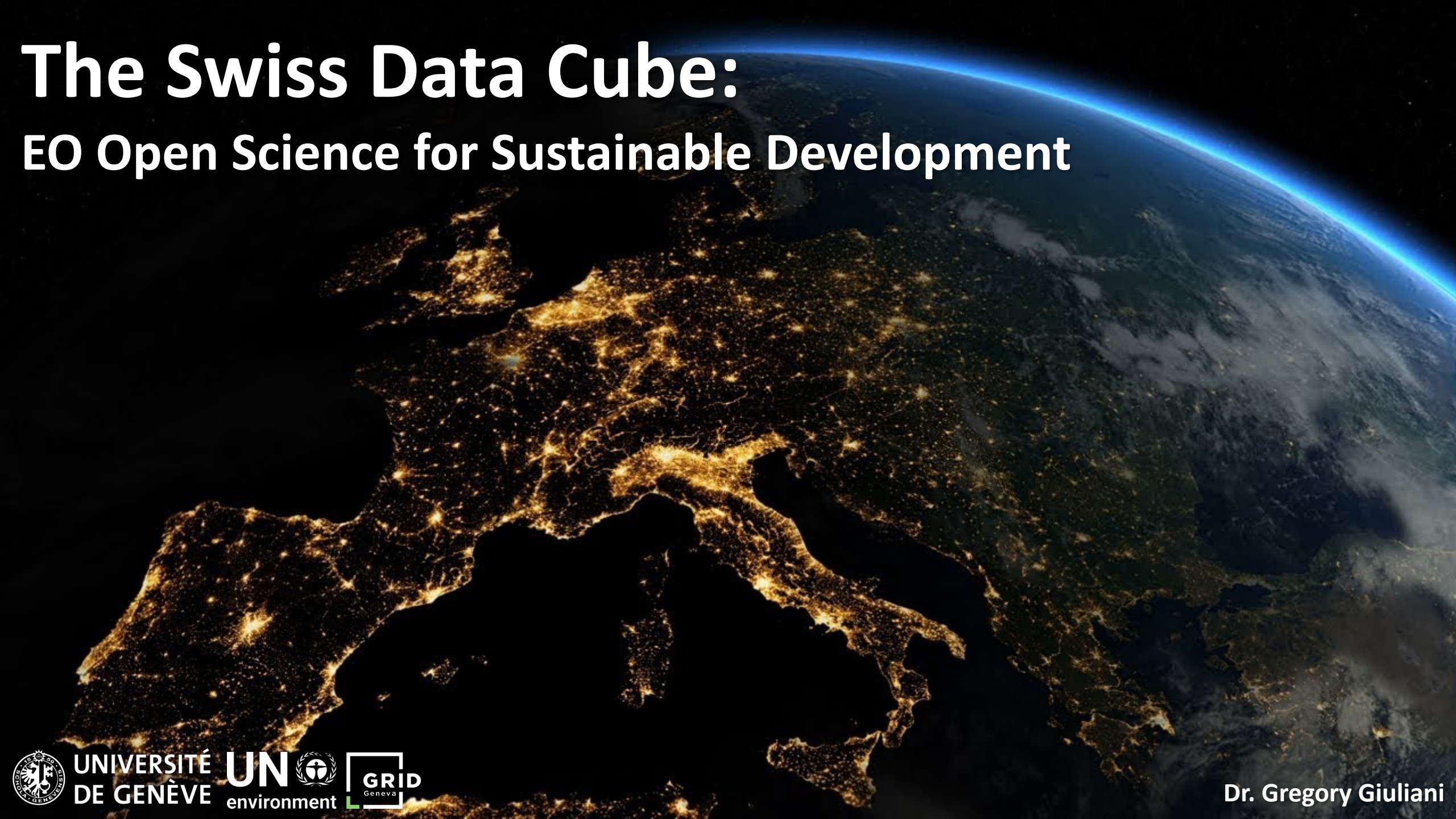
The Swiss Data Cube:

EO Open Science for Sustainable Development



UNIVERSITÉ DE GENÈVE

UN environment

GRID Geneva

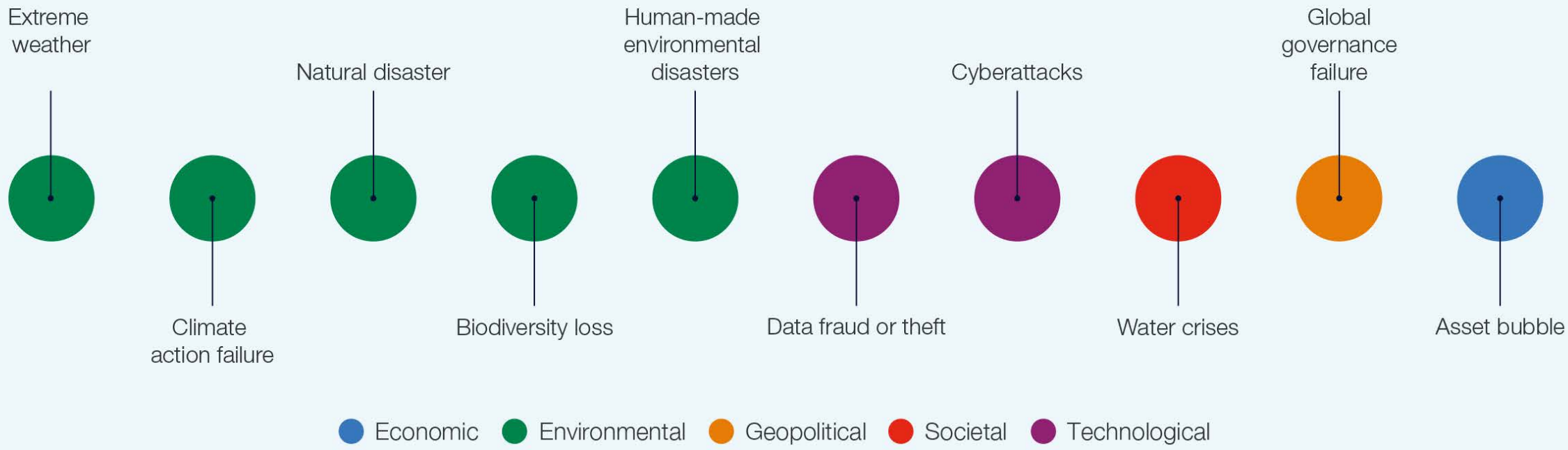
Dr. Gregory Giuliani

TOP 10 RISKS OVER THE NEXT 10 YEARS

Long-Term Risk Outlook: Likelihood

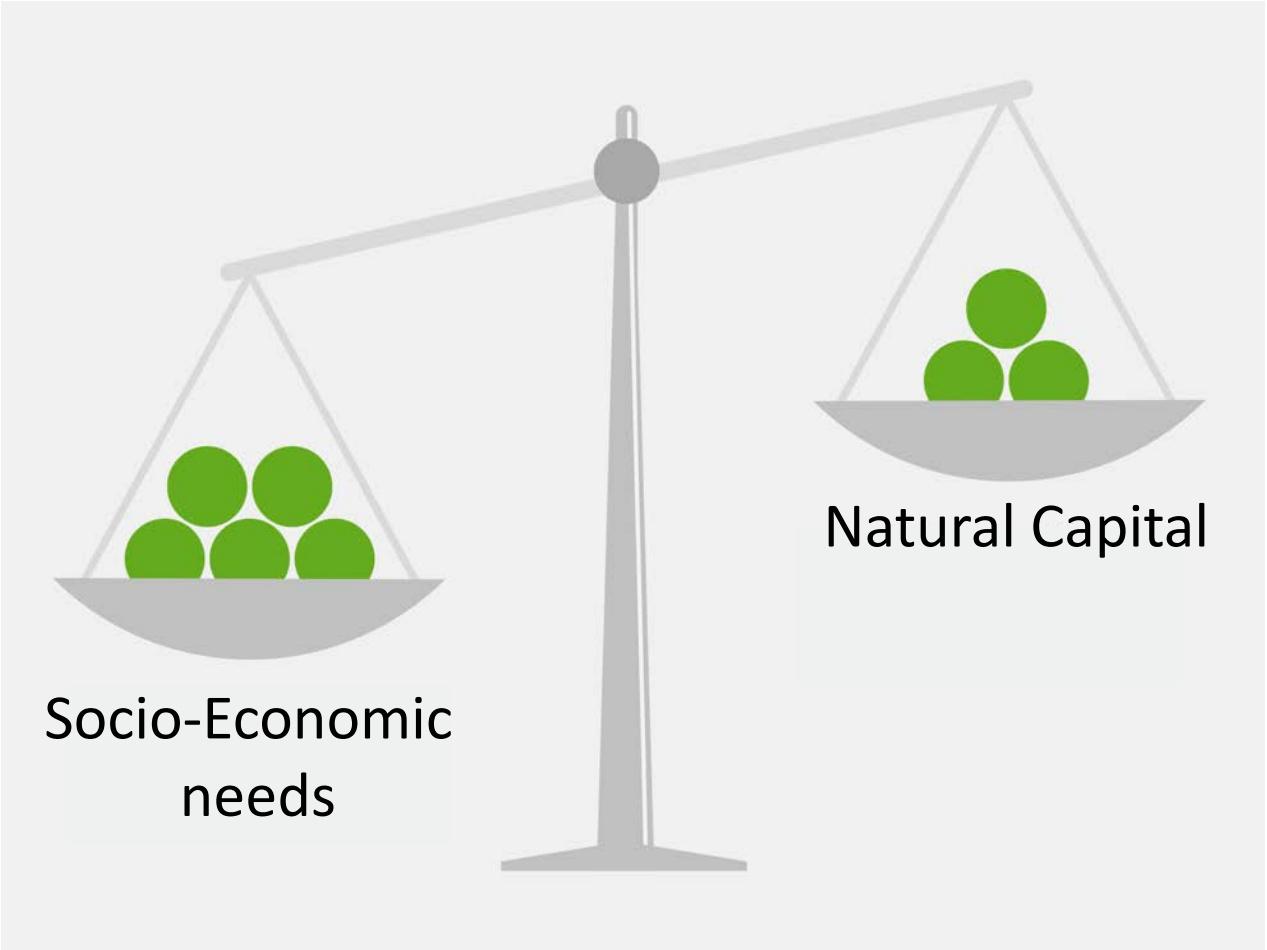
WORLD ECONOMIC FORUM

Multistakeholders

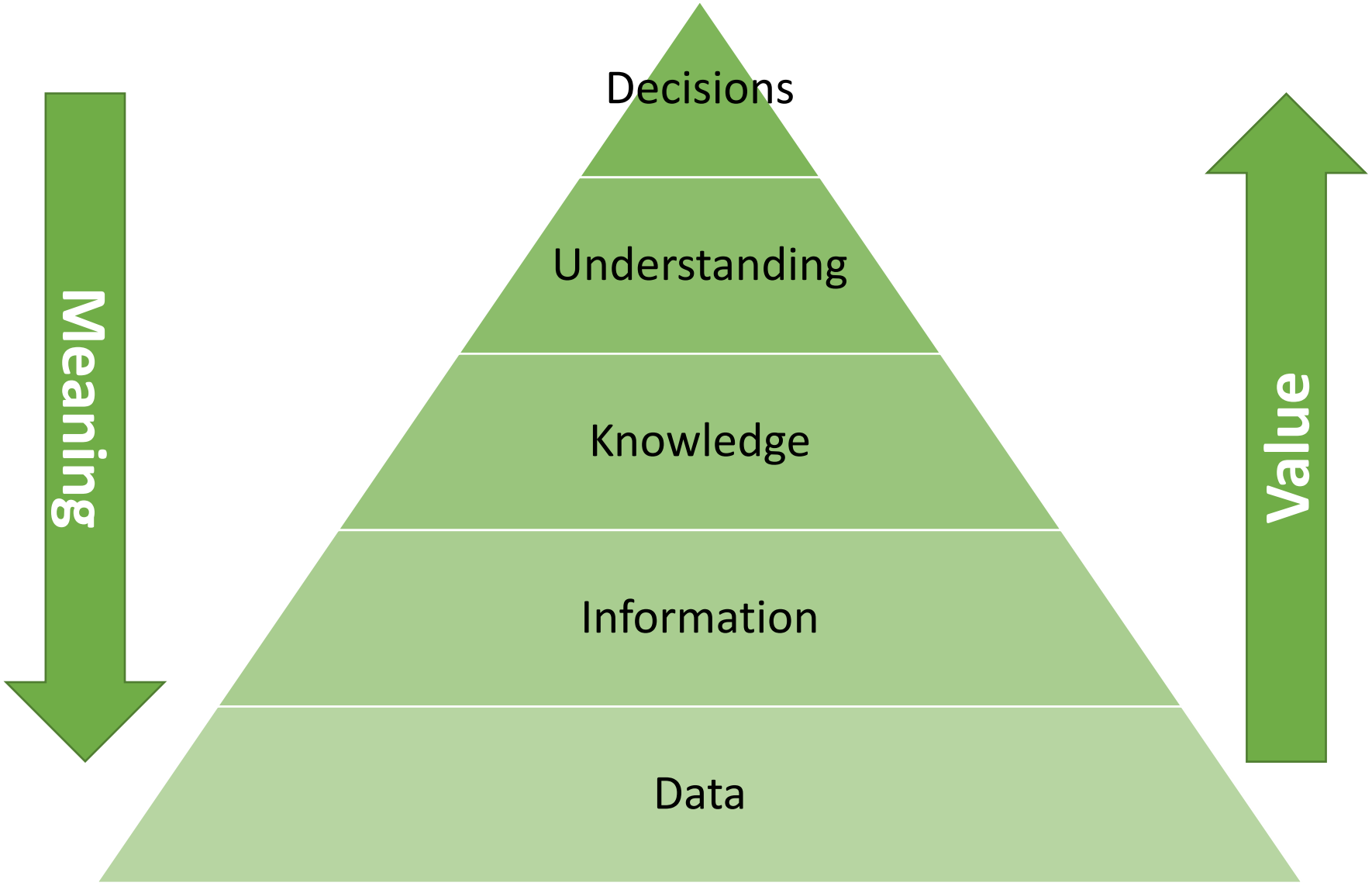


The key to sustainable development…

…is achieving a **balance between the exploitation of natural resources for socio-economic development**, and conserving ecosystem services that are critical to everyone' s wellbeing and livelihoods.



