Total electron content (TEC) map inpainting with DCGAN-PB - the increasing role of machine learning

Yang Pan[1] (yang.pan@mavs.uta.edu),
Mingwu Jin[1] (mingwu@uta.edu),
Yue Deng[1] (yuedeng@uta.edu)
[1]University of Texas at Arlington

Shunrong Zhang[2] (shunrong@mit.edu)
[2]Haystack Observatory, Massachusetts Institute of Technology

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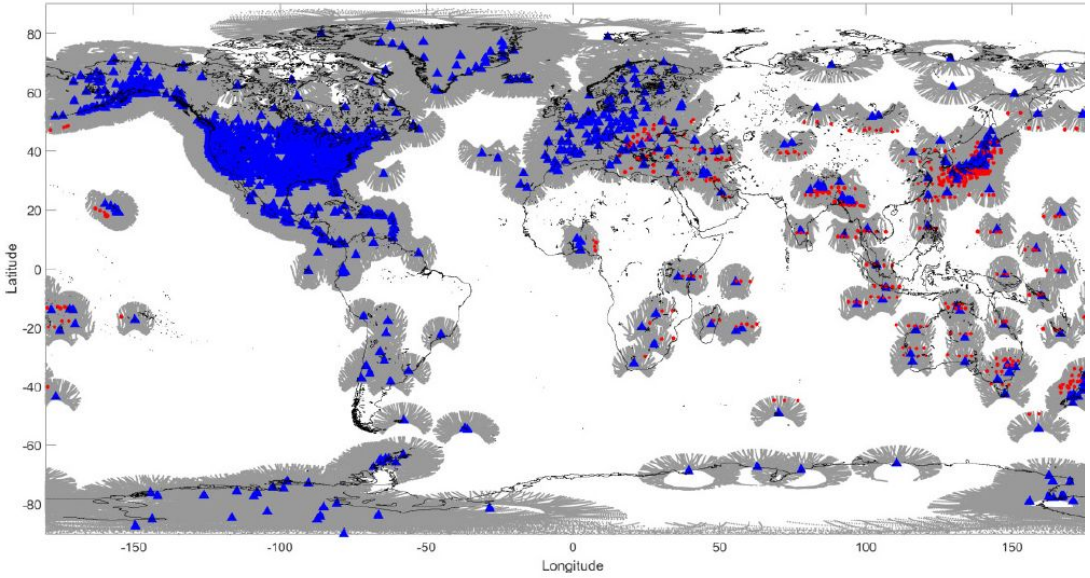
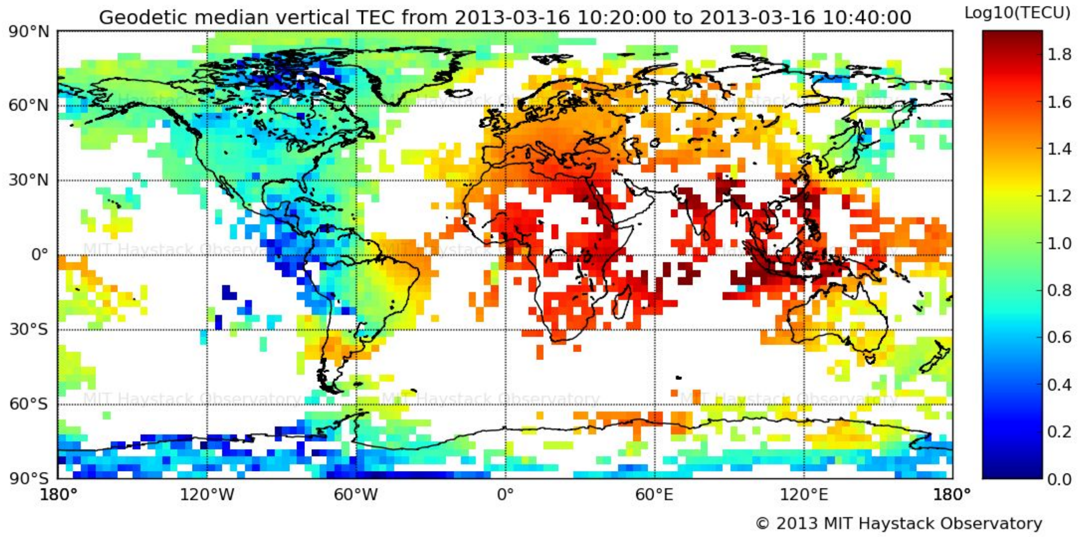
https://www.universetoday.com/13985/explore-earths-ionosphere-with-google-earth/
https://www.hiclipart.com/free-transparent-background-png-clipart-iivva

