DWD's progress
on operational use of Doppler Lidars

DL breakout session

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Motivation

"There is a need for higher vertical resolution observations of **temperature, wind and humidity** in the boundary layer…"

WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction, 2016

Lower troposphere (0-3 km)

Parameter		Observing cycle	Vertical resolution	Precision/Bias
temperature		10-30 min	20-300m	<0.5K / <1K
humidity		10-30 min	20-300m	<5% / <10%
wind (horizontal)	speed	10-30 min	20-200m	<0.5 m/s / <1m/s
	direction	10-30 min		<2° / <10°
Cloud properties		10-30 min	100-300m	

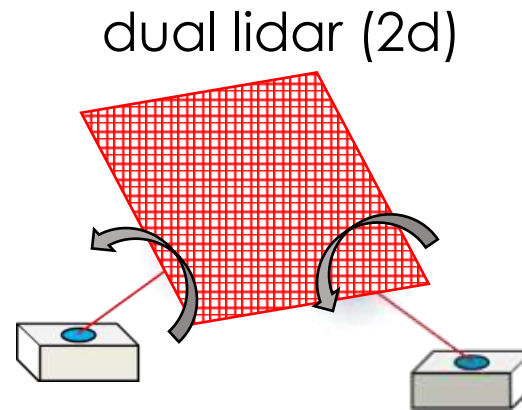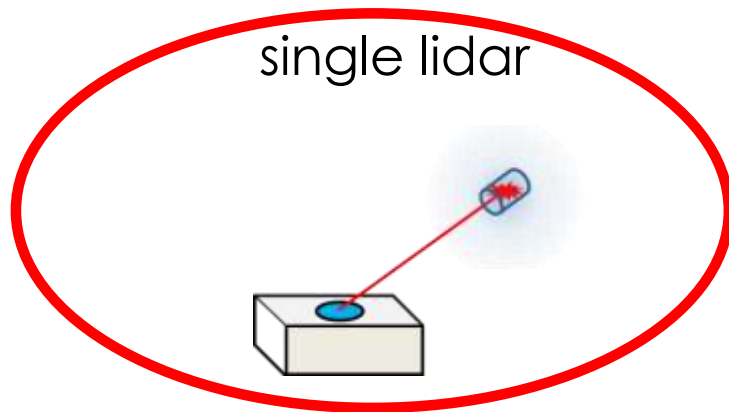Based on WMO – OSCAR: Nowcast, VSRF, high res NWP "breakthrough/goal"
https://www.wmo-sat.info/oscar/

qualitative extension of operational networks

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Standardized processing

Lidar characterization
quasi-operational network

Summary and Discussion points

Scan strategies

single lidar

dual lidar (2d)

Multi lidar

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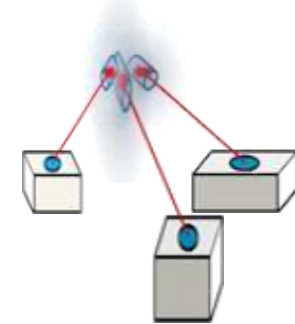
Coherent Doppler lidar at Lindenberg

since 2012

since 2021

instrument	wavelength [µm]	vertical res. [m]	unambiguous range [km]
Halo Photonics 1xStreamline XR 2xStreamline	1.5	20 – 50	12 @ 10 kHz
Leosphere Windcube 200s	1.5	25 50 100/200	3.75 @ 40 kHz 7.5 @ 20 kHz 15 @ 10 kHz

