Copernicus Sentinel Data & Philippine EO Ecosystem

EO AI/ML Training - Day 1, Session 1

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Welcome

Course Introduction

4-Day Advanced Training

- AI/ML for Earth Observation
- Philippine EO Professionals
- Focus: DRR, CCA, NRM
- Online format

Today’s Goals

- Understand Copernicus data
- Explore Philippine EO ecosystem
- Learn AI/ML fundamentals
- Hands-on Python and GEE

Session 1 Roadmap

1. Copernicus Programme Overview
2. Sentinel-1 Mission (SAR)
3. Sentinel-2 Mission (Optical)
4. Data Access Methods
5. Philippine EO Ecosystem
6. Philippine Copernicus Infrastructure (CopPhil)

Duration: 2 hours

Part 1: The Copernicus Programme

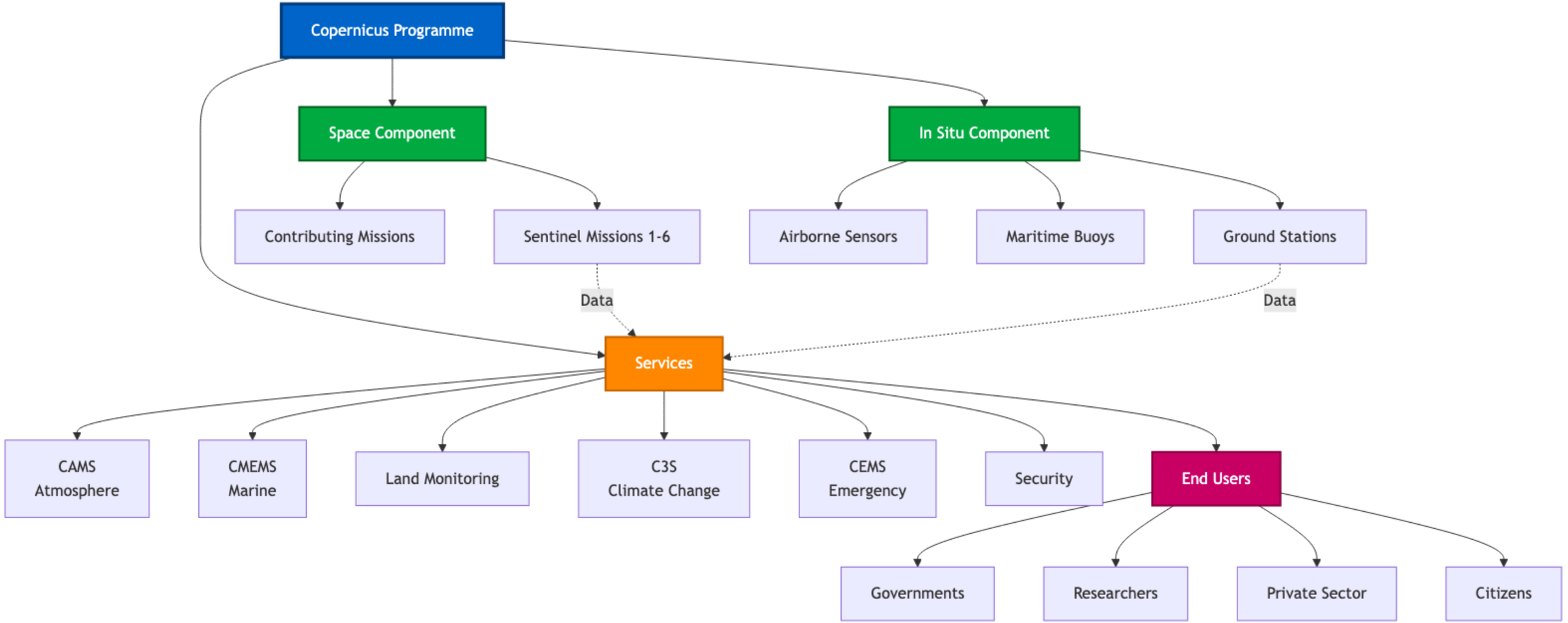
What is Copernicus?

