# Establishing, Growing Use of, Trusting, and Increasing Value from AI/ML-based Weather Decision Support Services and Solutions

**John Celenza, Weather Team Lead**

31 October 2024 👻

Zipline

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# Zipline: 2 Platforms

- P1 - Fixed wing aircraft, 3 meter wingspan
- P2 - a 5 prop e-vtol “docking” drone with a droid


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# Platform 1

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# CI-1 Zipline Daloa at Nightfall.

# Zipline launched with Walmart in 2021

**Pea Ridge, Arkansas**
**AR-1 (Colocated DC)**
Launched July 2021

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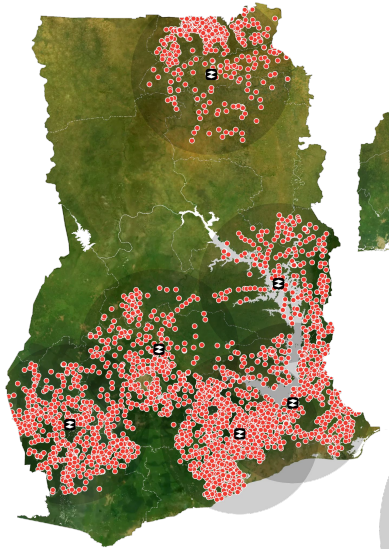
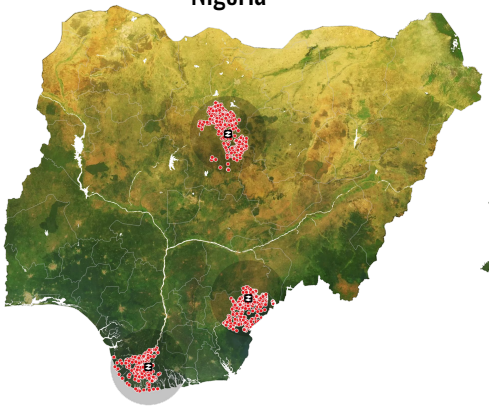
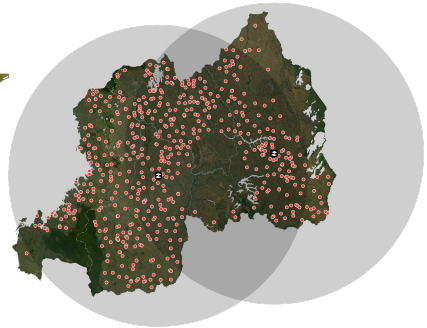
# Where We Fly



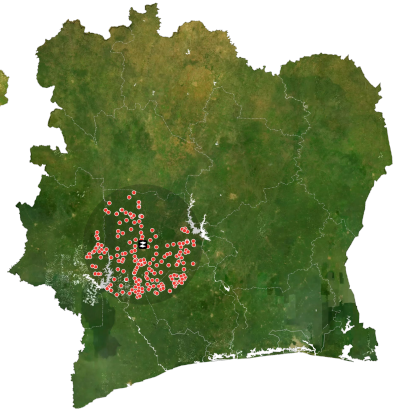
Ghana



Nigeria



Rwanda

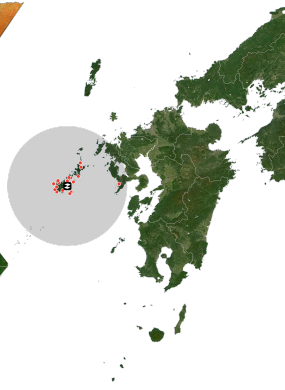


Côte d'Ivoire

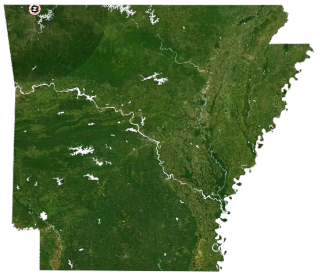
North Carolina
Remote Ops Control Center

Kenya

Utah



Japan



Arkansas

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Zips **fly the circumference** of Earth at least **every 8 hours**

NASA's Artemis flew 2M km in 25 days **Zipline flew 2.8M km** in the same 25 days

Artemis burned 755,000 gallons of fuel; Zipline burned **none**


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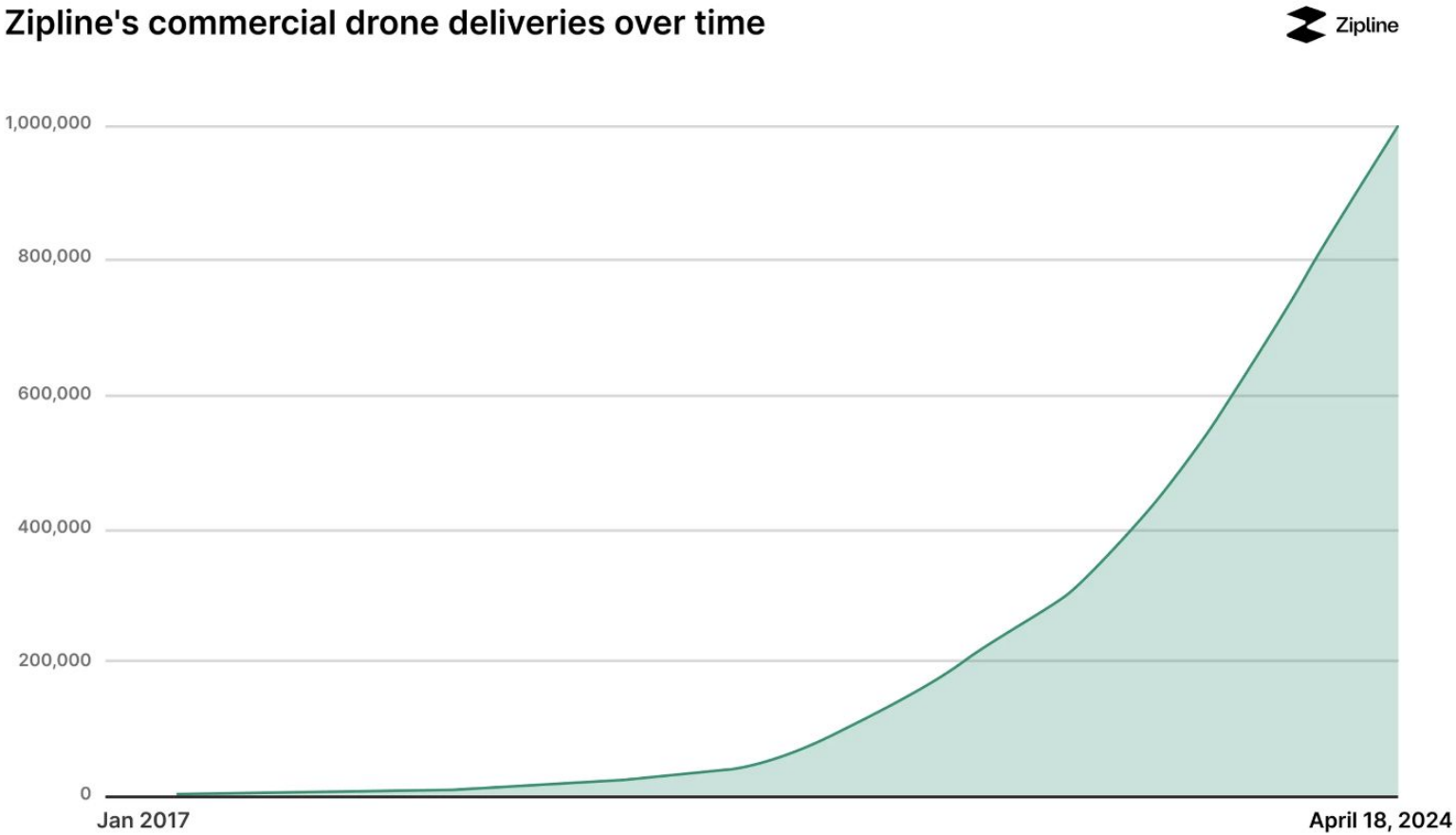
## Zipline's commercial drone deliveries over time



# Platform 2

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# Docking stations come in different shapes and sizes

## Integrated Station(s)

- Orders loaded from inside a building
- Better integrated into workflows
- Expandable high-volume versions available (if needed)
- ~2+ orders per minute

## Instamount Station

- Orders loaded outside in a parking lot
- Faster to get started
- ~1 order per minute


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# Delivery that's thoughtfully unnoticeable

## Instant Delivery

Zip quietly hovers above...

...while the delivery droid gently places deliveries in a matter of seconds

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# P1 Africa: It’s stormy!