The Challenge: Evidence-based policy-making

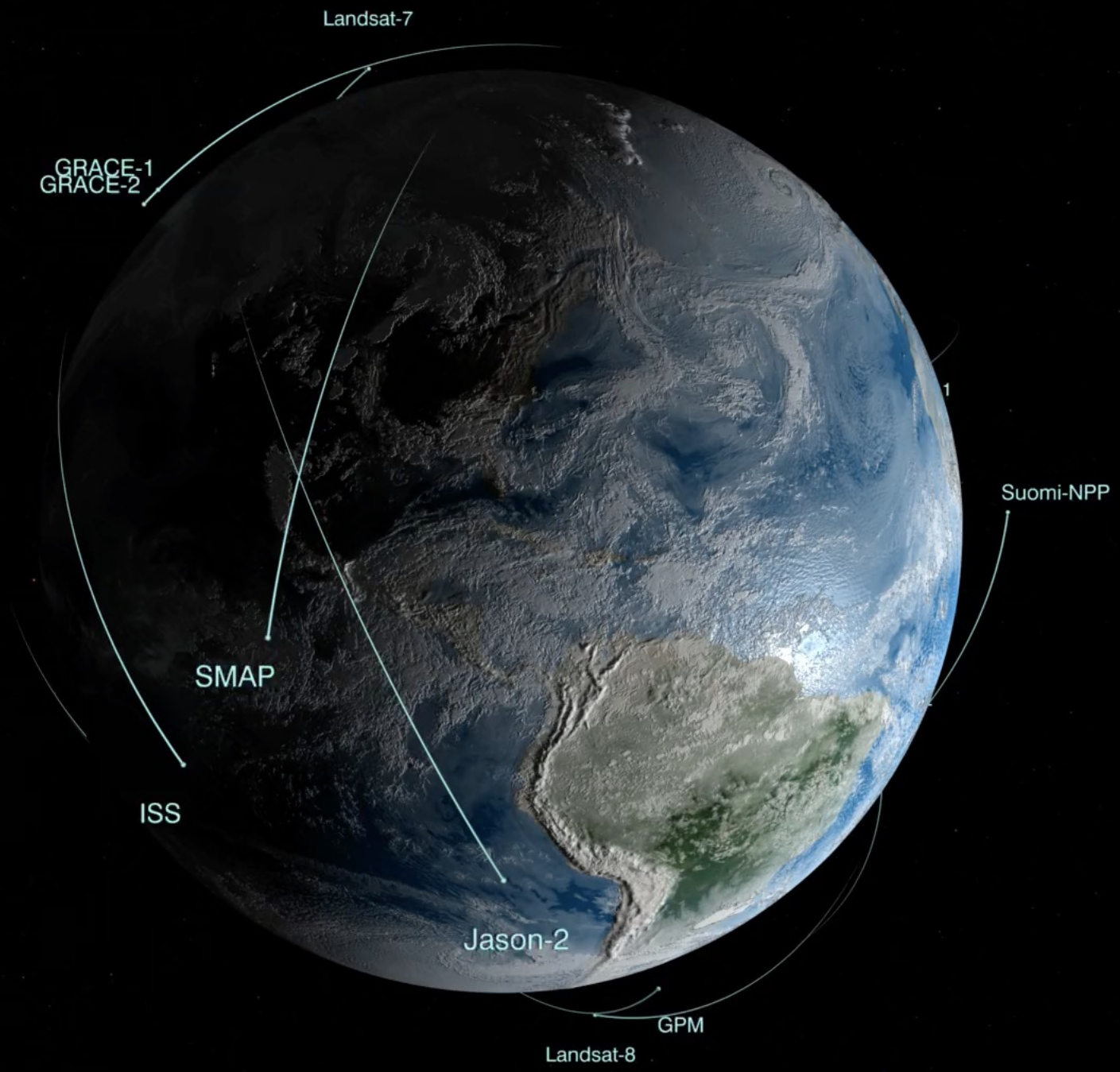


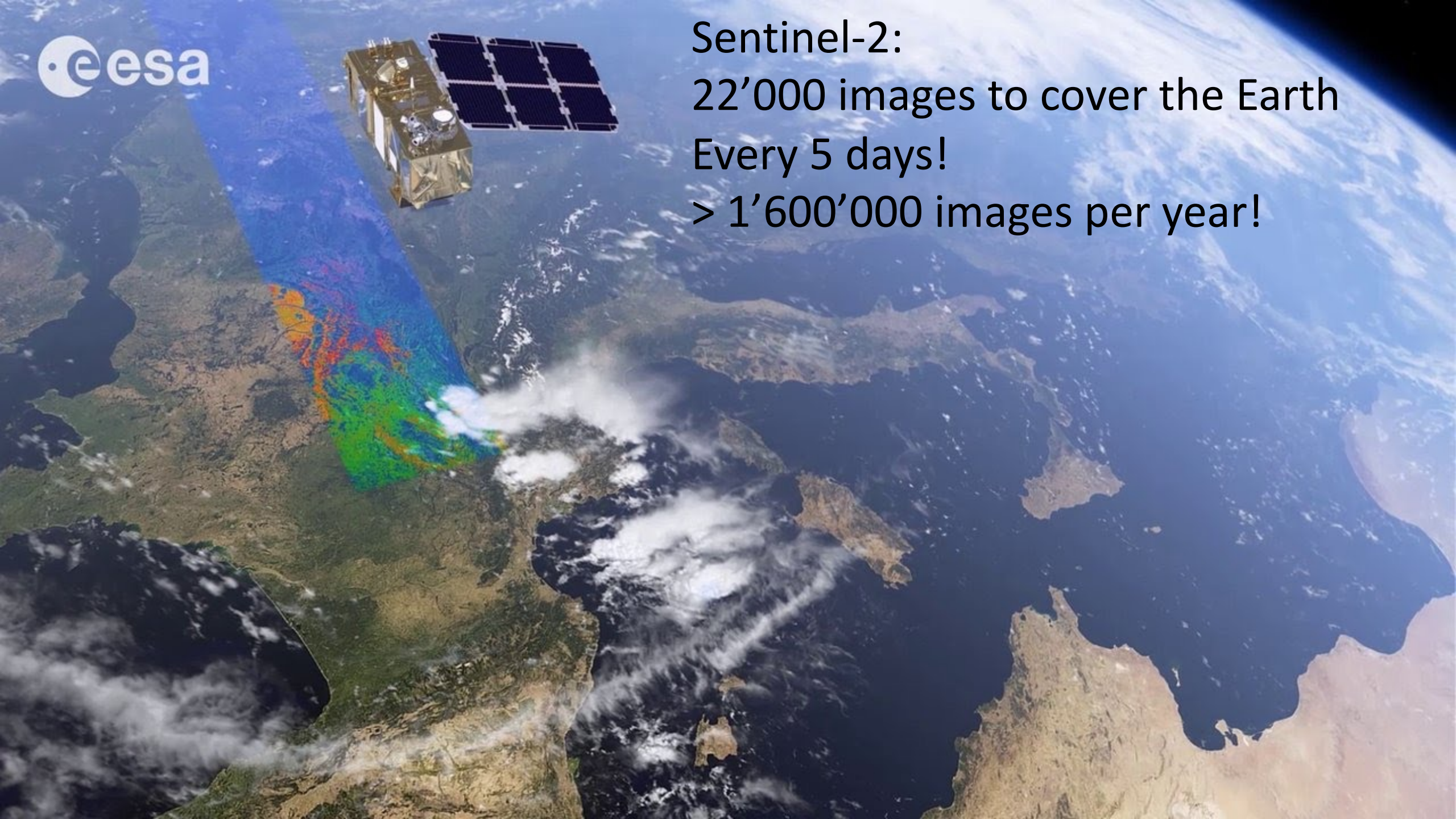
Action:
Societies decide how to use resources of our planet

Knowledge:
inform us about the limits of the planet

To better understand these changes…

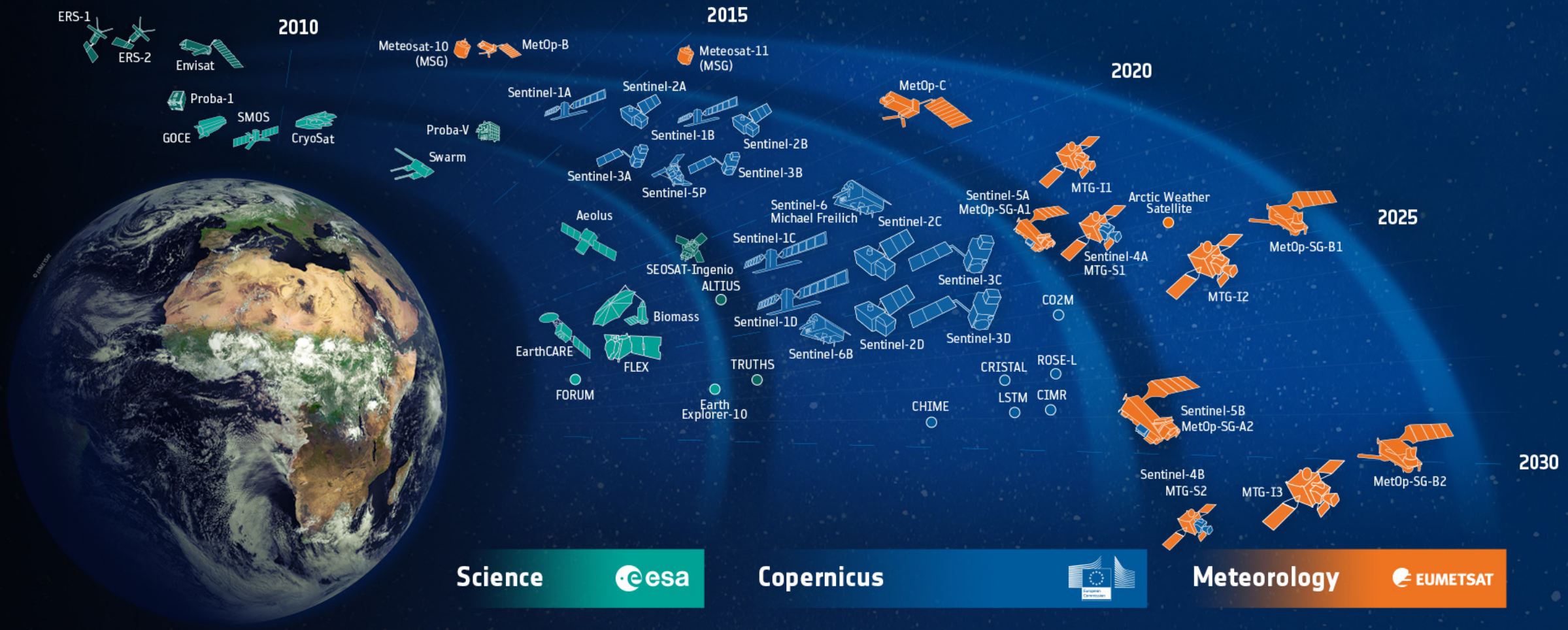
Our planet is under continuous observation from satellites



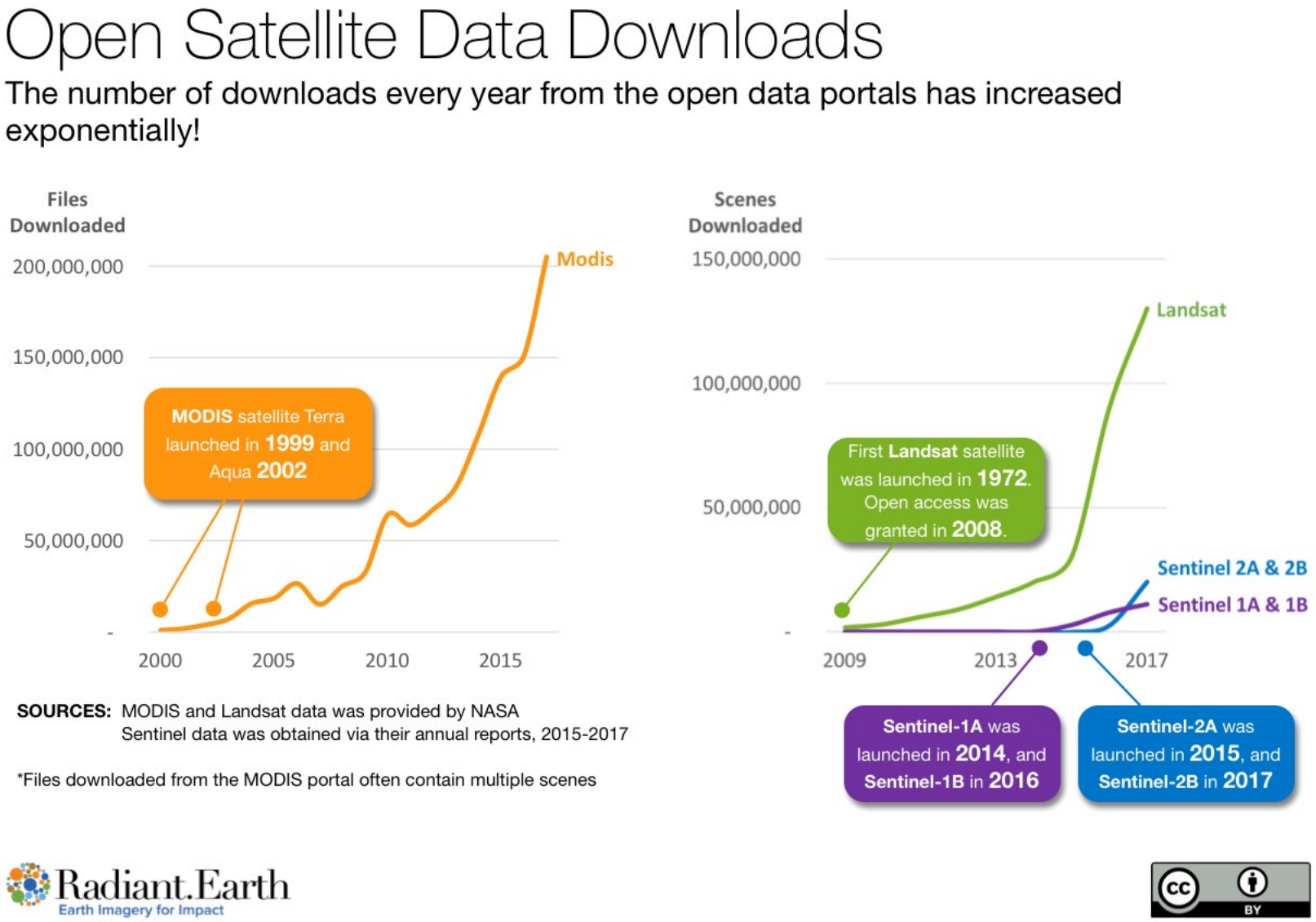


Sentinel-2:
22’000 images to cover the Earth
Every 5 days!
> 1’600’000 images per year!

Copernicus – Europe's Eye on Earth
Largest EO data provider in the World: 250TB/day data
Archive: 250PB of data stored, daily growth rate: 220TB



Increasing demand for free & open satellite data

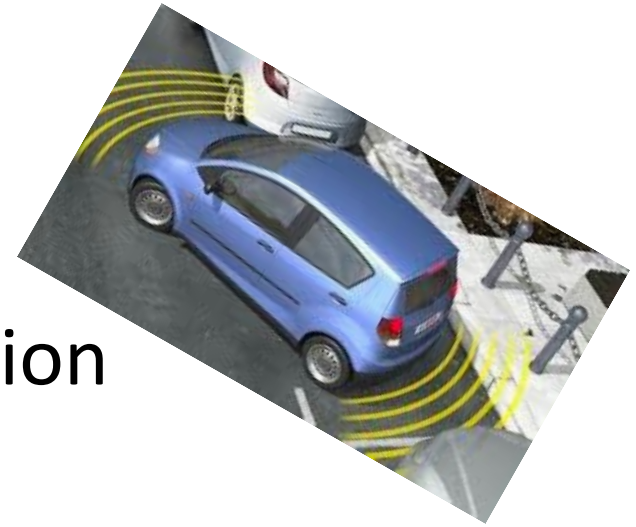


Data delivered to 186 countries ; Landsat: 53 images/day (2001) - 220’000 images/day (2017)

User shift to multi-year scenes at same location

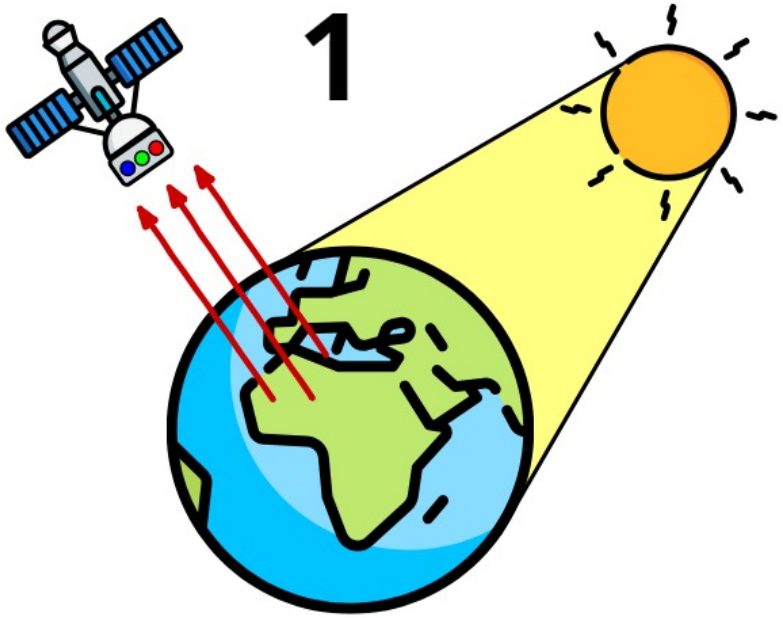
Types of satellites

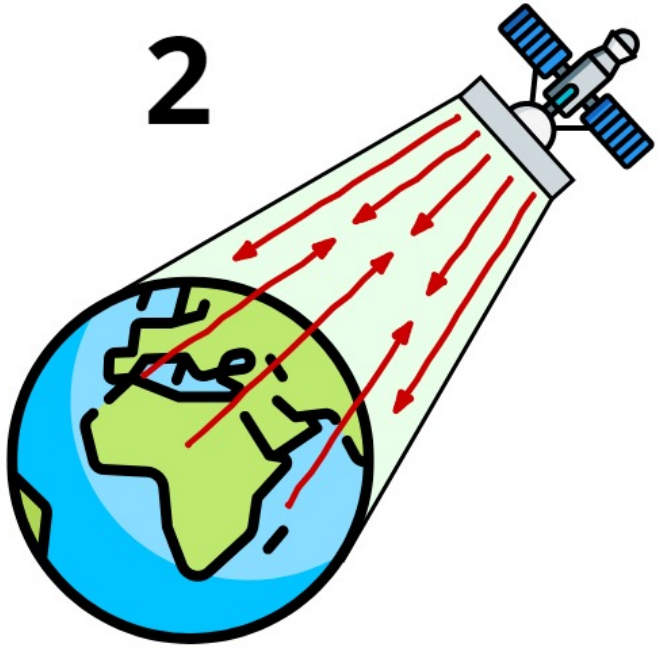
Passive
radiation from sunlight
(Sentinel-2&-3, Landsat, MODIS…)



