Improve the sub-seasonal forecast skills by the deep learning: a preliminary study by the GEFSv12 extended forecast

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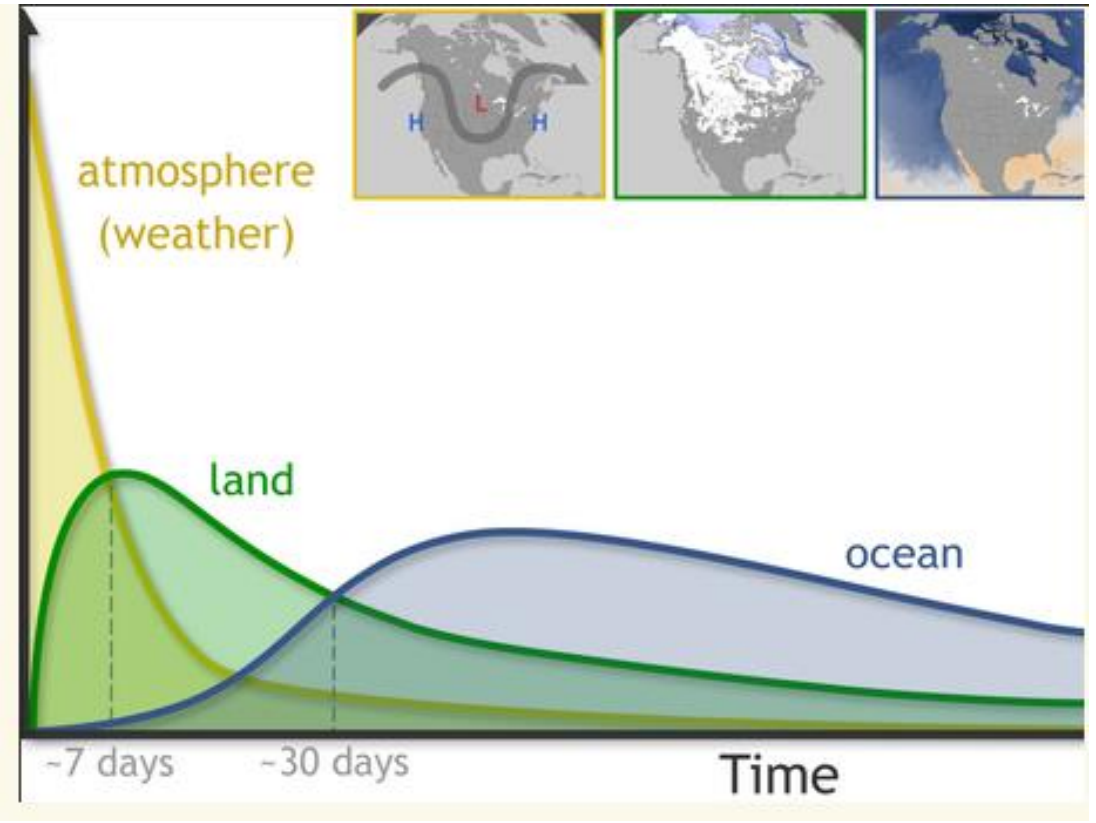
Motivation & Goal

- Explore the application of Artificial Intelligence/Machine Learning for S2S forecast
  - Remove the persistent bias in the dynamics forecast
  - Correct systemic deficient of the forecast model
  - Consolidate forecast signals with multiple field
  - Improve forecast signal by learning historical performance

