Machine Learning based Local Temperature Forecasting with Global Climate Effect

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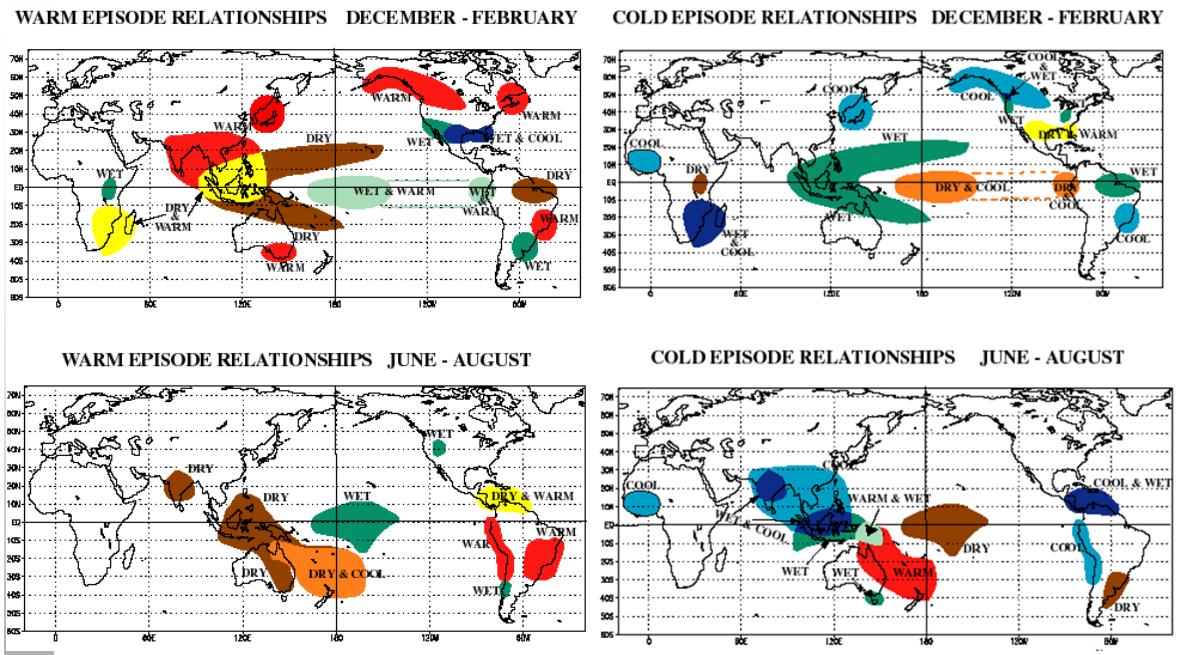
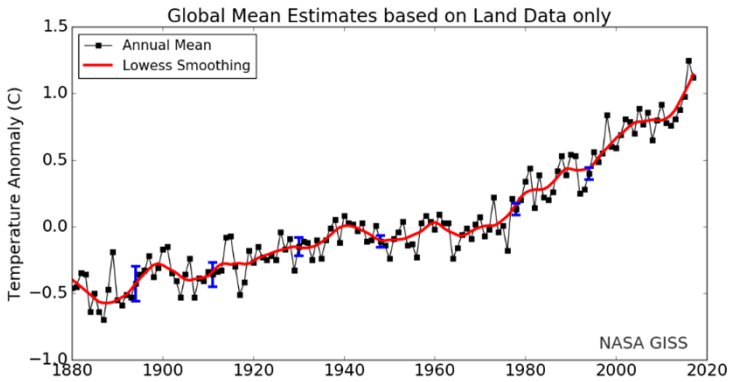
Introduction

