

# FengYu: A Foundation AI Model to Bridge the Regions in the Solar–Terrestrial Space

Presented to CGMS-53 Plenary session

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NSMC/CMA

# Sun

# Solar wind

Thermosphere-ionosphere



Solar active region

148,000,000 km

L1

1,500,000 km

Magnetosphere

# Earth

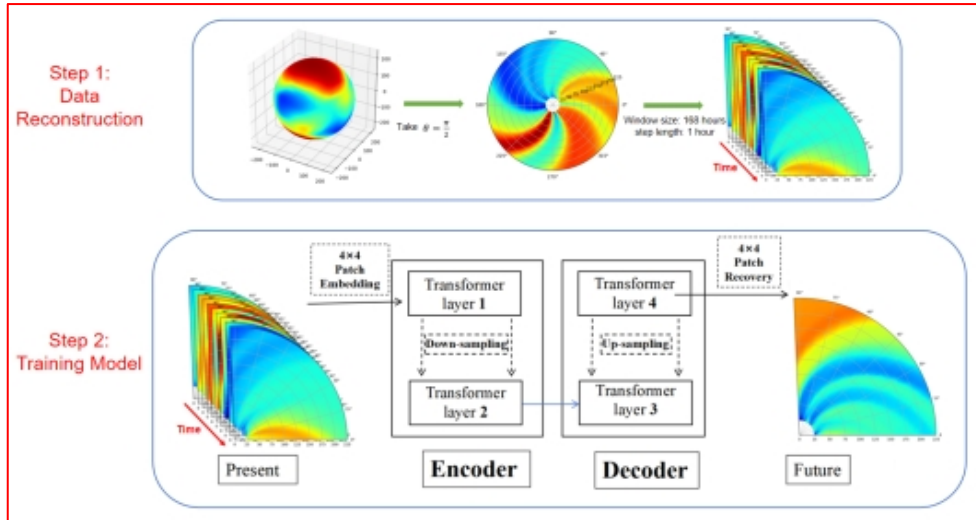
## Three core challenges in space weather forecasting:

1. Cross-scale coupling – spanning from solar eruptions to ionospheric disturbances.
2. High-dimensional parameter space – involving diverse physical quantities across regions.
3. Nonlinear system interactions – difficult to integrate into unified models.

