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Global Monitoring NOAA Annual Conference

ÀÿÛð ïÛøÃÛÝÿÛã

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ÇËÀÅ’ àÐÝÿúÛø’ ÅÈ
ËÒÞ ¸‚’ ¸˙˝ß

ICOS | INTEGRATED CARBON OBSERVATION SYSTEM

ÉÅÈÎ íÛÕÛÒøÚü ÉãûøÒÕõøÝÚõÝøÛ

- Integrated Carbon Observation System (https://www.icos-ri.eu/)
- Pan-European research infrastructure for greenhouse gas and carbon cycle observations
- 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)

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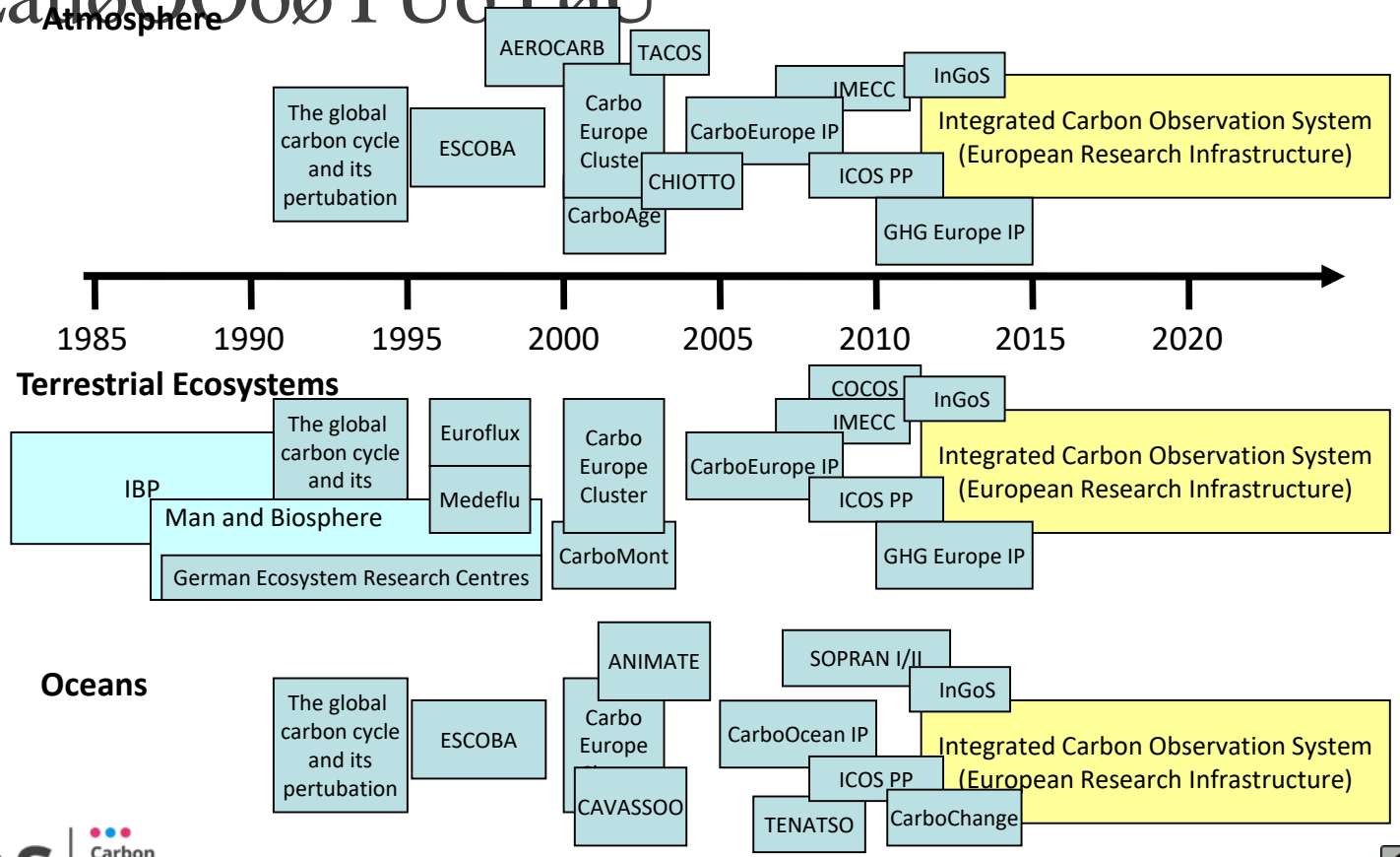

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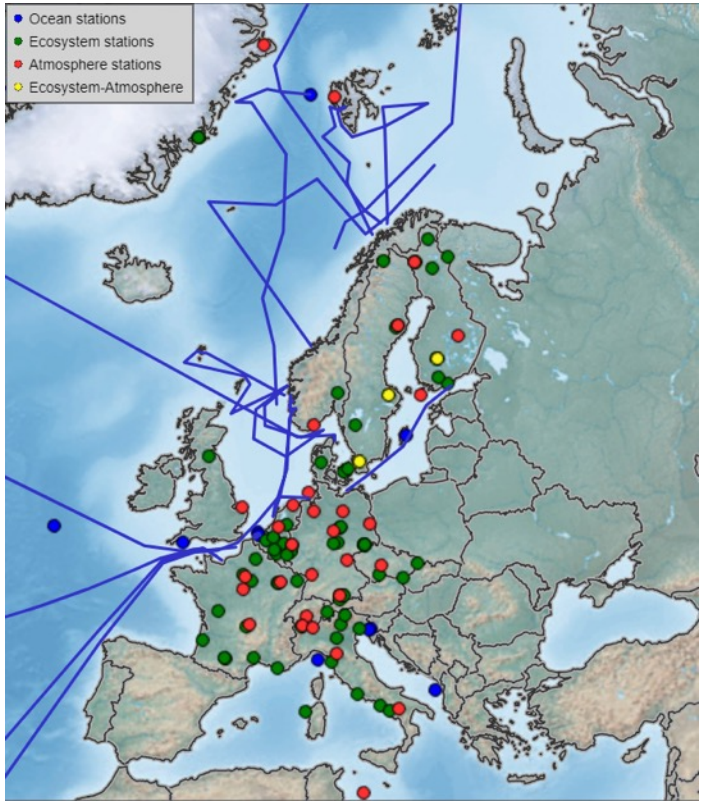

131 measurement stations

76 Ecosystem stations

34 Atmosphere stations

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

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ÉÅÈÎ íÉ ÎÛøýÙÚÛÕ õÐ ÃÛÃòÛøÕ

- 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.

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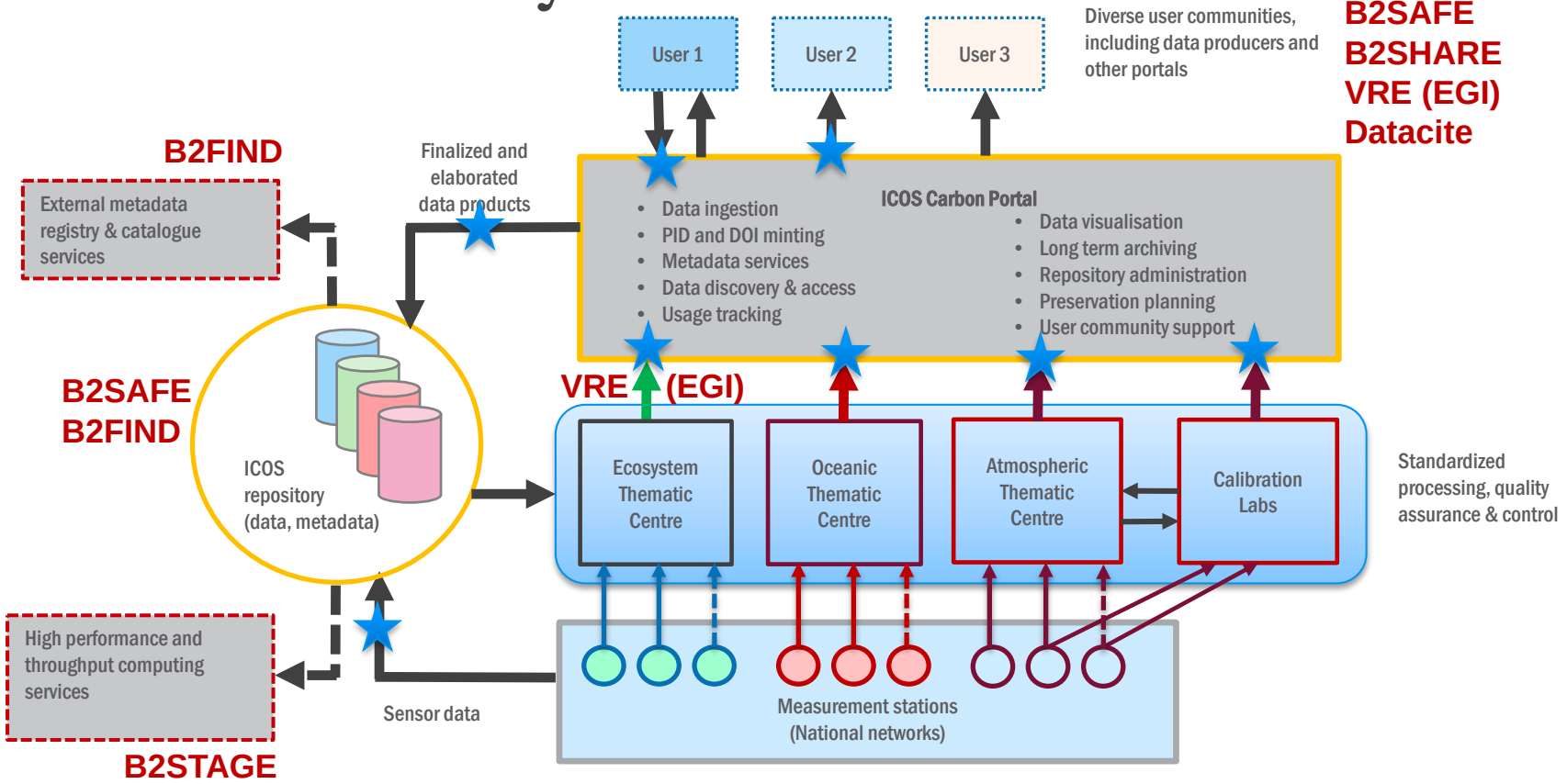
ÉÅÈÎ åÒõÒ æÿÐÐ



