T-FORS

Travelling Ionospheric Disturbances Forecasting System
(2023 – 2024)

Collaboration of PITHIA-NRF with the T-FORS project

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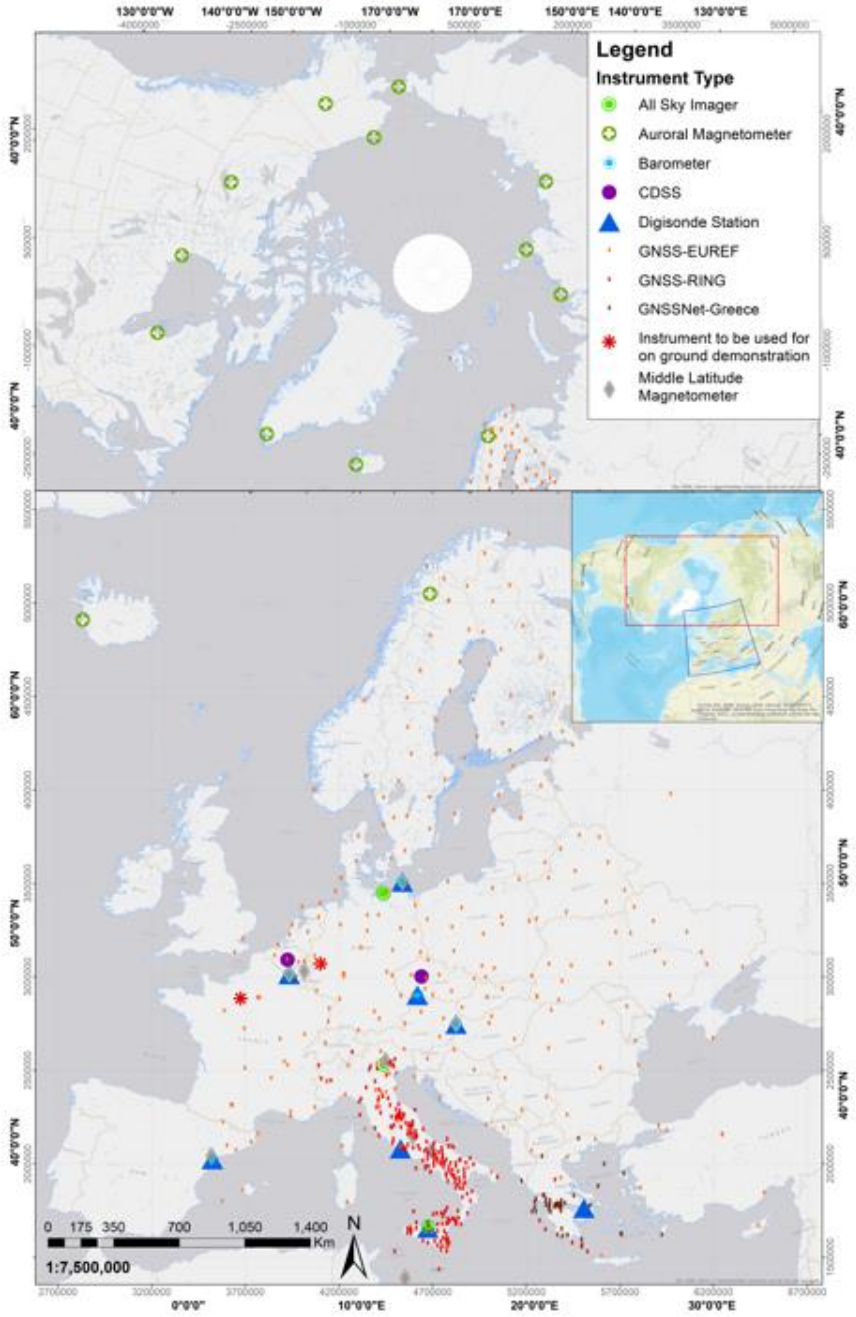
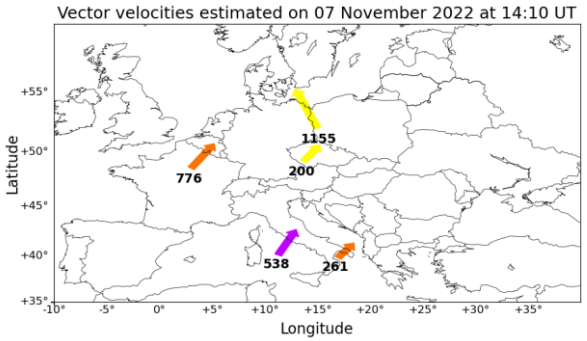
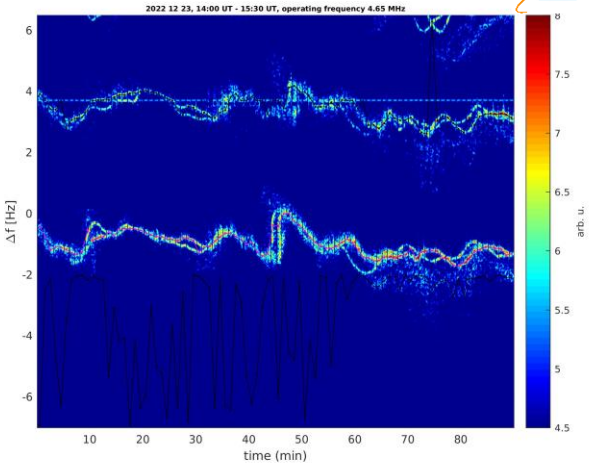
T-FORS: Rational

