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The Ecosystem Component of ICOS

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The Ecosystem Component of ICOS

1. Why ICOS ?
2. What is ICOS ?
3. The Ecosystem component of ICOS;
   - What is measured ? When ?
   - How are data controlled, quality checked,
   - How are they disseminated ?
4. Discussion

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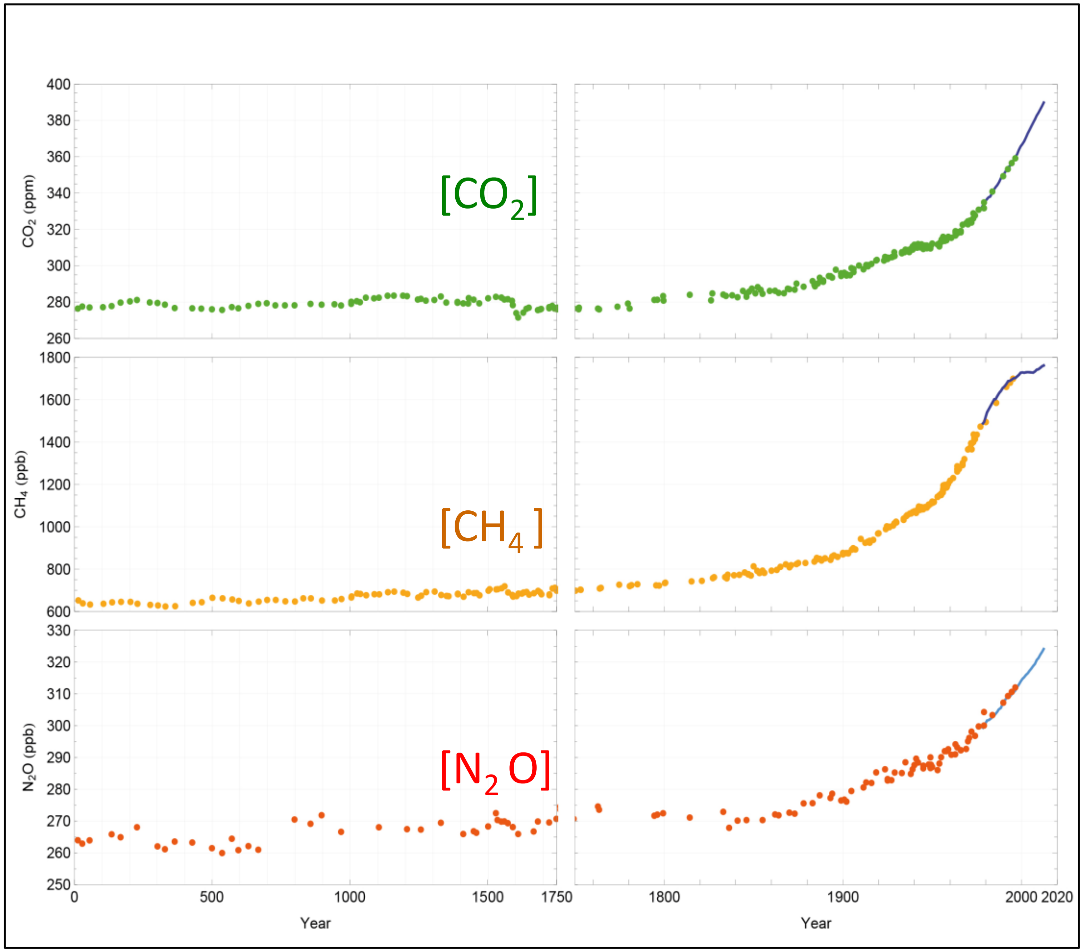
1. Why ICOS ?

- The exponential increase in GHG concentration

- Atmosphere and climate are changing



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1. Why ICOS ?

8.3±0.4 PgC/yr **90%**

1.0±0.5 PgC/yr **10%**

+

4.3±0.1 PgC/yr

46%

2.6±0.8 PgC/yr

28%

Calculated as the residual
of all other flux components

26%

2.5±0.5 PgC/yr

Source: [Le Quéré et al. 2012](); [Global Carbon Project 2012]()

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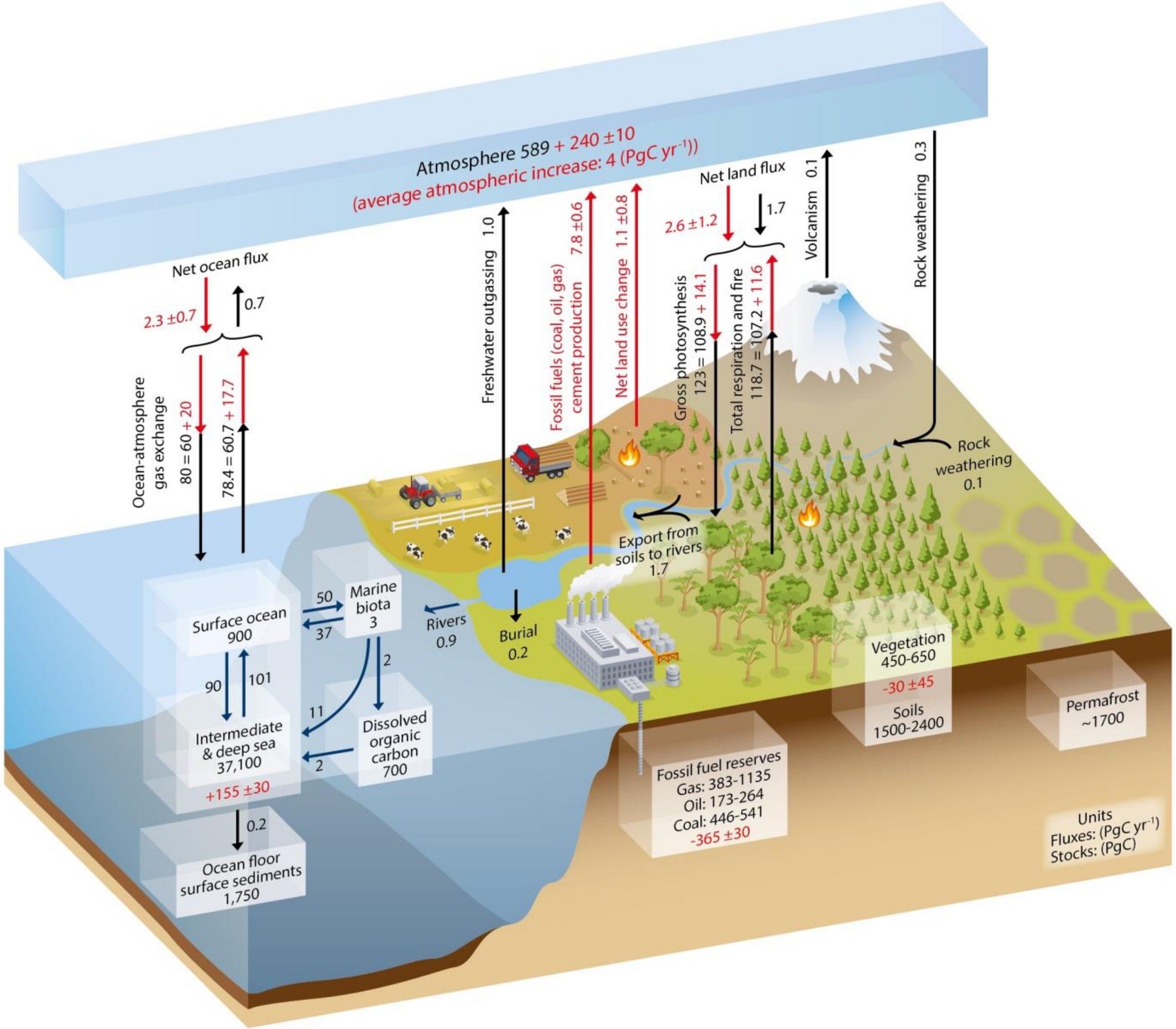
1. Why ICOS ?



The global carbon cycle
(in red anthropogenic sources)

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Temporal trend in the terrestrial sink

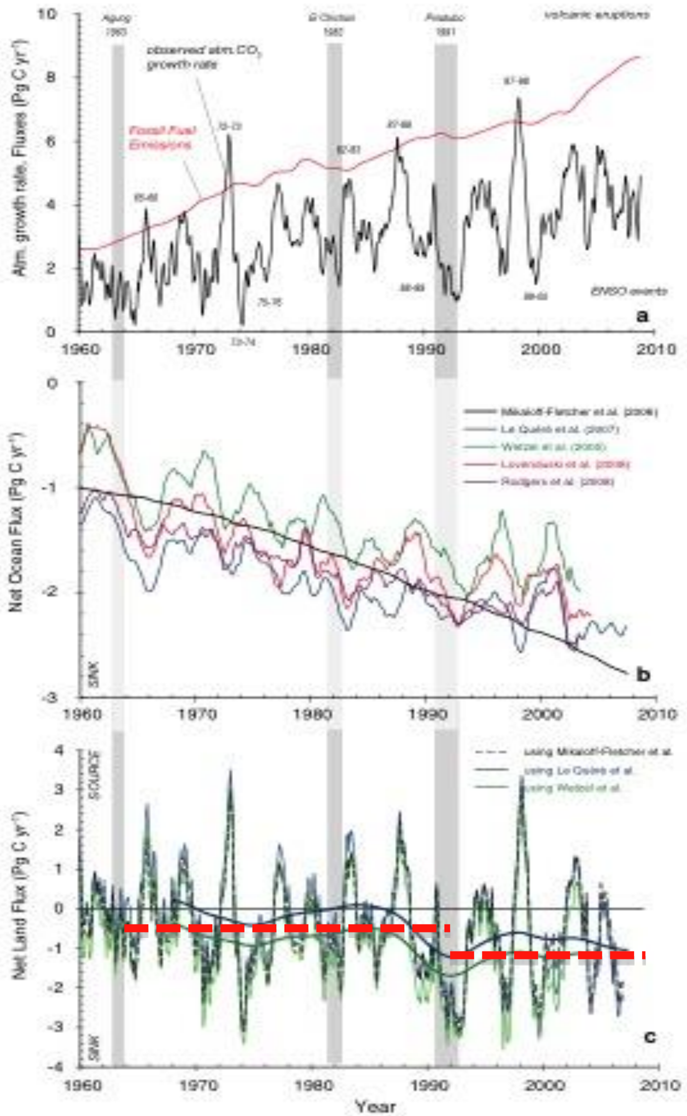
Fossil fuel emissions

Net CO2 increment in the Atmosphere

Modeled Ocean C sink
(5 models)

Residual flux
attributed to the Land:

- Not directly measured
- Large temporal variability,
- Unpredictable



- Sarmiento et al. *Biogeosciences* , 2010

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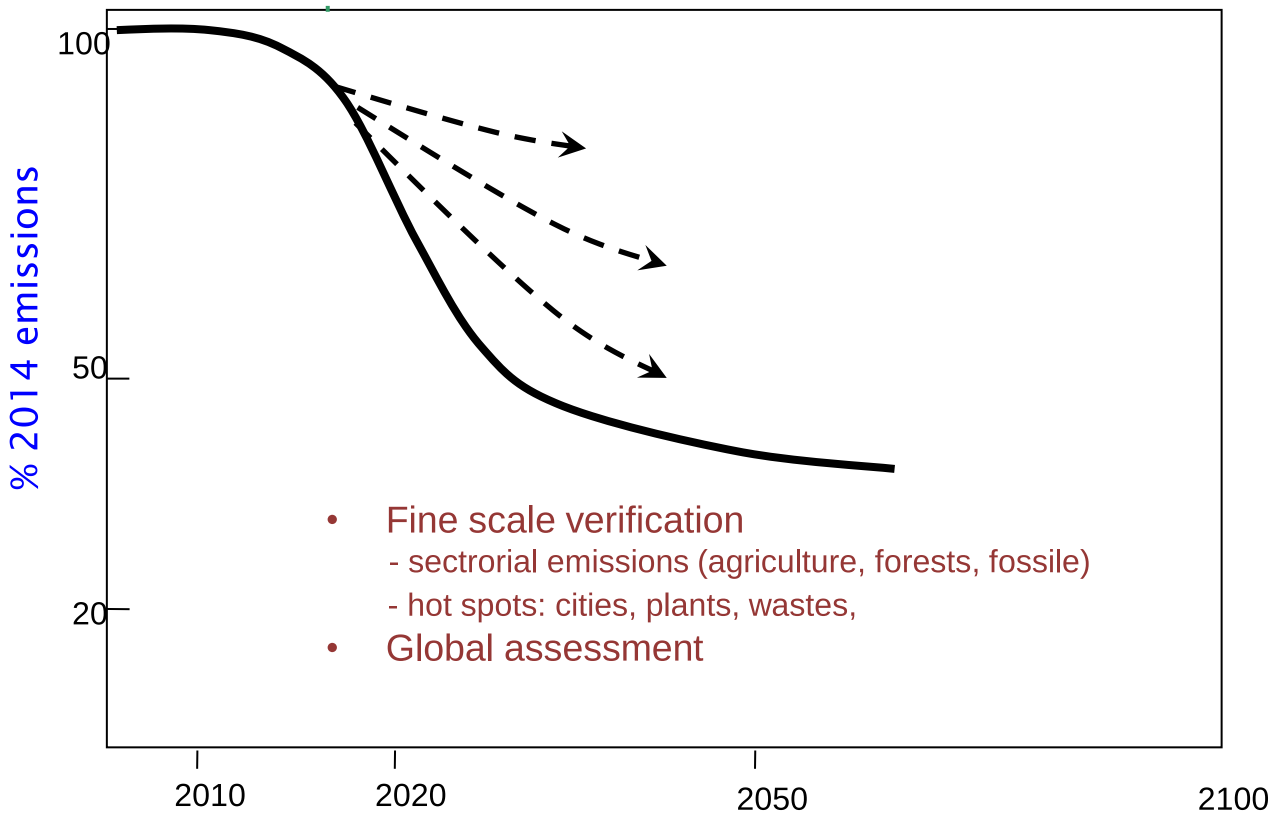
The future:

