University of Hawai'i at Manoa

Forecasting Reference Evapotranspiration (ETo) Using Non-Linear Autoregressive (NAR) Artificial Neural Network (ANN)

Presented By:

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Introduction

- Recurrent Neural Networks (RNNs) were used to forecast reference Evapotranspiration (ETo)
- Three RNN approaches are used:
  1. Univariate time series
  2. Multivariate single-step model time series
  3. Multivariate multi-step model time series

Three RNN Models

- Univariate time series
  - Trains a model using only a single feature (ET_o). Predicts a single timestep.
- Multivariate single-step model time series
  - Trains a model using multiple features. Predicts a single timestep.
- Multivariate multi-step model time series
  - Trains a model using multiple features. Predicts multiple timestep.

Reference Evapotranspiration (ET_o)

What is ET_o?

- ET_o is the evaporating power of the atmosphere
- ET_o is only affected by climactic conditions
- Example: wind speed, humidity, solar radiation, and precipitation

Penman-Monteith

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma(900/(T+273)U(e_s - e_a))}{\Delta + \gamma(1 + 0.34U)}$$

Factors Limiting Accuracy

- Moist air travels 800 miles from the Gulf of Mexico to Nebraska

- Other factors:
  - Changing freeze-free season
  - Hurricane remnants
  - Arctic Air
  - Blizzards, especially in the great plains

Why use RNNs to forecast ET_o?

- Hydrologic time-series (especially ET_o) are often non-linear with irregularities and noise

- RNNs are usually superior than traditional statistical approaches for analyzing non-linear timeseries

Benefits and Uses

- To calculate Evapotranspiration (ET) and Crop Evapotranspiration (ET_c)

