Interpretable Solar Flare Forecasting with Deep Learning

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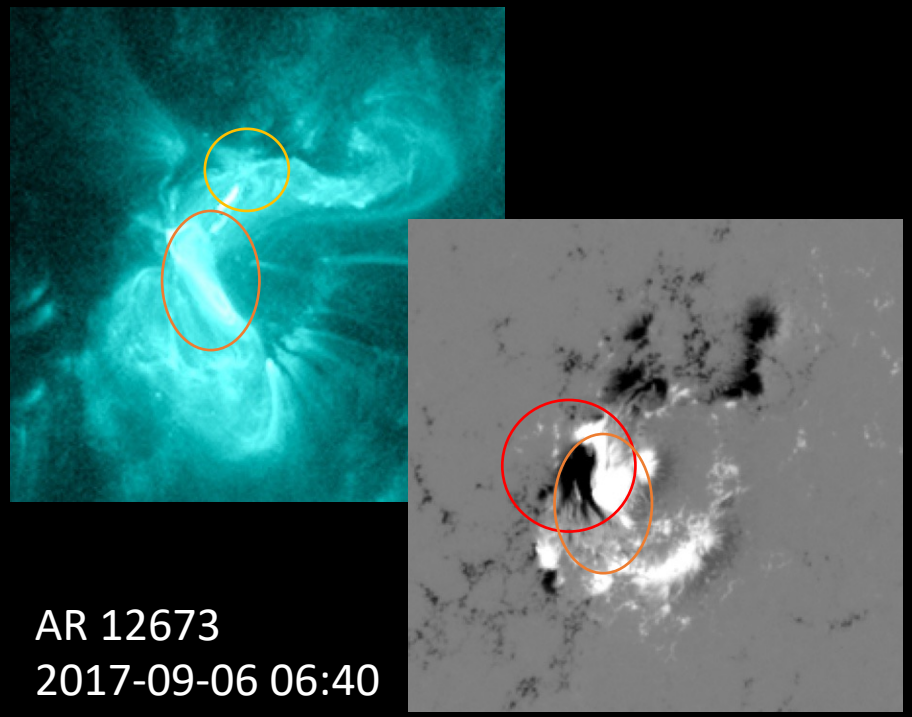

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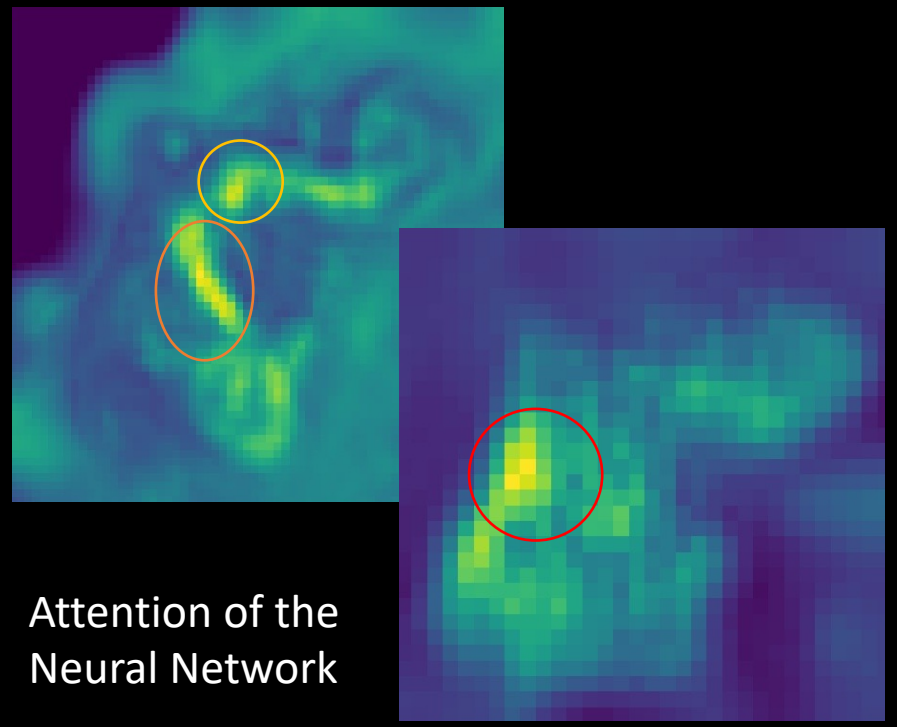
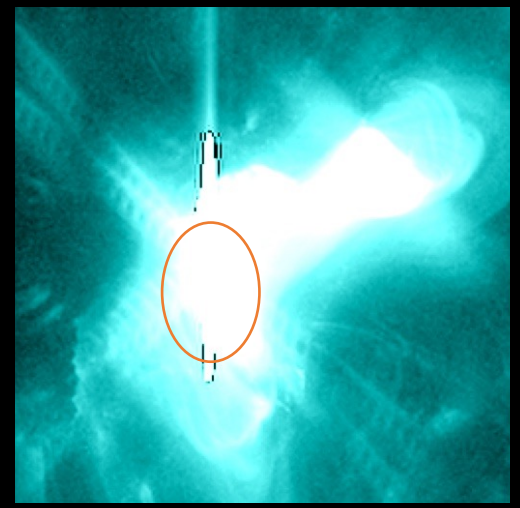


