Integration of Doppler wind lidars in E-Profile wind profiling network

Supplementary Material EGU25-16832

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EUMETNET

Introduction

Integration of Doppler wind lidars in E-Profile wind profiling network

- This is supplementary materials to the presentation EGU25-16832, Tue, 29 Apr, 14:50–15:00 (CEST), Room -2.15
- First international Doppler wind lidar network for operational meteorogoly
  - Focus on near real-time data distribution
- Open to instruments from different manufacturers and using different scan types
- Addition of DWL to E-Profile provides good complementarity to the other wind profiling techniques
  - Wind profiler
  - Weather radar

- Abbreviations used for the instruments:
  - GRE = Grenchen, Switzerland
  - PAY = Payerne, Switzerland
  - SCH or SHA = Schaffhausen, Switzerland
  - WL = Doppler wind lidar
  - WP = Wind profiler
  - RS = radiosonde
- Example: GREWL = Doppler Wind lidar in Grenchen
- Other abbreviations:
  - ws = wind speeds, wd = wind direction
  - RMS = root-mean square
  - RMSvd = RMS vector differences
  - PBL: planetary boundary layer, FT = Free troposphere

Goal

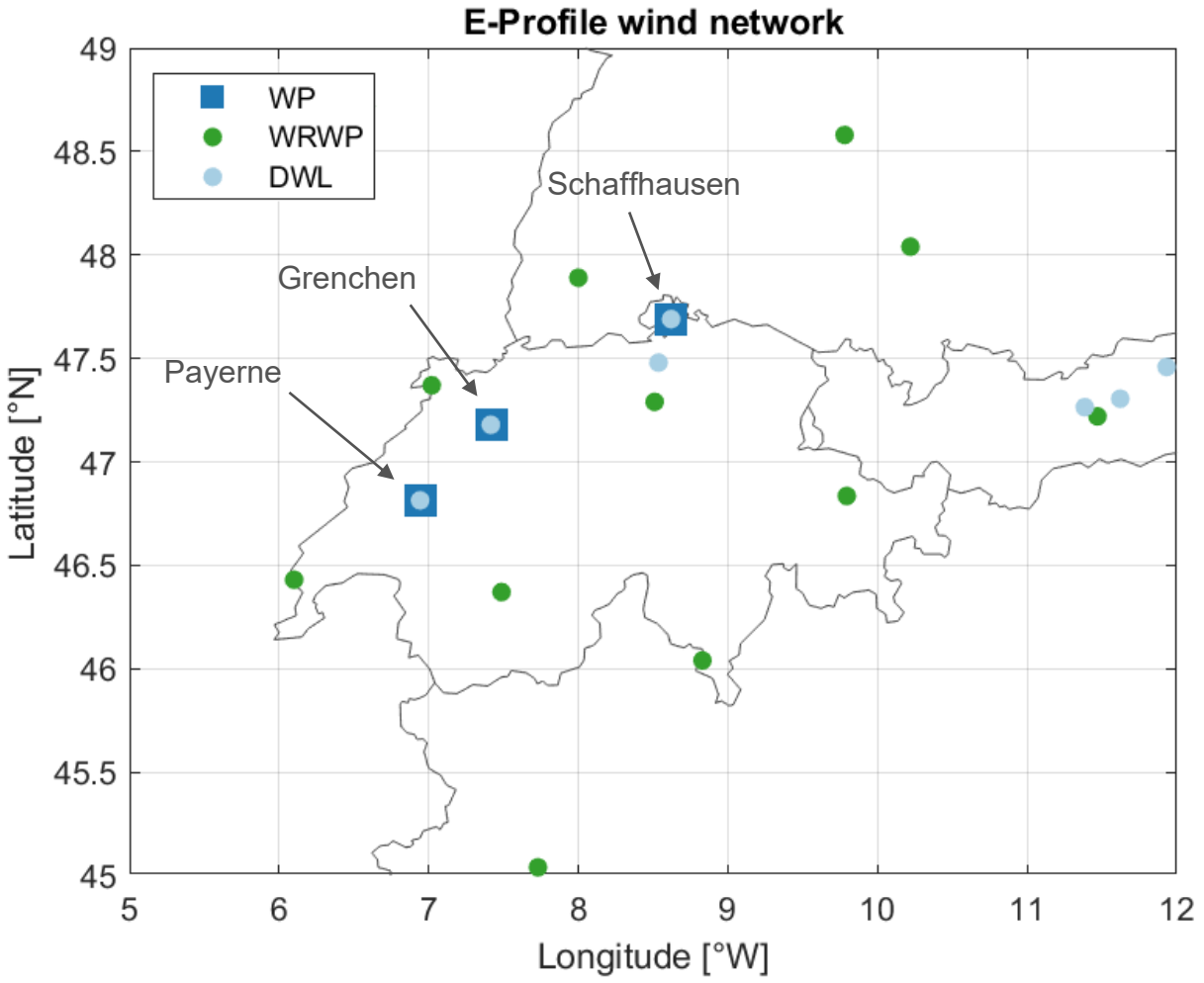
- Validate the E-Profile DWL time series
  - Centralized retrieval using the DL_toolbox developped by DWD
    - Focus of toolbox initially on HALO instruments
    - Adapted to VAISALA WindCube but validated mostly with HALO instruments
  - Centralized processing running on the European Weather Cloud
  - Since 15.11.2024, start of the GTS distribution
  - Only considering certain scan type (DBS)

- Determine whether **E-Profile real-time wind profiles** are meeting the OSCAR requirements for NWP
  - Global Numerical Weather Prediction and Real-time Monitoring

Scope

Swiss instruments only

- 3 Swiss stations (out of 14 DWLs in E-P)
  - All co-located with RWP which is used as a reference
  - RS in Payerne used as additonal ref.
- 3 VAISALA WindCube 200s
  - DBS scans, 50m resolution
  - TP mode at Payerne
  - PRF = 20’000 Hz for Grenchen and Schaffhausen
  - PRF = 10’000 Hz for Payerne



Time period and resolution considered

Since distribution of real-time data on the Global Telecommunication System (GTS)

Payerne and Grenchen:

- 15.11.2024 – 31.03.2025

Schaffhausen:

- Amplifier changed on 28.01.2025
  - Measurement mode has changed
  - We consider two periods:
    - P1: 15.11.2025 – 20.01.2025
    - P2: 01.02.2025 – 31.03.2025

Time resolution:

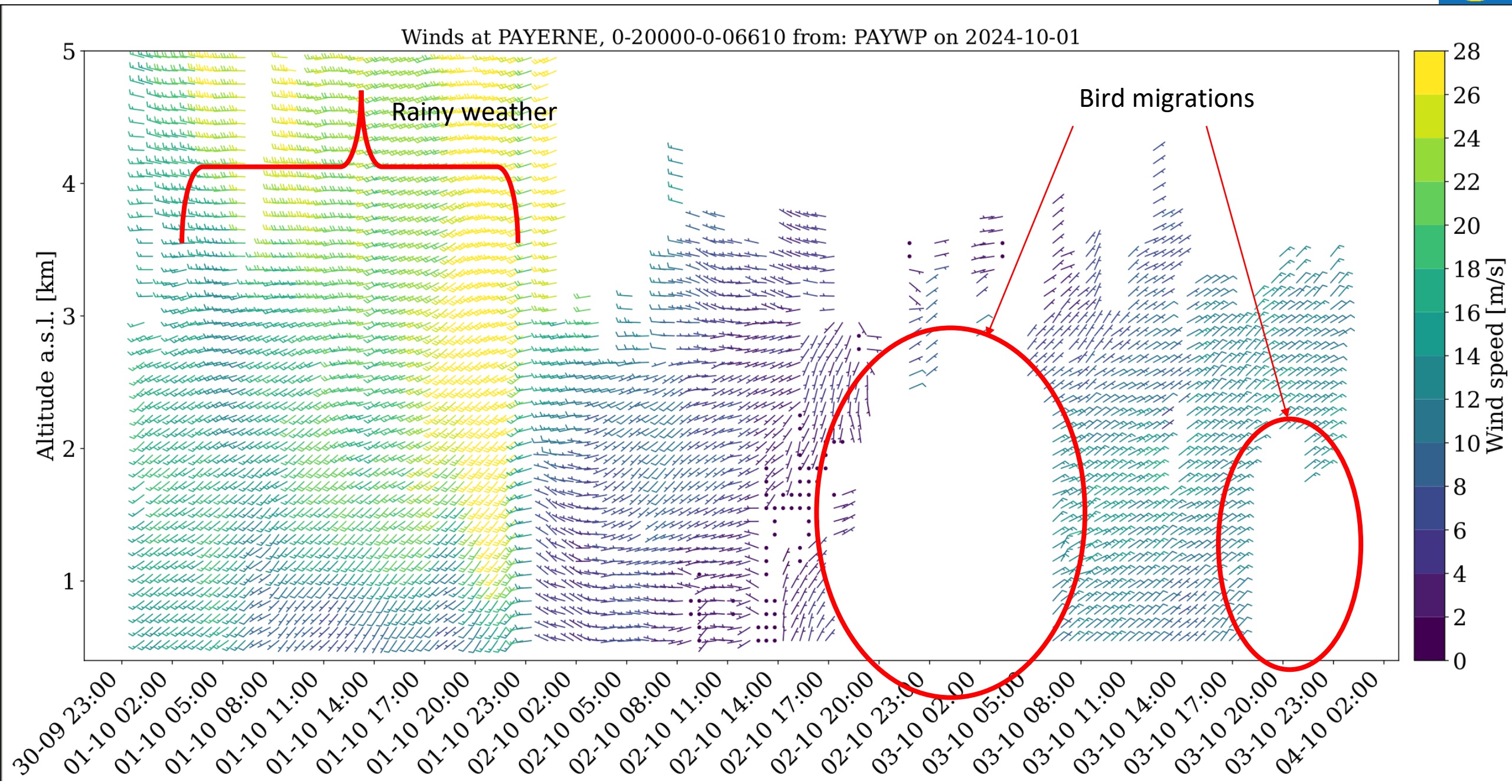
- DWL provides 10 min mean wind profile, averaged on 6-10 min
- RWP provides 30 min mean wind profile, averaged on 20 min
- 30 min (= OSCAR / breakthrough requirement for timeliness) mean wind profiles are used for the comparisons
  - DWL observation time checked against RWP before averaging -> mean DWL obs. time always within 10 min of RWP mean time

Data availability

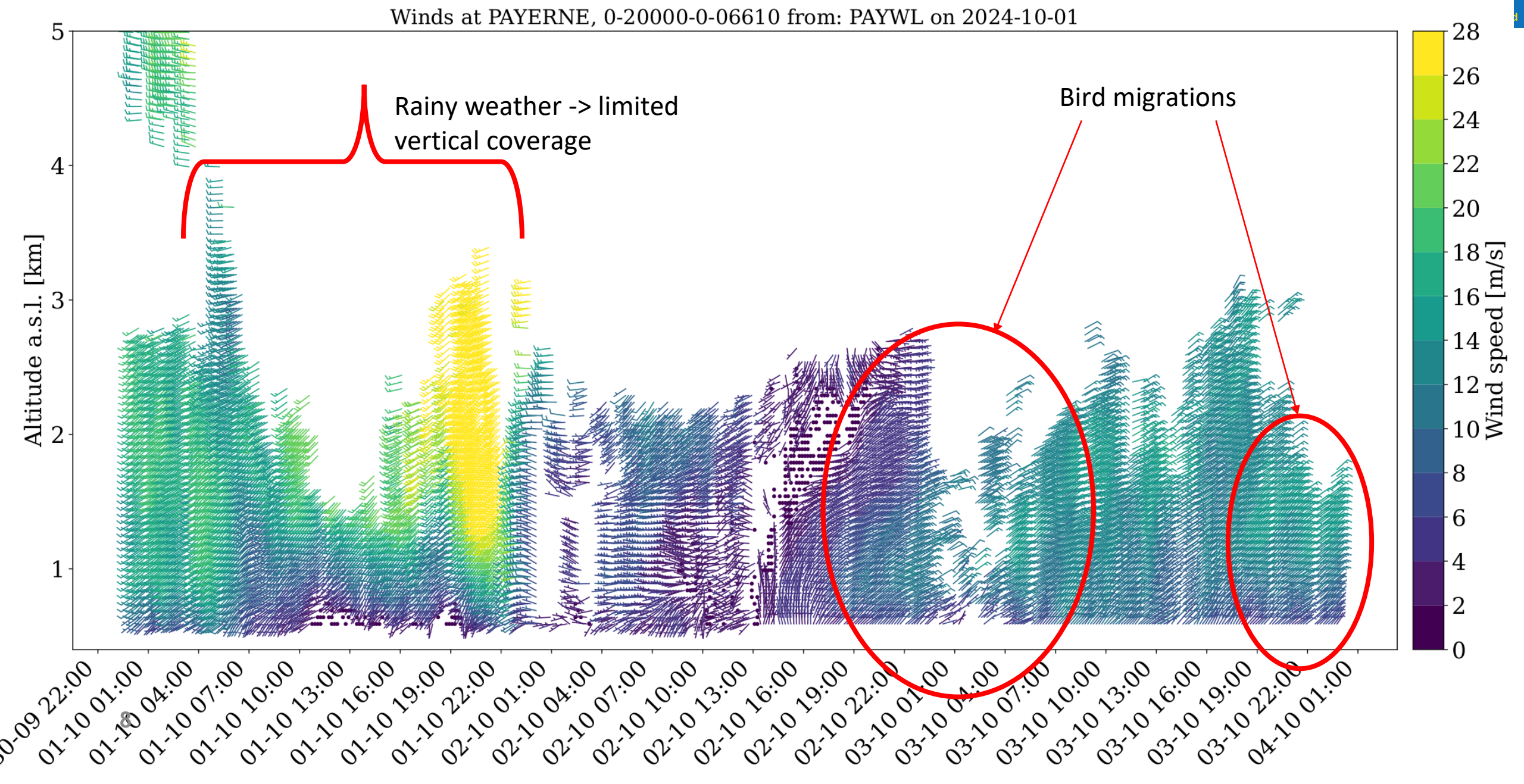
Complementarity WP and DWL

- Co-located WP and DWL offers good real-time availabilty which is valuable for operational meteorology
- Combined real-time availability mostly above 80% up to 2000 m
- Given the considered period (autumn and winter), acceptable real-time availabilities for DWL
  - Rapidly decreasing availability with height
  - Altitude of the 50% real-time availability around 1500 m for DWL
  - Real-time availability suffers from regular, short interruption from centralized DWL processing
    - Unknow connectivity (?) issue

