

# Open science in aviation, where are we now?

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3 April 2025

# Part 1: A brief history: open aviation data, tools, and events

# ADS-B: The start of open-science in aviation



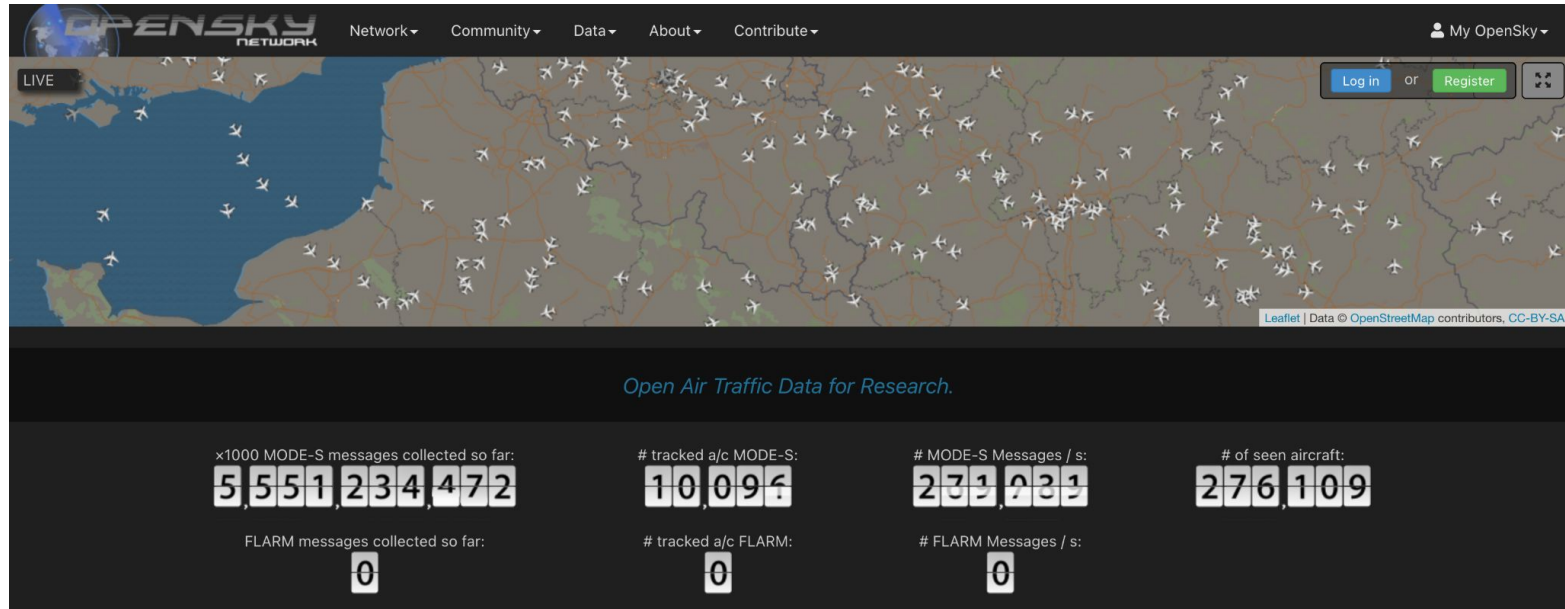
Why did it take off?

- Low cost
- Low power
- Small antenna
- Open broadcast

Who are the earlier adopters?

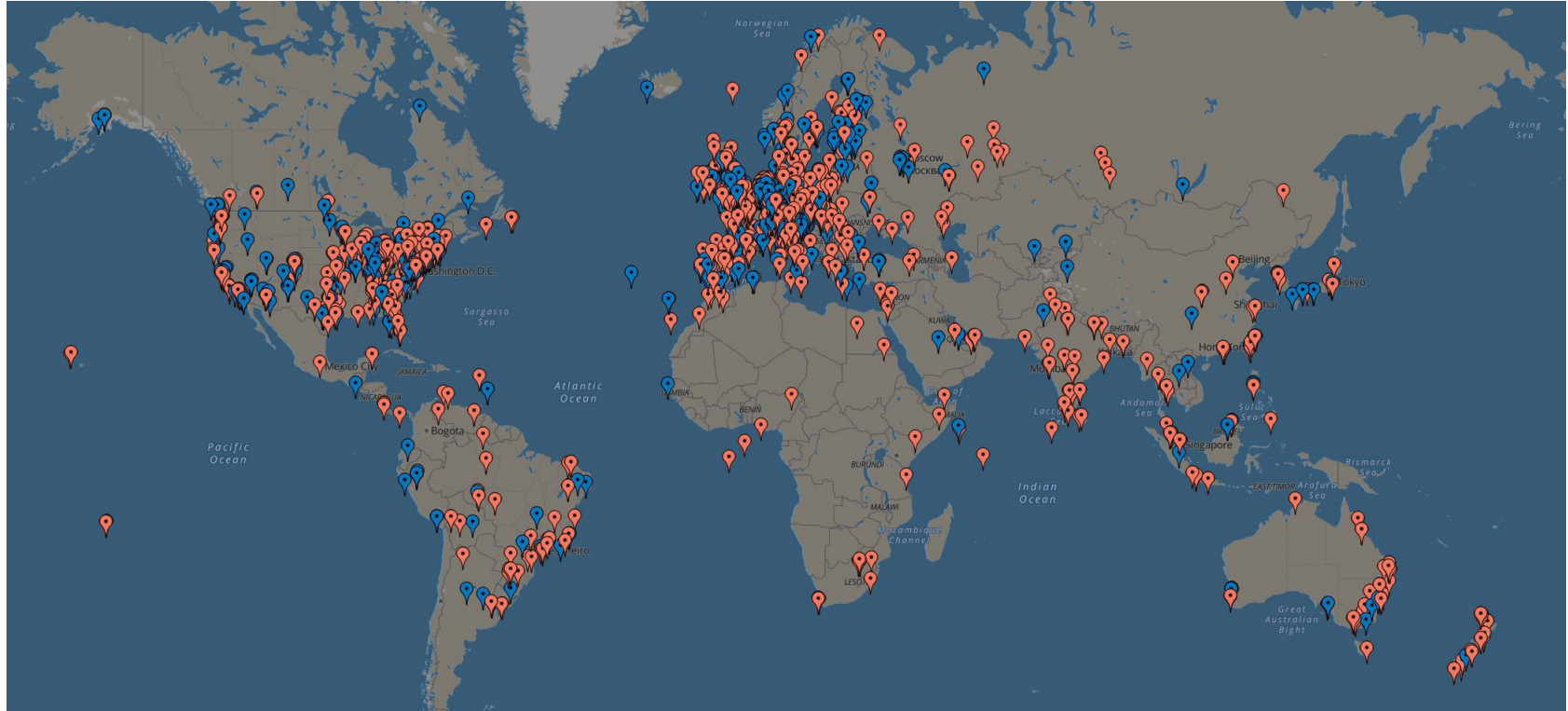
- Hobbyists
- Researchers
- Flight tracking websites

