Real-time alert systems in Julia

JuliaEO - Global Workshop on Earth Observation with Julia 2025

Iga Szczesniak, January 6 2025, Azores, Portugal

Prototype Vineyard Monitoring Dashboard

Vineyard Monitoring Made Simple 🍇

Location of the installed SOFIS sensors

Vinhas da Terceira project

Objectives

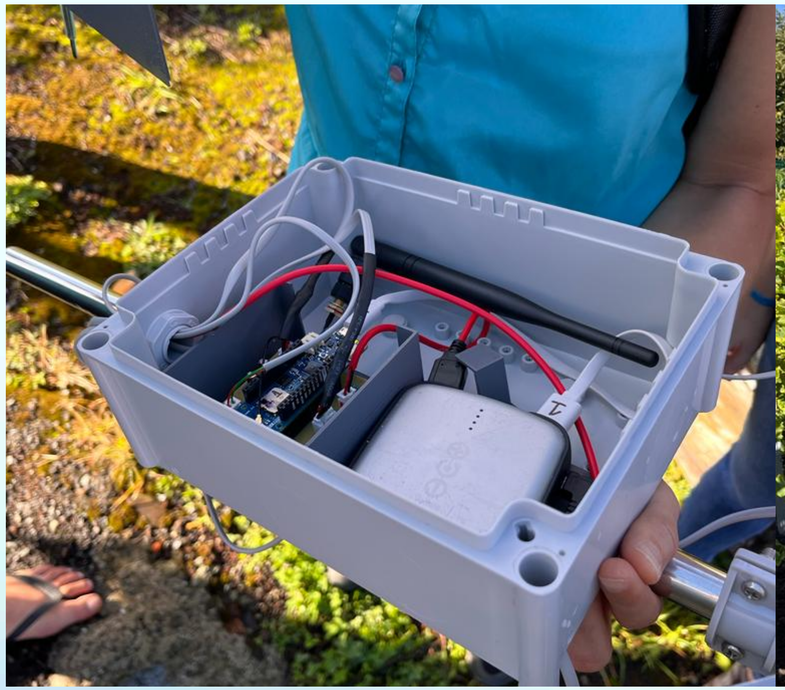
1. Real-time monitoring of vineyards on Terceira Island.

2. Develop a data visualization and automated alert system for downy mildew disease prevention.

SOFIS system

Capable to measure

- Temperature,
- Relative humidity,
- Precipitation,
- Wind speed,
- Wind direction,
- Photosynthetically Active Radiation.



SOFIS sensors installed in the vineyards in Biscoitos, Terceira Island.

4

Vineyards participated in this pilot project.

Why choose Julia for geospatial data analysis?

- Be easy to work with matrices and vectors.
- Have a package ecosystem for common geospatial operations.
- Have a build-in package manager; be a modern programming language.
- Solves a two-language problem.
- User friendly syntax for scientists and engineers without extensive programming background.

Dash.jl

A Julia framework for building interactive, web-based data apps

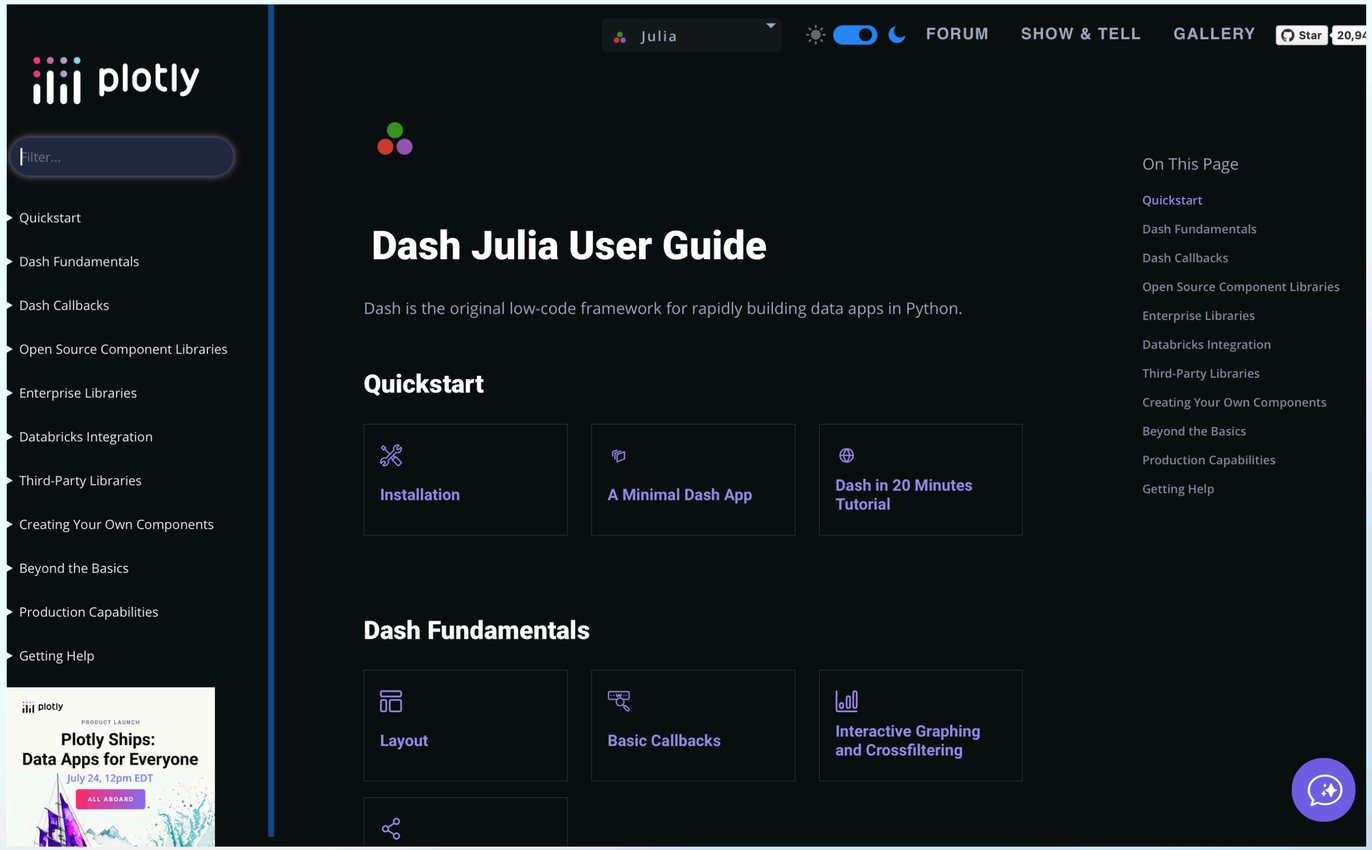
- Enables to create interactive, web-based dashboards directly from Julia code.
- Eliminates the need of switching between different programming languages/tools.
- Provides Julia interface to create web applications with interactive plots, graphs, maps, and other visual components.

