Hyperspectral superresolution, multi-image fusion and LiDAR for remote sensing forest studies

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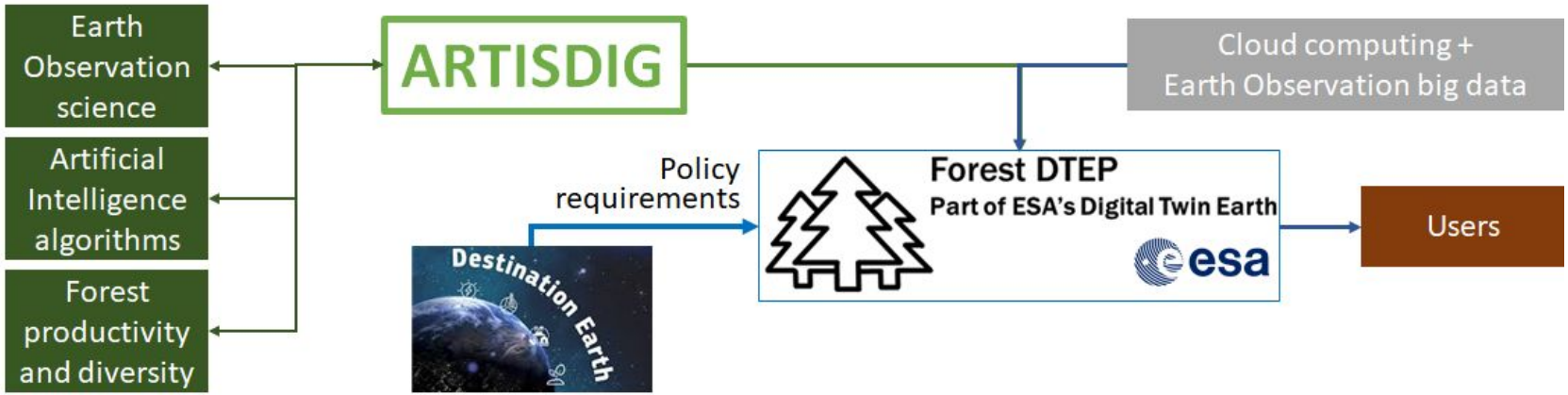
Background

- Research Council of Finland funded Green and Digital Transition project **Artificial Intelligence for Twinning the Diversity, Productivity and Spectral Signature of Forests (ARTISDIG)**
- Partners from Aalto ENG, VTT and LUKE



Research topics

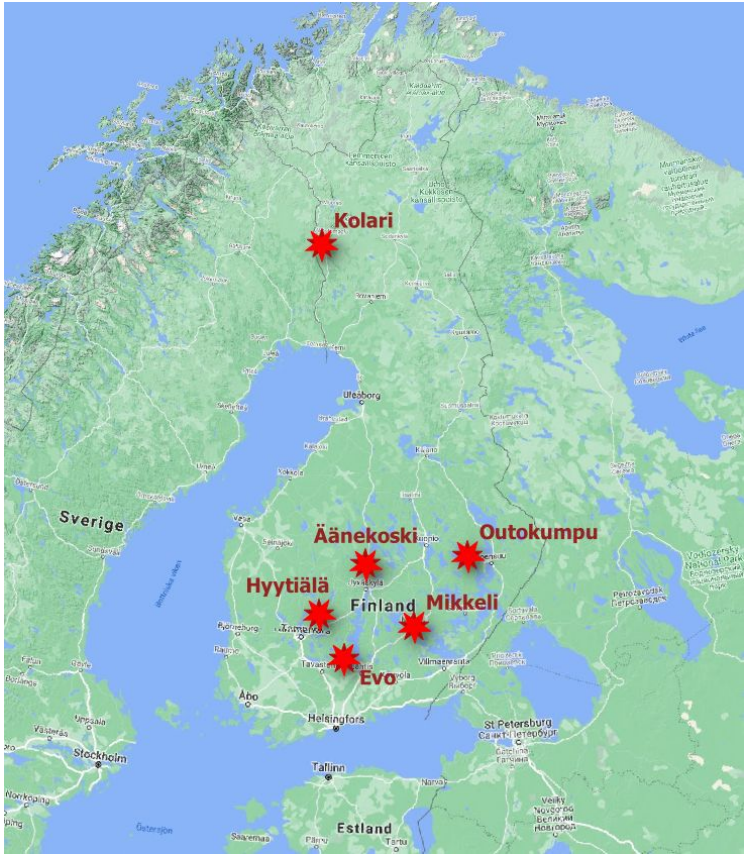
- Deep learning based methods e.g. Transformers for computer vision
- Superresolution of hyperspectral images
- Data fusion of high-resolution multispectral and low-resolution hyperspectral
- Modeling and prediction of forestry variables from hyperspectral images
- Individual tree detection and segmentation from LiDAR
- Tree species classification from tree segments and hyperspectral data
- Modeling of forest diversity and naturalness measures

