ADDRESSING GRAND CHALLENGES IN EARTH OBSERVATION SCIENCE: THE EARTH OBSERVATION DATA CENTRE FOR WATER RESOURCES MONITORING

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ABSTRACT:

Earth observation is entering a new era where the increasing availability of free and open global satellite data sets combined with the computing power offered by modern information technologies opens up the possibility to process high-resolution data sets at global scale and short repeat intervals in a fully automatic fashion. This will not only boost the availability of higher level earth observation data in purely quantitative terms, but can also be expected to trigger a step change in the quality and usability of earth observation data. However, the technical, scientific, and organisational challenges that need to be overcome to arrive at this point are significant. First of all, Petabyte-scale data centres are needed for storing and processing complete satellite data records. Second, innovative processing chains that allow fully automatic processing of the satellite data from the raw sensor records to higher-level geophysical products need to be developed. Last but not least, new models of cooperation between public and private actors need to be found in order to live up to the first two challenges. This paper offers a discussion of how the Earth Observation Data Centre for Water Resources Monitoring (EODC) – a catalyser for an open and international cooperation of public and private organisations – will address these three grand challenges with the aim to foster the use of earth observation for monitoring of global water resources.

1. INTRODUCTION

The scientific exploitation of earth observation (EO) data is becoming increasingly challenging for several reasons. The first reason is the sheer magnitude of the data generated by the latest generation of EO sensors. While in the past scientific users were confronted with data volumes in the order of tens to hundreds of Gigabytes, nowadays data volumes of several Terabyte have to be handled. Very soon, tens to hundreds of Terabytes up to Petabytes will become the norm for continental and global scale applications. The second reason is data complexity. Modern EO sensor technology is pushed towards the physical limits, making it necessary to understand each part of the measurement process and any unwanted interferences with significant detail.

It can also be expected that today's higher scientific standards will exert pressure on the EO community to engage in more extensive computations: While in the past it has often been sufficient to perform a scientific experiment with one single algorithm on a limited test data set, nowadays this is not an attractive scenario anymore. Today it is expected that algorithms are compared to competing algorithms and tested with data sets of significant size. Only this can ensure that the errors of each data set are well characterised and that each model output can be accompanied by an uncertainty range as well as by other quality flags. In some applications, like e.g. in climate change assessments, it is furthermore required that any subtle trends depicted by the data are carefully checked by using an ensemble of EO data retrieval algorithms.

The scientific community has already started to respond to these increasingly demanding requirements. Throughout Europe (and elsewhere) one can find a growing number of EO research teams that are capable of processing Terabyte large data sets with multiple algorithms in-house. To arrive at this point these research teams had to significantly invest in their information technology (IT) infrastructure and focus their work on selected sensor technologies and/or application domains. However, scientific groups capable of processing big EO data are still the minority. In the absence of sufficiently powerful and mature cloud services provided by space agencies or other public data centres, the most viable strategy that these scientific groups may adopt to significantly enhance their data processing capabilities is increased specialisation and cooperation. Also this is something one can already find throughout the EO science community in Europe. Thanks to the support of international funding programmes there are now many clusters of research teams that have been cooperating in a series of projects on specific topics.

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The increasing specialisation and cooperation of the EO science community has already led to remarkable advances in the provision of high-quality scientific EO data sets. Nonetheless, many of these developments stand on shaky grounds given that the scientific and technical know-how and data processing capabilities remain largely fragmented. This is because the cooperation between different EO teams is typically project-based and can end abruptly after the end of a project. Few EO teams cooperate on a more strategic level that involves e.g. the free sharing of software code or the joint use of common IT resources.

Recognising the needs for building strategic partnerships in EO science and applications, a group of public and private European organisations has developed a cooperation model – presented here for the first time in the scientific literature – that shall ensure that the above discussed grand challenges in EO can be addressed. This cooperation model is built around the insight that exponentially growing data volumes and the increasing complexity of the scientific algorithms demand a fundamental change in the way of how EO data are distributed and processed. From a technological perspective it should not be too difficult to put this cooperation model in practice thanks to the possibilities offered by modern IT technology (Section 2).