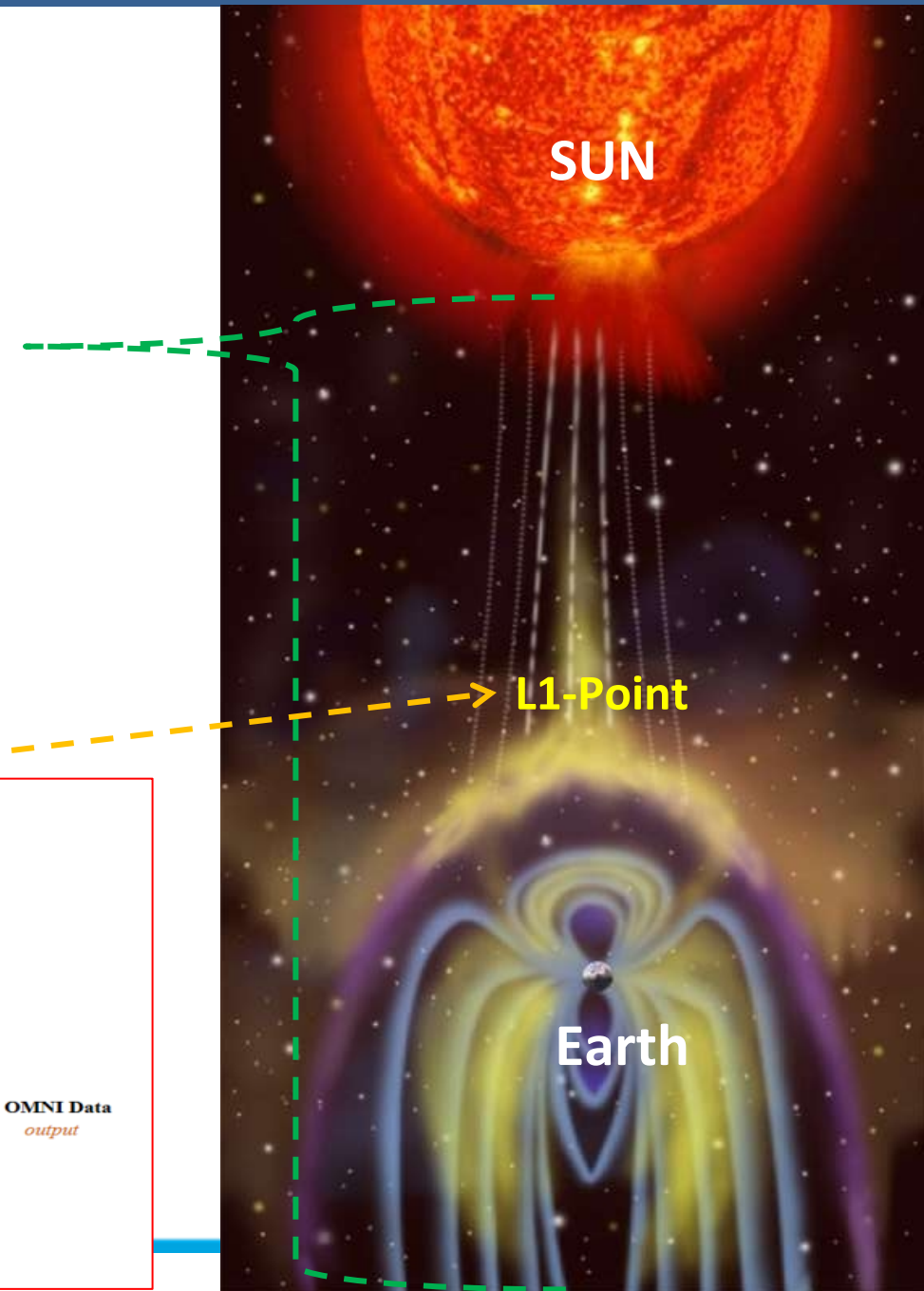
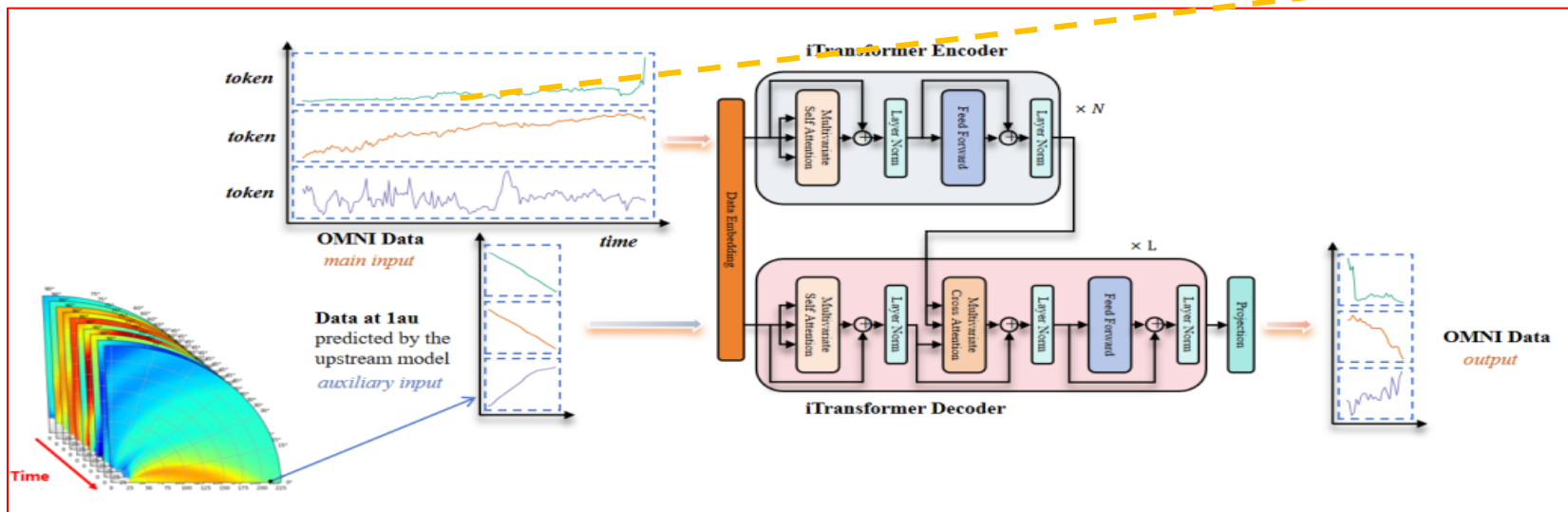


