Correcting vertical errors in a global DEM using a Mixture-of-Experts ensemble model

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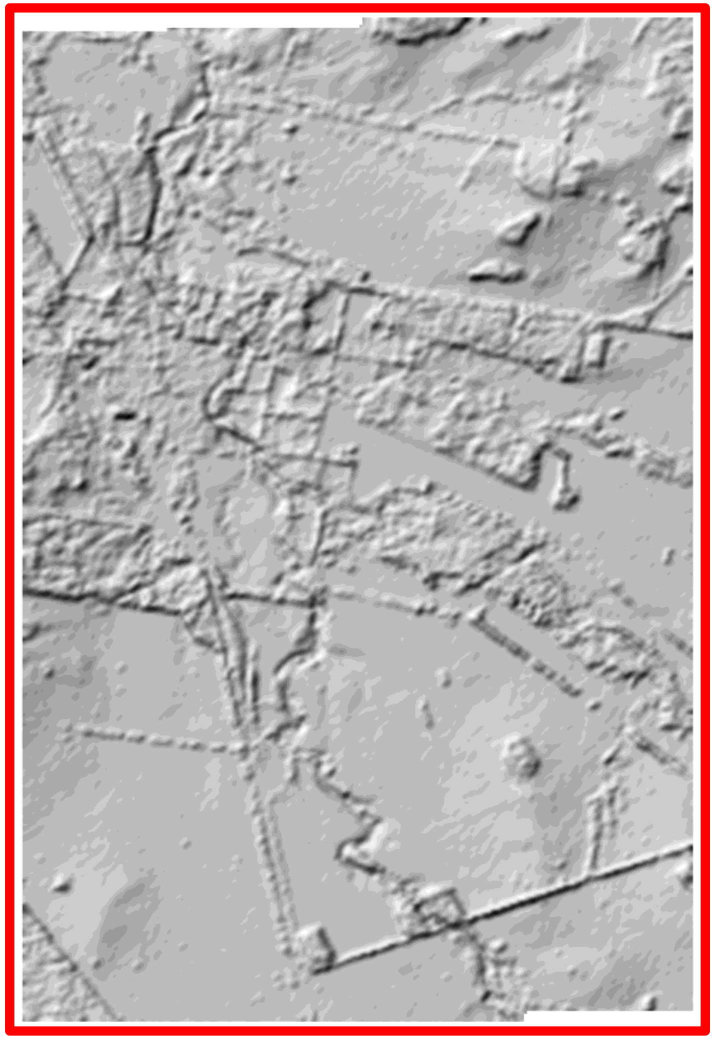
Flood models need accurate "bare earth" topography data



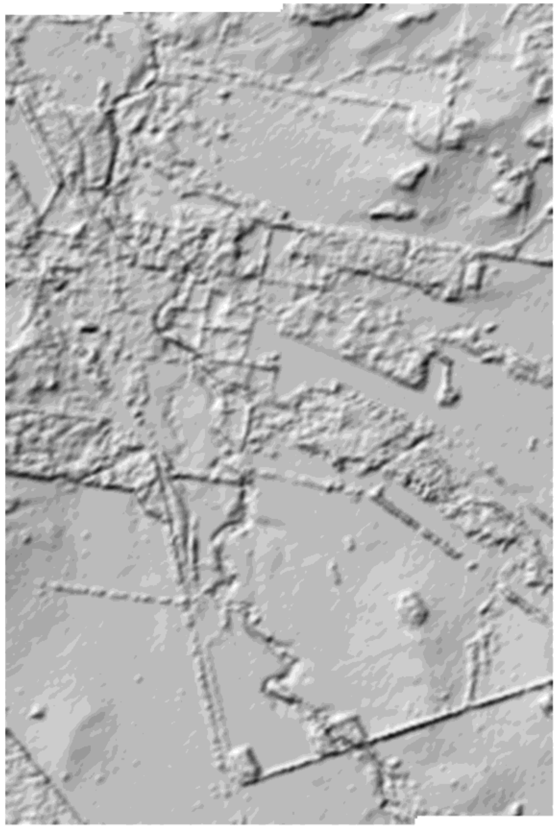
Bare earth topography
(Digital Terrain Model, **DTM**)

Copernicus DEM
(global Digital Elevation Model, **DEM**)

If we can predict the errors in a global DEM, we can remove them

Free global DEM

(e.g. Copernicus DEM)



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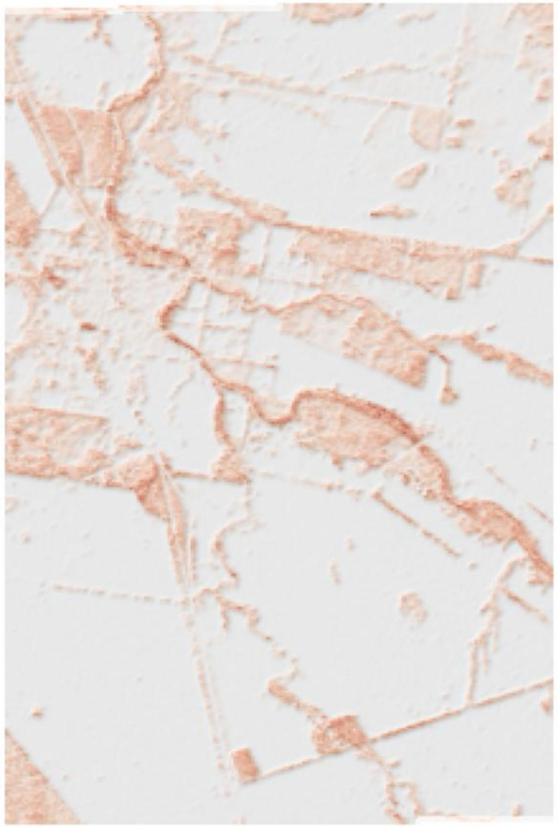
Predicted errors



