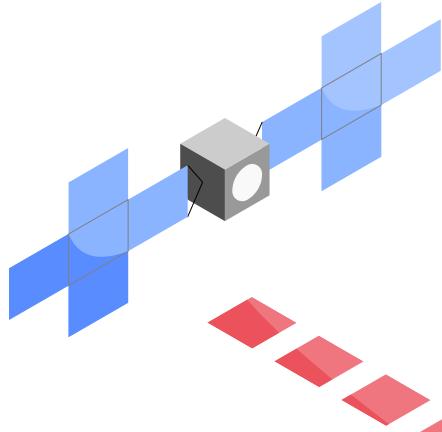


# JUICE on ESA DataLabs

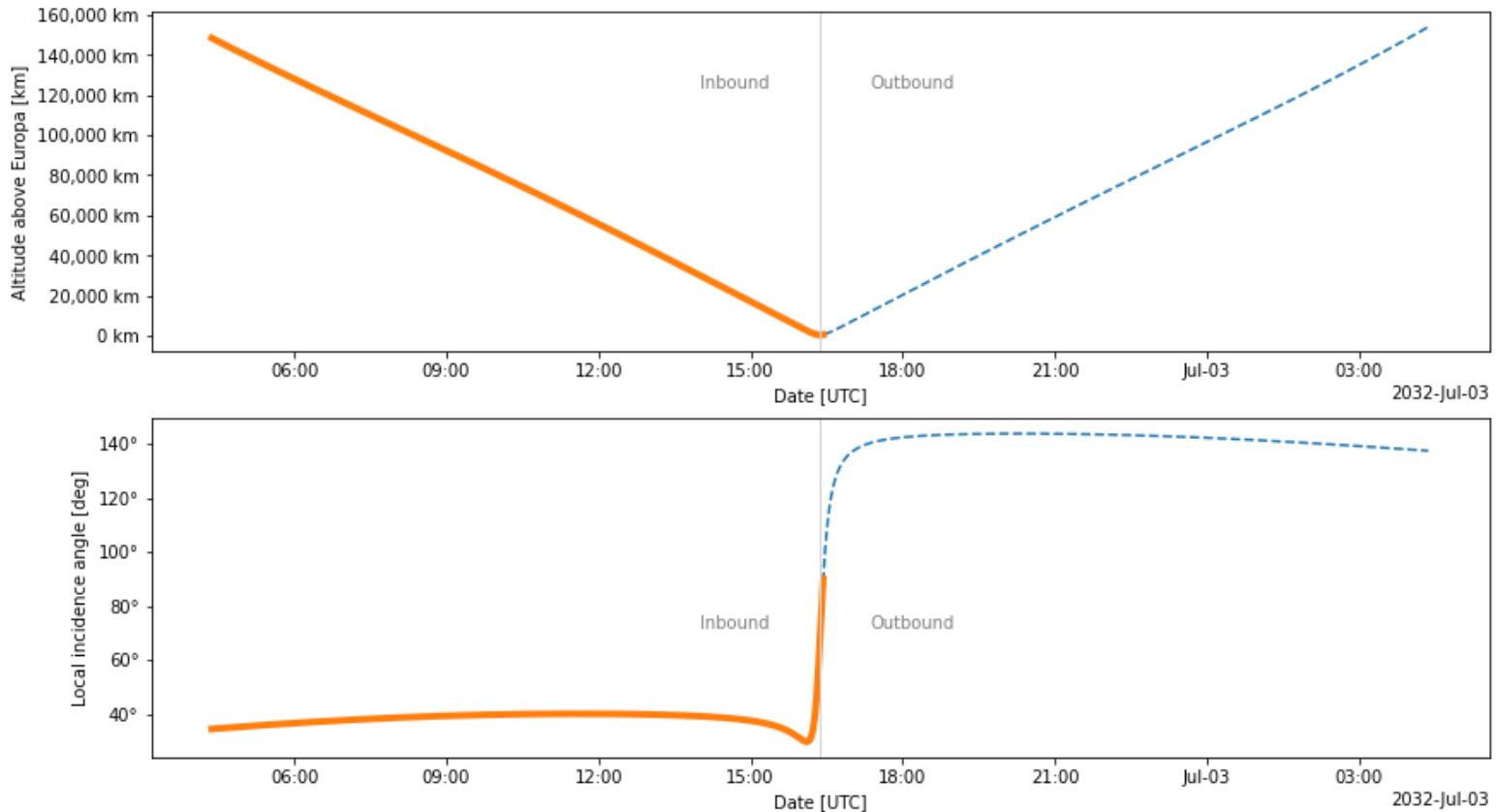
*Science planning opportunities and coverage analysis*

