UE: Scientific Methods and Writing

856.111 / 651.902
Assoc.-Prof. Stefan LANG, & Hannah Augustin, MSc
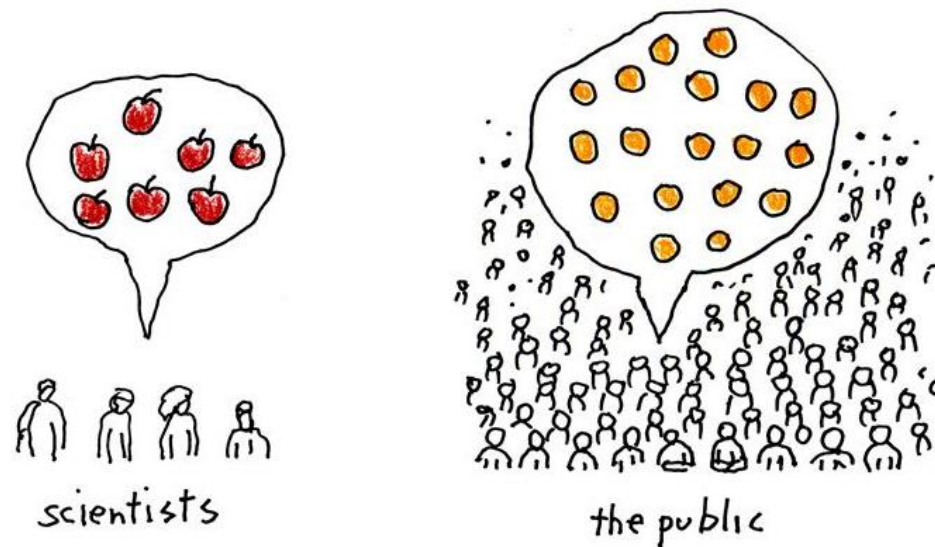
University of Salzburg
Department of Geoinformatics – Z_GIS

Z GIS

Scientific writing and reasoning
Lesson 08

science communication

scientists

the public

Open science

Truth & objectivity

Reasoning, logical fallacies

Open science

- *"Open science is a policy priority for the European Commission and the standard method of working under its research and innovation funding programmes as it improves the quality, efficiency and responsiveness of research."*

- European Open Science Cloud: multi-disciplinary environment to publish, find and reuse data, tools and services for research, innovation and educational purposes.

  - seamless access

  - FAIR (Findability, Accessibility, Interoperability and Reusability) management

  - reliable reuse of research data and all other digital objects produced along the research life cycle (e.g. methods, software and publications)

Open the door … remove the door

eosc

We Accelerate the Transition to Open Science;

https://ec.europa.eu/info/research-and-innovation/strategy/strategy-2020-2024/our-digital-future/open-science_en

Open science

- OpenEO Platform
  - intuitive programming libraries to process a wide variety of earth observation datasets
  - Open EO Editor: browser-based graphical user interface with progress graphs
  - large-scale data access and processing is performed on multiple infrastructures

- Pangeo
  - worldwide community for big data geoscience promoting open, reproducible, and scalable science, NumFOCUS sponsored
  - Pangeo deployment on EOSC features the European contributions to the community

openEO Platform

Pangeo Europe

PANGEO

NUMFOCUS
OPEN CODE = BETTER SCIENCE

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Reproducibility

- Advancing science and knowledge requires:
  - **openness**,
  - **transparency**,
  - **reproduction** and
  - **cumulative evidence** / common sense (reviews)

- Course by University of Jaume I: introduction to the main ideas and tools to acquire reproducible research practices
 - e.g., by creating **reproducible notebooks**

Reproducibility Research in the Geosciences

Links to concepts from the **EO4GEO Body of Knowledge** used in this course:

> GC | Geocomputation
  > **GC4 | Open Science**
> IP | Image processing and analysis
  > IP4 | Data quality
    > IP4-1 | Data quality standards
      > **IP4-1-6 | Replicability and reproducibility**

BoK Concept Chart

GC | IP

http://www.eo4geo.eu/training/reproducibility-research-in-the-geosciences/
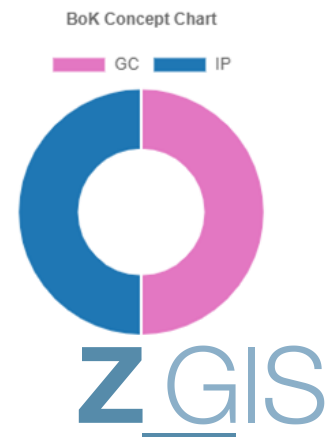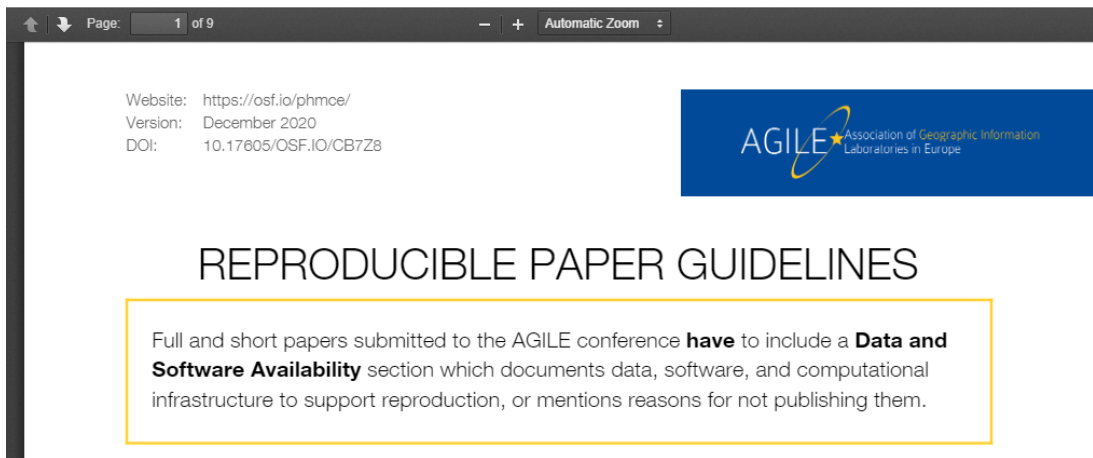
Reproducibility

