RESEARCH PRODUCTS ACROSS SPACE MISSIONS – A PROTOTYPE FOR CENTRAL STORAGE, VISUALIZAITON AND USABILTY

WHAT WE CAN LEARN AND USE FROM TERRESTRIAL DEVELOPMENTS

Mario d' Amore, Andrea Naß, Martin Mühlbauer, Torsten Heinen, Mathias Boeck, Jörn Helbert, Torsten Riedlinger, Ralf Jaumann und Günter Strunz

EGU • May 2020

DLR

STATUS QUO

PLANETARY SCIENCES

Digital data like raster images, data cubes and tables, terrain-model and photomosaics as well as the respective pieces of **meta information** are stores in **digital archives** or **repositories**.

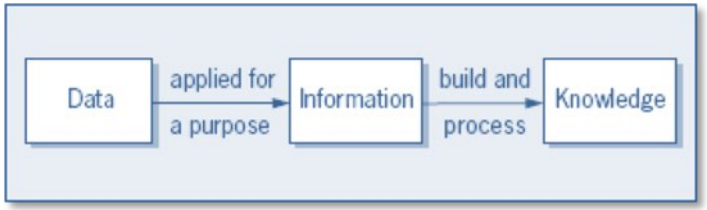
Main archives are …

PDS Planetary Data System

Planetary Science Archive

A number of **national space science institutes** and **agencies** across the globe may provide access to **archived mission data for a period of time**.

Use to compile **higher-level research products** to form a basis for **continued research, new scientific** and **engineering studies** and **to improve our understanding of the outer space**.



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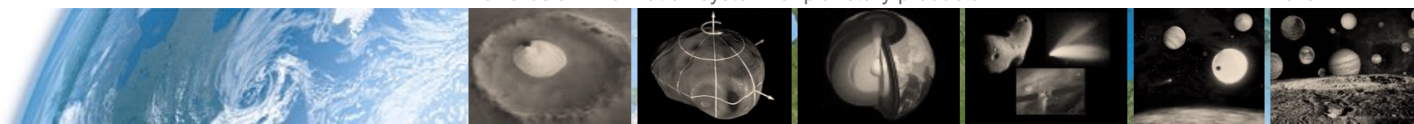
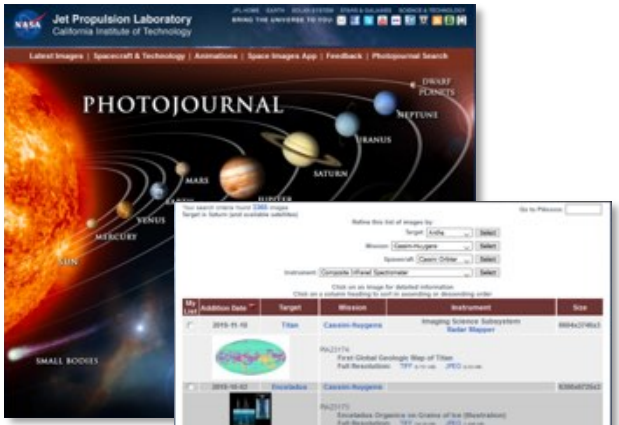


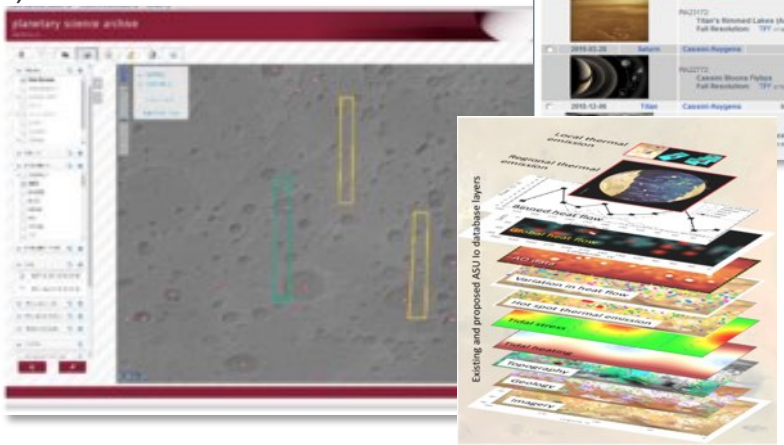
STATUS QUO

PLANETARY SCIENCES

In the **planetary sciences first efforts** are being made. e.g.

- the **Astropedia Annex** within **PDS** for registering and hosting derived geospatial products,
- the **Photojournal** hosted by **JPL,** A searchable collection of press release images from NASA planetary missions
- the **PSA** is simplifying the archiving needs to help promote the access to scientific products.
- **Individual database structures** managing data of different bodies, e.g. for Io





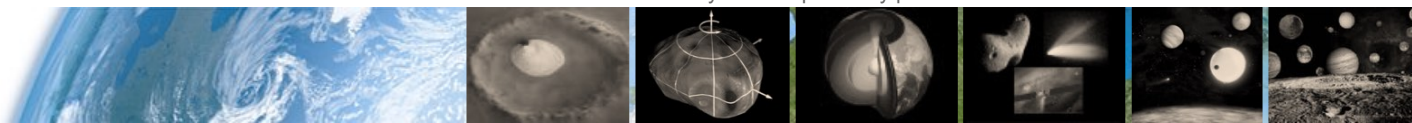
Williams et al., (2019) LPSC

Beside this main repositories **first initiatives** came handling data (infra)structure and accessibility:

PlanMap (Horizon2020)

VESPA (Europlanet)

MAPSIT (NASA)



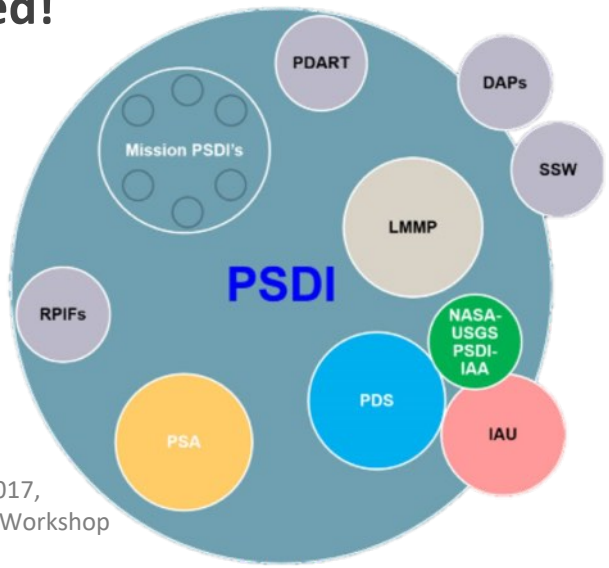
STATUS QUO

RE-USE OF SCIENTIFIC DATA – IN GENERAL

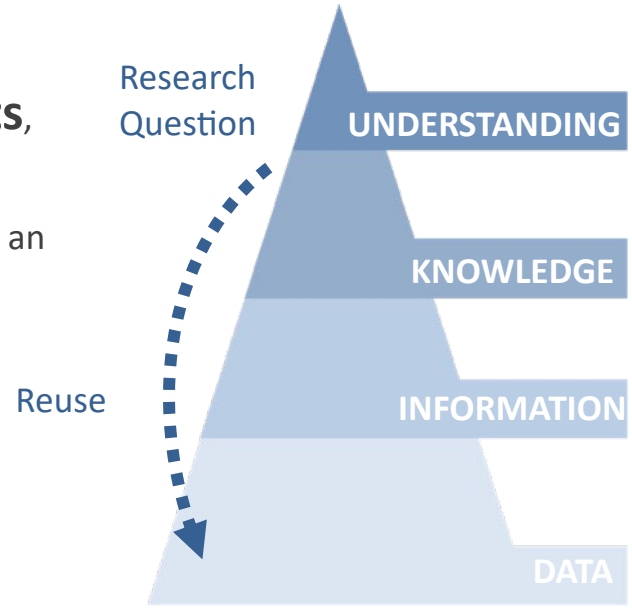
In order to achieve a

re-usability and **sustainability** for the **scientific results**,

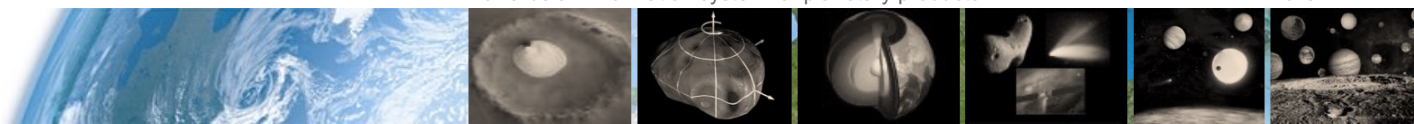
a **consistent** and **extensive data basis** accessible through an **common infrastructure** in a research environment **is needed!**



Gaddis et al., 2017,
Planetary Data Workshop



Therefore, **a formal coordination of organizational processes are required!**

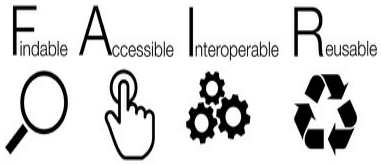


STATUS QUO

RE-USE OF SCIENTIFIC DATA – IN GENERAL

Open Access providing on-line access to scientific information,
refers to Peer-reviewed scientific research articles and Research data,
that is free of charge to the reader. (Horizon 2020 Online Manuals)

International Standards for metadata, data schemas, APIs

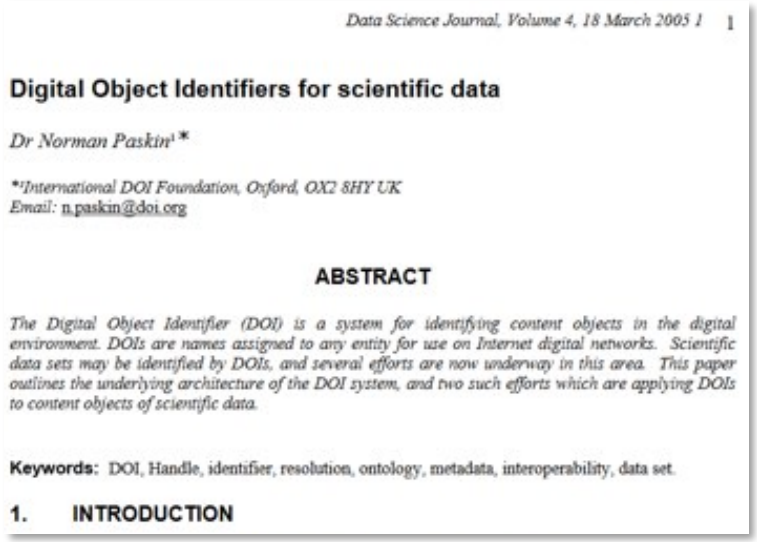
Principle of 

data (e.g. Wilkinson et al , 2016)

Publisher rules and **guidelines,** e.g. Nature and Elsevier

Requirements within **external funding**

Digital Object identifier for **scientific data**



Data Science Journal, Volume 4, 18 March 2005 1

Digital Object Identifiers for scientific data

Dr Norman Paskin[1]*

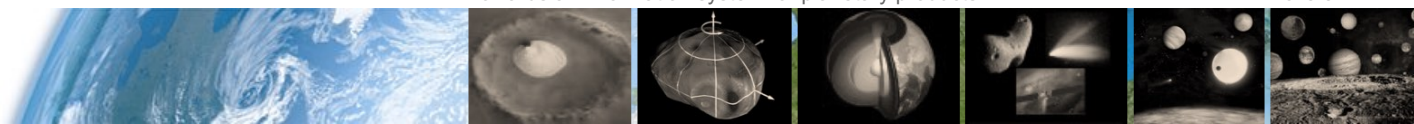
[1]International DOI Foundation, Oxford, OX2 8HY UK
Email: n.paskin@doi.org

ABSTRACT

The Digital Object Identifier (DOI) is a system for identifying content objects in the digital environment. DOIs are names assigned to any entity for use on Internet digital networks. Scientific data sets may be identified by DOIs, and several efforts are now underway in this area. This paper outlines the underlying architecture of the DOI system, and two such efforts which are applying DOIs to content objects of scientific data.

