

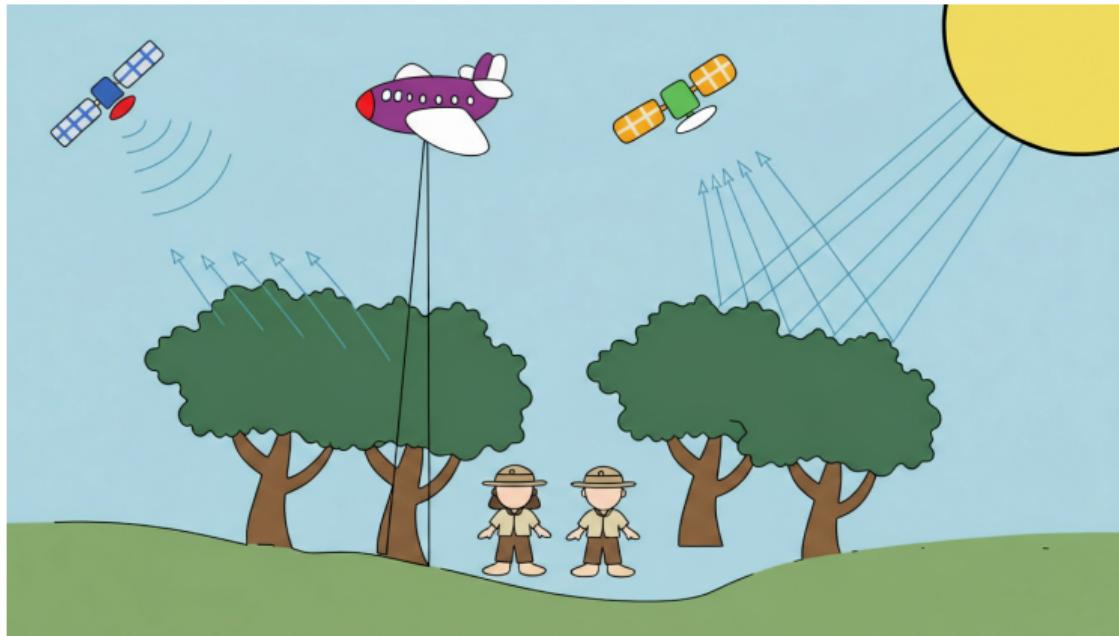
Télédétection et IFN : vers un meilleur suivi de la biomasse aérienne forestière

Nikola Besic (LIF - IGN, [✉ nikola.besic@ign.fr](mailto:nikola.besic@ign.fr) [🌐 nbasic.github.io](https://nbasic.github.io) [🐦 @nikobesic.bsky.social](https://twitter.com/nikobesic.bsky.social)),

Martin Schwartz, Selim Behloul, Yang Su, Cédric Vega, Henri Cuny, Amaël Le Squin, et Philippe Ciais

Journées annuelles
du PEPR FairCarbon,
Le Croisic, le 5 Novembre 2025

“POUR UNE SCIENCE BELLE,
UTILE ET PARTAGÉE.”

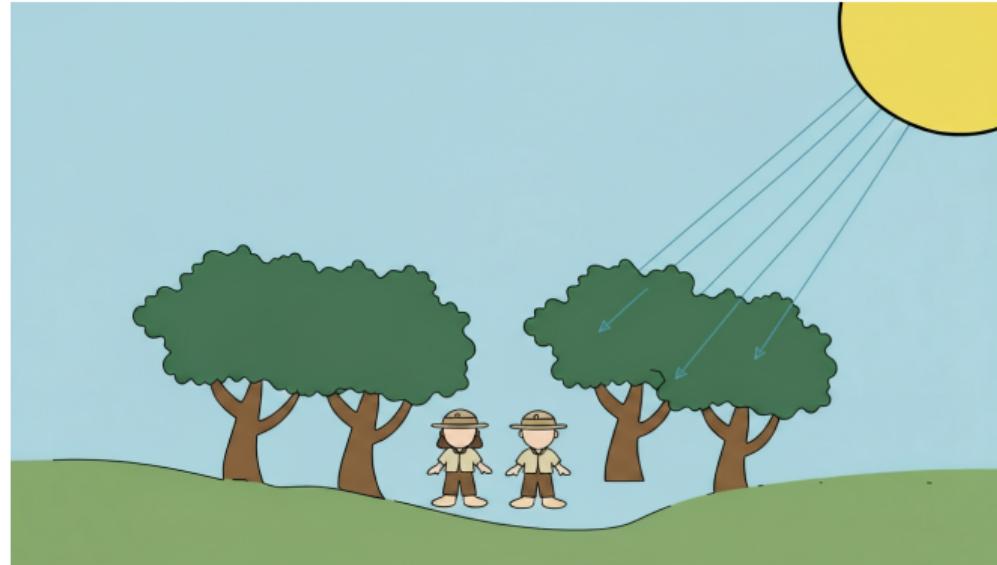


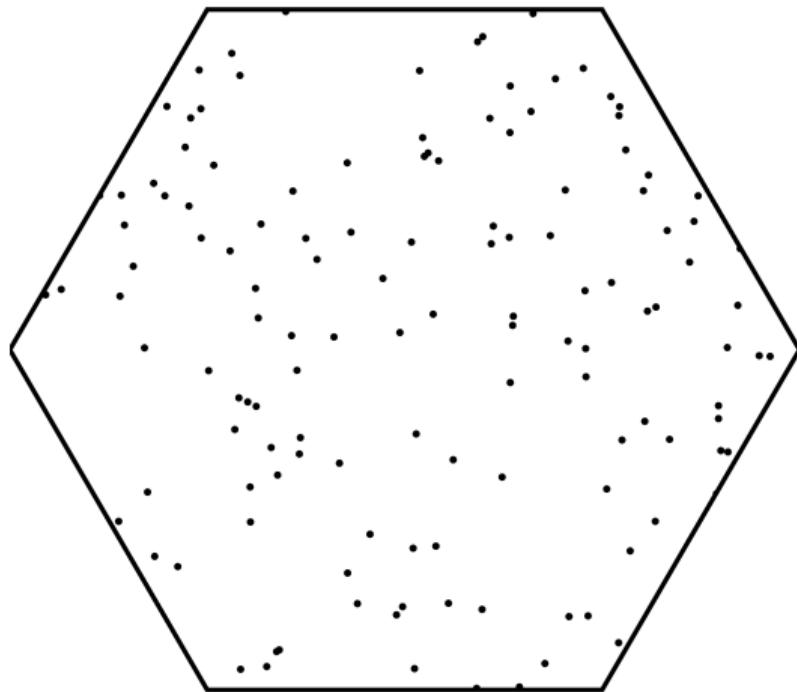
IFN

Télédétection

Télédétection + IFN

...



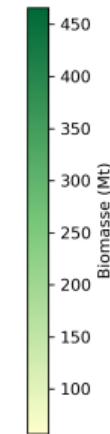
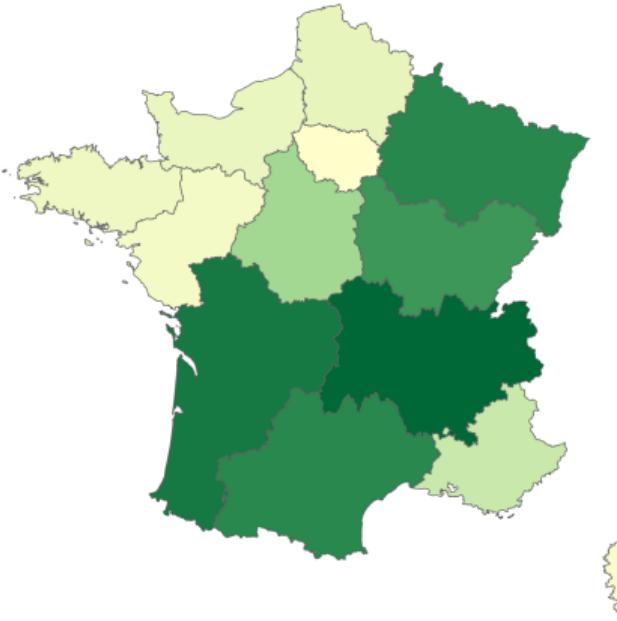


Estimations de l'Inventaire Forestier National (IFN) :

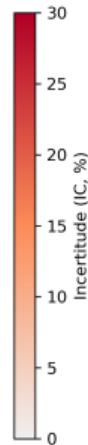
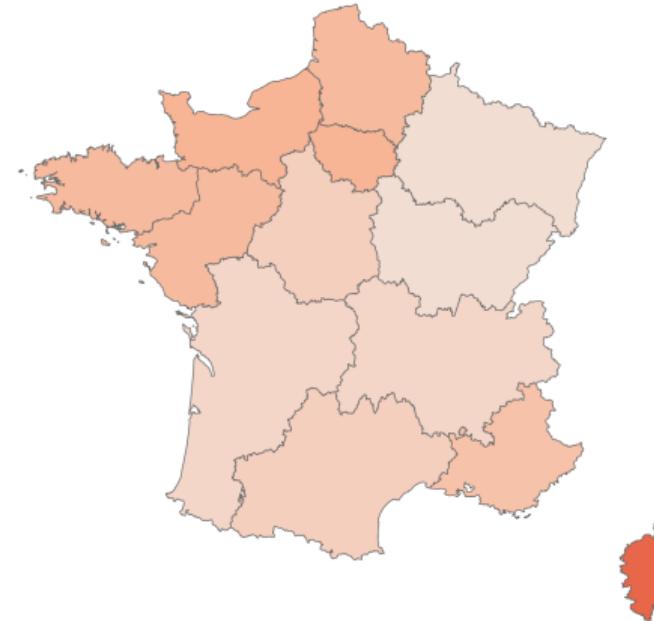
- Échantillon spatial aléatoire, conditionné par la photo-interprétation
 - Mesures locales des hauteurs, diamètres, etc., permettant d'estimer localement le stock de volume de bois, de biomasse aérienne, etc.
- Projet financé par Alamod (voir le poster d'Amaël Le Squin : "J'aime les arbres, du tronc à l'équation")**
- Inférence de ces variables pour des territoires allant de **l'échelle nationale aux régions administratives, départements, etc.**
 - Pas de biais, mais **une variance de l'échantillonnage (incertitude) potentiellement importante**

