ENSEMBLE LAND COVER MAPS FOR NUMERICAL WEATHER PREDICTION

Meteo-France AI day, Toulouse

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OUTLINE

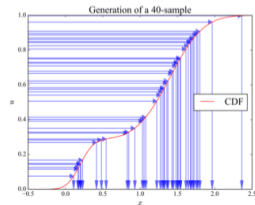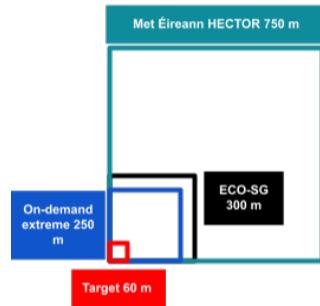# INTRODUCTION

WHY PRODUCE ENSEMBLE LAND COVER MAPS?

- Surface has a large influence on the weather
- Initial need = higher resolution physiography
  - 300 m is no longer sufficient for hectometric scale NWP
  - Leverage AI and many existing maps to produce a 60 m land cover map: **map translation**
- How to represent uncertainty at the surface?
  - Current solution: perturb parameterizations, not the data
  - With data-driven forecast, no parameterizations
  - Exploit UQ on input data: **ensemble land cover maps**

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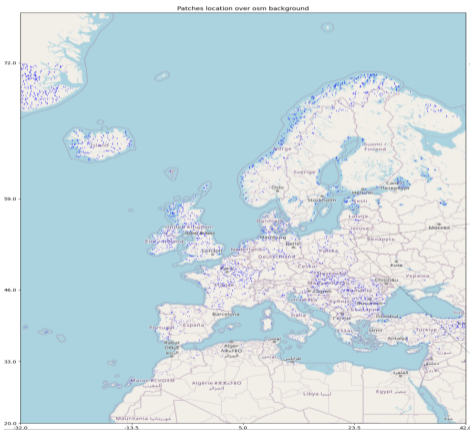MATERIAL

MATERIAL TO BUILD THE REFERENCE MAP

Primary labels

Secondary labels

Water specialist maps

Forest specialist maps

Crops specialist maps

Specialist maps
specific to a primary label, provide refined labels at high resolution

Backbone maps
give primary labels at high resolution

Water
Bareland
Snow
Forest
Shrubs
Grass
Crops
Flooded Vegetation
Urban

Sea and oceans
Lakes
Rivers
Bare land
Rocks
Permanent snow and ice
Boreal broadleaf deciduous
Temperate broadleaf deciduous
Tropical broadleaf deciduous
Temperate broadleaf evergreen
Tropical broadleaf evergreen
Boreal needleleaf evergreen
Temperate needleleaf evergreen
Boreal needleleaf deciduous
Shrubs
Boreal grassland
Temperate grassland
Tropical grassland
Winter C3 crops
Summer C3 crops
C4 crops
Flooded trees
Flooded grassland
LCZ1: compact high-rise
LCZ2: compact midrise
LCZ3: compact low-rise
LCZ4: open high-rise
LCZ5: open midrise
LCZ6: open low-rise
LCZ7: lightweight low-rise
LCZ8: large low-rise
LCZ9: sparsely built
LCZ10: heavy industry

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MATERIAL FOR AI/ML METHOD

◀ a) Random selection of 4000 high quality patches

▼ b) Split of one of these large patches into a training, testing and validation subsets

Train	Test
Val.	Train

Training, phase 1

- Land covers: ESA World Cover, OCS2018, CLC2018, ECOSG, ECOSG+
- Domain: France's mainland
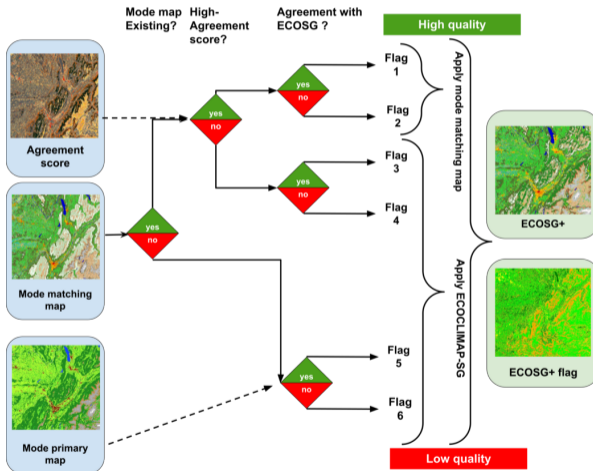
Training, phase 2