Keywords: DOI, Handle, identifier, resolution, ontology, metadata, interoperability, data set.

1. INTRODUCTION



STATUS QUO

RE-USE OF SCIENTIFIC DATA – IN SPATIAL

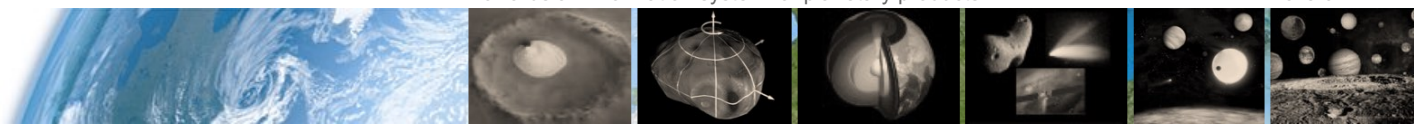
Spatial data infrastructure (SDI) is a **framework** of **spatial data, metadata, users** and **tools** that are interactively **connected** in order to use spatial data in an **efficient** and **flexible** way.

Earth sciences infrastructures growing organically.

These (might) **differ from** developments in the **planetary sciences**, but present a great potential

to avoid similar problems and handle challenges right from the beginning.

Different level of SDIs



STATUS QUO

INSTITUTE FOR PLANETARY RESEARCH

- Nearly all **data** could **spatially – related or referenced**
- Regional Planetary Image Facility and elib
- Connection to **international Organizations, Institutes,** and **Initiatives** like

PSA USER GROUP

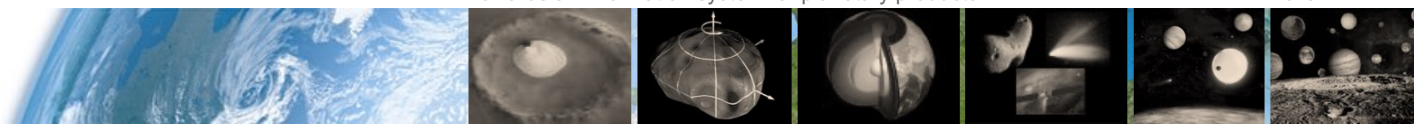
PSA

INTERNATIONAL PLANETARY DATA ALLIANCE IPDA

MAPSIT

PDS Planetary Data System

OpenPlanetary

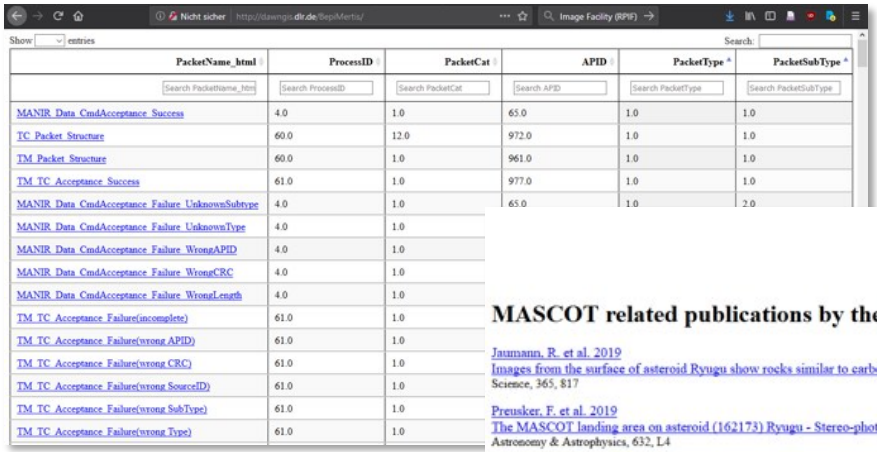


STATUS QUO

INSTITUTE FOR PLANETARY RESEARCH

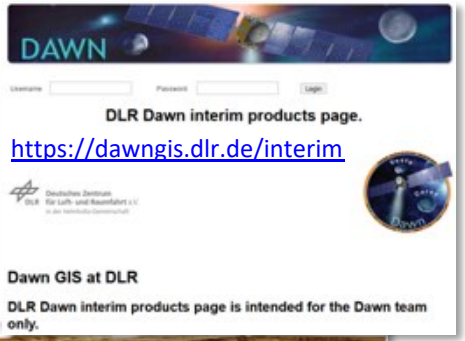
Mission data centrally managed in PostgreSQL via **metadata**

Scientific products are stored **decentral locally or on team sites.**



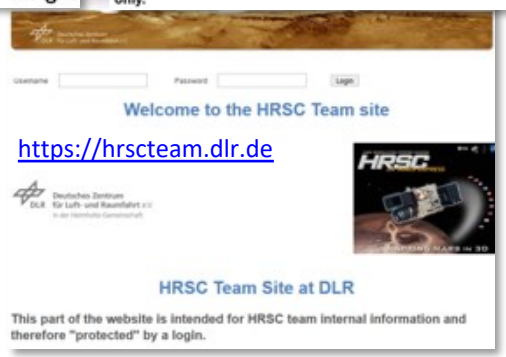
http://dawngis.dlr.de/BepiMertis/

https://insighthp3.dlr.de/hp3/



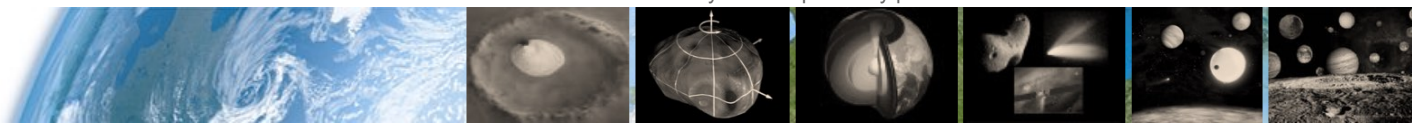
https://dawngis.dlr.de/interim

http://europlanet.dlr.de/Hayabusa2/MASCOT/index.html.



https://hrscteam.dlr.de

However, **first use cases for scientific results** in PostgreSQL exists.



STATUS QUO

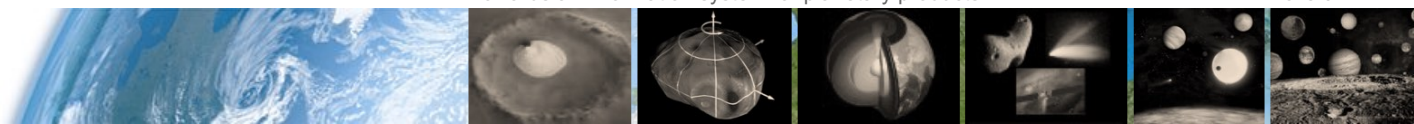
WHAT WE ARE WORKING FOR

Question is

How scientific products at PF can be archived long term and central, to enable crosslinks via spatial-temporal relations and metadata to build a sustainable and reusable base for further studies?

Therefore we

- Highlight the **potential of spatial and temporal relation within current Earth-based developments** in infrastructure, database and web-based accessibility.
- Underline the **benefit of provisioning research data and scientific products**.
- Present the **first prototype** for a **planetary information system** at PF.
- Consider challenges came up like **individual workarounds**, load, organize, access, deliver data etc.



SPECTRAL MEETS GEOLOGY

… MERTIS

… MASCS DATABASE

… EXAMPLES FOR JOINED RESEARCH AREAS

DLR

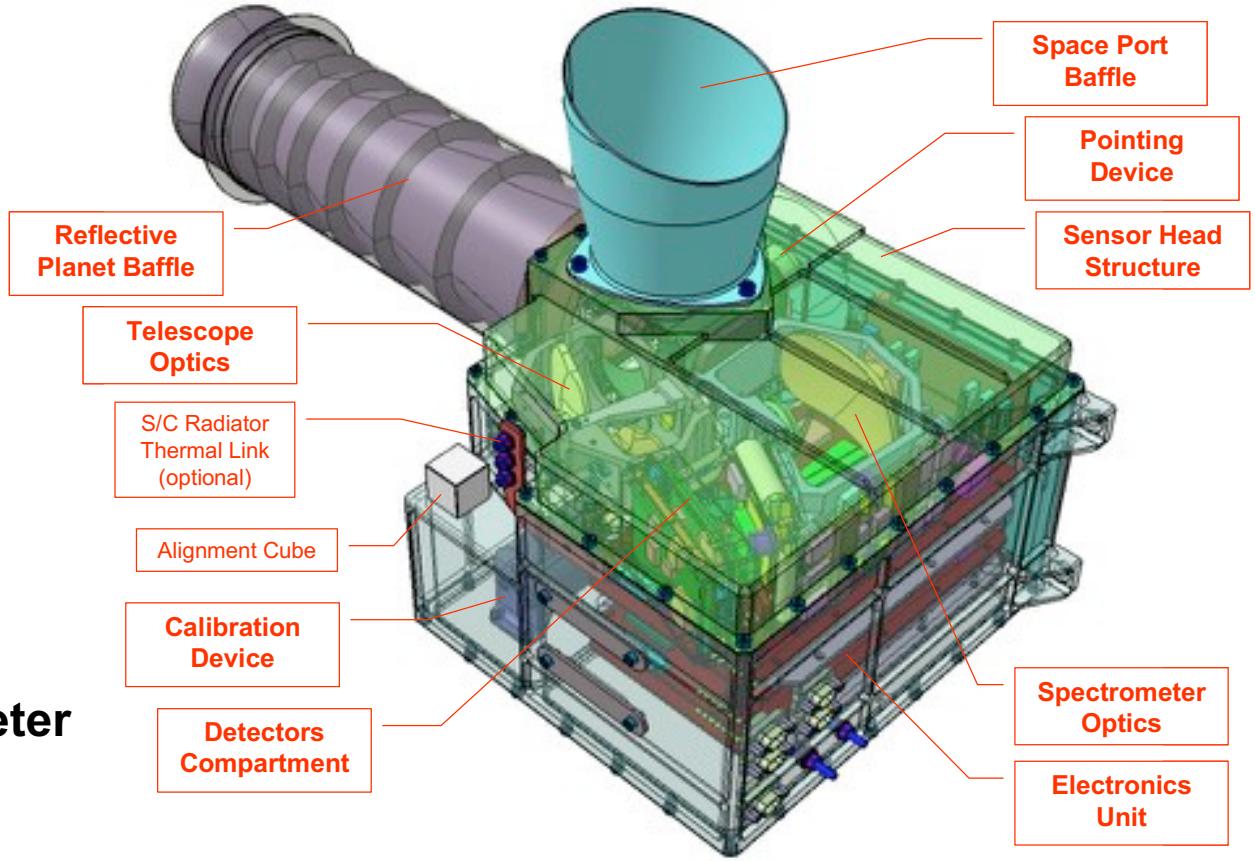
MERTIS – MERCURY RATIOMETER AND THERMAL INFRARED IMAGING SPECTROMETER

Principle Investigators

Prof. H. Hiesinger
University of Münster

Dr. J. Helbert
DLR

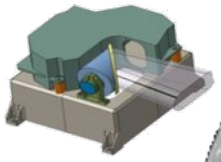
- **Monoblock**
- **3.1 kg - 10W**
- **Uncooled microbolometer**
- **7-14µm @ 200nm**
- **Global coverage @ up to 280m**
- **Integrated µ-radiometer 7-40 µm**
- **No comparable instrument on the NASA MESSENGER mission**

