Setting the Stage: The Role of Space Technology in Energy

ADB Data Room: Emerging Areas Sustainable Solutions Initiatives
Space Technology for Energy and Cross-Sector Innovation: Transforming the Asia-Pacific Region
13 February 2025

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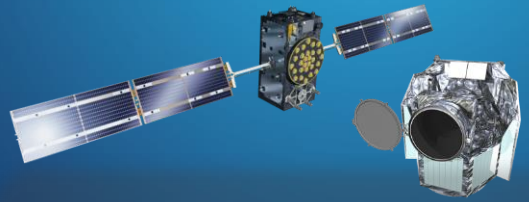
Climate Action, Sustainability and Science Department

The European Space Agency

What is the European Space Agency?

5 500+
ESA Workforce



Promoting cooperation among European States in space research, technology and applications, for exclusively peaceful purposes

Make Space for Europe

23
Member States

2025 Budget

€ 7.68 billion =
10.5 per European

ESA Member and Cooperating States

23 ESA Member States:

21 states of the EU (**AT**, **BE**, **CZ**, **DE**, **DK**, **EE**, **ES**, **FI**, **FR**, **IT**, **GR**, **HU**, **IE**, **LU**, **NL**, **PT**, **PL**, **RO**, **SE**, **SI**, **UK**)

Non-EU: **CH** and **NO**

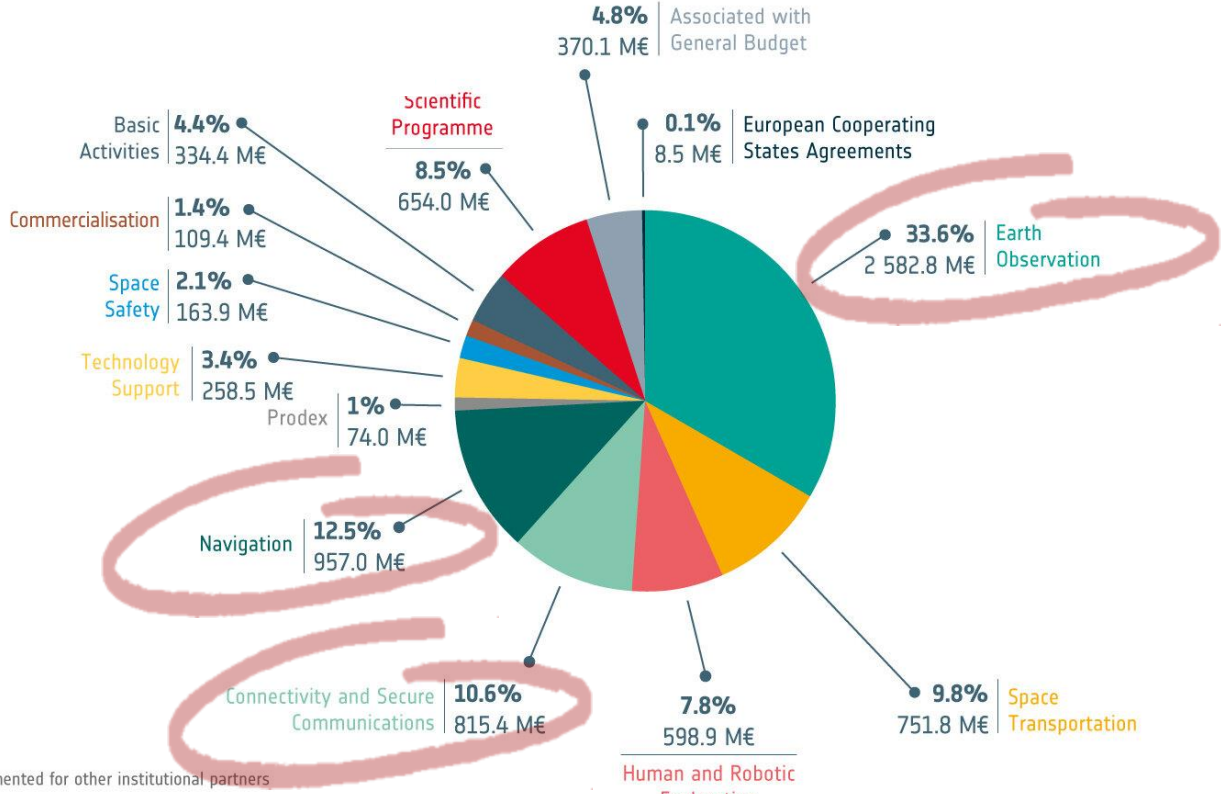
3 Associate Members: **SK**, **LT**, **LV**

Cooperation Agreements with ESA:

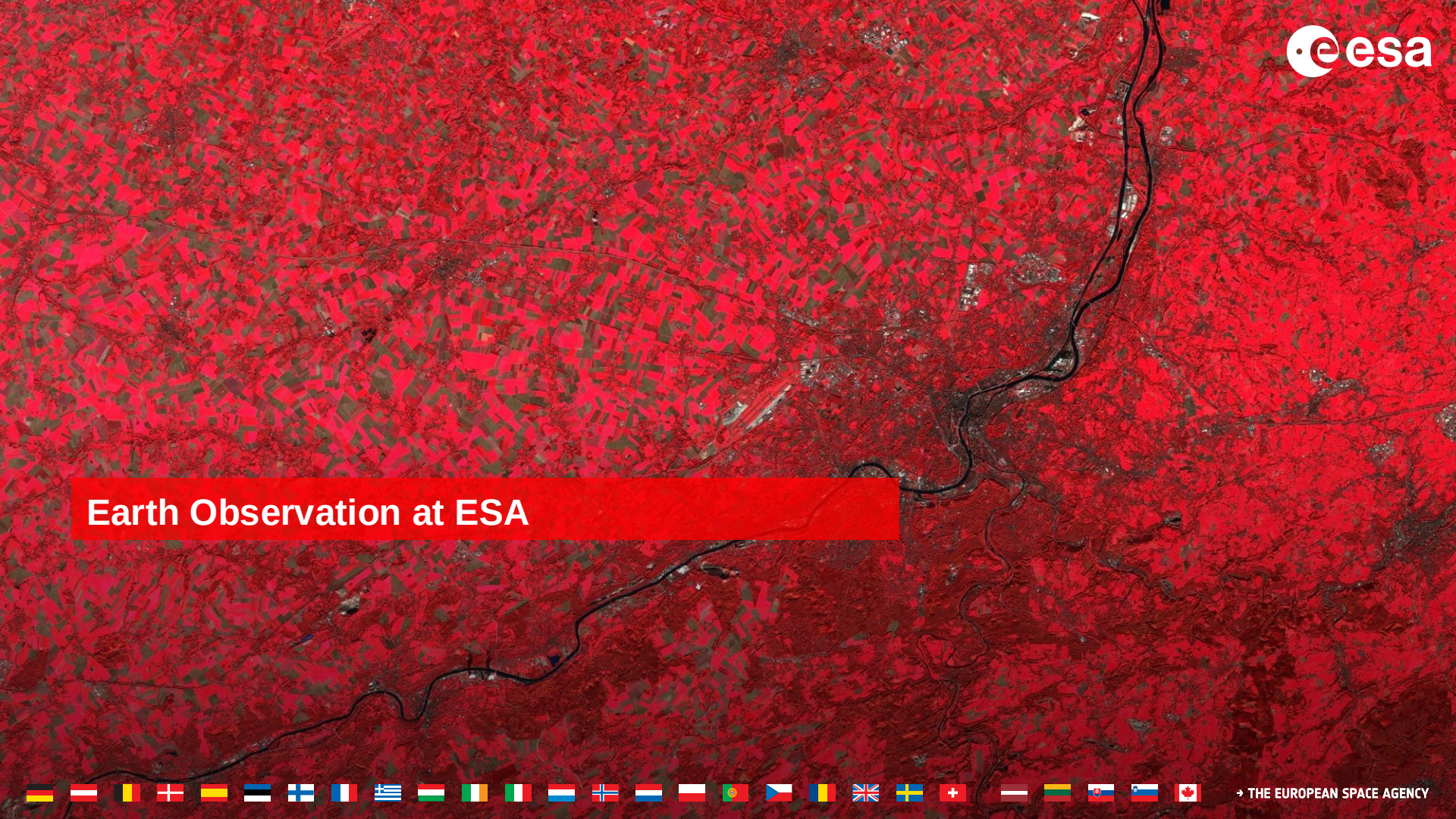
BG, **CY**, **HR**, **MT**

Canada takes part in some programmes under a long-standing Cooperation Agreement

ESA Budget by Domain for 2025: 7.68 B€*



*Includes activities implemented for other institutional partners



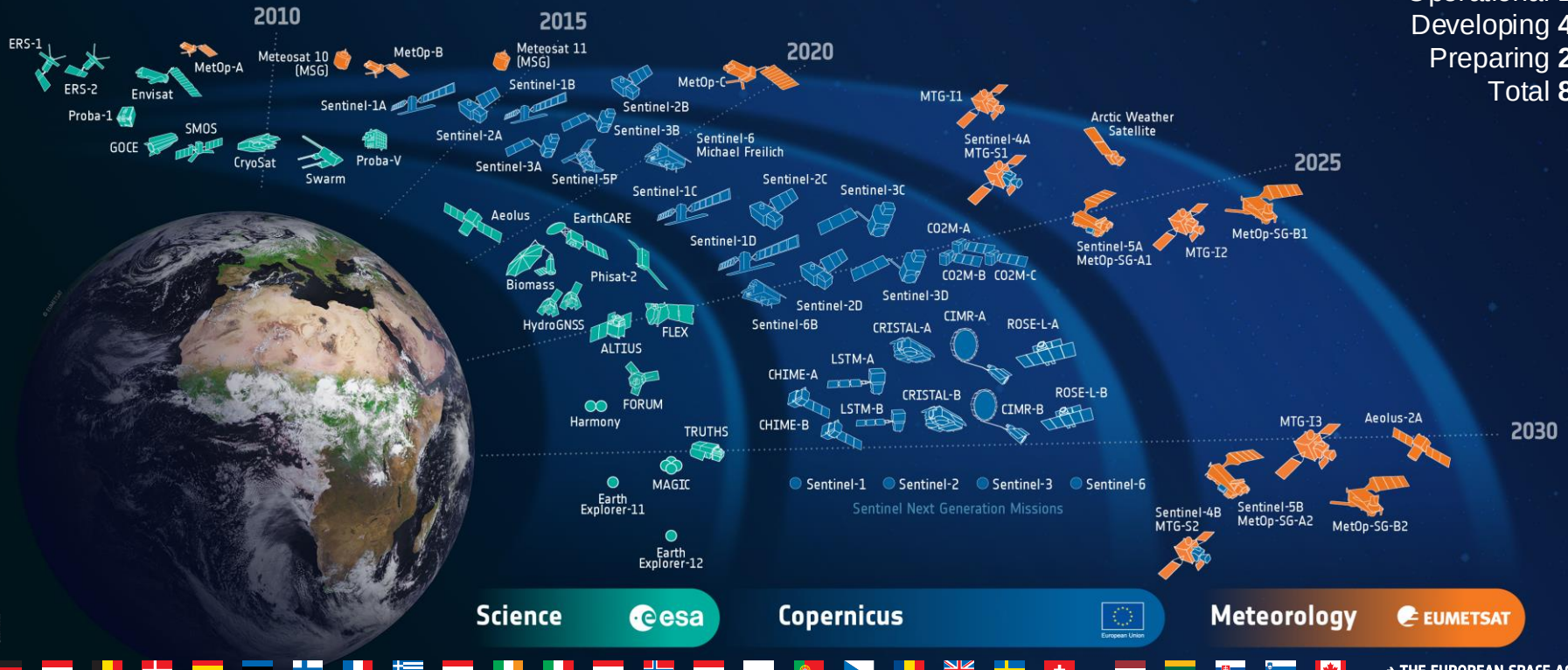
Earth Observation at ESA

ESA's Earth Observation Missions

World-class Earth Observation systems developed with European and global partners to address scientific and societal challenges

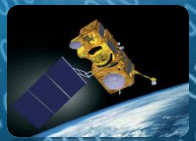
Satellites

Heritage **08**
Operational **16**
Developing **40**
Preparing **22**
Total **86**



The Era of Big Data

Satellite fleets



Advent of steady satellite data streams

Start the data revolution

Data are the foundation of energy development policies and program implementation

Building on ICT advances

High-performance computing infrastructures

ESA and the Development Sector

ESA EO programmes in Support of International Development

Dedicated programmatic instruments to channel ESA's cooperation with International Financial Institutions

- **eoworld, eotap, etc.:** 2008-2015
  Small-scale demonstrations of EO services in support of IFI projects to **raise awareness**

eoworld Earth Observation for Development
eotap earth observation for a transforming asia pacific
eoeuropa earth observation for development

- **EO4SD:** 2016-2023
  Consolidation of requirements and strategic engagement of development stakeholders to **build capacity** on EO services

eo4sd earth observation for sustainable development

urban development EO4SD · agriculture and rural development EO4SD · water resources management EO4SD · disaster risk reduction EO4SD · climate resilience EO4SD · marine resources EO4SD · fragility, conflict and security EO4SD · forest management EO4SD

- **GDA:** 2020-2025
  Mainstreaming of EO into development operations and financing, and **skills transfer** to IFI and client state stakeholders