- Reproducible papers @ AGILE conferences:
- Explicit criterion in paper reviewing process (monitored by Reproducible AGILE Team) ➜ Reproducibility review

15 Jul 2020
Integrating cellular automata and discrete global grid systems: a case study into wildfire modelling
Majid Hojati and Colin Robertson
AGILE GIScience Ser., 1, 6, https://doi.org/10.5194/agile-giss-1-6-2020, 2020

15 Jul 2020
What to do in the Meantime: A Service Coverage Analysis for Parked Autonomous Vehicles
Steffen Illium, Philipp Andreas Friese, Robert Müller, and Sebastian Feld
AGILE GIScience Ser., 1, 7, https://doi.org/10.5194/agile-giss-1-7-2020, 2020

15 Jul 2020
Spatial Data Lake for Smart Cities: From Design to Implementation
Rodrique Kafando, Rémy Decoupes, Lucile Sautot, and Maguelonne Teisseire
AGILE GIScience Ser., 1, 8, https://doi.org/10.5194/agile-giss-1-8-2020, 2020

15 Jul 2020
Extraction of The Spatio-temporal Activity Patterns Using Laser-scanner Trajectory Data
Hiroyuki Kaneko and Toshihiro Osaragi
AGILE GIScience Ser., 1, 9, https://doi.org/10.5194/agile-giss-1-9-2020, 2020

Compliance to reproducibility criteria

https://reproducible-agile.github.io/

What is truth?

"An inconvenient truth"

- Al Gore: first awareness on global warming

- Addressing society, in particular **youth** "*who have no choice but to confront the planetary emergency head-on*"

- Founder of the vision of a "Digital Earth"

- => ISDE

International Society for Digital Earth
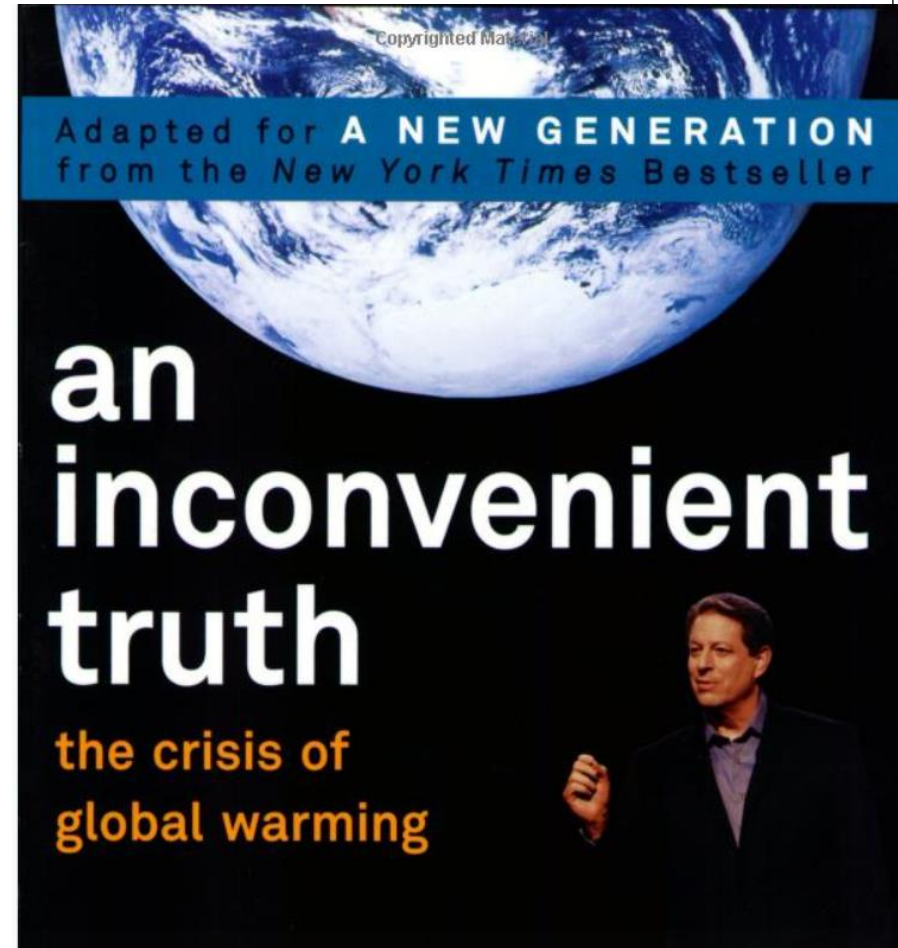
"An inconvenient truth" ➔ getting active

To mitigate adverse effects of climate change, you need to do something about it on local level

