

Examining the impact of equatorial plasma bubbles on the retrieval of electron density profiles (EDPs) via RO with machine learning

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Curtesy: Tonga Geological Services

Mega Terrestrial Event

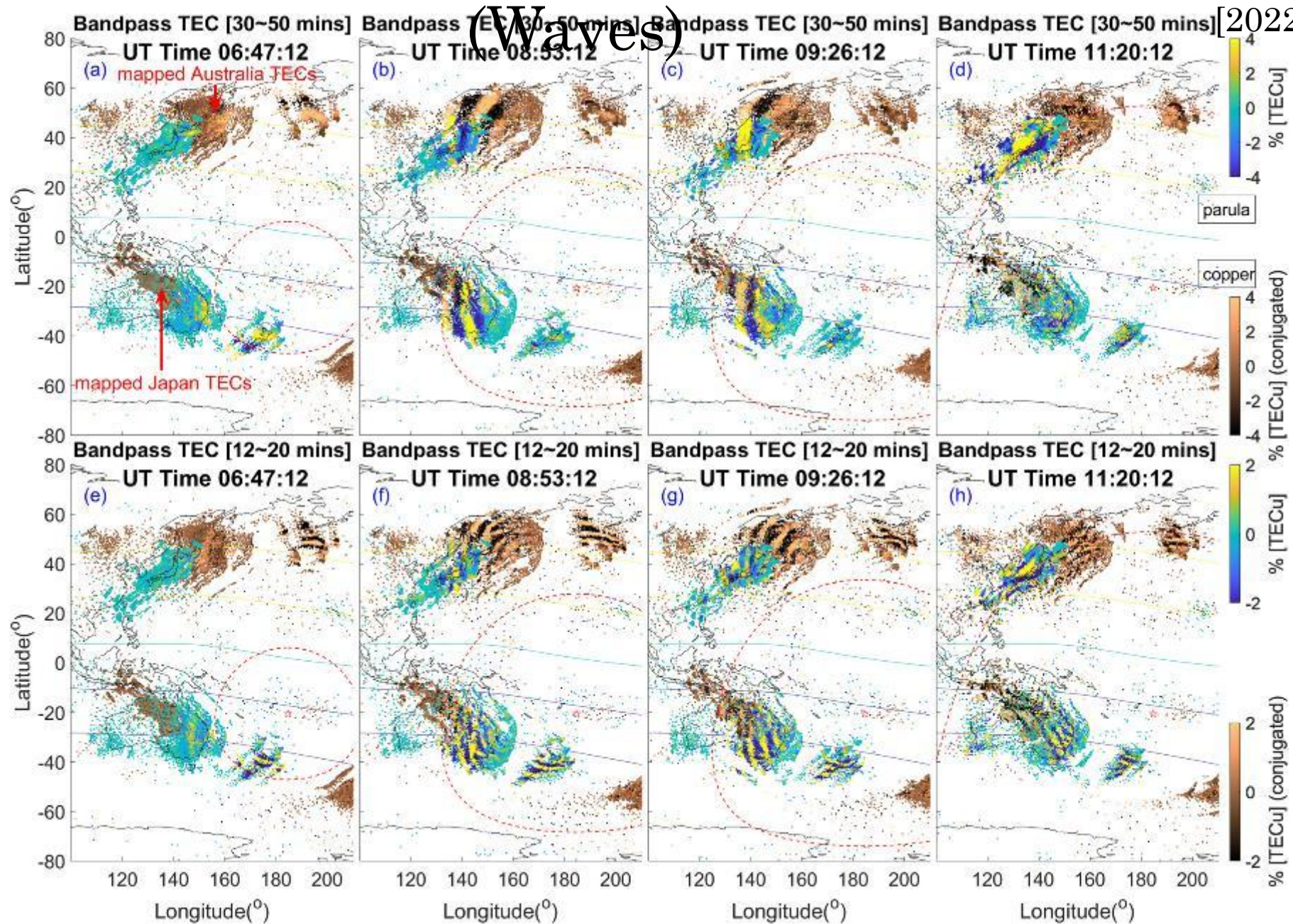
2022
Tonga
volcanic
eruptions

TIDs

Lin et al.

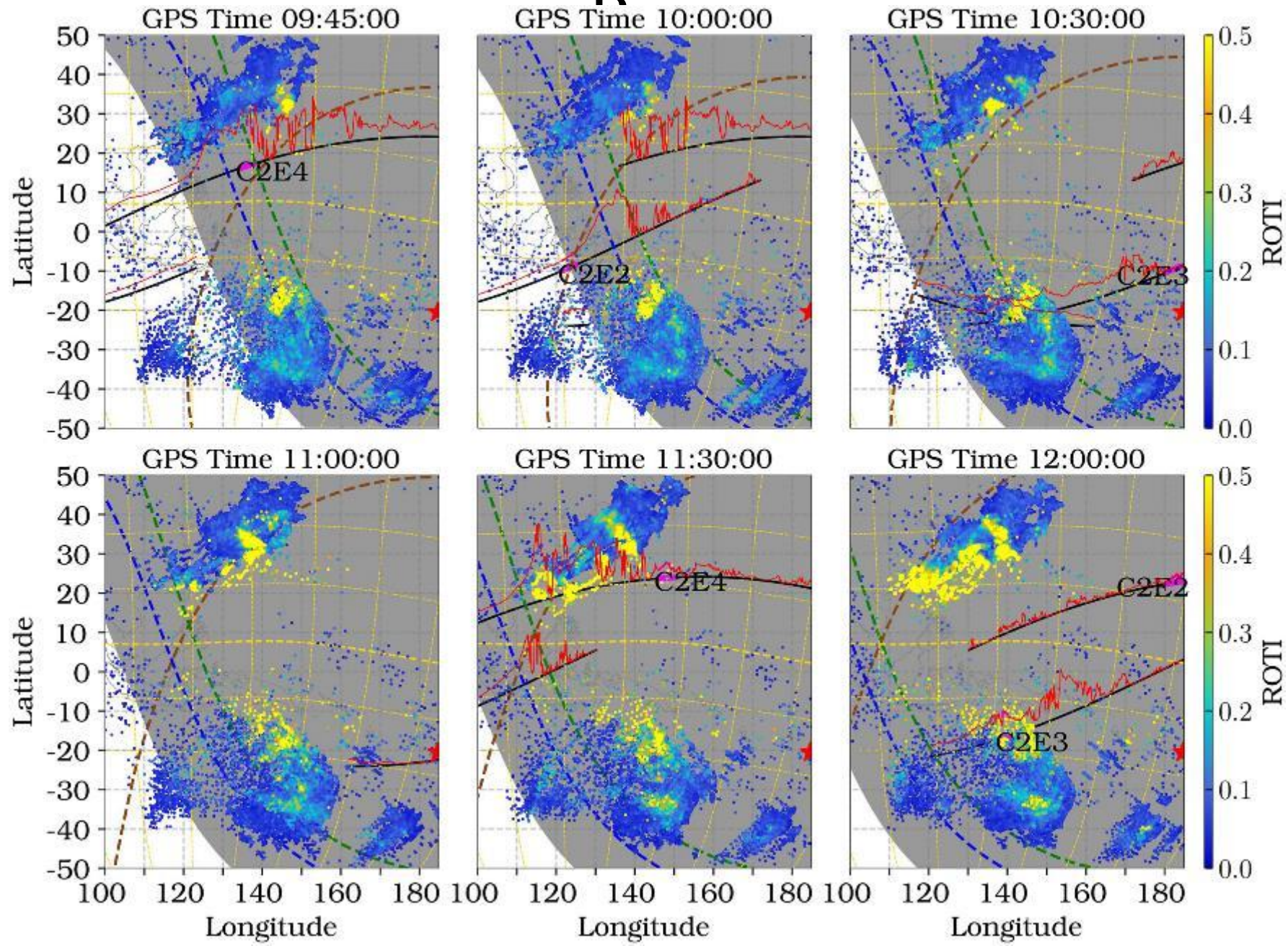
(Waves)

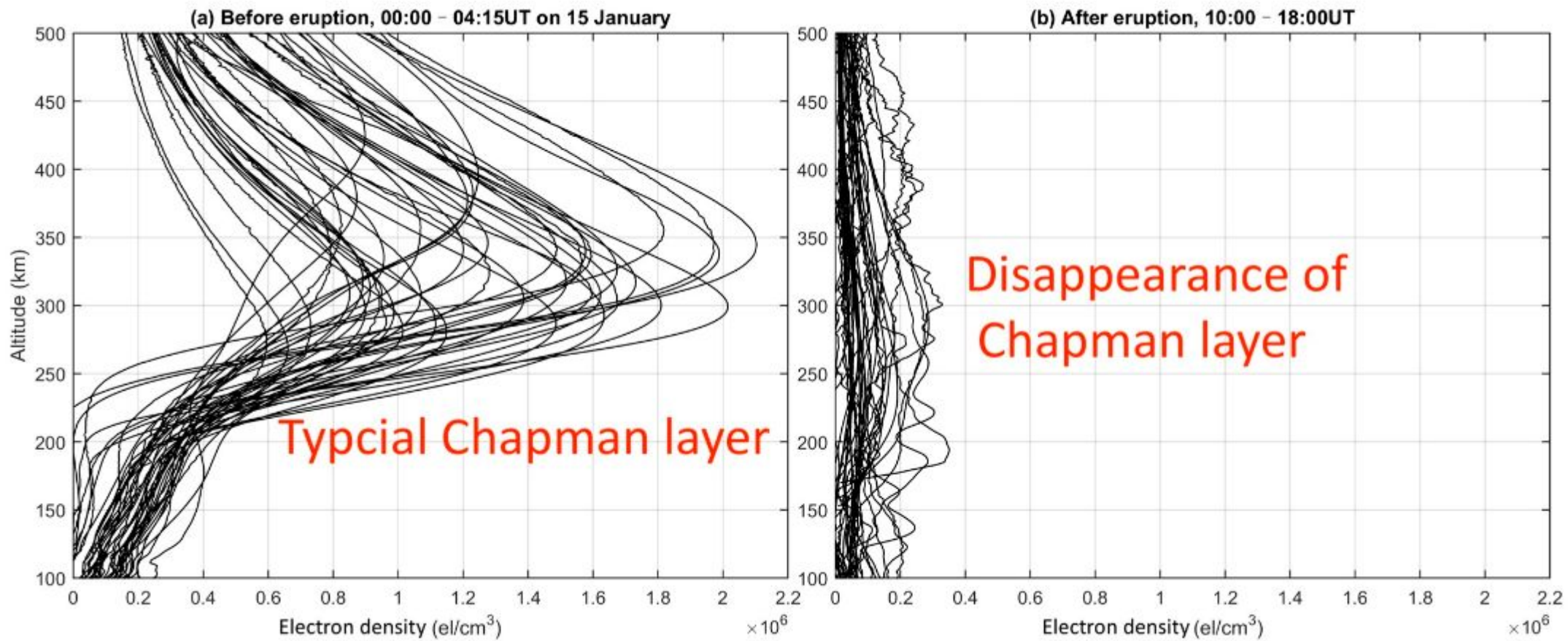
[2022]