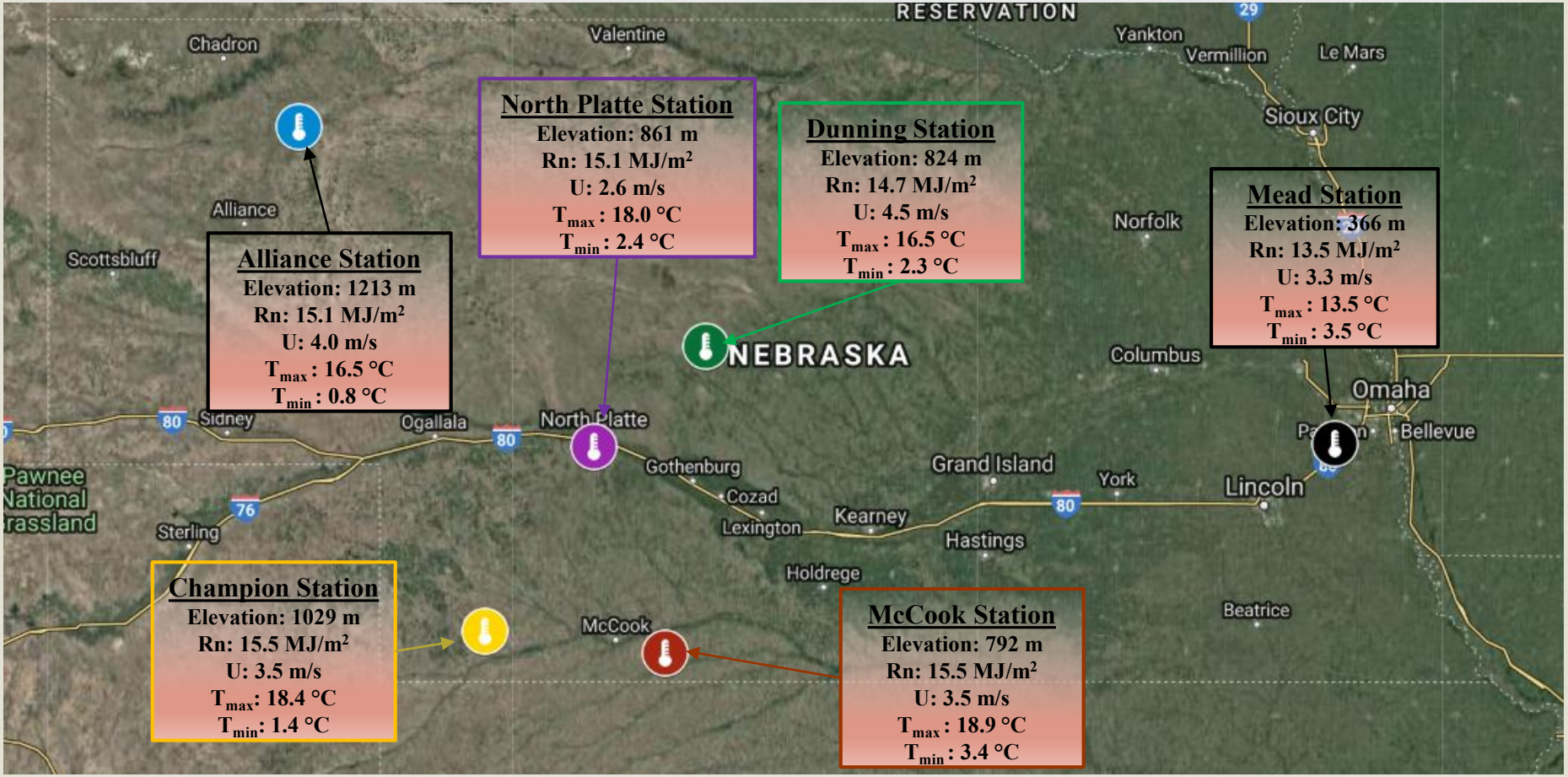
$$ET_c = K_c \, Et_o$$

- By the accurate forecast of ET_c, a more efficient irrigation schedule can be achieved

Data

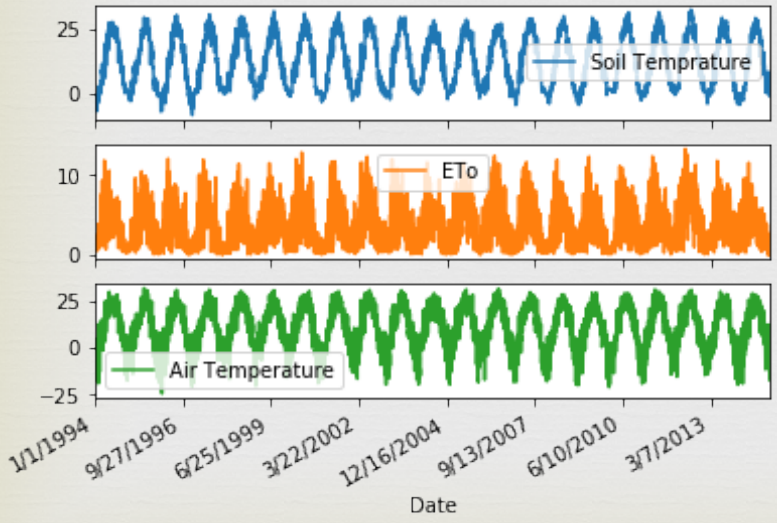
- For future research, six weather stations in Nebraska are selected in different hydrological and vegetative conditions to evaluate the model robustness in different environments
- Only Mead weather station was chosen for this project
- Stations record daily solar radiation, air temperature, wind speed, relative humidity, precipitation, and soil temperature
- The measurements are available on the High Plains Regional Climate Center (HPRCC) archive from 1994 to 2016