Inférence des stocks par région (2020 - 2024) :

Biomasse (aérienne + racinaire)

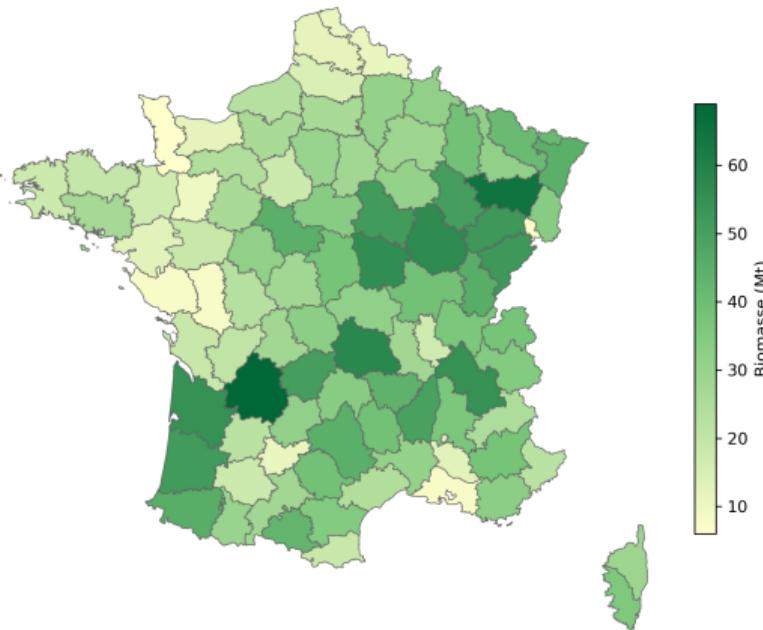


Incertitude

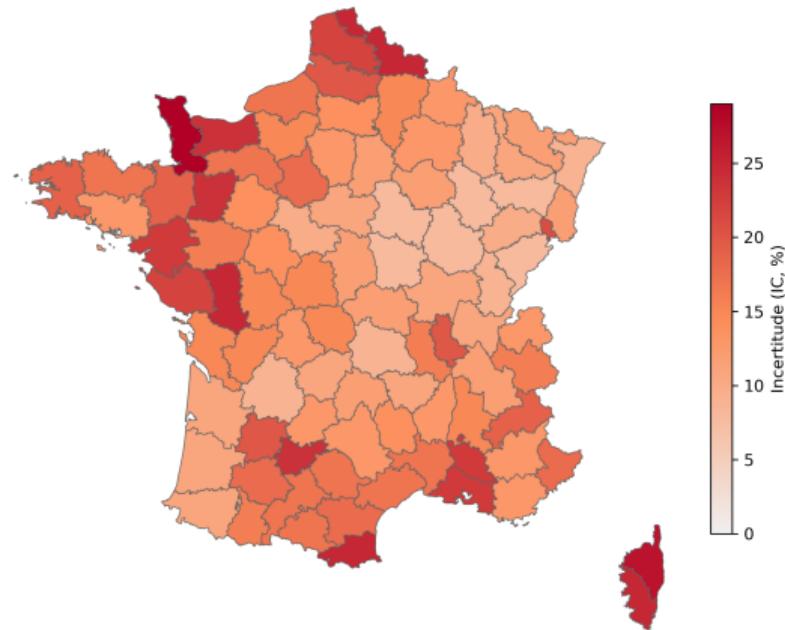


Inférence des stocks par département (2020 - 2024) :

Biomasse (aérienne + racinaire)

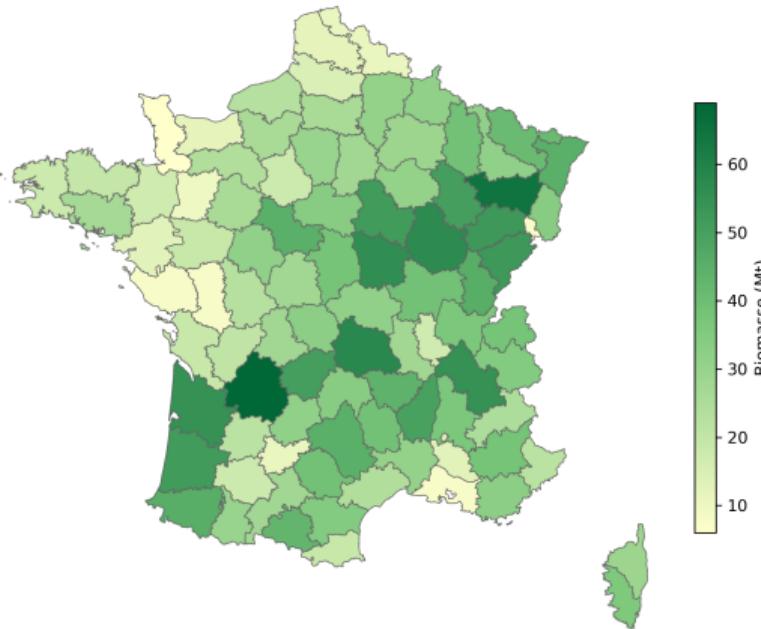


Incertitude

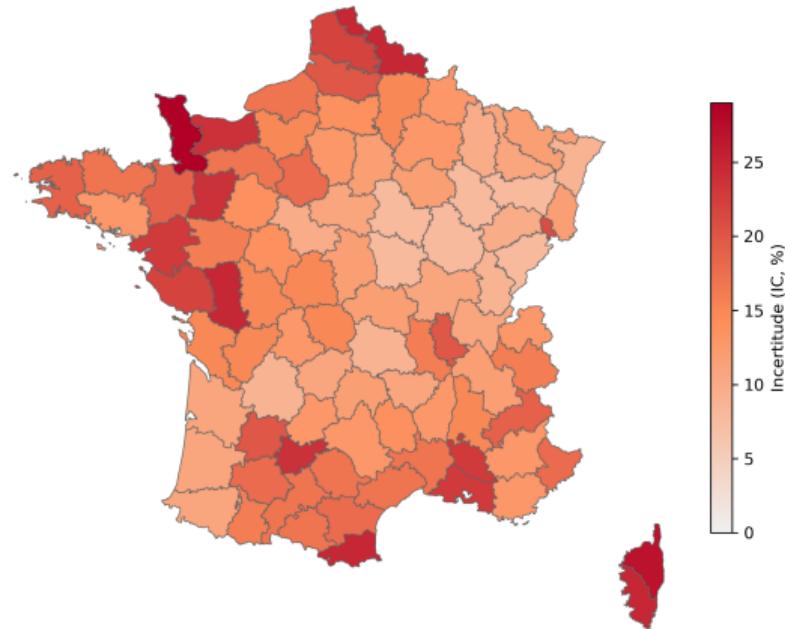


Inférence des stocks par département (2020 - 2024) :

Biomasse (aérienne + racinaire)



Incertitude



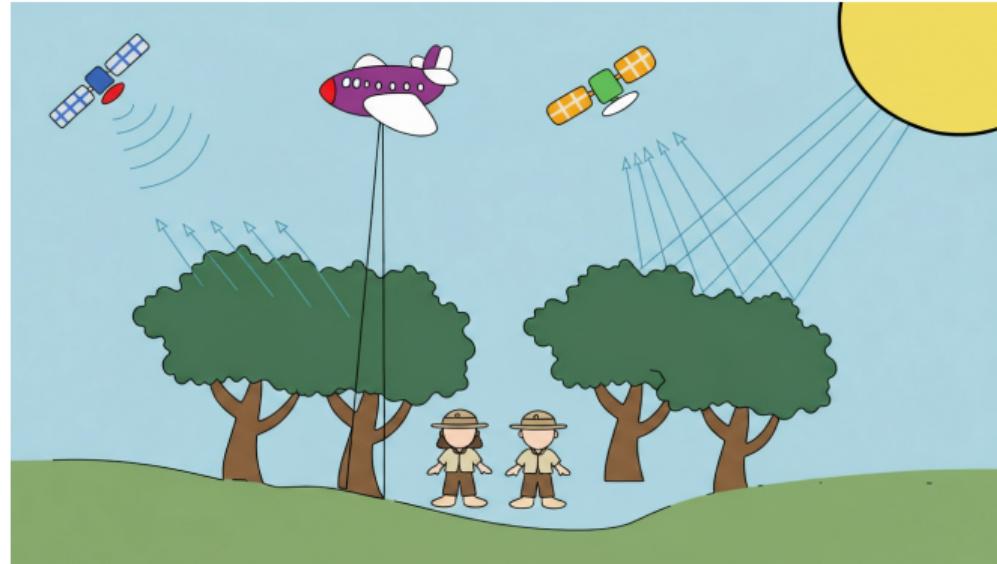
Et si on veut un rapportage annuel - à cause des perturbations etc. - ET voir ce qui se passe à l'échelle des massifs forestiers, des communautés de communes, etc. ?

