DAVID BERTSCH

MODELING DROUGHT IN THE UNITED STATES

PROBLEM 1

WHAT ARE THE CLIMATIC TRENDS OF DROUGHTS IN THE UNITED STATES?

APPROACH

- Investigate national drought data
  - Qualitatively assess the time series
  - Build a SARIMA model to forecast future national conditions

PROBLEM 2

CAN DROUGHTS IN LOCAL REGIONS ACROSS THE UNITED STATES BE MODELED IN ORDER TO MAKE PREDICTIONS OF FUTURE CONDITIONS?

APPROACH

- Map local drought data to rectangular grid
- Construct CNN model
  - Spatio-temporal
- Feed predictions back into model in order to generate long range forecast

CONCLUSIONS

- What are the climatic trends in the contiguous US?
  - Longer, more sudden, more extreme periods of drought
    - Need to improve model to generate meaningful quantitative predictions
    - Would be useful if a longer time span of historical data were available

HYPOTHESES

- Droughts in the US are trending towards more severe and longer-lasting.
- Areas that are the most prone to droughts are undergoing the most pronounced increases in drought levels.

CONCLUSIONS

- How can droughts in local regions be modeled in order to make future predictions
  - Possible to build CNN model to predict drought conditions based on prior data points
    - Did not complete this construction
- Eventually, the CNN model predictions could hopefully be fed into the input in order to generate long range forecasts

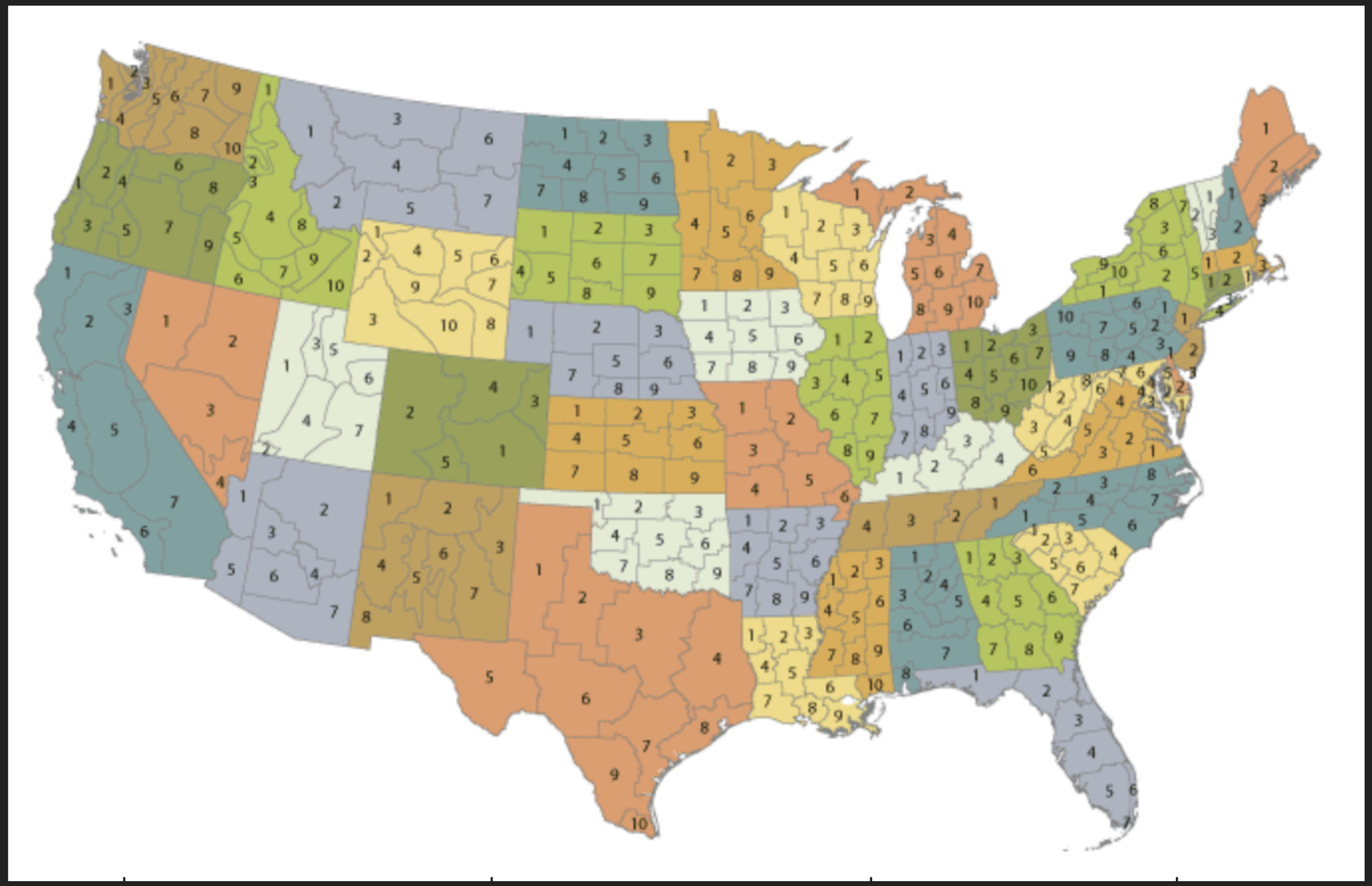
DATA

- US Drought Monitor
  - (University of Nebraska, USDA, NOAA)

			Ranges				
Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

DATA

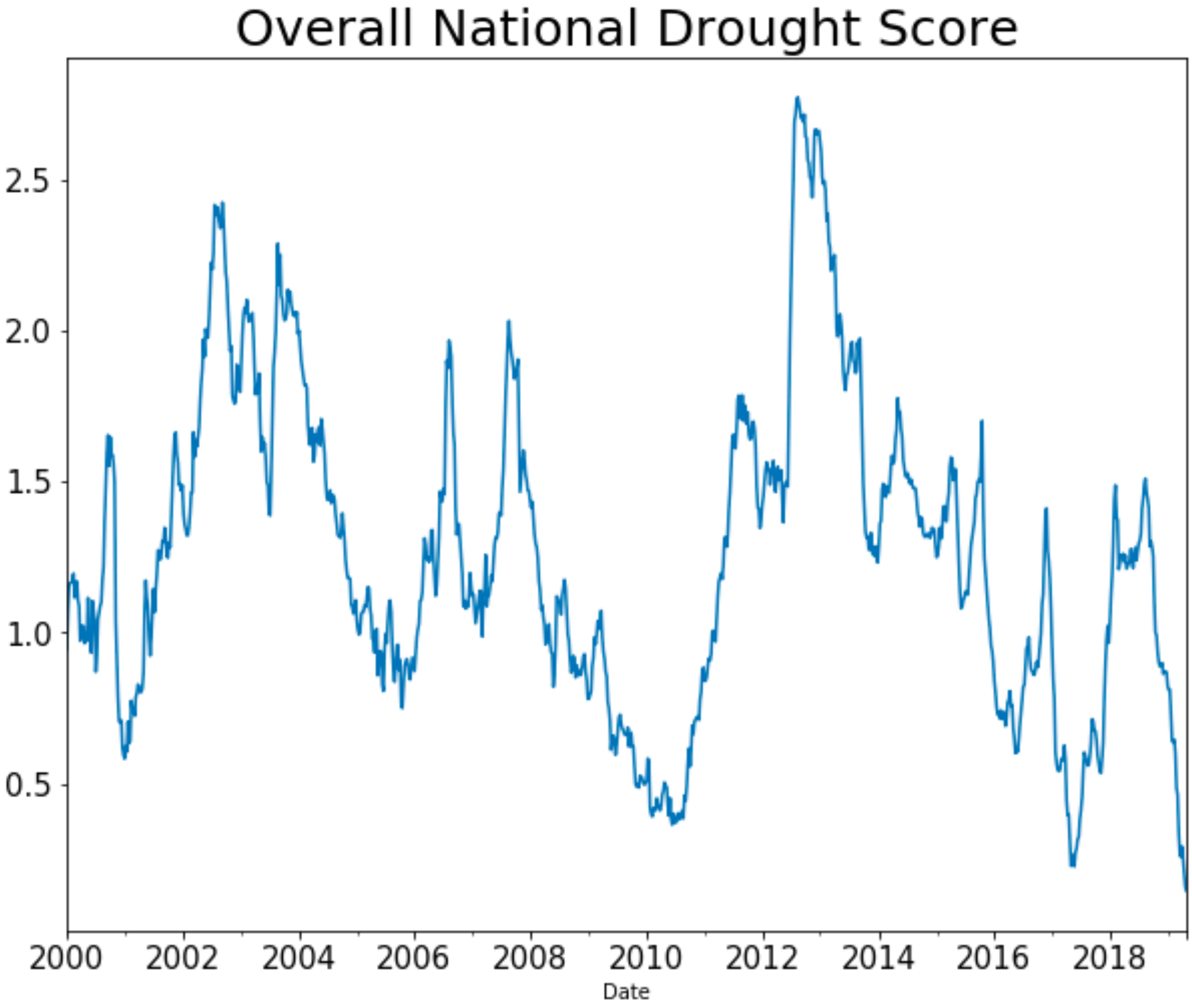
- National Aggregates
- Localized by Climate Divisions



