D1.7 Hackathon results

15/11/2024

Author(s): Laura Abraham, Louise Hendrickx, Quentin Groom, Nikol Yovcheva, Ward Langeraert, Duccio Rocchini and Shawn Dove

Funded by
the European Union

Prepared under contract from the European Commission
Grant agreement No. 101059592
EU Horizon Europe Research and Innovation Action

Project acronym:	**B3**
Project full title:	**Biodiversity Building Blocks for policy**
Project duration:	01.03.2023 – 31.08.2026 (42 months)
Project coordinator:	Dr. Quentin Groom, Agentschap Plantentuin Meise (MeiseBG)
Call:	HORIZON-CL6-2021-GOVERNANCE-01
Deliverable title:	Task 1.7: Hackathon results
Deliverable n°:	D1.7
WP responsible:	WP1
Nature of the deliverable:	Document
Dissemination level:	Public
Licence of use:	[cc-by]
Lead partner:	MeiseBG
Recommended citation:	Abraham, L., Hendrickx, L., Groom, Q., Yovcheva, N., Langeraert, W., Rocchini, D., Dove, S. (2024). ***Hackathon results***. B3 project deliverable D1.7.
Due date of deliverable:	November 30, 2024
Actual submission date:	Month n°xx

Deliverable status:

Version	Status	Date	Author(s)
1.0	Draft	4 October 2024	Laura Abraham (APM)
1.1	Draft	21 October 2024	Louise Hendrickx, Nikol Yovcheva, Ward Langeraert, Duccio Rocchini, Shawn Dove, Quentin Groom
1.2	Review	15 November 2024	Sandra MacFadyen and Peter Desmet
1.3	Final	21 November 2024	Laura Abraham (APM)

Table of contents

Key takeaway messages

- **Global collaboration:** Convened 86 participants from 20 countries and 46 affiliations in a hybrid format, fostering global networking and interdisciplinary collaboration in biodiversity informatics.
- **Skill development:** Enhanced participants expertise in biodiversity data cubes, GitHub, GBIF, and biodiversity indicator methodologies, as highlighted by a post-hackathon survey.
- **Impactful outputs:** Delivered innovative tools, workflows, and three preprints, all publicly accessible through the B3 GitHub repository, ensuring long-term accessibility and reuse.
- **Advancing Biodiversity Monitoring:** Demonstrated the potential of biodiversity data cubes for research, monitoring and policy contributing to B3's mission of standardising biodiversity data use.
- **Lessons Learned:** Highlighted the value of hybrid engagement, robust communication tools, and real-time feedback for improving future events.
- **Future Directions:** Provided a foundation for future advancements in biodiversity data initiatives, leveraging collaboration and technology to address global biodiversity challenges.

Executive summary

The B3 hackathon convened 86 participants in a hybrid format, creating a collaborative environment to innovate and advance biodiversity monitoring and policy integration using biodiversity data cubes. With representation from 46 affiliations across 20 countries, the event fostered global networking and knowledge exchange among professionals from diverse fields. A post-hackathon survey highlighted participants' significant skill gains in data cube usage, GitHub, GBIF and biodiversity indicators methodologies. The hackathon produced impactful outputs, including tools, workflows, and three preprints, all made publicly available through the B3 GitHub repository for further refinement and application (https://github.com/b-cubed-eu/hackathon-projects-2024). Submitted projects showcased the vast potential of biodiversity data cubes in research, monitoring, and visualisation, contributing to B3's broader mission of standardising and democratising biodiversity data for policy and research use. The hackathon also served as a vital networking event, strengthening connections within biodiversity informatics. The event also provided valuable lessons, including the importance of hybrid engagement, the need for robust communication tools, and the benefit of real-time feedback mechanisms to enhance future events. This report documents the hackathon's organisation, outcomes, summarizing the projects submitted, lessons learned and future directions for B3's biodiversity data initiatives. The hackathon demonstrated the power of collaboration and technology in tackling global biodiversity challenges, helping to create tools and knowledge that will benefit research and conservation for years to come.

Non-technical summary

The B3 hackathon brought together 86 participants from 20 countries in a hybrid event aimed at innovating and improving biodiversity monitoring and conservation using advanced tools known as "biodiversity data cubes." These data cubes organise and analyse large amounts of environmental data to support research and decision-making in conservation efforts. The event encouraged professionals from various fields, such as ecology, data science, and biodiversity informatics, to collaborate and share ideas.

During the hackathon, teams developed new tools, workflows, and techniques to better understand and manage biodiversity. This resulted in valuable outputs, including software tools and three scientific papers (preprints), all of which are now publicly available for further use and development.

The event also provided an excellent learning opportunity, with participants gaining new skills in working with data cubes, using coding repositories like GitHub, and applying biodiversity data to inform decision-making. Additionally, the hackathon facilitated global networking, helping to strengthen connections among experts in biodiversity science.

The event also provided key insights for future activities, such as the importance of efficient communication, hybrid event formats, and collecting real-time feedback. Overall, the hackathon demonstrated how collaboration and technology can help tackle global biodiversity challenges, creating tools and knowledge that will benefit research and conservation efforts for years to come.

List of abbreviations

GBIF	Global Biodiversity Information Facility
EV INBO	Eigen Vermogen van het Instituut voor Natuur- en Bosonderzoek
UNIBO	Alma Mater Studiorum - Universita Di Bologna
JLUG	Justus-Liebig-Universitaet Giessen
PENSOFT	Pensoft Publishers
MLU	Martin-Luther-Universitat Halle-Wittenberg
INRIA	Institut National De Recherche En Informatique et Automatique
UAVR	Universidade De Aveiro
CREAF	Ecological and Forestry Applications Research Centre

1. Hackathon overview

1.2. Event summary

Hackathons are widely recognized as dynamic environments for fostering creativity and collaboration in a concentrated time frame (Pe-Than et al. 2018; Meeus et al. 2022). For B3, hosting a hackathon was a strategic way to drive innovation and collaboration around the biodiversity data cube, a key deliverable of the B3 initiative. The primary goals of the hackathon were to:

1. **Familiarize stakeholders** with biodiversity data cubes, demonstrating their potential in biodiversity monitoring and policy-making.
2. **Encourage innovative applications** of data cubes for research and practical use cases.
3. Develop open-source tools and standardised datasets adhering to the **FAIR principles** (**F**indable, **A**ccessible, **I**nteroperable, and **R**eusable).
4. **Foster interdisciplinary collaboration** among biodiversity informaticians, researchers, and practitioners to create impactful tools and workflows.

By creating a space for skill development, knowledge exchange, and innovation, the event aligned with B3's mission to transform biodiversity monitoring into a responsive system that supports policymakers with timely, actionable insights.

The hackathon took place over a four-day period and employed a hybrid format, enabling both in-person and virtual participation to maximize accessibility and global engagement (Table 1).

Table 1. General overview of the hackathon title, date, duration and venue.

Title:	Hacking biodiversity data cubes for policy
Date:	2-5 April 2024
Duration:	4 days
Venue:	Hybrid event at Herman Teirlinck building, Brussels

Structure and activities

Participants were invited to submit project proposals aligned with B3's objectives (see section 2.1. Project themes) prior to the hackathon. During the event, they collaborated intensively to develop their projects, concluding with presentations to a panel of judges and their peers. Teams were free to form organically, with participants joining projects that aligned with their interests and expertise. The hackathon balanced competition with a collaborative spirit, emphasising knowledge sharing and mutual learning. A technical support team was on hand to provide guidance and offer training on data cube technologies. To enhance the experience, hacking sessions were alternated with keynote presentations, broadening participants' perspectives and sparking new ideas. By the end of the event, the hackathon delivered practical outcomes, including prototype tools, workflows, and methodologies that advanced the use of biodiversity data cubes in research and policy-making. This initiative underscored the potential of such events to catalyse progress in biodiversity informatics while advancing B3's mission.

Promotion

The promotion of the hackathon involved a multi-channel approach to ensure consistent branding and awareness. A logo (Figure 1), roll-up banner, PowerPoint template, as well as ticket and agenda designs (Figure 1) were created to maintain a cohesive and professional visual identity. A dedicated webpage (b-cubed.eu/b-cubed-hackathon) was regularly updated with key information such as registration details, project submissions and selected projects. Promotional efforts included the creation of an awareness-raising video and an aftermovie to highlight event moments. A news campaign featured key contributors to the hackathon. Two special newsletter editions and two press releases were published to engage potential participants and share event outcomes. These materials were further promoted via news items and social media channels, as well as archived in the project's Media Centre for future reference. Hackathon certificates were also provided to participants upon request.

