Project Number 282910

ÉCLAIRE

Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems

Seventh Framework Programme

Theme: Environment

21.14 (Final database report on intermediate and final database content, including QA/QC report)

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Organisation name of lead contractor for this deliverable :
NERC-CEH

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Dissemination Level		
PU	Public	y
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Objectives:

The objectives below represent the field-site experiments outlined in the description of work that produce data outputs for the ECLAIRE database:

- WP1:
  - To obtain 15 months of high temporal resolution flux data of key trace compounds (O3, NO, CO2, H2O) across a 9-site European flux network for the study of fluxes in relation to climatic drivers, using changing meteorological conditions at the sites as a proxy for climate.
  - To study the exchange of additional compounds (NH3, NOx, VOCs) through synchronised intensive measurement periods across the 9-site flux network, in relation to meteorological drivers, and to provide a test database for the evaluation of European chemical transport models.
  - To quantify the effect of aerosols on gross primary productivity through modulating in-canopy light levels for three forest ecosystems.
  - To quantify the importance of in-canopy chemical transformations on the deposition mechanism and effective emission of biogenic compounds into the atmosphere, through an integrated intensive measurement campaign above/within a polluted forest.
  - To make targeted measurements of NH3 exchange with Mediterranean semi-natural vegetation during distinct growth phases (active vs. dormant).
- WP2:
  - The aim of this work package is the study and quantification of key emission mechanisms to provide targeted data that can be used to derive parameterisations of the emission processes in WP1.3.
  - To obtain response curves of soil and litter emissions to meteorological drivers (temperature, moisture) for CO2, CH4, O3, N2O, NO, NO2 and NH3 across a wide range of soils.
  - To provide data on NO emissions after rewetting events as a basis to improve the mechanistic understanding and predictive capability, through novel laboratory experiments.
  - To quantify VOC emission responses under combined environmental change scenarios and develop a process understanding of the controls.
  - To investigate the effect of stresses (drought, heat) on BVOC emissions and the impact on O3 deposition and formation.
  - To quantify deposition rates of VOCs and their controls.
- WP10: To conduct relevant field-scale and controlled-exposure experiments on impacts of air pollution components on plant and ecosystem processes including interactions with climate change. Plant and ecosystem responses in terms of plant performance, carbon uptake and ecosystem carbon dynamics will be measured at 4 different ecosystem types.
- WP11: As part of measurements made at sites under WP10 studies will be made on three novel concepts to establish new empirical relationships for vegetation-air pollution interactions.
  - To quantify how climate change, including increasing background ozone concentration will enhance greenhouse gas and NO release and exacerbate the threat to vegetation caused by dry or wet N deposition, including the distinction between oxidized (NOy) and reduced (NHx) nitrogen forms.
  - To assess if BVOC emissions from vegetation will increase the potential for O3 and NOx uptake by plants, and detoxification of reactive oxygen species, leading to improved antioxidant properties and reduced emission of other stress-induced, reactive BVOC (e.g., LOX compounds).
  - To demonstrate if hygroscopic particles accumulating on leaves from aerosol and trace gas deposition may attract water and lead to enhanced transpiration and reduced drought tolerance.
- WP21: To ensure data quality and implement procedures for quality control

2. Activities and Results:

WP1 Data submissions

WP1.1: Field measurement data
To deliver 15 months of high temporal resolution flux data (O3, NO, CO2, H2O) + meteorology across a 9-site European flux network (Aug 2012 - Oct 2013).

All sites have submitted data for the requested length of time series. Most have submitted data to January 2014. There are still small datasets to come for a few sites for certain parameters. 1 min meteorology has been delivered for all sites where they had the instrumentation (except Bosco Fontana and Petrodolinskoye).
Datasets uploaded include:

- Deposition data
- Canopy leaf CO2 and H2O
- Ecosystem Management
- Gas and water exchange
- Gradients for RH and gases
- Meteorology
- Methods
- Site Metadata
- Soil Meteorology
- Soil and leaching data
- Soil gas flux
- VOC exchange data
- Vegetation data

WP1.2 - Intensive measurement periods across the flux network
Two contrasting measurement periods across the network. NO and NO2 by gradient and/or eddy-covariance, NH3 and VOCs. Auchencorth, UK April-May 2014.
Data delivered.

WP1.4: Bosco Fontana campaign data
Data forms have been added to the database. Data has now been uploaded to the database system.
Datasets captured include:

- Black carbon
- Gas Exchange
- PTR MS and PTR TOF
- Particles
- Site metadata and instrument data
- Soil Meteorology
- Leaf data
- Satellite data
- Soil flux

WP1.5: Targeted measurements of NH3 exchange with Mediterranean vegetation
Measurements have also been taken at a Mediterranean site in Spain. The data concerned did not look entirely as expected, and further quality investigation has been made into this dataset.

WP2: Controlled studies on exchange processes

WP2.1: Controlled emission measurements

Controlled emission measurements of CO2, CH4, N2O, NO and NH3 using monoliths and litter from the ÉCLAIRE flux network) – BFW
Data has been delivered

WP2.2: Quantifying the effect of re-wetting on NO emissions
Providing data on NO emissions after rewetting events on soil cores – KIT.
Final data is being processed and the time series experiment and statistical data will be archived in the ECLAIRE database.

WP2.3: Quantifying BVOCs exchanges in field experiments
Assessment of primary and secondary BVOC exchange rates.
Data captured and submitted

WP2.4 - Coupling between climate change induced stresses on vegetation
Plant chamber-reaction chamber system (JPAC) in order to separate stress induced emissions, O3 & NOx deposition within the eco-system, and photo-chemical ozone formation) – JUELICH.
Data has been delivered.