WHY: The raw TEC data is limited globally

- Due to the **limited coverage** of global navigation satellite system (GNSS) receivers on Earth, the raw TEC data is incomplete.
- Massachusetts Institute of Technology (MIT) records detailed TEC values (MIT-TEC) at geometric points but the coverage is about 48%.
- International GNSS service (IGS) consolidate final completed TEC maps (IGS-TEC). However, lots of manual works are embedded to generate the final TEC map.

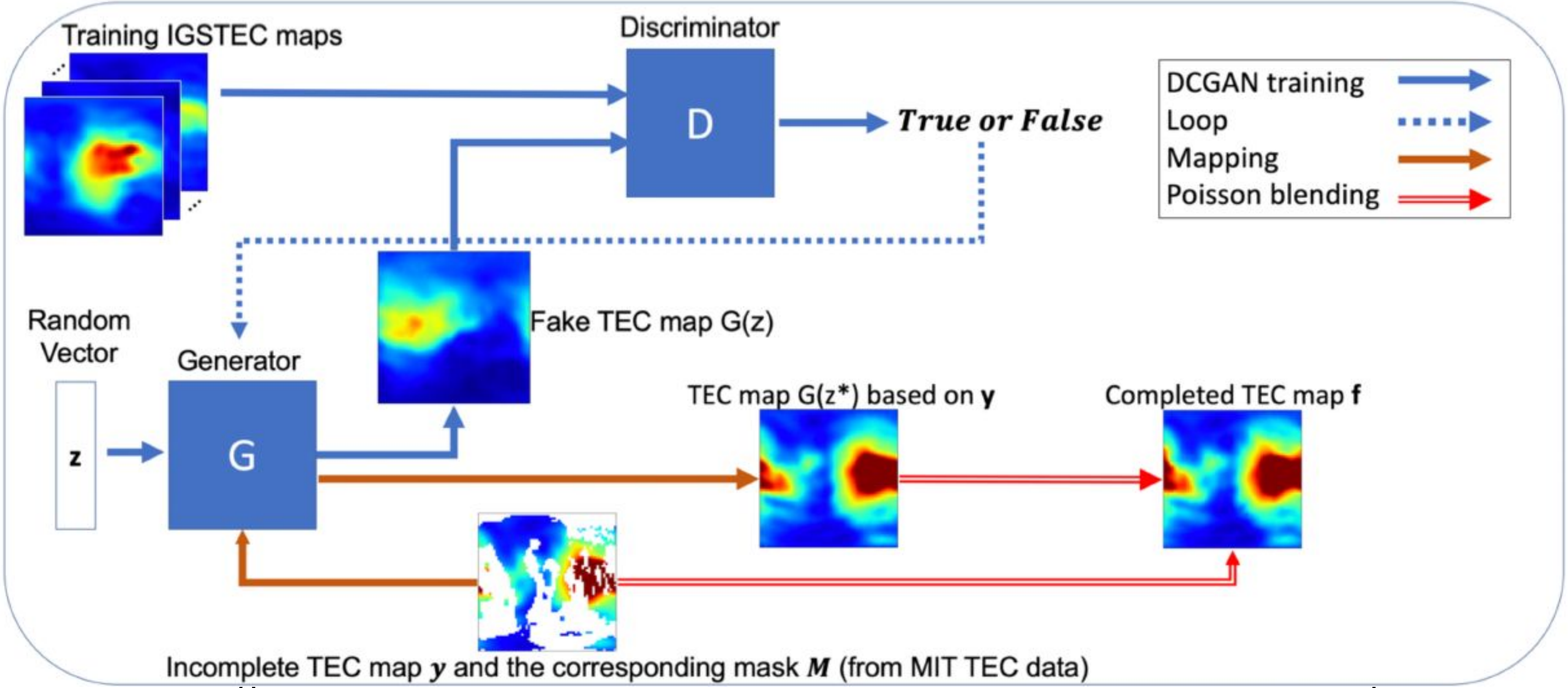


Global 3,189 receiving stations of IGS and CORS (Liu et al., 2019)



