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Bagging NFI, GEDI and Sentinel-2 data to produce high-resolution maps of forest volume

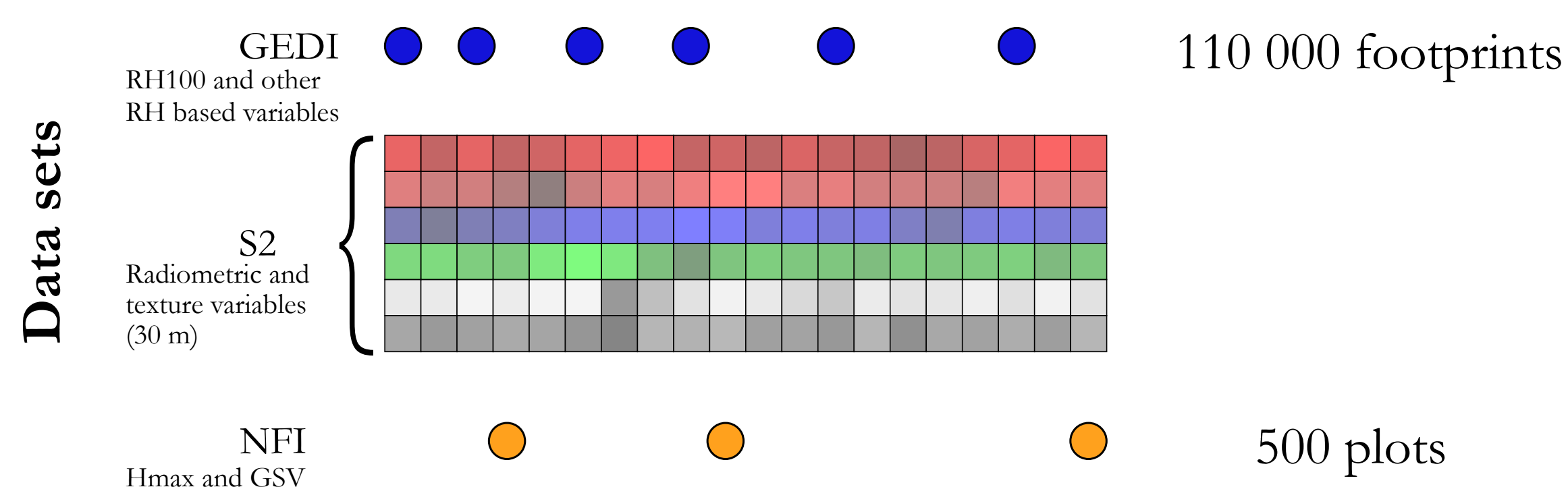
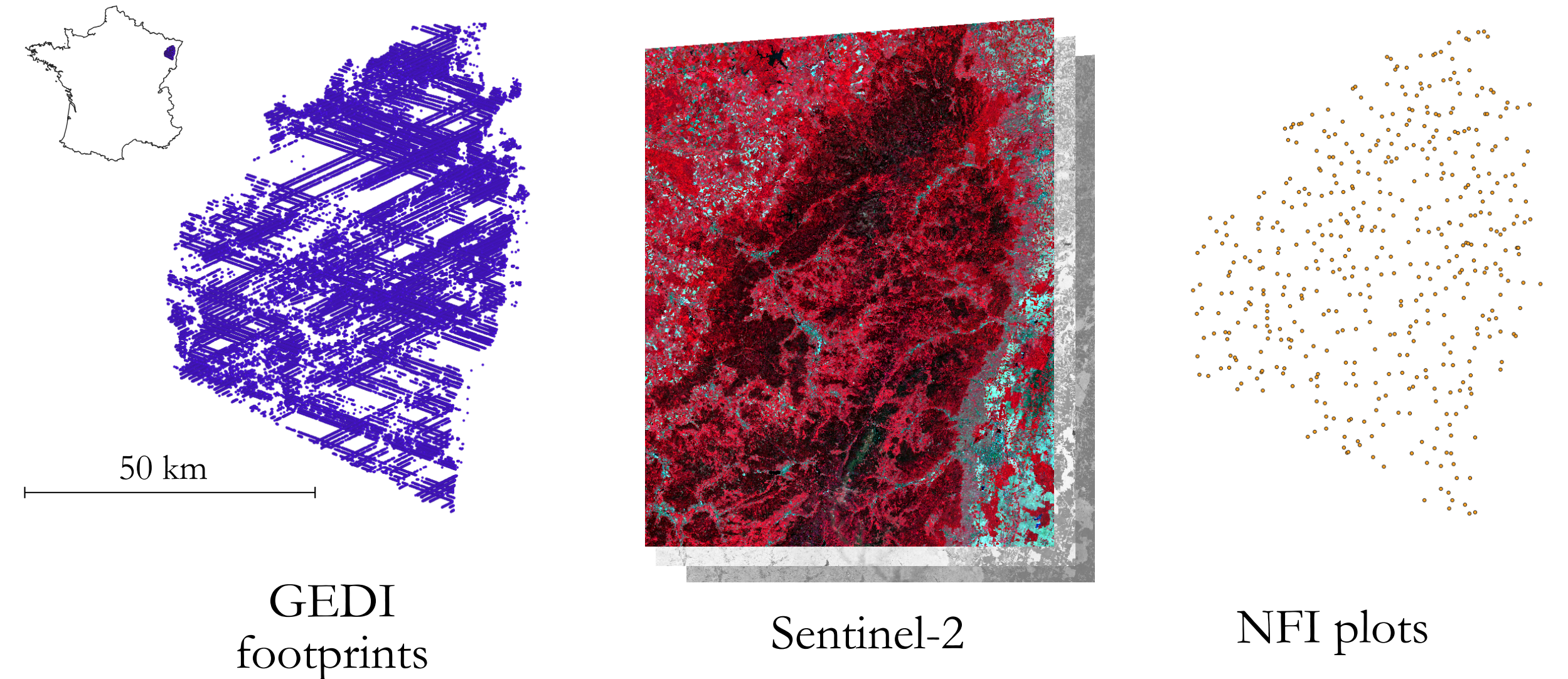
Anouk Schleich¹, Cédric Vega², Jean-Pierre Renaud³, Sylvie Durrieu¹



