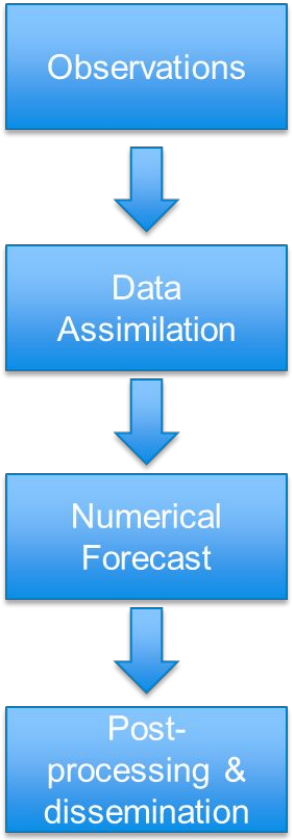
IEDSML
ASDLE2
CELMG0
SEMS12
EGOC01

MAY 2022

MINI-PROJECT
THE DAY AFTER TOMORROW

MACHINE LEARNING IN WEATHER FORECASTING

Weather Forecasting Workflow



Challenges:

- Size of the Earth
- Chaotic system
- Many model components, some processes not well understood

Where does ML fit in? Everywhere!

Observational screening, simple post-processing,

bias correction in data assimilation, emulation of parameterisation schemes,

spatio-temporal downscaling, ..., full replacement of current weather forecasting system [1]

[1] Schultz et al. 2021. Can deep learning beat numerical weather prediction? *Phil. Trans. R. Soc. A.* **379** https://doi.org/10.1098/rsta.2020.0097.

THE DAY AFTER TOMORROW CHALLENGE

Mock FEMA challenge

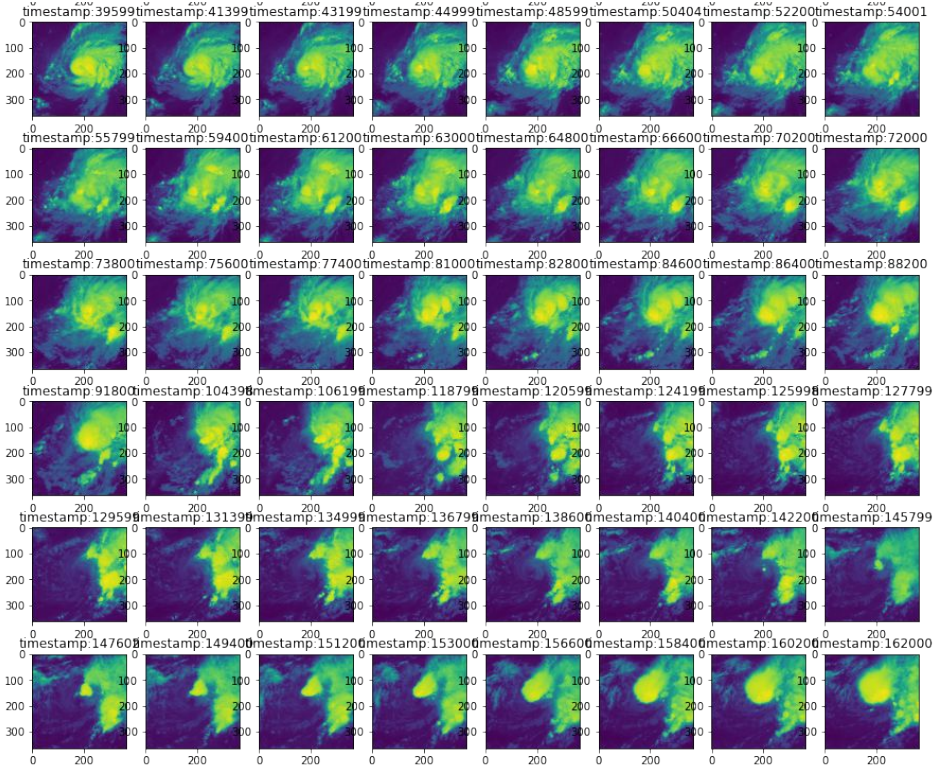
We will pretend that the **FEMA** (**F**ederal **E**mergency **M**anagement **A**gency) in the US have released an open competition to improve their emergency protocols under hurricane threats.

The call is open to **teams of ML specialists** (**you**) that can provide a solution to the problem of forecasting the evolution of tropical cyclones in real-time.

