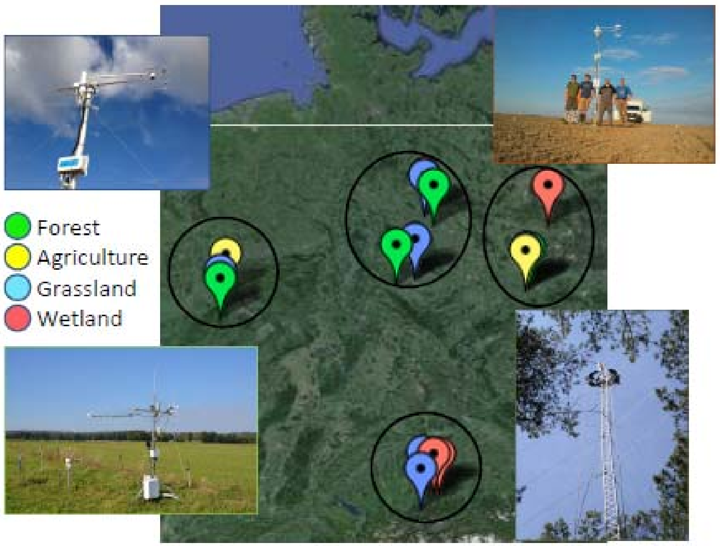
Standardising and maintaining micrometeorological long-term observations – First experiences from the ICOS approach



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Scientific Mission of ICOS (Integrated Carbon Observation System)

- Precise, long-term and internationally comparable data,
- Fundamental understanding of carbon cycle, greenhouse gas budgets and perturbations and underlying processes,
- Ability to predict future changes,
- Verify the effectiveness of policies aiming to reduce greenhouse gas emissions,
- Technical and scientific innovation,
- Education and capacity building.

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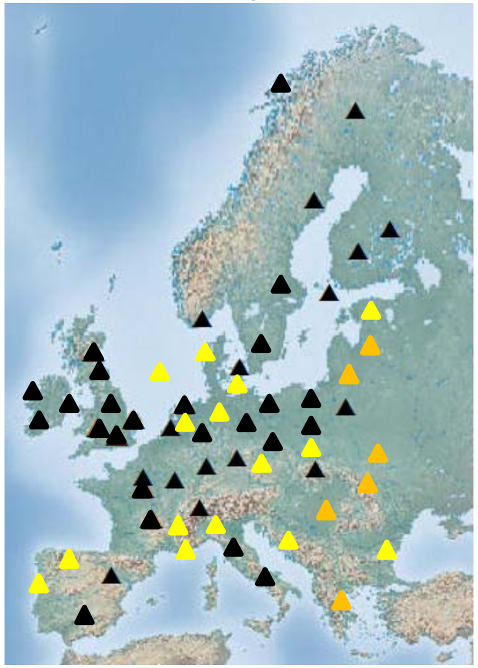
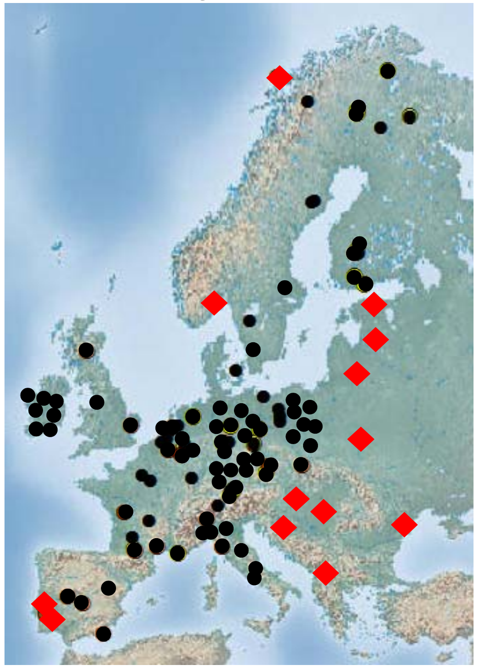
Observation networks