Fridays / Scientists For Future 27 Sept 2019

Photo: S Lang

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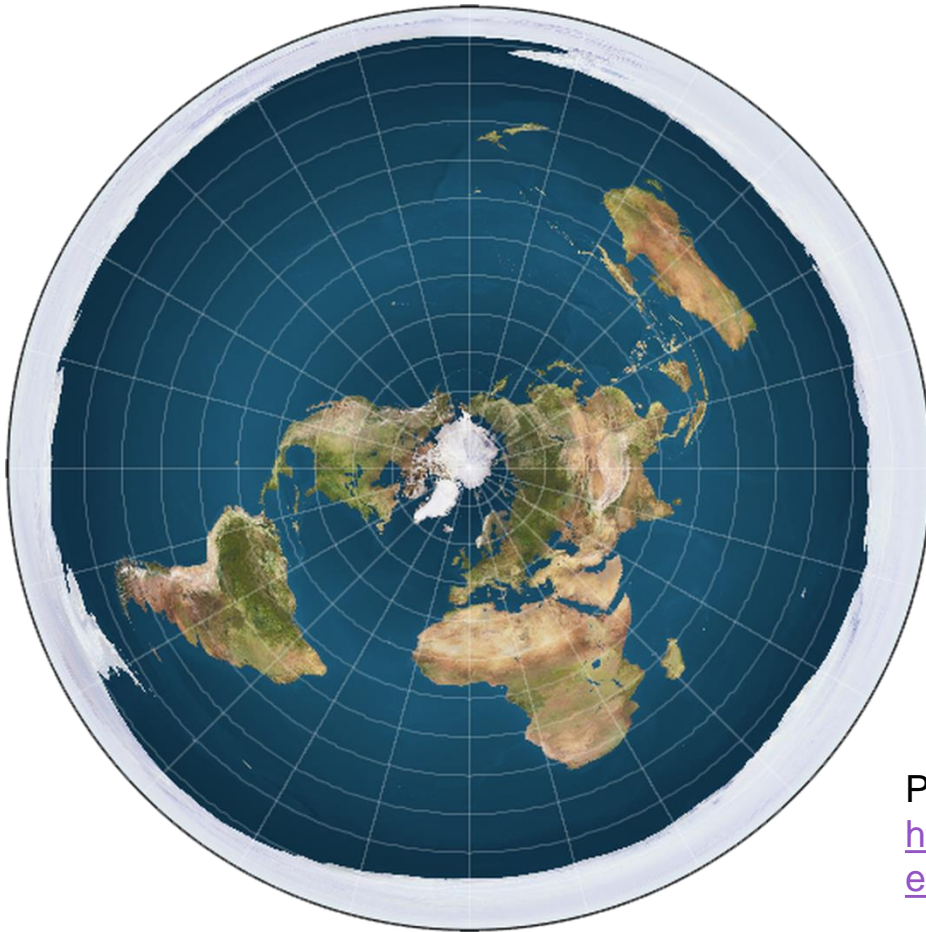# Elaborating, chain of arguments

To mitigate adverse effects of climate change, you need to do something about it on local level

- As a politician you can **claim** and (re-)**affirm 'truth'**
  - = the belief system of the party you are representing
- As a scientist, you'd need to **elaborate**, in a **chain of arguments**
  - A complete halt (or even reverse) of CC is unlikely considering the measures currently being discussed. The question arises how we can minimize and mitigate adverse effects
  - Recent research findings suggest we can cope with CC by adaptation strategies
  - It has been shown that these are effective on community level
  - Currently (to the best of my/our knowledge) there are no CC adaptation strategies on community level implemented in …

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Challenging the truth

- Flat Earth Theory

http://www.sueddeutsche.de/panorama/flat-earth-theory-der-mann-der-beweisen-will-dass-die-erde-eine-scheibe-ist-1.3772817

https://www.washingtonpost.com/

Podcast:
https://www.scientificamerican.com/podcast/episode/flat-earthers-what-they-believe-and-why/

