Observations of Stratospheric Winds from the Novel Aeolus Satellite Mission and the Loon Balloon Network

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(1) ESA, (2) Loon, (3) ECMWF

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Introduction

First ever **Doppler Wind Lidar** in space

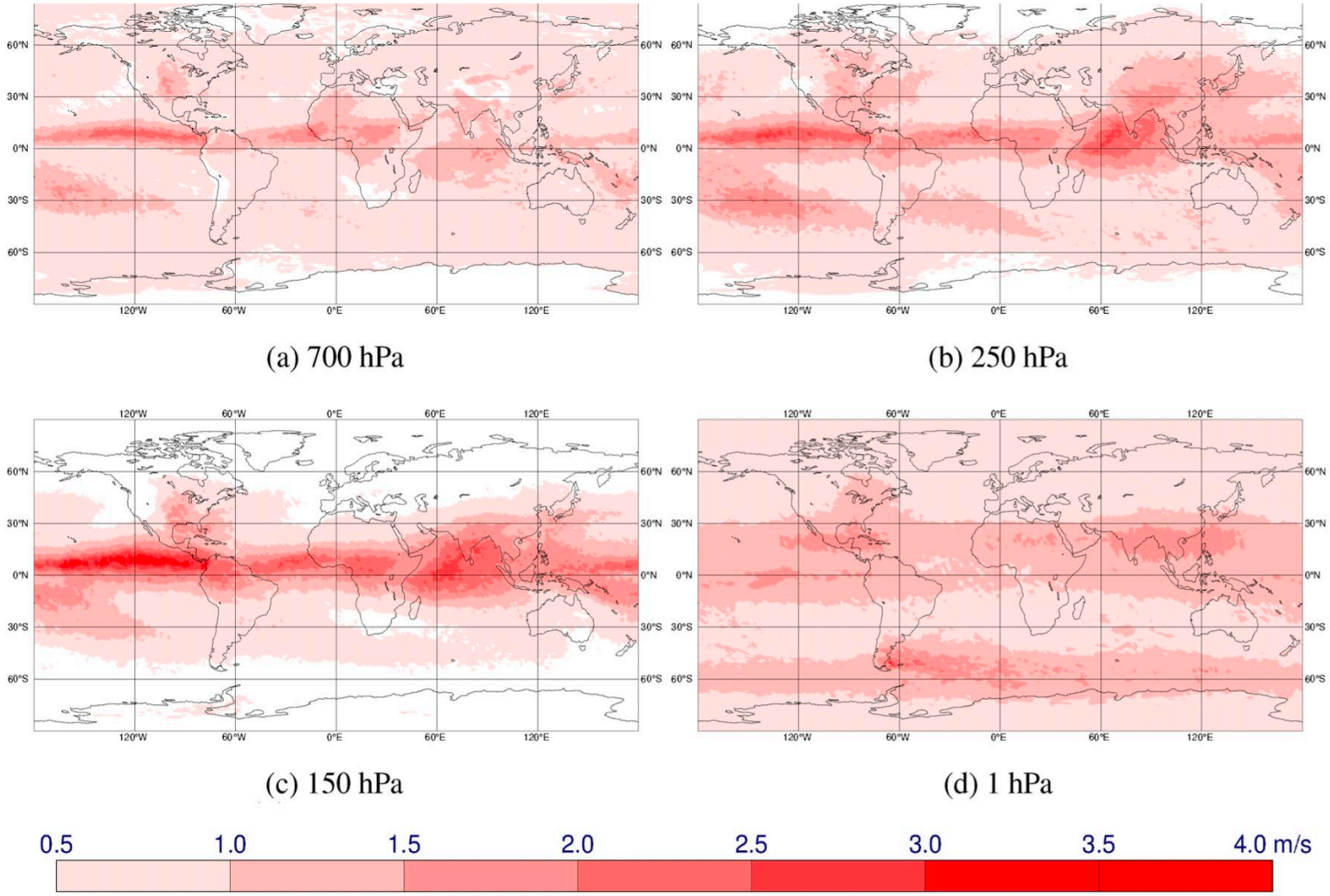
Direct wind profiles on global scale

High potential for **improving weather forecast**

Essential to assess **data quality** including **error estimates**

