GEOF-322

A brief Introduction to Doppler Wind Lidars

22 February 2022, Christiane Duscha

Outcomes of this Lecture

1) What is the potential and what are the shortcommings of different Lidar systems?

2) What does a Lidar observe?

3) How can we utilise these observations?

Types of Doppler Wind Lidar

Wind Profiling Lidar

+ mobile
+ cheap

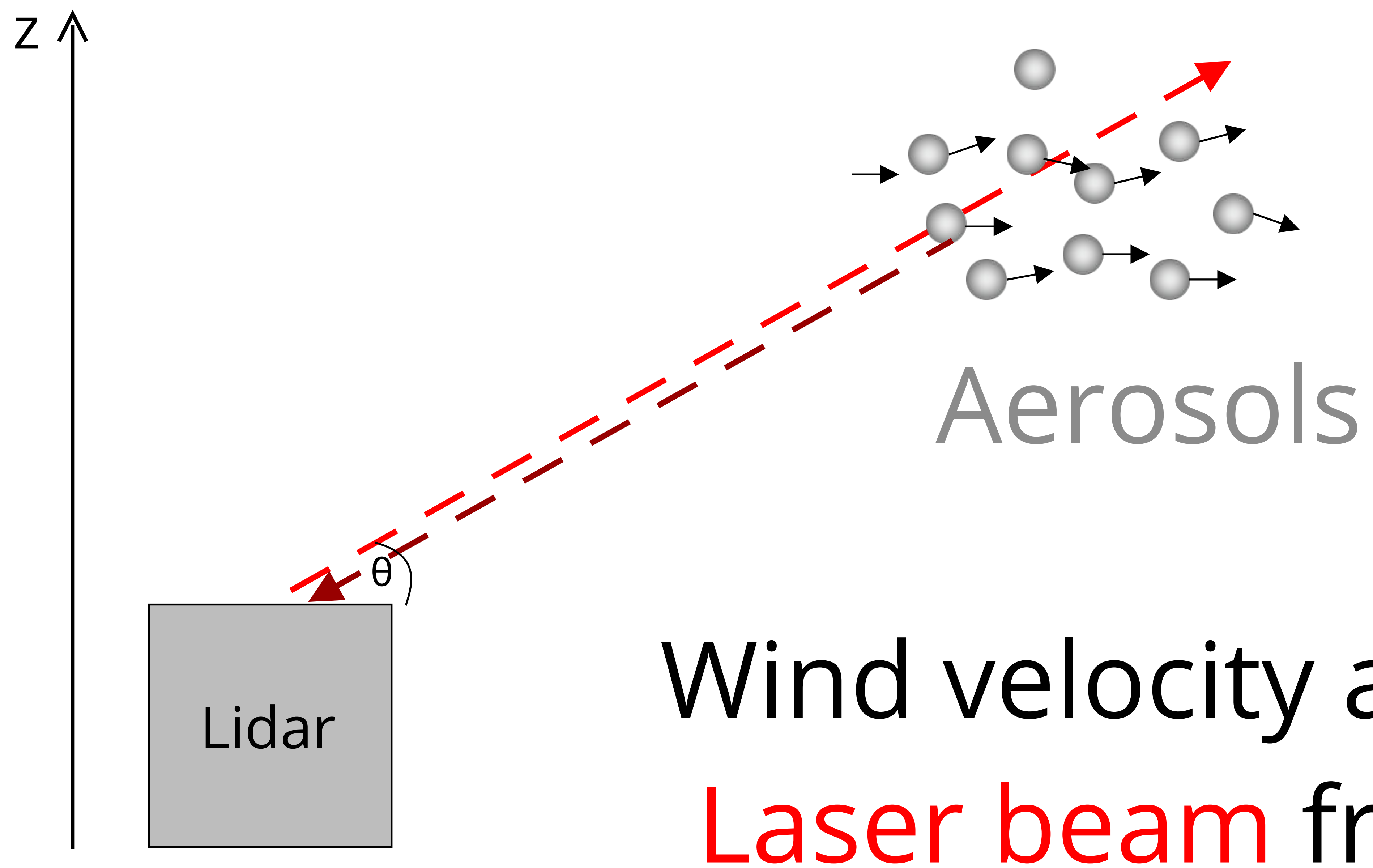
- short range (~200 -300m)
- fixed measurement pattern
  (only wind profiles)