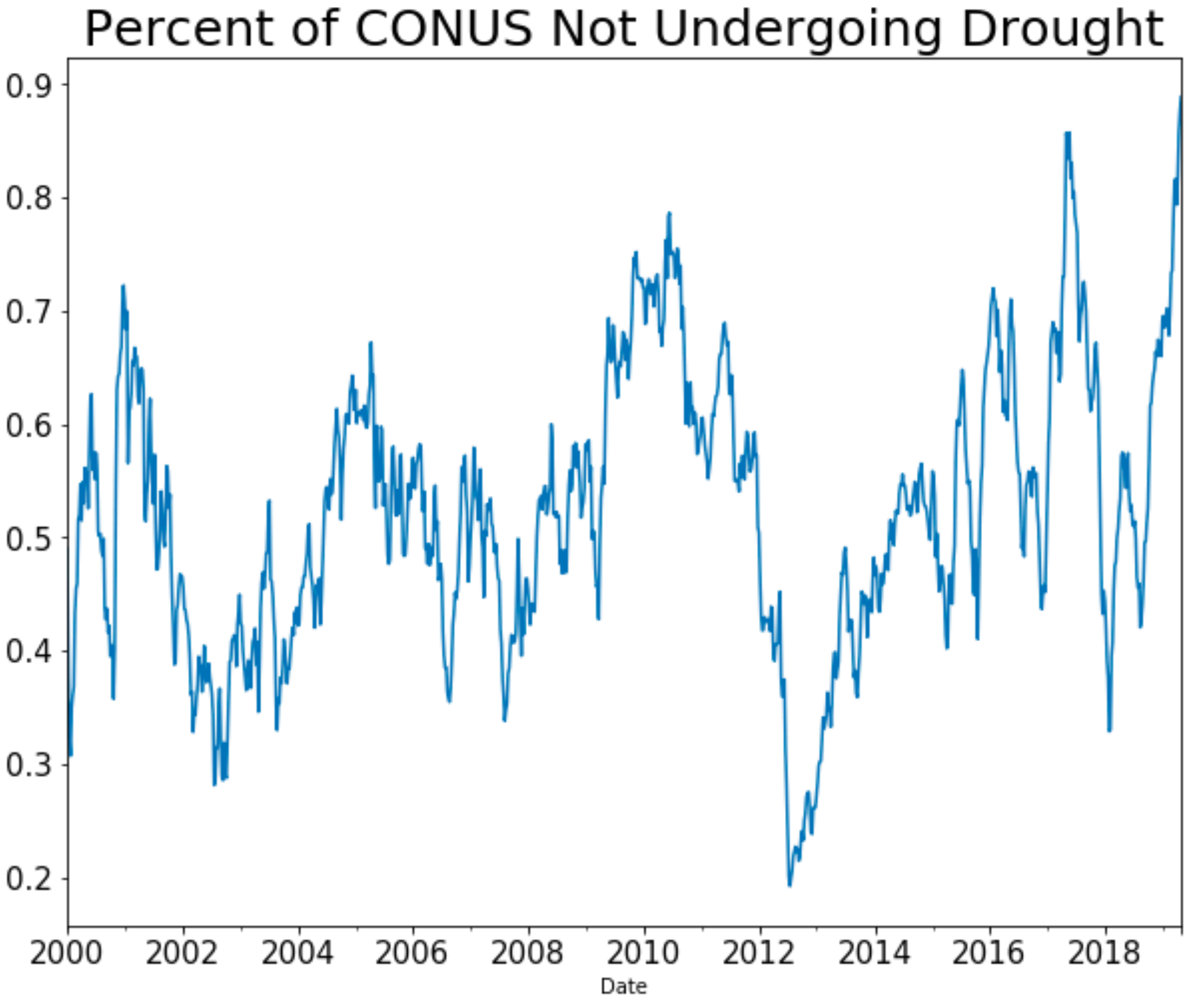
NATIONAL TIME SERIES

- Qualitative Assessment of time series
- SARIMA models for each drought metric
- Tune/Iterate
- Forecast forward

NATIONAL TIME SERIES



NATIONAL TIME SERIES



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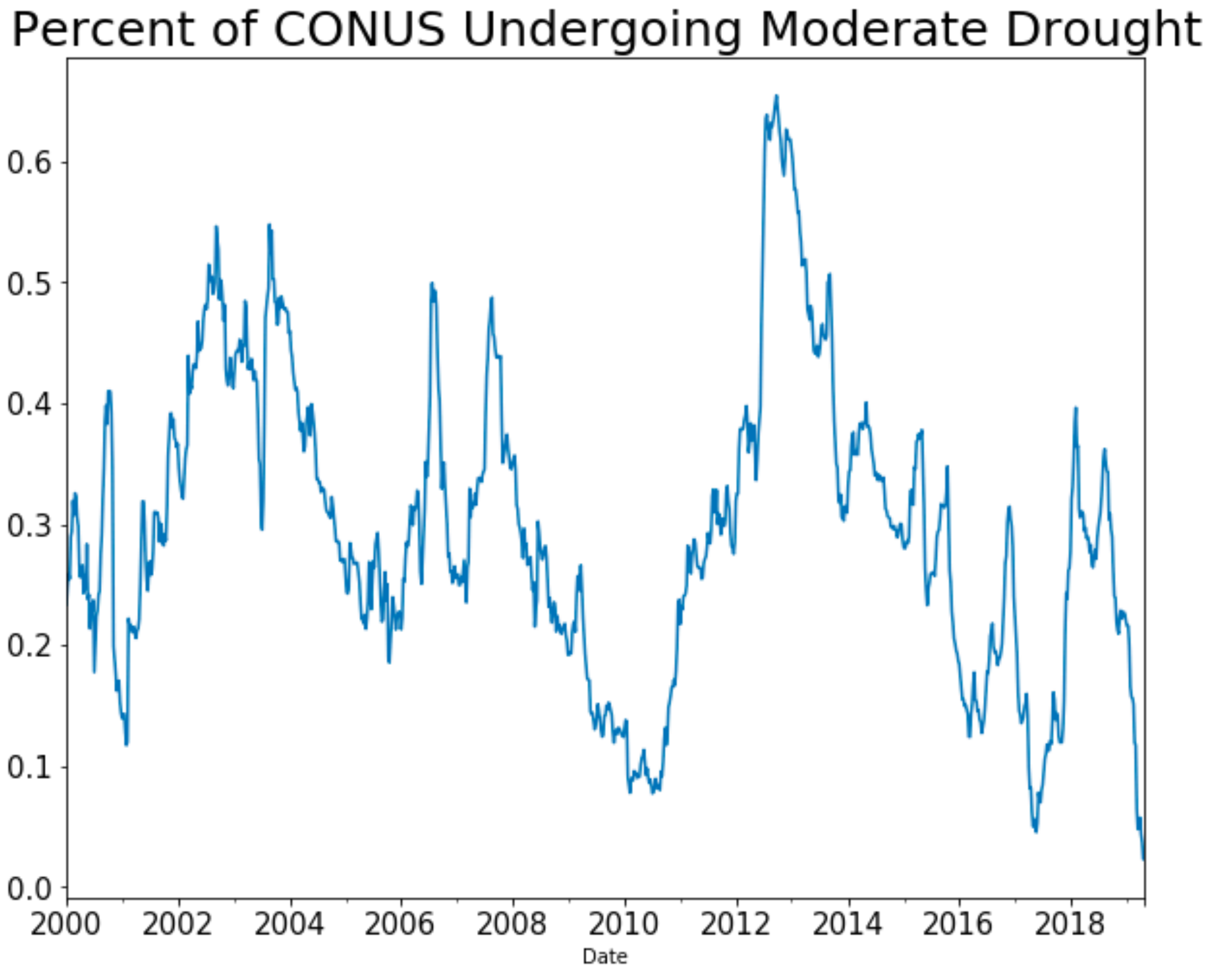

