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Interlinked Dynamics: Exploring the Correlations between Surface Temperature, Atmospheric CO2, Sea Level Rise, and Land Cover Changes

MADE Final Presentation

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Introduction

Climate Change is a critical issue affecting various environmental contexts

- Rising global temperatures and shifting precipitation patterns
- Increased frequency and severity of extreme weather events (e.g., hurricanes, droughts)
- Melting polar ice and glaciers contributing to sea level rise
- Changes in ecosystems and biodiversity loss
- Impacts on agriculture, water resources, and human health

Research Focus

Investigative Questions

- How do changes in atmospheric CO2 concentrations correlate with rising sea levels over time?
- Is there a correlation between rising mean surface temperatures and land cover changes?

Significance

- Understanding these correlations helps in predicting future climate scenarios
- Informs policy-making and climate adaptation strategies
- Provides insights into mitigating adverse effects on the environment and society

Challenges

Integration of data

- Joining data from different sources but at the same time keep them standardized in terms of structures and measures

Quality of data

- Dealing with the nonexistent values and ensuring that data is actual
- Some of the tasks involved in the management of various levels of detail are for instance: Monthly information that can be contrasted with yearly information

Coverage over time

- Make sure that datasets have to have overlapping periods for correlation analysis that makes sense

Alignment of geographical features

- Classification of data into pre-defined areas of geography (for instance; countries, regions)
- It would be possible to describe relationships between the different elements as rather complex

Restrictions in computing capabilities

- To handle large amounts of data and perform complex statistical analysis since that is one of its strengths

Data Uncertainty

- Managing risks and instabilities as to climate-related data and predictions

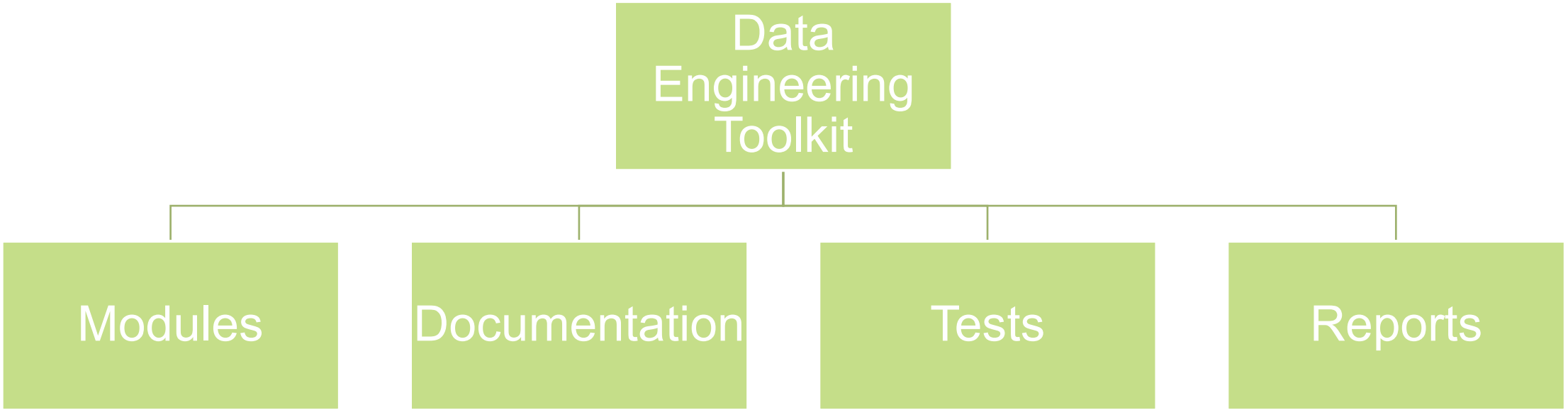
Data Sources, Structure and Quality

- Annual Surface Temperature Change [2] (1961–2021): Time series, Yearly frequency, <8% missing data, no incorrect data
- Monthly Atmospheric CO2 Concentrations [1] (1958-2023): Time series, Monthly frequency, no missing data, no incorrect data
- Change in Mean Sea Levels [3] (1993-2022): Time series, Monthly frequency, no missing data, no incorrect data
- Land Cover Altering Indicator [4] (1992–2020): Time series, Yearly frequency, <0.3% missing data, no incorrect data