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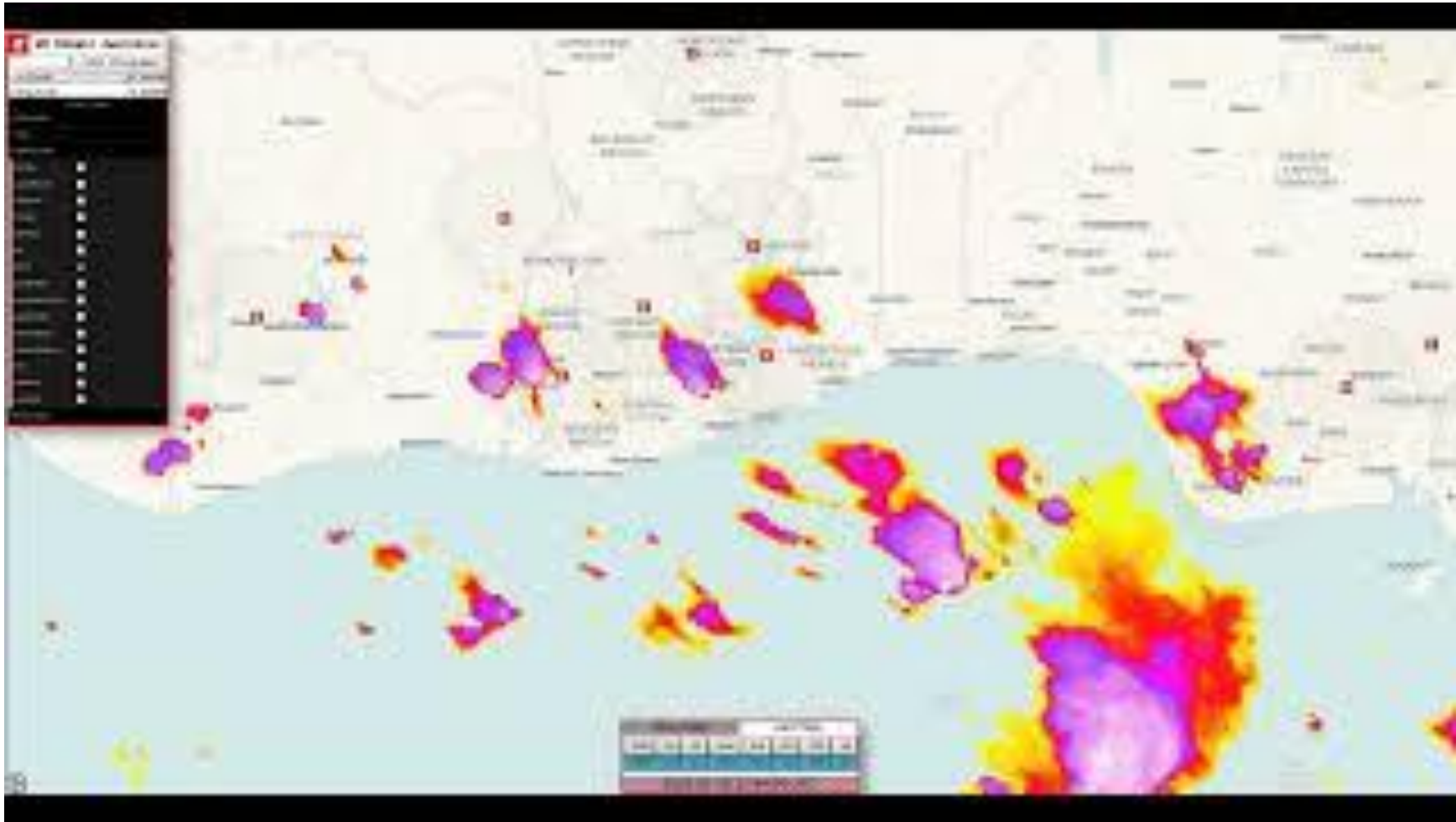
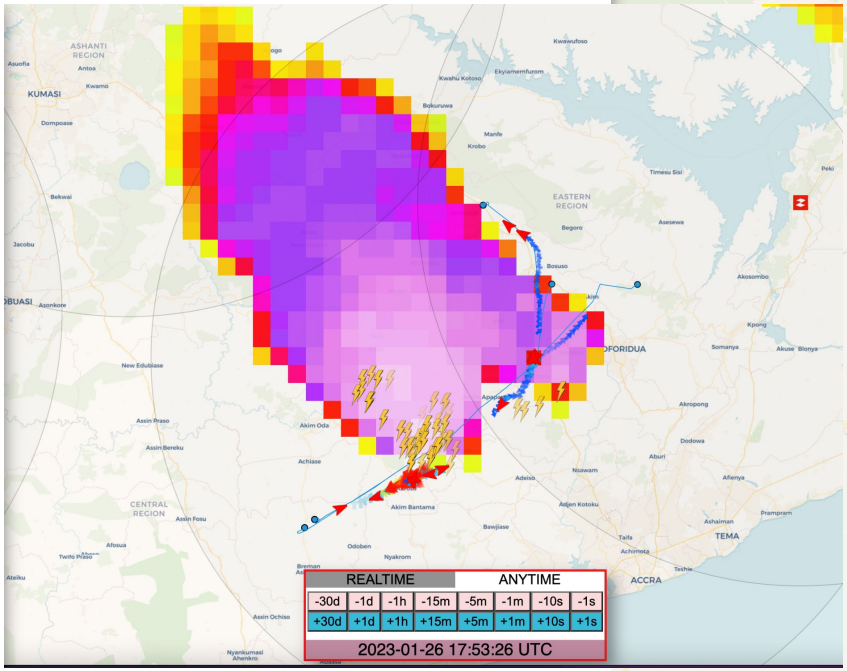
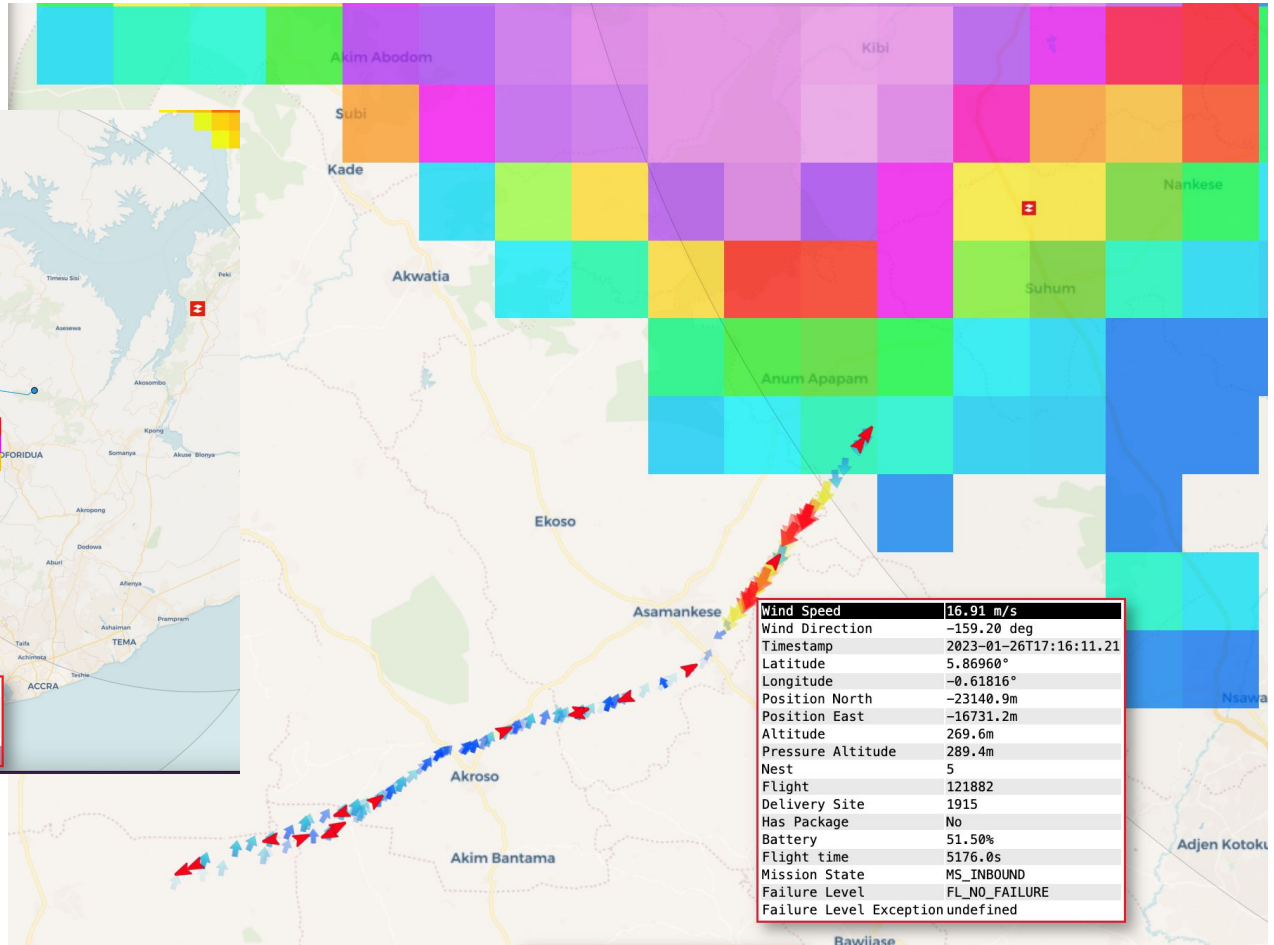
# Western Africa Severe Weather

