Integrated Carbon and Greenhouse Gas Observations

a societal and a scientific challenge

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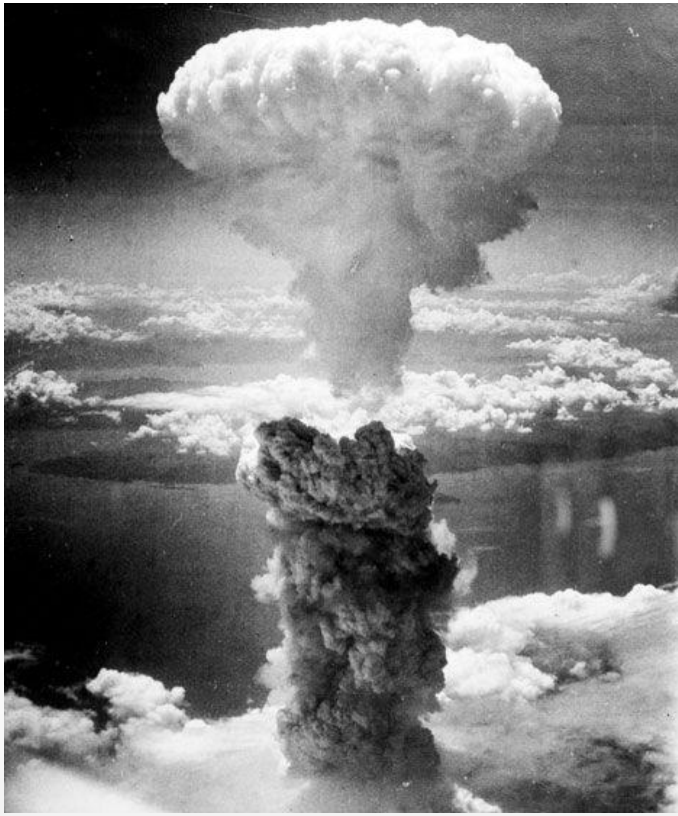
Scientific knowledge and society
The story of nuclear winter

Aboveground testing of nuclear bombs was banned 1963 after measuring high radioactivity in the atmosphere.

In the 1980 several studies showed that a nuclear war could not be survived by any side, since the dust and the aerosols carried up to the stratosphere would lead to a drop of average global temperature by 8 – 11° C meaning that those who survive the direct effects of the bombs would die from cold and starvation.

Severe reduction of nuclear weapons in the 1990ties.



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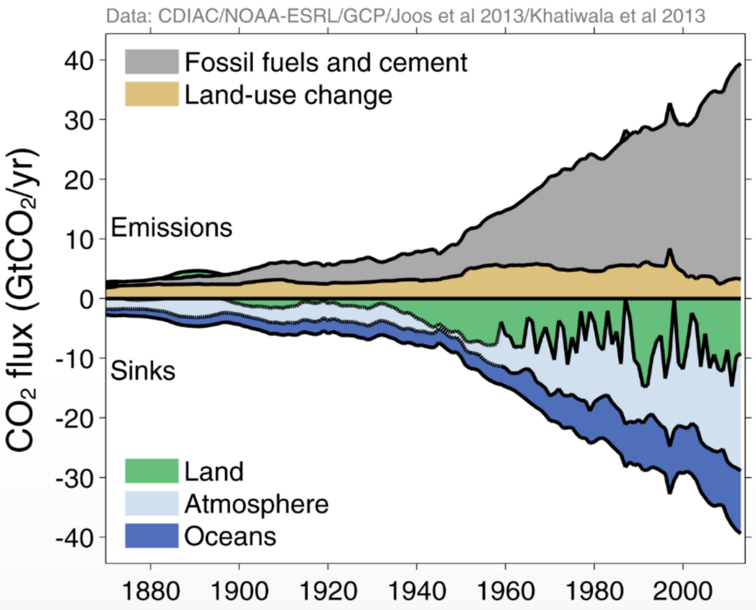
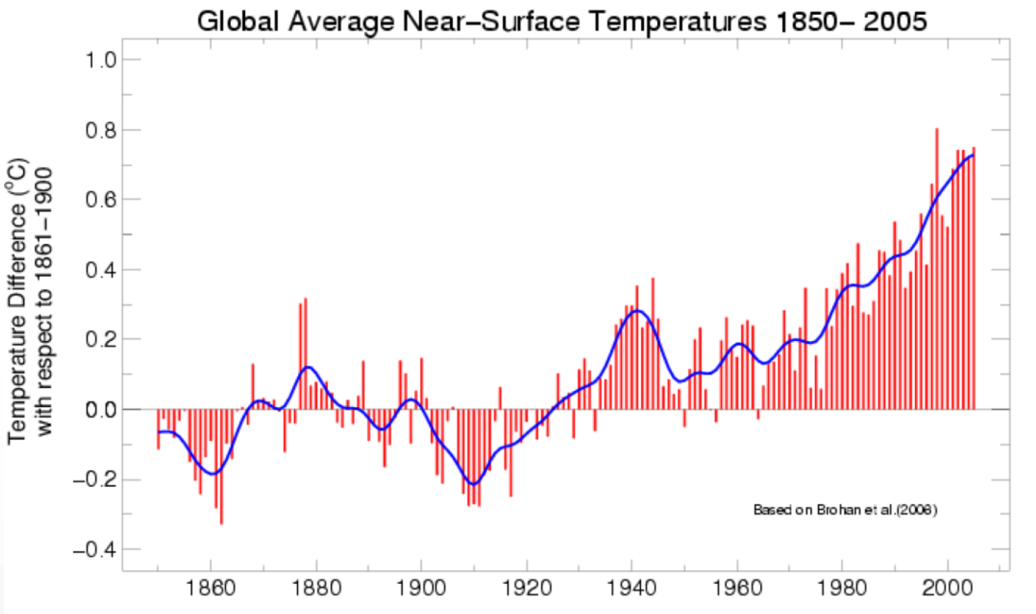
What can we learn for today's societal innovation regarding climate change





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The STERN REVIEW:
The Economics of Climate Change