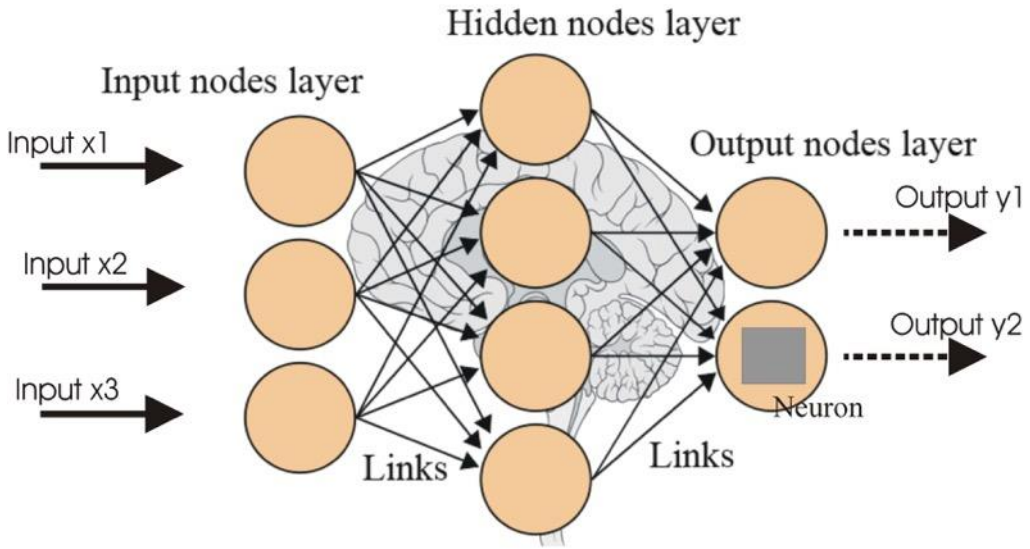
Subseasonal predictability

- Improve sub-seasonal P/T forecast signal
  - Z500 geopotential anomaly (Fan et al 2020)
  - Soil moisture anomaly
    - Shin et al 2020 JHM "Twins" experiment
    - Leaky bucket model
    - offline LDAS style simulation: forced by observed P and T meteorological forcing



From Paul Dirmeyer (COLA/GMU)

Neural Network (NN)



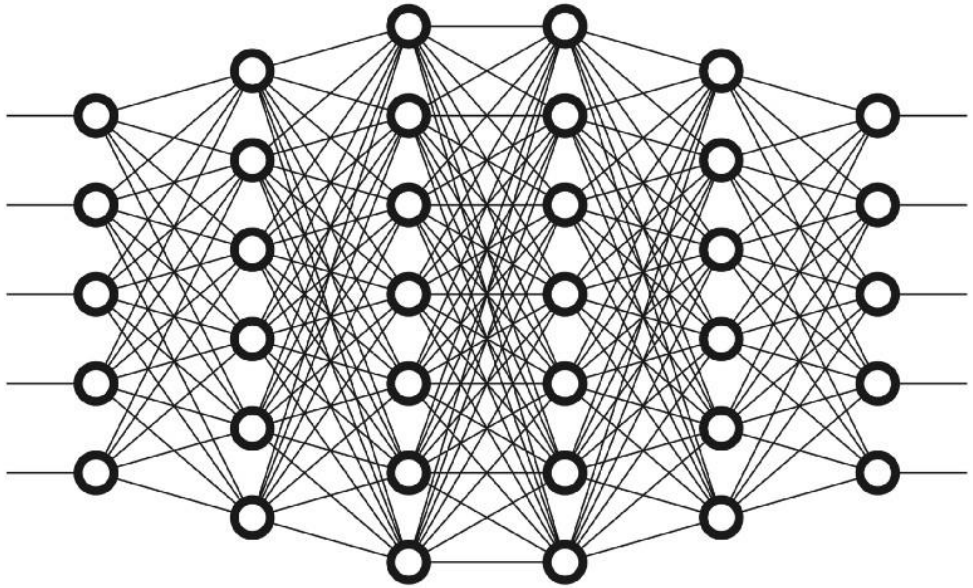
CFSv2 week1-week6 bias correction (Fan et al 2021 WAF)

Based on the EMC [Vladimir Krasnopolsky](#) NN package

- Fortran with BLAC
- Single process single thread

significantly improve the Week 3-4 forecast accuracy and greatly increase the efficiency

