

Mulig forlenget finansiering av hub/noder etablert i 2017

Fagråd for eInfrastruktur ønsker å undersøke hva en mulig forlenget finansiering i 1-2 år av hub/noder etablert i 2017 kan gi av resultater. De hub/nodene som ønsker å søke om forlenget finansiering bes gjøre det ved å svare *kort og stikkordmessig* på spørsmålene nedenfor.

Svarfrist er **fredag 29. november 2019** og svaret sendes pr e-post til **einfrastruktur-sekretariat@uio.no**.

Ordningen med eInfrastrukturmidler skal evalueres i 2020. Fagrådet har startet arbeidet med en egenevaluering og alle som er tildelt slike midler i 2017-19 vil bli bedt om å levere tilsvarende rapport. Eventuelle svar på nedenstående spørsmål vil også være hub/nodens innspill til fagrådets egenevaluering.

Hub/node:	GeoHive, renamed UiO Hive
Hub/node-leder:	Brit-Lisa Skjelkvåle, John F. Burkhart, Coordinator: Simon Filhol
Vertsorganisasjon	Department of Geosciences
Nettside:	https://www.mn.uio.no/geo/english/research/projects/hive/index.html

1. Hva er de tildelte midlene brukt til?

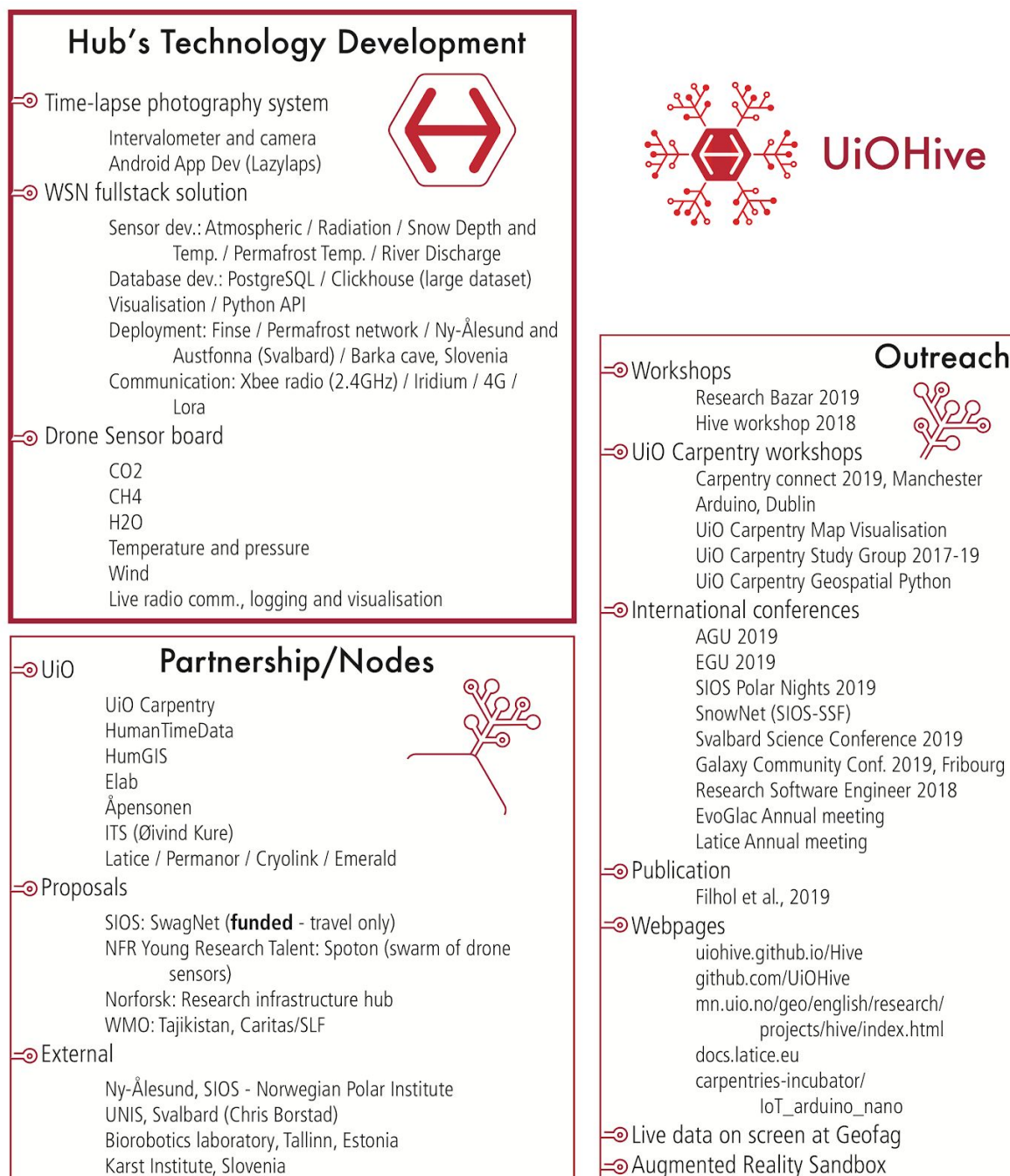
Angi hvordan midlene tildelt i perioden 2017-19 er benyttet (i hele 1000 kr). Oppgi eventuell egenfinansiering og om midler er fordelt til noder.