Key features of Dash.jl

- Data visualization (charts, graphs, maps, tables...),
- Real-time data updates,
- Customizability,
- Interactive elements.

Dash for Julia User Guide

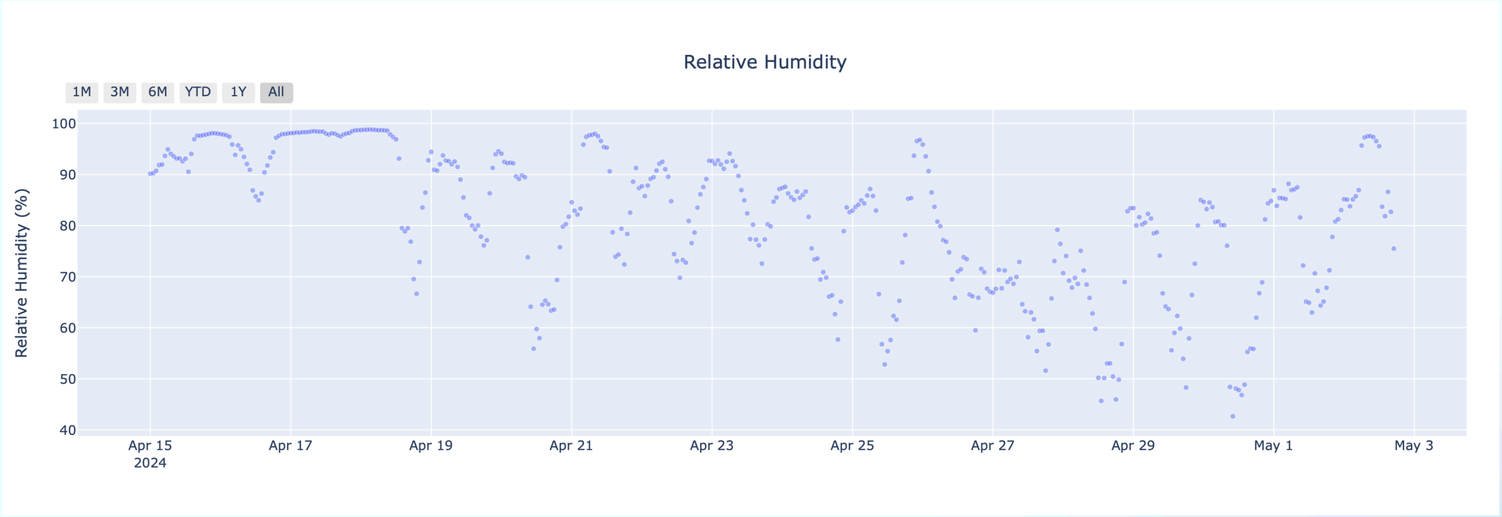
- Link here: *https://dash.plotly.com/julia*.

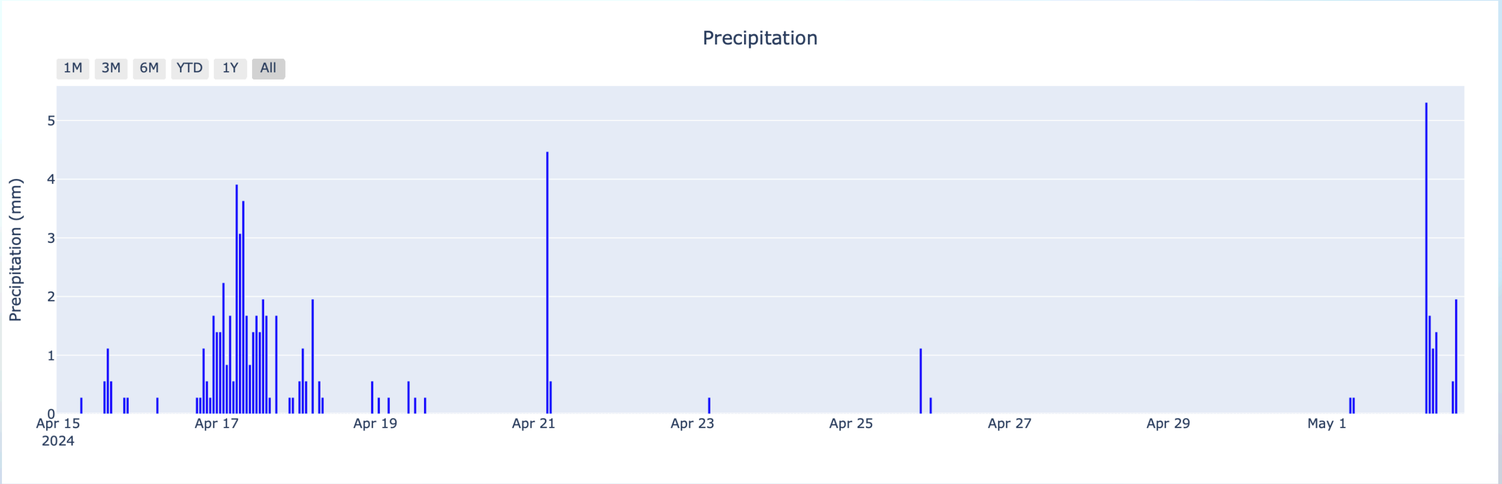


Dash Julia documentation.

