



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.

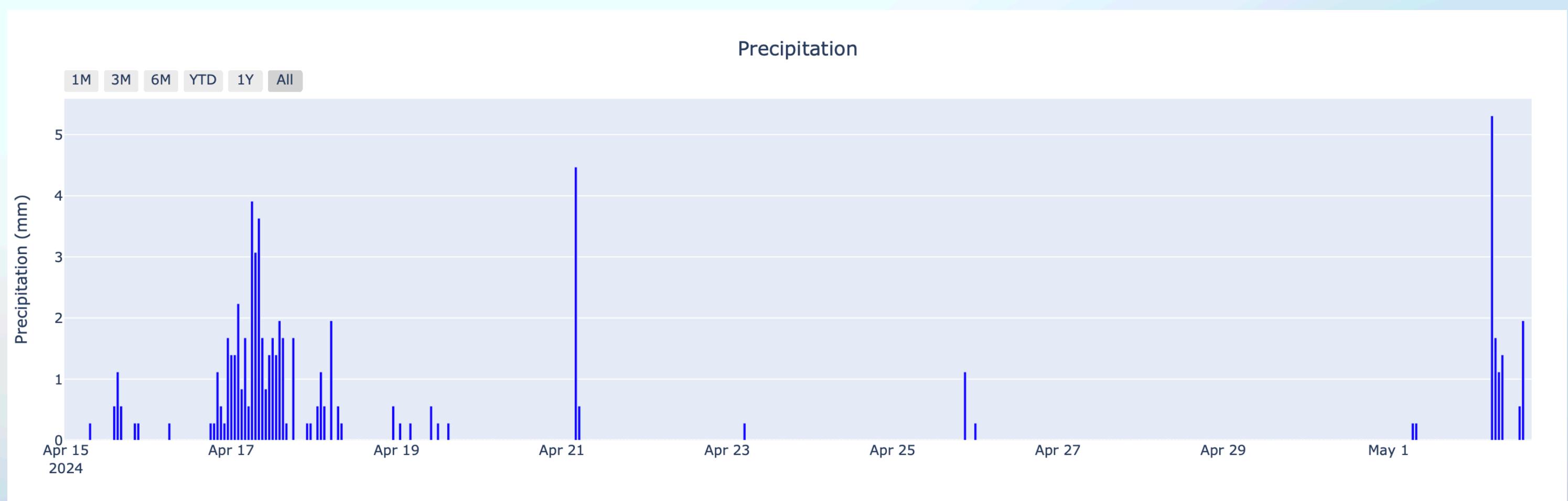
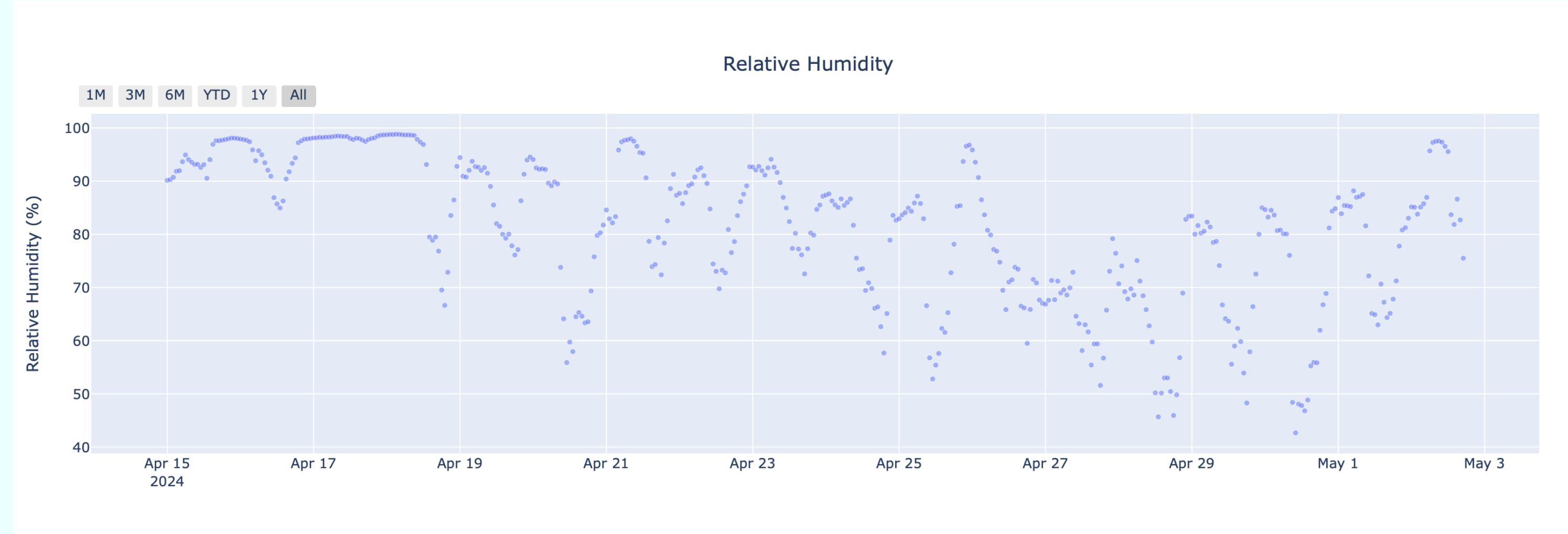
On This Page

- 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.

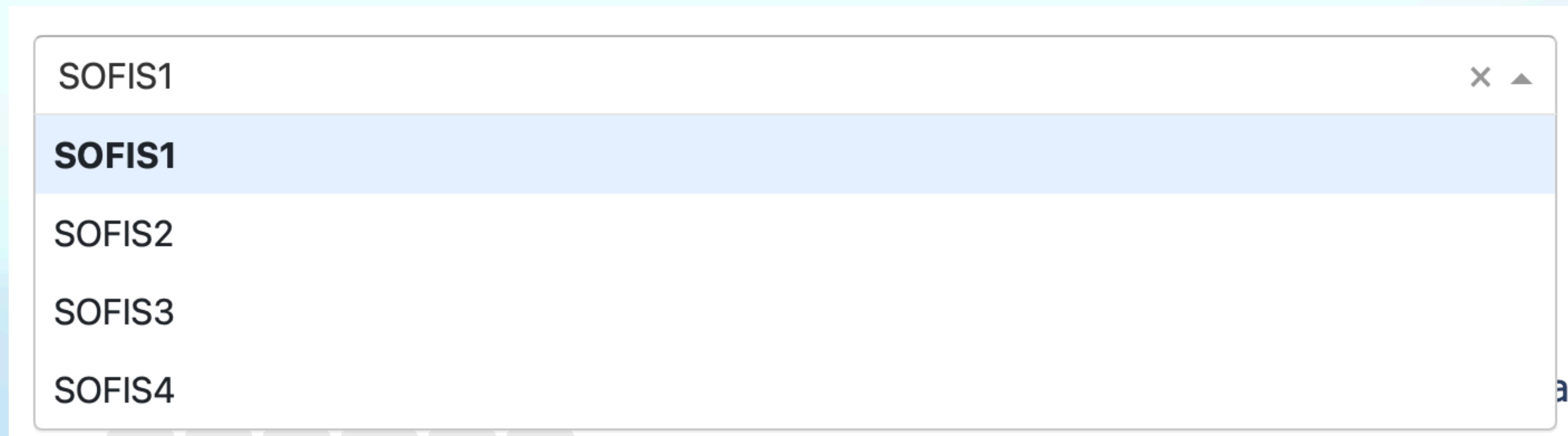
Graphs

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



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.

