Deutsches Geodätisches Forschungsinstitut
Technische Universität München
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ICML | 2021
Thirty-eighth International Conference on Machine Learning

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Time-series Forecasting of Space Weather using Ensemble Machine Learning

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Space Weather (SW):

- Varying conditions between the Sun and Earth (limited understanding)
- Impacts the technologies (satellites, navigation, communications, power grids).

Objectives:

- ML for the SW in the Earth's ionosphere.
- Corrections for navigation applications and early-warning.
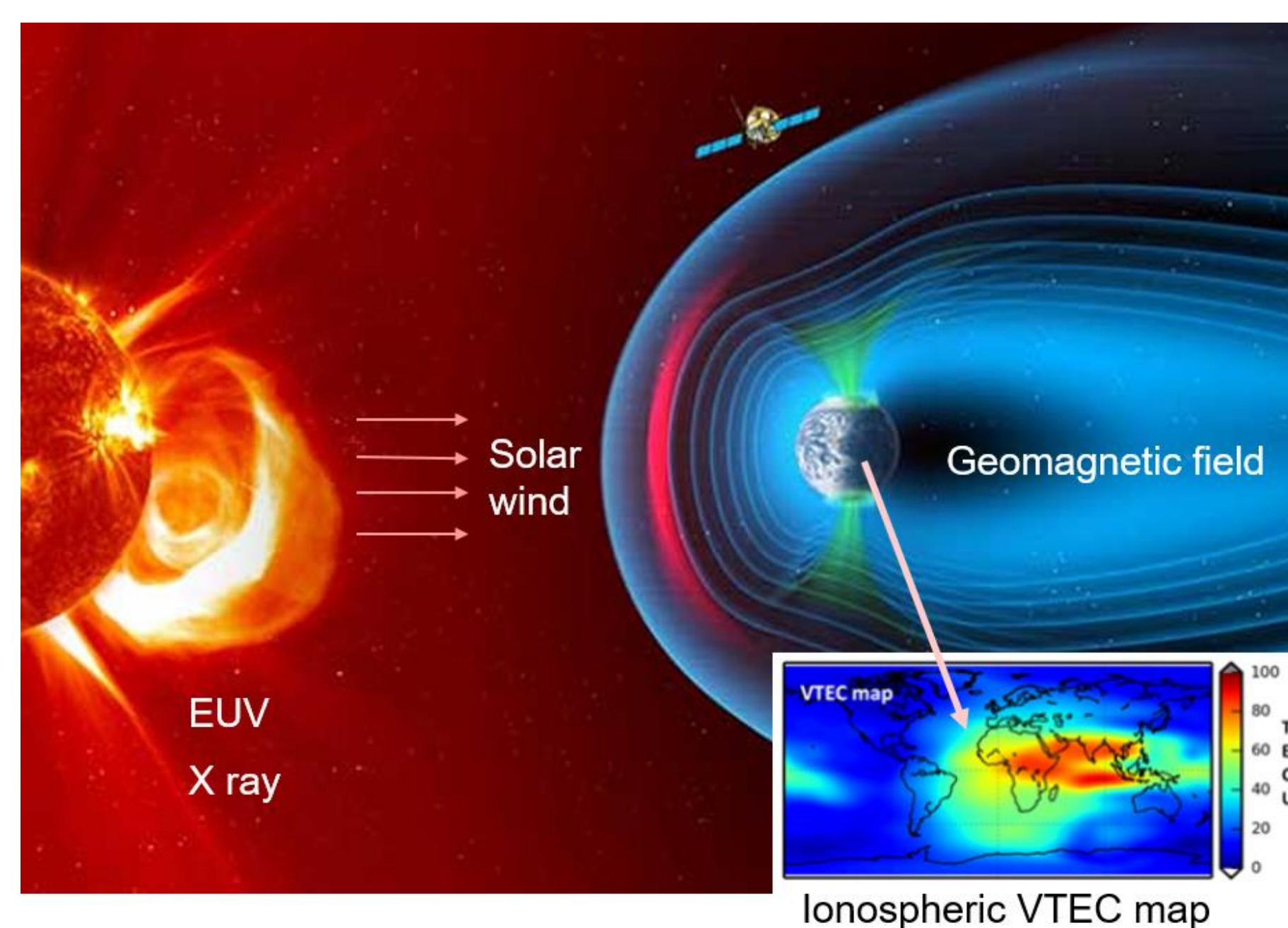- Discovering of knowledge and functions to describe SW processes.