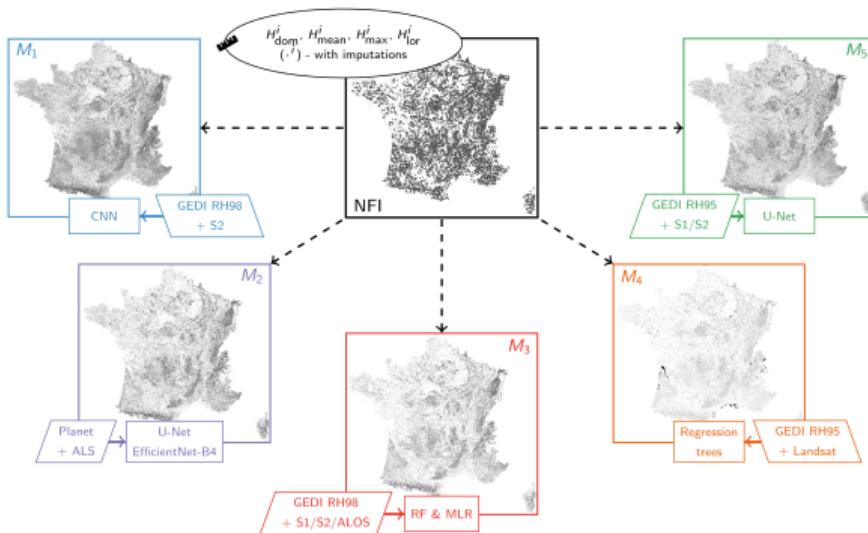
IFN

Télédétection

Télédétection + IFN

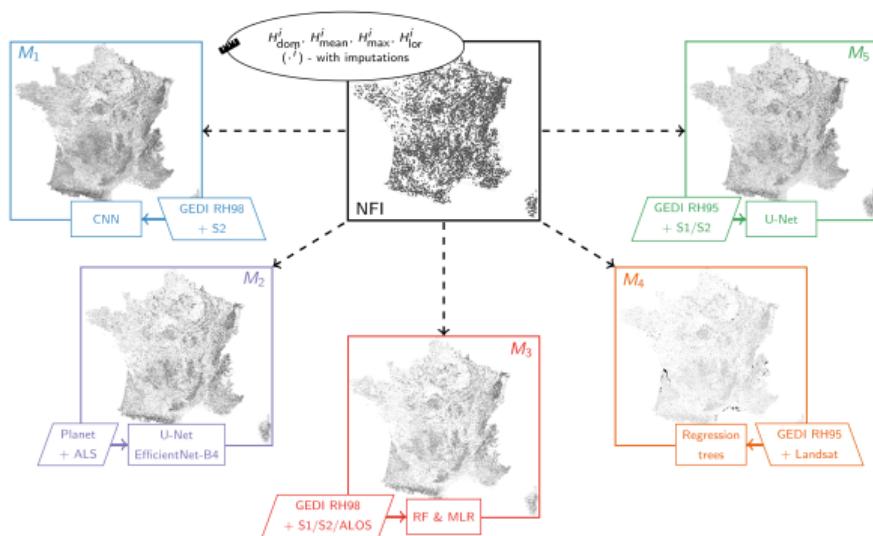
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Le plus évident à faire :
spatialiser la hauteur de la canopée

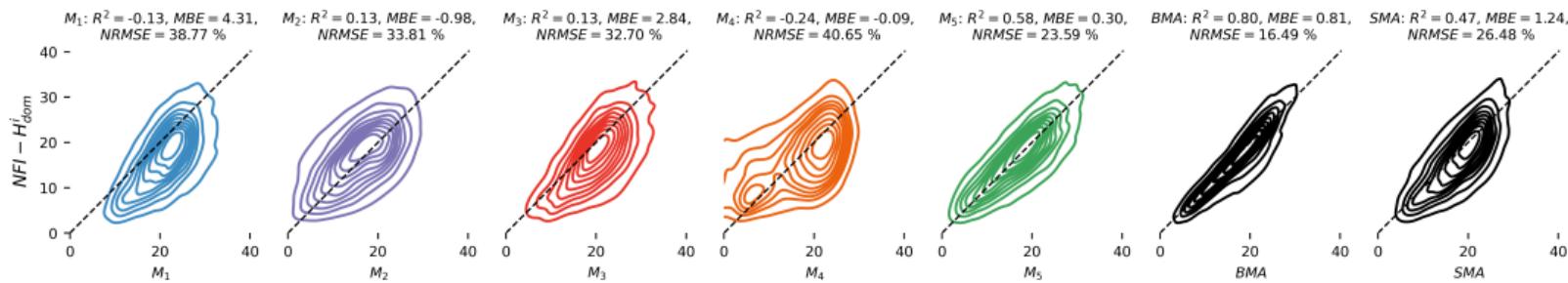
(N. Besic, N. Picard, C. Vega, J.-D. Bontemps, L. Hertzog, J.-P. Renaud, F. Fogel, M. Schwartz, A. Pellissier-Tanon, G. Destouet, F. Mortier, M. Planells-Rodriguez, and P. Ciais , "Remote sensing-based forest canopy height mapping: some models are useful, but might they provide us with even more insights when combined?," *Geoscientific Model Development*, 18, 337–359, 2025. DOI: 10.5194/gmd-18-337-2025)

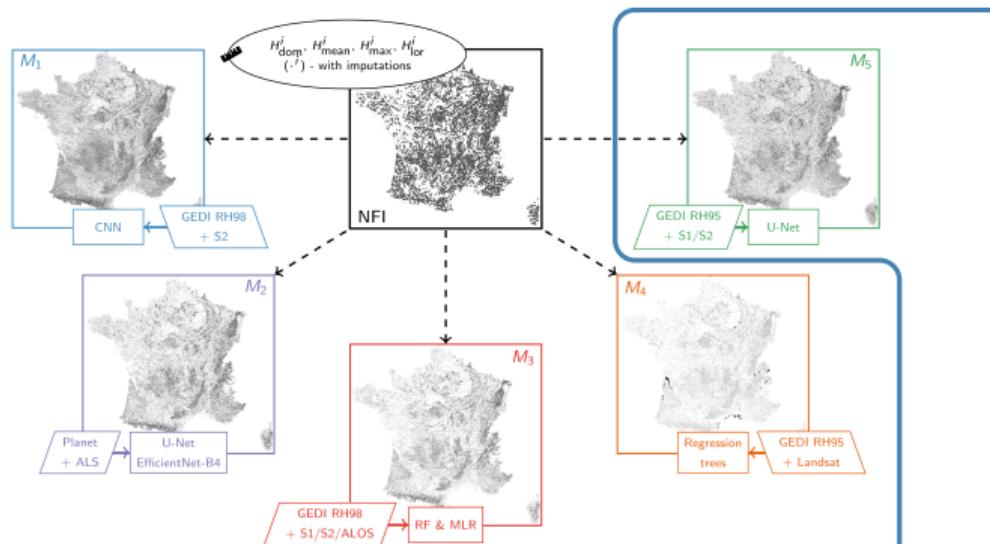


Le plus évident à faire :
spatialiser la hauteur de la canopée

Et on le fait bien !

(N. Besic, N. Picard, C. Vega, J.-D. Bontemps, L. Hertzog, J.-P. Renaud, F. Fogel, M. Schwartz, A. Pellissier-Tanon, G. Destouet, F. Mortier, M. Planells-Rodriguez, and P. Ciais, "Remote sensing-based forest canopy height mapping: some models are useful, but might they provide us with even more insights when combined?," *Geoscientific Model Development*, 18, 337–359, 2025. DOI: 10.5194/gmd-18-337-2025)