- Temperature directly affects to human living
  - Food, clothing and shelter
- Global climate change makes weather prediction hard
  - Pacific Ocean water temperature makes unexpected climate
  - Global warming makes annual average temperature increasing
- Predict future temperature of Ulsan
  - Predict avg. temperature of next month/week with past information
  - Oceanic Nino Index (ONI) is used to enhance prediction accuracy
  - Average monthly temperature prediction achieves up to 1.27 MSE
    - Without ONI data, monthly temperature prediction up to 2.18 MSE

Background



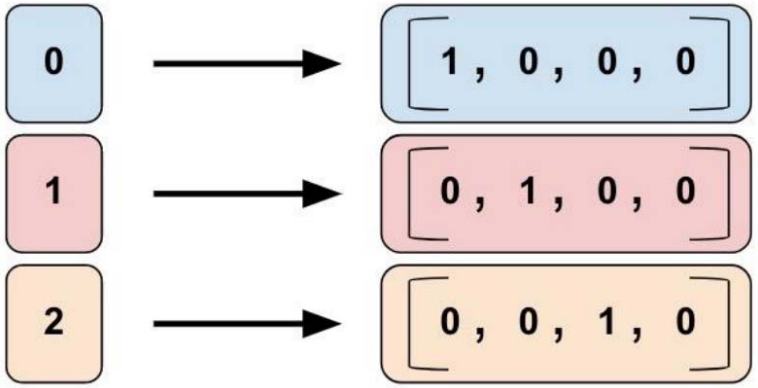


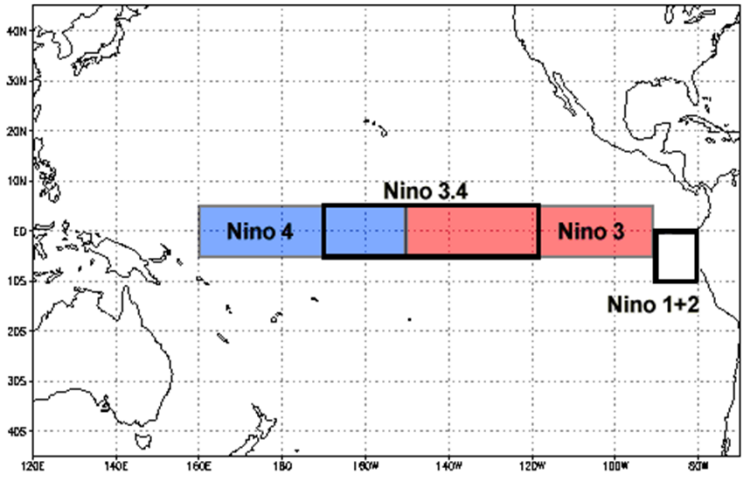
- Pacific Ocean abnormal water temperature effect
  - El nino: warm ocean surface makes warm winter in Korean peninsula
  - La nina: cold ocean surface makes cold winter in Korean peninsula

- Global warming
  - Annual average temperature increases

Cite: https://data.giss.nasa.gov, http://www.noaa.gov

Data Specification





- Features
  - Year: numeric feature
  - Month: categorical feature
  - Historical average temperature: numeric feature
    - Average monthly/weekly temperature of recent 3 months/weeks
  - Oceanic Nino Index (ONI): numeric feature
    - 3 month running mean of sea surface temperature anomalies in the Nino 3.4 region