Time series example: wind profiler in Payerne

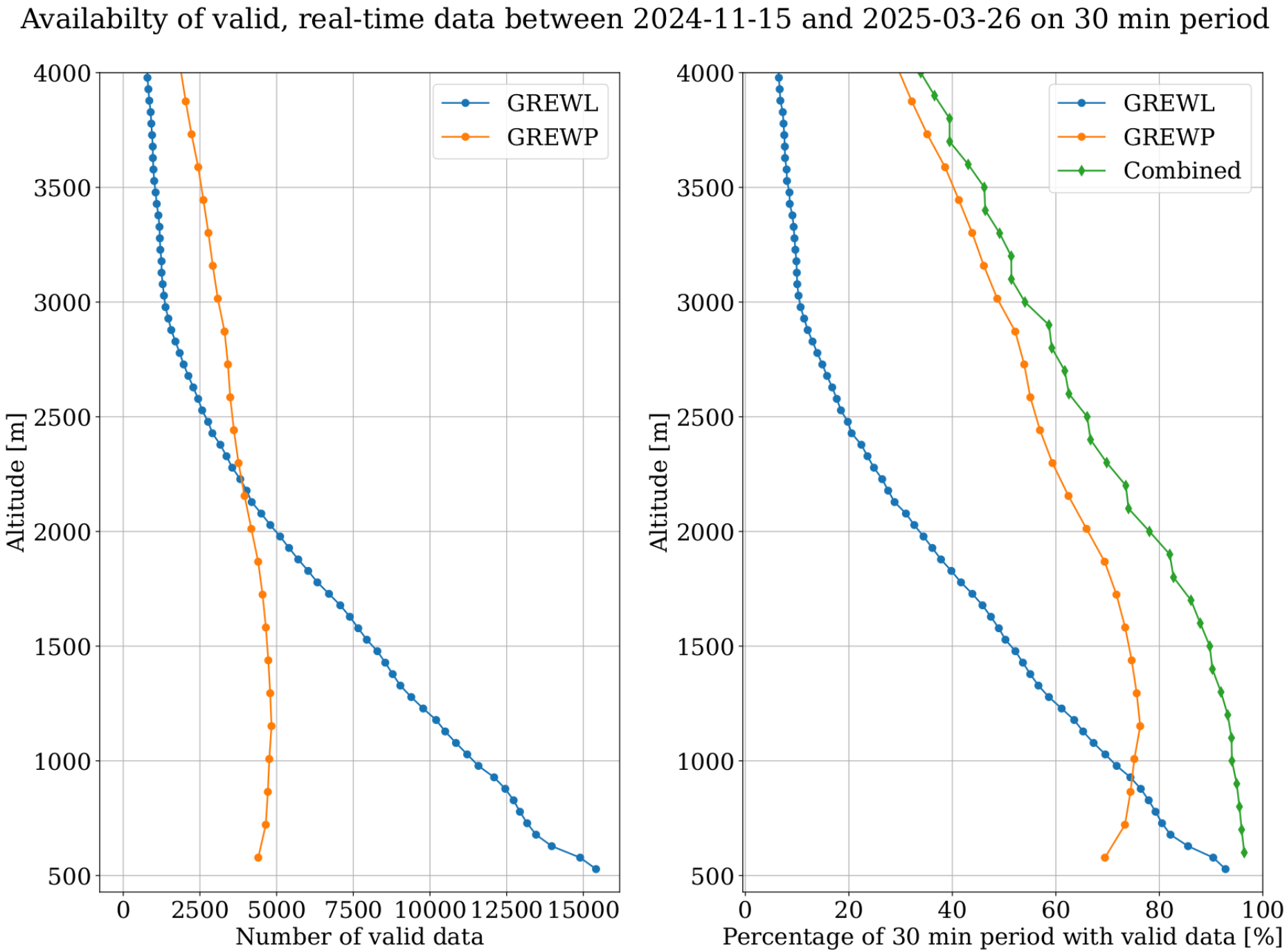


Time series example: Doppler wind lidar in Payerne



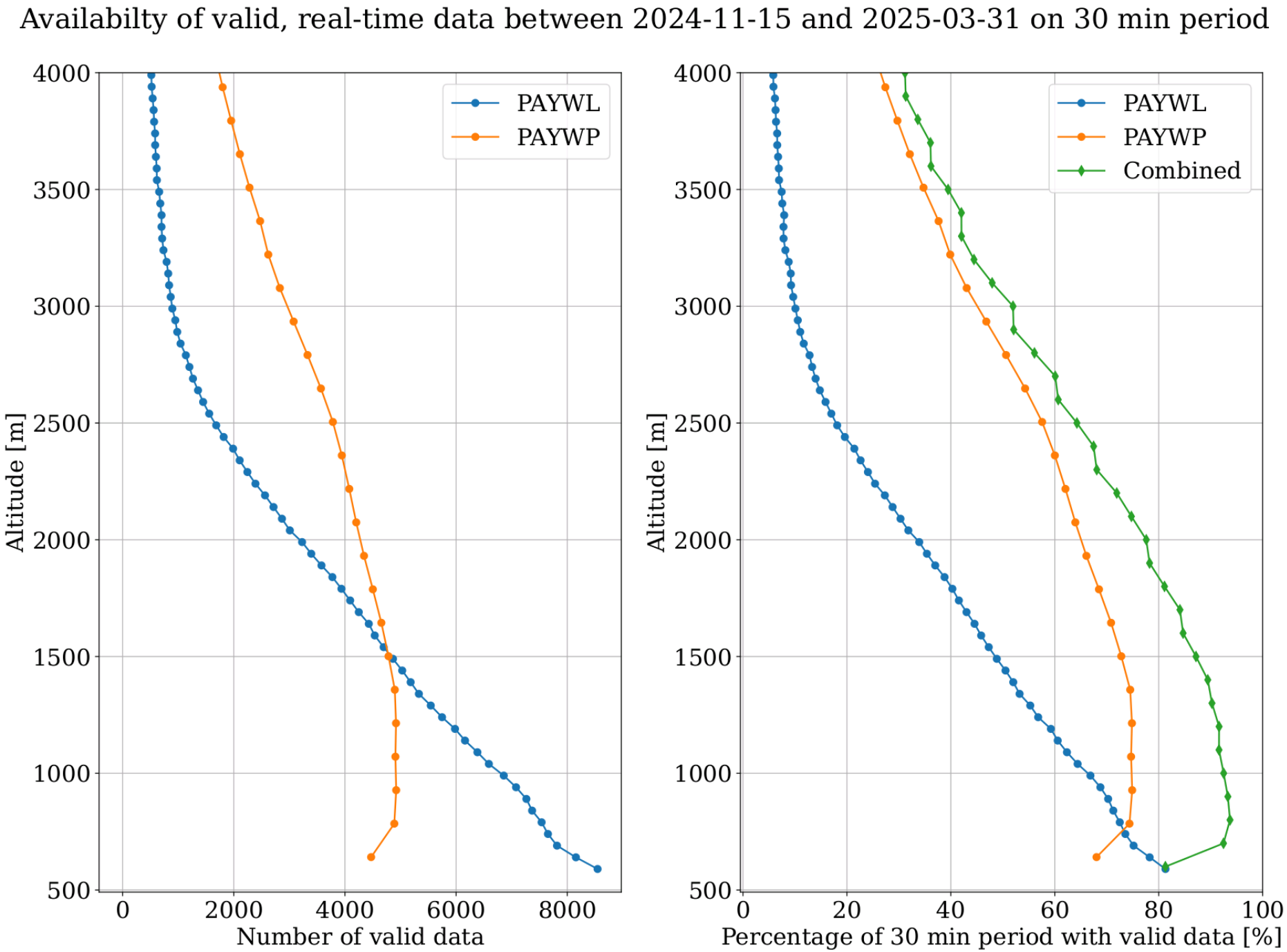
Data availability

Grenchen



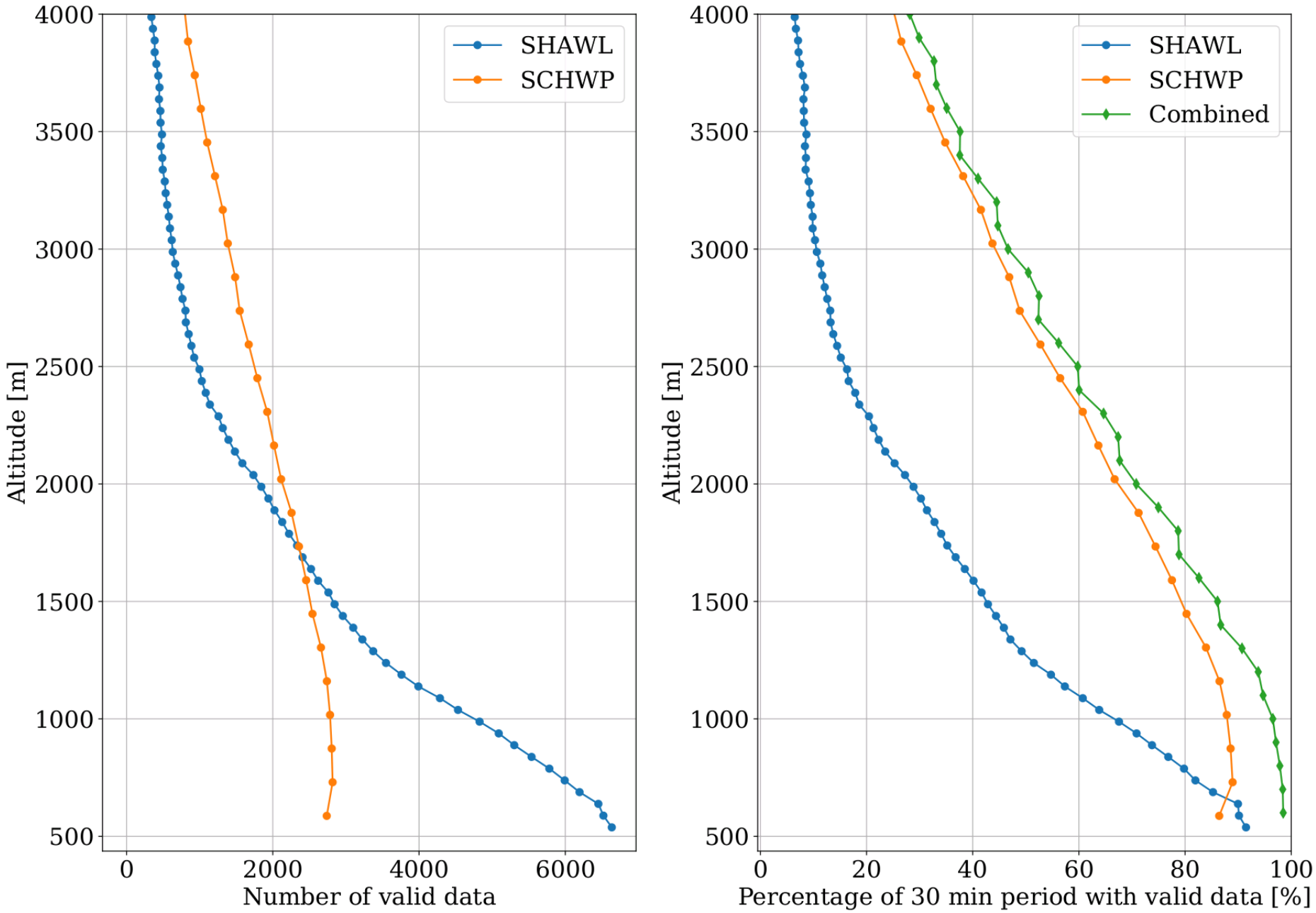
Data availability

Payerne



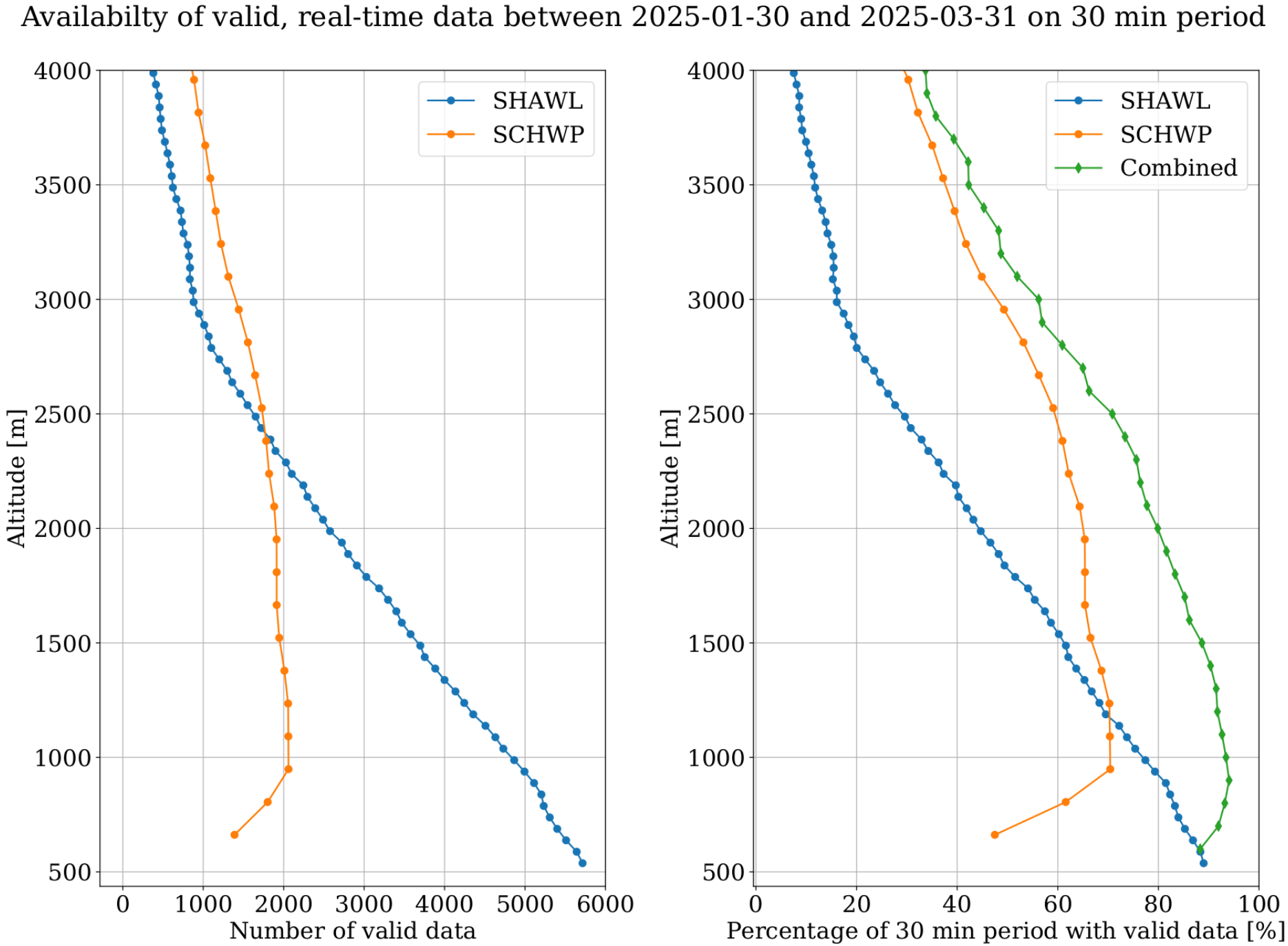
Data availability

Schaffhausen, P1



Data availability

Schaffhausen, P2



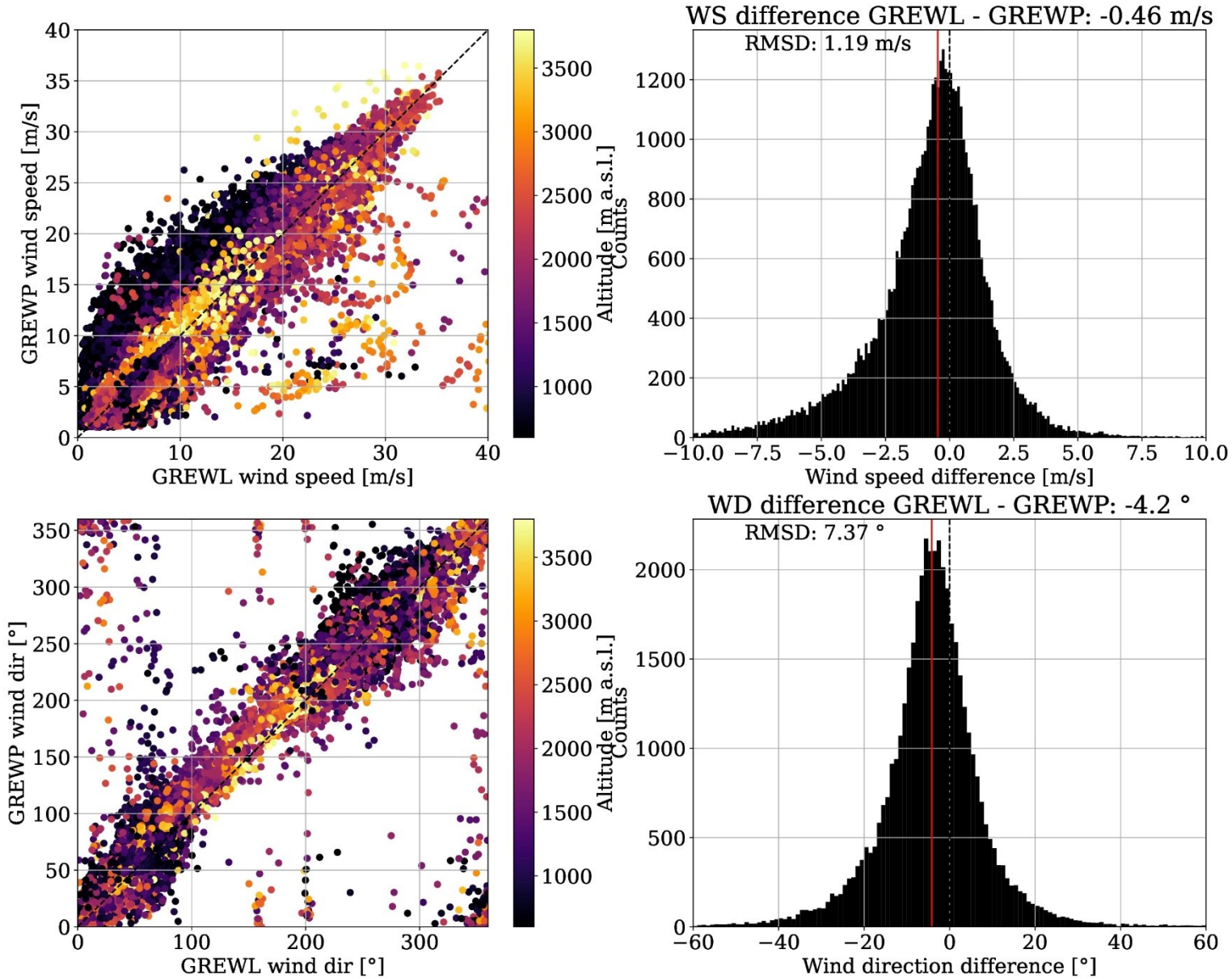
Comparison DWL vs WP

Results introduction

- Full time series are shown in Appendix 1.
- Unless otherwise stated, the plots always show the difference between the DWL and the WP (DWL – WP)
- Profile plots are cut to an altitude of 4000m as above there are not enough profiles for comparisons

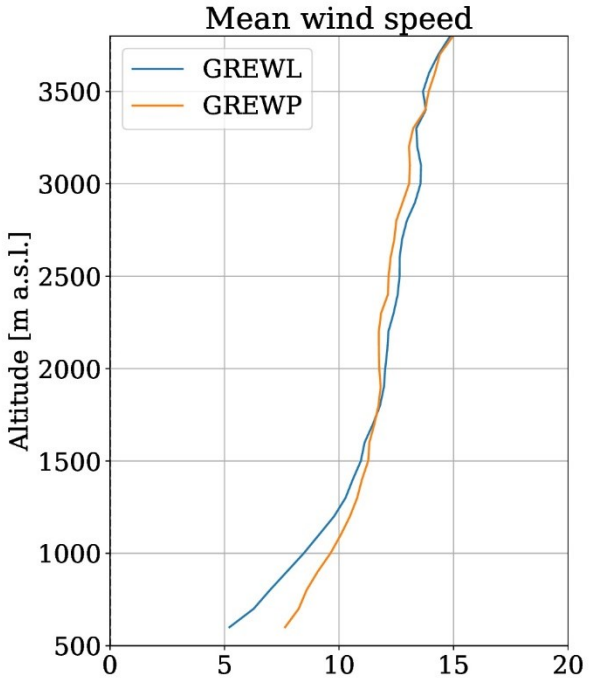
Wind comparisons

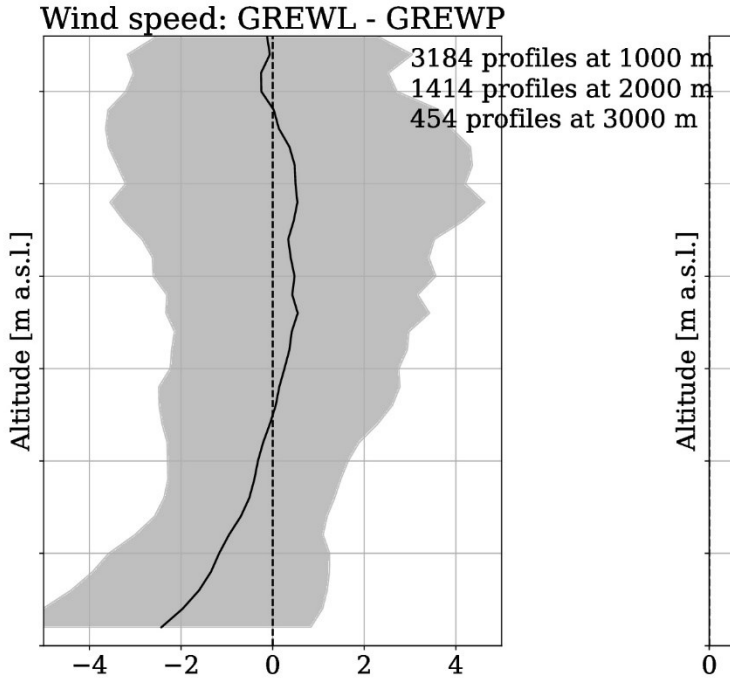
Grenchen

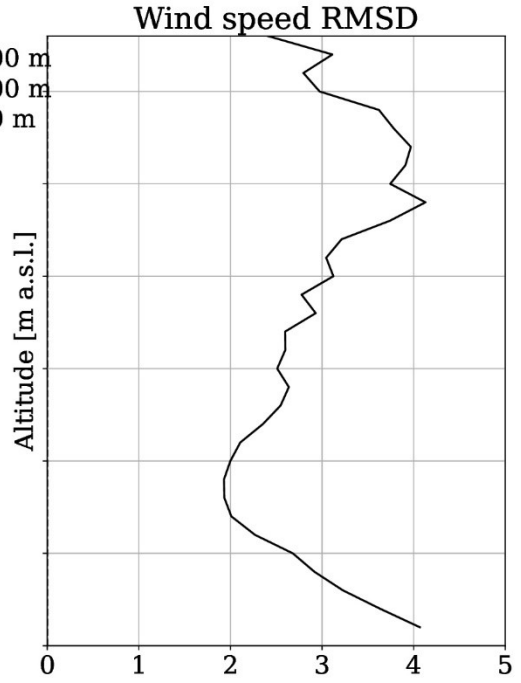


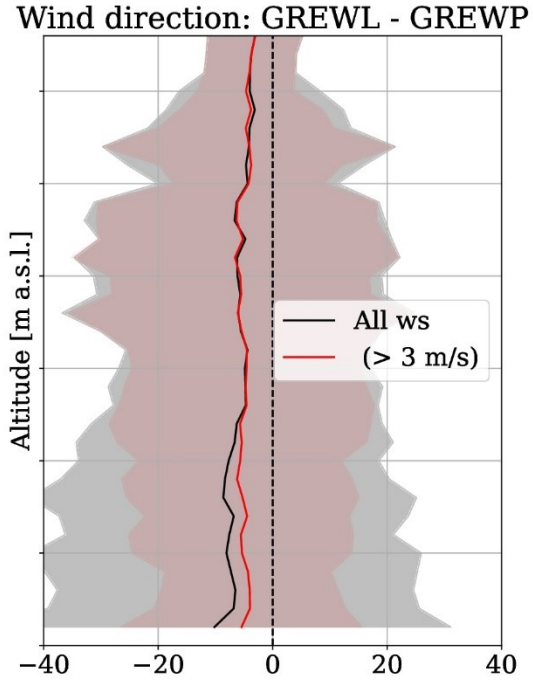
Profiles

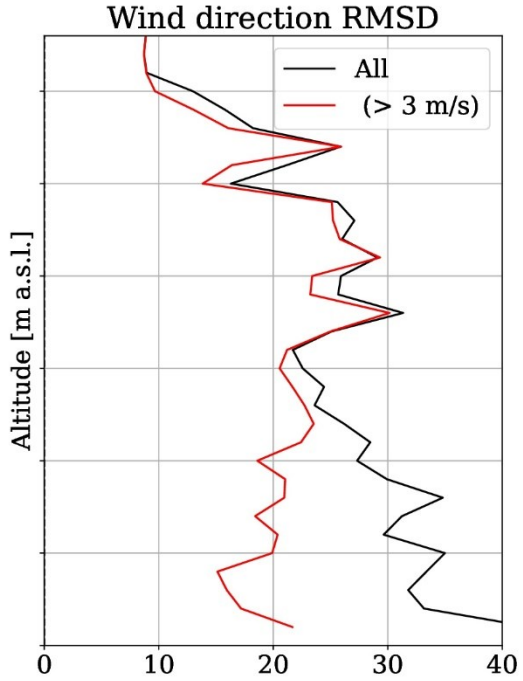
Grenchen







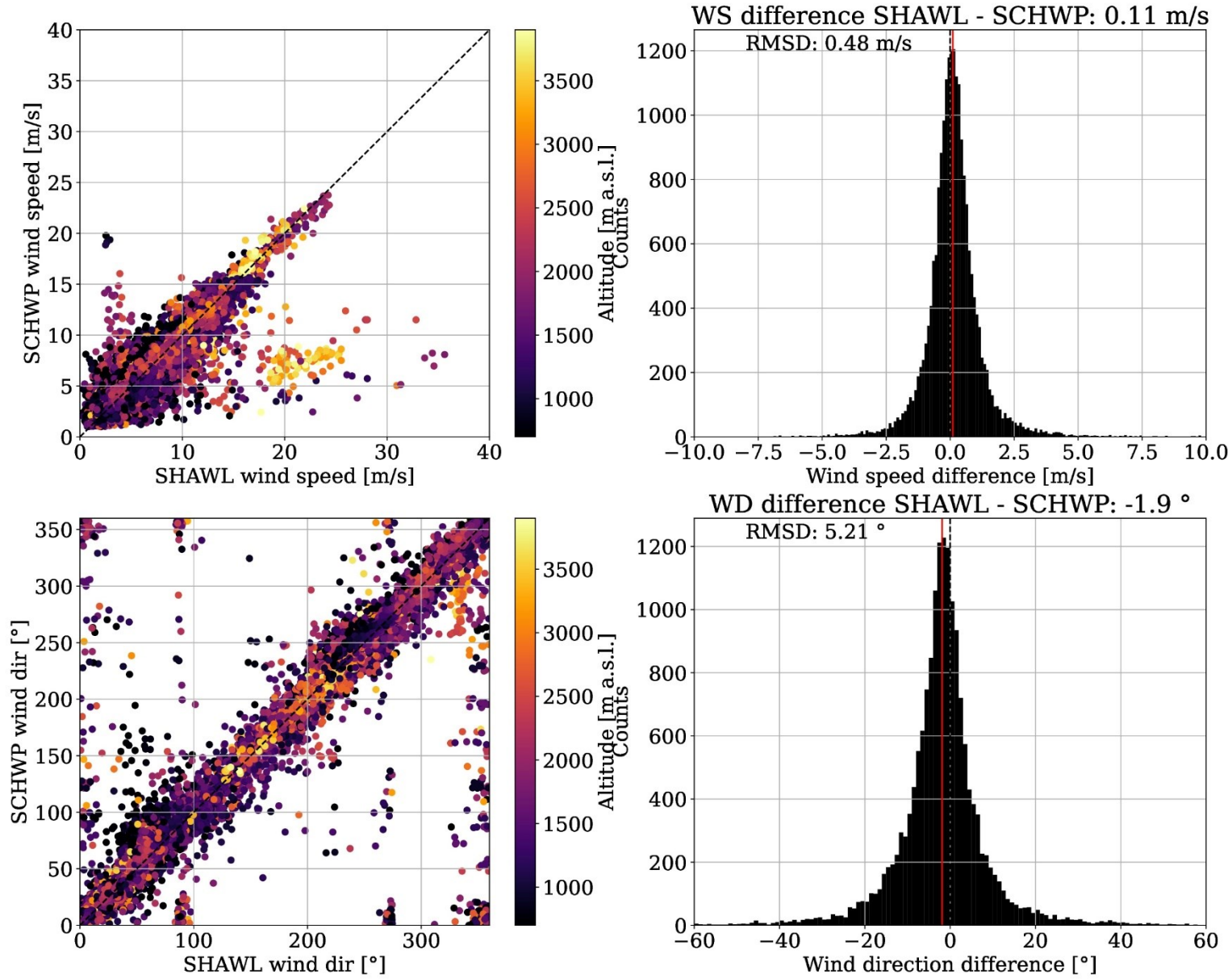




Wind comparisons

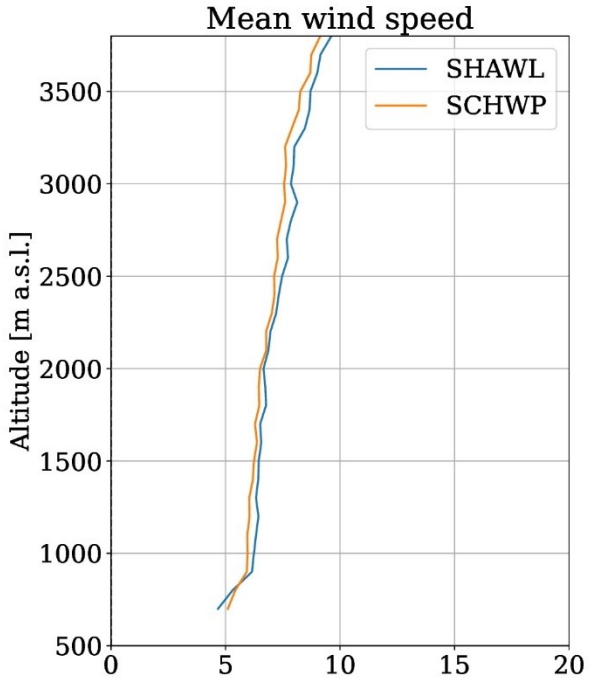
Schaffhausen, P2

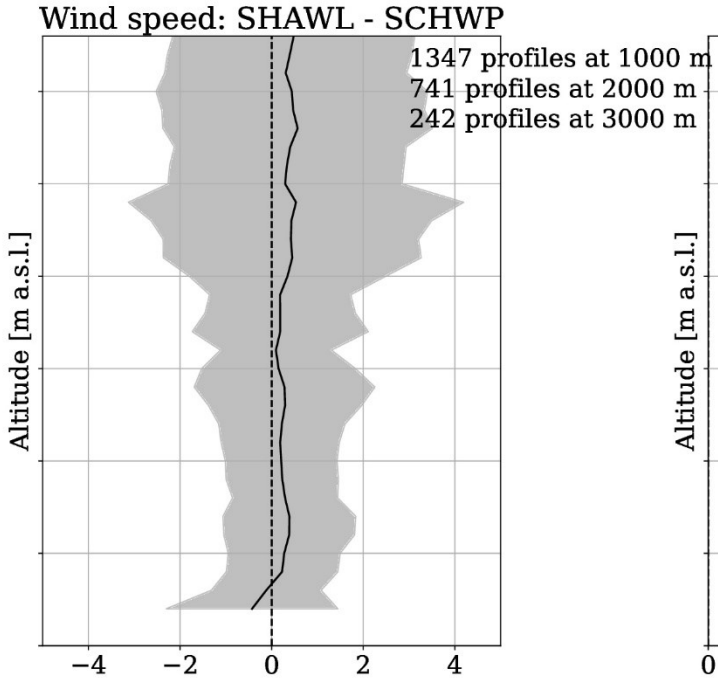
Wind speed and direction comparison between SHAWL and SCHWP