B. Seignovert, G. Tobie, C. Vallat, N. Altobelli, I. Belgacem & M. Costa

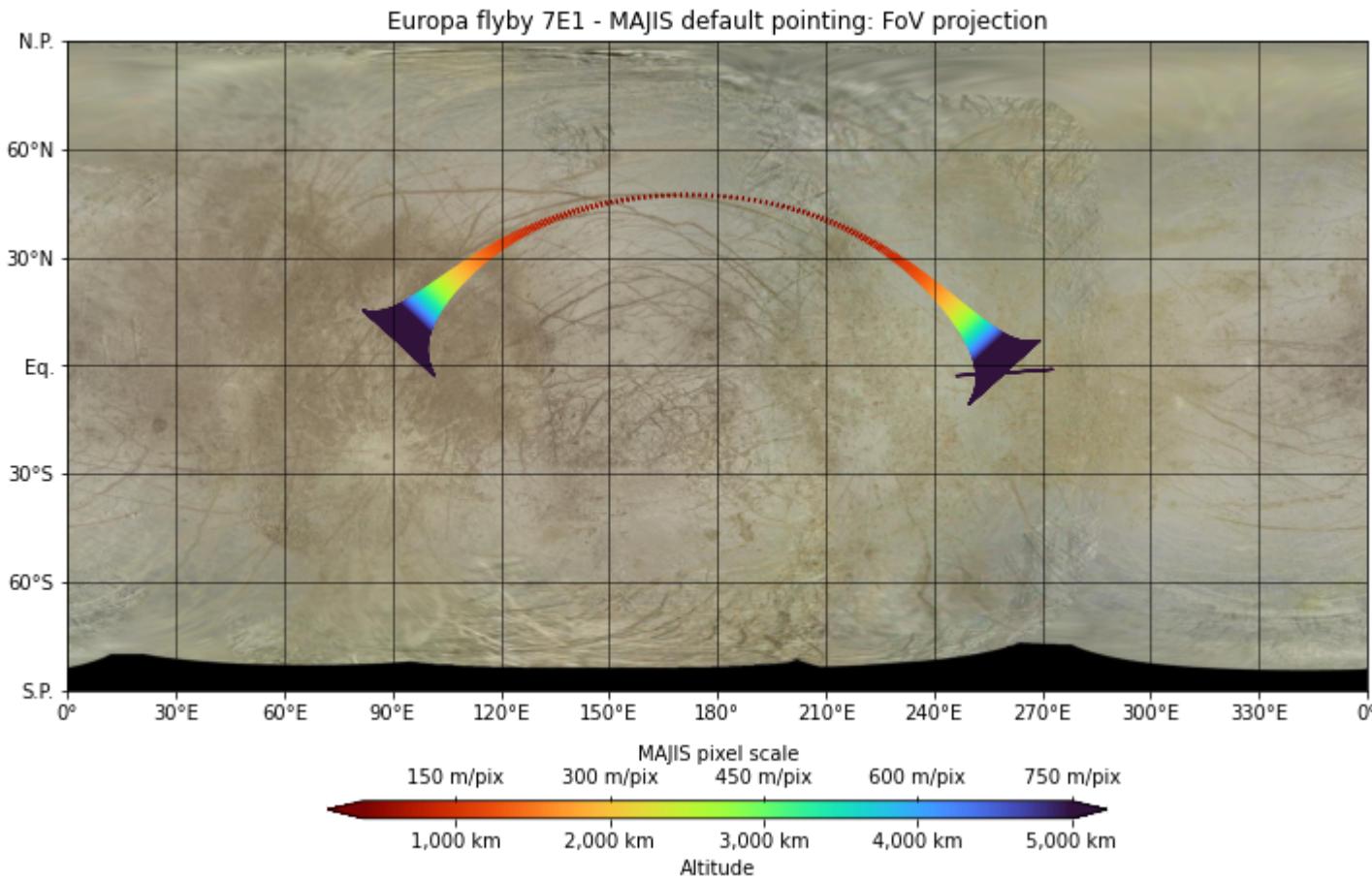


# Mission planning

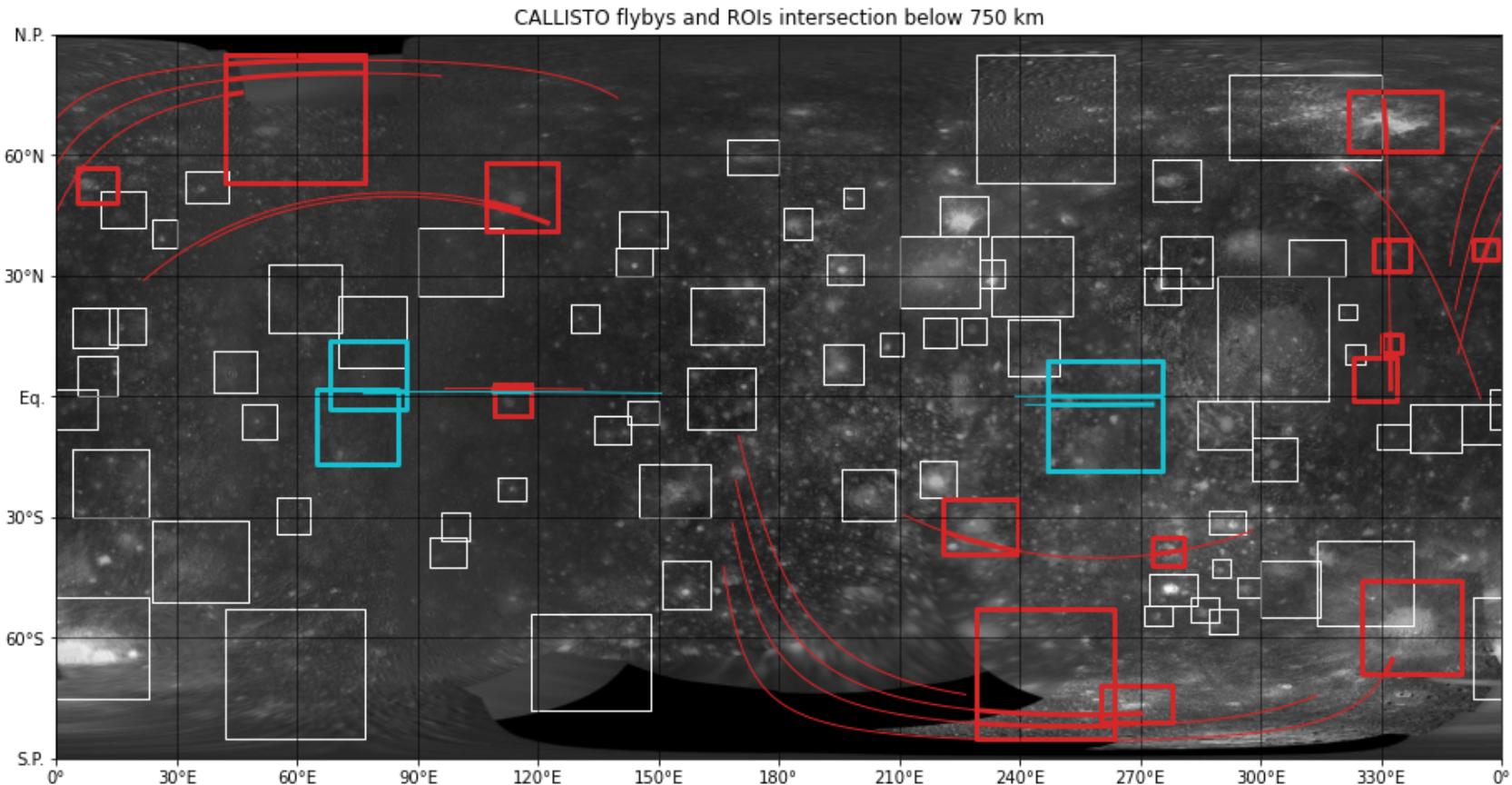
# 1 - Timelines and filtering



## 2 - Tracks and footprints

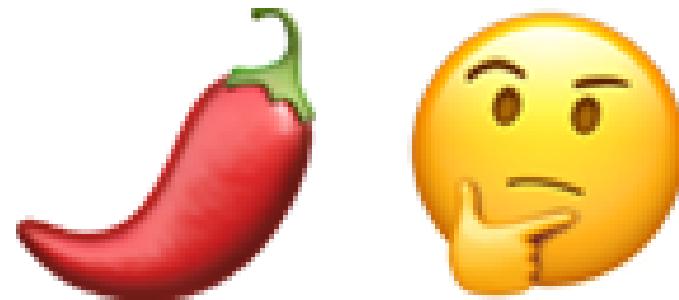


# 3 - Regions of interest intersections



# **SPICE**

# SPICE



# S<sub>p</sub>acecraft P<sub>lanet</sub> I<sub>nstrument</sub> C<sub>amera</sub> E<sub>vents</sub>



The Navigation and Ancillary Information Facility

[+ View the NASA Portal](#)

**SPICE**

An Observation Geometry System  
for Space Science Missions

Click here for [announcements](#) regarding SPICE data, software, tutorials and training; last updated **November 1, 2022**.

**If you are unfamiliar with SPICE, click here after reading the text below.**

NASA's Navigation and Ancillary Information Facility (NAIF) offers NASA flight projects and NASA funded researchers the "SPICE" observation geometry information system to assist scientists in planning and interpreting scientific observations from space-based instruments aboard robotic planetary spacecraft. SPICE is also used in support of engineering tasks associated with these missions. While planetary missions were the original focus, today SPICE is also used on some heliophysics and earth science missions.

