



# 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



# Vinhos 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>.

The screenshot shows the homepage of the Dash Julia User Guide. The top navigation bar includes a dropdown for 'Julia', a light/dark mode toggle, and links for 'FORUM', 'SHOW & TELL', 'GALLERY', and a 'Star' button with the number '20,94'. The main content area features the Plotly logo and a sidebar with a 'Filter...' input field and a list of topics: Quickstart, Dash Fundamentals, Dash Callbacks, Open Source Component Libraries, Enterprise Libraries, Databricks Integration, Third-Party Libraries, Creating Your Own Components, Beyond the Basics, Production Capabilities, and Getting Help. A banner at the bottom left promotes 'Plotly Ships: Data Apps for Everyone' with a launch date of July 24, 12pm EDT. The right side of the page is titled 'Dash Julia User Guide' and describes Dash as the original low-code framework for rapidly building data apps in Python. It contains sections for 'Quickstart' (Installation, A Minimal Dash App, Dash in 20 Minutes Tutorial), 'Dash Fundamentals' (Layout, Basic Callbacks, Interactive Graphing and Crossfiltering), and a sidebar titled 'On This Page' listing various documentation categories.

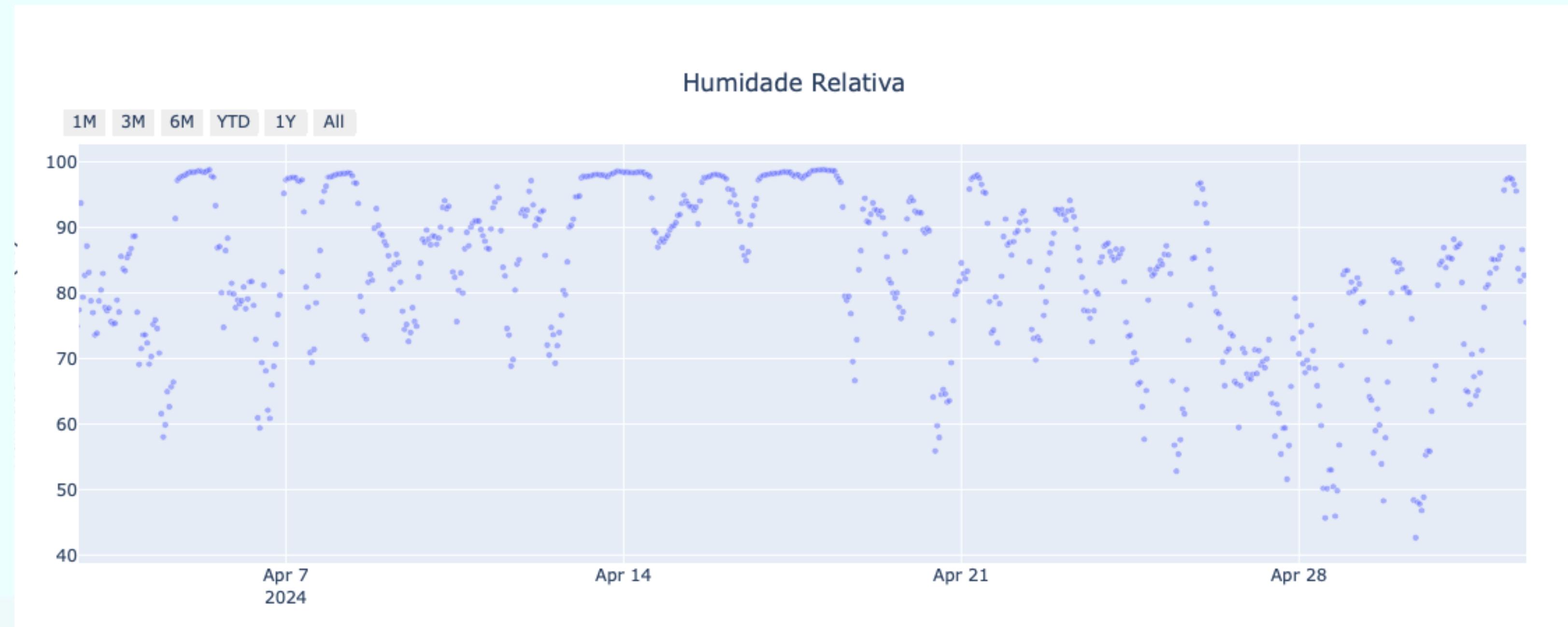
On This Page

- Quickstart
- Dash Fundamentals
- Dash Callbacks
- Open Source Component Libraries
- Enterprise Libraries
- Databricks Integration
- Third-Party Libraries
- Creating Your Own Components
- Beyond the Basics
- Production Capabilities
- Getting Help

Dash Julia documentation.

# Graphs

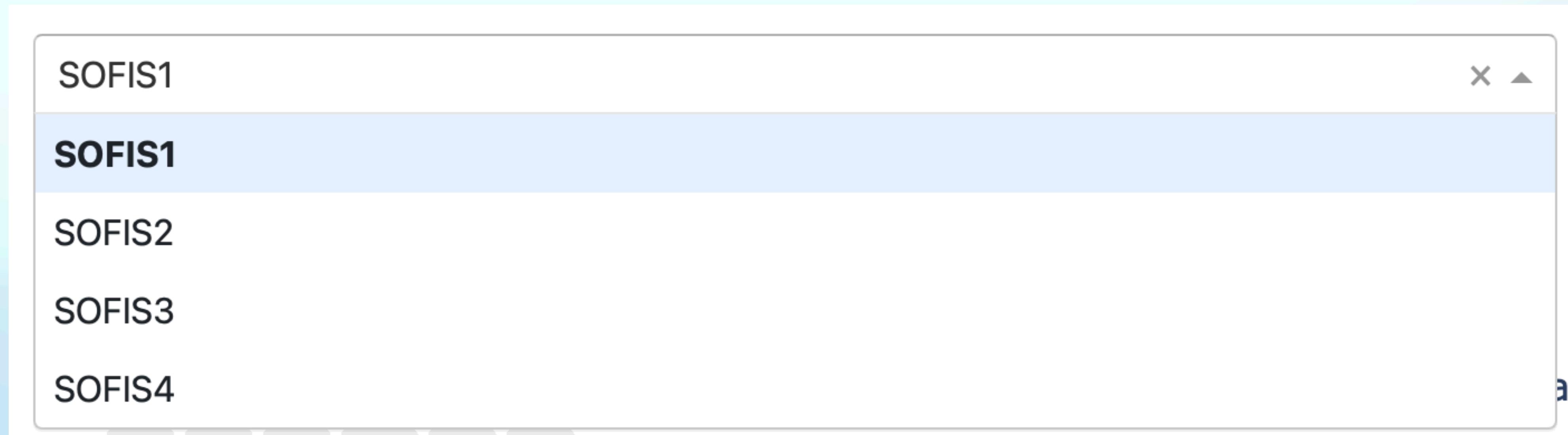
- Interactive and responsive,
- Built on top of Plotly.js,
- Support over 35 chart types including scientific plots.