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Challenging the truth
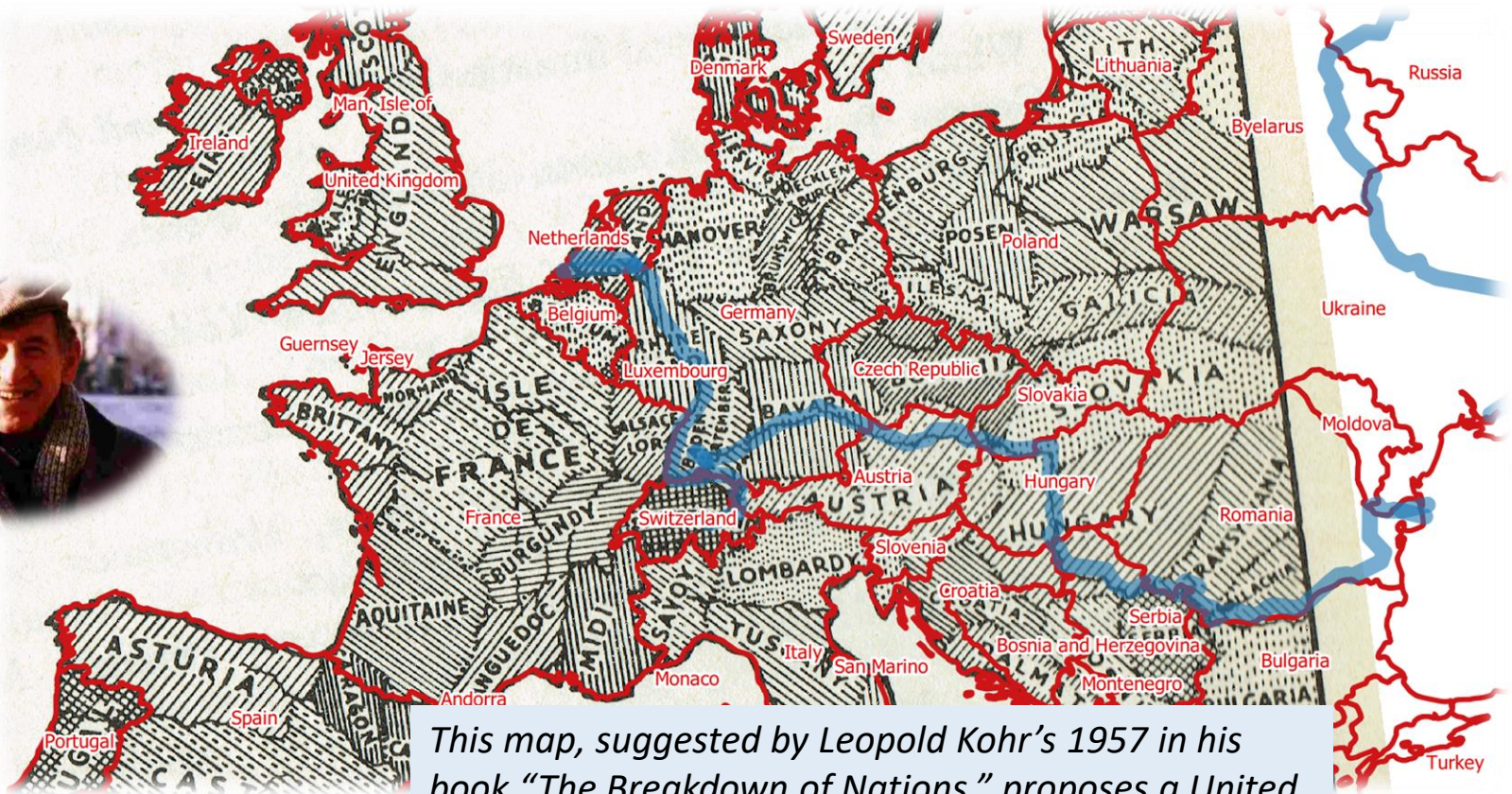
This map, suggested by Leopold Kohr's 1957 in his book "The Breakdown of Nations," proposes a United States of Europe in which the continent is broken into small, similarly sized regions, along cultural or existing political boundaries, that are too small on their own to cause any harm.

https://maptitude1.tumblr.com

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Towards European degrees?
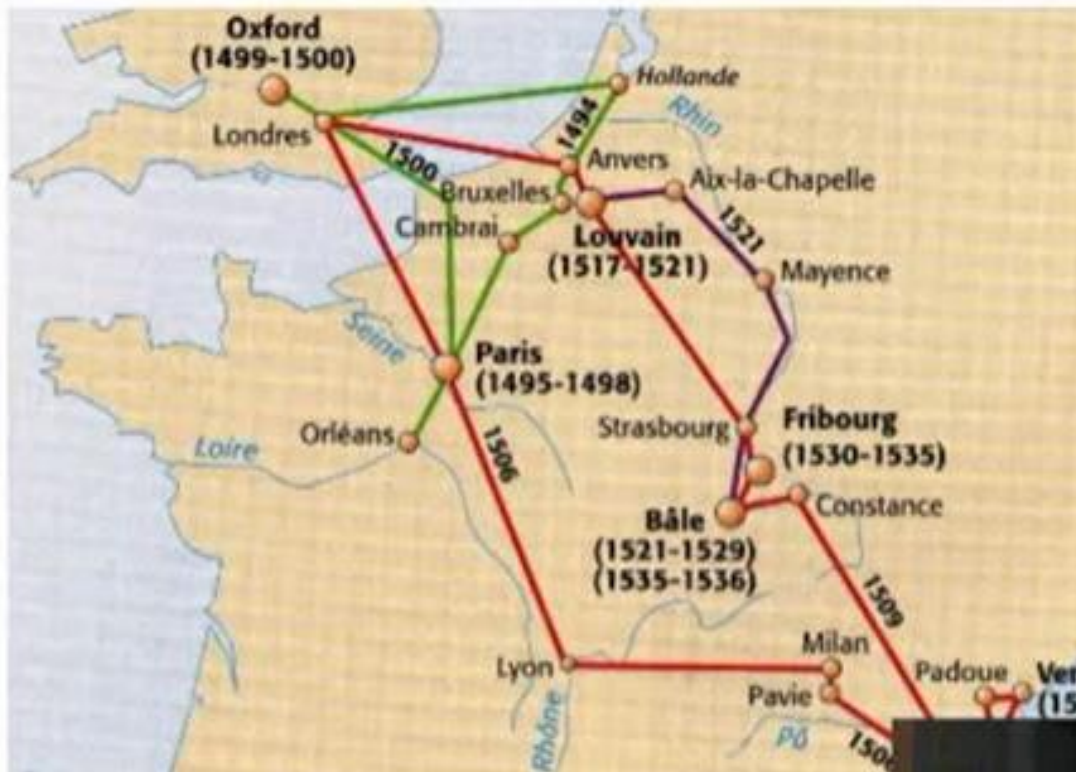
Academic mobility (Erasmus' travels)

P Magnette

Europe around the year 1500
What changed … what remained?

