EUROVOLC

European Network of Observatories and Research Infrastructure for Volcanology

Deliverable Report

D6.1 Survey of volcano DP and of the Krafla Volcano Laboratory DP

Work Package:	*Networking volcano observations of sub-surface processes and initiating access to observations from the Krafla Volcano Laboratory*	
Work Package number:	*WP6*	
Work Package leader:	*Freysteinn Sigmundsson*	
Task (Activity) name:	*Networking volcano geophysical and geochemical observations of sub-surface processes and initiating access to multidisciplinary observations from the Krafla volcano laboratory*	
Task number:	*Task 6.1 and Task 6.2*	
Responsible Activity leader:	*UI, INGV and LV*	
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Type of Deliverable:	*Report [X]* *Prototype [ ]*	*Demonstrator [ ]* *Other [ ]*
Dissemination level:	*Public [X]* *Prog. Participants [ ]*	*Restricted Designated Group [ ]* *Confidential (consortium) [ ]*

Programme: H2020

Project number: 731070

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Summary

This deliverable report summarizes work during the initial 18 months of EUROVOLC that fall under Task 6.1.1 and Task 6.2.1 within Work Package 6 (Networking volcano observations of sub-surface processes and initiating access to observations from the Krafla Volcano Laboratory). The work relates closely to the EPOS Implementation Phase (EPOS-IP) project and is designed to complement activities within EPOS-IP. Under Task 6.1.1 in EUROVOLC, the partners have identified and agreed on a list of Data, Data Products, Services and Software (DDSS) selected to be networked in EUROVOLC. This report describes the selection process and the contributions of partners. Task 6.2.1 focuses on the Krafla laboratory volcano area. A set of DDSS has been identified that the Landsvirkjun power company evaluates mature enough to be networked.

Introduction

The work in Work Package 6 is focused on preparing data and data products representing observations of volcanological sub-surface processes and making the data openly accessible to the Earth science community. The data and products represent observations on several different European volcanoes and volcanic areas (**Task 6.1**), as well as a selection of specific, multidisciplinary data sets and data products from the Krafla volcano in Iceland, stored at the Krafla Volcano laboratory (**Task 6.2**), which is part of the Landsvirkjun power company operating the geothermal utilization of the Krafla volcanic area. The activities in the work package are closely linked to activities taking place within the Implementation Phase of the European Plate Observing System project (EPOS-IP) and will utilize some of the services already generated in EPOS-IP to facilitate and maintain long-term access to the data and data products.

The work presented in this deliverable was carried out under subtasks 6.1.1 and 6.2.1, whose aims are to survey geophysical, volcanological and geochemical data and products from volcanic areas and recommend suitable data sets, not yet available through the EPOS services, to be networked in EUROVOLC, utilizing wherever possible the EPOS delivery framework to facilitate and maintain long-term access to the data. **Subtask 6.1.1** considers data and products from general European volcanic areas, while **Subtask 6.2.1** focuses on data and products from the Krafla Volcano Laboratory in Iceland.

EPOS – The European Plate Observing System

The following overview of EPOS, the European Plate Observing System, is provided to help the reader understand to scope of data networking activities within EUROVOLC.

EPOS is a long-term plan (see Figure 1) to enable integrated use of data, data products, and facilities from distributed research infrastructures of solid Earth science in Europe. EPOS, which is on the European roadmap for research infrastructures is now approaching the end of its implementation phase (on 30 September 2019) and about to enter into the final operational phase.

Figure 1. Overview of the timeline/roadmap and different phases of the EPOS project (from EPOS-IP proposal).

The EPOS roadmap extends from its conception phase in 2002 through the Preparatory Phase project (**EPOS-PP**) funded by the European Commission's 7th Framework programme and followed by the on-going Implementation Phase project (**EPOS-IP**) funded by the EC's Horizon 2020 programme. The Implementation Phase project ends in October 2019, when the EPOS European Research Infrastructure Consortium (**EPOS ERIC**) organization takes over the long-term operation of EPOS. The EPOS roadmap has two major milestones. Firstly, the *Implementation Phase project* which developed and constructed the present EPOS e-infrastructure. Secondly, the establishment of the EPOS European Research Infrastructure Consortium (**EPOS ERIC**) in November 2018, which declared EPOS a legal entity that will take over operating, maintaining and further developing the e-infrastructures and services at the end of the Implementation phase. **EPOS-IP** is a four-year collaborative project of 47 partners, 6 associate partners and several international organizations for a total of 25 countries involved, while EPOS ERIC is a long-term legal organization, presently including only 13 member countries, but growing fast to include all the member countries of the implementation phase.

The **EPOS-IP** project built the EPOS integrated research platform by implementing Thematic Core Services (**TCS**) for the diverse communities contributing to EPOS. One of these thematic services is the Volcano Observations Thematic Core Service (VO-TCS), which EUROVOLC will utilize to provide access to some of the networked data. The different TCSs will be integrated within the full EPOS framework, covering legal, governance and financial aspects, and ensuring technical connection to the Integrated Core Services **(ICS)** at the center of the delivery framework. This integration will provide interoperability, data management and access to services, as well as ensuring compliance with the EPOS data access policy.

A sketch timeline/roadmap for the EPOS Implementation Phase is shown in Figure 2. The figure describes the four main phases and three major checkpoints of EPOS-IP. Presently, phase 4 is approaching its end (on 30 September 2019). During the four phases many services have been generated and sent through the validation checkpoints, including validation of compliance with predefined technical, financial and legal criteria.

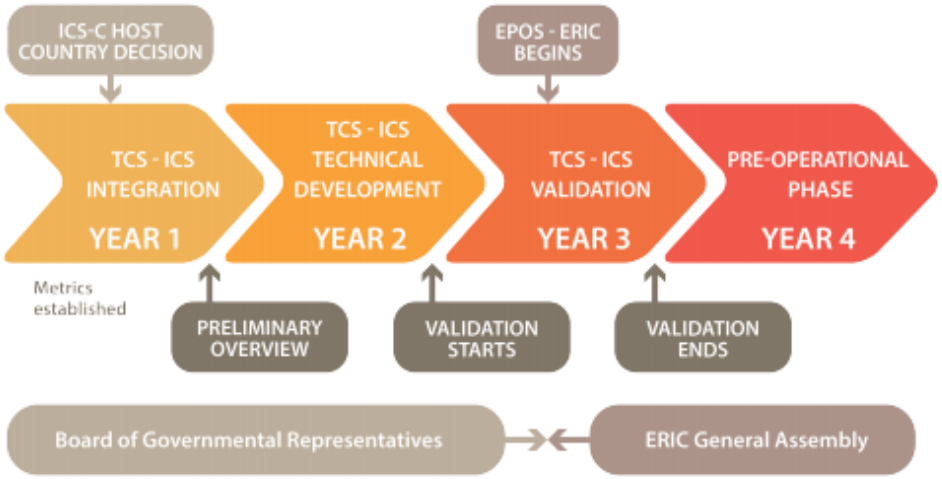

Figure 2. Workflow plan of the EPOS IP project and its three main checkpoints (from EPOS-IP proposal):
1. At the end of Year 1: Preliminary overview of the implementation of Thematic Core Services (TCS) and Integrated Core Services (ICS) to assess their progress.
2. At the end of the Year 2: Identification of the DDSS elements that will pass Technical Readiness Assessment and enter into the one-year Validation Phase.
3. At the end of the Year 3: Assessment of progress and impact in order to validate the maturity of the DDSS elements (together with their Service Providers) that can enter into the pre-operational phase.