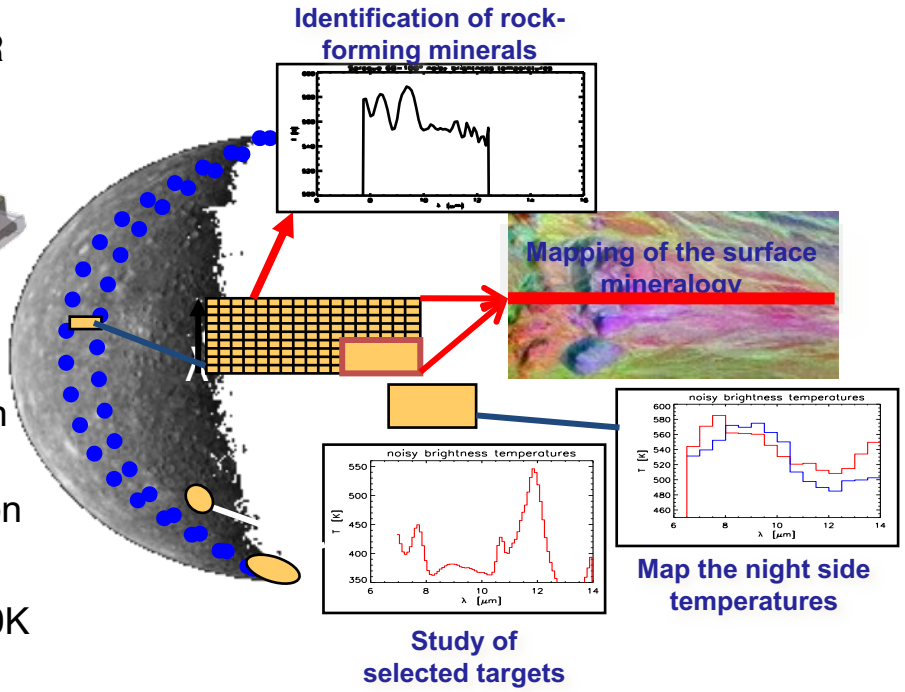


Scientific goals of MERTIS

MERTIS has four main scientific objectives, building on the general science objectives of the Bepi-Colombo mission.

1. **Study of Mercury's surface composition in the TIR**
2. **Identification of rock-forming minerals**
   - Spectral range 7-14µm
   - Spectral resolution better than 200nm
3. **Global mapping of the surface mineralogy**
   - Global mapping with spatial resolution better than 500m
   - 10% of the planet with better than 500m resolution
4. **Study of surface temperature and thermal inertia**
   - NETD <1K for typical nightside temperature of 80K





MASCS DLR Database – Structure

MeasurementsTable

Column	Type
seq_counter	smallint
sc_time	integer
packet_subseconds	smallint
int_time	smallint
int_count	smallint
period	smallint
dark_freq	smallint
temp_1	real
temp_2	real
nir_gain	smallint
other_channel_on	boolean
nir_lamp_on	boolean
vis_lamp_on	boolean
binning	smallint
start_pixel	smallint
end_pixel	smallint
spectrum_number	smallint
spectrum_met	integer
spectrum_subseconds	integer
[...]	
[...]	
rad_avg_345_355	real
rad_avg_445_455	real
rad_avg_495_505	real
rad_avg_545_555	real
rad_avg_595_605	real
rad_avg_645_655	real
rad_avg_700_750	real
rad_avg_845_850	real
dark_scan	smallint
temp_1_flag	smallint
temp_2_flag	smallint
target_latitude_set_0	real
target_longitude_set_0	real

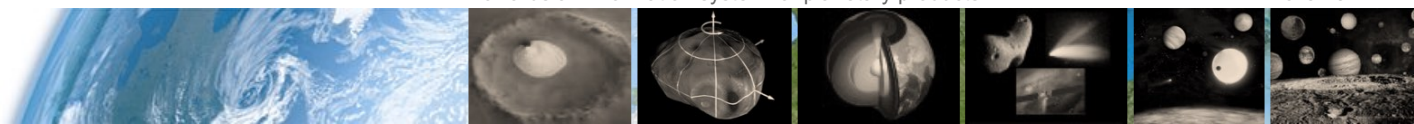
ROI Tables

Regular Grid

name	lonmin	lonmax	latmin	latmax	xres	yres
Kuiper/Rudaki Area 0.5 dpp	-70	-30	-15	5	0.5	0.5
Kuiper/Rudaki Area 1 dpp	-70	-30	-15	5	1	1
Global Map 1 dpp -80/+80 lat	-180	180	-80	80	1	1
Global Map 4 dpp -80/+80 lat	-180	180	-80	80	4	4
Global Map 10 dpp -80/+80 lat	-180	180	-80	80	10	10
Bluetongue .3 dpp grid	-107.95	-101.95	-12.14	-6.44	0.3	0.3
Bluetongue .6*.84 dpp grid	-108.64	-103.24	-13.82	-6.26	0.6	0.84

User defined targets

name	id	group_id	group_name
internal deposits	1	1	Kuiper Crater
Murasaki crater interior	2	1	Kuiper Crater
central peak	3	1	Kuiper Crater
external reference area	4	1	Kuiper Crater
impact_melt	5	2	bluetongue
internal_deposits	6	2	bluetongue
reference_ext_area	7	2	bluetongue
central_peak	8	2	bluetongue



MASCS DLR Database – Structure

meassuremnts

Column	Type
data_ind	integer
[...]	
target_latitude_set_0	real
target_longitude_set_0	real
fov	**geography(Polygon)**
fov_center	**geography(Point)**

1-to-1 relation

ROIs

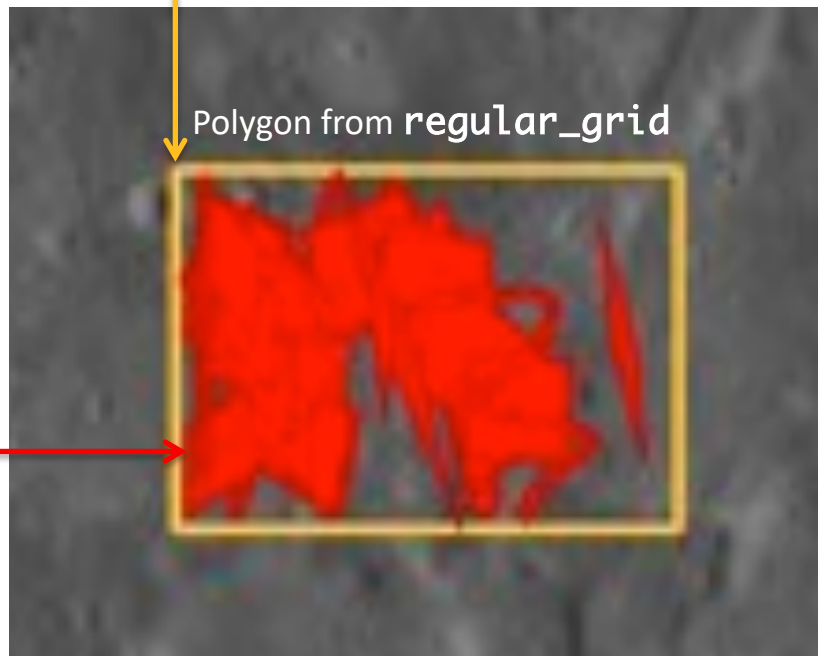
name	id	group_id	group_name
internal deposits	1	1	Kuiper Crater
Murasaki crater interior	2	1	Kuiper Crater
central peak	3	1	Kuiper Crater
external reference area	4	1	Kuiper Crater
impact_melt	5	2	bluetongue
internal_deposits	6	2	bluetongue
reference_ext_area	7	2	bluetongue
central_peak	8	2	bluetongue

intersection

Column	Type
id_poly	integer
id_meas	integer

1-to-1 relation

The intersection table is automatically updated on data table or user polygon tables change



FOV from meas_data_small

[see example 3 on the next page]

MASCS DLR Database – Data Extraction

Waters Crater, Mercury

[lat,lon = -8.96,105.45, IAU https://planetarynames.wr.usgs.gov/Feature/15086]

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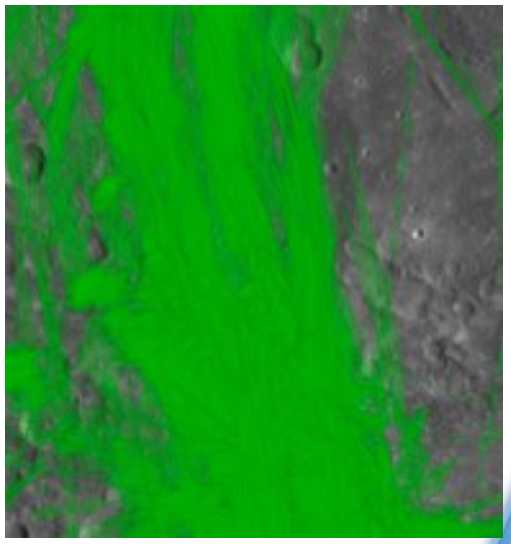