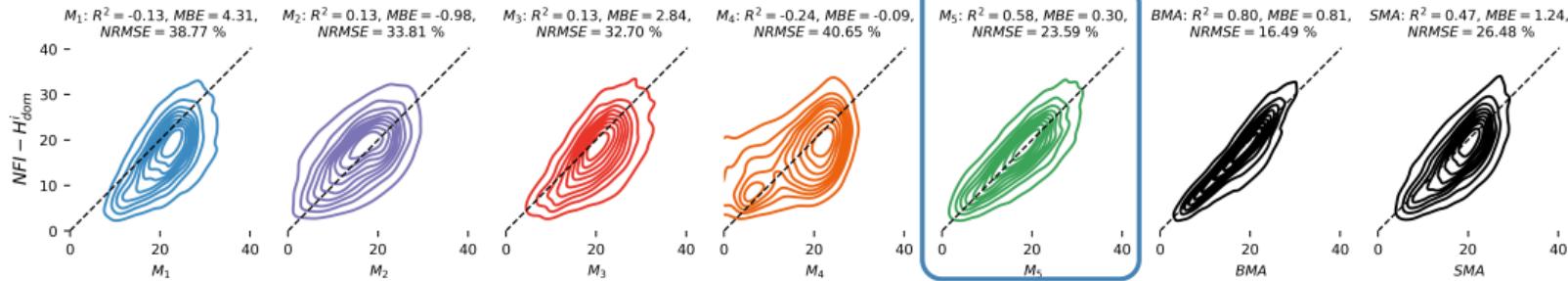


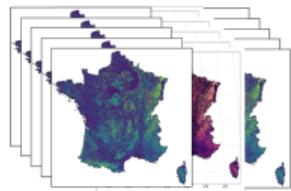


Le plus évident à faire :
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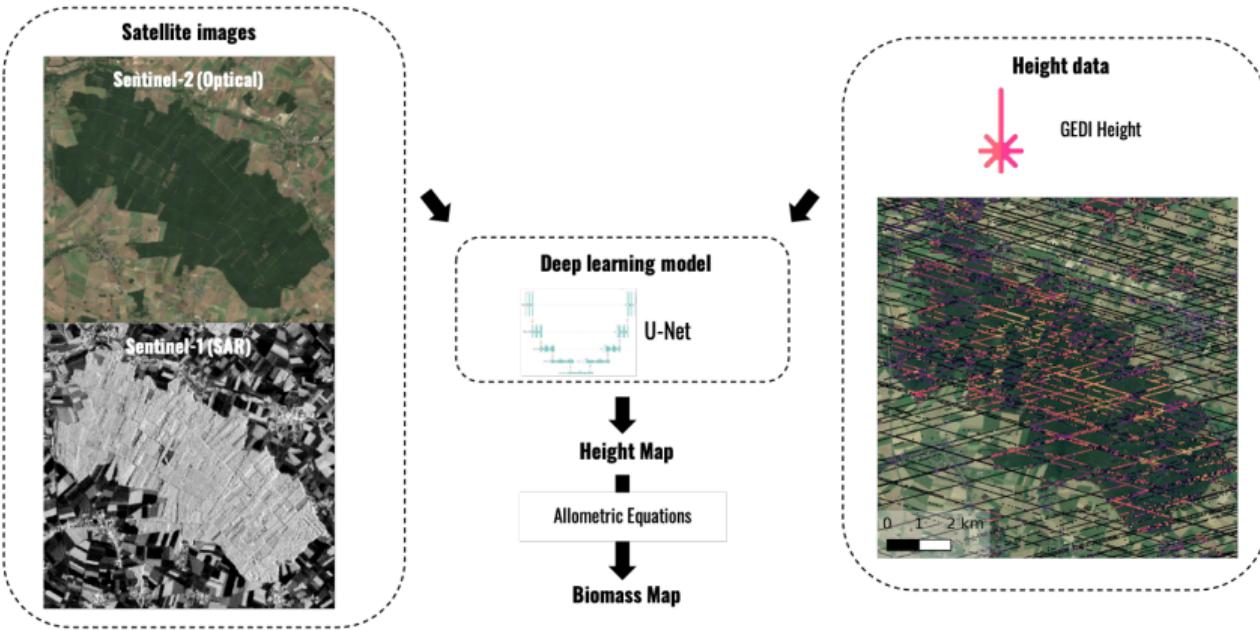
Et on le fait bien !

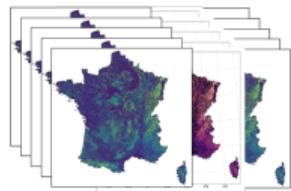
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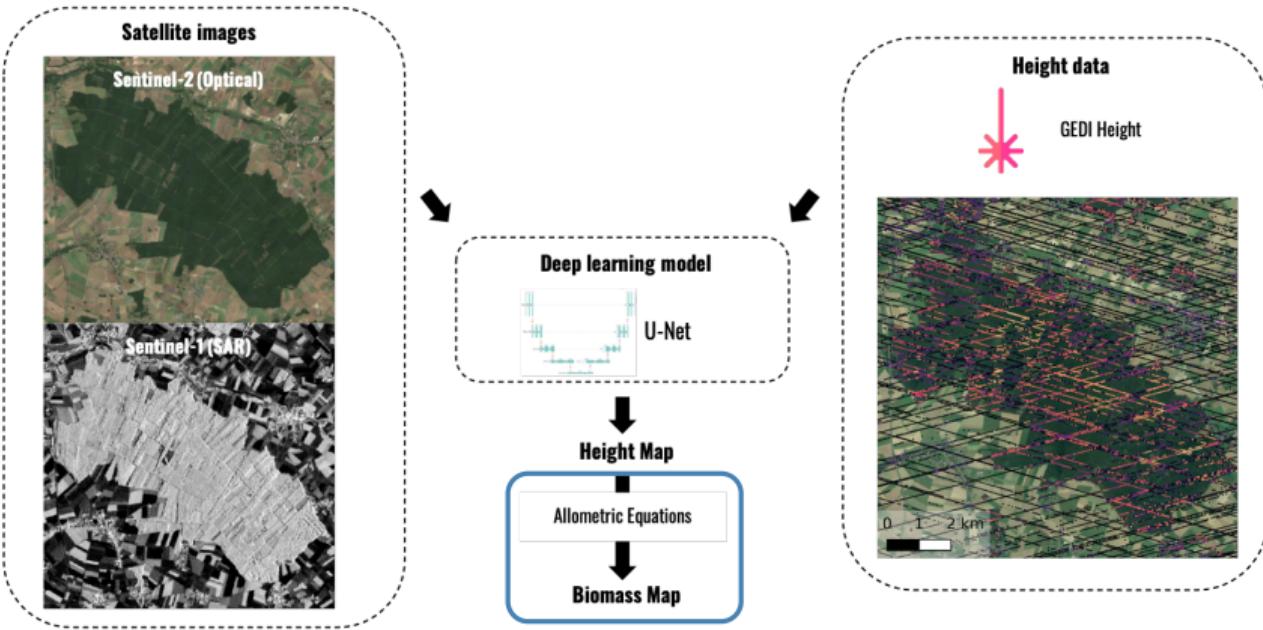


(M. Schwartz, P. Ciais, E. Sean, A. de Truchis, C. Vega, **N. Besic**, I. Fayad, J.-P. Wigneron, S. Brood, A. Pelissier-Tanon, J. Pauls, G. Belouze, and Y. Xu, "Retrieving yearly forest growth from satellite data: A deep learning based approach," *Remote Sensing of Environment*, Volume 330, 2025. DOI: 10.1016/j.rse.2025.114959)

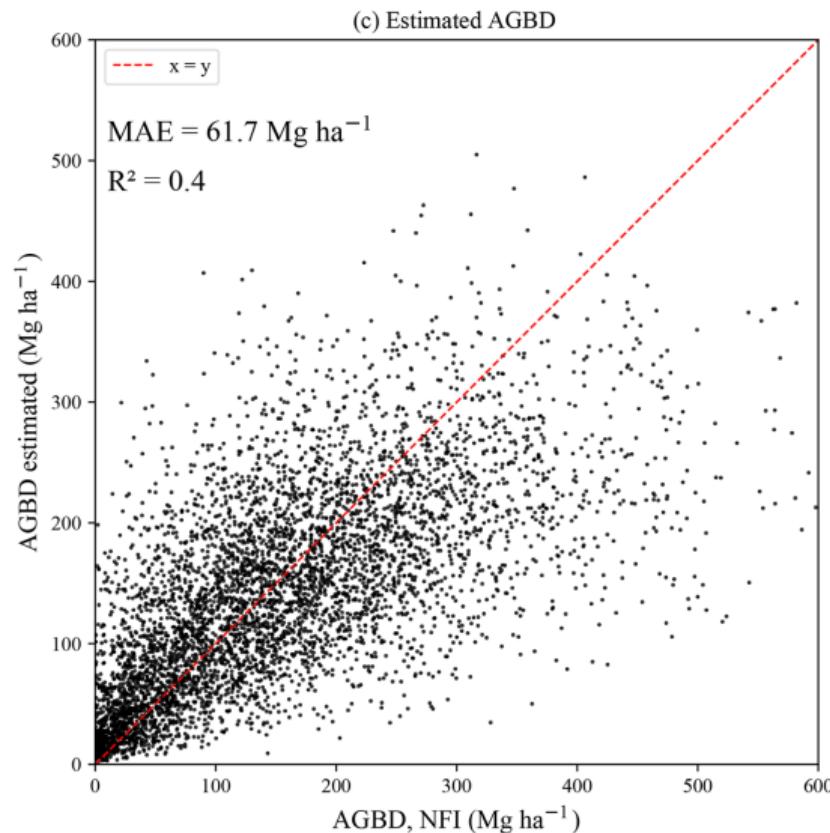
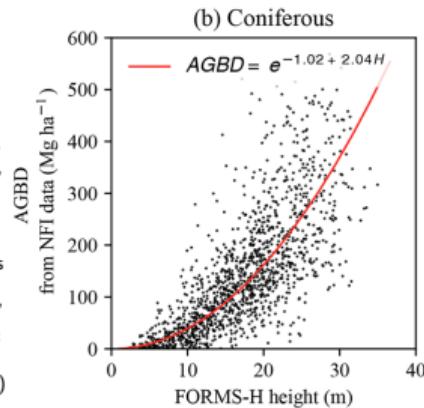
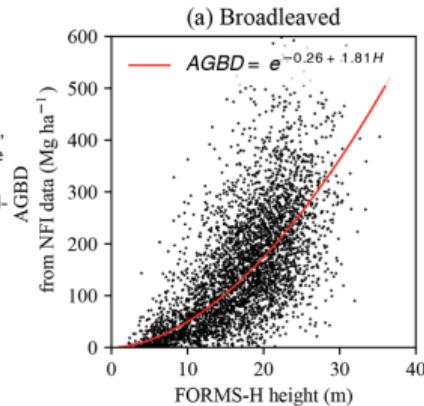




(M. Schwartz, P. Ciais, E. Sean, A. de Truchis, C. Vega, **N. Besic**, I. Fayad, J.-P. Wigneron, S. Brood, A. Pelissier-Tanon, J. Pauls, G. Belouze, and Y. Xu, "Retrieving yearly forest growth from satellite data: A deep learning based approach," *Remote Sensing of Environment*, Volume 330, 2025. DOI: 10.1016/j.rse.2025.114959)

