identitas

Remotely monitored animal behaviour using sensor ear tags on cattle in Switzerland

K.Ueda, U. Heikkilä, N. Gobbo Oliveira Erünlü, S. Rieder

Framework: Study to evaluate usability of a digital sensor ear tag product under Swiss conditions and Swiss requirements

12.12, "Remote monitoring of cattle using sensor ear tags" (S.Rieder)
53.14, "Social network analysis of cattle and horses inferred from sensor ear tag (SET) and GPS based data" (U.Heikkilä)

1) Background: study setting and technology
2) Individual behaviour, high-frequency BLE data
3) Remote monitoring data from Alpine herds
4) Outlook / ongoing trials

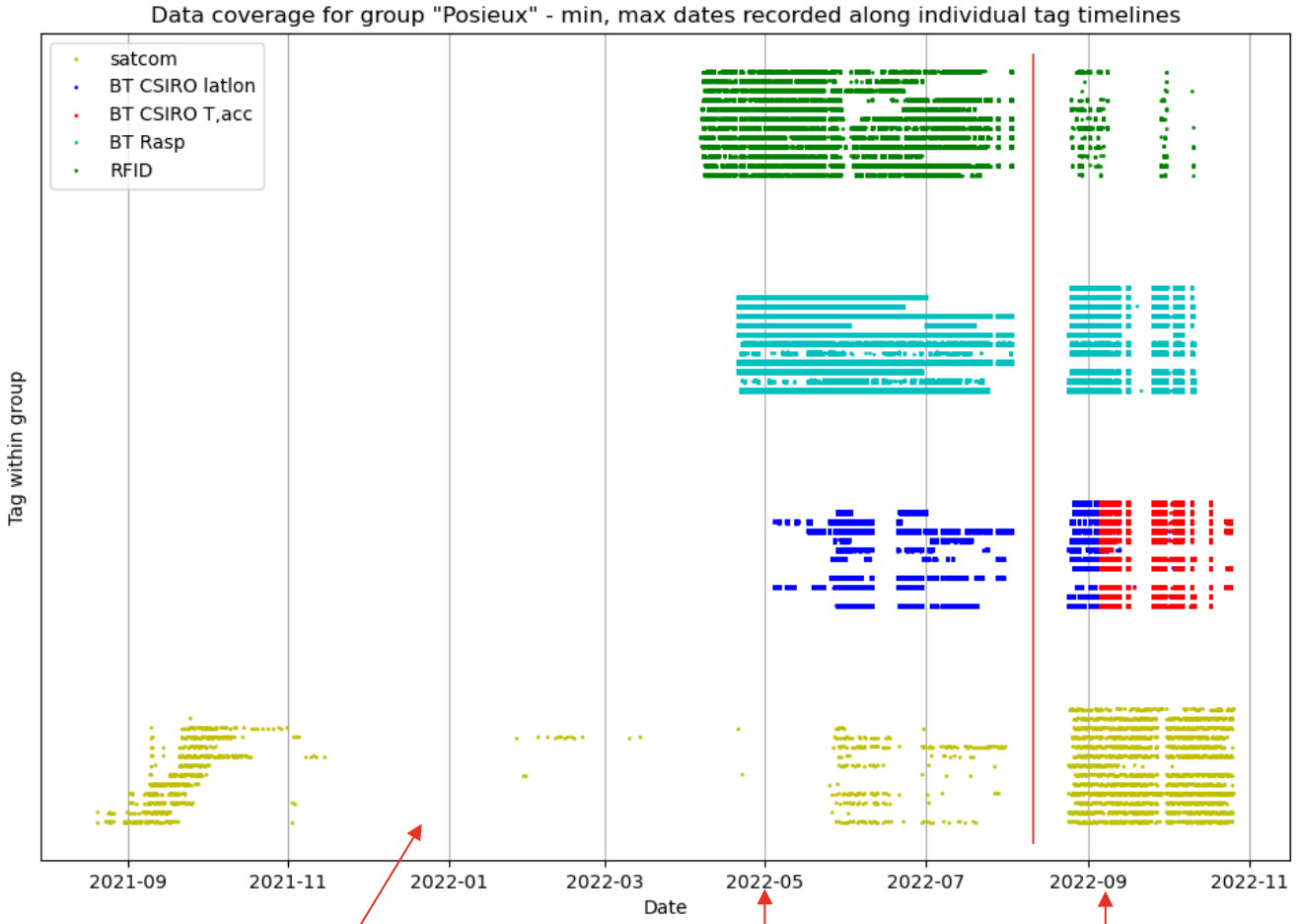
Acknowledgements

Colleagues @ Agroscope
Colleagues @ Identitas

CSIRO, Data61, Ceres

Funding: FOAG/BLW/OFAG

1) Data acquisition sensor ear tag



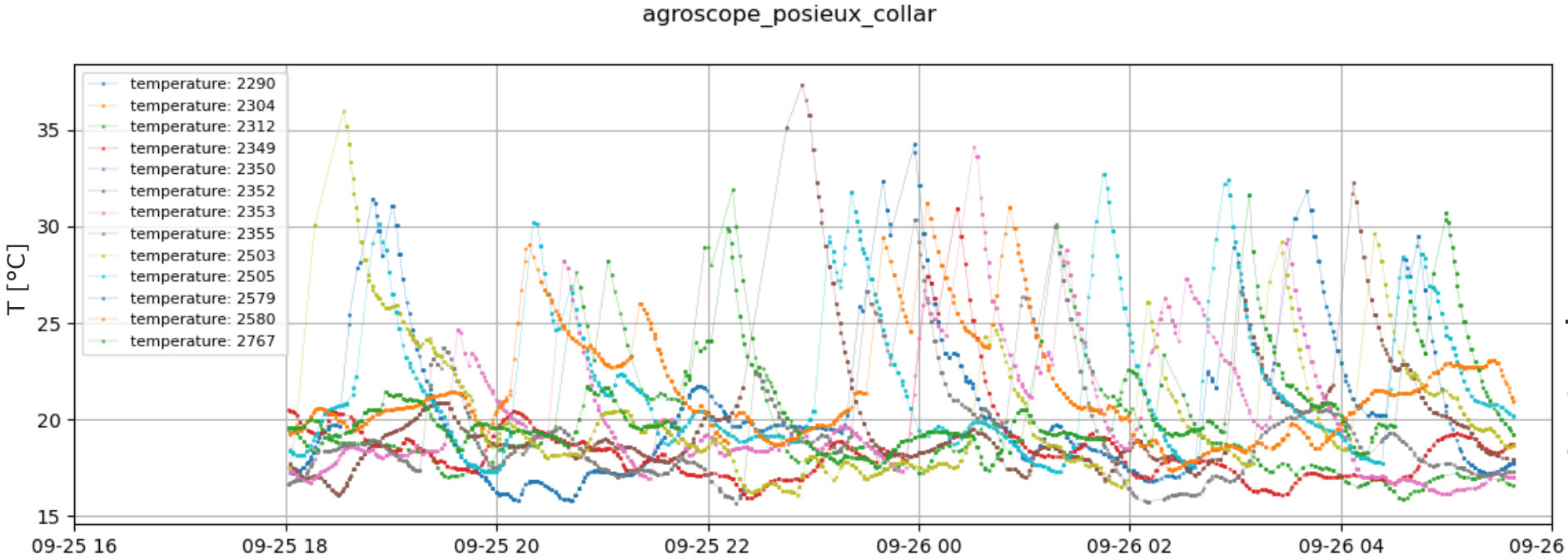
Barn-dominated winter

All channels set up (ear)

Maximum data (collar)

August 2022

2) BLE data – temperature … ?

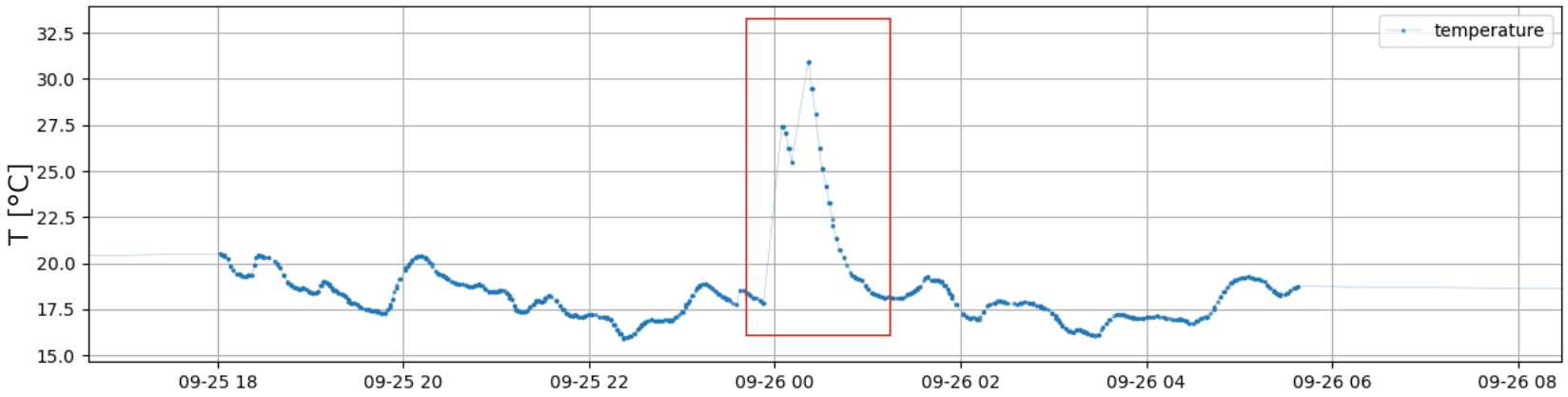


No diurnal signal?

Spread of 5-20°C

Too noisy for quantitative analysis …?

Superimposed signals:

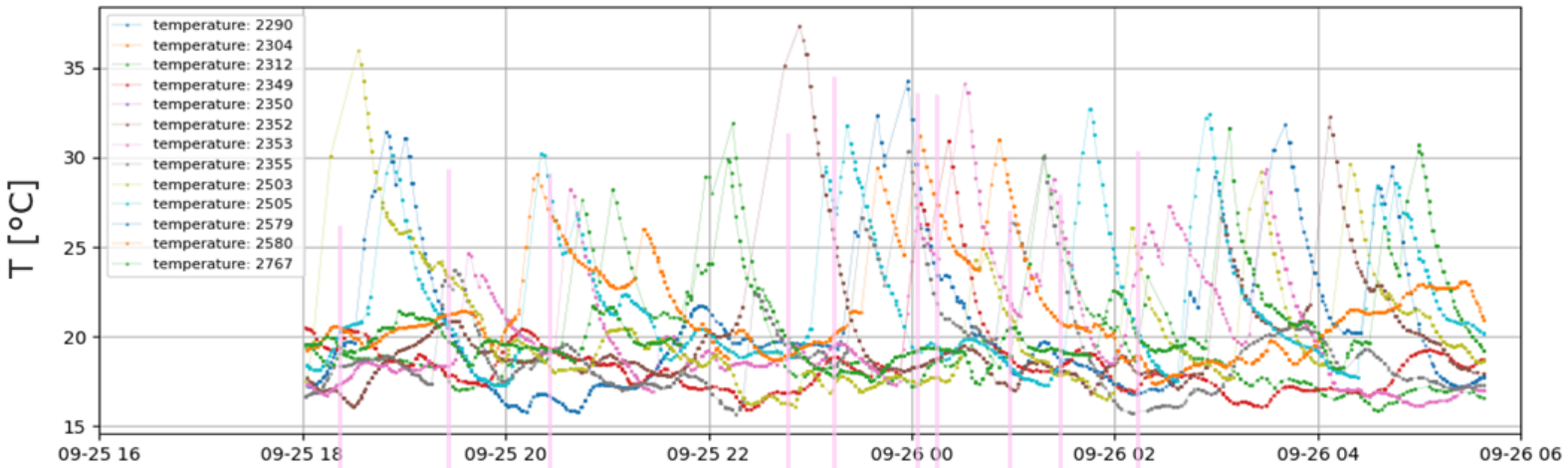


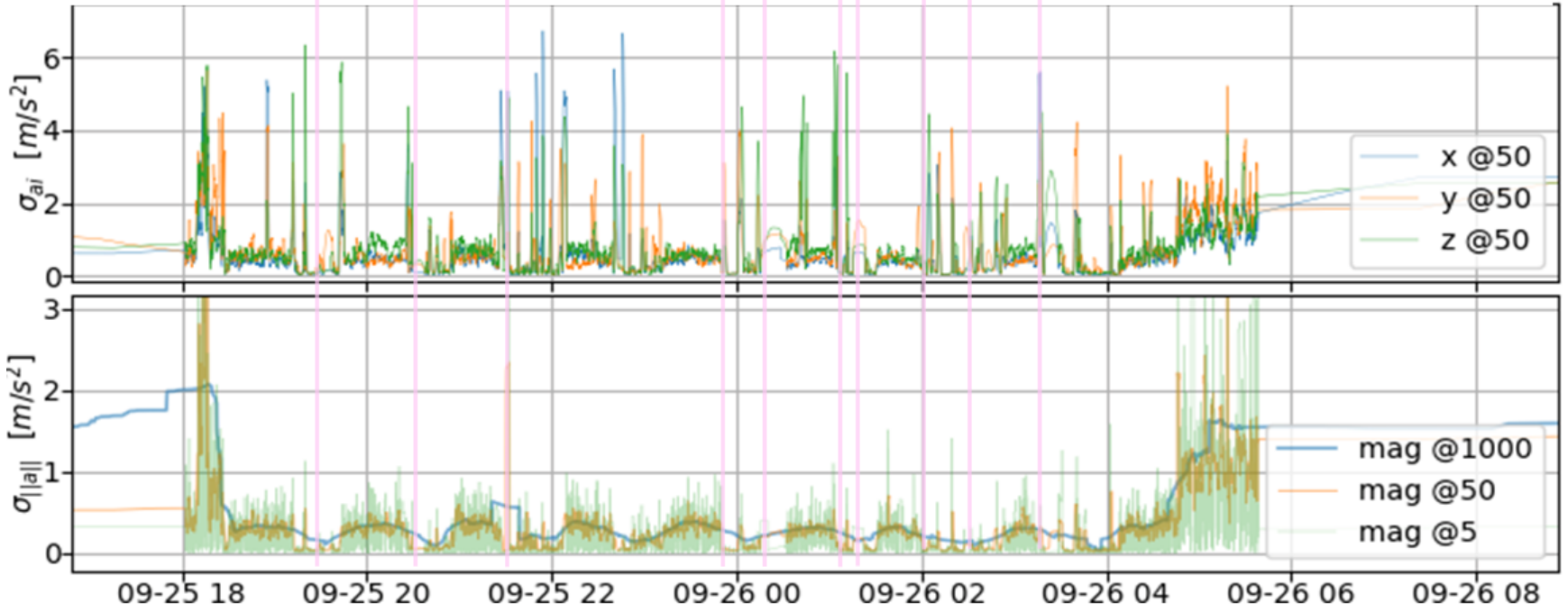
”Jumps”, increases of >10°

~ exponential decay

(=> cooling)

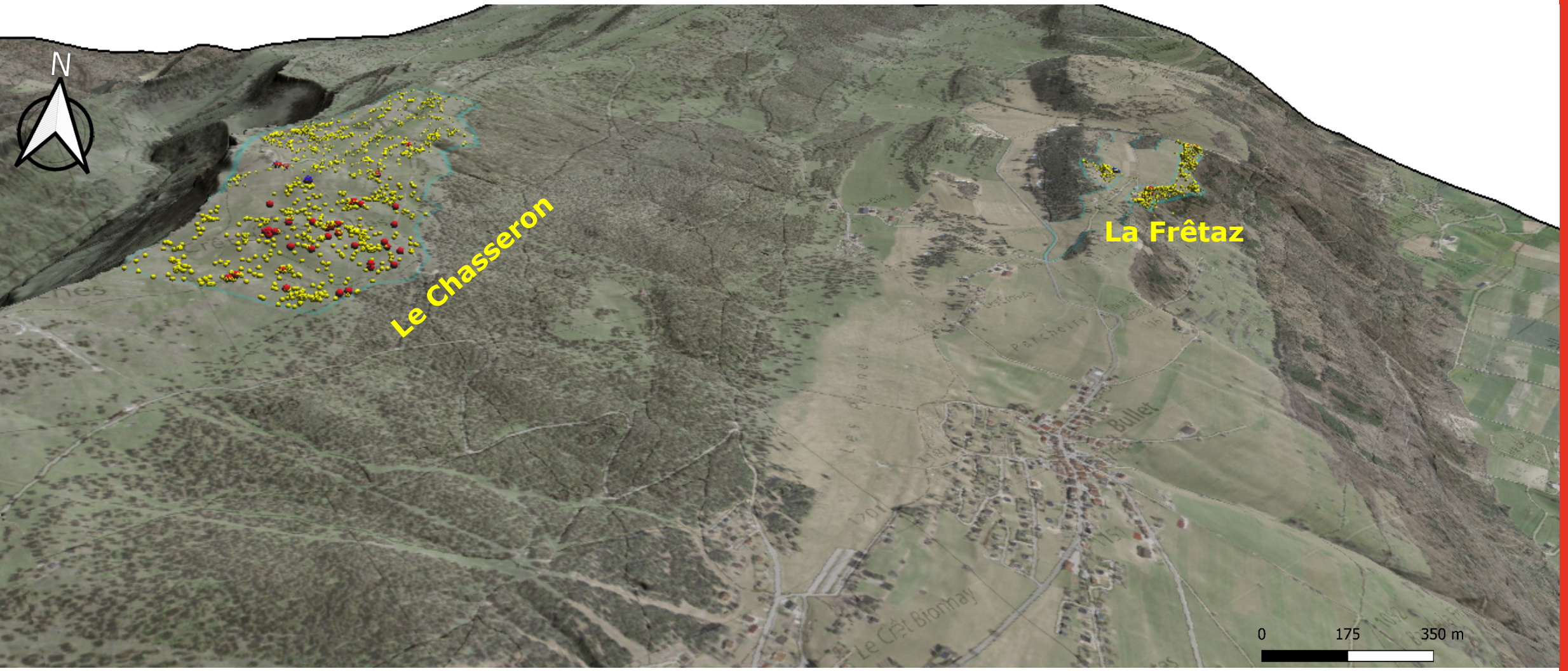
2) Behaviour – nightly activities



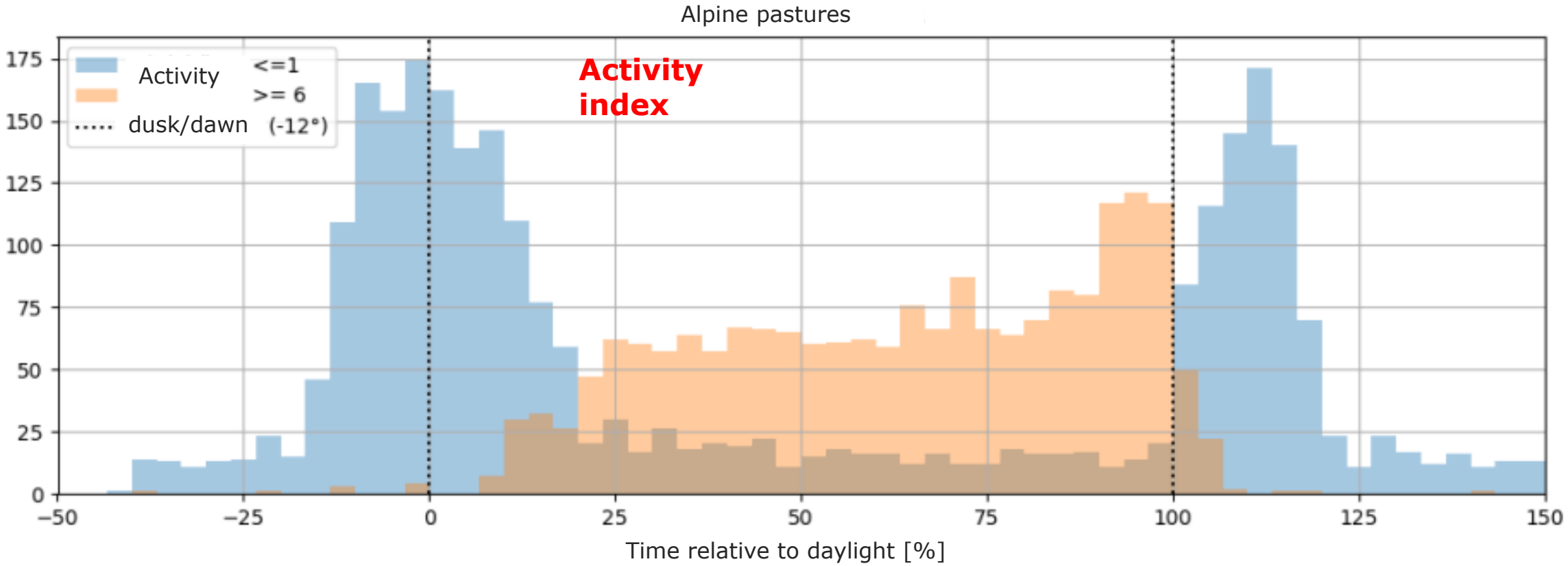


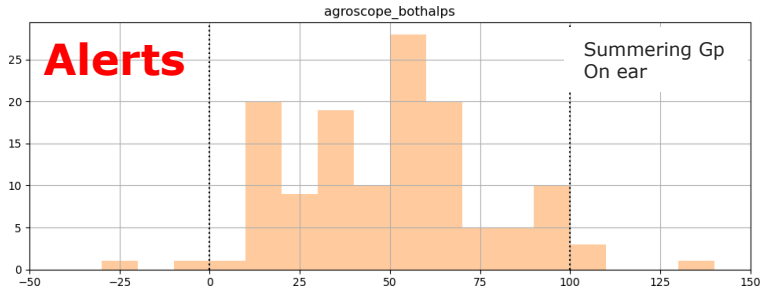
Phases of stable motion correlate with incipient temperature rise