MIT-TEC map with data gaps (http://cedar.openmadrigal.org/)

WHAT: DCGAN-PB model



Pan et al., (2020)

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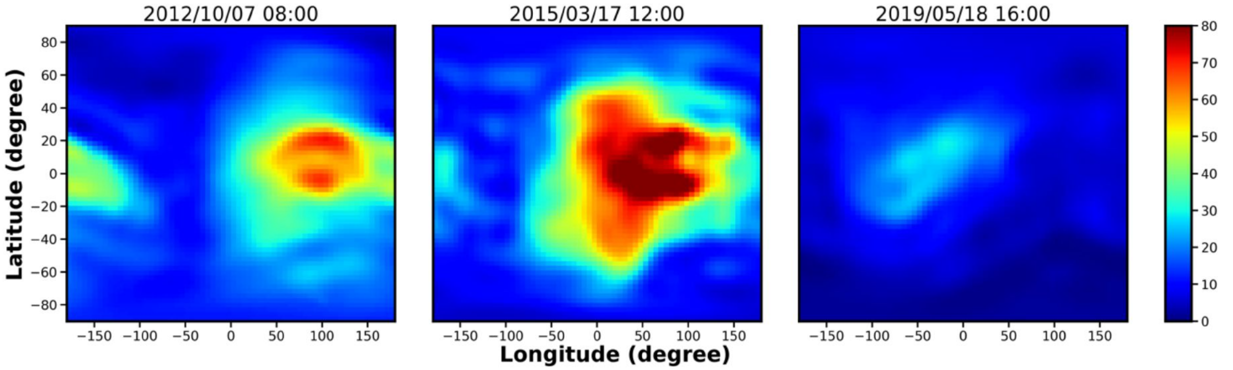
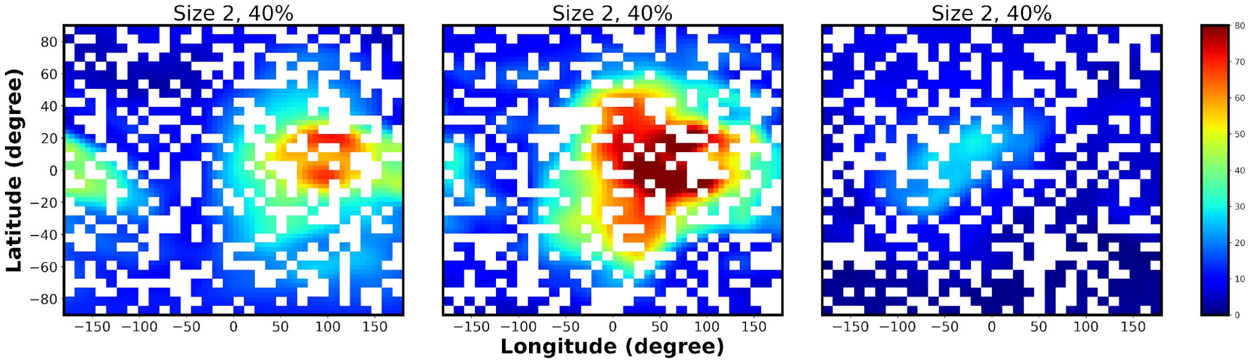
generated TEC values fill the incomplete TEC map through Poisson blending (PB).