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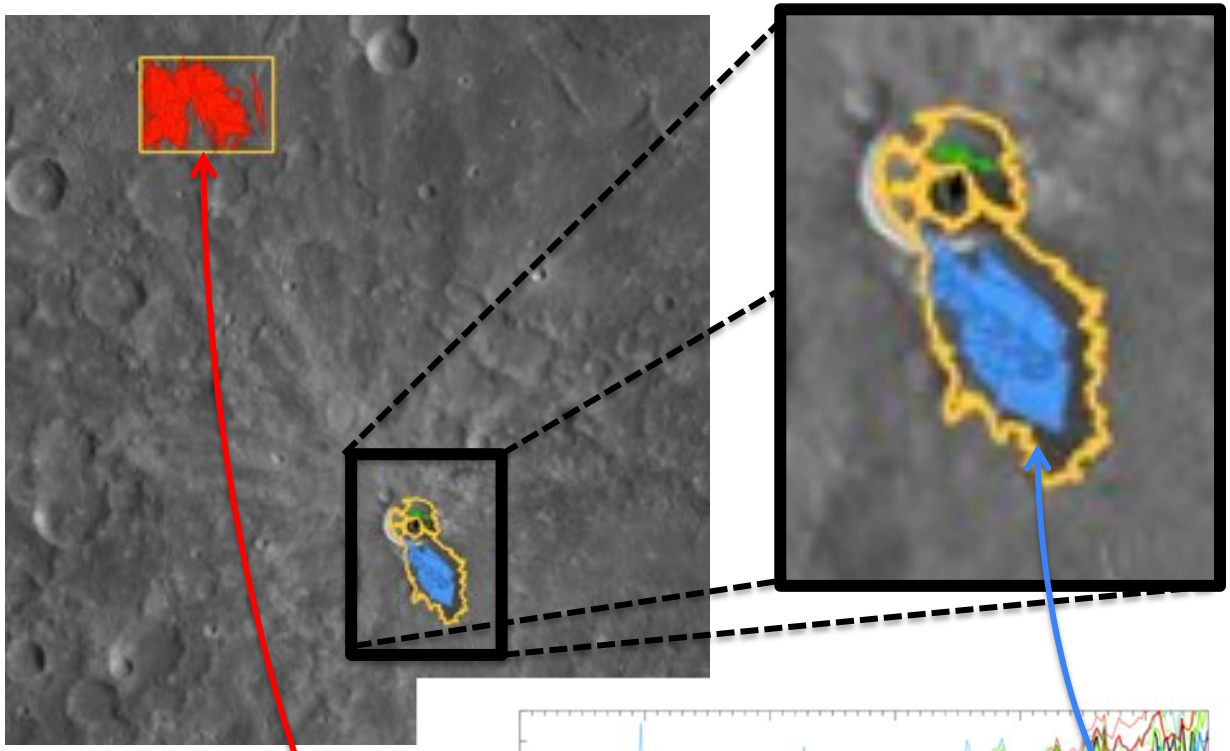
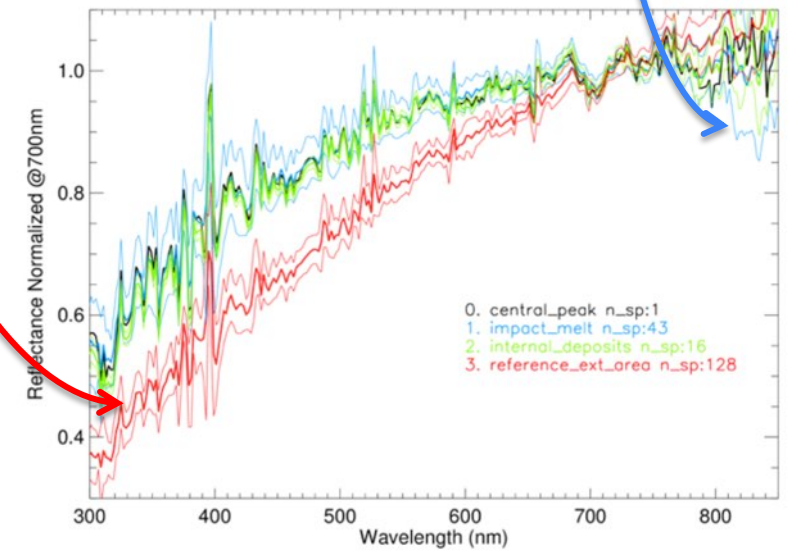




Towards an i

Piero D'Incecco, Jörn Helbert, Mario D'Amore, Alessandro Maturilli *et al.*,
"Shallow crustal composition of Mercury as revealed by spectral properties and geological units of two impact craters,"
Planetary and Space Science, vol. 119, pp. 250–263, 2015, doi: 10.1016/j.pss.2015.10.007.

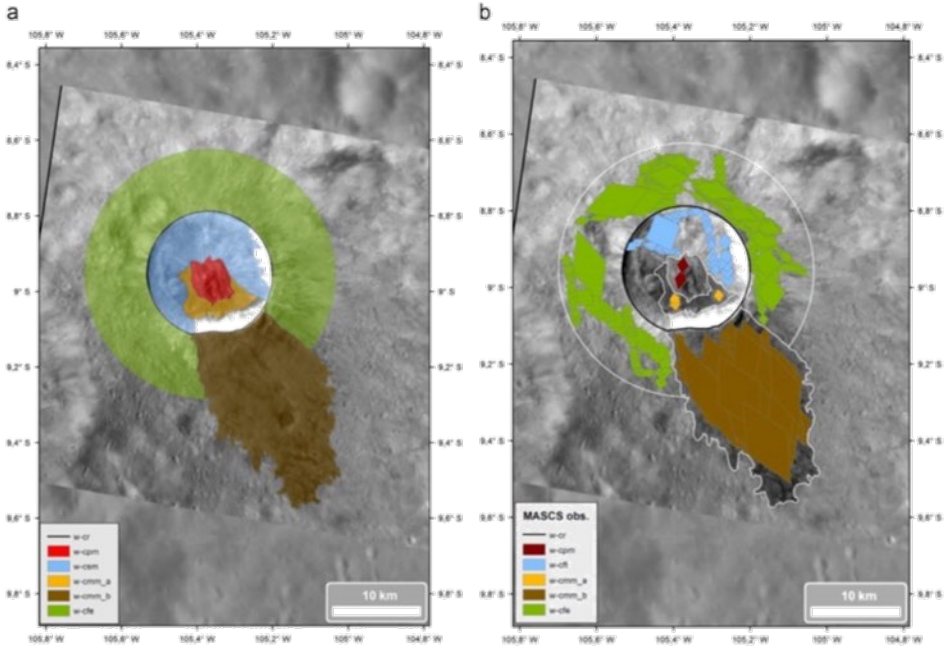


Fig. 2. (a) Waters crater (8.9 S, 105.4 W) geologic map. The mapped units are: Waters crater peak material (*w-cpm*), Waters crater floor and terraces (*w-cft*), Waters crater internal melt material (*w-cmm_a*), Waters crater external melt material (*w-cmm_b*) and Waters crater fresh ejecta (*w-cfe*). (b) MASCS coverage over Waters crater (8.9 S, 105.4 W). Moreover, Waters crater rim (*w-cr*) is defined. Polygons represent MASCS footprints and have been color coded to match the different geologic units displayed in 2a. Both panels use MDIS NAC image EN0229495136M at 44 mpp overlain on the MDIS monochrome global mosaic at 250 mpp as their background.

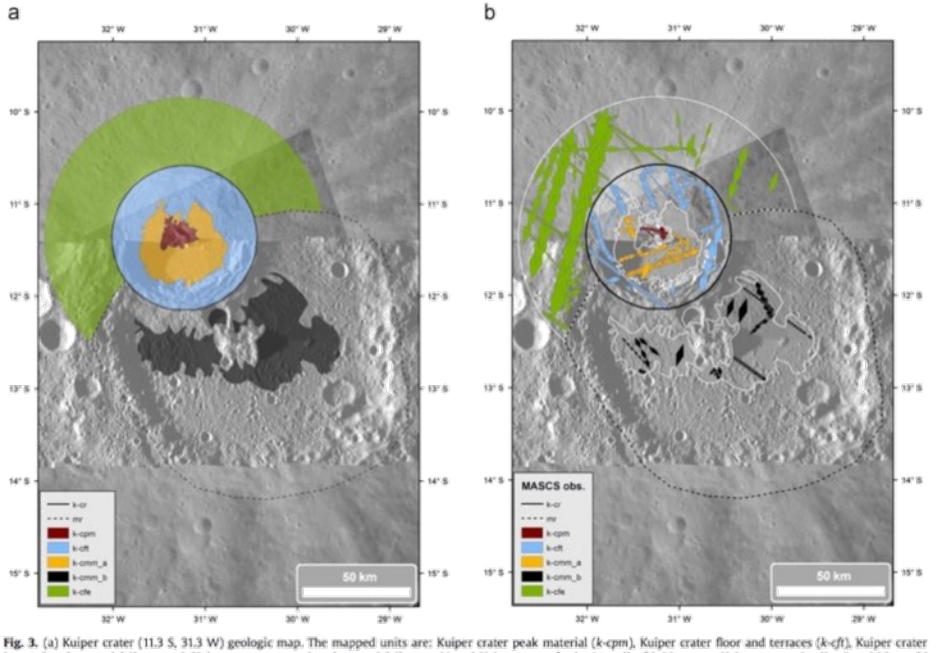


Fig. 3. (a) Kuiper crater (11.3 S, 31.3 W) geologic map. The mapped units are: Kuiper crater peak material (*k-cpm*), Kuiper crater floor and terraces (*k-cft*), Kuiper crater internal melt material (*k-cmm_a*), Kuiper crater external melt material (*k-cmm_b*) and Kuiper crater fresh ejecta (*k-cfe*). Moreover, Kuiper crater rim (*k-cr*) and Murasaki crater rim (*mr*) are defined. (b) MASCS coverage over Kuiper crater (11.3 S, 31.3 W). Polygons represent MASCS footprints and have been color coded to match the different geologic units displayed in 3a. Both panels use MDIS NAC images EN0223659984M, EN0228372224M, EN0228372226M, EN0228372268M and EN0228372270M overlain on MDIS WAC image EW0234436341 as their background.

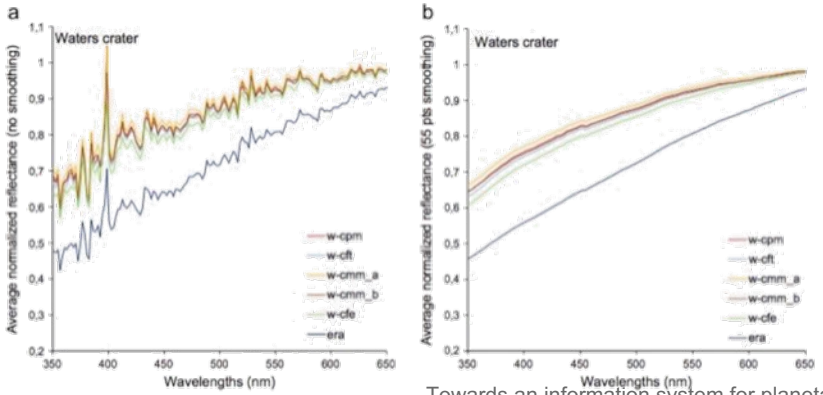


Fig. 5. MASCS mean normalized spectra for Waters crater (8.9 S, 105.4 W). The spectra have been normalized at 700 nm to approximate photometric correction. Each mean spectrum is color coded to match the units displayed in Fig. 2a and the MASCS footprint displayed in Fig. 2b. (a) MASCS mean normalized spectra without smoothing. (b) MASCS mean normalized spectra smoothed with a 55 points sampling interval.

