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NFDI4Earth Academy – A model for a joint NFDI Academy

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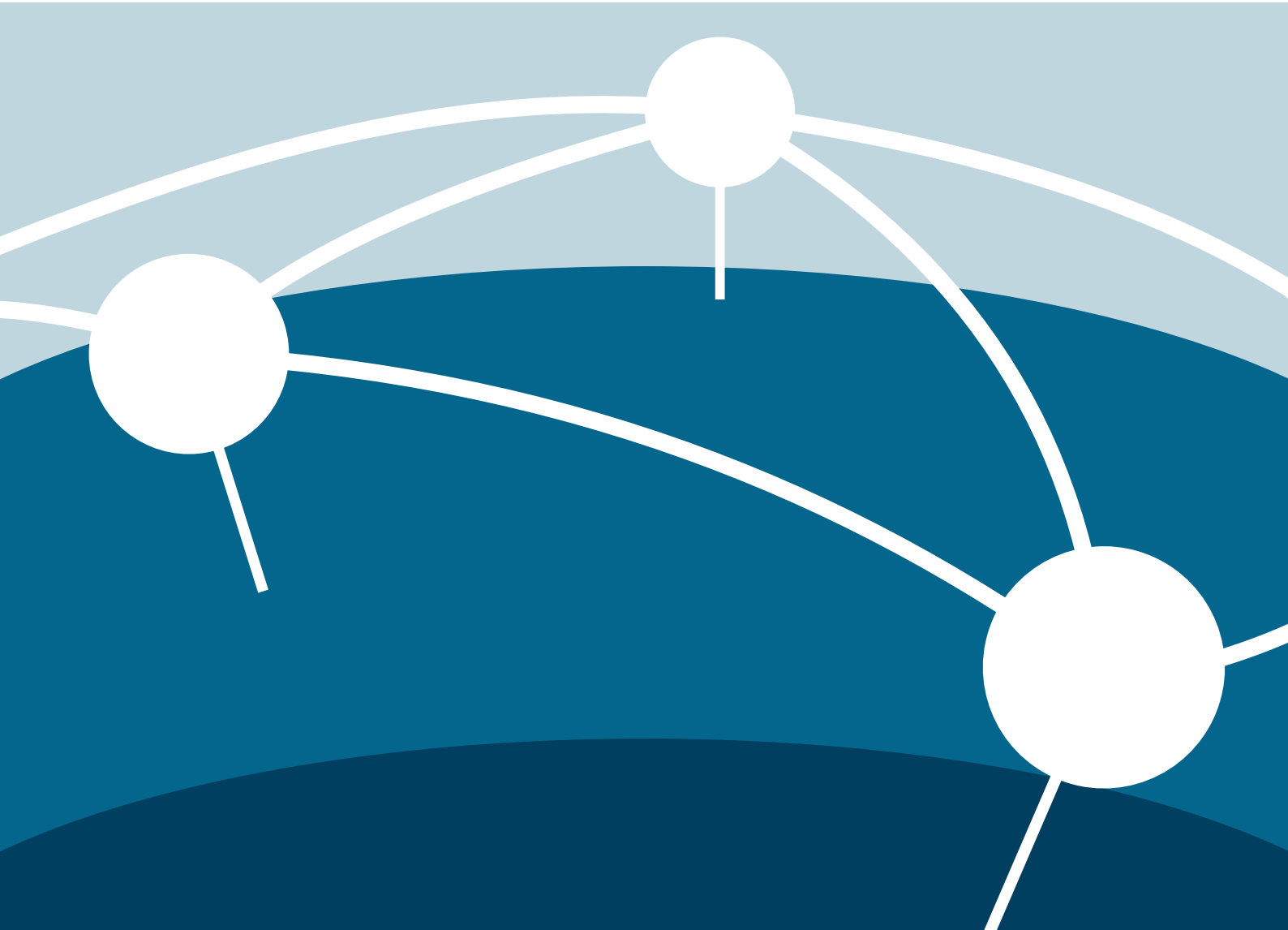

