# Deep Neural Networks With Convolutional and LSTM Layers for SYM-H and ASY-H Forecasting

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## 1. Work description

- DNN combining Convolutional and LSTM layers to forecast the SYM-H and ASY-H geomagnetic indices.

- Two networks with the same architecture, one for each index, for better accuracy.

- The ASY-H index is significantly harder to forecast.

- Full description: **https://doi.org/10.1029/2021sw002748**

## 2. Database

- 42 intense geomagnetic storms between 1998 and 2018, SYM-H achieved values lower than -100 nT.

- IMF data measured by ACE (1-second resolution) and SYM-H and ASY-H indices values (5-min averages).

- IMF data grouped to the indices resolution computing mean and standard deviation.

- Plasma is not used due to large amount of missing data.

- Input features (last 200 minutes):
  - 5-min avg and std of the IMF strength.
  - 5-min avg and std of the X, Y, and Z GSM components of the IMF.
  - SYM-H and ASY-H indices.

- Output features:
  - Forecast of SYM-H and ASY-H for next 1 and 2 hours.
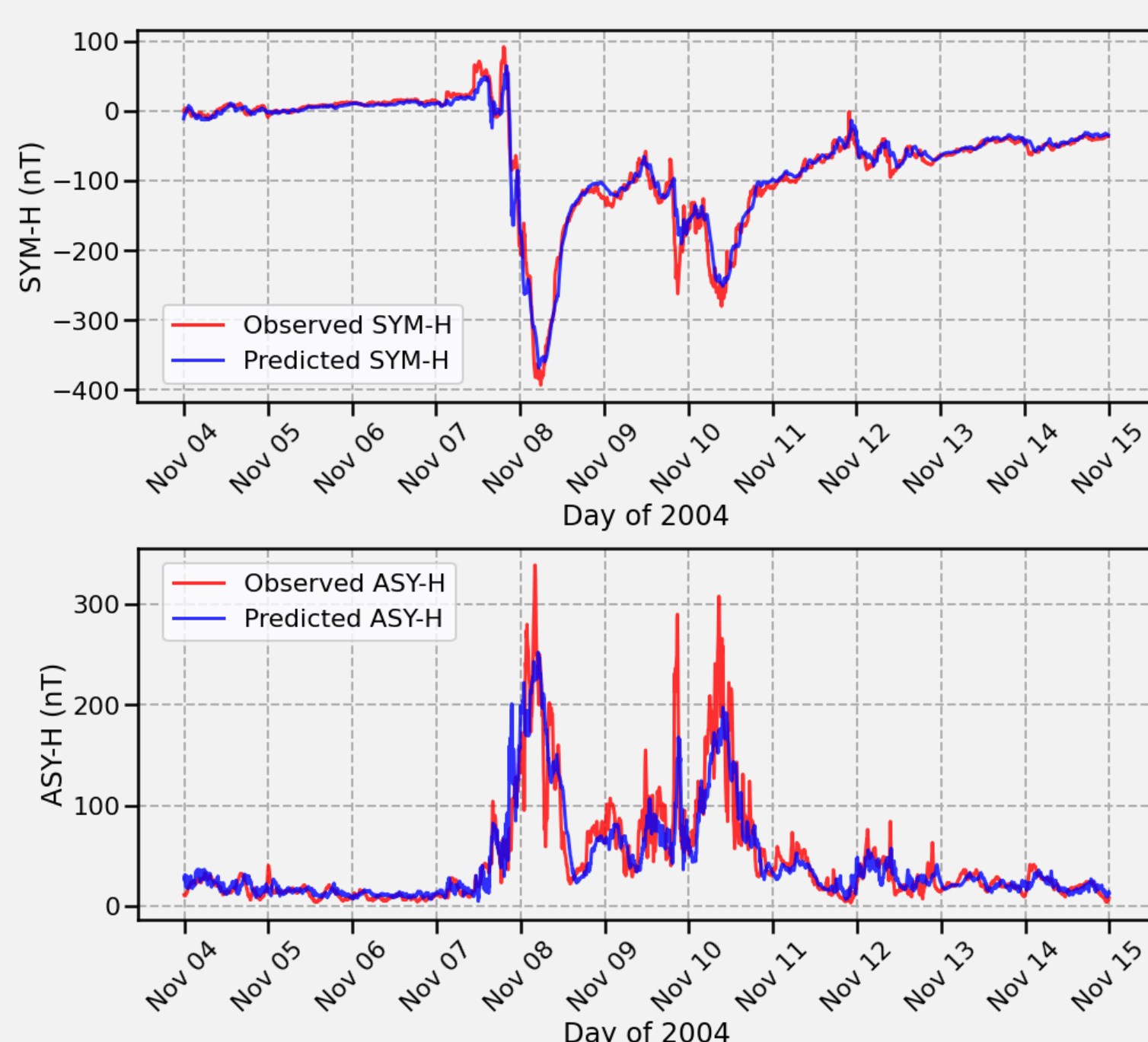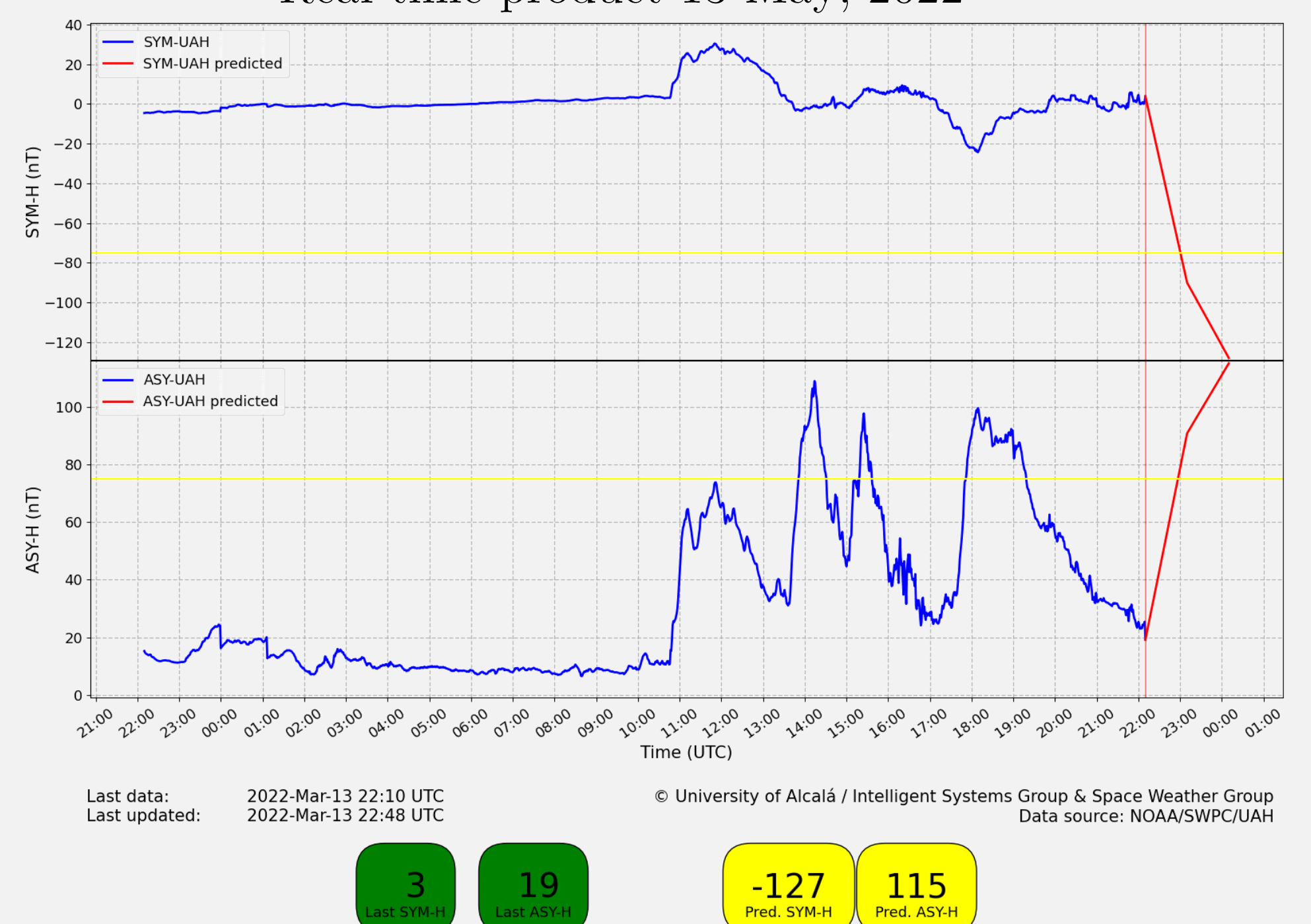
## 3. Neural Network Architecture
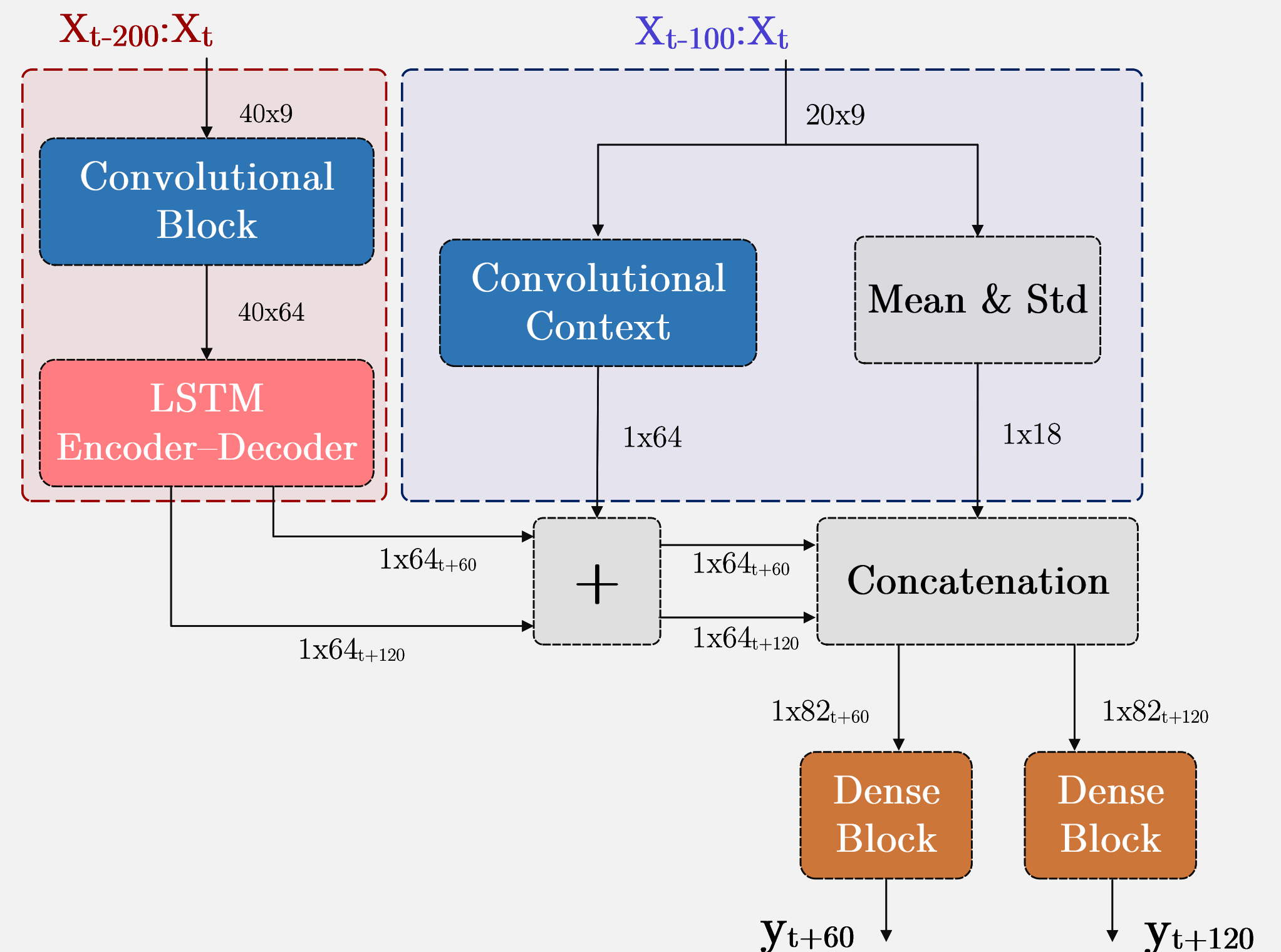


## 4. Metrics

| Dataset | Index | Mean RMSE | Mean R2 |
|---|---|---|---|
| **Test Storms** | SYM-H 1h | 7.861 | 0.930 |
| | SYM-H 2h | 10.527 | 0.875 |
| | ASY-H 1h | 13.300 | 0.727 |
| | ASY-H 2h | 15.213 | 0.647 |
| **Quiet Period 2013 - 2020** | SYM-H 1h | 4.717 | 0.888 |
| | SYM-H 2h | 6.208 | 0.805 |
| | ASY-H 1h | 8.459 | 0.545 |
| | ASY-H 2h | 9.786 | 0.389 |

## 5. Forecasting results

Storm of November, 2004 observed and prediction.



Real time product 13 May, 2022[1]



## Acknowledgements

1. Real time product available at: **http://www.senmes.es**