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T-FORS

Travelling Ionospheric Disturbances Forecasting System

Project Overview

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T-FORS Innovation Day, Toulouse, 23 November 2023

Main Objective

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The main objective of the T-FORS project is the ***development of new validated models able to issue forecasts and alerts for TIDs several hours ahead***, exploiting a broad range of observations of the solar corona, the interplanetary medium, the magnetosphere, the ionosphere and the atmosphere.

TID detection

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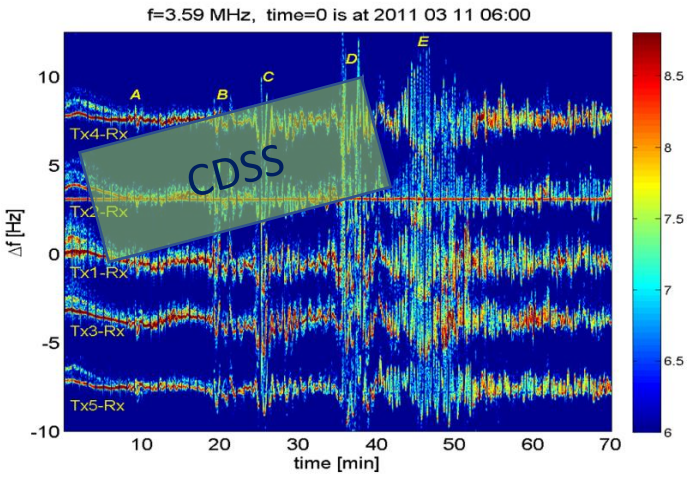

