

Modeling

Mathematical Framing of Real-World Problems

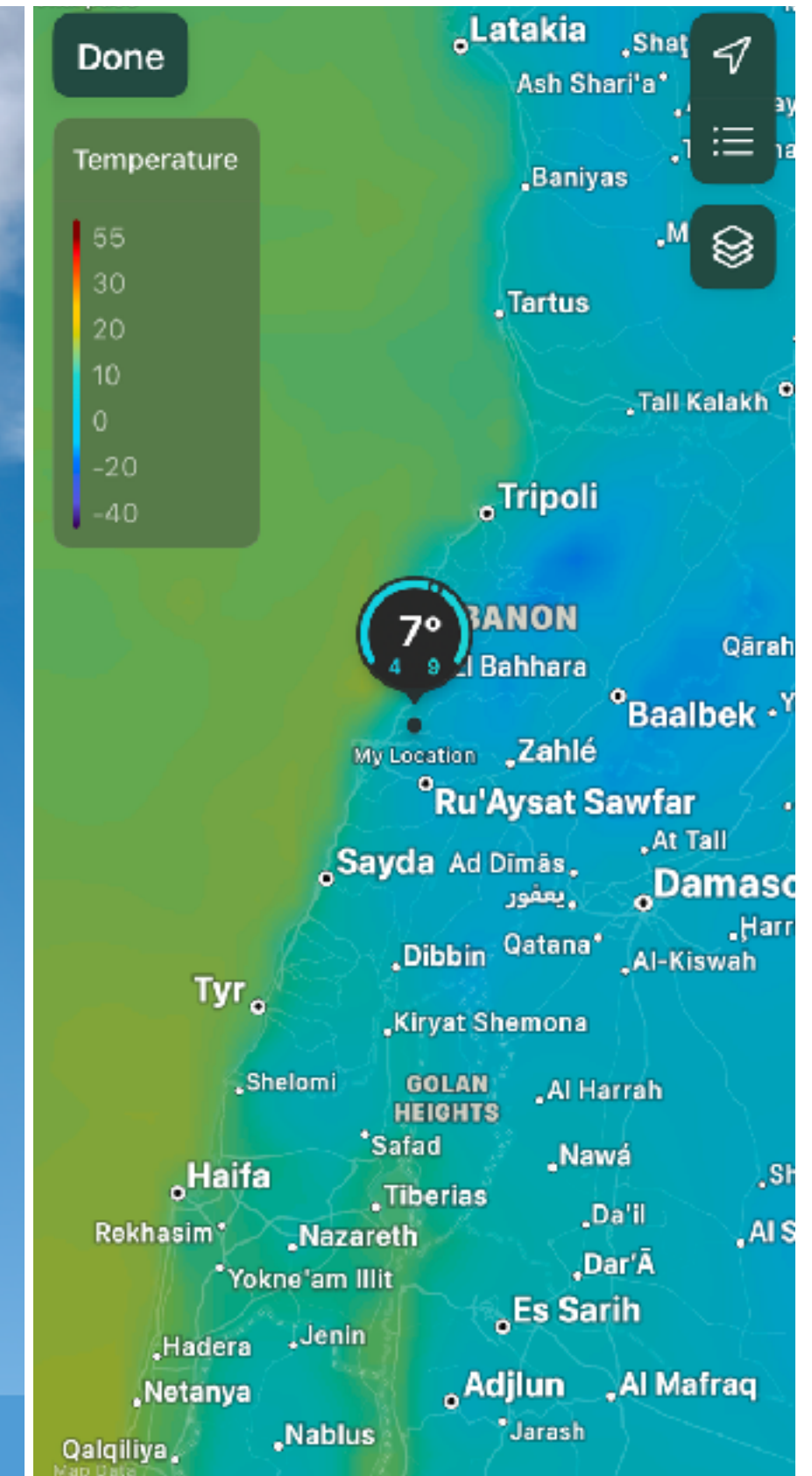
