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Lexcube: An Interactive Earth Science Data Cube Visualization

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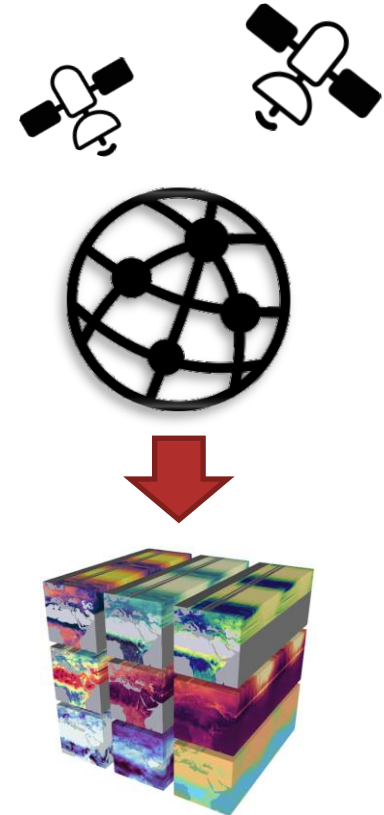
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RESEARCH PROBLEM

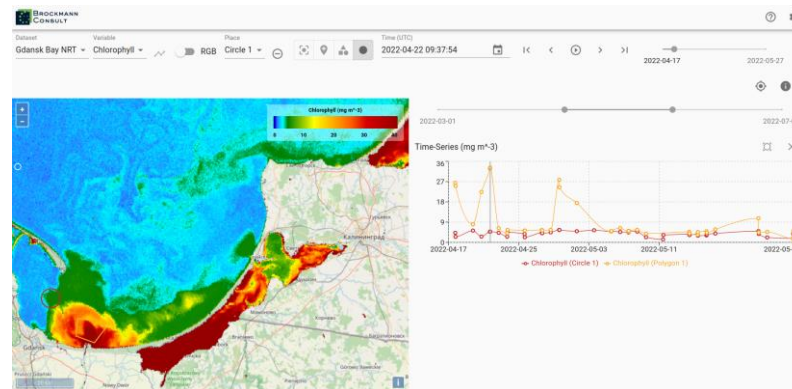
- The Earth is constantly monitored and analyzed via satellite remote sensing [1]
- With increasing spatiotemporal resolutions, data set sizes are increasing
 - It becomes more difficult to explore the data and extract knowledge, e.g., about the anthropogenic interventions on the ecosystems [2]
- Earth system data cube concept proposes gridding and integration of data sets, increasing interoperability [3]



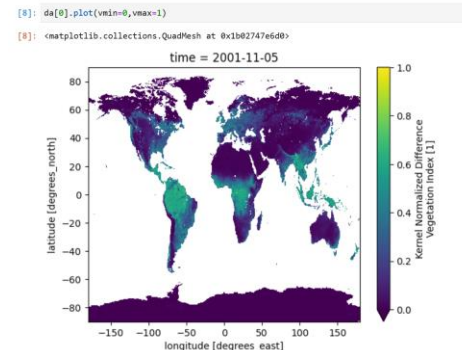


RELATED WORK

- Existing visualization packages are powerful, however they:
 - Are usually limited to 2D plotting
 - Do not work on large data sets (100s of GBs) or only with noticeable latency
 - Sometimes have complex (user) interfaces that can be overwhelming
 - Do not work natively on mobile devices, e.g., for field work



⬆ Figure: A 2D map in **xcube-viewer** [4].



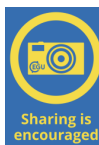
⬅ Figure: A 2D plot generated using **matplotlib** [5] in a Jupyter notebook.



