

## **Organic matter cycling along geochemical, geomorphic and disturbance gradients in forests and cropland of the African Tropics - Project TropSOC Database Version 1.0**

### **Key Contributors to Database and Manuscript**

Sebastian Doetterl<sup>1,2</sup>, Benjamin Bukombe<sup>2</sup>, Laurent Kidinda<sup>9</sup>, Daniel Muhindo<sup>6</sup>, Mario Reichenbach<sup>2</sup>,  
Laura Summerauer<sup>1</sup>, Florian Wilken<sup>1,2</sup>, Peter Fiener<sup>2</sup>

### **Technical Contributors to Database and/or Data Ingestion**

Rodrigue K. Asifiwe<sup>6</sup>, Fernando Bamba<sup>6</sup>, Matthew Cooper<sup>8</sup>, Clovis Kabaseke<sup>8</sup>, Annina Maier<sup>1</sup>, Moritz Mainka<sup>2</sup>, Julia Mayrock<sup>2</sup>, Serge M. Mukotanyi<sup>6</sup>, Leon Nabahungu<sup>12</sup>, Anna Stegmann<sup>2</sup>, Robin Unseld<sup>2</sup>,  
Cordula Vogel<sup>9</sup>

### **Conceptual Contributors**

Geert Baert<sup>3</sup>, Marijn Bauters<sup>3,4</sup>, Pascal Boeckx<sup>3</sup>, Georg Cadisch<sup>5</sup>, Landry N. Cizungu<sup>6</sup>, Alison Hoyt<sup>7</sup>,  
Karsten Kalbitz<sup>9</sup>, Basile B. Mujinya<sup>10</sup>, Boris Rewald<sup>11</sup>, Johan Six<sup>1</sup>, Bernard Vanlauwe<sup>12</sup>, Kristof Van  
Oost<sup>13</sup>, Kris Verheyen<sup>4</sup>

- <sup>1)</sup> Department of Environmental System Sciences, ETH Zurich, 8092 Zürich, Switzerland
- <sup>2)</sup> Institute of Geography, Augsburg University, Augsburg, Germany
- <sup>3)</sup> Department of Green Chemistry and Technology, Ghent University, Ghent, Belgium
- <sup>4)</sup> Department of Environment Forest & Nature Lab, Ghent University, Ghent, Belgium
- <sup>5)</sup> Institute of Plant Production and Agroecology in the Tropics and Subtropics, University of Hohenheim, Stuttgart, Germany
- <sup>6)</sup> Faculty of Agricultural Sciences, Université Catholique de Bukavu, DR Congo
- <sup>7)</sup> Max Planck Institute for Biogeochemistry, Jena, Germany
- <sup>8)</sup> School of Agriculture and Environmental sciences, Mountains of the Moon University, Fort Portal, Uganda
- <sup>9)</sup> Chair of Soil Resources and Land Use, Institute of Soil Science and Site Ecology, TU Dresden, Germany
- <sup>10)</sup> Biogeochemistry and ecology of tropical soils and ecosystems, University of Lubumbashi, DR Congo
- <sup>11)</sup> Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria
- <sup>12)</sup> Institute of Tropical Agriculture, Central Africa and Natural Resource Management, CGIAR, Nairobi, Kenya
- <sup>13)</sup> Earth and Life Institute, UCLouvain, Louvain-la-Neuve, Belgium.

Corresponding author: sdoetterl@usys.ethz.ch

### **Authors Contributions**

SD functioned as the project leader. SD and PF were lead coordinators for compiling the data base, responsible for data analysis and designed the metadata. BB, MC, LK, DM, MR, LS and FW were collecting and creating datasets and also analysed these data before inclusion into the database. All technical contributors participated via data collection. All conceptual contributors participated in the design of the study and gave advice and feedback during the campaign. SD and PF wrote the paper. All authors supported data analysis and gave feedback during the writing process.