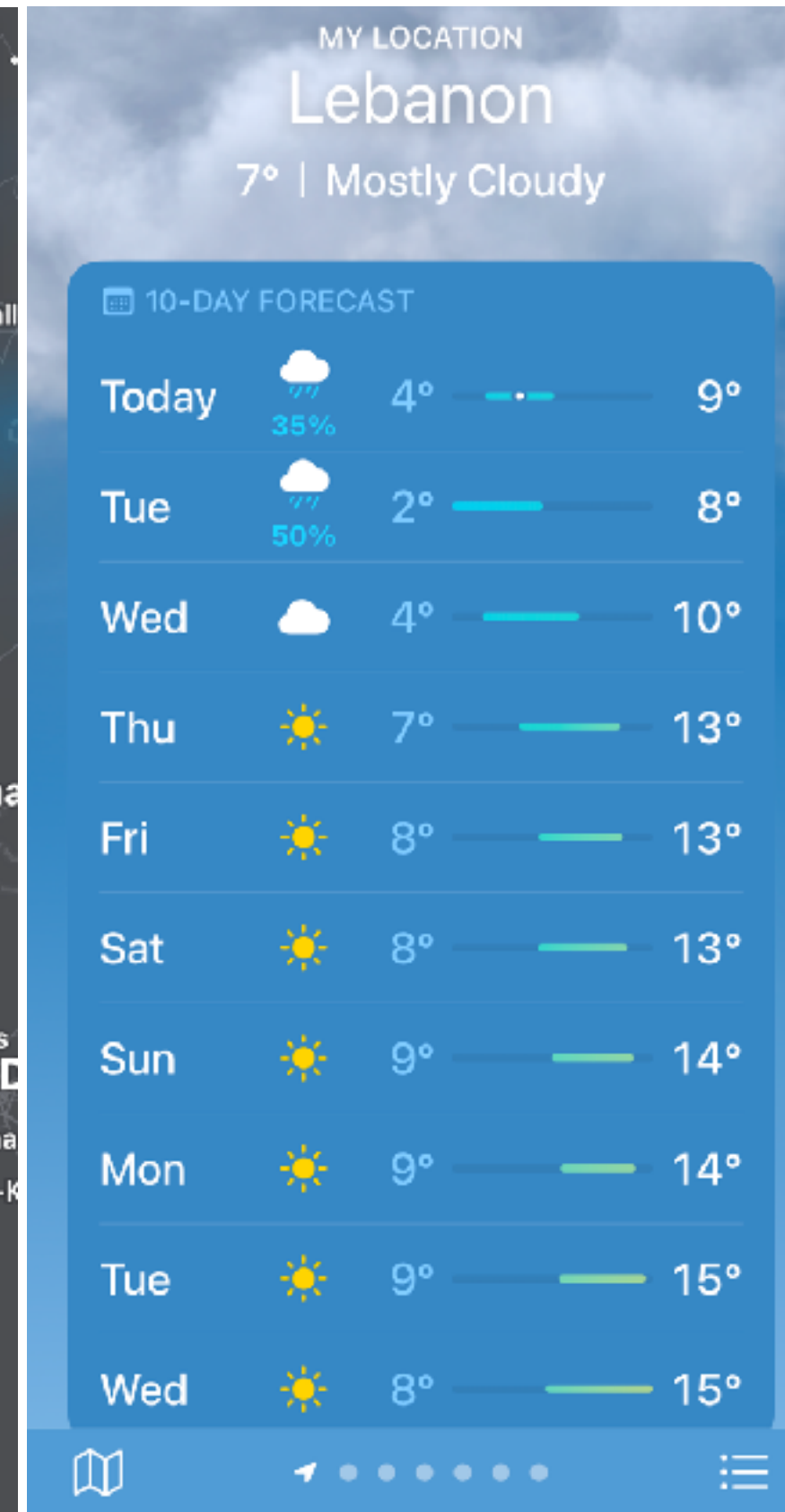
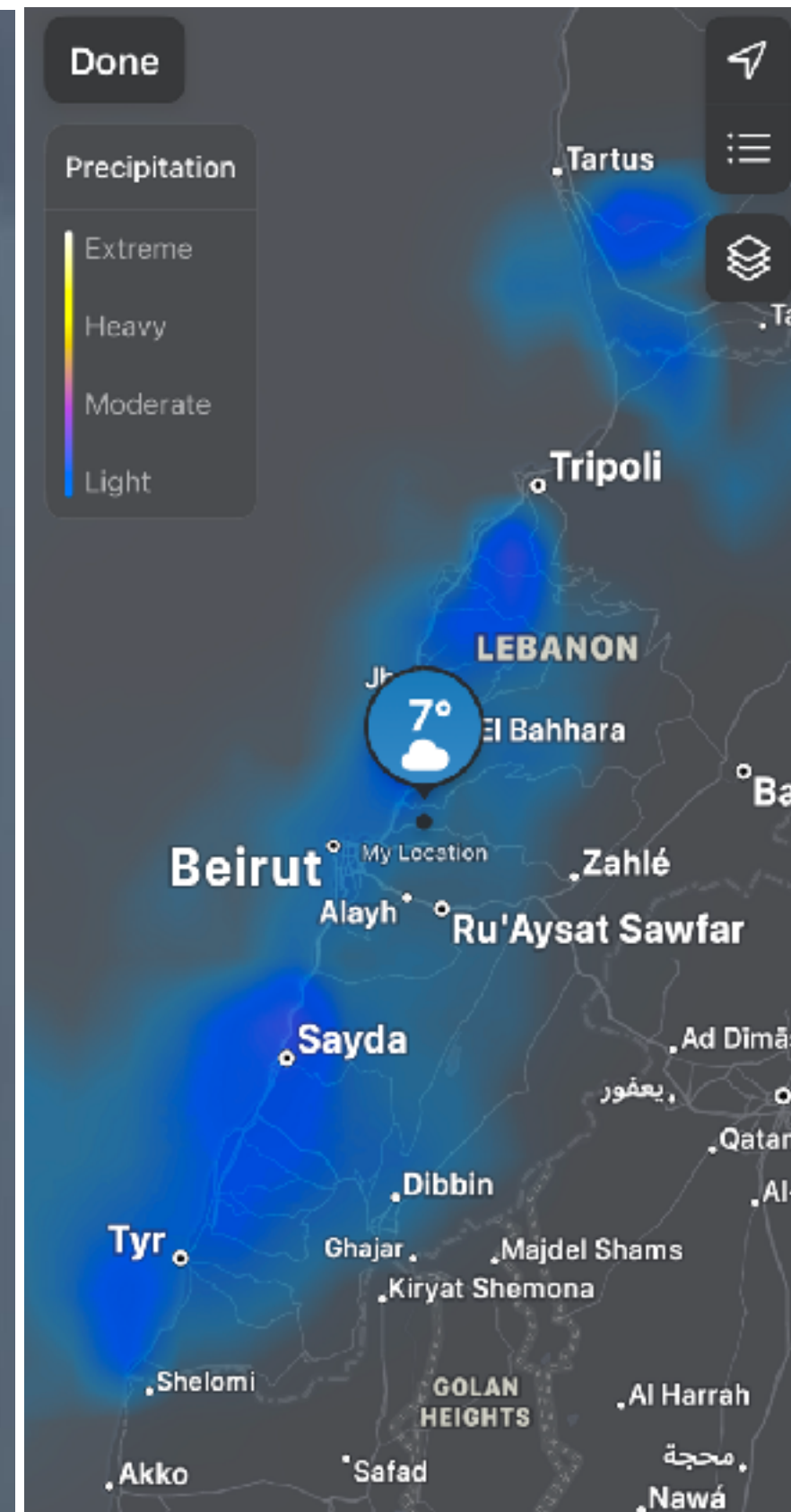
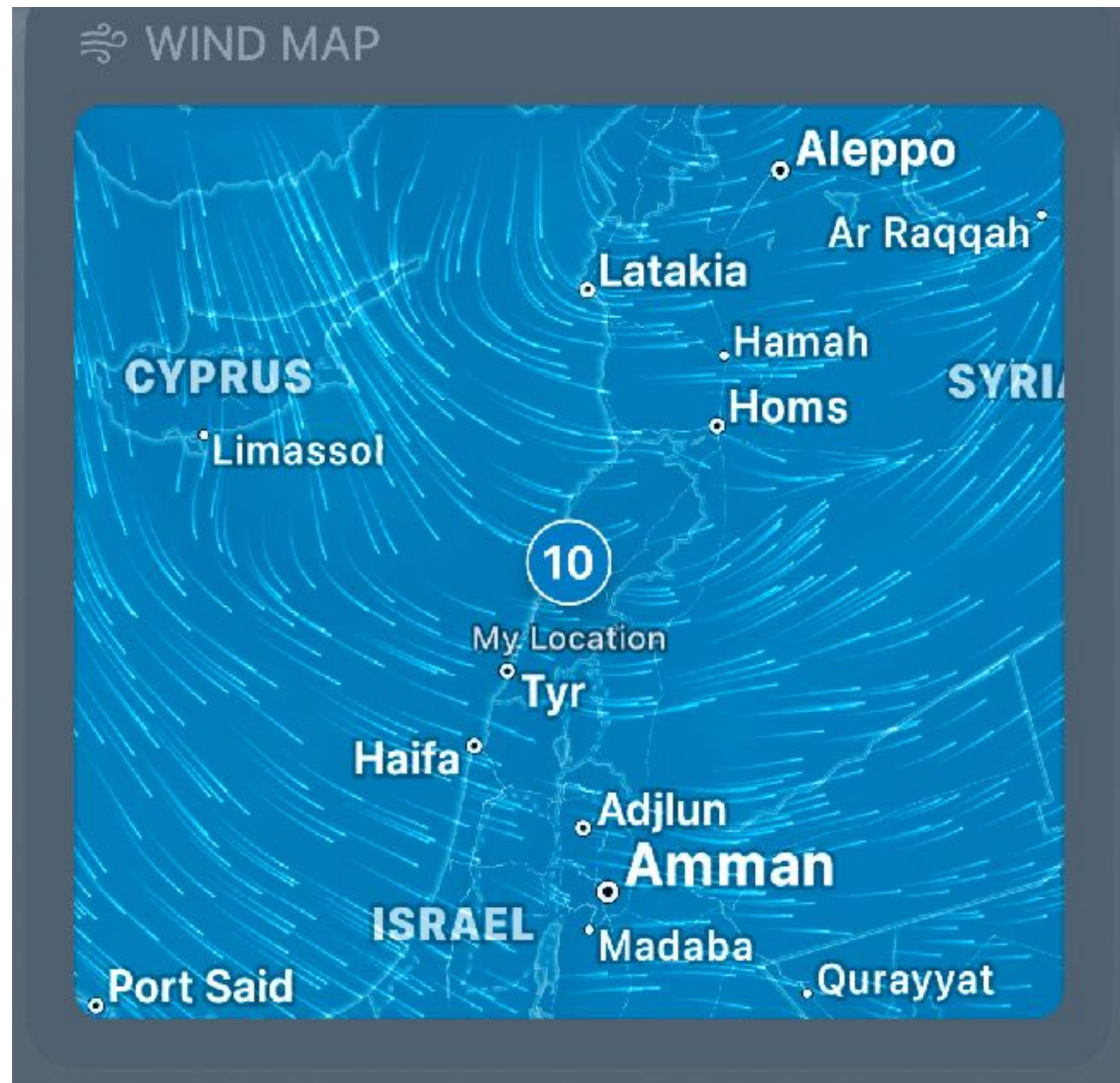
Joseph Bakarji