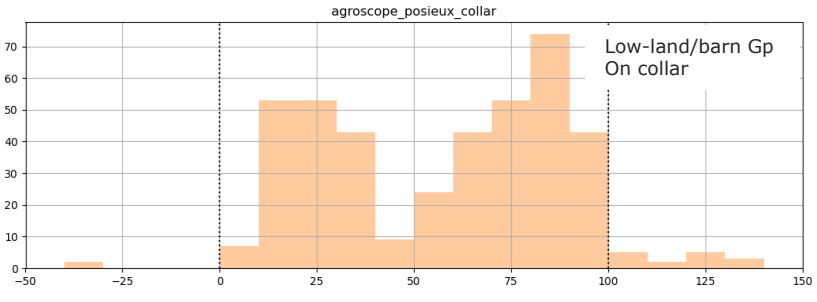
3) Remote herd tracing

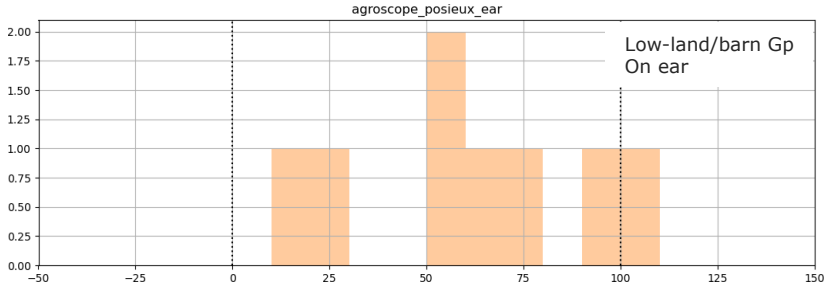


3) Behaviour – diurnal activity variations



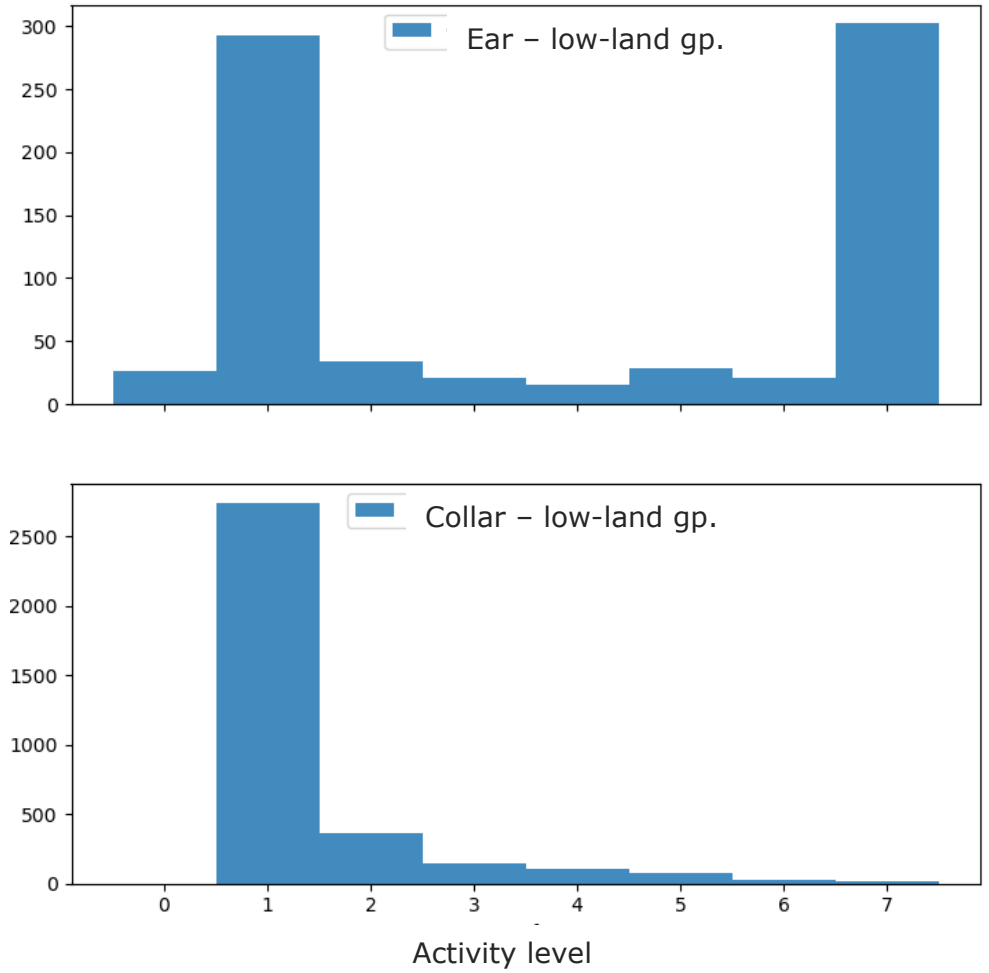




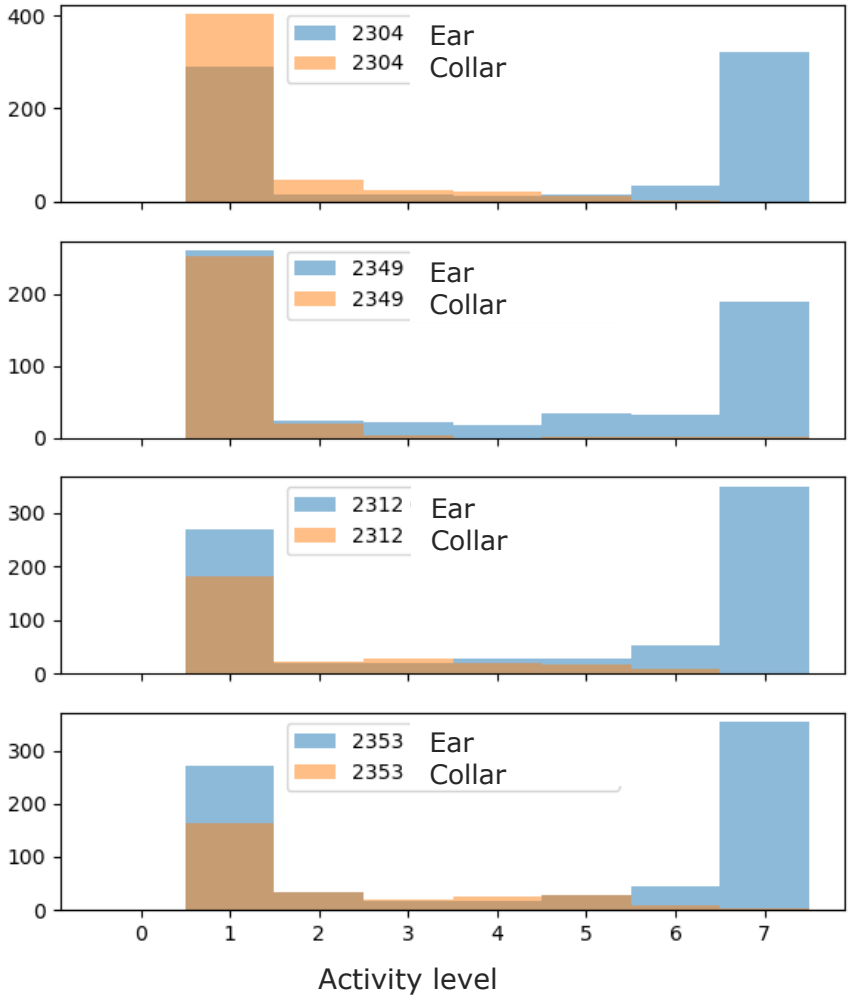


3) Behaviour – comparing activity by fixation

Comparison of activities by mode of fixation
New born / low-land group

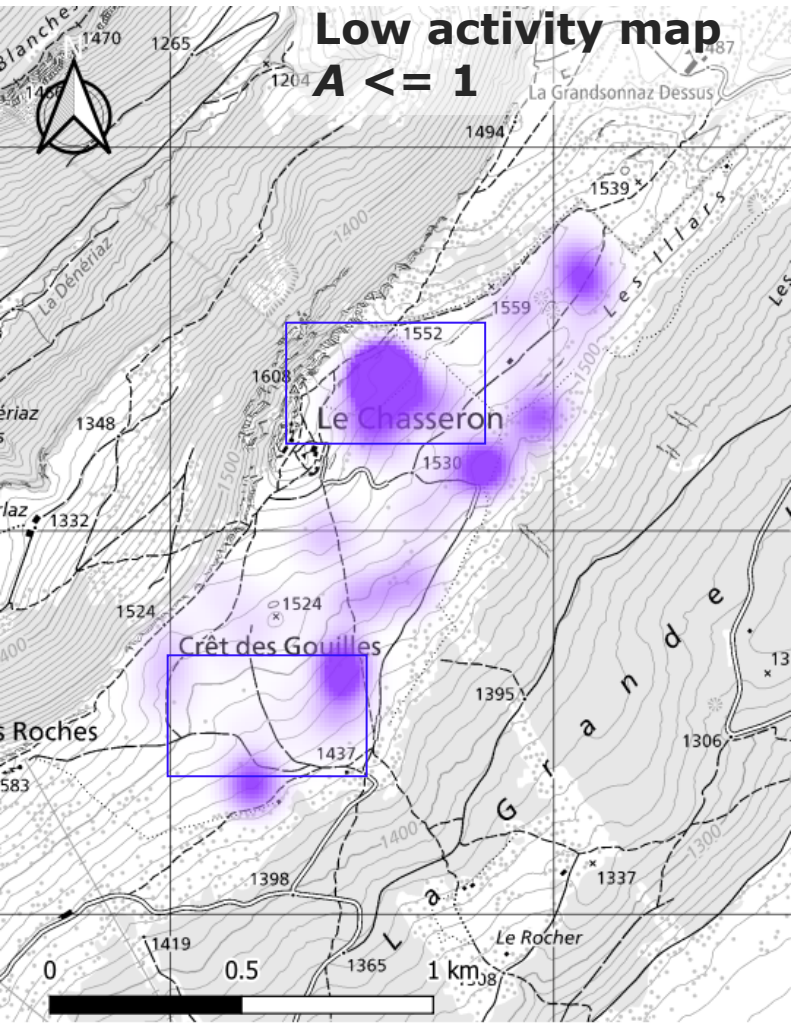


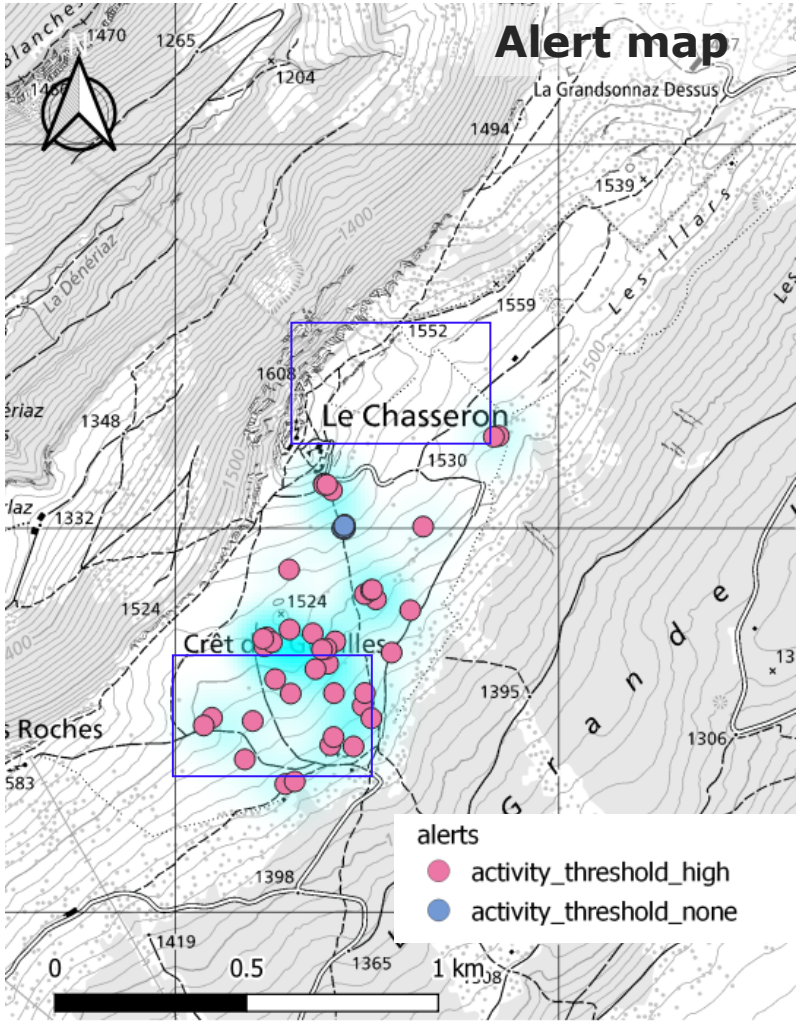
Comparison of activities by mode of fixation
Individual tags (two deployments)

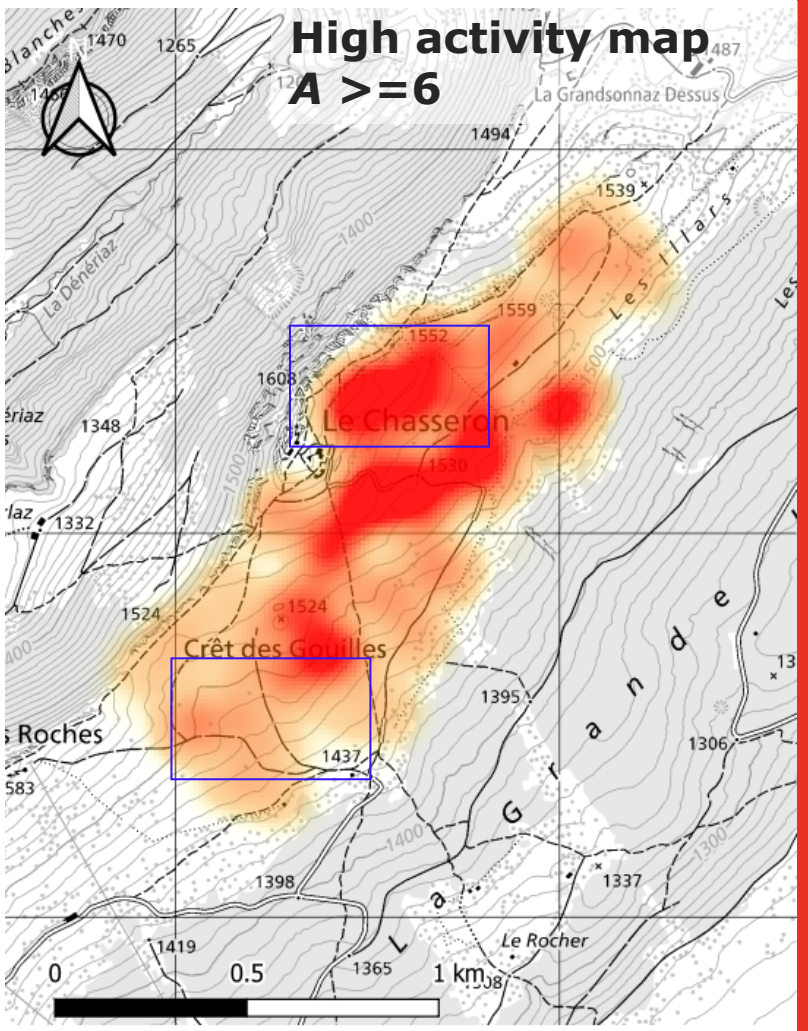


All analyses: 1.5.2022-15.7.2022 for ear fixation, 1.9.2022-1.10.2022 for collar

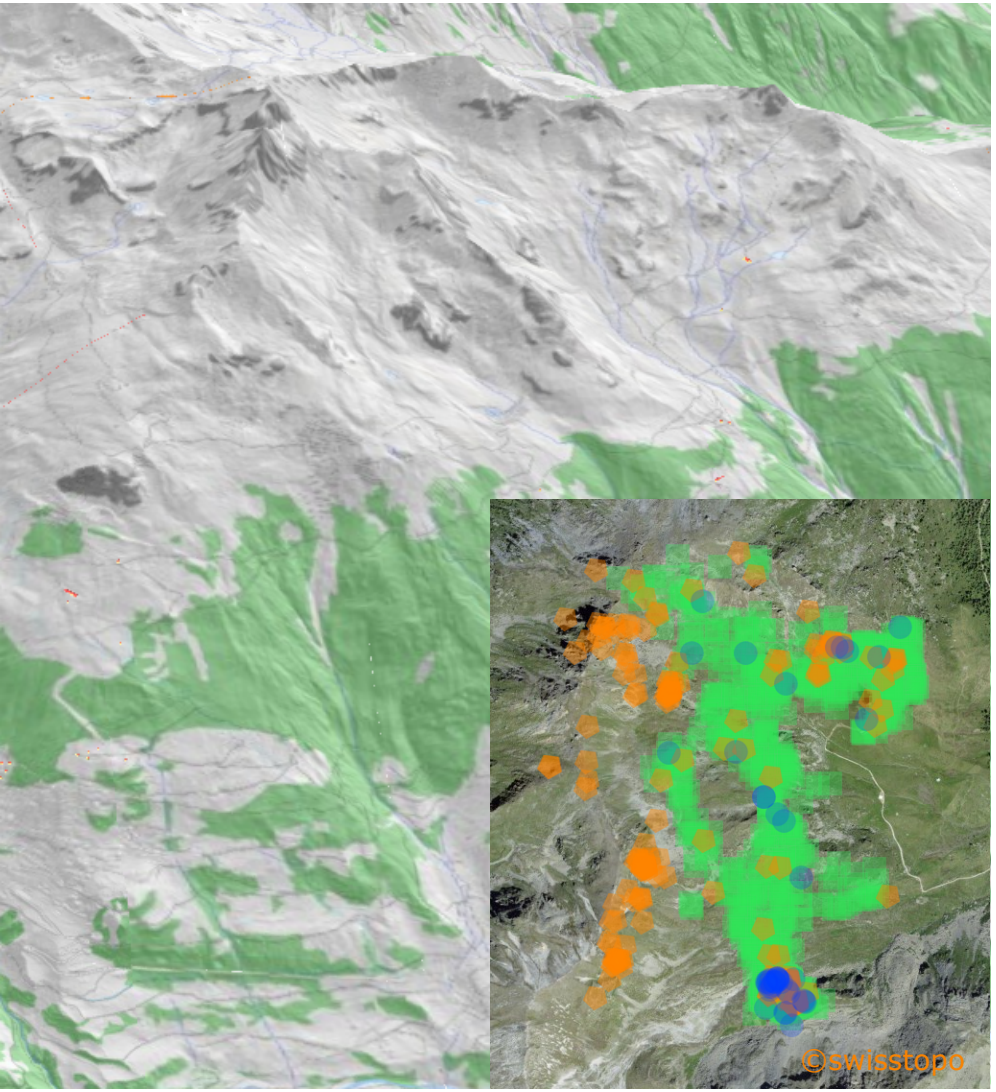
3) Behaviour: activity and alert maps

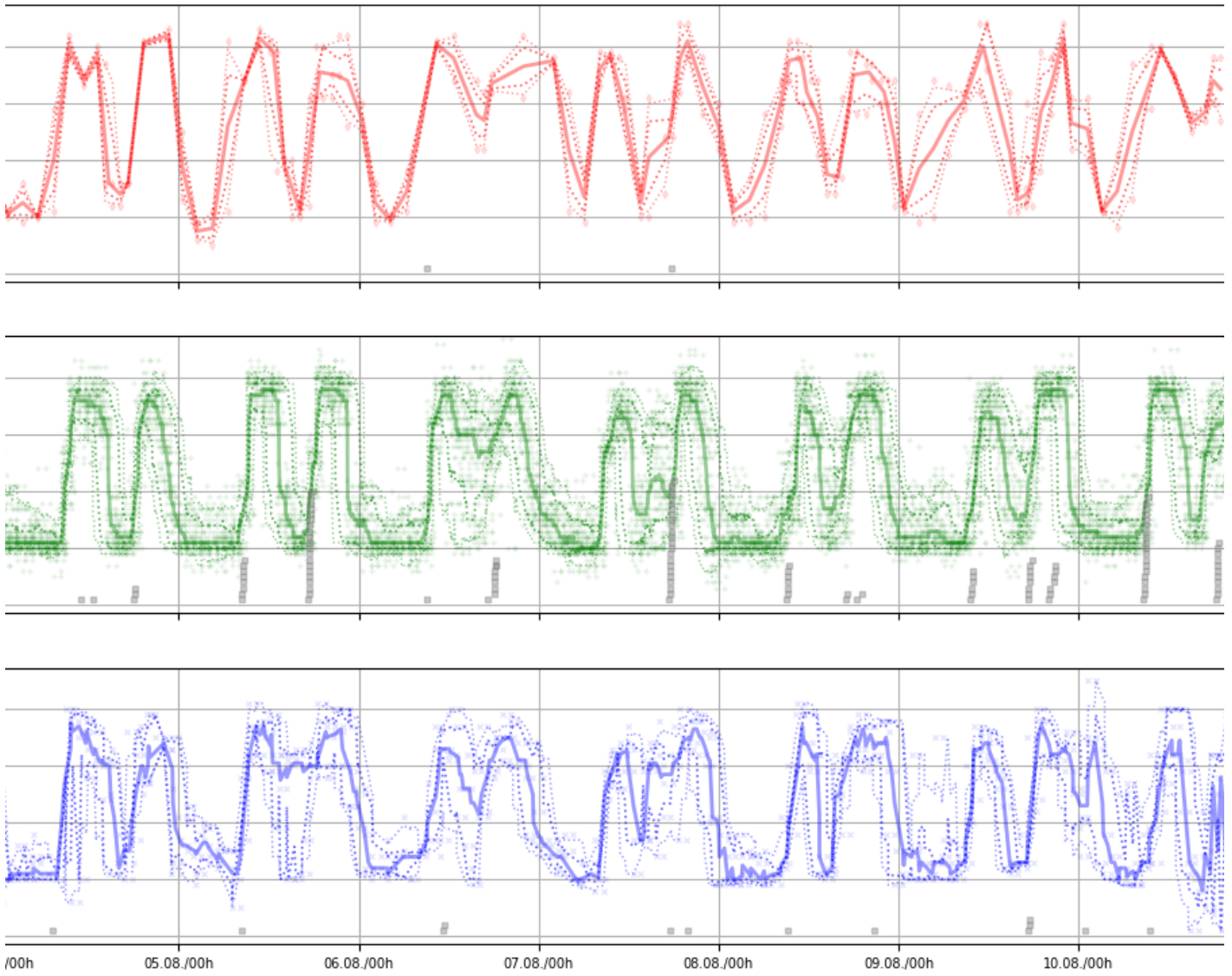






4) Ongoing trials and outlook





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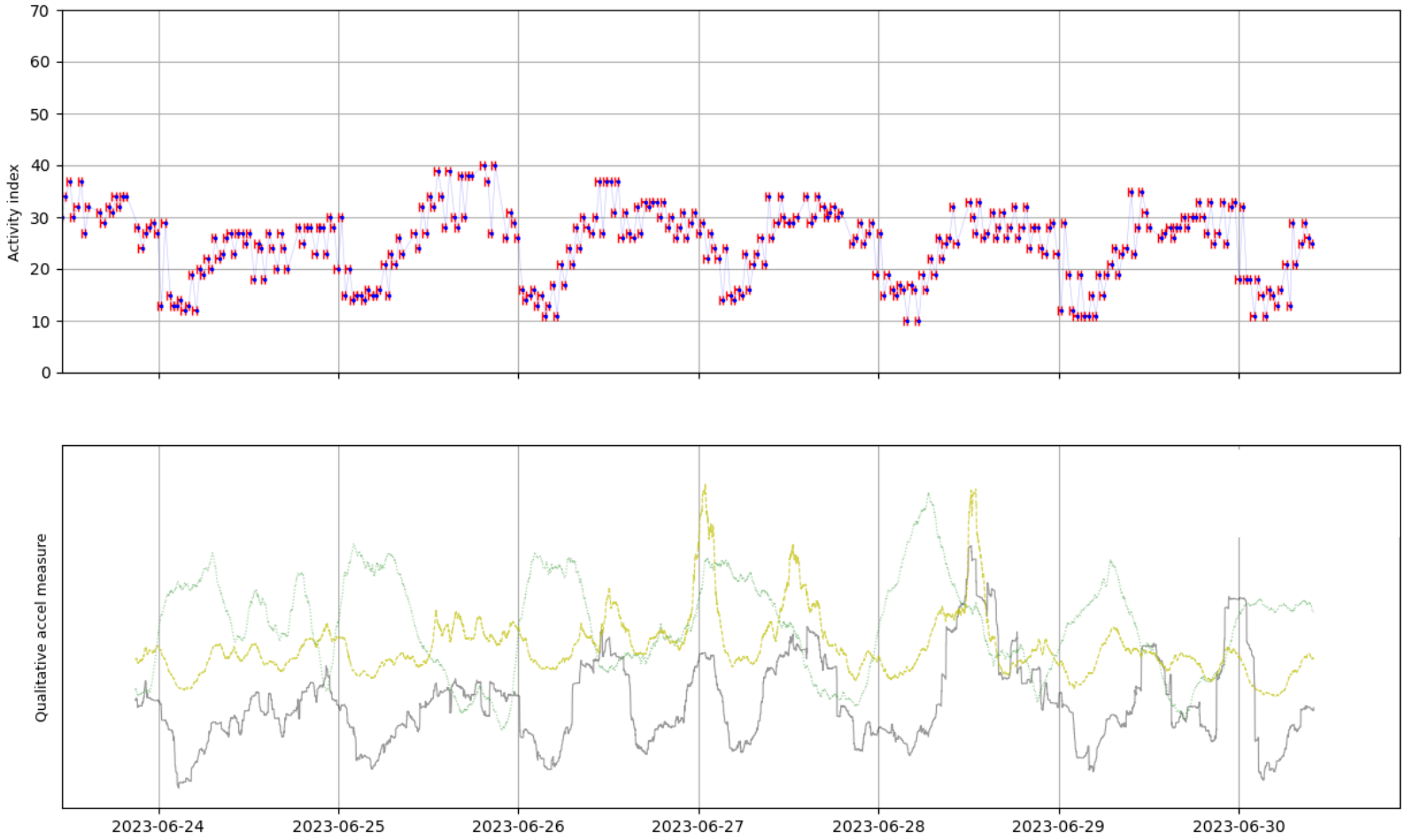