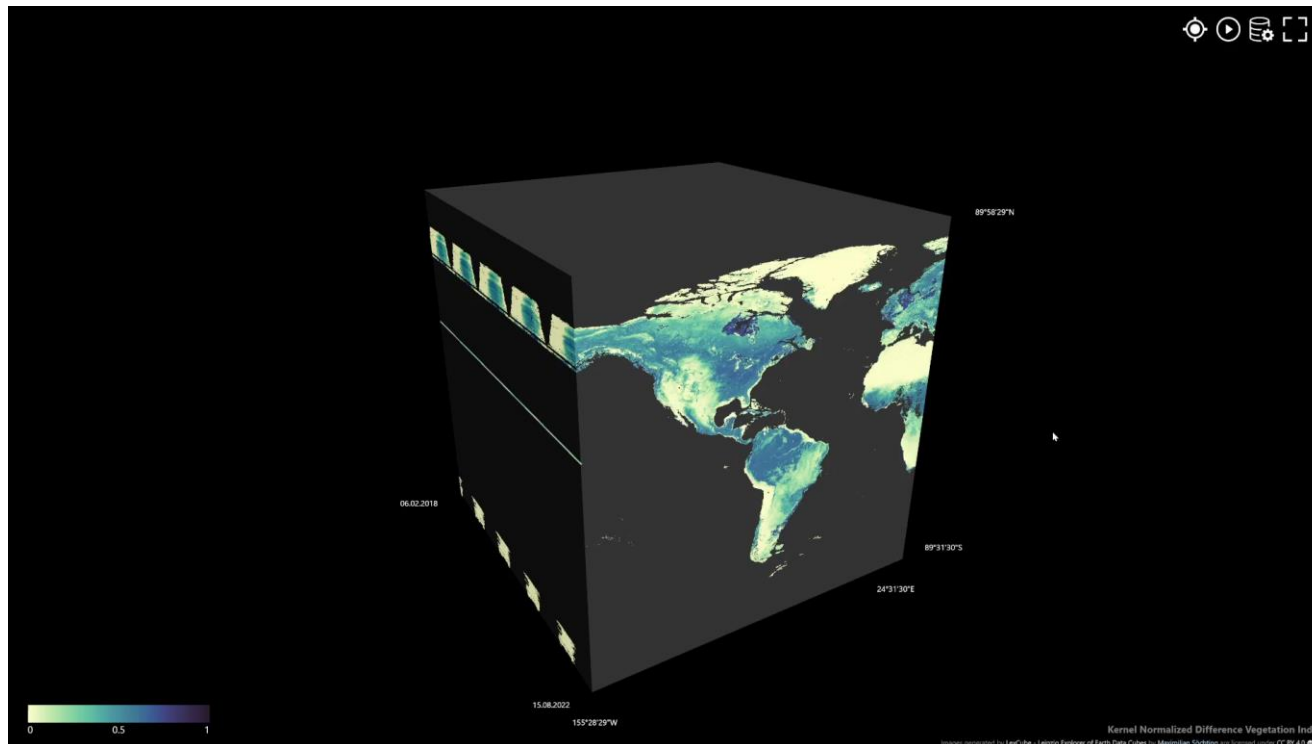
Lexcube – CONCEPT

- Interactive 3D earth science **data cube** visualization
- Works with data sets of **hundreds of gigabytes** with low latency (<1s)
- **Intuitive UI** – click/touch and drag anywhere, minimal menus
- **Native mobile device support** with GPS tracking and touch controls





DEMO



Data visualized: kNDVI based on global MODIS data (2018 – 2022), 2.2 TB

Try it yourself!

Works on phones,
laptops and tablets.



