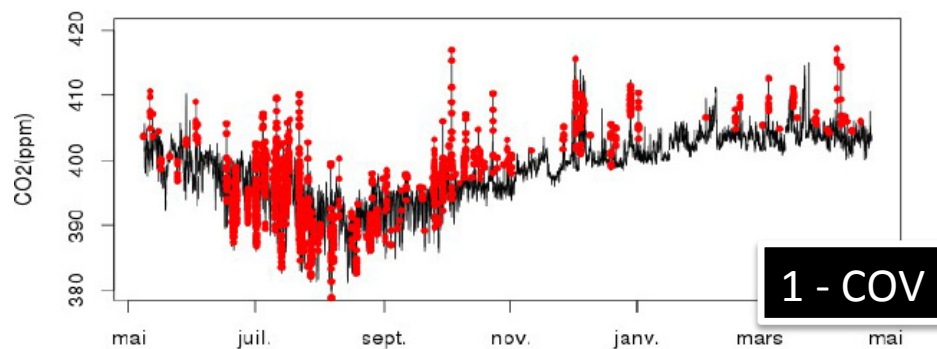
*Fratini et al., BG, 2014*



# Improved data processing at ATC: data flagging, spike detection

Detection and flagging local exhaust plumes, with 2 methods.

1. **C**oefficient of **V**ariation (**COV**), [Hagler et al. (2012)]
2. **S**tandard **D**eviation of the background (**SD**) , [Drewnick et al. (2012)]



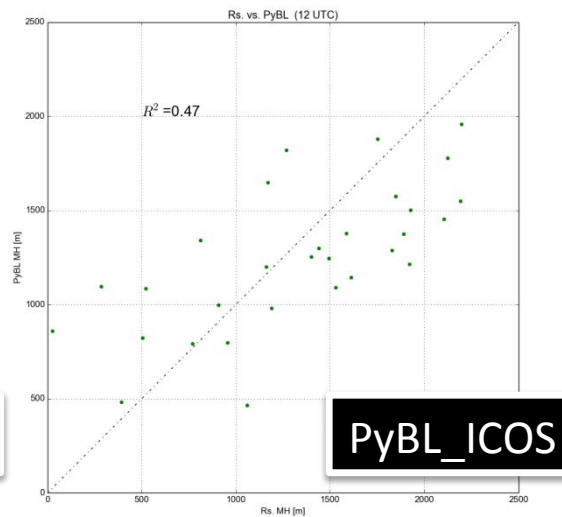
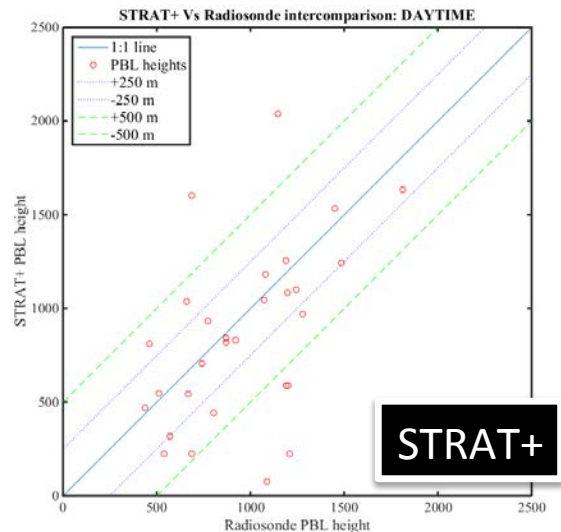
- 1.95 % of data are flagged
- Positive and negative peaks are flagged

*See also: Hazan et al., in prep.*

- Only positive peaks are flagged
- 0.033 % of data are flagged
- 93 % of flagged data are between 06hr and 16hr UTC

# BLH: intercomparison of algorithms

## BLH retrieval algorithm – Comparisons with nearest radiosounding



Correlation at 12:00 UTC is low.

- Definition of mixing height derived from radiosondes does not match definition of mixing height derived from optical backscatter method

Correlation at 00:00 UTC is nonexistent.

- Mixing height during night too low to be measured by optical backscatter methods (low signal-to-noise ratio and the incomplete-overlap region under 400m).

