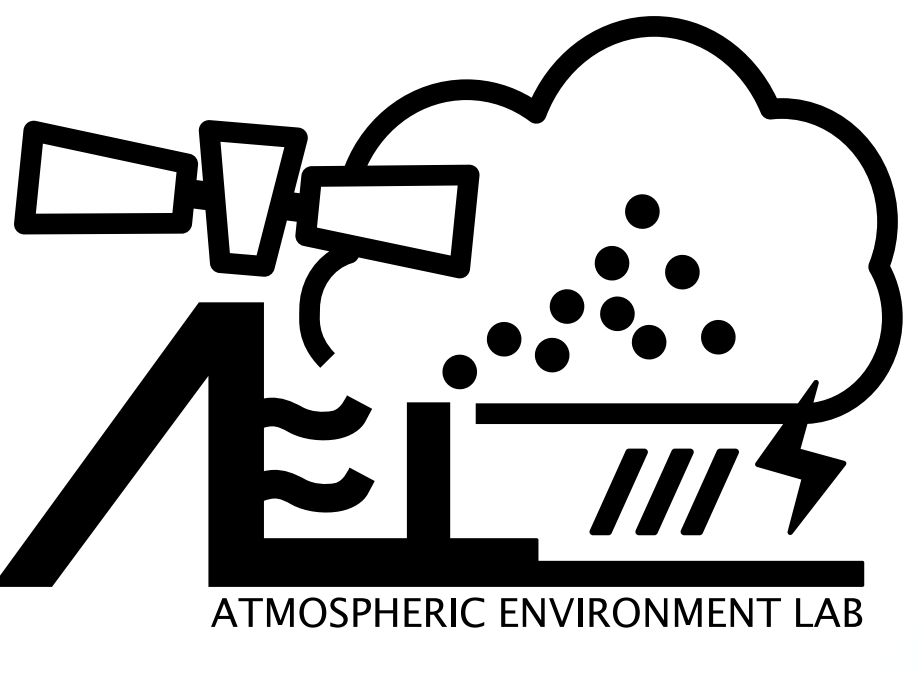


Machine Learning Detection of Fog/Low Cloud over Eastern Taiwan Mountains from Himawari-8 Satellite True-color Images



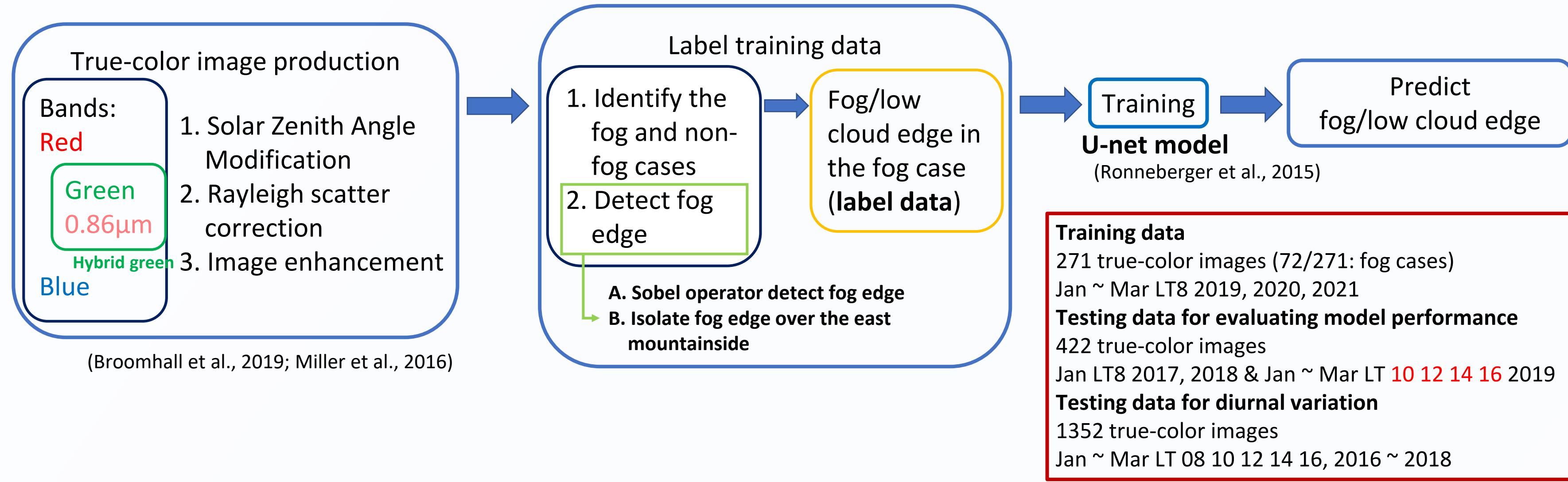
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The fog/low cloud during the cold season frequently blanket the eastern Taiwan mountains areas, known for the montane cloud forest. These fog/low clouds can provide significant water supplies to local areas and support the biodiversity of the montane cloud forest. However, it remains challenging to identify the appropriate temporal and spatial scales of these fog/low clouds due to limited ground observations in the complex terrain. The objective of this work is to detect these mountain fog/low cloud from the Himawari-8 satellite true-color image by applying the machine learning technique (U-net).

