

Cloud-basierte Web-Anwendungen und Jupyter Notebooks im Zusammenhang mit globalen Luftqualitätsdaten

Martin G. Schultz, Jülich Supercomputing Centre (m.schultz@fz-juelich.de)

With a lot of material from

JUPYTERLAB - SUPERCOMPUTING IN YOUR BROWSER

Training course "Introduction to the usage and programming of supercomputer resources in Jülich"

2022-05-16 | JENS H. GÖBBERT (J.GOEBBERT@FZ-JUELICH.DE)

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TOAR-I 2014-2019

Tropospheric Ozone Assessment Report (TOAR)

Global metrics for climate change, human health and crop/ecosystem research



Mission:

To provide the research community with an up-to-date scientific assessment of tropospheric ozone's global distribution and trends from the surface to the tropopause.

Deliverables:

- 1) The first tropospheric ozone assessment report based on all available surface observations, the peer-reviewed literature and new analyses.
- 2) A database containing ozone exposure metrics at thousands of measurement sites around the world, freely accessible for research on the global-scale impact of ozone on climate, human health and crop/ecosystem productivity.

Stakeholders:

Member of the Helmholtz Association



Task Force on Hemispheric Transport of Air Pollution



TOAR-I publications in Elementa

<https://collections.elementascience.org/toar>



Wong, P.J. et al. 2018 Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability and trends. *Elem Sci Anthrof*. 6: 28. DOI: <https://doi.org/10.1257/elementa.279>

REVIEW

Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability and trends

P. J. Young^{1,2*}, V. Naik³, A. M. Fiore^{4,5}, A. Gaudel^{6,7}, J. Guo⁸, M. Y. Lin^{9,10}, J. L. Neff¹¹, D. D. Parrish^{12,13}, H. E. Reiper^{14,15}, J. L. Schmitt¹⁶, S. Timles¹⁷, O. Wildt¹⁸, L. Zhang¹⁹, J. Ziemke^{20,21}, J. Brandt²², A. Delcourt²³, R. M. Doherty²⁴, C. Geels²⁵, M. I. Hegglin^{26,27}, L. Hu²⁸, U. Imml²⁹, R. Kumar³⁰, A. Luhar^{31,32}, L. Murray³³, D. Plummer³⁴, J. Rodriguez³⁵, A. Saliz-Lopez^{36,37}, M. G. Schultz^{38,39}, M. T. Woodhouse³⁸ and G. Zeng³⁸



Schultz, M.G. et al. 2018 Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations. *Elem Sci Anthrof*. 6: 38. DOI: <https://doi.org/10.1257/elementa.294>

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations

Martin G. Schultz^{1,2}, Sabine Schröder¹, Olga Lyapina¹, Owen R. Cooper², Ian Galbally⁴, Irina Petropavlovskikh^{1,3}, Erika von Schneidemesser¹, Hiroshi Tanimoto⁵, Yasin Elshorbany^{6,7}, Marish Naja⁸, Rodrigo J. Seguel⁹, Ute Dauer¹⁰, Paul Eckhardt¹¹, Stefan Feigenson¹⁰, Martin Fliebig¹², Anne-Gunn Hjeltebrekk¹³, You-Deog Hong¹⁴, Peter Christian Kjeld¹⁵, Hiroshi Kaudoune¹⁶, Gary Lear¹⁷, David Tarasick¹⁸, Mikio Ueno¹⁹, Markus Wallach²⁰, Daniel Baumgardner²¹, Ming-Tung Chang²², Robert Gillett²³, Mervyn Gault²⁴, Scott Moxley²⁵, Richard Monks²⁶, Tao Wang²⁷, Katrina Shulz²⁸, Jose A. Adame²⁹, Gerard Ancelle³⁰, Francesco Apulone³¹, Paolo Artaxer³², Maria E. Barletta³³, Magdalena Bogucki³⁴, Pablo Bonasoni³⁵, Limsoon Chan³⁶, A. C. Cooley³⁷, A. M. Fiore³⁸, J. Guo³⁹, M. Y. Lin⁴⁰, J. L. Neff⁴¹, D. D. Parrish^{42,43}, H. E. Reiper^{44,45}, J. L. Schmitt⁴⁶, S. Timles⁴⁷, O. Wildt⁴⁸, L. Zhang⁴⁹, J. Ziemke^{50,51}, J. Brandt⁵², A. Delcourt⁵³, R. M. Doherty⁵⁴, C. Geels⁵⁵, M. I. Hegglin^{56,57}, L. Hu⁵⁸, U. Imml⁵⁹, R. Kumar⁶⁰, A. Luhar^{61,62}, L. Murray⁶³, D. Plummer⁶⁴, J. Rodriguez⁶⁵, A. Saliz-Lopez^{66,67}, M. G. Schultz^{68,69}, M. T. Woodhouse⁶⁸ and G. Zeng⁶⁸



Ancelle, G. et al. 2018 Tropospheric Ozone Assessment Report: Global view of changes in the tropospheric ozone burden and budget. *Elem Sci Anthrof*. 6: 20. DOI: <https://doi.org/10.1257/elementa.2020.008>

REVIEW

Tropospheric Ozone Assessment Report: A critical review of changes in the tropospheric ozone burden and budget from 1850 to 2100

A. T. Archibald^{1,2,3*}, J. L. Neff⁴, Y. F. Elshorbany⁵, O. R. Cooper^{3,6}, P. J. Young^{1,2,9}, H. Akiyoshi¹⁰, R. A. Cox¹¹, M. Coyle^{12,13}, N. M. Deushi¹⁴, A. Finch¹⁵, G. J. Frost¹⁶, I. E. Galbally^{16,17}, G. Gerosa¹⁸, C. Granier^{18,19}, P. T. Griffiths¹³, R. Hossaini^{1,2,8}, L. Hu¹⁹, P. Jöckel²⁰, B. Josse²¹, M. Y. Lin²², M. Mertens²⁰, O. Morgenstern²¹, M. Naja²⁴, V. Naik²⁵, S. Oltmans²⁶, D. A. Plummer²⁷, J. E. Revell²⁸, A. Saliz-Lopez²⁹, P. Saxena³⁰, Y. M. Shin³¹, I. Shahid³¹, D. Shallcross³², S. Timles³³, T. Trickl³⁴, T. J. Wallington³⁵, T. Wang³⁶, H. M. Worden³⁵, and G. Zeng³³

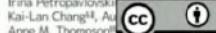


Tarasick, D. et al. 2018 Tropospheric Ozone Assessment Report: Trends ozone from 1877 to 2016: observed levels, trends and uncertainties. *Elem Sci Anthrof*. 6: 35. DOI: <https://doi.org/10.1257/elementa.350>

REVIEW

Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties

David Tarasick¹, Ian E. Galbally^{1,4}, Owen R. Cooper^{1,2}, Martin G. Schultz², Gerard Ancelle¹, Thierry Lebel^{1,5}, Timothy J. Wallington¹, Jerry Ziemke^{1,6}, Xiong Li¹, Martin Steinbacher^{1,7}, Johannes Staehelin^{1,8}, Corinne Vigouroux^{1,9}, James W. Hannan^{1,10}, Omaira García^{1,11}, Gilles Foret^{1,12}, Prodromos Zanis^{1,13}, Elizabeth Weatherhead^{1,14}, Irina Petropavlovskikh^{1,15}, Mohammad Osman^{1,16,17}, Jana Liu^{1,18}, Kai-Lan Chang^{1,19}, Aliaa El-Sherif^{1,20}, Juan Cuesta^{1,21}, Gaëlle Dufour^{1,22}, Valeria Thouret^{1,23}, Billie Hassell^{1,24}, Thomas Trick^{1,25} and Jessica L. Neu^{1,26}



Feng, Z. et al. 2018 Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health. *Elem Sci Anthrof*. 6: 12. DOI: <https://doi.org/10.1257/elementa.273>

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Present-day ozone distribution and trends relevant to human health

Zob L. Fleining¹, Ruth M. Doherty¹, Erika von Scheidegger¹, Christopher S. Malley^{1,2,3*}, Owen R. Cooper^{1,4}, Joseph P. Pfeiffer¹, Augusto Colino^{1,5}, Xiaobin Xu¹, David Simpson^{1,6}, Martin G. Schultz^{1,7}, Allen S. Lefohn^{1,8}, Samira Hamid¹, Roseea Noolka^{1,9}, Steeve Solberg^{1,10} and Zhaozhong Feng¹



Wu, G. et al. 2018 Tropospheric Ozone Assessment Report: Present-day tropospheric ozone distribution and trends relevant to vegetation. *Elem Sci Anthrof*. 6: 41. DOI: <https://doi.org/10.1257/elementa.291>