Attention of the
Neural Network



X-class Flare
2017-09-06 09:20

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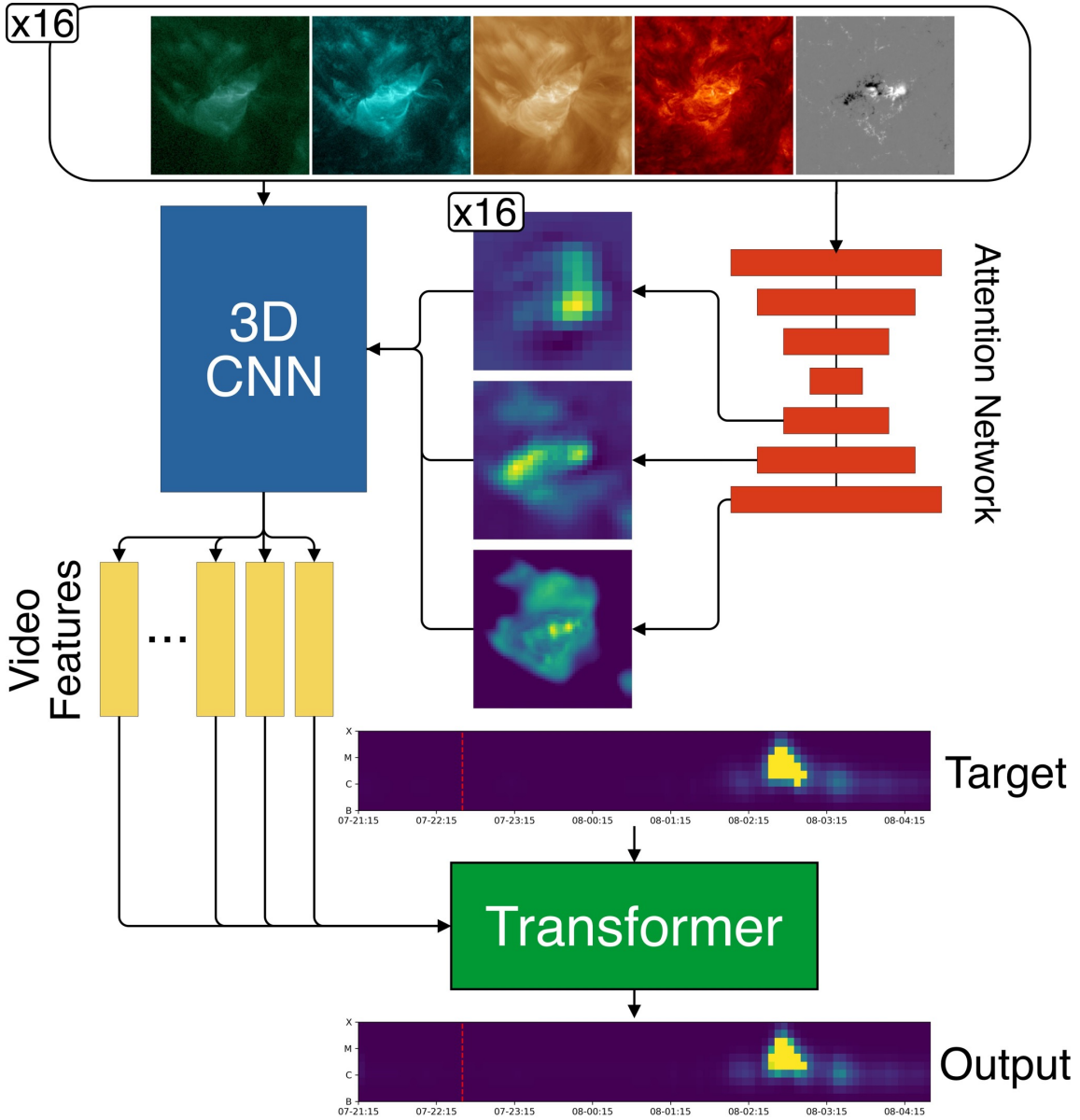
Method