ÎõÒõÙÐã ÿÒòÛÿÙãÜ

- Two classes of stations: I, II, associated
  - Class I : full set of parameters + additional parameters
  - Class II: minimal set of measured parameters
  - Associated: minimal set, only step 1, protocol not 100% (only ECO)
- Only Class I and II qualified stations will deliver “ICOS data”
- Two step process
  - Step 1: Design and setup check by TC
  - Step 2: Construction and operational test, data evaluated by TC and MSA
- Started in 2016
- Now: 11 atmosphere + 3 ecosystem stations approved

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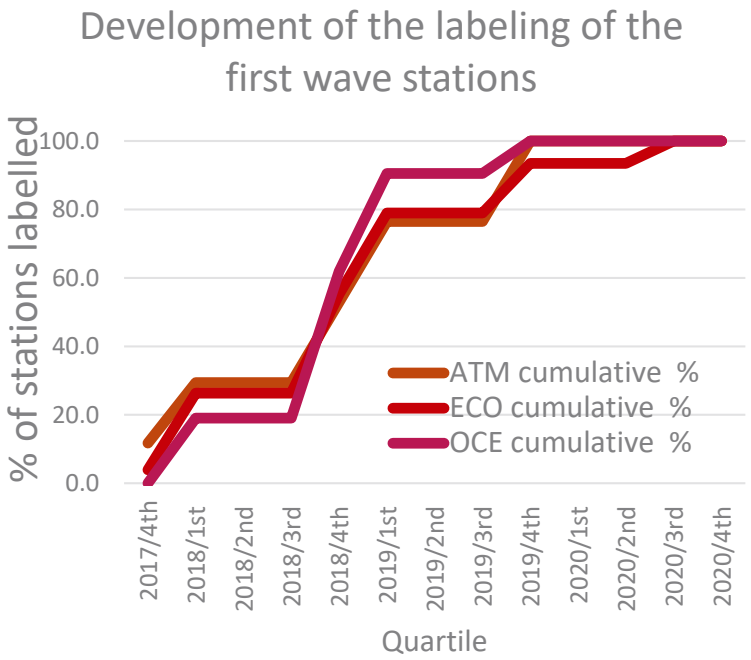
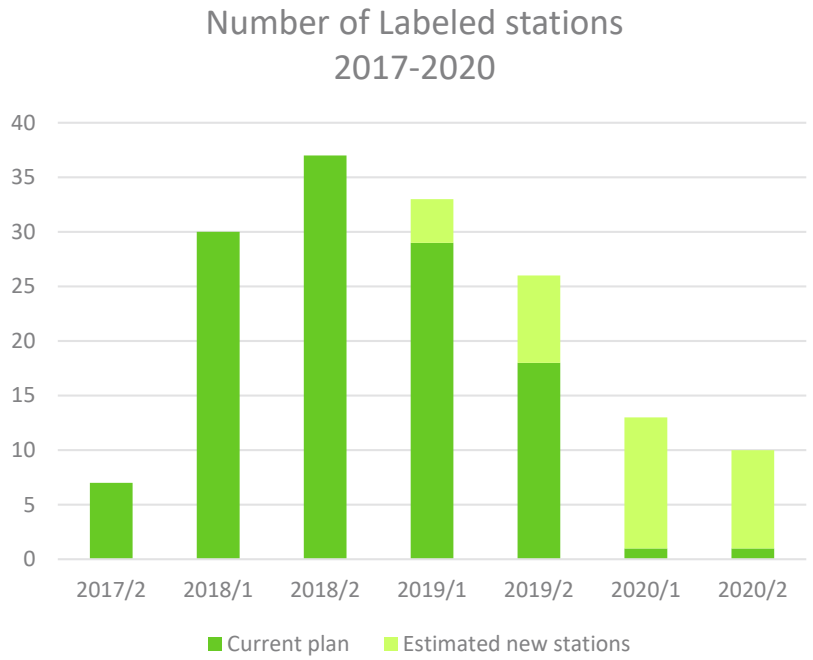
ÎõÒõÙÐã ãÛõÐÐøŸ ÿÒòÛÿÙãÜ đÿÒããÙãÜ





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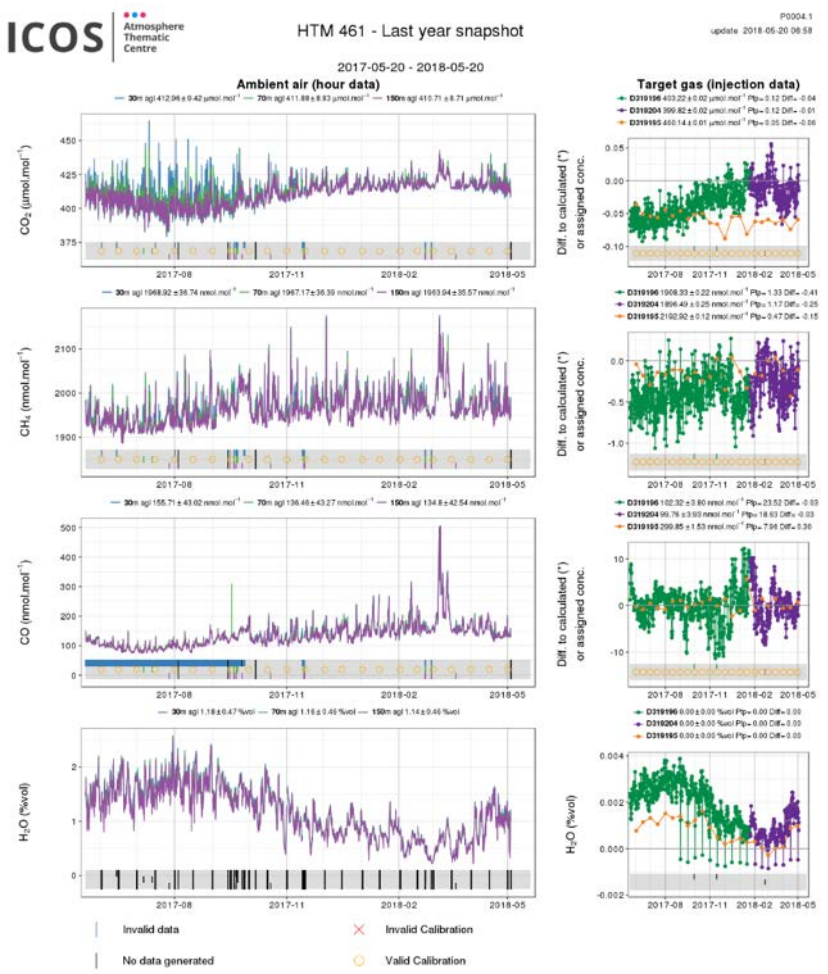