Licenses and Permissions

- The data sources are publicly available on IMF under open-data licenses
- Detailed license information can be found at License

Overview of the Project



Data Pipeline Module

Sub-Modules

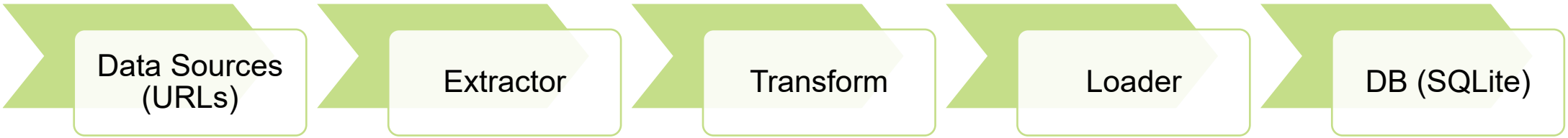
- Extractor, Transform, Loader

ETL Process

- Data extraction, column deletion, data standardization, data loading

Output

- SQLite database with high-quality, consistent data



Data Exploration Module

Sub-Modules

- Visualization: Functions for visualizations and maps
- Helper: Functions for further processing and reshaping data for visualization

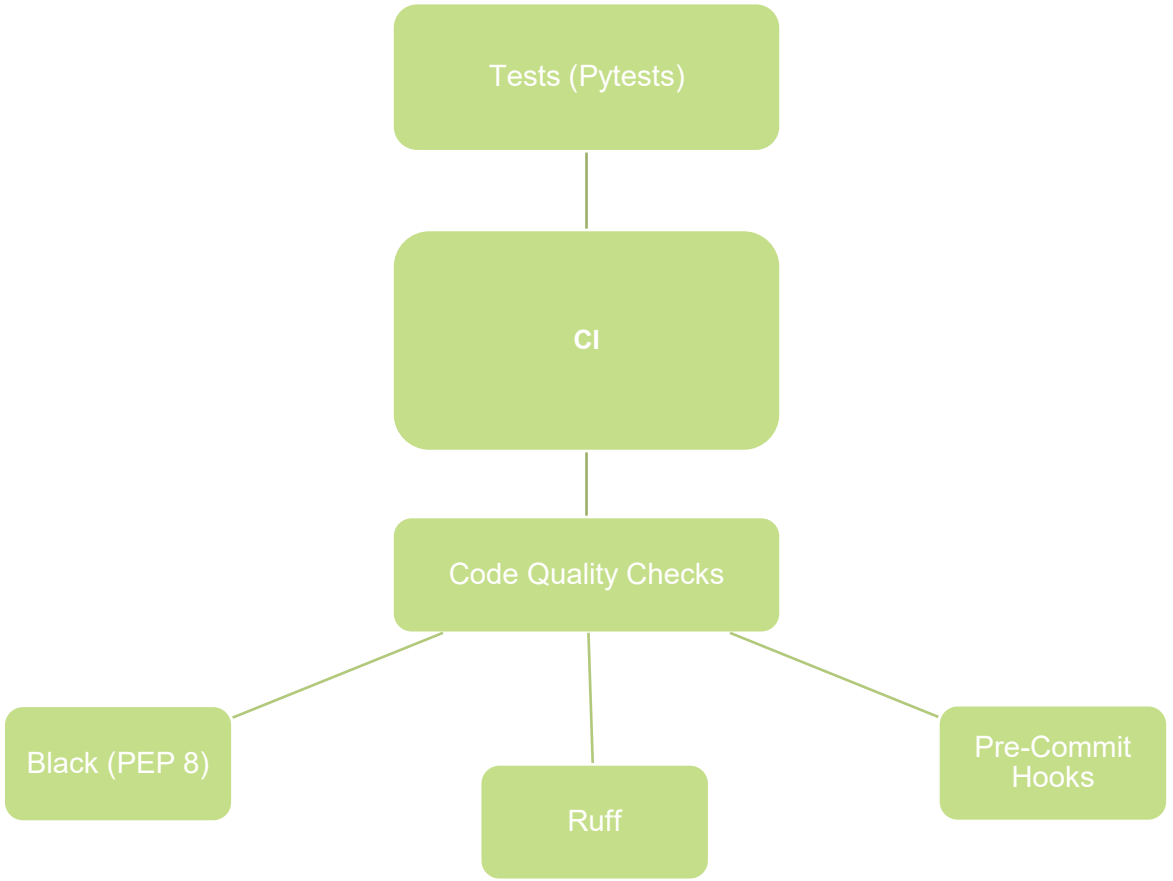
Deployment: CI (Tests & Code Quality Checks)

