

RESEARCH THEME

A STUDY ON OPTIMAL ROUTE SELECTION FOR SHIP WEATHER ROUTING

- SHIP OPERATIONAL PERFORMANCE MODELING WITH AI

TUMSAT, Applied Marine Environmental Studies
SHI YOUMING

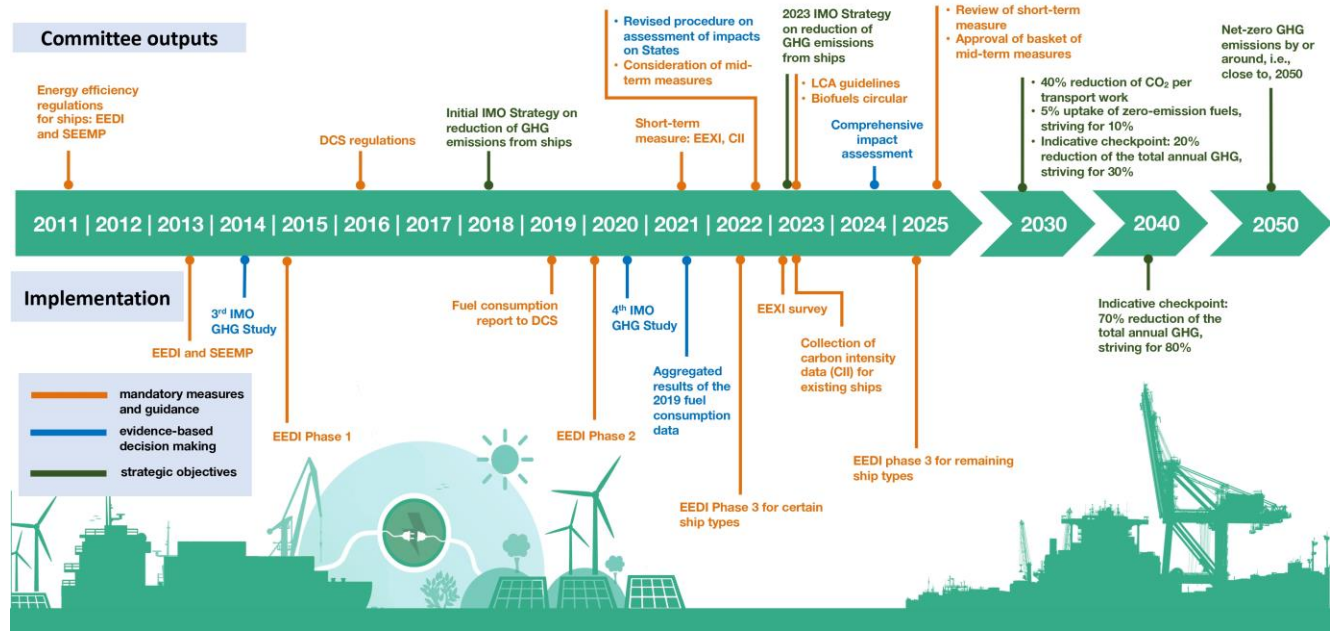
AGENDA

- Career Introduction
- Background and motivation
- Weather Routing
- Vessel Characteristics
- Methodology Modeling Coding
- Results and Discussion
- Weather Forecast