Needs

- GPU computing nodes for training DL Transformer models
- Support for PyTorch models
- Storage for a few large files (luckily not many small files)
- Interactive visualizations
- LUMI, Puhti and Mahti have offered these

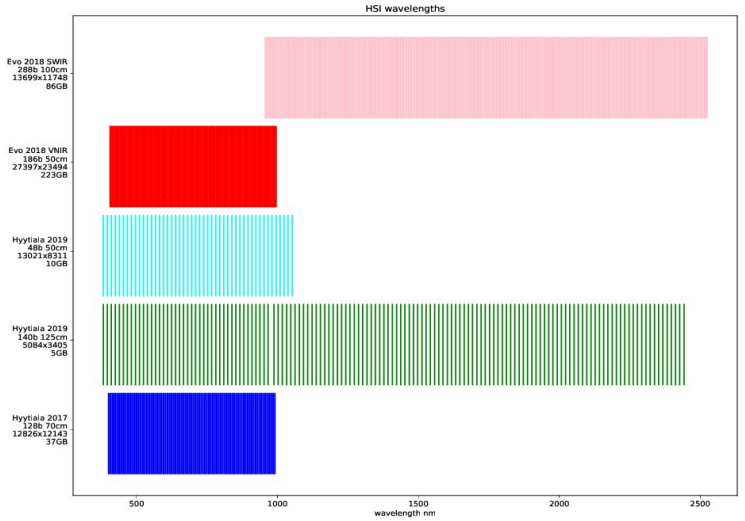
Data

- Airborne and satellite hyperspectral images
- LiDAR 3D point clouds
- Forestry data
- Hyytiälä area 9 km x 9 km
- Evo area 12 km x 14 km