EUMETNET's

E-PROFILE activities until 2023

Rolf Rüfenacht, Alexander Haefele, Simone Bircher and the E-PROFILE team

ACTRiS — standard operating procedures/quality

PROBE COST ACTION

COST ACTION 1823 — topic in several working groups, e.g. operations & data quality, networks application renewables
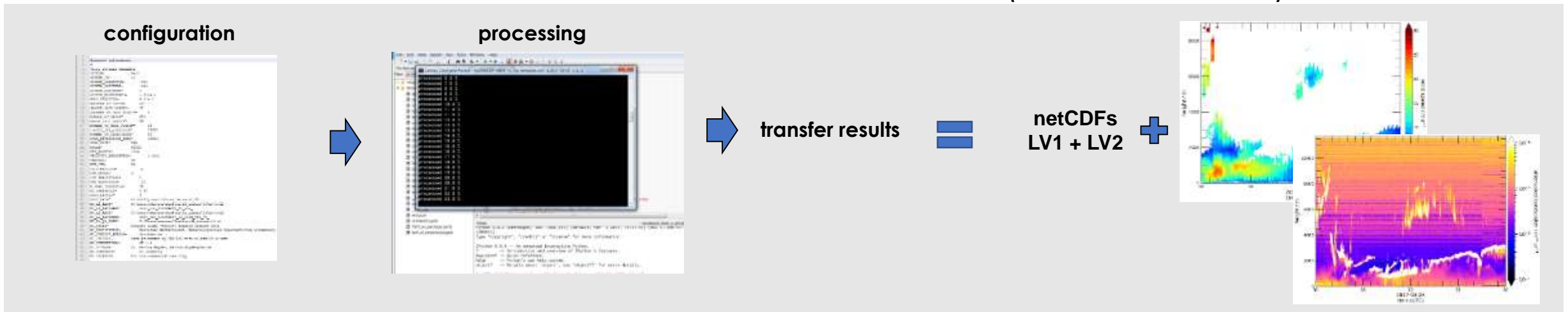
long-term

?
Best practice method
long-term performance
quality assured product
near-real time operations

cross-validation

?
system dependent quality
spot problems early
test algorithm robustness

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DWD

Standardized LV2 Product

Purpose – standard processing and archiving

- **easy to handle** tool to generate
  Raw to **LV1** and **LV2** product for Doppler lidar measurements
  → **mean wind + uncertainties**
- **quasi-operational**
- Where can I get the latest version?
  https://github.com/mkay-atm/dl_toolbox

- Works on **Unix/Linux** and **Windows**
- optimized for **VAD-retrieval**, compatible with **continuous scan mode (CSM)**
  → **near real-time** processing (tested @DWD)
  → **daily processing**
  → **other scan mode** can be included (future)
  → **vertical wind statistics** and others (in prep.)
- Functions as a regular Python package
- **free to use** (non-commercial)

configuration   processing   transfer results   netCDFs LV1 + LV2

Funded by the European Union

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DL Toolbox Improvements & User guide
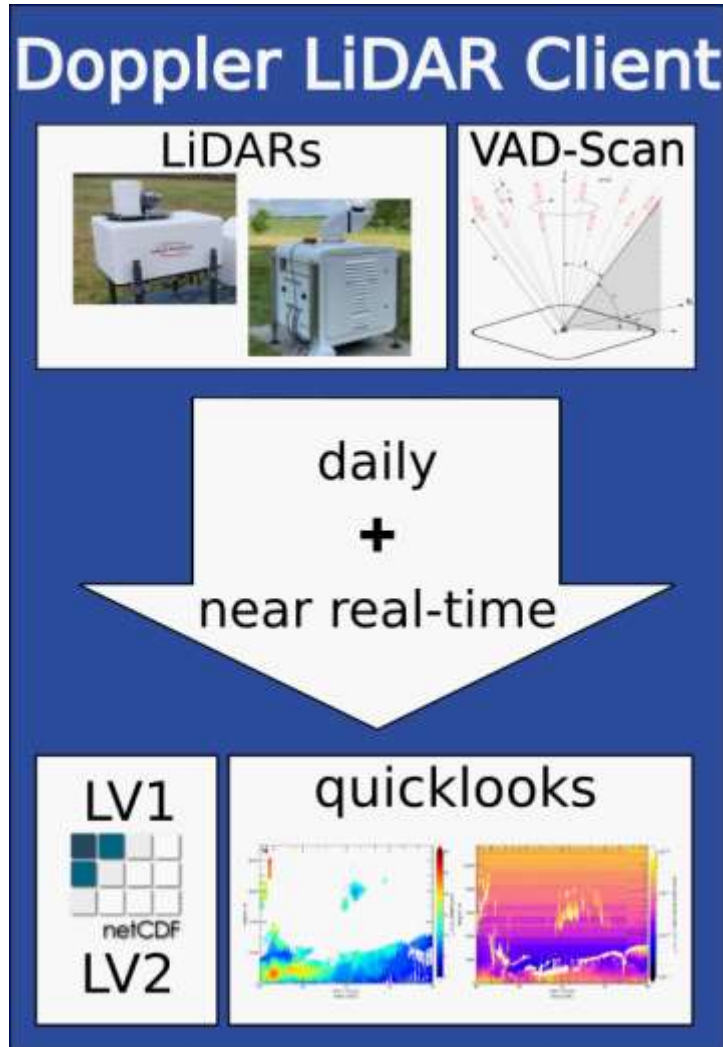
With the help of PROBE VMGs