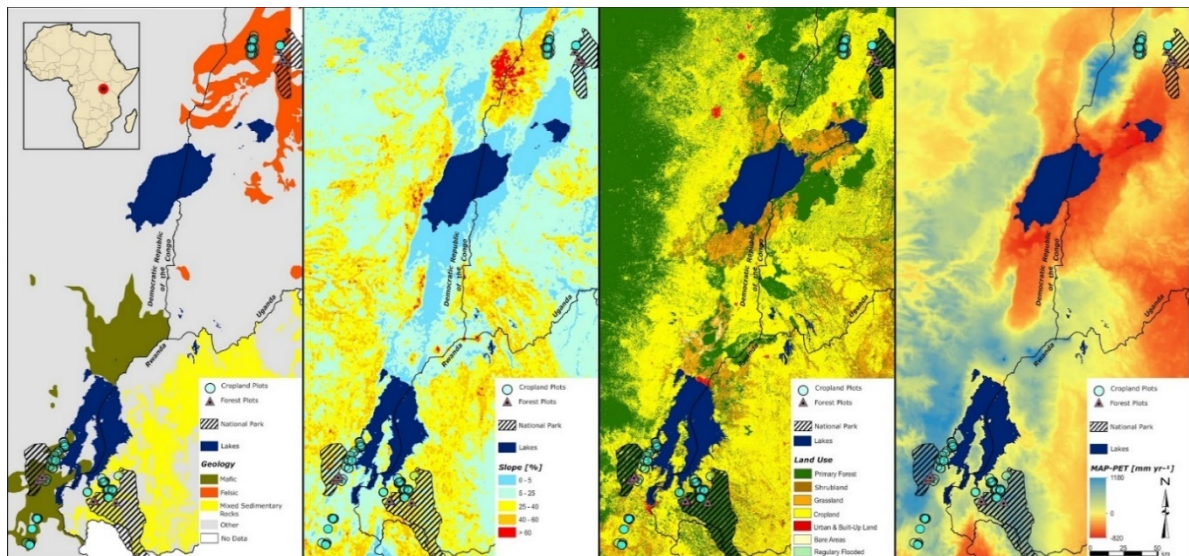
When using these data, please cite the original publication:

Doetterl S., Asifiwe R.K., Baert G., Bamba F., Bauters M., Boeckx P., Bukombe B., Cadisch G., Cizungu L.N., Cooper M., Hoyt A., Kabaseke C., Kalbitz K., Kidinda L., Maier A., Mainka M., Mayrock J., Muhindo D., Mujinya B.B., Mukotanyi, S.M., Nabahungu L., Reichenbach M., Rewald B., Six J., Stegmann A., Summerauer L., Unseld R., Vanlauwe B., Van Oost K., Verheyen K. Vogel C., Wilken F., Fiener P. Organic matter cycling along geochemical, geomorphic and disturbance gradients in forests and cropland of the African Tropics - Project TropSOC Database Version 1.0. *Earth System Science Data* XXX, DOI XXX, 2021.

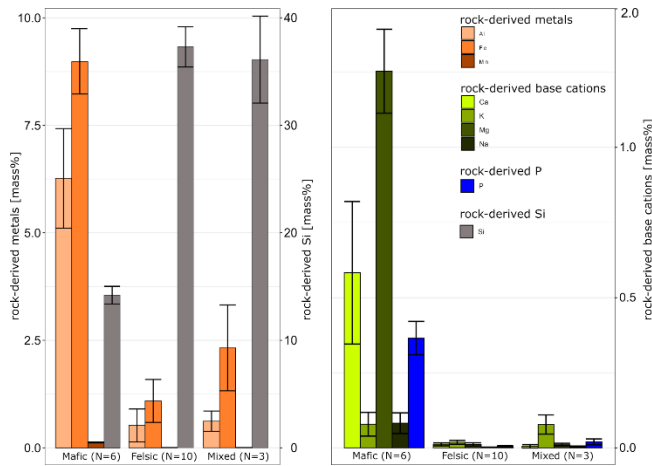
## 0. Introduction of test region and project & data base structure

This database is the result of scientific activities from 2017-2020 within project TropSOC, funded via the Emmy-Noether-Program of the German Research Foundation (project ID 387472333). The main objective of project TropSOC was to develop a mechanistic understanding of soil organic carbon dynamics including plant and microbial response to soil properties in the African tropics. In addition, the project aimed at understanding landscapes as a whole and assessing how humans re-shape and affect tropical ecosystems. A more detailed description of the project objectives can be found in Doetterl et al. (2021). Here we focus on a short description of the study sites, which puts the data presented in this database in a broader context.

