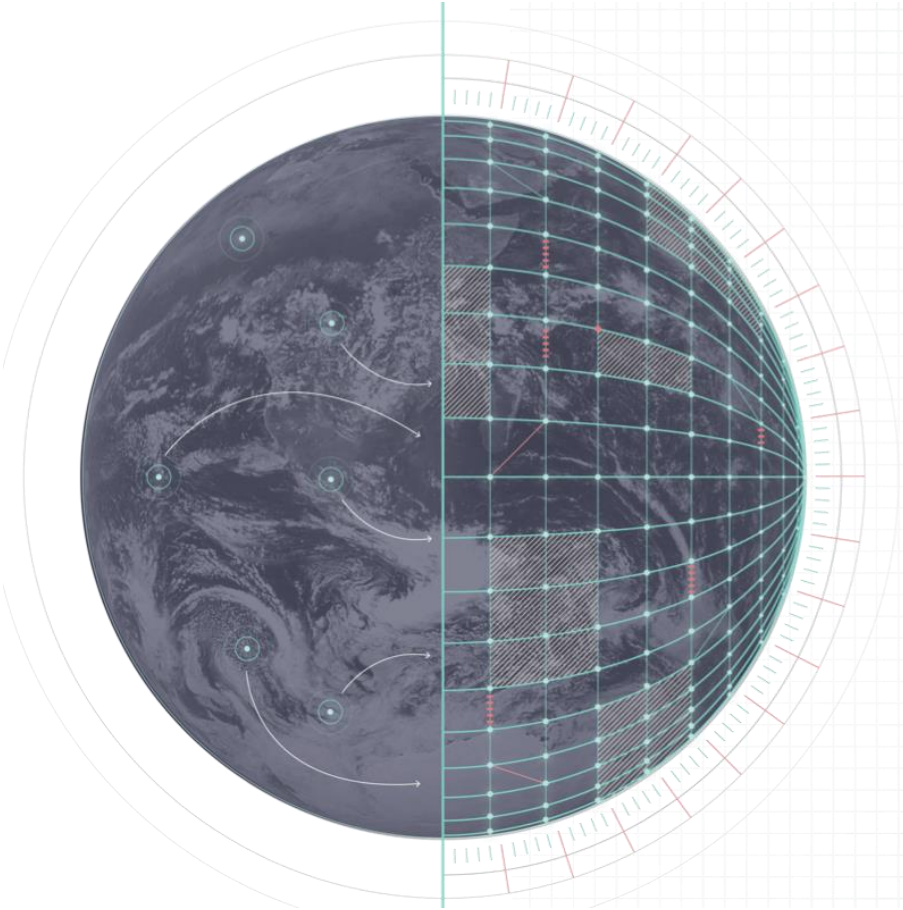


DESTINATION EARTH

HARVESTER SEASONS WEBINAR 6.2.2024

DE370d – HarvesterDestinE

FMI - Miriam Kosmale, Anni Kröger, Tuomo Smolander, Golda Prakasam, Mikko Moisander, Mikko Strahlendorff

MetsäTeho – Heikki Ovaskainen, Asko Poikela

Spatineo – Sampo Savolainen, Stanley Festus, Isabel Donner

Funded by the European Union

Destination Earth implemented by ECMWF esa EUMETSAT

DESTINATION EARTH

FORESTRY CONDITIONS CLIMATE SERVICE

The challenge:

- Forestry machines are heavy, but compact soil is bad for forest growth
- Some conditions allow environmentally sustainable trafficability of forest land
  - Winter with deep frozen soil or deep snow or summer with dry soil

The solution:

- a service to predict frozen soil depth, snow and soil moisture from Copernicus C3S seasonal predictions to plan longer ahead good forest trafficability conditions
- estimate carbon emission impacts of harvesting with several different management options gaining efficiency and limiting potential production shortfalls.

The partners:

- **FMI**, Finnish Meteorological Institute
- **METSÄTEHO**, Finnish forestry sector developers
- **SPATINEO**, geospatial developer

ECMWF

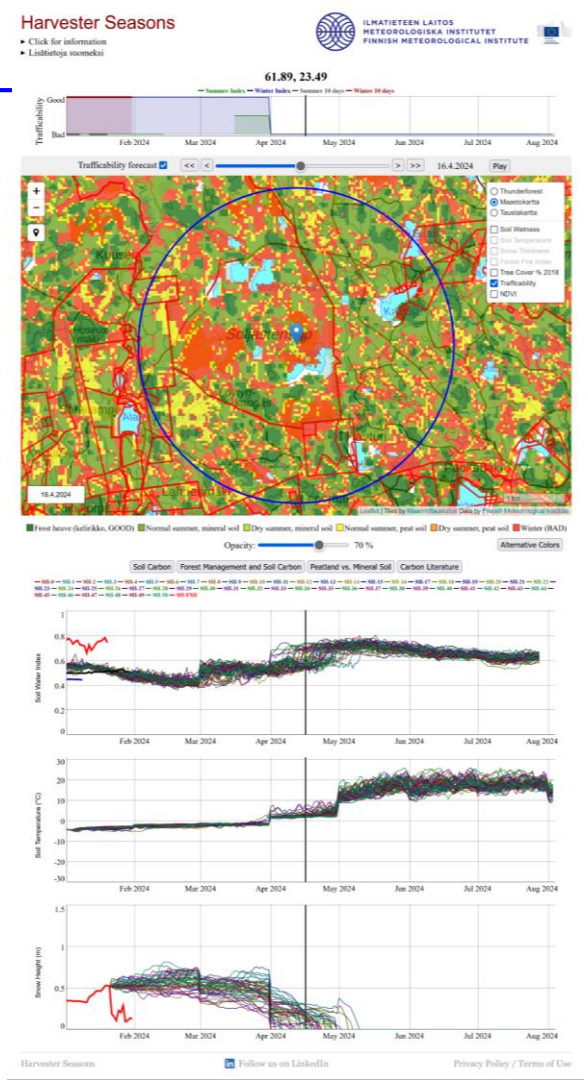
Key Users:

Forestry operators, forest owners, timber procurement, consultants, regulators

DESTINATION EARTH

TEST.HARVESTERSEASONS.COM

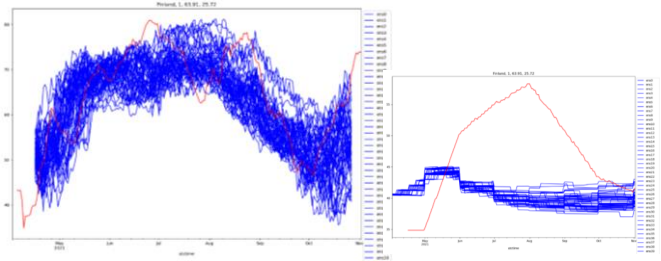
- Service went online in May 2020
- Runs since 2023 March from CSC/Kajaani cloud platform
- 6+ months foresight on forest trafficability for harvesters is based on 90% of 51 seasonal forecast ensemble members agreeing on conditions good or bad, rest uncertain.
- Monthly update Copernicus Climate Change seasonal (215-day) and daily Destination Earth 5-day forecasts
  - Data available for Europe, but high resolution trafficability maps, parcels only in Finland, Europe has 30m trafficability maps on **test**
  - Forecasts are bias adjusted for 2000-2019 ERA5-Land climate
  - New ml-soil wetness forecasts much better (publication under review for Frontiers in Remote Sensing)



frontiers

Gradient boosting-based soil wetness for forestry climate adaptation in HarvesterSeasons service -training a model to forecast soil water index from a comprehensive set of IFS model predictors in Destination Earth

Mikko Strahlendorff[1*], Anni Kröger[1*], Golda Prakasam[1], Miriam Kosmale[1], Mikko Moisander[1], Heikki Ovaskainen[2], Asko Poikela[2]

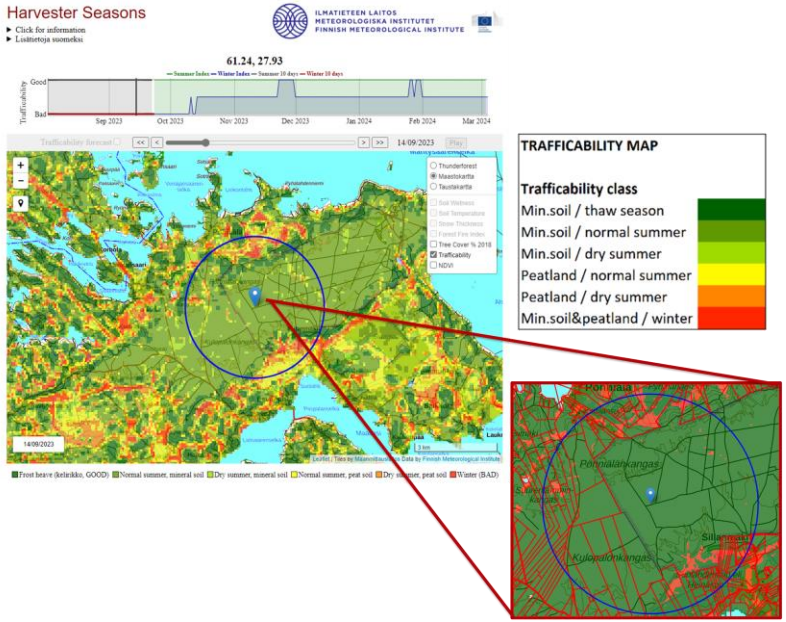


TRAFFICABILITY

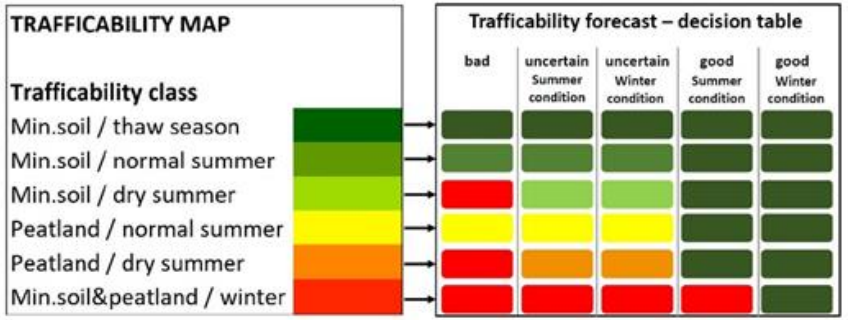
Forest trafficability in Service Harvester Seasons

- Input: Physical information
  - Soil wetness => Summer
  - Soil temperature and snow depth => Winter
- Classification of terrain as a base static map based on topographic wetness index from airborne laser scanning and terrain type

  (ref. "Korjuukelpoisuuskartta" by Metsäkeskus/Finnish Forest Center)

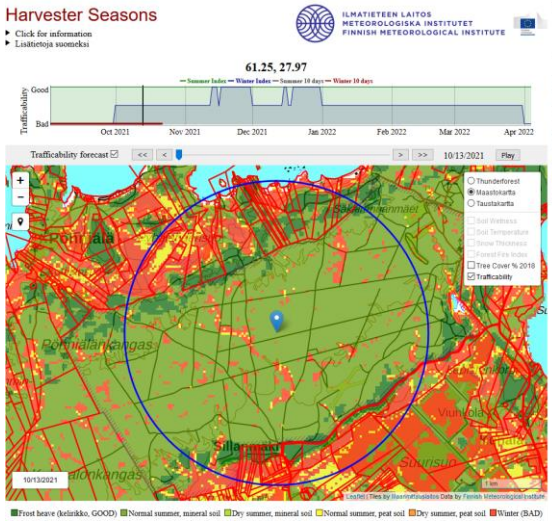


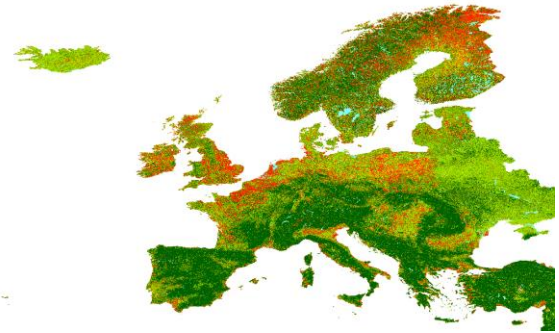
Trafficability scheme for Finland:
Classifikation map in 16m resolution with 6 classe
+ weather and seasonal probabilistic forecasts