# Solar Wind Forecasting model

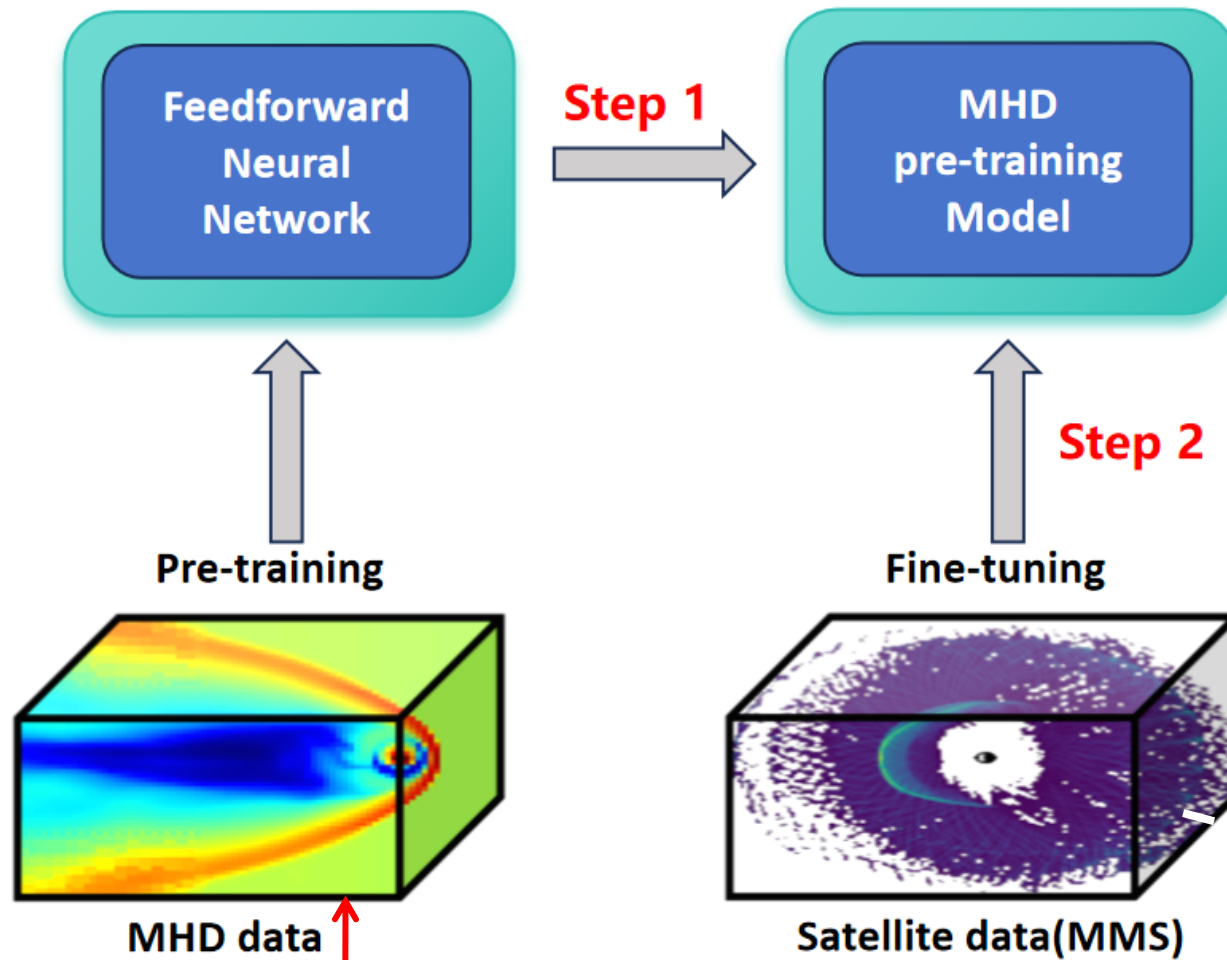
## Step1: Global Solar Wind Forecasting model



