Measurement campaign DD4ZRH

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Project Management

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

4D wind information for the aviation – DD4ZRH

Results from the field campaign 2023 around Zurich Airport

Team Wetterradar Dienstleistungen für die Armee: Samuel Monhart, Martin Lainer, Rebecca Gugerli, Daniel Wolfensberger, Zaira Schauwecker and support from many others at MeteoSwiss

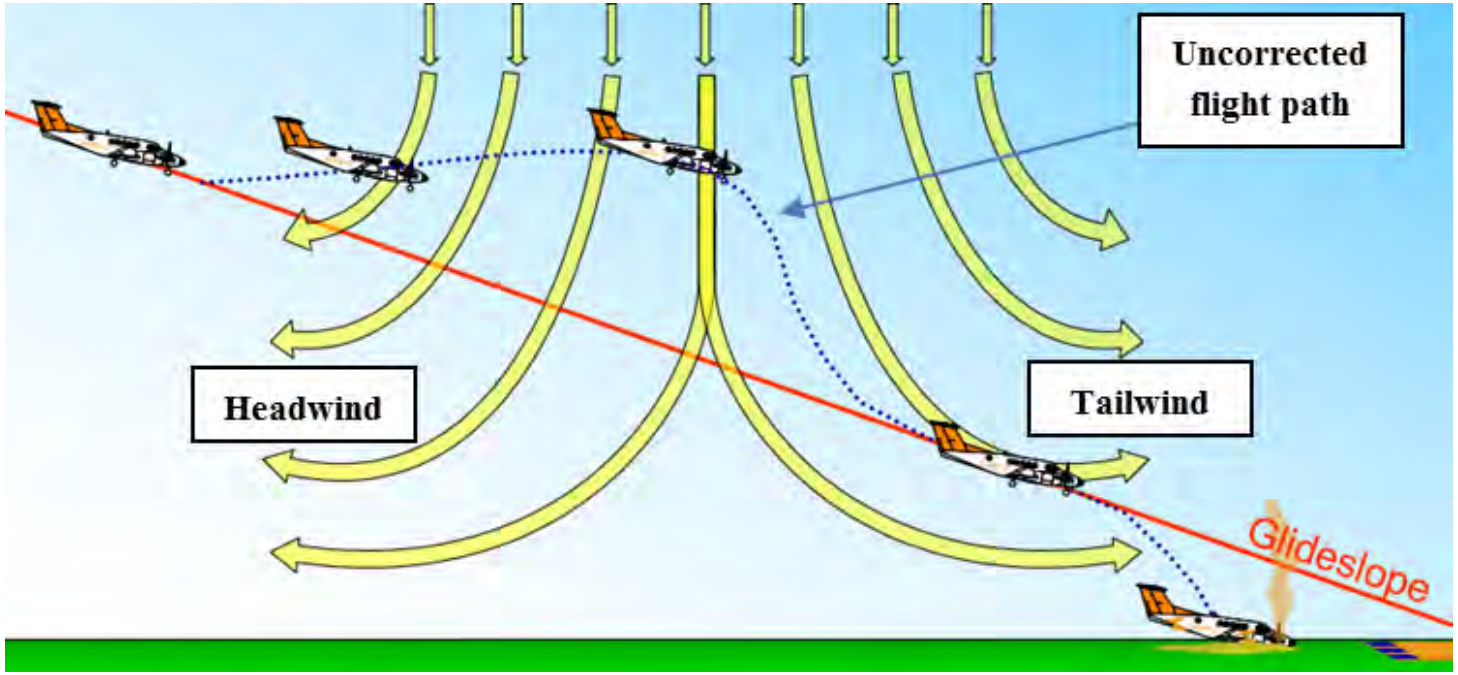
Why is wind important for the aviation?

How can we measure wind -- A look behind the scenes

Field campaign around the Zurich airport (DD4ZRH)

Why is wind information important?

- Phenomena
  - Head and tail winds
  - Cross winds
  - Wind shear

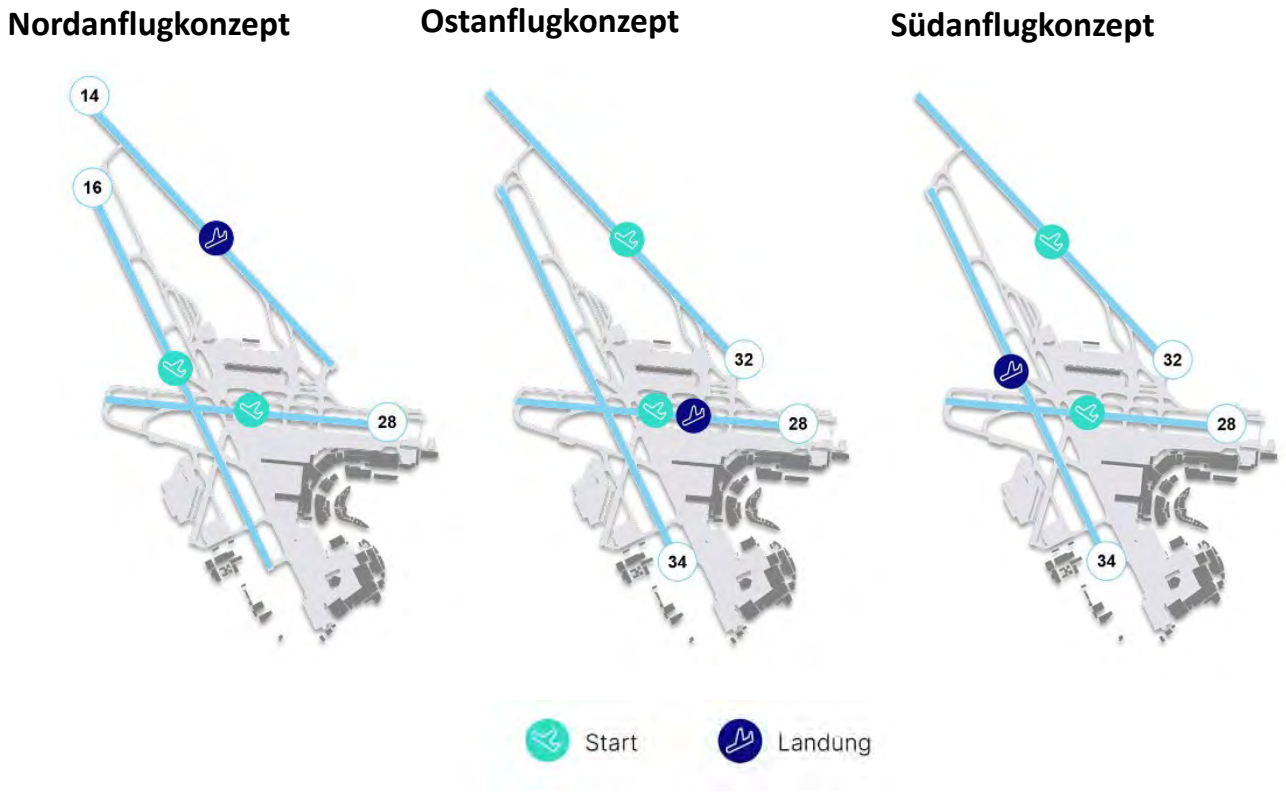


Source: https://community.wmo.int/en/activity-areas/aviation/hazards/turbulence

Why is wind information important?

- Phenomena
  - Head and tail winds
  - Cross winds
  - Wind shear
- Airport management
  - Flight concepts
  - Safety
  - Load optimization

➔Wind (shear) above approaches



Source: https://www.flughafen-zuerich.ch/de/unternehmen/medien-politik-und-investoren/politik-und-wirtschaft/betriebskonzepte

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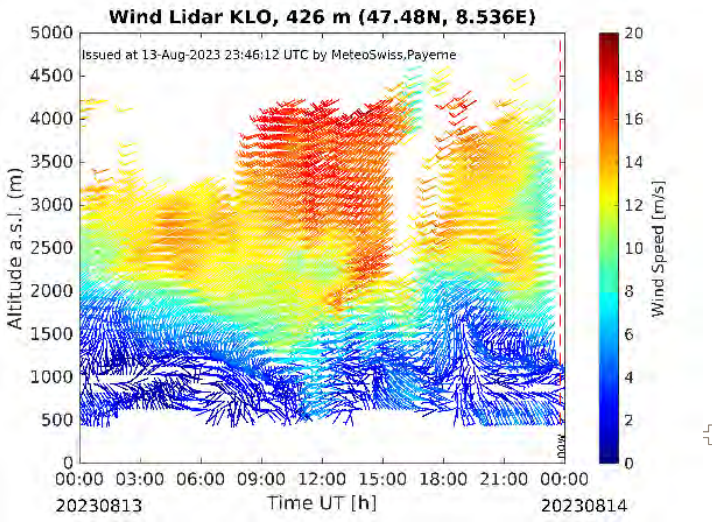
How can we measure wind?