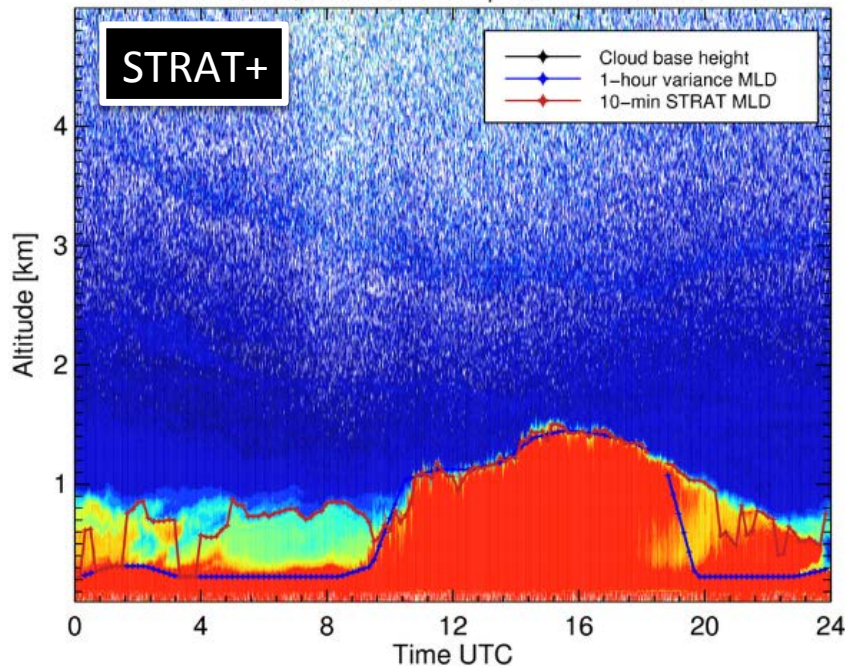
Period (2 months)	Radiosondes	Number of cases with differences between STRAT+ and radiosonde PBL height in absolute terms:		
		< 250 m	< 500 m	> 1000 m
Midday	52	26 (50%)	38 (73.0%)	4 (8%)
Midnight	52	44 (84.6%)	49 (94.2%)	1 (2%)
Total	104	70 (67.3%)	87 (83.7%)	5 (0.05%)



# BLH: toward a unified machine-independent algorithm

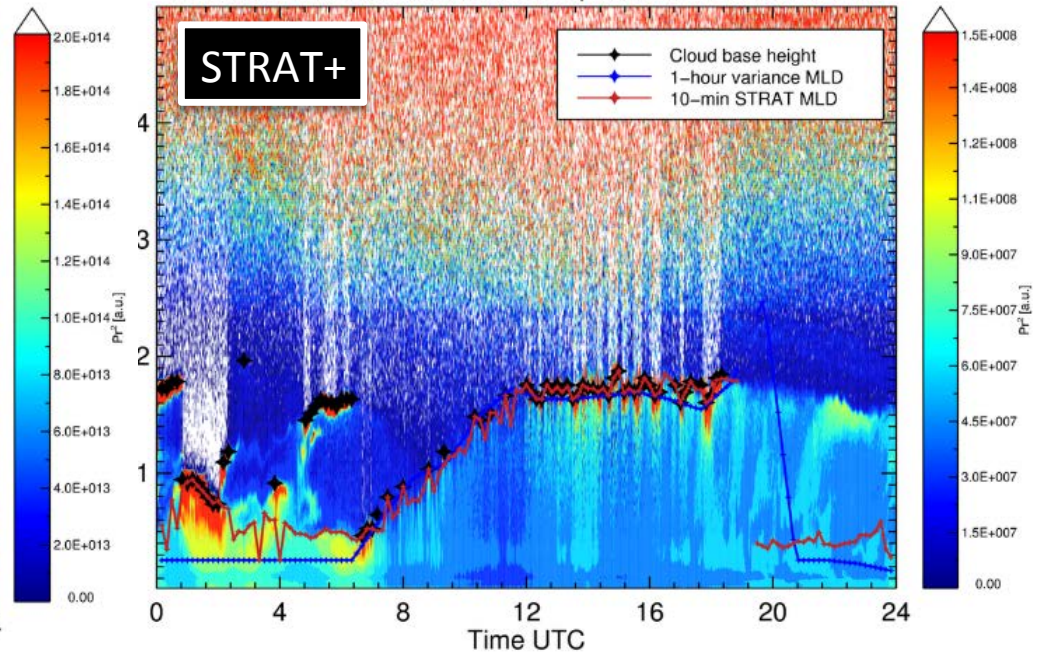
## BLH retrieval algorithm – tuning to different ceilometers

MLD: SIRTA, 08/04/2015 | Resol = 030s, 030m



BLH time series for SIRTA (Jenoptik CHM15k).