The EPOS system considers accessibility in terms of so-called **DDSS**. This is an acronym for **Data, Data Products, Services and Software** provided by individual institutions, consortia or organizations which already are or will become part of the EPOS ERIC organization and will utilize the EPOS delivery system to provide and maintain long-term open access to the data. The DDSSs will be accessible through services which are compliant with the EPOS technical rules. Furthermore, to be part of the EPOS platform, the DDSSs must also be validated with respect to predefined legal, governance and financial criteria, as well compliance with the EPOS data access policy.

A functional service that makes a **DDSS** element findable and downloadable includes completing metadata description for the product according to community standards and if a metadata standard does not exist, then it needs to be defined. The access service to the data or product itself is provided through an Application Programming Interface (**API**). Additionally, some data distributed through EPOS may have restrictions, requiring registered access, authorization, time embargoes or charges. To enable and manage such access specialized e-infrastructure, Authentication, Authorization and Accounting Infrastructure (**AAAI**) is required. Implementation of such software is not yet fully completed in EPOS and requires collaboration between the EPOS **ICS** and the **TCS**.

In EUROVOLC one of the work packages, WP20 provides Virtual Access to the EPOS Volcano Observations Thematic Core Service (VO-TCS) through a portal or gateway, which will be further developed in the project. The EUROVOLC WP6 partners will utilize as much as possible the EPOS VO-TCS and the EPOS delivery framework to generate access to the data and products they intend to network in EUROVOLC.

Subtask 6.1.1: Survey and recommendations for geophysical, volcanological and geochemical data that have not been implemented in EPOS-IP

The goal of Subtask 6.1.1 is to define a list of DDSSs that, according to the roadmap for service implementation in the Volcano Observations TCS (VO-TCS), were not likely to be implemented within the EPOS-IP project. Therefore, these DDSSs were deemed appropriate to be moved to Subtask 6.1.1. of EUROVOLC.

Indeed, the DDSSs, to be on the implementation roadmap of EPOS, must follow a strict validation process within fixed time frames, confirming they are functional and suitable to be included in the EPOS portfolio of services. Validation means that the DDSSs and relevant services must be compliant with the technical rules and the legal, governance and financial criteria of EPOS. The networking activities within EURVOLC WP6 were thus planned to complement those that take place within EPOS-IP.

To this aim, the activity of Subtask 6.1.1 was firstly focused to critically examine a list of the DDSSs provided by the VO-TCS (WP11 in EPOS-IP). The Partners selected from this list a number of DDSSs suitable for implementation in EUROVOLC, considering their own priority, availability, maturity level (mainly in terms of metadata formats), and, possibly, the multidisciplinarity. The chosen DDSSs were updated after the end of January 2019, when VO-TCS definitively stated which DDSSs were going to be implemented within EPOS-IP (see **Table 1**). Therefore, the remaining DDSSs could then potentially be completed by EUROVOLC.

Table 1. List of all EPOS volcanological services provided by the VO-TCS on 31 January 2019 for testing and validation in EPOS-IP. The list includes 27 distinct services of which some are provided by more than one partner and shows the contributions of services by each partner. The light grey DDSS were not completed within the accepted time window and will not be delivered within EPOS-IP, instead some of them will be completed in EUROVOLC.

DDSS - ID	DDSS Name	Completed in EPOS-IP	Not completed	INGV	IMO	UCA/ OPGC	CSIC	IPGP
WP11-DDSS-001	Velocity seismic waveforms	2019		X	X			X
WP11-DDSS-002	Acceleration /Accelerometer waveforms	2019		X				X
WP11-DDSS-003	GNSS raw data (Rinex Data- 15s)	2019		X	X			
WP11-DDSS-005	Tiltmeter		>2019					
WP11-DDSS-006	Tide gauge		>2019					
WP11-DDSS-022	Ground-based radar data	2019			X			
WP11-DDSS-023	Ground-based visible and thermal / IR camera	2019			X			
WP11-DDSS-024	Ground-based doppler radar near-source eruptive parameters	2019				X		
WP11-DDSS-025	Ground-based UV scanner spectra	2019			X			
WP11-DDSS-026	Collections of magmatic rocks	2019				X		
WP11-DDSS-027	Earthquake parameters (hypocentral and magnitude)		>2019					
WP11-DDSS-031	Reports on volcanic activity	2019		X	X			X
WP11-DDSS-032	Aviation colour codes for volcanoes	2019			X			
WP11-DDSS-033	Catalogue of eruptions	2019			X			
WP11-DDSS-036	Chemical analysis and physical properties of gas, water and rocks	2019		X		X		
WP11-DDSS-041	Soil CO2 fluxes		>2019					
WP11-DDSS-046	SO2 flux		>2019					
WP11-DDSS-047	Volcanic Plume (Ash + SO2)	2019				X		
WP11-DDSS-049	Thermal anomaly (lava flow)	2019				X		
WP11-DDSS-050	Wrapped Differential Interferograms (Phase and Amplitude)	2019		X		X		
WP11-DDSS-051	InSAR lava flow maps	2019				X		
WP11-DDSS-053	Ground-based Doppler radar spectra	2019				X		
WP11-DDSS-054	SO2 concentration probabilistic hazard maps	2019			X			
WP11-DDSS-056	Spatial probability analysis/maps	2019					X	
WP11-DDSS-057	Lava flow invasion hazard maps	2019					X	
WP11-DDSS-058	Tephra fallout hazard maps for explosive volcanoes	2019			X		X	
WP11-DDSS-059	PDCs hazard maps (EH;GVF; Deception)	2019					X	
WP11-DDSS-060	Probabilistic volcanic hazard assessment (maps)	2019					X	
WP11-DDSS-064	Effects on health and recommendations for response to SO2 from volcanic eruptions	2019			X			
WP11-DDSS-065	Daily ash/gas forecasting maps	2019			X			
WP11-DDSS-067	Station information (GPS)	2019			X			
WP11-DDSS-070	Software catalogue for petrological to geophysical modelling	2019		X			X	
	Number of services	27	5					
		distinct	distinct	7	13	8	6	3

Taking into account the availability of DDSSs summarized in Table 1, the EUROVOLC Partners selected those ones to be networked in EUROVOLC, which are summarized in **Table 2**. This list will be delivered to Subtask 6.1.2, which will be active from month 18 to month 36.