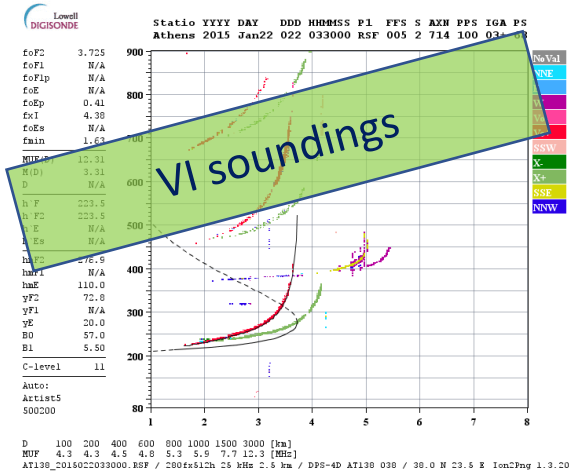

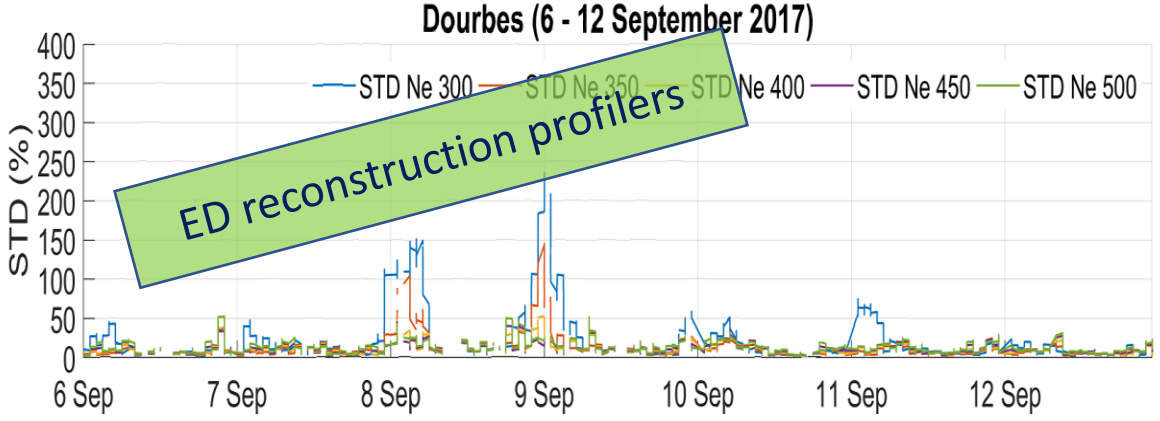

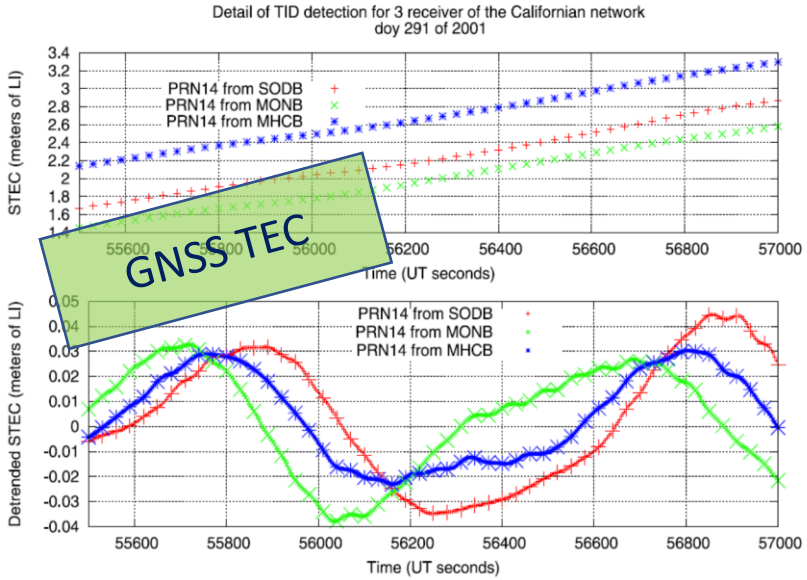

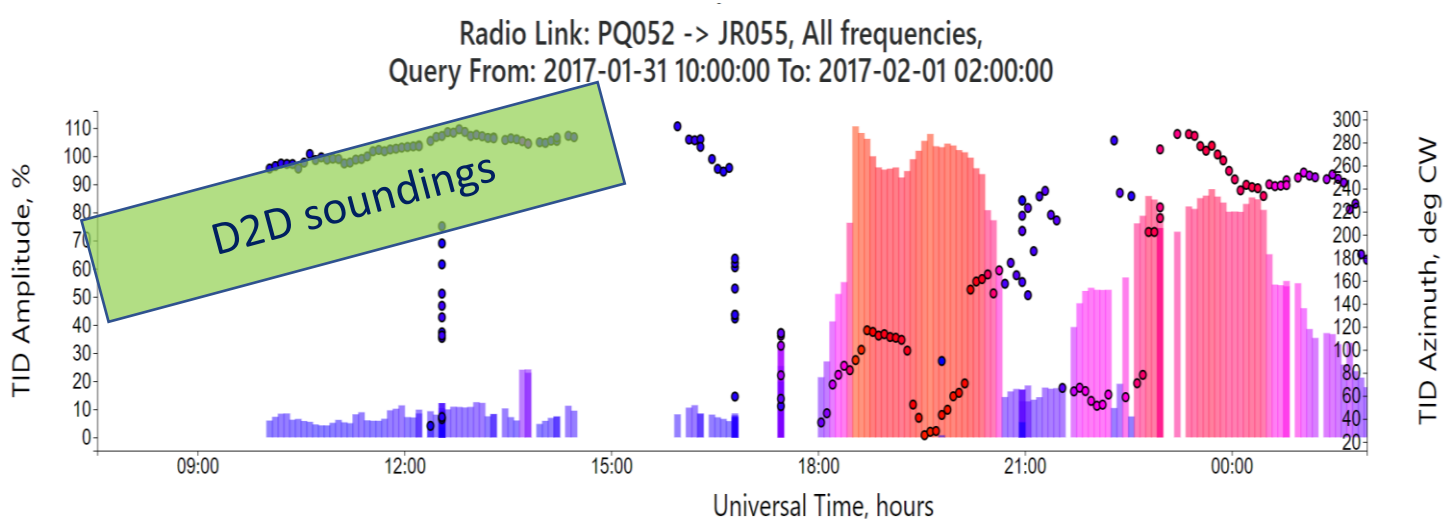

LSTIDs

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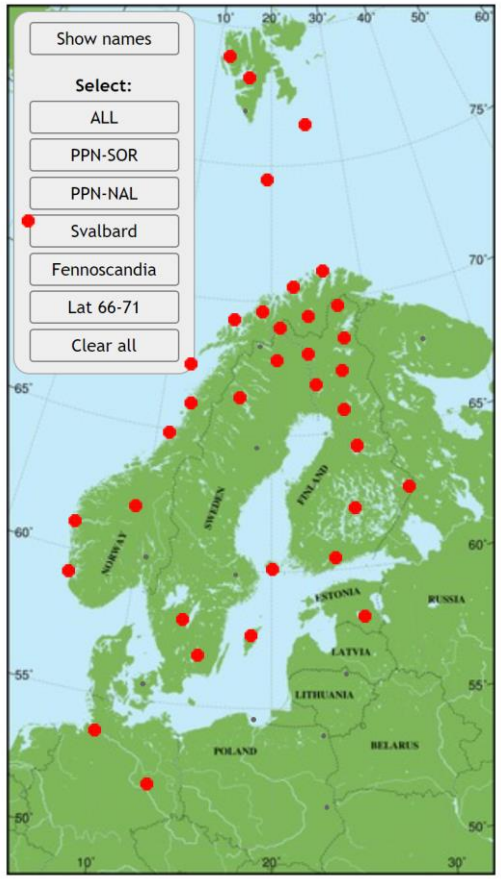
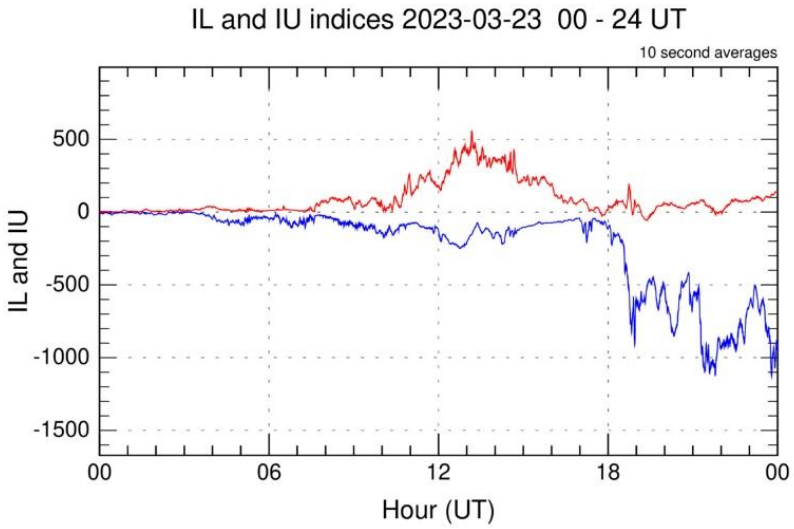
Substorms and geomagnetic storms cause energy injection @ high latitude inducing Joule heating

