Time Series Forecasting With LSTM Network Based Model for ENSO

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Abstract

We applied LSTM networks to study El Niño Southern Oscillation (ENSO) in this paper, which can been viewed as a time series forecasting problem on climate change field. We designed different experiments to testify the effectiveness of prediction models with different time series steps. the result showed that the LSTM networks have the ability to capture the long dependencies between the SST data, then forecast the ENSO phenomenon of 15~16 successfully, which show great potential as the supplement with the conventional prediction models, especially with longer multiple steps forecast ahead.

1 Introduction

The El Niño-Southern Oscillation (ENSO) is an irregularly periodic variation during the eastern equatorial Pacific, which is considered as the dominant mode of interannual climate variability observed globally (Wunsch 1990). ENSO is associated with many climate changes globally (Fraedrich 1994; Wilkinson et al.1999), so a skillful prediction of ENSO is highly desired.

So far, both dynamical and statistical models are applied for forecasting ENSO (Barnston 2012). The dynamical models use physical equations of the ocean and atmosphere to forecast ENSO and the statistical models use mathematical formulations to learn from the observed data to forecast ENSO. However, ENSO is not predicted well enough up to 6 months due to the existence of predictability barrier (Goddard et al., 2001), and the computationally are very expensive while applying those climate models. Those two points remain room for further study for this problem.

Recently, some researchers have attempted to apply machine learning methods for this problem, especially deep learning methods. LSTM networks have been applied to predict sea surface temperature (Zhang 2017) and tropical cyclones (Li 2017), which are highly related to ENSO phenomenon (Hong 2001; Catto 2012). A hybrid model with ANN and ARIMA model have also been used to predict ENSO, and the result is slightly better than an ensemble prediction model (Nooteboom 2018). Those preliminary results show great potential with LSTM networks for studying ENSO case, which will be discussed further in this paper.

The structure of this paper as follow: Section 2 formalizes the ENSO forecasting problem, which we transferred as a time series problem here. In Section 3, we discussed the data and applied model details. The experiment result and detailed parameters setting are reported in Section 4. The paper concludes with a summary and discussion in Section 5.

2 Problem Formulation

1.Prediction ENSO 🡪 using Nino 3.4 as the predictand;  
2.Predict Nino 3.4 🡪 a time series forecasting problem with multiple steps ahead.

Nino3.4 as the predictand

Predict ENSO 🡪 time series problem of predict Nino 3.4 index with multiply steps(the predictand).

3 Data and Model

Dataset Description

1.Data source 🡪   
<https://www.esrl.noaa.gov/psd/gcos_wgsp/Timeseries/Nino34/> （From 1870~2018 May, we use from 1870.01~2017.12 ）  
2.Some data Analysis (why no need normalization and pre-processing)

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“The training sequences are sliding windows”

MIMO Time Series Forecasting

Introduction of multiple input and multiple output and why we need multiple steps for ENSO case.

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LSTM Network

Brief introduction of LSTM networks

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4 Experiment

Tools introduction(Kears), parameter setting, metric(MSE)…

Compare with Convention Neural Networks

Detailed

Compare with Climate Models

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Prediction of ENSO during 2015~2016

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5 Conclusion

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Applied LSTM for ENSO case and compare the result with classical models, the result show great potential for this problem.

Works todo :

1.more complex data setting (considering the inner Dynamics mechanism) ;  
2. Single is not enough to cover all ENSO information, grid dataset is a optional;

References

Wunsch, C. 1990. El Nino, La Nina, and the Southern Oscillation. *Science* 248(4957), 904-906.

Barnston, A. G., Tippett, M. K., L'Heureux, M. L., Li, S., & DeWitt, D. G. 2012. Skill of real-time seasonal ENSO model predictions during 2002–11: Is our capability increasing?. *Bulletin of the American Meteorological Society* 93(5), 631-651.

Zhang, Q., Wang, H., Dong, J., Zhong, G., & Sun, X. 2017. Prediction of sea surface temperature using long short-term memory. *IEEE Geoscience and Remote Sensing Letters* 14(10), 1745-1749.

Nooteboom, P. D., Feng, Q. Y., López, C., Hernández-García, E., & Dijkstra, H. A. 2018. Using Network Theory and Machine Learning to predict El Niño. *arXiv preprint arXiv*:1803.10076.

Rayner, N. A., Parker, D. E., Horton, E. B., Folland, C. K., Alexander, L. V., Rowell, D. P., ... & Kaplan, A. 2003. Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *Journal of Geophysical Research: Atmospheres* 108(D14).

Goddard, L., Mason, S. J., Zebiak, S. E., Ropelewski, C. F., Basher, R., & Cane, M. A. 2001. Current approaches to seasonal to interannual climate predictions. *International Journal of Climatology* 21(9), 1111-1152.

Li, Y., Yang, R., Yang, C., Yu, M., Hu, F., & Jiang, Y. 2017. Leveraging LSTM for rapid intensifications prediction of tropical cyclones*. ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences*, 4.

Hong, C. H., Cho, K. D., & Kim, H. J. 2001. The relationship between ENSO events and sea surface temperature in the East (Japan) Sea. *Progress in oceanography* 49(1-4), 21-40.

Catto, J. L., Nicholls, N., & Jakob, C. 2012. North Australian sea surface temperatures and the El Niño–Southern Oscillation in observations and models*. Journal of Climate* 25(14), 5011-5029.

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References

Clancey, W. J. 1984. Classification Problem Solving. In *Proceedings of the Fourth National Conference on Artifi­cial Intelligence,* 49-54. Menlo Park, Calif.: AAAI Press.

Engelmore, R., and Morgan, A. eds. 1986. *Blackboard Sys­tems.* Reading, Mass.: Addison-Wesley.

Hasling, D. W.; Clancey, W. J.; and Rennels, G. R. 1983. Strategic Explanations in Consultation. *The International Journal of Man-Machine Studies* 20(1): 3–19.

Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Department of Computer Science, Stanford University, Stanford, CA.

Robinson, A. L. 1980a. New Ways to Make Microcircuits Smaller. *Science* 208:1019-1026.

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