Table 2: List of DDSSs (Data, Data products, Software, Services) that partners of EUROVOLC identified suitable for implementation in EUROVOLC (marked by X)

Number	DDSS Name	CIVISA	CSIC	IMO	INGV	UCA-OPGC	IGG-CNR	Univ. Iceland	Univ. Leeds	HSGME
WP11-DDSS-001	Velocity seismic waveforms	X		X						X
WP11-DDSS-002	Acceleration/Accelerom. waveforms									X
WP11-DDSS-003	GNSS raw data (Rinex Data-15s)			X						X
WP11-DDSS-005	Tiltmeter			X						
WP11-DDSS-013	Groundwater temperature				X					

WP11-DDSS-016	Fumarole temperature									X
WP11-DDSS-026	Collections of magmatic rocks		X		X	X	X			
WP11-DDSS-027	Earthquake parameters (hypocentral and magnitude)	X		X						X
WP11-DDSS-030	GNSS time series			X	X			X		
WP11-DDSS-031	Reports on volcanic activity									
WP11-DDSS-033	Catalogue of eruptions						X			
WP11-DDSS-034	Maps of recent and past lava flows				X					
WP11-DDSS-036	Chemical analysis and physical properties of gas, water and rocks						X			X
WP11-DDSS-041	Soil CO2 fluxes									X
WP11-DDSS-050	Wrapped Differential Interferograms (Phase and Amplitude)								X	
WP11-DDSS-051	InSAR lava flow maps					X				
WP11-DDSS-053	Ground-based Doppler radar spectra					X				
WP11-DDSS-055	Volcanic hazard Event Tree		X							
WP11-DDSS-061	Spatial probability Tool (QVAST)		X							
WP11-DDSS-067	Station information - GNSS			X						
WP11-DDSS-072	Mean LOS velocity			X				X		

The details of the DDSSs structure provided by each Partner is given in **Tables 3 – 11** below. Each table provides information about each DDSS concerning its organization, storage, standardized structures, format, as well as the presence of associated metadata and the existence of a structured service for their distribution. This information will be delivered to Subtask 6.1.2 (M18-36).

There are 8 rows in each table (a, b, c, d, e, f, g, h):
a) ID of the DDSS to be implemented in EUROVOLC according to EPOS-IP (e.g. WP11-DDSS-001)
b) Name of the DDSS to be implemented in EUROVOLC according to EPOS-IP (e.g. Velocity seismic waveforms)
c) Metadata. Choose among: i) Available (standard format or proprietary?); ii) to be done; iii) other
d) Data organization. Choose among: i) Structured directories (on disk); ii) Database; iii) georeferenced database; iv) table; v) other
e) Access. Choose among: i) Open; ii) closed; iii) embargo; iv) other
f) Date when the DDSS is presumed to be released
g) API is for Application Programming Interface; the type of service that the providers build to make the data searchable and downloadable. Choose among: i) Available and working (standard API or proprietary?); ii) to be done ; iii) other
h) AAAI is for Authentication, Authorization and Accounting Infrastructure. Choose among: (i) Available (which standard?); ii) to be done ; iii) other. These are the means of the service to check if the users are authorized to access the data, and this also will identify them.

Table 3: CIVISA

Data to be provided by CIVISA and to be added to the EPOS services:

- Velocity seismic waveforms (WP11-DDSS-001) for two stations, one near Sete Cidades Volcano and another near Fogo Volcano, since 2018,
- Earthquake parameter data (WP11-DDSS-027) for located earthquakes in S. Miguel Island since 2018.

a) DDSS – ID	**WP11-DDSS-001**	**WP11-DDSS-027**
b) DDSS Name	Velocity seismic waveforms	Earthquake parameters (hypocentral and magnitude)
c) Metadata	to be done	to be done
d) Data organization	structured directories (on disk)	other (file .xml)
e) Access	embargo	open
f) Release date	2020	2020
g) Web Service/API	to be done	to be done
h) AAAI	to be done	to be done

Table 4: CSIC

CSIC already provides access through the EPOS delivery system to the following data products from Spanish and other worldwide volcanoes:

- Spatial probability maps (WP11-DDSS-056) for Deception Island (Antarctica), San Miguel (El Salvador), La Garrotxa (Spain), Lanzarote (Spain), and El Hierro (Spain).
- Lava flow invasion hazard maps (WP11-DDSS-057) for Deception Island, La Garrotxa, Lanzarote and El Hierro.
- Tephra fallout hazard maps (WP11-DDSS-058) for Lanzarote.
- Pyroclastic Density Currents hazard maps (WP11-DDSS-059) for Deception Island, La Garrotxa and El Hierro.
- Probabilistic volcanic hazard assessment (maps) (WP11-DDSS-060) for Deception Island, La Garrotxa, Lanzarote and El Hierro.

Furthermore, three new data, data products and software, not yet provided by CSIC, will be added to the EPOS services. These data types are:

- Collection of magmatic rocks (WP11-DDSS-026) from diverse volcanic areas including Spanish volcanoes.
- Volcanic hazard Event Tree (WP11-DDSS-055) for Spanish volcanoes.
- Spatial probability tool QVAST (WP11-DDSS-061).

a) DDSS – ID	**WP11-DDSS-026**	**WP11-DDSS-055**	**WP11-DDSS-061**
b) DDSS Name	Collection of magmatic rocks	Volcanic hazard Event Tree	Spatial probability Tool (QVAST)
c) Metadata	Available IGSN metadata to be completed with EUROVOLC standard	Available	Available
d) Data organization	georeferenced database	Jpg -files	file
e) Access	Catalogue of the collection - Open Physical samples – Other (Restricted)	Open	Open
f) Release date	Mid-end 2020 (depending on the release of the metadata standard)	Beginning 2020	Mid 2020
g) Web Service/API	To be done	To be implemented within https://volcanboxws.obsea.es	To be finished
h) AAAI	Not required for the catalogue of the collection Authentication needed to access physical samples.	Not required	To be finished

Table 5: IMO

IMO already provides access through the EPOS delivery system to the following data:

- Seismic waveform data (WP11-DDSS-0001) from 6 stations through the European Integrated Data Archive (EIDA) at Orfeus (www.orfeus-eu.org/data/eida/),
- GNSS Rinex data (WP11-DDSS-003) from 5 stations,
- GNSS station information (WP11-DDSS-067) from 5 stations.

IMO and UI are both suppliers of the Icelandic GNSS data, but IMO is the Service Provider through existing API services at IMO. In EUROVOLC the number of GPS and seismic stations providing data through the EPOS delivery system will be increased and data from seismic and GPS stations close to recent volcanic events in Iceland will be added.