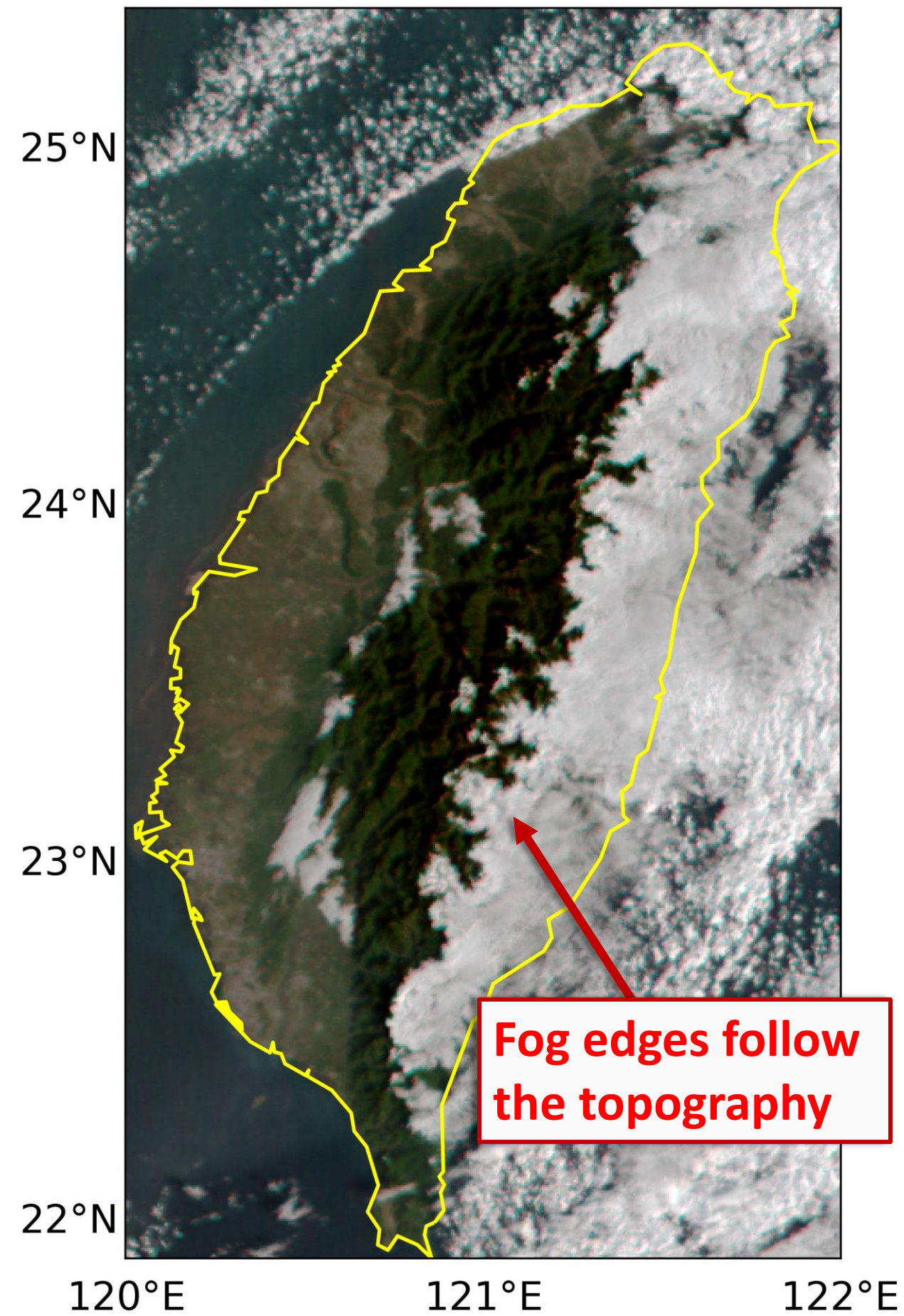
Data processing & training flow chart



Data characteristic

In the view of the satellite from the top of the atmosphere, the mountain fog top can form a clear edge closely following the topographic features

2018/01/12 LTS08 true color



- Himawari-8 provides high temporal and spatial resolution observations
- By detecting fog/low cloud edges, we can determine the max height of the fog occurrence area
- The detection process is similar to the identification of different objects in the image

