ICOS improved sensors, network and interoperability for GMES

ICOS - greenhouse gas observations for GEO and Copernicus

ICOS-INWIRE

J.-D. Paris, N. Schneider, C. Gerbig,
H. Dolman, D. Papale, T. Vesala,
A. Carrara, A. Lindroth, T. Warneke, and all
ICOS-INWIRE contributors

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n°313169.

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.

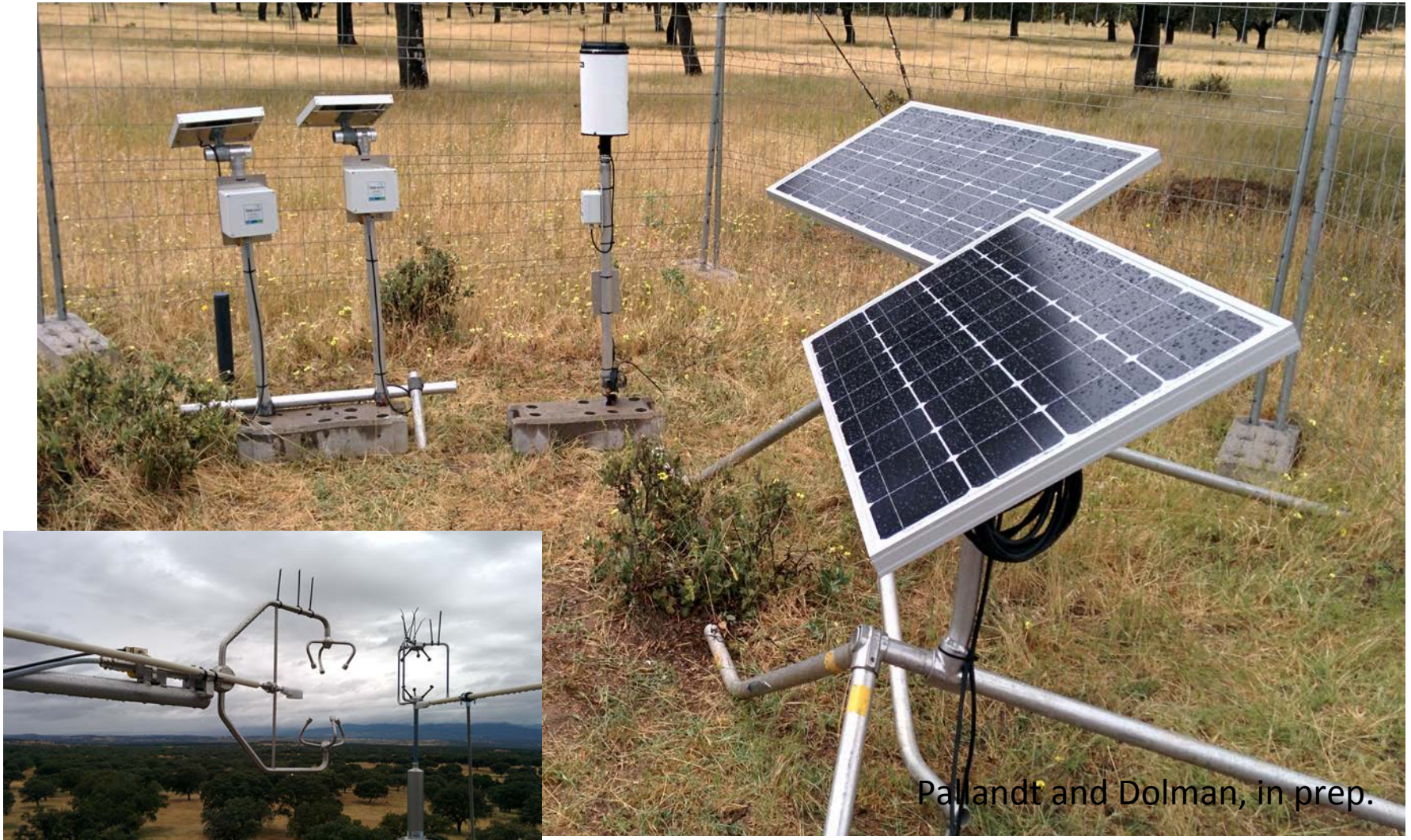
Approach:

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

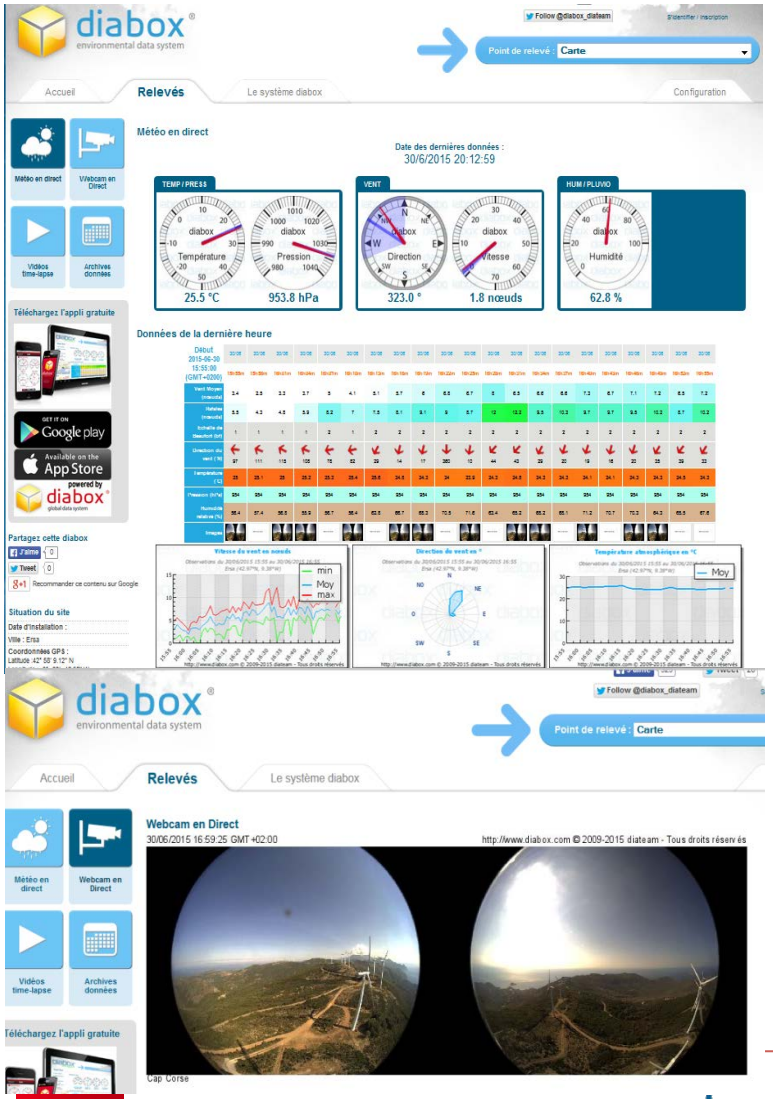
- More NRT data to Copernicus and cal/val support capability
- Less gaps in data due to robust, autonomous sensor systems
- Improved algorithms for ICOS, interoperable data and integrated datasets for users.