Explaining

- **Explaining** is a key objective of scientific writing
  - *What is it (for)? How does is work? Why was it worth doing it? How did you do it? What do you conclude?*
  - Consider needs and interest of readers, and balance with your own motivation
  - Explain, if possible, correlations ➔ causality
- **Clarity**
  - Required in each step of scientific thinking, i.e.
  - Statement of problem, formulating hypotheses or research questions, carrying out investigations, presenting results.

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Can everything be explained?

Covid-19 pandemic

Explain
Virology, immunology
Statistics, simulation
Cause-effect relationships

"Why?"

War in the Ukraine

Comprehend
Cultural science
Linguistics, Slavistics
Political sciences

Climate change

Explain + comprehend +?
(Highly interdisciplinary approach required)

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Objectivity and impartiality

- *Scientific findings often challenge the **common belief**, thus:*
- Statements should be objective (based on evidence), not subjective (based on imagination, or unsupported opinion)
  - Words like *possible*, *probably*, etc. indicate insufficient reasoning or evidence
- Opinions (not even from authorities) are not facts
- Any assumptions or limitations of your work
  - Words like *obviously*, *surely*, *of course*
- Not leaving anything for speculation
  - E.g. details on data acquisition (including time, conditions, etc.)
- Range of validity of conclusions
- Not being biased by preconceived ideas
  - sometimes difficult, e.g. consider climate change
- Not omitting any evidence that could challenge or contradict hypothesis

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Order and accuracy

- Order and structure
  - See (session #2), IMRaD

- Accuracy

- Care in observation, recording, analysing & **precision** in measurement
  - Or: sufficient awareness about it and declaration of limitations (e.g. when using remote sensing data)

- **Repeatability**, transparency and verifiability
  - Every investigation should be repeatable (comprehensive description including software etc.)
  - Every conclusion must be verifiable

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Reasoning

- Completeness in reasoning
  - Comprehensive treatment of subject (depending on type of work)
  - No gaps in argument, no omissions ➔ chain of arguments
  - 'water proof' reasoning

Evidence has shown …　　　　*That means …*

| Line of argument 1 | Conclusion 1 |

Therefore … Line of argument 2 — Conclusion 2

…

Line of argument *n* — Conclusion *n*

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Reasoning

- Logical reasoning
  - Readers should be convinced by **logical argument**
    - rather than by **repetition**, **exaggeration** or **over-/understatements** or any other 'literary' style, such as:
    - **anthropomorphisms** (treating things as humans): *the experiment suggests*, *data point to the fact*, *from the perspective of the studied landscape* …
    - **teleological** expressions - activity or process is described as if it were a goal (quite common in scientific writing though). Such expressions imply an explanation already and obscure the need for logical treatment. *The slope has terraces for rice cultivation*, *Open source GIS are freely available for volunteered geographic information*.
  - Simplicity (observing **Ockhams' Razor***)

*William of Ockham, theologist, 14th century: don't multiply entities, don't think more complicated as necessary

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Simplicity

- Ockhams' Razor
  - Theologist (14th century): don't multiply entities, don't think more complicated as necessary
- Gestalt theorem (Wertheimer 1925)
  - Principle of good gestalt
  - Simple forms are more readily perceived
  - Simple, yet plausible, explanations are usually preferred over more complex ones
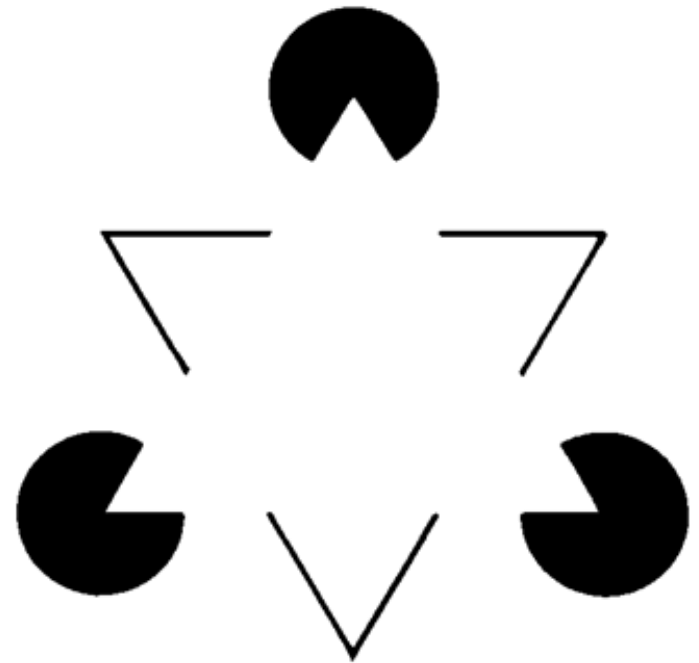
Deductive reasoning

- Deduction ('top-down' explanation)
  - Reasoning from one or several statements (**premises**) to reach a **conclusion**
  - Links premises with conclusions by **logical certainty** ('water-proof', see above)
  - If all premises are true, and the rules of deductive logic are followed, then the conclusion is **necessarily true**

Premise A
"All birds have wings"

Premise B
"Niki has wings"

Conclusion
"Niki is a bird"

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Deductive reasoning

- Deductive **fallacy**
  - A conclusion that is based on an **invalid** argument
  - Even with a set of true premises, the conclusion can be wrong (interruption of logical process)
  - E.g. consider the previous invalid statement
    - For some x, P(x) applies.
    - For some x, Q(x).
    - Therefore for x, P(x) and Q(x) apply

    "All birds have wings"
    "The plane has wings"
    "The plane is a bird"

  - **'All'- statements**: can easily be falsified, especially if unsupported (and you hardly find references that support 'all'-statements unanimously!), plus they are usually not required

Required?