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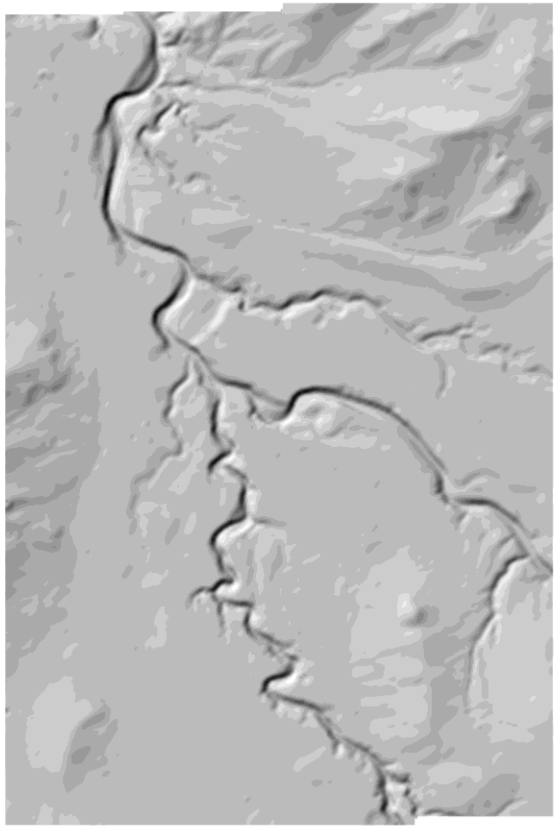
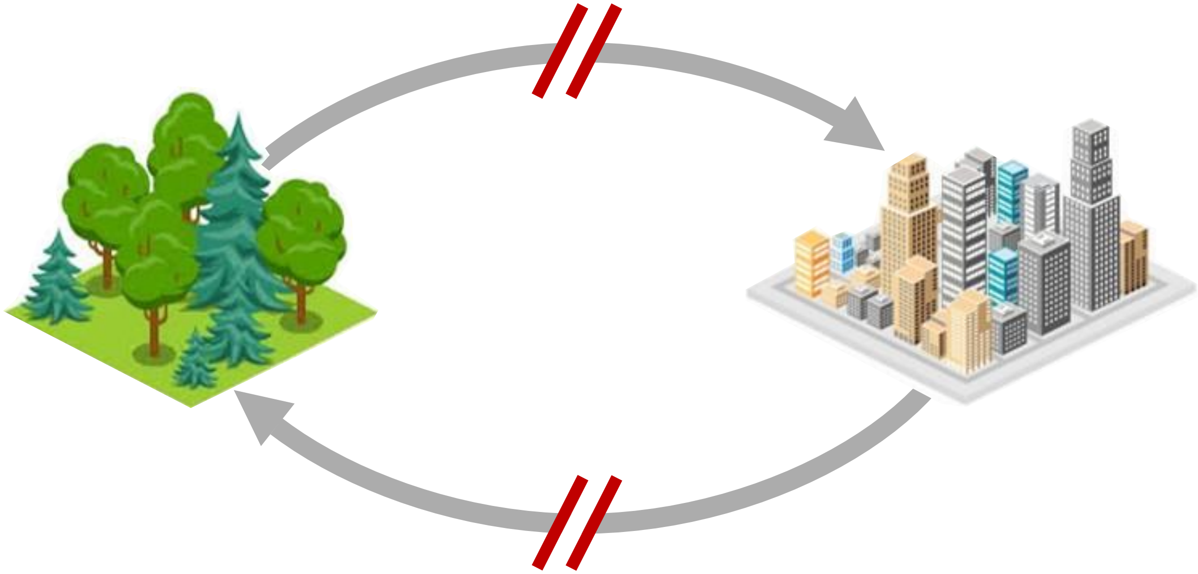
Bare earth topography

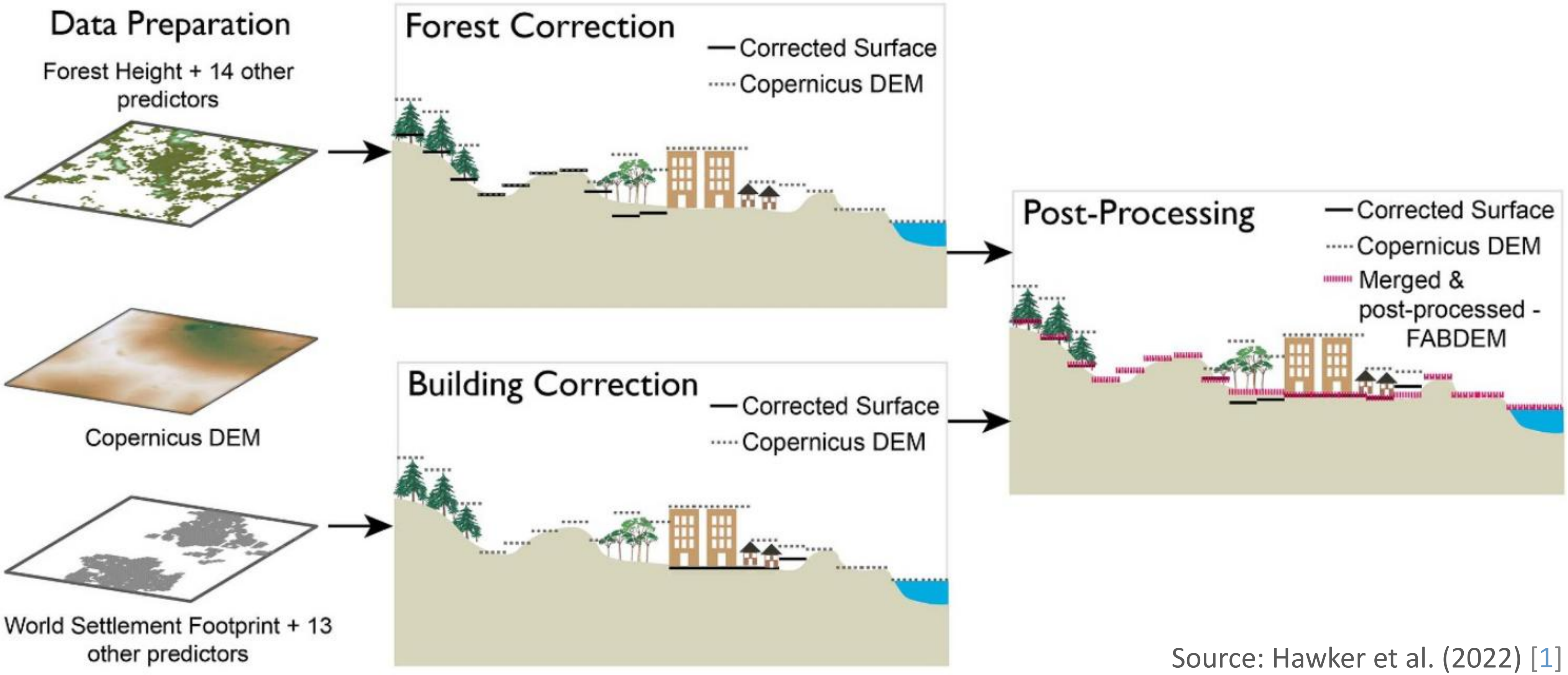


Can a single model learn to predict errors everywhere?

- Or should we use separate models for different environments?