GHG concentrations trajectories :



- Fine scale verification
  - sectrorial emissions (agriculture, forests, fossile)
  - hot spots: cities, plants, wastes,
- Global assessment

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The challenge : measure the terrestrial sink

Wish list:

- Systematic observations over land, atmosphere and ocean
- Long term continuity of observations
- Consistent *in situ* and remotely sensed data
- Continuous ranges of spatial and temporal scales
- Integrated data assimilation capabilities

Realities:

- Many different national programs
- Bottom up networks to be assembled

Questions

Verification of reduction policies:

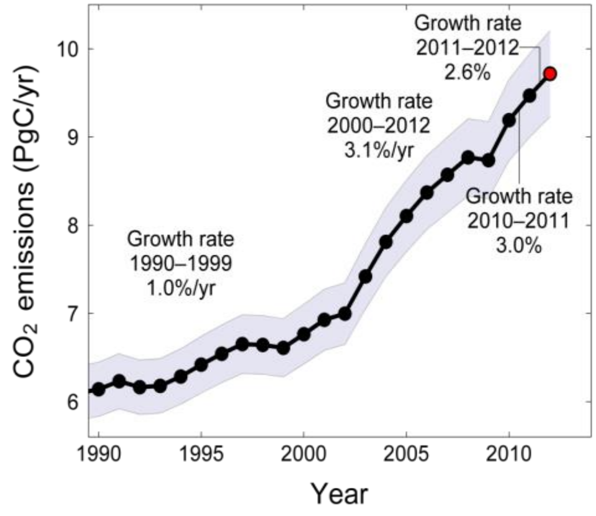
- Crops, cattle, forest
- Infrastructures, regional management
- Industry
- Governmental policies

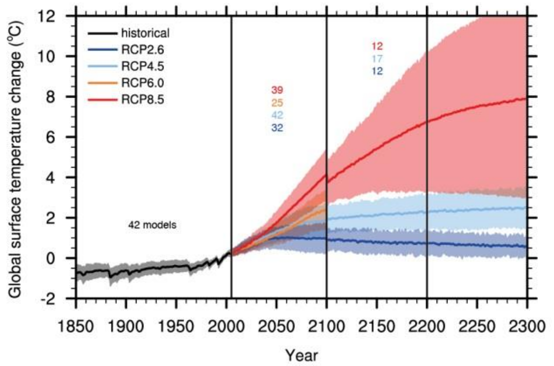
Narrowing the uncertainties on GHG balance at relevant scales:

- Management unit, farms, forest districts
- Cities
- Region, states
- Countries
- Continents

Managing the future:

- Widening our understanding of GHG cycle
- Enhancing our predictive capacity





Answers: a world class infrastructure dedicated to the accurate GHG cycle monitoring;

- Distributed, accurate, precise and continuous environmental monitoring

→ Checking the impacts of policies on the environment

- Densifying and homogeneising measurements networks
- Make them interoperable and consistent

→ Narrowing uncertainties in GHG cycles

- Linking ground to space observations
- Enhancing models and data assimilation into models

→ Assessing the present and anticipating the future of GHG cycle and climate

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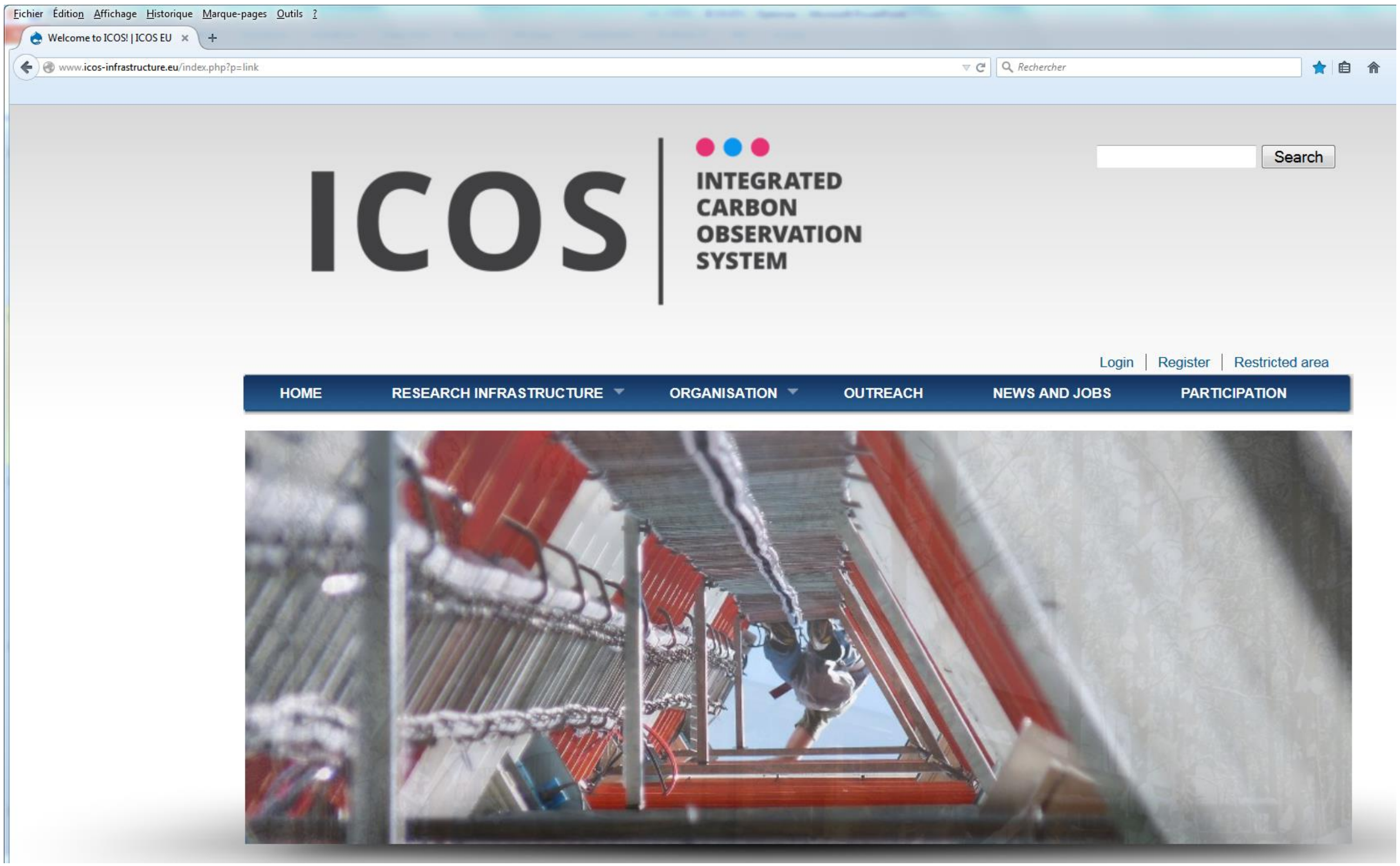
2. What is ICOS ?



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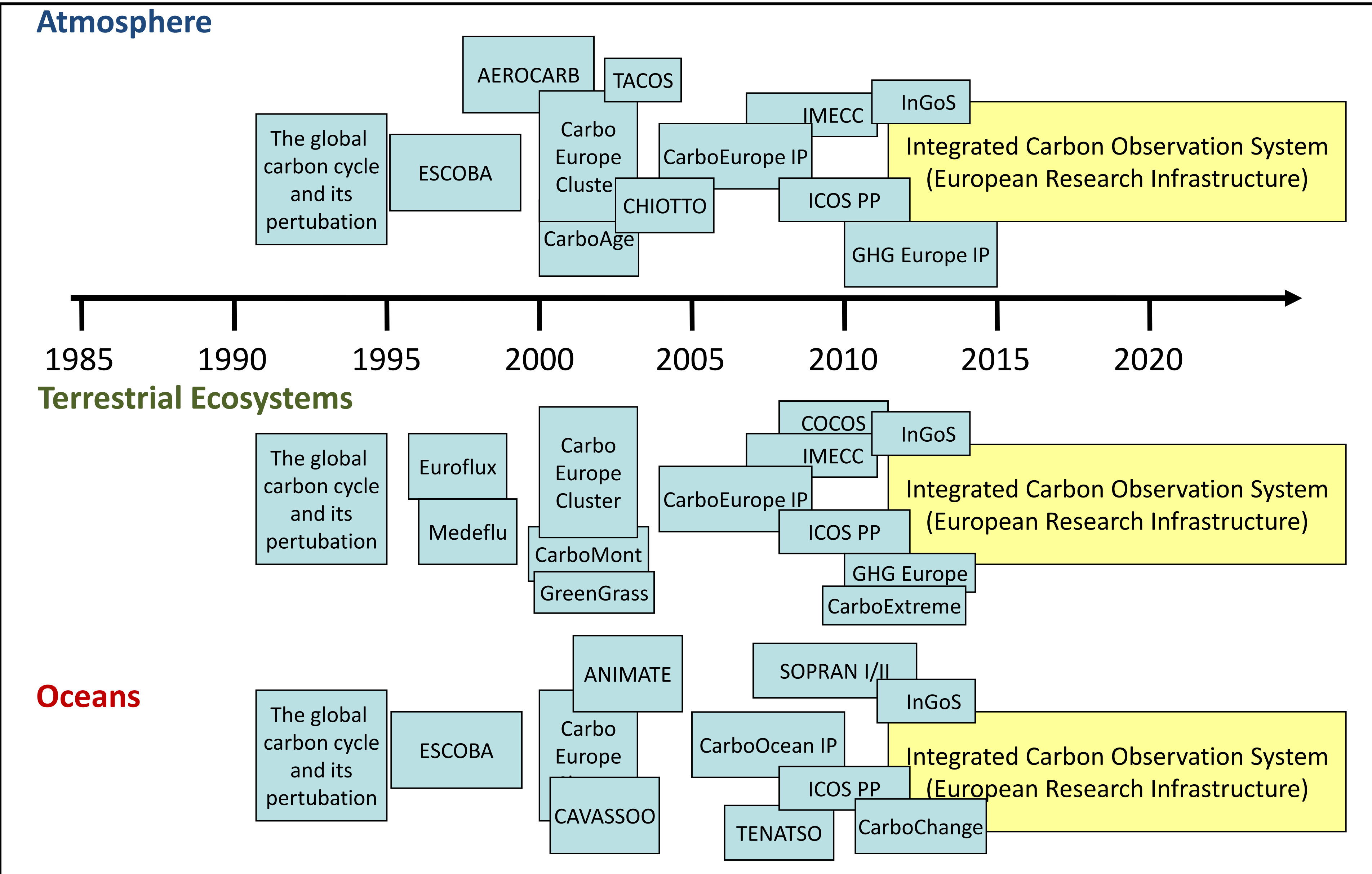
The ICOS scientific mission

ICOS is a network of sites where GHG atmospheric concentrations and terrestrial and oceanic fluxes over Europe and key regions of European interest are measured

ICOS data and structure will support:

- A fundamental **understanding** of carbon cycle, greenhouse gas budgets and perturbations and underlying processes,
- The ability to **detect changes** in regional GHG fluxes, early warning of negative developments, **response** of natural fluxes to disturbances and **predict future changes** in GHGs balances providing timely information to policy makers,
- The **verification** of the effectiveness of policies aiming to reduce greenhouse gas emissions and/or increase carbon sequestration, or the estimates of ecosystem services
- technical and scientific **innovation**, mobility of researchers, education and capacity building , including support to new European research programs

ICOS history in short (1/2)



ICOS history in short (2/2)

R&D, design studies

2001-2008

CarboEurope-IP,
CarboOcean-IP
Other research projects
National networks

ICOS ERIC 2014
European Research Infrastructure Consortium

Preparatory phase (EC-FP7)

2008-2013

EU funding

Transition phase

Construction phase

2011-2016

National contributions

Operational phase

2015-…

National contributions + EU funding

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Environmental and GHGs related European RIs

(not exhaustive list)