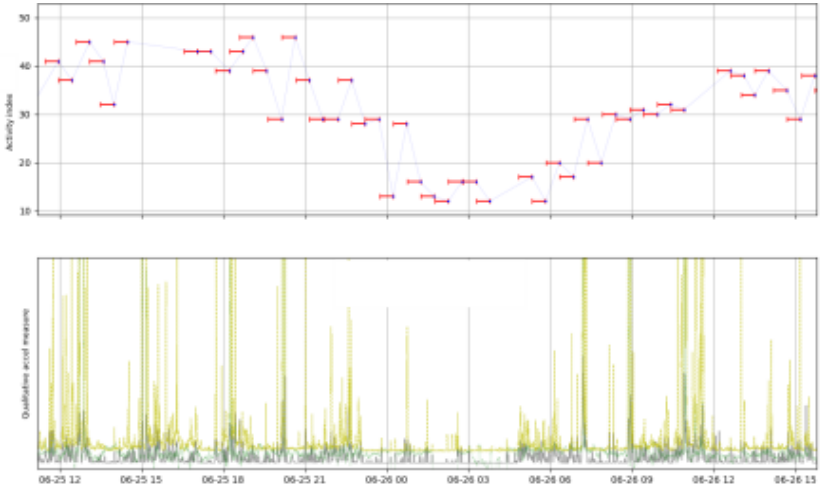

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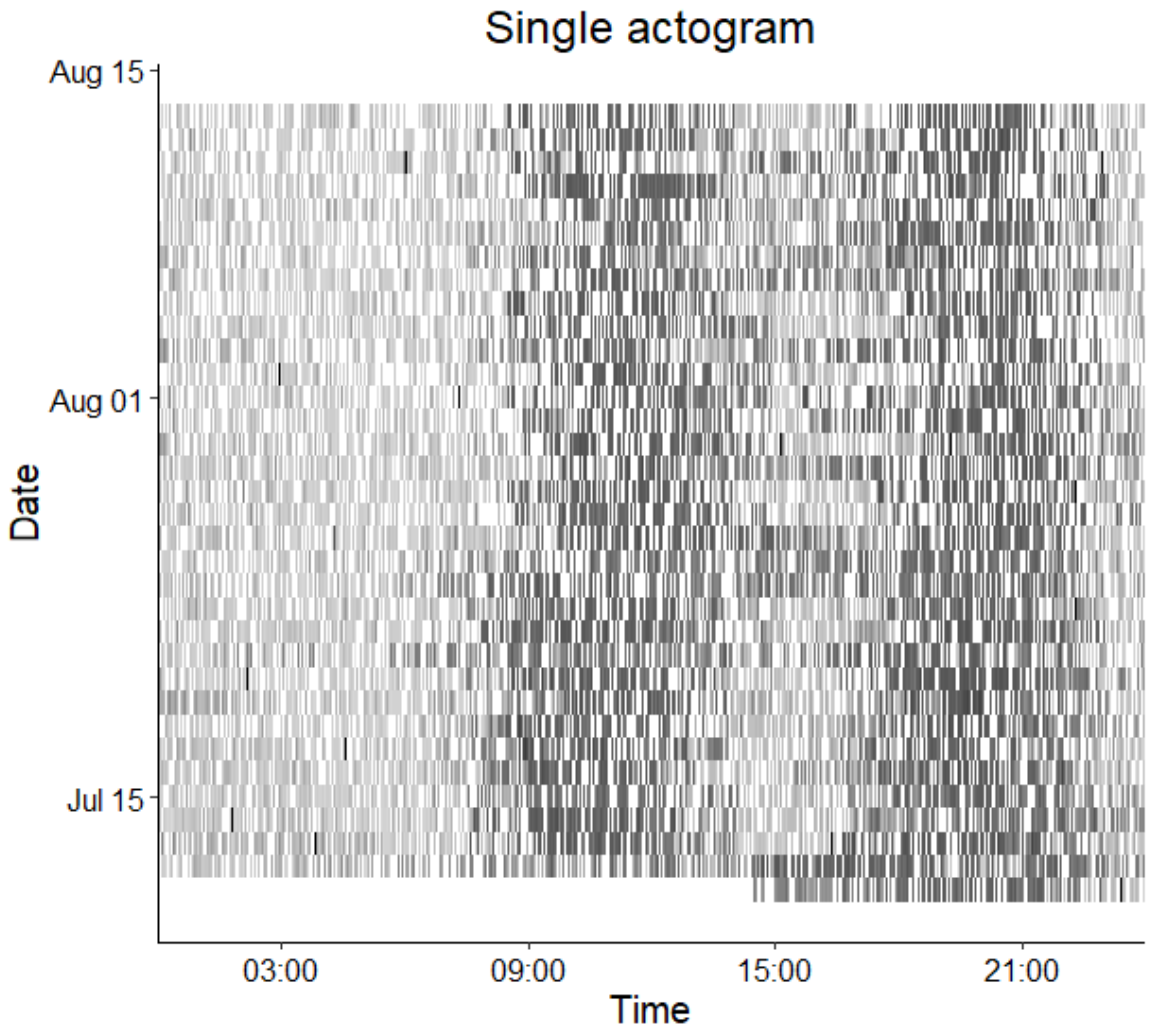
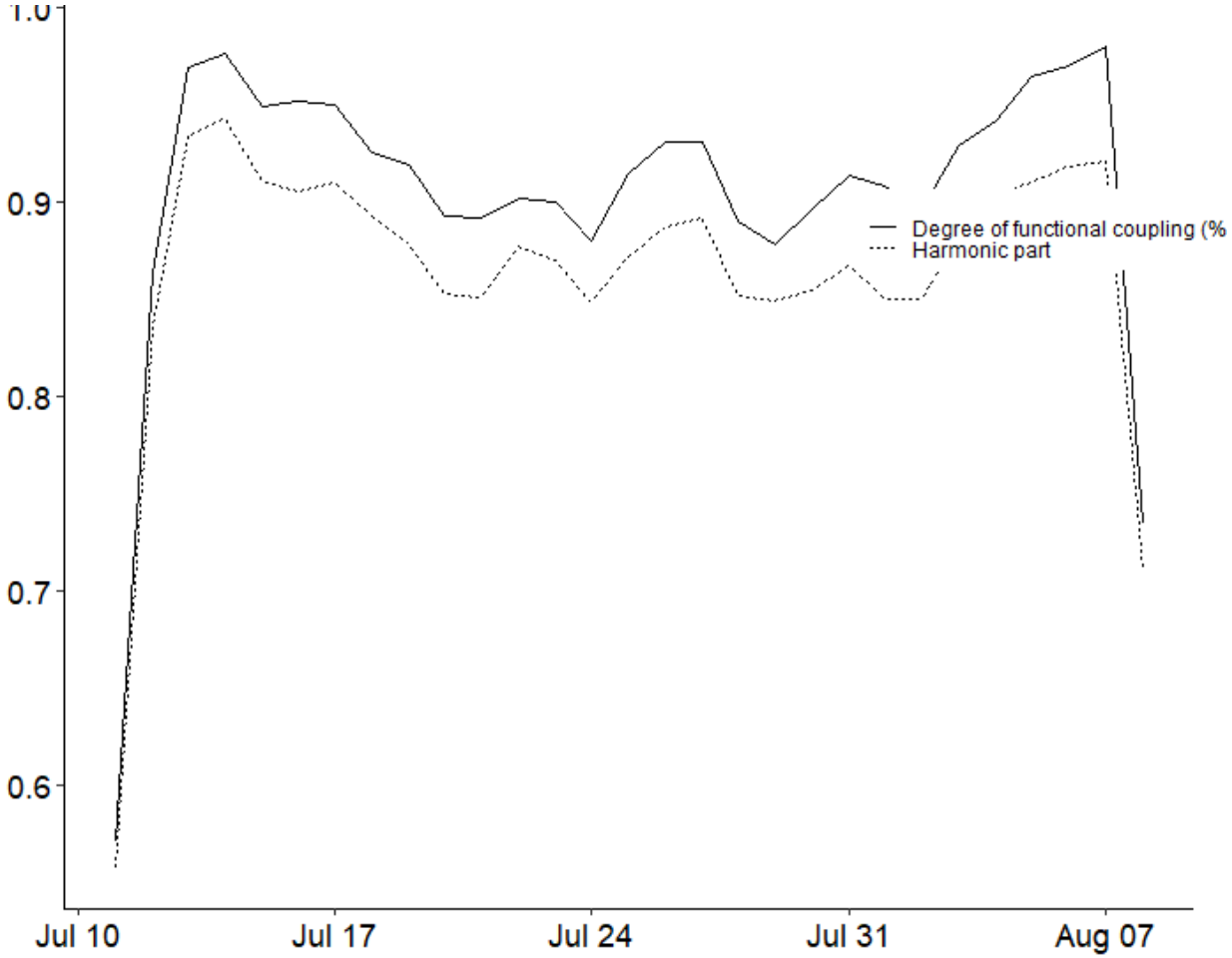
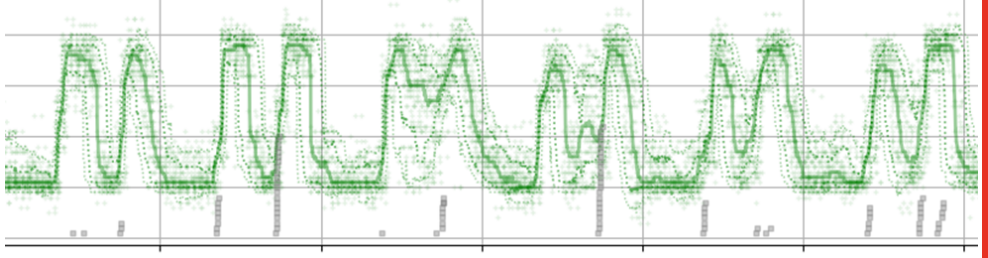
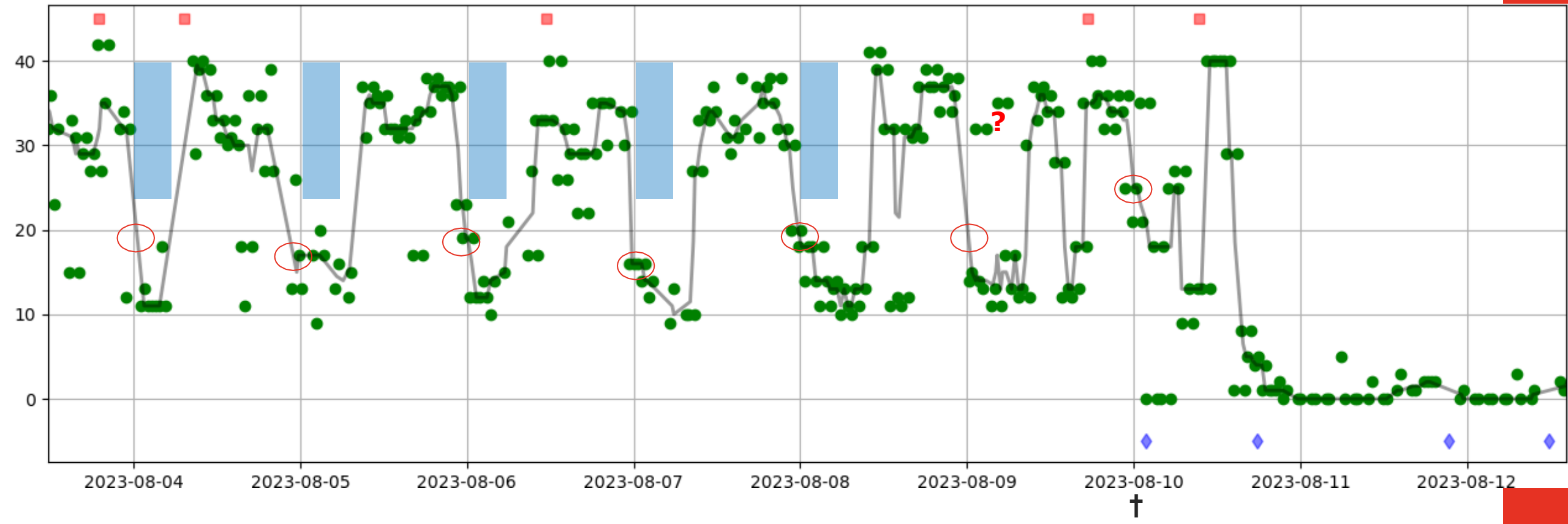




digiRhythm package: https://cran.r-project.org/web/packages/digiRhythm/index.html

4) Animal killed by wolf





Summary

12.12, "Remote monitoring of cattle using sensor ear tags" (S.Rieder)
53.14, "Social network analysis of cattle and horses inferred from sensor ear tag (SET) and GPS based data" (U.Heikkilä)

Individual animal behaviour:

- Differences in ear versus collar activity classification notable
- Night high-*t*-resolution sub-sample of behaviour range – sleep position?
- «Scarce» activity measures reasonably sample accelerometry trends

Herd behaviour:

- Diurnal activity reflected in low-*t*-resolution sampling
- Spread in behaviour (sub-groups, individuals) to be investigated

Predator exposure mitigation:

- Data expression of reported/labelled «incidents» to be analysed

Appendix

Material for questions

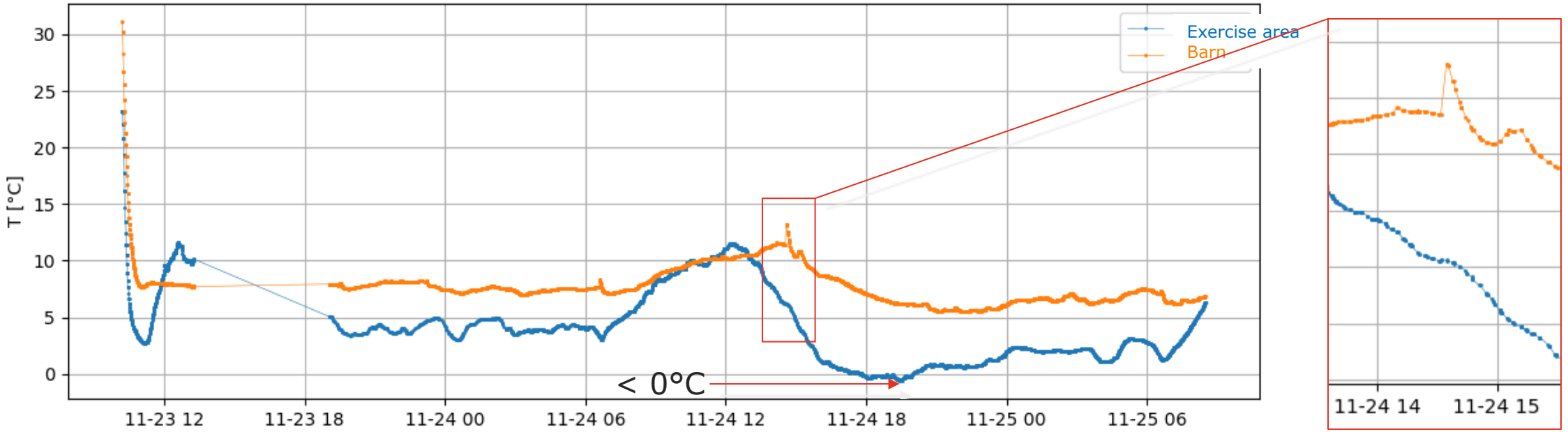
Bluetooth – temperature

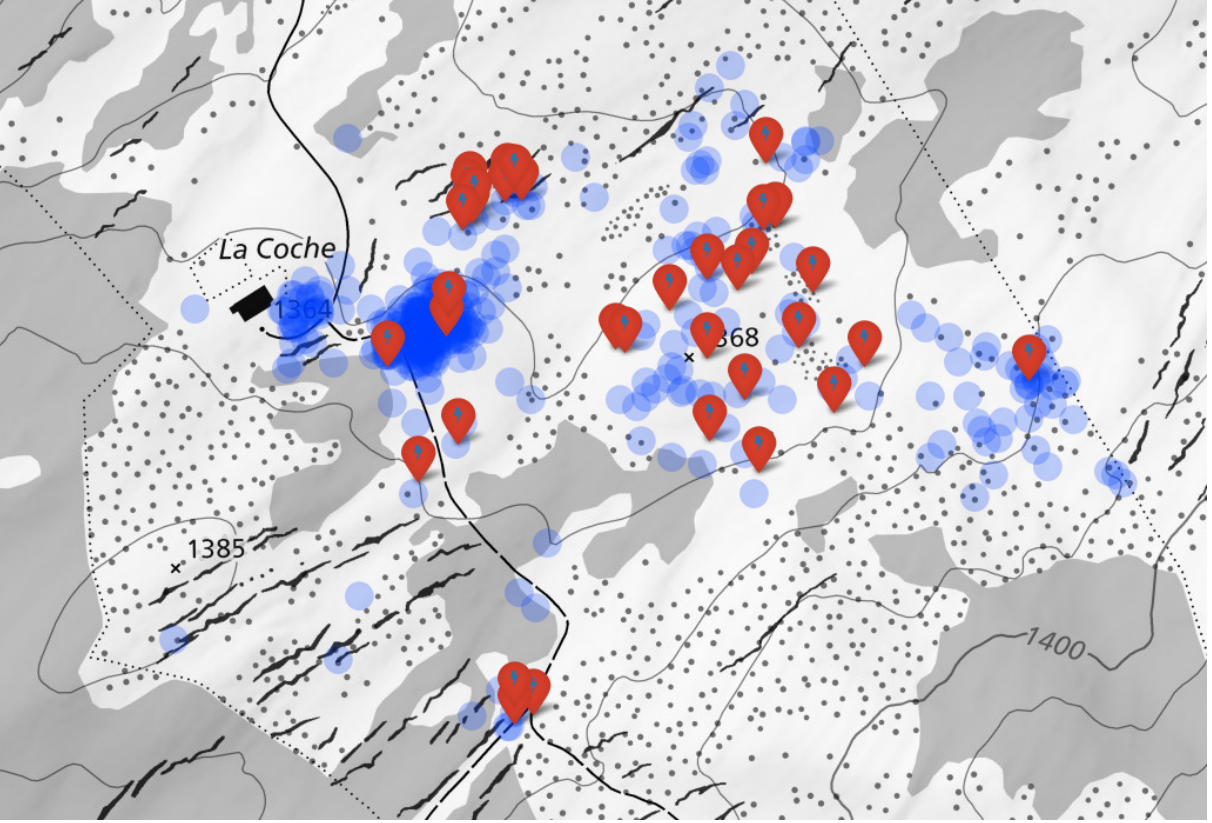
Reference measurements

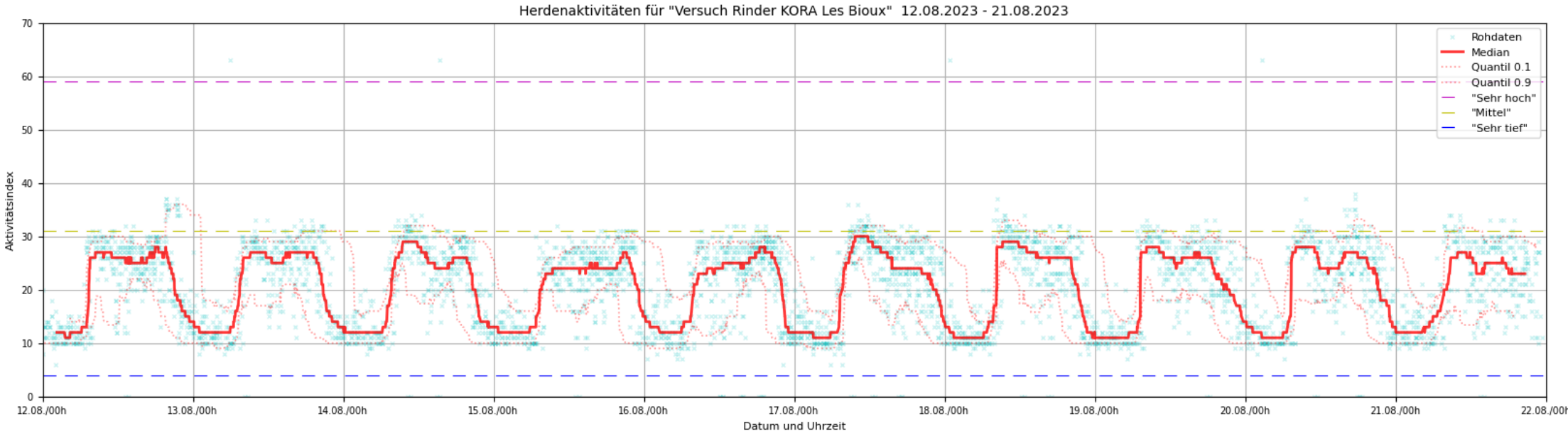
- ~No spikes. Spikes animal-related?
- Incipient cooling
- No simple use for position determination
- Reflects diurnal variation
- As before, modulated/buffered inside barn

Discrimination time-dependent

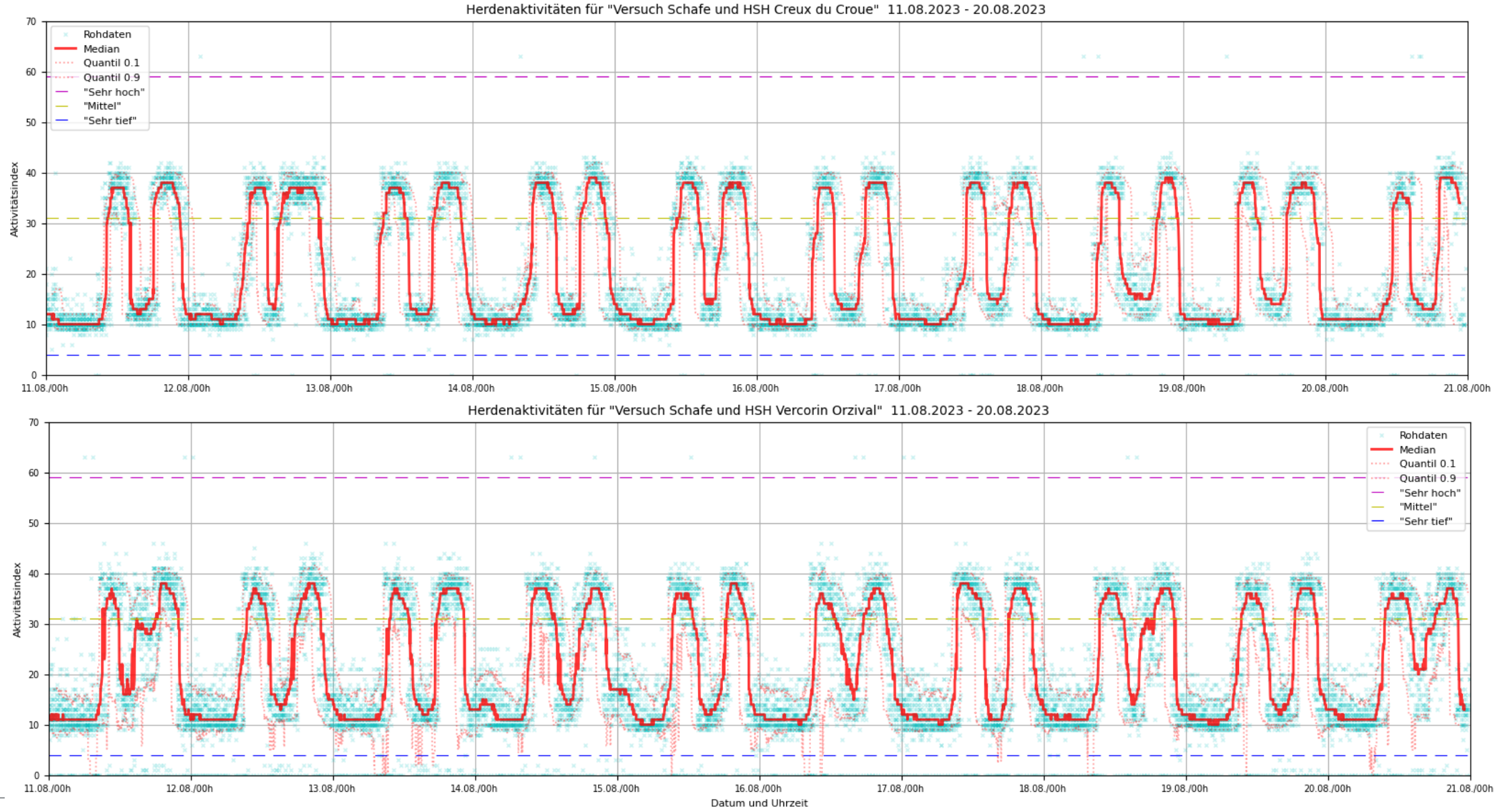
=> Need for constant fix reference?



