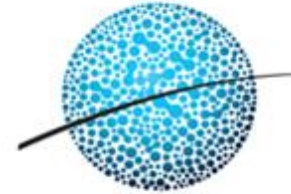




**Asia-Pacific  
Economic Cooperation**



**APEC 2022  
THAILAND**



**APCC**  
APEC CLIMATE CENTER



# Weather Prediction by using Support Vector Machine

**Dr. Wattana Kanbua**

**Director of Meteorological Development Division  
Thai Meteorological Department**

# Outline

**Natural Disaster in Thailand**

**Precipitation and Air Temperature**

**Existing of TMD forecasting systems**

**Use AI to forecast weather**

**Machine Learning : SVM**

**Results**

**Conclusion**

The APEC Climate Symposium (APCS) 2022 will be held on 15-16 September at 1:30-3:30 (UTC)



# Flooding



The event will be held in a hybrid format (online/offline in Cha-Am, Thailand) in cooperation with Thai Meteorological Department (TMD).



# Drought



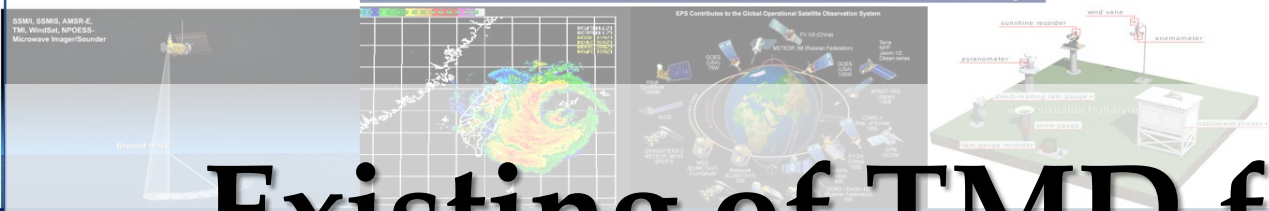
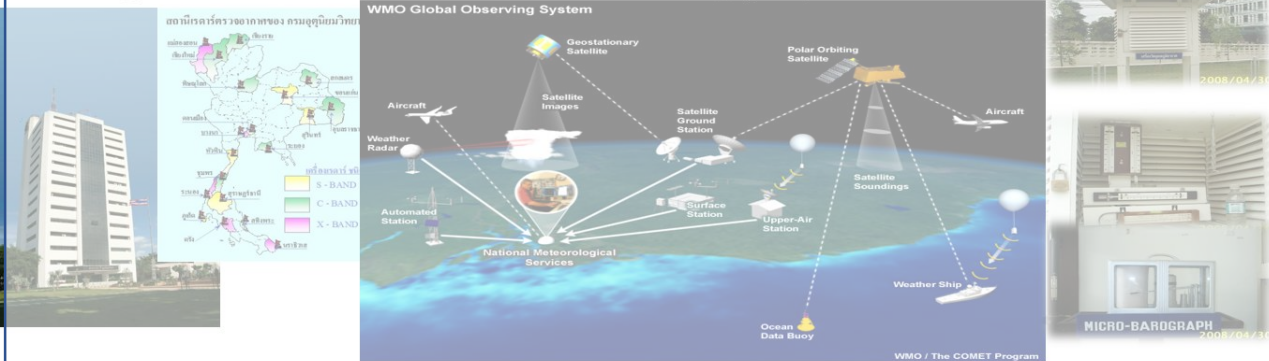
# Cold weather



# Precipitation and Air Temperature

- Meteorologists have measured things such as air pressure and relative humidity,
- but the only actual variables of the atmosphere are precipitation and air temperature.
- Every other parameter is a result of the interaction of these 2 variables.
- Since amount of precipitation and air temperature are so important in the atmosphere, it stands to reason that these are the two most important elements for describing climate.
- Therefore, forecasting and monitoring precipitation and air temperature are fundamental issues for society and various sectors of the economy.
- We can plan the activities of human beings and be prepared to deal with droughts, floods and cold weather.

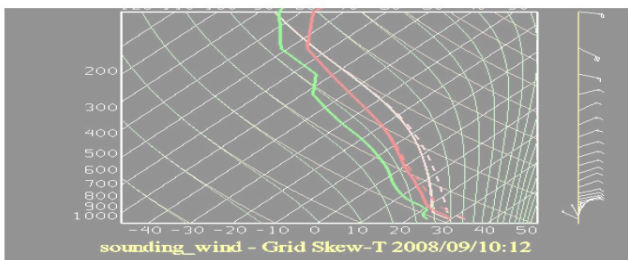
Meteorological measurement system and information exchange(GTS)



Network of meteorological stations of Thai Meteorological Department



# Existing of TMD forecasting systems

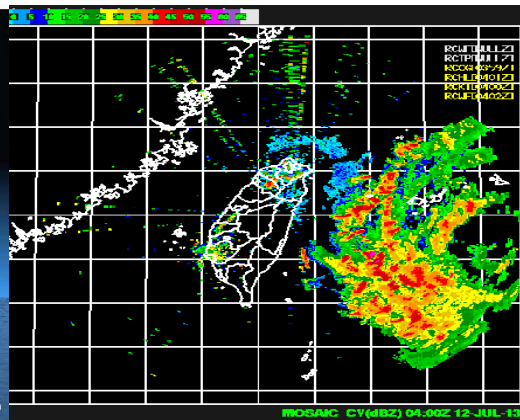
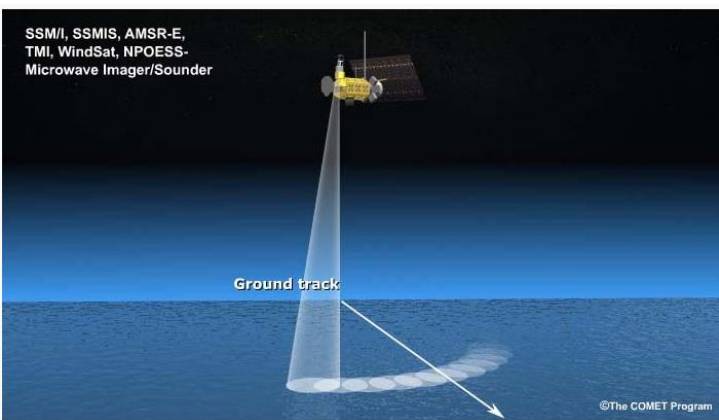
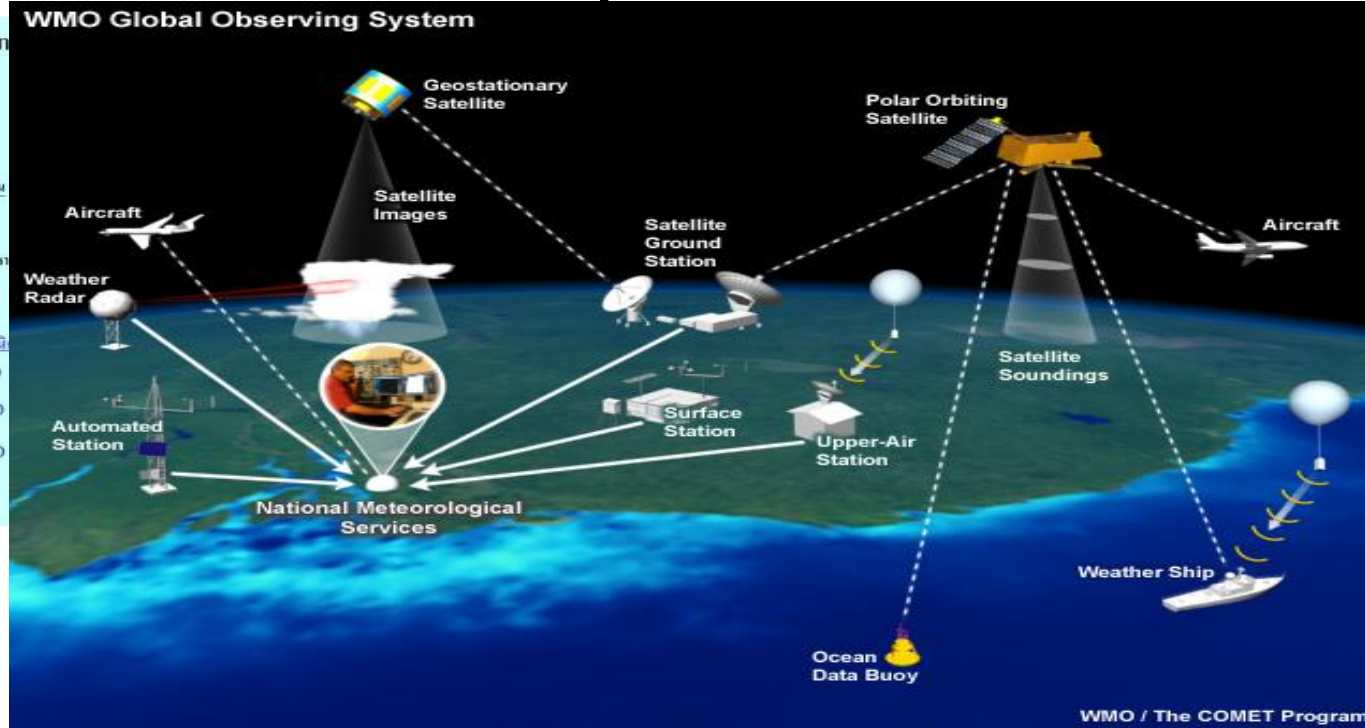


High-Performance Computer Weather Forecasting Development Project Processing System (Phase 1)"