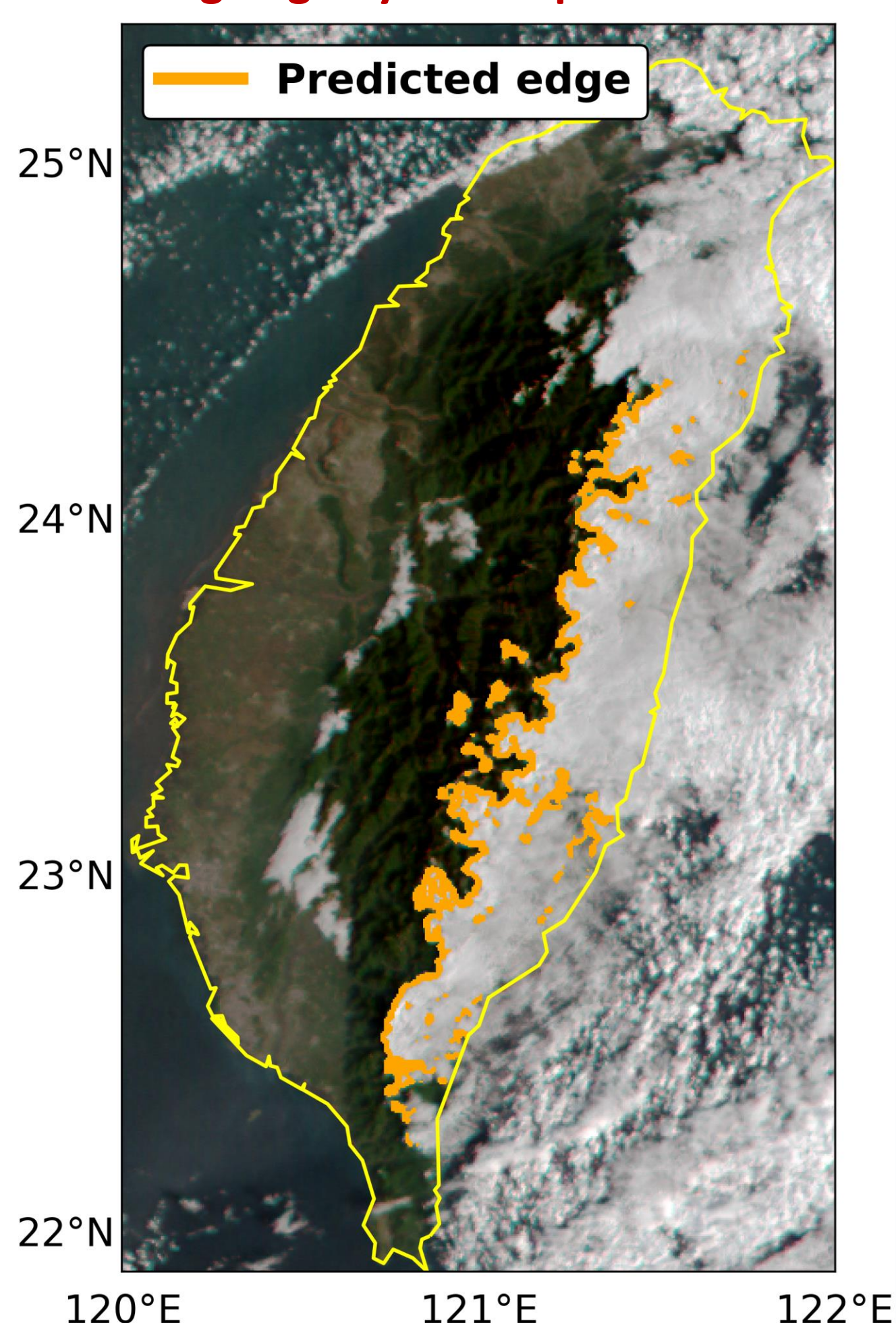
Machine learning model: U-net

U-net model is a convolutional neural network architecture and is widely used in image segmentation.

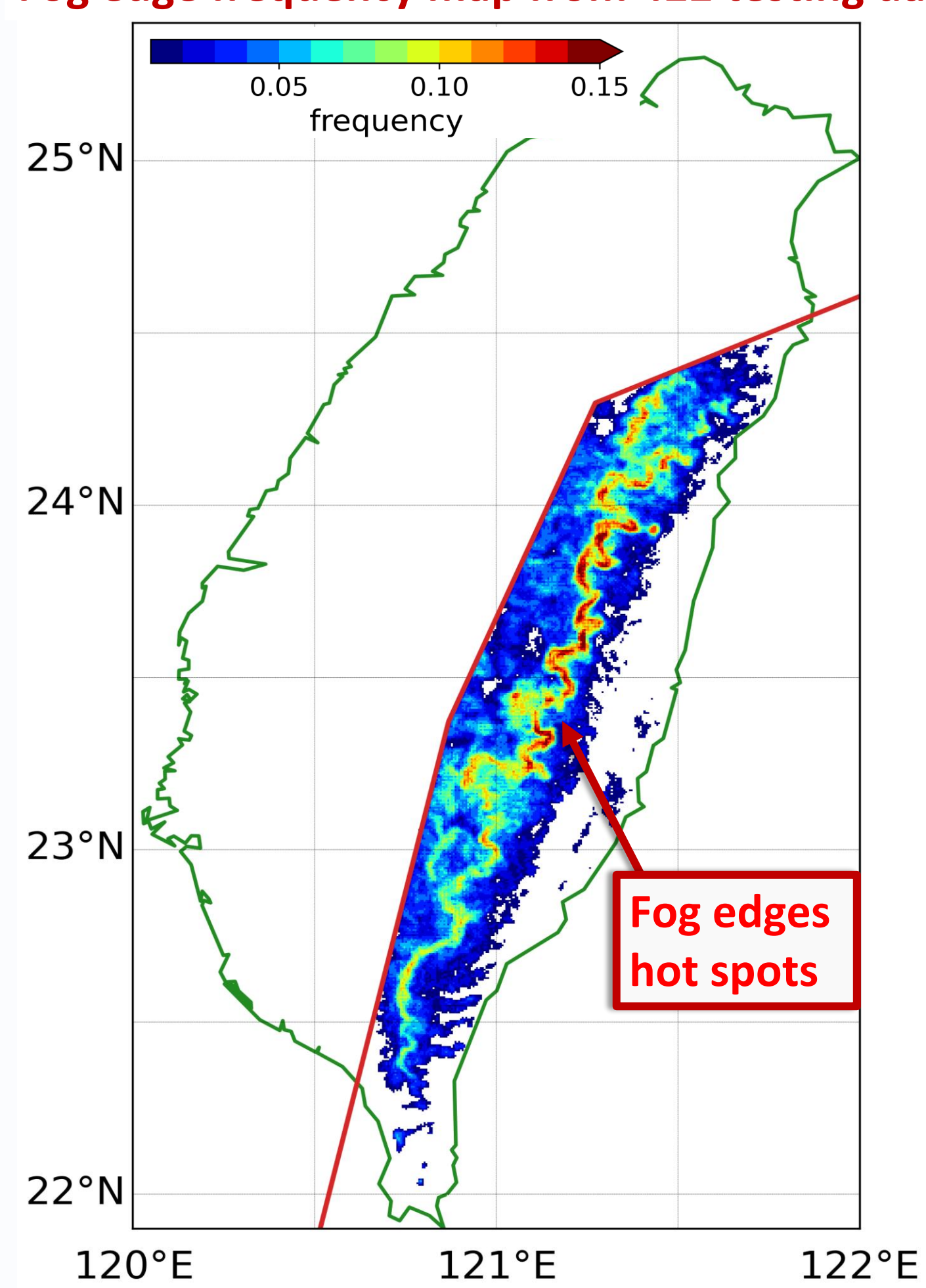
- Good at image segmentation
- Good performance under small data volume