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Executive summary

Interdisciplinary collaboration is increasingly vital in science, driven by digital transformation and the surge in research data. As early career scientists navigate the complexities of interdisciplinary research, it is imperative to provide structural support. The concept of the NFDI4Earth Academy offers a network of doctoral and postdoctoral scientists interested in bridging Earth system and Data Sciences beyond institutional borders. By fostering an open science and learning environment, the NFDI4Earth Academy provides specialised training courses and facilitates collaborations within the NFDI4Earth consortium, with access to all NFDI4Earth innovations and services. NFDI4Earth Academy Fellows are empowered to advance their research endeavours by exploring and integrating new methods, connecting with like-minded peers, and developing skills and a mindset for open and data-driven science across disciplinary boundaries. This unique two-year NFDI4Earth Academy program incorporates peer mentoring and flexible event structures tailored to meet the specific training needs of the NFDI4Earth Academy Fellows. Co-created by NFDI4Earth Academy Fellows and NFDI4Earth Academy coordinators, the program ensures adaptability and dynamism. We propose the NFDI4Earth Academy concept as a model for cross-community training for early career scientists in the NFDI. The envisioned NFDI-wide operating NFDI4Earth Academy can include early career scientists from all disciplines, with an emphasis on Data Science methods in domain specific research and research data management.

NFDI4Earth Academy – A model for a joint NFDI Academy

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Abstract

Interdisciplinary collaboration is increasingly vital in science, driven by digital transformation and the surge in research data. As early career scientists navigate the complexities of interdisciplinary research, it is imperative to provide structural support. The concept of the NFDI4Earth Academy offers a network of doctoral and postdoctoral scientists interested in bridging Earth system and Data Sciences beyond institutional borders. By fostering an open science and learning environment, the NFDI4Earth Academy provides specialised training courses and facilitates collaborations within the NFDI4Earth consortium, with access to all NFDI4Earth innovations and services. NFDI4Earth Academy Fellows are empowered to advance their research endeavours by exploring and integrating new methods, connecting with like-minded peers, and developing skills and a mindset for open and data-driven science across disciplinary boundaries. This unique two-year NFDI4Earth Academy program incorporates peer mentoring and flexible event structures tailored to meet the specific training needs of the NFDI4Earth Academy Fellows. Co-created by NFDI4Earth Academy Fellows and NFDI4Earth Academy coordinators, the program ensures adaptability and dynamism. We propose the NFDI4Earth Academy concept as a model for cross-community training for early career scientists in the NFDI. The envisioned NFDI-wide operating NFDI4Earth Academy can include early career scientists from all disciplines, with an emphasis on Data Science methods in domain specific research and research data management.

Keywords: Data Science, training, Early Career Scientists, NFDI, NFDI4Earth

1. Introduction

Interdisciplinary collaboration is increasingly necessary to tackle global challenges and advance knowledge (Ledford, 2015; Wissenschaftsrat, 2020). As a result, institutions expect their researchers to engage in broad-based research, and funding agencies are shifting their priorities towards interdisciplinary approaches (Rylance, 2015). In addition, digital transformation and the rapid increase of collected research data drive new scientific methods for retrieving, connecting, and analysing data, based on the principles of Open Science (Cheng et al., 2020; UNESCO, Accessed 2024-07-09). Therefore, there is a need for systematic training approaches within all scientific disciplines which thematically address the interface between various scientific disciplines and Data Science, foster collaborative skills, and embed the culture of Open Science. However, current existing support structures for doctoral and postdoctoral researchers in the German academic system are usually not designed for the necessary guidance and training to meet these requirements and work beyond disciplinary borders. Early career scientists face several challenges in interdisciplinary research, mainly arising from the complexity of integrating domain-specific knowledge, recognizing and dealing with diverse scientific perspectives, building relevant networks, and applying new methods and techniques they have to learn on the fly. To address these challenges, early career scientists can benefit from a specific training concept that accompanies and supports their (post-)doctoral projects. This concept needs to emphasise holistic problem-solving skills, hands-on experiences, mentorship, and networking opportunities, driven by the specific needs of early career scientists. The NFDI4Earth Academy (Academy) offers such a training concept for NFDI4Earth Academy Fellows (Fellows), focusing on interdisciplinary research at the interface between the Earth System Science (ESS) and Data Science.