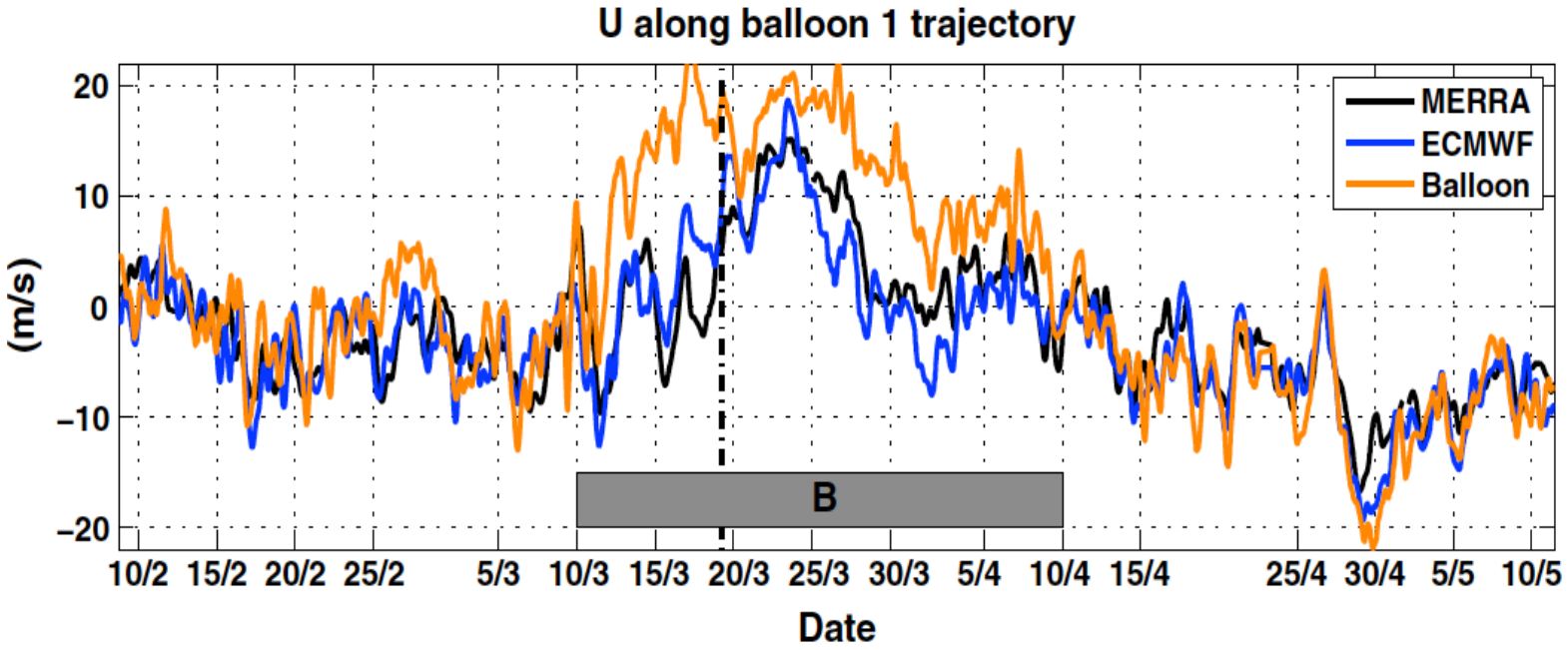
Introduction

- Assimilation of Aeolus winds indicate highest NWP impact in the tropics, in the upper troposphere (*Rennie et al., 2021*)
- Lack of independent observations for model validation
- Radiosonde data provides very accurate profiles, but only for single locations
- Super pressure balloons provide long-term reference winds in high altitudes



Rennie et al. 2021, QJRMS, Impact of Aeolus winds on zonal wind speed for the mid-2020 period.