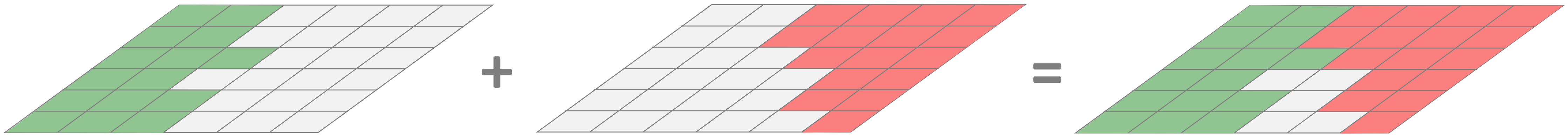
FABDEM [1] used two models: Forest & Buildings

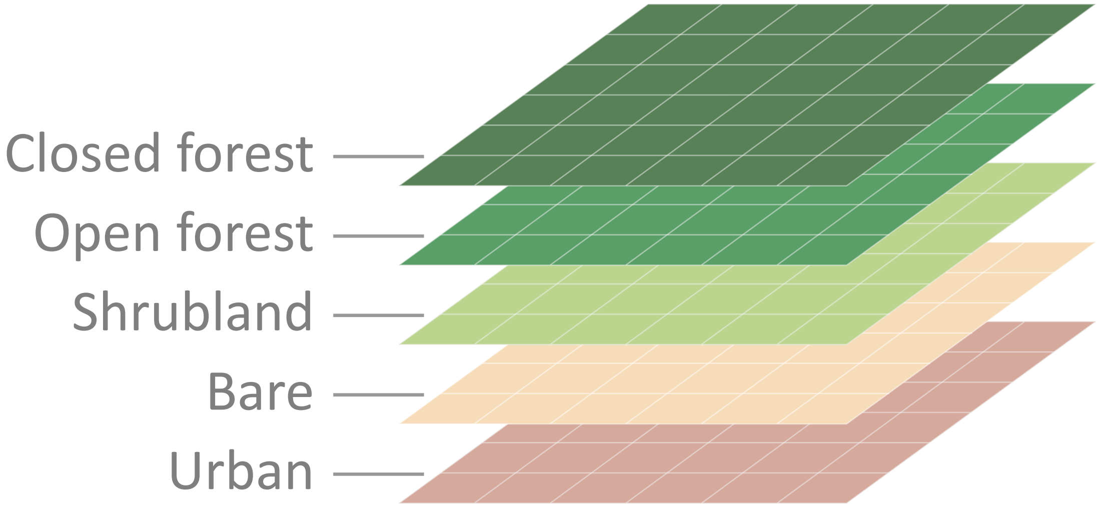


Source: Hawker et al. (2022) [1]

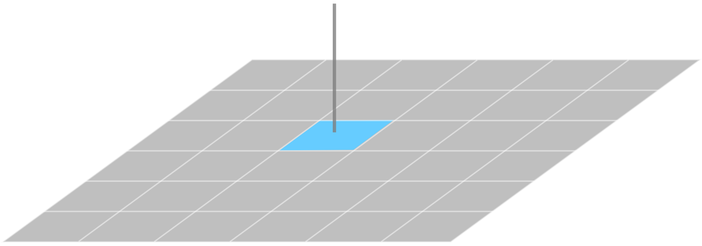
Moving beyond discrete modelling domains

e.g. forest model combined with buildings model and merged [1]



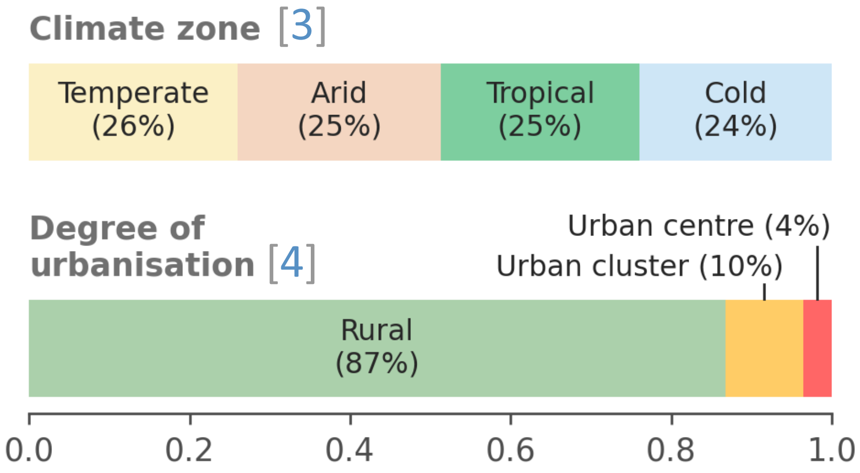


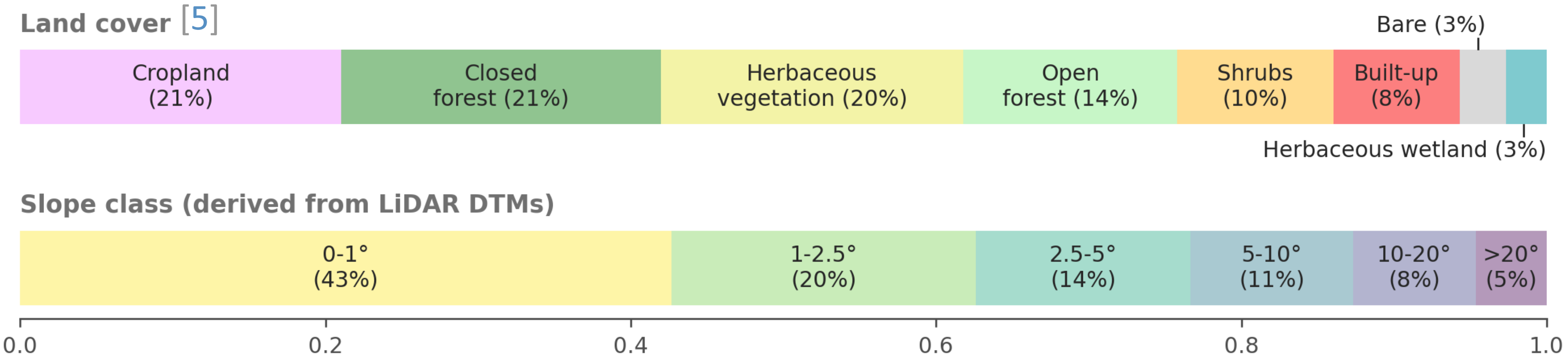
Each prediction is a weighted average of specialist model predictions [2]