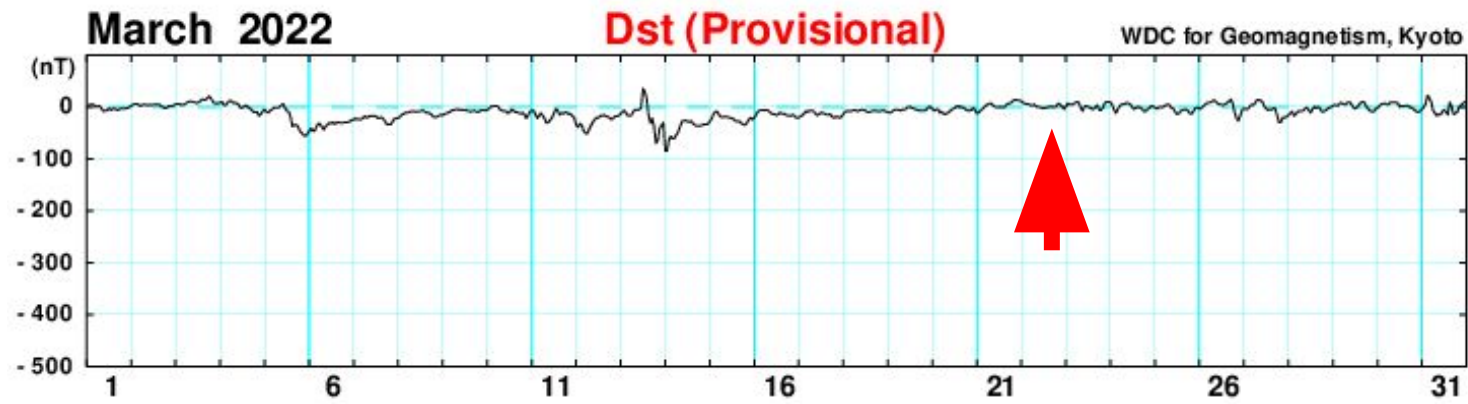


EP

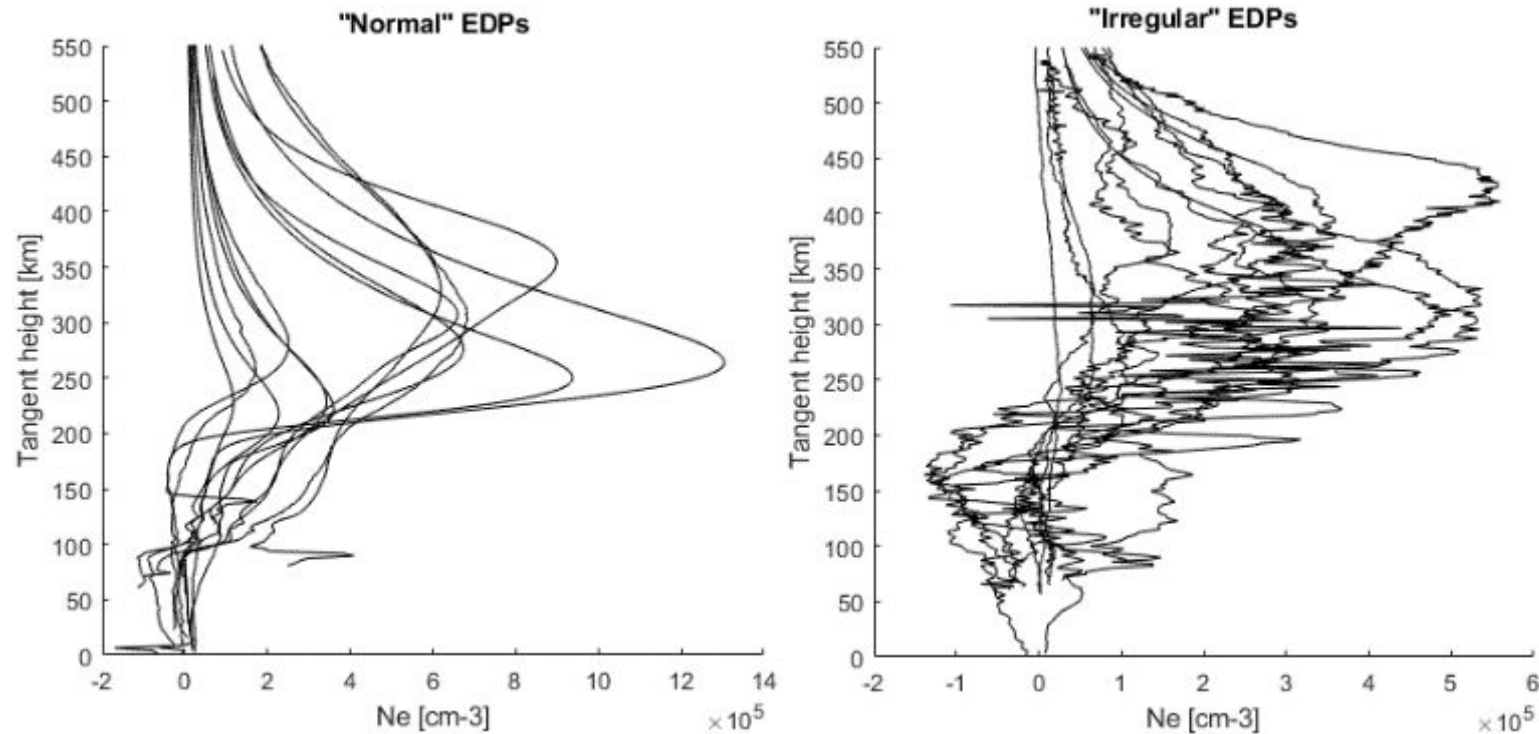
Rajesh et al. [2022]







DOY 081, 2022



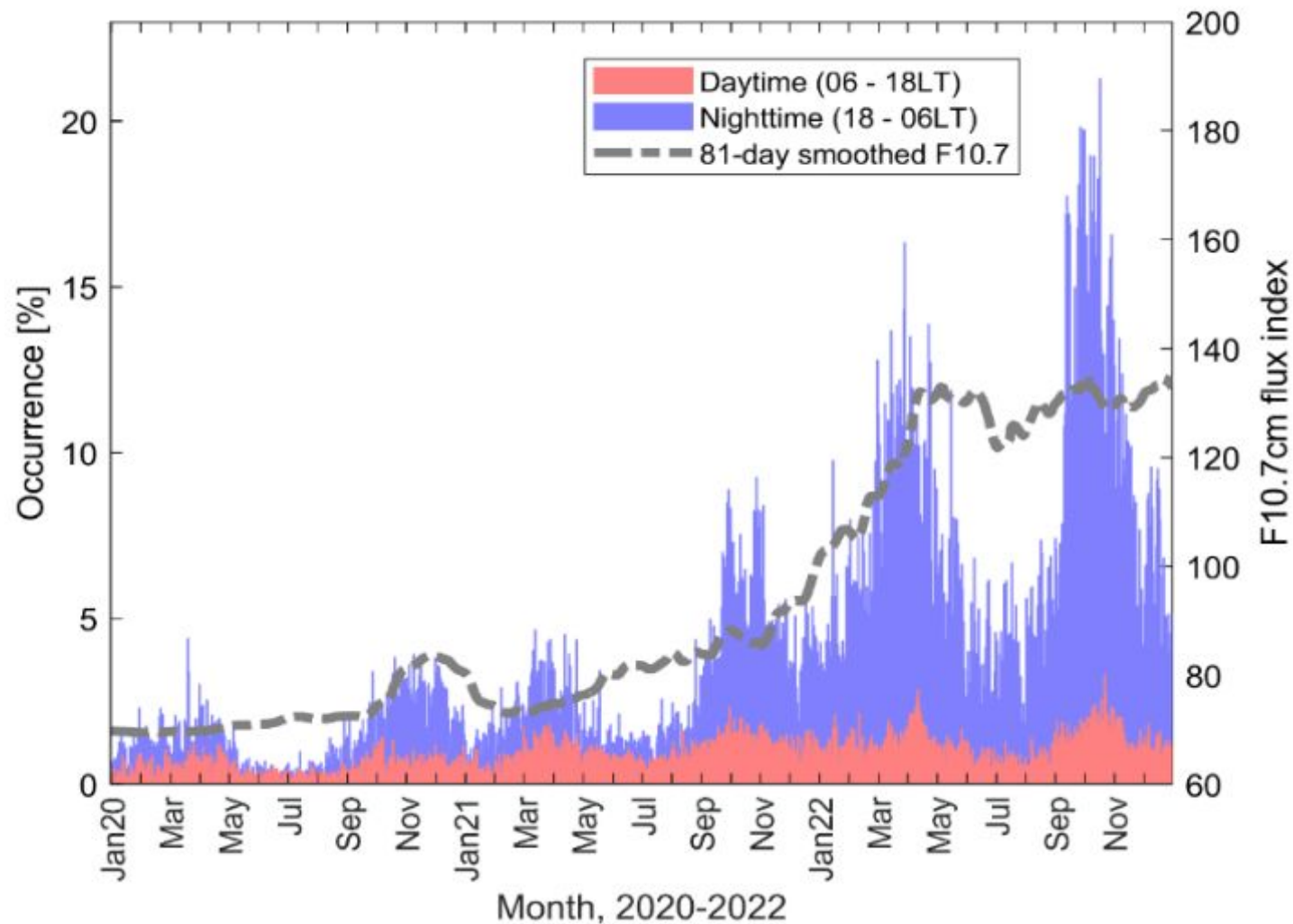
Define
"Irregular"

Source: TACC (Taiwan Analysis Center for COSMIC)

Criteria:

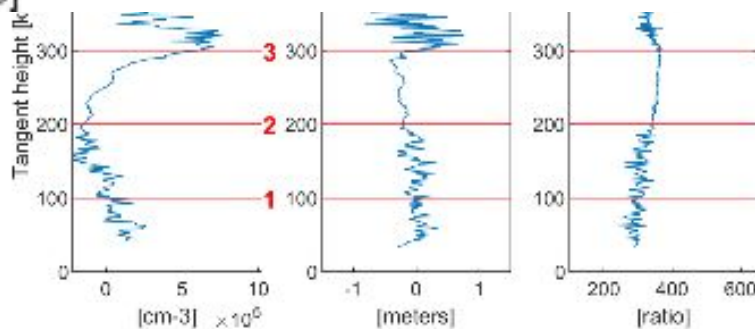
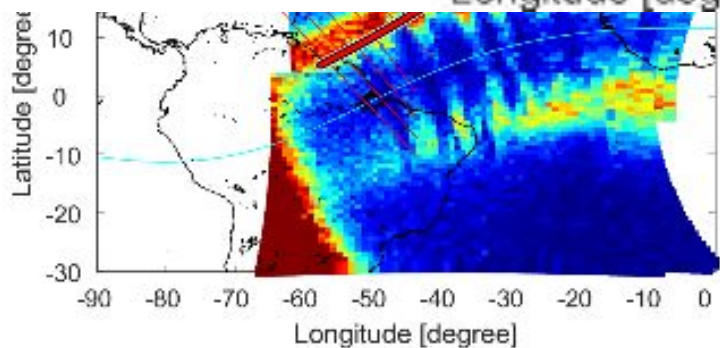
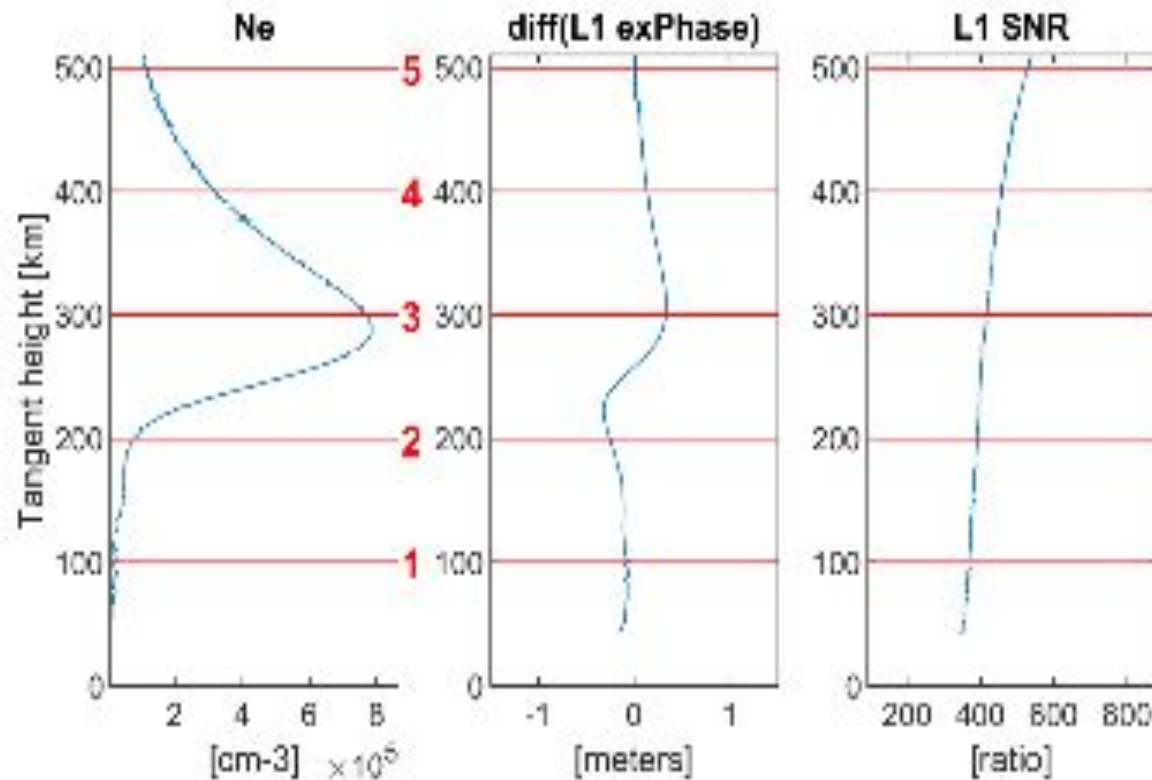
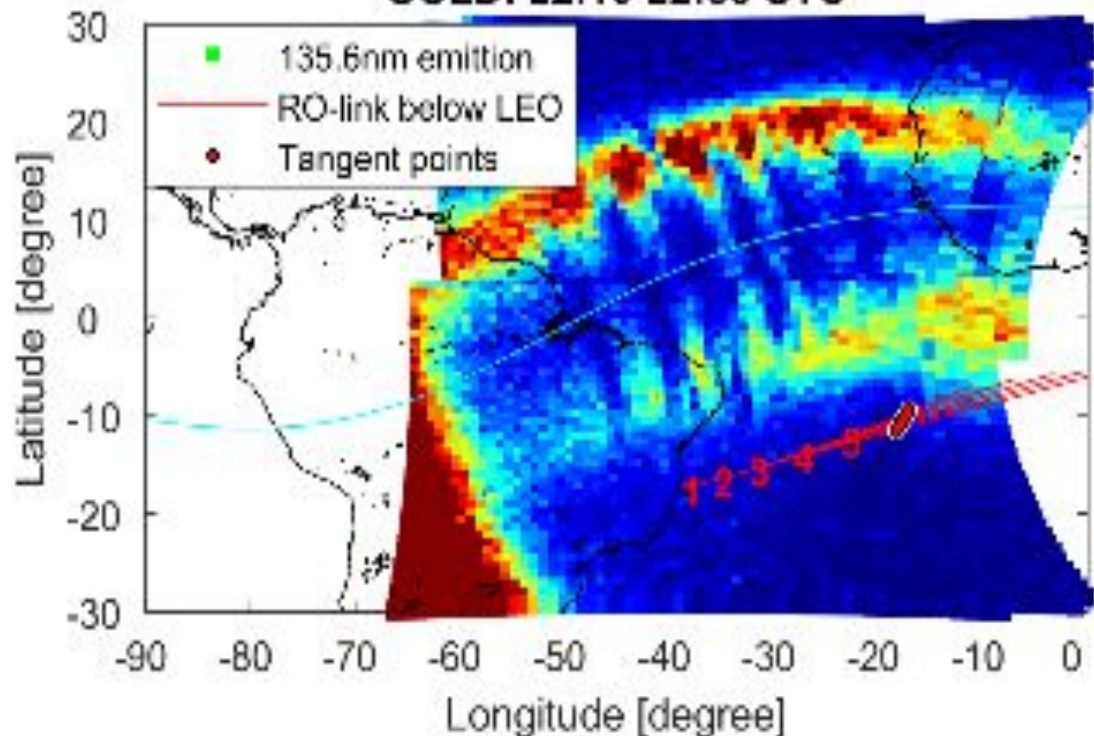
F-region (200 - 450 km)