RESEARCH ARTICLE

Tropospheric Ozone Assessment Report: Present-day tropospheric ozone distribution and trends relevant to vegetation

Gina Mills^{1,2}, Håkan Pleijel¹, Christopher S. Malley^{1,3}, Baerbel Sinha¹, Owen R. Cooper^{1,4}, Martin G. Schultz^{1,5}, Howard S. Neufeld^{1,6}, David Simpson^{1,7}, Katrina Sharps¹, Zhaozhong Feng¹, Giacomo Gerosa¹, Harry Harrens¹, Kazuhiko Kobayashi^{1,8}, Pallavi Saxena^{1,9}, Elena Paollett^{1,10}, Vinayak Singh¹ and Xiaobin Xu^{1,11}



Chang, K.L. et al. 2018 Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia. *Elem Sci Anthrof*. 6: 40. DOI: <https://doi.org/10.1257/elementa.283>

RESEARCH ARTICLE

Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia

Kai-Lan Chang¹, Irina Petropavlovskikh¹, Owen R. Cooper^{1,2}, Martin G. Schultz^{1,3} and Tao Wang¹

Surface ozone is a greenhouse gas and pollutant detrimental to human health and crop and ecosystem productivity. The Tropospheric Ozone Assessment Report (TOAR) is designed to provide the research community with an up-to-date observation-based overview of tropospheric ozone's global distribution and trends. The TOAR Surface Ozone Database contains ozone metrics at thousands of monitoring sites



Ru, Y. et al. 2018 Long-term changes of regional ozone in China: implications for human health and ecosystem impacts. *Elem Sci Anthrof*. 6: 13. DOI: <https://doi.org/10.1257/elementa.409>

RESEARCH ARTICLE

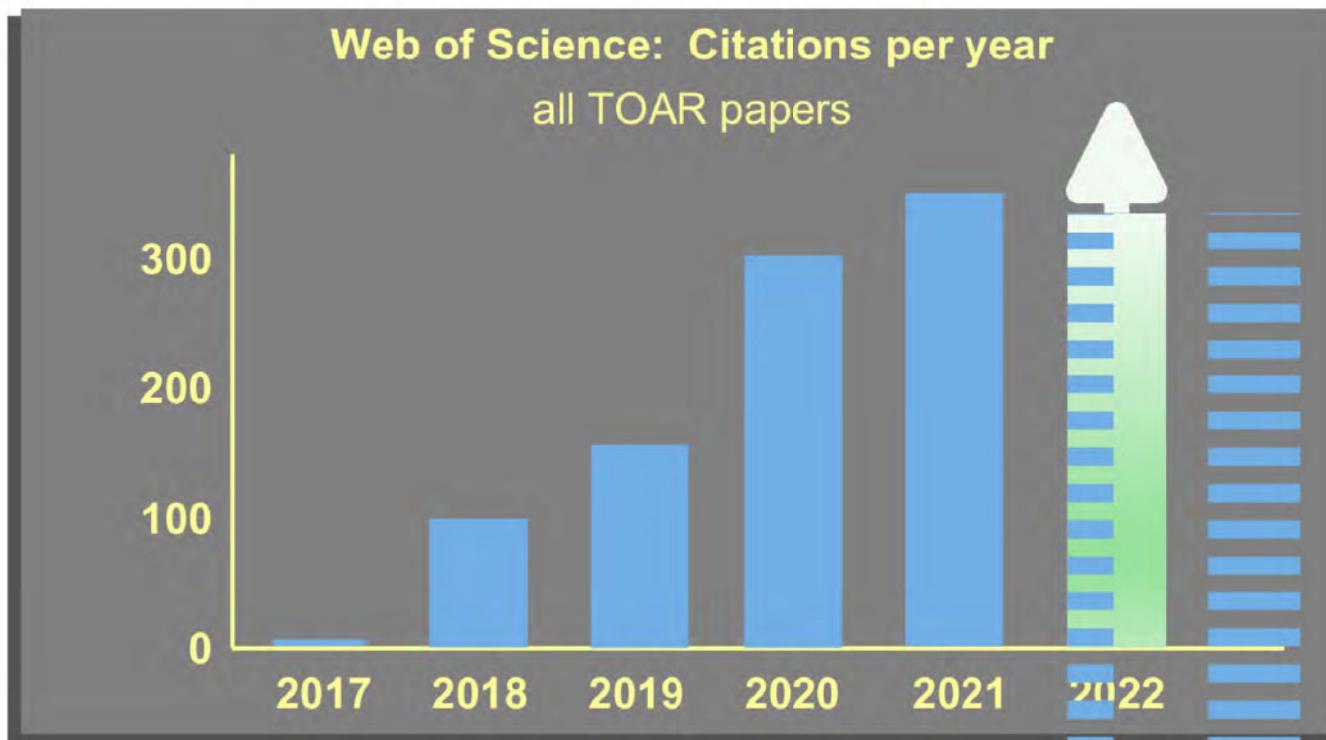
Long-term changes of regional ozone in China: implications for human health and ecosystem impacts

Xiaobin Xu¹, Weili Lin¹, Wanyun Xu¹, Junli Jin¹, Ying Wang¹, Gen Zhang¹, Xiaochun Zhang¹, Zhiqiang Ma¹, Yuanzhen Dong¹, Qianli Ma¹, Dajiang Yu¹, Zou Li¹, Dingding Wang¹ and Huorong Zhao¹



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TOAR-I publications are highly cited



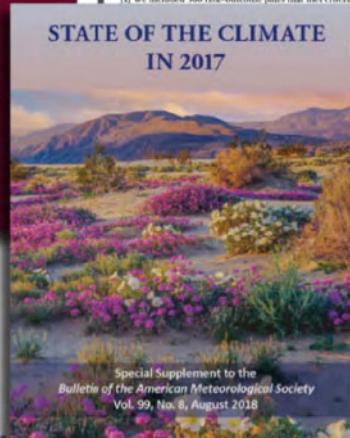
TOAR-I Fostering independent research

Dozens of independent studies have utilized the TOAR database

SCIENTIFIC ASSESSMENT OF OZONE DEPLETION: 2018



World Meteorological Organization
United Nations Environment Programme
National Oceanic and Atmospheric Administration
National Aeronautics and Space Administration
European Commission



Member of the Helmholtz Association

Global Burden of Disease

Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019

GBD 2019 Risk Factor Collaborators*

Summary

Background Rigorous analysis of levels and trends in exposure to leading risk factors and quantification of their effect on human health are important to identify where public health is making progress and in which cases current efforts are inadequate. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 provides a standardized and comprehensive assessment of the magnitude of risk factor exposure, relative risk, and attributable burden of disease.

Methods GBD 2019 estimated attributable mortality, years of life lost (YLLs), years of life lived with disability (YLDs), and disability-adjusted life-years (DALYs) for 87 risk factors and combinations of risk factors, at the global level, regionally, and for 204 countries and territories. GBD uses a hierarchical list of risk factors so that specific risk factors (e.g., sodium intake), and related aggregates (e.g., diet quality), are both evaluated. This method has six analytical steps: (1) We included 560 risk-outcome pairs that met criteria for confirming or precluding evidence on the basis of research designs and study characteristics; (2) we conducted a formal dose-response analysis for each outcome pair for new evidence; (2) Relative risks were estimated as a function



Lancet 2020; 396:1235–49
For the list of Collaborators see page 1236

1236–1255

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ARTICLES

<https://doi.org/10.1038/s41558-020-0743-y>

nature
climate change



Vegetation feedbacks during drought exacerbate ozone air pollution extremes in Europe

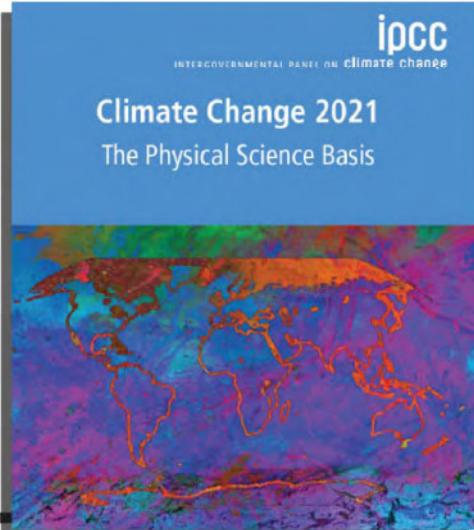
Meiyun Lin^{1,2}, Larry W. Horowitz², Yuanyu Xie^{1,2}, Fabien Paulot², Sergey Malyshev², Elena Shevliakova², Angelo Finco², Giacomo Gerosa², Dagmar Kubistin² and Kim Pilegaard²