A scatter plot made in PlotlyJS.jl.

# Dropdown

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



A dropdown list example.

# Slider

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

Select Range Age

A horizontal slider with five points labeled 23, 30, 40, 50, and 65. The slider is a blue line with open circles at each point. The numbers are positioned below the slider.

23      30      40      50      65

Select Department

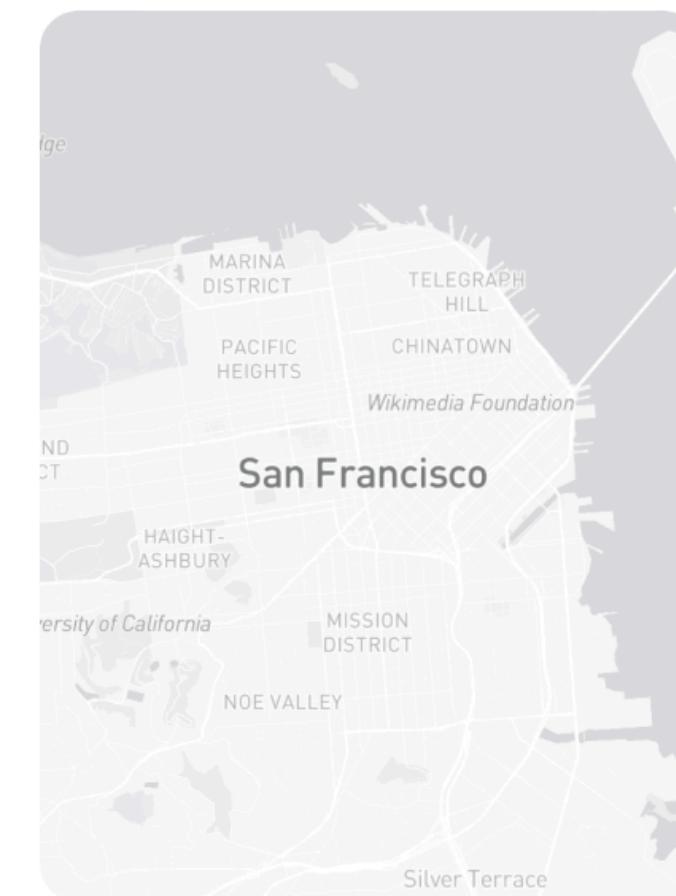
A list of selected departments: Marketing and Logistic. Each item has an 'X' icon to its left. A close button with an 'X' and a downward arrow is located on the right side of the list.

x Marketing    x Logistic    x ▾

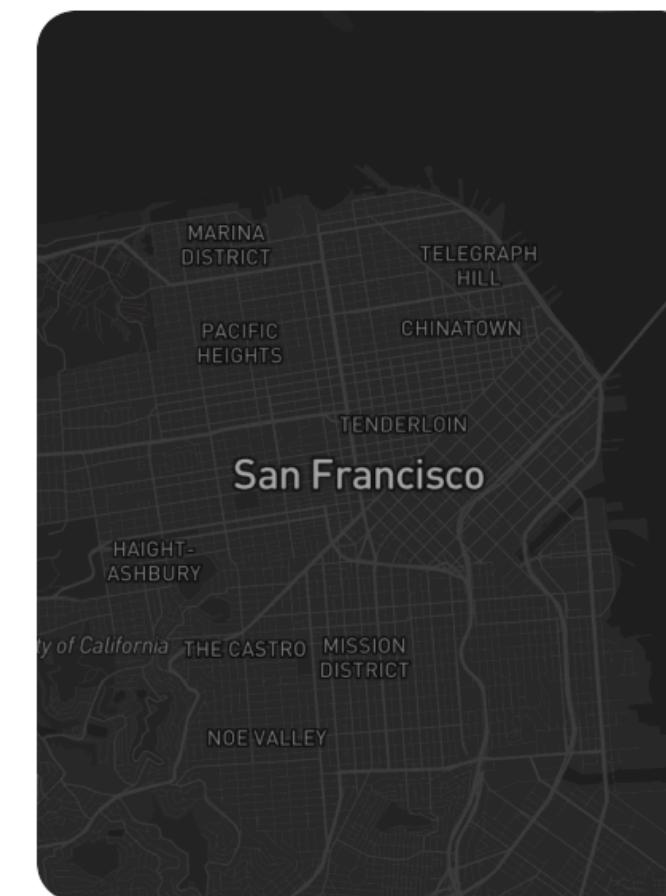
A slider example.