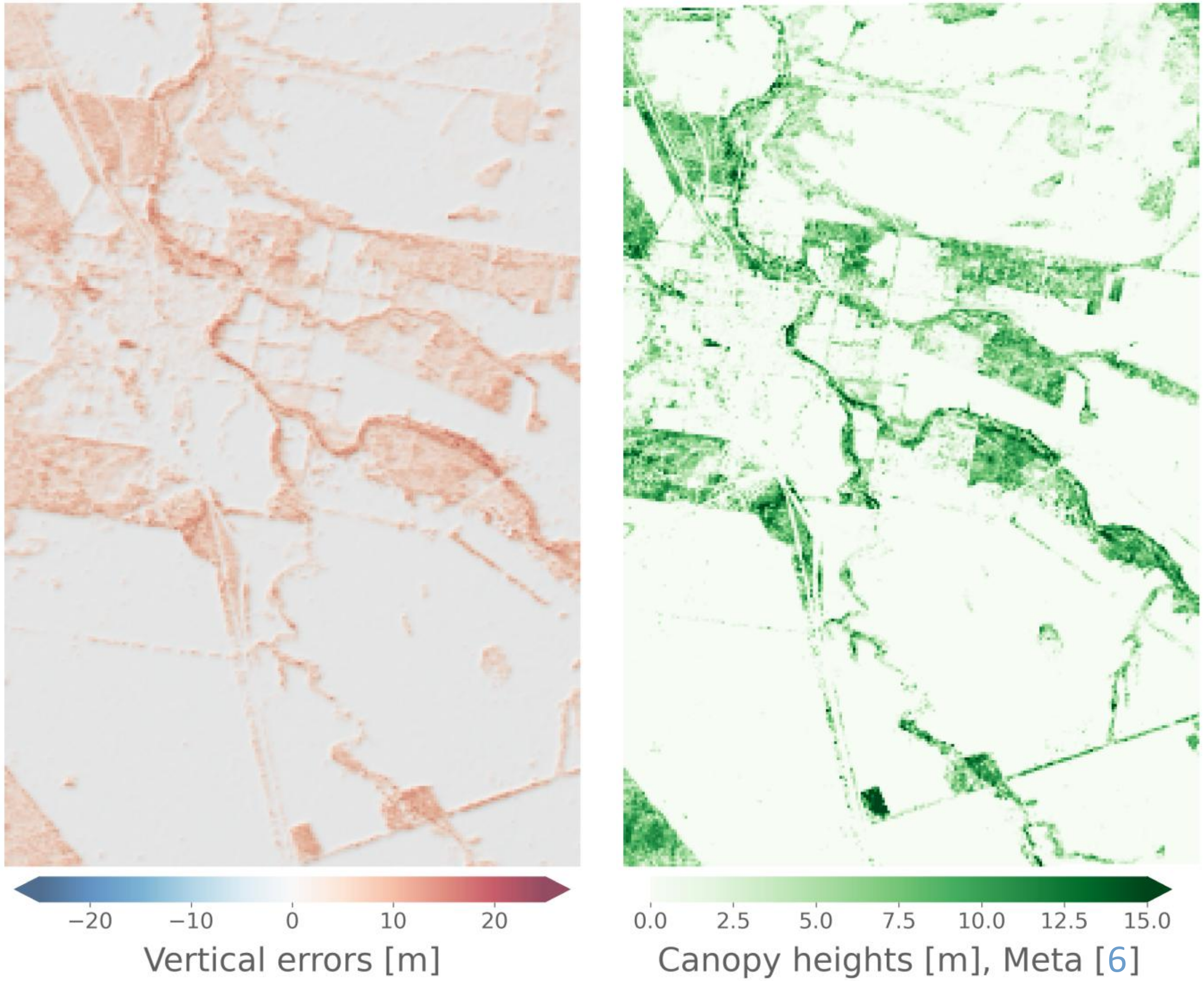
Weights vary based on context (input data)

Large & diverse reference database – 72 airborne LiDAR DTMs





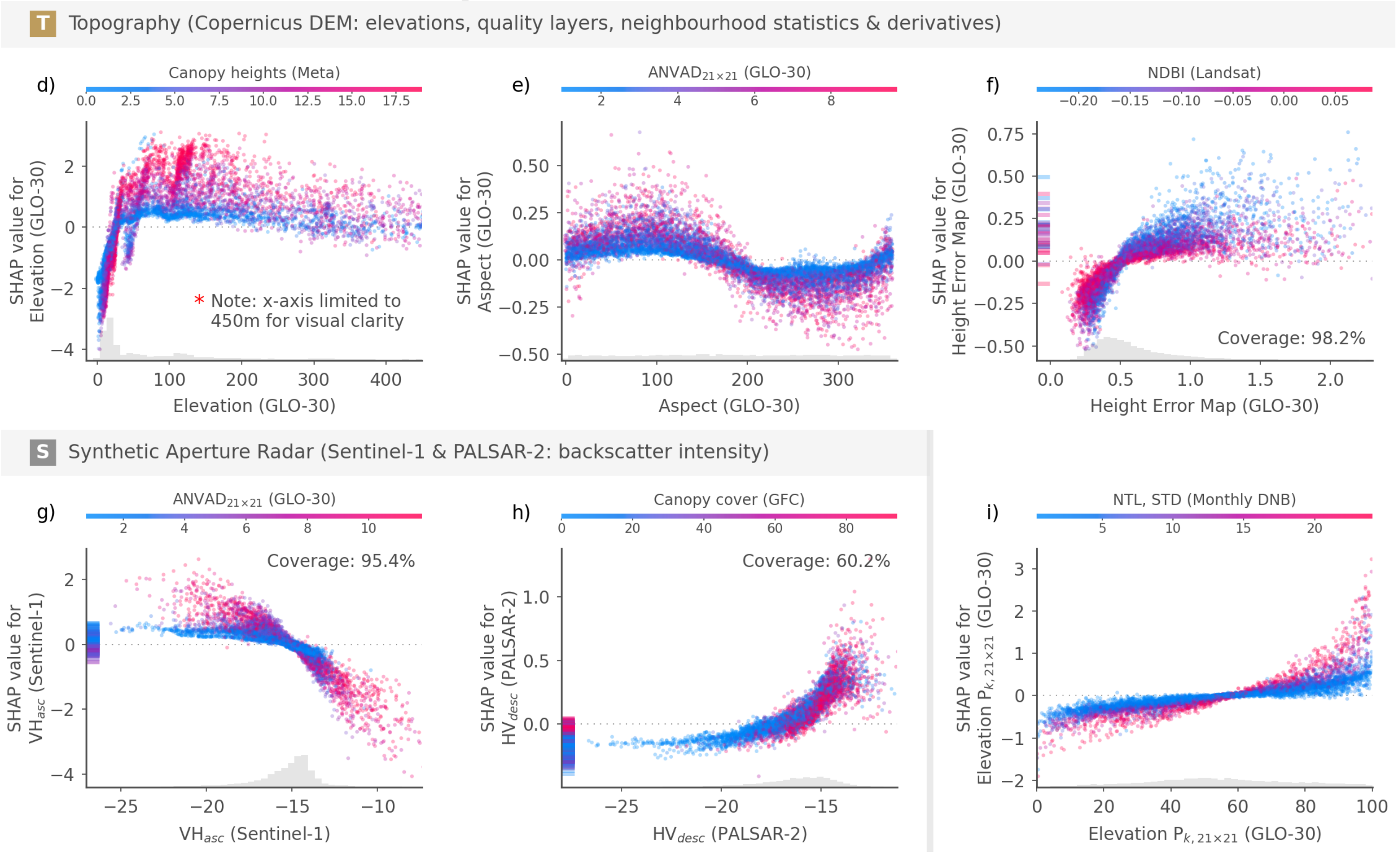
Select input variables relevant to Copernicus DEM errors



