integrated carbon observation system

A European infrastructure dedicated to high precision monitoring of greenhouse gases

ICOS
Greenhouse gas monitoring network

A research Infrastructure to measure, understand and predict the global cycles of greenhouse gases

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• ICOS is an integrated European research infrastructure, accepted to European (ESFRI) and national infra roadmaps

• national measurement stations (like ICOS-Finland) + European level organisation (ICOS-EU)

• ~ 60 atmospheric and ecosystem sites and ~ 10 ocean sites

• covers both **concentration** and ecosystem-atmosphere **exchange** and **cycles** of **CO_2, CH_4 and N_2O**

• provides a tool for national and European **greenhouse gas inventories**

-**HQ**: Finland + France

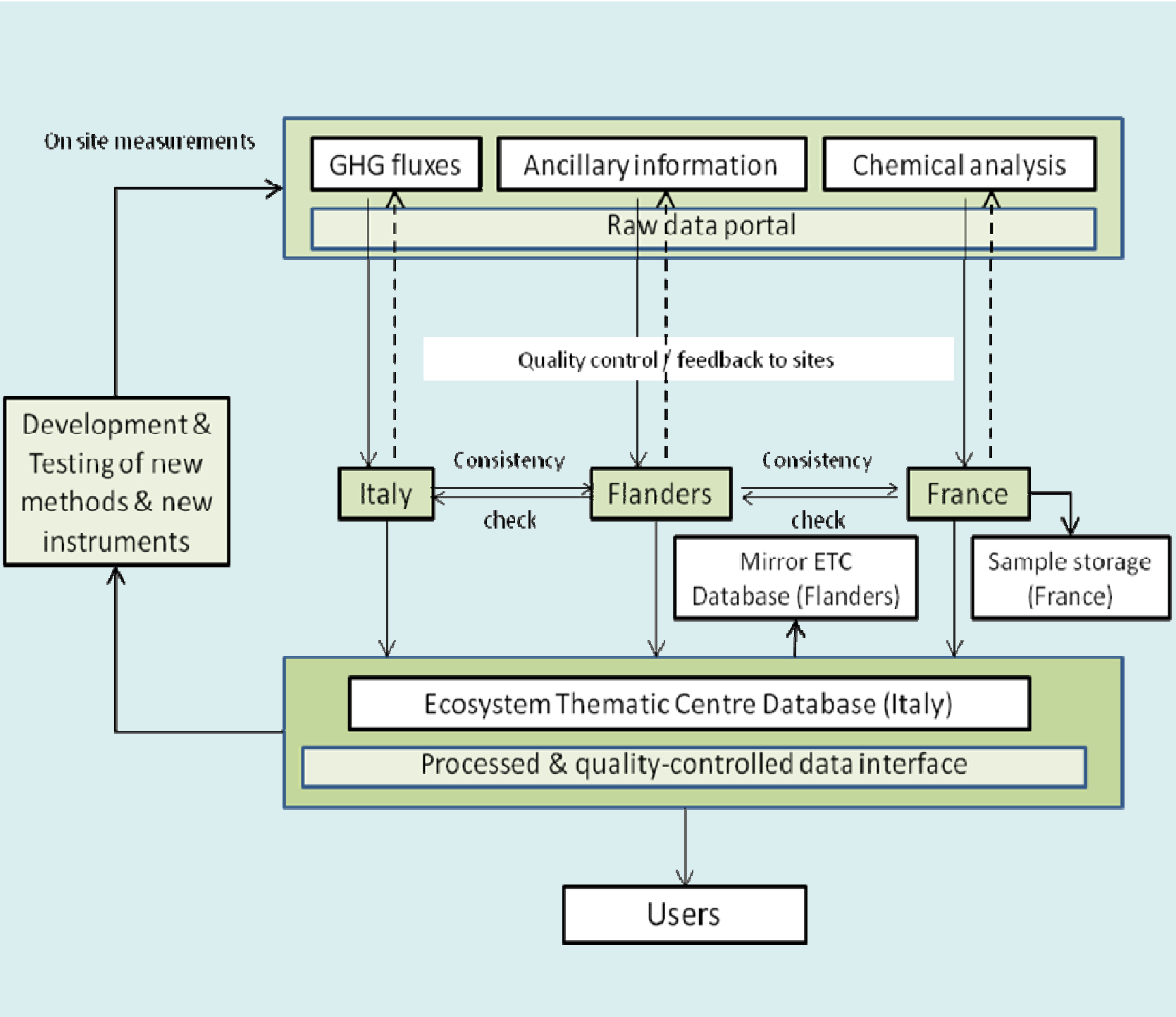
- **Atmospheric Thematic Centre** (France + Finland): tall tower concentrations, inversion-based sources/sinks, 100 – 1000 km