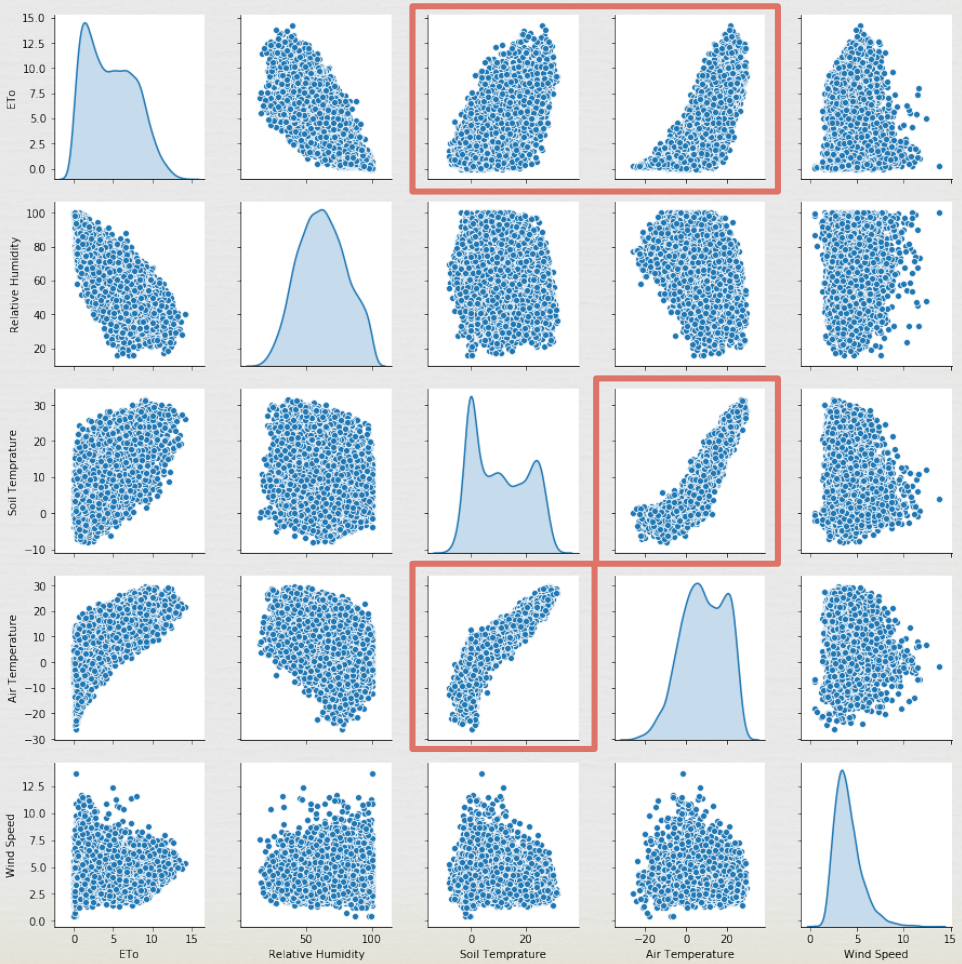
Data


RESERVATION
Chadron
Valentine
Yankton
Vermillion
Le Mars
Sioux City
Alliance
Scottsbluff
Norfolk
Columbus
Omaha
Bellevue
Sidney
Ogallala
North Platte
Gothenburg
Cozad
Lexington
Kearney
Grand Island
York
Lincoln
Hastings
Holdrege
Sterling
Pawnee National Grassland
McCook
Beatrice
NEBRASKA
80
76
29
North Platte Station
Elevation: 861 m
Rn: 15.1 MJ/m²
U: 2.6 m/s
T_max : 18.0 °C
T_min : 2.4 °C
Dunning Station
Elevation: 824 m
Rn: 14.7 MJ/m²
U: 4.5 m/s
T_max : 16.5 °C
T_min : 2.3 °C
Alliance Station
Elevation: 1213 m
Rn: 15.1 MJ/m²
U: 4.0 m/s
T_max : 16.5 °C
T_min : 0.8 °C
Mead Station
Elevation: 366 m
Rn: 13.5 MJ/m²
U: 3.3 m/s
T_max : 13.5 °C
T_min : 3.5 °C
Champion Station
Elevation: 1029 m
Rn: 15.5 MJ/m²
U: 3.5 m/s
T_max: 18.4 °C
T_min: 1.4 °C
McCook Station
Elevation: 792 m
Rn: 15.5 MJ/m²
U: 3.5 m/s
T_max : 18.9 °C
T_min : 3.4 °C