Each one of the groups will be working on the design and implementation of their solution, and present it in a short pitch that will be evaluated by a panel composed by: experts in storm forecasting and budget holders (the money people).

Motivation

Hurricanes can cause upwards of 1,000 deaths and $50 billion in damages in a single event, and have been responsible for well over 160,000 deaths globally in recent history. During a tropical cyclone, humanitarian response efforts hinge on accurate risk approximation models that can help predict optimal emergency strategic decisions.



https://mlhub.earth/data/nasa_tropical_storm_competition

To download it you must create an account with Radient MLHub

DATASET

- **NASA Satellite images** of tropical storms
- **494 storms** around the Atlantic and East Pacific Oceans (precise locations undisclosed)
- Each with **varied number of time samples** (4 - 648, avg 142)
- Labelled by id, ocean (1 or 2) and wind speed

```
train_metadata.head()
```

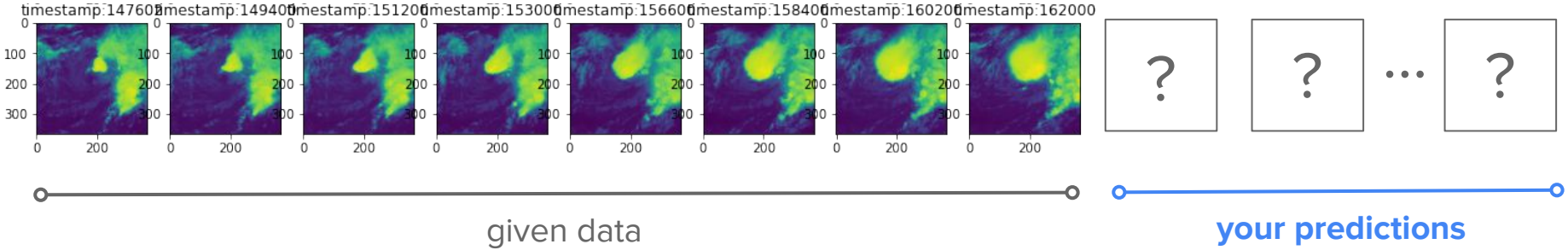
	image_id	storm_id	relative_time	ocean	wind_speed
0	abs_000	abs	0	2	43
1	abs_001	abs	1800	2	44
2	abs_002	abs	5400	2	45
3	abs_003	abs	17999	2	52
4	abs_004	abs	19799	2	53

OBJECTIVE

Original competition objective:

Wind speed classification task from storm satellite images

Your objective will be, given one active hurricane where some satellite images have already been made available, to generate a **ML/DL-based solution** able to generate as many **future image predictions** as possible based on these existing images **for that given storm**:



OBJECTIVE

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Wind speed classification task from storm satellite images

Your objective will be, given one active hurricane where some satellite images have already been made available, to generate a **ML/DL-based solution** able to generate as many **future image predictions** as possible based on these existing images **for that given storm**:

1. You can choose **any storm with more than 100 time samples** to design, train, and present your results in the pitch. You can also use several storms, but your network will only be required to work on a single storm, which means your solution will be trained from a particular storm dataset (current satellite images) every time.

2. There are **no restrictions** about network architecture, loss function, or any other design decisions.

3. Your submission will be judged by the panel on your results and also on a **provided test set**.

TEST SET: SURPRISE STORM

On **Thursday 1pm** we will ask you to retrain or evaluate your model on a particular storm **(to be disclosed)**

You will need to report two evaluation metrics for the prediction of the **five last time samples** of such storm: Mean Squared Error **(MSE)** and Structural Similarity Index Measure **(SSIM)**.

Note: you must make sure that the last five time samples of the storm are **not** included in your training set.