The 'model' machine learning scientist

- **Curiosity** to find learn about models and explore datasets.
- **Initiative** to take part in projects with an unfamiliar area of expertise.
- **Ability to identify** whether a problem requires machine learning or not.
- **Ability to quickly learn** enough background about the subject matter required for you to develop a sound hypothesis. e.g. how do you deal with weather data?
- **Ability to distill** complex real-world problems into mathematical representations, answering questions such as: what is the hypothesis, the are fitting parameters etc.
- **Coding maturity** to be able to test existing models, and develop new solutions. And having found a solution, the ability to package it into a product others will use.

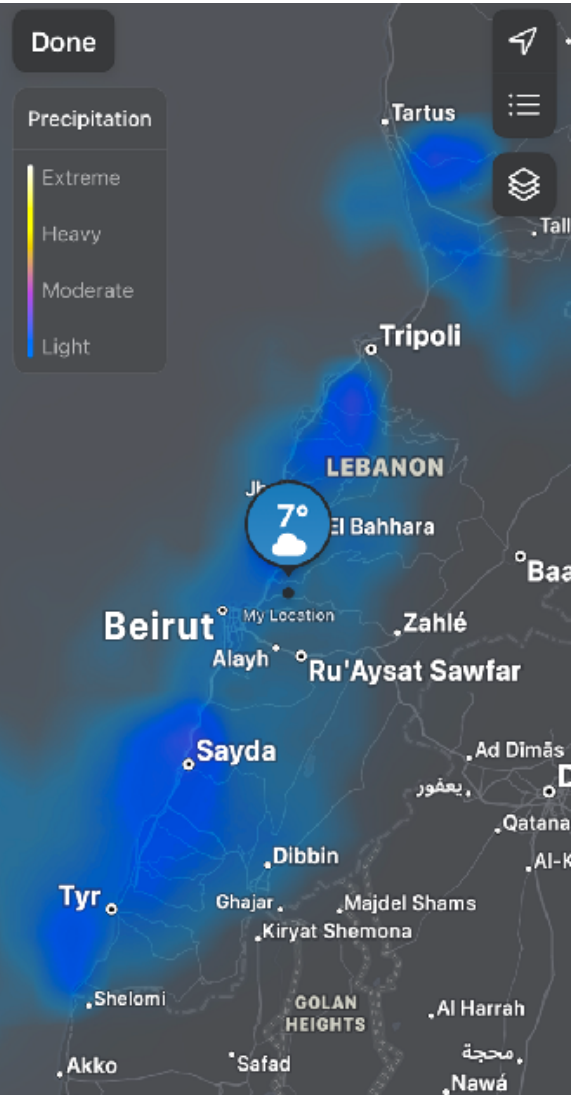
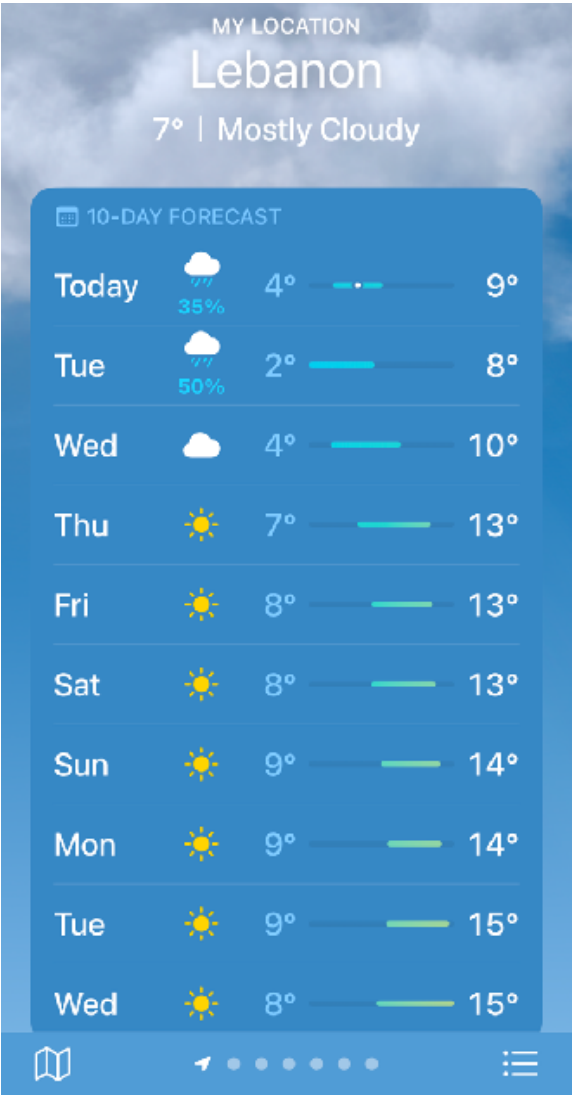
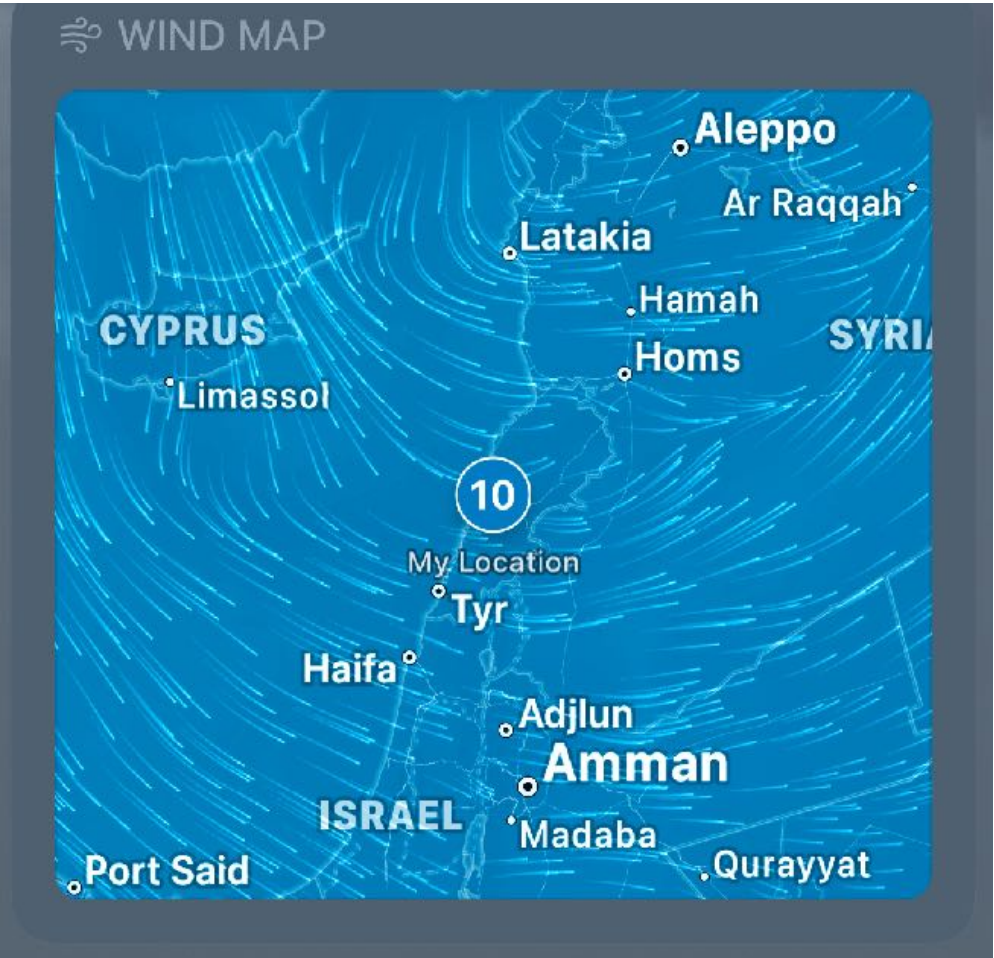
Here's an example