Table 3.1 Highlights of possible climate impacts discussed in this chapter

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate-related diseases (predominantly diarrhoea, malaria, and malnutrition) Reduction in winter mortality in higher latitudes (Northern Europe, USA)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermohaline Circulation starts to weaken
2°C	Potentially 20 - 30% decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5 - 10% in Africa)	40 – 60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15 – 40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7 m sea level rise
3°C	In Southern Europe, serious droughts occur once every 10 years 1 - 4 billion more people suffer water shortages, while 1 – 5 billion gain water, which may increase flood risk	150 - 550 additional millions at risk of hunger (if carbon fertilisation weak) Agricultural yields in higher latitudes likely to peak	1 – 3 million more people die from malnutrition (if carbon fertilisation weak)	1 – 170 million more people affected by coastal flooding each year	20 – 50% of species facing extinction (according to one estimate), including 25 – 60% mammals, 30 – 40% birds and 15 – 70% butterflies in South Africa Collapse of Amazon rainforest (according to some models)	Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon Rising risk of collapse of West Antarctic Ice Sheet Rising risk of collapse of Atlantic Thermohaline Circulation
4°C	Potentially 30 – 50% decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15 – 35% in Africa, and entire regions out of production (e.g. parts of Australia)	Up to 80 million more people exposed to malaria in Africa	7 – 300 million more people affected by coastal flooding each year	Loss of around half Arctic tundra Around half of all the world's nature reserves cannot fulfill objectives	
5°C	Possible disappearance of large glaciers in Himalayas, affecting one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world cities such as New York, London, and Tokyo		
More than 5°C	The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such "socially contingent" effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.					

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A first approach

- Societal innovation in the context of environmental problems is depending on knowledge.
- This knowledge ideally is based on the best available science.
- It should be integrated by trans-disciplinary cooperation.
- Scientists should be independent and transparent.

Paris agreement at COP 21
requires best available science on greenhouse gases

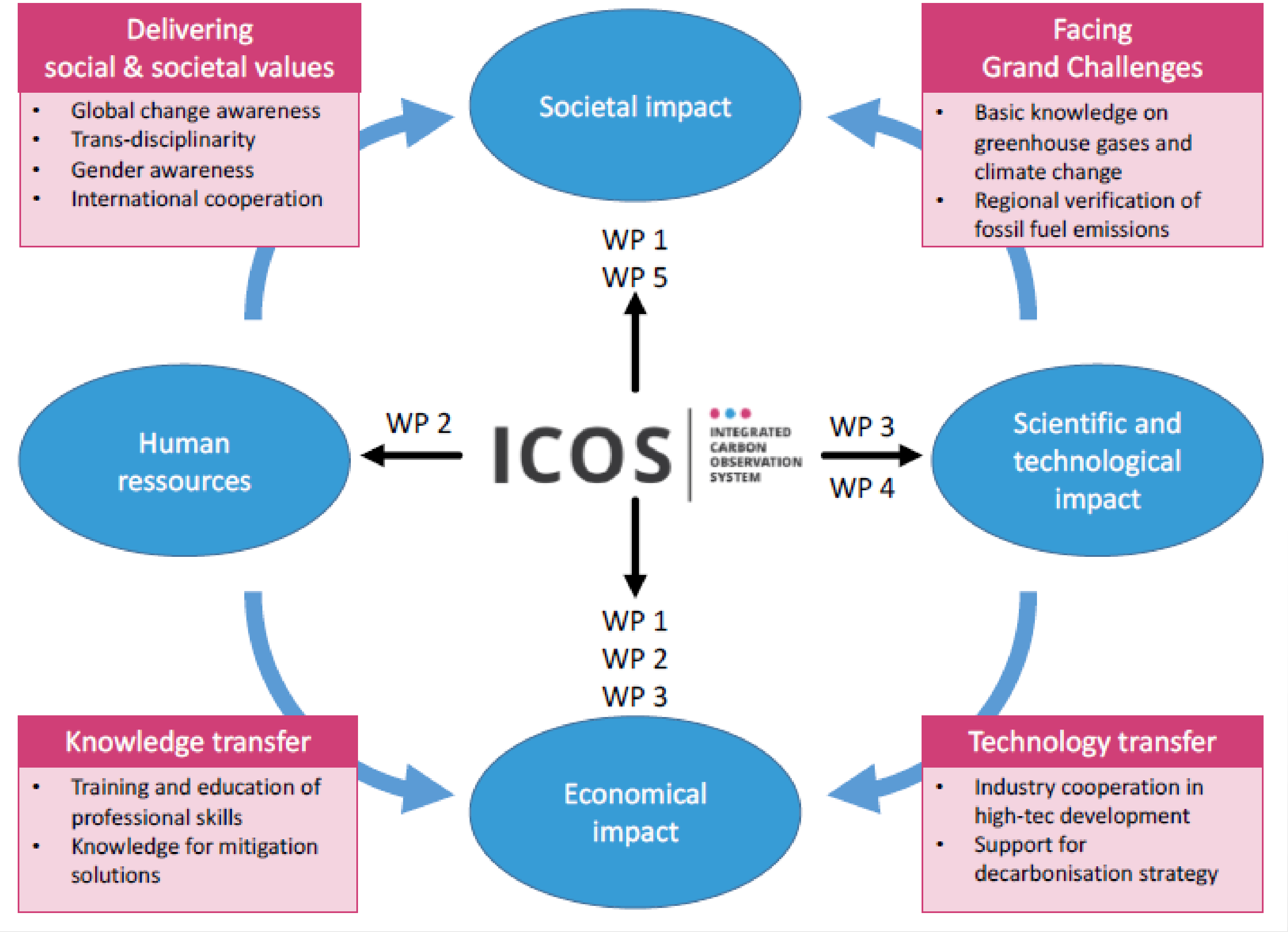
United nations conference
on climate change
COP21/CMP11

Best available science should:

- be general in terms of providing a global picture be regional to provide information specific verification questions (Art. 14),
- be problem-oriented and able to answer specific question (e.g. urban fluxes or agricultural practices),
- be able to provide knowledge to increase quality of inventories
- be able to contribute to adaptation
- support developing countries
- avoid doubling efforts

Research Infrastructures

Society faces many future challenges. [...] Research Infrastructures are one key instrument in bringing together a wide diversity of stakeholders to look for solutions to many of the above-mentioned problems. They can be seen as a focal point for such interactions, in addition to inspiring new research ideas and attracting young enquiring minds. (ESFRI Roadmap 2006)