$10\text{km Max(Abs}(\Delta\text{Ne})) > 10^5 \text{ cm}^{-3}$



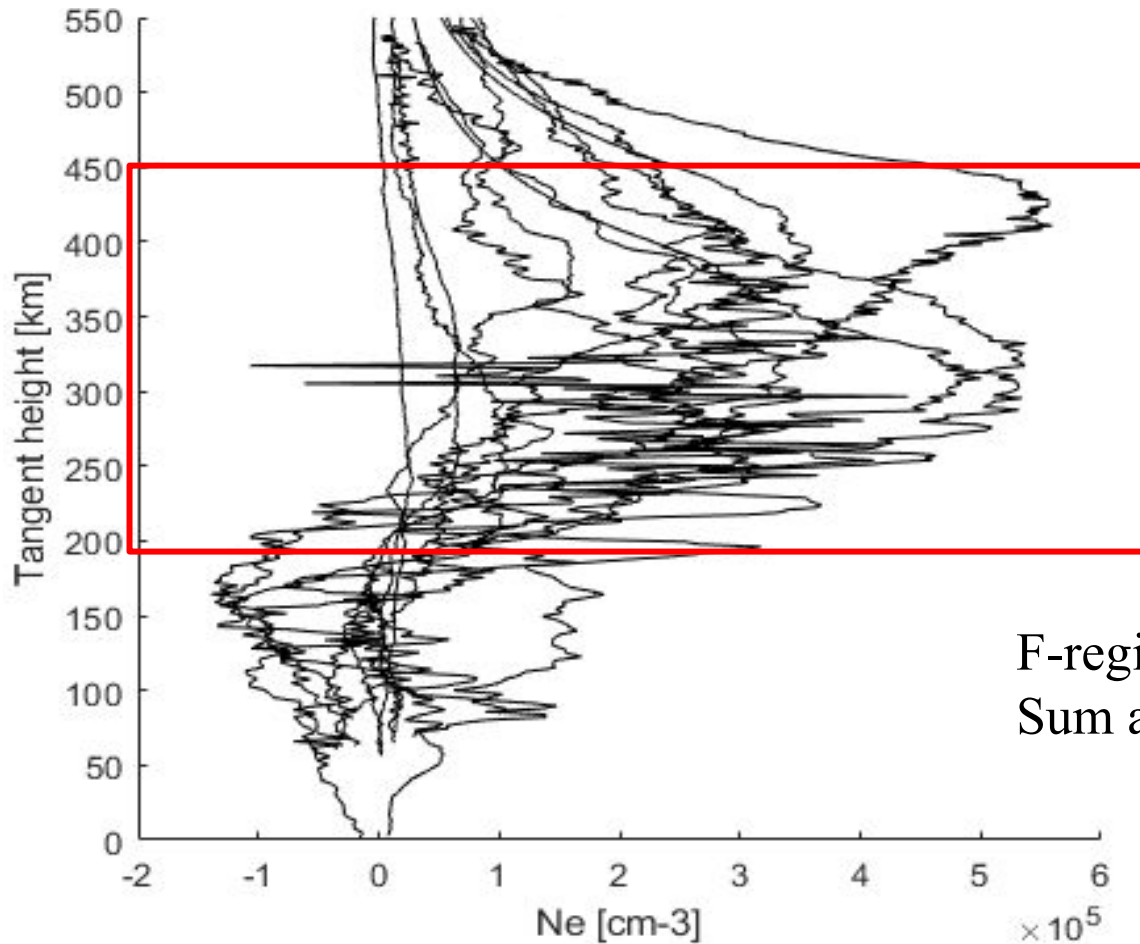
Constant
criteria
tells

EDP: 2022.009 22:07UTC C2E2-R01
GOLD: 22:10-22:55 UTC



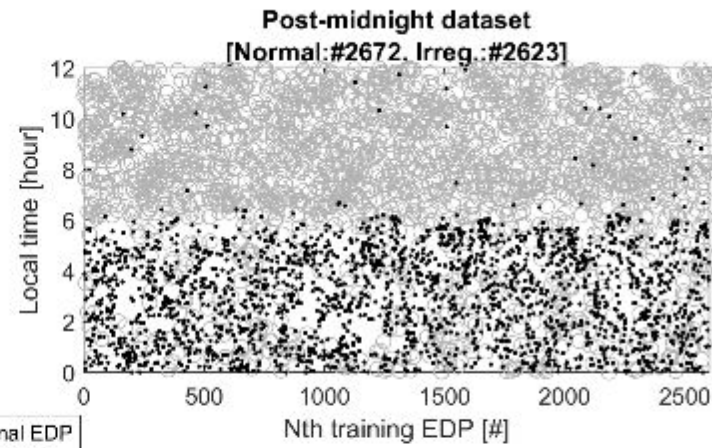
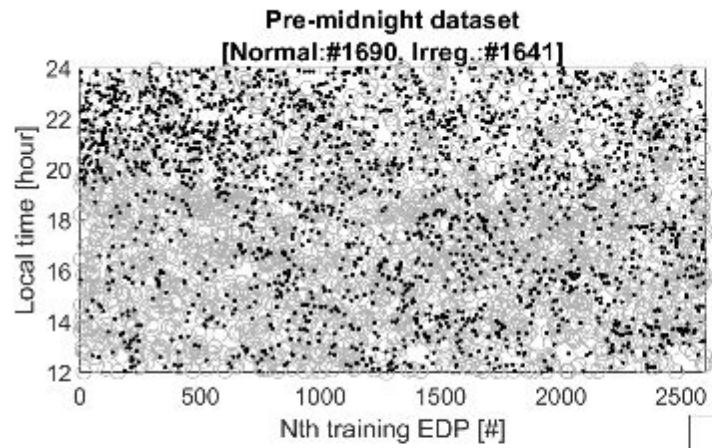
Is constant criteria sufficient to detect irregular EDPs?

Adapted criteria: Machine learning

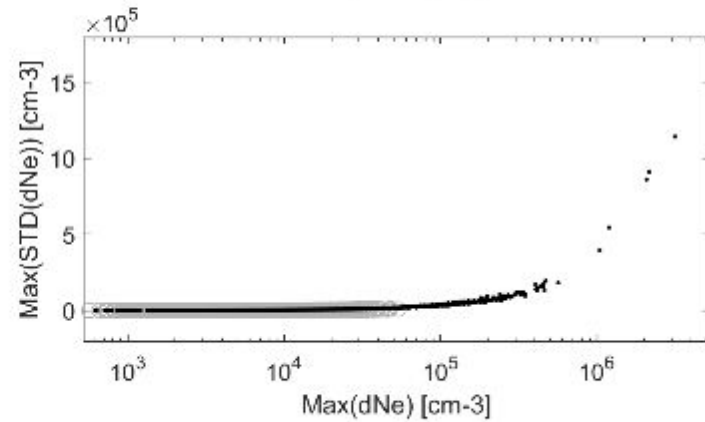
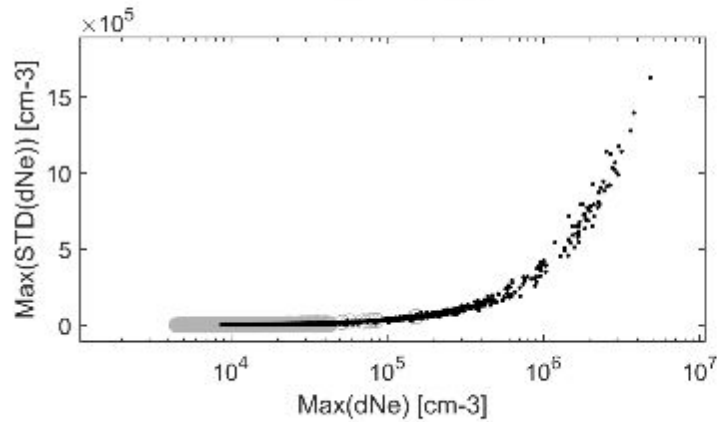
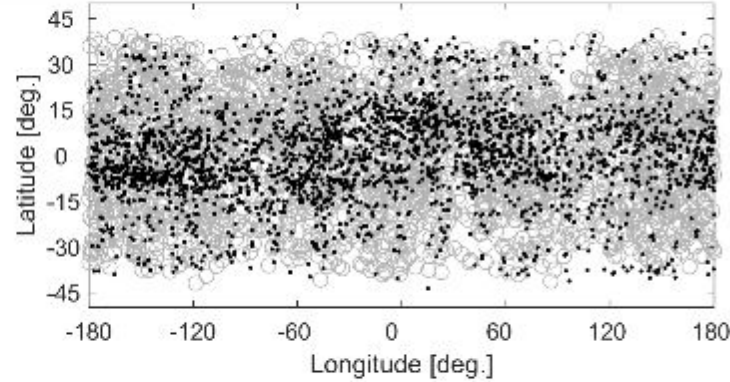
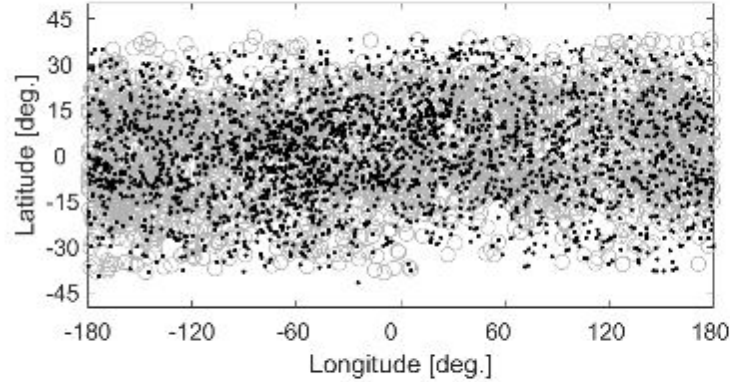


F-region (200 - 450 km)