However, the "soft" aspects behind such a strategic cooperation are significantly more challenging. Probably the most important soft aspect is building mutual trust between the cooperating partners: trust that one's own EO data hosted at somebody else's data centre remain easily accessible; trust that the cooperation will respect intellectual property rights (IPRs); and trust that the cooperation will be beneficial for one's own organisation in the long run. While some of these aspects can formally be regulated, others can only be confirmed in practice. Trust is an intangible asset and can *per se* not be guaranteed by whatever means. Nonetheless, it can be promoted in a step-by-step manner if the cooperation follows cultural principles such as open-mindedness, willingness to share, and transparency. From an organisational point of view, it is important that all actively engaged cooperation partners have a voice when it comes to important decisions. Last but not least, the cooperation model must allow anticipating and resolving potential conflicts at an early stage.

When developing the cooperation model for the Earth Observation Data Centre for Water Resources Monitoring (EODC), as introduced in this paper, care was taken that the soft aspects discussed above are accounted for as well as possible. Section 3 describes the mission and thematic goals of EODC. This is followed by a discussion of the cooperation model in Section 4. Section 5 introduces the use case and services that will be offered by EODC. Finally, Section 6 gives an outlook.

2. A NECESSARY PARADIGM SHIFT

2.1 Approaches to Data Distribution and Processing

As noted above, fast growing data volumes and more stringent scientific requirements are questioning common practices for distributing and processing of EO data. So far, the ground segment of EO missions has been set up to distribute satellite data to hundreds or even thousands of remote sensing experts for higher level data processing. These experts passed on the value-added data to application oriented users who use the EO data in their specific application domain (e.g. hydrology, urban planning, etc.) in one of many ways (for model validation and calibration, for direct model input or as input to data assimilation schemes, etc.). The advantage of this approach is that each organisation involved in this value-adding chain has full control over its own data and software. This gives each organisation the security that its IPRs are maintained. Furthermore, it may give each organisation the impression to be largely independent from the other players in this value-adding chain.

However, this approach is inefficient given that the number of copies of each data record increases with each additional data host. Furthermore, it means that each individual EO expert organisation has to build up expertise in essentially the same basic data processing steps (reading, quality control, data base management, georeferencing, radiometric correction, etc.). Now, that the data acquisition rate of novel EO satellites has increased up to a point that challenges our technical capabilities to distribute[1] and process the data in near-real-time (mostly due to bandwidth- and I/O limitations), this approach becomes increasingly unattractive from an economic point of view. Therefore – not even yet considering the many benefits that may arise out of cooperative undertakings – new approaches for working with the data are urgently needed. Simply put, the solution is to "bring the software to the data" instead of "moving the data to the software". This sounds simple, but its realisation will lead to a complete overhaul of the way of how EO data processing and distribution is organised.

2.2 Virtualisation and Cloud Computing

Traditional processing facilities had been laid out for one specific task and data volume. The processing software was usually implemented for the target hardware and operated on it. While this approach provides a good basis for long-term operation, it does encounter problems when the data volume changes, e.g. when a satellite instrument is reconfigured or when a new mission is added, and the foreseen processing resources end up being insufficient.

In recent years, modern facilities implemented a virtualisation layer to decouple the software from the physical hardware it is running on. This enables the operators to change the hardware setup at any time, either adding resources, or replacing them with newer, more powerful units, or reassigning them to other tasks in a 7×24 environment. Many virtualisation environments even allow a transparent migration from one hardware platform to another, without having to stop the processing task. Operating in a virtual environment opens up the possibility to run multiple, independent processing tasks at the same time, partitioning the physical resources based on the relevance of the data. As each task runs in its own isolated domain, it cannot interfere with other tasks. There is a variety of virtualisation technologies available, ranging from a full virtualisation of the entire hardware and operating system, to a partial one, where only some elements like e.g. data access are abstracted. Virtualisation is implemented for all major operating systems.