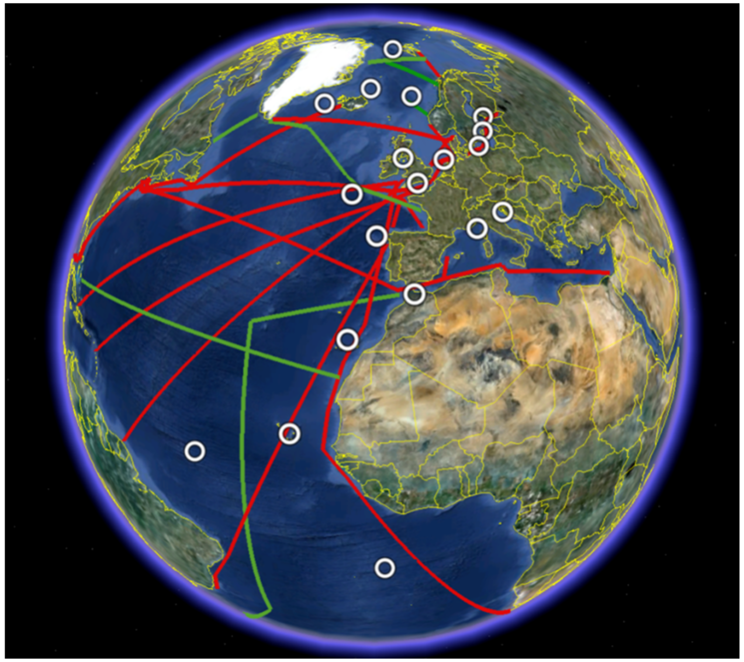
Atmosphere



Ecosystems



Oceans



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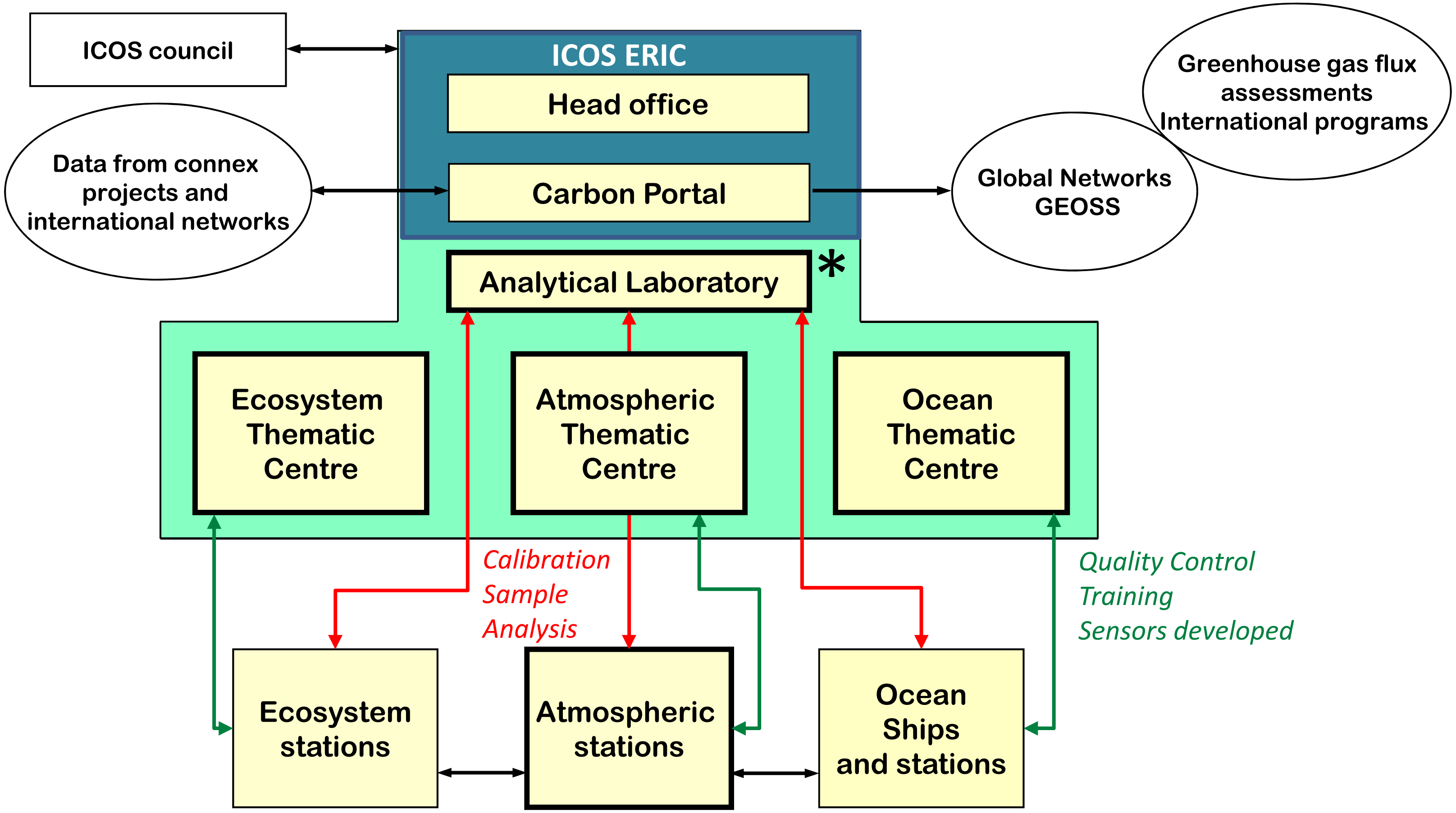
The structure of ICOS-RI



