The Edge of the World and Beyond

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DR.
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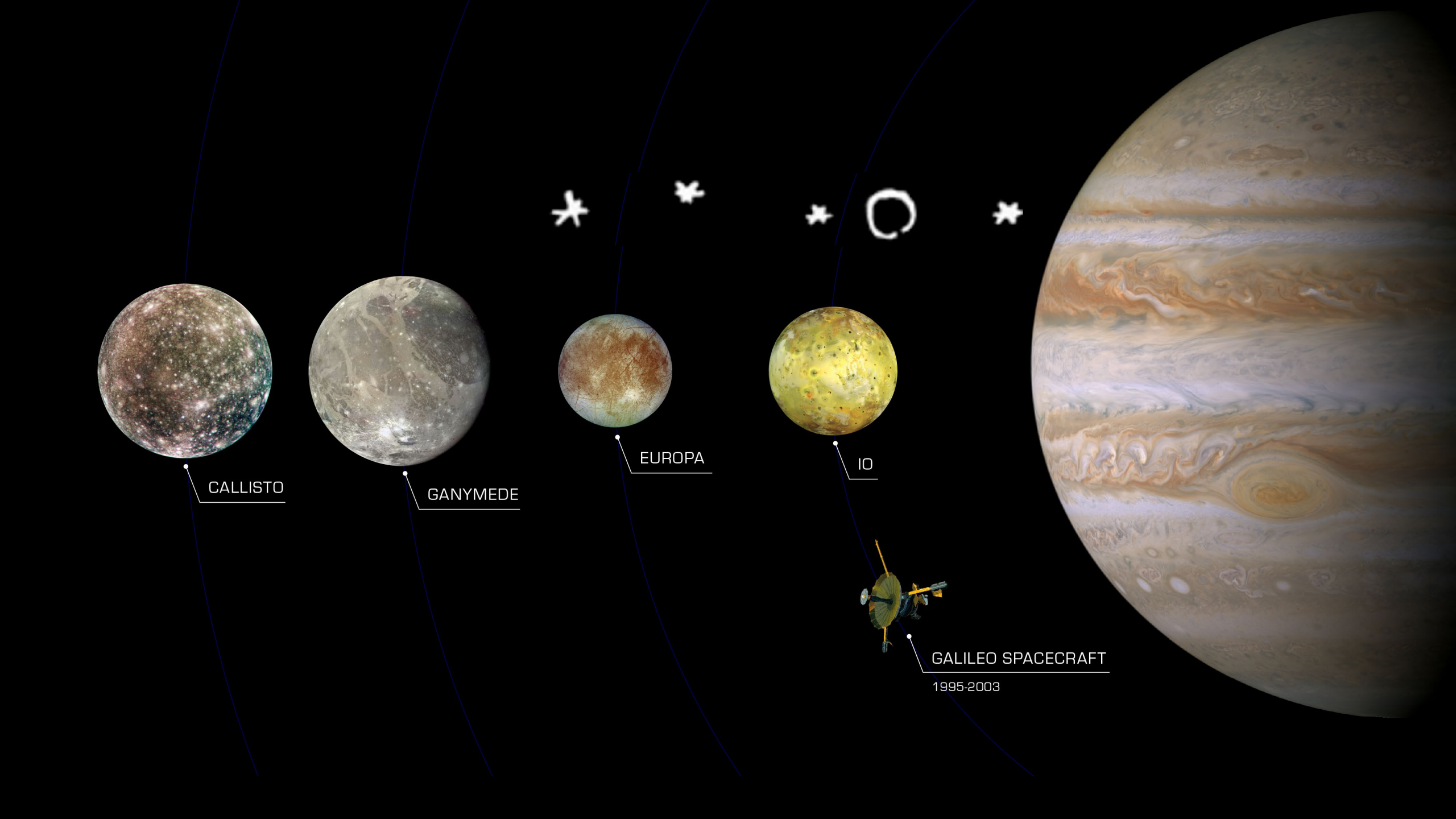
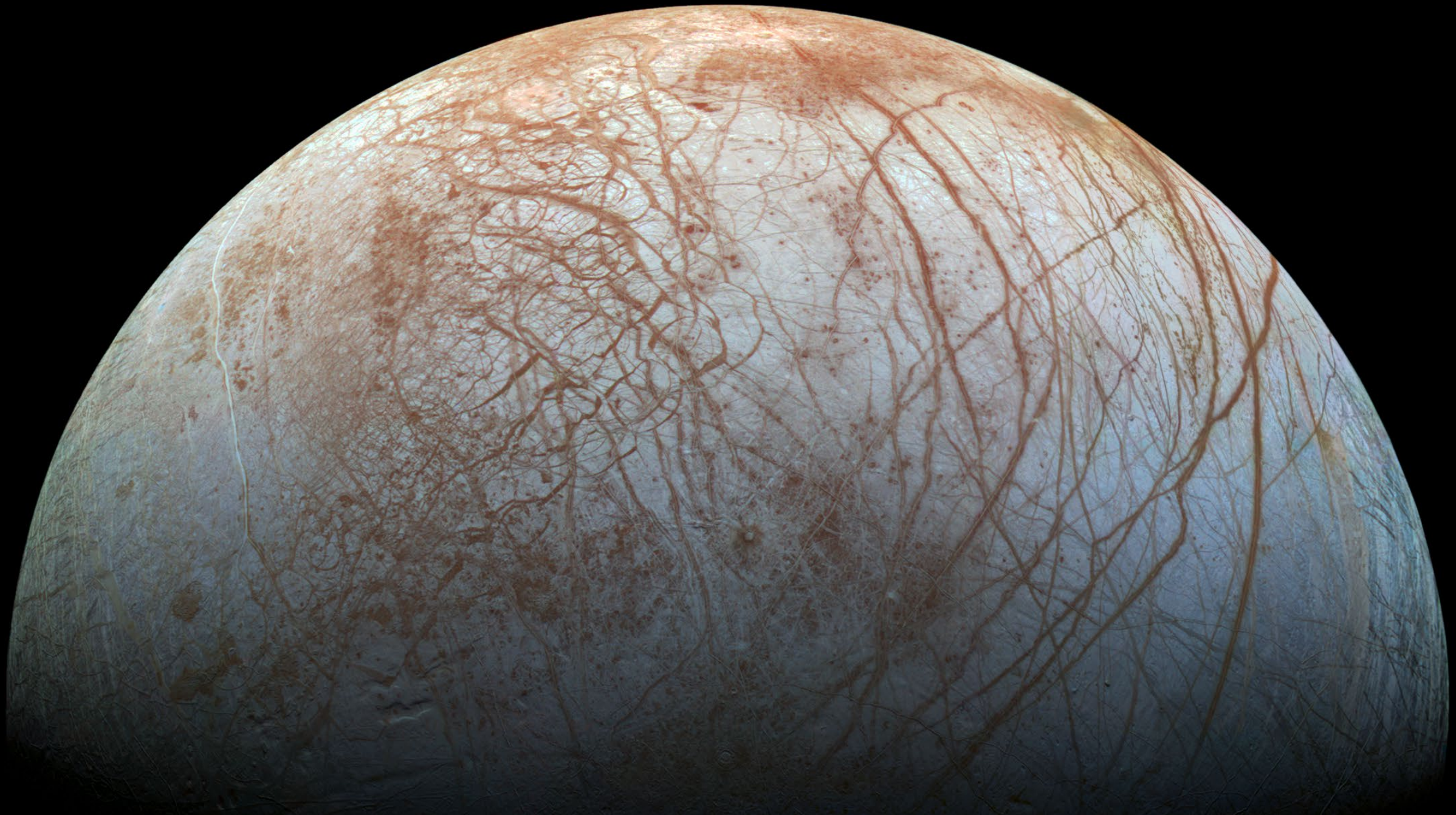
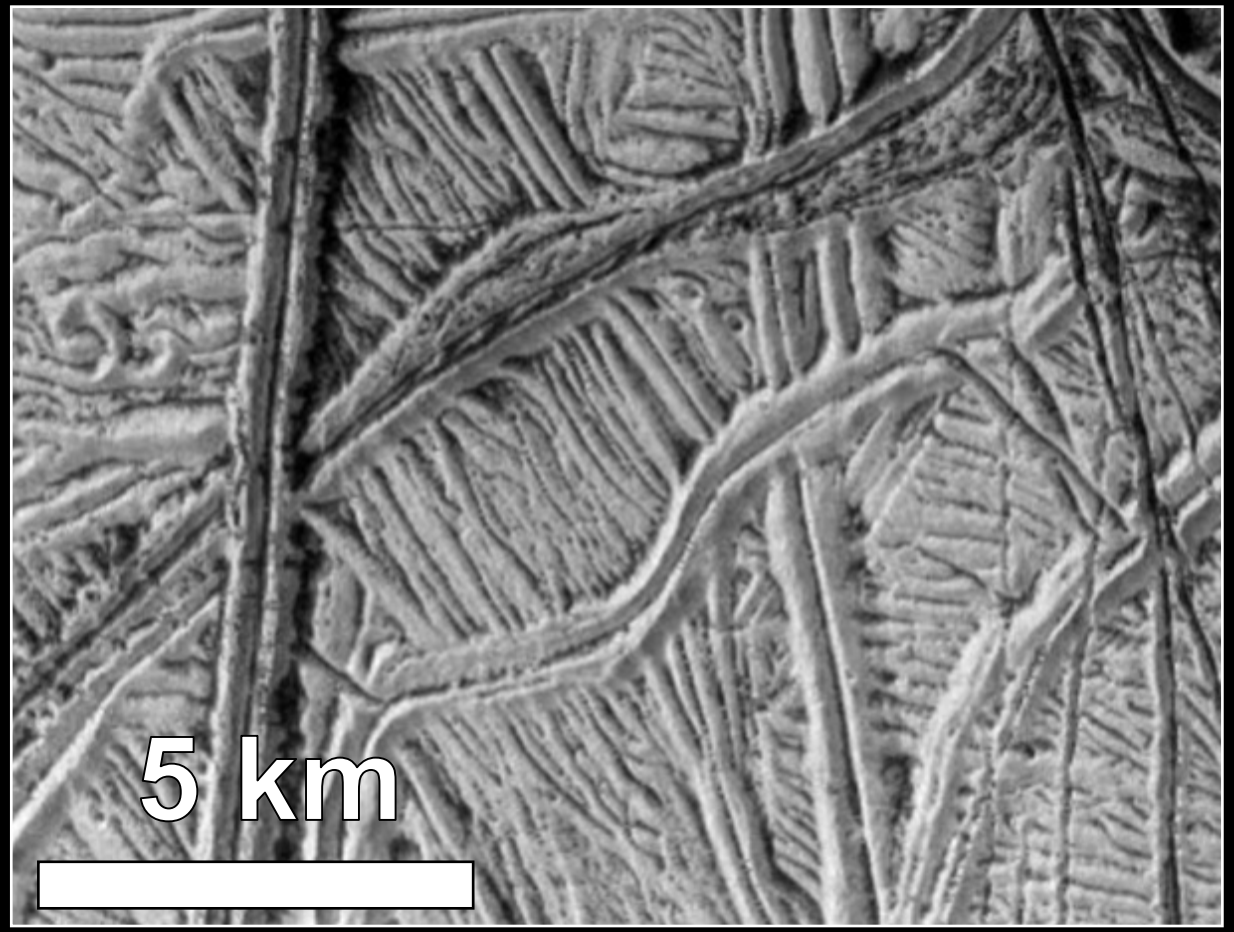