Graphs

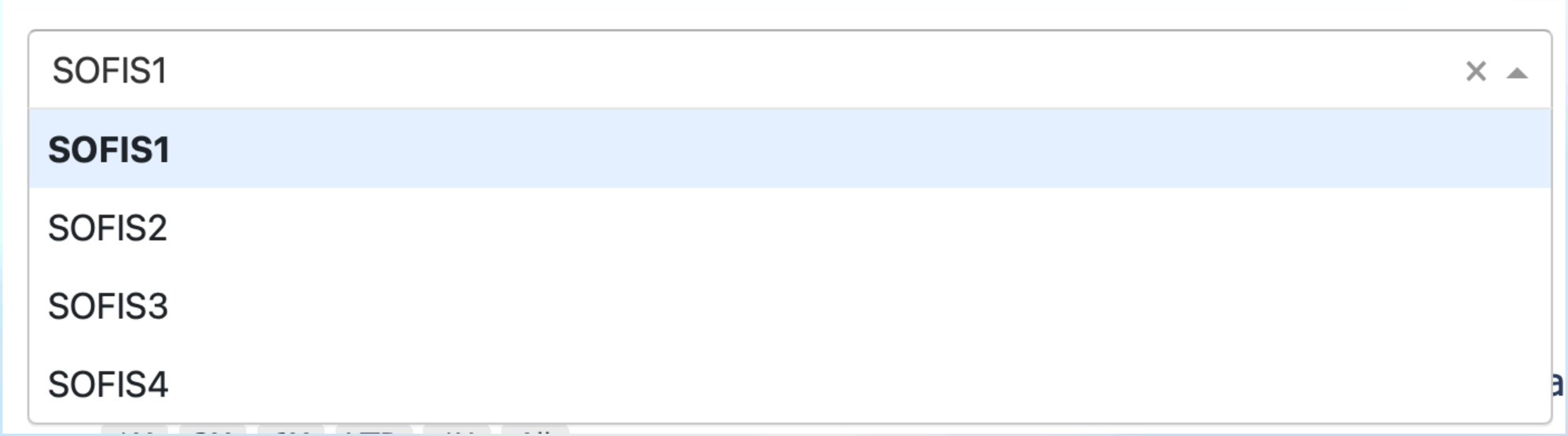
- Interactive and responsive,
- Built on top of Plotly.js,
- Support over 35 chart types including scientific plots.





Dropdown

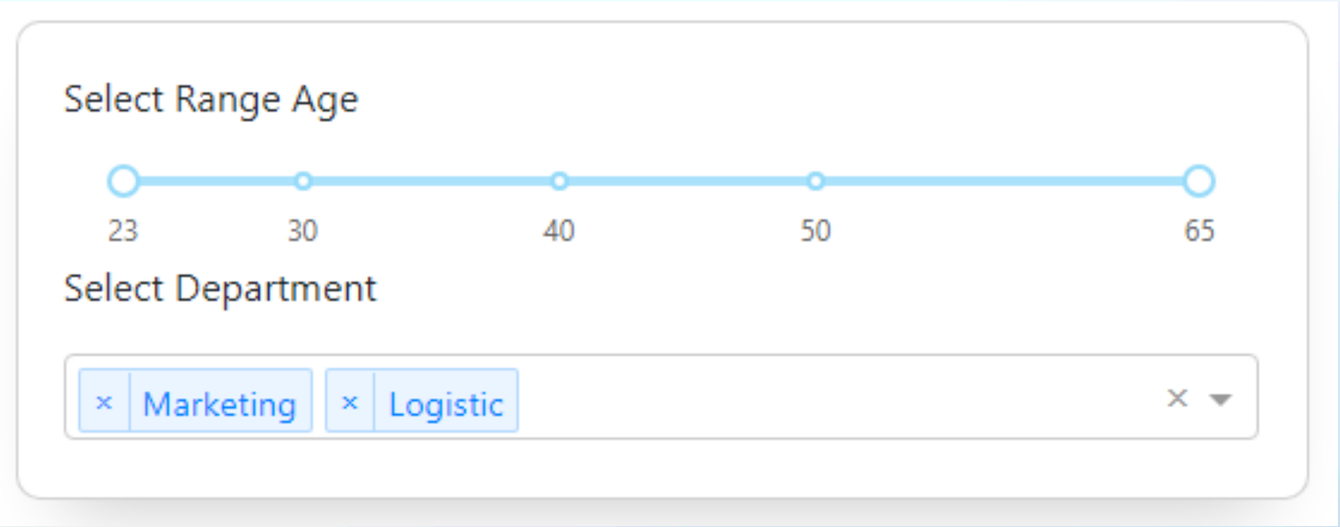
- To select by a variable, parameter, column...



A dropdown list example.

Slider

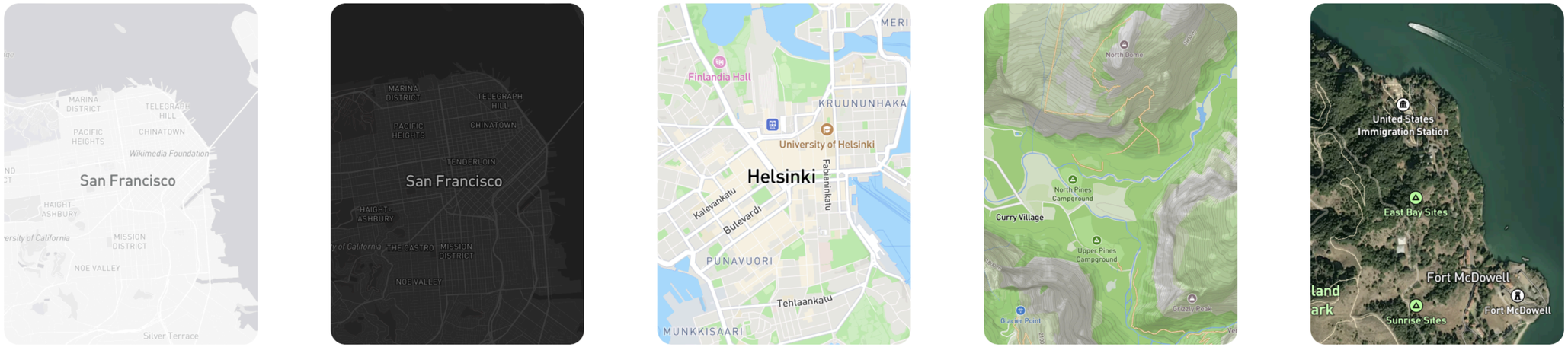
- Display a range of data.
- Time series analysis and handling dates.



A slider example.

Support for Mapbox

- Bring a location technology to display geospatial data e.g. coordinates.