Formål	2017	2018	2019	Sum
Lønn, frikjøp	- kr	- kr	592 kr	592 kr
Anskaffelser, investeringer	- kr	213 kr	142 kr	355 kr
Kompetanseutvikling	- kr	76 kr	252 kr	328 kr
Andre kostnader	- kr	2 kr	71 kr	73 kr
SUM	- kr	291 kr	1057 kr	1348 kr
Egenfinansiering	- kr	350 kr	350kr	700 kr
Fordelt til noder	- kr	kr	kr	kr

UiO Hive (initially named GeoHive) was originally awarded 1650 kNOK from USIT to cover costs associated with the hub development. On top of this funding, the Department of Geosciences has offered the equivalent of 700 kNOK to support 3 months salary a year for the engineer John Hulth for 2018 and 2019. The funding, not entirely expired at the time of this report supported purchase of equipment (off the shelf products as well as developed part of the hub activities), salary for the hub coordination (Simon Filhol), financial support for engineers with specific competence, and organization

of a workshop. The technology developed as well as the set of competences gathered within the hub Hive raised interests outside of the University of Oslo. In spring 2019, the Norwegian Polar Institute contracted us for a total amount 140 kNOK to design, build and deploy a network of low-cost weather station in Svalbard. This activity will be followed in spring 2020 too. Other research groups have approached Hive thanks to the eclectic collection of knowledge the hub has brought together. While this interest from outside UiO cannot sustain financially the hub, it shows the value generated with the hub initiative and progress.

Figure 1: Summary of the Hub's activities, partnership and outreach for the past two years.



2. Hva slags nettverk er bygd opp?

Redegjør for hvilke noder som inngår i hub/noden, om det har vært samarbeid med andre hub/noder og hvilke andre som har vært involvert i virksomheten.

The Hive hub activities can be summarized in three main categories, 1) development of new technologies (hardware and software), 2) establishment of collaboration in terms of nodes or partnership, and finally 3) outreach activities. Figure 1 shows the detailed list of all these activities. Through the hub Hive, the team not only gathered a new set of skills and competences, but actually build new tools for research. These tools are using the latest electronic and software technologies available in fields such as Internet of Things (IoT), databases, microprocessors, or even Android application. The new collection of tools, knowledge and competences accumulated through Hive generated new ideas that were directly or indirectly incorporated in pending and even successful proposals. Through a variety of outlets, Hive members have spread the word to a local but also an international audience.