Europe’s Eyes on Earth

- EU flagship Earth Observation program
- Family of Sentinel satellites
- **Free and open data policy**
- Operational since 2014

“Looking at our planet and its environment for the benefit of all European citizens”

Copernicus Programme Architecture



Copernicus Programme Structure showing Space Component, Services, and End Users

The Sentinel Family

Sentinel-1 (SAR)

- C-band radar imaging
- All-weather, day/night
- **1C (2024) + 1D (2025)** in operation
- 6-day repeat (two satellites)

Sentinel-2 (Optical)

- Multispectral imaging
- 13 spectral bands
- **2B + 2C** in routine operation
- 5-day repeat (two satellites)

Sentinel-3 (Ocean/Land)

- Ocean and land monitoring
- Sea surface temperature
- Ocean color, vegetation

Sentinel-5P (Atmosphere)

- Air quality monitoring
- Atmospheric composition

Copernicus Applications

Emergency Management

- Flood mapping
- Fire detection
- Disaster response

Climate & Environment

- Deforestation monitoring
- Agricultural monitoring
- Water quality assessment

Sentinel-1: SAR Mission

Sentinel-1 Overview

Mission Configuration (November 2026)

- **Sensor:** C-band Synthetic Aperture Radar
- **Satellites: 1C** (2024) and **1D** (2025); 1A retired June 2026
- **Orbit:** Polar sun-synchronous
- **All-weather, day/night capability**



Key Advantage: Penetrates clouds and works at night

Sentinel-1 Technical Specifications

Parameter	Value
Sensor Type	C-band SAR (5.405 GHz)
Revisit Time	6-12 days (constellation)
Swath Width	250 km (IW mode)
Spatial Resolution	5m × 20m (IW mode)
Polarization	VV + VH or HH + HV
Orbit	693 km altitude

SAR: How It Works

1. Satellite sends **microwave pulses** to Earth
2. Signal **reflects** from surface
3. Sensor measures **backscatter intensity**
4. Different surfaces = different backscatter

Sentinel-1 Polarization

What is Polarization?

- Orientation of radar wave
- VV: Vertical send/receive
- VH: Vertical send/Horizontal receive
- HH: Horizontal send/receive

Applications

- **VV:** Good for water/flood mapping
- **VH:** Sensitive to volume scattering (vegetation)
- **VV/VH Ratio:** Discriminates surface types

Backscatter Characteristics by Target

Surface Type	Backscatter	Appearance	Reason
Water (smooth)	Very Low	Dark/Black	Specular reflection
Urban/Buildings	Very High	Bright White	Corner reflectors
Forest/Vegetation	Medium-High	Gray	Volume scattering
Agricultural Fields	Medium	Light Gray	Surface roughness
Bare Soil (dry)	Low-Medium	Dark Gray	Smooth surface
Bare Soil (wet)	Medium	Medium Gray	Increased dielectric

Key Insight: Water appears dark, structures appear bright - the basis for flood mapping!

Sentinel-1 Imaging Modes

Interferometric Wide Swath (IW) - **250 km swath** - 5m × 20m resolution - **Default over land** - Philippine standard mode

Extra Wide Swath (EW) - 400 km swath - 20m × 40m resolution - Maritime/polar regions

Strip Map (SM) - 80 km swath - 5m × 5m resolution - Emergency response - High detail needed

Wave (WV) - Ocean waves - Not used for land

Sentinel-1 Data Products

Level-1 GRD (Ground Range Detected)

- Multi-looked (reduced speckle)
- Projected to ground range
- **Most commonly used**
- Faster to process
- Smaller file size
- **Applications:**
  - Change detection
  - Classification
  - Flood mapping
  - Ship detection

Level-1 SLC (Single Look Complex)

- Preserves phase information
- Complex-valued pixels
- Required for InSAR
- Larger files
- **Applications:**
  - Ground deformation
  - Interferometry
  - Coherence analysis
  - Subsidence monitoring

GRD vs SLC - Which to Choose?

Factor	GRD	SLC
Use Case	Most applications	Interferometry only
Processing	Ready to use	Complex processing
File Size	~1 GB	~4 GB
Speckle	Reduced	Full speckle
Phase	Not preserved	Preserved
Typical User	Most analysts	Advanced specialists

For this training and most Philippine applications: Use GRD

Sentinel-1 Pre-Processing “Under the Hood”

What Happens Before You See SAR Data?

For this training, we use **pre-processed Sentinel-1 GRD data**. Here’s what happens “under the hood”:

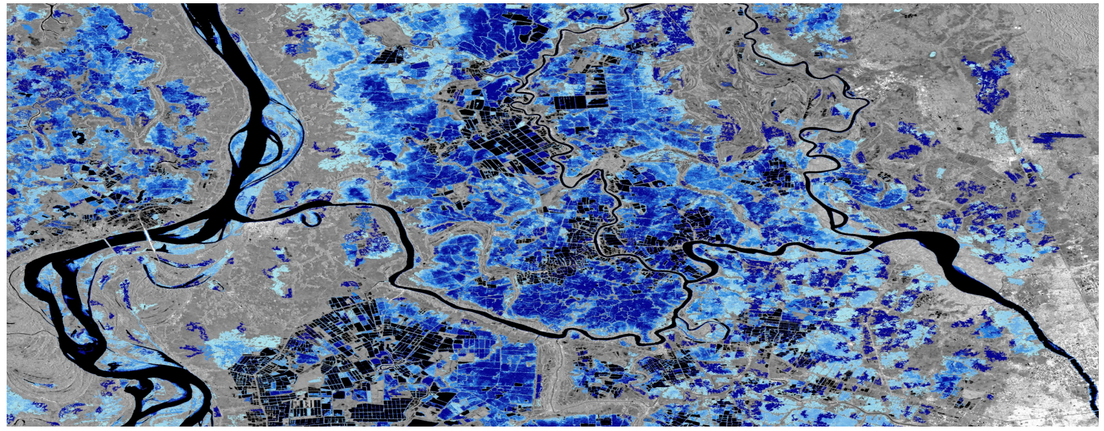
S1 Processing Pipeline:

1. **GRD Download** → Raw ground-range detected amplitude
2. **Radiometric Calibration** → Convert to backscatter coefficient (σ^0)
3. **Terrain Correction (RTC)** → Remove topographic distortions using DEM
4. **Speckle Filtering** → Reduce SAR noise (Lee, Refined Lee, or Gamma-MAP filters)
5. **Conversion to dB** → γ^0 (gamma-naught) in decibels for visual interpretation
6. **Tiling/Clipping** → Extract area of interest

For Day 3 flood mapping labs: We provide analysis-ready patches with these steps already applied

Sentinel-1 Applications

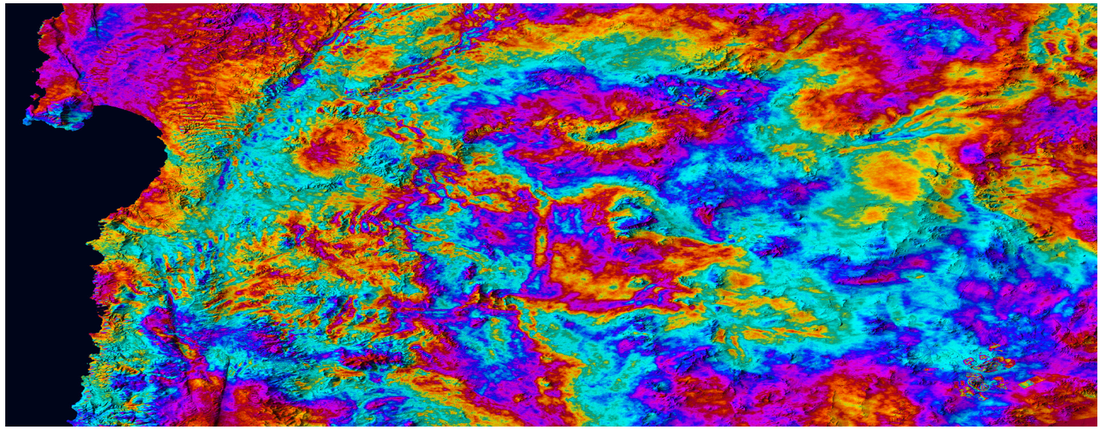
Flood Mapping



Copernicus Sentinel-1 Flood Monitoring

- Water appears dark in SAR
- Works through clouds
- Near real-time monitoring

Deformation Monitoring



Sentinel-1C Interferogram of Northern Chile

- InSAR technique
- Millimeter precision
- Volcano and earthquake monitoring

Philippine Example: Flood Monitoring

November 2020: Typhoon Ulysses

- Extensive flooding in Luzon
- Sentinel-1 detected flood extent
- Rapid mapping capability

Key Benefits

- No cloud interference
- Quick response time
- Used for rapid damage assessment
- Supported emergency response