- Topography
- Multispectral (Landsat)
- Synthetic Aperture Radar
- Vegetation
- Urbanisation

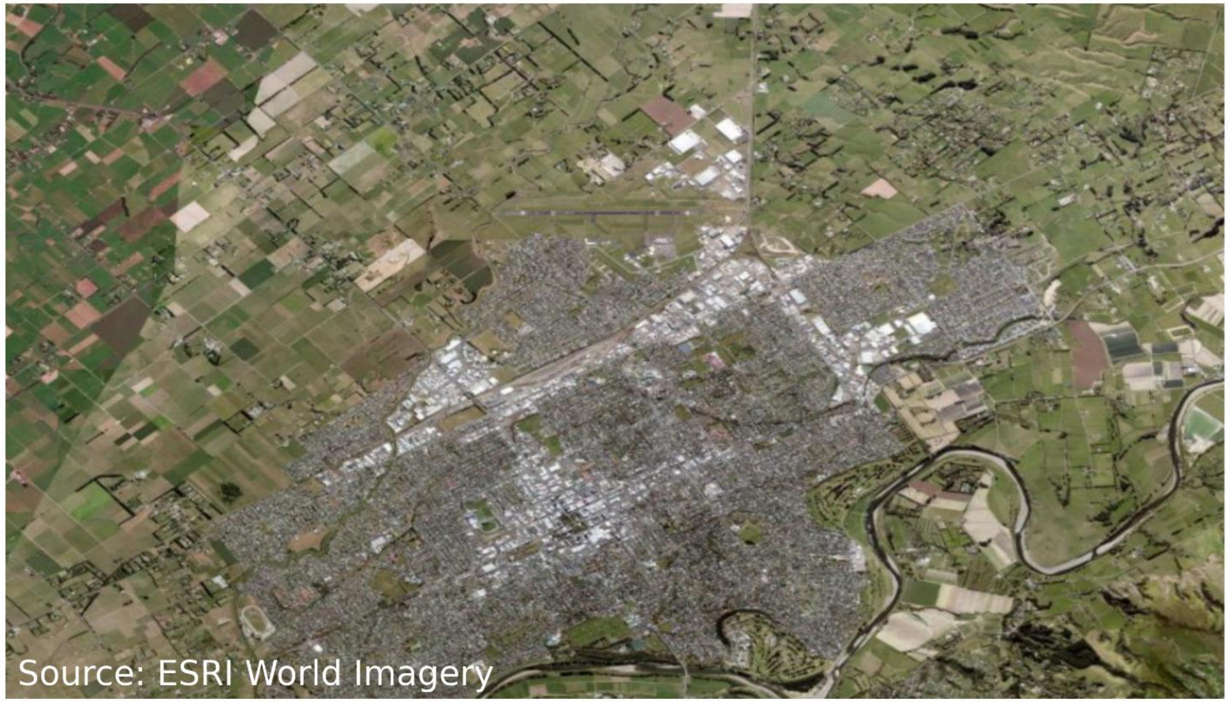
Verify using state-of-the-art explainability methods [7]

Closed Forest [baseline: 7.21m] **Open Forest** [baseline: 2.76m] **Buildings** [baseline: 1.49m]

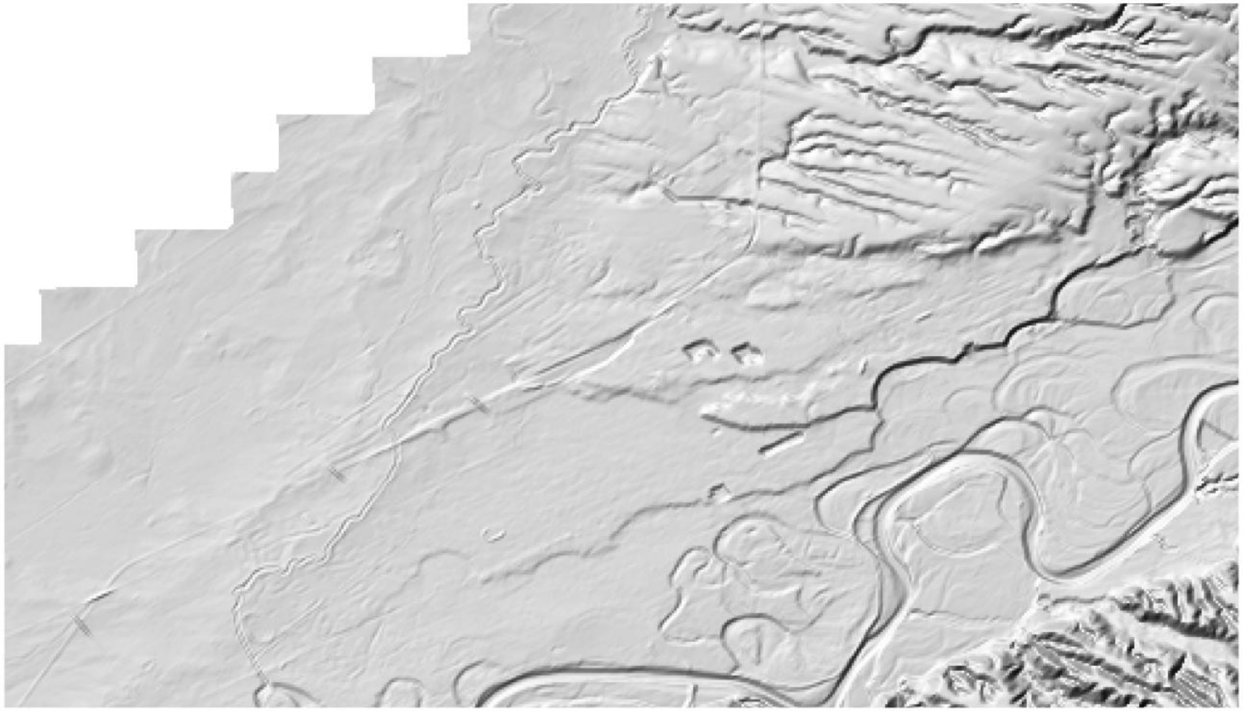


Preliminary results: discrete ensemble (no meta-model yet)

Palmerston North (New Zealand)