Furthermore, four new data types, not yet provided by IMO will be added to the EPOS services. These data types are:

- Tiltmeter data (WP11-DDSS-005) from one station close to a recent volcanic event,
- Earthquake parameter data (WP11-DDSS-027) for located earthquakes in Iceland since 1991,
- GNSS time series (WP11-DDSS-030) for selected sites near Bárðarbunga volcano,
- Mean LOS velocity (WP11-DDSS-072) maps (or differential interferograms) covering Bárðarbunga (or Holuhraun)

a) DDSS – ID	**WP11-DDSS-005**	**WP11-DDSS-027**	**WP11-DDSS-030**	**WP11-DDSS-072**
b) DDSS Name	Tiltmeter	Earthquake parameters (hypocenter and magnitude)	GNSS time series	Mean LOS velocity
c) Metadata	to be done	to be done	to be done	to be done
d) Data organization	In IMO database	In SeismComp3 database	Table	Structured directories
e) Access	Open	Open	Open	Open
f) Release date	1 May 2020	1 May 2020	1 May 2020	1 May 2020
g) Web Service/API	to be done	to be done	to be done	to be done
h) AAAI	To be done	to be done	to be done	to be done

Table 6: INGV

INGV data types which will be added to the EPOS services are:

- Groundwater temperature (WP11-DDSS-013), but the exact data coverage (volcanic areas, geographic locations and time periods) will be provided in the second half of the EUROVOLC project.
- Collections of magmatic rocks (WP11-DDSS-026) for selected rock samples collected at Mt. Etna during monitoring activity.
- GNSS time series (WP11-DDSS-030) for stations measured during GNSS survey at Etna from 2000 to 2008.
- Map of recent and past lava flows (WP11-DDSS-034) for historic activity of Mount Etna, as reported in the "Geological map of Mount Etna" (Branca et al., 2011).

a) DDSS – ID	**WP11-DDSS-013**	**WP11-DDSS-026**	**WP11-DDSS-030**	**WP11-DDSS-034**
b) DDSS Name	Groundwater temperature	Collections of magmatic rocks	GNSS time series	Maps of recent and past lava flows
c) Metadata	Available	To be done	To be done	Available
d) Data organization	Structured directories	Structured directories	Structured directories	Structured database
e) Access	Closed	Other (restricted)	Open	Open
f) Release date	December 2020	December 2020	December 2020	December 2020
g) Web Service/API	INGV format	To be done	INGV format	INGV format
h) AAAI	Authentication needed to access data	Authentication needed to access data	Authentication needed to access data	Authentication needed to access data

Table 7: OPGC

The three DDSS listed in the following table are a part of what is being made available within EPOS-IP. Part of the work on preparing them has been carried out within EUROVOLC.

a) DDSS – ID	**WP11-DDSS-026**	**WP11-DDSS-051**	**WP11-DDSS-053**
b) DDSS Name	Collections of magmatic rocks	InSAR lava flow maps	Ground-based Doppler radar spectra
c) Metadata	Available (standard proprietary format)	Available (standard proprietary format)	Available (standard proprietary format)
d) Data organization	Database	Georeferenced database	Database
e) Access	Other (Restricted)	Open/Registered	Open
f) Release date	Under validation by EPOS-ICS; 2020	Under validation by EPOS-ICS;2020	Under validation by EPOS-ICS; 2020
g) Web Service/API	Available but awaiting validation by EPOS-ICS	Available but awaiting validation by EPOS-ICS	Available but awaiting validation by EPOS-ICS
h) AAAI	To be done	To be done	To be done

Table 8: IGG-CNR

IGG-CNR will provide the types of DDSS listed below:

- Collection of magmatic rocks (WP11-DDSS-026) from Monte Amiata volcano, one of the Quaternary volcanoes of Italy, positioned in the southern portion of Tuscany region. Some rocks came from acid lava flows and domes of the subaerial activity. Nevertheless, the offered rocks comprise also portions of the cores from two deep drilling performed inside the Monte Amiata volcanic cover by means of the continuous coring technique.
- Catalogue of eruptions (WP11-DDSS-033), which is a part of a catalogue of the eruptions of the Active Italian Quaternary volcanoes. The data base, which contains bibliographical information on about 3500 ancient texts and reports, is distributed by means of the LIBERO platform at the URL: https://library.isti.cnr.it/index.php/it/risorse/collezioni-speciali-e-donazioni. Data comprehend also the information about the location of the various texts inside the main National and specialized Italian Libraries.
- Chemical analyses and physical properties of gas, water and rocks (WP11-DDSS-036), from the Italian active volcanoes under surveillance which have been collected and mapped inside an Informational Retrival Systhem that will be open once homogenized with standards improved in EPOS-IP.

a) DDSS – ID	**WP11-DDSS-026**	**WP11-DDSS-033**	**WP11-DDSS-036**
b) DDSS Name	Collection of magmatic rocks	Catalogue of eruptions	Chemical analyses and physical properties of gas, water and rocks
c) Metadata	Available (standard proprietary format)	Available (standard proprietary format)	IGG-CNR
d) Data organization	Structured directories (on disk)	Data Base	Available (standard proprietary format)
e) Access	Will be free when the data organization will be normalized with the other project units	Open	Data Base
f) Release date	2020	2020	Will be free when the data organization will be normalized with the other project units
g) Web Service/API	To be done	Available and working by means of a LIBERO interface at the URL:	31 August, 2019
h) AAAI	To be done	http://146.48.64.164/libbiv/WebOpac.cls	To be done

Table 9: University of Iceland

University of Iceland will provide GNSS time series from geodetic stations in the Northern Volcanic Zone of Iceland since 2013. This forms a part of subtask 6.2.1, as the area covered includes the Krafla laboratory volcano. Mean line-of-sight (LOS) velocities from ground-to-satellite inferred from interferometric analysis of synthetic aperture radar satellite images (InSAR) and retrieved approximate east and up components of displacements for most of Iceland in the 2015-2018 period will also be provided.

a) DDSS – ID	**WP11-DDSS-030**	**WP11-DDSS-072**
b) DDSS Name	GNSS time series	Mean LOS velocity
c) Metadata	to be done	to be done
d) Data organization	Table	Table
e) Access	Open	Open
f) Release date	1 June 2020	1 June 2020
g) Web Service/API	to be done	to be done
h) AAAI	to be done	to be done

Table 10: University of Leeds

UNIVLEEDS will provide interferograms to evaluate ground deformation at volcanoes. Currently volcanoes in mainland Europe are covered. There are plans to expand the coverage, to delivering all European volcanoes (including territories). The long-term goal is to provide interferograms for all volcanoes globally.

a) DDSS – ID	**WP11-DDSS-050**
b) DDSS Name	Wrapped Differential Interferograms (Phase and Amplitude)
c) Metadata	Available (standard format)
d) Data organization	Structured directories
e) Access	Open
f) Release date	1 November 2019
g) Web Service/API	Available and working (proprietary)
h) AAAI	to be done

Table 11: HSGME

HSGME will provide continuous, multidisciplinary data from Santorini and periodic data on fumarolic composition from Nisyros. The types of DDSS are listed in the following table, but the exact data coverage (volcanic areas, stations and time periods) will be available in the later half of the EUROVOLC project.

a) DDSS – ID	**WP11-DDSS-001**	**WP11-DDSS-002**	**WP11-DDSS-003**	**WP11-DDSS-016**
b) DDSS Name	Velocity seismic waveforms	Acceleration /Accelerometer waveforms	GNSS raw data (Rinex Data- 15s)	Fumarole temperature
c) Metadata	Available	Available	Available	Available
d) Data organization	Database/Structured direct.	Database/Structured direct.	Database/Structured direct. (Rinex)	Structured directories
e) Access	Open	Open	Open	Open
f) Release date	2019	2019	2020	2020
g) Web Service/API	Available and working (EIDA)	Available and working (EIDA)	Available (UNAVCO)	to be done
h) AAAI	other	other	other	other

(continued)

a) DDSS – ID	**WP11-DDSS-027**	**WP11-DDSS-036**	**WP11-DDSS-041**
b) DDSS Name	Earthquake parameters (hypocentral and magnitude)	Chemical analysis and physical properties of gas, water and rocks	Soil CO2 fluxes
c) Metadata	Available	Available	Available
d) Data organization	Structured directories	Structured directories	Structured directories
e) Access	Open	embargo	Open
f) Release date	2020	2020	2020
g) Web Service/API	to be done	to be done	to be done
h) AAAI	other	other	other

Subtask 6.2.1: Overview of present storage and repositories of data, metadata and products at the Krafla Volcano laboratory and recommendations for access.