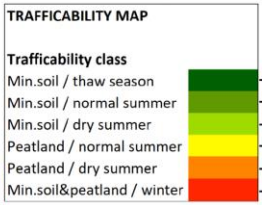


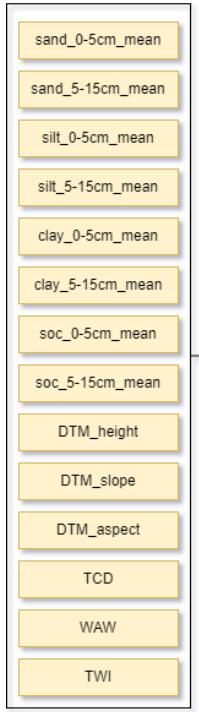
➡ simple trafficability index:
green=good, red=bad, yellow/orange=trafficable in optimal conditions (bearing thru dry/frozen soils or strong snow)

TRAFFICABILITY MAP FOR EUROPE



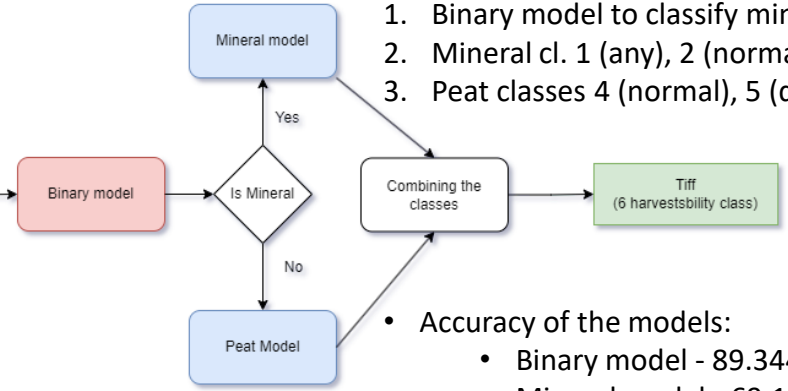






Fit Finnish map to predictors/features

- Copernicus DEM 30m
  - Topographic Wetness Index, Height, Slope and Aspect
- Copernicus Global Land Monitoring Service
  - Tree Cover Density, Water and Wetness 10m
- Soilgrids.org
  - Sand, clay, silt and organic carbon 250m at layers 0-5cm and 5-15cm



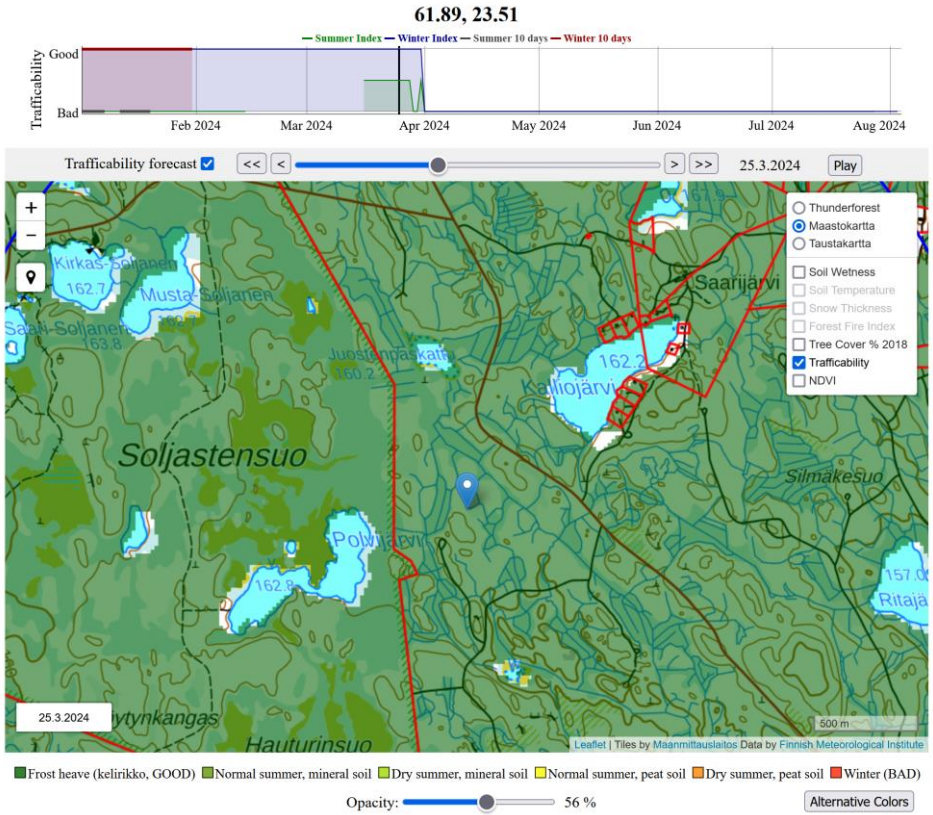
1. Binary model to classify mineral or peat soil
2. Mineral cl. 1 (any), 2 (normal), 3 (dry), 6 (winter)
3. Peat classes 4 (normal), 5 (dry), 6 (winter)