The SPICE system is freely available to space agencies, scientists and engineers around the globe, subject to the provisions explained on the [Support](#) and [Rules](#) web pages. It is also available to the general public with the caveat that [support from NAIF is VERY LIMITED](#).

[Home](#)  
[Announcements](#)  
[About SPICE](#)  
[About NAIF](#)  
[For New Projects](#)  
[For the Public](#)  
[Data Toolkit Utilities](#)  
[WebGeocalc](#)  
[Cosmographia](#)  
[Documentation](#)  
[Tutorials](#)  
[Lessons](#)  
[Training](#)  
[Bugs](#)  
[Useful Links](#)  
[Rules](#)  
[Giving Credit](#)  
[Feedback](#)

- Developed by NASA / JPL
- Started in 1982
- 1st public release ~1995
- Used in many space missions
- Fully tested
- Very reliable
- C / Fortran / IDL / Matlab / Java

# SPICE

spacecraft planet instrument camera events



**SPICE » Home**

- Home**
- Data**
- Missions**
- WebGeocalc**
- Cosmographia**
- Training**
- Planetary Science Archive**

---

**DATA**

**OPERATIONAL KERNELS**  
The following links provide access to operational kernels for ESA's missions:

- SPICE FTP repository
- SPICE HTTP repository
- SPICE BitBucket repositories

**PDS ARCHIVED KERNELS**  
Archived kernels in PDS3 and PDS4 standards for ESA missions hosted by the Planetary Science Archive (PSA):

- Ancillary data at the PSA

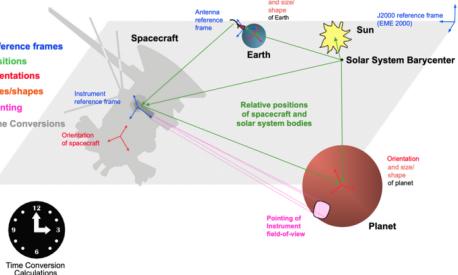
**SERVICES**

**WEBGEOCALC**  
WebGeocalc is a web-based graphical user interface to many of the observation geometry computations available for the "SPICE" system.

- WebGeocalc

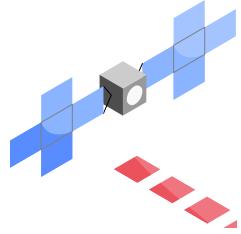
More information can be found [here](#).

**COSMOGRAPHIA**  
Cosmographia is an interactive tool used to produce 3D visualization of a given planetary mission; spacecraft trajectories and orientations, instrument field-of-views and footprints. Cosmographia for ESA Planetary missions is available [here](#).



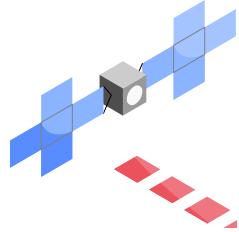
- Expert users
- Mission / instrument specific
- Complex setup
- Very large *kernels* dataset

See Alfredo Escalante talk at 3 PM



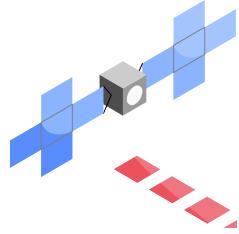
# moon-coverage

- Python 3.8+ object oriented library
- Open-source BSD licence
- Use only `numpy`, `matplotlib` and `spiceypy`



# moon-coverage

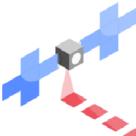
- Python 3.8+ object oriented library
- Open-source BSD licence
- Use only `numpy`, `matplotlib` and `spiceypy`
- Developed at the ***LPG/Nantes Université***
- Founded by ***ESA JUICE SOC***



# moon-coverage

- Python 3.8+ object oriented library
- Open-source BSD licence
- Use only `numpy`, `matplotlib` and `spiceypy`
- Developed at the ***LPG/Nantes Université***
- Founded by ***ESA JUICE SOC***
- Fully [tested](#) and [documented](#) package
- Available on [PyPI](#) (0.12.0)
- Deployed on [ESA Datlabs](#) in April 2021

# moon-coverage.univ-nantes.fr



## Moon Coverage Documentation

Search the docs ...

**GET STARTED**

- Installation and updates
- Kernel management
- Presentation of the tool in video

**TRAJECTORY CALCULATIONS**

- Spacecraft Trajectory
- Instrument Trajectory
- Flyby Trajectory
- Regions of Interest

**SPICE TOOLS**

- SPICE kernel
- SPICE metakernel

ReadTheDocs v: stable ▾

## Moon Coverage Documentation

The [moon-coverage](#) python package is a toolbox to perform surface coverage analysis based on orbital trajectory configuration. Its main intent is to provide an easy way to compute observation opportunities of specific region of interest above the Galilean satellites for the ESA-JUICE mission but could be extended in the future to other space mission.