Introduction



Courtesy of Podglajen et al. 2014

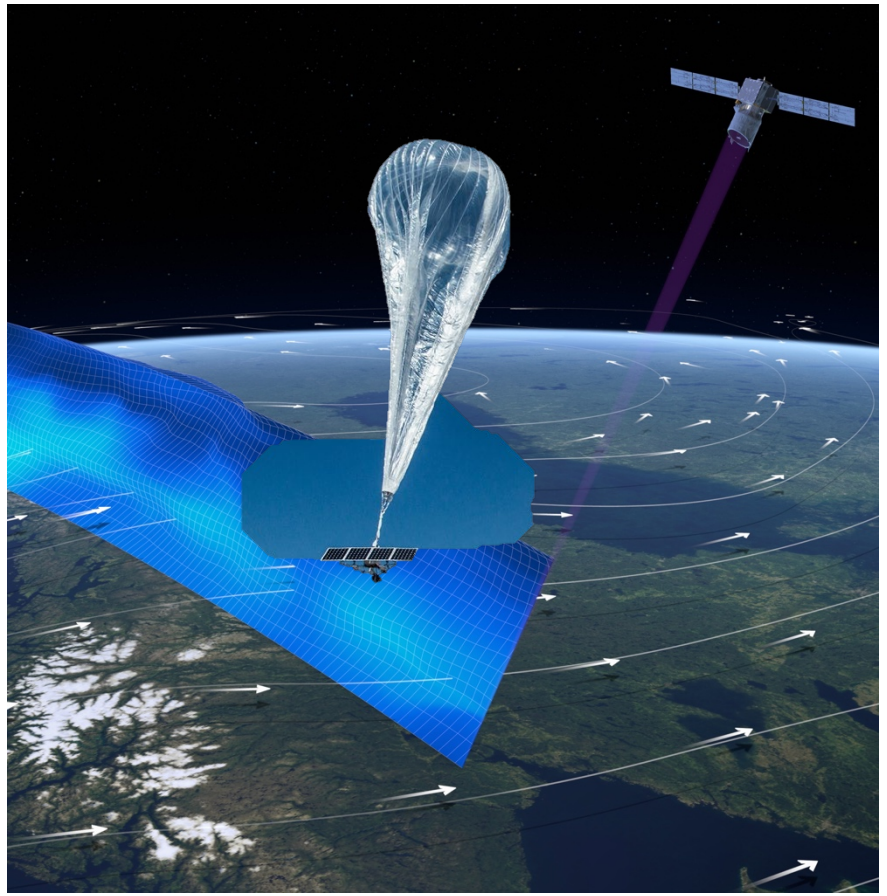
- However, large differences between model and observations are found in UTLS *(Podglajen et al. 2014, LMD balloon study)*

→ Super-pressure balloon observations offer unique oppurtunities for Aeolus product validation and for quantification of the horizontal representativeness errors of Aeolus winds