CALLISTO
GANYMEDE
EUROPA
IO
GALILEO SPACECRAFT
1995-2003



Europa's Surface

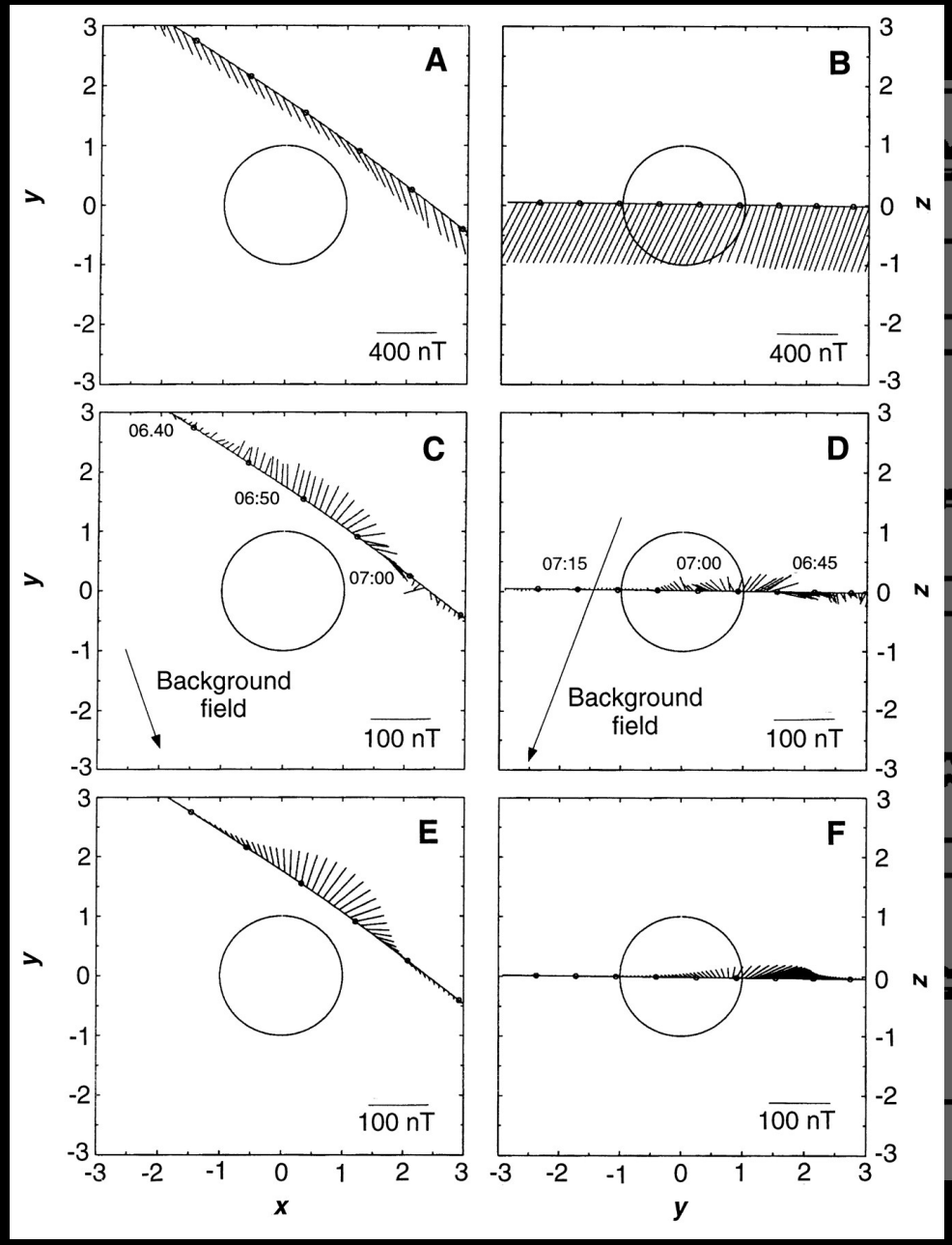
RIDGED PLAINS

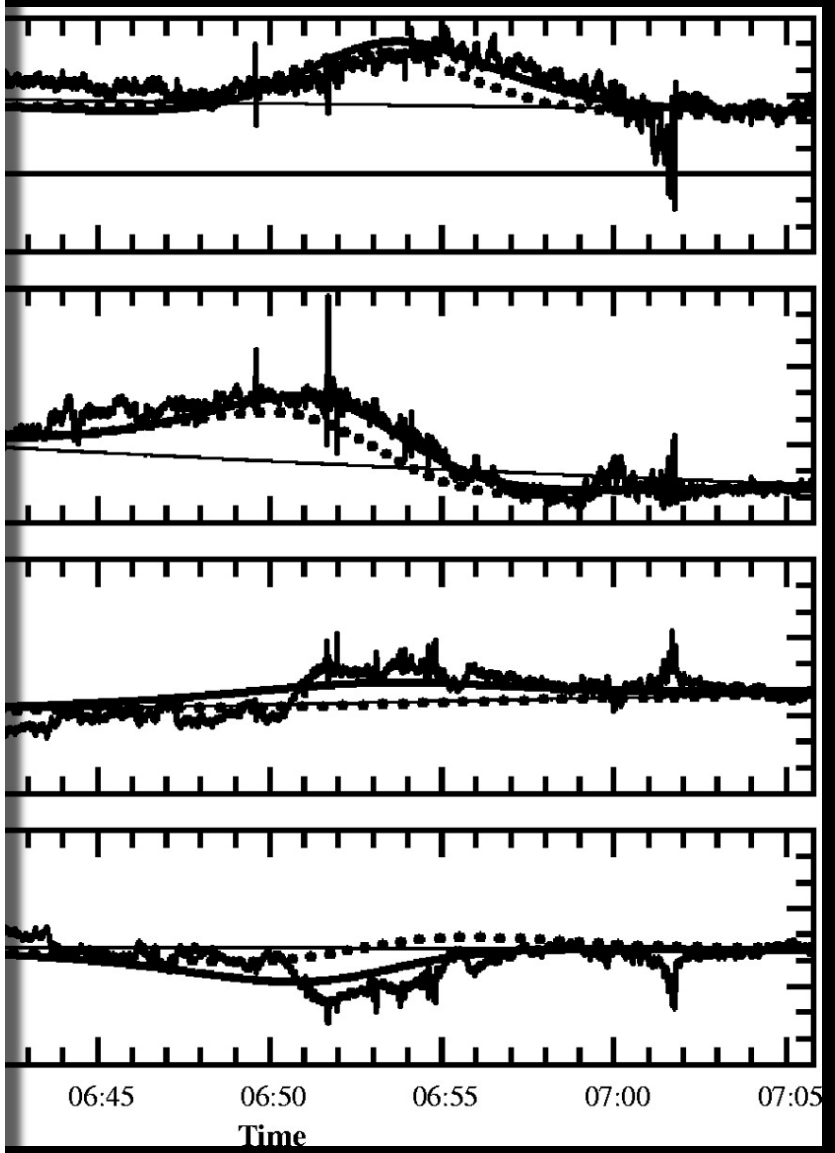


Europa's Surface

CRATERS

Dr. M. Kivelson
Discovery: 1997





Cross-Section of Europa

Surface Ice Crust
Ridged and fractured ice formations

Thick Ice Shell
Layers beneath the surface

Subsurface Ocean
Liquid water ocean

Rocky Seafloor