MLD: Bruxelles, 03/05/2014 | Resol = 030s, 030m



The same for Bruxelles (Vaisala CL51).

- Cloud base height
- 1-hour variance MLD splined at 10-min resolution
- 10-min STRAT MLD as final attribution

Bravo-Aranda et al., in prep.





## Rapid delivery of GHG column data from TCCON sites for **Bialystok, Orleans and Ny Alesund**

- Automated delivery within 2 weeks after the measurements
- Automated quality check and flagging of data
- Manual quality check is done on a 3-monthly basis.

### Day zero

- Acquisition of data
  - Slices to spectra overnight
- on site**

### Day three

- Produce model-profiles and copy to sites
- in Bremen**  
(poor internet-connection is sufficient)

### Day four

- Daily retrieval over night
- on site**

### Mondays

- Automated quality check and upload to server



**ICOS** Atmospheric Thematic Centre

Home | Data products | Stations | Documents

Home > TCCON Fast Delivery Product

### TCCON Fast Delivery Product

Submitted by admin on Thu, 05/28/2015 - 17:00

**Terms of Use**

The following data available from this web page is "Rapid delivery TCCON" (RD-TCCON) data of total column averaged  $\text{CO}_2$  mole fractions are retrieved from solar absorption spectra obtained at the following four sites of the Total Carbon Column Network (TCCON): Ny Alesund, Orleans, Bialystok and Reunion. The retrieval has been done with the TCCON retrieval software.

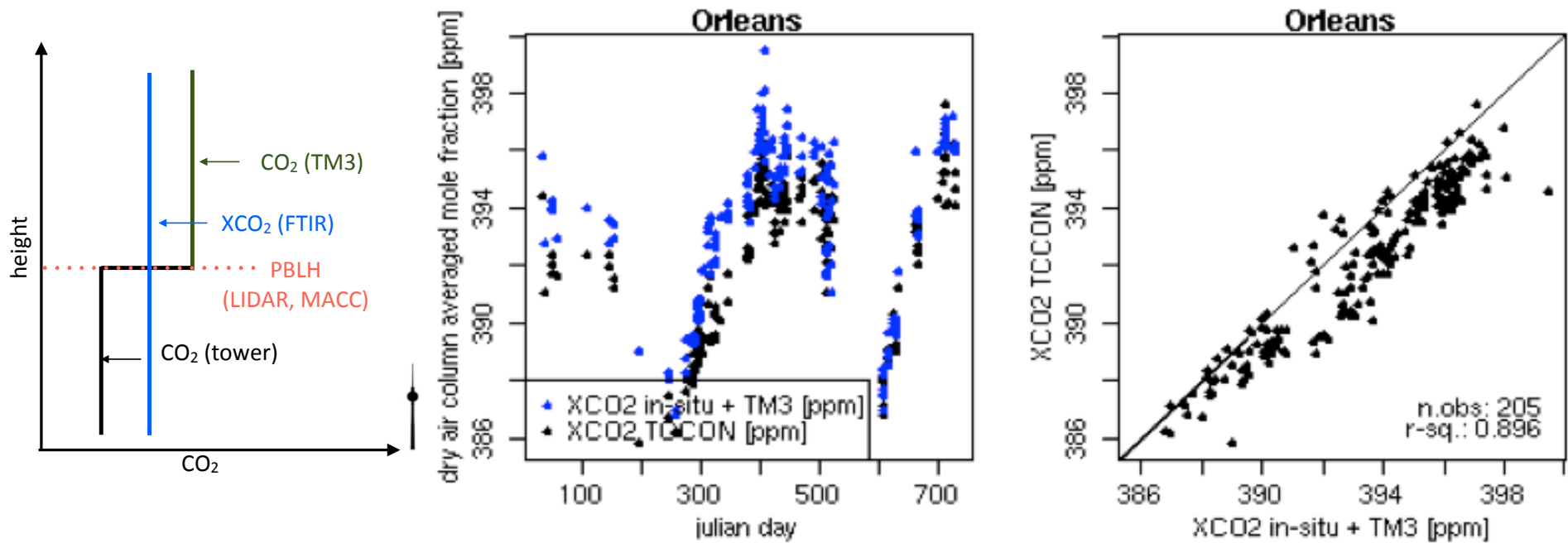
RD-TCCON data are automatically processed data that have not passed through any review by TCCON scientists intended for use in applications where a lesser quality of the data is acceptable, for example, for assimilation forecast models or for an initial, preliminary validation of satellite retrievals. Rapid delivery data should not be mixed with final TCCON data available from CDIAC. Any communication or presentation using the RD-TCCON must clearly announce the distinction between the rapid-delivery and the final TCCON data. The final TCCON data are available from the TCCON database <http://tccon.ornl.gov/>