WP 9 - Literature data mining
Compiled data are stored in an Access Database where queries can be run for different processes (Leaf-scale, Dynamic and Ecosystem scale processes) and Vegetation Types - Crops, Grassland/Wetland/ Heath & Trees
Download instructions from the ECLAIRE website (via email request):
http://www.eclaire-fp7.eu/WP9-data-mining-database

WP10/WP11 Data submissions
Data have been uploaded for the 4 different ecosystem types:

Table 1: Data uploaded for different ecosystem types.

Ecosystem	Site 1	Site 2
Forest	Bangor (UK) 2012-2013	Curno (It) 2012-2014
Grassland		Alp Flix (Sui) 2004-2010
Agriculture	Santa Olalla (Es) 2011-2012	Riso Phytotron (Dk) 2009-2011
Shrubland	Brandburg (Dk) 2006-2012	Whim Bog (UK)2012-2013

Additional measurements have associations with WP11 where they have also contributed to the overall measurements in WP10: Whim Bog (2013), Bonn (2012)

WP 11.1: Peat bog experiment on N-climate-O3 interactions.
Measurements are ongoing on the O3 'field release' experiment on the Whim ombrotrophic bog set up in 2014/15. This experiment will continue after the end of ECLAIRE using national funding and will continue to use the ECLAIRE database. Once data has been collected and analysed data will be stored in the Eclaire database.

WP11.3: Effects of aerosol deposition on stomatal function
Datasets for sunflowers, pine and beech experiments have all been submitted to the database.

WP21: Standards and Data Management

The ECLAIRE website (eclaire-fp7.eu) is the main dissemination platform for the project. At the end of the project there were 134 users. Figure 1 shows the home page accessed at www.eclaire-fp7.eu.

Figure 1: ECLAIRE website

ÉCLAIRE data portal (D21.8) – NERC

The ECLAIRE database provides data archiving and storage for work packages 1,2,10 and 11. The ECLAIRE data portal now has 74 registered users. Users can download data via the Reporting interface shown in Figure 2. Over 600 data download requests have been made since the inception of the ECLAIRE database.

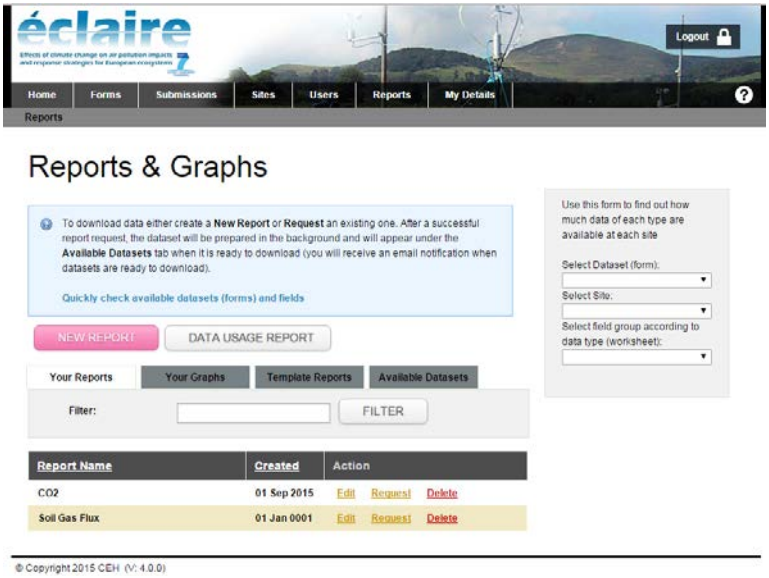


Figure 2: ECLAIRE database Reporting & Graphing page

Uploading and storing of data are facitlaited throught the Forms page (Figure 3).

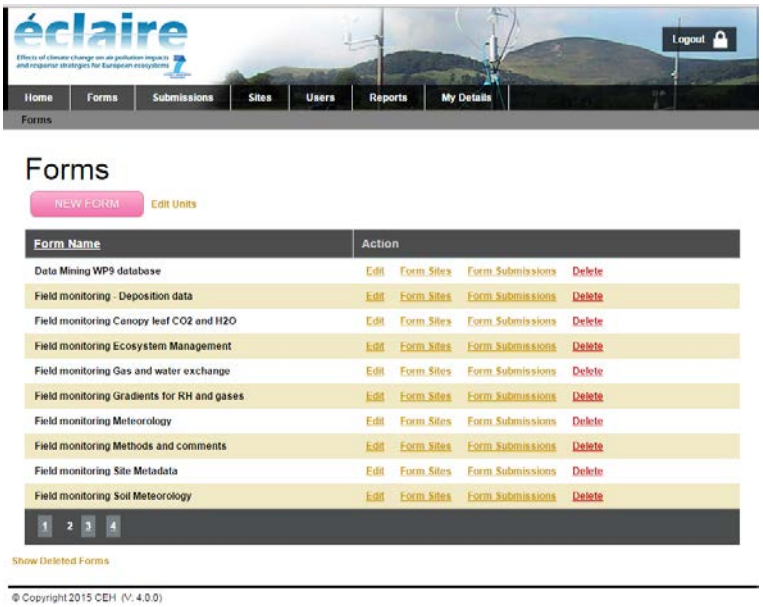


Figure 3: ECLAIRE database - Forms used for data uploading and downloading

Further updates and feature requests have been documented for future development and improvements:

- Change permissions for Data Usage report so uploaders/PIs can only see requests for their site.
- Make attachments available with the requested dataset rather than at the point of requesting the dataset
- Add the ability to find out which sites have data for a particular field when creating report
- Add the ability to add attachments to submissions at any time without having to reject and resubmit data
- Only notify PIs of a download after a user's download has successfully completed
- Provide a message to a user if a download fails
- Investigate factors that may cause a report to fail