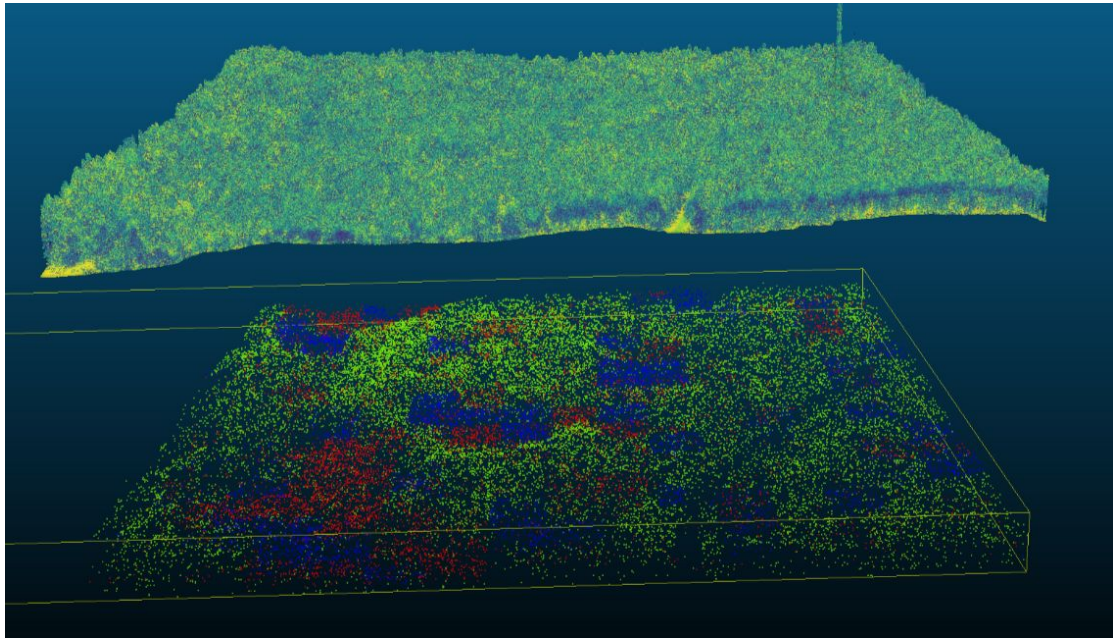
Hyperspectral data

- ENVI files e.g. VNIR 186b 50cm 27397x23494 223GB
- GeoTIFF files e.g. tens of 186b 1000x1000 700MB
- Sampled and stored in HDF5 or Numpy files for faster DL model training



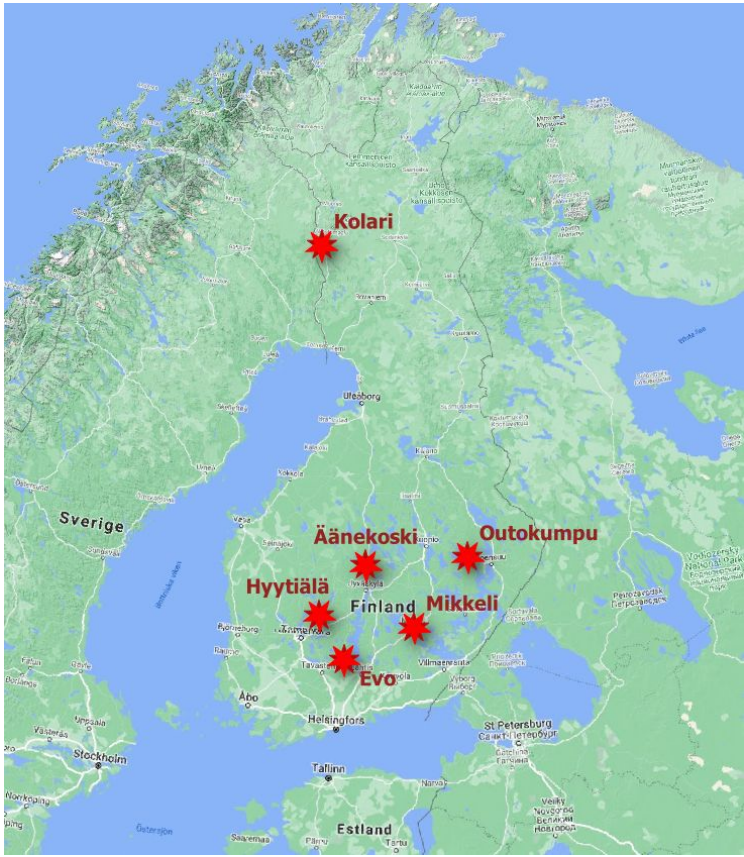
LiDAR data

- LAZ files 350MB
- 5–50 samples/m2



Forestry data

- Finnish Forest Centre data
- OGC GeoPackage files
- 57 variables 16m x 16m grid 1GB
  - categorical e.g. main tree species
  - continuous e.g. average tree height



Tools & libraries

- GDAL
- QGIS (also locally)
- CloudCompare (also locally)
- git + DVC
- Python
  - spectral, rasterio
  - geopandas, shapely
  - h5py
  - torch, torchvision, torchmetrics, pytorch_lightning
  - pdal, dask, mlflow

Some results

- Individual tree detection and segmentation
- Resolving and utilizing hyperspectral pixels of each tree