[1] A curious implication of these huge data volumes is that for some satellites, data distribution will have to rely (again) to some extent on regular surface mail (shipping of tapes or external hard drives). This is simply because the transmission rates over the internet are, without special provisions, in general too slow for downloading more than just a few dozen to hundreds of high-resolution images within acceptable time periods.

The ability to run software virtually anywhere has given rise to large data centres specialising on providing processing resources and services to third parties. These services are divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS), depending on the focus of the facility. Not knowing the exact physical location of the service, but only accessing it over the internet with elastic backend resources at hand, this concept has been given the designation of cloud computing.

One of the most striking differences compared to traditional data centres, is that services are provided on a highly flexible basis: customers can book all services on demand, depending on their specific user requirements. Typical pricings are by hours of operation and/or gigabyte of storage. This flexibility is particularly useful when large, archived data-sets need to be re-processed with an updated software package. This is not part of the regular, day-to-day operation, but only happens in irregular intervals, yet the necessary resources will be a multiple of what is required for real-time processing.

2.3 Pilot Services

Cloud computing in support to EO science and applications is still only in its infancy. Nonetheless, it is a quickly growing field that has already led to first remarkable scientific results. Probably the most remarkable achievement was the study lead by the University of Maryland that was recently published in Science by Hansen et al. (2013). The authors processed over 650,000 Landsat 7 scenes at Google's Earth Engine (https://earthengine.google.org/) to produce the first 30 meter resolution maps of global forest change for the period 2000-2012. While the accuracy of the automatically derived forest cover maps still needs to be investigated, it is already clear now that this will become an invaluable data set for studying and inter-comparing forest cover change processes at local, national and global scale.

In Europe, particularly the European Space Agency (ESA) has actively promoted the development of cloud technologies in support to EO science and applications. One of ESA's earlier developments was the Grid Processing on Demand (G-POD) platform (https://gpod.eo.esa.int/) that integrates high-speed connectivity, distributed processing resources and large volumes of data to provide science and industrial partners with a shared data processing platform fostering the development, validation and operations of new earth observation applications. One disadvantage of G-POD has been that it lacks the flexibility to carry out developments on the platform itself, which is a severe restriction from a scientific point of view. Another example is an European initiative called Helix Nebula (http://helix-nebula.eu/). Helix Nebula aims to become a general-purpose Science Could for meeting the needs of IT-intense scientific disciplines, from particle physics to biomedical research and earth observation. ESA has been one of the key partners of the Helix Nebula consortium, taking responsibility for one of the four flagship use cases. Helix Nebula is still in a pilot phase, hence it is not yet possible to foresee in which specific ways Helix Nebula will eventually support the wider EO science community. A final example is the Climate and Environmental Monitoring from Space (CEMS) facility (https://sa.catapult.org.uk/cems) that was recently established in Harwell, United Kingdom (UK). CEMS was created to assist, amongst other objectives, the climate science community by bringing together expertise from academic, institutional, and commercial organisations. So far, CEMS has had a strong national orientation, i.e. it has mostly served the needs of the UK science community.

These pilot projects have demonstrated that novel IT technologies, including virtualisation, cloud computing, parallelisation, are making it indeed technically feasible to change the current paradigm in EO data distribution and processing. However, there are (at least from our perspective as potential users of these cloud services) still many uncertainties as regards the governance, data and software stewardship, and the possibility for active scientific cooperation in all pilot cloud services discussed above. Therefore, we think that it is important to present the mission, cooperation model and use cases chosen for EODC in detail in the following sections.