Delivering social & societal values
Global change awareness
Trans-disciplinarity
Gender awareness
International cooperation
Societal impact
Facing Grand Challenges
Basic knowledge on greenhouse gases and climate change
Regional verification of fossil fuel emissions
WP 1
WP 5
Human ressources
WP 2
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WP 3
WP 4
Scientific and technological impact
WP 1
WP 2
WP 3
Knowledge transfer
Training and education of professional skills
Knowledge for mitigation solutions
Economical impact
Technology transfer
Industry cooperation in high-tec development
Support for decarbonisation strategy

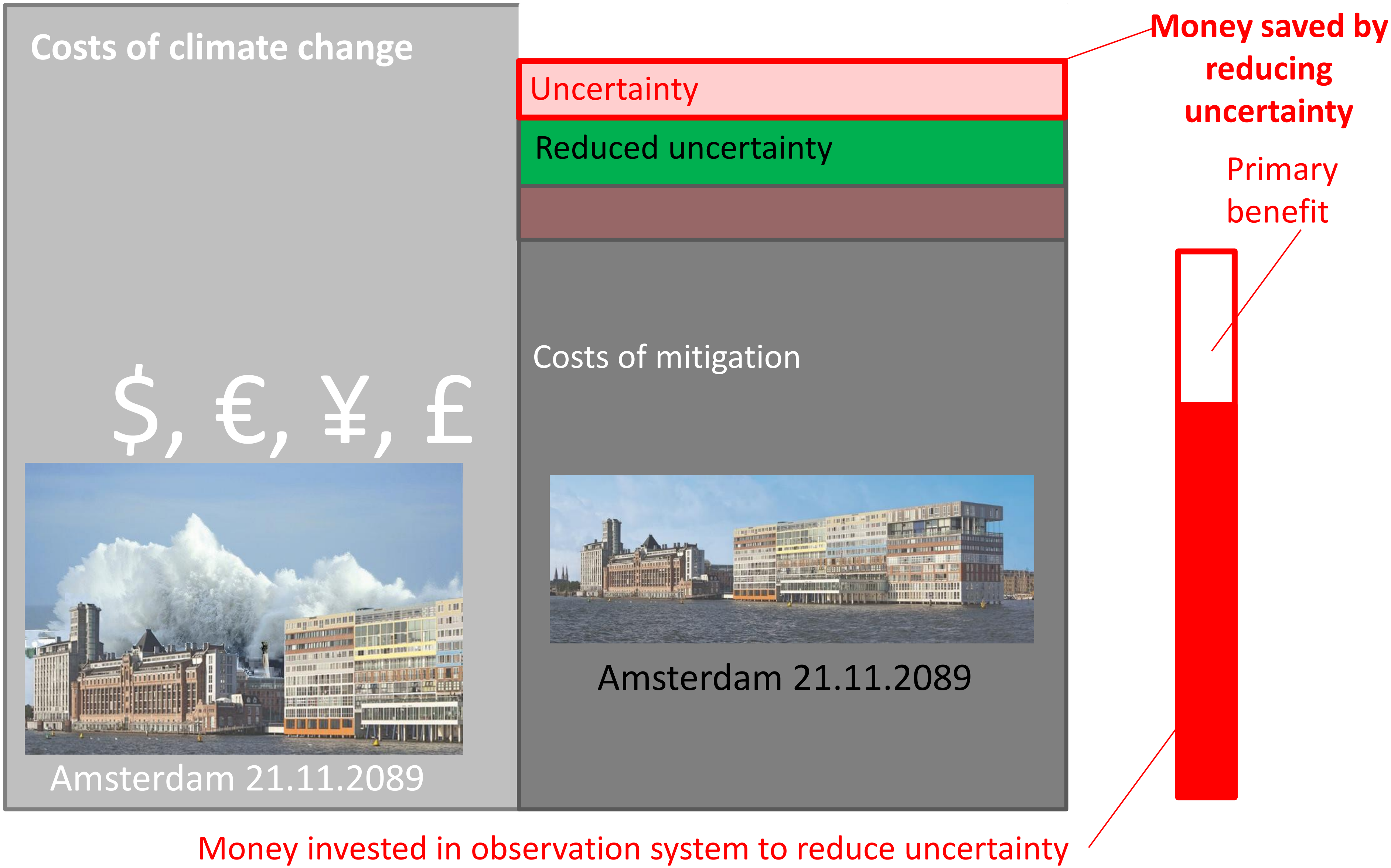
Impact

To show the impact of ICOS will be crucial for its long-term sustainability:

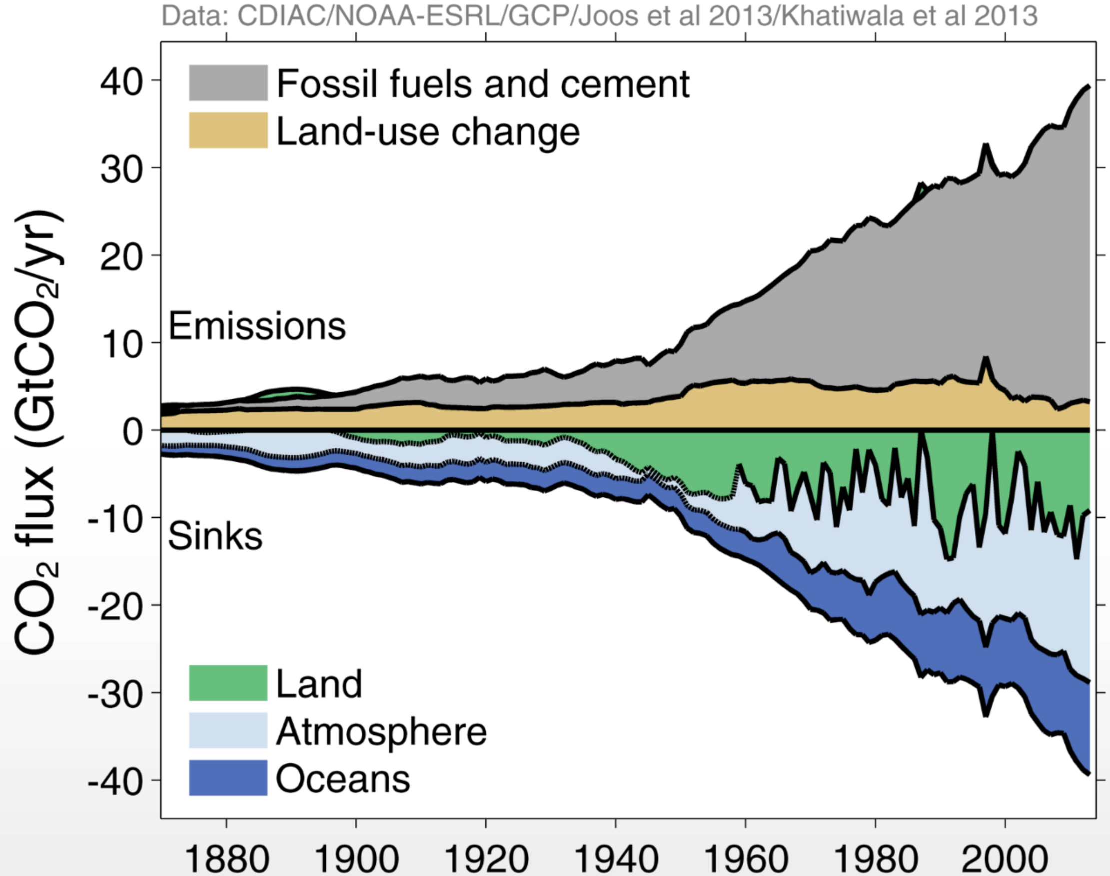
- Scientific impact: data usage, products, publications;
- Technological impact: how fast can new technologies be implemented? (clearly resource dependent);
- Societal impact: increase sustainability and resilience of our societies, indicators to be developed, e.g. by measuring connectivity to IPCC, SBSTA, GCOS, GEO etc.;
- Economic impact: commercial applications of data or technical innovation by new sensors.

ICOS will be a pilot study here for all ENVRIs.

Profit from investments into environmental observations

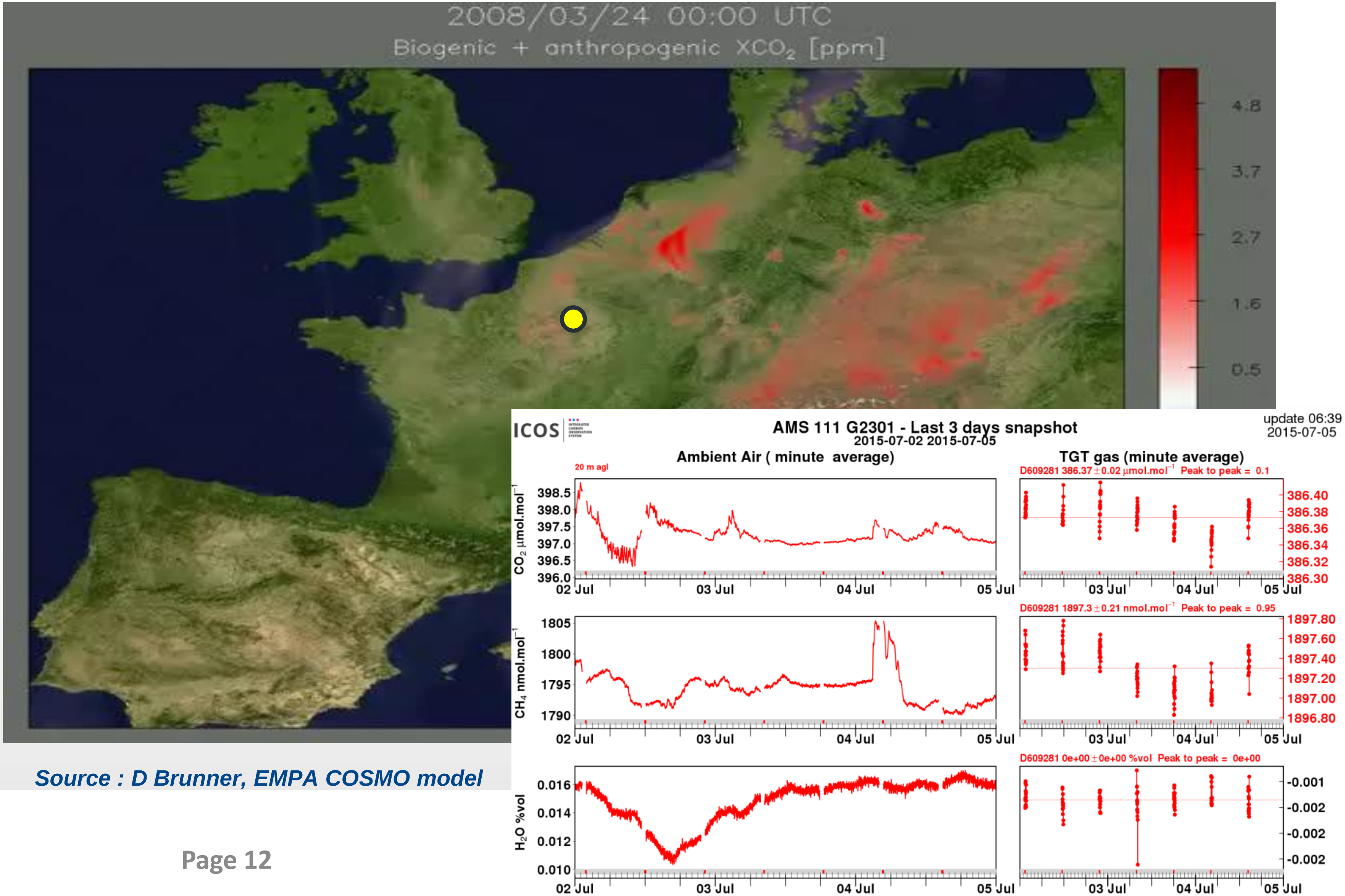


Emissions are partitioned between the atmosphere, land, and ocean



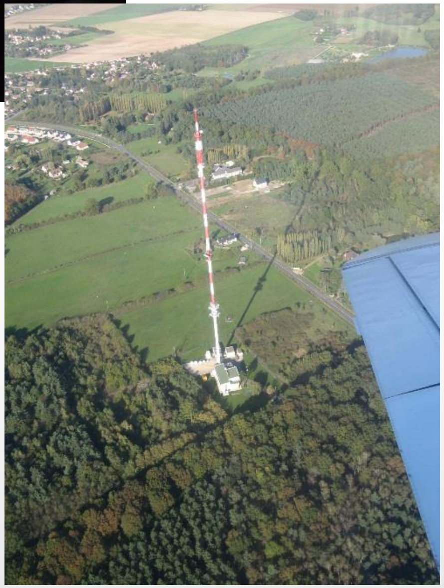
Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Joos et al 2013; Khatiwala et al 2013; Le Quéré et al 2014; Global Carbon Budget 2014