*Analytical Laboratories:
Central Radiocarbon Laboratory (CRL) & Flask and Calibration Laboratory (FCL)

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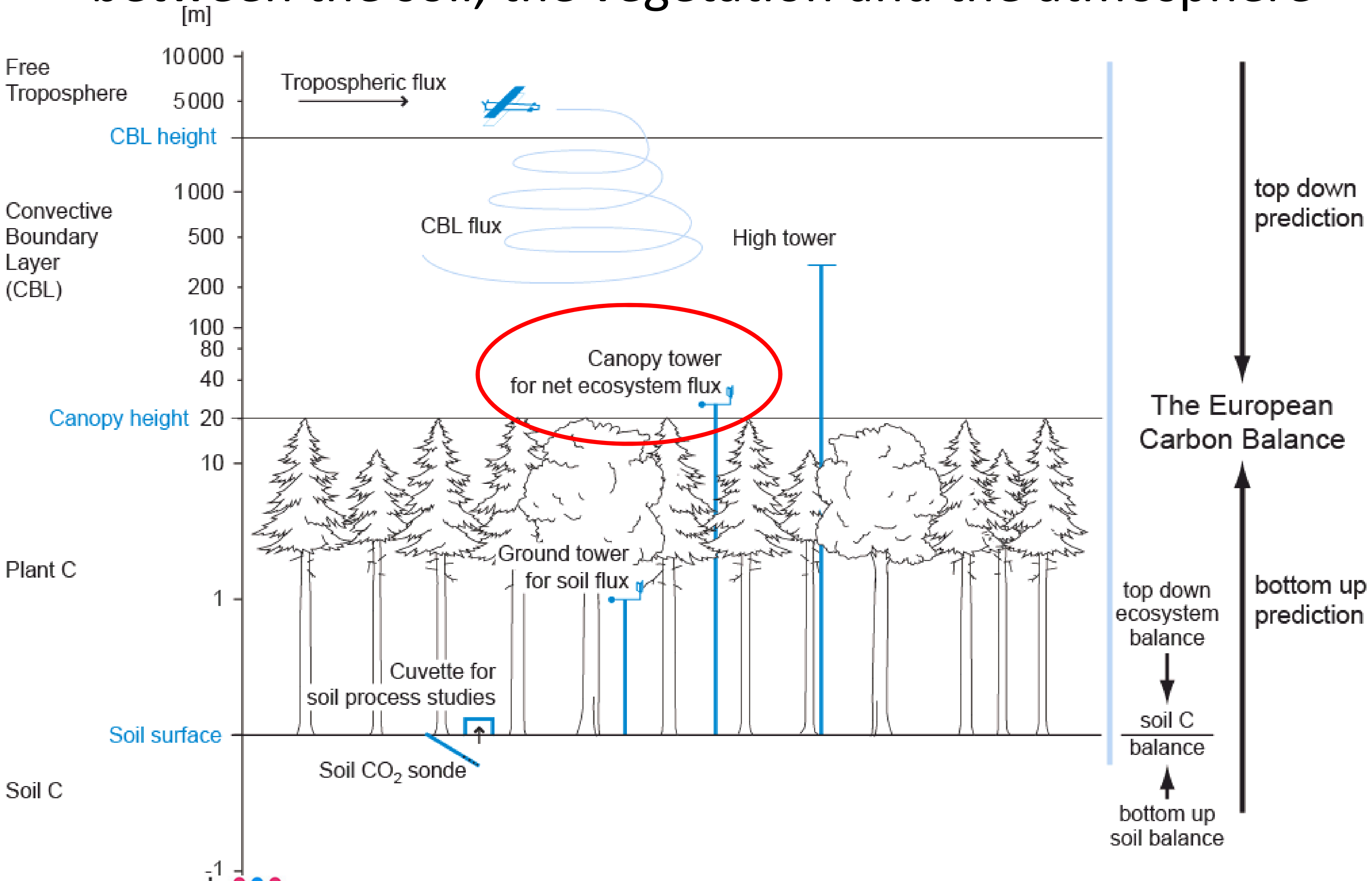
Ecosystem network: Observing the turbulent CO_2-flux between the soil, the vegetation and the atmosphere



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Mandatory Variables for ICOS Ecosystem Class 1 Sites

