Comparison of ARMAX (autoregressive moving average transfer function) and RNN (recurrent neural network) models to predict geostationary keV electrons

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Predict hourly, geostationary 40 keV electron flux (GOES-13 MAGED instrument) using IMF B and Bz; solar wind velocity (V), number density (N), and pressure (P); Kp and SymH

Previous hour's flux can also be included as a predictor. Is it helpful?

Two methods of empirical modelling:

1. ARMAX: AutoRegressive-MovingAverage Transfer Function
   - AR and MA terms used to model flux behavior over time
   - Influence of predictors added to this
   - Predicts values of future flux
2. RNN: Recurrent Neural Network :
   - Predicts probability of belonging to a class, not values
   - Classify data: above and below 75th percentile
   - Predict probability of being above that threshold
   - Temporal machine learning: inputs are time sequences

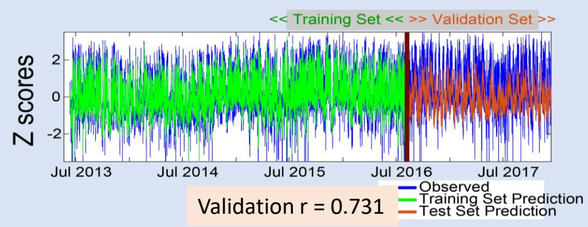
A basic ARMAX model, AR1, MA1and2, describes temporal behavior of flux
(Autoregressive term at t=1, moving average terms at t=1 and 2)

Influence of IMF and SW parameters added to this base model

Reasonable description of data in training period (through July 2016)

Reasonable validation correlation in validation period (r = 0.731)