Data

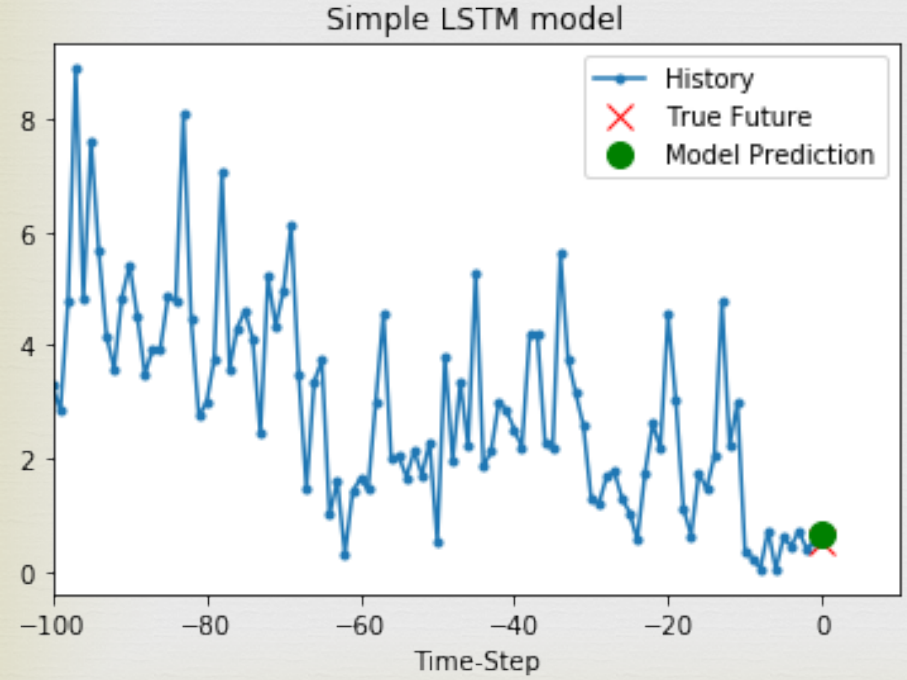
- Co-relations were observed using scatter plots