I. Context, Objective & Data

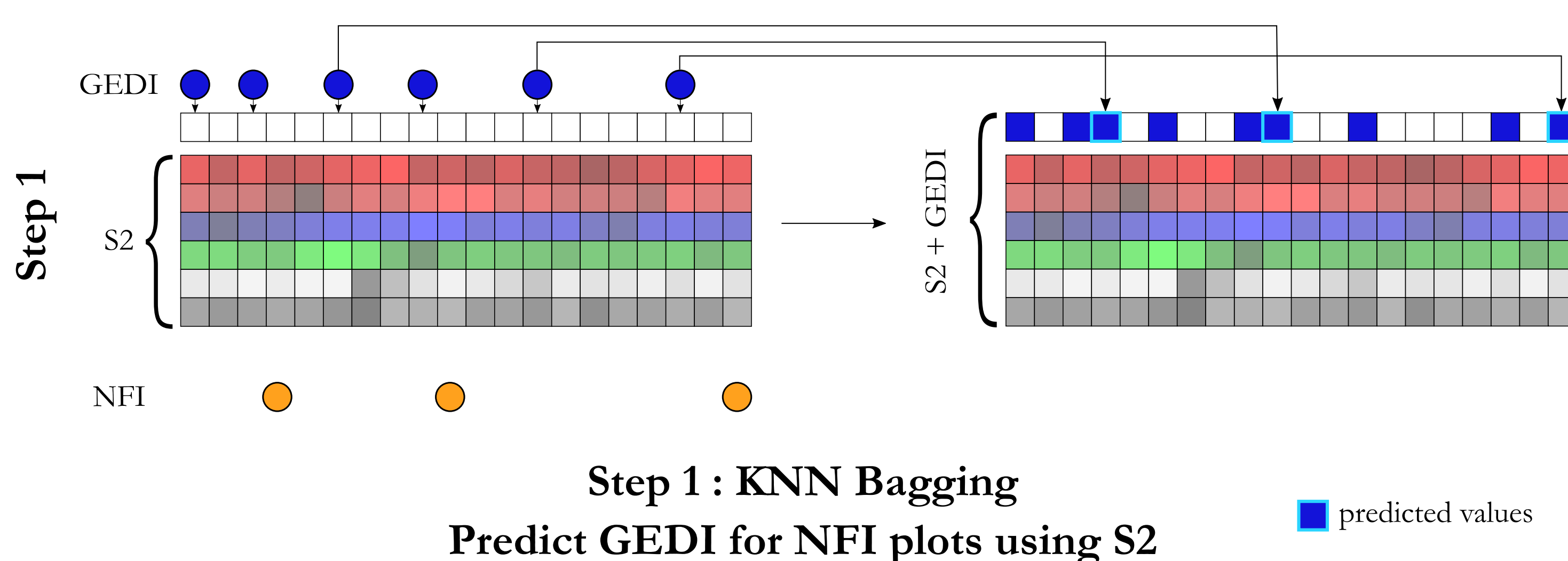
GEDI samples forest structures at a very high density at an almost global scale, and is a good candidate to improve Multisource forest inventories. However, one key issue is the difficulty to obtain spatial matching between GEDI and field reference data for both calibrating and validating models.