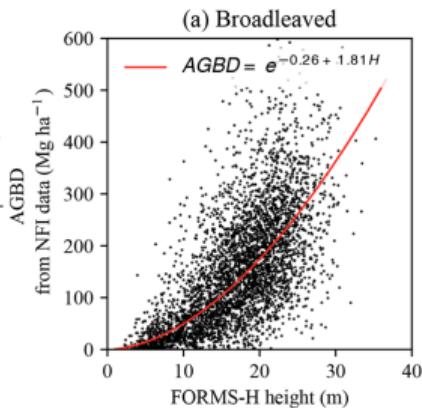


(M. Schwartz, et al.: FORMS: Forest Multiple Source height, wood volume, and biomass maps in France at 10 to 30 m resolution based on Sentinel-1, Sentinel-2, and Global Ecosystem Dynamics Investigation (GEDI) data with a deep learning approach, *Earth Syst. Sci. Data*, 15, 4927–4945, 2023, DOI: 10.5194/essd-15-4927-2023)

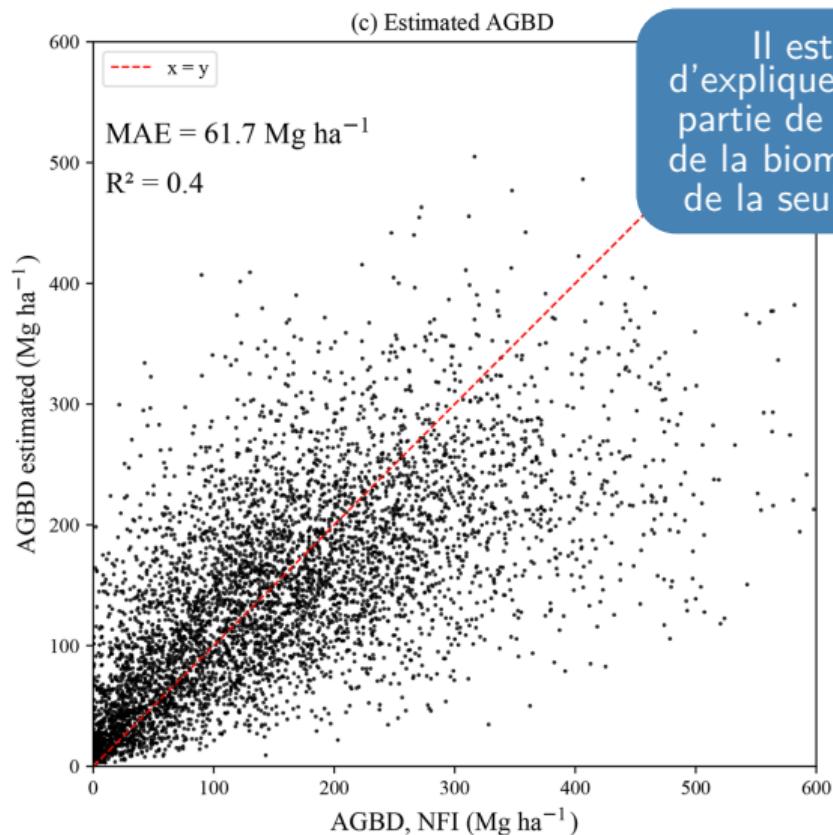
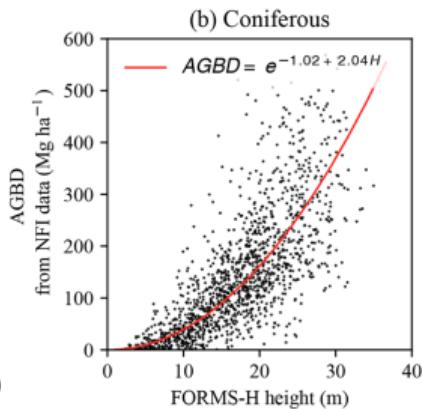


(Y. Su, M. Schwartz, I. Fayad, M. Garcia, M. Zavala, J. Tijerin-Trivino, J. Astigarraga, V. Cruz-Alonso, S. Liu, X. Zhang, S. Chen, F. Ritter, **N. Besic**, A. d'Aspremont, and P. Ciais, "Canopy height and biomass distribution across the forests of Iberian peninsula," *Nature Research - Scientific Data*, 12, 678, 2025. DOI: 10.1038/s41597-025-05021-9)

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Il est difficile d'expliquer une grande partie de la variabilité de la biomasse à partir de la seule hauteur...

Open-Canopy project



Lidar HD



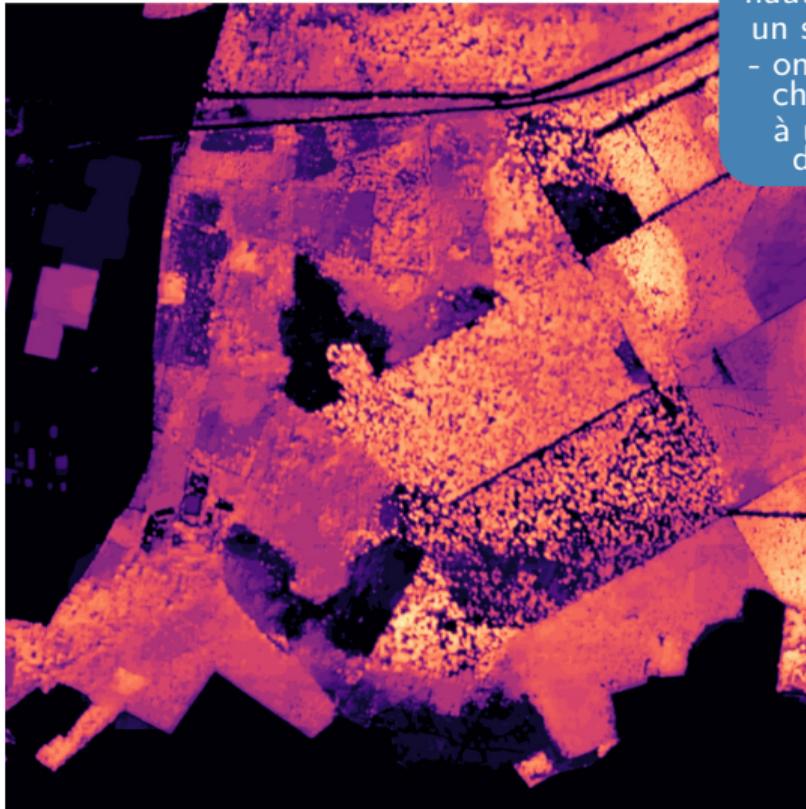
Vision transformer model



SPOT

(F. Fogel, Y. Perron, N. Besic, L. Saint-André, A. Pellissier-Tanon, M. Schwartz, T. Boudras, I. Fayad, A. d'Aspremont, L. Landrieu, and P. Ciais, "Open-Canopy: Towards Very High Resolution Forest Monitoring," Proceedings of the Computer Vision and Pattern Recognition Conference (CVPR), pp. 1395-1406, 2025.)

2014



En attendant, la hauteur fait déjà un super boulot - on détecte des changements à une échelle de 1,5 m !

Open-Canopy project



Lidar HD

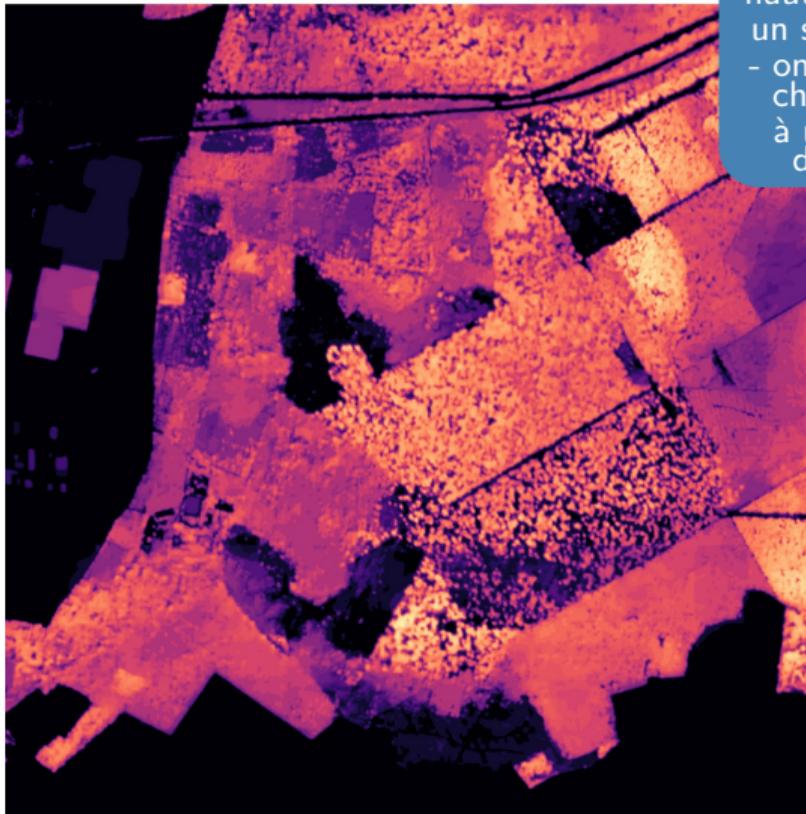


Vision transformer model



SPOT

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Open-Canopy project



Lidar HD



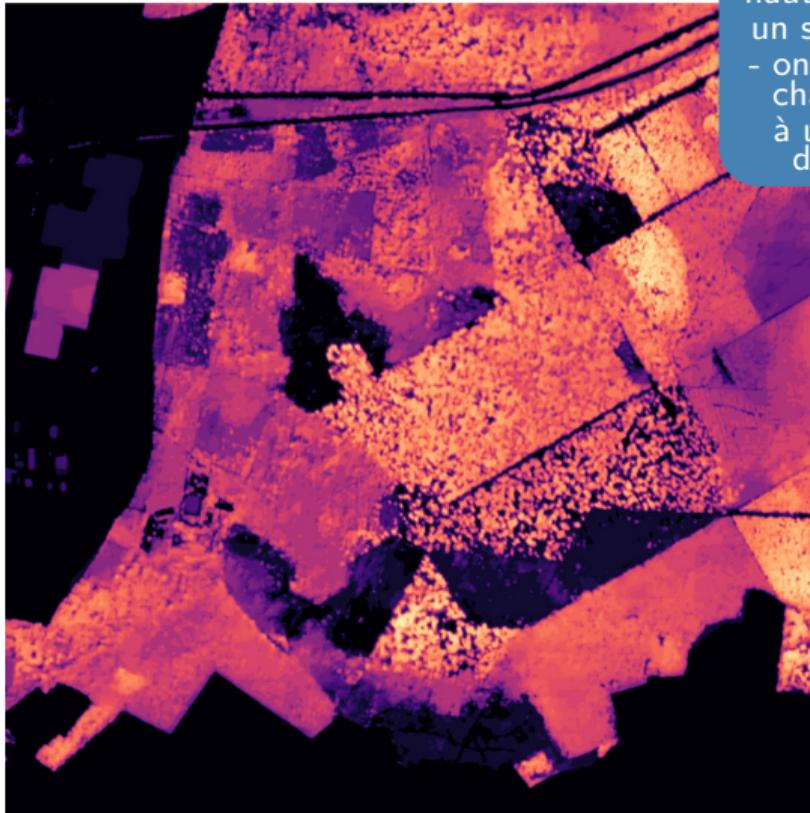
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SPOT