# The OpenSky Network

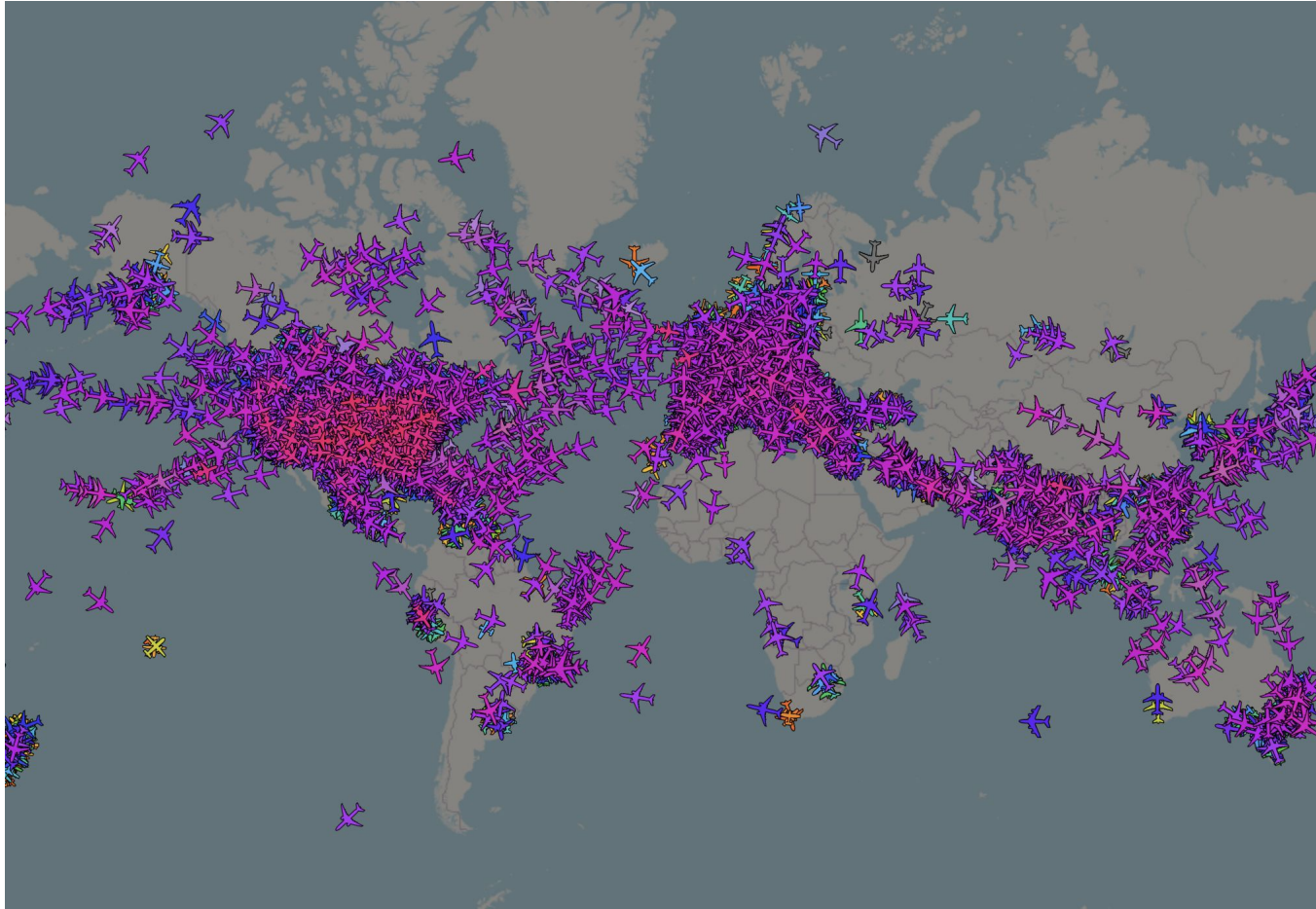


- Started in 2012 as a joint research between **armasuisse** (Switzerland), **University of Kaiserslautern** (Germany), and **University of Oxford** (UK)
- In 2015, became an independent non-profit organization serving community open data for research