Light | Dark | Streets | Outdoors | Satellite Streets

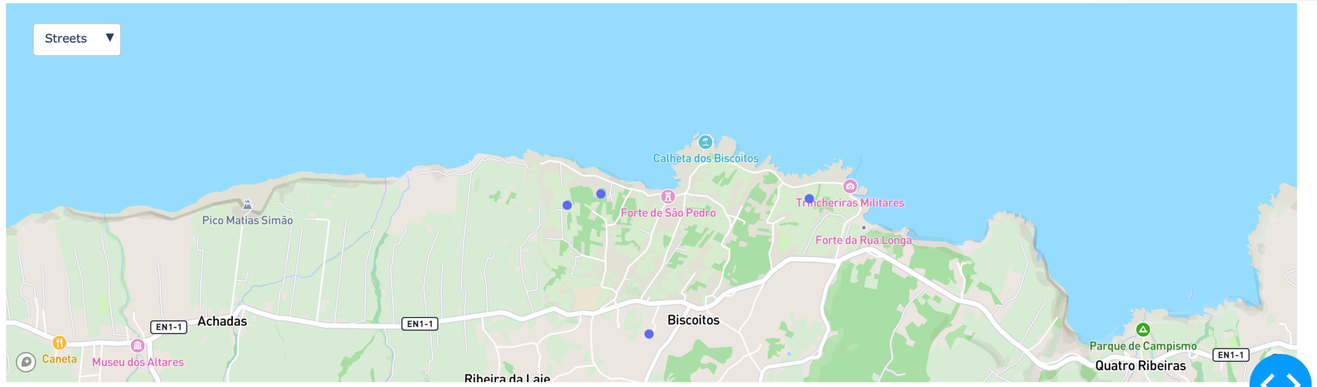
Mapbox's map styles.

Support for Mapbox

Location of the sensors

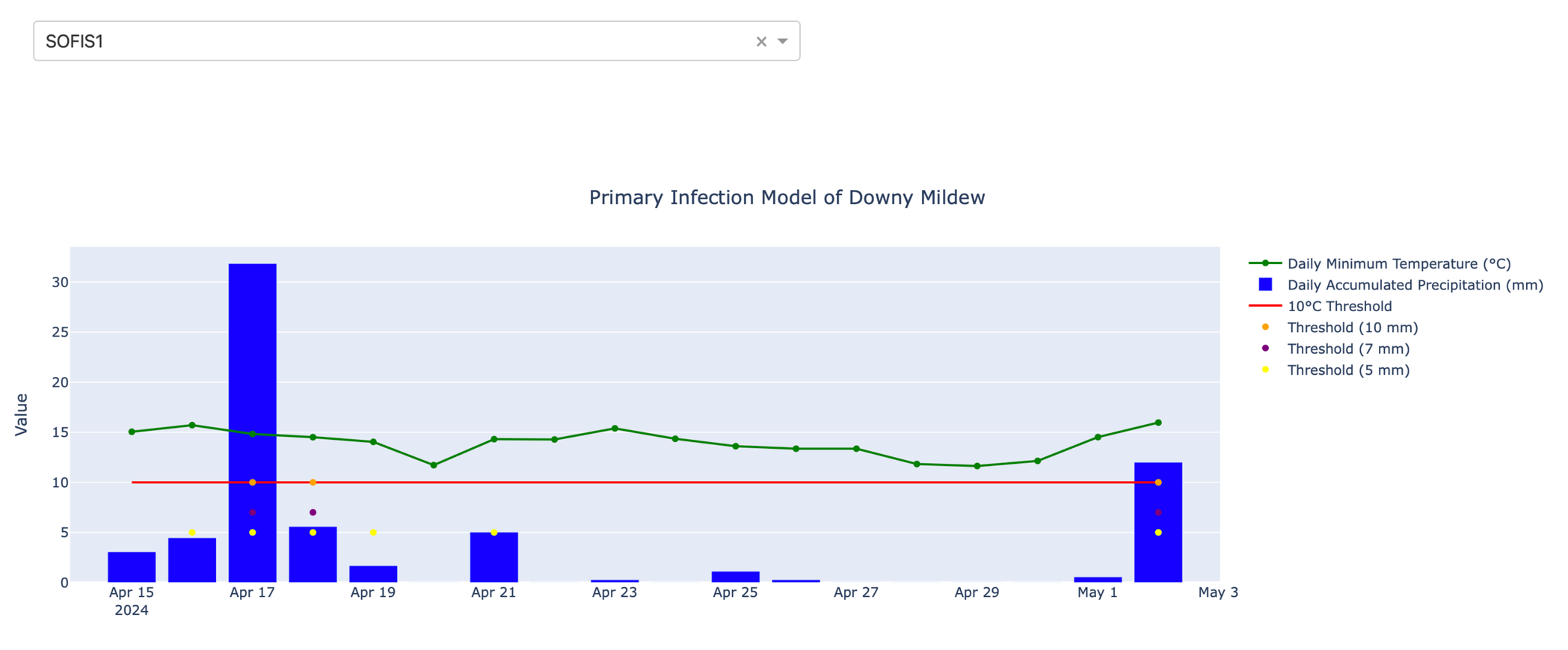
Location of the installed SOFIS sensors

Location of the installed SOFIS sensors



Risk of primary infection of downey mildew

Calculating the “10-10-10” model



Model of primary infection of downey mildew.

Vineyard monitoring dashboard

A step-by-step process

1. Liaise with stakeholders.
2. Design the dashboard layout.
3. Develop graphs and visualisations.
4. Implement risk calculation model for downey mildew.
5. Add interactive elements.
6. Deploy the dashboard on the web.

Let’s open the live dashboard!

https://services.aircentre.org/agrodigital/terceira/

Live dashboard.

Let’s open the Jupyter notebook!

https://github.com/igaszczesniak/dashboard-julia

Jupyter notebook.

Validation of IoT measurements

- Data analysis in scientific work and papers.