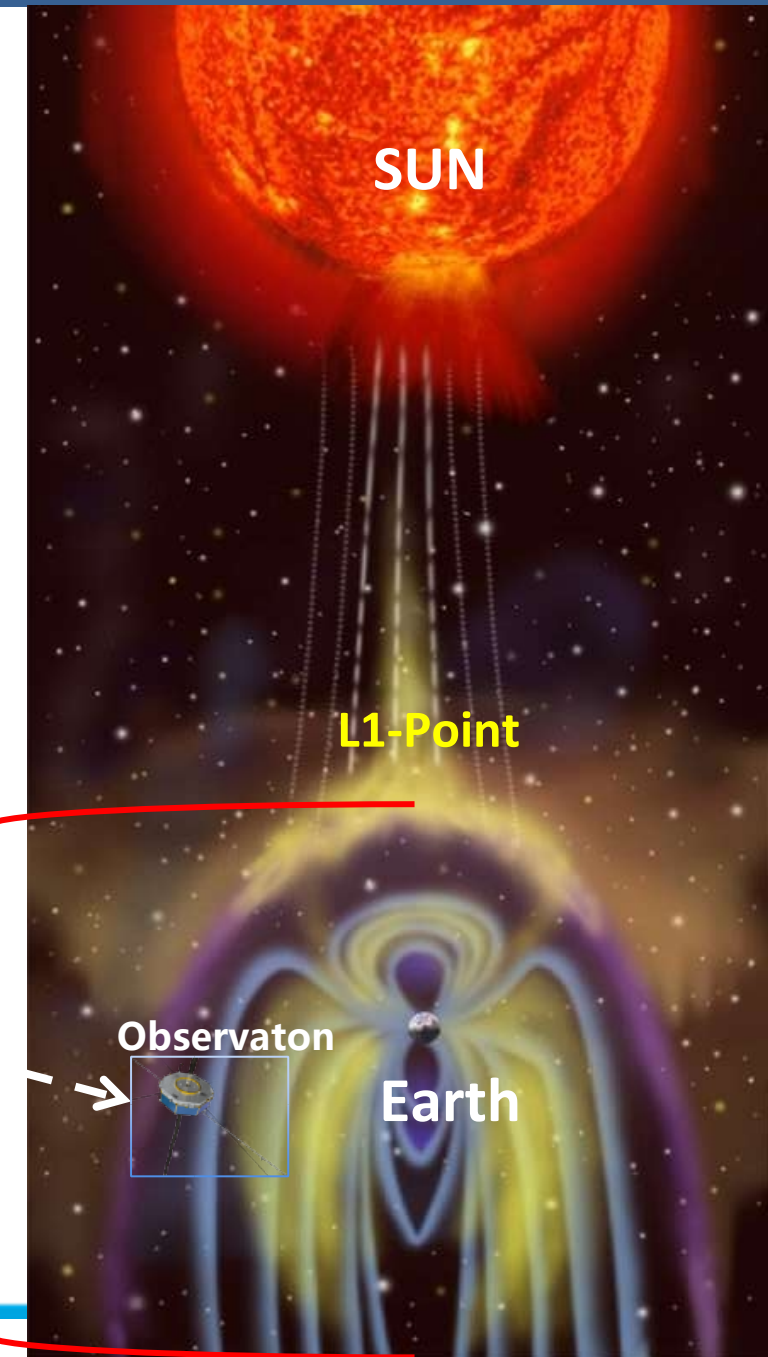
## Step2: L1-Point Solar Wind Forecasting Model