# OpenSky coverage



# OpenSky coverage



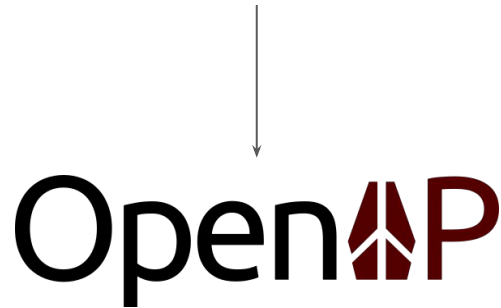


# The Open Aviation Data **Portal** (a.k.a. just a website)



<https://mode-s.org/atmdata/>

# The start of open-source movement for aviation research



pyModeS





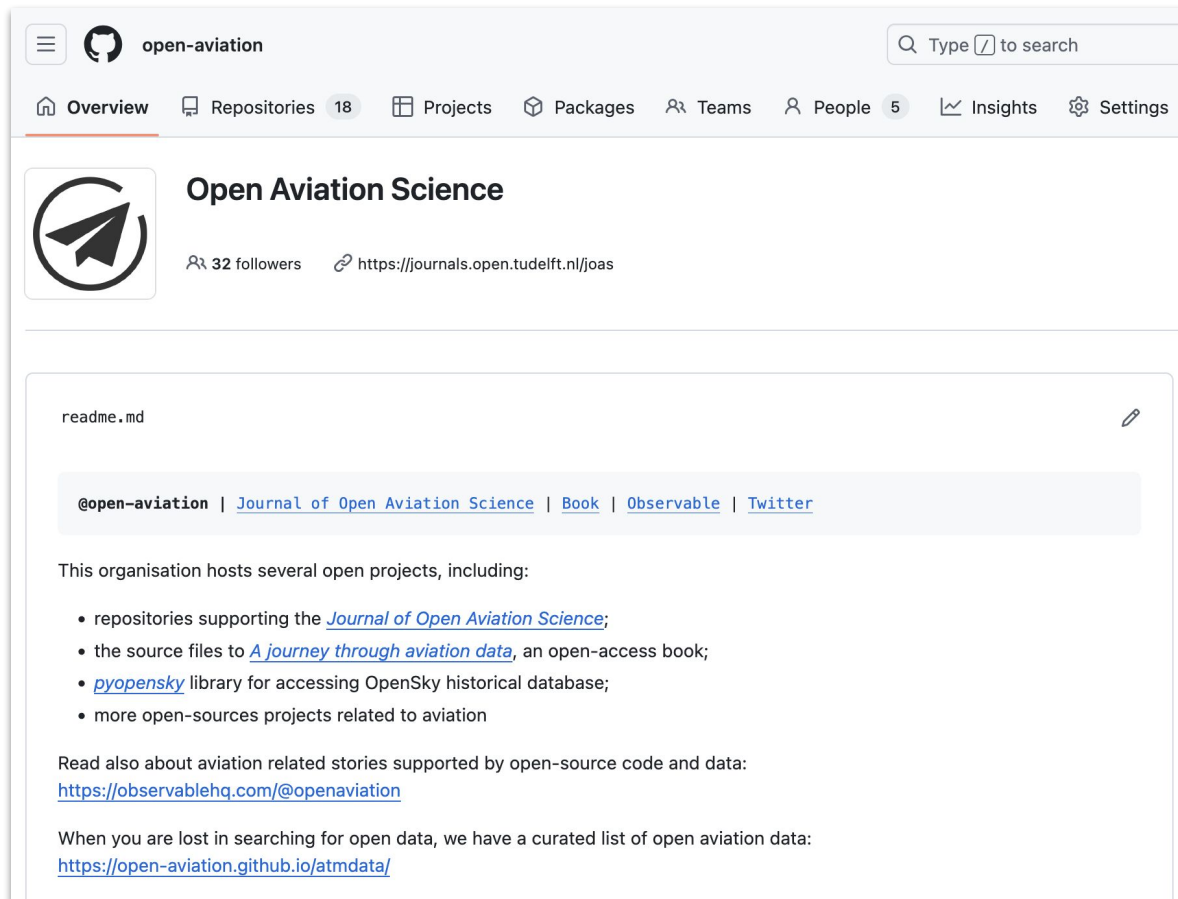
# Where do we ~~party~~ exchange research ideas?



- [2015, Oxford, United Kingdom](#)
- [2016, Oxford, United Kingdom](#)
- [2017, Kaiserslautern, Germany](#)
- [2018, Frankfurt, Germany](#)
- [2019, Zurich, Switzerland](#)
- [2020, Virtual, Eurocontrol](#)
- [2021, Brussels, Belgium](#)
- [2022, Delft, Netherlands](#)
- [2023, Toulouse, France](#)
- [2024, Hamburg, Germany](#)

## Part 2: Recent developments

# The basecamp on GitHub




The screenshot shows the GitHub profile page for the organization 'open-aviation'. The header includes the GitHub logo, the organization name, and a search bar. Below the header is a navigation bar with tabs for Overview, Repositories (18), Projects, Packages, Teams, People (5), Insights, and Settings. The main content area features the organization's profile picture (a stylized paper airplane), the name 'Open Aviation Science', 32 followers, and a website link. Below this is a 'readme.md' section containing a list of links to the organization's projects and a detailed description of the projects hosted.

open-aviation

Search: Type  to search

Overview Repositories 18 Projects Packages Teams People 5 Insights Settings

 **Open Aviation Science**

32 followers <https://journals.open.tudelft.nl/joas>

readme.md

@open-aviation | [Journal of Open Aviation Science](#) | [Book](#) | [Observable](#) | [Twitter](#)


This organisation hosts several open projects, including:

- repositories supporting the [Journal of Open Aviation Science](#);
- the source files to [A journey through aviation data](#), an open-access book;
- [pyopensky](#) library for accessing OpenSky historical database;
- more open-sources projects related to aviation

Read also about aviation related stories supported by open-source code and data:  
<https://observablehq.com/@openaviation>

When you are lost in searching for open data, we have a curated list of open aviation data:  
<https://open-aviation.github.io/atmdata/>

# Aesthetics, it's always about aesthetics.



## Open Aviation

We are a group of passionate researchers and professionals working to make access to aviation data and models open.

Public notebooks


Public collections

## Public notebooks

Sort

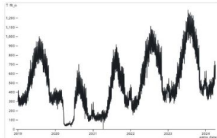
Published

Showing all 9 notebooks




**Decode ADS-B and Mode S messages with rs1090**

Open Aviation  
Dec 27




**Departure, Arrival, Internal and Overflight (DAIO) flights per Country FIR in Europe**

Open Aviation  
Apr 6, 2024



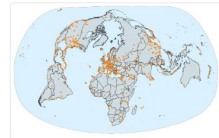
**Firefighting activities of civil security aircraft in France**

Open Aviation  
Mar 8, 2023 · ☆ 2



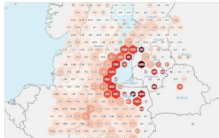
**OurAirports data**

Open Aviation  
Aug 30, 2022 · ☆ 5




**Airports around the world**

Open Aviation  
Aug 30, 2022 · ☆ 5




**GPS jamming around Kaliningrad**

Open Aviation  
Mar 15, 2022 · ☆ 16



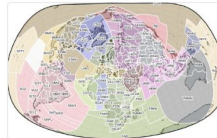
**Flying to Kaliningrad during the Russian flight ban**