- Label
  - Average temperature of next month/week in Ulsan

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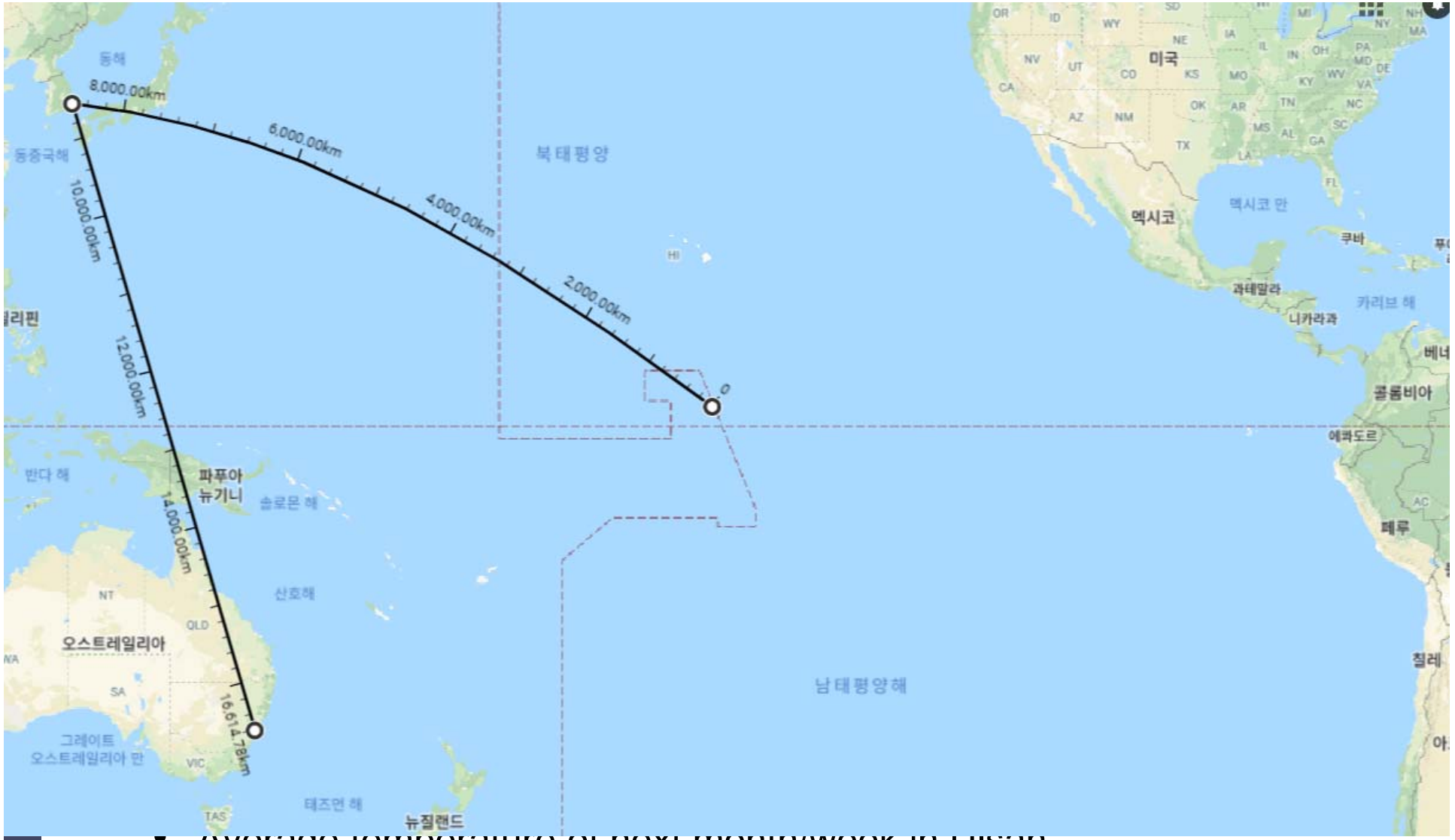

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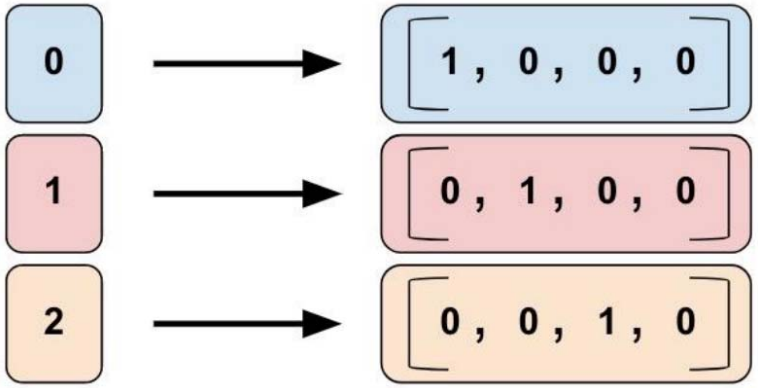