Krafla is a central volcano in the Northern Volcanic Zone in northern Iceland (Figure 3), a divergent plate boundary between the North American plate and the Eurasian plate.The goal of this task is to prepare an overview of present storage and repositories of data, metadata and products at the Krafla Volcano laboratory and prepare recommendations for how to access these data and products. The area covers both the Krafla caldera, as well as the Bjarnarflag geothermal area in the Krafla fissure swarm south of the caldera (Figure 3).

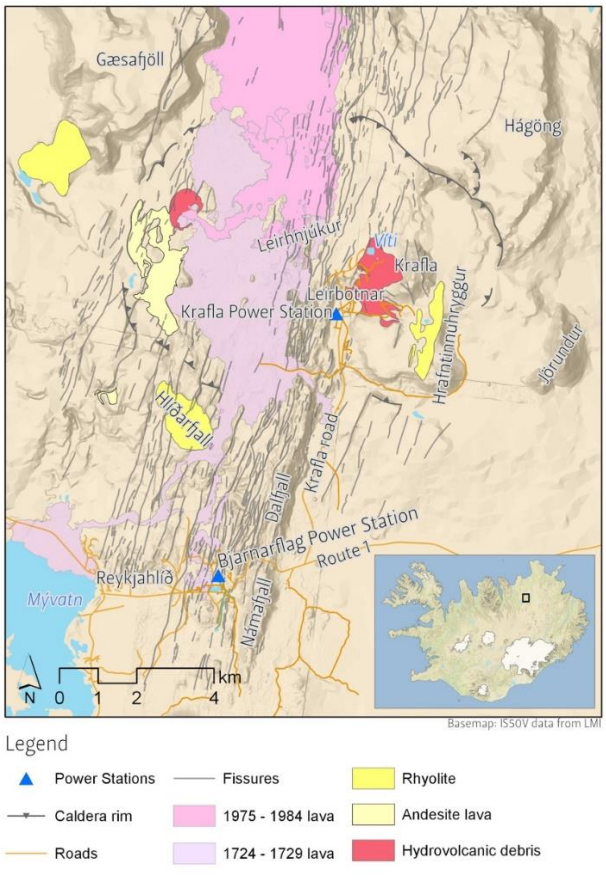

Figure 3. Geological map of part of the Krafla volcanic system in north-east Iceland (see inset), showing the central volcano with its caldera, the Krafla and Bjarnarflag geothermal areas, and power stations. Basemap and infrastructure data from Landmælingar Íslands (National Land Survey of Iceland) and Landsvirkjun (The National Energy Company). Geological feature data from ÍSOR (Iceland Geosurvey).

The following gives an overview of present storage and repositories of data, metadata and products in the Krafla area and recommendations for access, prepared within the EUROVOLC project. These are accessible data sets at Landsvirkjun (LV) at present (July 2019).

Part of the data are available through a shared online folder. To get access to the folder contact Ásgrímur Guðmundsson at Landsvirkjun (Asgrimur.Gudmundsson@landsvirkjun.is).

The data sets are of three types: (i) Boreholes and borehole data, (ii) seismic data and (iii) geodetic data. Seismic and geodetic data are available through websites at Iceland Geosurvey and University of Iceland, respectively.

The data sets include:

- Boreholes: Coordinates for depth values (many wells are deviated).
- Borehole data:
  - Formation temperature: x,y,z, and temperature value
  - Pressure: x,y,z, and pressure value (in bars)
  - Caliper logs: x,y,z (in cm or mm)
  - Lithological logs, x,y,z, value
    - Resistivity: 16” and 64” (ohm)
    - Neutron-Neutron (API-units)
    - Gamma ray (API-units)
    - Lithology: Figures (jpg, ping, pdf)
    - Distribution of alteration minerals: Figures (jpeg, ping, pdf)
- Seismic Supported through ÍSOR and Landsvirkjun
- GNSS (GPS) Supported through University of Iceland

Other data sets are being evaluated at present and may be accessible at a later time.
Further description (as relevant) of the data sets follows.

Boreholes and well paths

Well Paths (Well Paths.csv) trajectory of all wells, including deviated wells.
For location of wells on maps – see Figure 4.

Tables available have well path, with following columns:
MD (measured depth);ITEM_NAME;LATITUDE;LONGITUDE;X (ISNET93);Y (ISNET93);Z (m a.s.l.)