Surface stations

e.g. SwissMetNet Stations
Local point measurements
- Ultrasonic Anemometer
- Cup Anemometer with wind direction vane

Remote sensing



e.g. EMER-Met stations & Weather Radar Network
Profile measurements
- Wind Lidar
- Radar Wind Profiler
- Weather Radar

3 Dimensional wind field (Dual Doppler)
- Weather Radar
- Lidar

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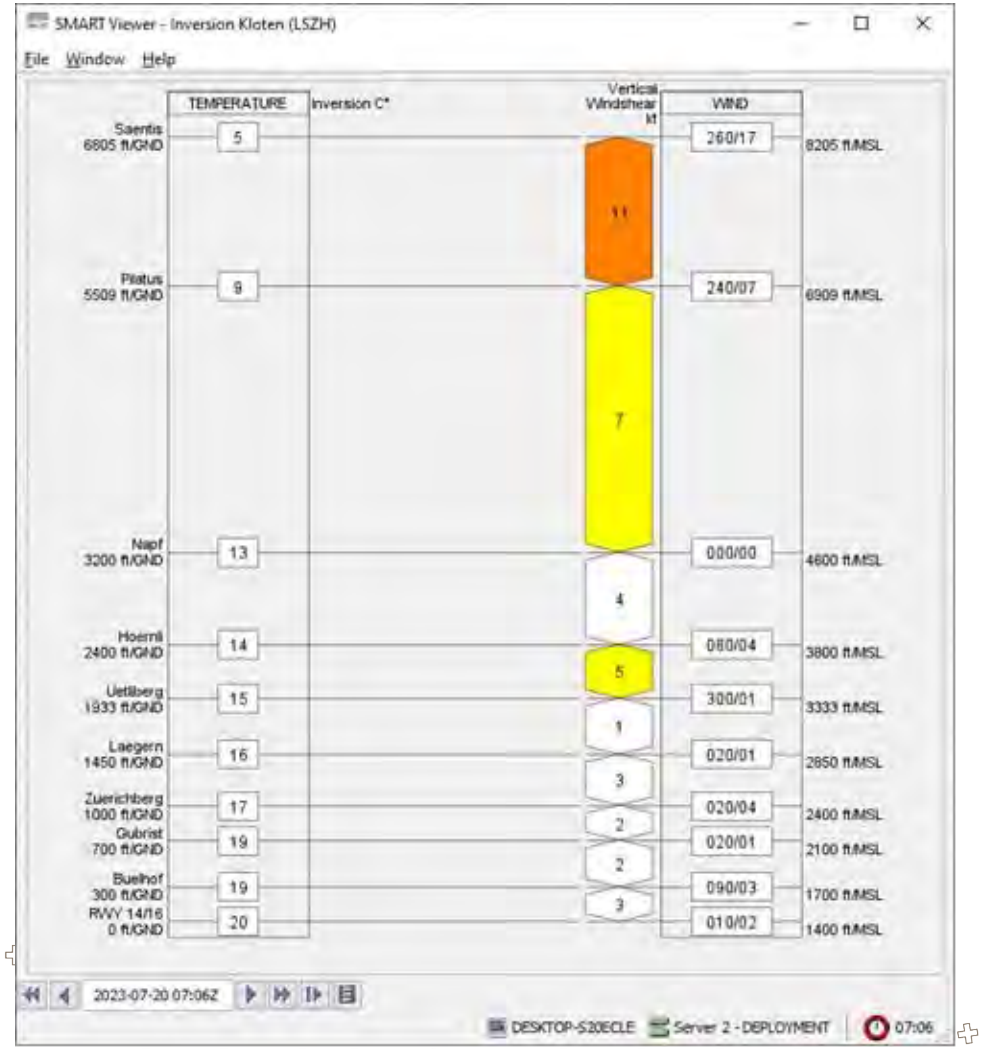
Surface station: SMART wind shear

Wind shear based on surface station Network

Challenges:

Layer thickness, Distance to Airport, Terrain influence



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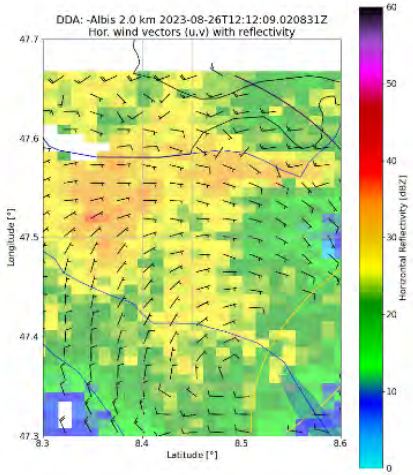
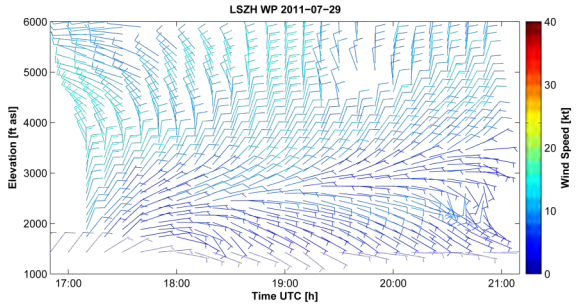
Remote sensing of wind

Weather Radar (Radio detection and ranging system)

Frequency: 2-10GHz (λ = 3-10cm)
Sensitiv to: Precipitation (and non-meteorological scatterers)
Methods: Dual Doppler Analysis (DDA) & Velocity Azimuth Display (VAD)
Results: 3-dimensional wind field (RHI/PPI) & vertical profiles
Data gaps: In dry atmosphere (no precipiation)



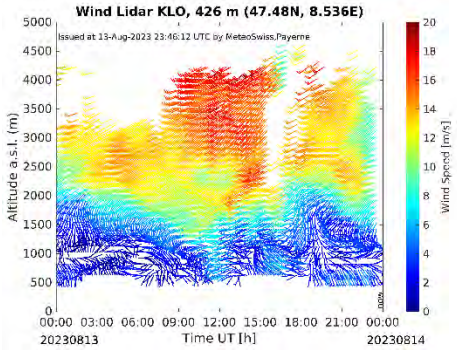


Radar wind profiler

Frequency: 50MHz-1GHz (λ = 20-600cm)
Sensitiv to: Fluctuations of refractive index (turbulences)
Methods: Velocity Azimuth Display (VAD) / Doppler Beam Swinging (DBS)
Results: Vertical profiles
Data gaps: In a dry and calm atmosphere

Doppler wind Lidar (Light detection and ranging system)

Frequency: Infrered Laser (λ = 1.54µm)
Sensitiv to: Aerosols
Methods: Velocity Azimuth Display (VAD) / Doppler Beam Swinging (DBS)
Results: 3-dimensional wind field (RHI/PPI) & vertical profiles
Data gaps: In aerosol-free layers, inside and above clouds (attenuation)



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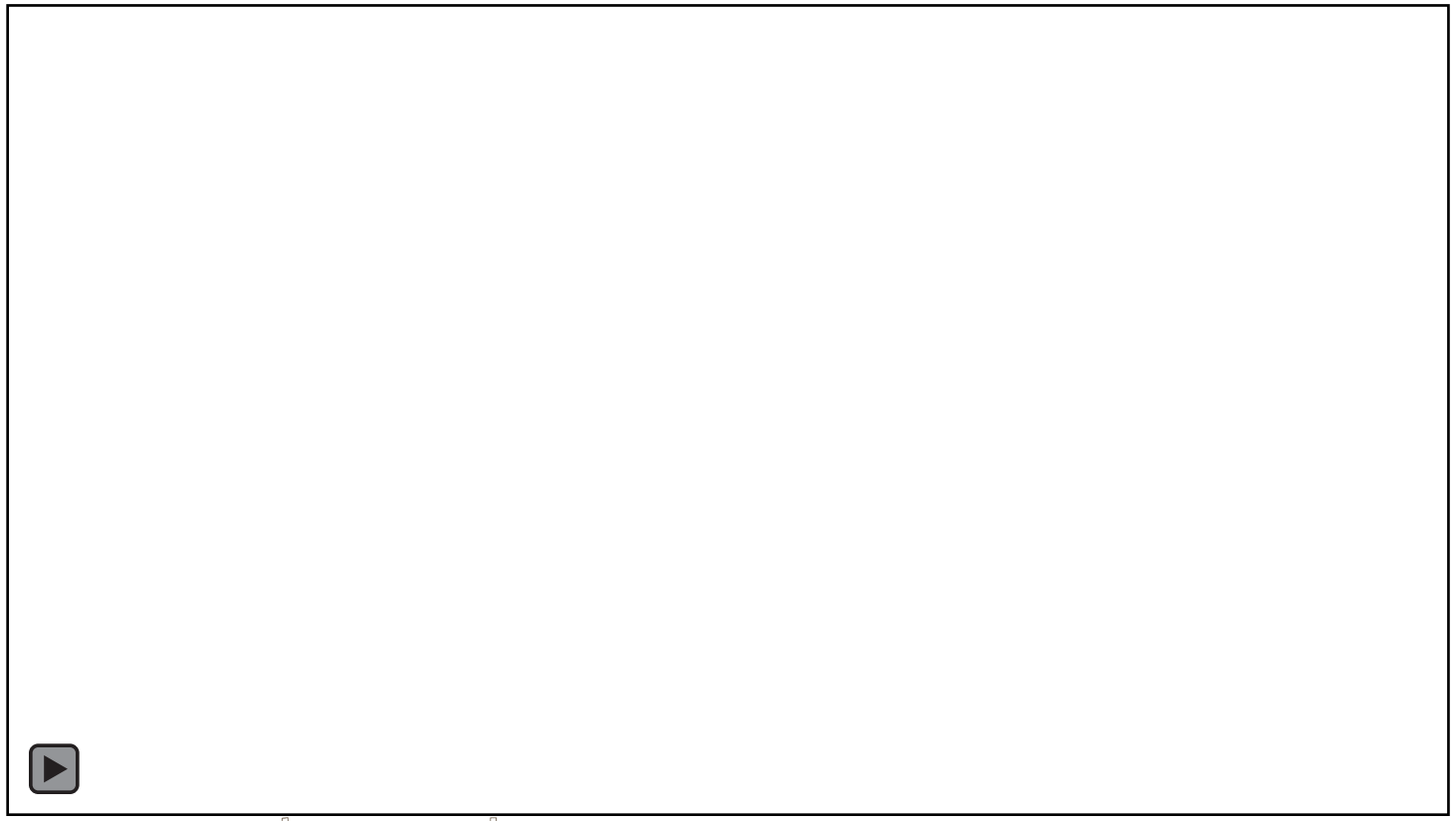
Remote sensing of wind