Figure 1. B3 hackathon logo and QR code linking to the hackathon agenda developed by Pensoft.

1.3. Organisers and attendees

The hackathon was organised by Meise Botanic Garden with support of several partners, including GBIF, MLU, INBO, INRIA, PENSOFT, JLUG, UB and UAVR. The event was coordinated by Quentin Groom, with Laura Abraham serving as the organiser and host of the hackathon. Ruben Mollet acted as the helpdesk contact, while Louise Hendrickx was the designated contact for virtual attendees. Mathias Dillen provided technical support throughout the event.

A total of 86 participants attended the hackathon, including members of the organising and scientific committees as well as registered attendees. Participants represented 46 different institutions (Table S2) across 20 countries (Table S3), including 9 team leaders, 8 students, and 23 committee members. Among these, 60 participated in person, while 26 joined virtually.

The ticket distribution for the event, illustrated in Figure 2, shows the percentages of various ticket categories, including organising team, virtual registration, general admission, technical coach, keynote speaker, jury member, student in person, and student virtual.

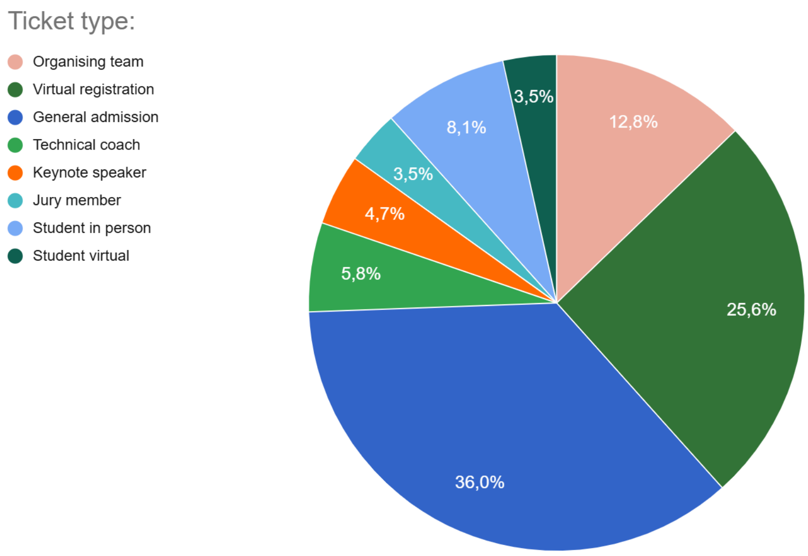

Figure 2. Distribution of ticket types for the hackathon: a pie chart displaying the percentages of various ticket categories.

Inclusivity measures

The hackathon was designed to be inclusive, enabling individuals from diverse backgrounds to participate. To achieve this, several measures were implemented. Firstly, a hybrid event format was adopted, allowing participants to join either in person or virtually, accommodating those in different geographic locations or with varying personal circumstances. The event was widely promoted across multiple platforms, including universities, to ensure broad accessibility.

To further enhance inclusivity, the event offered various levels of participation, catering to both beginners and experts. Resources such as technical coaches were available to support participants of all skill levels.

To evaluate and improve inclusivity efforts, a Google Form was used during registration to collect background data, including demographics, fields of study, and affiliations. Figure 3 provides a visualisation of the geographic regions represented by participants, illustrating the global reach of the event.

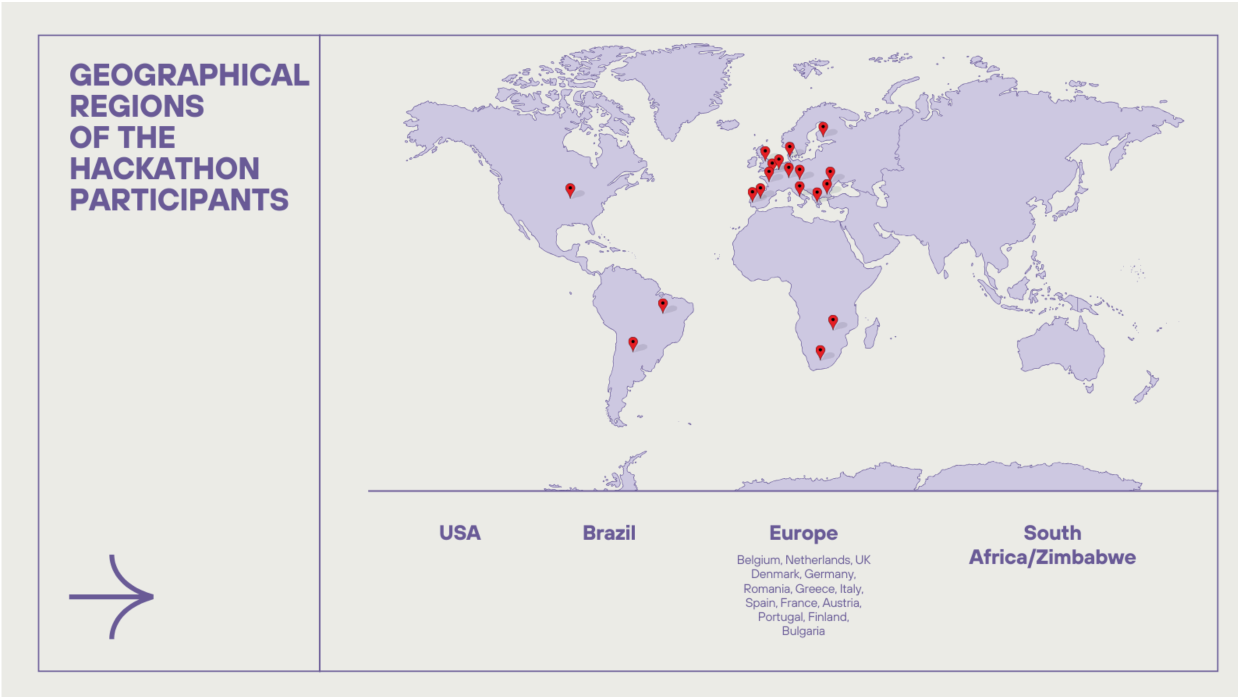

Figure 3. Visualisation of the geographic regions of the participants involved.

The professional backgrounds of participants spanned a diverse range of fields, as indicated by 68 responses collected during registration (the original list is available in the annex as Table S4):

1. **Ecology**: 14 mentions
2. **Biodiversity informatics**: 13 mentions
3. **Marine biology**: 7 mentions
4. **Remote sensing**: 6 mentions
5. **Ecological modelling**: 5 mentions

These were grouped into broader categories to highlight interdisciplinary representation:

- **Biology/Biodiversity/Ecology**: 47 mentions (including subfields such as Marine Biology and Ecological Modelling)
- **Data Science/Remote Sensing/Geospatial**: 17 mentions (including Earth System Data Science, Remote Sensing, and GIS)
- **Mathematics/Statistics/Computational**: 5 mentions
- **Technology/AI/Computer Science**: 4 mentions (including fields like Artificial Intelligence and Machine Learning)

Gender distribution

Gender distribution data was collected during registration, with 81 participants responding. The multiple-choice options provided were: "Female," "Male," "Non-binary," "Other," and "I don’t wish to answer." Figure 4 presents an overview of the gender distribution across all participants, as well as specific groups such as the jury, keynote speakers, technical coaches, and organising team.