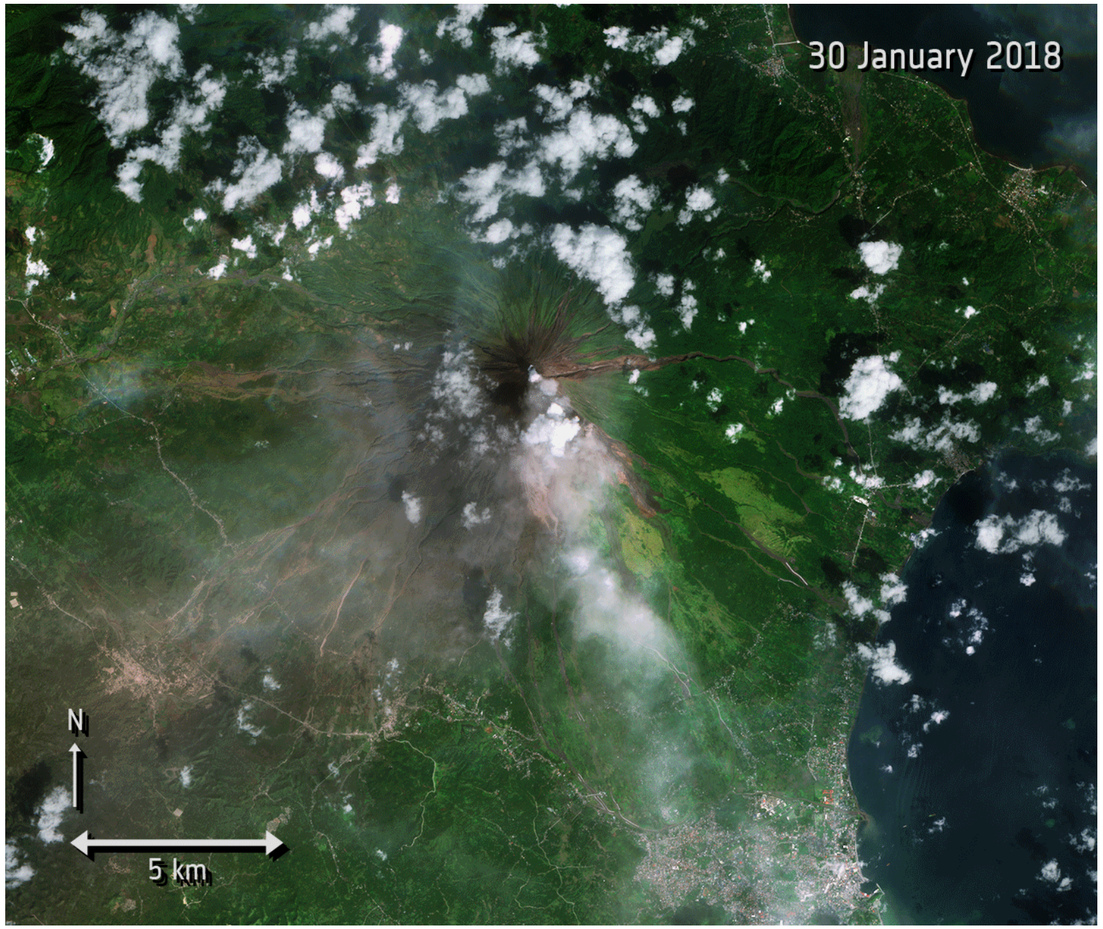
Sentinel-2: Optical Mission

Sentinel-2 Overview

Key Specifications:

- **13 spectral bands** (visible, NIR, SWIR)
- **10m to 60m** spatial resolution
- **290 km swath** width
- **5-day revisit** (2B + 2C constellation)
- **L1C & L2A** processing levels

Philippine Example: Mayon Volcano



Sentinel-2 monitoring of 2018 eruption

- False-color composite highlighting lava flows

Sentinel-2 Spectral Bands

Band	Name	Wavelength (nm)	Resolution	Purpose
B1	Coastal Aerosol	443	60m	Aerosol correction, water color
B2	Blue	490	**10m**	Water bodies, atmospheric
B3	Green	560	**10m**	Vegetation health
B4	Red	665	**10m**	Vegetation discrimination
B5	Red Edge 1	705	20m	Vegetation stress detection
B6	Red Edge 2	740	20m	Vegetation classification
B7	Red Edge 3	783	20m	Vegetation stress, chlorophyll
B8	NIR	842	**10m**	Biomass, water bodies
B8A	NIR Narrow	865	20m	Atmospheric correction
B9	Water Vapor	945	60m	Atmospheric correction
B10	SWIR Cirrus	1375	60m	Cirrus cloud detection
B11	SWIR 1	1610	20m	Moisture content, fire
B12	SWIR 2	2190	20m	Moisture, geology, soil

Red Edge Bands - Sentinel-2’s Special Capability

What is Red Edge?

- Transition zone between red and NIR (700-780nm)
- **Three dedicated bands (B5, B6, B7)**
- Sensitive to chlorophyll content
- Rare among free high-resolution sensors

Applications:

- Early vegetation stress detection
- Crop health monitoring
- Forest disease identification
- Pre-harvest yield estimation

Philippine Use Cases:

- **Rice crop assessment** - Monitor crop health and nitrogen status during panicle initiation in Nueva Ecija rice paddies
- **Coconut disease detection** - Identify stem bleeding disease and pest infestations through spectral signatures
- **Mangrove health monitoring** - Track vegetation stress and recovery in Palawan mangrove forests using red edge indices

Red edge bands detect stress weeks before visible bands show changes

Sentinel-2 Data Products

Level-1C (L1C)

- Top-of-Atmosphere reflectance
- Radiometrically corrected
- Geometrically refined
- No atmospheric correction
- **Use:** If you need raw data for custom processing

Level-2A (L2A)

- Bottom-of-Atmosphere (surface) reflectance
- Atmospherically corrected
- **Analysis-ready**
- Scene Classification Layer included
- **Use:** For most applications - RECOMMENDED

Always use Level-2A when available - it’s analysis-ready!

