Leibniz Institute of
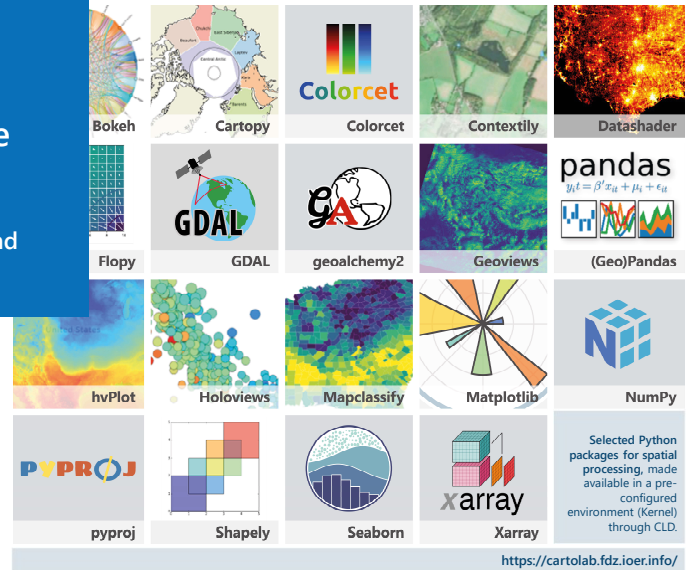Ecological Urban and
Regional Development

IOER RDC Carto-Lab Docker

An RDM Infrastructure for Transparent, Open, and Reproducible Spatial Data Science

Alexander Dunkel, Marc Löchner, Dirk Burghardt, Maria Nieswand

Spatial data science faces significant RDM hurdles: complex software dependencies ("dependency hell"), ensuring long-term computational reproducibility, and facilitating collaborative, transparent research. Carto-Lab Docker (CLD) is a practical RDM infrastructure designed as a FAIR-enabling environment. It provides a versioned, pre-configured Docker container running JupyterLab to empower researchers and streamline workflows from analysis to publication.

Bokeh	Cartopy	Colorcet	Contextily	Datashader
Flopy	GDAL	geoalchemy2	Geoviews	(Geo)Pandas
hvPlot	Holoviews	Mapclassify	Matplotlib	NumPy
pyproj	Shapely	Seaborn	Xarray	Selected Python packages for spatial processing, made available in a pre-configured environment (Kernel) through CLD.

https://cartolab.fdz.ioer.info/

Our Approach: A Three-Pillar RDM Infrastructure

Solving the Environment Problem.
CLD delivers a complete, versioned computational environment as a single Docker image.

Guaranteed Reproducibility

- **Versioned Images:** Pull specific CLD versions (e.g., `v0.15.7`) to perfectly replicate the exact environment a project was created in, years later.
- **No More "Dependency Hell":** All spatial packages (GDAL, QGIS, GRASS, Mapnik) and their complex C-dependencies are pre-compiled and compatibility-tested.
- **Fast Environment Switching:** Two curated, pre-configured environments for Python and R, each packed with a compatible set of essential spatial libraries.

Enhanced Collaboration

Enabling Team Science.
CLD is built for collaborative workflows, from onboarding new colleagues to co-authoring complex analyses.

- **Live Collaboration:** Share interactive JupyterLab sessions via a secure link, allowing multiple users to code and write in the same notebook simultaneously.
- **Seamless Onboarding:** New team members can start instantly with a pre-configured environment, including Git access, without local setup.
- **Isolated Team Instances:** At IOER, we provide dedicated, 24/7 instances for researchers, offering zero startup time and user-controlled versioning.

From Notebook to FAIR Output.
CLD integrates CI/CD pipelines to automate the publication of research directly from Jupyter Notebooks.

Integrated Publication

- **Archivable & Citable:** The entire process facilitates the creation of a complete, archivable replication package.
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Launch & Re-use   Build Upon & Contribute

Carto-Lab Docker in Action

Training & Education Materials

- Multiple authors used CLD's collaborative features and pre-configured Git access to co-develop the NFDI4Biodiversity Jupyter Book. The entire book is generated and deployed automatically from Jupyter Notebooks via a CI/CD pipeline.
- You can run and interact with these materials directly in your web browser via the Base4NFDI Jupyter Hub
- URL: training.fdz.ioer.info

URL: doi.org/10.71830/6ILS40

Mobile Cartography Workshops

- Carto-Lab Docker serves as the backbone for the annual 'Mobile Cartography Workshops' at the TU Dresden Institute of Cartography.
- In a hybrid format, students can immediately start experimenting with complex visualizations using Jupyter and Tagmaps, without any local software installation, focusing on creative tasks rather than environment setup.

URL: code.ad.ioer.info/jupyter_python_datascience/

Reproducible Publications

- CLD was used to create and publish the complete set of supplementary notebooks for a peer-reviewed paper in *Land*.
- This allows readers to replicate every figure and analysis, ensuring full transparency and adherence to FAIR principles.
- For further publications authored with CLD, see: cartolab.fdz.ioer.info/notebooks/

URL: doi.org/10.3390/land13071091

Advanced Spatial Analysis

- CLD is extensible. We provide workflows and dedicated container images that include complex tools that are difficult to install or cloud deploy, such as QGIS, GRASS GIS for large-scale raster analysis, and Mapnik for custom OpenStreetMap rendering.
- See these QR-Codes for two examples:

Tag Maps rendering with Mapnik

Viewshed analysis in GRASS and Jupyter

Past (Origin), Present (Stability), and Future (Community)

From Research, for Research	Long-Term Stability & Support	Open & Community-Driven
Born from the needs of the DFG VGIscience program, Carto-Lab Docker was started in 2018 to solve the practical challenges of creating consistent and shareable environments for spatial analysis.	Since 2025, Carto-Lab Docker is officially hosted and supported by the Research Data Centre at the IOER. This institutional backing guarantees long-term maintenance, sustainability, and its integration into a professional RDM service portfolio.	Built on a foundation of open-source principles (MIT/CC BY 4.0), Carto-Lab Docker welcomes community engagement. Our public GitHub mirror serves as the central hub for reporting issues, starting discussions, and contributing code or documentation to shape the project's future.

Integration with the RDM Ecosystem

Carto-Lab Docker is not a monolithic system but a flexible component that integrates with standard tools and platforms across the open research data lifecycle.

Gitlab
Code, Versioning & CI/CD Pipelines

Github
Community, Issues & Contributions

quay.io Registry
Archived & Versioned Container Images

JupyterHub & Kubernetes
Scalable Deployment (e.g., Cloud Workshops)