Fifth Anniversary of the TropiScat-2 Experiment: Insights for the BIOMASS Mission & beyond

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[2]AMAP (botAnique&Modélisation de l'Architecture des Plantes, UMR CIRAD-CNRS-INRAE-IRD-Université de Montpelier)

[3]IMS (Laboratoire de l'Intégration du Matériau au Système, UMR CNRS-INP-UnivBordeaux)

[4]EcoFoG (Écologie des Forêts de Guyane, UMR AgroParisTech-CIRAD-INRA-CNRS-Université de Guyane)

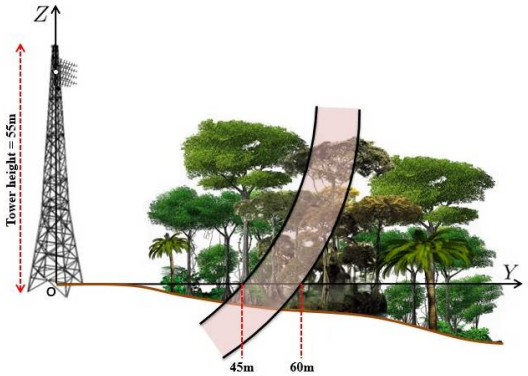
[5]ONERA (The French Aerospace Lab, Toulouse)

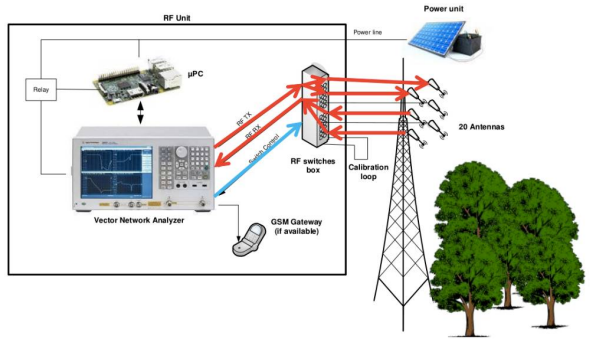
Outline

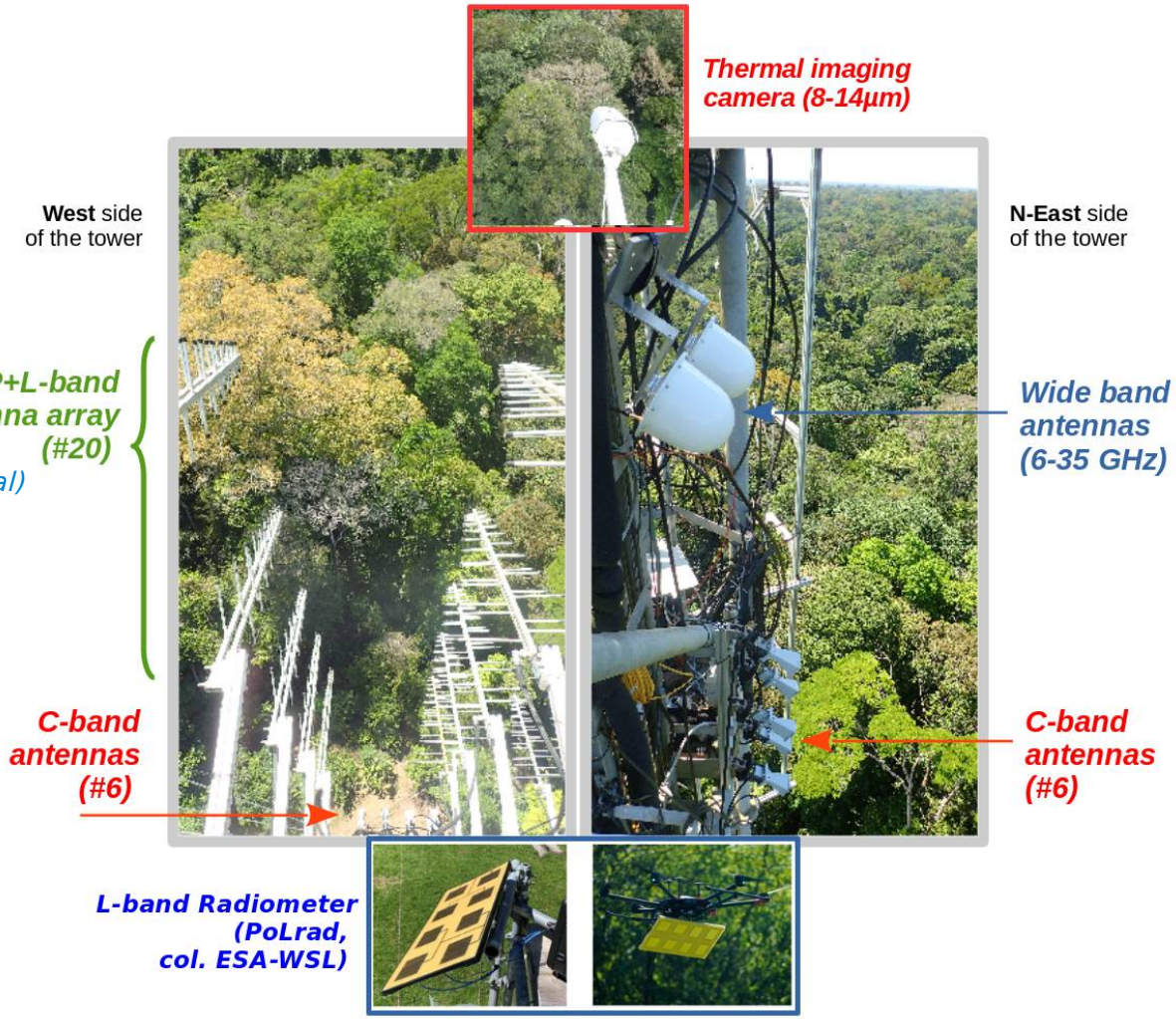
- **Experiment overview**
  - Story, main features & sister campaigns
  - Timeline with the key events & periods
- **Key results at P-band**
  - Temporal decorrelation: short & long-term baselines
  - Evolution of backscattered Intensities
- **Synergies**
  - L & C-bands related results
  - TropiRad : Passive measurements at L-band
  - Thermal imaging
- **Spatialisation**
  - Key G/V Tomo decomposition
  - Meteo data from EO

➢ *Heritage of [Tropi,Afri]Scat campaigns:*

- ***TropiScat***
  [2011-2014, ESA & CNES fundings, top of Guyaflux tower in French Guiana]
- ***AfriScat***
  [2015-2017, ESA & CNES fundings, top of Ankasa flux tower in Ghana]
- ***TropiScat-2***
  [on-going since March 2018, CNES fundings, top of Guyaflux tower]
  → pursue the previous time series
  → consolidate the cross-analysis with in-situ measurements (esp. VWC)
  *→ explore synergies between **P**, **L** and **C** bands, active & passive (L-band, thermal)*







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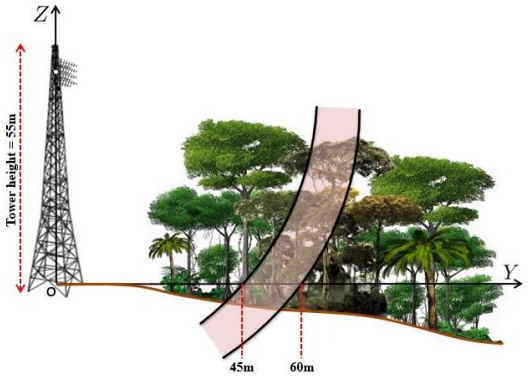