Reducing surface ozone to meet the European Union's target for human health has proven challenging despite stringent controls on ozone precursor emissions over recent decades. The most extreme ozone pollution episodes are linked to heatwaves and droughts, which are increasing in frequency and intensity over Europe, with severe impacts on natural and human systems. Here, we use observations and Earth system model simulations for the period 1960–2018 to show that ecosystem-atmosphere interactions, especially induced by soil moisture and vegetation, exacerbate ozone pollution over Europe. The use of vegetation feedbacks would break ozone episodes during European heatwaves, such as the 2003 one, affecting much of the air quality improvements gained from regional emissions controls. As the frequency of hot and dry summers is expected to increase over the coming decades, this climate penalty could be severe and therefore needs to be considered when designing clean air policy in the European Union.

ipcc

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Climate Change 2021 The Physical Science Basis



ENVIRONMENTAL SCIENCE & TECHNOLOGY LETTERS

pubs.acs.org/journal/eletlq

Rapid Increases in Warm-Season Surface Ozone and Resulting Health Impact in China Since 2013

Xiao Li, Lin Zhang,¹ Xiulin Wang, Meng Gao, Ke Li, Yuzhong Zhang, Xu Yue, and Yuanhang Zhang²

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Article Recommendations

Supporting Information

ABSTRACT: China's nationwide ozone monitoring network initiated in 2013 has observed severe surface ozone pollution. This network, combined with the recent Tropospheric Ozone Assessment Report (TOAR) data set, offers a unique opportunity to study the global surface ozone trends and trends. Here, we report quantitative estimates of the warm-season (April–September) surface ozone trends and resulting health impacts at Chinese cities in 2013–2019. Both the parametric and nonparametric linear trends for 12 ozone metrics (annual mean, 8-h maximum daily average, and seasonal average) are determined. We find that all ozone metrics except urban Chinese urban areas have increased significantly since 2013. The warm-season daily maximum 8-h average (MDA8) ozone levels increased by 2.4 ppb (5.0% year⁻¹) with over 90% of the sites showing positive trends and 30% with trends larger than 3.0 ppb year⁻¹. The annual mean ozone levels increased by 1.0 ppb (2.0% year⁻¹). Chinese cities, compared with the urban ozone trends in any other region worldwide reported in TOAR, ozone metrics reflecting the cumulative exposure effect on human health and vegetation such as SOM03 and AOT-40 have increased at even faster rates (>10% year⁻¹). We estimate that the total premature respiratory mortalities attributable to ambient MDA8 ozone exposure in 69 Chinese cities are 64,370 in 2019, which has increased by 60% compared to 2013 levels and requires urgent attention.

TOAR-II Primary Goal and Scientific Scope

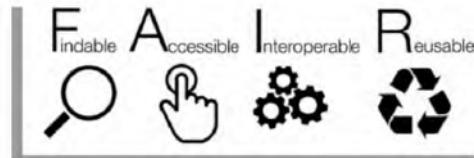


Final Product: An observation-based, up-to-date assessment of tropospheric ozone's distribution and trends on regional, hemispheric and global scales.

TOAR-II will assess the physical science basis for tropospheric ozone's global distribution and trends (*similar to IPCC Working Group I*)

TOAR-II will also explore and quantify the **impacts** of tropospheric ozone on human health, crop and ecosystem productivity and climate change (*similar to IPCC Working Group II*)

Foundation: An enhanced data infrastructure based on open data and FAIR principles





Purpose of TOAR data:

To provide globally consistent metrics for analyses of health, vegetation, and climate impacts from ozone air pollution



We provide data + analysis services

The TOAR Data Infrastructure

... comprises of



The TOAR database of global ground-level air quality observations



Web services for accessing and processing of TOAR data and metadata



Publication services for original TOAR datasets



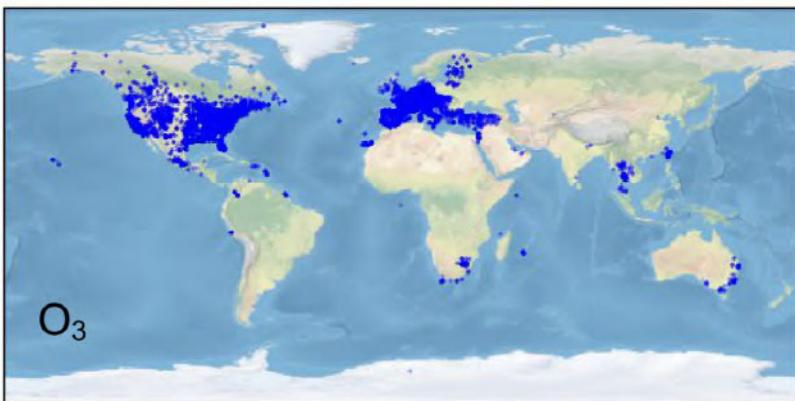
Tools, source code, and documentation



The TOAR Database

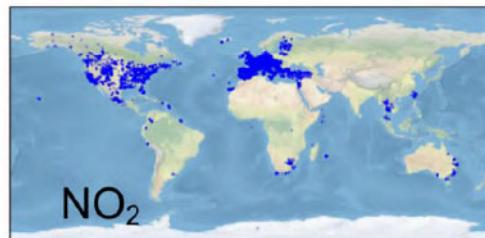
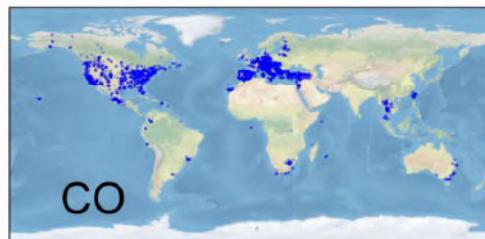
Current status as of 01 Sept 2022

stations: 20,100; time series: 81,231;
data records: 3,403,601,152



You can also find and submit data of PM_x, NO,
BC, various VOCs and meteorological variables.

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The TOAR Data Commitment

TOAR is fully committed to



Open Data: all data collected in TOAR must be freely available with no use constraints

- ⌚ CC-BY 4 license; citations&acknowledgements

We won a 2nd price
in the German
**Open Data Impact
Award 2021**



FAIRness: make it easy to find, access, interoperate and re-use TOAR data, also in other contexts

- ⌚ elaborated metadata schema; REST-API;
coordination with other data centres



Reproducibility: TOAR analyses shall be fully reproducible, even when the database grows

- ⌚ use of PIDs, versioning, QC flags, FDOs



The TOAR Data REST API

<https://toar-data.fz-juelich.de/api/v2>

2.6 Search (combined endpoint of stations and timeseries)

This endpoint enables queries that filter for a combination of metadata of stations and timeseries.
Any combination of query options (except for id) from both [2.4 Stationmeta](#) and [2.5 Timeseries](#) is possible here.

Example from the [TOAR Quick Start Guide](#):

https://toar-data.fz-juelich.de/api/v2/search/?bounding_box=49.7,50.8&variable_id=5,4&limit=None

The above command will get you all the time series within an area between 49°N 7°E and 50°N 8°E that record ozone or pm1.

JSON	Raw Data	Headers
	Save Copy Collapse All Expand All (slow) <input type="button" value="Filter JSON"/>	
▼ 0:		
id:	18776	
label:	""	
order:	1	
sampling_frequency:	"hourly"	
aggregation:	"mean of two values"	
data_start_date:	"1990-01-01T01:00:00+00:00"	
data_end_date:	"2021-11-30T14:00:00+00:00"	
data_origin:	"instrument"	
data_origin_type:	"measurement"	
provider_version:	"N/A"	
sampling_height:	2	

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Summary of TOAR data resources



Data portal: <https://toar-data.org>



Access to data & documentation:
<https://toar-data.fz-juelich.de>



Training material:
<https://go.fzj.de/toar-data-training>
<https://go.fzj.de/toar-user-git>

Jupyter notebooks for TOAR analyses

<https://go.fzj.de/toar-user-git>

esde > toar-public > TOAR Data User Workshop 2022

TOAR Data User Workshop 2022

Project ID: 4766

31 Commits 1 Branch 0 Tags 4.3 MB Project Storage

main toar-data-user-workshop-2022

Find file Clone

updated the map plot of all stations
Niklas Selke authored 6 days ago

2137cb51

README No license. All rights reserved

Name	Last commit	Last update
contributed	Add new directory	2 months ago
pdf_exports	updated the map plot of all stations	6 days ago
.gitignore	added a .gitignore file and made some chan...	2 months ago
2022-02-Logo-TOAR-DataBase.p...	Upload New File	3 months ago
GettingStarted.ipynb	added saving to file to GettingStarted.ipynb ...	2 months ago



BENEFITS

Why Jupyter is so popular among Data Scientists

Some of the reasons ...