Open Aviation  
Mar 14, 2022 · ☆ 12



**How flights between Europe and Eastern Asia got disrupted**

Open Aviation  
Mar 11, 2022 · ☆ 18

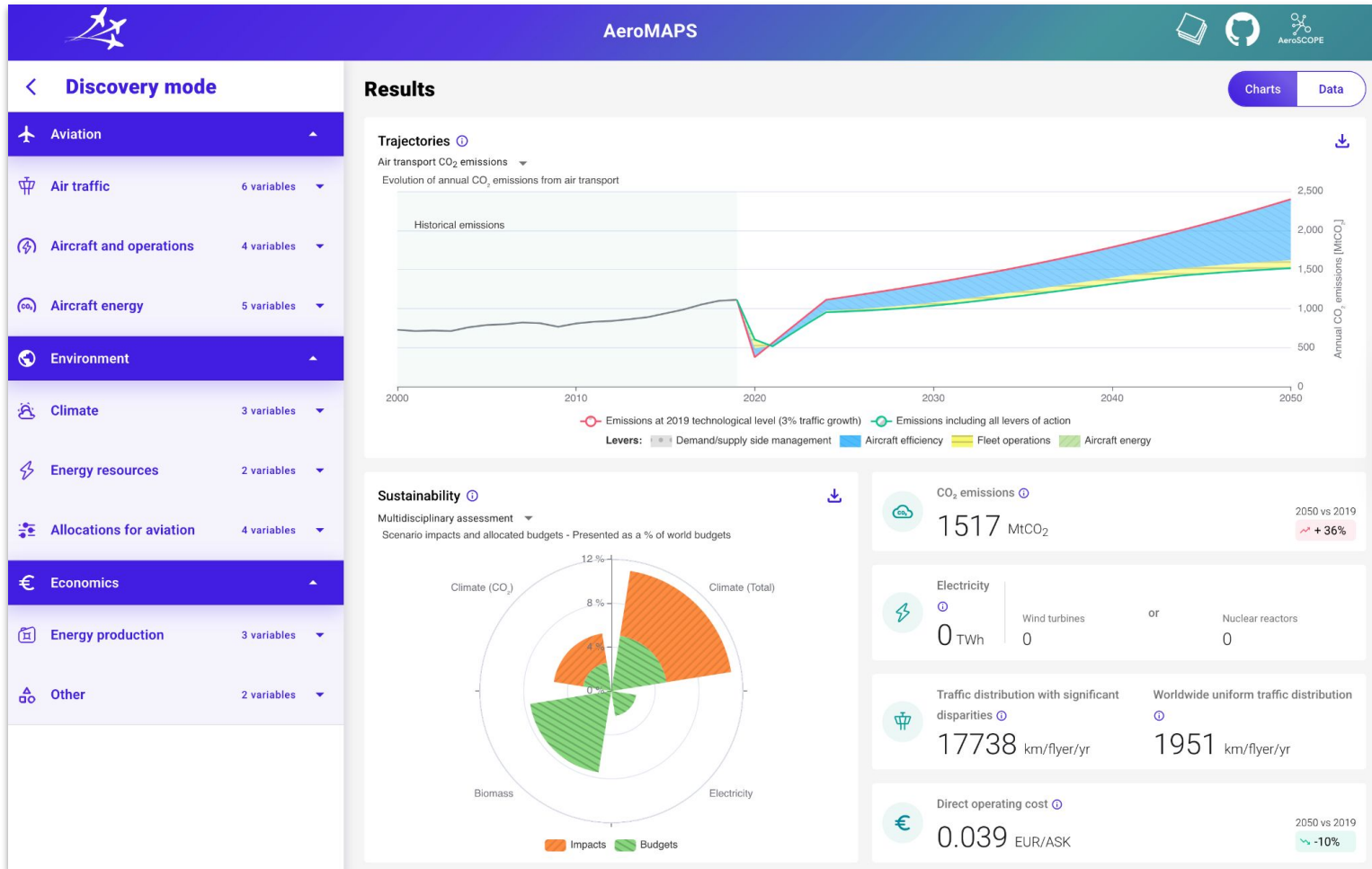


**Flight Information Regions**

Open Aviation  
Jan 30, 2022 · ☆ 27

<https://observablehq.com/@openaviation>

# New open-source projects: AeroMAPS



# New open-source projects: **MERCURY**



## **Mercury – An open-source platform for the evaluation of air transport mobility**

07/06/2024 - Open-source tools for Air Traffic Management modelling and research



**UNIVERSITY OF  
WESTMINSTER** 

# New open-source projects: Impunity & pitot

## Impunity: A Python library to check physical units

>>> Get Started <<<

### Easy to use

Based on a decorator, to add on any annotated function or class

### Support for various annotation styles

Usable with Annotated object or string annotations

### Integration with popular Python type checkers.

Can be used along mypy for powerful typing systems

### No additional runtime overhead

Impunity works directly on the AST for a static analysis of your code

```
@impunity
def speed(d: "m", t: "s") -> "m / s":
    return d / t
```

```
speed(10, 10) # returns 1
```

```
@impunity
def speed(d: "m", t: "s") -> "km / h":
    return d / t
```

```
speed(10, 10) # returns 3.6
```

```
@impunity
def speed(d: "m", t: "s") -> "feet":
    return d / t
```

```
# Warning: "Incompatible unit returned"
```

```
@impunity
def speed(d: "m", t: "s") -> "m / s":
    return d + t
```

```
# Warning: "Types are not compatible"
```

## pitot

tests **passing** coverage **unknown** mypy **checked** code style **black** license **MIT**  
pypi **v0.3.2** downloads **2.4k/month** conda-forge **v0.3.2** downloads **3.8k**

pitot is a Python toolbox providing efficient aeronautic calculations.

