o2r opening reproducible research

Publishing Reproducible Geoscientific Papers: Status quo, benefits, and opportunities

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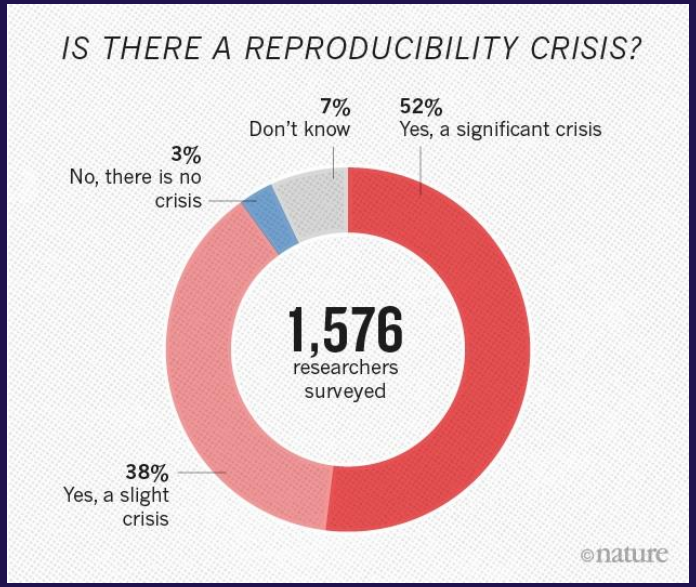
Open reproducible research

Reproducible research refers to achieving exactly the same results (e.g. tables, figures, numbers) as reported in the paper by using the same source code and data. In **Open reproducible research**, these materials are publicly accessible.

Replicable research refers to coming to similar conclusions based on newly collected data or a newly implemented analysis.

Replicability & reproducibility are essential for scientific work.

Konkol et al. (2017): Opening the publication process with executable research compendia. http://www.dlib.org/dlib/january17/nuest/01nuest.html



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Baker, M. (2016). 1,500 scientists lift the lid on reproducibility. *Nature News*, *533*(7604), 452.

Why is unreproducible research a problem?

- Difficult to find errors in the analysis
- Reviewers cannot verify but need to trust the results

  → Extra effort from authors and reviewers required
- Analysis not fully understandable
- Materials not reusable (sustainable)

Computational geosciences: papers based on code/data

- What is the status quo of open reproducible research in the computational geosciences?

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+ *Outlook*
+ *Open questions*

Agenda

- What is the status quo of open reproducible research in the computational geosciences?
- Which incentives are provided by open reproducible research beyond re-computable results?
- How can we assist geoscientists in publishing open reproducible research?
- How can we create interactive geoscientific papers to realize the incentives provided by ORR?

+ Outlook
+ Open questions

What is the status quo of ORR in the computational geosciences?

The status quo of ORR in the comp. geosciences

- 49% say they publish reproducible research results often or always

Konkol et al. (2018): Comp. reproducibility in geoscientific papers: Insights from a series of studies with geoscientists and a reproduction study. https://doi.org/10.1080/13658816.2018.1508687

https://www.smileybedeutung.com/whatsapp-smileys-bedeutung/liste-smileys-menschen-whatsapp

The status quo of ORR in the comp. geosciences

- 49% say they publish reproducible research results often or always

- 33% say their papers include links to datasets often or always

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The status quo of ORR in the comp. geosciences

- 49% say they publish reproducible research results often or always

- 33% say their papers include links to datasets often or always

- 12% say their papers include links to source code often or always

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The status quo of ORR in the comp. geosciences

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- 33% say their papers include links to datasets often or always

- 12% say their papers include links to source code often or always

- 7% say they try to reproduce others' results often or always

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The status quo of ORR in the comp. geosciences

Cultural issues

Obstacles while authors publish reproducible research:
e.g. no incentives for making code/data accessible, missing tools

Obstacles while readers reproduce others' work:
e.g. missing materials, too much effort

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Required changes in the scientific culture

- Better citation systems/acknowledgement for code/data
- Handling errors in papers: should not end a career
  - But: ERCs help to detect errors earlier (during review)
- “Leaving the comfort zone”: Just publishing PDF files without code and data was accepted but it is not enough

The status quo of ORR in the comp. geosciences

Technical issues

- Minor, e.g. when a library was not installed
- Substantial, e.g. a wrong file directory
- Severe, e.g. a flawed functionality
- Sys.-dependent, e.g. different software versions