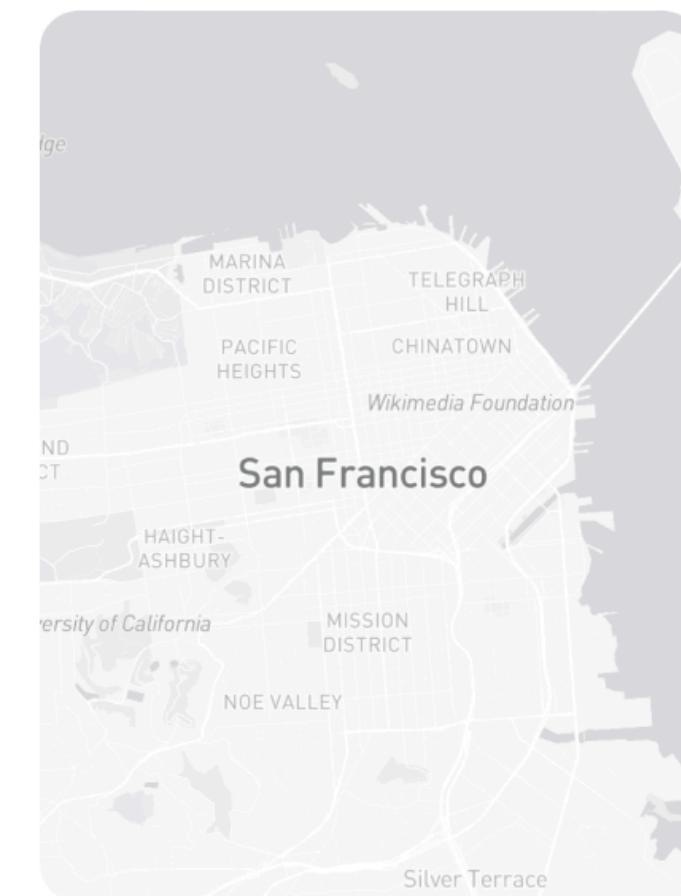
Select Department

A list of selected departments. It shows two items: "Marketing" and "Logistic", each preceded by a small "x" icon. There is also an "x" icon and a downward arrow icon at the end of the list.

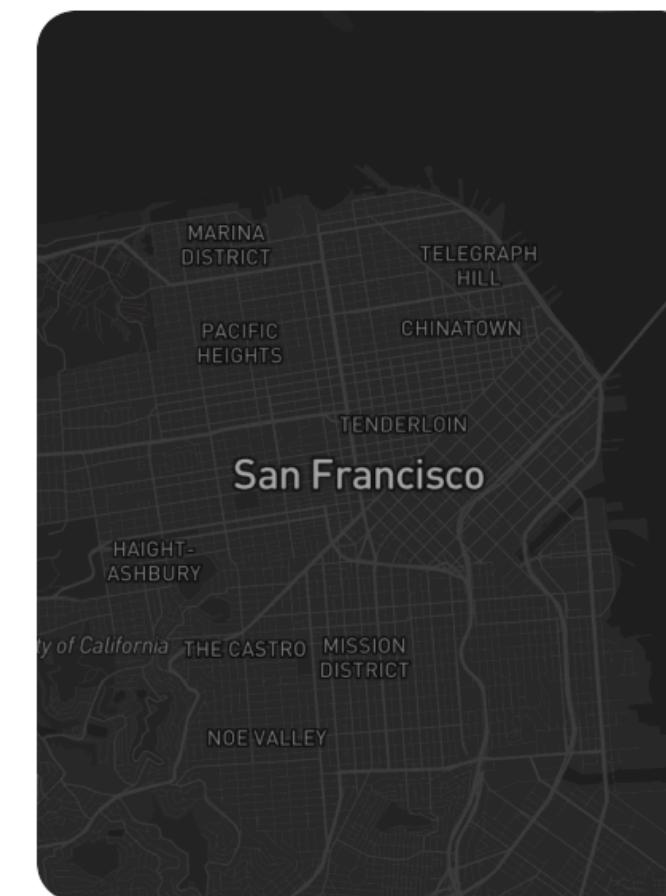
A slider example.

Support for Mapbox

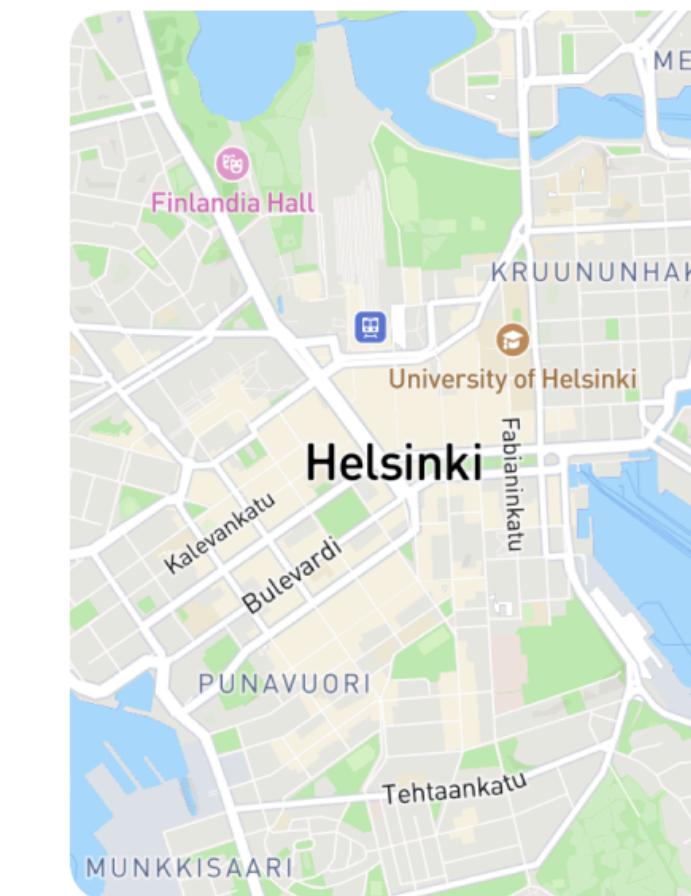
- Bring a location technology to display geospatial data e.g. coordinates.