Wireless ecosystem site



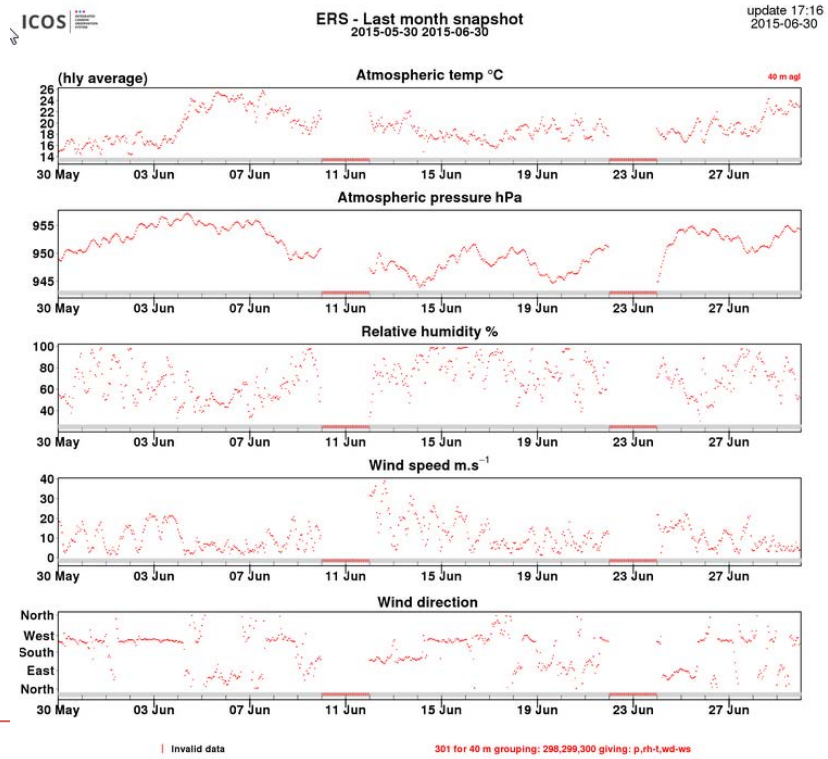
Pallandt and Dolman, in prep.

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



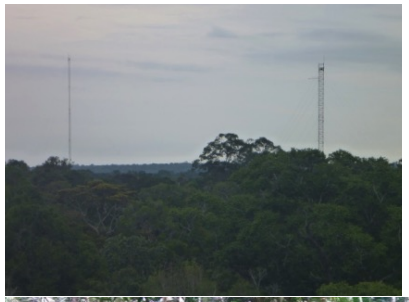
Enhancing robustness of sensors

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

- 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

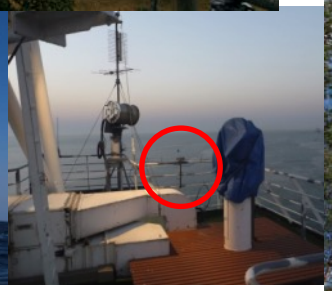
Field tests from Arctic to tropics & deserts


Norunda, Sweden


Amazonian Tall Tower Observatory (ATTO), Brazil

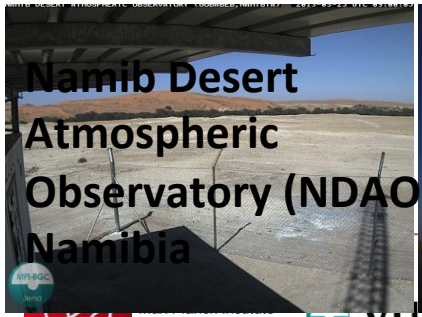

Las Majadas, Spain


R/V Meteor




Hyytiälä, Finland


Tropical sites Lamto (Ivory Coast) & French Guyana


Namib Desert Atmospheric Observatory (NDAO), Namibia

for Biogeochemistry VU UNIVERSITY AMSTERDAM Tuscia UNIVERSITY OF HELSINKI CEAM FUNDACION CENTRO DE ESTUDIOS AMBIENTALES DEL MEDITERRANEO LUND UNIVERSITY Universität Bremen

Toward EC standard and harmonization of vocabulary

CIMO arrangements

Proposal for a WMO standard on Eddy Covariance,

First draft July 2015.

Han Dolman
Department of Earth Sciences
VU University Amsterdam
the Netherlands
han.dolman@vu.nl