PLANETARY MEETS TERRESTRIAL

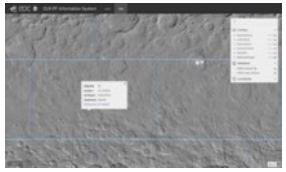
… INFORMATION SYSTEMS

… EOC-GEOSERVICE

… UKIS

DLR

STRUCTURE OF INFORMATION SYSTEMS

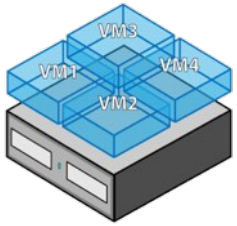


Web client (UKIS)

Data services (EOC-Geoservice)

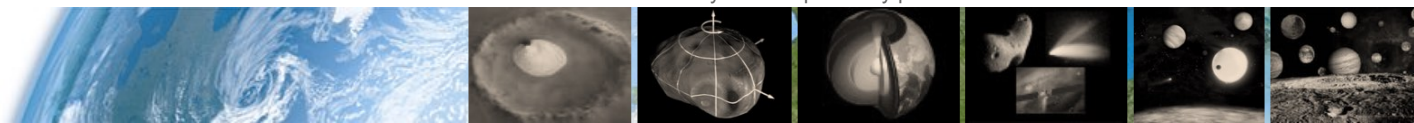
Database (EOC-Geoservice)

Operating system



Virtualization

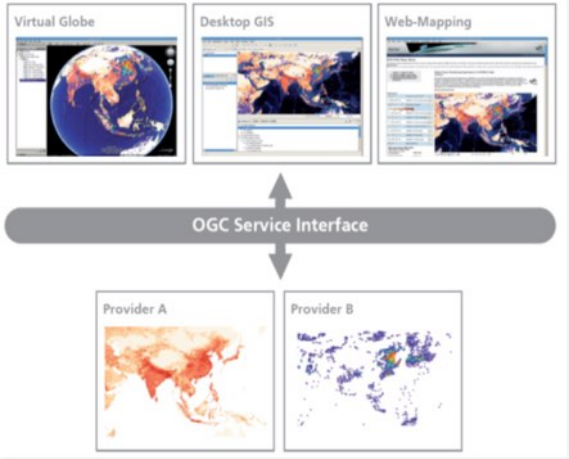
Hardware



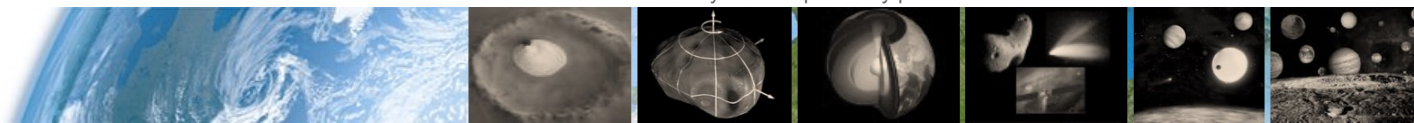
PLANETARY MEETS TERRESTRIAL

EOC-GEOSERVICE

- For users: web-based access to data and products of DLR‘s Earth Observation Center (EOC) via standardized geo data services

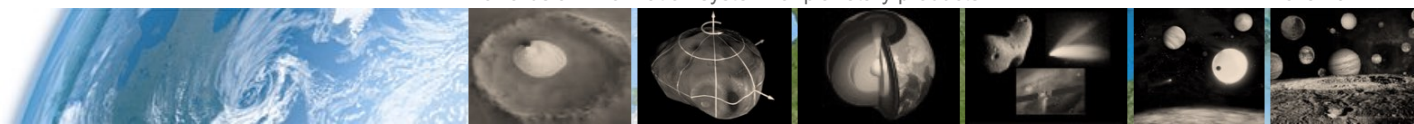


- For EOC: platform for publishing remote sensing data and products



UKIS

- UKIS is an abbreviation for „Umwelt- und Kriseninformationssysteme“ (Environmental and Crisis Information Systems)
- Task: development of reusable software that can be applied in all departments of our institute
- Goal: facilitation and acceleration of the implementation of web-based information systems for environmental and crisis applications
- Trend: open source (on http://github.com/dlr-eoc)



PLANETARY MEETS TERRESTRIAL

UKIS EXAMPLES

ZKI Activations

Earth‘s Gravity Field

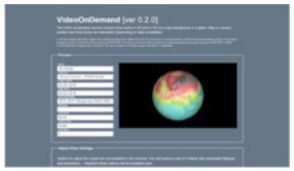
Maritime Safety

SOS Children‘s Villages

Water Detection

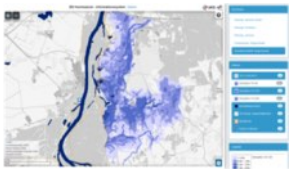
Tsunami Early Warning

Video Production



Snow Cover

Coasts

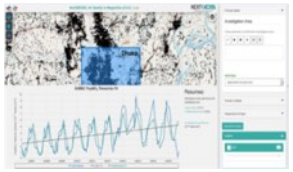


Flood Simulation

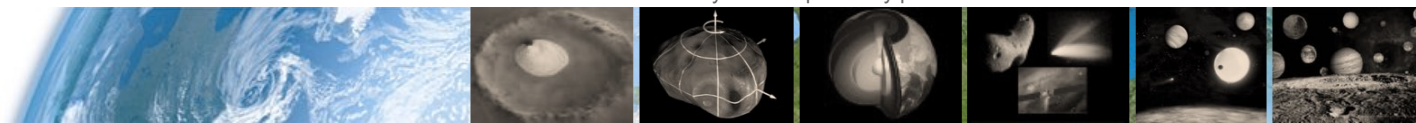
Change Detection

Fire Detection

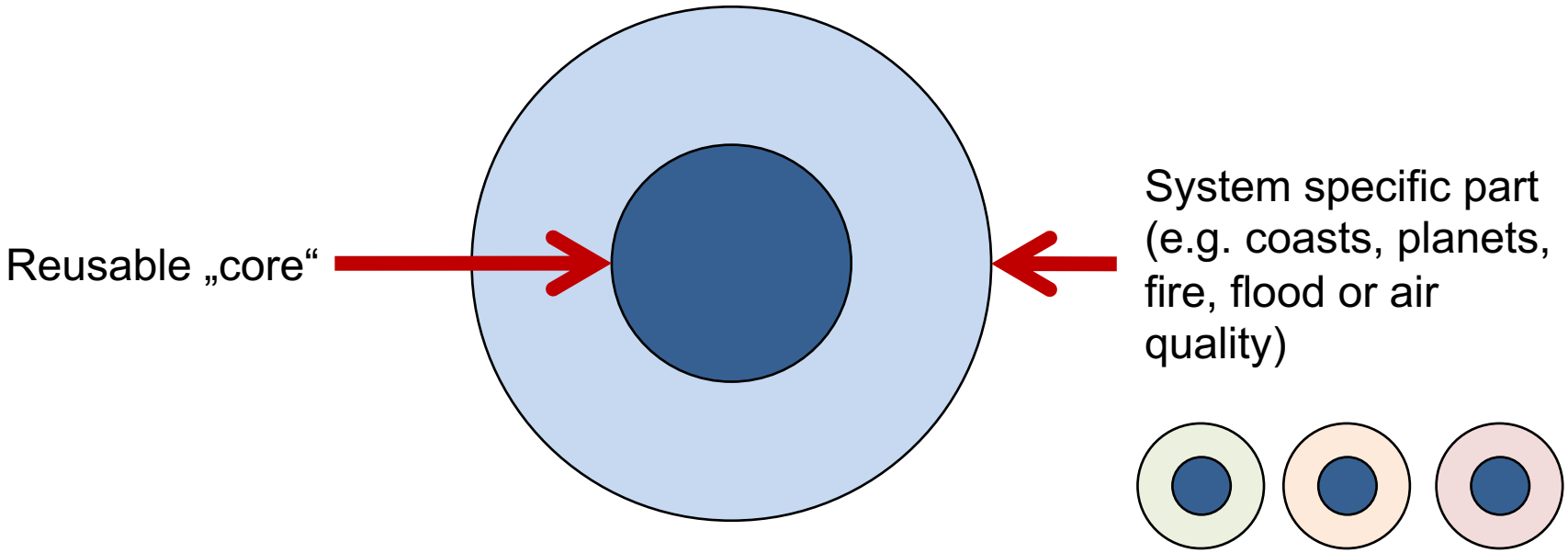
Air Quality



EOC-Geoservice



STRUCTURE OF THE UKIS WEB CLIENT



FIRST IMPLEMENTATION

… QUESTIONS WE LIKE TO ANSWER

… SAMPLE DATA SET

… PROTOTYPE

DLR

FIRST IMPLEMENTATION

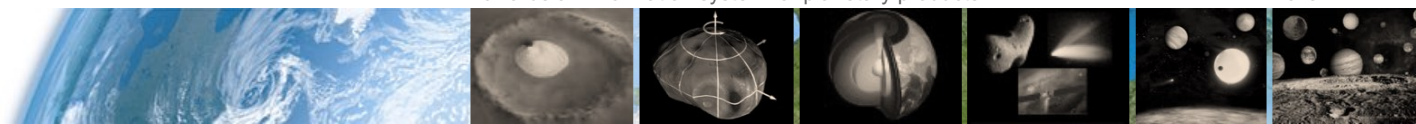
QUESTIONS WE LIKE TO ANSWER

DFD has data of **Earth Observation**, **PF** of **planetary data** .

However, **questions** and challenges are **comparable**:
How data can be

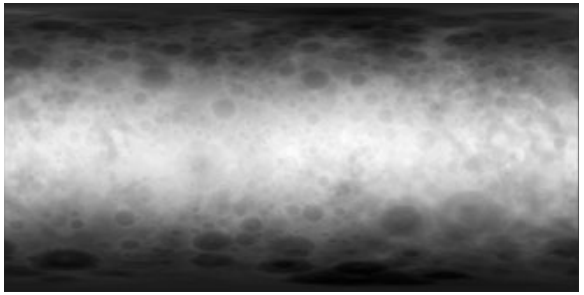
- **structurally organized** (data model),
- **uniformly described** (metadata),
- **commonly accessible** (standards),

- **visualized** and
- **linked to other scientific information** like publication ?