# Support for Mapbox

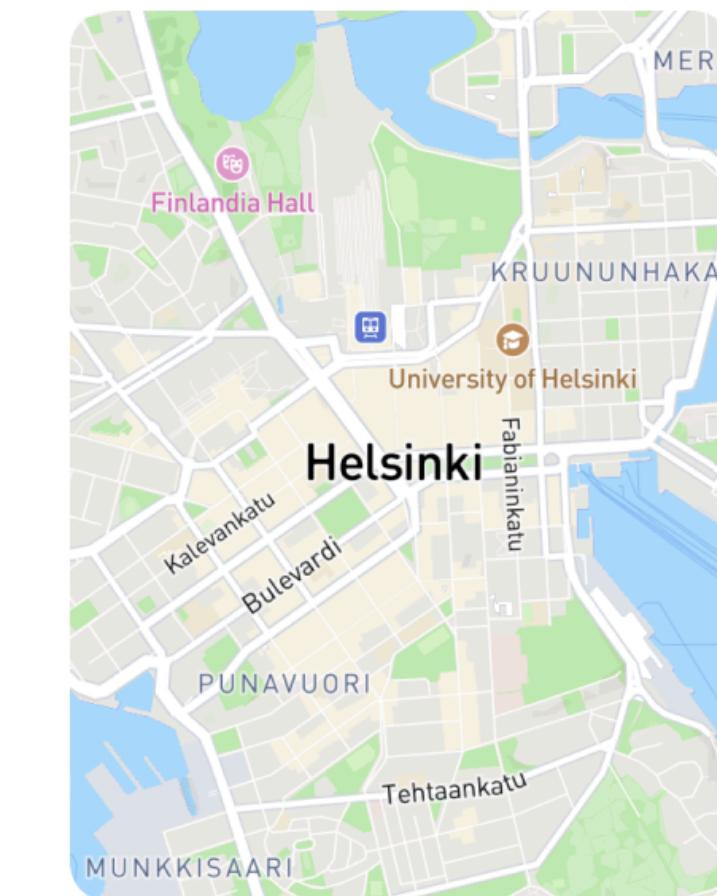
- Bring a location technology to display geospatial data e.g. coordinates.



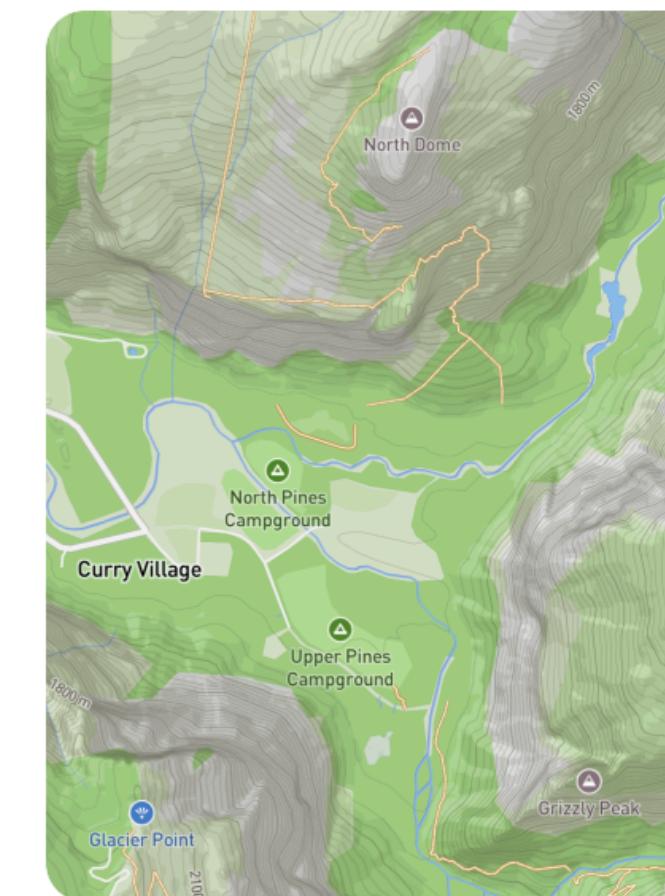
Light



Dark



Streets



Outdoors



Satellite Streets

Mapbox's map styles.

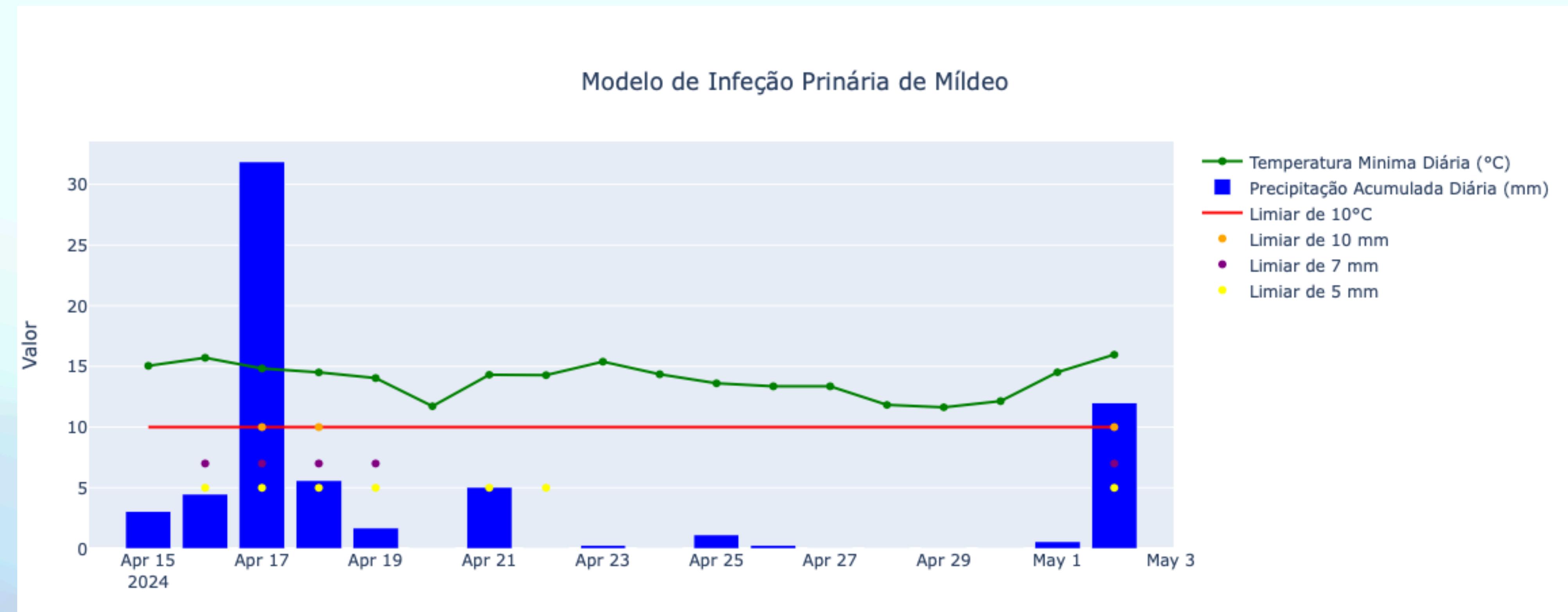
# Support for Mapbox

Location of the vineyards



# Risk of primary infection of downey mildew

Calculating the “10-10-10” model



# 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 SOFIS measurements

- Data analysis in scientific work and papers.