Fig.1: SW processes. Image: ESA (background), DGFI-TUM (VTEC map).

Data:

- ✓ **Inputs**: Solar activity, solar wind, geomagnetic field, time (hour and day of the year) …
- ✓ **Output**: Vertical total electron content (VTEC) in the ionosphere at high-, mid- and low- latitudes
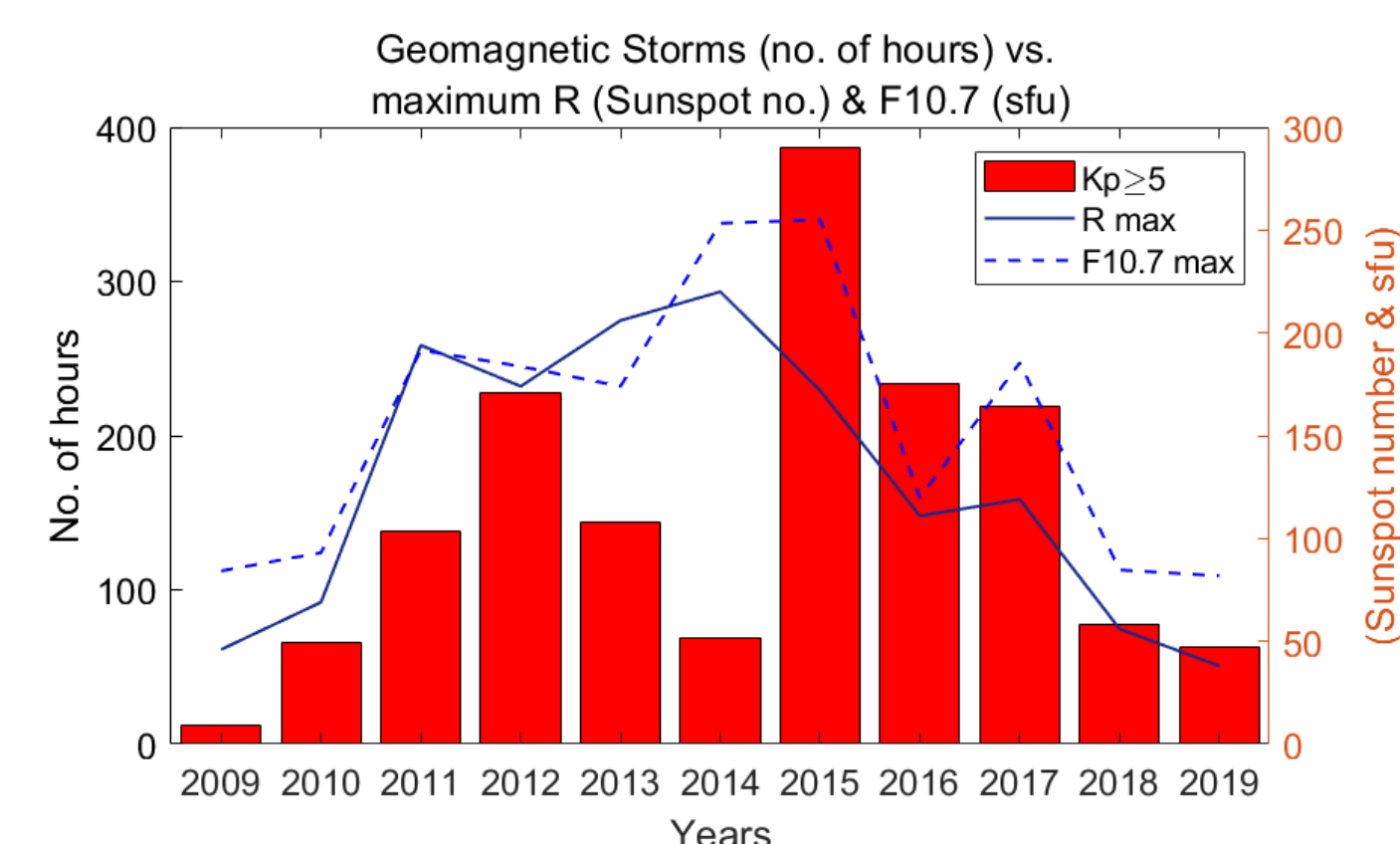- ✓ **Training & cross-validation:** 2015-2016. **Test:** 2017