1. **DWD & Meteoswiss**
    → enable use of Streamline & Windcube, User Guide
2. **DWD, Dhara Consulting Services (Jana Preissler)**
    & Meteoswiss
    with data contributions from E-PROFILE & PROBE
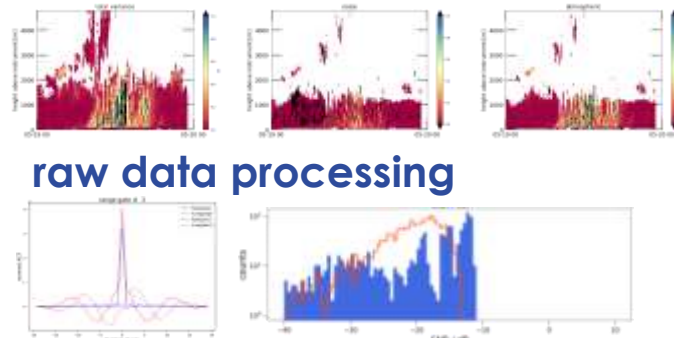   **→ assure full compatibility with Streamline & Windcube**
    + minor improvements to the plotting

The Client is now capable of handling old and new Windcube data formats and is made easily accessible via a user guide. --

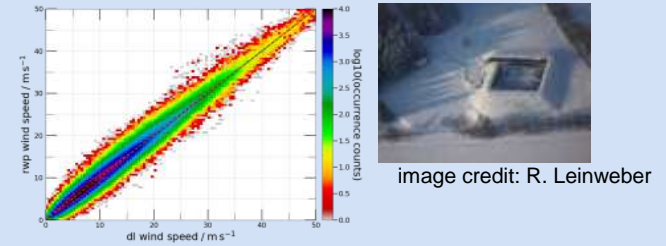Table 1: List of usable systems and available products[a]

System	Scan Type	LV1	LV2	Quicklooks
Halo Streamline	VAD/UserX	yes	yes	LV1/LV2
Halo Streamline	DBS/UserX	yes	yes	LV1/LV2
Halo Streamline	Stare	yes	no	LV1
Halo Streamline	RHI	yes	no	no
Vaisala Windcube	fixed VAD & VAD /w TP	yes	yes	LV1/LV2
Vaisala Windcube	DBS /w TP	yes	yes	LV1/LV2
Vaisala Windcube	fixed & Stare /w TP	yes	no	LV1
Vaisala Windcube	RHI /w TP	yes	no	no
Vaisala Windcube	PPI /w TP	yes	no	no

[a] that users can process with DWL toolbox

Doppler LiDAR Client

LiDARs   VAD-Scan

daily + near real-time

LV1   quicklooks
netCDF
LV2

Products
- **Mean wind** from **VAD, DBS**

- Future updates
  vertical wind statistics

  raw data processing

https://github.com/mkay-atm/dl_toolbox

Long-term assessment

image credit: R. Leinweber

almost 10 years

Cross-validation
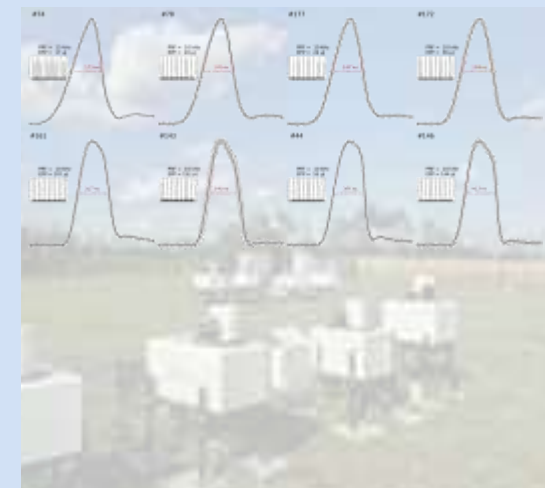
image credit: F. Beyrich