sensors

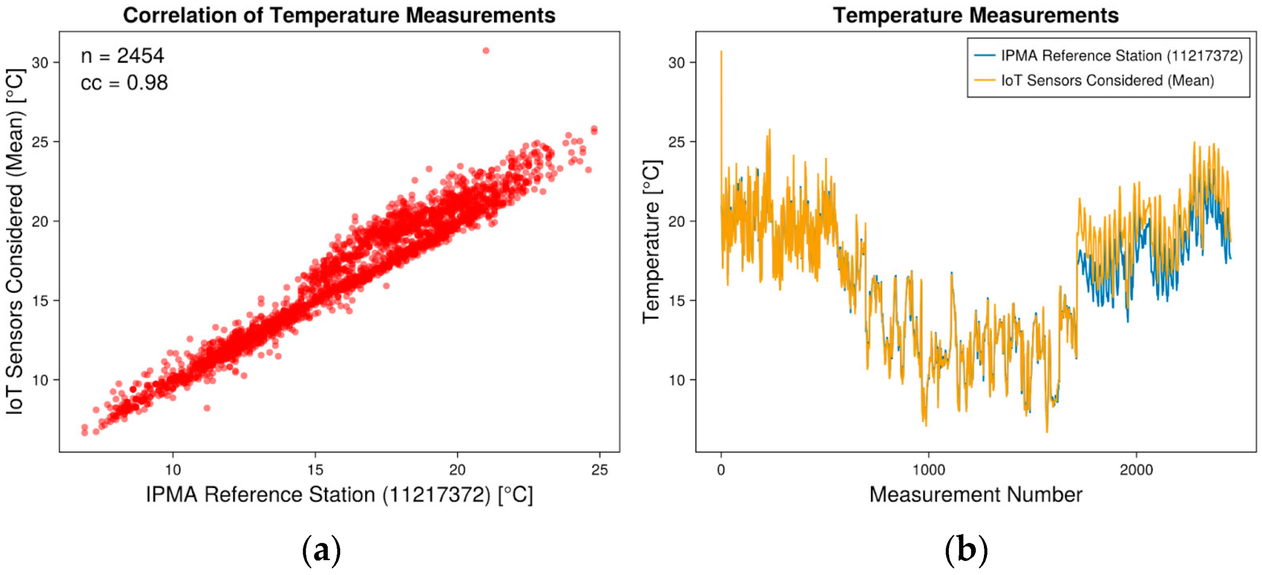
MDPI

Article

Assessing the Presence of *Pithomyces chartarum* in Pastureland Using IoT Sensors and Remote Sensing: The Case Study of Terceira Island (Azores, Portugal)

Mariana Ávila [1,2], João Pinelo [1], Enrique Casas [2], César Capinha [3,4], Rebecca Pabst [5], Iga Szczesniak [1], Elizabeth Domingues [6], Carlos Pinto [7], Valentina Santos [8], Artur Gil [9,*] and Manuel Arbelo [2]

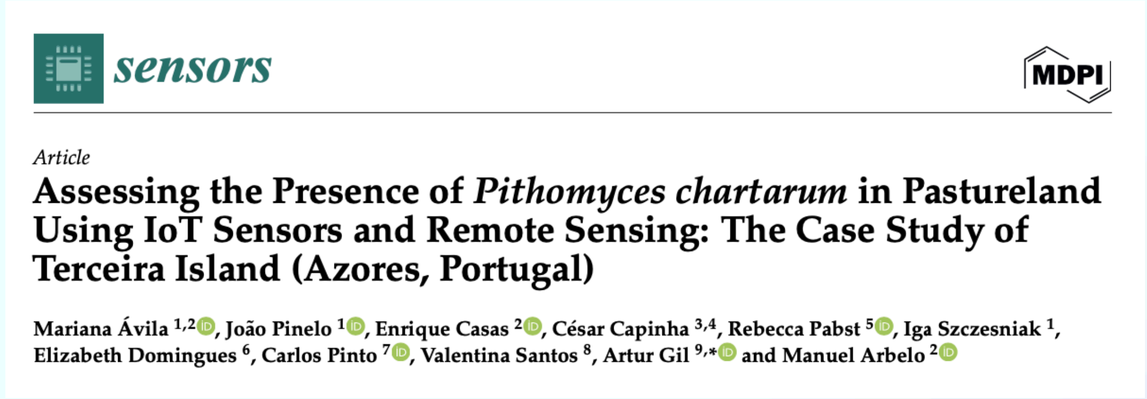
A recent paper with data analysis made in Julia.



(a) Correlation plot of mean temperature measurements from installed IoT sensors and the reference meteorological station. **(b)** Temperature measurements.

Validation of IoT measurements

- Data analysis in scientific work and papers.



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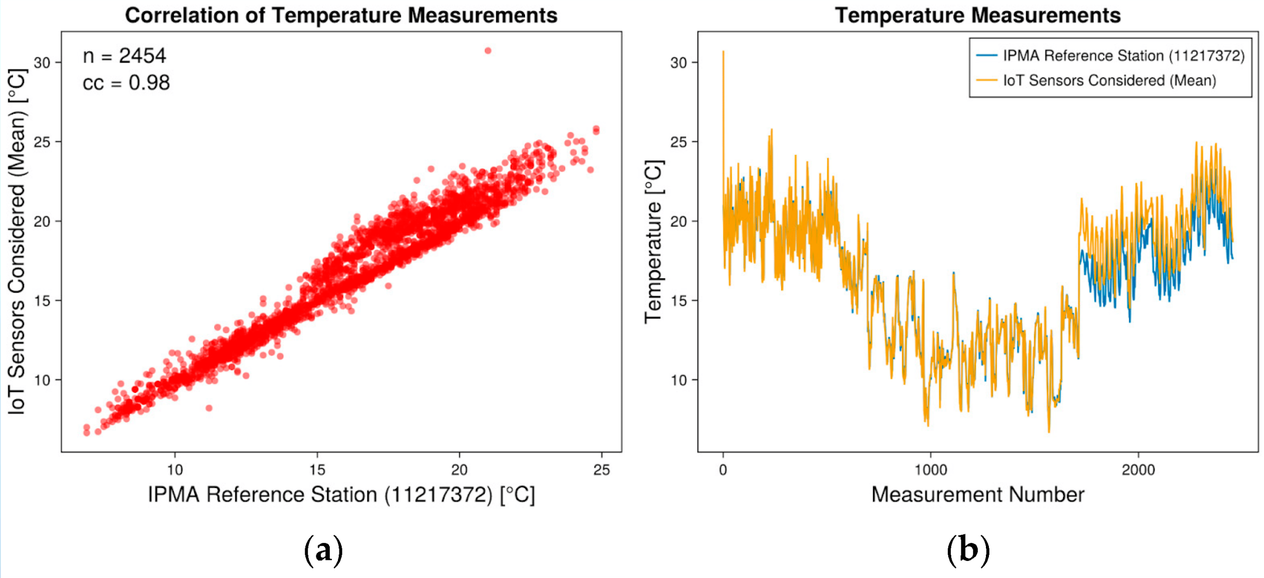


(a) Correlation plot of mean temperature measurements from installed IoT sensors and the reference meteorological station. **(b)** Temperature measurements.