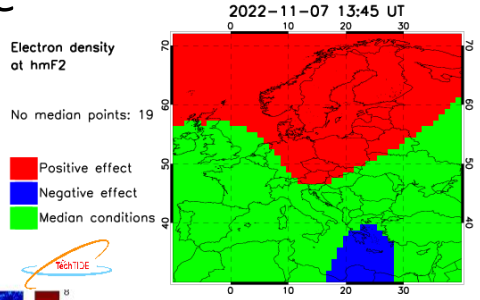
TIDs affect the performance of technological systems that use the ionosphere as a propagation medium or operate in the ionosphere.

- ESA SSA SWE Service Network and TechTIDE H2020 project have ***documented specific users' requirements.***
- From past projects, the T-FORS participants have established ***big data collections of both TID drivers and TID detection results.***









Main Objective

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.

Specific Objectives

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;

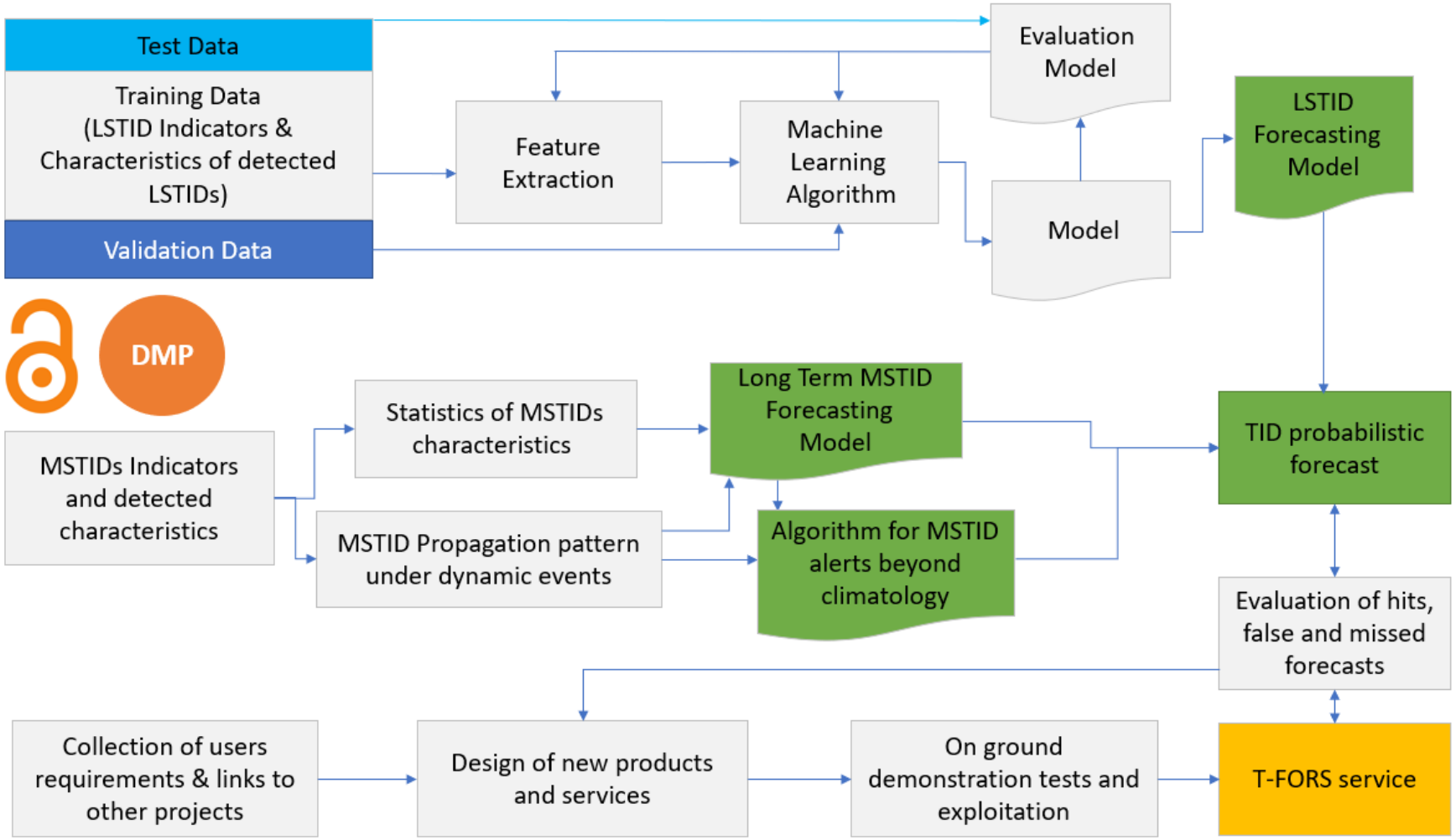
b. Improve scientific understanding of the origin and evolution of TIDs that will lead to a proposed ***inventory of potential early indicators***, assessing the validation results of the prediction models;