8 systems side-by-side
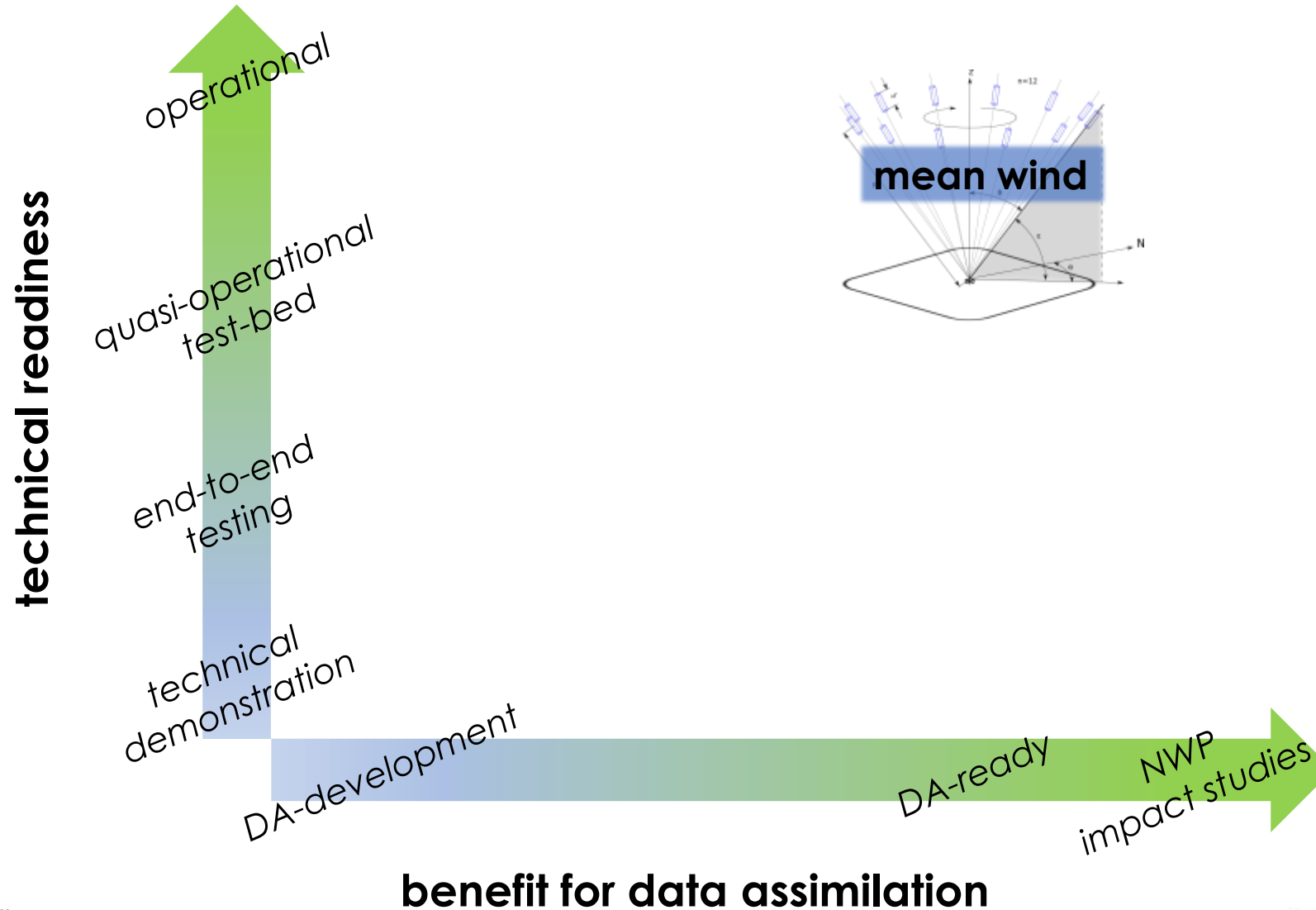
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benefit for data assimilation

Standardized processing

Lidar characterization
quasi-operational network
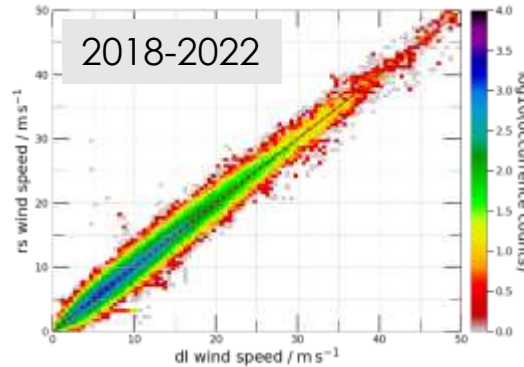additional LV2