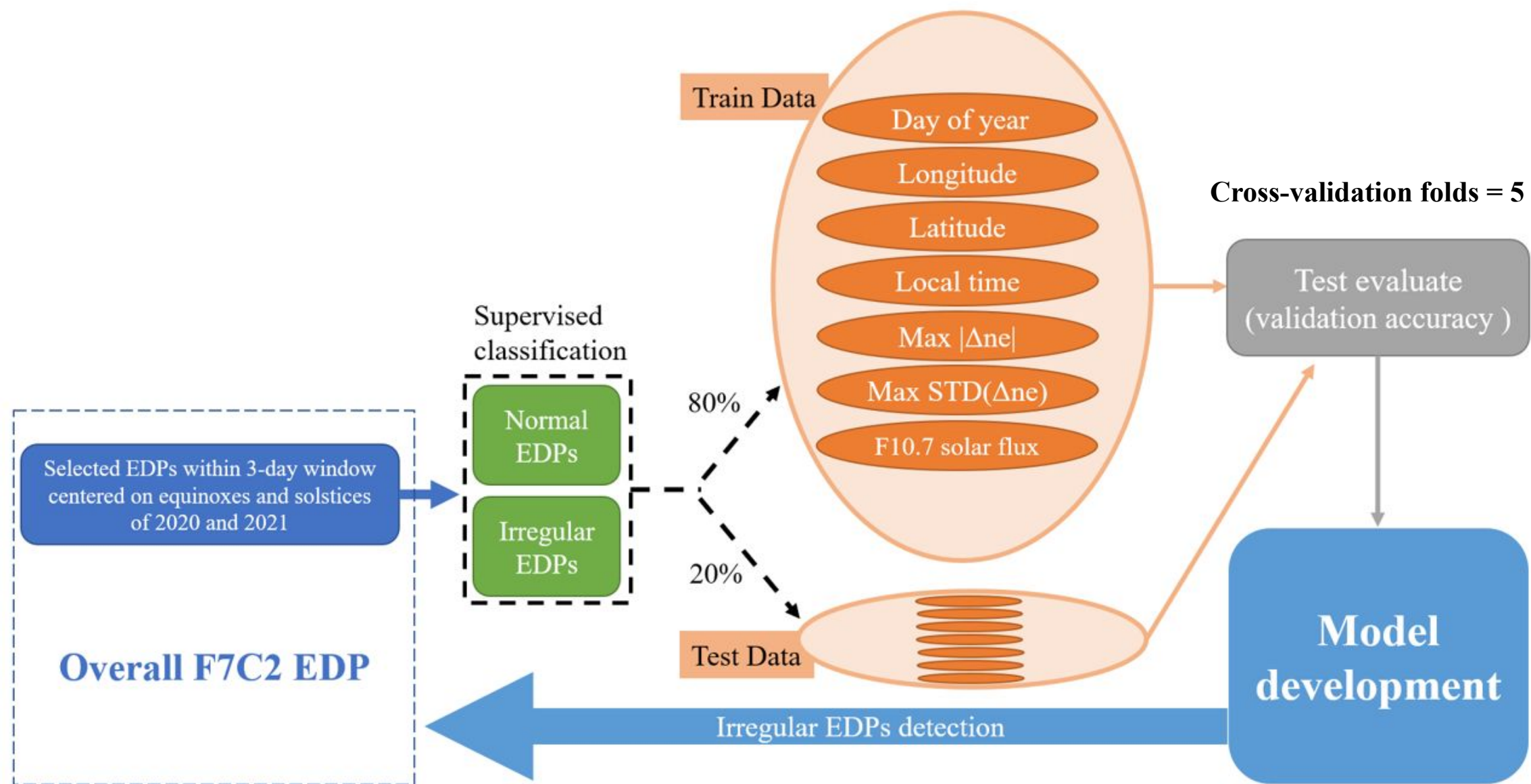
Sum altitudes of fluctuating > 50km

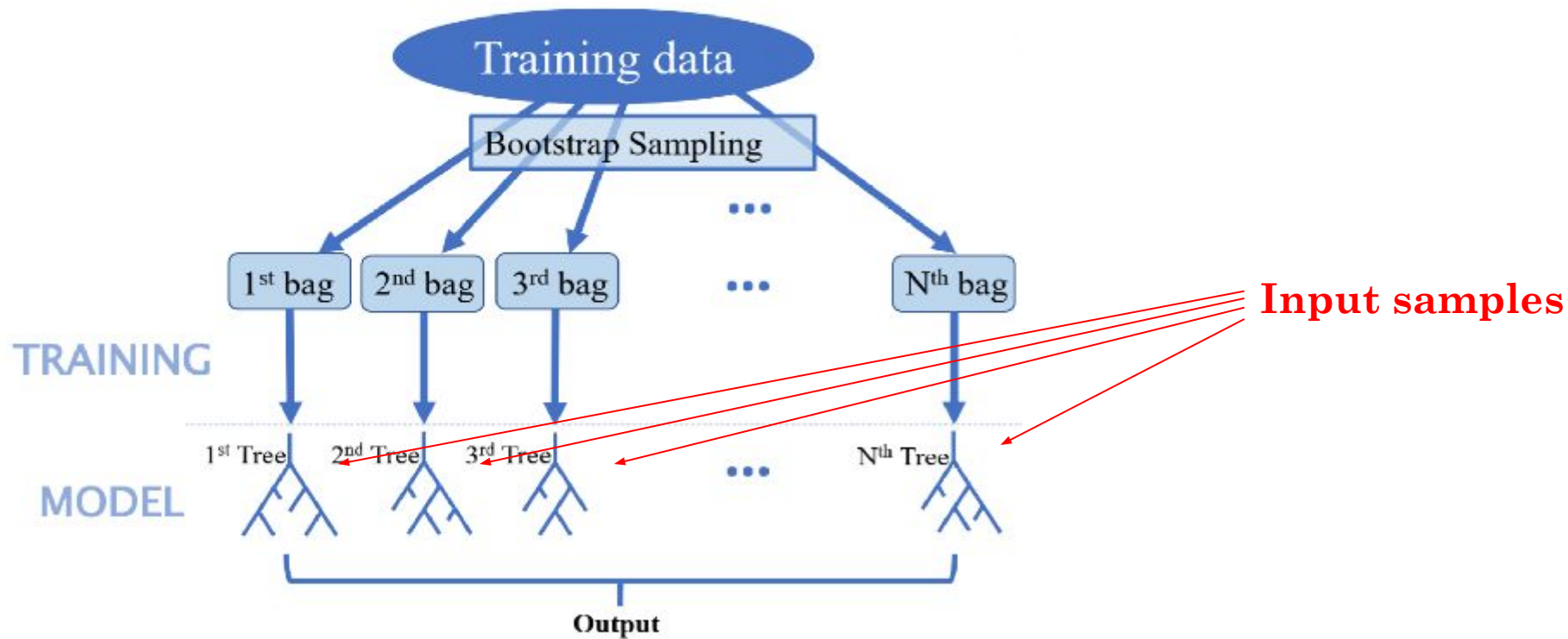


○ Normal EDP
● Irreg. EDP



Distribution of training data





Pre-midnight

True Class	Norm.	1528	162
	Irreg.	74	1567
		Norm.	Irreg.
		Predicted Class	

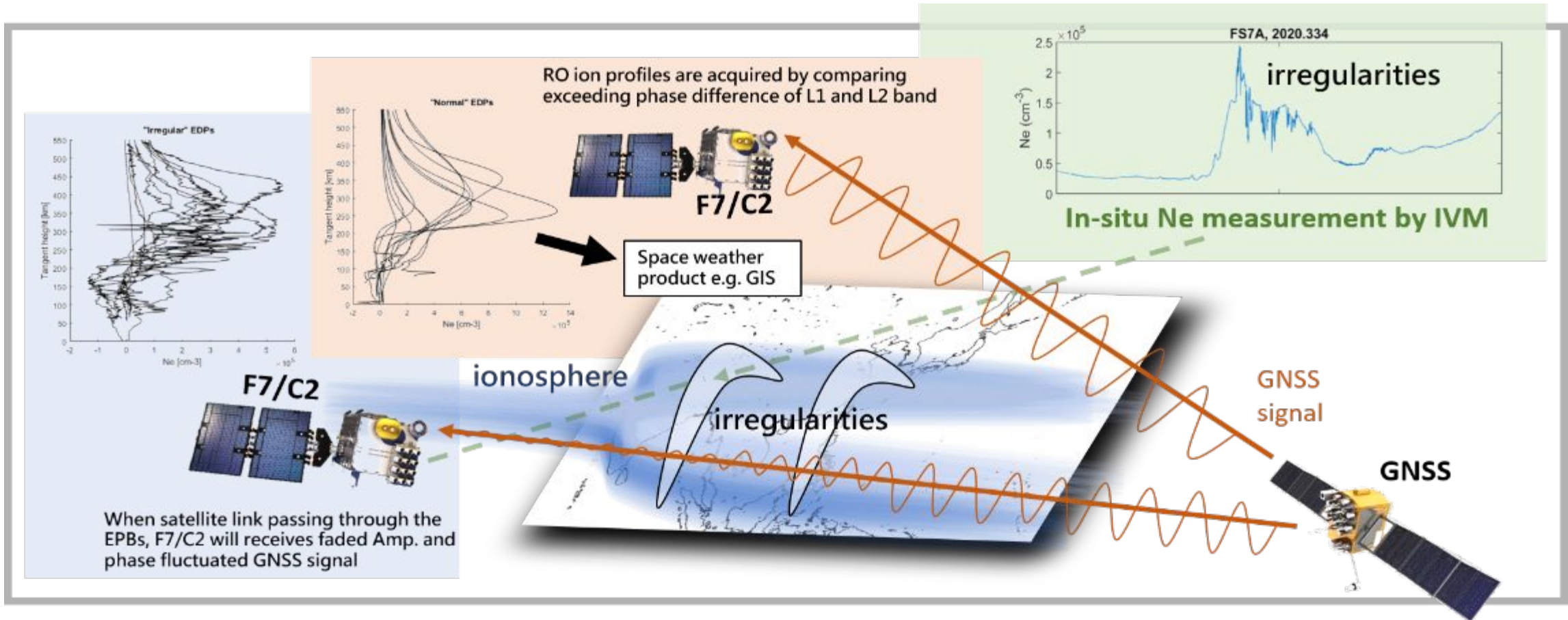
F-score = 0.928
 Preci. = 0.954
 Recall = 0.904
 κ value = 0.858

Post-midnight

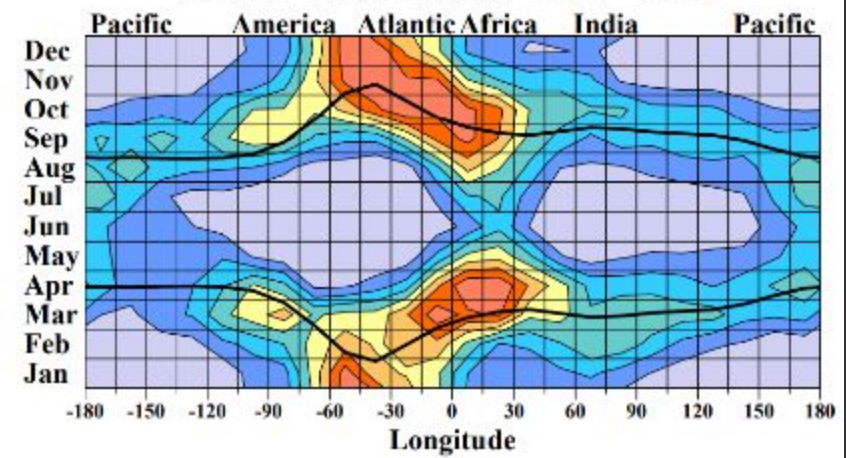
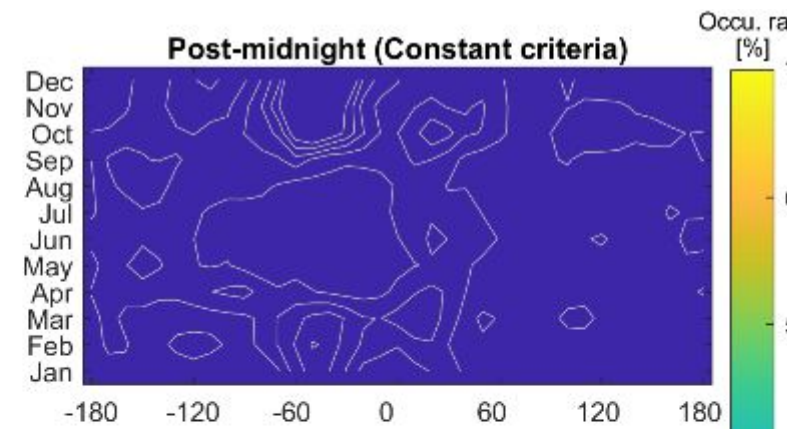
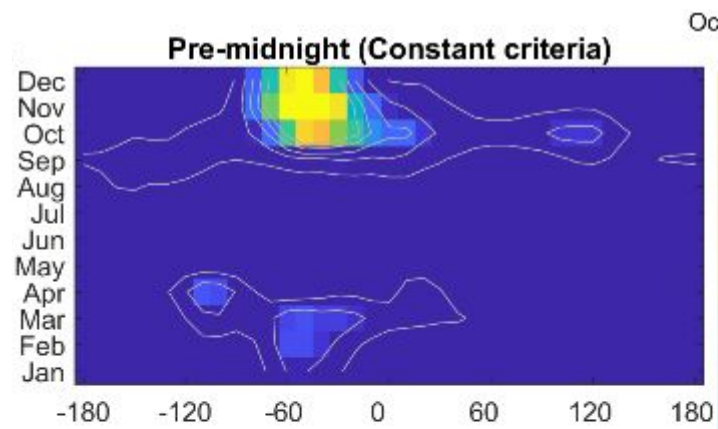
True Class	Norm.	2460	212
	Irreg.	121	2502
		Norm.	Irreg.
		Predicted Class	