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2016



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Open-Canopy project



Lidar HD



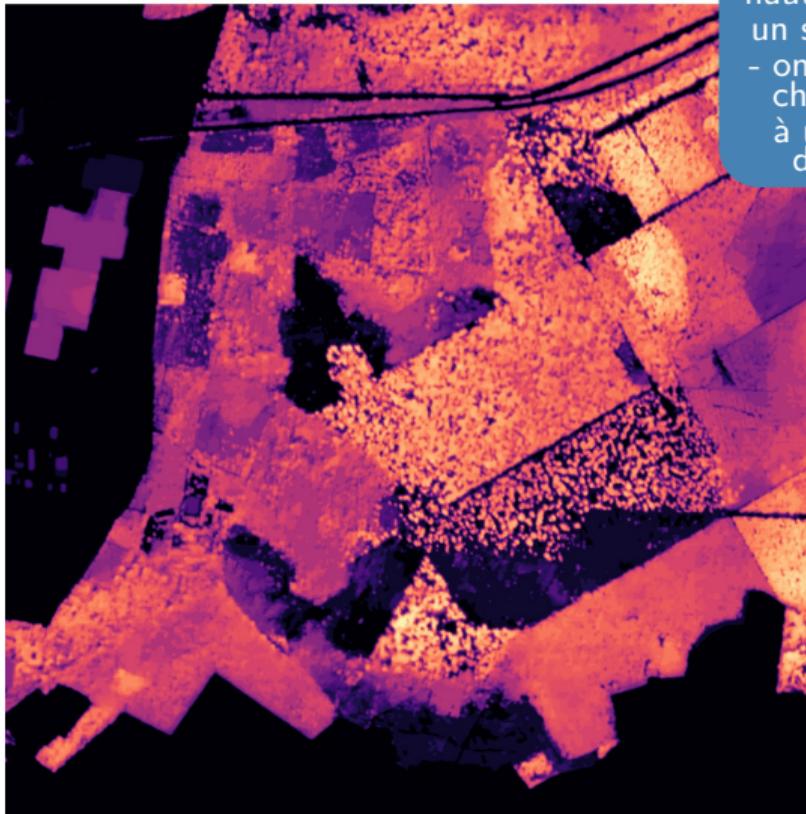
Vision transformer model



SPOT

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2017



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Open-Canopy project



Lidar HD



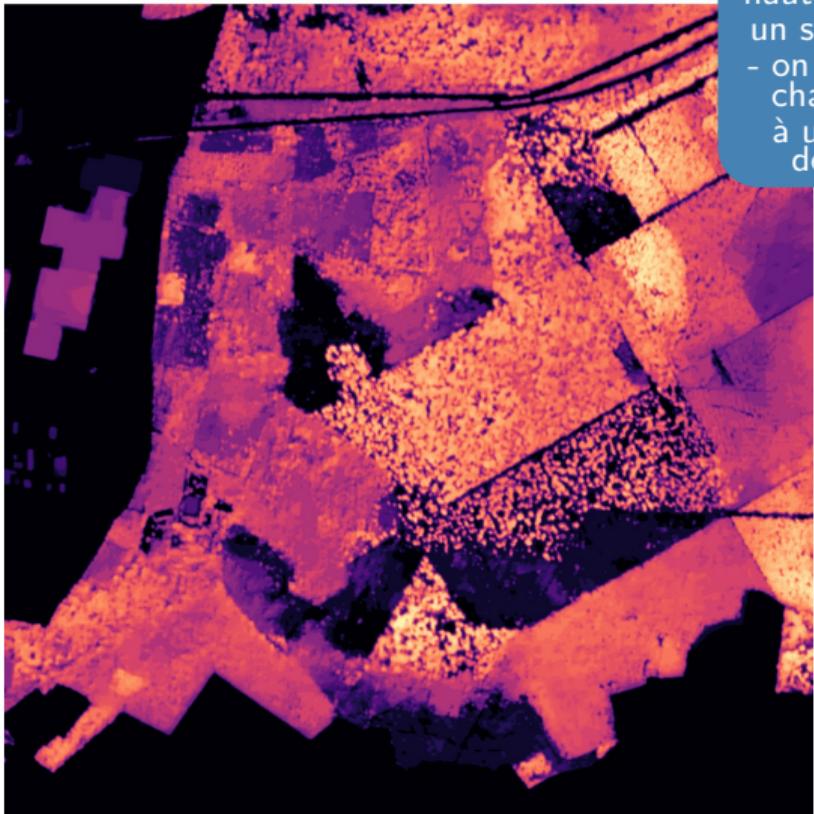
Vision transformer model



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2018



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Open-Canopy project



Lidar HD



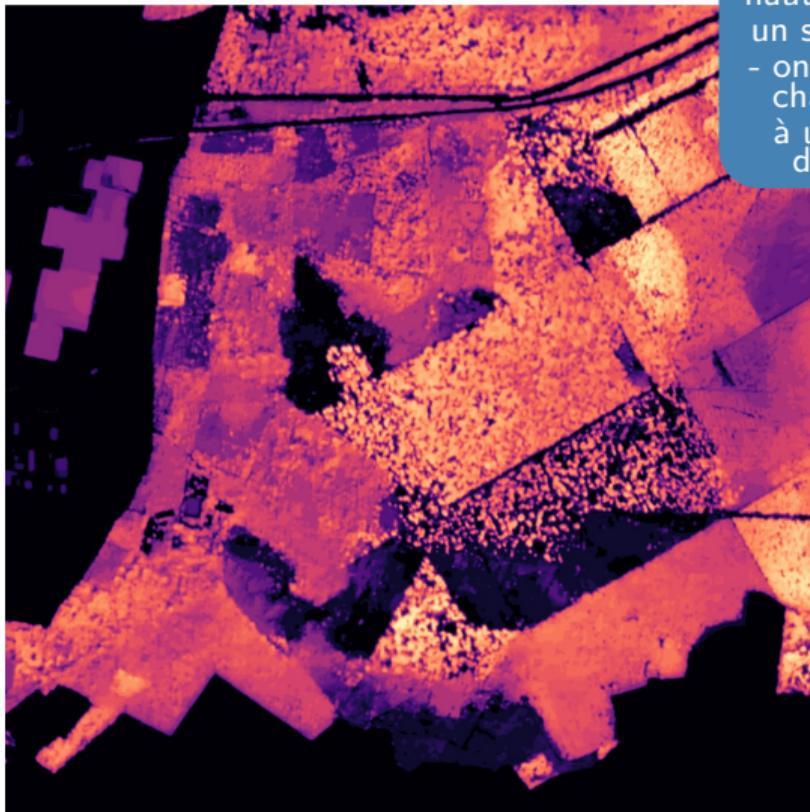
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2019