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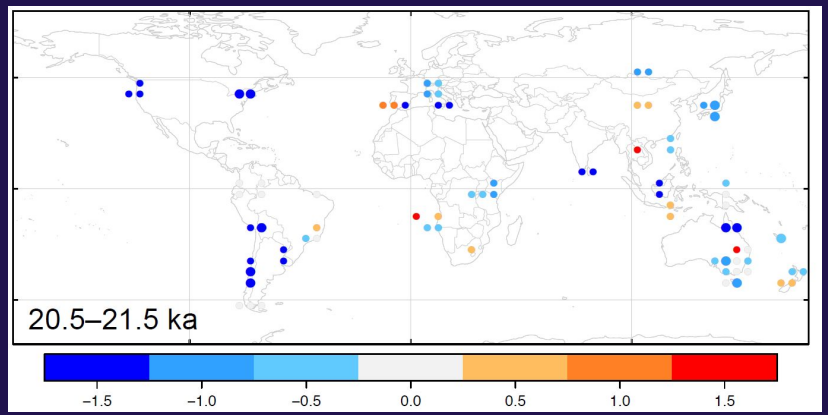

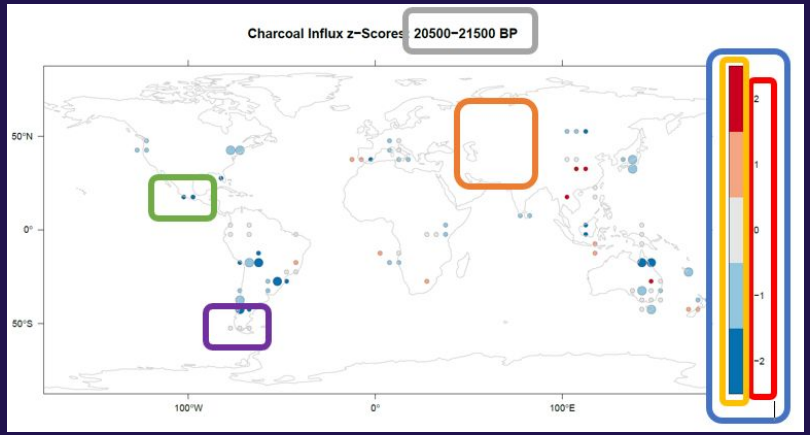

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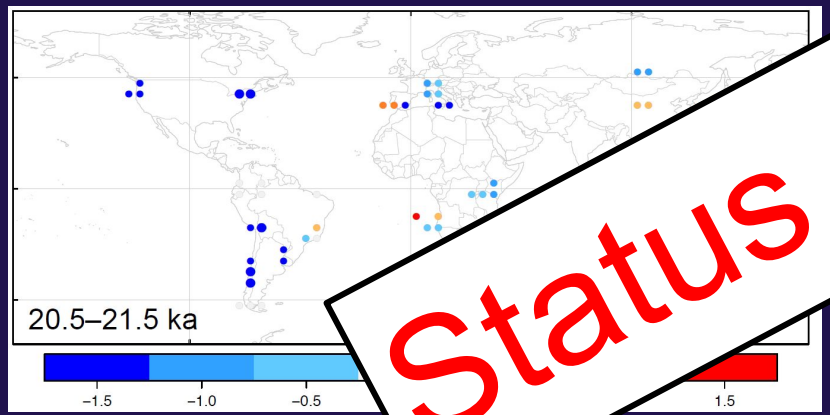
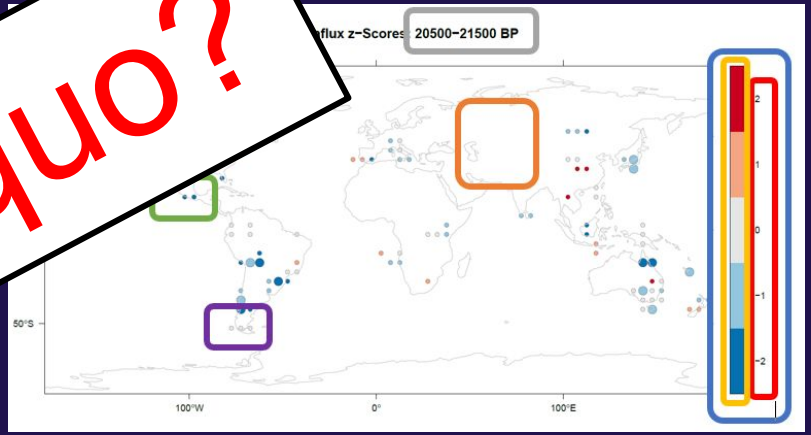


Status quo?