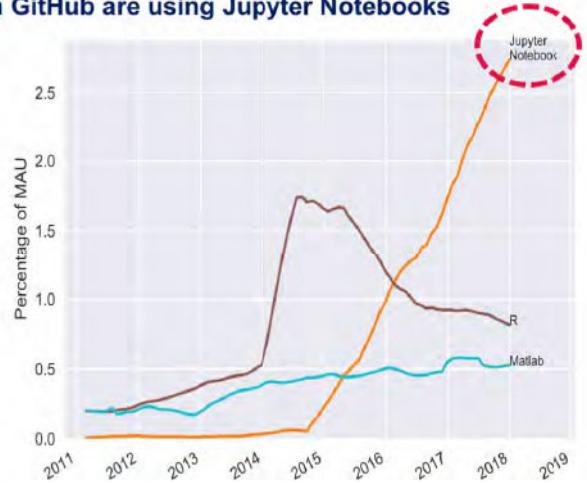
- Jupyter allows to **view the results of the code in-line** without the dependency of other parts of the code.
- Jupyter mixes easy for users who extend their code **line-by-line with feedback** attached all along the way
- Jupyter Notebooks support visualization and include rendering data in **live-graphics and charts**.
- Jupyter is maintaining the **state of execution of each cell** automatically.
- Supports IPyWidget packages, which provide **standard user interface** for exploring code and data interactively.
- Platform and language **independent** because of its representation in JSON format.

MOTIVATION

Rise of Jupyter's popularity

- In 2007, Fernando Pérez and Brian Granger announced „**Ipython**: a system for interactive scientific computing“ [1]
- In 2014, Fernando Pérez announced a spin-off project from IPython called **Project Jupyter**.
 - IPython continued to exist as a Python shell and a kernel for Jupyter, while the Jupyter notebook moved under the Jupyter name.
- In 2015, GitHub and the Jupyter Project announced native rendering of Jupyter notebooks file format (.ipynb files) on the **GitHub**
- In 2017, the **first JupyterCon** was organized by O'Reilly in New York City. Fernando Pérez opened the conference with an inspiring talk. [2]
- In 2018, **JupyterLab** was announced as the next-generation web-based interface for Project Jupyter.
- In 2019, JupyterLab 1.0 ...
- In 2020, JupyterLab 2.0 ...
- In 2021, JupyterLab 3.0 ...

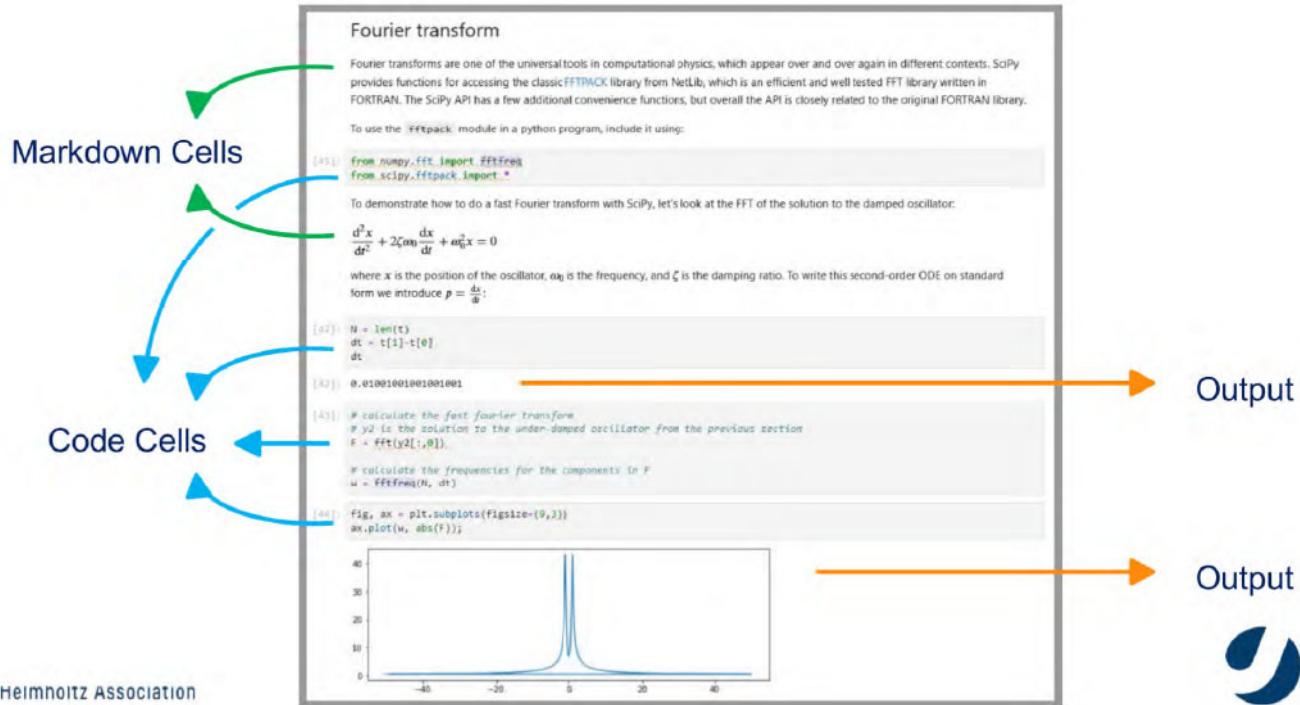
Counting how many **Monthly Active Users (MAU)** on **GitHub** are using **Jupyter Notebooks**



<https://www.benfrederickson.com/ranking-programming-languages-by-github-users/>
<https://github.com/benfred/github-analysis>

JUPYTER NOTEBOOK

creating reproducible computational narratives



TERMINOLOGY

What is JupyterLab

JupyterLab

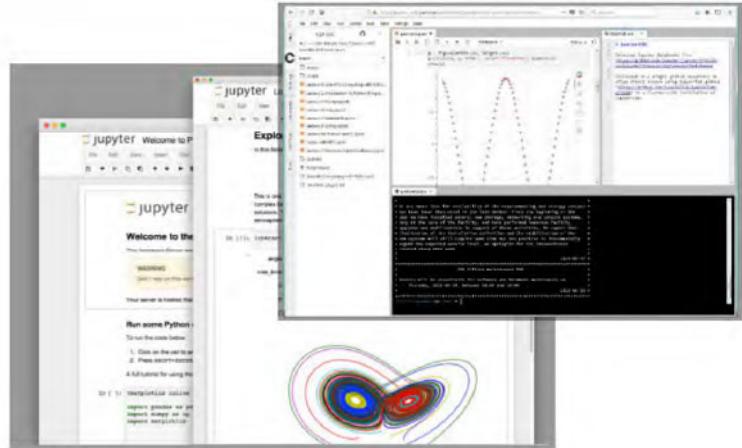
- **Interactive** working environment in the web browser
- For the creation of **reproducible** computer-aided narratives
- **Very popular** with researchers from all fields
- Jupyter = Julia + Python + R

Multi-purpose working environment

- Language agnostic
- Supports execution environments (“*kernels*”)
 - For dozens of languages: Python, R, Julia, C++, ...
- Extensible software design („*extensions*“)
 - many server/client plug-ins available
 - Eg. in-browser-terminal and file-browsing

Document-Centered Computing (“*notebooks*”)

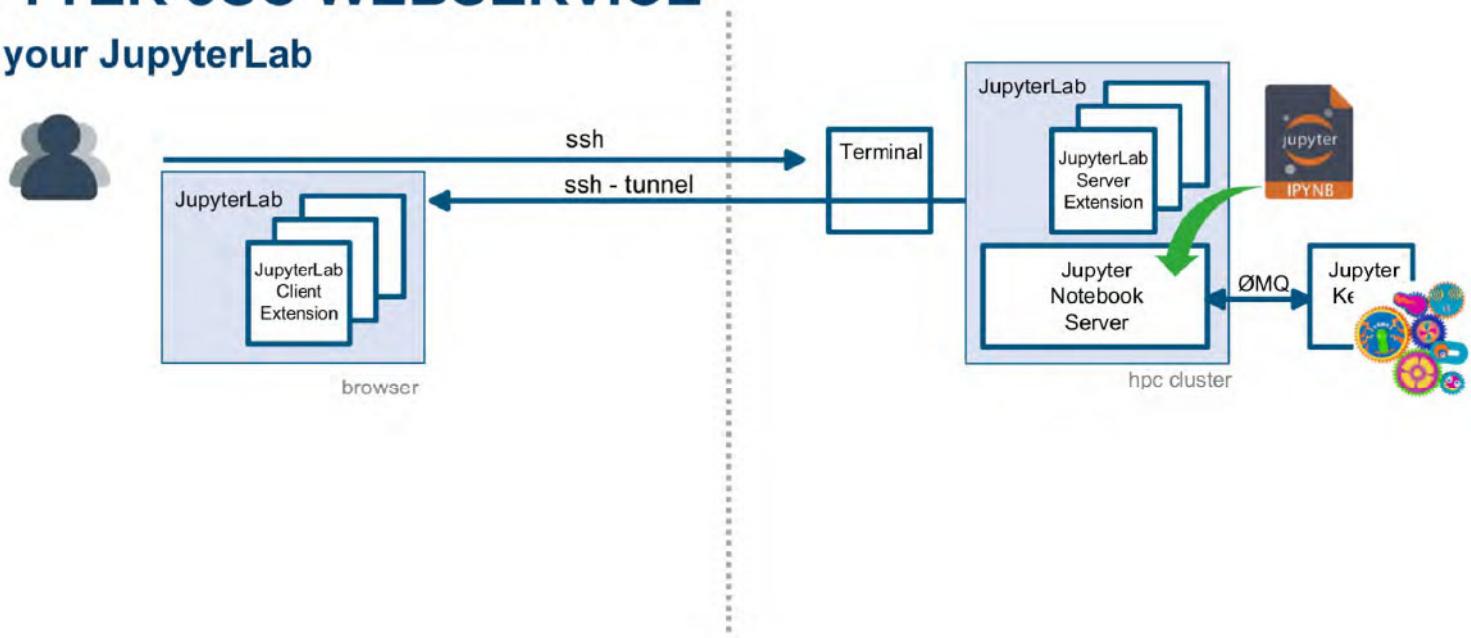
- Combines code execution, rich text, math, plots and rich media.
- All-in-one document called Jupyter Notebook