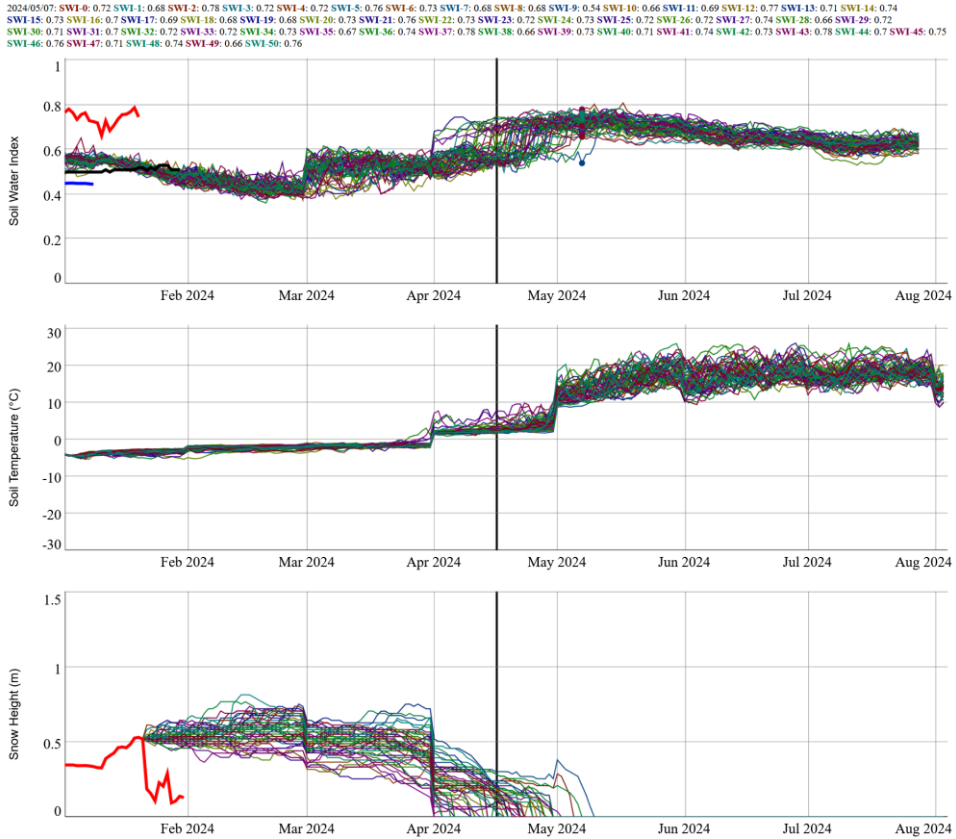
- Accuracy of the models:
  - Binary model - 89.344%
  - Mineral model - 69.157%
  - Peat Model - 82.635%

Produced for European countries with water bodies included for clarity
RENAME to trafficability as an input from users at FORMEC

