Presenting the New Middle Atmospheric Doppler-Rayleigh Wind Lidar at Kühlungsborn

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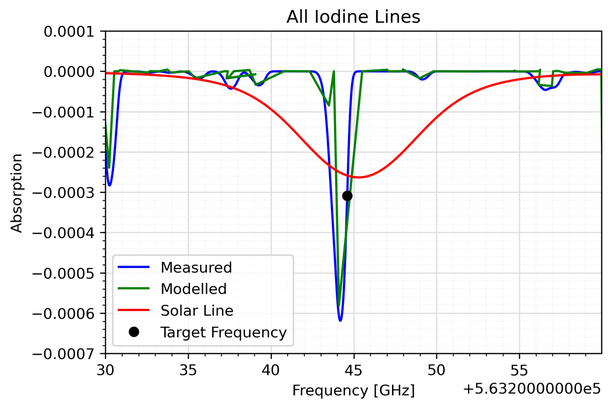
Abstract

We present the scientific motivation, some technical details, algorithm design, and first results from a newly developed Doppler-Rayleigh wind lidar constructed at the Leibniz Institute for Atmospheric Physics in Kühlungsborn, Germany. Horizontal winds are one of the key parameters needed to study atmospheric dynamics. Accurate wind measurements in the stratosphere and mesosphere are required as inputs to improve and extend re-analyses and numerical weather forecasting. Currently, Doppler-Rayleigh lidar is the only technique capable of measuring both winds and temperatures between ~20 and 80 km.

Motivation

- Radars and resonance lidars can provide winds and temperatures above ~80 km
- Smaller radars and Raman systems provide the same below ~20 km
- In the middle Rayleigh lidar can provide temperature
- There are no observations of wind over most of the atmosphere
- Doppler-Rayleigh lidar is the only technique currently available for winds

Spectral Reference



An I2 gas cell provides a spectral reference for both the stabilized seeder laser and the "zero Doppler shift" reference line for returned signal

Lidar in Action

The Kühlungsborn wind lidar is in regular operation at IAP. We have achieved 33 nights of measurements (~210 hours) from mid-February to mid-June. Our aim is to assemble a robust, high-cadence wind and temperature dataset from which to conduct climatological studies and high-resolution case studies of mesoscale dynamics and NLCs.

Beam Pointing

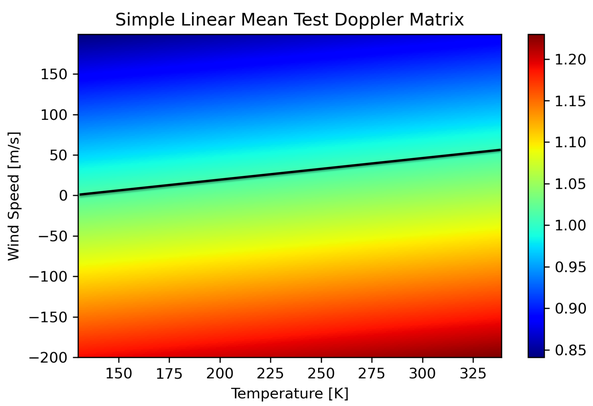
Two tiltable 70 cm telescopes pointing 25° off zenith

Configured to view North and East

Center (RA, Dec):	(83.863, 47.645)
Center (RA, hms):	$05^h\ 35^m\ 27.218^s$
Center (Dec, dms):	+47° 38' 42.812"
Size:	3.93 x 3.16 deg
Radius:	2.521 deg
Pixel scale:	18.7 arcsec/pixel
Orientation:	Up is 62.1 degrees E of N

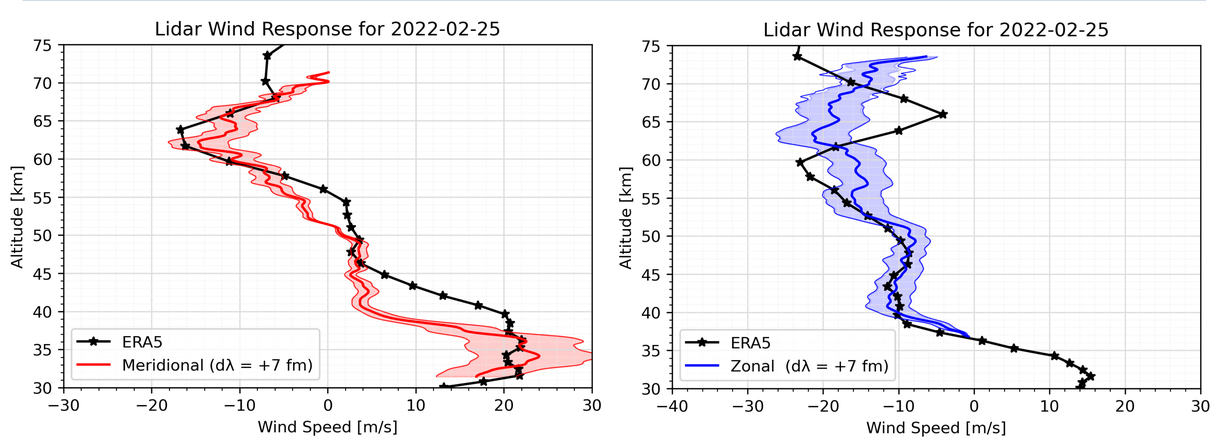
Co-axial cameras mounted on each telescope allow for precise pointing and beam stabilization

Method



Signal is split and measured both with and without an I2 gas cell. The ratio of the two signals (colour scale) is related to the wind speed. The black line represents zero wind speed. Thermal broadening contributes a small non-linear component

First Results



First results from the Kühlungsborn wind lidar. Left (red) meridional winds from lidar, right (blue) zonal winds, black in both panels is ERA5. We see a general reproduction of the measured wind in ERA5. Larger discrepancies exist in the zonal wind estimate from ERA5 above ~55 km. This underscores the need for measurement of middle atmospheric winds as opposed to model only estimates.