GeoNet: Building Science Gateway Alliances for the GeoHazard Community

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Outline

- STARnet
- GeoHazard Community Needs
- GeoNet Schema
- GeoNet Use Cases
- Conclusions

STAR^{net} Federation

The STAR^{net} Gateway Federation was inaugurated in January 2014 with founding members:

1. ***INAF Astrophysical Observatory of Catania (INAF-OACT), IT***
   Specialized for Astrophysical Visualization
2. ***INAF Astronomical Observatory of Trieste (INAF-OATS), IT***
   Specialized for Plank ESA Mission
3. ***INAF Astronomical Observatory of Teramo (INAF-OATE), IT***
   Specialized for evolutionary stellar models
4. ***Centro Italiano Archivi Astronomici of Trieste (INAF-IA2), IT***
   Specialized for archives and Virtual Observatory
5. ***University of Portsmouth Higher Education Institution (UoP), UK***
   Specialized for Modified Gravity Models
6. ***Astronomical Institute of the Slovak Academy of Sciences (AI-SAS), SK***
   Specialized for interstellar objects (comets)

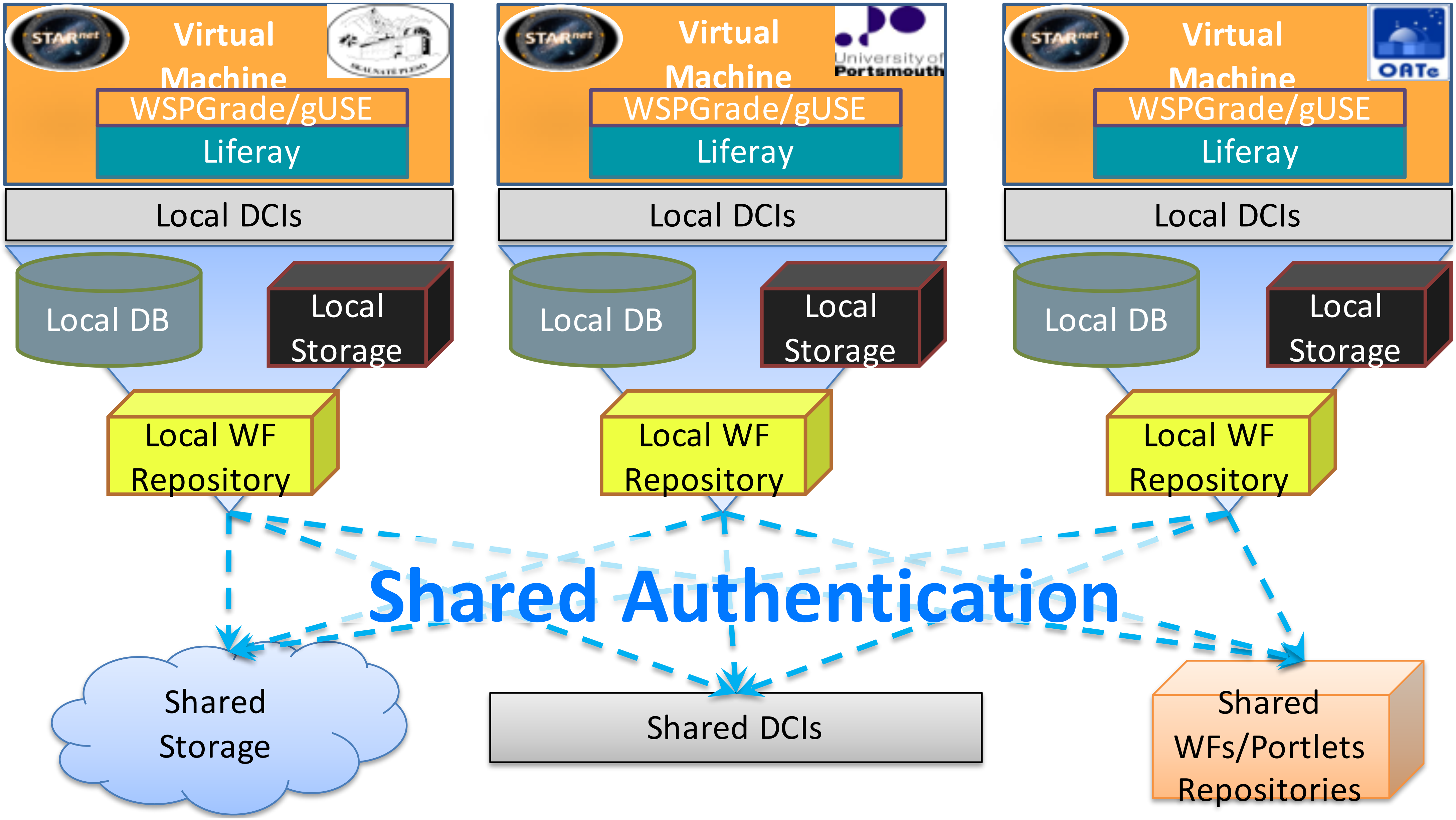
Later on adding:

7. ***VIALACTEA Consortium***
   Specialized in star formation in the Milky Way

STAR^{net} Scope

- The focus of the federation is to foster a research collaboration by means of developing services, such as *authentication*, *infrastructure access*, *handling of big data* archives *and workflow repositories*.

- The ultimate aim is for all partners to advance their scientific research in handling big data on a large scale and explore new collaboration opportunities and support for research funds. Each gateway contains *applications specific to the partner* but can also include *federation applications*.


Virtual Machine
WSPGrade/gUSE
Liferay
Local DCIs
Local DB
Local Storage
Local WF Repository
Virtual Machine
University of Portsmouth
WSPGrade/gUSE
Liferay
Local DCIs
Local DB
Local Storage
Local WF Repository
Virtual Machine
OATs
WSPGrade/gUSE
Liferay
Local DCIs
Local DB
Local Storage
Local WF Repository
Shared Authentication
Shared Storage
Shared DCIs
Shared WFs/Portlets Repositories

STAR^{net} SSOAuthentication

STARnet first option of SSO Authentication uses LDAP. Liferay supports LDAP and it is easier to connect to a centrally managed system to the gateways. New users create an account on the fly to the LDAP server during the first login.

The SSO with *Shibboleth* was tested. It provides SSO services allowing a wide range of login handler ranging from LDAP to X.509 user certificate login. The Identity Provider is a Java Servlet web application and user identity information are pulled from an LDAP service. The Liferay authentication is performed using a Liferay Hook plugin.

Issues in Deploying STAR^{net}

Typically, when a federated gateway solution such as STARnet is deployed among members there are:

- different policies for data storage and maintenance;
- different policies for user access levels;
- different sw / hw technological infrastructures;
- different security levels.