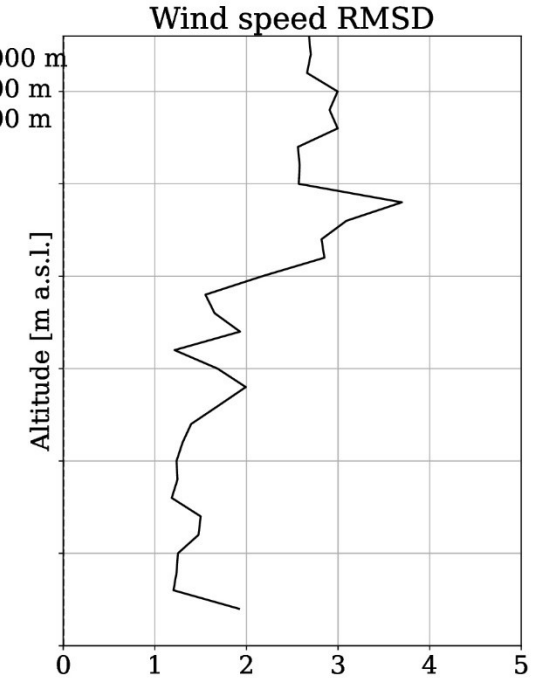


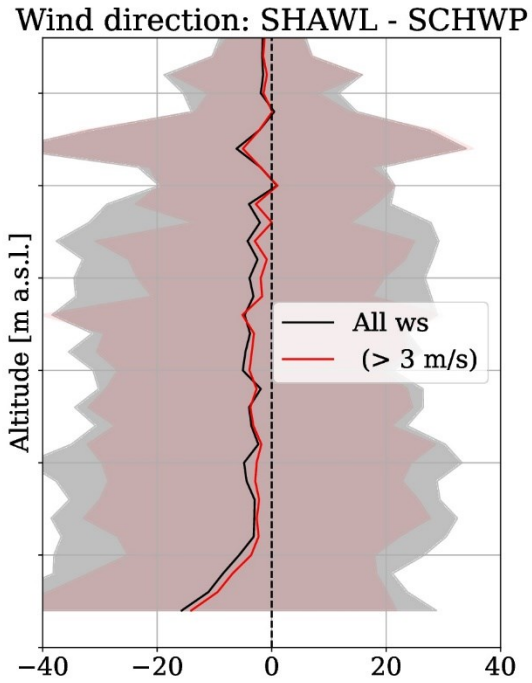
Profiles

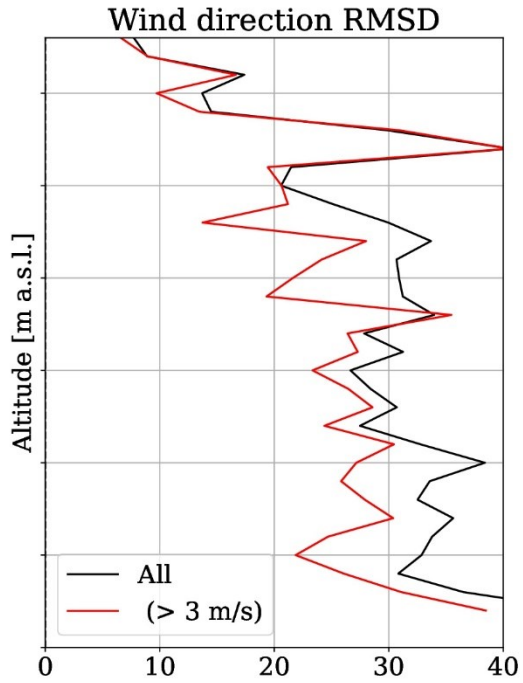
Schaffhausen, P2





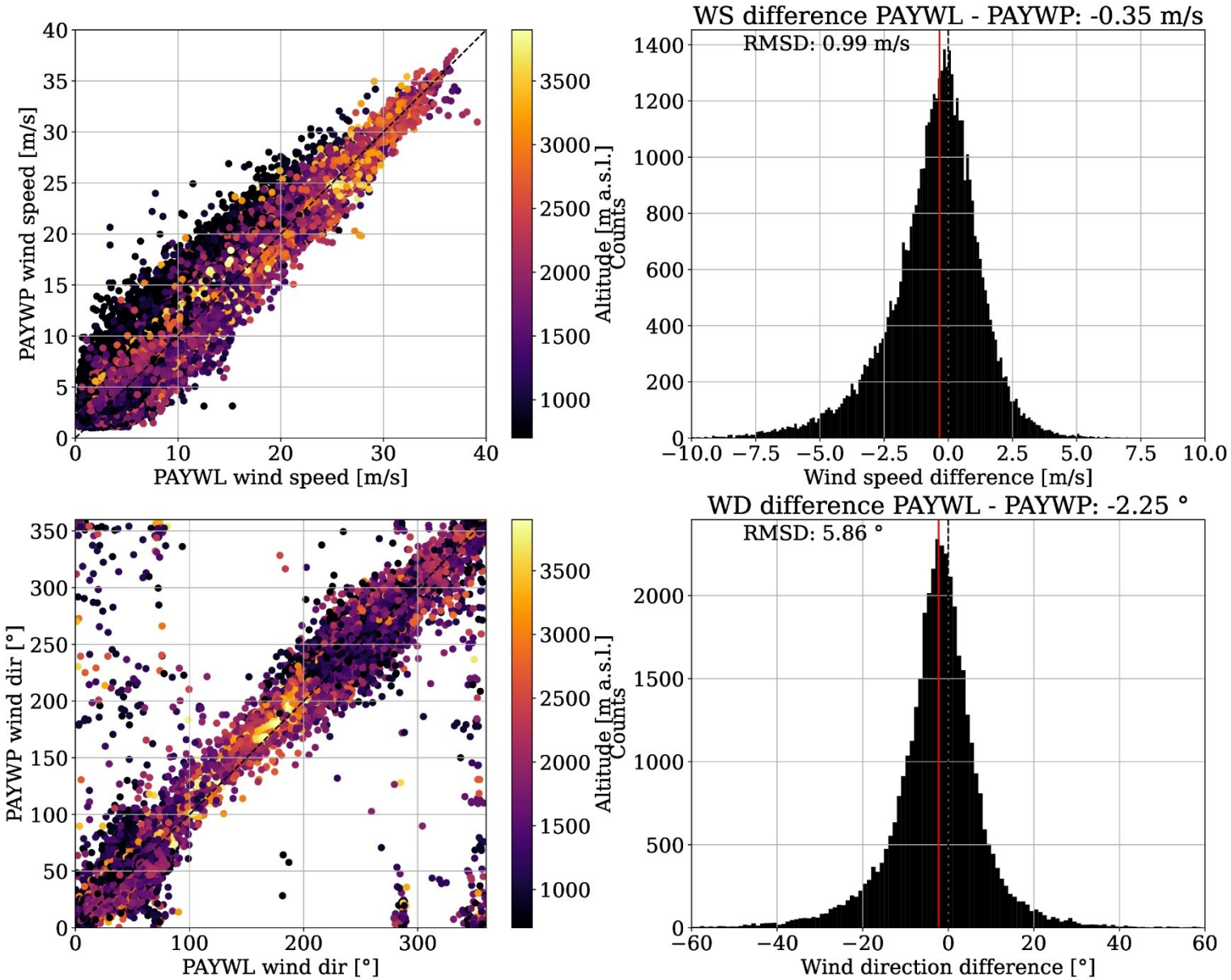






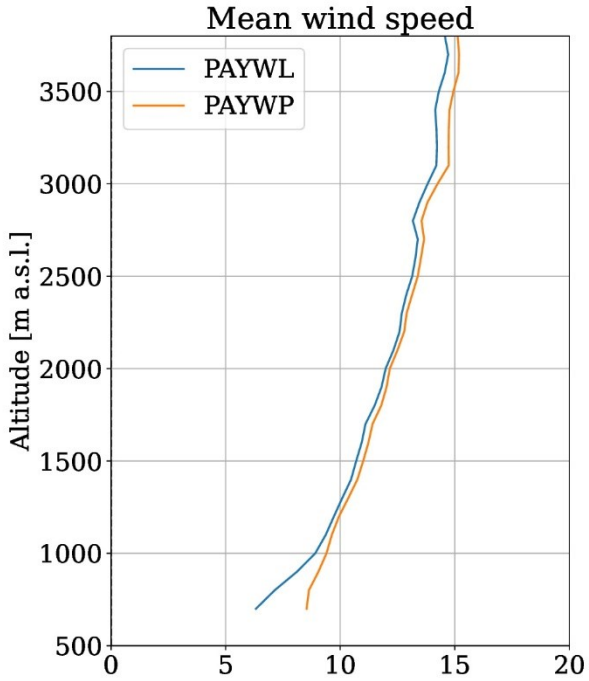
Wind comparisons

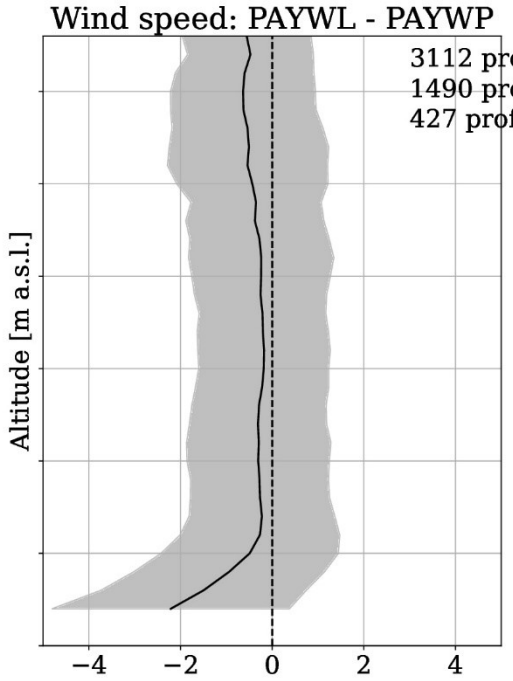
Payerne

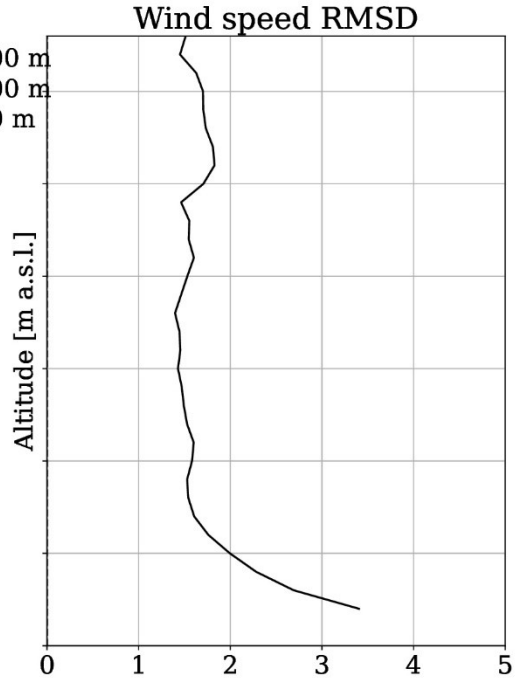


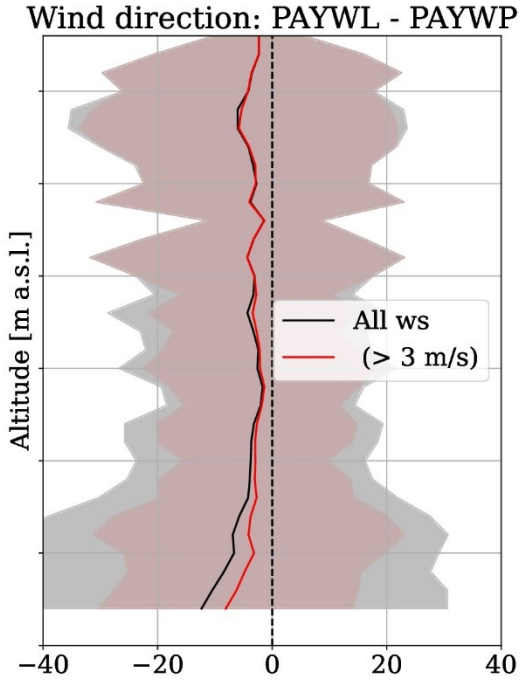
Profiles

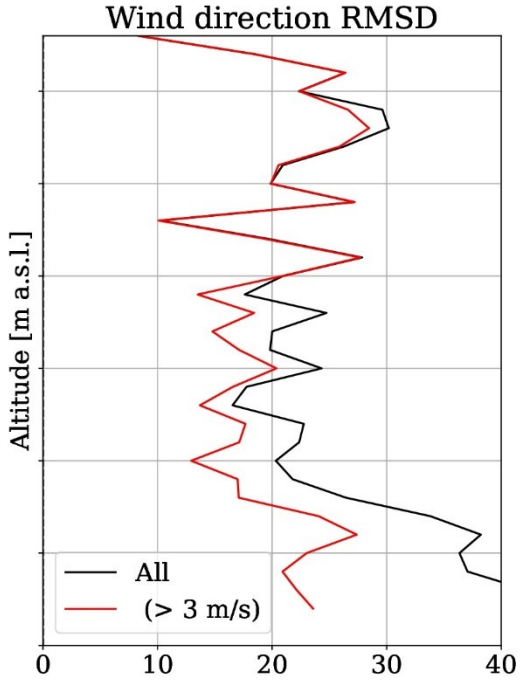
Payerne





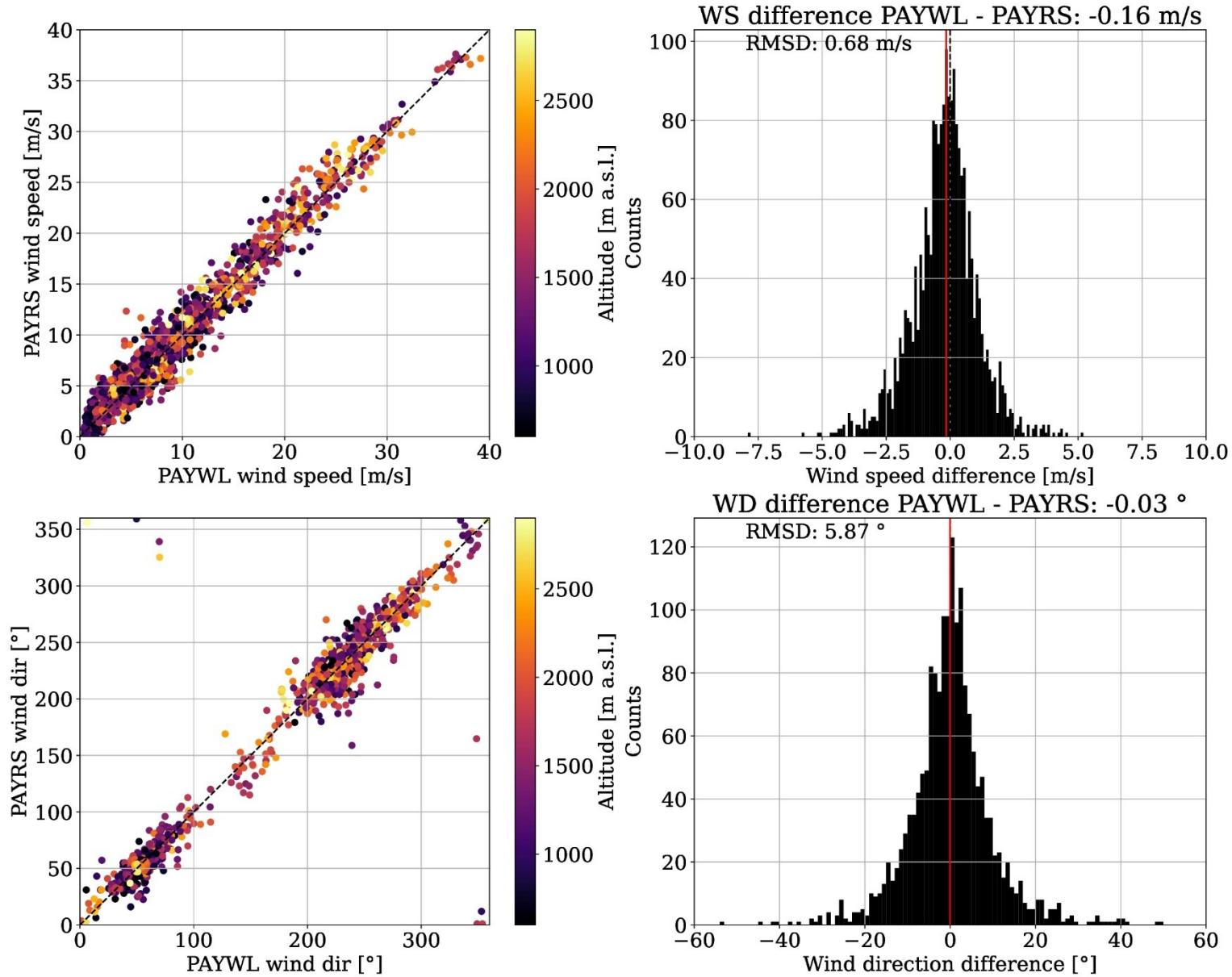






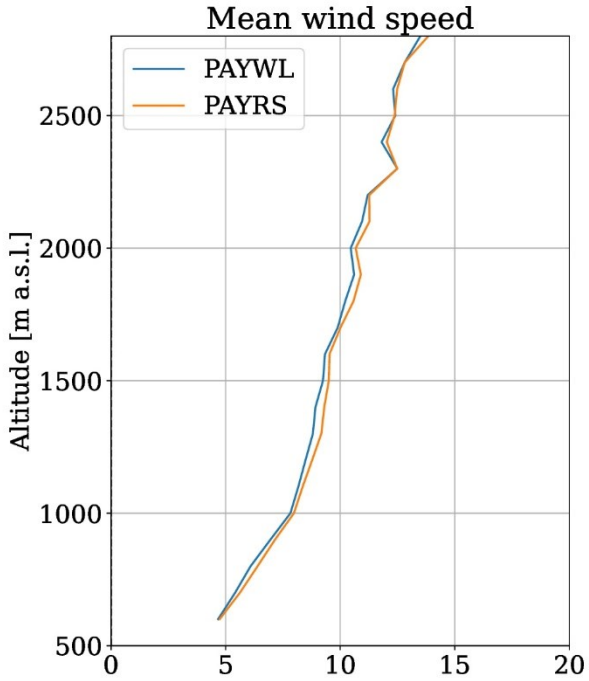
Wind compa

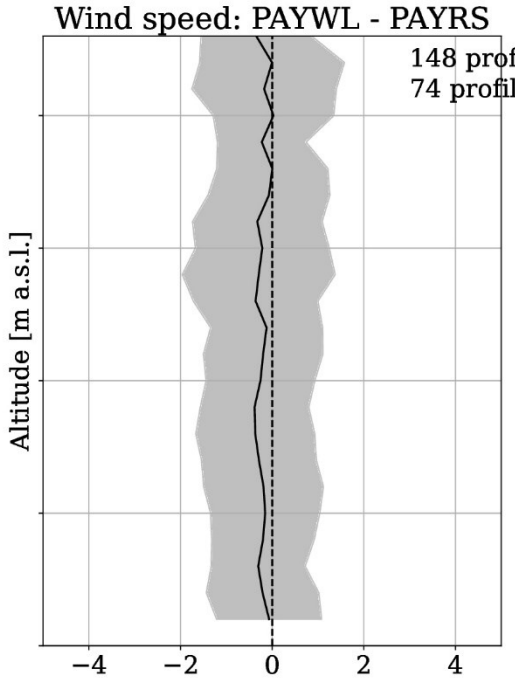
Payerne, RS

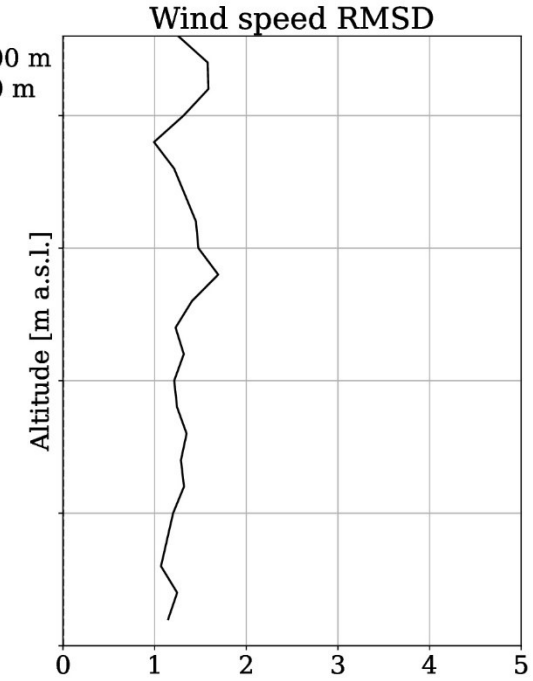


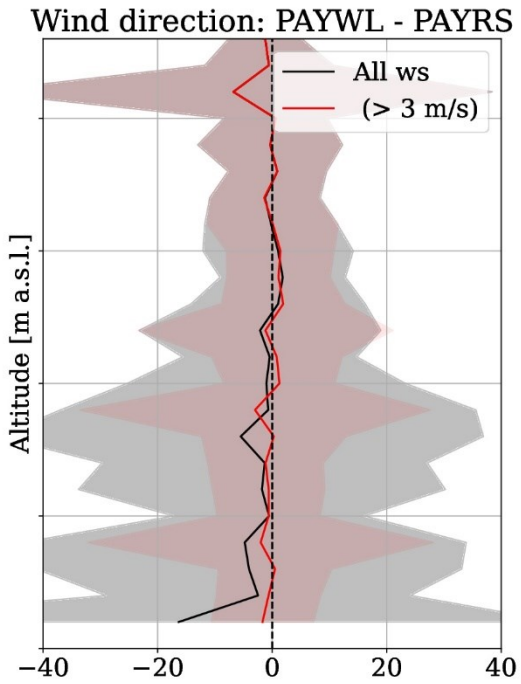
Profile

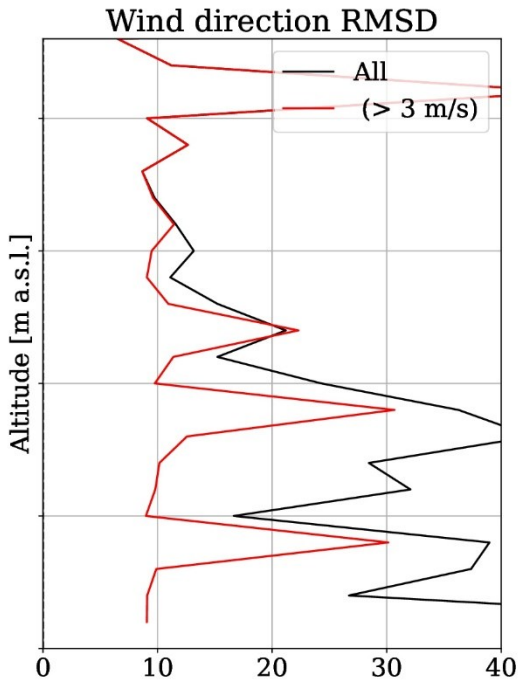
Payerne, RS



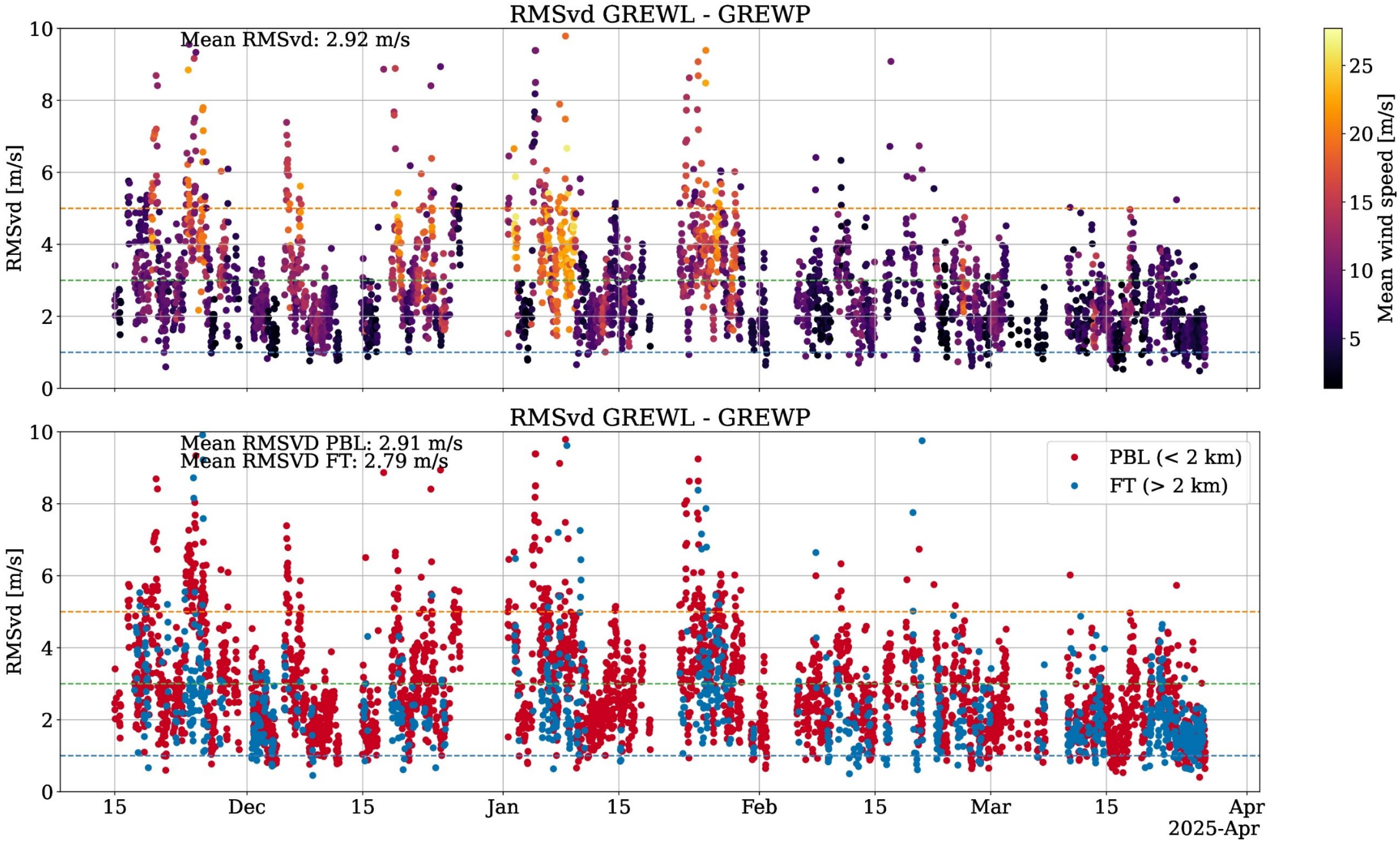