Weather data



Good questions to ask about the weather

Weather data



Wind

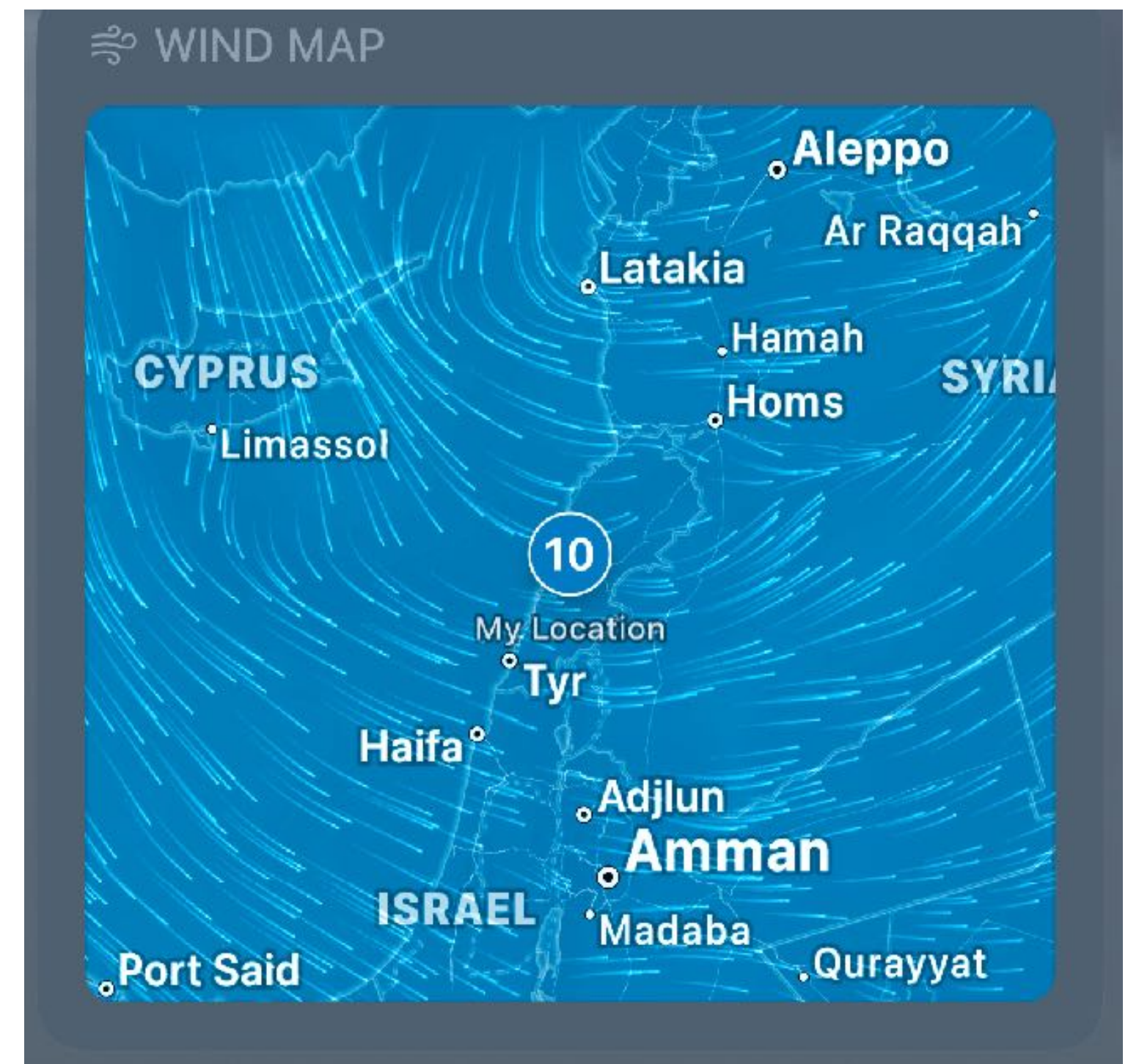
How is the data collected?

What does it look like?

What are the measurements of interest?

What are existing models?

What are existing models?