Summary and Discussion points

VAD – long-term assessment

The radiosonde (4/day) and the radar wind profiler are used as operational references
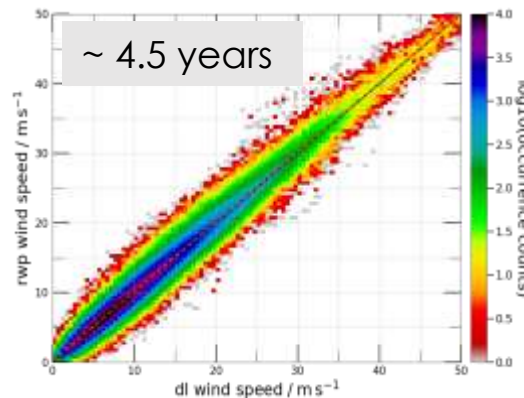
radiosonde

DL vs. radiosonde profiles

2018-2022

		speed / ms^{-1}	direction / °
ABL	max(MEAN)	0.55	0.77
	max(RMSE)	0.11	0.43
Free Troposphere	max(MEAN)	0.72	3.72
	max(RMSE)	0.20	1.00

radar wind profiler

DL vs. radar wind profiler

~ 4.5 years

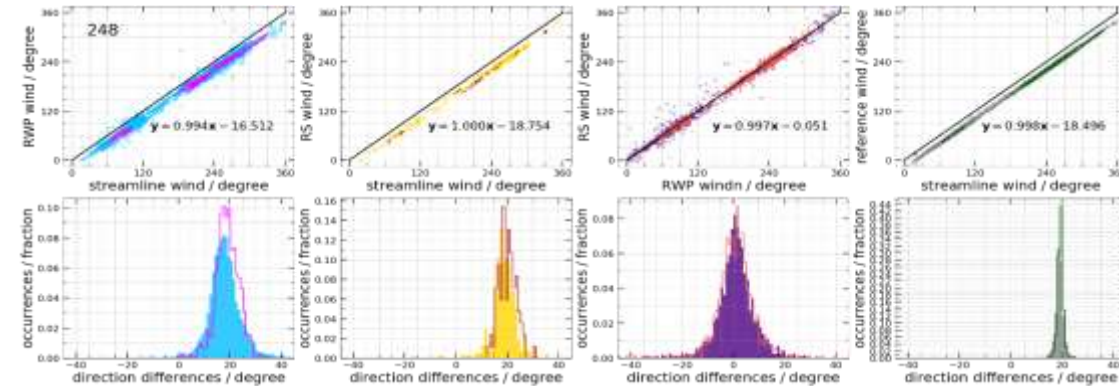|		speed / ms^{-1}	direction / °
ABL	max(MEAN)	- 0.18	- 2.9
	max(RMSE)	1.12	12
Free Troposphere	max(MEAN)	- 0.56	- 1.4
	max(RMSE)	1.66	10