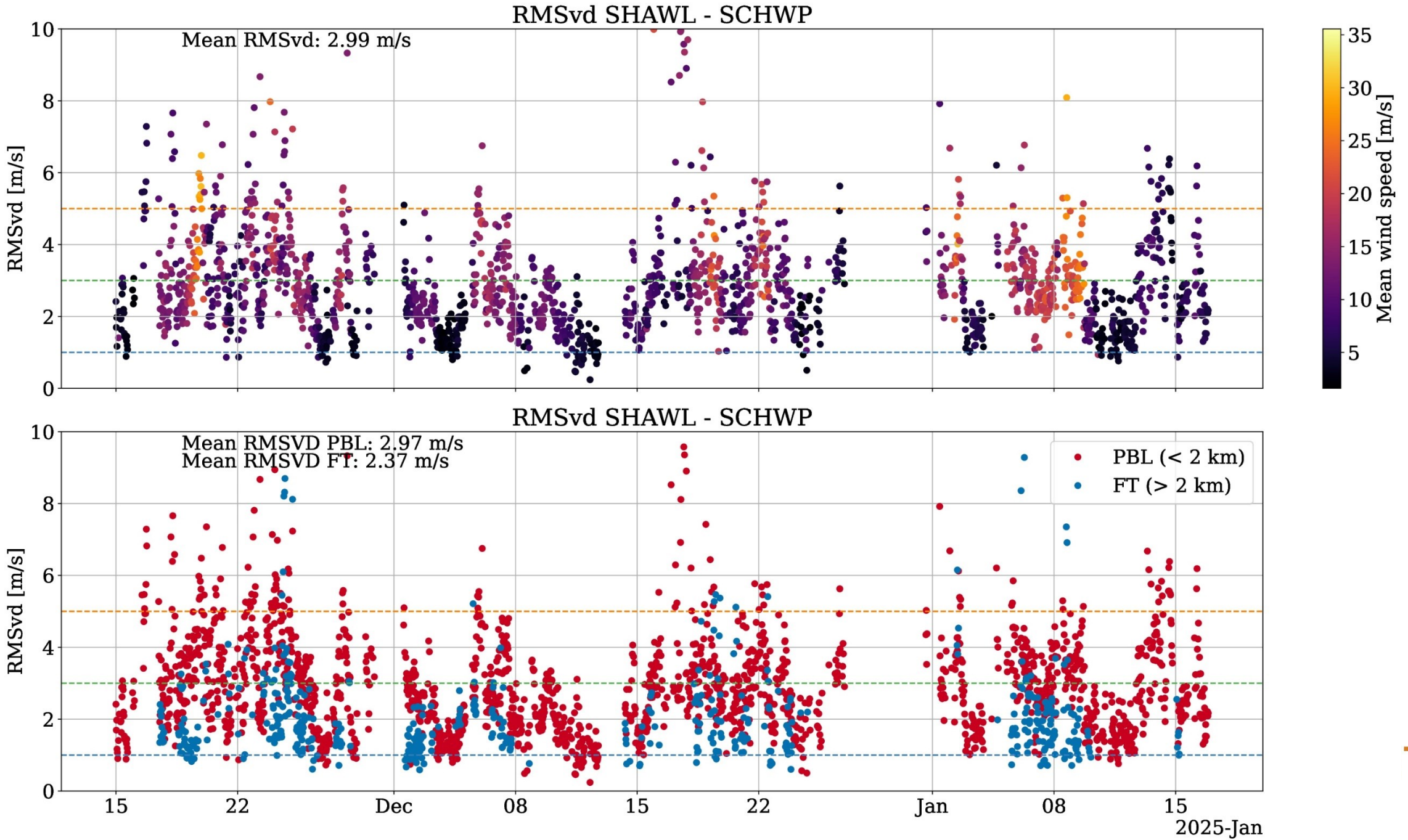




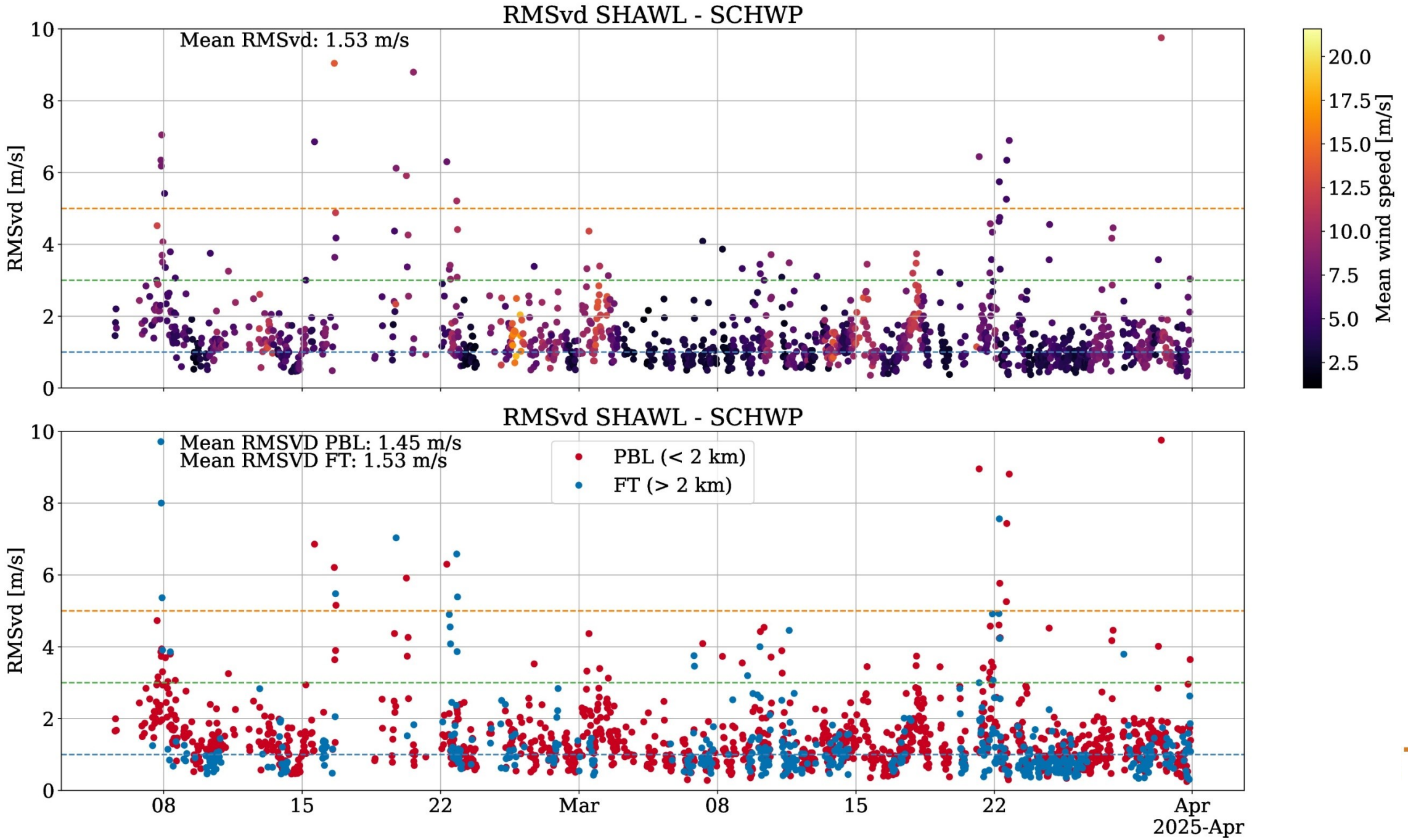
RMSvd: Grenchen



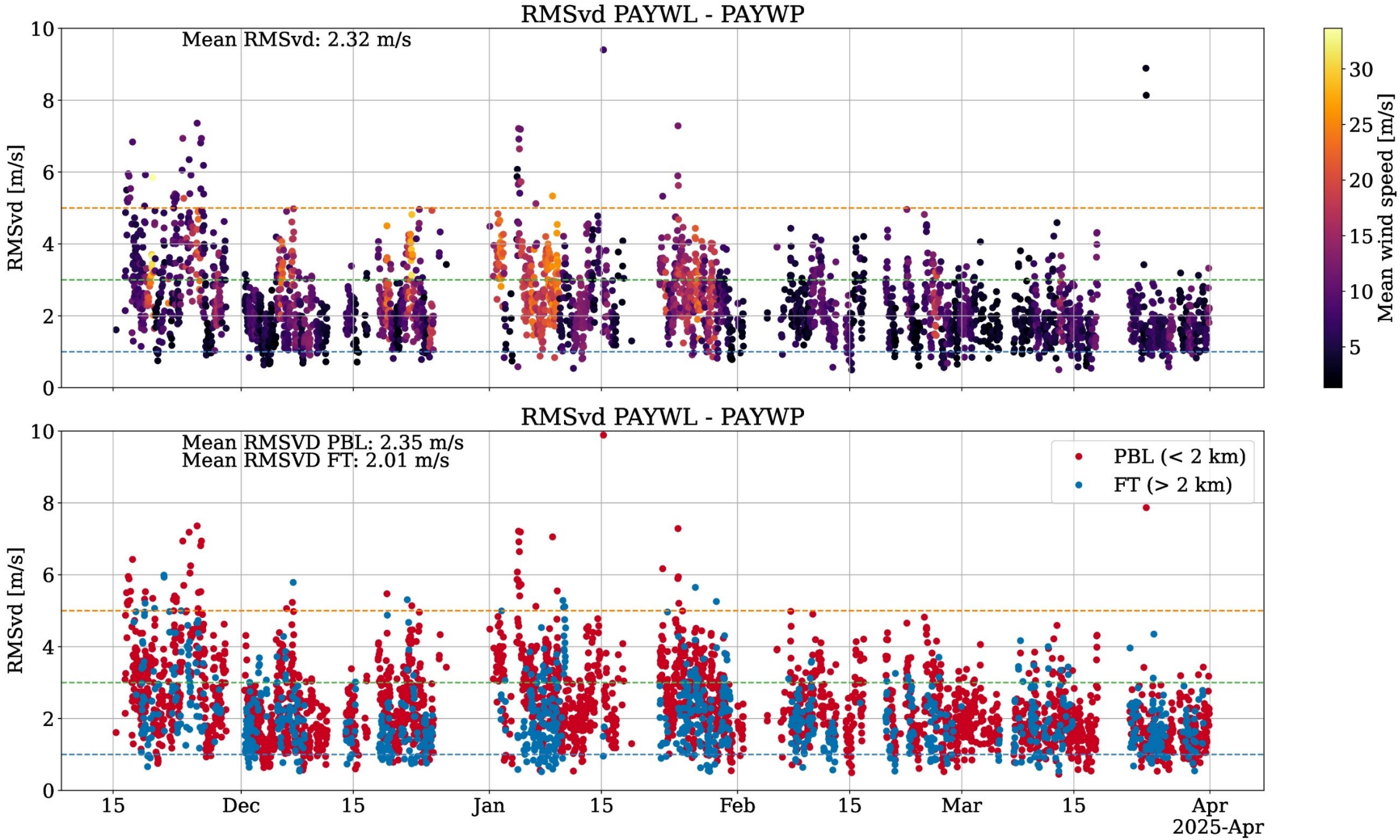
RMSvd: Schaffhausen, P1



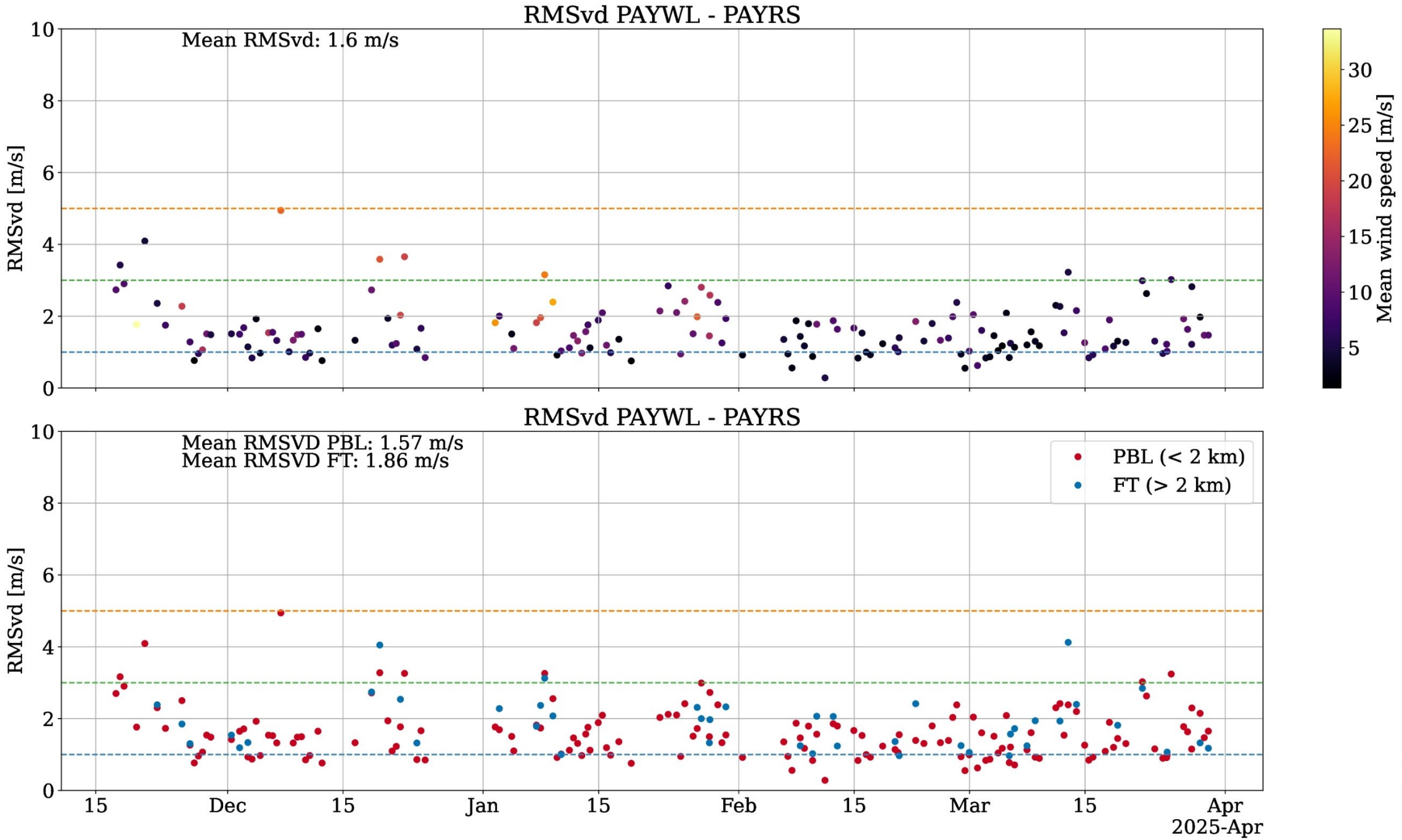
RMSvd: Schaffhausen, P2



RMSvd: Payerne



RMSvd: Payerne, RS



Results summary

Colored according to OSCAR uncertainties requirements

OSCAR requirements:
Goal
Breakthrough
Thresholds

Station	Overall median bias ws [m/s] | wd [°]		Overall median RMSD ws [m/s] | wd [°]		Mean RMSvd	Mean RMSvd PBL	Mean RMSvd FT
Grenchen	-0.46	-4.2	1.19	7.37	2.92	2.91	2.79
Schauffhausen, P1	-0.61	-3.89	1.1	5.9	2.99	2.97	2.37
Schauffhausen, P2	0.11	-1.9	0.48	5.21	1.53	1.45	1.53
Payerne	-0.35	-2.25	0.99	5.86	2.32	2.35	2.01
Payerne, RS	-0.16	-0.03	0.68	5.87	1.6	1.57	1.86