Wind Scanning Lidar

+ long range
+ programmable

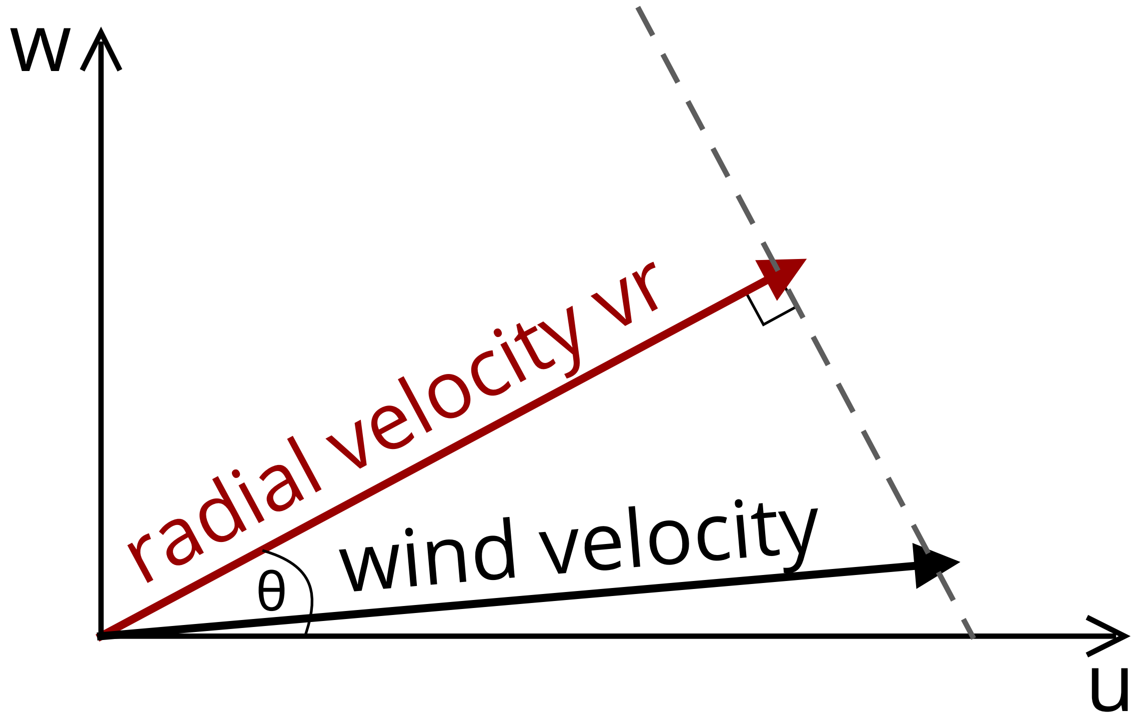
- heavy (~ 300kg)
- expensive

Measurement priciple lidar



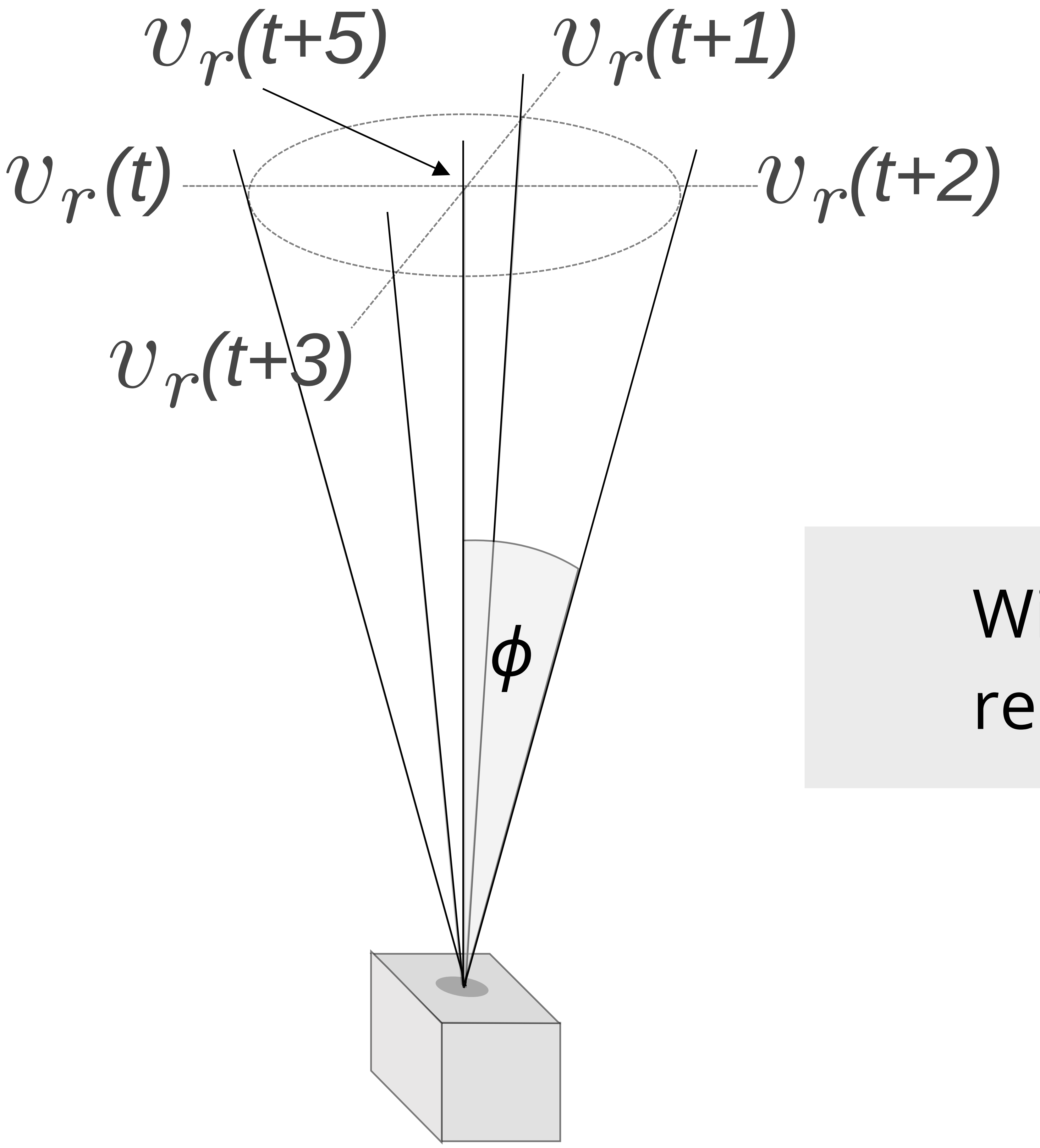
Interaction of Laser beam at distance *r* with Aerosol particles, which are transported by the wind

Wind velocity along the **line of sight** (LOS) of the Laser beam from **doppler shift** (radial velocity)



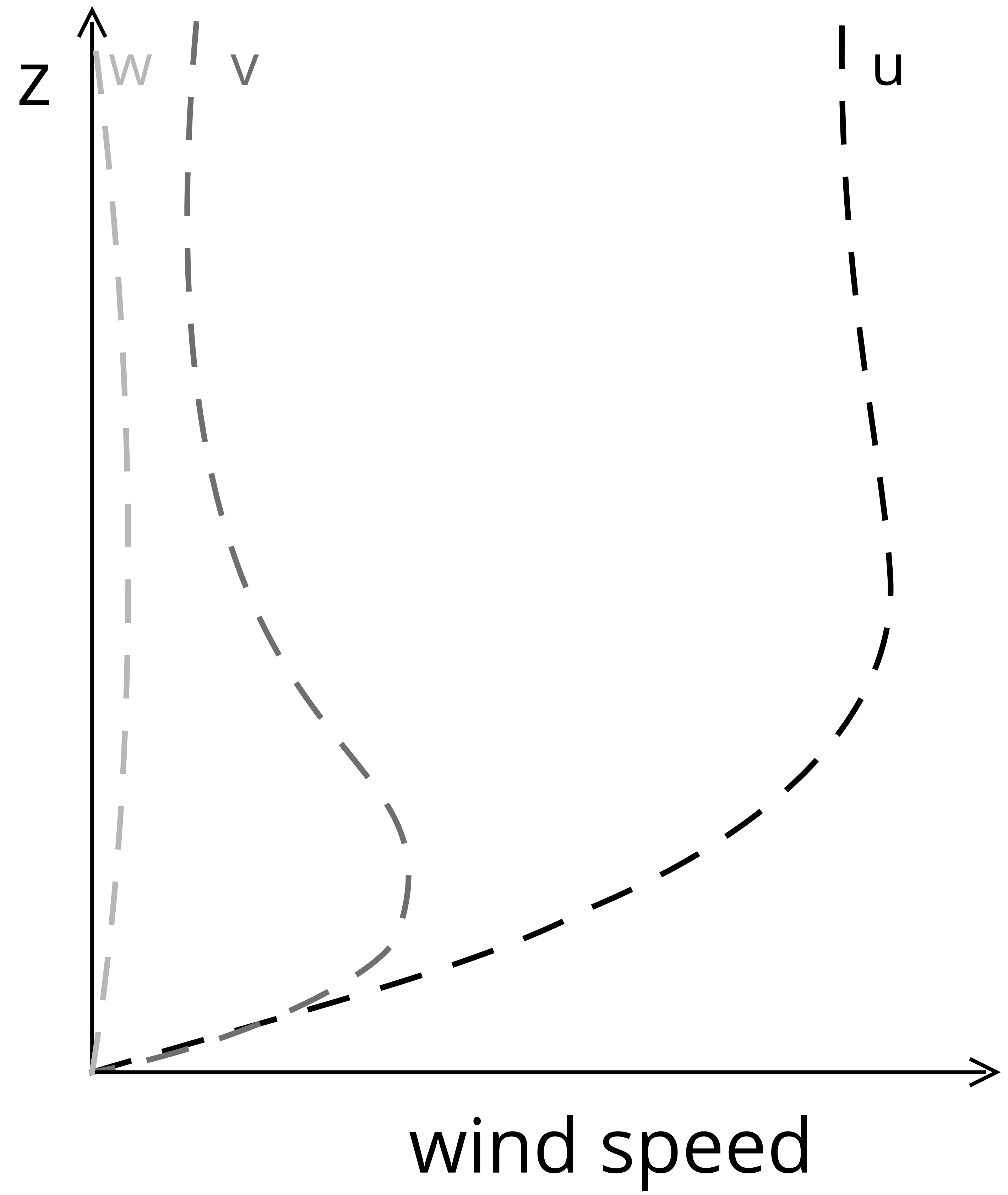
$$v_r(r,\theta) = u(r,\theta)\,cos\theta + w(r,\theta)\,sin\theta$$