F-score = 0.934
 Preci. = 0.953
 Recall = 0.921
 κ value = 0.874

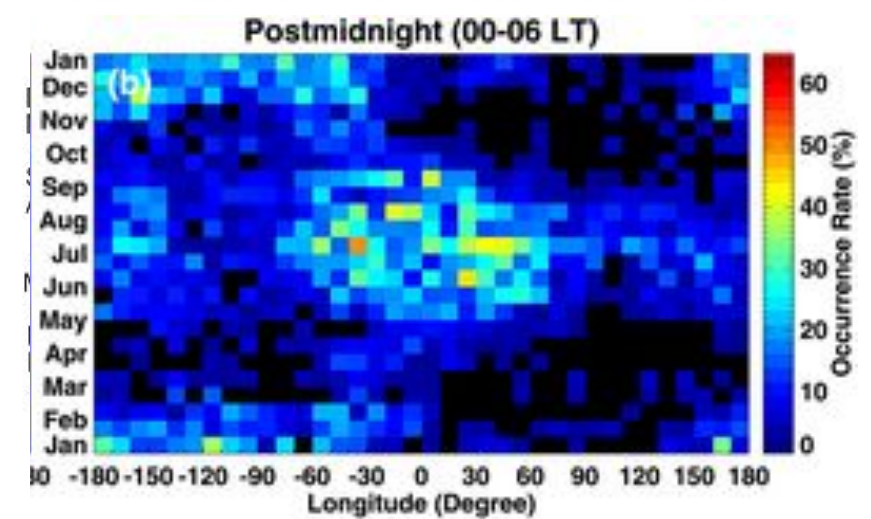
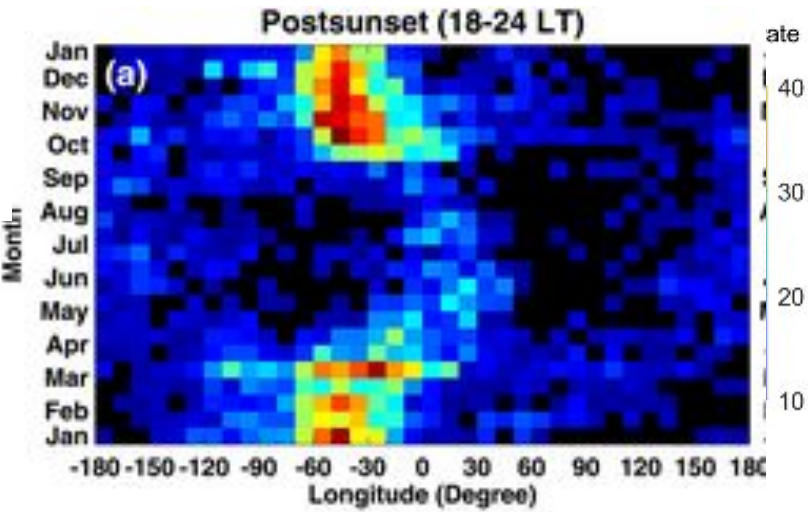
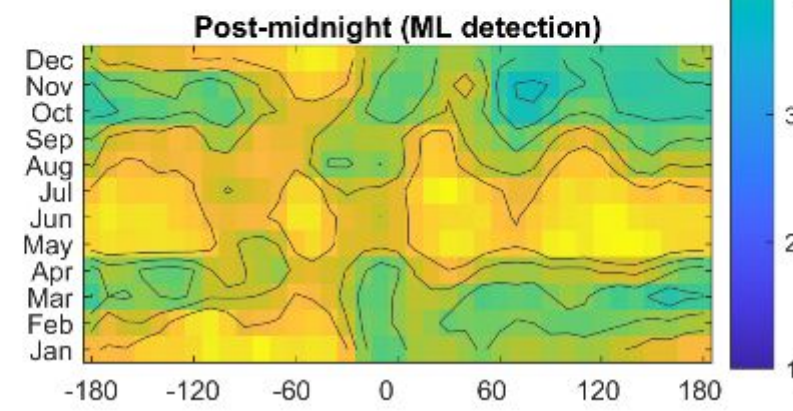
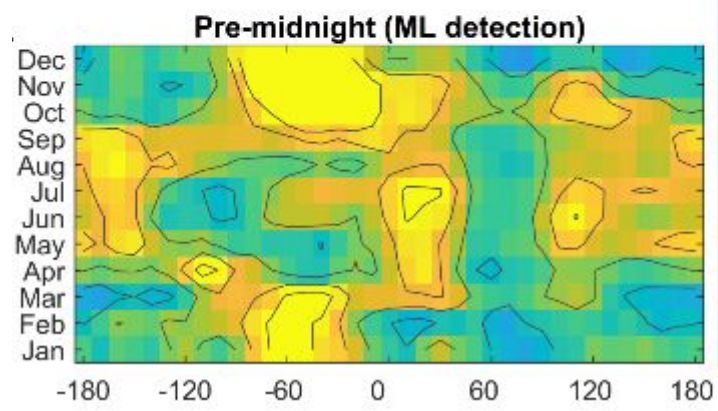
Climatology results



DMSP EPB Rates 1989 - 2004

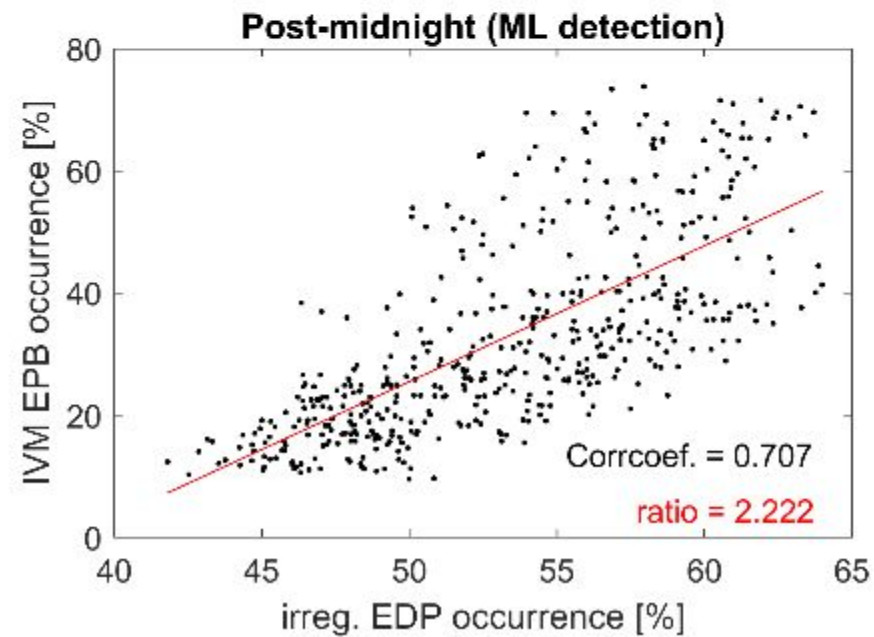
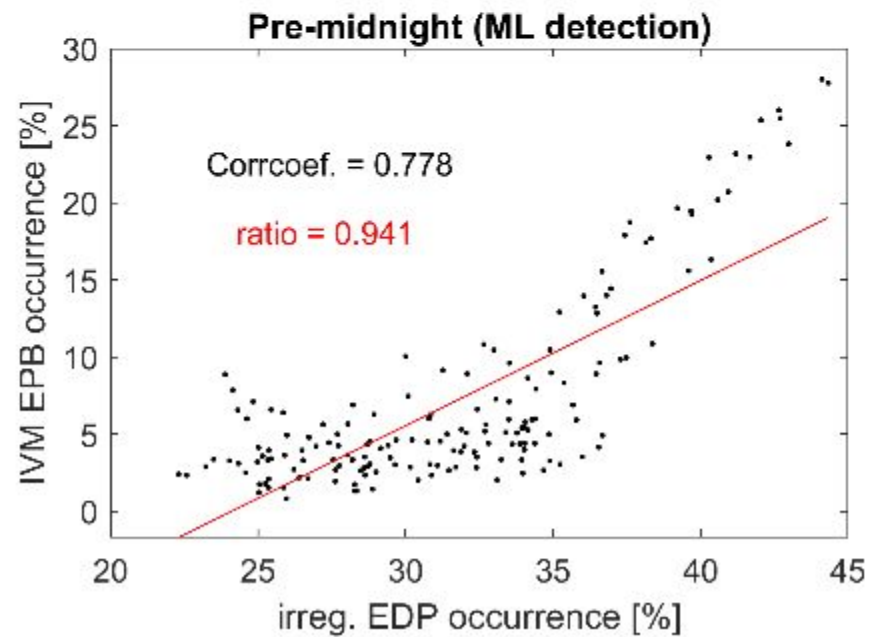
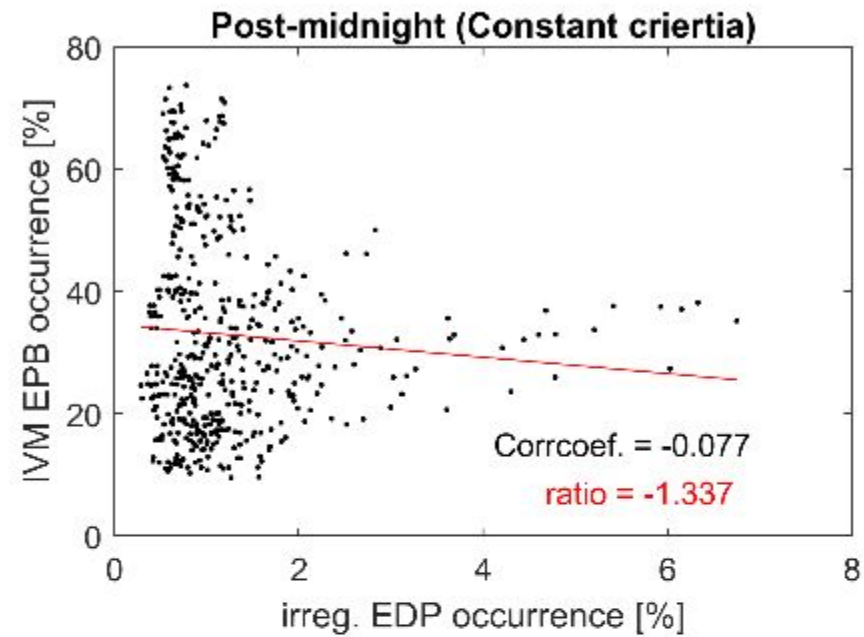
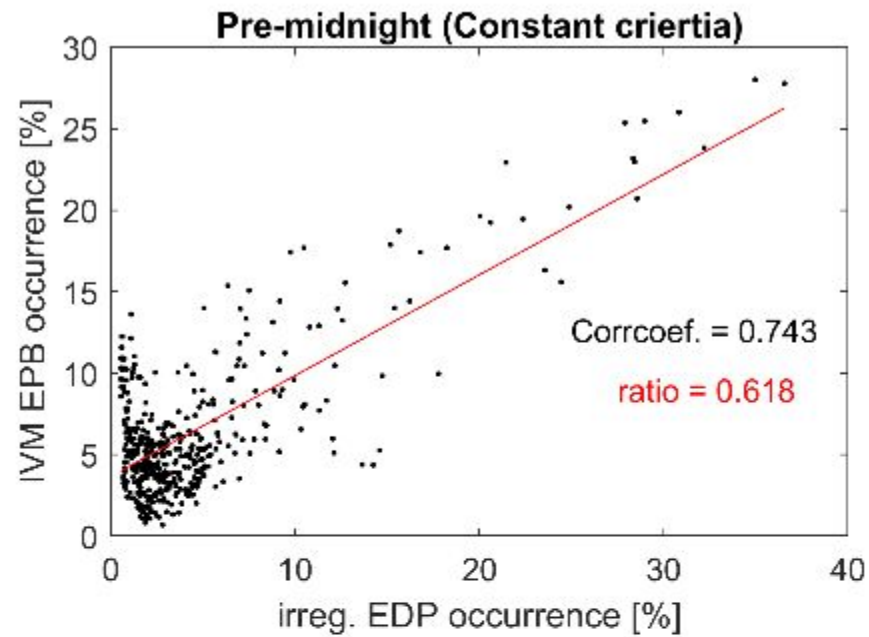


