ICOS Sites and Data handling and processing

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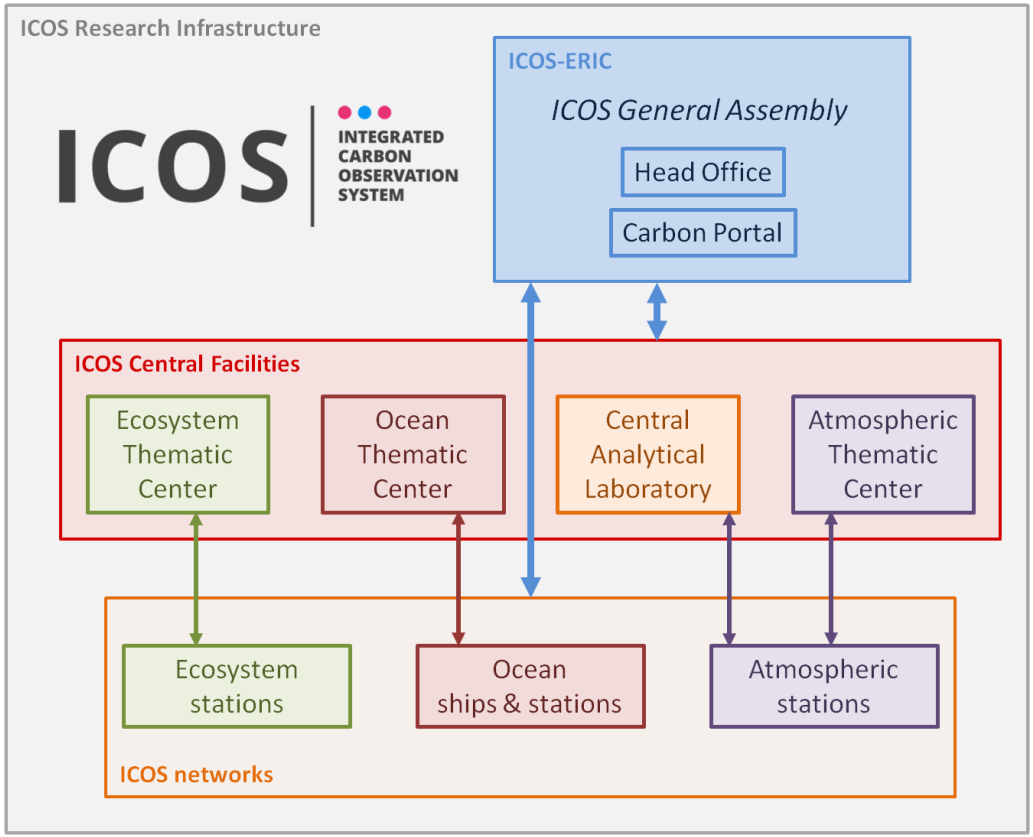
ICOS Ecosystem Thematic Centre

What is ICOS

www.icos-ri.eu

1. A networks of sites measuring
2. Four thematic centres that coordinate the activity of the sites
3. One EU level head-office and web portal

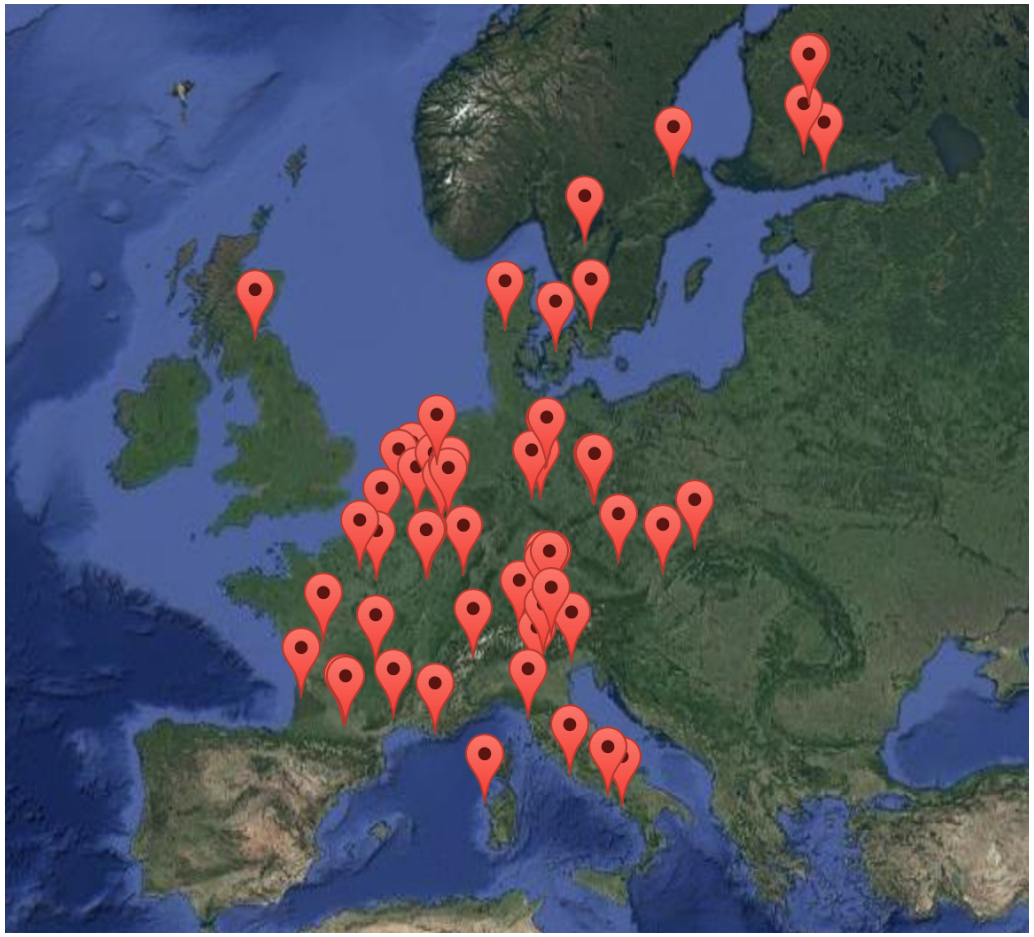


Ecosystem network: 81 (currently) ecosystem sites measuring CO_2, CH_4 and N_2O fluxes, **Atmospheric network:** 34 towers measuring concentrations, **Ocean network:** 21 ships and fix stations measuring concentrations

The ICOS **Thematic Centers**: coordinate the networks, do the centralized processing, test and development of new methods and sensors. The **Carbon Portal** is the data distribution entry point.

The ICOS Ecosystem Network

Not all the countries in Europe are currently members of ICOS and for this reason the distribution of stations is not homogeneous like in the European Database network. ICOS is a subset



The ICOS Ecosystem Stations

Site	Setup	Metadata	Processing	Data	Variables	Policy	Participation
Class 1	Standard	Mandatory	Centralized from raw	Raw data, NRT, same format	CO_2, CH_4 and N_2O, full set of meteo	CC BY	Agreed by the country, 6keuro year^{-1} contribution
Class 2	Standard	Mandatory	Centralized from raw	Raw data, NRT, = format	CO_2, large set of meteo	CC BY	Agreed by the country, 3keuro year^{-1} contribution
Associated	Free	Reduced set mandatory	Postproc. Centralized	HH, every 6 months	One flux and basic meteo	CC BY	Agreed by the country, 1.5keuro year^{-1} contribution
non-ICOS	Free	Suggested	Postproc. Centralized	free	free	FLUX-NET	Free

ICOS data (including raw) are uploaded in the ICOS Carbon Portal (with checksum and metadata) and receive a PID that is used to track access.