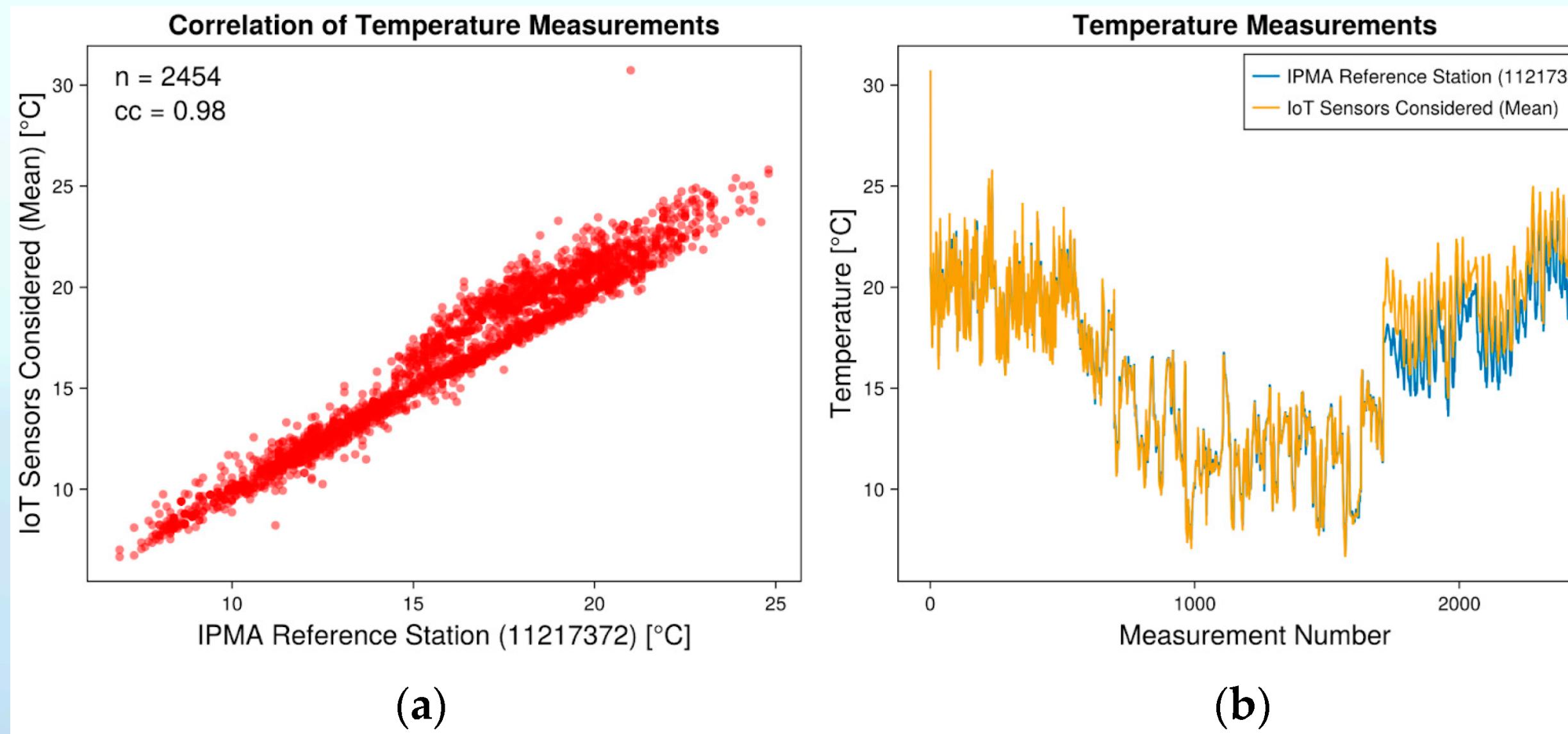


Article

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

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

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 SOFIS measurements

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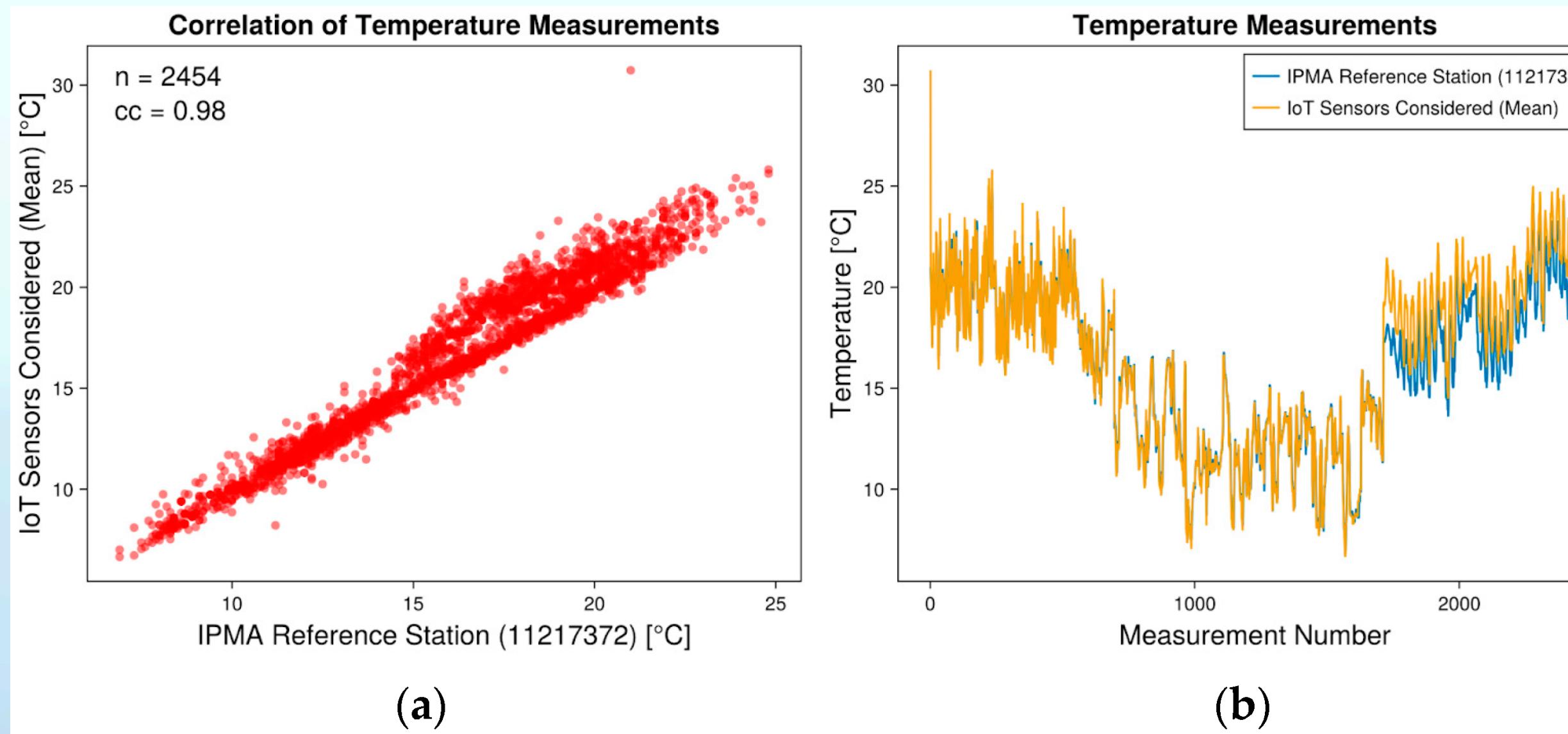