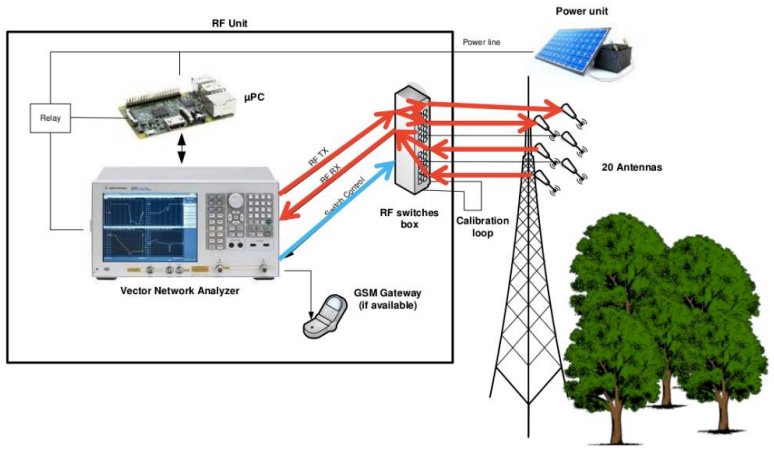

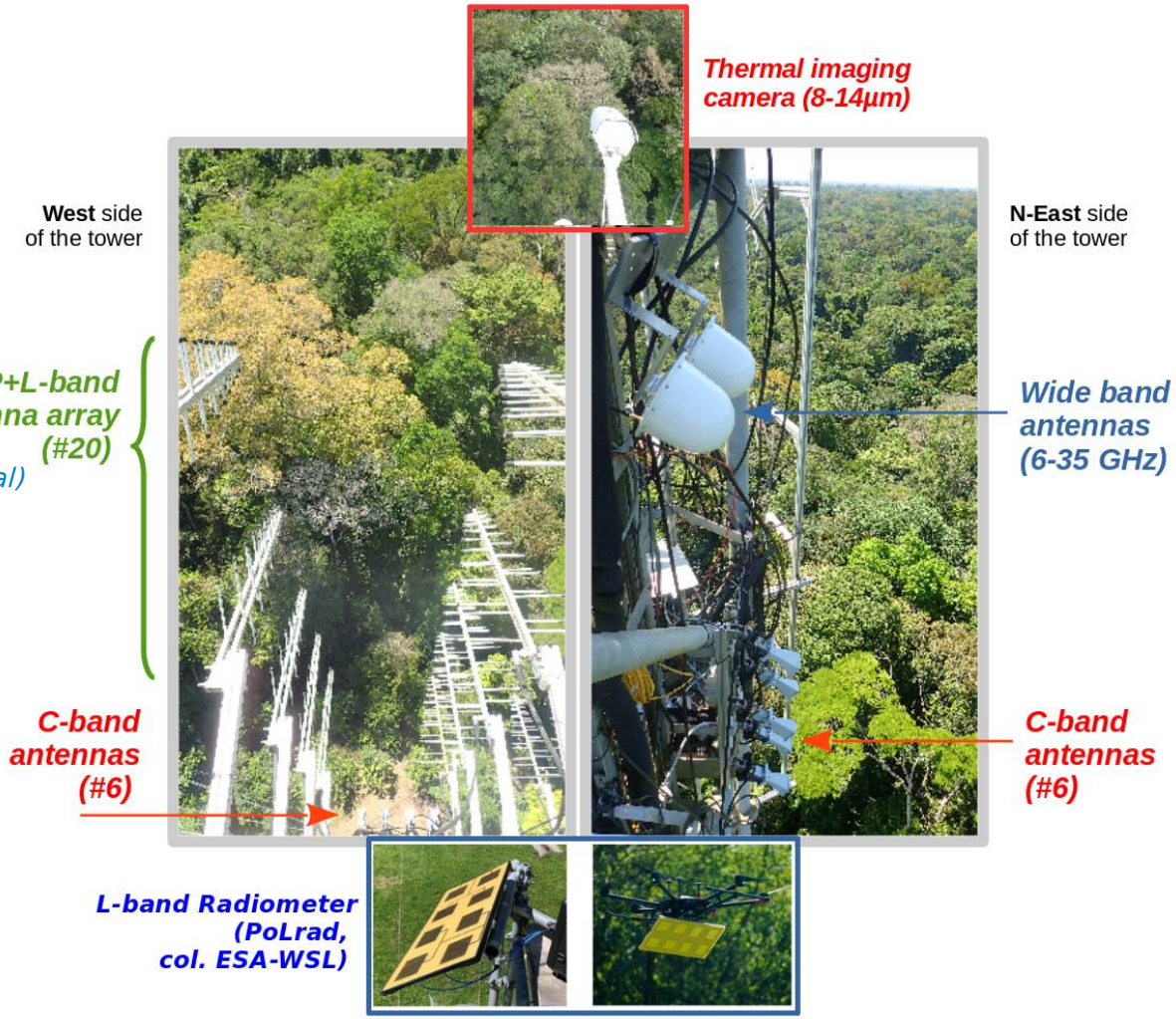

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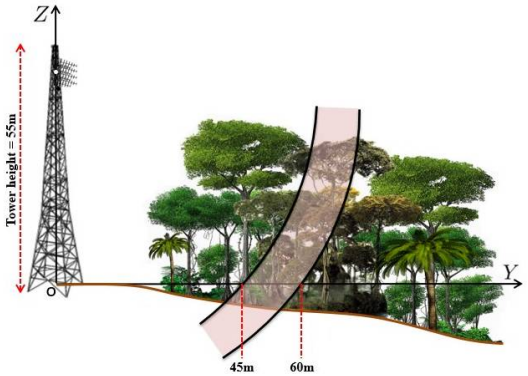
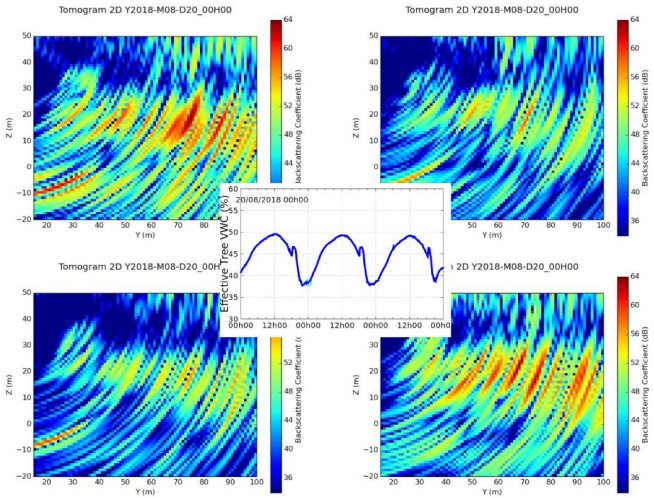
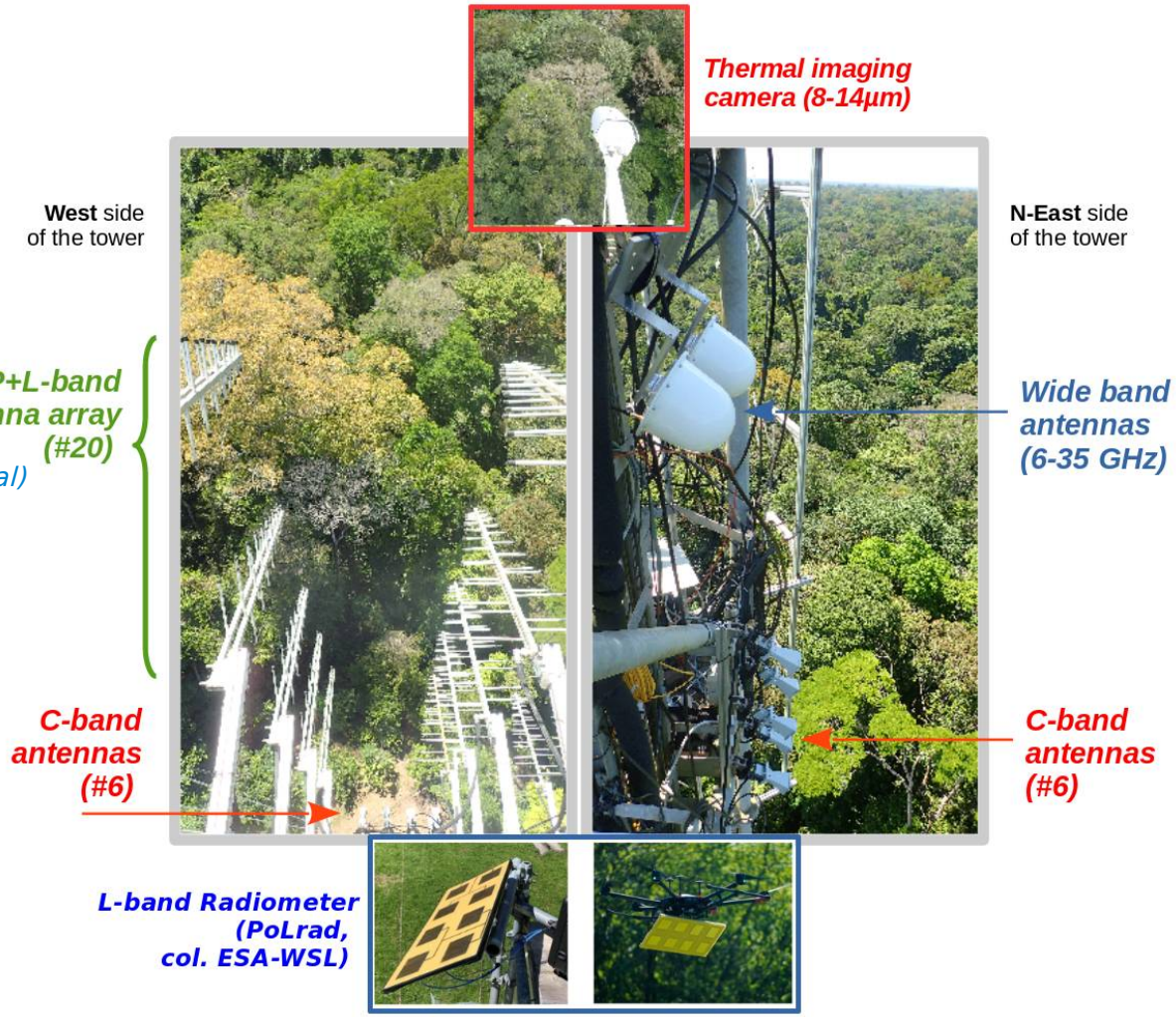
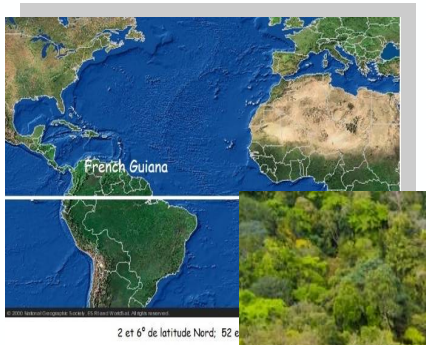


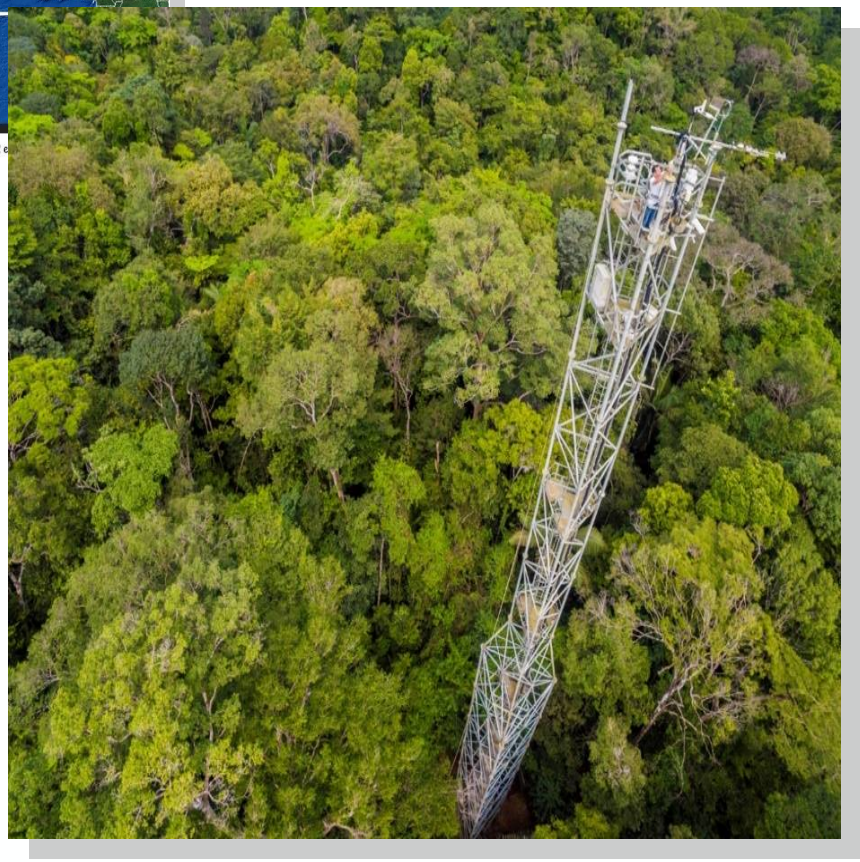




Experiment overview
→ Guyaflux tower & test site

- A tropical wet forest French Guiana, South America –
- Altitude : 10 – 40 m above sea level
- annual rainfall 3102 mm±70 mm
& average annual air temperature 25.7±0.1 °C (2004-2014),
cf. [Aguillos et al. 2019]
- The Guyaflux experimental unit covers >400 ha
of undisturbed forest
- 620 tree ha-1 tree density (DBH >0.1 m)
- Tree species richness is 140 species ha^{-1}
- 10 plots of 0,45 ha ≈ 3000 trees
- Tower is 55 m high
- 20 m higher than overall canopy height





* contact : benoit.burban@inrae.fr

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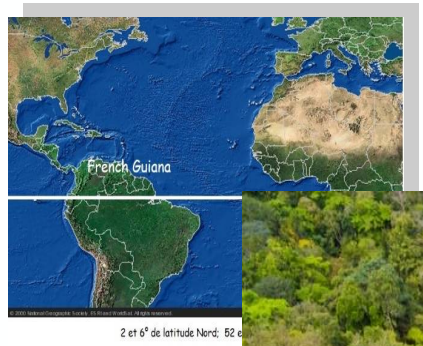

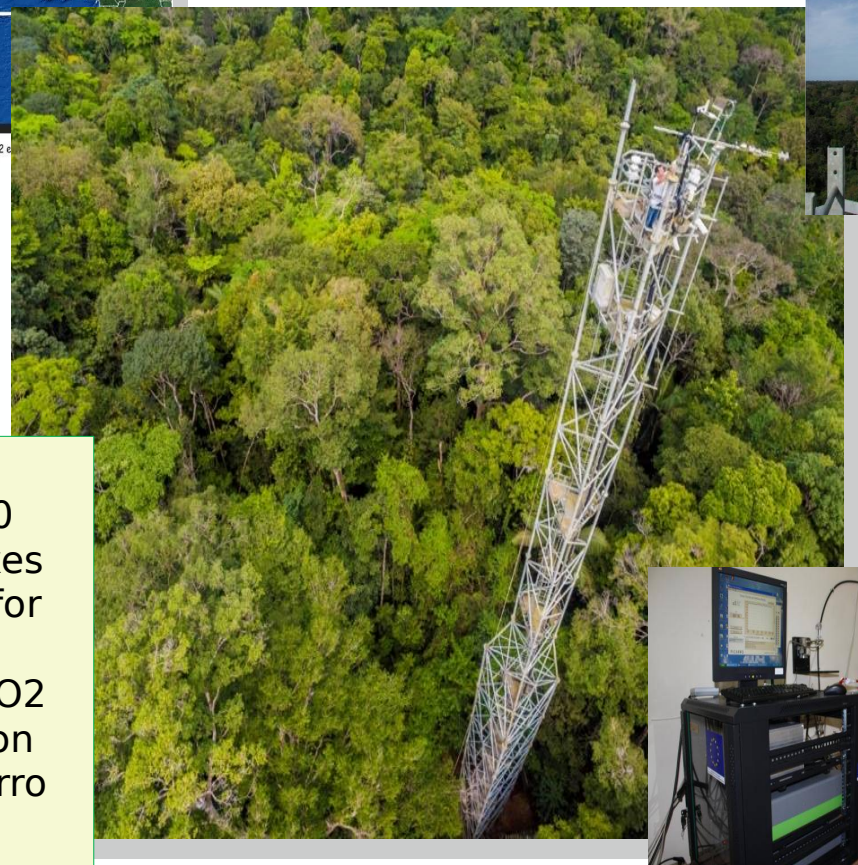

Fluxes analysers :
- Licor 7000 and 7500 for CO2 and H2O fluxes
- Los gatos analyser for CH4 and N20 fluxes
- Picarro G2301 for CO2 and CH4 concentration
- Licor 8150 and Picarro G2308 for soil fluxes (CO2, CH4, N2O)

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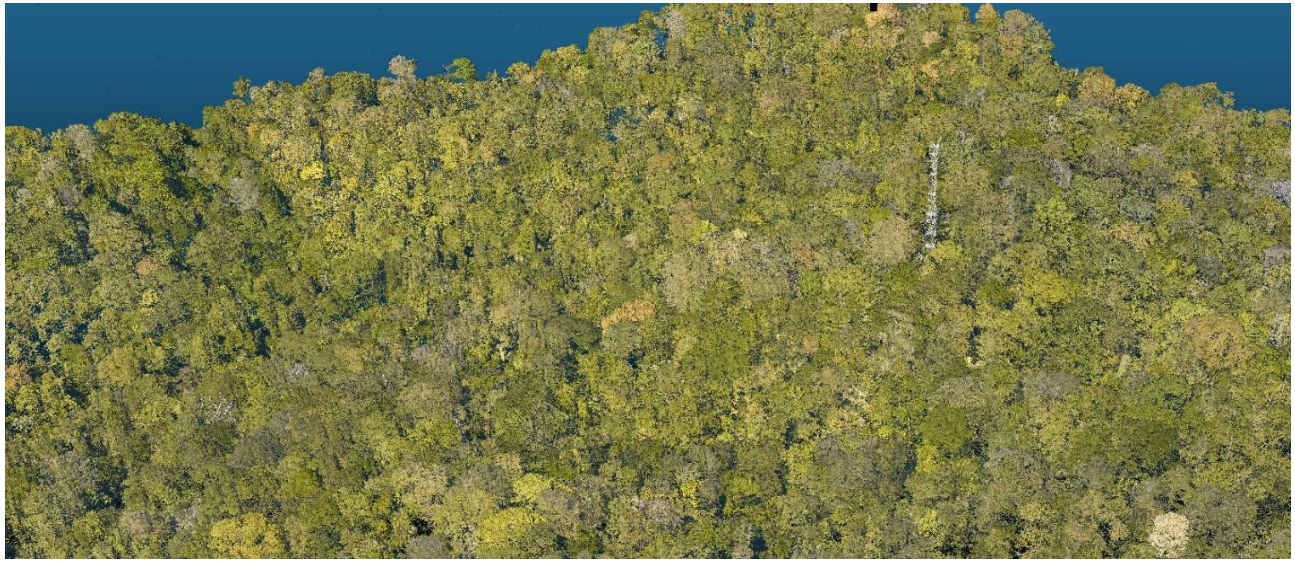
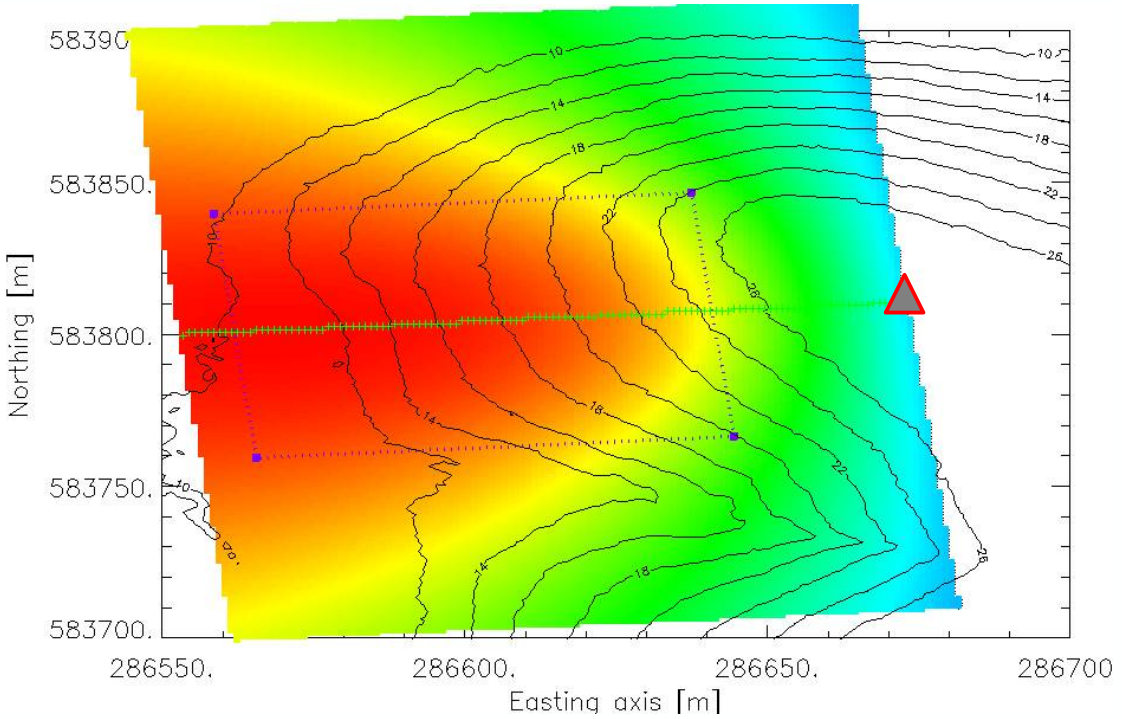
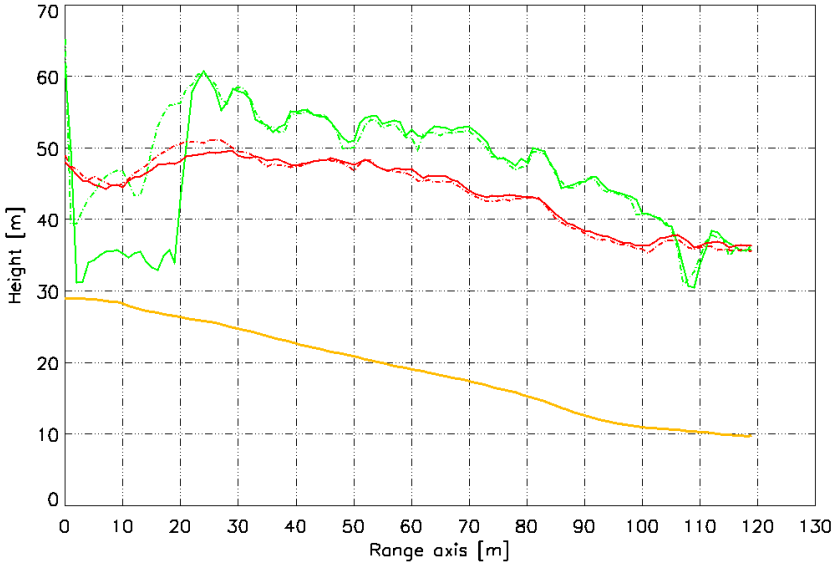
- Fairly homogeneous topography (10% opposite slope along range)
- Forest height between 25-30 m
- Advanced field measurements covering the footprint (~1ha) :