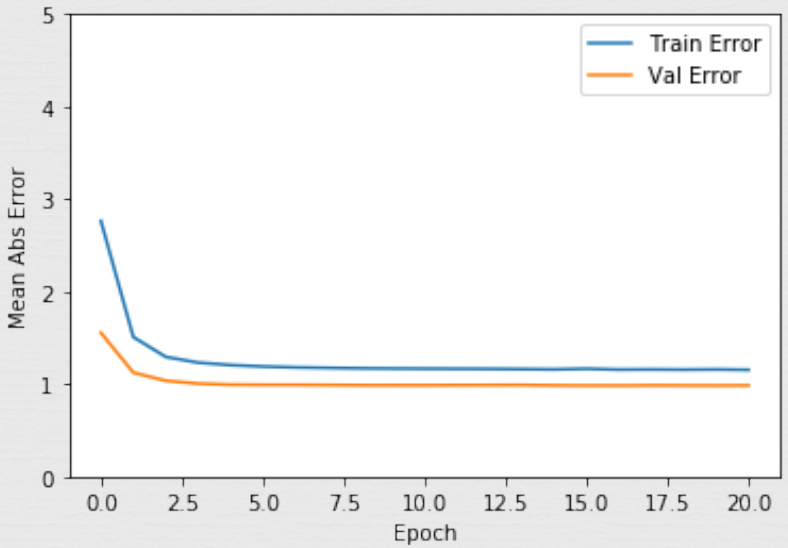




Calibration and Training Uni-variate

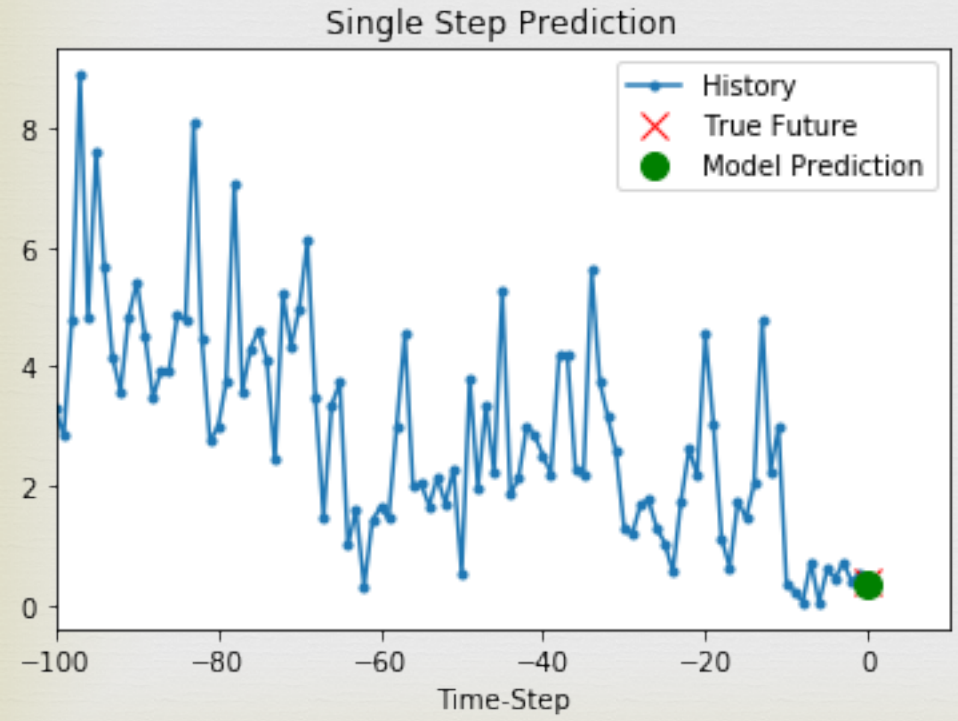
- 100 days are used to forecast 1 day ahead