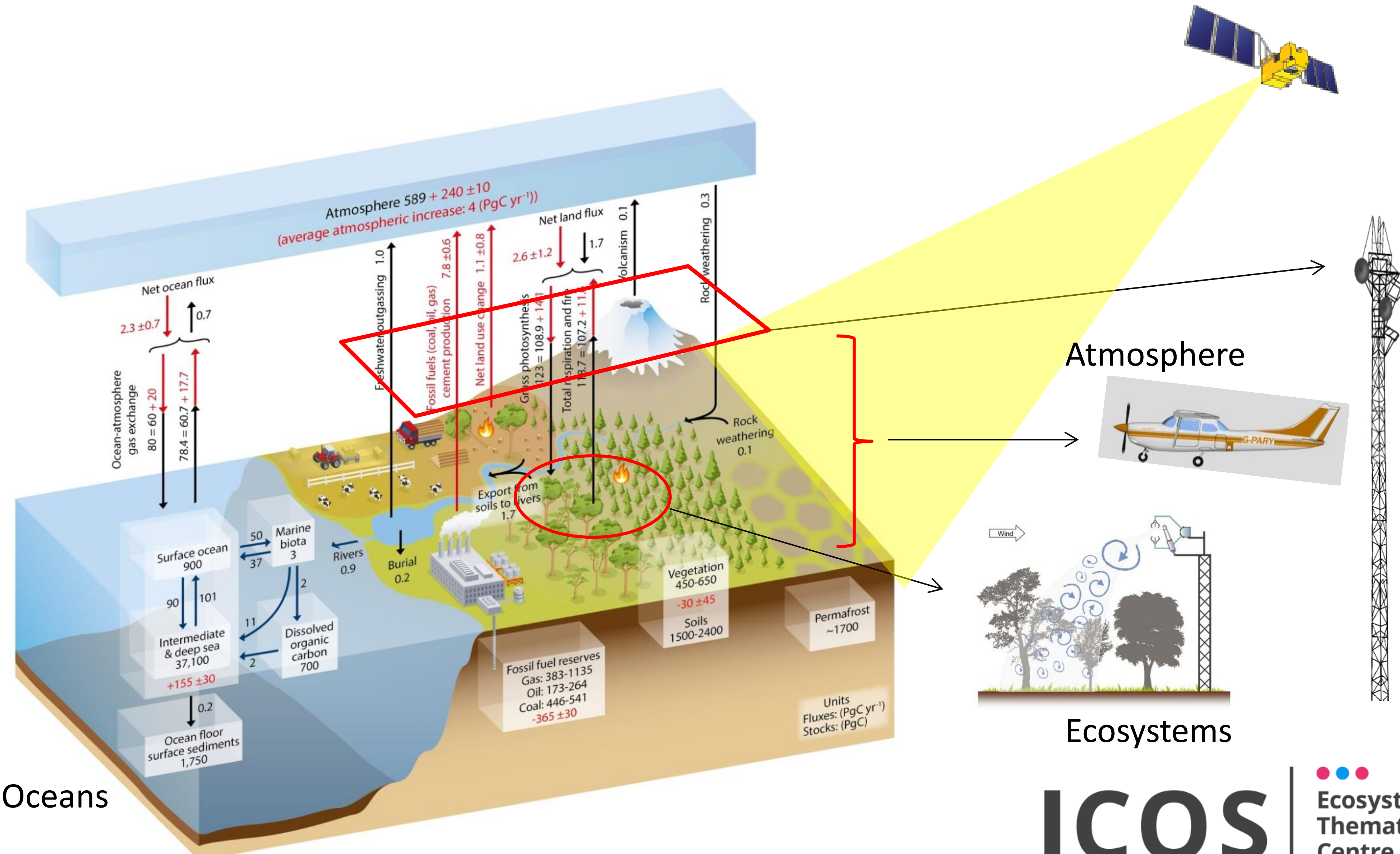
Integrated long term, high precision observations of GHGs in the atmosphere and at the ocean and land surface

Infrastructure for observations of atmospheric composition from long-range in-service aircraft of international airlines

European e-Science infrastructure for biodiversity and ecosystem research

Research infrastructure for experimental manipulation of managed and unmanaged terrestrial and aquatic ecosystems

GHG cycle: the ICOS observation strategy



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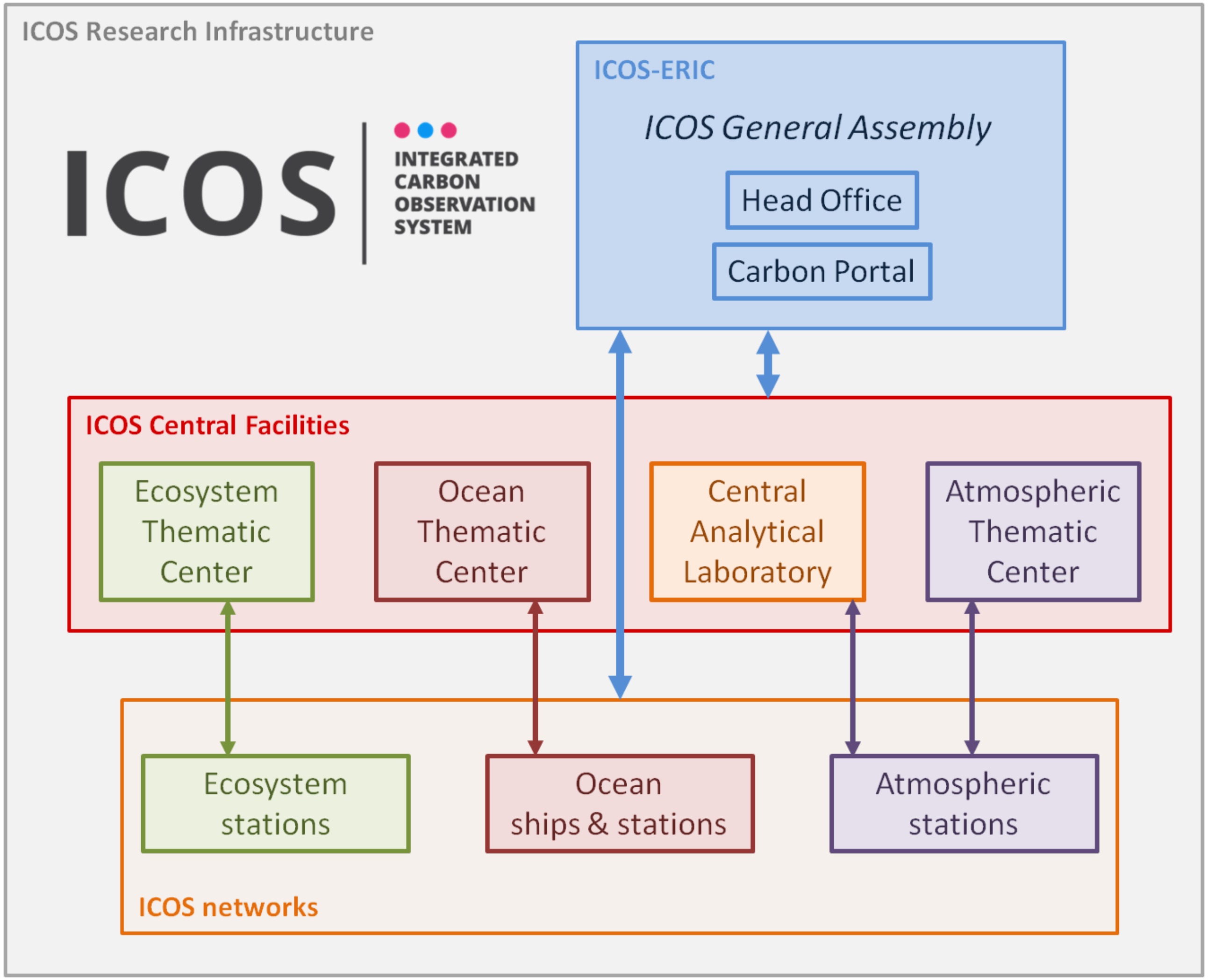
2. What is ICOS ?

ICOS is:

1. A networks of sites measuring GHGs in the ecosystem, atmosphere and ocean compartments
2. Four thematic centres that coordinate the activity of the sites
3. One EU level head-office and web portal



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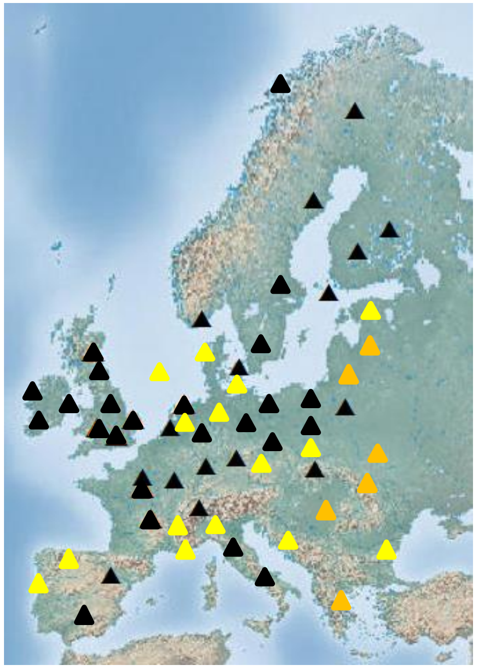
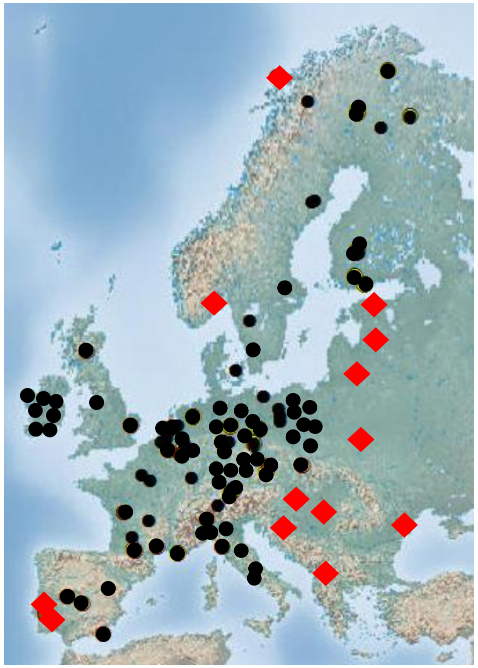
The 3 ICOS monitoring networks

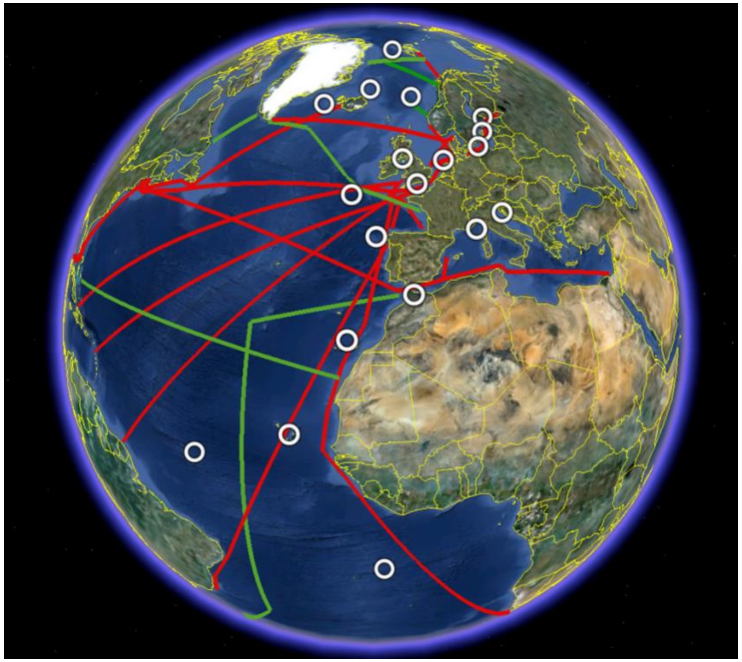
Atmosphere



Ecosystems



Oceans



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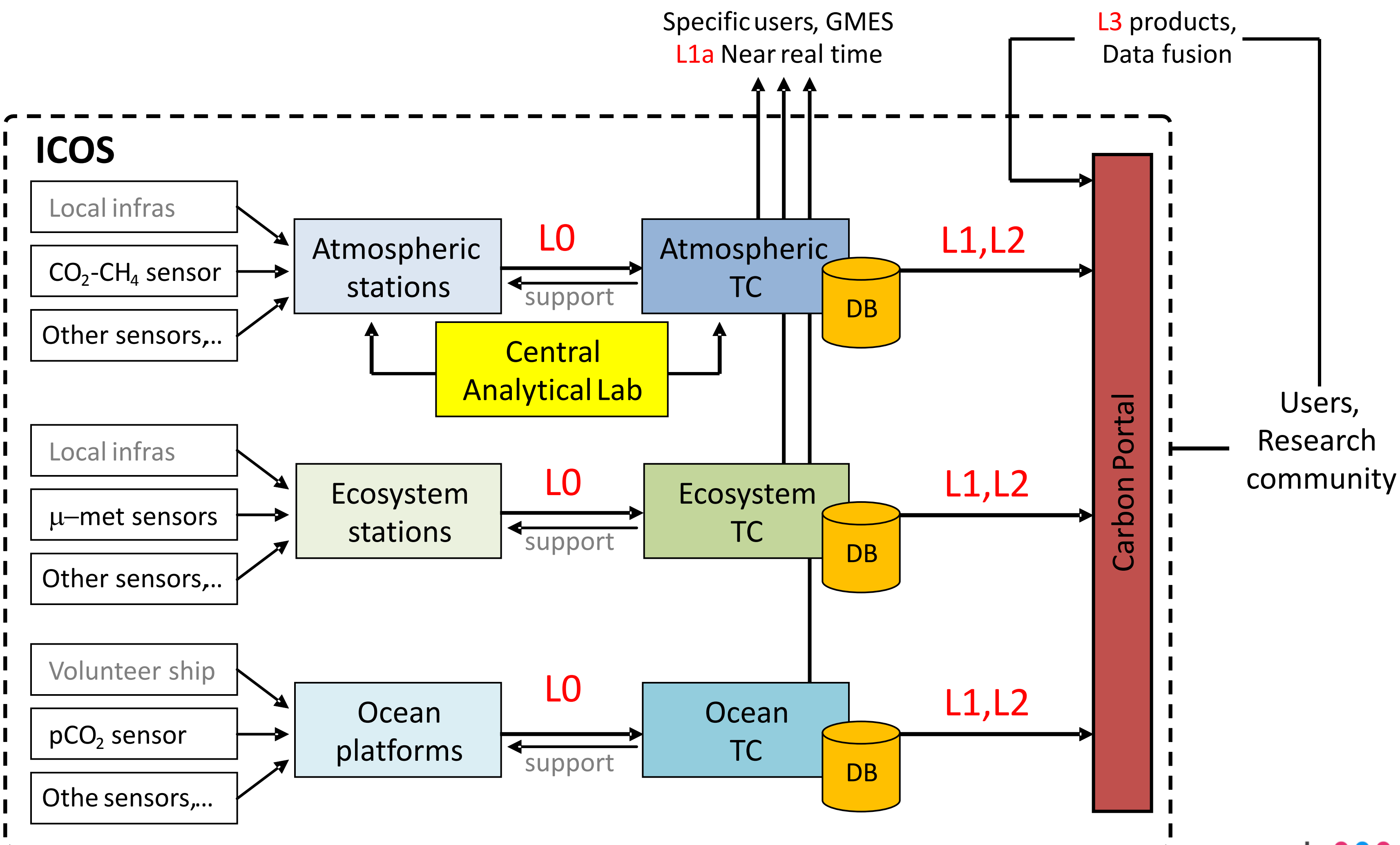
Data flow through ICOS