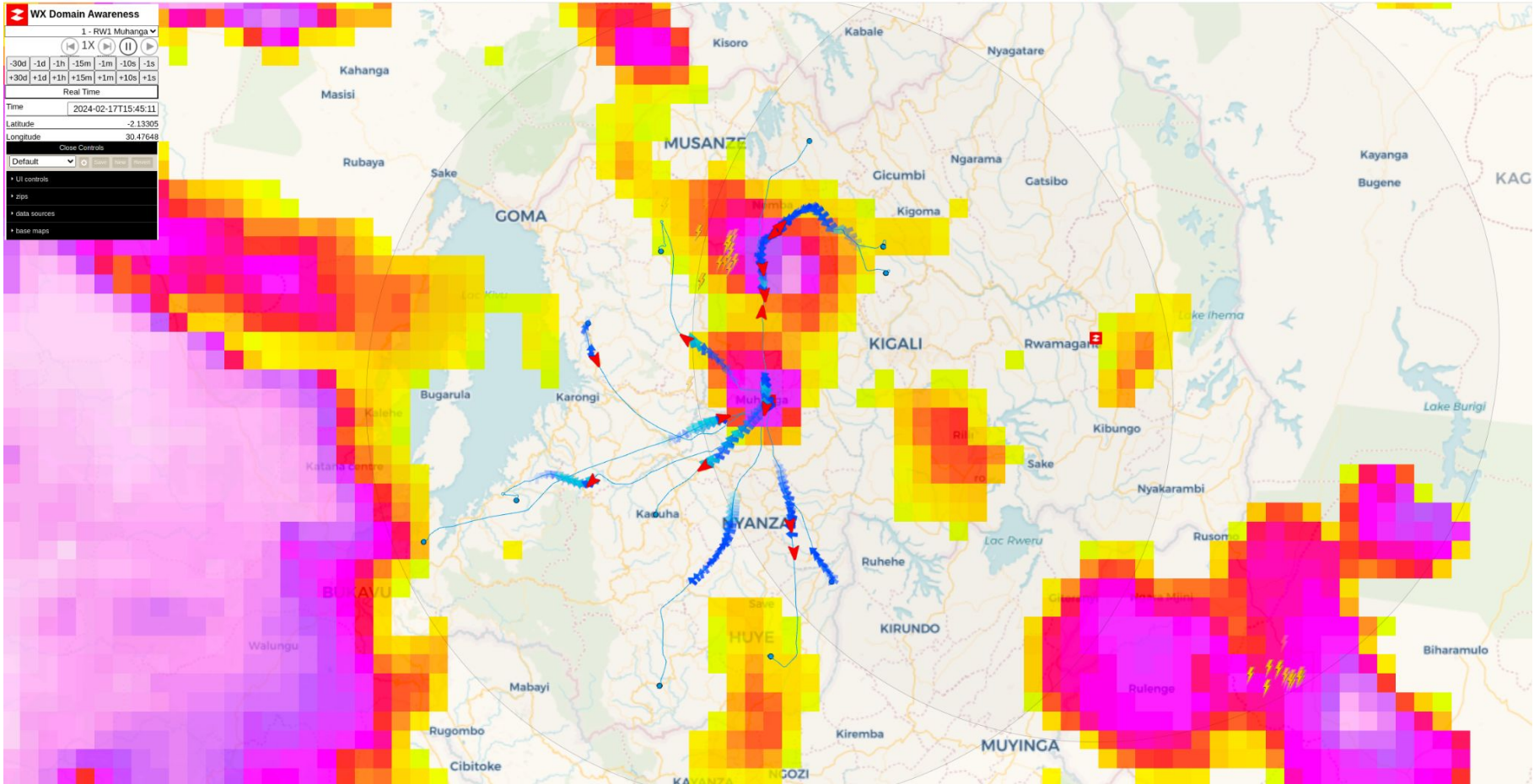


# 2023-01-26 Ghana



# Typical Snapshot



# Avoiding Severe Wind: Let’s build a Model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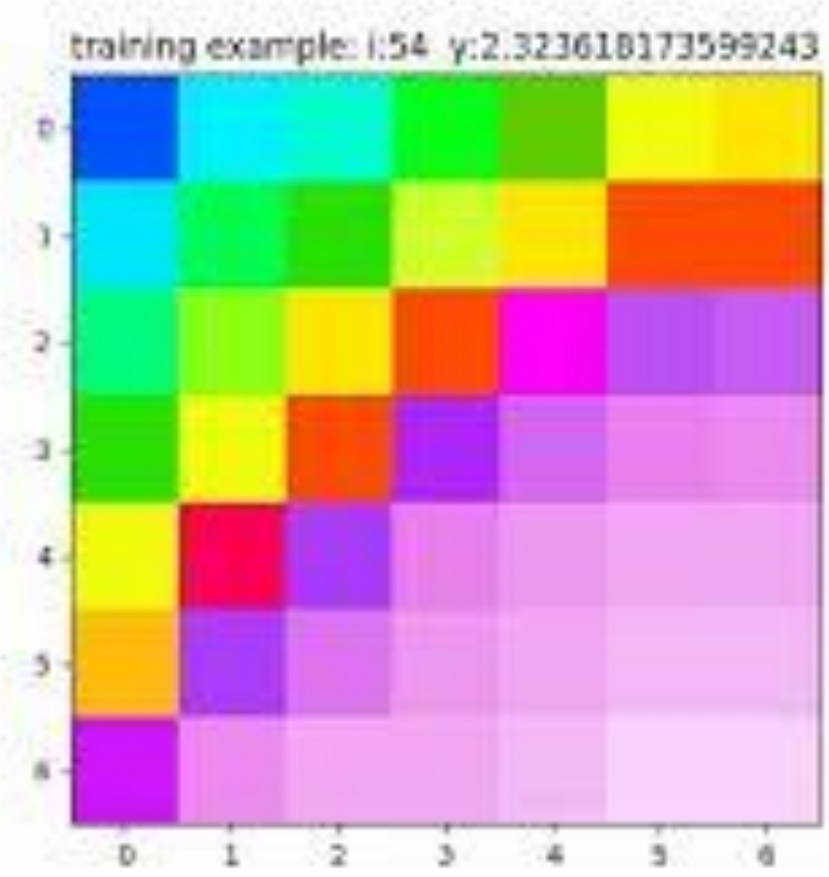
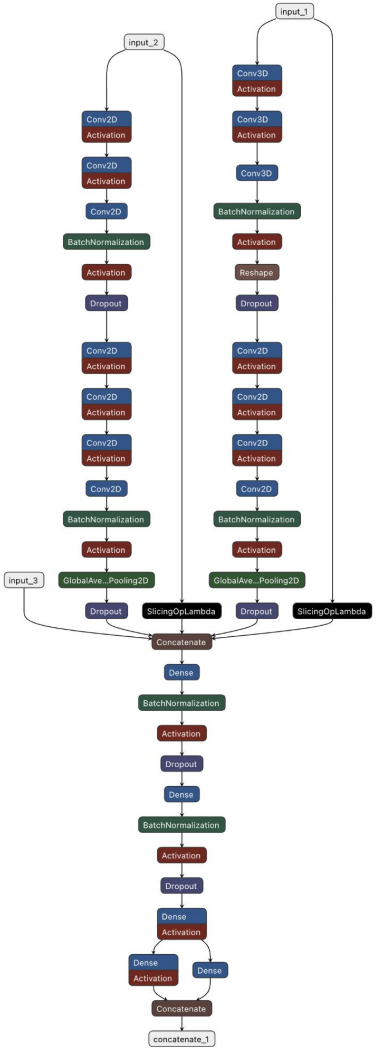
# What Zips Measure