We propose a solution based on a k-nearest neighbour (KNN) bagging approach [1],[2], to bridge the gap between GEDI and national forest inventory (NFI) data. It relies on the use of continuous auxiliary information, here Sentinel-2 (S2).



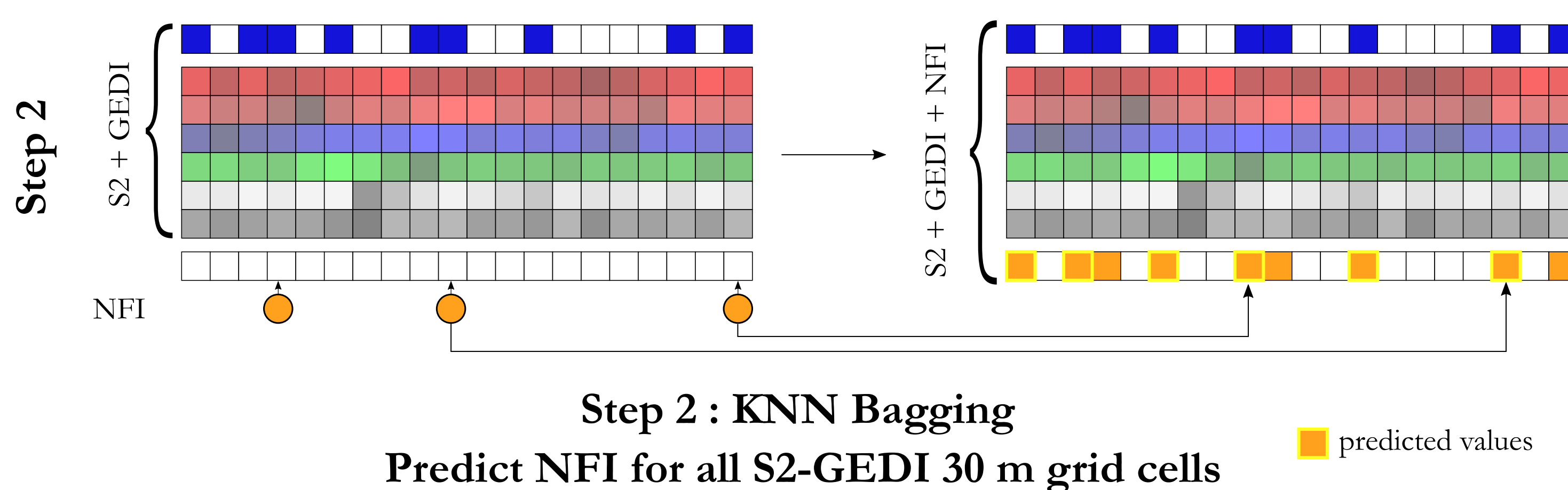
The approach was tested over the Vosges mountains in France to predict growing stock volume (GSV) at a 30 m plot level. The data vector included 10 GEDI RH values, from GEDI RH derived variables, S2 spectral band textures, S2 vegetation indices, and S2 temporal differences.