<u>Data Centre for Components 4 and 5: Afolu data centre - JRC</u>

Due to a server upgrade at JRC, the AFOLU database became ‘end of life’ but the upgrade path failed and proved very hard to fix. Since then we have commission JRC to produce a new revised AFOLU

database. We have investigated best options and found that a combination of DRUPAL and DKAN has sufficient flexibility to store spatial datasets. Since August 2015 JRC have:

- prepared a server at JRC and installed the necessary software
- adapted the default DRUPAL/DKAN data base to our needs, i.e. implementing many of the features we had in the old 'AFOLUDATA portal', adapting design etc.
- made all the procedures to bring the new data portal online

3. Milestones achieved:

Milestone number	Milestone name	Lead benef-iciary number	Delivery date from Annex I	Comments
MS100	Common measurement protocols for C1 and C3 agreed and distributed	5	12	Complete. Further discussion were undertaken at the Zagreb 3rd GA to finalise measurement parameters for forest ecosystem field types for WP1.1.
MS104	DP and DMP first drafts written and agreed by DMC (**D21.7**)	1	6	Complete and online
MS106	ÉCLAIRE data portal online with user registration	1	12	Online with 74 users http://eclairedata.ceh.ac.uk
MS107	Data uploaded and QA checked for months 1-18	1	24	Completed
MS108	Data uploaded and QA checked for months 19-36	1	40	Completed
MS109	Final data uploaded, final QA/QC reports	1	48	Completed

4. Meetings:

Demonstrations on the ECLAIRE database were given at the following General Assemblies. This involved training in uploading for site managers and downloading data for other ECLAIRE users.

- 2nd GA Edinburgh, 2012
- 3rd GA Zagreb, 2013
- 4th GA and the Open Science Conference Budapest, 2014
- 5th GA Edinburgh, 2015

5. List of Documents/Annexes:

Appendix A: Quality control of flux network data in the ECLAIRE database

QA/QC by data users

Much of the control of the data submitted to the ECLAIRE database originating from the C1 10-site flux network occurred by the users of the data for the following activities:

- Use of the flux data to test and further improve parameterisations of emission and deposition (within WPs 1, 3 and 4)
- Validation of LandscapeDNDC against field measurements (WP3)

- Cross-site analysis of the partitioning of ozone flux into stomatal and non-stomatal components and analysis of the effect of ozone dose on carbon uptake (conducted with WP1)
- Use of ozone flux data as well as meteorological variables to assess the performance of a global chemistry and transport model (UKCA) (WP1 and collaboration with PEGASOS)
- Development of BVOC emission parameterisations from new field data (WPs 1 & 3)

Because these activities required the bulk of the submitted data, these analyses highlighted, in communication with the data providers: (i) periods for which existing data had not been submitted, (ii) out-of-range data that appeared to have been submitted in incorrect units (partly caused by the fact that ECLAIRE used different units than the previous FP6 NitroEurope IP for some variables), (iii) missing metadata elements, (iv) missing variables, in particular related to site description and so-called 'on-off' measurements; and (v) some poorly quality controlled data. These issues were brought to the attention of the site-managers / data providers so that so that revised data could be re-submitted.
In addition, two actions were taken to further assess data quality.

Assessment of data ranges

The analysis of the averages and data ranges in the database provides an indication whether data have been submitted in the correct units and whether they contain physically impossible values that indicate poor quality control.
Some issues were identified through this analysis (Tables 1 and 3) and missing, revised or filtered data were requested from the data providers. Some data gaps, however, are expected. For example, PAR was also uploaded separately as 1-minute values and the present analysis is based on 30-minute values, sites do not show up here that only uploaded 1-minute values. Similarly, the requirement of NOx fluxes was relaxed at some sites (e.g. where fluxes were below the measurement level).