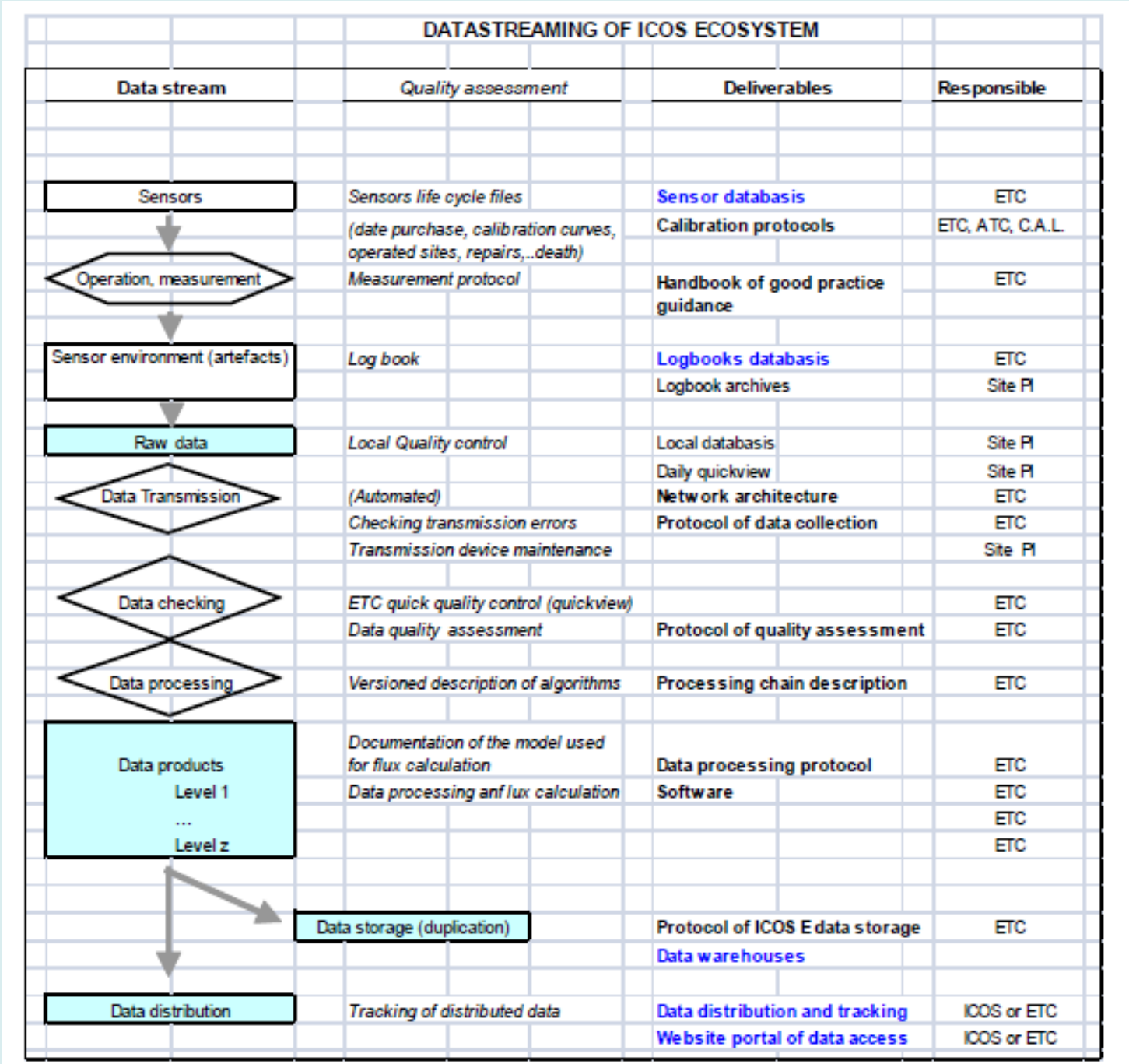
- **Ecosystem Thematic Centre** (Italy + Belgium + France): Eddy Covariance flux towers and tens of meteorological, -ecophysiological and soil variables, net exchange, 100 m–1 km

- **Analytical lab** (Germany): calibration and standard gases

- **Ocean Thematic Centre** (Norway + Spain + UK?): ocean/sea concentrations

- **Carbon portal** (?): data discovered and accessed; users post elaborated data products


On site measurements
GHG fluxes
Ancillary information
Chemical analysis
Raw data portal
Quality control / feedback to sites
Development & Testing of new methods & new instruments
Consistency check
Consistency check
Italy
Flanders
France
Mirror ETC Database (Flanders)
Sample storage (France)
Ecosystem Thematic Centre Database (Italy)
Processed & quality-controlled data interface
Users