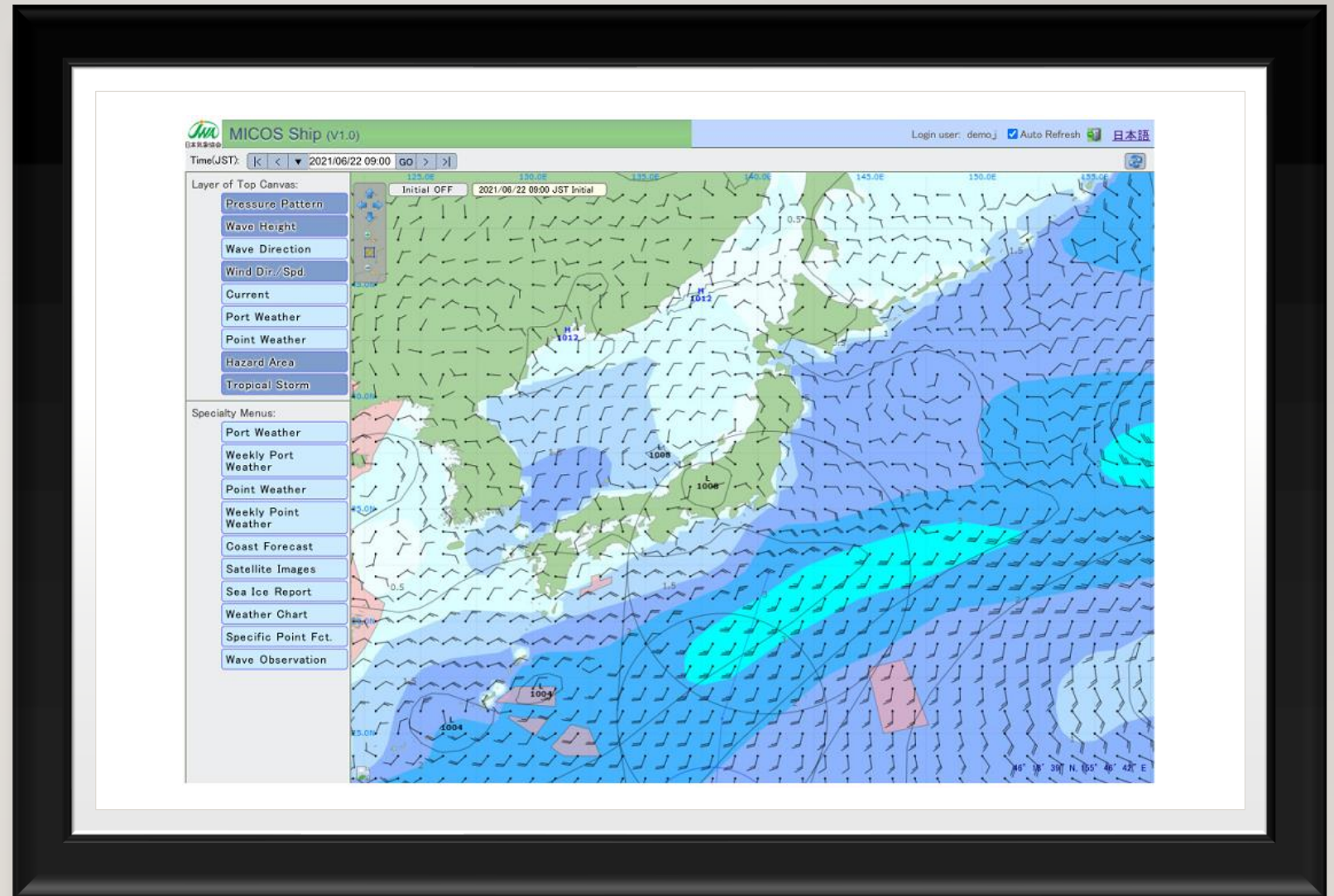
BACKGROUND AND MOTIVATION

Addressing climate change