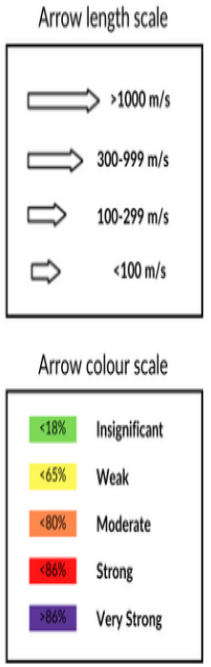
Geomagnetic field disturbances detected along a meridional chain of magnetometer @ ground

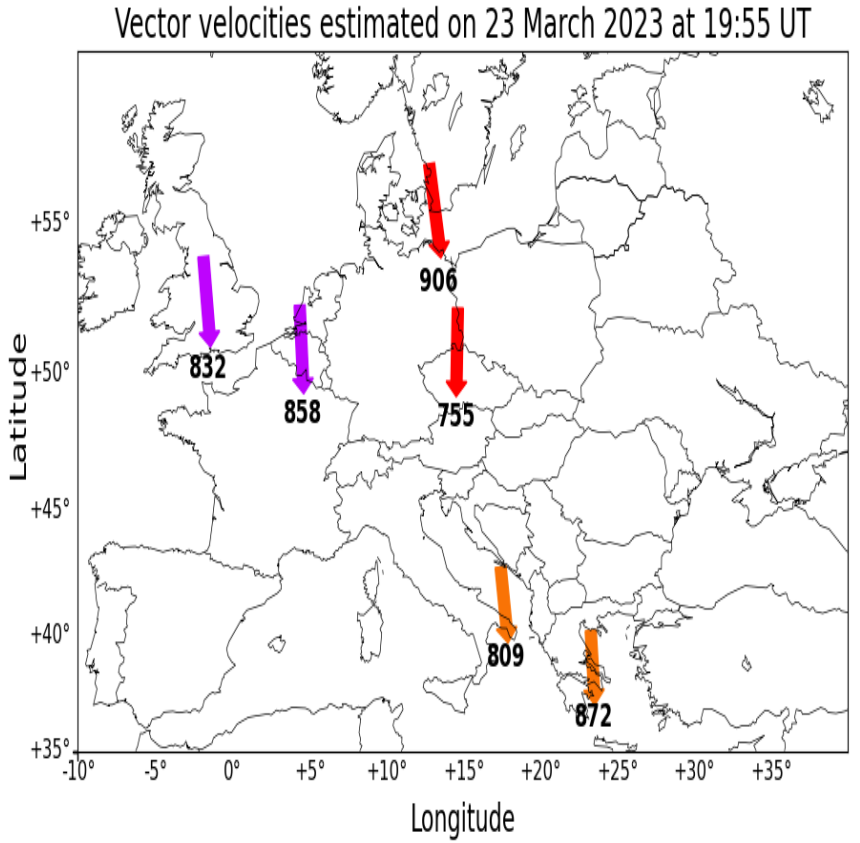
Equatorward Propagation of LSTIDs from auroral latitudes

