Working with Research Data

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September 12, 2017

Outline

- Accessing and reusing research data
- Computational environments for data processing
- Curating and storing data, from files to databases
- Research data versioning and backup

Data Access

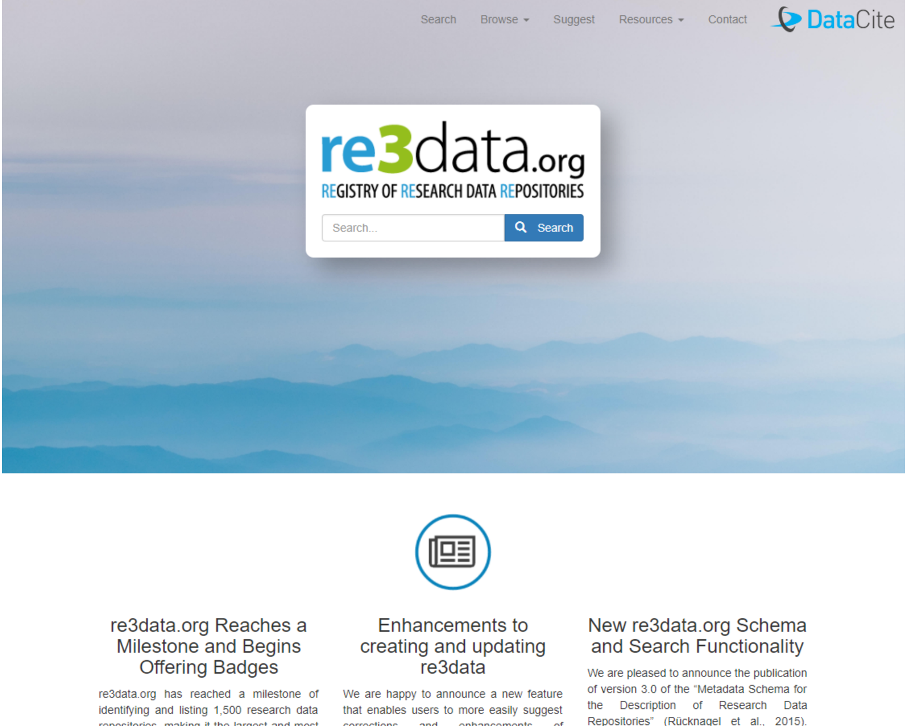
- It's complicated but it is improving
- Drivers for better access
  - Open Data imperative
  - Credit for publishing data
  - Increase return on investment in scientific research
  - Funders requiring data to be published
- Correspondingly, supporting infrastructures is
  - Increasing in number and quality
  - Adopting principles, guidelines, standards
  - Supporting human and programmatic access

Data Access

- You know how to access *your* data
- More difficult is access to data authored by others
- Presumes others have published their data
- Then you may be able to
  - Find their data
  - Retrieve the data
  - Reuse the data

Find Data

- Useful data can be found in a lot of places
- Online or offline, e.g. printed books
- In data repositories or as files on a server
- You could try a Google search
- Or ask your supervisor and fellow students
- The authors of papers you read may cite data and/or sources
- Specialized search, e.g. Registry of Research Data Repositories