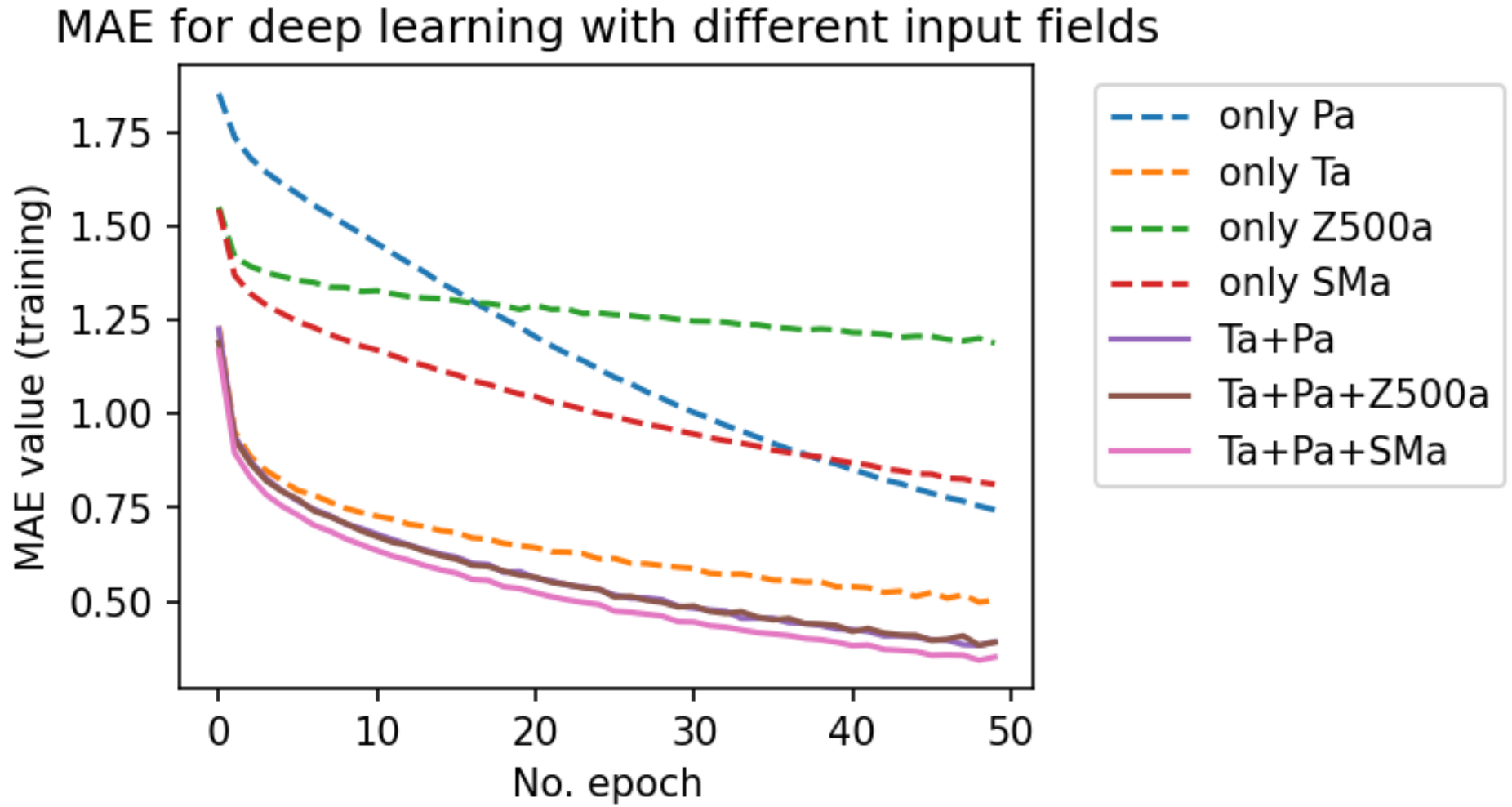
Deep Learning (DL)

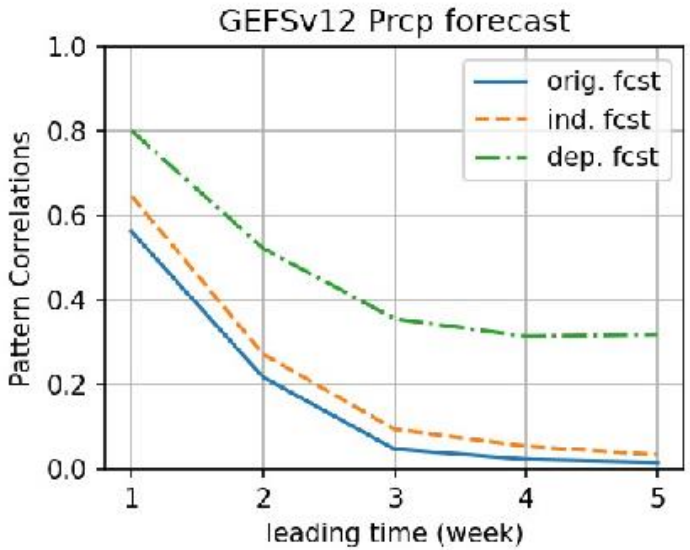


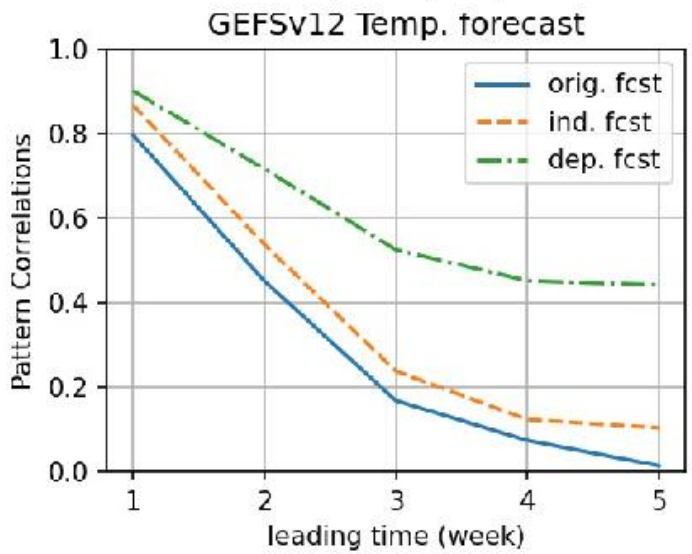
Implemented by the Keras and Tensorflow by Google™