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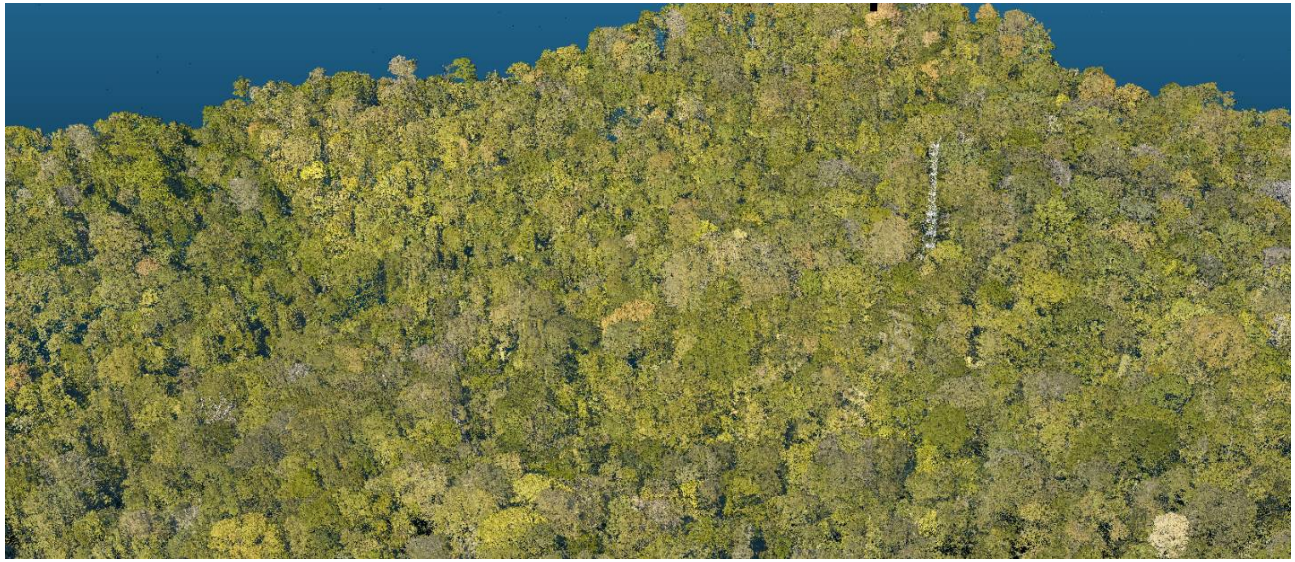
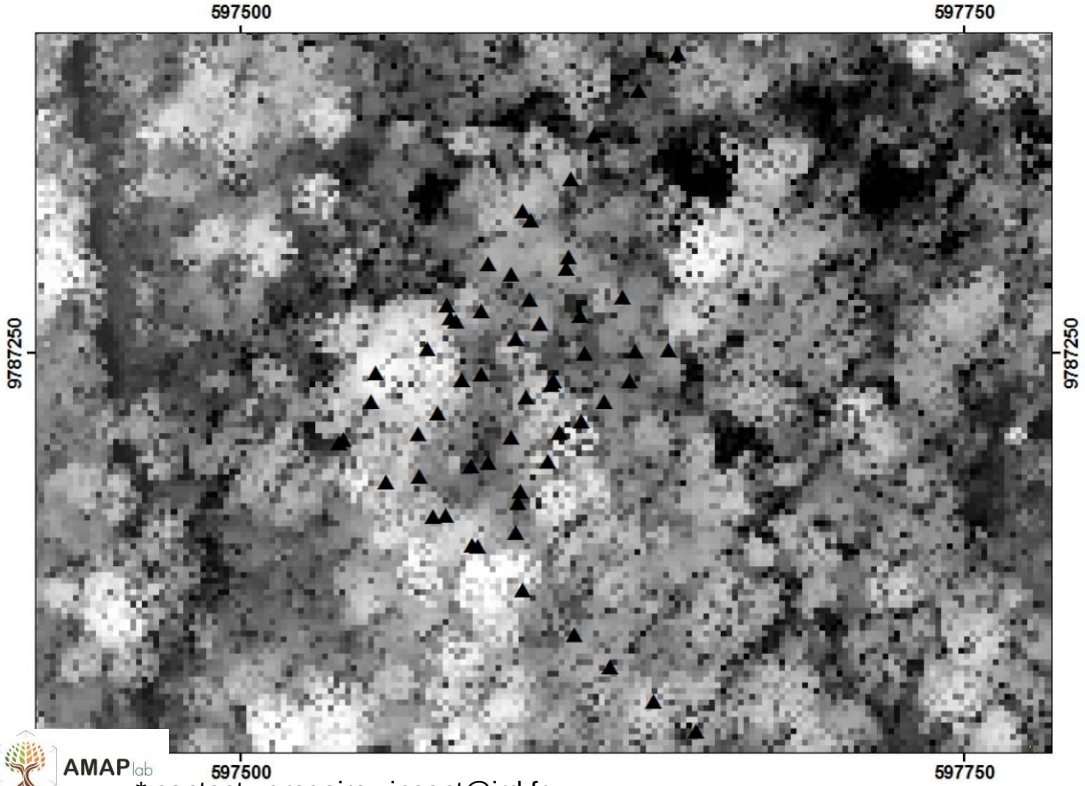
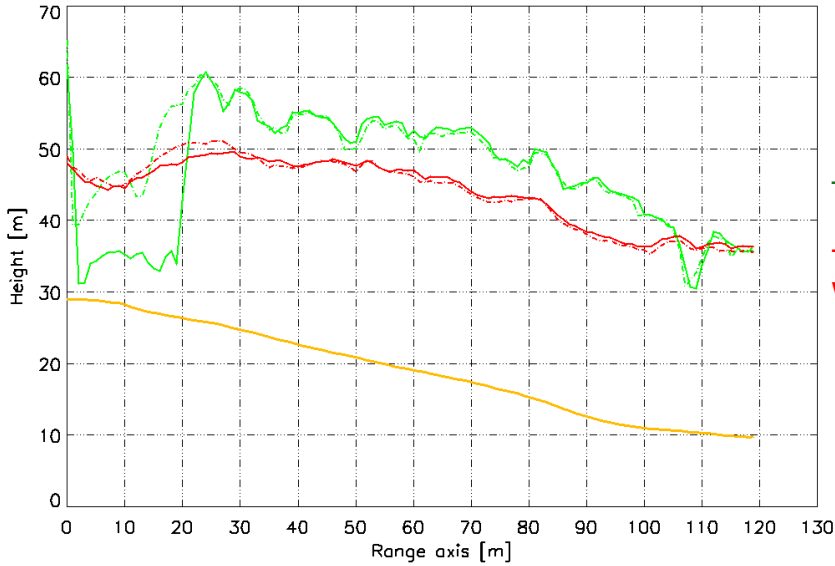




ALS CHM & DTM



– 10m avg

– Gant weighted

AMAP lab
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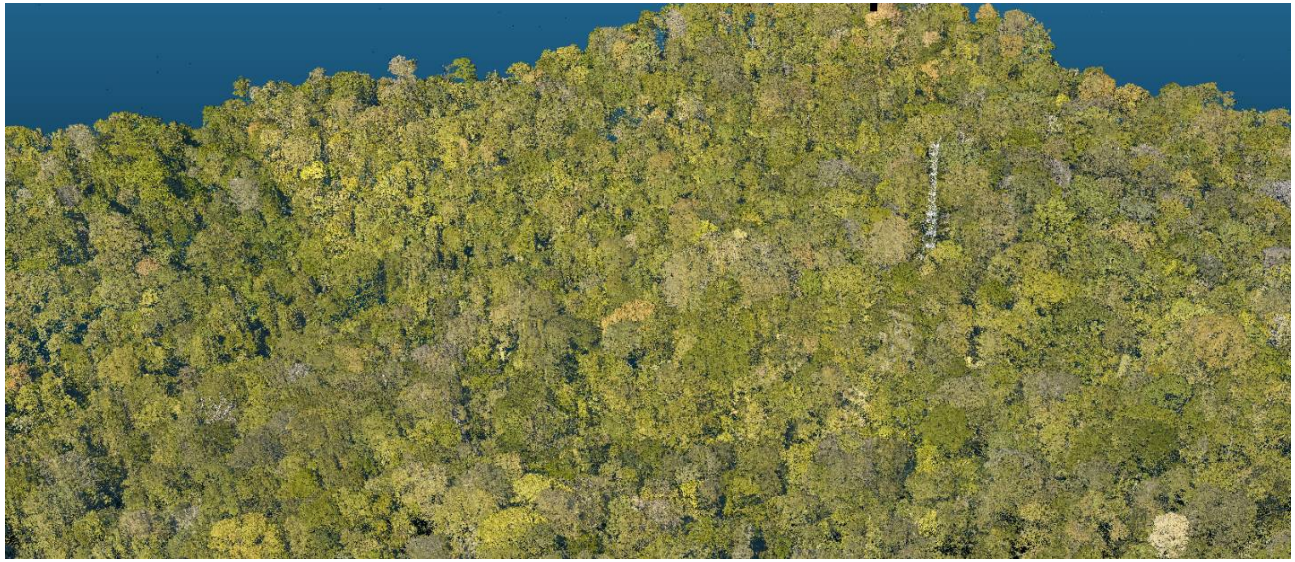

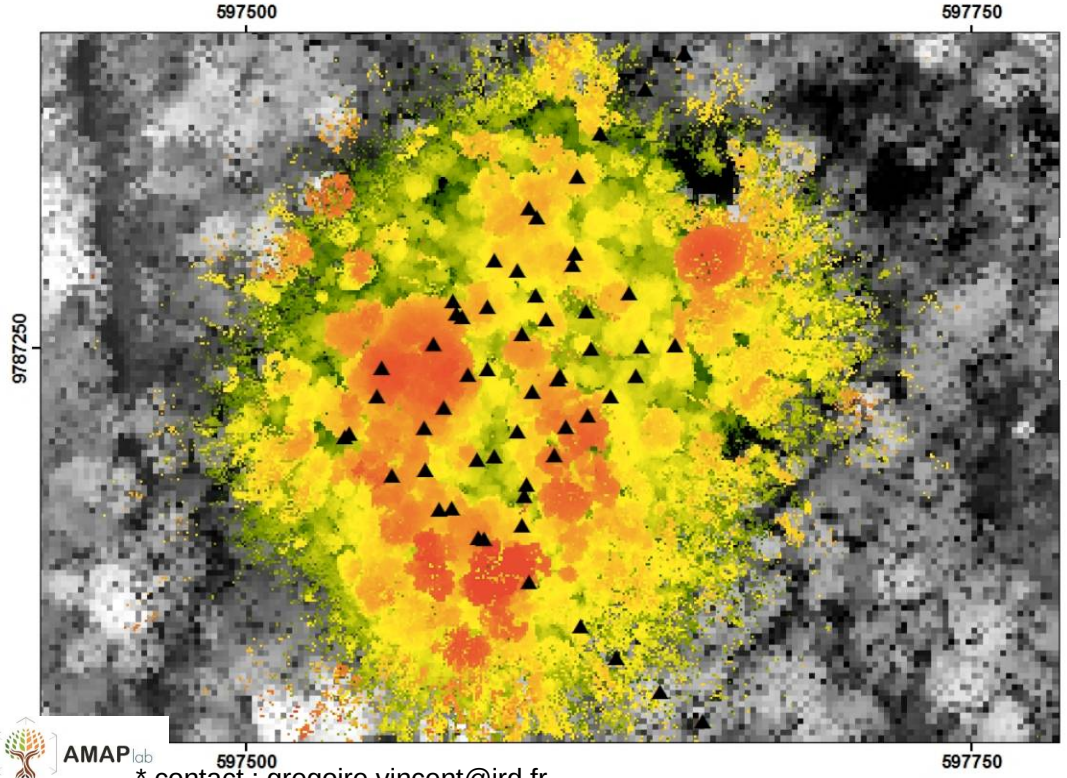

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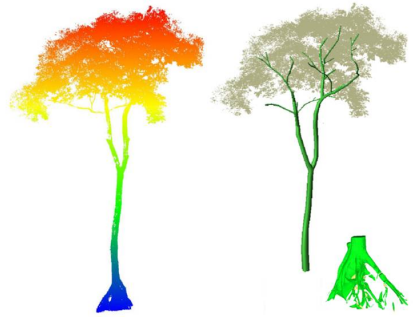
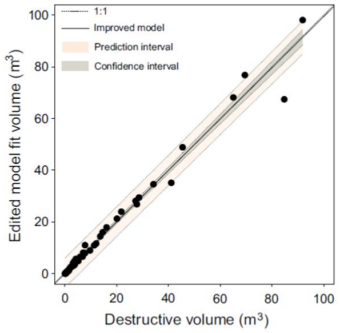
Terrestrial
& [Aerial,Drone]
Laser