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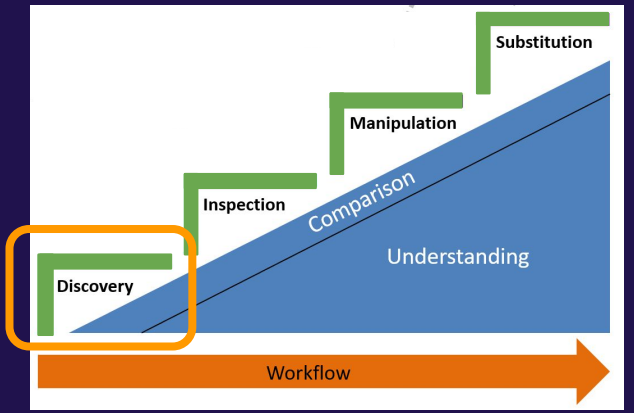
Which incentives are provided by open reproducible research beyond re-computable results?

Incentives for publishing ORR

ORR can help you to...

- ...make your research better findable



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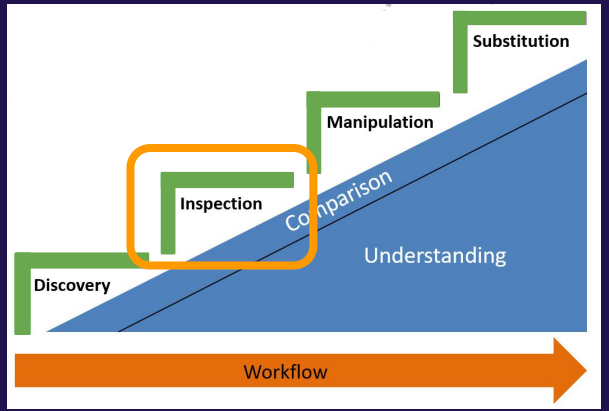

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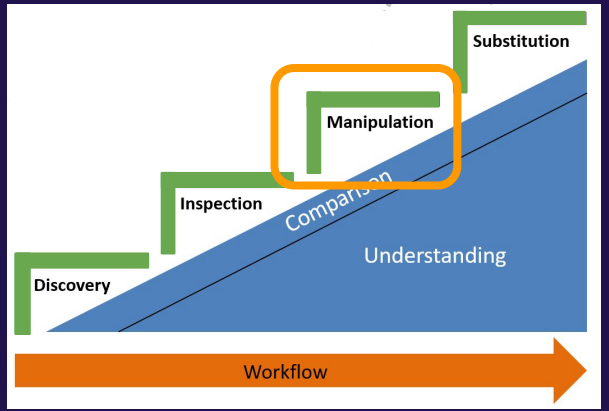

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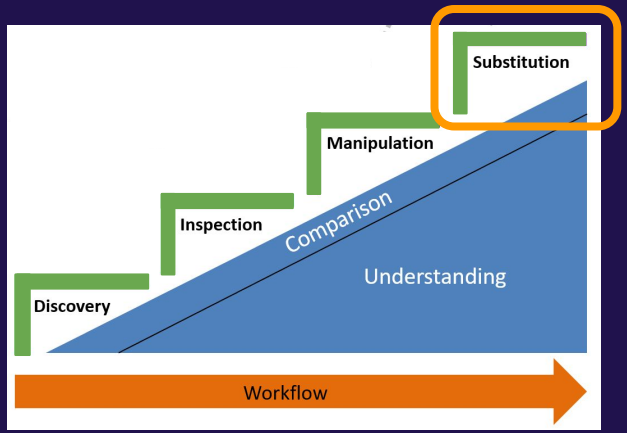
Incentives for publishing ORR

ORR can help you to...

- ...make your research better findable
- ...show reviewers how specific results were achieved
- ...create interactive figures for changing parameter values
- ...make your materials reusable (also for yourself)



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How can we assist geoscientists in publishing open reproducible research?