Fig. 2: Hours of SW storms in geomagnetic field (Kp) vs. max. solar activity (R, F10.7).
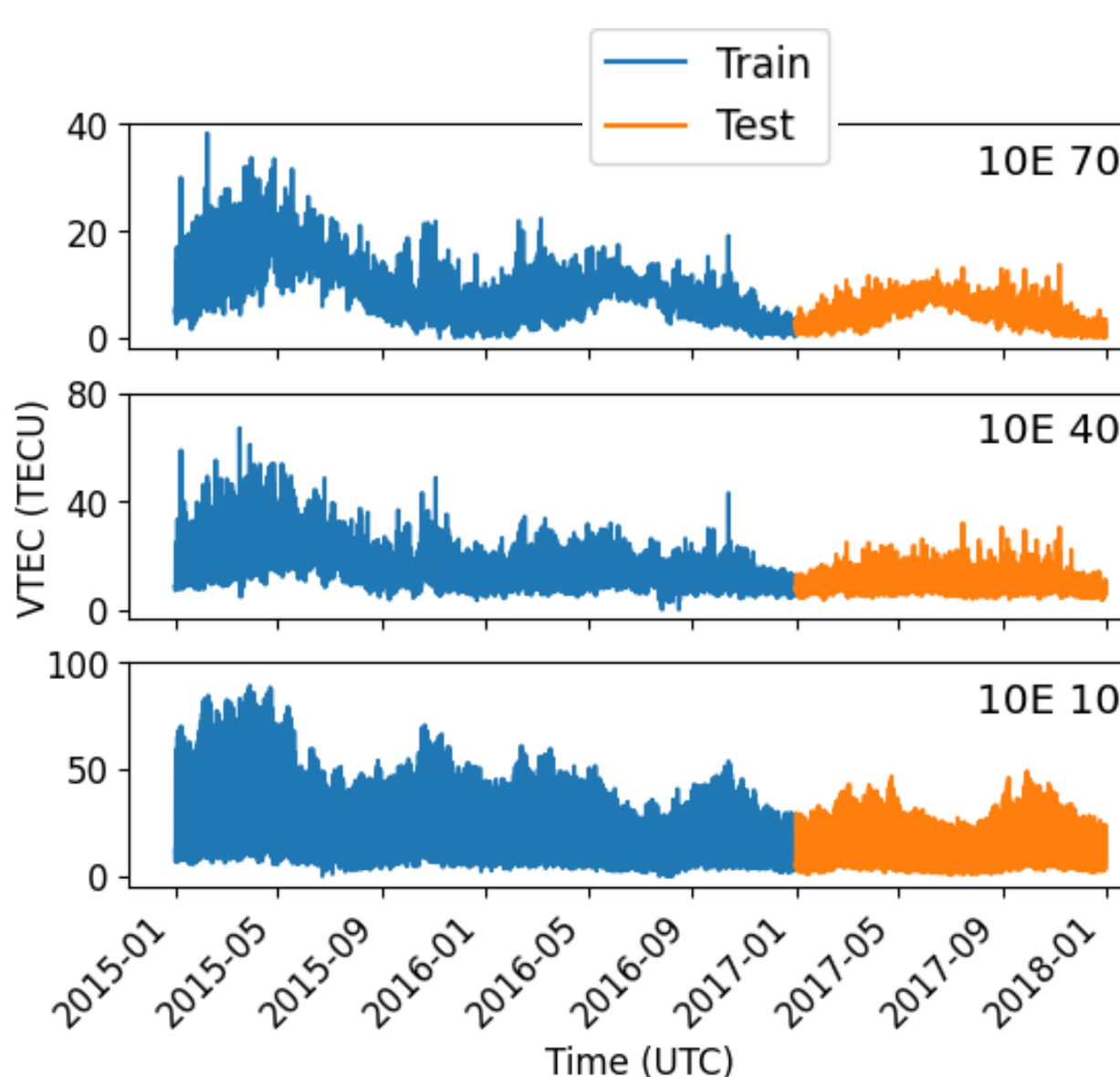