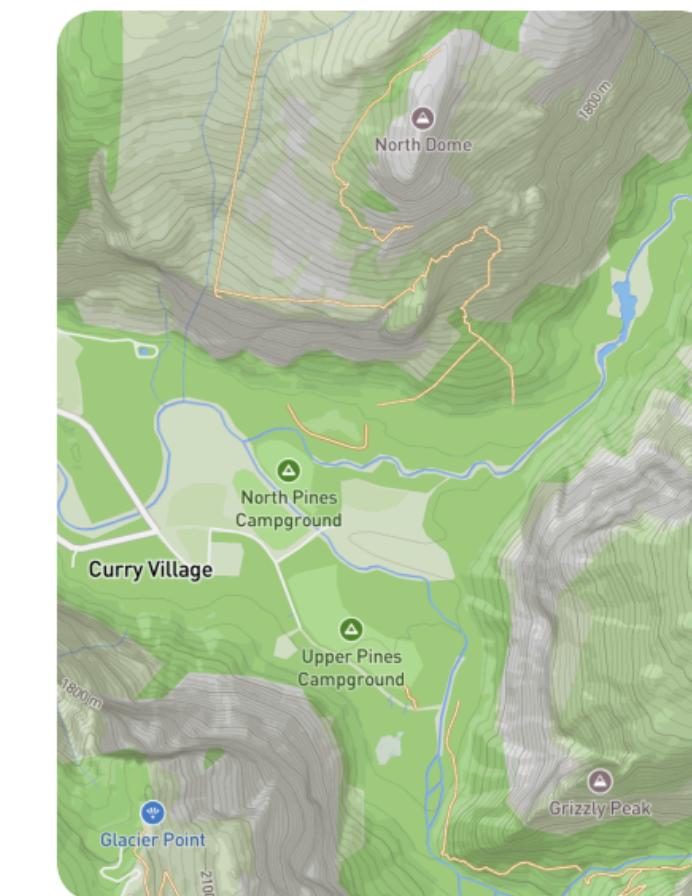
Light



Dark



Streets



Outdoors



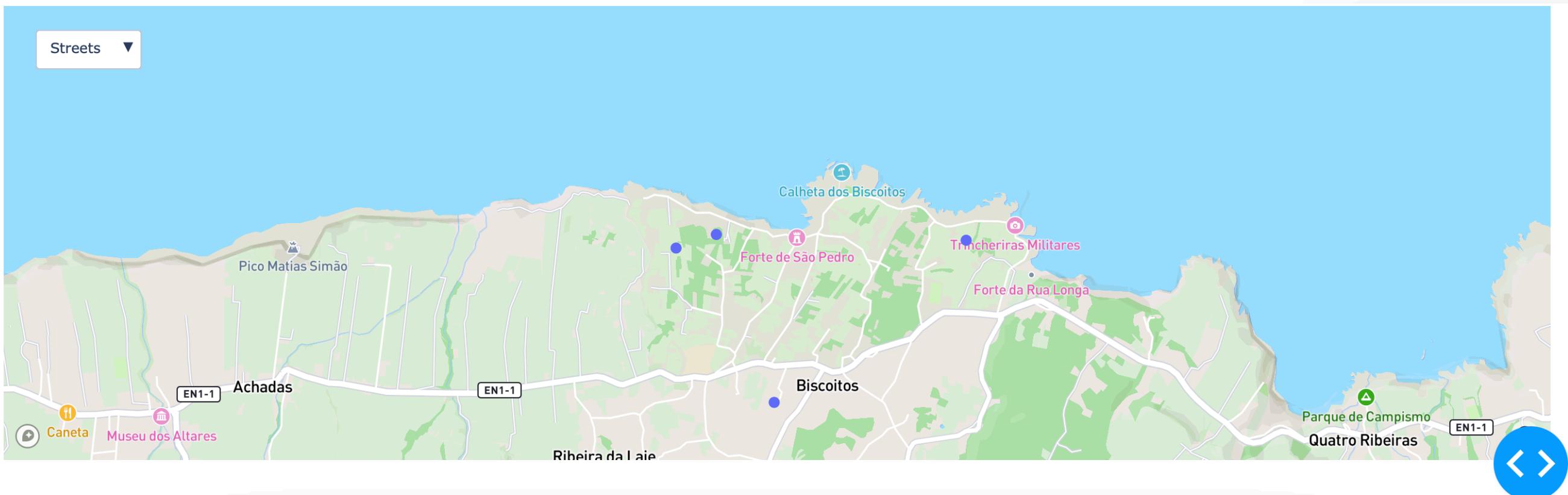
Satellite Streets

Mapbox's map styles.