Silicate rock core and potential hydrothermal activit

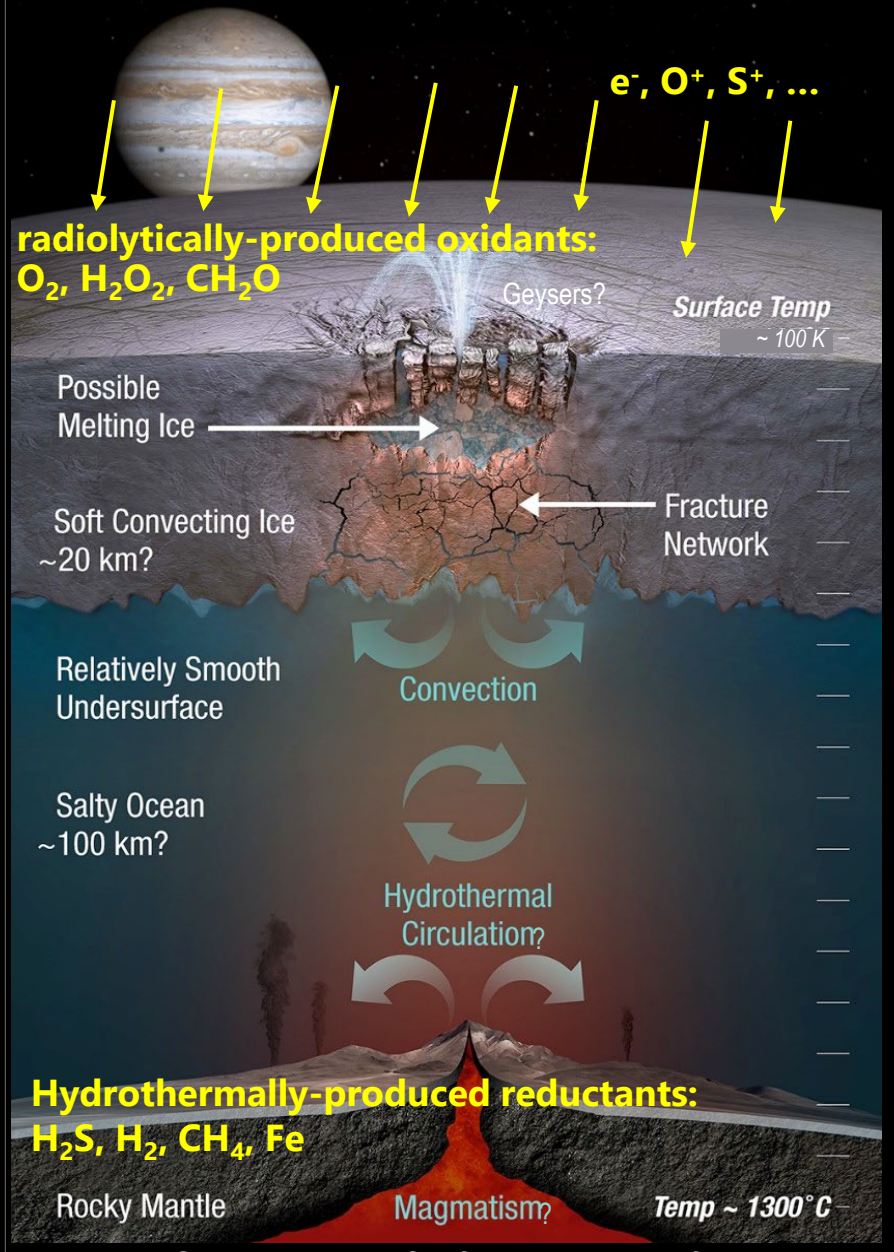
Ingredients of Life?

Water
Much more than all of Earth's oceans

Essential Elements
From formation and impacts

Chemical Energy
From above and below

Stability
"Simmering" for 4 billion years



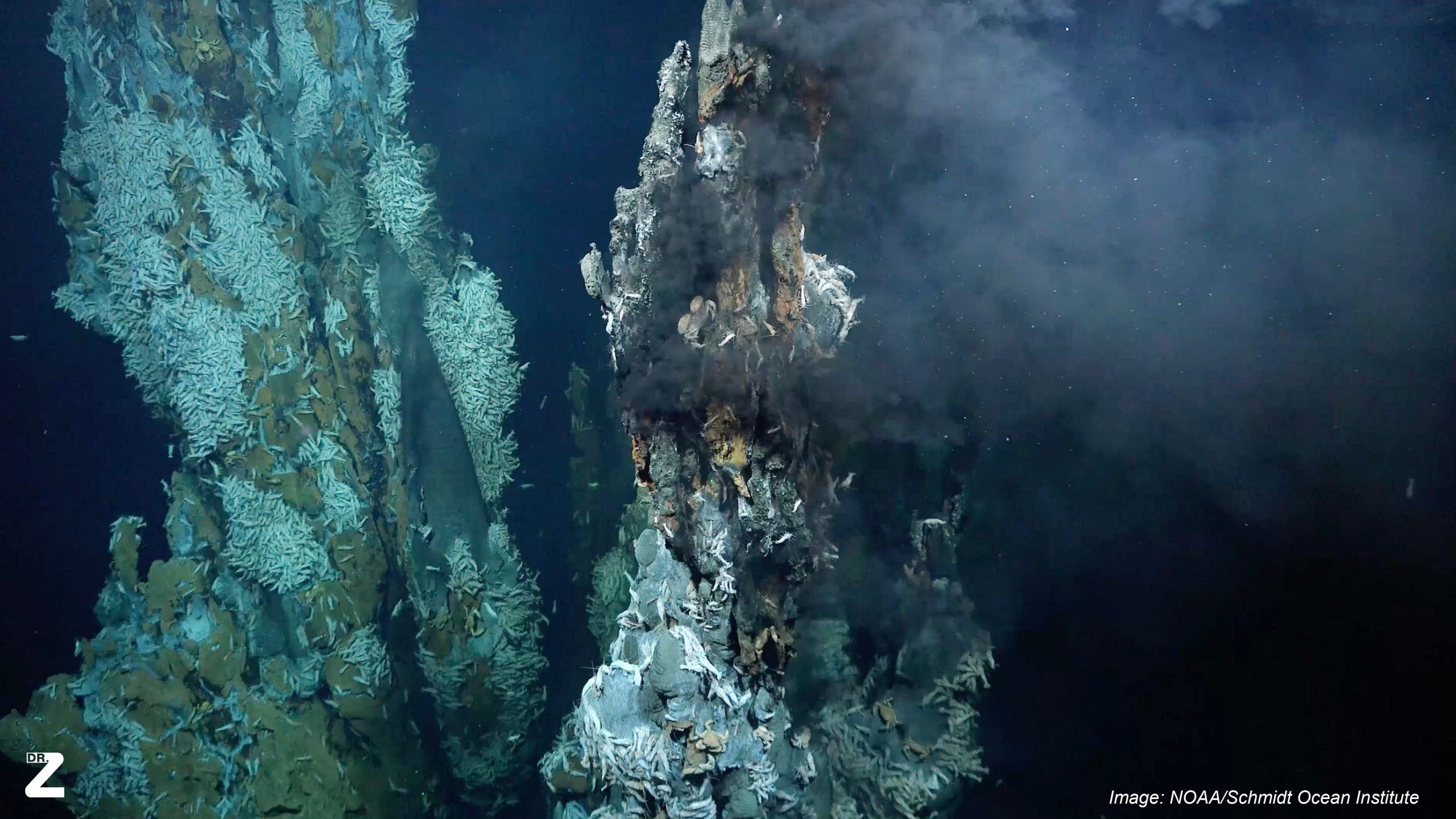
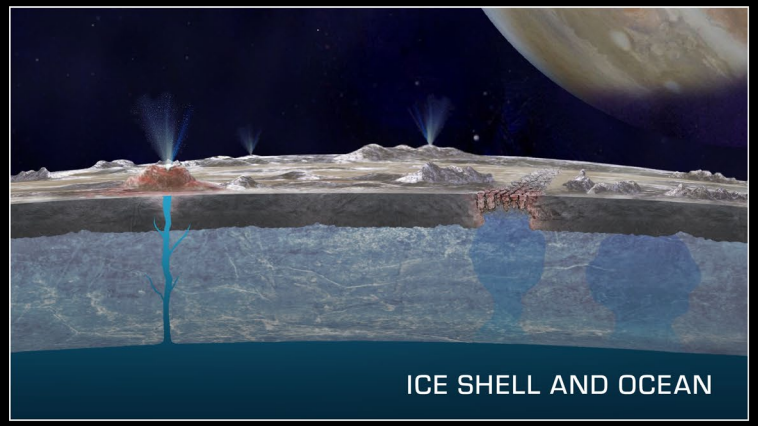
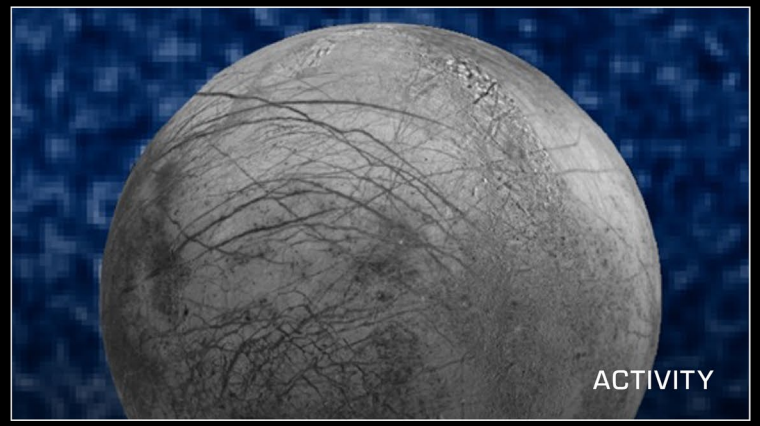