Gentile et al. [2006]



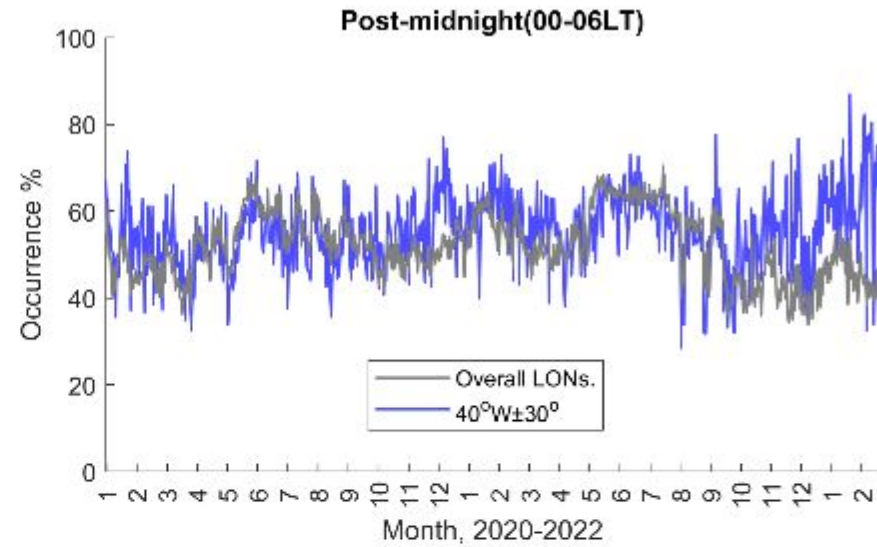
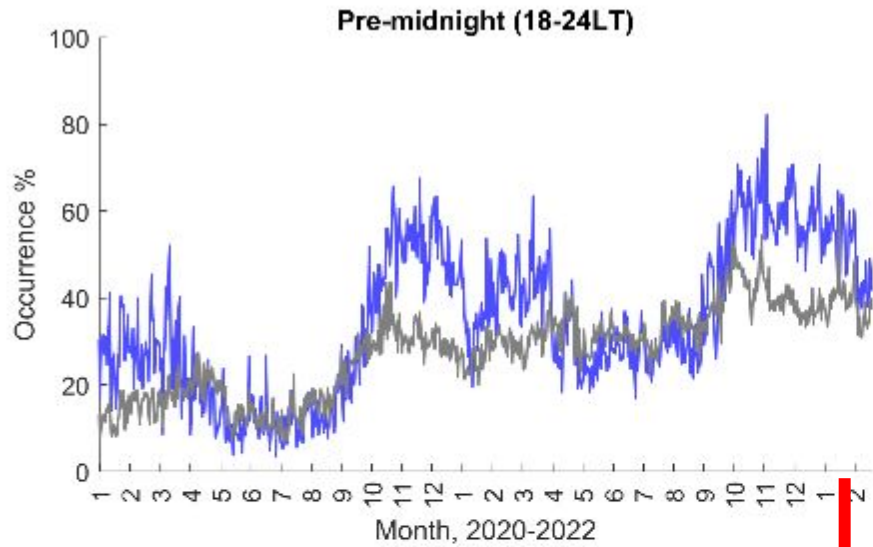
Swarm
2013-2019

Aa et al., [2020]

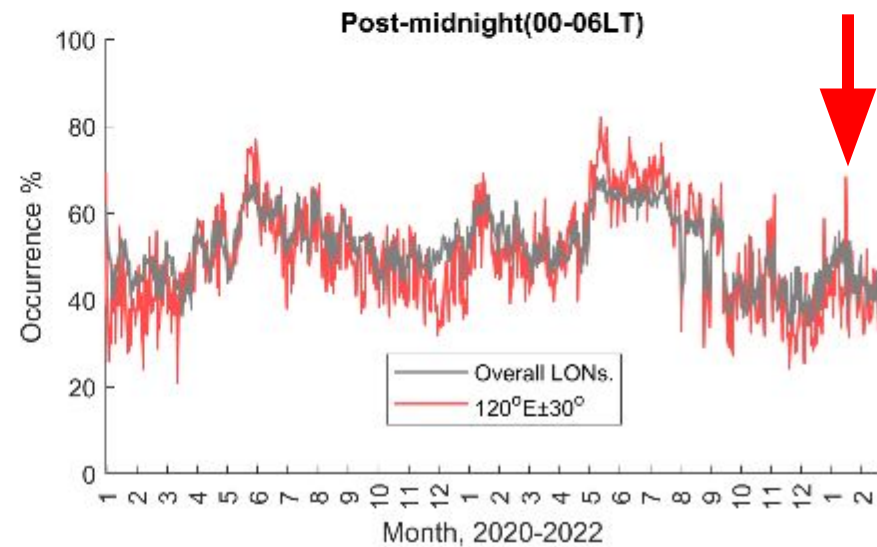
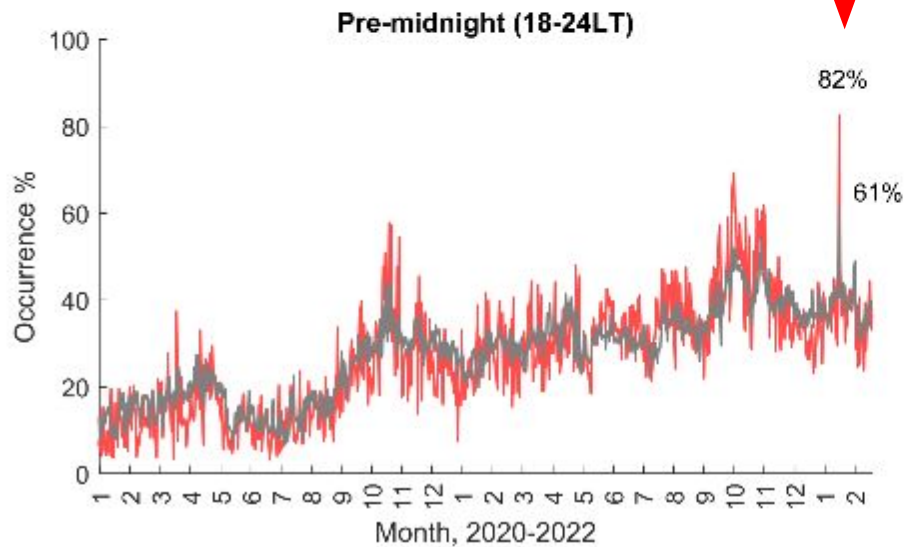