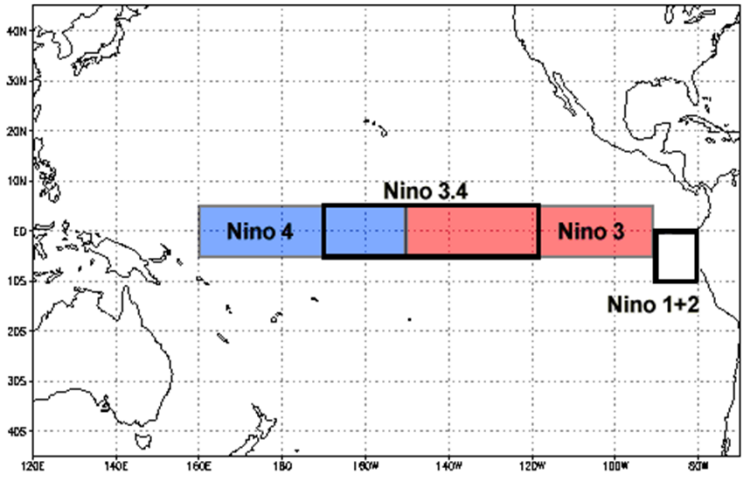

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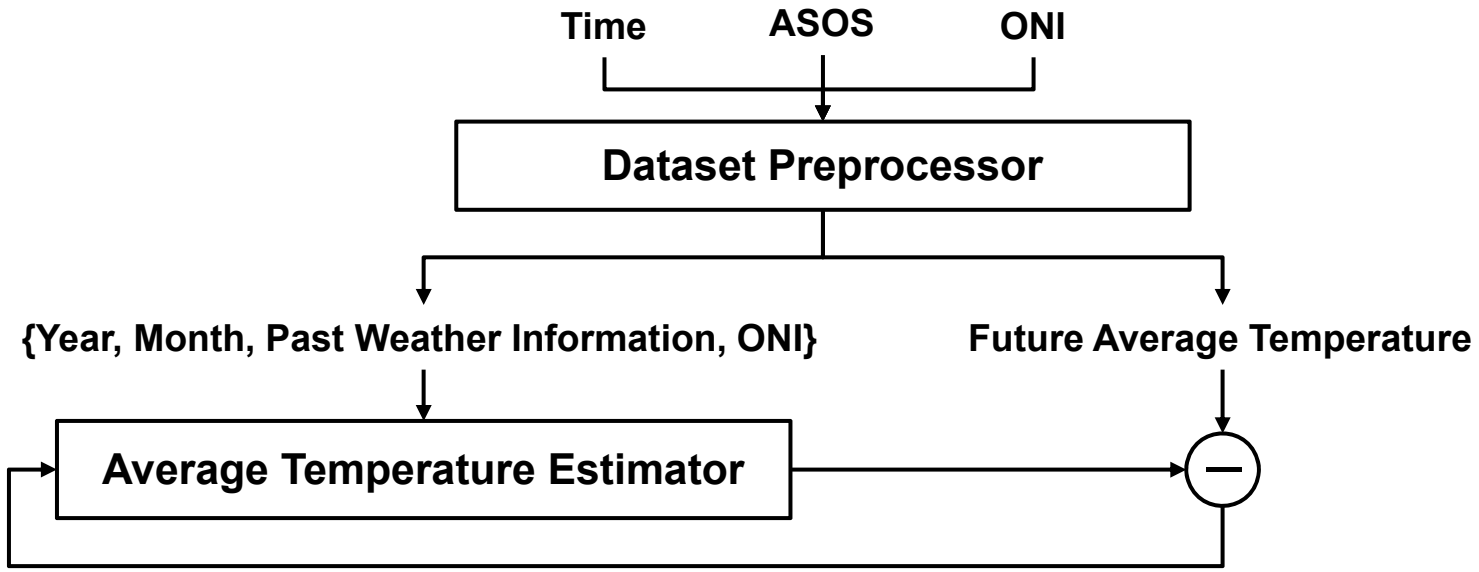
Overview