2.1. Oversikt over nodene

Nodes can be split in between internal and external nodes to UiO. Internal to UiO, Hive has partnered with a variety of entities across campus for technological development, outreach, or even inspiration for proposal writing. In terms of technology development, Hive reached out to Elab (electronic workshop at the physics department), and Prof. Øivind Kure at the department of Technology Systems who provided guidance to the development strategy. Hive built a rich network of outreach via the Software Carpentry network and workshop activities as well as the open maker space Åpensonen at IFI. As Hive is hosted at the Department of Geosciences, Hive capitalizes on the natural support of on-going research projects such as the UiO Strategic Initiative LATICE, the NFR research projects Permanor, EMERALD, and Cryolink as examples.

In terms of outreach, Hive has strengthened coordination for workshops with the UiO Carpentry project, and strongly benefited of this network to spread knowledge of the hub in international meetings.

2.2. Samarbeid med andre hub/noder

As part of our activities, our members connected to other relevant hubs such as HumGIS and HumanTimeData. HumGIS established a new Geospatial Information System (GIS) platform which, geoscientists have a large amount of experience with. We connected with them via attending and participating in meetings organized by the hub. We also met with the members of HumanTimeData as well as attended their meeting. We specifically exchanged on best practices and methodology for time series data treatment and storage, which both hubs sought to spread within our respective research groups. This meeting led to identify a need, across departments, for managing, storing and visualizing time series data for research but also educational purposes.

2.3. Involvering av IT-organisasjonen sentralt (USIT) og lokalt

In a later stage, Hive has drawn the local IT (dep. Geosciences) attention and expertise in designing and implementing a database solution for the data produced by the hub Wireless Sensor Networks

(WSN). As more research projects are using the newly developed technology and infrastructure within Hive (WSN, database, webAPI, visualization), there is an up-coming need for a database infrastructure allowing multiple projects to store data along side metadata. Including historical data within such e-infrastructure could be envisioned too.

Currently we are efficiently using and demonstrating some advanced usage of the UH-IAAS infrastructure USIT supports. As an example, our data collection and visualization platform operates via three separate but coordinated UH-IAAS instances. Our advanced usage of the instances has generated direct interest from our own internal IT and we are recognized for paving the way for future data acquisition deployments.

Otherwise, Hive members have been assisted in routine needs for IT resources (UiO user profile) access to computing resources and personal help.

2.4. Andre involverte i hub/noden

Hive has rapidly sought knowledge, resources or collaboration outside UiO to built the new e-infrastructure. We established lasting contact with collaborators in software and hardware engineering. Hive is using the services offered by UH-IAAS for the deployment of virtual machine (linux OS) to host databases, database manager, and documentation website. Lastly, Hive also partnered with external organization for the deployments and testing of hardware. The Norwegian Polar Institute contracted Hive for the deployment of a wireless sensor network (WSN) in Svalbard within an infrastructure investment plan from Svalbard Integrated Arctic Earth Observing System (SIOS). This was a direct test and usage of the WSN solution developed within Hive expertise and resources. Travel for this deployment was funded from SIOS through the grant SwagNET in which some Hive members were co-PIs. Hive also deployed in partnership with researchers of the Karst Research Institute in Slovenia a full setup for time-lapse photogrammetry (also developed within the Hive hub) (Filhol et al., 2019). Lastly, Hive recently visited the Center for BioRobotics of the University of Tallinn, Estonia, for future collaboration on developing WSN open-source solution.

Hive has triggered a number of ideas and is now directly or indirectly included in a variety of pending proposals.

3. Hvilke resultater er skapt?

Beskriv hvilke resultater i form av kompetansebygging, eInfrastrukturressurser og -tjenester, tekniske løsninger, møteplasser og samarbeidsarenaer med mer som er utviklet i regi av hub/noden i 2017-19

3.1. Kompetanseutvikling

UiO Hive has worked to gather a broad breath of competences and expertise through its nodes for e-infrastructure development for environmental sciences. Informed from growing variety fields of scientific expertise, Hive has allowed to bring together software developers, hardware engineers, and field scientists and technicians. Hive has cultivated a network of outreach specialist giving workshops at UiO or elsewhere.