Sentinel-2 Band Combinations

True Color (Natural) - **RGB:** B4-B3-B2 (Red-Green-Blue) - Looks like a photograph - Good for visual inspection

False Color Infrared - **RGB:** B8-B4-B3 (NIR-Red-Green) - **Vegetation appears RED** - Classic for vegetation assessment

SWIR Composite (Agriculture) - **RGB:** B11-B8-B2 - Highlights crop moisture - Soil moisture visible

SWIR-NIR-Red (Burn/Fire) - **RGB:** B12-B8-B4 - **Active fires appear BRIGHT** - Burn scars dark purple

Sentinel-1 vs Sentinel-2

Complementary Capabilities

Aspect	Sentinel-1	Sentinel-2
Sensor Type	Radar (SAR)	Optical (MSI)
Weather	All-weather	Cloud-affected
Time	Day & night	Daytime only
Resolution	5m × 20m	10m / 20m / 60m
Revisit	6-12 days	5 days
Bands	Polarizations (2)	Spectral bands (13)
Best For	Water, structure, moisture	Vegetation, land cover, color

S1 Flood Mapping Tip

VV polarization shows dark water (low backscatter from smooth surfaces)

Best practice: Compare **pre-event vs post-event** delta for reliability

Synergy: Pair S1 (flood extent through clouds) with S2 (vegetation damage when clear) for complete impact assessment

Synergistic Use Cases

Flood Mapping

- **S1:** Detect water extent (through clouds)
- **S2:** Assess damage to vegetation/crops (when clear)
- **Combined:** Complete flood impact assessment

Forest Monitoring

- **S1:** Detect structural changes, biomass
- **S2:** Identify tree species, health
- **Combined:** Comprehensive forest mapping

☕ 5-Minute Break

Stretch Break

Stand up • Grab water • Back in 5 minutes

Data Access Methods

Platform Choices for This Training

Which Platform for Which Task?

Understanding where to work is crucial - don't try to train deep models on GEE or download 100GB in Colab!

Task	Platform	Why	Limitations
Data Prep & Exploration	**Google Earth Engine**	Petabyte catalog, no download, cloud composites	Small direct-download limit (use Export tasks); monthly compute quota; no deep learning training
ML Training (RF, shallow)	**GEE or Colab**	RF works in GEE; small data in Colab	GEE memory limits; Colab free tier quotas
Deep Learning (CNN, U-Net)	**Local GPU / Colab Pro**	Requires PyTorch/TensorFlow	Colab free = limited GPU time; large models need local resources
Large-Scale Processing	**CopPhil Infrastructure / COARE**	Philippine-hosted Sentinel data + JupyterLab; HPC (COARE)	Requires registration; learning curve for APIs
Quick Viz & Download	**Copernicus Browser**	Interactive, fast previews	Manual selection; bulk downloads tedious

Quotas/Pitfalls to know: - GEE: Memory errors with large computations (tile exports!); noncommercial projects

Copernicus Data Space Ecosystem

New Platform (2023+)

- Replaced SciHub
- Modern interface
- API access
- Free registration

URL: https://dataspace.copernicus.eu

Features

- Search by location/date
- Preview before download
- Direct download
- Bulk processing

SentiBoard Operations Dashboard

- **Real-time mission status**
- Data availability insights
- Acquisition plans
- Quality metrics
- Interactive dashboard

URL: https://operations.dashboard.copernicus.eu

Google Earth Engine

Planetary-Scale Platform



- Petabyte-scale data catalog
- All Sentinel-1 & Sentinel-2 data
- Cloud-based processing
- Free for registered noncommercial Cloud projects (monthly compute quota)
- **No download needed!**

We'll use GEE extensively in this training

URL: https://earthengine.google.com

Alternative Data Sources

Alaska Satellite Facility (ASF)

- Sentinel-1 specialist
- User-friendly interface
- Preprocessing tools
- https://asf.alaska.edu