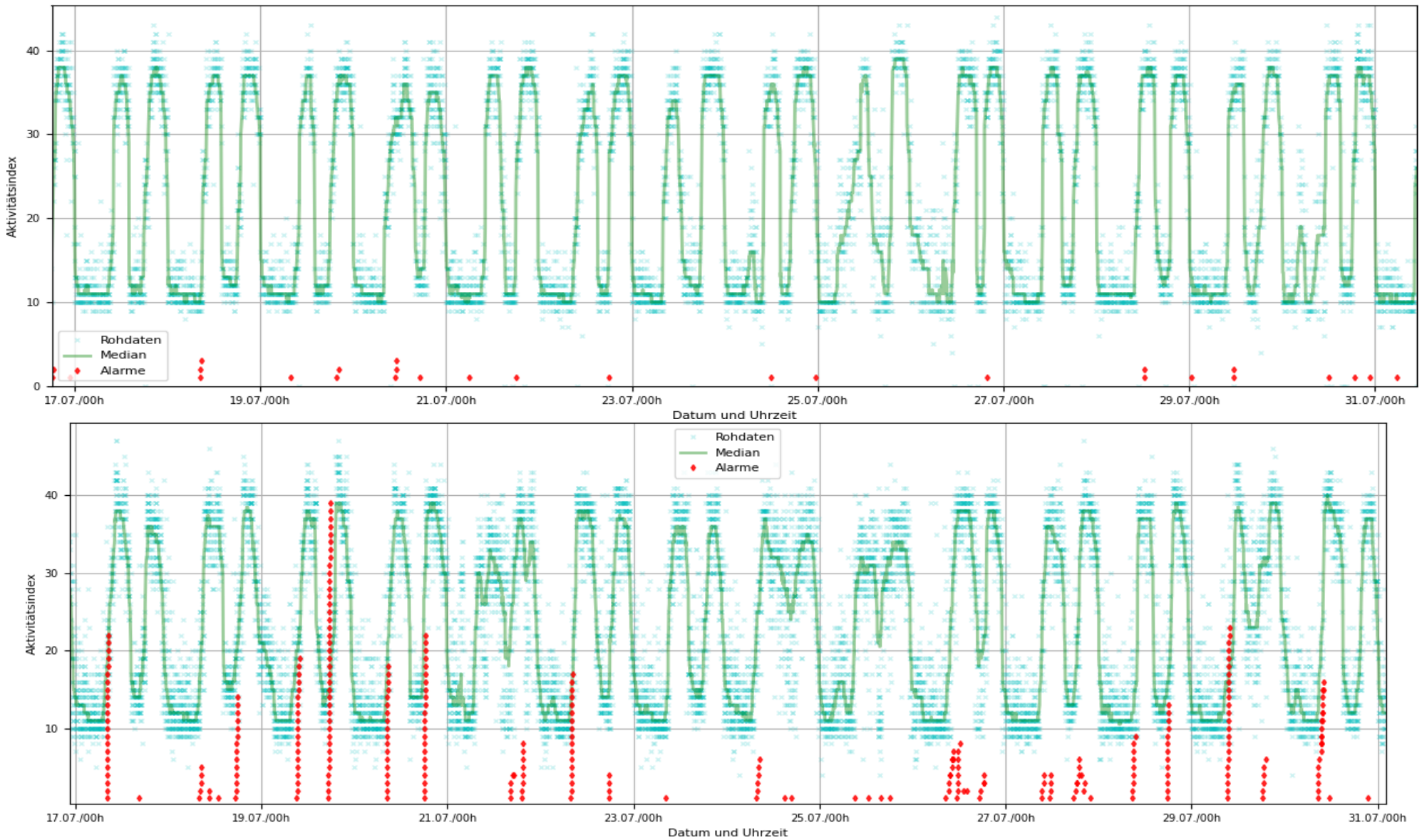

La Coche
1364
1368
1385
1400

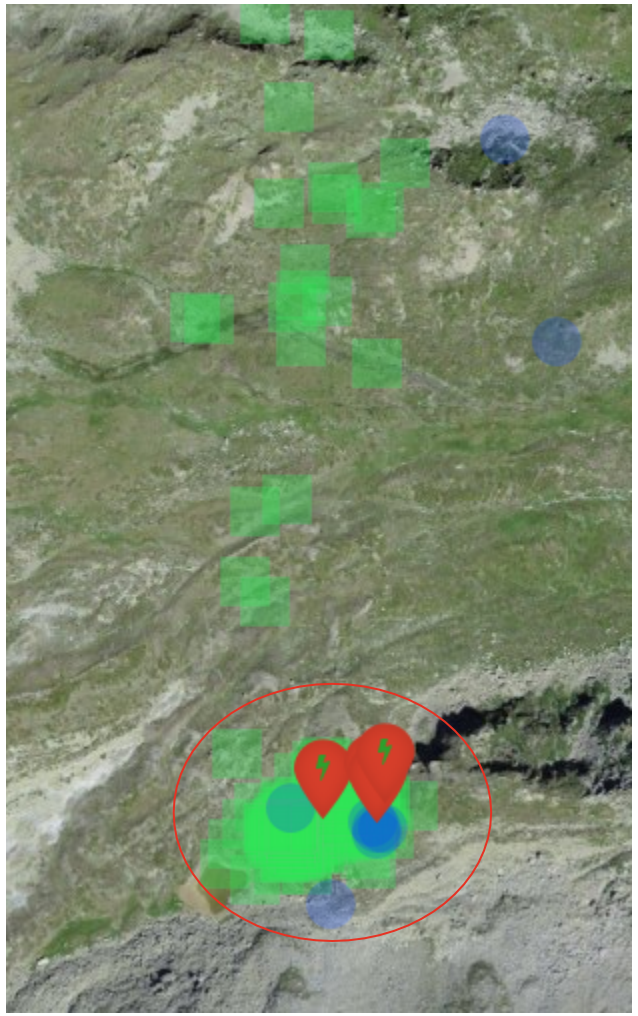

Herdenaktivitäten für "Versuch Rinder KORA Les Bioux" 12.08.2023 - 21.08.2023
Rohdaten
Median
Quantil 0.1
Quantil 0.9
"Sehr hoch"
"Mittel"
"Sehr tief"
Aktivitätsindex
0
10
20
30
40
50
60
70
12.08./00h
13.08./00h
14.08./00h
15.08./00h
16.08./00h
17.08./00h
18.08./00h
19.08./00h
20.08./00h
21.08./00h
22.08./00h
Datum und Uhrzeit

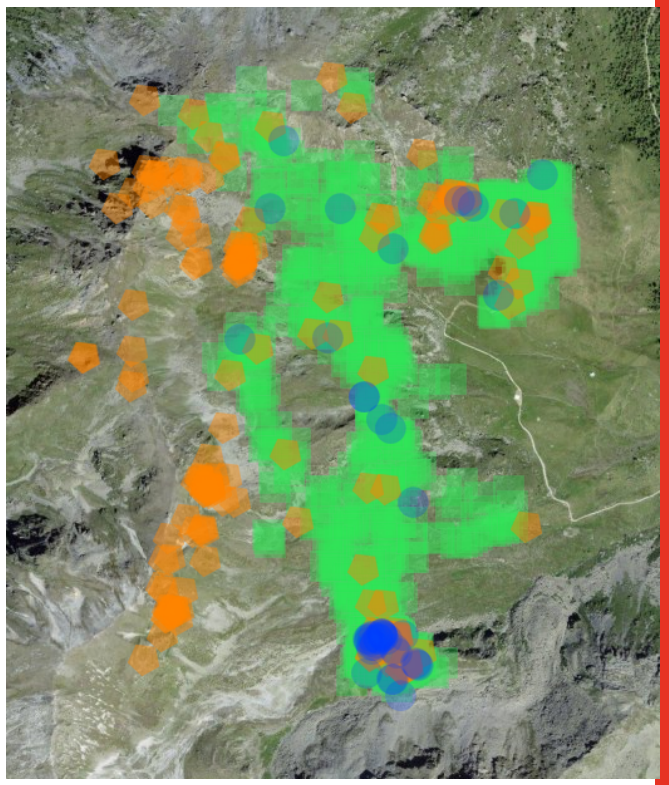
Two sheep herds (Jura vs. Valais)



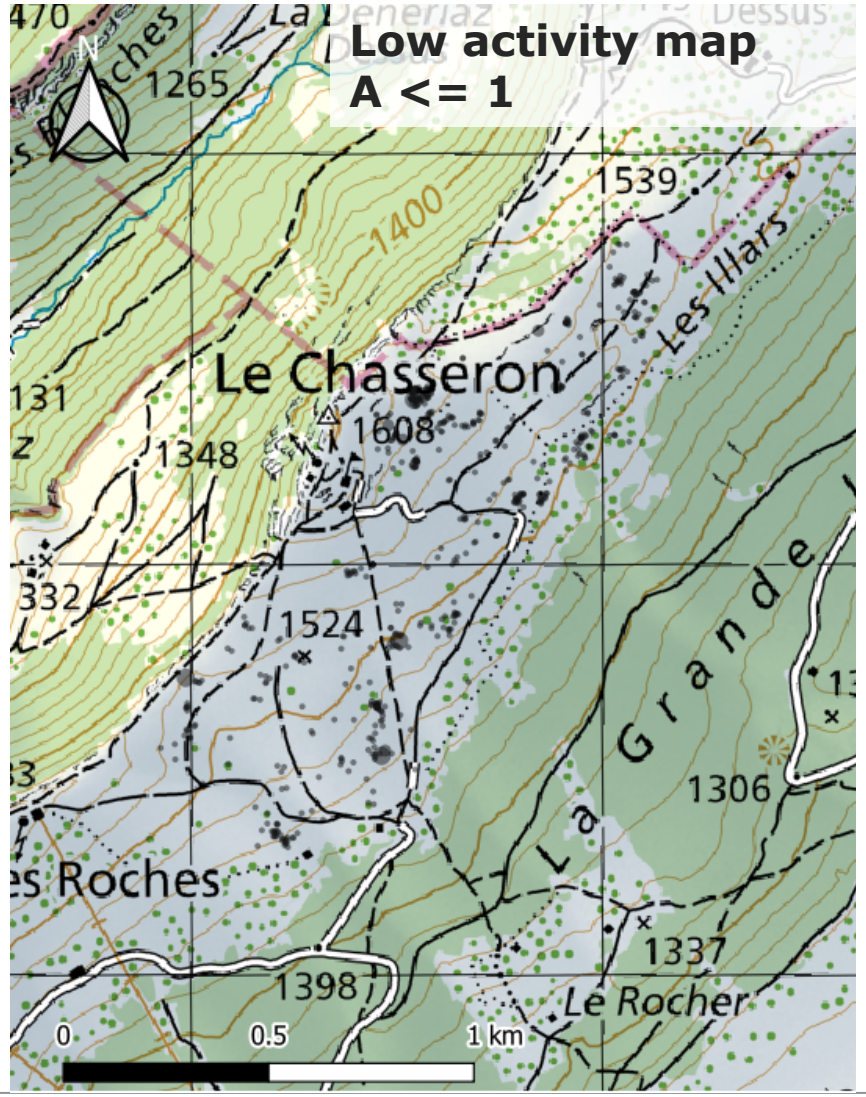
Activity and alerts – do we see the shepherd?

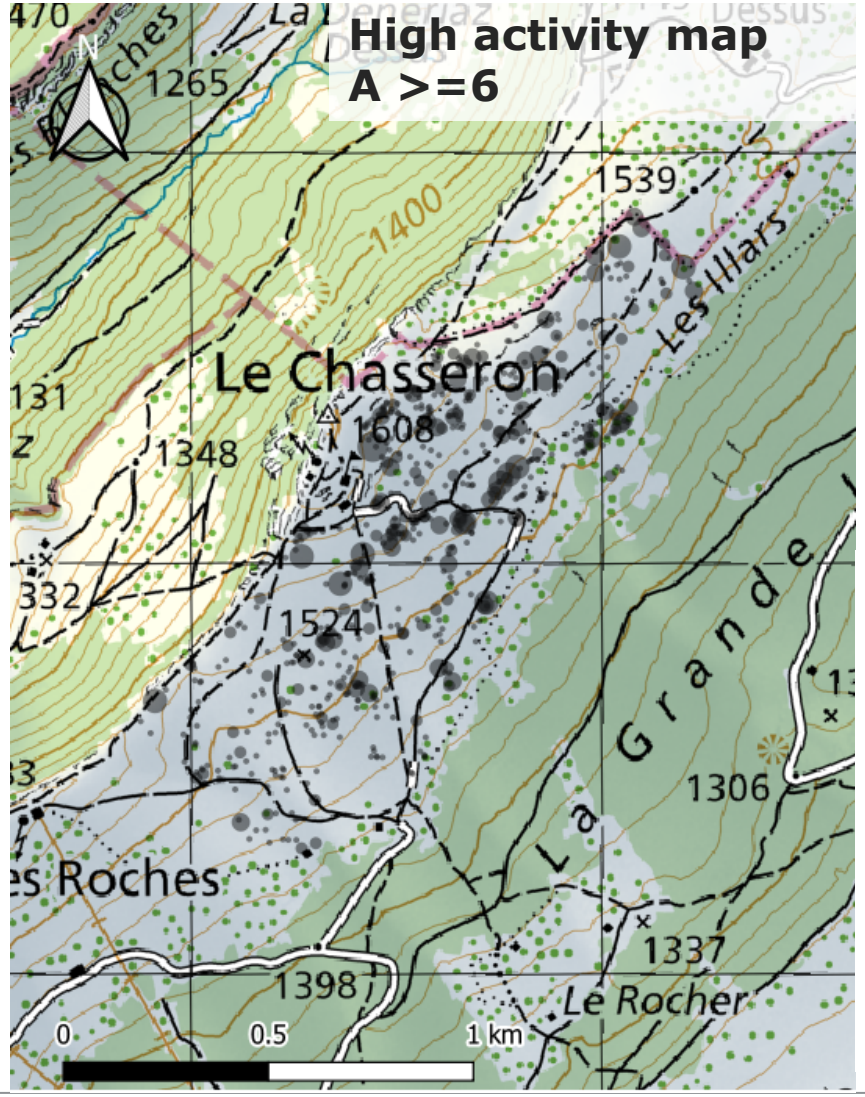






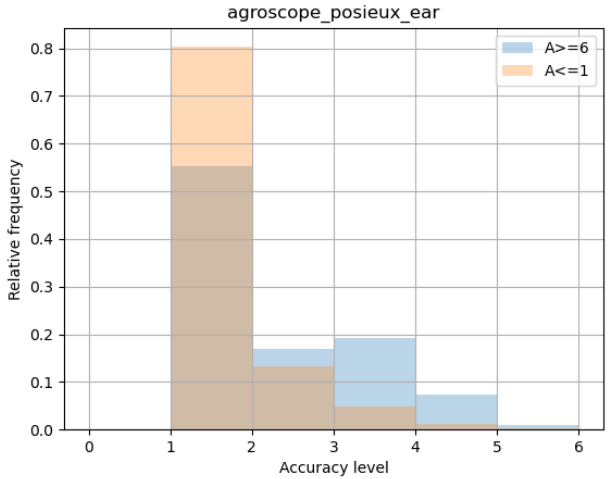
Position data – herd tracing (satcom)



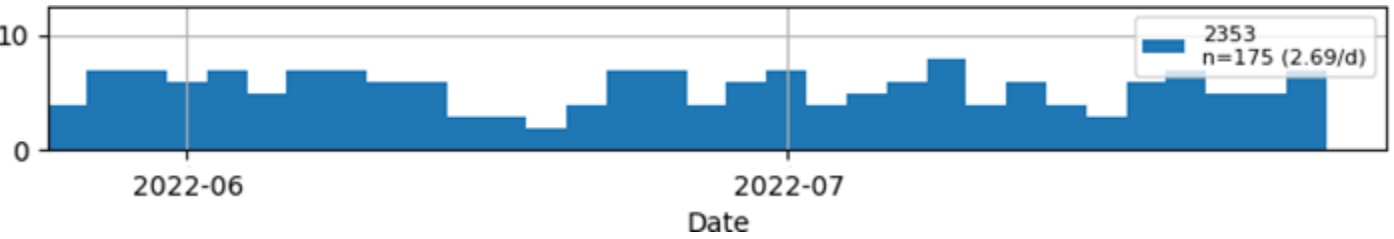


Position quality flag: more uncertain under high activity

(circles not to scale)