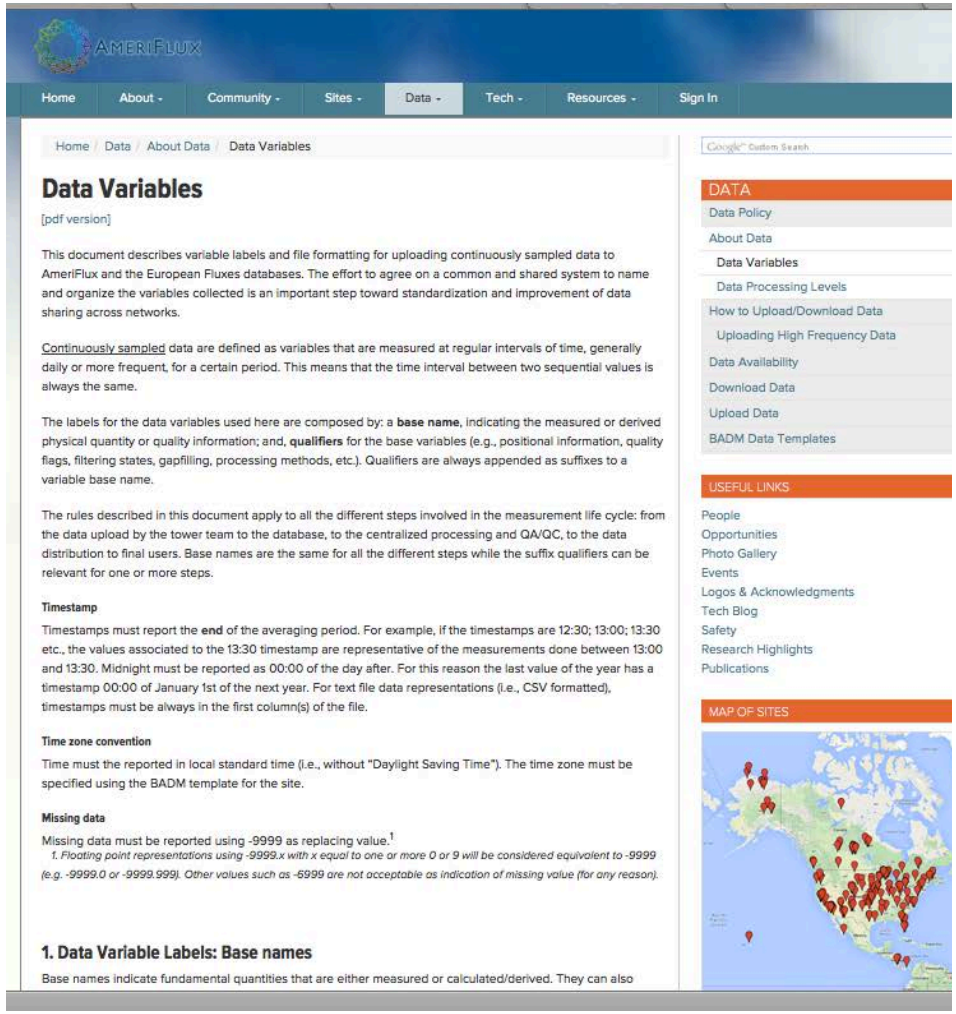
Background

The exchange of momentum, heat, water vapor, CO_2 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 (CO2, H2O, Temperature, CH4, 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). 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).

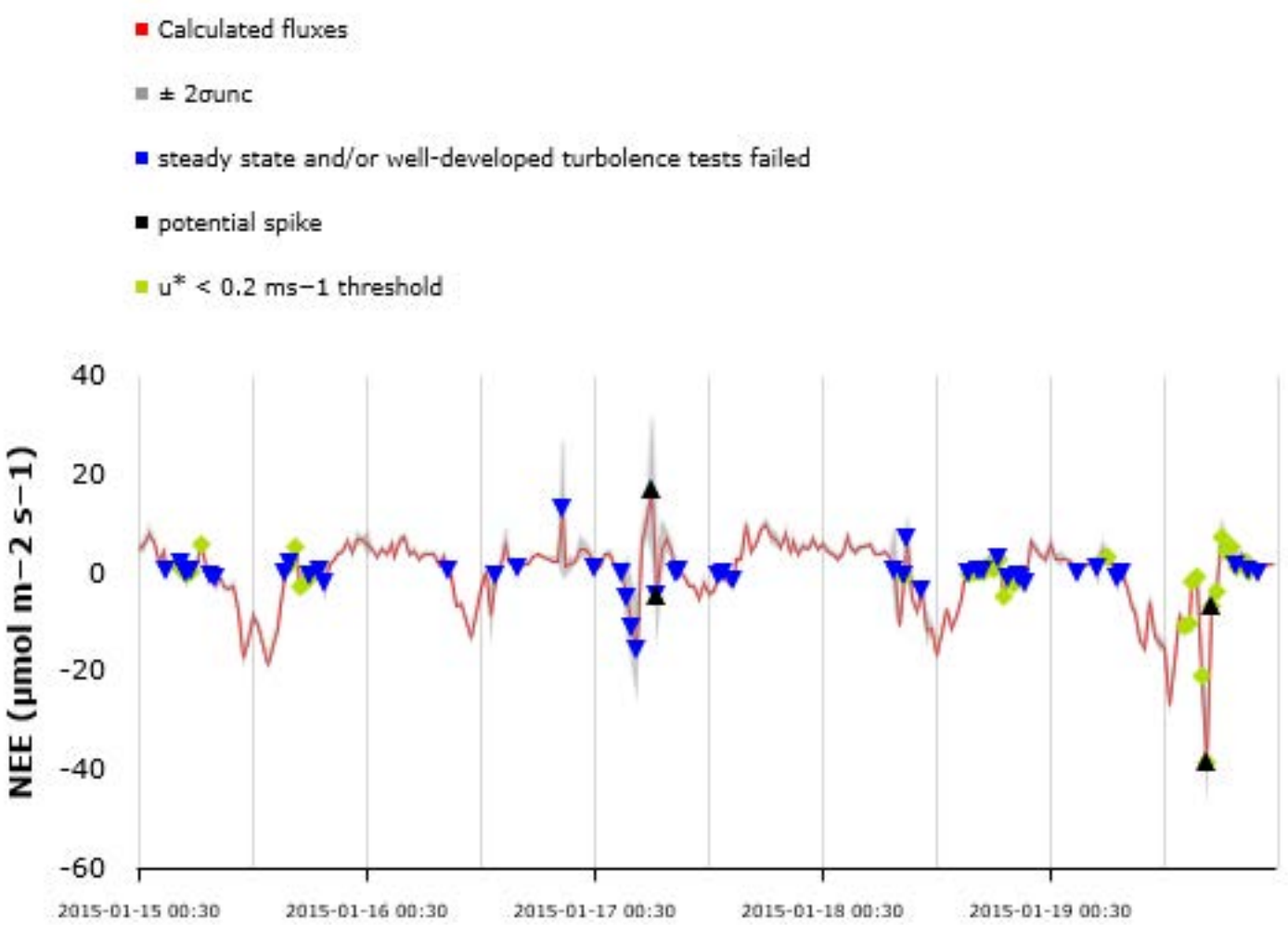
Site selection

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



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).