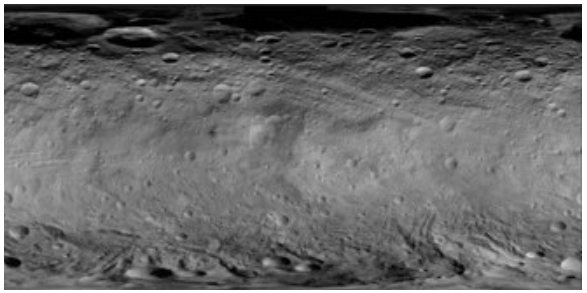


FIRST IMPLEMENTATION

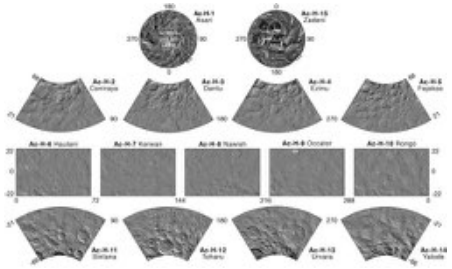
SAMPLE DATA SET – DAWN, CERES



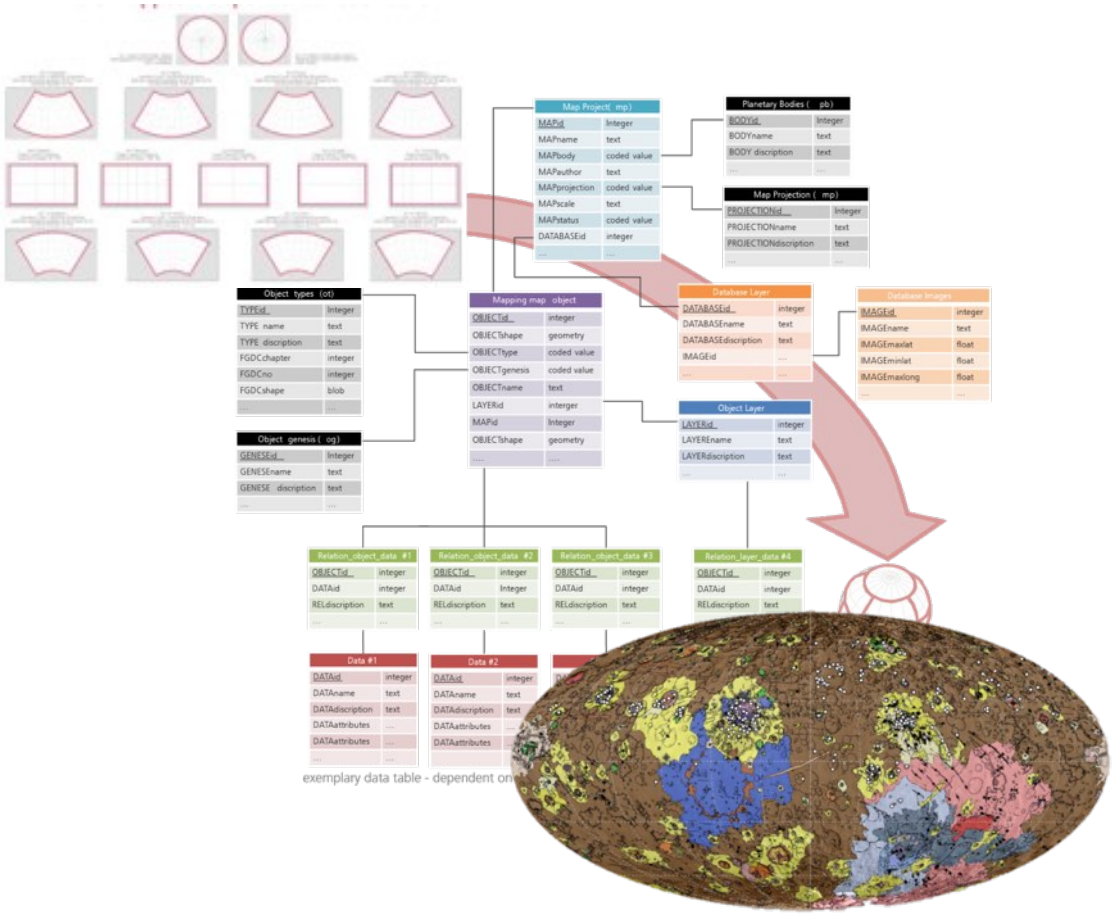
Ceres Dawn FC2 HAMO Global DTM



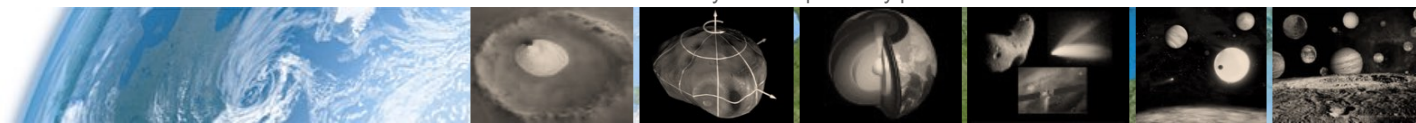
Ceres Dawn FC2 HAMO Global



Roatsch et al (2016) *PSS*



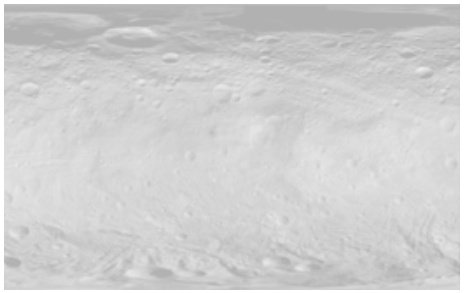
Naß and the Dawn Mapping Team (2019) *EPSC*
Williams (2018) *ICARUS*



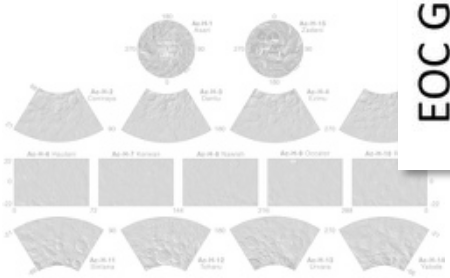
FIRST IMPLEMENTATION

SAMPLE DATA SET – DAWN, CERES

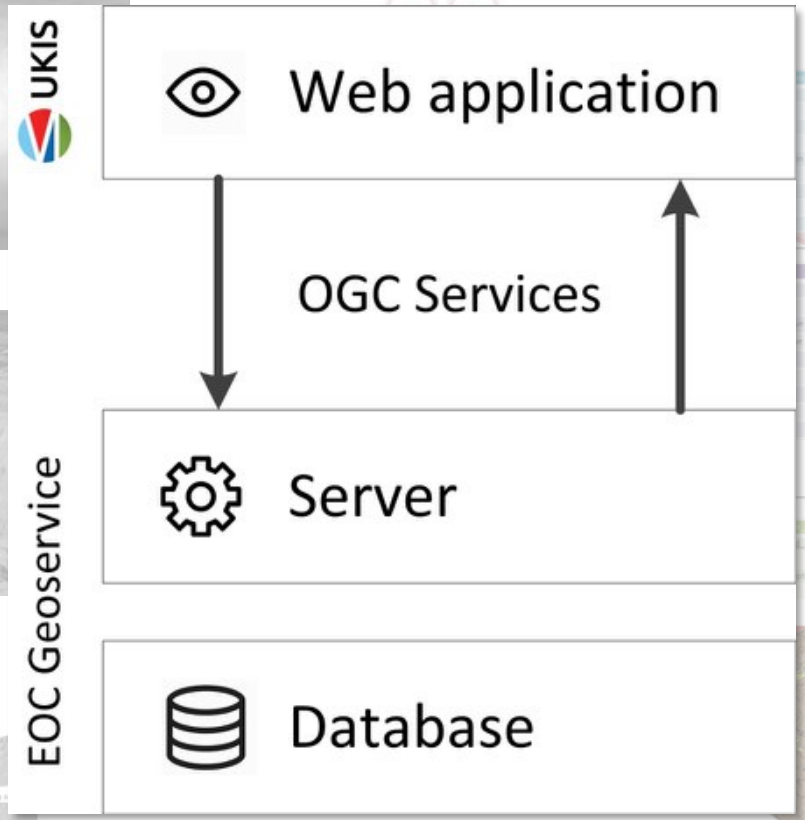
Ceres Dawn FC2 HAMO Global DTM



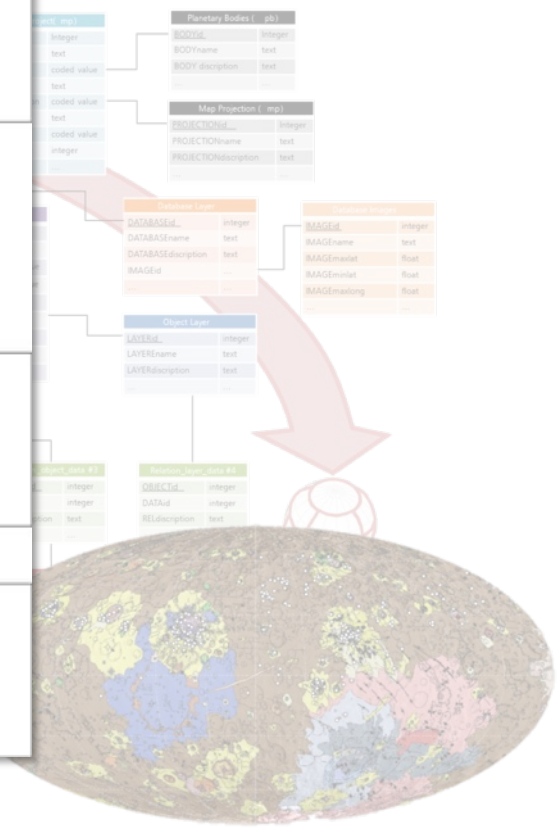
Ceres Dawn FC2 HAMO Global



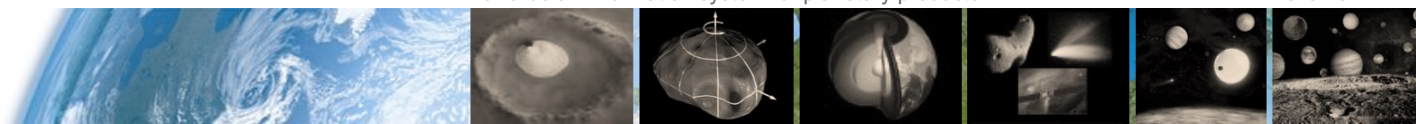
Roatsch et al (2016) *PSS*



Schematic structure of DLR's EOC Geoservie and UKIS.
Naß, d'Amore, Mühlbauer, Heinen, Böck,
Helbert, Riedlinger, Jaumann, Strunz (2020) LPSC, EGU