ECMWF

GETTING CLOSE TO THE PARCEL, MAP DETAILS



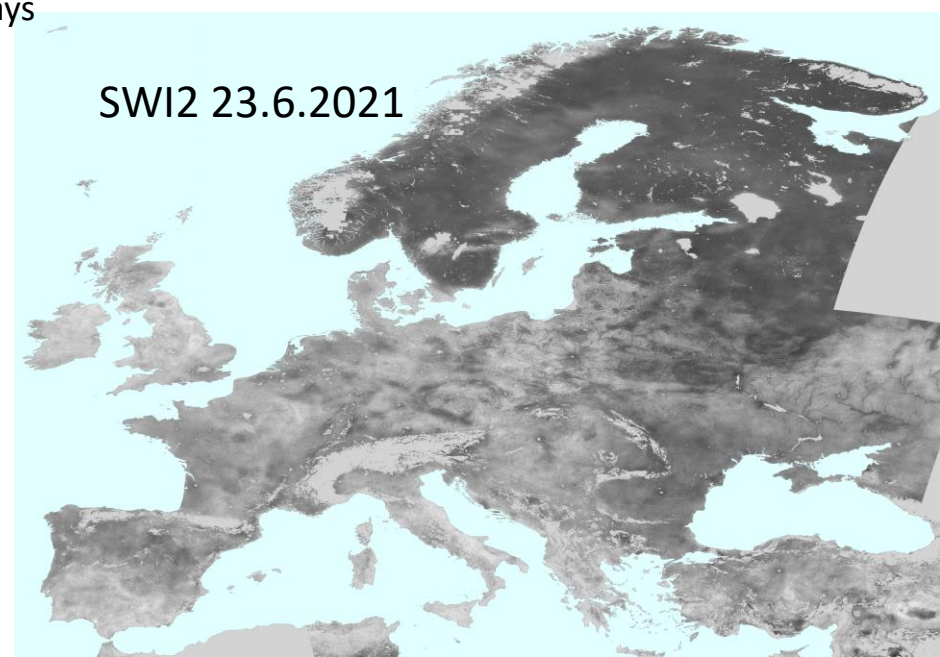


ECMWF

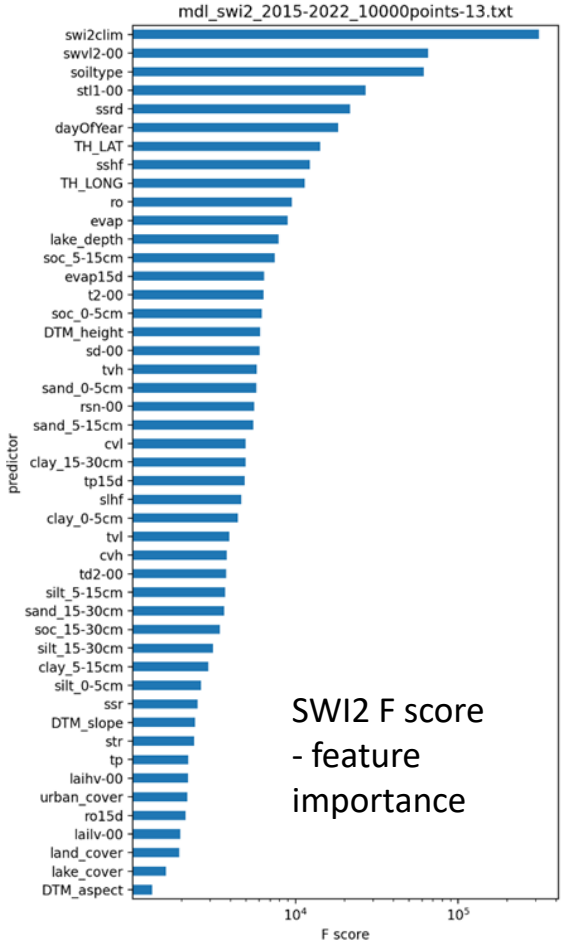
SOIL WATER INDEX … AS ML PREDICTANT

- Reference Wagner et al., 1999a: Soil wetness in deeper layers depends on the surface soil wetness of the past days – the more days combined the deeper the wetness is related to
- Satellites can measure surface soil wetness
- Copernicus 1km SWI product combines different satellite observations
  - ASCAT/METOP B/C: resolution 12,5 km, with obs every hour
  - Sentinel-1 A/~~B:~~ resolution 10m, with obs every ~~3~~/6 days
  - Microwave sensors => see thru clouds
- Endproduct is 1 km resolution daily over Europe
- SWI2 matches approximately the 7-28 cm deep soil layer
- No product in mountains and on snow covered terrain
- Significant improvement with 1 km observations to the previous product based on ERA5-Land 9 km model output

- https://land.copernicus.eu/global/products/swi

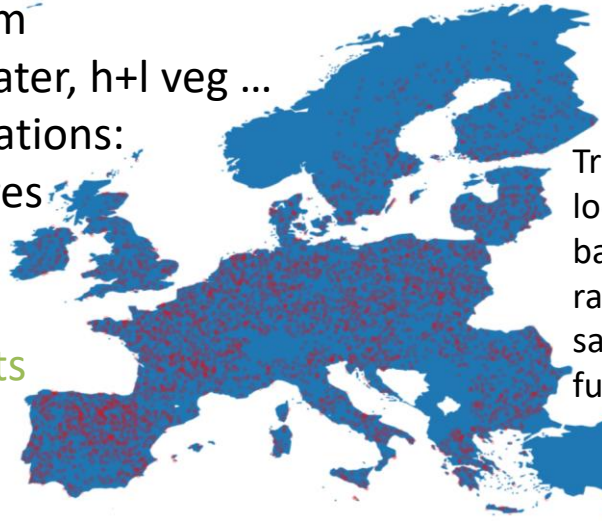


RESULTS FROM SOIL MOISTURE/SWI ML



SWI2 F score - feature importance

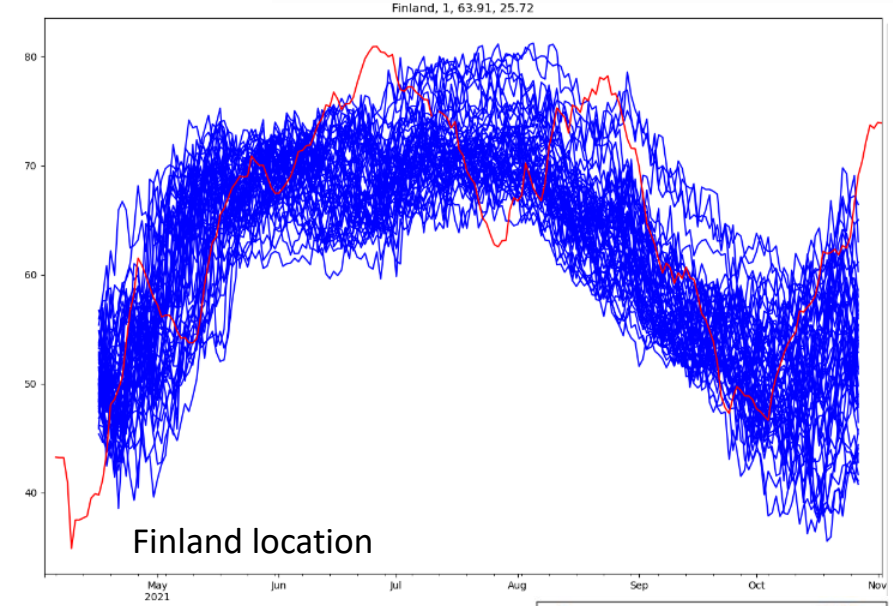
- Chosen runs with 10 000 stations from 63 000 LUCAS points
- Prediction pipeline works for 9km ERA5L grid seasonal
  - Production at 4km for Extremes DT
- Best RMSE in optuna 7,04 % for XGBoost 7,03 % for lightgbm
  - XGBoost MAE 5,5 %, lgbm MAE 5,5 %
- Features were expanded to include
  - SWI climatology 2015-2020 based means ++ effect
  - IFS climatology at 1km
    - urban, inland water, h+l veg …
- Representativeness of locations:
- Stabile model at 46 features
- Predictor able to do 1km
- -> Flexible ml-dev code
- 633 Optuna + 27 model fits
- 448 Lgbm & 212 Xgboost

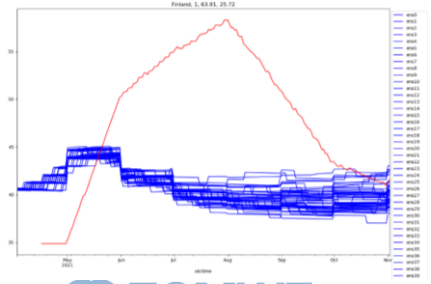


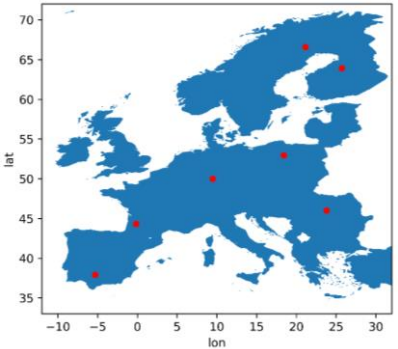
Training locations based on random sample of full timelines

