ICOS and IG^{3}IS

Alex Vermeulen

With contributions from:

ICOS Carbon Portal,

ICOS Head Office,

The ICOS RI Team

ICOS | INTEGRATED CARBON OBSERVATION SYSTEM

ICOS Research Infrastructure (not a project!)

- Integrated Carbon Observation System (https://www.icos-ri.eu/)
- Pan-European research infrastructure for greenhouse gas and carbon cycle observations
- Consistent long term (>20 years), high precision, high quality observations
- ERIC since November 2015, ESFRI “landmark” since 2016
- Integrates 3 domains: atmosphere, ecosystem and ocean
- All data open access: Creative Commons Attribution 4.0 International (CC4BY)

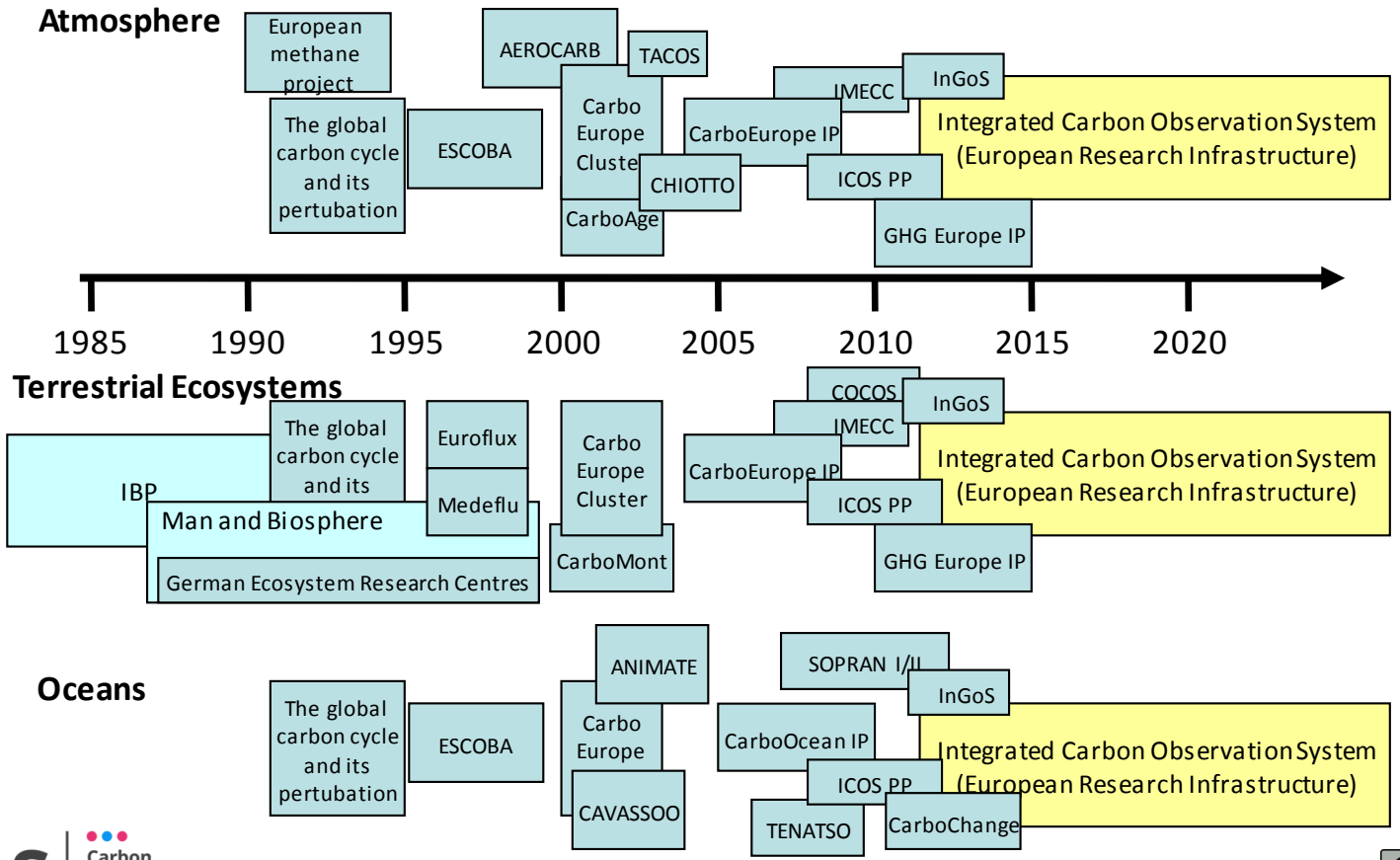
34 atmosphere stations

76 ecosystem stations

21 ocean stations (incl. ships)

ICOS Carbon Portal

ICOS from projects to Research Infrastructure



ICOS Carbon Portal

ICOS – all about reliable data

Integrated Carbon Observation System

Informs:

- Scientists (IPCC, UNFCCC)
- Policy makers
- General public

Generate high quality observation data of greenhouse gas concentrations and exchange fluxes

Transparent – open data (CC4BY)

From raw to elaborated data products

Clear data lifecycle

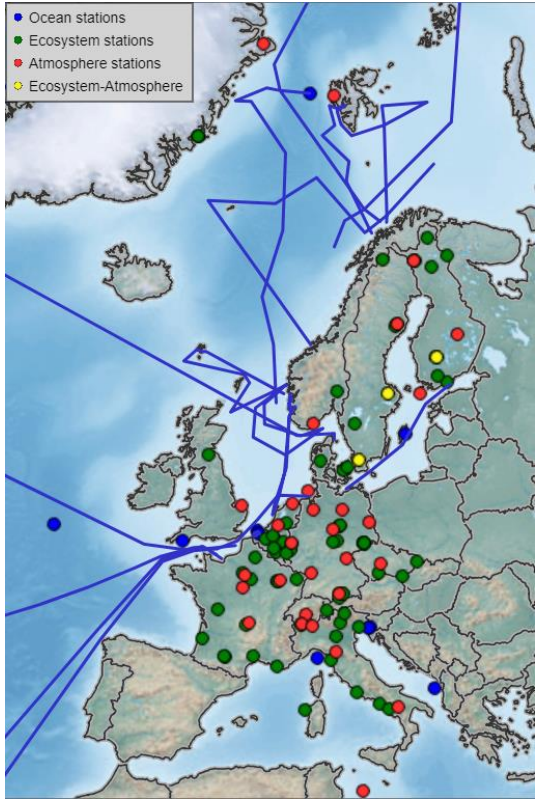
Catalyser of biogeochemical science

Improve knowledge and inform on

- Anthropogenic and natural fluxes
- Detect climate feedbacks
- Emission trends

Timely and factual information, beyond debate!

ICOS Stations



130 measurement stations

76 Ecosystem stations

33 Atmosphere stations, 22 tall towers

21 Ocean stations

including stations in French Guyana, La Reunion, Cape Verde (not visible here)

12 member states

Several countries considering: Hungary, Lithunia, Spain, Ireland, Romenia, Greece, Poland, South-Africa

ATM station spec: https://icos-atc.lsce.ipsl.fr/filebrowser/download/27251

ECO instructions: http://www.icos-etc.eu/icos/documents/instructions

The ICOS $^{14}CO_2$ network









ICOS Carbon Portal

ICOS RI Services to members

- Uniform station design (for atmosphere following GAW recommendations+)
- Community defined common measurement protocols, standardized instrumentation
- Central data processing at (distributed) Thematic Centers (TC)
  - Full processing chain from raw to full QC'ed product, traceable, transparent
  - PI's contribute metadata, check data, add quality flags
- Central Calibration lab (Germany)
  - Flask and $^{14}CO_2$ analysis
  - Provision & reassignment of spiked natural air working standards and targets (WMO scales)
- Station networks run by nations -> monitoring station assemblies
- Legal representation in ERIC, Head Office (Finland) plus Carbon Portal (Sweden)
  - Central administration
  - Coordination, together with heads of TCs and MSA chairs
  - Communication
  - International strategy and relations: WMO GAW, SOCAT, Fluxnet,, GEO Carbon and GHG Initiative
  - Central data portal, open access, attribution and usage tracking
- Financial contributions by member states
  - Membership, partially dependent on GDP
  - Station contribution, dependent on domain, Class (I, II, associated)
- Nations contribute to 80% of HO, CP, TC, CAL, rest from member contrib.