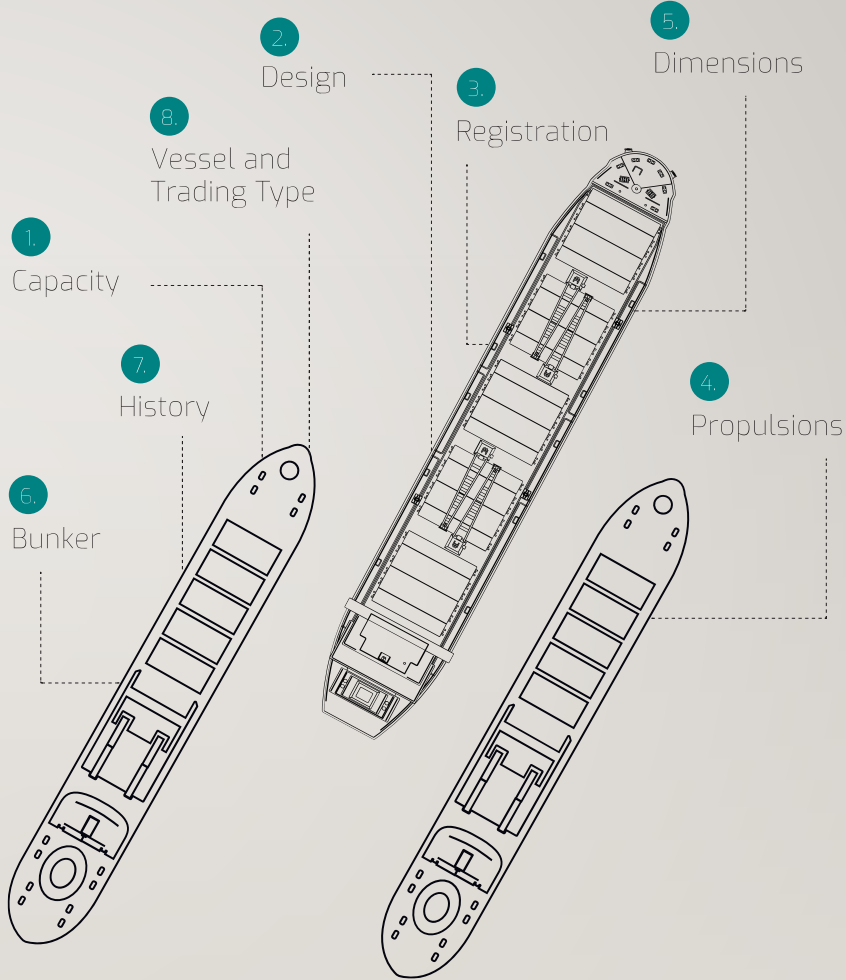
Over a decade of regulatory action to cut GHG emissions from shipping