SWI2 VERIFICATION APRIL 2021 SEASONAL FORECAST

Germany Spain Finland France Poland Romania Sweden ALL

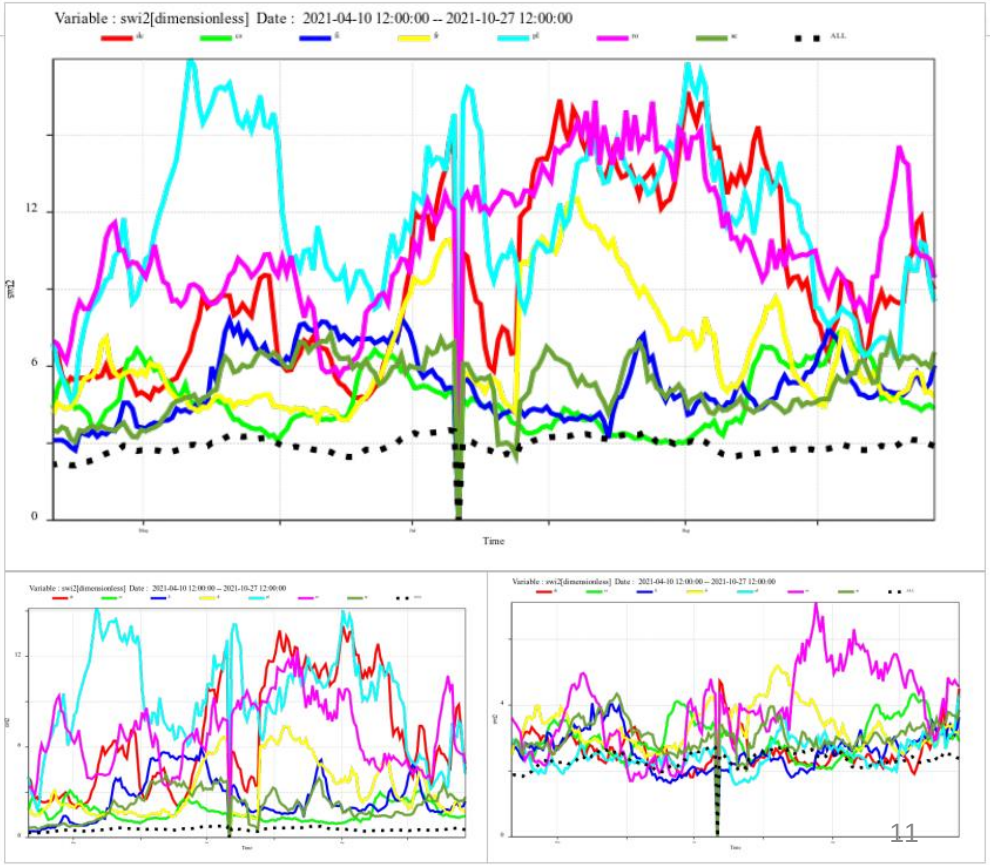






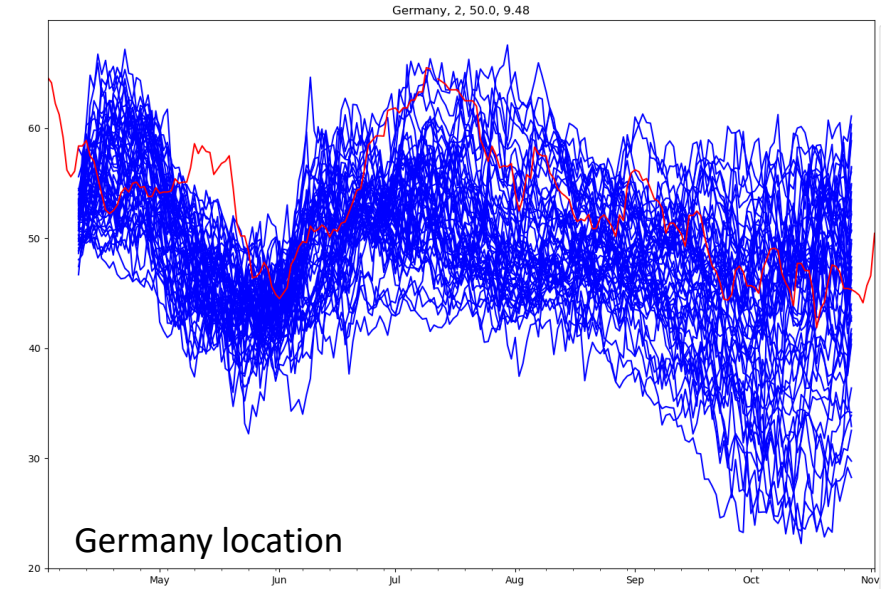
ECMWF

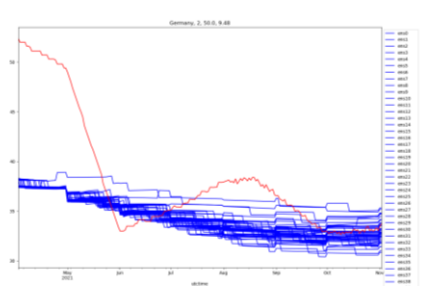
CRPS of 7 countries plus and full European box