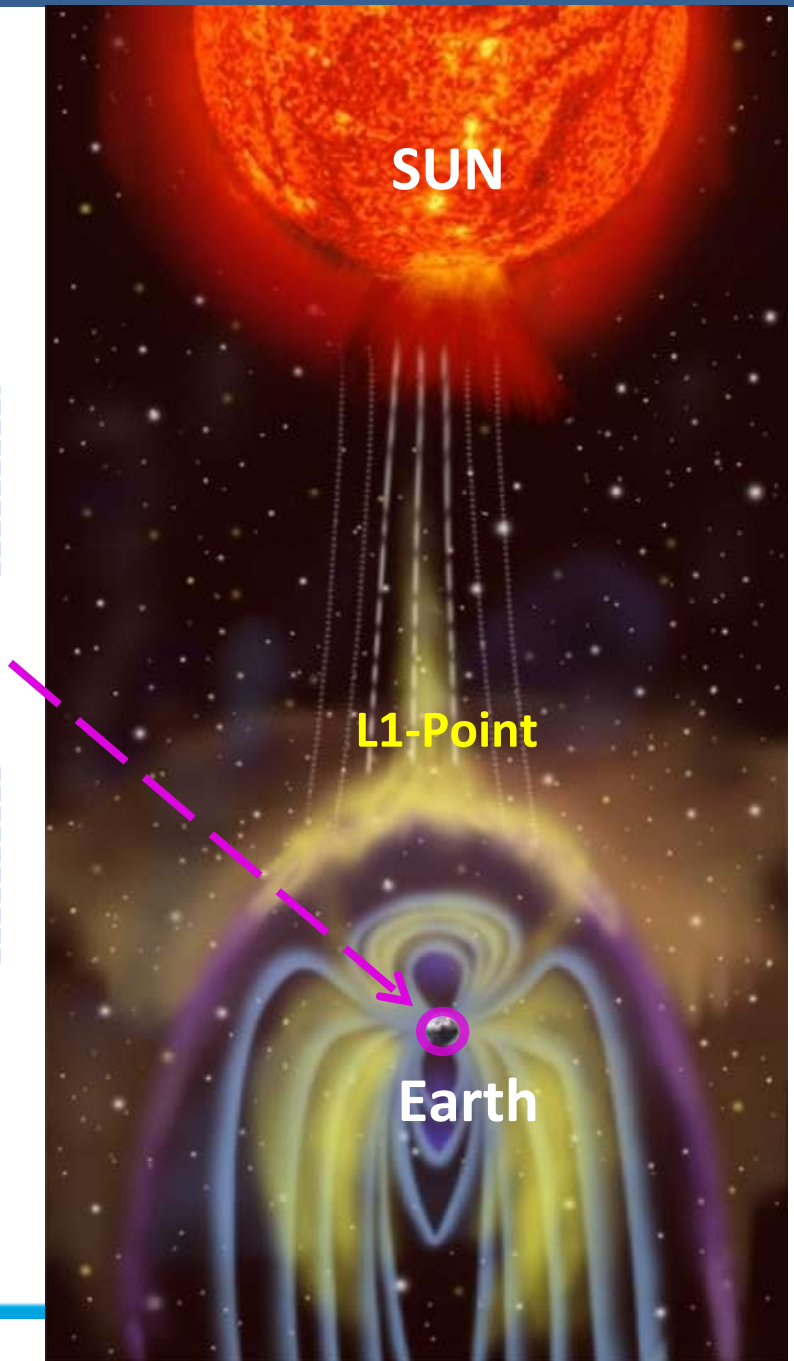