One of the primary goals for Hive was to establish a low-cost wireless sensor network solution for environmental science, the hub build an expertise in state of the art IoT solution, communication

protocols for low-power system and remote location, solar power solution for autonomous devices, digital sensor technology, database solutions, and even Android application. In parallel, the hardware development required acquisition of knowledge and competence in electronic design, device functional and practical design. Overall Hive has allowed us to build skills in product development, combining end user requirements with design and manufacturing pragmatism. Because Hive evolves within the scientific community (from student to professor), it integrates at its core the needs of research and education within the e-infrastructure it is developing. This unique setup allows a two-way discussion in between technical experts and scientists at every stage of development, allowing new space for creative thinking.

Members of Hive have use time to develop tutorials about the technology used in the Hive e-infrastructure, to invite students and researchers not familiar with those technologies and their complex jargon to participate and appropriate these new tools. These tutorials covered topics in IoT technology, programming languages (e.g. Python, R), data analysis and machine learning techniques for geosciences.

3.2. eInfraressurser og -tjenester

UiO Hive objective has been to gather knowledge and resources to build e-infrastructure for environmental sciences with a focus on building on the latest technology available. The core e-infrastructure accomplishment is a new wireless sensor network solution for remote, harsh and cold environments (eg. Alpine, Arctic). The goal has been to build a full pipeline for data in which scientist can have full control on from the time the observation is made at the sensor tip, through the communication chain all the way to the database. Hive e-infrastructure relies as much as possible on open-source solution for its inherent long term low cost but especially for aspects concerning full transparency and robustness of such licensed solution (e.g. Linux OS, Python language, PostgreSQL and Clickhouse database, etc).

So Hive has provided support to build three main types e-infrastructure:

- **WSN full stack.** The WSN consists of small and low-cost weather station using low power, miniature and solid state sensors. The stations push data in near real-time via 4 possible communication system (2 types of low power radio network, 4G mobile network, and satellite Iridium). The data are collected by a self designed application running on UH-IAAS Linux virtual machine servers, and stored onto a database. This newly built e-infrastructure is now providing a robust data workflow for 5 research projects.
- **Time-lapse photogrammetry.** Time-lapse photogrammetry is a common tool to environmental sciences for which a limited number of off the shelf solution exist for harsh and remote area. Hive supported the development of two technical solutions for capturing time-lapse photographs, one based on camera hardware, and another on Android phone. On top of this hardware, an open source software was published to compute 3D models out of the photographs. This new method was published in Filhol et al. (2019), and is currently available on Github (<https://github.com/UiOHive/photo4D>)
- **Drone sensor board.** The drone sensor board combines low cost sensors (CO2/CH4 concentrations, air temperature, pressure and humidity), a live communication and logging platform onto a field laptop. Thanks to the recently acquired knowledge of prototyping in Hive, the proof of concept quickly turned into a bachelor project at the Department of

Geosciences about land and atmospheric interactions (CO2 fluxes), and is now a pending NFR proposal (SPOTON).

Overall, Hive has built e-infrastructures now used by multiple projects and allowed for creative ideas. It brought technology solution to researchers and students that allows for new scientific approach, lower cost of maintenance and most importantly being at the forefront of environmental sciences. By connecting with groups outside UiO, Hive ensured using widespread technology, and is now looking forward to coordinate and converge the development efforts with international groups for mutual benefit in the long term. The usage of open-source tools is a clear philosophical choice towards a societal exigency for transparency in the scientific process.

3.3. Møteplasser, samarbeidsarenaer

UiO Hive hub is meeting in various physical places with a core team at the Department of Geosciences. During the past two years, UiO Hive hub and nodes have meet in formal and informal settings at Åpensonen, UiO Carpentry workshops, and international conference and meetings.

The hub also established online collaborative platforms with a formal webpage, a website (<https://uiohive.github.io/Hive/>), collaborative tutorials and a Github group (<https://github.com/UiOHive>). Knowledge about the WSN e-infrasructure is gathered in the documentation (<https://docs.lattice.eu/> **User:**doc, **password:** Eec2oa9r).