Profiling lidar



Wind speed
reconstruction

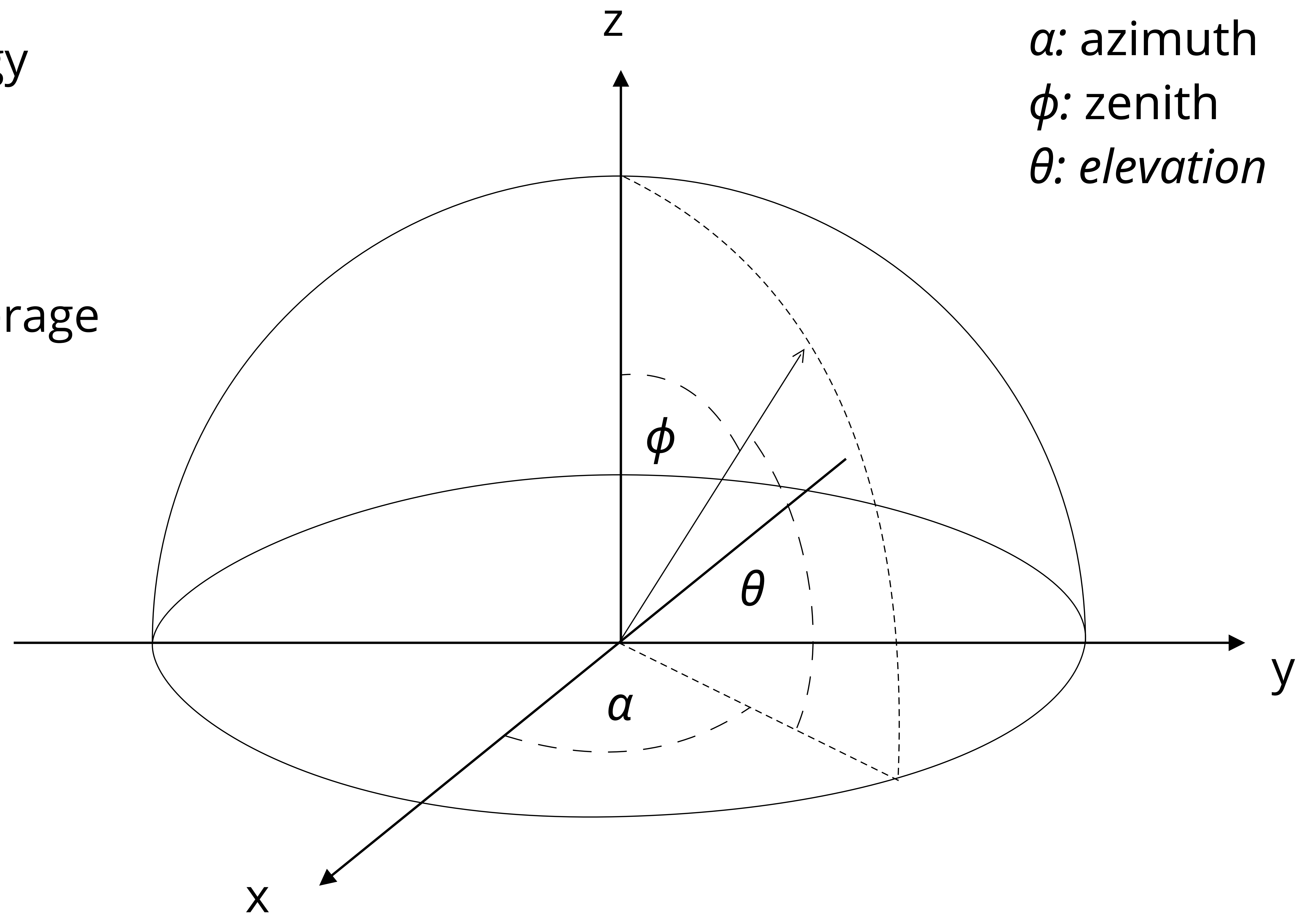
Wind profile
(3 wind speed components)



Scanning lidar

Are not limited to a single strategy
(e.g. observing the wind profile)