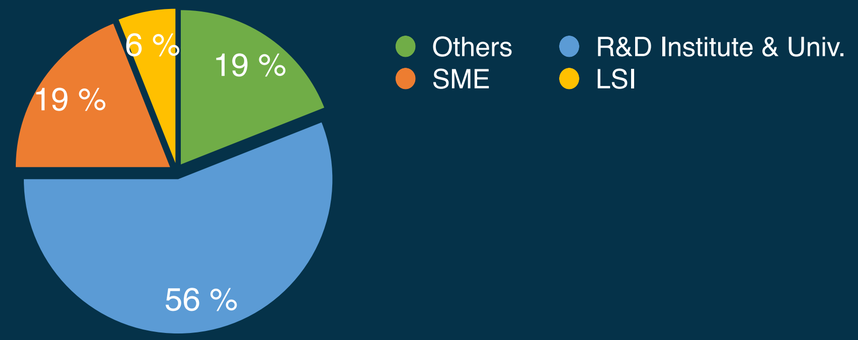
Link to the paper.

Final thoughts

- *Dash.jl* can be a way to go to build interactive, web-based dashboards.
- Alternatives are *Bonito.jl* and *Genie Framework*.
- Julia is a good choice for *fast* prototyping, especially testing solutions that come from scientific research.
- Julia has a mature package ecosystem to build data-driven applications in various fields.

Discovery Element

- → **Open Science** – Open innovation to discover and explore the disruptive innovation of tomorrow
- → **Activities via Open Space Innovation Platform (OSIP)**
  - → External driven - Reaching out for best ideas from anybody
  - → Lowest ever entrance barrier to space innovation
  - → Inverted logic: first smart idea, then the process
  - → Fast feedback, engagement and decisions
- → **Exploratory first steps funded**:
  - → Co-sponsored research, studies and early technology development activities
- → Integrates Commercialisation objectives of Agenda 2025



Discovery year in numbers:

~150 activities

100% Industry/Academia driven Open Competition

~15m € contracts

~75% SME's, R&D inst. and academia

Discovery Schemes

It's that simple to start:

1. Go to **ideas.esa.int** -> Campaigns or the Open Ideas Channel
2. Check whether your idea is novel and eligible – in case of doubt: ask on OSIP
3. Submit your idea and start discussing with ESA experts

Categories

STUDIES
up to 100k€

EARLY TECHNOLOGY DEVELOPMENT
up to 175k€

CO-SPONSORED RESEARCH
up to 90k€

DISCOVERY AND PREPARATION VIA OPEN INNOVATION

LATEST CAMPAIGNS

3575 IDEAS

1676 IDEAS → Disc. & Prep. CAMPAIGNS

1899 IDEAS → OPEN DISCOVERY CHANNEL

OPEN SPACE INNOVATION PLATFORM

PREPARATION ACTIVITIES

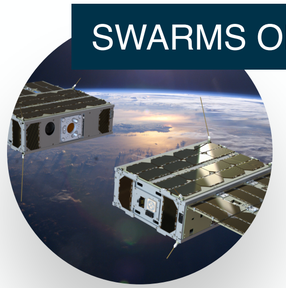
270 CO-SPONSORED RESEARCH ACTIVITIES

181 STUDIES

242 EARLY TECHNOLOGY DEVELOPMENTS

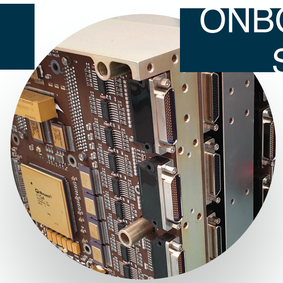
https://activities.esa.int

SWARMS OF CUBESATS



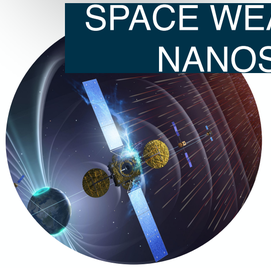
74 ideas, 7 studies

ONBOARD SOFTWARE



106 ideas, 14 studies

SPACE WEATHER NANOSATS



47 ideas, 5 studies

SPACE 4 GREEN FUTURE

75 ideas, 3 studies

NEW MISSION CONCEPTS

201 ideas, 8 studies

COGNIT. CLOUD COMP.

