Optimizing Data-Driven Weather Forecasting: A Global Data-Driven Weather Model Using Adaptive Multiwavelet Transform Operators (AMWT)

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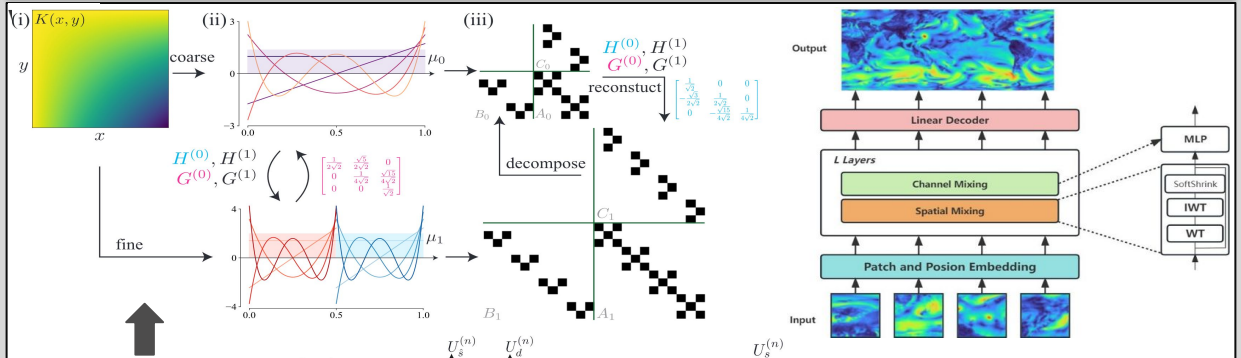
Introduction

- Weather forecasting plays a significant role in modern society, impacting economic planning across various sectors including agriculture and energy production.
- Traditional Numerical Weather Prediction (NWP) models have been widely used, but the increasing demand for data-driven Deep Learning models arises from their lower computational cost, improved speed, and enhanced efficiency.
- Our research focuses on enhancing weather prediction by introducing the Adaptive Multiwavelet Transform Operator (AMWT) [1] model as an improvement on the Adaptive Fourier Neural Operator (AFNO) model used by FourCastNet [2].

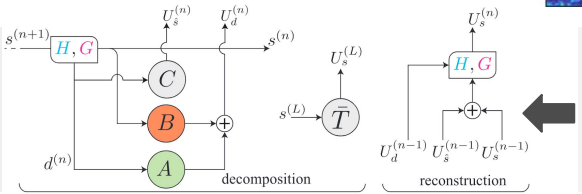
Methods

- We reduced the size and dimensions of the ERA5 dataset to streamline the experimentation phase, ensuring more efficient computations without compromising the essential information in the dataset.
- To perform our comparative analysis, we trained two distinct models, namely AFNO and AMWT, employing the same reduced dataset and compared their output and performance.

AMWT Architecture



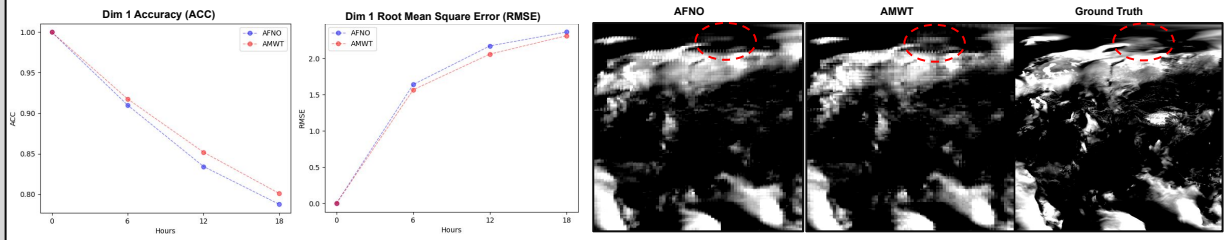
Given the kernel K(x,y) of an integral operator T. The basis for different measures (μ_0,μ_1) at two different scales (coarse=0, fine=1) projects the kernel into 3 components A_i,B_i,C_i [1]



Left: Decomposition cell using A,B,C and T(coarsest scale) performs decomposition from scale n + 1 to n

Right: Reconstruction module using fixed predefined filters $H^{(i)}$,$G^{(i)}$ performs inverse multiwavelet transform from scale n - 1 to n

Results



Conclusion / Future Work

- Our preliminary results demonstrate a substantial improvement in accuracy and a reduction in error when using AMWT compared to AFNO in weather forecasting tasks.
- A key merit of AMWT is its ability to make high-resolution predictions when trained on low-resolution datasets.
- We aim to further test AMWT on other PDE-solving tasks, exploring its applicability in various scientific and engineering domains.

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References

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[2] T. Kurth *et al.*, "FourCastNet: Accelerating global high-resolution weather forecasting using adaptive Fourier neural operators," *Proceedings of the Platform for Advanced Scientific Computing Conference*, 2023. doi:10.1145/3592979.3593412