RAdio **D**etection **A**nd **R**anging system



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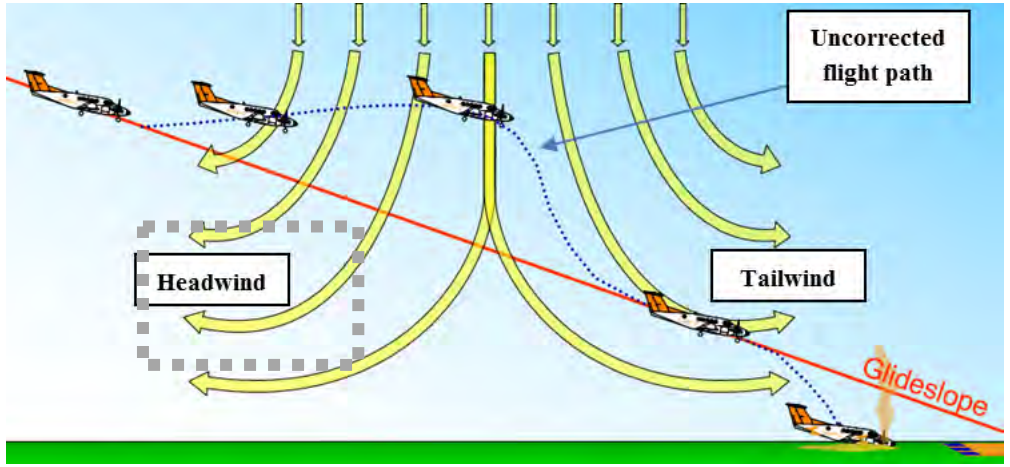
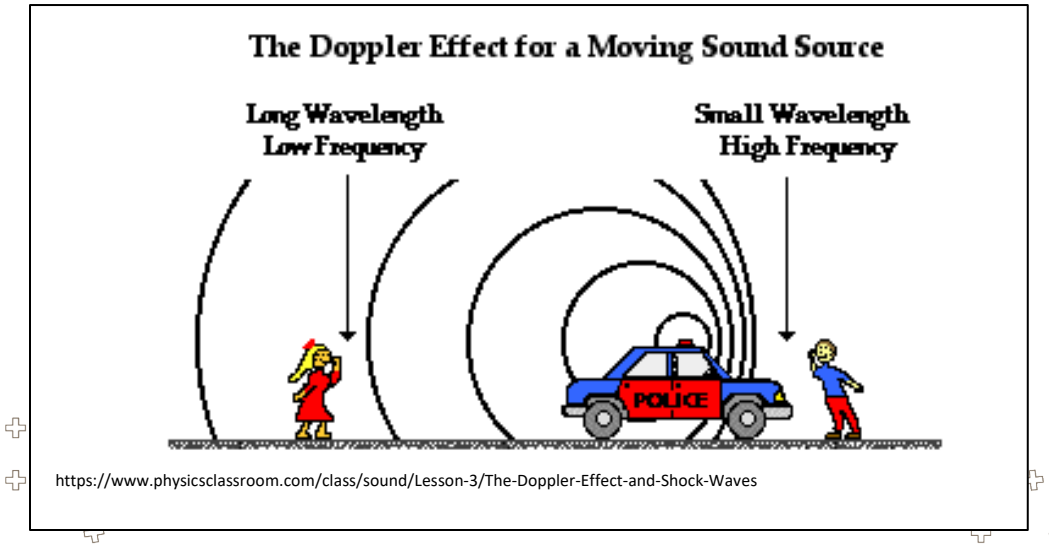
Remote sensing principles: Doppler effect



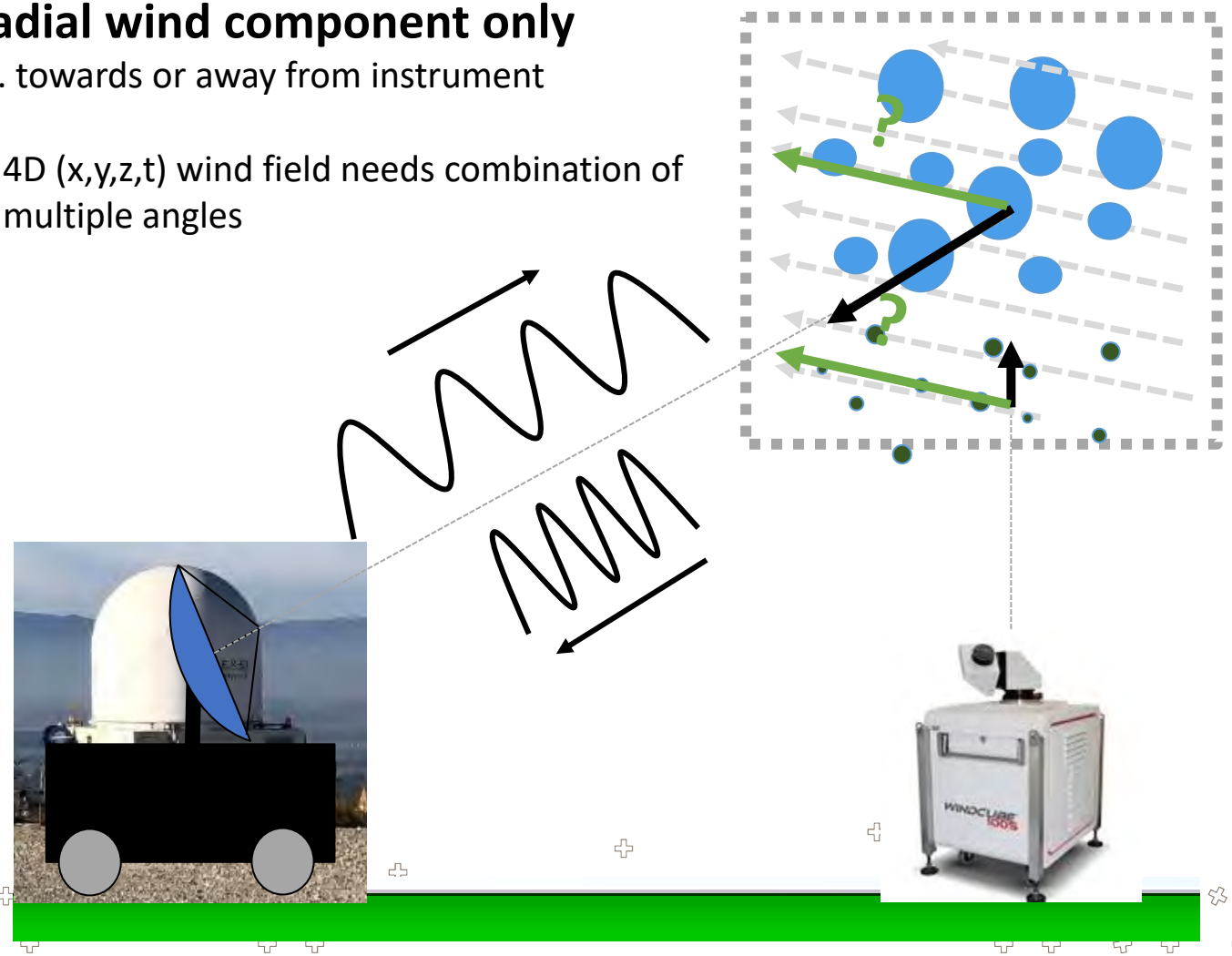
Radial wind component only

i.e. towards or away from instrument

➔ 4D (x,y,z,t) wind field needs combination of multiple angles



https://www.physicsclassroom.com/class/sound/Lesson-3/The-Doppler-Effect-and-Shock-Waves