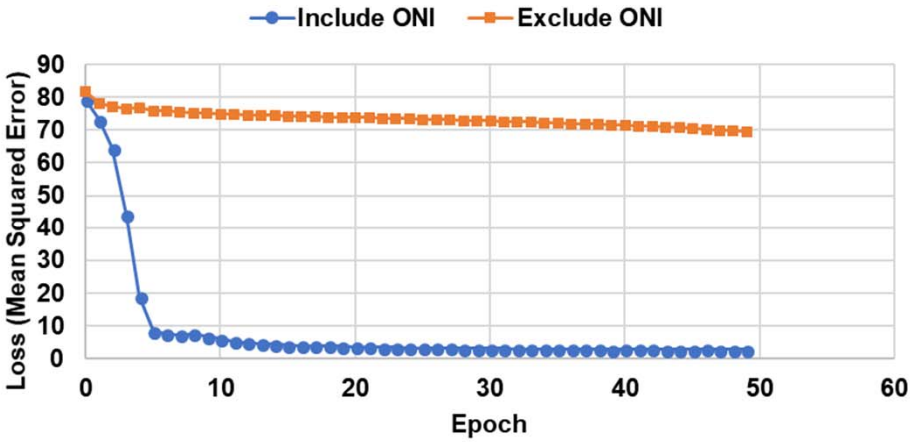


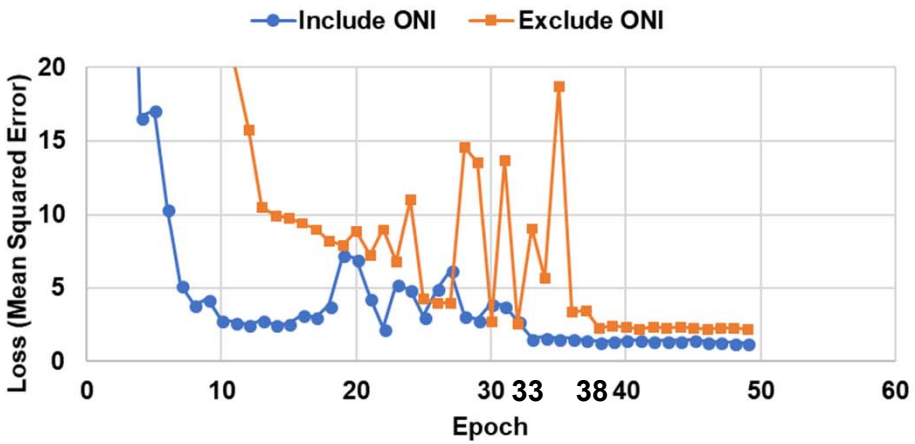
- Dataset preprocessor
  - Make input and output dataframe with time, ASOS and ONI dataset
  - Divide dataset into two dataset
    - One for training and the other for test
- Average temperature estimator
  - Train time, past weather information, and ONI information
    - Average monthly temperature: average temperature
    - Average weekly temperature: average temperature, humidity, air pressure
  - Predict average temperature of next month/week

Methodology

- Input dataset
  - Ulsan temperature
    - Korea Meteorological Administration (KMA)
    - Automated Surface Observing System (ASOS)
  - Oceanic Nino Index (ONI)
    - National Oceanic and Atmospheric Administration (NOAA)
    - Extended Reconstructed Sea Surface Temperature (ERSST)
- Deep neural network (DNN) regressor
  - 100 neurons for each 20 layers
  - Loss is defined by mean squared error
    - $\mathrm{MSE} = \frac{1}{N}\sum(x_i - \hat{x})^2$
- Epoch: 50
- Batch size: 1