Continuous Integration (CI)

- Seamless integration using Github Actions
- **Automated Testing:** Pytest is used as testing framework
  - Every module and every method is tested individually
- Automate code quality checks
- Ensure consistent formatting
- Prevent common issues pre-commit

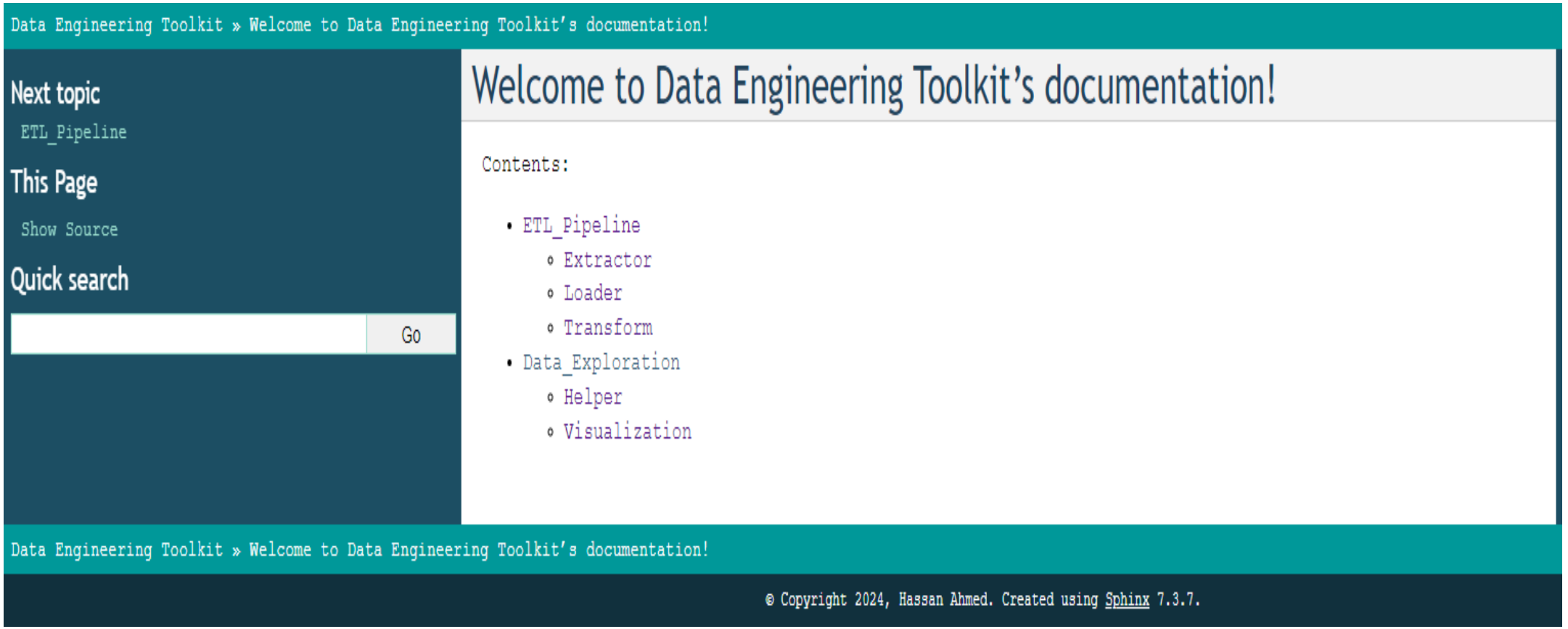
Hooks and Functions

- **Pre-commit Hooks:**
- trailing-whitespace: Removes trailing spaces
- end-of-file-fixer: Adds newline at end of files
- check-yaml: Validates YAML files
- check-added-large-files: Blocks large files
- check-ast: Checks Python syntax
- requirements-txt-fixer: Fixes requirements.txt formatting
- **ruff:** Lints and auto-fixes Python code
- **black:** Formats Python code to PEP 8 standards



Documentation (HTML) -I

- Viewable in web-browser
- Local and easily updated to reflect any changes
- Code comments are rendered, searchable, and structured



Documentation (HTML) - II

Transform

etl_pipeline.transform

etl_pipeline.transform.**add_new_column**(*df: DataFrame, column_name: str, values: Any*) → DataFrame

Add a new column with specified values.

Parameters:	• **df** (*pd.DataFrame*) – DataFrame to which the new column will be added. • **column_name** (*str*) – Name of the new column. • **values** (*Any*) – Values for the new column.
Returns:	DataFrame with the new column added.
Return type:	pd.DataFrame

etl_pipeline.transform.**change_column_type**(*df: DataFrame, column_name: str, new_type: Any*) → DataFrame

Change the data type of a specified column.

Parameters:	• **df** (*pd.DataFrame*) – DataFrame in which the column type will be changed. • **column_name** (*str*) – Name of the column to change the type of. • **new_type** (*Any*) – New data type for the column.
Returns:	DataFrame with the column type changed.
Return type:	pd.DataFrame

etl_pipeline.transform.**delete_columns**(*df: DataFrame, columns: List[str]*) → DataFrame

Deletes specified columns from the DataFrame.

Parameters:	• **df** (*pd.DataFrame*) – DataFrame from which columns will be deleted. • **columns** (*List[str]*) – List of columns to delete.
Returns:	DataFrame with specified columns deleted.
Return type:	pd.DataFrame