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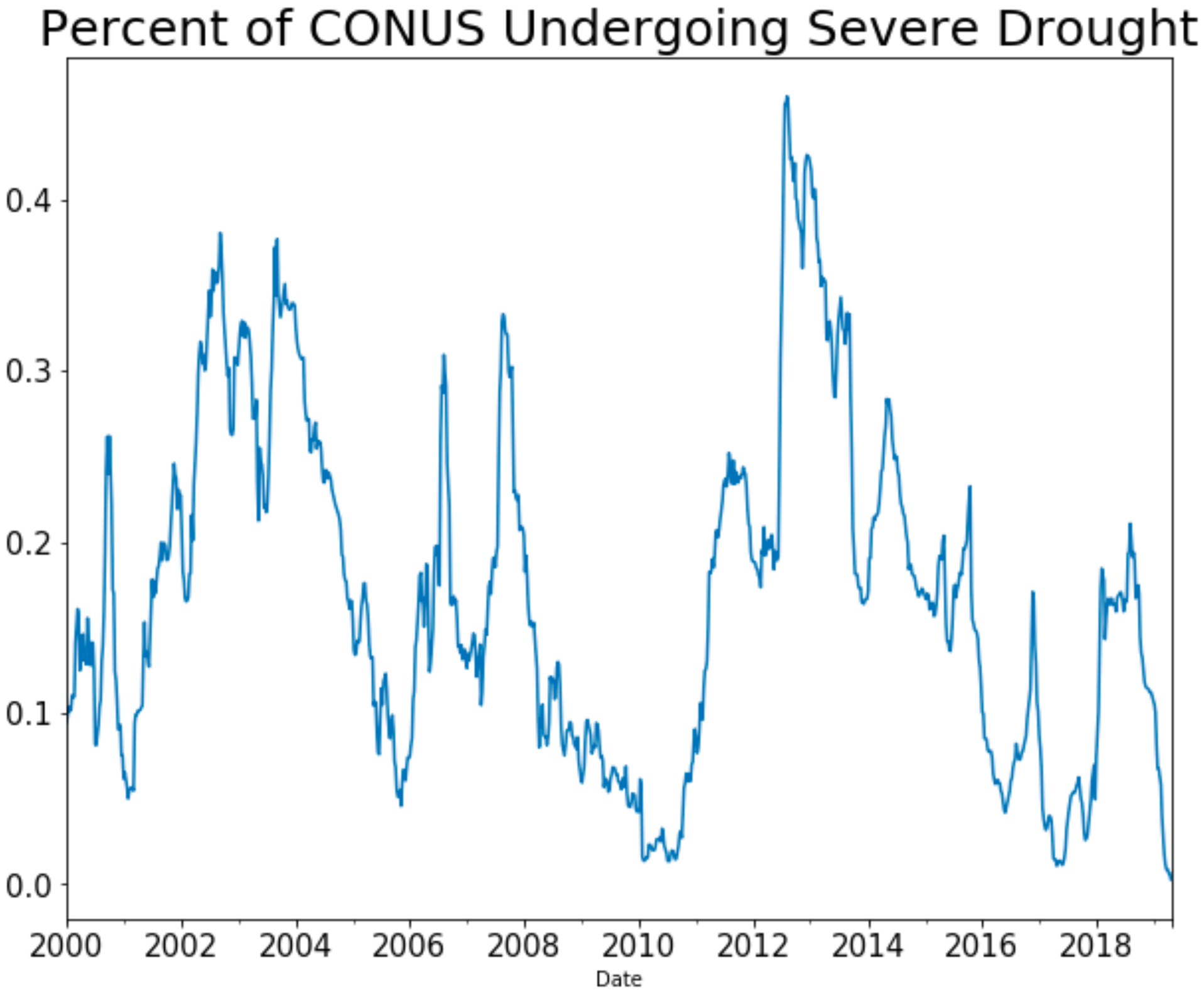