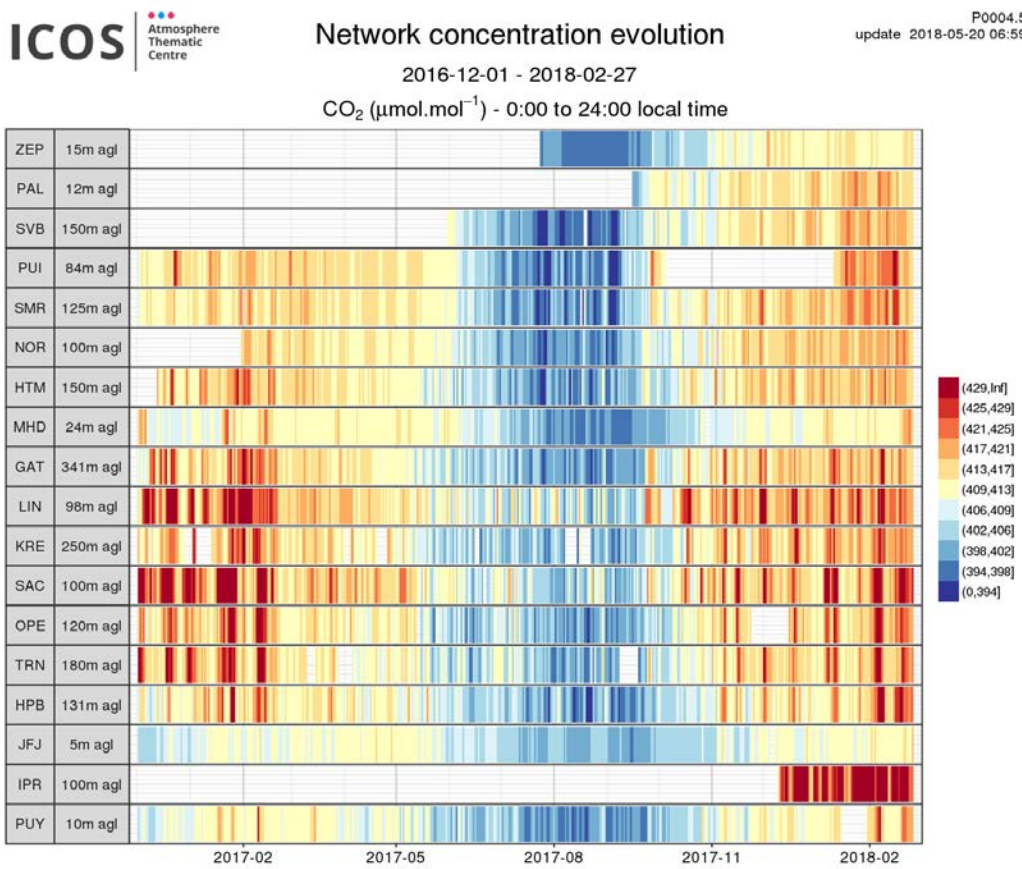

https://icos-atc.lsce.ipsl.fr/dp

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

ICOS Carbon Portal

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ÀòÐÝõ æÀÉí’’’

- stands for Findable, Accessible, Interoperable, Reusable
- was coined by FORCE11 in 2014, out of discussions in the Life Sciences community
- not a standard, but a set of principles
- has become the new fashion (and Holy Grail!)
- is increasingly called for by funders & policy makers

*FORCE11, 2014 (https://www.force11.org/fairprinciples)

ICOS CP is ‘FAIR avant la lettre’, concept paper is from 2013!

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ÉÅÈÎ ÅÒøòÐã èÐøõÒÿ ÕÞÕõÛÃ ÛÿÛÃÛãõÕ

- ✓ **Semantic web (WEB 3.0), open linked data, the web is the database, everything is a URL**
- ✓ Machines first, humans second
- ✓ Machine actionable through standard http protocol, RESTful API
- ✓ nonSQL, RDF database
- ✓ Open SPARQL endpoint
- ✓ **Metadata based on ontology, all elements have (linked) URIs**
- ✓ 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 checksum of data object: Data Integrity control**
- ✓ High granularity of Data Objects
- ✓ Support for versioning
- ✓ Support for collections
- ✓ **Fully scalable and portable (dockerized), ready for the cloud**
- ✓ **Data objects in trusted long term repository (B2SAFE, 2 replicates)**
- ✓ Open software, shared through GITHUB, GPL licence
- ✓ Efficient, robust, flexible and safe
- ✓ NGiNX proxy redirects to services (https://service.domain.eu), domain determines RI

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- Generates dyna
- Ontology inform
  - Data L
  - Data F
  - License
  - DOI mi
  - Etc.
- Dynamic la
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- User interfa
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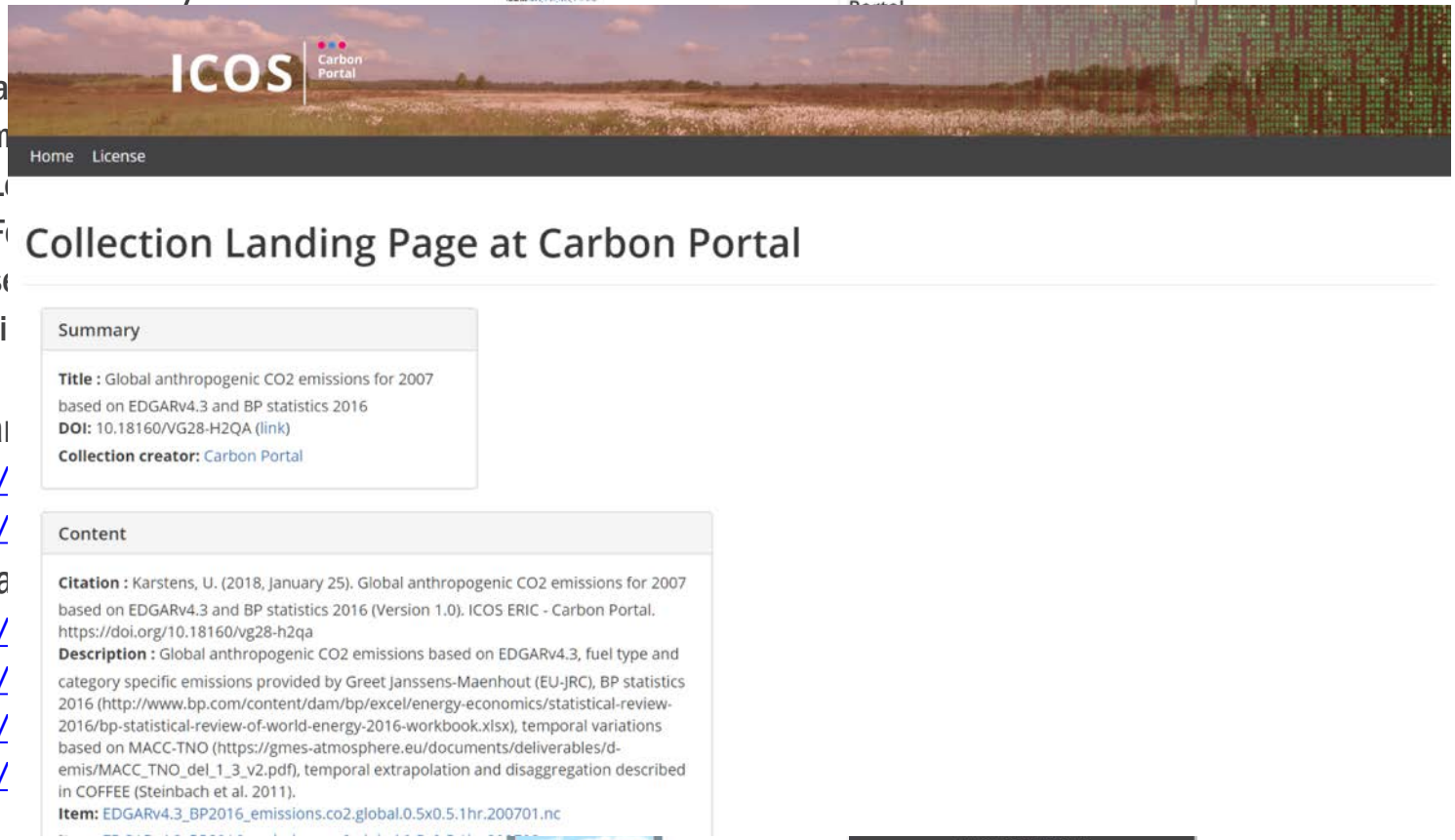
  - https:/
  - https:/



åÒõÒ ÕÛøýÙÚÛÕ

üõõđÕȷ˚˚úÒõÒ’ÙÚĐÕ¸Úđ’ÛÝ

- Access of data object link triggers:
  - Licence check
  - Usage count
  - https download
- Data links can be harvested and linked transparently into other portals: license check, download and usage count still under full control, no redistribution needed
- Fully interactive search frontend (REST)
- Data cart (in user profile)
- Preview interactive charts/maps (REST)
- Supports versions, collections (subsetting planned)

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Exclusive sneak preview:

First ICOS Final Quality Controlled Data Product release

TODAY in this theater!

