Ionospheric Irregularities Reconstruction Using Multi-Source Data Fusion via Deep Learning – Tian et al.

→ response to the editor and reviewer

NB: In the followings, the comments from the reviewers are written in **black** and our responses in **green**.

Reviewer #2 (Formal Review for Authors):

General Comments
This is a high-quality manuscript offering a novel insight into how AI techniques can be used to support the prediction of Es layer morphology. The model is able to capture the Es climatology incredibly well, and therefore represents a significant step forward in the field of Es layer modelling. A number of minor typographical corrections have been suggested to aid readability, but overall, the article is well written and structured.

→ We thank the referee for examining our work and giving a positive assessment.

Specific Comments
Does the first paragraph in the results section (Lines 189-197) fit better in the methods section?

→ Thanks for the suggestion. We agree with you. We have moved the first paragraph in the results to the algorithms subsection in the methods section (**Lines 194-202, 215-221**).

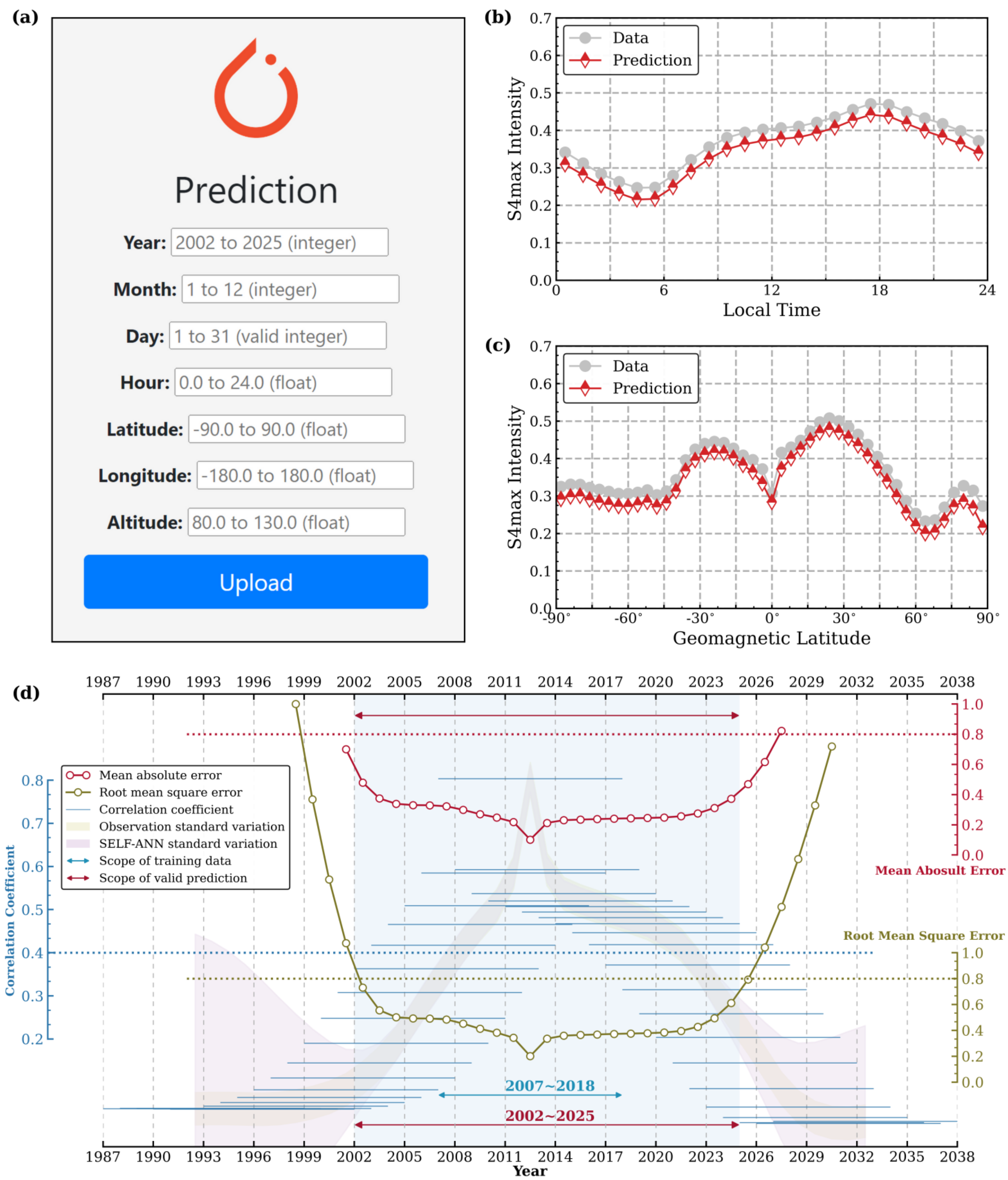
It is mentioned that the model offers "faster computation speed and a wider valid time scope" (Line 341) but the specific time scope is not detailed. In lines 357-358 it says the wider valid time scope spans approximately one full solar cycle. This would be useful to move to when it is first discussed in line 341. However, it isn't clear what the actual time range of the application and its predictability is – what calendar years is the model able to predict Es layers in? The time scope is wider than what? The SELF-ANN GitHub page is referenced but the time scope isn't clear from the readme there either.