Detection of LSTIDs by the HF Inteferometry method over Digisonde stations









MSTIDs

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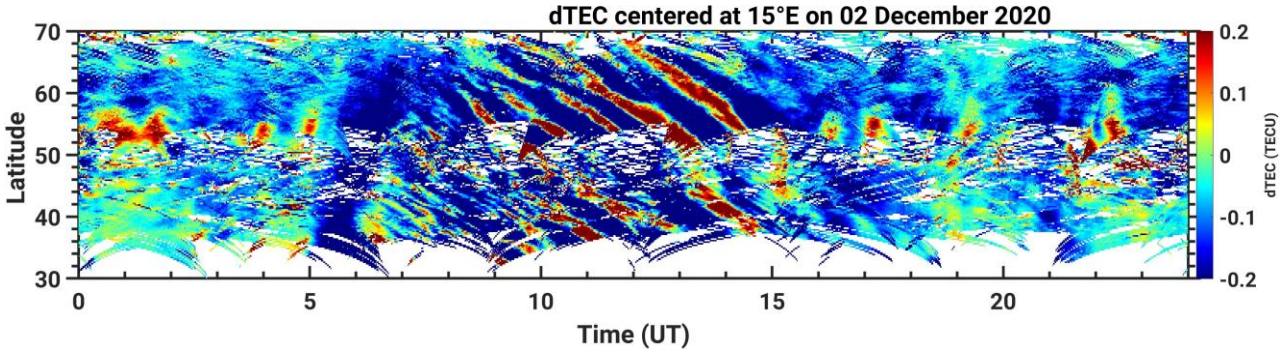
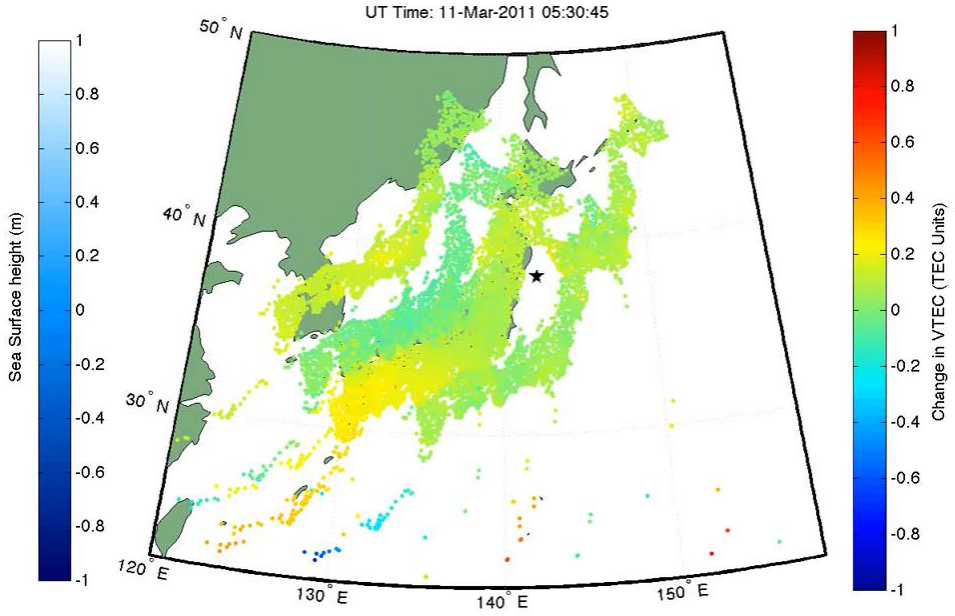
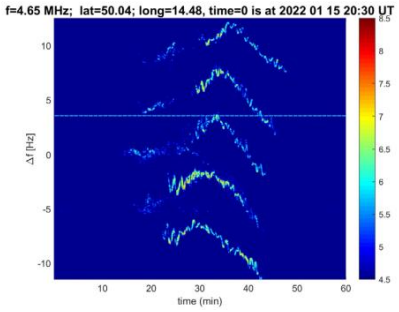
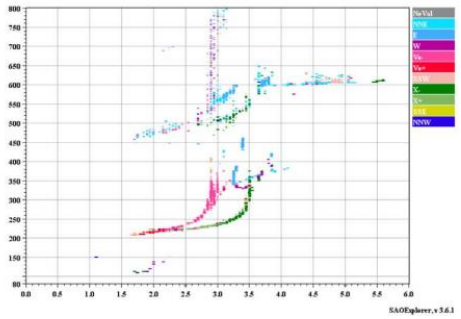
Recurrent physical phenomena such as the solar terminator crossing, the polar vortex, tropospheric jet streams and sporadic E layers



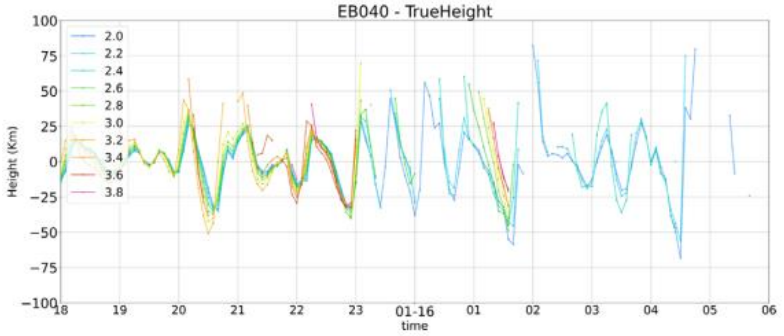




CDSS data



Ionograms



Detrended Ne profiles

Dynamic phenomena occur randomly (such as tropospheric deep convection, earthquakes, natural and anthropogenic explosions).