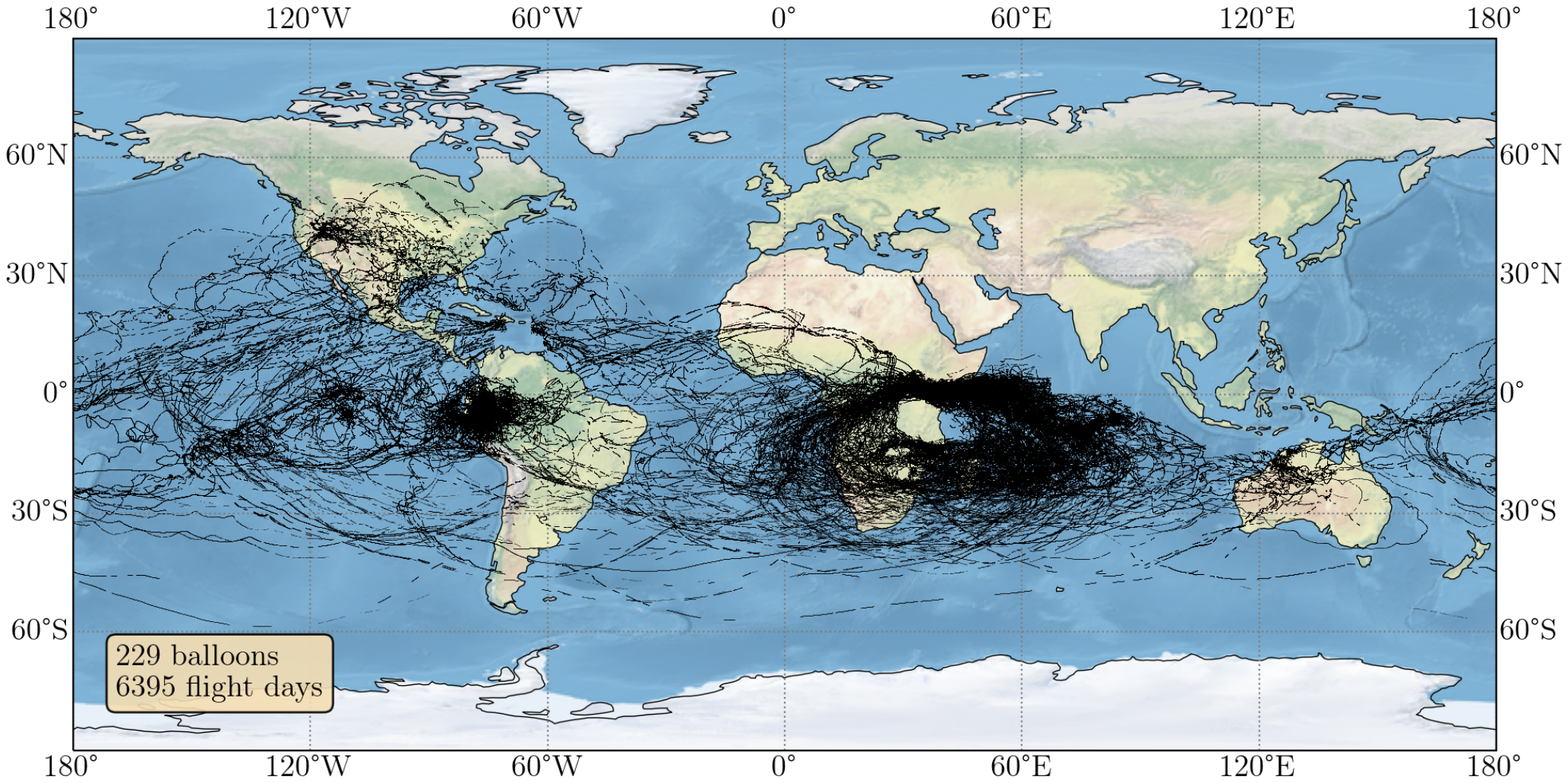
Introduction

- Super pressure balloons drifting in 16-21 km altitude
- Providing internet connection in remote regions
- Measurements of GPS location, altitude, atmospheric variables
- AI algorithm to move balloons up and down for steering