First conclusions

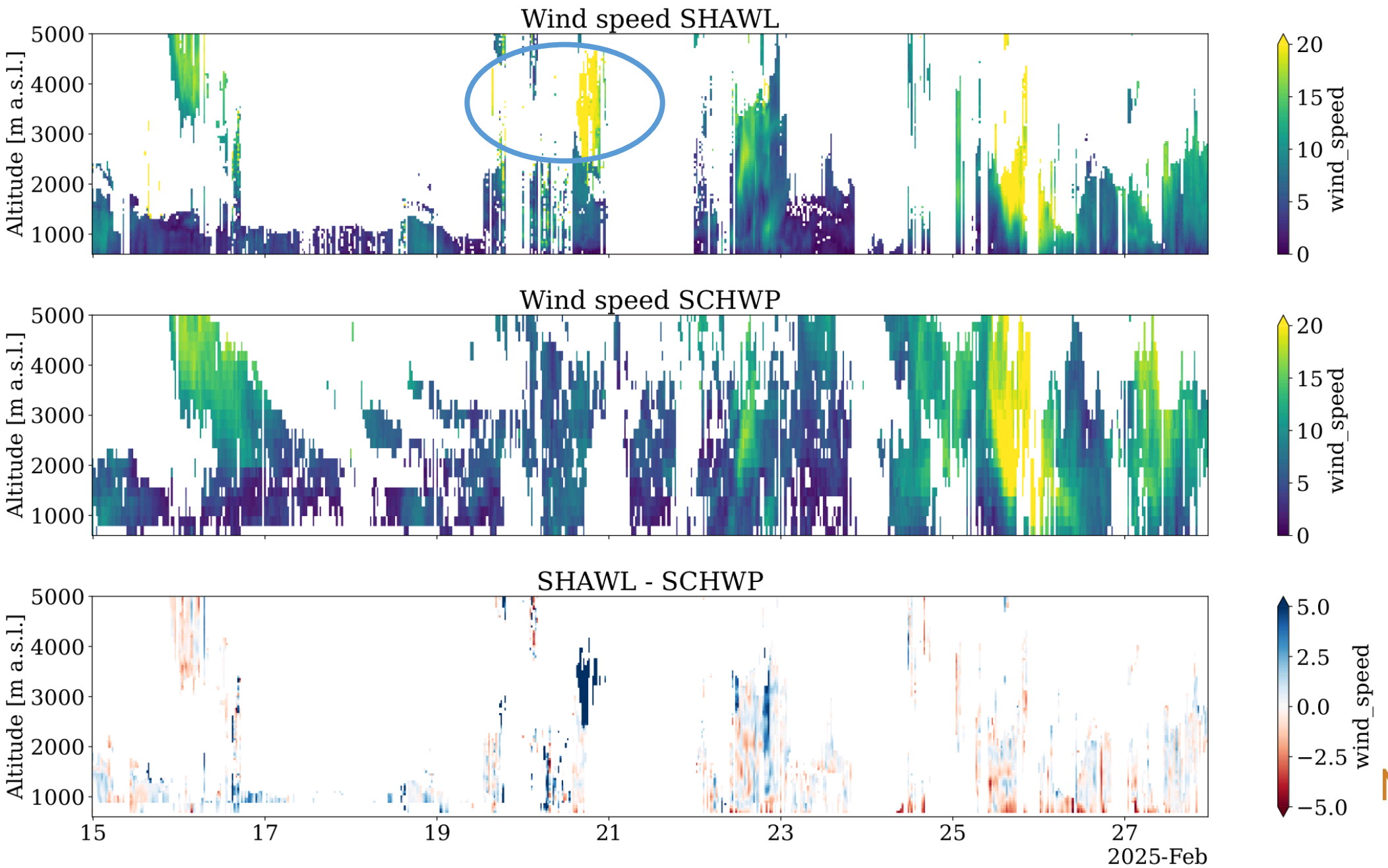
- Clear negative wind speed bias below ~1500m from DWL compared to WP
  - Seen at the 3 stations
  - BUT not during P2 at Schaffhausen
  - Good agreement between DWL and RS in Payerne
    - Bias at low altitudes likely comes from WP measurements and not from DWL
- Positive biases at Schaffhausen and Grenchen above 2000 m, not seen in Payerne
  - This is a consequence of range aliasing because PRF for SCH and GRE is too high (see case study later)
  - Range aliasing also affect altitude lower than 2000 m but its effects is not well seen in the overall statistics
- Bias on the WP could be linked to new amplifiers and seem to be impacted by the weather conditions:
  - Large RMSvd arise mostly during rainy or foggy conditions
  - Bias reduced for Schaffhause P2 w.r.t P1 and Grenchen P2 (not shown)

→ investigations on these biases are in progress at MeteoSwiss

Some more conclusions

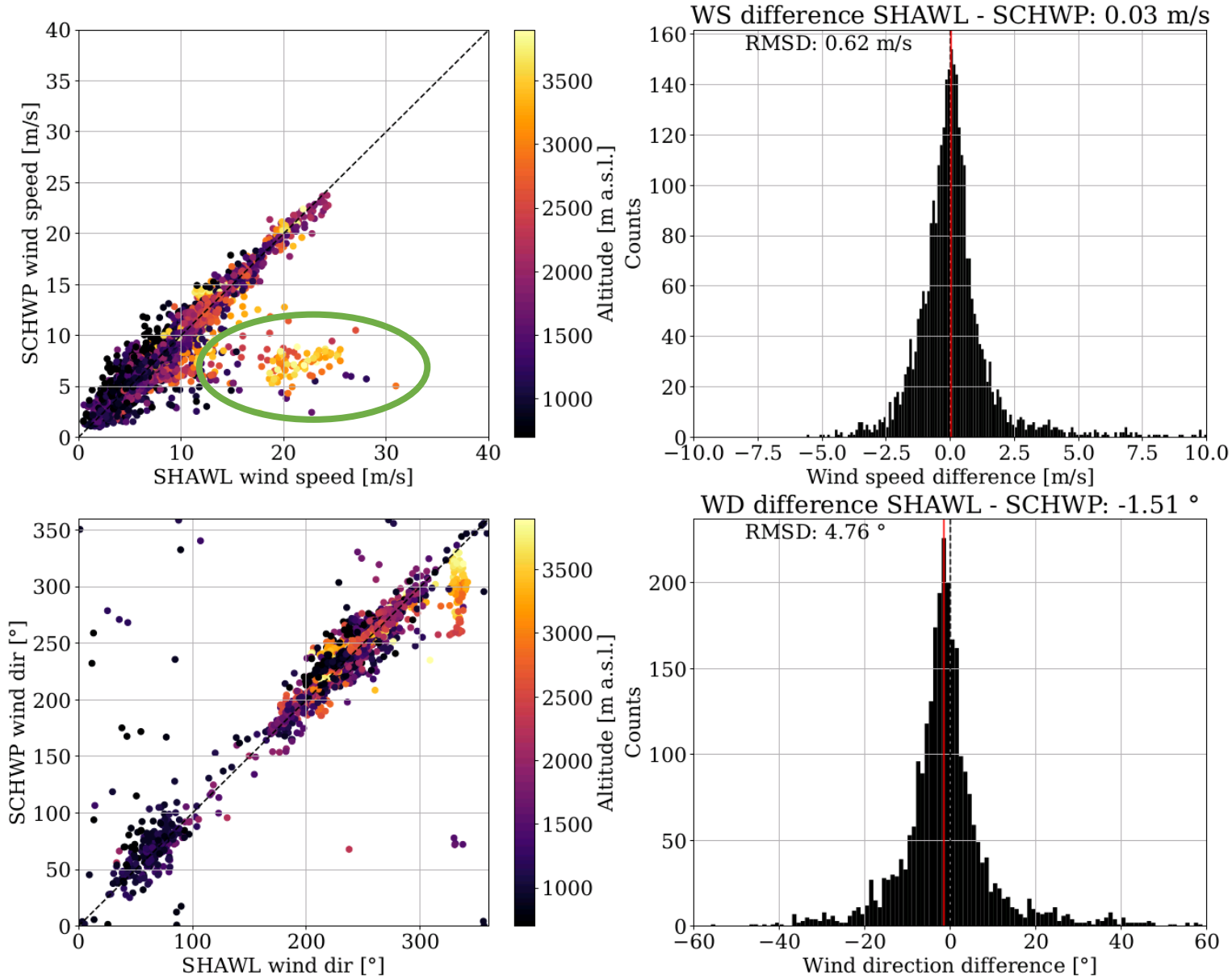
- Comparisons presented here must be considered with care because:
  - Grenchen suffers from dubious WP measurements at low altitude + range aliasing
  - Schaffhausen suffers from dubious WP measurements at low altitude + range aliasing
    - Clear improvement during the P2 is likely a combination of:
      - Change in the amplifiers
      - Better general weather conditions
  - Payerne suffers from dubious WP measurements at low altitude but NOT from range aliasing
  - Overall comparisons against the RS in Payerne is likely the most representative of E-Profile DWL wind profile quality
    - Agreement between DWL and RS in Payerne is good !
- The above likely explains the relatively worth statistics found here compared to other studies (e.g. Päschke et al., 2015)
- Despite the bias, statistics all fall within the OSCAR threshold requirements
- E-Profile DWL wind profiles have been evaluated in the frame of TEAMx (see Poster EGU25-16079):
  - Equivalement quality between E-P retrieval and manufacturer retrieval

Range aliasing: an example



Range aliasing:

Wind speed and direction comparison between SHAWL and SCHWP



Take home messages

- E-Profile DWL network is running and provides continuous, near real-time wind profiles with relatively good data availability since November 2024
- E-Profile wind retrievals with DL_toolbox meet the OSCAR threshold requirements
- DWL in Payerne agrees well with co-located RS measurements and is of similar quality than wind profiles provided directly by the manufacturers
- Issue identified with the 3 WP at lower altitude (Height above ground < 500 m)
  - Results in large biases in the DWL vs WP comparisons
  - Considering a period less impacted (Schaffhausen, P2) shows a relatively good agreement between DWL and WP measurements
- Range aliasing heavily affects the DWL at Grenchen and Schaffhausen
  - Easy to identify but difficult to filter in real-time…
- E-Profile needs to define its requirements in order to setup a fully operational DWL network

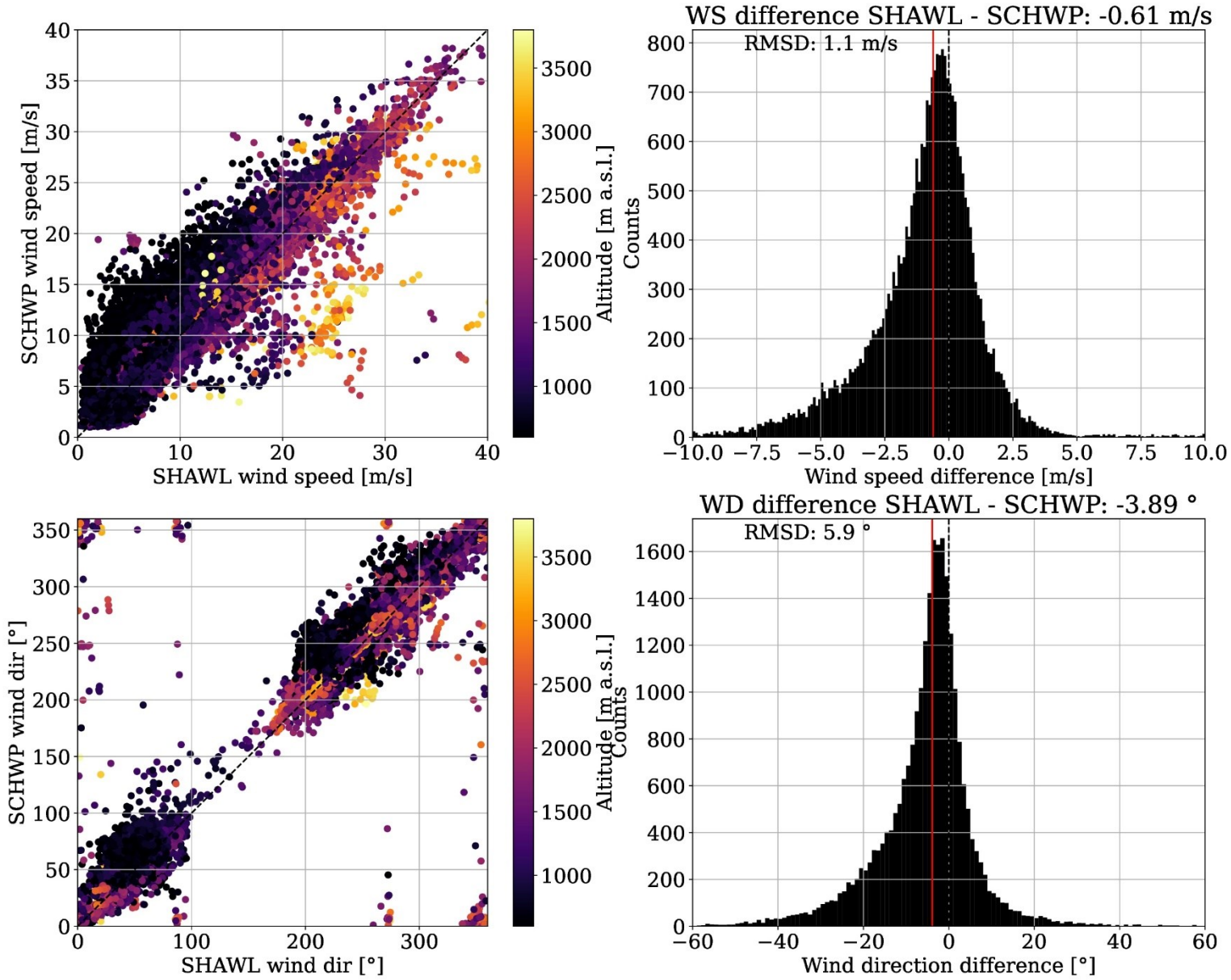
Appendices

OSCAR requirements

Id	Variable	Layer	App Area	ATP	Uncertainty	Layer/s Quality	Coverage Quality	Stability / decade	Hor Res	Ver Res	Obs Cyc	Timeliness	Coverage	Conf Level	Val Date	Source	General Comment	Applicatio Area Comment
310	Wind (horizontal)	MUSM	2.1 Global Numerical Weather Prediction and Real-time Monitoring		1 $m.s^{-1}$ 5 $m.s^{-1}$ 10 $m.s^{-1}$				50 km 100 km 500 km	1 km 2 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm	2009-02-10	John Eyre		
311	Wind (horizontal)	FT	2.1 Global Numerical Weather Prediction and Real-time Monitoring		1 $m.s^{-1}$ 3 $m.s^{-1}$ 8 $m.s^{-1}$				15 km 100 km 500 km	0.5 km 0.7 km 1 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	tentative	2020-03-30	Masahiro Kazumori (PoC GNWP)		
312	Wind (horizontal)	UTLS	2.1 Global Numerical Weather Prediction and Real-time Monitoring		1 $m.s^{-1}$ 3 $m.s^{-1}$ 5 $m.s^{-1}$				15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm	2009-02-10	John Eyre		
313	Wind (horizontal)	PBL	2.1 Global Numerical Weather Prediction and Real-time Monitoring		1 $m.s^{-1}$ 3 $m.s^{-1}$ 5 $m.s^{-1}$				15 km 100 km 500 km	0.5 km 1 km 3 km	60 min 6 h 12 h	6 min 30 min 6 h	Global	firm	2009-02-10	John Eyre		