The data use policy below is largely adapted from the TCCON data use policy ([https://tccon-wiki.ornl.gov/Network\\_Policy/Data\\_Use\\_Policy](https://tccon-wiki.ornl.gov/Network_Policy/Data_Use_Policy)), but some points are modified to account for the special case of rapid-delivery data, including column averaging kernels and a priori profiles are contained in the netCDF files provided for GGG2 on how to properly use the averaging kernels and a priori profiles for the RD-TCCON data are on the TCCON wiki page ([https://tccon-wiki.ornl.gov/Network\\_Policy/Data\\_Use\\_Policy/Auxiliary\\_...](https://tccon-wiki.ornl.gov/Network_Policy/Data_Use_Policy/Auxiliary_...)).

**Use of Data**

The data are made freely available to the public and the scientific community, and are the product of extensive research and

# 'Interoperability' of ICOS and TCCON



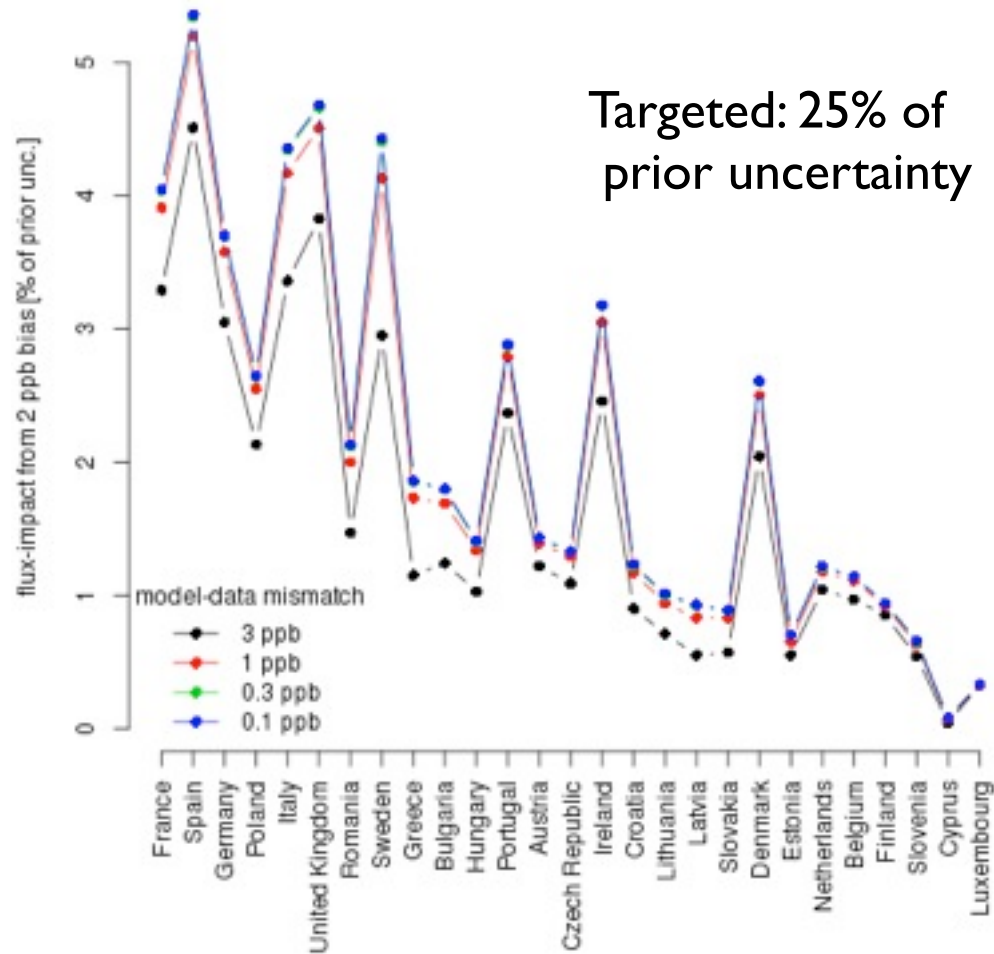
D. Feist et al.