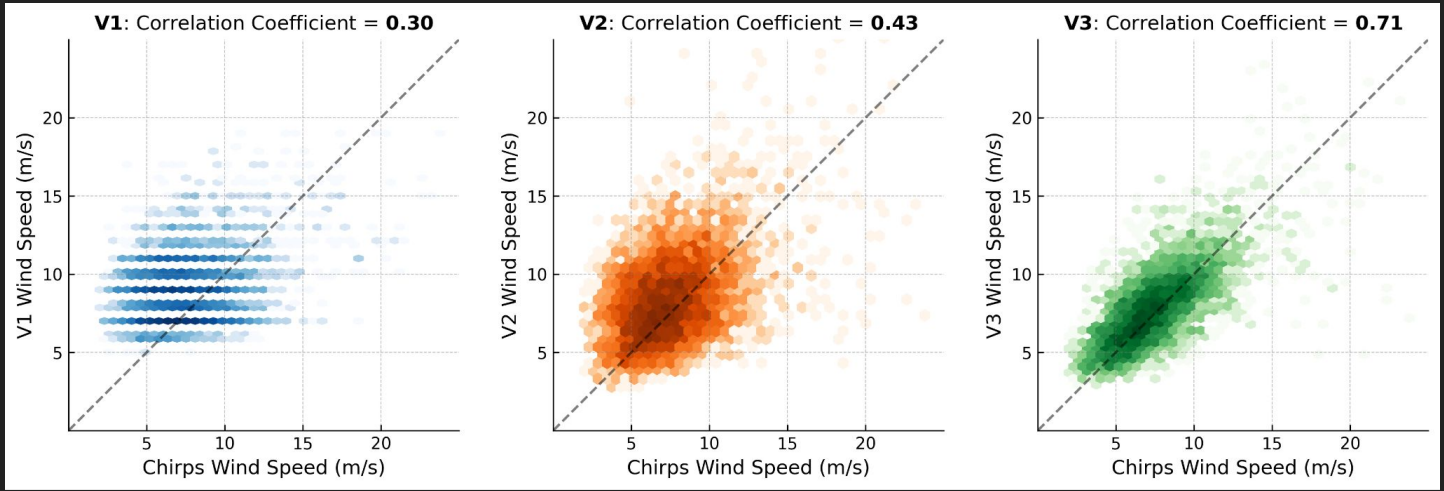
**Observational Frequency** - 50 Hz
**Average Flight Duration** - <1 Hour Globally
**Variables**

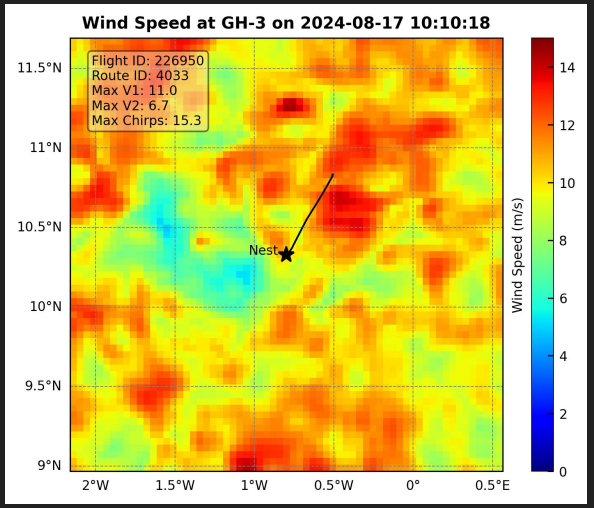
- **Wind Component (NED) -** ~ ±1.5 m/s
- **Temperature -** ~ ± 2.5 ℃
- **Relative Humidity**
- **Static Pressure -** High accuracy, used for pressure altitude

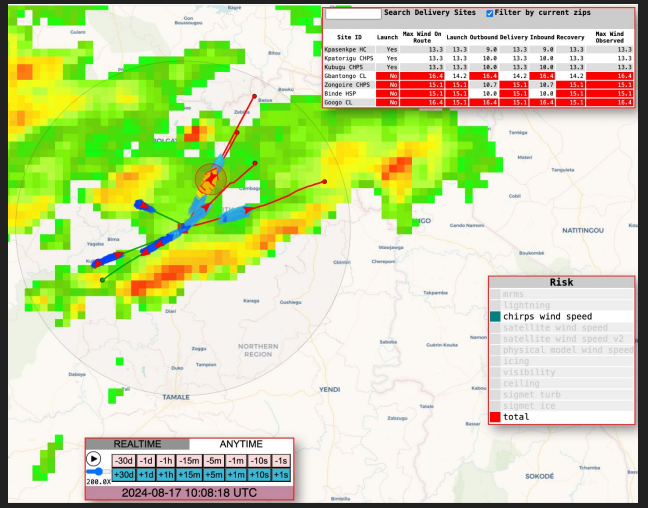
# Let's train a model!




input_1
input_2
input_3
Conv3D
Activation
Conv2D
BatchNormalization
Reshape
Dropout
GlobalAve...Pooling2D
SlicingOpLambda
Concatenate
Dense
concatenate_1


V1: Correlation Coefficient = 0.30
V2: Correlation Coefficient = 0.43
V3: Correlation Coefficient = 0.71
V1 Wind Speed (m/s)
V2 Wind Speed (m/s)
V3 Wind Speed (m/s)
Chirps Wind Speed (m/s)


Wind Speed at GH-3 on 2024-08-17 10:10:18
Flight ID: 226950
Route ID: 4033
Max V1: 11.0
Max V2: 6.7
Max Chirps: 15.3
Nest
Wind Speed (m/s)
11.5°N
11°N
10.5°N
10°N
9.5°N
9°N
2°W
1.5°W
1°W
0.5°W
0°
0.5°E


Search Delivery Sites
Filter by current zips
Risk
chirps wind speed
total
REALTIME
ANYTIME
2024-08-17 10:08:18 UTC
NATITINGOU
SOKODÉ
TAMALE
YENDI
NORTHERN REGION

# Trusting AI: How do we use this model responsibly?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# Trusting AI

## It's all about safety

- What are the lines of defense to ensure safety?
- How do we quantify risk and business impact?

# Trusting AI

## It's all about safety

Zip Safety Through Engineering

- **Bully** the weather - be nimble and thrustful
- **Avoid** the weather - through forecasting and nowcasting
- **Safely** end flight - parachute deployment

**Being the meteorologist, I am going to talk about avoiding the weather.**

# Trusting AI

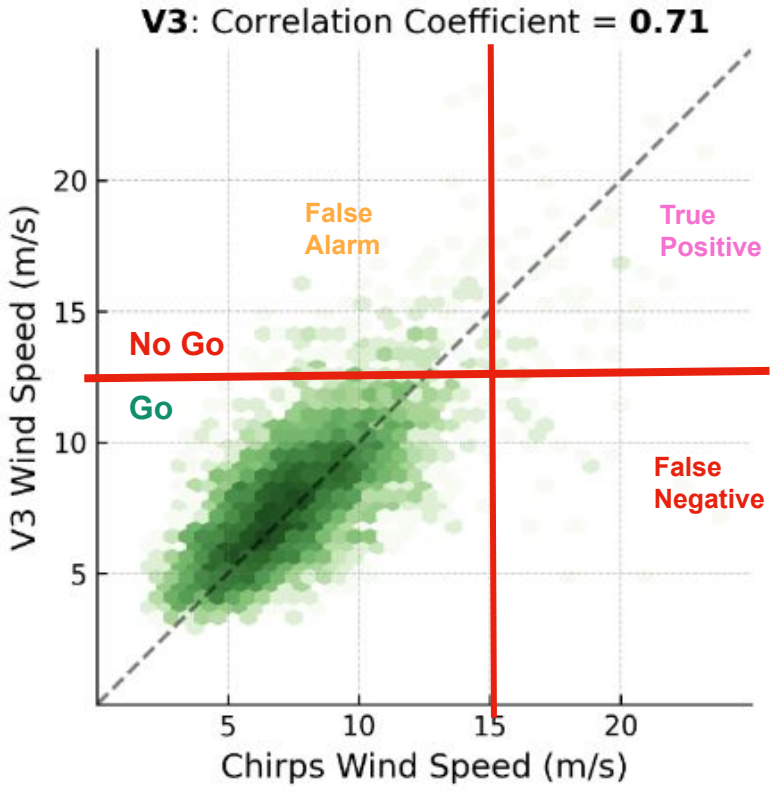
## It's all about safety - Probability of Parachute vs Delay

**The Forecasting Trade:**

When we have a predictor, we need to determine a threshold that separates the good from the bad;

the nominal flights from the parachute deploying flights.

We trade safety for delay when choosing a threshold.



# Trusting AI

## It's all about safety - Probability of Parachute vs Delay

To compute **probability of parachute deployment** over a set of forecasting thresholds, we find the following probabilities.