GDA

gda.esa.int

European Space Agency: IFI Partnerships

Institutional partnerships

ESA secondees/resource persons

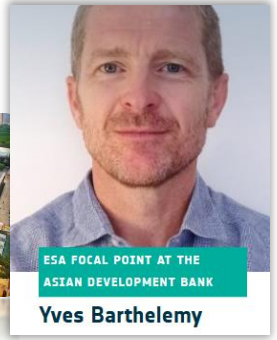
THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

2011-15 A. Burzykowska
2016-21 C. Aubrecht
2021-24 A. Chunet
2024- F. Cian

IFAD

IDB

ADB ASIAN DEVELOPMENT BANK



2017-22 P. Manunta
2024- Y. Barthelemy

Earth Observation and Energy

→ THE EUROPEAN SPACE AGENCY

Earth Observation and Clean Energy

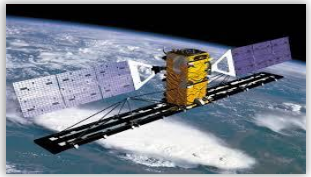
Earth Observation can support with:

- Renewable energy **resource mapping**, by providing detailed and long-term statistics on solar irradiance, wind speed and direction, runoff due to snow cover, geothermal anomalies, biomass crops, etc.
- Energy **demand characterisation**, by mapping settlements, important public infrastructure, potential irrigation areas and other indicators of high electricity consumption economic activity.
- Production and transmission infrastructure **site selection**, by combining resource information with information on the local or regional environment, existing land and infrastructure characteristics, natural hazards, etc. In the case of solar energy, this would include the assessment of the PV (photovoltaic) potential that can be harvested from (urban) rooftops, water bodies, etc. In the case of transmission infrastructure, this includes the deployment of least-cost solutions, via grid expansion/intensification/densification and mini-grids.
- Creating **inventories of existing energy infrastructure**, by mapping features such as HV (high-voltage) and, more importantly MV (medium-voltage) and LV (low-voltage) power infrastructure and networks, etc. Monitoring of electrification progress.
- Managing **energy production operations**, by providing information on available and/or forecasted biomass crops, available solid fuel in the form of waste accumulated at managed waste sites, extreme weather events that would cause significant variations in the expected energy demand, etc.
- Assessing **energy infrastructure vulnerability** by estimating climate and disaster risks (floods, landslides, erosion, etc.), and by monitoring external threats such as human and natural (vegetation) encroachment on transmission lines, etc.

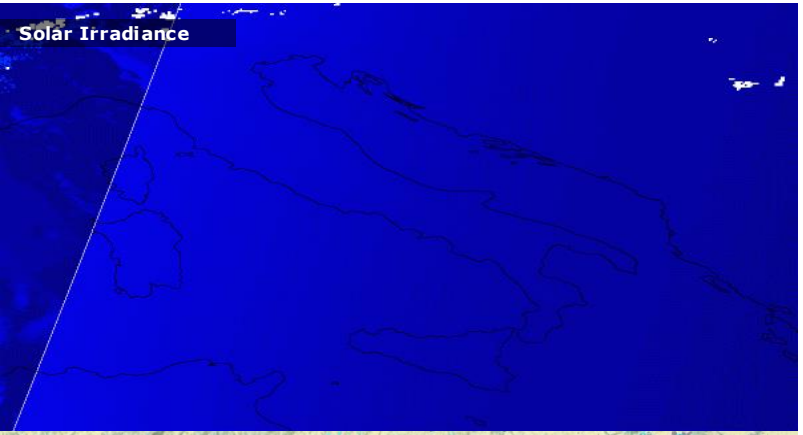
Earth Observation Products for Renewable Energy

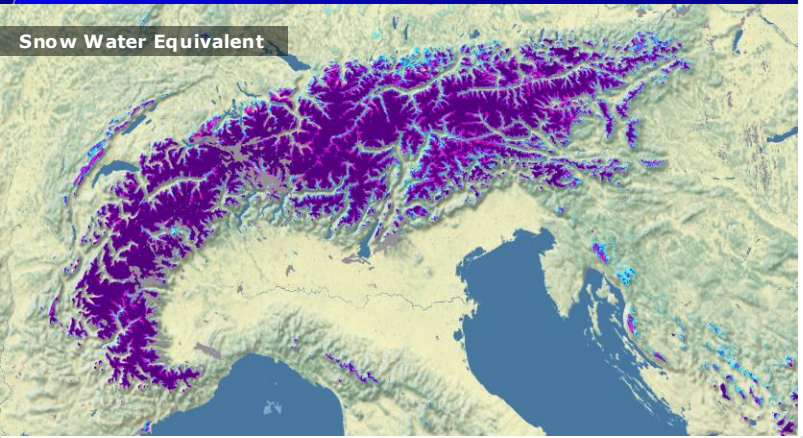
	Marine	Wind	Hydro	Solar	Biomass	Storage	Electrification
Wave/current/tide resource data	●	●					
Offshore wind speed and direction resource data	●	●					
Snow cover extent			●	●			
General land cover type and change			●	●	●	●	●
Digital Elevation Models		●	●	●		●	●
Soil moisture, precipitation			●		●		
Infrastructure and ground stability indicators (displacement rates, etc.)			●			●	●
River and lake parameters			●				
Solar irradiance				●			
Land surface temperature				●	●		
Atmospheric composition (aerosols)				●			
NRT parameters as input to mesoscale modelling/forecasting	●	●	●	●	●		
Basic mapping (proxies of electricity demand)							●

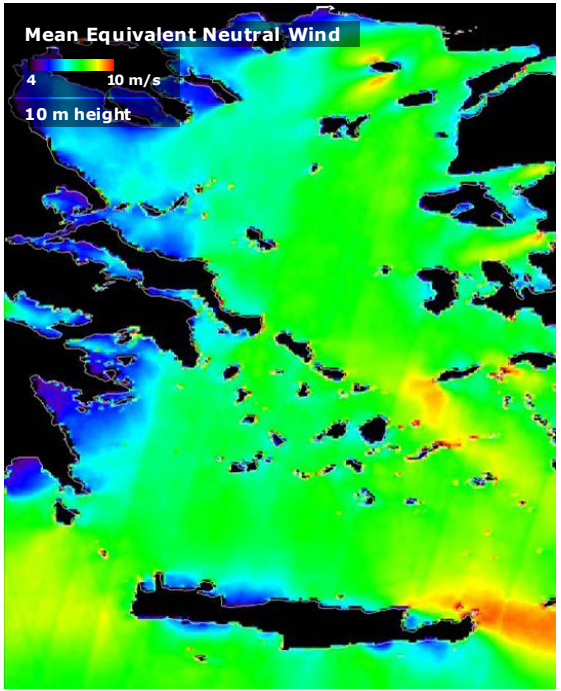
- Main data sources:
  - ESA/Copernicus missions (30 years)
  - National missions in Europe/Canada, including smallsats
  - Meteorological satellites (1981 onwards)