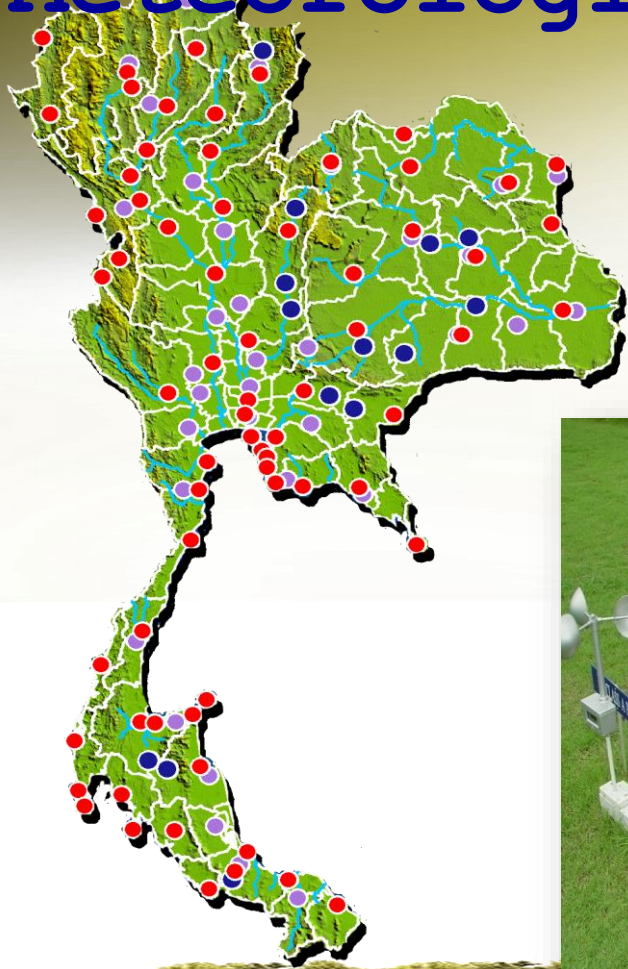


- System computer types**
- HPE Apollo 2000 series
  - Proliant XL170r Gen 9
  - 192 Nodes (compute) (3 tyes)
  - Performance : 228 TF
  - Main memory : 128 GiB per node
  - High-speed storage: 3PB
  - Operating system : Linux
  - Model : WRF-ARW

# Meteorological measurement system and information exchange (GTS)



# Network of meteorological stations of Thai Meteorological Department

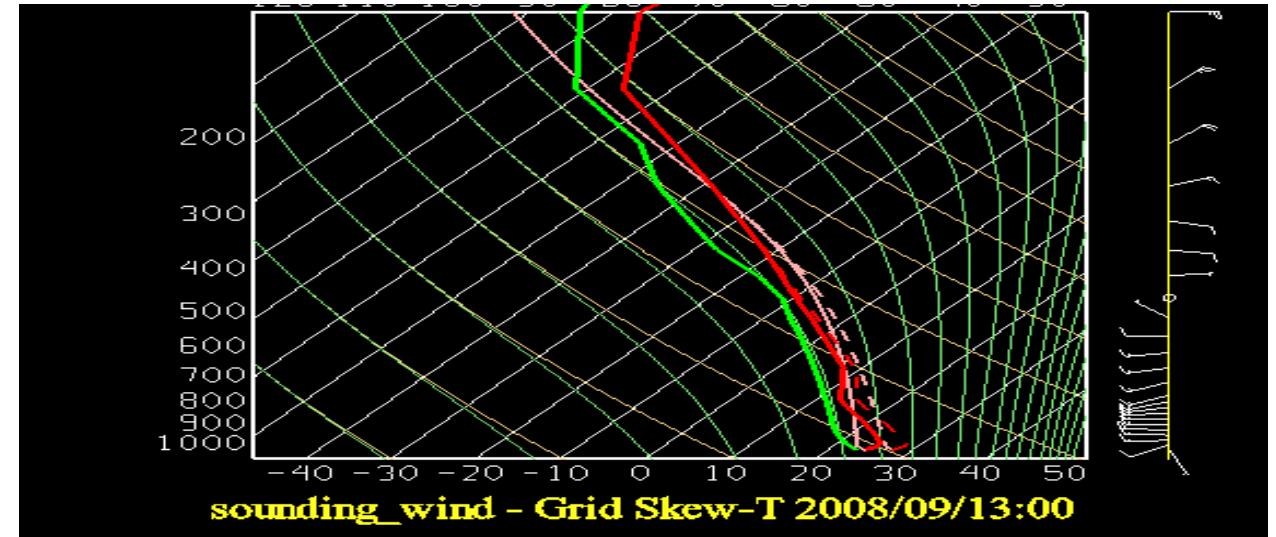


- ★ Headquarter (BKK)
- Regional Met. Centers(4)
- Surface stations (71)
- Agromet. stations (33)
- Hydromet. stations (16)
- Upper Air stations (11)

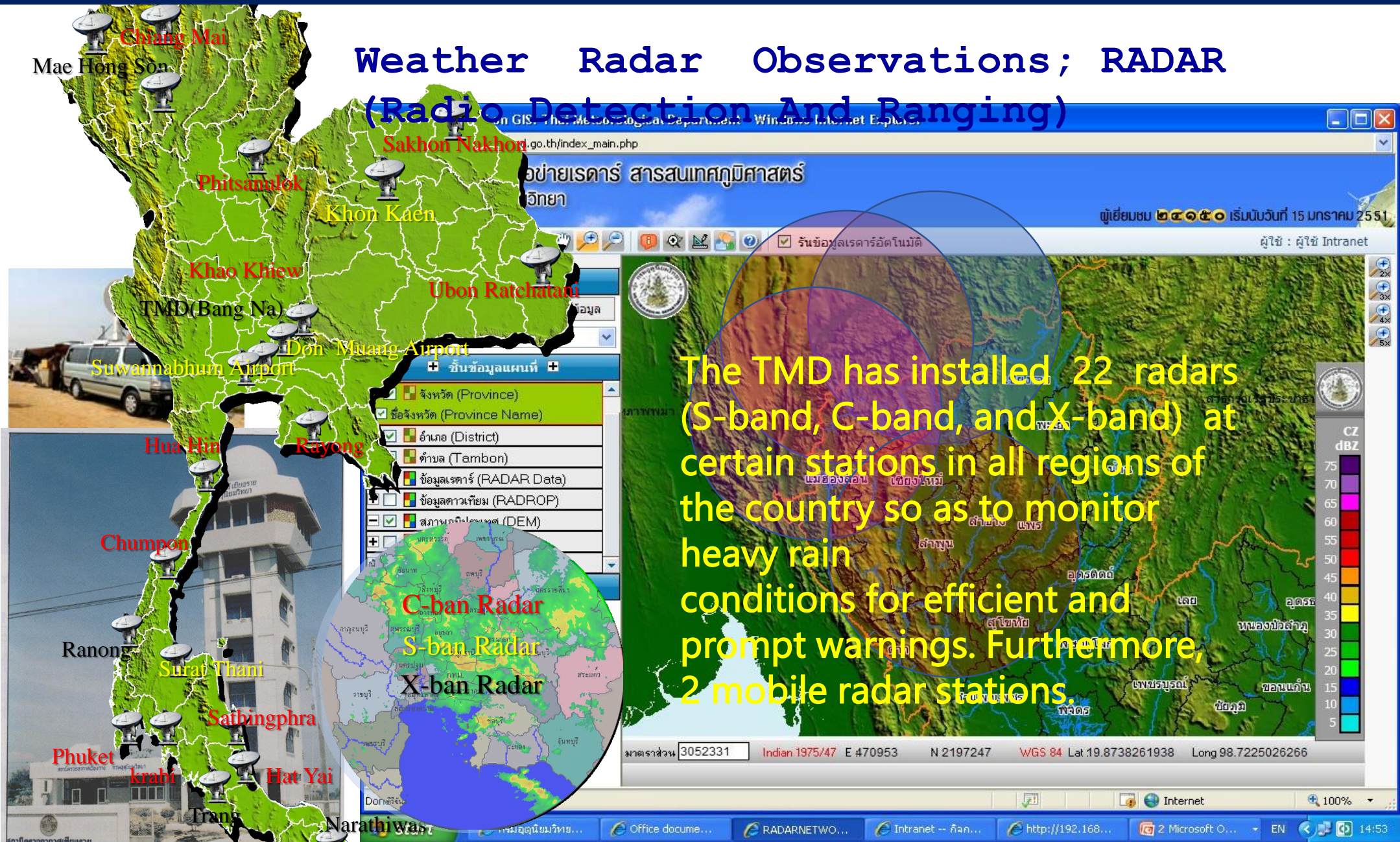


## Upper air observation stations

- . Pilot balloon
- . Rawinsonde
- . Radiowind



# Weather Radar Observations; RADAR (Radio Detection And Ranging)



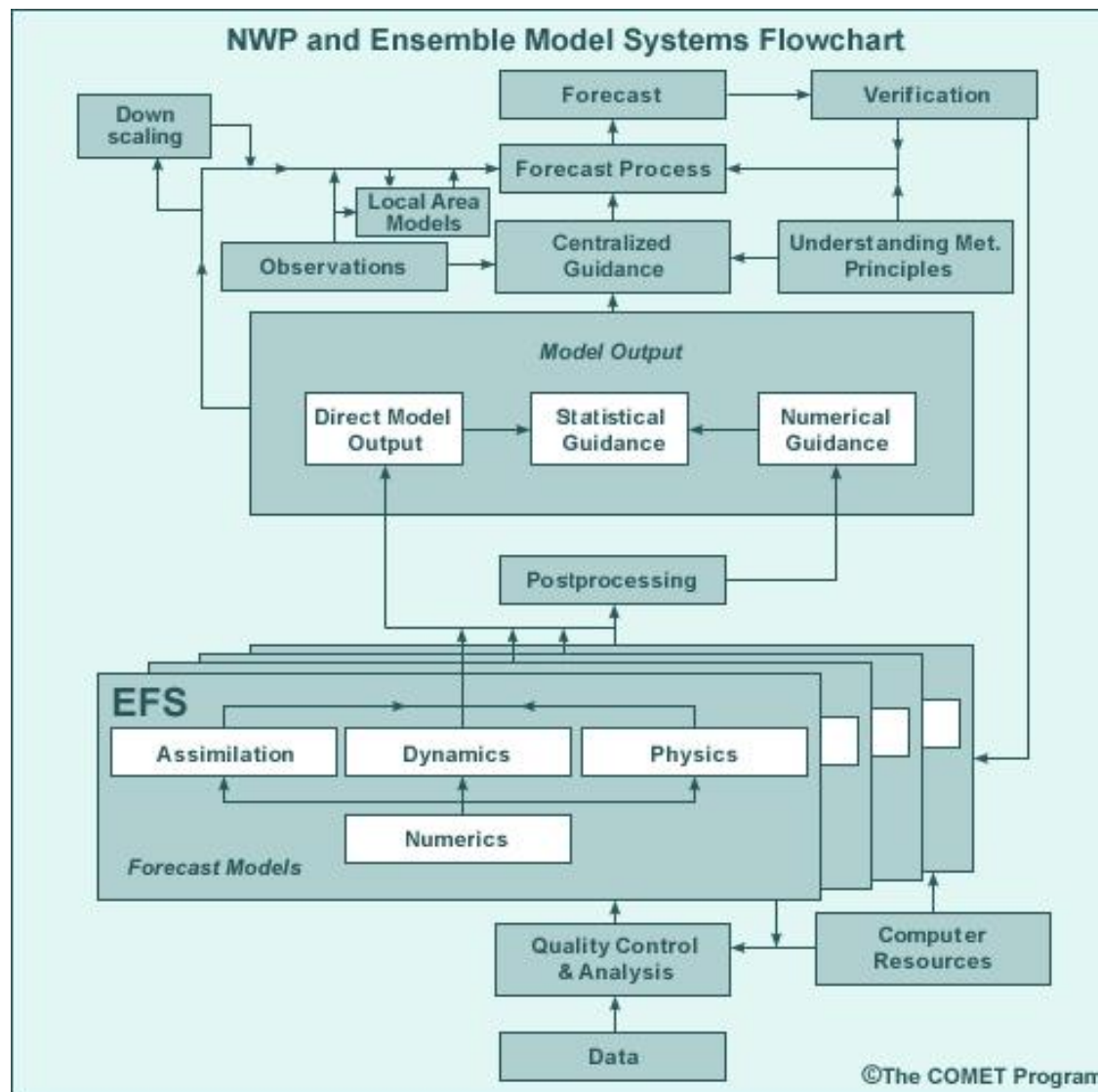
## High-Performance Computer Weather Forecasting Development Project Processing System (Phase 1)