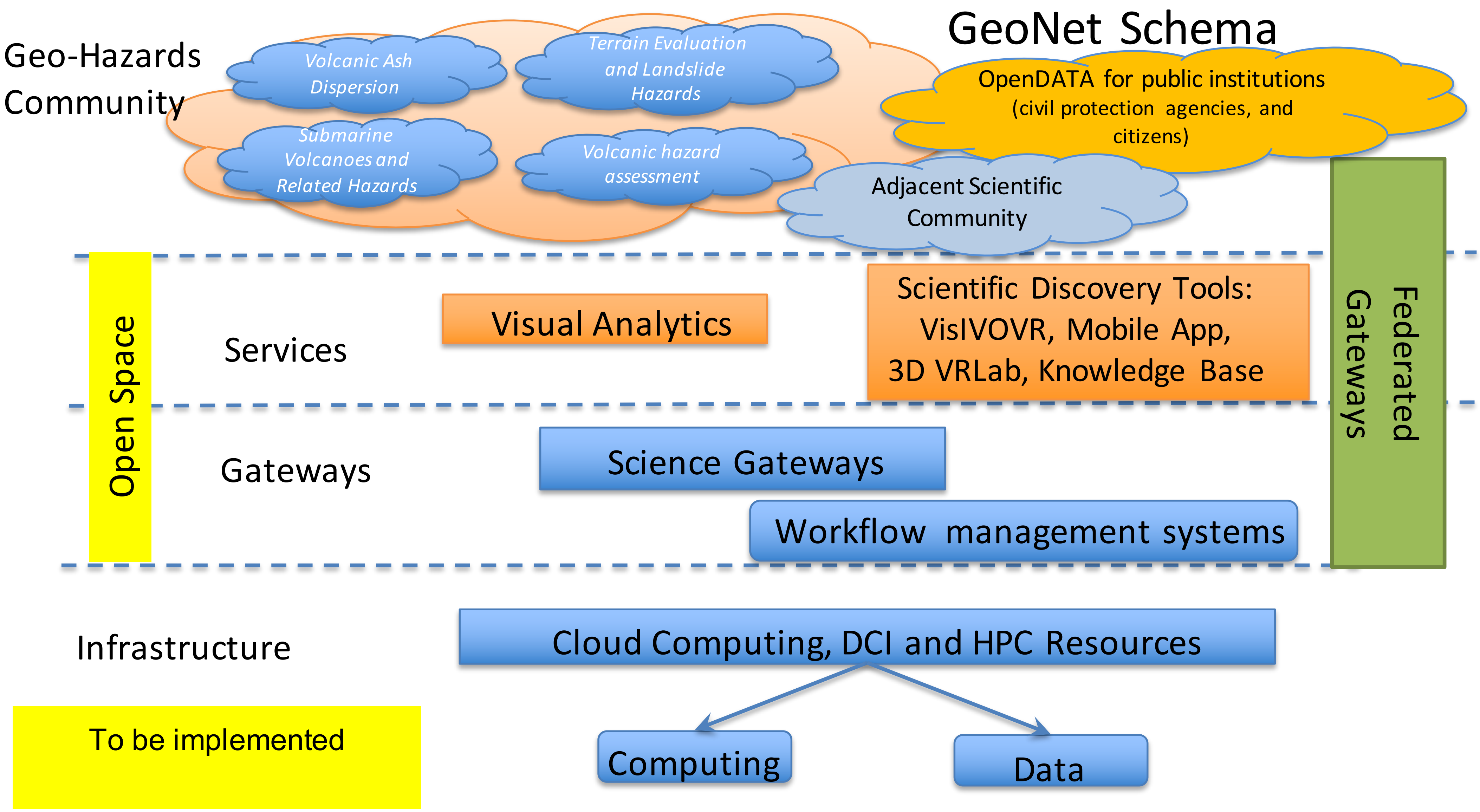
From Astrophysics to GeoHazards: Common Themes and New challenges

Common Themes

- services for big (simulation and observation) data storage and analysis;
- complex, highly heterogeneous datasets;
- transparent access to DCIs to execute complex scientific pipelines;
- collaborative activities for teaching / research

New Challenges

- *open source* (astro) vs *comercially* available S/W (geosciences)
  - issues with licensing, DCI deployment, customization...
- *institutional* (astro) vs *field* (geo) work
  - issues with connection speeds, for data transfers, processing, latency...
- *highly immersive end user applications*
  - mobile platforms, virtual / augmented reality, tactile interfaces...
  - usable also by non-scientists e.g. civil protection agencies or others...


GeoNet Schema
Geo-Hazards Community
Volcanic Ash Dispersion
Terrain Evaluation and Landslide Hazards
Submarine Volcanoes and Related Hazards
Volcanic hazard assessment
OpenDATA for public institutions (civil protection agencies, and citizens)
Adjacent Scientific Community
Open Space
Services
Visual Analytics
Scientific Discovery Tools: VisIVOVR, Mobile App, 3D VRLab, Knowledge Base
Federated Gateways
Gateways
Science Gateways
Workflow management systems
Infrastructure
Cloud Computing, DCI and HPC Resources
Computing
Data
To be implemented