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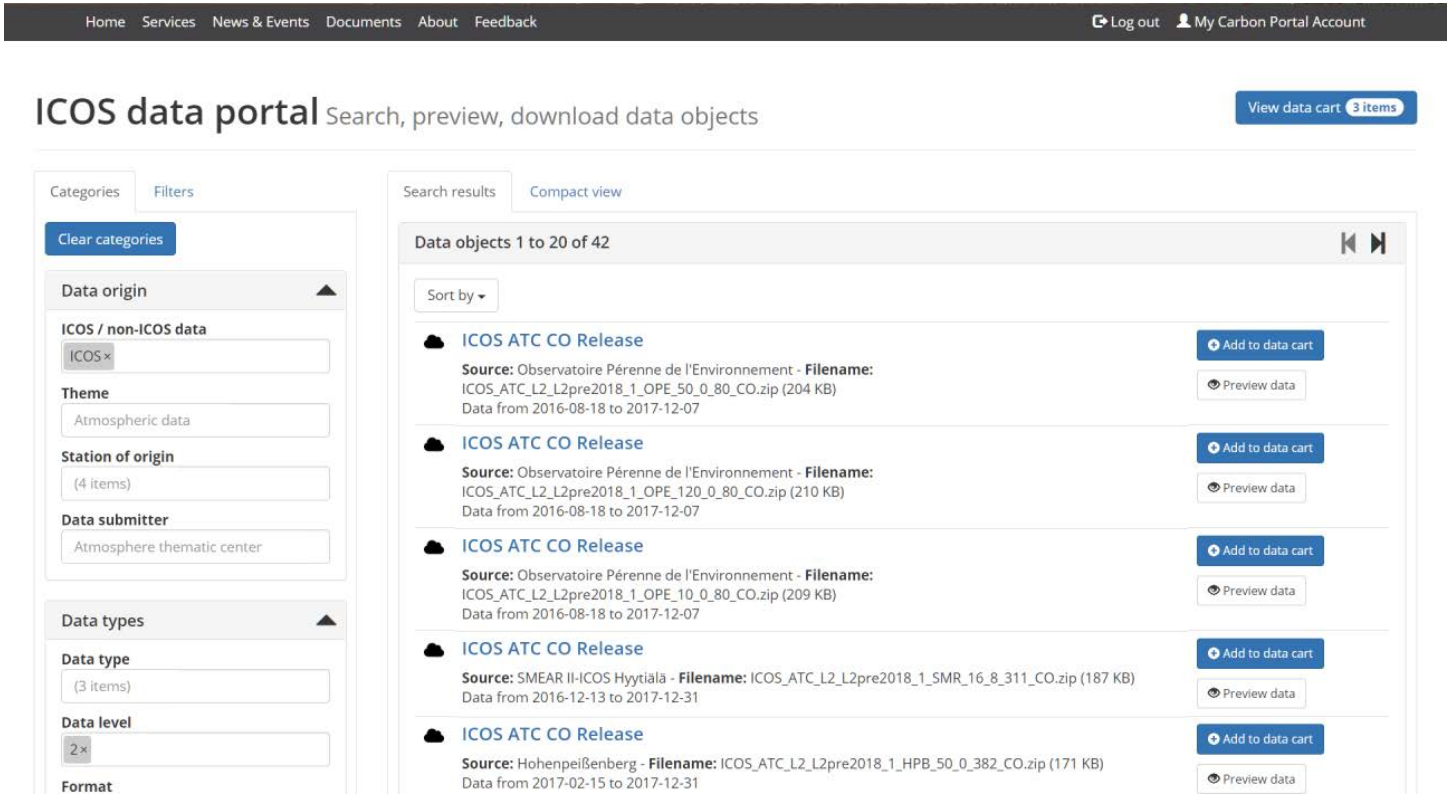

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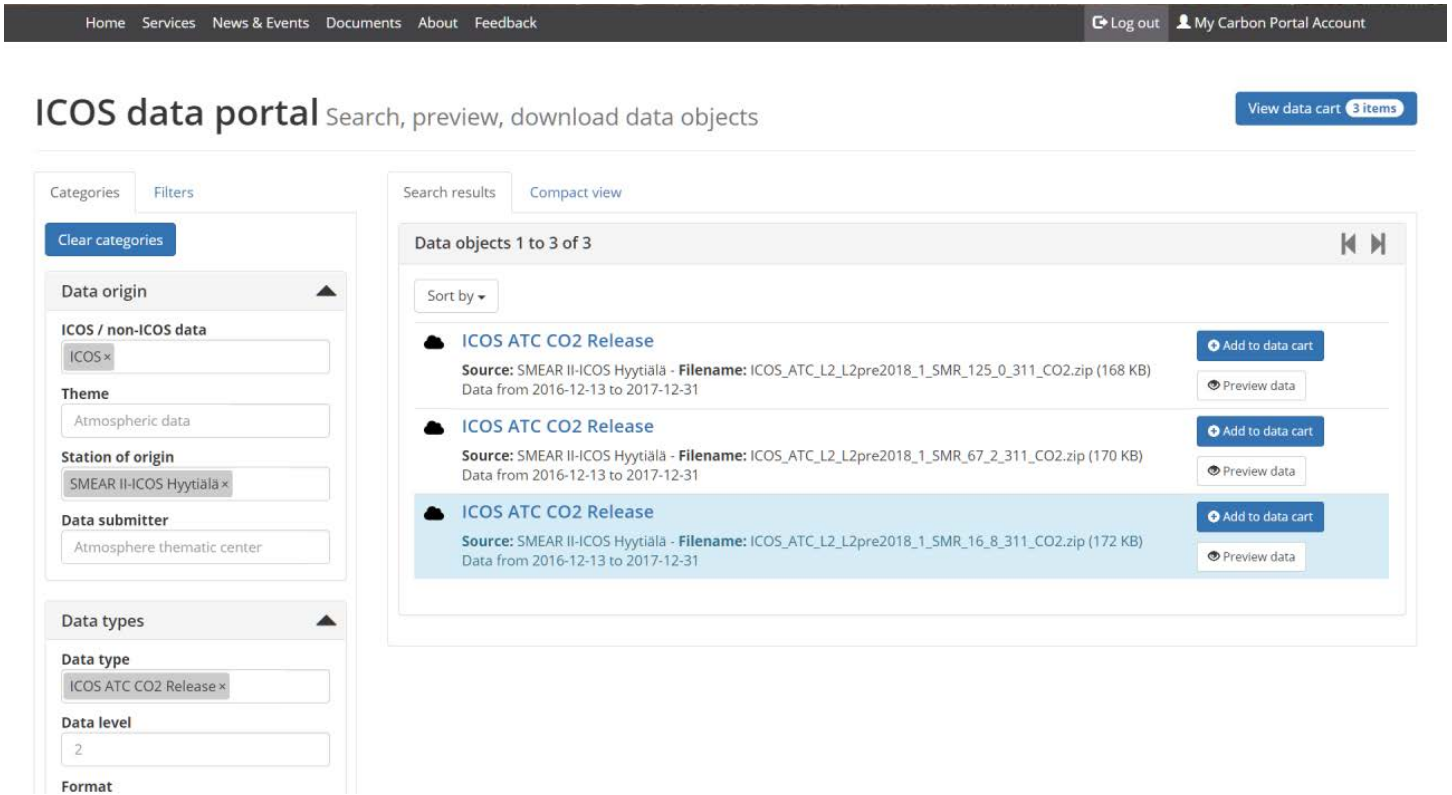