Study sites of project TropSOC are situated within the border region between the Congo and the Nile basin and are spread across South and North Kivu (Democratic Republic of the Congo), Western Rwanda and Southwestern Uganda (see Figure 1). Human disturbance (e.g. deforestation) in the Congo Basin is still comparably low, with deforestation currently spreading along river systems into largely pristine forests of local mountain ranges. Growing population in the lowlands and the reliance on subsistence farming for food as well as charcoal production for energy threaten these remaining forests and drive an acceleration of deforestation, which leads to erosion and land use change in steep terrains. Overall, the study area provides a unique combination of (i) different geologically parent material for soil formation (Figure 2), (ii) varying land use representing different levels of disturbance by human activities and (iii) steep terrain with slopes up to 60% prone to soil redistribution, making it an ideal study area to identify the relative strength of various environmental controls on tropical soil C dynamics.



**Figure 1.** Overview of the study area with respect to major investigated factors (from left to right): soil parent material geology, slope steepness, land use, climate (expressed as mean annual precipitation – potential evapotranspiration) (Doetterl et al. 2021).



**Figure 2.** Chemical composition of unweathered rock samples of soil parent material in the three studied geochemical regions studied. Total elemental concentration of main elements with relevance for plant nutrition and SOC stabilization. Error bars represent the standard error of the mean.

Our intention was to study pristine forest sites vs. cropland sites. Hence, the database is structured into two main parts, one representing forest and the other representing cropland data. Another part of the database presents the basic information, structure and connections between datasets. A further part contains meteorological data that represents forest and cropland study sites. Forest and cropland soils developed from three geochemical distinct parent material (mafic, felsic, mixed sedimentary rocks) were sampled following a stratified random plot design where plots are at different topographic position (3 to 6 plots per topo-

**Table 1.** Topographic information of pristine forest and cropland plots in the studied geochemical regions. Slope and altitude are displayed as minimum and maximum values.

	felsic sub-region in Uganda					
	forest plots			cropland plots		
<i>topographic position</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>
slope [%]	3 - 5	9 - 55	3	1 - 5	7 - 50	1 - 5
altitude [m] a.s.l	1304 - 1306	1271 - 1420	1272-1277	1507 - 1797	1466 - 1830	1587 - 1768
	mixed sedimentary rocks sub-region in Rwanda					
	forest plots			cropland plots		
<i>topographic position</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>
slope [%]	3	9 - 60	1	3 - 5	8 - 50	2 - 5
altitude [m] a.s.l	1908 - 1939	1891 - 2395	1882 - 1889	1719 - 1837	1565 - 1952	1556 - 1758
	mafic sub-region in DR Congo					
	forest plots			cropland plots		
<i>topographic position</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>	<i>plateau</i>	<i>sloping</i>	<i>valley</i>
slope [%]	3	11 - 60	1 - 2	0 - 5	8 - 43	0 - 3
altitude [m] a.s.l	2208 - 2227	2188 - 2248	2181 - 2310	1477 - 1731	1486 - 1774	1505 - 1708