Support for Mapbox

Location of the sensors

Location of the installed SOFIS sensors

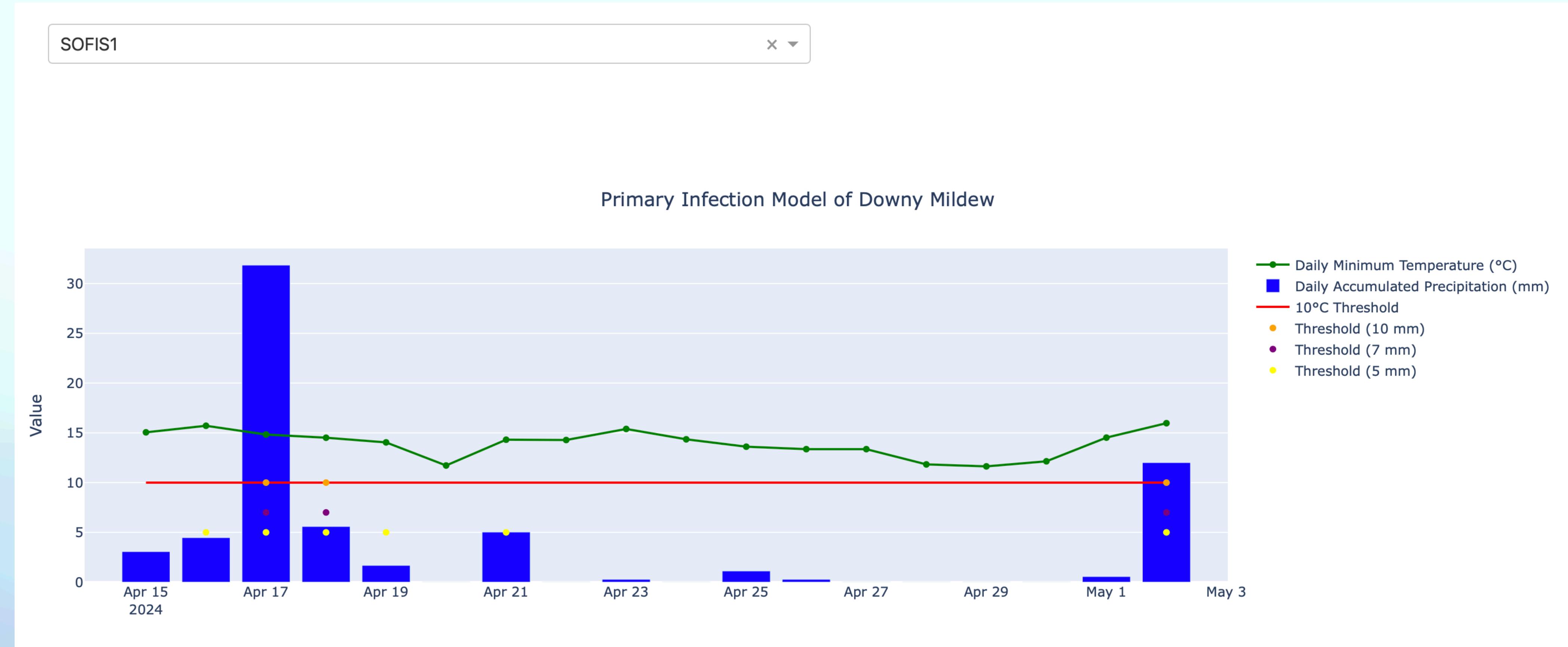


Location of the installed SOFIS sensors



Risk of primary infection of downey mildew

Calculating the “10-10-10” model



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.

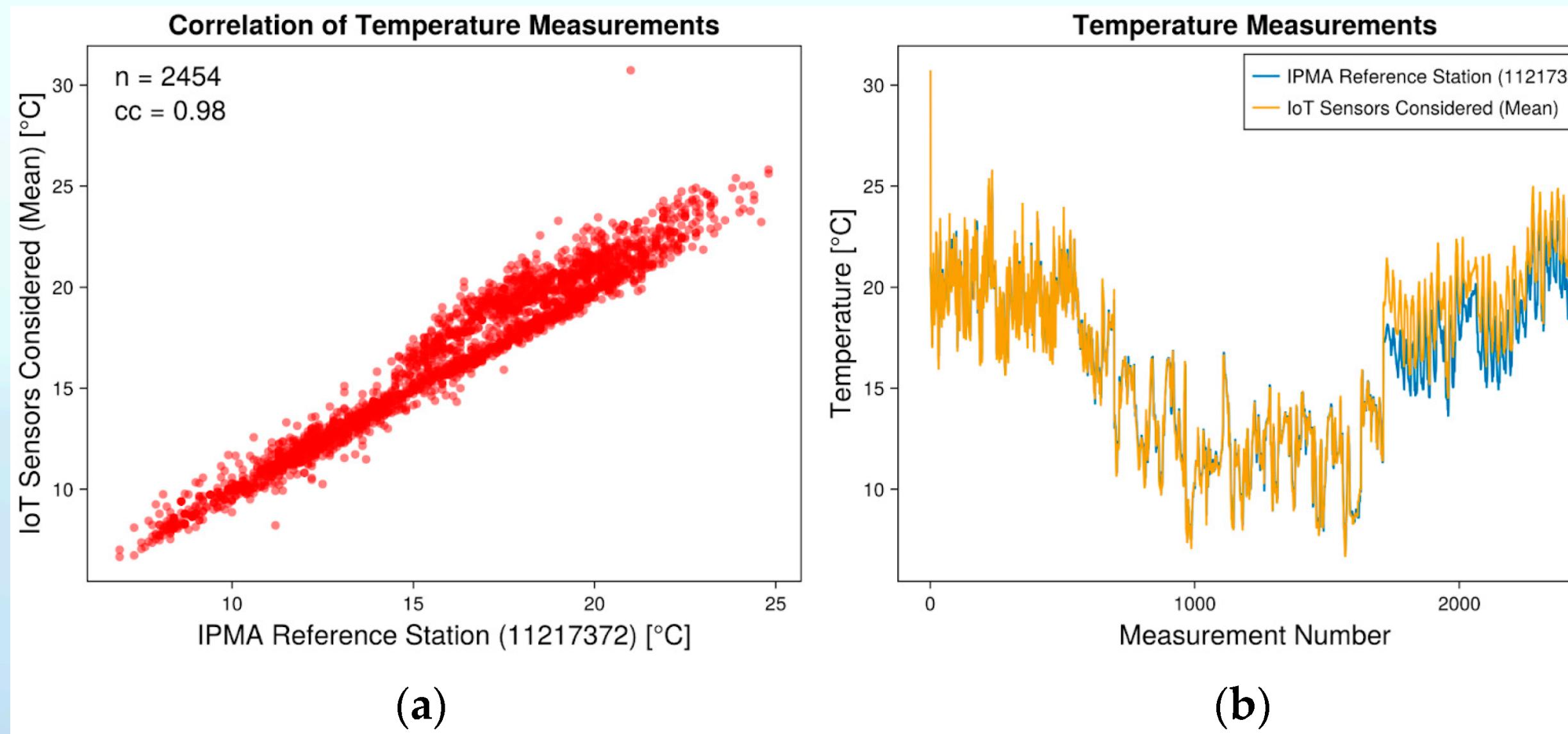


Article

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.