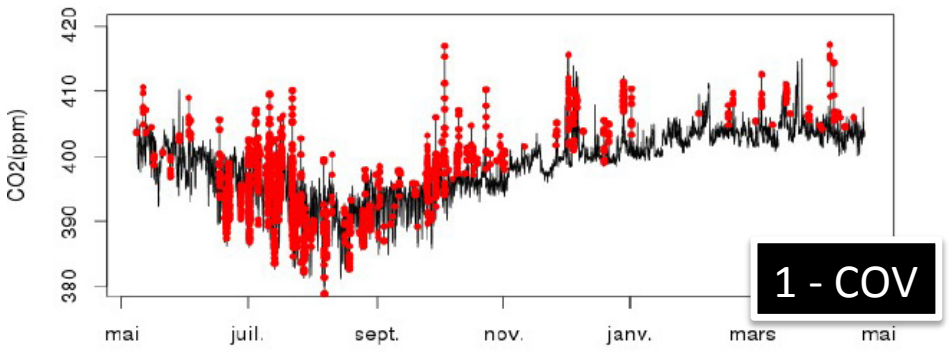


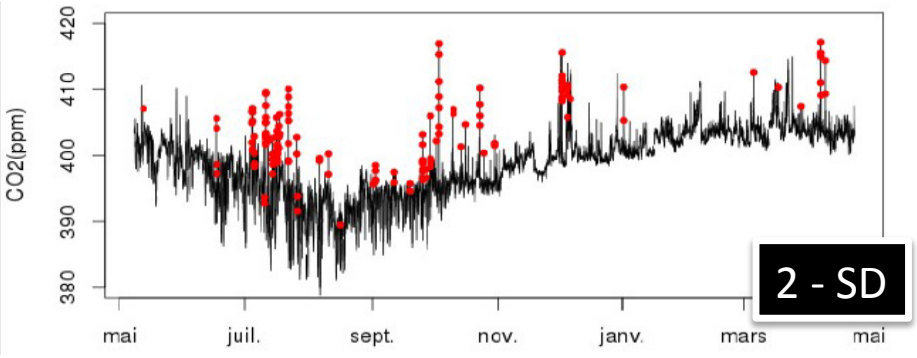
Fratini et al., BG, 2014

Improved data processing at ATC: data flagging, spike detection

Detection and flagging local exhaust plumes, with 2 methods.

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





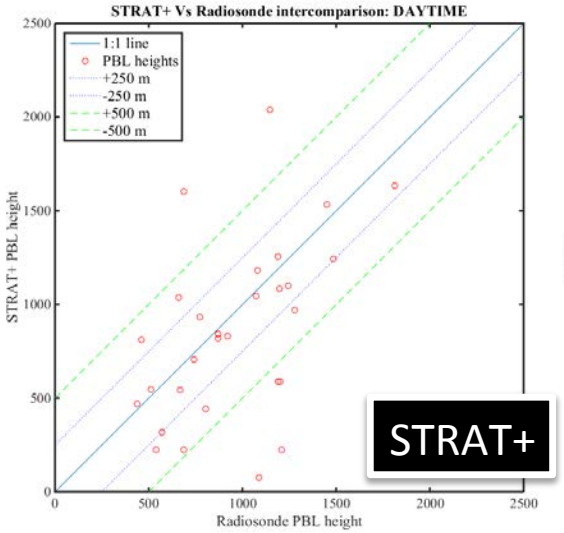
- 1.95 % of data are flagged
- Positive and negative peaks are flagged

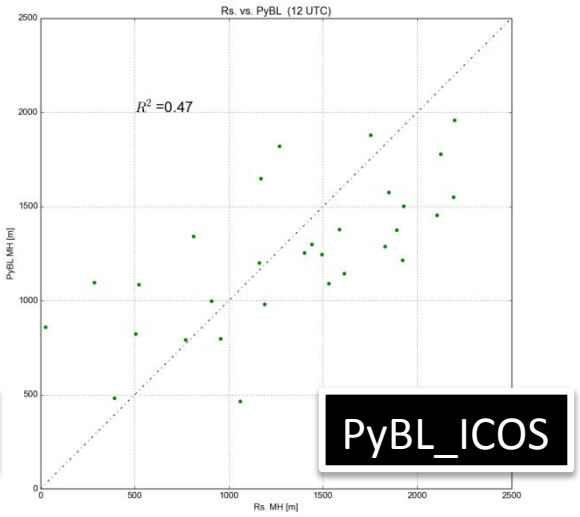
See also: Hazan et al., in prep.