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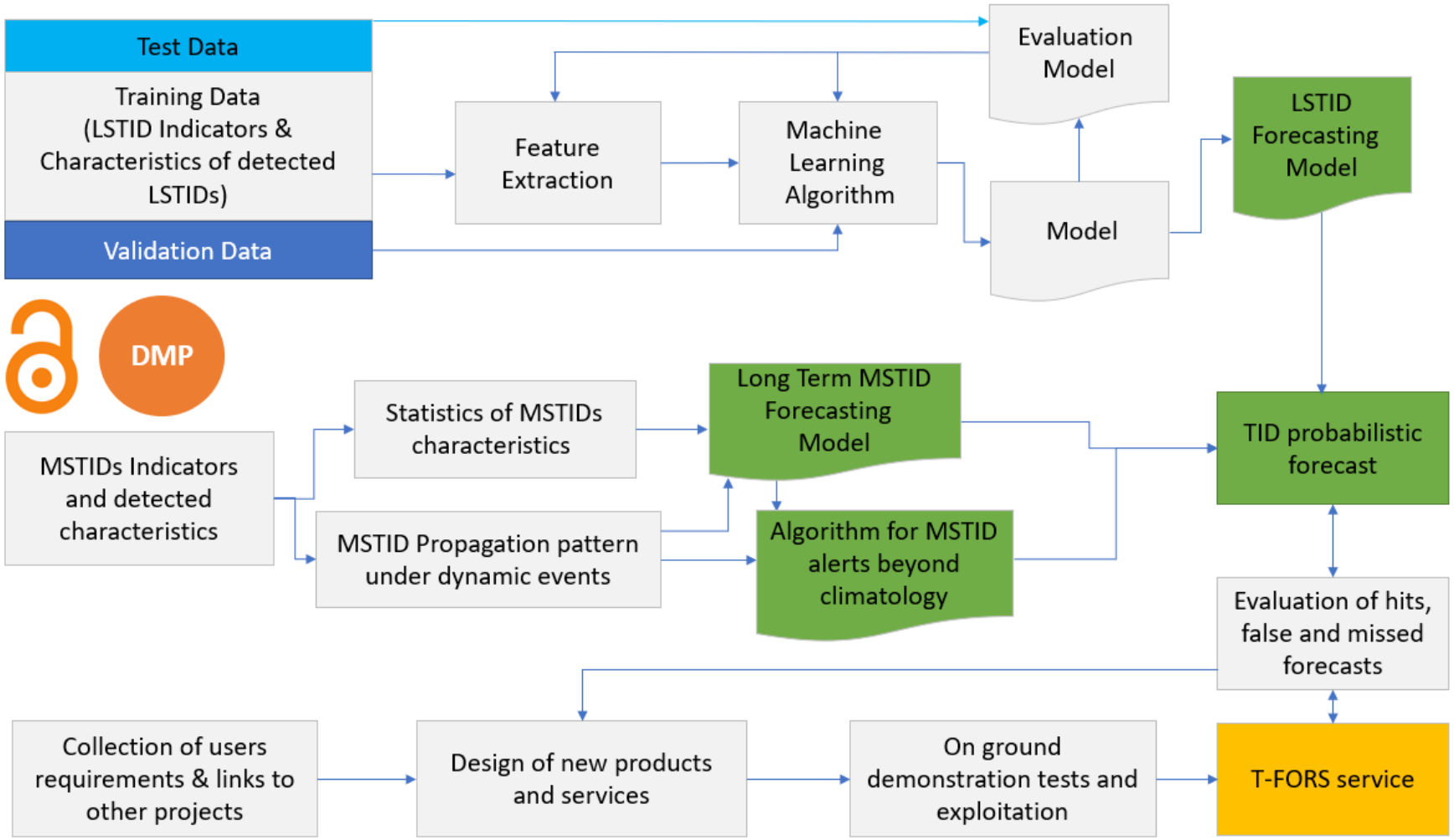
Methodology



Specific Objectives

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a. Develop ***new prediction models*** based on databases of detected TID characteristics and of their drivers developed in the frames of past Horizon 2020 and national projects, using ***Machine Learning (ML Learning) algorithms*** to forecast the occurrence and propagation characteristics of large scale TIDs and ***statistical modelling*** to estimate the occurrence probability and propagation pattern of medium scale TIDs;

b. Improve scientific understanding of the origin and evolution of TIDs that will lead to a proposed ***inventory of potential early indicators***, assessing the validation results of the prediction models;

c. Develop ***prototype services*** based on requirements from the users' community and following harmonized standards and quality control procedures similar to the best practices of meteorological services and relevant community activities;

d. Perform ***on ground demonstration tests for the validation of the usability of the T-FORS prototype services***, analyzing the effects of TIDs on HF skywave radars and relevant applications and the effects on HF direction finding systems;

e. Propose a ***comprehensive architectural concept***, including the densification of ground instrument networks, and new space missions, and possible future adjustments in order to develop a real-time operational service compatible and complementary to the ESA Space Weather services.