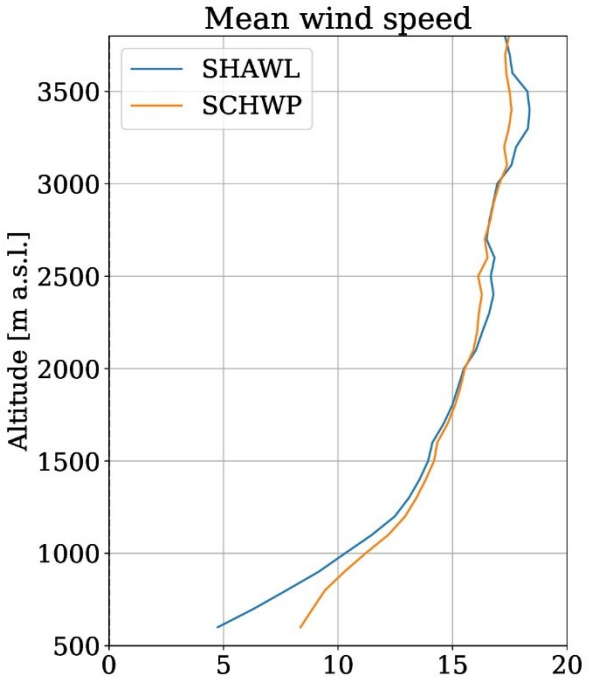
Wind comparisons

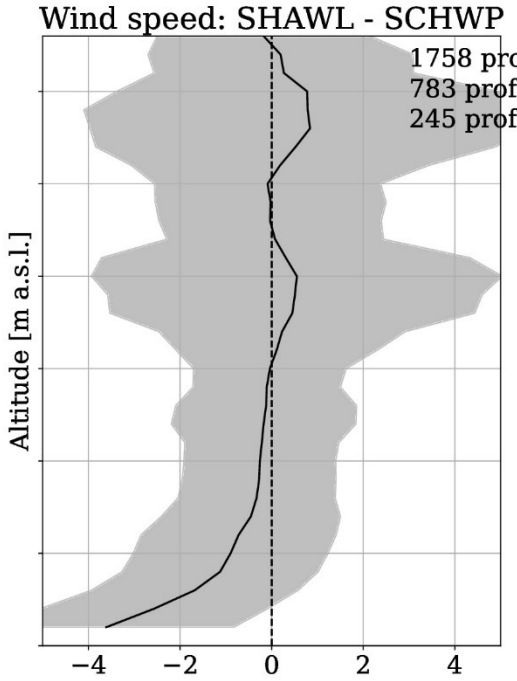
Schaffhausen, P1

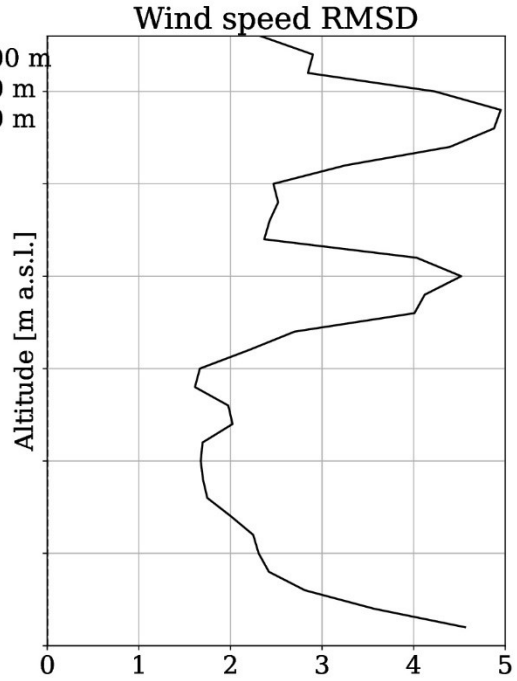


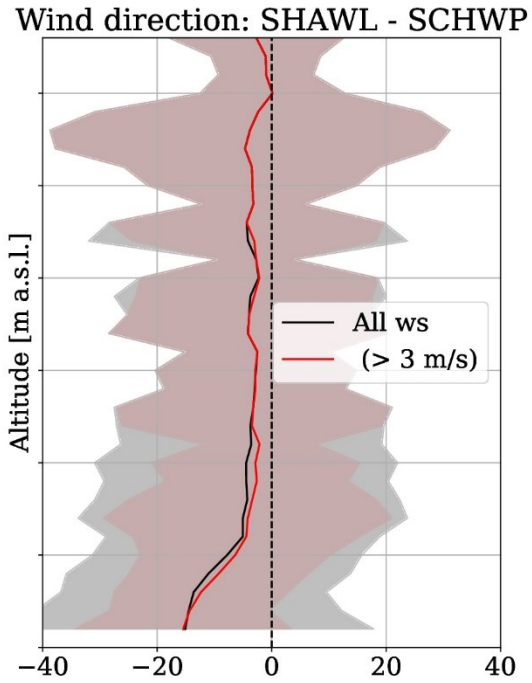
Profiles

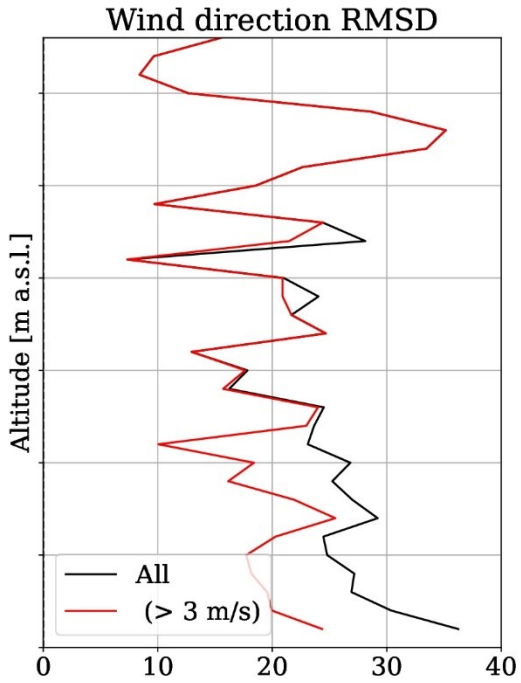
Schaffhausen, P1



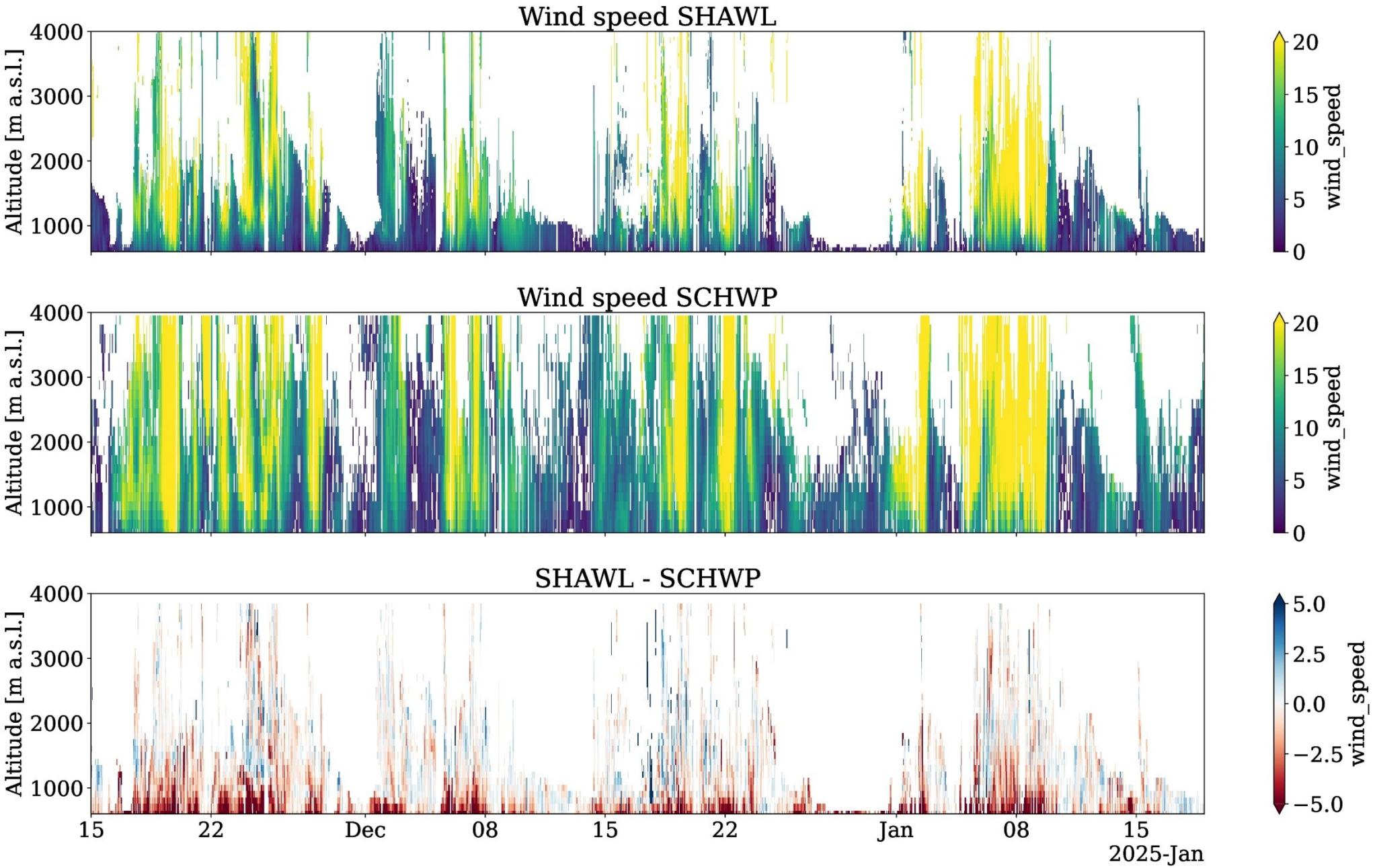




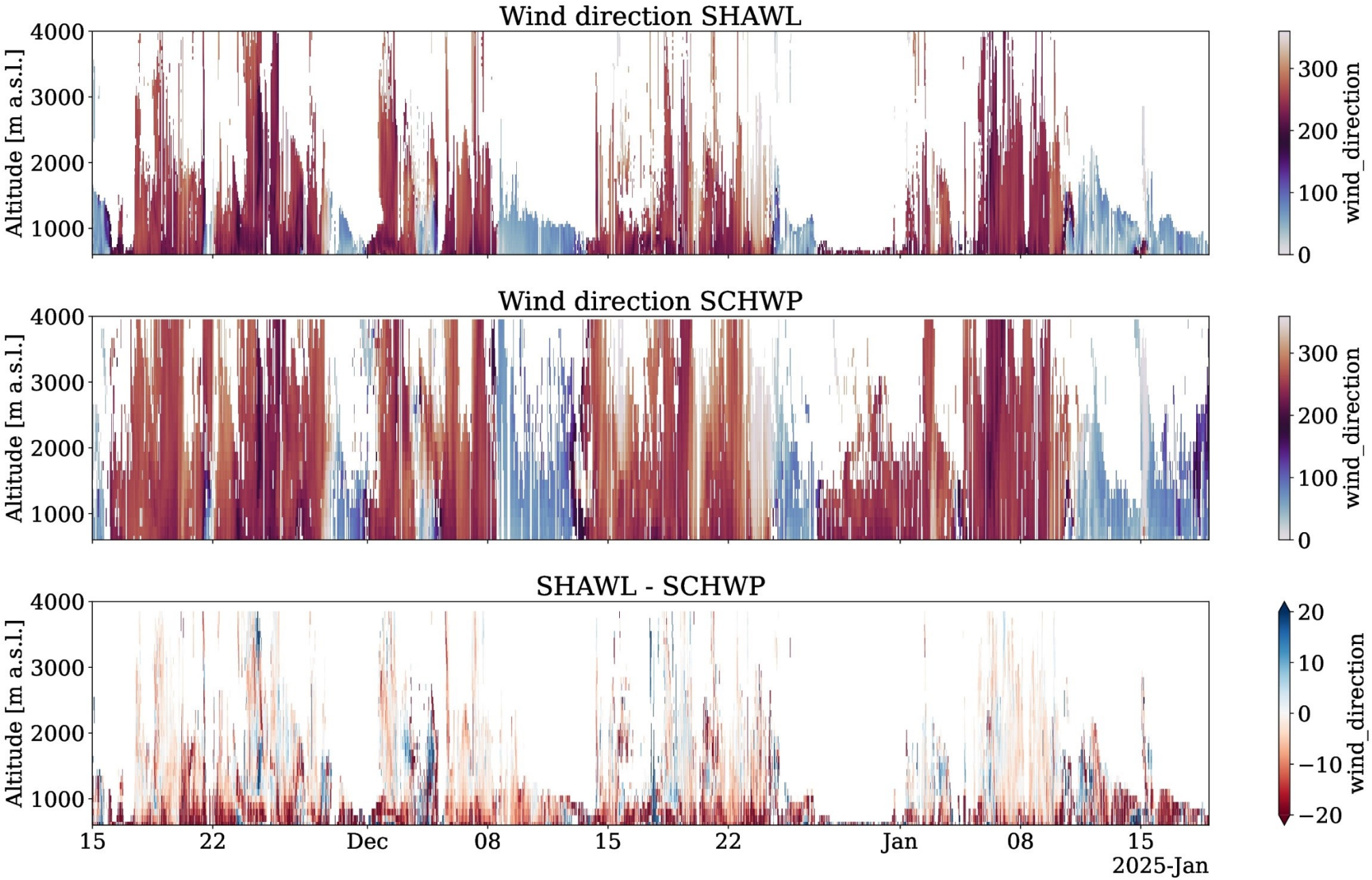




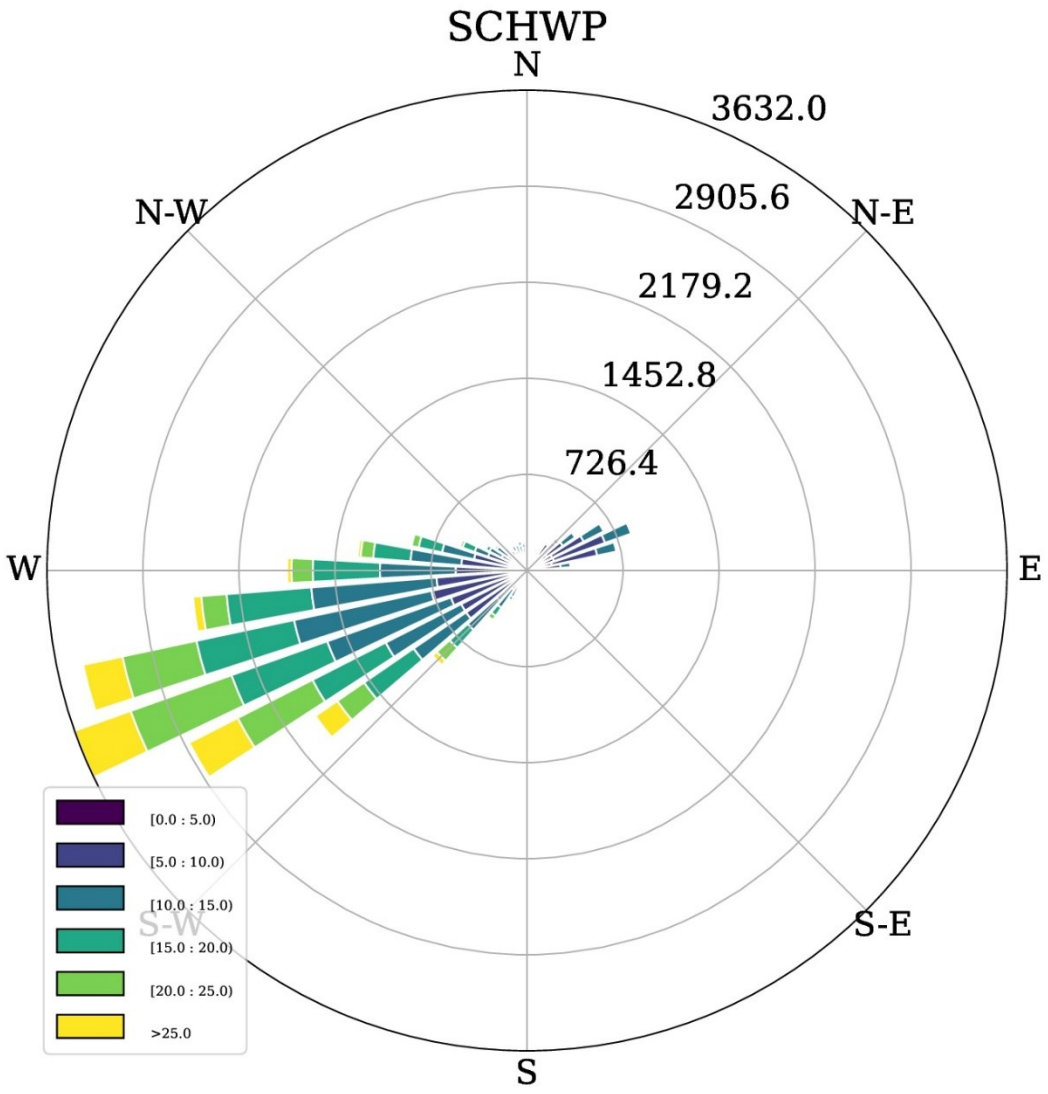
Full 30 min averaged time series: Schaffhausen, P1

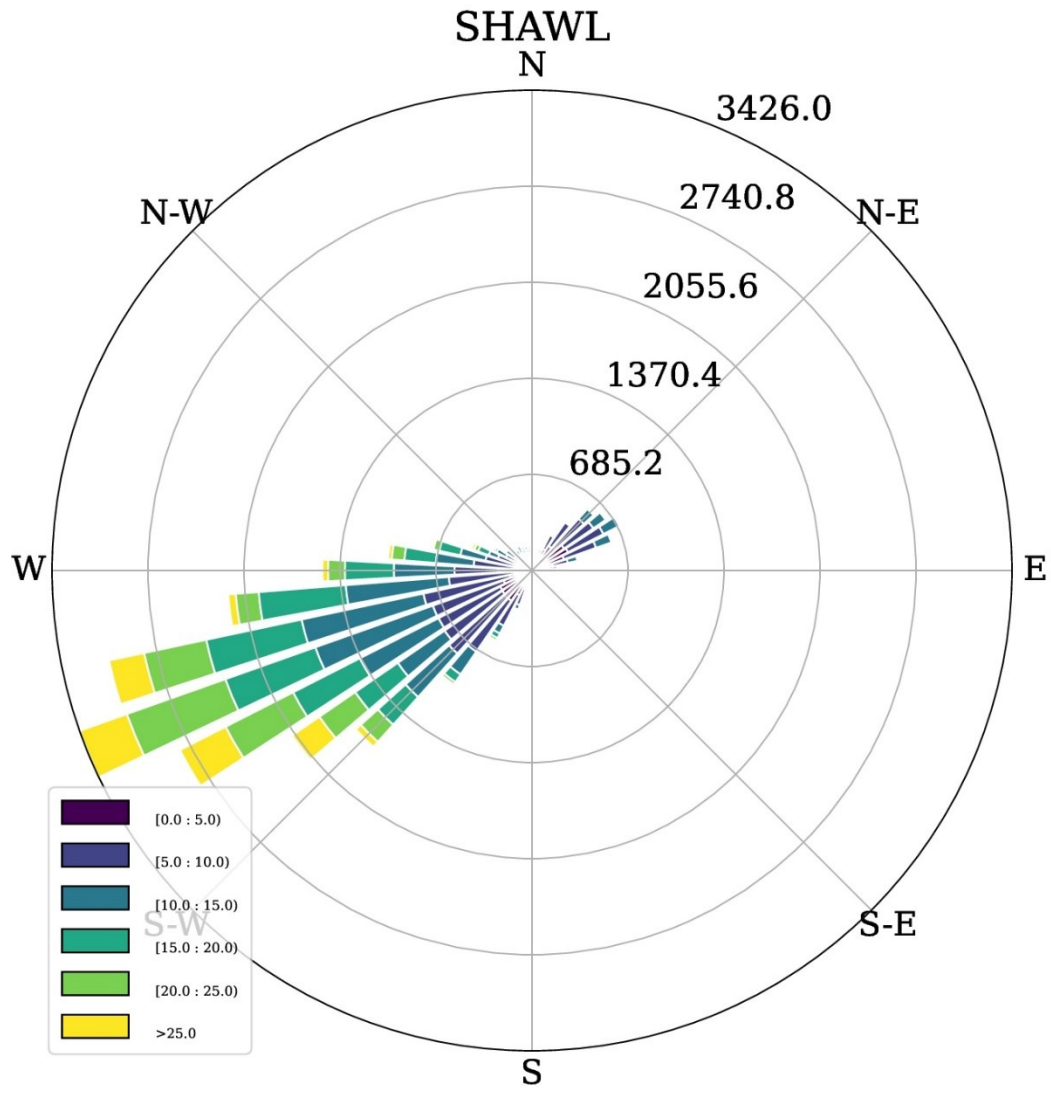


Full 30 min averaged time series: Schaffhausen, P1

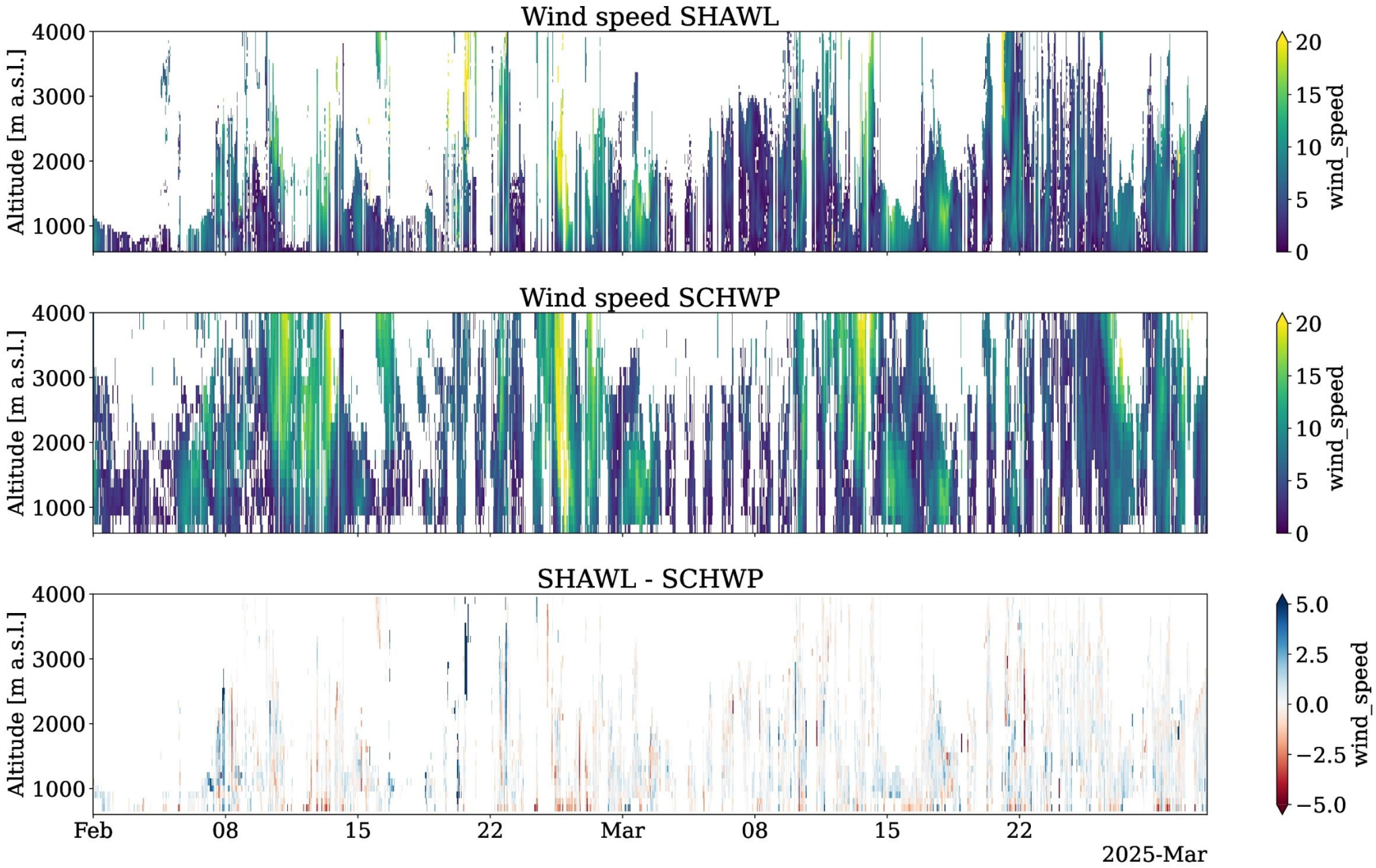


Wind rose: Schaffhausen, P1

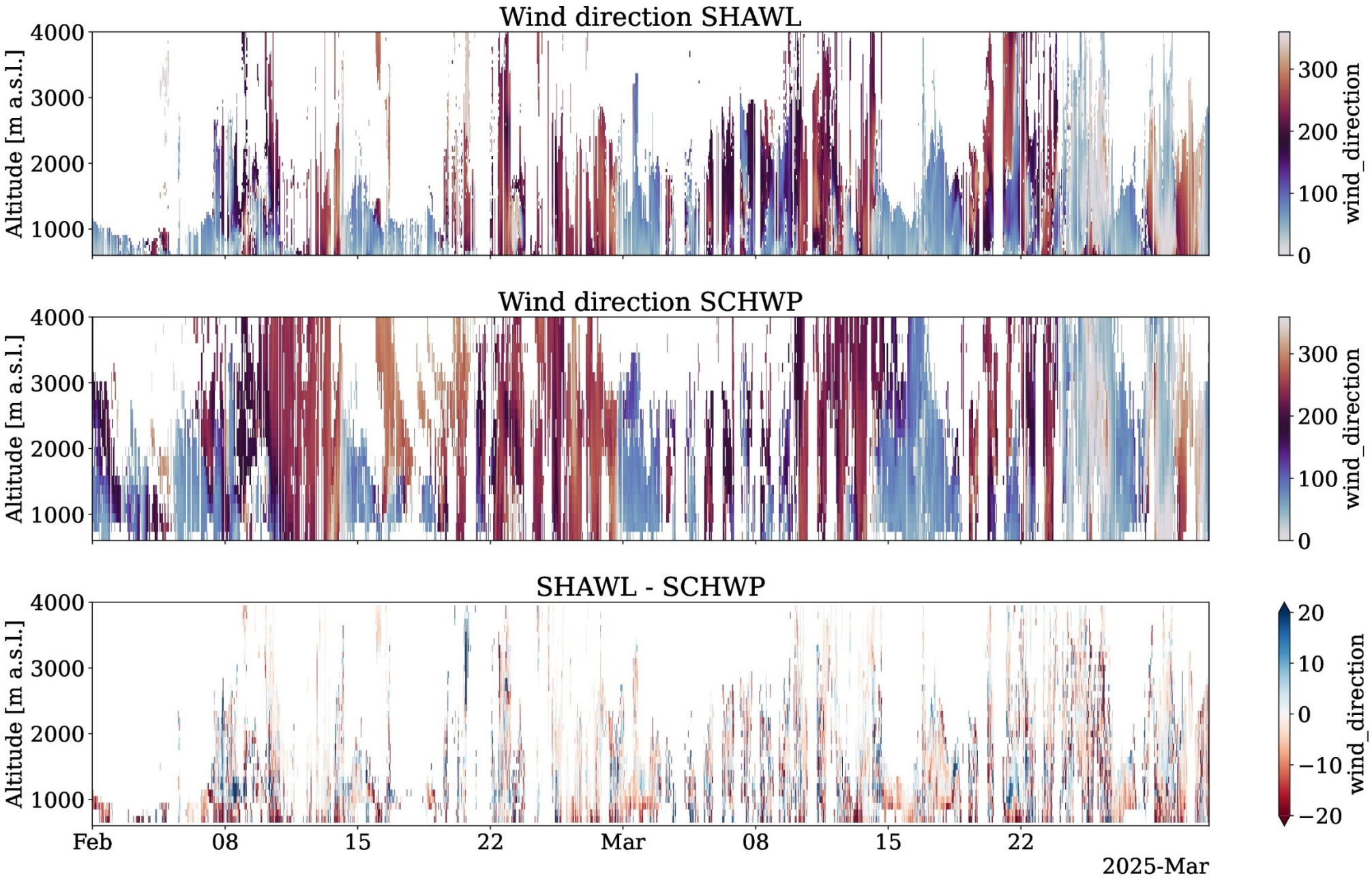




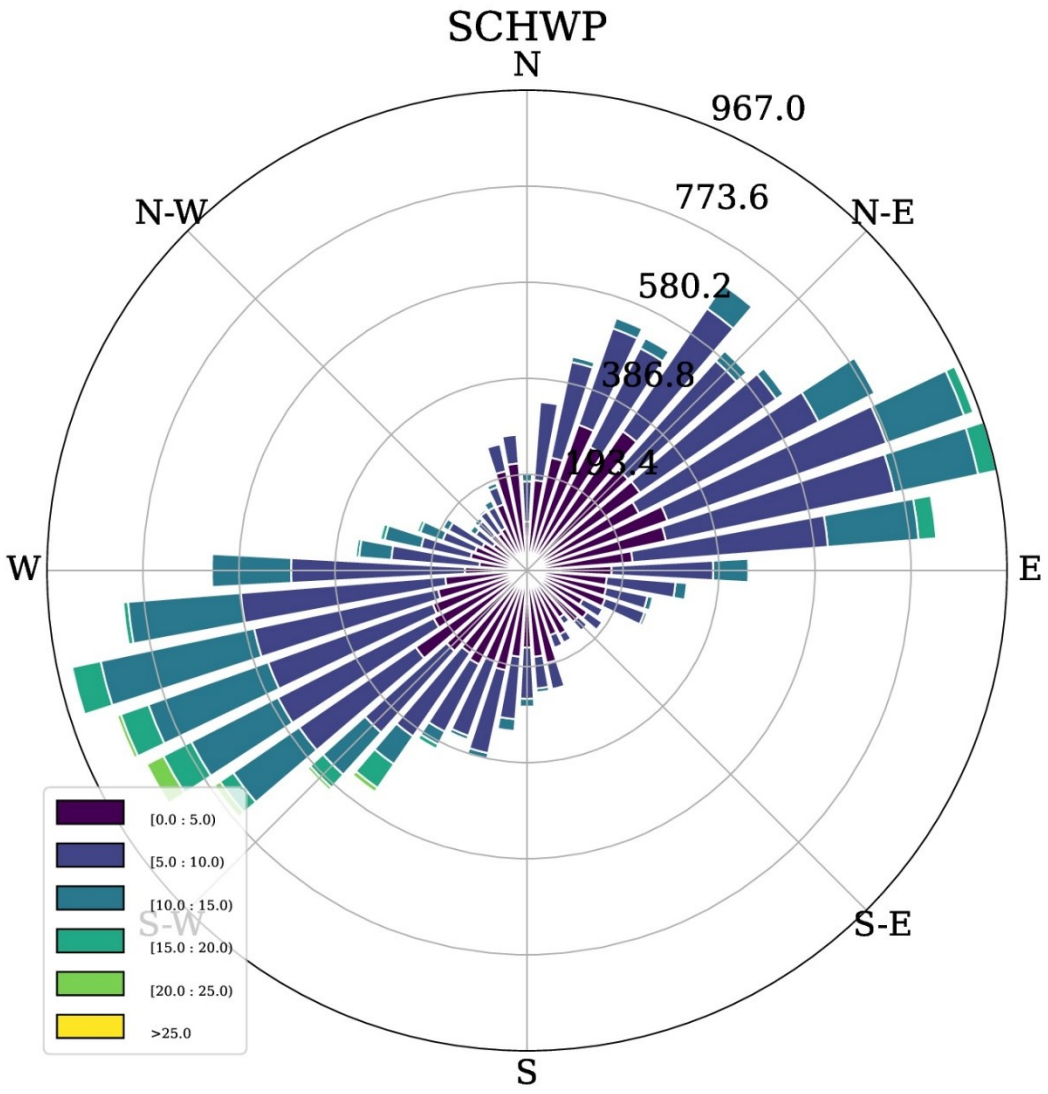
Full 30 min averaged time series: Schaffhausen, P2