Fog edge detection

Fog edge by model prediction



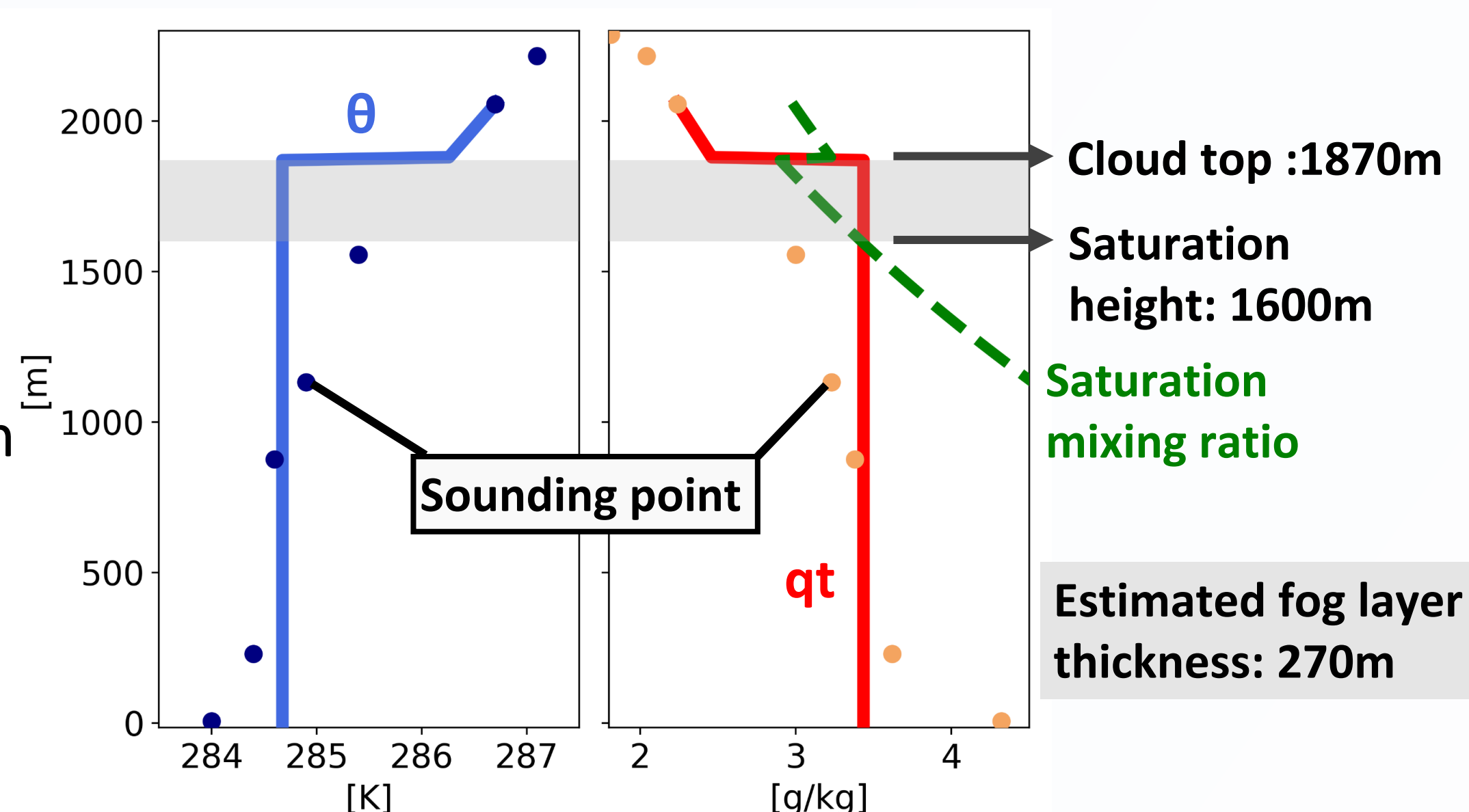
Fog edge frequency map from 422 testing data