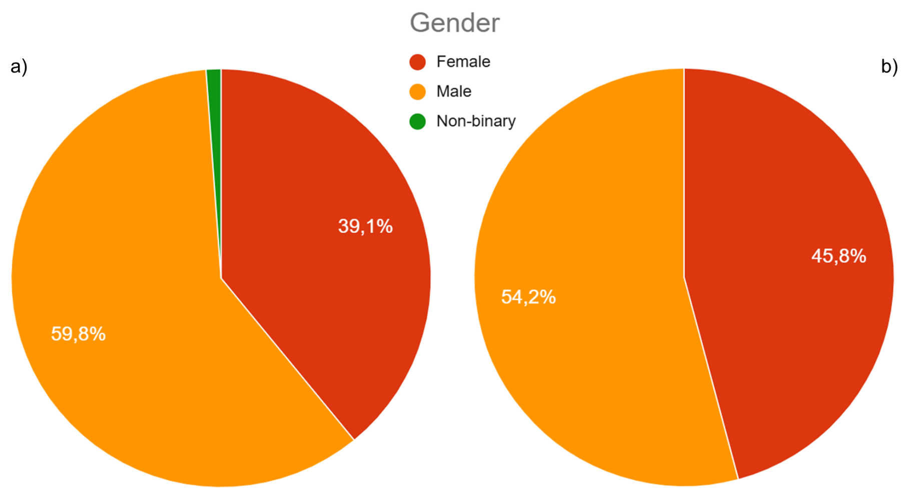

Figure 4. Visualisation of a) total gender distribution, and b) gender distribution by participant categories, such as jury members, keynote speakers, technical coaches and the organising team.

Code of conduct

A comprehensive code of conduct was implemented to ensure a respectful, inclusive, and collaborative environment. This code outlined expected behaviors, prohibited activities, and clear procedures for reporting and addressing any concerns. Its presence played a key role in fostering a positive and supportive atmosphere for all participants.

1.4. Agenda and structure

The hackathon spanned four days, beginning on day 1 with registration, an opening session to explain concepts, project pitches, and an engaging keynote by Andrew Rodrigues on building and using data cubes. These sessions were conducted on Zoom, with Slack serving as the primary communication platform for agenda updates. In the afternoon, teams were formed, followed by hacking sessions and a social event to encourage networking and camaraderie.

By day 4, participants had finalised their projects, prepared presentations, and pitched their ideas to a jury. The event concluded with an afterparty, where the winners were announced.

A typical hacking day consisted of two keynote presentations, with hacking sessions alternated with coffee breaks and lunch, as shown in the schedule for day 3 (Figure 5). On day two, a group picture was taken with the participants (Figure 6). The full agenda can be accessed here.

Day 3 – 4 April

08:00–08:30	Welcome
08:30–09:00	**Yanina Sica: Global biodiversity indicators and their usage in different global assessment**
09:00–10:30	Hacking
10:30–11:00	Break
11:00–12:30	Hacking
12:30–13:30	Lunch
13:30 - 14:00	**Lucy Bastin: Connectivity data cubes:** tracking functional habitat connectivity
14:00–14:30	Break
14:30–17:00	Hacking

Figure 5. An example of a typical day in the four-day hackathon, featuring two presentations and hacking sessions alternated with coffee breaks and lunch. This shows the agenda for day 3, which took place on the 4th of April.

Figure 6. Group picture of the hackathon participants taken on day 2 (April 3).

On day 1, each project pitched a concise 5-minute summary of their idea (a link to the slide deck for all the projects, except project 6, is provided here; project 6 can be found here), offering an overview of all the projects. This was essential not only for introducing the projects but also for participants who had not yet selected a project to join.

Keynote speakers from sister projects of B3, such as AD4GD and FAIRiCUBE, as well as from related fields of research, were invited to deliver informative and inspiring presentations. These sessions sparked fruitful discussions and provided valuable learning opportunities for participants.

Table 5 provides an overview of all the keynote speakers, their institutions, occupations, presentation titles, and links to the slides. The keynote presentations were conducted in a hybrid format, enabling online participants to follow along. They were recorded and made available to all participants. However, we chose not to share the recordings outside the hackathon organisation, as not all keynote speakers consented to this.

Table 5. Overview of all the keynote speakers presenting at the hackathon, including their institution/project, occupation, presentation title, and link to the slides.

Name	Institution	Current occupation	Presentation title and link to the slides

Andrew Rodrigues	GBIF	Data Partnerships Officer	Building Data cubes and how to use them - LINK
Lucy Bastin	All Data 4 Green Deal (AD4GD)	Reader in Computer Science at Aston University	Connectivity data cubes: tracking functional habitat connectivity - LINK
Yanina V. Sica	JLUG	Research Fellow & Science coordinator for IPBES Data and Knowledge unit	Global biodiversity indicators and their usage in different global assessment - LINK
Evangelia Drakou	Harokopio University of Athens	Assistant Professor at the Geography Department	Enhancing biodiversity and ecosystem services data: addressing ontological challenges, interoperability, spatial insights, and GEOBON's essential variables initiative - LINK
Katharina Schleidt*	Umweltbundesamt	CEO Data Modeler, Data Networking Expert, FAIRiCUBE	Bringing terrestrial biodiversity data together with space based products

**Katharina Schleidt was unable to attend the hackathon but provided valuable advice and assistance.*

Judging criteria and evaluation

Five experts from universities and sister projects, each with diverse areas of expertise, were invited to join the jury panel for the hackathon (Table 6). Iason Jongepier chaired the panel and developed an evaluation system to score the competing projects. The jury began by categorising the projects based on their main objectives, as outlined in the project submission files. This process resulted in the creation of three prize categories, with one winner selected per category, leading to a total of three prizes (Table 7).

Table 6. Overview of the jury panel members, their institutions and current occupations.

Name	Institution	Current occupation
Lucy Bastin	Aston University, UK	Reader in Computer Science, All Data 4 Green Deal (AD4GD)
(Chair) Iason Jongepier	University Antwerp	Digital cartography

Julien Radoux	Université catholique de Louvain	Dr. Researcher and LifeWatch scientist
Katharina Schleidt*	Umweltbundesamt	CEO Data Modeler, Data Networking Expert, FAIRiCUBE
Ivette Serral Montoro	CREAF	Geospatial data (GIS and remote sensing), EC project AD4GD

**Katharina Schleidt was unable to attend the hackathon but provided valuable advice and assistance.*

Table 7. The three categories, along with the projects that fit into each, are as follows:

CATEGORIES	PROJECTS
Best Data Cube Interoperability and/or integration	1/4/5/7/9/10
Best Monitoring and/or Modelling	3/4/5/6/8/11
Best Visualisation, Use cases and/or Training	1/2/4/5/8

Projects were evaluated based on predefined criteria, including data cube interoperability and/or integration, monitoring and/or modelling capabilities, and the development of visualisations, use cases and/or training resources. A cross-table outlines the criteria used for judging the projects and explains the process for selecting winners.

The jury noted several key considerations:

1) Some projects qualified for multiple categories, while others were more closely aligned with one of the overall objectives of B3.
2) In cases where multiple projects tied with the highest scores in a category, the number of top rankings was used to break the tie. If still unresolved, the head of the jury made the final decision.
3) A single project could win in multiple categories; however, the prize for the category in which the project scored highest was awarded to that project, while the runner-up was considered for the other category.

Four jury members were present throughout the hackathon, actively engaging with teams and observing their work. On the final day, each jury member assigned scores to the contending projects - 3 points for the top choice, 2 for the second, and 1 for the third. The total scores were then tallied, eliminating the need for a rigid scoring system while ensuring fairness and clarity in the selection process.

2. Project development and support

2.1. Project themes

This section provides an overview of the projects submitted for the hackathon. The primary aim of the event was to experiment with biodiversity data cubes and explore the needs and preferences of potential end-users. Participants were encouraged to propose project ideas before the event, focusing on data cubes while ensuring alignment with the B3 objectives. These objectives were summarised on the hackathon webpage (Figure 7).