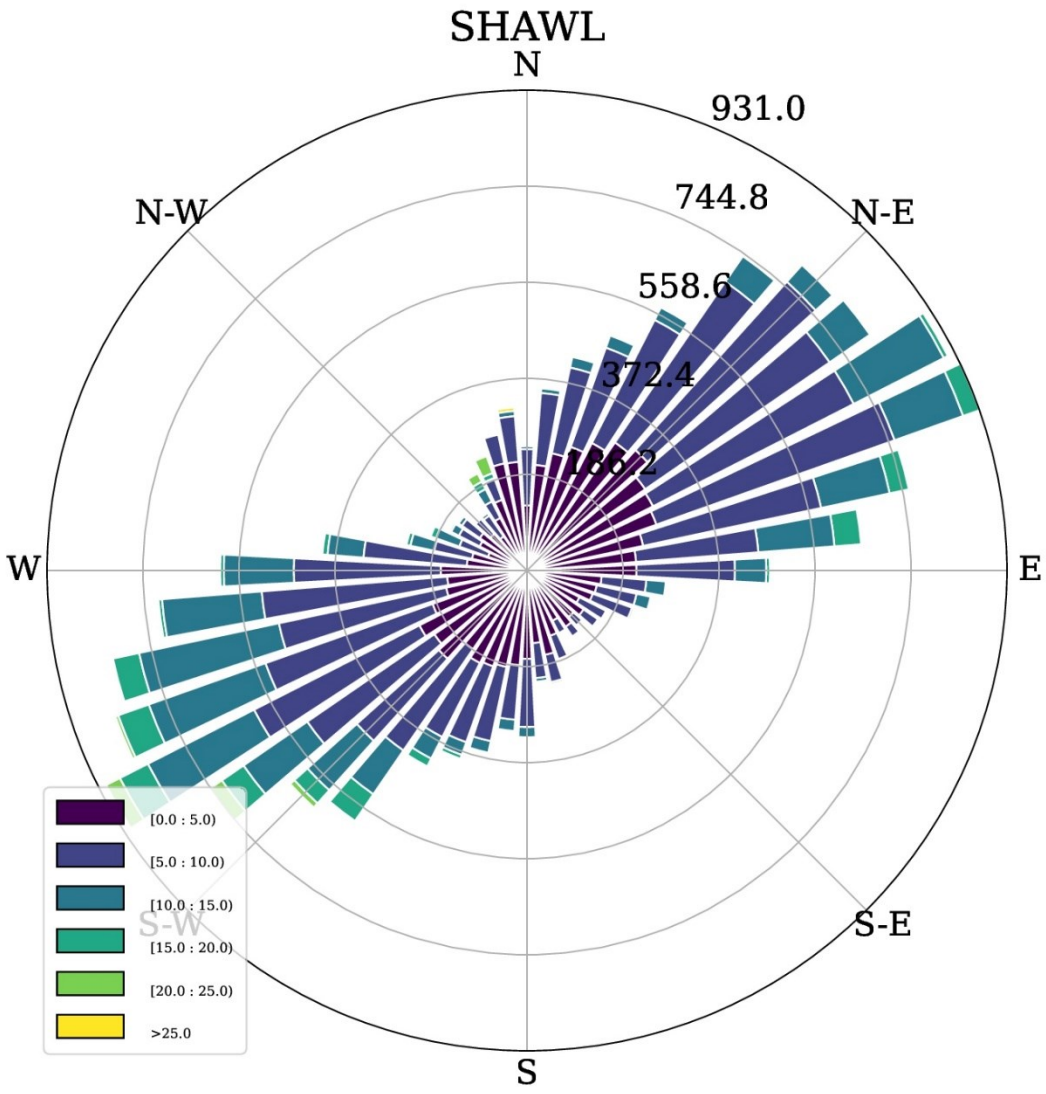


Full 30 min averaged time series: Schaffhausen, P2

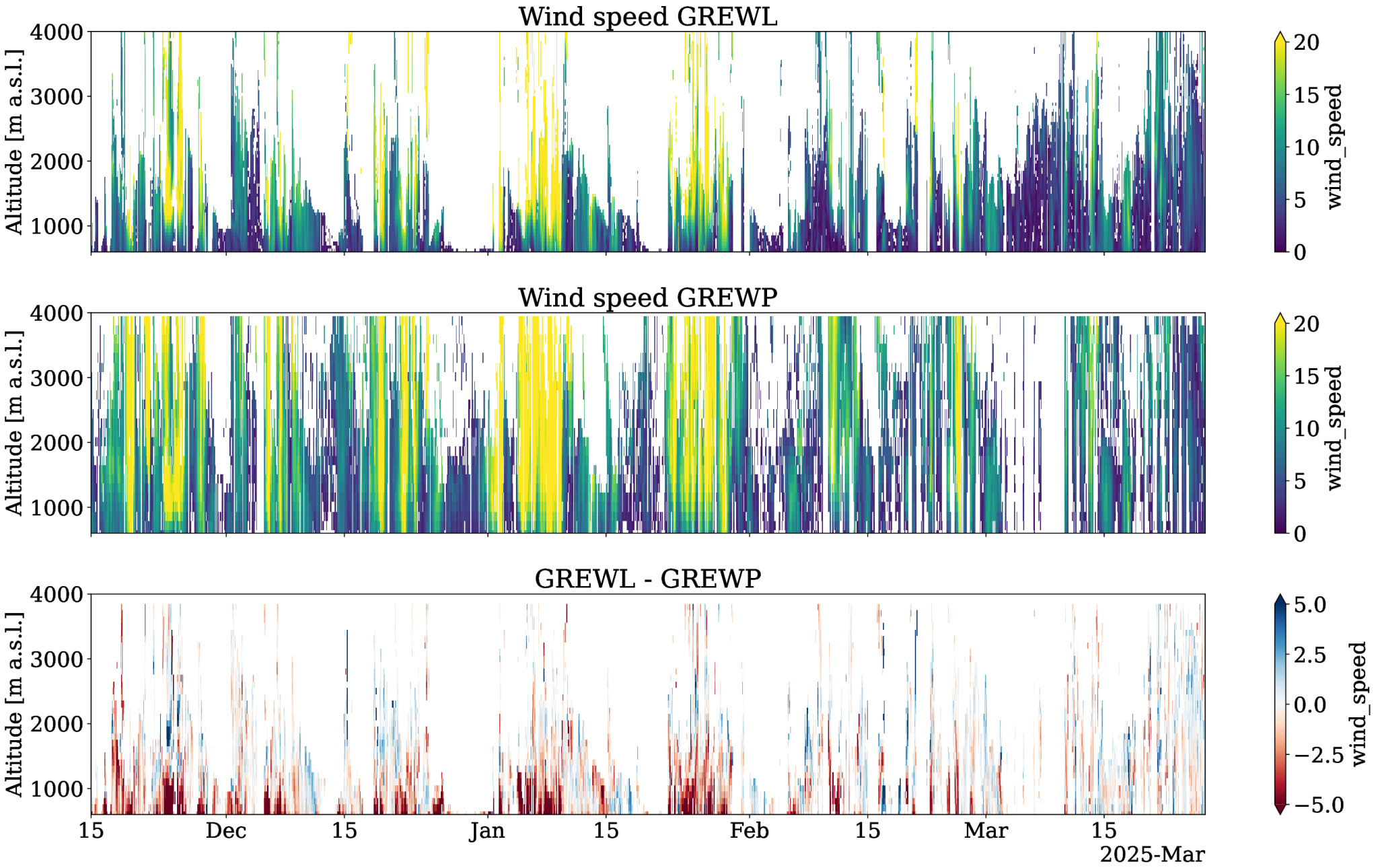


Wind rose: Schaffhausen, P2

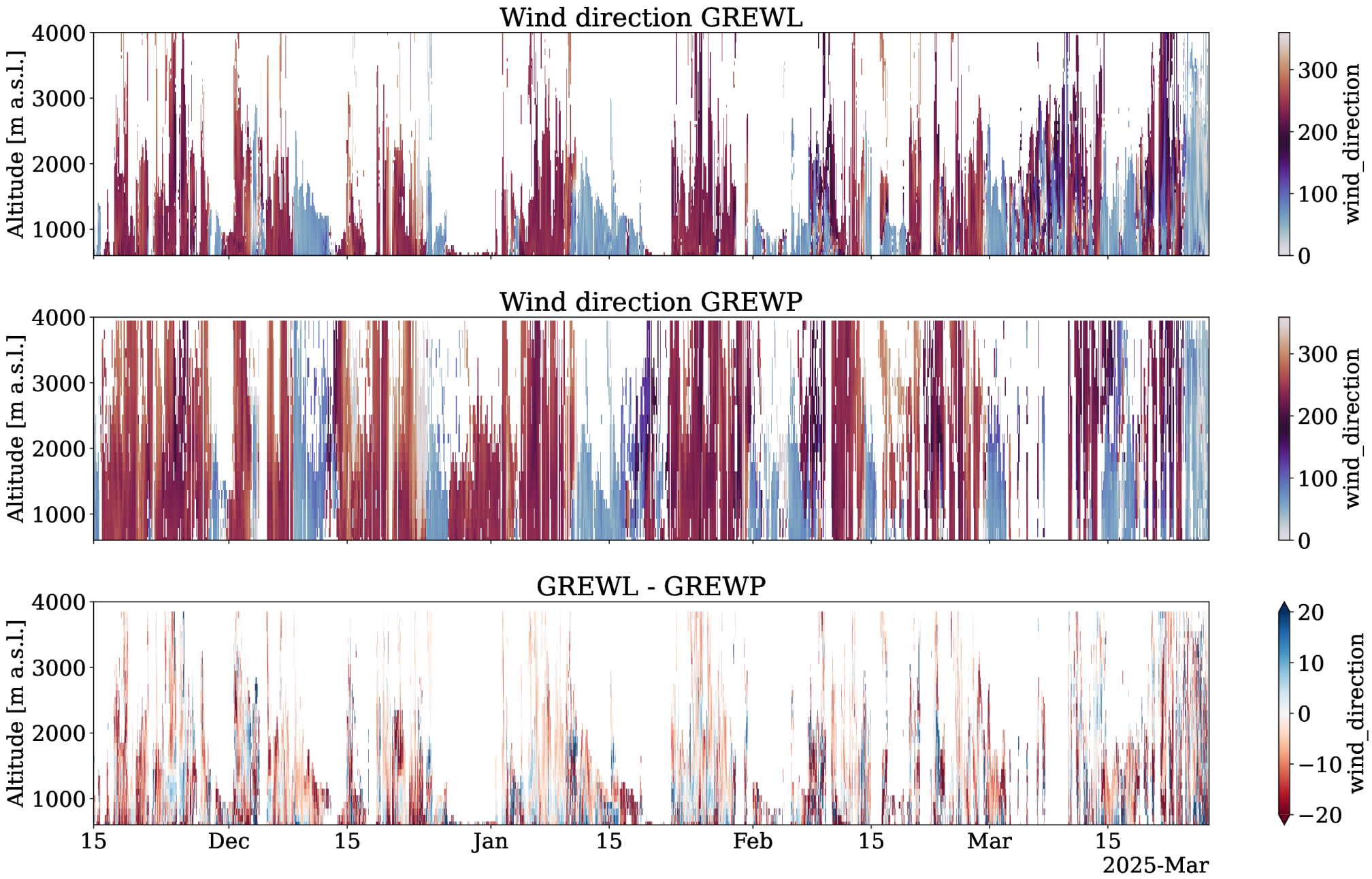




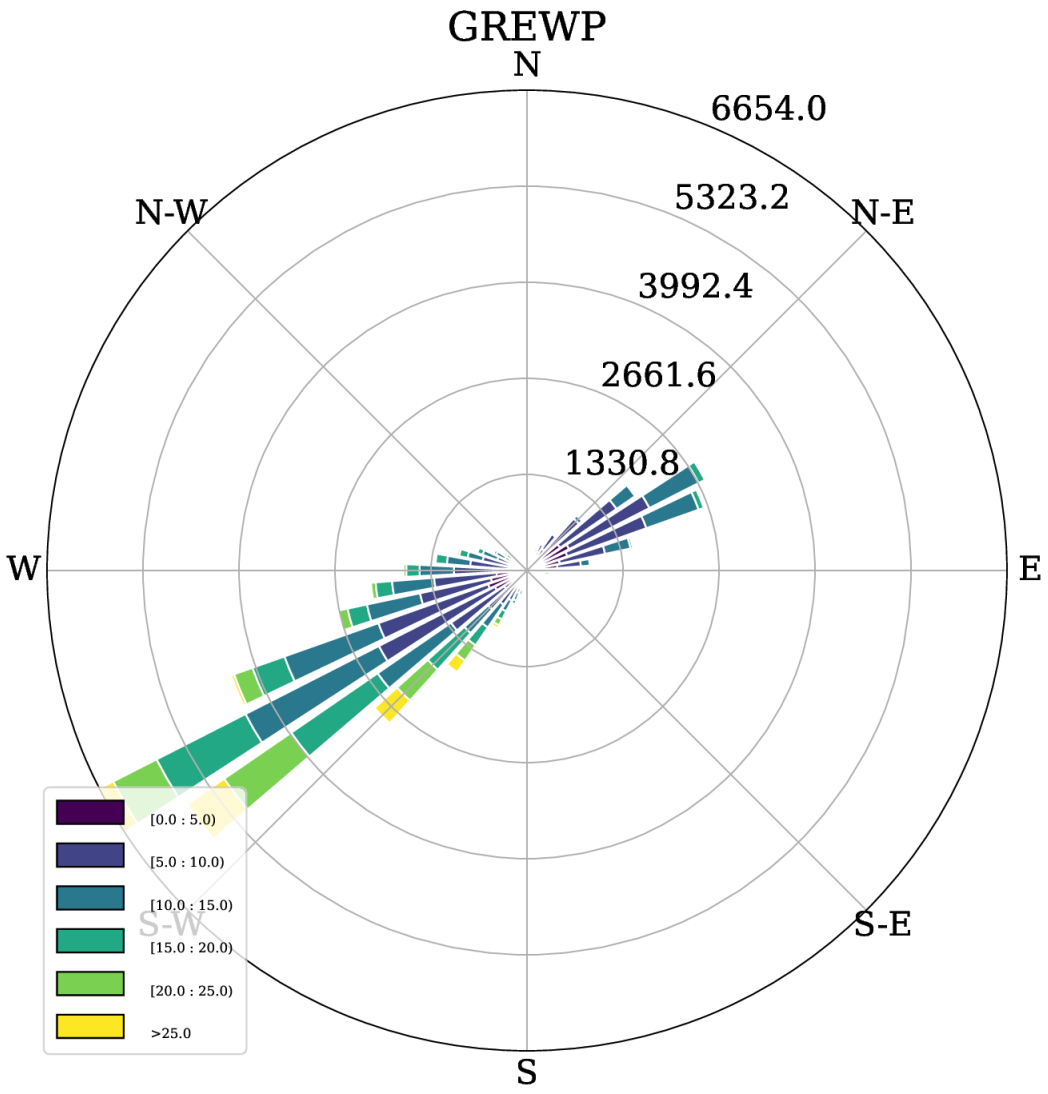
Full 30 min averaged time series: Grenchen