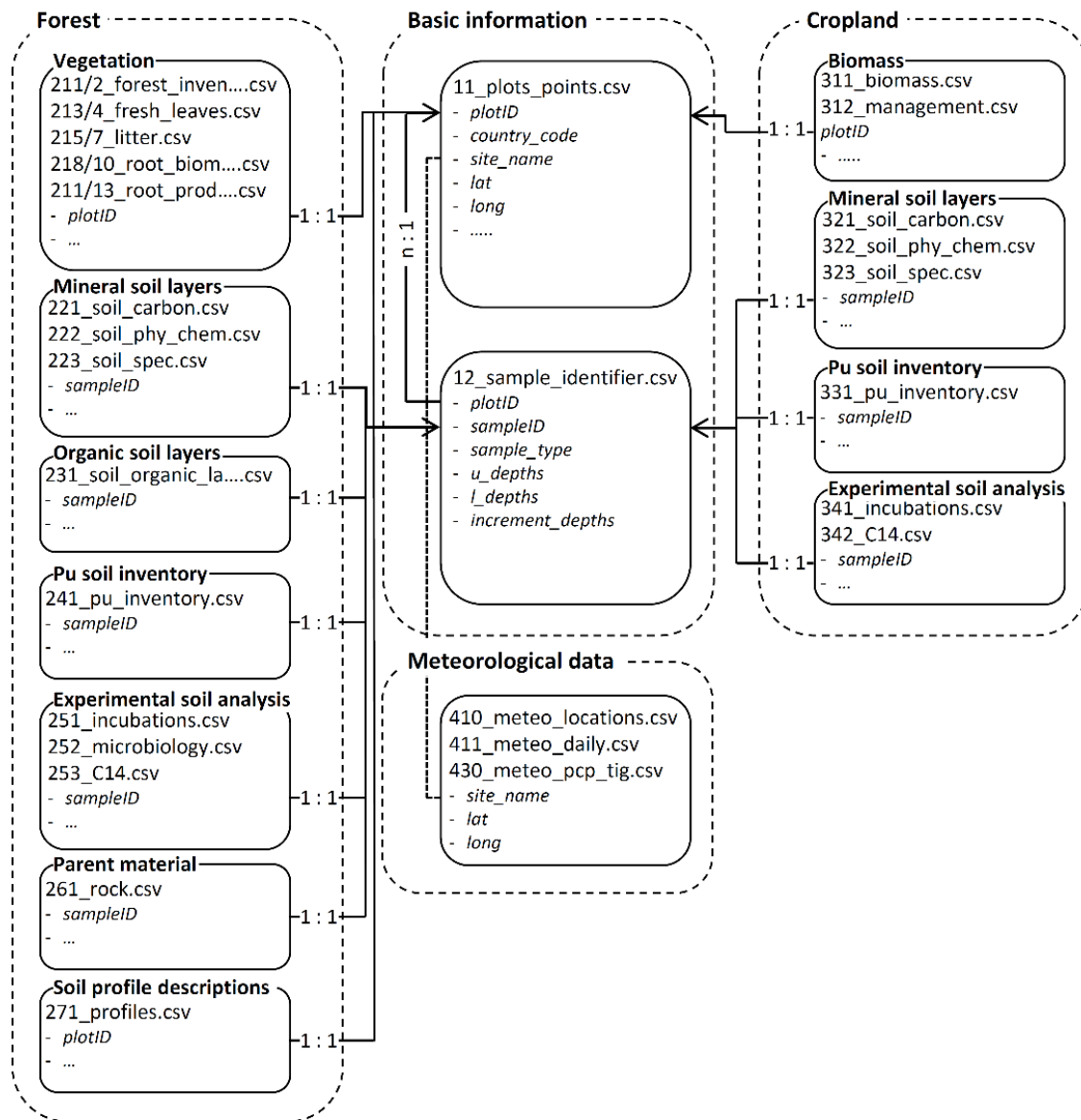
graphic positions “plateau”, “sloping” and “valley”) to study the potential effect of soil geochemistry, land use and soil redistribution on soil C dynamics. Details of the plot and sampling design is given with the individual data-sets and in Doetterl et al. (2021), while a first overview regarding the characteristics of these plots are given in Table 1 and 2.

**Table 2.** Mean chemical and physical soil characteristics following wet chemistry analyses for forest and cropland plots of the different geochemical regions. Mean values ( $\pm$  standard errors) were calculated averaging results from 36 forest plots and 87 cropland plots for three soil depths (0 - 10cm, 30 - 40cm, 60 - 70cm).