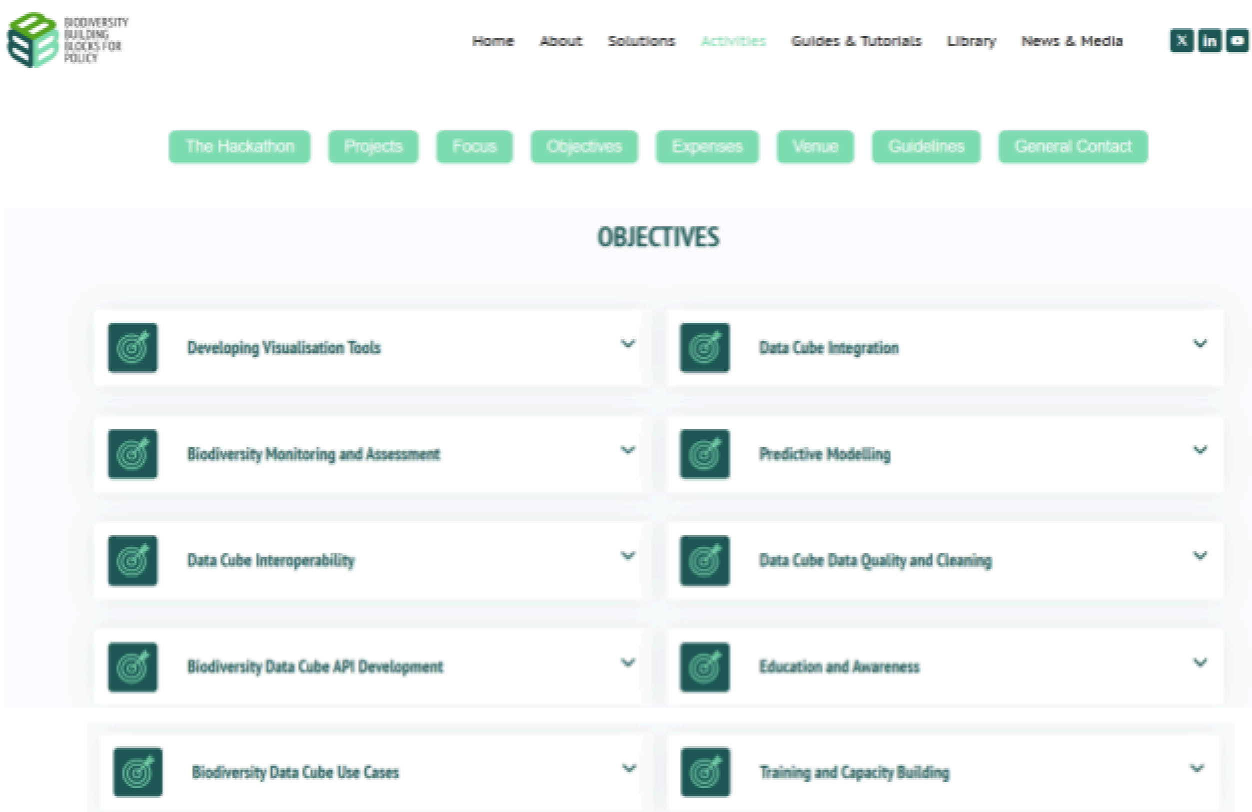

Figure 7. An example of the hackathon webpage displaying the B3 objectives, featuring a dropdown arrow that users can click to view a brief description of each objective.

The B3 objectives served as guidelines for team leads to develop their project ideas and draft their submissions for the hackathon. These objectives included the following:

- **Developing visualisation tools**: Create user-friendly and interactive data visualisation tools that enable researchers and policymakers to effectively explore and understand biodiversity data cubes.
- **Data cube integration**: Investigate methods to integrate diverse datasets, such as satellite imagery and climate data, with biodiversity data cubes to provide a comprehensive view of ecosystems and species distributions.
- **Biodiversity monitoring and assessment:** Develop algorithms and techniques to assess biodiversity trends from data cubes, identify critical conservation areas, and monitor changes in species distributions over time and space.

- **Predictive modelling**: Build models that predict species habitat suitability, biodiversity hotspots, and potential threats to specific ecosystems.
- **Data cube interoperability:** Promote standards and methods for ensuring data cube interoperability, facilitating the sharing and combining of biodiversity data cubes with other environmental data from various sources.
- **Data cube data quality and cleaning:** Develop techniques to identify and handle data inconsistencies and errors in biodiversity data cubes, ensuring accurate and reliable analyses.
- **API development:** Explore approaches to building data services that facilitate access to and interaction with biodiversity data cubes.
- **Education and awareness:** Design educational tools and platforms that leverage biodiversity data cubes to raise awareness about biodiversity conservation and engage the public in conservation efforts.
- **Use cases:** Identify and explore potential use cases for biodiversity data cubes across various sectors, such as agriculture, health, urban planning, and conservation policymaking.
- **Training and capacity building:** Organise tutorials to provide participants with the skills and knowledge needed to work with data cubes, covering topics like cube construction, data analysis and visualisation.

Projects could be submitted via a Google Form from November 1 to December 17, 2023. B3 members evaluated the submissions based on the responses provided in the application form, specifically assessing whether they fulfilled at least one of the required objectives outlined above. Accepted projects were listed on the B3 hackathon webpage in late December 2023. Registration for participants opened on January 2, 2024. In-person registration closed on February 29, 2024, while virtual registration remained open until April 2, 2024.

The submission form included the following questions:

- **Applicant Name + Surname**
- **Project name**
- **Abstract (max 300 words):** a concise summary of your project, its goals, and its value.
- **Problem statement (max 300 words):** Describe the problem your project aims to solve and why it matters.
- **Use of data cubes (max 150 words):** Explain how you intend to use data cubes in your project.
- **Alignment with B3 objectives (max 200 words):** Explain how your project aligns with at least one B3 objective.
- **Skills needed in your team:** List the key skills required for your project.
- **Project lead(s):** Provide the names of the team leaders. Multiple leaders are allowed.
- **Engagement strategy (max 100 words):** During the hackathon everyone should be treated equally and be given the same opportunities to contribute. Describe your plan for engaging team members and ensuring effective collaboration, especially with remote participants.
- **Permission to publish (required for acceptance):** Check the box to grant permission for your project submission to be published on electronic media. If your project is

accepted, it will be added to the B3 webpage. Additionally, we plan to integrate feedback and the outcomes of the projects in our overarching B3 project. Your participation is crucial for our collective success.

We received 11 project submissions. A detailed list of projects, along with their responses, is available in the project submission files. Table 8 provides a summary of all participating projects, including team leads, project titles and team sizes. Project 1 was cancelled due to unforeseen circumstances. During the hackathon, Project 2 and Project 8 merged into one team. Teams could be formed either prior to or at the start of the hackathon, in a self-organising manner, allowing participants to work on projects they were passionate about while collaborating with others.

Table 8. Overview of the hackathon projects, including team leads, project titles and team sizes.

Project number	Team Lead	Project Title	# members
2 + 8	Ward Langeraert & Matilde Martini	Unveiling Ecological Dynamics Through Simulation and Visualization of Biodiversity Data Cubes & Virtual B3 - How reliability and uncertainty of biodiversity sampling affect SDM: build virtual species to cope with real problems!	11
3	Noelia Jimenez Martinez	Intelligent Nature Positive Impact Data for the Financial Services	6
4	Maxime Ryckewaert	Irokube: Deep-SDM and Critical Habitats Mapping Empowered by Data Cubes	5
5	Salvador Jesus Fernandez Bejarano	Tackling Ocean Biodiversity Crisis with Marine Data B-Cubes	10
6	Saverio Vicario	Phenological Diversity trends by remote sensing-related datacubes	4
7	Barbara Magagna	Interoperable eLTER Standard Observation variables for Biosphere	3
9	Andrew Rodrigues	Species occurrence cube portability	6
10	Heliana Teixeira	Effects of integrating species occurrences from different sources into Data Cubes: facilitating detection of data balance, biases, scale and other effects.	6
11	Shawn Dove & Yanina Sica	GUI for general biodiversity indicators	10

Self-organisation process

Before official registration opened, submitted projects, required skills, technical guidelines and a GitHub repository were advertised on our webpage. The projects are available on the GitHub repository: [hackathon-projects-2024](), which contains technical guidelines, templates and project information. Participants were expected to use a separate repository for the software they developed.

During registration, participants reviewed project abstracts and indicated their preferences through a Google form (Figure 8). They could also introduce themselves in project-specific Slack channels, enabling them to expand their networks early on. This preparation allowed teams to be more organised and effective during the hackathon (Pe-Than et al., 2018).

On the first day, team leads presented their projects and participants connected during breaks or online via designated Slack channels to join teams. Teams formed based on shared interests using a selection-by-attraction approach, with flexibility for participants to switch projects or merge projects as needed. Each team was provided with a GitHub code repository for the software they developed.