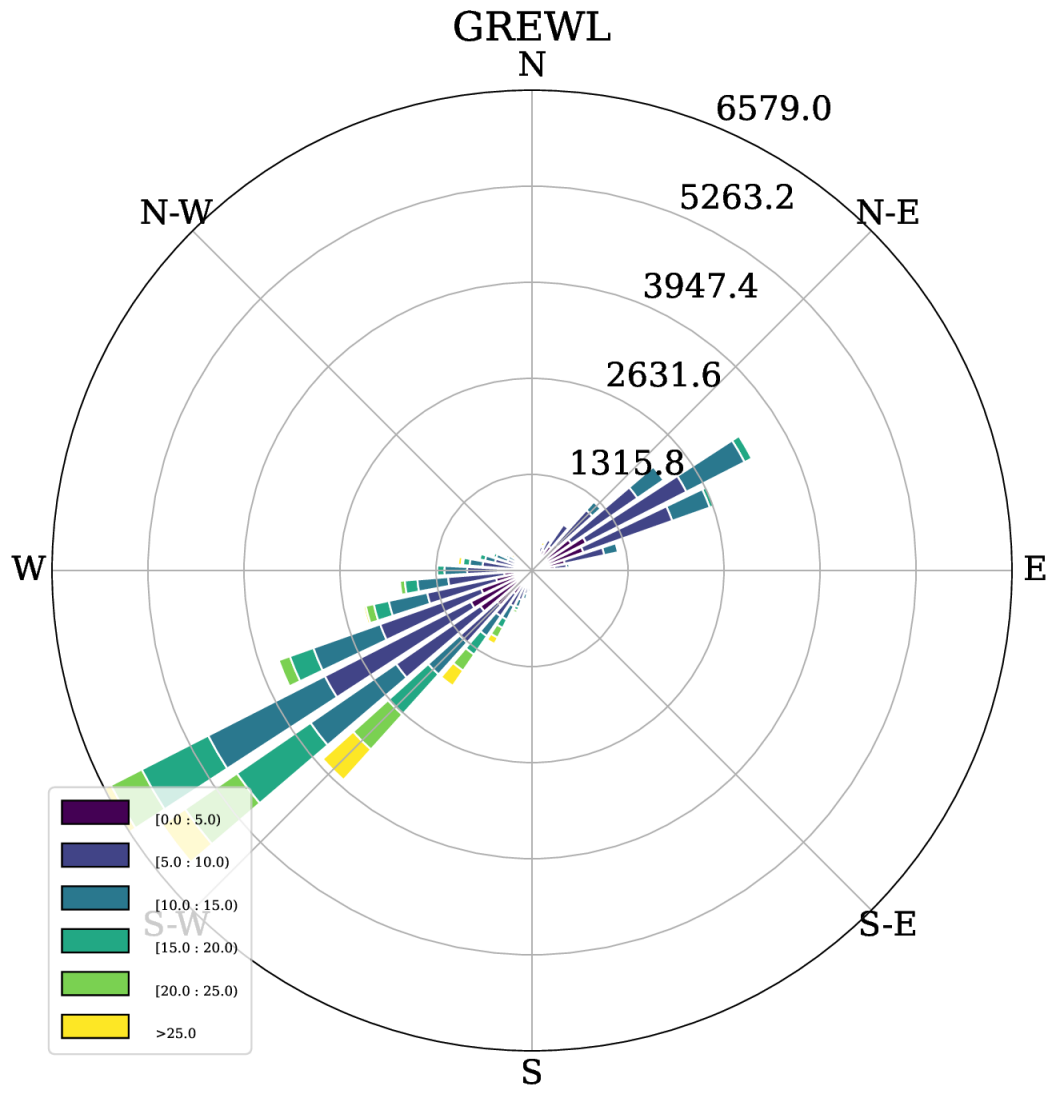


Full 30 min averaged time series: Grenchen

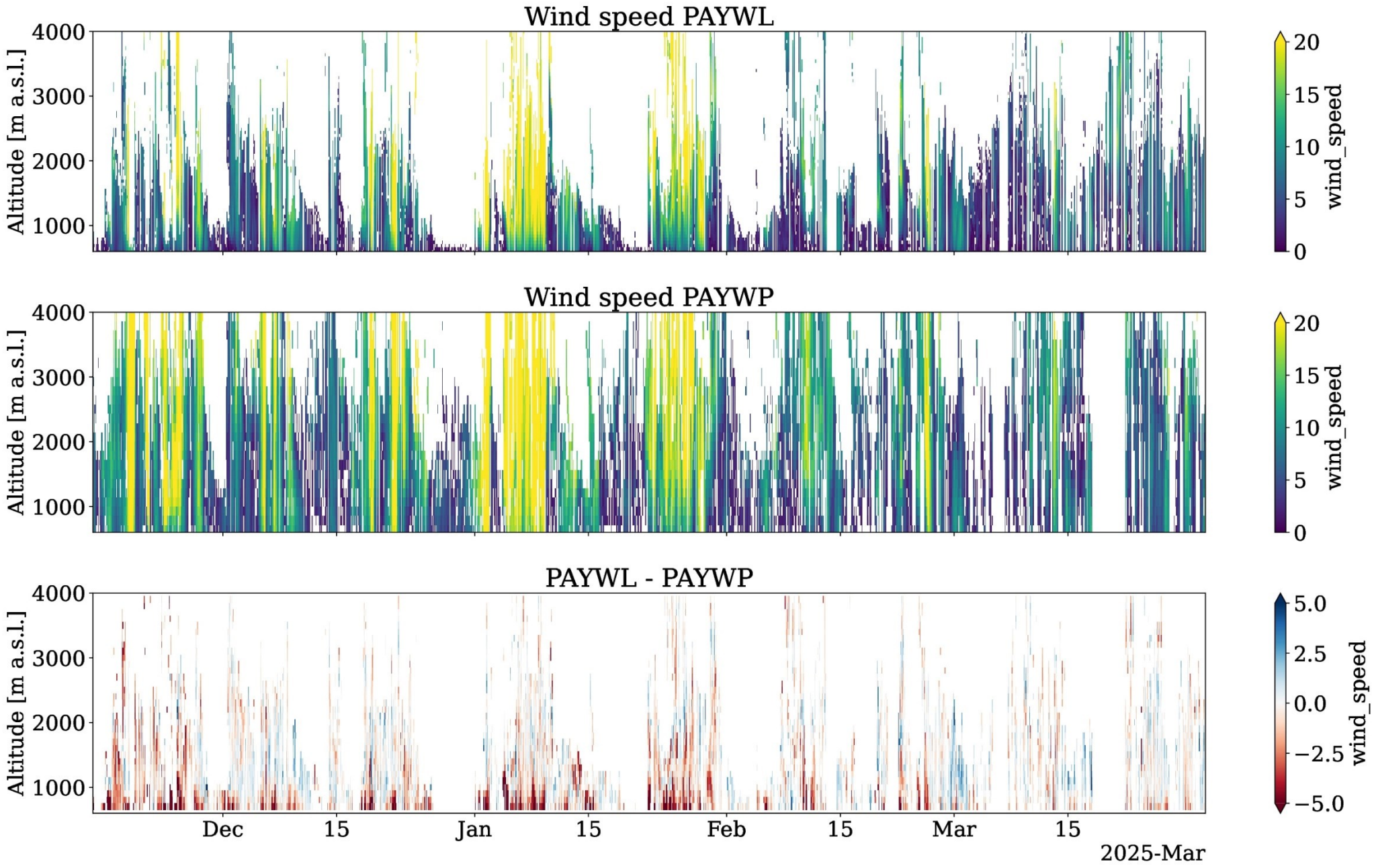


Wind rose: Grenchen

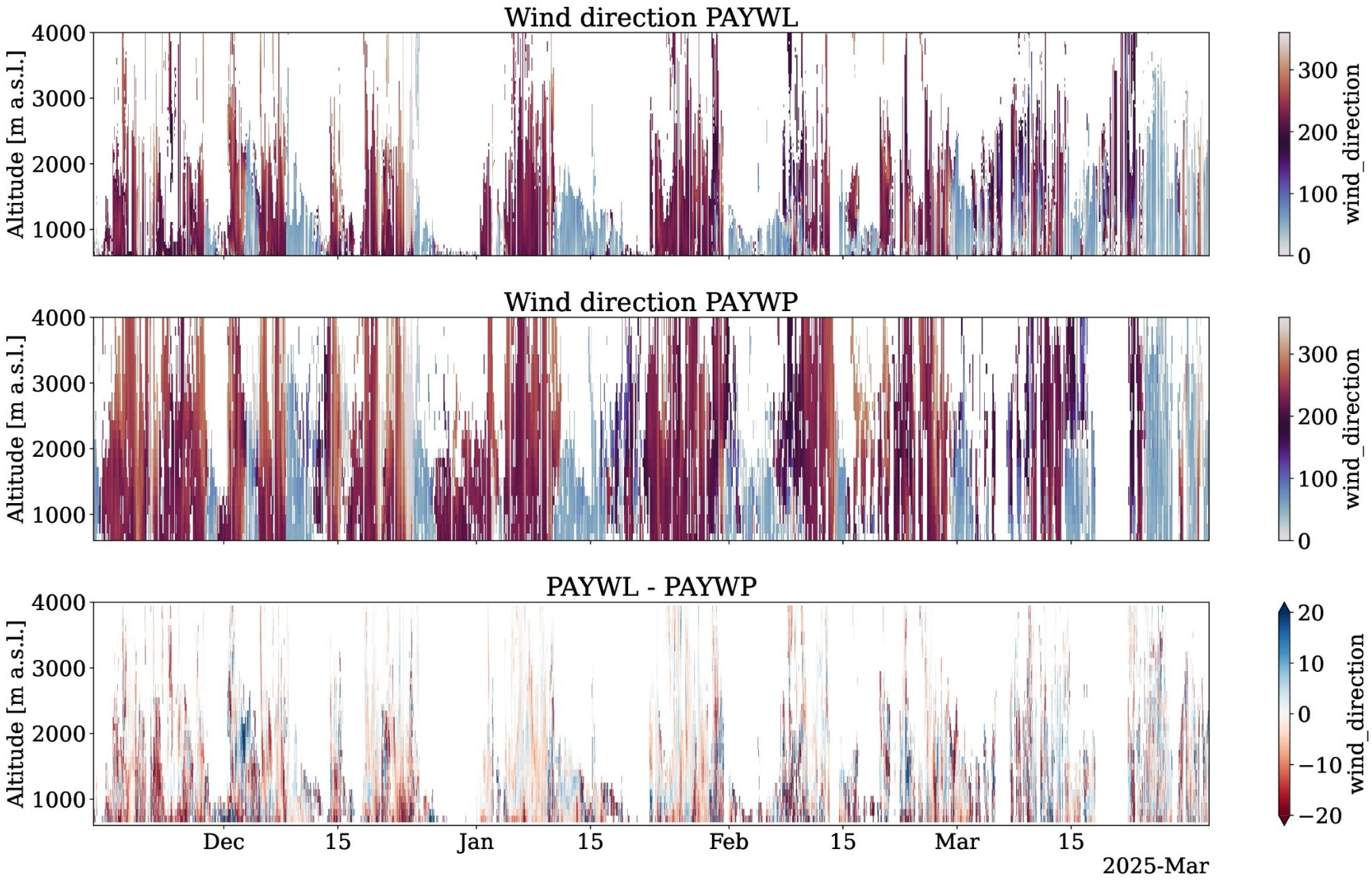




Full 30 min averaged time series: Payerne



Full 30 min averaged time series: Payerne



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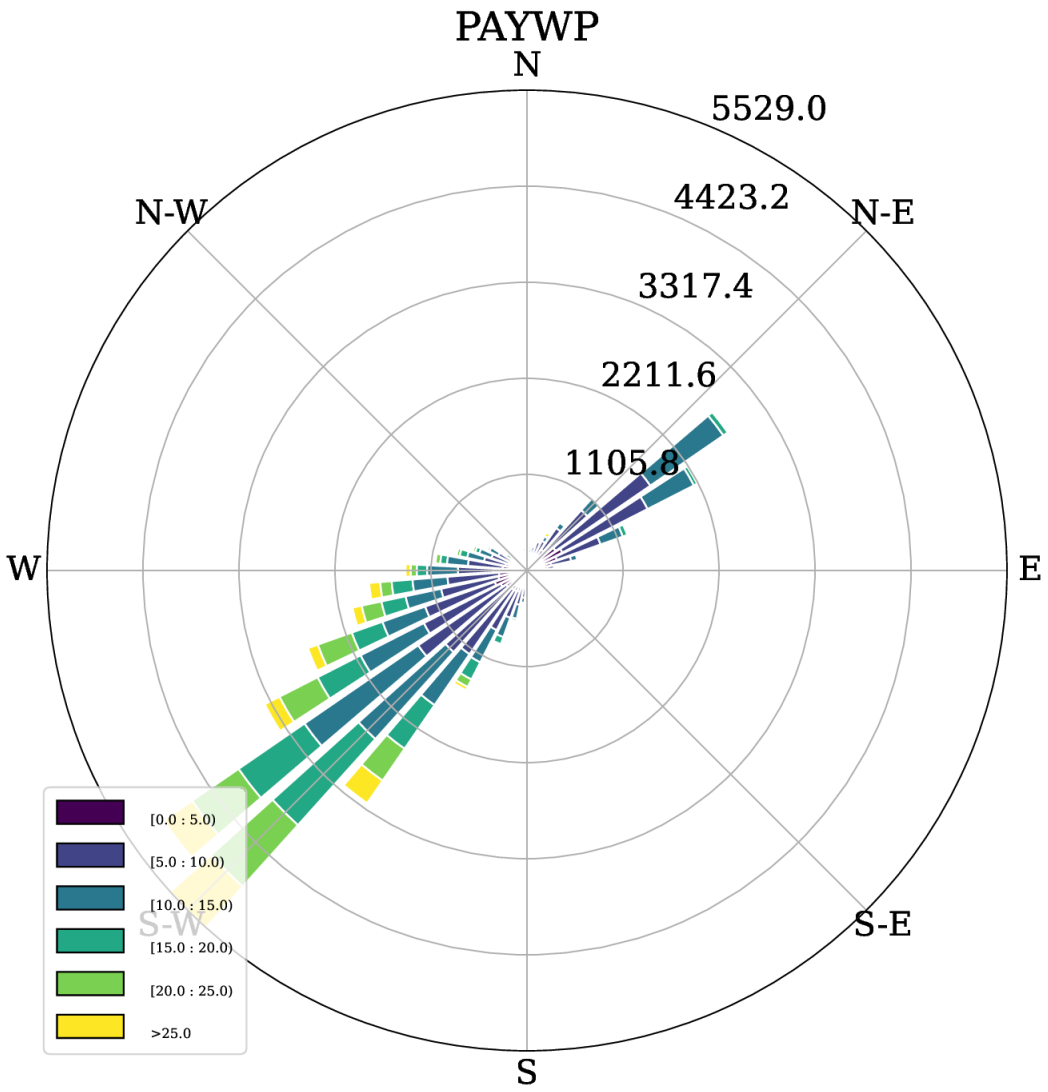
PAYWP
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N-E
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S-E
S
S-W
W
N-W
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3317.4
2211.6
1105.8
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[5.0 : 10.0)
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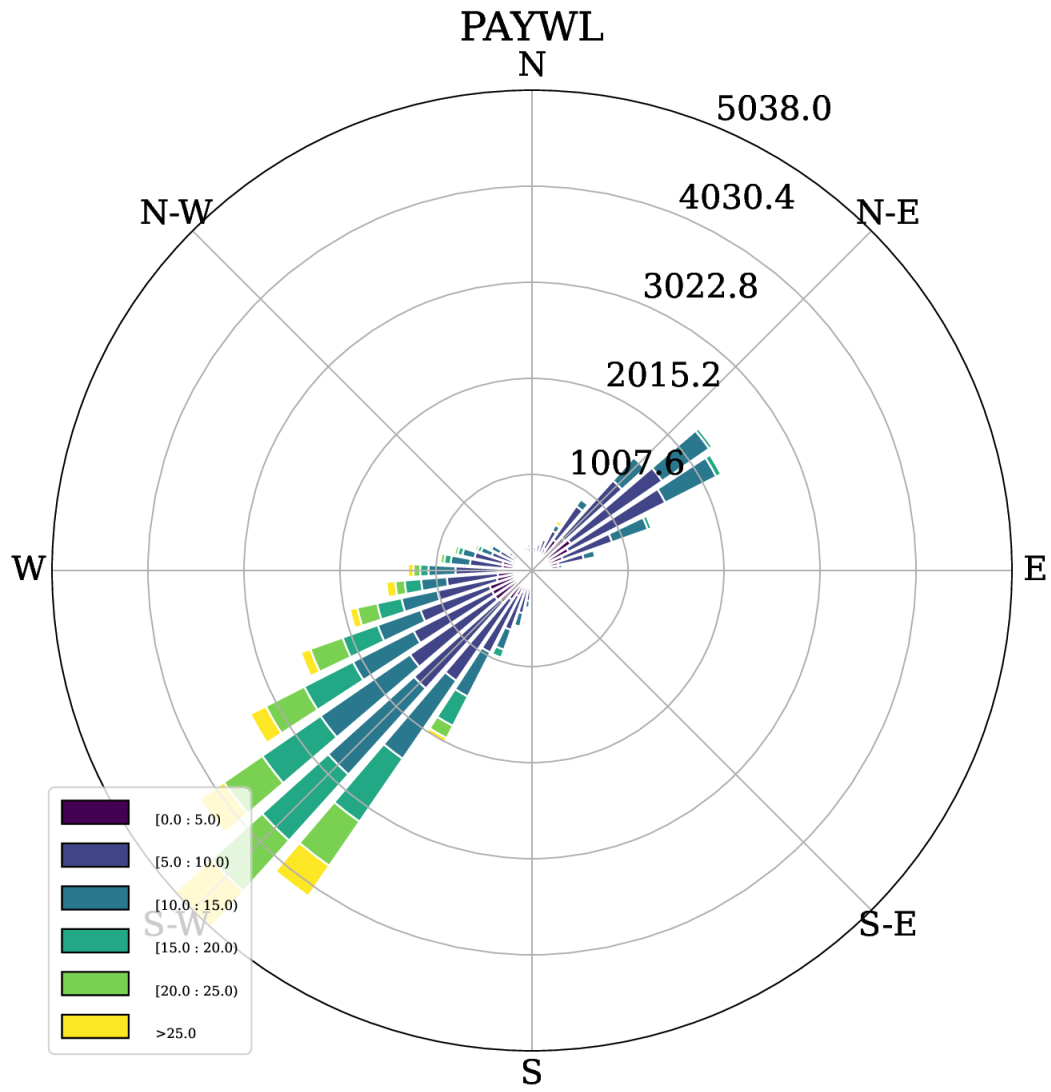
>25.0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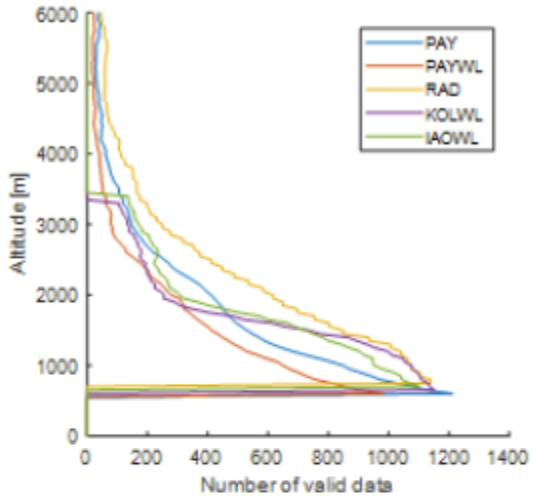
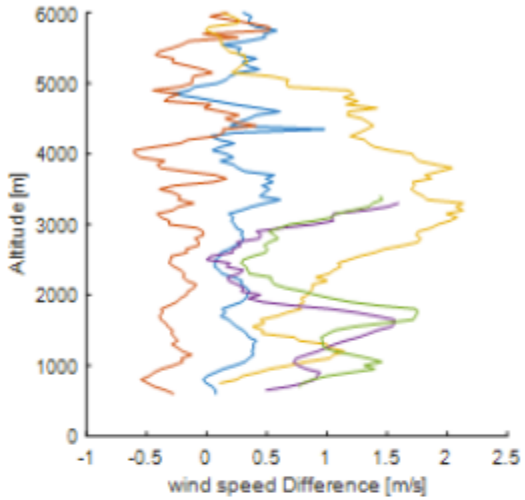
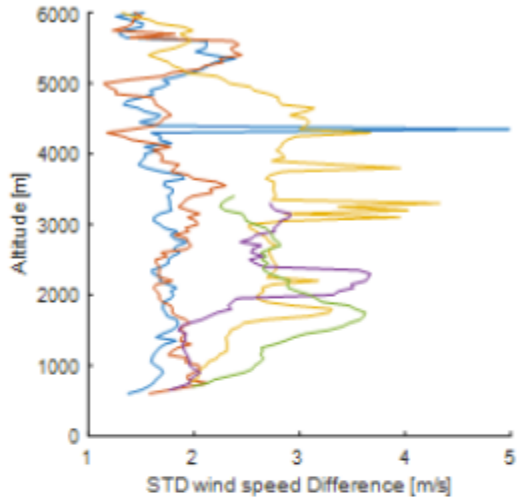
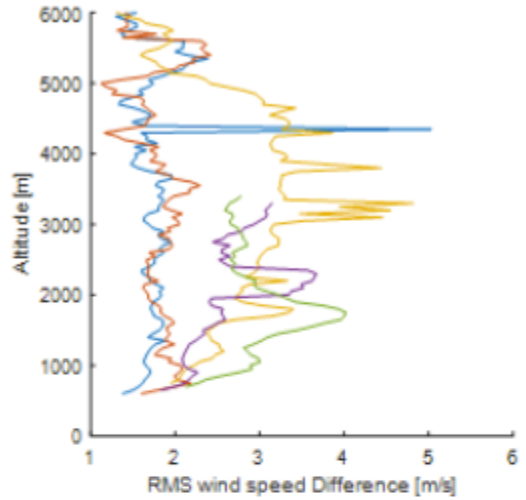
Evaluation DWL: Difference with KENDA within TEAMx

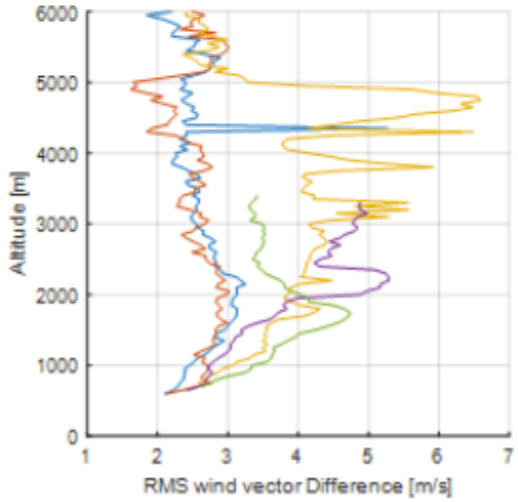
See also Poster EGU25-16079

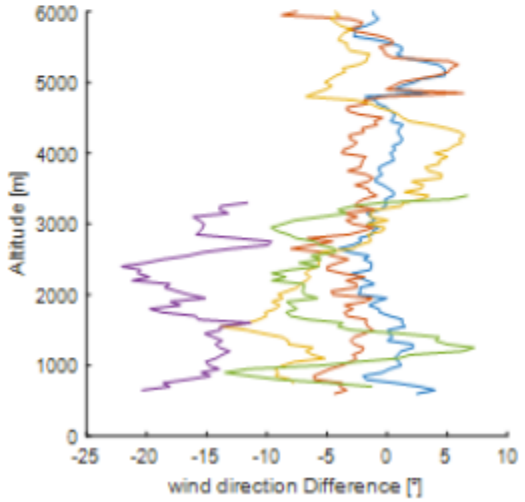


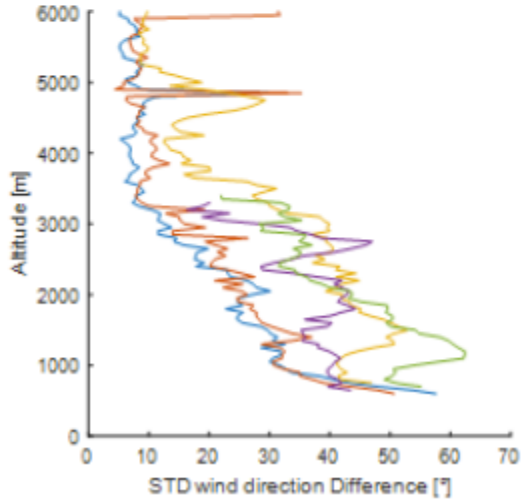


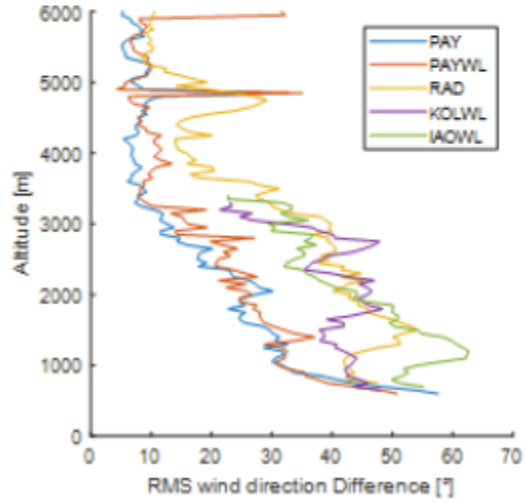






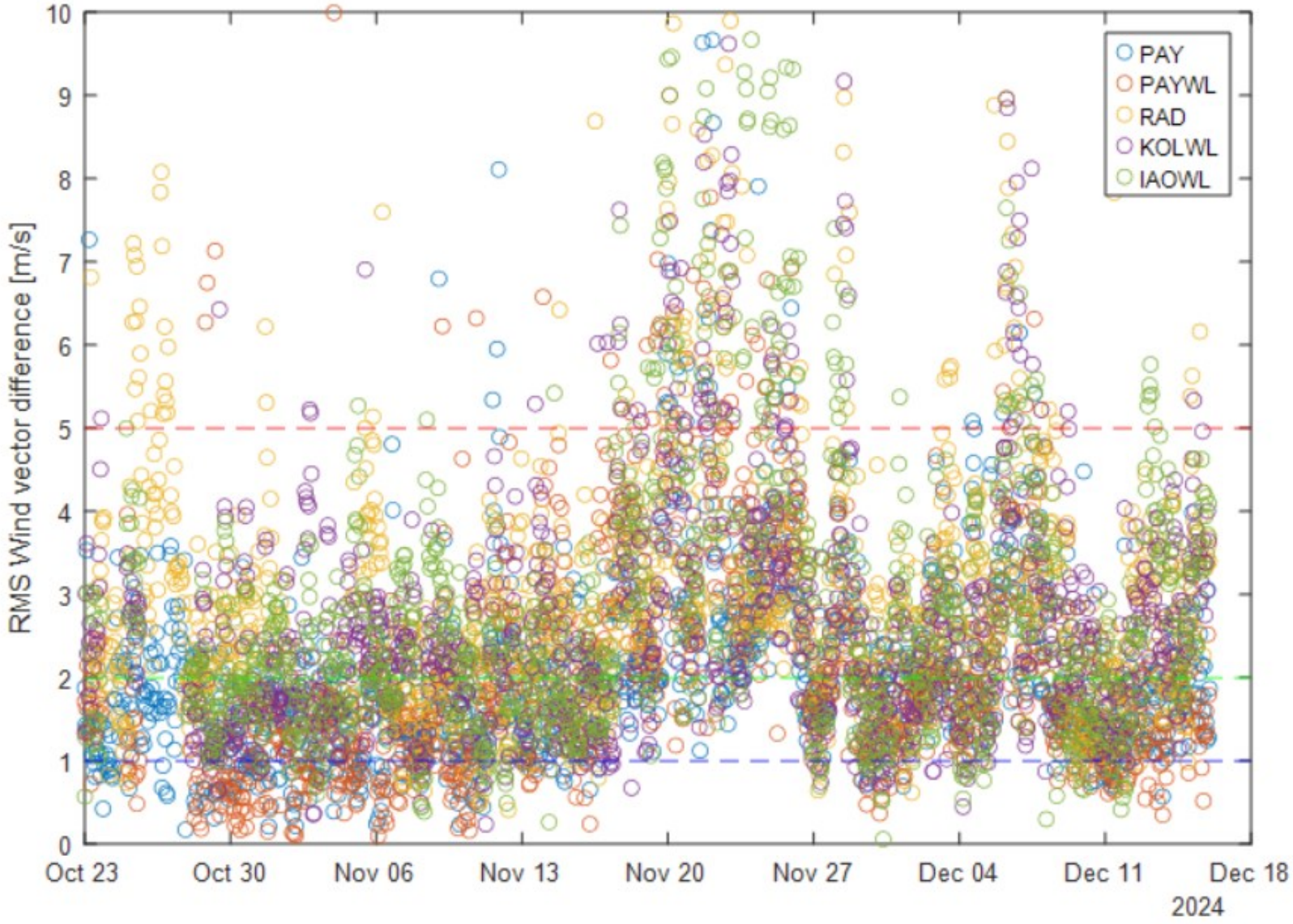






Evaluation DWL: Difference with KENDA within TEAMx

See also Poster EGU25-16079



RMS_{PAY}: 2.6848m/s
RMS_{PAYWL}: 2.6803m/s
RMS_{RAD}: 3.7829m/s
RMS_{KOLWL}: 3.3865m/s
RMS_{IAOWL}: 3.6849m/s