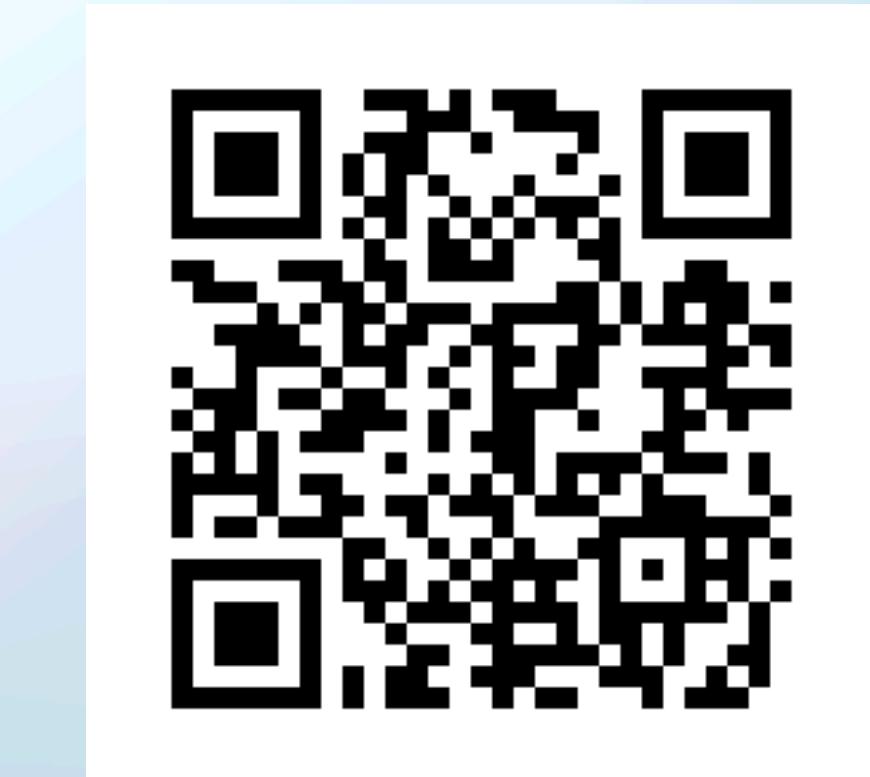
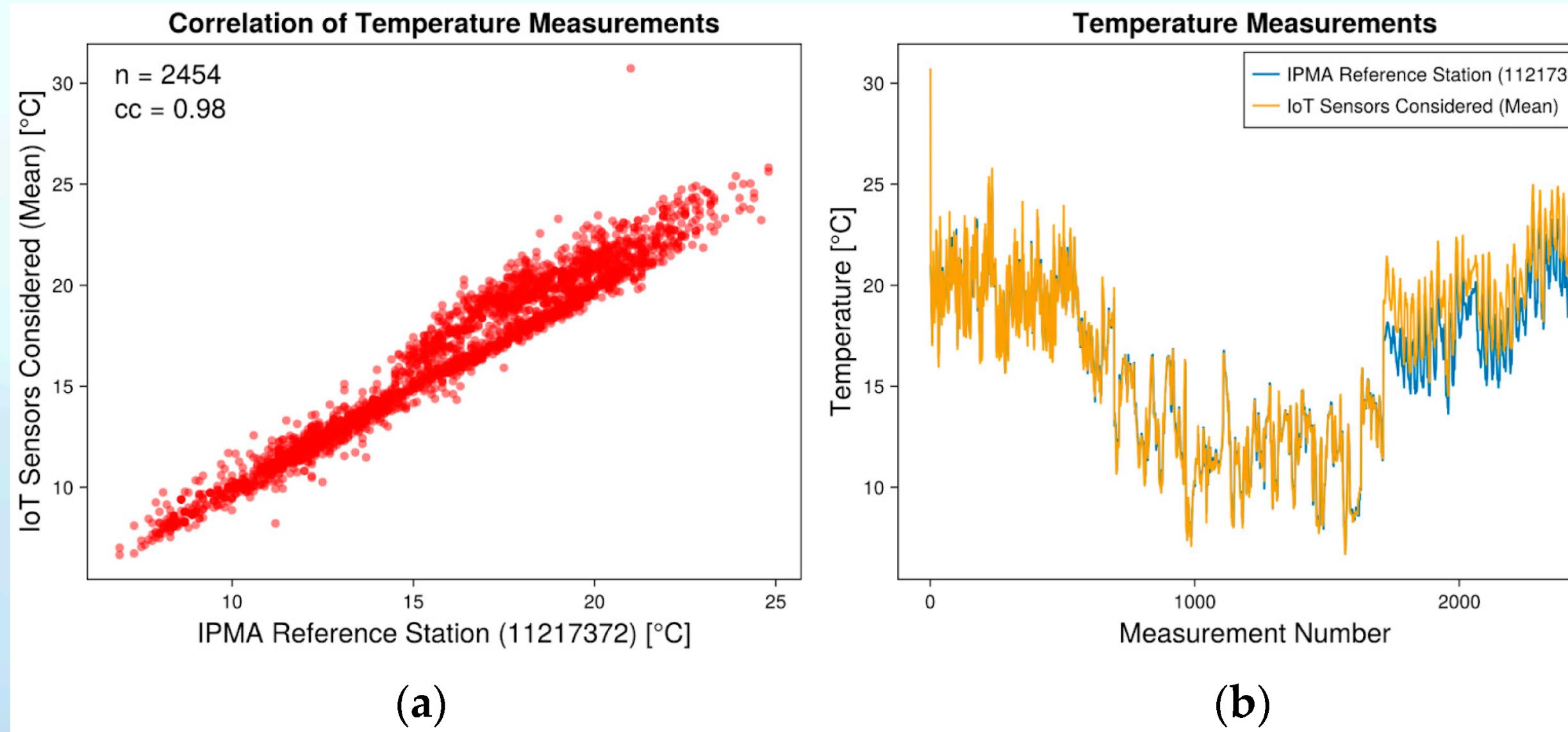


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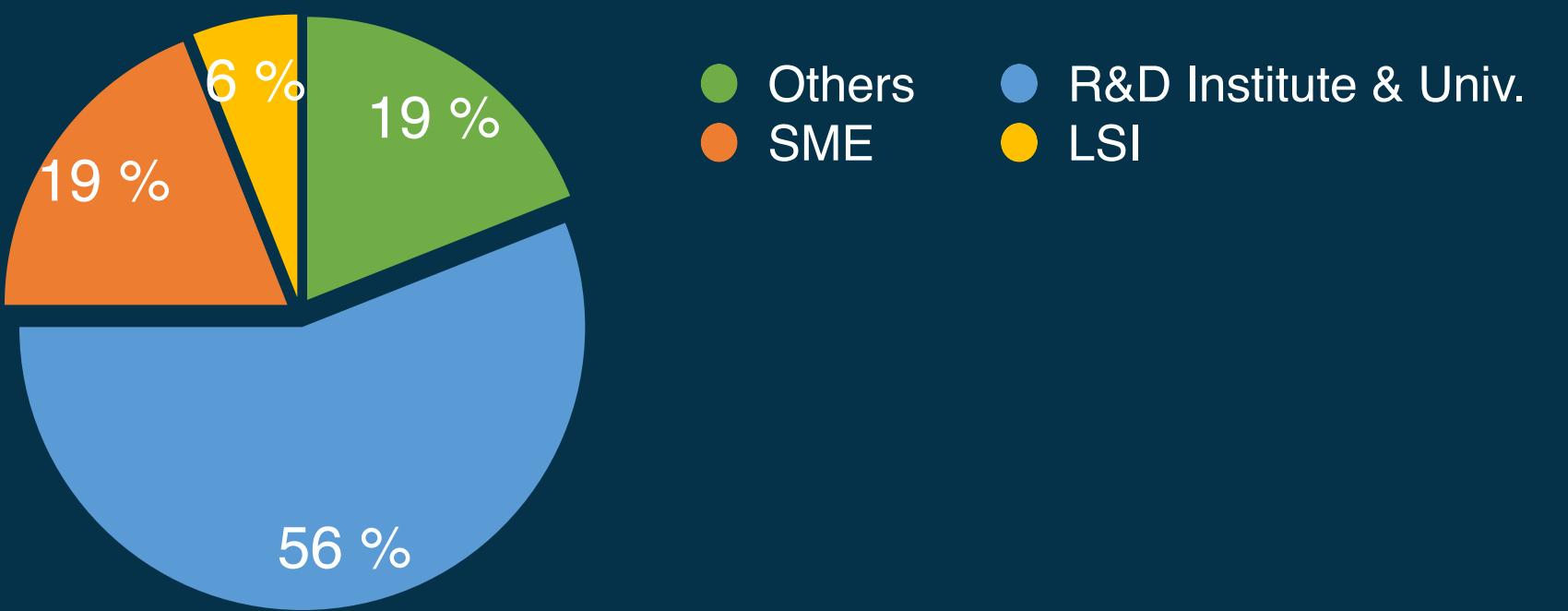
Link to the paper.