geochemical region	mafic sub-region in DR Congo		felsic sub-region in Uganda		mixed sedimentary rocks sub-region in Rwanda	
land use	forest	cropland	forest	cropland	forest	cropland
<b>soil chemistry</b>						
pH (KCl)	3.78 $\pm$ 0.10	4.28 $\pm$ 0.04	4.87 $\pm$ 0.13	5.02 $\pm$ 0.07	3.43 $\pm$ 0.07	3.97 $\pm$ 0.02
CEC [me/100 g]	38.71 $\pm$ 1.44	20.71 $\pm$ 1.04	14.17 $\pm$ 0.94	29.08 $\pm$ 1.13	14.86 $\pm$ 1.49	20.80 $\pm$ 1.74
share of bases in CEC [%]	13.70 $\pm$ 2.91	18.21 $\pm$ 1.87	66.44 $\pm$ 4.65	48.01 $\pm$ 2.36	4.29 $\pm$ 1.20	12.03 $\pm$ 1.44
ECEC [me/100g]	10.06 $\pm$ 1.04	6.20 $\pm$ 0.36	11.25 $\pm$ 1.09	14.67 $\pm$ 0.74	5.33 $\pm$ 0.41	6.60 $\pm$ 0.56
share of bases in ECEC [%]	43.07 $\pm$ 5.87	56.55 $\pm$ 3.92	84.99 $\pm$ 2.68	92.52 $\pm$ 0.61	7.12 $\pm$ 0.72	34.22 $\pm$ 3.54
Si [%]	11.59 $\pm$ 0.20	12.97 $\pm$ 0.39	18.47 $\pm$ 0.79	17.20 $\pm$ 0.52	18.69 $\pm$ 1.52	15.65 $\pm$ 0.57
Al [%]	10.55 $\pm$ 0.34	12.19 $\pm$ 0.27	9.07 $\pm$ 0.56	8.50 $\pm$ 0.53	7.16 $\pm$ 0.77	11.18 $\pm$ 0.35
Fe [%]	11.00 $\pm$ 0.25	12.01 $\pm$ 0.67	4.46 $\pm$ 0.32	7.07 $\pm$ 0.40	5.32 $\pm$ 1.07	7.461 $\pm$ 0.71
Mn [%]	0.19 $\pm$ 0.02	0.22 $\pm$ 0.06	0.18 $\pm$ 0.02	0.23 $\pm$ 0.03	0.01 $\pm$ 0.00	0.07 $\pm$ 0.02
SOC [%]	3.89 $\pm$ 0.45	2.16 $\pm$ 0.18	1.63 $\pm$ 0.24	2.26 $\pm$ 0.18	3.31 $\pm$ 0.38	2.57 $\pm$ 0.19
SON [%]	0.38 $\pm$ 0.04	0.18 $\pm$ 0.01	0.16 $\pm$ 0.02	0.20 $\pm$ 0.01	0.19 $\pm$ 0.03	0.21 $\pm$ 0.01
SOC/SON [-]	10.23 $\pm$ 0.18	11.72 $\pm$ 0.31	10.28 $\pm$ 0.22	10.47 $\pm$ 0.24	18.96 $\pm$ 1.13	12.14 $\pm$ 0.25
P [%]	0.23 $\pm$ 0.02	0.14 $\pm$ 0.02	0.08 $\pm$ 0.01	0.47 $\pm$ 0.06	0.09 $\pm$ 0.01	0.12 $\pm$ 0.01
bioavailable P [mg/kg soil]	22.34 $\pm$ 2.72	4.77 $\pm$ 0.70	17.39 $\pm$ 4.00	172.96 $\pm$ 10.27	12.27 $\pm$ 4.27	5.08 $\pm$ 1.06
Total reserve base cat. [%]	0.62 $\pm$ 0.10	0.28 $\pm$ 0.04	1.56 $\pm$ 0.10	2.88 $\pm$ 0.27	1.07 $\pm$ 0.24	1.05 $\pm$ 0.17
<b>soil physics</b>						
BD [g/cm <sup>3</sup> ]	1.05 $\pm$ 0.03	1.24 $\pm$ 0.03	1.66 $\pm$ 0.04	1.29 $\pm$ 0.03	1.27 $\pm$ 0.05	1.22 $\pm$ 0.04
clay [%]	54.20 $\pm$ 2.91	64.63 $\pm$ 2.34	38.62 $\pm$ 1.77	36.02 $\pm$ 1.28	37.74 $\pm$ 2.90	44.49 $\pm$ 1.86
silt [%]	14.24 $\pm$ 0.74	13.88 $\pm$ 1.05	9.48 $\pm$ 0.53	17.77 $\pm$ 0.64	22.63 $\pm$ 2.25	21.46 $\pm$ 1.39
sand [%]	31.56 $\pm$ 2.81	21.49 $\pm$ 1.50	51.90 $\pm$ 1.48	46.21 $\pm$ 0.89	39.63 $\pm$ 3.63	34.05 $\pm$ 1.49

### Description of database

An overview of all datasets presented in this database is given in Table 3. Datasets are given as tab-delimited .csv files. For each .csv file the metadata describing data structure and assessment methods are given in a .pdf file of the same name. Moreover, additional .pdf files for each main section of the database (basic information, forest, cropland, and meteorology) are given, providing an overview of the structure within each section. Note that the **'basic information'** section of the database provides the linkages between individual data, e.g. from soil analysis and the location and/or soil depths where these samples were acquired (for linkages see also Figure 3).