and several instruments can be
combined to achieve spatial coverage

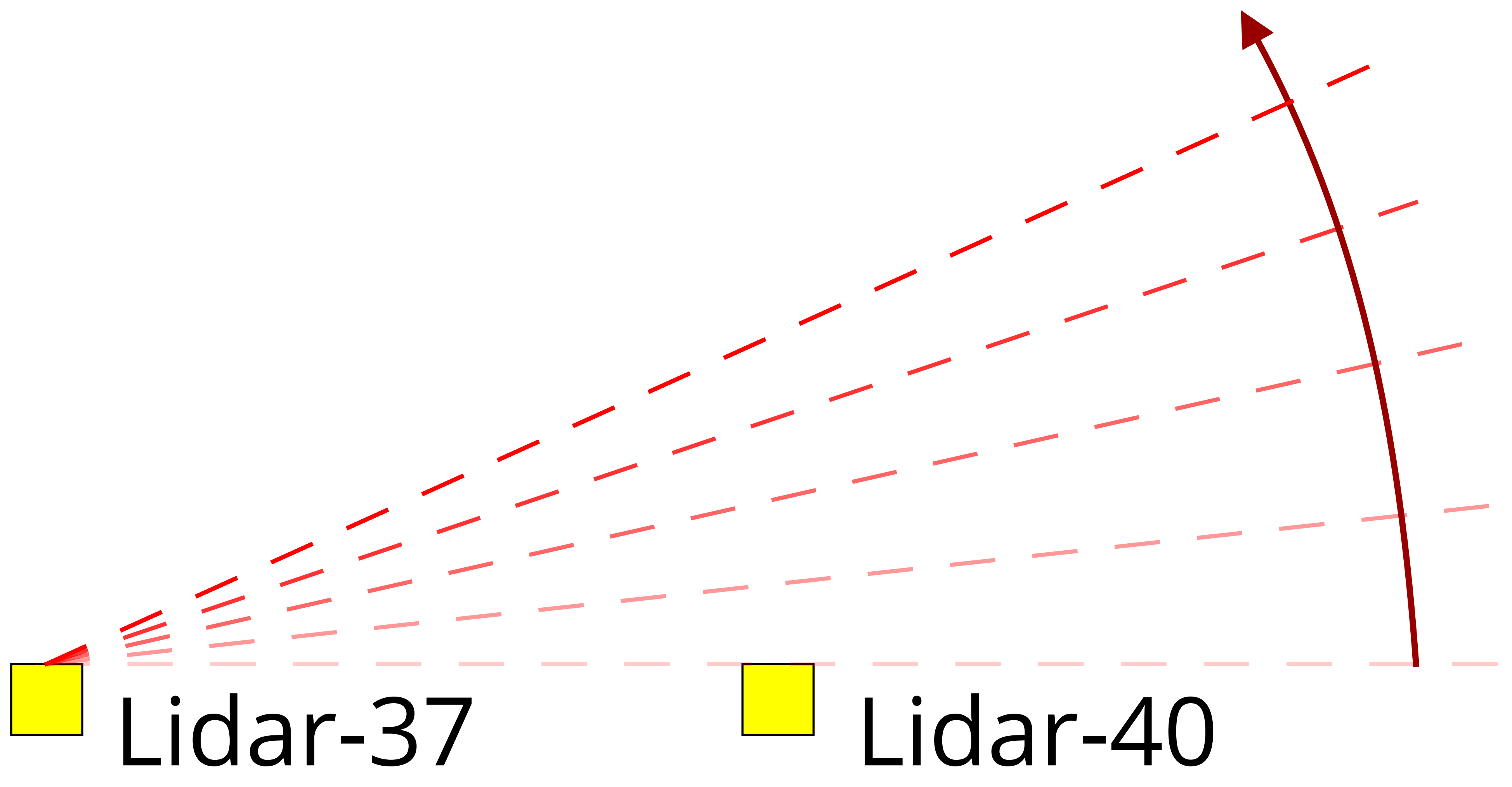


α: azimuth
ϕ: zenith
θ: elevation

Scanning strategy

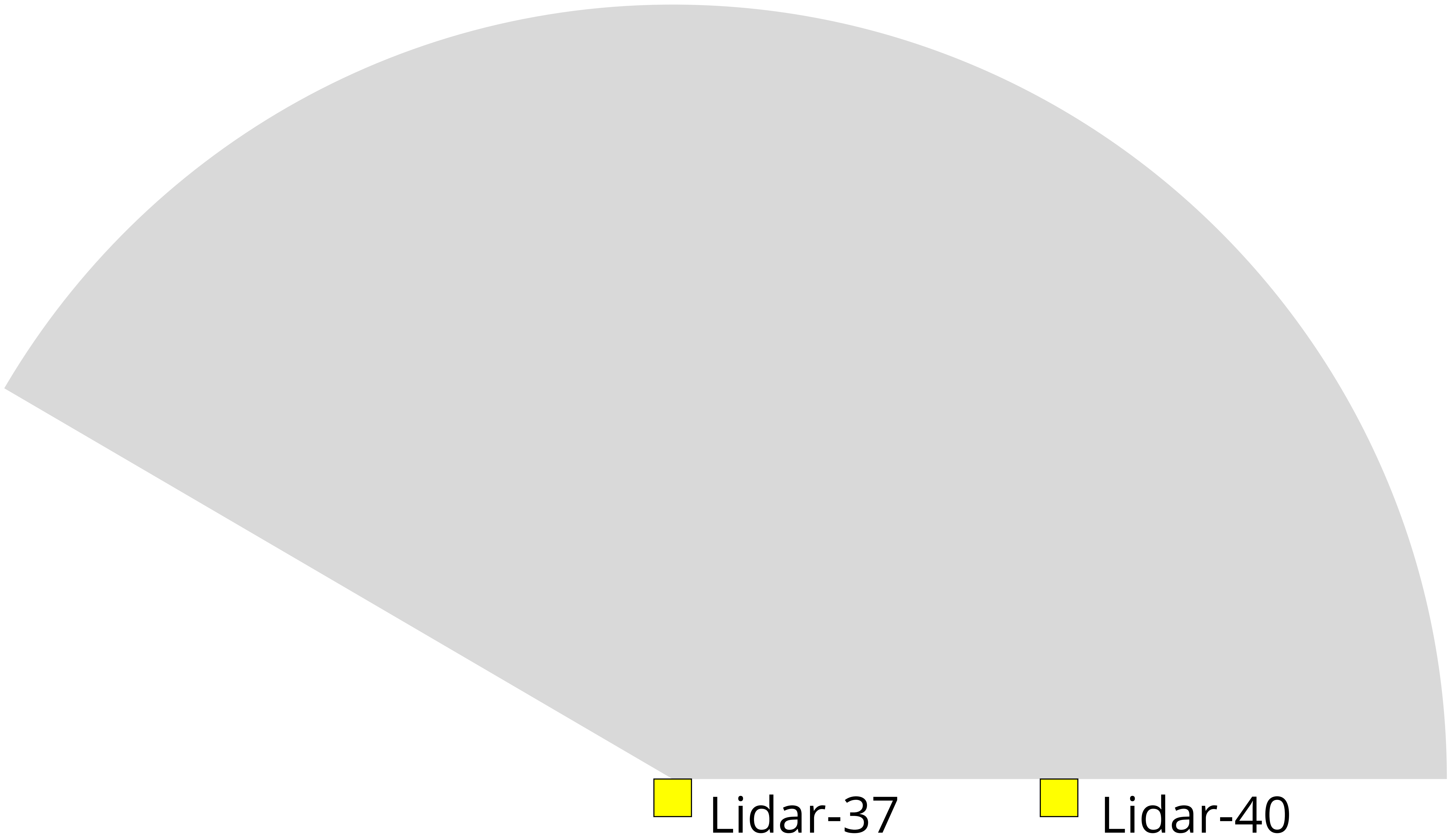
Example: combine two scanning Lidars

Rotate the lidar beam with increasing elevation angle, θ, within the vertical cross-section between the lidar



Scanning strategy

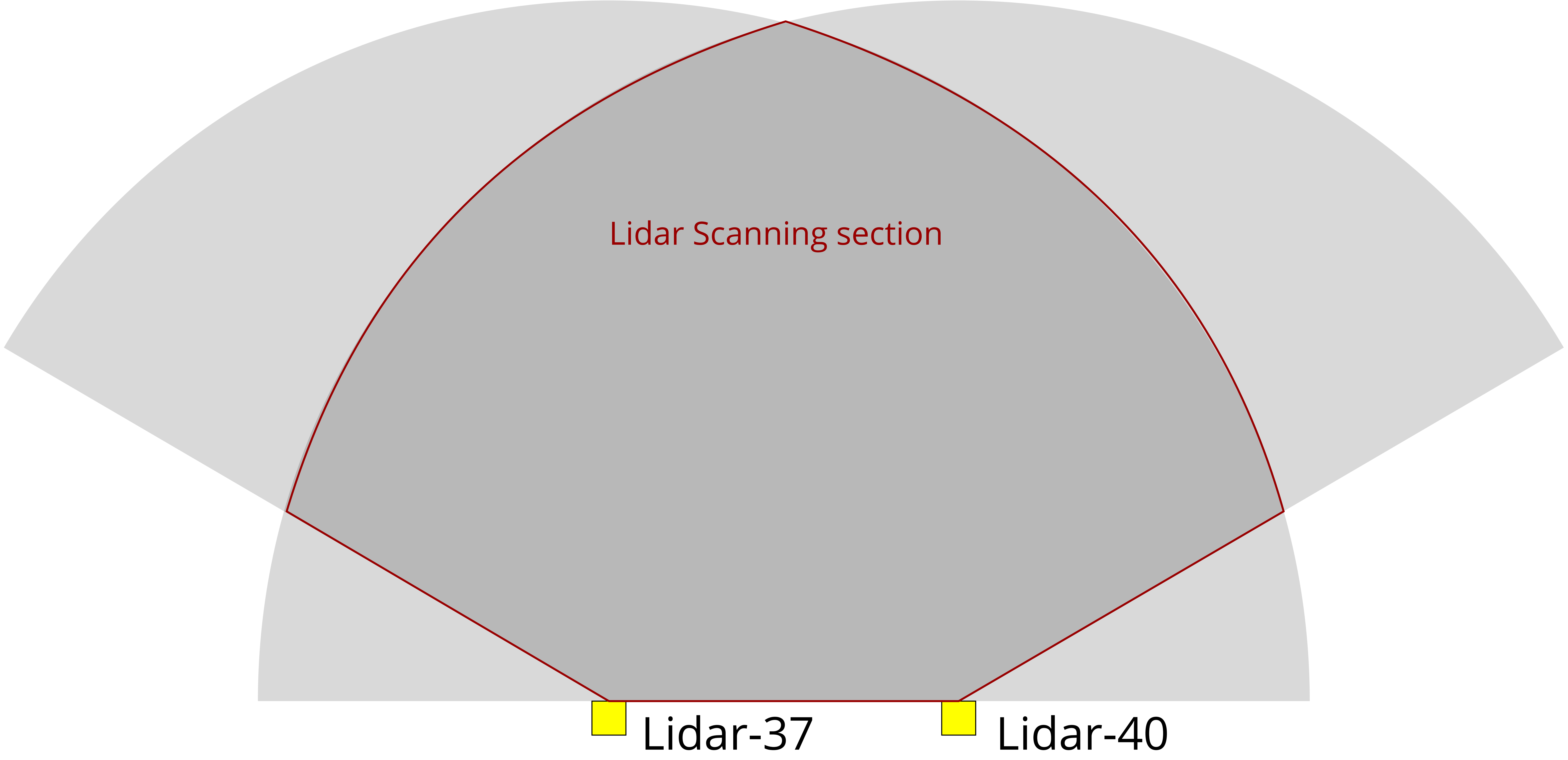
Rotate the beam of Lidar-37 between θ = 0° and θ = 150°