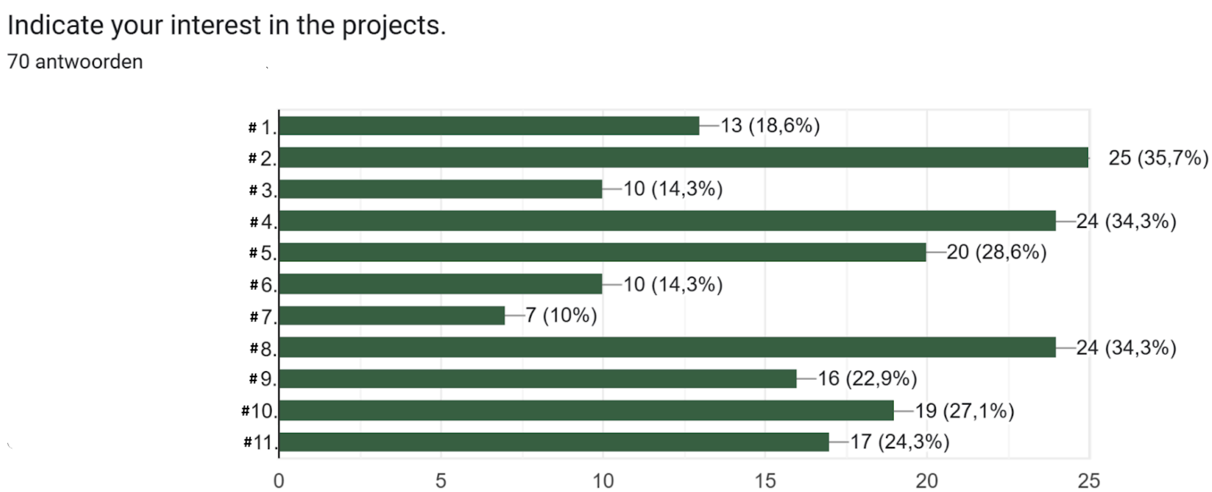

Figure 8. A question from the Google form where hackathon participants indicated their interest in the projects.

2.2. Technical support and resources

The technical support team played a pivotal role in ensuring participants had access to the necessary mentorship, tools and platforms for a successful hackathon experience. Table 9 provides an overview of the technical support team members, including their institutions, occupations and areas of expertise. The team was available both on-site and online, offering real-time assistance to participants and ensuring a smooth, productive event.

Table 9. Overview of the technical support team, including their respective institution, occupation, and areas of expertise.

Name	Institution	Current occupation	Expertise
Matthew Blissett	GBIF	Software developer	Big data software development, GBIF API (including cube downloads)
Shawn Dove	JLUG	Developing and adapting biodiversity indicators using GBIF data cubes	Global biodiversity indicators using statistical and modelling techniques
Peter Desmet	EV INBO	Open data coordinator	Biodiversity information standards
Toon Van Daele	EV INBO	Methodological & statistical support for ecological projects	Ecological & hydrological modelling, statistical analysis
Rocìo Beatriz Lobos	UNIBO	Ph.D. student research focuses on the application of machine learning methods to satellite images and the analysis of land cover changes in large areas	Machine Learning & Remote Sensing

3. Hackathon outcomes

3.1. Outcomes and winning projects

On the final day of the hackathon (5th April 2024), all teams presented their projects to a panel of jury members and fellow participants. The presentation slides and the recording of the presentations are both accessible for review. The hackathon resulted in both tangible and qualitative outcomes.

Tangible results:

- New prototypes, features, and visualisations

- Improved documentation and publications
- Workflows and R scripts
- GitHub repositories with code and documentation

These outcomes were gathered through project submissions, final presentations, preprints, and GitHub repositories.

Qualitative results:

- Enhanced knowledge and skills in using data cubes and collaborative programming (e.g., GitHub)
- Networking and collaboration opportunities

These insights were collected via post-hackathon survey feedback on learning experiences, and networking opportunities, and monitored Slack channels.

Winning projects

Awards were given to the best projects in three categories:

- Best data cube interoperability and/or integration
- Best monitoring and/or modelling
- Best visualisation and/or training

Prizes included Amazon vouchers of varying amounts for first- and second-place winners, and several goodies donated by GBIF for third- place winners.

Best data cube interoperability and/or integration

- **First place:** Project #9 Species occurrence cube portability
- **Second place:** Project #10 Effects of integrating species occurrences from different sources into data cubes: facilitating detection of data balance, biases, scale, and other effects
- **Third place:** Project #7 Interoperable eLTER standard observation variables for biosphere

Best monitoring and/or modelling

- **First place:** Project #4 Irokube: Deep-SDM and critical habitats mapping empowered by data cubes
- **Second place:** Project #6 Phenological diversity trends by remote sensing-related data cubes
- **Third place:** Project #5 Tackling ocean biodiversity crisis with marine data cubes

Best visualisation and/or training

- **First place:** Project #2&8 Unveiling Ecological Dynamics Through Simulation and Visualization of Biodiversity Data Cubes + Virtual B3 - How reliability and uncertainty of biodiversity sampling affect SDM: build virtual species to cope with real problems!
- **Second place:** Project #11 GUI for general biodiversity indicators
- **Third place:** Project #5 Tackling Ocean Biodiversity Crisis with Marine Data B-Cubes

3.2. Project outcomes

Project 2 & 8 Unveiling Ecological Dynamics Through Simulation and Visualization of Biodiversity Data Cubes + Virtual B3 - How reliability and uncertainty of biodiversity sampling affect SDM: build virtual species to cope with real problems!

The project successfully developed a simulation framework for biodiversity data cubes using the R programming language. The framework allows researchers to create data cubes from scratch with varying parameter settings or virtual species. It enables the modelling of species distributions and the analysis of how factors such as spatial clustering and sampling effort influence data quality and indicator robustness under different scenarios. The project emphasised the importance of simulating ecological dynamics to understand how biases and uncertainties affect species distribution models (SDMs). The developed code and workflows were distributed as an installable R package, providing valuable resources for further research and application in biodiversity monitoring. The project directly contributed to multiple B3 objectives and therefore contributed to several work packages such as WP4 (“Modelling current and future scenarios”) and WP5 (“Creating indicators of biodiversity change and quality measures”).

Useful links:

- Hackathon presentation: [slide 83 - 104]
  B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: B3-eu/gcube: Simulation framework for biodiversity data cubes (github.com)
- Website: Simulating Biodiversity Data Cubes • gcube (B3-eu.github.io)
- Preprint: Langeraert, W., Barhdadi, W., Brosens, D., Cortès, R., Desmet, P., Di Musciano, M., … Van Daele, T. (2024, October 28). Unveiling ecological dynamics through simulation and visualization of biodiversity data cubes. https://doi.org/10.37044/osf.io/vcyr7

Project 3: Intelligent Nature Positive Impact Data for the Financial Services

The project demonstrated the integration of biodiversity data cubes into species distribution models (SDMs) to predict the potential spread of vineyard pests, particularly the leafhopper *Homalodisca vitripennis*, in the UK. By comparing models using both occurrence and presence/absence data, findings highlighted that data cubes naturally retain spatial adjacency, which is advantageous for Convolutional Neural Networks (CNNs). However, current grid systems pose usability challenges, leading the team to focus on refining grid systems optimised for CNNs and integrating them with climate prediction layers for enhanced forecasting of pest distribution and biodiversity impacts.

Useful links:

- Hackathon presentation: [slide 29 - slide 37]
  B-Cubed Hackathon End project Presentation Template.pptx

Project 4 Irokube: Deep-SDM and Critical Habitats Mapping Empowered by Data Cubes

The project investigated the integration of biodiversity data cubes with other datasets, such as satellite imagery and bioclimatic variables, to identify critical habitats. This is achieved through species distribution models (Deep-SDM) and habitat modelling (HDM) based on deep learning. Using floristic data from Belgium as a case study, the researchers demonstrated how data cubes can enhance the identification and monitoring of critical habitats, highlighting their potential to support public policy in conservation and biodiversity management.