re3data.org Reaches a Milestone and Begins Offering Badges

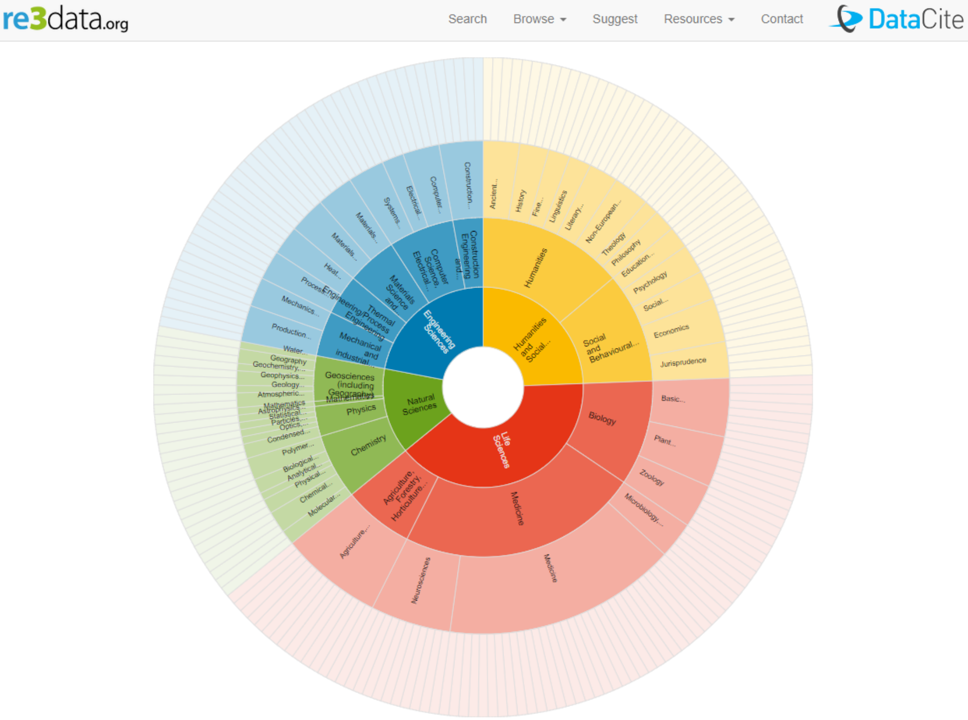
re3data.org has reached a milestone of identifying and listing 1,500 research data repositories, making it the largest and most

Enhancements to creating and updating re3data

We are happy to announce a new feature that enables users to more easily suggest corrections and enhancements of

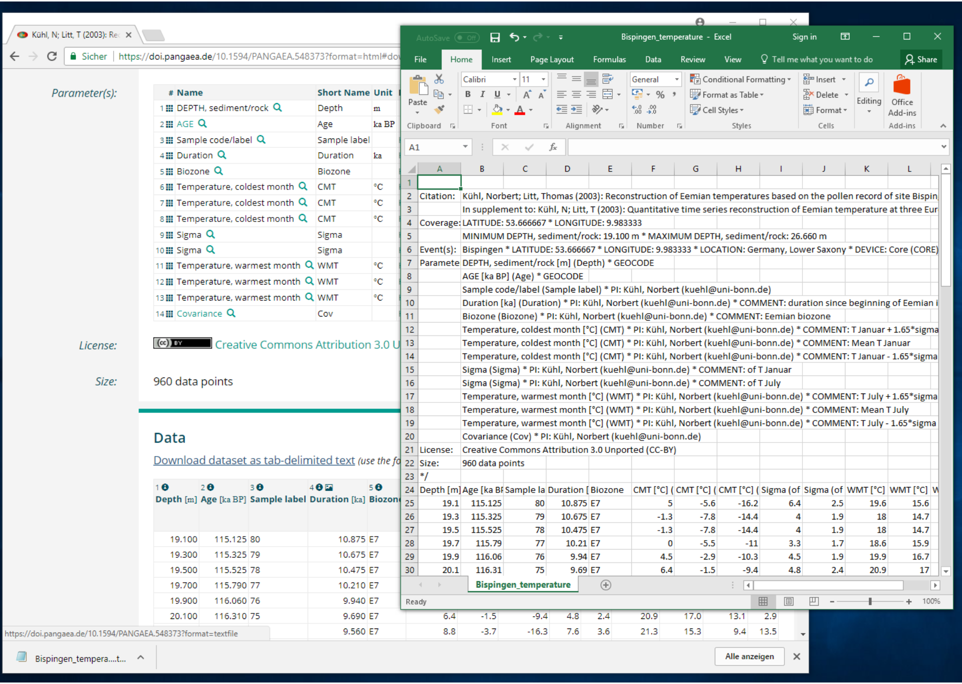
New re3data.org Schema and Search Functionality

We are pleased to announce the publication of version 3.0 of the "Metadata Schema for the Description of Research Data Repositories" (Rücknagel et al., 2015).