3.4. Annet

All Hive members made an effort in disseminating the existence and the purpose of Hive on campus, nationally, and in international settings.

Figure 2: Hive branding logo



4. Hvilken effekt har resultatene av hub/nodens virksomhet hatt?

Beskriv kort hvilke effekter virksomheten har hatt for forskere og forskningsgrupper of for forskningen ved universitetet.

The establishment of collaboration with a variety of partners, increase efficiency in the design of new e-infrastructure based on short term demand for researcher, stir ideas within the community in the value of welcoming new technology such as IoT, database, or dynamic visualization which are not yet widespread used or even accepted. The supported researchers then succeeded in collecting data in challenging environmental conditions (Finse, Svalbard), gaining knowledge that were beyond their

own reach (data previously not measured at such high spatial and temporal time scale) and publishing innovative results in peer-reviewed scientific journals.

5. Hva er de viktigste lærdommene og erfaringene fra arbeidet hittil?

Med henblikk på framtidig utvikling av hub/node-virksomheten, beskriv kort hva som er de viktigste lærdommene og erfaringene – positive såvel som negative – å ta med seg fra hub/nodens virksomhet disse årene.

The most important lesson from the hub and a core project/goal is to cultivate the creative and productive momentum within the hub, and attract other/new parties (nodes). The success of the hub is also directly dependent on the number of dedicated work hours to coordinate the hub and maintain focus. Finally, the budget flexibility was key to an adapted evolution of the e-infrastructure development based on the various and unexpected obstacles met along the way.

One issue is that the concept of Hub and node is easily misunderstood when presented to people not initially aware of such structure. But more importantly, the experience of Hive highlighted the value of having multidirectional communication in between the various groups (the nodes) with at the center a core team (the hub) encompassing the broader range of all the nodes included (see 2.2).

6. Hva er hub/nodens exit-strategi?

Skal resultatene av virksomheten videreføres i noen form og i tilfelle hva skal videreføre, hvordan er det tenkt skje og hvem vil ha ansvar for drift og videreutvikling.

UiO Hive has established an effective suite applications that together creates a novel product for research. Per the mandate of the original funding, the product brings together interdisciplinary expertise to provide a coherent resource that we believe is presently in high demand. One of the key aspects and value of Hive activities has been exactly this cross-disciplinary nature and the initial seed funding and presently requested extension are vital to foster this, given traditionally heterogeneous funding sources and timing.