CO_2, H_2O and sensible heat fluxes (eddy covariance)	Soil Temperature profile
Eddy covariance CH_4 and N_2O	Soil Water Content profile
CO_2 and H_2O vertical profile	Groundwater level
LW_in, LW_out, SW_in, SW_out, Net_SW, Net_LW, Canopy temperature	Trunk and branch temperature
PAR/PPFD incident	Tree diameter
PAR/PPFD below canopy + ground reflected	Phenology-Camera
PAR/PPFD reflected	Soil CO_2 automatic chambers
Diffuse PAR/PPFD radiation	CH_4 and N_2O fluxes by automatic chambers
Spectral reflectance	LAI
Soil Heat flux	Above Ground Biomass
Temperature and RH profile	Soil carbon content
Rain precipitation	Litterfall
Snow precipitation	Leaf N content
Snow height	Soil water N content
Air Pressure	DOC concentration
Wind speed and wind direction	C and N import/export by management

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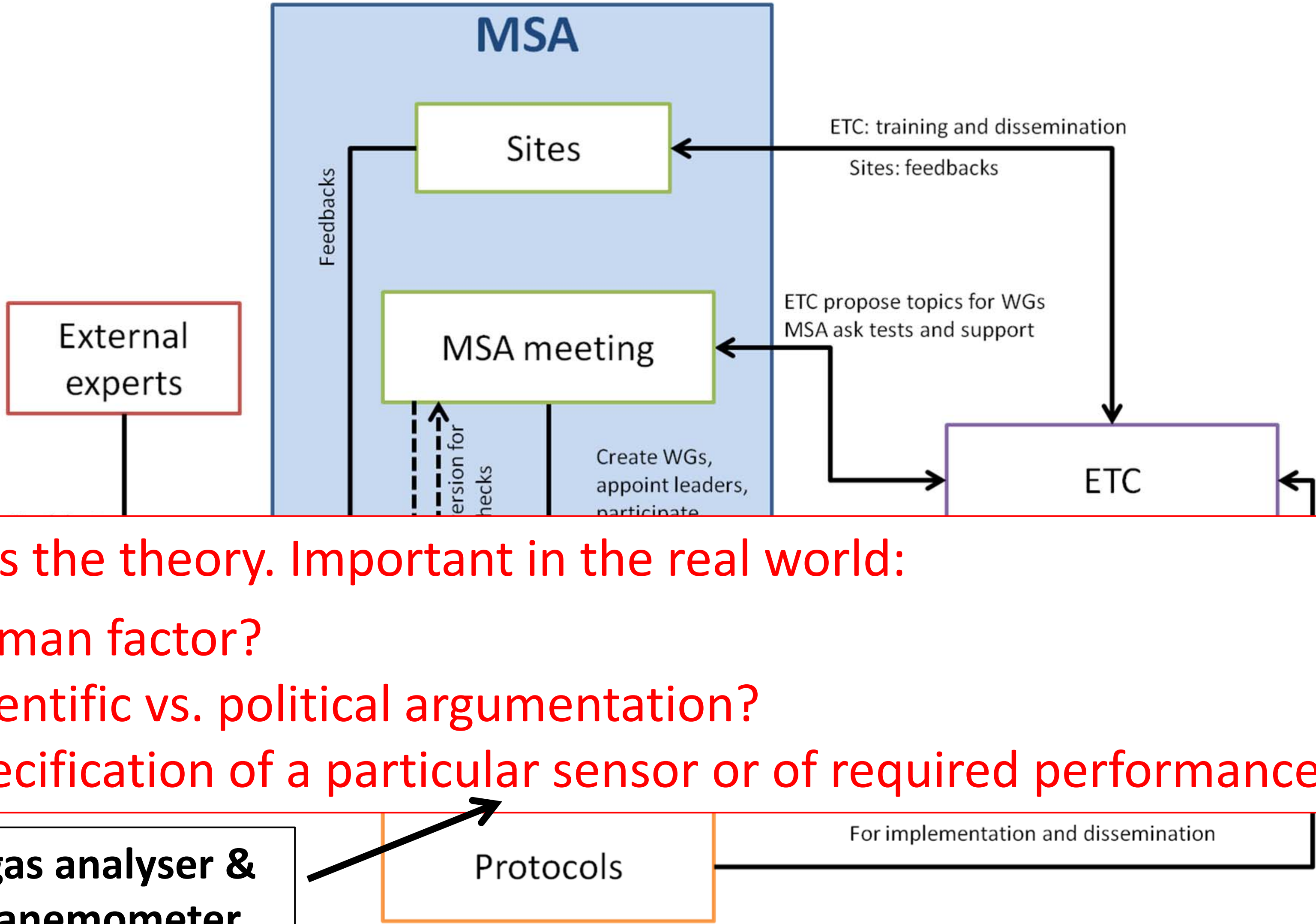
Ecosystem Program: Standardisation of Measurement Protocols



This is the theory. Important in the real world:

- Human factor?
- Scientific vs. political argumentation?
- Specification of a particular sensor or of required performance?