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Open-Canopy project



Lidar HD

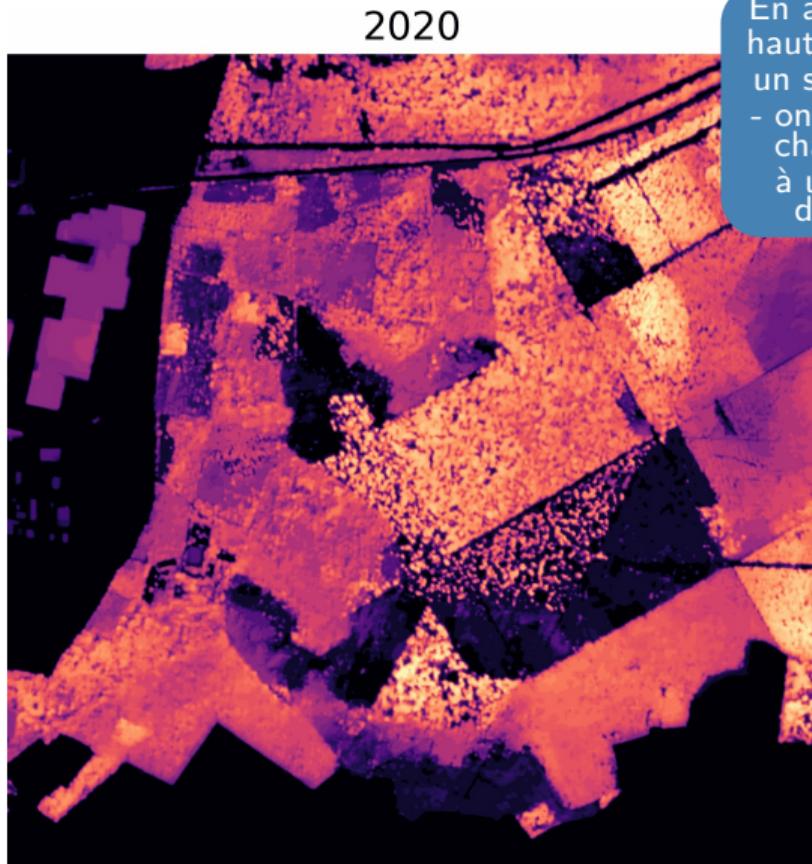


Vision transformer model



SPOT

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Open-Canopy project



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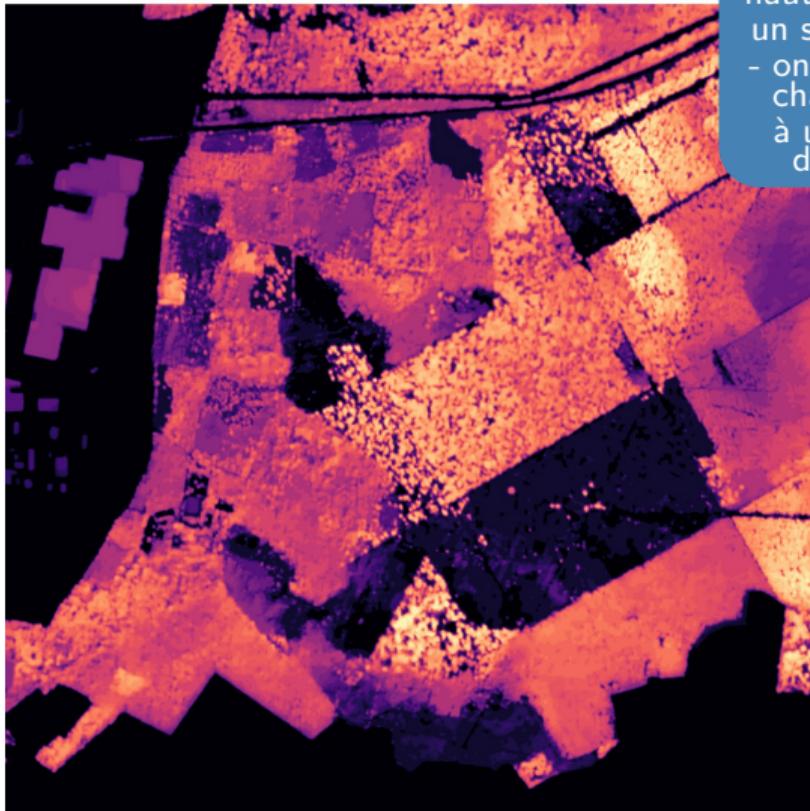
Vision transformer model



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2021



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Open-Canopy project



Lidar HD



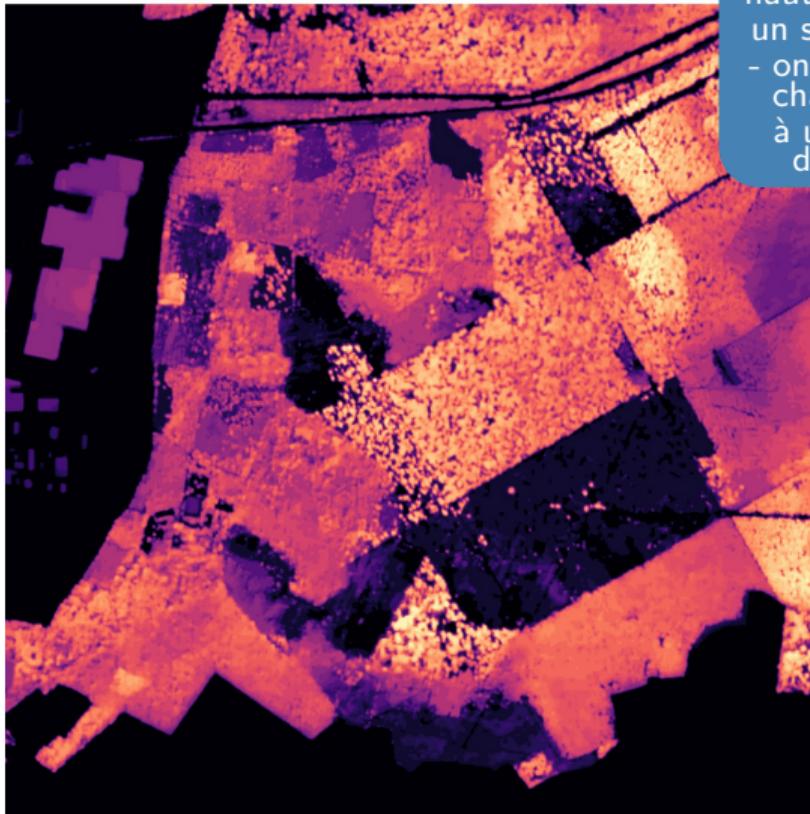
Vision transformer model



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2022



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Open-Canopy project



Lidar HD

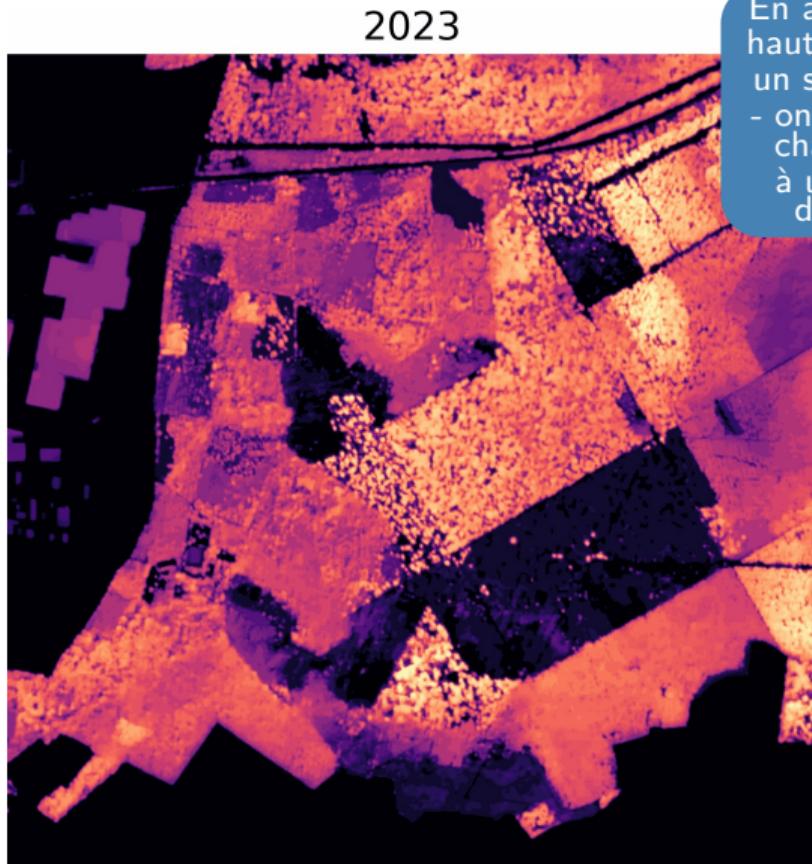


Vision transformer model



SPOT

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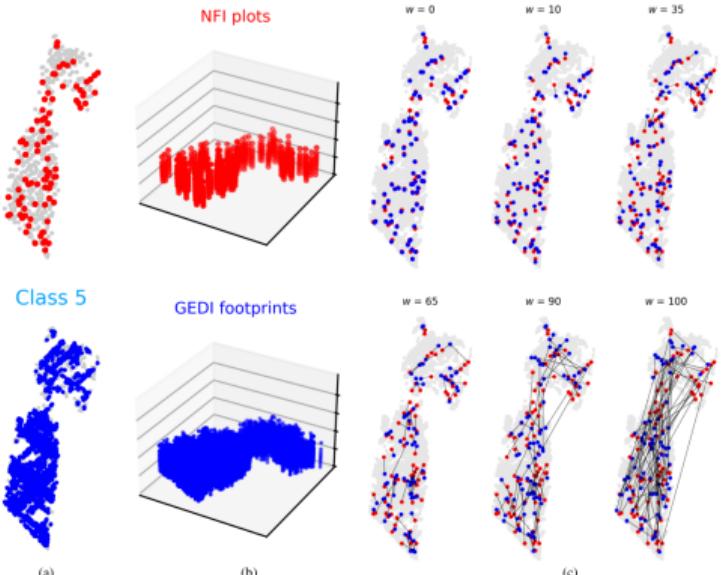
Comment améliorer la spatialisation de la biomasse en France métropolitaine ?

Comment améliorer la spatialisation de la biomasse en France métropolitaine ?

IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING

A pairing by structural class as a way to handle the spatial mismatch between GEDI lidar measurements and the National Forest Inventory plots?