II. Method



Estimate GEDI variables based on S2 for every 30 m grid cell matching NFI plots :
Model trained on 109 500 GEDI footprints and tested on 500 test footprints

- 1) **Variable selection** : choose S2 variables correlated with GEDI variables
- 2) **Bagging** (n=1000) → 1000 predicted GEDI candidates per grid cell
- 3) **Select** best GEDI footprint candidate per cell by minimising residuals to the mean prediction
- 4) **Evaluation** : assess quality on test data set by comparing predicted and real GEDI variables

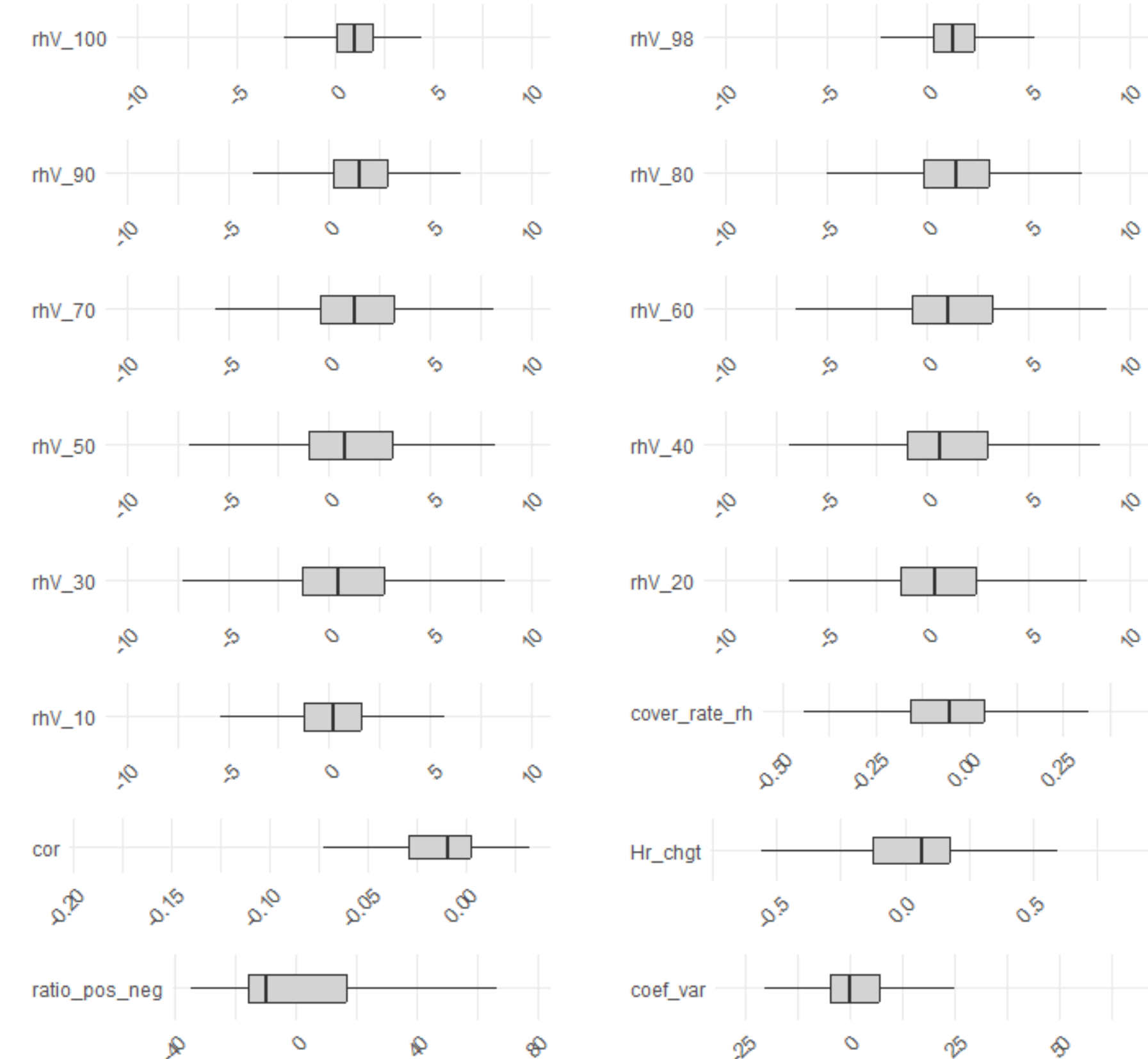


Estimate NFI GSV for any cell having S2 and GEDI variables :
Model trained on 80 % of the NFI plots and tested on remaining 20 %