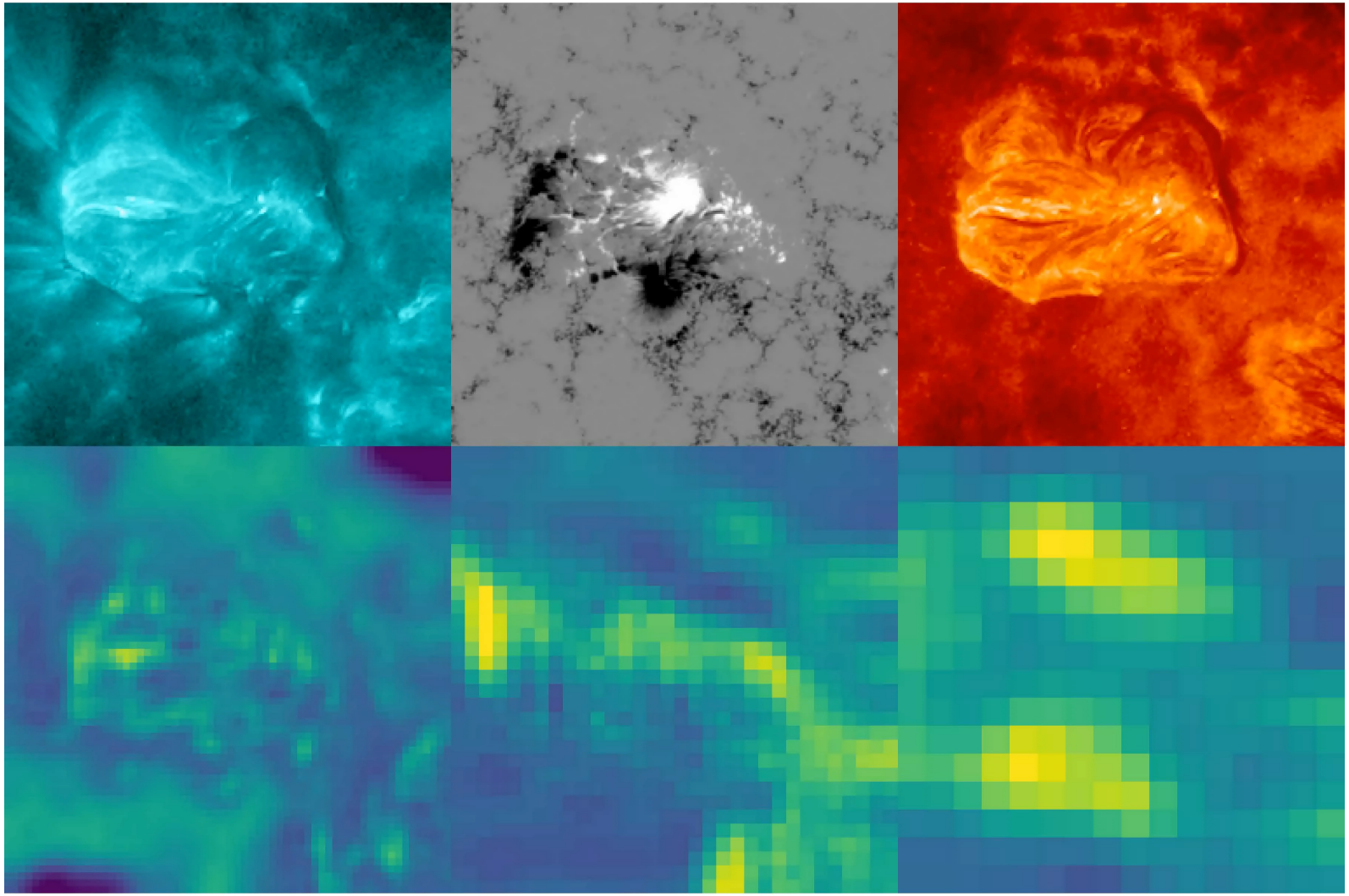
- 6h flare prediction
  - Learning to detect precursors
  - Probability density in class-time space
- Attention Mechanism
  - Scientific return with interpretable deep learning
- 3D CNN
  - Extract features from video sequence
- Transformer (Vaswani et al. 2017)
  - ‘Translation’ of feature series to prediction series