Who is supporting all this?

In 2002 EU formed the **ESFRI (European Strategy Forum on Research Infrastructures)** as strategic instrument for decisions on research infrastructures (RI) development in Europe

EU provides funding only to develop the concept and some test activities. After this the proposed RI is established only if EU countries accept to pay for it.

Funding for ICOS is coming from the participating countries (***ministries*** but also ***universities***, ***agencies***, ***research centers***)

The ICOS Ecosystem Thematic Centre (ICOS ETC)

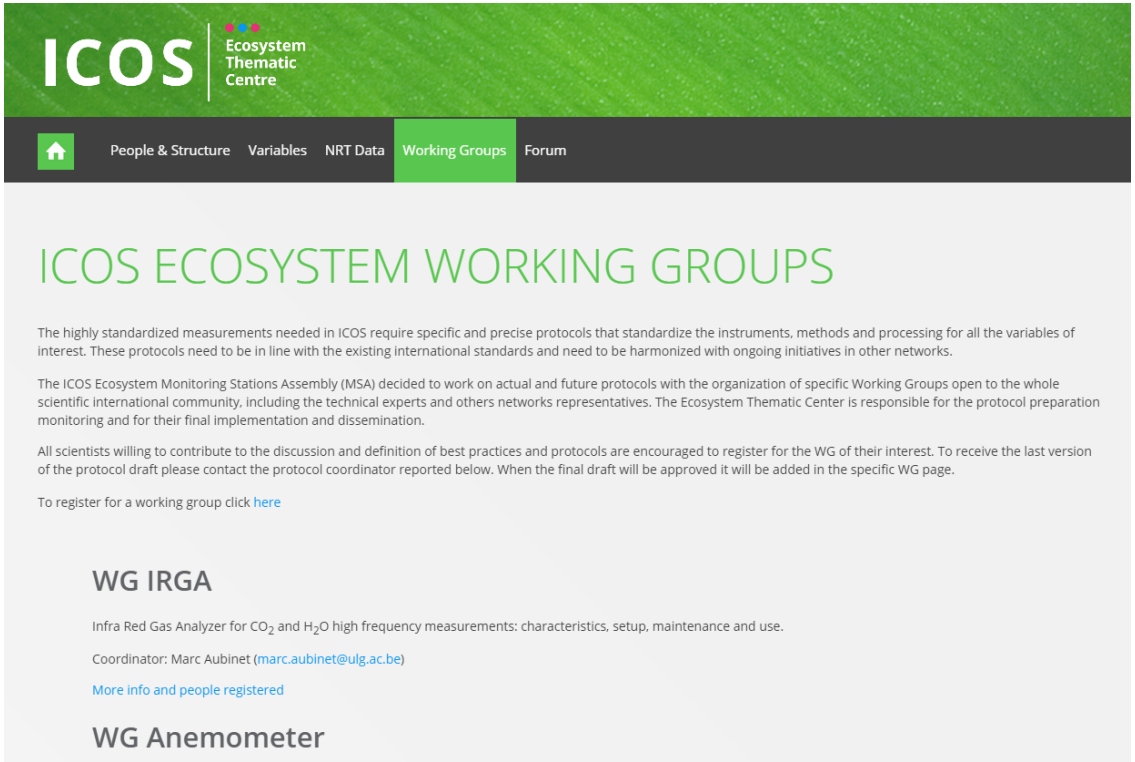
The ICOS ETC is coordinated by Italy (Viterbo) and has offices also in France (Bordeaux) and Belgium (Antwerp). About 9 full time people work at the ETC for a large range of tasks:

- **Check the quality** of the measurements arriving real time (raw data)
- **Process the data** and calculate fluxes and final products
- Coordinate with the assembly of the PIs the **development of measurement protocols**
- Test and develop **new methods and sensors**, interacting with the companies and other networks
- **Evaluate** the performances of the stations
- Perform **chemical analysis** of soil and vegetation samples
- **Assistance** to the ecosystem network and training

ICOS | Ecosystem Thematic Centre

ICOS methods and protocols definition

ICOS Protocols defined by the scientific community through Working Groups open to everybody globally.



Now actively working are WG on **EC over water bodies** (Ivan Mammarella coordinator) and WG on **EC over urban areas**. Plus one on **QC of meteo** You are all invited to sign in:

www.icos-etc.eu/icos/working-groups

ICOS – Protocols are translated in technical manuals

Instruction documents

Protocols are translated in Instruction manuals written and edited by ETC and including practical and easy to apply information about setup and data collection.

The documents are available for everybody online with a DOI:

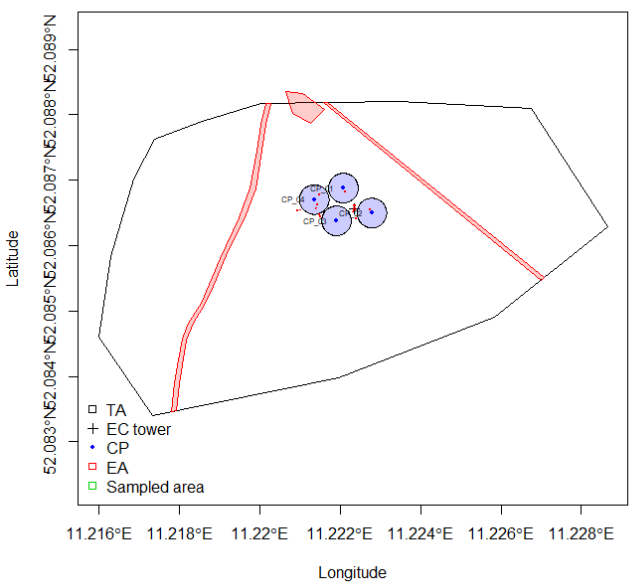
www.icos-etc.eu/documents/instructions

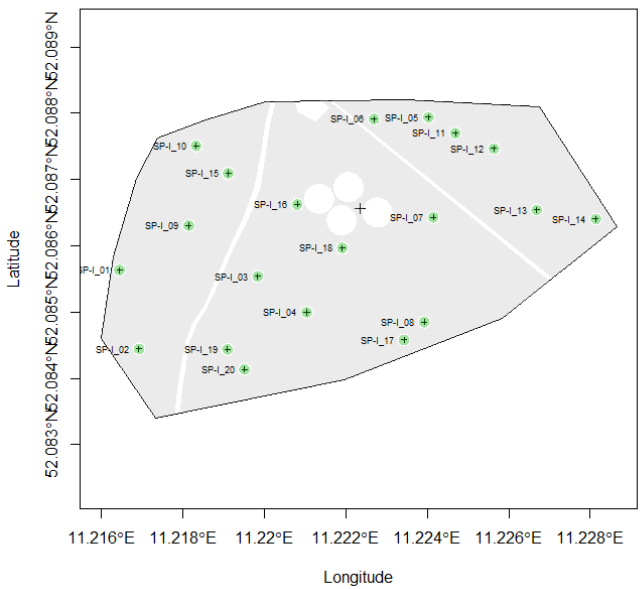
Improve the link with Remote Sensing and sites quality

For each ICOS station a Target Area is defined by the PIs, as the portion of land that they want to monitor with the EC tower. This vector polygon is representing the core ecosystem.