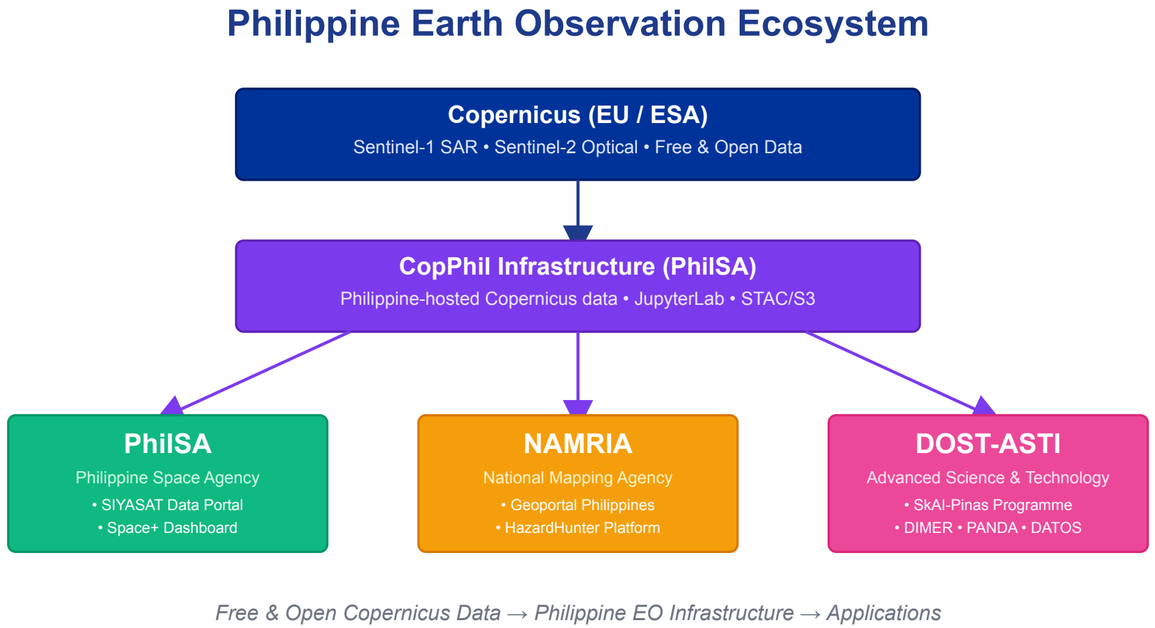
AWS Open Data

- Sentinel-2 on AWS
- Cloud-optimized
- Pay for compute only
- Programmatic access

In the Philippines: the CopPhil Infrastructure (Copernicus mirror site) serves Sentinel data from local servers - see the end of this session

Part 2: Philippine EO Ecosystem

Overview of Philippine EO Landscape



- **PhilSA:** Space data and operations
- **NAMRIA:** National mapping and geospatial data
- **DOST-ASTI:** AI and remote sensing R&D
- **PAGASA:** Climate and weather data

Philippine Space Agency (PhilSA)

PhilSA: National Space Agency

Established: August 2019

Mandate:

- Central civilian space agency
- Promote space data use
- Build national capacity
- Support DRR, CCA, NRM
- Hosts the CopPhil Centre and its Copernicus data infrastructure

Website: https://philsa.gov.ph

SIYASAT Data Portal

Purpose

- Secure data archive **operational**
- Visualization system
- Data distribution
- Maritime & terrestrial monitoring

Data Types

- NovaSAR-1 radar imagery
- AIS ship tracking data
- Processed products
- Analysis-ready data

Space+ Data Dashboard

- **User-friendly web portal**
- Browse satellite imagery
- Visualization tools
- Download datasets
- **No programming required**
- Open to government, researchers, public

PhilSA Initiatives (2025 snapshot)

Space Business Innovation Challenge

- Empowers Filipino innovators
- Free satellite data access
- Build solutions for local needs
- Earth observation focus
- Weather & environmental data

Training Programs

- Downstream data utilization
- Practical applications
- Capacity building nationwide
- Partnership with DOST

COARE Infrastructure (DOST-ASTI)

Computing and Archiving Research Environment

- High-performance computing
- Data archiving capabilities
- Science cloud facilities
- Supports data-intensive research
- Enables AI/ML workflows

NAMRIA

NAMRIA: National Mapping Authority

National Mapping and Resource Information Authority

Role:

- Official mapping agency
- Authoritative geospatial data
- Topographic maps
- Hazard maps
- Land cover datasets

Website: https://www.geoportal.gov.ph

Typical uses in this course

- Administrative boundaries
- Reference land cover for validation
- Hazard context layers

NAMRIA Geoportal

One-Stop Shop for Philippine Geospatial Data

- National basemaps (1:50,000 scale)
- Administrative boundaries
- Topographic maps
- Thematic maps
- **Downloadable shapefiles and rasters**