Temperature

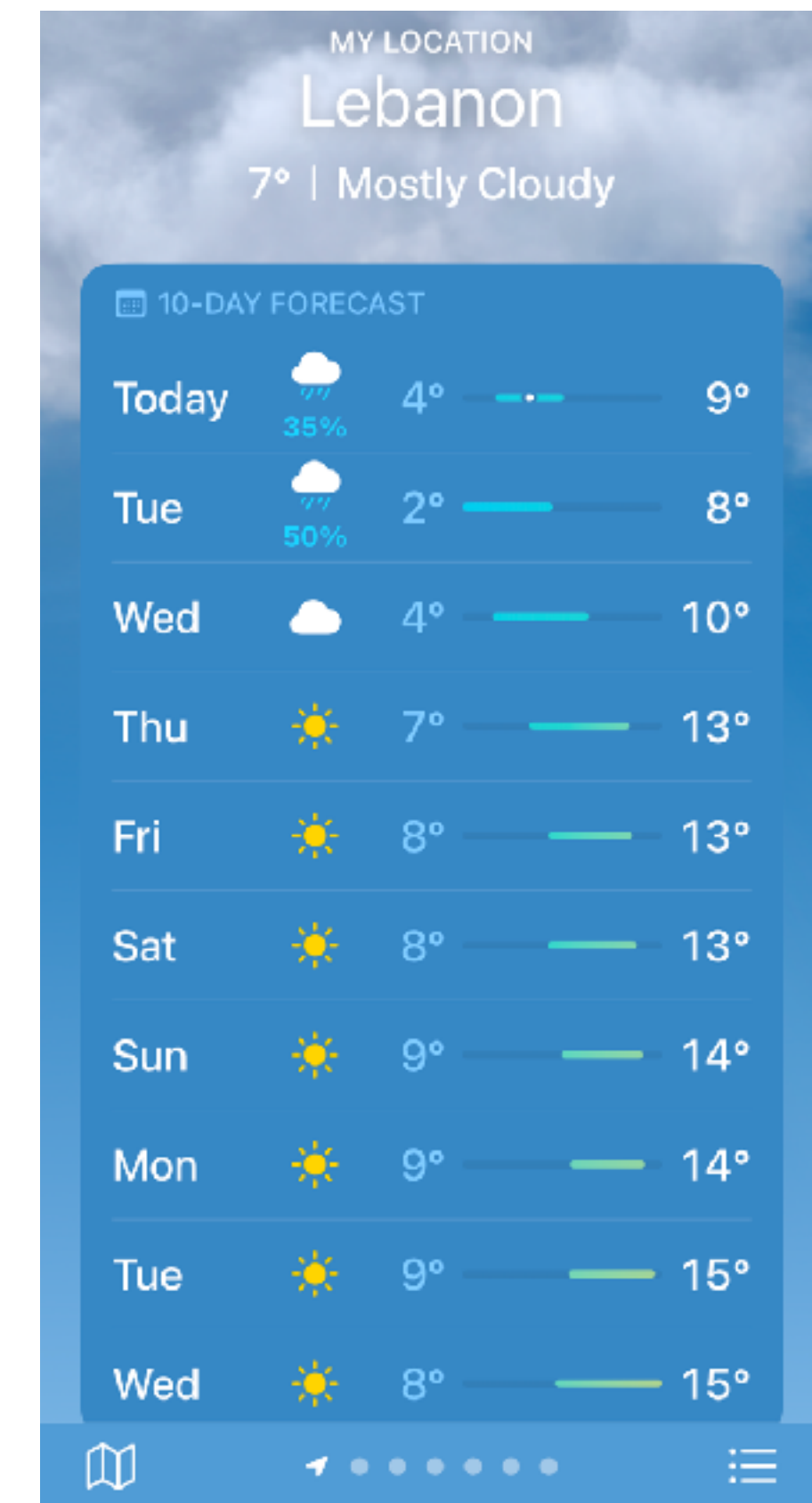
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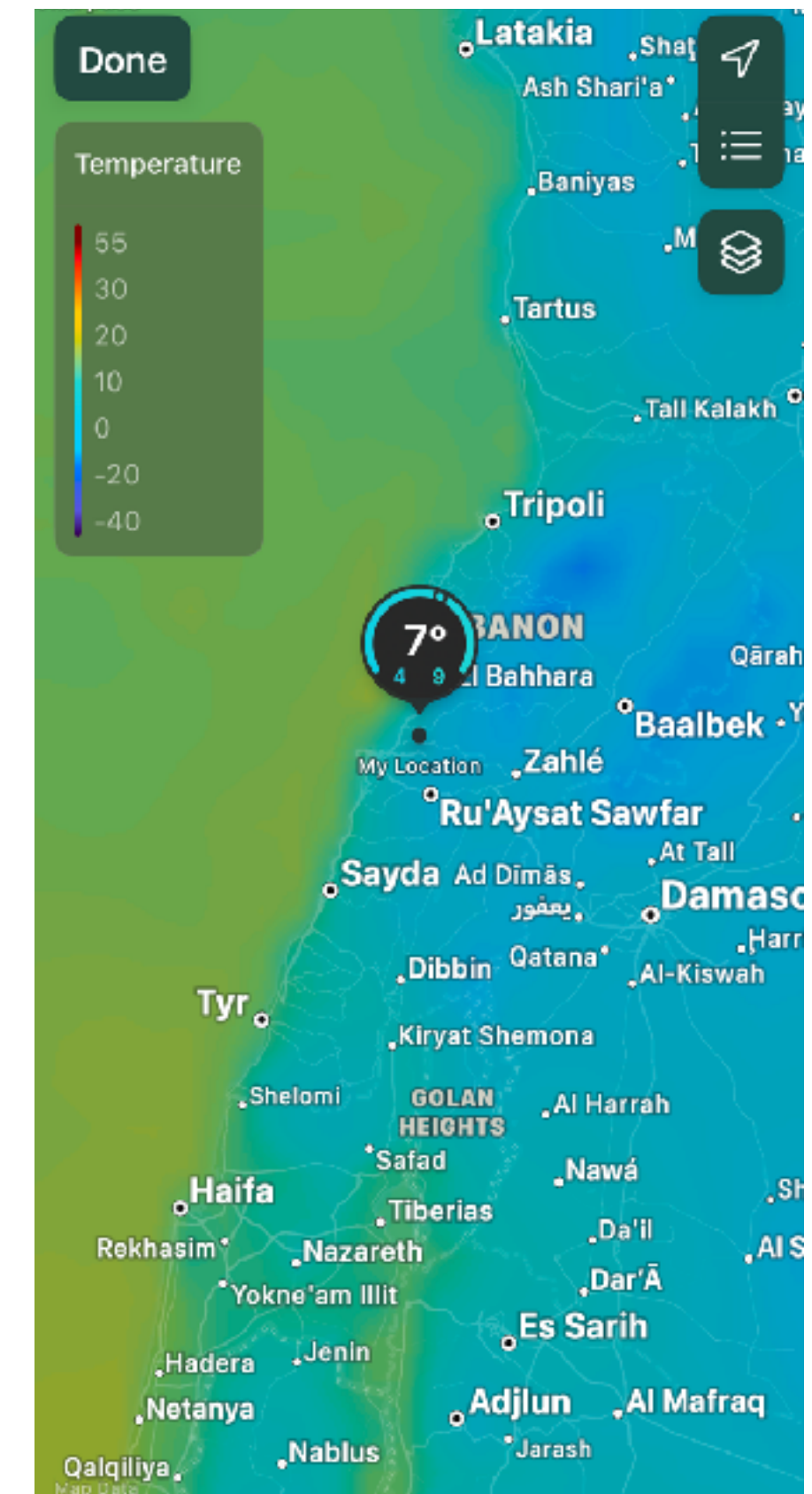
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Precipitation