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



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



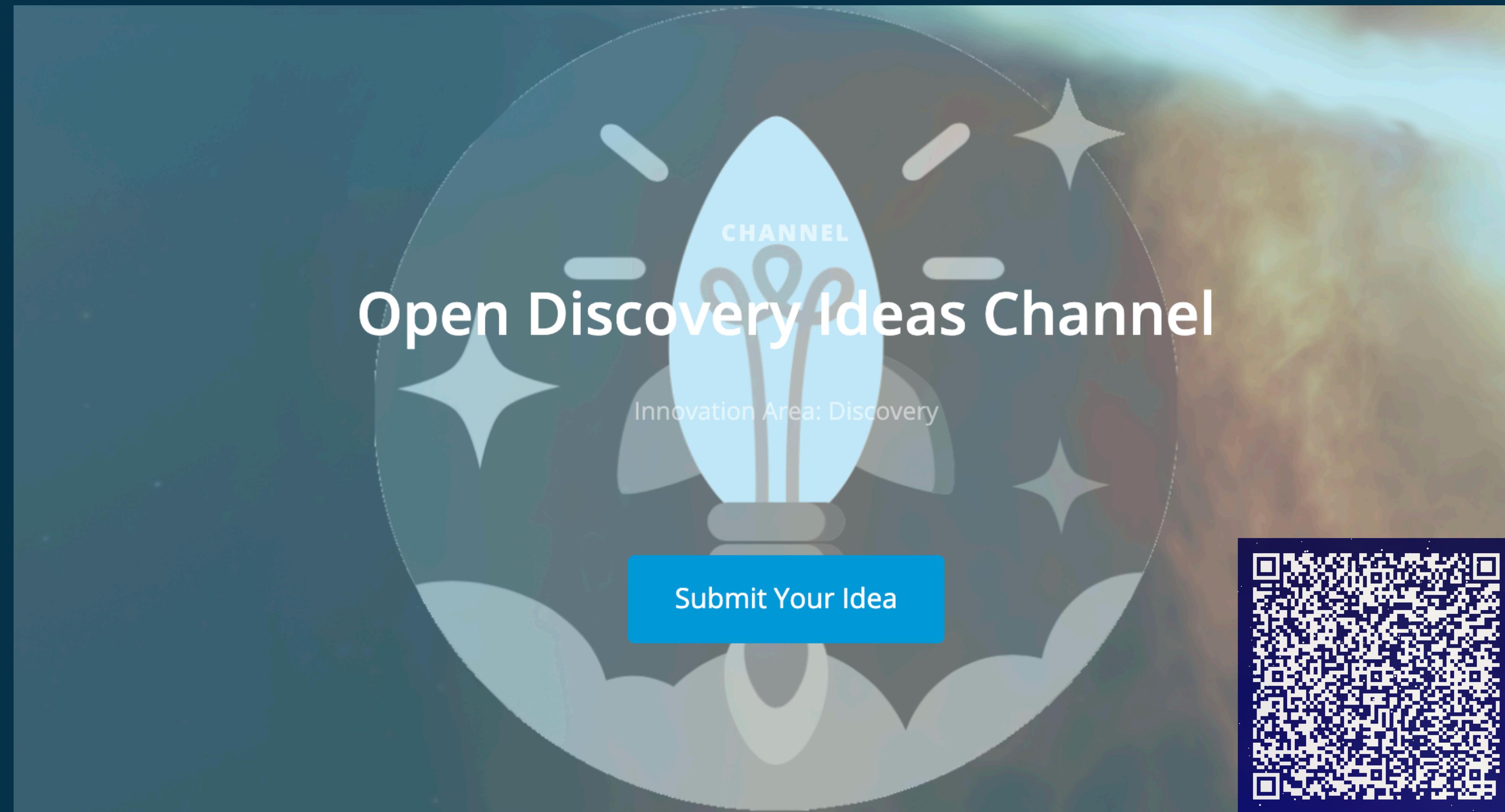
242
EARLY
TECHNOLOGY
DEVELOPMENTS



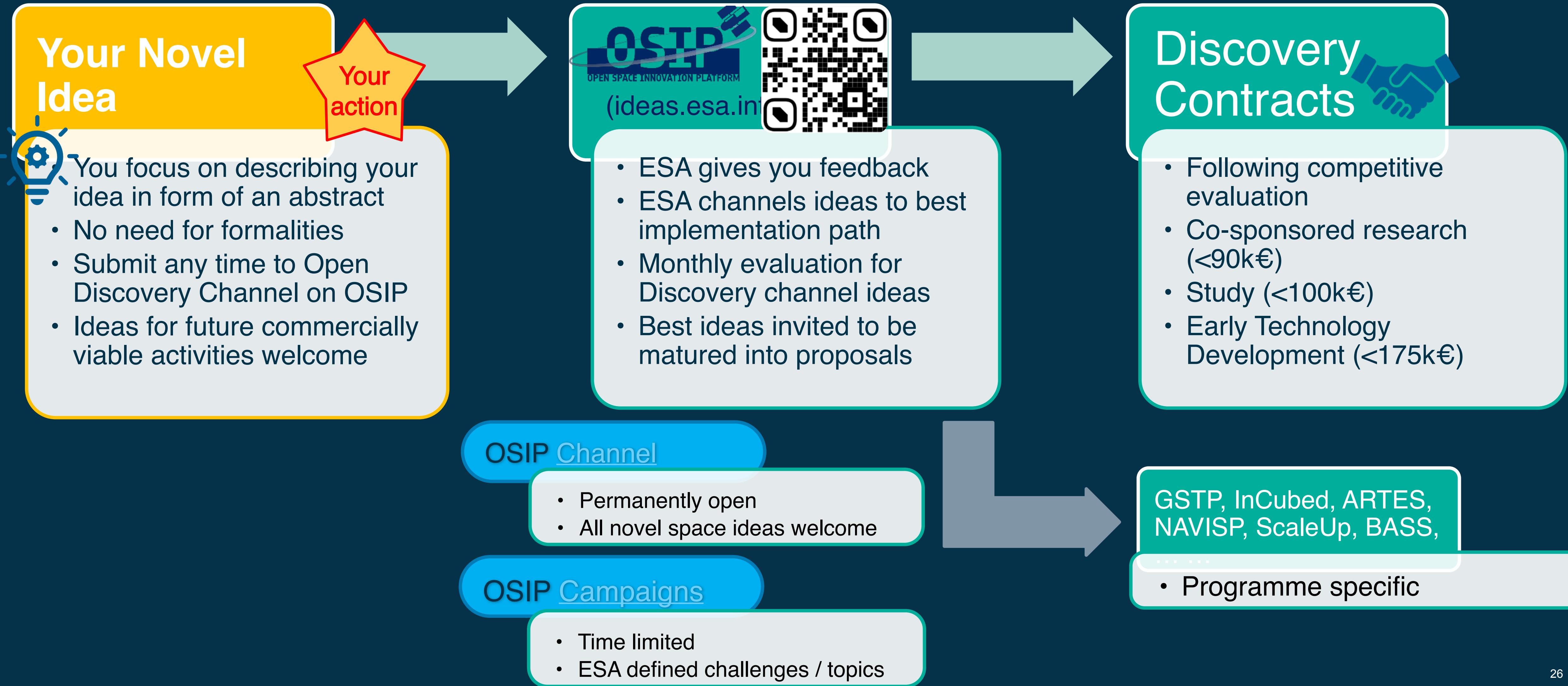
<https://activities.esa.int>



Open Discovery Ideas Channel



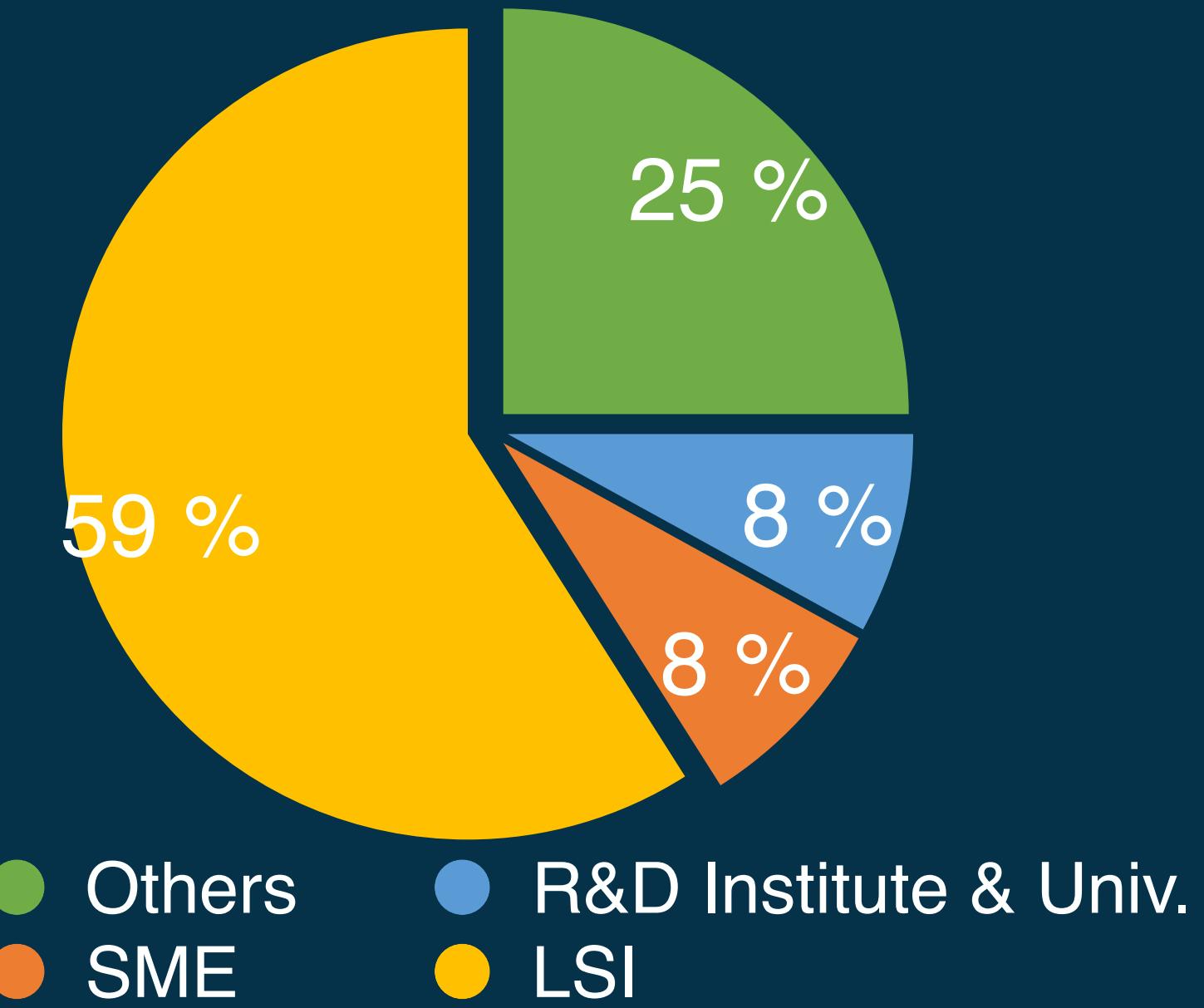