The algorithm:

For each "forecasting threshold" - eg, 0 to 30 m/s
  For every flight sample - these samples can be from real flights, or a proxy
    *ith* P(parachute deployment) =
      P(parachute deployment | wind speed in flight) *
      (1 - P(forecast model predicted above forecasting threshold | flight sample time/location))

  P(parachute deployment | forecasting threshold) =
    mean(list of *ith* P(parachute deployment))

# Trusting AI

## It's all about safety - Probability of Parachute vs Delay

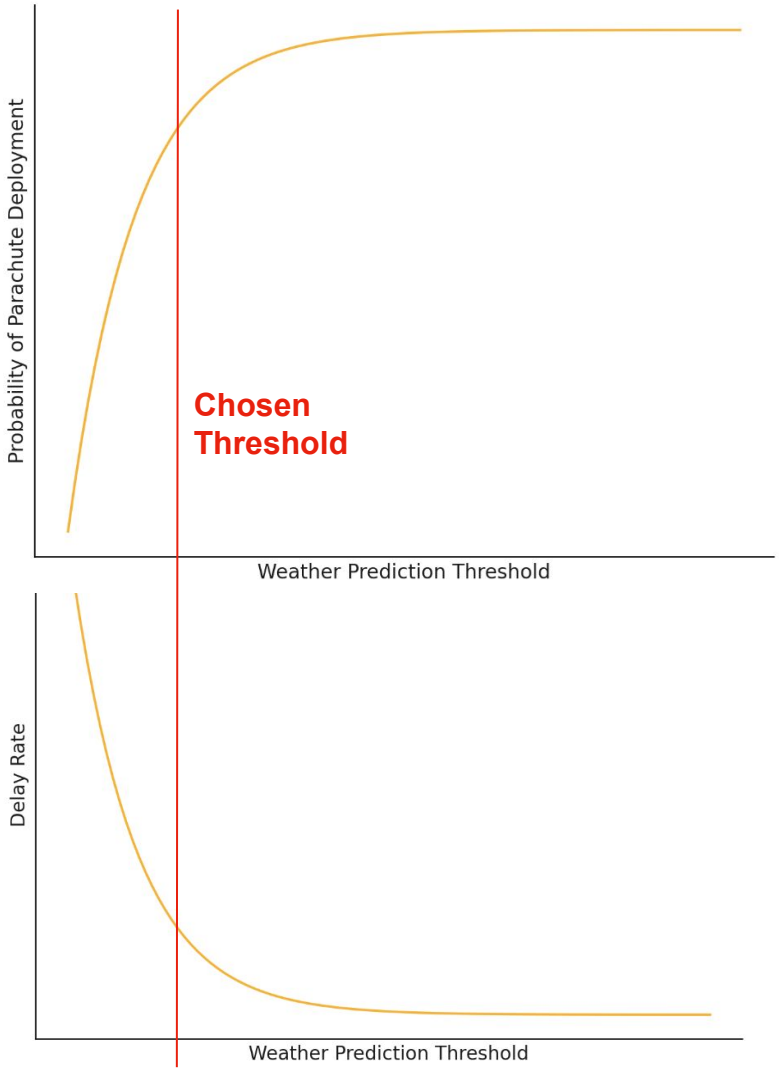
**Examples:**

- if we threshold our wind model to **0 m/s** (no go if the wind exceeds 0 m/s), then we have 100% safety, but 100% delay (non operation)
- if we threshold to **100 m/s**, then we have the safety of **non-mitigation**, but 0% delay

The right answer could be the 2nd bullet if we've bullied the weather.
Most of the time, the right answer is somewhere in between.

# Trusting AI
## From ML to Operations

- Operations Team -
  - Maximum Uptime
  - Minimize Delay to customer
  - Operate Safely
- Weather Team -
  - Maximize Safety
  - Minimize Frustration for Operator
  - Maximize Confidence with Regulator



# Trusting AI

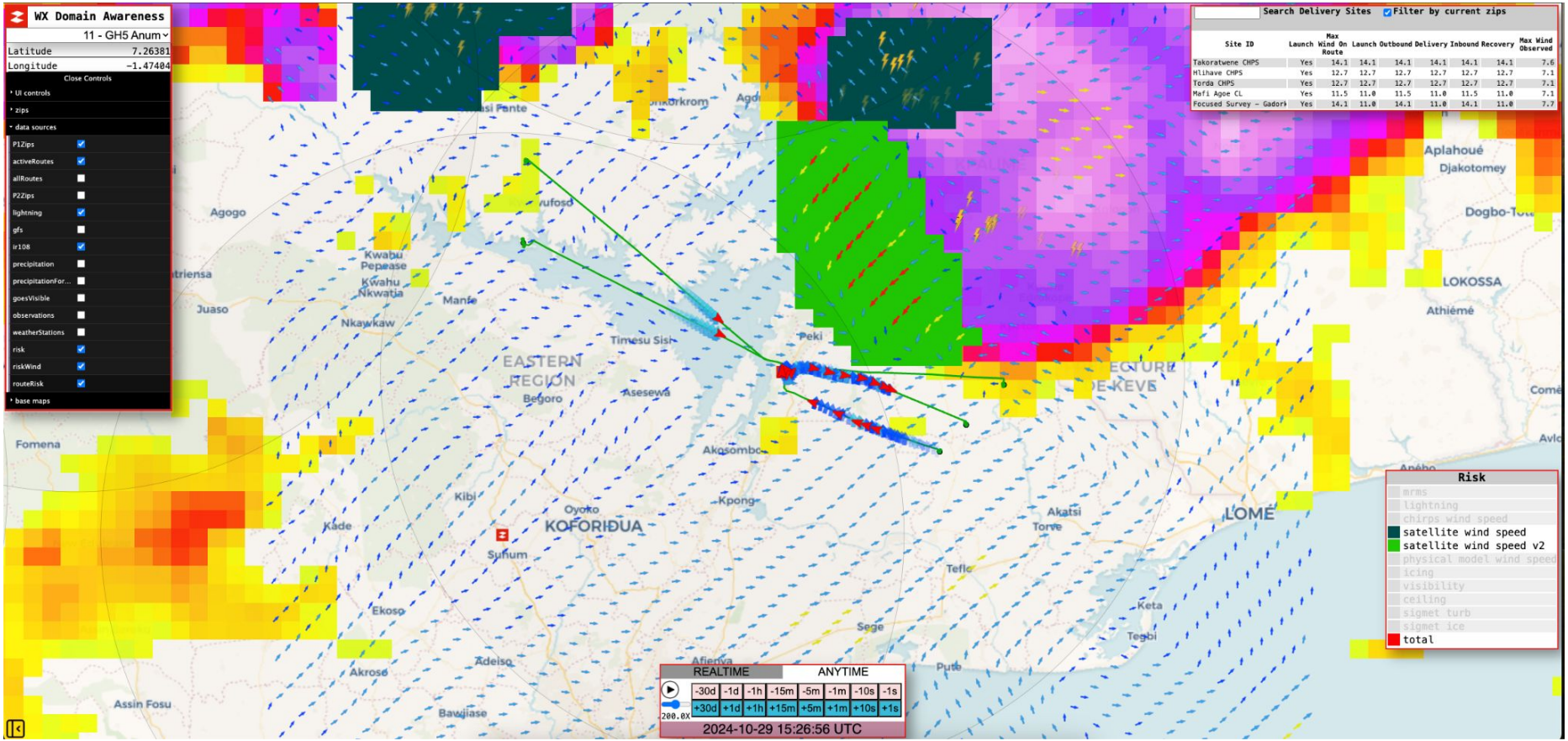
## It's all about safety - The Tried and True Way?

**But do we totally trust the AI? No.**

Zipline puts humans and nowcasting in the loop

- **Zips measure the wind** - true observation limits risk to other aircraft
- **Pilots in Command** - observers on the ground can make informed decisions
- **Meteorologist Expertise** - we staff meteorologists to observe the entire fleet