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;

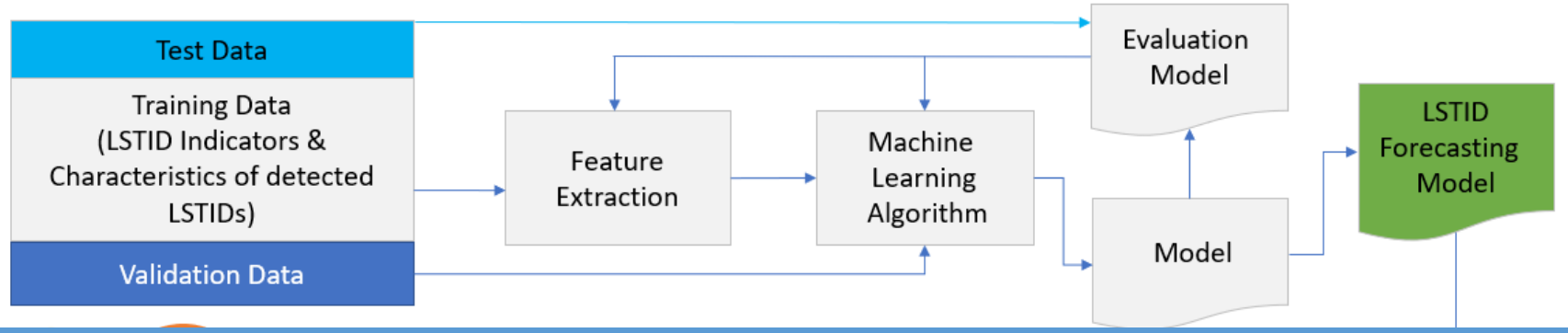
d. Perform ***on ground demonstration tests for the validation of the usability of the T-FORS prototype services***, analyzing the effects of TIDs on HF skywave radars and relevant applications and the effects on HF direction finding systems;