Implementations are:

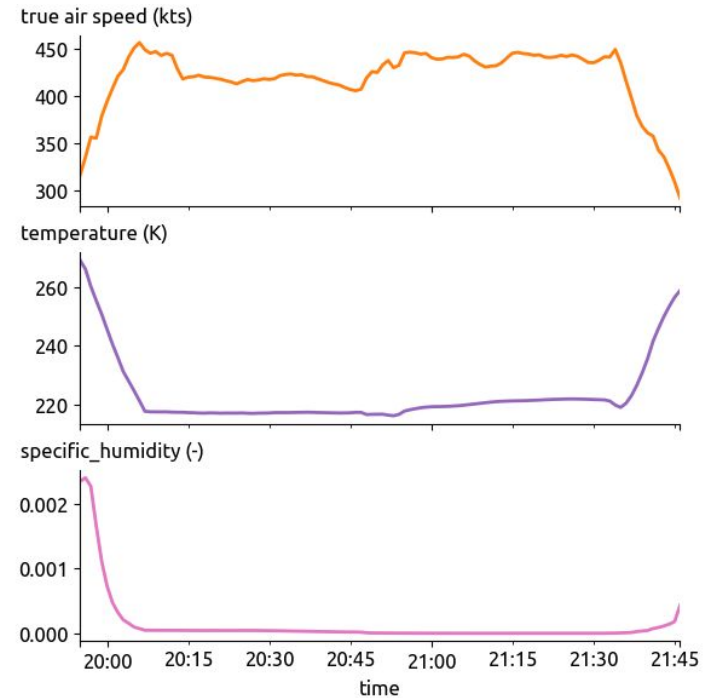
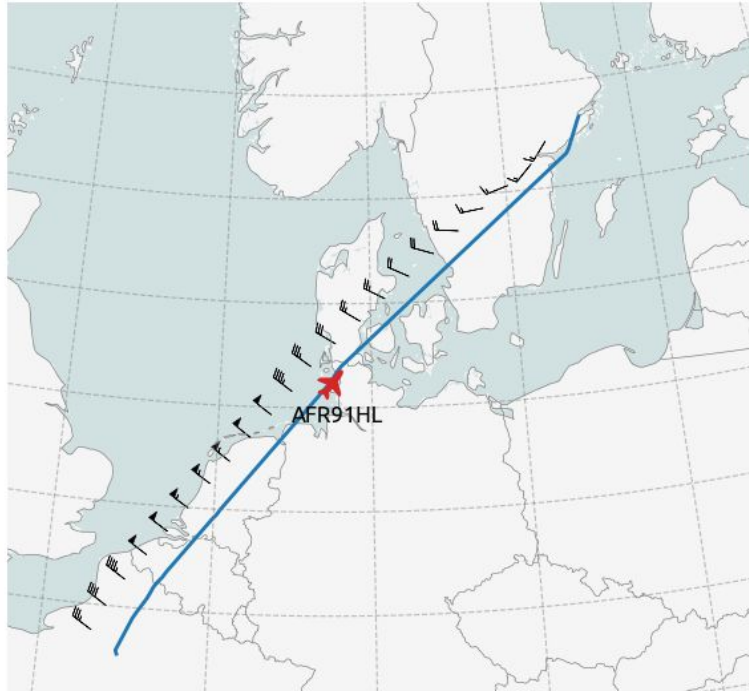
- **efficient**, based on NumPy or state-of-the-art libraries;
- provided with **typing stubs**;
- unambiguous with **physical units**, with the help of the [impunity](#) library, based on annotations.

The following functions are currently available:

- International Standard Atmosphere (temperature, density, pressure, and speed of sound);
- conversions between various air speeds: CAS, TAS, EAS and Mach number;
- geodetic calculations (distance, bearing, great circle, etc.) on a WGS84 ellipsoid.



# New open-source projects: **fastmeteo**



# New open-source projects: rs1090 & jet1090

## jet1090

jet1090 is a powerful tool for aviation enthusiasts ✈️, researchers 🔬, and developers 👩‍💻, which offers a **reliable, efficient, and flexible solution** for real-time ADS-B and Mode S data decoding and analysis.

jet1090 aims to be an essential open-source tool in the tangram suite for **tracking live flights** ✈️, **analyzing real-time aviation traffic patterns** 📊, and **creating polished visualizations** 📺 with minimal code.



### Tip

See the navigation links in the header or side-bar.

Click ☰ (top left) on mobile.