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A recent paper with data analysis made in Julia.



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 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>





Categories



**STUDIES**  
up to 100k€

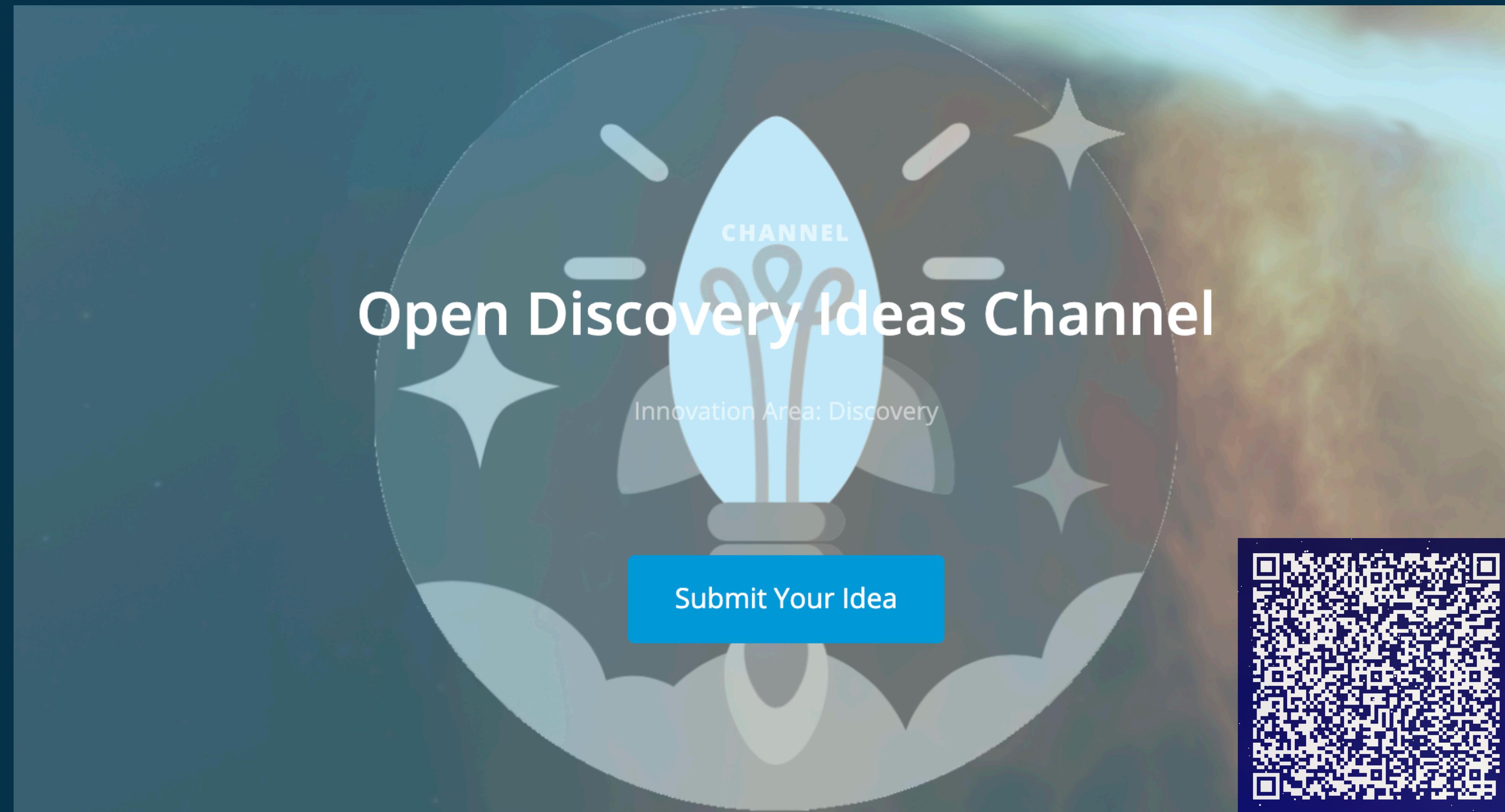


**EARLY TECHNOLOGY  
DEVELOPMENT**  
up to 175k€

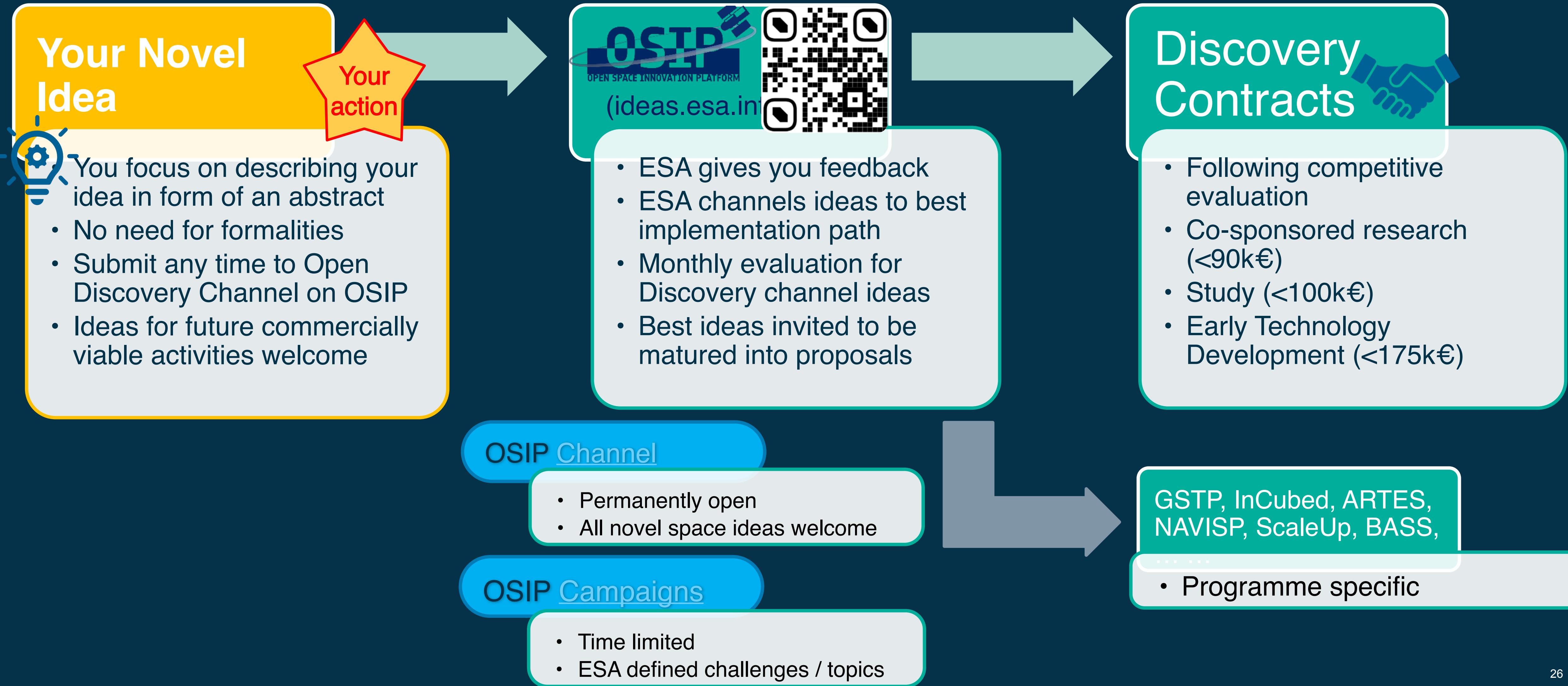