"All plant species have different habitat criteria that need to be met in order for the species to be able to grow in a certain location."

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Inference

- Inference
  - From **premises** to **conclusions** (logical, statistical, etc.)
  - More than **explanation**
- If **A** applies, then **B**
  - e.g. facts, value ranges

Index	Spectral Categories	Spectral Rule (based on reflectance measured at Landsat TM central wave bands: b1 is located at 0.48 μm, b2 at 0.56 μm, b3 at 0.66 μm, b4 at 0.83 μm, b5 at 1.6 μm, b7 at 2.2 μm)	Pseudo-color
1	Snow/ice	$b4/b3 \leq 1.3$ AND $b3 \geq 0.2$ AND $b5 \leq 0.12$	
2	Cloud	$b4 \geq 0.25$ AND $0.85 \leq b1/b4 \leq 1.15$ AND $b4/b5 \geq 0.9$ AND $b5 \geq 0.2$	
3	Bright bare soil / sand / cloud	$b4 \geq 0.15$ AND $1.3 \leq b4/b3 \leq 3.0$	
4	Dark bare soil	$b4 \geq 0.15$ AND $1.3 \leq b4/b3 \leq 3.0$ AND $b2 \leq 0.10$	
5	Average vegetation	$b4/b3 \geq 3.0$ AND ($b2/b3 \geq 0.8$ OR $b3 \leq 0.15$) AND $0.28 \leq b4 \leq 0.45$	
6	Bright vegetation	$b4/b3 \geq 3.0$ AND ($b2/b3 \geq 0.8$ OR $b3 \leq 0.15$) AND $b4 \geq 0.45$	
7	Dark vegetation	$b4/b3 \geq 3.0$ AND ($b2/b3 \geq 0.8$ OR $b3 \leq 0.15$) AND $b3 \leq 0.08$ AND $b4 \leq 0.28$	
8	Yellow vegetation	$b4/b3 \geq 2.0$ AND $b2 \geq b3$ AND $b3 \geq 8.0$ AND $b4/b5 \geq 1.5$ [a]	
9	Mix of vegetation / soil	$2.0 \leq b4/b3 \leq 3.0$ AND $0.05 \leq b3 \leq 0.15$ AND $b4 \geq 0.15$	
10	Asphalt / dark sand	$b4/b3 \leq 1.6$ AND $0.05 \leq b3 \leq 0.20$ AND $0.05 \leq b4 \leq 0.20$[a] AND $0.05 \leq b5 \leq 0.25$ AND $b5/b4 \geq 0.7$[a]	
11	Sand / bare soil /	$b4/b3 \leq 2.0$ AND $b4 \geq 0.15$ AND $b5 \geq 0.15$[a]	

OBSERVATION VS. INFERENCE

OBSERVATIONS
- That plant is extremely wilted.
- The car stopped running.

INFERENCES
- That plant is extremely wilted due to a lack of water.
- The car stopped running because it was out of gas.
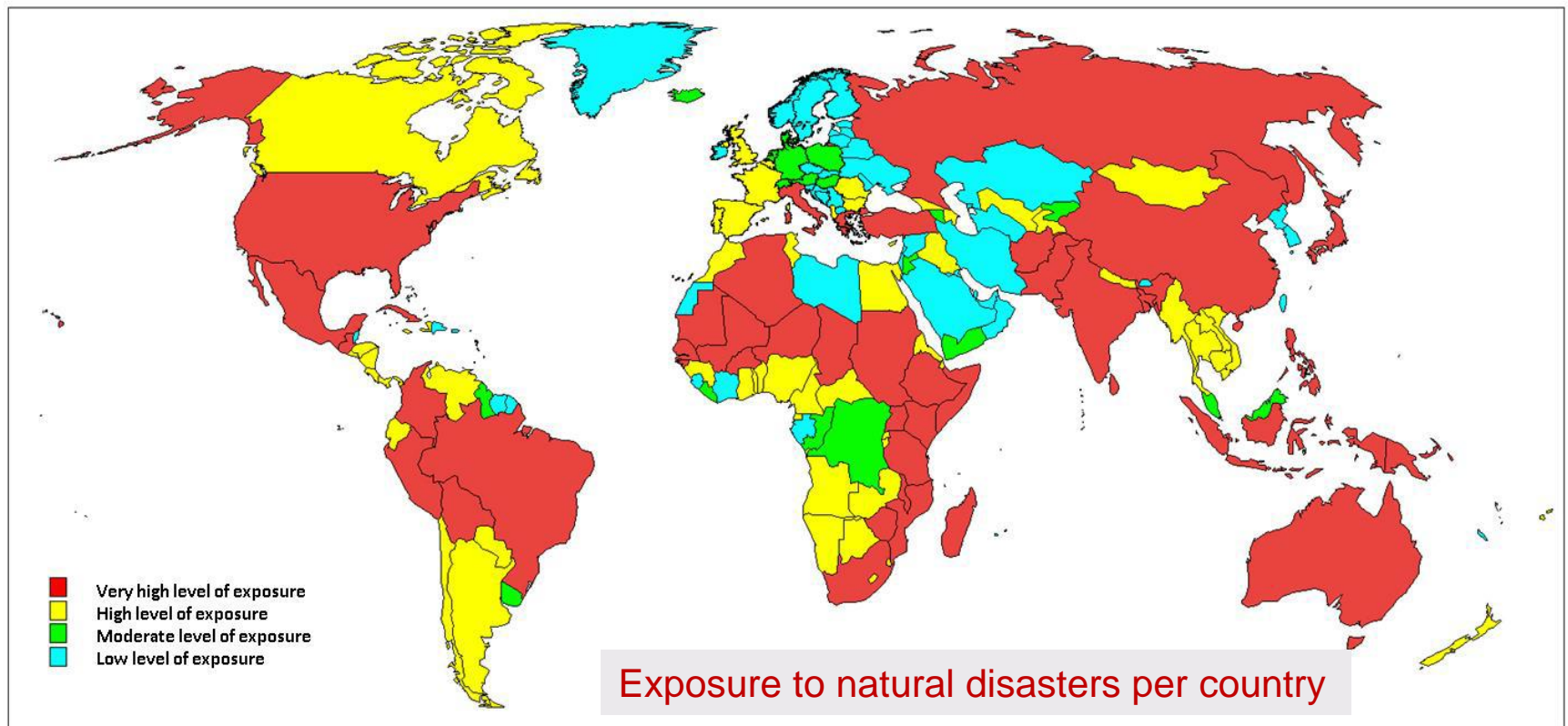
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Inductive reasoning