HOW: The performance of our model

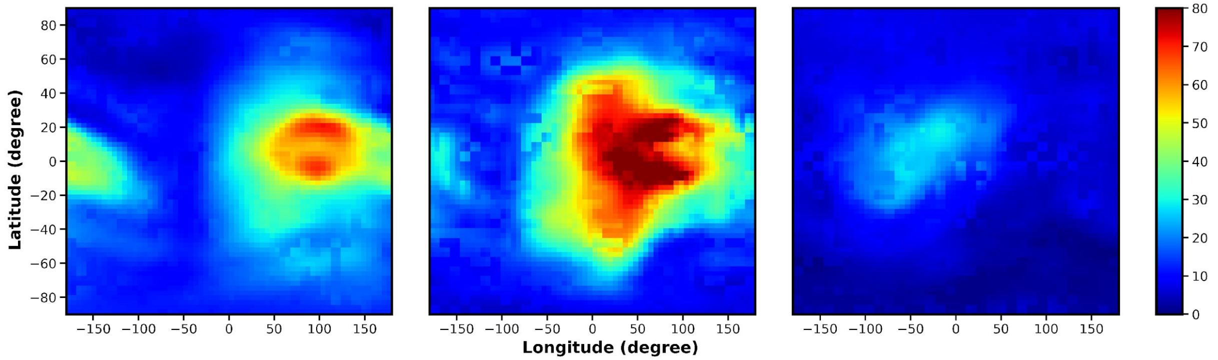
F10.7=98 F10.7=115 F10.7=72

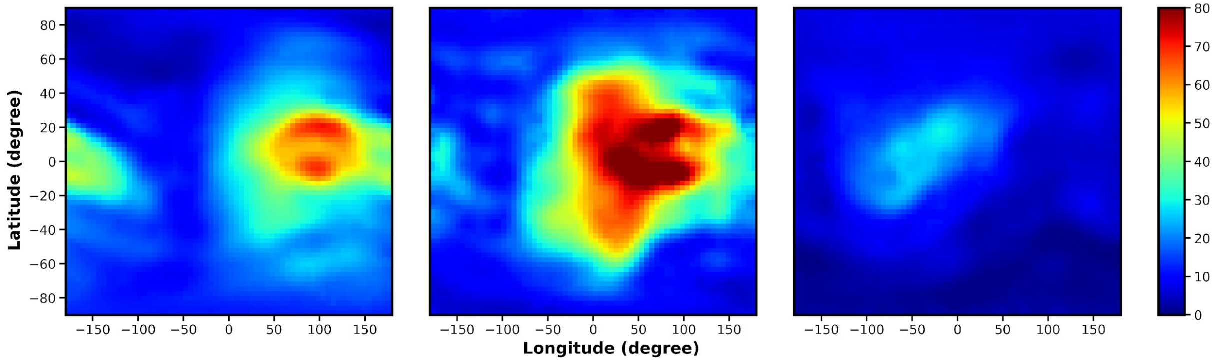




Original IGS TEC maps at different solar activities