Active
transmit radiation

(Sentinel-1&-6,
Jason, Tandem-X…)





Spatial resolution = Pixel size

Freely available

Aqua (MODIS)
250m Resolution

Landsat-8
30m Resolution

Sentinel-2
10m Resolution

Commercial satellites

PlanetScope (Dove)
3m Resolution

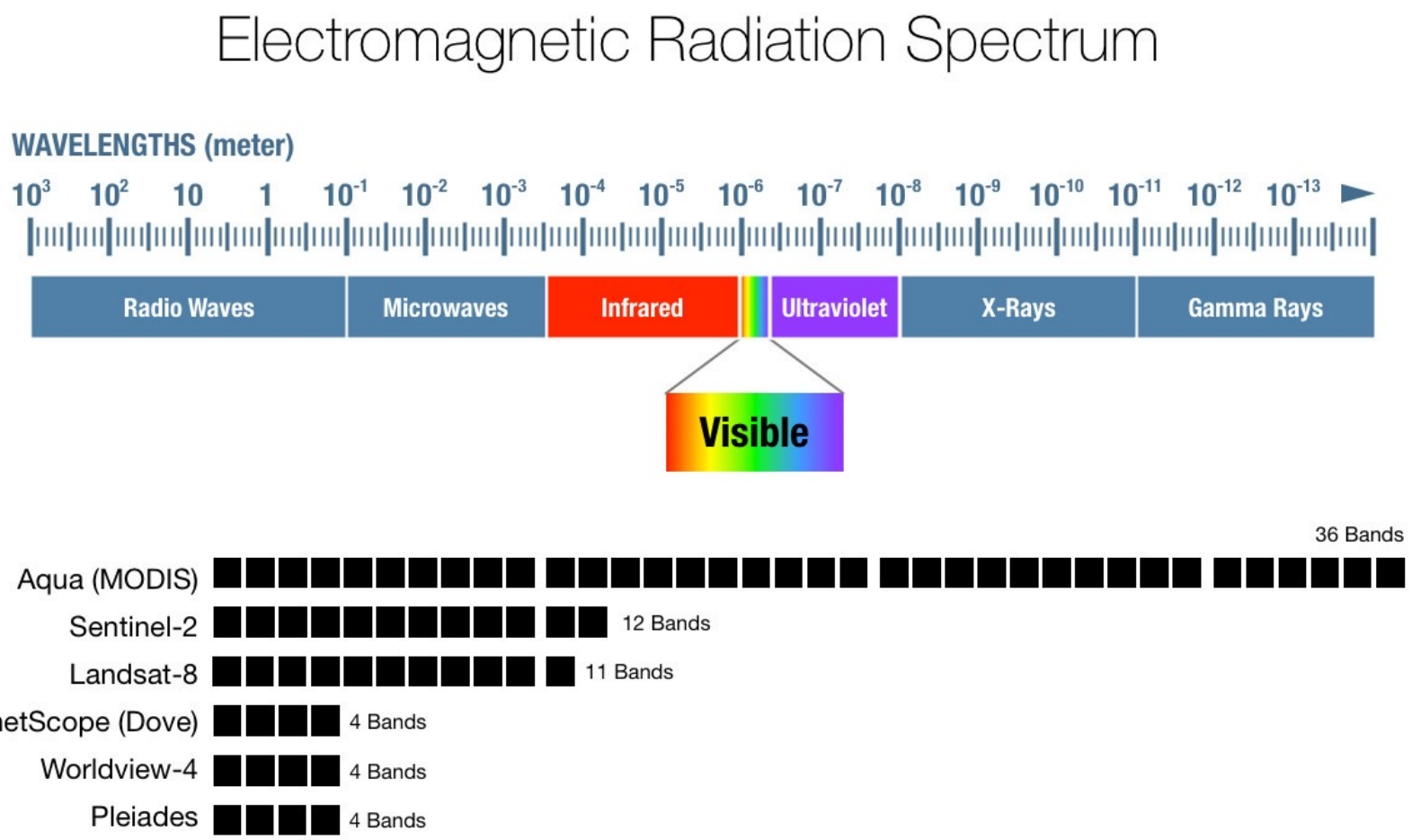
Pleiades
0.5m Resolution

Worldview-4
0.3m Resolution

Radiant.Earth
Earth Imagery for Impact

Not just photos…

The number of bands of radiation in the electromagnetic spectrum that a satellite can sample (visible, infrared, ultraviolet, microwave, x-ray, etc.)

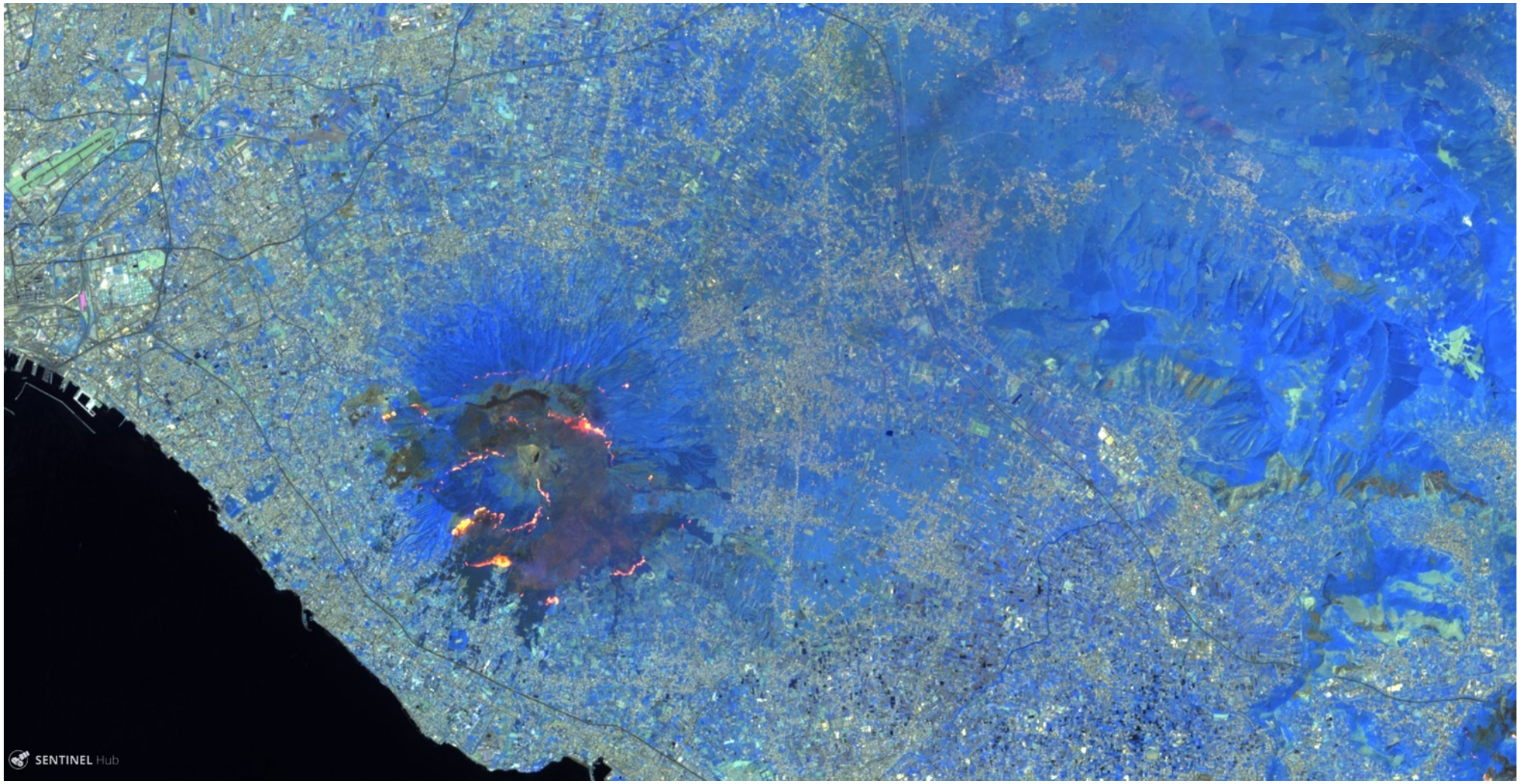


Radiant.Earth
Earth Imagery for Impact

Spectral resolution

- Vesuve ITA
- Sentinel-2
- 12-July-2017
- Red, green, blue

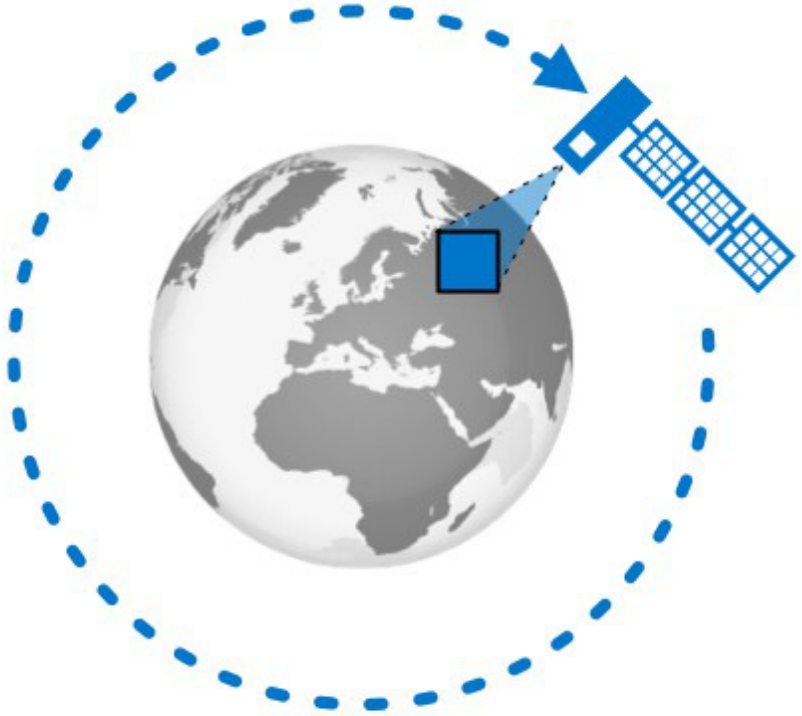
Spectral resolution

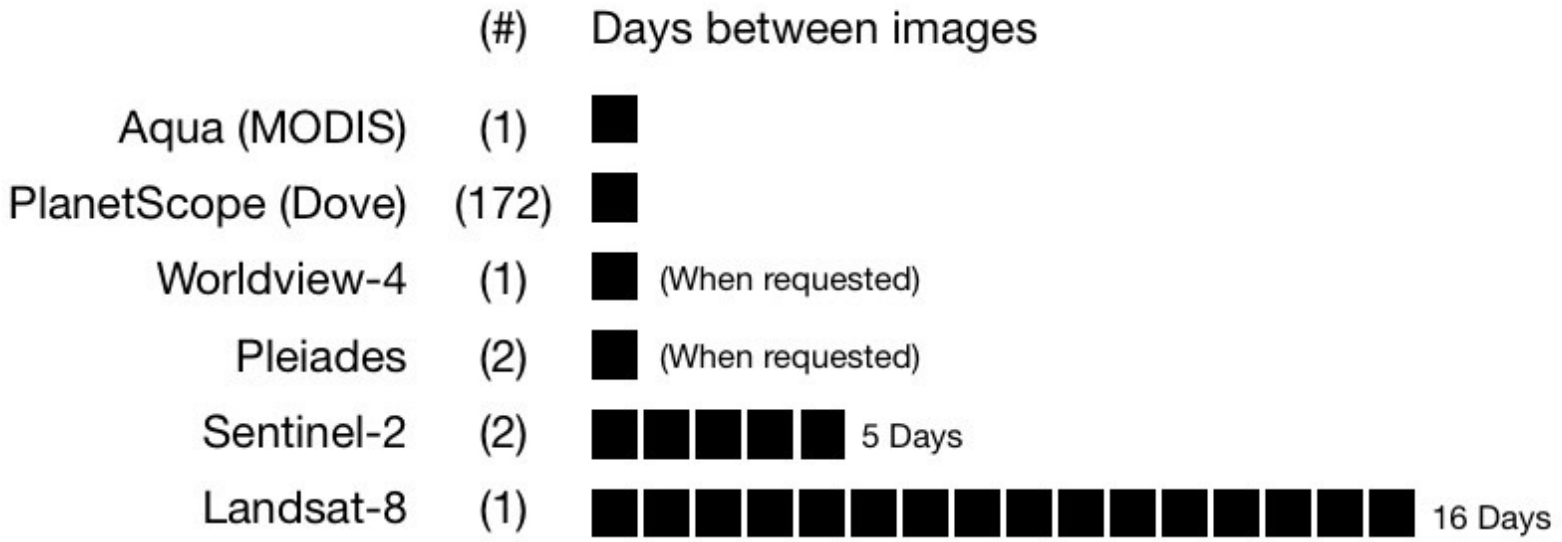


- Vesuve ITA
- Sentinel-2
- 12-July-2017
- SWIR2, SWIR1, NIR

Temporal resolution

Temporal resolution varies by satellite and describes the time it takes for an individual satellite to orbit and revisit a specific area. Some satellites operate as a constellation with multiple satellites working together to increase their global coverage daily.