→ Thank you for highlighting this issue. We concede that the manuscript did not fully clarify the specific effective time range for the simplified version of the SELF-ANN tool. Predictive experiments were conducted with the simplified model across different 12-year interval. We have modified the sentence structure and incorporated relevant descriptions (**Fig. 8; Lines 387-393, 395-396, 410-414; Captions Fig. 8**). Additional information has also been included in the GitHub readme (https://github.com/RuleNHao/SELF-ANN).

→ To enhance computational speed, we developed a simplified version of SELF-ANN, which requires only time and spatial parameters to predict the corresponding S4 index with response times at the scale of seconds. The training data for this tool encompassed the COSMIC data from 2007 to 2018, a span covering one full solar cycle. Typically, the model demonstrates superior performance within the scope of the training dataset. To evaluate performance beyond the training data, we varied the input years in the model to obtain corresponding predictions, subsequently contrasting them with observational data.

→ More specifically, we evaluated the model's performance over different 12-year cycles by varying the input year intervals, ranging sequentially from 1987 to 1998, 1988 to 1999, up to 2027 to 2038. We observed that the model achieved its peak performance within the training period from 2007 to 2018 (correlation coefficient was 0.804), with a subsequent decline in performance as the time frame extended. Ultimately, we selected 2002 to 2025 as the effective time range for the simplified model. Evaluation metrics within this range remained within acceptable bounds: for 2002-2013, MAE was 0.323 and RMSE stood at 0.484, while for 2014-2025, the MAE was 0.245 and RMSE was 0.378.

→ The revised Fig. 8 below presents an evaluation of the predictive performance of the simplified SELF-ANN, including the specific effective time range in Fig. 8a. Figure 8b-8c remain unchanged. Figure 8d displays the statistical results, with blue arrows denoting the range of training data, and bidirectional red arrows indicating the effective time frame of the tool.



Technical Corrections

(1) Line 1: Consider rephrasing to “Ionospheric sporadic E layers (Es) are intense plasma irregularities between 80 and 130 km in altitude, which are generally unpredictable”.

→ Corrected (**Lines 1-3**).

(2) Line 26: It may be useful to elaborate/break this down further into the different formation mechanisms, splitting the references up.

→ We agree with you, corrected (**Lines 29-37**).

→ In the revised manuscript, we primarily detailed the formation mechanisms of the Es layer at different latitudes. We briefly outlined the wind shear formation mechanism of temperate or mid-latitude Es, the equatorial electrojet mechanism at equatorial or low-latitude Es, and the auroral particle precipitation factors at auroral or high-latitude Es.