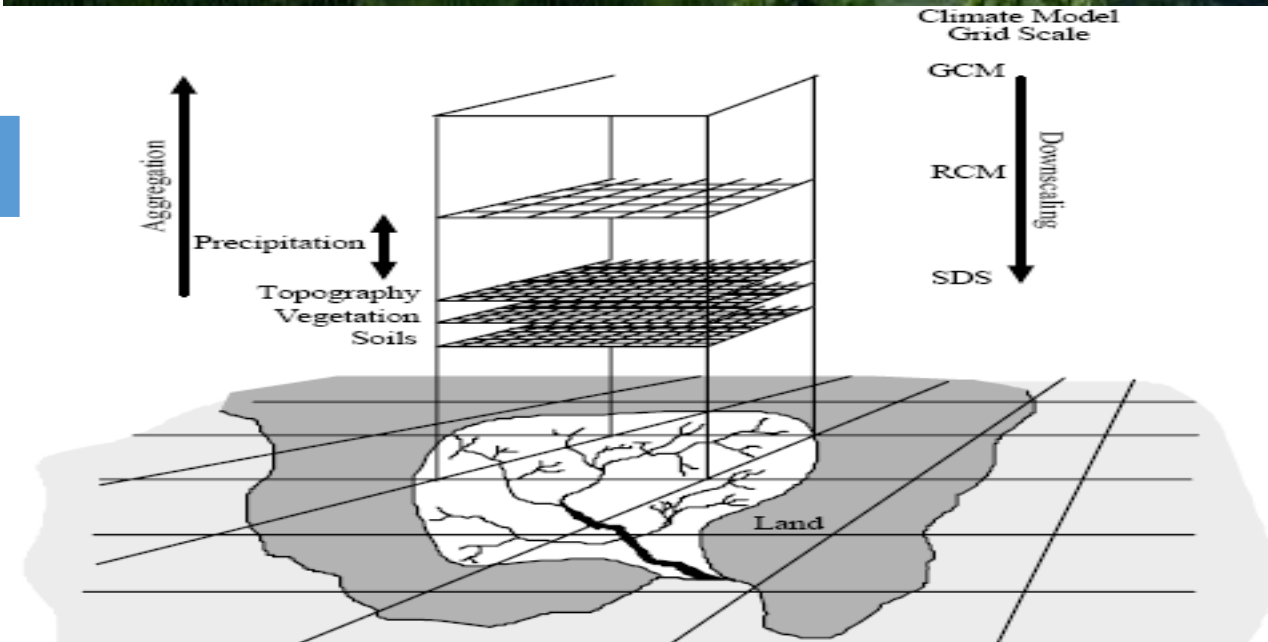
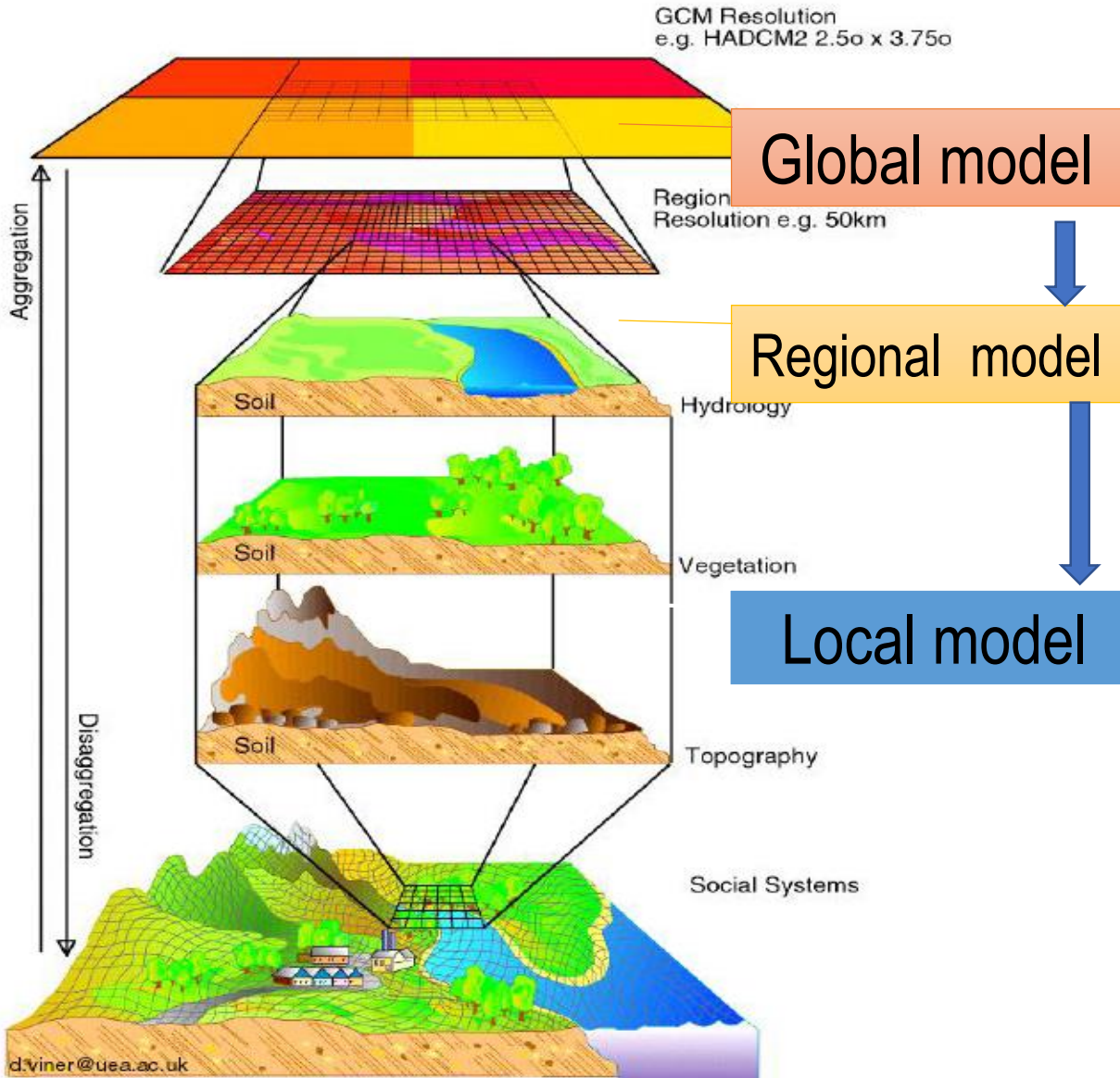
### System computer types

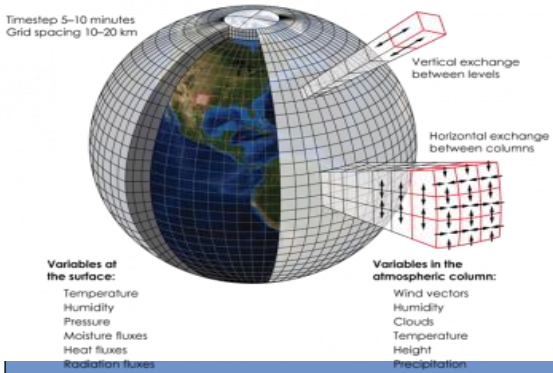
- HPE Apollo 2000 series  
Proliant XL170r Gen 9
  - 192 Nodes (compute) (3 types)
  - Performance : 228 TF
  - Main memory : 128 GiB per node
  - High-speed storage: 3PB
- Operating system : Linux  
Model : WRF-ARW