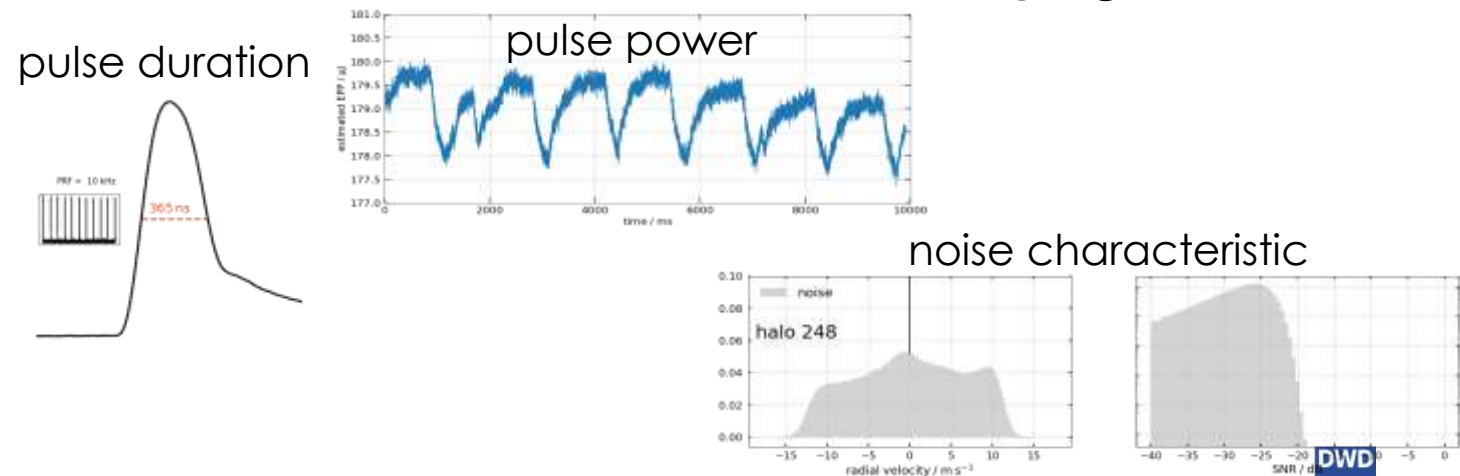→ very good agreement with references
High correlation, small BIAS and RSMEs