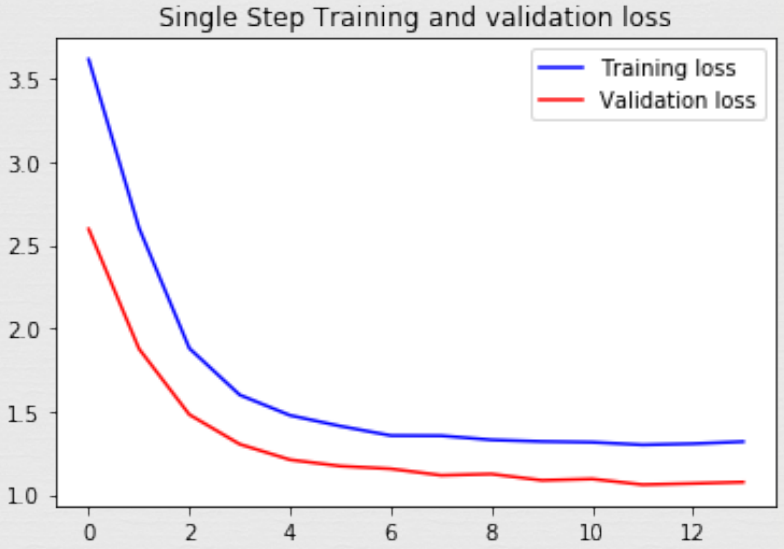




Calibration and Training Multi-variate Single-step

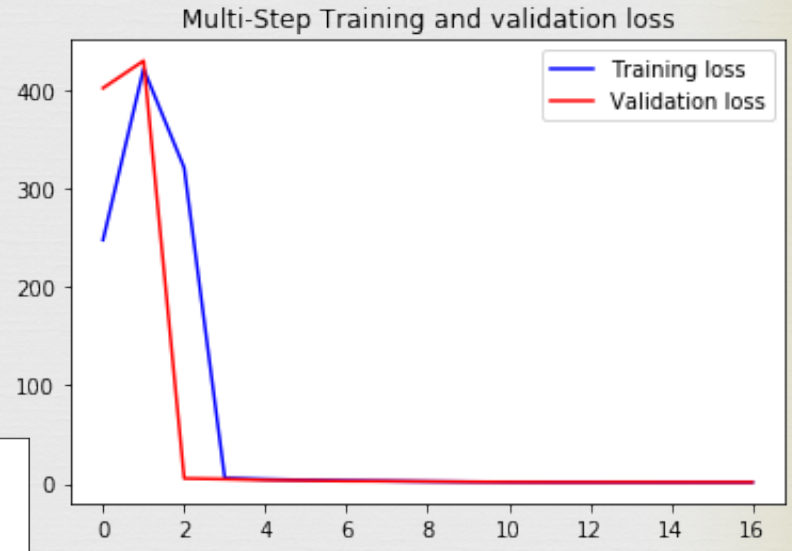
- 100 days are used to forecast 1 day ahead

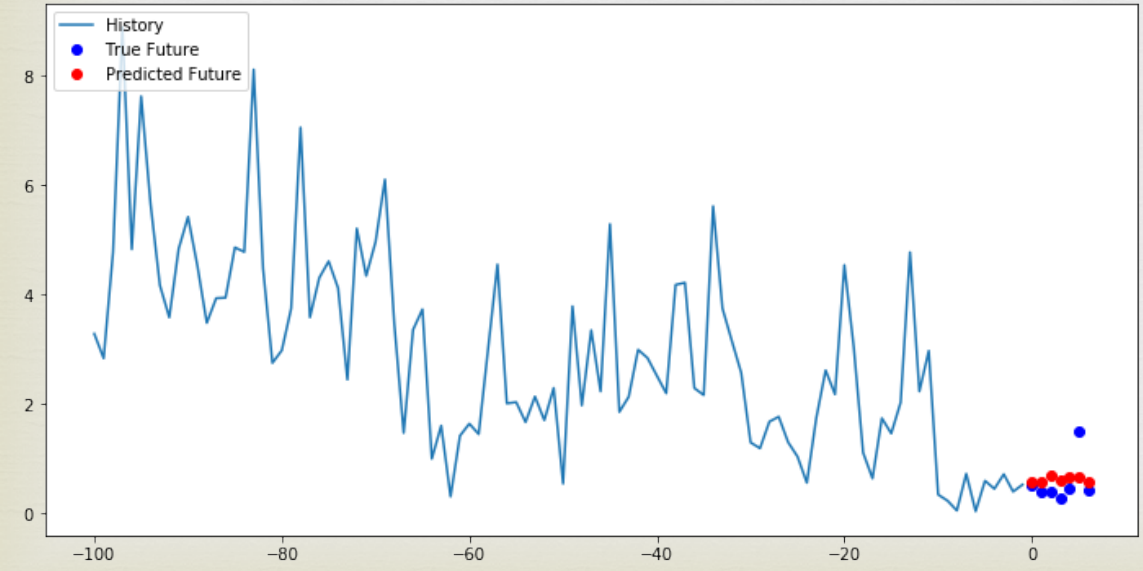




Calibration and Training Multi-variate Multi-step

- 100 days are used to forecast 7 day ahead





References

- Link to my RNN https://colab.research.google.com/drive/1jKPjVs6Q6aXDL_7nIP-jNVQ5eZ4NyOoS
- "Keras : TensorFlow Core." *TensorFlow*, https://www.tensorflow.org/guide/keras.
- Brownlee, Jason. "Time Series Prediction with LSTM Recurrent Neural Networks in Python with Keras." *Machine Learning Mastery*, 5 Aug. 2019, https://machinelearningmastery.com/time-series-prediction-lstm-recurrent-neural-networks-python-keras/.

Thank You

Any Questions?