Table 1. Statistics of data in ECLAIRE database - meteorology

Parameter		UK AMo	IT BFo	HU Bug	IT Cpz	Fr Gri	FI Hyy	IT Isp	CH Pos	UA Pet	NL Spe
T air [°C]	μ	7.44	13.16	10.48	16.11	10.52	4.36	13.71	8.97	9.65	9.86
	σ	5.86	9.04	9.84	6.78	7.07	9.32	8.04	8.26	10.76	6.96
	Min	-8.01	-7.63	-15.08	-3.67	-11.93	-21.98	-3.60	-15.10	-22.55	-8.78
	Max	29.14	35.08	39.34	35.10	36.84	27.79	33.60	32.90	35.65	34.17
	N	24864	17962	24509	51407	35087	24644	26386	24864	34074	24864
RH [%]	μ	86.55	80.49	77.50	81.19	79.47	80.51	66.39	80.77	79.82	84.65
	σ	11.80	21.12	20.50	13.06	15.48	19.40	19.16	14.91	19.98	16.12
	Min	30.53	15.54	16.06	21.00	14.79	16.93	8.8	26.8	20.05	22.14
	Max	100.00	100.00	100.00	99.00	99.90	99.91	96.50	100.00	100.00	100.32
	N	24864	17960	24492	51307	35087	17512	26386	24864	34074	24864
Precip [mm / 30 min]	μ	0.06	0.06	0.01	0.04	0.04	0.04	0.09	0.06	0.02	0.05
	σ	0.26	0.46	0.18	0.40	0.27	0.22	0.62	0.36	0.26	0.31
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max	12.12	25.20	11.00	25.20	20.40	7.68	25.75	30.30	21.60	13.46
	N	24864	18401	24490	51279	35087	16032	26386	24864	34073	23820
Pa [kPa]	μ	97.94	-	99.80	101.29	99.73	99.09	98.55	94.15	100.46	100.24
	σ	1.16	-	0.74	0.66	0.95	1.00	0.75	0.76	0.79	0.92
	Min	93.90	-	97.14	98.50	96.40	95.17	95.72	91.40	97.00	96.84
	Max	100.70	-	102.35	103.40	102.00	101.66	100.74	96.20	102.77	102.32
	N	24864	-	24492	51279	35087	24644	26383	24864	34074	24864
Rg [W m^{-2}]	μ	84.86	111.59	135.32	173.52	131.84	85.01	150.62	140.08	73.42	102.84
	σ	150.72	188.86	224.05	258.84	213.16	156.74	240.02	230.78	116.85	179.02
	Min	0.02	0.00	0.00	0.00	-13.27	-4.55	-7.63	0.00	-1.00	0.00
	Max	835.00	803.00	1038.0	1014.0	1066.0	855.73	1035.0	1088.3	498.40	957.25
	N	24864	18624	24507	51279	35087	24757	26386	24864	34074	24864
PAR tot [μmol m^{-2} s^{-1}]	μ	165.34	-	262.91	-	-	172.24	283.36	261.96	191.03	224.83
	σ	293.38	-	439.31	-	-	315.78	469.76	449.7	302.5	387.49
	Min	0.02	-	0.00	-	-	-5.72	0.00	0.00	-1.00	-0.29
	Max	1725.0	-	2027.5	-	-	1706.1	2179.6	2112.3	1277.3	2084.0
	N	24864	-	24560	-	-	24834	26383	20072	34074	24385
PAR ref [μmol m^{-2} s^{-1}]	μ	-	143.13	24.41	-	10.90	8.44	14.69	25.78	-	9.32
	σ	-	241.50	58.58	-	32.94	14.81	22.09	72.71	-	15.85
	Min	-	-358.00	0.00	-	-49.75	-2.85	-0.10	0.00	-	-0.08
	Max	-	1177.0	1217.7	-	820.00	155.89	111.59	1201.3	-	117.96
	N	-	18399	24560	-	34439	16435	26383	20252	-	24386
PAR diff [μmol m^{-2} s^{-1}]	μ	101.12	147.95	-	-	141.96	59.43	124.69	147.10	-	119.95
	σ	161.50	377.77	-	-	199.21	119.86	22.09	207.45	-	185.92
	Min	0.02	-930.94	-	-	0.00	-3.42	-0.01	0.00	-	4.35
	Max	1678.0	2007.5	-	-	1156.0	827.87	111.59	1210.0	-	1125.0
	N	24858	18400	-	-	35086	18041	26383	10875	-	7344
Rn [W m^{-2}]	μ	20.86	72.37	57.93	107.14	48.02	42.58	88.02	62.78	76.53	49.99
	σ	88.62	181.36	151.02	193.67	143.29	128.86	208.49	154.37	162.41	151.62
	Min	-222.40	-161.10	-210.75	-71.13	-153.90	-94.17	-118.52	-99.20	-76.35	-102.46
	Max	514.60	784.00	740.64	711.35	717.00	685.61	839.39	760.00	708.51	783.90
	N	24864	17684	24509	29746	34389	16082	26832	24589	35078	24760

Table 2. Statistics of data in ECLAIRE database - micrometeorology

Parameter		UK AMo	IT BFo	HU Bug	IT Cpz	Fr Gri	FI Hyy	IT Isp	CH Pos	UA Pet	NL Spe
Wind speed [m/s]	μ	4.22	2.15	2.72	2.19	2.67	2.59	1.42	1.68	3.47	3.49
	σ	2.47	1.12	1.63	1.37	1.69	1.07	1.23	1.59	1.92	1.38
	Min	0.01	0.01	0.10	0.00	0.00	0.08	0.02	0.01	0.03	0.16
	Max	19.40	9.50	12.1	10.3	12.89	8.22	9.19	10.32	12.78	12.52
	N	32688	24148	18416	47306	35088	22215	26350	24750	25706	24864
u_* [m/s]	μ	0.34	0.28	0.18	0.42	0.23	0.48	0.26	0.15	0.24	0.49
	σ	0.28	0.20	0.12	0.29	0.15	0.25	0.24	0.11	0.14	0.28
	Min	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.001	0.01	0.02
	Max	3.58	1.60	2.03	2.64	2.65	1.70	1.92	1.65	1.31	2.40
	N	32075	24148	18333	42033	32980	21856	26208	19605	25706	21825
σ_w [m/s]	μ	0.38	-	0.22	0.45	0.31	0.61	0.36	0.17	-	0.63
	σ	0.25	-	0.15	0.30	1.32	0.30	0.27	0.12	-	0.34
	Min	0.02	-	0.00	0.00	0.01	0.02	0.02	0.01	-	0.01
	Max	3.15	-	0.90	2.98	186.86	2.04	2.19	2.79	-	2.41
	N	33053	-	18565	42124	32982	22215	26208	23809	-	24473
H [W / m^{-2}]	μ	11.30	22.64	27.08	50.02	8.96	11.81	4.92	5.23	23.39	8.90
	σ	68.29	65.69	54.27	128.77	53.37	71.25	65.84	29.83	62.94	80.20
	Min	-247.00	-177.66	-54.92	-99.97	-444.21	-200.86	-338.98	-272.90	-214.10	-279.62
	Max	798.21	545.62	280.86	598.65	749.67	529.24	611.17	226.10	692.30	751.54
	N	36914	24015	14703	47868	34515	24534	26161	21499	25465	24864
λE [W / m^{-2}]	μ	14.54	49.95	49.19	34.35	35.50	27.22	47.97	54.93	43.26	33.11
	σ	34.09	88.79	77.18	57.85	60.50	50.88	99.25	81.11	75.94	53.63
	Min	-239.36	-1440.7	-80.42	-20.00	-453.88	-88.74	-165.03	-16.6	-227.92	-117.69
	Max	679.83	1644.89	535.22	299.66	680.73	422.92	765.46	443.80	607.22	856.00
	N	36914	23302	14693	36601	34487	21233	24770	16037	25483	24864
Tsoil (0.1 m) [%][1]	μ	7.68	12.56	11.65	16.11	11.17	6.40	12.04	13.53	12.54	8.78
	σ	3.71	6.02	6.01	4.29	5.54	4.14	5.48	6.17	10.87	4.42
	Min	1.68	2.71	1.98	7.69	1.44	0.92	0.00	0.64	-7.85	0.61
	Max	15.88	24.18	24.62	24.61	21.82	13.46	21.40	27.19	64.0	17.93
	N	24855	18689	25488	44096	24717	24835	25429	12923	25247	24864
SWC (0.1 m) [%][2]	μ	80.96	9.44	8.80	5.61	29.64	33.15	25.00	40.29	40.73	38.06
	σ	5.13	5.04	4.16	7.33	4.55	8.57	6.99	10.21	25.06	5.09
	Min	55.80	2.27	4.32	0.01	18.94	10.50	0.00	15.50	0.00	26.44
	Max	90.4	36.27	27.77	34.06	37.46	56.50	75.27	52.70	89.93	50.40
	N	24839	8945	25489	40218	20527	19335	25482	12922	18377	24864
Leaf wetness [%]	μ	-	-	23.58	13.61	0.61	-	0.35	24.98	25.77	12.61
	σ	-	-	22.56	31.14	1.37	-	0.30	31.01	16.76	21.05
	Min	-	-	-159.06	0.00	0.001	-	-0.13	0.00	10.3	0.00
	Max	-	-	95.86	100.00	17.28	-	1.15	100.00	82.39	100.00
	N	-	-	25138	45602	7283	-	9447	20923	1981	24385