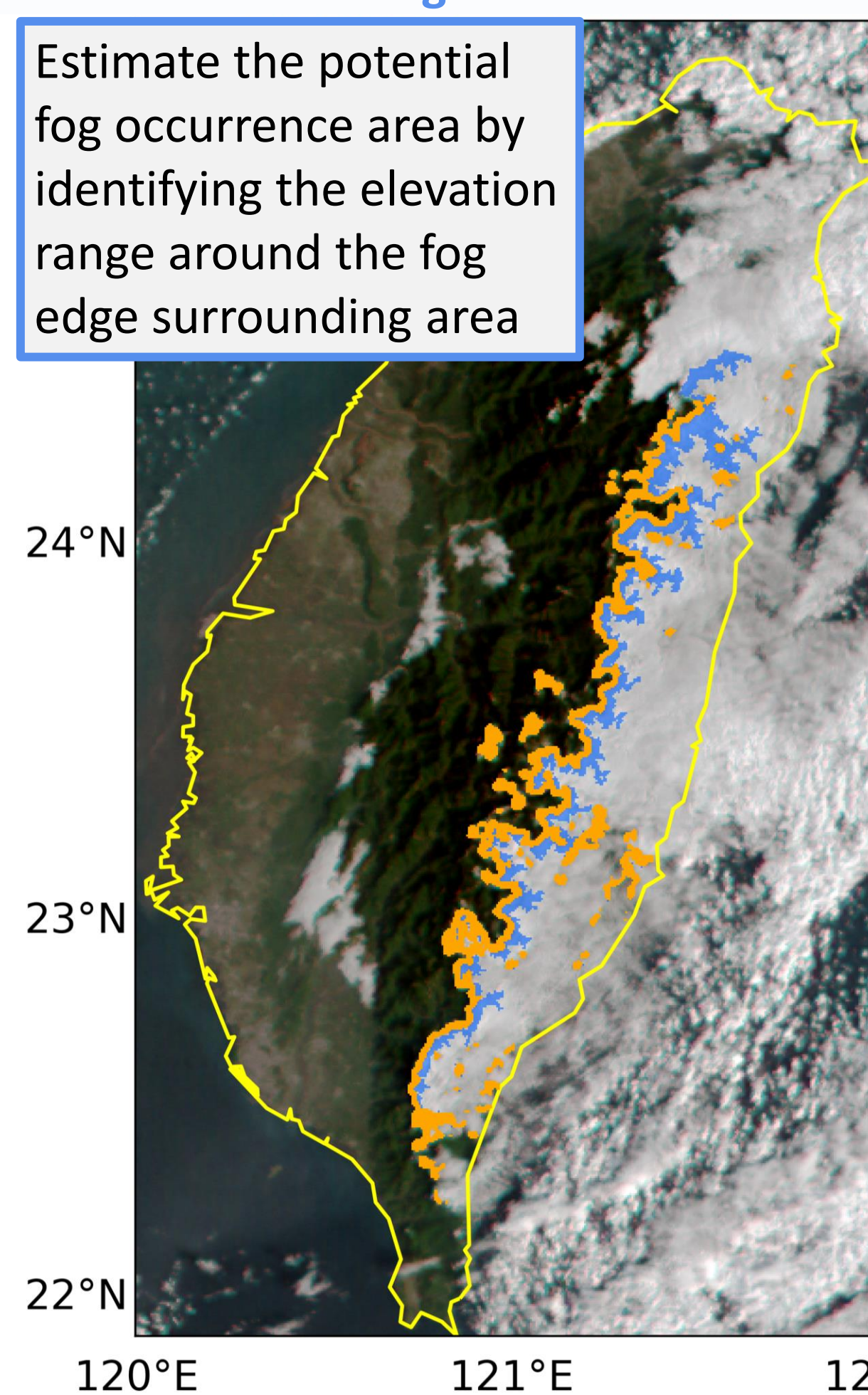
- At specific elevations, the climatology of the fog edge hot spots can be captured
- ~89% accuracy for predicting fog-occurring images at the LT 08 and >70% for different LTs

