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TAKING THE PULSE OF OUR PLANET FROM SPACE

Use of Sentinel-1 for peatland hydrological condition monitoring in near-natural, damaged and restored northern peatlands

L. Toča[ab], K. Morrison[a], R.R.E. Artz[b], A. Gimona[b], T. Quaife[a]

[a] Department of Meteorology, University of Reading, Reading, Whiteknights, RG6 6BB, UK

[b] The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK

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Why peatlands?

- Largest natural terrestrial carbon store
- Valuable ecosystem services
- 'Cinderella habitat’
- Scotland: £250 million ten-year funding for 250,000 ha of degraded peatland restoration

Why water level?

- Carbon accumulation
- GHG exchange
- Restoration success

Why radar?

- Weather and sunlight independent
- Penetration capability
- Free regular satellite data resources available

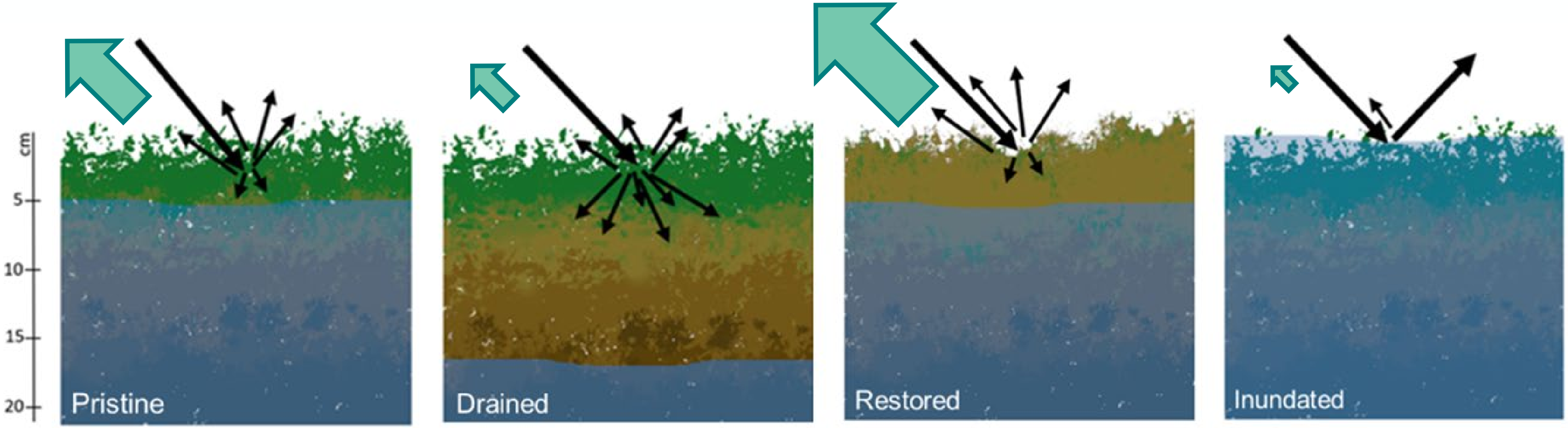


Figure 1. Radar backscatter characteristics based on the water level position in peatlands.

Bog-in-a-box

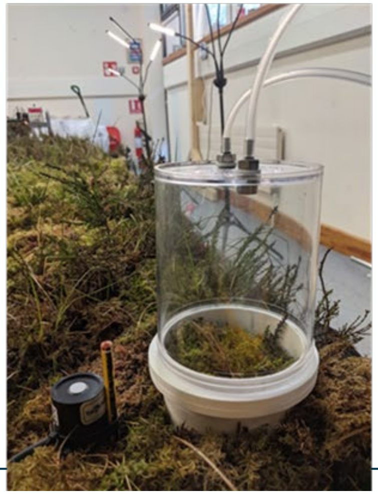
Radar system:

- 4-8GHz C-band antenna
- VV, VH, HH, HV
- Tomographic profiling (TP) method *(technical description: Morrison and Bennett, 2014. doi: 10.1109/TGRS.2013.2250508)*