Table 3. Statistics of data in ECLAIRE database – gas fluxes

Parameter	UK AMo	IT BFo	HU Bug	IT Cpz	Fr Gri	FI Hyy	IT ISP	CH POS	UA Pet	NL Spe

[1] Tsoil - Bos: 0.05, Bug: 0.05, Hyy: 0.07, Pos: 0.05, Spe: 0.08

[2] SWC - Bos: 0.05, Bug: 0.03, Pos: 0.05, Spe: 0.05

CO_2 conc [ppm]	μ	378.38	409.99	427.84	407.77	396.58	399.09	401.84	434.33	388.7	389.09
	σ	19.49	44.86	73.24	27.73	46.16	8.94	18.72	36.99	17.27	14.69
	Min	340.01	320.00	240.26	334.2	300.01	368.22	355.49	375.2	330.03	354.7
	Max	516.76	626.39	944.87	636.54	600.00	457.74	533.19	874.3	499.89	474.86
	N	32076	23068	23592	34354	32296	22932	25710	17570	25136	18063
CO_2 flux [μmol m^{-2} s^{-1}]	μ	-0.10	-0.05	-0.28	-1.66	-0.51	-0.55	-1.21	-0.40	-0.17	-1.28
	σ	3.14	10.56	3.56	6.86	7.00	4.67	8.65	7.26	3.65	6.18
	Min	-19.76	-137.24	-25.01	-24.99	-80.19	-26.41	-69.47	-35.50	-24.59	-41.62
	Max	45.66	148.80	12.94	14.98	168.92	12.05	41.87	25.00	9.99	33.92
	N	36914	23214	25488	35194	34441	24864	26350	24864	25034	24864
O_3 conc [nmol m^{-3}]	μ	1277.4	1140.1	1144.5	1427.9	1140.9	1218.7	1215.7	1043.0	1091.0	893.8
	σ	302.28	1033.1	632.2	737.58	574.83	395.03	825.39	661.33	438.37	506.29
	Min	211.81	-259.45	38.7	8.98	-115.49	0	-0.75	-105	7.99	0.00
	Max	2273.5	12268	3552.2	5938.2	4303.7	2516.3	4585.9	3197.0	2492.3	8698.4
	N	18737	24147	25403	40980	35085	24195	22104	23504	21313	22923
O_3 flux [nmol m^{-2} s^{-1}]	μ	-3.40	-3.57	-1.68	-2.98	-2.48	-0.06	-4.75	-3.26	-	-4.21
	σ	33.83	5.13	1.53	3.11	2.77	0.07	6.90	3.44	-	9.30
	Min	-939.00	-50.98	-11.25	-33.52	-36.40	-0.8	-64.28	-22.8	-	-161.3
	Max	4153.0	24.13	0.81	0.10	8.62	0.30	46.01	3.80	-	80.74
	N	18727	23238	16177	41118	32661	14370	22040	20286	-	16837
NO conc [nmol m^{-3}]	μ	8.60	268.38	20.14	84.69	190.16	1.50	109.35	120.35	13.31	39.24
	σ	98.36	511.67	16.20	343.57	479.24	4.67	319.24	290.46	41.73	130.72
	Min	-275.24	1.61	0.31	-15.45	0.00	-3.94	-7.98	0.00	0.00	0.00
	Max	7958.6	6565.4	426.56	4720.8	11184	147.18	5746.9	4823.3	2330.3	3243.2
	N	26271	9194	9355	14166	9763	24084	15938	22910	14877	23015
NO flux [nmol m^{-2} s^{-1}]	μ	-0.08	-	0.03	-	-462.88	-	-	0.06	-	-0.70
	σ	1.16	-	1.17	-	1787.0	-	-	0.16	-	2.48
	Min	-36.59	-	-10.65	-	-9880	-	-	-1.88	-	-70
	Max	55.35	-	30.97	-	81.10	-	-	2.98	-	51.99
	N	26263	-	5893	-	10549	-	-	9810	-	16837
NO_2 conc [nmol m^{-3}]	μ	116.49	260.31	212.79	309.2	356.03	-	391.96	313.59	91.07	280.73
	σ	119.65	516.66	85.93	334.32	350.23	-	331.19	276.28	97.53	227.41
	Min	-89.62	0.00	16.8	-7.98	0.00	-	11.10	0.20	0.00	-204.1
	Max	1773.4	6821.3	1115.0	2312.2	6307.1	-	2409.5	3409.3	2310.1	2023.5
	N	26271	8850	10241	14166	9763	-	15938	20626	15224	23014
NO_2 flux [nmol m^{-2} s^{-1}]	μ	-0.14	116.01	-0.10	-	-40811	-	-	-0.16	-	-0.22
	σ	1.93	2657.5	3.00	-	24342	-	-	0.31	-	3.72
	Min	-58.28	-135496	-24.02	-	-56500	-	-	-2.04	-	-63.18
	Max	89.58	97633	28.18	-	26000	-	-	1.08	-	220.95
	N	26263	8117	6064	-	10549	-	-	3885	-	16831