The NFDI4Earth Academy advances the Young Academy concept in the Geo.X research network for geosciences in Berlin and Potsdam (see Research networks). Here, the idea of cross-career training at the interface of geosciences with data and social sciences was not just developed, but successfully applied and trialled between 2017 and 2022 (Geo.X, Accessed 2024-07-09). This proven training approach has now

been rolled out Germany-wide as NFDI4Earth Academy which is part of the NFDI4Earth, the consortium for Earth system sciences of the German National Research Data Infrastructure (NFDI). Within the NFDI, 26 consortia covering all scientific disciplines are working towards improving sustainable access to research data to enhance data management, sharing, and reusability. Education and training are crucial elements in strengthening Data Science and research data management (RDM) competencies and promoting FAIR and open science.

Within the NFDI4Earth consortium, 72 partner institutions collaborate to provide simple, efficient, open, and – whenever possible – unrestricted access to all relevant Earth system data, scientific data management, and data analysis services. In this landscape, the three research networks Geo.X, Deutsche Allianz Meeresforschung (DAM), and Geoverbund ABC/J manage the NFDI4Earth Academy.

In this paper, we describe the concept of the NFDI4Earth Academy, which, due to its interdisciplinary and bottom-up approach, stands in contrast to the concepts of most other training structures, e.g. graduate schools. Our concept can serve as a blueprint for other interdisciplinary, open, and innovative initiatives in science. We are constantly evaluating and adjusting it according to our experience and new insights, and we propose the Academy's approach of Academy-Fellow driven programs with interdisciplinary collaboration, hands-on learning, and Open Science principles, as a promising model for all consortia of the NFDI to consider.

2. Characteristics of the NFDI4Earth Academy

2.1. Overall Goals

The NFDI4Earth Academy is dedicated to accomplishing three key goals:

1. The Academy aims to equip early career scientists with expertise in integrating Earth system and Data Sciences methods. Given the rapid evolution of computational methods and artificial intelligence, such interdisciplinary abilities are essential for addressing global challenges and generating novel insights.
2. The Academy serves as a platform for networking, specialised training, and collaborative research. It fosters the mindset and skills crucial for conducting open and data-driven science among early career scientists and cultivates a collaborative and inclusive community. In this way, the Academy establishes a research culture grounded in openness, collaboration, and innovation.
3. The Academy facilitates the integration of robust RDM practices into open and data-driven scientific workflows. Academy Fellows benefit from access to the full spectrum of NFDI4Earth innovations and services, enabling them to incorporate cutting-edge tools and technologies into their research projects. This not only aids in adopting FAIR and open RDM practices but also validates the utility of NFDI4Earth developments, which are tailored to the changing needs of active researchers.

Research networks

Geo.X is the research network for Earth and Planetary Sciences in Berlin and Potsdam. This network of universities and non-university research institutions focuses on developing collaborative projects, promoting the next scientific generation, fostering synergies in teaching, and sharing use of scientific infrastructure. Geo.X is funded by the Geo.X partner institutions.

The **Geoverbund ABC/J** connects scientists from different disciplines, jointly working on solutions to the pressing challenges of the future. The Geoverbund ABC/J creates attractive framework conditions for excellent research and the education of students, and promotes early career scientists. It is a cooperation of the RWTH Aachen, the universities Bonn and Cologne, and the Research Centre Jülich.

The **German Marine Research Alliance (DAM)** is an association of 24 marine research institutions to strengthen the sustainable management of costs, seas, and oceans. Through its activities in the core areas of research, data management and digitalization, coordination of infrastructures, and transfer, the DAM develops orientation and practical knowledge for politics, business, and civil society. The DAM is funded by the BMBF and the northern German states.