Assisting geoscientists in publishing ORR

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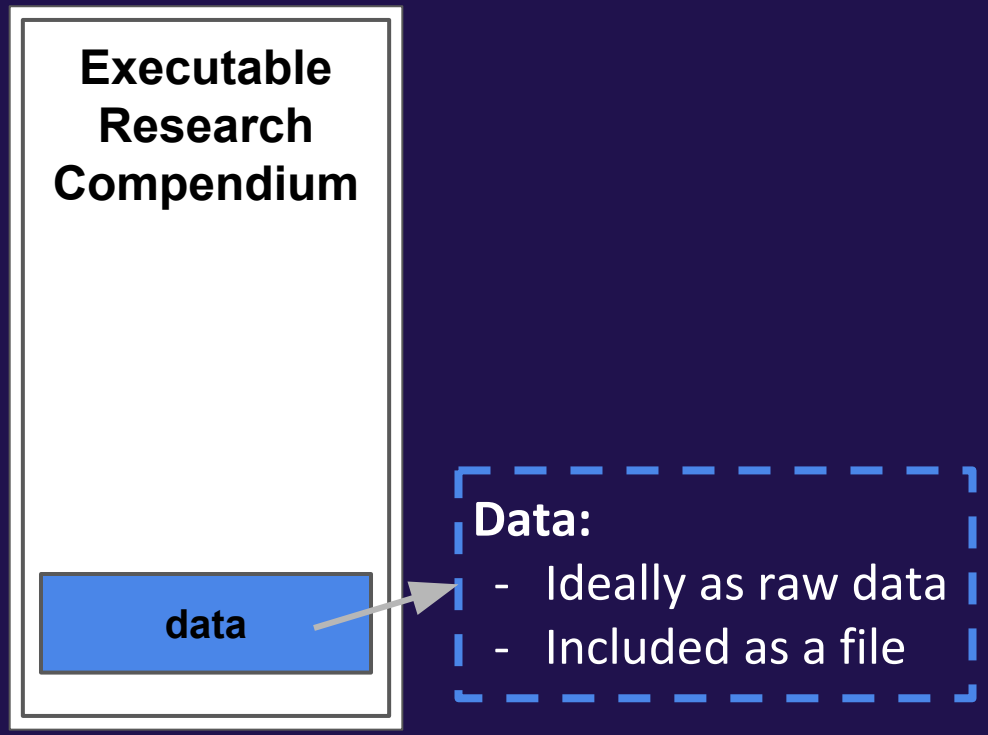

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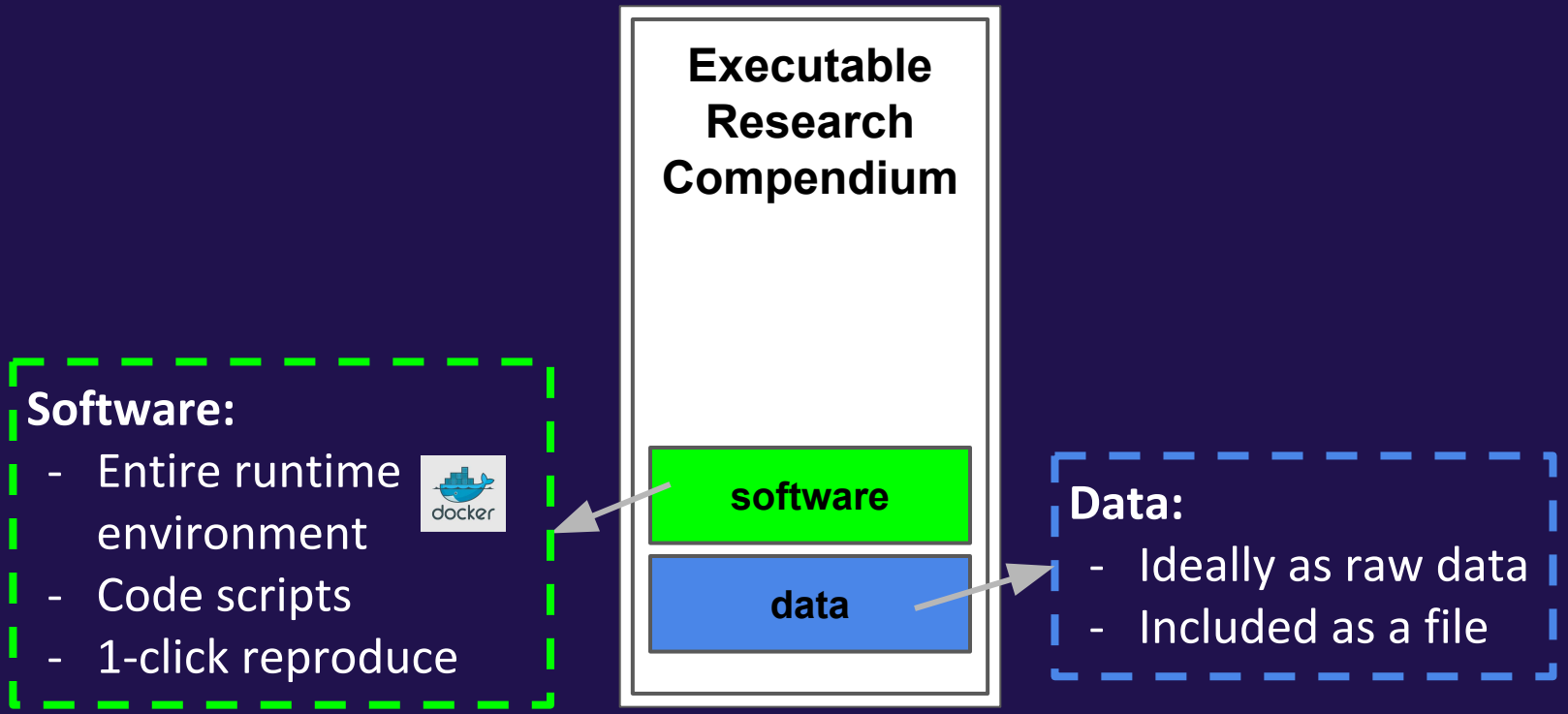