3. EARTH OBSERVATION DATA CENTRE FOR WATER RESOURCES MONITORING

3.1 Addressing the Data Scarcity Problem

Despite the fact that the number of EO data services providing data for water cycle monitoring has been steadily increasing in recent years, users keep on expressing their concern that not enough data useful for water resources management are available. This data scarcity problem is particularly eminent in the less developed parts of world. As stated in the fourth World Water Development Report (WWAP, 2012): "Information about water supply and use is becoming increasingly important to national governments, who need reliable and objective information about the state of water resources, their use and management. Farmers, urban planners, drinking water and wastewater utilities, the disaster management community, business and industry, and environmentalists all need to be informed. The data required to populate the indicators are seldom systematically or reliably available at a global, national, regional or basin level. If actual data are not obtained, trends will not be tracked, even if they are substantial."

But even in the developed parts of the world, where high-density in situ sensor networks are often available, the lack of data is being felt. This is because the spatio-temporal variability of many land surface processes is so high that these cannot be adequately captured by local-scale in situ measurements. Therefore, a recent report of the German National Academy of Science and Engineering (acatech) on the "Georessource Wasser – Herausforderung Globaler Wandel" (acatech, 2012) recommends to make more use of new and innovative technologies, such as those offered by remote sensing.

3.2 Towards the Foundation of EODC

In recognition of the data scarcity problem in water resource management and many other EO applications over land, and with a view on the high potential of the upcoming Sentinel satellites, the basic ideas for a collaborative earth observation data centre were first formulated in 2011 by a working group that was tasked to give recommendations on Austria's space activities in the period up to 2020. Thanks to an overall very positive reception of these ideas, they were hence included in a Space Strategy document published by the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) in November 2012 (BMVIT, 2012). In this document, the foundation of an Earth Observation Data Centre for Water Resources Monitoring was officially put forward for the first time, highlighting the potential of the centre for improving the competitiveness of Austria in the space sector. Despite its

Austrian origins, EODC had an international perspective from the very beginning.

In two consecutive feasibility studies funded by the Austrian Research Promotion Agency (FFG) and the European Space Agency (ESA), the possibilities for realising this centre as a cooperative undertaking between public and private organisations have been investigated (Wagner et al., 2012). The understanding gained in these feasibility studies lead to the formulation of a cooperation model that was inspired by the example of 52°North (http://52north.org/), an open international network of partners from research, industry, and public administration for developing open source software in the geoinformation domain.

The sustainability of the EODC cooperation network will be guaranteed through the foundation of a company that will act as promoter and catalyser for this open and international cooperation of public and private organisations. The EODC company was founded as an Austrian limited liability company ("GmbH = Gesellschaft mit beschränkter Haftung") in May 2014. The main founding partners are the Vienna University of Technology (http://www.tuwien.ac.at/), the Central Institution for Meteorology and Geodynamics (http://www.zamg.ac.at/), and the companies GeoVille (http://www.geoville.com/) and Catalysts (http://www.catalysts.cc/).

3.3 Mission

The mission of EODC is to work together with its partners from science, the public and the private sectors in order to foster the use of earth observation data for monitoring of global water resources by

- setting up, managing and operating a virtualised, distributed EO data centre
- providing collaborative IT infrastructure for archiving, processing, and distributing EO data
- organising collaborative software development processes for establishing fully automatic end-to-end EO data processing chains
- building up comprehensive competence in processing large quantities of EO data

Its ambition is to enhance the social benefits of EO technology by serving, in particular, private and public organisations that actively support social and environmental development goals (e.g. humanitarian non-governmental organizations or environmental agencies).

To fulfil its mission the EODC GmbH shall act as a community facilitator:

- Organise the EODC Cooperation Network, assembling research labs, public agencies, private companies, and engaged users as to leverage the maximum of synergies for innovative ideas, concepts and practical implementations.
- Organise communities within this network as to identify common field of interests, align strategies and organise joint activities like workshops and R&D projects.
- Provide a platform for supporting communication and collaboration between partners, thus facilitating the development of new concepts and technologies.
- Organise the management, quality assurance and distribution of jointly developed software.
- Collect and maintain usage rights for jointly developed software, and provide licences for other users.
- Broadly communicate the network activities and its results in order to develop EODC as a brand for excellent R&D cooperation.