# 2024-10-28 Ghana 5



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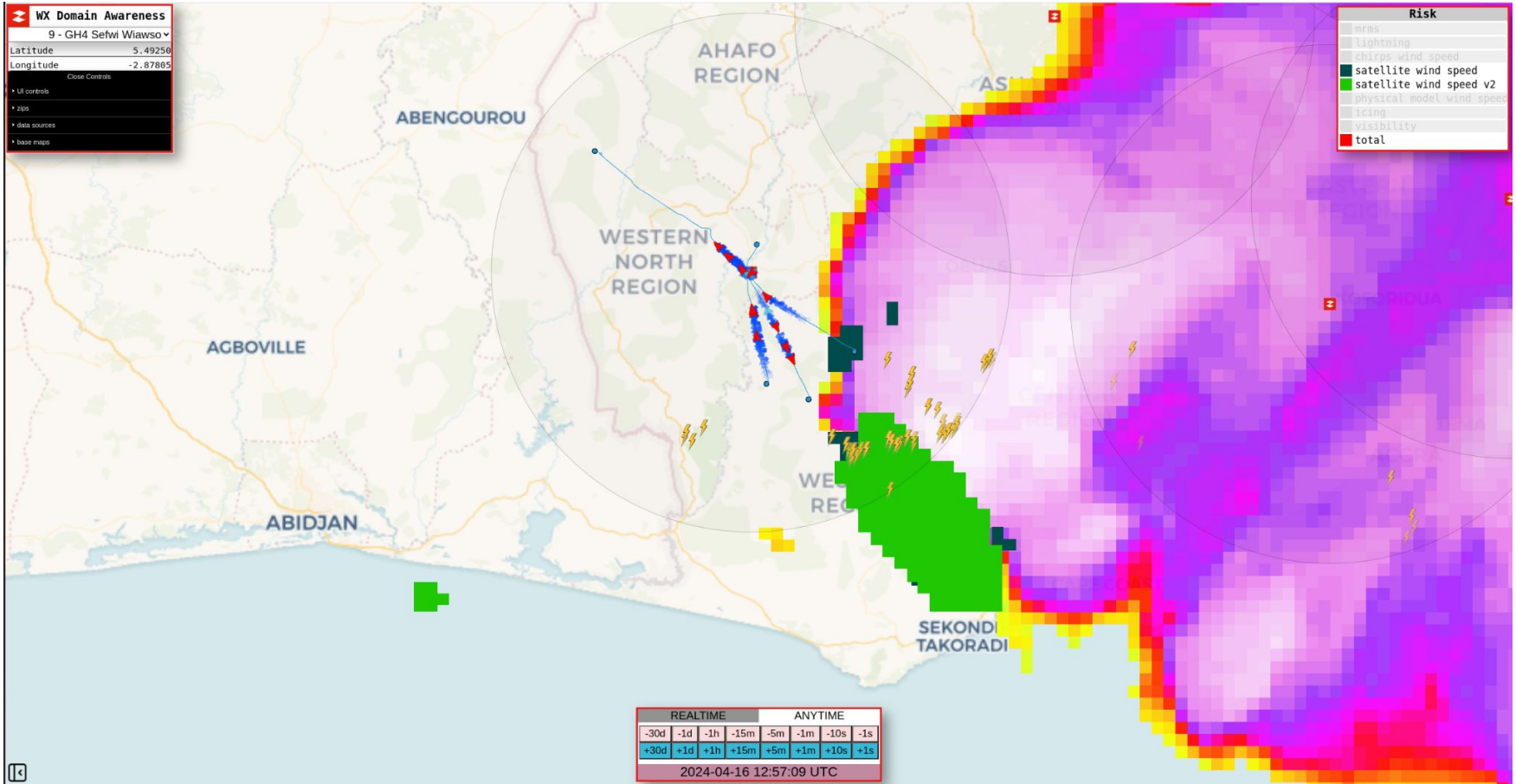
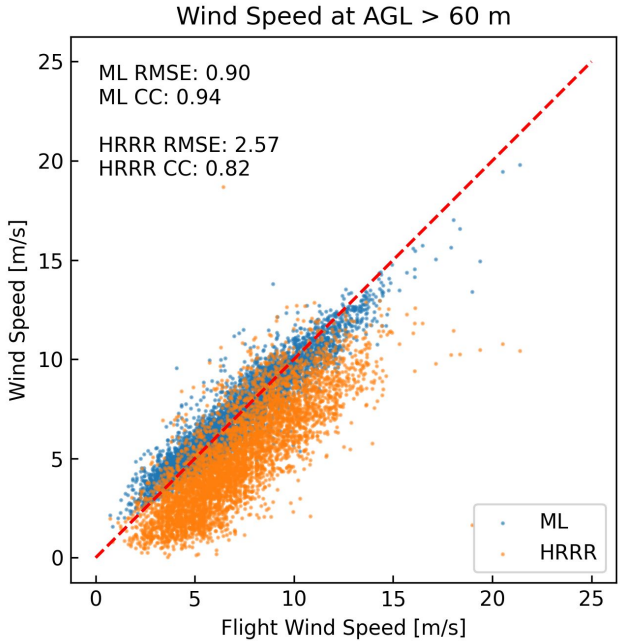
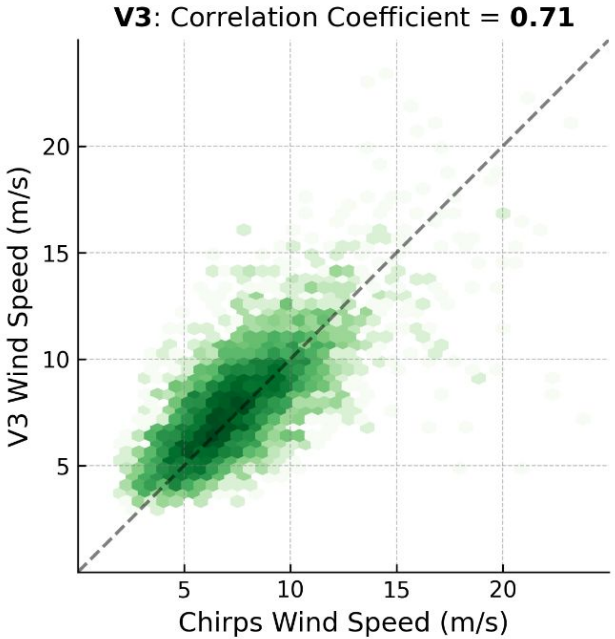


# Comparing Satellite to HRRR NWP Performance

## P1 AR-1 vs HRRR

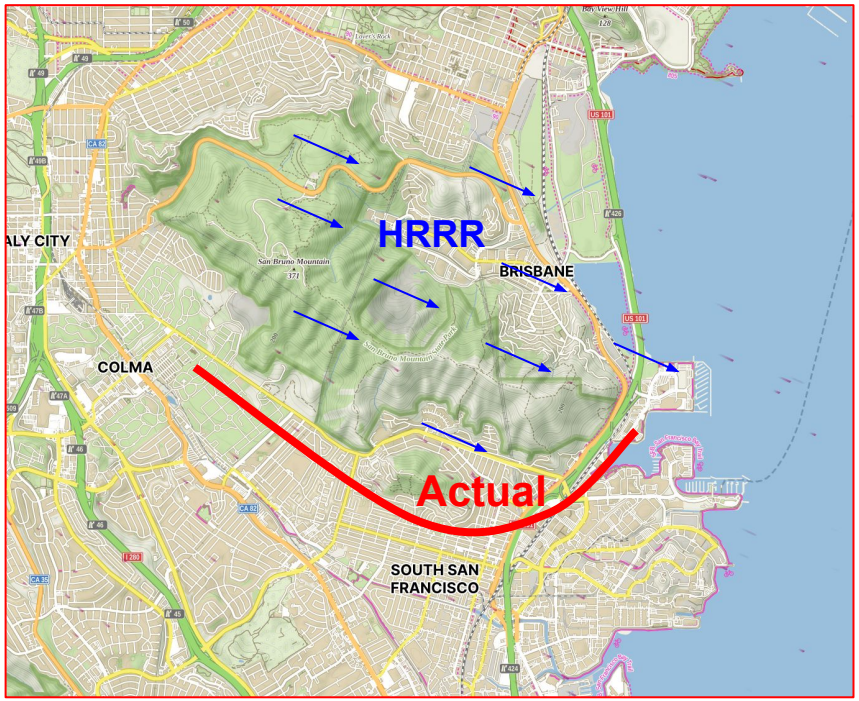



## P1 Africa vs METEOSAT



# With Terrain: HRRR Doesn't Cut It

- HRRR can't "see" San Bruno Mountain's Curved flow
- It's a pretty big feature
- I live this curved flow on my bike daily!





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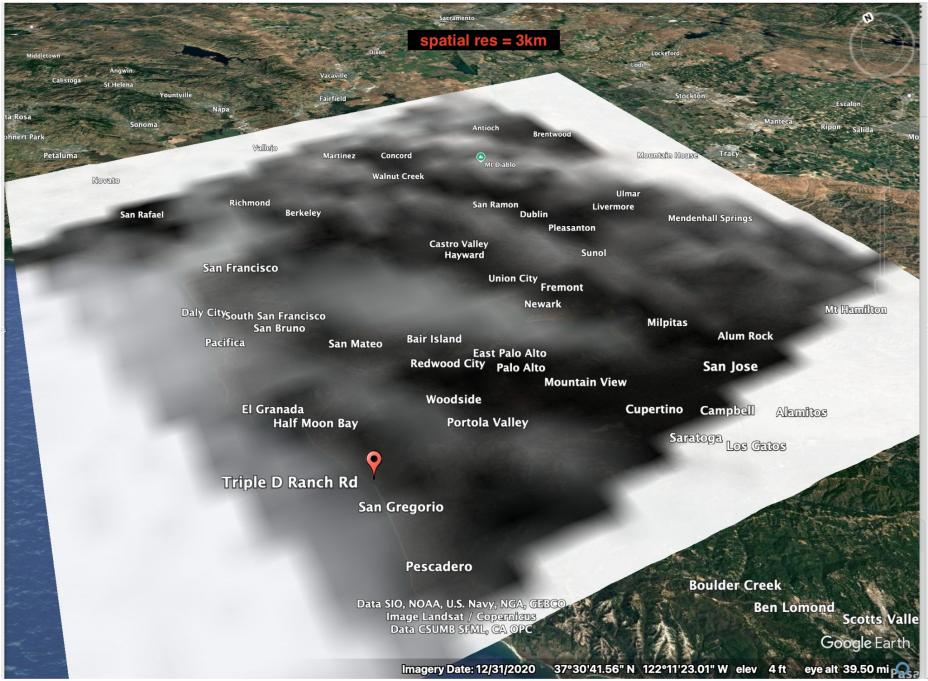
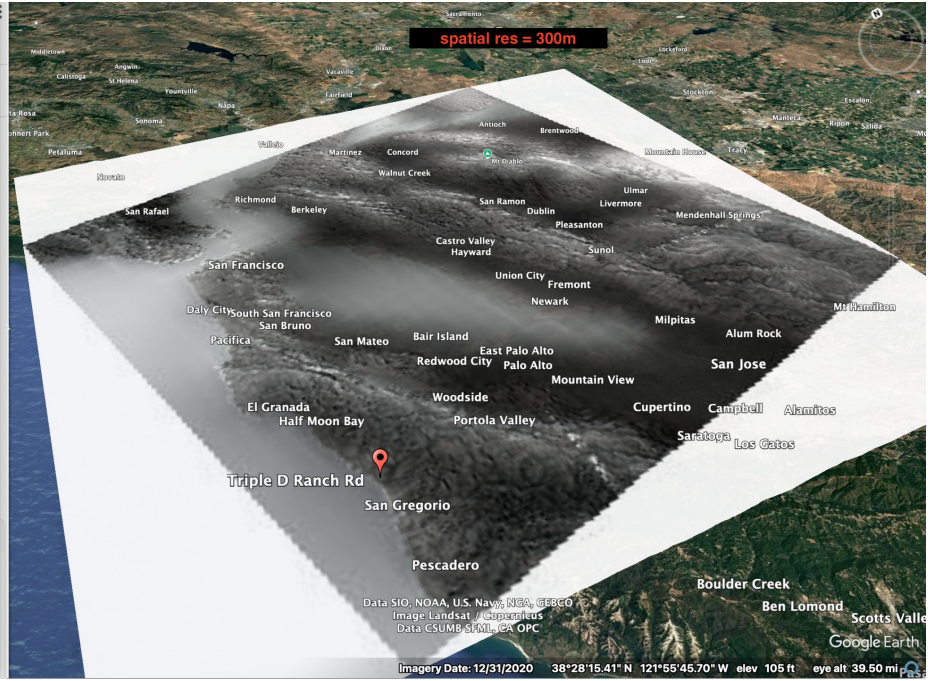
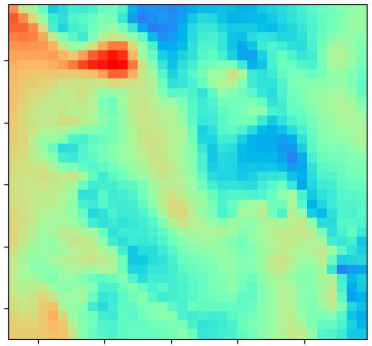
# Downscaling Experiments - HRRR 3 km to 330 m