Clean Energy: Resource Assessment



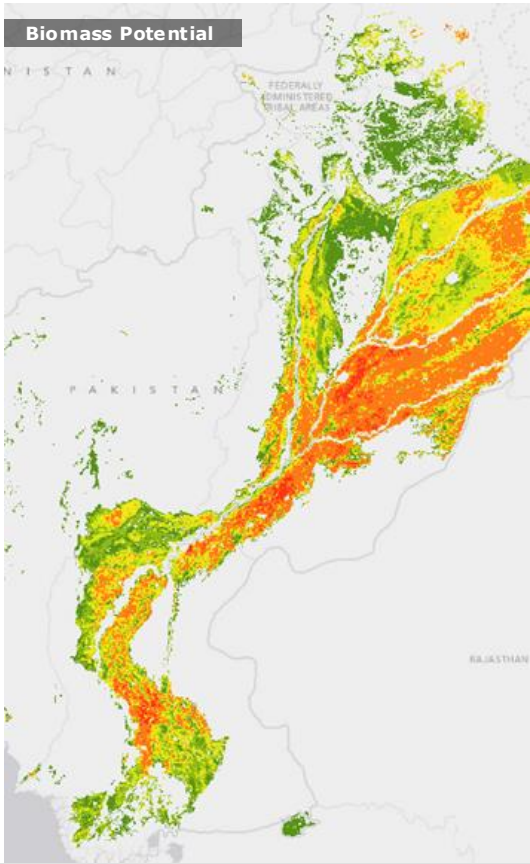




Example: EO feeding into:

IRENA International Renewable Energy Agency

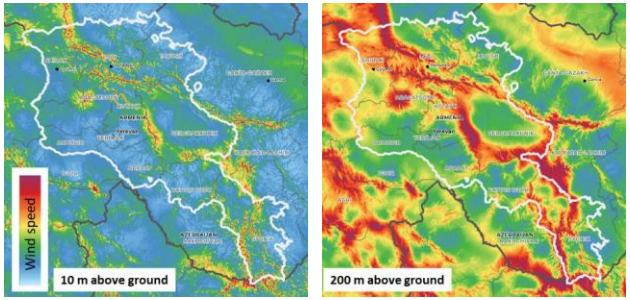
Global Atlas FOR RENEWABLE ENERGY



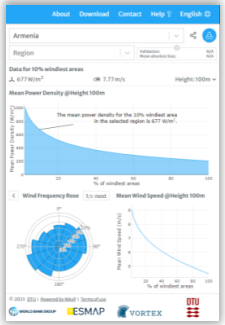
Use Case: Updating the National Wind Atlas Armenia

- TA-6959 ARM: Viability Assessment for Potential Wind Power Electricity Generation Projects:
  - Feasibility study
  - Existing data is not always suitable (e.g. mismatch in hub-height)
  - Good scalability (Uzbekistan project)
  - EO can enhance and improve existing information

Existing information



Existing layers (globalwindatlas.info) and other information



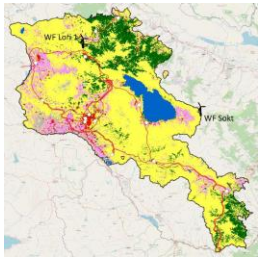
Existing energy infrastructure

Protected areas

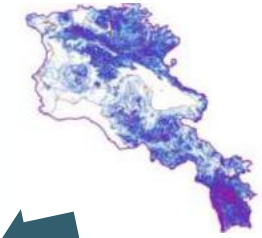
- **Improved simulated average horizontal wind speed for standard heights**
- **Power density for standard heights**
- **Selection and ranking of sites based on available infrastructure (grid, access routes), no-go areas and wind potential**

Complementary EO-based information

Elevation



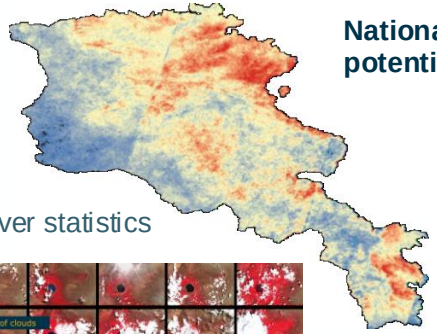
Land Cover



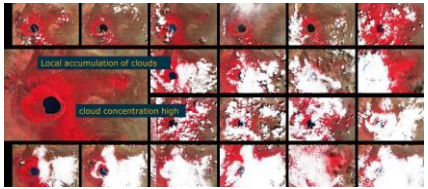
Slope

Vegetation height

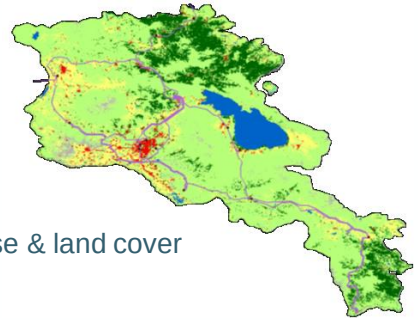
Use Case: Rooftop Solar Potential, Armenia



Cloud cover statistics

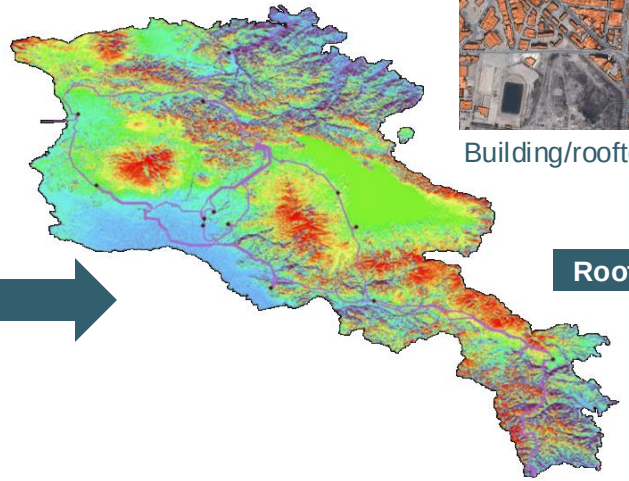


Land use & land cover



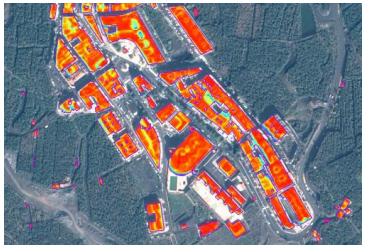
National, regional and local/rooftop solar potential, Armenia