re3data.org
Search
Browse
Suggest
Resources
Contact
DataCite
Engineering Sciences
Construction Engineering and...
Computer Science, Electrical...
Materials Science and...
Thermal Engineering/Process Engineering
Mechanical and industrial...
Construction...
Computer...
Electrical...
Systems...
Materials...
Materials...
Heat...
Process...
Mechanics...
Production...
Water...
Humanities and Social...
Humanities
Social and Behavioural...
Ancient...
History
Fine...
Linguistics
Literary...
Non-European...
Theology
Philosophy
Education...
Psychology
Social...
Economics
Jurisprudence
Natural Sciences
Geosciences (including Geography)
Mathematics
Physics
Chemistry
Geography
Geochemistry,...
Geophysics...
Geology...
Atmospheric...
Mathematics
Astrophysics...
Statistical...
Particles,...
Optics,...
Condensed...
Polymer...
Biological...
Analytical...
Physical...
Chemical...
Molecular...
Life Sciences
Biology
Medicine
Agriculture, Forestry, Horticulture...
Basic...
Plant...
Zoology
Microbiology...
Medicine
Neurosciences
Agriculture...

Retrieve Data

- Typically download of one or more files
- An API for programmatic retrieval may be available
- Data repositories generally support search
- Often data are retrieved as they were deposited (original format)
- Repository may standardize data during ingestion



Parameter(s):

#	Name	Short Name	Unit
1	DEPTH, sediment/rock	Depth	m
2	AGE	Age	ka BP
3	Sample code/label	Sample label	
4	Duration	Duration	ka
5	Biozone	Biozone	
6	Temperature, coldest month	CMT	°C
7	Temperature, coldest month	CMT	°C
8	Temperature, coldest month	CMT	°C
9	Sigma	Sigma	
10	Sigma	Sigma	
11	Temperature, warmest month	WMT	°C
12	Temperature, warmest month	WMT	°C
13	Temperature, warmest month	WMT	°C
14	Covariance	Cov	

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Size: 960 data points

Data

Download dataset as tab-delimited text *(use the fo*

1 Depth [m]	2 Age [ka BP]	3 Sample label	4 Duration [ka]	5 Biozone									
19.100	115.125	80	10.875	E7									
19.300	115.325	79	10.675	E7									
19.500	115.525	78	10.475	E7									
19.700	115.790	77	10.210	E7									
19.900	116.060	76	9.940	E7									
20.100	116.310	75	9.690	E7	6.4	-1.5	-9.4	4.8	2.4	20.9	17.0	13.1	2.9
			9.560	E7	8.8	-3.7	-16.3	7.6	3.6	21.3	15.3	9.4	13.5