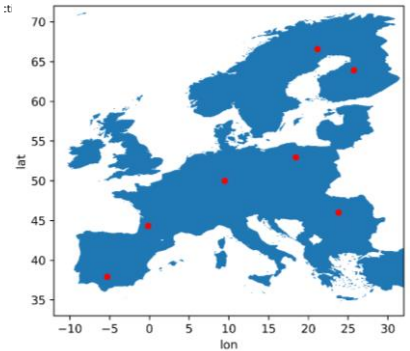


SWI2 VERIFICATION APRIL 2021 SEASONAL FORECAST

Germany Spain Finland France Poland Romania Sweden ALL

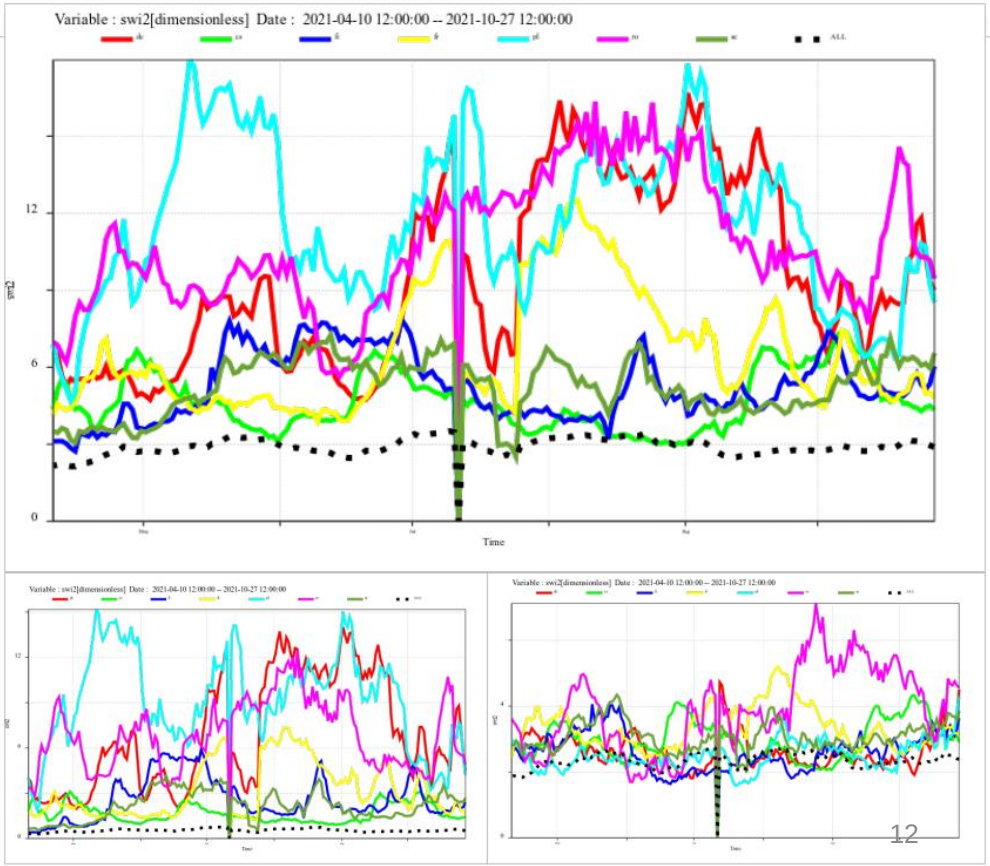




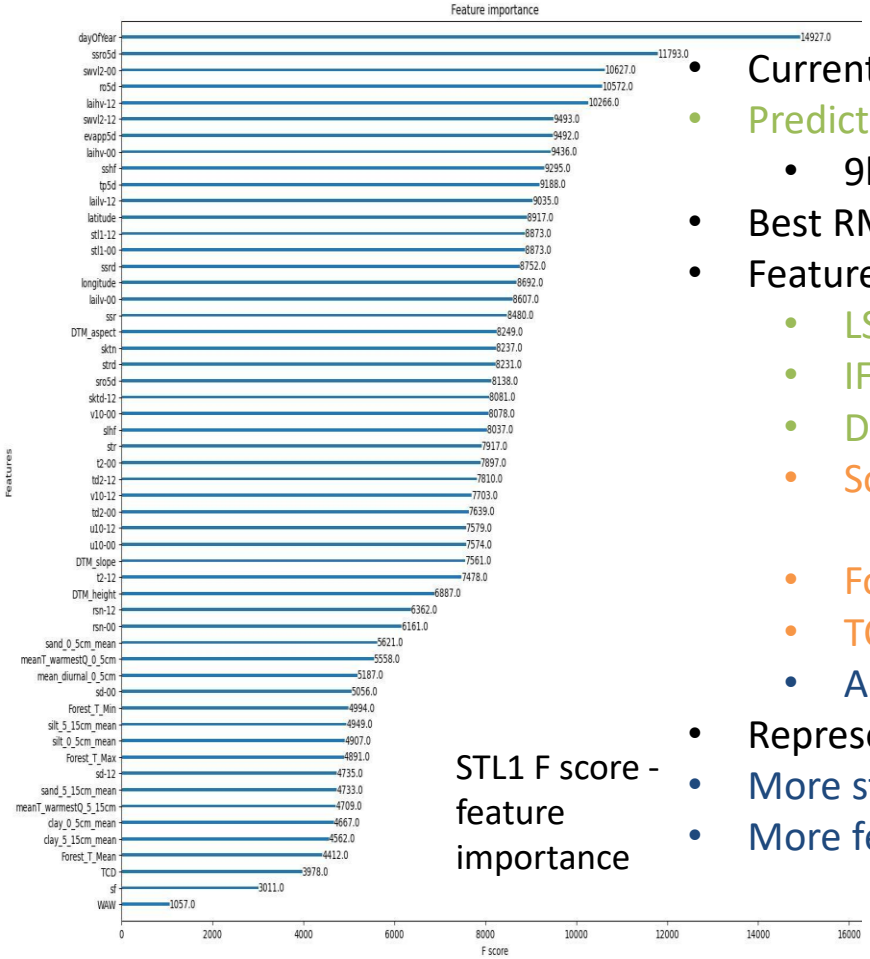


ECMWF

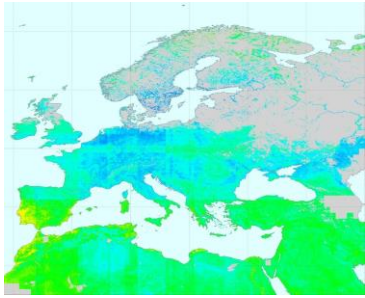
CRPS of 7 countries plus full European box