- 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

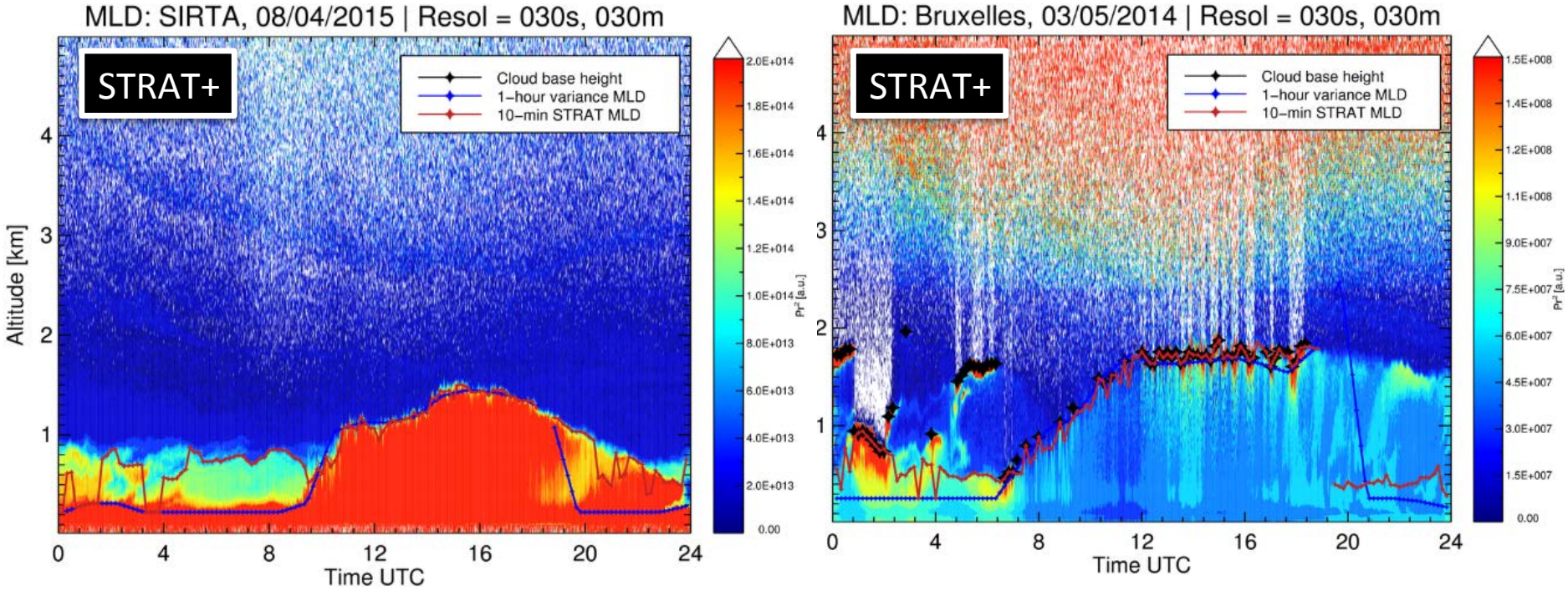
Correlation at 00:00 UTC is nonexistent.

→ 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



BLH time series for SIRTA (**Jenoptik CHM15k**).

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.

Test of new lidars

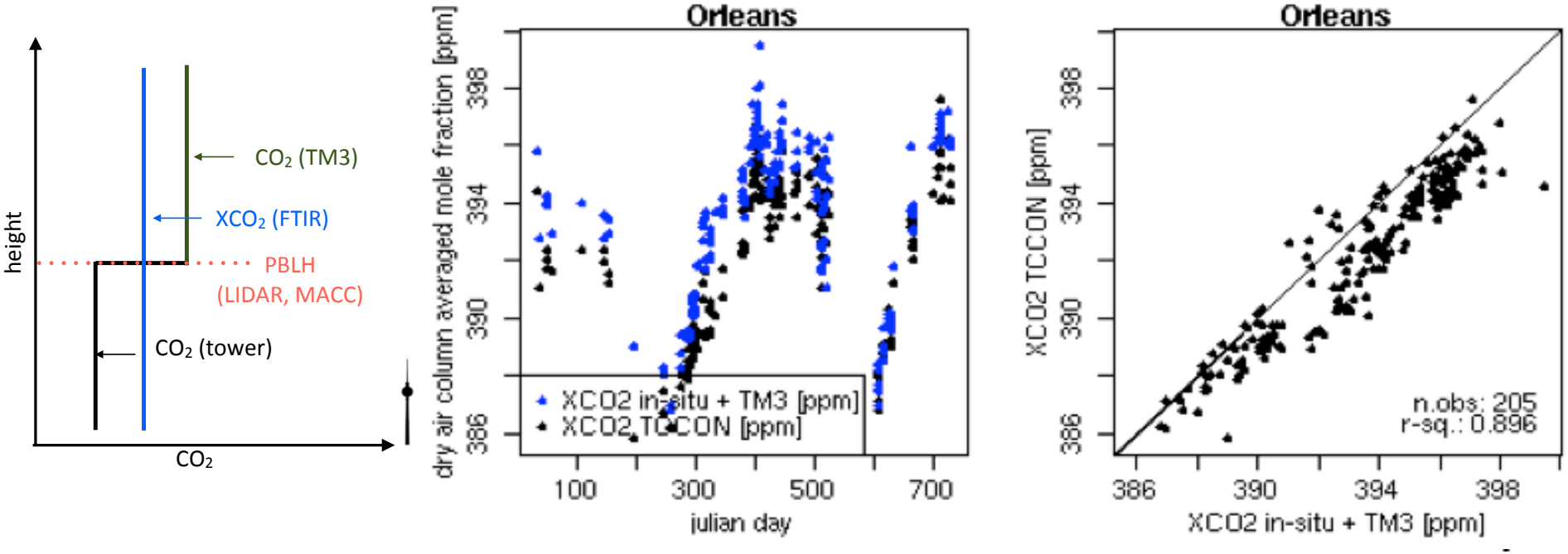
Rapid delivery of TCCON data

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	Day three	Day four	Mondays
- Acquisition of data - Slices to spectra overnight on site	- Produce model-profiles and copy to sites in Bremen (poor internet-connection is sufficient)	- Daily retrieval over night on site	- Automated quality check and upload to server

‘Interoperability’ of ICOS and TCCON



D. Feist et al.

Task 6.1 Assessment of compatibility requirements (MPG)

Atmospheric network:

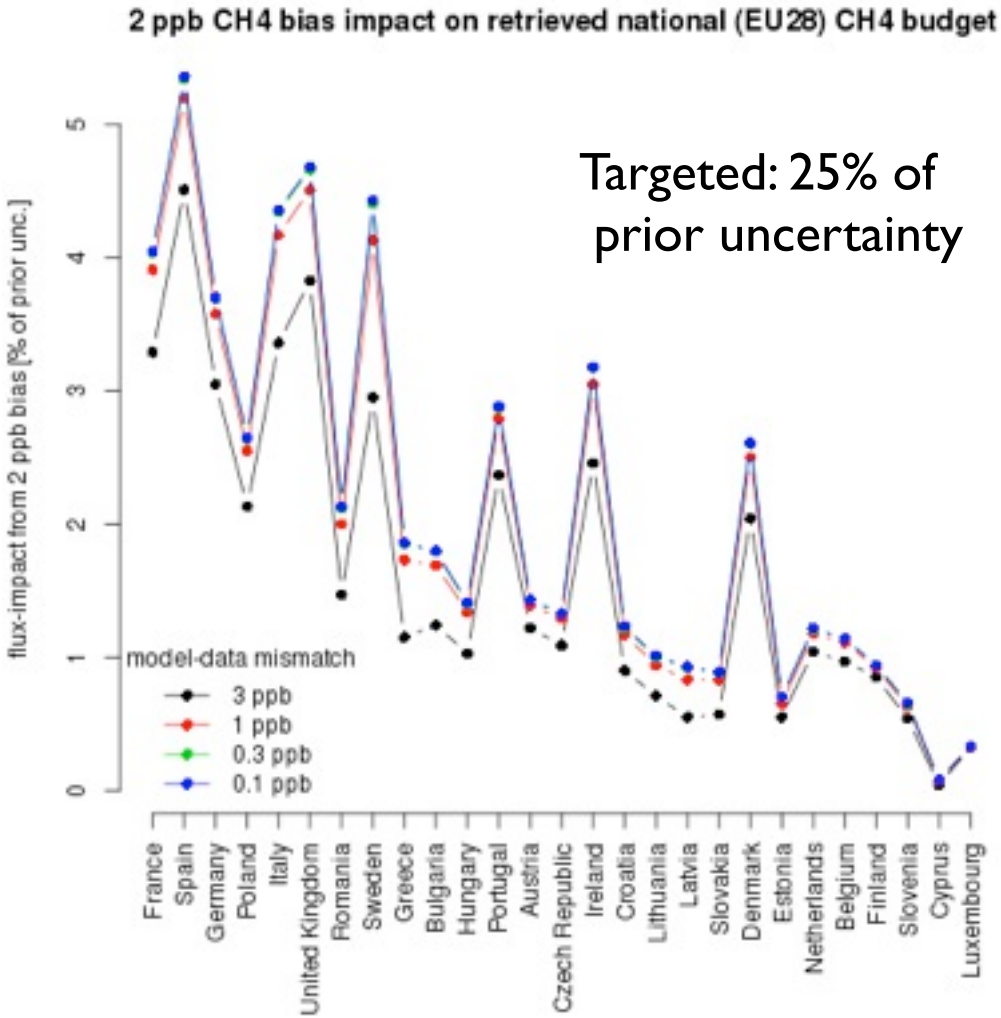
Model-data mismatch errors:

Targeted flux uncertainties:

A-priori uncertaintues:

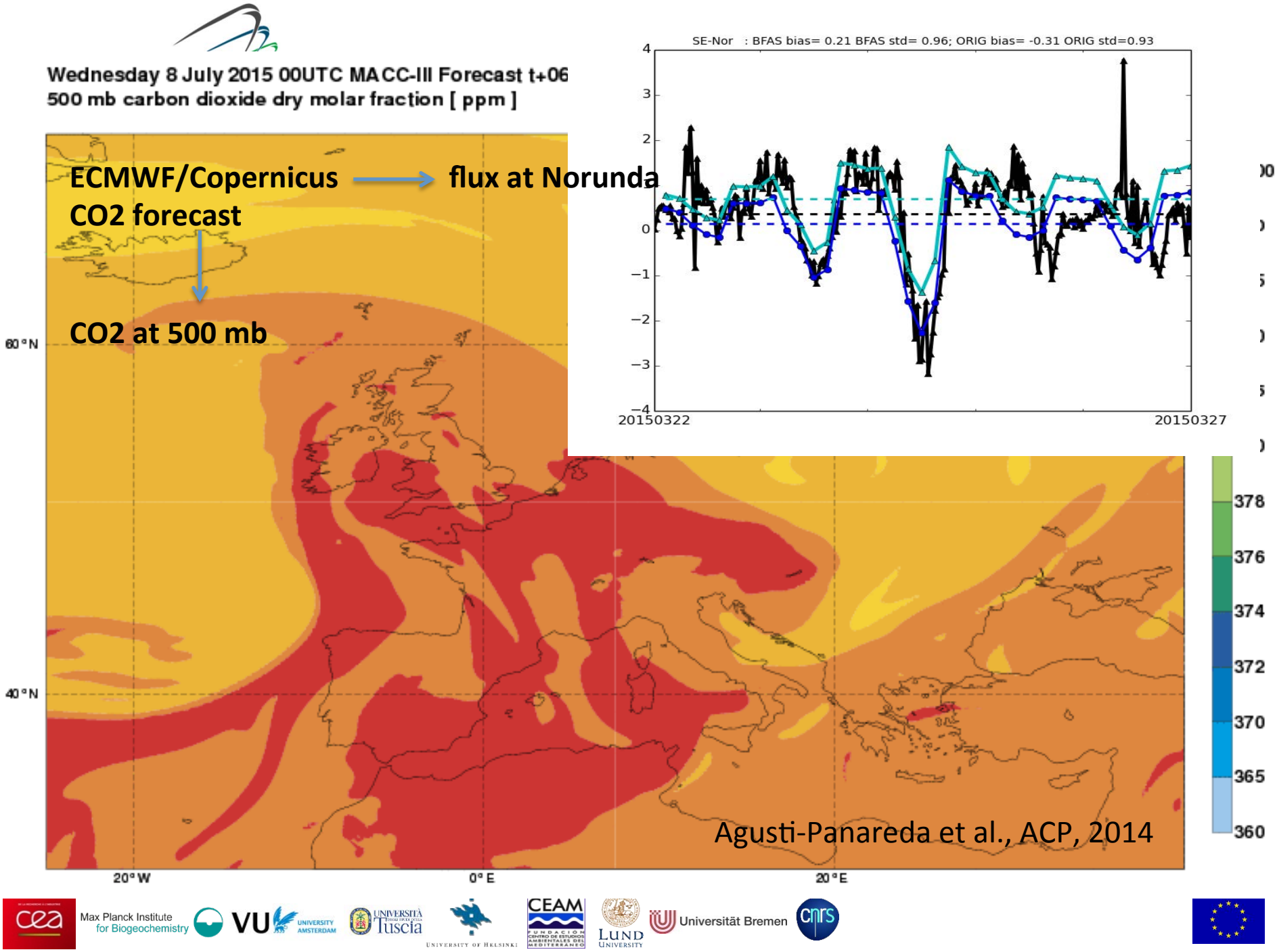
Impact from measurement bias (2 ppb):