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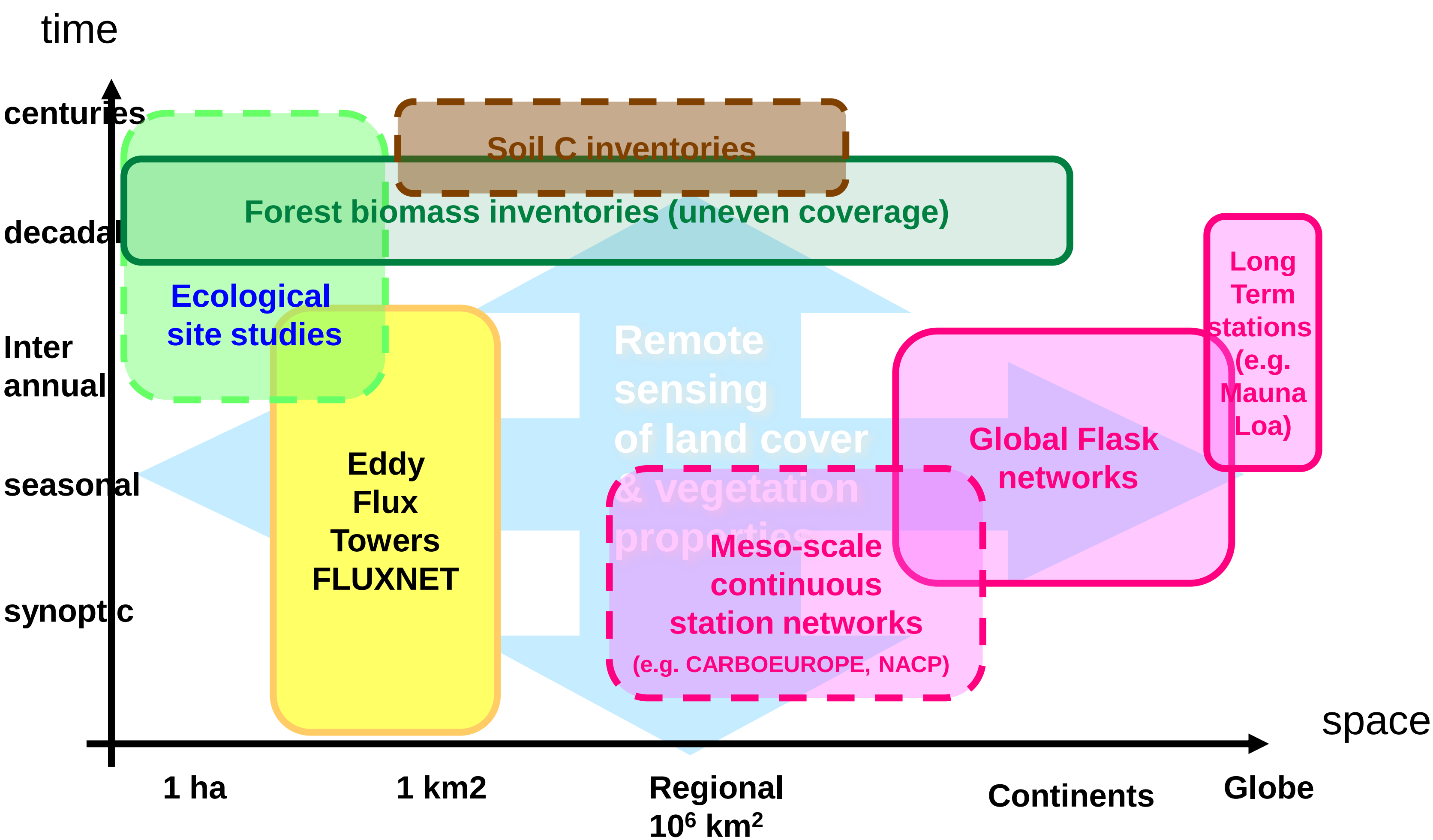
Observations across time and space scales



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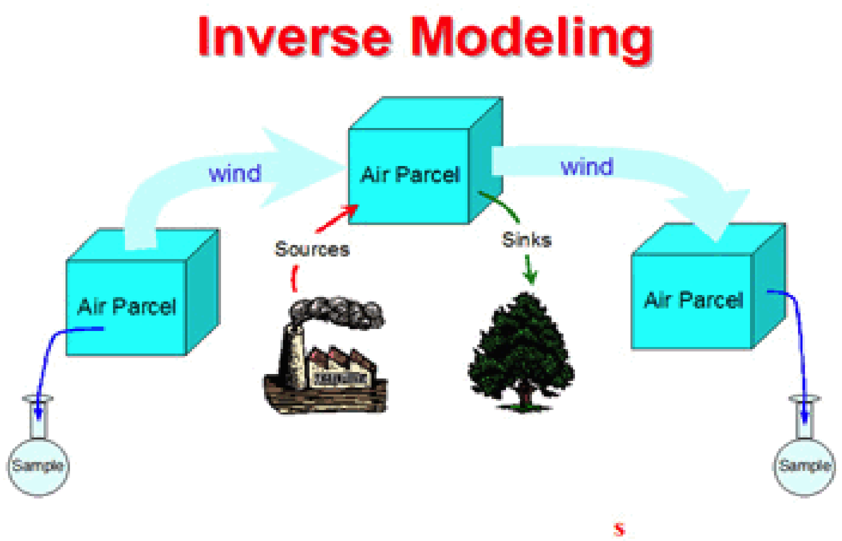
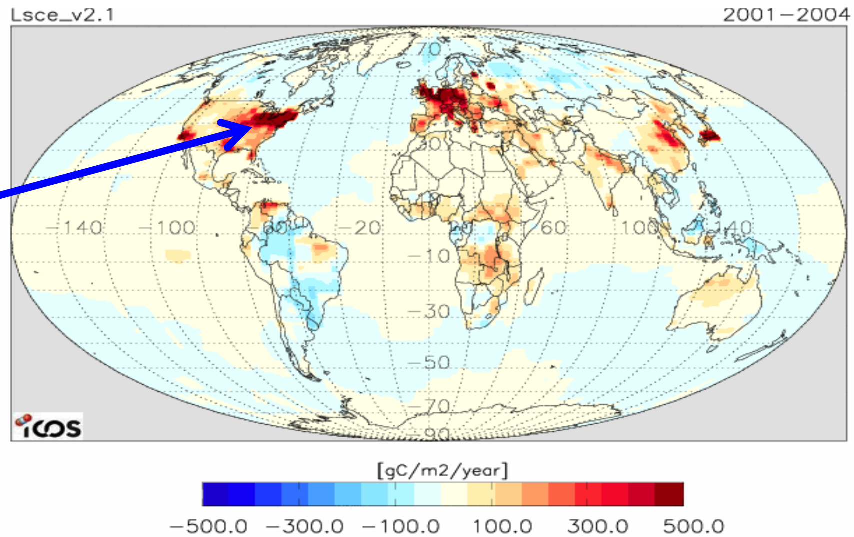
Atmospheric inversion



Provides continous estimate of surface flux at 50 x 50 km daily resolution

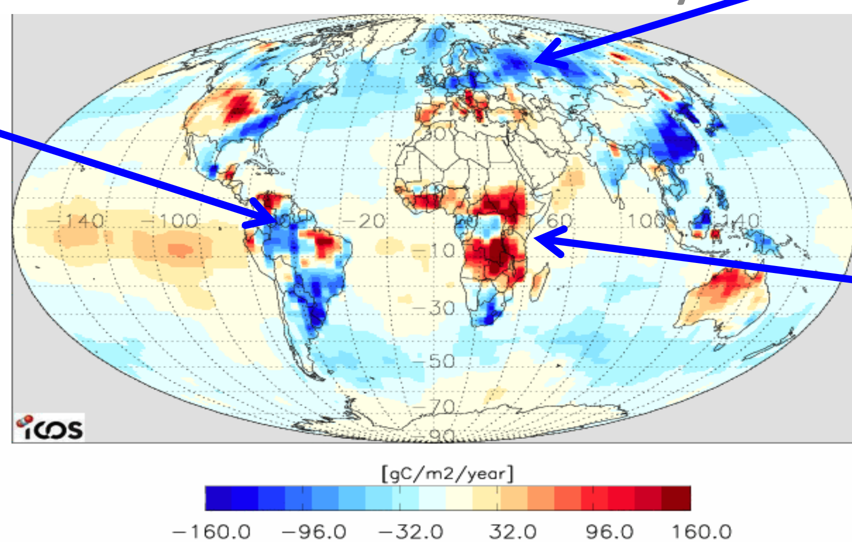
☺ Global description of CO2 fluxes

Fossil + natural fluxes



Fossil fuel CO2 emissions over industrialized regions

Natural fluxes only



Northern forest regrowth

Uptake over Undisturbed tropical forest

Recent CO2 loss over drought affected regions

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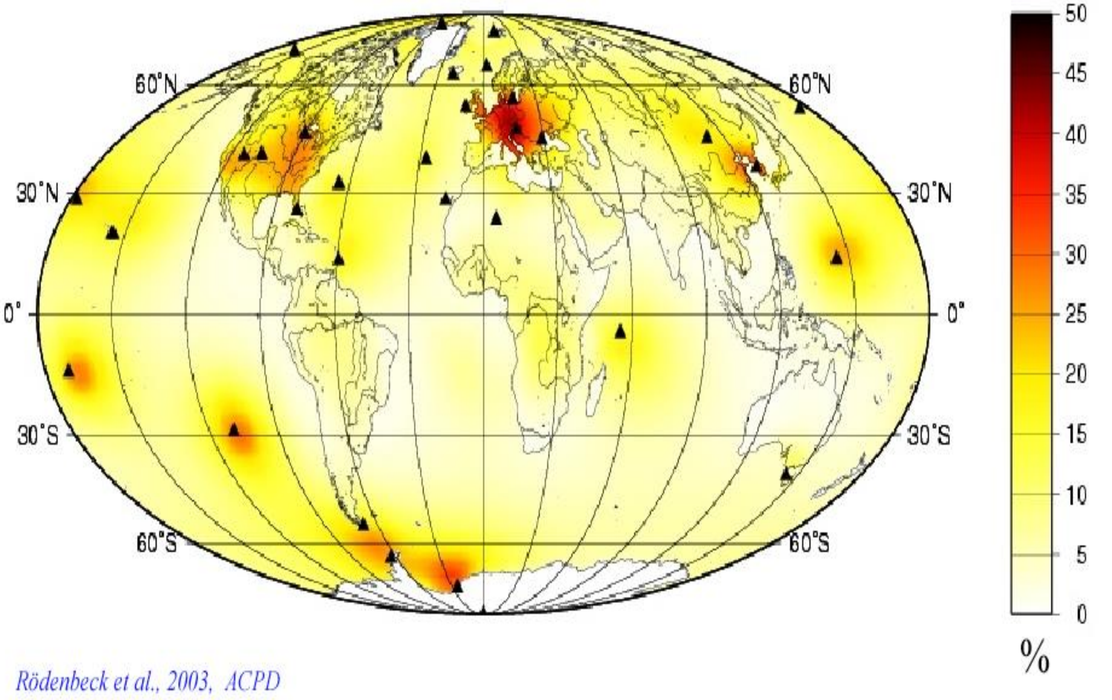
☹ Uncertainties remain very large

Error reduction delivered by stations data
1995-2000

Marginal error reduction in the Tropics and over oceans



Lack of stations, over continents

3. The Ecosystem component of ICOS

Structure and services

ETC Coordination

- Communication & interactions with ICOS ecosystem stations and Central Facilities
- Organization of the annual assessment of ETC operations
- Prepare the annual report and plan of the following year to be presented to the assembly

Data Unit

- Near real time data/metadata collection
- Automatic data QAQC and processing
- Data sharing, distribution and archiving
- Development of tools for data exploration and validation
- Alert service in case of data problems or inconsistencies

Test Unit

- Evaluation of new sensors and prototypes
- New methods development
- Interactions with instrument manufacturers and research centers
- Roving system management for sites validation and parallel measurements

Network Unit

- Assistance to the ICOS ecosystem stations
- Evaluation of the ICOS stations performances
- Training sessions for sites managers and technicians
- Soil and vegetation samples analysis and long term storage
- Organization of the working groups for protocols development

How this has been possible and what the community gained

One of the most difficult task has been the definition of a common data policy.

Key aspects of the agreed data policy

- No co-authorship without substantial additional intellectual inputs
- Possibility to ask to be involved in the activities
- Access through a proposal to minimize overlaps with ongoing activities ad network level

What we gained as community sharing our data

- Improved quality due to external users playing with our measurements
- High level of visibility and data request, needed to get stakeholder attention
- New connections both as community and as single scientists
- Possibility to get involved in synthesis papers

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Moving from scientific network to research infrastructure

In Europe with ICOS and in US with NEON and AmeriFlux, we are moving in the direction of long-term, highly standardized and completely open access research infrastructures.

ICOS | INTEGRATED CARBON OBSERVATION SYSTEM

Integrated long term, high precision observations of GHGs in the atmosphere and at the ocean and land surface

neon — National Ecological Observatory Network, Inc.