Socio-economic impact: from Observations to Decisions

Framework Convention on Climate Change

SBSTA

Data sharing
Data management
(incl. metadata)

From data to knowledge

Model-Data Fusion projects

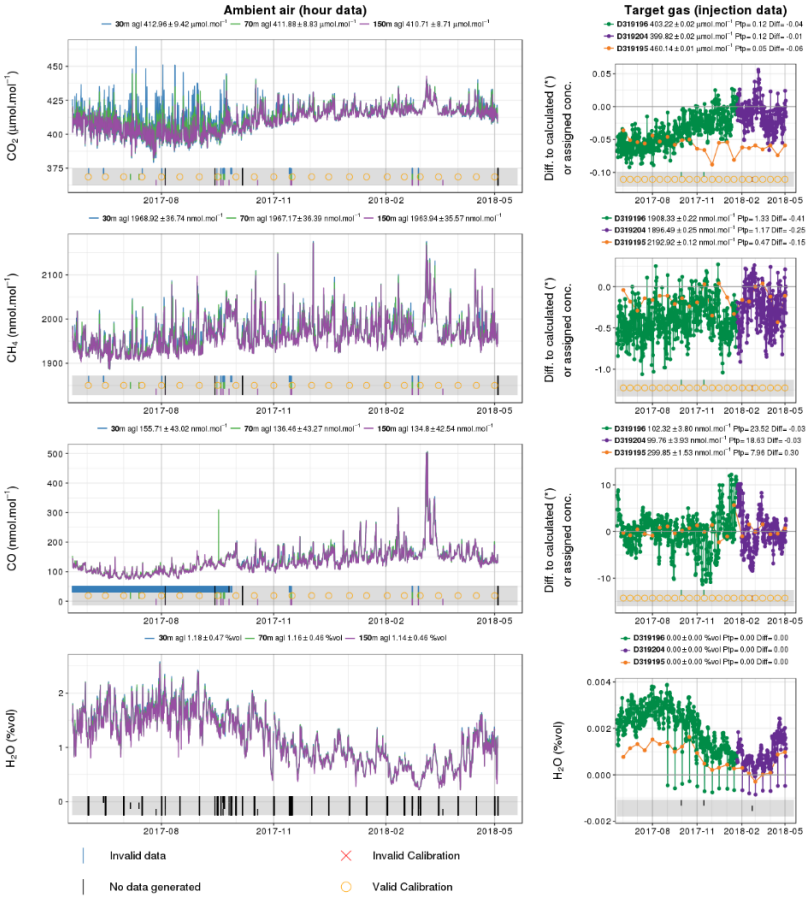
Decisions have economic impact.
How to measure the economic impact of the UNFCCC process?
And the role of the RIs?
Any KPIs?

ICOS Atmosphere Thematic Centre

HTM 461 - Last year snapshot

P0004.1
update 2018-05-20 06:58

2017-05-20 - 2018-05-20



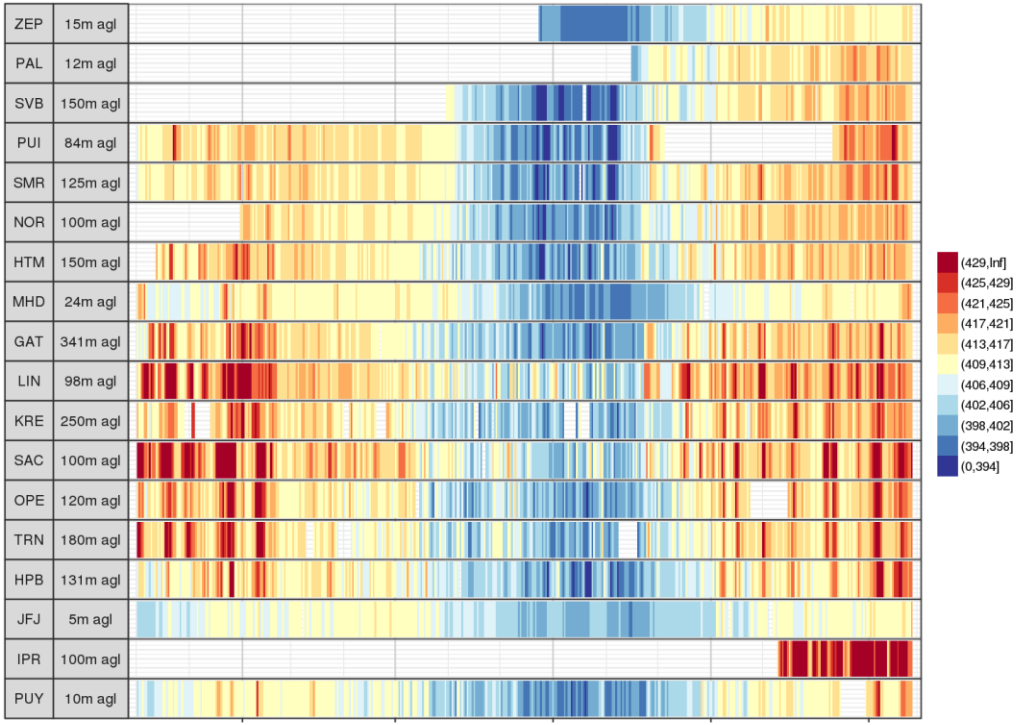
ICOS Atmosphere Thematic Centre

Network concentration evolution

P0004.5
update 2018-05-20 06:59

2016-12-01 - 2018-02-27

CO_2 ($\mu mol.mol^{-1}$) - 0:00 to 24:00 local time

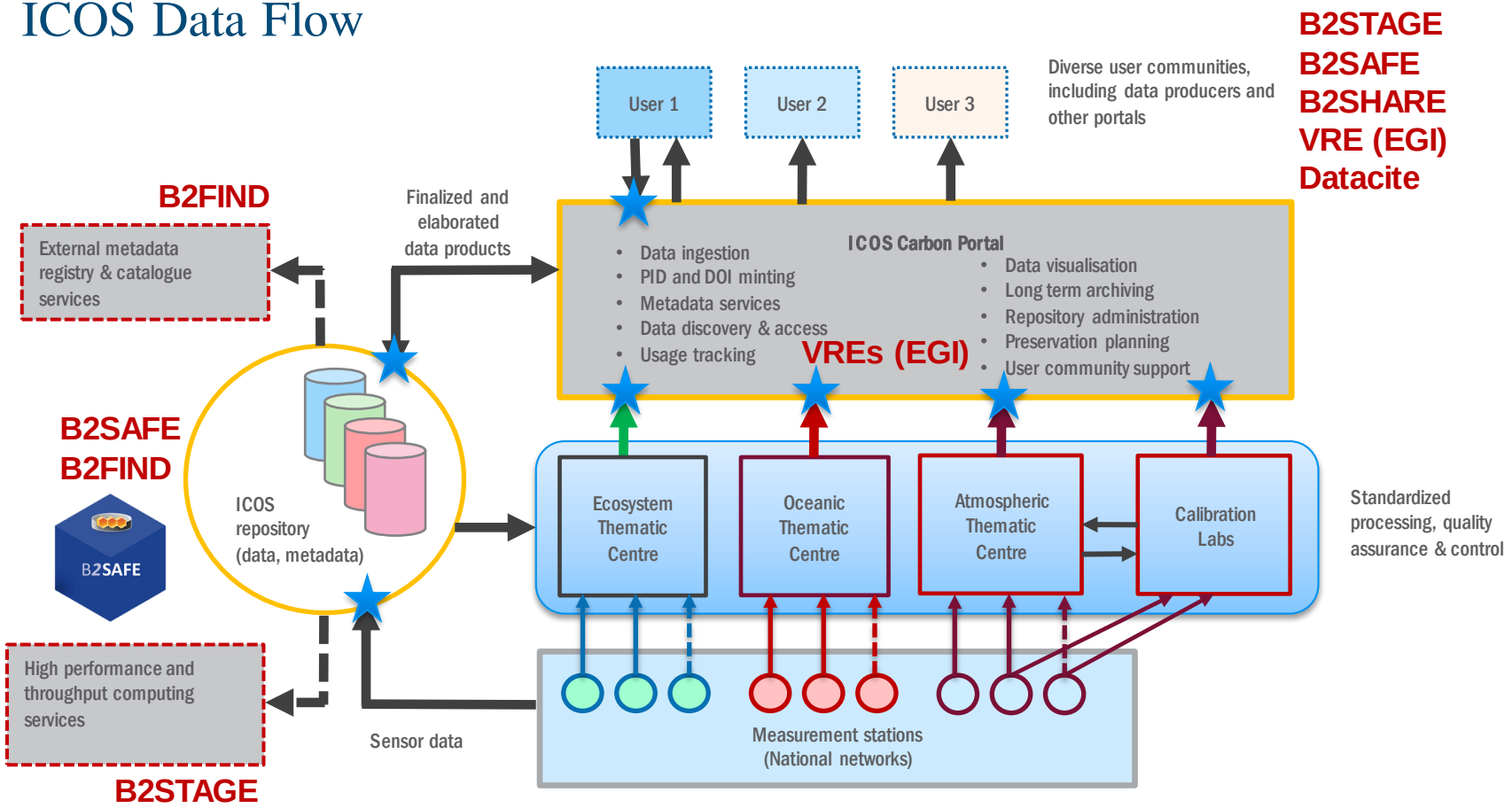


https://icos-atc.lsce.ipsl.fr/dp

Hazan et al., 2016: Atmos. Meas. Tech., 9, 4719-4736, doi:10.5194/amt-9-4719-2016, 2016.