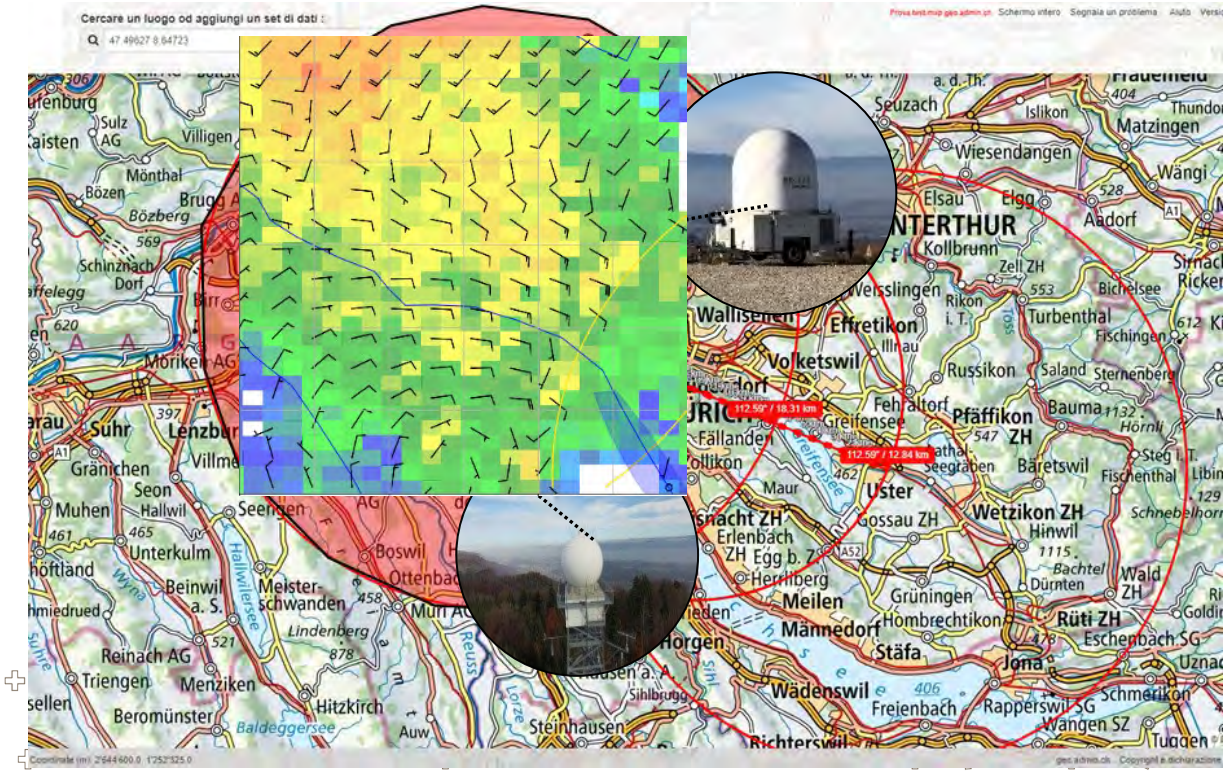


From radial to horizontal winds

3 dimensional wind field:

Methods: - Dual Doppler Analysis (DDA)

Instruments: Weather Radar and Wind Lidar



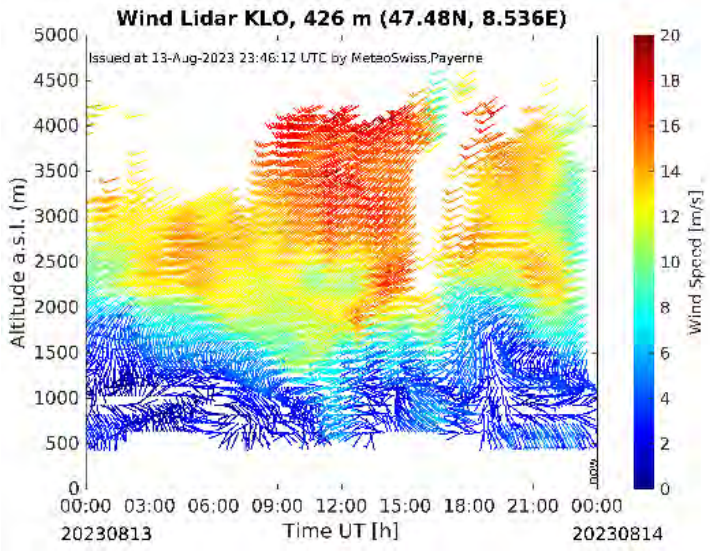
Wind profile:

Methods : - Doppler Beam Swinging (DBS)

- Velocity Azimuth Display (VAD)

Instruments: Wind Lidar, Radar Wind Profiler, Weather radars

Wind Lidar



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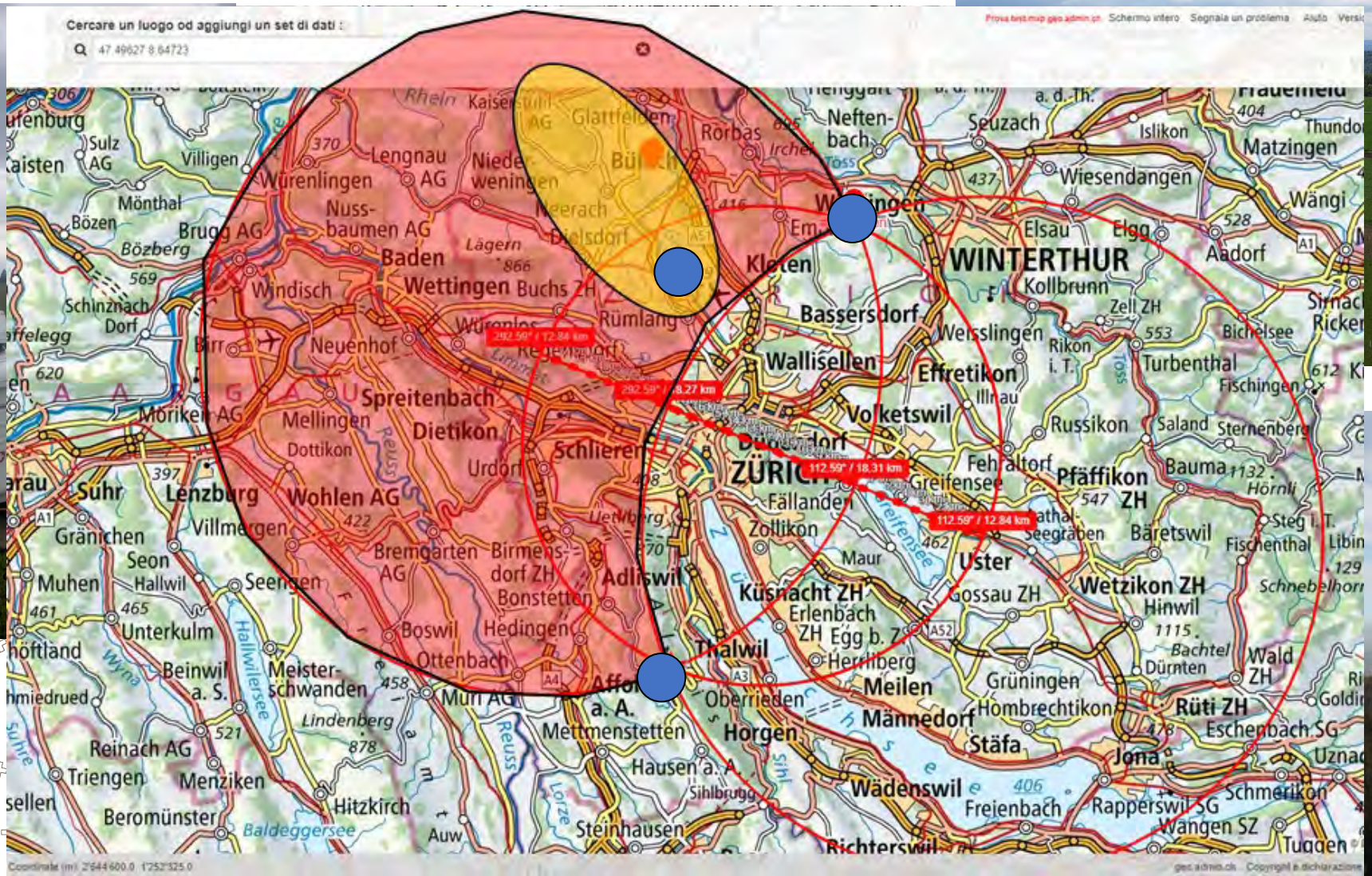
Dual Doppler for Zurich (DD4ZRH)

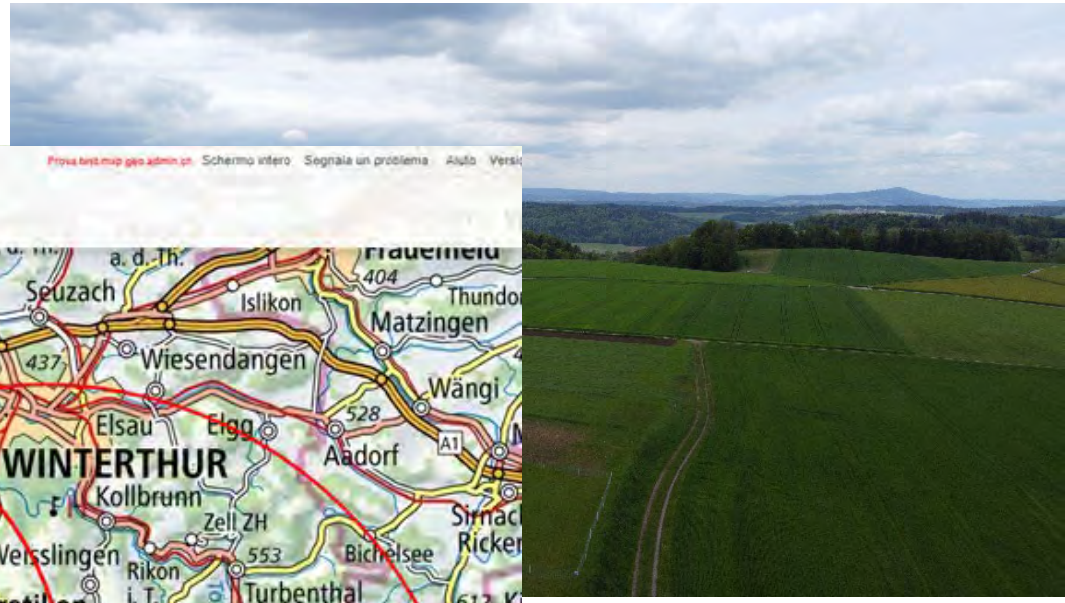
June – October 2023

Wind Lidar (WindCube)