annual and national scale



Targeted: 25% of prior uncertainty

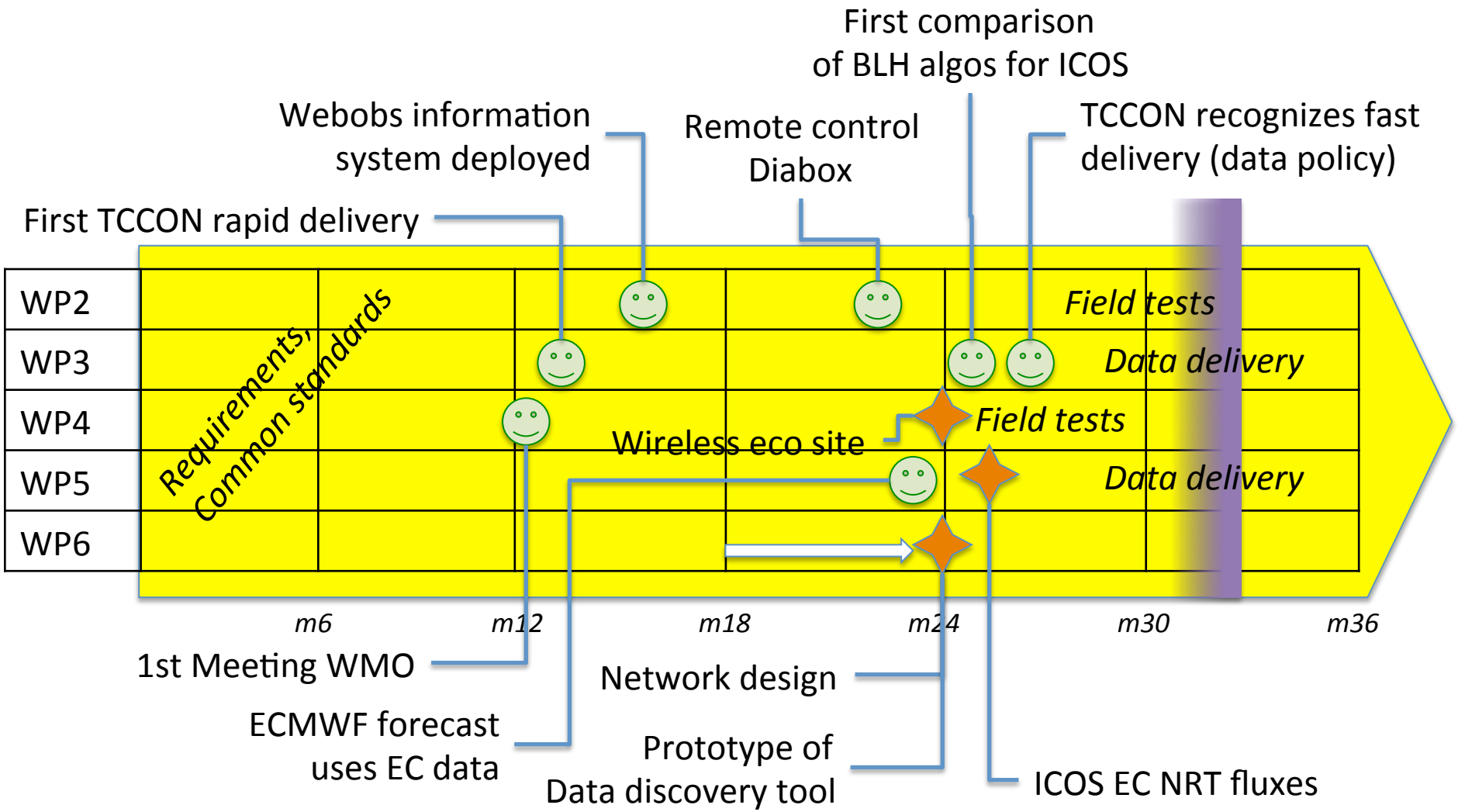
Kountouris, Gerbig et al., in prep


Wednesday 8 July 2015 00UTC MACC-III Forecast t+06
500 mb carbon dioxide dry molar fraction [ppm]
ECMWF/Copernicus
CO2 forecast
CO2 at 500 mb
flux at Norunda
SE-Nor : BFAS bias= 0.21 BFAS std= 0.96; ORIG bias= -0.31 ORIG std=0.93
4
3
2
0
−1
−2
−3
−4
20150322
20150327
60°N
40°N
20°W
0°E
20°E
378
376
374
372
370
365
360
Agusti-Panareda et al., ACP, 2014