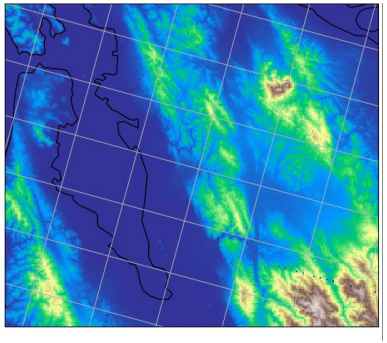



# Downscaling Model

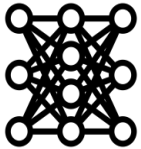
3 km wind from HRRR



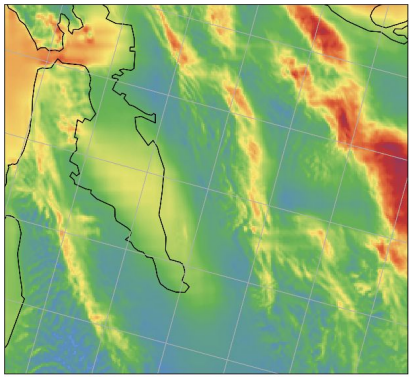
330 m DEM



**Inferring 330 m wind field**



330 m **reconstructed** wind





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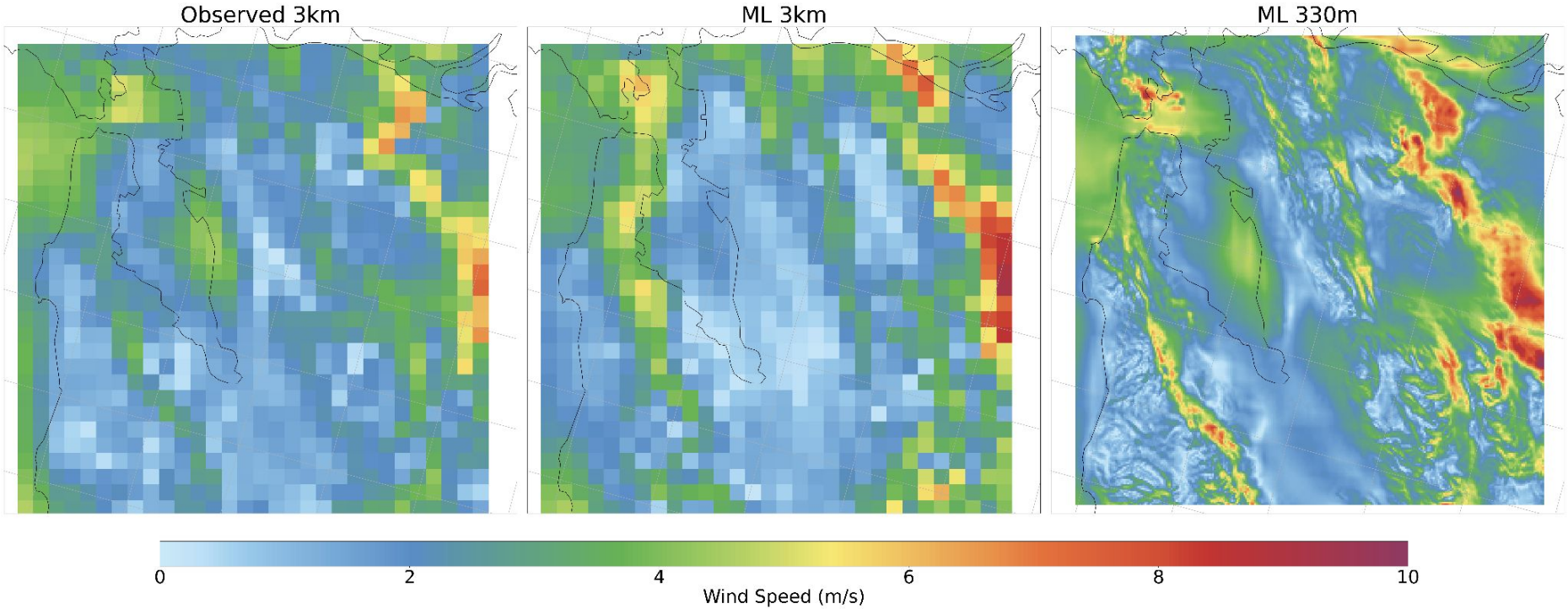
# Inference for CNN

2023-04-02T06:00:00.000000000

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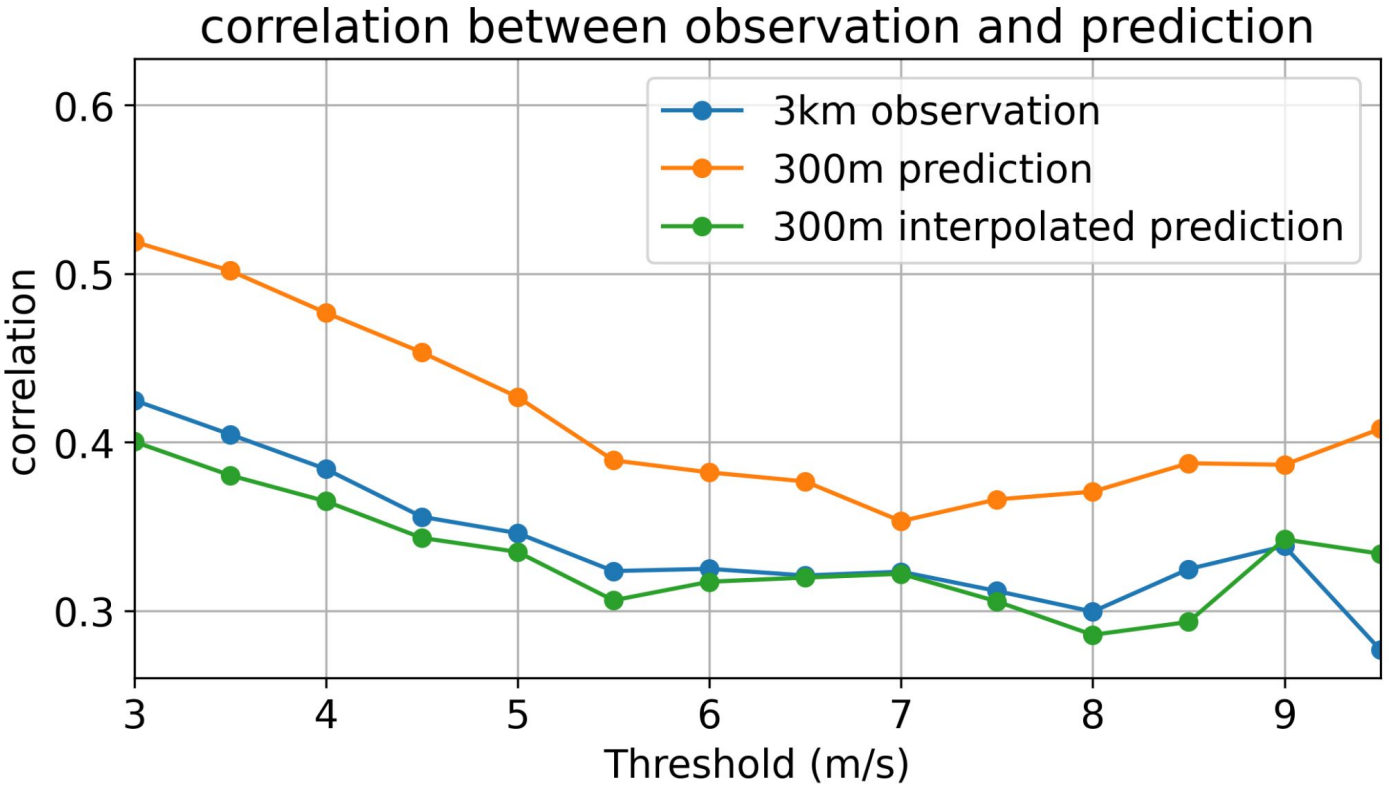
# Validation with madis at different thresholds

