TropiDash: towards a comprehensive tropical cyclone hazard dashboard

Code4Earth 2023 Challenge 14 - Tropical Cyclone Hazard Dashboard

Link to the challenge: https://github.com/ECMWFCode4Earth/challenges_2023/issues/11

Team

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Summary

Abstract

This project will produce a platform on Jupyter notebooks able to visualize key meteorological parameters in plots and maps to better understand tropical cyclone hazards evolution. It will gather the currently used and most effective visualizations and reproduce them in a dashboard applying interactive elements. The end user will be provided with sound documentation which will enable the platform usage and enhancement after the end of the project. The development of the project is envisioned following 4 major phases:

1. Existing context recognition
2. Platform design
3. Platform development
4. Ensure the future maintenance

A GitHub repository will be created, which will be the unique landing point containing the ongoing progress of the project as well as the actual finished deliveries (unless stated otherwise by ECMWF representatives). After the end of the project dissemination activities like participation to conferences and webinars are expected where the dashboard will be shared and promoted to a broader audience.

Problem description

Tropical cyclones (TCs) are hydrometeorological extreme phenomena consisting of low pressure systems with high speed winds spinning. These seasonal phenomena have devastating consequences on human societies from human casualties to extensive damages on civil infrastructures. IPCC[1] conclusions on climate change projections indicate that in the future more stronger cyclones will affect extensive areas around the globe. This project aims to contribute in TC data dissemination to help in population preparedness and resilience against extreme meteorological events. This project is not only addressed to the scientific community but also to a broader audience.

Currently, ECWMF has available charts of TC. Nevertheless, some limitations arise such as the lack of existing reproducible dashboard featuring multiple products from multiple sources, a poor interactivity with existing charts, potential areas for improvement such as widgets and/or filters to customize visualisation data, and a need for data to be visualised for a broader audience.

Milestones and deliverables

The project milestones will follow the project structure:

- **M1. Recognition completed**
  The milestone will be reached once we successfully manage to gather all the background information needed for the development of the project. This means having a clear idea of which are the hazards related to tropical cyclone events, which are the relevant indicators and meteorological parameters for their description, what are the current tools available for visualizing tropical cyclone hazards and if they lack something in specific, and having identified, analyzed and processed the input data correctly.

- **M2. Platform designed**
  The achievement of this milestone will ensure a clear design of the platform that we want to develop, listing all the components and how they interact with each other. Using a top-down approach we will start by addressing how the data sources are accessed, which data processing tools are available for the users, and what is the structure of data visualization. Having defined these 3

steps together with the decision of the Jupyter plugins we want to use, we will then decompose the whole process of the platform in sub-processes. Each sub-process will have specific classes, functions or pieces of code to compute and display the corresponding results.

- **M3. Platform developed and documented**
  The achievement of this milestone will result in the developed platform online with appropriate documentation. This will be the more operational phase where we will implement the design decided by reaching M2 and write a user guide for the fruitful utilization and future updates of the platform.

Deliverables follow the milestones structure of the project. Each deliverable will follow under one of the 3 major steps and will correspond to the achievement of a specific task:

- **D1. Background information acquisition and existing products review (M1)**
  - **D1.1 Context report -** Report containing key variables and indicators identified as relevant for tropical cyclones hazard and a summary of the current charts and products used for tropical cyclone hazards visualization.
  - **D1.2 Data description report -** Report containing information about the available data for the project (e.g. sources, temporal resolution, spatial resolution, temporal horizon).

- **D2. Tropical Cyclone Hazard Dashboard design (M2)**
  - **D2.1 Dashboard design report -** A report containing: a flowchart showing the platform structure: a general idea of the storytelling, access to input data, data processing tools, data visualization tools, a list of possible charts, available widgets for the users; a description of the Jupyter plugins selected; and a definition of functions and classes needed for each sub-process with clear inputs, outputs and tasks performed.

- **D3. Tropical Cyclone Hazard Dashboard implementation and documentation (M3)**
  - **D3.1 Tropical Cyclone Hazard Dashboard -** The final result: a dashboard built on Jupyter able to visualize key variables to tropical cyclone hazard forecasting.
  - **D3.2 Dashboard documentation -** Annexed information necessary for the dashboard utilization, future updates and eventual customization.
  - **D3.3 Video Tutorial -** A video guide to show to a broader audience how to use the dashboard with a particular example.