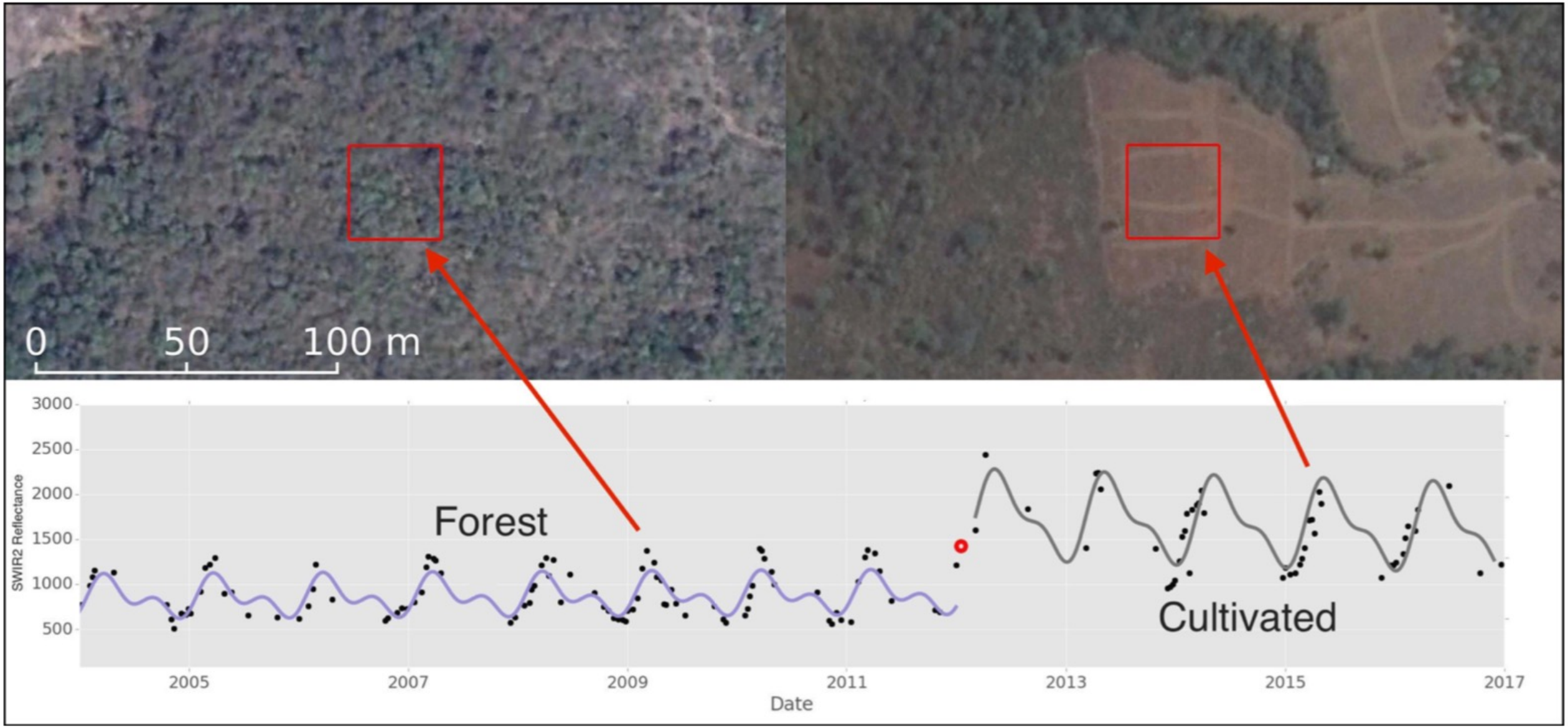




Radiant.Earth
Earth Imagery for Impact

Temporal resolution…

…A game changer

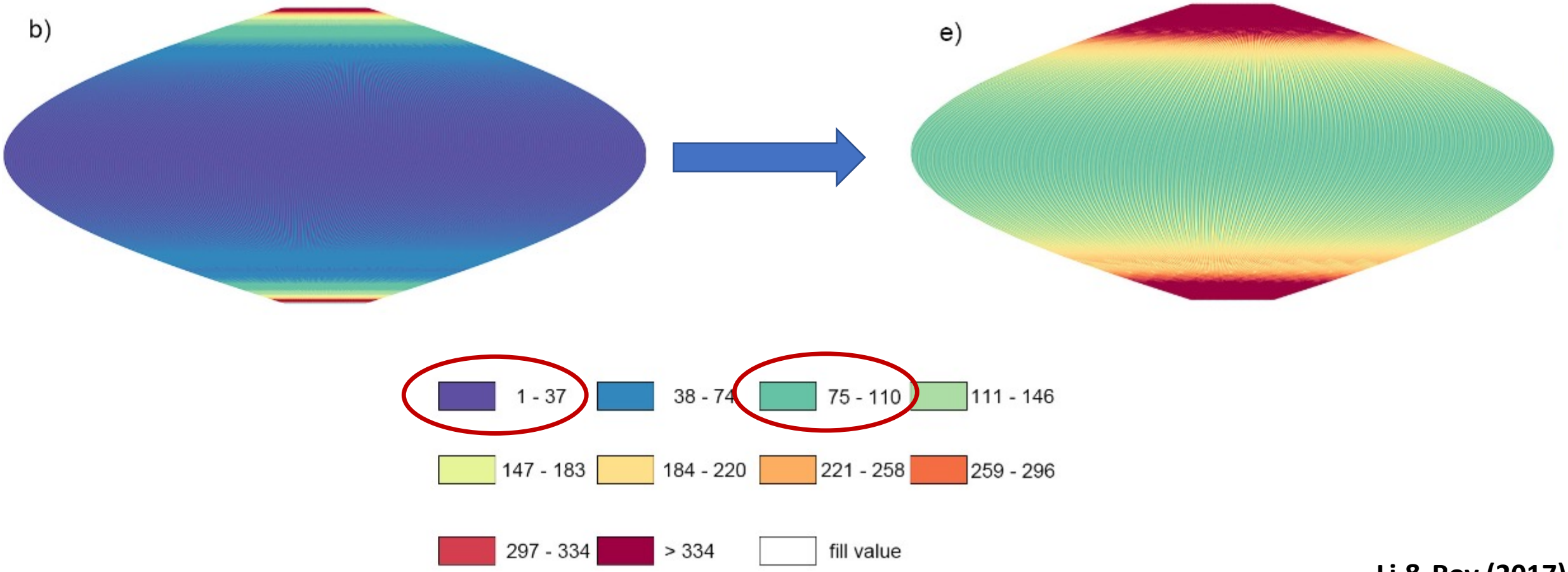


Temporal resolution…

…A game changer

Landsat 8

Landsat 8 + Sentinel-2A&B



Li & Roy (2017)

Monitoring the Earth in (near) real-time is now a reality!

Big Data Challenges in EO Science…

- Data Volume
- Data Variety/Heterogeneity (e.g., sensors, spatial-temporal-spectral resolution)
- It requires scientific knowledge to understand what data is needed… optical (which resolution?), radar (which type?)
- It is hard to access or download
- It is hard to prepare… atmospheric correction, grid formats, pixel alignment, speckle filtering
- It requires capacity building and training

How to transform this large amount of data in useful information and support evidence-based decisions?

Traditional remote sensing product process

Petabyte heirarchical archive:

Millions of individual scenes. Tape store accessed by robot.

Orthorectification calibration, cloud masking, atmospheric correction, mosaicing.

Search catalogue order scenes.

Identify footprint of product in space or time.

Client requests product.

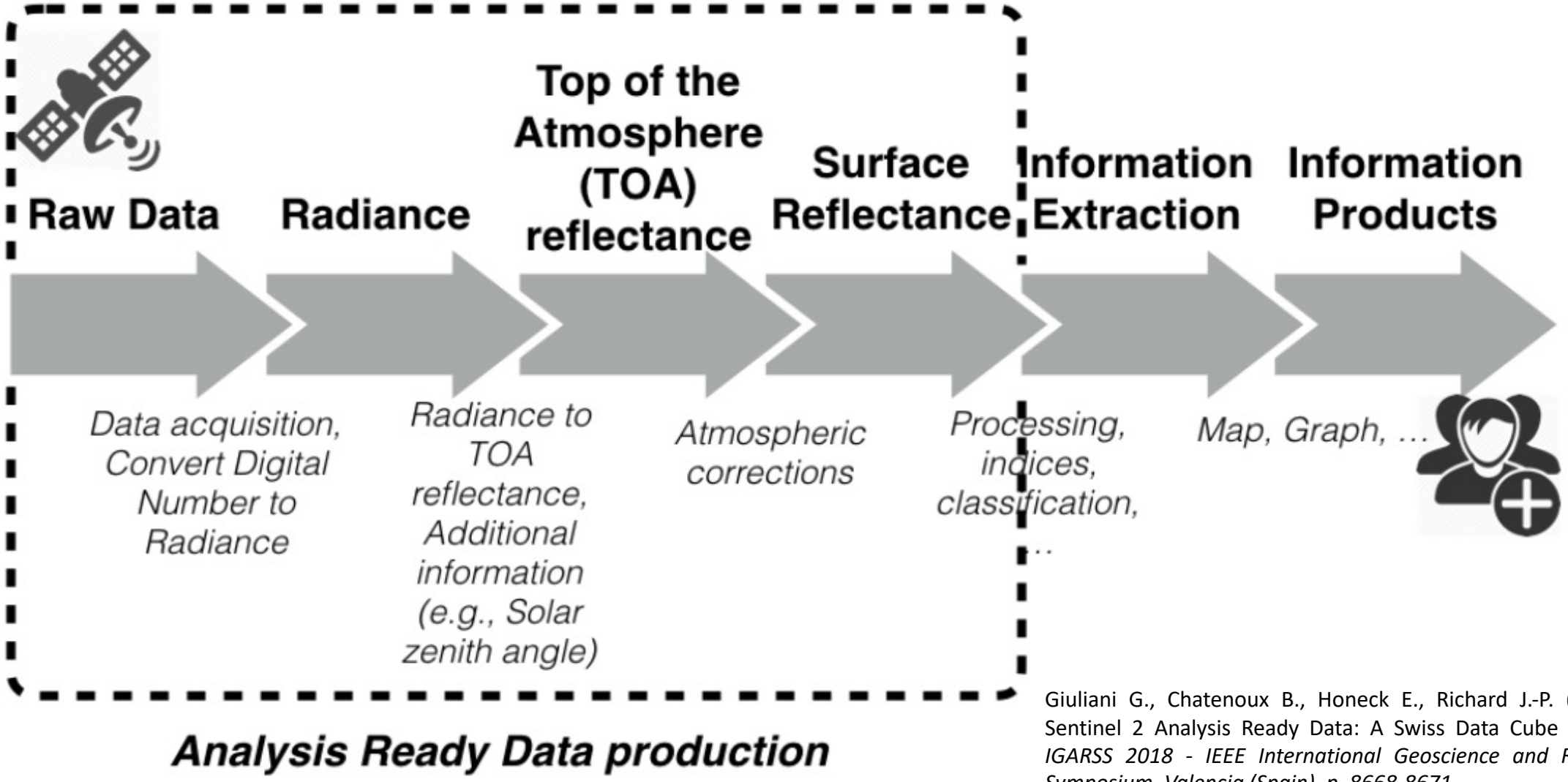
Feature extraction, algorithm application spectral unmixing.

Product packaging and delivery.

Courtesy of Geoscience Australia

Analysis Ready Data are key to reduce the burden on EO data users!

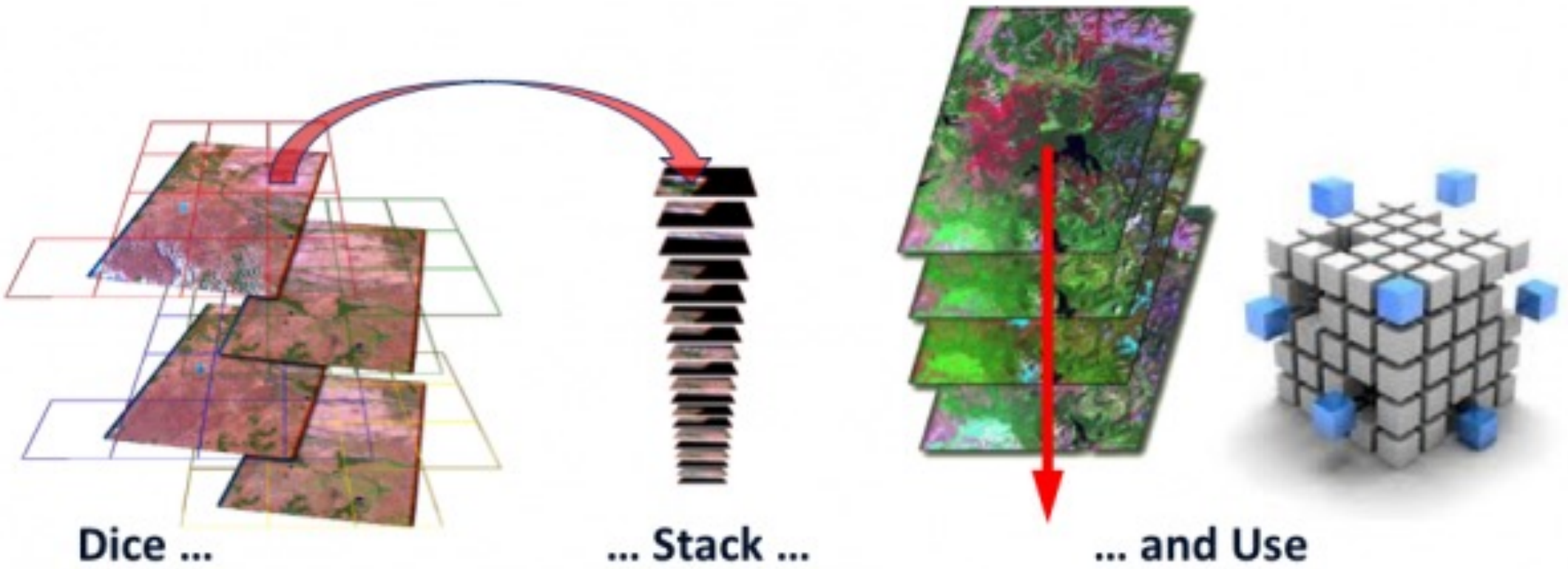
Spending more time in analyzing data than searching & pre-processing data…



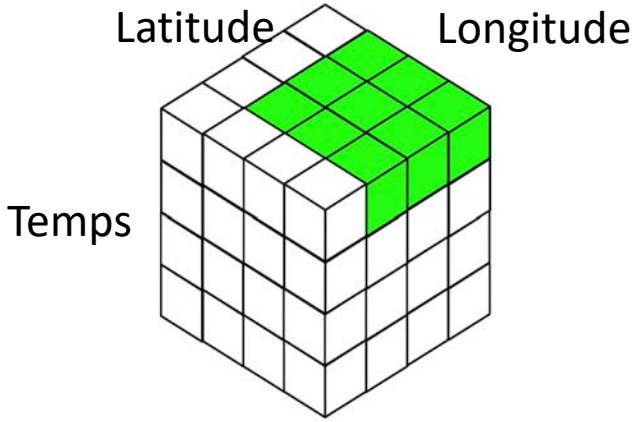
Giuliani G., Chatenoux B., Honeck E., Richard J.-P. (2018) Towards Sentinel 2 Analysis Ready Data: A Swiss Data Cube Perspective. *In: IGARSS 2018 - IEEE International Geoscience and Remote Sensing Symposium. Valencia (Spain). p. 8668-8671*

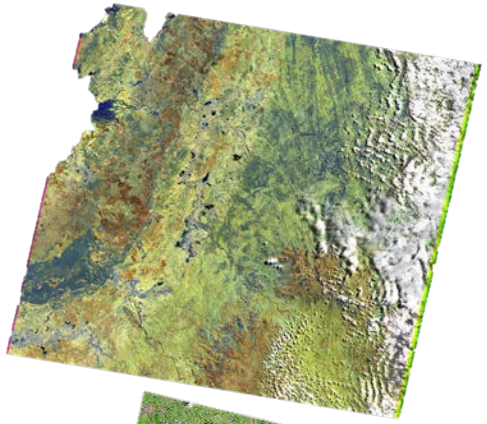
What are Data Cubes?

Time-series multi-dimensional (space, time, data type) stack of spatially aligned pixels used for efficient and effective access and analysis.

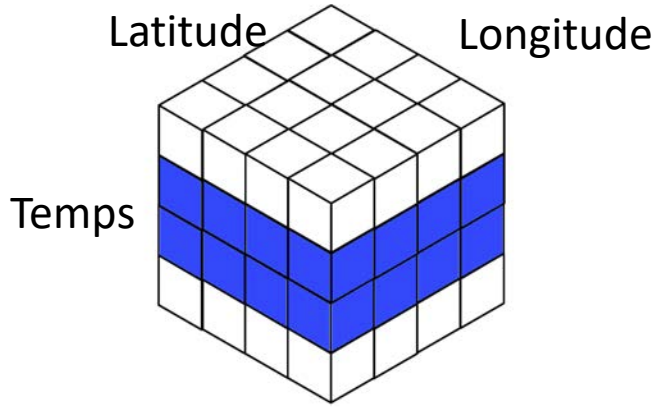


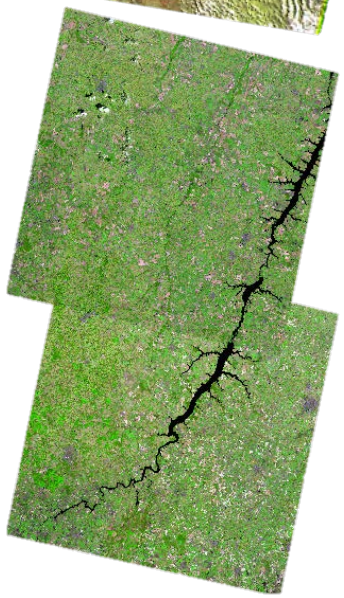
Courtesy of GeoScience Australia



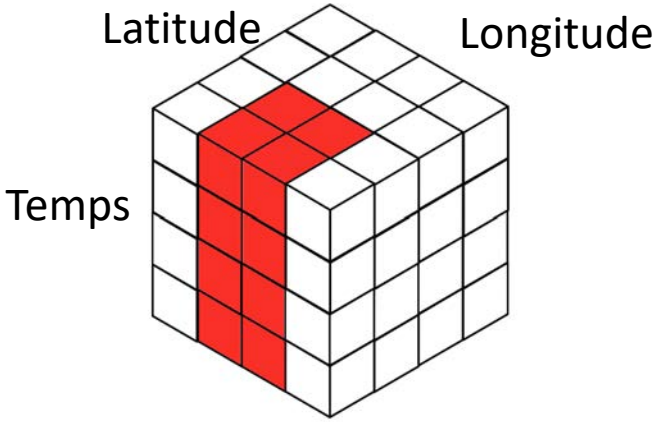


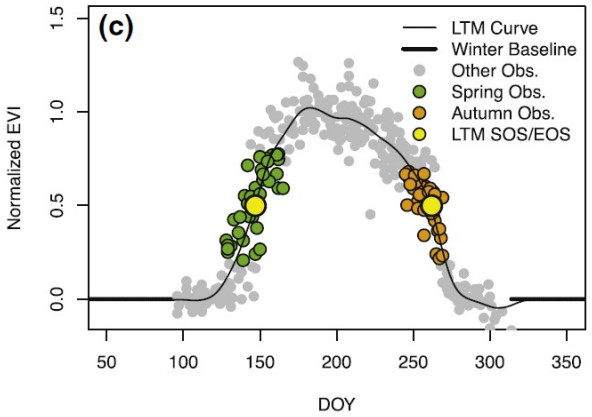
A single time slice, similar to a standard **“scene”** can be used to assess a single point in time