Together with its Cooperation Partners, EODC will pursue the following technical goals:

- Connect to one of ESA's data hubs for receiving EO data from the satellite core ground segments
- Process in-coming EO data in near-real-time (NRT)
- Distribute NRT data through a rolling archive
- Run a science integration and software development cloud platform
- Maintain shared code libraries
- Provide access to complete EO mission data archives
- Enable, organise and carry out processing efforts

3.4 Thematic Goals

For proper water resources management it is essential to have an integrated view of the complete water cycle which entails that, in principle, quite a broad range of parameters needs to be observed (Wagner et al., 2009). This includes rather static or slowly varying parameters such as the topography, permanent water bodies, vegetation structure, and dynamic parameters such as precipitation, soil moisture, inundation area, snow cover, glaciers, freeze/thawing, etc. (Figure 1).

Satellite	Temporal	Product
Sentinel 1	static	Water Bodies
		Forest / Non Forest
		Rice
	dynamic	Water Bodies
		Rice and growing status
		Soil Moisture
		Soil Water Index
		Start of Soil Water Season
		Drought / Wet Indices
		Flooding
		Snow
		Freeze
Sentinel 2	static	Forest / Non Forest
		Biomass Indices
		Landcover
		Glacier area
	dynamic	Forest Functional parameters
		Evapotranspitation
Sentinel 3	static	Glacier area
	dynamic	Snow

Figure 1: Main satellites and data products to be considered by EODC.

The static and slowly varying parameters can be mapped using high-resolution airborne and satellite measurements; for monitoring dynamic parameters sensor systems with a short repeat interval are required (Wagner et al., 2011). Most of the latter have quite a low spatial resolution in the order of 250 m to tens of kilometres, which has been a limiting factor in many applications. But thanks to the unique design and technical characteristics of the upcoming Sentinel satellites it will be possible to monitor many of these dynamic land surface parameters at a high spatial and temporal resolution. Therefore, the Sentinel satellites will become a very important source of data for EODC. In the beginning EODC will concentrate on some few key thematic products such as soil moisture and dynamic water body maps. The main sensors of interest will be Sentinel-1 (a radar satellite) and Sentinel-2 (an optical imaging satellite in continuity of SPOT and Landsat).

4. COOPERATION MODEL

4.1 Cooperation Network

The EODC Cooperation Network consists of an open number of cooperation partners. According to the intentions and contributions of potential partners, three partnership levels have been defined (Figure 2):

- Principal Cooperation Partners
- Associate Cooperation Partners
- Developers

Apart from the developers, who are individuals (e.g. PhD students) taking part in EODC's collaborative software development process, cooperation partners must be organisations that support the operations of EODC through (i) contracting of services offered by EODC and (ii) active contribution to the collaborative development process in one or more EODC Communities. Principal Cooperation Partners have the right to appoint one member of the EODC Advisory Board, which gives them a voice in the formulation of the overall strategy and roadmap of EODC.

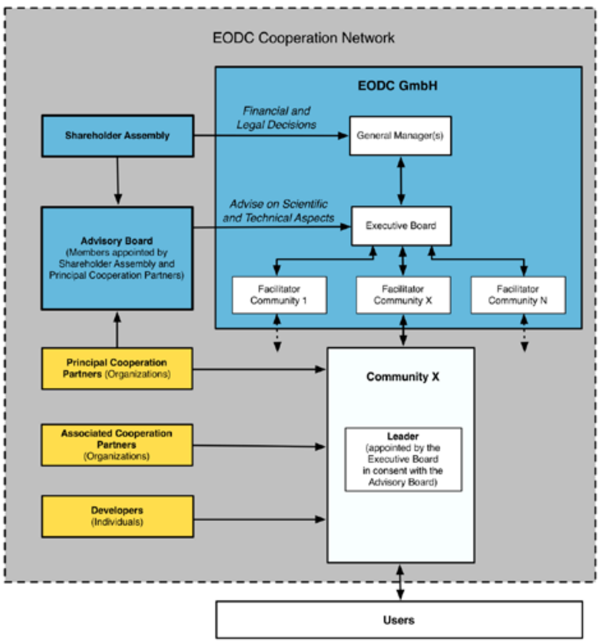

Figure 2: Cooperation Network and organizational structure of EODC.