## Conceptual model of a model forecast system from data at the bottom to forecast at the top

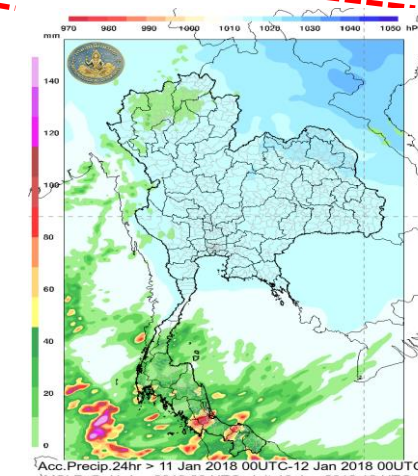
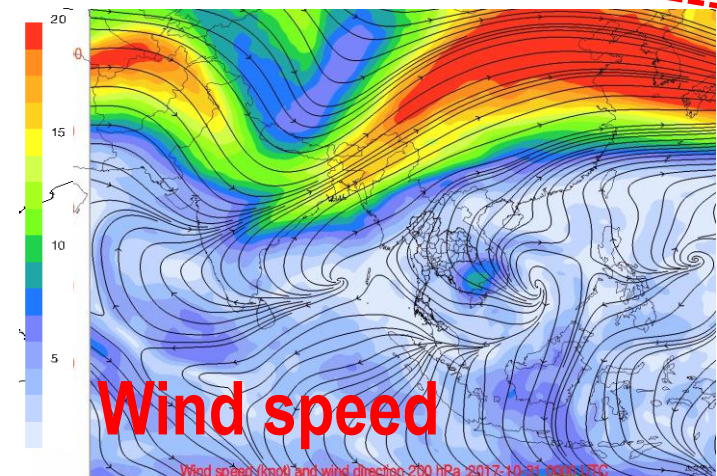
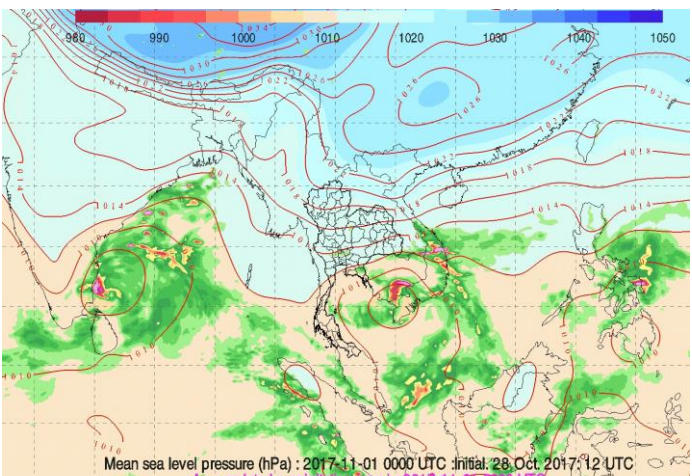
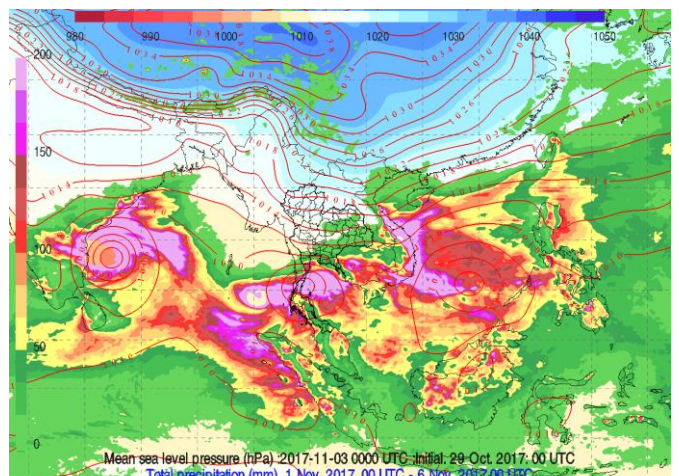
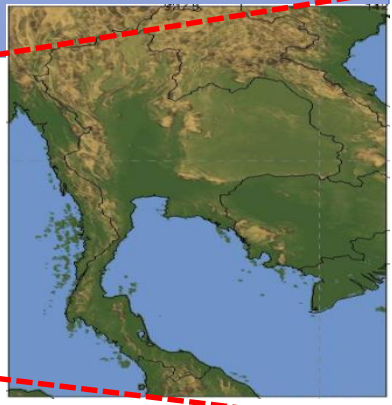
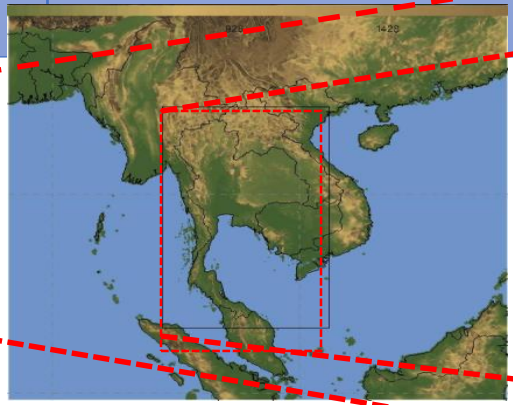
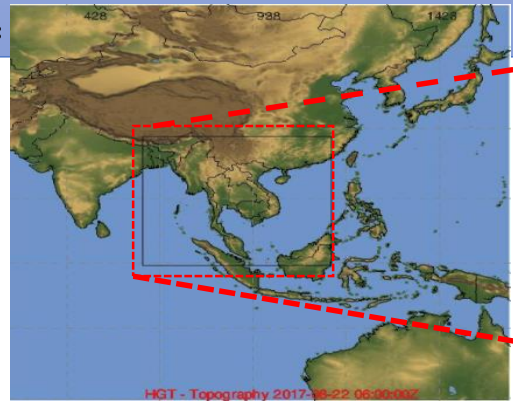


**(Dynamic downscaling Technique)**

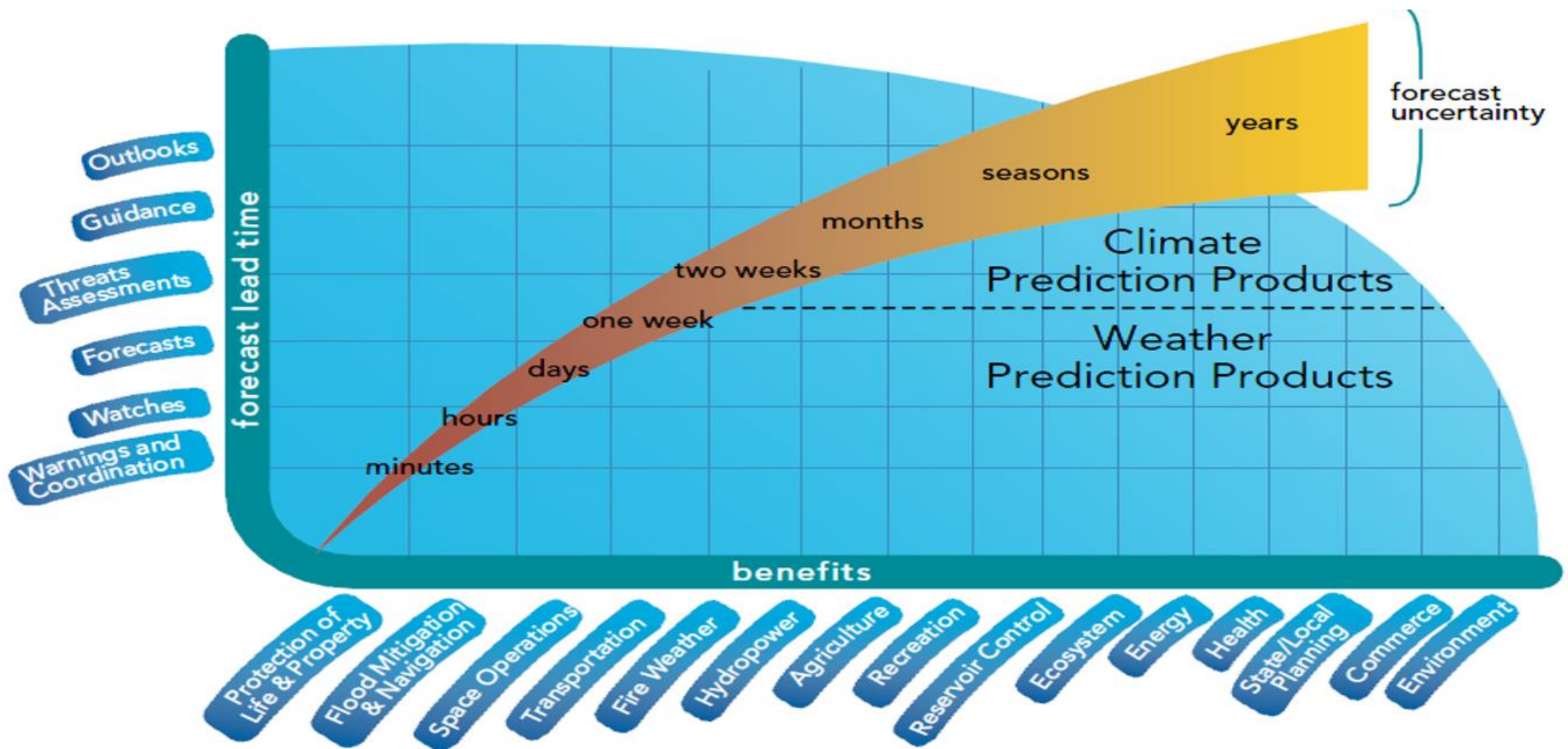




Grid point	Grid spacing/time forecast
$1483 \times 741 \times 19 = 20,879,157$	27 กม. (Fc 397 Days)
$585 \times 555 \times 40 = 12,987,000$	18 กม. (Fc 10 Days)
$547 \times 544 \times 40 = 11,902,720$	6 กม. (Fc 3 Days)
$547 \times 913 \times 4$	



## Tolerances of the weather forecast depending on the time.

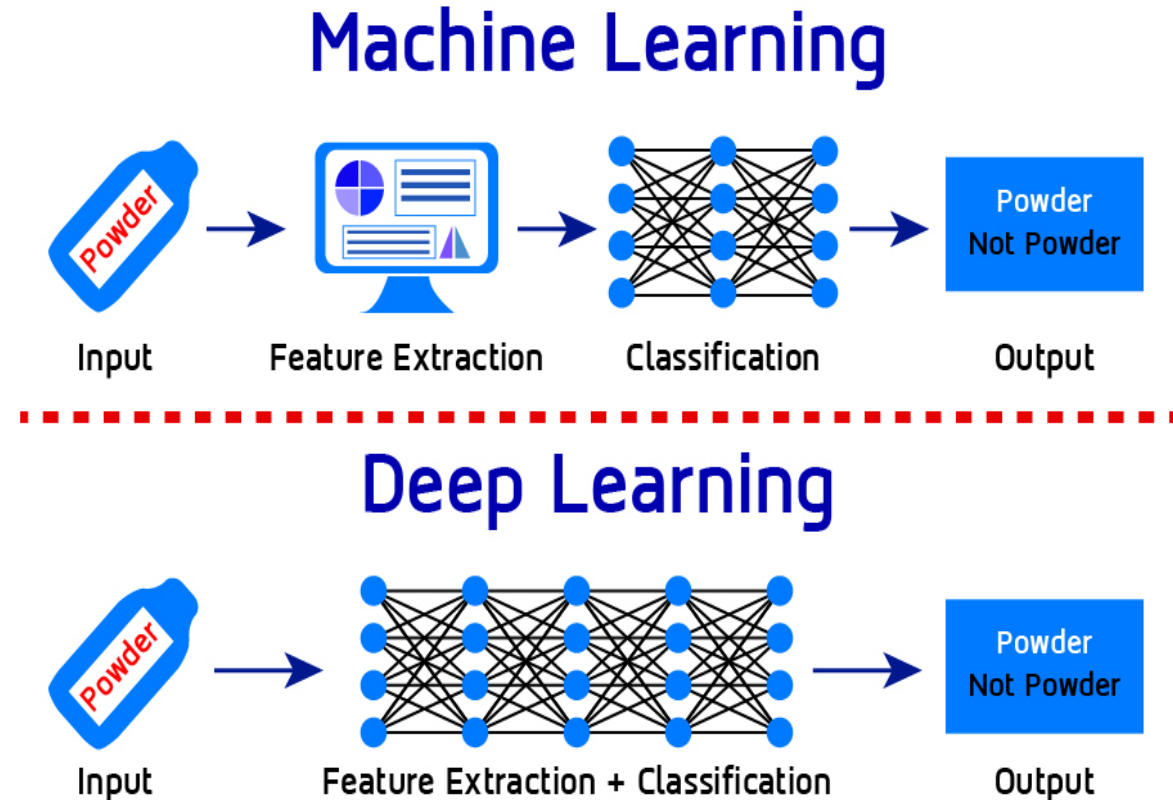


# Use Artificial Intelligence to forecast weather

- Artificial Intelligence (AI) and data science technologies, specifically machine learning, bridge the gap between numerical weather predictions model and real-time guidance by improving accuracy.
- AI techniques also extract otherwise unavailable information from forecast models by fusing model output with observations to provide additional decision support for forecasters and users.
- Machine Learning, based on statistical methods, has been widely used to improve the accuracy of the prediction of air temperature and precipitation.