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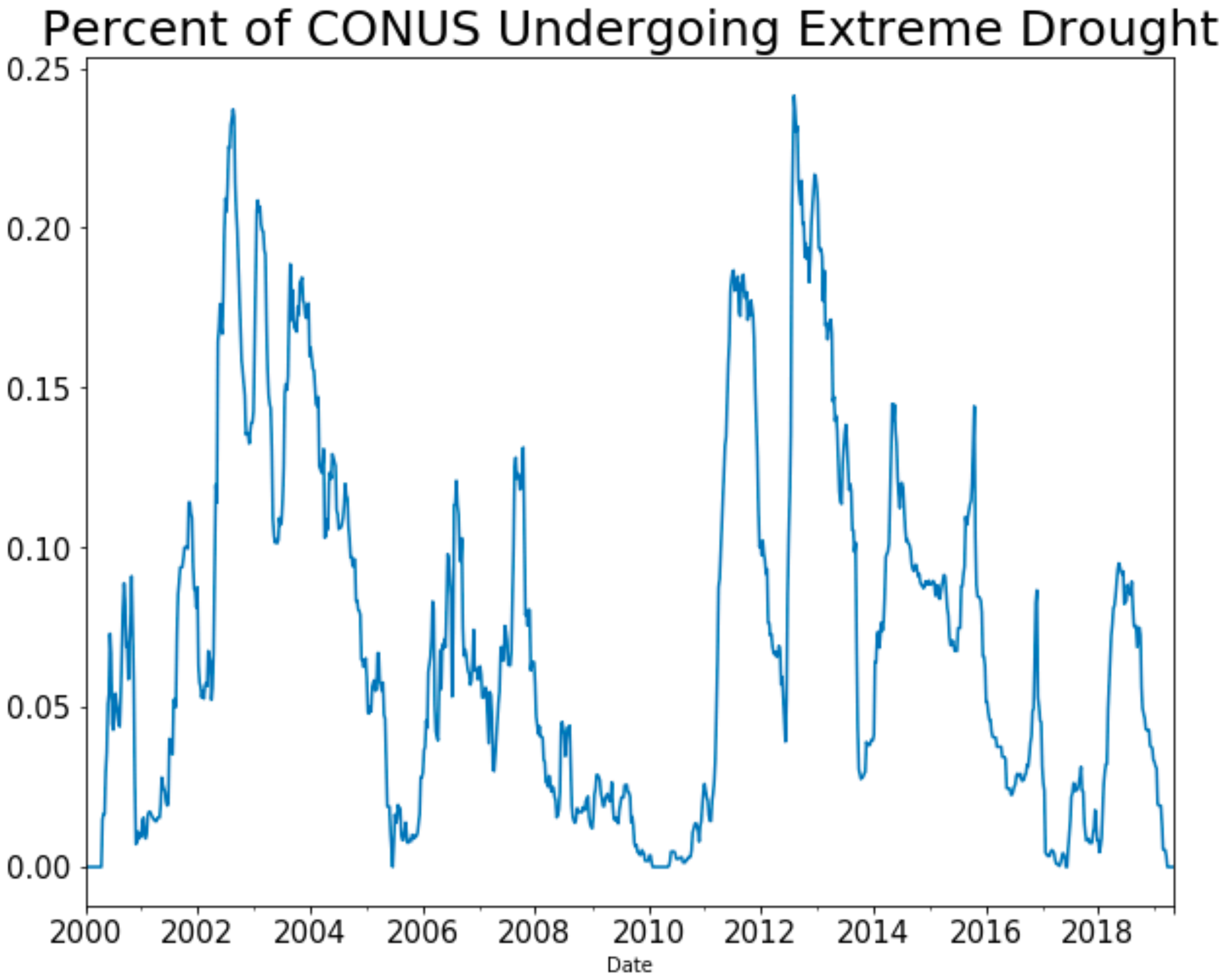

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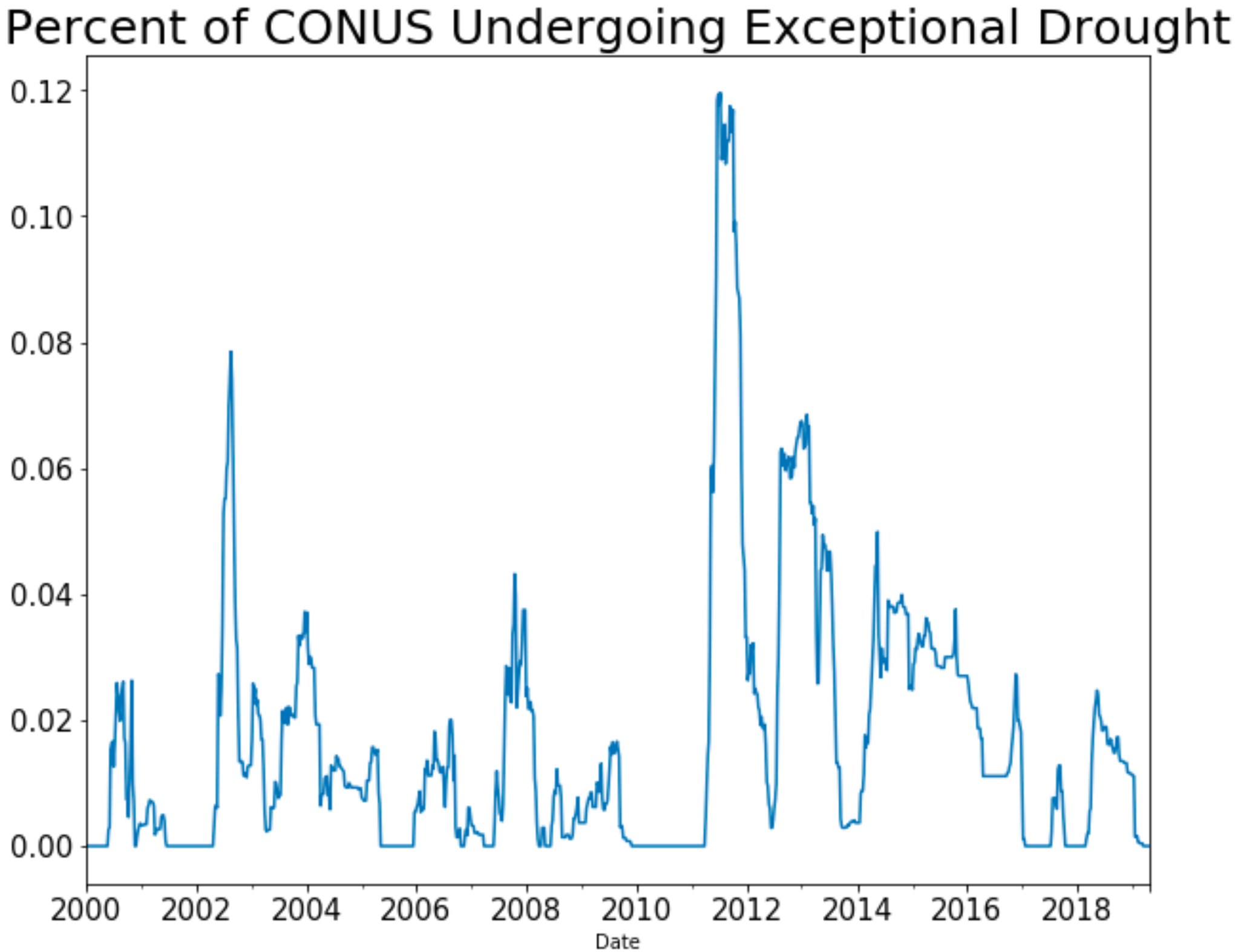
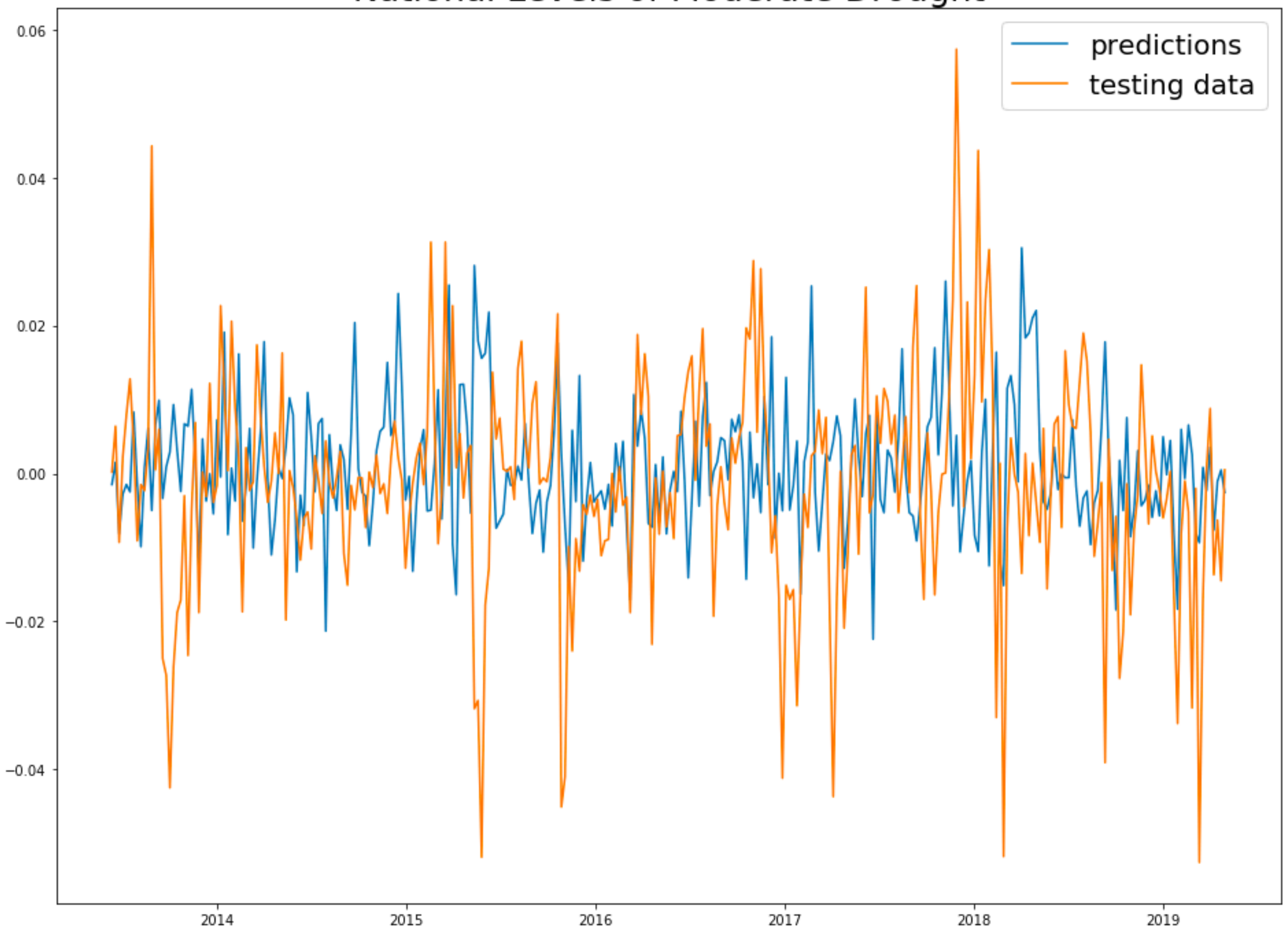