Improve the link with Remote Sensing and sites quality

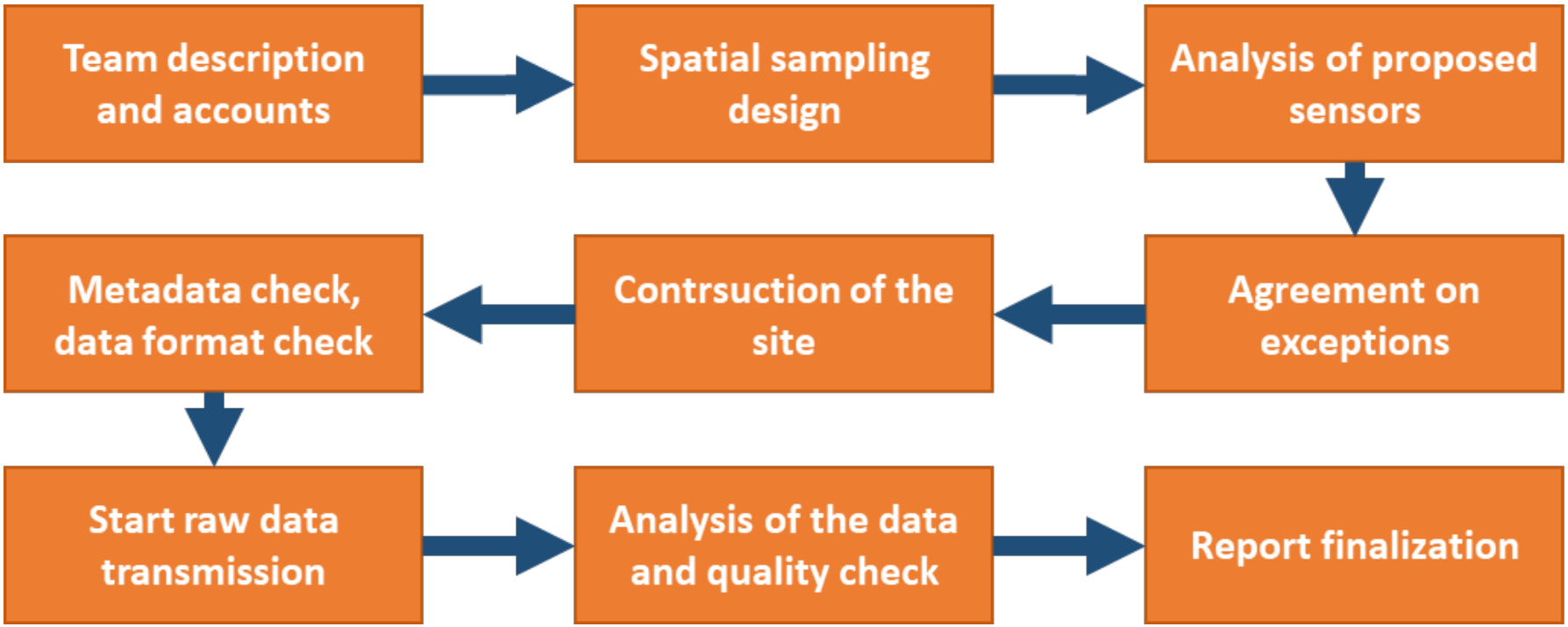
Once defined, the Target Area is characterized with a number of sparse ancillary data measurements (species, biomass, GAI, Soil sampling, trees characteristics etc.) following a stratified random design (prepared by the ETC). In addition fix plots for repeated multiannual ancillary measurements are defined by the PI.





Quality first – the labelling process

Not all the proposed sites are accepted. To ensure quality and standardization all the proposed stations are checked and approved by the ICOS ETC for quality and compliance with the ICOS standard



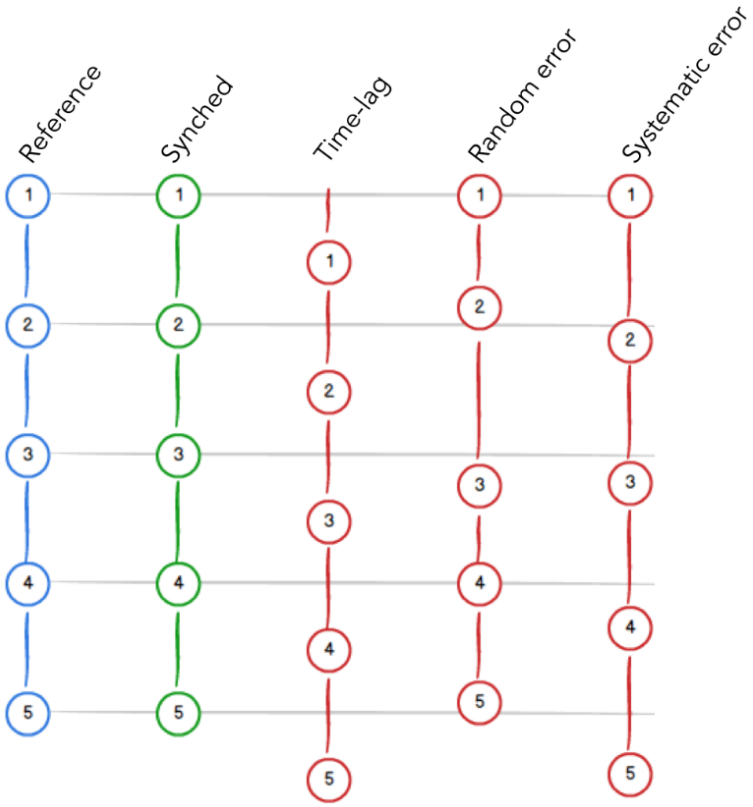
Quality first – test on data

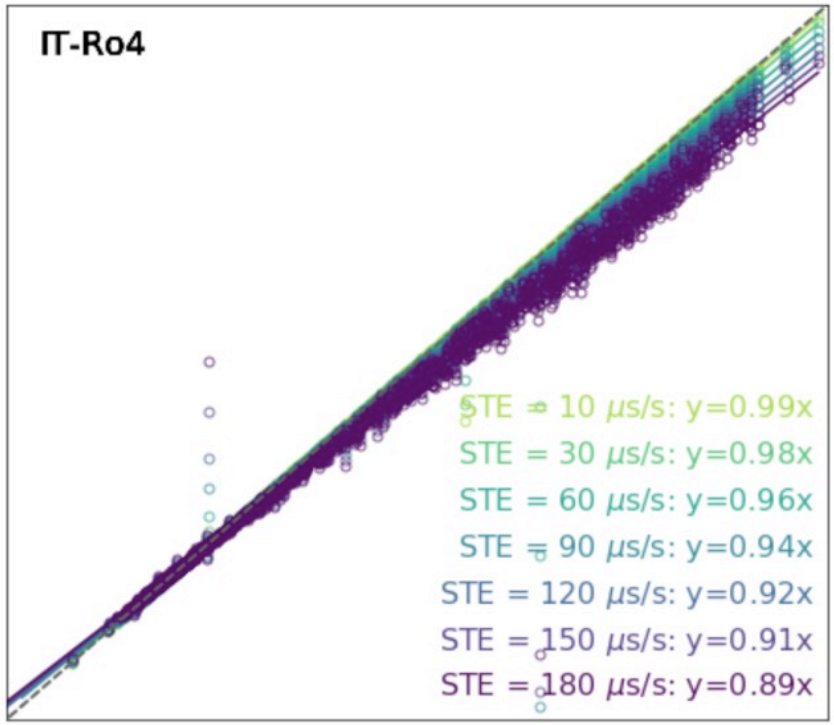
Four tests are applied on the data collected during the labelling:

1. **Not more than 40%** of raw data can be **missing or removed** during the quality check (during the fluxes calculation)
2. At least **70% of the "good fluxes"** must have a footprint contribution of 70% **from the Target Area**
3. **In case of heterogeneity in the Target Area**, sectors where footprint contribution is at least 70% for at least 20% of time must be **well represented during both night and day** and in different periods of the year
4. The areas selected for **continuous ancillary** data monitoring must be **representative of the Target Area**

Sensors diagnostic and synchronization

Diagnostics from sensors are critical to identify issues and clean data. However you need to collect all digitally and this opens a potential issue on data synchronization if not done professionally.