Scanning strategy

Rotate the beam of Lidar-37 between θ = 0° and θ = 150°

Rotate the beam of Lidar-40 between θ = 180° and θ = 30°



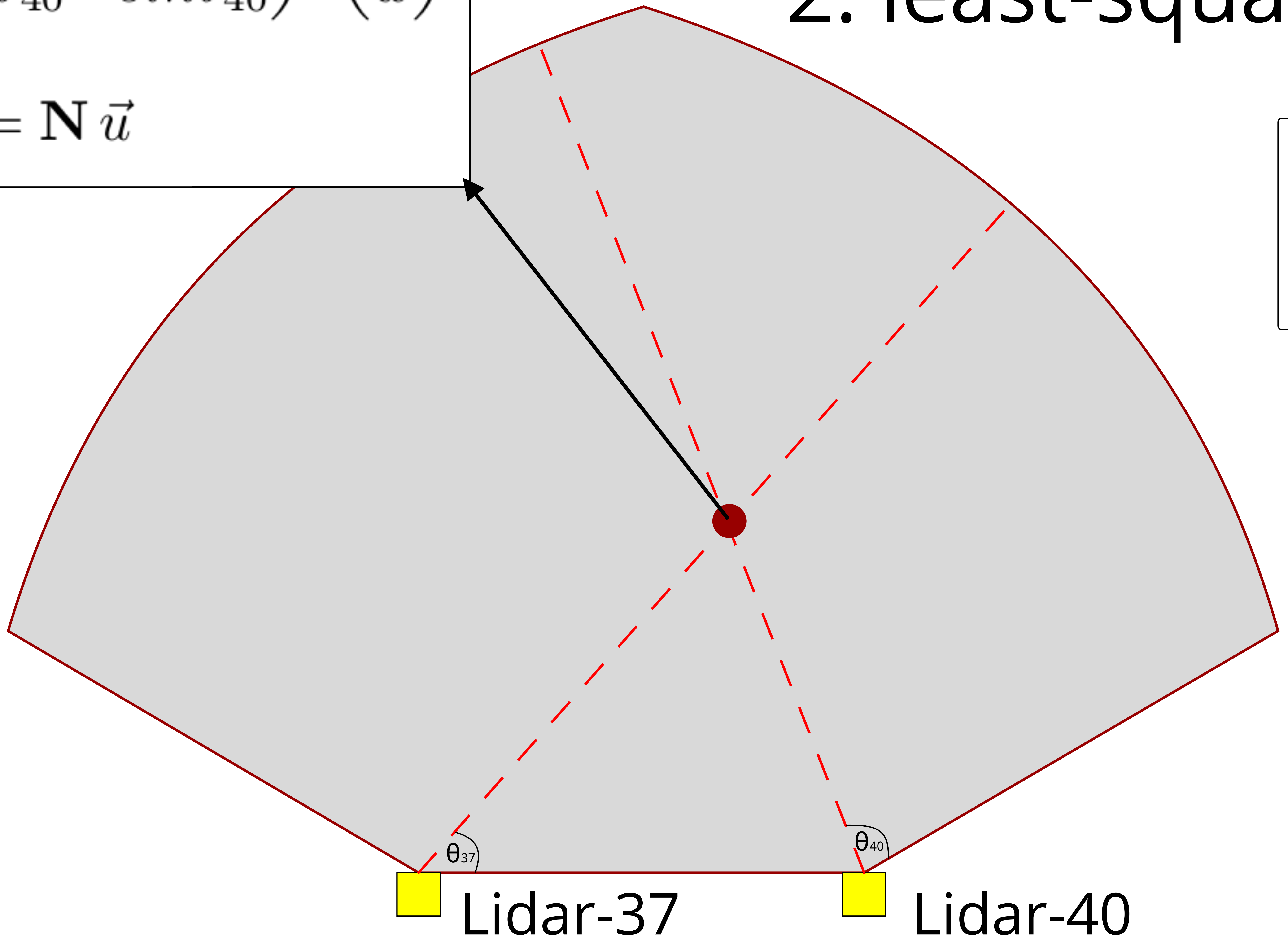
Reconstruction of wind field

$$\begin{pmatrix} v_{r37} \\ v_{r40} \end{pmatrix} = \begin{pmatrix} cos\theta_{37} & sin\theta_{37} \\ cos\theta_{40} & sin\theta_{40} \end{pmatrix} \begin{pmatrix} u \\ w \end{pmatrix}$$

$$\vec{v_r} = \mathbf{N}\,\vec{u}$$

1. to cartesian grid
2. least-squares approach

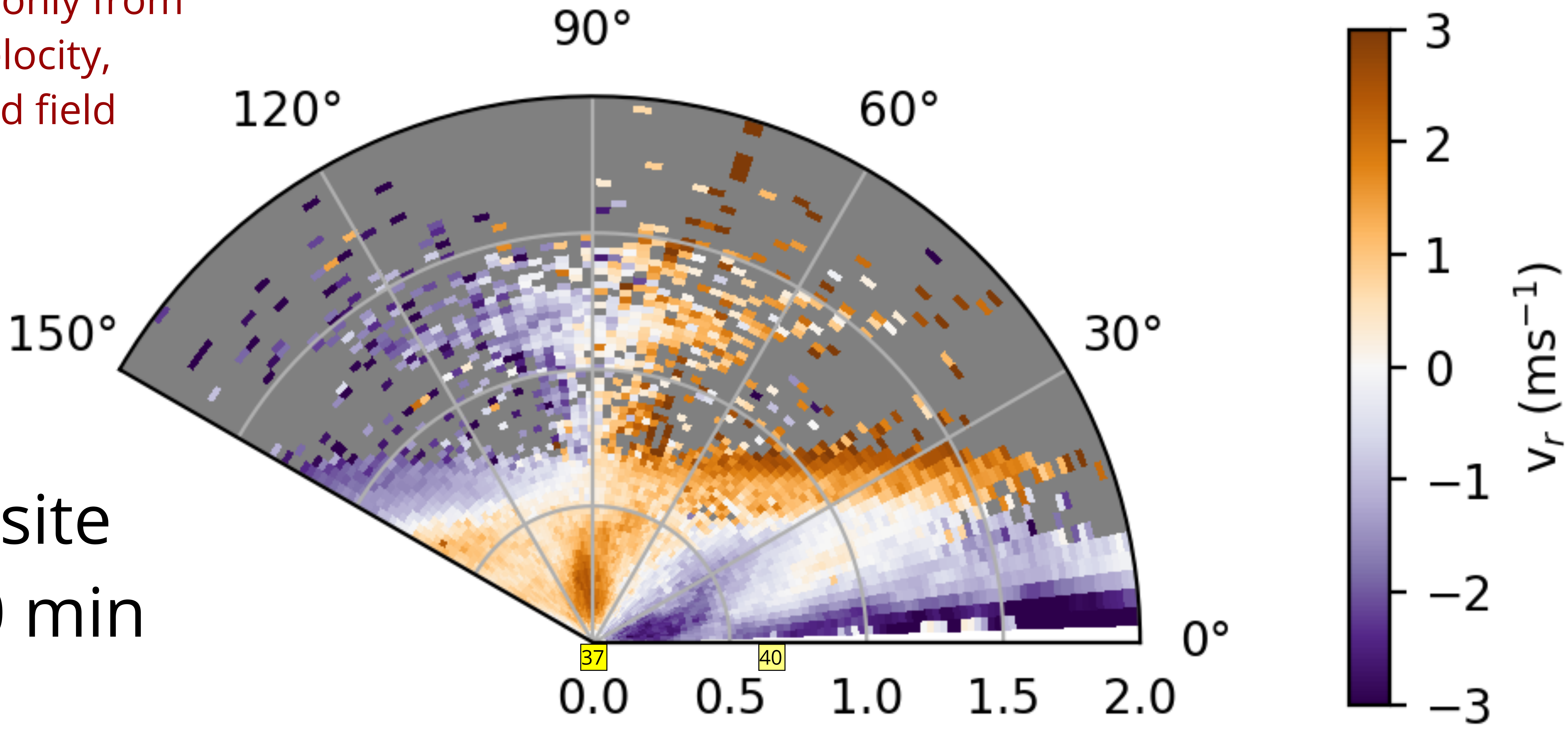
$$\hat{\vec{u}} = (\mathbf{N}^T\mathbf{N})^{-1}\mathbf{N}^T\vec{v_r}$$



Example observations from last year

28.05.21 9:30 UTC, 2° resolution (Lidar-37)