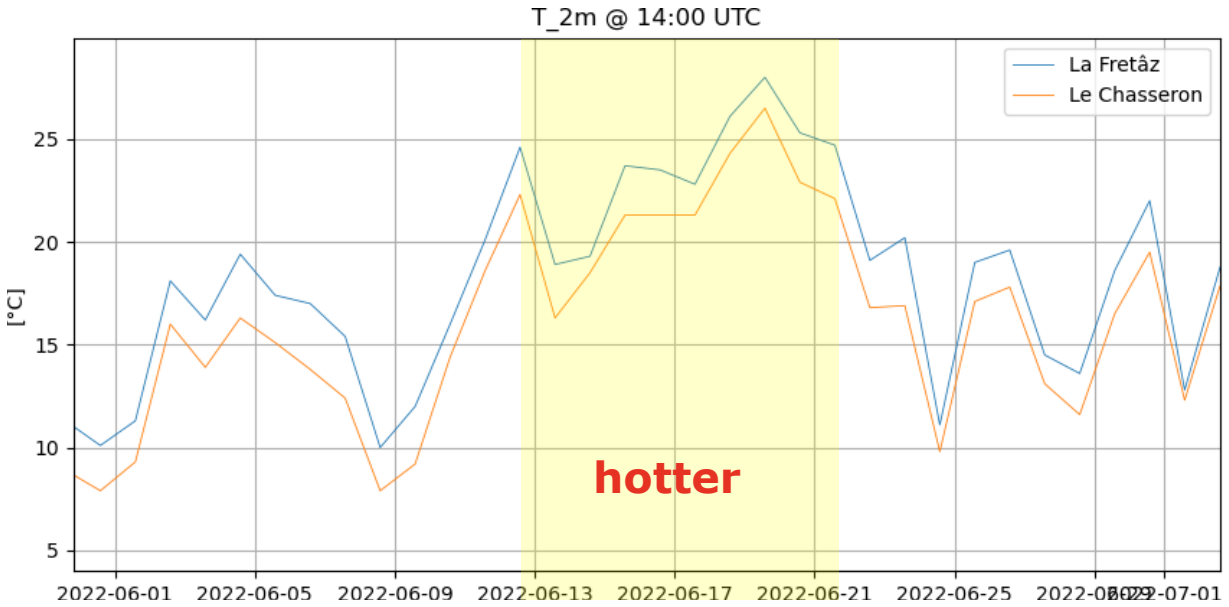


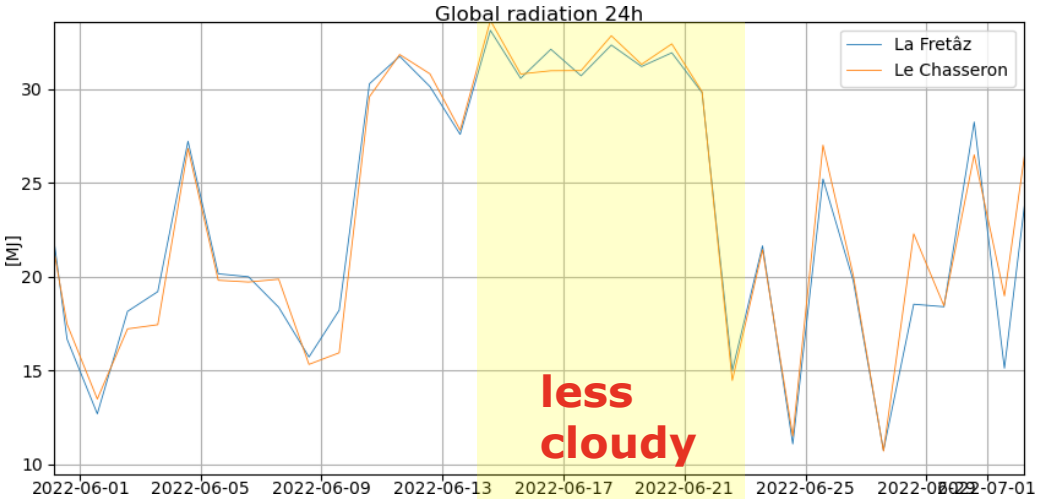
Weather measures – Alpine pastures

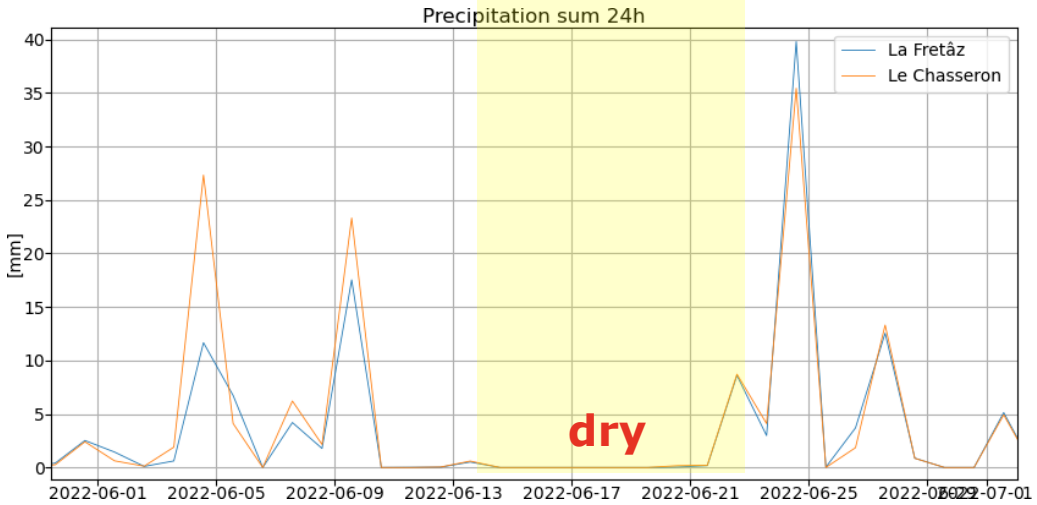


Clear, sunny weather anti-correlated with number of successful transmissions

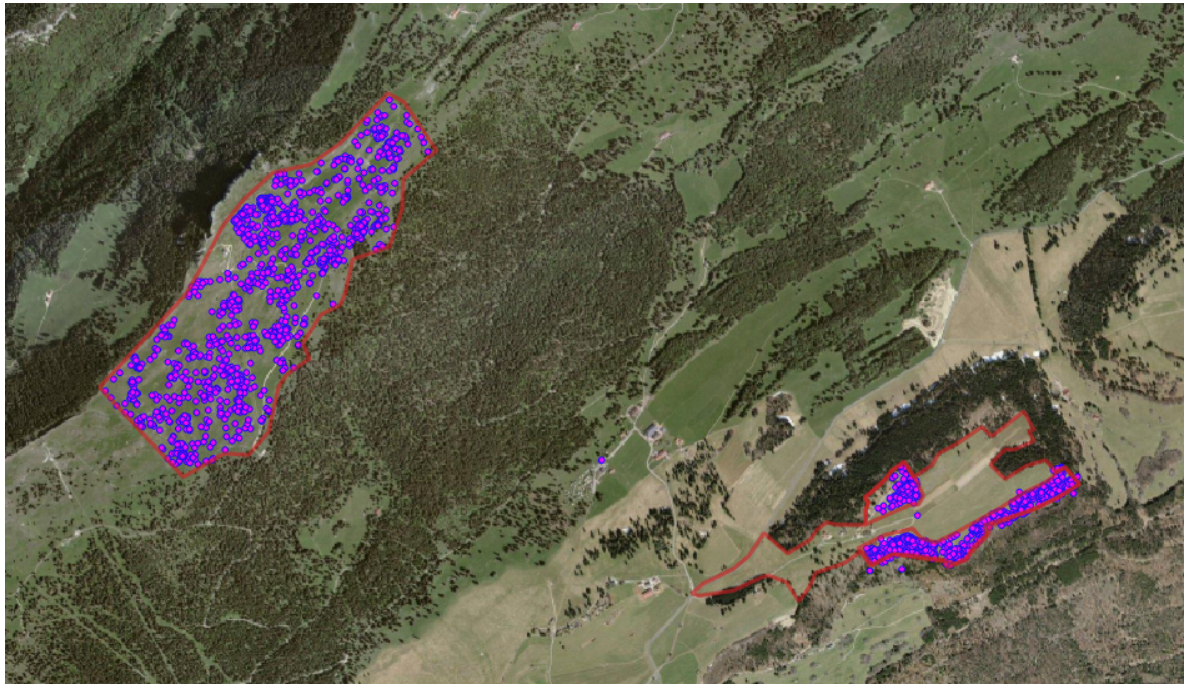
=> Clouds not directly relevant

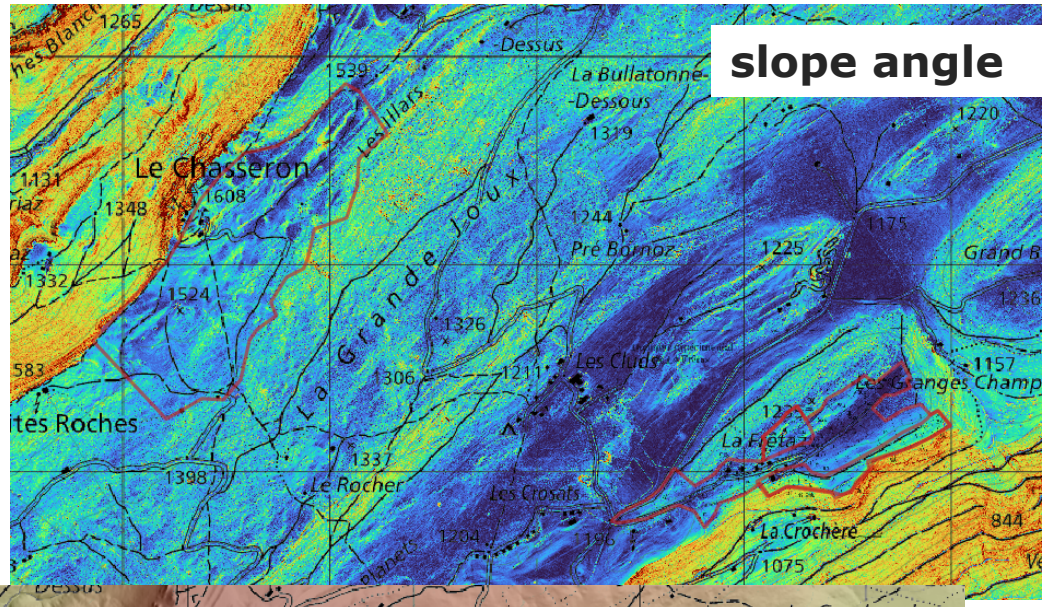


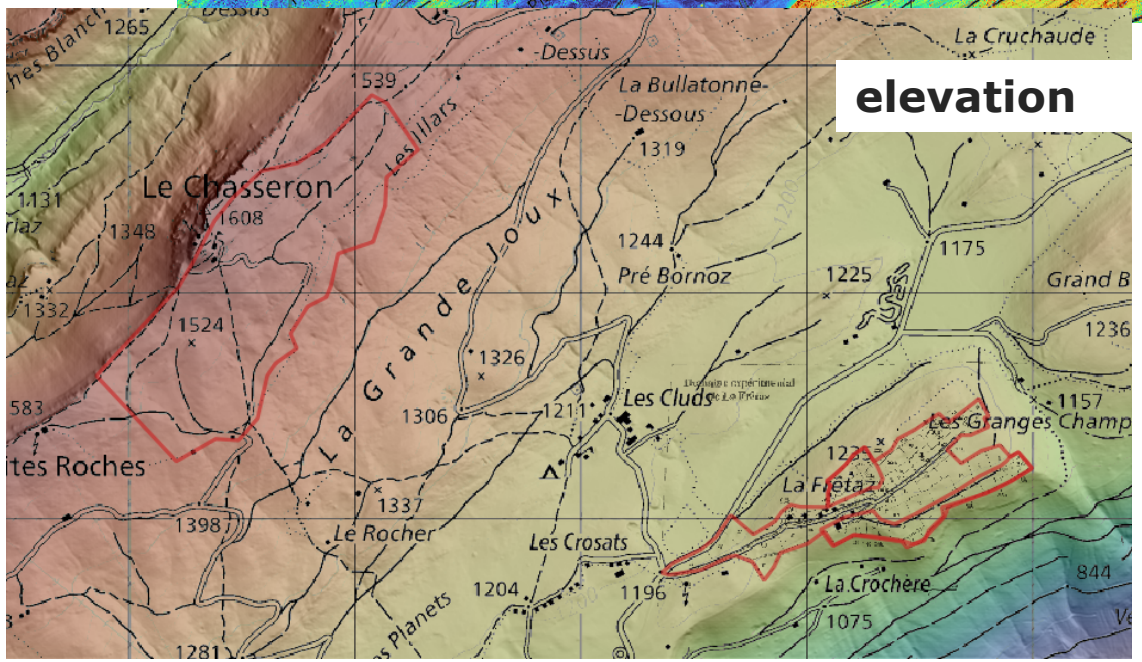




Topography – Alpine pastures







Topographic barrier – Alpine pastures

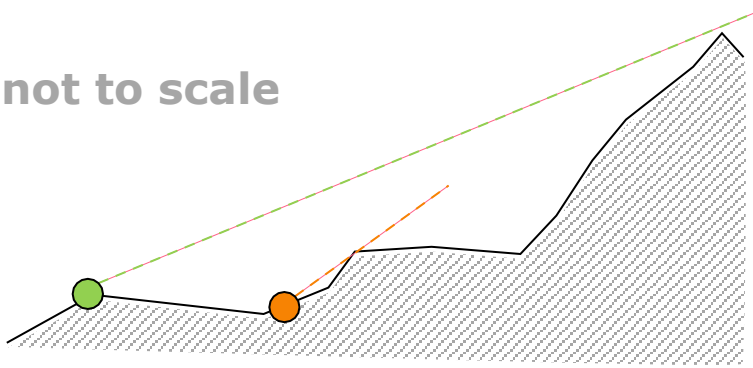
Calculate on grid:

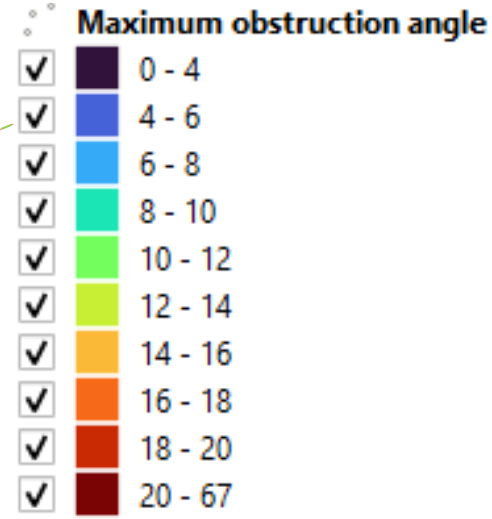
What is the maximum obstruction angle against the horizon?

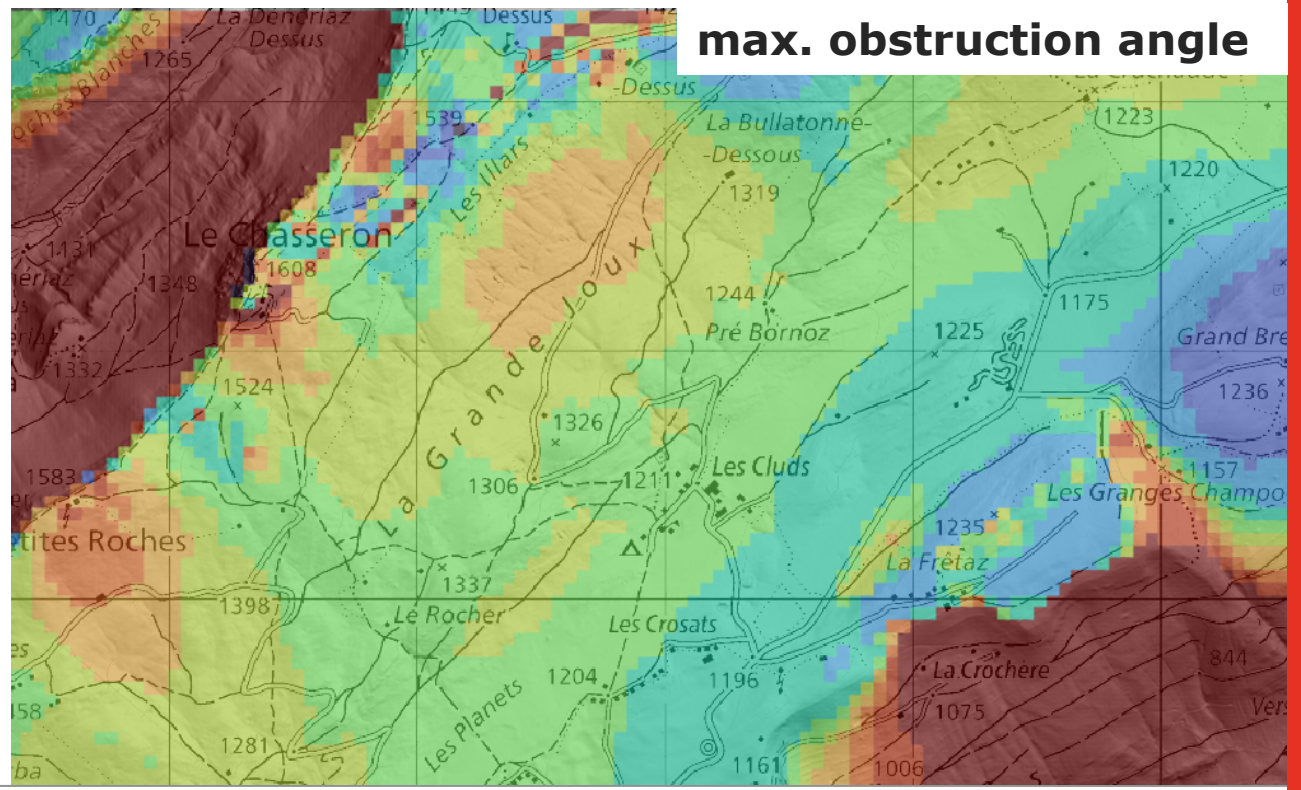
Proxy for satellite visibility

All directions considered equally

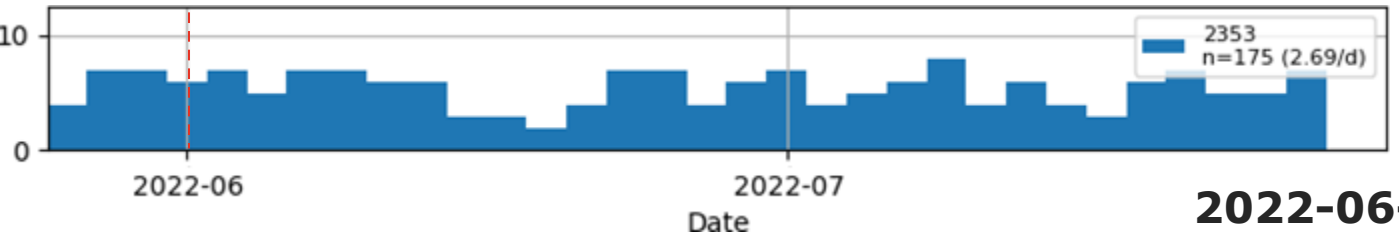
Reference: highest crest line (LIDAR DEM)