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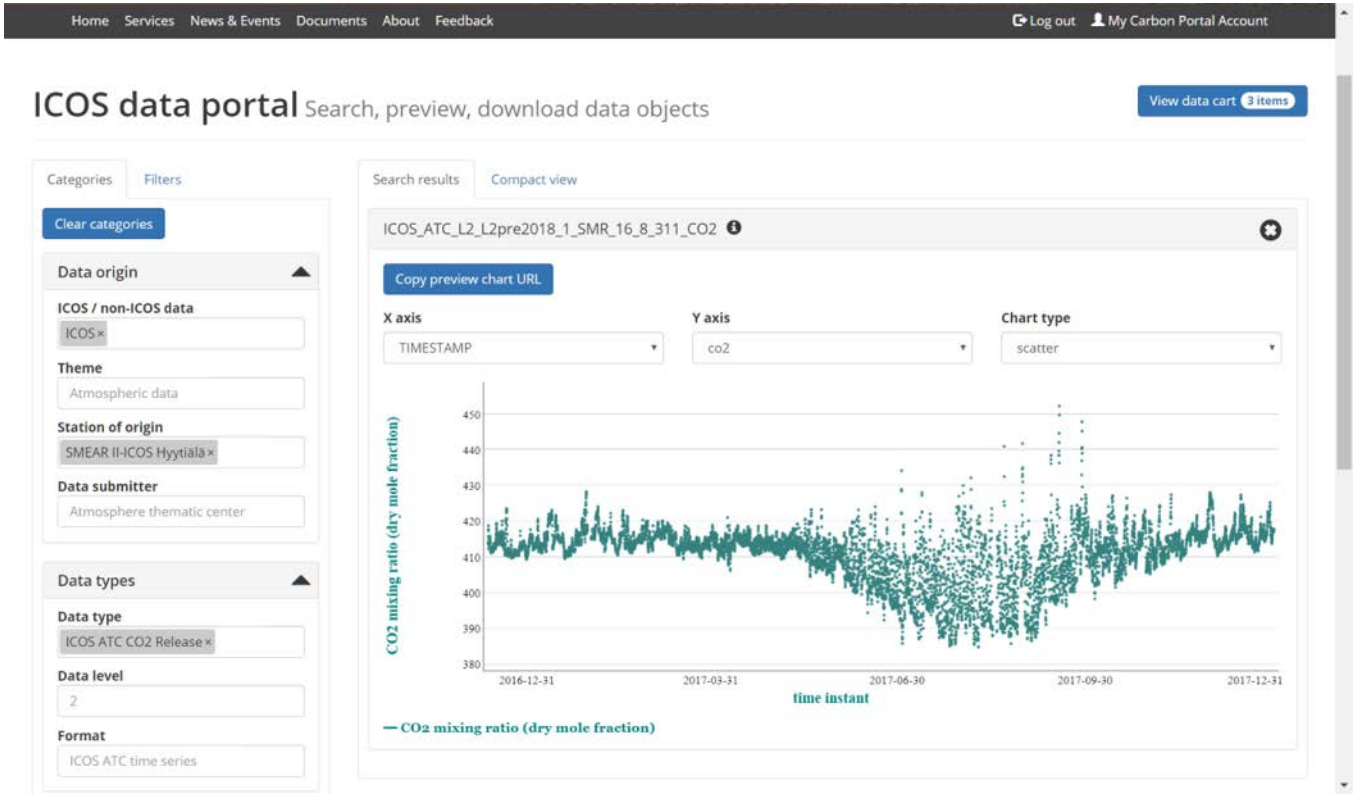


åÒõÒ ÕõÒõÙÕõÙÚÕ

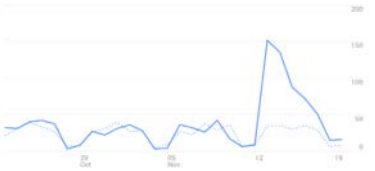
ICOS Data Statistics

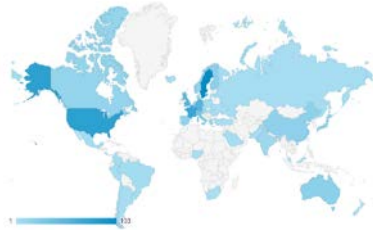
Data object specification filter

Specification	Specification
Format	Format
Data level	Data level
Stations	Stations
Contributors	Contributors
Theme	Theme
Country codes	Country codes

Data objects 1 to 100 of 714

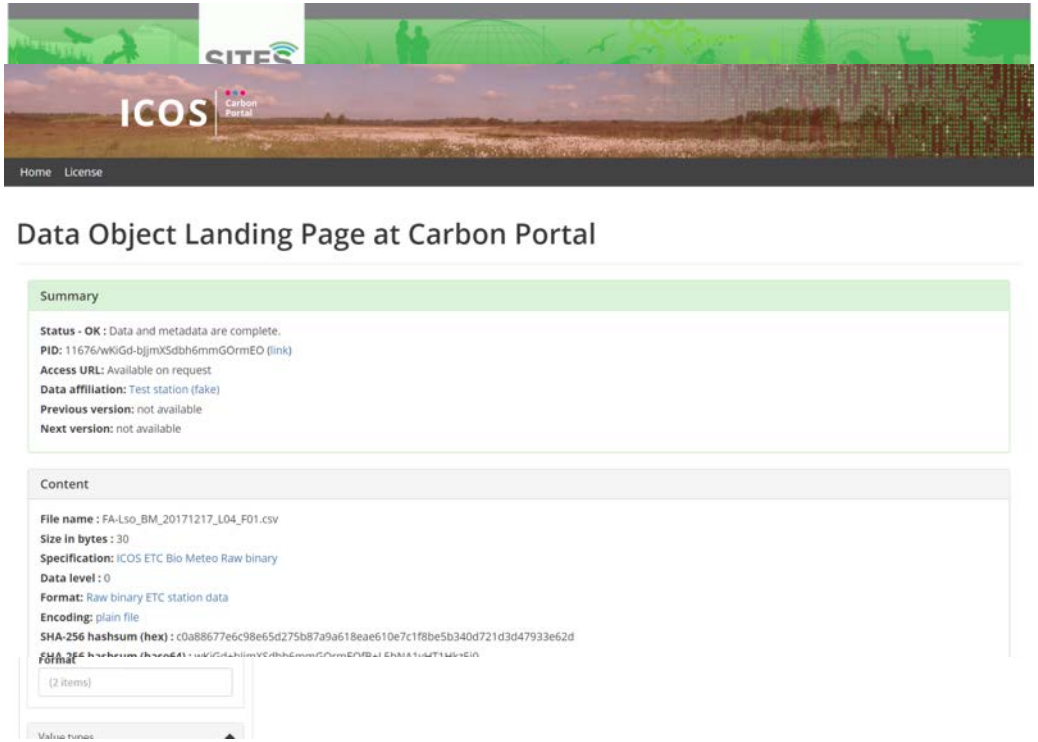
File Name	Landing Page	Count
National_Carbon_Emissions_2017v1.1.xlsx	G6PjIjYC6Ka_nummSJ5lO8SV	738
Global_Carbon_Budget_2017v1.1.xlsx	sdfRNhhI5EN_BckuQQfGpdvE	695
Global_Carbon_Budget_2017v1.2.xlsx	-OrQ3afxxWEwG-LMJDyfVRot	172
EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.200908.nc	-Ds8OPhCs4jTWMyTVyH9C5Xg	74
26NA20050107_CO2_underway_SOCATv3.tab	8LQ1E5J8_YEf4WRe9HoDtb8Y	69
26NA20090429_CO2_underway_SOCATv3.tab	-W0-6-DTVlV6CBEaMrkVwqCn	55
26NA20050107_CO2_underway_SOCATv3	4EBNDi4n1Csr0BPyZiLP4azd	44
INGOS_CH4_release2014.rar	DWdS18nrTlilcGS4VRZWOx4V	34
EDGARv4.3_BP1016_emissions.co2.global.0.5x0.5.1hr.2006.nc	7cevZ-6GGvcODTZm06K9XaUg	30
26NA20090713_CO2_underway_SOCATv3.tab	-OSSxfTbnRiH_zXnQ3S2kgXP	22
EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.200903.nc	R47ZPU24izAdSw7UPfKH6r97	22
LIN_399_20160101.zip	txyYC11yowGOaCkQgoOjuOVX	20
EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.201401.nc	01qNk22759d-ONSv7cMXTmap	20
11SS20140327_CO2_underway_SOCATv4.tab	-0WJzcoz-4IJmh375ytDkSFF	19
26NA20050115_CO2_underway_SOCATv3.tab	SWIYhpwoTKlCpTny-11UHkrW	18
06AQ20021126_CO2_underway_SOCATv3.tab	-q1BVSmeL7ka5yD2eobyoLRg	18
EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.201506.nc	-qk3ou6GZGHRcWL6VPO0hvja	18
EDGARv4.3_BP2016_emissions.co2.global.0.5x0.5.1hr.201201.nc	534iHwwPjGjttbBQuAciCvuk	18