WEATHER ROUTING

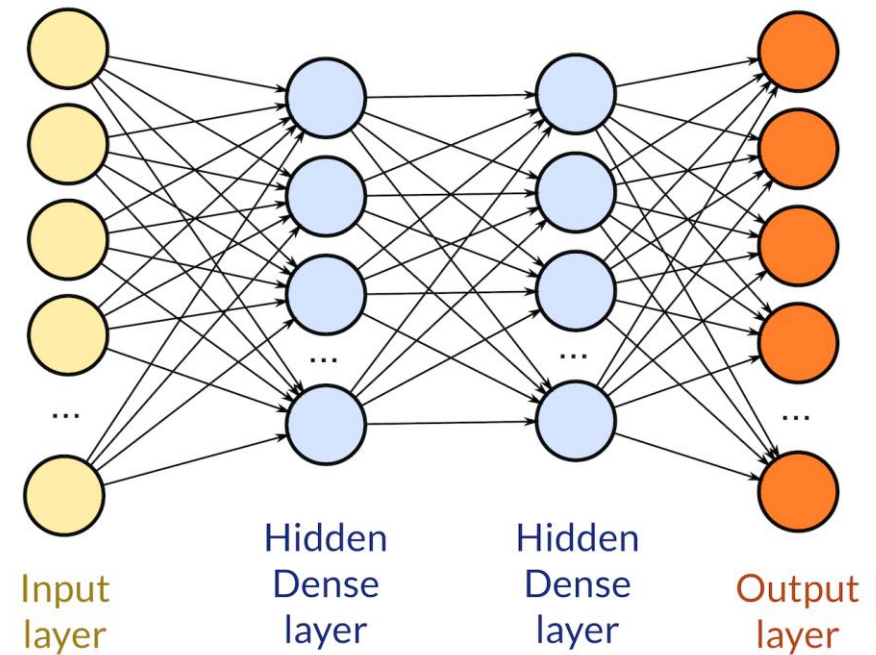


VESSEL CHARACTERISTICS



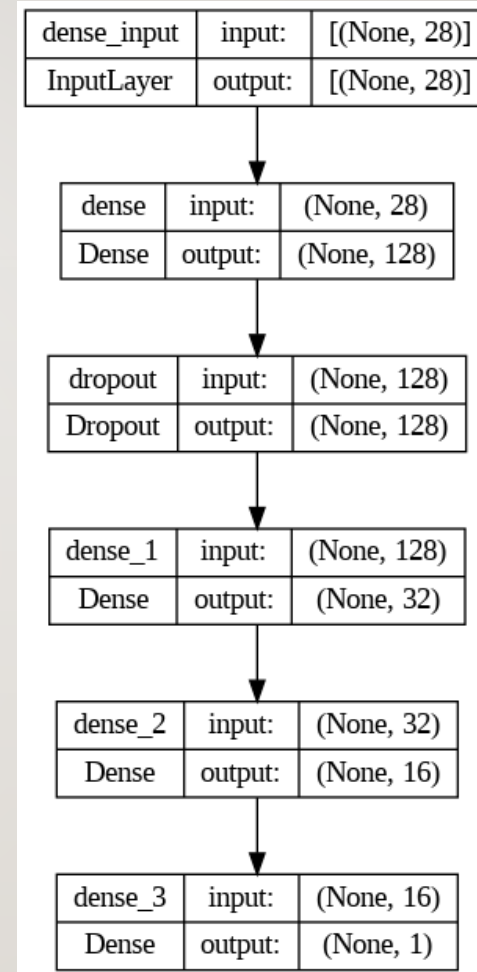
METHODOLOGY

- Deep learning
- Tool: Python



MODELING

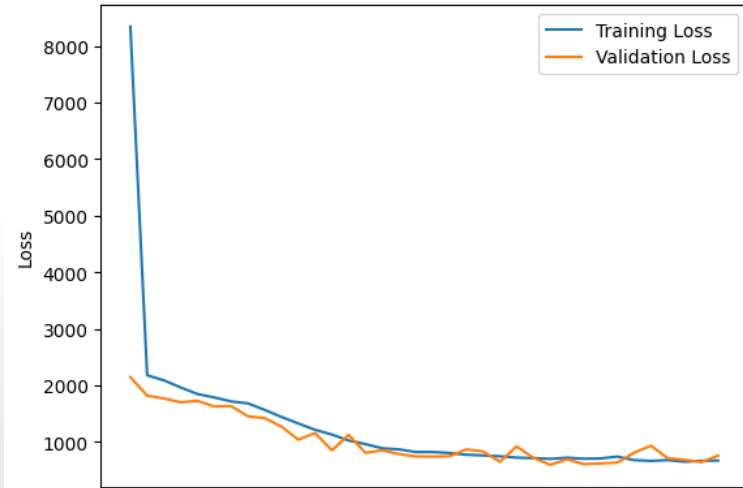
- Data
- Input Data
- Split the data
- Build the deep learning model
- Train the deep learning model
- Model validation and verification