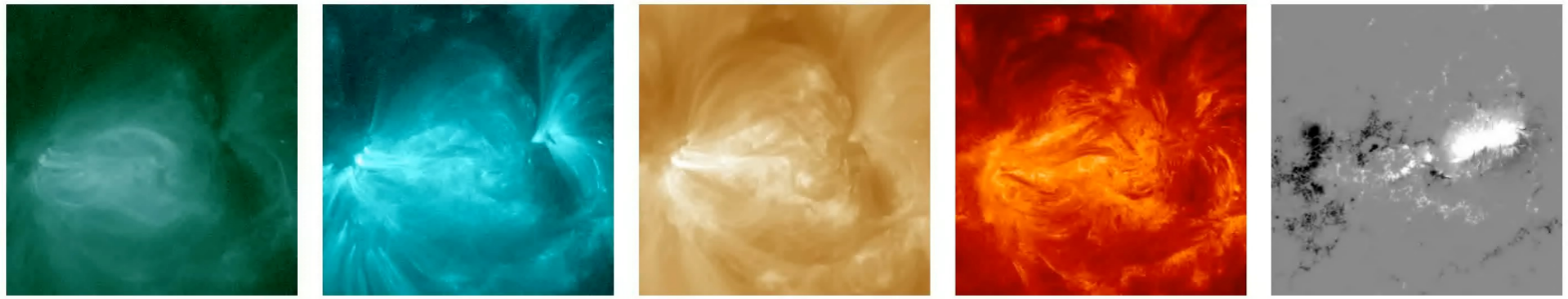
Results – attention maps

M8 flare: 2014-12-17

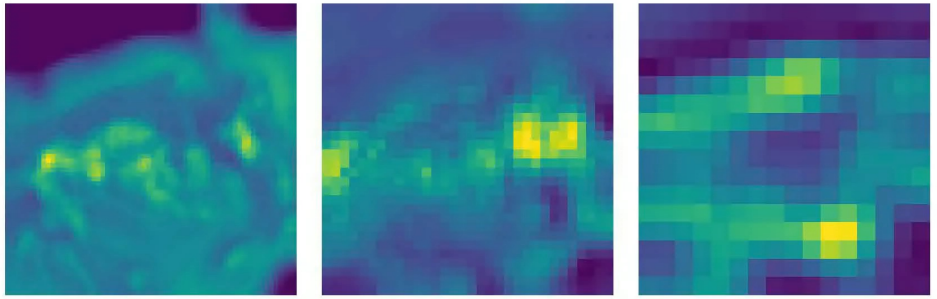
6 hours before eruption

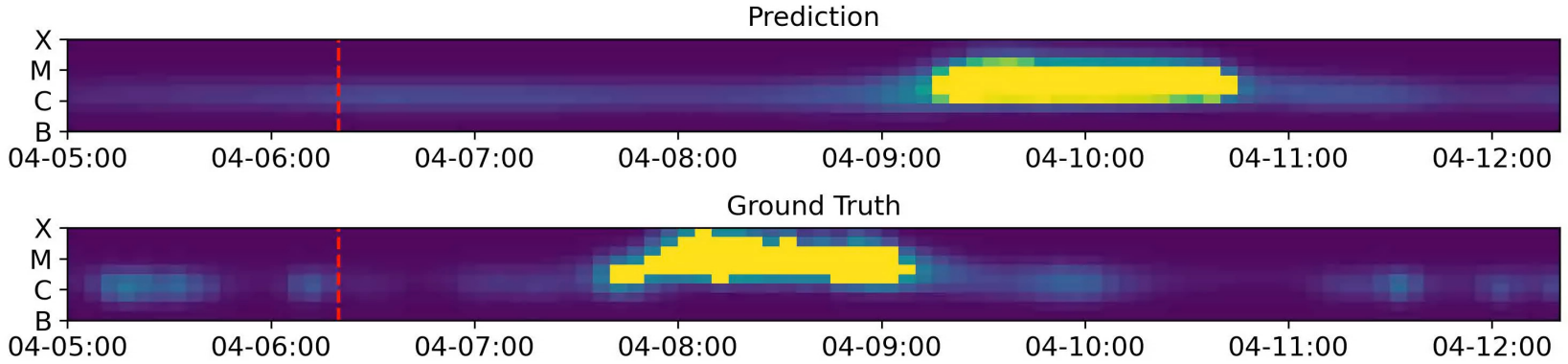


Results

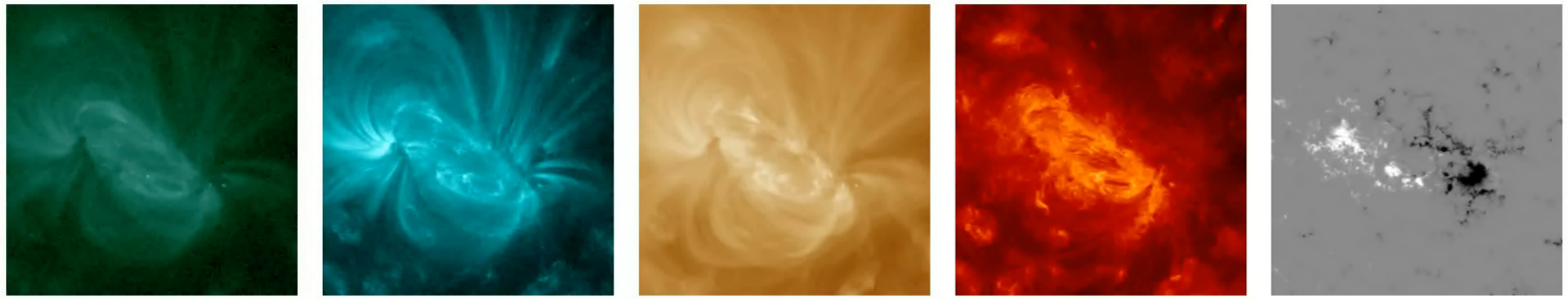


M1 Flare: 2014-12-04