It is actively developed by the [Laboratory of Planetology and Geosciences](#) (CNRS-UMR 6112) at Nantes University (France), under [ESA-JUICE](#) funding support.



By LPG Nantes  
© Copyright 2020-2022 - All right reserved.

Next >  
[Installation and updates](#)

# How to install it?



Python



```
pip install moon-coverage
```



Conda-Forge

Coming soon...

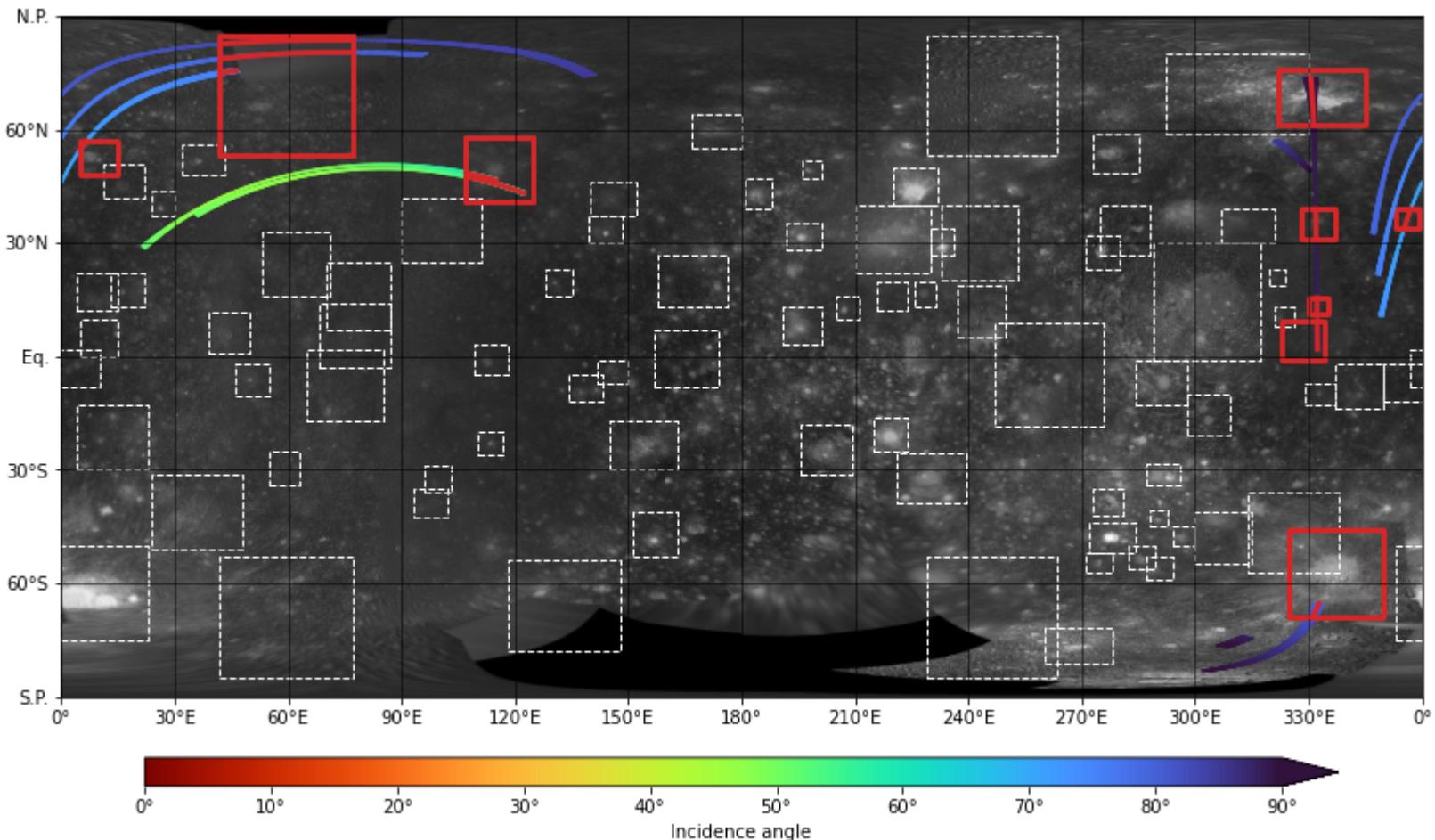


# 20 lines from scratch to plot!



```
1 import matplotlib.pyplot as plt
2 from moon_coverage import TourConfig, CALLISTO, CallistoROIs
3
4 tour = TourConfig(mk=5.0, spacecraft='JUICE', instrument='MAJIS_IR', target='Callisto')
5
6 fig = plt.figure()
7 ax = fig.add_subplot(projection=CALLISTO)
8
9 ax.add_collection(CallistoROIs(edgecolor='white', linestyle='--'))
10
11 for flyby in tour.flybys:
12     traj = flyby.where((flyby.alt < 750) & (flyby.inc < 90))
13
14     ax.add_collection(traj.fovs('inc', vmin=0, vmax=90))
15
16     if traj in CallistoROIs:
17         ax.plot(traj & CallistoROIs, color='red')
18         ax.add_collection((CallistoROIs & traj)(edgecolor='red'))
19
20 ax.colorbar(vmin=0, vmax=90, label='inc', extend='max')
```

# Callisto flybys planning



**Demo time !**



ESA Datalabs [0.3.0/BETA]

# Create Datalab

Find a datalab in ESA datalabs catalog

Filter results

 <b>aladin</b> Aladin is an interactive sky atlas allowing the user to visualize digitized astronomical images or full surveys, superimpose entries from astronomical catalogues or databases, and interactively access related data and information from the <i>Simbad database</i> , the <i>VizieR</i> service and other services for all known astronomical objects in the field.	 <b>filezilla</b> FileZilla	 <b>fv</b> FV - An image display and visualization tool for astronomical data
 <b>jl-esdc</b> JupyterLab ESDC	 <b>jl-euclid-dps</b> Euclid DPS JupyterLab	 <b>jl-herschel</b> Herschel JupyterLab
 <b>jl-juice</b> JupyterLab with JUICE moon coverage tool (0.12.0).	 <b>jl-pangaia</b> PanGaia JupyterLab	 <b>jupyterlab</b> Plain JupyterLab for demonstration of basic functionality.
 <b>jwst</b> JupyterLab JWST	 <b>jwst-miricle</b> JupyterLab JWST Miricle	 <b>jwst-nips</b> JupyterLab JWST NIPS