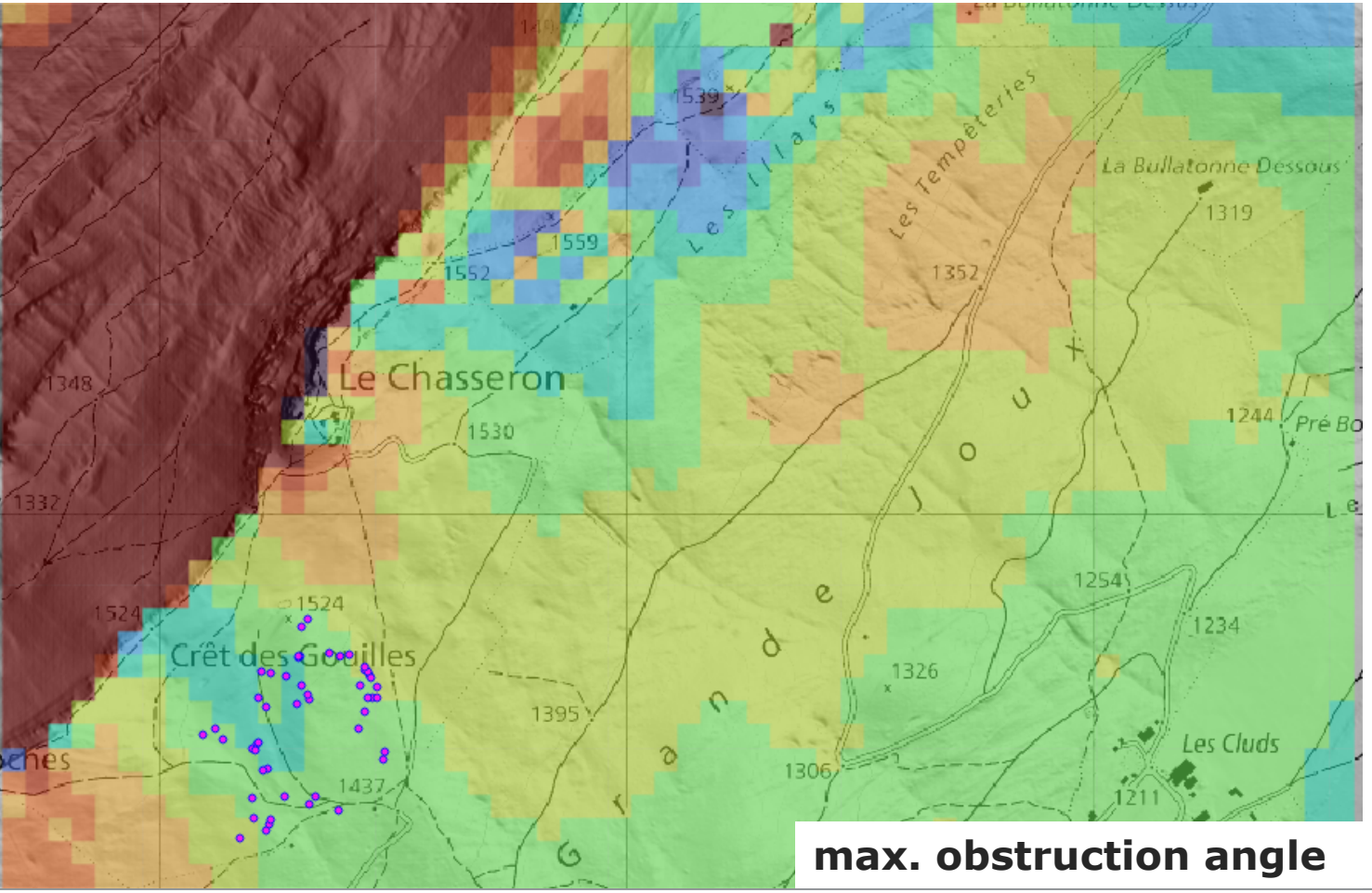




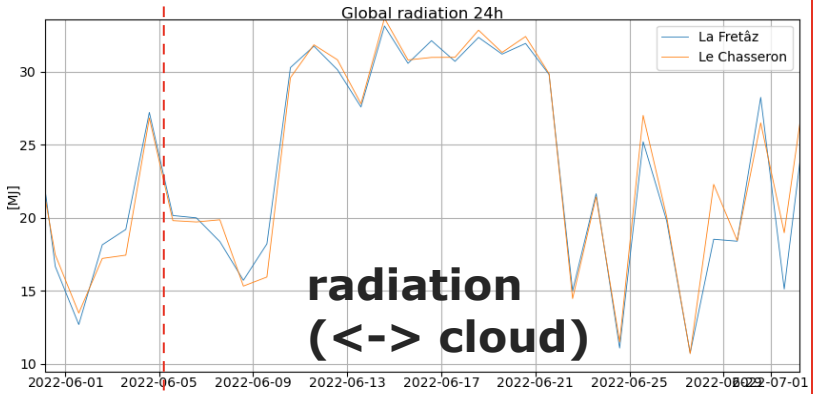
Topographic shadow – herd location

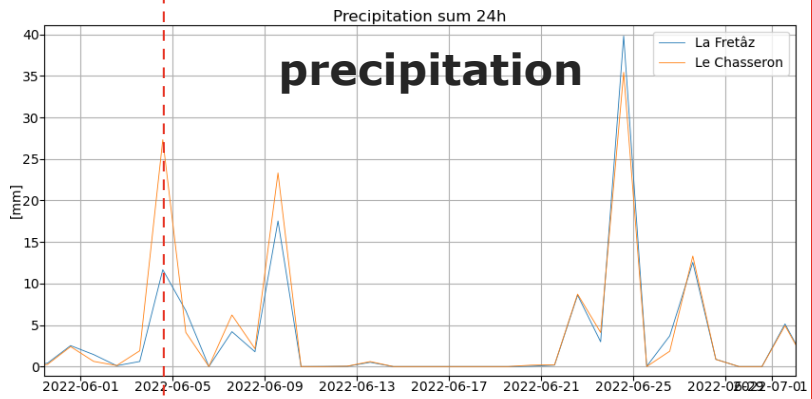


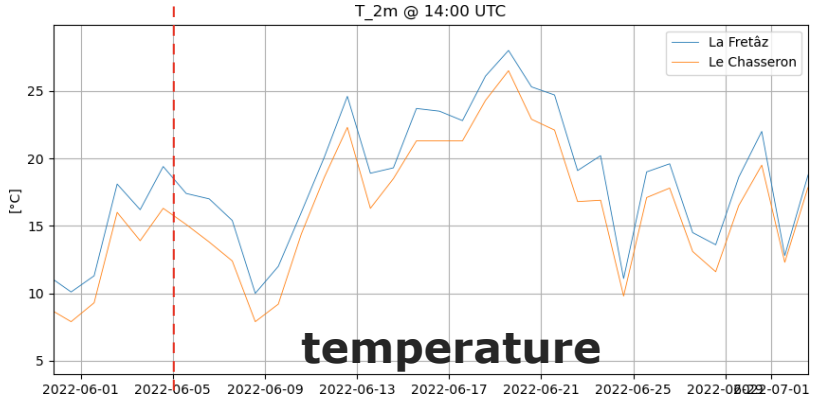
2022-06-01



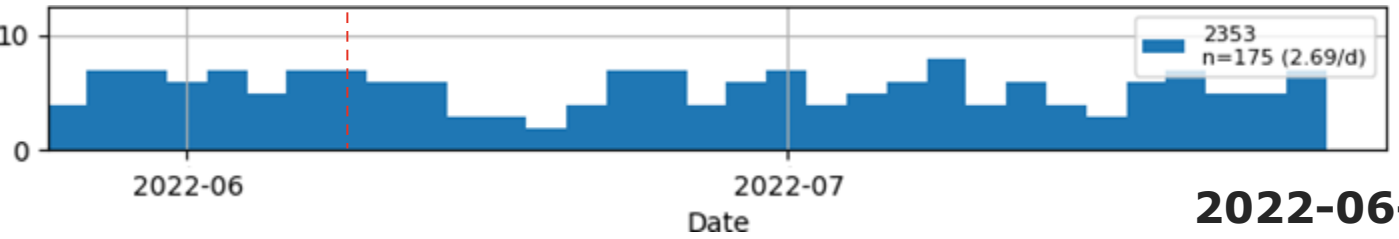
max. obstruction angle



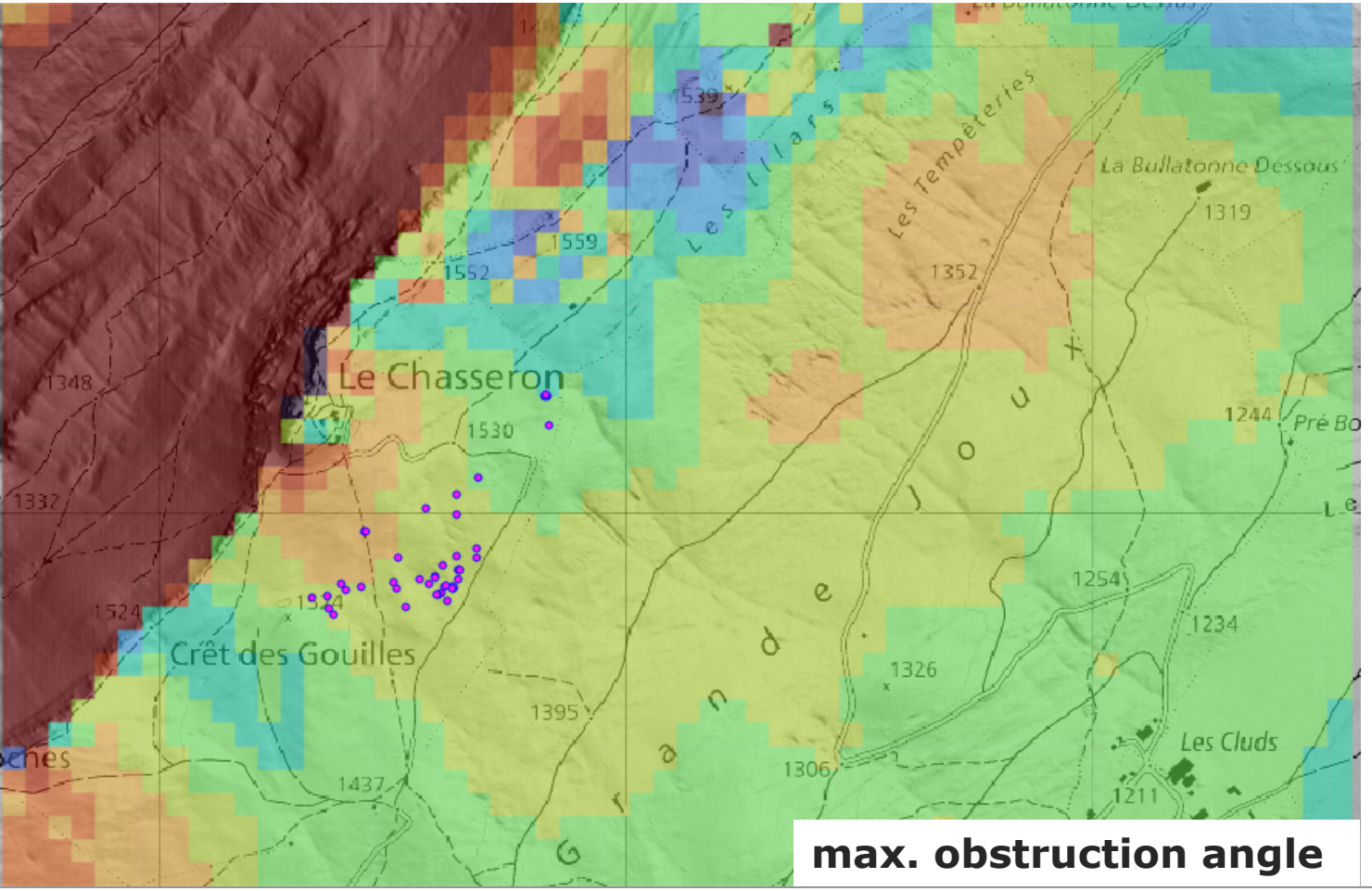




Topographic shadow – herd location



2022-06-09



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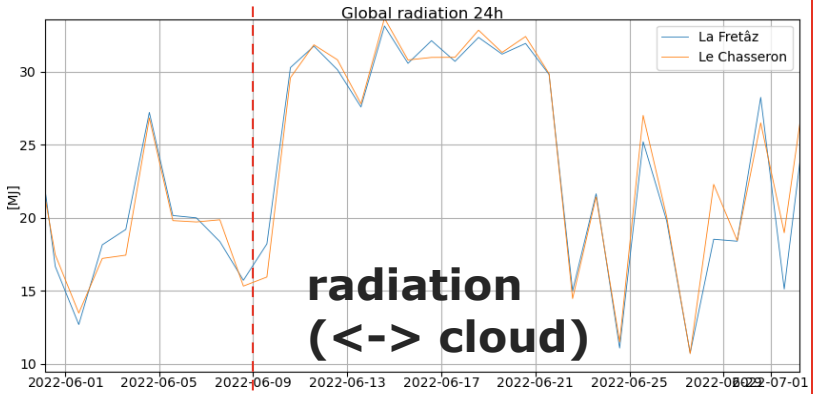
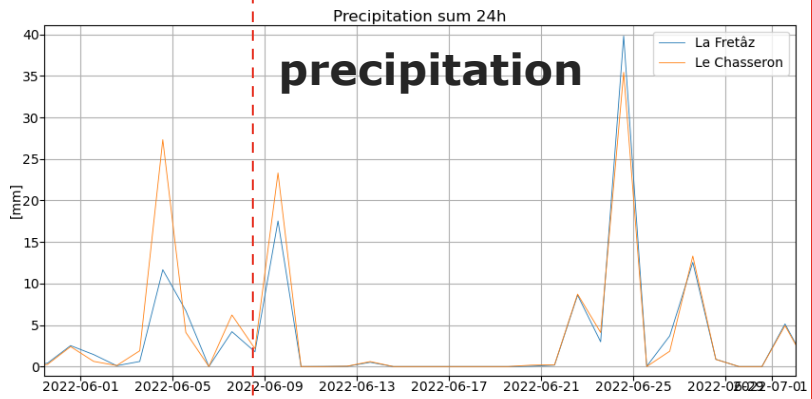
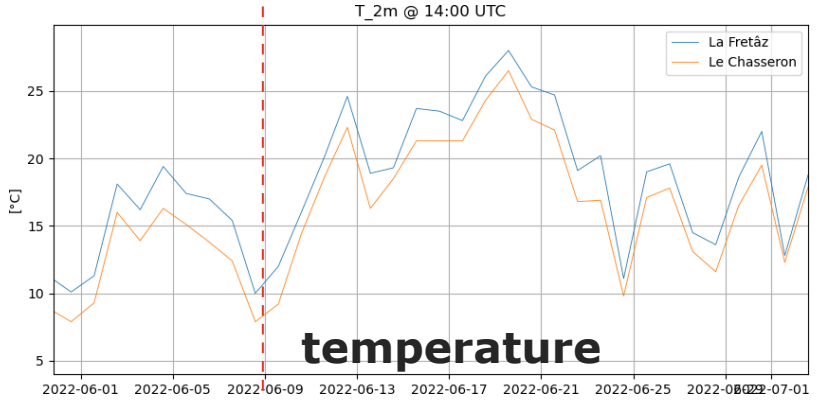
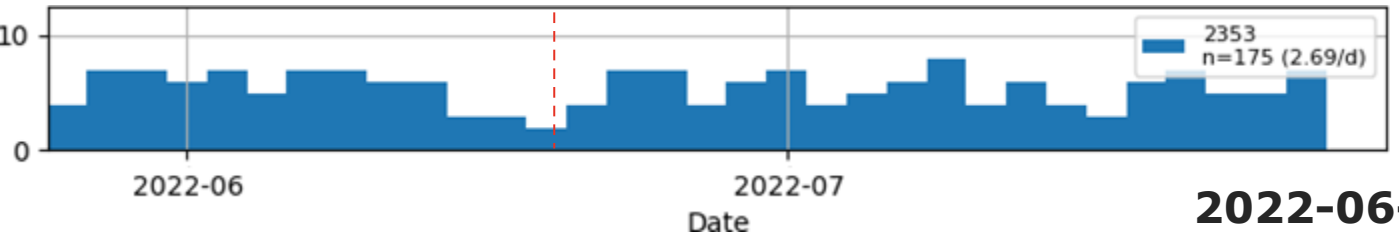


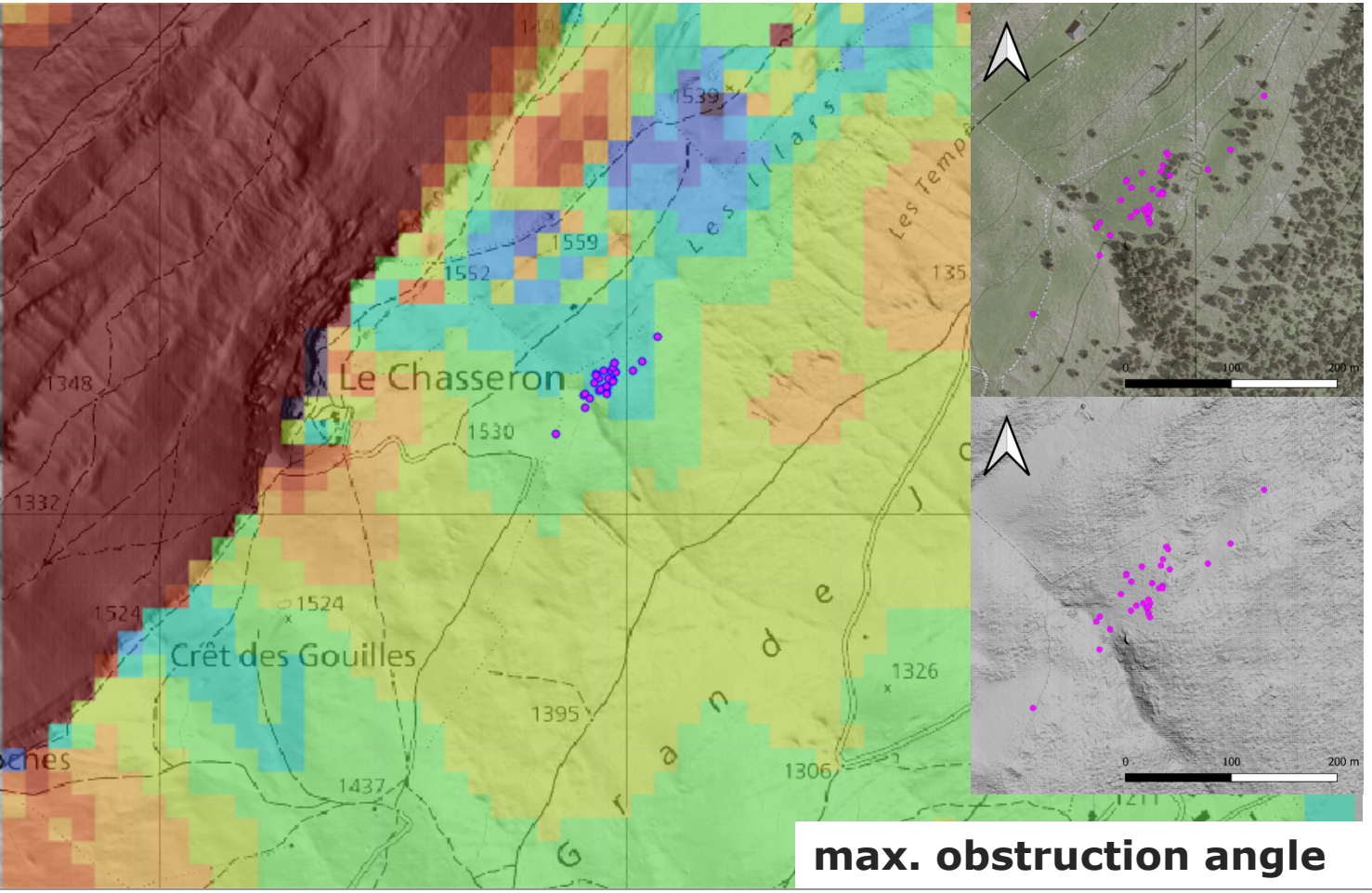




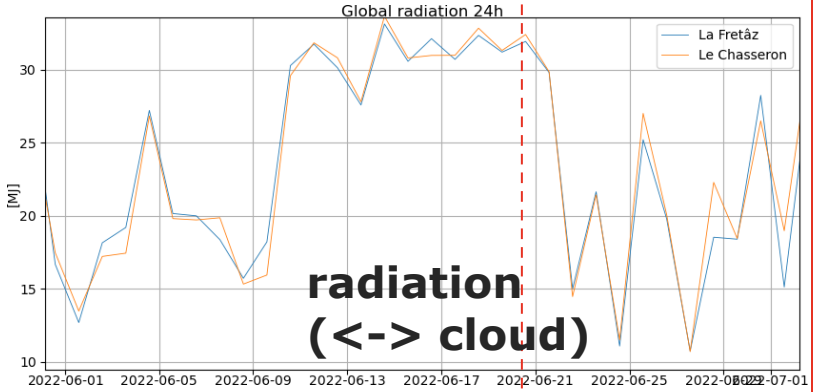
Topographic shadow – herd location

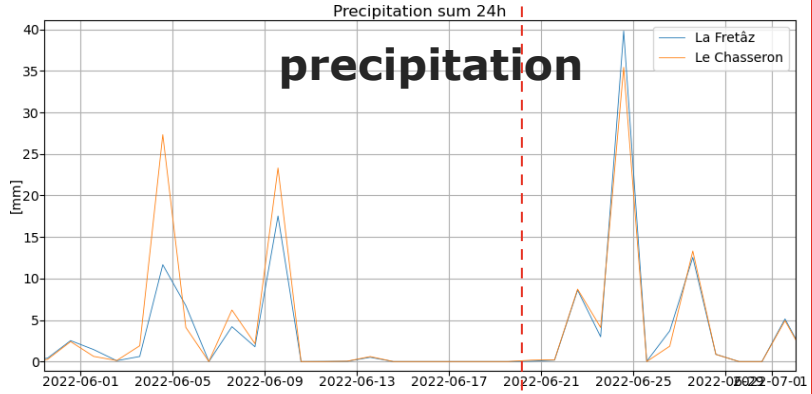


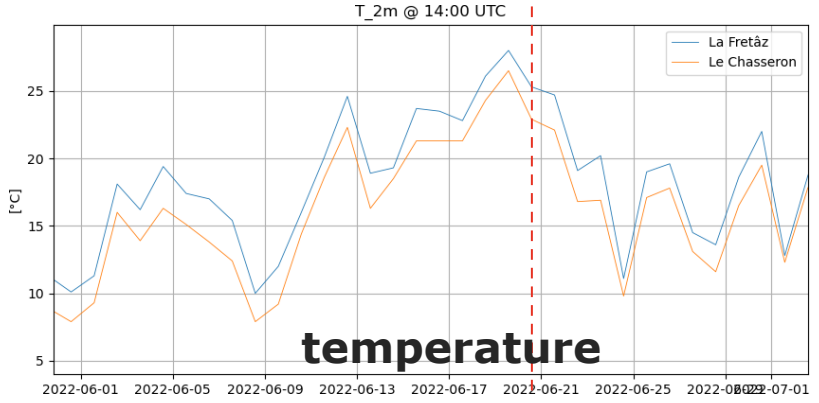
2022-06-19



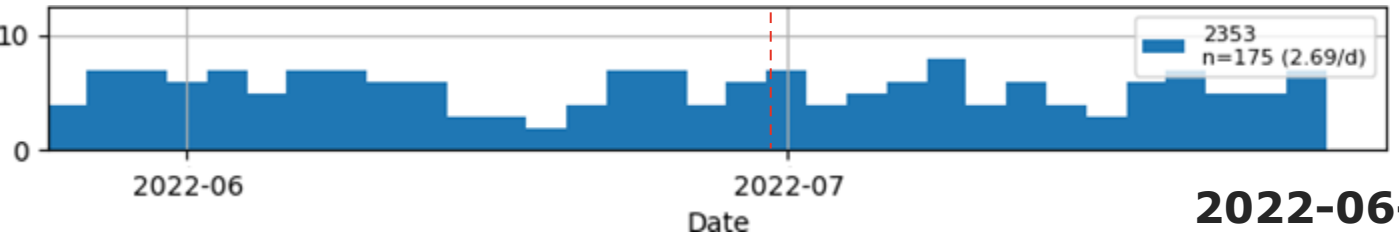
max. obstruction angle







Topographic shadow – herd location



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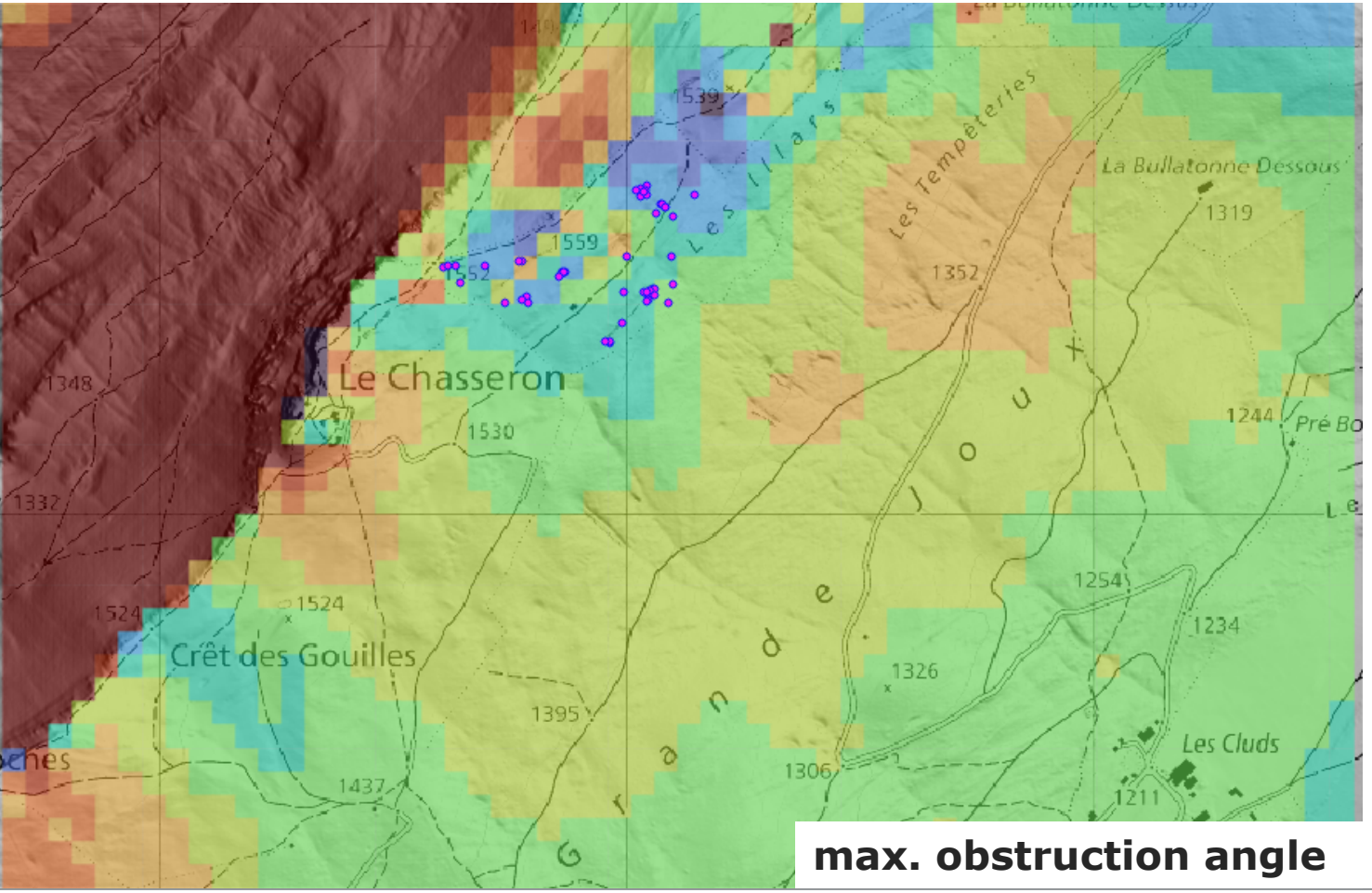
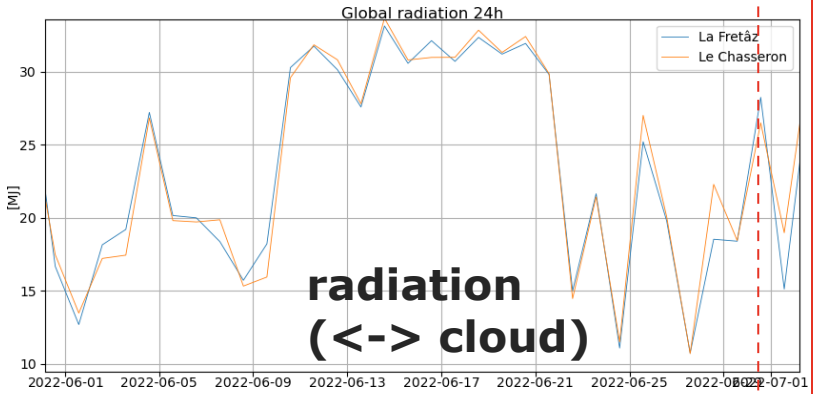
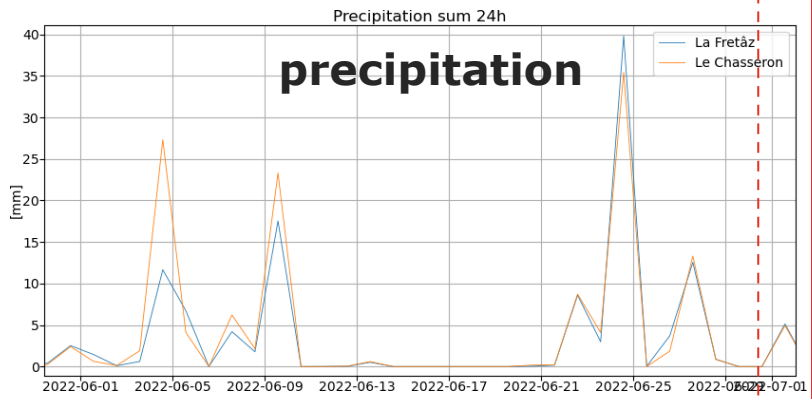
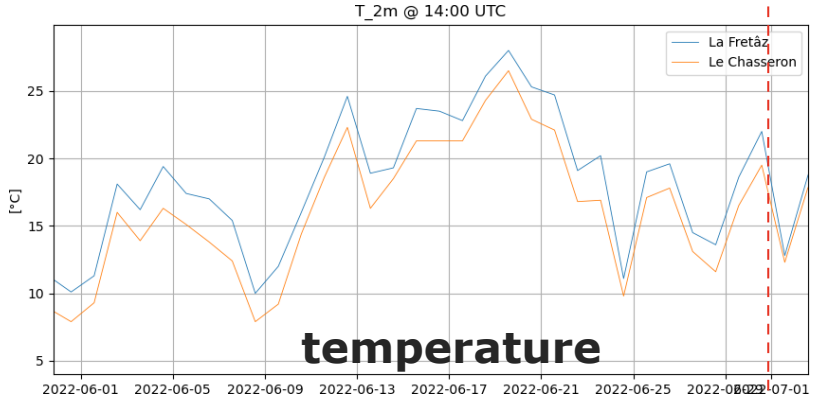