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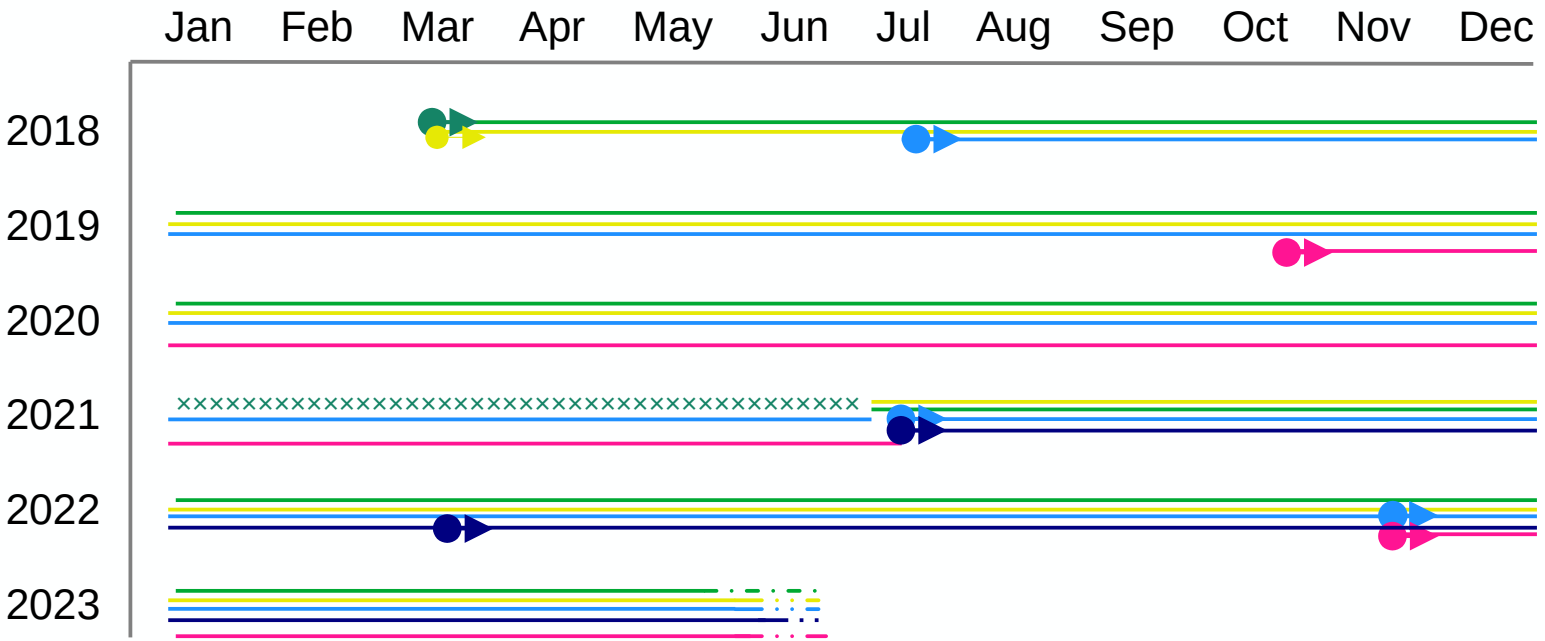
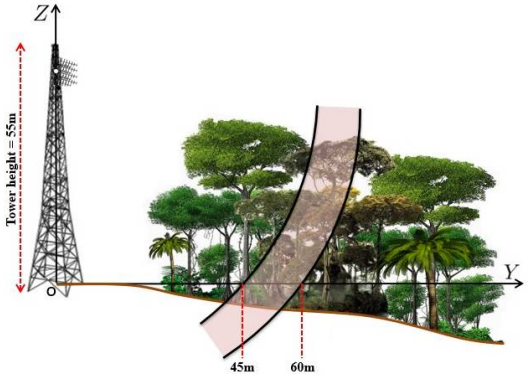
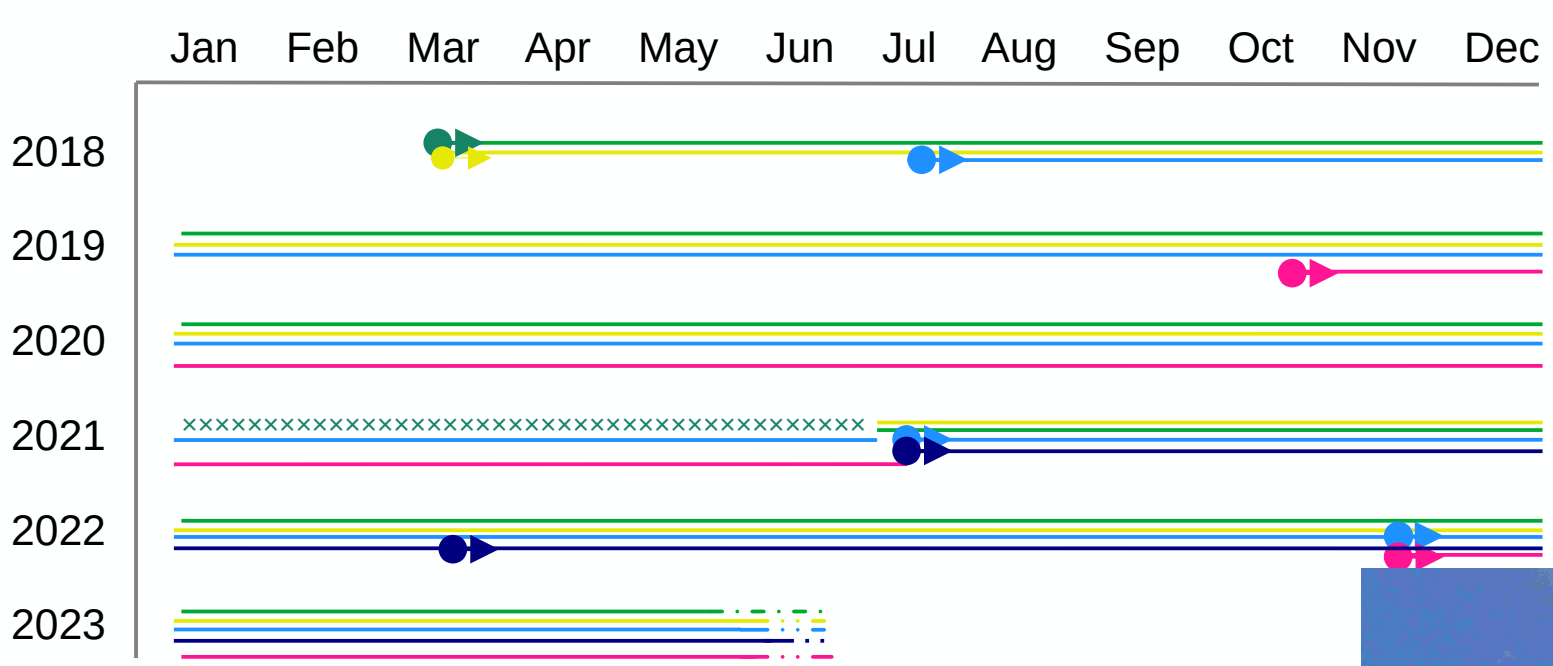

Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2018
2019
2020
2021
2022
2023
-3%
-14%
-5%
+36%
+25%
(...)
-- P-band
-- L-band
-- C-band
-- L-band ε,TB
-- Th ε,TB


Z
Tower height = 55m
O
Y
45m
60m

Experiment overview
→ Timeline & key events



-3%

-14%

-5%

+36%

+25%

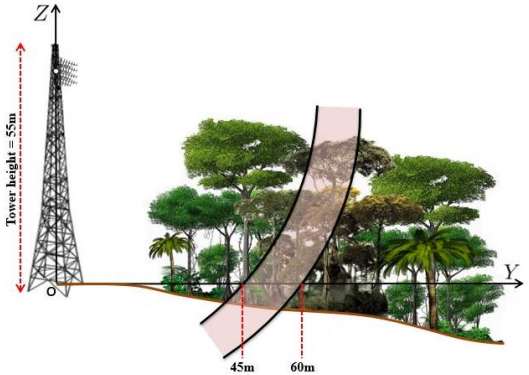
-- P-band

-- L-band

-- C-band

-- L-band ε,TB

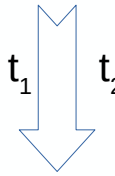
-- Th ε,TB



Key results at P-band
→ Temporal decorrelation

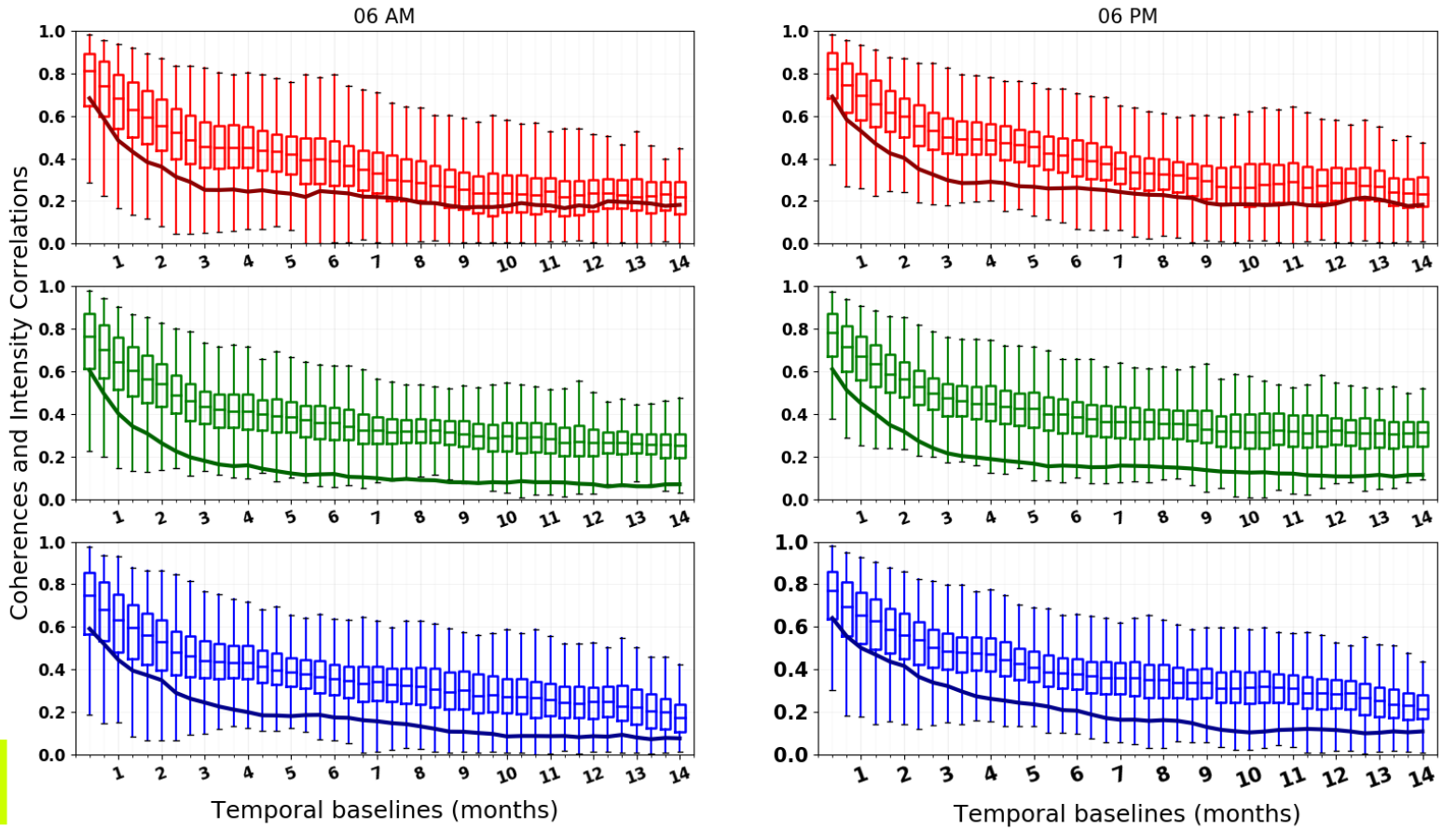
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

20xx



$$\rho(t_1, t_2) = \left\| \frac{S(t_1) \,.\, S(t_2)^*}{\sqrt{\|S(t_1)\|^2 \|S(t_2)\|^2}} \right\|$$

$$\gamma_{(t_1,t_2)} = \frac{\sum_{k=1}^{K} \sum_{seq}^{\{A,B,C\}} \sum_{i=i_{min}}^{i_{max}} S^k_{seq,t_1}(i)\, S^k_{seq,t_2}(i)^*}{\sqrt{\sum_{k=1}^{K} \sum_{seq}^{\{A,B,C\}} \sum_{i=i_{min}}^{i_{max}} ||S^k_{seq,t_1}(i)||^2 \sum_{k=1}^{K} \sum_{seq}^{\{A,B,C\}} \sum_{i=i_{min}}^{i_{max}} ||S^k_{seq,t_2}(i)||^2}}$$



S. El Idrissi Essebtey, L Villard, P. Borderies, T. Koleck, B. Burban and T. Le Toan, "Long-term Trends of P-band Temporal Decorrelation over a Tropical Dense Forest - Experimental results for the BIOMASS mission", IEEE IGRS 2021