ICOS Carbon Portal

ICOS Data Flow



ICOS data at Carbon Portal in numbers 2018-9-10 (now)

- Registered user accounts: 223 (42 ORCID)
- Data object downloads: 16 204 (34 795)
- Unique IPs of downloads: 2 840 (4000)
- Stored Data Objects: 38 044 (58 482)
- ICOS Data Objects: 32 269 (35 241)
  - L0 ICOS Data Objects: 24 795 (34 979)
  - NRT ICOS Data Objects: 7 277 (128, now dynamic data)
  - L2 ICOS Data Objects: 137 (134)
- Minted DOIs: 38 (42)

Two projects to develop ICOS & the network

RINGO 2016-2020

Development of ICOS

- Drones and aircores
- City observations
- Connections to TCCON
- $^{14}CO_2$ and Flask sampling strategy
- Historical time series
- Metadata harmonisation

SEACRIFOG 2017-2019

Food security and climate in Africa

- Ecosystem fluxes
- Capacity building
- Training
- Network design
- Many African partners

Achievements

Tremendous progress in ICOS Research Infrastructure

- Definition of data lifecycle
- Station design and protocols
- Station qualification (labelling) well underway to more than 130 stations
- First high quality data products now available
- 'FAIR' open data portal ready
- Globally well connected:
  - WMO GAW, Fluxnet, SOCAT, Geo Carbon and GHG initiative, IG^{3}IS, Copernicus
- Innovations in measurements and data products
  - EUDAT2020, ENVRIplus, RINGO and soon ENVRIFAIR)

Requirements for IG^{3}IS projects success

- Connection to global obs. network
- Regional high resolution obs. network
- Transparent and open data system
- Largely improved atmospheric transport models
- Multiple models/methods
- Not just one answer: uncertainty analysis
- Use of tracers like $^{14}CO_2$
- Cooperation with bottom-up inventory
- Don’t forget the biogenic sources and sinks!

ICOS Data Statistics

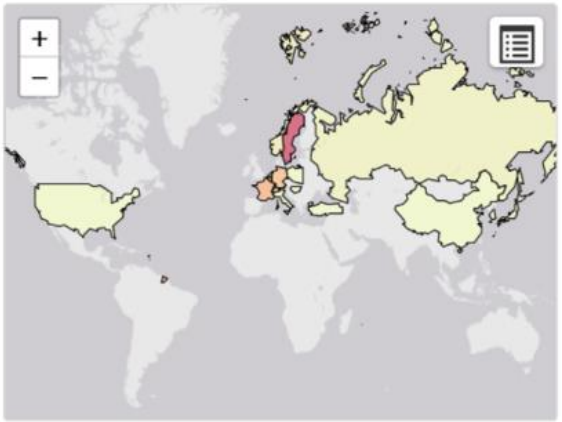
Data object specification filter

Specification	Specification
Format	Format
Data level	Data level
Stations	Stations
Contributors	Alex Vermeulen×
Theme	Theme
Country codes	Country codes

Data objects 1 to 4 of 4

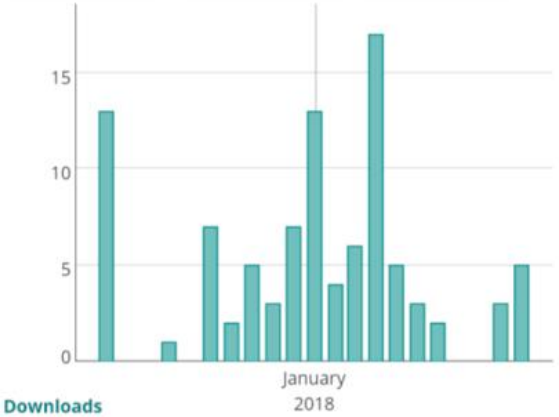
File Name	Landing Page	Count
INGOS_CH4_release2014.rar	DWdS18nrTliIcGS4VRZWOx4V	46
INGOS_CH4_release2014.rar	jDf17GEVm78p5GEz9hYMSNki	39
INGOS.RAR	JsY0mNz-2qZzuuD3uo0Dmr-U	6
COMET_ECN.rar	k_uxwoz8nqA9y-F-XJ_0BMpl	5

Downloads per country



Downloads per time period

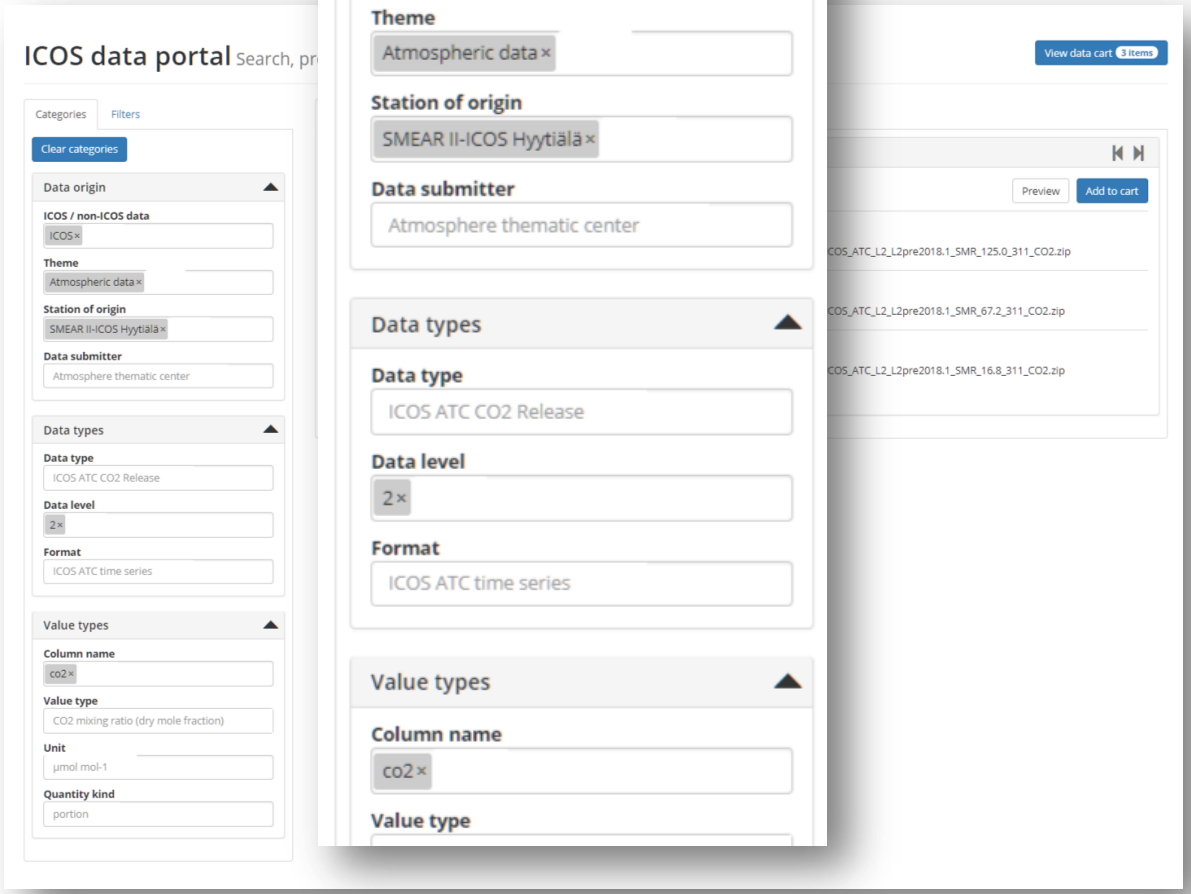
Per week | ✔ Per month | Per year



Find Data; faceted search

https://data.icos-cp.eu/portal

https://data.icos-cp.eu/portal/#s earch?theme=%5B%22Atmospheric%20data%22%5D&level=%5B2%5D &sickos=%5B %22ICOS %22 %5D&station= %5B%22SMEA



ICOS data portal Search, preview, download data objects

View data cart 3 items

ces991n00.ecn.as.cn.co2.nl.hr2011 spo789s00.noaa.as.cn.co2.nl.hr2011 mhd653n00.lsce.as.cn.co2.nl.hr2011