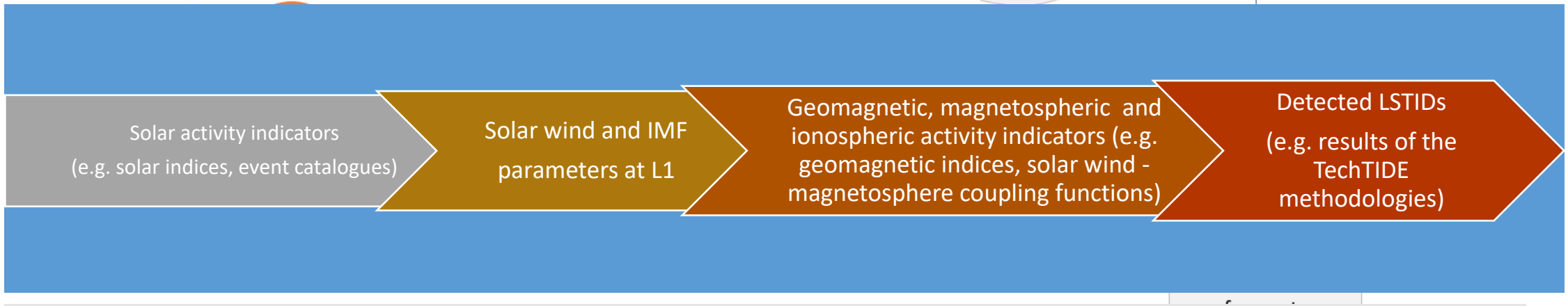
e. Propose a ***comprehensive architectural concept***, including the densification of ground instrument networks, and new space missions, and possible future adjustments in order to develop a real-time operational service compatible and complementary to the ESA Space Weather services.

