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What If The Easiest Part of the Global Atmospheric System For Machines To Learn Is The Dynamics?

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We present a deep convolutional neural network (CNN) to forecast four variables on spherical shells characterizing the dry global atmosphere: 1000-hPa height, 500-hPa height, 2-m surface temperature and 700-300 hPa thickness. The variables are carried on a cubed sphere, which is a natural architecture on which to evaluate CNN stencils. In addition to the forecast fields, three external fields are specified: a land-sea mask, topographic height, and top-of-atmosphere insolation. The model is recursively stepped forward in 12-hour time steps while representing the atmospheric fields with 6-hour temporal and roughly 1.9 x 1.9 degree spatial resolution. It produces skillful forecasts at lead times up to about 7 days. The model remains stable out to arbitrarily long forecast lead times.

As an example of its climatological behavior, panel (a) in the figure shows the 1000-hPa and 500-hPa height fields from a free running forecast 195 days after a July initialization. The model correctly develops active wintertime weather systems in response to the seasonal changes in top-of-atmosphere insolation. As a qualitative comparison, panels (b) and (c) show the verification and the climatology for the same January 15th.

While our model certainly does not provide a complete state-of-the-art weather forecast, its skill is less than 2 days of lead time behind the approximately equivalent horizontal resolution T63 137L IFS. It is difficult to make a rigorous timing comparison between our model, which runs on a GPU, and the T63 IFS which was run on a multi-core CPU, but reasonable wall-clock estimates suggest our model is three orders of magnitude faster. It remains to be seen how more advanced deep-learning weather prediction models will compare to current NWP models with respect to both speed and accuracy, but these results suggest they could be an attractive alternative for large-ensemble weather and sub-seasonal forecasting.

Thematic area

1. Machine Learning for Model Identification and Development - Including Model identification, Fast Emulation of Parameterisations, Data driven Parameterisations

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