Solar



Rooftop solar

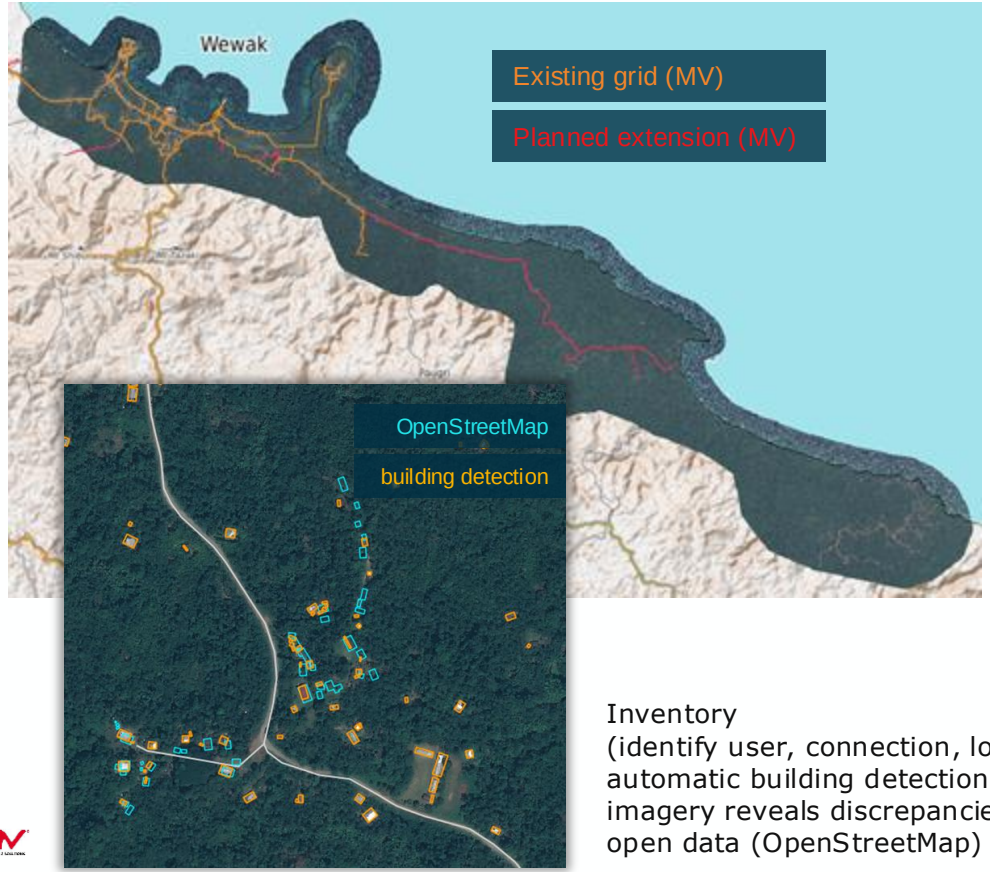
Building/rooftop extraction



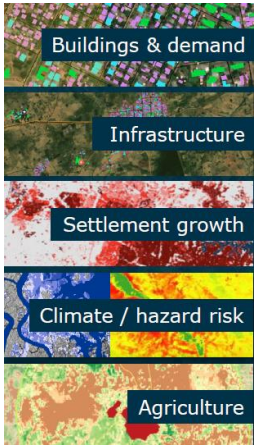
Use Case: Energy Demand Assessment (Mini-Grids), Papua New Guinea

- *ADB:* Power Sector Development Investment Program (47356-001) & Development Project (47356-002)

- Setting: Six provincial diesel mini-grids to be replaced/extended by hydro/photovoltaic
- Key question: Where can existing mini-grids be extended for maximum impact, i.e. connecting additional households?
- Based on demand assessment
- Other considerations:
  - Design and expansion cost
  - Settlement growth
  - Productive use of energy
  - Climate / hazard risk



Various EO-based layers

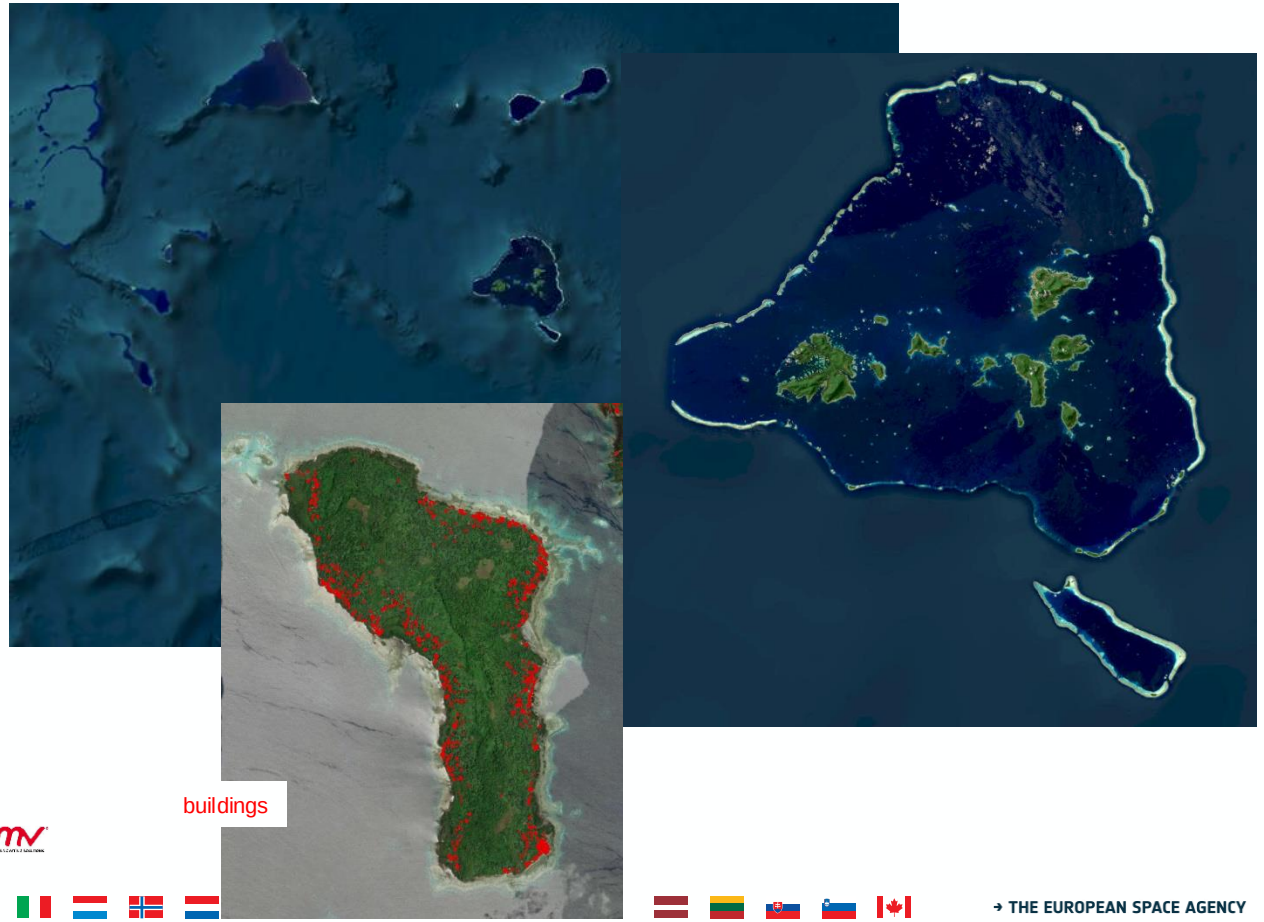


Inventory
(identify user, connection, location):
automatic building detection in recent EO imagery reveals discrepancies with existing open data (OpenStreetMap)