Useful links:

- Hackathon presentation: [slide 38 - 57]
  B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: https://github.com/AgentschapPlantentuinMeise/irowine
- News article: B3 HACKATHON 2024 (umr-tetis.fr)

Project 5 Tackling Ocean Biodiversity Crisis with Marine Data B-Cubes

The project demonstrated how marine data cubes can be used to assess the risk of invasive species by integrating biological occurrences with environmental data like chlorophyll and phytoplankton concentrations. By generating B-Cubes from cloud-optimised data and leveraging Parquet formats for efficient processing, the team developed species distribution models predicting habitat suitability and identifying potential invasion hotspots. The approach highlights the potential for early detection systems, offering a scalable method for ecological modelling that can inform policy, improve rapid response efforts, and support biodiversity conservation through proactive monitoring of at-risk areas.

Useful links:

- Hackathon presentation: [slide 10 - slide 28]
  B-Cubed Hackathon End project Presentation Template.pptx

Project 6 Phenological Diversity trends by remote sensing-related datacubes

The project enhanced the rasterdiv R package to analyse phenological diversity using time series from satellite data cubes. By integrating Dynamic Time Warping (DTW) for temporal analysis, the tool now better captures vegetation trait diversity across different seasons. This allows for more accurate assessments of plant community responses to environmental changes and stress factors, aiding in biodiversity monitoring and conservation. The methodology was successfully applied in Italian grasslands, demonstrating its potential to identify biodiversity hotspots and guide protected area management through more detailed and dynamic mapping of ecosystem diversity.

Useful links:

- Hackathon presentation: Project 6 s. vicario.pdf
- GitHub: https://github.com/Samuel-Green/B-3-Hackathon-Project-6 & https://github.com/mattmar/rasterdiv/tree/bcubed_hackathon
- Preprint: Shayle, Elliot S., et al. "Phenological Diversity Trends with Remote Sensing Datacubes." BioHackrXiv, 8 June 2024. Web. https://doi.org/10.37044/osf.io/pqfws

Project 7 Interoperable eLTER Standard Observation variables for Biosphere

The project advanced the FAIRification of eLTER biodiversity datasets by developing workflows to convert time-series data into semantically enriched, interoperable data cubes. Key observations, including plant species cover, bird occurrences, and meteorological data from the Zöbelboden LTER site, were represented as occurrence cubes using array and NetCDF. These cubes were annotated with FAIR vocabularies and metadata, aligned with I-ADOPT, Darwin Core, and other standards. The resulting FAIR Digital Objects enable integration with environmental data for enhanced ecosystem analysis, supporting long-term monitoring and harmonisation efforts across eLTER and global biodiversity initiatives.

Useful links:

- Hackathon presentation: [slide 70 - slide 82] B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: B3-eu/hackathon-project-7: This space is dedicated to hosting "Project 7 - Interoperable eLTER Standard Observation variables for Biosphere" as part of the B3 Hackathon 2024 - Hacking Biodiversity Data Cubes for Policy. (github.com)

Project 9 Species occurrence cube portability

This project developed scripts and tutorials to convert species occurrence cubes from GBIF-mediated data into multiple widely-used formats, such as NetCDF and GeoTIFF. By expanding beyond the default CSV format, these enhancements improve the cubes' interoperability, making them ready for geospatial analysis and environmental modelling. The team explored alignment with OGC API standards and tackled challenges in representing spatio-temporal information. The outputs support broader accessibility and integration of biodiversity data across scientific applications.

Useful links:

- Hackathon presentation: [slides 5 - slide 9] B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: [B3-eu/project9: Species Occurrence Cube Portability @ B3 Hackathon 2024 - Hacking Biodiversity Data Cubes for Policy. (github.com)]

Project 10 Effects of integrating species occurrences from different sources into Data Cubes: facilitating detection of data balance, biases, scale and other effects

This project investigated the effects of integrating species occurrence data from diverse sources into Data Cubes, focusing on how data heterogeneity impacts species trend assessments. By combining well-curated datasets with broader but variable sources like GBIF, the team aimed to visualise biases and data imbalances, helping researchers make informed data selections. The workflow included Darwin Core mapping, cube creation, merging, and post-processing, culminating in tools for better species distribution modelling. The outcomes contribute to enhancing data integration methods for biodiversity monitoring while supporting informed decisions in ecological assessments and policy implementation.

Useful links:

- Hackathon presentation: [slide 105 - slide 112] B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: https://github.com/B3-eu/hackathon-projects-2024/tree/main/projects/10

Project 11 GUI for general biodiversity indicators

This project focuses on developing a graphical user interface (GUI) for calculating and visualising biodiversity indicators using species occurrence cubes. The GUI, designed as a Shiny app, aims to make complex analyses accessible to non-technical users, such as policymakers and practitioners, by eliminating the need for coding skills. The app allows users to select taxa, regions, and indicators on a map, then generates interactive visualisations of biodiversity indicators. The goal is to enhance the usability of biodiversity data and indicators by bridging the gap between scientific tools and decision-making processes, aligning closely with B3 objectives for broader impact. This project contributes directly to WP5, specifically Task 5.1 on “General biodiversity variables and indicators.”

Useful links:

- Hackathon presentation: [slide 58 - 69]
  B-Cubed Hackathon End project Presentation Template.pptx
- GitHub: https://github.com/B3-eu/b3gbi

Extra project FowlPlay

The ‘FowlPlay’ project, led by Quentin Groom and Maarten Trekels, investigates the potential of open sex data available through the Global Biodiversity Information Facility (GBIF) to study sex ratios in ducks across Europe. Using biodiversity data cubes derived from over 4 million occurrences and nearly 5,000 datasets mobilised by GBIF, the project examines temporal and spatial dynamics in sex distribution across various duck species. This study highlights the value of sex data in biodiversity research, particularly for monitoring sex ratios in sexually dimorphic species and emphasises the utility of openly accessible biodiversity data for ecological and conservation purposes. By uncovering patterns in sex distribution, the project showcases how sex-specific data can enhance our understanding of species biology and inform conservation strategies.

Useful links:

- GitHub: https://github.com/b-cubed-eu/fowlplay
- Preprint: Groom, Q., & Trekels, M. (2024). FowlPlay (1.2). Zenodo. https://doi.org/10.5281/zenodo.12793722

4. Participant feedback and insights

4.1. Survey results

After the hackathon, participants were invited to complete a survey to share their experiences and the knowledge they had gained during the event. The survey aimed to assess the participants’ learning outcomes and collect insights on how the new concepts and tools could be applied in their future work. Responses were collected via Simple Polls in the #general channel on Slack.

To assess the diversity of learning outcomes, participants were asked: ***“Did you learn more about any of the following subjects? (Please add your option and select all that apply)”***. This question received 27 responses, with participants able to select multiple topics (Table 10).

Table 10. Survey responses to the question “Did you learn more about …”.

Topic	Number of selections
Data cubes	23
GitHub	13

GBIF	13
Biodiversity indicators	8
Data Cube Extraction	7
Essential Biodiversity Variables (EBVs)	7
Biodiversity Policy	5
Data Visualization	5
Shiny	5
Python	4
Geographic Information Systems (GIS)	2
R Programming	2
Cloud Computing	1
Rasterdiv Package	1
FAIR Data Management	1
Jupyter Notebook	1
Deep Learning	No response reported
DarwinCore	No response reported
Artificial Intelligence (AI)	No response reported

Applying biodiversity data cubes in future work

The survey also included a question regarding the future application of biodiversity data cubes in participants' own work. The responses indicate that many participants see potential value in these tools. The question asked was: *"Do you anticipate or intend to utilise biodiversity data cubes in your own work?"* (Table 11).

Table 11. Survey responses to the question "Do you anticipate to utilise biodiversity data cubes in your work".

Answers	Number of responses
I use them to calculate biodiversity indicators	7
Yes	3
No	No response reported

B3 members: new ideas and collaborative benefits

One of the key goals of the hackathon was to generate innovative ideas to advance the work of the B3 project. When B3 members were asked about new ideas and collaborative benefits gained, they highlighted two main takeaways: (*The open-ended question was posed only to B3 members.*)

1) Cross-project collaboration
2) Enhanced strategies for biodiversity monitoring

Answer from Project 4:

"For us, there are two real advantages:

1. *(We) the members of project 4 were able to work together, knowing that 3 European projects were represented in the team (Mambo, Guarden and B3) and that this highlighted the complementary relationship between the projects.*
2. *We were able to develop a pipeline for an interesting case study aimed at identifying critical habitats from these biodiversity data cubes that can help public policy (habitat monitoring)."*

Conclusion of the survey

The survey conducted after the hackathon provides valuable insights into participants' learning outcomes, the potential future application of biodiversity data cubes, and the collaborative benefits for B3 members. The results indicate that participants gained the most knowledge in the following areas: data cubes (23 selections), GitHub (13 selections), and GBIF (13 selections), making these the top three learning areas.