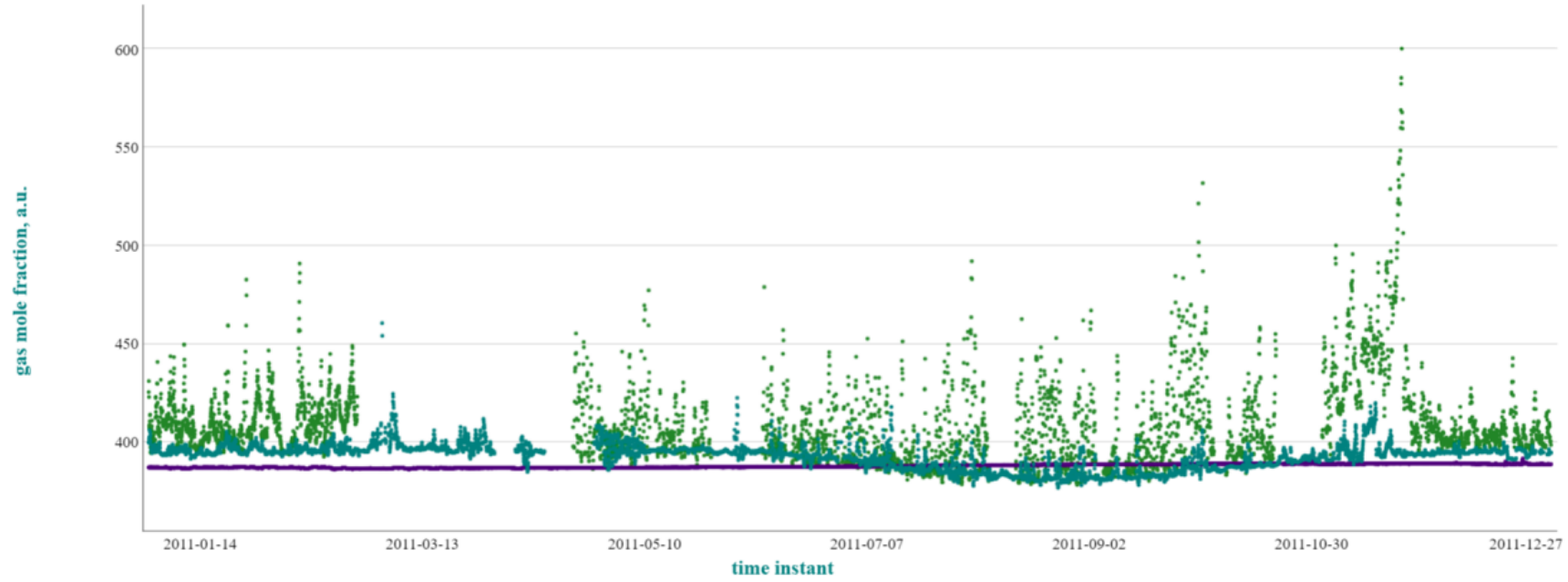
Copy preview chart URL

Add to cart

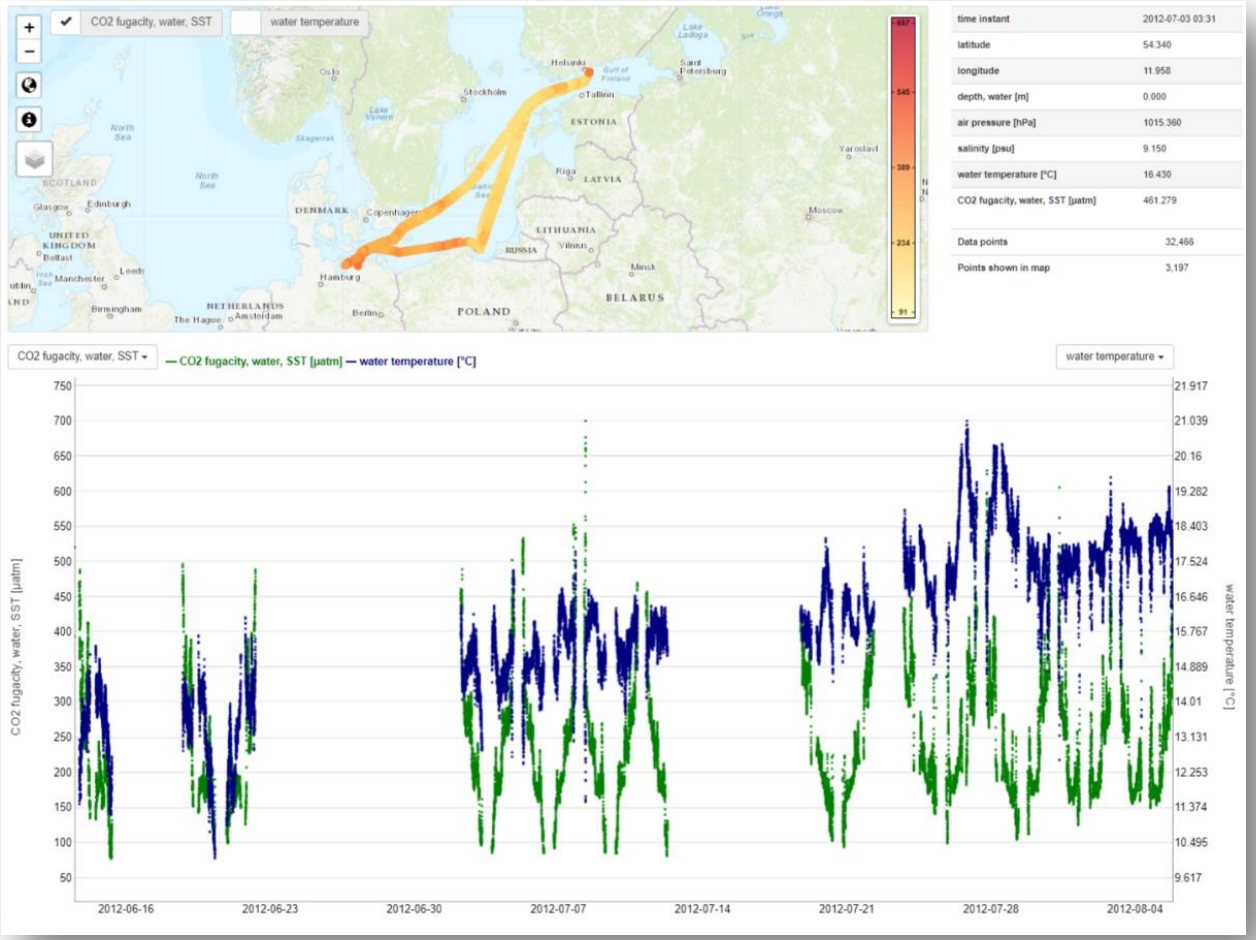
X axis: TIMESTAMP

Y axis: PARAMETER

Chart type: scatter



https://data.icos-cp.eu/map-graph/?objectid=2UboWPA8fW3L0IEY_ZVfwIaM#{%22y1%22:7,%22y2%22:6,%22map%22:7,%22center%22:{%22lat%22:57.25528038552833,%22lng%22:18.286902046878048},%22zoom%22:5}



ICOS Carbon Portal

ICOS data portal Search, preview, download data objects

View data cart 7 items

Back to search

EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.200809

https://data.icos-cp.eu/netcdf/6T0zQII1VzJHDmJL5ZU5s4qE/?date=2008-09-01T08:00:00Z&gamma=0.1&center=51.17187,8.16406&zoom=3

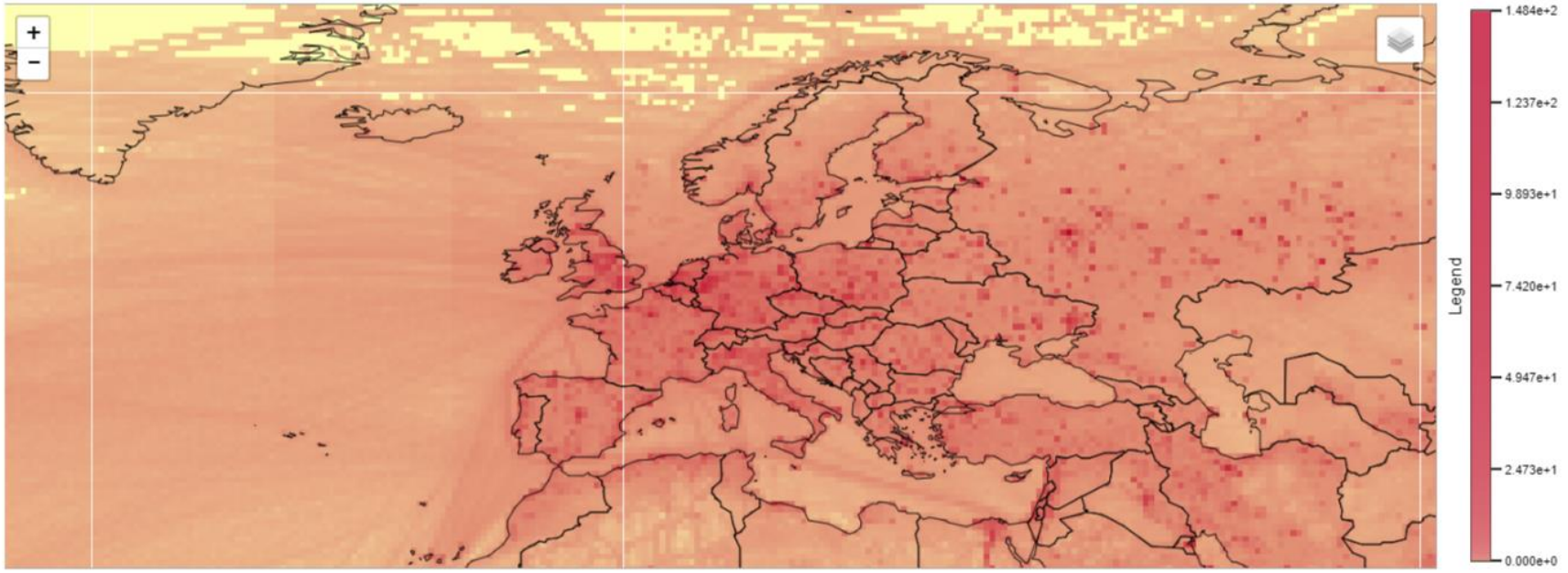
Variable: emission

Date: 2008-09-01T08:00:00Z

Playback:

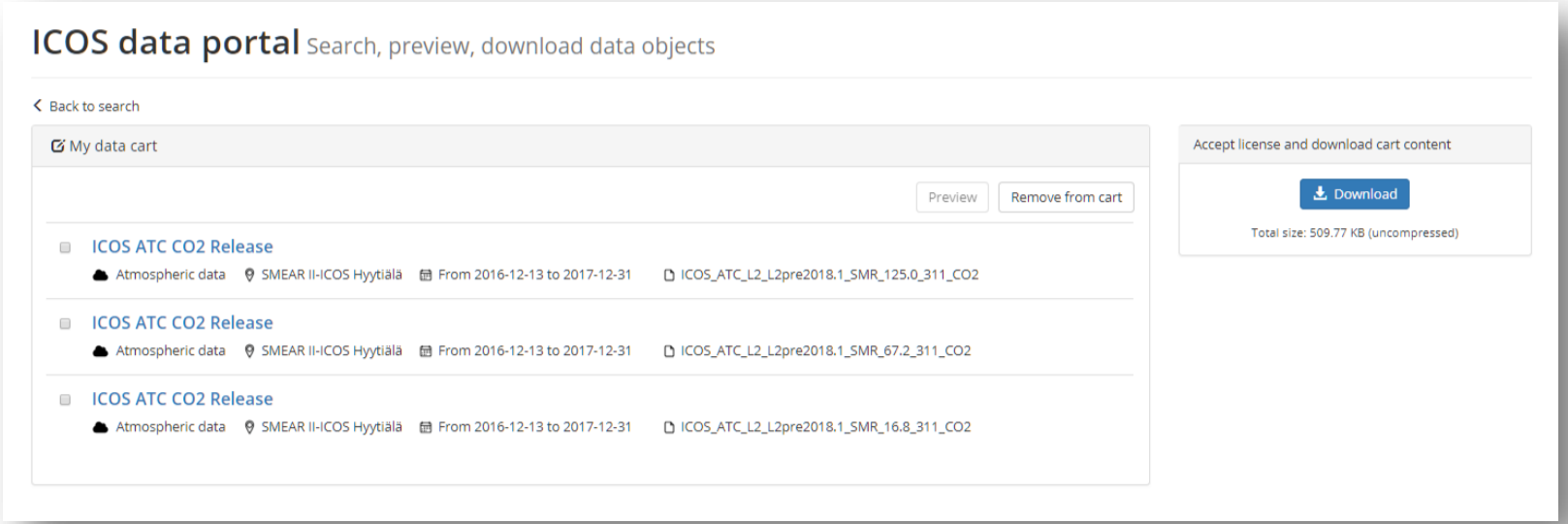
Playback delay: Medium (up to 5 fps)

Gamma: 0.1

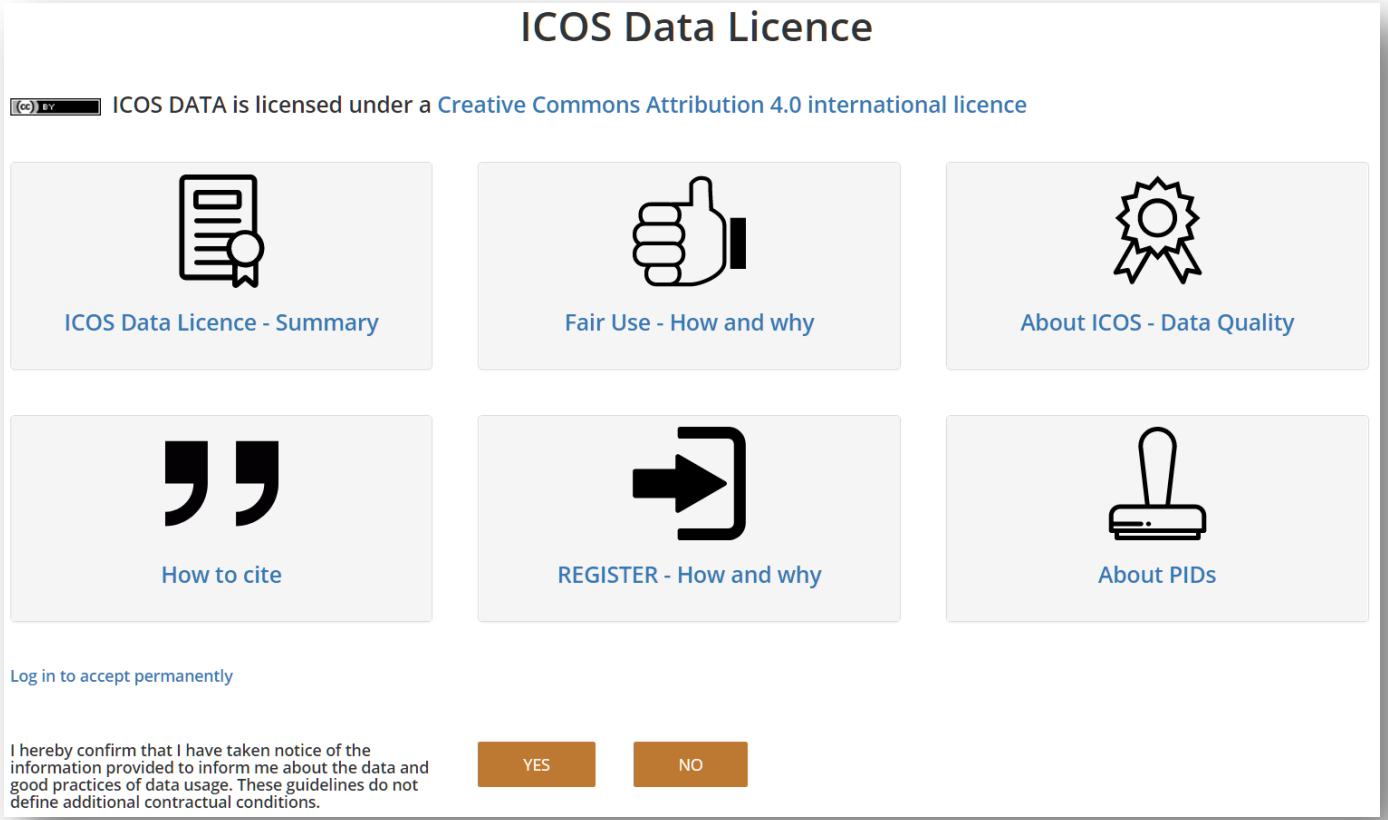


ICOS Carbon Portal

Data cart, download all in one

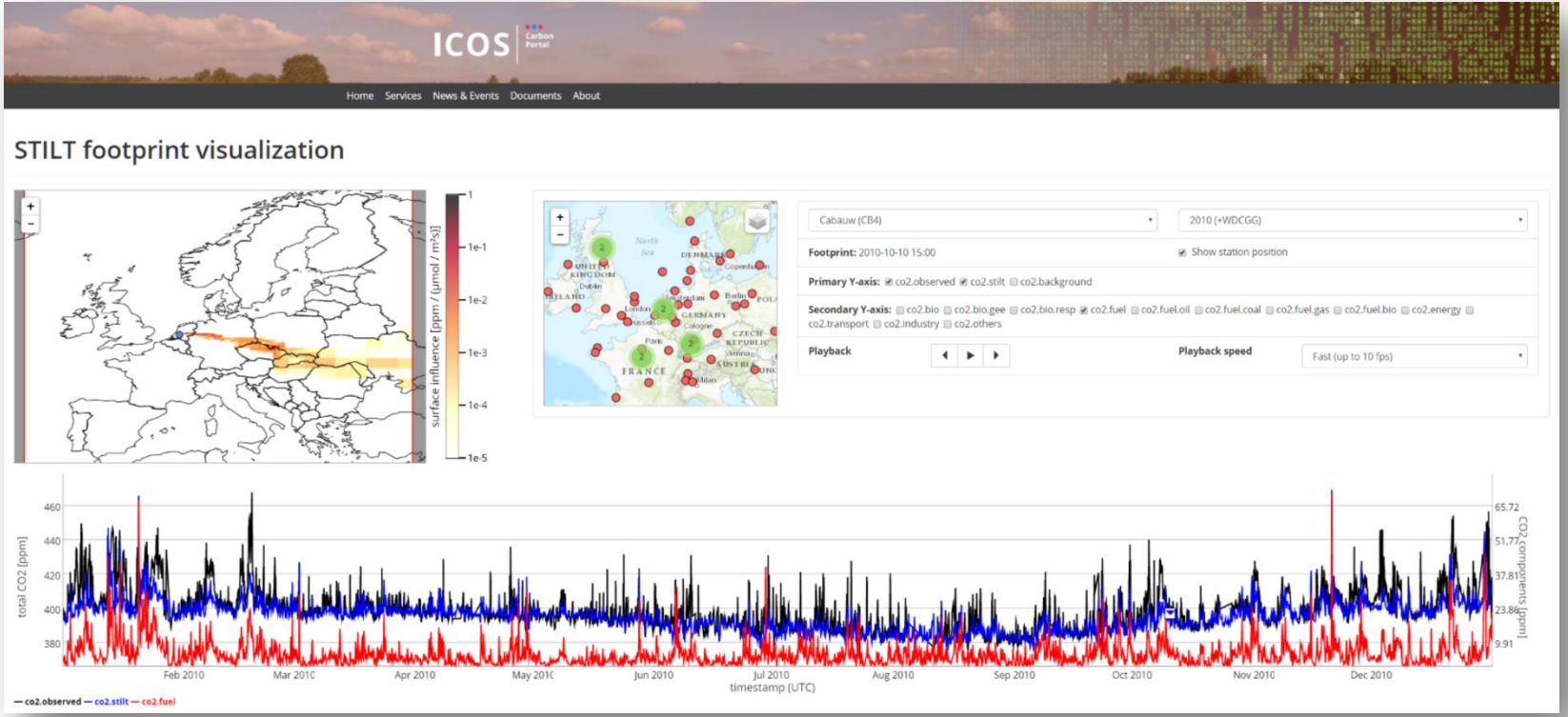


Data licence acceptance (ICOS Data)