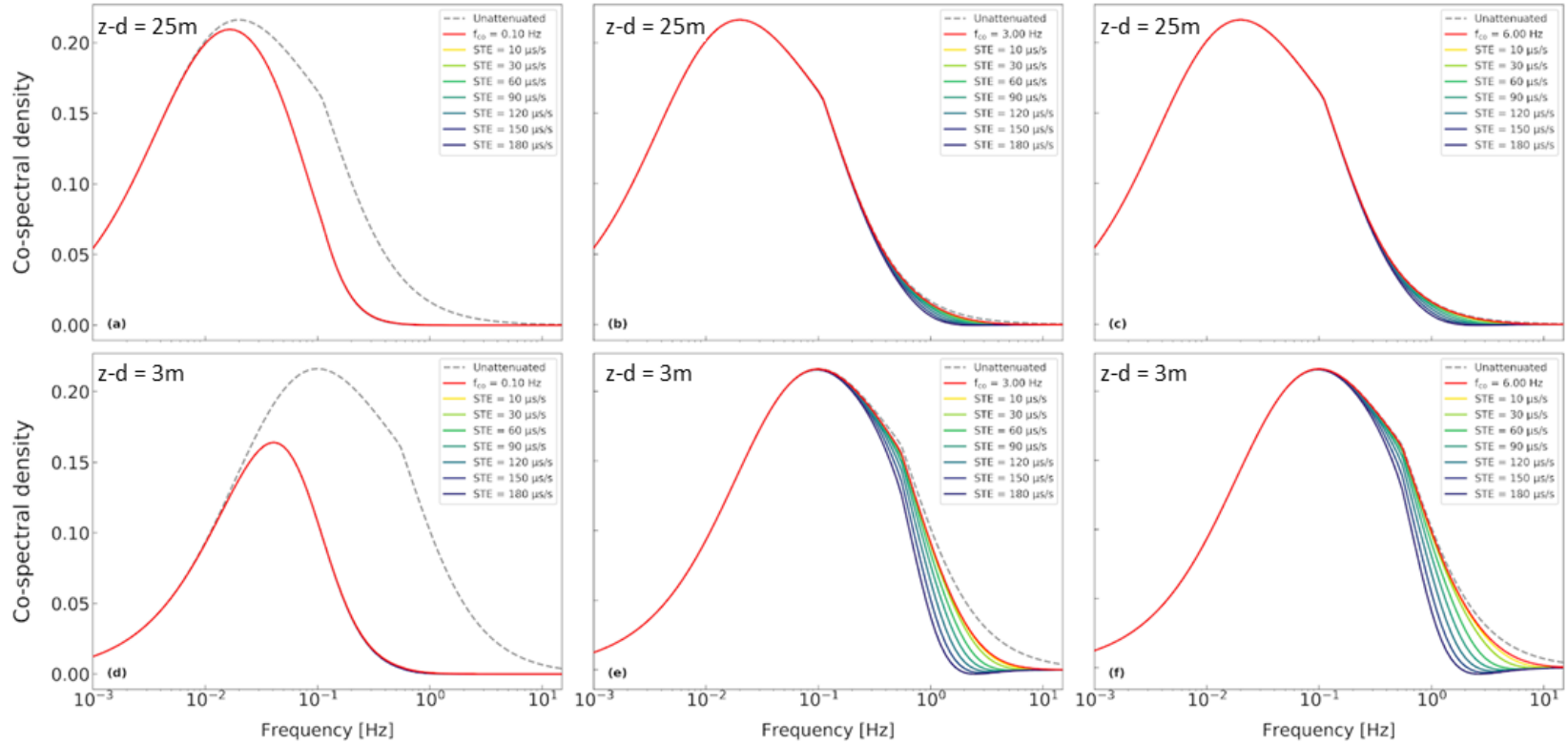




Fratini et al. 2018 Biogeosciences

Sensors diagnostic and synchronization

The problem can affect all the digital streaming systems that are not well designed. The problem acts like a high frequency filter.



cutoff freq. 0.1 Hz *cutoff freq. 3.0 Hz* *cutoff freq. 6.0 Hz*

Fratini et al. 2018 Biogeosciences

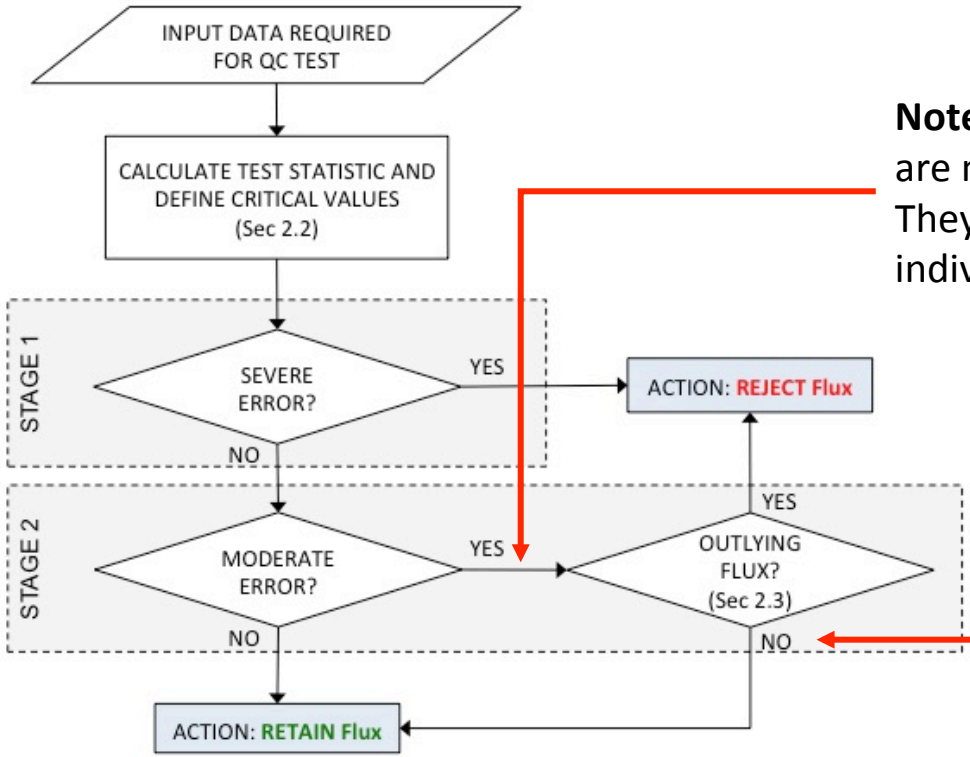
QA-QC filtering strategy

A good data filtering is critical for the quality of the final product. Objective QAQC are complex but needed, making maximum use of metadata, instruments flags and status indicators and statistical tests.