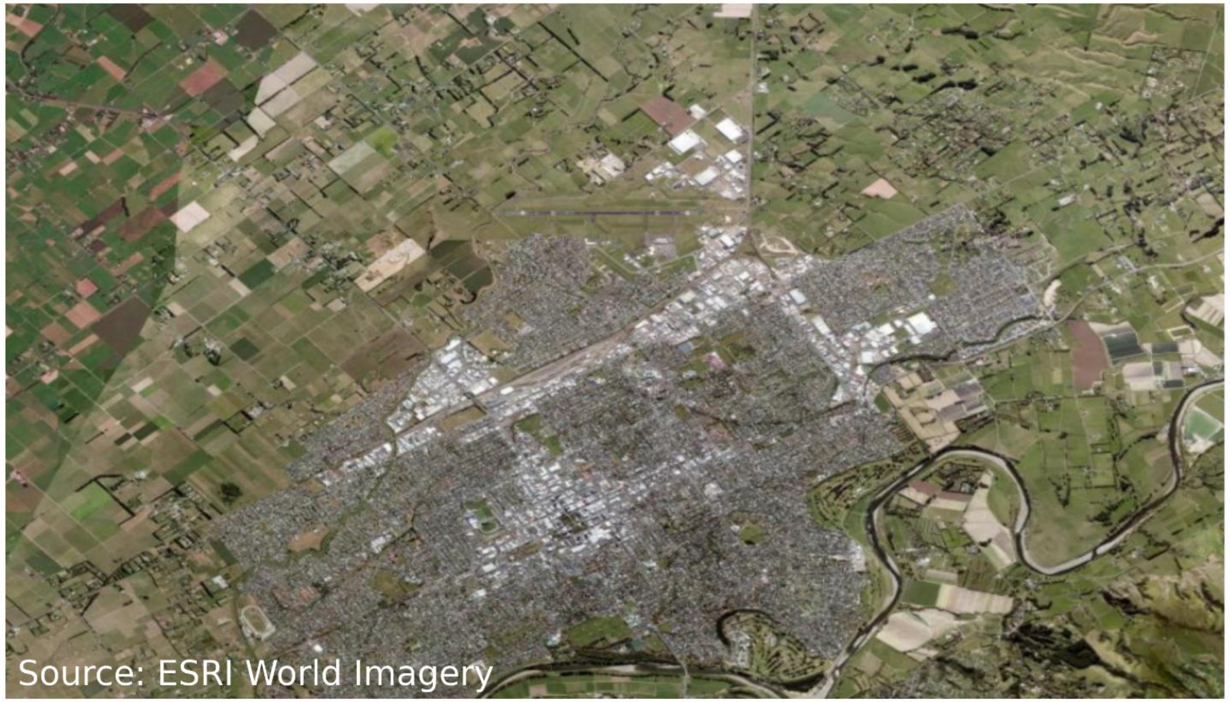
LiDAR **DTM**



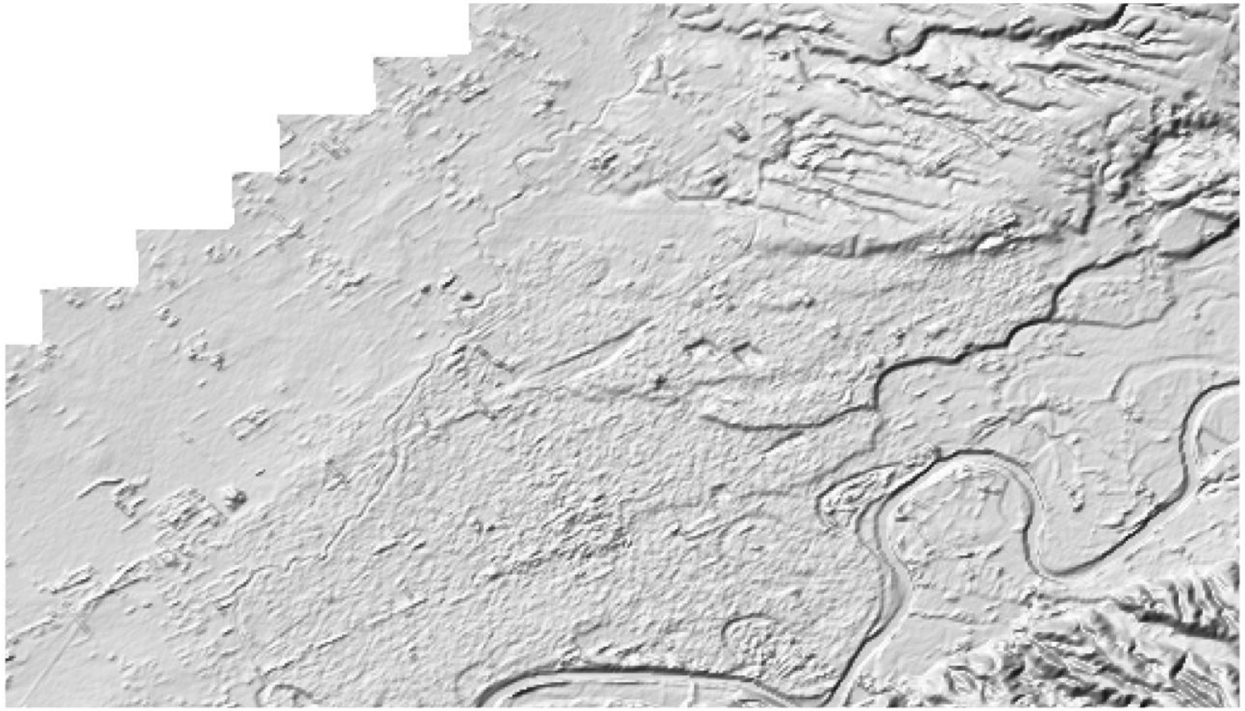
Source: Toitū Te Whenua | LINZ (2020) [8]

Preliminary results: discrete ensemble (no meta-model yet)

Palmerston North (New Zealand)