68 ideas, 12 studies

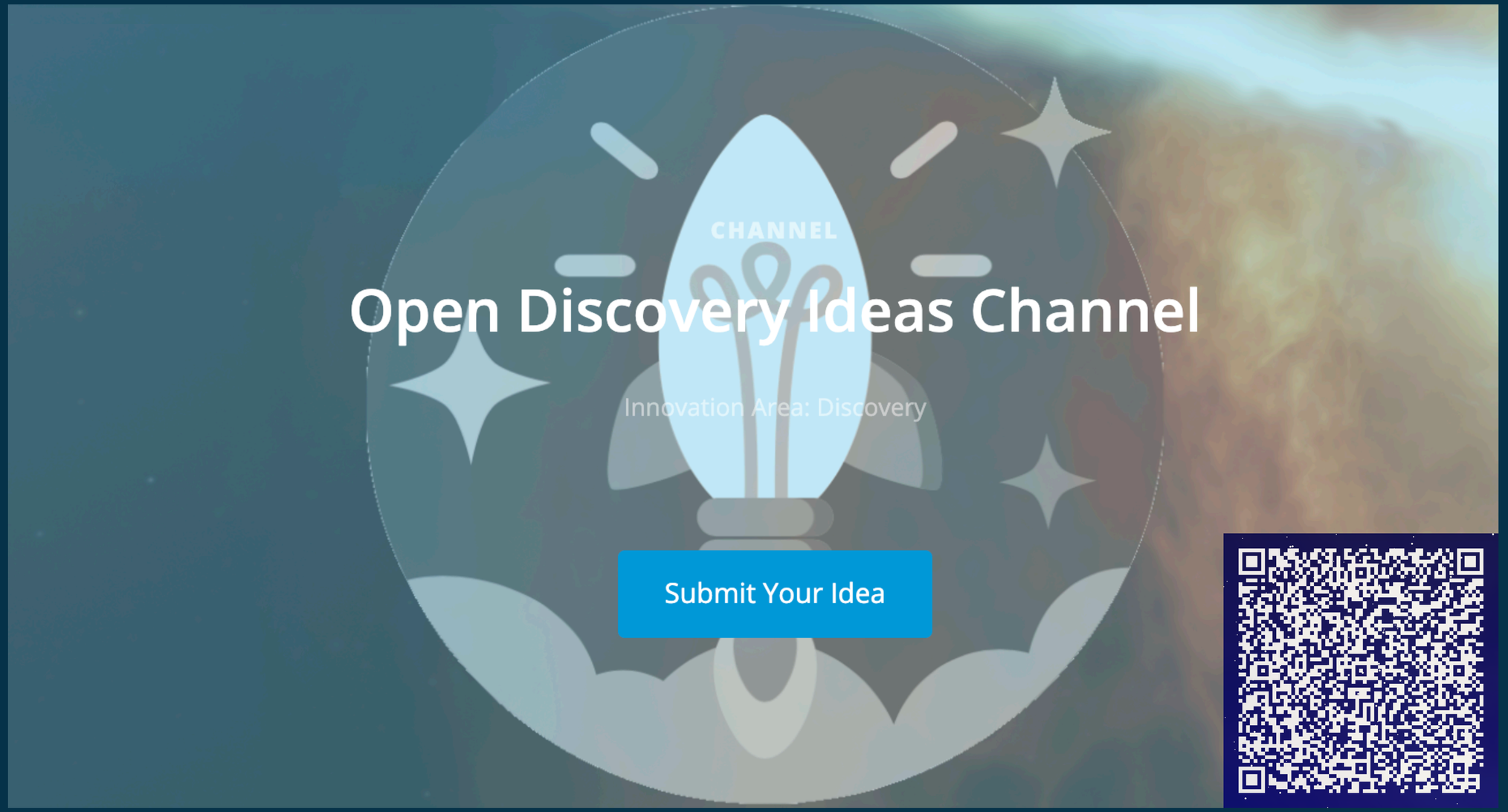
RFI FOR IOS MISSION

17 ideas, 4 studies

COMMERC. OF PATENTS

15 ideas, 7 studies

Open Discovery Ideas Channel



First steps for novel ideas – Discovery Element Process Steps

Your Novel Idea

Your action

- You focus on describing your idea in form of an abstract
- No need for formalities
- Submit any time to Open Discovery Channel on OSIP
- Ideas for future commercially viable activities welcome

OSIP OPEN SPACE INNOVATION PLATFORM

(ideas.esa.int)

- ESA gives you feedback
- ESA channels ideas to best implementation path
- Monthly evaluation for Discovery channel ideas
- Best ideas invited to be matured into proposals

Discovery Contracts

- Following competitive evaluation
- Co-sponsored research (<90k€)
- Study (<100k€)
- Early Technology Development (<175k€)

OSIP Channel

- Permanently open
- All novel space ideas welcome

OSIP Campaigns

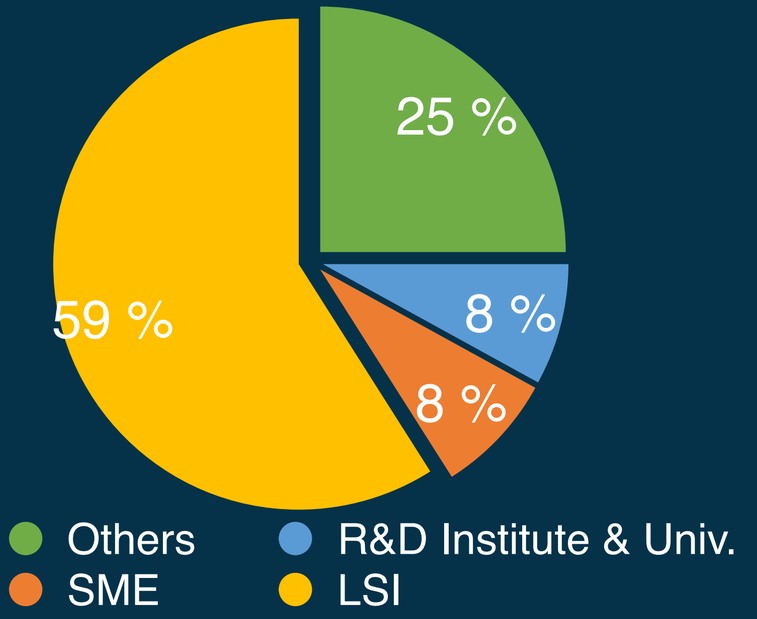
- Time limited
- ESA defined challenges / topics

GSTP, InCubed, ARTES, NAVISP, ScaleUp, BASS, … …

- Programme specific

Preparation of Future Missions

- Prepares and enables future mission and programmes through
  - pre-phase A studies (including CDF studies)
  - phase-A studies and dedicated system analyses to establish robust trade-offs for mission designs
  - SysNova Challenges
- Across all ESA activity domains
- Develops open competitive first designs of all new missions based on best concepts without geo-return constraints (encouraging wider participation)
- Technology pre-developments to de-risk mission adoption
- Prepares new mission concepts and programmatic lines
- Supporting industry: MBSE, 0Debris, building blocks (ADHA, APA)
- Exploring new roles of ESA (with industry & commercialisation directorate)



Preparation year in numbers:

~30	All	~16m€	~25%
future mission studies	ESA Members & Associate Members	contracts	SME's, R&D inst. and academia

PREPARATION OF NEW MISSIONS

The Preparation Element is supporting all directorates within ESA. Emphasis is put on inter-directorate cooperation and efficient sharing of knowledge and resources

Preparation funded Phases

~12 full CDFs per year + 2 to 3 Micras

~20 pre-Phase A/year
Parallel activities

~10 Phase A & co-funded Phase A/B1s per year
Parallel activities`

CDF → Pre-Phase A → Phase A → Phase B1

Recent activities
- Cislunar STM
- Vigil-2
- SATNAV IOD
- Argonaut Artemis Mission (#2)
- Mars Mission 1
- Aurora-C
- SW Mission to Lagrange L3
- Mission to outer Planets (L4)

Recent activities
- European Moon Rover System
- EE11
- Space-based Solar Power System (SBSP)
- Argonaut M#1
- Laser Momentum Transfer (LMT) in-orbit verification
- Low-cost Mars Mission

Recent activities
- Sentinel 2 NG
- Sentinel 3 NG
- M7
- Ramses - Apophis mission
- NEOMIR
- DRACO System Study
- STEREOID
- AEOLUS-2