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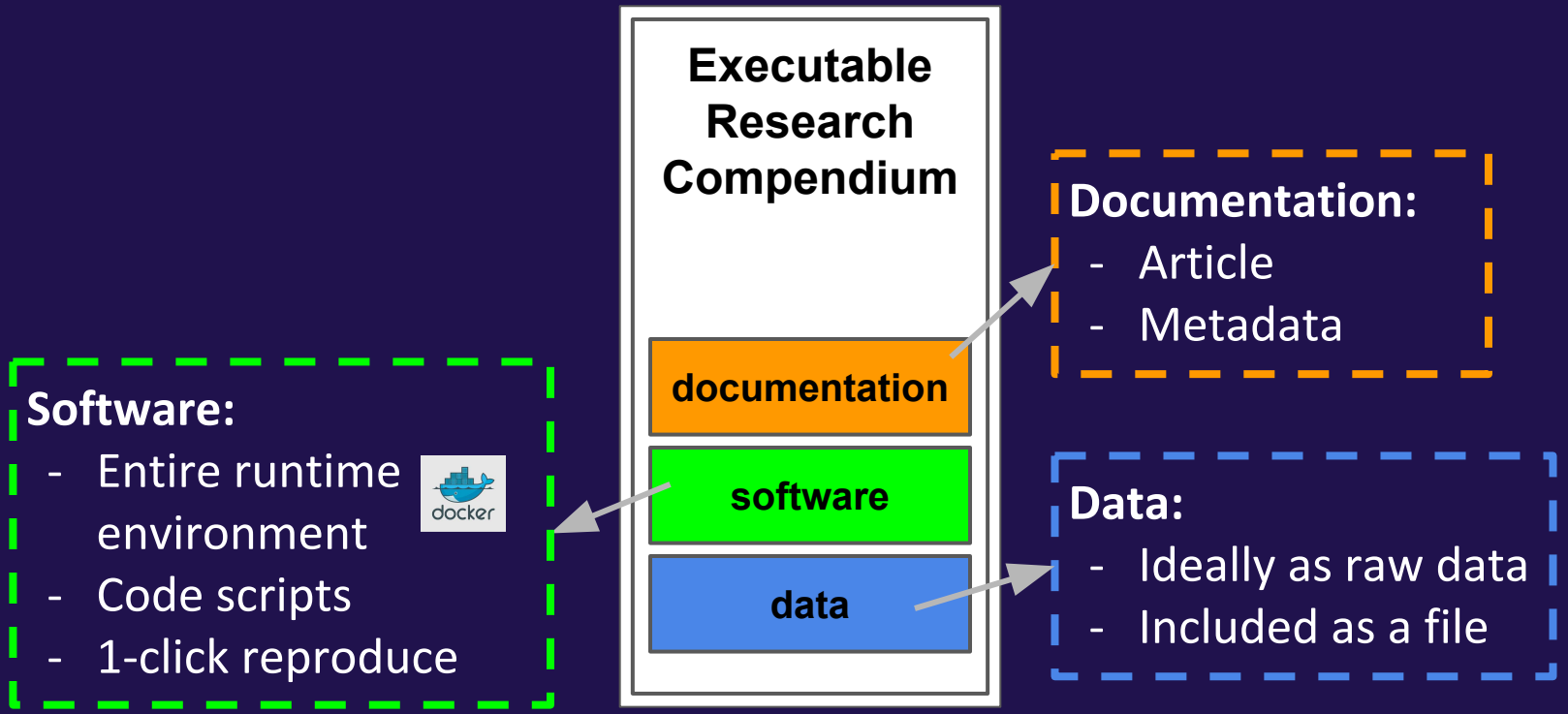