Analysis of the energy balance closure

From a theoretical point of view it is expected that the available energy at the surface balances the observed turbulent fluxes of sensible heat (H) and latent heat (λE). The available energy consists of the net radiation (difference between incoming and outgoing short and long-wave radiation components), i.e.:

$$Rn - G = H + \lambda E \quad (1)$$

In addition, storage within the canopy air space and the biological material of the canopy itself can be important for tall canopies (e.g. forests) but it tends to cancel at the diurnal cycle and should therefore

not systematically bias the relationship implied in Eq. (1). The degree to which the energy balance is attained provides some indication on whether the four parameters that enter Eq. (1) are plausible. However, most previous studies have identified a gap in the energy balance closure with turbulent fluxes some 10 to 30% smaller than the available energy, even if turbulent fluxes are perfectly quality controlled. The reason for this is still an area of active research. Nevertheless, a non-closure of > 30% or a significant over-closure may highlight a problem in the data.

Figure 1 compiles the comparison of turbulent fluxes against available energy with satisfactory results, overall. This analysis is based on all delivered measurements and includes data taken at low wind speed when fluxes become less certain. This may be the reason why the degree of scatter differs between sites and is relatively large at Cpz, the unfunded site, where wind speed is relatively low. Another feature in the data is the occasional occurrence of positive deviations in the turbulent fluxes at night-time at Gri, BFo, Isp and, most evident at AMo, although their occurrence is infrequent.

The non-closure of the energy budget was best at some forest sites, reaching about 15% at Hyy and Cpz, 26% at Spe and BFo, but as large as 40% at Isp. At the shorter vegetation sites it was 22% at AMo, about 32% at Gri, Pos and Bug, and 28% at Petrodolinkoye. The type of IRGA differed between sites. Open-path analysers (LiCOR-7500) were used at most sites (BFo, Bug, Gri, Pet, Pos and Spe), whilst encapsulated open-path analysers (LiCOR-7200) were used at Cas and Isp. Closed-path IRGAs were used at the remaining sites, Model LiCOR 6262 at Hyy and LiCOR 7000 at AMo. Corrections for line-damping are significant at these two latter sites, inducing additional uncertainty, but the non-closure is well within the range of the other sites.

The reason for the poor energy balance closure at Isp is not clear at present. Because the fetch is quite limited at this site a fuller analysis should be conducted depending on atmospheric conditions and wind direction. It is also possible that the measurement of *Rn* is not particularly representative of the flux footprint.