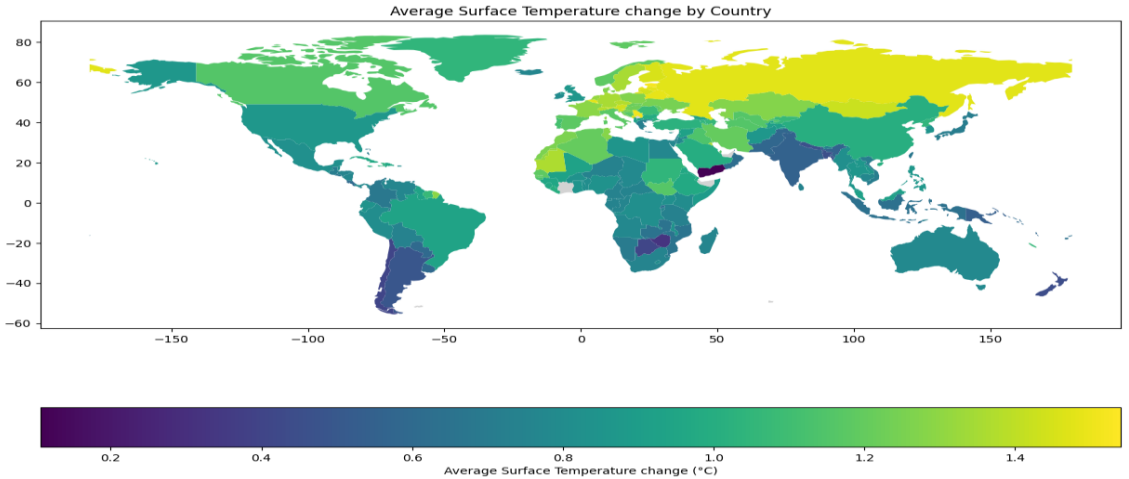
Analysis - I

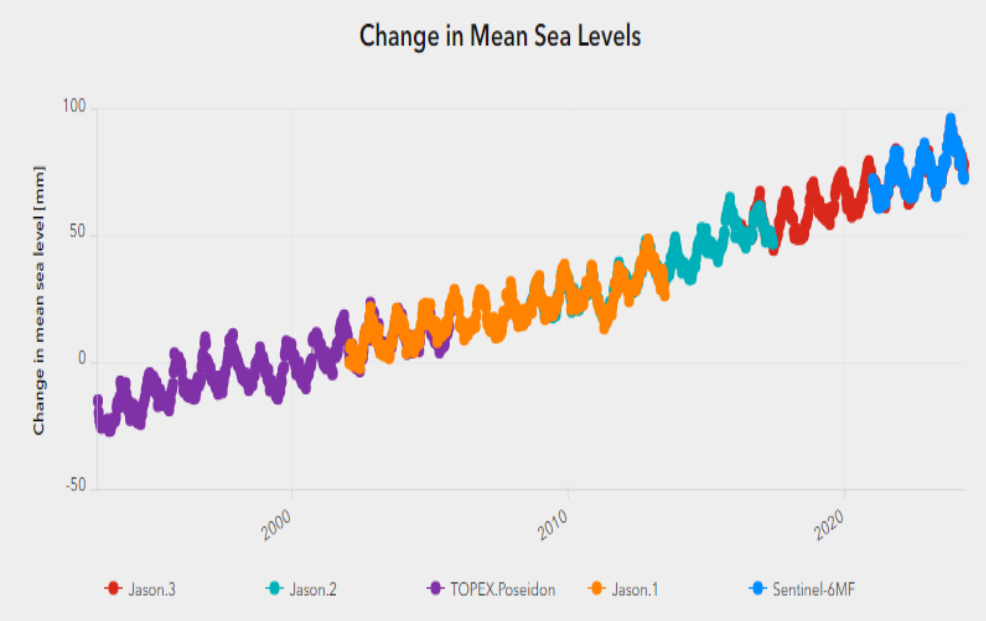
Temperature Change