- Land covers: ESA World Cover, ECOSG, ECOSG+
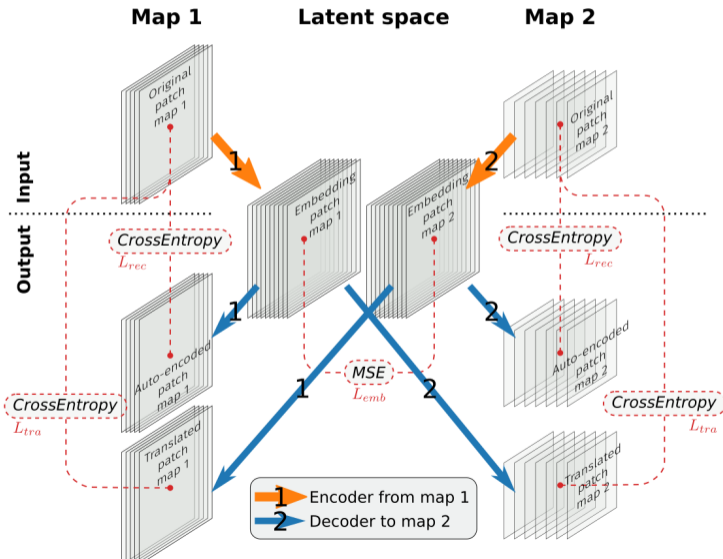- Domain: 4000 random patches on EURAT

Testing

- Domain: 4000 (other) random patches on EURAT

METHODS

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AGREEMENT-BASED REFERENCE MAP BUILDING

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THE MAP TRANSLATION APPROACH

Retained configuration: CNN auto-encoder (4 double conv layers) with 50 channels in the latent space.

Translation from ESA World Cover to ECOSG+

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EVALUATION METHOD

ECOSG+

- Compare to LUCAS
  - + European coverage, in-situ
  - - Only primary labels
- Compare to Irish NLC map
  - + Very high resolution
  - - Only primary labels, limited coverage
- Compare to IMO map (Bolli Palmason)
  - + ECOSG labels
  - - Limited coverage

ECOSG-ML

- Evaluate AI inference
  - Compare to ECOSG+ on the EURAT-test subset
- Evaluate the final map (inference + merging)
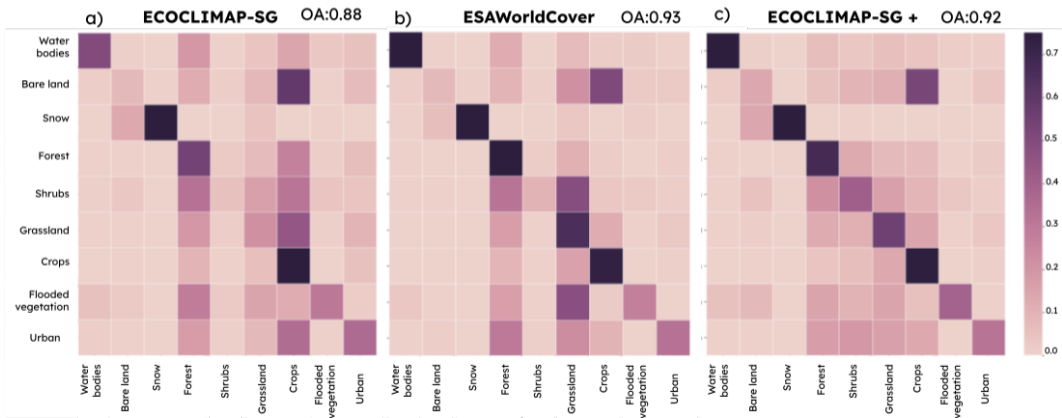 - Repeat the evaluation of ECOSG+

Both

- Baseline is ECOSG
- Qualitative evaluation
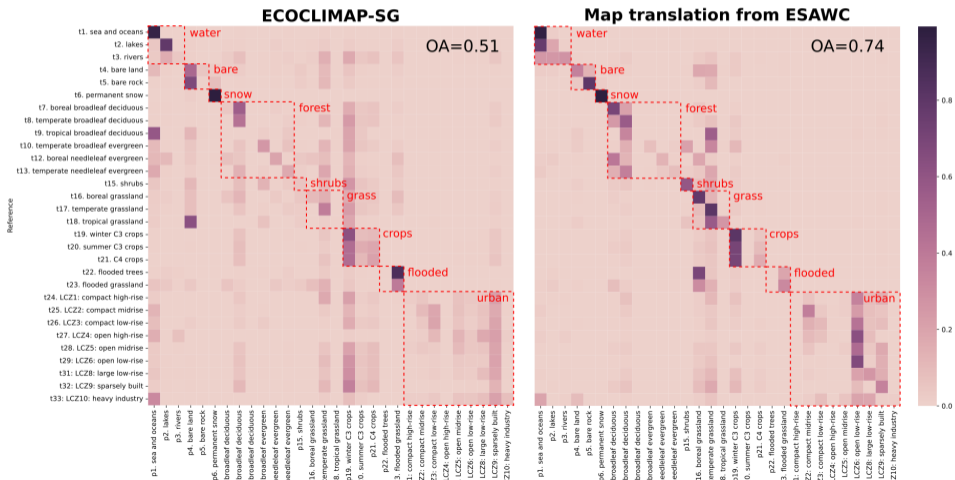 - Select limited set of small patches showing all labels

