Mapping Greenhouse Gas Emissions Using Satellite and Model-Based Datasets

Introduction

Objective: Develop a system to map and monitor GHG emissions using satellite data and model-based datasets.

GHG Types: Focus on key gases like Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O).

Purpose: Climate modeling, policy support, environmental management.

Step 1 — Defining the Scope

Geographical Scope: Global, national, or regional levels.
Temporal Scope: Select time intervals such as daily, weekly, or monthly.
Target Greenhouse Gas Types: CO_2, CH_4, N_2O, among others.
Purpose: Applications may include scientific research, policy advisement, and strategies for emission reduction.

Step 2 : Identifying Data Sources

Satellite Datasets:

- NASA's OCO-2 (CO_2 measurements)
- Sentinel-5P (CH_4 and trace gas data)
- GHGSat (industrial emission tracking)

Model-Based Datasets:

- EDGAR (global greenhouse gas emissions)
- CarbonTracker (CO_2 estimations)
- TROPOMI (methane and CO_2 monitoring)

Step 3 : Data Preprocessing

- Data Access: Obtain satellite and model data in netCDF and HDF5 formats.
- Coordinate Alignment: Make sure all data adheres to a uniform spatial projection, particularly WGS84.
- Temporal Alignment: Align the timeframes of satellite and model data either daily or monthly.
- Gap Filling: Address any gaps in satellite data resulting from issues like cloud cover.

Step 4 : Data Integration and Fusion

- Fusion of Satellite and Model Data: Integrate datasets to enhance the accuracy of emissions mapping.
- Gridding: Resample the data into uniform grids, such as 1°x1°.
- Statistical Methods: Employ Kalman filtering or analogous techniques to minimize uncertainty.

Step 5 :Analysis and Visualization

- GHG Concentration Mapping: Utilize GIS tools such as ArcGIS, QGIS, and Google Earth Engine.
- Emission Hotspot Identification: Employ machine learning techniques to pinpoint areas with high emissions.
- Trend Analysis: Illustrate temporal trends and seasonal patterns effectively.

Step 6 : Validation and Calibration

- Ground-Based Validation: Compare satellite data with ground observations, such as those from the NOAA network.
- Error Analysis: Evaluate uncertainties arising from sensor limitations and atmospheric conditions.
- Recalibration: Refine models by incorporating insights from error analysis and ground-truth data.

Step 7 : Reporting and Visualization Tools

- Dashboards: Develop interactive tools for stakeholders utilizing platforms such as Power BI, Tableau, or custom applications.
- Automated Reporting: Implement regular updates on greenhouse gas (GHG) trends, providing insights through monthly or quarterly reports.

Step 8 : Forecasting and Prediction

- Predictive Modeling: Utilize machine learning or statistical models to forecast future emissions.
- Scenario Analysis: Simulate the impact of various policies on emissions, such as carbon pricing.

Step 9: Collaboration and Data Sharing

- Stakeholder Engagement: Involvement of key entities such as governments, researchers, and international organizations (e.g., IPCC).
- Open Data Platforms: Utilization of platforms like Zenodo and OpenGHGMap for public data sharing and collaborative efforts.

Step 10: Tools and Platforms

- GIS Software: ArcGIS, QGIS
- Programming Languages: Python (including libraries such as rasterio, pandas, and netCDF4), R
- Cloud Platforms: Google Earth Engine, Amazon Web Services (AWS), Microsoft Azure
- Databases: PostgreSQL with PostGIS for the management of spatial data

Conclusions

- Key Takeaway: Combining satellite and model-based data enhances GHG emissions mapping, aiding climate policy and environmental management.
- Future Steps: Focus on implementation, scaling the system, and collaborating with global stakeholders.
- This outline clearly presents each step in the system development process for a presentation.

Thanks