Following the example of 52°North, collaborative developments on the scientific and technical level are organised in so-called Communities (Figure 2). Communities are set up and terminated by the EODC Executive Board in consent with the Advisory Board. They are coordinated by a Community Leader who is coming either from one of the Principal Cooperation Partners or EODC. The work of the Community Leader will be supported by a Community Facilitator who will in all cases be EODC staff. If agreed by the Advisory Board then the Community Leader and the Community Facilitator might be one and the same person. This solution is relevant in case of small Communities and in case none of the Principal Cooperation Partners can commit their personnel for fulfilling the tasks of the Community Leader. The main tasks of the Community Leaders are to drive the definition of the Communities' goals and roadmap. The Community Facilitators shall support the Community Leaders as to foster effective collaboration and tangible benefits for the participating institutions and individuals.

4.2 EODC Cloud

Rather than pursuing a centralised approach for the provision of the IT infrastructure, the basic idea of EODC is to provide a collaborative/federated cloud connecting several data centres throughout Europe (Figure 3). The resulting virtual and decentralised IT infrastructure is referred to as EODC Cloud.

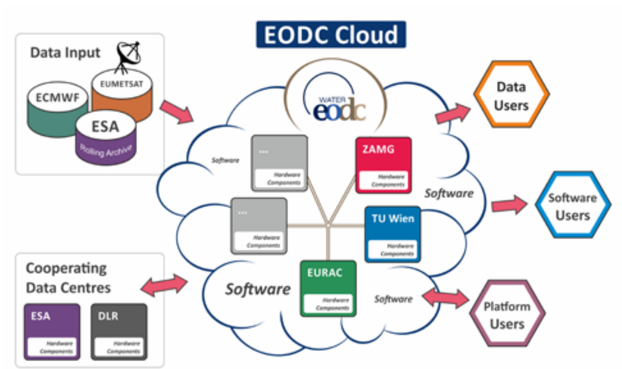

Figure 3: Illustration of how EODC will connect the IT infrastructure of different organisations through a cooperative cloud.

While its software will in principle be available throughout the whole network, care will be taken that data sets are not duplicated in different physical locations. In other words, each participating data centre will host only a limited number of data sets e.g. coming from only one or few satellites or being related to one or few particular data services (soil moisture, water bodies, snow parameters, land cover, etc.). An additional element of distinction between the data centres will be whether they serve near-real-time services (e.g. for flood forecasting, numerical weather prediction, etc.) or re-processing services (e.g. for climate applications, environmental impact assessments, etc.). Data processing will be carried out as close as possible to where the input data are being stored. This will minimise the costs arising from distribution and multiple data storage.

4.3 Cloud Environments

EODC will bring science and operations together by structuring the computer cloud in so-called environments that cover all necessary development stages from early scientific experimentation to full-fledged operational services (Figure 4).

Science Integration & Software Development (SID) Environment: This environment will be the place where scientists and software developers meet in order to 1) develop new algorithms for selected test sites, 2) validate, consolidate and select scientific algorithms, 3) integrate selected algorithms and software in the shared code library, and 4) perform source code and version control. An important criterion for the success of the SID environment will be the flexibility it offers to its scientific users, i.e. there shall be as few restrictions as possible with respect to the use and development of new software.