Types of error	**Test** ***(examples)***
Integrity of raw-data (gaps, diagnostics of the instruments, wind sectors etc.)	% of not available records
Instrumental problems not detected by the diagnostic e.g. - Signal resolution (limited digits) - Dropouts (continuous fix value) - Presence of spikes - Discontinuities (jumps in the	Statistical tests (e.g. kurtosis)
Violation of stationary conditions	Foken and Wichura (1996), Mahrt (1998)
Lack of well-developed turbulence conditions	Foken and Wichura (1996)
Suitability of spectral correction procedure	Spectral correction factor magnitude

QA-QC filtering strategy

An integration strategy for the different tests results must be used and it should be objective, reproducible and traceable. A two stage procedure involving also an outlier detection test is under refinement.



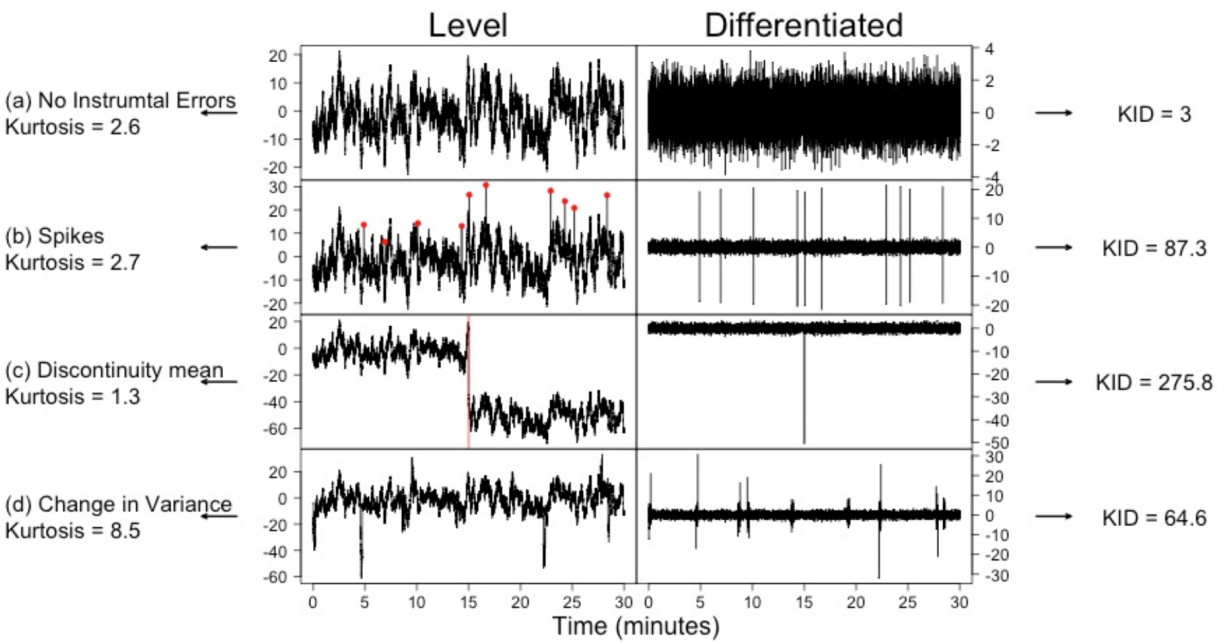
Note: moderate flags are not combined. They are treated individually

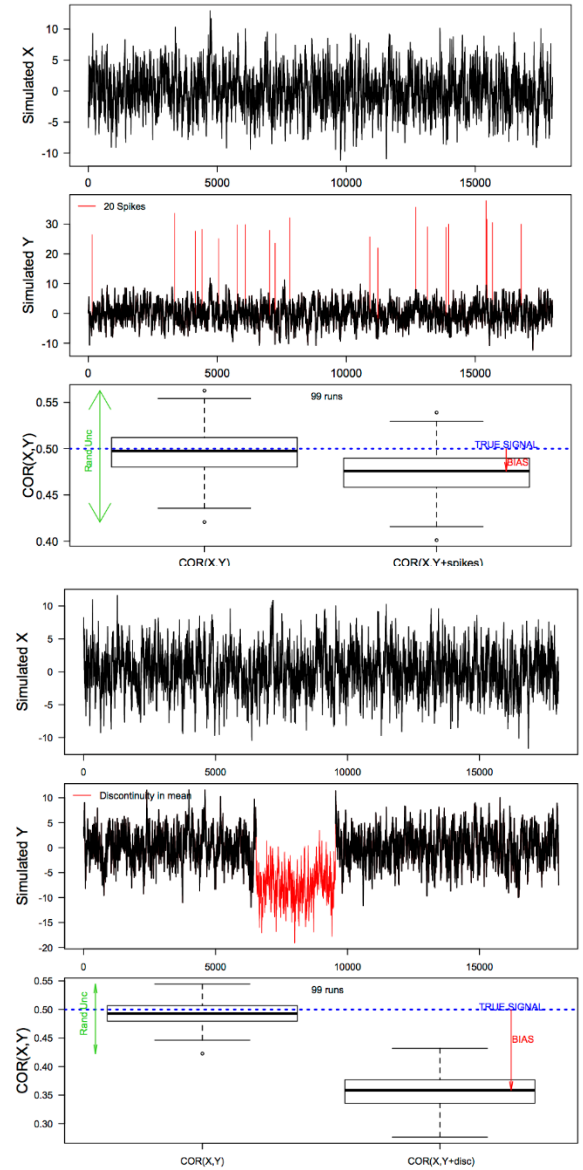
Note: if outlier but without flags it is retained

Vitale et al. *in prep*

QA-QC filtering strategy - development

A lot of improvements and developments needed to make it statistically robust and usable in an automatic way