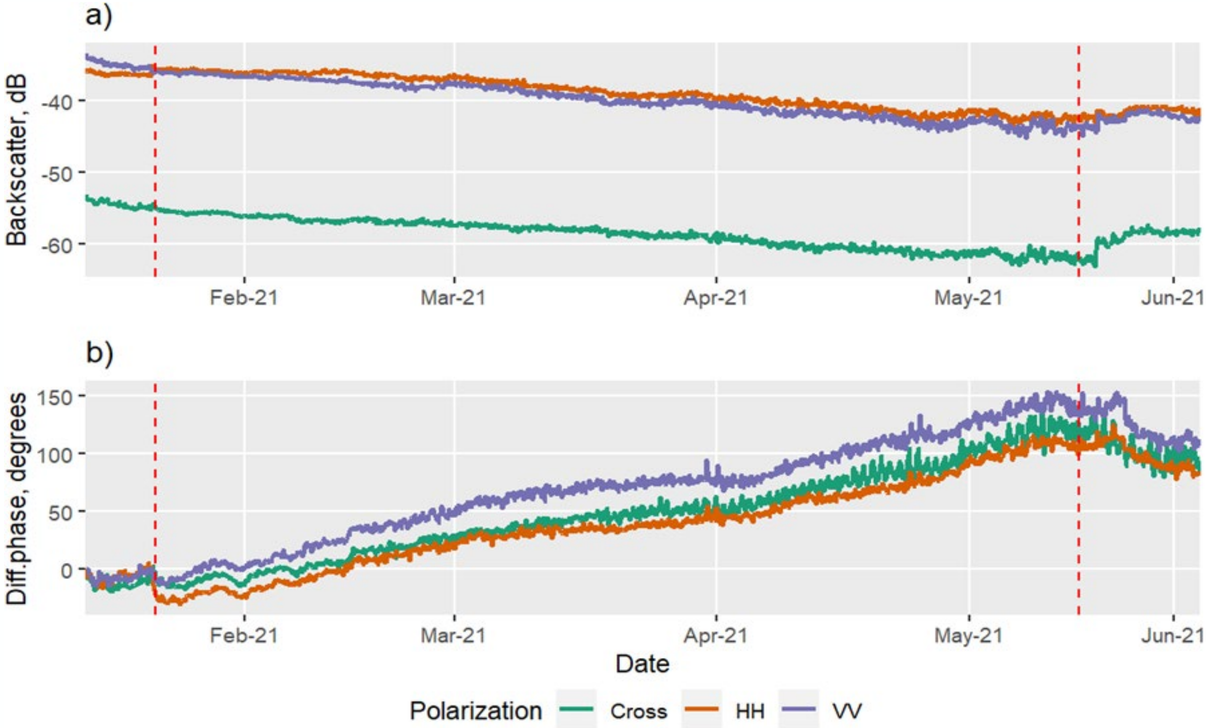
- 6 soil moisture probes, dip well for water level (WL), and flux data measurements.
- Acclimatization (2 months), drought phase (4 months), re-wetting (1 month).

Main objective:

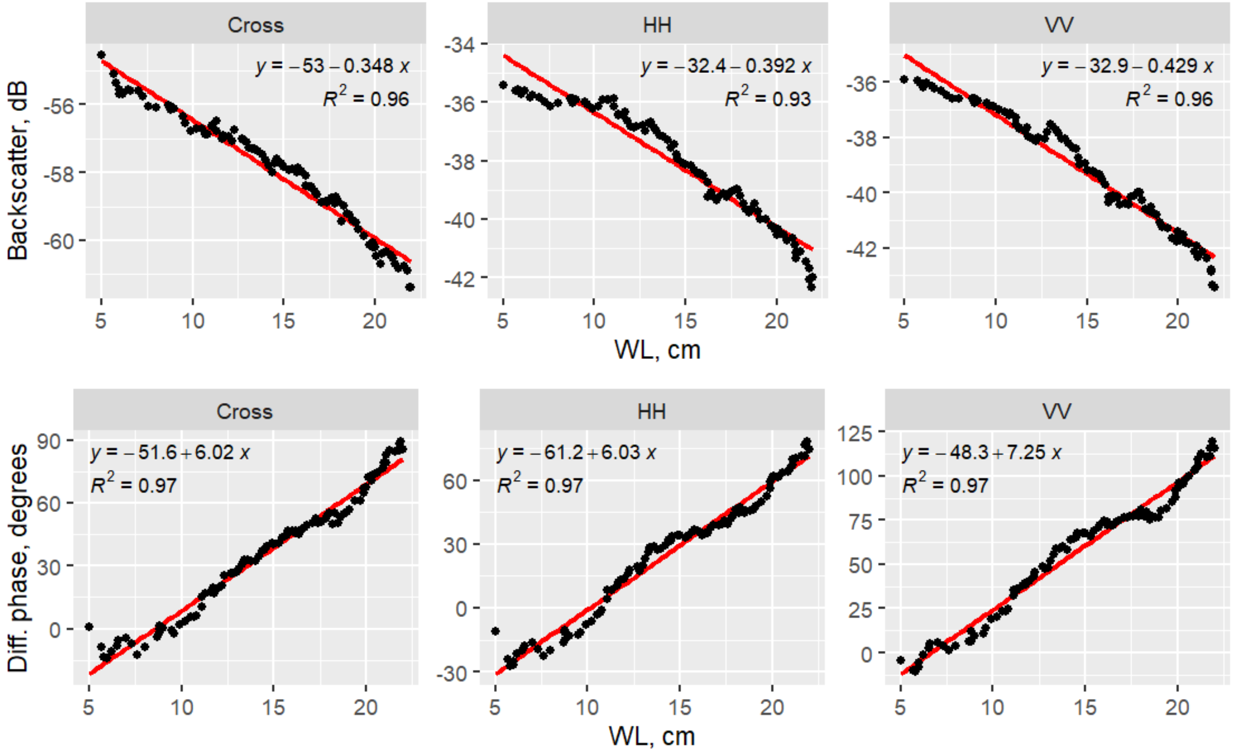
Investigate the radar backscatter dependency on different peatland hydrological regimes in high detail.



- 6000+ scans completed.
- A clear decrease in backscattering strength and phase increase with the progression of the drought.
- Decrease in backscatter by 8dB (VV), 7dB (HH) and 8dB (Cross-pol).
- Increase in phase (corresponding to an increase in distance) by 140° or 10mm (VV), 110° or 8mm (HH), 110° or 8mm (Cross-pol).



- A strong negative linear relationship (R^2>0.9) found between backscatter values and the water level.
- Backscatter signal strongest at the beginning of the experiment (WL 5cm).