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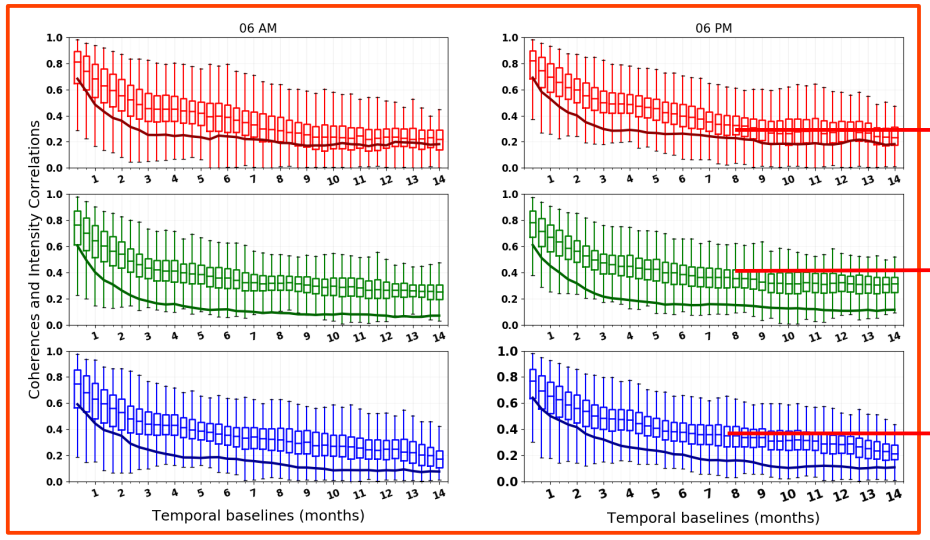
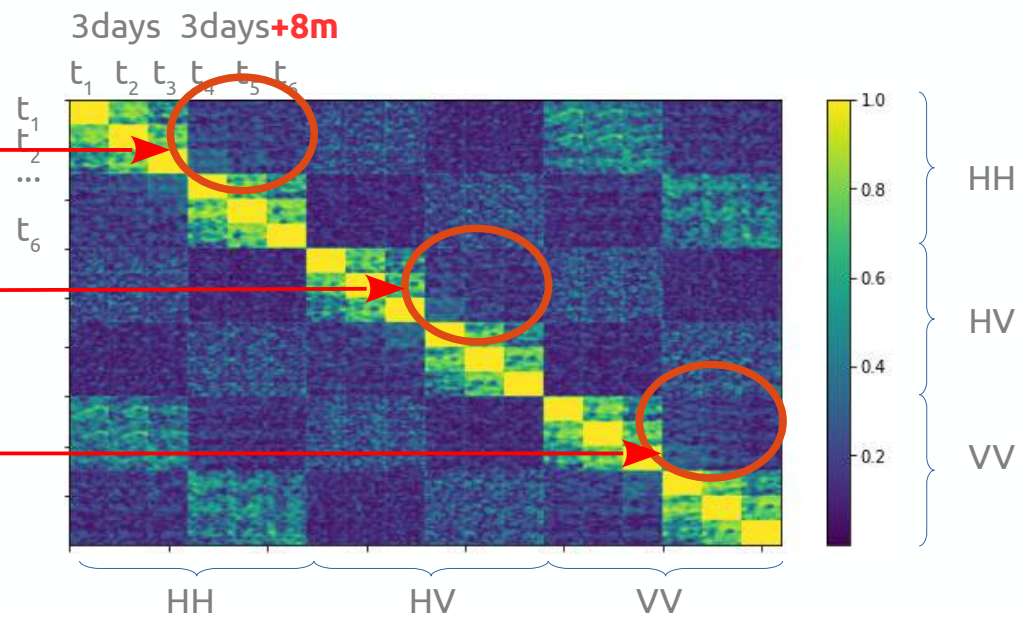
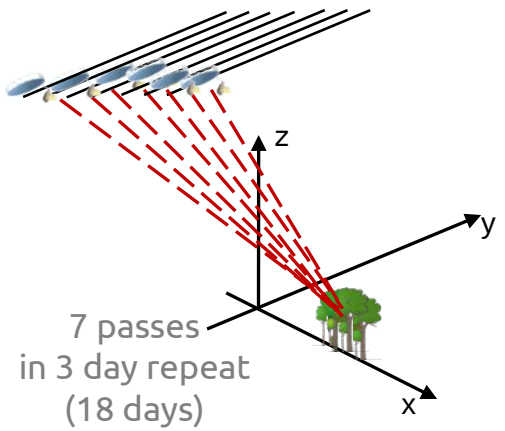


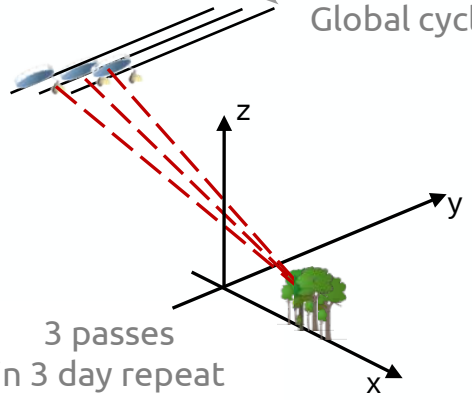


TOM Phase (~16m) | **INT Phase (~40m)**

Global cycle#1 **(~8m)**



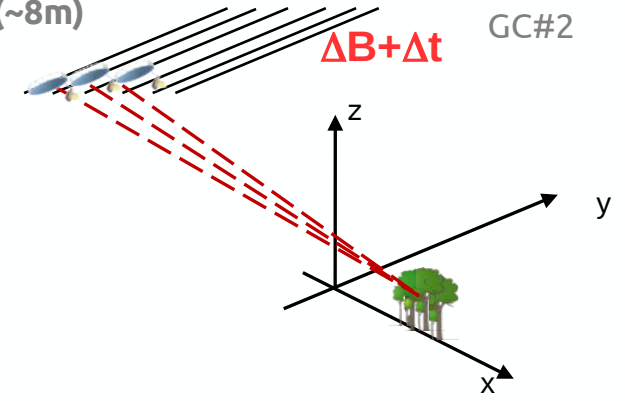
7 passes
in 3 day repeat
(18 days)



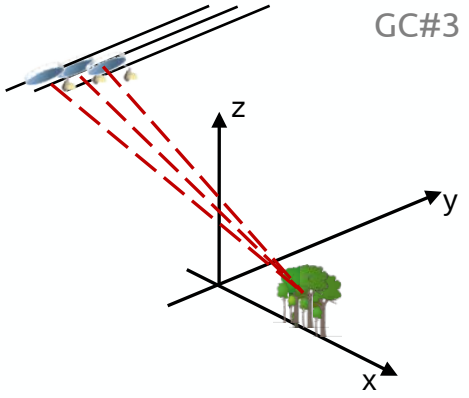
3 passes
in 3 day repeat
(6 days)