**CO-SPONSORED  
RESEARCH** up to 90k€

# Open Discovery Ideas Channel



# First steps for novel ideas – Discovery Element Process Steps



# 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

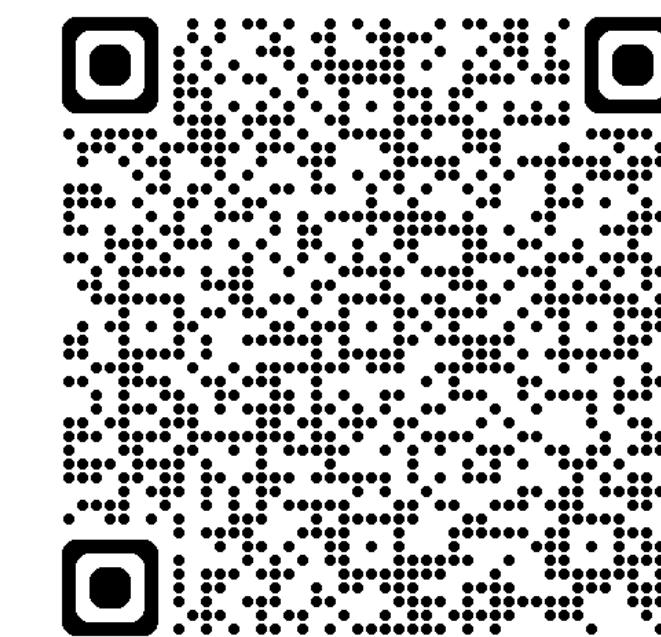
Nominally up to 1 year at the ESA site where the ESA Co-supervisor is located.

> 50 researchers

## Dedicated Visiting Researcher channel:

For any funded research project. ([link](#))