Methodology



LSTIDs

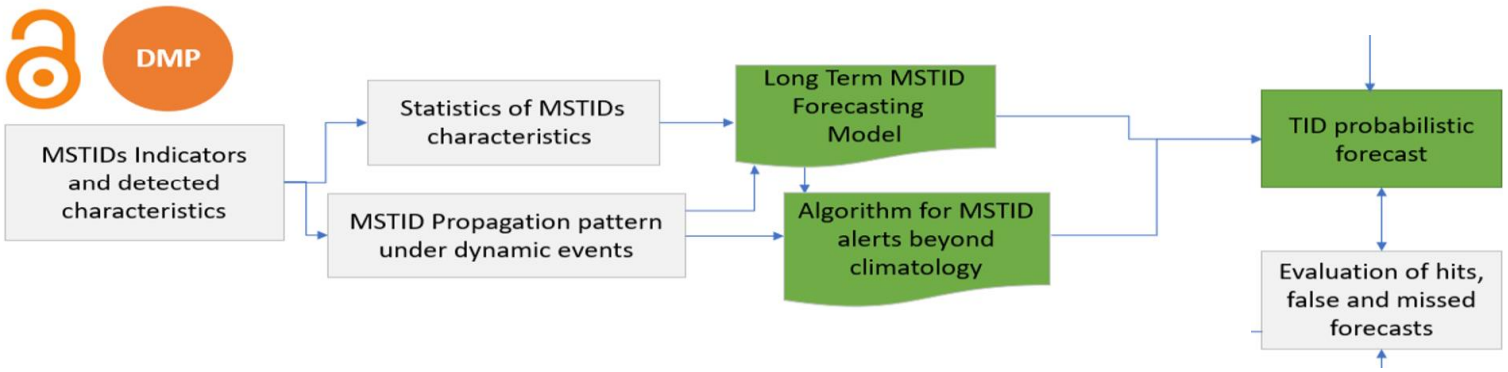




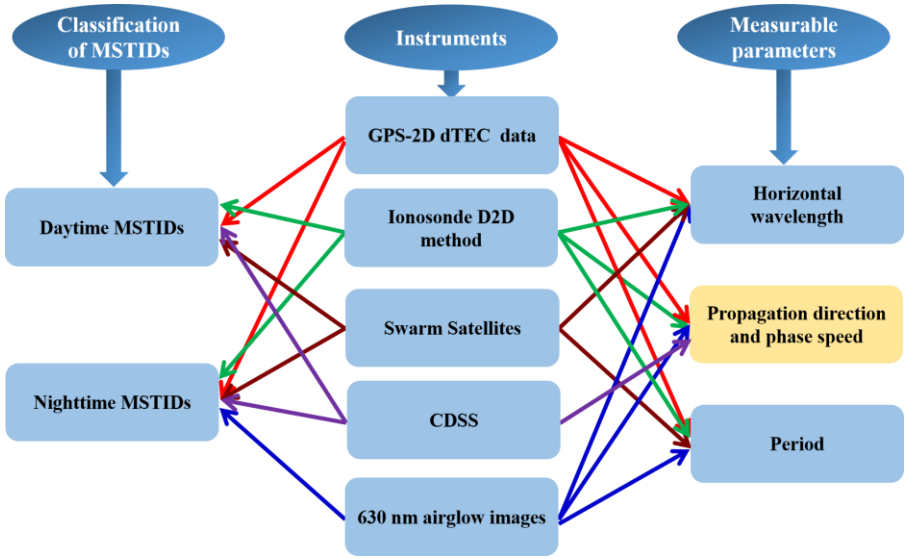
Forecast LSTIDs occurrence and characteristics from several hours to some minutes in advance (with increasing level of confidence) by:

- Building an inventory of indicators for LSTIDs
- Exploitation of ML techniques using selected indicators

MSTIDs



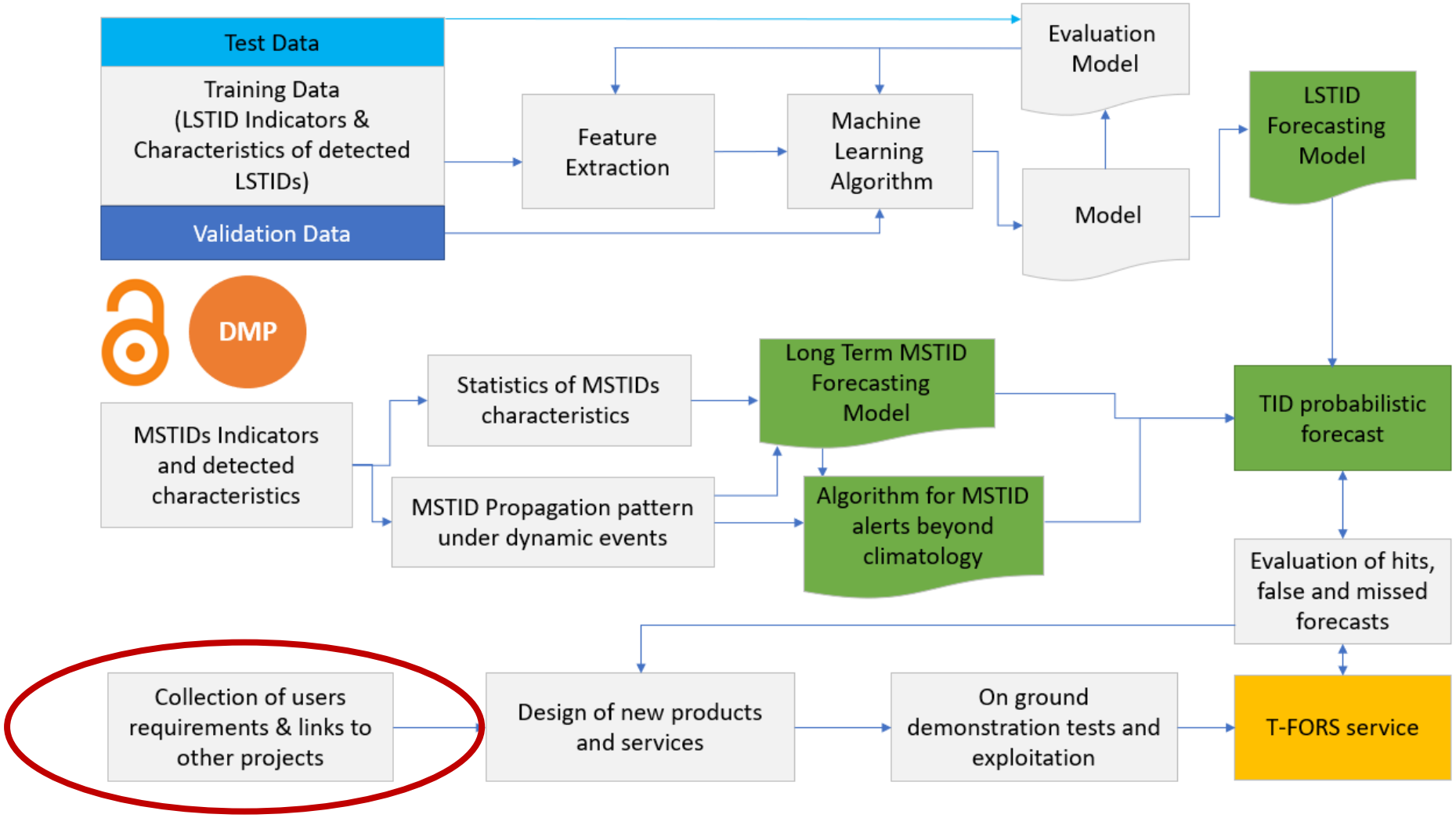
Climatological model (empirical)