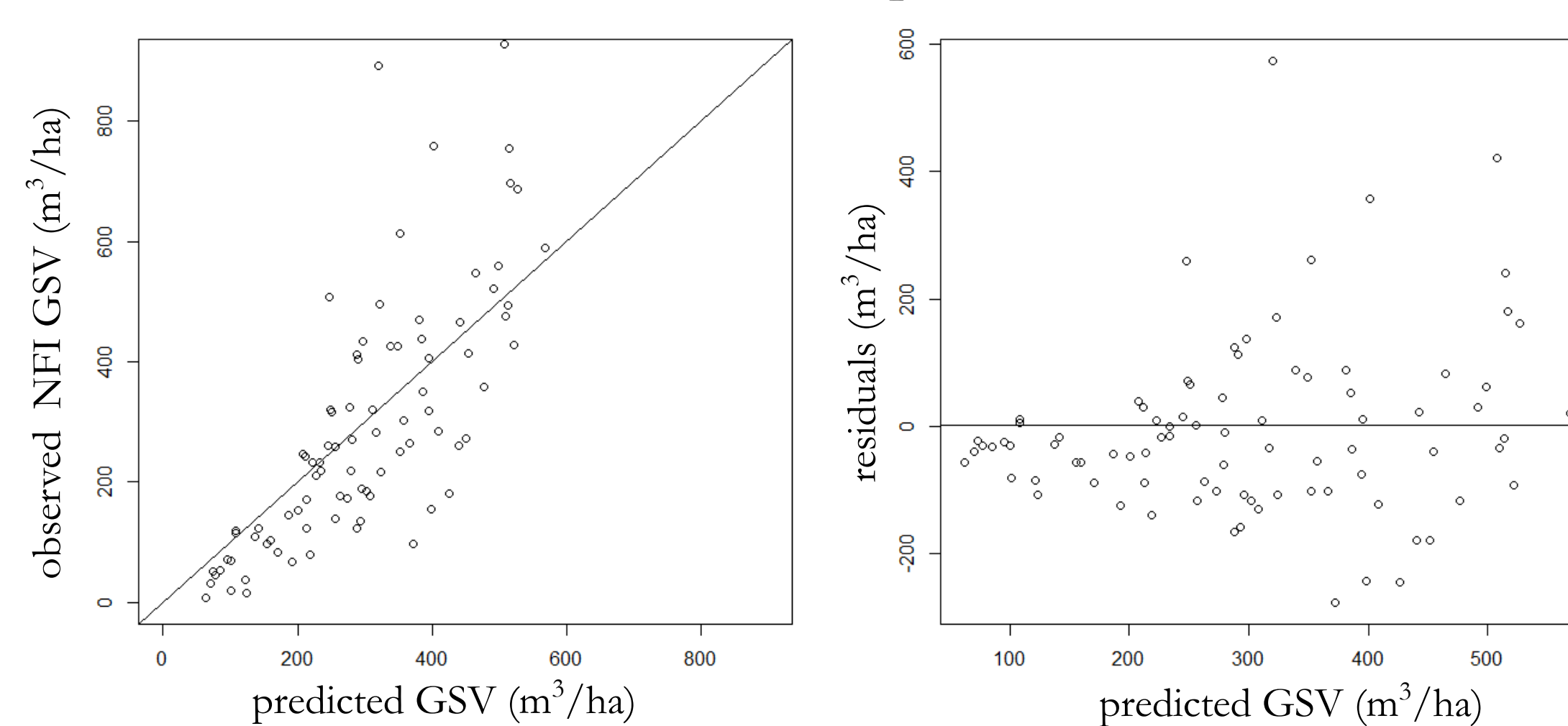
- 1) **KNN Bagging with variable selection** (n=1000) → 1000 predicted GSV_i per grid cell
- 2) **Define** per grid cell final predicted $GSV = \frac{1}{n} \sum_{i=1}^n GSV_i$
- 3) **Evaluation** : assess quality on the 20 % test data set by comparing predicted and real NFI volumes