But model fails to predict the highs and lows



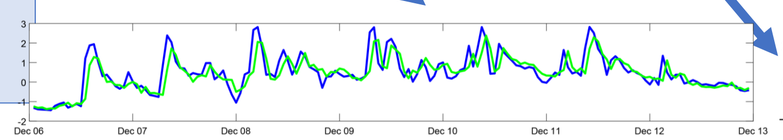
Base ARMAX model misses highs and lows

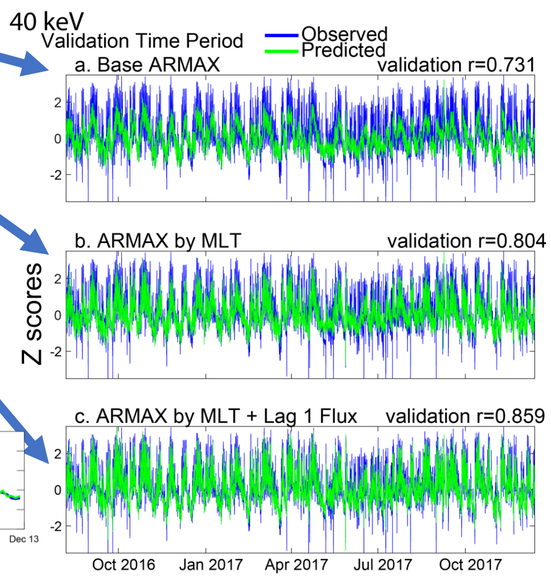
Model improved by adding MLT

Highs and lows still not predicted well

Adding previous hour's flux improves ability to predict highs and lows

But predictions lag

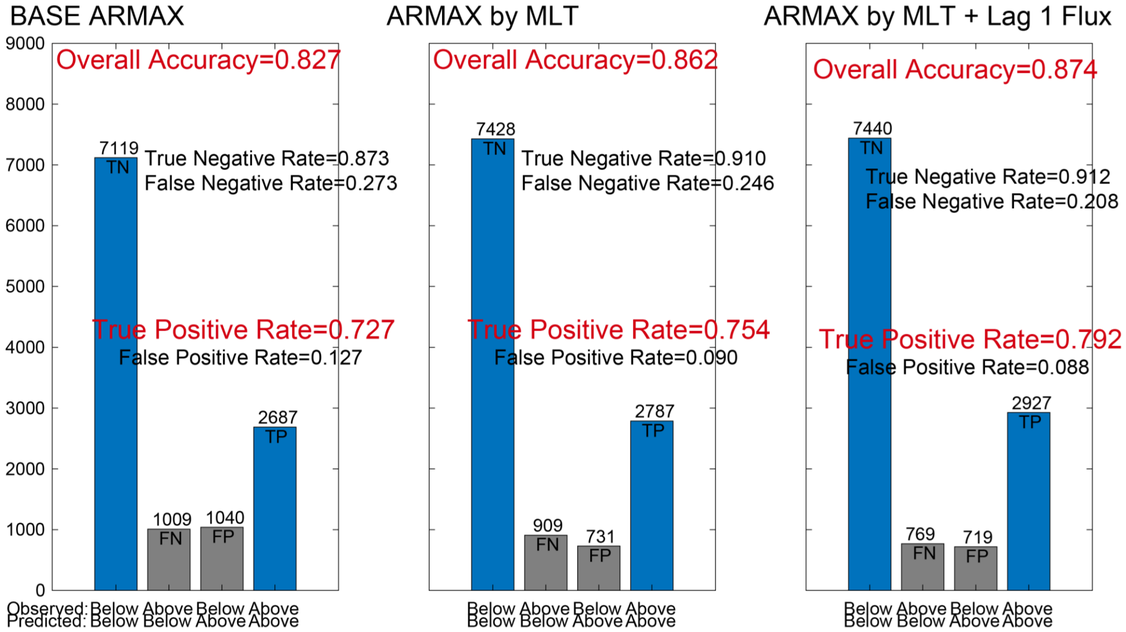




Would classification by 75th percentile improve prediction?

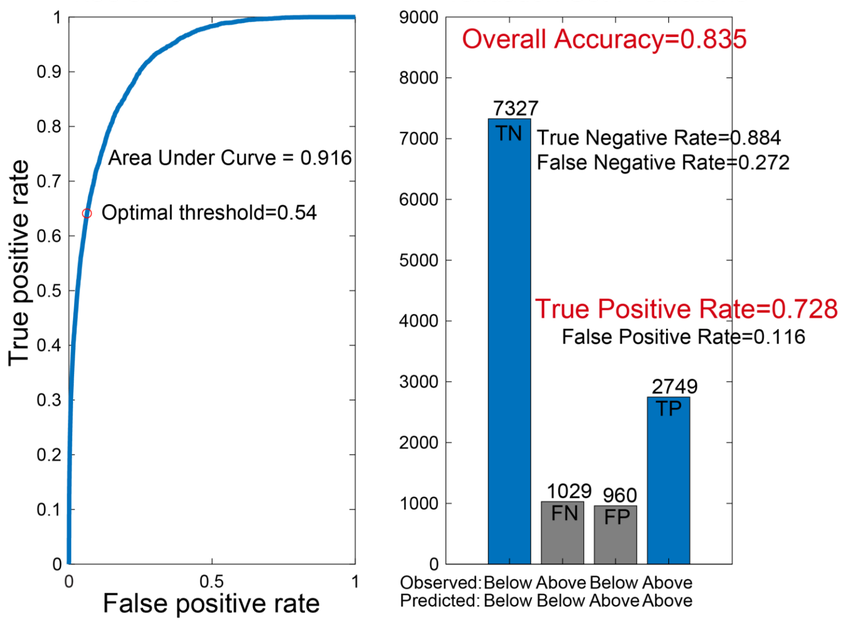
Classification by ARMAX model:

But including previous flux and accounting for MLT provide only small improvements



Classification by RNN model:

Classification accuracy similar to ARMAX model



- Predicting *values* using an ARMAX model is difficult. Either highs and lows are not well predicted, or predictions lag behind observations.
- Both ARMAX and RNN can be used as classifier models.
- ARMAX and RNN perform similarly at 40 keV in predicting flux > 75th percentile

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