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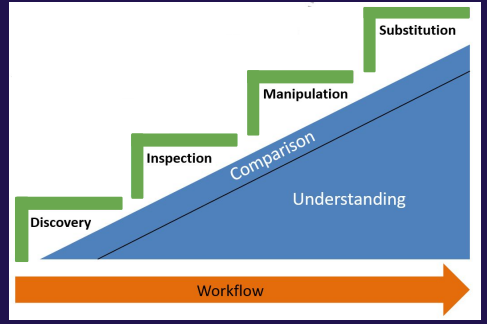

Software:

- Entire runtime environment
- Code scripts
- 1-click reproduce

Executable Research Compendium

- ?
- documentation
- software
- data

Documentation:

- Article
- Metadata

Data:

- Ideally as raw data
- Included as a file

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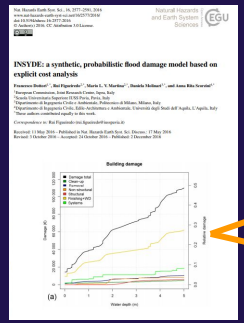
How can we create interactive geoscientific papers to realize the incentives provided by ORR?

Creating interactive scientific papers

Idea:
Connecting only those source code lines and data subsets that are needed to produce a specific computational result.



INSYDE: a synthetic, probabilistic flood damage model based on explicit cost analysis

Building damage

```
velocity = 2.0 #m/s
ComputeDamage <- function (velocity) {
        #do some analysis
        printFigure1()
}
```

Activity	Price	Volume
Pumping	2.5	m³
Disposal	35.0	m³
Cleaning	2.4	m³
dehumidification	5.0	m³

Konkol et al. (2019). Creating interactive scientific publications using bindings. https://doi.org/10.1145/3331158

Creating interactive scientific papers

A **binding** describes which source code lines and data subsets were used to produce an individual computational result, such as a figure, table, or number in the text.

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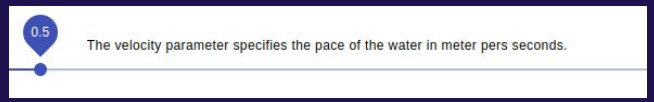

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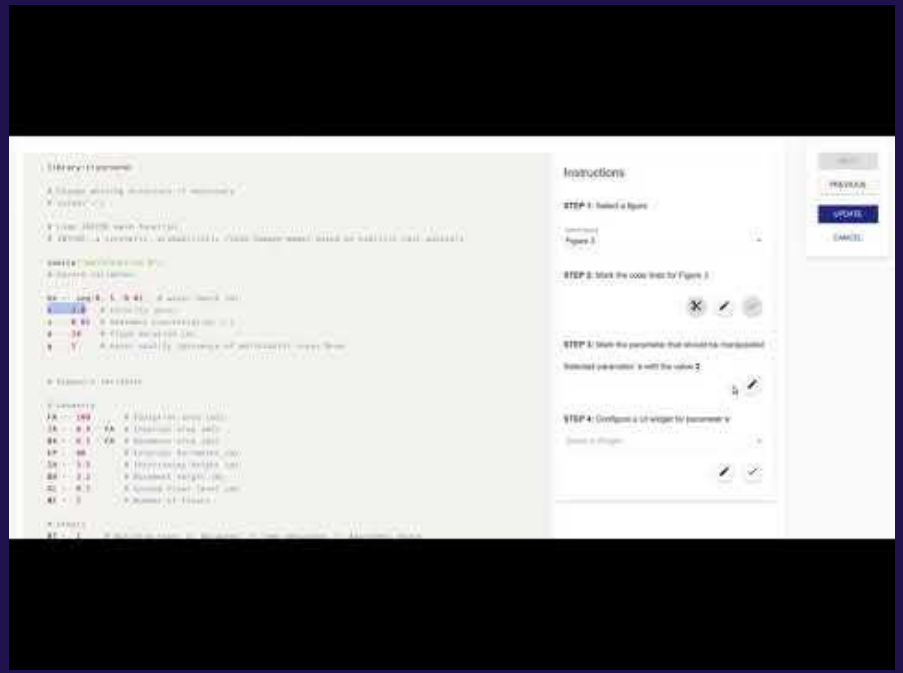
Creating interactive scientific papers (author's perspective)