Concentration of GHG in the lower Atmosphere

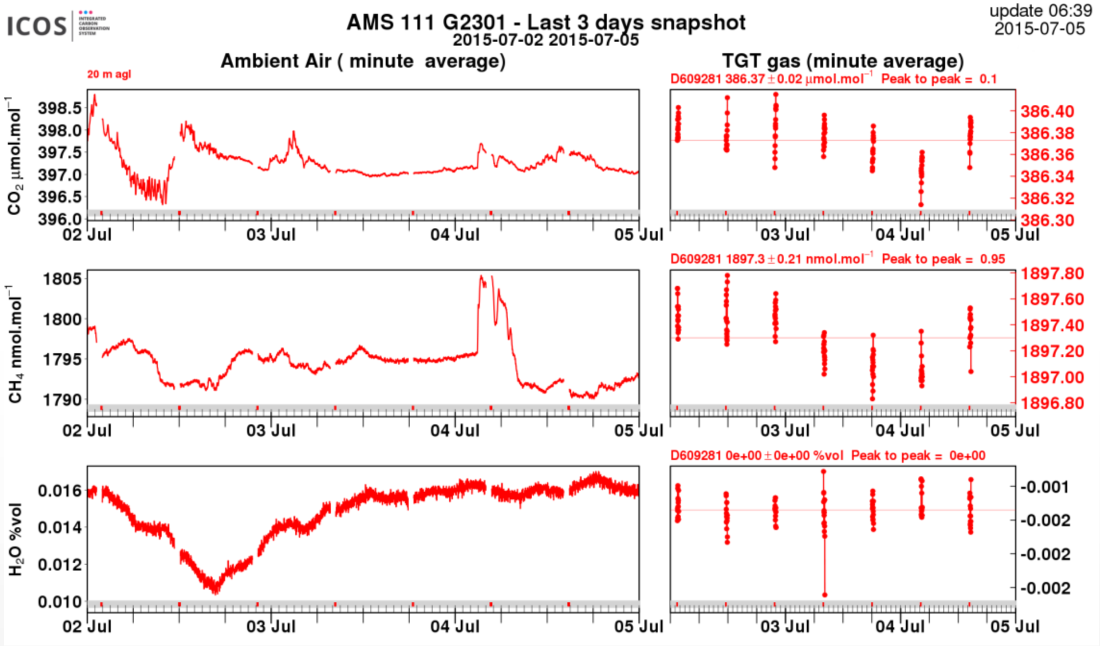


Source : D Brunner, EMPA COSMO model

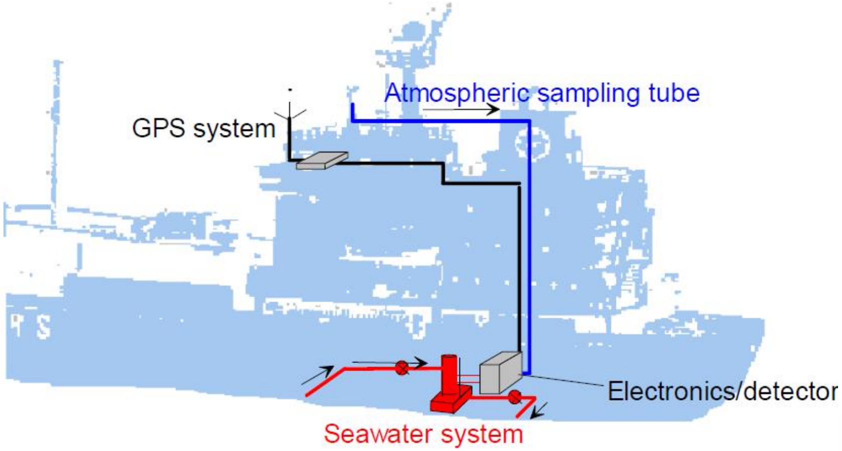
Concentration of GHG in the lower Atmosphere



Near Real Time Data



Greenhouse gas exchange between Oceans and Atmosphere



Fugacity of CO_2 (fCO_2) and partial pressure of CO_2 (pCO_2)