The survey also shows a promising level of interest in the future application of biodiversity data cubes. Seven participants indicated that they are already using data cubes to calculate biodiversity indicators, and an additional three participants expressed interest in using these tools in their work. Notably, no one outright rejected the idea, suggesting a strong openness to applying these tools in their professional activities.

For B3 members, the collaboration across multiple projects (e.g. Mambo, Guarden and B3) allowed members to appreciate the complementary strengths of each project. This cross-project synergy was identified as a significant benefit. They also emphasised the development of practical solutions.

In summary, the hackathon provided valuable opportunities for learning, future tool application, and collaboration. The feedback reflects both technical advancements and the strengthening of connections between related biodiversity initiatives.

4.2. Lesson learned and future recommendations

The venue at Herman Teirlinck was well-suited for a hybrid event, offering efficient spaces for participants to work on-site while accommodating remote attendees. The hackathon successfully attracted a relevant audience, particularly potential end-users of data cubes. The number of participants was ideal for fostering meaningful connections, collaboration and knowledge-sharing.

However, while the timing of the event, coinciding with a public holiday in Belgium, was intended to encourage student participation, it also led to increased accommodation prices at nearby hotels, which may have impacted overall attendance. Virtual participants primarily engaged with the event through their teammates. Although a designated point of contact on Slack was available to support online attendees with questions, this resource was rarely utilised. In contrast, having a team of technical coaches available in person proved invaluable, as it provided participants with knowledgeable contacts for technical guidance.

Slack was used as the primary communication platform, but the lack of a paid plan resulted in the loss of message history and shared files. For future events, upgrading to a paid plan or selecting a more robust communication platform would help preserve valuable information. Additionally, while individual repositories were created for each project, linking these to a central repository would improve accessibility and discoverability of the developed software.

The post-hackathon survey received fewer responses than anticipated, likely due to its distribution several days after the event or the method by which it was conducted. Distributing feedback surveys on the last day of the event, while participants are still engaged, would likely yield higher response rates.

Feedback for Future Improvement:

- **Event timing and logistics:** Schedule future hackathons during periods when accommodation is more affordable and accessible in Brussels, which could increase participation and reduce costs for attendees.
- **Interactive and networking opportunities:** Explore additional opportunities to incorporate interactive elements and networking activities into the event to enhance the virtual experience.
- **Communication platform:** Upgrade to a paid communication platform or select a more robust one to retain message history and shared files, ensuring that important information is not lost.
- **Structured feedback mechanism:** Implement a more structured feedback system during the event, rather than post-event, to capture insights from participants in real time for inclusion in the final report.
- **Central repository for software:** Link individual project repositories to a central repository to improve software accessibility and discoverability, making it easier for others to find and contribute to the developed resources.
- **Survey timing:** Distribute feedback surveys on the last day of the event to encourage higher response rates, and consider alternatives to Slack polls for clearer and more effective participant feedback.

5. Conclusion and next steps

5.1. Impact on B3 objectives

The B3 hackathon made significant strides towards achieving the project's core goals by fostering collaboration, driving innovation, and building capacity, thus ensuring meaningful progress in biodiversity monitoring.

Engaging stakeholders and expanding reach

The hackathon effectively introduced stakeholders to biodiversity data cubes, demonstrating their potential for advancing biodiversity research, monitoring, and policy-making. With 86 participants from fields such as data science, biodiversity informatics, and ecological modeling, the event showcased the real-world applications of data cubes. Participants represented 46 institutions across 20 countries, creating a global network of experts and laying the foundation for ongoing collaborations. The event also encouraged synergies with sister projects like AD4GD and FAIRiCUBE, furthering shared objectives in biodiversity data standardisation.

Building skills and driving innovation

The hackathon provided a hands-on learning environment where participants gained practical experience in the creation, integration, and application of biodiversity data cubes. According to a post-event survey, attendees developed valuable skills, including expertise in data cube methodologies, GitHub collaboration, GBIF and biodiversity indicator methodologies. This training equips participants with the tools necessay to address biodiversity challenges effectively.

Delivering lasting results

The event produced tangible outcomes that will have a lasting impact:

- Three preprints documenting innovative approaches and methodologies, shared with the scientific community to enhance visibility and impact.
- A comprehensive set of GitHub repositories openly hosting code and workflows, ensuring accessibility for reuse, adaptation, and further development.
- Diverse projects exploring applications of biodiversity data cubes, driving advancements in research, visualization, and monitoring.

Creating tools for sustained impact

The projects underscored the vast potential of biodiversity data cubes in informing research and policy decisions. By demonstrating their utility, the hackathon engaged stakeholders across various sectors and highlighted the importance of data cubes in ecosystem monitoring and decision-making. Furthermore, the preprints, repositories, and tools produced during the event ensure continued use and development, extending their impact well beyond the project's lifecycle.

The hackathon successfully combined innovation, collaboration, and training to create impactful tools, foster a global network of stakeholders, and lay a solid foundation for advancing biodiversity informatics.

Project highlights:

- **Project 2 & 8:** Created the *gcube* framework, a powerful tool for simulating ecological dynamics and analysing the impacts of sampling uncertainties. Results were published in a preprint.
- **Project 3:** Demonstrated the applicability of biodiversity data cube technologies in business contexts to monitor biodiversity trends.
- **Project 4:** Experimented with integrating biodiversity data cubes with satellite imagery and bioclimatic variables, showcasing their potential for enhanced habitat modeling.
- **Project 5:** Integrated biological occurrence data with environmental variables to build species distribution models, predicting habitat suitability and identifying potential invasion hotspots.
- **Project 6:** Extended existing implementations of Rao's Q diversity indices to incorporate temporal dimensions, adding relevant biological contexts. Results were published in a preprint.
- **Project 7:** Advanced the FAIRification of eLTER biodiversity datasets by creating workflows to convert time-series data into semantically enriched, interoperable data cubes.
- **Project 9:** Provided practical tools and tutorials for converting species occurrence cubes into standard formats (NetCDF, GeoTIFF), supporting interoperability.
- **Project 10:** Investigated how integrating species occurrence data from various sources into data cubes impacts trend assessments, visualising biases and imbalances to guide data selection.
- **Project 11:** Developed a graphical user interface (GUI) for the *b3gbi* package, enabling users to calculate and visualise biodiversity indicators using species occurrence cubes.

- **Extra Project (FowlPlay):** Focused on incorporating sex ratio data of organisms into biodiversity analyses. Results were published in a preprint.

5.2. Follow-up plans

The hackathon set the stage for significant progress in the B3 project, fostering collaborative innovation and laying the groundwork for ongoing development. Several initiatives have been implemented to sustain this momentum:

1. **Slack channels:** The Slack communication channels remained active after the hackathon, allowing participants to continue discussions, exchange insights, and collaborate on future improvements.
2. **Preprints on BioHackrXiv:** Teams were encouraged to publish their findings on BioHackrXiv, increasing the visibility of their work. As a result, three projects have already produced preprints (see the ‘Project outcomes’ section for more details). This dissemination of findings is essential for extending the impact of the hackathon.
3. **GitHub repositories:** A central GitHub repository, titled ‘Hackathon-projects-2024’, was created to host all the projects from the event. Participants were also encouraged to create separate repositories for the specific software they developed, ensuring clarity and ease of collaboration. This repository structure helps foster further development and collaborative efforts post-event.
4. **Post-hackathon explorations:** The discussions continued well beyond the event, with participants exploring topics inspired by the hackathon. For instance, one participant delved deeper into the concept of hexagonal grids and shared their findings in a GitHub issue here. These ongoing explorations reflect the hackathon’s role as a catalyst for future research.
5. **B3 webinar**: On April 15, 2024, Ward Langeraert hosted a webinar to showcase the outcomes of Projects 2 and 8. The session demonstrated how users can apply the R code in practice and included discussions on improving the framework for future applications. This webinar further contributed to the knowledge-sharing and dissemination of the project’s findings.