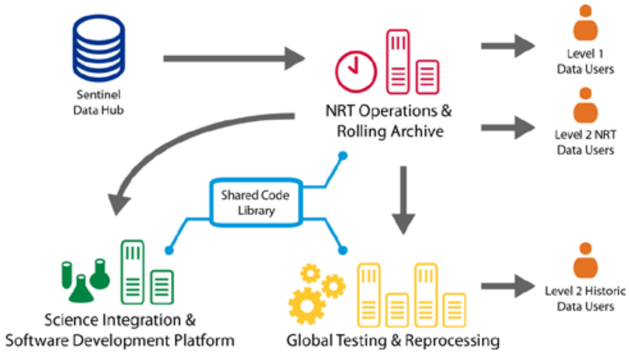

Figure 4: Architectural design of the EODC Cloud connecting the scientific user community with the software development and operations teams.

Global Testing & Reprocessing Facility (GTR) Environment: This component will serve to 1) test the scientific algorithms on a global scale, 2) validate and optimise the software, 3) reprocess the historic data archives on a regular basis, and 4) estimate parameters of the retrieval models in support of the NRT operations. These reprocessing capabilities are essential to guarantee the quality of the operational data services and deliver at the same time valuable historic data bases that are needed by the operational users in order to adapt and calibrate their models to make them fit for use with the operational data streams.

Near-real-time Operations & Rolling Archive (NORA) Environment: This part of the cloud will process and distribute EO data to the EO expert teams and users alike. In particular, it shall 1) receive low level EO data from ESA's data hub, 2) redistribute the acquired EO data over the rolling archive, and 3) process and distribute higher level data products in NRT for specific applications.

5. USE CASES

5.1 Who is Addressed?

Despite the competitive nature of science, scientists working in earth observation have a strong tradition of cooperating closely together. Especially in the last two decades, the cooperative aspects of science have been further prompted through international scientific organisations (such as ISPRS) and international funding opportunities (such as offered by ESA and the European Union). Nonetheless, cooperation often stops after the end of a project. Additionally, sharing of software code and IT resources for processing of EO data is not wide-spread. Thanks to cloud computing, the technological basis is laid to potentially change this situation.

But just offering access to large EO data archives and powerful cloud computing may not be enough. The innovate approach of EODC is to encourage scientists to participate in collaborative science activities by

- offering the principal possibility to become part of a cooperation network through an attractive cooperation model.
- free sharing of custom-made EO data processing software on a cloud platform.
- promoting the development of open source software packages.
- promoting benchmarking activities and inter-comparison projects.

The targeted science communities are

- Remote sensing scientists working on algorithms for retrieving geophysical data products such as soil moisture, water bodies, freeze/thawing, land cover, etc. over land.
- Application-oriented scientists creating value-added data products based on the retrieved geophysical variables.
- Scientific users of the EO data products wishing to validate or further use the available EO data themselves.

Scientific users of EO data are encouraged to bring in their expertise in application-oriented models, e.g. runoff models that are able to use EO data as input (topography, land cover, etc.) or for assimilation (soil moisture, water bodies, etc.).

5.2 Services

EODC will offer a range of services that can be broadly categorised in four different service types:

- Community building services
- Data services
- Software services
- Platform services

Typically, the development and roll out of new services operated or enabled by EODC will be like this: The partners of the EODC Cooperation Network identify a common interest in a particular type of activity (e.g. building of community platforms, access to data, computing resources, software, platform capabilities) and start developing and implementing a prototype system through one EODC Community. Initially, only the Community partners will be able to use this prototype system, but once a certain level of maturity has been reached, the possibility to roll it out as an operational service that can be offered to any paying third-party user can be considered.

5.3 Collaborative Software Development

One central task of EODC is to organise collaborative development processes within Communities to establish software needed for its services. All software code that is created through such collaborative processes shall be available for free to all Community partners on the EODC Cloud (i.e. but not on their own computers, except if explicitly agreed). In other words, when working in the EODC Cloud, Community partners shall pay licencing fees only in case that they use software developed by other EODC Communities, non-free pre-existing software or commercial software.