 <b>jwst-nsrt</b> JupyterLab JWST NSRT	 <b>qfitsview</b> QFitsView - An image display and visualization tool for astronomical data	 <b>theia-python</b> Theia Python Editor
 <b>x-cosmographia</b> Cosmographia	 <b>x-ds9</b> SAOImageDS9 - An image display and visualization tool for astronomical data	 <b>x-glab</b> GNSS-Lab Tool (gLAB)
 <b>x-octave</b> Scientific Programming Language.	 <b>x-topcat</b> Tool for OPerations on Catalogues And Tables	



→ THE EUROPEAN SPACE AGENCY



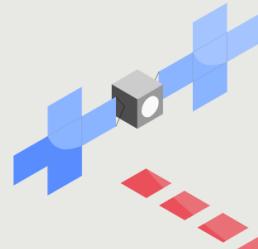
ESA Datalabs [0.3.0/BETA]



# Datalab Launch

## jl-juice

JupyterLab with JUICE moon coverage tool (0.12.0).



### Options

Name (optional)

JUICE coverage

select datalab as soon as its interface is available

+ LAUNCH IT!

× CANCEL

<https://datalabs.esa.int/datalab-launch-wizard/jl-juice>

THE EUROPEAN SPACE AGENCY

esa

## ESA DataLabs [0.3.0/BETA]

File Edit View Run Kernel Git Tabs Settings Help

DataLabs\_workshop\_2022.ipynb

Python 3 (ipykernel)

**ESA DataLabs workshop - JUICE demo**

2022/11/24 | B. Seignovert, G. Tobie, C. Vallat, N. Altobelli, I. Belgacem & M. Costa

The presentation can be found here: [slid.es/seignovert/datalabs-2022](https://slid.es/seignovert/datalabs-2022)

```
[1]: # DataLabs JUICE kernels location
%env KERNELS_JUICE=/media/data/kernels/JUICE/kernels
env: KERNELS_JUICE=/media/data/kernels/JUICE/kernels
```

### Callisto flybys planning example

```
[2]: import matplotlib.pyplot as plt
from moon_coverage import TourConfig, CALLISTO, CallistoROIs

[3]: tour = TourConfig(mk=5.0, spacecraft='JUICE', instrument='MAJIS_IR', target='Callisto')

fig = plt.figure(figsize=(16, 7))
ax = fig.add_subplot(projection=CALLISTO)

ax.add_collection(CallistoROIs(edgecolor='white', linestyle='--'))

for flyby in tour.flybys:
    traj = flyby.where((flyby.alt < 750) & (flyby.inc < 90))

    ax.add_collection(traj.fovs('inc', vmin=0, vmax=90))

    if traj in CallistoROIs:
        ax.plot(traj & CallistoROIs, color='red')
        ax.add_collection((CallistoROIs & traj)(edgecolor='red'))

ax.colorbar(vmin=0, vmax=90, label='inc', extend='max');
```

