Master 1 Environmental Risks:
GIS - Python Coding

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Assignment Title: Environmental Risk Analysis using Sentinel-1 SAR Data

General Objective

To conduct a scientific study in the format of a **Google Colab notebook**, structured like an academic publication, focusing on a major environmental event (e.g., flood, landslide, wildfire, etc...).

The main goal is to process and analyze Sentinel-1 SAR (Synthetic Aperture Radar) data to detect and illustrate changes before and after the selected event.

Students may also propose the processing of other satellite data (Sentinel-2, MODIS, Landsat, etc.) if they believe it allows for a more effective study of the chosen event.

The notebook structure must adhere to the format of a complete scientific publication.

Students are advised to check https://developers.google.com/earth-engine/tutorials/community/detecting-changes-in-sentinel-1-imagery-pt-1 (the first of four Google Earth Engine Sentinel-1 change detection tutorials) and are welcome to use codes from these.

Notebook Structure

1. Abstract

A concise summary of 5 to 10 lines outlining the objective, data used, methodology, and main results.

2. Introduction **(1/2 page)**

- Presentation of the environmental phenomenon under study.
- Scientific and environmental relevance of the study.
- Brief presentation of Sentinel-1 SAR data (or other satellite data used) and their applications for detecting environmental changes.
- Include **2 to 3 bibliographic references** focused on the use of Sentinel-1 SAR or other satellite data for environmental change or event detection.

3. Materials **and Methods (1 page maximum)**

- **Description of Sentinel-1 (or other) data used:** Acquisition type (VV, VH, orbit, resolution, etc.), temporal period, and chosen geographical area.
- **Presentation of tools and libraries** (Google Earth Engine, Python, etc.).
- **Principle of the applied methods:** Temporal composite, change detection, affected area extraction.
- **Mention of the code used, developed, or adapted**
- Students **may use other approaches, methods, or code** found on the Internet or in scientific publications, provided they **cite them**.

4. Results

Part 1: Image Visualization

Include two main code blocks:

- Composite image **Before** the event: RGB composite from images acquired several weeks or months prior.
- Composite image After the event: Same principle, covering the post-event period.

These visualizations must be performed by building upon the course-provided code, which is derived from the Earth Engine dataset tutorials.

Each image must be accompanied by a brief descriptive paragraph.

Part 2: Quantitative (Exploratory) Analysis

- Exploratory section: Any attempt at analysis is encouraged, even without spectacular results.
- Objective: To understand the capabilities, advantages, and limitations of Sentinel-1 data (or other data used).
- Possibilities: Estimate affected areas, measure variations in radar or optical signal, qualitatively identify modified zones.
- **Any attempt is considered successful if it demonstrates an understanding of the data's potential and the methods.**
- Possible presentation format: Annotated images, graphs, or tables with a brief description.

5. Discussion **(1/2 page to 1 page maximum)**

- Interpretation of the results obtained, even if partial.
- Comparison before/after the event.
- **Critical analysis** of the capacity of the data used (Sentinel-1 or others) to detect and characterize changes: sensitivity, resolution, acquisition conditions, advantages, and limitations according to the data type.

- Reflection on the **difficulties encountered**, lessons learned from the work, and the contribution of the processing relative to the objectives.

6. Conclusion (1 paragraph)

- A synthetic paragraph on the work's contributions.
- Essential points understood or learned.
- Avenues for improvement or future perspectives.

7. Bibliography

Include **3 to 5 references** focusing on the use of Sentinel-1 SAR or other satellite data for environmental change or event detection.

Technical and Oral Guidelines 🗣️💻

- **Submission:** Notebook in **.ipynb** format (Google Colab).
- **Code:** No limits on the number of code cells or code length. The code does not need to be commented or fully understood; the student should only present the graphs or results that they *do* understand. No complex equations should appear in the text unless they are understood.
- **Oral Presentation: 3 minutes** focused on a key technical aspect, followed by **2 to 3 minutes** of discussion.
- **Use of AI:** Students are strongly encouraged to use **all available AIs** (ChatGPT, Gemini, Copilot, etc.) for text drafting, bibliographic analysis, code generation or explanation, and oral preparation. **There is no limit to the use of AI.** The key requirement is that the student **understands and can discuss** everything they present.
- **Focus:** The emphasis is on **understanding Sentinel-1 SAR data**, their characteristics, advantages, and limitations.
- **Goal:** The goal is to gradually become a specialist in this type of data and acquire a solid foundation for processing and interpretation.

📚 **Appendix I: Suggested Case Studies & Bibliographic References**

Suggested Environmental Case Studies

Students should choose a well-documented environmental event with clear **Before** and **After** Sentinel-1 data available.

Risk Phenomenon	Suggested Timeframe	Geographical Examples	Relevance of SAR Analysis
Flood	Recent event (within the last 2 years)	Severe rainfall events in Europe, North America, or Asia (e.g., Pakistan, Germany, Australia).	**Water extent mapping** (due to the strong decrease in backscatter over smooth water), delineation of submerged areas.
Wildfire	Recent fire season (e.g., Summer 2023)	Major fires in the Mediterranean region, North America, or South America.	**Burn scar detection** (SAR signal changes based on post-fire surface roughness and moisture), all-weather capability to penetrate smoke/clouds.
Landslide/Mass Movement	Post-cyclone or extreme rainfall event	Mountainous regions affected by localized large-scale movements (e.g., after a major storm).	**Scar detection** (change in surface roughness and topography), potential exploration of advanced InSAR techniques for displacement (if ambition allows).
Coastal Change / Erosion	Major storm event or long-term monitoring	Deltas, river mouths, or areas with rapid shoreline retreat.	Monitoring of shoreline movement, impact of storms on intertidal zones.

Key Bibliographic References

1. **Giustarini, L., et al. (2016). Mapping flood extent from Sentinel-1 data using change detection techniques.** *Remote Sensing of Environment, 180, 26–42. (A key paper for flood detection using SAR and change detection methods).*
2. **Konishi, T., et al. (2019). Detection of landslides triggered by heavy rainfall using Sentinel-1 SAR data.** *International Journal of Applied Earth Observation and Geoinformation, 79, 163–175. (Focuses on SAR for mass movement monitoring).*
3. **Filipponi, F. (2019). Sentinel-1 GRD preprocessing workflow.** *Remote Sensing, 11(6), 766. (Good resource for understanding necessary SAR data pre-processing steps).*
4. **Lasaponara, R., & Masini, N. (2017). Satellite SAR and optical data for supporting forest fires detection and post-event analysis: a case study in Apulia, Italy.** *Natural Hazards and Earth System Sciences, 17, 981-996. (Combines SAR and optical data for comprehensive fire analysis).*
5. **Google Earth Engine (GEE) Documentation. Change Detection with Sentinel-1 Imagery.** *(Essential technical reference for practical implementation.)*