Estimate fog thickness: mixed-layer model - an physics-informed approach

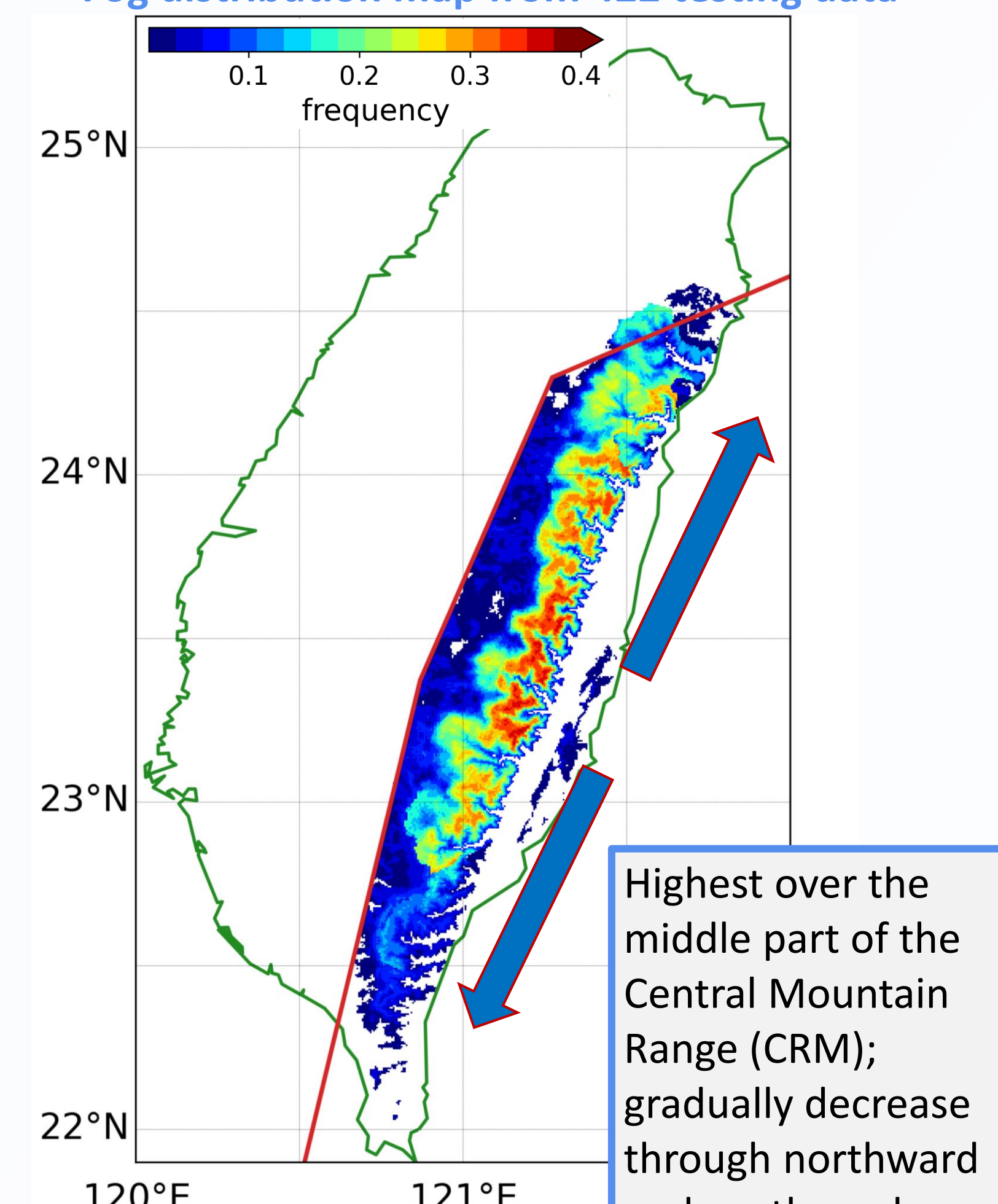
- Fog edge top height (cloud top) --> Boundary layer top
- θ profile --> Saturation mixing ratio
- Moisture profile --> saturated elevation