Dual Doppler for Zurich (DD4ZRH)

June – October 2023





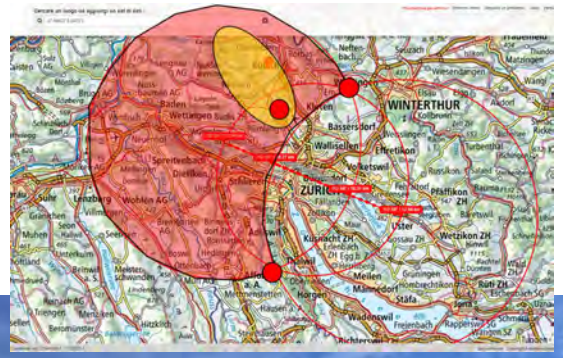
Dual Doppler for Zurich (DD4ZRH)

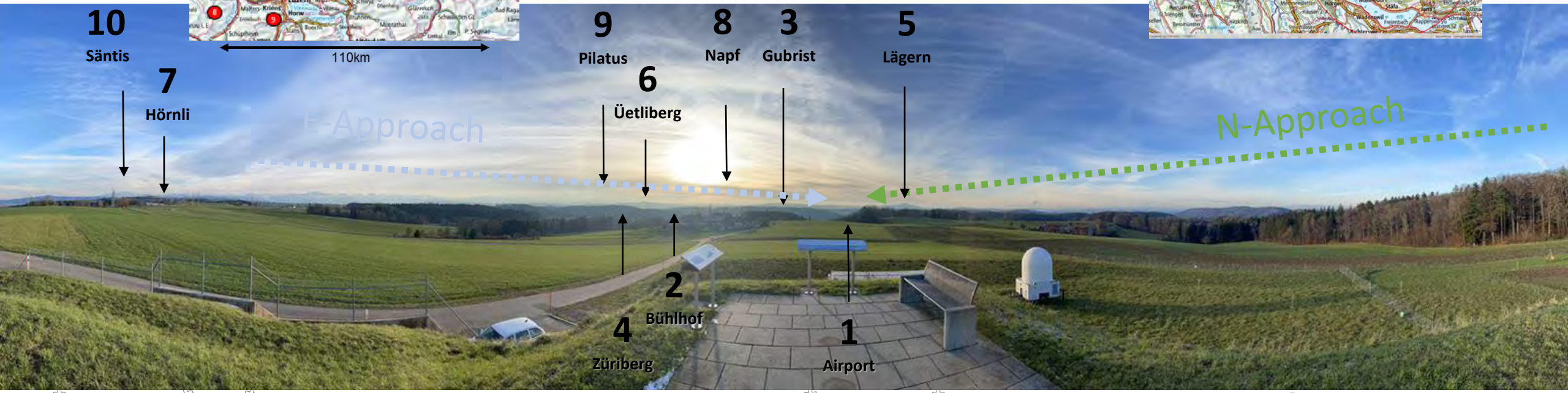
E

S

W

N





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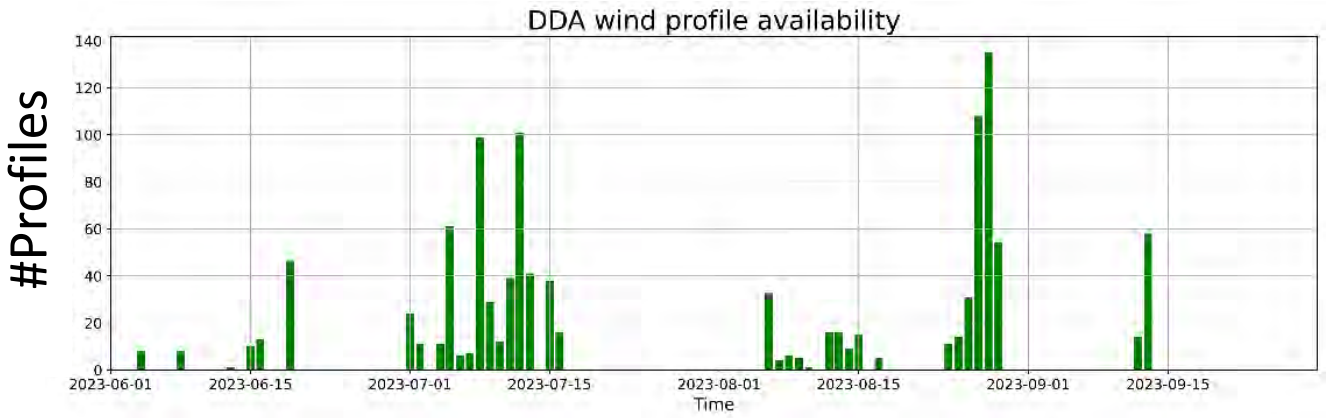
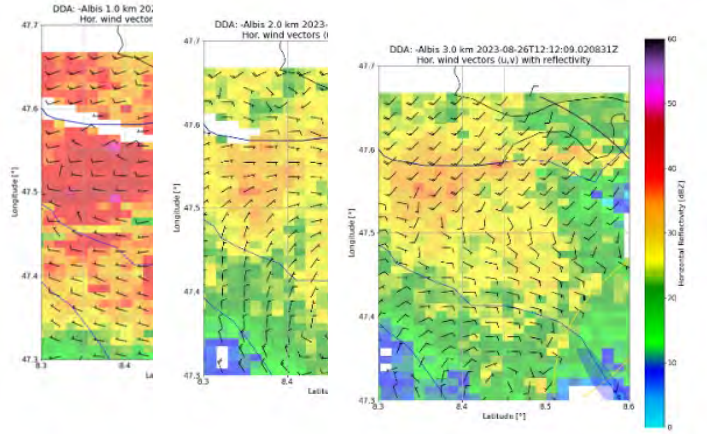
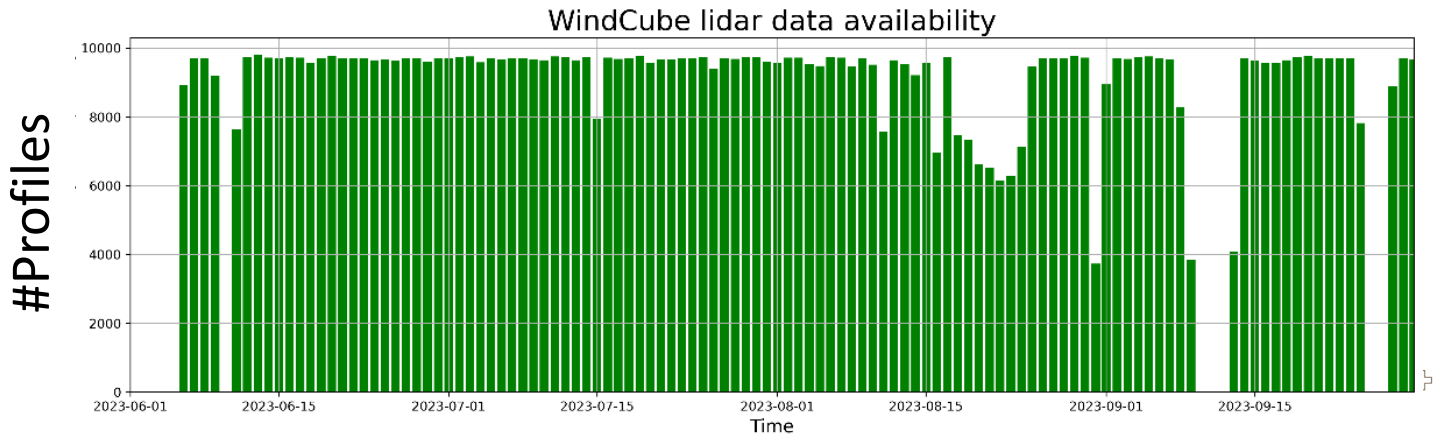
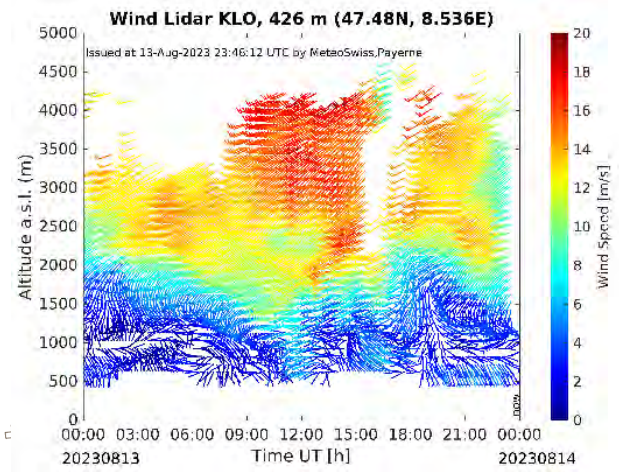
Data availability