First steps for novel ideas – Discovery Element Process Steps



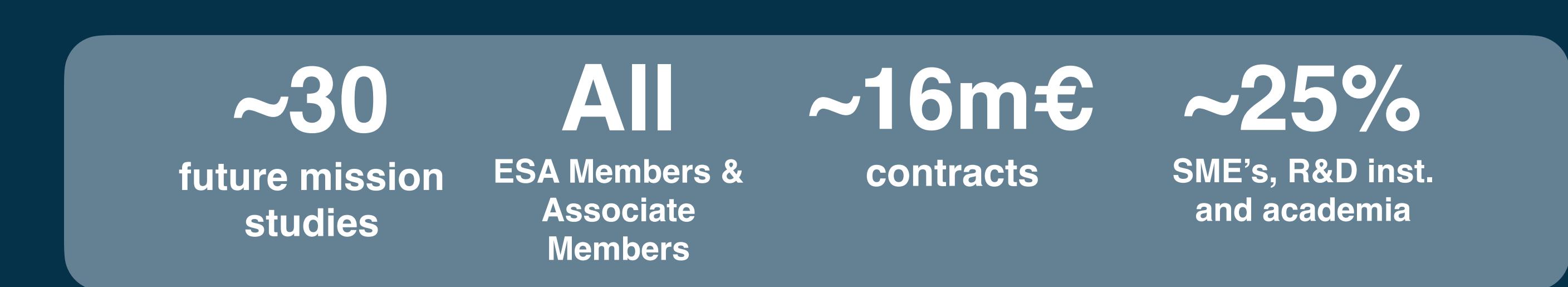
Preparation of Future Missions



- 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 2023²⁸

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

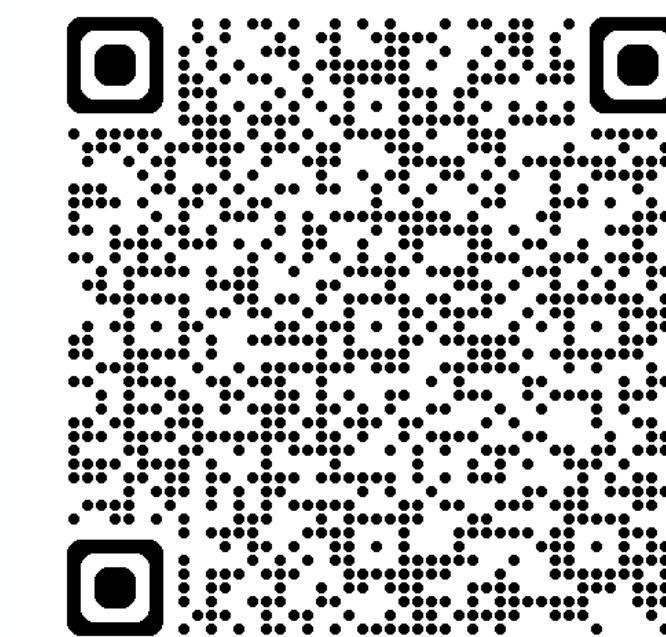
Nominally up to 1 year at the ESA site where the ESA Co-supervisor is located.