ΔB+Δt

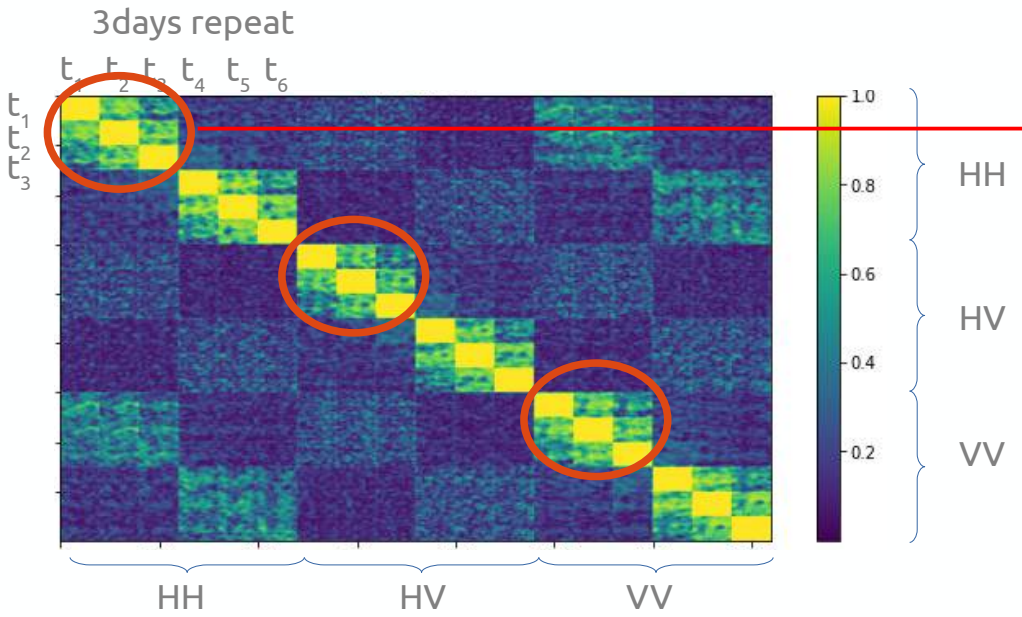
GC#2

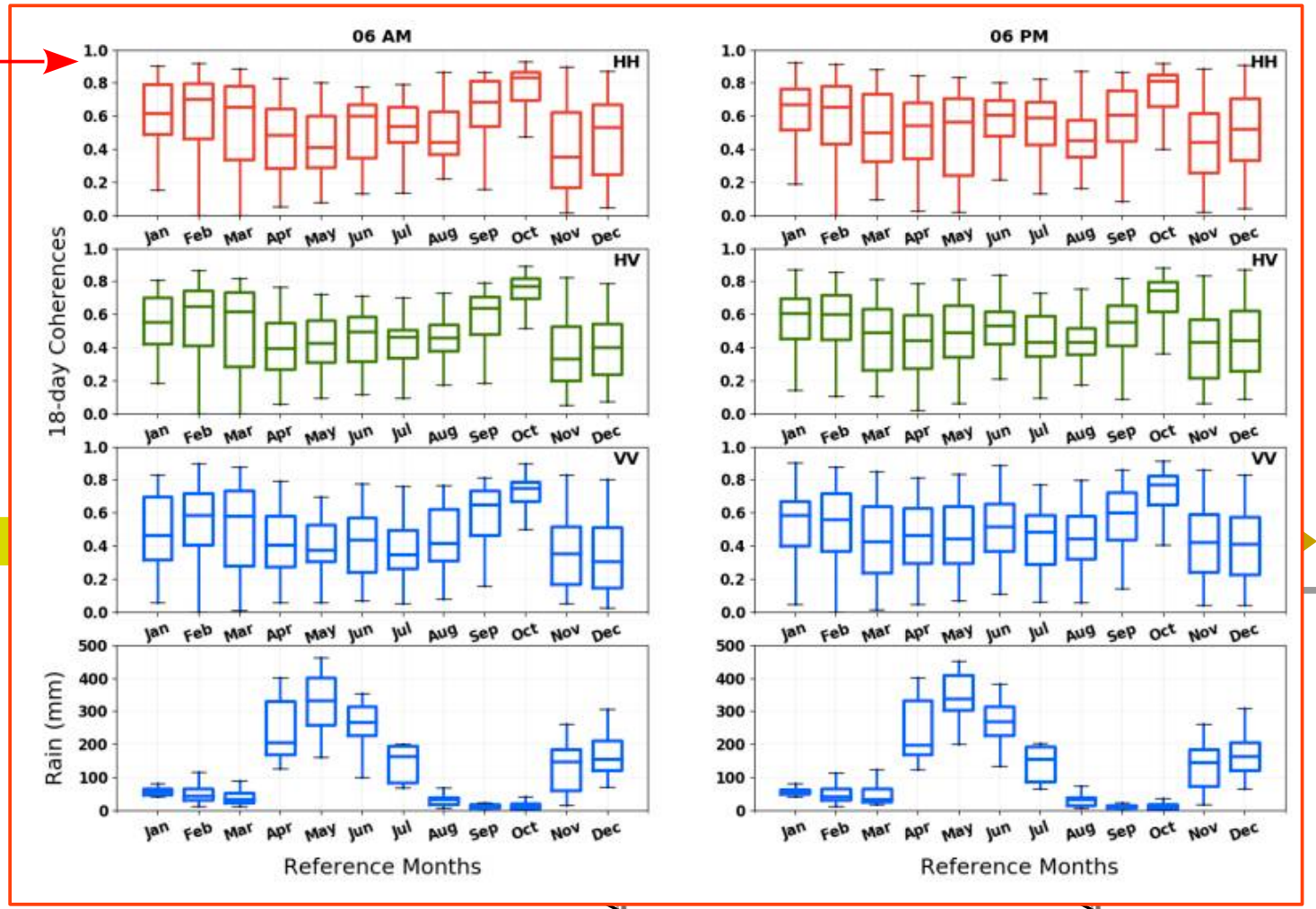


GC#3

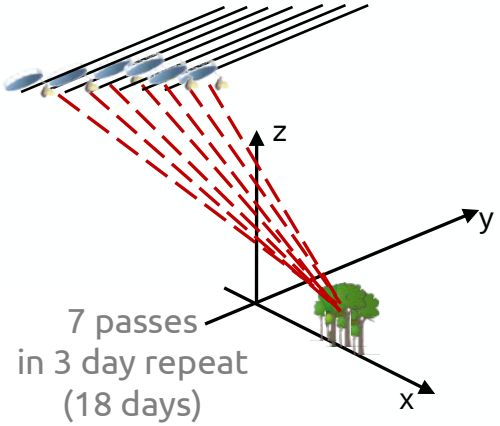


Key results at P-band
→ Temporal decorrelation

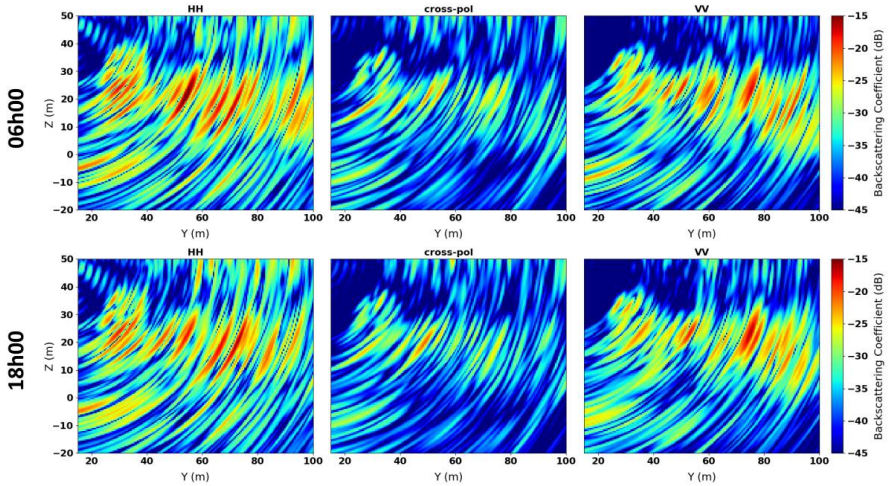


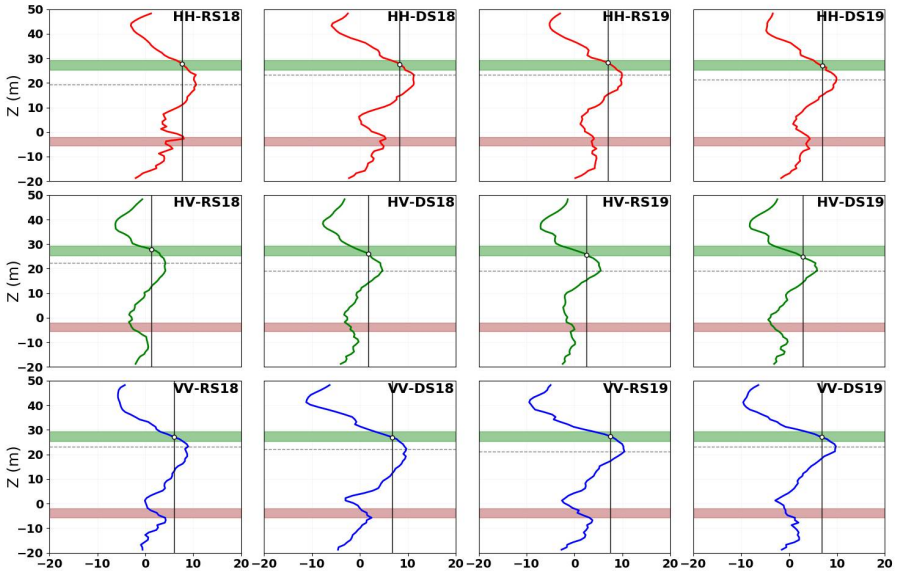


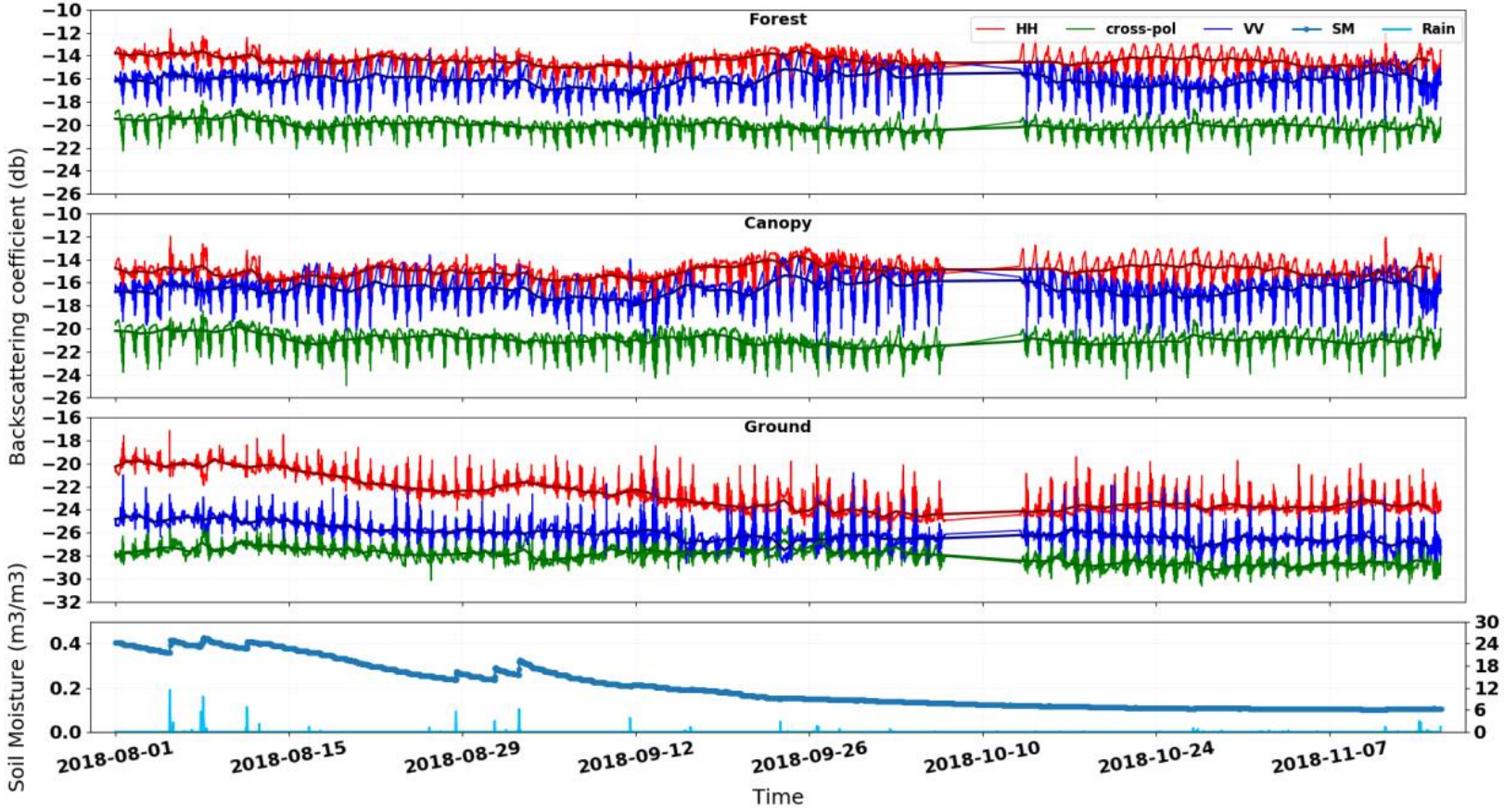
TOM Phase (~18m)



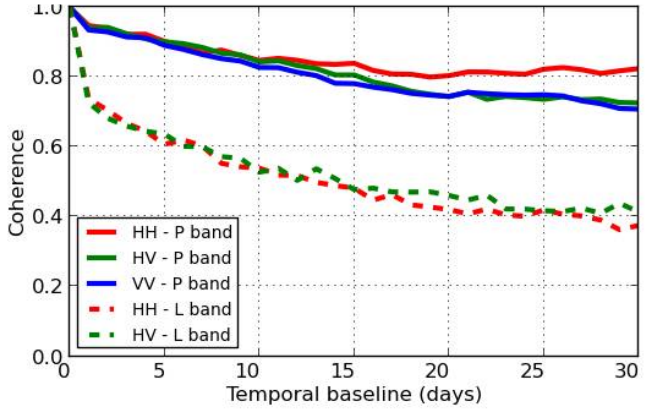
Key results at P-band
→ Evolution of backscattered intensities

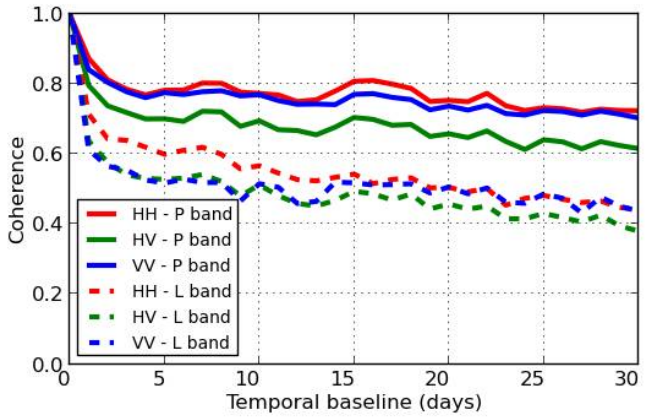




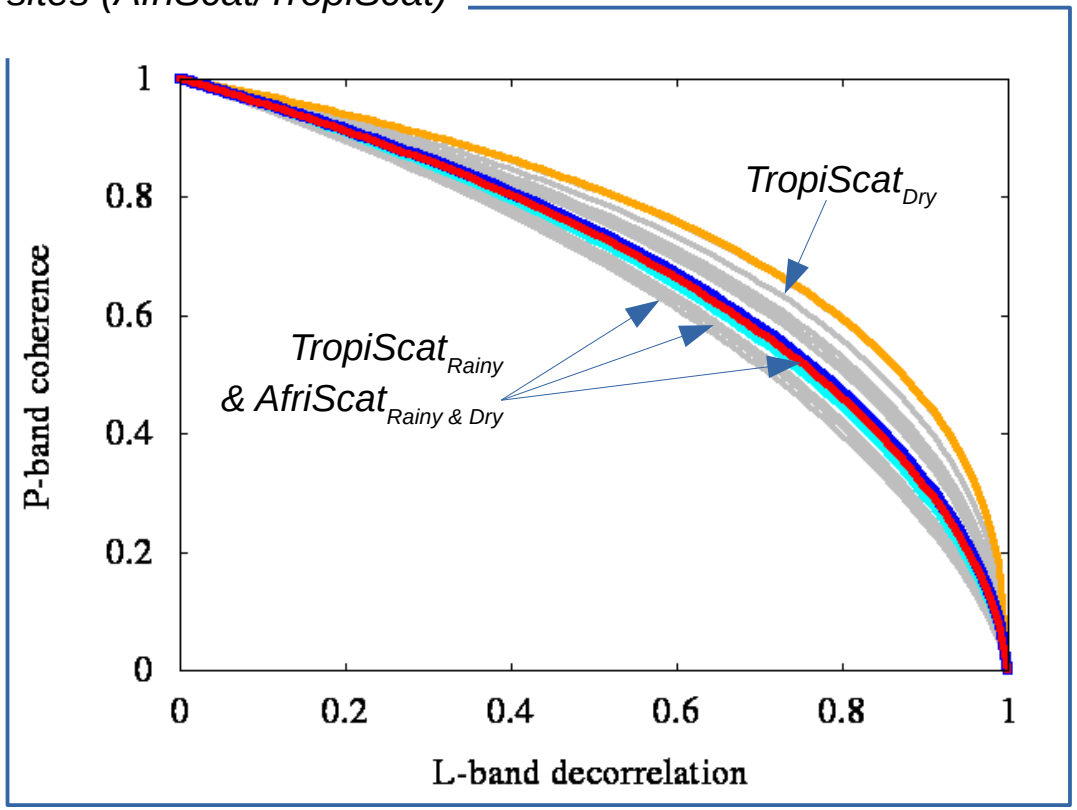


Compared Temporal Decorrelation at P and L bands, for dry & rainy seasons

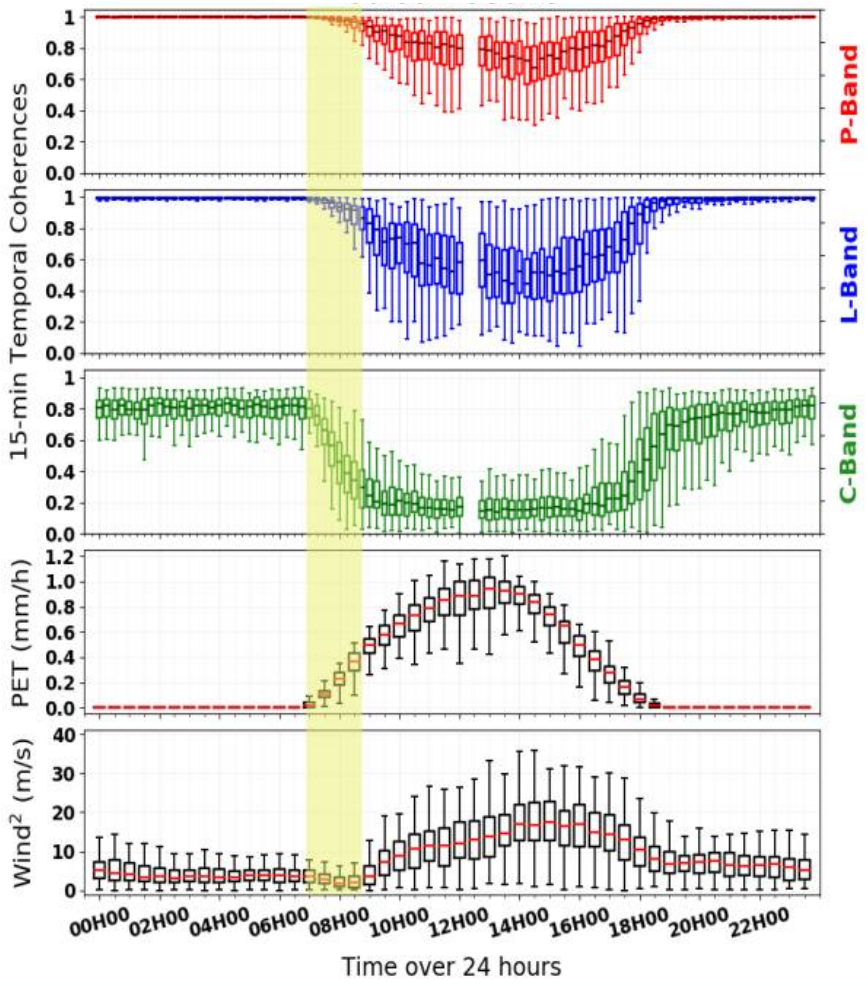




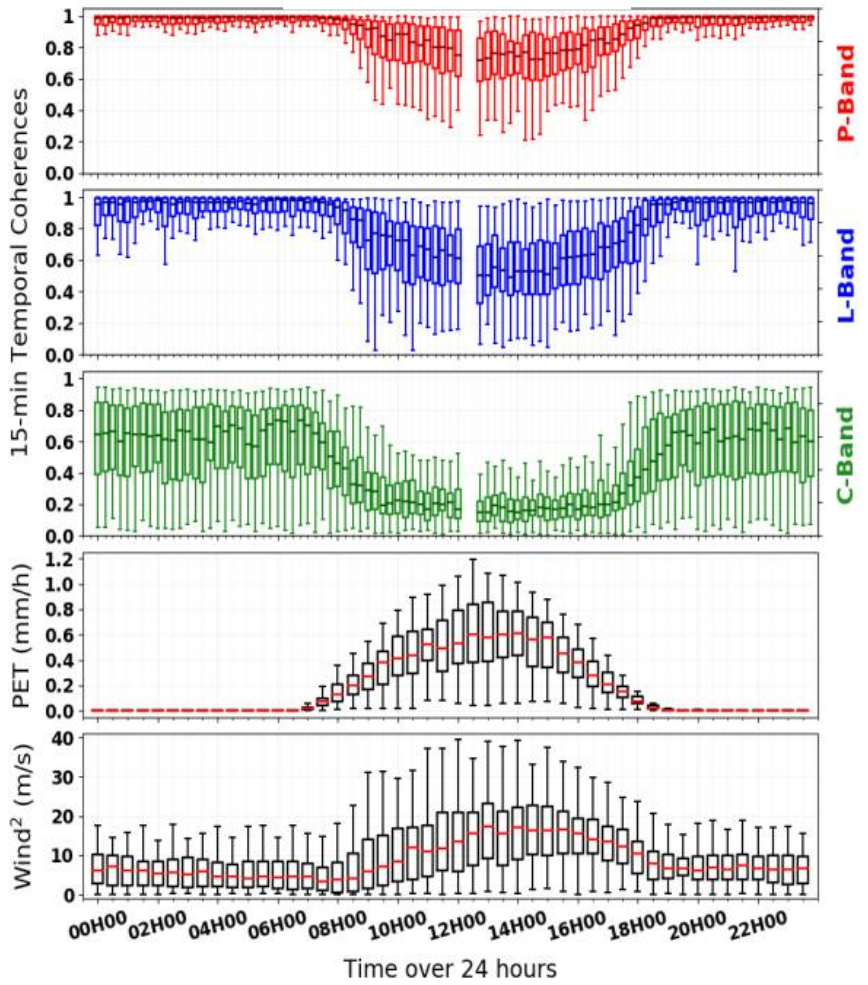
→ testing across periods (dry/rainy) & test sites (AfriScat/TropiScat)