In summary, the hackathon has laid a strong foundation for continued progress in the B3 project, with follow-up actions, collaborative opportunities and impactful research outputs that will sustain the momentum of the event and drive future innovation.

6. Acknowledgements

We would like to extend our sincere thanks to all the project leads and participants for their dedication and energy, which made this hackathon so impactful. Our appreciation also goes to our external advisory board members - Lucy Bastin, Evangelia Drakou and Katharina Schleidt - for their invaluable contributions as keynote speakers and/or jury members.

A special thank you to our external jury panel: chaired by Iason Jongepier and to Julien Radoux and Ivette Serral Montoro for their essential roles in the evaluation process. We are also grateful to our keynote speakers, Andrew Rodrigues and Yanina Sica, for their insightful presentations. We would like to express our gratitude to the technical support team: Rocìo Beatriz Cortes

Lobos, Matthew Blissett, Peter Desmet, Shawn Dove and Toon Van Daele, for their expertise and invaluable assistance during the hackathon.

A particular thanks go to Mathias Dillen for his organisational support throughout the event. We also wish to acknowledge the Meise team - Quentin Groom, Steven Janssens, Ruben Mollet, Louise Hendrickx, Lissa Breugelmans, Maarten Trekels, Melanie De Nolf and Christophe Van Neste - for their helping hands throughout.

We would like to thank Katharina Heil, ELIXIR (Hub) Communities Coordinator, for her advice in organising the hackathon and for promoting it during Biohackathon Europe. We are also grateful to GBIF for generously providing goodies, which were used as prizes for our participants. Finally, we thank Sandra MacFadyen and Peter Desmet for their insightful comments on the deliverable, which helped to improve the final text.

We also wish to acknowledge the support of the Research Foundation - Flanders (FWO) and KU Leuven, whose contributions were instrumental in making this event possible. This hackathon was funded by the European Commission under Grant agreement No.101059592.

7. References

Groom, Q., & Trekels, M. (2024). FowlPlay (1.2). Zenodo. https://doi.org/10.5281/zenodo.12793722

Langeraert, W., Barhdadi, W., Brosens, D., Cortès, R., Desmet, P., Di Musciano, M., … Van Daele, T. (2024, October 28). Unveiling ecological dynamics through simulation and visualization of biodiversity data cubes. https://doi.org/10.37044/osf.io/vcyr7

Meeus S., Addink W., Agosti D., Arvanitidis C., Balech B., Dillen M., Dimitrova M., González-Aranda J.M., Holetschek J., Islam S., Jeppesen T.S., Mietchen D., Nicolson N., Penev L., Robertson T., Ruch P., Trekels M., Groom Q. (2022) Recommendations for interoperability among infrastructures. Research Ideas and Outcomes 8: e96180. https://doi.org/10.3897/rio.8.e96180

Nolte, A., Pe-Than, E. P. P., Affia, A. A. O., Chaihirunkarn, C., Filippova, A., Kalyanasundaram, A., ... & Herbsleb, J. D. (2020). How to organize a hackathon--A planning kit. arXiv preprint arXiv:2008.08025.

Pe-Than, E. P. P., Nolte, A., Filippova, A., Bird, C., Scallen, S., & Herbsleb, J. D. (2018). Designing corporate hackathons with a purpose: The future of software development. IEEE Software, 36(1), 15-22.

Shayle, E. S., Marcantonio, M., Labadessa, R., Richiardi, C., & Vicario, S. (2024, June 8). Phenological Diversity Trends with Remote Sensing Datacubes. https://doi.org/10.37044/osf.io/pqfws

8. Annex

Additional materials and data collected during the hackathon.

Table S2: List different institutes that participated in the hackathon.

#	Affiliations
1	Meise Botanic Garden (MeiseBG)
2	Global Biodiversity Information Facility (GBIF) Secretariat
3	Research Institute for Nature and Forest (INBO)
4	Flemish Marine Institute (VLIZ)
5	Alma Mater Studiorum - Universita di Bologna (UNIBO)
6	Institute for Electromagnetic Sensing of the Environment (CNR-IIA)
7	Geography department, Harokopio University of Athens, Greece
8	Max Planck Institute for Plant Breeding Research
9	Ecological and Forestry Applications Research Centre (CREAF)
10	University of Twente
11	GO FAIR Foundation (GFF)
12	Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM)
13	Universidade Federal Fluminense (UFF)
14	Belgian Biodiversity Platform
15	Université catholique de Louvain
16	Research Centre for Ecological Change, University of Helsinki
17	Philipps Universität Marburg
18	The Royal Belgian Institute of Natural Sciences (RBINS)
19	National Institute for Research in Digital Science and Technology (Inria)
20	Nature Metrics

21	Stellenbosch University (SUN)
22	Justus Liebig University of Giessen (JLUG)
23	ASEAN centre for Biodiversity (ACB)
24	Pensoft
25	Aston University
26	KU Leuven
27	Utrecht University
28	University of L'Aquila
29	University of Turin
30	Fondazione Edmund Mach
31	University of Aveiro (UAVR)
32	Martin-Luther-Universitat Halle-Wittenberg (MLU)
33	Paul Valéry University of Montpellier (UPVM)
34	Joint European Research Center (JRC)
35	Ovidius University of Constanta
36	Ghent University
37	German Centre for Integrative Biodiversity Research (iDiv)
38	University Antwerp
39	Newcastle University
40	Helmholtz Centre for Environmental Research - UFZ
41	Arizona State University / NEON
42	Laboratoire d'Informatique, Robotique et Micro-électronique de Montpellier (LIRMM)
43	Naturalis Biodiversity Center
44	CSC - IT Center for Science Ltd.
45	University Leipzig
46	University of Potsdam

Table S3. Geographic distribution of participants by country.

#	Country

1	United Kingdom
2	Belgium
3	Bulgaria
4	Denmark
5	Argentina
6	Greece
7	Italy
8	Spain
9	France
10	Austria
11	Portugal
12	Zimbabwe
13	Finland
14	USA
15	South Africa
16	Netherlands
17	Romania
18	Brazil
19	Philippines
20	Germany

Table S4. Original list of fields of study collected from 68 participants.

Field of study	Field of study	Field of study	Field of study	Field of study
Biology	landscape ecology, GIS, knowledge engineer	Research Data Management	Macroecology, plant ecology	Biodiversity informatics, data stewardship, behavioural/evolutionary ecology
Ecology	Data management	species distribution; invasion dynamics; crowdsourcing	Biogeography	Ecology
Biodiversity informatics	ecological modelling	Antarctic biodiversity data	Environmental biology	Earth System Data Science & Remote

				Sensing
biology, biodiversity informatics	Marine biotechnology	Species distribution modelling + Virtual Species	Conservation genetics	GIS, biodiversity, habit connectivity, data cubes (not experienced, but it is a desired experience)
Marine Biology, Ecological Modelling	Marine Biology	Deep Species Distribution Models	Marine Ecology (Project submitted #10)	Artificial Intelligence
Earth System Data Science and Remote Sensing	Biodiversity GBIF	Machine Learning and Data	Geoscience and Biodiversity	Biodiversity Informatics
Ecological Modelling	geomatics	Biodiversity and AI	Biodiversity data	Satellite Remote Sensing
Statistics / Ecological modelling	Marine Ecology	Biodiversity informatics, Mathematics	Ecology	Machine Learning
Marine ecological modelling	Geospatial Data Engineer	Biodiversity Informatics, Ecology	biological invasions	Anthropocene Biogeography, Ecogeography, & Macroecology
Botany and Information Technology	Ecology	Ecology	Biodiversity Informatics	Computer Science
Earth Observation	Marine Biology	Biodiversity informatics	Ecology	Plant Evolution - molecular genetics
Remote Sensing	Community ecology, macroecology, biogeography	Biodiversity Informatics	Mathematical/computational ecology	Biodiversity informatics
Biodiversity informatics	Mathematics	Biodiversity Informatics	Geographic Information System, Remote Sensing	Earth System Data Science and Remote Sensing
Biodiversity Informatics	Computational ecology	geospatial data		

The full project list and answers of the project submissions for the 2024 Hackathon.
Document link: [Hackathon 2024 - Project submissions - Google Documenten]()