2.2. Learning environment and training approach

To achieve these goals, the NFDI4Earth Academy creates an agile and open environment, where Fellows play a pivotal role in shaping the content and direction of their educational and research pursuits. These bottom-up processes empower our Fellows to pursue their passions, fostering autonomy, curiosity, and self-confidence. We understand that moving away from traditional top-down structures may be challenging for those accustomed to more prescriptive educational environments. That's why our programme offers a balance between providing guidance and facilitating open exploration. Through collaborative projects, peer mentoring, and specialised training courses, we create opportunities for interdisciplinary collaboration, enabling Fellows to leverage diverse perspectives and expertise to tackle complex scientific problems. As part of the NFDI4Earth community, Fellows have access to cutting-edge tools and technologies, ensuring their research remains at the forefront of innovation.

2.3. Roles and responsibilities

The NFDI4Earth Academy is an integral part of the NFDI4Earth ecosystem leveraging the resources of the coordinating research networks Geo.X, DAM and Geoverbund ABC/J and those of other NFDI4Earth partners. This strategic integration ensures the Academy's access to a broad range of locations, experts, computational resources, infrastructure, and support.

To ensure synergies between the coordinating sites, each of the three networks employs one coordinator with assigned responsibilities. They set the organisational framework, initiate all bottom-up processes, encourage the development of collaborative research approaches, and ensure Fellows take the initiative. Together with the Fellows, the coordinators develop the content of the events and provide logistical support and event organisation. Furthermore, they continuously evaluate the Academy's progress and make adaptations, if necessary. The coordinators also facilitate collaboration with other partners and initiatives and components of NFDI4Earth, as well as with other NFDI consortia and external training initiatives. The Fellows have a multifaceted role as learners, mentors and trainers for their co-Fellows and potential scientific collaborators. They adopt a common code of conduct and are encouraged to take the lead in organising and conceptualising Academy events, fostering community engagement, and driving various activities. Two elected Fellow representatives are responsible for voicing the concerns and opinions of their peers within the Academy and the NFDI4Earth.

2.4. Recruitment and Selection Process

The Academy is looking for Earth system scientists with a background in Data Science or statistics, as well as data scientists or statisticians with a deep interest in Earth system science. Both doctoral and postdoctoral researchers are eligible, provided that they have a minimum one-year contract at a German institution from the Academy's starting point. It is desirable for candidates to have experience in interdisciplinary research, strong Earth system science skills, enthusiasm for working with data, Research Data Management (RDM), data analysis, mathematics, coding (Matlab, R, Python, etc.), as well as independent thinking, intrinsic motivation, and clear research goals. A further priority is the motivation to actively contribute to and participate in the Academy's activities.

The application process, outlined in the call announcement (Gödde et al., 2023a,b), requires concise descriptions of motivation, current research projects, and affiliation to Data Science. A diverse panel of experts, comprising Earth system scientists, data scientists, and former Fellows of various career stages, reviews the applications in a two-stage process. The initial decentralized online review is based on an agreed-upon criteria catalogue and focuses on the scientific competencies and suitability of the Academy. In the second stage, the committee discusses the results of the pre-review and selects a cohort of around 35 Fellows based on the quality of candidates and the available budget. In general, the selection process considers diversity in subjects, people, and institutions.

A regularly updated overview of our cohorts and selection committees is available on Zenodo (Gödde et al., 2024a,b).