Only gas analyser & Sonic anemometer

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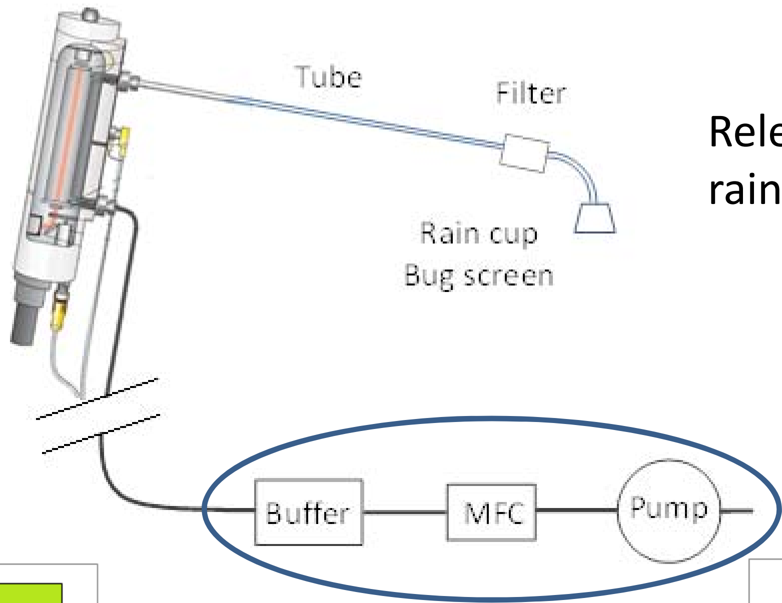
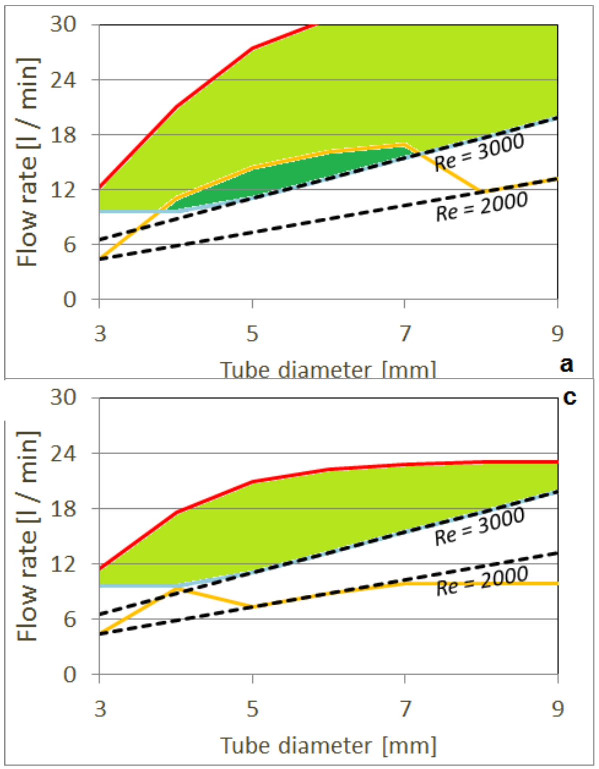
Example CO_2 sensor:

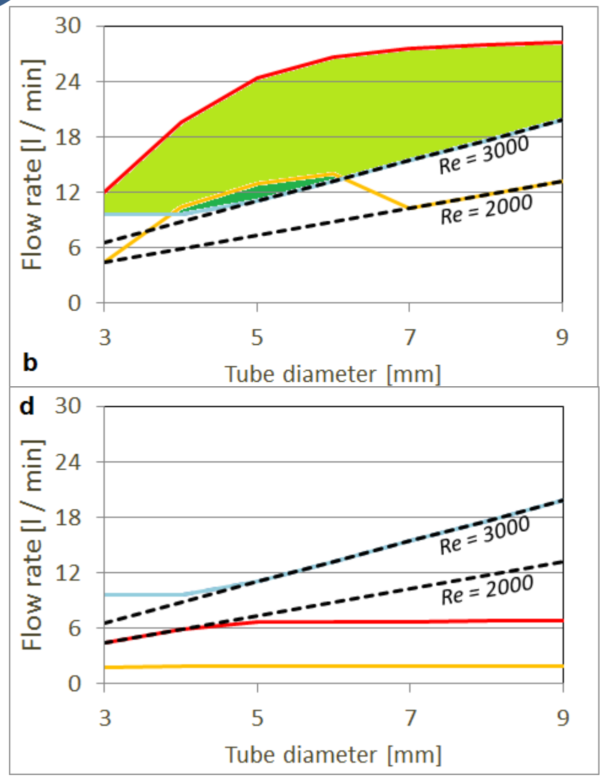
LI-7200 development as result of interaction between pre-ICOS scientist networks and manufacturer



Licor Flow Module?