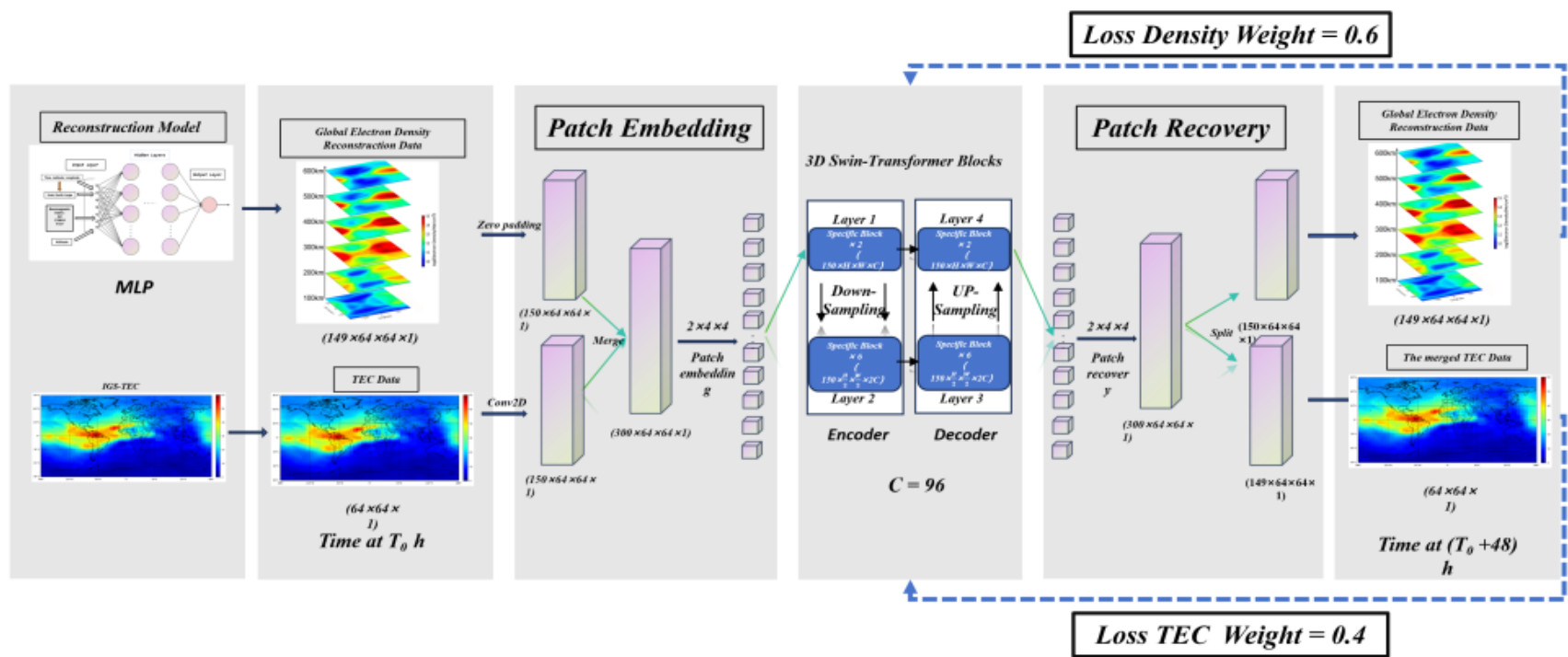
# Magnetosphere Forecasting model