max. obstruction angle



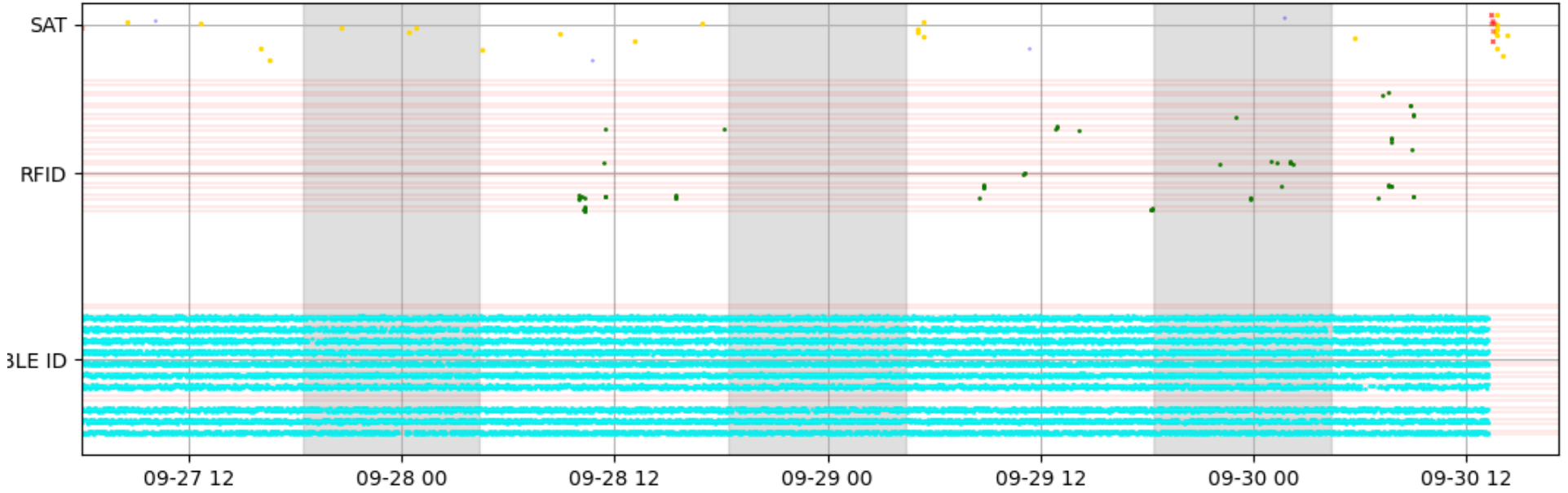




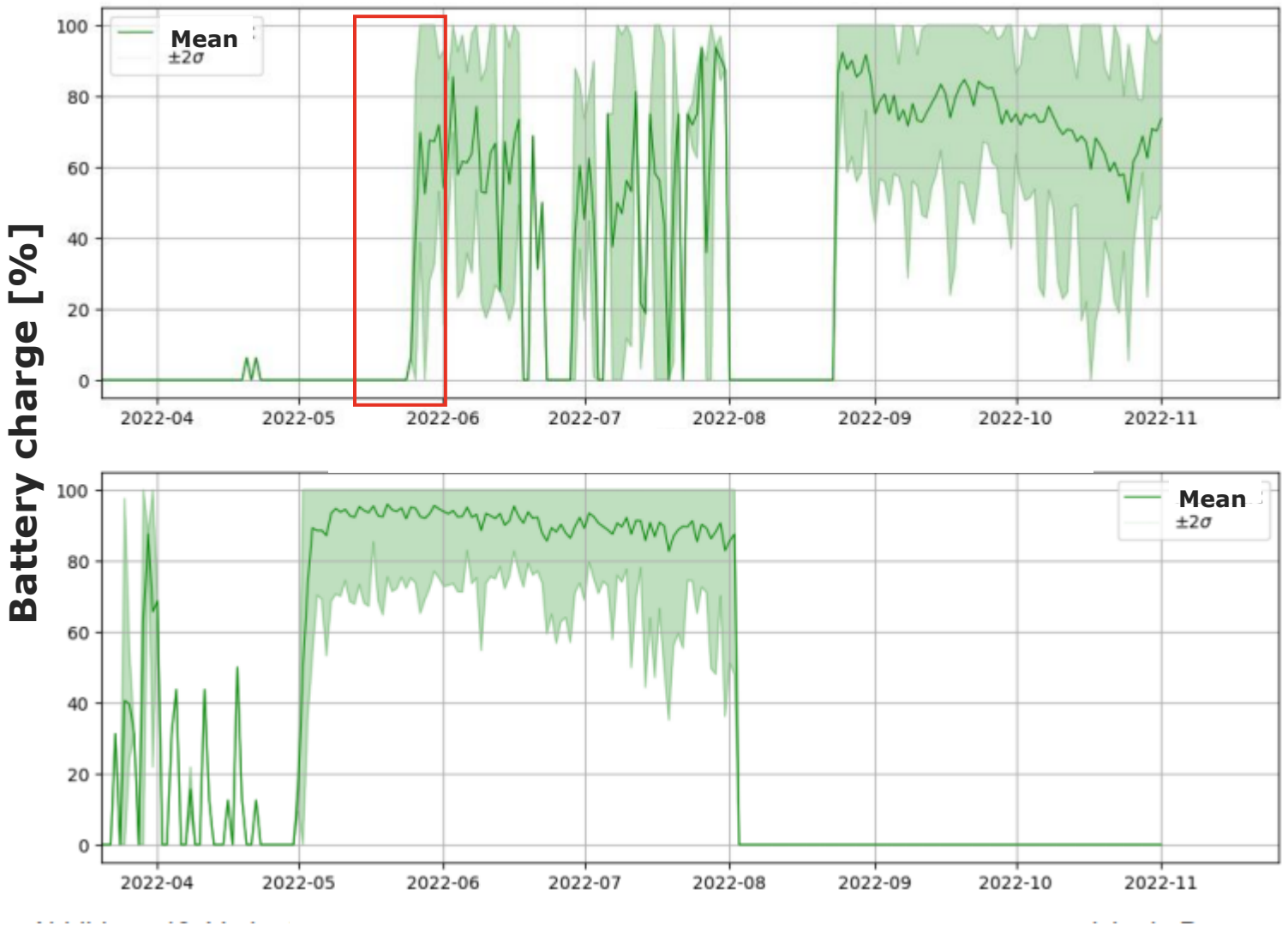
Behaviour – alerts

Immobility alerts alway related to
- Loss of tag (ear)
- Maintenance/tagging

High activity alerts
- both on Alpine pasture / on ear, and low-land / collar
- Wider interest (CH) in context of herd panic / predator occurrence



Energy autonomy – battery levels 2022



Low-land, barn-based group

Mostly in barn until end of May
Mixed stays until August
Frequently on pastures from August

Summering group

Moved from low-land to alpine pasture end of May;
on pasture from end of April

Background

Evaluated device

- Three data channels: Satcom, Bluetooth, RFID
- Energy autonomy (solar panel)
- Research backing
- Open, diversified software environment

Findings

- Energy supply challenging during winter / stable period
- Automated reporting feasible / technical hurdles require additional effort
- Behaviour and activity measurements promising

Conclusions (umbrella project)

- Short-term continuation => use tags on collar
- Short-term continuation => only summering (energy, infrastructure)
- Mid-to long-term => develop BLE channels

Swiss animal husbandry conditions

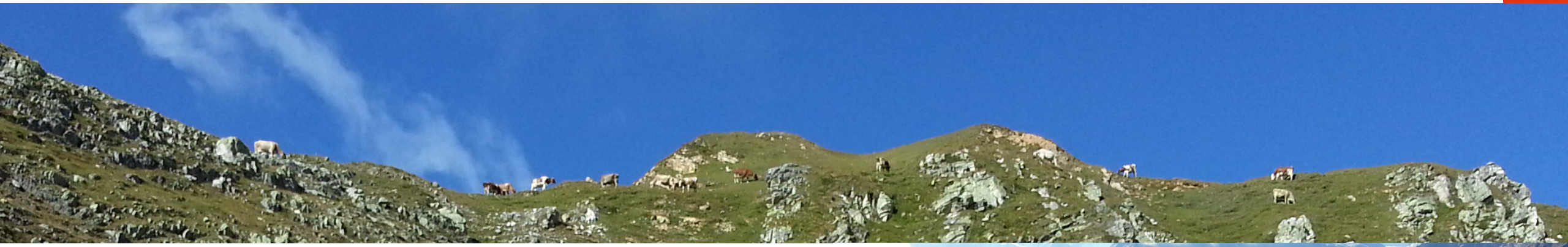
Administration:
- Central tracing and identification requirements
- Steering – public subsidies as incentives for series of activities (regulations)

[Themen – publication Agroscope]

Geography:
- Restricted space (three geo area, 7 zones) competition – industry, urban
- Topographic constraints

Sector:
- Seasonal with barn and summering husbandry
- Smaller farms – often family-run, limited resources and administrative capacities (median: 30 animals)
- Strong public interest

Swiss husbandry conditions – topography, summering



Usable area spread over large elevation range
… only snow-free during summer

Fencing and herding challenging – wolf loss

Two-tier husbandry model: All-year husbandry, and temporary summering husbandry

⇒ No external energy, poor mobile network
⇒ Relief and topographic shadowing

Swiss husbandry conditions – barn and exercise area

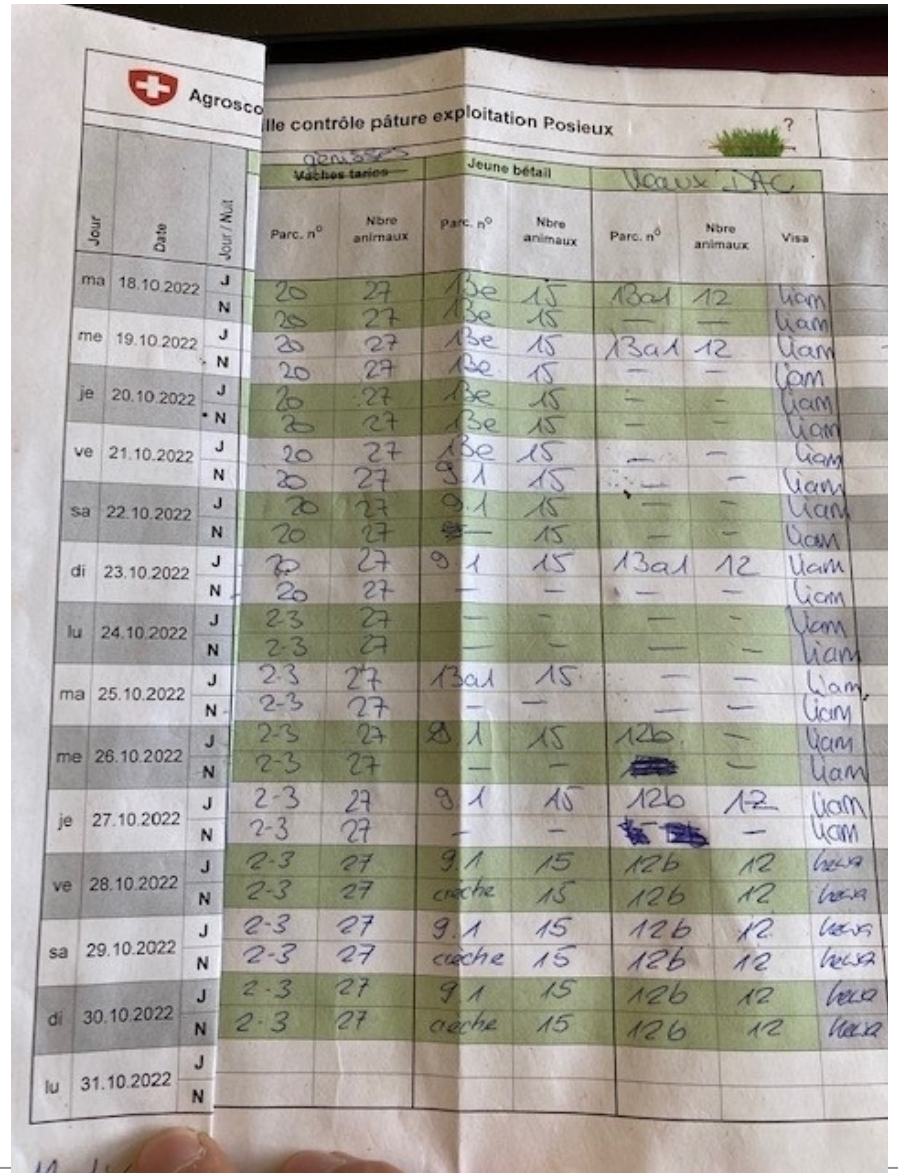
Stationary in barn : during winter months

Welfare - compensation: adjacent exercise area

⇒ Dark

⇒ +/- infrastructure available

Swiss husbandry conditions – documentation



Herd has access to pasture or exercise area

Paperwork

Self-declaration (plausibility, policing)

Automated documentation

Use:
- Satcom positions checked against polygons
- Outdoor RFID antenna (exercise area)

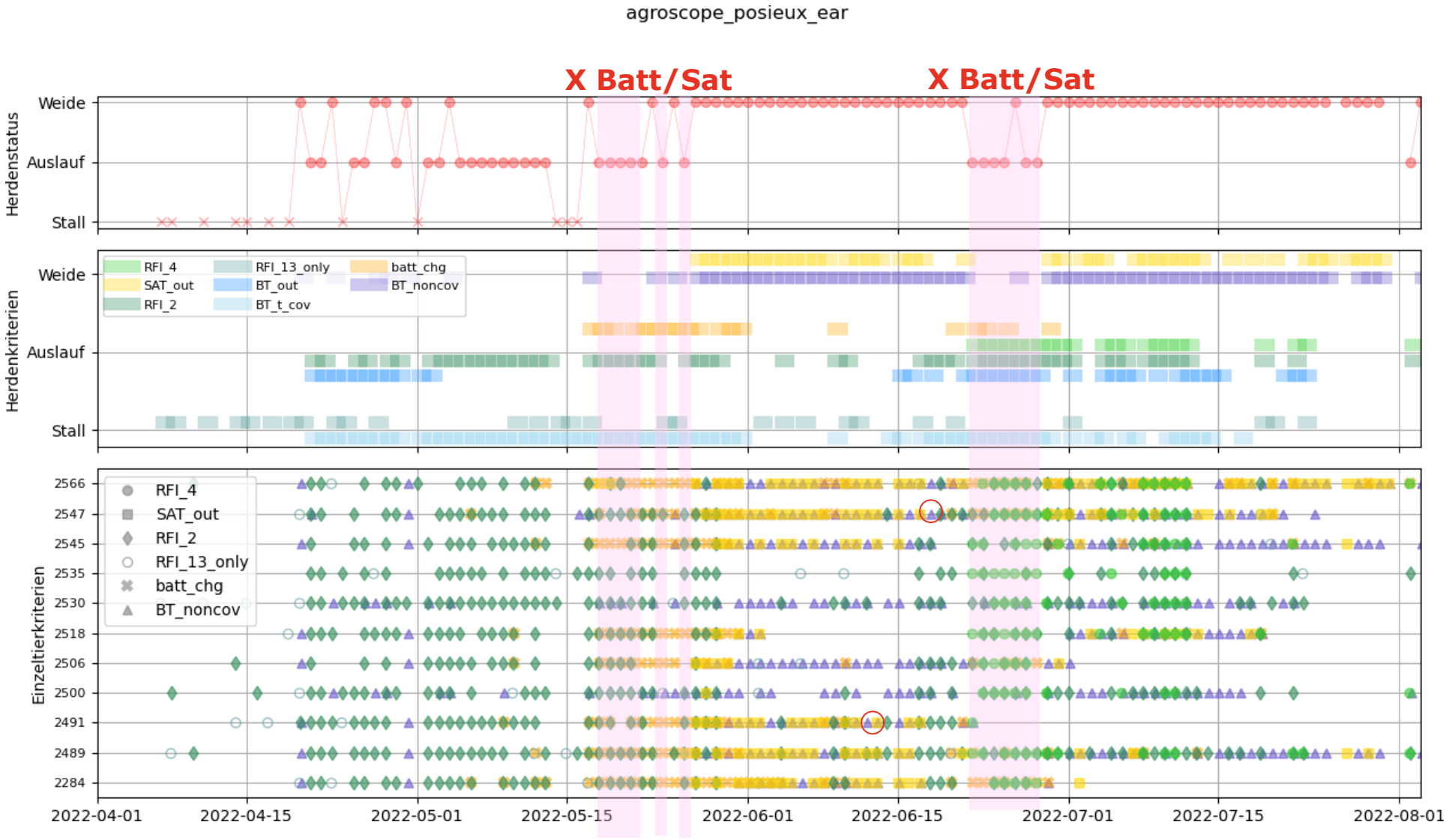
Supplement with:
- Consistent data gaps (pasture)
- IPS heuristics (exercise area)
- Charge current (proximal/outdoors)
- Door frame RFID antenna (exercise area)
- Indoor RFID antenna only (barn)
- Constant bluetooth signal (barn environment)

… transferrable to other barn environments?

Tabelle 2: Verarbeitungsablauf Auslauf- und Weidejournal

Datenkanal	Auswertungsart	Güte-klasse	Voraussetzung	Abgeleiteter Journal-status
SATCOM	Positionsangaben innerhalb von Wei-deumrissen unter Berücksichtigung Messungenauigkeit	I	Min. 2 Signale innerhalb Weide	Herde hat Weidegang am Kalendertag
RFID	Kontakte an Aus-senantenne	I	>= 1 Signal	Herde hat Zugang zu Auslaufbereich am Ka-lendertag
BLE (RFID)	Antennen und SOM demonstrieren Funktion; SOM nicht registriert für Zeitfenster	II	Validierung min 1h/SOM; Min. 2h/SOM konsistente Erfassungslücke. Für min. 2 Tiere. Möglich für Wei-den mit Abstand zu Stall-umfeld.	Herde hat Weidegang am Kalendertag
BLE	Lokalisierung im IPS wird gegen Umrisse Stall und Auslaufbereich ver-glichen	IV	Min. 20% der IPS-Koordinaten pro laufen-dem 4h-Fenster im Aus-lauf; min. 12 Fenster x Tiere	Herde hat Zugang zu Auslaufbereich am Ka-lendertag
BLE	Ladestrom	II	Min. 2 Werte > 1000 µA pro SOM, min. 3 Tiere	Herde hat Zugang zu Auslaufbereich am Ka-lendertag
RFID	Gehäufte Lesungen im Türrahmen	II	Min. 6 Tiere mit Kontakt zur Rahmenantenne	Herde hat Zugang zu Auslaufbereich am Ka-lendertag
RFID	Lesungen aus-schliesslich an In-nenantennen	III	Min. 2 Tiere	Stallaufenthalt der Herde, sofern kein Weide- oder Auslauf-wert gesetzt. Verhin-dert Nichteintreten für den Tag
BLE	Durchgehende Er-fassung	IV	Min 22h auf 6 Tieren	Stallaufenthalt der Herde, sofern kein Weide- oder Auslauf-wert gesetzt. Verhin-dert Nichteintreten für den Tag
Alle	Datenmangel	IV	Keine der o.g. Kriterien trifft zu	Keine Aussage für den Kalendertag getroffen

Automated documentation



Automated documentation

Bottleneck: phases in May and June, where

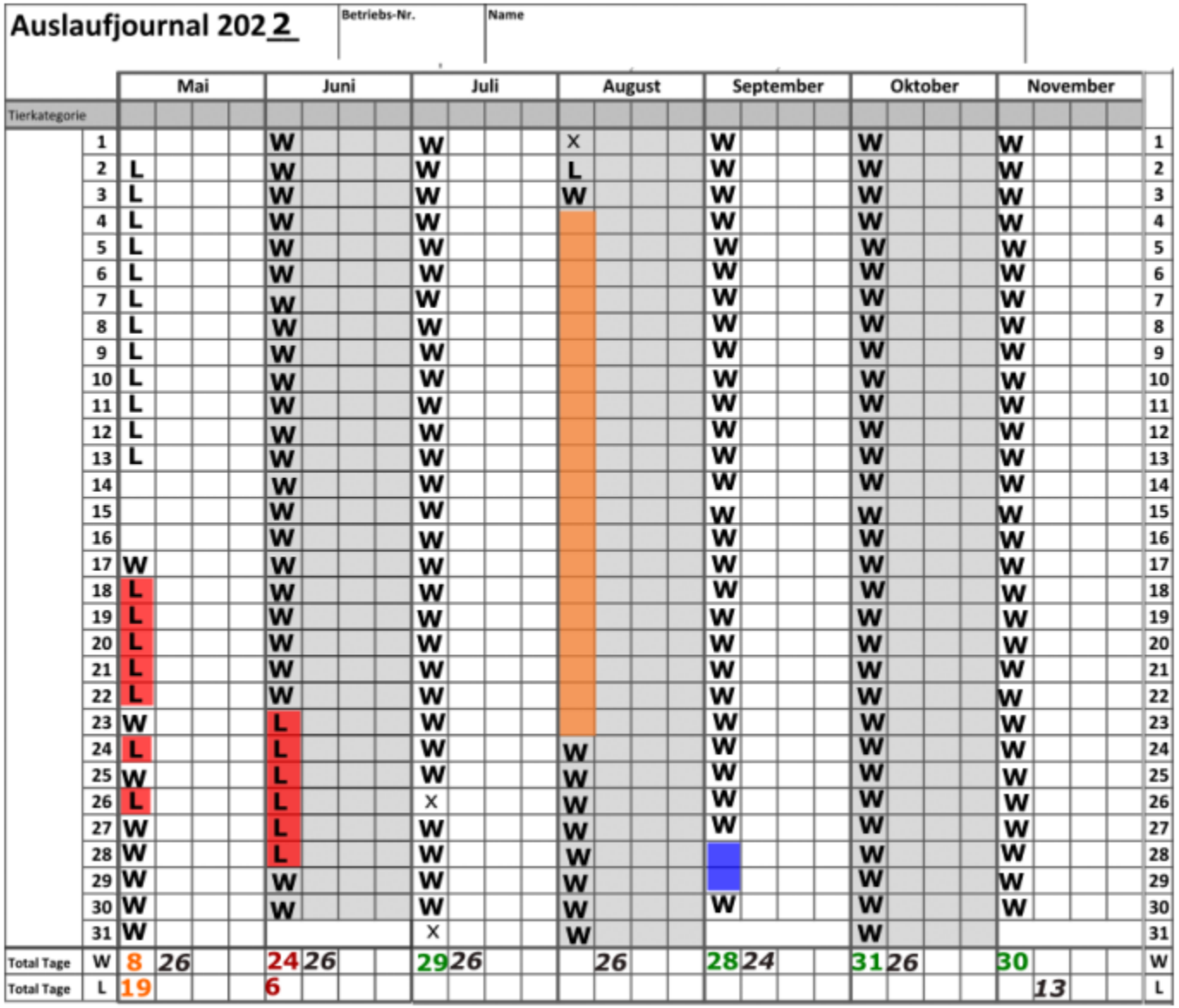
- Battery levels were subcritical, and satcom transmission failed

- Cattle grazed on pasture immediately adjacent to barn

  (BLE IPS not indicating)