# Artificial Intelligence (AI)

It is an innovation that creates change and leads to the development of the technology of the future. But AI's analytical thinking process consists of sub-components.



# Use Artificial Intelligence to forecast weather

Many methods are widely used including

- linear/nonlinear regression,
- canonical correlations,
- Artificial Neural Network (ANN),
- Relevance Vector Machine (RVM).
- Support Vector Machine (SVM)
  - SVM is one of the most popular methods using supervised machine learning algorithm.
  - It is used for both classification and regression tasks.

# Support Vector Machine (SVM)

- The main objective of SVM is to find the optimal hyperplane which linearly separates the data points in two components or classes by maximizing the margin or equivalently minimizing the magnitude of weighted vector  $\|w\|$  as follows:

$$\min_w \frac{\|w\|^2}{2}$$

$$\text{s.t. } y_i(w \cdot x_i + b) - 1 \geq 0 \quad \text{for } i = 1, 2, \dots, N$$

where the training data's of the form  $\{x_i, y_i\}$  and  $b$  is the biased term.

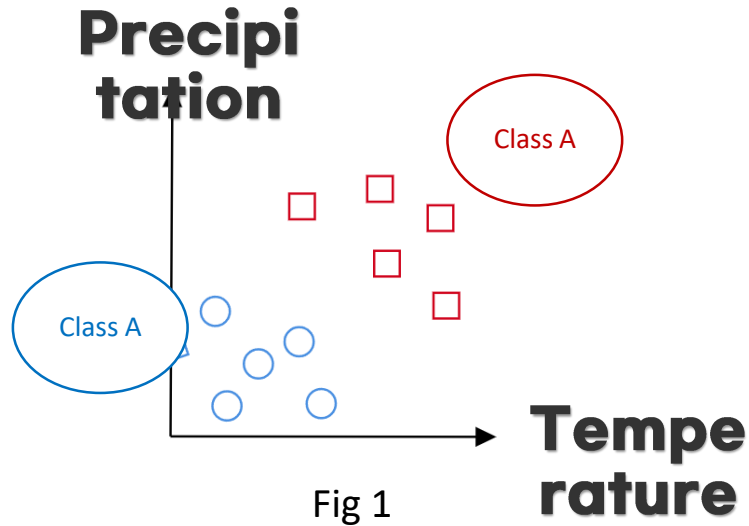
- To obtain the optimal valued of  $\|w\|$ , the following dual optimization formulation is used.

$$\max_{\lambda_i} \sum_{i=1}^N \lambda_i - \frac{\sum_{i,j=1}^N \lambda_j \lambda_i y_j y_i x_i x_j}{2}$$

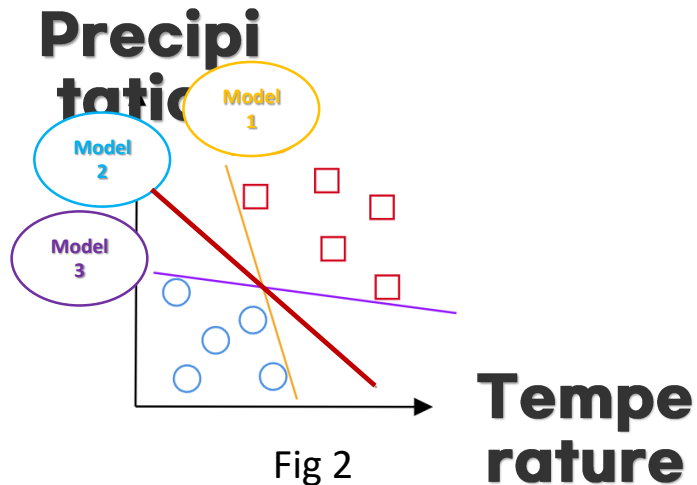
where  $\lambda_i$  are Lagrange multipliers.

# Concept of Support Vector Machine

Support Vector Machine (SVM) is a machine learning that is Supervised Learning by finding a hyperplane between each data type. with the largest margin from the data location



From the distribution of the data in Fig. 1, it can be clearly divided into two groups. Usually we use a linear model (or linear equations) to divide the data into two classes, but this linear model can be multiple lines as shown in Figure 2.



- We should choose a model that is not overfitting or models that do not remember the format of the data too much training
- From the example, it can be seen that the model 1 and the model 3 There will be a point where the linear model is too close to each data class.
- That is, if there is new information a little further away, the prediction will be wrong.
- Therefore, in this example, model 2 (red line) should be selected



The Climate Forecast System (CFS) models the interactions between Earth's oceans, land, and atmosphere on a global scale. The model is produced by several dozen scientists under guidance from the National Centers for Environmental Prediction (NCEP), and generates hourly data with a  $\frac{1}{2}^\circ$  horizontal resolution (approximately 56 km).

[About](#)

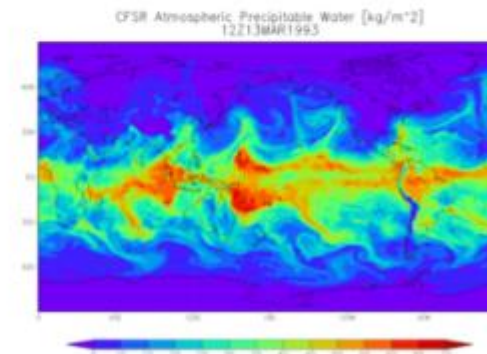
[Operational](#)