ÏÕÛø ÙãõÛøûÒÚÛÛ ÚÝÕõÐÃÙþÒòÿÛ

Depends e.g. on domain calling meta and data service



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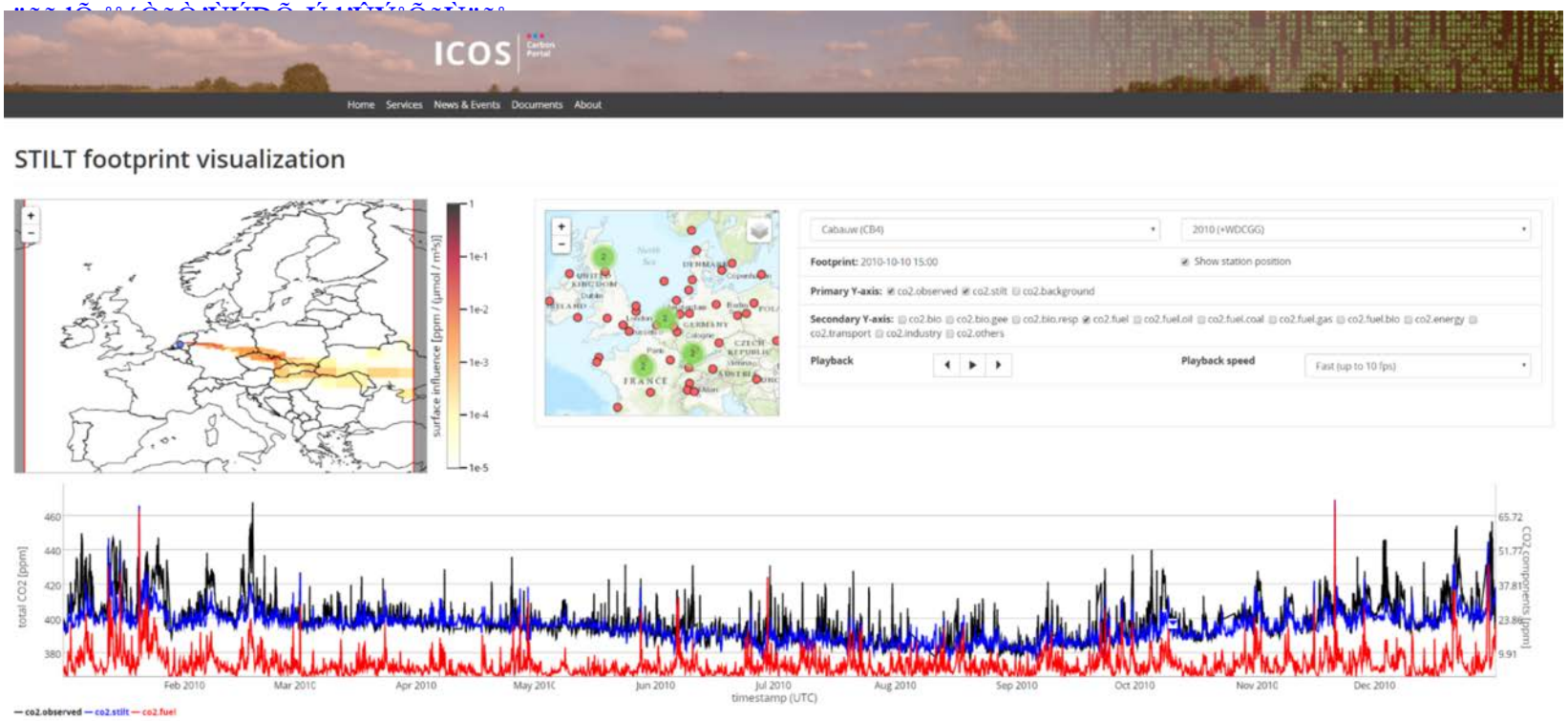

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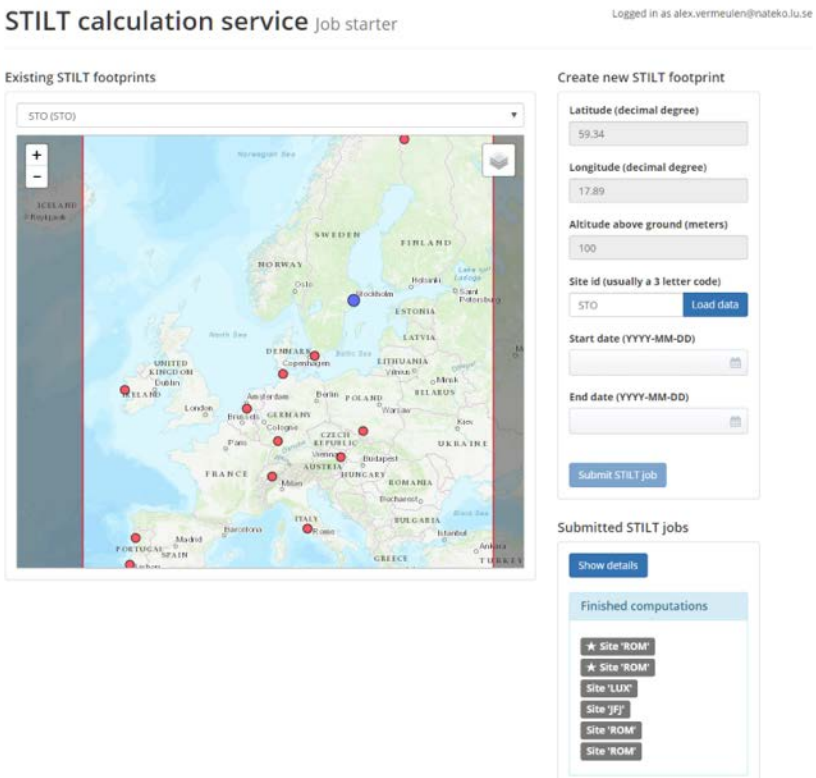

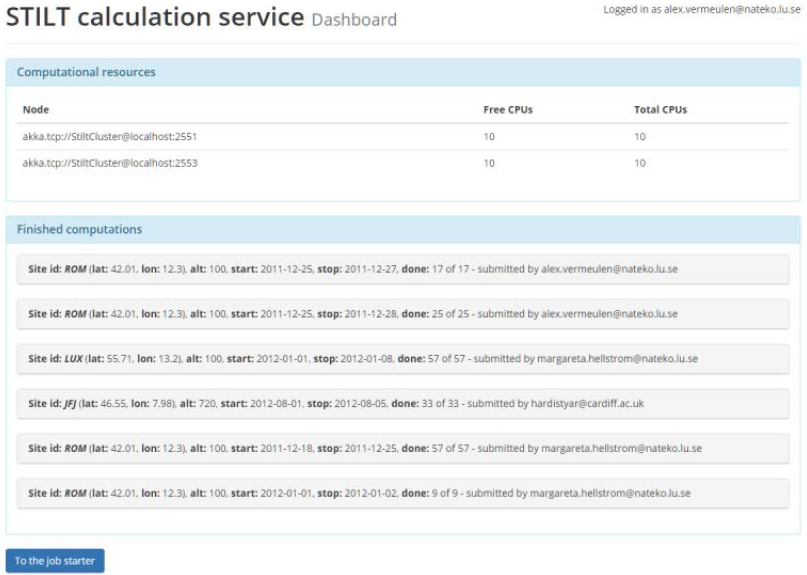

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ĂĐyyŬŏĐøŬŏŬĐă Ŭă ĭıÆĘŬj ĕYđPŏŬø ãĐõÛòĐĐŸÕ

jupyter GCP-inversions-comparison_v4.0 ATV Last Checkpoint: 08/14/2017 (autosaved)