MLTIDs alerts: criteria and inventory of parameters

Data source	Sources of MSTIDs
NAO index, GOES-R	Polar vortex
NAO index, GOES-16	Jet streams
Weather maps, satellite data	Deep convection
Ionosonde	Sporadic-E layers
LANL earthquake prediction	Earth quake
CDSS, Ionosonde	Inter-hemispheric coupling

Methodology



WP1 Strategy and Capabilities	WP2 LSTID ML Learning forecasting models	WP3 MSTIDs climatology & probabilistic forecasting	WP4 T-FORS Demonstration and Evaluation.	WP5 Dissemination, Exploitation and Communication (DEC)
Preparation phase (T01 – T06)	Designing the forecasting methodology (T01 – T05)	Designing the MSTID forecasting methodology (T1-T5)	T-FORS functional requirements (T05 – T11)	Definition of DEC strategy (T1 - T04)
T-FORS standards, quality control and best practices (T05 – T18)	LSTID Model Development, forecasts and alerts (T06 – T15) Validation of models' performance and inventory of LSTIDs indicators (T12 – T18)	MSTIDs climatological model (T03 – T11) Alerts (T05 – T14) Validation and compilation of an inventory of activity indicators (T08 – T14)	Development, deployment of real-time services (T12 – T20) On ground demonstration tests (T18 – T22)	Dissemination activities (T04 - T24) Communication activities (T03 - T24) Exploitation and Innovation (T10 – T24)
Architectural concept for an operational European TID forecasting service (T18 – T24)	Release of functional algorithms (T15 – T20)	Release of functional algorithms (T14 – T17)	Release of final T-FORS services (T20 – T24)	Final reporting on DEC activities (T24)

Design phase

Development and validation phase

Finalization phase

TARGET GROUPS

1. Service providers

- ESA SWE Service Network
- ISES
- ICAO

2. Operators and managers of applications concerned

- Debris tracking systems
- The civil air traffic control.
- Users of single frequency GNSS
- Operators of geophysical investigations
- Direction finding systems.
- SMEs developers of SWE and SST services

3. The research community.

- Model developers
- PhD students
- Research Infrastructures

EXPECTED OUTCOMES

1. Enhance their services portfolio with unique and standardized products on expected TIDs in Europe

2. Use open science for the development of **mitigation actions**; **Improved operation** of systems that are critical for the civil safety; Re-use of T-FORS models aiming at its **application in other world regions**. Support **insurance companies to evaluate the risks** in critical infrastructures from severe TIDs.

3. Re-use T-FORS open science results; **Coordinated operation** of instruments; Derivation of **high level datasets**; **Enhance the capabilities of Research Infrastructures** with the integration of T-FORS data and models; **Attract new scientists** in the field.

Collaboration pathways with PITHIA-NRF

- Standardization, networking with stakeholders, dissemination, communication :
  - **Standards, formats and vocabularies for data and metadata description** are of mutual interest for both networks.
  - T-FORS plans to **register the key forecast models in the PITHIA-NRF e-science center** to be available with open access for re-use, experimentation and further development by all interested users from academia and market sector.
  - T-FORS will organize a training school for PhD students and young researchers. The school will offer theoretical lectures on the TIDs triggering mechanisms and detection methodologies and practical courses on the data processing methodologies for TID detection and forecast models. **The school will be co-organized with PITHIA-NRF project.**
- Optimization of observing capabilities (e.g., coordinated observing facilities).

Horizon Europe

Thank you for your attention!

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

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