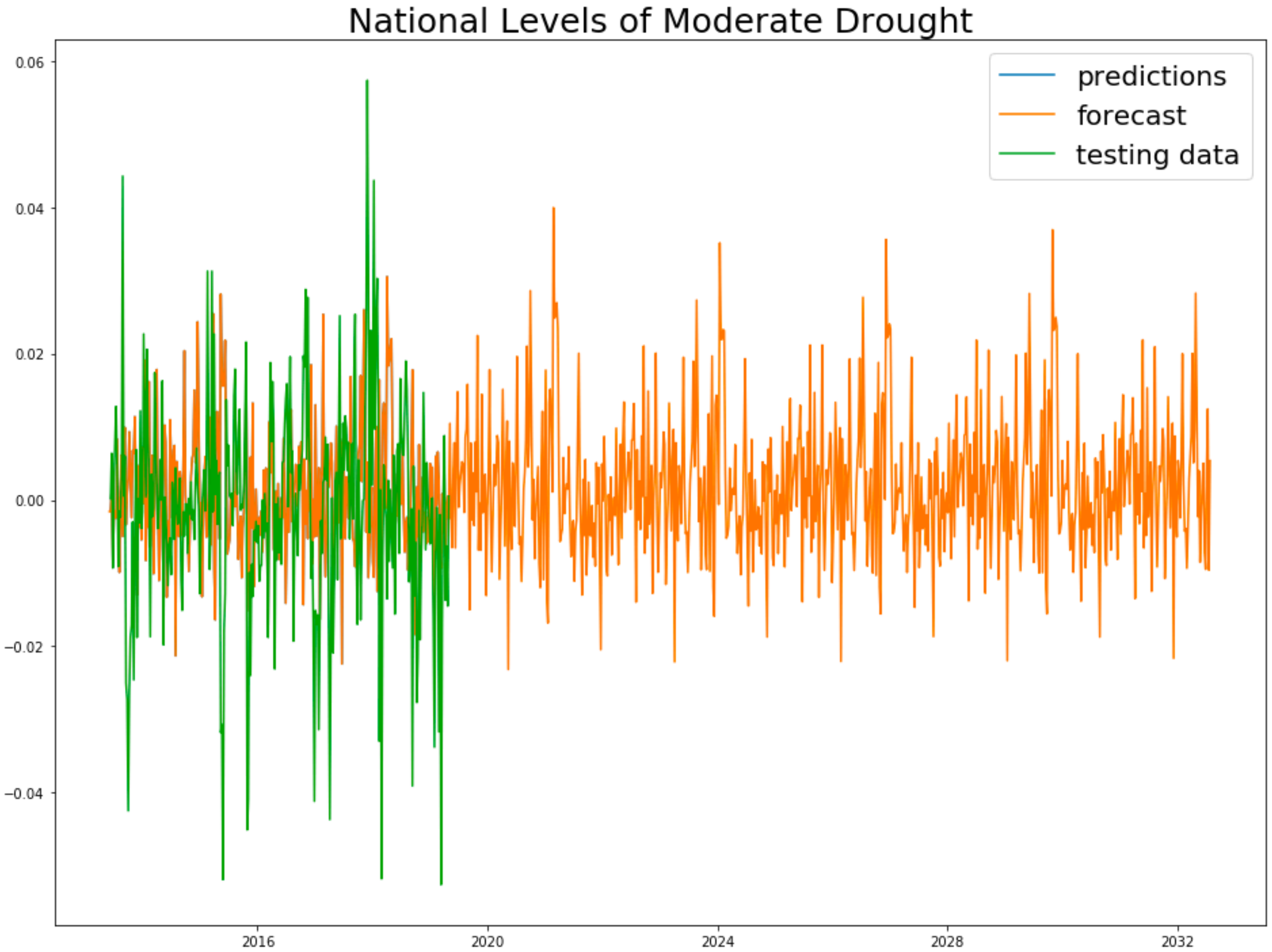
NATIONAL TIME SERIES

- Are there any noticeable trends in more recent years?
  - Longer periods of drought
  - More extreme sudden fluctuations
  - Exaggerated trend for more extreme metrics

NATIONAL TIME SERIES MODEL

- What are the takeaways from modeling?
  - My SARIMA models are good at capturing the seasonal fluctuations and the long term trends
  - My models are not good at predicting sudden fluctuations