Random mask consisting squares in length 2 units, 40% of the area masked

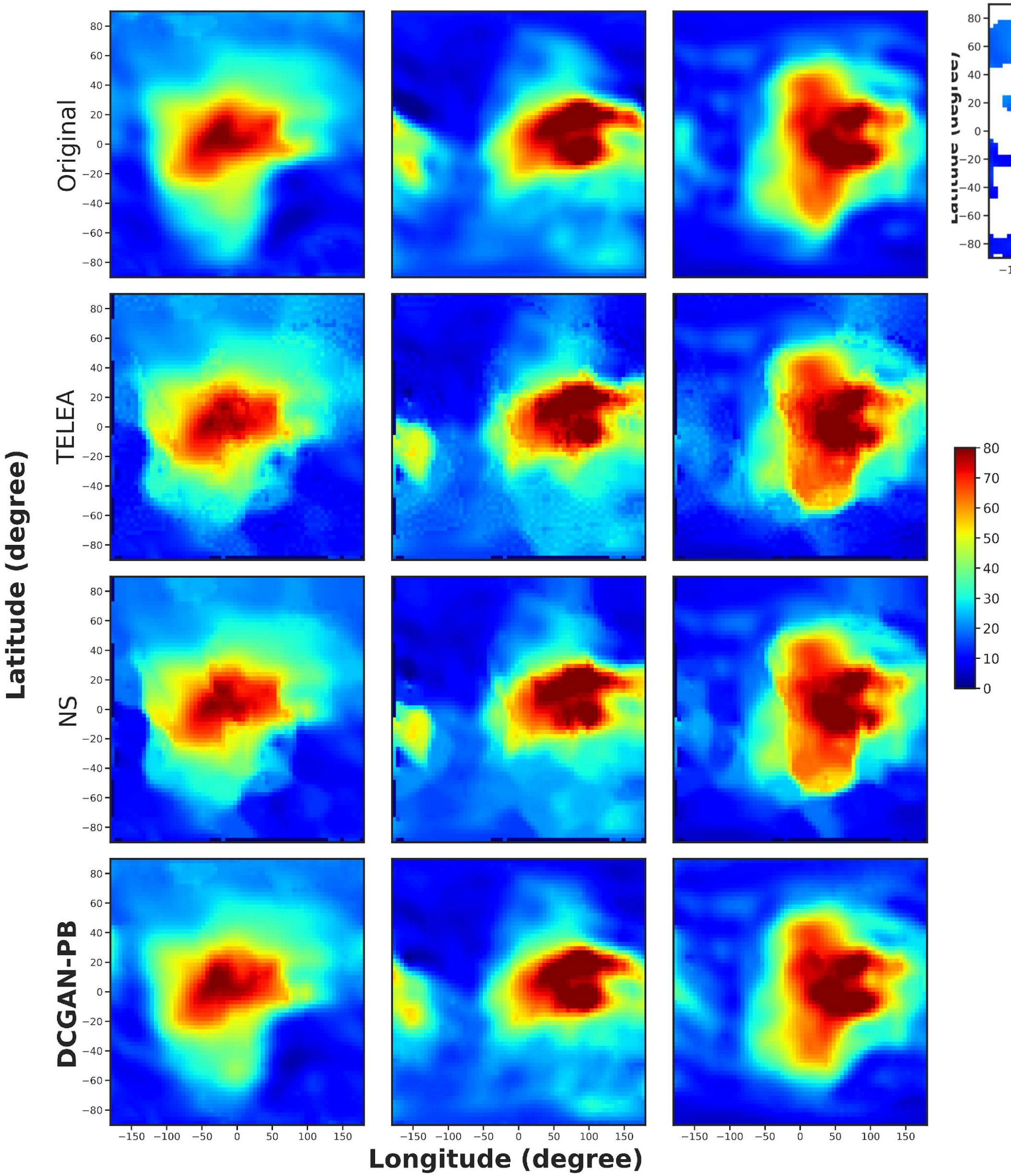


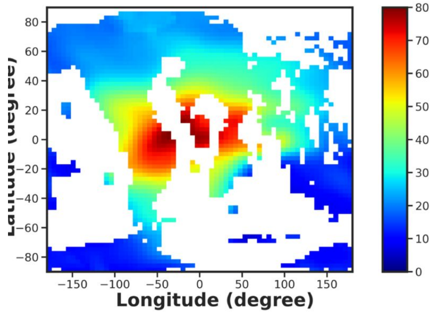


The overall results are decent but with many mosaic-style artifacts.