<https://jupyterlab.readthedocs.io>

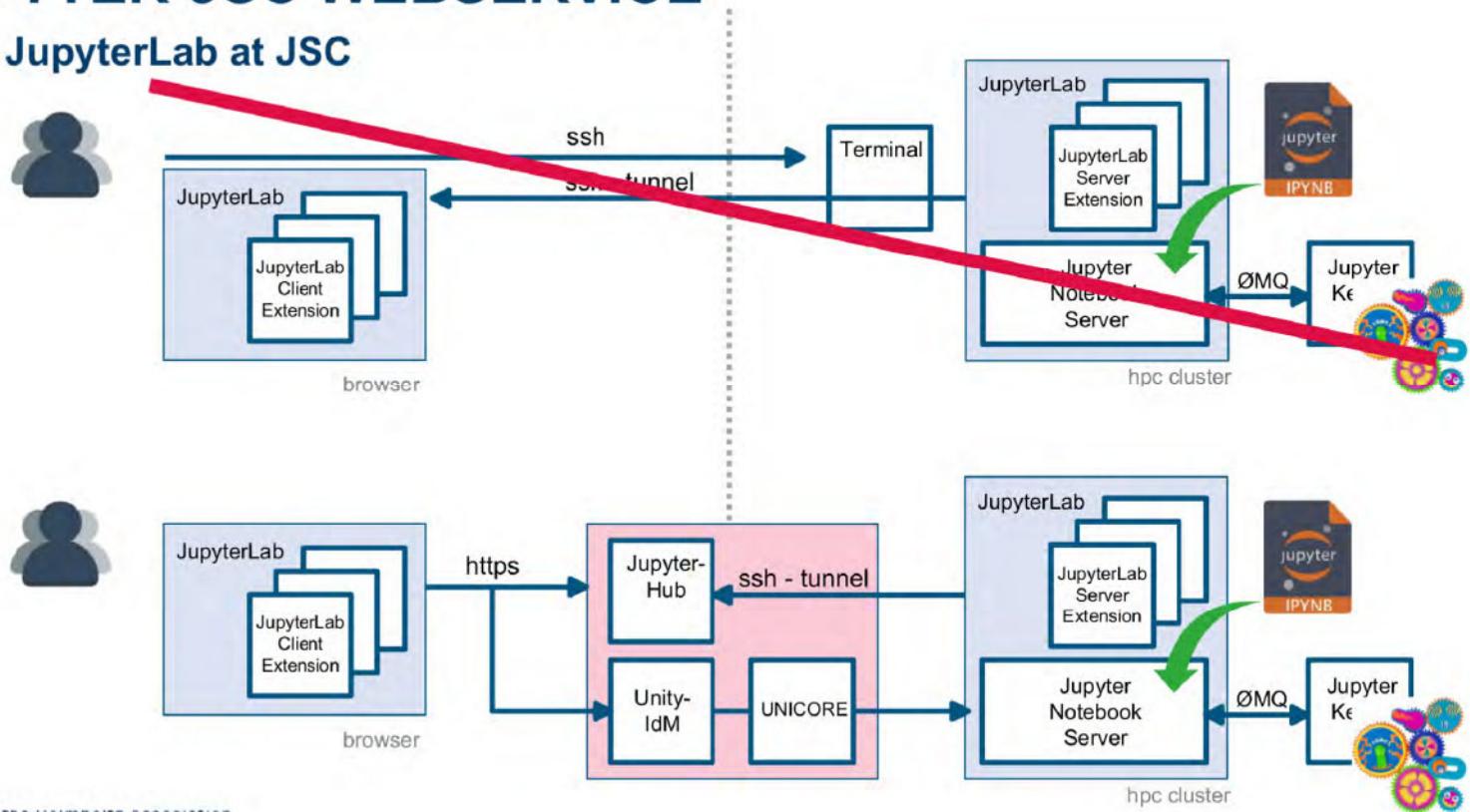
JUPYTER-JSC WEBSERVICE

Start your JupyterLab



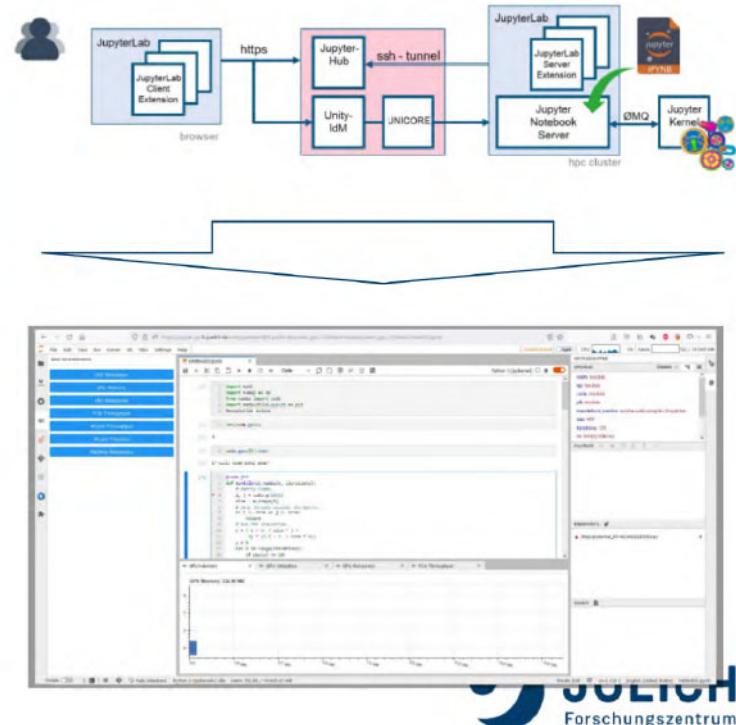
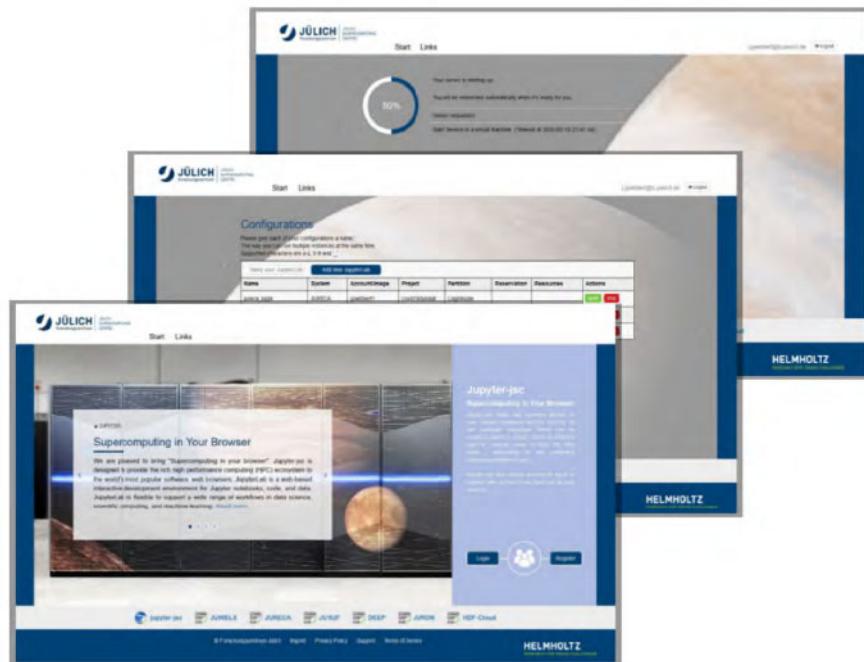
JUPYTER-JSC WEBSERVICE