*Commitment average for the timeframe 2018 to 2023

VISITING RESEARCHERS – ACCESS TO ESA LABS

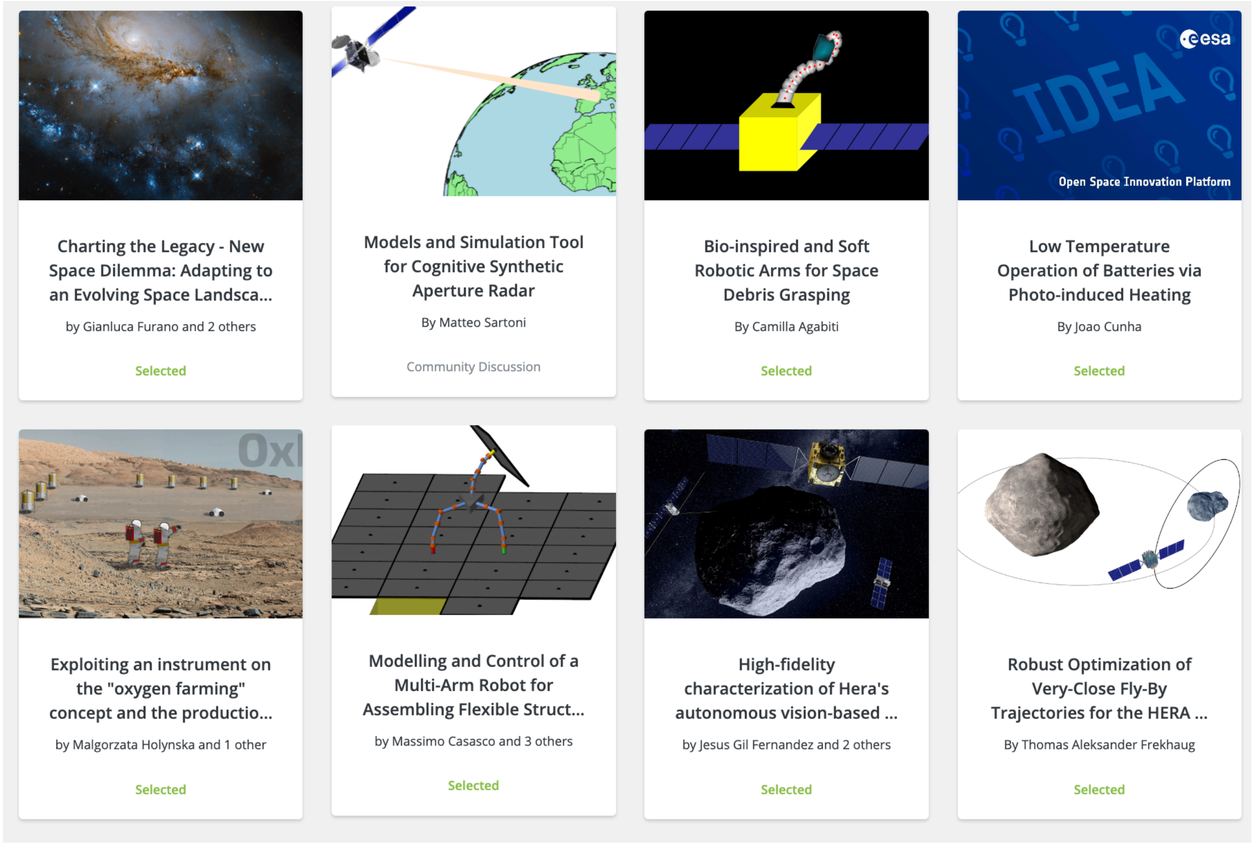
Visiting Researcher schemes aim to support research projects that would benefit from ESA labs, facilities or expertise.

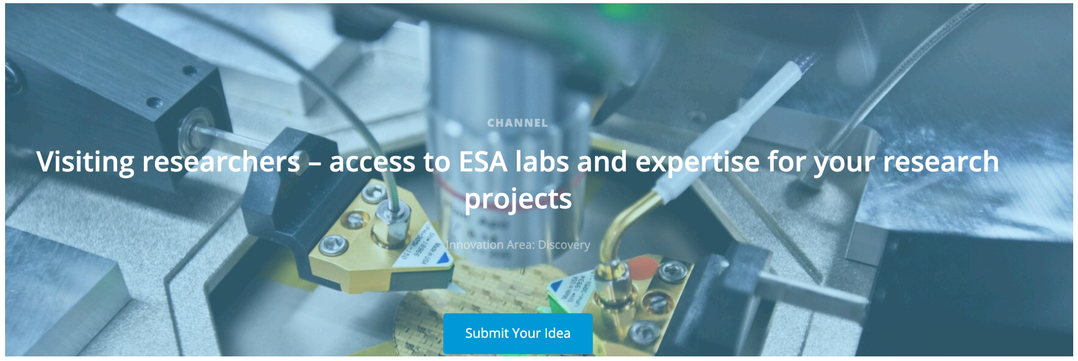
Co-sponsored visiting researcher
Nominally up to 1 year at the ESA site where the ESA Co-supervisor is located.

> 50 researchers

Dedicated Visiting Researcher channel:
For any funded research project. (link)

- 8 ESTEC
- 9 participating labs

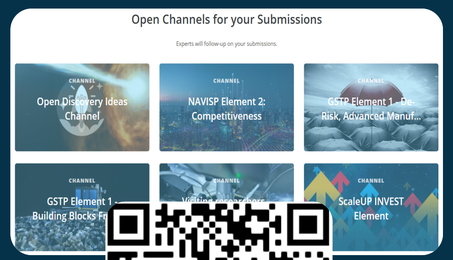




Useful links

OSIP
OPEN SPACE INNOVATION PLATFORM

- Channel and Campaign.
- Entry to Discovery Element
- Submission of pre-proposals and outline proposals for GSTP.

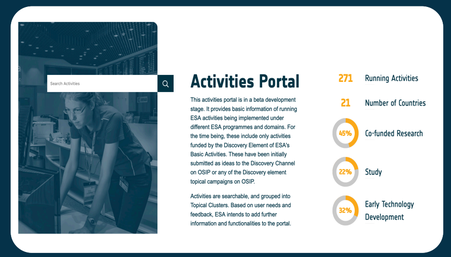


esa esa-star Publication

- Registration of new companies
- Invitations to tenders.
- News/Procurement related announcements: Preparation, TDE WP, GSTP Compendia Publication

Activities Portal

- Running activities
- Visibility on interim results and publications
- Updated by contractor
- Simplified interaction with ESA



ENABLING & SUPPORT

Discovery and Preparation

- Discovery & Preparation
- Highlights

ENABLING & SUPPORT

shaping the future

- TDE/GSTP information
- TDE/GSTP achievements

Nebula Public Library

The knowledge bank of ESA's R&D programmes

- Discovery, Preparation activities achievement summary
- TDE and GSTP public summaries

Thank you!

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