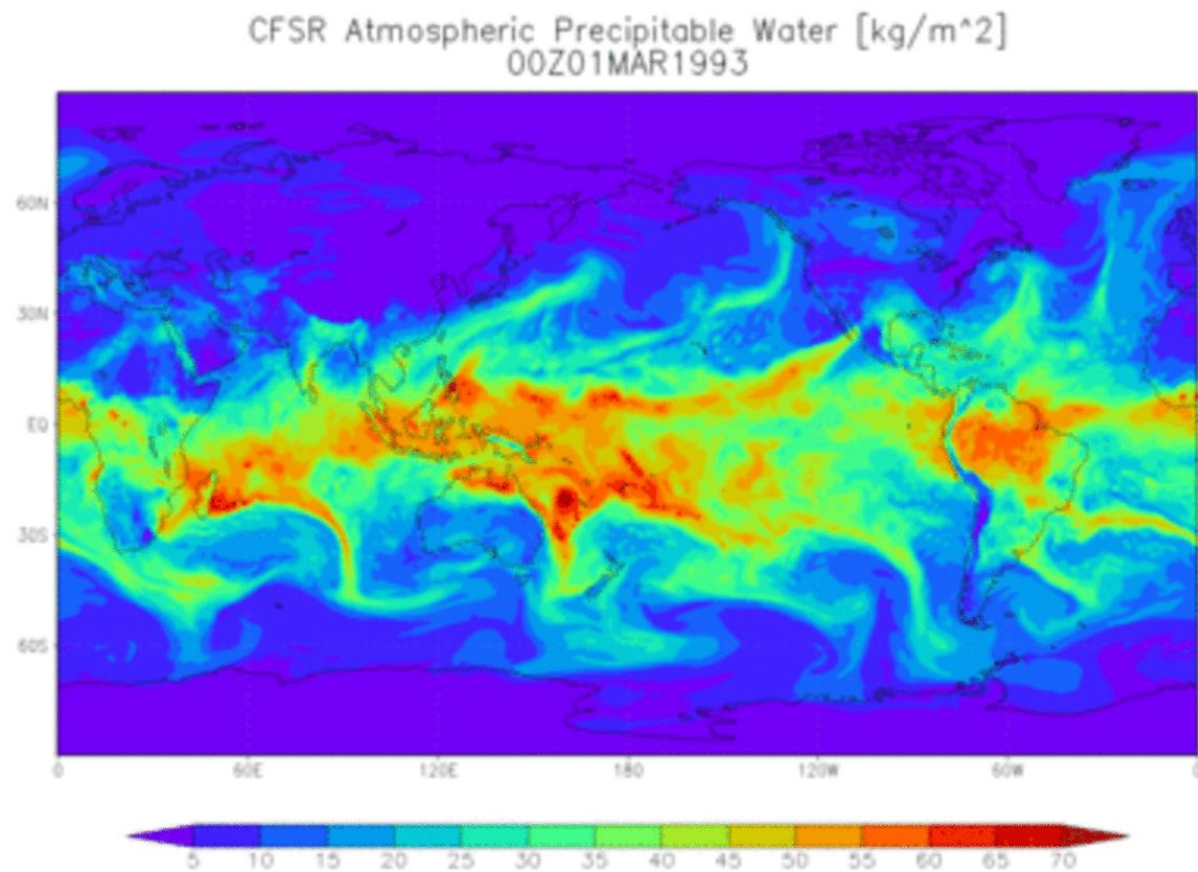
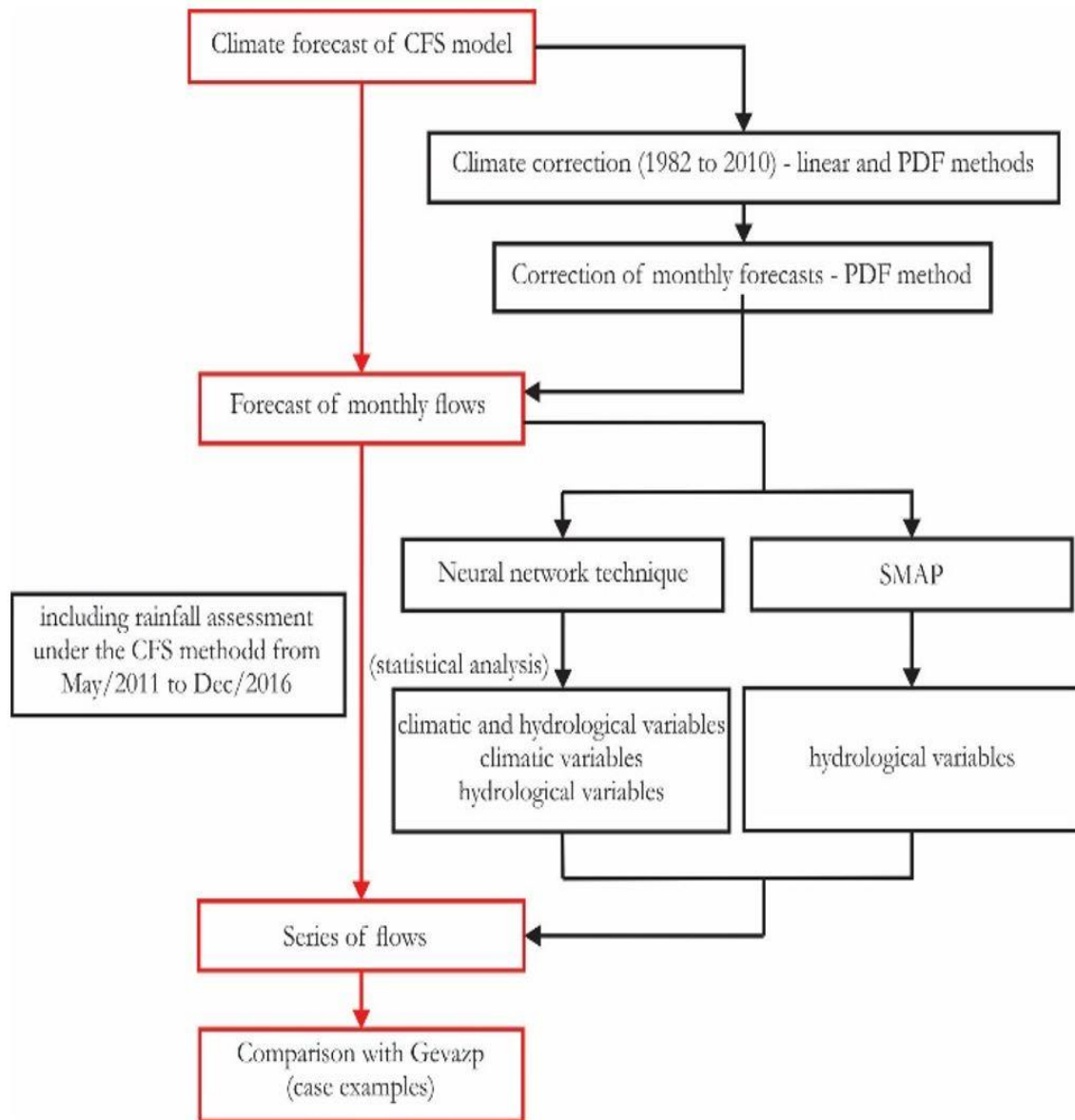
[Historical](#)

[Calibration](#)

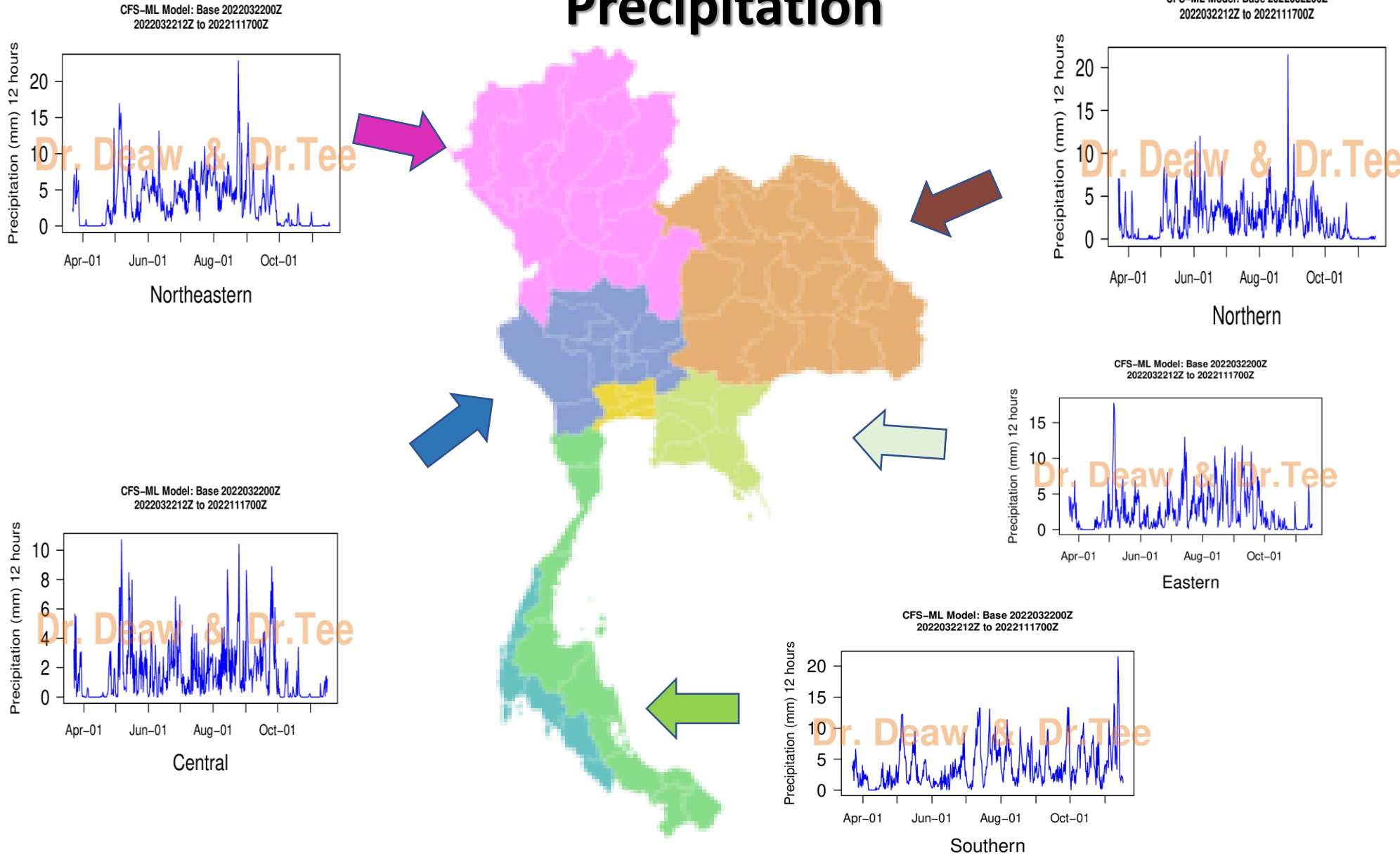
## Specifications and Data Access

CFS uses the latest scientific approaches to incorporate observations from a variety of data sources, including surface observations, upper air balloon observations, aircraft observations, and satellite observations. NCEI provides access to near real-time historical model data, while real-time data are available on NCEP servers through the [CFS 7-day rotating archive](#).





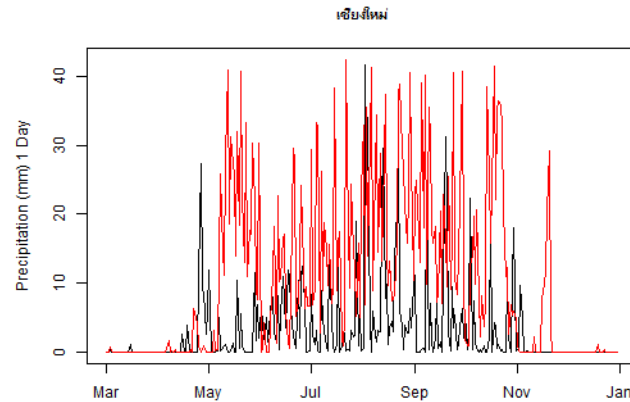
# Precipitation



# Chiangmai

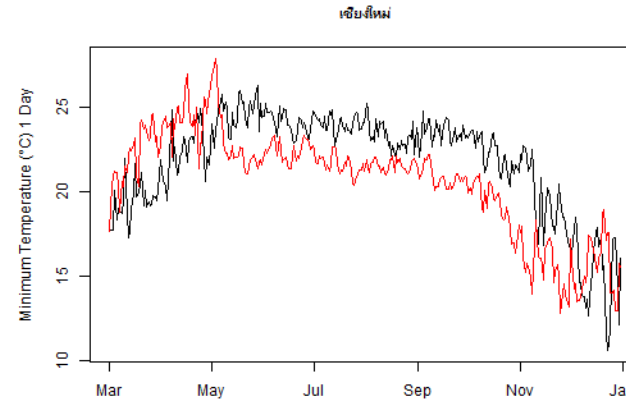


## Precipitation



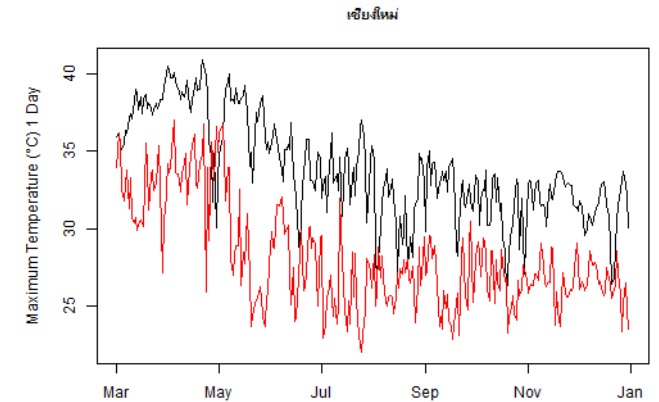
MAE = 9.33

## Min Temp



MAE = 2.59  
MAPE = 12.32

## Max Temp



MAE = 5.78  
MAPE = 16.82

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

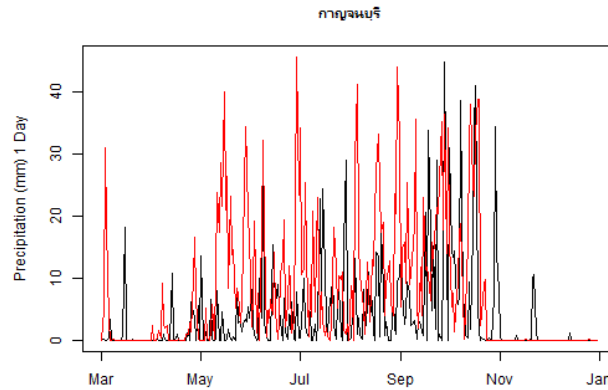
The Mean Absolute Error (MAE) is a very good KPI to measure forecast accuracy. As the name implies, it is the mean of the absolute error.