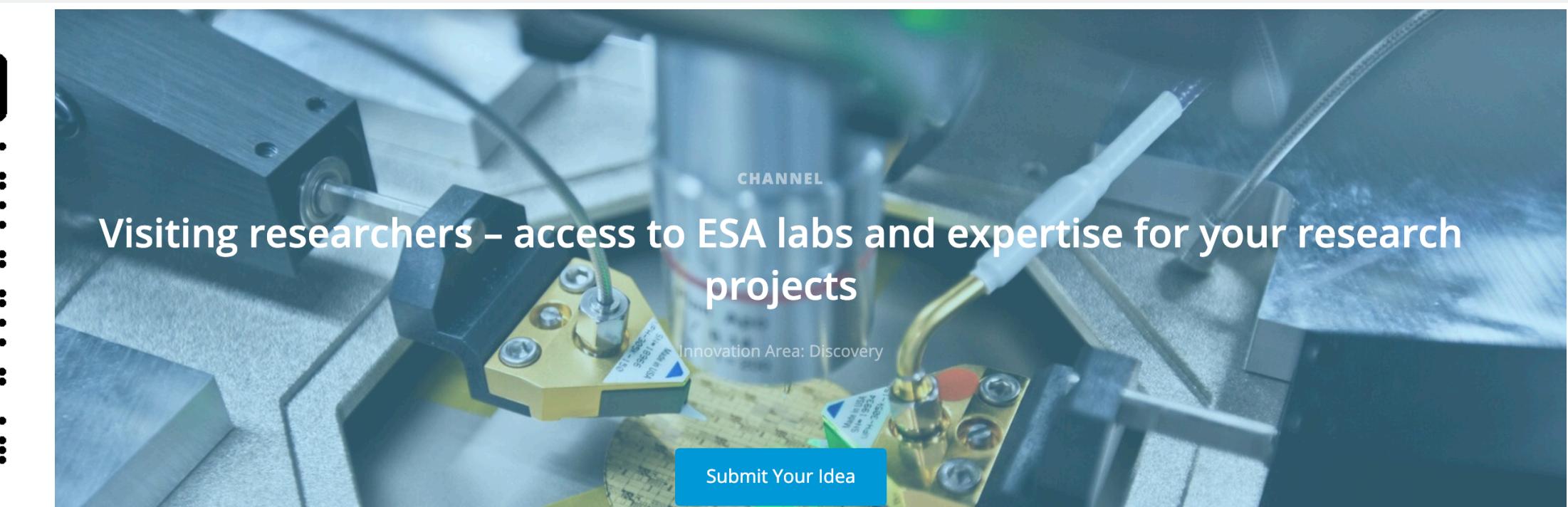
- 8 ESTEC
- 9 participating labs



ESA UNCLASSIFIED - For ESA Official Use Only

The grid displays 8 research projects:

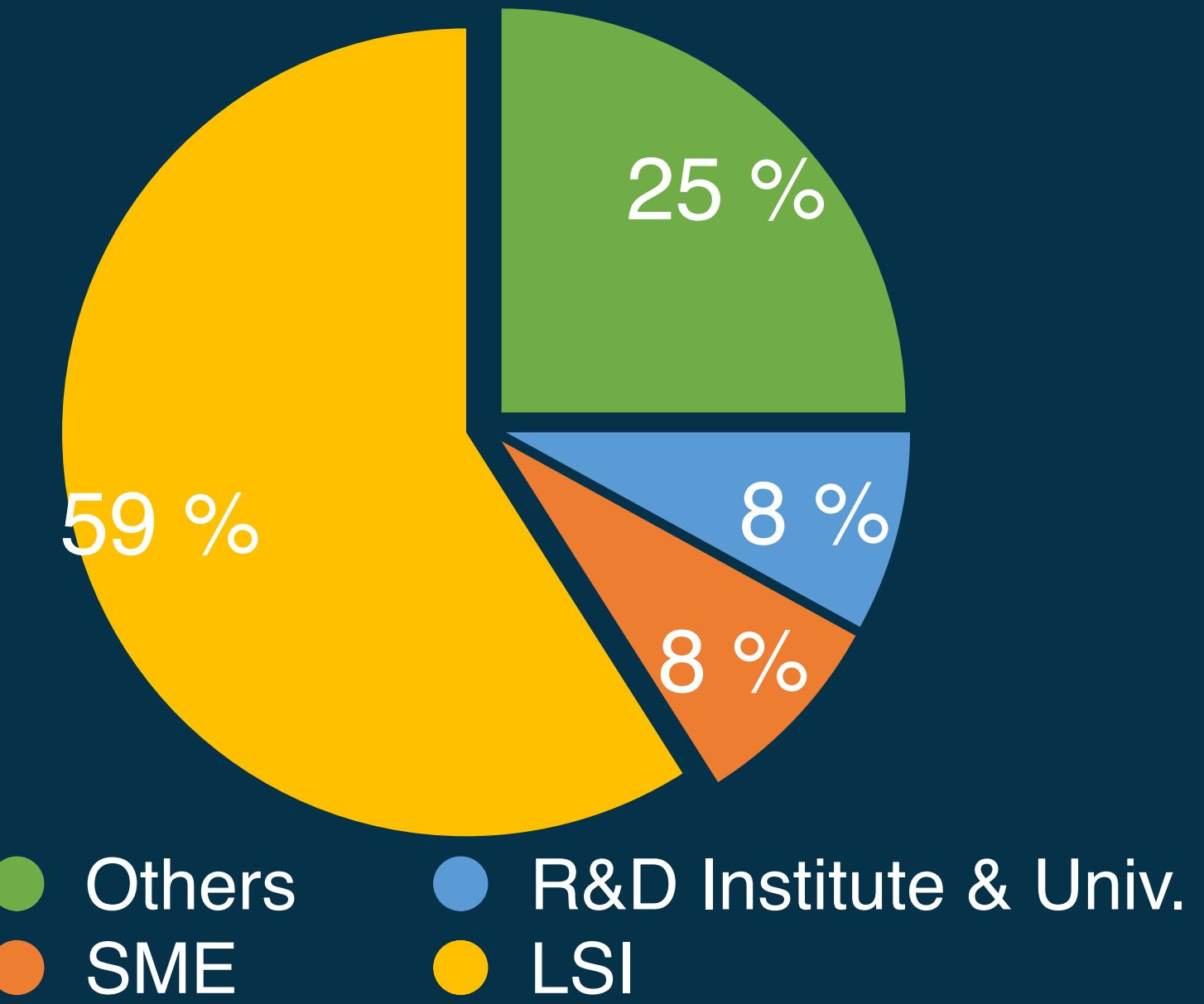
- Charting the Legacy - New Space Dilemma: Adapting to an Evolving Space Landscape**  
by Gianluca Furano and 2 others  
**Selected**
- Models and Simulation Tool for Cognitive Synthetic Aperture Radar**  
by Matteo Sartoni  
**Community Discussion**
- Bio-inspired and Soft Robotic Arms for Space Debris Grasping**  
by Camilla Agabiti  
**Selected**
- Low Temperature Operation of Batteries via Photo-induced Heating**  
by Joao Cunha  
**Selected**
- Exploiting an instrument on the "oxygen farming" concept and the production of oxygen on Mars**  
by Małgorzata Holynska and 1 other  
**Selected**
- Modelling and Control of a Multi-Arm Robot for Assembling Flexible Structures**  
by Massimo Casasco and 3 others  
**Selected**
- High-fidelity characterization of Hera's autonomous vision-based navigation system**  
by Jesus Gil Fernandez and 2 others  
**Selected**
- Robust Optimization of Very-Close Fly-By Trajectories for the HERA mission**  
by Thomas Aleksander Frekhaug  
**Selected**