Use Case: Energy Demand Assessment, Chuuk, Federated States of Micronesia

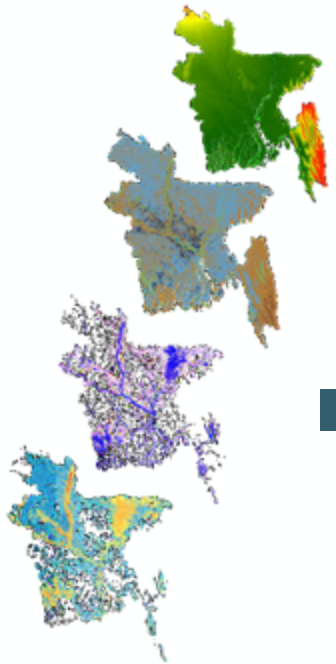
- *ADB:* Climate-Resilient Energy and Water Sector Project (CREWS)
- *World Bank:* Access and Renewable Increase for Sustainable Energy (ARISE)

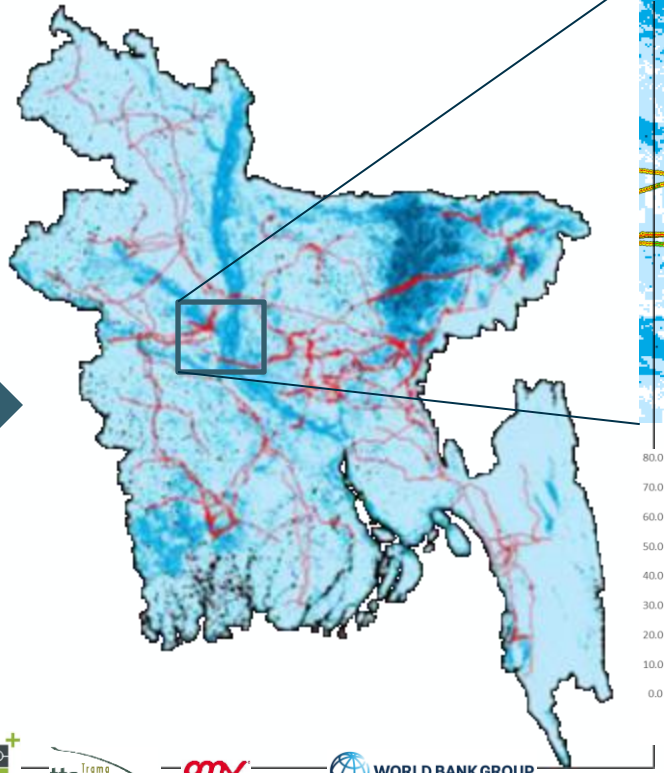
- Setting: energy inventory and demand assessment over sparely-populated group of many scattered islands
- Inventory
  - Houses/ existing infrastructure
  - Demand
  - Network planning and cost optimisation
- Exposure to erosion/landslide/flood threats

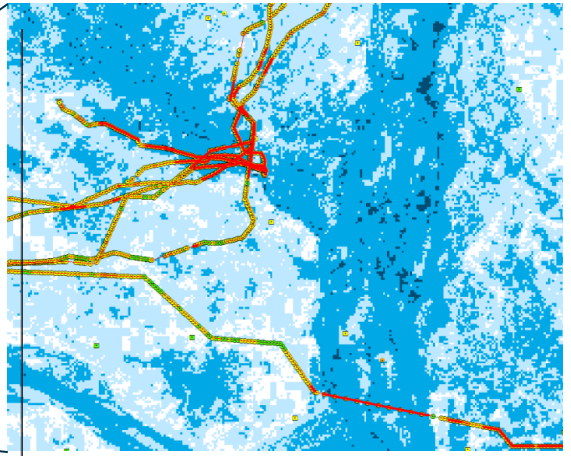


Use Case: Network Vulnerability to Flooding, Bangladesh

Various EO-based layers



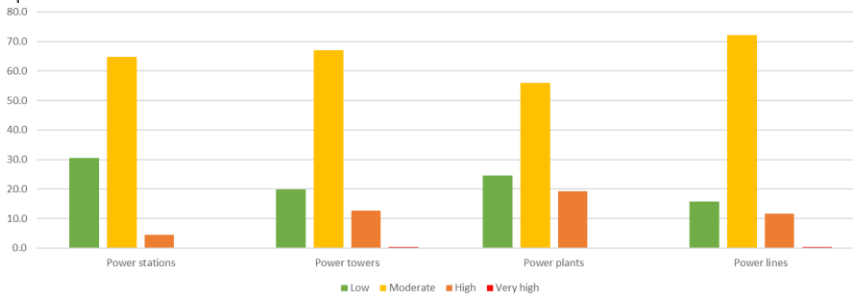




Asset Vulnerability
- Low
- Moderate
- High
- Very high

- Low
- Moderate
- High
- Very high

Flood Vulnerability
- Low
- Moderate
- High
- Very high



Asset exposure (%)