Start JupyterLab at JSC

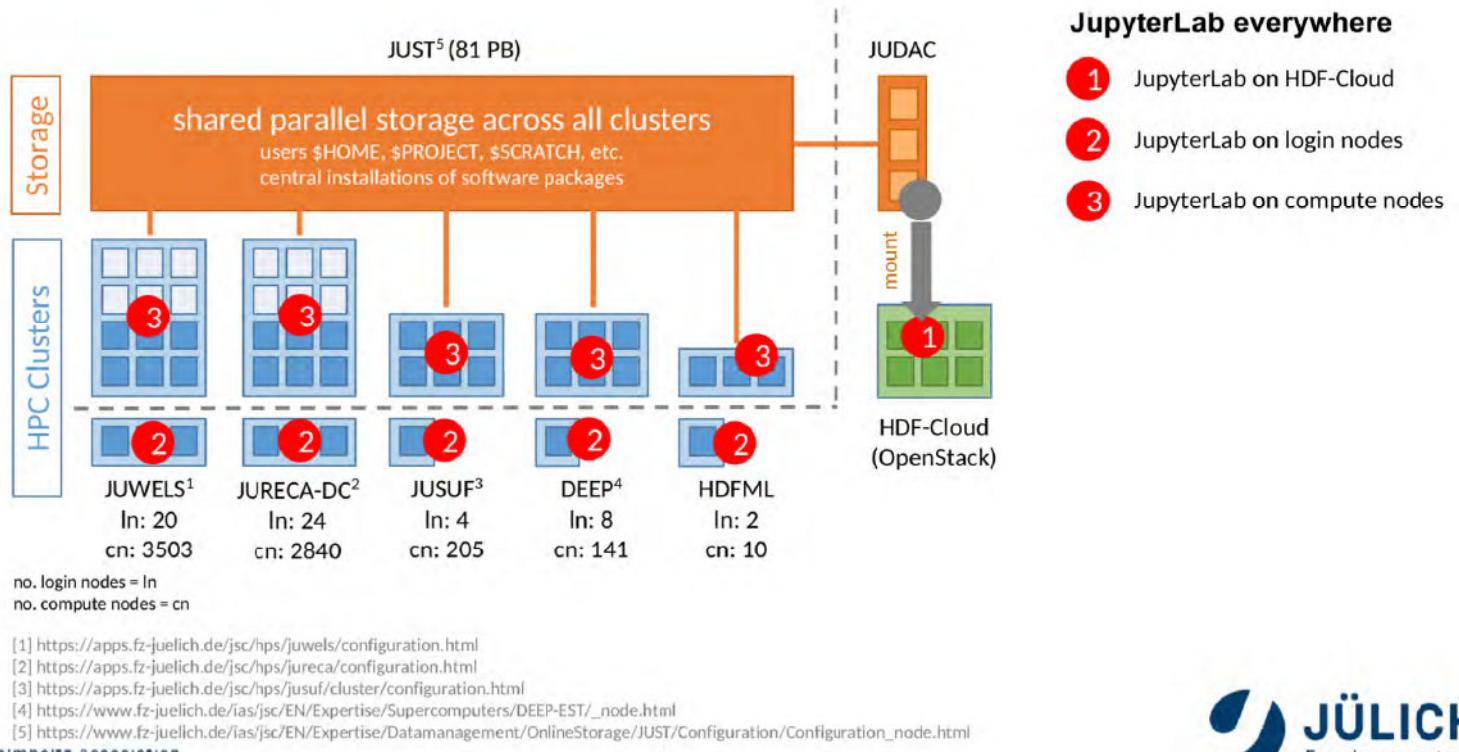


JUPYTER-JSC WEBSERVICE

Start JupyterLab at JSC

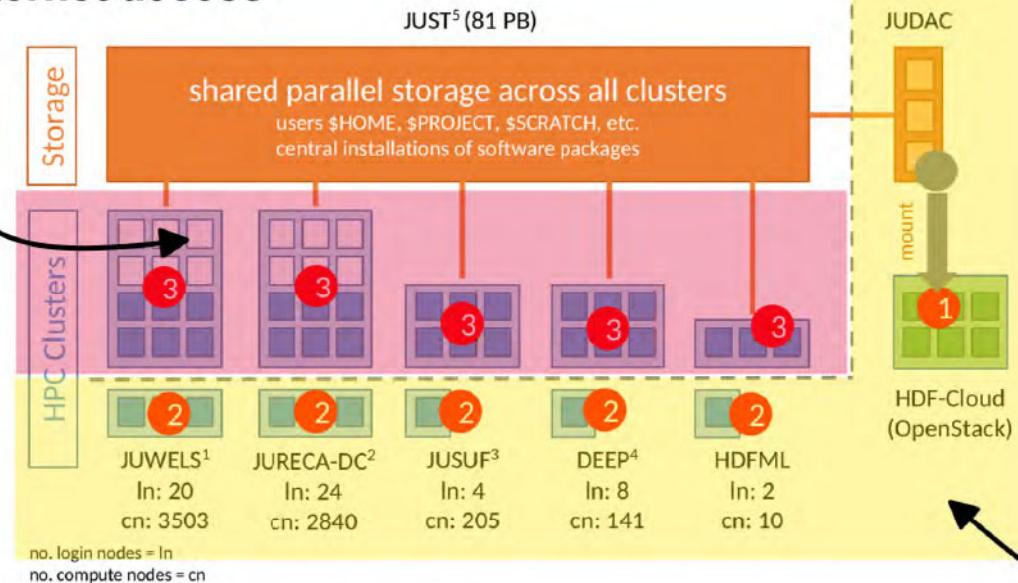


JUPYTERLAB EVERYWHERE



JUPYTERLAB EVERYWHERE

NO internet access



JupyterLab everywhere

- 1 JupyterLab on HDF-Cloud
- 2 JupyterLab on login nodes
- 3 JupyterLab on compute nodes

internet access

[1] <https://apps.fz-juelich.de/jsc/hps/juwels/configuration.html>

[2] <https://apps.fz-juelich.de/jsc/hps/jureca/configuration.html>

[3] <https://apps.fz-juelich.de/jsc/hps/jusuf/cluster/configuration.html>

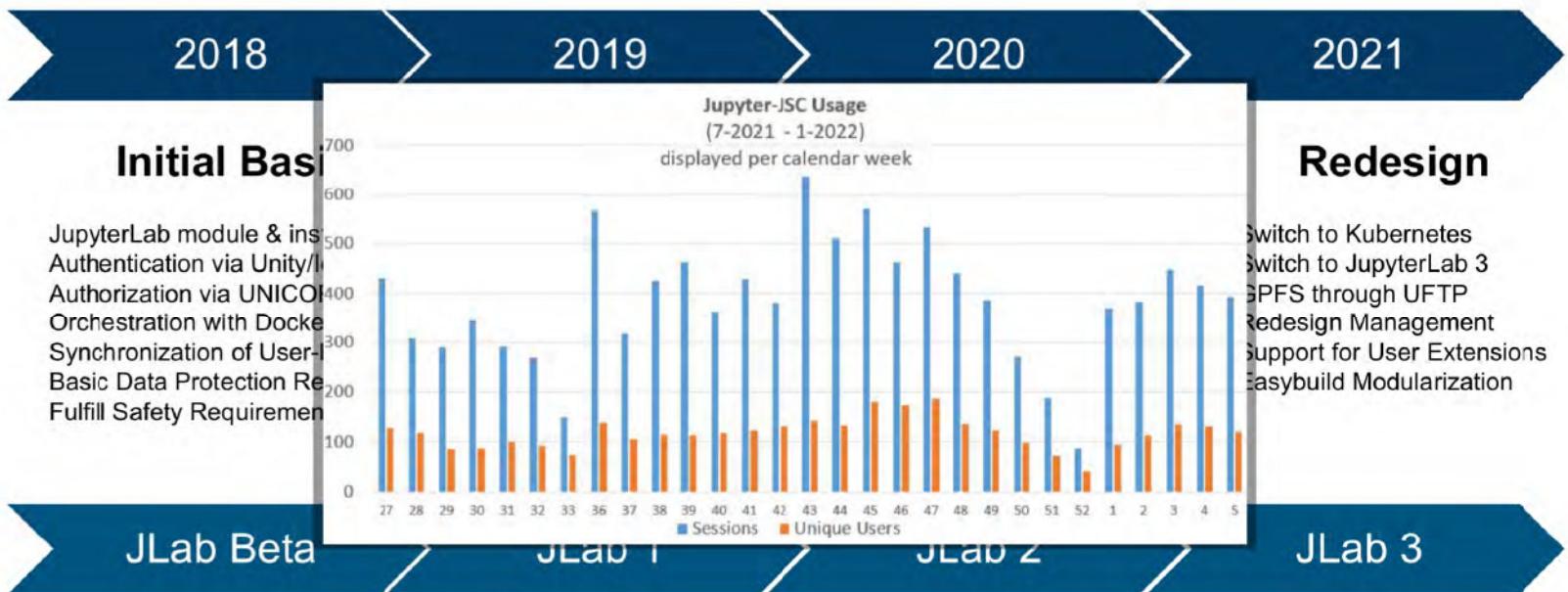
[4] https://www.fz-juelich.de/ias/jsc/EN/Expertise/Supercomputers/DEEP-EST/_node.html