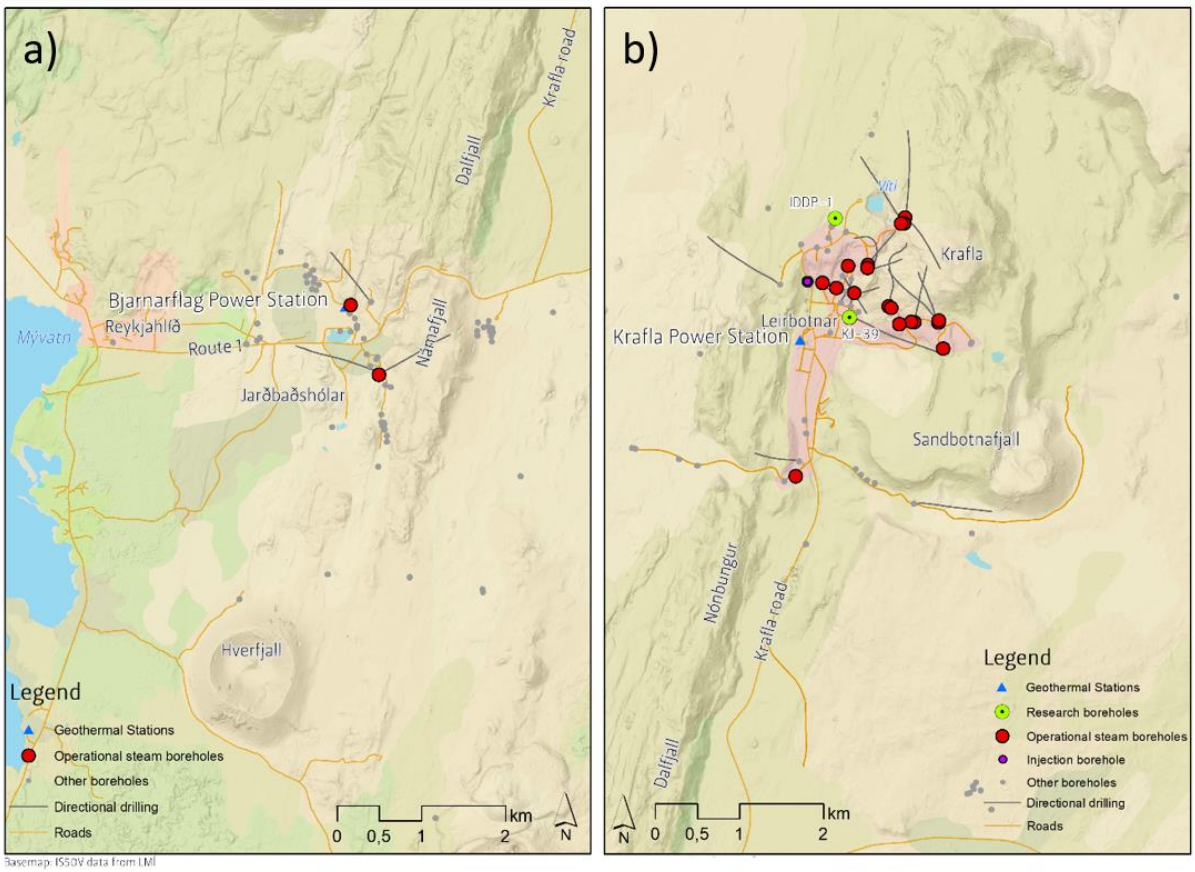

Figure 4. Location of wells, well paths and power plants in the Krafla and Bjarnarflag geothermal areas. Green dots show the location of the IDDP-1 and KJ-39 wells where magma has been intersected. See legends for other features. Basemap and infrastructure data same as in Figure 3.

Borehole data

Available files:
Formation Temperature (Formation Temperature.csv)
Groundwater Level and Temperature (Groundwater Level and Temperature.csv)
THR Reinjection (THR Reinjection.csv)
Well Logs (Well Logs.csv) classified as lithological logs

Lithological logs

For a graphical examples of lithological logs and interpretation – see Figures 5 and 6.

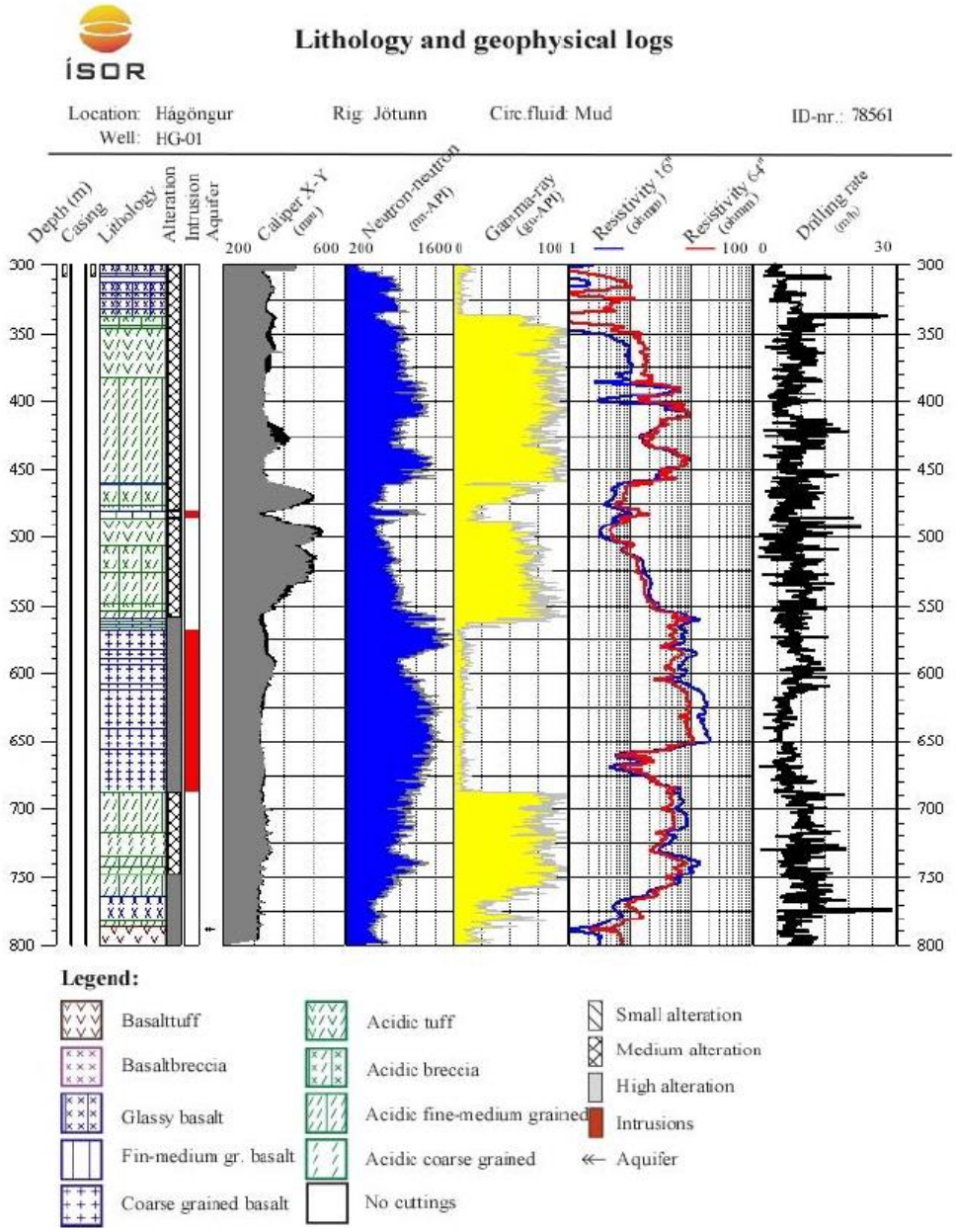

Figure 5. Example of composite logs in high a temperature well in Iceland.