# Task 6.1 Assessment of compatibility requirements (MPG)

Atmospheric network:  
 Model-data mismatch errors:  
 Targeted flux uncertainties:  
 A-priori uncertainties:  
**Impact from measurement bias (2 ppb):**  
 annual and national scale

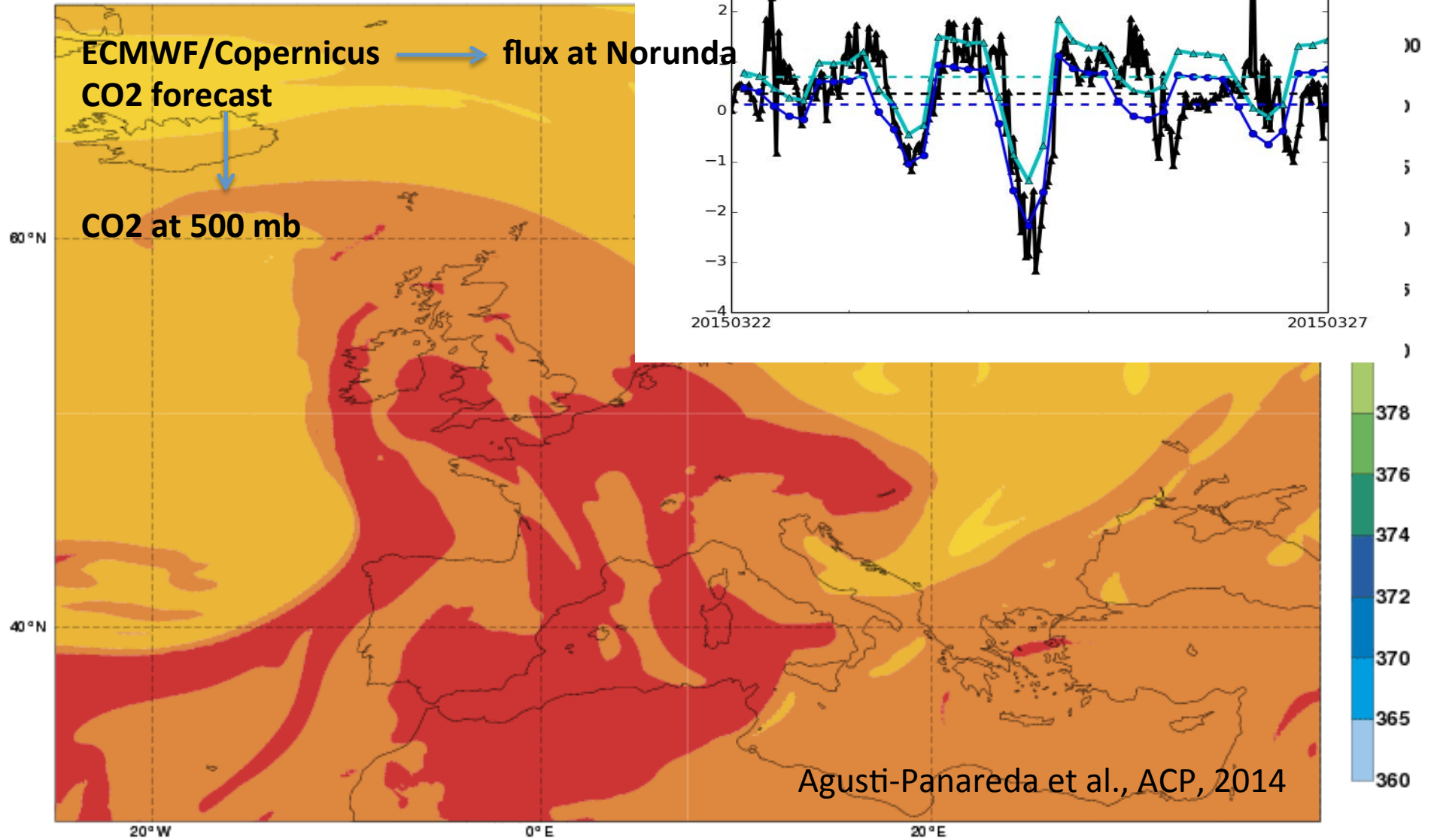
2 ppb CH<sub>4</sub> bias impact on retrieved national (EU28) CH<sub>4</sub> budget



