STC-ViT: Spatio Temporal Continuous Vision Transformer for Weather Forecasting

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Introduction

Operational weather forecasting system relies on computationally expensive physics-based models. Recently, transformer-based models have shown remarkable potential in weather forecasting achieving state-of-the-art results. However, transformers are discrete models which limit their ability to learn the continuous spatio-temporal features of the dynamical weather system. We address this issue with STC-ViT, a Spatio-Temporal Continuous Vision Transformer for weather forecasting. STC-ViT incorporates the continuous time Neural ODE layers with multi-head attention mechanism to learn the continuous weather evolution over time.

Aims

The main aim of this study is to predict extreme events at high resolution. To achieve this aim future studies would look at:

- Climate Emulation
- Weather and climate downscaling
- Explainable Artificial Intelligence

Methods

We propose STC-ViT which leverages the continuous learning paradigm to effectively learn the complex spatio-temporal changes even from weather data recorded at coarser resolution. The idea is to parameterize the attention mechanism by converting it into a differentiable function. Continuous temporal attention is calculated sample-wise and combined with the patch wise spatial attention to learn the spatio-temporal mapping of weather variables in the embedding space of the vision transformer. Furthermore, we add derivation as a pre-processing step to prepare the discrete data for continuous model and explore the role of normalization in continuous modelling.

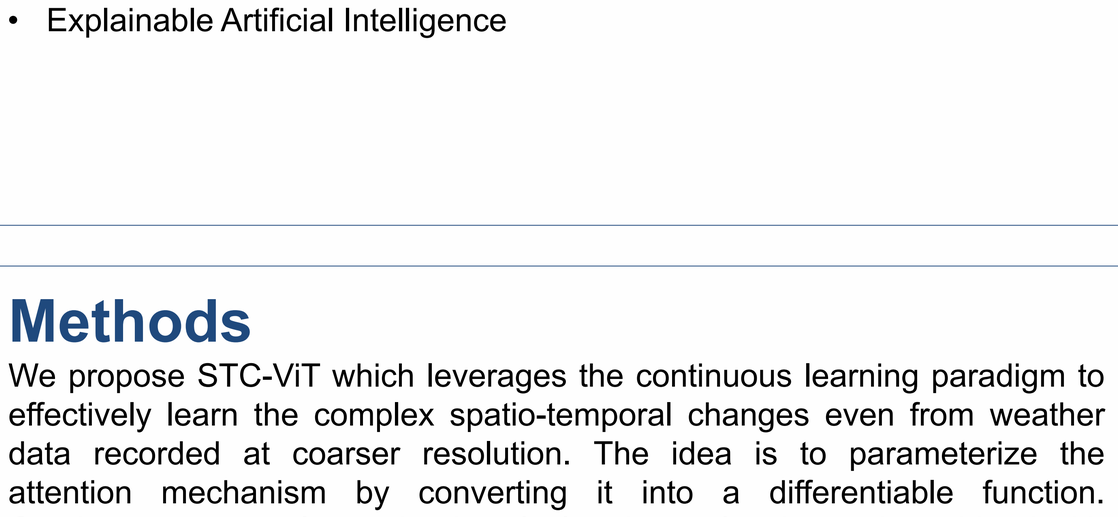

Figure 1: Temporal derivatives of image time series

Results

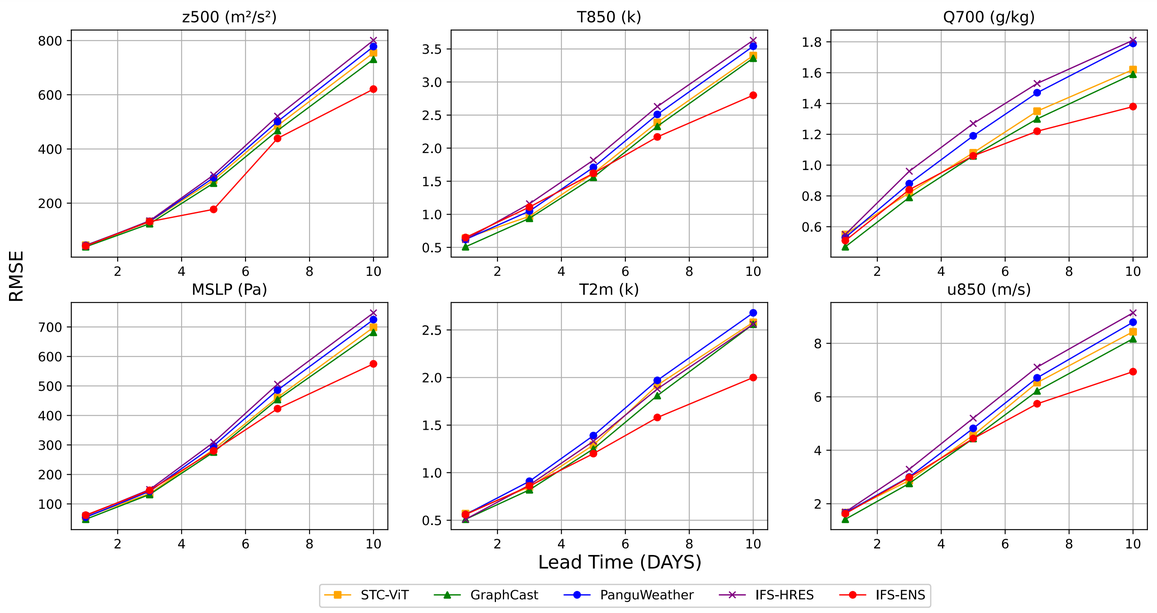

Figure 2: RMSE comparison of STC-ViT trained at 1.40625 degree with GraphCast and PanguWeather trained at 0.25 degree , IFS-ENS at 0.2 degree and IFS-HRES at 0.1 degree resolution data for lead times ranging from 1 to 10 days