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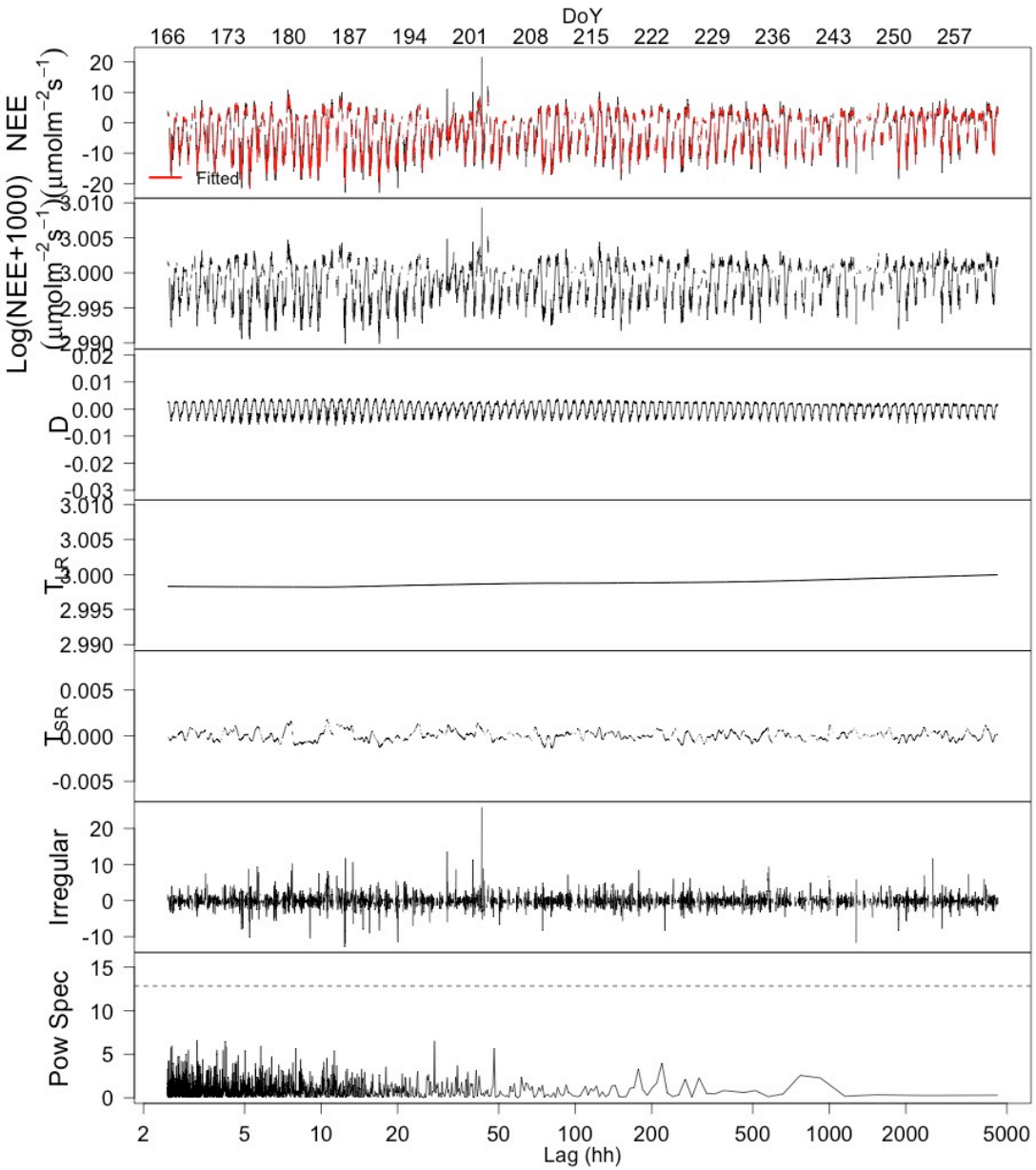
QA-QC filtering strategy – development outlier det.



Fitting, residuals and then statistical analysis of residuals distribution based on flux classes

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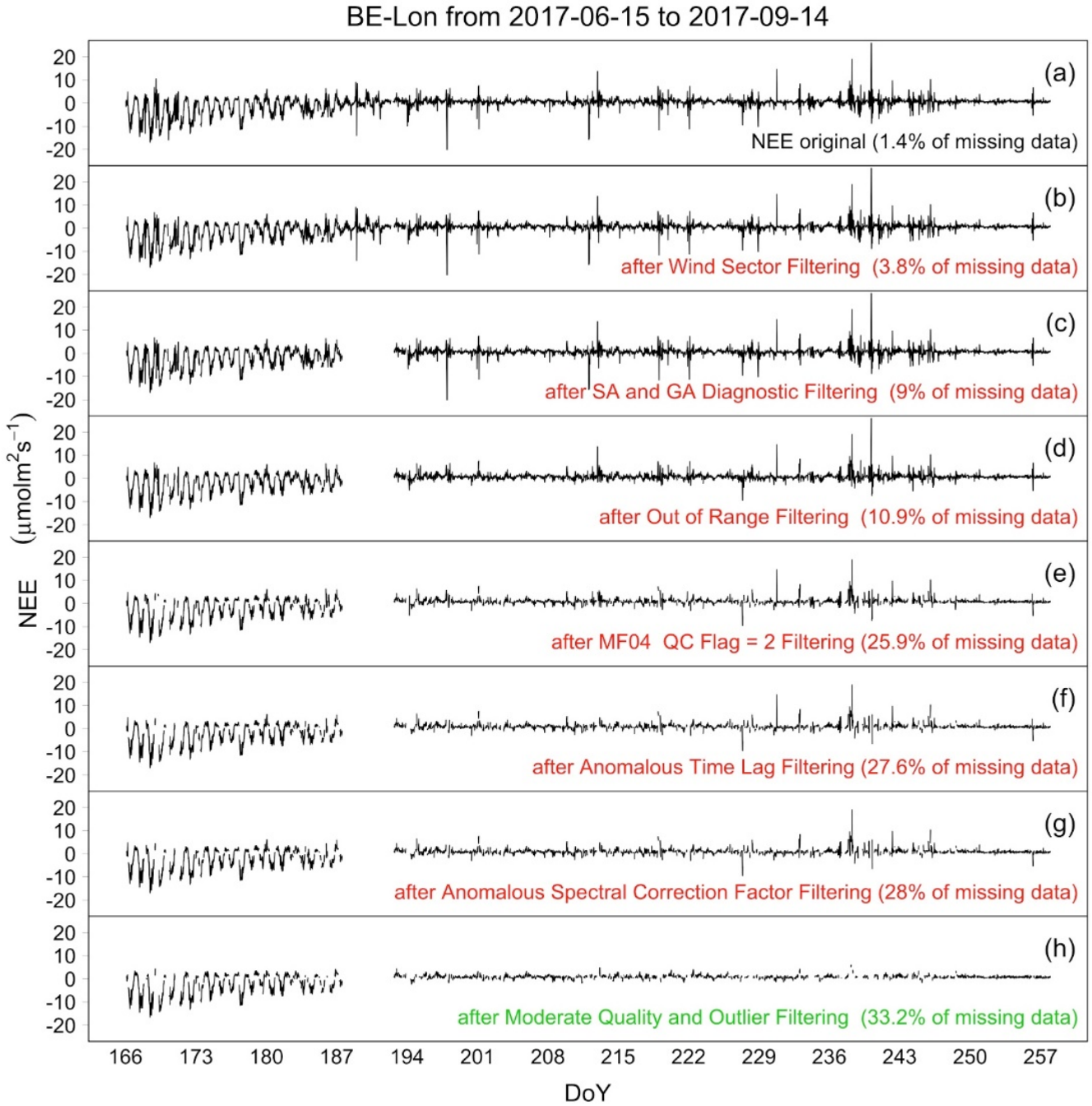
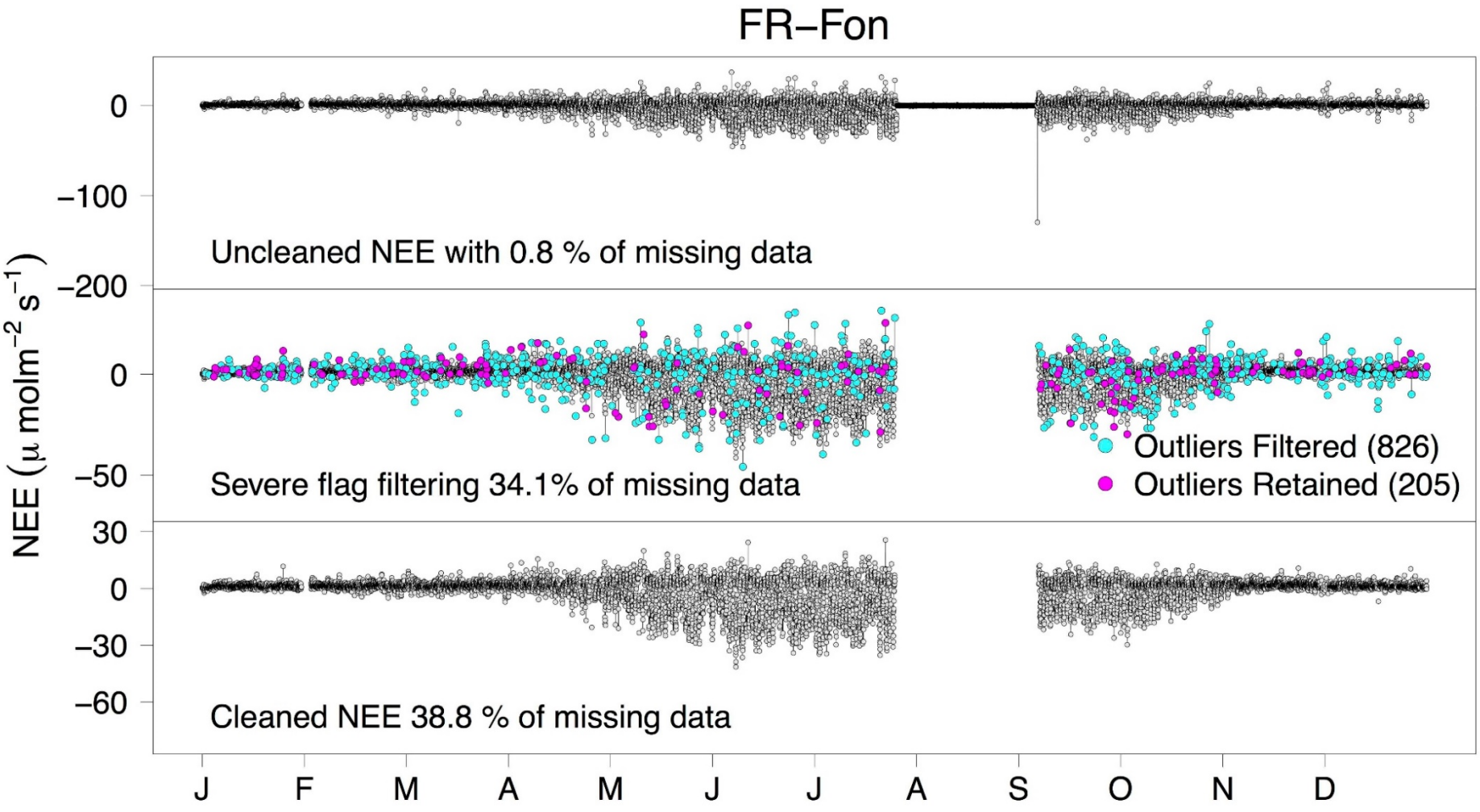
QA-QC results