Kountouris, Gerbig et al., in prep



Wednesday 8 July 2015 00UTC MACC-III Forecast t+06  
500 mb carbon dioxide dry molar fraction [ ppm ]



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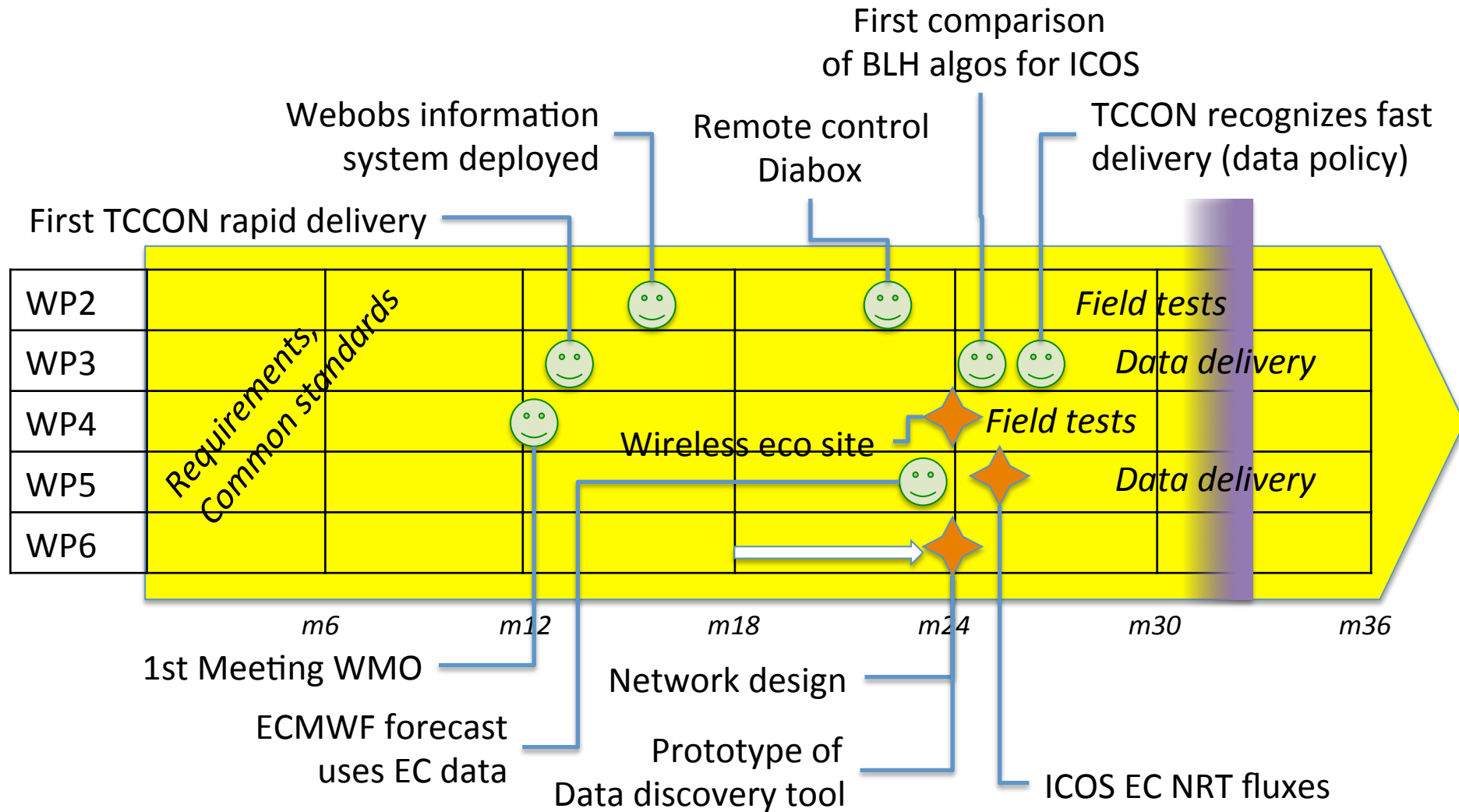
CNRS