2.5. Curriculum and Training Events

The Academy programme deviates from traditional graduate school curricula in two ways: First, we emphasise peer mentoring over teacher-based learning. Secondly, we provide a core

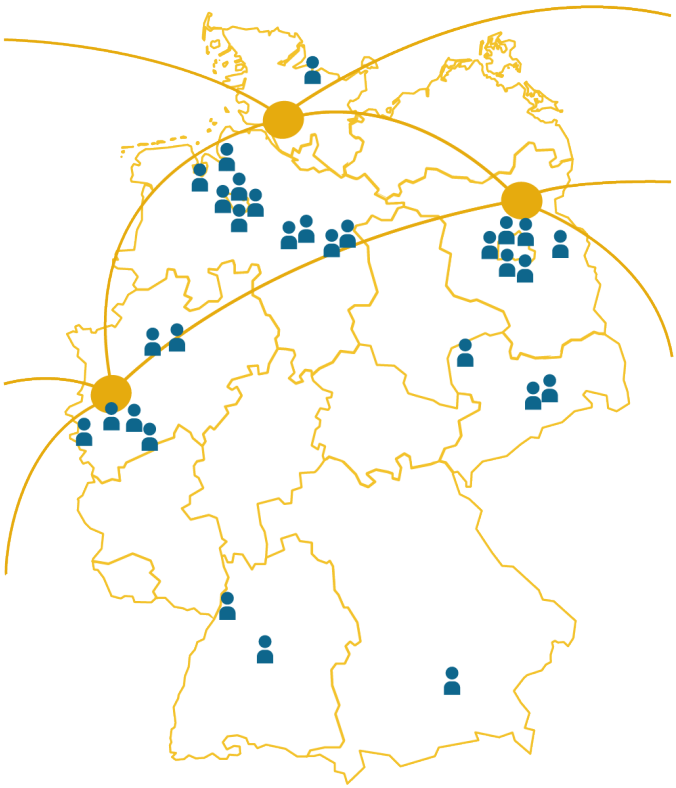

Figure 1: The location of all the institutions from which a Fellow has joined the NFDI4Earth Academy in the first and in the second cohort.

event structure with three events per year, determined by the Fellows in an agile bottom-up process to ensure that it meets the Fellows' training needs. In addition to the core events, Fellows will have the opportunity to organise and host additional workshops, meetings, and other events. There is also a special focus on connecting Fellows to existing training opportunities, especially regarding RDM topics and the strong integration and linkage to all NFDI4Earth developments (Figure 2).

2.6. Core events (Year 1)

During the first year, three core events focus on research data management and Data Science skills, and on establishing connections between the Fellows.

1. The programme starts with a two-day in-person **Kick-off retreat**, where Fellows get to know each other, present their research projects, and discuss their interests and existing skills in Data Sciences. Together with the coordinators, they develop a roadmap for the Academy programme and identify the main topics of interest for the cohort.
2. The series of **Cohort Calls** are bi-weekly virtual workshops focusing on research data management, reproducibility, and Open Science, spanning over two months. This format fosters fruitful discussions and active participation among the Fellows.
3. The **Seasonal School** is on training in Data Science Methods. Its duration and programme depend on the Fellows' specific preferences and Data Science skills. They actively