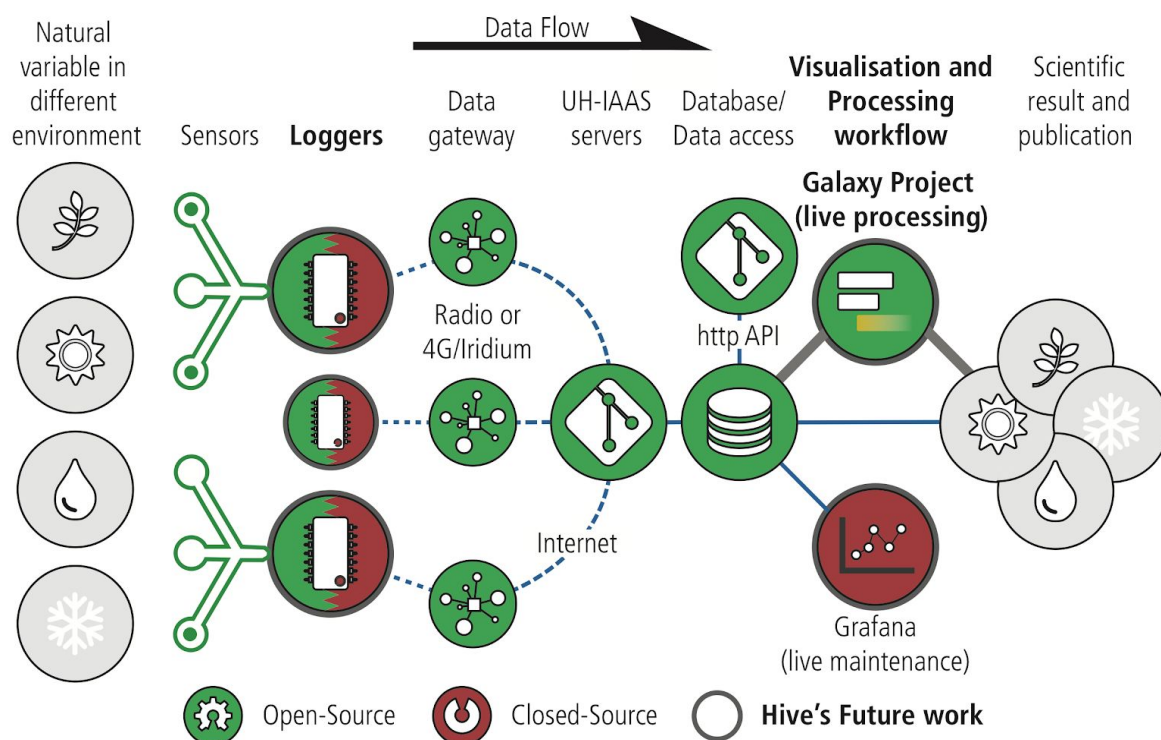
UiO Hive has already started to garner attention both nationally and internationally as a resource and partner within proposals. We anticipate to build the reputation in the coming phase and have confidence that our expertise will allow us to be a key partner within upcoming National and EU-funded projects. In addition, we believe there are several clear pathways toward commercialization of some of the innovations we have developed, and we intend to pursue this pathway as well.

UiO Hive will seek avenues to increase its influence via partnership with on-going and pending research projects, and with national infrastructure project (e.g. SIOS) by providing its competence in building e-infrastructure services for geosciences. The innovation environment created by Hive could justify an upcoming application to the NFR IKTPLUSS funding scheme for digital innovation to consolidate Hive investment in using and building new technology. Lastly, because many of the technologies used are developed in and can possibly interest a broad variety of fields and industrial sectors, we are planning in participating to international programs like the Mozilla Foundation Open Leader Hardware program.

7. Hva vil en forlenget finansiering av hub/noden muliggjøre?

Angi hva en forlenget finansiering er ment å dekke, – kompetanseutvikling, utvikling og drift av eInfrastrukturressurser og -tjenester med mer.

Figure 3: The Hive's e-infrastructure: Toward a full stack open-source solution for environmental science



UiO Hive thrives to 1) bring the latest technology to students and scientists by bridging the knowledge and communication gap between engineers and end users, and 2) build the tools needed to comply with the FAIR principles of data management (Wilkinson et al., 2016), and the exigence from the scientific community and citizens for a transparent scientific process only possible via open-source licensed technology. The funding will therefore cover efforts to overcome the two identified obstacles to the current e-infrastructure, reinforce our national and international network of partners, and nurture a culture for appropriating these new technologies through workshops on campus.

As previously mentioned, the Hive philosophy is to integrate new open-source technology and build upon them to build the tools that scientists in natural sciences will use tomorrow. The first two years of the hub provided tremendous knowledge building, and a successful proof of concept for an IoT system for research purpose (Figure 3). A future step of development for Hive would be to take advantage of its now well established national and international network to lead the development of a fully open source and generic system encompassing sensor development, data logging, communication protocol, storage, visualization and analysis. The vision for such a scientific full stack solution is to provide the necessary e-infrastructure to transition natural sciences to contemporary available technology at a low cost, with scalability, transparency and ease of use.

Today, the e-infrastructure Hive has two primary obstacles for accomplishing our vision, 1) a component of our WSN system still relies on a closed source hardware solution, and 2) an elegant and comprehensive api providing direct access to the data by the end user is not fully completed (Figure 3). We have a roadmap to address these two main obstacles and have gathered the appropriate knowledge and expertise under the Hive umbrella to accomplish the goal to provide an innovative full stack solution catered for science.