QA-QC results

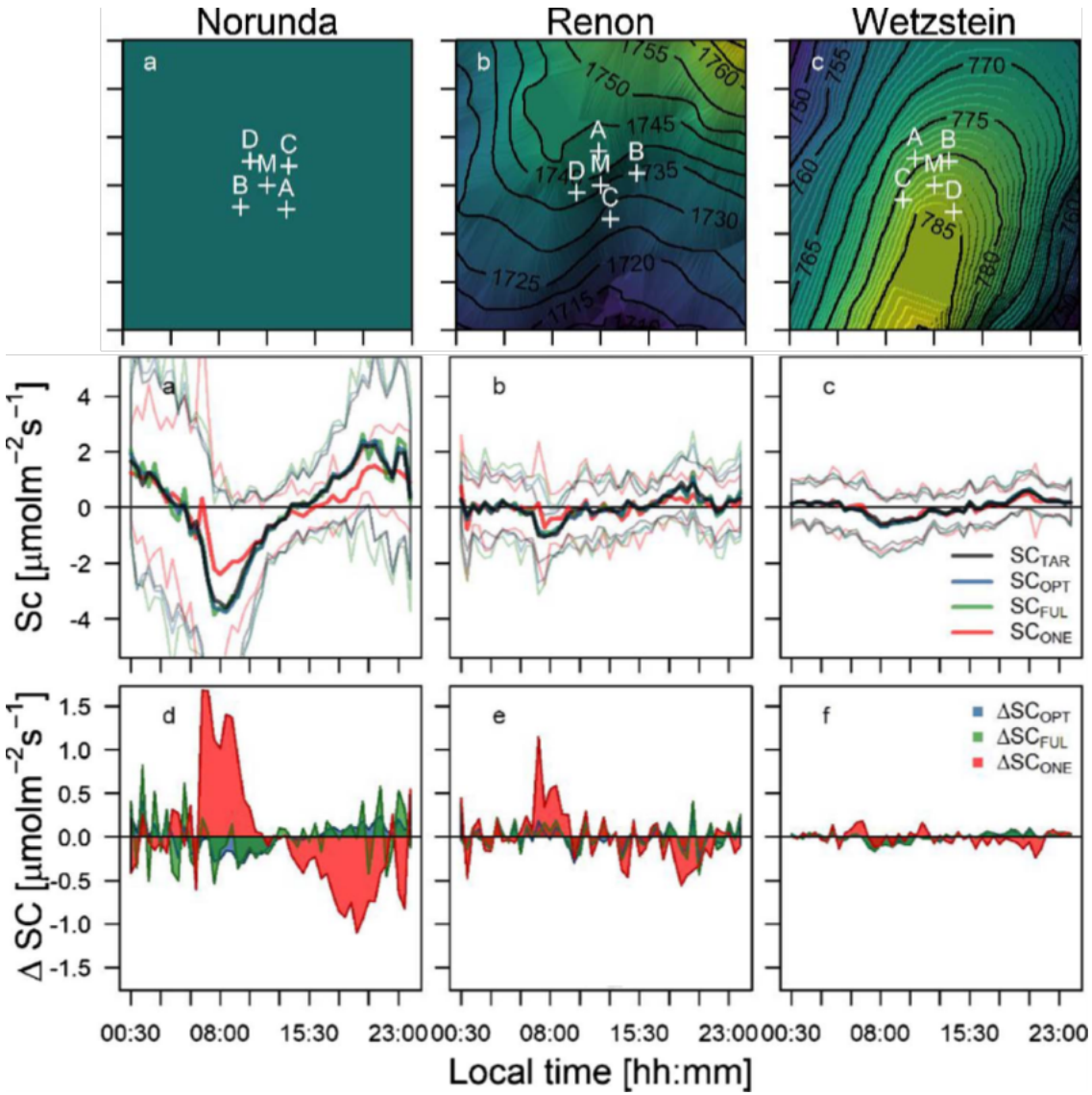


Storage flux measurement strategy

How much is it important to correctly measure the storage flux? And which is the best setup?

Analysis made using a cluster of 5 towers in three different sites.