RESULTS FROM SOIL TEMPERATURE/STL1 ML



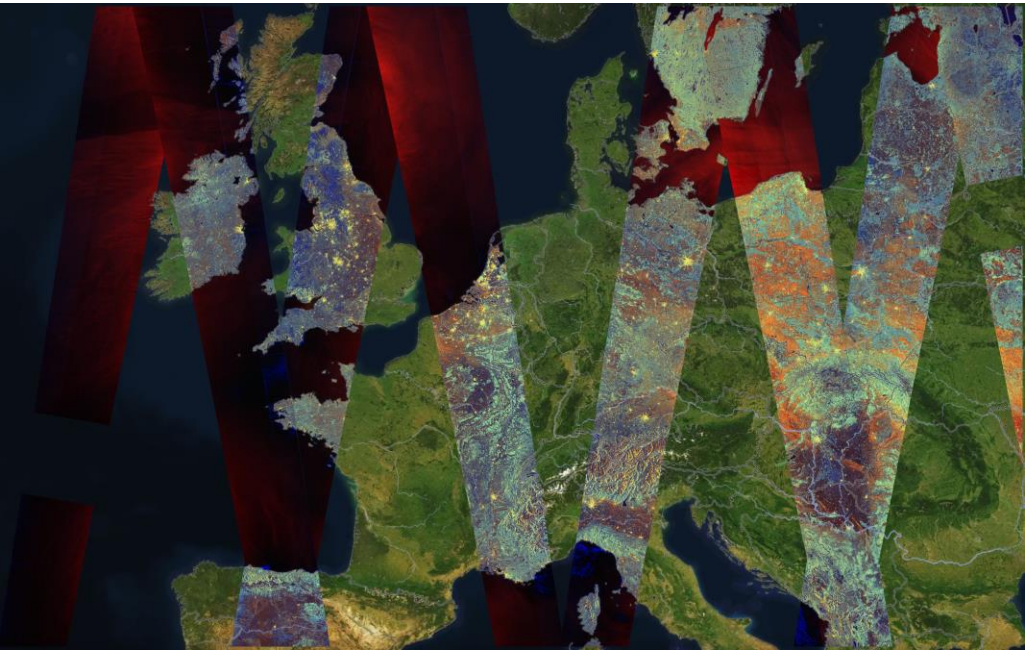
STL1 F score - feature importance



- Current runs with ~1 500 stations
- Prediction pipeline for 4km EDTE grid
  - 9km ERA5L seasonal setup follows
- Best RMSE in 5 Xgboost optuna runs 2.21 C, MAE 1.39 C
- Features inproduction included, dropped and to be tested
  - LSASAF climatology 2015-2022 based means
  - IFS climatology at 1km h+l veg+lc
  - DEM height, slope, aspect
  - Soil grids
    - Soil carbon issue
  - Forest Temp 25m
  - TCD WAW 10m
  - AMSR LST
- Representativeness not enough!
- More stations 5-8cm and ISMN
- More feature engineering

Training locations based on available obs

SNOW DEPTH DOWNSCALER

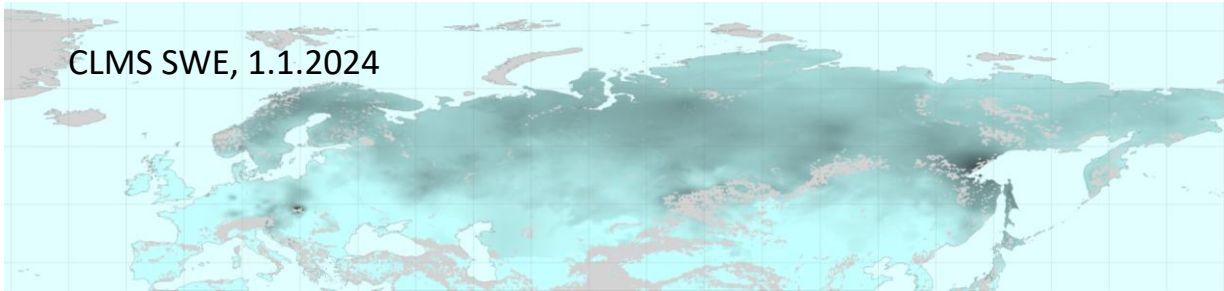


EO predictors for snow depth downscaler

- Copernicus DEM
- Land Cover from EC at 1km
- Snow Cover Extent from CLMS
- S-1 GRD

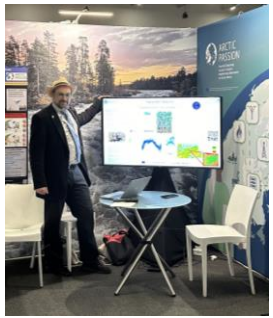
Lievens et al 2022 shows relation between snow change and SAR backscatter change. Potential snow depth downscaler from this using training with surface obs. 9844 stations from ECA and 190 FMI stations (not on map!)

- ERA5-Land predictors 9km
  - Snowfall, snow density, precipitation
  - Evap, runoff
  - Radiation fluxes
  - Soil temp, wetness
  - Temperature, humidity
  - Wind
  - Leaf-area indexes
  - Pressure level variables (ERA5)
- CLMS snow-water equivalent 5km obs and climatology
- S-1 GRD 500m



ECMWF

EVENTS SHOW LOTS OF INTEREST IN DESTINE/HARVESTER



GEO week: GEO GLAM & African nations interest in the soil wetness and improved extreme and climate forecasts!

EuroGEO workshop in Bolzano

Winter Satellite workshop in Espoo