Long term, high standardized measurements of ecological parameters in terrestrial and aquatic ecosystems.

AmeriFlux

Long term coordinated ecosystem fluxes measurements in terrestrial ecosystems

Current state of the network

- ✓ **44 site** in **8 Countries funded**

(Belgium, Czech Republic, Finland, France, Germany, Poland, Sweden, Switserland)

  - 32 class I and 12 class II
    - 20 forests,
    - 14 croplands & grasslands
    - 6 peatland,
    - 4 wetlands and aquatic sites,

- ✓ **12 sites in 4 countries applied** for funding
- ✓ more than 20 associated sites

Ecosystem protocols preparation

- Different working groups:
  - Eddy covariance measurements
  - Ancillary data (biomass, LAI, litter)
  - Soil and vegetation sampling
  - Meteorological measurements
  - Chamber measurements
  - Processing of data
  - Phenology
  - ...
- Internal and external experts
- Open for everybody to join

  http://www.europe-fluxdata.eu/icos/working-groups

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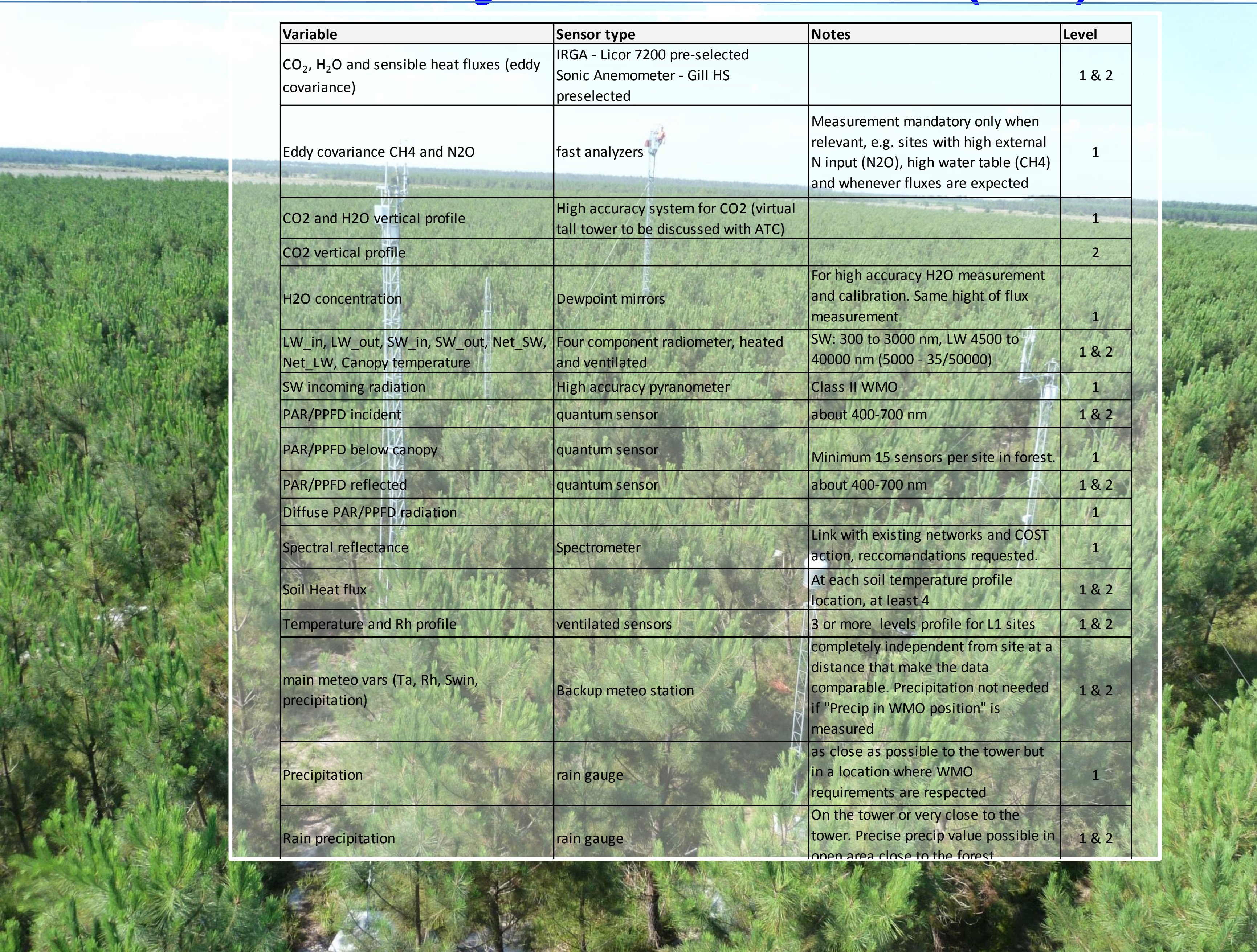
Ecosystem variables (1/2)



Variable	Sensor type	Notes	Level
CO_2, H_2O and sensible heat fluxes (eddy covariance)	IRGA - Licor 7200 pre-selected Sonic Anemometer - Gill HS preselected		1 & 2
Eddy covariance CH4 and N2O	fast analyzers	Measurement mandatory only when relevant, e.g. sites with high external N input (N2O), high water table (CH4) and whenever fluxes are expected	1
CO2 and H2O vertical profile	High accuracy system for CO2 (virtual tall tower to be discussed with ATC)		1
CO2 vertical profile			2
H2O concentration	Dewpoint mirrors	For high accuracy H2O measurement and calibration. Same hight of flux measurement	1
LW_in, LW_out, SW_in, SW_out, Net_SW, Net_LW, Canopy temperature	Four component radiometer, heated and ventilated	SW: 300 to 3000 nm, LW 4500 to 40000 nm (5000 - 35/50000)	1 & 2
SW incoming radiation	High accuracy pyranometer	Class II WMO	1
PAR/PPFD incident	quantum sensor	about 400-700 nm	1 & 2
PAR/PPFD below canopy	quantum sensor	Minimum 15 sensors per site in forest.	1
PAR/PPFD reflected	quantum sensor	about 400-700 nm	1 & 2
Diffuse PAR/PPFD radiation			1
Spectral reflectance	Spectrometer	Link with existing networks and COST action, reccomandations requested.	1
Soil Heat flux		At each soil temperature profile location, at least 4	1 & 2
Temperature and Rh profile	ventilated sensors	3 or more levels profile for L1 sites	1 & 2
main meteo vars (Ta, Rh, Swin, precipitation)	Backup meteo station	completely independent from site at a distance that make the data comparable. Precipitation not needed if "Precip in WMO position" is measured	1 & 2
Precipitation	rain gauge	as close as possible to the tower but in a location where WMO requirements are respected	1
Rain precipitation	rain gauge	On the tower or very close to the tower. Precise precip value possible in open area close to the forest	1 & 2

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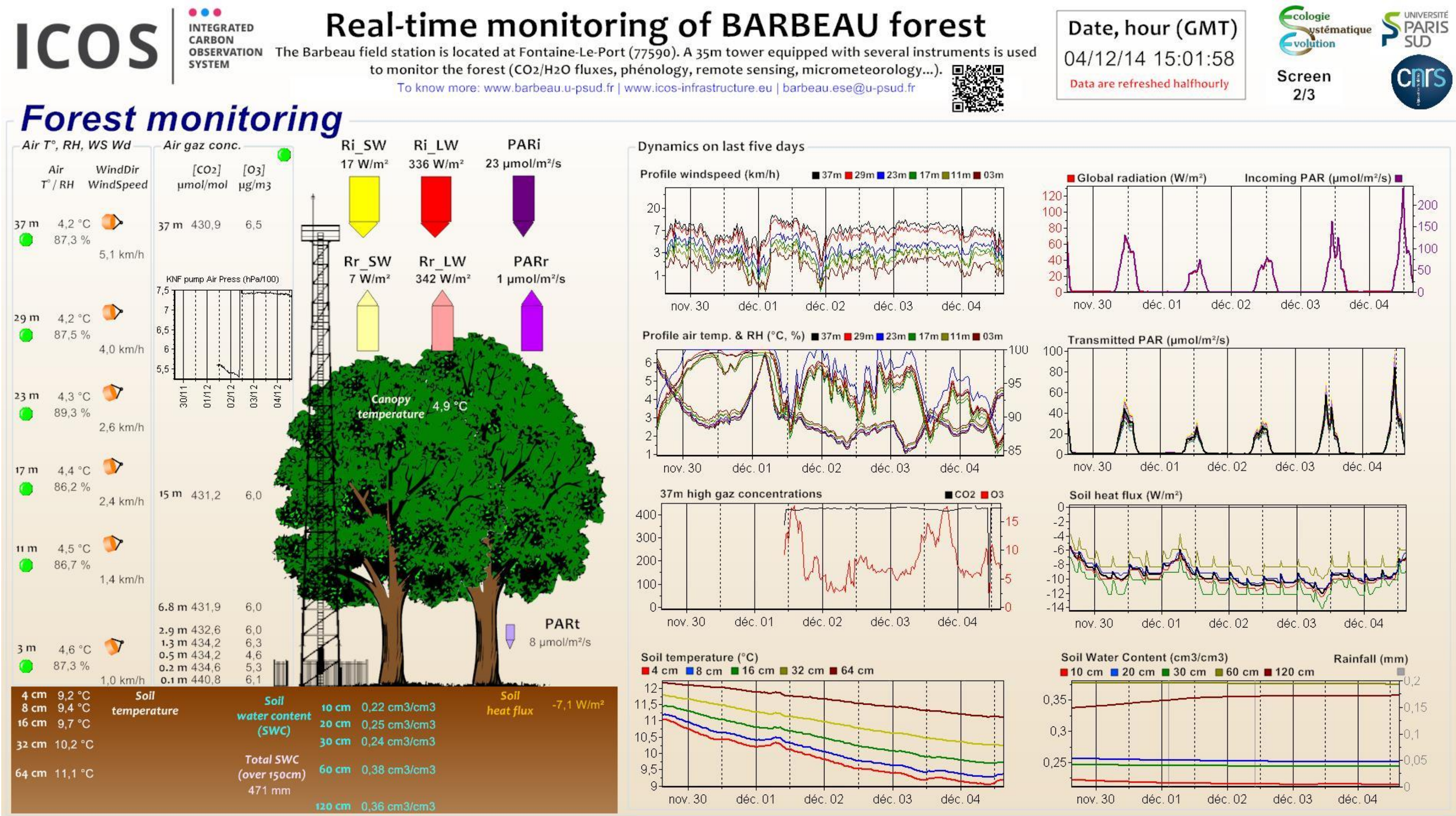
Snow precipitation			1
Snow heigt			1 & 2
Soil Water Content profile		Minimum 4 profiles with 5 depths for L1 sites, one profile with 5 depths and 3 superficial rplicates for L2. Depth site specific according to the soil structure and root vertical distribution	1 & 2
Soil Temperature profile		Minimum 4 profiles with 5 depths for L1 sites, one profile with 5 depths and 3 superficial rplicates for L2. Depth site specific according to the soil structure and root vertical distribution	1 & 2
Air Pressure	barometer		1 & 2
Trunk and branches temerature		minimum 5 sensors	1
Groundwater level	Pressure transducer		1 & 2
trees diameter	automatic dendrometer bands	Minimum 6 trees monitored	1
Phenology-Camera	Webcam		1
Soil CO2 automatic chambers	Standard chamber in preparation, protocol in the meantime	Manual campaign in the footprint area also needed every 2-3 years	1
CH4 and N2O fluxes by automatic chambers	Standard chamber in preparation, protocol in the meantime	Measurement mandatory only when relevant, e.g. sites with high external N input (N2O), high water table (CH4) and whenever fluxes are expected. Manual campaign in the footprint area also needed every 2-3 years	1
Wind speed and wind direction	2D anemometer		1
LAI	Hemispherical photos or yield		1 & 2
Above Ground Biomass		Tree heights (yearly), diameters (yearly), crop and grass biomass direct estimation biomass/carbon content ratio for different parts of the plants	1 & 2
Soil carbon content		every 5 years: C/N, density, once the particle distribution	1 & 2
Litterfall		Quantity and C N, leaves and not. Protocol that include branches and dead trees (inventory)	1
Leaf N content		20 samples 3 times per year in L1 sitres, once per year in L2 sites	1 & 2
Soil water N content		only sites where N2O fluxes are measured	1
DOC concentration		2 depths	1
C and N import/export by management			1 & 2

NRT data available at Site level (French Fontainebleau « Barbeau » site)



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Eddy covariance technique

+ Continuous measurements of net exchange of CO_2, H_2O CH_4, N_2O and energy
+ Continuous measurements of meteorological variables
+ CO2 net flux can be partitioned between photosynthesis (GPP) and respiration (RE)