CODING

- dropout layer
- L2 regularization
- early stopping
- RandomizedSearchCV


```
38/38 [=====] - 0s 4ms/step - loss: 490.1053 - val_loss: 859.3292
Epoch 239/250
38/38 [=====] - 0s 4ms/step - loss: 494.8739 - val_loss: 800.2040
Epoch 240/250
38/38 [=====] - 0s 4ms/step - loss: 481.8333 - val_loss: 799.1134
Epoch 241/250
38/38 [=====] - 0s 4ms/step - loss: 484.9197 - val_loss: 890.9042
Epoch 242/250
38/38 [=====] - 0s 5ms/step - loss: 471.6371 - val_loss: 904.3082
Epoch 243/250
38/38 [=====] - 0s 4ms/step - loss: 487.9840 - val_loss: 742.1472
Epoch 244/250
38/38 [=====] - 0s 4ms/step - loss: 481.5121 - val_loss: 879.6406
Epoch 245/250
38/38 [=====] - 0s 4ms/step - loss: 477.2276 - val_loss: 1054.4269
Epoch 246/250
38/38 [=====] - 0s 5ms/step - loss: 479.5275 - val_loss: 638.7800
Epoch 247/250
38/38 [=====] - 0s 5ms/step - loss: 495.5905 - val_loss: 979.7047
Epoch 248/250
38/38 [=====] - 0s 5ms/step - loss: 489.1031 - val_loss: 683.9896
Epoch 249/250
38/38 [=====] - 0s 4ms/step - loss: 486.9833 - val_loss: 666.9257
Epoch 250/250
38/38 [=====] - 0s 5ms/step - loss: 483.3699 - val_loss: 685.2339
54/54 [=====] - 0s 2ms/step - loss: 701.0287
Test loss: 701.0286865234375
```



RESULTS AND DISCUSSION

MSE: 701

RESULTS AND DISCUSSION

```
1/1 [=====] - 0s 26ms/step
Selection 1
True value: 222.0
Predicted value: 198.76146
1/1 [=====] - 0s 19ms/step
Selection 2
True value: 126.0
Predicted value: 135.70766
1/1 [=====] - 0s 19ms/step
Selection 3
True value: 252.0
Predicted value: 244.47794
1/1 [=====] - 0s 24ms/step
Selection 4
True value: 258.0
Predicted value: 235.48267
1/1 [=====] - 0s 20ms/step
Selection 5
True value: 198.0
Predicted value: 183.89572
```

WEATHER FORECAST

Complexity makes weather forecast challenging.

- Initial Value Sensitivity
- Lack of monitoring data
- Lack of computing power

Edward Lorenz



- Professor of Meteorology at the Massachusetts Institute of Technology
- In 1963 derived a three dimensional system in efforts to model long range predictions for the weather
- The weather is complicated! A theoretical simplification was necessary

WEATHER FORECAST

$$\frac{\partial u}{\partial t} + \dot{\sigma} \frac{\partial u}{\partial \sigma} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} - f v - \frac{u v}{r} \tan \phi + g \frac{\partial z}{\partial x} + c_p \theta \frac{\partial \pi}{\partial x} + F_x = 0$$

$$\frac{\partial v}{\partial t} + \dot{\sigma} \frac{\partial v}{\partial \sigma} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + f u + \frac{u^2}{r} \tan \phi + g \frac{\partial z}{\partial y} + c_p \theta \frac{\partial \pi}{\partial y} + F_y = 0$$

$$\frac{\partial(gz)}{\partial \sigma} + c_p \theta \frac{\partial \pi}{\partial \sigma} = 0,$$