Potential fog occurrence area

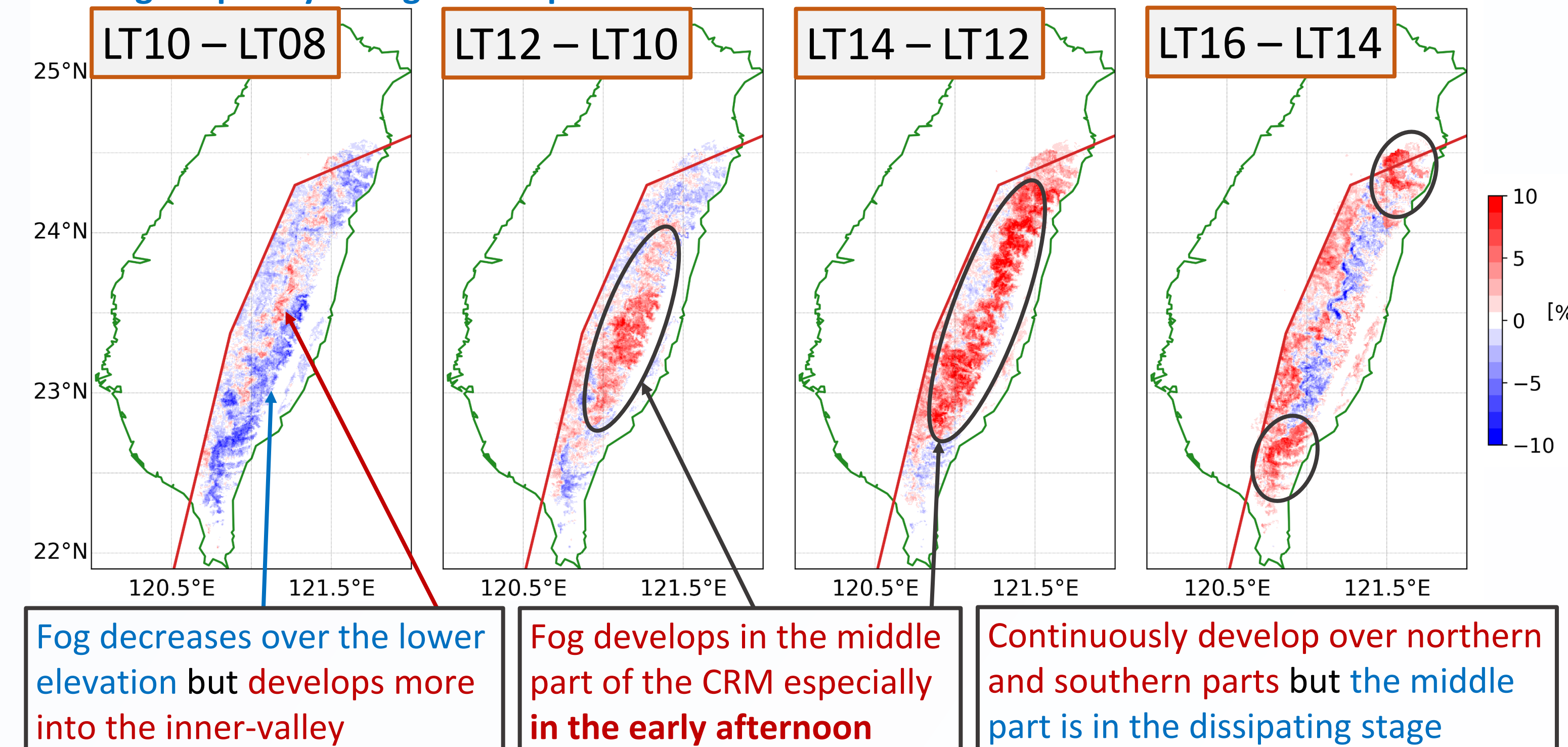


Fog distribution map from 422 testing data



Diurnal variation of fog development

Fog frequency change in the past two hours

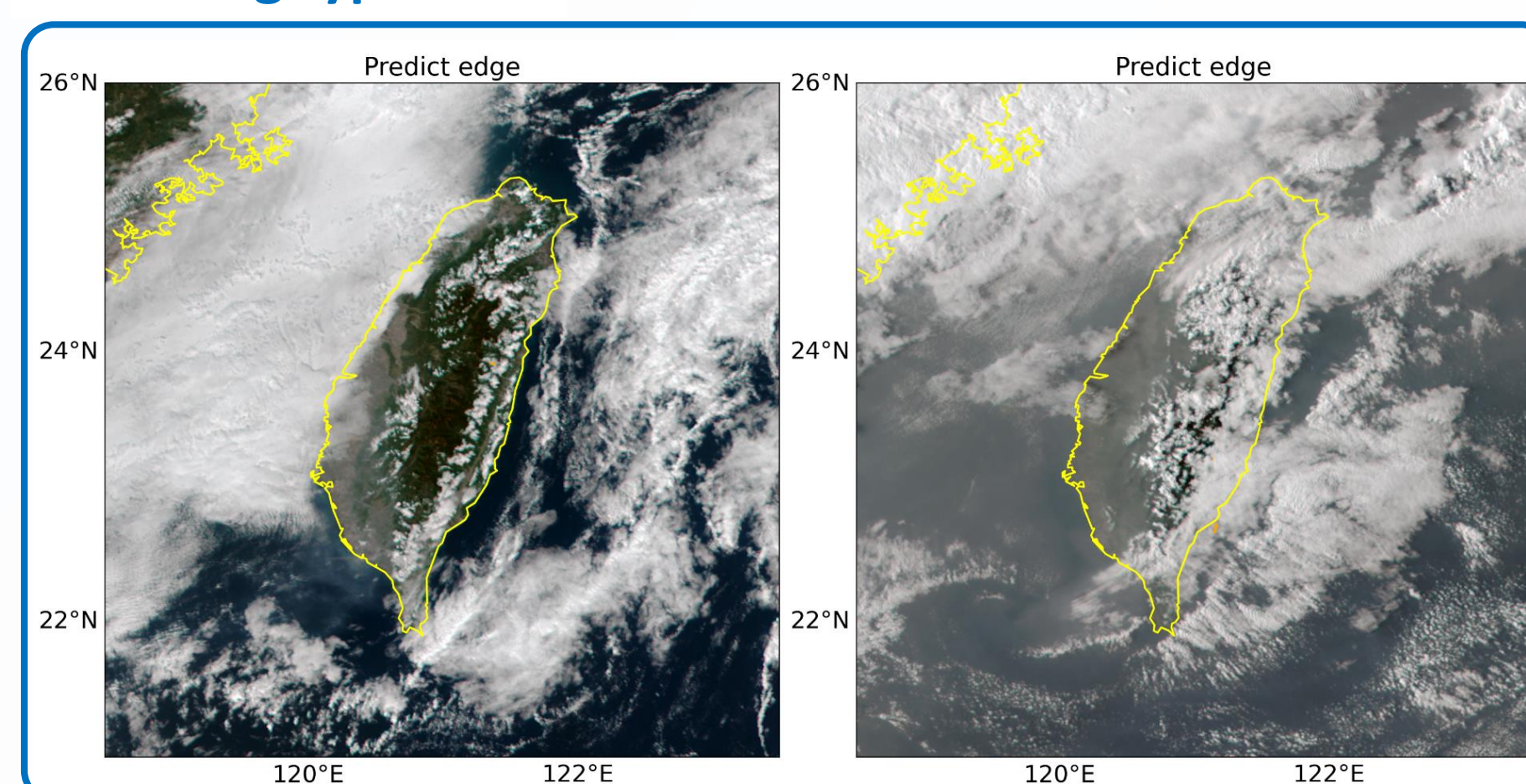


- The life cycle of fog development differs among different river basins
- Semi-realistic simulation (Taiwan-VVM) will be involved to verify the mechanism behind these diurnal variations (the role of local