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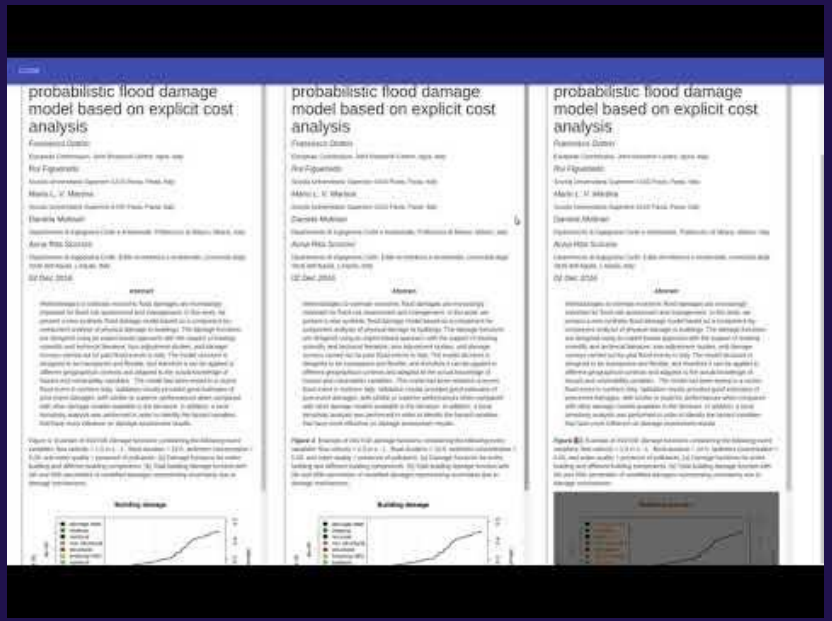
Using interactive scientific papers (reader's perspective)



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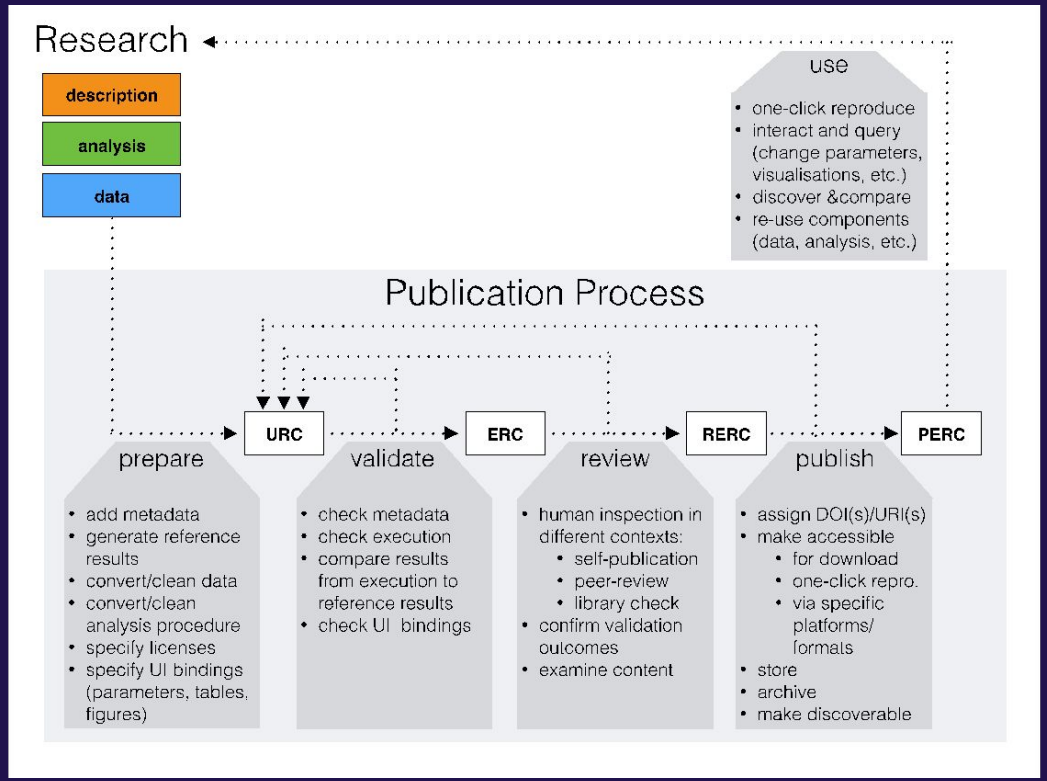
Publication process