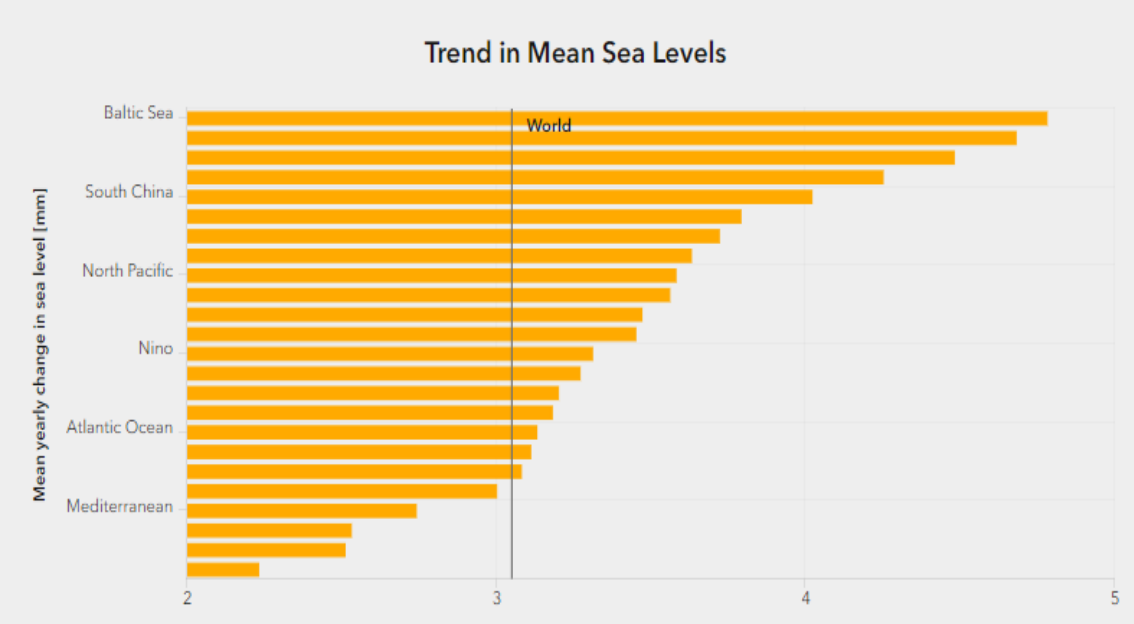
- The Northern Hemisphere, especially higher latitudes like Russia and Canada, show significant increases