The event will be held in a hybrid format (online/offline in Cha-Am, Thailand) in cooperation with Thai Meteorological Department (TMD).

# Kanchanaburi

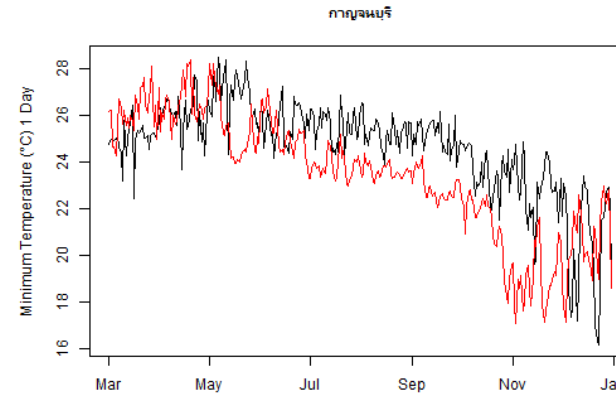


## Precipitation



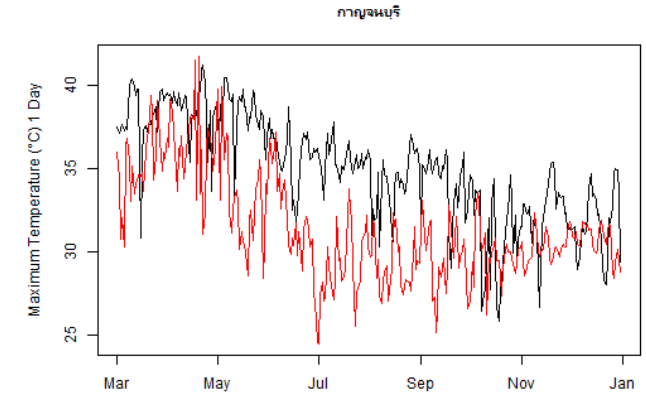
MAE = 7.22

## Min Temp



MAE = 1.92  
MAPE = 7.96

## Max Temp



MAE = 3.86  
MAPE = 10.85

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

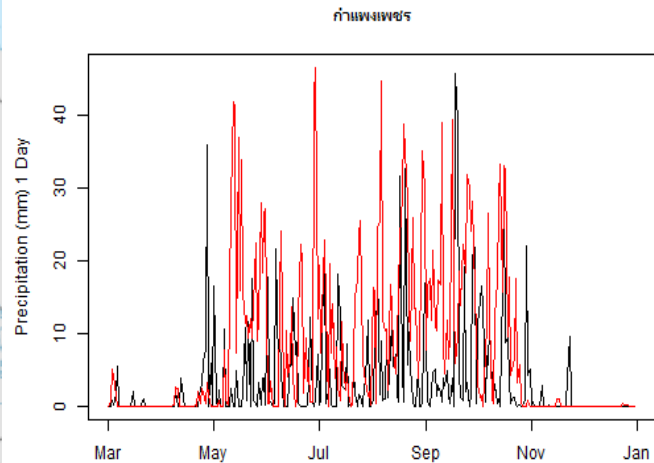
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# Kamphaeng Phet

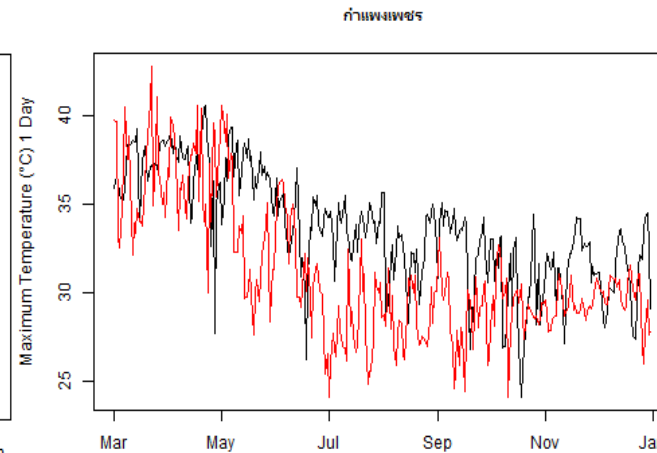


## Precipitation



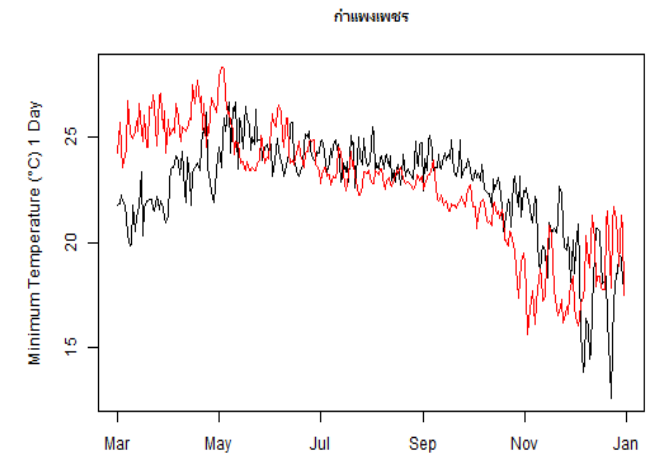
MAE = 7.18

## Min Temp



MAE = 2.03  
MAPE = 9.43

## Max Temp



MAE = 3.44  
MAPE = 10.13

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

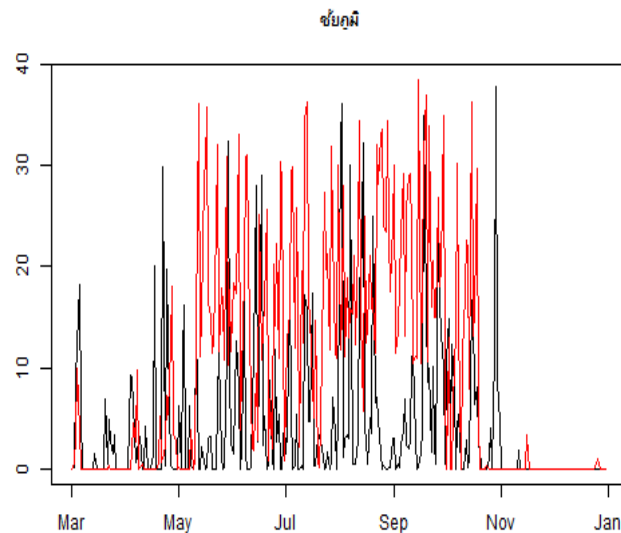
The Mean Absolute Error (MAE) is a very good KPI to measure forecast accuracy. As the name implies, it is the mean of the absolute error.