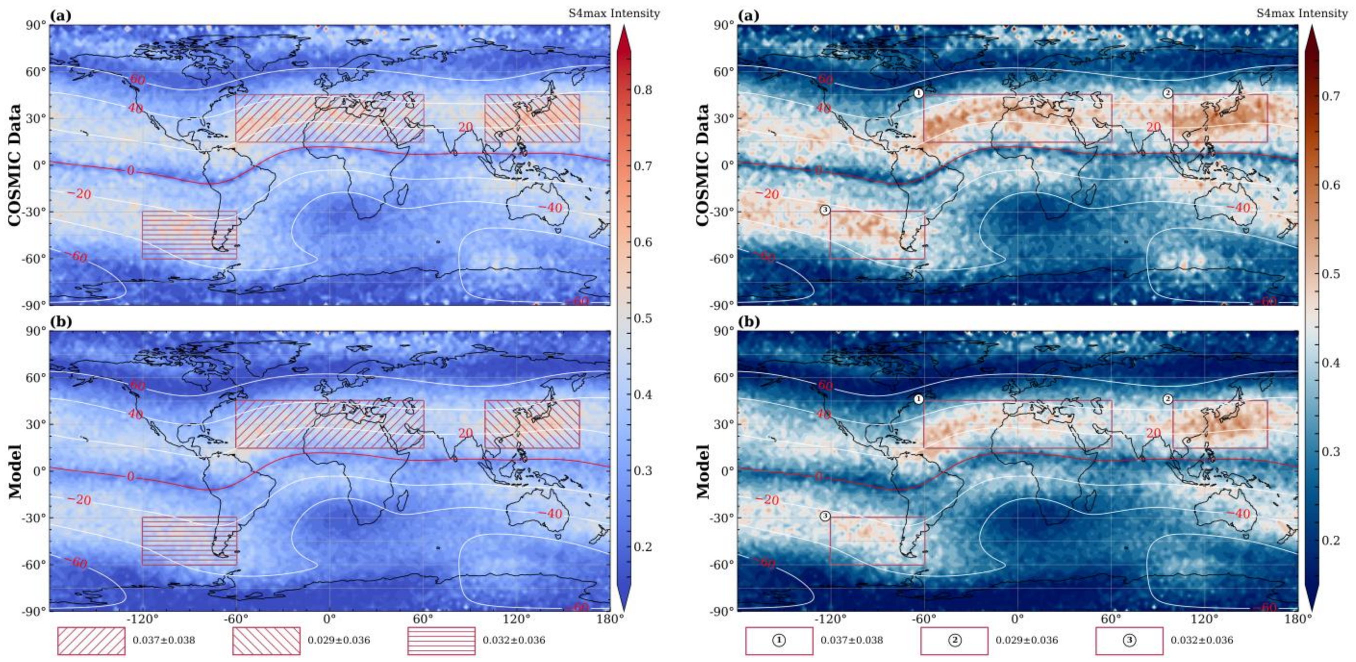
(3) Line 88: “We has” => “we have”.

→ Corrected (**Lines 100-102**).

(4) Figure 3: Consider revising colour scheme to improve contrast between areas of high/low intensity. Do the boxes need to be shaded? Just a red outline may be clearer.

→ Thanks for your suggestion. The caption and description of Fig. 3 have been modified (**Fig 3; Lines 263; Captions Fig. 3**).

→ To enhance contrast, we modified the color scheme and the display range of the color bar. Concurrently, shadows on the boxes were removed and replaced with numerical identifiers, as shown below. Original image on the left, modified image on the right.



(5) Lines 284-285: Consider rephrasing to “due to the ions failing to converge vertically” or “since the ions fail to converge vertically”.

→ Corrected (**Lines 325-327**). We have rephrased to “due to the ions failing to converge vertically”.

(6) Line 297: “in this study, as depicted in” => “in this study is depicted in”

→ Corrected (**Lines 339-341**).

(7) Line 321-324: Consider removing “trained on COSMIC satellite RO data” and putting foEs in brackets to aid

readability.

→ Thanks for your suggestion. Corrected (**Lines 365-370**).

(8) Line 325: Consider removing “square”.

→ Corrected (**Lines 370-373**).

(9) Line392: “In sum” => “In summary”.

→ Corrected (**Lines 449-452**).