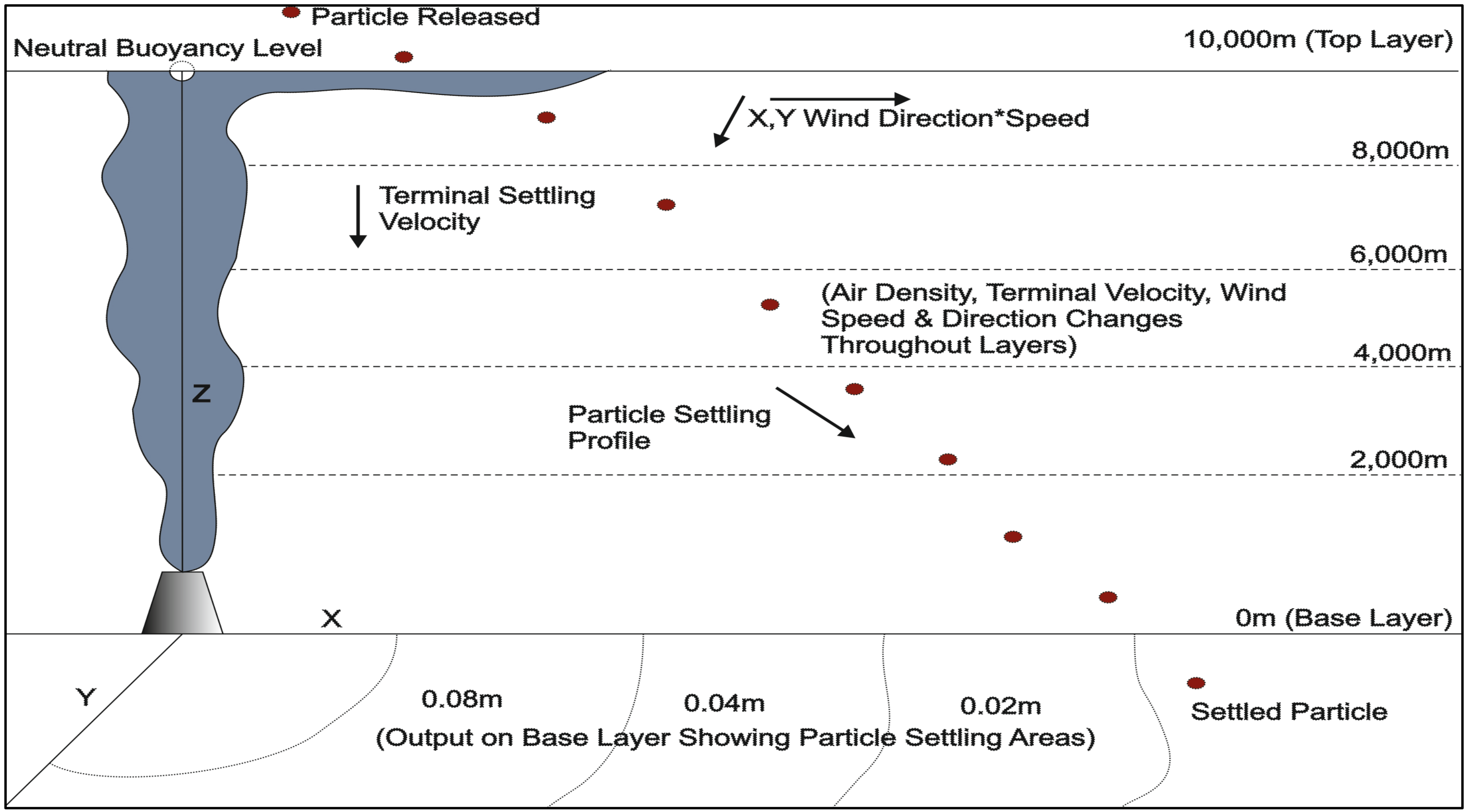
GeoNet Use Case 1

Simulations of Volcanic Ash Dispersion

- Volcanic ash cloud data is *highly complex / heterogeneous*
  - *particle motion in 3D;*
  - *meteorological weather data;*
  - *remote sensing and topography data.*
- *Monte Carlo simulations* are deployed using variable inputs *to generate multiple ash cloud models* (parameter sweep)
- For increased understanding of ash behaviour in the atmosphere and developing better risk models on the *impacts* to *people*, *environment and infrastructure* affected by an eruption.
- Need for fast and accurate *risk models of natural hazards for re-insurance industry*
- Need for Volcanic Ash Advisory Centres (VAACs), e.g. http://www.metoffice.gov.uk/aviation/vaac/