Timeline

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Existing context recognition			D1.1 D1.2													
Platform design								D2.1								
Platform development															D3.1	
Ensure the future maintenance																D3.2 D3.3
Milestones			**M1**					**M2**								**M3**

Project structure and phases

Existing context recognition

This phase will focus on recognizing and understanding both the key tropical cyclone hazard variables and the current state of visualizations tools useful for the dashboard. The available data will be inspected, arranged and described. The phase structure can be summarized as:

- Identify key variables and indicators needed to be shown to better understand and forecast tropical cyclone hazards
- Produce a summary of what are the current charts and products used for tropical cyclone hazards visualization
- Data inspection: understanding and arrangement of the available data

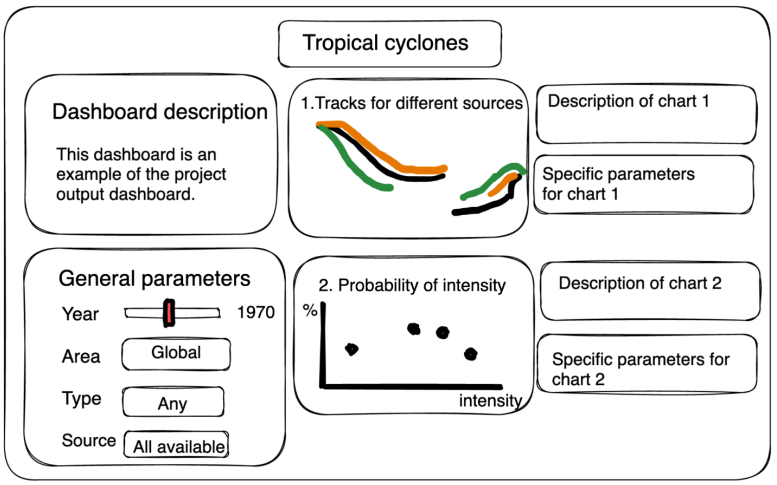
Platform design

This phase of the project focuses on the design of the platform, addressing all the relevant aspects that guarantee its correct operation. After having identified all the components it is crucial to plan how they are built and how they interact with each other. The fundamentals steps are:

- Understand how the platform accesses the data sources:
    - Is the notebook connecting to a remote database and accessing a specific set of data following the user request? In that case, which database can be accessed through an API?
    - Does the user have to provide the necessary data for the notebook to work? In that case, which data formats will the platform be able to handle?

- Plan which data processing tools are available on the platform and which ones are available to the users so they can utilize them to tackle more specific tasks.
    - Transform data with Pandas
    - Enable the possibility to save intermediate transformed data in a binary file
- Plan how to structure the data visualization
    - Decide how to visualize the data so that the information is displayed in the most effective and user friendly way. For each specific variable, parameter or indicator, understand what are the most significant kinds of graphs to visualize it (e.g histogram, bar chart, pie chart, colored map).
    - Understand if a part of the data visualization of the dashboard can be represented in an interactive display to improve the user experience (e.g having the possibility to switch on the same kind of map between different cyclone events, in order to have a quick and simpler comparison).
- Explore the available Jupyter plugins (e.g. Voilà, Jupyter Dashboards Layout Extension) and decide which ones better fit the dashboard.
- Define and design the dashboard structure following the plan of the previous steps.
    - What are the different sub-processes composing the notebook?
    - What are the processing tools accessed in each part?
    - What are the maps and graphs produced in each part?
    - What are the necessary functions and classes in each part to perform the computations required? Clearly define their inputs, outputs and the task performed.
- Define the notebook's user interface based on dashboard structure and the necessities identified.

A preliminary example of the output is the following:



Platform development

This is the phase in which the platform is actually developed. Functions, classes and the dashboard structure will be coded to have a functional notebook ready to be used. The dashboard will be tested on the available datasets. The steps which will be followed are:

- Code the necessary functions and classes for the user-requested data processing and the static and interactive data visualization
- Construct the notebook structure for data visualization: produce a user friendly and customizable dashboard
- Use the test dataset to produce the designed visualizations and analyze the results of the dashboard

Ensure the future maintenance

This phase will be carried in parallel to the previous one and will enable the effective usage of the dashboard to the end users, producing sound documentation and working examples. Schematically:

- Produce the documentation to support the notebook utilization and maintenance
- Construct a few working examples to better show the applications of the platform and make them available online