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# Chaiyaphum

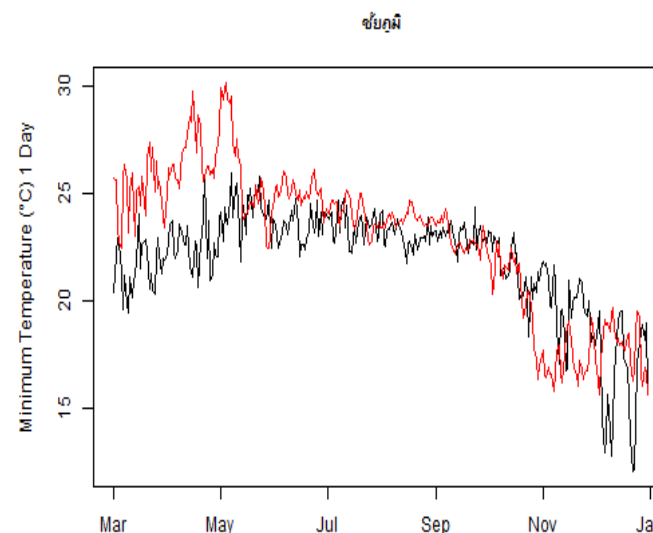


## Precipitation



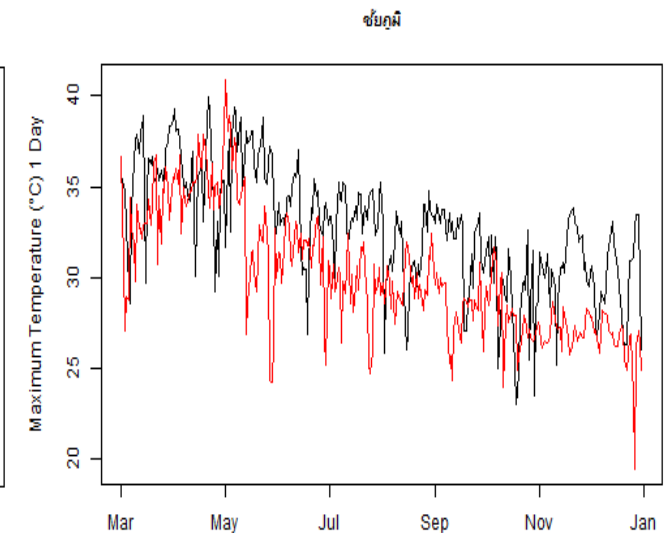
MAE = 8.85

## Min Temp



MAE = 2.08  
MAPE = 10.07

## Max Temp



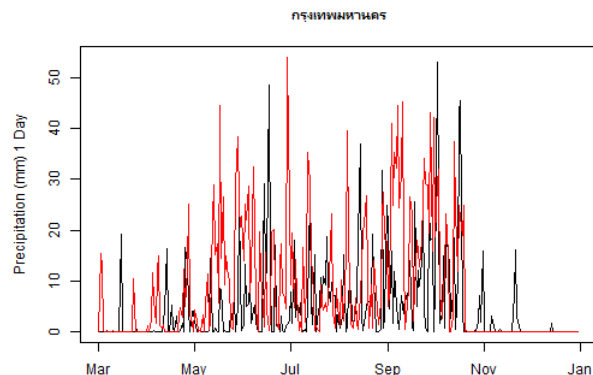
MAE = 3.38  
MAPE = 10.22

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

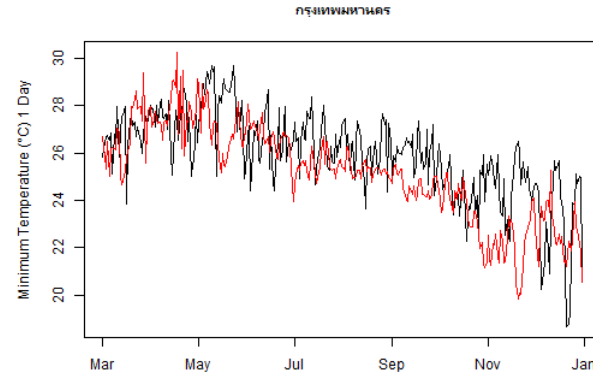
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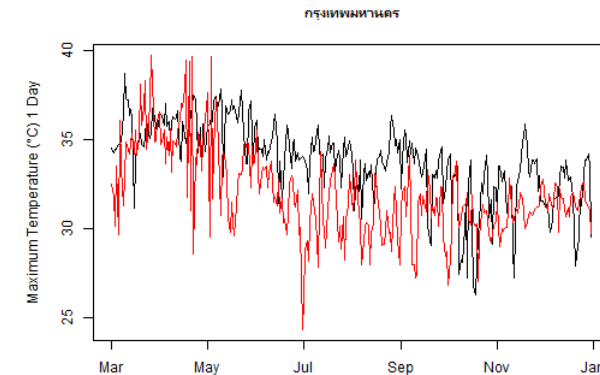
# Bangkok



MAE = 7.65



MAE = 1.49  
MAPE = 5.78



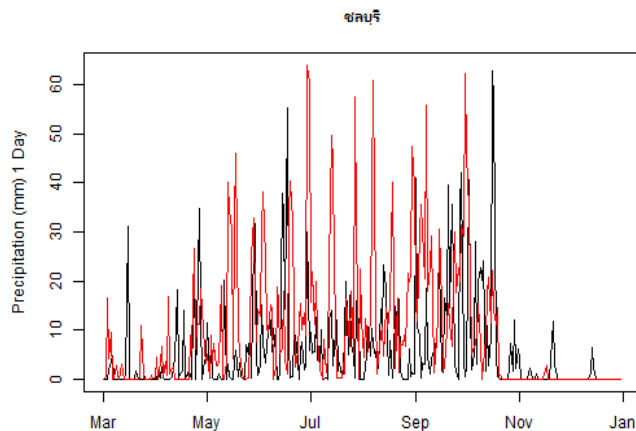
MAE = 2.62  
MAPE = 7.69

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

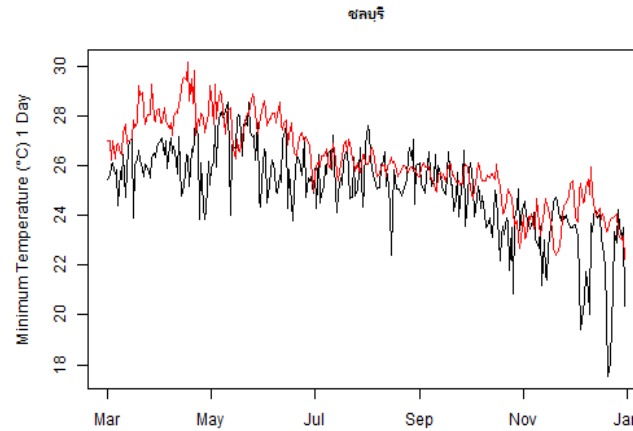
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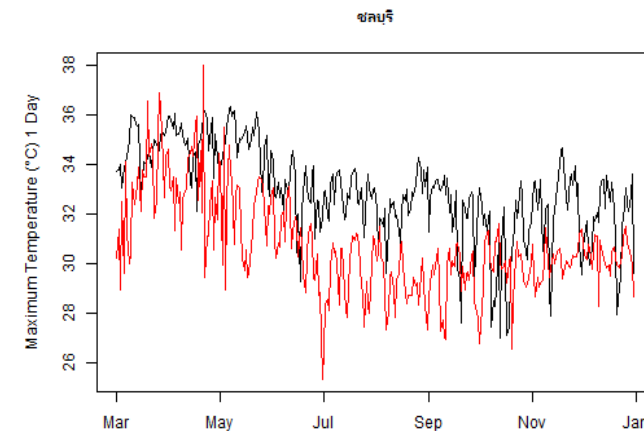
## Chonburi



MAE = 8.91



MAE = 1.40  
MAPE = 5.81



MAE = 2.55  
MAPE = 7.70

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

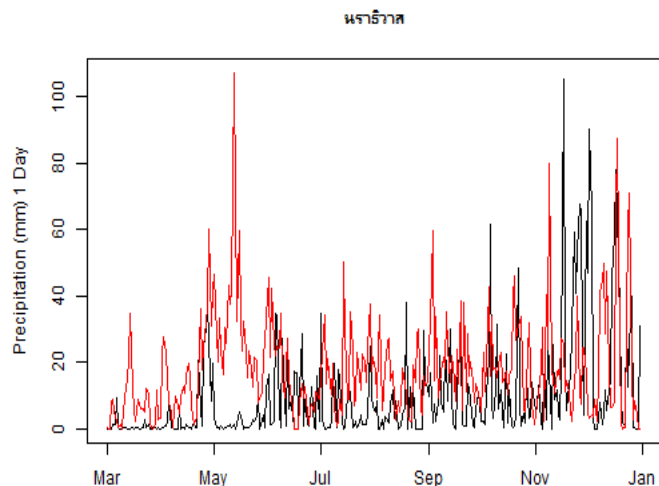
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# Narathiwat

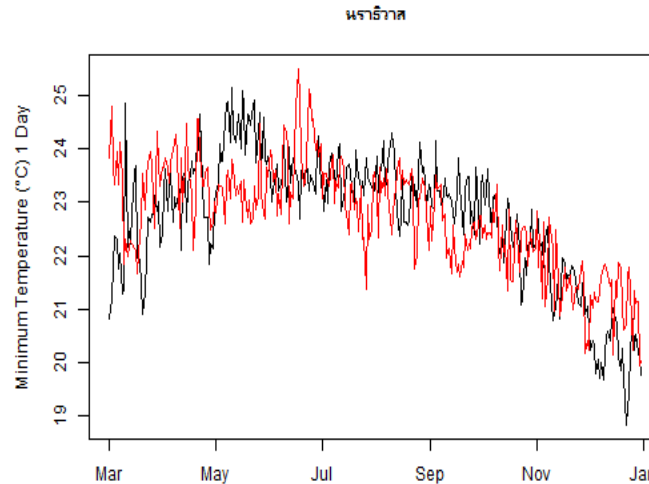


## Precipitation



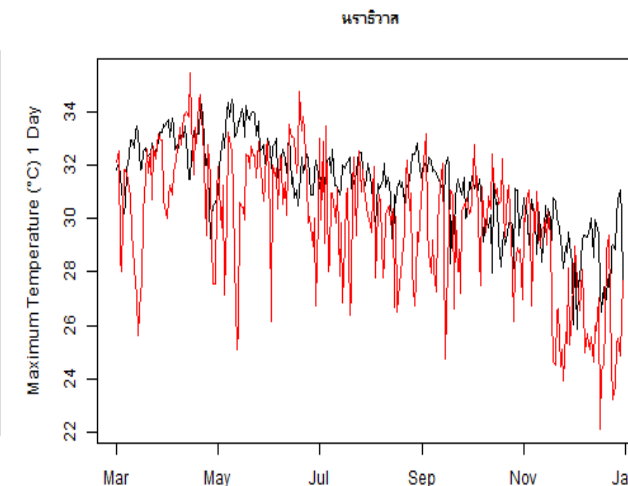
MAE = 15.88

## Min Temp



MAE = 0.81  
MAPE = 3.58

## Max Temp



MAE = 2.02  
MAPE = 6.49

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

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# Results

- In this study, time series climate dataset collected at the weather stations in Thailand is used for training and phases in Support Vector Machine (SVM) method.
- The training set is from 2011 to 2019 whereas the test set used for model validation of prediction is from 1 March 2020 to 31 December 2020.
- The figure presents the observed data (black line) against the prediction (red line) of precipitation, minimum temperature and maximum temperature in 6 regions of Thailand including the northern, north-eastern, central, eastern, and southern regions shown as the provinces of Kamphaeng Phet, Chaiyaphum, Bangkok, Chonburi, and Narathiwat, respectively.
- It is shown that MAE ranges from 0.72 to 2.08 and MAPE ranges from 3.18 to 10.07 for minimum temperature whereas MAE ranges from 1.92 to 3.88 and MAPE ranges from 6.27 to 10.26 for maximum temperature.
- In contrast, MAE ranges from 6.98 to 18.64 for precipitation.

The Mean Absolute Percentage Error (MAPE) is one of the most commonly used KPIs to measure forecast accuracy.

The Mean Absolute Error (MAE) is a very good KPI to measure forecast accuracy. As the name implies, it is the mean of the absolute error.

# Conclusion

- **Precipitation** can have devastating economic consequences.
- Globally they are among the most destruction natural hazards.
- Many years ago precipitation from storms were responsible for nearly half of all natural disaster losses worldwide.
- Total damage in billions of US dollars.
- Cooperation of member in all matters will reduce the loss of both life and property.
- Applying AI techniques along with a physical understanding of the environment can significantly improve the prediction skill for multiple types of high-impact precipitation from tropical cyclones.
- The AI approach and machine learning are also a contribution to the growing field of computational sustainability.
- SVM model can give good prediction on air temperature.
- The prediction on precipitation is fairly good as it is known that the precipitation depends on various parameters.
- However we still need to use existing approach along with the AI technique.
- Because AI technique requires plenty data to create good prediction model.



**THANK YOU**

**FOR YOUR ATTENTION**