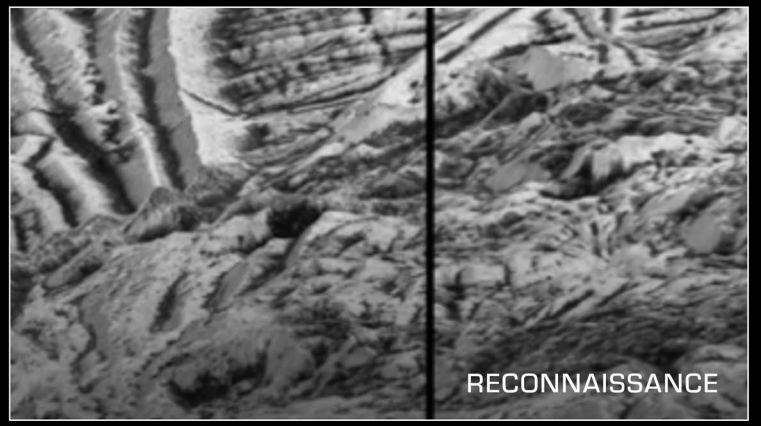
Image: NOAA/Schmidt Ocean Institute

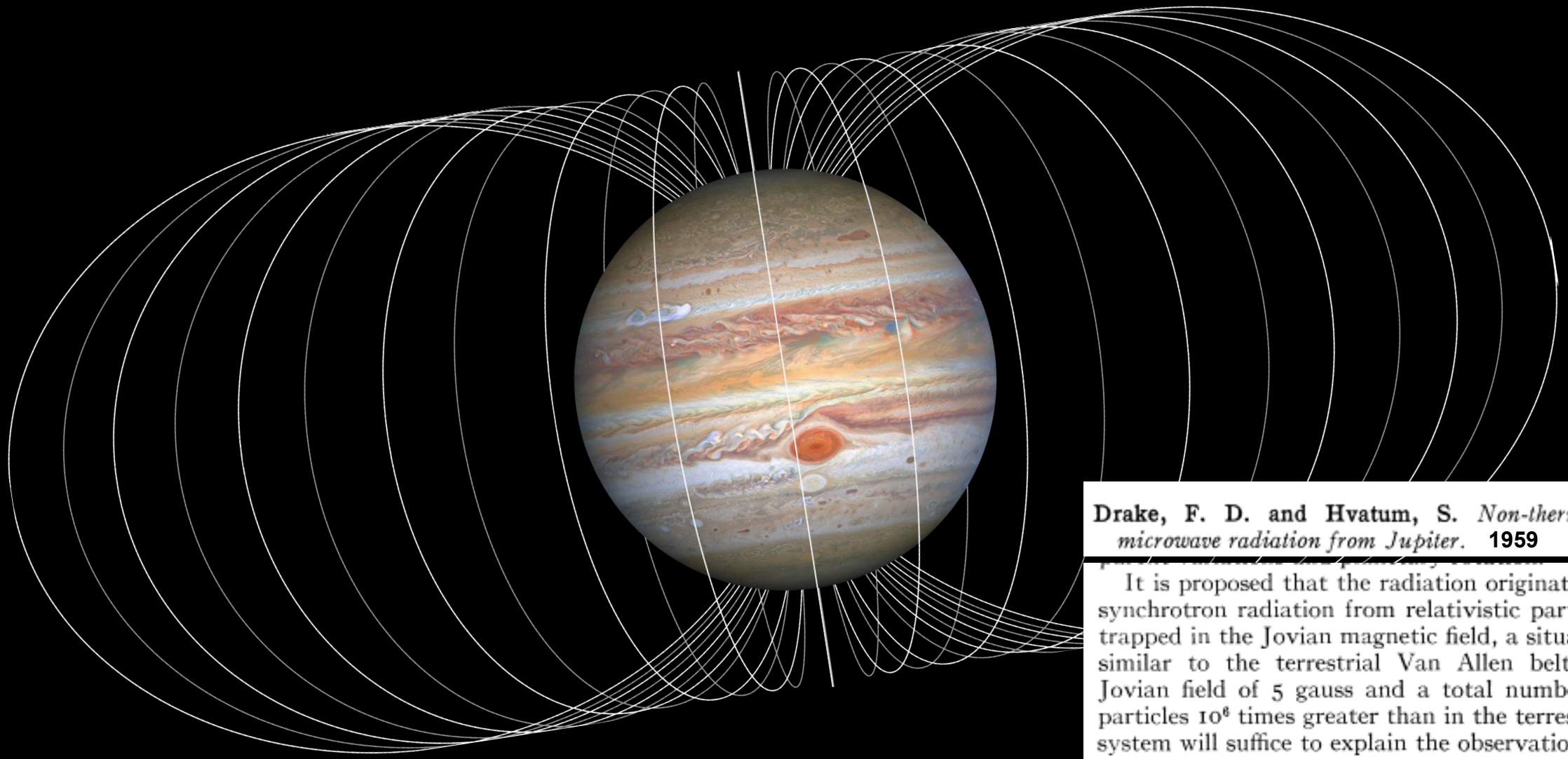
Europa Clipper Mission Science

GOAL: TO EXPLORE EUROPA AND INVESTIGATE ITS HABITABILITY







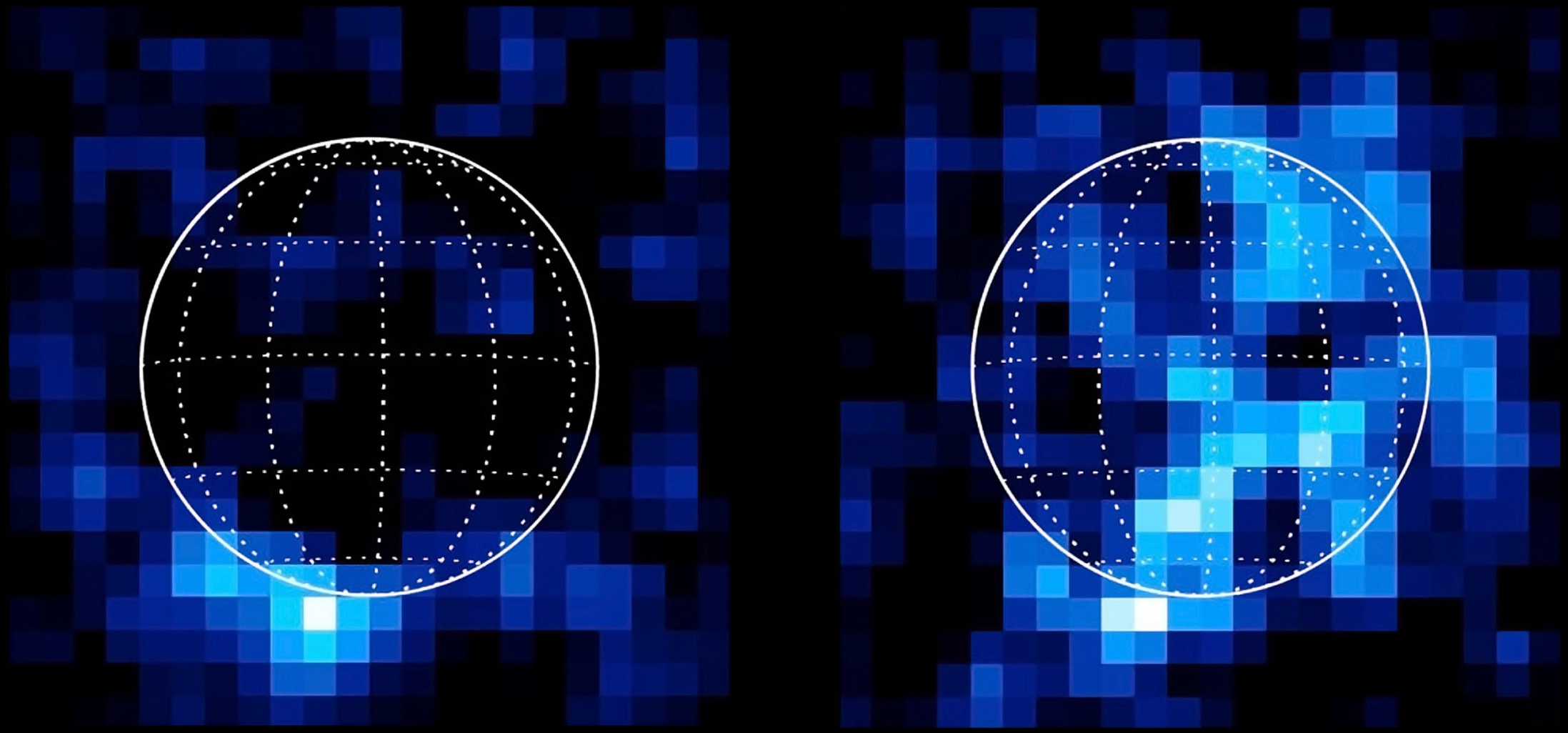


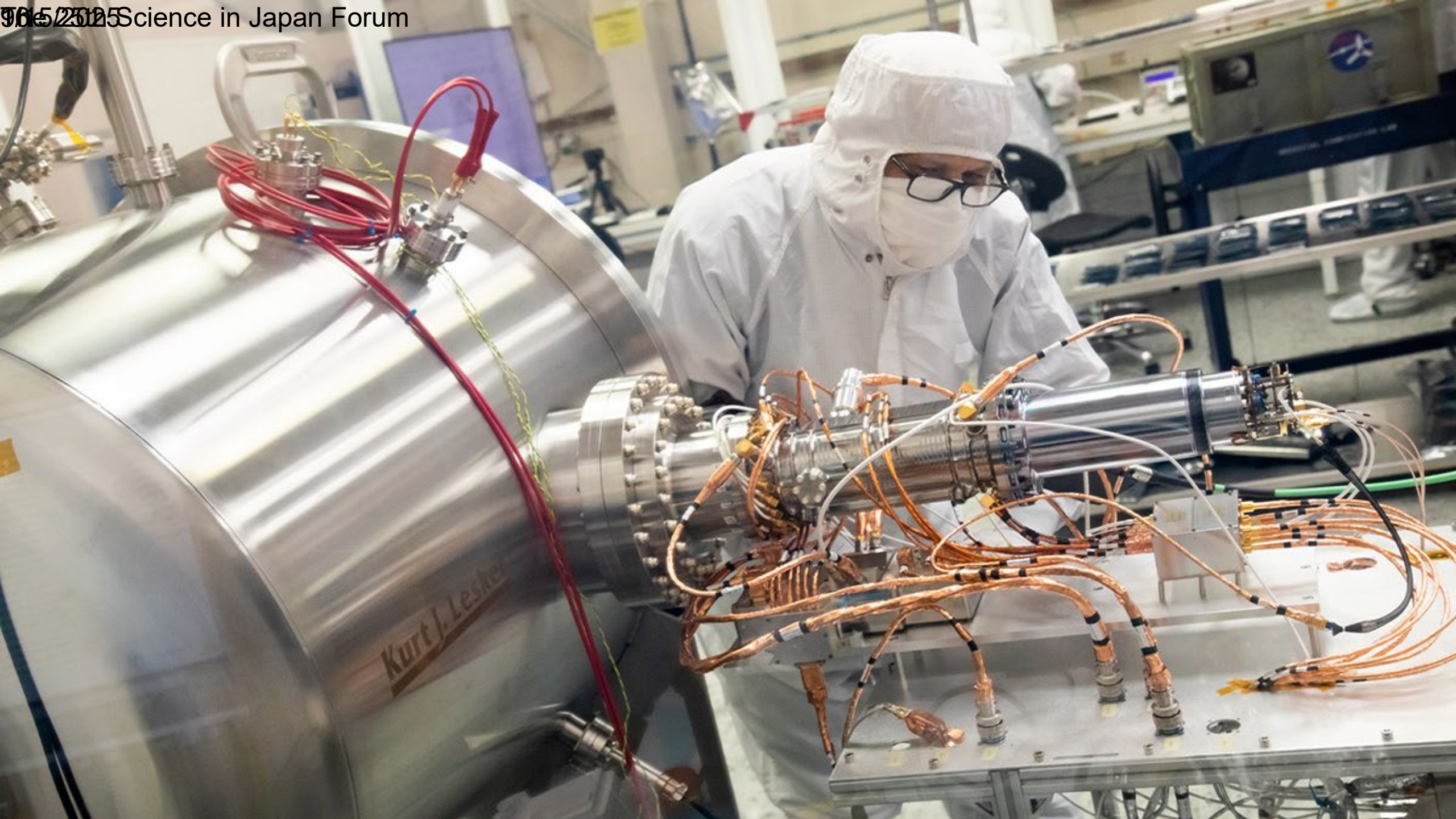
Drake, F. D. and Hvatum, S. *Non-thermal microwave radiation from Jupiter.* **1959**

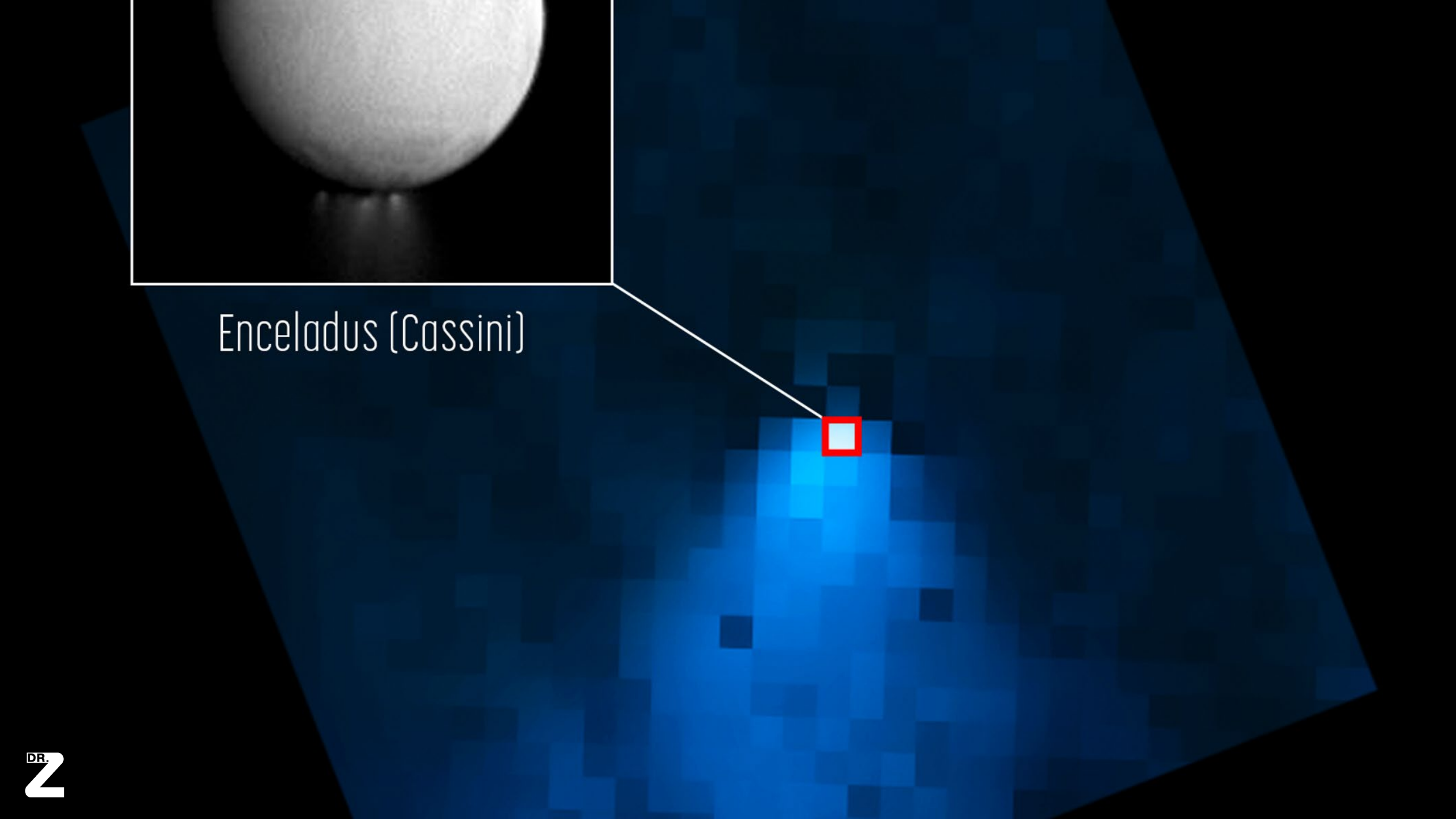
It is proposed that the radiation originates as synchrotron radiation from relativistic particles trapped in the Jovian magnetic field, a situation similar to the terrestrial Van Allen belts. A Jovian field of 5 gauss and a total number of particles 10^6 times greater than in the terrestrial system will suffice to explain the observations.

National Radio Astronomy Observatory
Green Bank, W. Va.

Plumes?


Hydrogen
Oxygen


Kurt J. Lesker


Enceladus (Cassini)

ESA L4 – Enceladus Mission

- ESA’s next large mission: to explore the moons of the giant planets
- Science focus: a Saturn tour with an Enceladus lander, plume sampling & in-situ life detection
- Science Expert Committee (EC): defined mission priorities — Enceladus lander + plume sampling