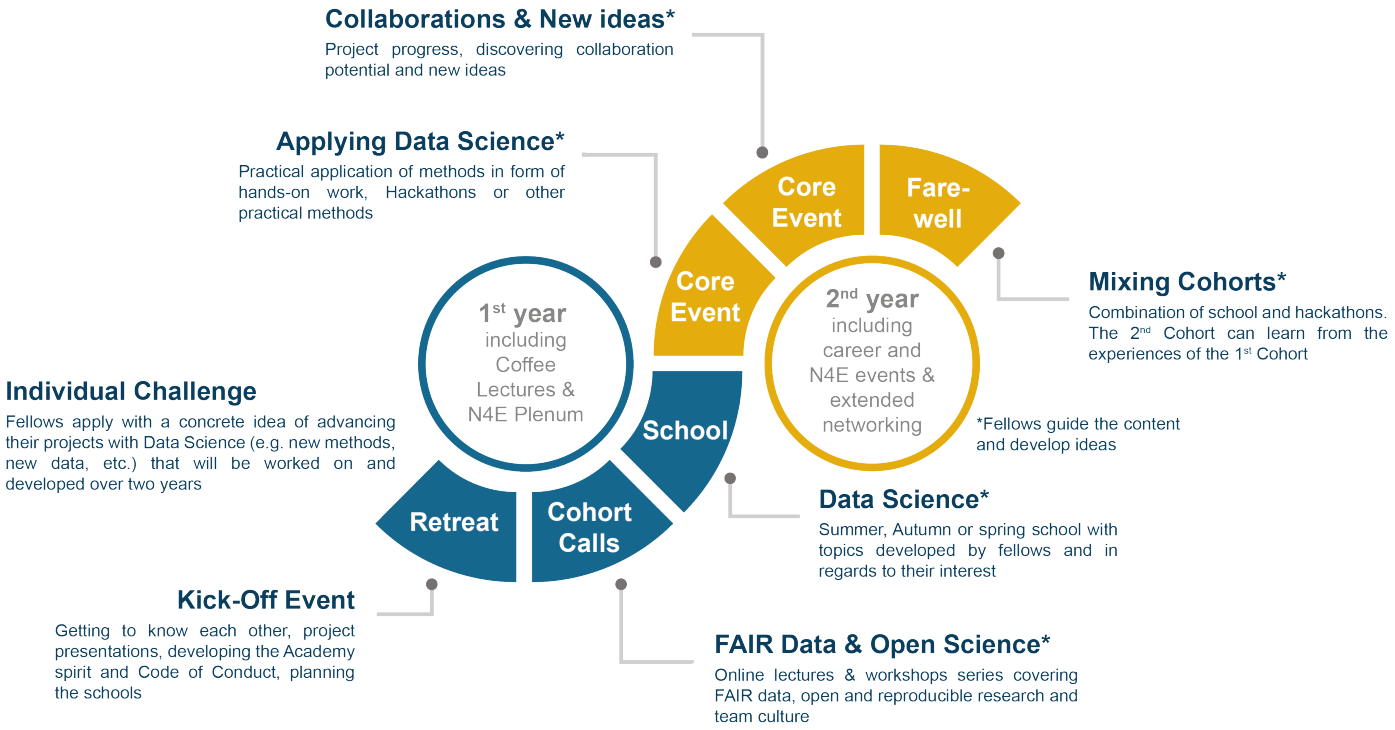

Figure 2: Overview of the core events in the two-year concept of the NFDI4Earth Academy.

participate in planning the school and can propose specific topics and lecturers to meet their specific learning and training needs.

2.7. *Core events (Year 2)*

In the second year, the core programme focuses on collaborative and networking events, while continuing to include training opportunities. All three events include the following activities, as well as the training provided in a seasonal school, but the focus of each event will vary according to the Fellows' preferences:

1. During a **Hackathon**, Fellows can engage in specifically designed challenges or on their own research projects, depending on their preferences and the focus of the respective event. The Hackathon format helps to acquire new skills, collaborate on challenging problems and think creatively.
2. The **Think Tank** aims to strengthen synergies between Fellows themselves, but also with the NFDI4Earth community, and to develop new ideas. Potential outcomes could be a joint research project or scientific paper.
3. The final joint **Cross-Cohort meeting** of the outgoing and incoming cohorts ensures knowledge transfer between them, as well as additional networking opportunities.

In addition to these core events, we provide regular online Coffee Lectures, usually during the first and fourth quarters of the year. These online events feature presentations on Data Science and research data management in the Earth system sciences, followed by discussions and possibilities for exchange. Furthermore, we offer access to external training opportunities, such as the Helmholtz Academy for Information and Data Science (HIDA) or DataTrain (University Bremen Research Alliance), focusing on various competencies in research data management and Data Science across disciplines.

A comprehensive overview of our past and current events is available on Zenodo (Gödde et al., 2024a,b).