Correlation





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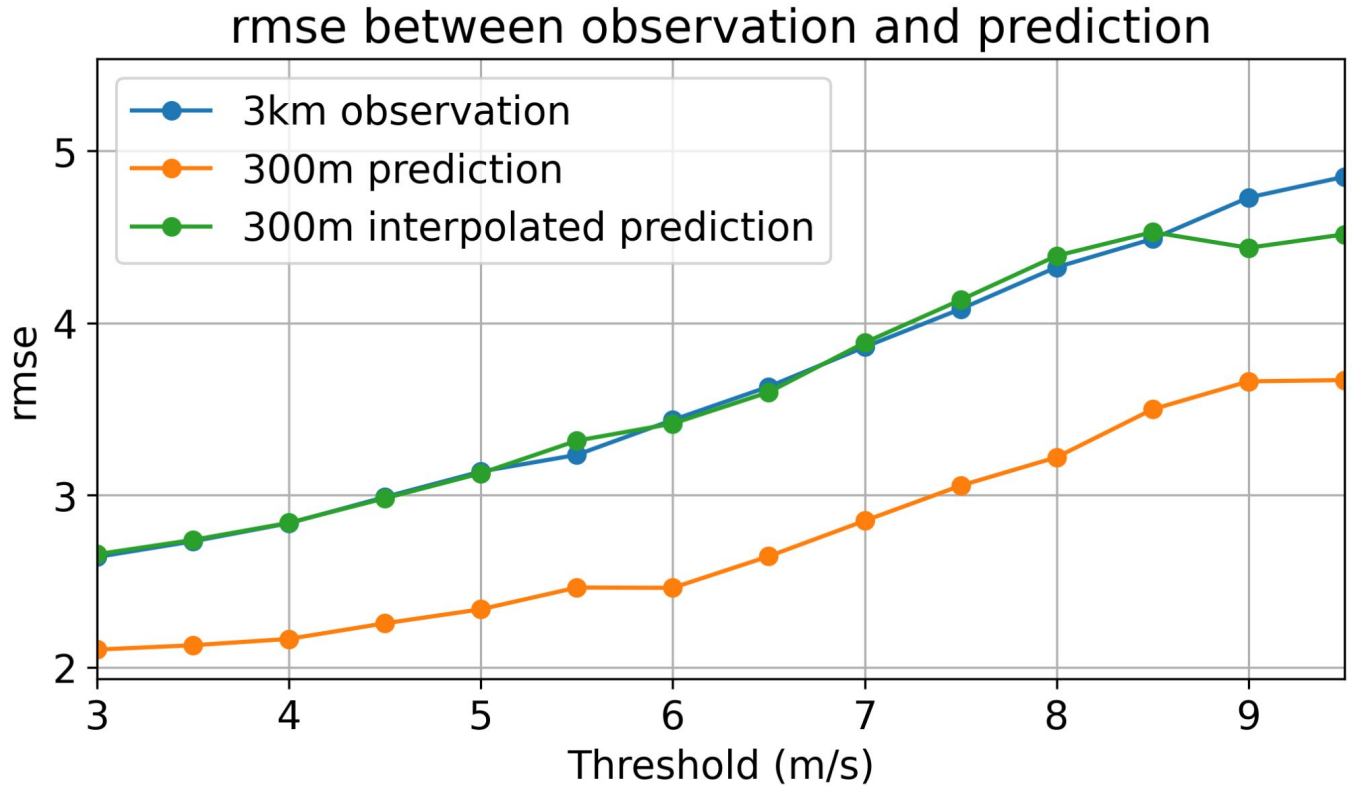
# Validation with madis at different thresholds

RMSE





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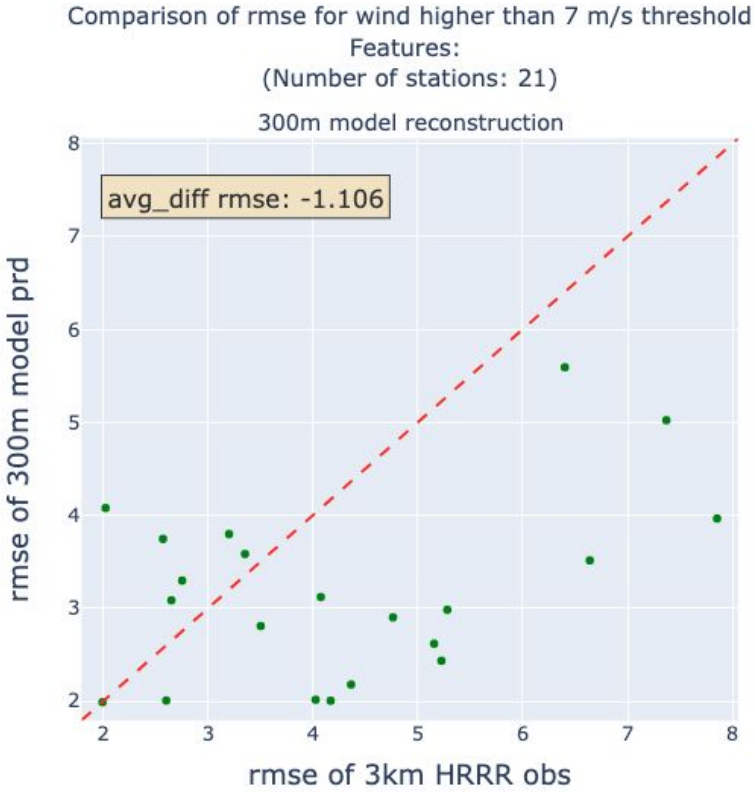
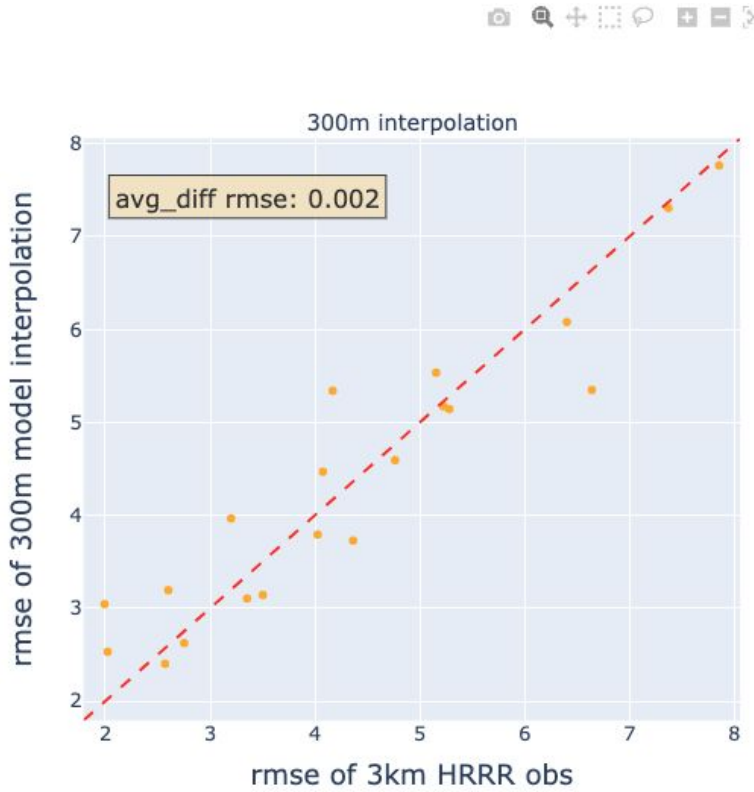
# Validating for wind above certain threshold

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# Thank you!

**Questions?**

- **Contact: john.celenza@flyzipline.com**


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