circulation: mountain and valley winds, moisture transport, etc.)

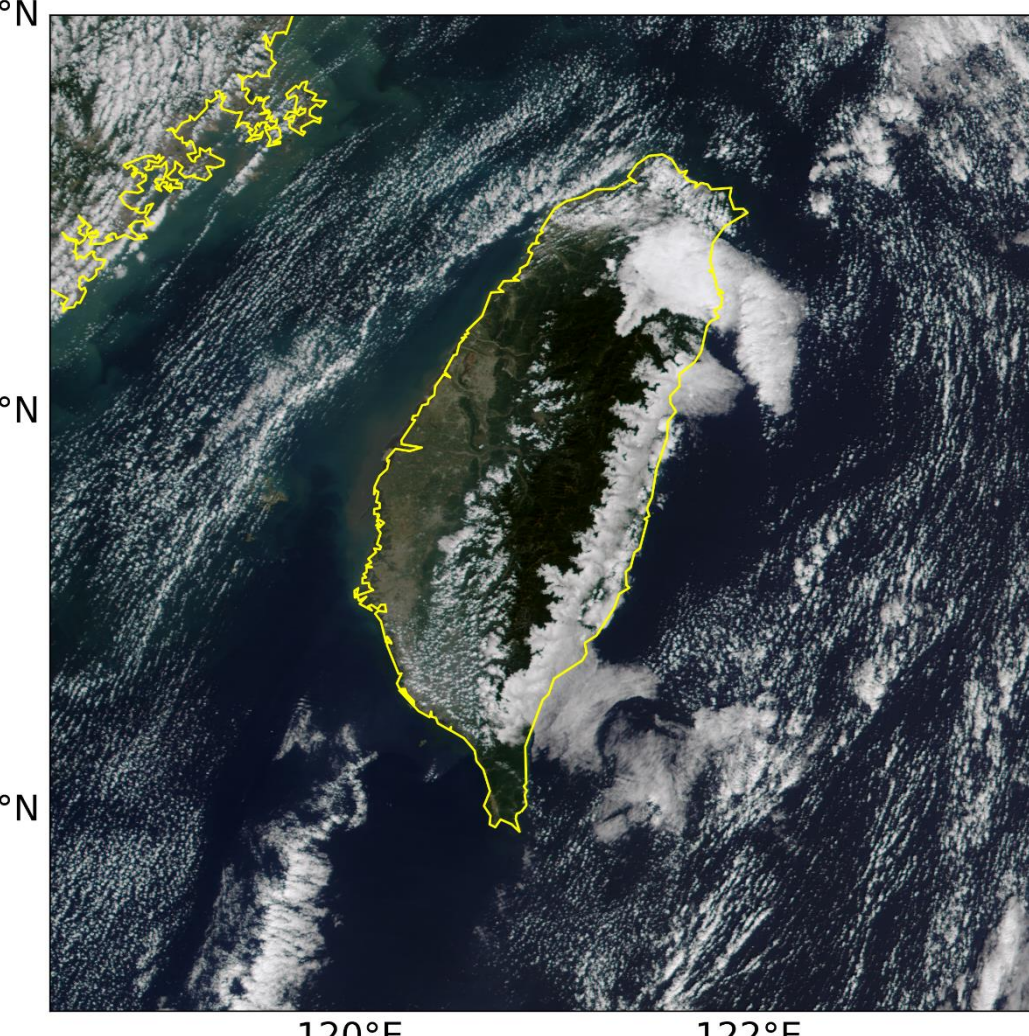
Future work

- More training data can be included, allowing for the further increase of the model performance
- The feasibility of applying the current U-net model to other satellite products can be discussed (e.g. MODIS true color image)

Other Fog types



MODIS true color image



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