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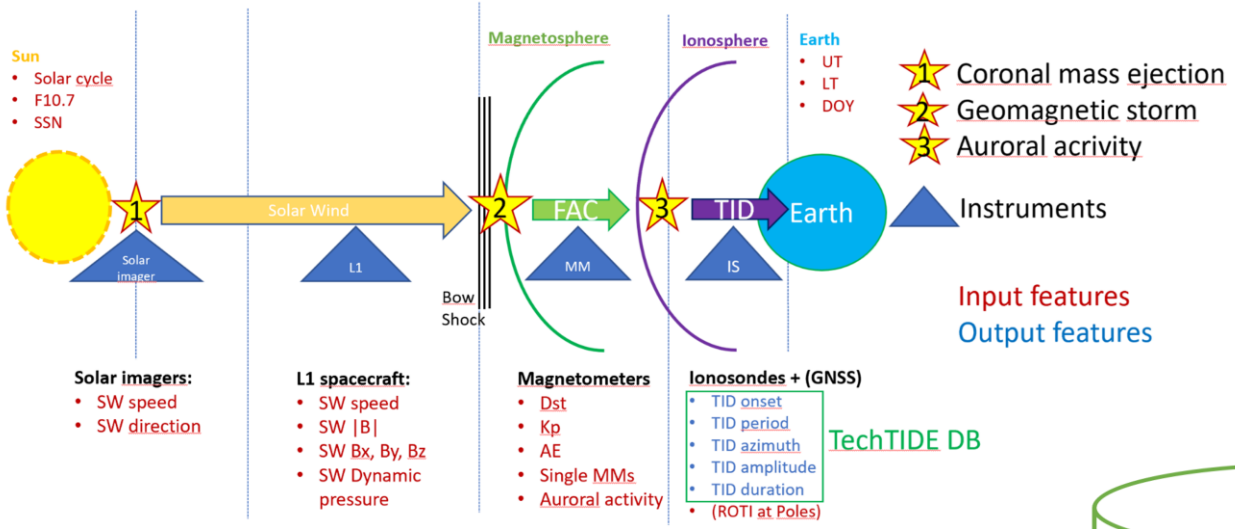
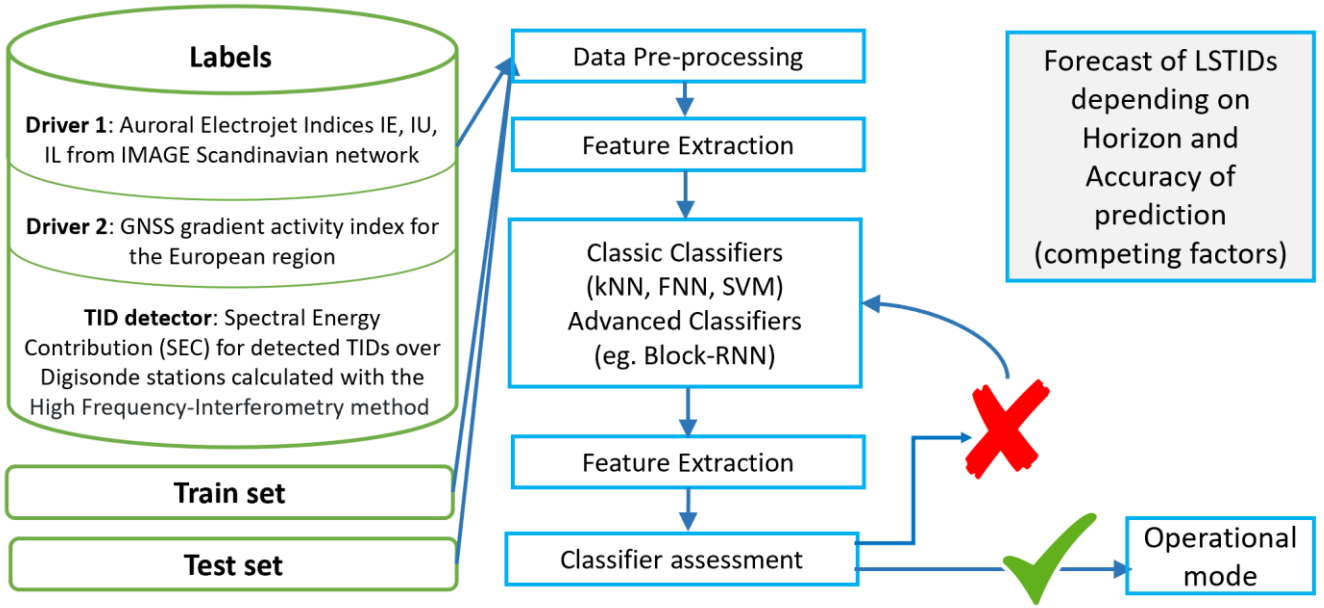
First results from LSTID forecasting models



General methodology for LSTID forecast

Application using classical and advanced NN classifiers



MSTID climatology
Preliminary results

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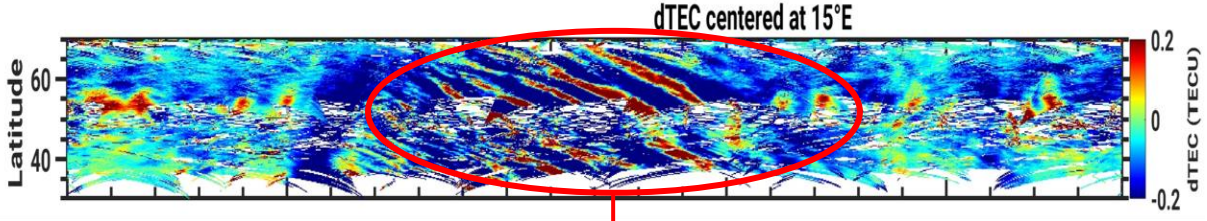