All partners of the EODC Cooperation Network are invited to contribute one or several of their pre-existing software packages to collaborative developments. In case that the contributing partner is a state-funded research organisation (university, agency, etc.) then pre-existing software can only be used by EODC in one of the following two scenarios[2]:

- The contributed software is Open Source software.
- The contributing partner receives financial compensation equivalent to the market price for the IPRs either in form of licencing fees or by buying the software.

If the contributing partner is a private company or undertaking then no such restrictions apply. In any case, EODC will promote the use of Free and Open Source Software Licences in order to enhance the social benefits of its work and to minimise the risks of blocking situations (e.g. if IPR prevents to use selected parts of an EO processing chain).

5.4 Benefits

EODC will help its scientific partners and users to make “better” science by allowing them to

- focus their efforts on scientific problems (rather than having to deal with standard processing tasks such as data management, geometric- and radiometric correction, etc.)
- test their algorithm on larger EO data sets.
- compare their algorithms to other state-of-the-art algorithms.
- validate their results with extensive reference data sets.
- participate in benchmarking activities.

This will mean that they will be able to generate innovative research more quickly as having to rely just on their in-house capabilities. Ultimately, this should help them to increase their number of high-quality publications and citations to their work.

6. OUTLOOK

In the start-up phase of EODC, a main focus will be on the establishment of the organisation, the building of collaborative platforms, and the step-by-step trust building between the public and private partners. Furthermore, the initial capabilities for receiving, processing and distribution of the Sentinel-1 data will be developed. Near-real-time data reception, processing and redistribution capabilities will be established at ZAMG, Austria’s meteorological service. The first long-term data archive and scientific cloud platform are currently being developed by TU Wien. The latter platform will benefit from the high performance computing capabilities of the third generation of the Vienna Scientific Cluster (http://vsc.ac.at/).

Thematically, one of first focus areas of EODC will be the retrieval of soil moisture and water bodies using Sentinel-1. Sentinel-1A, the first of a fleet of Sentinel satellites, was launched on 3 April 2014 with a Soyuz rocket from Kourou, French Guiana. Already one of the first images acquired by its Synthetic Aperture Radar (SAR) demonstrates the high potential Sentinel-1 for operational monitoring of water resources on a global scale (Figure 5). As shown in this figure, Sentinel-1 captured a major flood event in the Caprivi Flood Plain of the Zambesi river in north-east Namibia, at the borders to Zambia and Botswana. Such flood extent maps, when made available within a few hours after data reception, can help improving flood forecasting, flood management and planning of relief efforts.

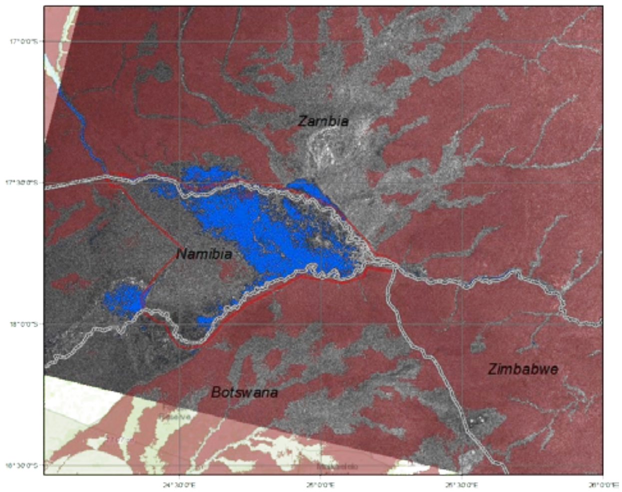

Figure 5: One of the first Synthetic Aperture Radar (SAR) images acquired by Sentinel-1A on 13 April 2014 captured the extent of a flood (blue areas) in the Caprivi plain of the Zambezi River in Namibia. The flood map was retrieved by TU within the framework of ESA’s TIGERNET project coordinated by GeoVille (http://www.tiger-net.org/).

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[2] See current jurisdiction on state aid, e.g. the Communication 2006/C323/01 “Community Framework for state aid for research and development and innovation” as published in the Official Journal of the European Union.

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