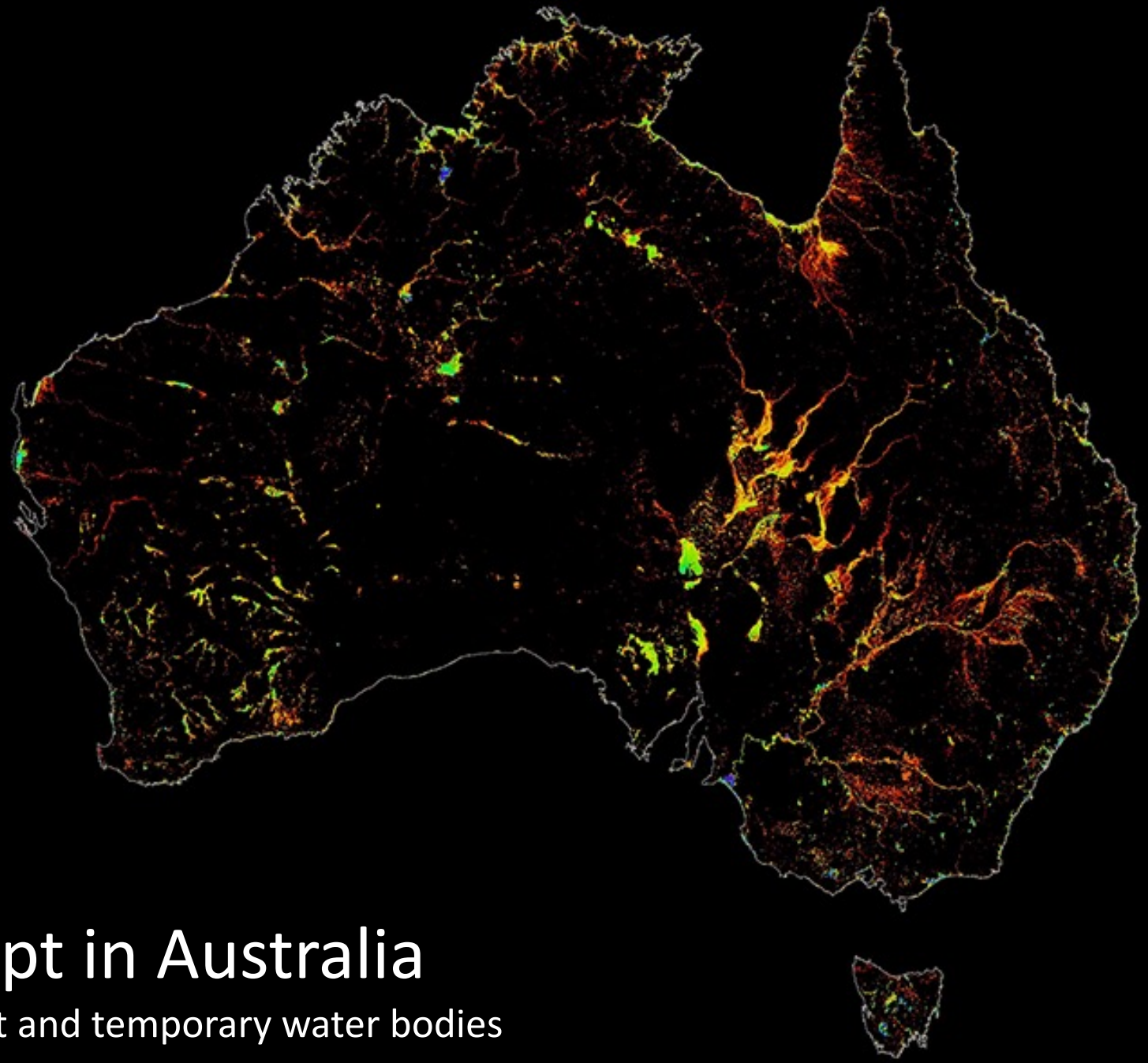
Several time slices can be combined into one to form a “**Mosaic**”. This is often used to reduce clouds or create seasonal or annual images.





Time Series analyses consider the variation of data over time to assess change

Adapted from CEOS



Proven concept in Australia

… to observe permanent and temporary water bodies

Governments have **national and international reporting commitments** and obligations as well as national environmental programs.

They all **need information that is synoptic, consistent, spatially explicit**, sufficiently detailed to **capture anthropogenic impacts**, and national in scope.

EO Data Cubes can provide the **long baseline required to determine trends, define present, and inform future**. This can fit these interests to inform programs and communities.

Plan directeur de recherche Environnement 2021-2024

Domaines et thèmes de recherche prioritaires

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Office fédéral de l'environnement OFEV

Thèmes de recherche prioritaires 2021-2024

1 Perspectives d'avenir : relevé de données et modélisation fondée sur celles-ci

1.1 Étude et modélisation quantitatives de l'incidence des grandes tendances globales sur l'environnement en Suisse.

1.2 Modélisation de tendances et de perspectives pour divers domaines environnementaux, à partir de données rétrospectives, en particulier de séries chronologiques spatialement distribuées.

1.3 Élaboration de méthodes pour la prise en compte des aspects écologiques et régionaux dans l'élaboration d'une vue d'ensemble systémique servant de base à la prise de décision.

1.4 Optimisation des réseaux et des méthodes de mesure, en particulier en ce qui concerne la combinaison de la télédétection et des mesures in situ, le développement des méthodes de télédétection des changements, l'analyse des opportunités et des risques des nouvelles méthodes d'observation environnementale.

1.5 Élaboration de bases pour le monitoring systématique à long terme des polluants persistants et des métaux lourds dans les organismes et les milieux environnementaux.

1.6 Détermination des facteurs pertinents pour l'examen des indicateurs utilisés actuellement dans le cadre des comptes rendus sur l'environnement et mise au point d'un système de veille (radar) pour les questions environnementales qui devraient être étudiées à l'avenir.

1.7 Développement de la bibliothèque de données environnementales et de la science ouverte (« open science ») : analyse des effets des stratégies de libre accès (« open access ») et de transparence des données gouvernementales (« open government data ») sur la recherche dans le secteur environnemental.

2 Diffusion d'informations, communication et mutation des valeurs

2.1 Évaluation et optimisation du système de rapports sur l'environnement pour chaque média (supports imprimés, voie électronique) et public cible, et étude de la manière dont les groupes cibles pertinents peuvent être identifiés et atteints.

2.2 Élaboration de méthodes d'agrégation et de regroupement des informations pour une communication optimale des données environnementales.

2.3 Élaboration d'approches pour communiquer les impacts environnementaux invisibles, intangibles et imperceptibles, tels que la perte de biodiversité ou la micropollution.

2.4 Analyses de l'efficacité des mesures de communication (médias sociaux, campagnes, etc. et élaboration d'un modèle d'impact pour la communication sur les questions environnementales complexes.

2.5 Enregistrement des paramètres démographiques pertinents (connaissances, attitudes, etc.) pour une communication axée sur les groupes cibles.

2.6 Étude des possibilités d'influencer la mutation des valeurs en vue d'une transformation sociale.

3 Promotion des compétences environnementales chez les professionnels

3.1 Identification des facteurs pertinents pour l'acquisition et l'application des compétences environnementales chez les professionnels.

3.2 Mesure de l'efficacité des actions choisies dans les domaines professionnels pertinents en matière environnementale.

3.3 Étude de la contribution possible de la numérisation à la promotion des compétences environnementales.

4 Transformation numérique

4.1 Étude des opportunités et des risques de la numérisation en termes d'impact sur l'environnement et les ressources, et identification des conditions-cadres nécessaires pour que la numérisation puisse exercer un effet majoritairement positif sur l'environnement.

4.2 Étude du potentiel de la transformation numérique de la société et de l'économie pour l'observation de l'environnement (monitoring, programme Copernicus), l'exécution de la législation environnementale et la communication environnementale.

DATA SOVEREIGNTY IS ESSENTIAL FOR COUNTRIES

SWISS DATA CUBE *in Numbers*

A unique Analysis Ready Data Archive

Updated every week!

37 years
FROM 1984 to 2021

7 sensors
LANDSAT 5/7/8;
SENTINEL-1/2 A-B

10-30-90m
PIXEL RESOLUTION

> 450 million
PIXELS

> 1000 billion
OBSERVATIONS

~ 15000 images
INGESTED

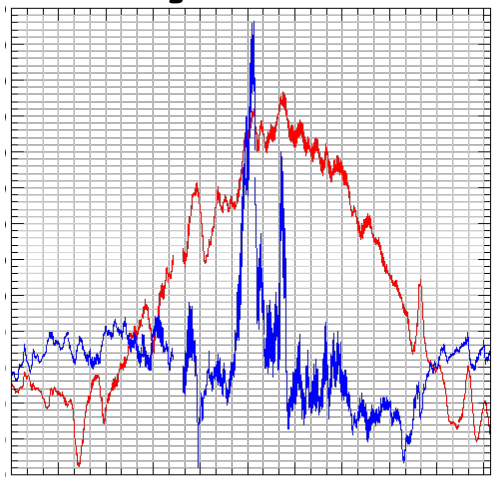
~7 TB
ANALYSIS READY DATA

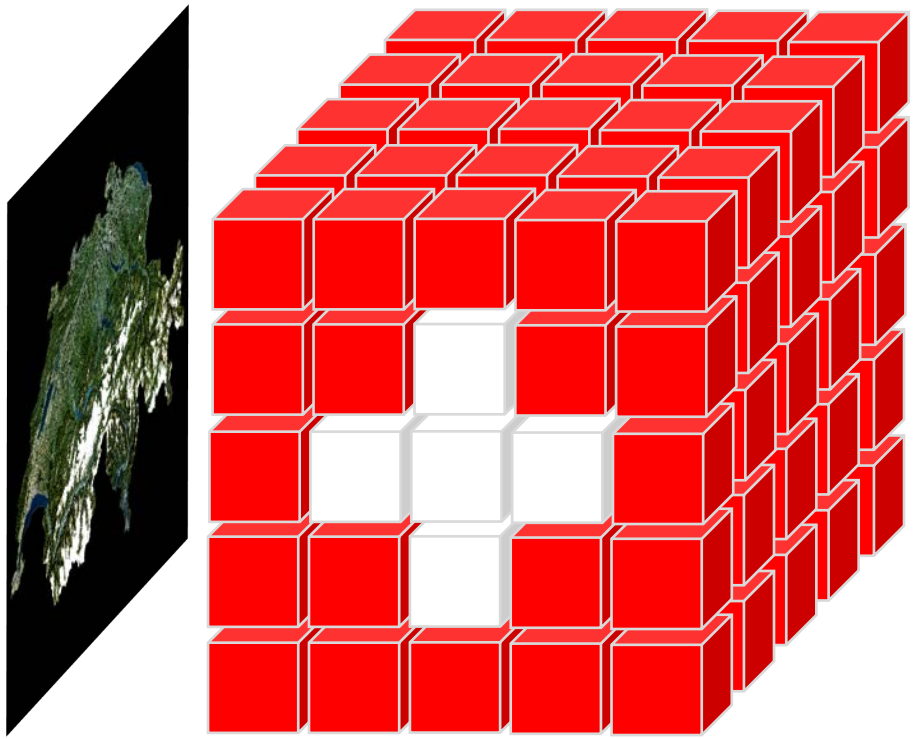
~10 millions CHF
COST OF DATA WITHOUT OPEN DATA ACCESS POLICY

GRID Genève · UNIVERSITÉ DE GENÈVE · University of Zurich[UZH] · WSL

Giuliani G., Chatenoux B., De Bono A., Rodila D., Richard J.-P., Allenbach K., Dao H., Peduzzi P. (2017) Building an Earth Observations Data Cube: lessons learned from the Swiss Data Cube (SDC) on generating Analysis Ready Data (ARD). *Big Earth Data 1(1):1-18*

Switzerland is the second country in the World …to use a Data Cube





Pioneer & Leading country on this technology for monitoring the environment!

Open Data Cube - https://www.opendatacube.org

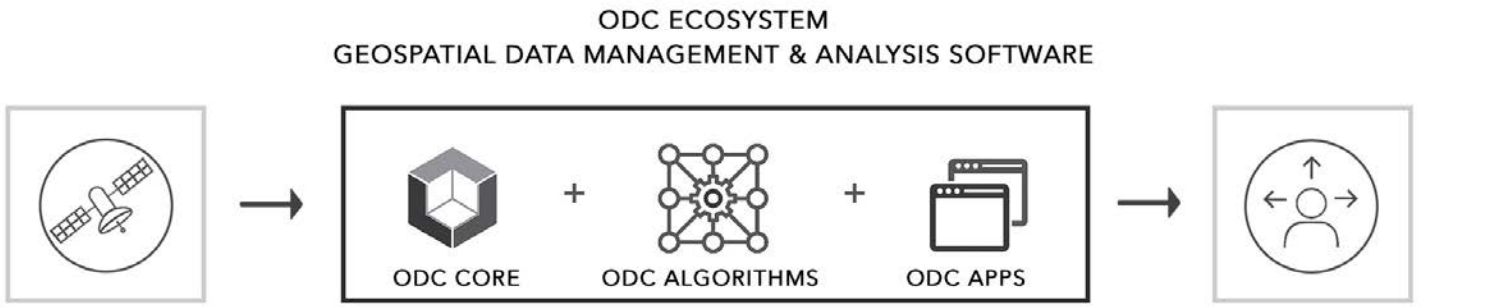
OPEN DATA CUBE

About Overview Install Applications Resources News Contact

Open Data Cube

The Open Data Cube (ODC) is an Open Source Geospatial Data Management and Analysis Software project that helps you harness the power of Satellite data. At its core, the ODC is a set of Python libraries and PostgreSQL database that helps you work with geospatial raster data. See our GitHub repository here>>.

The ODC seeks to increase the value and impact of global Earth observation satellite data by providing an open and freely accessible exploitation architecture. The ODC project seeks to foster a community to develop, sustain, and grow the technology and the breadth and depth of its applications for societal benefit.



SATELLITE DATA
Examples:
- *Landsat*
- *Sentinel*
- *MODIS*

FLEXIBLE DEPLOYMENT
Depending on your application, the Open Data Cube can be deployed on HPC, Cloud, and local installations. Typical installations run on Linux, MacOS, and Windows.