National Levels of Moderate Drought
predictions
testing data
0.06
0.04
0.02
0.00
−0.02
−0.04
2014
2015
2016
2017
2018
2019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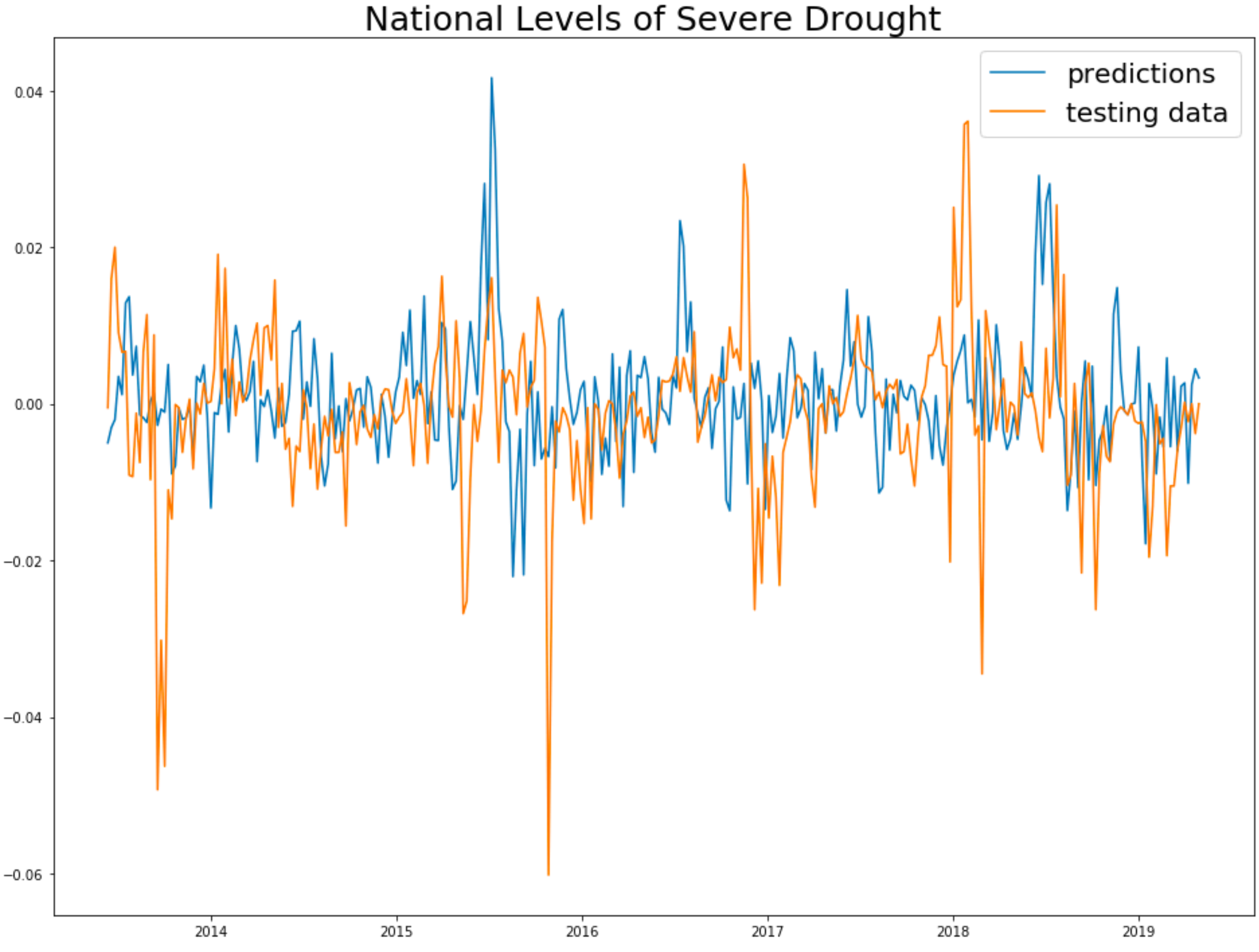
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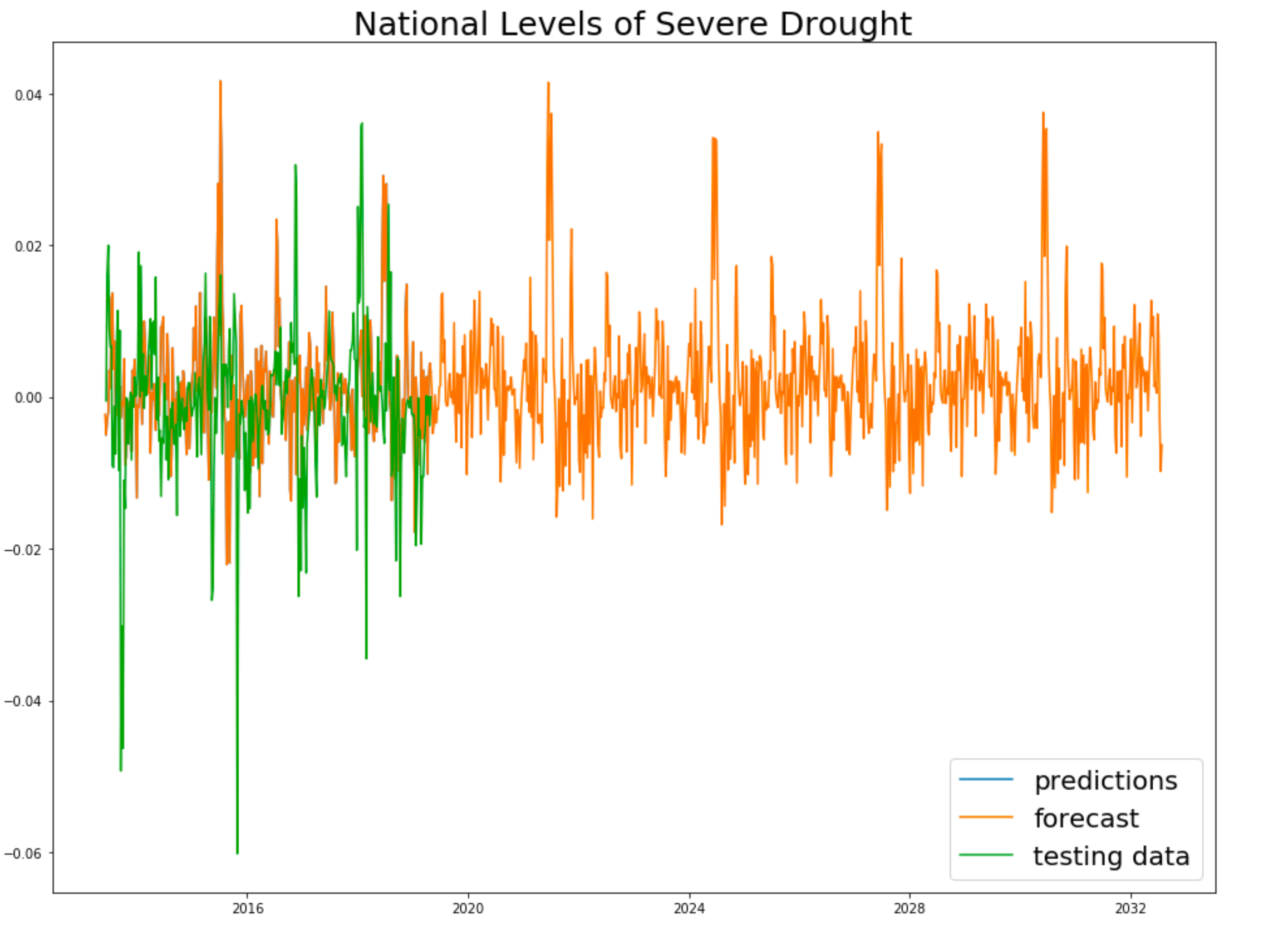
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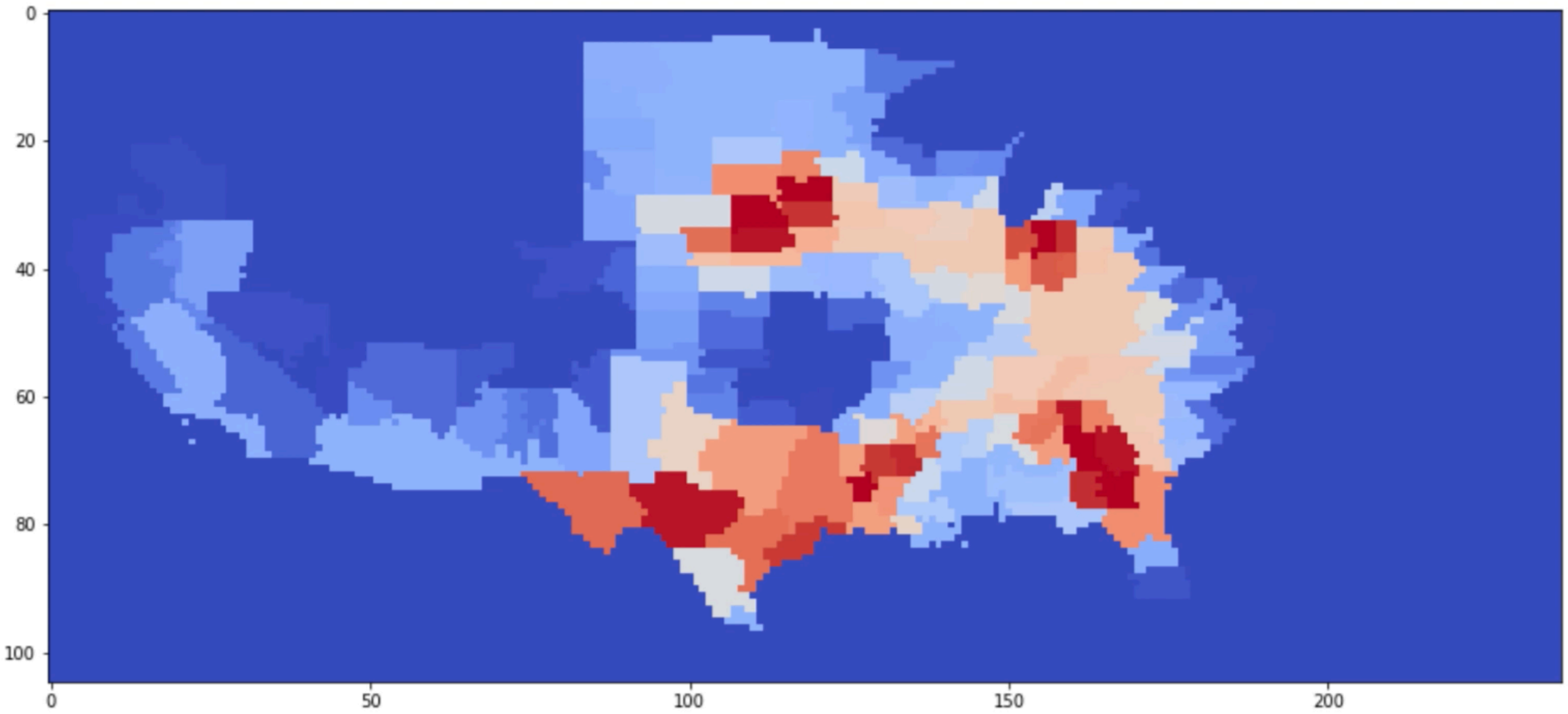
NATIONAL TIME SERIES MODEL