> 50 researchers

Dedicated Visiting Researcher channel:

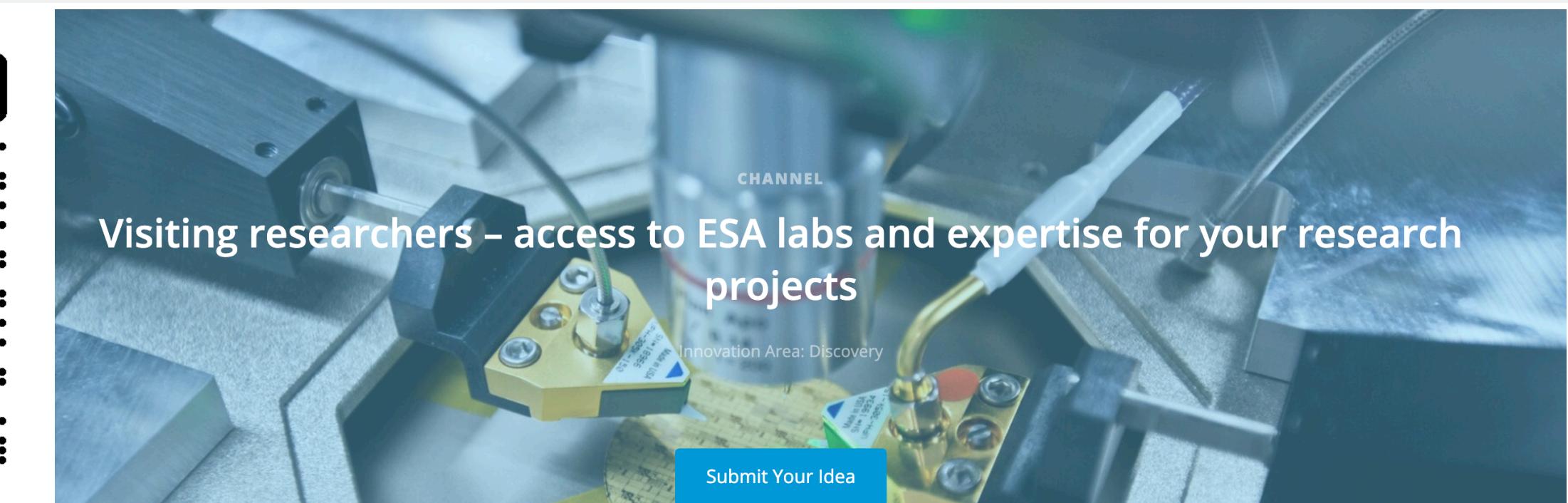
For any funded research project. ([link](#))

- 8 ESTEC
- 9 participating labs



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



ESA UNCLASSIFIED - For ESA Official Use Only

Useful links



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

Open Channels for your Submissions
Experts will follow up on your submissions.

CHANNEL Open Discovery Ideas Channel
CHANNEL NAVISP Element 2: Competitiveness
CHANNEL GTP Element 1: De-Risk, Advanced Manuf...

CHANNEL GSTP Element 1: Building Blocks for GSTP 2022
CHANNEL ScaleUP INVEST Element



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

TECHNOLOGY DEVELOPMENT ELEMENT (TDE) WORK PLAN 2021-2022
1-10601

This is the TDE Work Plan 2021-2022 of the Technology Development Element (TDE) as part of the Basic Activities, in response to basic TDE Requirements and its funding. This document describes the work plan to be conducted by the ESA Technology Division, which was published in 2020 and encompasses all ESA activities. The technology and engineering targets, defined in TDE technology working areas, both academic and industrial, for the implementation of the European space programme. They include 30% improvement of spacecraft development time by 2025, one order of magnitude better cost efficiency with generic, 30% faster development adoption of innovative technology, meeting European contributions to space debris by 2030. The TDE plan a systematic approach towards achieving these targets. The TDE Work Plan 2021-2022 addresses the mission needs for Earth Observation, Exploration, Space Transportation, Telecommunications, Navigation and Space Safety. The work plan for 2021-2022 is divided into three main sections: Work Plan, Work Plan Summary and Work Plan Annexes. The annexes provide detailed information on specific topics such as the Work Plan for the application domain and per competence domains. Deviations to Tenders will be continuously issued on EMETTS. Read this

Announcement Date: 20/11/2020 09:00:00
Last Update On: 20/09/2021 12:00:00
Update Reason: Imported from EMETTS

Contractor: Any
Application Domain: Choose some options
Competence Domain: Choose some options
Start Year: 2021
End Year: 2022
Running year: Running year

Authorized Contact Person: Gun Lennart Casali
Secting Service: DPT Measures
Technology Domains: Technology Development

Tender Type: Open To Tenders From: Open Competition
EU-Open Competition
EU-SE
EU-Other
S-N Non Space
Technology Keywords: Products Keywords:



Activities Portal

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

Activities Portal
This activities portal is in a beta development stage. It provides basic information of running ESA activities being implemented under different ESA programmes and domains. For the time being, these include only activities funded by the Discovery Element of ESA's Basic Activities. These have been initially gathered from the Discovery Channel on OSIP or any of the Discovery element topical campaigns on OSIP.
Activities are searchable, and grouped into Topical Clusters. Based on user needs and feedback, ESA intends to add further information and functionalities to the portal.

271 Running Activities
21 Number of Countries
45% Co-funded Research
22% Study
33% Early Technology Development



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: Any	Choose some options	- Any -	Technology Domain: Choose some options
Start Year	Application Domain: Choose some options	Competence Domain: Choose some options	Country: Choose some options
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:
Austria, 21-D-TEC-01, AUSTRIAN ACADEMY OF...

+ Filter by start year:
2021-2022

+ Filter by end year:
2021-2022

+ Filter by keywords:
Advances in Technological Quantum Optics

+ Filter by contractor:
2021-2022





Thank you!

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[linkedin.com/in/iga-szczesniak/](https://www.linkedin.com/in/iga-szczesniak/)
igaszczesniak.github.io/