June July August September





MeteoSwiss

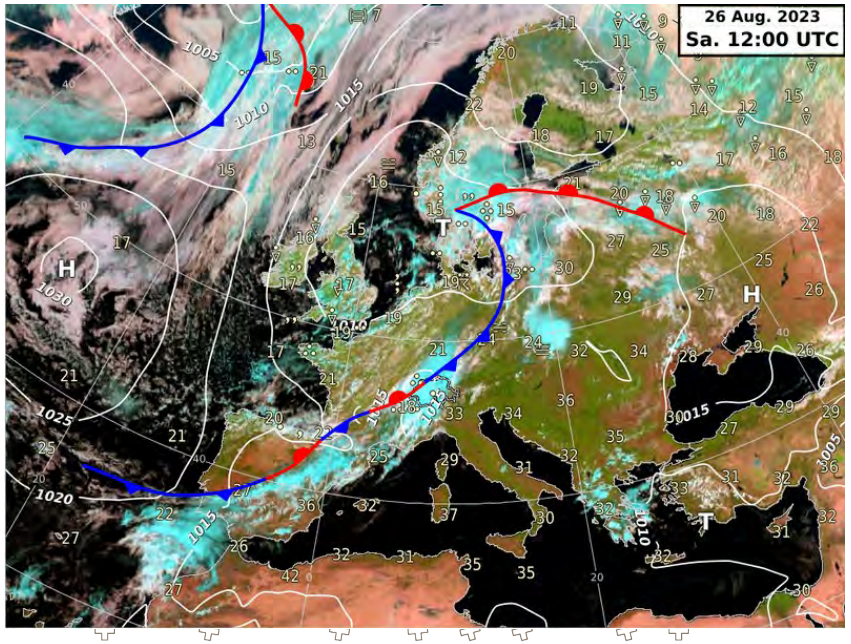
Example: 26th August 2023

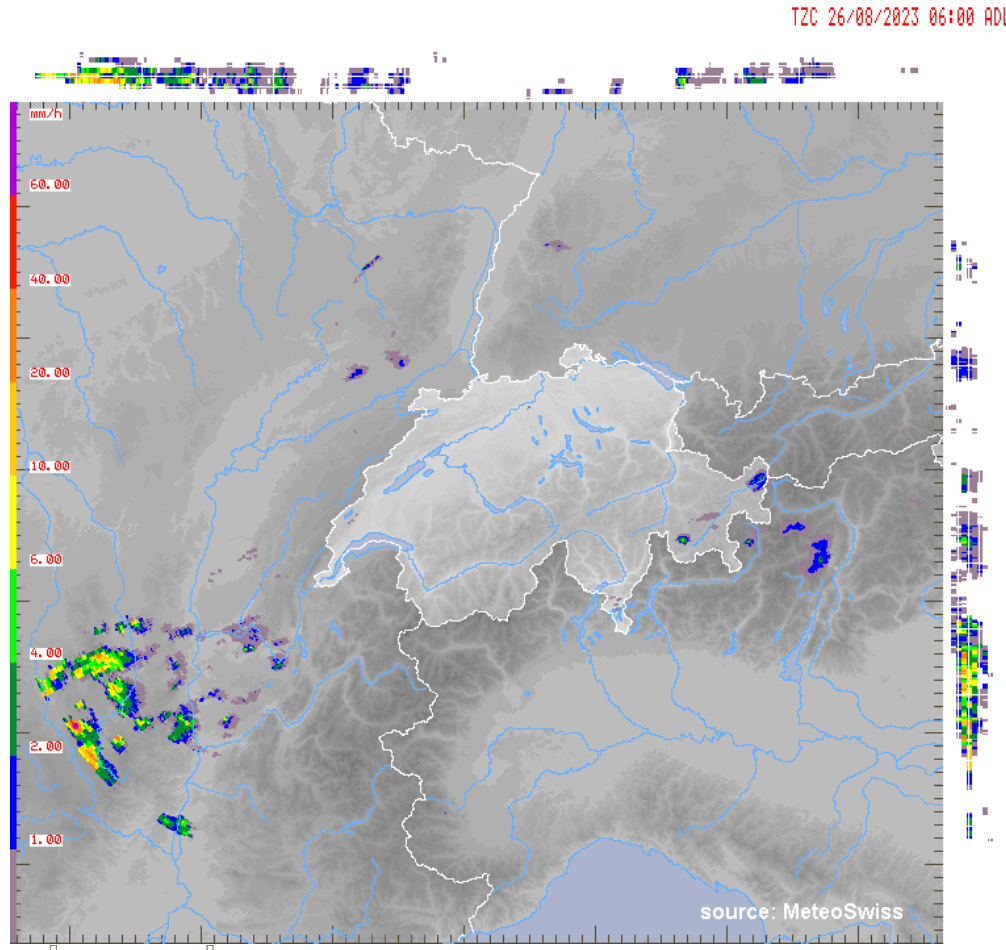
Wetterlage
Samstag, 26. August 2023

Trog über Westeuropa, Bodentief von den Britischen Inseln langsam Richtung Südskandinavien verlagernd. Luftmassengrenze eingelagert in Südwestströmung erreicht aus Nordwesten die Schweiz, dahinter fliesst allmählich kühlere Luft zur Alpennordseite.

Bemerkungen

Um Mitternacht Gewitterlinie vom Tessin und Bündnerland gegen Osten abziehend. Dahinter vorübergehend trocken. In den Alpen am Vormittag noch recht sonnig, 2 bis 5 Sonnenstunden, im Norden wie auch im Süden oft bewölkt, im Norden 0-1 Stunde Sonnenschein, im Süden 1-3 Stunden. Temperatur am Morgen am Genfersee und im Süden bei 10 bis 22 Grad, sonst in den Niederungen um 18 Grad. Am Vormittag aus Westen aufkommender Niederschlag, zunächst in Form von teils eingelagerten Gewittern (bewarnt mit EMBD TS SIGMET, Blitzwarnung für LSZH), damit einhergehender Druckanstieg (bewarnt mit Starkwindwarnungen für Seen und Flugplätze), Mittelland Böen um 15 bis 20 kt, Voralpentäler um 28 kt. Im Süden am Nachmittag teils