Fig. 3: VTEC for high (70N), mid (40N) and low (10N) latitudes, training and test.
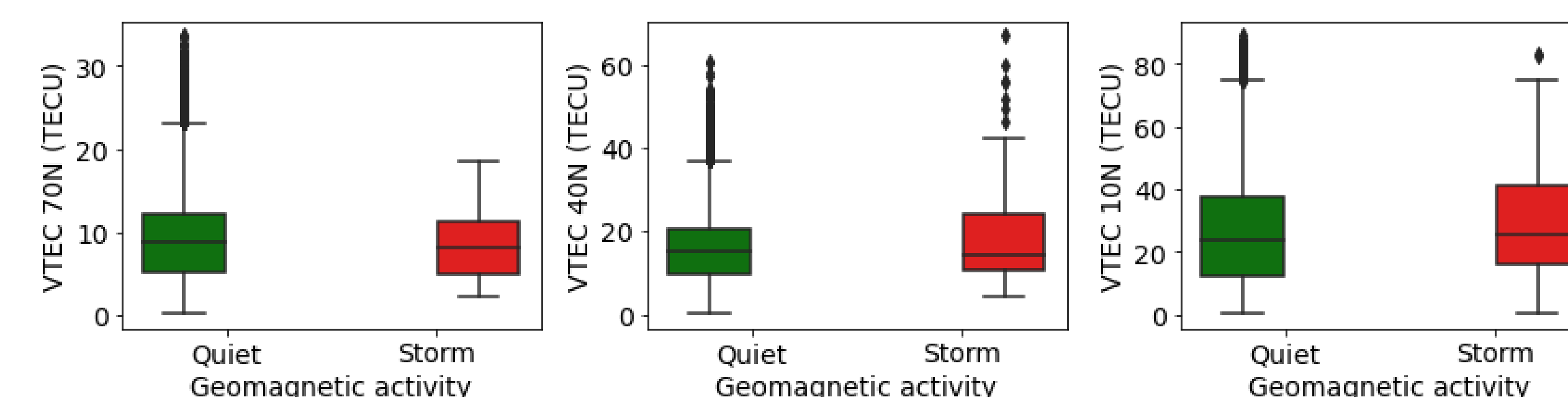

Fig. 4: Boxplots of VTEC (left: 70N, mid: 40N, right: 10N) for quiet and storm conditions (2015-2016).