- Induction ('bottom-up' explanation)
  - Inherently **uncertain** (thereby not necessarily 'worse' or even wrong!)
  - Conclusion is based on evidence and (inductive) probabilities, and is – at best – credible
  - E.g. Probabilistic modelling
  - Suggesting truth, but not ensuring it
  - Based on generalization

"Most birds can fly. Discovering a new bird, I can assume this bird can fly"(➔ how do I know this is a bird? – issue of categorization)
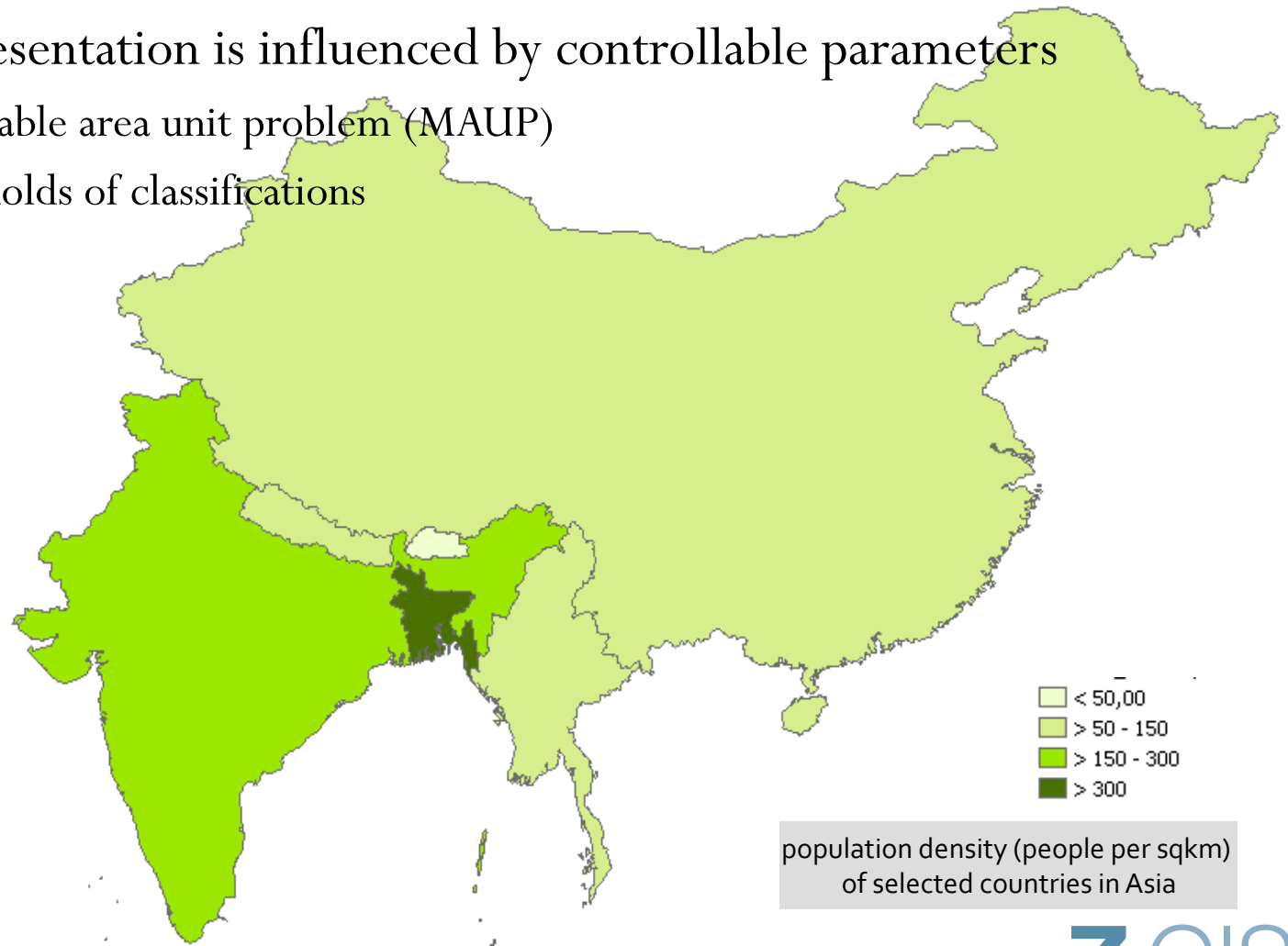
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Ecological fallacy