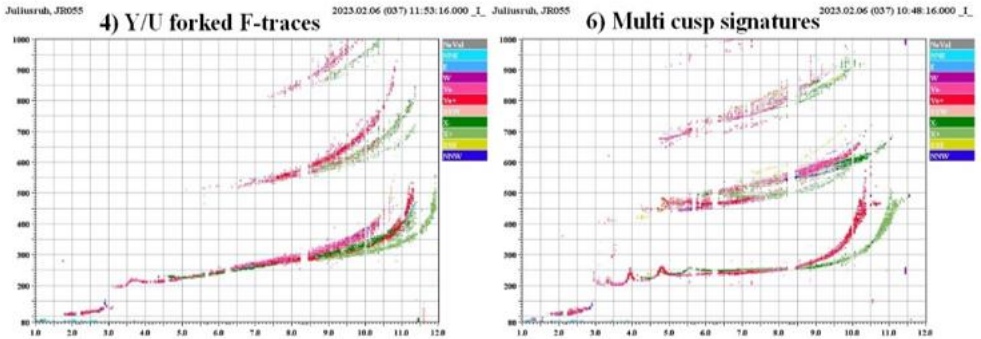

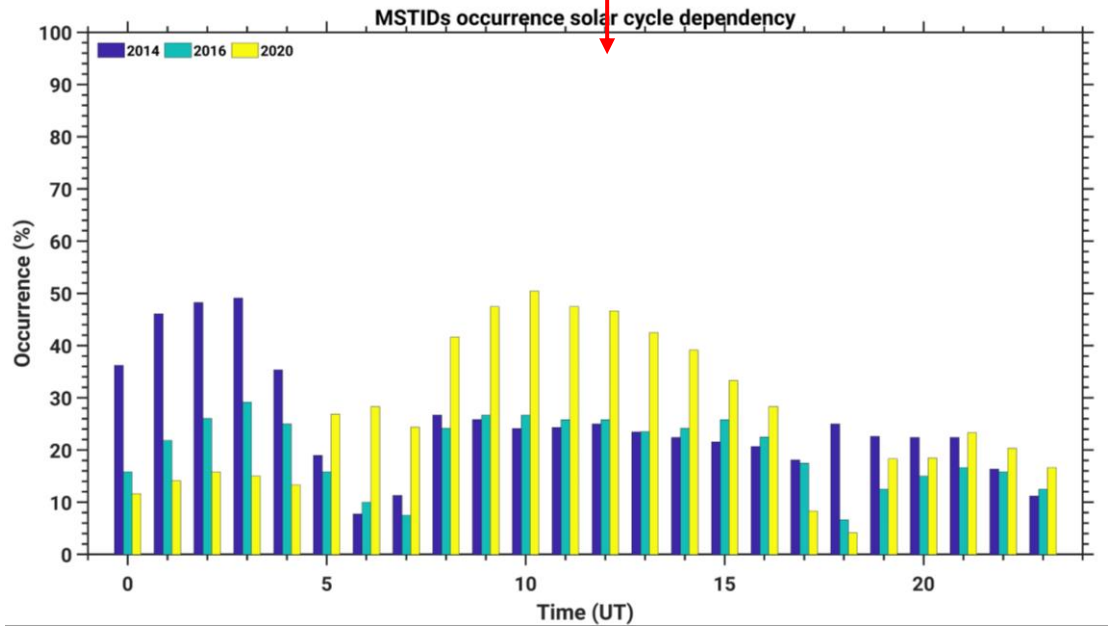

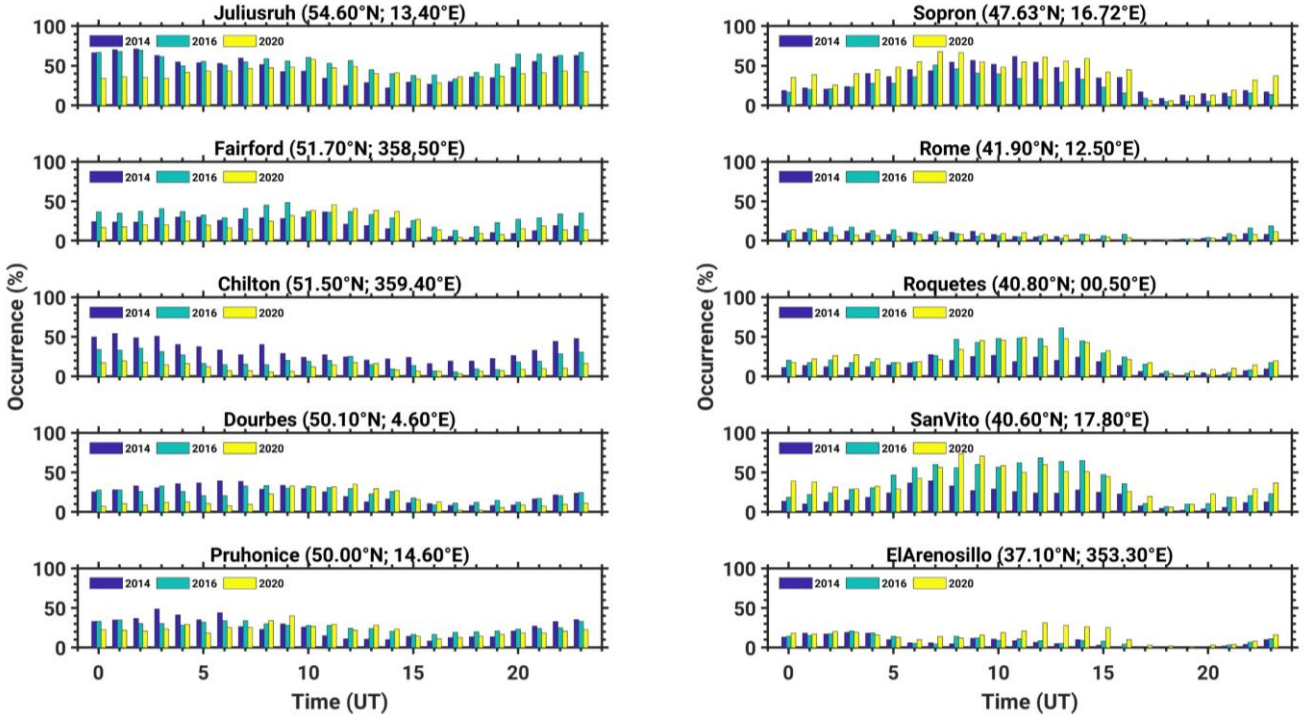

Built a TID forecasting system to support offline and online operations

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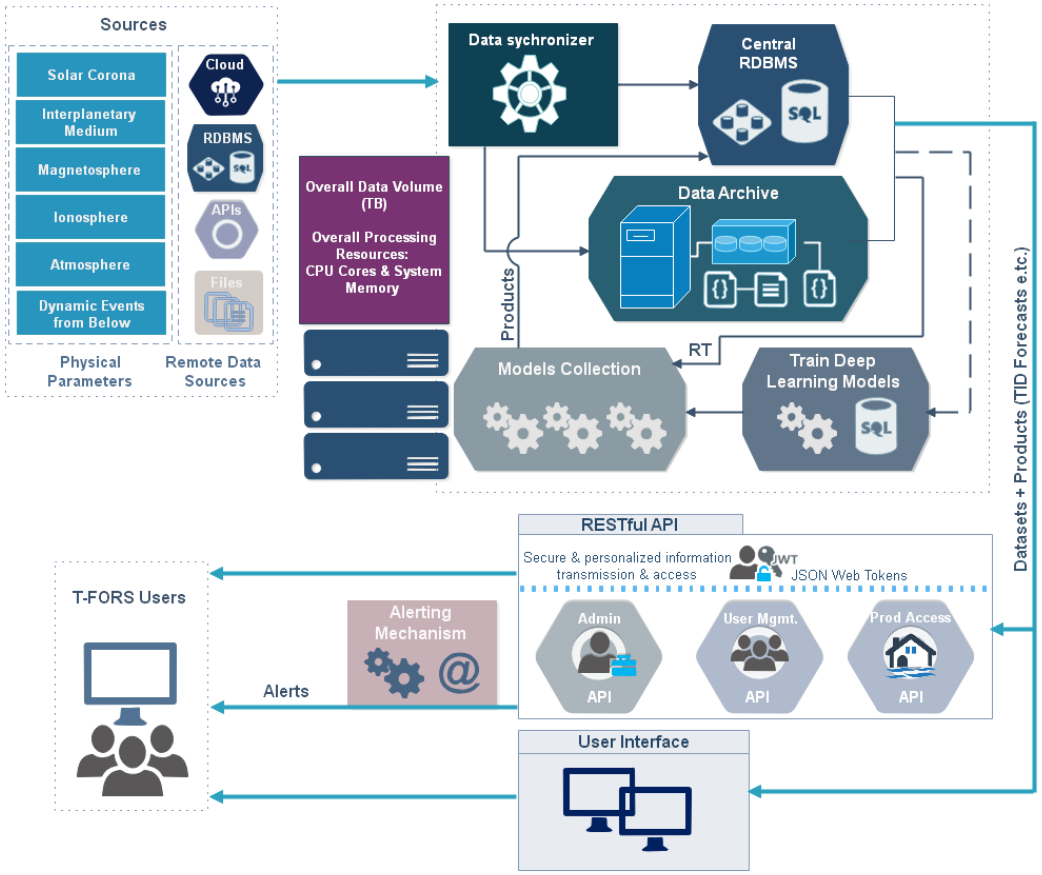

T-FORS IT system initial requirements

Necessary technologies :

1) For the offline models a training infrastructure capable for AI model training and optimisation routings (re-training).

2) For real-time and offline processing of relevant datasets, as well as the dissemination of model products, a small Cluster comprising of:
   - a processing server capable for executing either offline or in real-time the statistical and ML-trained models;
   - a DB server to dynamically store metadata regarding the spatio-temporal data coverage, modelled products coverage, alerts, as well as auxiliary information regarding user hierarchy (authentication and authorisation metadata);
   - a webserver to expose and disseminate datasets and derived products (via programming Restful APIs or fully customised and user-friendly UI).

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Thank you for your attention!

WEB: https://www.t-fors.eu

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