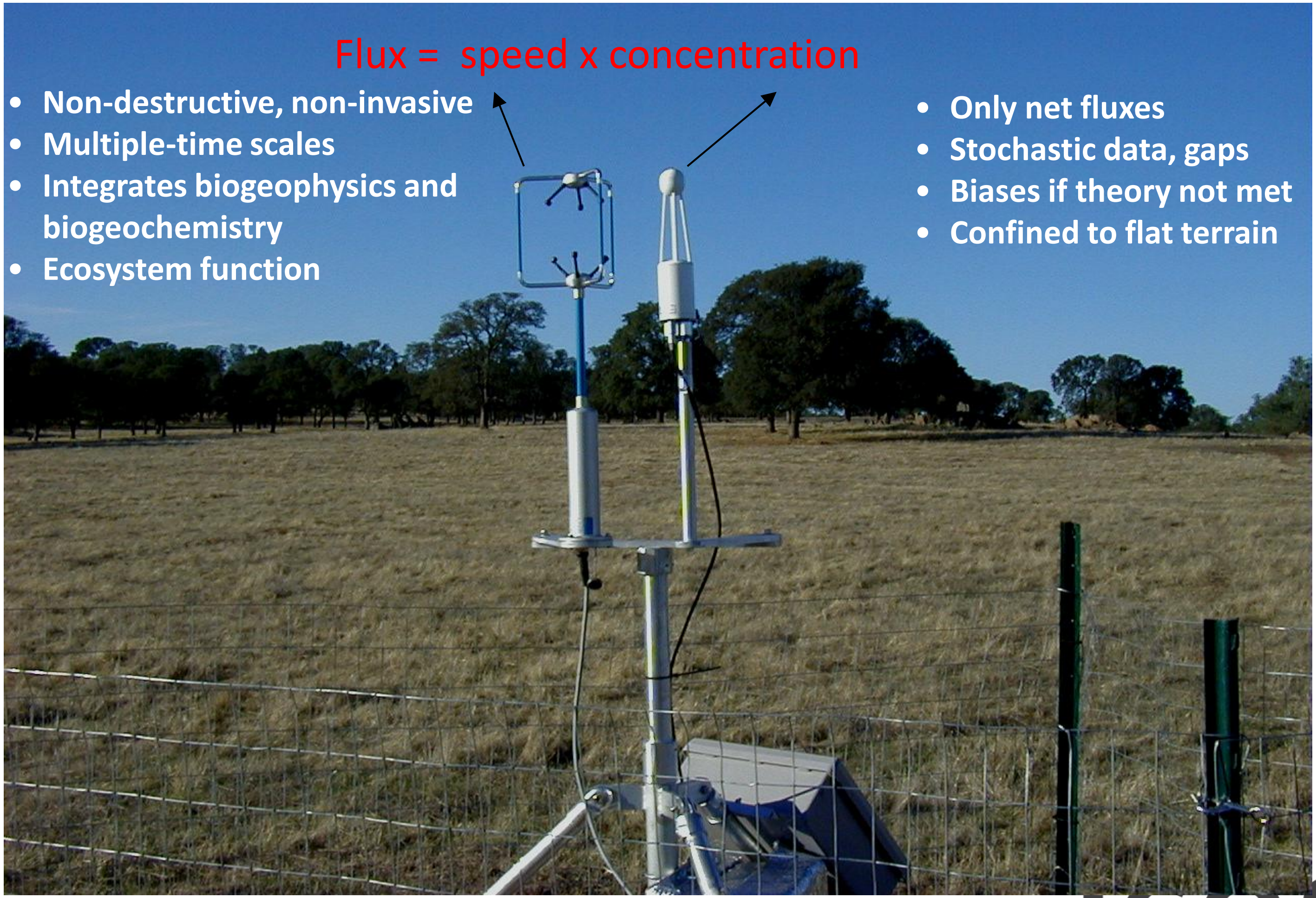

Photo: Baldocchi

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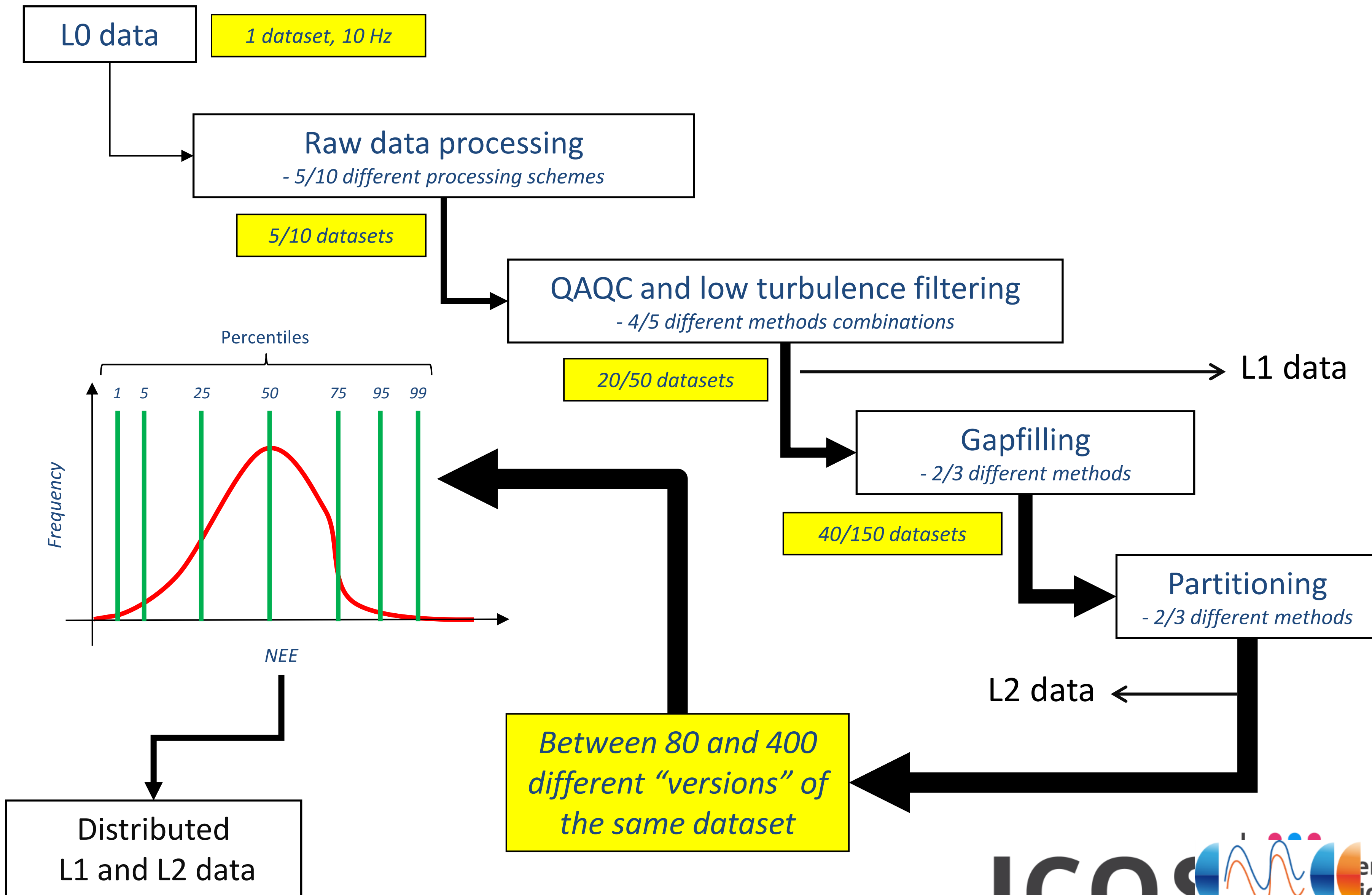
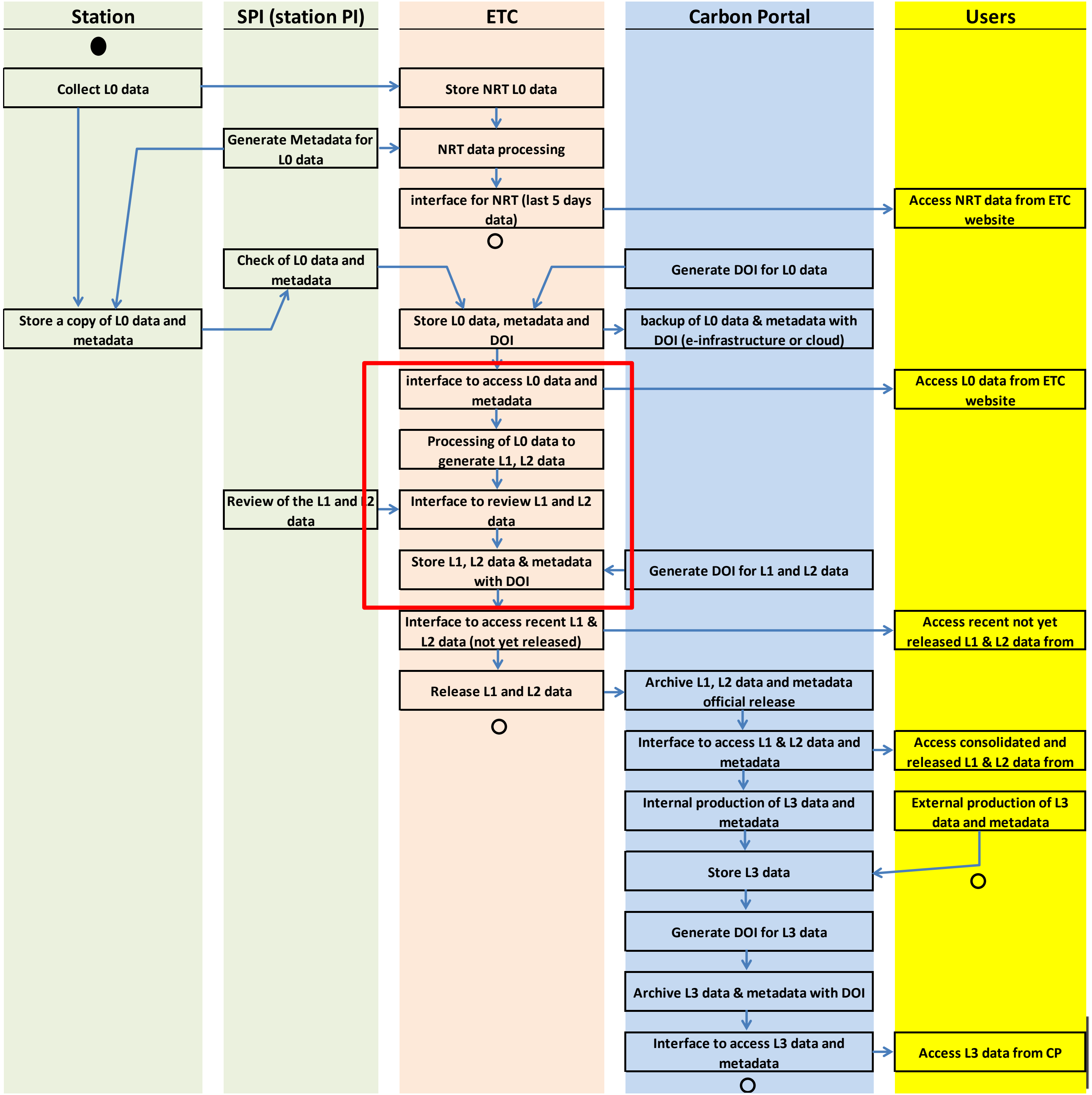
Data processing for fluxes calculation and uncertainty estimation (L0 → L1 → L2)



Ecosystem Data flow. (Reference model)



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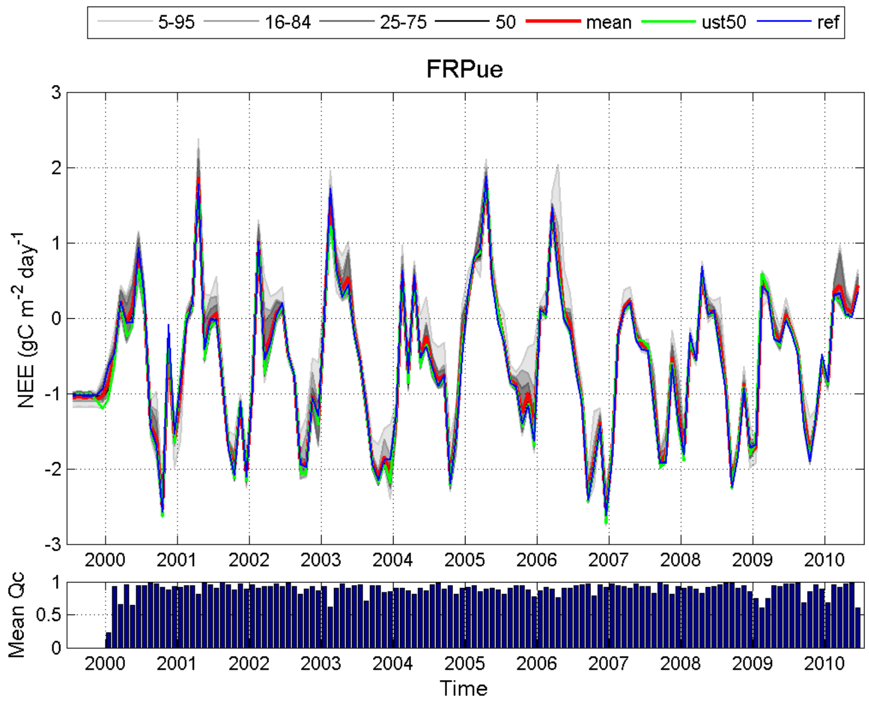
Implementations under development:

1) Central data processing and uncertainty estimation of EC data



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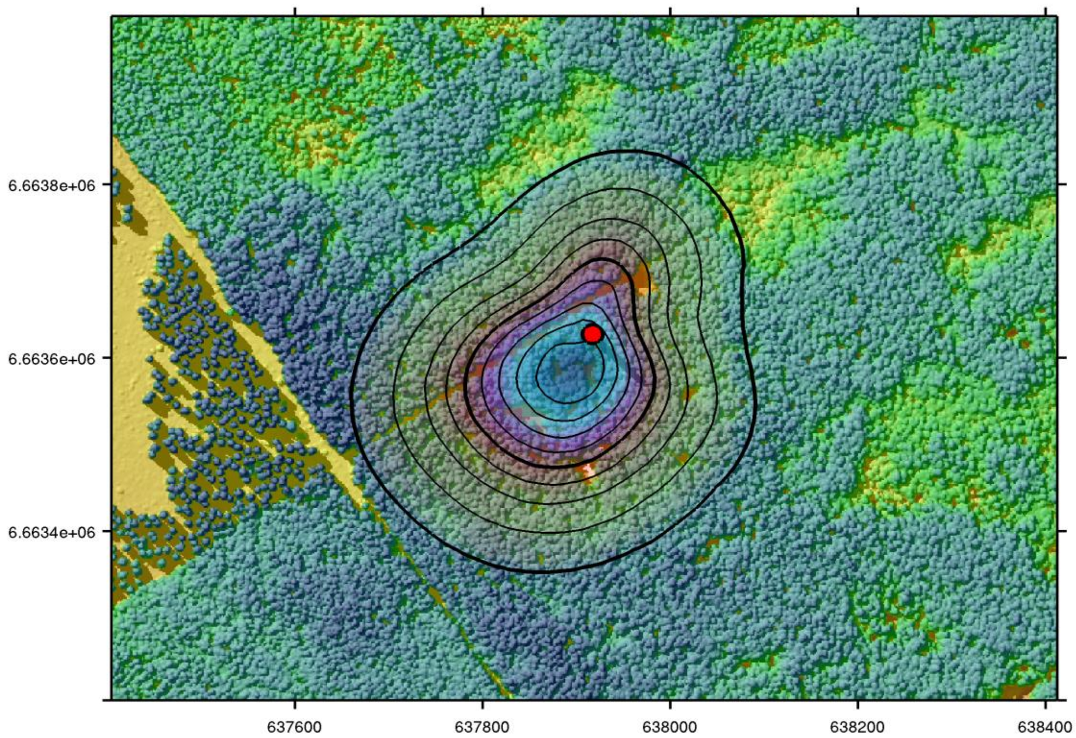
Implementations under development:

2) detailed footprint analysis applied centrally at ETC

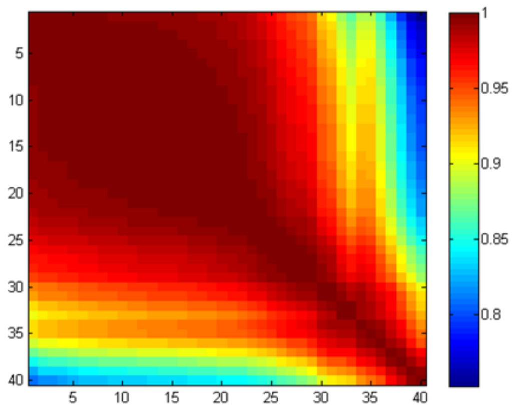


- Example: Norunda (Sweden)
- Footprint source contribution
- Based on airborne Lidar
- Application for Remote sensing

Courtesey Natasha Kljun

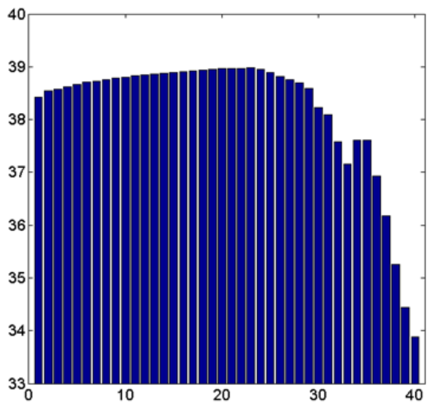
Data processing for fluxes calculation and uncertainty estimation

Model Efficiency matrix

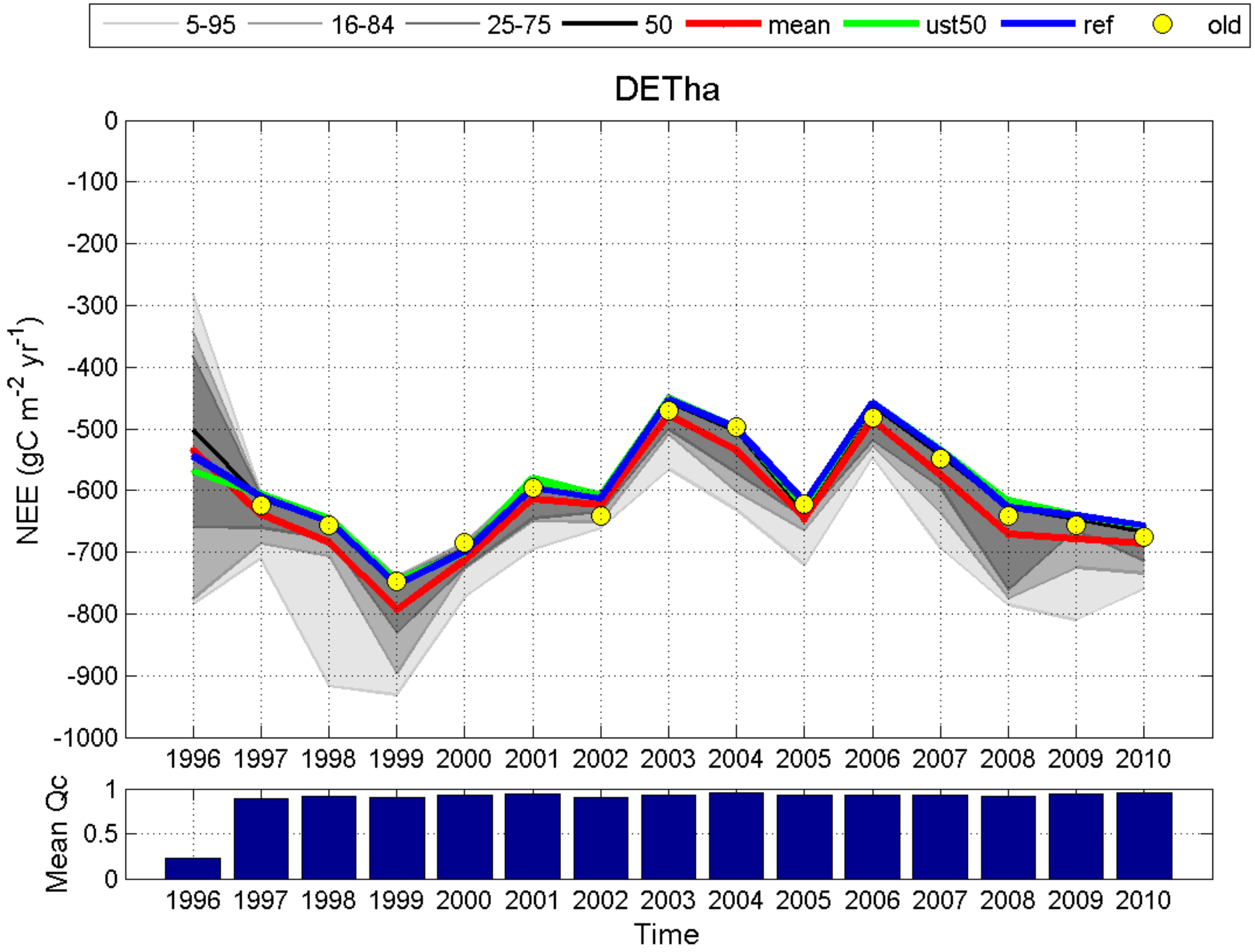


Model efficiency is calculated for each pair of the different processing schemes results

Sum of the ME



Run with higher ME sum is selected as reference, all used to define uncertainty



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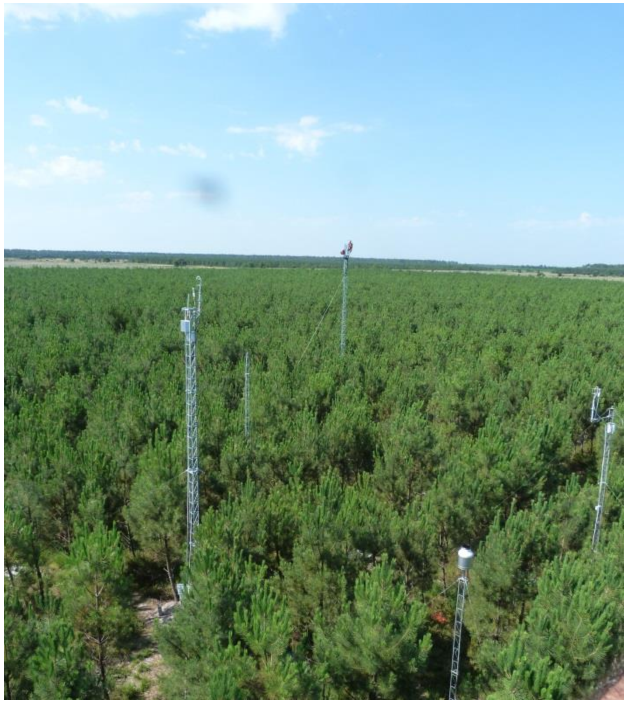
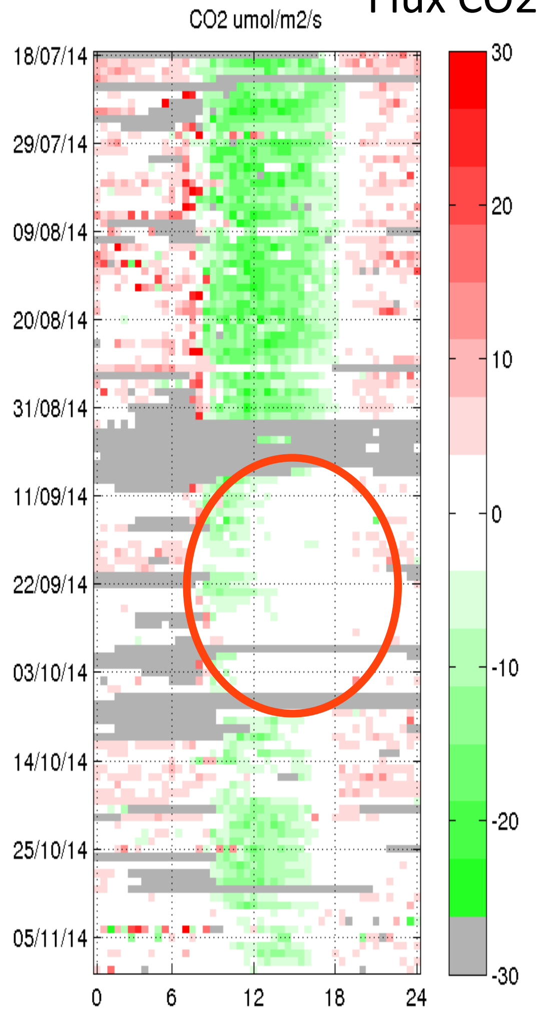
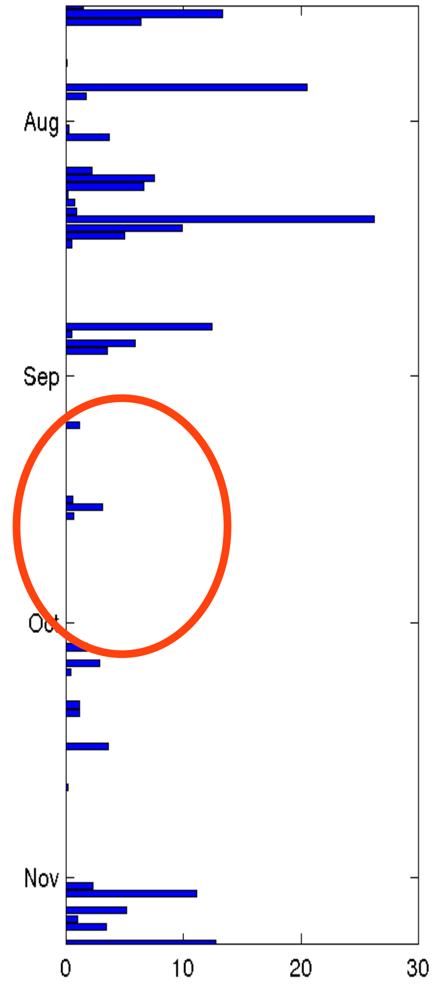
Some results 2014: managed forests

Late summer drought



Site de Pin maritime à Salles .
(Lafont, Chipeaux, et al.)