- Payload Working Group (PWG): shaping strawman payload & technology roadmap until 2026

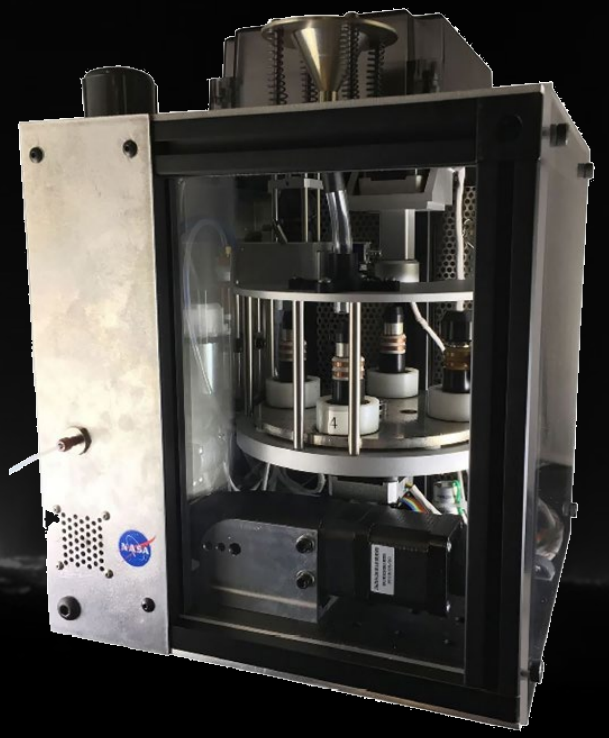
Swiss members

Prof. Audrey Vorburger
University of. Bern,
Expert Committee

Dr. Florian Kehl
ETH/UZH, Payload Working Group

Enceladus Sample Acquisition & Extraction

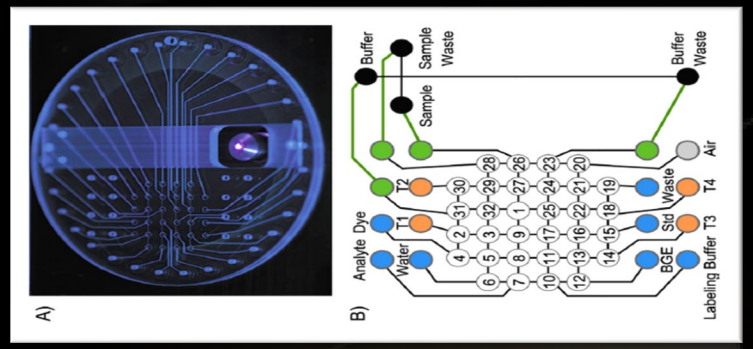
- Challenge at Enceladus: ice samples must be acquired, melted & organics released
- JPL extractor prototype with on-going Swiss collaboration: automated subcritical water system for extraction of biomolecules
- Field-tested in Atacama Desert rover mission
- SPI relevance: test next-gen extractors in Arctic/Antarctic ice analog



Kehl et al. 2019

Microfluidic Organic Analyzer

- JPL Collaboration: Capillary electrophoresis with laser-induced fluorescence (CE-LIF): detects amino acids at parts-per-trillion, including chirality (key biosignature)
- Swiss fluid handling module: reagent storage, fluid routing, and clean transfer of icy samples to analyzers
- Lab-on-a-Chip study for in-situ life detection on Enceladus (ETH & CSEM, ESA contract)
- Polar & Alpine sites as testbeds for low-biomass, icy-world analog experiments



Mora & Kehl et al. 2020

Willis et al.