Relevance of standardising rain cup, filter, pump etc. ?!



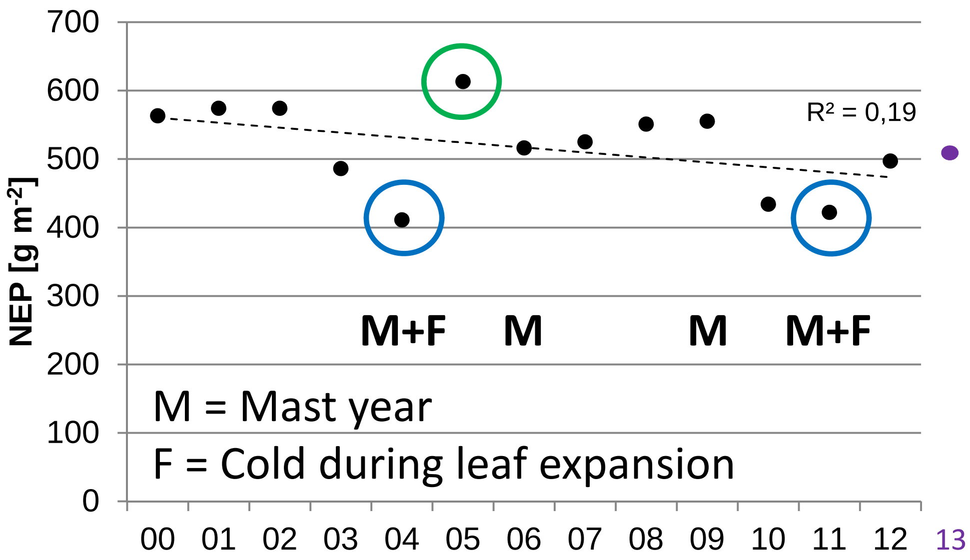


Red: maximum flow rate with external pump. Orange: maximum flow rate with LI-7200 flow module. Blue: Flow rate required for frequency response > 5 Hz. Black: Thresholds for laminar (Reynolds number, Re < 2000) and turbulent flow (Re > 3000).

a) Swagelok 2 µm Filter (new)
b) & c) gradual pollution
d) „Arco-50" 1 µm Filter

Data Interpretation: importance of BADM!

Interannual variability (IAV) at Hainich ICOS site



Lowest annual net CO_2 uptake in 2004 and 2011, highest in 2005. Variation cannot be explained by climatic variations (summer drought 2003 & 2006, wettest year = 2007, coldest = 2010, warmest = 2011)!

Driving factors traditionally taken into account:

Irradiance and temperature → photosynthesis (Farquhar model)

Photosynthesis and air humidity → stomatal conductance (Ball-Berry model)

Soil temperature and soil moisture → soil respiration

(growing season length: overstory vs. understory?)

Comparison of canopy photos from Hainich ICOS site:

mid July 2010 (left)

mid July 2011 (bottom)

Mast years:
High fruit production changes optical canopy properties and NEP!

Collaboration with more biologically active networks can reveal driving factors for IAV of NEP.

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ICOS Carbon Portal shall provide "easy plots and comparisons between sites" – should evaporation (to calculate water use efficiency) be included?

- Data quality in 'Fluxnet' not yet good enough with respect to H_2O fluxes.
- Comparability between pre-ICOS and ICOS data?
- Corrections for closed path gas analysers?
- ET as residual of energy balance and sensible heat flux?
- Or maintain Bowen Ratio?
- Complementary measurements of individual ET components?
- Cooperation with hydrological observatories.

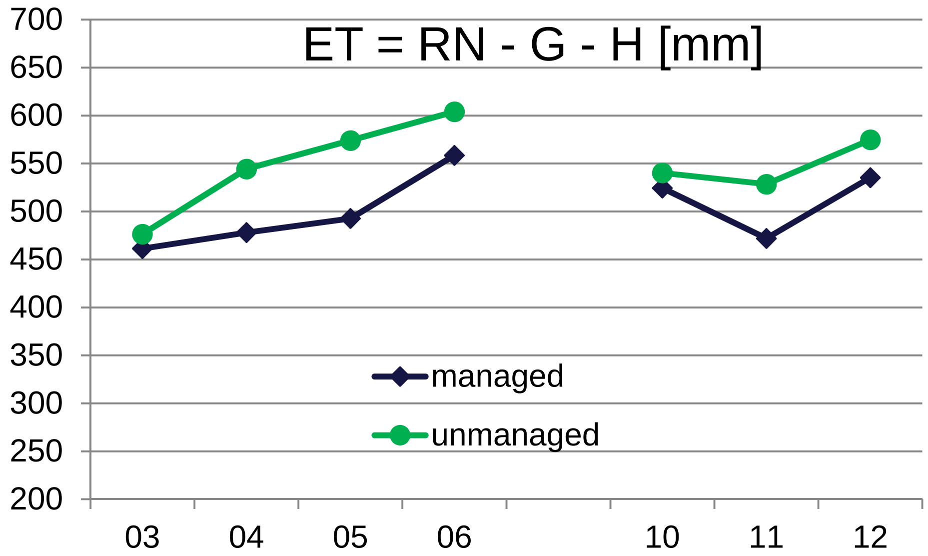
Example for correction at Hainich ICOS site and a neighbouring beech forest:

Energy Balance Equation: $R_N - G = H + \lambda E$

Available energy = net radiation minus soil heat flux

Sensible heat flux measured with Eddy Covariance using sonic temperature data

$ET = (R_N - G - H) / \lambda$



Results look much more plausible than for uncorrected λE. (Higher LAI and more rainfall at the unmanaged site)

For shorter time steps (e.g. diurnal variations) the heat storage in the biomass needs to be considered.

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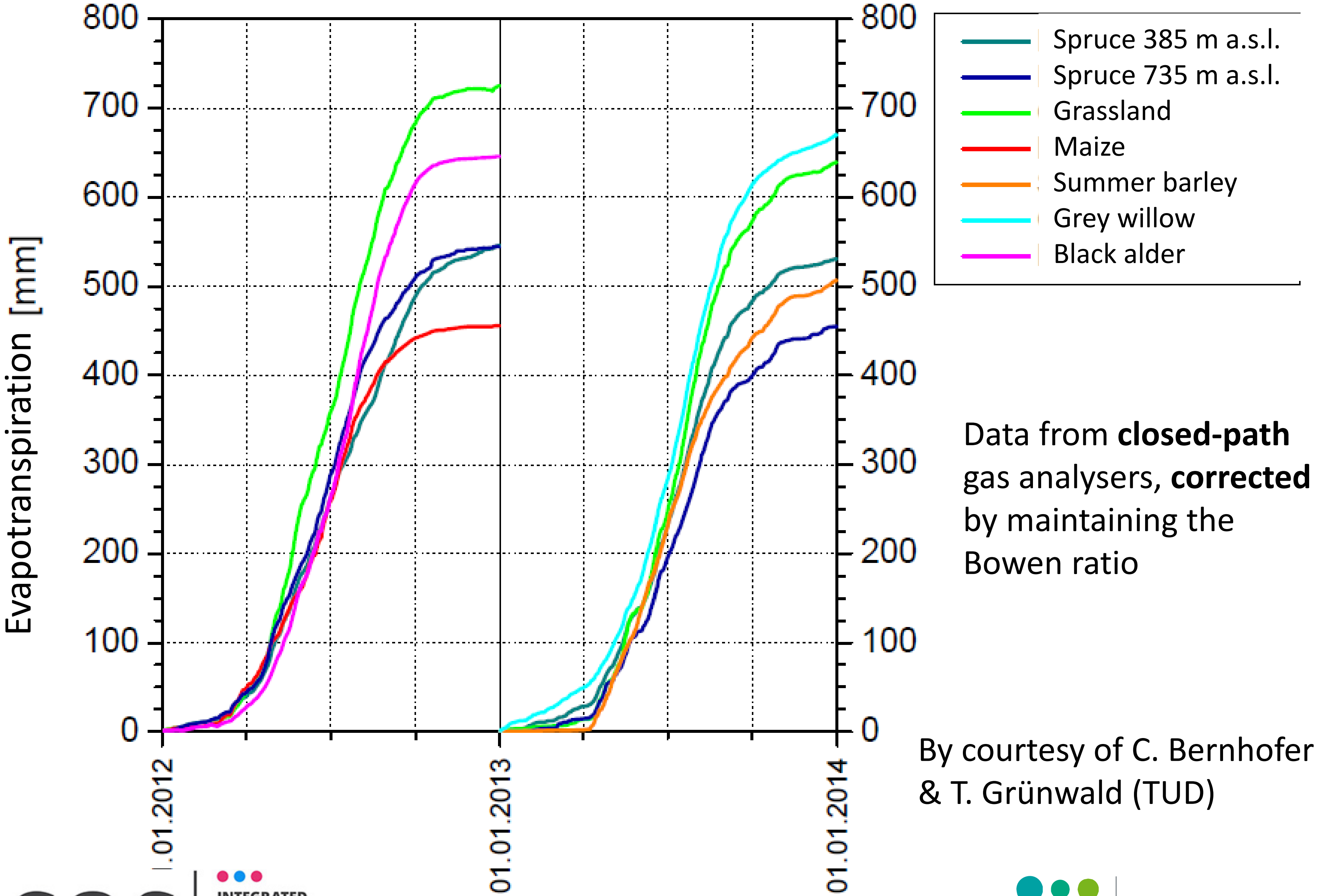