Dry season



Rainy season

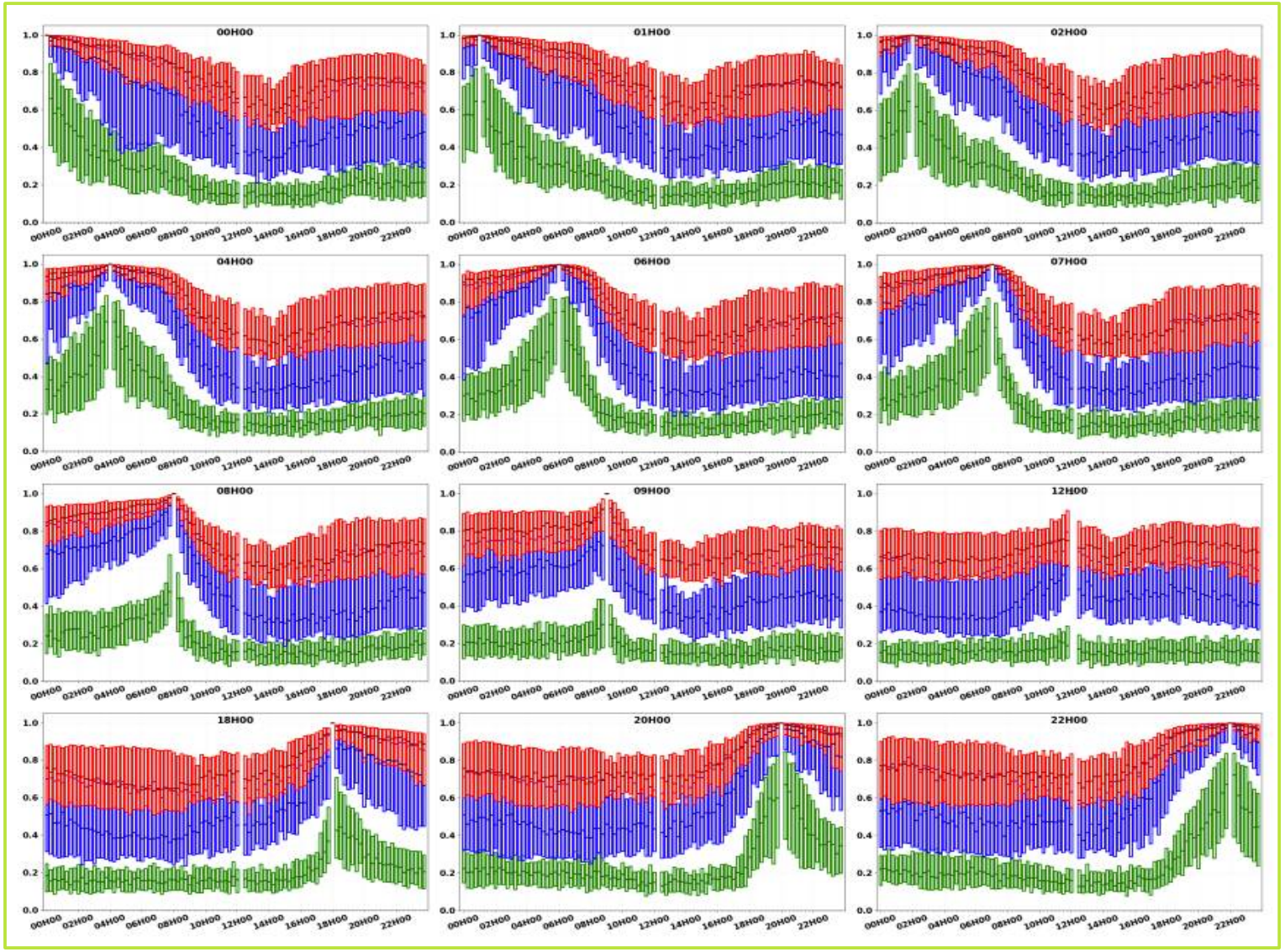


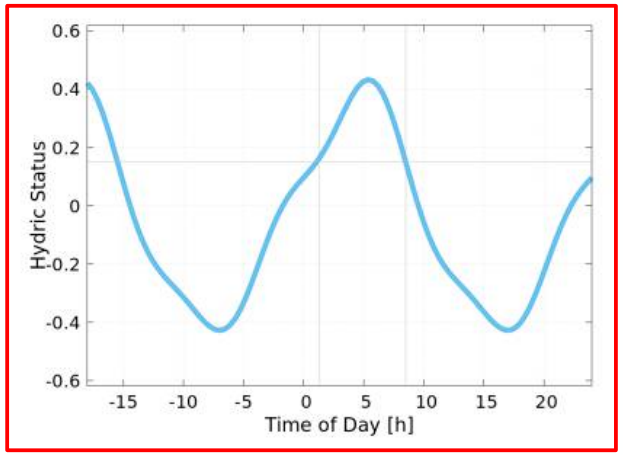
15 min coherences distribution during the day at P, L,C bands

Evapotranspiration

Wind speed

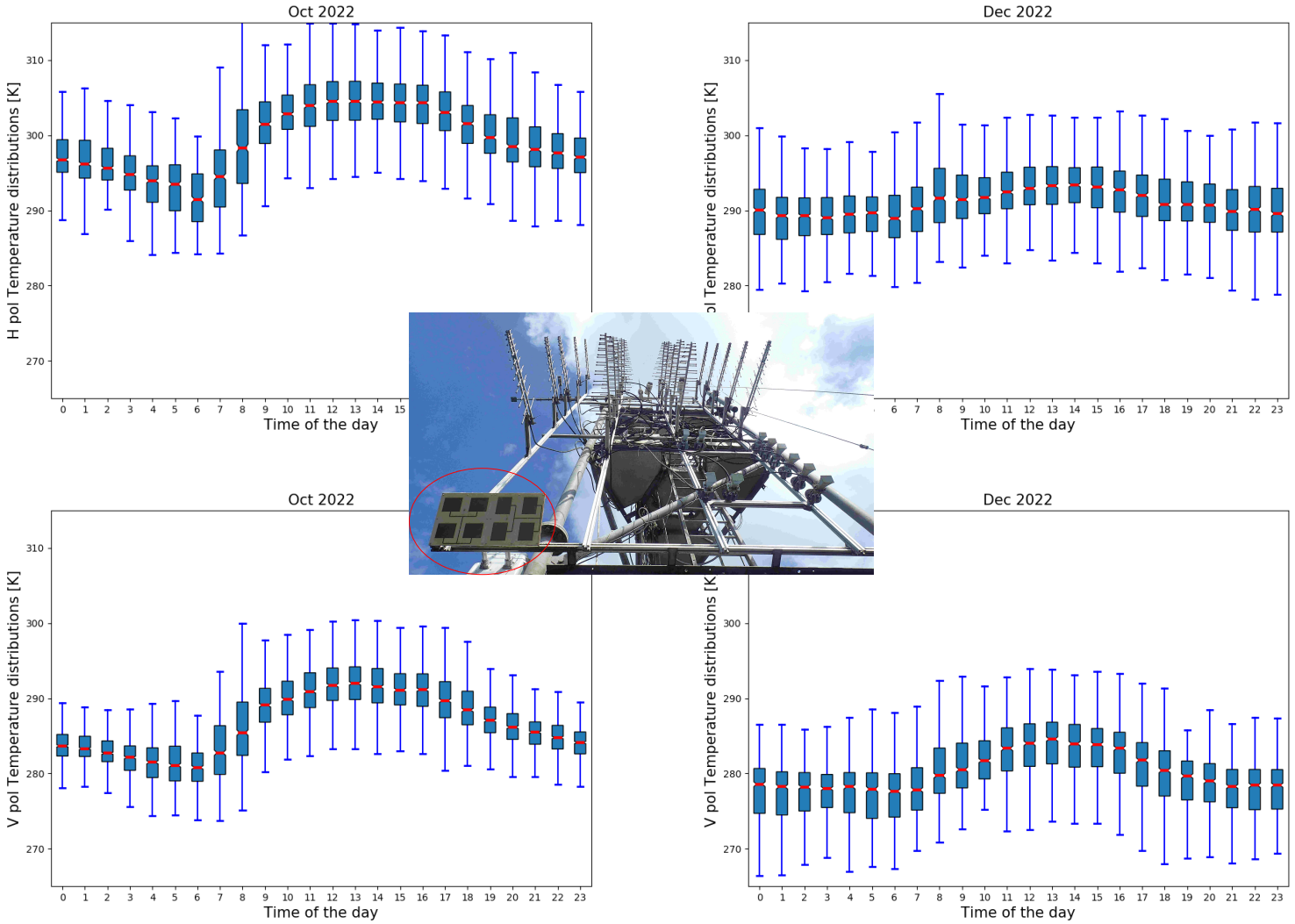
Prospects of synergies
→ High revisit coherences





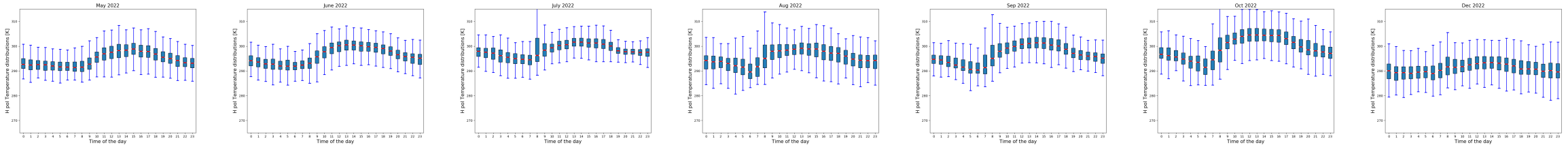
→ reconstructed similarity index ('hydric status') which would explain the sub-daily decorrelation patterns

Prospects of synergies
→ TropiRad : Passive measurements at L-band

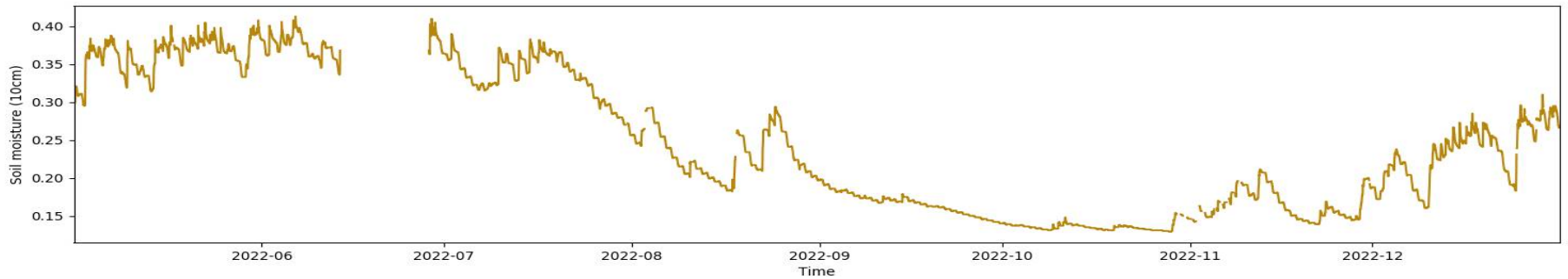


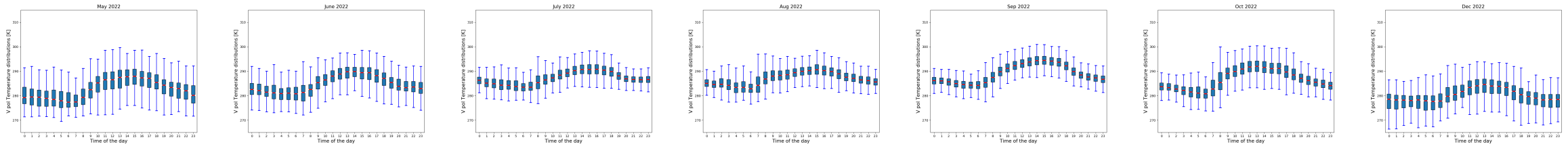
Prospects of synergies
→ TropiRad : Passive measurements at L-band