[5] https://www.fz-juelich.de/ias/jsc/EN/Expertise/Datamanagement/OnlineStorage/JUST/Configuration/Configuration_node.html

HISTORY OF JUPYTERLAB AT JSC



HISTORY OF JUPYTERLAB AT JSC



JUPYTER EXTENSIONS

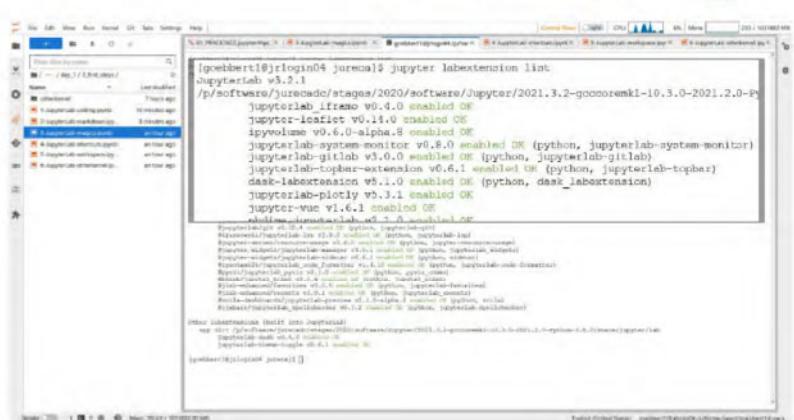
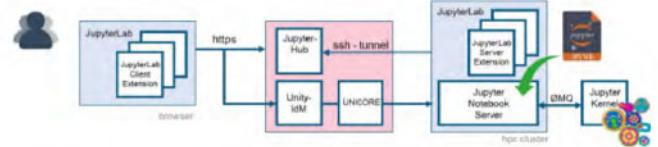
Some general information

List the installed JupyterLab extensions

- Open the Launcher
 - Start a Terminal
 - Run command `jupyter labextension list`

Extensions are installed in JupyterLab's Application Directory, which

- stores any information that JupyterLab persists
 - including settings and built assets of extensions
 - default location is <sys-prefix>/share/jupyter/lab
 - can be relocated by setting \$JUPYTERLAB_DIR
 - contains the JupyterLab static assets
 - (e.g. static/index.html)
 - **JupyterLab < 3:**
any change requires a rebuild of the whole JupyterLab to take effect!
 - **JupyterLab >= 3:**
introduced prebuild extensions, which are loaded at startup time



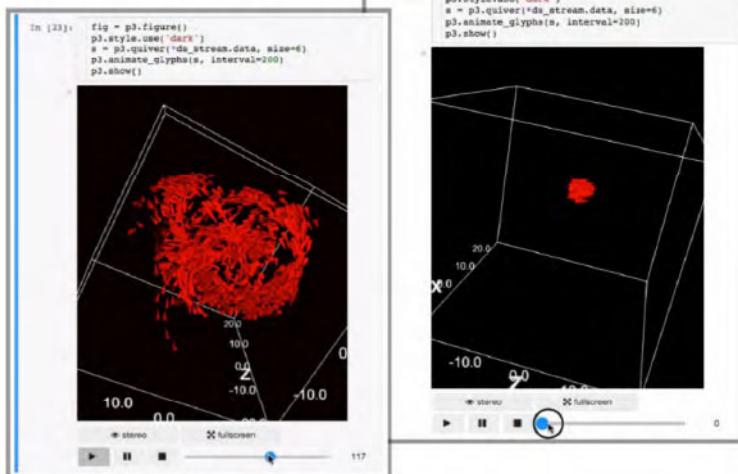
<https://jupyterlab.readthedocs.io/en/stable/user/extensions.html>

JUPYTER-JSC EXTENSIONS

Installed by default

IPyVolume

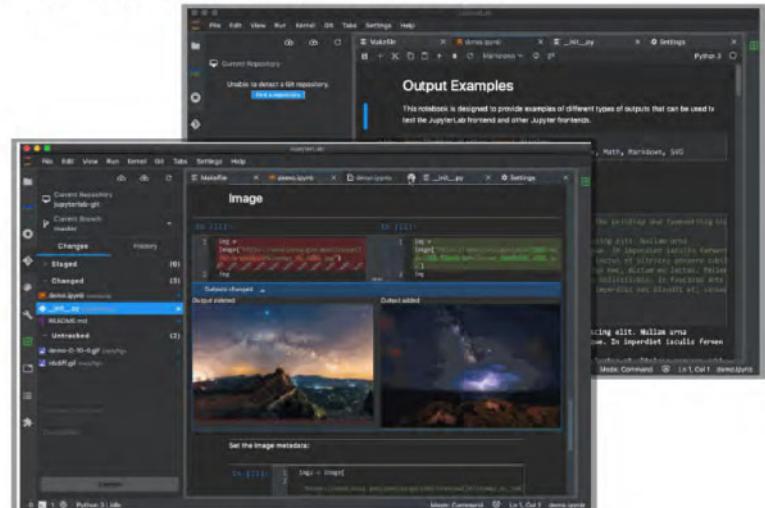
3d plotting for Python in the Jupyter notebook based on IPython widgets using WebGL



<https://github.com/maartenbreddels/ipyvolume>

JupyterLab-Git

JupyterLab extension for version control using Git



<https://github.com/jupyterlab/jupyterlab-git>

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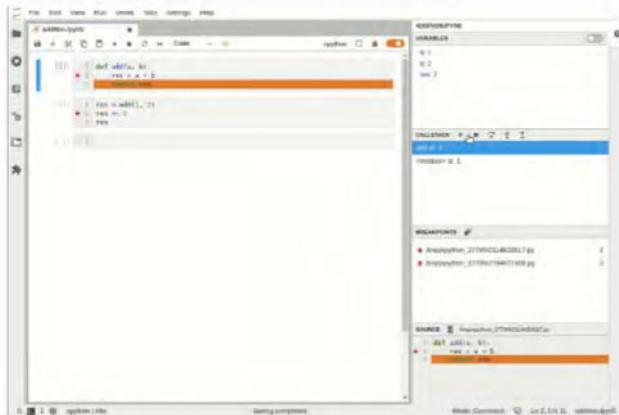
JUPYTER-JSC EXTENSIONS

Installed by default

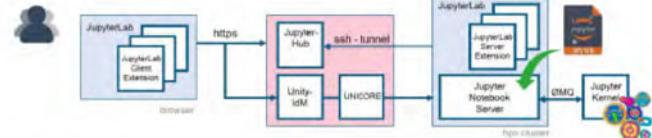
JupyterLab - Visual Debugger

JupyterLab 3.0 now ships with a Debugger front-end by default.

This means that notebooks, code consoles and files can now be debugged from JupyterLab directly! For the debugger to be enabled and visible, a kernel with support for debugging is required.



<https://jupyterlab.readthedocs.io/en/stable/user/debugger.html>



JupyterLab-toc

A Table of Contents extension for JupyterLab.

This auto-generates a table of contents in the left area when you have a notebook or markdown document open. The entries are clickable, and scroll the document to the heading in question.

A screenshot of the JupyterLab interface. On the left, there's a 'Table of Contents' sidebar with a tree view of a notebook. The tree includes sections like 'Working with Time Series', 'Dates and Times in Python', 'Pandas Time Series: Indexing by Time', 'Pandas Time Series Data Structures', 'Resampling, Shifting, and Windowing', and 'Resampling and converting frequencies'. On the right, there's a main notebook area with a cell containing the text 'Working with Time Series'. The status bar at the bottom indicates 'Running'.

<https://github.com/jupyterlab/jupyterlab-toc>

JUPYTER-JSC EXTENSIONS

Installed by default

PyThreeJS

A Python / ThreeJS bridge utilizing the Jupyter widget infrastructure.
<https://threejs.org> - lightweight, 3D library with a default WebGL renderer.