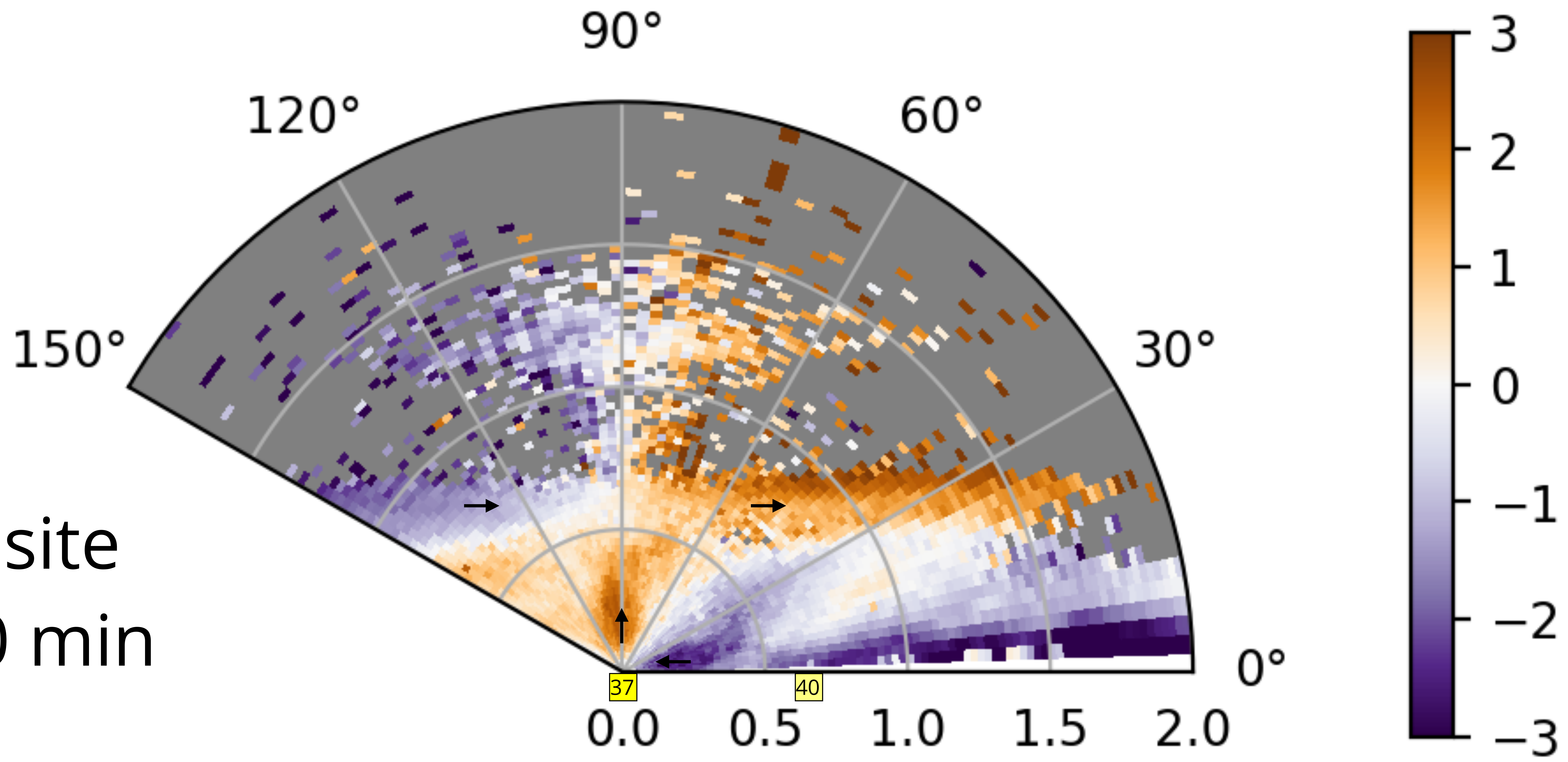
Can you tell only from the radial velocity, how the wind field looks like?



Composite over 10 min

Example observations from last year

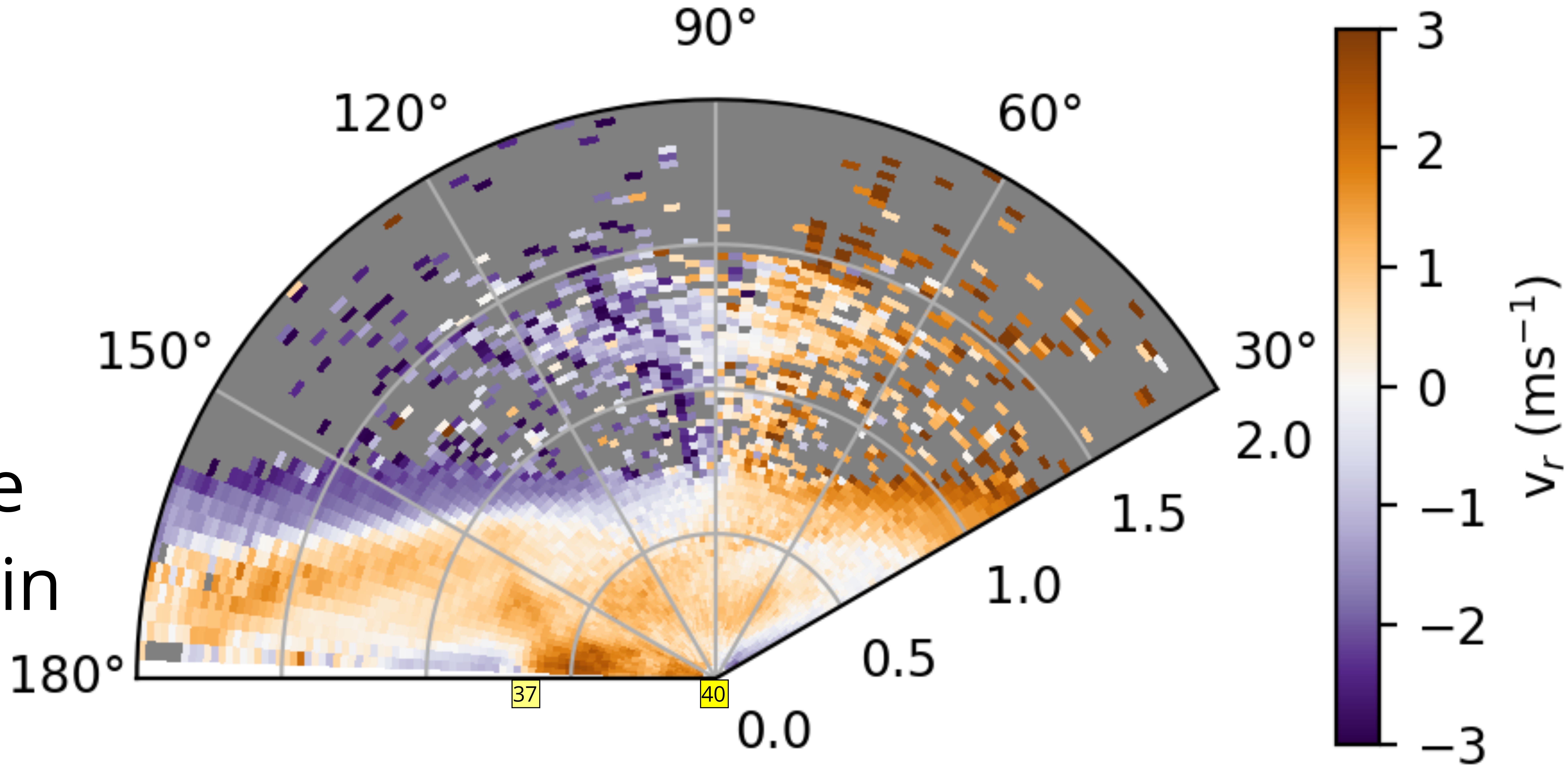
28.05.21 9:30 UTC, 2° resolution (Lidar-37)