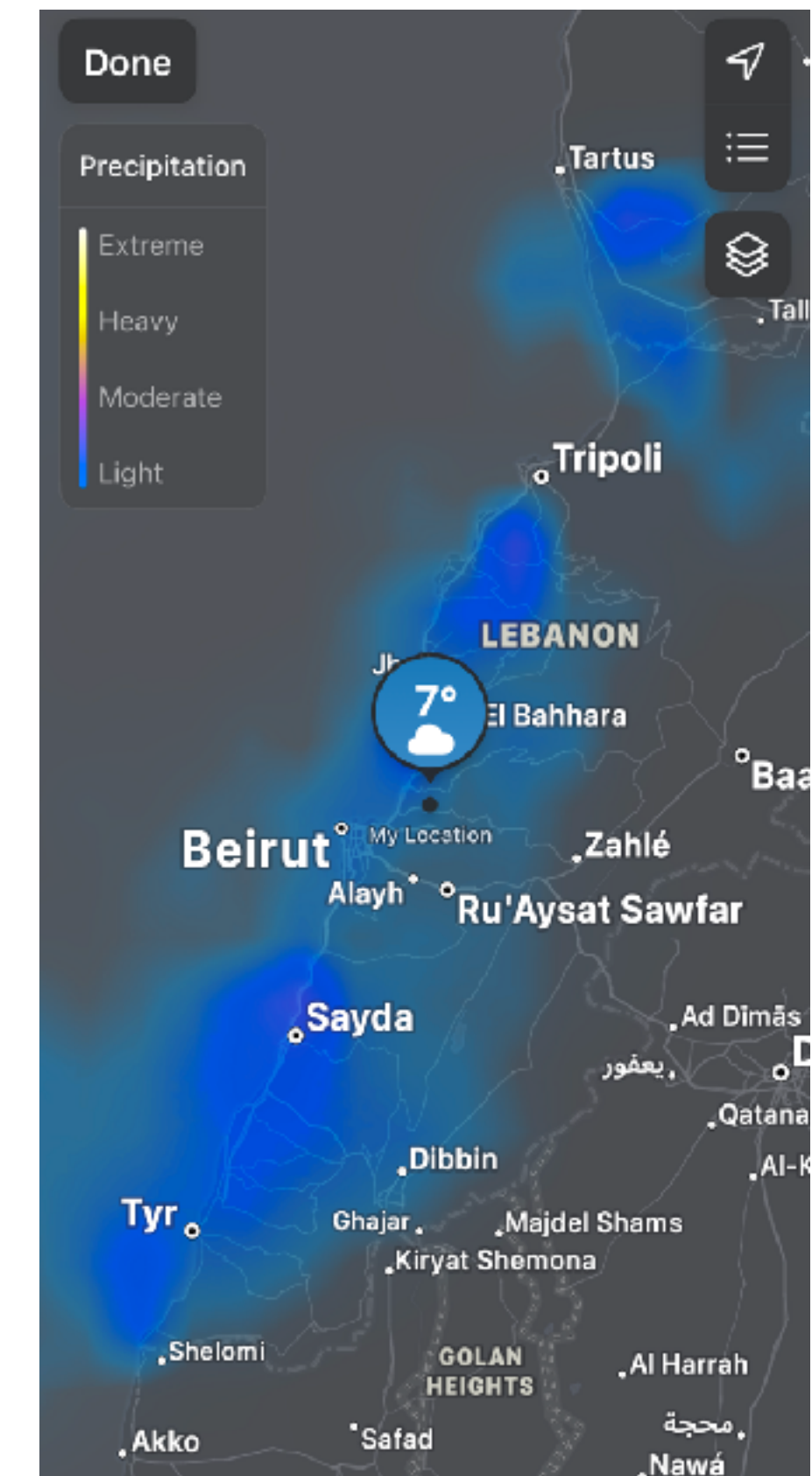
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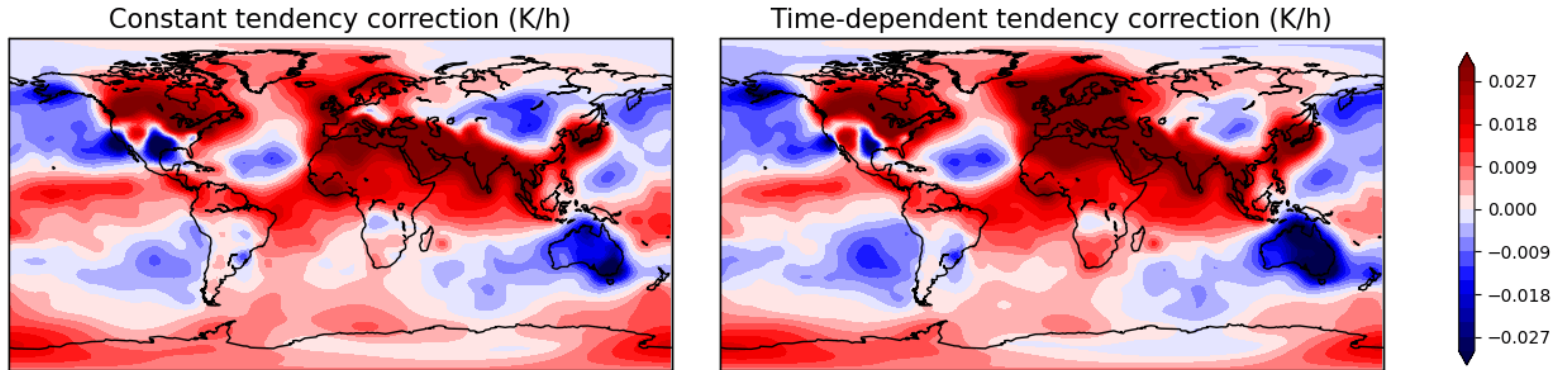
What are existing models?

What are existing models?



Who models weather? And do they use ML?

