Clifford Neural Operators on Atmospheric Data Influenced Partial Differential Equations

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MERRA-2 climate reanalysis dataset

Trained on the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) dataset at an hourly temporal resolution with the following data variables:

- ***SLP*** *(sea-level pressure)*
- ***U10M*** *(zonal 10m wind)*
- ***V10M*** *(meridional 10m wind)*

Implementation:

1. Defining 2 basis vector e_1, e_2 and 1 multi-vector e_1e_2

2. Take input multivector and create a dual function given by:

$a = a_0 + a_1e_1 + a_2e_2 + a_{12}e_1e_2$

$(a_0 + a_{12}i_2) + e_1 (a_1+a_2i_2)$

3. Perform Clifford Fourier transform on each part and revert back and concatenate both

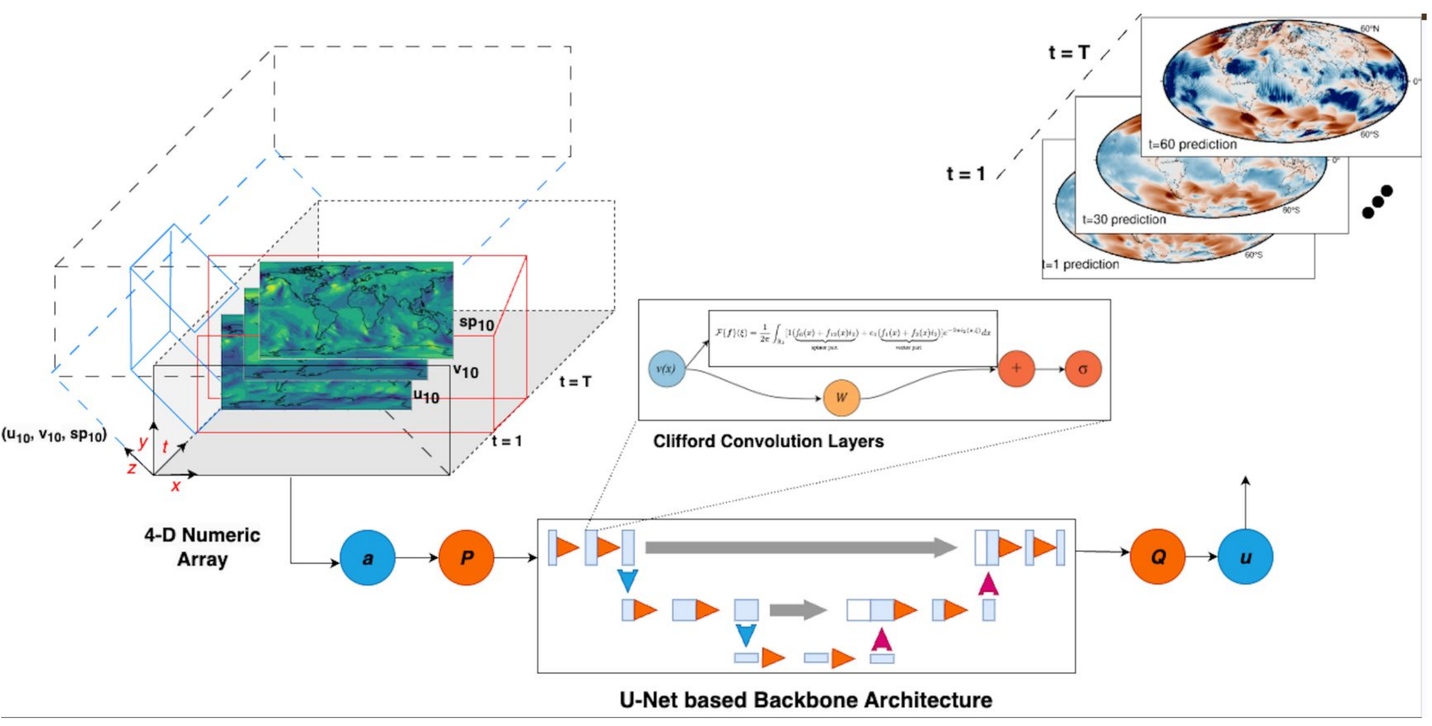
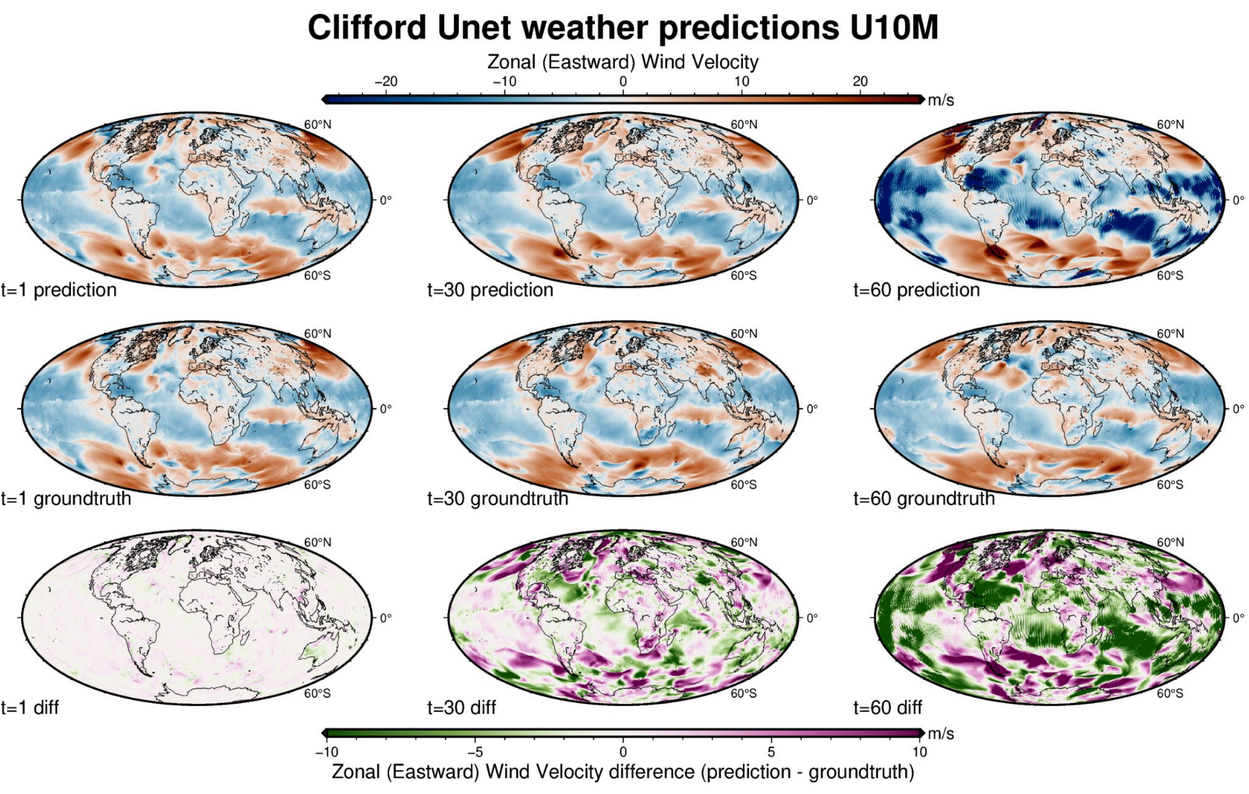
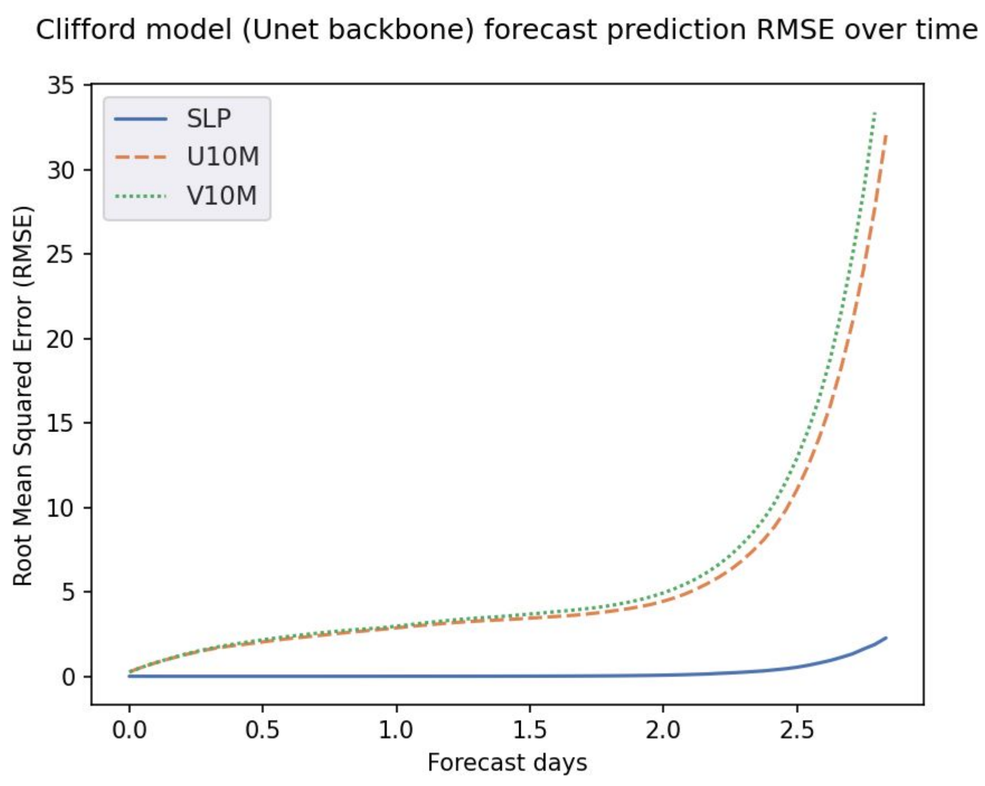


Fig. 2 (above) Illustration of the Clifford-based Neural Operator model with U-Net3 backbone. Inputs (left) are passed in as a 4D tensor of shape [time(t), latitude(y), longitude(x), blades(z)], where blades are surface pressure (sp10), zonal wind (u10) and meridional wind (v10). The model is trained to make weather predictions one timestep ahead, i.e. passing input at t=0 will produce an output at t=1. Example zonal wind outputs are shown on the top right for auto-regressive predictions t=1 hr, t=30 hr and t=60 hr (2.5 days).



U10 prediction from the initial condition at t = 0 to 60 timesteps based on Clifford Fourier convolutions using U-Net as backbone

Instead of treating SLP/U10M/V10M as three different 'channels', we use ***Clifford convolutions*** *and* ***Clifford Fourier transform layers*** *as neural partial differential equation (PDE) surrogates to capture the geometric relationship between scalar fields (SLP) and vector fields (U10M, V10M).*



RMSE of U10M, V10M and SLP prediction from the initial condition at t=0 to 2.5 days based on Clifford Fourier convolutions with U-Net as backbone

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