Google + TensorFlow

The learning rate based different combination of predictor fields : for week1 temperature




GEFSv12 Prcp forecast
orig. fcst
ind. fcst
dep. fcst
Pattern Correlations
leading time (week)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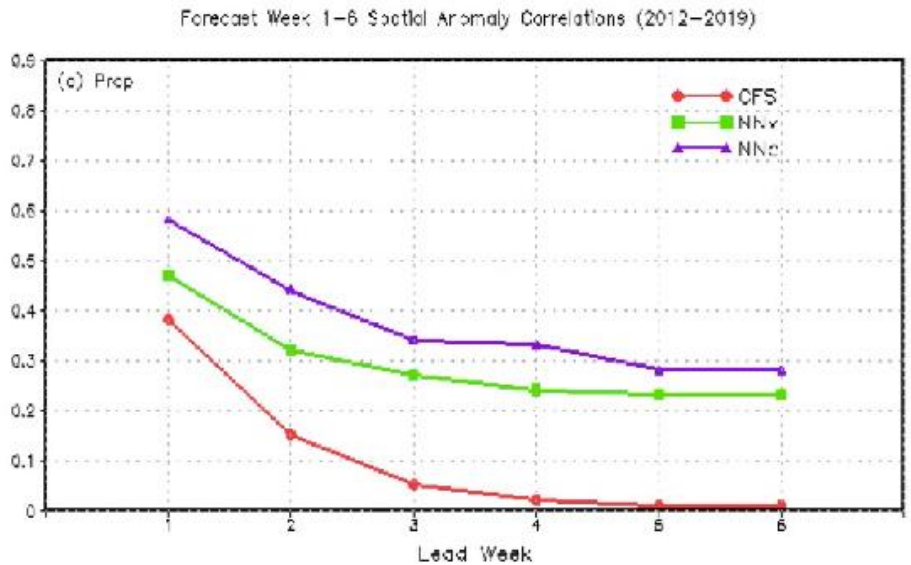
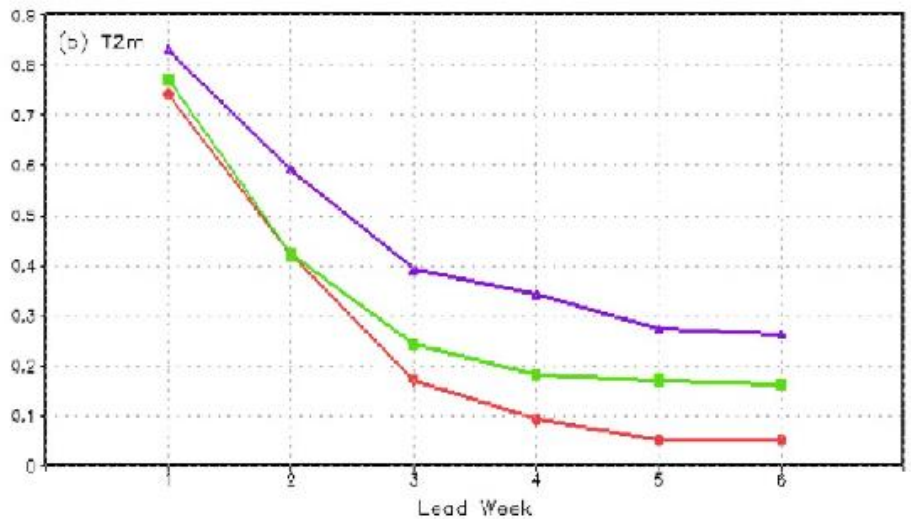

Forecast Week 1-6 Spatial Anomaly Correlations (2012-2019)
(c) Prcp
CFS
Lead Week


(b) T2m
Lead Week

conclusions

- GEFSv12 reforecasts during 2000-2019, weekly extended forecast up to 35 days
- utilized leave-one-year-out cross-validation to evaluate the entirely 20 years hindcast skill
- results indicated the independent forecast, in which the forecasts are derived by cross-validated DL model, show margin improvement at both Temperature and precipitation forecast.
- The improvement is equivalent to another similar study by the neuron network (NN) for CFSv2 forecast (Fan et al 2021)
- However, for the dependent forecast, in which prediction is trained by all available hindcast without cross-validation, the deep learning model shows greatly improve over the Neuron network, and with average ACC reach 0.5 at week-5 forecast.