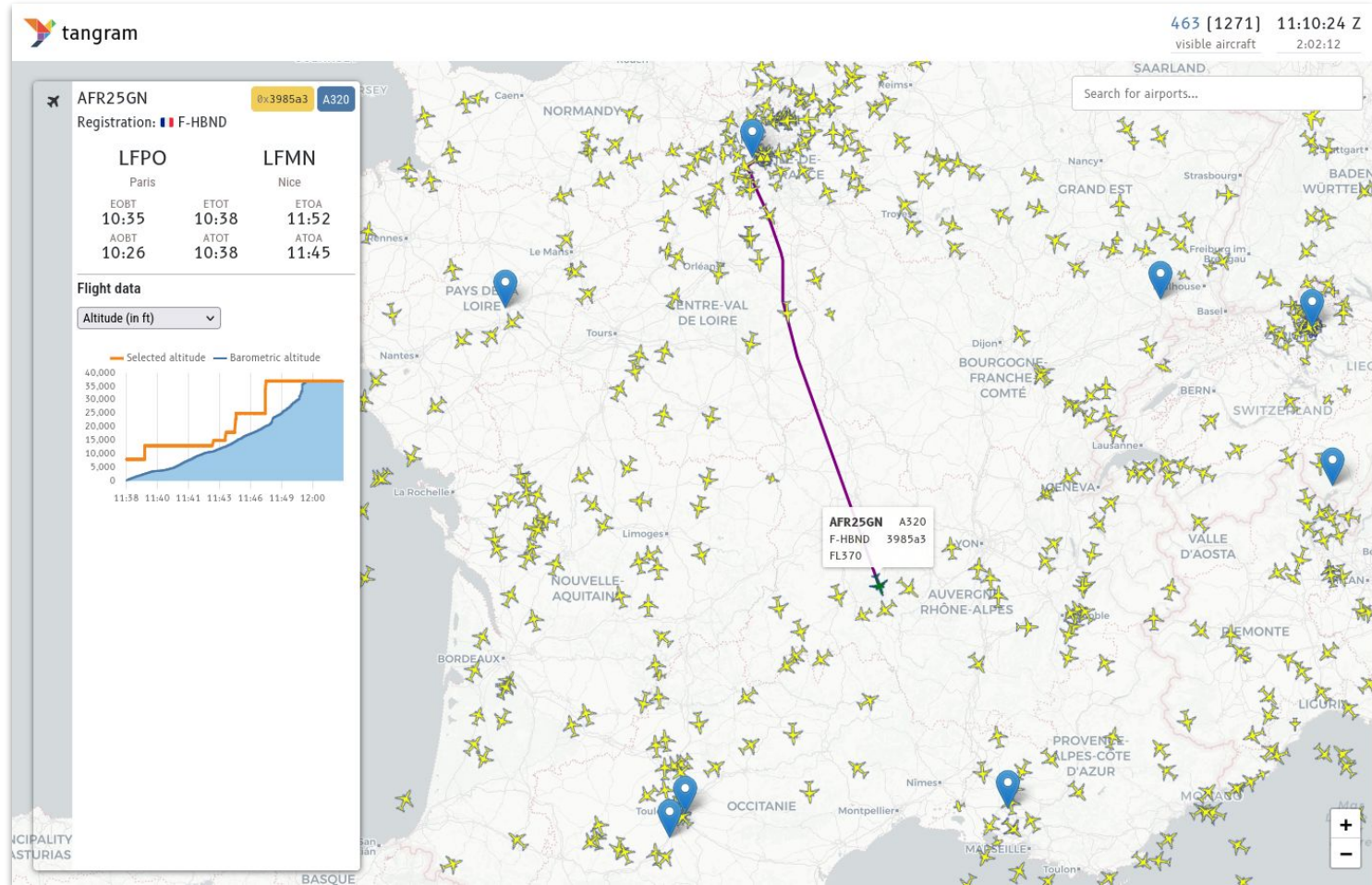
```
jet1090
```

icao24	callsig	type	sqwk	lat	lon	alt	sel	gs	tas	ias	mach	vrate	trk	hdg	roll	nac	last	first
e48df6	TAM8085	B77W	2211	49.731	-2.572	31000	=	508	482	306	0.82	384	212.7	216.7	0.175	11		21:25
e48ba8	TAM8071	B77W	2563	46.891	-5.322	32000	=	478	482	301	0.82	64	245.3	251.8	0	11		21:24
ae1178	RCH290	C17	6637			34000												21:24
abfa8e	FDX5225	B77L	4113	51.341	2.6474	32000	=	474	494	311	0.85	32	280.1	288.2	0	10		21:24
abf0c7	FDX5232	B77L	1000	49.028	2.4015	4250	100	218	232	223	0.36	2048	326.6	326.7	11.42	10		21:24
a6329d	GTI9549	B744	3532	42.833	-4.887	38175	370	494	484	272	0.85	-896	103.8	104.0	-0.52	9		21:24
a53013	UPS251	B752	2003	51.283	1.5045	33025	=	471	462	284	0.8	0	100.7	92.10	-0.17	11		21:24
a50c4b	UPS273	B752	2061	51.465	9.2144	22750	120	487	438	317	0.72	-2112	240.8	249.0	-4.21	11		21:24
89655b	UAE4	A388	2247	51.242	1.1701	22350	290	450	428	322	0.72	1440	99.31	93.61	0	10		21:24
896538	ETD5GZ	B789	3146	50.256	9.7858	36950	=	515	484	275	0.84	-128	121.5	108.8	-0.52	9		21:24
8964b0	UAE28Y	A388	4615	49.809	8.3023	37000	=	522	494	284	0.86	0	112.1	97.38	-0.35	10		21:24
8964a2	UAE8T	B77W	3015	47.550	8.5364	6325	120	224	226	209	0.35	2848	81.91	73.12	-2.81	9		21:24
896471	UAE7L	A388	0410	45.439	10.466	28300	330	438	446	301	0.76	1280	102.9	92.98	-0.70	10		21:24

jet1090 (685 aircraft)

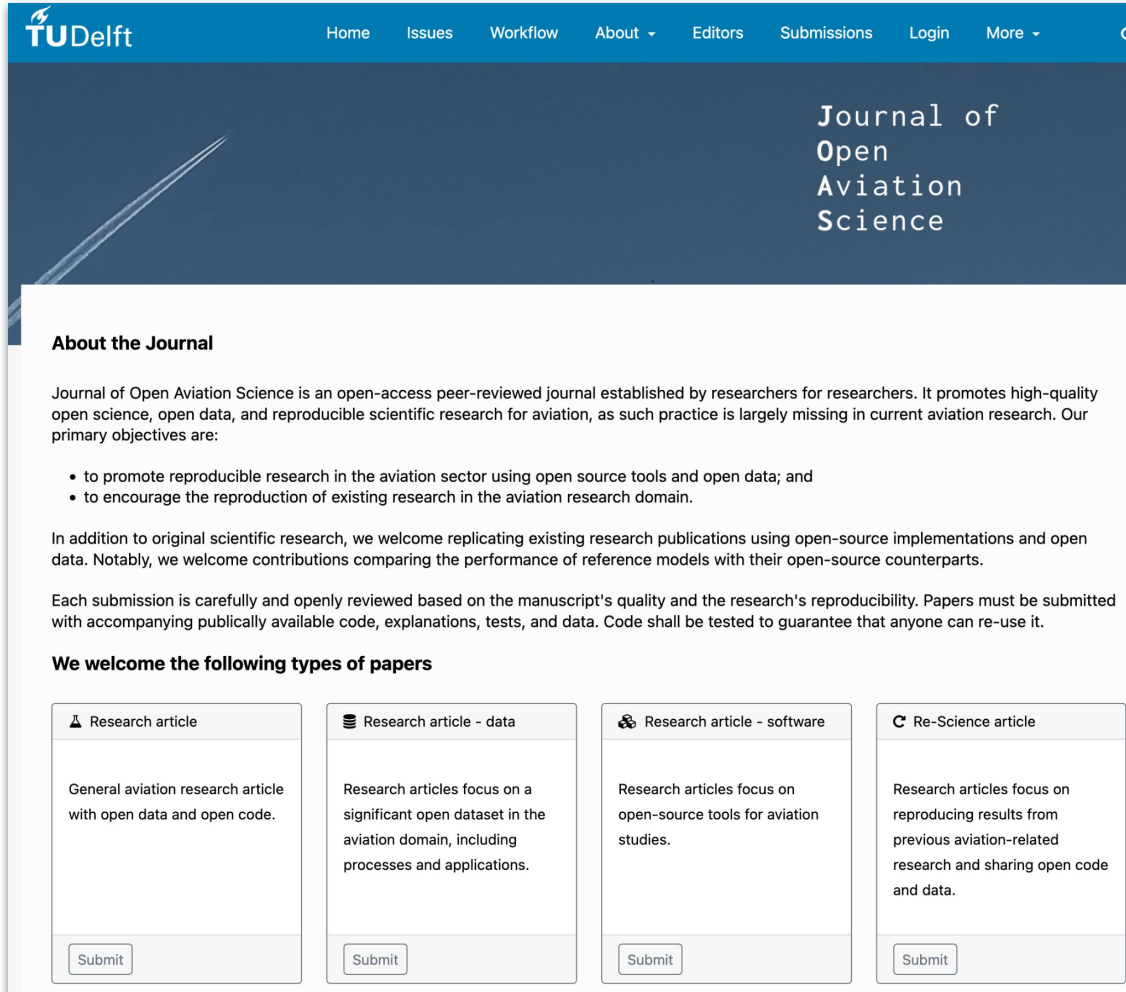
(Esc/Q) quit | (↑/K) up | (↓/J) down | (T/G) top