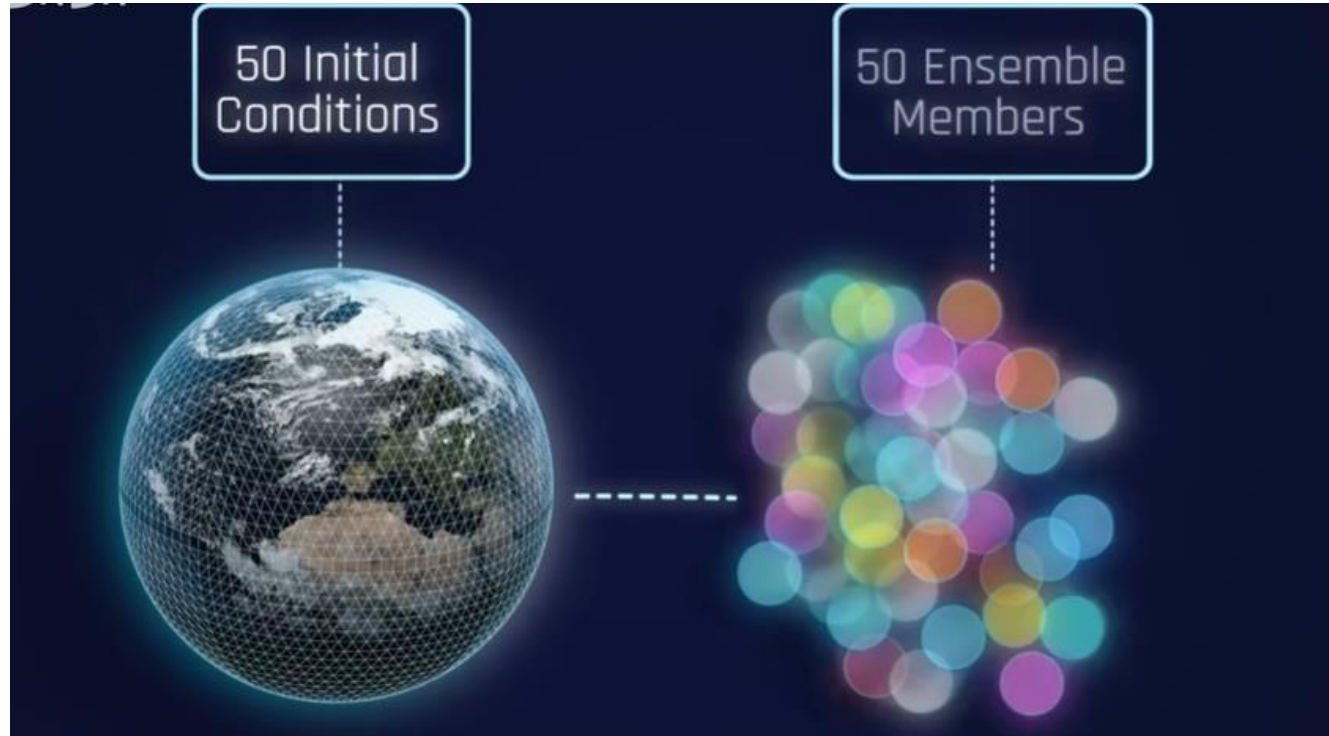
$$\frac{\partial \theta}{\partial t} + \dot{\sigma} \frac{\partial \theta}{\partial \sigma} + u \frac{\partial \theta}{\partial x} + v \frac{\partial \theta}{\partial y} + H = 0,$$

$$\frac{\partial p_s}{\partial t} + \frac{\partial}{\partial \sigma} (\dot{\sigma} p_s) + \frac{\partial}{\partial x} (u p_s) + \frac{\partial}{\partial y} (v p_s) - \frac{v p_s}{r} \tan \phi = 0, \quad \pi = \left(\frac{p}{P}\right)^\kappa.$$