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Outlook

Second phase:

- 2.5-year project, 2 RAs
- Collaboration between ULB, ifgi and publishers

Goal 1

- Pilot applications
  - collaboration with journals
  - implementation of UI and the repro. services
  - Self-hosted pilot
    - Open journal system plugin
    - Host OJS instance
    - ERC @ education

ELSEVIER

Copernicus Publications
The Innovative Open Access Publisher

ulb Münster

Outlook

Goal 2: Eliminate barriers

- creating bindings
- robust UI
- Update specification and documentation

Goal 3: Evaluation

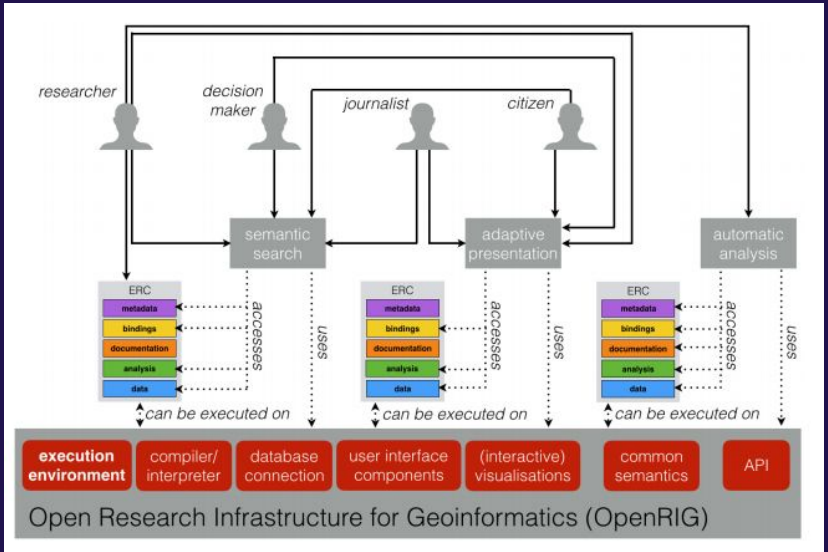
- technology: stress tests, monitoring
- user study about the understanding of ERCs

Beyond:

- reproducible infrastructure @ WWU
- “more geo” in schol. comm. platforms

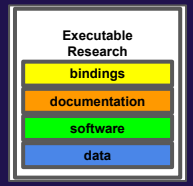
Open Research Infrastructure for Geoinformatics

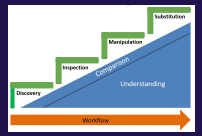
- Hub for ERCs
- Comparing ERCs
- Semantic search
- Harmonise figures across ERCs
- Adapt visualizations to needs of different stakeholders
- Combine parts of ERCs

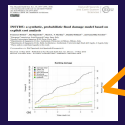


Kray, C., Pebesma, E., Konkol, M., & Nüst, D. (2019). Reproducible Research in Geoinformatics: Concepts, Challenges and Benefits (Vision Paper). In *14th International Conference on Spatial Information Theory (COSIT 2019)*. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.

5 Take-home messages in 30 seconds







```
ComputeDamage <- function(he, v, d, s, q,
  FA, IA, BA, EP, IH, BH, GL, NF, BT, BS,
  repVal, up, uncert, nrSim = NA) {
```

Activity	Price	Volume
Pumping	2.5	m³
Disposal	35.0	m³
Cleaning	2.4	m³
dehumidification	5.0	m³

Take-home messages

- Accessible code/data is not necessarily **reproducible**
- Incentives for publishing ORR outweigh the extra effort
- ERCs make research verifiable (one-click reproduce)
- Bindings help to understand how parameters affect results
- PDFs are not suitable for communicating (geo)scientific comp. research (particularly when published as ERCs)

Some take-home questions

Open questions

- How to handle biased data and code?
- How about privacy?
- Is more scientific output (papers) a desired goal?
- Does reproducibility lower the motivation for replicating data/code?