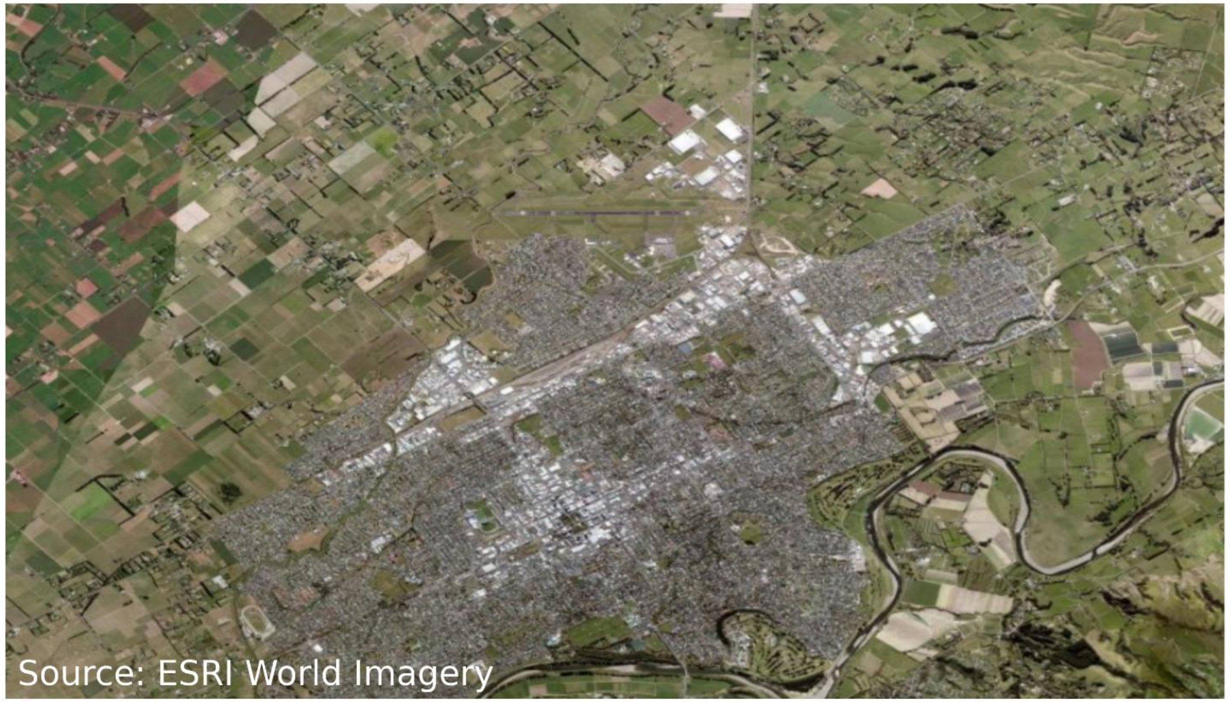
Copernicus **DEM**



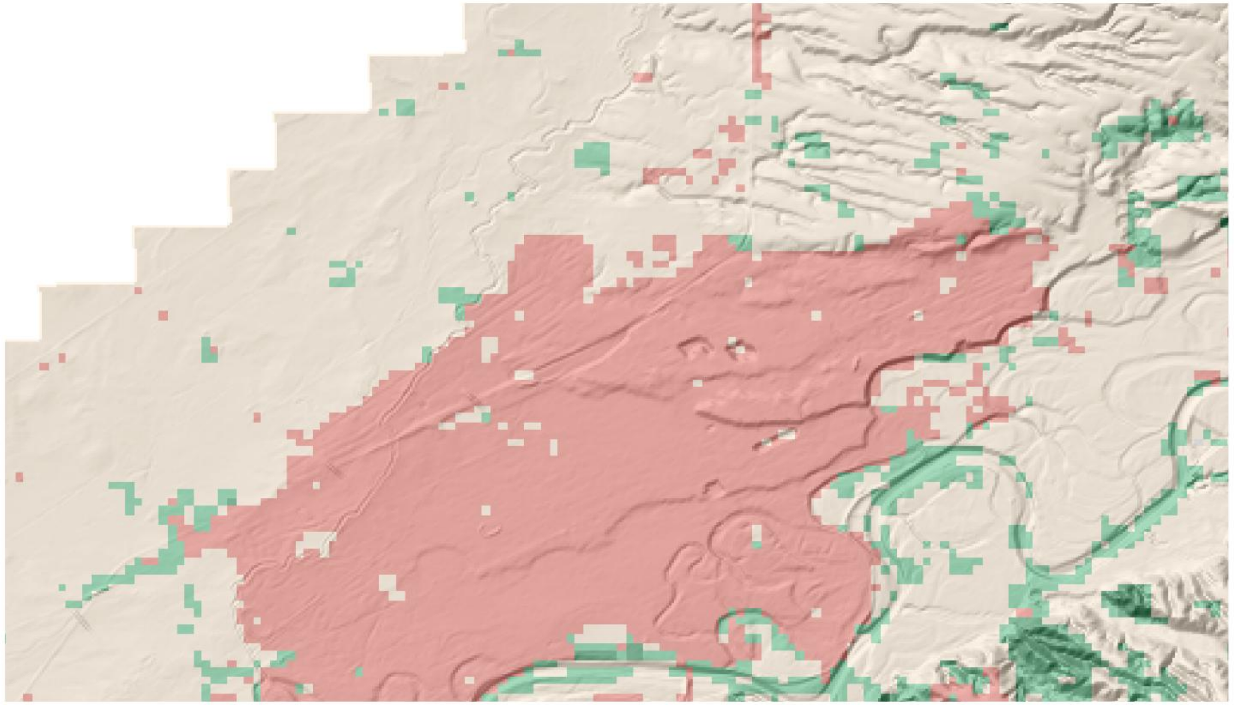
Preliminary results: discrete ensemble (no meta-model yet)

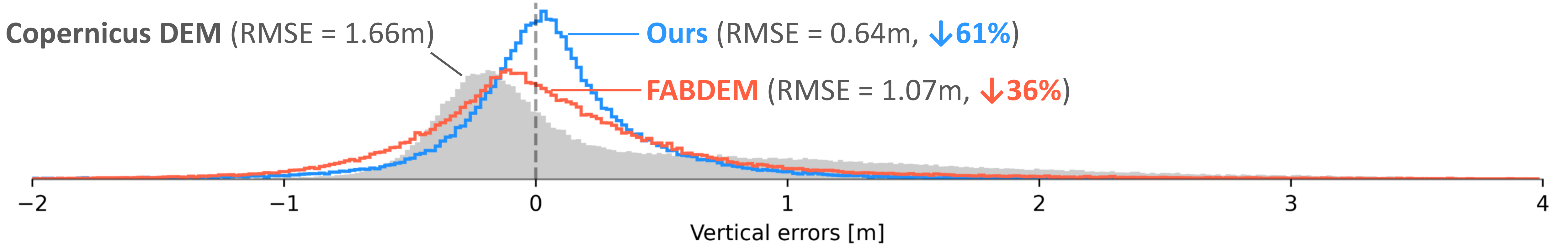
Domains: Closed Forest Open Forest Short Vegetation Buildings Bare

Palmerston North (New Zealand)