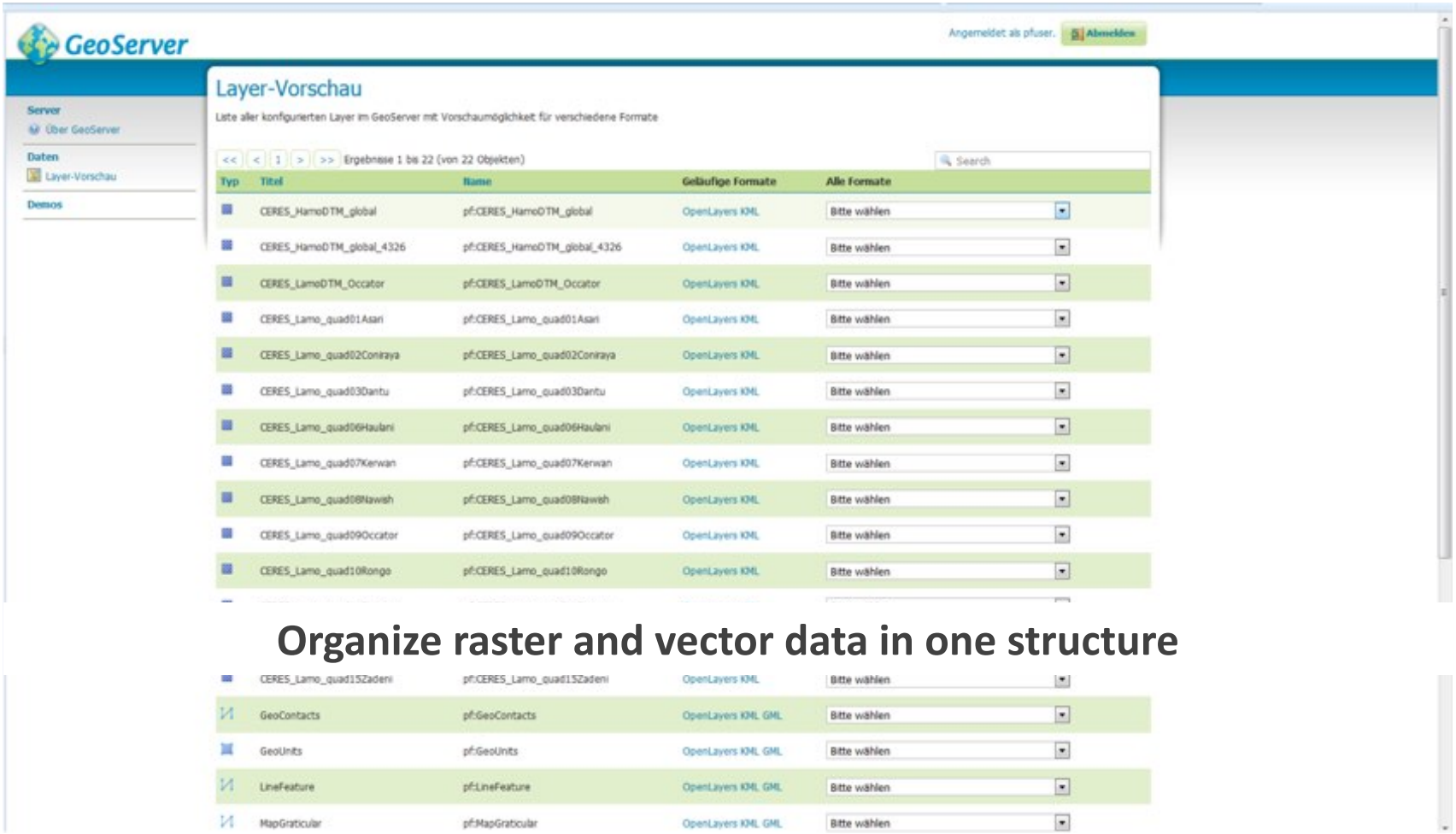


Naß and the Dawn Mapping Team (2019) *EPSC*
Williams (2018) *ICARUS*

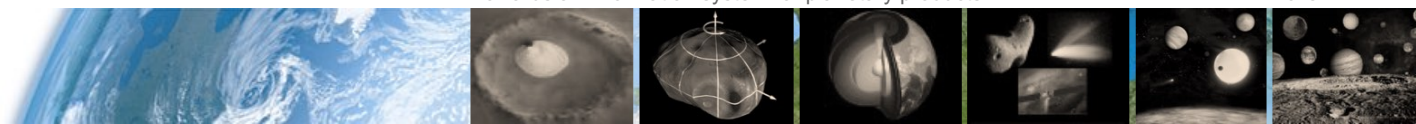


FIRST IMPLEMENTATION

EOC GEOSERVICE, GEOSERVER

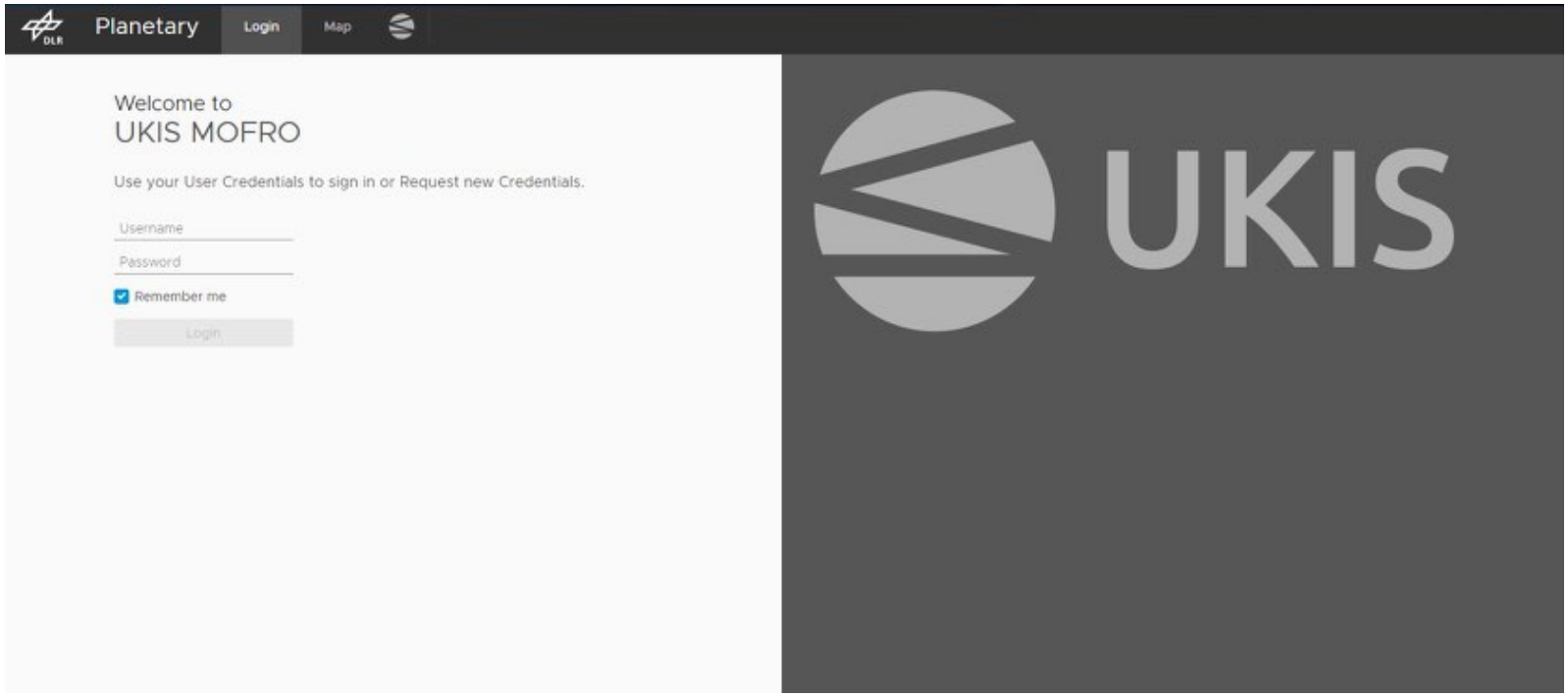


Organize raster and vector data in one structure



FIRST IMPLEMENTATION

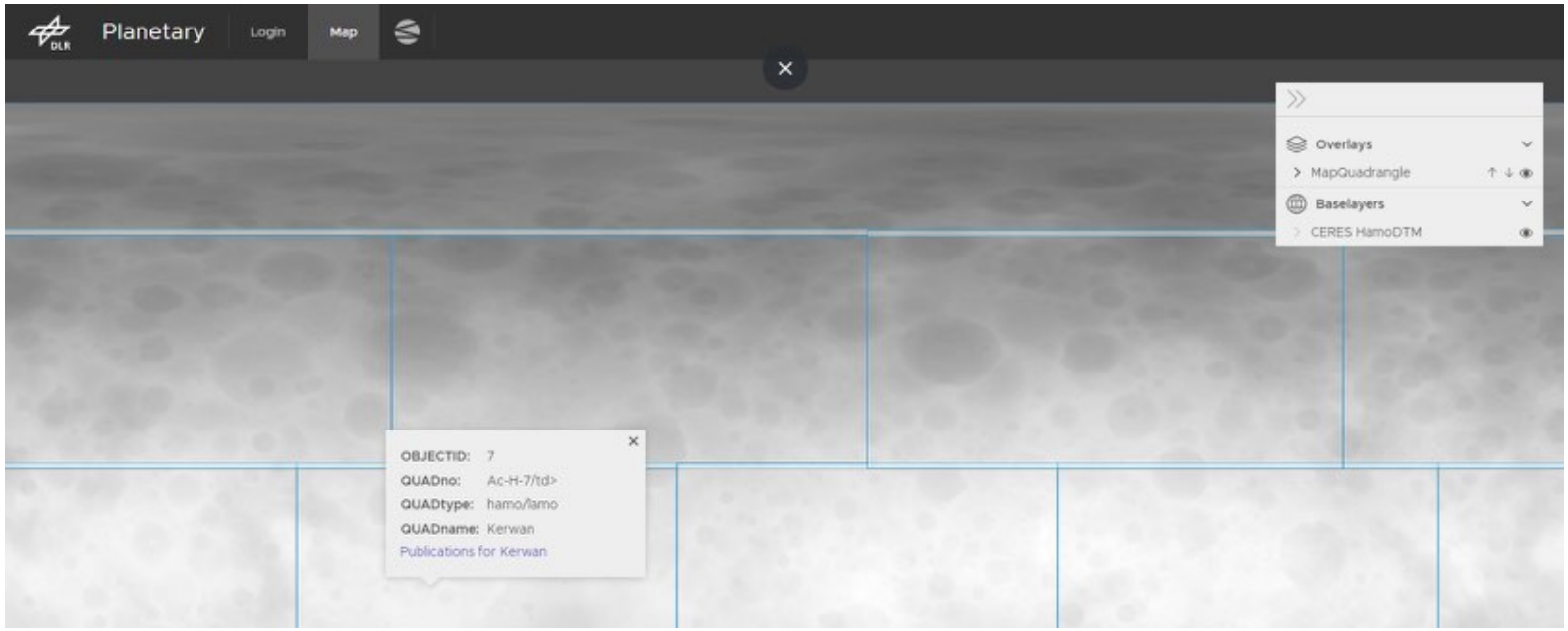
UKIS-BASED INFORMATION SYSTEM FOR PF



Login GUI for the users

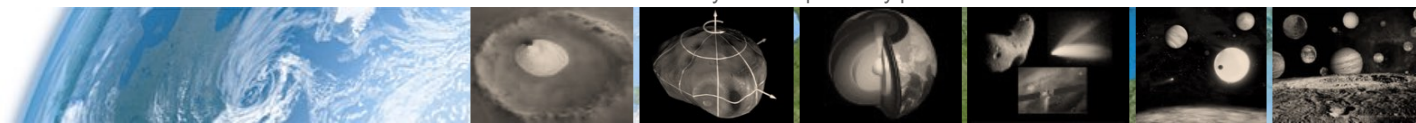
FIRST IMPLEMENTATION

UKIS-BASED INFORMATION SYSTEM FOR PF



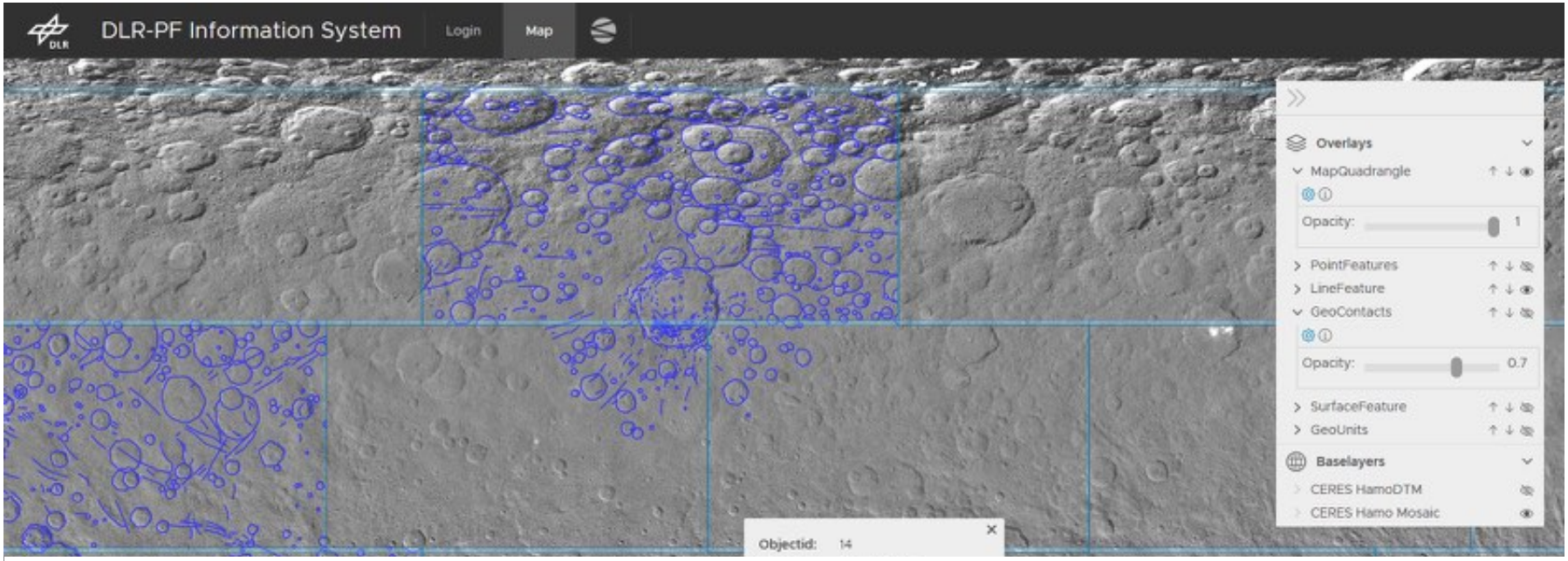
Global Datasets

DTM + quadrangle borders + add attributes



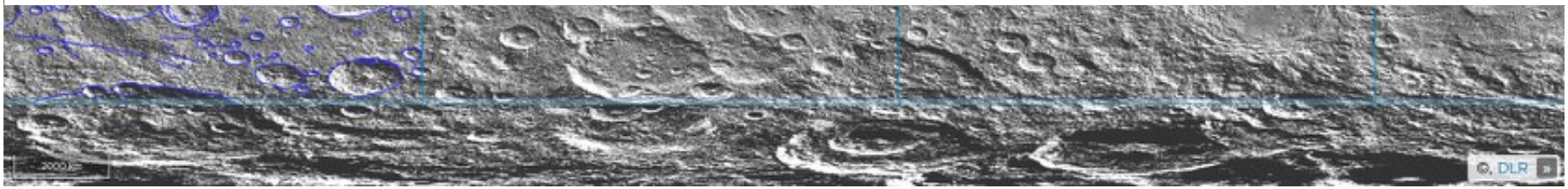
FIRST IMPLEMENTATION

UKIS-BASED INFORMATION SYSTEM FOR PF



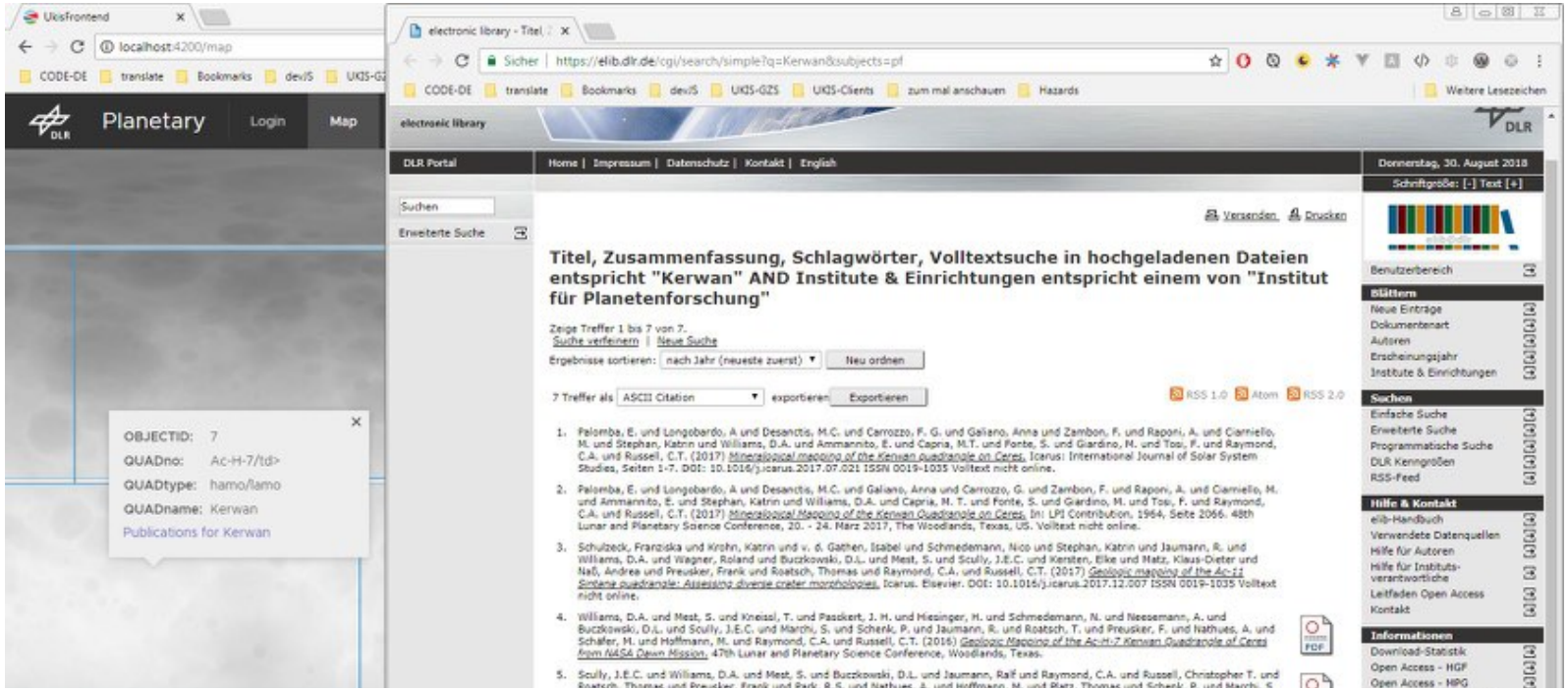
Global Datasets

HAMO mosaic + Geologic mapping examples



FIRST IMPLEMENTATION

UKIS-BASED INFORMATION SYSTEM FOR PF



Crosslink to ELIB via metadata and attributes

FIRST IMPLEMENTATION

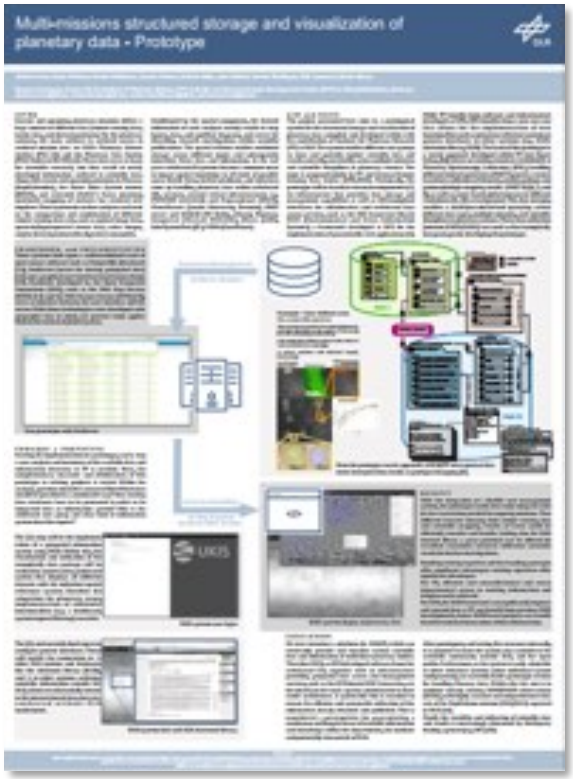
NEXT STEPS

- **discuss** current implementation **with planetary colleagues at LPSC** and the **terrestrial community at EGU**