GeoNet Use Case 1

Simulations of Volcanic Ash Dispersion



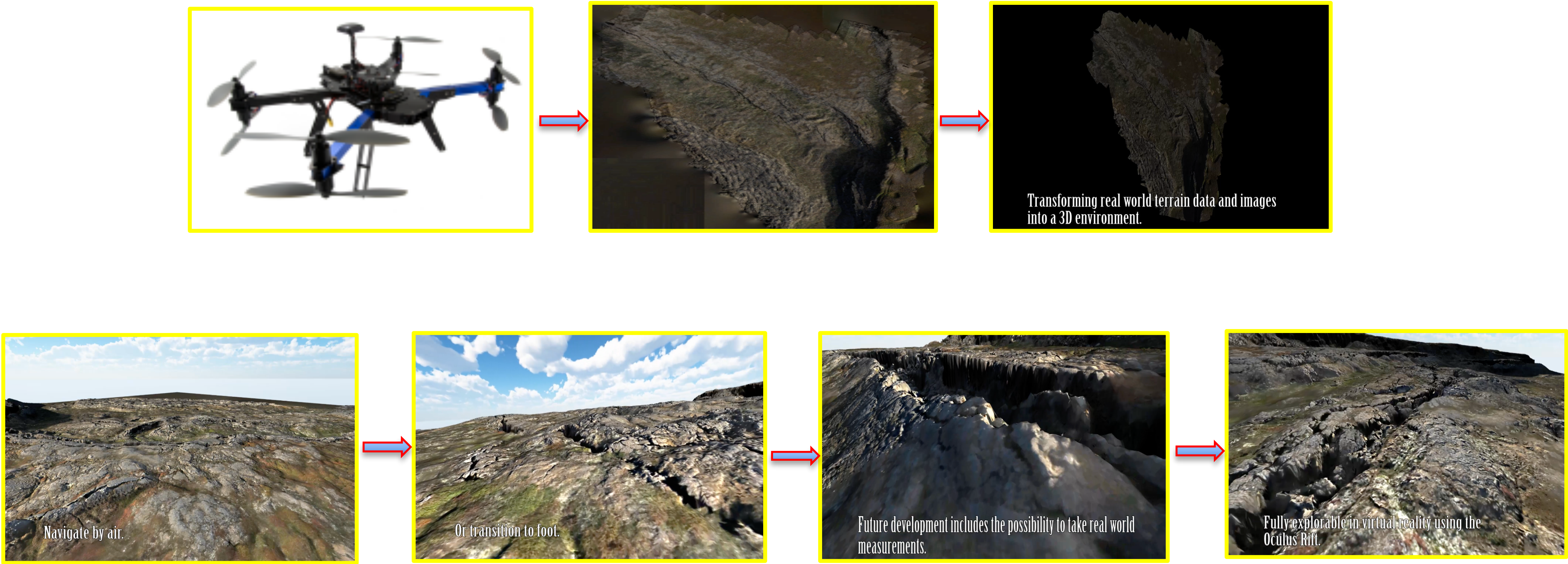
GeoNet Use Case 2

Terrain Evaluation using UAVs

- To identify and classify features on the Earth's surface in order *to locate hazardous areas*, e.g.
  - sinkholes and karst features,
  - *slope movement* and landslides and
  - *tectonic features* produced by seismic activity.
- A typical pipelines/workflow involves several steps:
  - an aided study, e.g. deploying visualization and existing data retrieval,
  - *algorithms for analysis of images* taken over the site of interest (including satellite imagery or aerial photography) and
  - *field mapping*, to visit the site to map the features and validate results of the first two stages to generate a final interpretation and series of recommendations.
- Field mapping is nowadays being supplemented by the use of imagery and terrain elevation data acquired from field deployed UAVs
- Aim is to ***fully integrate*** such tools into the geoscientists *workflows*

GeoNet Use Case 2

Terrain Evaluation using UAVs



GeoNet Use Case 2

Terrain Evaluation using UAVs

- SG benefits in *improving productivity*
  - Handling of UAV data requires lengthy data processing using complex multi-step workflows that must often be undertaken in the office and away from the field;
  - If UAV technology is to be deployed more widely and effectively, then a new approach for data handling is required to automate as much of the UAV data processing pipelines.

⇒ Allowing such pipelines to be completed while in the field will dramatically *improve productivity* of field based activities, thereby allowing geoscientists *to view UAV results quickly while still in the field and adapt their field mapping accordingly*, rather than having to wait until they return to the office as they do currently - *data processing on the go!*