2.8. *Collaboration within NFDI4Earth*

Academy Fellows are part of the NFDI4Earth community and play a pivotal role as early adopters of NFDI4Earth findings and solutions. Therefore, diverse ways for bringing in their needs, interests and knowledge are vital for the NFDI4Earth. Some key opportunities are:

- Taking an active role at the annual NFDI4Earth Plenary by presenting research (e.g. in poster sessions) and hosting workshops or networking sessions.
- Participation in all NFDI4Earth initiatives, such as the NFDI4Earth Interest Groups, which focus on specific topics for in-depth discussion.
- Applying for additional funding for short projects via the NFDI4Earth Pilot and NFDI4Earth Incubator calls.
- Discussing advanced RDM and data analysis methods within the NFDI4Earth community

- Accessing and testing the self-training material provided by the NFDI4Earth EduTrain portal, which offers valuable training material.
- Gaining visibility by including information on their research as an article or success story via the NFDI4Earth NFDI4Earth OneStop4All, the central entry point to all NFDI4Earth developments.

3. Evaluation concept

We continuously evaluate the Academy to ensure the quality of its offerings and the Fellows' expectations align with the content and direction of the programme. This assessment covers both the overall Academy concept and individual events. Although all evaluations are anonymous, the academic level of the respondent is a crucial factor in ensuring the satisfaction of both doctoral and postdoctoral researchers and is therefore required in each evaluation. Furthermore, we track the outcomes of the Academy, including scientific collaborations and research papers.

The evaluation process comprises two questionnaires: An introductory survey at the beginning of the program assesses Fellows' expectations, including time commitment to the Academy, personal development, networking within NFDI4Earth and beyond, and knowledge of RDM and Data Science. At the end of the two-year programme, we evaluate via a concluding questionnaire the fulfilment of personal expectations and the growth of skills and knowledge. This helps to highlight the programmes' strengths, identify areas for development, and drive adaptation.

Moreover, we evaluate each event, considering organisational aspects, the quality and impact of lectures or presentations, and the individual benefits for the Fellows. The feedback from these event evaluations directly influences subsequent events and is integrated into future planning processes.

4. Alumni Network

Following the two-year programme of the Academy, Fellows are invited to join the NFDI4Earth Academy Alumni Network to stay actively involved and connected within the Academy and NFDI4Earth community. Alumni will continue to receive all information on NFDI4Earth innovations and upcoming Academy events via mailing list, and are encouraged to participate as experts, teachers, and facilitators, providing knowledge and skills to the subsequent cohorts of Fellow. This helps to create a strong and sustainable network and strengthens the peer-mentoring environment also beyond the Academy.

5. Next possible steps

Our concept has demonstrated remarkable effectiveness in bridging Earth system and Data Sciences, leading us to propose the NFDI4Earth Academy as a model for interdisciplinary, open, and innovative training initiatives across all NFDI consortia - the NFDI Academy. The NFDI Academy aims to empower the next scientific generation for interdisciplinary research and promote a collaborative research culture to drive impactful discoveries and address complex challenges at the intersection of different scientific disciplines and Data Sciences. The transition from the Earth system sciences-specific training structure to the broader NFDI-wide Academy is a process that can be implemented step-by-step, ensuring a smooth and manageable change:

By collaborating with other interested NFDI consortia, the programme of the following (third) NFDI4Earth Academy cohort can systematically integrate joint training formats and topics that align with the interests and needs of these NFDI consortia. The involvement of topic-related NFDI sections as well as specific NFDI4DataScience and/or Base4NFDI activities may help to identify topics of general interest.

Building on the lessons learned from the third NFDI4Earth Academy cohort, the subsequent Fellow cohort will be recruited in multiple consortia. Particularly predestined for this are consortia that previously collaborated by offering joint training formats. Joint coordination and funding of this cross-consortia cohort is a prerequisite to ensure equal consideration of the involved consortia' interests.

Finally, we propose the establishment of an institutionalised NFDI Academy, which could be implemented as a Base4NFDI service, open to early career scientists from all disciplines and consortia in the NFDI. This step not only creates synergies between the consortia but also supports the NFDI's mission to develop research data infrastructures tailored to the scientific community. Additionally, we can contribute to the necessary cultural change in the next scientific generation.

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