- Ideas for improvement
  - Further tuning
  - More historical data

LOCALIZED DATA

- Map the climate zones to a grid
- Assign drought values
- Stack of pixelated images

LOCALIZED DATA



LOCALIZED MODEL

- CNN model
  - X: previous data points
    - Shape: # of lags x (# lat grids * # long grids) x 1
  - Y: single data point vector
    - Shape: (# lat grids * # long grids) x 1

LOCALIZED MODEL TUNING PARAMETERS

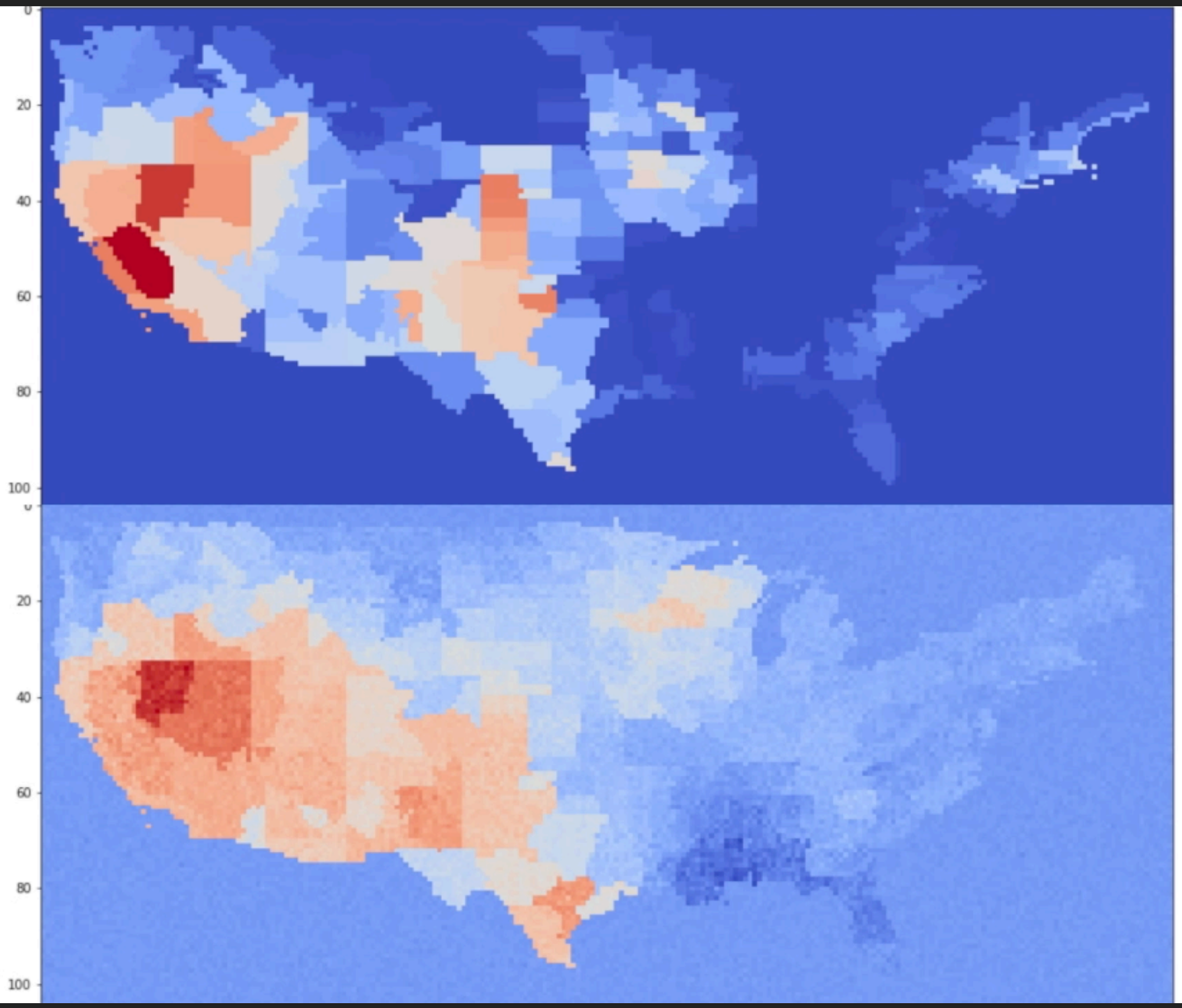
- Which lags to include
- How many lags to include
- How many epochs to run