Algorithms: Decision Tree (DT), Random Forest (RF), AdaBoost (AB), XGBoost (XGB), Voting regressor (VR): RF, AB & XGB
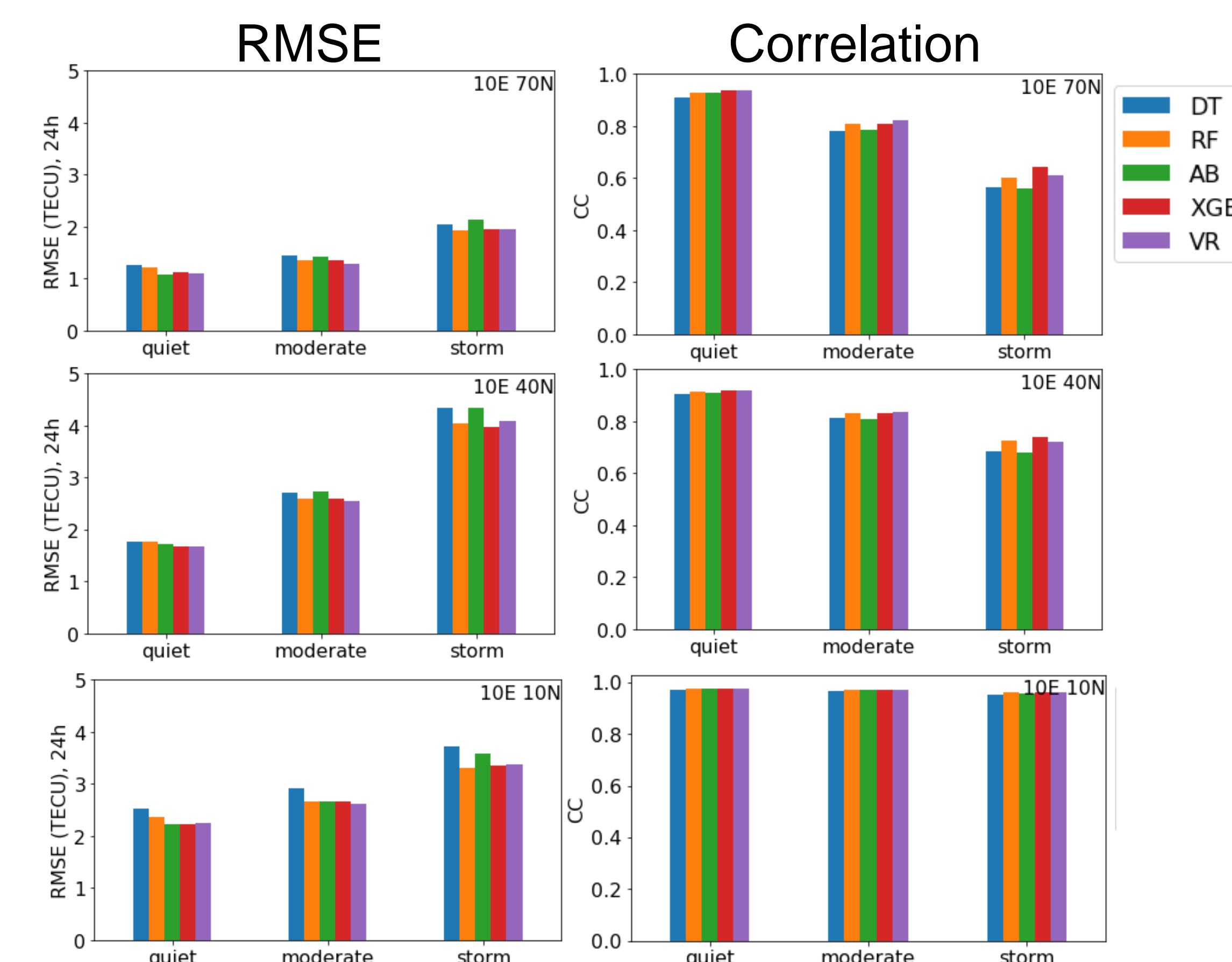
Test: 24-hour forecast

Fig. 5: Left RMSE, right correlations between gound-truth and predicted VTEC values for quiet (Kp<3), moderate (3≤Kp<5) and storm (Kp≥5) conditions.