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2	Citation:	Kühl, Norbert; Litt, Thomas (2003): Reconstruction of Eemian temperatures based on the pollen record of site Bispin										
3		In supplement to: Kühl, N; Litt, T (2003): Quantitative time series reconstruction of Eemian temperature at three Eur										
4	Coverage:	LATITUDE: 53.666667 * LONGITUDE: 9.983333										
5		MINIMUM DEPTH, sediment/rock: 19.100 m * MAXIMUM DEPTH, sediment/rock: 26.660 m										
6	Event(s):	Bispingen * LATITUDE: 53.666667 * LONGITUDE: 9.983333 * LOCATION: Germany, Lower Saxony * DEVICE: Core (CORE)										
7	Paramete	DEPTH, sediment/rock [m] (Depth) * GEOCODE										
8		AGE [ka BP] (Age) * GEOCODE										
9		Sample code/label (Sample label) * PI: Kühl, Norbert (kuehl@uni-bonn.de)										
10		Duration [ka] (Duration) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: duration since beginning of Eemian i										
11		Biozone (Biozone) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: Eemian biozone										
12		Temperature, coldest month [°C] (CMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: T Januar + 1.65*sigma										
13		Temperature, coldest month [°C] (CMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: Mean T Januar										
14		Temperature, coldest month [°C] (CMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: T Januar - 1.65*sigma										
15		Sigma (Sigma) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: of T Januar										
16		Sigma (Sigma) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: of T July										
17		Temperature, warmest month [°C] (WMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: T July + 1.65*sigma										
18		Temperature, warmest month [°C] (WMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: Mean T July										
19		Temperature, warmest month [°C] (WMT) * PI: Kühl, Norbert (kuehl@uni-bonn.de) * COMMENT: T July - 1.65*sigma										
20		Covariance (Cov) * PI: Kühl, Norbert (kuehl@uni-bonn.de)										
21	License:	Creative Commons Attribution 3.0 Unported (CC-BY)										
22	Size:	960 data points										
23	*/											
24	Depth [m]	Age [ka BP	Sample la	Duration [	Biozone	CMT [°C] (	CMT [°C] (	CMT [°C] (	Sigma (of	Sigma (of	WMT [°C]	WMT [°C]
25	19.1	115.125	80	10.875	E7	5	-5.6	-16.2	6.4	2.5	19.6	15.6
26	19.3	115.325	79	10.675	E7	-1.3	-7.8	-14.4	4	1.9	18	14.7
27	19.5	115.525	78	10.475	E7	-1.3	-7.8	-14.4	4	1.9	18	14.7
28	19.7	115.79	77	10.21	E7	0	-5.5	-11	3.3	1.7	18.6	15.9
29	19.9	116.06	76	9.94	E7	4.5	-2.9	-10.3	4.5	1.9	19.9	16.7
30	20.1	116.31	75	9.69	E7	6.4	-1.5	-9.4	4.8	2.4	20.9	17

Reuse Data

- Complicated!
- Generally substantial processing needed to make reuse possible
- Even if accessible, data are generally not interoperable
- Lack syntactic interoperability due to different formats
- Lack semantic interoperability due to different terminology
- Data and metadata quality may not be adequate
- Different resolution, gaps, outliers, insufficient information, ...
- Data need to be integrated: common syntax and semantics
- A lot of time required to prepare for reuse

Data Processing

- Assume integrated data
- Your next step is to process them for your purpose
- Staggering amount of methods
- Programming (scripting) languages
- Computational environments and other tools
- Processing results in new (derived) data
- Various kinds of processing, transformation, interpretation, ...

Curating and Storing Data

- Data need to be identified, described, quality controlled, etc.
- Curated data are stored and possibly preserved
- How you curate and store data depends on various factors, e.g.
  - Longevity: from temporary to preserved data
  - Sharing: with yourself or a community
  - Dynamism: from static files to queriable databases

Databases

- Many kinds but relational most common
- Help structuring data, be consistent with datatypes
- Flexible data retrieval with declarative language (SQL)
- Access to data from programming languages (Python, R, Java, ...)
- Processing of large data quantities
- Access management and security
- Backup and replication

Databases

```
create table data (
  id integer primary key,
  time timestamp,
  latitude double precision,
  longitude double precision,
  temperature double precision
)
```

Databases

```
insert into data values(
  1,
  timestamp '2016-07-26 00:00:00',
  -70.650000,
  -8.250000,
  -19.3
)
```

Databases

```
select
  id, time, latitude, longitude, temperature
from data

select * from data where temperature < -15
```

```
  id |        time         | latitude | longitude | temperature
----+---------------------+----------+-----------+-------------
   1 | 2016-07-26 00:00:00 |   -70.65 |     -8.25 |       -19.3
```

From Python

```
import pyodbc

con = pyodbc.connect(’DRIVER=...;SERVER=...;PORT=...;
                      DATABASE=...;UID=...;PWD=...’)
cur = con.cursor()

cur.execute(’select latitude, longitude, temperature
             from data where temperature < -15’)

for row in cur.fetchall():
print(’Latitute: {}; Longitude: {}; Temperature: {}’
      .format(row[0], row[1], row[2])

cur.close()
con.close()
```

Backup and Versioning

- Your (Word) manuscripts are data
- Backup your other data as you backup your manuscripts
- Avoid memory sticks as backup media
- Test your backup strategy: can you recover lost files?
- Make sure to version your data
- Including if you collaborate only with yourself
- Remote version control can act as backup

Take aways