- "*An ecological fallacy (or ecological inference fallacy) is a logical fallacy in the interpretation of statistical data where inferences about the nature of individuals are deduced from inference for the group to which those individuals belong*" [Wikipedia]

Gilles 2012

Very high level of exposure
High level of exposure
Moderate level of exposure
Low level of exposure

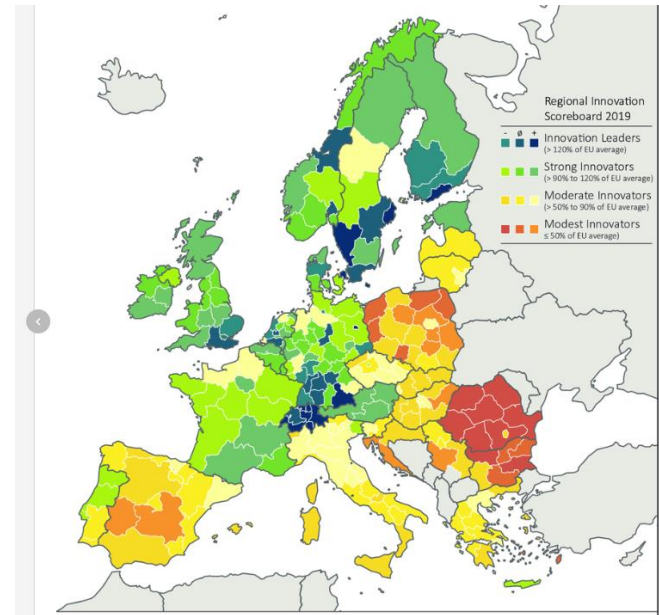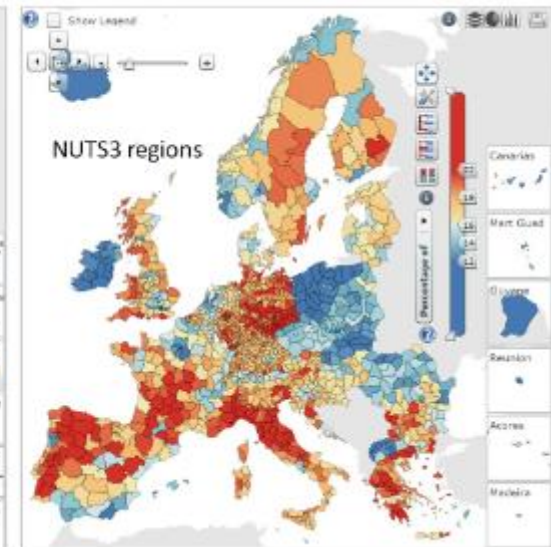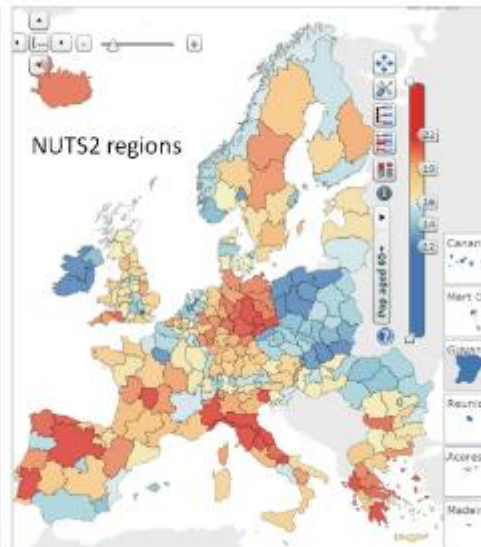Exposure to natural disasters per country

Ecological fallacy
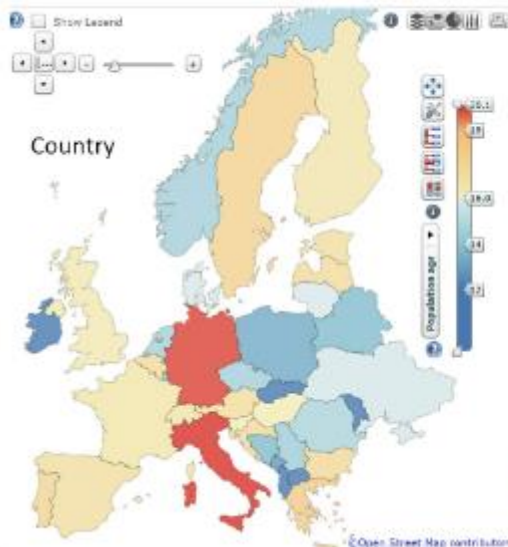
- Data presentation is influenced by controllable parameters
  - Modifiable area unit problem (MAUP)
  - Thresholds of classifications

population density (people per sqkm) of selected countries in Asia

- < 50,00
- > 50 - 150
- > 150 - 300
- > 300

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Ecological fallacy

Europe eXplorer "ageing population 65+

Z_GIS University of Salzburg | LANG & AUGUSTIN

A quote at last

- "*We shall not cease from exploration and the end of all our exploring will be to arrive where we started and know the place for the first time*" (T.S. Elliot)

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