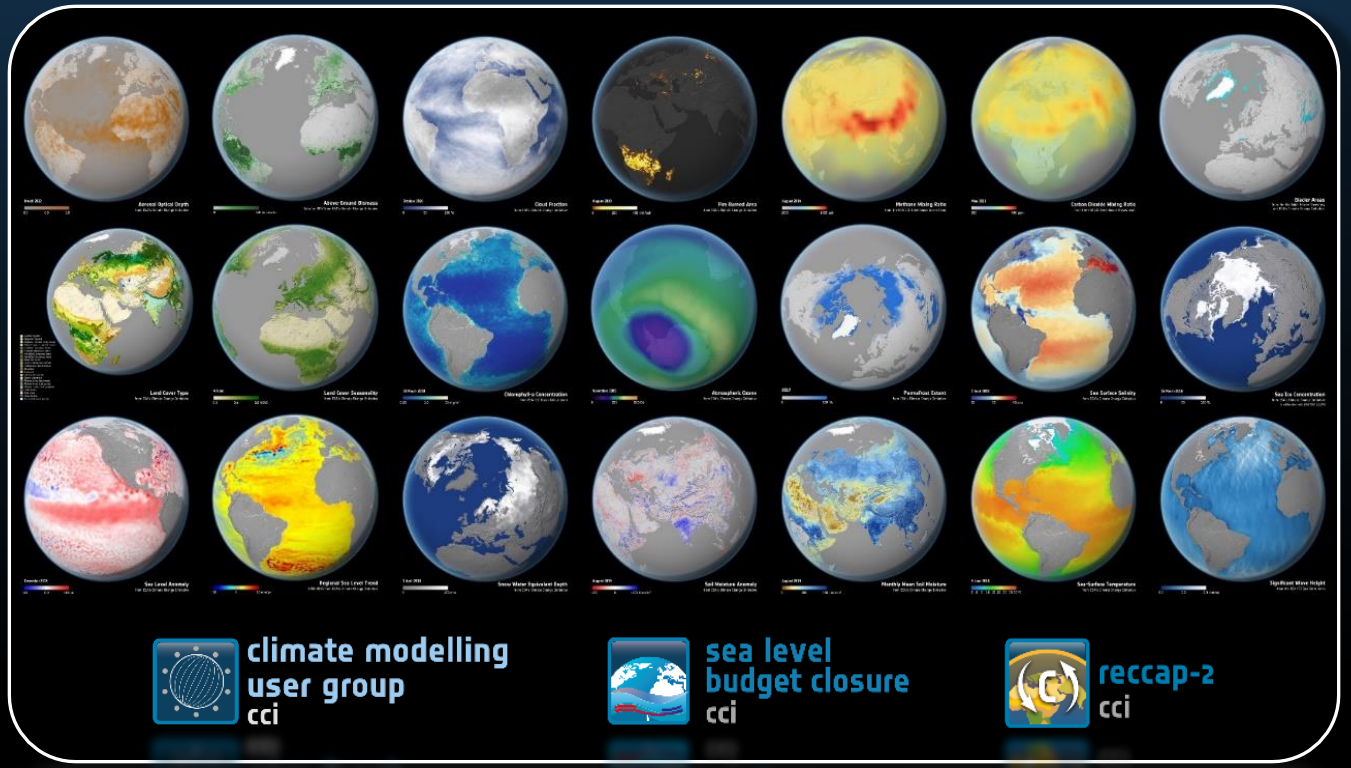
Earth Observation and Energy-Related Areas:

Climate Resilience, Urban Development, Disaster Risk

ESA Climate Change Initiative: Climate Space

- CCI is a response to UNFCCC's need for **systematic global climate observation**
- ECV datasets provide **long-term empirical evidence** to predict & understand key parts of the climate
- 54 defined ECVs, 36 monitored from space, **21 under development** by ESA

Monitoring 21 Essential Climate Variables (ECV)