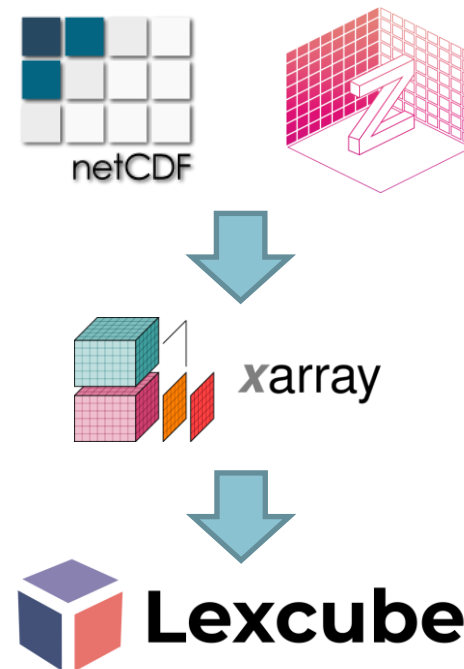
lexcube.org





OPEN-SOURCE TECHNOLOGY

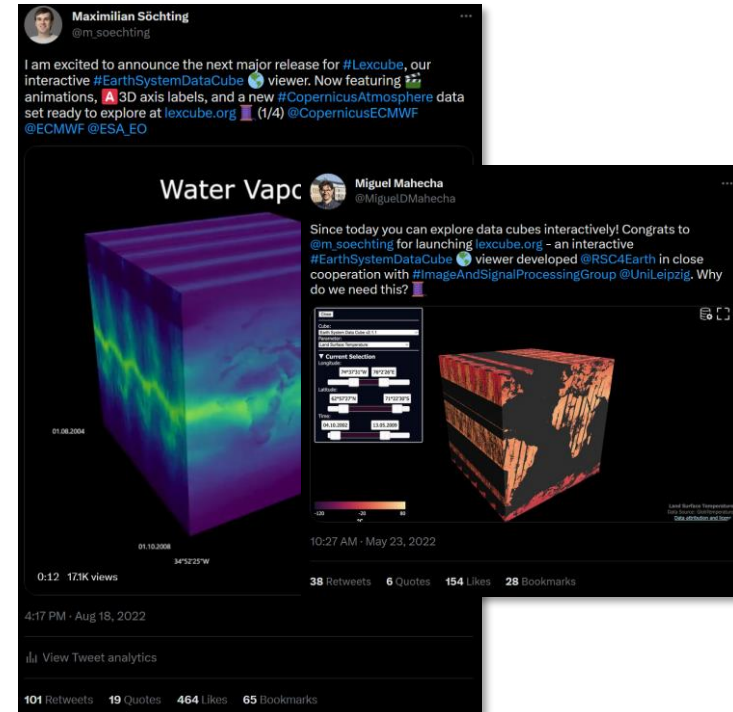
- Lexcube is built in a client-server architecture:
 - TypeScript (JavaScript) client using Three.js
 - Python server using FastAPI and Xarray [4]
 - Transferred data is tiled and compressed using ZFP [5]
 - Client-server data exchange using REST and Websockets
- Integration into existing data cube ecosystem – works with any gridded Zarr or NetCDF file





OUTREACH & IMPACT

- 2,800 users and 163,000 API requests on lexcube.org since public release in May 2022
- 774 likes, 205 retweets and 21,000 video views on Twitter over three tweets
- Great qualitative feedback from various domain experts
 - *“Fantastic tool! Looking forward to investigate extremes case studies [with Lexcube]!”* (Sebastian Sippel, Climate and Earth System Scientist at ETH Zurich)



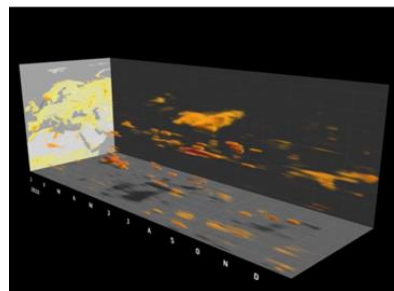
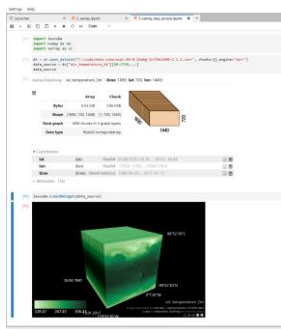


FUTURE WORK

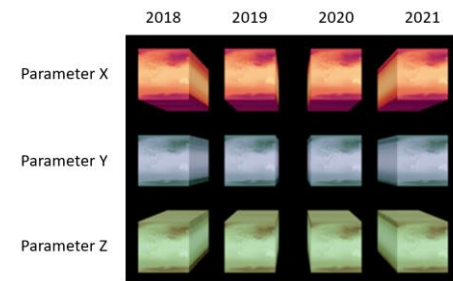
1. Jupyter notebook integration & open-source release
 - Visualize any 3D array in a very accessible way, right in the notebook

→ within the next months

2. 3D volume visualization
 - Explore the “insides” of the cube
3. Multi-cube visualization
 - E.g. 2D grid of mini-cubes



Video Source: [ESA](#)





LITERATURE

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- [4] Xcube-viewer: <https://github.com/dcs4cop/xcube-viewer>
- [5] Matplotlib: <https://matplotlib.org/>
- [6] E. Hovmöller. The trough-and-ridge diagram. *Tellus*, 1(2):62–66, 1949. doi: 10.1111/j.2153-3490.1949.tb01260.
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