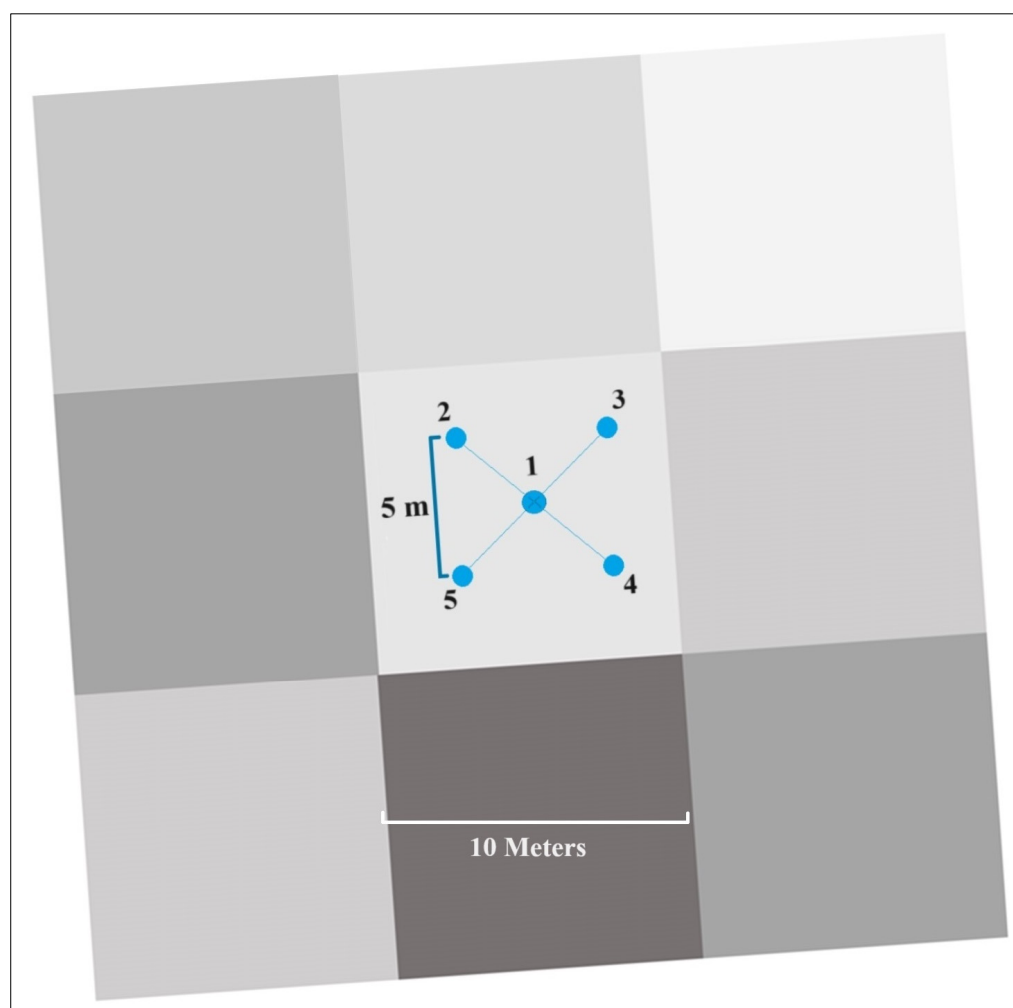
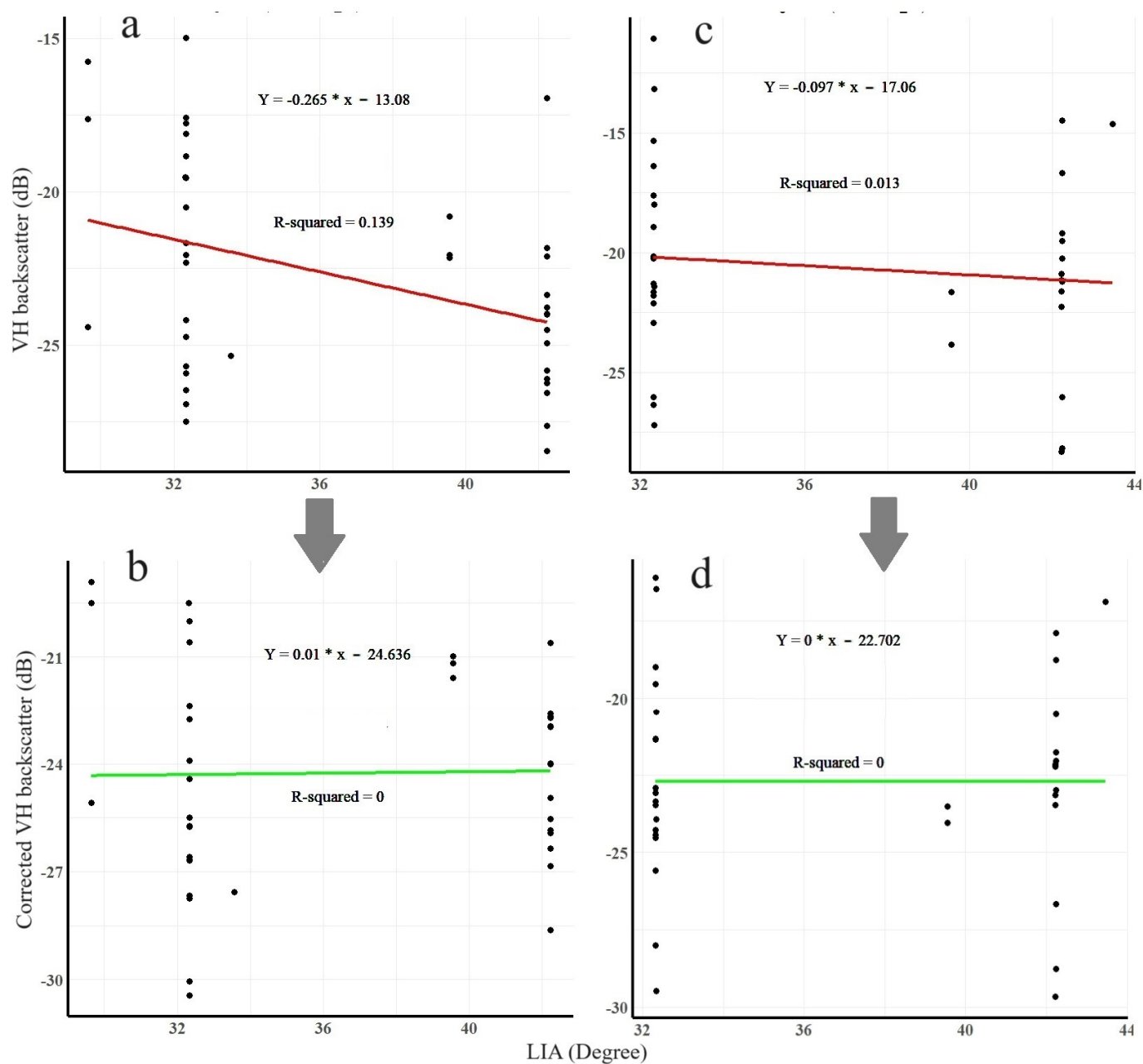


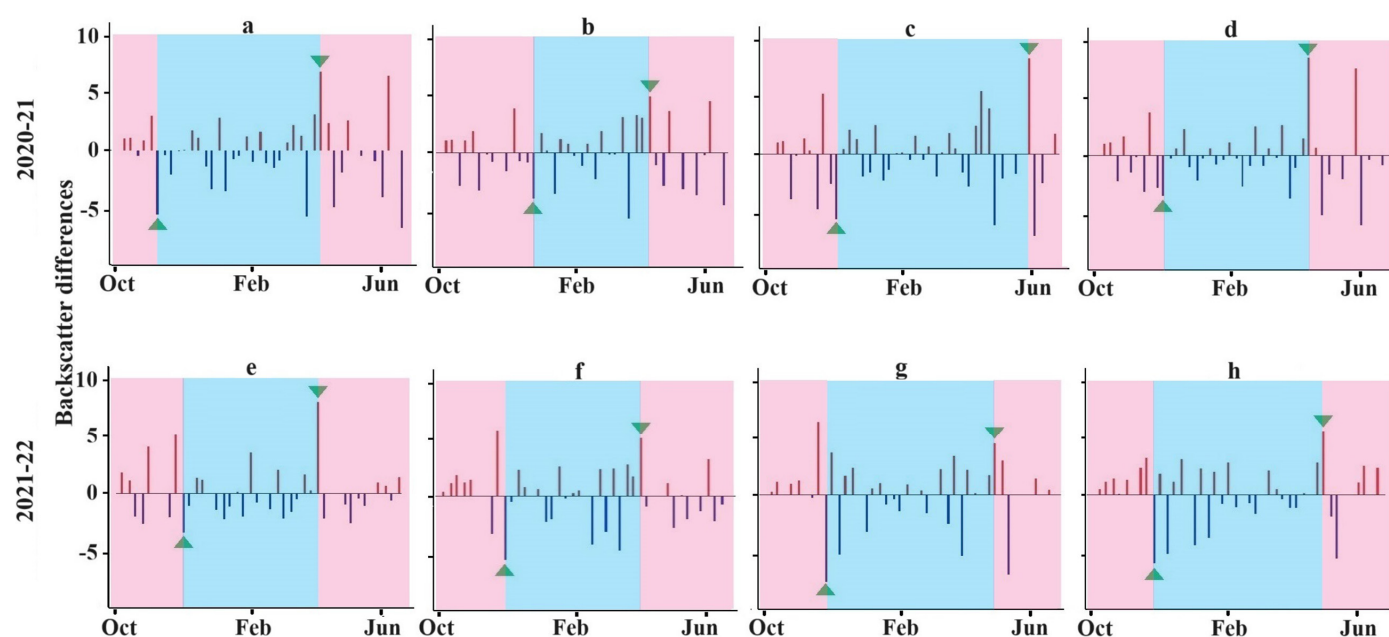
## Supplementary Material



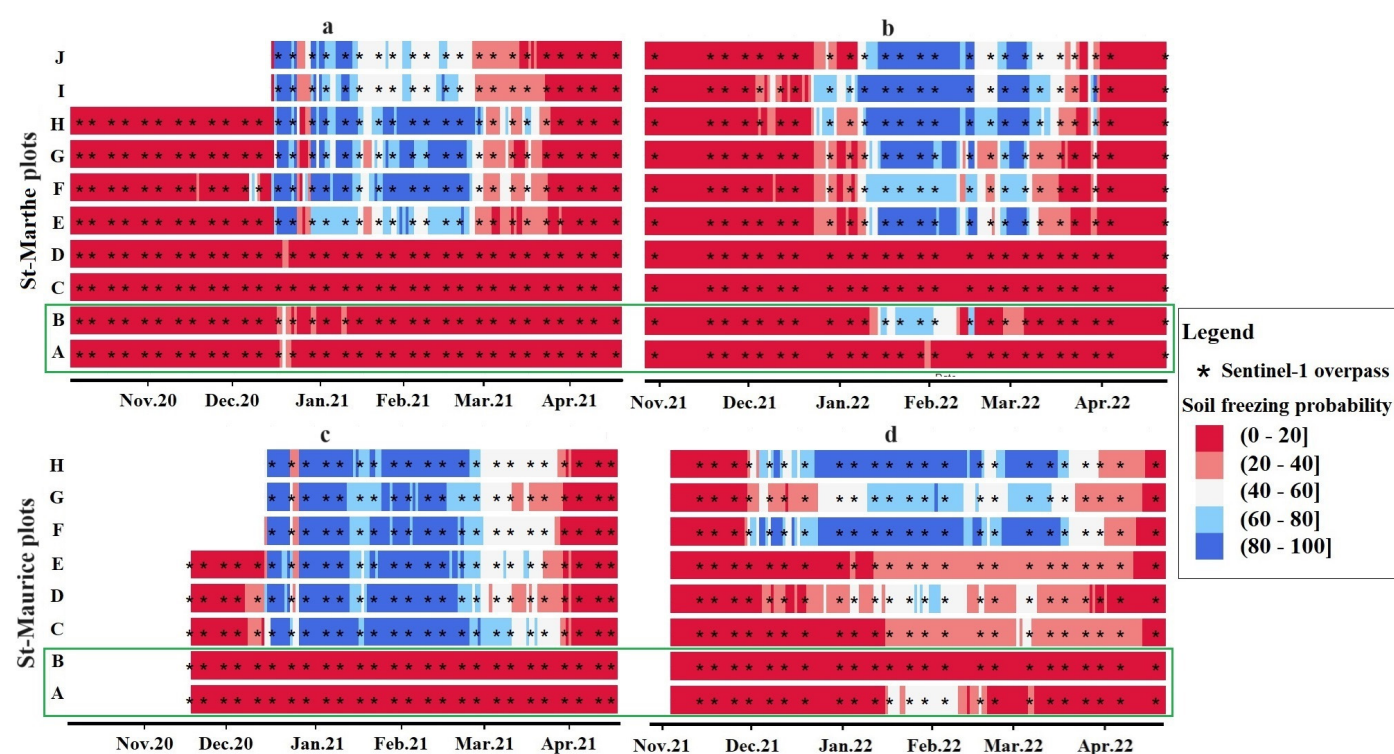
**Figure S1.** Schematic representation of the measurement configuration for soil temperature measurements (2 cm and 10 cm depths), aligned with the Sentinel 1 pixel size of 10 meters. The geometry of the configuration includes five soil pits (blue points) arranged in a cross shape with a distance of 5 meters between each pit.