DATASTREAMING OF ICOS ECOSYSTEM
Data stream
Quality assessment
Deliverables
Responsible
Sensors
Sensors life cycle files
Sensor databasis
ETC
(date purchase, calibration curves, operated sites, repairs,..death)
Calibration protocols
ETC, ATC, C.A.L.
Operation, measurement
Measurement protocol
Handbook of good practice guidance
ETC
Sensor environment (artefacts)
Log book
Logbooks databasis
ETC
Logbook archives
Site PI
Raw data
Local Quality control
Local databasis
Site PI
Daily quickview
Site PI
Data Transmission
(Automated)
Network architecture
ETC
Checking transmission errors
Protocol of data collection
ETC
Transmission device maintenance
Site PI
Data checking
ETC quick quality control (quickview)
ETC
Data quality assessment
Protocol of quality assessment
ETC
Data processing
Versioned description of algorithms
Processing chain description
ETC
Data products
Level 1
...
Level z
Documentation of the model used for flux calculation
Data processing anf lux calculation
Data processing protocol
Software
ETC
ETC
ETC
Data storage (duplication)
Protocol of ICOS E data storage
Data warehouses
ETC
Data distribution
Tracking of distributed data
Data distribution and tracking
Website portal of data access
ICOS or ETC
ICOS or ETC

Ecosystem data products

- *Level 0*: currents and voltages
- *Level 1*: Raw data screened and filtered centrally at ETC
- *Level 2*: Consolidate half hourly fluxes
- *Level 3*: Additional QAQC applied to the half hourly fluxes (a.o. footprint control)
- *Level 4*: Gap-filled data aggregated at different time resolutions
- *Level 5*: Ecological derived variables (photosynthesis etc.)
- *Level 6: Ancillary data & Multiple-constraint –approved flux data*

Data processing philosophy

- Near Real Time data collection & processing
- Communicate with station PIs immediately in case of problem, annually in case of no problem
- Archive the data, and ensure the traceability (metadata)
- Deal with data from associated sites (*if they meet the ICOS requirements*)
- Provide data products and quicklook tools

CORE VARIABLES CONTINUOUS	CORE VARIABLES DAILY TO MONTHLY	CORE VARIABLES YEARLY
CO_2, H_2O and energy fluxes	Leaf Area Index (LAI)	above ground biomass by laser technology
soil heat flux	soil respiration (automatic chambers technique);	soil carbon
high precision CO_2 concentration vertical profile	CH_4, N_2O by automatic chambers	stem diameter
net radiation	plant respiration (chamber technique)	above-ground Net Primary Production (NPP)
incoming/reflected/diffuse global radiation	phenology	litter fall
incoming/outgoing longwave radiation		C and N import and export on managed sites
Albedo		bulk N deposition
incoming/reflected Photosynthetic Active Radiation (PAR)		leaf N content
Spectral reflectance in selected wavelength		soil water N content
relative humidity		land-use history
temperature vertical profile		managements and natural disturbances
soil temperature and water content profile		
wind speed and direction		
air pressure		
canopy temperature		
precipitation, through-fall, ground water level, snow depth		
sap flow		

Table 3: List of mandatory variables for ICOS-Ecosystem Station-L1

CORE VARIABLES CONTINUOUS	CORE VARIABLES DAILY TO MONTHLY	CORE VARIABLES YEARLY
CO_2, H_2O and energy fluxes	Leaf Area Index (LAI)	biomass (above ground)
soil heat flux	CH_4, N_2O by manual chambers[2]	soil carbon
normal precision CO_2 concentration vertical profile	phenology	stem diameter
net radiation		above-ground Net Primary Production (NPP)
incoming/reflected/diffuse global radiation		litter fall
incoming/outgoing longwave radiation		C and N import and export on managed sites
Albedo		land-use history
incoming/reflected Photosynthetic Active Radiation (PAR)		managements and natural disturbances
relative humidity		
temperature vertical profile		
soil temperature and water content profile		
wind speed and direction		
air pressure		
precipitation, through-fall, ground water level, snow depth		

Table 4: List of mandatory variables for ICOS-ES-L2

Finnish ICOS stations

ICOS station

Supporting station

Atmospheric stations
- ICOS Pallas-Sodankylä GAW-station
- **Utö-Baltic Sea** (under construction)
- **ICOS Hyytiälä** (starting 2012
- **ICOS Puijo-Koli** (started 2011)

Full ecosystem stations
- SMEAR II Hyytiälä: pine forest + Siikaneva wetland (fen + bog) + Lake Kuivajärvi
- Pallas-Sodankylä

4 supporting ecosystem stations
- SMEAR I Värriö (pine)
- SMEAR III Helsinki (urban)
- FMI Tammela-Lettosuo (wetland)
- FMI Kaamanen (wetland)

Carbon portal

• ICOS in-situ data need processing (e.g. filtering) which defines lower level data.

• further application of models for producing so called elaborated data-products, such as maps of regional GHG fluxes, which define higher level data

• although ICOS is not providing higher products, it can organize access to products derived from ICOS data

• users may post their elaborated data products to the ICOS carbon portal, thus made available in a user-friendly interface to the public

Present status and Future

- EU-funded preparation project is going on (2008-2013)
- Operation/monitoring 2013 - 2031

“**Astrophysicists have Hubble, nuclear physicists have CERN, biogeochemists have FLUXNET**”.
a reviewer of Nature paper (Valentini et al., 2000)