INFORMED DECISIONS
Examples:
- *Deforestation*
- *Water Quality*
- *Illegal Mining*

Learn More

Australian Government
Geoscience Australia
CEOS
USGS science for a changing world
CSIRO
CATAPULT Satellite Applications
AMA ANALYTICAL MECHANICS ASSOCIATES

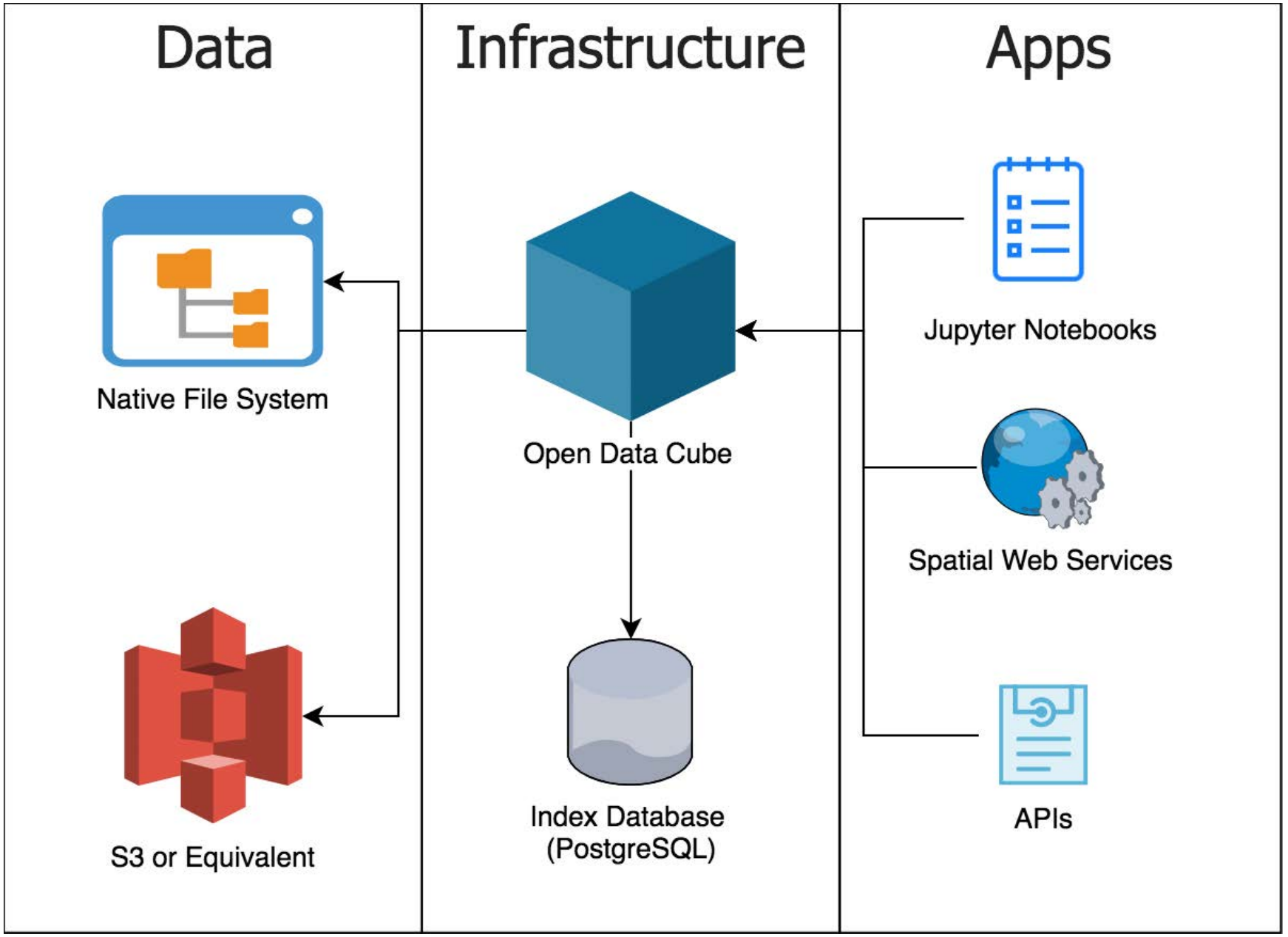
What is the Open Data Cube?

OPEN DATA CUBE

A Python Library that facilitates working with raster data

Courtesy UK Catapult

Technical components



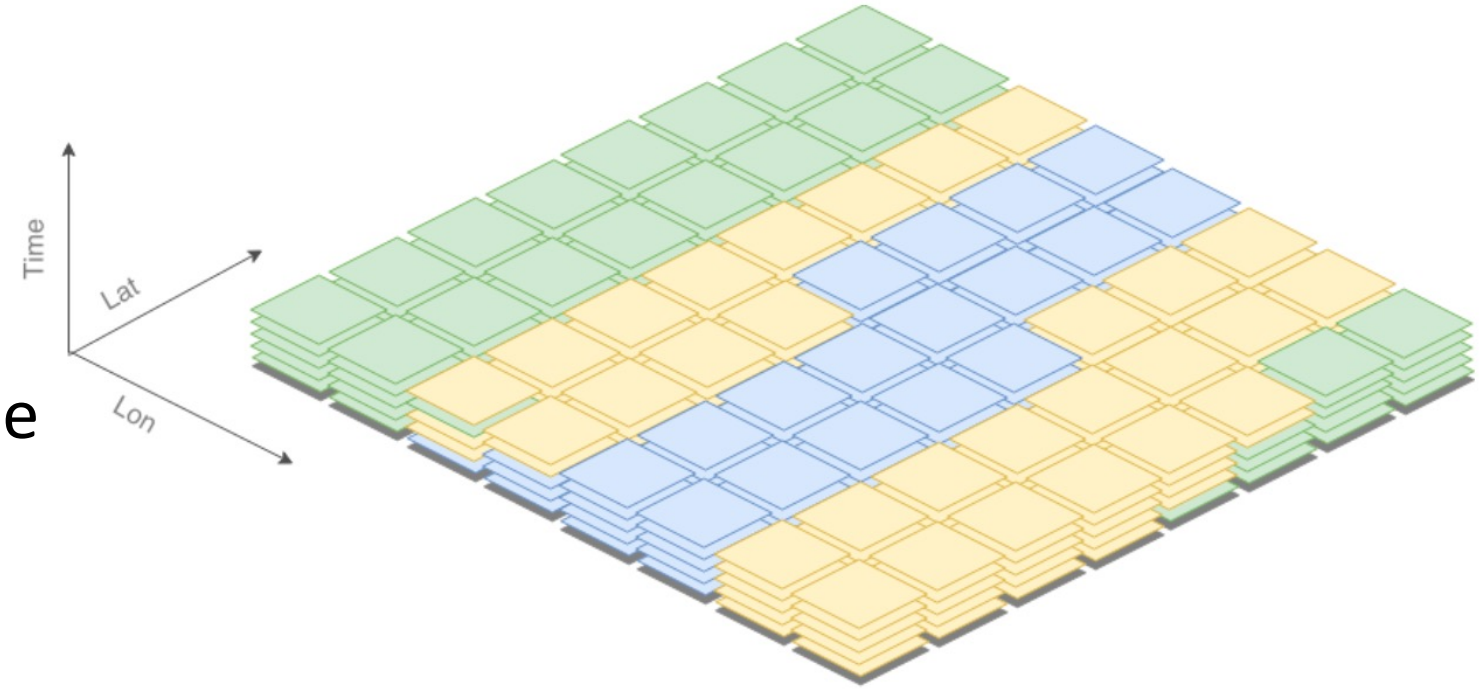
In a nutshell:

- Data
- An Index
- Software

Courtesy UK Catapult

Dense Data

- A versatile representation
- All points map to a value
- Easy to select/index
- Efficient representation in memory
- Called “Raster Data”
- Data Cube analysis case is spatially and temporally dense



Courtesy UK Catapult

Why Python?

- Numpy
- Scipy
- Scikit-learn
- Matplotlib

> I have used a combination of Perl, Fortran, NCL, Matlab, R and others for routine research, but found out this general- purpose language, Python, can handle almost all in an efficient way from requesting data from remote online sites to statistics, and graphics.

Courtesy UK Catapult

Why do we need Data Cubes?

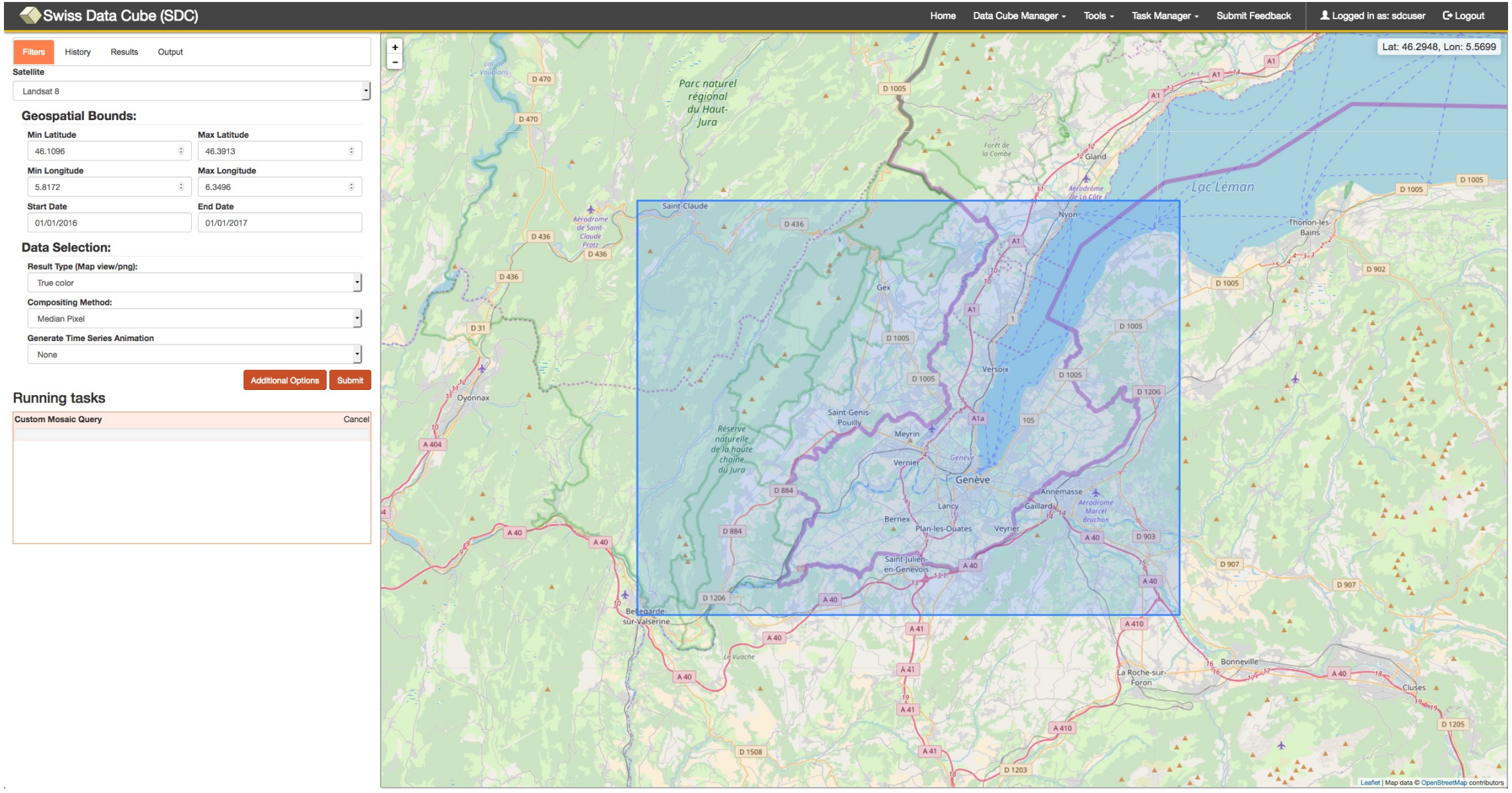
OPEN DATA CUBE

- Makes it easier to use satellite data by reducing preparation time
- Makes it easier to query data in time and space for powerful application products
- Provides free and open-source software and algorithms for the cloud or a local computer
- Allows community development, shared capacity building and organized algorithms
- Enables efficient time series analyses and data interoperability

Courtesy UK Catapult

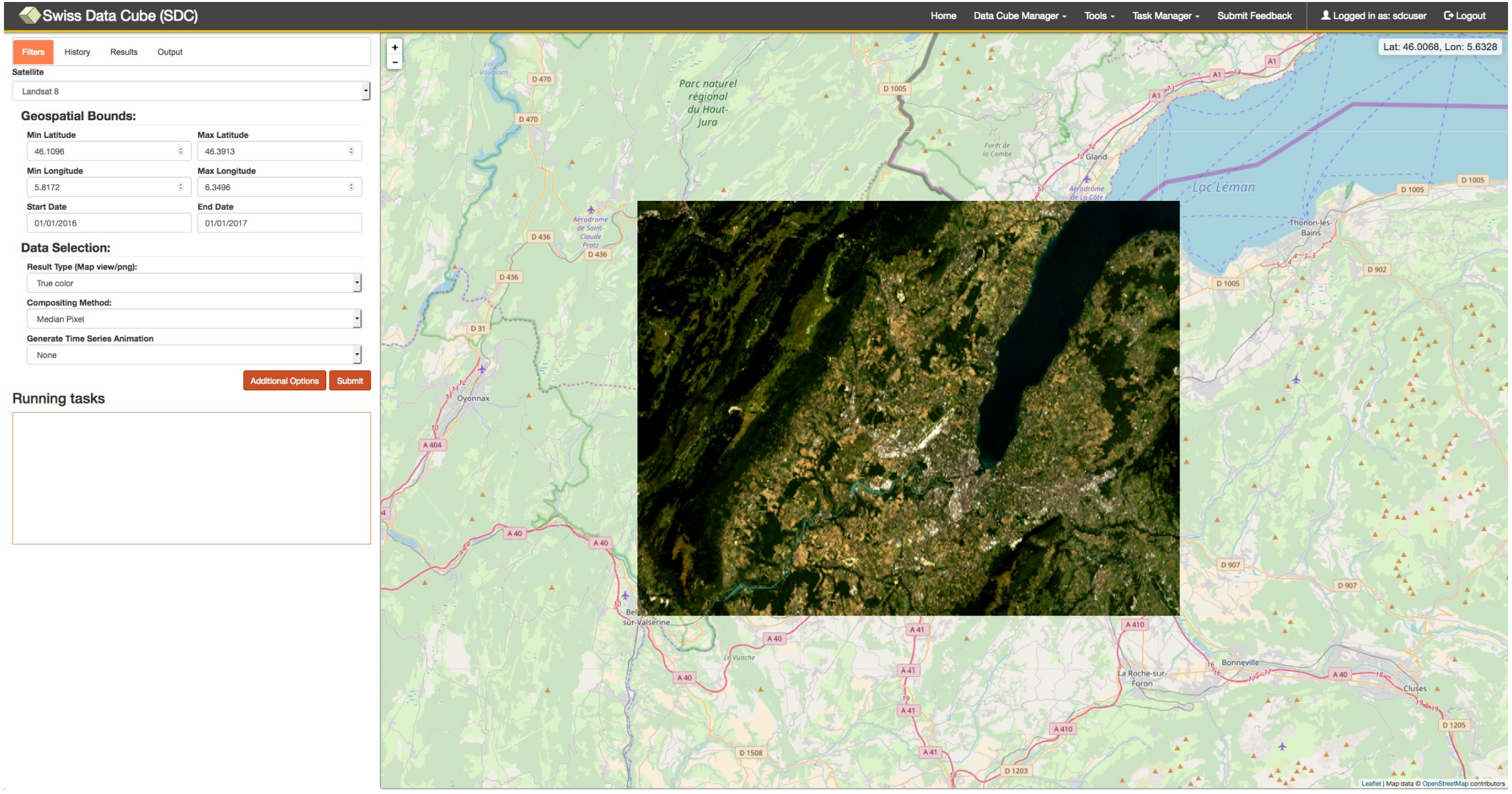
How to use the Swiss Data Cube?

Define your area of interest, your algorithm and your time-frame



How to use the Swiss Data Cube?

And get the result!