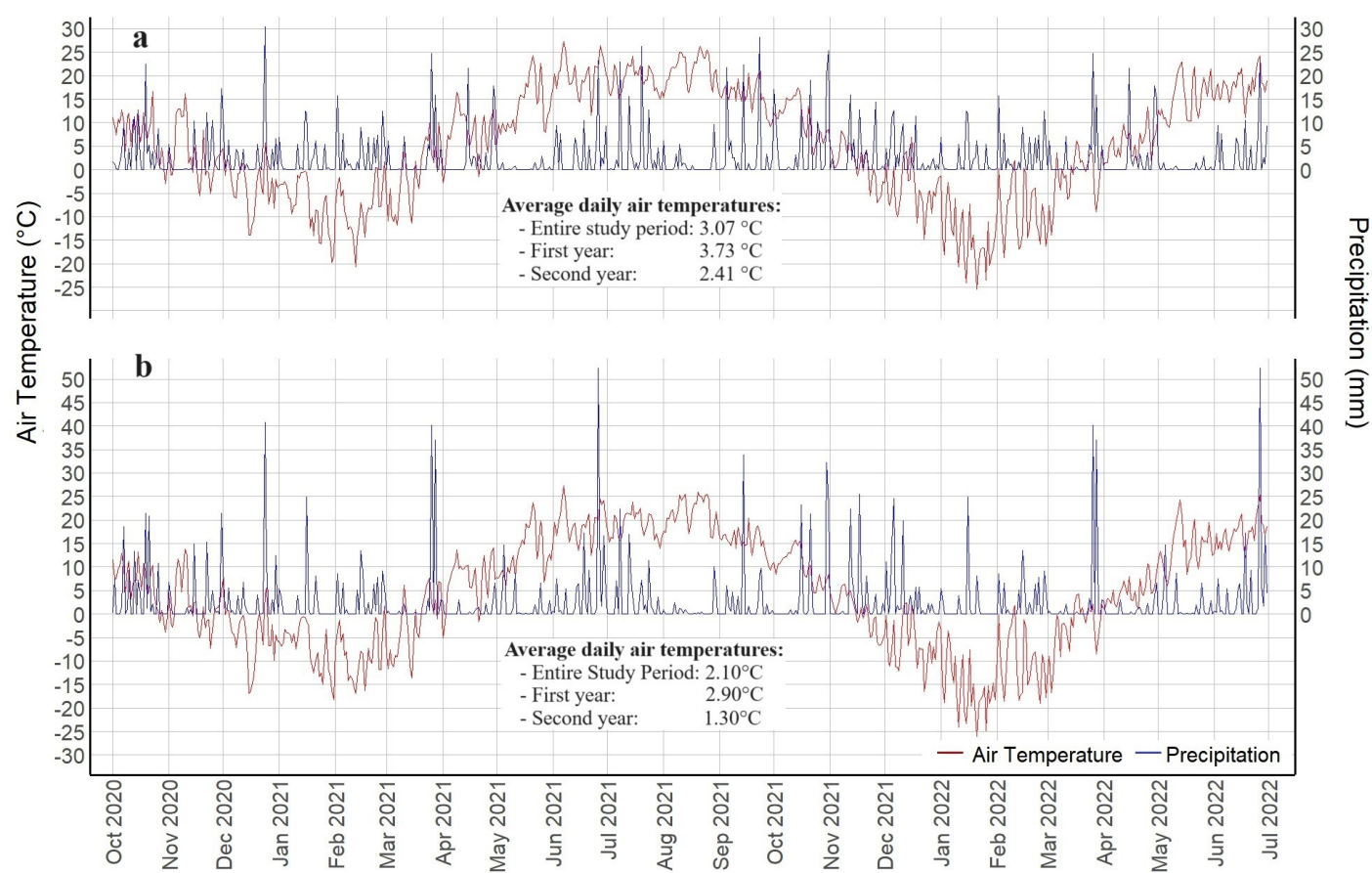
**Figure S2.** Correction of local incidence angles in St-Maurice's C plot with the corresponding linear equation. **(a)** VH backscatter before correction in 2020-21. **(b)** The corrected VH backscatter in 2020-21. **(c)** VH backscatter before correction in 2021-22. **(d)** The corrected VH backscatter in 2021-22. **Note:** The range of backscatter values under the same LIA reflect temporal variations due to soil freeze-thaw, as well as potential wetting/drying effects during the shoulder seasons and changes in surface roughness. The near-zero slope in the regression equation indicates that, following LIA correction, the backscatter signal remains stable across varying incidence angles. The zero R-squared value post-correction highlights the effectiveness of the LIA correction method in reducing incidence angle dependency.