**Figure 3.** Overview of linkages between datasets in the TropSOC database v1.0.

**Table 3.** Structure of the TropSOC database. For each topic a .pdf file is given that entails an overview for the available data sets. Each dataset comprises a data-containing .csv file and an additional metadata-containing .pdf file of the same name.

Introduction & structure of the data base	0_intro_structure.pdf
<b>1. Basic information</b> 1.1. Location and basic background information for all plots and points where data were collected 1.2. Data base internal connection between location of plots and points and soil data from different soil depths	<b>1_basic_information.pdf</b> 11_plots_points.csv/pdf 12_sample_identifier.csv/pdf
<b>2. Forest</b> 2.1. Vegetation 2.1.1. Forest inventory 2.1.2. Forest inventory aggregated 2.1.3. Fresh leaves chemistry 2.1.4. Fresh leaves chemistry aggregated at species level 2.1.5. Litter fall 2.1.6. Litter fall aggregated to seasonal values 2.1.7. Litter fall aggregated to annual values 2.1.8. Root biomass 2.1.9. Root biomass aggregated to seasonal values 2.1.10. Root biomass aggregated to annual values 2.1.11. Root productivity 2.1.12. Root productivity aggregated to seasonal values 2.1.13. Root productivity aggregated to annual values 2.2. Mineral soil layers 2.2.1. Soil carbon and nitrogen including organic matter fractions 2.2.2. Physicochemical soil properties from laboratory analyses 2.2.3. Physicochemical soil properties from NIR-MIR spectroscopy 2.3. Organic soil layers 2.4. Pu soil inventory 2.5. Soil experiments 2.5.1. Incubation experiments 2.5.2. Microbial biomass and enzyme experiments 2.5.3. <sup>14</sup> C data from bulk soil and CO <sub>2</sub> measurements 2.6. Parent material 2.7. Soil profile descriptions	2_forest.pdf 211_forest_invent.csv/pdf 212_forest_invent_agg.csv/pdf 213_fresh_leaves.csv/pdf 214_fresh_leaves_agg.csv/pdf 215_litter.csv/pdf 216_litter_seasonal.csv/pdf 217_litter_annual.csv/pdf 218_root_biomass.csv/pdf 219_root_biomass_seasonal.csv/pdf 2110_root_biomass_annual.csv/pdf 2111_root_prod.csv/pdf 2112_root_prod_seasonal.csv/pdf 2113_root_prod_annual.csv/pdf 221_soil_carbon.csv/pdf 222_soil_phy_chem.csv/pdf 223_soil_spec.csv/pdf 231_soil_organic_layer.csv/pdf 241_pu_inventory.csv/pdf 251_incubation.csv/pdf 252_microbiology.csv/pdf 253_c14.csv/pdf 261_rocks.csv/pdf 271_profiles.csv/pdf
<b>3. Cropland</b> 3.1. Biomass & management 3.1.1. Biomass yield based on plot data 3.1.2. Land management data 3.2. Mineral soil layers 3.2.1. Soil carbon and nitrogen including organic matter fractions 3.2.2. Physicochemical soil properties from laboratory methods 3.2.3. Physicochemical soil properties from NIR-MIR spectroscopy 3.3. <sup>239+240</sup> Pu soil inventory 3.4. Soil experiments 3.4.1. Incubation experiments 3.4.2. <sup>14</sup> C data from bulk soil and CO <sub>2</sub> measurements	3_cropland.pdf 311_biomass.csv/pdf 312_management.csv/pdf 321_soil_carbon.csv/pdf 322_soil_phy_chem.csv/pdf 323_soil_spec.csv/pdf 331_pu_inventory.csv/pdf 341_incubation.csv/pdf 342_c14.csv/pdf
<b>4. Meteorological data</b> 4.1. Locations of meteorological stations 4.2. Daily meteorological data from six meteorological stations 4.3. High resolution 5 min triggered precipitation data	4_meteo.pdf 410_meteo_locations.csv/pdf 420_meteo_daily.csv/pdf 430_meteo_pcp_tig.csv/pdf