Land Cover Mapping Project

Latest: 2020 National Land Cover

Classes:

- Forest types
- Agriculture
- Built-up areas
- Water bodies
- Wetlands
- Barren land

Data Formats:

- Shapefile
- GeoTIFF
- CSV
- GeoJSON
- KML
- PNG

Portal: https://land-cover-mapping-project-namria.hub.arcgis.com

HazardHunterPH Portal

Comprehensive Hazard Assessment Platform

Hazard Types:

- Earthquake-induced hazards
- Active fault lines
- Tsunami susceptibility
- Liquefaction zones
- Landslide hazards

Applications:

- Disaster risk assessment
- Land use planning
- Infrastructure siting
- Emergency preparedness

URL: https://hazardhunter.georisk.gov.ph/map

How NAMRIA Complements Sentinel Data

Sentinel Imagery Provides:

- Current conditions
- Frequent updates
- Large-area coverage
- Multi-temporal analysis

NAMRIA Data Provides:

- **Ground truth for validation**
- **Training labels for ML models**
- Historical baselines
- Official classifications
- Hazard context

Using NAMRIA/Space+ as Label Sources

For Day 2 Palawan RF lab: 1. Download NAMRIA land cover shapefile (authoritative classes) 2. Overlay on Sentinel-2 imagery 3. Extract training points per class (forest, agriculture, water, etc.) 4. Train Random Forest classifier 5. Validate predictions against NAMRIA hold-out samples

Space+ Dashboard also provides admin boundaries and infrastructure layers for context in all visualizations.

Example: Use Sentinel-2 to map current land cover, validate against NAMRIA's official 2020 map, detect changes

DOST-ASTI AI Initiatives

DOST-ASTI Overview

Advanced Science and Technology Institute

- Lead agency for EO and AI R&D
- Remote sensing expertise
- Machine learning development
- National AI infrastructure
- **P2.6 billion investment until 2028**

Website: https://asti.dost.gov.ph

Platforms covered next

- DATOS, SkAI-Pinas
- DIMER, AIPI, ALaM
- COARE (computing)

DATOS: Remote Sensing Help Desk

- **Remote Sensing and Data Science Help Desk**
- Rapid analytics during disasters
- Flood mapping from satellite imagery
- Damage assessment
- Crop mapping (rice, sugarcane)
- Road network detection
- Supports emergency response agencies

SkAI-Pinas Programme

Philippine Sky AI Program (2021-2028)

- Flagship AI R&D programme
- **Part of P2.6B DOST AI investment**
- Democratize AI across Philippines
- Remote sensing & big data focus

Reported reach (2025)

- 300+ institutions supported
- Universities & colleges
- SMEs & research teams
- Local government units

DIMER: AI Model Hub

Democratized Intelligent Model Exchange Repository

- Digital “model store”
- Pre-trained AI models
- Ready-to-use
- Filipino-specific challenges

Available Models

- Landslide detection
- Traffic surveys
- Crop monitoring
- Land cover classification
- Flood detection

AIPI: AI Processing Interface

Purpose

- Streamline large-scale remote sensing tasks
- Reduce computational barriers
- Run AI models on ASTI servers
- Process hundreds of images efficiently

Example: Apply an AI model to 100 Sentinel-2 images over entire region without your laptop

ALaM: Automated Labeling Machine

Challenge

Creating labeled training data is:

- Time-consuming
- Expensive
- Requires expertise
- Major bottleneck for AI

ALaM Solution

- Automate labeling process
- Crowdsourcing capabilities
- Expert validation
- Build training datasets

Result: Faster creation of high-quality training data for Filipino contexts

How DOST-ASTI Tools Work Together

1. **ALaM** creates training data
2. Train models and share via **DIMER**
3. Process large datasets with **AIPI**
4. Deploy for operational use via **SkAI-Pinas**
5. Support disaster response through **DATOS**

PAGASA & Other Data Sources

PAGASA: Weather & Climate Data

Philippine Atmospheric, Geophysical and Astronomical Services Administration

Data Types:

- Historical rainfall
- Temperature records
- Typhoon tracks
- Climate forecasts
- Weather observations

Integration: Combine with satellite data for climate analysis

Where to find it

- https://www.pagasa.dost.gov.ph
- PANaHON: https://www.panahon.gov.ph

Synergy: Satellite + Ground Data

Satellite Data (Sentinel)

- Spatial coverage
- Consistent acquisition
- Multiple variables
- Time series

Ground Data (Philippine agencies)