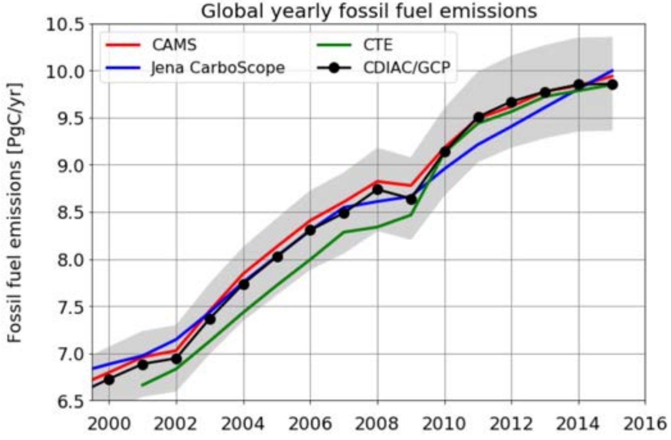
Control Panel Logout

File Edit View Insert Cell Kernel Widgets Help Python 2

Markdown CellToolbar

1990 1995 2000 2005 2010 2015

In [14]:
```
#Plot fossil fluxes used in the inversions
#Options are available for monthly and annual (see above)
fig=plt.figure(figsize=(10,7))
plt.plot(plot_df_CAMS.index,plot_df_CAMS.ff_CAMS,label='CAMS',linewidth=3,color='red')
plt.plot(plot_df_Jena.index,plot_df_Jena.ff_Jena,label='Jena CarboScope',linewidth=3,color='blue')
plt.plot(plot_df_CTE.index,plot_df_CTE.ff_CTE,label='CTE',linewidth=3,color='green')
plt.plot(df_cdiac.index,df_cdiac['FF'],'o-',markersize=10,label='CDIAC/GCP',color='black')
plt.fill_between(df_cdiac.index,df_cdiac['FF']-0.05*df_cdiac['FF'],df_cdiac['FF']+0.05*df_cdiac['FF'],color='lightgray')
plt.ylim(6.5,10.5)
#plt.ylim(5.5,11)
plt.xlim(dt.datetime(2000,1,1),dt.datetime(2016,1,1))
if Temporal_Resolution == 'yearly':
    plt.xticks(np.arange(dt.datetime(2000,7,1),dt.datetime(2017,1,1),dt.timedelta(2*365)))
plt.title('Global %s fossil fuel emissions'%Temporal_Resolution,size=20)
plt.ylabel('Fossil fuel emissions [PgC/yr]', labelpad=20)
plt.legend(loc='best',fontsize=16,ncol=2)
plt.tick_params(axis='x', pad=12)
fig.savefig('data/figures/Fossil_fuel_comparison_%s'%Temporal_Resolution,dpi=300)
```



Atmospheric CO2 growth rate

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ÎÝÃÃÒøÞ ˝

Tremendous progress in ICOS Research Infrastructure

- Definition of data lifecycle
- Station design and protocols
- Station qualification (labelling) well underway
- First high quality data products are now available
- ‘FAIR’ data portal ready
- Globally well connected: WMO GAW, Fluxnet, SOCAT, Geo Carbon and GHG initiative, IG3IS, Copernicus
- Innovations in measurements and data products (RINGO project)

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ÎÝÃÃÒøÞ ¸

Strong identification and ingestion
coupled to
Open linked data
are essential elements to easier fulfil FAIR principles

Makes impact analysis, reuse of the data and traceability easy because of

- proper attribution of contributors,
- usage tracking
- licence checking

ICOS Carbon Portal implements many basic and universal elements of a functional data portal in a scalable, portable, modular and (re)usable way, ready for cloud deployment and fully open source (GPL v3):

https://github.com/ICOS-Carbon-Portal/

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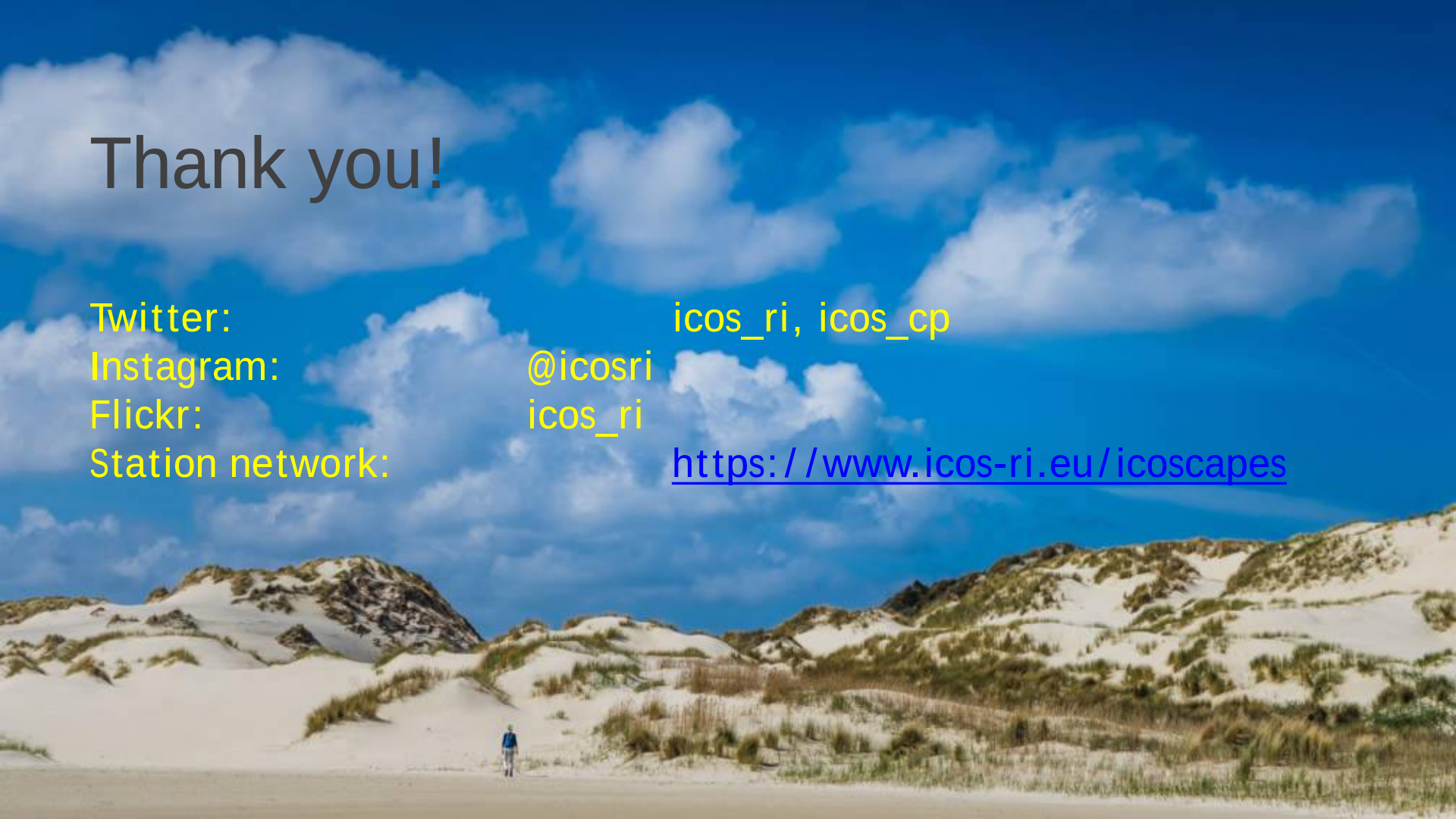
Thank you!

Twitter:		icos_ri, icos_cp
Instagram:	@icosri	
Flickr:	icos_ri	
Station network:		https://www.icos-ri.eu/icoscapes



ÅÒøòÐã èÐøõÒÿ îÛÚüãÐÿÐÜÞ ÕõÒÚŸ

Backend:

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

Front end:

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

Infrastructure:

- NGiNX, Docker, JVM, EGI Cloud, B2SAFE, Ansible

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ÎõøÒõÛÜÞ ¸˙˝ß¸¸˙¸´

- Expansion and consolidation of the network
  - Network design, adaption to new requirements, Paris agreement
  - Integration of TCCON
  - Ensure sustainability
- Stimulate scientific studies
  - Support scientific studies, provide platform for modelling and computing through CP
  - Extend user base, connect to society with policy relevant results
- Innovation
  - Continuous innovation, new types of observations, instruments
- Enhance international cooperation
  - Promoting our standards, federated data portal, extend the user base
  - Closer international cooperation, Fluxnet, SOCAT, IG3IS, GEO-C
- Communicate Science with society
  - UNFCCC, IPCC, Paris agreement
  - City, regional networks and data products (forestry, agriculture)
  - General communication on climate change, raising awareness

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ÉÅÈÎ åÒõÒ

- Level 0
  - raw sensor output (either mV or physical units)
- Level 1/NRT
  - calibrated and automatically Quality Assured data
- Level 2
  - final observation data products
- Level 3
  - elaborated data products, ICOS data

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èÛøÕÙÕõÛãõ åÒõÒ ÉúÛãõÙûÙÚÒõÙÐã ÝÕÙãÜ ÚüÛÚŸÕÝÃÕ

- Combines the benefit of PID with using the data checksum
- Uniquely identifies the data object, avoids duplicates
- Ensures the integrity of the data
- Allows complete transparency of data provenance
  - For observations, intermediate data and model results
- Makes data objects findable independent of storage location
- PID resolves to (dynamic) landing page: link data and metadata
- Avoids
  - data rot
  - unnecessary duplicates