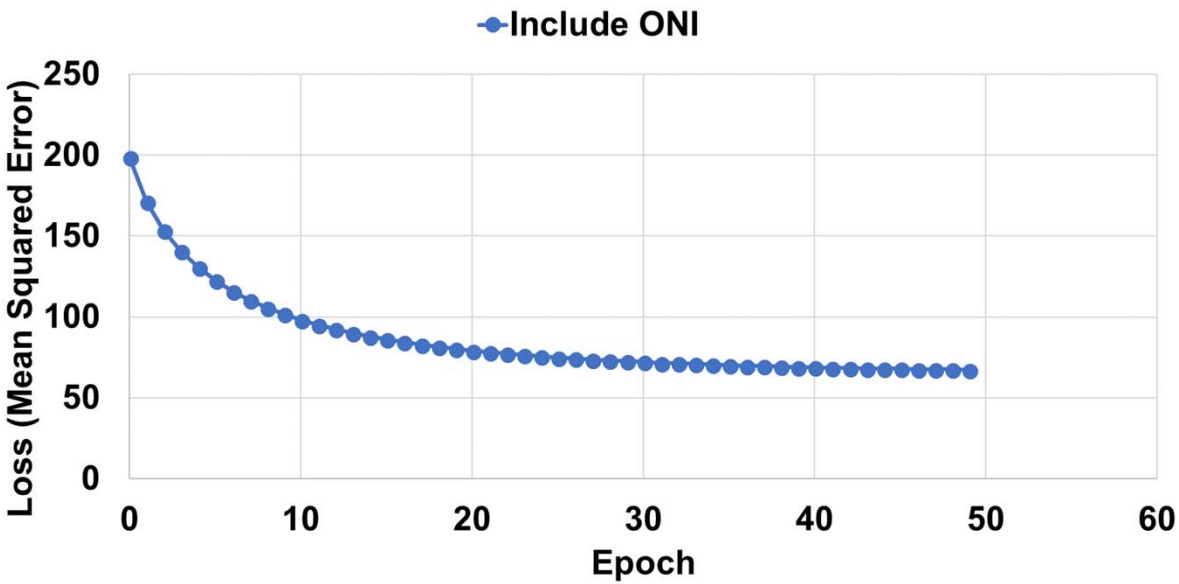
Monthly Average Temperature Prediction





- Train 20 years and test with 5 years (1990-2009, 2010-2014)
  - Include (exclude) ONI achieves 2.83 (69.47) of minimum loss
- Train 64 years and test with 2 years (1981-2014, 2015-2016)
  - Include (exclude) ONI achieves 1.27 (2.18) of minimum loss
- Global climate effect should be considered
  - Achieve much higher temperature prediction accuracy within same dataset
  - Need less amount of dataset to achieve similar accuracy
  - Reduce learning time until converges

Weekly Average Temperature Prediction



- Error is higher than that of the monthly prediction
  - Loss is higher than 60 after converged
  - Additional features have little or no effect
    - E.g., humidity, sea-level pressure

- More fine-grain global climate data is needed

Conclusion

- Predict average monthly/weekly temperature with machine learning
  - Use past local temperature, and Pacific Ocean temperature
    - ASOS is used to get Ulsan temperature
    - ONI is used to get the effect of Pacific Ocean temperature
  - Predict average temperature of next month/week in Ulsan
    - ASOS is used to evaluate accuracy
- Implement the model with TensorFlow API
  - Achieve up to 1.27 mean squared error
- Shows importance of using Pacific Ocean temperature
  - ONI increases accuracy of Ulsan temperature prediction
  - ONI reduces learning overhead
    - Similar accuracy with 1/3 of dataset
    - Less epoch to converges