Nikola Besic , Sylvie Durrieu , Anouk Schleich , and Cédric Vega 

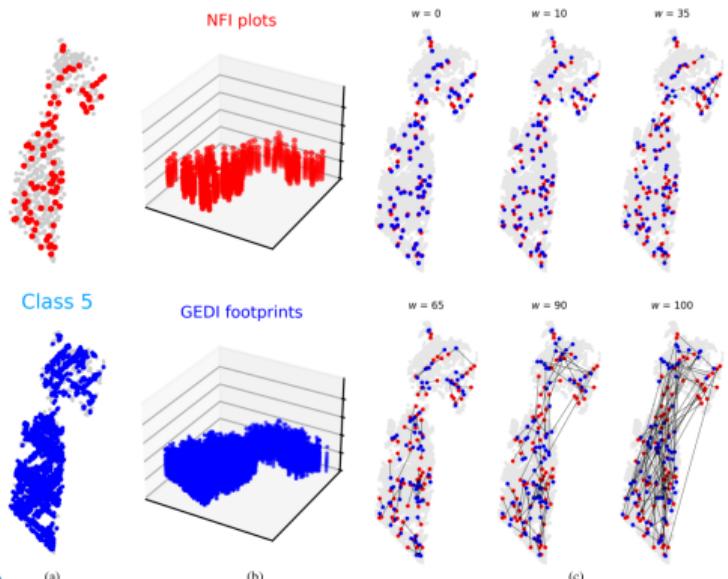


Comment améliorer la spatialisation de la biomasse en France métropolitaine ?

IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING

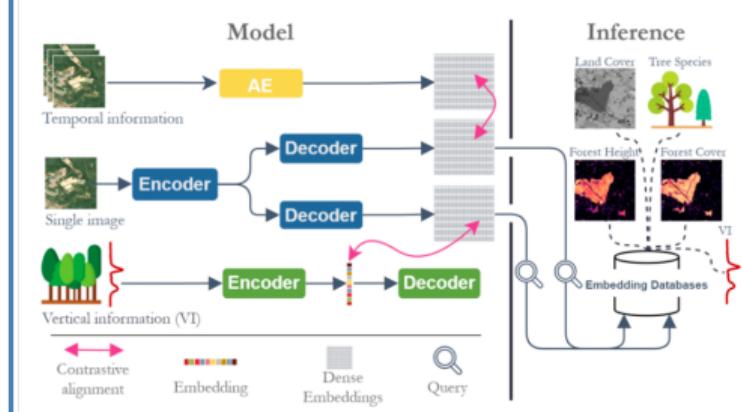
A pairing by structural class as a way to handle the spatial mismatch between GEDI lidar measurements and the National Forest Inventory plots?

Nikola Besic , Sylvie Durrieu , Anouk Schleich , and Cédric Vega 



DUNIA: Pixel-Sized Embeddings via Cross-Modal Alignment for Earth Observation Applications

Ibrahim Fayad ^{1,2}, Max Zimmer ³, Martin Schwartz ¹, Fabian Giesecke ⁴, Philippe Ciais ¹, Gabriel Belouze ¹, Sarah Brood ⁵, Aurelien De Truchis ², Alexandre d'Aspremont ^{5,2}



Comment améliorer la spatialisation de la biomasse en France métropolitaine ?

Les meilleures estimations sur les placettes IFN

-
Alamod
+

+
XyloDenseMap
(le poster d'Amaël)



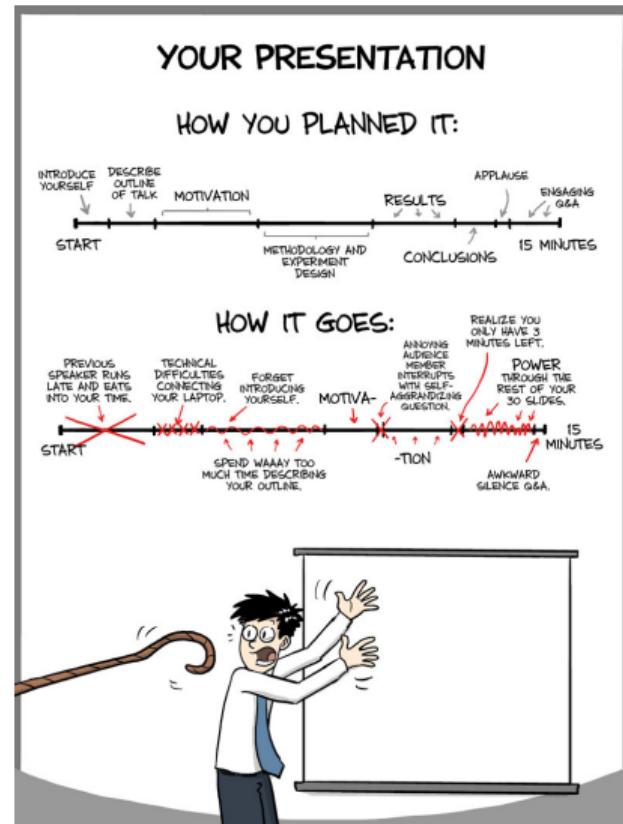
Voir le poster de Selim Behloul (LIF & LSCE) :

"Accurate LiDAR-based simulations of French forest vertical structure for improved biomass estimates"

IFN

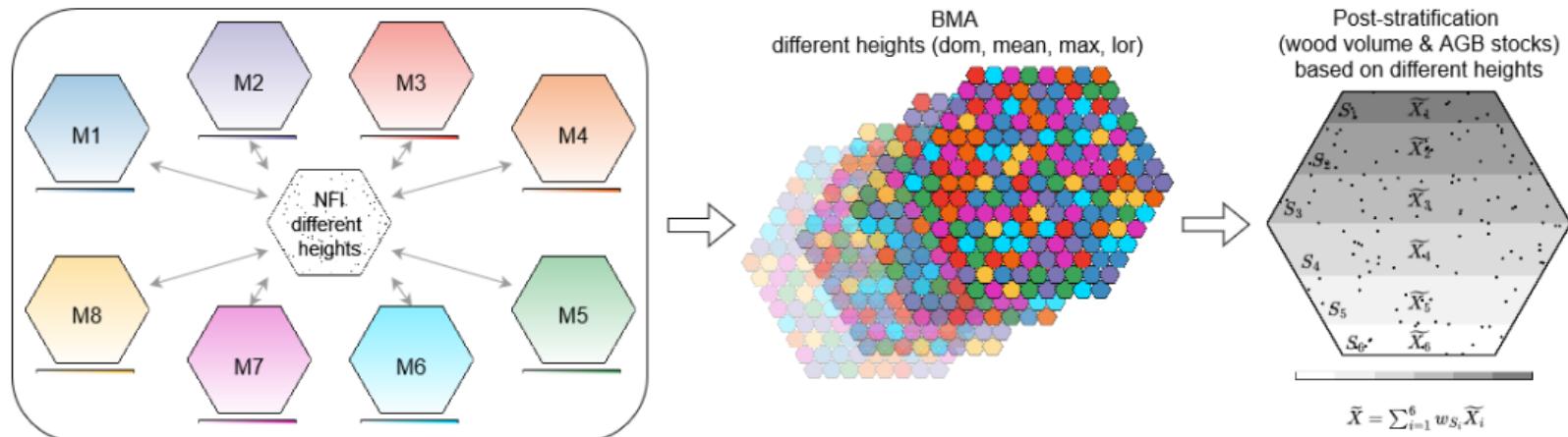
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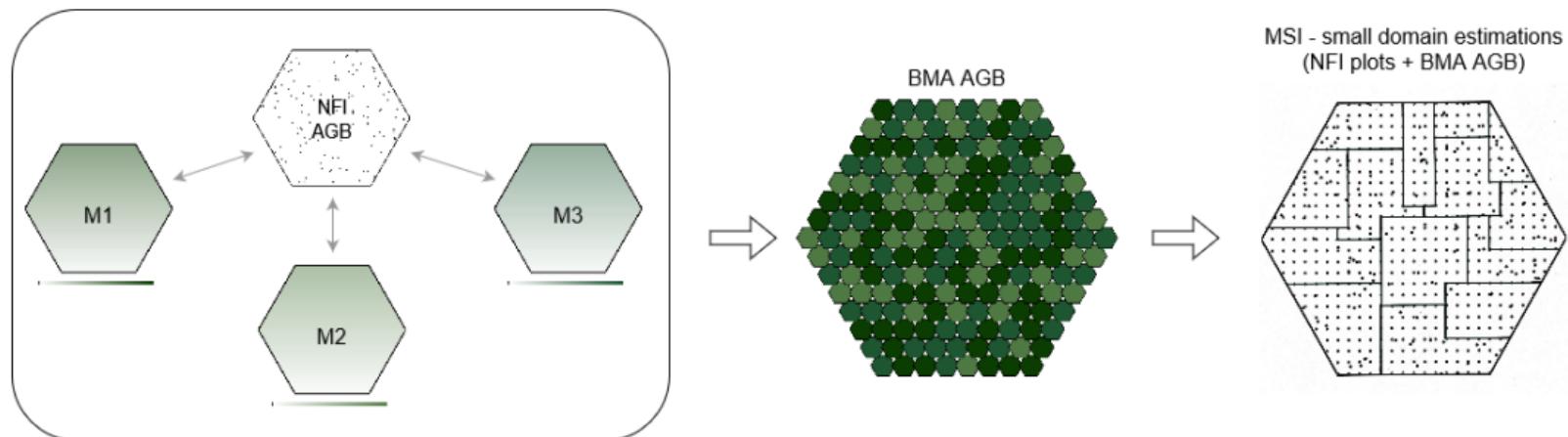
source : PHD comics

Moyenne bayésienne de modèles IA pour la cartographie haute résolution de la hauteur de la canopée – Application à la post-stratification d'un inventaire forestier à grande échelle



Exploiter la complémentarité des modèles d'IA pour affiner les inventaires forestiers à grande échelle via une nouvelle post-stratification, réduisant la variance et améliorant la précision des estimations de volume et de biomasse.

Moyenne bayésienne de modèles IA pour la cartographie haute résolution de la biomasse aérienne – Vers un inventaire forestier à grande échelle assisté par modèle



Améliorer la précision spatiale tout en préservant l'absence de biais grâce aux Inventaires Multi-Sources et à la fusion Bayésienne (BMA) de modèles d'IA appliquée aux placettes IFN.



 Sète, 2024