EO for Urban Development: Information Types

Built-Up Extent, Imperviousness

Building Footprints and 3D Models

Green Areas/Networks

Population Density

Transport Infrastructure

Waste Sites

Informal Settlements

Baseline Optical Products

Urban and Peri-Urban
Land Use / Land Cover

Detailed

Change

Specialised Observations

Microwave radar, thermal radiometry, troposhperic spectrometry

Flood Risk

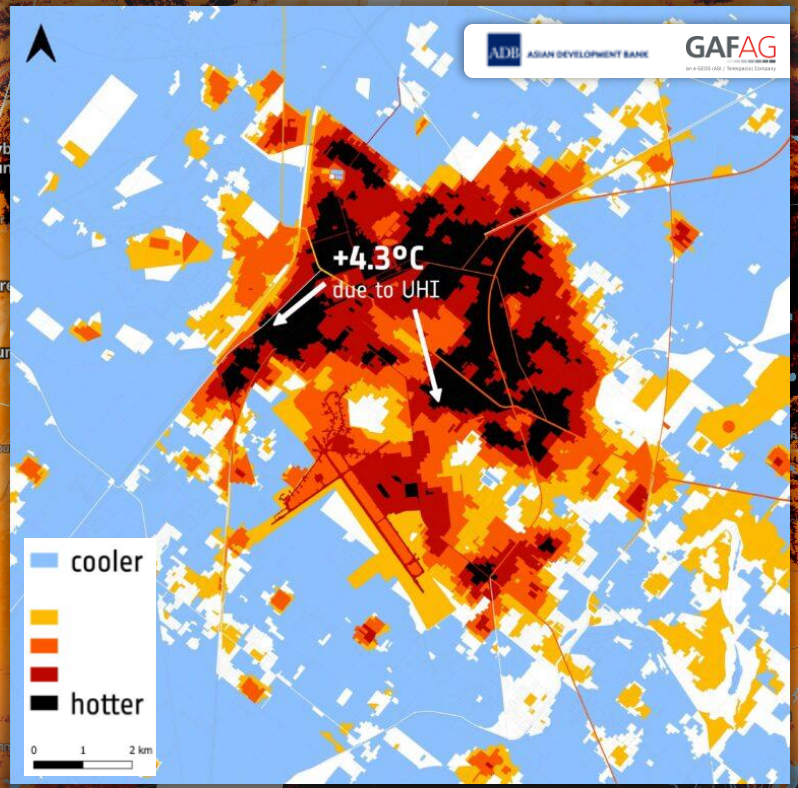
Landslide Risk

Terrain Motion

Urban Heat Islands

Air Quality

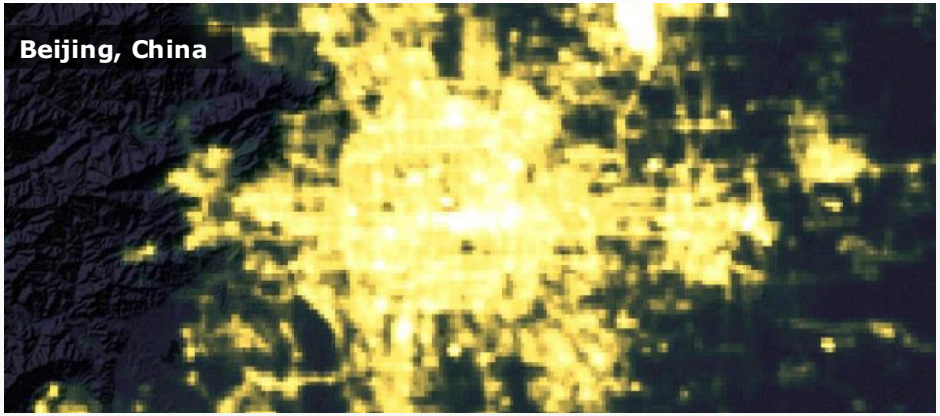
Urban Heat



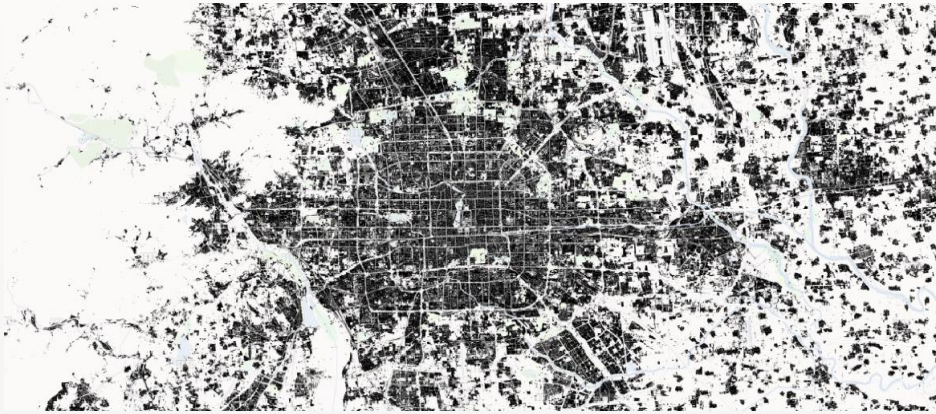
Surface Urban Heat Island Intensity, Sargodha, Pakistan, July 2021

Sentinel-3 LST

Electrification and Overall Economic Activity



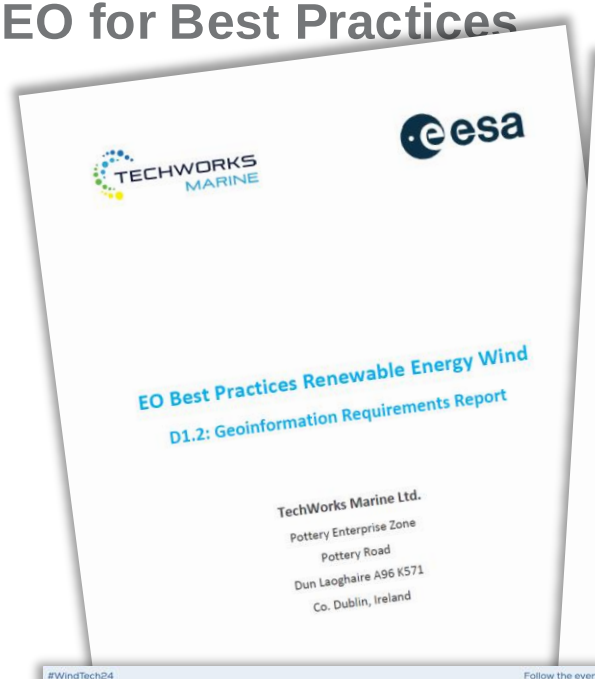
VIIRS-DNB Night-Time Lights
monthly average (**500 m**)

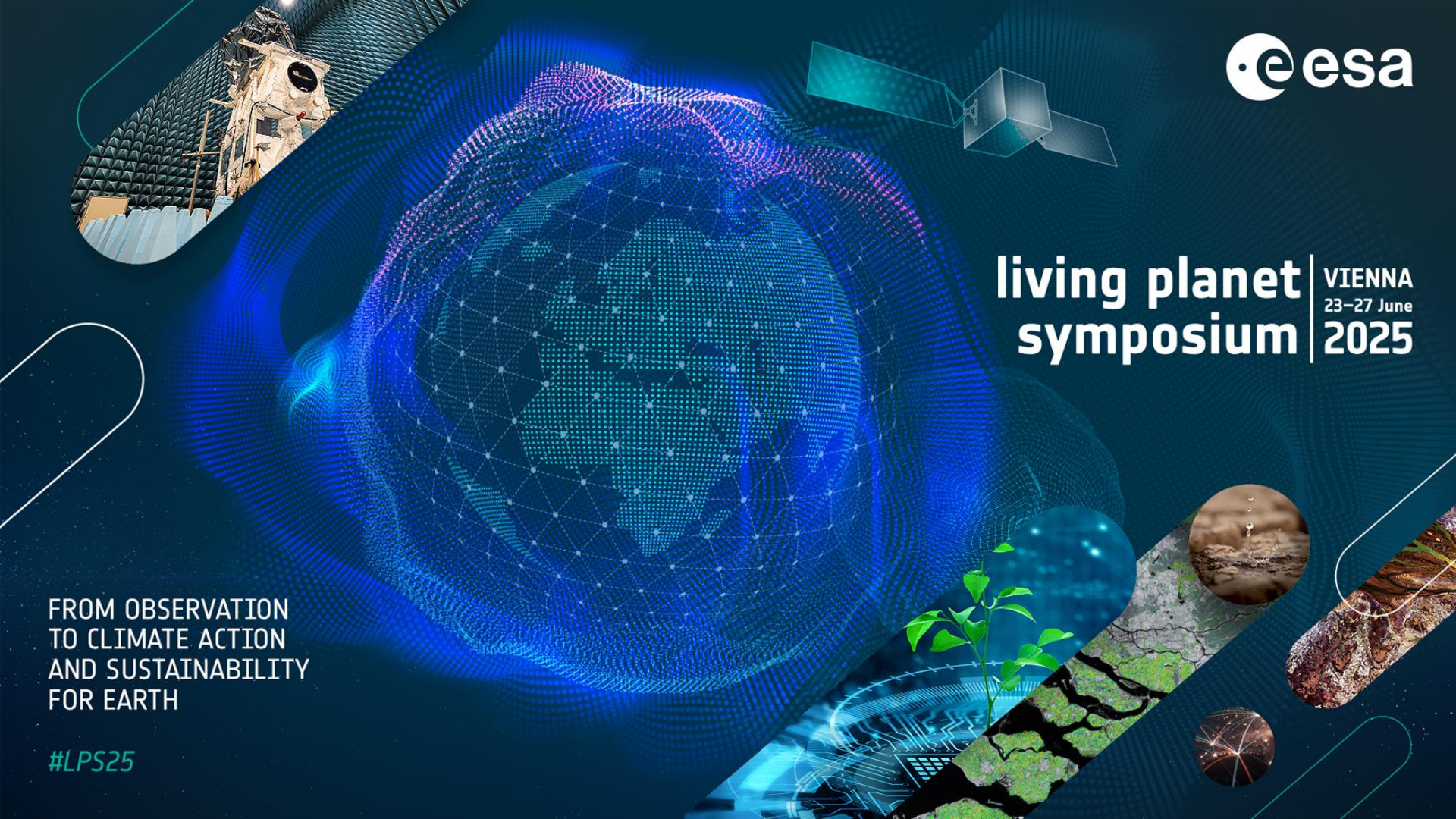


Built-up areas (DLR World Settlement Footprint, 10 m)

Luojia 1-01 Night-Time Lights (**130 m**)

EO for Best Practices

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