Google It: machine learning for weather prediction



Machine learning is set to play a growing role in numerical weather prediction, but physics-based forecasting techniques will continue to be important

European Centre for Medium-Range Weather Forecasts is currently pursuing a three-pronged approach:

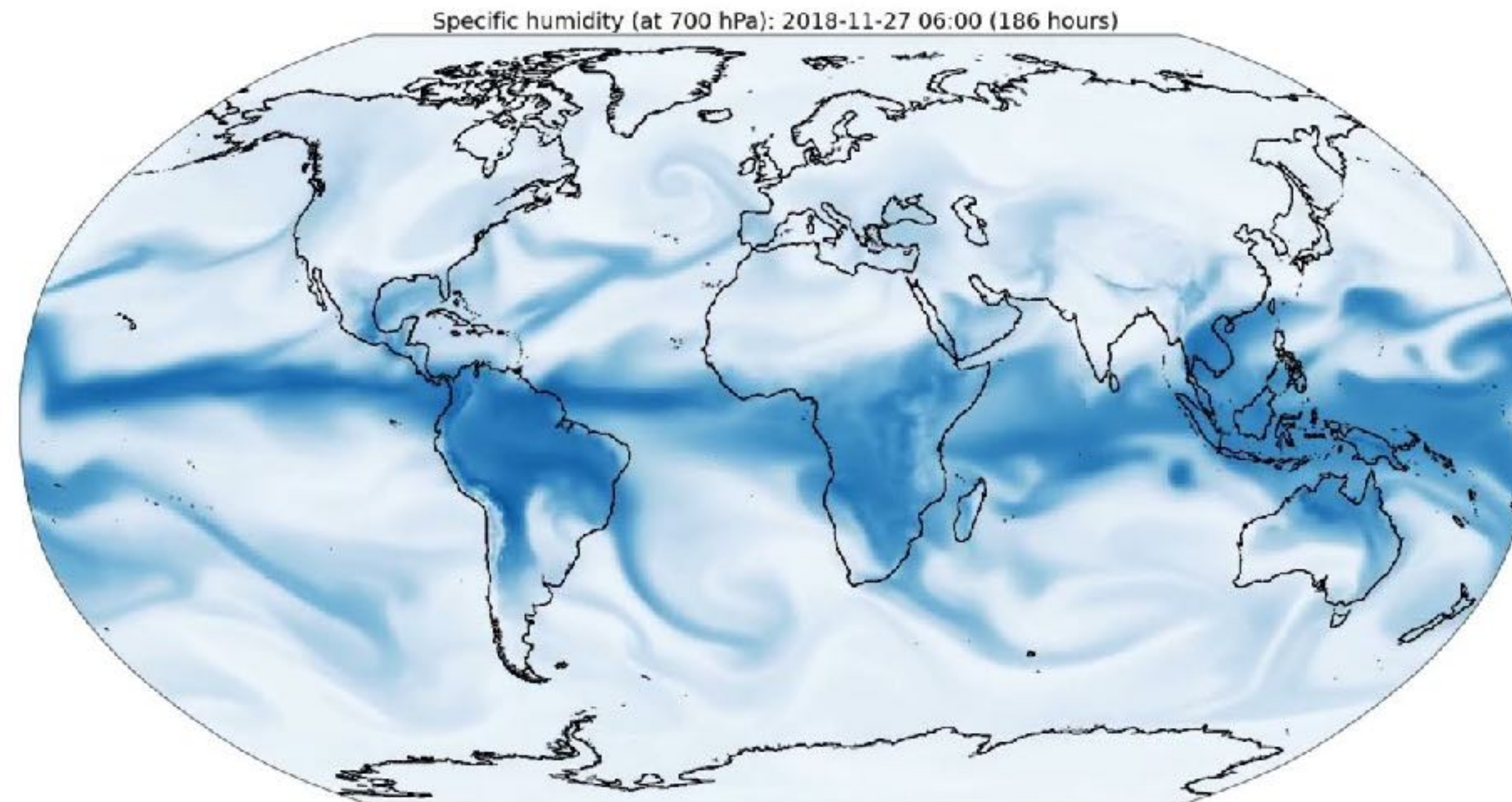
- The use of machine learning to boost traditional techniques,
- The development of a pure machine-learning forecasting model,
- An experimental use of machine learning on weather observations to build a forecasting system.

For the longer term, we will start investigating the design of a **foundation model** for weather and climate.

<https://www.ecmwf.int/en/about/media-centre/news/2024/machine-learning-play-growing-role-weather-forecasting-says-dg#:~:text=Machine%20learning%20is%20well%20suited,and%20to%20produce%20global%20forecasts.>

Big Tech tackling non-tech problems

GraphCast: AI model for faster and more accurate global weather forecasting - Deep Mind



- Forecasts typically rely on Numerical Weather Prediction (NWP), which begins with carefully defined **physics equations**, which are then translated into computer algorithms run on supercomputers. While this traditional approach has been a triumph of science and engineering, designing the equations and algorithms is time-consuming and requires deep expertise, as well as costly compute resources to make accurate predictions.
- GraphCast is a weather forecasting system based on machine learning and Graph Neural Networks (GNNs), which are a particularly useful architecture for processing spatially structured data.

Research papers

Open Access

Review

Machine Learning Methods in Weather and Climate Applications: A Survey

by Liuyi Chen ¹, Bocheng Han ¹, Xuesong Wang ², Jiazhen Zhao ³, Wenke Yang ¹ and Zhengyi Yang ^{1,*}  

¹ School of Computer Science and Engineering, University of New South Wales, Sydney, NSW 2052, Australia

² Commonwealth Scientific and Industrial Research Organisation, Data 61, Sydney, NSW 2015, Australia

³ Key Laboratory of Meteorological Disaster, Nanjing University of Information Science and Technology, Nanjing 210044, China

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Abstract

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Research papers

machine learning for weather prediction



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Machine learning in weather prediction and climate analyses—applications and perspectives

[PDF] [mdpi.com](#)

[B Bochenek](#), [Z Ustrnul](#) - Atmosphere, 2022 - [mdpi.com](#)

... The main goal of this study is to present a review of the **machine learning** ... of **machine learning** techniques as a new method that helps to solve important and complex issues in **weather** ...

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[M Holmstrom](#), [D Liu](#), [C Vo](#) - Meteorol. Appl, 2016 - [cs229.stanford.edu](#)

... intelligence used mainly **machine learning** techniques, mostly ... three papers on **machine learning** for **weather prediction** we ... to be the popular **machine learning** model choice for **weather** ...