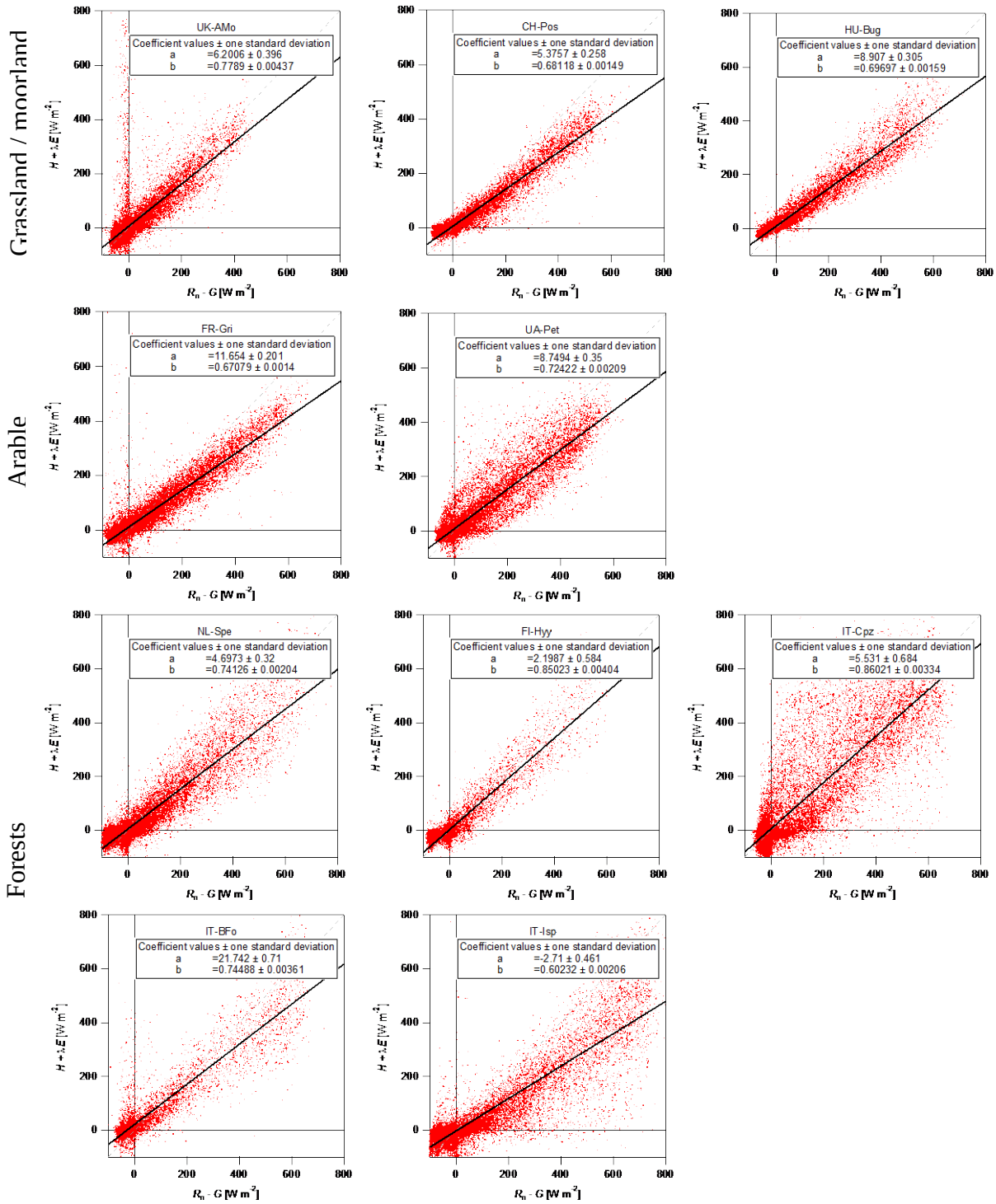
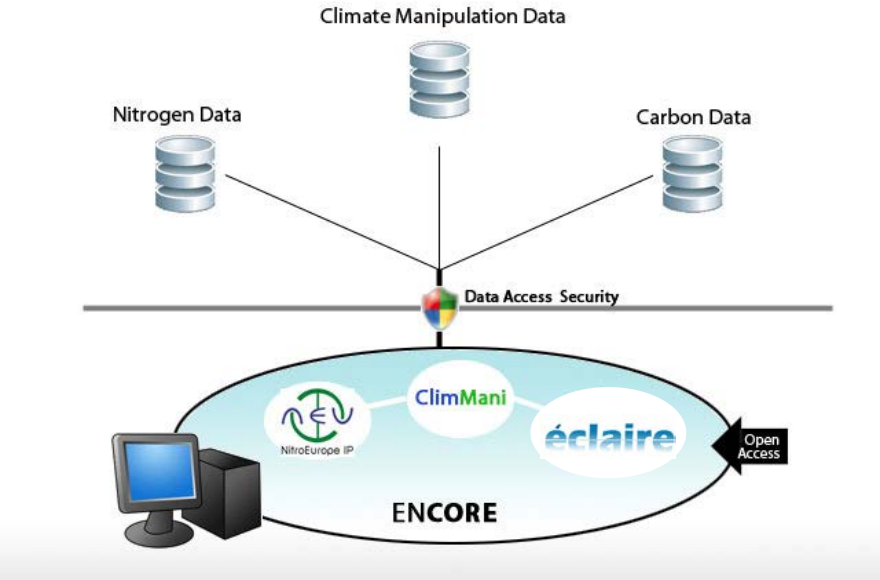


Figure 1. Summaries of the energy budget closures across the flux network.

Appendix B: ENCORE - Environment and Climate interactions - Observations and Responses in Ecosystems

Concept and Aims – To build a web tool that can search for data across multiple databases. Currently we have environmental flux and field manipulation data across two EU projects – NitroEuropeIP and ECLAIRE FP7. Since there is a lot of overlap in terms of the field sites and data collected it led to an opportunity to create a data discovery tool that can pull out data from both sets of databases. Thereby users do not have to log into two different database to search for data. They can use ENCORE to seamlessly find data across multiple projects.



ENCORE Benefits

- Use of common vocabulary enabling better integration of data
- Ability to add on databases (web services)
- Harmonised approach to units
- Data remain with the project
- ENCORE respects permissions of data author