User feedback

- 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**

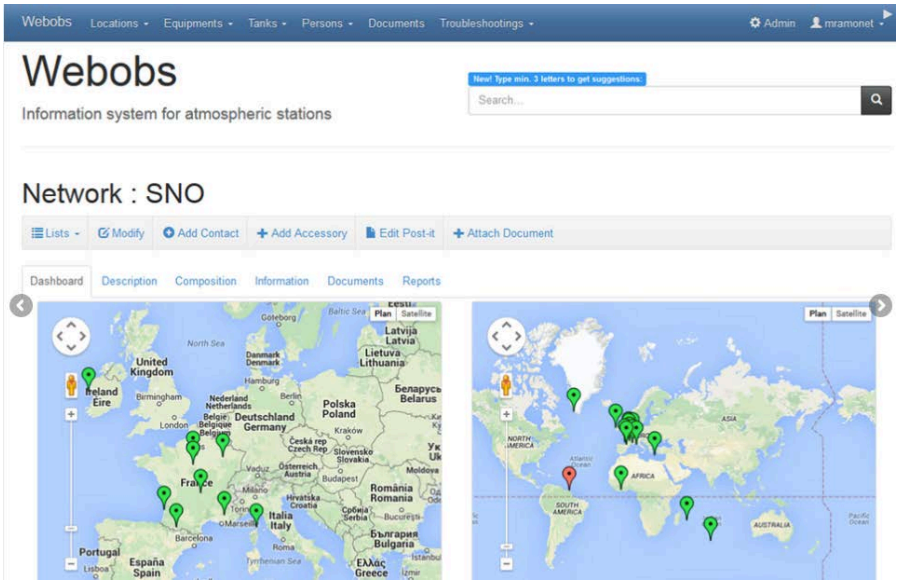
Many things have happened…

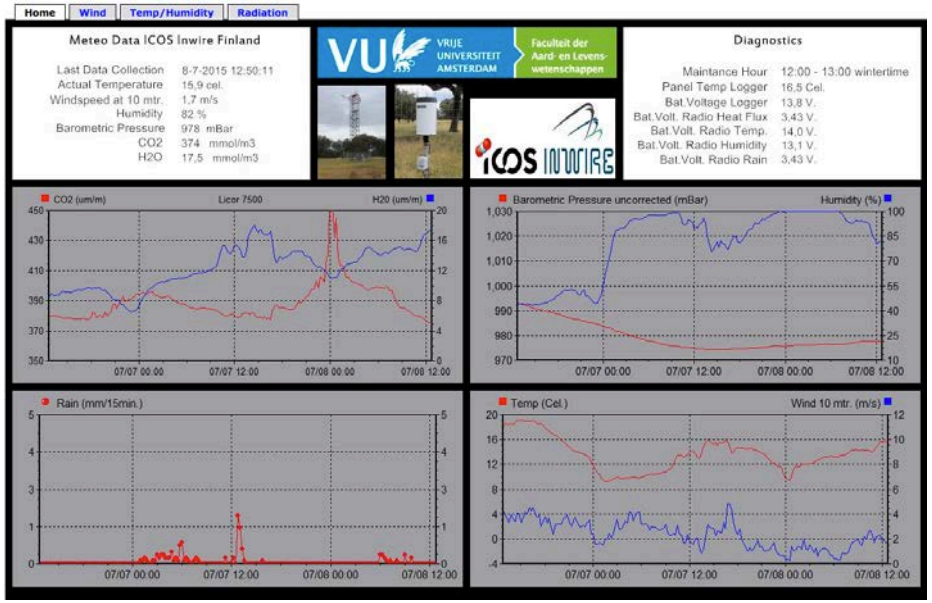


Highlights and Achievements

WEBOBS: Collaborative network management and troubleshooting

✓ 'wireless site' NRT data



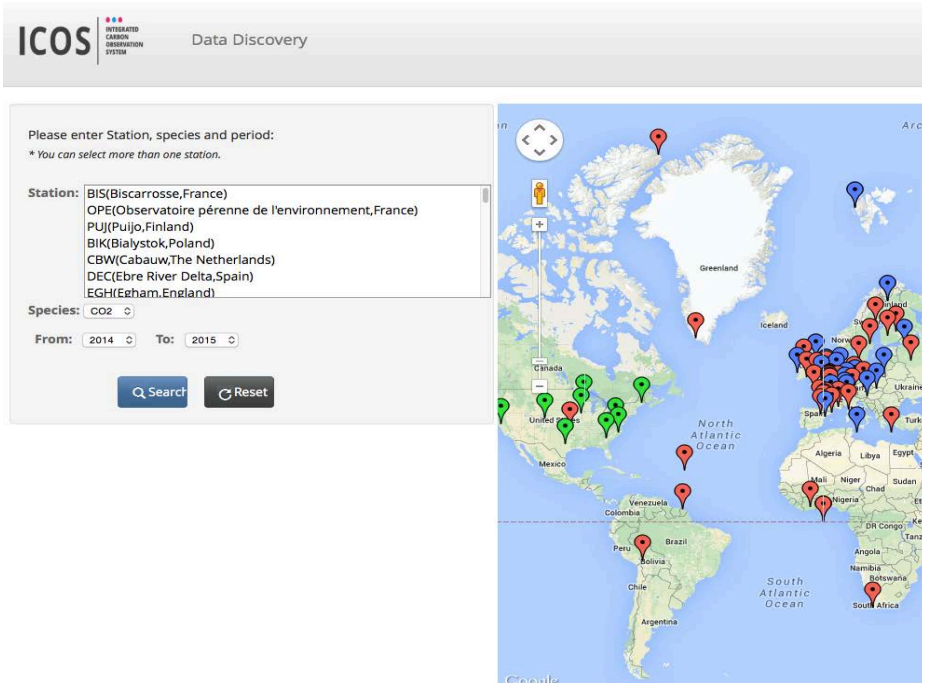


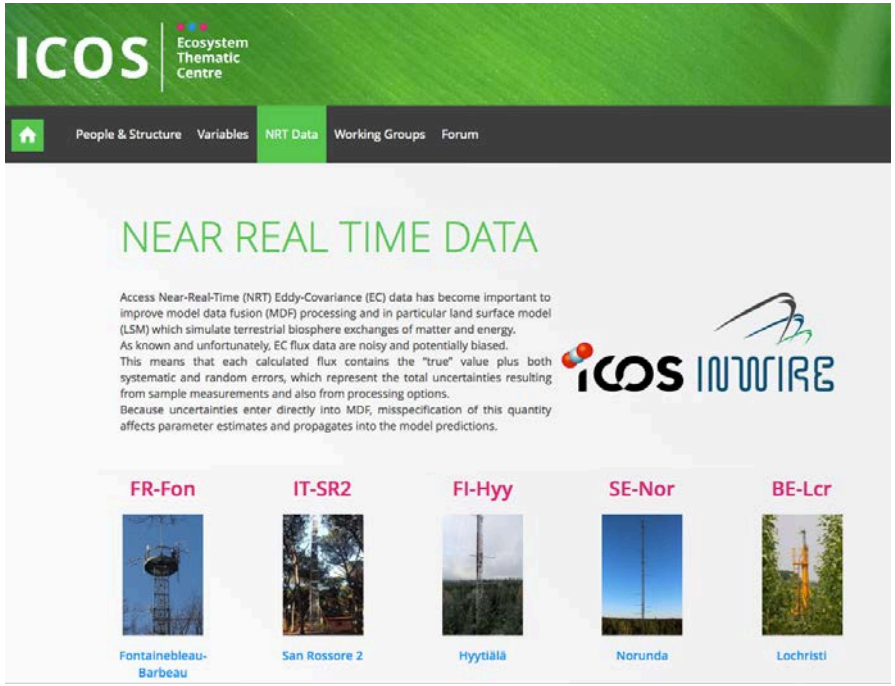
http://icos.vu.nl

Highlights and Achievements

✓ GHG sites discovery

✓ Eddy Covariance NRT data at ETC





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

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

Thank you

Tech reports
NRT data access
Research papers

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