May 2022 → Dec 2022



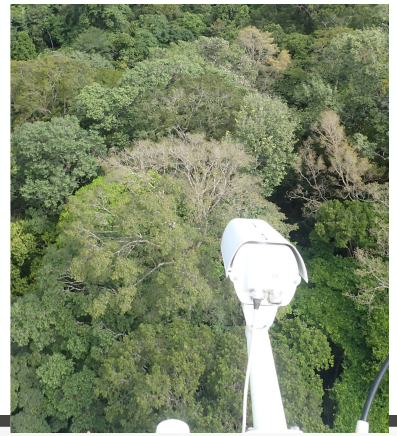
H pol

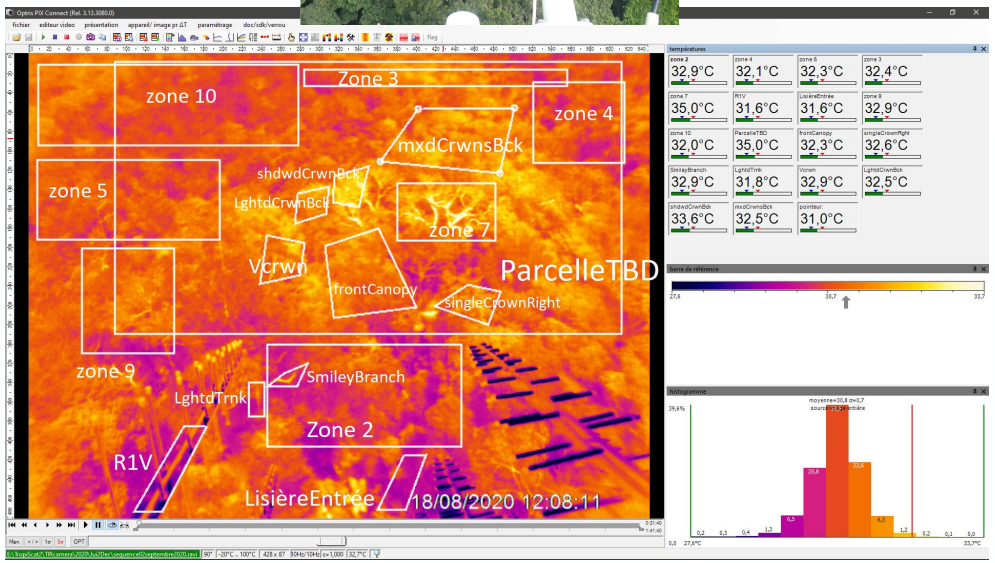


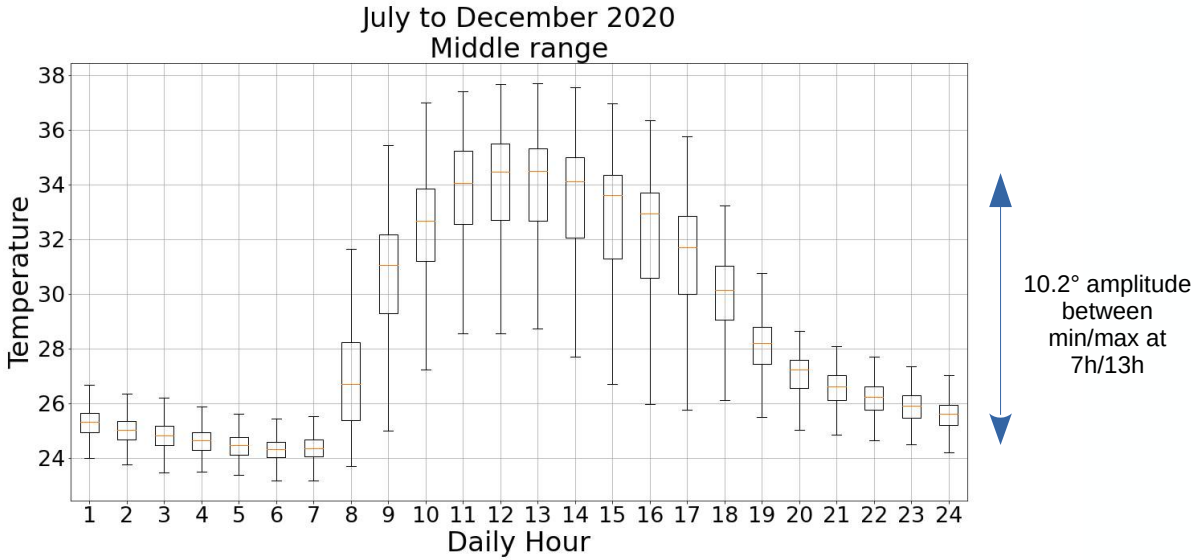


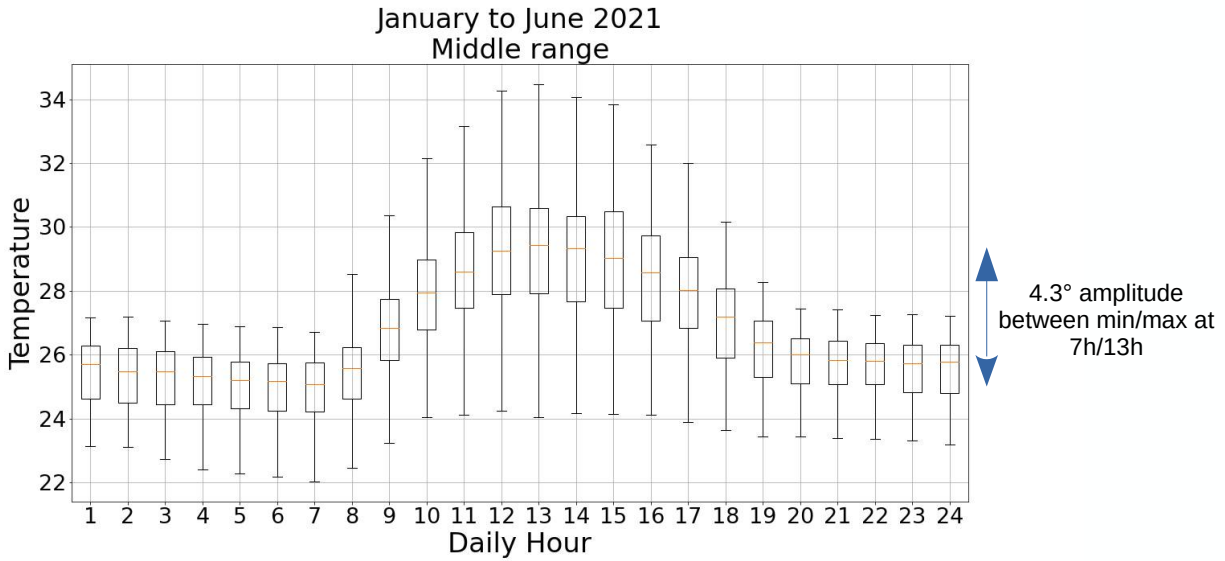
V pol

Prospects of synergies
→ Thermal imaging

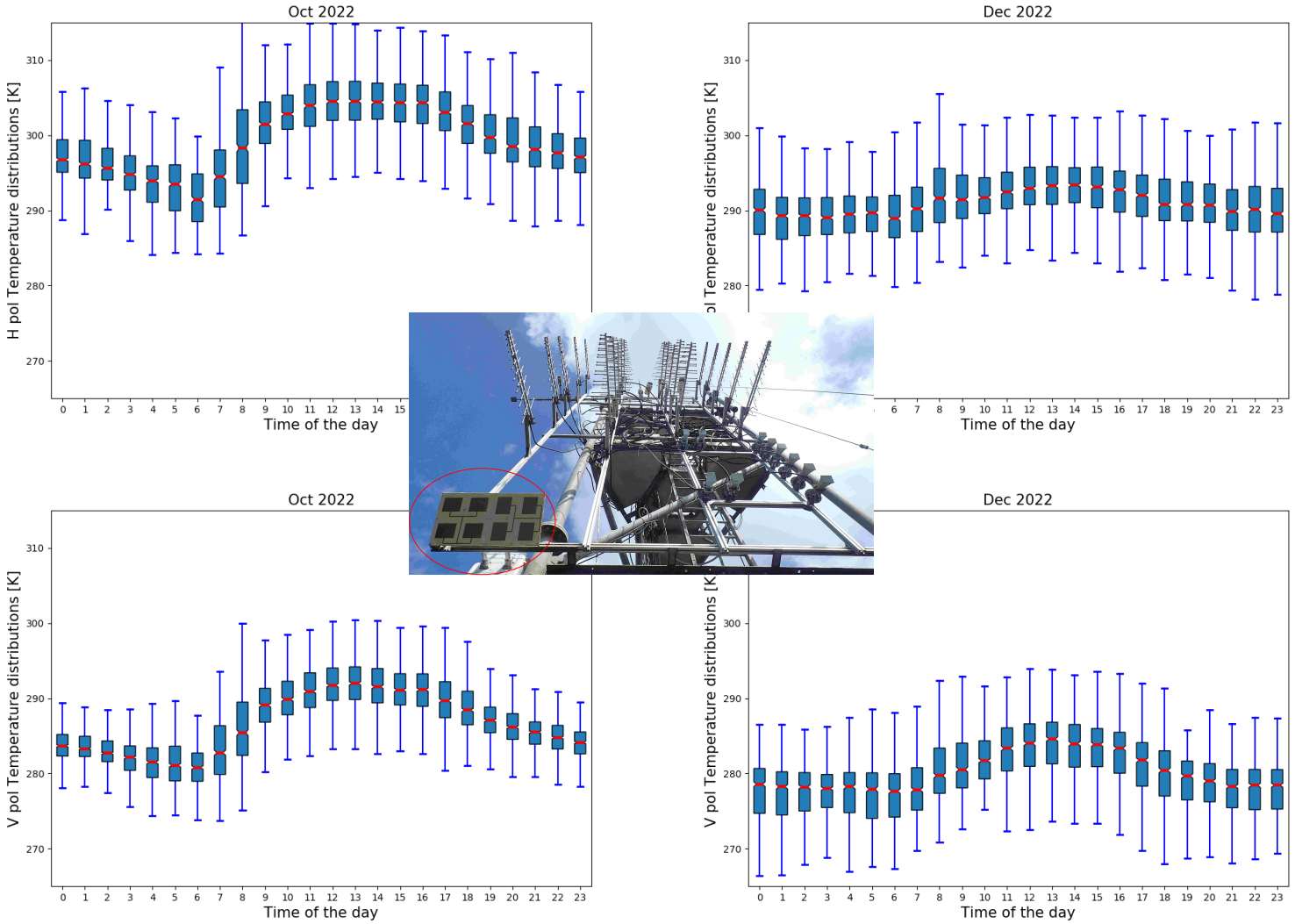




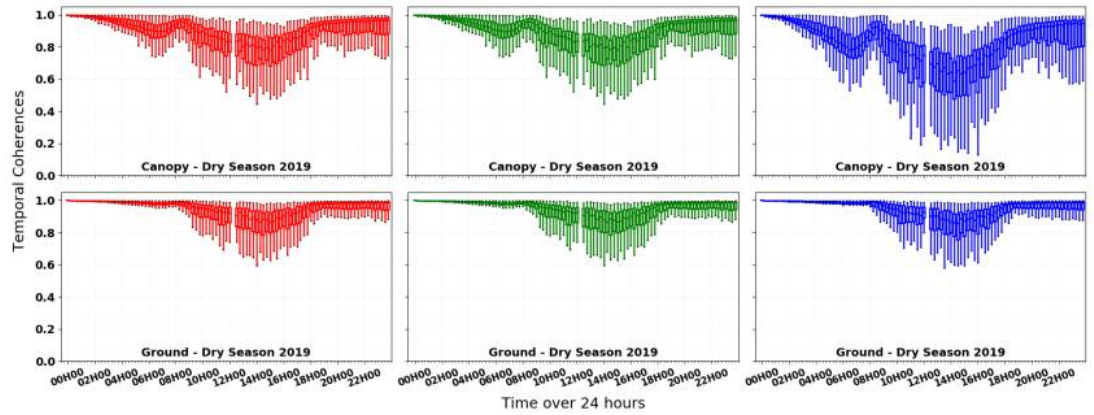




Prospects of synergies
→ TropiRad : Passive measurements at L-band



➢ Spatialisation of the TropiScat P-band data



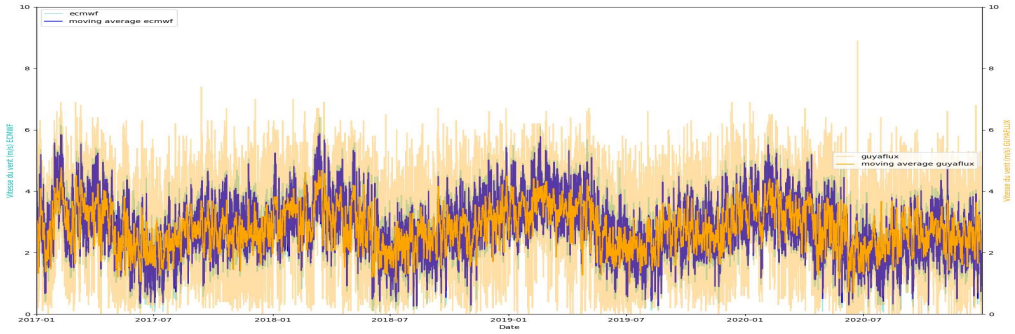
γ_V

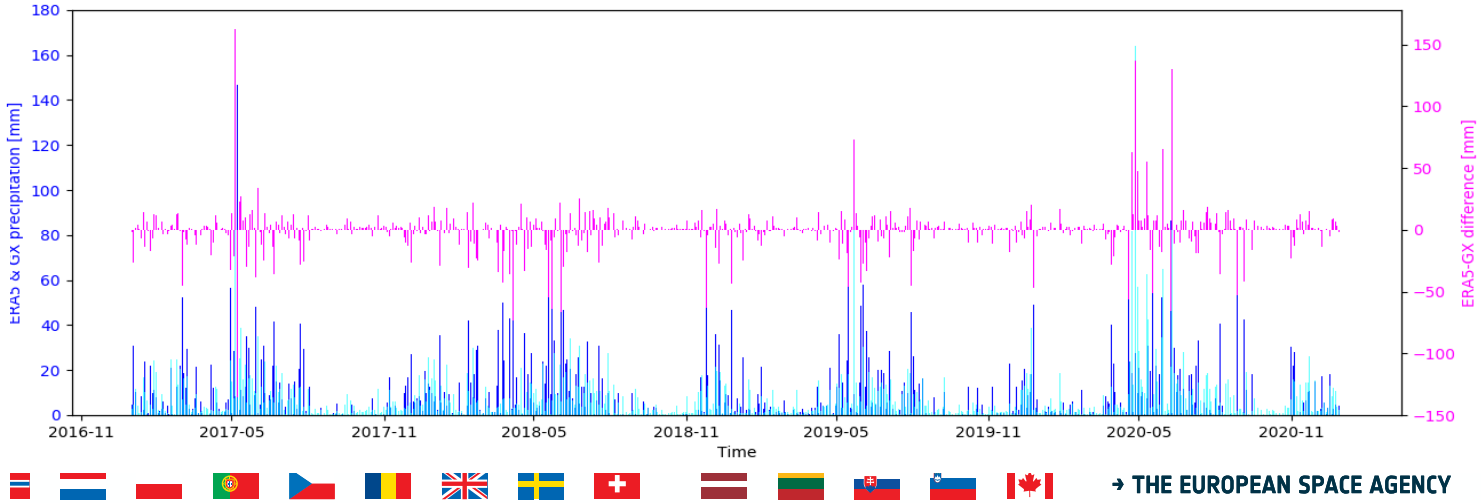
$\gamma_{tot} = \gamma_V / (1+\mu_{qp}) + \gamma_G \cdot \mu_{qp} / (1+\mu_{qp})$

γ_G

➢ Meteo data from EO

* ERA5-Land products (hourly data, 1950 to present):
https://cds.climate.copernicus.eu/#!/search?text=ERA5&type=dataset





Conclusions & further propects

- A key milestone achieved with 5 years (Biomass lifetime) of TropiScat data, including tomographic P-band data **plus** quasi simultaneous L and C-bands data, providing a very unique database to anticipate the effects of temporal variability

- In addition to the vertical structure analysis, the Tomographic capabilities enable to to spatialize the results to other forest structure (through the G/V ratio), **but** according to the meteorological conditions during these 5 years (far from stationary), going ahead is essential to increase the diversity of environmental factors, esp. with CC effects (cf. reduced dry seasons)

- Beyond Biomass related results, TropiScat-2 enable to highlight the added value of quasi sim L & C and high revisit (sub daily) to better caracterize VWC & ET, and that estimating dry biomass can not bypass fresh matter...