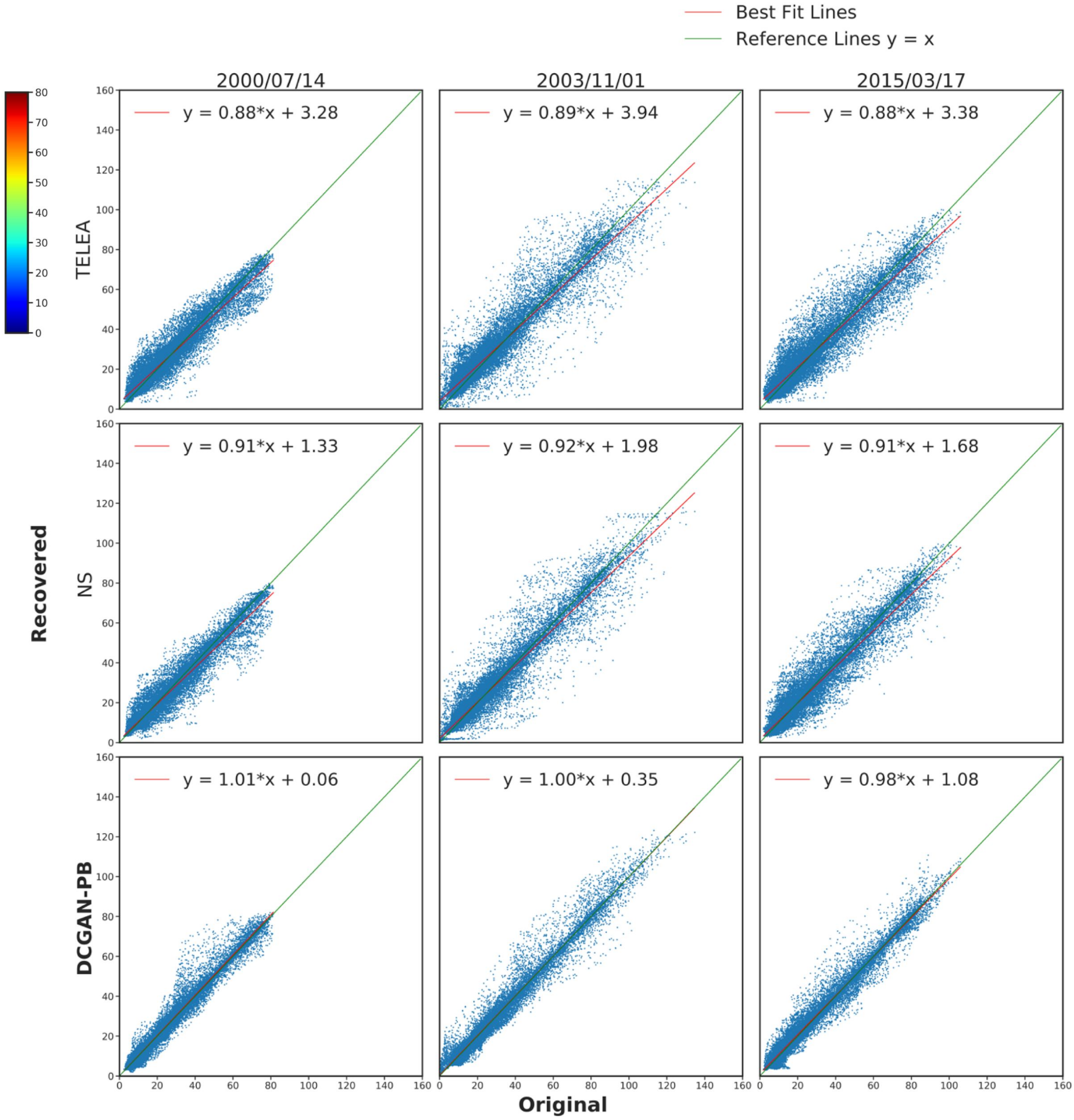
The best results achieved with artifacts eliminated after Poisson blending

