T-FORS NEWSLETTER

TRAVELLING IONOSPHERIC DISTURBANCES FORECASTING SYSTEM

IN THIS ISSUE

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T-FORS AT A GLANCE

Travelling Ionospheric Disturbances (TIDs) constitute a specific type of space weather disturbance affecting the performance of critical space and ground infrastructure by disrupting operations and communications in multiple sectors. T-FORS aims at providing new models able to interpret a broad range of observations of the solar corona, the interplanetary medium, the magnetosphere, the ionosphere and the atmosphere, and to issue forecasts and warnings for TIDs several hours ahead. Machine Learning techniques are used to train the models based on existing databases developed in the frames of past Horizon 2020 projects, to estimate the occurrence probability of medium scale TIDs and to forecast the occurrence and propagation of large scale TIDs. Prototype services are developed based on specifications from the users' community and following harmonized standards and quality control similar to the best practices of meteorological services. On ground demonstration tests are organised, by aerospace and civil protection agencies, to validate the performance of the T-FORS prototype services. A comprehensive architectural concept is proposed, including the densification of ground instrument networks, and new space missions, and possible future adjustments in order to develop a real-time operational service fully compliant and complementary to the ESA Space Weather services.

T-FORS

PUBLICATIONS

Here we list papers submitted in peer-reviewed journals, at the time of this issue, under review process. A full list of publications, presentations and reports related to T-FORS can be found on the project website.

- Segarra A., Altadill D., de Paula V., Navas-Portella V., *"Large scale Traveling Ionospheric Disturbances climatology over Europe for the period 2014-2023"*. Submitted to Journal of Space Weather and Space Climate. Available as pre-print at ESS Open Archive. DOI: 10.22541/essoar.173457203.32250299/v1.
- Ventriglia V., Guerra M., Cesaroni C., Spogli L., Altadill D., Segarra A., Galkin I., Barta V., Verhulst T.G.W., de Paula V., Navas-Portella V., Berényi K.A., Belehaki A., *"An Explainable Machine Learning model for Large-Scale Travelling Ionospheric Disturbances forecasting"*. Submitted to Journal of Space Weather and Space Climate. Available as pre-print at ESS Open Archive. DOI: 10.22541/essoar.173376695.54382526/v1.
- Urbář, J., Chum, J, Rejfek, L., Truhlík, V., Baše, J., Hsiao, T-Y., Kostelecký, J., Liu, J-Y., Chang, L., Guerra, M., Pica, E., Spogli, L., Trýb, J., Bozóki, T., Rusz, J., Mošna, Z., Kouba, D., and D. Burešová. *"GNSS positioning accuracy degradation during ionospheric disturbances"*. Submitted to Journal of Space Weather and Space Climate.
- D. Aksonova, K.D., Panasenko, S.V., Buresova, D.,Goncharenko, L.P., Zhangc, S-R., Domnin, I.F. *"Magnetically quiet-time traveling ionospheric disturbances over mid-latitude Eastern Europe observed by the Kharkiv incoherent scatter radar during the 24th solar cycle"*. 2024JA033583. Submitted to JGR- Space Physics.
- Habarulema, J. B. Zhang, Y., Lu, G., Buresova, D., Katamzi-Joseph, Z., Buchert, S., Okoh, D., Wu, Q., Borries, C., Fagundes, P.R., Li, R and Z. Qinghe. *"The 23-25 March 2023 geomagnetic storm: Ionospheric observations and modeling results over the African-European sector"*. 2024JA033515. Submitted to JGR- Space Physics.
- Themelis K., Belehaki A., Koutroumbas K., Segarra A., de Paula V., Navas-Portella V., Altadill D., *"Short-term forecast for the occurrence of Large Scale Travelling Ionospheric Disturbances at European middle latitudes using Neural Networks"*. Submitted to Journal of Space Weather and Space Climate. DOI: 10.5281/zenodo.14537424.
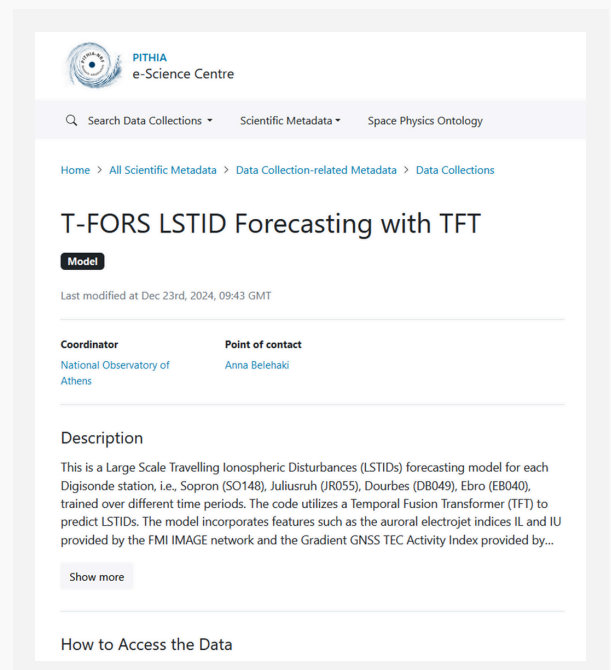
- Barta V., Potužníková K., Koucká Knížová P., Chum J., Mielich J., Guerra M., Buresova D., Mani S.,Verhulst T.G.W., Berényi K.A., Altadill D., Segarra A., Kouba D., Mošna Z., Buzás A. Spogli L., Urbář J., de Paula V., Ventriglia V., Belehaki A., "Multi-instrument analysis of MSTIDs generated by an intensive jet-front system with severe convection in Europe in August 2023". Submitted to Journal of Space Weather and Space Climate.