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Ask GPT

how is machine learning used for weather modeling and prediction

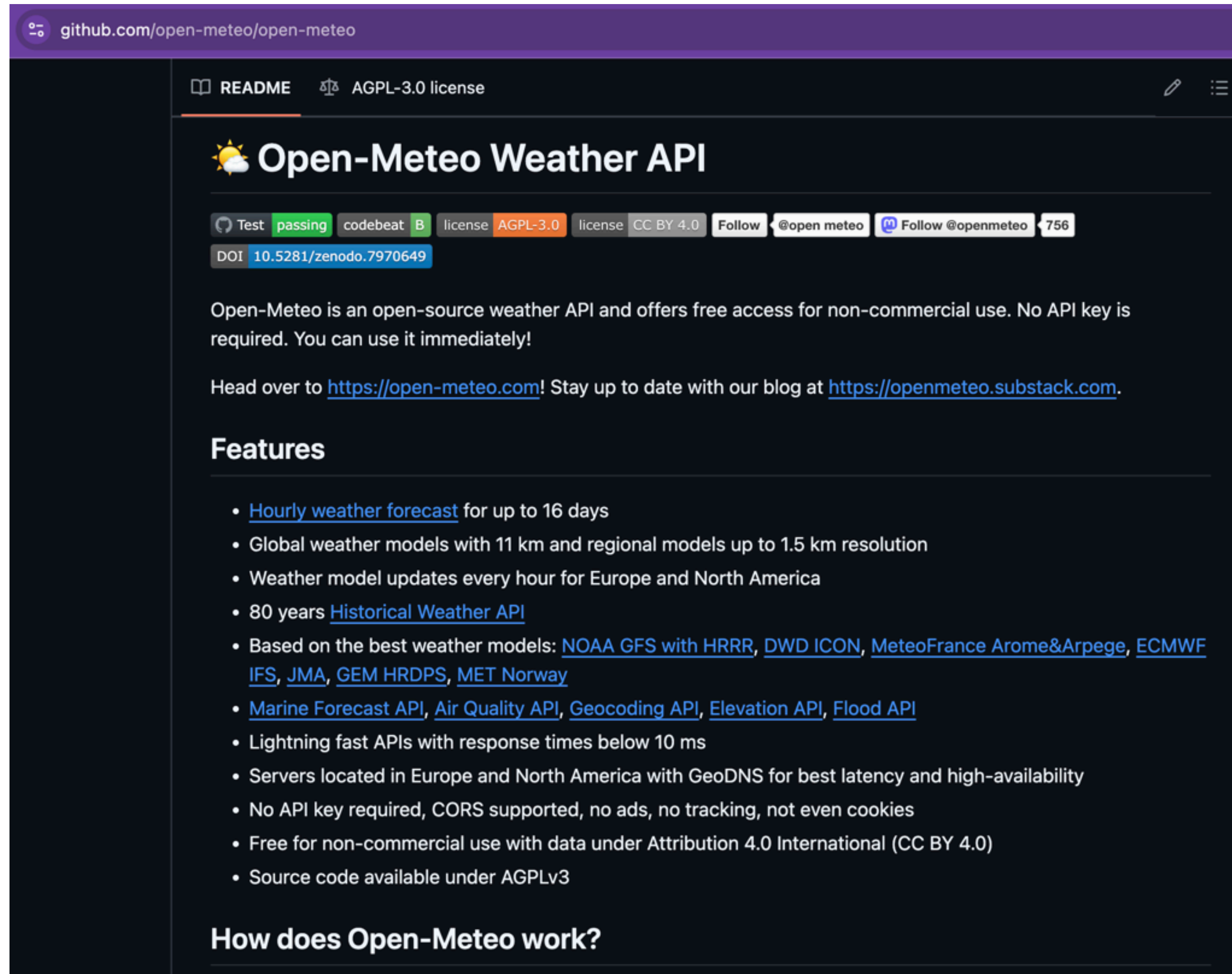


Machine learning (ML) has become an integral part of weather modeling and prediction, enhancing traditional methods by leveraging large datasets and providing more accurate, granular, and timely forecasts. Here's how ML is used in this field:

1. Data Integration and Preprocessing

- **Data Sources:** Weather models use diverse datasets, including satellite imagery, radar data, ground-based sensors, and historical climate records.
 - **Feature Engineering:** ML models preprocess raw data to extract meaningful features, such as temperature gradients, wind patterns, or atmospheric pressure variations.
-

Start implementing!



The screenshot shows the GitHub repository page for 'open-meteo/open-meteo'. The page has a dark theme. At the top, the repository name and license (AGPL-3.0) are visible. Below the repository name, there's a section for 'Open-Meteo Weather API' with a sun and cloud icon. This section includes badges for 'Test passing', 'codebeat B', 'license AGPL-3.0', 'license CC BY 4.0', 'Follow @open_meteo', 'Follow @openmeteo', and '756' stars. A DOI link '10.5281/zenodo.7970649' is also present. The main text states: 'Open-Meteo is an open-source weather API and offers free access for non-commercial use. No API key is required. You can use it immediately!'. It then provides links to the website 'https://open-meteo.com' and a blog 'https://openmeteo.substack.com'. A 'Features' section follows, listing various capabilities like hourly forecasts, global models, historical data, and different API types. The page ends with a section titled 'How does Open-Meteo work?'.

github.com/open-meteo/open-meteo

README AGPL-3.0 license

Open-Meteo Weather API

Test **passing** codebeat **B** license **AGPL-3.0** license **CC BY 4.0** Follow @open_meteo Follow @openmeteo 756

DOI [10.5281/zenodo.7970649](https://doi.org/10.5281/zenodo.7970649)

Open-Meteo is an open-source weather API and offers free access for non-commercial use. No API key is required. You can use it immediately!

Head over to <https://open-meteo.com>! Stay up to date with our blog at <https://openmeteo.substack.com>.

Features


- [Hourly weather forecast](#) for up to 16 days
- Global weather models with 11 km and regional models up to 1.5 km resolution
- Weather model updates every hour for Europe and North America
- 80 years [Historical Weather API](#)
- Based on the best weather models: [NOAA GFS with HRRR](#), [DWD ICON](#), [MeteoFrance Arome&Arpege](#), [ECMWF IFS](#), [JMA](#), [GEM HRDPS](#), [MET Norway](#)
- [Marine Forecast API](#), [Air Quality API](#), [Geocoding API](#), [Elevation API](#), [Flood API](#)
- Lightning fast APIs with response times below 10 ms
- Servers located in Europe and North America with GeoDNS for best latency and high-availability
- No API key required, CORS supported, no ads, no tracking, not even cookies
- Free for non-commercial use with data under Attribution 4.0 International (CC BY 4.0)
- Source code available under AGPLv3

How does Open-Meteo work?

Start implementing!


github.com/pangeo-data/WeatherBench

README Code of conduct MIT license



WeatherBench: A benchmark dataset for data-driven weather forecasting

🔥🔥🔥 [WeatherBench 2](#) has been released. It provides an updated and much improved benchmark including more comprehensive and more easily accessible datasets. 🔥🔥🔥

 [Binder](#)

If you are using this dataset please cite

Stephan Rasp, Peter D. Dueben, Sebastian Scher, Jonathan A. Weyn, Soukayna Mouatadid, and Nils Thuerey, 2020. WeatherBench: A benchmark dataset for data-driven weather forecasting. arXiv: <https://arxiv.org/abs/2002.00469>

This repository contains all the code for downloading and processing the data as well as code for the baseline models in the paper.

Reach out and ask

- After you do all your research, if you know someone who has expertise in the field, **ask them!** Your mechanical engineering friends, a professor at your university, an author of a paper, etc.
- Go back to pen and paper, and make sure you understand the modeling framework and assumptions.
- Implement a simple algorithm on a simple dataset if you can: it will improve your intuition about the data; even if it's fake data.
- ...

We did it all “wrong”