Or use the Python API

Jupyter Notebook

jupyter test2_Aletsch_LB_RGB Last Checkpoint: 09/26/2017 (autosaved) Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

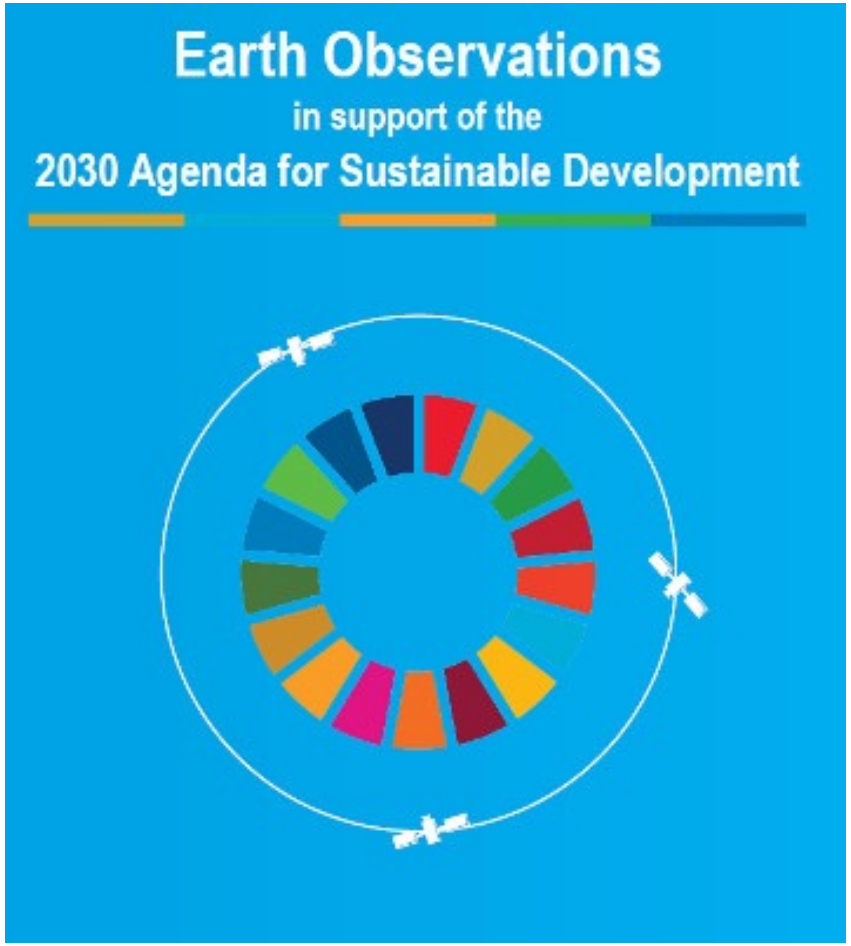
Code

Out[8]: <matplotlib.text.Text at 0x7f19aff47b00>

In [7]:
```
max_time = 18
for i in range(0,max_time):
    plt.figure(figsize=(6, 6))
    sel = scaled2.isel(time=i)
    plt.imshow(sel)
    plt.axis('off')
    t = pd.to_datetime(str(sel['time'].values))
    plt.title(t.strftime('%d %m %Y'),loc='right')
    plt.title('RGB Glacier Aletsch',loc='left')
```

Earth Observations is useful for monitoring SDG's

GEO GROUP ON EARTH OBSERVATIONS



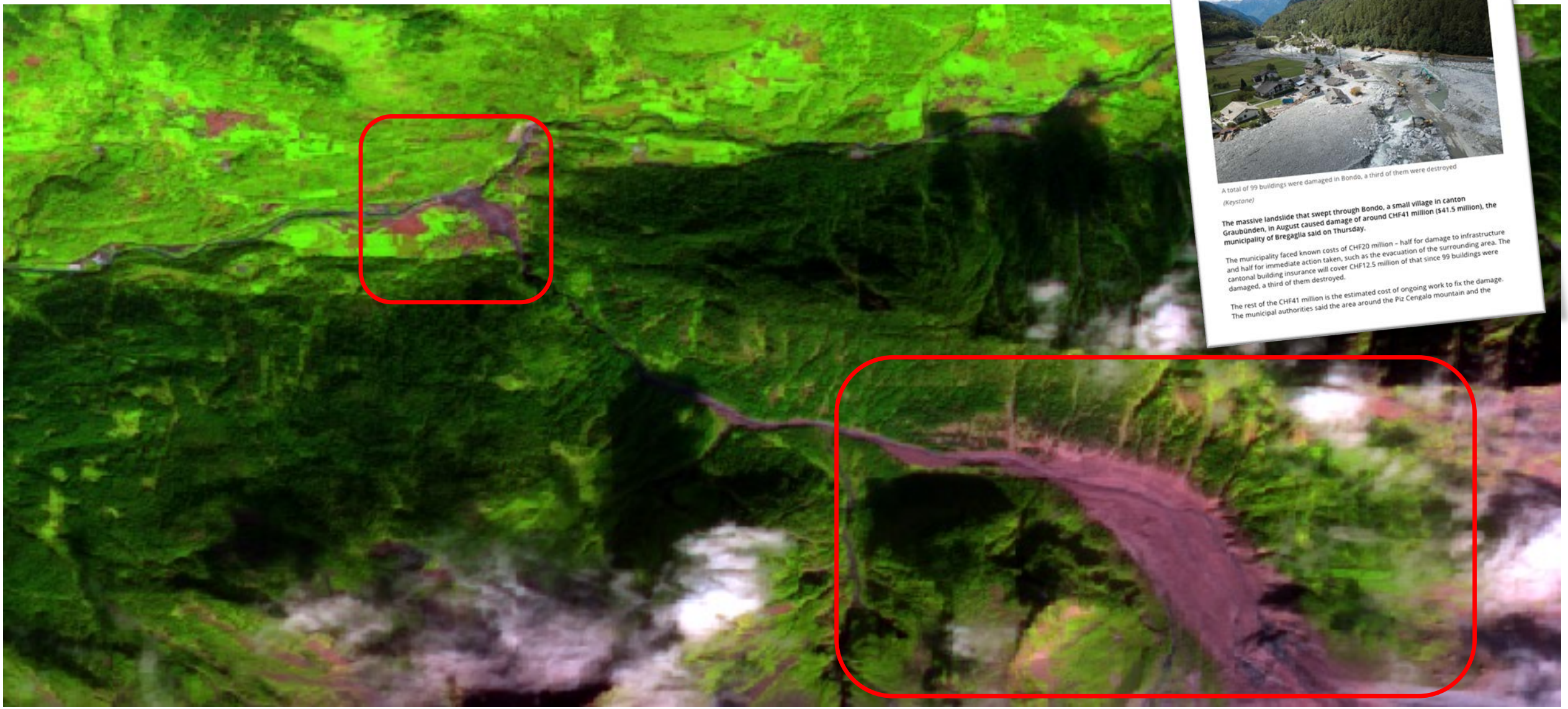
http://earthobservations.org/geo_sdgs.php

EARTH OBSERVATION AND GEOSPATIAL INFORMATION LINKAGES TO SDG GOALS, TARGETS AND INDICATORS

SUSTAINABLE DEVELOPMENT GOALS

Target (Contribute to progress on the Target, not necessarily the Indicator)									Goal	Indicator (Direct measure or indirect support to the Indicator)					
							1.4	1.5	1 No poverty	1.4.2					
						2.3	2.4	2.c	2 Zero hunger	2.4.1					
					3.3	3.4	3.9	3.d	3 Good health and well-being	3.9.1					
									4 Quality education						
								5.a	5 Gender equality	5.a.1					
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6 Clean water and sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
					7.2	7.3	7.a	7.b	7 Affordable and clean energy	7.1.1					
								8.4	8 Decent work and economic growth						
					9.1	9.4	9.5	9.a	9 Industry, innovation and infrastructure	9.1.1	9.4.1				
						10.6	10.7	10.a	10 Reduced inequalities						
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11 Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
				12.2	12.4	12.8	12.a	12.b	12 Responsible consumption and production	12.a.1					
					13.1	13.2	13.3	13.b	13 Climate action	13.1.1					
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14 Life below water	14.3.1	14.4.1	14.5.1			
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15 Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
								16.8	16 Peace, justice and strong institutions						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17 Partnerships for the goals	17.6.1	17.18.1				

Bondo Landslide – 23 august 2017



NATURAL CATASTROPHE

Bondo landslide damage estimated at CHF41 million

By swissinfo.ch and agencies

DEC 14, 2017 - 21:29

A total of 99 buildings were damaged in Bondo, a third of them were destroyed

(Keystone)

The massive landslide that swept through Bondo, a small village in canton Graubünden, in August caused damage of around CHF41 million ($41.5 million), the municipality of Bregaglia said on Thursday.

The municipality faced known costs of CHF20 million – half for damage to infrastructure and half for immediate action taken, such as the evacuation of the surrounding area. The cantonal building insurance will cover CHF12.5 million of that since 99 buildings were damaged, a third of them destroyed.

The rest of the CHF41 million is the estimated cost of ongoing work to fix the damage. The municipal authorities said the area around the Piz Cengalo mountain and the

Leuk forest fire – 13 august 2003

Huge fire rages near alpine resort

AUG 14, 2003 - 14:02

The biggest single forest fire in Switzerland for three decades has forced emergency services to draft in the Swiss army to help battle the flames.

Dry conditions and winds of around 45kmh fuelled the blaze near the spa resort of Leukerbad.

Some 125 soldiers were mobilised to help firefighters tackle the blaze which ravaged 450 hectares of forest in canton Valais.

Around 450 hectares of forest went up in smoke around Leuk.

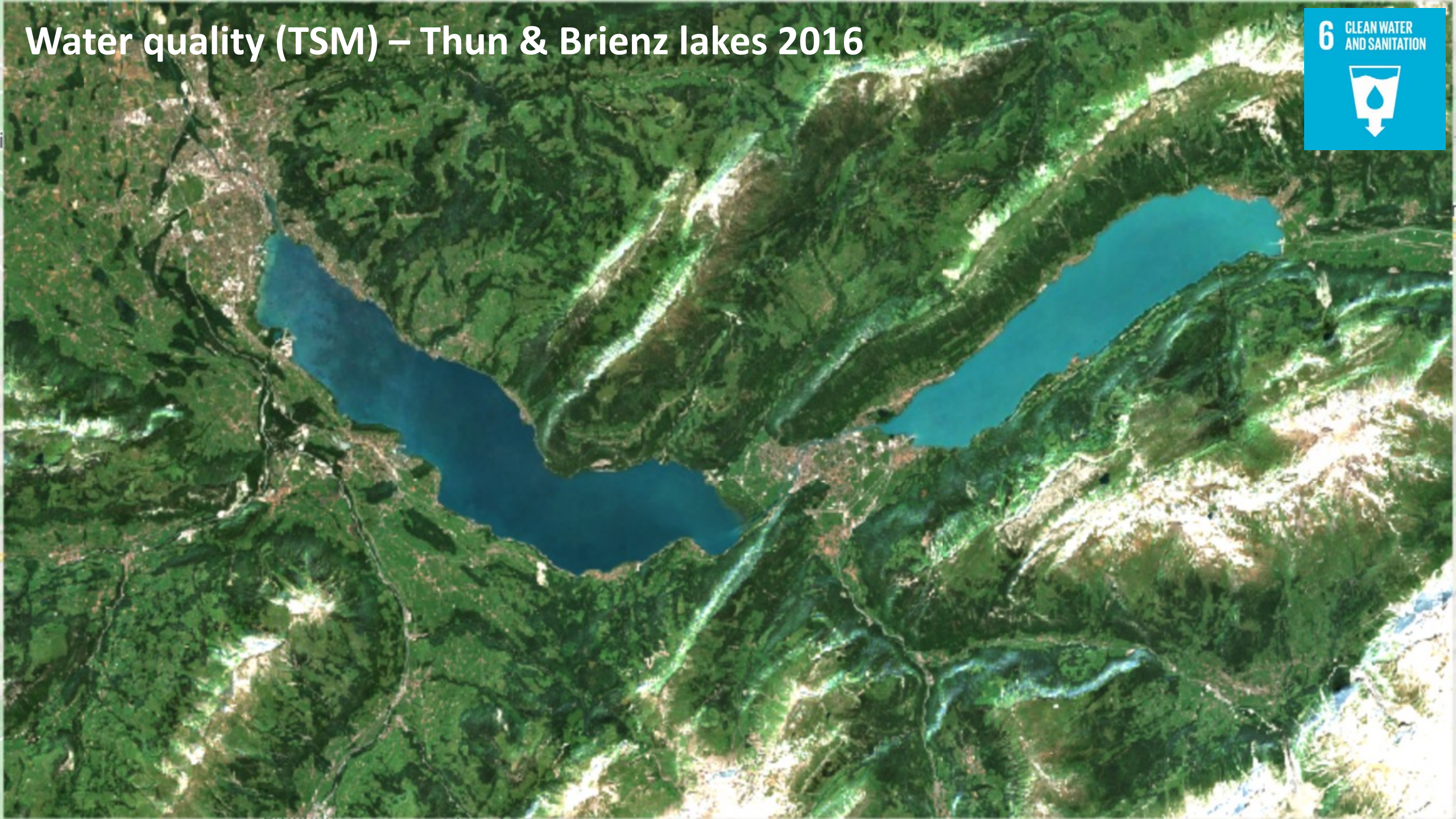
(Keystone)

Seven helicopters – including two army Superpumas - and more than 300 firefighters were drafted in to contain the fire, which cantonal police believe could have been ignited by a cigarette. One worker was admitted to hospital with slight injuries.

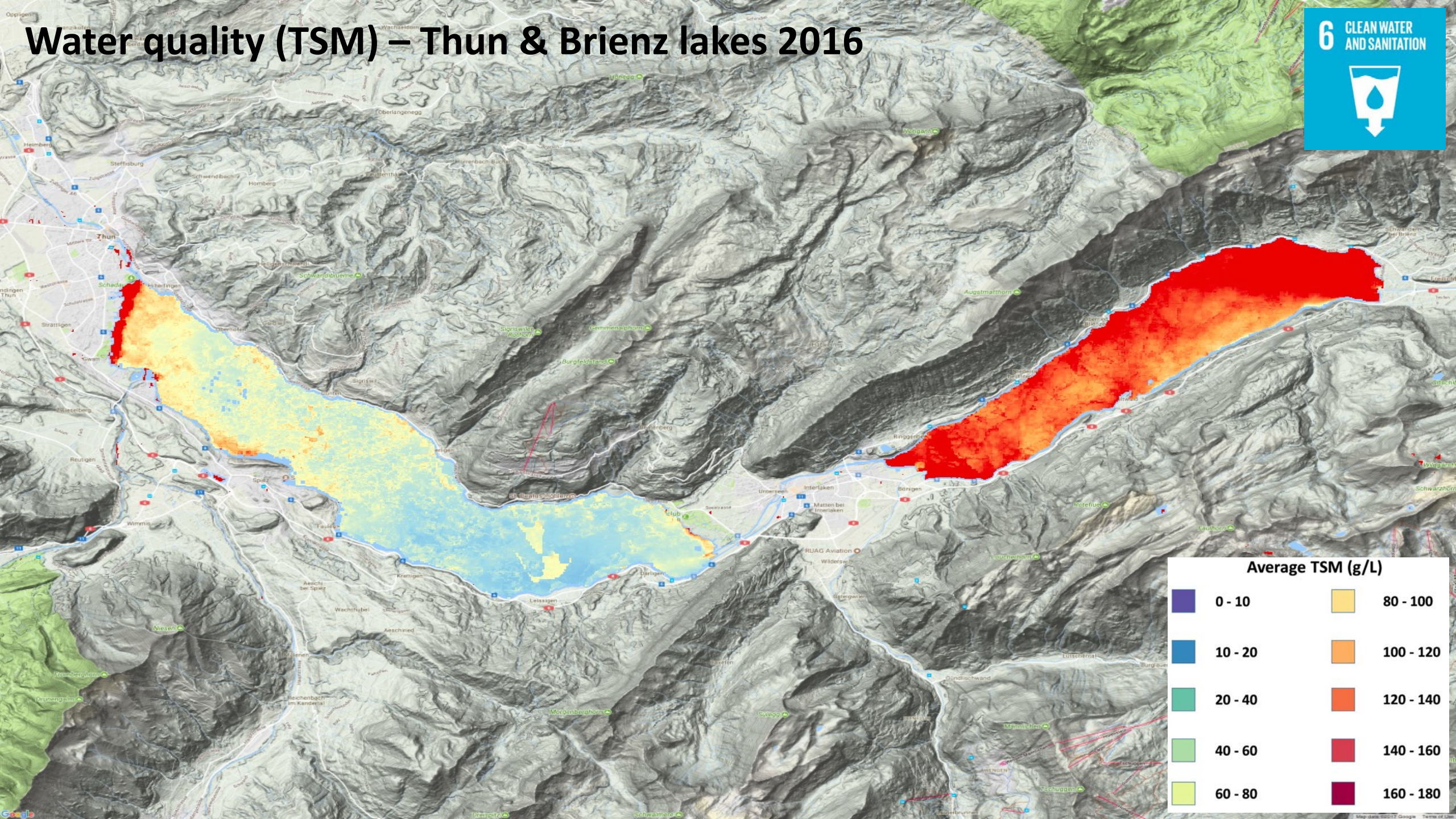
The blaze began on Wednesday evening and rapidly spread to an altitude of 2,000 metres. Shortly before midnight, hundreds of people living in the nearby towns of Leuk, Wyler and Albinen had to be evacuated.

They were able to return home late on Thursday even though the fire continued to burn in patches.