Sea Level Rise

- Trend of rising sea levels from 1993 to 2021 due to thermal expansion and melting ice caps, highest in the Baltic Sea



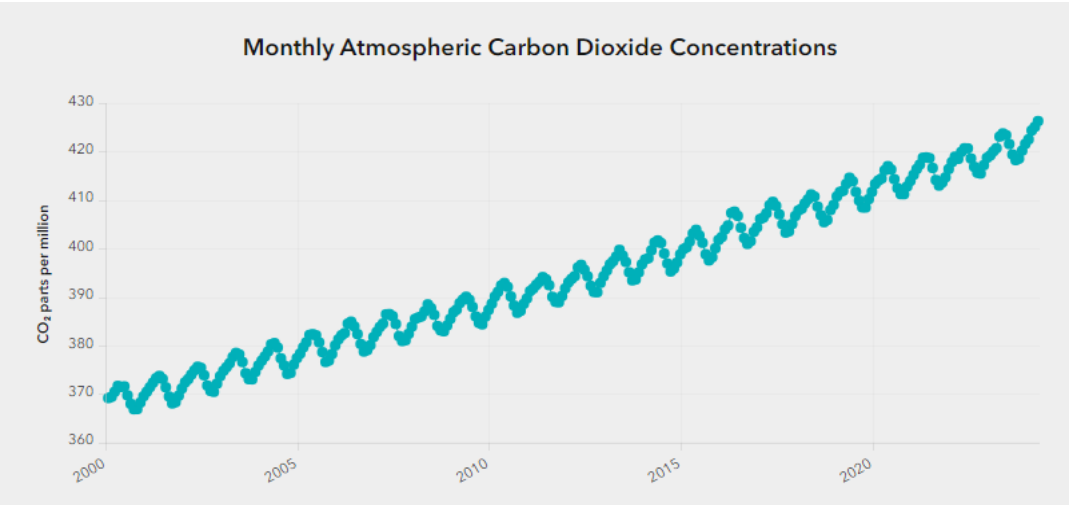




Analysis - II

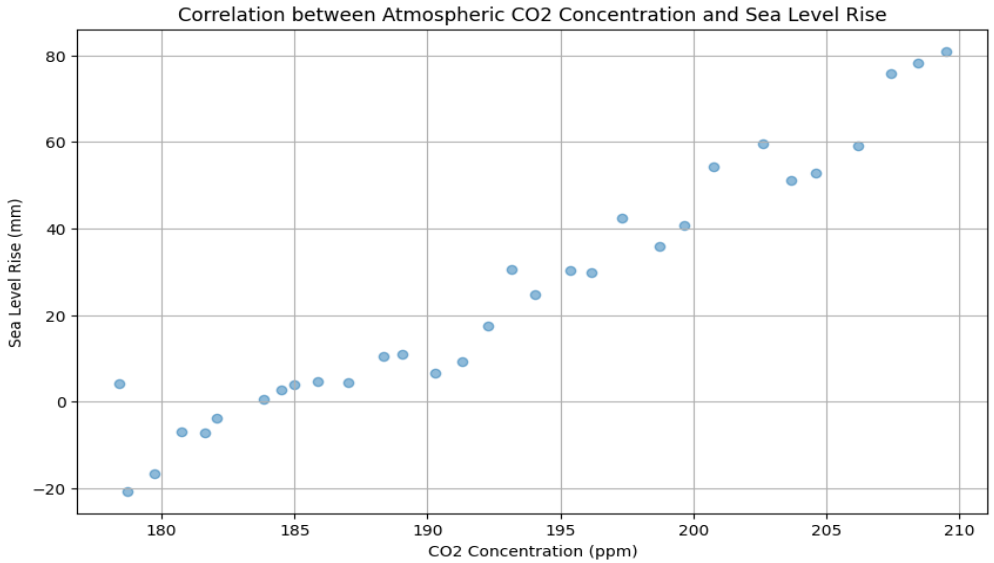
CO2 Levels

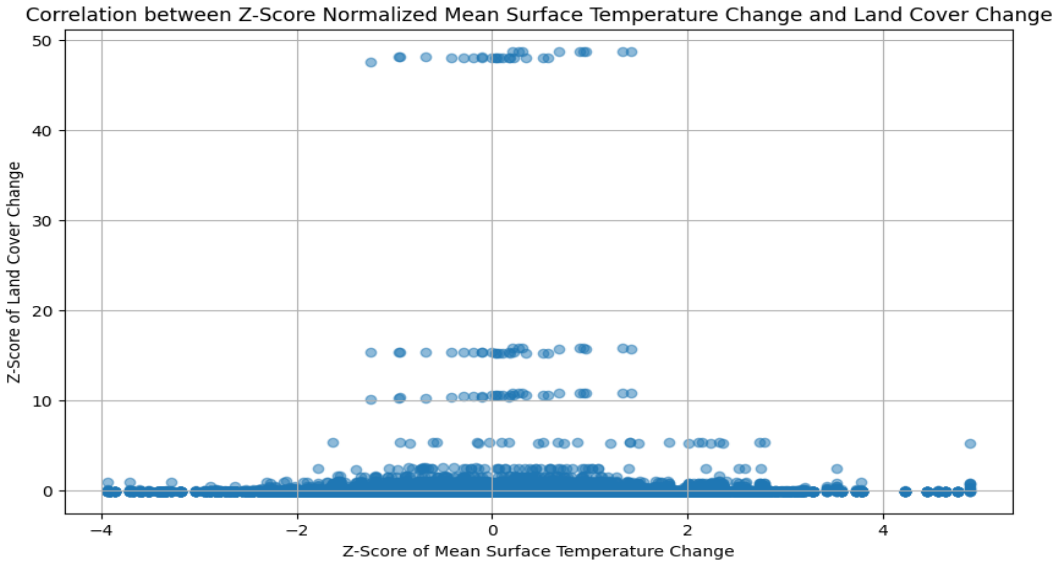
- Steady increase in atmospheric CO2 concentrations from 2000 to 2021, continuous rise with seasonal variations



Correlation Analysis

- Strong positive correlation between CO2 and sea level rise
- No significant correlation between surface temperature and land cover





Conclusion

CO2 and Sea Level Rise

- CO2 levels are on the rise and so is the level of sea
- There is a positive correlation between these two
- This indicates that CO2 increase leads to thermal expansion and due to heat and ice melts leading to the rise of sea levels

Relationship between Temperature and Land Cover

- No significant relationship was identified in this study
- Possible influences: The decision-making policies connected to global climate regulations, methods of agriculture and their impact on the land, and the readiness of ecosystems to bounce back

Implications

- Impact of CO2: Clear link to the greenhouse effect
- The dynamics of the changes in the land cover can be associated with many factors other than temperature

Thank You
Any Questions?

References

1. NOAA/GML Dr. Pieter Tans and Scripps Institution of Oceanography Dr. Ralph Keeling. World monthly atmospheric carbon dioxide concentrations. https://climatedata.imf.org/datasets/9c3764c0efcc4c71934ab3988f219e0e_0/about, 2024.

2. FAO. Temperature change. https://climatedata.imf.org/datasets/4063314923d74187be9596f10d034914_0/about, 2024.

3. NOAA Laboratory for Satellite Altimetry. Sea level rise. https://climatedata.imf.org/datasets/b84a7e25159b4c65ba62d3f82c605855/about, 2024.

4. FAO; IMF staff calculations. Land cover. https://climatedata.imf.org/datasets/b1e6c0ea281f47b285addae0cbb28f4b/about, 2024.