Technology and Functionality

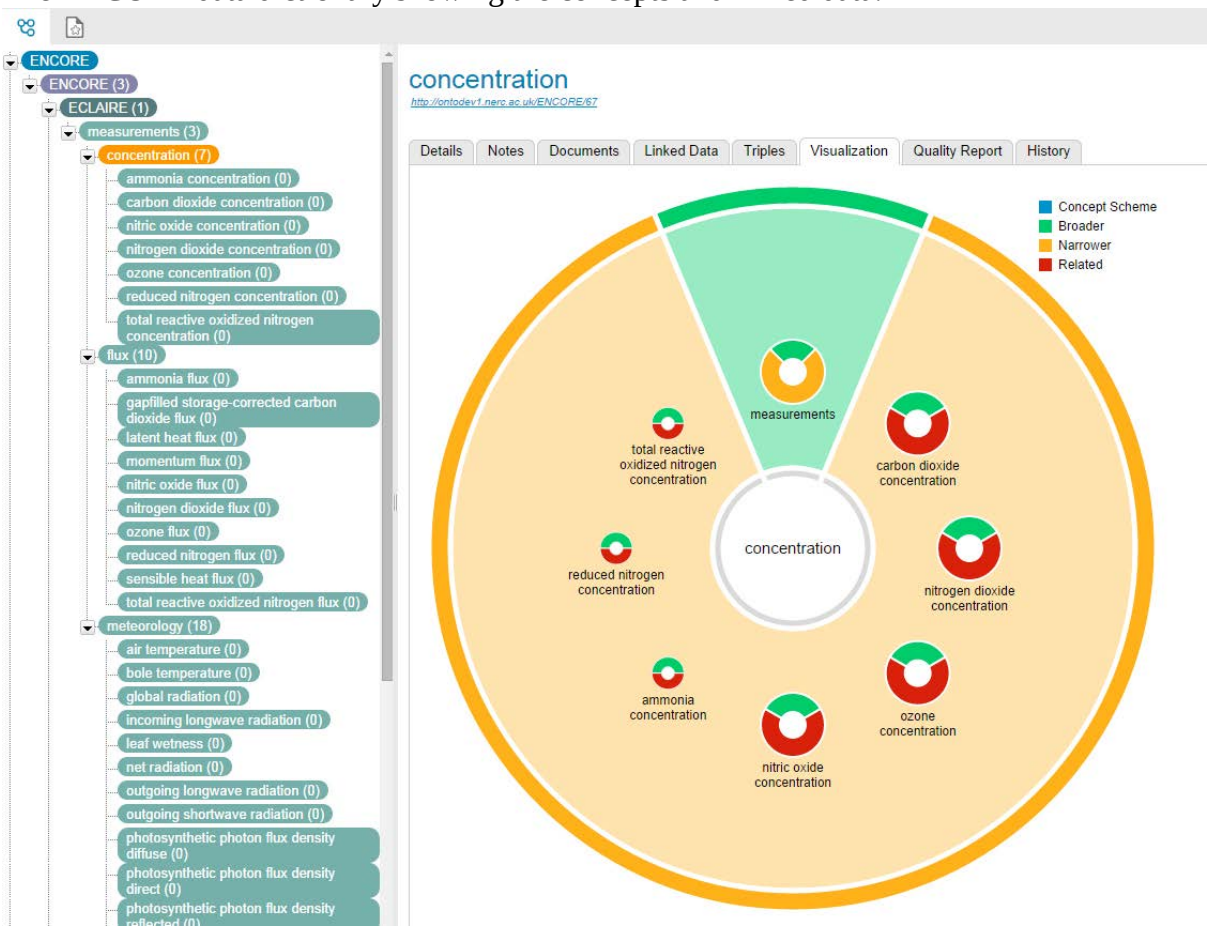
- Web services (api code) are used that can ENCORE can use to talk to connected databases. Tells the system the users, fields, data. Updates are run overnight to tell the system about new users or new data
- Data Dictionaries (linked data) – help to describe data in multiple ways using taxonomies. Improves data searching for users.
- Projects - any project database can be linked to the ENCORE system
- Sites - ENCORE supports site-based, time series data, and manipulation data
- Fields - ENCORE supports multi-field data using field dictionaries fields and site will be imported by admin from project ‘nodes’ to ENCORE.
- Role-based security Accessible areas of the application will be controlled by a role-based security mechanism. The role based approach will stop users from accessing data from the ECLAIRE project (unless you already a member of the ECLAIRE project database).
- Reporting - the primary function of ENCORE is reporting – allowing users of the application to query fields, sites and date ranges across multiple projects

Progress

Progress has been made with the initial development concept and design. We now have a fully working system that can bring back data from both ECLAIRE and NitroEurope databases. The system relies on a database dictionary approach which has been devised and built using the Poolparty software (https://www.poolparty.biz). The dictionary can be added to at any time and ENCORE will search and find that change on its regular set of nightly updates.

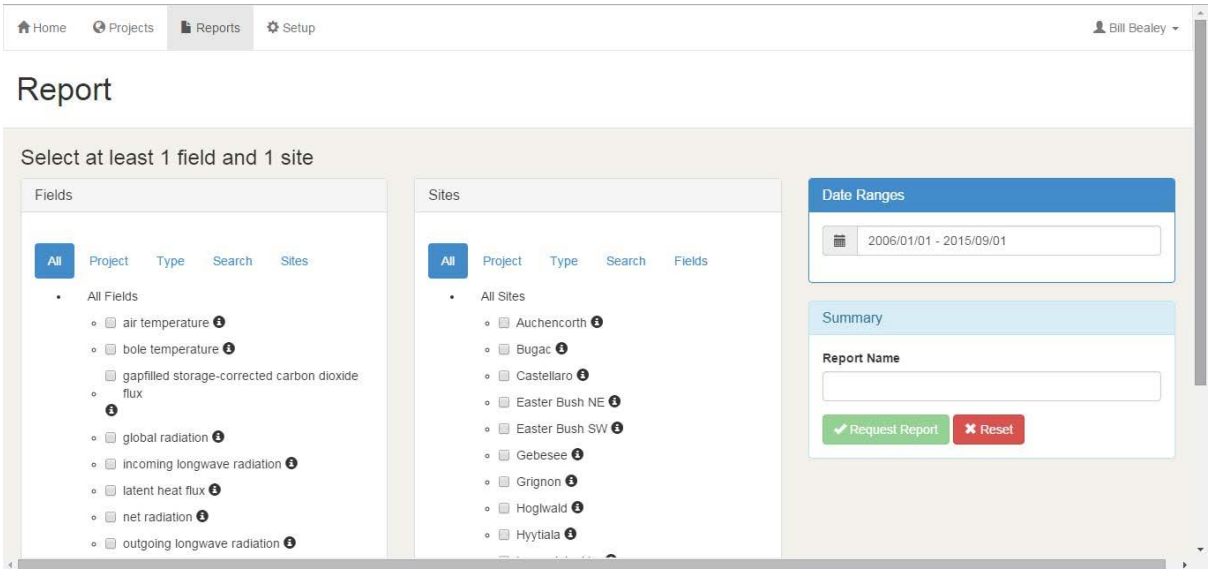
Data Dictionary

The ENCORE data dictionary showing the concepts and linked data.



Reporting

The reporting (data download) tool calls the data dictionary to match fields (parameters) by project, field type (e.g. flux or met), sites, and by a semantic search. As the user select field the Sites on the right hand side filters itself to give the sites where there is data for the selected fields.



Further Development

Further development is now planned to add more data fields to the dictionary, implement the role based approach and then we can start rolling it out to ECLAIRE and NitroEurope users for evaluating its usefulness and capabilities. ENCORE itself will be open for any user based on a registration process.