First, we will focus on designing a new open data logging platform both in terms of hardware and software. We plan on using technologies compatible with other groups worldwide that the efforts can, on a long term, be coordinated and mutually beneficial. Existing analogous projects (e.g. MayflyDIY) lack both a complete stack of technology to handle data within an integrated framework, and an inherent design for deployment in harsh environments. Technologies we are looking forward to integrate are the microprocessor Cortex M0, the Arduino program compiler, and the MQTT data protocol system. Concepts behind our design will be low power, low cost, resilience, robustness, and more importantly, easy integration of new sensors or communication system.

Second, the UiO Hive hub's interactions with researchers on dataflow and data collection highlighted a clear need for developing/sharing open and reproducible workflows as well as advanced data management and ready-to-use visualisation tools. To build on the newly established full stack application built within the past two years thanks to Hive (figure 3), we plan on incorporating a new flexible interactive environment called the [Galaxy Project](#). Galaxy is an open source infrastructure aiming at generating publication ready figures from a transparent workflow and allowing for efficient data analytics and integrated visualisation using a variety of languages (e.g. Python, R, Julia) within notebook format. Galaxy is designed to build processing pipeline in a very dynamic and collaborative manner in order to provide the scientific context behind each dataset, thus redefining the old and static classical publishing of scientific results. We plan to contribute and develop Galaxy training material to facilitate the usage of the UiO Hive's tools by students, researchers and beyond.

This new entire open-source data pipeline from the sensor tip to dynamic visualization envisioned here is novel, pushing the limits of currently established observational and analytical solution in environmental sciences and education, and most importantly transferable to other fields of sciences or research groups. **The goal for Hive is to lead this development and place UiO and our members at the forefront of technological appropriation allowing for new scientific approaches.** Looking into future perspective, once a robust platform is designed and can be used, more and new sensors can be developed for other geosciences research interests, as for example biosensors and passive sensors for terrestrial ecosystems, or new and smaller sensors for atmospheric-aerosols research. The potential of Hive for climate and geosciences research activities, especially in the polar areas, is considerable, and can provide an immense benefit to the international research community.

8. Hva vil dette koste?

Angi hvilke kostnader vil en forlenget finansiering dekke.

Formål	2020	2021	Sum
Lønn, frikjøp	500 kr	500 kr	1000 kr
Anskaffelser, investeringer	250 kr	250 kr	500 kr
Kompetanseutvikling	500 kr	500 kr	1000 kr
Andre kostnader	50 kr	50 kr	100 kr
SUM	1300 kr	1300 kr	2600 kr
Egenfinansiering			
- Dept. Geosciences	350 kr	350 kr	700 kr
Annenfinansiering			
- SIOS	250 kr	250 kr	500 kr

*All values in thousands of kroner

The budget covers salary for a researcher (7 month a year), investment in equipment, hiring of specific competences and the organization of annual workshop and travel to meet with national and international partners. SIOS (represented by Dr. Jean-Charles Gallet, Norsk PolarInstitutt) is providing 500 kNOK as investment in equipment and to a lesser extent support for engineering competence. This support is a mutual benefit between Hive and SIOS to develop further and especially test in real and extreme conditions the sensors developed. Hive can also gain in visibility by being even more involved in a large and national strategic project as SIOS is, and increase its visibility through SnowNet, an active network of young researchers working on interdisciplinary snow research topics in Svalbard (Gallet, PI).

From the current budget there are still 1.5 month of researcher salary for Dr. S. Filhol for 2020. The 7 months planned in this new budget will be used to hire a new researcher specialized in front-end visualization of scientific data.

We are expected with this additional person to increase the hub's momentum and therefore increase significantly the hub's influence and productivity.

References

Filhol, S., Perret, A., Girod, L., Sutter, G., Schuler, T. V., & Burkhart, J. F. (2019). Time-lapse Photogrammetry of Distributed Snowdepth During Snowmelt. *Water Resources Research*.

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., ... & Bouwman, J. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific data*, 3.