LOCALIZED MODEL EVALUATION

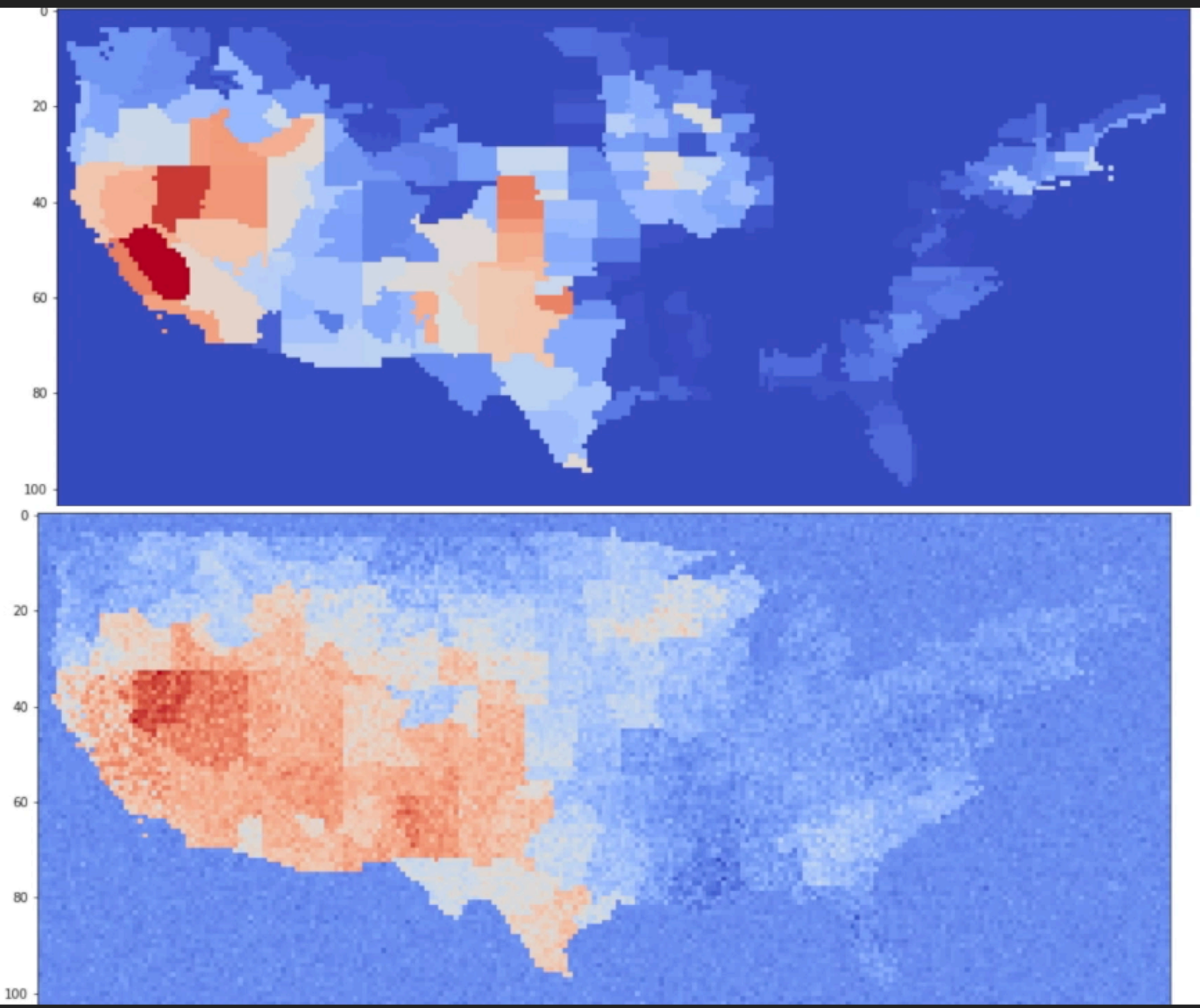
- MSE (loss function)
- MAE
- R2 score*

- Difficult to assess quantitatively
  - Qualitative assessment

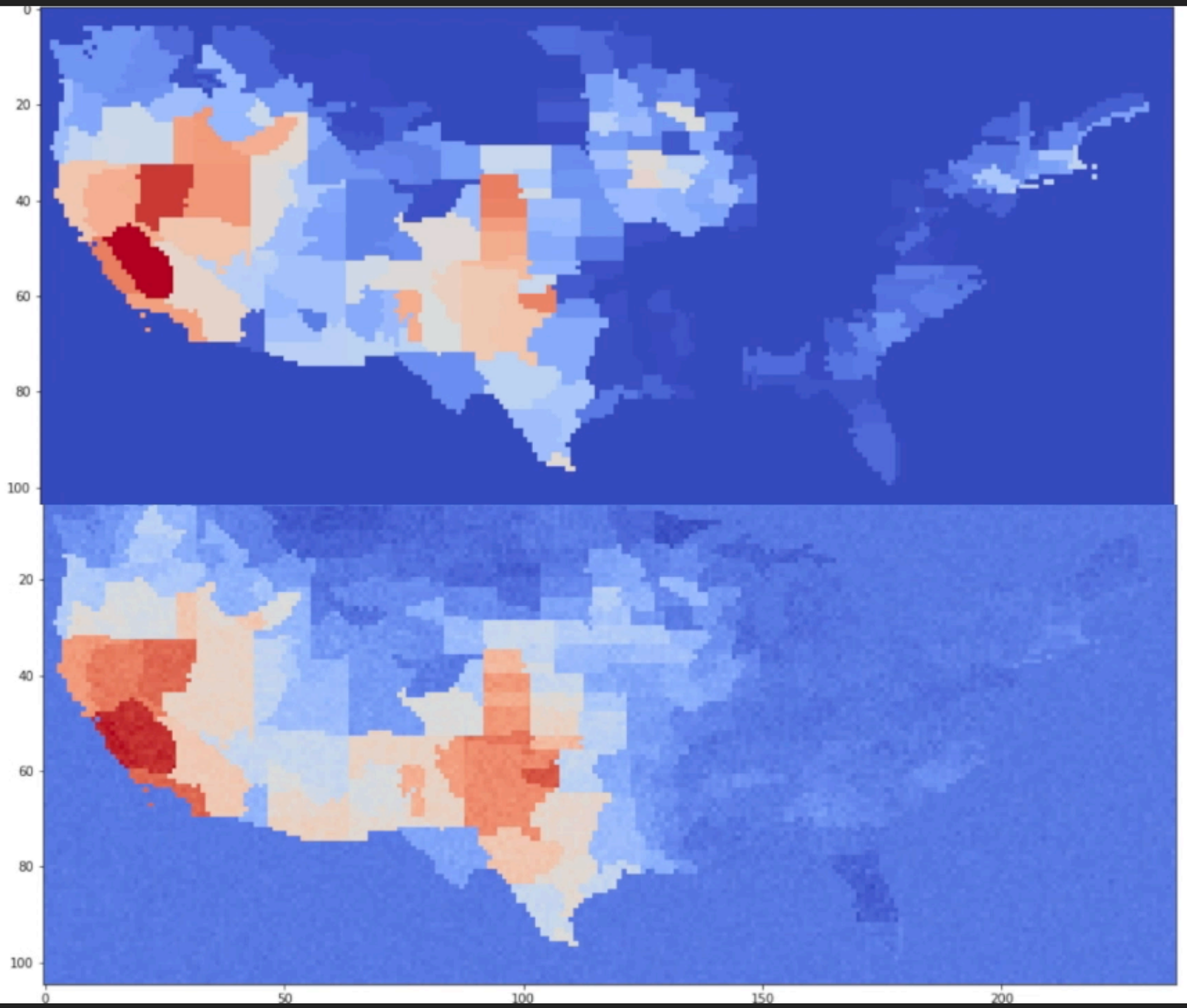
LOCALIZED MODEL EVALUATION – 4 LAGS, 25 EPOCHS



LOCALIZED MODEL EVALUATION – 8 LAGS, 25 EPOCHS



LOCALIZED MODEL EVALUATION – 4 LAGS (SPREAD), 50 EPOCHS



LOCALIZED MODEL

- Ideas for improvement
  - Construct Keras R2 score for vector
  - Further tuning
  - Eventually work into recurrent model
  - Compare against individual models for each location

CONCLUSIONS

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