III. Results

Residuals between real and predicted GEDI variables



Observed and predicted GSV

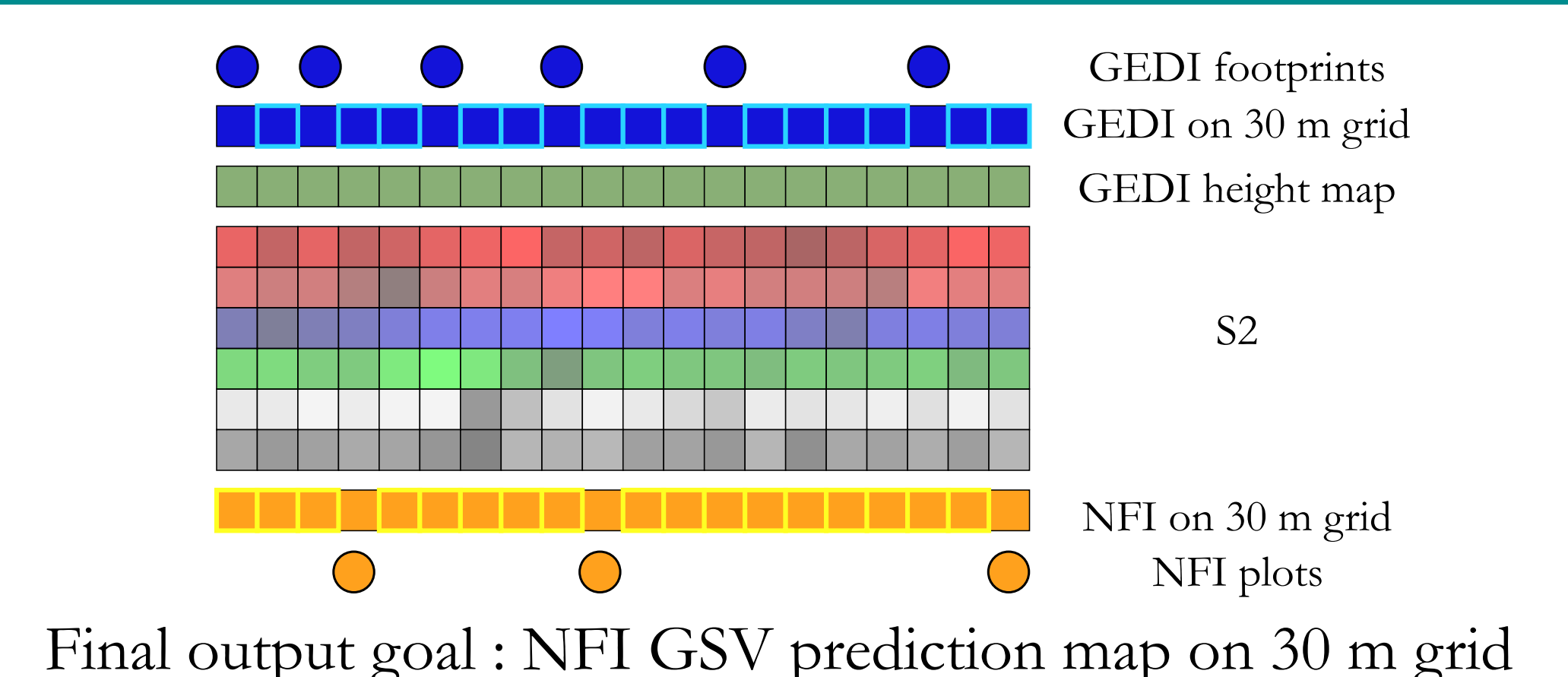


57 % of the GSV variance can be explained by our approach.

RMSE = 137 m³/ha
bias = 6.8 m³/ha

IV. Perspectives

- Improve predictions by optimizing variables (e.g. add LAI) and variable selection
- Expand to entire area using existing GEDI height maps (e.g. [3],[4],[5])



References : [1] Sagar et al. 2022 (10.1016/j.isprsjprs.2022.08.016), [2] Breiman 1996 (10.1007/BF00058655), [3] Schwartz et al. 2023 (10.5194/essd-2023-196), [4] Potapov et al. 2021 (10.1016/j.rse.2020.112165), [5] Lang et al. 2022 (10.48550/arXiv.2204.08322)

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