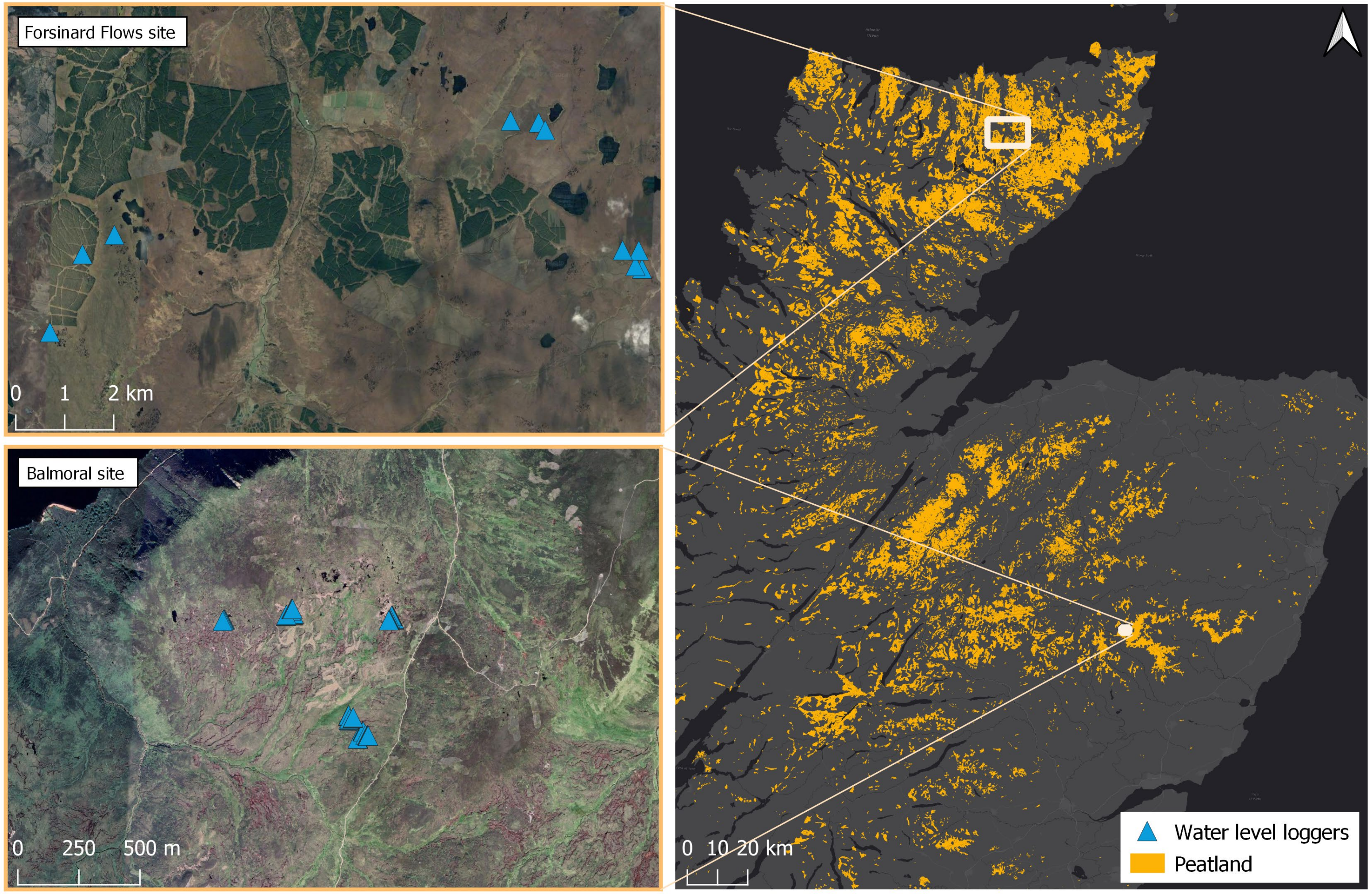


...and what about the real world?

Two research areas:

- **Forsinard Flows Nature Reserve**
  - blanket bog
  - drained and subsequently afforested in the past
- **Balmoral site in Cairngorms Natural park**
  - upland blanket bog
  - heavily eroded

- 2-3 years of water level measurements from 16 locations.
- GEE workflow for Sentinel-1 time-series data (filtered, averaged, vegetation sine curve applied)
- Lidar data for surface roughness analysis.



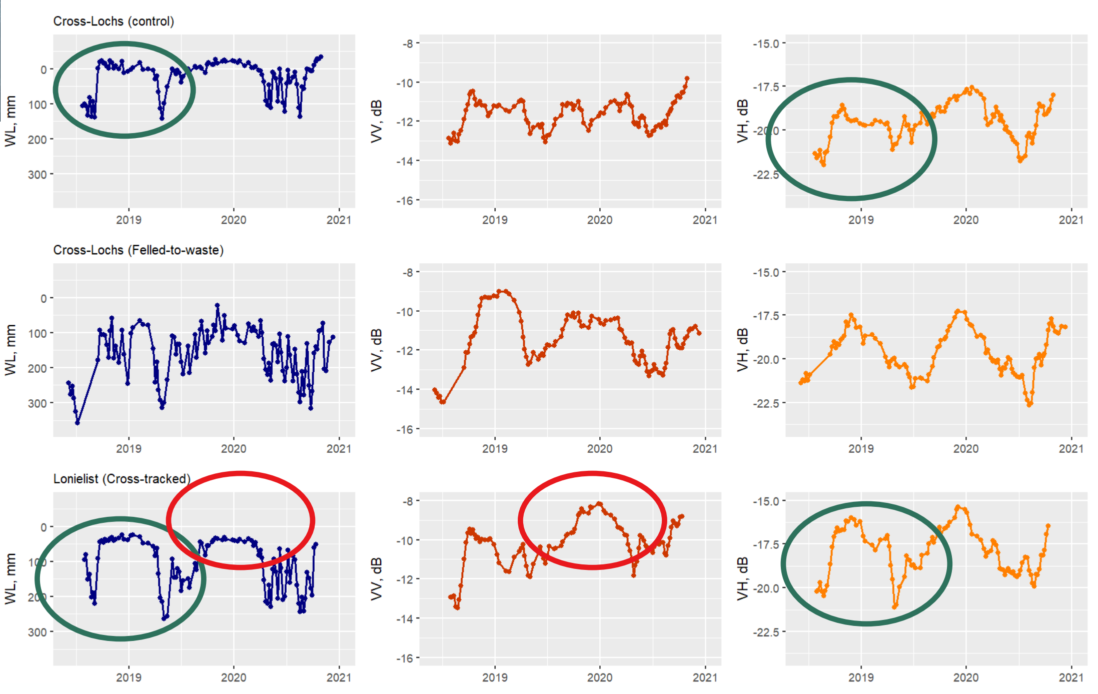


Figure 2. Water level, VV and VH time series in near-natural and restored sites.