Coordination Group for  
Meteorological Satellites



# Ionosphere Forecasting model

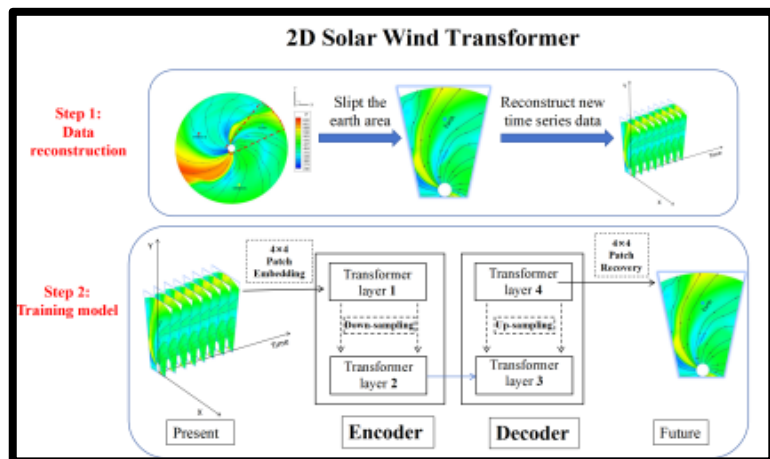




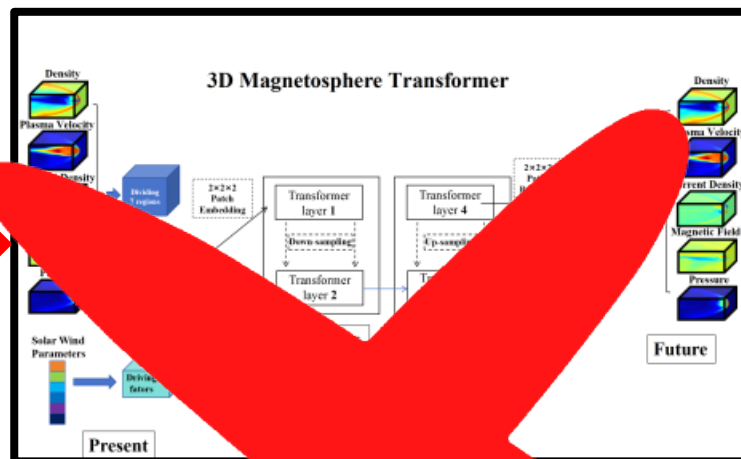
**How to achieve coherent model integration? ----- It remains a significant challenge!**