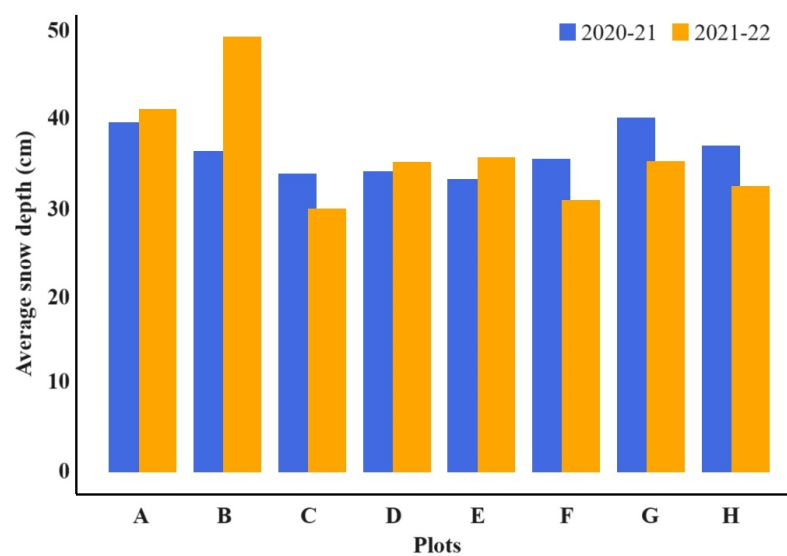
**Figure S3.** Examples of the approach used to identify the soil freezing and thawing transitions in backscatter signals in the of the EFTA method. The most negative backscatter differences (upward green triangles) before February represents the most probable onset of the freezing period (delineated in light blue), while the most positive difference (downward green triangles) after February represent the most probable onset of soil thawing (delineated in light red). (**a, b, c, and d**) correspond to St-Marthe's I and J plots and St-Maurice's G and H plots, respectively, for the year 2020-21. (**e, f, g, and h**) correspond to St-Marthe's I and J plots and St-Maurice's G and H plots, respectively, for the year 2021-22.



**Figure S4.** Spatial and temporal variations in freezing probability (10 cm) along with corresponding the S1 overpass for all agro-forest plots in St-Marthe. (a and b) FT variations based on freezing probability in St-Marthe's plots over two study periods (2020-21 and 2021-22). (c & d) FT variations based on freezing probability in St-Maurice's plots over two study periods (2020-21 and 2021-22). In each site, forest plots are represented by A and B plots (green rectangle). For St-Marthe's J and I and St-Maurice's F, G, and H plots, the initiation of soil temperature monitoring started later, resulting in an absence of freezing probability values.



**Figure S5.** Time series plot of daily precipitation and air temperature, October 2020 to June 2022, for two study sites. **(a)** St-Marthe. **(b)** St-Maurice. Note: the average daily air temperatures for the entire study period, as well as for the first and second years (October to June), were calculated for both St-Marthe and St-Maurice.



**Figure S6.** Average snow depth (meters) in agro-forested plots of St-Maurice over two study years in 2020-21 and 2021-22. Plot classification: 'A' and 'B' as forest plots; 'C' to 'H' as agricultural plots. Measurement period: End of November to March each year. Method: Using snow ruler, snow depth recorded at five points within a 5m x 5m square per plot, including a central point. Calculation: Average of five measurements per plot, aggregated to represent overall snow depth for each plot.