$fCO_2 = \gamma\ pCO_2 = [CO_2] / K'0$

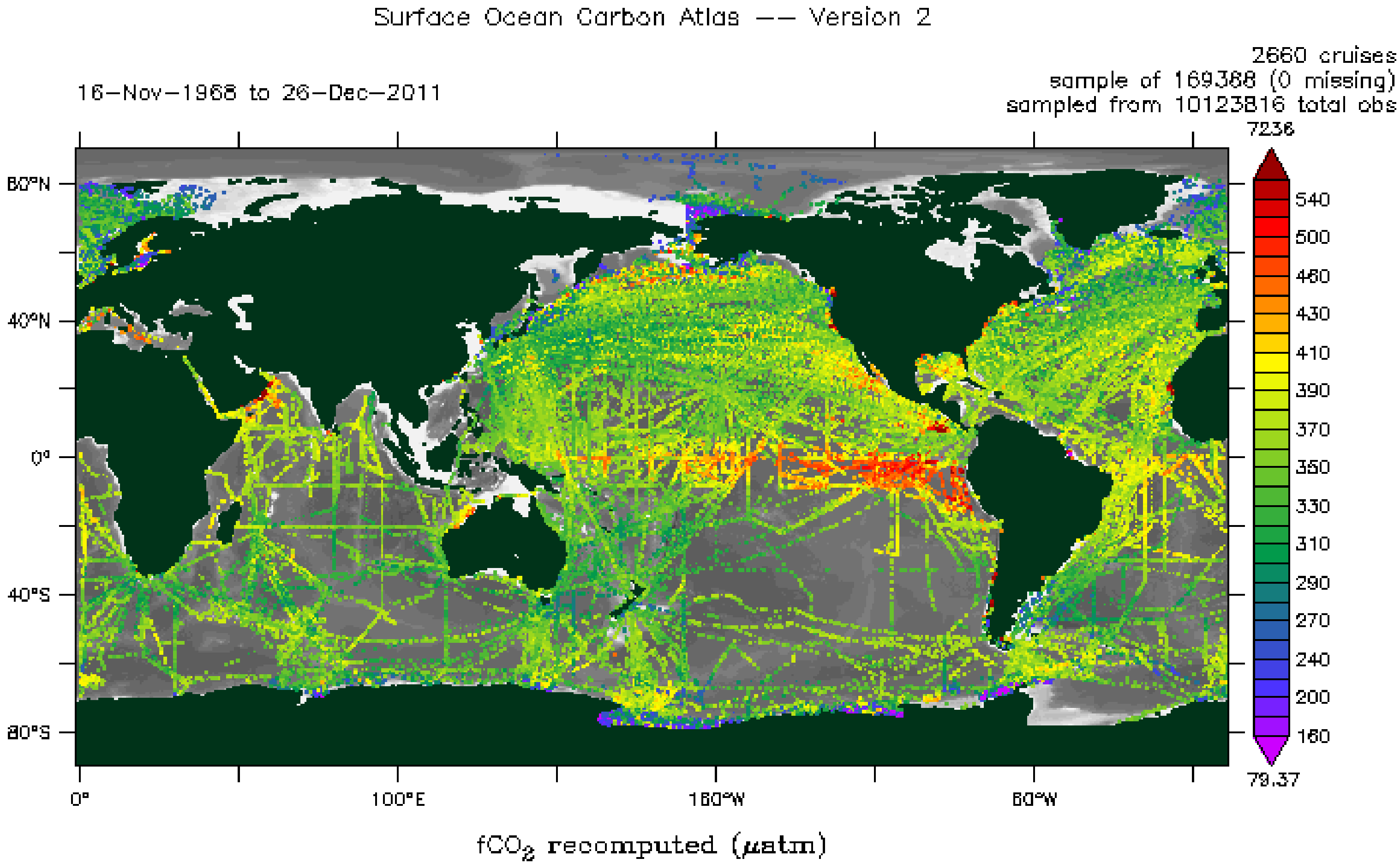
$(\gamma \sim 0.996\text{-}0.997)$

[curtesy: Dorothee Bakker]

Schuster and Watson (2007) JGR

http://www.socat.info

Overall data availability



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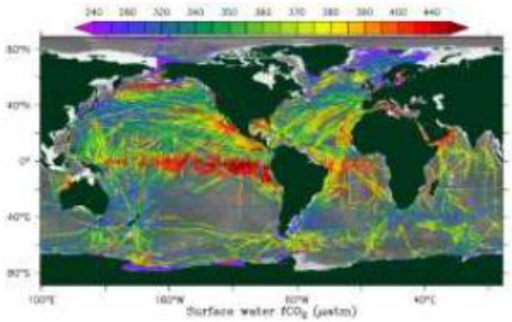
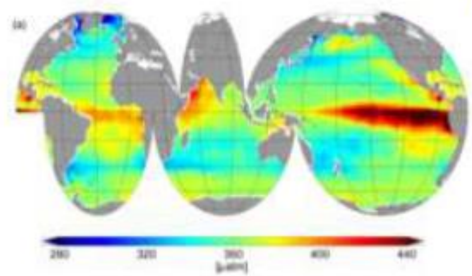
Ocean fluxes



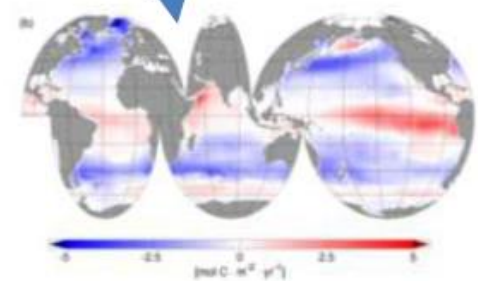
A SOCAT data product
(synthesis or gridded)

A mapping method



Surface water fCO_2
(here 1998-2011)

Gas transfer parameterisation,
wind speed

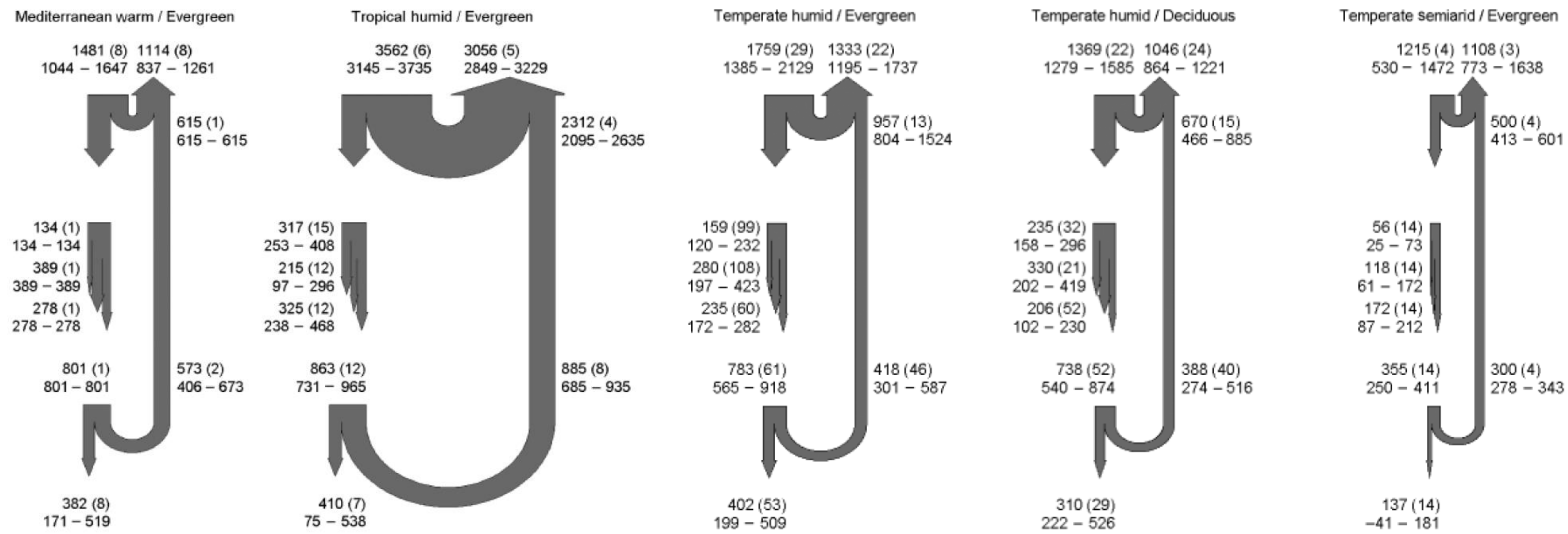


Air-sea CO_2 flux
(here 1998-2011)