Four ICOS stations will be equipped with Doppler lidars

- **Comparing with references**

- **Monitor lidar characteristics + housekeeping**

pulse duration

pulse power

noise characteristic

Basis for SOPs for future networks

Operational monitoring
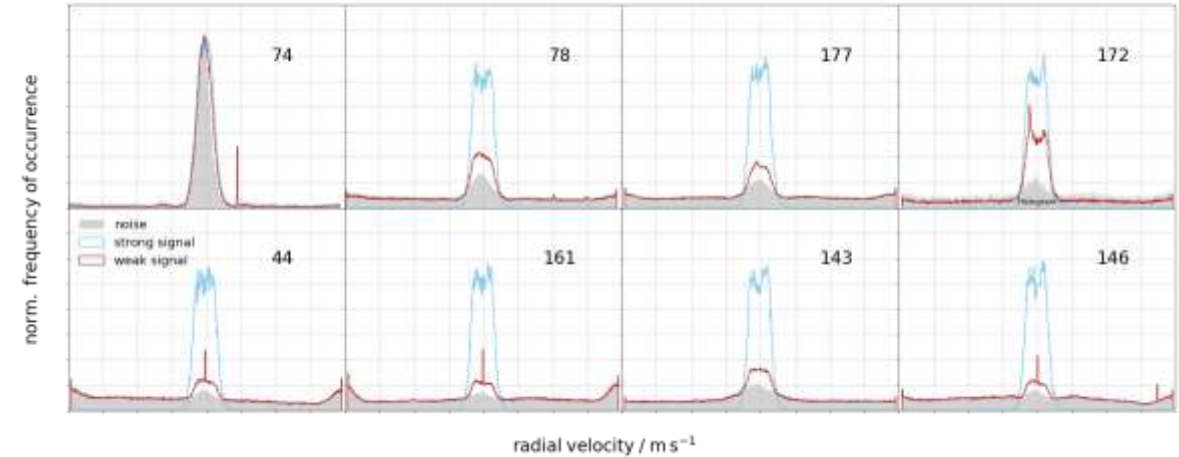
Examples

elevation test

environmental aspects
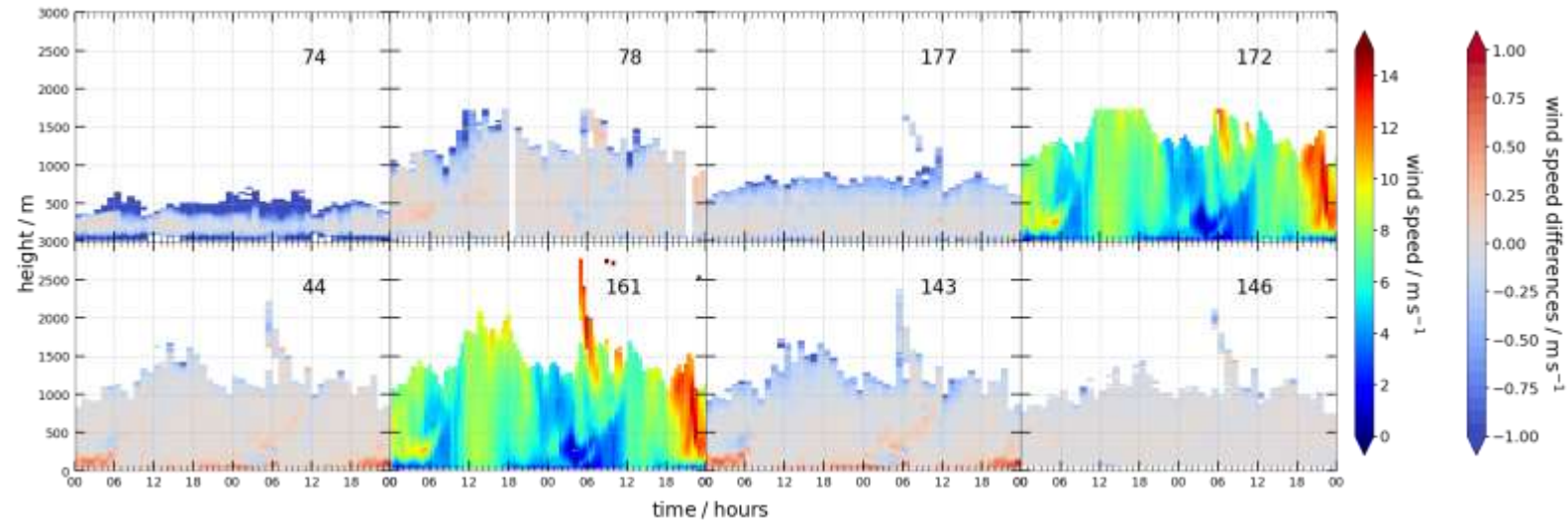

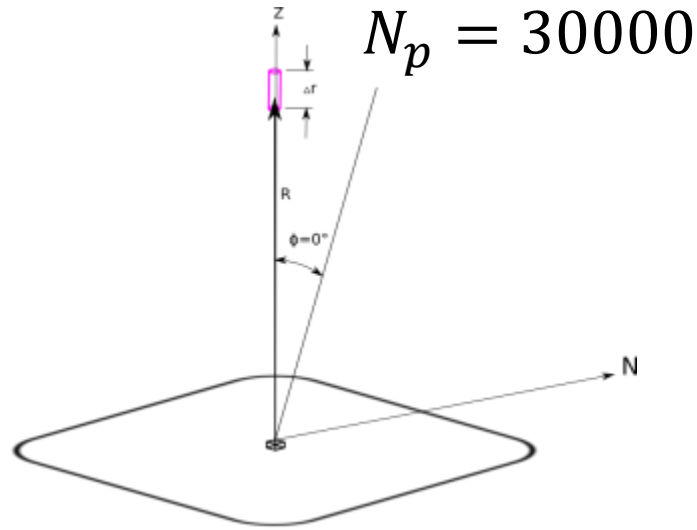**Necessary for network use**

How comparable are DLs?