Climatology-2

Atlantic

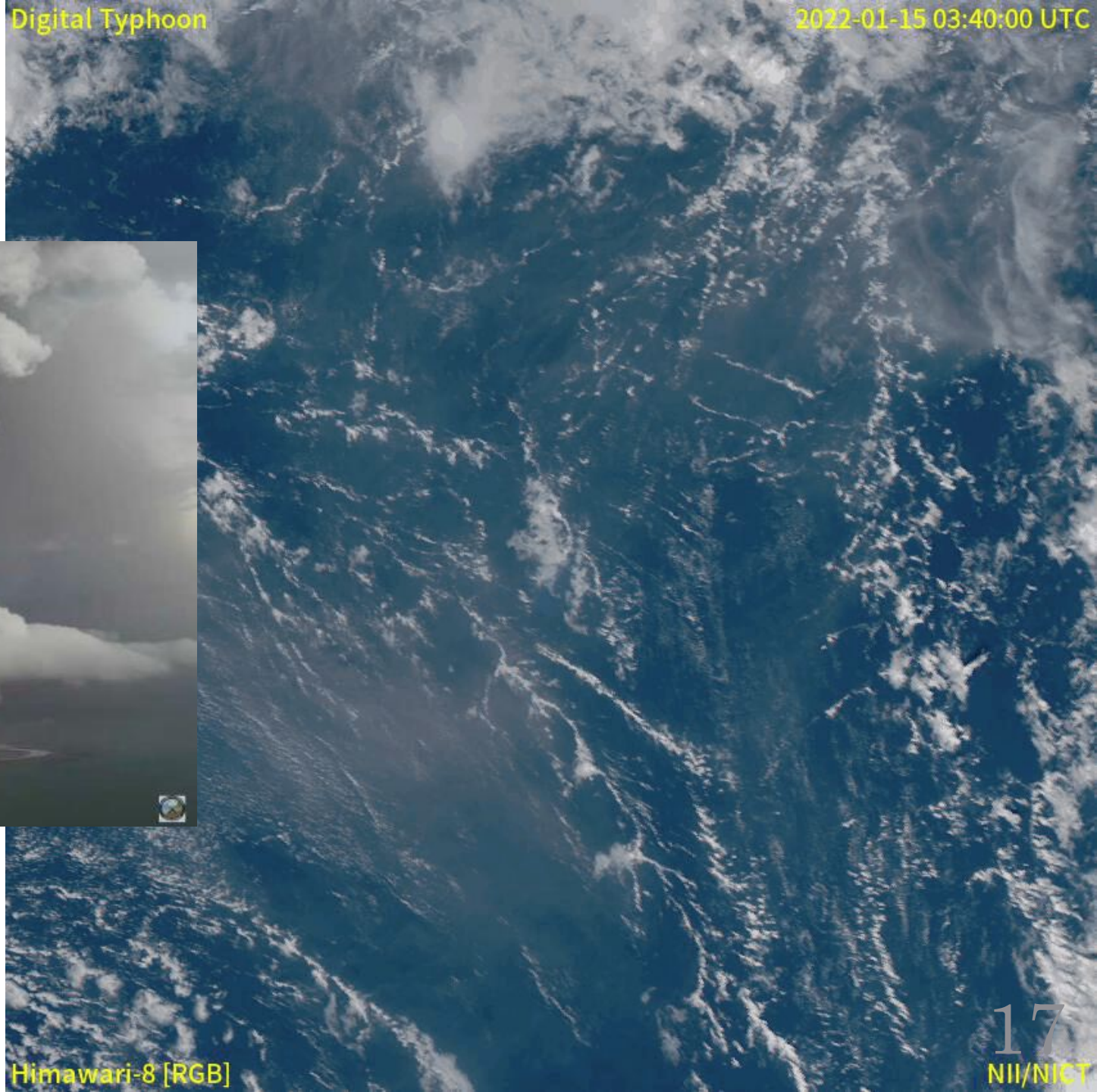


East Asia



Digital Typhoon

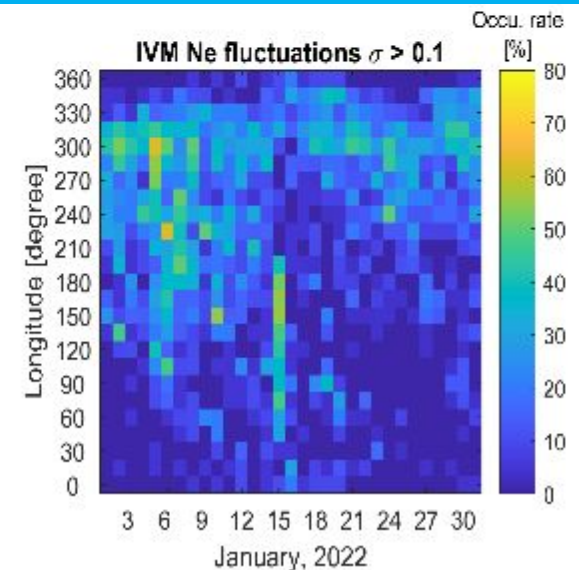
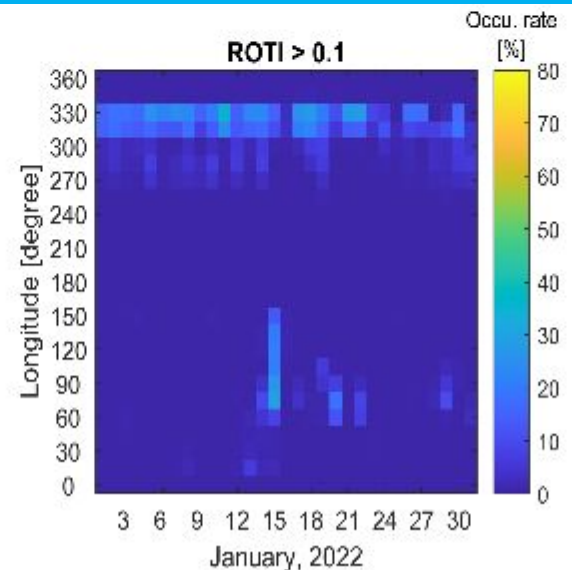
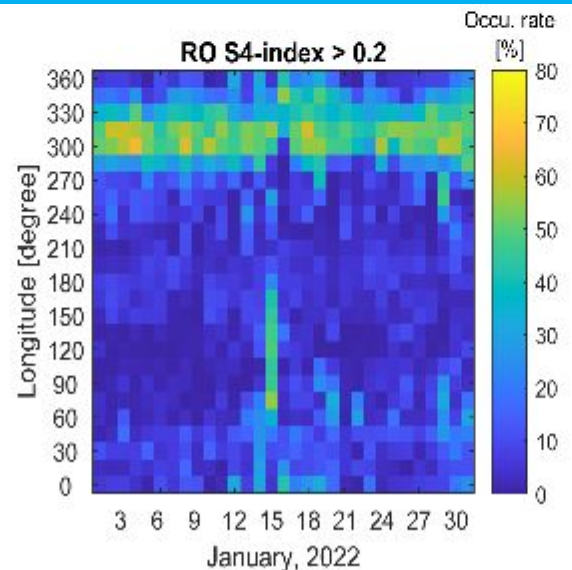
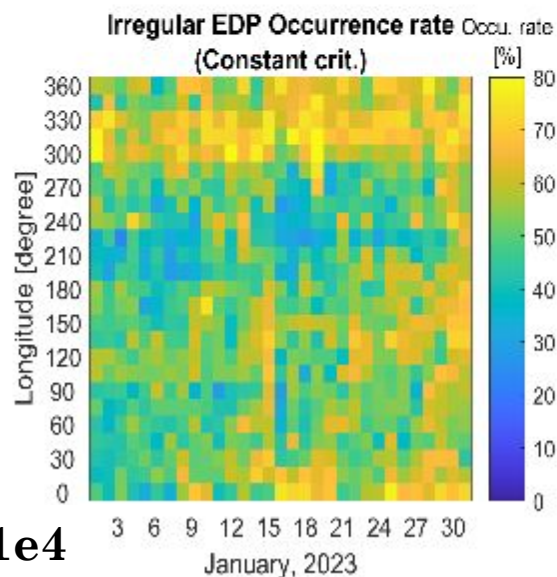
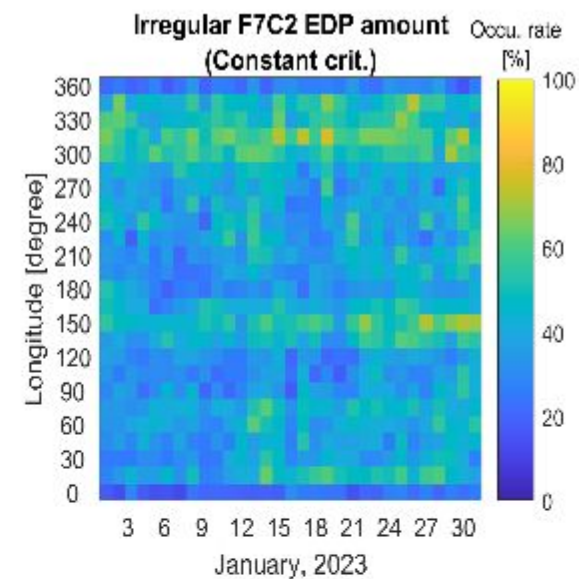
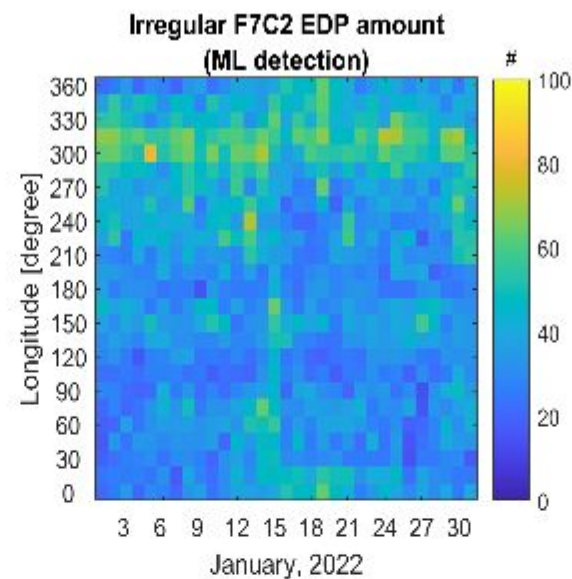
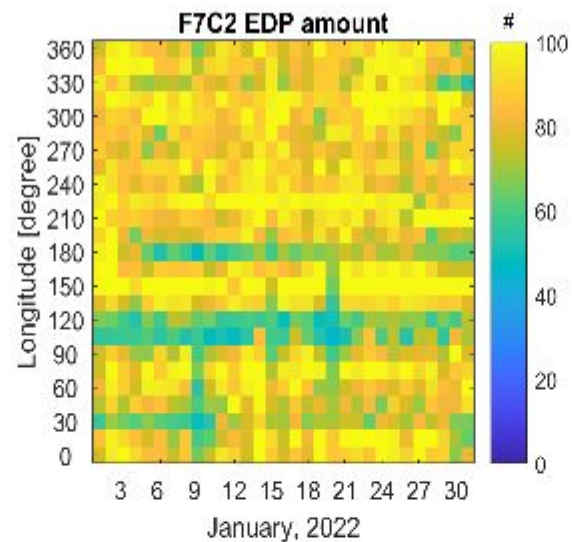
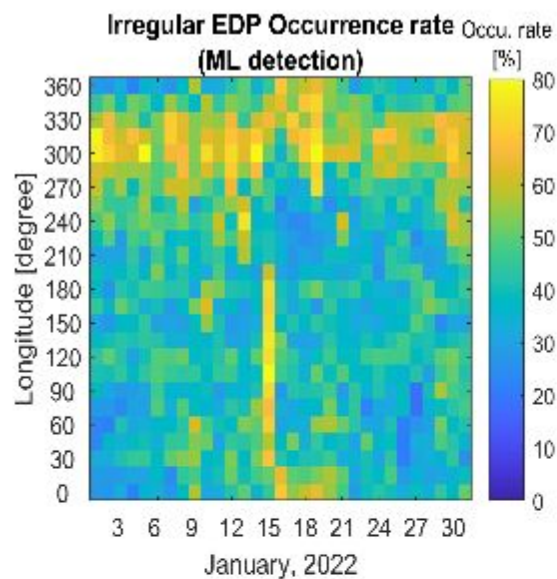
2022-01-15 03:40:00 UTC



Curtesy: Tonga Geological Services

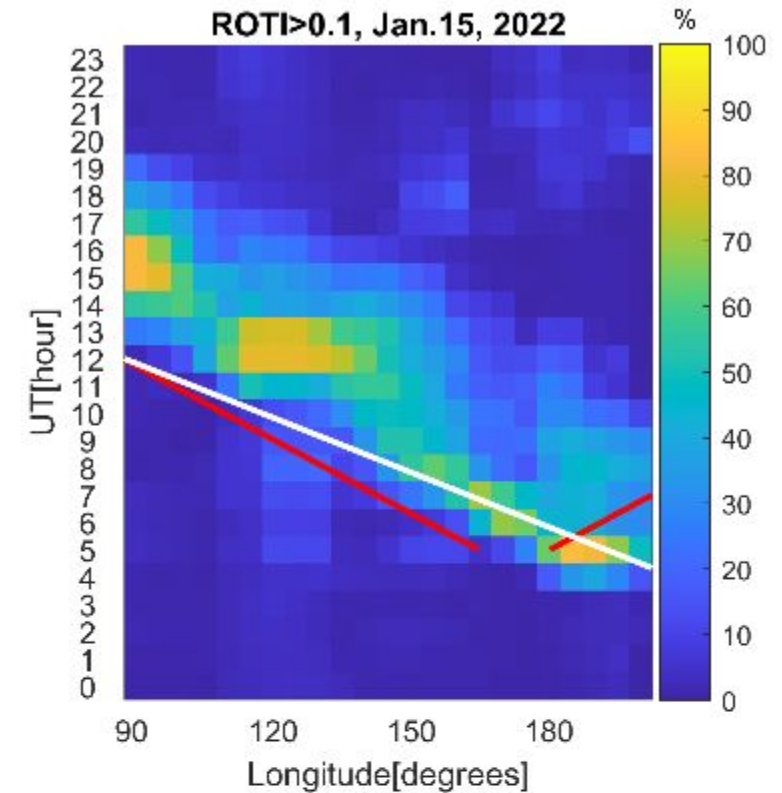
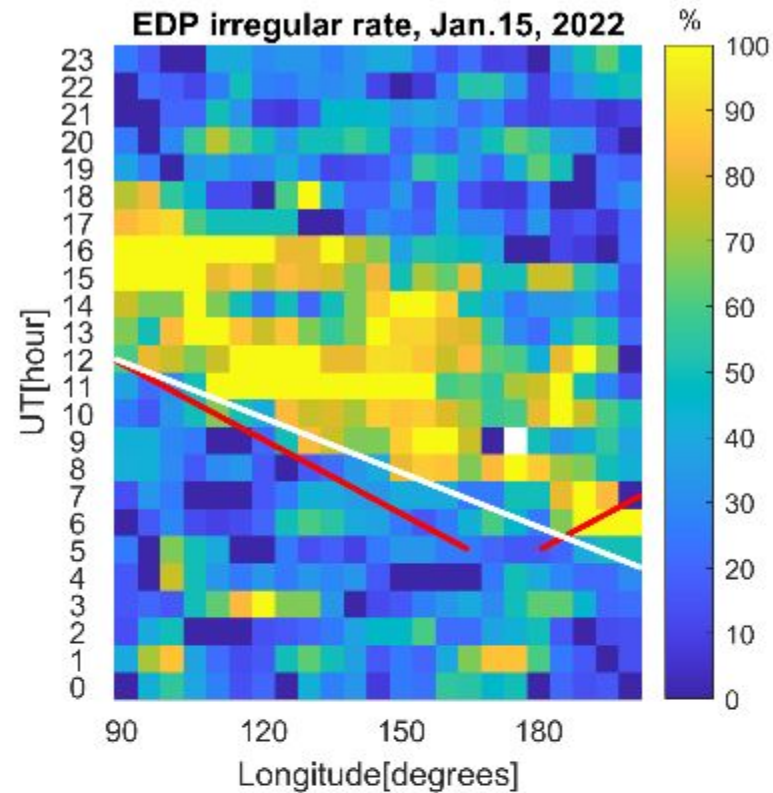
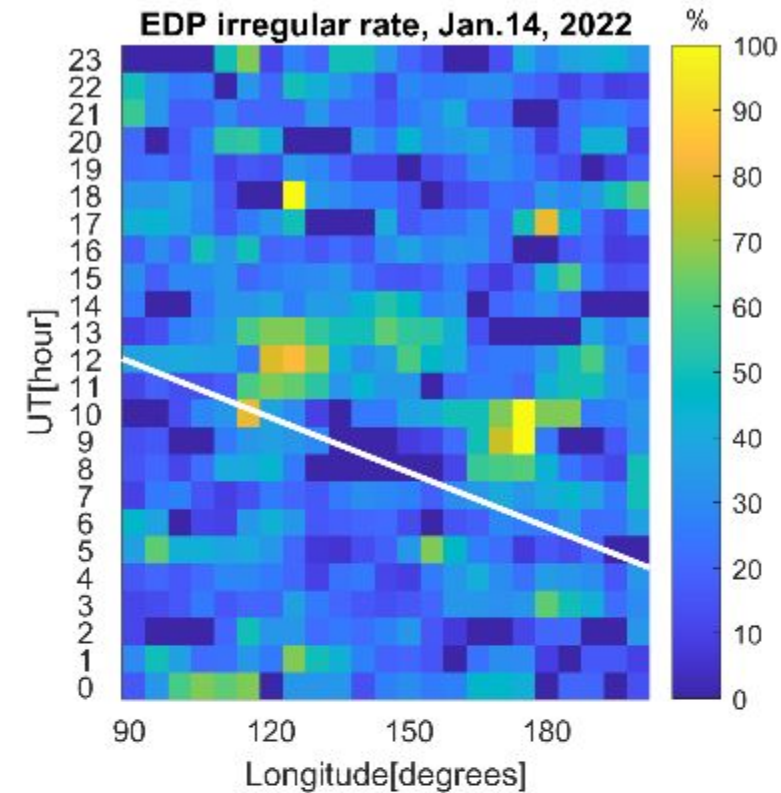
Japan Meteorological Agency