The (spatial/temporal) variability in data-based air-sea CO_2 flux estimates can improve land CO_2 flux estimates by atmospheric inversion (Rödenbeck et al., 2014). (Figures Bakker et al., 2014; Landschützer et al., 2014).

Greenhouse gas exchange between Ecosystems and Atmosphere

Carbon and Greenhouse Gas Balances of Ecosystems



Luyssaert et al. 2007

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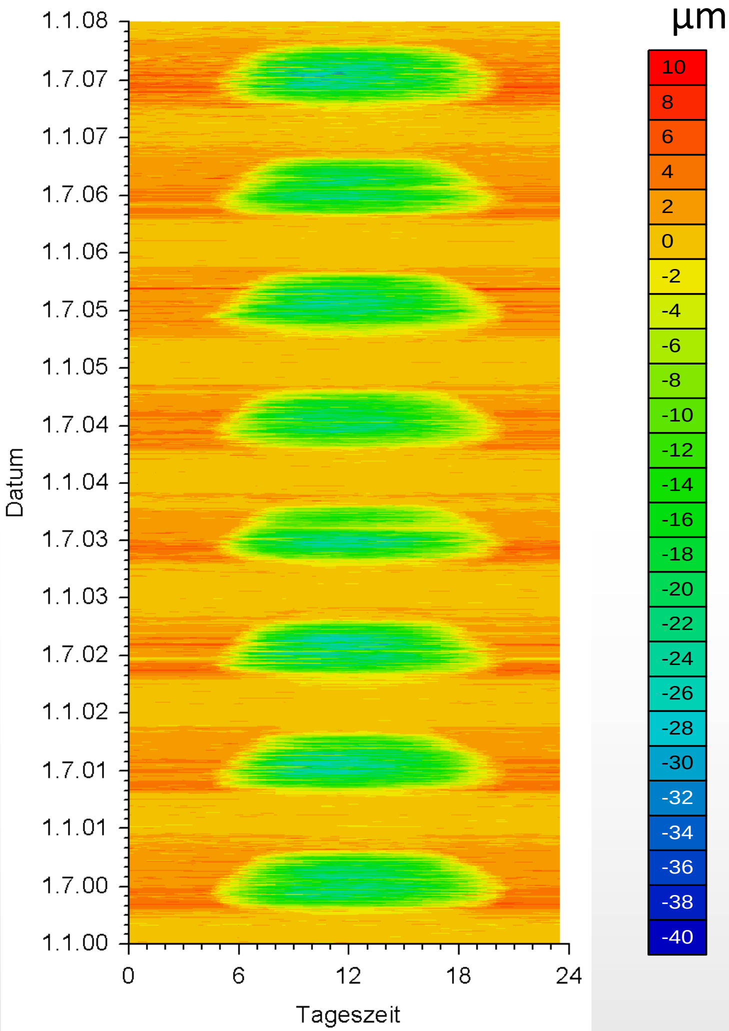
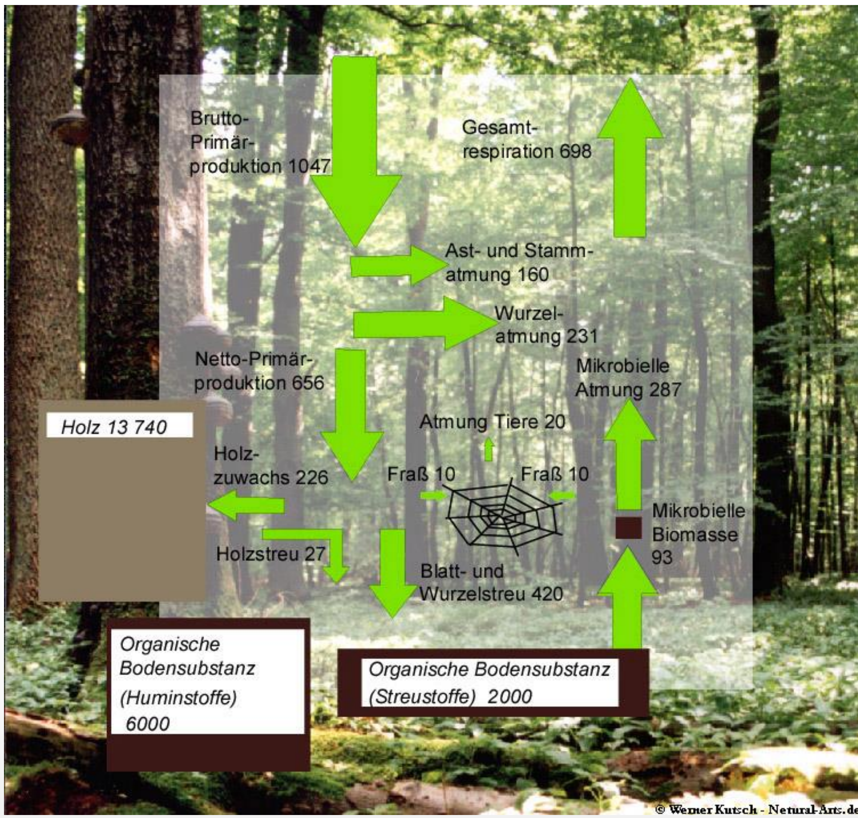
Forests