- Large interest (ECMWF) in NRT data from ICOS and wish NRT practice also from other GHG networks.
- Stability in data formats and access
- Network extension is needed: ICOS toward the East (Russia, eastern Europe) and TCCON in the Tropics.
- Hourly/half hourly atmospheric measurement OK.
- Provision of data from ICOS and TCCON to MACC must be continued and the scientific discussion strengthened.
- Future ICOS-Copernicus meetings need to be organized, possibly with a wider participation of other users. **Strong link need to be maintained**

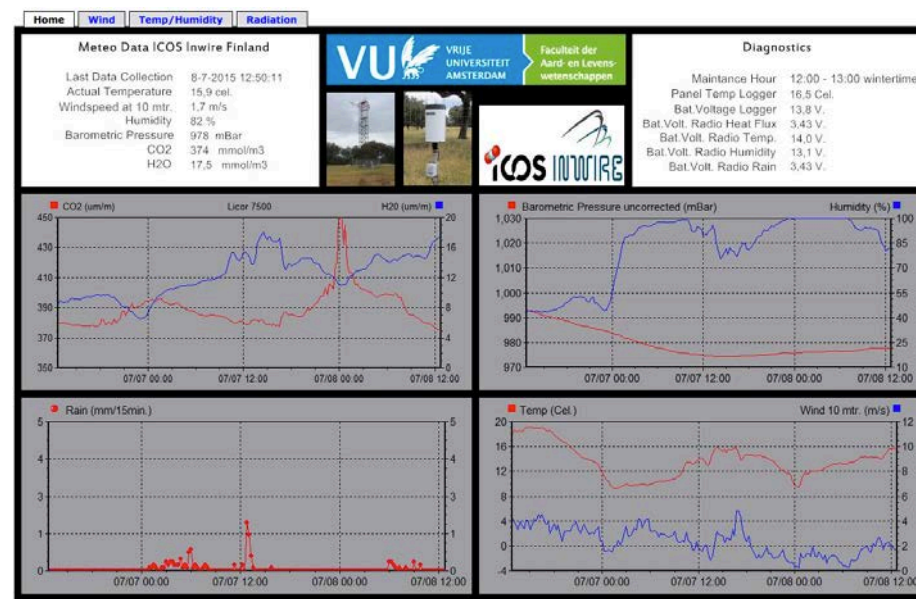
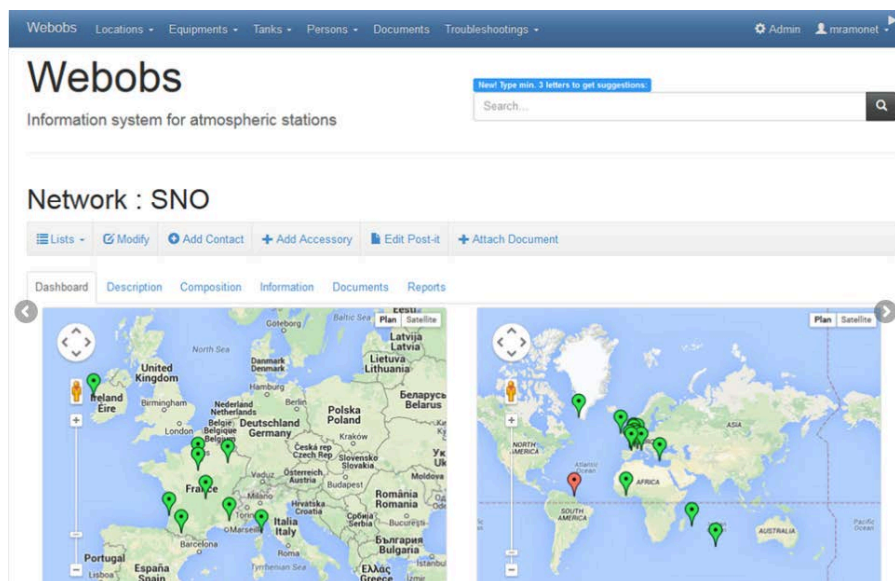