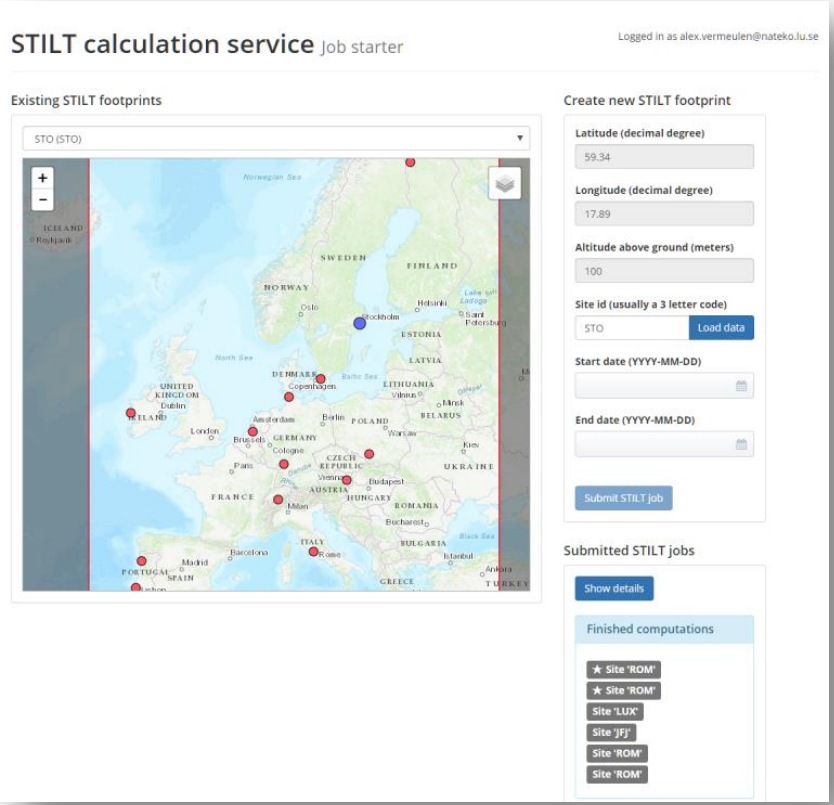
Dynamic linking of elaborated and obs data

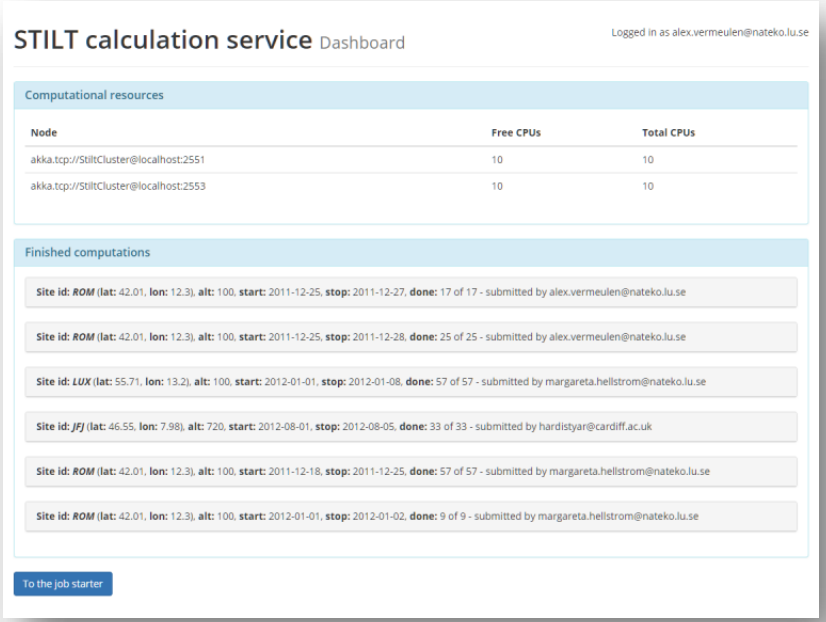
https://stilt.icos-cp.eu/viewer/



VRE to run atm transport model, workflow

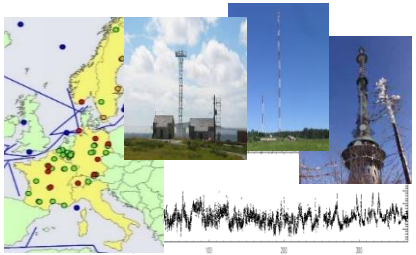
https://stilt.icos-cp.eu/worker/





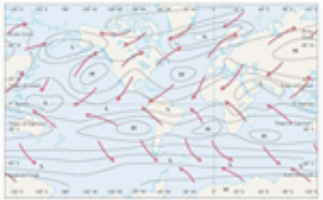
Elaborated product example: Greenhouse gas flux estimates based on inverse modelling

Atmospheric+Ecosystem observations



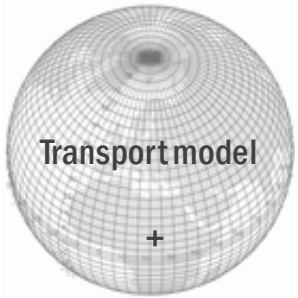
GB's
~M cpuh

Meteorological driver fields



TB-PB's

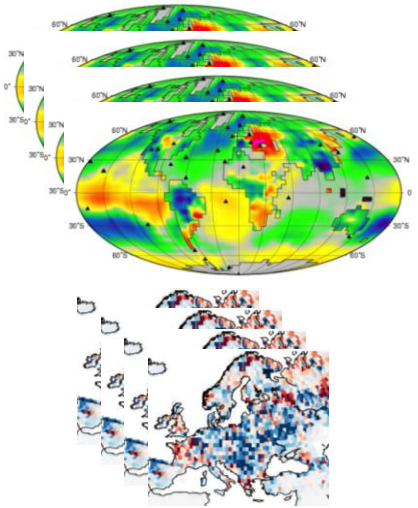
Inversion



Optimization

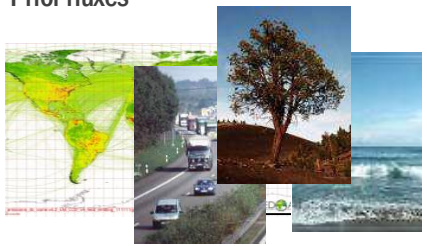
Level 3:
GB-TB's

Optimized flux estimates



+ uncertainty estimates
+ optimized 3-d concentrations

Prior fluxes



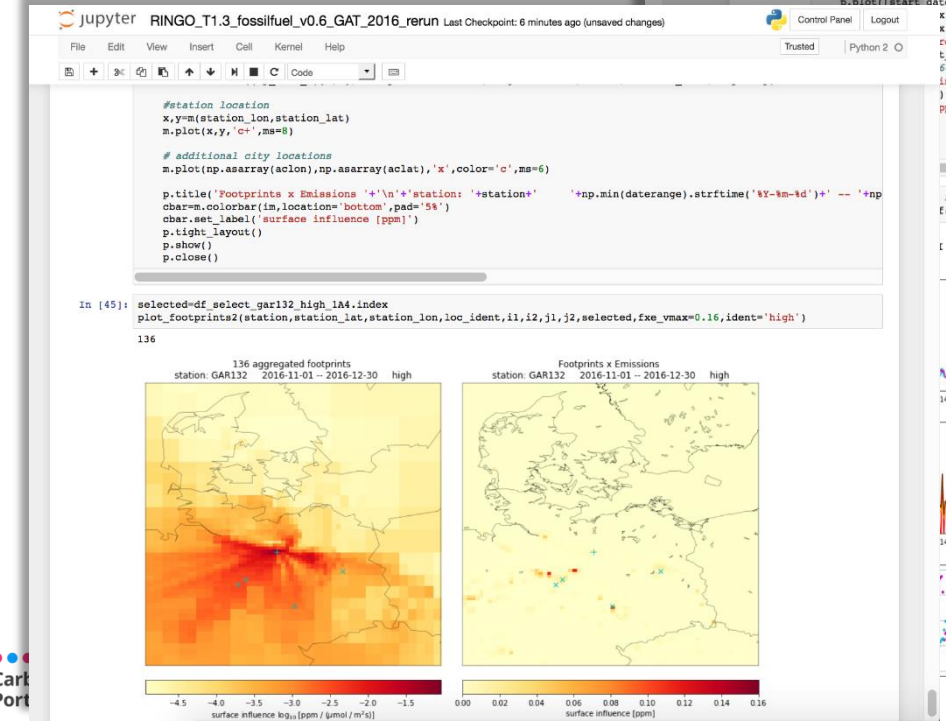
TB's
~M cpuh

TB's RAM
M cpuh-
G cpuh

ICOS Carbon Portal

Interactive analysis tools for model results & data

- Analysis of simulated fossil fuel CO_2 time series (RINGO)
- Evaluation of sampling strategies
- EUROCOM inversion intercomparison
- …