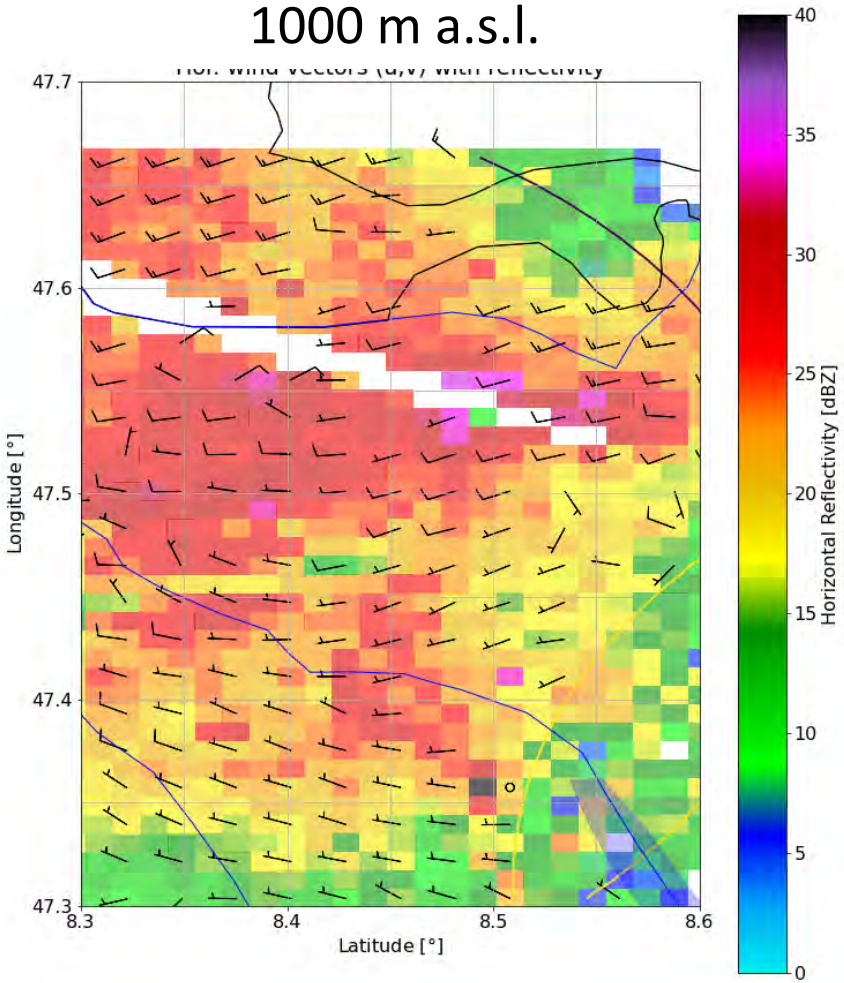


MeteoSwiss

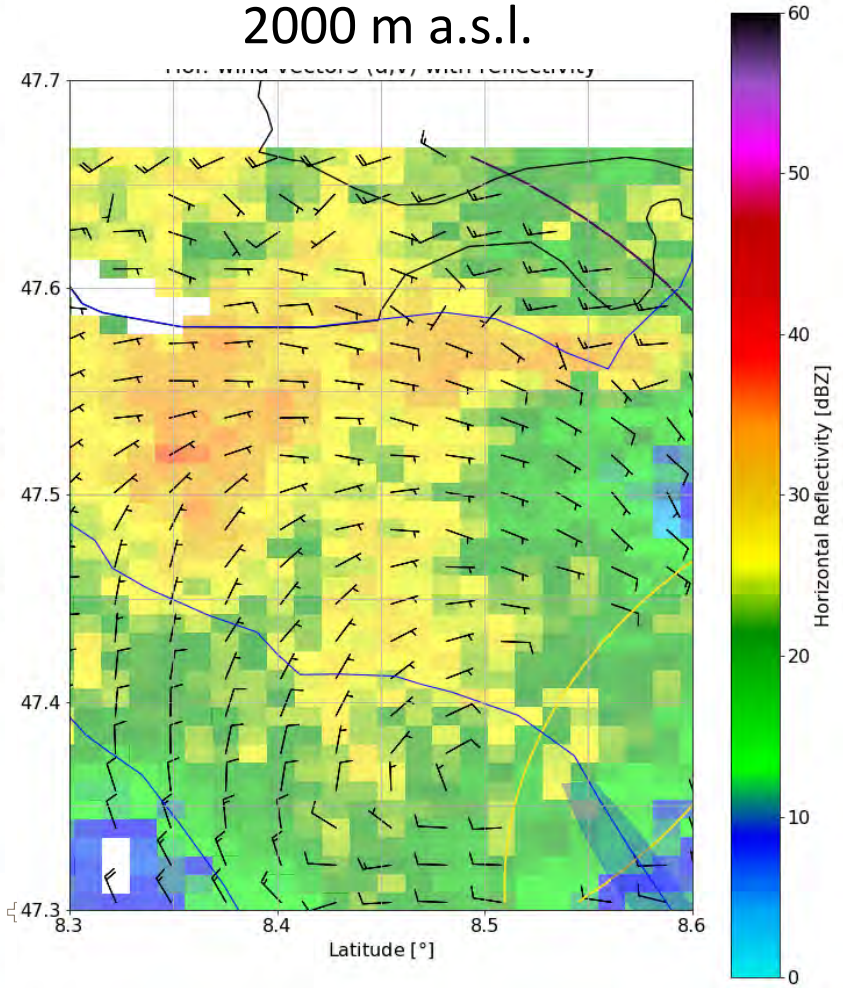
Example: 26th August 2023

Wind direction and speed (wind barbs) and reflectivity (colour)

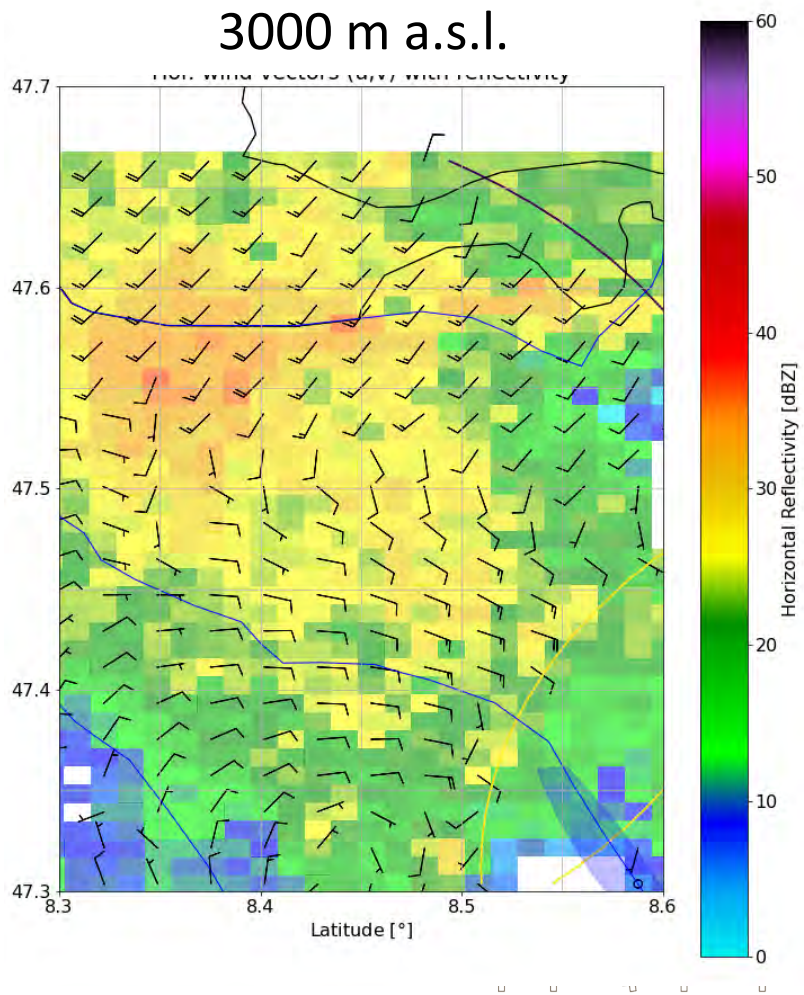
1000 m a.s.l.



2000 m a.s.l.



3000 m a.s.l.



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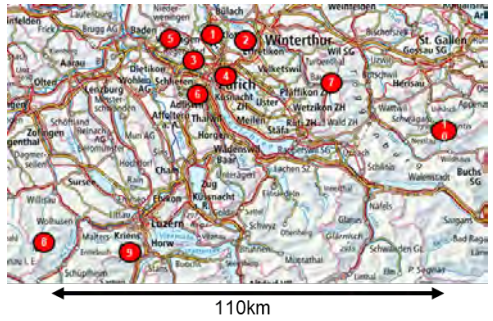
Example: 26th August 2023

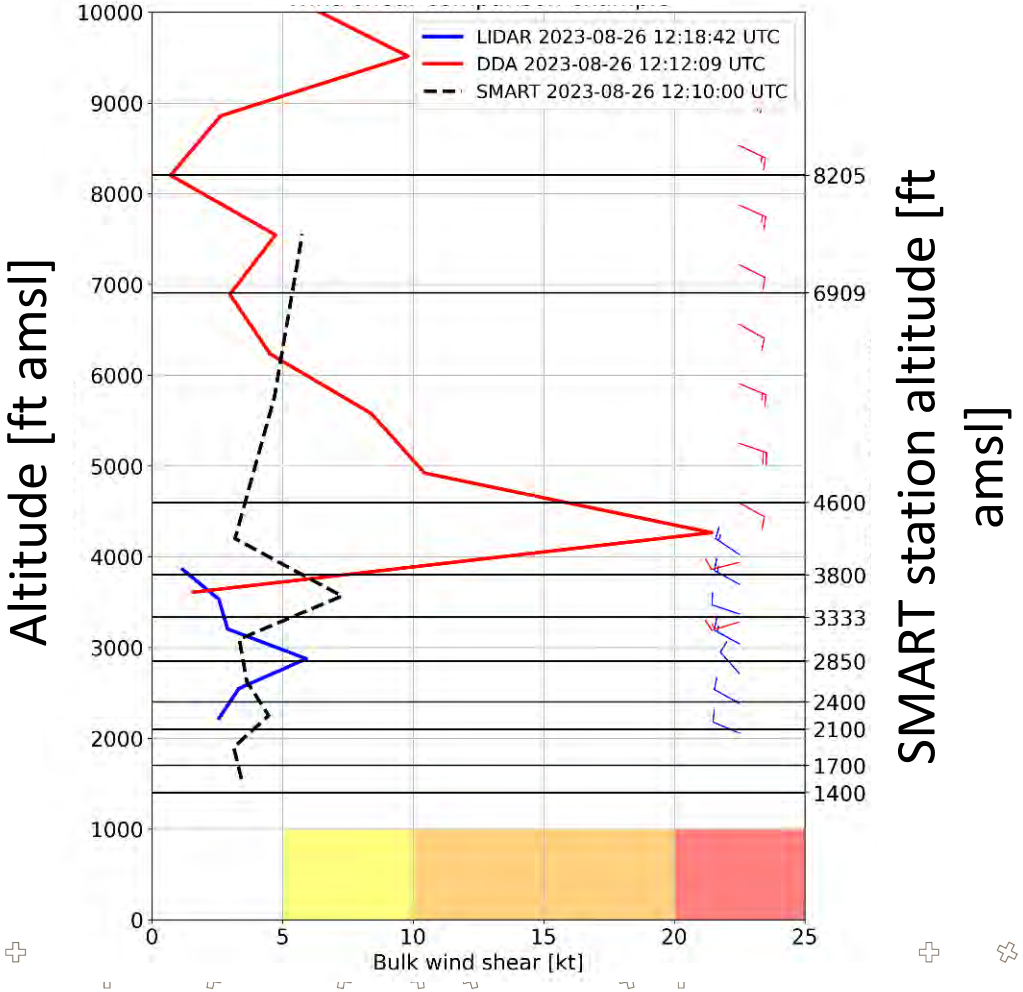


SMART

Lidar

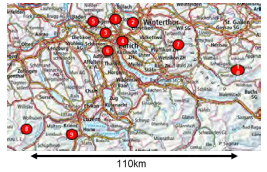
Radar (DDA)