Data from **closed-path** gas analysers, **corrected** by maintaining the Bowen ratio

By courtesy of C. Bernhofer & T. Grünwald (TUD)

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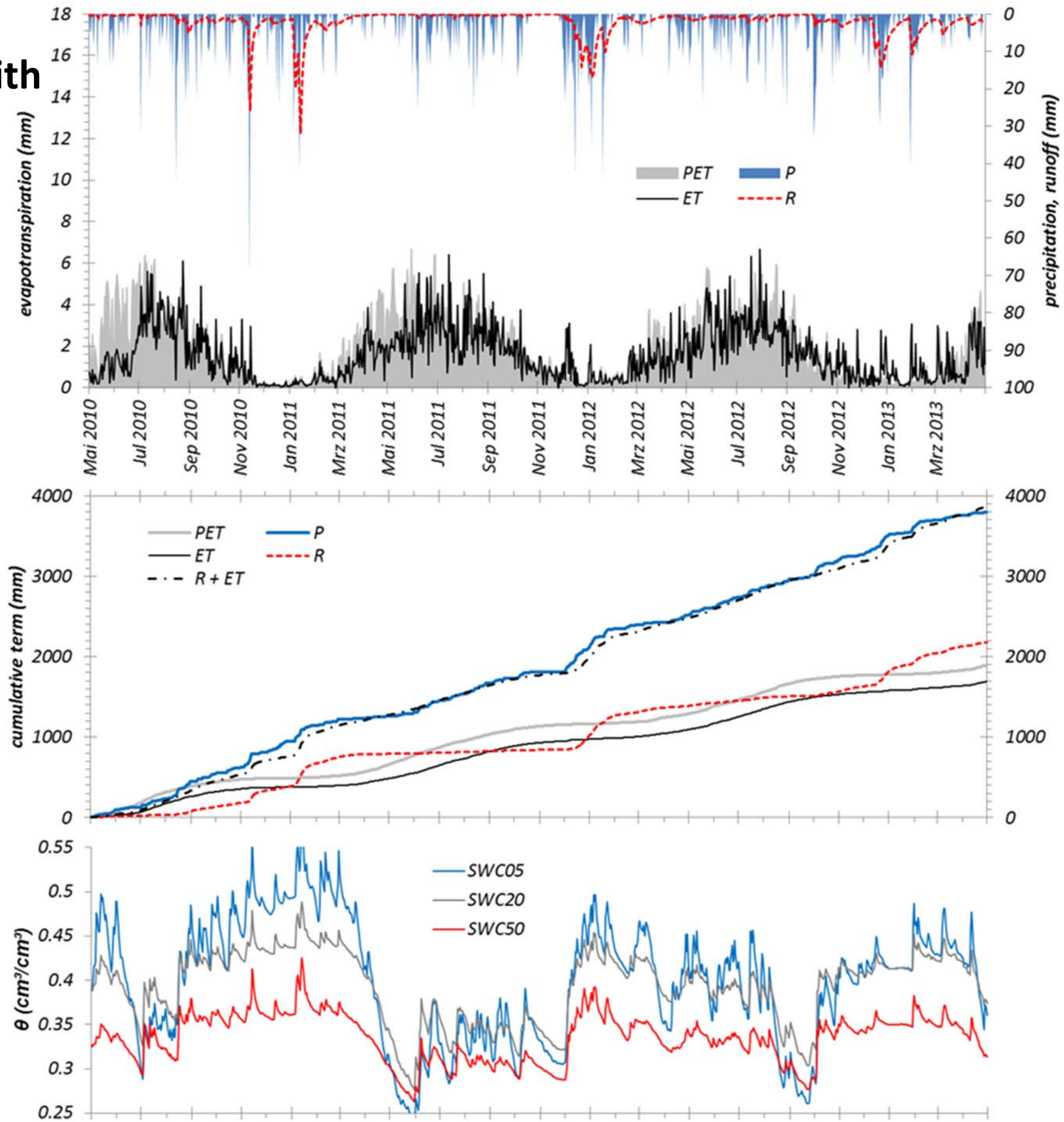
Collaboration with hydrological observatories to validate λE estimates:

ICOS & TERENO site Wüstebach



Uncorrected data from **open-path** gas analyser

By courtesy of H. Bogena, M. Schmidt, N. Borchard, and A. Graf (FZJ)

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Conclusions & open questions

1) Standardisation in ICOS:

- CO_2 flux on flat terrain +/- OK.
- But how to deal with complex topography?
- Water vapour fluxes?
- Biological data?

2) Analysis of IAV:

- How can consistency with pre-ICOS measurements be ensured?
- How can effects of irregular weather patterns or biological activities be predicted?

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