# Tangram — OpenSky on your laptop, also prettier



## Part 2: Open Journal

# JOAS - Journal of Open Aviation Science



The screenshot shows the homepage of the Journal of Open Aviation Science (JOAS). The header features the TU Delft logo and a navigation menu with links to Home, Issues, Workflow, About, Editors, Submissions, Login, and More. The main title 'Journal of Open Aviation Science' is displayed in a large, white, serif font against a dark blue background. Below the title, the 'About the Journal' section provides a description of the journal's mission and primary objectives. It lists two main goals: promoting reproducible research in the aviation sector using open source tools and open data, and encouraging the reproduction of existing research in the aviation research domain. The section also mentions that the journal welcomes replicating existing research publications using open-source implementations and open data. Each submission is carefully and openly reviewed based on the manuscript's quality and the research's reproducibility. Papers must be submitted with accompanying publicly available code, explanations, tests, and data. Code shall be tested to guarantee that anyone can re-use it. Below the 'About the Journal' section, there is a section titled 'We welcome the following types of papers' which lists four types of papers: Research article, Research article - data, Research article - software, and Re-Science article. Each type has a brief description and a 'Submit' button.

**About the Journal**





Journal of Open Aviation Science is an open-access peer-reviewed journal established by researchers for researchers. It promotes high-quality open science, open data, and reproducible scientific research for aviation, as such practice is largely missing in current aviation research. Our primary objectives are:

- to promote reproducible research in the aviation sector using open source tools and open data; and
- to encourage the reproduction of existing research in the aviation research domain.

In addition to original scientific research, we welcome replicating existing research publications using open-source implementations and open data. Notably, we welcome contributions comparing the performance of reference models with their open-source counterparts.

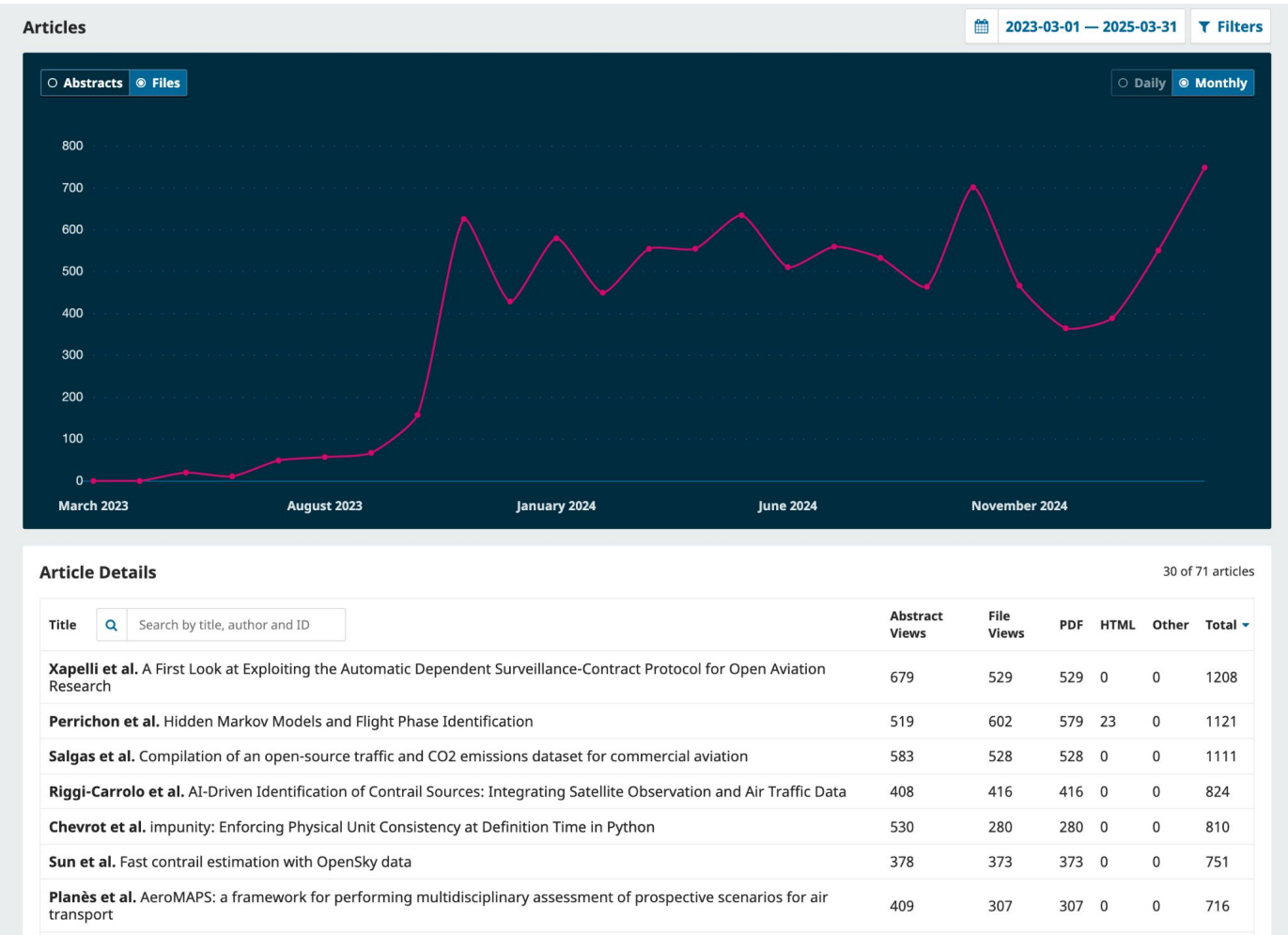
Each submission is carefully and openly reviewed based on the manuscript's quality and the research's reproducibility. Papers must be submitted with accompanying publicly available code, explanations, tests, and data. Code shall be tested to guarantee that anyone can re-use it.