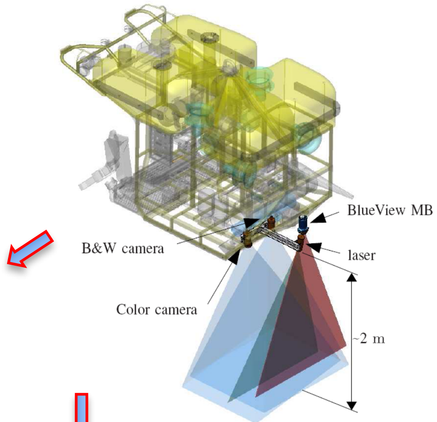
GeoNet Use Case 3

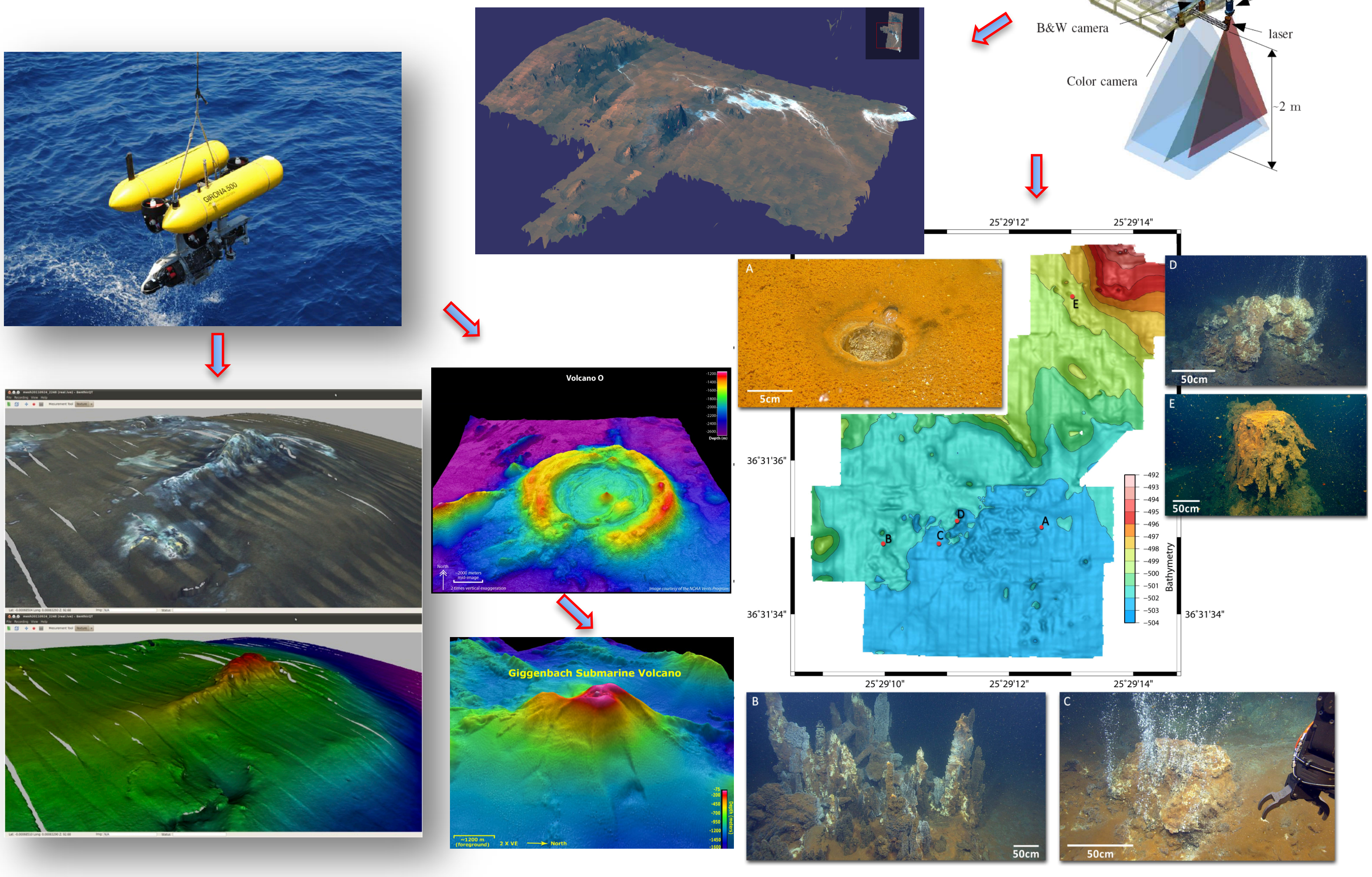
Mapping Submarine Volcanoes using ROVs and AUVs