Himawari-8 [RGB]



1e4

The irregular EDPs occur after sunset terminator and lamb waves

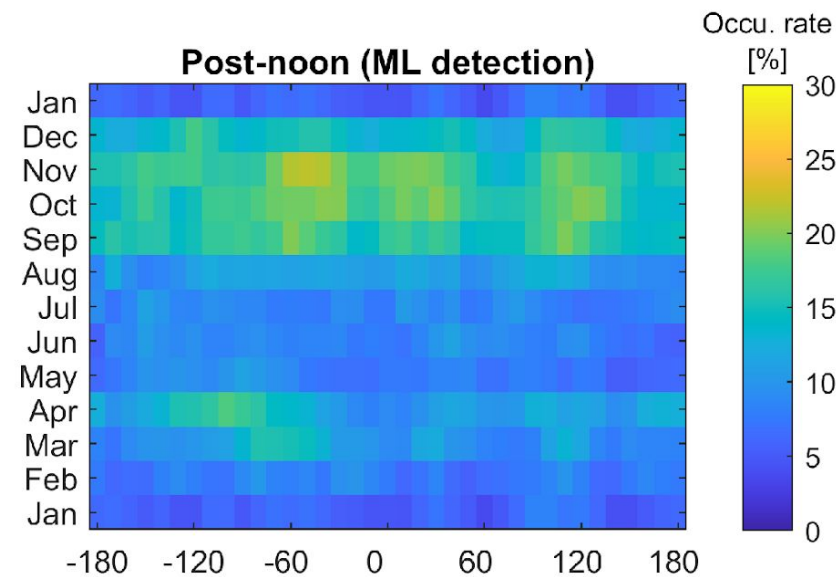
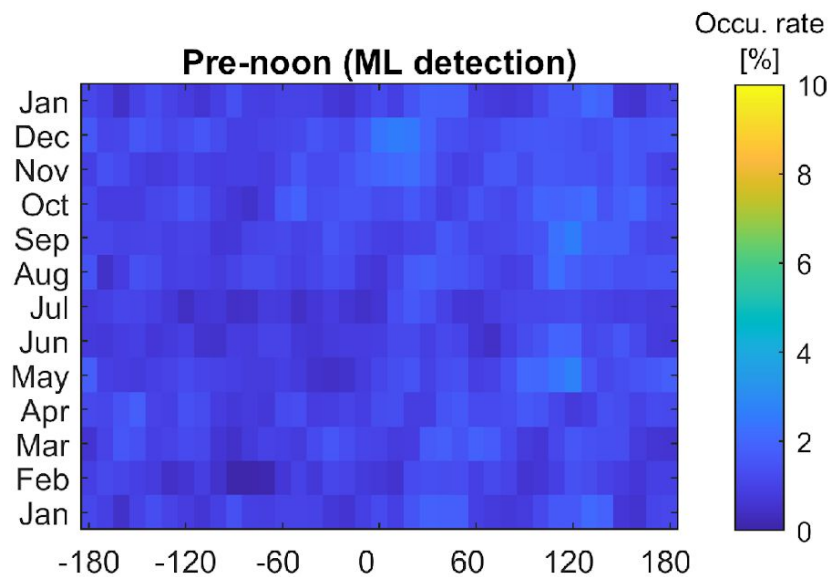
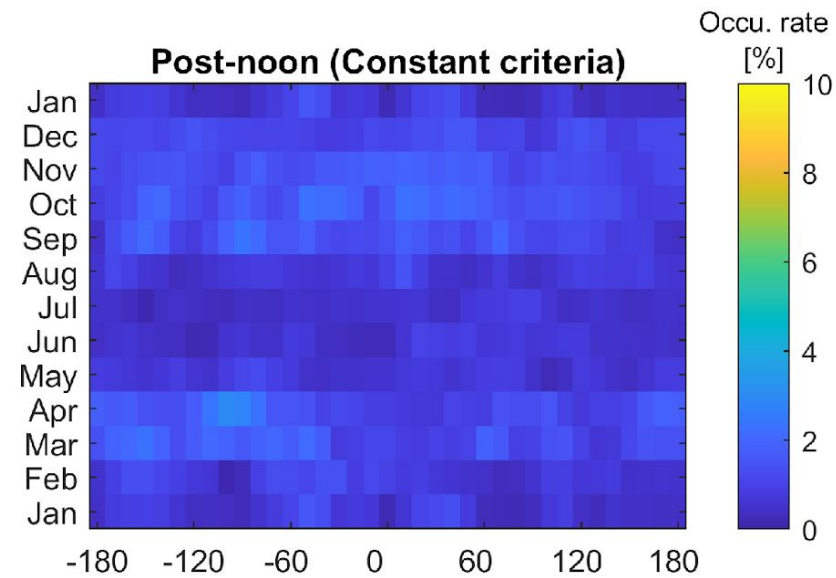
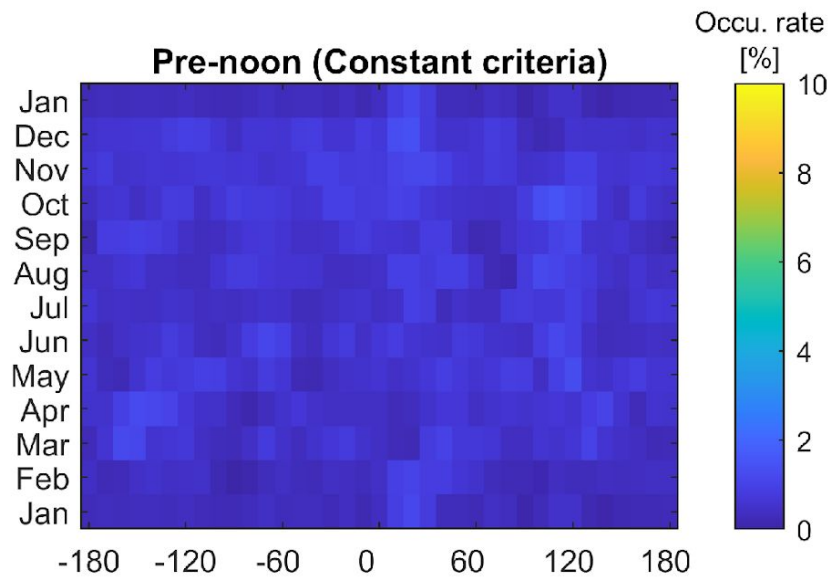


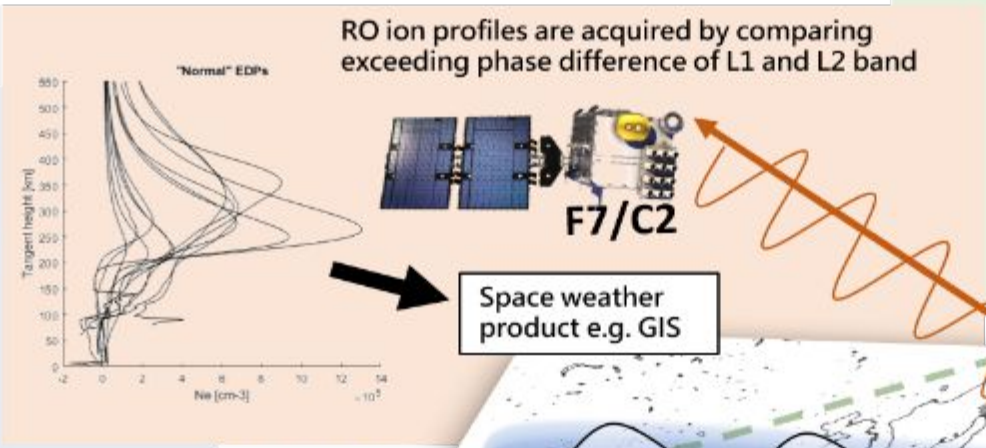
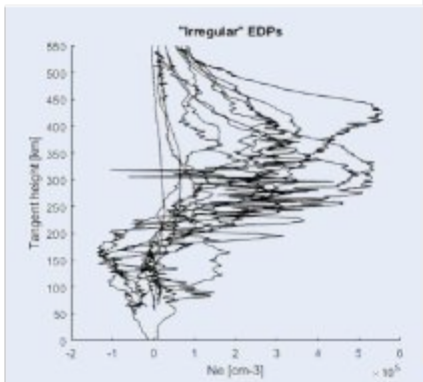
Conclusions

- The occurrence of irregular EDPs is unexpectedly high, indicating RO is highly sensitive to the plasma irregularities.
- The volcanic activity of Hunga Tonga-Hunga Ha'apai resulted in a significant occurrence of irregular EDPs. The intense surface events significantly disrupt the ionosphere and subsequently impacting RO observations.
- The chronological experiment observed the arrival time of eruption induced Lamb waves, sunset terminator, and the EDP irregular rate indicates that the major contribution of the irregular EDPs is the EPBs rather than the TIDs.
- The highly varying ionospheric conditions exhibit variability on diurnal, longitudinal, seasonal, solar activity, and day-to-day scales. The developed adaptive ML model can be utilized in operational settings to automatically identify poor-quality EDPs.
- The good agreement of the climatology comparison with independent assessments of EPB distribution in this study, which would consist various F7/C2 RO geometries, and its sensitiveness during the Mega Terrestrial Event, shows that geometry dependent effects do not impact the performance of the model. If future opportunities allow for the integration of observations from high inclination orbit satellites into the developed model, it can be applied to more complex missions.



**Thank You Very
Much !**





RO ion profiles are acquired by comparing exceeding phase difference of L1 and L2 band



F7/C2

Space weather product e.g. GIS

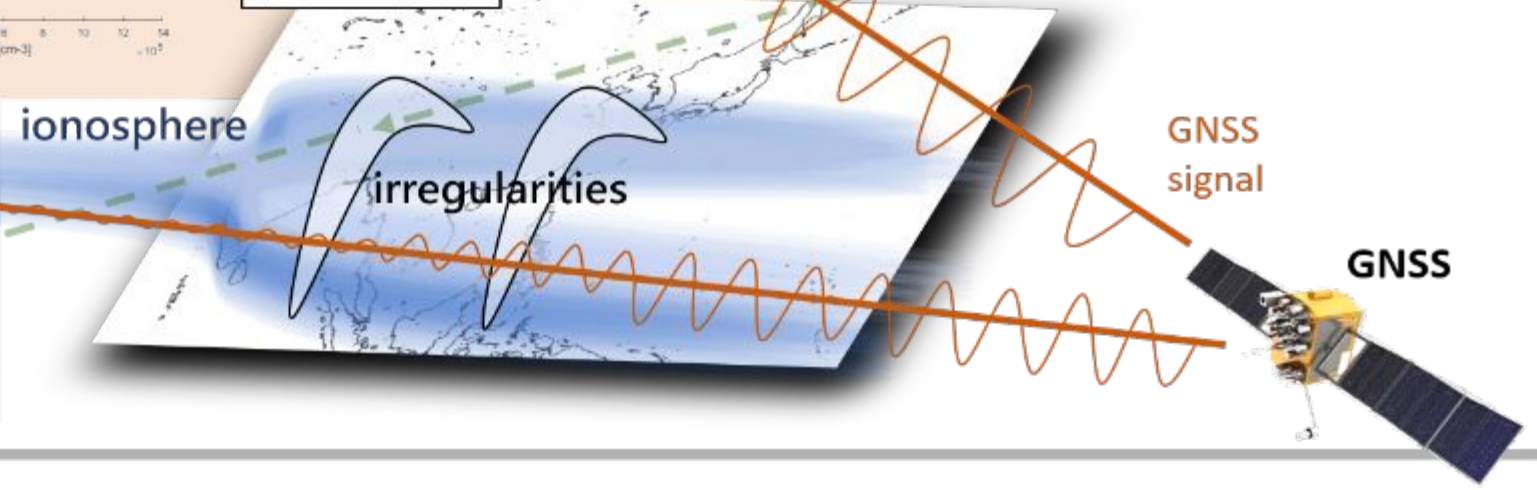


In-situ Ne measurement by IVM



F7/C2

When satellite link passing through the EPBs, F7/C2 will receives faded Amp. and phase fluctuated GNSS signal



ionosphere

irregularities

GNSS signal

GNSS

The irregular EDPs occur after sunset and lamb wave