ASSESSMENT

Peer evaluation .....10 points

Presentation .....20 points

Sustainability and packaging .....20 points

Workflow and design decisions: data inspection, data pre-processing, data split, architectures, learning and evaluation metrics... (shown in notebook)
.....25 points

Metrics on surprise storm .....15 points

Creativity .....10 points

Total.....**100 points**

- No requirement to design network from scratch. However it's your responsibility to understand what you find online and to adapt it to this problem. You must explain **why** you made this decisions (do not forget citations).
- **Marks** will be awarded for more advanced solutions and better performance but the bulk of marks will be associated with a sustainable and clear workflows that shows well-justified design decisions.
- You also be responsible for designing optimisation and evaluation metrics of your network, as well as your data splitting (**experimental design**)

PRO TIPS

- It is often a good idea to start simple and expand later!
- **Data analysis**: take some time to understand the dataset, what it contains and how it is distributed. Make decisions based on this information
- Carefully decide how to **split train and validation** sets based on nature of dataset and the given task.
- Don't underestimate **planning**. Have a clear work plan with well-defined milestones that can be flexible to adapt to any unexpected situation (including contingency plans). Plan how to work together to **complete these tasks in time**.
- You are required to develop **original solutions**. But you can also use any code from the lectures, even from the web (duly cited). Expect to be critically questioned on your decisions, and explicitly indicate what portions of any code you use are **your original contributions**.

DELIVERABLES

Github repository containing:

- **One notebook** showcasing the workflow that led to best results (including any data inspection and treatment). It should include the solutions of the **storms you have selected** throughout development, as well as results (and metrics: MSE & SSIM) for the **surprise storm** released on Thursday.
- **Packaged utility scripts** that support the development of your workflow
- Any material produced to address software **sustainability**. This includes good documentation, any user guidance you decide is appropriate, etc.

Presentation:

- 15 min presentation to be uploaded to your assigned Teams channel

These should be completed and uploaded by **Friday (27/5) 4pm**

PRESENTATION CONTENT

Your presentation is a **pitch** to the FEMA panel to convince them to acquire the product you have developed.

It should include:

- Problem **background** and **motivation**.
- Description of your **solution design**: data treatment, model, losses and metrics, workflow, etc.
- **Main results** including evaluated metrics (MSE and SSMI) on the surprise storm.
- **Critical discussion** of the challenges of the project, and the advantages and limitations of your solution.

DEVELOPMENT PLATFORM

One Colab Pro+ license per group will be provided by the college to run your models!

You should **organise** with your team how to use that wisely

You are encouraged to **develop packaged scripts** from the beginning and use them in your notebook for easier collaboration and co-development.

SCHEDULE

Monday (23/5)	**Tuesday (24/5)**	**Wednesday (25/5)**	**Thursday (26/5)**	**Friday (27/5)**
Project introduction General questions Groups set up	Work on mini project & Support sessions	Work on mini project & Support sessions	Work on mini project & Support sessions **Surprise Storm release (1pm)**	Work on mini project & Support sessions **Submission deadline (4pm)** Wrap up session **Social (5pm)**

SUPPORT SESSIONS

Working rooms: RSM-1.51 and RSM-1.49

Groups get to meet one GTA per day (except Monday) for 25 min

Slots for meetings will be allocated in Teams

- Groups with members working remotely will have the support sessions held online

Try and prepare questions in advance

Supporting staff: Lluis, Debbie, George, Alex, Raul

SUPPORT SESSIONS

BST Time-zone

GROUP	Tuesday	Wednesday	Thursday	Friday
Katrina	Raul (10:00h)	Lluis (10:00h)	Debbie (10:00h)	Alex (10:00h)
Galveston	Raul (10:30h)	Lluis (10:30h)	Debbie (10:30h)	Alex (10:30h)
Camille	Raul (11:00h)	Lluis (11:00h)	Debbie (11:00h)	Alex (11:00h)
Harvey	Raul (11:30h)	Lluis (11:30h)	Debbie (10:30h)	Alex (11:30h)
Sandy	Debbie (10:00h)	Alex (10:00h)	Raul (10:00h)	Lluis (10:00h)
Andrew	Debbie (10:30h)	Alex (10:30h)	Raul (10:30h)	Lluis (10:30h)
Maria	Debbie (11:00h)	Alex (11:00h)	Raul (11:00h)	Lluis (11:00h)
Irma	Debbie (10:30h)	Alex (11:30h)	Raul (11:30h)	Lluis (11:30h)