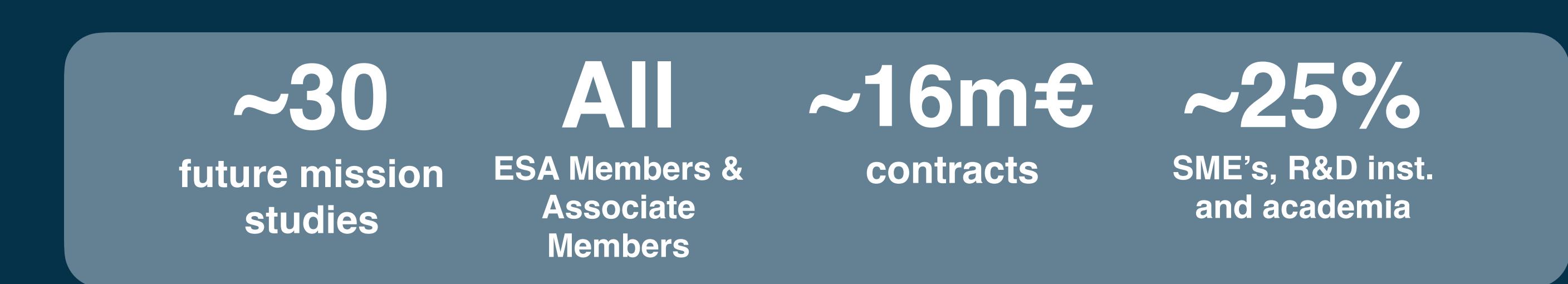
# Preparation of Future Missions



- 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:**



# 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

CDF

~20 pre-Phase A/year  
*Parallel activities*

Pre-Phase A

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

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

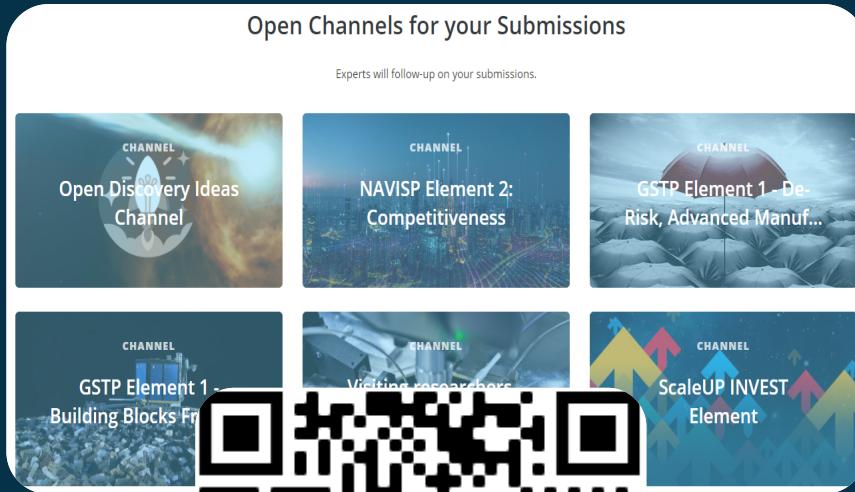
- Sentinel 2 NG
- Sentinel 3 NG
- M7
- Ramses - Apophis mission
- NEOMIR
- DRACO System Study
- STEREOID
- AEOLUS-2

\*Commitment average for the timeframe 2018 to 2023<sup>29</sup>

# Useful links



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

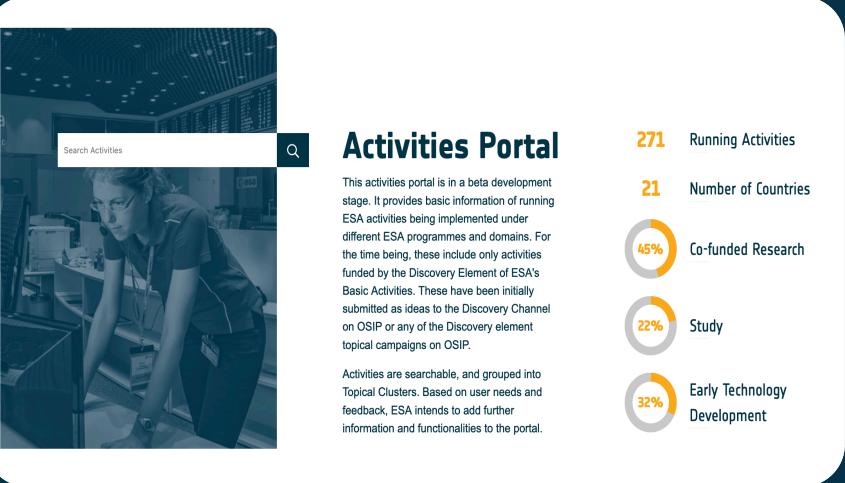


- Registration of new companies
- Invitations to tenders.
- News/Procurement related announcements:
- Preparation, TDE WP, GSTP Compendia
- Publication



## 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

Nebula Public Library

The knowledge bank of ESA's R&D programmes

MULTI-PROGRAMME SEARCH ADVANCED SEARCH TIMELINE HELP

Fulltext search  Programme  Status  Country

Contractor  Application Domain  Competence Domain  Technology Domain

Start Year  End Year  Running year  Apply Clear filters

Search  1391 results found  1 2 3 4 5 6 7 8 9 ... next last

+ Filter by programme:  21 D-TEC-01  AUSTRIAN ACADEMY OF...  2021 - 2022

+ Filter by start year:  2021-2022  2022-2023

+ Filter by end year:  2021-2022  2022-2023

+ Filter by keywords:  Advances in Technological Quantum Optics

+ Filter by contractor:  Austria  Austria Space Agency  Austrian Academy of Sciences  Austrian Space Forum





# Thank you!

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