Simple 0 1 Python 3 (ipykernel) | Idle Mode: Command Ln 3, Col 88 DataLabs\_workshop\_2022.ipynb

THE EUROPEAN SPACE AGENCY

esa

## ESA DataLabs [0.3.0/BETA]

File Edit View Run Kernel Git Tabs Settings Help

DataLabs\_workshop\_2022.ipynb

Filter files by name

- / data / kernels /
- Name Last Modified
- BEPICOLOMBO a year ago
- CHANDRAYAAN-1 14 years ago
- COMET-INTERCEPTOR 2 months ago
- EnVision 3 years ago
- esa\_generic 3 years ago
- ExoMars2016 a year ago
- ExoMarsRSP 4 years ago
- Gaia 3 years ago
- GIOTTO 3 years ago
- hera 5 months ago
- HUYGENS 4 years ago
- INTEGRAL 7 months ago
- JUICE 2 years ago
- JWST 3 years ago
- LPF 3 years ago
- MARS-EXPRESS 5 years ago
- ROSETTA 5 years ago
- SMART-1 3 years ago
- SOLAR-ORBITER 3 years ago
- VENUS-EXPRESS 4 years ago

**ESA DataLabs workshop - JUICE demo**

2022/11/24 | B. Seignovert, G. Tobie, C. Vallat, N. Altobelli, I. Belgacem & M. Costa

The presentation can be found here: [slid.es/seignovert/datalabs-2022](https://slid.es/seignovert/datalabs-2022)

```
[1]: # DataLabs JUICE kernels location
%env KERNELS_JUICE=/media/data/kernels/JUICE/kernels
env: KERNELS_JUICE=/media/data/kernels/JUICE/kernels
```

**Callisto flybys planning example**

```
[2]: import matplotlib.pyplot as plt
from moon_coverage import TourConfig, CALLISTO, CallistoROIs

[3]: tour = TourConfig(mk=5.0, spacecraft='JUICE', instrument='MAJIS_IR', target='Callisto')

fig = plt.figure(figsize=(16, 7))
ax = fig.add_subplot(projection=CALLISTO)

ax.add_collection(CallistoROIs(edgecolor='white', linestyle='--'))

for flyby in tour.flybys:
    traj = flyby.where((flyby.alt < 750) & (flyby.inc < 90))

    ax.add_collection(traj.fovs('inc', vmin=0, vmax=90))

    if traj in CallistoROIs:
        ax.plot(traj & CallistoROIs, color='red')
        ax.add_collection((CallistoROIs & traj)(edgecolor='red'))

ax.colorbar(vmin=0, vmax=90, label='inc', extend='max');
```

Simple 0 1 Python 3 (ipykernel) | Idle Mode: Command Ln 3, Col 88 DataLabs\_workshop\_2022.ipynb

THE EUROPEAN SPACE AGENCY

esa

## ESA DataLabs [0.3.0/BETA]

File Edit View Run Kernel Git Tabs Settings Help

DataLabs\_workshop\_2022.ipynb

Python 3 (ipykernel)

**ESA DataLabs workshop - JUICE demo**

2022/11/24 | B. Seignovert, G. Tobie, C. Vallat, N. Altobelli, I. Belgacem & M. Costa

The presentation can be found here: [slid.es/seignovert/datalabs-2022](https://slid.es/seignovert/datalabs-2022)

```
[1]: # DataLabs JUICE kernels location
%env KERNELS_JUICE=/media/data/kernels/JUICE/kernels
env: KERNELS_JUICE=/media/data/kernels/JUICE/kernels
```

### Callisto flybys planning example

```
[2]: import matplotlib.pyplot as plt
from moon_coverage import TourConfig, CALLISTO, CallistoROIs

[3]: tour = TourConfig(mk=5.0, spacecraft='JUICE', instrument='MAJIS_IR', target='Callisto')

fig = plt.figure(figsize=(16, 7))
ax = fig.add_subplot(projection=CALLISTO)

ax.add_collection(CallistoROIs(edgecolor='white', linestyle='--'))

for flyby in tour.flybys:
    traj = flyby.where((flyby.alt < 750) & (flyby.inc < 90))

    ax.add_collection(traj.fovs('inc', vmin=0, vmax=90))

    if traj in CallistoROIs:
        ax.plot(traj & CallistoROIs, color='red')
        ax.add_collection((CallistoROIs & traj)(edgecolor='red'))

ax.colorbar(vmin=0, vmax=90, label='inc', extend='max');
```

Simple 0 1 Python 3 (ipykernel) | Idle Mode: Command Ln 3, Col 88 DataLabs\_workshop\_2022.ipynb

Menu

Moon coverage - Noteboo...