Water quality (TSM) – Thun & Brienz lakes 2016



Water quality (TSM) – Thun & Brienz lakes 2016



6 CLEAN WATER AND SANITATION

Water Observations

Water observations / Maximum observations

0% - 0.5%	25% - 37.5%
0.5% - 1.25%	37.5% - 50%
1.25% - 2.5%	50% - 62.5%
2.5% - 6.25%	62.5% - 75%
6.25% - 12.5%	75% - 87.5%
12.5% - 25%	87.5% - 100%

Water detection – Drought impact (2018)


11 SUSTAINABLE CITIES AND COMMUNITIES
Urbanization – Bulle 1985/2018

11 SUSTAINABLE CITIES AND COMMUNITIES

Modelling Accessibility to Urban Green Areas Using Open Earth Observations Data: A Novel Approach to Support the Urban SDG in Four European Cities

by Gregory Giuliani [1,2,*], Ekkehard Petri [3], Eduard Interwies [4], Veronika Vysna [3], Yaniss Guigoz [1,2,5], Nicolas Ray [1,5] and Ian Dickie [6]

[1] Institute for Environmental Sciences, University of Geneva, Bd Carl-Vogt 66, CH-1205 Geneva, Switzerland

[2] United Nations Environment Programme, GRID-Geneva, 11 chemin des Anémones, CH-1211 Châtelaine, Switzerland

[3] European Commission—Eurostat, 5 Rue Alphonse Weicker, L-2721 Luxembourg, Luxembourg

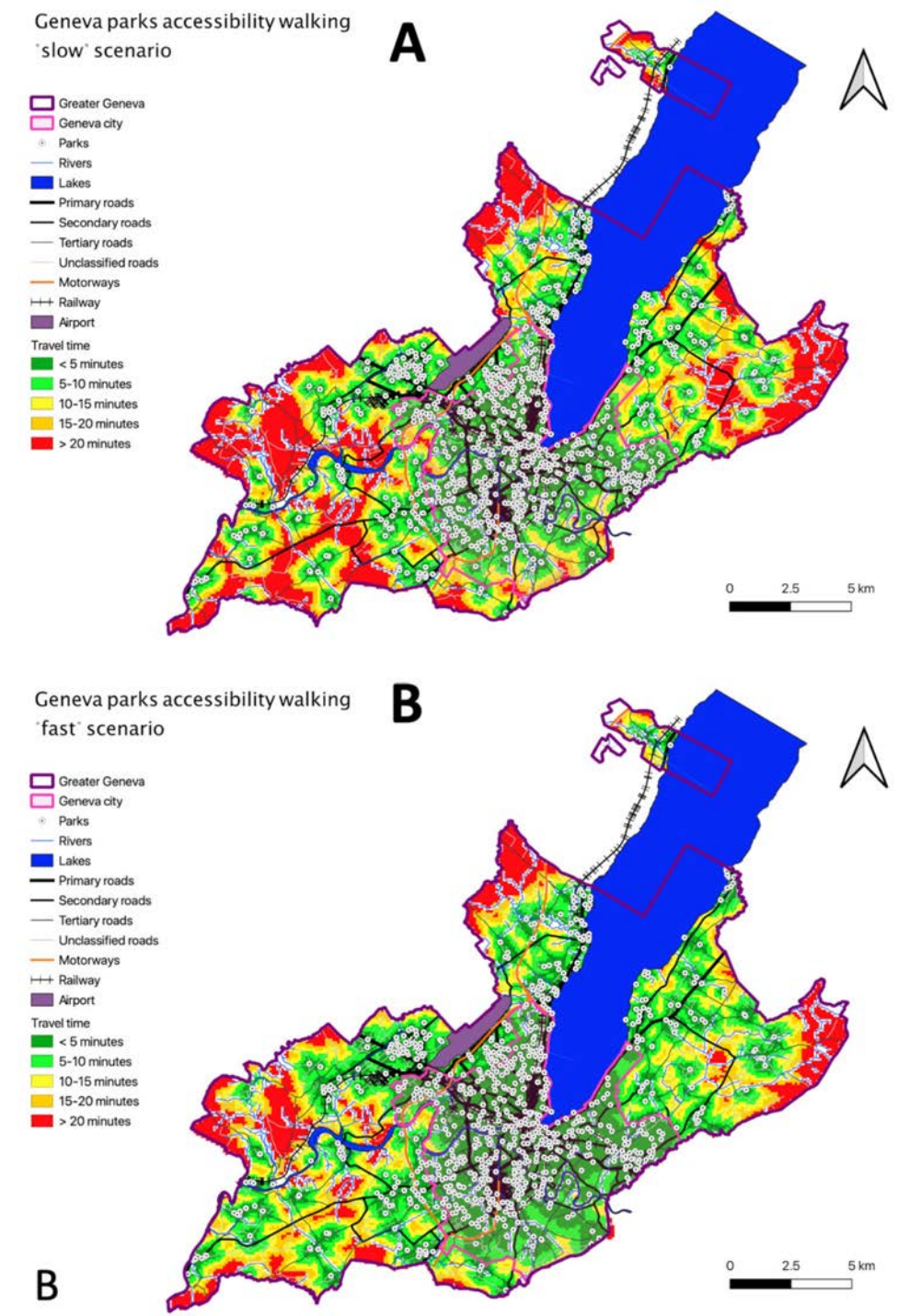
[4] Intersus—Sustainability Services, Chodowieckistr. 2, 10405 Berlin, Germany

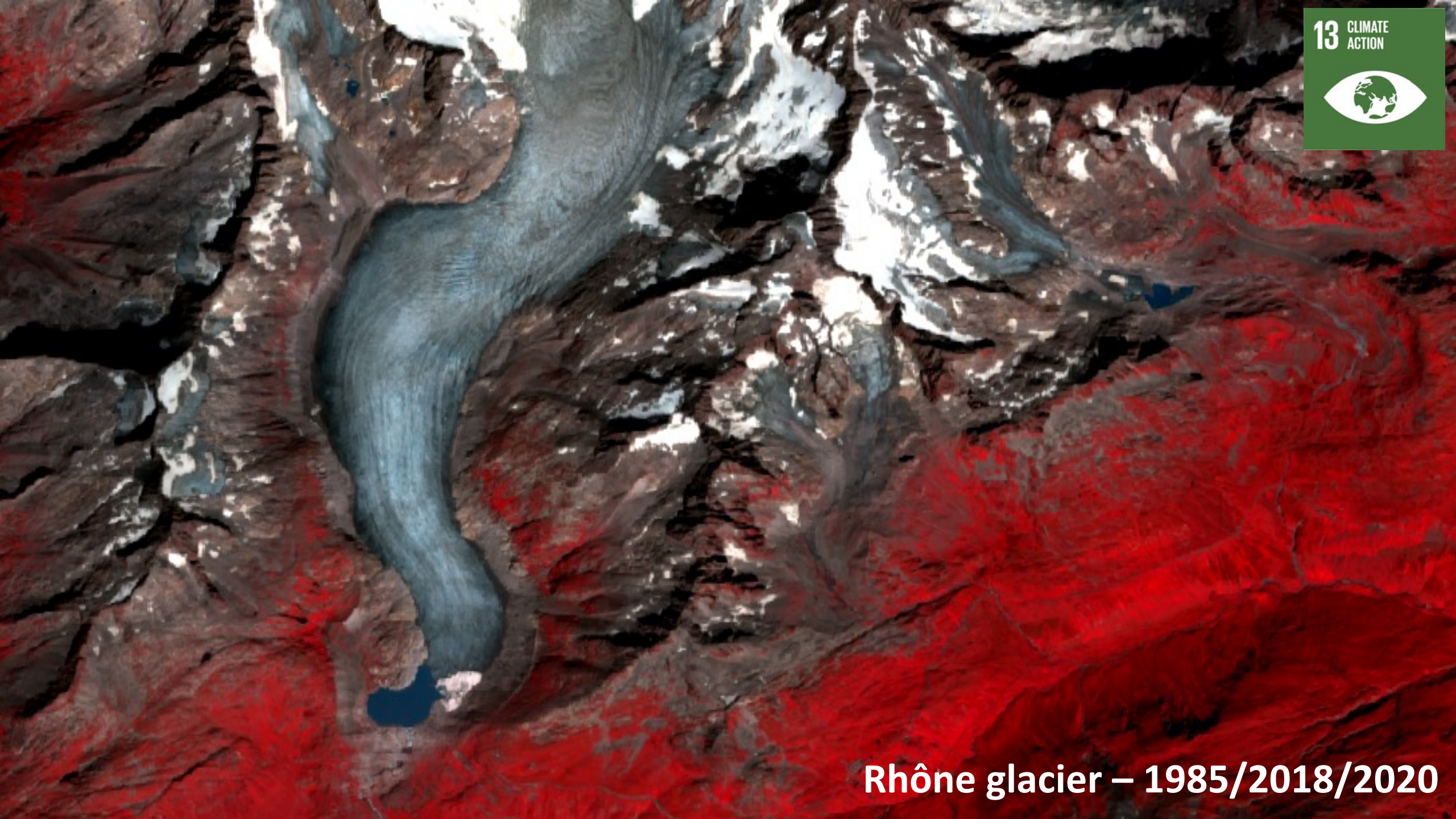
[5] GeoHealth Group, Institute of Global Health, University of Geneva, 9 chemin des Mines, CH-1202 Geneva, Switzerland

[6] Eftec—Economics for the Environment, 4 City Road, London EC1Y 2AA, UK

[*] Author to whom correspondence should be addressed.

Remote Sens. **2021**, *13*(3), 422; https://doi.org/10.3390/rs13030422





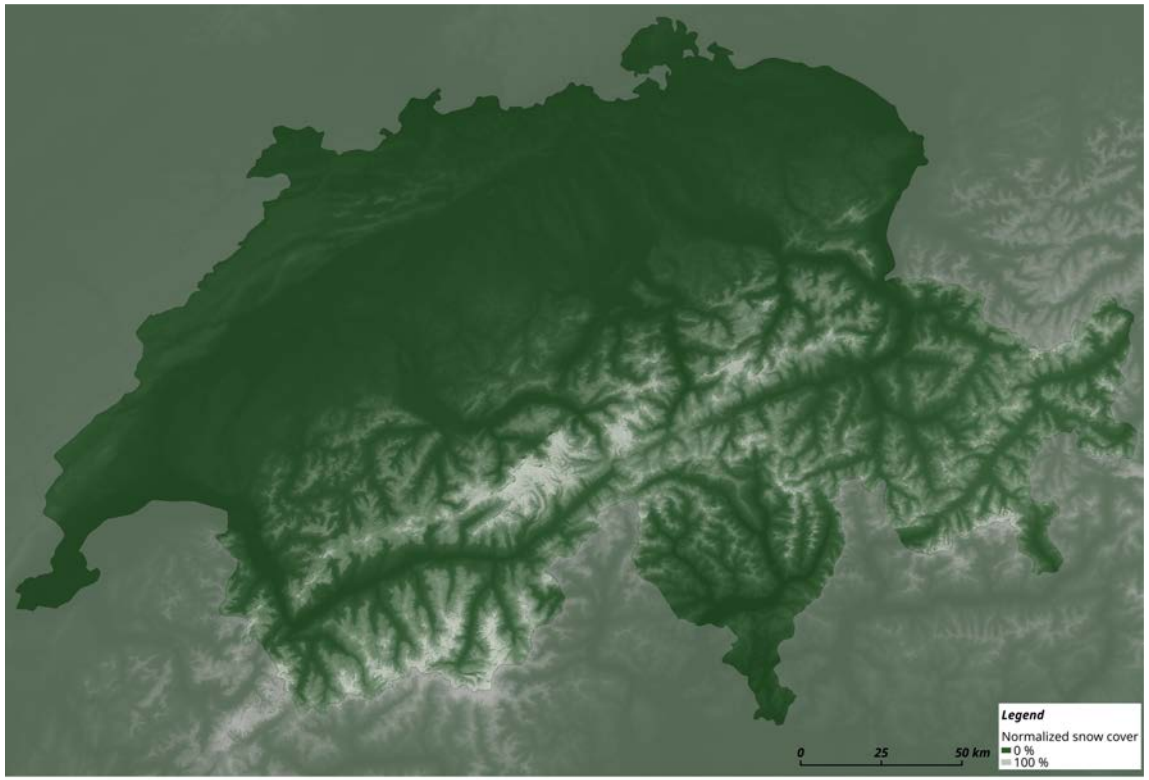
Rhône glacier – 1985/2018/2020

Snow cover mapping

Snow is an important form of water storage

Snow cover is an Essential Climate Variable

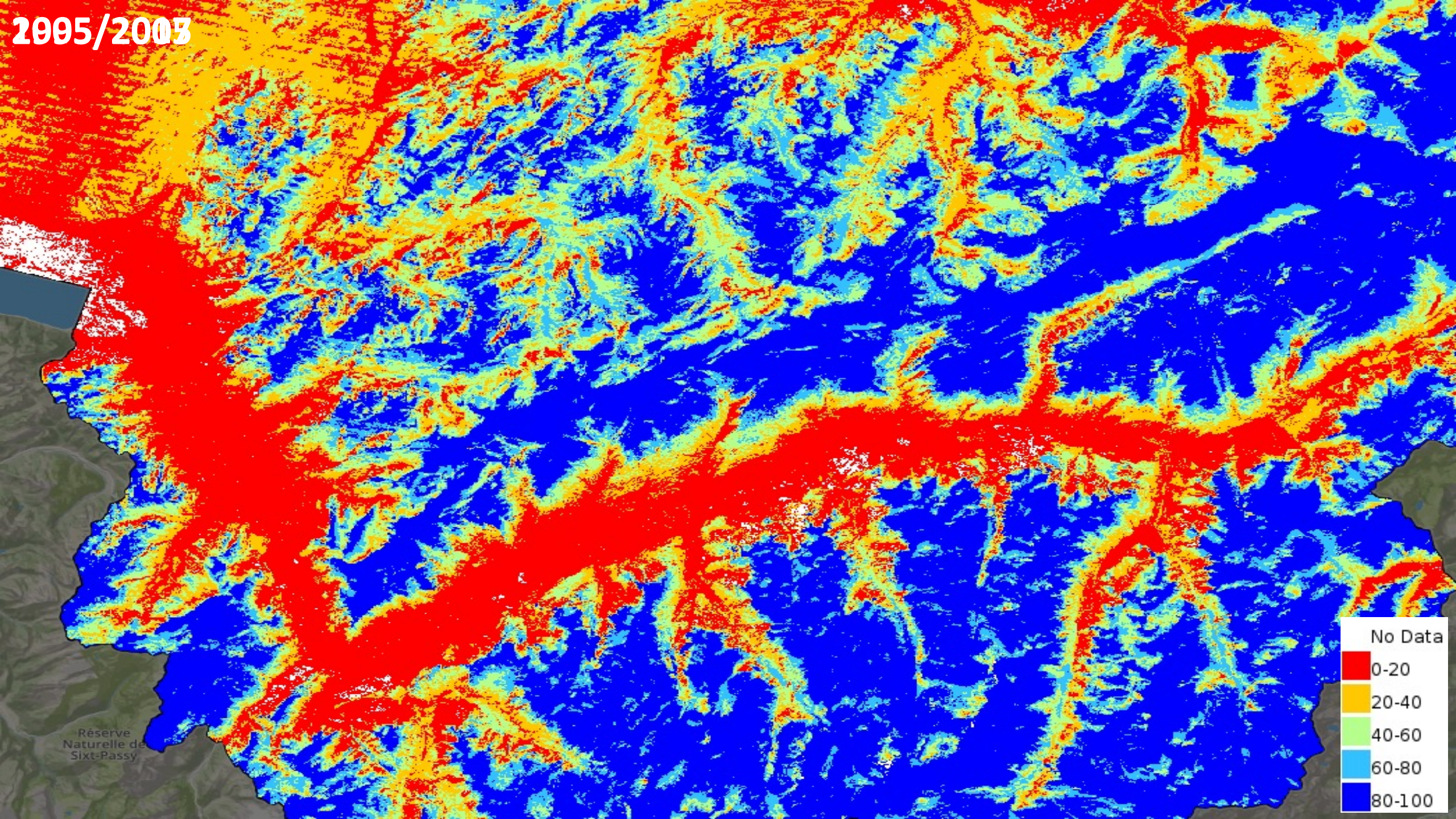
A natural resource: indicator of climate change; essential for water-resource management; affects various ecosystem services



Normalized swow cover in Switzerland April-August 2017

Using Sentinel-2 data

Frau L., Rizvi S., Chatenoux B., Richard J.-P., Giuliani G. (2018) Snow Observations from Space: An approach to map snow cover from three decades of Landsat imagery across Switzerland. *In: IGARSS 2018 - IEEE International Geoscience and Remote Sensing Symposium. Valencia (Spain). p. 8672-8675*


2005/2007
Réserve
Naturelle de
Sixt-Passy
No Data
0-20
20-40
40-60
60-80
80-100

Snow Cover changes for the last 20 years!

Permanent snow area decreased of 4% (2100km^2) while surface where snow is rare has increased of 8% (5200km^2).