- *To identify and classify features* on underwater volcanic fields in order to *located hazardous areas*, e.g.
  - Craters and hydrothermal vent fields
  - submarine landslides and debris avalanches and
  - Fault surfaces and fractures
- A typical workflow involves several steps:
  - *Producing high resolution swath maps* and seafloor photomosaics
  - *creating a 3D terrain models* of the seafloor outcrops using structure from motion techniques
  - *Interpretation of submarine volcano layering* and general *geological structure* by using
  - integration of processed seismic, acoustic, optical, bathymetric (and any other) data inside a *3D visual environment for data modelling, management and analysis.*
- AUV and ROV vehicles collect near-bottom high resolution microbathymetry datasets including images to generate photomosaics of the seafloor as well as high-resolution video imagery from a fault surface outcrop or a landslide or an underwater volcano to generate high-resolution marine terrain models with texture-mapped imagery.
- Aim is to integrate all the acoustic datasets within ***3D immersive visualisation environments*** *for marine geohazards illustration.*

GeoNet Use Case 3

Mapping Submarine Volcanoes





GeoNet Use Case 3

Mapping Submarine Volcanoes using ROVs and AUVs

- SG benefits in *improving productivity*
  - Preparing an open high performance digital environment based on new and emerging technologies to process and render the data to build a 3-D virtual reality underwater environments for different types of geohazards.
  - Development of monitoring and monitoring-simulation tools for submarine volcanic hazards including user-driven innovation expected to facilitate development of new monitoring instrumentation.

⇒ This activity will be useful to *develop novel instrumentation* (such as high temperature resilient sensors for ROVs and AUVs) that will be able to *operate in submarine volcanoes* and can be further used in extreme underwater environments.

⇒ The services are expected to have a significant demand within the *international community* such as Submarine Volcanic Commission.

⇒ Such applications will assist not only on the live monitoring of the volcanoes but also on *emergency* planning from decision makers *in the case of a real submarine volcanic eruption*.

GeoNet Use Case 4

Volcanic and Seismic Hazards

- Volcanic hazard assessment requires collection of various data by different techniques in order to surveying and monitoring active volcanoes.
- The objective is to experiment ref. the feasibility of a *new approach based on drone surveys* and field checks coupled with *processing of the drone images to automatically extract geological, structural and volcanological information.*
- Surveys will be done at horizontal/sub-horizontal terrains (mostly finalized to measure the areal extension of volcanic deposits and the fracture field) and at vertical rock cliffs.
- Field checks will allow to measure the deposit thickness that, coupled with the values of areal extension, will give the deposit volume.
- The aim is to not only furnish a platform tool that will be exploited by all the world community working on these topics but to also furnish an infrastructure that will enable to calculate quickly the effects immediately after a volcanic event occurred, allowing for a fast assessment of possible increased threats on nearby regions.

GeoNet Use Case 4

Volcanic and Seismic Hazards

SG Workflow:

- Drone-surveyed images will be processed for quality control with a *new customized open source software*;
- Images will then be automatically analysed by another *dedicated new software in order to map fractures and extract the relevant quantitative information* like fracture orientation, fracture length, fracture spacing;
- The fracture field reconstructed in this way will *be compared with classical approaches of study based on direct measurements in the field of structures*.

⇒ The focus is on two key areas: 1) *active seismic zones of Iceland*. These represent areas of extensional tectonics and thus characterized by fissures and normal faults, and by a quite dense vegetation cover. 2) *south-western part of the Caucasus (Georgia)* because this is characterised by compressional tectonics dominated by active folds and reverse faults, and by a quite dense vegetation cover.

Conclusions

- We are developing a prototype ecosystem by:
  - *integrating and adapting as necessary StarNET components* within an open space tailored for the *GeoHazard Community* containing workflows and applications;
  - to advance use of cloud technologies in order to facilitate application development and deployment including application usage as SaaS, PaaS, IaaS.
- Although StarNet already contains several *core services* for data organisation and management these need *adaptation to handle GHC* data sources and methodologies.
- *Core services* for processing data through complex workflows also have *to be adapted for GHC* needs as they require non-trivial processing pipelines, e.g. *innovative visualizations for quick exploration of regions surrounding volcanic areas* to interpret regional volcanic settings.
- *The ultimate vision* is to build novel mechanisms for seamless glueing of customised gateways enabling deployment of fully *federated approaches to applications, services and e-infrastructure layers, across a range of scientific disciplines.*