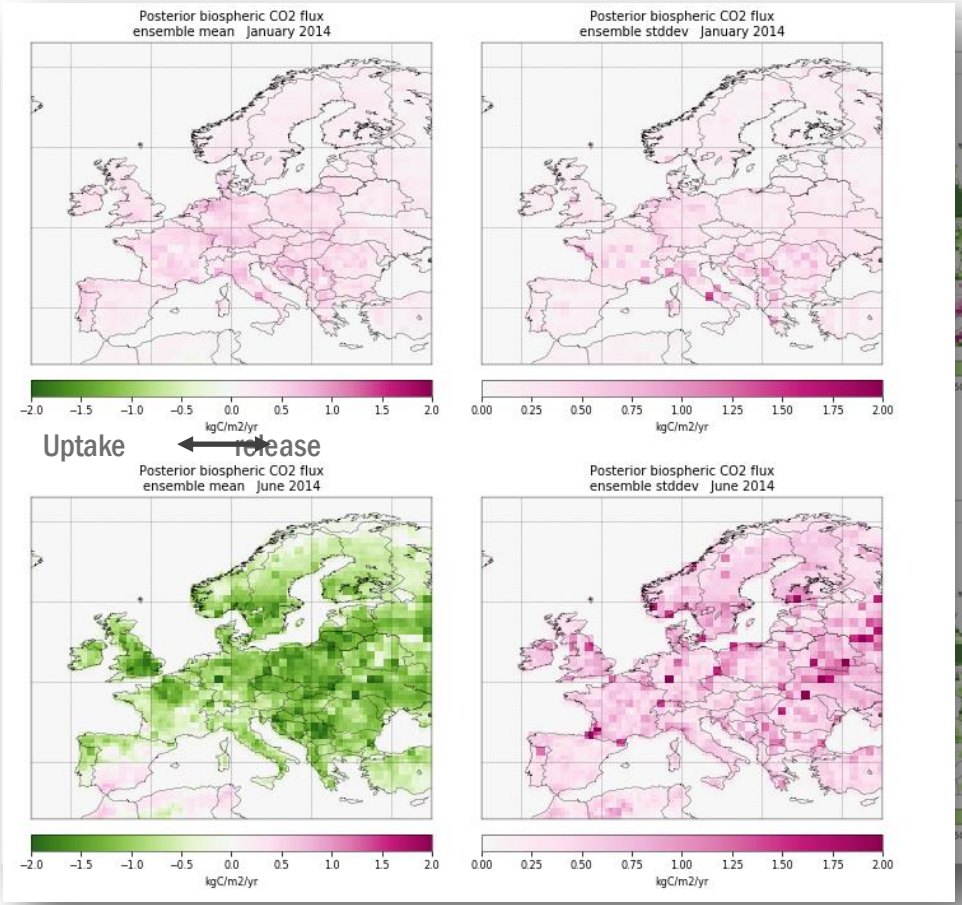


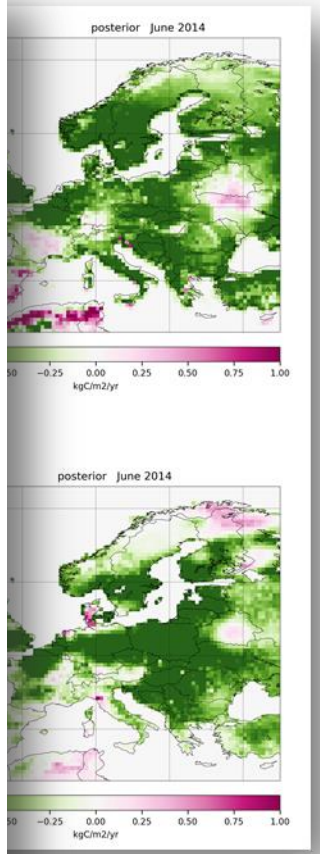
EUROCOM inversions: preliminary biospheric CO_2 flux estimates

JAN/JUN 2014

Example

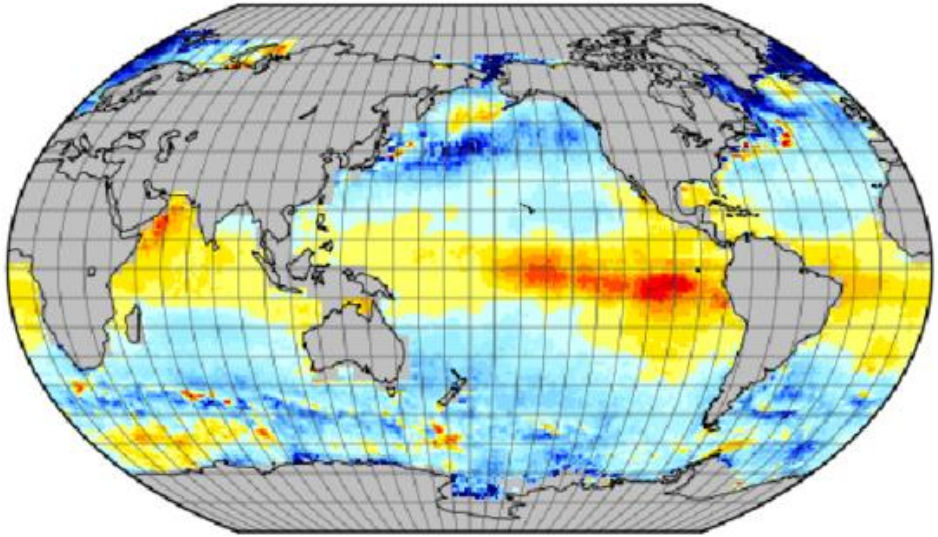
Do not cite or quote!

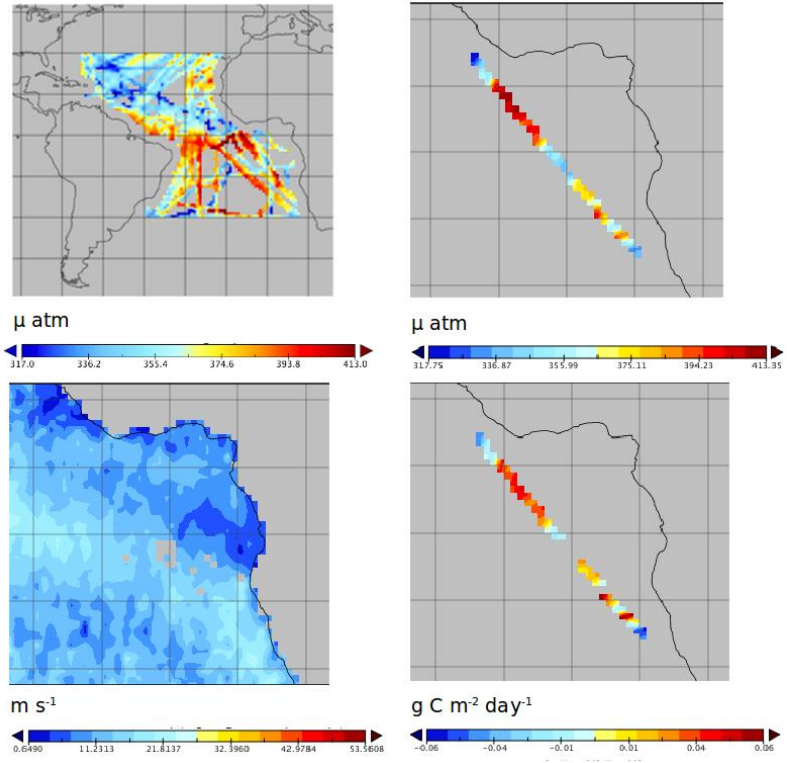




ICOS Carbon Portal

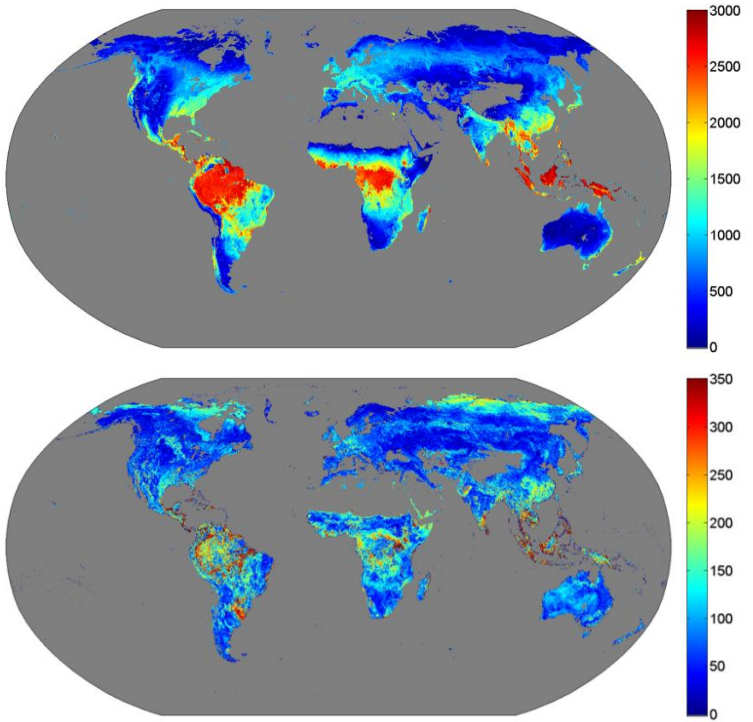
Examples of potential operational science products