- Terrain ruggedness index (TRI): the amount of elevation difference between adjacent cells of a DSM (from LiDAR).
- Mean TRI:
  - Natural: 0.07 m
  - Felled to waste: 0.6 m
  - Felled + additional management: 0.1 m

- Moderate agreement between water level and radar backscatter in two sites ($R^2 > 0.5$), weak in three sites ($0.3 < R^2 < 0.5$) and very weak ($R^2 < 0.3$) in 6 sites.

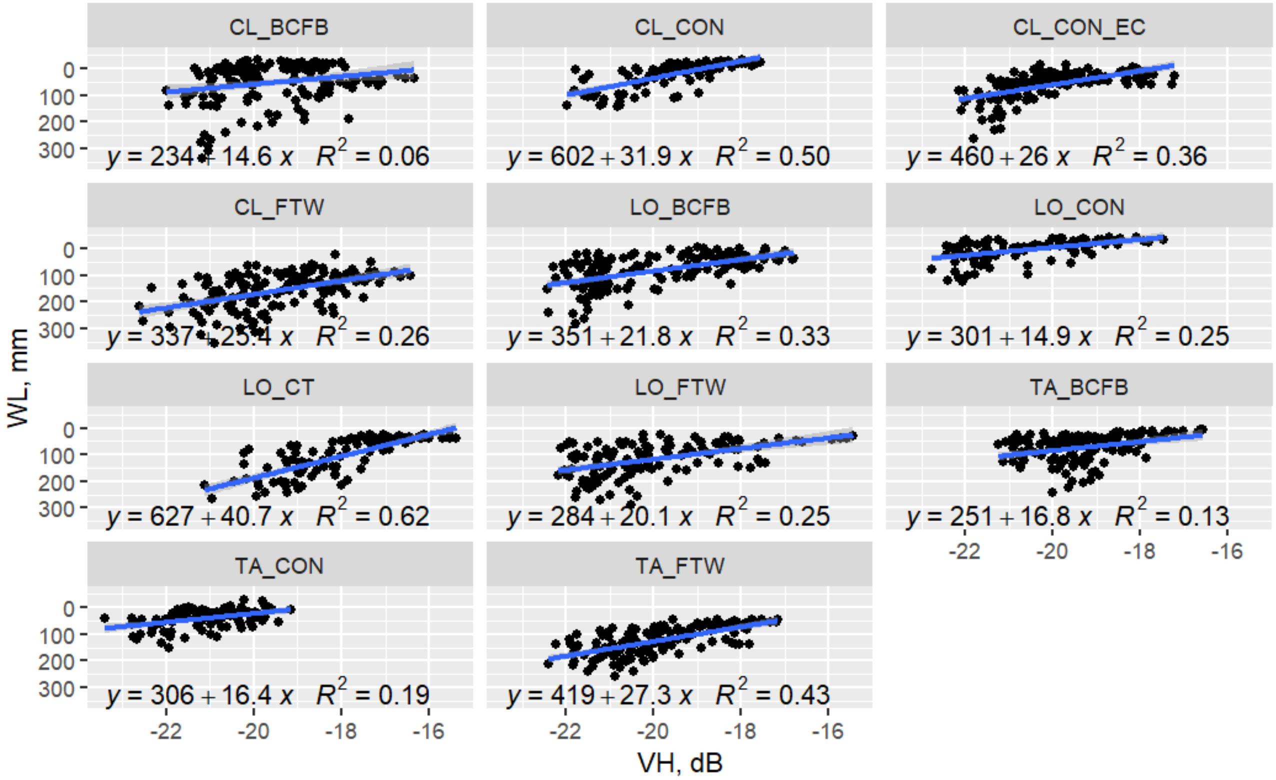
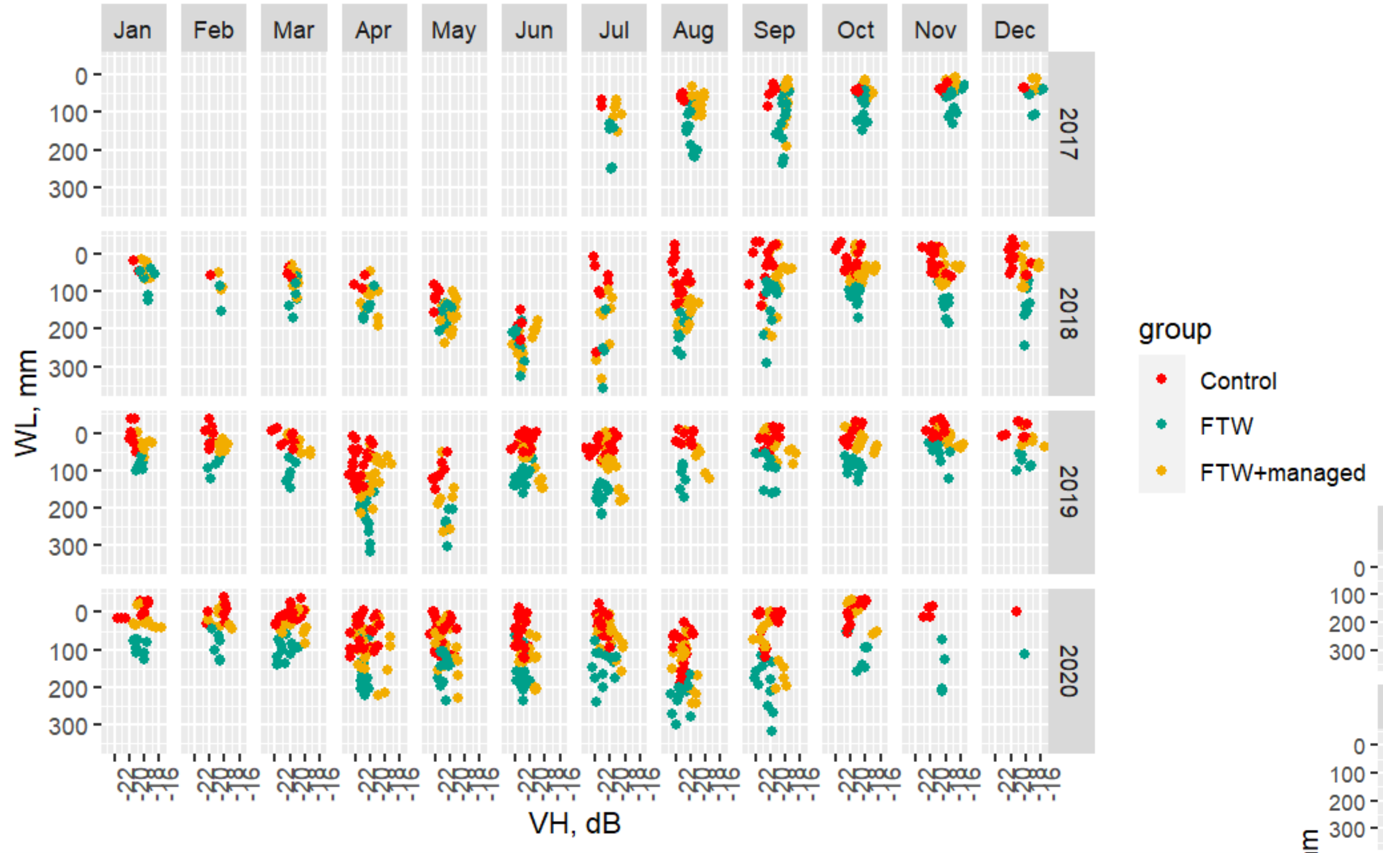
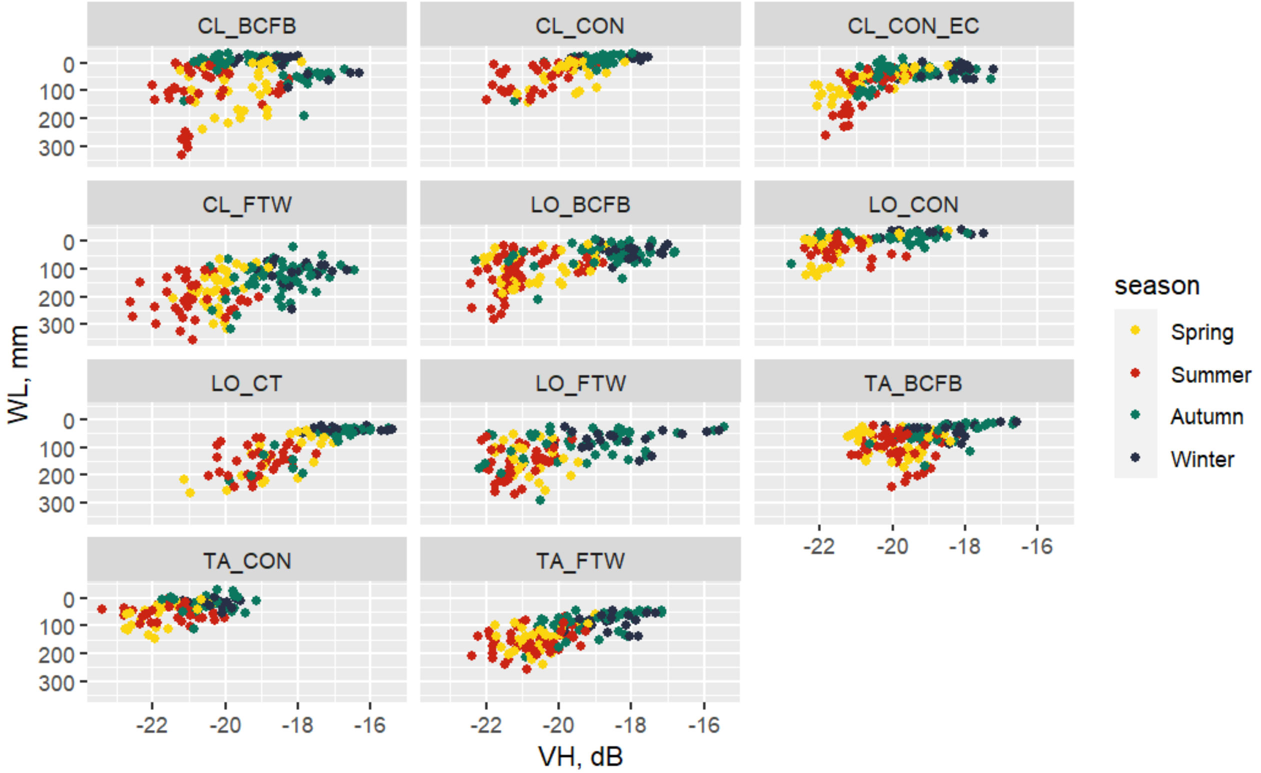