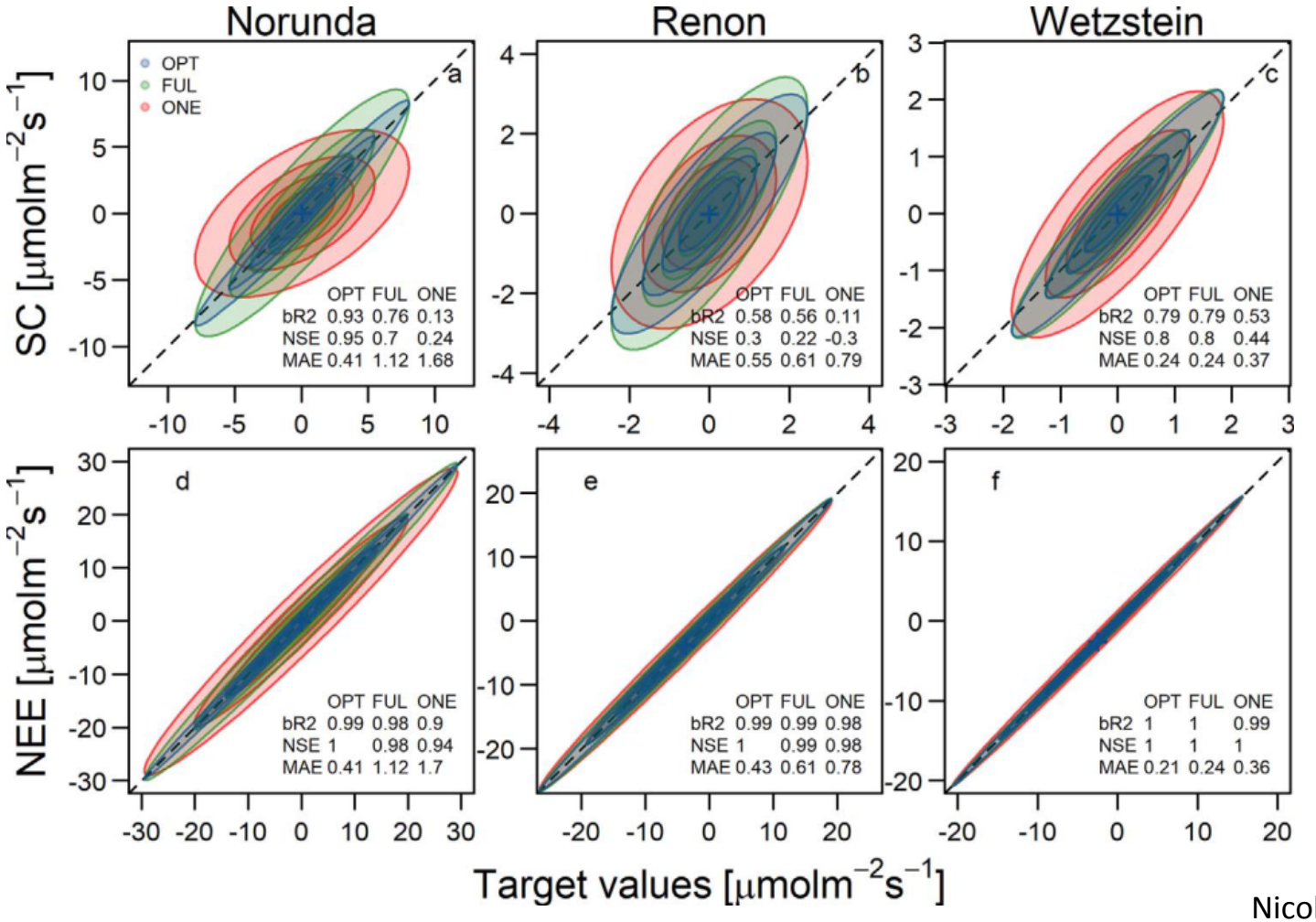
- *= 5 profiles for 5 levels*
- *= 1 profile + 4 points ground*
- *= 1 profile*
- *= No profile, single point*



Nicolini et al. 2018

Storage flux measurement strategy

= 1 profile + 4 points ground *= 1 profile* *= No profile, single point*



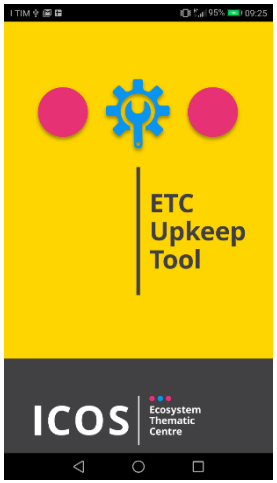
Nicolini et al. 2018

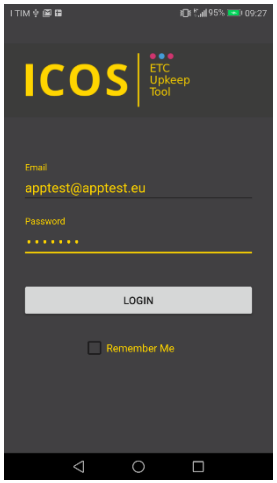
Metadata organization and collection

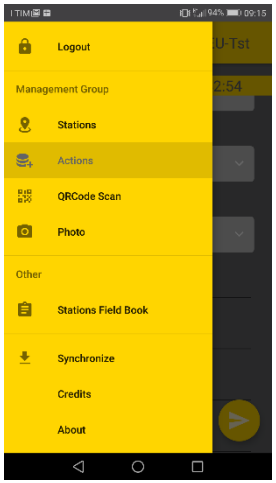
BADM is the only method, also in ICOS

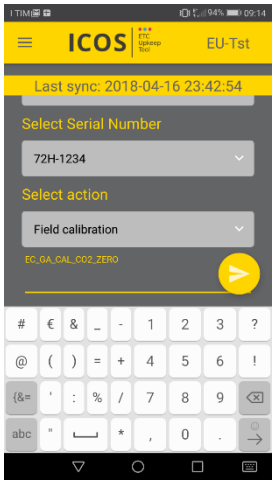
Starting from raw data (not only EC and meteo but also DHP, single trees info, spatial sampling design, veg and soil samples etc.) required about 350 new variables. They are all following the BADM structure, rules, principles and not overlapping with the existing shared across networks.

Possible with template Excel or csv (www.icos-etc.eu/documents/templates), with web interface and for the sensors maintenance and installation with a mobile APP (Android only)









The ICOS ETC Upkeep Tool APP

Includes a digital FieldBook that the team can consult also online. If you want to try:
User: apptest@apptest.eu
PW: apptest

Google Play

Collaboration

In the last years there have been a number of great achievements in the collaboration between **AmeriFlux** and **European-ICOS** networks, also thanks to EU funding dedicated to the international collaboration.

1) **Common centralized data processing** so that the data are fully compliant. This also helped to save resources (no duplications, develop codes together, common repository in GitHub).
2) Same **variable names, codes, descriptions, units and structure**. To call the same thing in the same way in USA and in Europe.
3) **Same metadata and ancillary data system and templates (BADM)**, with same options and rules. In this way also the metadata and ancillary data are fully comparable and well organized.
4) **Standard system to assign FLUXNET codes (CC-###)** to the sites (used also in the FLUXNET synthesis activities) so that the stations are uniquely and internationally recognized

ICOS is not developing anithing overlapping with what we are doing together. The European Database is following exactly the same schemes of AmeriFlux.

Conclusions

1) **ICOS is completely open access** (data, protocols, instructions, working groups etc.), you are all invited to use and participate.
2) Quality on **Eddy Covariance can be still improved a lot**, in particular for “new” measurements like over **water** and **urban**. Join the Working Group if interested.
3) The use of **common rules** in different networks and a constant **discussion and coordination** make the tools and docs developed easily applicable across networks and improvements and bugs spotting and fixing faster (larger communities)
4) **Collaboration among regional networks** is important, we should always continue and make it even more deep. And it helps to establish very nice **human relations**.