:: csem

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Here‘s an Idea – How about we establish a **„Swiss Ocean Worlds Polar Testbed“?**

- **Analogue environments:** Arctic/Antarctic sites + Swiss glaciers as stand-ins for Enceladus/Europa conditions
- **Astrobiology focus:** labs for biosignature detection, contamination control, ultra-low bioload experiments
- **Technology testbed:** validation and verification of sample handling, in-situ chemical analyzers, and life detection instruments
- **Robotics & access:** testing drills, legged robots, and autonomous systems on ice and permafrost terrain
- **Swiss ecosystem:** ETH, universities, SPI, WSL + industry provide cross-disciplinary expertise
- **International collaboration:** open platform inviting ESA, NASA, and global partners, i.e. also climate scientists

AI generated

F. Kehl

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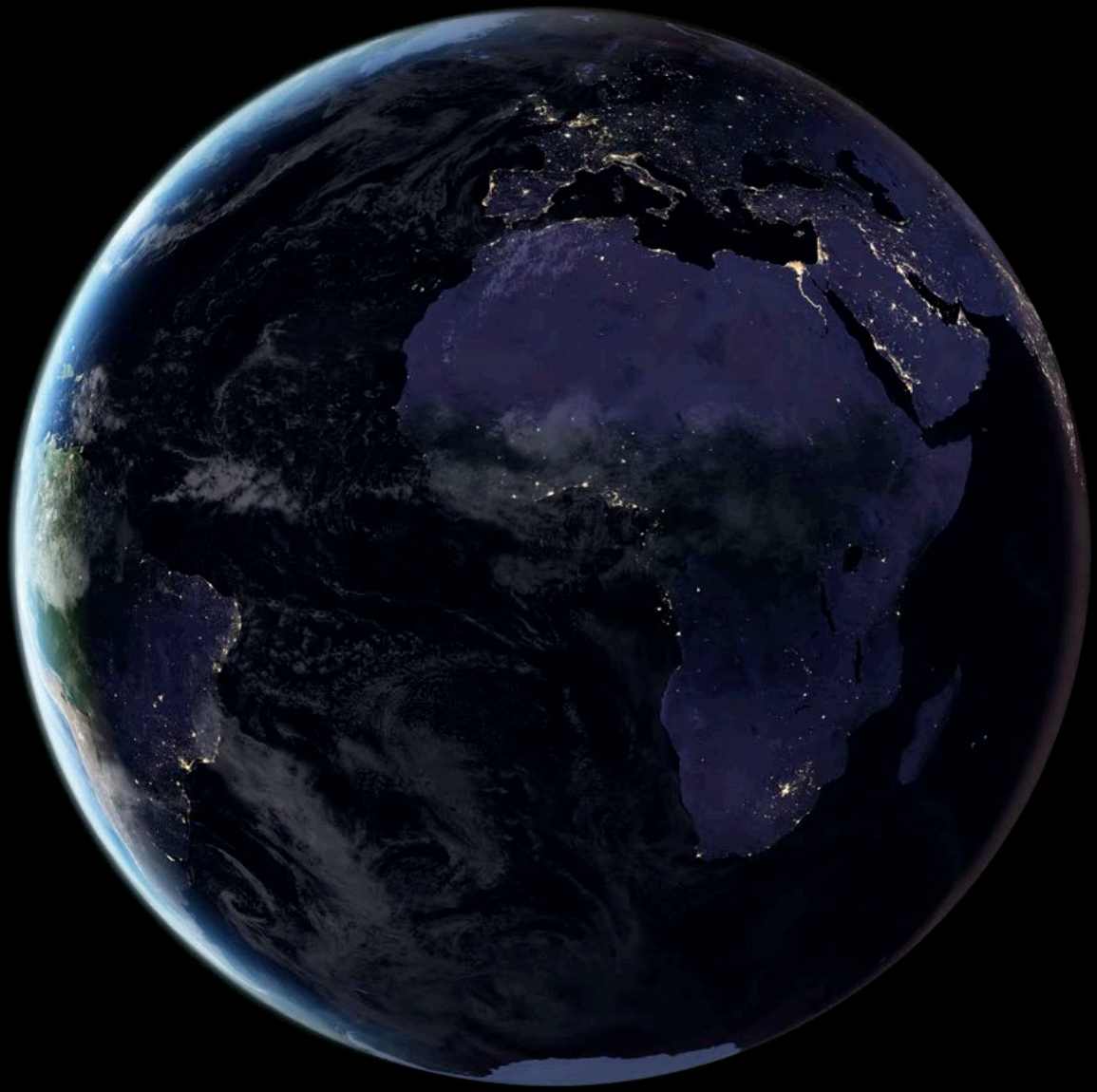
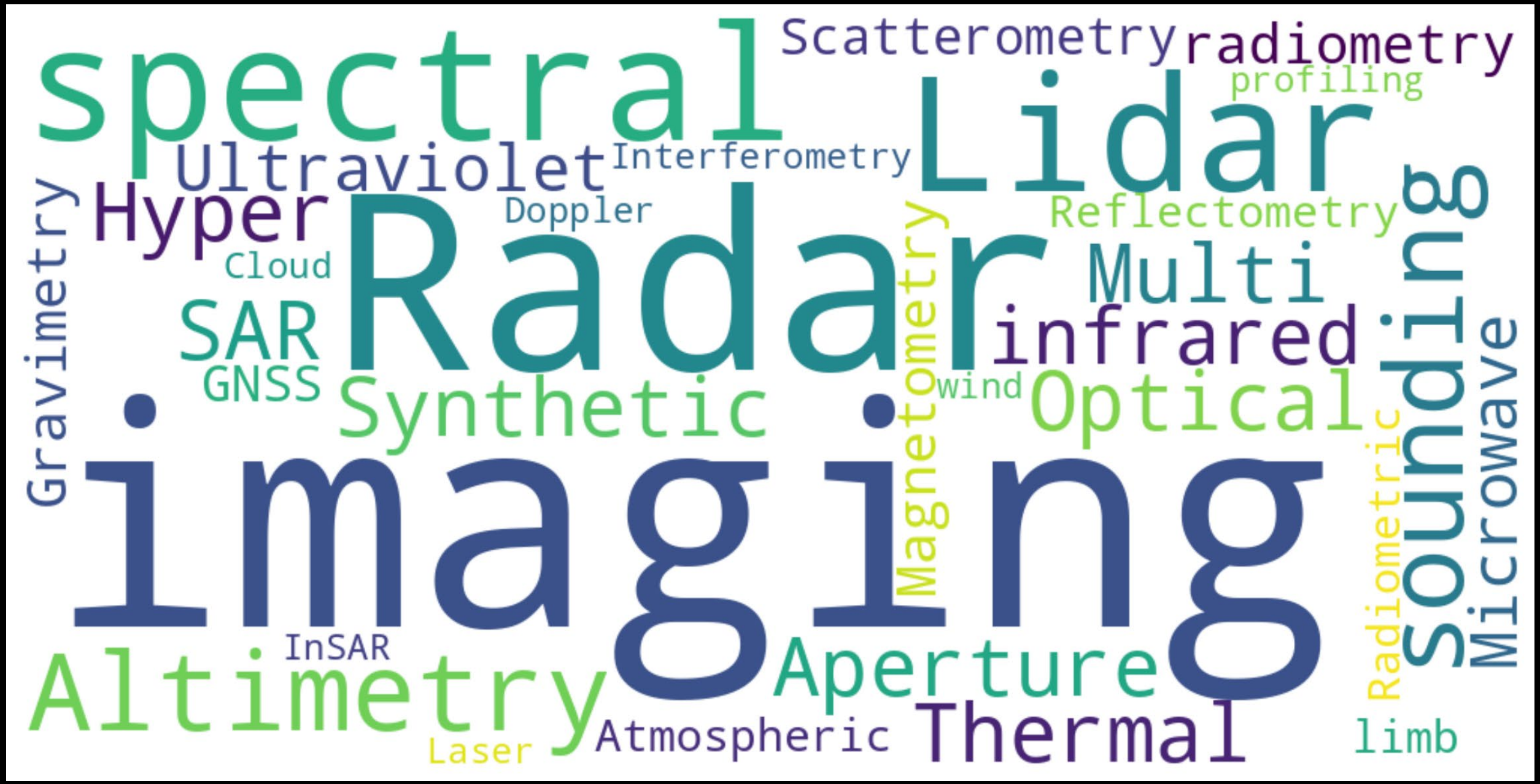



spectral
Scatterometry
radiometry
Lidar
profiling
Ultraviolet
Interferometry
Hyper
Doppler
Reflectometry
Gravimetry
Cloud
Radar
Multi
SAR
infrared
sounding
GNSS
Synthetic
Optical
Magnetometry
wind
Microwave
imaging
Radiometric
InSAR
Aperture
Altimetry
Thermal
Atmospheric
limb
Laser