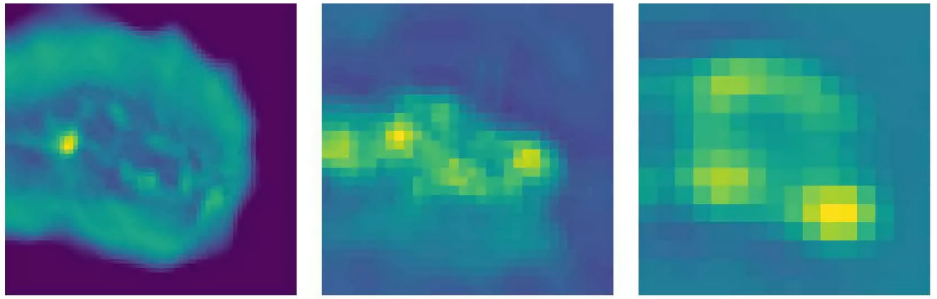




Results

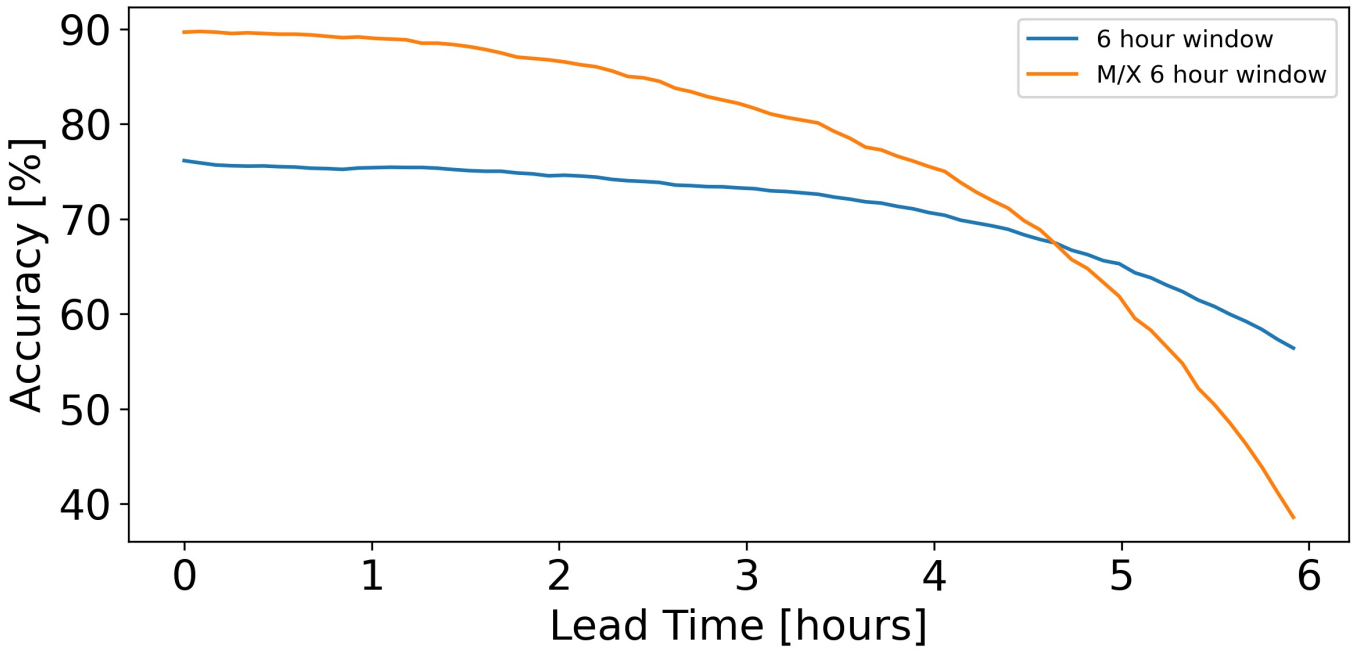


Flare quiet active region
2013-11-05



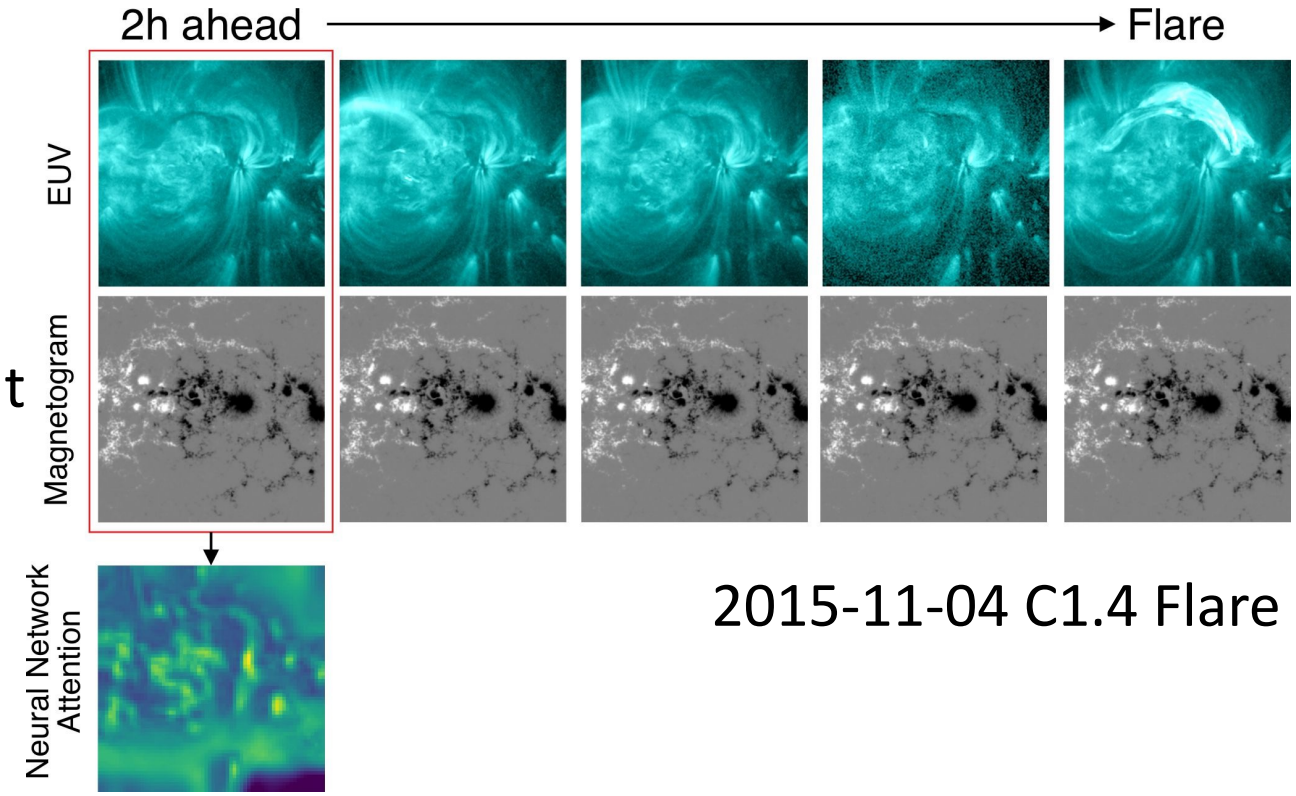
Evaluation

- Reduced to binary prediction
- Preliminary statistical evaluation (test set – ~5,000 samples)
  - Precision = **83%**
  - Recall = **73%** All, **89%** M/X
  - $TSS = \frac{TP}{TP+FN} - \frac{FP}{FP+TN}$ = **0.53**



Conclusion

- Automated method for solar flare prediction
  - Short-term predictions (6 hours)
  - Good prediction for large flares (89% recall)
  - Small flares and correct timing difficult
- Attention mechanism gives insight into the neural network interpretation of flare onset conditions



2015-11-04 C1.4 Flare

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