Wind shear

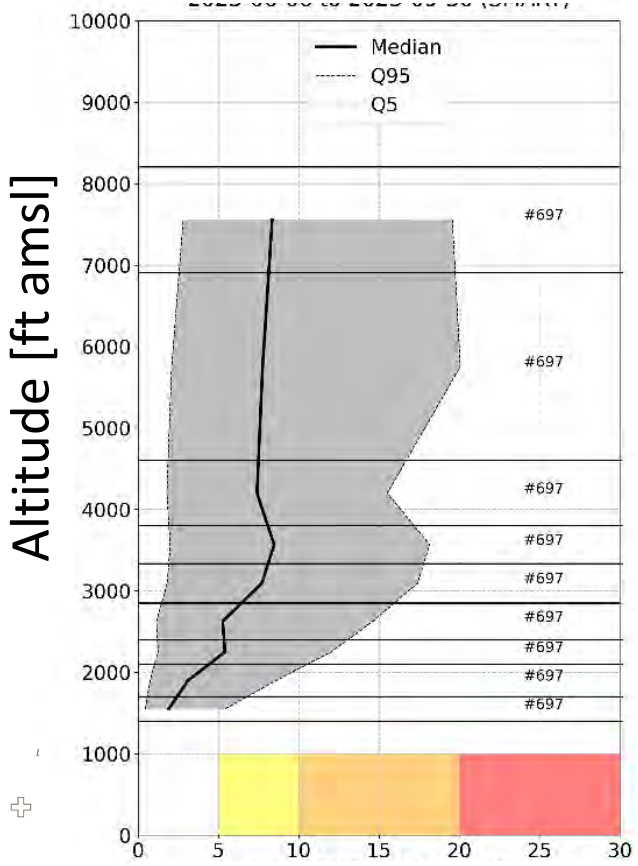


MeteoSwiss

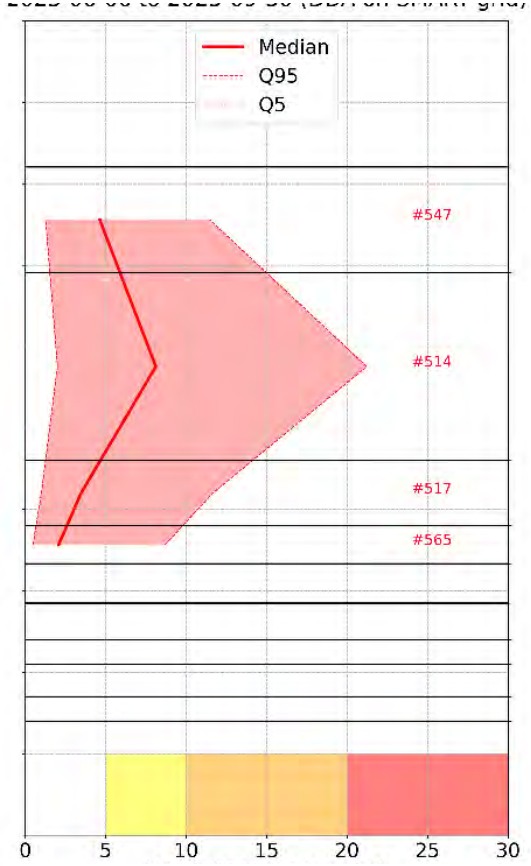
Wind shear during **wet** conditions : June - September



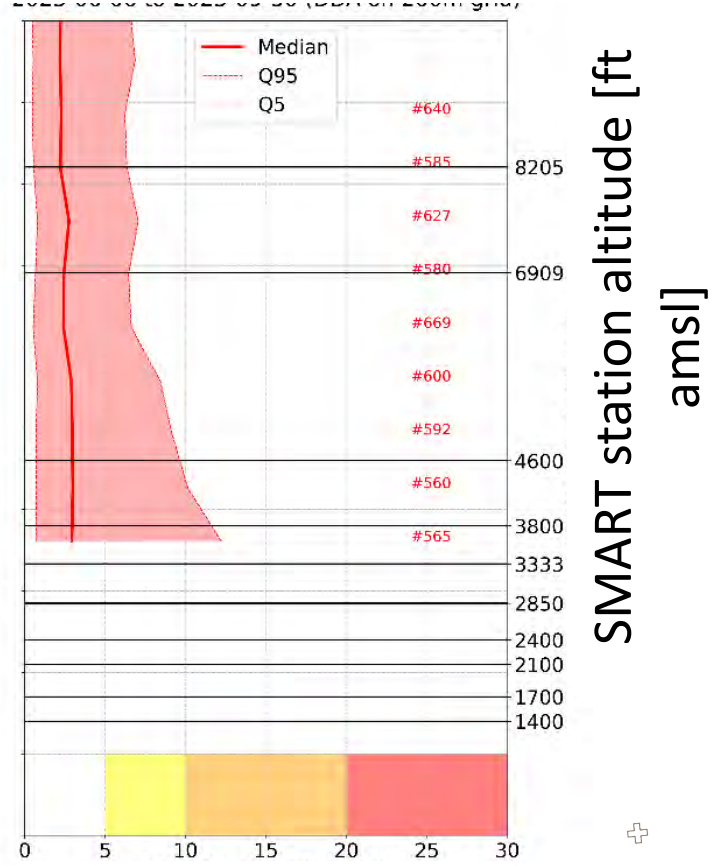
SMART
@station heights



Weather Radar
DDA @ SMART levels



Weather Radar
DDA @ 200m resolution



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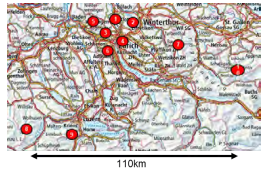
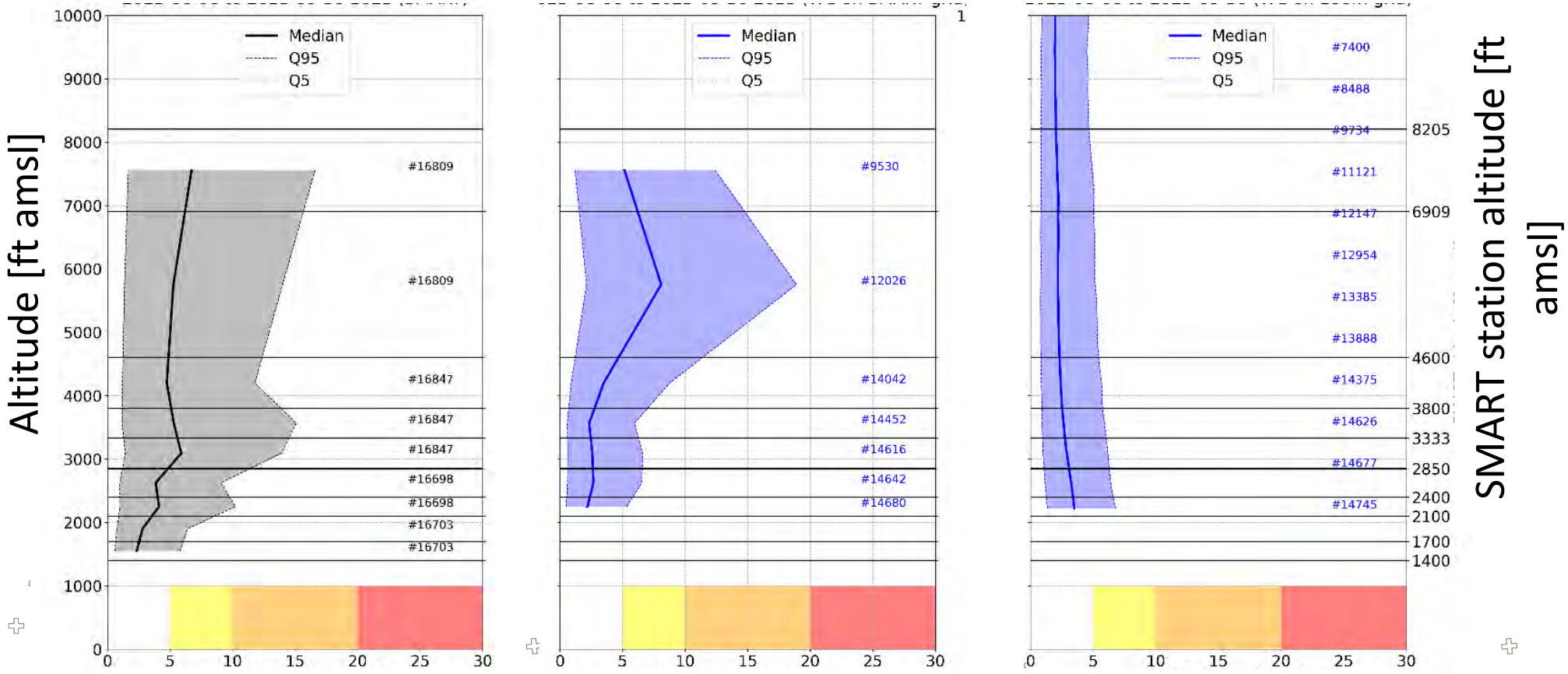
Wind shear during **dry** conditions : June - September



SMART
@ station heights

Wind Lidar
@ SMART levels

Wind Lidar
@ 100m resolution



Meteo

Summary

Preliminary analysis

- Wind shear

Exploitation

- Wind speed and direction
- Model verification, Nowcasting
- Data source für different existing projects (SMART, LORD, AMAROC)

Future possibilities

- Combine NWP data and observations
  - Timeliness & availability
- Robustness of estimates
  - Methodology developments for DDA
- Assess topographical effect in SMART wind shear product
- Weather radar applications
  - Attenuation
  - Convection, hail, heavy precipitation, lightning