Online Session

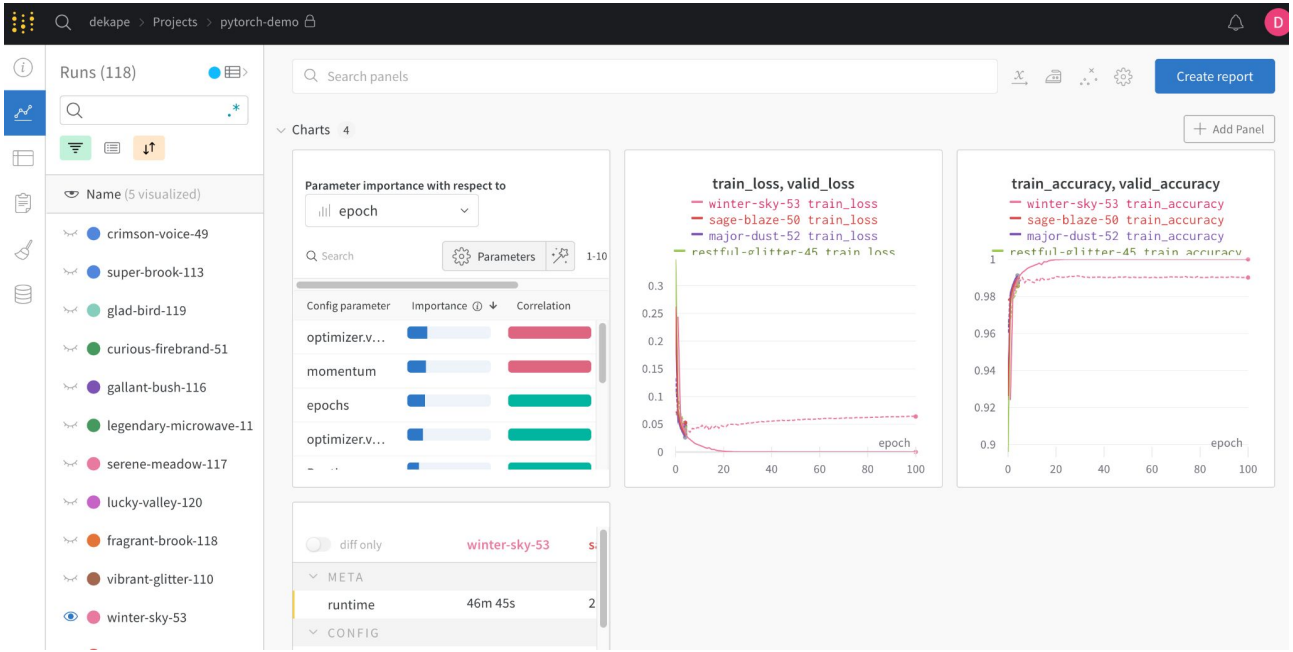
SUPPORT SESSIONS

BST Time-zone

GROUP	Tuesday	Wednesday	Thursday	Friday
Gilbert	Lluis (10:00h)	George (10:00h)	Alex (10:00h)	Debbie (10:00h)
Ivan	Lluis (10:30h)	George (10:30h)	Alex (10:30h)	Debbie (10:30h)
Hugo	Lluis (11:00h)	George (11:00h)	Alex (11:00h)	Debbie (11:00h)
Dorian	Lluis (11:30h)	George (11:30h)	Alex (11:30h)	Debbie (10:30h)
Michael	Alex (10:00h)	Debbie (10:00h)	Lluis (10:00h)	George (10:00h)
Wilma	Alex (10:30h)	Debbie (10:30h)	Lluis (10:30h)	George (10:30h)
Florence	Alex (11:00h)	Debbie (11:00h)	Lluis (11:00h)	George (11:00h)

Online Session

FINAL NOTE: WEIGHTS & BIASES



When you run hundreds of models, it's important to keep track of what you have done!

W&B allows you to do that and more, also lets you work in teams

Demo script on MNIST classifier will be made available for reference of usage

Not compulsory for this project

Example: https://wandb.ai/dekape/pytorch-demo?workspace=user-dekape

LINKS TO GET STARTED

https://mlhub.earth/data/nasa_tropical_storm_competition

https://github.com/radiantearth/mlhub-tutorials/blob/main/notebooks/NASA%20Tropical%20Storm%20Wind%20Speed%20Challenge/nasa-tropical-storm-wind-speed-challenge-getting-started.ipynb

https://github.com/radiantearth/mlhub-tutorials/blob/main/notebooks/NASA%20Tropical%20Storm%20Wind%20Speed%20Challenge/nasa-tropical-storm-wind-speed-challenge-benchmark.ipynb

GOOD LUCK! 💪