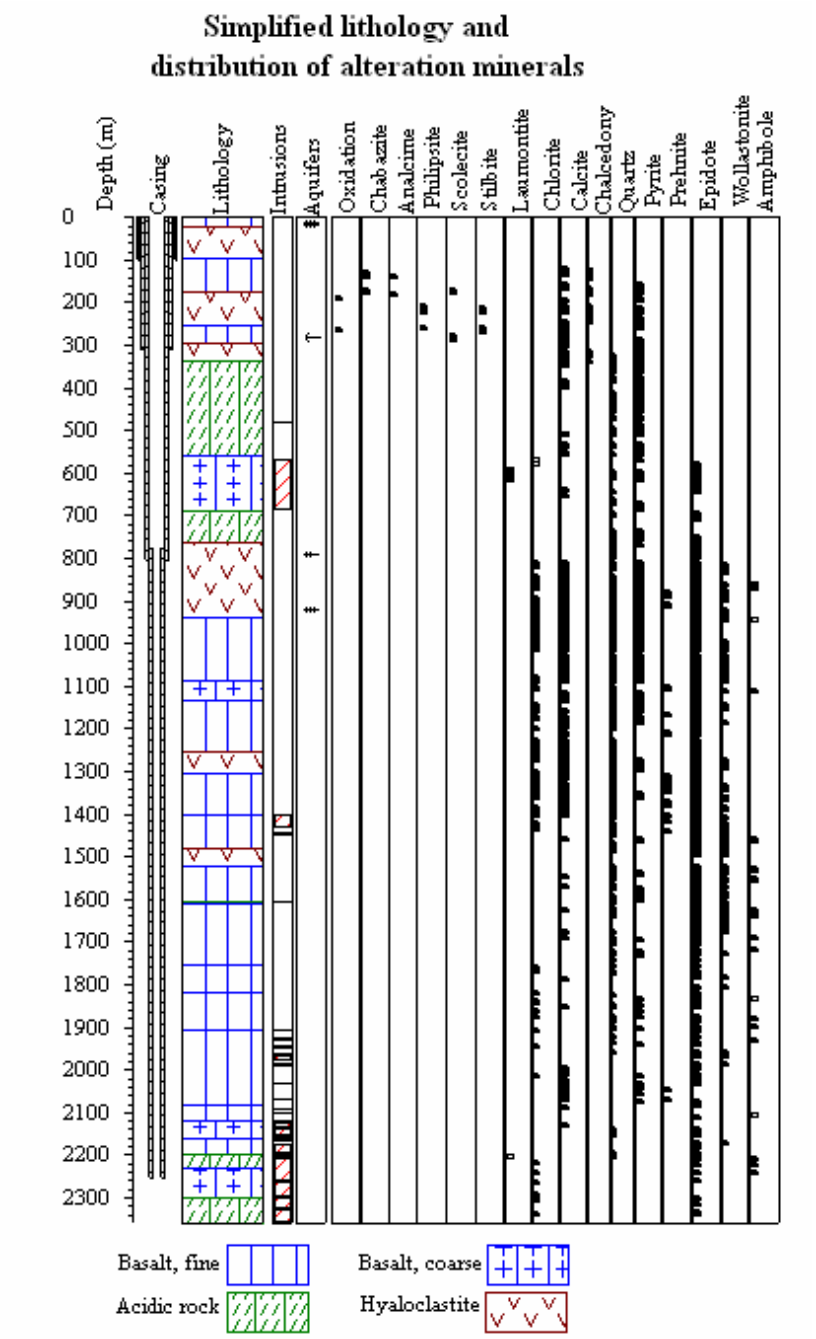

Figure 6. Example of simplified lithology and distribution of alteration minerals from a drillhole.

Tables can be provided with the following information

Caliper logs: Measure of the dimension (geometry) of the well, that show cavities where the well is drilled through soft formation, scaling in the well, etc. The tools have either 3 or 4 arms (two pairs). A caliper log is measured continuously from bottom to top and the device sends the data to the surface in real time.

Resistivity logs 16", 64" & SP: Measures the electric resistivity of the rock around wells. The resistivity depends on the porosity of the rock along with salinity and the temperature of the liquid in the porous medium.

Neutron logs (n-n): A neutron source (Am-Be/Ra-Be), placed in the device, sends out high energy neutrons. The n-n logs are useful for estimation of the porosity.

Natural gamma ray logs: A natural gamma radiation of rock comes from radioactive isotopes, especially K, U's and Th. A correlation interposes silica content in Icelandic rock and its natural gamma radiation.

The well log columns in available tables include:

DEPTH;VALUE;ITEM_NAME;START_DATETIME;BHTASK_ID;TASK_TYPE_NAME;PURPOSE;FLOW_RATE;FLOW_RATE_UOM;WATER_LEVEL;WATER_LEVEL_UOM;WH_PRESS;WH_PRESS_UOM;CURRENT_DEPTH;CURRENT_DEPTH_UOM;LOWER_DEPTH;LOWER_DEPTH_UOM;UPPER_DEPTH;UPPER_DEPTH_UOM;TASK_TYPE;ELEV_REF;MEAS_DIR;MEAS_EQUIP;MEAS_METHOD;SENSOR;TASK_STAFF;WORK_NO;LAST_UPDT_DATE

Gyroscopic logging: Used in directional drilling to steer the drill bit along the planned track of the well. Real-time information about the inclination, the azimuth (true-north) and gyro-toolface of the well is recorded. The information is used to calculate the exact coordinates of the track. Two types of instruments are used, one type used for kick-off measures individual points, and the other type records continuously.

Seismic data

ÍSOR - Iceland GeoSurvey runs a local seismic network in NE-Iceland, including the Krafla area, for Landsvirkjun. All information about the seismic network in NE-Iceland is available at: http://lv.isor.is (the text is presently in Icelandic, but plans are to translate it to English).

The format of seismic data is MSEED per day. Three files, one for each component. The sampling frequency in NE-Iceland network is 200-250 per sec.

GNSS (GPS) data

Landsvirkun has an extensive program of ground deformation measurements in North Iceland, in collaboration with University of Iceland and their co-workers. This includes repeated Global Navigation Satellite System (GNSS) geodetic measurements, in the past using the Global Positioning System (GPS).
An extensive network of campaign GPS-sites has been measured yearly. Landsvirkjun owns also three continuously operating GPS-stations (CGPS) in geothermal areas of north Iceland (Krafla, Bjarnarflag, Þeistareykir). The stations are operated by University of Iceland. Data from both campaign and continuous GPS sites is available for networking. Two types of data sets are available: (i) raw data as collected at GPS sites, in standard RINEX format (Receiver Independent Exchange Format), and (ii) processed time series of displacements. It is suggested these data will be freely available for all, partly through a dedicated website at University of Iceland:
http://www.icelandsupersite.hi.is/gps/ts/NVZ.html

Time series of displacements
The data at this website includes the time series of ground displacements. The GPS data have been analysed using the GAMIT/GLOBK 10.6 software at University of Iceland. Sites positions were evaluated in the ITRF2014 reference frame using over 100 worldwide reference stations. Only GPS satellites with a good phase center location were included in the processing to prevent any scale error

in the GPS solutions [Zhu et al., 2003]. The data were corrected for ocean tidal loading using the FES2004 model [Lyard et al., 2006]. Daily geocentric XYZ positions for time-series covering the time period from summer 1997 to summer 2018 are available. These positions are then converted to LLH (latitude, longitude, height) and ENU (east, north, up) in the ISN93 cartographic projection.
For each GPS site, a plot of the time series is available, and a text file with the following information:

Decimal year	Time of observation in decimal years
E	East displacement (meters)
N	North displacement (meters)
U	Up displacement (meters)
σE	1 sigma uncertainty in east component (m)
σN	1 sigma uncertainty in north component (m)
σU	1 sigma uncertainty in up component (m)

One can select if the time series are displayed in ITRF2014 reference frame or relative to the Eurasian Plate. See Figures 7 and 8 for example of time series: plot and data.