Composite
over 10 min

Example observations from last year

28.05.21 9:30 UTC, 2° resolution (Lidar-40)

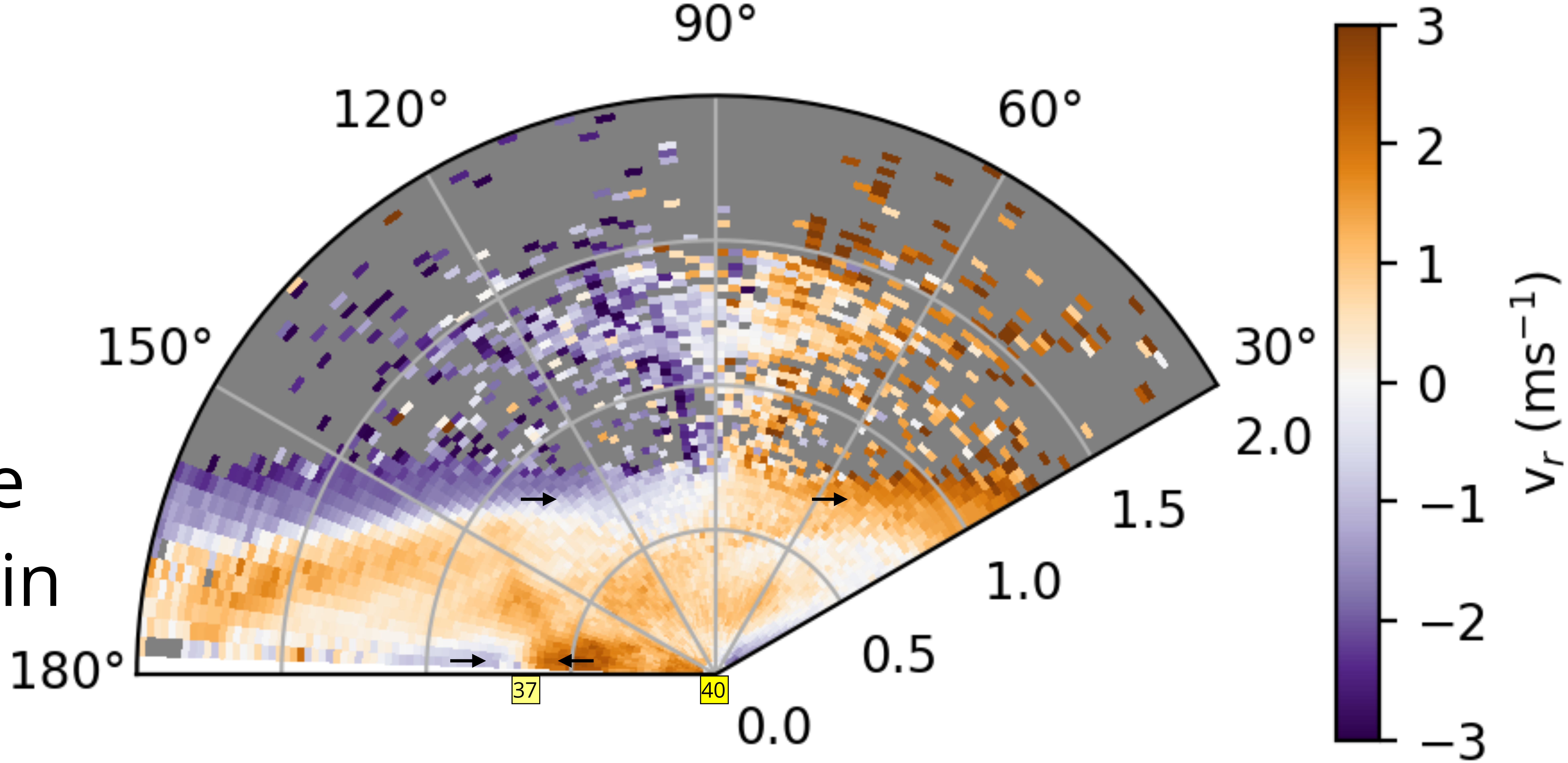


Composite over 10 min

Example observations from last year

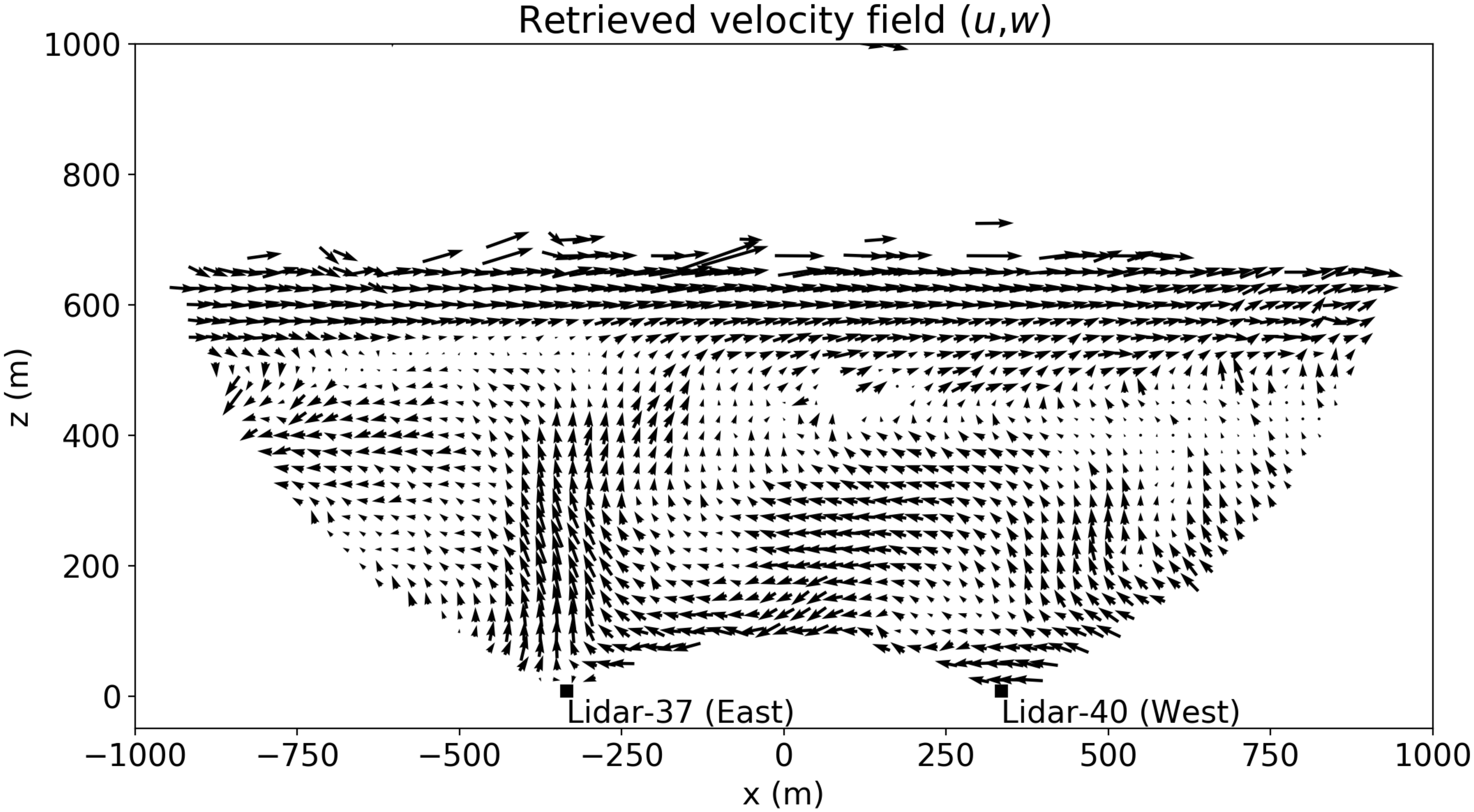
28.05.21 9:30 UTC, 2° resolution (Lidar-40)