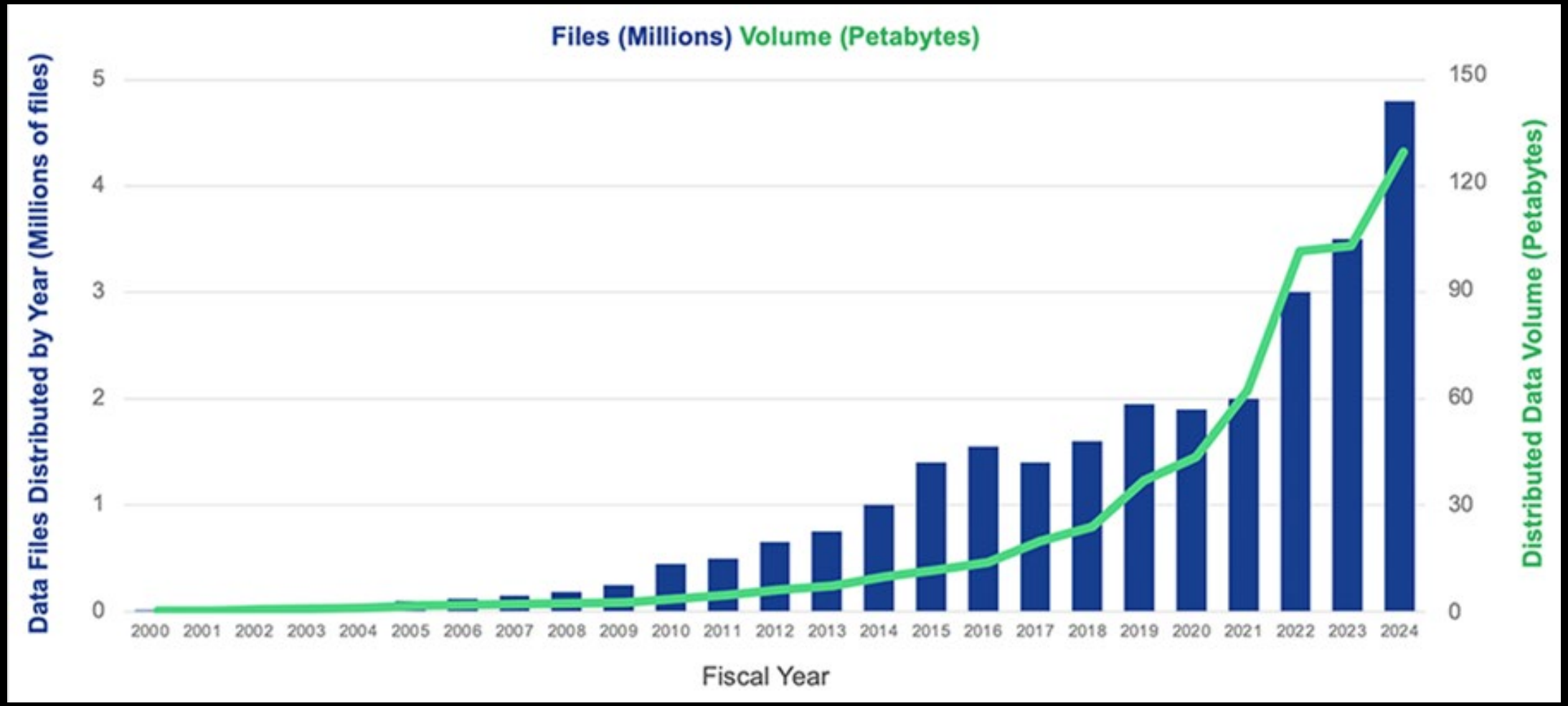
Earth Observation Ecosystem Downstream Data Lake

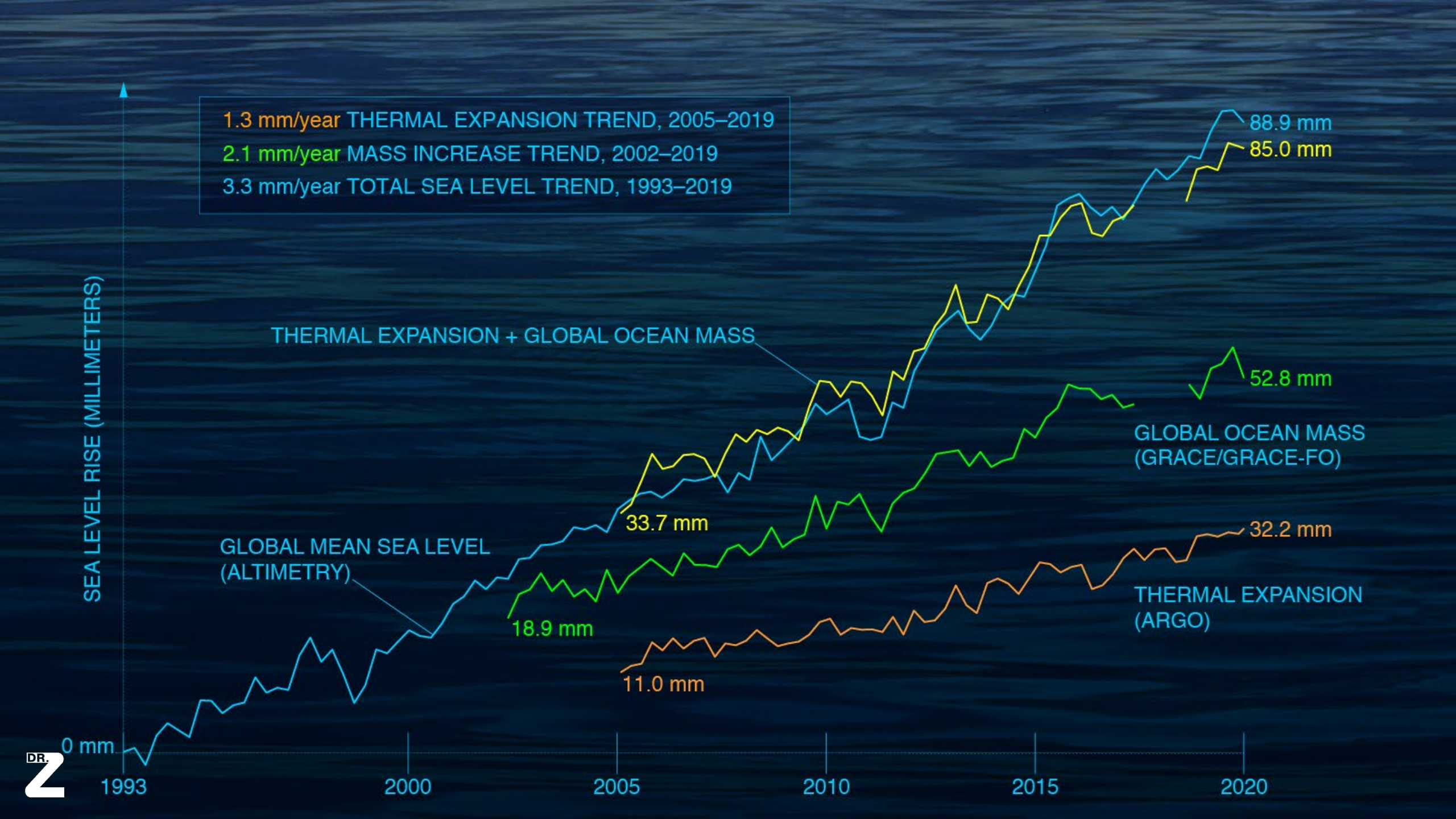
2010
2015
2020
2025
2030
ERS-1
ERS-2
MetOp-A
Envisat
Proba-1
GOCE
SMOS
CryoSat
Swarm
Meteosat 10 (MSG)
MetOp-B
Proba-V
Sentinel-1A
Sentinel-2A
Sentinel-3A
Meteosat 11 (MSG)
Sentinel-1B
Sentinel-2B
Sentinel-3B
Sentinel-5P
MetOp-C
Sentinel-6 Michael Freilich
Aeolus
EarthCARE
Biomass
Phisat-2
HydroGNSS
ALTIUS
FLEX
FORUM
Harmony
TRUTHS
MAGIC
Earth Explorer-11
Earth Explorer-12
Sentinel-1C
Sentinel-2C
Sentinel-3C
Sentinel-1D
Sentinel-2D
Sentinel-3D
Sentinel-6B
MTG-I1
Sentinel-4A MTG-S1
Arctic Weather Satellite
CO2M-A
CO2M-B
CO2M-C
CRISTAL-A
CIMR-A
ROSE-L-A
LSTM-A
CHIME-A
CRISTAL-B
CIMR-B
ROSE-L-B
LSTM-B
CHIME-B
Sentinel-5A MetOp-SG-A1
MTG-I2
MetOp-SG-B1
MTG-I3
Aeolus-2A
Sentinel-4B MTG-S2
Sentinel-5B MetOp-SG-A2
MetOp-SG-B2
Sentinel-1
Sentinel-2
Sentinel-3
Sentinel-6
Sentinel Next Generation Missions
Science
esa
Copernicus
European Union
Meteorology
EUMETSAT

Earth Data

- **Current NASA Earth Observing Data:** ~150 petabytes (PB), expected to exceed 500 PB by 2030.
- **NASA operates 90 instruments and spacecraft**, generating over 20 PB of additional data annually.
- Modern missions are significantly increasing data volumes.
- **The data mentioned refers only to downloaded data**—onboard spacecraft store up to 10x more before compression.
- **These figures do not include** datasets from commercial entities