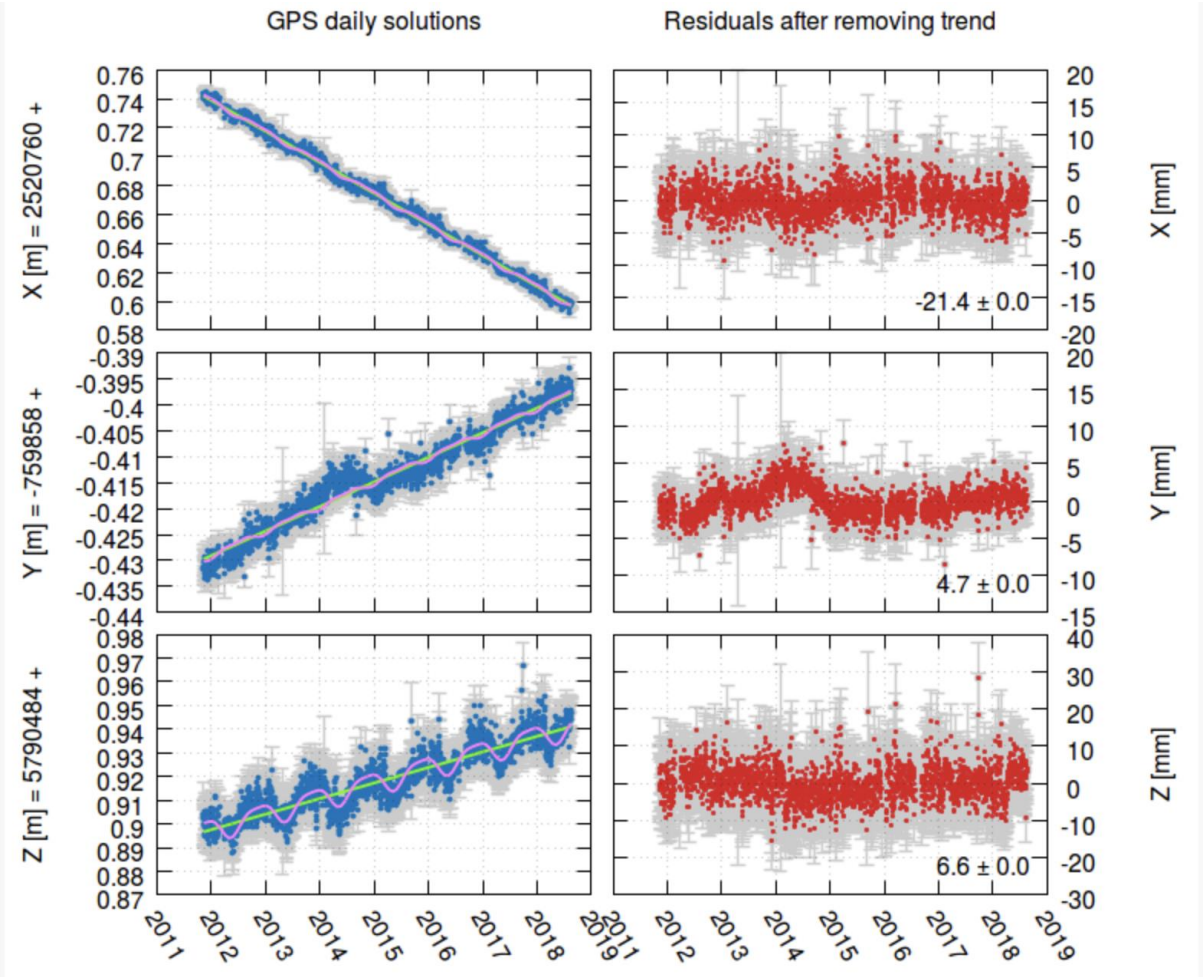

Figure 7. Example of time series data.

```
2011.85342 2520760.74095 -759858.43135 5790484.90412 0.00632 0.00324 0.01369 -0.447 0.735 -0.415
2011.85616 2520760.74329 -759858.43158 5790484.90294 0.00387 0.00222 0.00772 -0.315 0.677 -0.307
2011.85890 2520760.74047 -759858.42976 5790484.89975 0.00518 0.00290 0.01009 -0.340 0.676 -0.342
2011.86164 2520760.74107 -759858.43042 5790484.89991 0.00413 0.00251 0.00832 -0.321 0.683 -0.315
2011.86438 2520760.74283 -759858.43241 5790484.90292 0.00381 0.00227 0.00757 -0.303 0.680 -0.307
2011.86712 2520760.74255 -759858.43096 5790484.89985 0.00349 0.00210 0.00698 -0.312 0.678 -0.317
2011.86986 2520760.74203 -759858.43350 5790484.89917 0.00420 0.00250 0.00843 -0.330 0.678 -0.327
2011.87260 2520760.74074 -759858.43006 5790484.89857 0.00384 0.00227 0.00748 -0.328 0.688 -0.330
2011.87534 2520760.74231 -759858.43179 5790484.90109 0.00360 0.00216 0.00710 -0.323 0.680 -0.323
2011.87808 2520760.74121 -759858.42936 5790484.89928 0.00402 0.00239 0.00799 -0.326 0.679 -0.311
2011.88082 2520760.73943 -759858.43048 5790484.89546 0.00364 0.00213 0.00715 -0.317 0.676 -0.320
2011.88356 2520760.73983 -759858.43028 5790484.89483 0.00346 0.00208 0.00699 -0.315 0.671 -0.320
2011.88630 2520760.74340 -759858.43146 5790484.90530 0.00384 0.00229 0.00764 -0.312 0.680 -0.319
2011.88904 2520760.74316 -759858.43083 5790484.90526 0.00382 0.00230 0.00760 -0.314 0.676 -0.317
2011.89178 2520760.74303 -759858.42985 5790484.90053 0.00354 0.00213 0.00707 -0.312 0.668 -0.318
2011.89452 2520760.74391 -759858.43101 5790484.90452 0.00333 0.00196 0.00653 -0.331 0.664 -0.325
2011.89726 2520760.74528 -759858.43054 5790484.90495 0.00347 0.00205 0.00688 -0.320 0.662 -0.323
2011.90000 2520760.74376 -759858.43092 5790484.90420 0.00328 0.00196 0.00653 -0.314 0.669 -0.323
2011.90274 2520760.74116 -759858.43165 5790484.90062 0.00343 0.00195 0.00657 -0.281 0.680 -0.297
2011.90548 2520760.74111 -759858.43222 5790484.90060 0.00330 0.00191 0.00648 -0.279 0.671 -0.293
2011.90822 2520760.73986 -759858.43184 5790484.90055 0.00346 0.00191 0.00655 -0.283 0.682 -0.290
2011.91096 2520760.74036 -759858.43132 5790484.90090 0.00371 0.00219 0.00728 -0.298 0.683 -0.282
2011.91370 2520760.73852 -759858.43208 5790484.89808 0.00343 0.00201 0.00672 -0.272 0.673 -0.285
2011.91644 2520760.74130 -759858.43220 5790484.90064 0.00321 0.00191 0.00619 -0.284 0.664 -0.307
2011.91918 2520760.74296 -759858.43294 5790484.90426 0.00338 0.00194 0.00648 -0.289 0.662 -0.312
2011.92192 2520760.74007 -759858.43286 5790484.90085 0.00339 0.00198 0.00669 -0.305 0.678 -0.310
2011.92466 2520760.74095 -759858.43368 5790484.90124 0.00333 0.00192 0.00662 -0.310 0.679 -0.307
2011.92740 2520760.73956 -759858.43358 5790484.89928 0.00277 0.00163 0.00554 -0.290 0.673 -0.294
2011.93014 2520760.74011 -759858.43029 5790484.89741 0.00276 0.00160 0.00543 -0.293 0.674 -0.297
2011.93287 2520760.73850 -759858.42808 5790484.89477 0.00324 0.00187 0.00641 -0.304 0.678 -0.301
```

Figure 8. Example of numerical values of time series GPS-data