- **Prototype for Mercury** in preparation to BepiColombo
- **Prototype for Mars** as conclusive status of HRSC

- Look for **more case studies**

- **Metadata** for **describe** data **as uniform as possible** and **flexible as necessary.**



Naß, d'Amore, Mühlbauer, Heinen, Böck, Helbert, Riedlinger, Jaumann, Strunz (2020) LPSC, EGU

BENEFIT FOR US

… SPATIAL AND TEMPORAL POTENTIAL

… PROVISIONING RESEARCH DATA

… SUSTAINABLE SOFTWARE

… CHALLENGES

… BUT!

DLR

BENEFIT

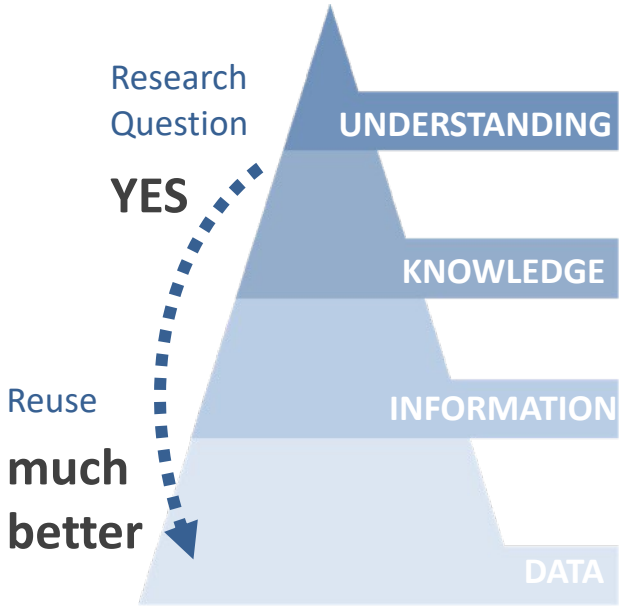
BUT …

before we can continue we need to discuss

…. Funding?
…. Responsibility?
…. Data Models ?
…. User groups?
…. Sustainability?
…. Re-use?

Furthermore, **topics** like

…. Semantic search?
…. Linked data Open | linked data?
…. Text Analyses?
…. Ontology?



And this is where we like to start the discussion …

THANK YOU!

Mario d' Amore, Andrea Naß, Martin Mühlbauer, Torsten Heine, Mathias Boeck, Jörn Helbert, Torsten Riedlinger, Ralf Jaumann und Günter Strunz

German Aerospace Center (DLR) Berlin and Oberpfaffenhofen

Contact

Mario.dAmore@dlr
Andrea.Nass@dlr.de
Martin.Muehlbauer@dlr.de

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