- Navas-Portella V., Altadill D., Blanch E., Altadill M., Segarra A., de Paula V., Timoté C.C., Juan J.M., "*Estimation of the drift velocity of Equatorial Plasma Bubbles using GNSS and digisonde data*". Accepted in Journal of Space Weather and Space Climate. DOI: 10.1051/swsc/2024038.

ADVANCEMENTS IN LSTID FORECASTING: TOWARDS NEAR REAL-TIME OPERATIONS

Although the project is now coming to an end, the INGV team is working intensively to make the catalogue-based LSTID forecasting model over the European continent available in near real-time. In fact, efforts are now focusing on the development of an architecture that will allow the model and its forecasts to be served on near real-time data, so that it can be integrated into Space Weather monitoring platforms.

Additionally, its registration within the PITHIA-NRF e-Science Centre is currently ongoing, to provide the model to the broader community.

Furthermore, the HFI-SEC based LSTID forecasting model over Digisonde locations has been registered in and is available through the PITHIA-NRF e-Science Centre.

PITHIA
e-Science Centre

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T-FORS LSTID Forecasting with TFT

Model

Last modified at Dec 23rd, 2024, 09:43 GMT

Coordinator
National Observatory of Athens

Point of contact
Anna Belehaki

Description

This is a Large Scale Travelling Ionospheric Disturbances (LSTIDs) forecasting model for each Digisonde station, i.e., Sopron (SO148), Juliusruh (JR055), Dourbes (DB049), Ebro (EB040), trained over different time periods. The code utilizes a Temporal Fusion Transformer (TFT) to predict LSTIDs. The model incorporates features such as the auroral electrojet indices IL and IU provided by the FMI IMAGE network and the Gradient GNSS TEC Activity Index provided by...

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EVENTS

Third Space Weather Italian Community

On 28 November 2024, the T-FORS catalogue-based model was presented during the 3rd Space Weather Italian Community (SWICo) Congress.

SWICo is a meeting and discussion forum for the entire Italian community involved in the Space Weather disciplines, also open to non-SWICo members.

During this event, INGV presented a poster entitled "*An explainable machine learning model for large-scale travelling ionospheric disturbances forecasting*", getting good feedback from the community.

T-FORS Final Meeting

On 3 December 2024 the T-FORS partners gathered in Athens for the 4th and final General Assembly Meeting. Participants from NOA, INGV, OE, ROB, BGD, IAP-P, IAP-L, GFP, FI and ONERA attended the event, which was dedicated to the project developments and achievements, as well as to the roadmap for an operational European TID forecasting service.

T-FORS Second Innovation Day

After the First Innovation Day, which helped raise awareness among leading experts in the field of space weather and ionosphere on the problem of the TID impact on their systems, the Second Innovation Day was held in Athens on 4 December 2024. This event was in connection with the update of the final prototypes for the T-FORS project.

27 external participants and 22 T-FORS members were registered to participate to the event.

"T-FORS has conducted R&D on standards which are relevant to WMO. With additional development, T-FORS products have relevance in global scales", Kirsti Kauristi (FMI)

"TIDs affect the HF Over the Horizon Radars in respect to the availability and the accuracy of the operations. T-FORS can support these systems with warnings regarding the area to be affected, the expected level of disturbance due to TIDs and the duration of the phenomenon.", Philippe Brouard (ONERA)

"For Low Frequency Radio Telescopes, such as LOFAR, knowing conditions in the ionosphere in advance is of major importance. T-FORS alerts for expected TIDs at least 1 hour in advance can mitigate the risk of collecting noisy LOFAR observations and can avoid the cost of processing and store bad data", Maaijke Mevius (ASTRON)

After a presentation of the T-FORS project's progress and achievements, various demonstrations of the products developed were proposed, such as:

- a demo of HF-SEC-based model by NOA, a trained validated and fine-tuned Temporal Fusion Transformer that can be applied individually to each Digisonde station,
- a demo of LSTID forecasting model by INGV, based on CatBoost algorithm and trained on a catalogue of ~1600 LSTID event, forecasting within 3 hours,
- a demo of MSTID probabilistic forecasting model by IAP-L, based on a quartiles method for probabilistic forecasting.

The final T-FORS services are available through the T-FORS Repository.

Next, several presentations on ancillary and complementary work, carried out in the framework of the DISPEC project, have been proposed. The DISPEC principal ambitions are: first the derivation of high-level data products with specified data quality flag and defined data level, and second the re-use of DISPEC data products by the research community.

Then, different stakeholders presented their activities related to ionosphere, which could be potentially impacted by TIDs:

- iFURTHER project (a concept of HF inter-connected HF based systems, in multistatic geometry, for surveillance and detection of target in Europe),
- a new architecture OTH radar (by university of Birmingham),
- ESA Space weather network,
- Weather Meteorological Organization aspirations on space weather service,
- ionospheric predictions for low frequency radio astronomical observations (LOFAR).

In conclusion the Second Innovation Day has been considered as very successful by the community. From all the stakeholders' feedback, aware of T-FORS products and convinced by their strong interest, a solid roadmap of future activities can be drawn.

The presentations given during this event are available through the T-FORS website and YouTube Channel.

T-FORS PARTNERS

ABOUT

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Travelling Ionospheric Disturbances
Forecasting System (T-FORS)

Topic
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Observatorio del Ebro Fundación

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1 January 2023 - 31 December 2024

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