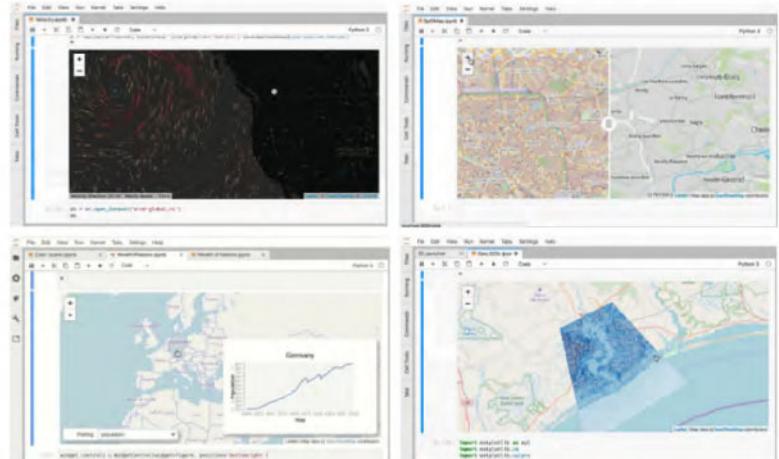
```
In [8]: T = """
function SphereGeometry() {
    // Create a grid and the ranges 2 vector (0, 2*pi)
    var w = 2 * Math.PI;
    var v = 2 * Math.PI / 4;
    var x = Math.sin(v);
    var y = Math.cos(v);
    var z = Math.sin(w);
    return new THREE.Vector3(x,y,z)
}
...
surf_g = ParameterGeometry(function() {
    surf = new THREE.MeshPhongMaterial({color: green, side: THREE.DoubleSide});
    surf2 = new THREE.MeshPhongMaterial({color: yellow, side: THREE.DoubleSide});
    scene = Scene();
    children = [surf, surf2, AmbientLight(color: #FFFFCC)];
    a = PerspectiveCamera(100, 100, 100, 1000, 1000);
    children = [directionalLight(color: white, intensity: 1), a];
    intensity = 0.1;
    return children;
});
render = Renderer(camera, scene, controls=OrbitControls(controlling));
display(render);
}
```



<https://github.com/jupyter-widgets/pythreejs>

IPyLeaflet

A Jupyter / Leaflet bridge enabling interactive maps in the Jupyter notebook.



<https://github.com/jupyter-widgets/ipyleaflet>

... and more

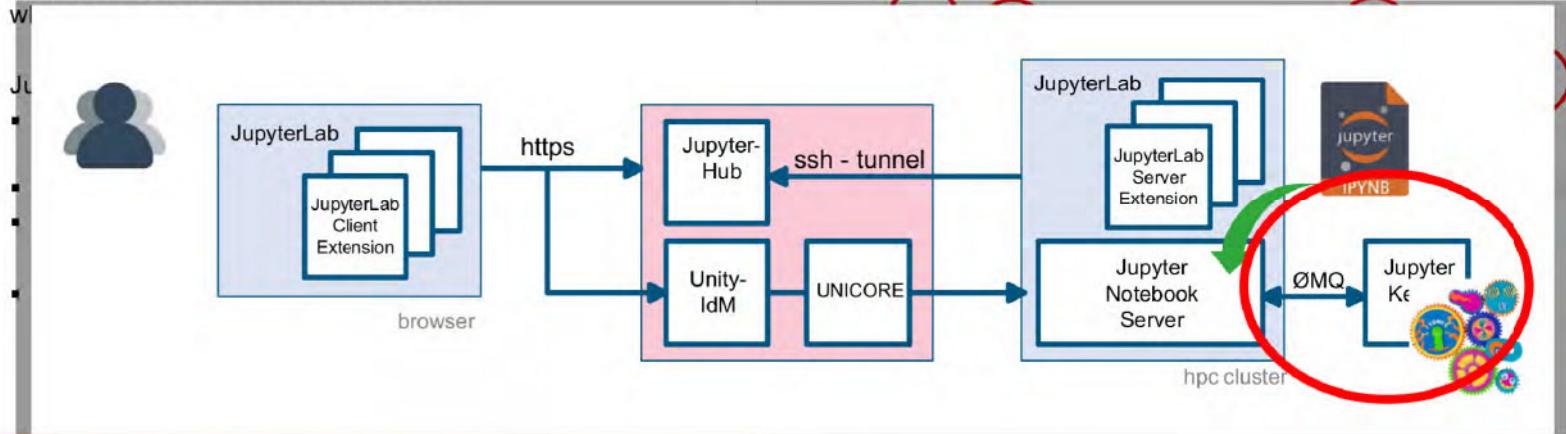
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JUPYTER KERNEL

How to create your own Jupyter Kernel

Jupyter Kernel

A "kernel" refers to the separate process

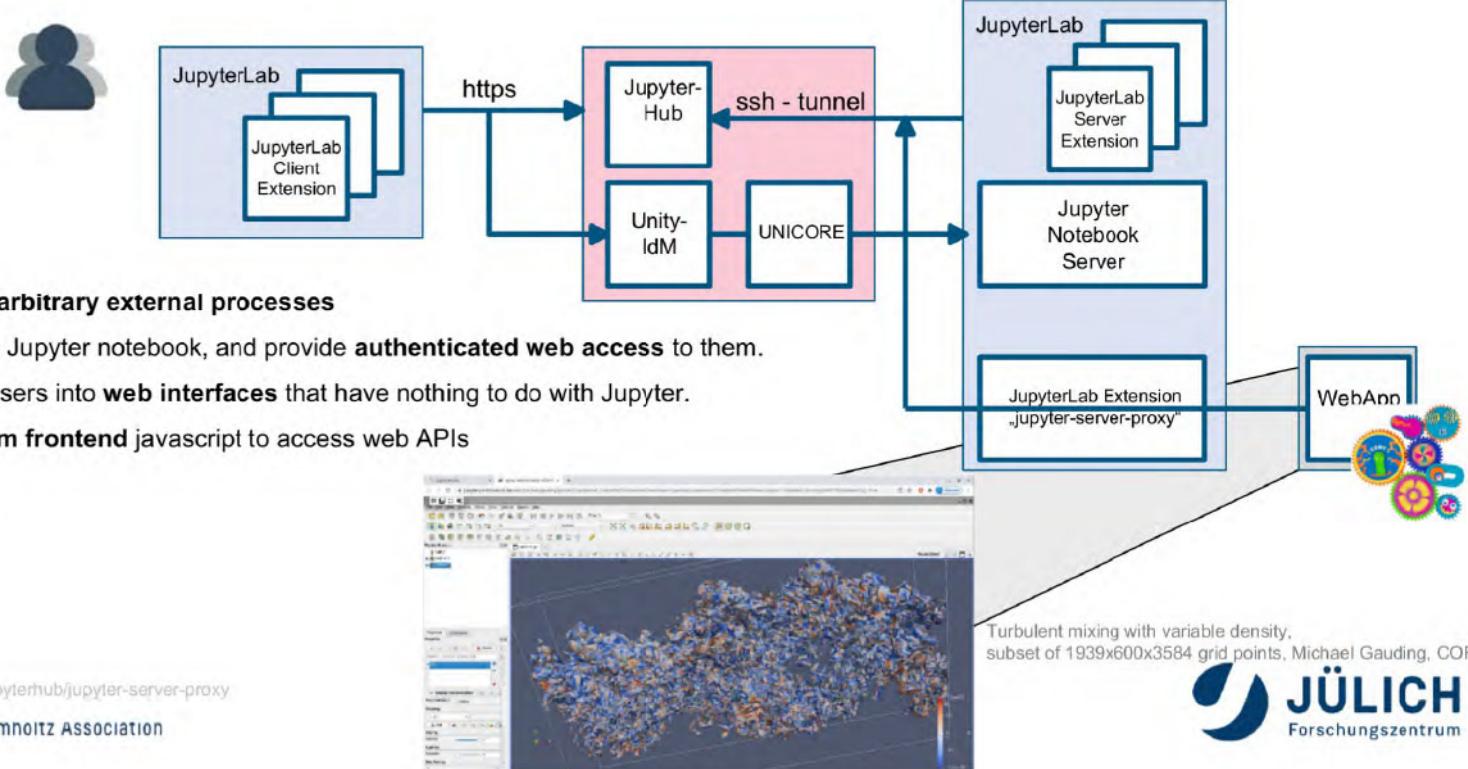


You can easily **create your own kernel** which for example runs your specialized virtual Python environment.

<https://github.com/jupyter/jupyter/wiki/Jupyter-kernels>

JUPYTERLAB – WEBSERVICE PROXY

Extension: jupyter-server-proxy



QUESTIONS?

<https://jupyter-jsc.fz-juelich.de>



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