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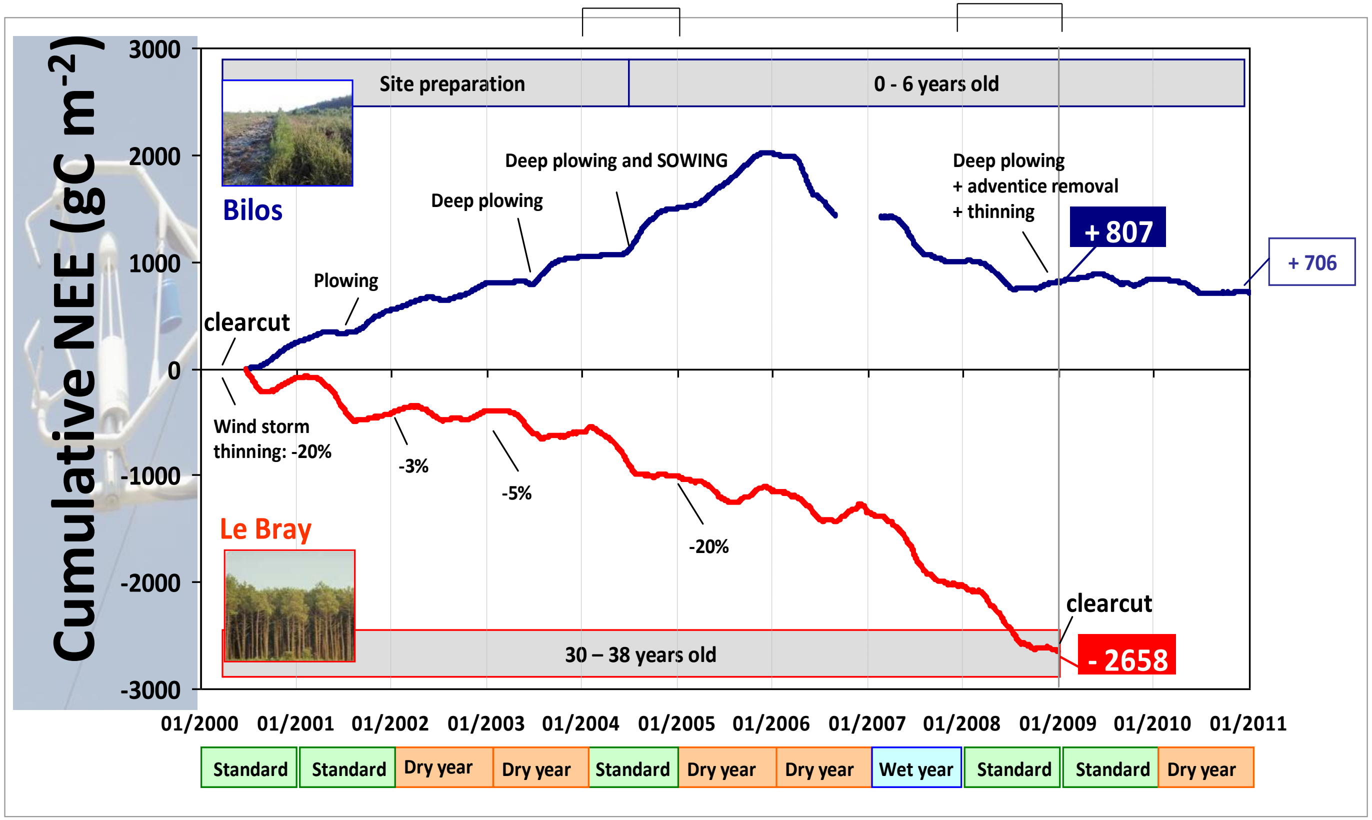
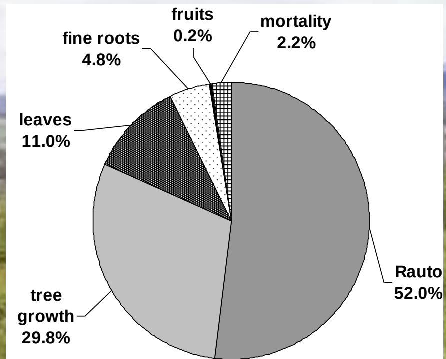
More results

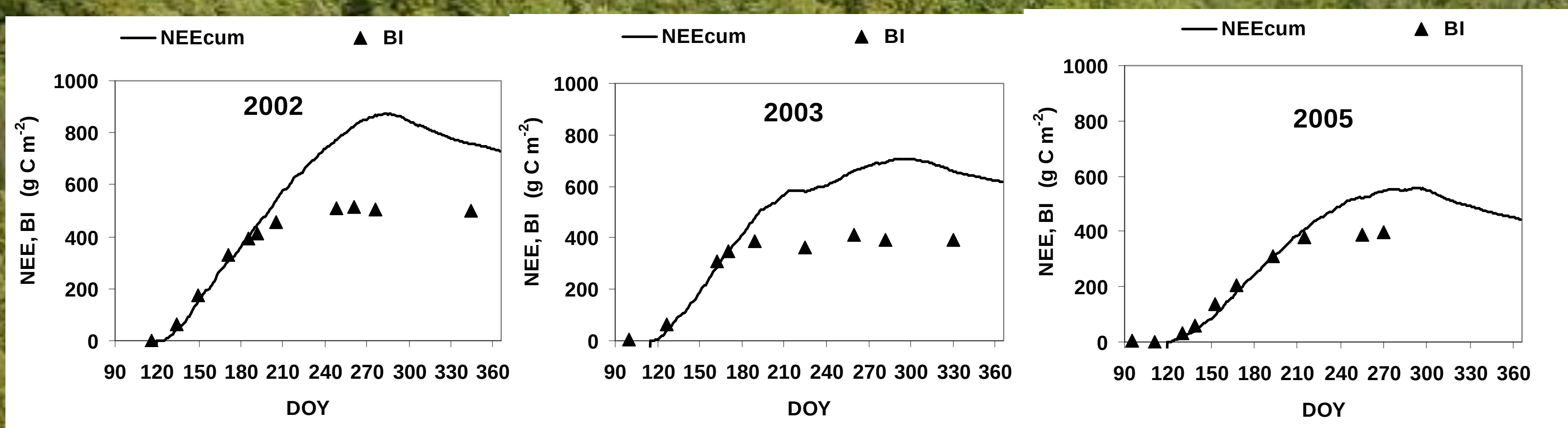


Environmental and management controls on Net Ecosystem fluxes

(Moreaux et al. 2012, Lafont et al. 2014 , Luyssaert et al. 2014)

Drought effects on flux and carbon stock increment

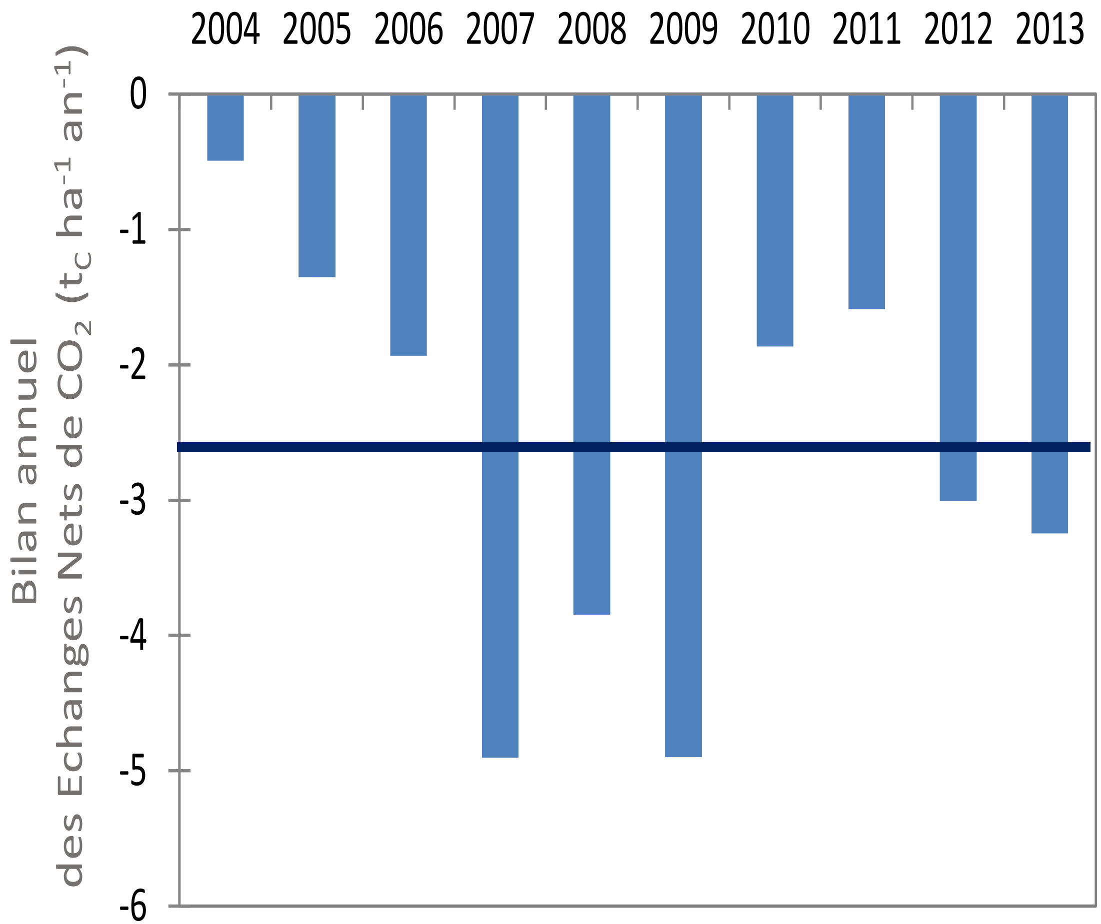




La sécheresse affecte plus les flux de CO2 que l'incrément en C de la biomasse (site de Hesse, Granier et al. An For Sci)

Résultats scientifiques: forêt primaire

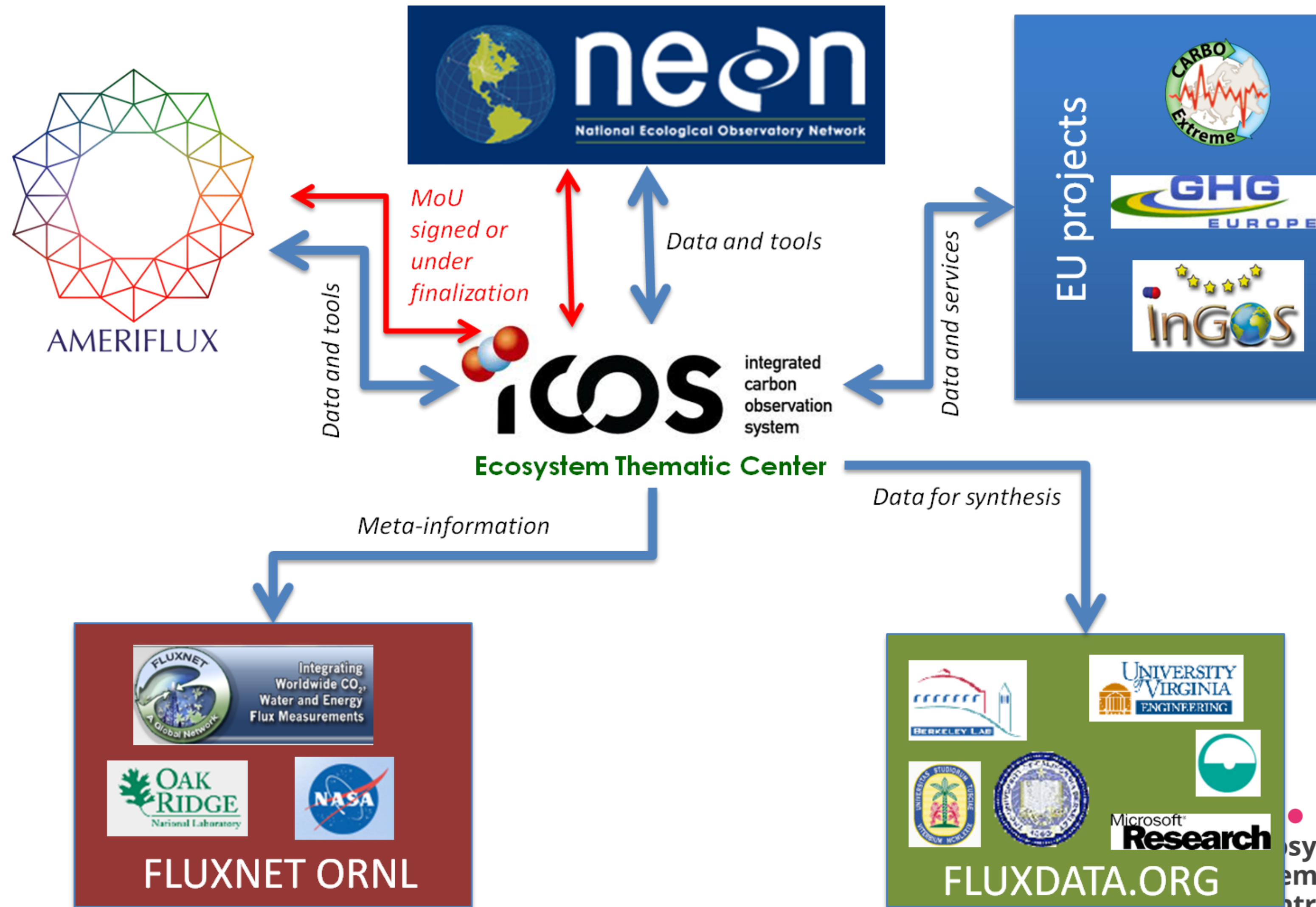
Bilan annuel de carbone de 2004 à 2013 de la forêt tropicale humide (site Guyaflux à Kourou).



Le fonctionnement se rétablit après les épisodes de sécheresse (2005 et 2010);

Bonal, Burban et al.

ICOS ETC collaborations and data exchanges



International standardization - BADM

International standardization is one of the ETC priorities. It requires time because discussions are complex but the results is something very stable in time because to be changed the agreement of different networks is needed.

BADM is one of the examples. Currently the BADM version for the instruments information is under the final check, guidelines are ready and under English review. Will be sent very soon.

Structure like the previous version but variables better organized, explanations clear (we hope), all the info needed to process raw data.

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International standardization – variable codes

The variable codes and structure has been also standardized with Ameriflux and under standardization also with OzFlux and NEON using the same system.

The "three indexes" approach (e.g. TA_1_1_1) currently used by us and proposed has been accepted. Same for the units that will be according with SI.

Documents ready will be online this week. This has an impact on the part of protocols related on data submission. Already discussed with some of the protocols coordinators however the section can be removed and a common document on this prepared by ETC.

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4. ICOS- OPtimise

ICOS Footprint questions

- Eddy Flux footprint and radiation sensors
- Footprint spatial homogeneity
  - Management
  - Diseases and pests damages
  - Natural inhomogeneities
- Vegetation composition, structure,
- Nocturnal vs diurnal footprints, incidence on GPP & RE estimates

Upscaling observations and data

- Management unit, farms, forest districts
- Plant functional types
- Biomes (vegetation belts)
- Continents

Calibration- validation of results elaborated from reflectance spectral data

- Homogeneised traceable observations , foliar analysis
- Long term (2015-2035)
- Data freely available,
- Large network covered, consistent with companion networks
- Large opportunities for hosting dedicated sensors, experiments

ICOS Ecosystem Thematic Centre