Figure 3. Water level and Sentinel-1 backscatter relationship in Forsinard Flows research site.



- Higher water table depth in a peatland **does not** automatically mean higher radar backscatter!



- A clear impact of the 2018 European spring-summer drought event.

- Seasonal trends in S-1 time series (higher values in autumn and winter, lower in spring and summer).

Peatlands - complex ecosystems

Challenges when analysing WL - backscatter relationship:

- Topography & microtopography (gullies, hummocks, hollows, pools)
- Ridge and furrow pattern from past forestry
- Soil and vegetation moisture content, inundation
- Varying vegetation
- Soil density and texture
- Data accuracy

Take-away points

1. Both the laboratory experiment and the time series analysis have shown a potential for **SAR** to be used as a **proxy for near-surface hydrology** over peatlands, however...
2. While a controlled environment can yield a very **close relationship** between radar signal and moisture status (R^2>0.9), field data suggests only a **moderate to very low relationship** (0.1 > R^2 < 0.7).
3. Other **parameters** need to be taken into consideration when investigating radar backscatter over peatlands:
    1. Topography & microtopography
    2. soil and vegetation moisture content, inundation,
    3. vegetation,
    4. soil density and texture
    5. accuracy of all data (field gathered and remotely sensed).

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Scenario DOCTORAL TRAINING PARTNERSHIP

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Thank you

Questions?

Linda Toča

l.toca@pgr.reading.ac.uk

@linda_toca