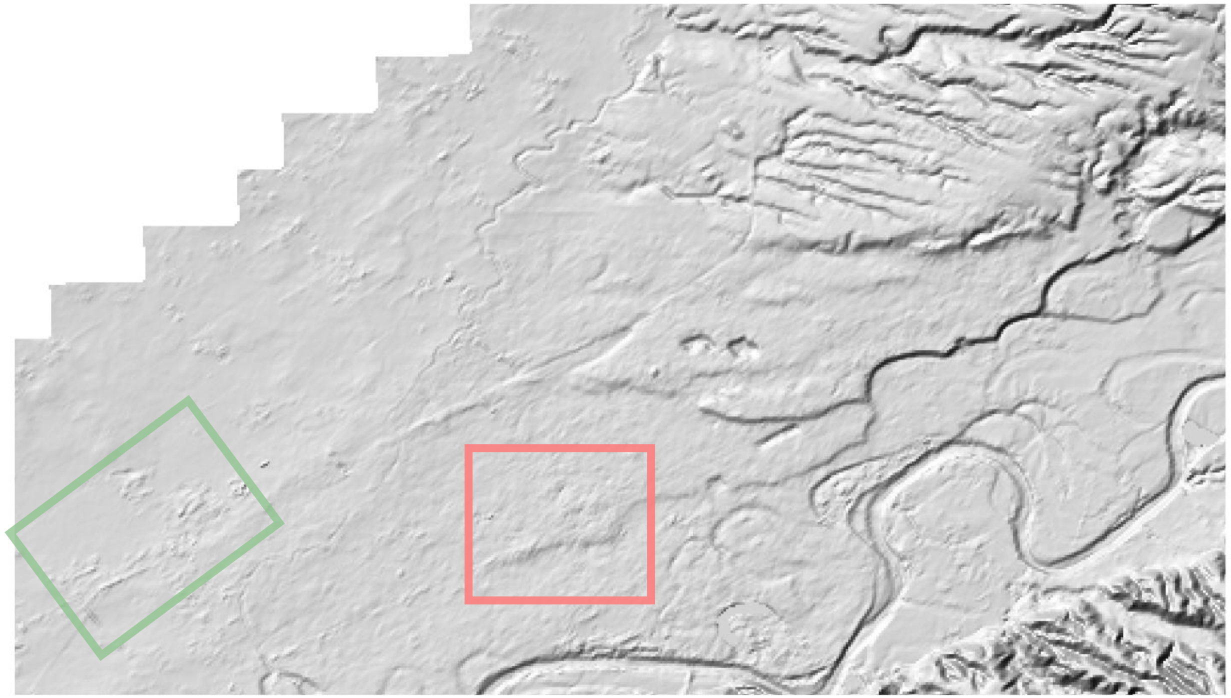


Modelling domains

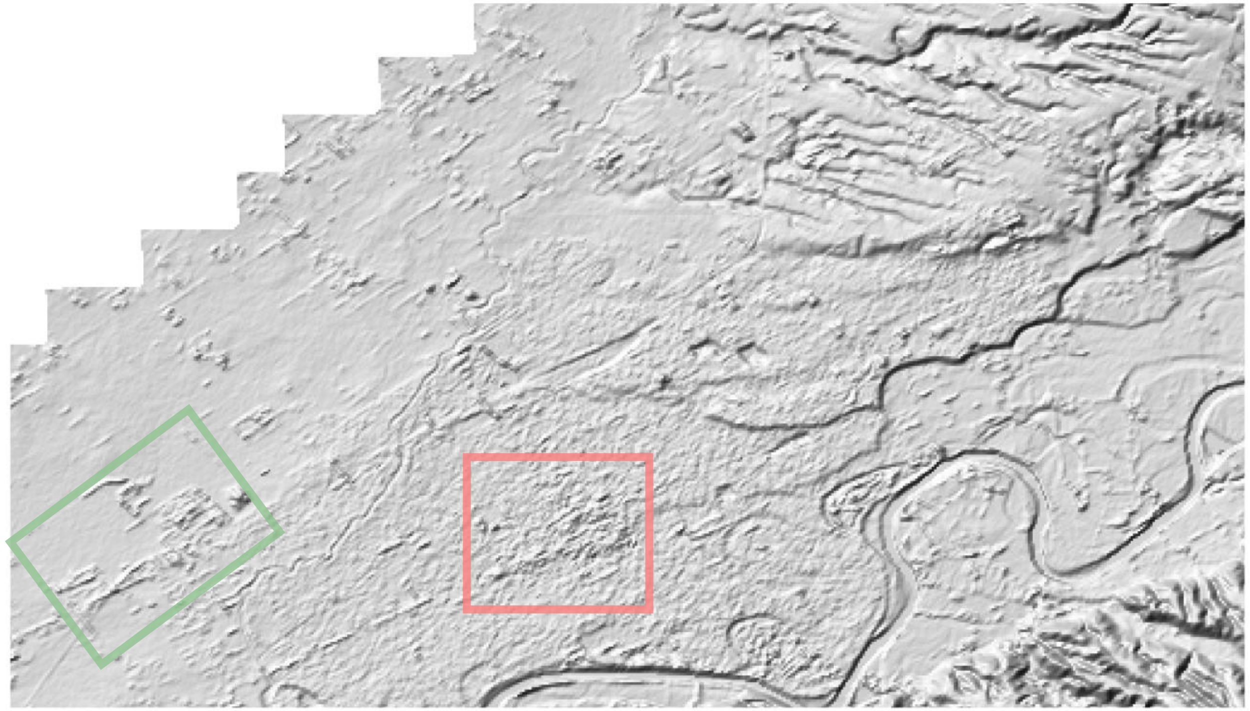




Copernicus DEM corrected by ensemble



Original Copernicus DEM



References

[1] Hawker, L., Uhe, P., Paulo, L., Sosa, J., Savage, J., Sampson, C., Neal, J., 2022. A 30 m global map of elevation with forests and buildings removed. Environ. Res. Lett. 17 (2), 024016. http://dx.doi.org/10.1088/1748-9326/ac4d4f.

[2] Jacobs, R.A., Jordan, M.I., Nowlan, S.J. and Hinton, G.E., 1991. Adaptive mixtures of local experts. Neural computation, 3(1), pp.79-87.

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[7] Lundberg, S.M., Erion, G., Chen, H., DeGrave, A., Prutkin, J.M., Nair, B., Katz, R., Himmelfarb, J., Bansal, N., Lee, S.-I., 2020. From local explanations to global understanding with explainable AI for trees. Nat. Mach. Intell. 2 (1), 56–67. http://dx.doi.org/10.1038/s42256-019-0138-9.

[8] Toitū Te Whenua | Land Information New Zealand (LINZ). 2020. Manawatū-Whanganui - Palmerston North LiDAR 1m DEM (2018). Available online: https://data.linz.govt.nz/layer/104502-manawatu-whanganui-palmerston-north-lidar-1m-dem-2018/

Questions & suggestions welcome!

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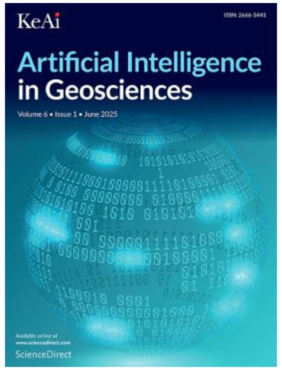
Meadows, M., Jones, S., & Reinke, K. (2024). **Vertical accuracy assessment of freely available global DEMs (FABDEM, Copernicus DEM, NASADEM, AW3D30 and SRTM) in flood-prone environments**. International Journal of Digital Earth, 17(1), 2308734.



Meadows, M., Reinke, K., & Jones, S. (2025). **Explaining machine learning models trained to predict Copernicus DEM errors in different land cover environments**. Artificial Intelligence in Geosciences, 100141.