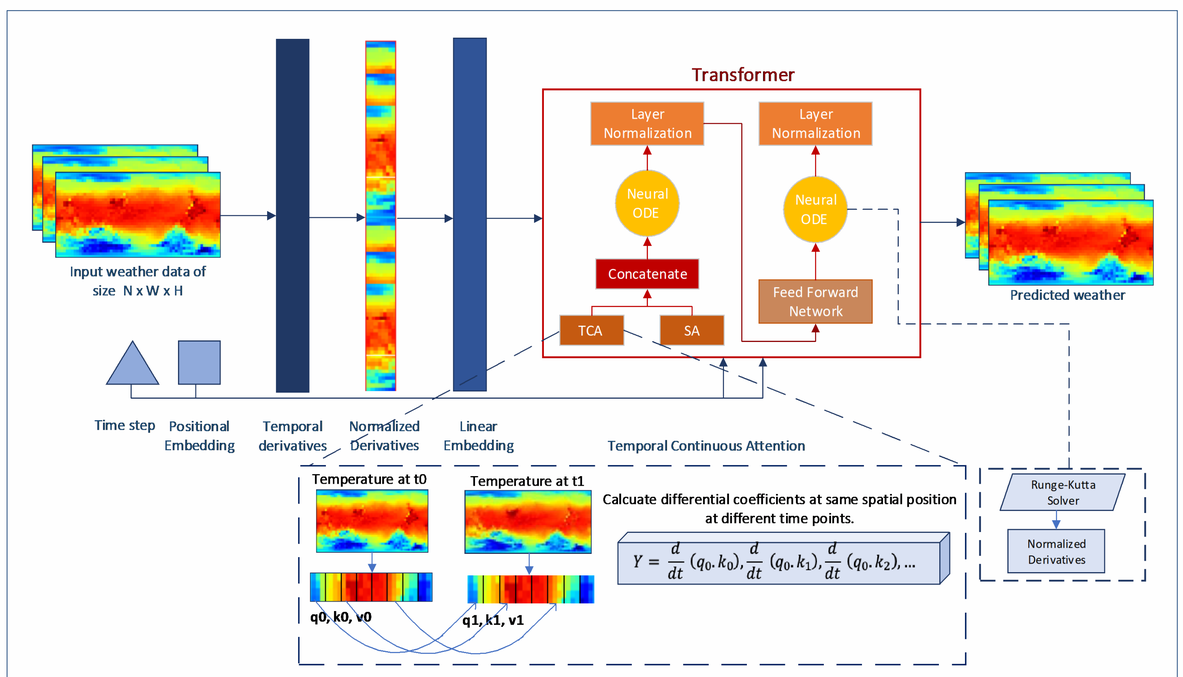

Figure 3: Prediction pipeline of STC-ViT

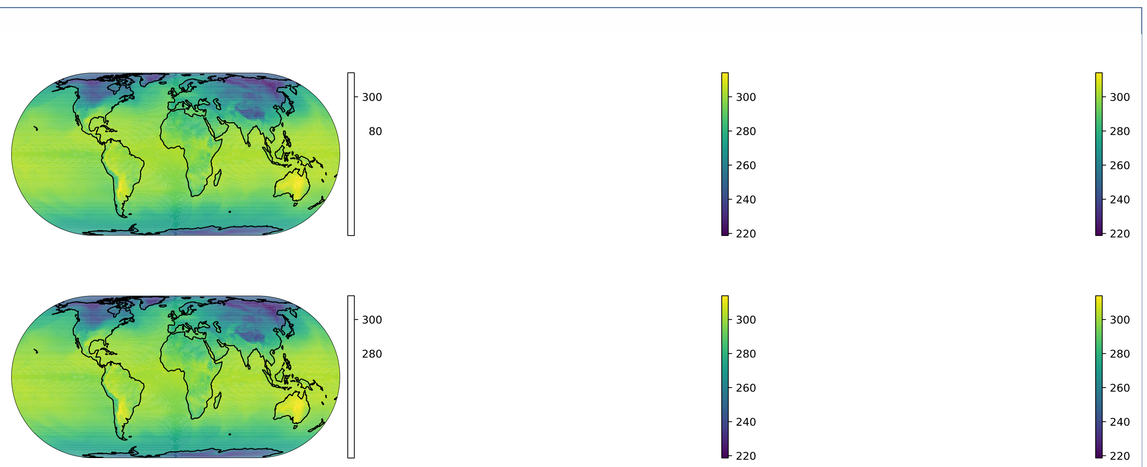

Figure 4: Temperature at 2-meter forecasts

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