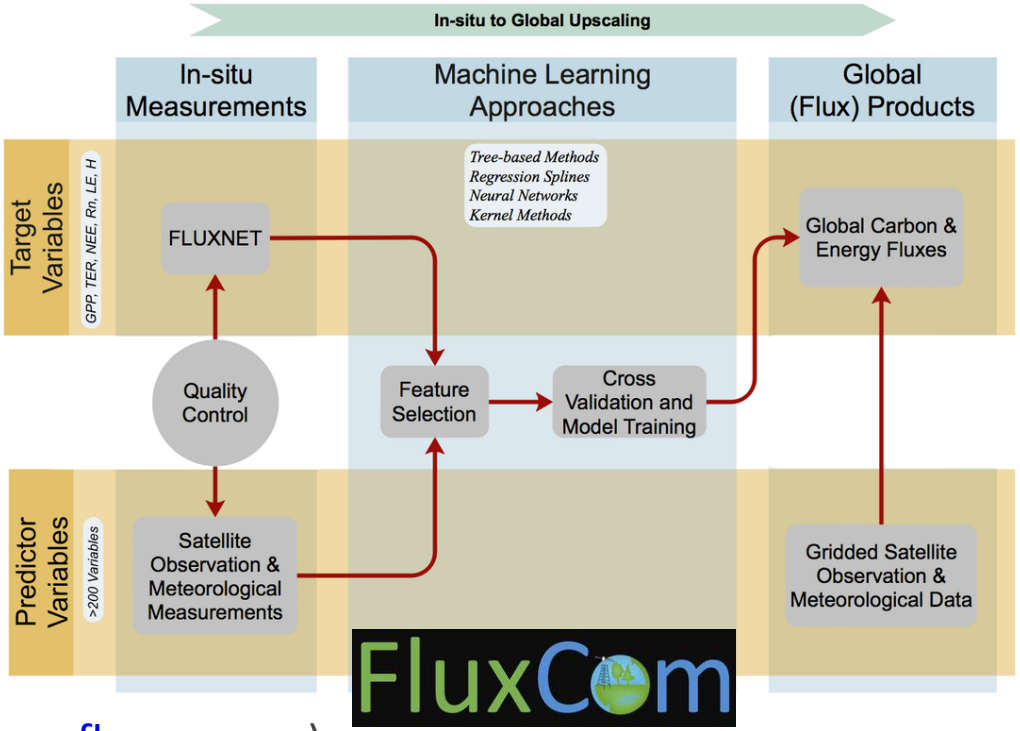




Fluxengine:
http://www.oceanflux-ghg.org/Products/FluxEngine

Examples of potential operational science products



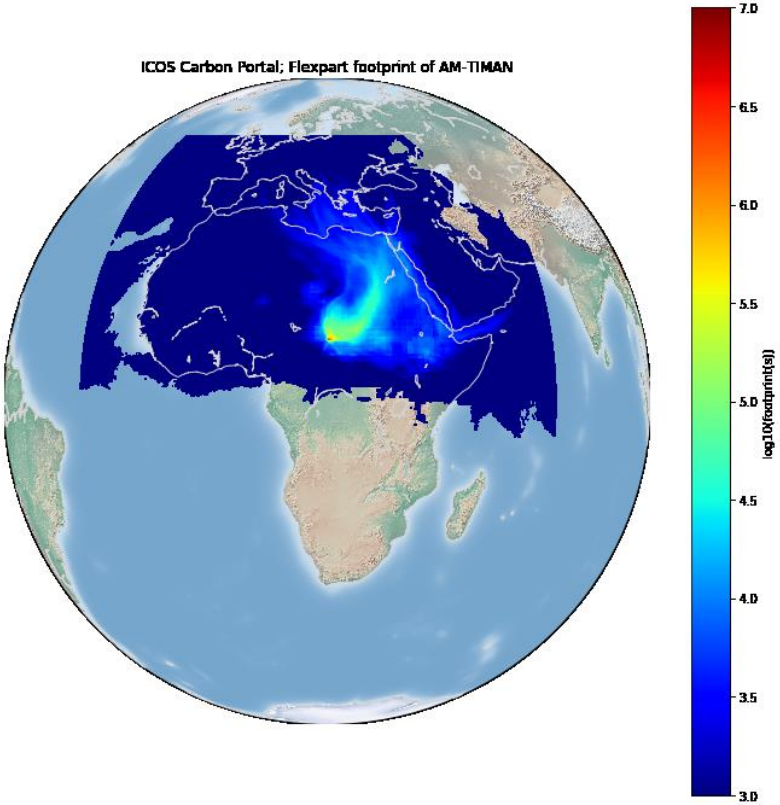


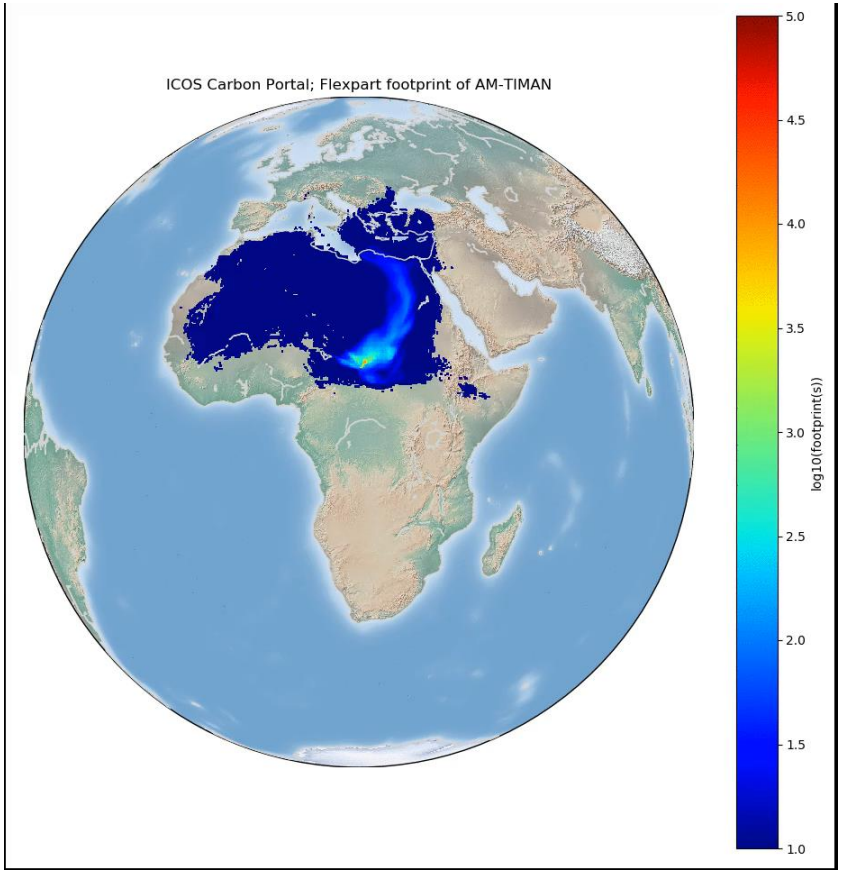
FLUXCOM GPP+uncertainty (http://www.fluxcom.org)

Model-data fusion upscaling of ecosystem flux obs+meteo model+satellite+DGVMs

ICOS Carbon Portal

Africa network design





ICOS Carbon Portal

Thank you!


ICOS
INTEGRATED
CARBON
OBSERVATION
SYSTEM
ICOS Finland www.icos-infrastructure.fi | www.icos-ri.eu | #ICOScapes together with Konsta Punkka

ICOS Carbon Portal, system elements

- ✓ All services fully scalable and portable (dockerized)
- ✓ Open software, shared through GITHUB, GPL licence
- ✓ Data objects in trusted long term repository (B2SAFE, 2 replicates)
- ✓ Semantic web (WEB 3.0), linked open data
  - ✓ Metadata based on ontology, all elements have (linked) URIs
  - ✓ nonSQL, RDF database
  - ✓ Open SPARQL endpoint
  - ✓ Versioned meta data store: roll-back, time dependent queries
- ✓ Persistent identifiers, linking to data object and metadata: DOI and/or Handle system
  - ✓ PID based on SHA256 checksum of data object: Data Integrity control
  - ✓ Maximum granularity of Data Objects
- ✓ Support for versioning, collections for DOI
- ✓ Machine actionable through standard http(s) protocol, RESTful API in backend and frontend
- ✓ NGiNX proxy redirects to services (https://service.domain.eu), domain completely configurable and stylable
- ✓ Can be deployed as single portal backend with multiple frontends or as set of federated portals using one or more interoperable metadata stores

Carbon Portal Technology stack

Backend:

- MongoDB
- Java and Scala, Akka
- RDF, OWL, SPARQL, Postgres, Eclipse, RDF4J

Front end:

- Javascript, Redux, Leaflet, OpenLayers, React, Bootstrap, RESTHeart

Infrastructure:

- NGiNX, Docker, JVM, EGI Cloud (Grid), B2SAFE, Jupyter Hub, Ansible