RESULTS

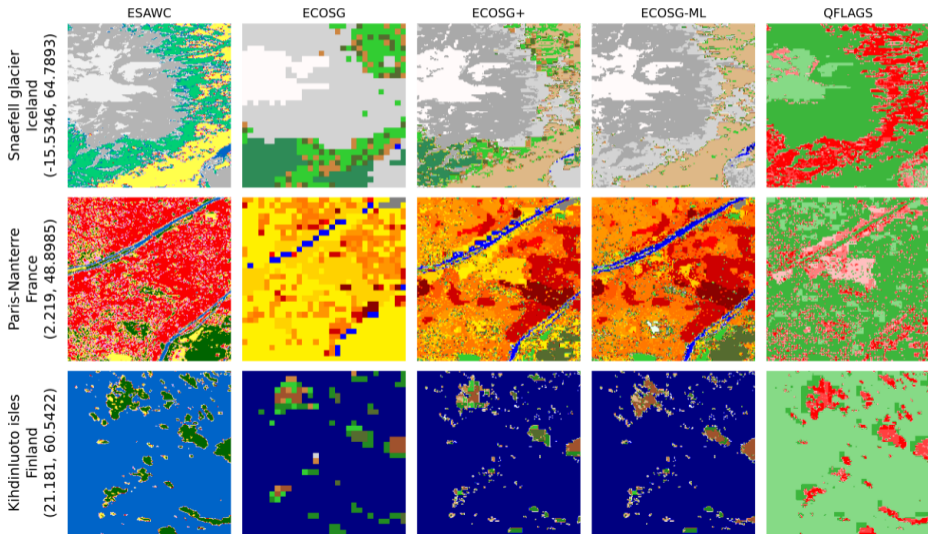# QUANTITATIVE EVALUATION (1/2) -- ECOSG+ VERSUS LUCAS
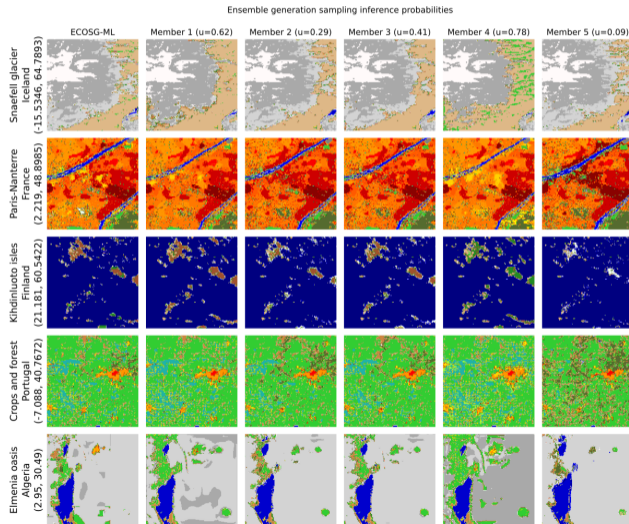
Primary labels over Europe

QUANTITATIVE EVALUATION (2/2) -- INFERENCE VERSUS ECOSG+

All labels over EURAT-test

ECOCLIMAP-SG OA=0.51

Map translation from ESAWC OA=0.74

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QUALITATIVE EVALUATION -- 0.0833º SQUARES

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ENSEMBLE GENERATION OF LAND COVER: SAMPLING COVER PROBABILITIES

Ensemble generation sampling inference probabilities

CONCLUSION

CONCLUSION

- We built a reference map (ECOSG+) at 60 m resolution with ECOSG labels by mixing 40+ different land cover maps.
- ECOSG+ is then used to train an AI that translates ESA World Cover to ECOSG+
- The final map, ECOSG-ML, uses ECOSG+ labels where the quality flag is 1 or 2 and inference results elsewhere.
- Quantitative evaluation give scores above the baseline of ECOSG
  - Overall accuracy of inference reaches 0.74 on EURAT-test (0.51 for ECOSG)
  - Overall accuracy of ECOSG+ reaches 0.91 on Ireland (0.87 for ECOSG)
  - For ECOSG+, evaluation domain needs to be extended (soon)
- Qualitative evaluation is good in most places, but artefacts or misclassifications can easily be found.
- Reproduce results: **https://github.com/ThomasRieutord/MT-MLULC**