Total Data Volume & Data Files by Year

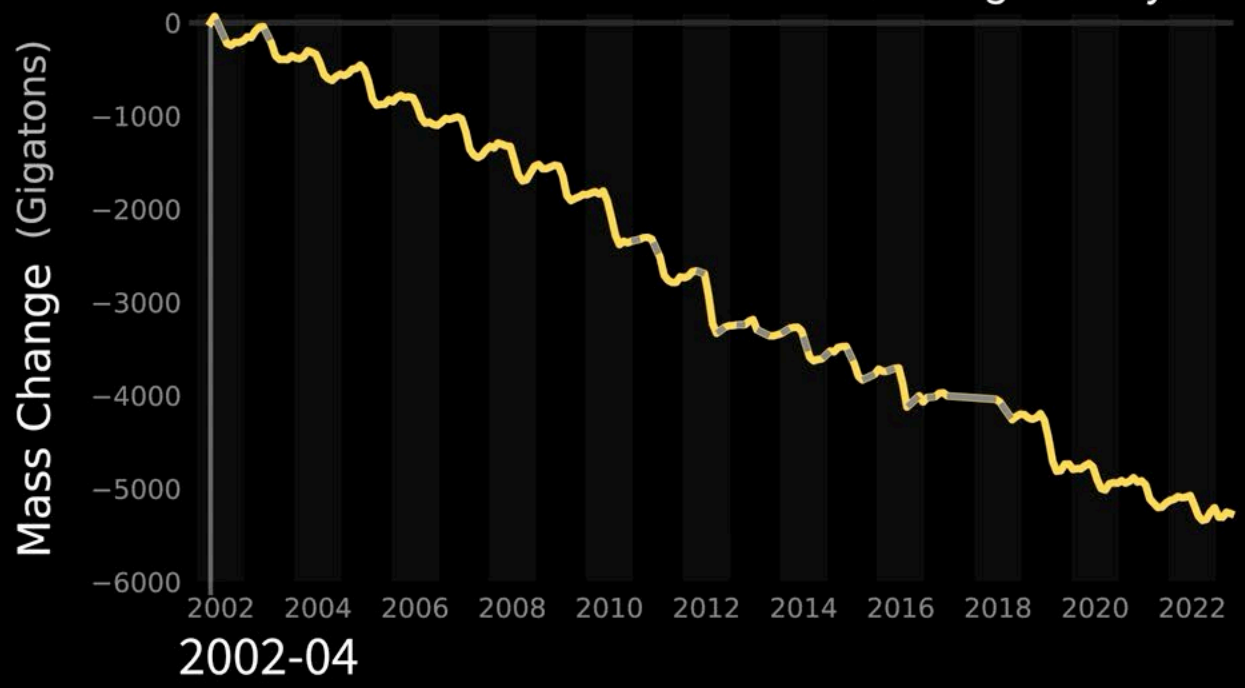



1.3 mm/year THERMAL EXPANSION TREND, 2005–2019
2.1 mm/year MASS INCREASE TREND, 2002–2019
3.3 mm/year TOTAL SEA LEVEL TREND, 1993–2019
SEA LEVEL RISE (MILLIMETERS)
THERMAL EXPANSION + GLOBAL OCEAN MASS
88.9 mm
85.0 mm
33.7 mm
GLOBAL MEAN SEA LEVEL (ALTIMETRY)
52.8 mm
GLOBAL OCEAN MASS (GRACE/GRACE-FO)
18.9 mm
32.2 mm
THERMAL EXPANSION (ARGO)
11.0 mm
0 mm
1993
2000
2005
2010
2015
2020

2002-04

GRACE AND GRACE-FO
Observations OF Greenland Land Ice Mass Changes

Average Mass Loss:
271 Gigatons/year



Ice Mass Change
(meters water equivalent relative to 2002)

DR. Z

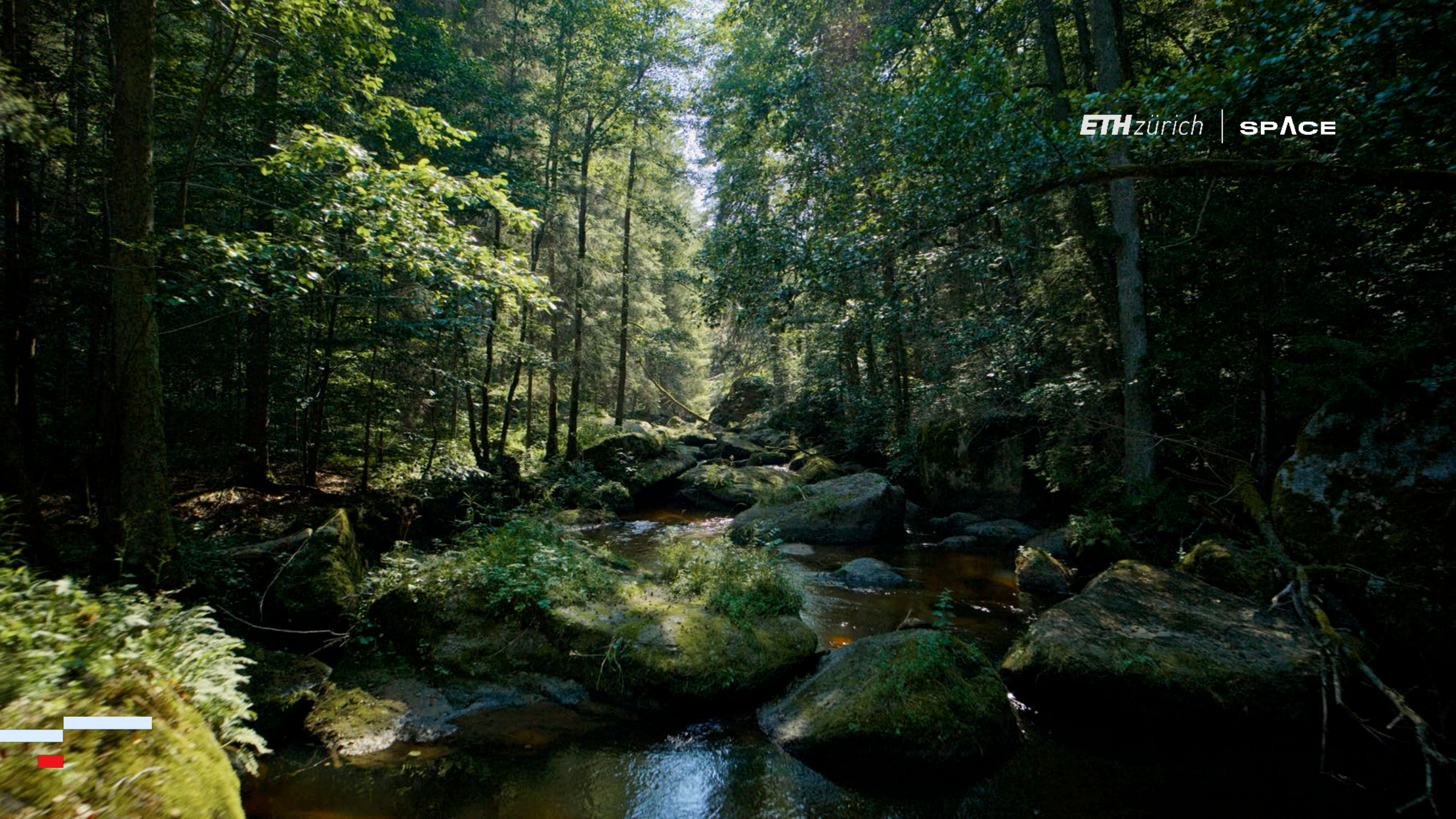

DR.
2
August 22, 2025

DR.
Z

Landslide Monitoring Challenge

- Hundreds of "hot spots" are monitored with GPS, crack sensors, cameras, and radar
- Many dangerous events occur away from monitored areas – mountains move before becoming identified threats
- Surprises happen in ice/permafrost zones and beyond due to various mechanical disturbances

Solution needed: AI-powered Alpine surveys to detect movement patterns plus advanced, cost-effective drone and landscape sensors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Mission Statement

GeoLab transforms abundant space data into practical solutions that create economic value and address Switzerland's most pressing challenges.

We leverage Switzerland's unique position as the world's ultimate testbed—highly instrumented, geographically diverse, and perfectly sized—to develop scalable applications that benefit farmers, governments, and communities locally before expanding globally.

Core Positioning

What We Want to Be

The global standard for space data applications, bridging the gap between abundant satellite information and real-world problem solving.

What We're Not

Another academic research center producing mostly fundamental science papers. We focus on actionable and affordable solutions, protect lives, and create economic opportunities.

Our Advantage

Switzerland offers unmatched density of ground sensors, geographic diversity in a compact area, and a business environment that makes it the perfect proving ground for space data applications.


Transforming Applications
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Avalanche Prevention
Precision Agriculture
Snow Intelligence
Hyperlocal Weather
Underwater Monitoring
Forest Health
This isn't about better technology. It's about saving lives and protecting our environment.

Roadmap to Reality

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2025: Launch
15 major research projects focusing on avalanche prediction, precision agriculture, and underwater monitoring.

2027: Scale & Integrate
First spin-off companies emerge. Technology transfer accelerates. Lab innovations become market solutions.

2030: Lead & Transform
Swiss GeoLab becomes the global hub for Earth observation innovation with worldwide impact.

150M

Swiss Francs
Total investment to bring this vision to reality

150

Researchers/ Implementers
World-class scientists and engineers dedicated to the mission. Swiss quality sensors and drones deployed.

+++

Potential Impact
Disasters prevented, lives saved, environmental protection ensured

Current Core Team

ETH zürich | SPACE

Prof. Dr.
Thomas Zurbuchen

Departement Erd- und Planetenwissenschaften

Leiter Nationale Innovationsinitiativen für Space

Prof. Dr.
Verena Griess

Departement Umweltsystemwissen-schaften

Institut für Terrestrische Ökosysteme

Prof. Dr.
Konrad Schindler

Departement Bau, Umwelt und Geomatik

Institut für Geodäsie und Photogrammetrie

Core Faculty
ETH AI Center

Prof. Dr.
Roland Siegwart

Departement Maschinenbau und Verfahrenstechnik

Institut für Robotik und intelligente Systeme

Wyss Zurich Translational Center

Associated Faculty
ETH AI Center

Prof. Dr.
Marc Pollefeys

Departement Informatik

Institut für Visual Computing

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ETH AI Center

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Departement Bau, Umwelt und Geomatik

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Associated faculty
ETH AI Center

Thank you

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Institut für Terrestrische Ökosysteme

https://form.ethz.ch/the-group/people/person-detail.verena-griess.html