HOW: The performance of our model



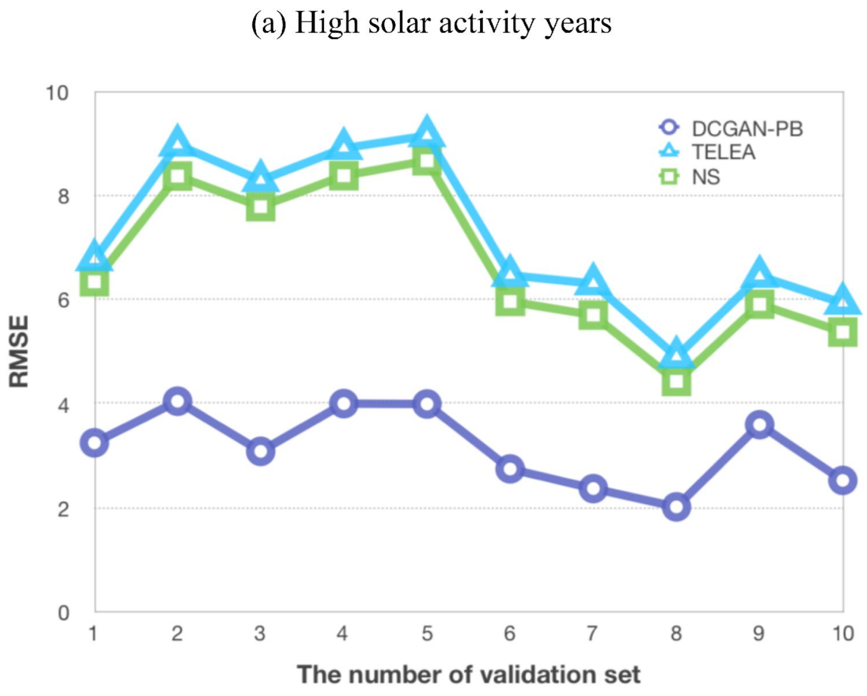


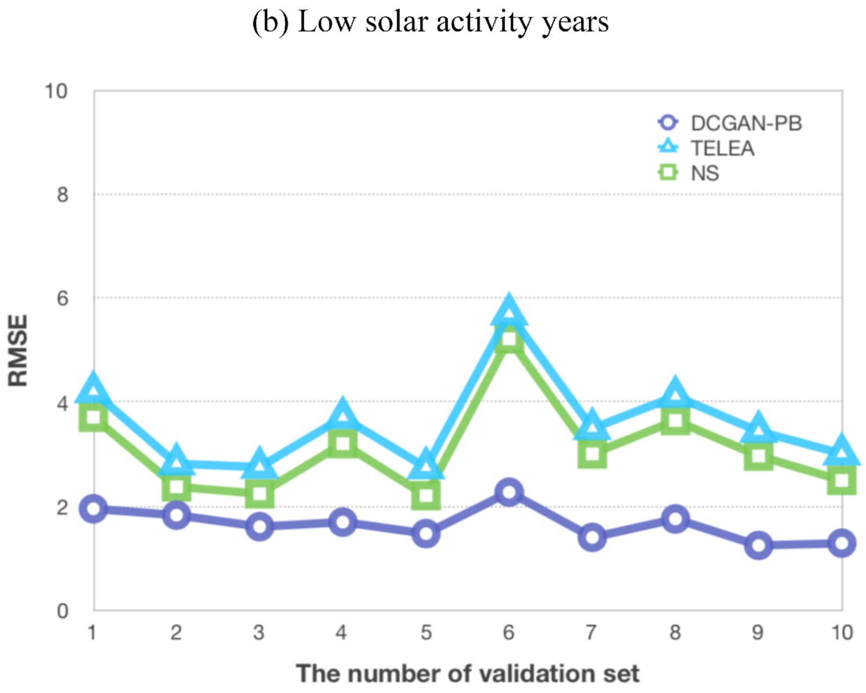
MIT-TEC mask



comparison of inpainting results between our DCGAN-PB model and other traditional methods. And our model recovers with the best performance as indicated by the fit lines.

HOW: The performance of our model





Yang et al., 2020

10-fold cross validation is used for TEC data from 1999 to 2018 (18-year data for training and 2-year data for test, each test data includes a solar activity high year and a solar activity low year). The root mean squared error (RMSE) values are used as the quantitative metric.

Our model achieves the least and stable RMSE values (the average RMSE about 3 TECu for high solar activity years and less than 2 TECu for low solar activity years), comparing to the other two traditional inpainting methods.

Summary:

- The machine learning model DCGAN-PB learns the distribution of TEC maps and recover the incomplete TEC map with decent performance.
- Our model has the best performance against some traditional inpainting methods.
- With the development of more advanced neural networks, it is full of potential to improve the performance for the inpainting task.

Publication info:

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