# Many things have happened...



WEBOBS: Collaborative network management and troubleshooting

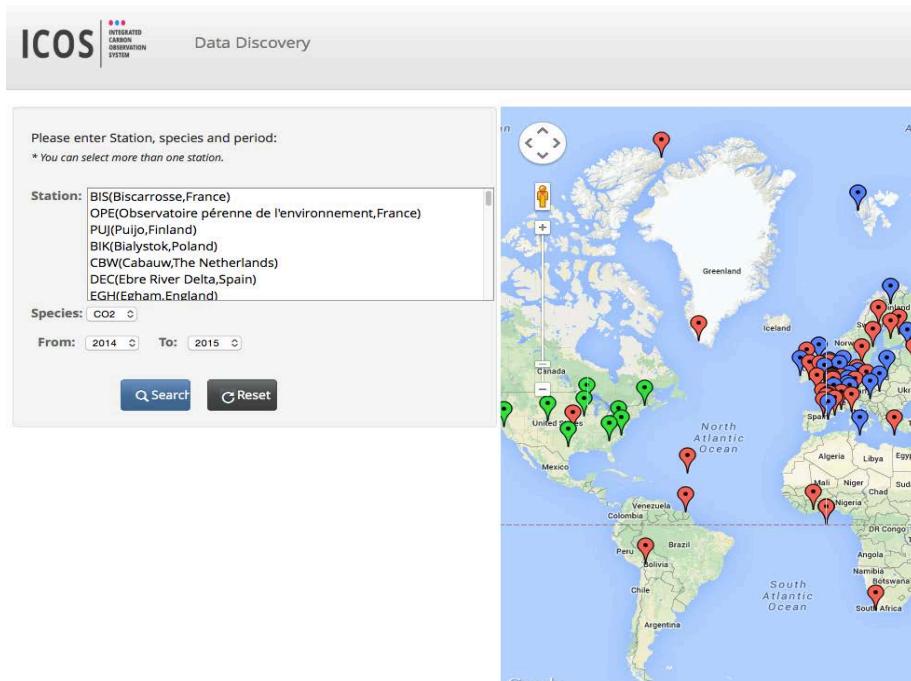
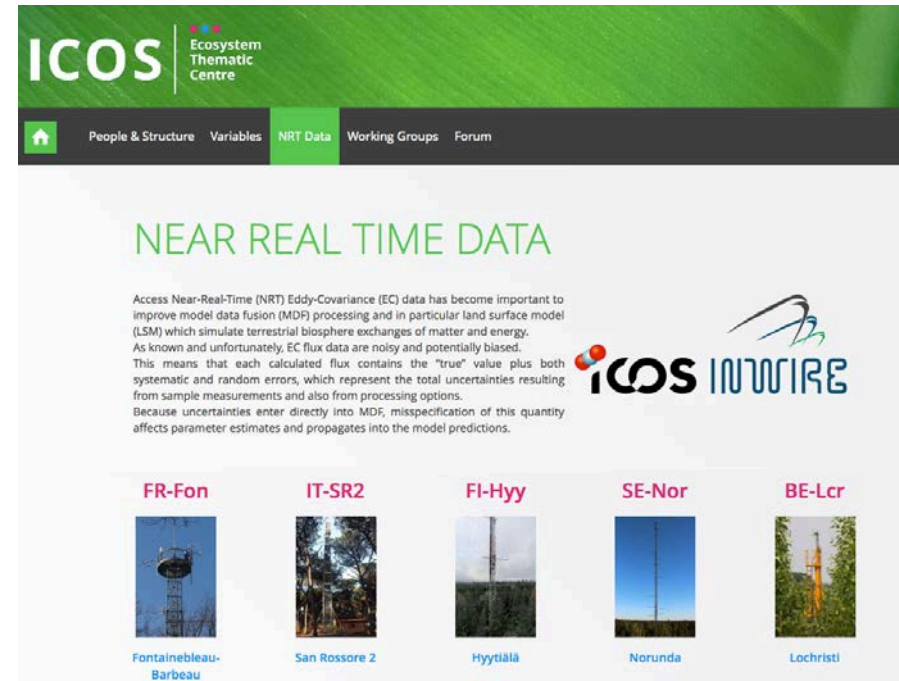
✓ 'wireless site' NRT data



<http://icos.vu.nl>

✓ GHG sites discovery

✓ Eddy Covariance NRT data at ETC

<https://icos-atc.lsce.ipsl.fr/databrowser/>

<http://www.europe-fluxdata.eu/icos/nrt-data>



Tech reports  
NRT data access  
Research papers

<http://www.icos-inwire.lsce.ipsl.fr>