7/27/2021 – 7/28/2021 – slow CSM mode

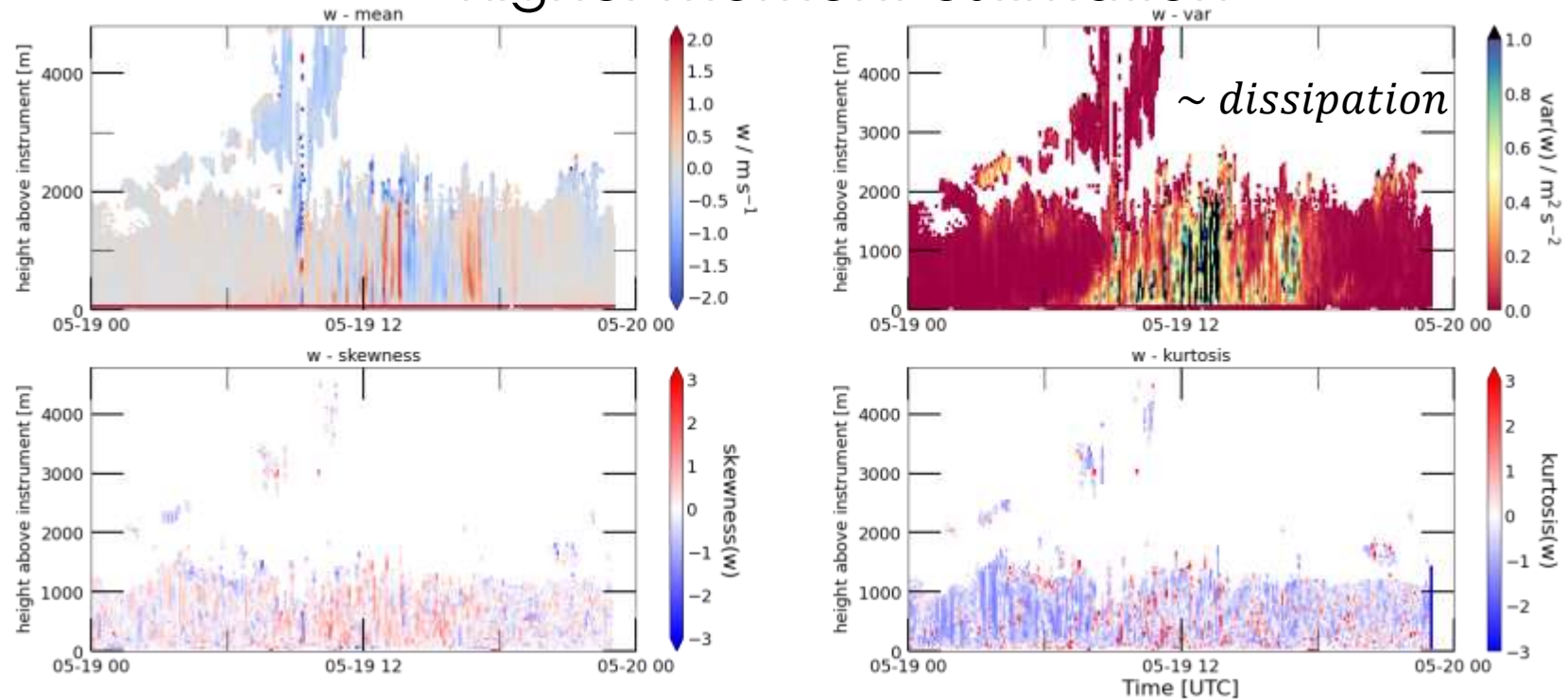The FESSTVaL experiment offered the unique opportunity to compare eight Halo photonics systems side-by-side

$N_p = 30000$

higher moment estimation

$\sim dissipation$

adapted from Päschke et al. [2015]

- important for **convective boundary layer** and **stability** (Du et al. 1994)
- w-statistics requires **frequent stare measurements**
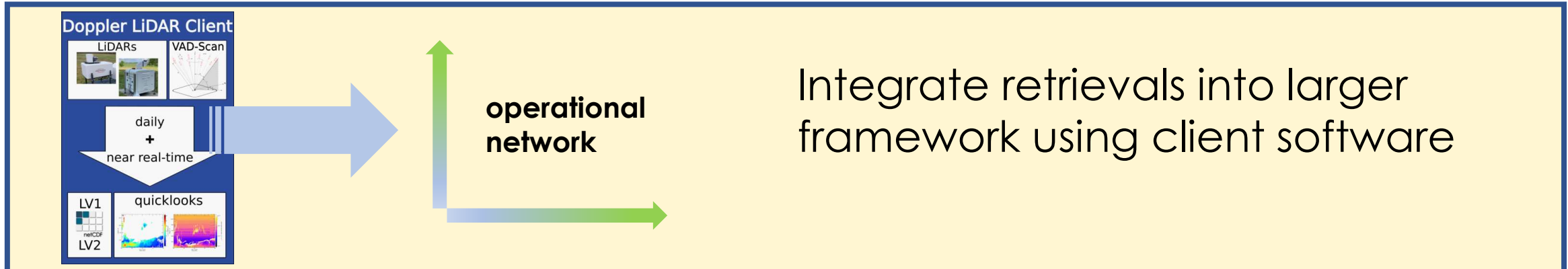- system noise can significantly reduce performance

Standardized processing

Lidar characterization
quasi-operational network
additional LV2

Summary and Discussion points

Summary and Future plans

Integrate retrievals into larger framework using client software

Develop products utilizing the backscatter signal

Discussion points

Discussion points

Standardized LV1 format → look radar wind profiler

User-friendly DL-client → issue reporting!

Added value products → system characterization