- Point validation
- Ground truth
- Meteorological context
- Local expertise

Combined = More robust analysis and higher confidence

Philippine Copernicus Infrastructure (CopPhil)

CopPhil Infrastructure (Copernicus Mirror Site)

- **Philippines-hosted copy of Copernicus Sentinel data**, updated daily
- Covers the Philippine land and sea area (>1.8 million km^2)
- Hosted at PhilSA; cloud platform operated by CloudFerro
- **Data Explorer** (search & download), **JupyterLab**, STAC catalogue, S3 object-storage access, Knowledge Base
- Free registration: https://application.infra.copphil.philsa.gov.ph

Portal: https://infra.copphil.philsa.gov.ph (online as of November 2026)

CopPhil Digital Campus

What it is

- Online learning platform (Moodle)
- Self-paced EO courses
- Materials from past Philippine Copernicus training events

URL: https://courses.copphil.philsa.gov.ph

Typical content

- Ground motion (InSAR)
- Land cover, forest and crop monitoring
- Coastal / benthic habitat mapping

Building a Sustainable EO Ecosystem

1. **Data Access:** CopPhil Infrastructure + Copernicus Data Space Ecosystem
2. **Processing:** COARE + AIPI + Google Earth Engine
3. **Models:** DIMER repository
4. **Training:** CopPhil Digital Campus, EO College
5. **Operations:** DATOS + Agency integration
6. **Community:** SkAI-Pinas network

Result: Complete infrastructure for operational EO AI/ML**

Summary & Integration

Key Takeaways

1. **Copernicus** provides free, high-quality satellite data globally
2. **Sentinel-1** (SAR) works day/night, all-weather - essential for tropics
3. **Sentinel-2** (optical) provides rich spectral information - 5 day revisit
4. **Multiple access methods** available (Data Space, GEE, Mirror Site)
5. **Philippine agencies** provide complementary data and expertise
6. **CopPhil Infrastructure** gives Philippine-hosted access to Copernicus data

How It All Connects

- **Satellite data:** Copernicus Sentinels, PhilSA missions
- **Ground truth:** NAMRIA maps, PAGASA observations, field data
- **AI models:** DIMER, SkAI-Pinas projects, your own models
- **Processing:** GEE, COARE, AIPI, CopPhil Infrastructure
- **Result:** operational DRR, CCA and NRM applications

Example Workflow: Flood Mapping

1. **Acquire** Sentinel-1 SAR data (GEE or Mirror Site)
2. **Validate** with PAGASA rainfall data
3. **Process** using AI model from DIMER
4. **Scale** processing via AIPI
5. **Combine** with NAMRIA hazard maps
6. **Deliver** to NDRRMC via DATOS

This is what integrated EO capacity looks like!

What’s Next in Day 1?

Session 2 (Next)

- AI/ML fundamentals
- Supervised vs unsupervised learning
- Neural networks basics
- Data-centric AI
- → **5-min Concept Check** (3 questions)

Sessions 3 & 4

- Hands-on Python (GeoPandas, Rasterio)
  - **Pre-run pip installs** to save time
- Google Earth Engine tutorial
  - **Start from ready script**, modify filters only
- Access real Sentinel data
- **SCL cloud/shadow masking** (not QA60)

Session Summary

What We Covered:

✅ Copernicus Programme & free/open data policy
✅ Sentinel-1 (SAR) - all-weather monitoring
✅ Sentinel-2 (Optical) - 13 bands, 10m resolution
✅ **Constellation status (Nov 2026):** S1C + S1D; S2B + S2C (2A in extension)
✅ Philippine EO infrastructure (PhilSA, NAMRIA, DOST-ASTI)
✅ Data access platforms (SIYASAT, Geoportal, SkAI-Pinas)

Q&A

Copernicus & Sentinel

- Mission specifications?
- Data products & formats?
- Access methods?
- Processing levels?

Philippine EO Ecosystem

- Agency roles & mandates?
- Data access procedures?
- Integration with Copernicus?
- P2.6B AI investment details?

Next: Session 2

Core Concepts of AI/ML for Earth Observation

Coming up after break:

- What is AI/ML and why for EO?
- The EO AI/ML workflow
- Supervised vs unsupervised learning
- Introduction to deep learning
- Data-centric AI approaches

See you in Session 2! 🚀

Thank You!

Contact & Resources

European Platforms:

Copernicus Data Space: https://dataspace.copernicus.eu

CopPhil Infrastructure: https://infra.copphil.philsa.gov.ph

Philippine Platforms:

PhilSA: https://philsa.gov.ph

NAMRIA Geoportal: https://www.geoportal.gov.ph

DOST-ASTI: https://asti.dost.gov.ph

15-minute break before Session 2