Composite over 10 min



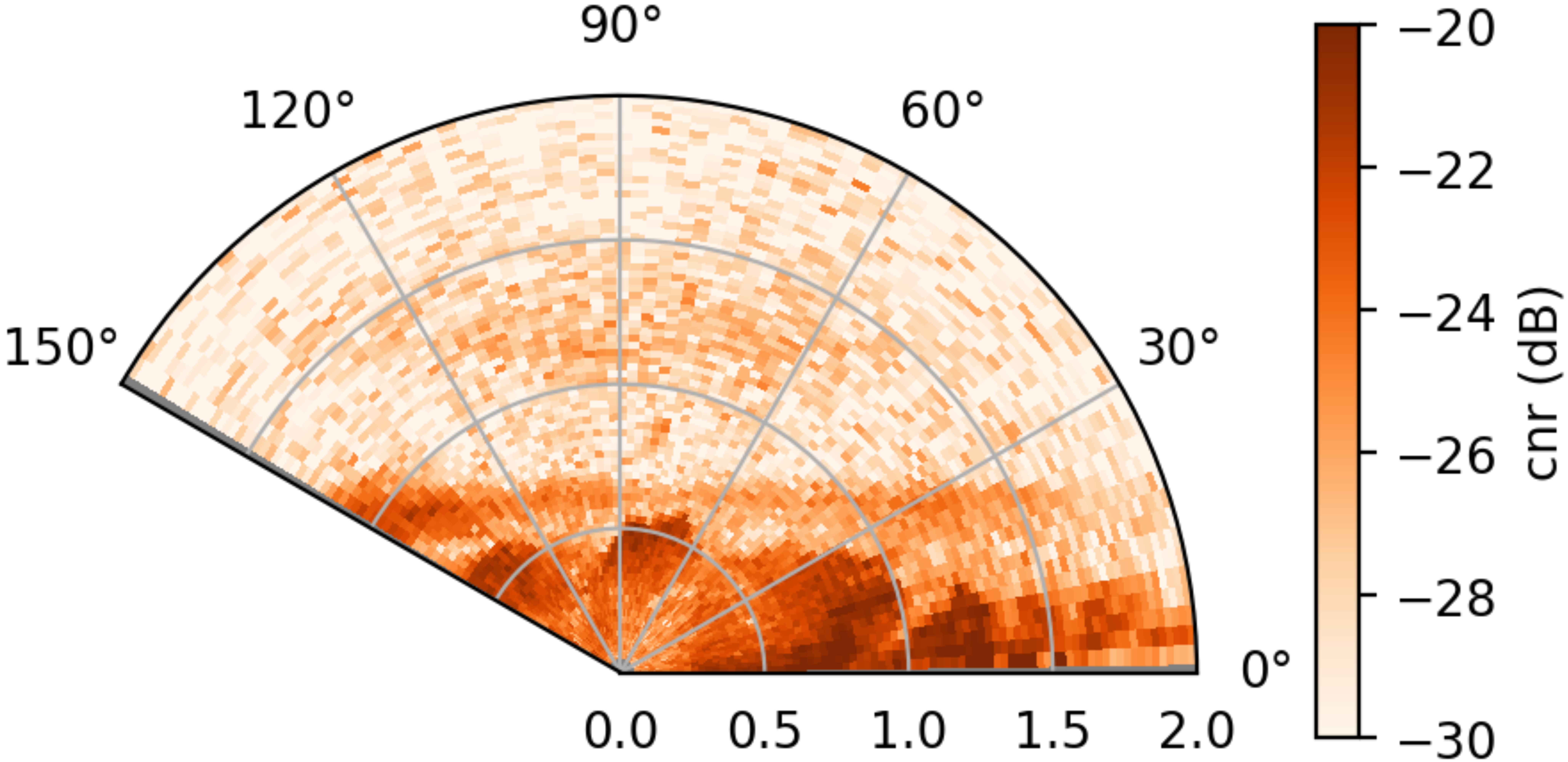
Reconstructed wind field

Example from 28.05.21 9:30 UTC



Carrier to noise ratio

A measure for strength of back-scatter from Aerosols



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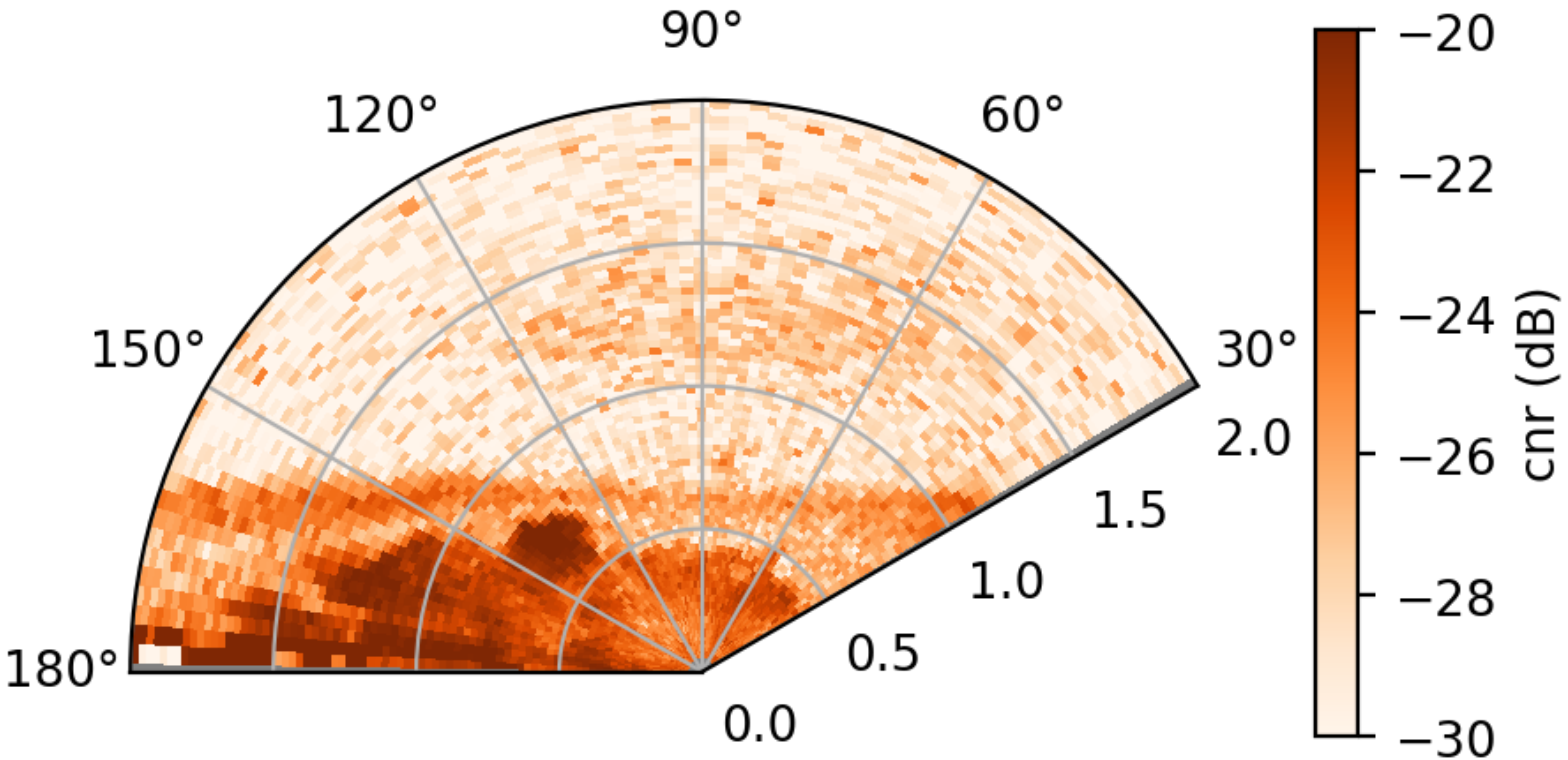

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