PS:

DOIs are PIDs+metadata scheme

PIDs and DOIs all resolve through both Handle and DOI system

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ÈđÛã ¨ýÛøÕÙÐãÛú¯ ÿÙãŸÛú úÒõÒ ÕõÐøÛ

- The web becomes the database
- All data and metadata accessible through standard http(s), no drivers required
- Easy to link portals (of portals)
- Data is streamed dynamically, efficient and secure
- License check, usage tracking while streaming
- Services on top create and are triggered by URLs (REST interface) and PIDs as parameters (enable citation of result)

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ÉãÜÛÕõÙÐã

- Only data objects (DO) of known data type (profile) are accepted
- Ingestion only through machine-to-machine interface
- DO are registered at ingestion with metadata profile
- Data linked to metadata store through profile
- Data on the fly hashed and streamed to trusted repository,
- Only true and complete transfers are kept, then DOI and/or PID minted
- Metadata profile informs on:
  - Provenance
    - Producer
    - Location
    - Time period
  - Data type = Object Specification (URL)
  - Hashsum (SHA256)
  - Evt. version, license

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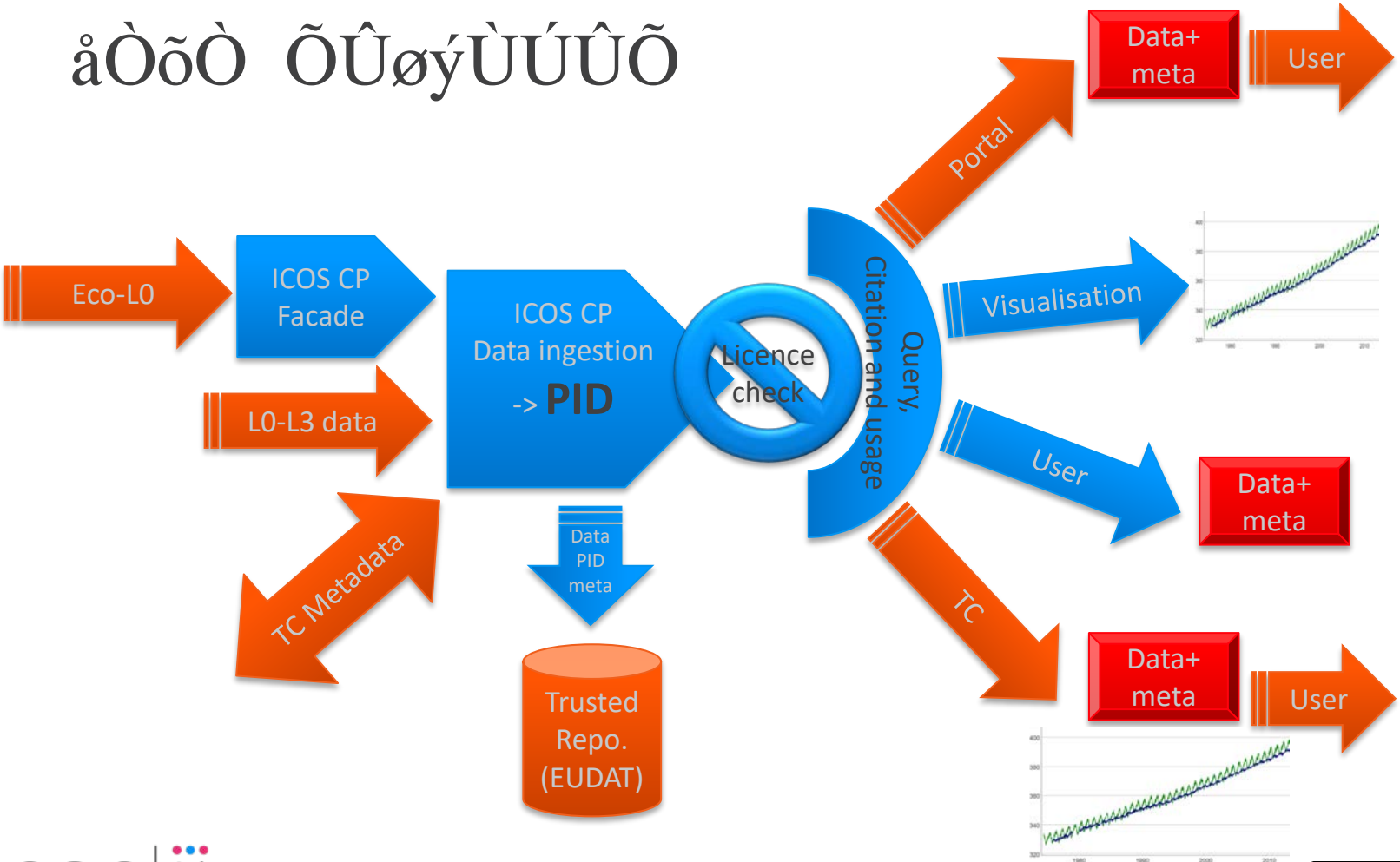

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ICOS Data Licence

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ICOS Data Licence - Summary

Fair Use - How and why

About ICOS - Data Quality

How to cite

REGISTER - How and why

About PIDs

Log in to accept permanently

I hereby confirm that I have taken notice of the information provided to inform me about the data and good practices of data usage. These guidelines do not define additional contractual conditions.

YES NO

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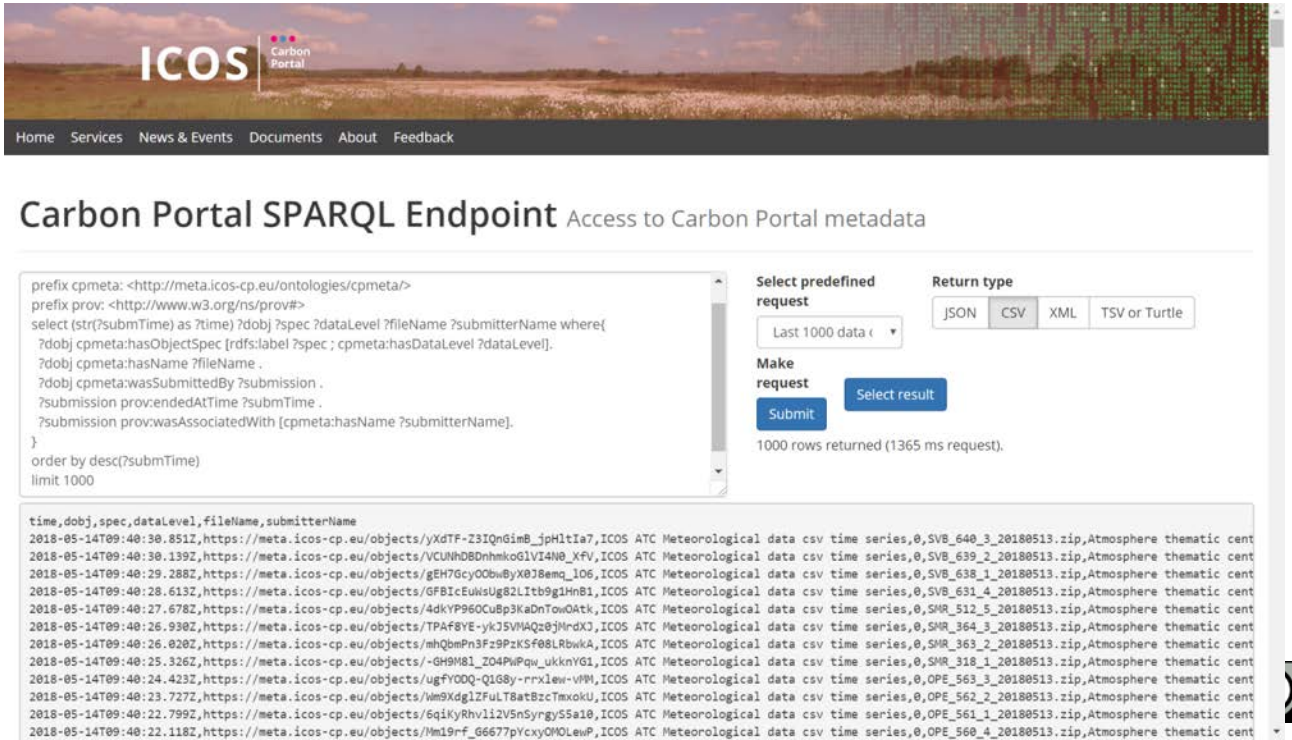
- All queries for metadata through SPARQL
- Also ontology (OWL) itself can be queried (machine-to-machine)



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