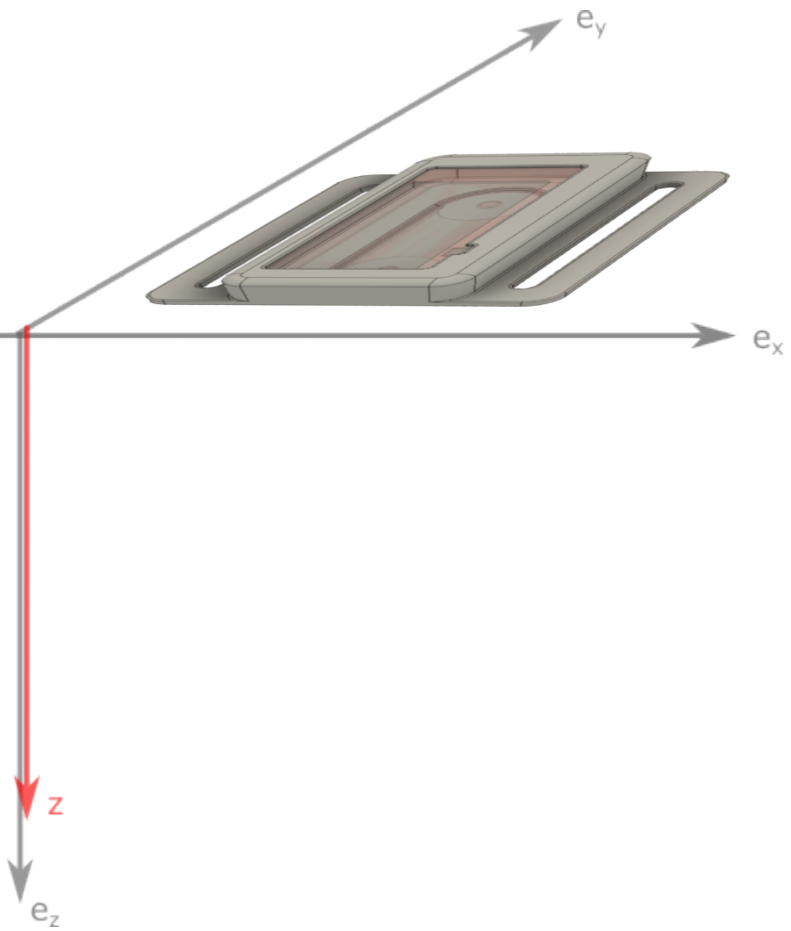
Failure rate ca. 6% - immature

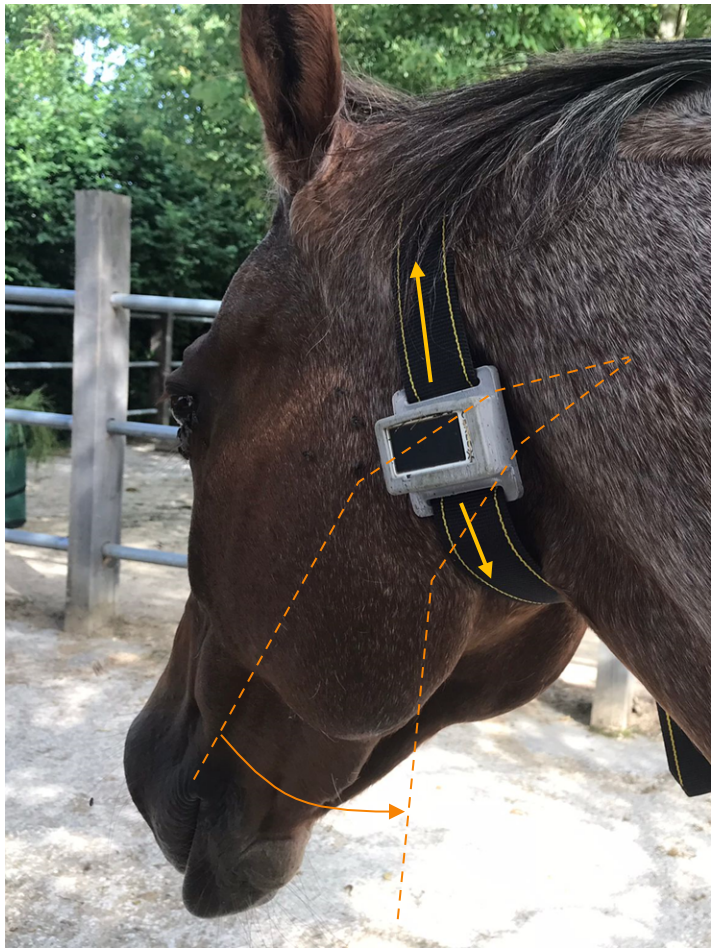
W – pasture
L – exercise area

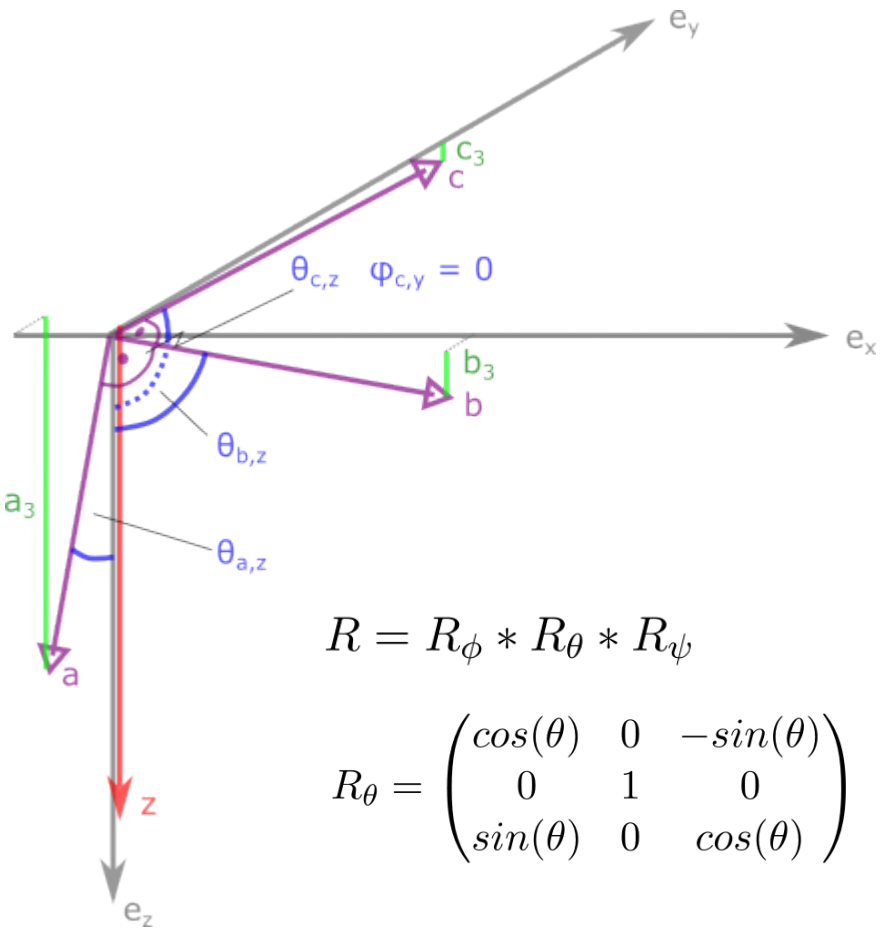


Accelerometry data (Bluetooth transmission)

Additional high-value target: behaviour classification (cf. activity)



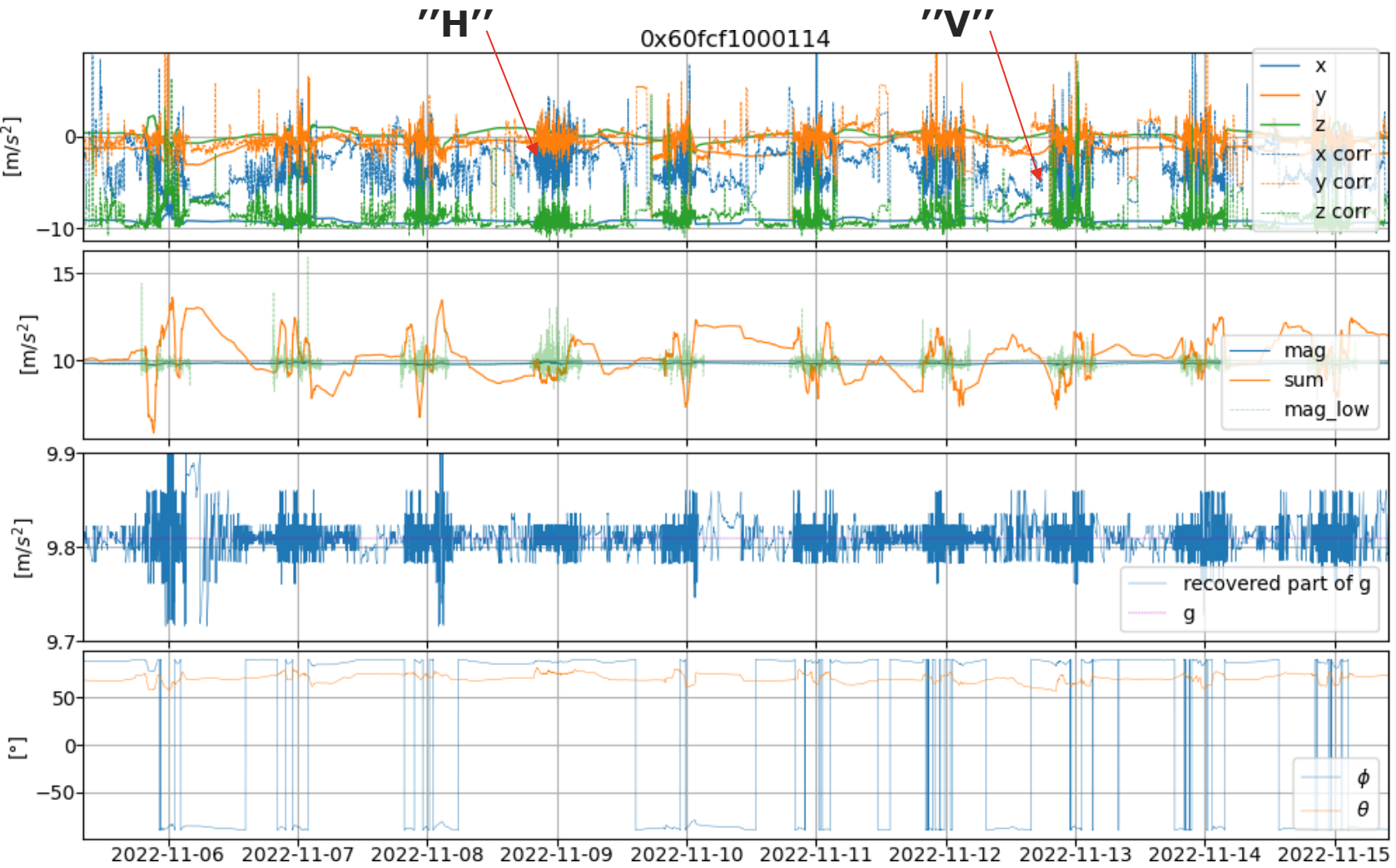




$$R = R_\phi * R_\theta * R_\psi$$

$$R_\theta = \begin{pmatrix} cos(\theta) & 0 & -sin(\theta) \\ 0 & 1 & 0 \\ sin(\theta) & 0 & cos(\theta) \end{pmatrix}$$

Accelerometry data (Bluetooth transmission)



Rerotated accelerations

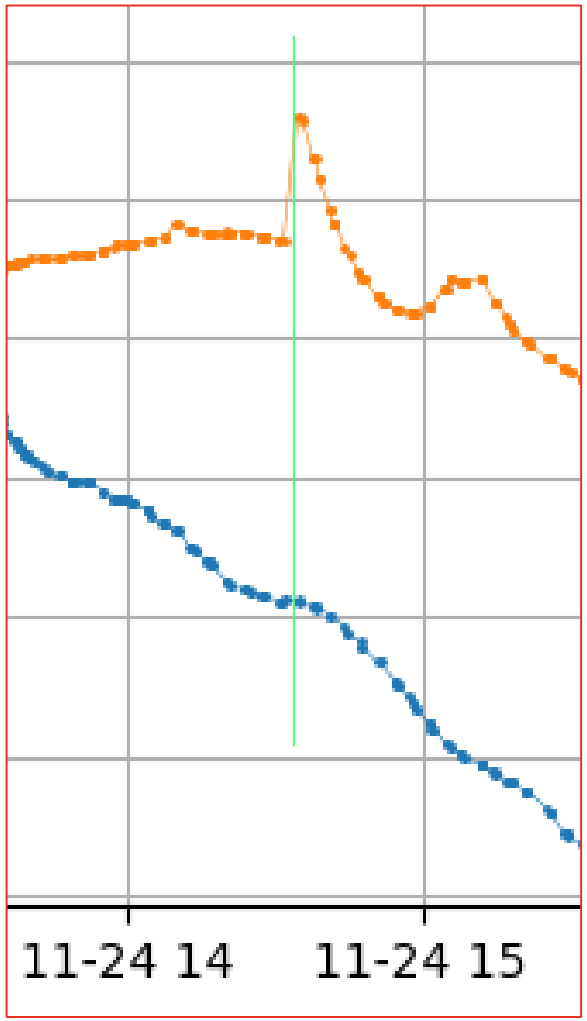
Base-line for rerotation?

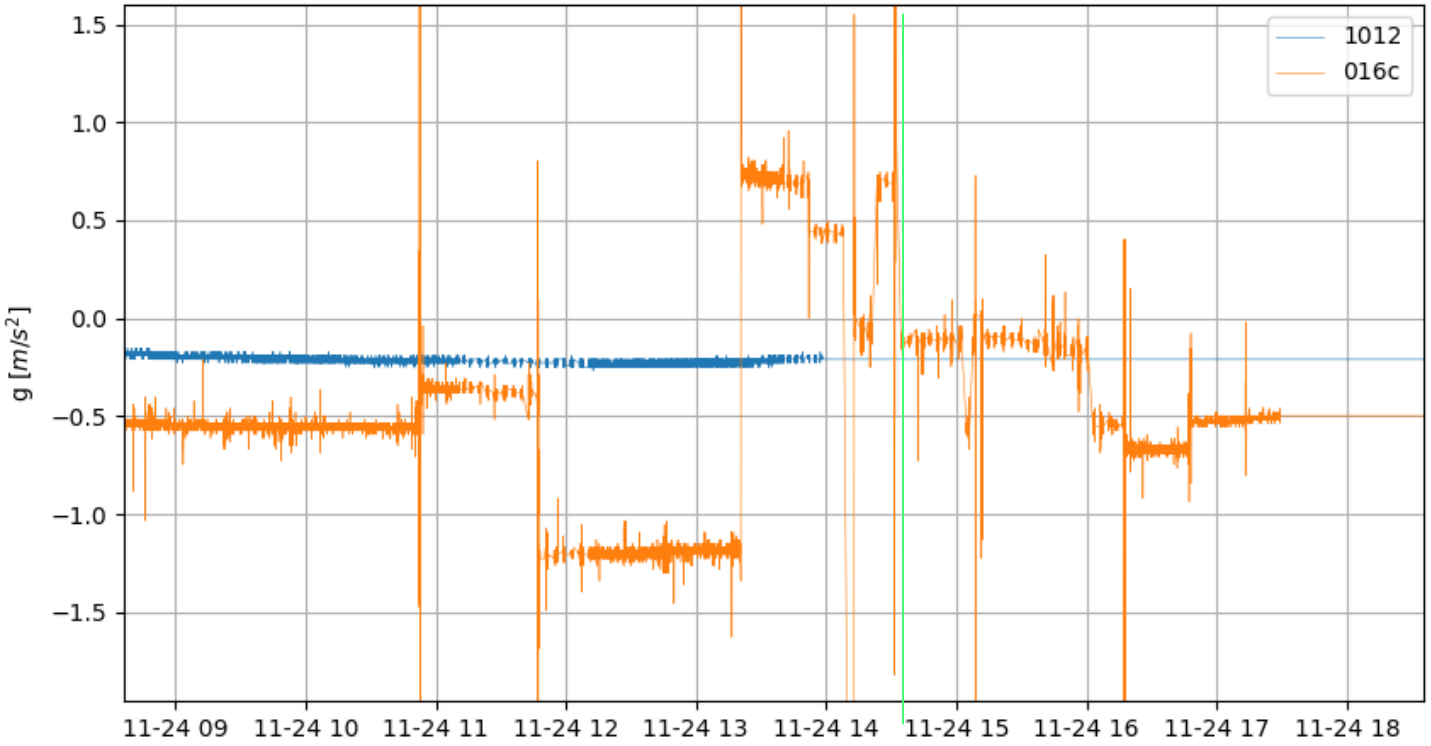
Perfect static conditions should yield 0/0/9.81 m/s^2

Activity reflected by variation of magnitude
=> Reliable enough

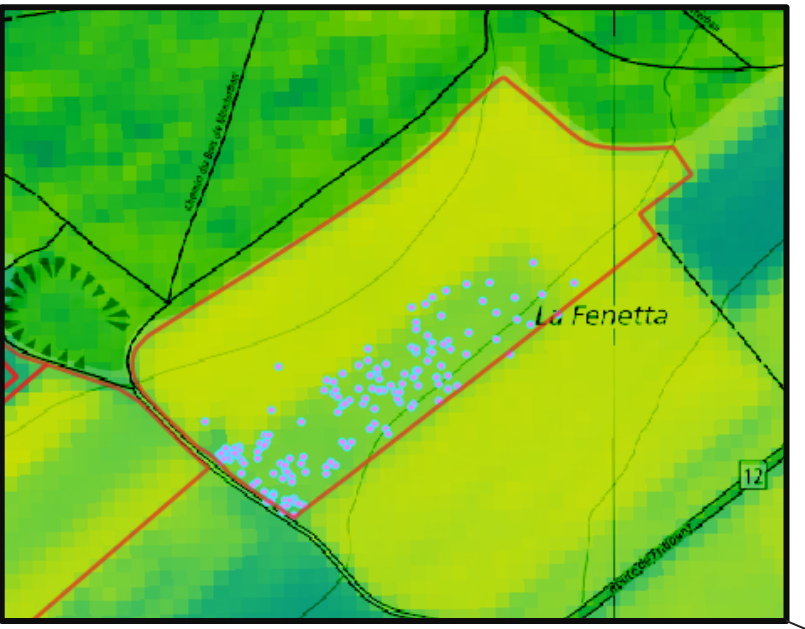
3-axial decomposition necessary?

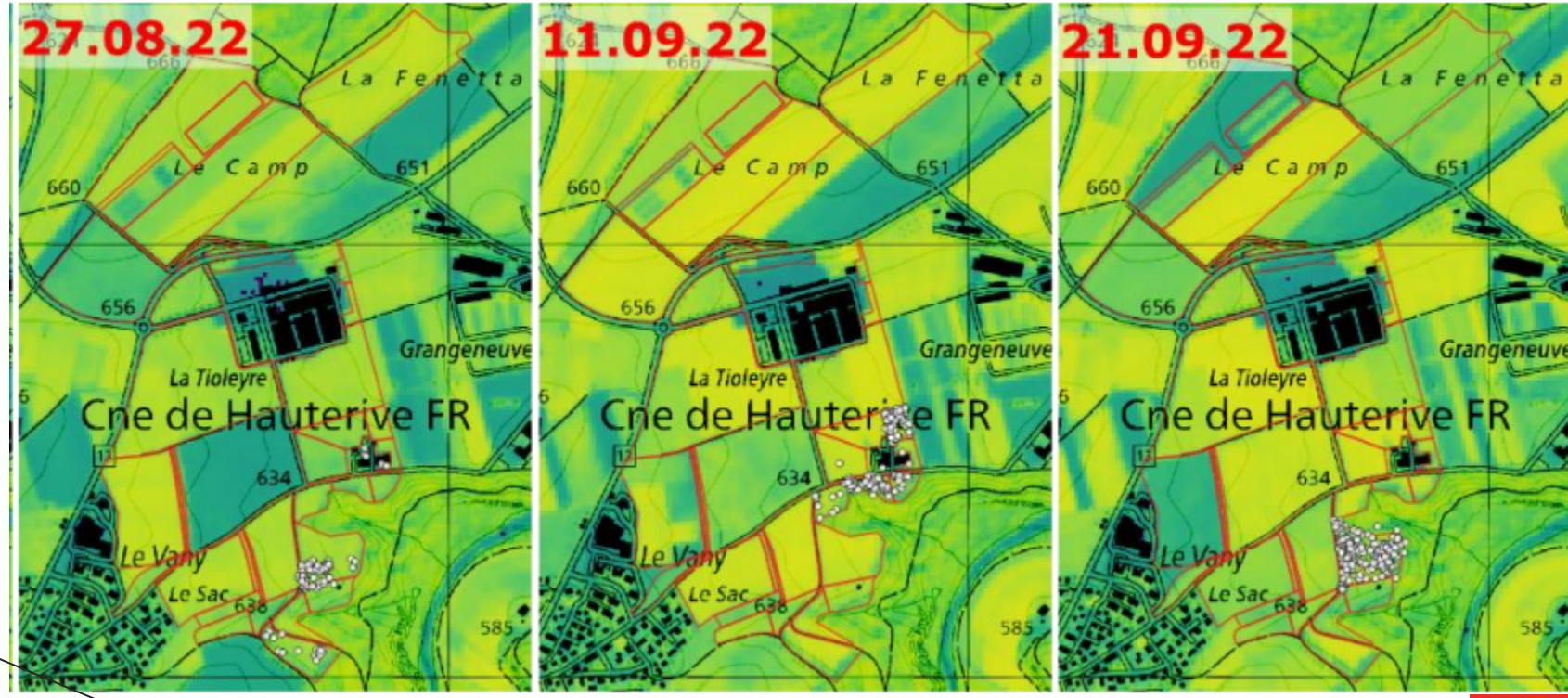
=> No information for location status elaborated

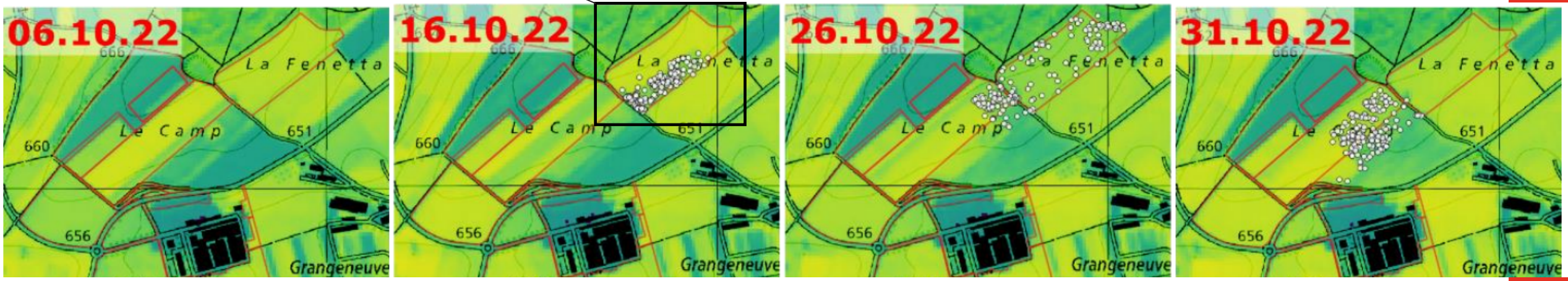

11-24 14
11-24 15


1012
016c
g [m/s²]
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
11-24 09
11-24 10
11-24 11
11-24 12
11-24 13
11-24 14
11-24 15
11-24 16
11-24 17
11-24 18

Added value products – NDVI / land use







NDVI / land use

Drought season 2022, Alpine pastures