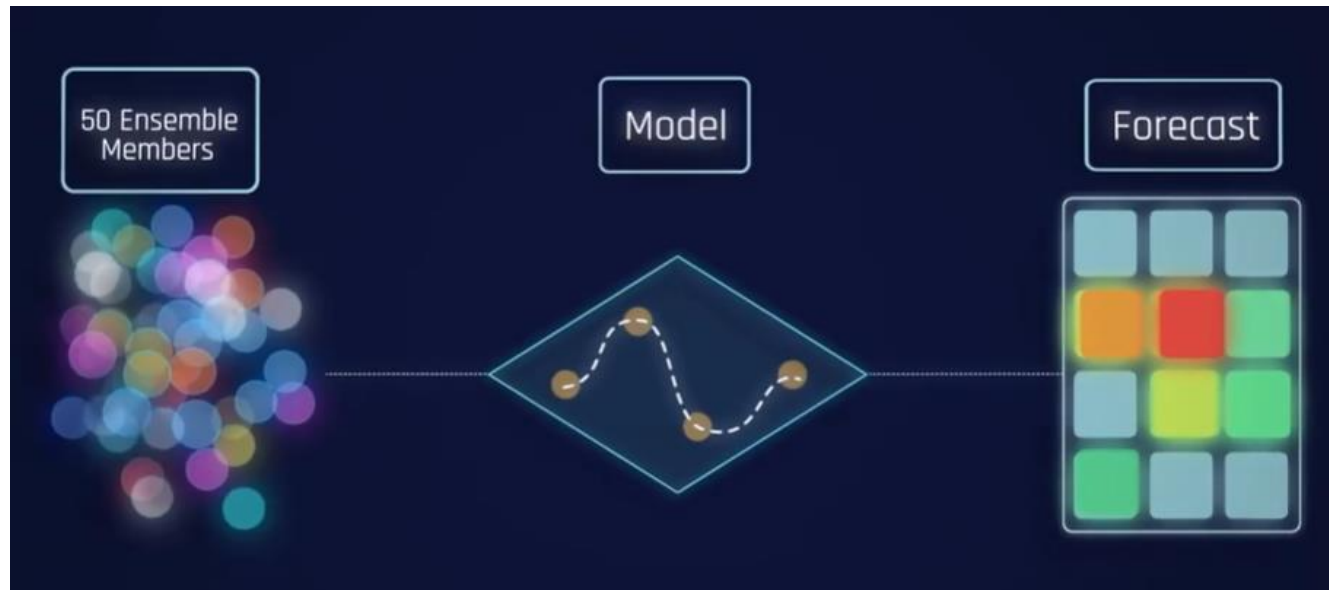
WEATHER FORECAST



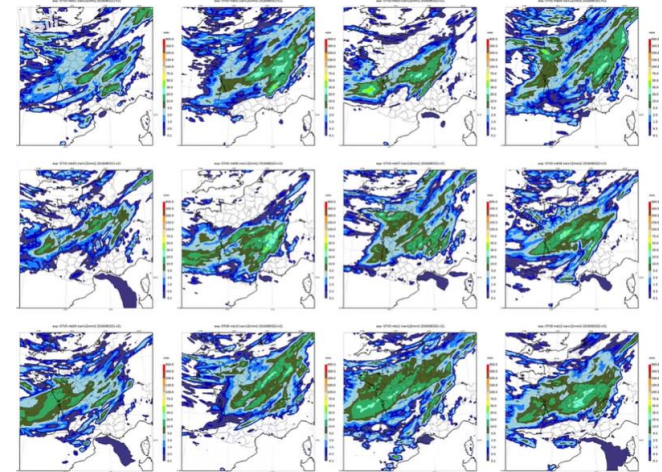
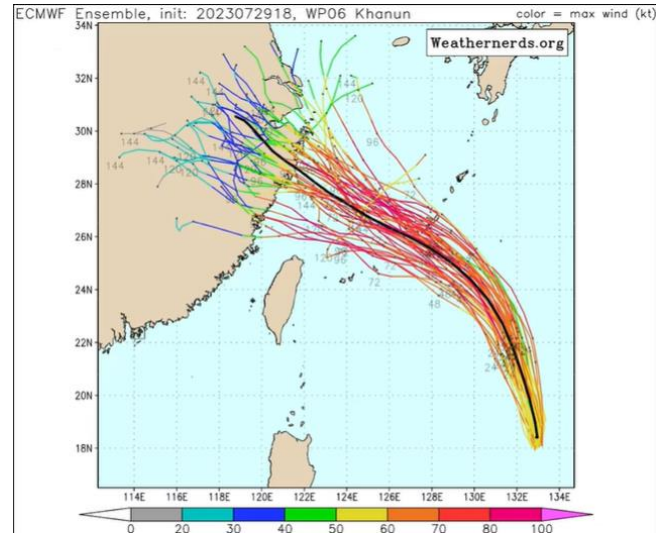
WEATHER FORECAST



WEATHER FORECAST



WEATHER FORECAST



WEATHER FORECAST





THANK YOU