Emission of CO_2

Uptake of CO_2



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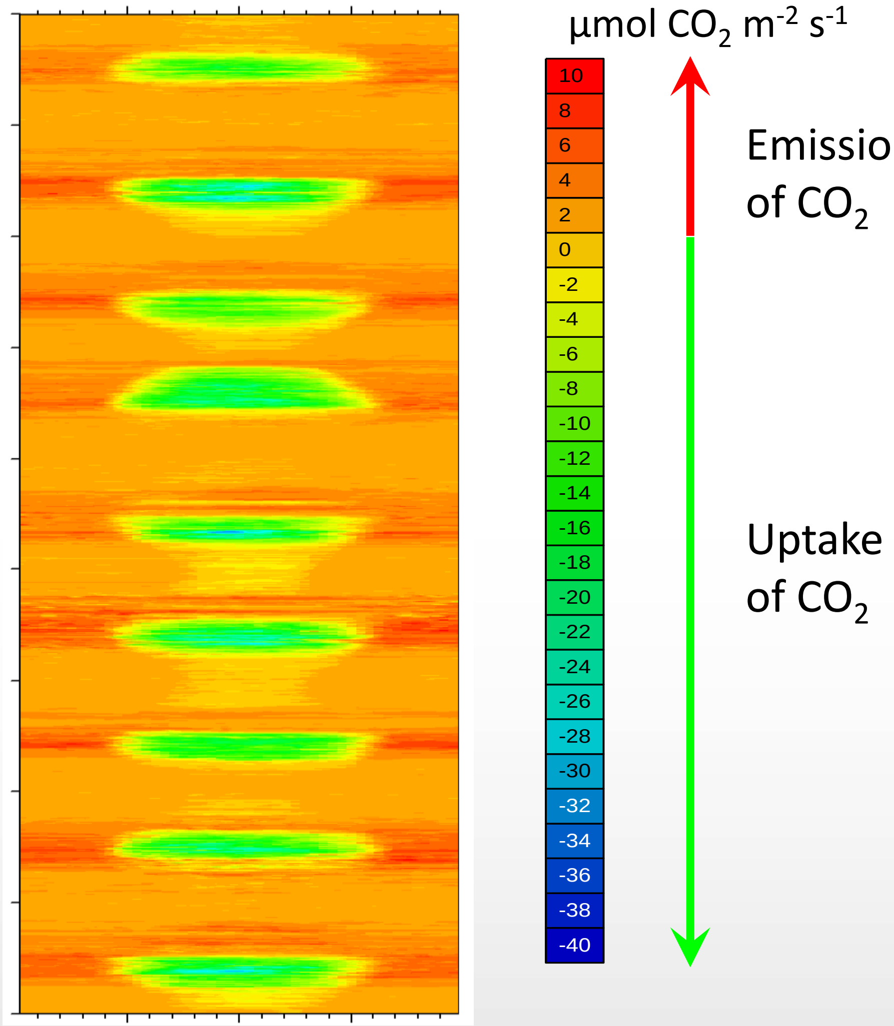
Cropland



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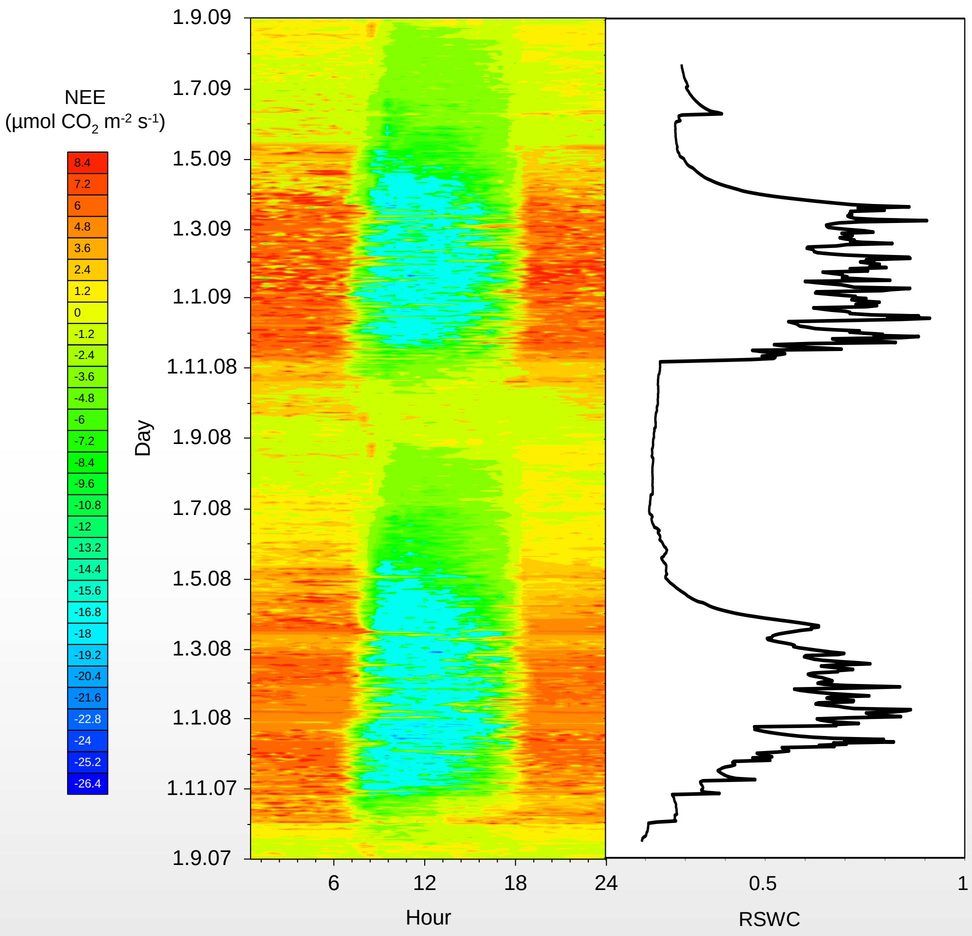
Miombo Woodland (Zambia)



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The Integrated Carbon Observation System (ICOS) Vision and Scientific Mission

- 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.

Current status of ICOS: 9 signature countries, > 100 stations and VOS lines, 2016 fully operational

~100 Mio € Investments
~20 Mio € per year running costs

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Thank you for your attention!

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