**We welcome the following types of papers**

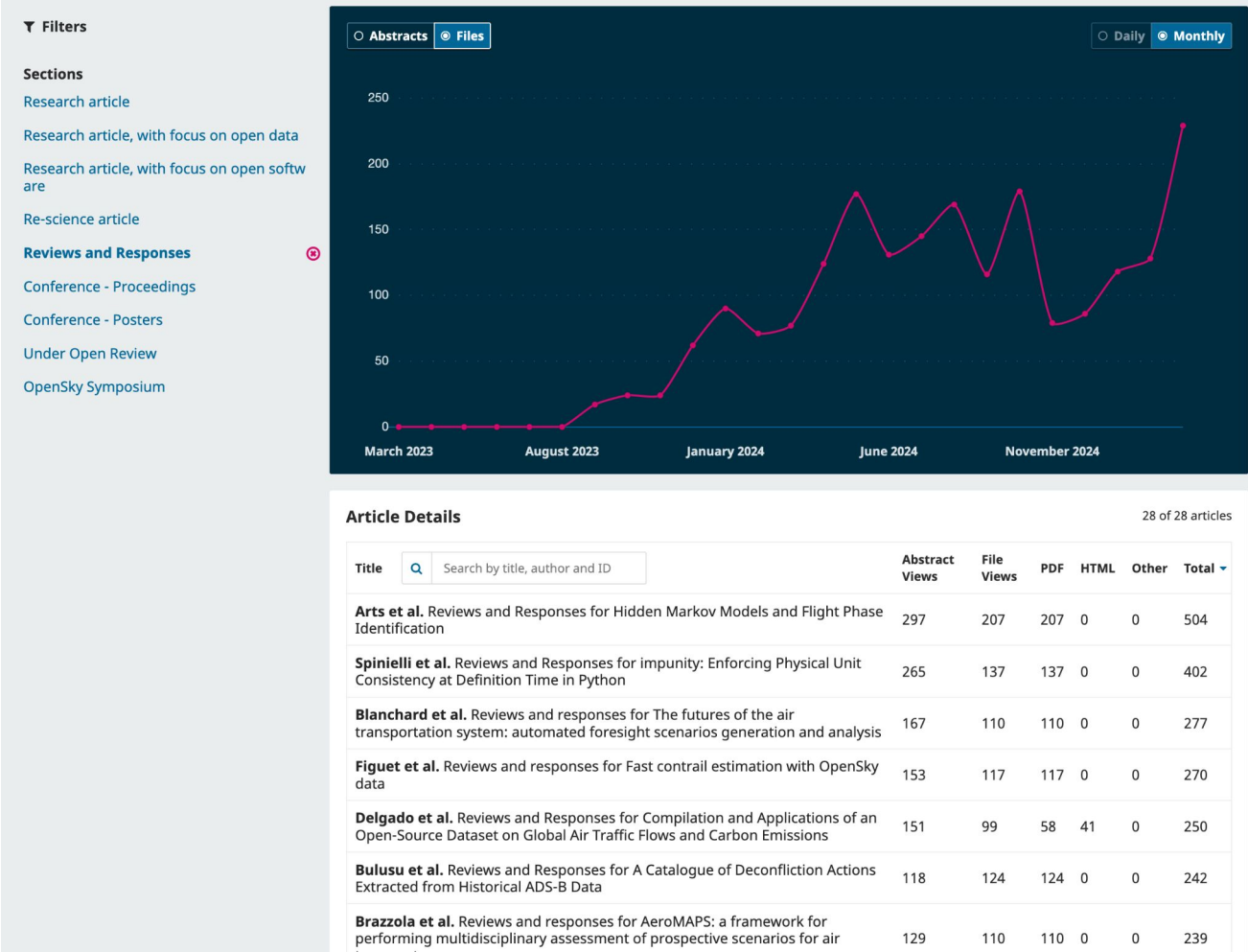
 Research article	 Research article - data	 Research article - software	 Re-Science article
General aviation research article with open data and open code.	Research articles focus on a significant open dataset in the aviation domain, including processes and applications.	Research articles focus on open-source tools for aviation studies.	Research articles focus on reproducing results from previous aviation-related research and sharing open code and data.
<a href="#">Submit</a>	<a href="#">Submit</a>	<a href="#">Submit</a>	<a href="#">Submit</a>

Open access  
Free publication

Open code  
Open data  
Open peer review



# Impact of open peer reviews





# Example process

<https://journals.open.tudelft.nl/joas/article/view/7402>

# Recap

- I don't know where can I find “x” data
  - <https://mode-s.org/atmdata/sources/>
- I don't know what good open-source tools are out there
  - <https://github.com/open-aviation>
- I don't know where should I publish my work
  - <https://journals.open.tudelft.nl/joas>