- Project information
- Repository
- Issues 2
- Merge requests 0
- CI/CD
- Deployments
- Settings

ESA JUICE Datalabs > Moon coverage - Notebooks

## Moon coverage - Notebooks

Project ID: 85

17 Commits 1 Branch 4 Tags 46.8 MB Project Storage 4 Releases

Topics: juice datalabs jupyter

Collection of example notebooks based on the moon-coverage tool.

pipeline passed launch binder

main moon-coverage-notebooks / + Find file Web IDE Clone

Fix JUICE PTR links in README (!16)  
Benoit Seignovret authored 1 day ago

✓ 23c475bf

README BSD 3-Clause "New" or "Revised" License CI/CD configuration Configure Integrations

Name	Last commit	Last update
.binder	Upgrade to 0.12.0 and add new use cases...	2 days ago
imgs	Bump moon-coverage version to 0.11.0 a...	4 months ago
notebooks	Fix JUICE PTR links in README (!16)	1 day ago
.bumpversion.cfg	Upgrade to 0.12.0 and add new use cases...	2 days ago
.gitignore	Initial commit	11 months ago
.gitlab-ci.yml	Enforce metakernel version in the exempl...	3 months ago
LICENSE.md	Fix typos and update LPG affiliation	10 months ago
README.md	Fix JUICE PTR links in README (!16)	1 day ago
jupyter_config.json	Bump moon-coverage version to 0.11.0 a...	4 months ago
poetry.lock	Upgrade to 0.12.0 and add new use cases...	2 days ago
project.toml	Upgrade to 0.12.0 and add new use cases...	2 days ago

« Collapse sidebar

<https://juigitlab.esac.esa.int/datalab/moon-coverage-notebooks>

THE EUROPEAN SPACE AGENCY

esa

**ESA Datalabs [0.3.0/BETA]**

File Edit View Run Kernel Git Tabs Settings Help

README.ipynb

Moon-coverage examples

The `moon-coverage` tool is a Python package to plan and visualize planetary surface coverage. Built on top of `spiceypy` it provides an object-oriented approach to perform spacecraft trajectory computations, instrument field of view projections and region of interest intersections. Originally developed for the ESA-JUICE mission, this tool can handle many space mission (Europa-Clipper, BepiColombo, EnVision, Juno...).

This notebook provides a collection of examples on how-to-use the `moon-coverage` tool version `0.12.0` in the context of the JUICE mission. The complete documentation of this module can be found on [here](#) for additional details.

```
[1]: from moon_coverage import __version__
      f'You current version of the moon-coverage is: {__version__}'
```

[1]: You current version of the moon-coverage is: 0.12.0

Available notebooks

	View	Download
(1) Kernel management		
(2) Trajectories calculations		
(3) Regions of Interest intersection		
(4) ESA events files		
(5) Europa 7E1 scenario		
(6) MAJIS coverage opportunities		
(7) Pointing Timeline Request (PTR)		

spice\_kernels.ipynb

## Using the SPICE kernels with the moon-coverage

This notebook present a few examples on how you can manage your own SPICE kernels set with the `moon-coverage`.

### Download a single kernel from a remote location

We will start by downloading a leap seconds kernel. To do that, we will use the `kernel-download` command line interface that was installed with the `moon-coverage`:

```
[1]: !kernel-download --help
usage: kernel-download [-h] [-r REMOTE] [--nasa MISSION] [--esa MISSION]
                      [--iaya MSSSTON] [-o KERNELS_DIR] [-f] [-s]
```

trajectory\_examples.ipynb

```
[1]: ax.set_title('MAJIS footprints during 2G2 flyby (Feb. 13th 2032)');
```

MAJIS footprints during 2G2 flyby (Feb. 13th 2032)

N.P.  
60°N  
30°N  
Eq  
30°S  
60°S  
S.P.  
0°  
200 m/pix 400 m/pix 600 m/pix 800 m/pix 1,000 m/pix

Mode: Command Ln 1, Col 1 trajectory\_examples.ipynb

# DataLabs advantages

- No setup for the user
- Access to all ESA SPICE kernels (no download required)
- Re-use of existing notebooks (git plugin)

# Current limitations



- Limited number of users



- Volume manual mounting



- No team shared workspaces



- Tools upgrade (👉 SciApps)



- Real time collaboration



- Open in ESA DataLabs



launch

ESA DataLabs

This presentation:



[slid.es/seignovert/datalabs-2022](https://slid.es/seignovert/datalabs-2022)

The tool:



[moon-coverage.univ-nantes.fr](http://moon-coverage.univ-nantes.fr)

Contact us:

[moon-coverage@univ-nantes.fr](mailto:moon-coverage@univ-nantes.fr)