**Global space weather model must reflect coupling, not just sequencing!**

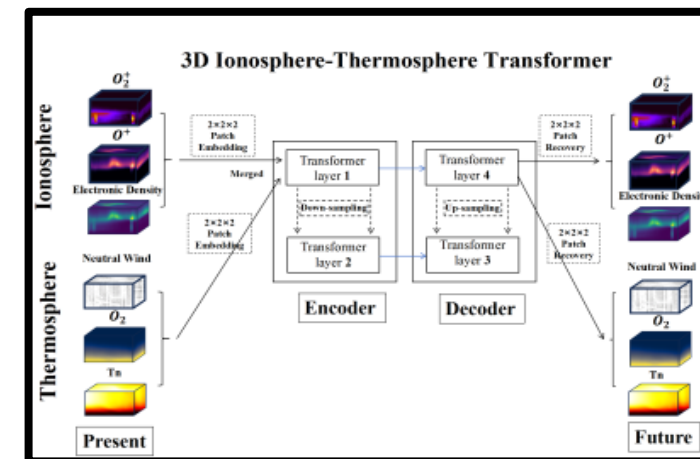
### Solar Wind model

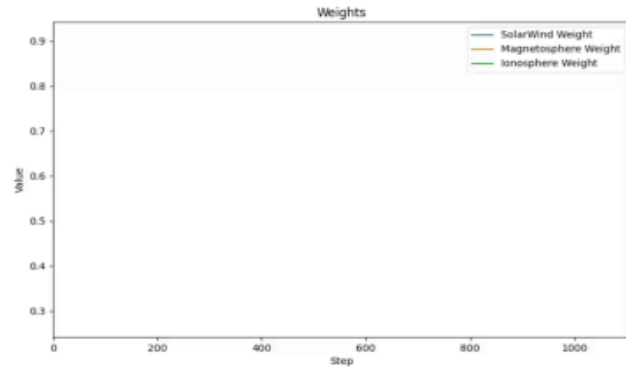


### Magnetosphere model

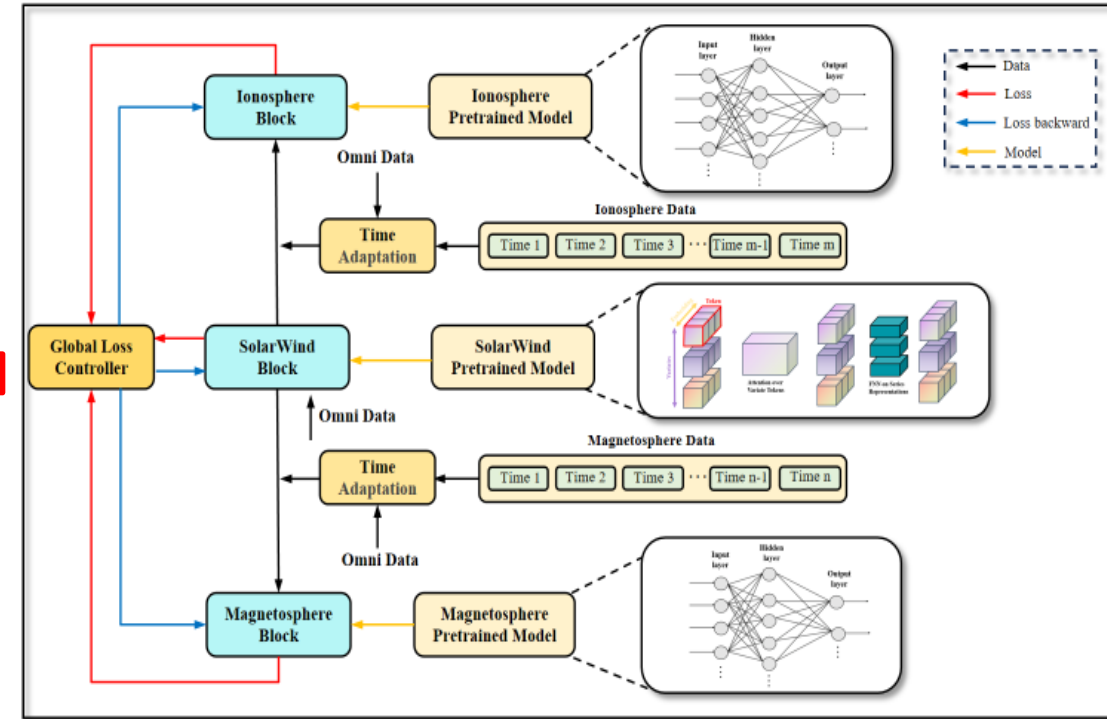
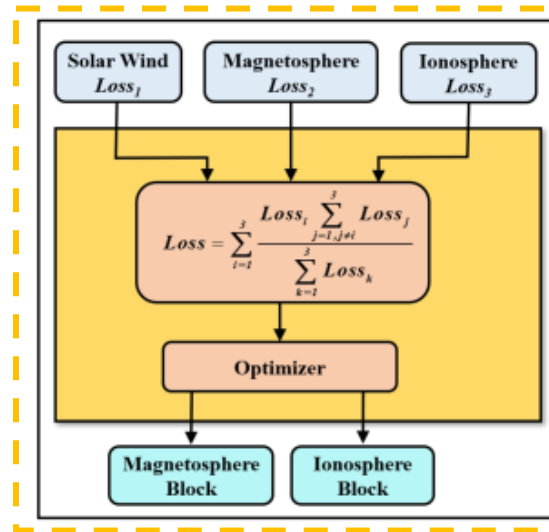


### Ionosphere model





## Global Loss Controller



## Physical Basis for Coupling Optimization:

Due to the solar wind speed being much greater than the local Alfvén speed, the solar wind can effectively influence the magnetosphere and ionosphere, but not vice versa. In contrast, the magnetosphere and ionosphere interact bidirectionally and are both modulated by solar wind forcing.

## Integrating FengYu AI into Next-Generation Space Weather Forecasting

- **Embracing the causal flow of space weather**

- The Sun-to-Ionosphere energy flow forms a clear causal path, ideal for AI to learn and forecast space weather.

- **Modeling physics by region, not one-size-fits-all**

- Different physics across solar wind, magnetosphere, and ionosphere demand tailored AI architectures for each layer.

- **Learning from sparse and heterogeneous observations**

- By fusing GNSS, LEO, and geostationary signals on adaptive grids, FengYu extracts value even from incomplete data.

- **Coordinated optimization across subsystems**

- A dynamic loss mechanism ensures that downstream predictions adjust responsively to upstream disturbances.