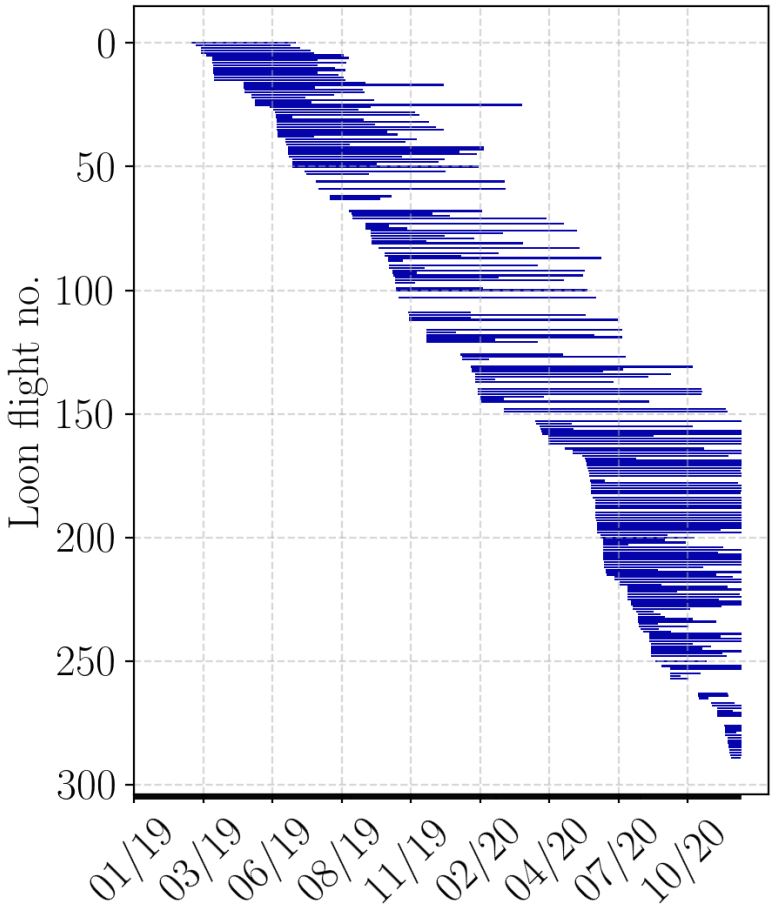
Image: https://x.company/projects/loon/

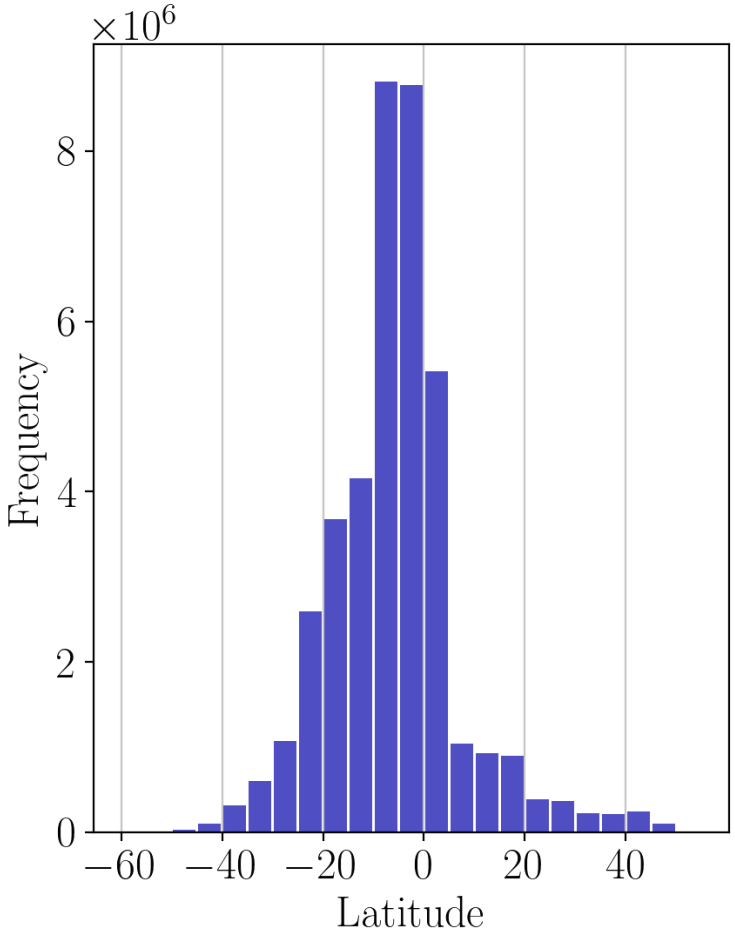


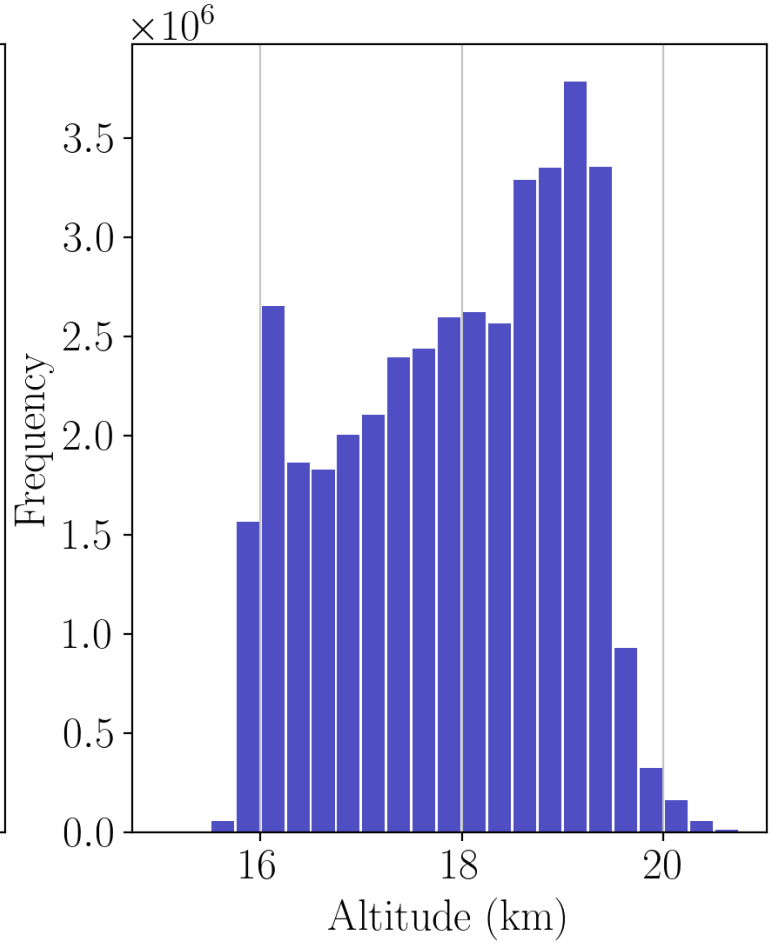
Data: Loon trajectories March 2019 – December 2020



Data: Aeolus Loon collocated measurements







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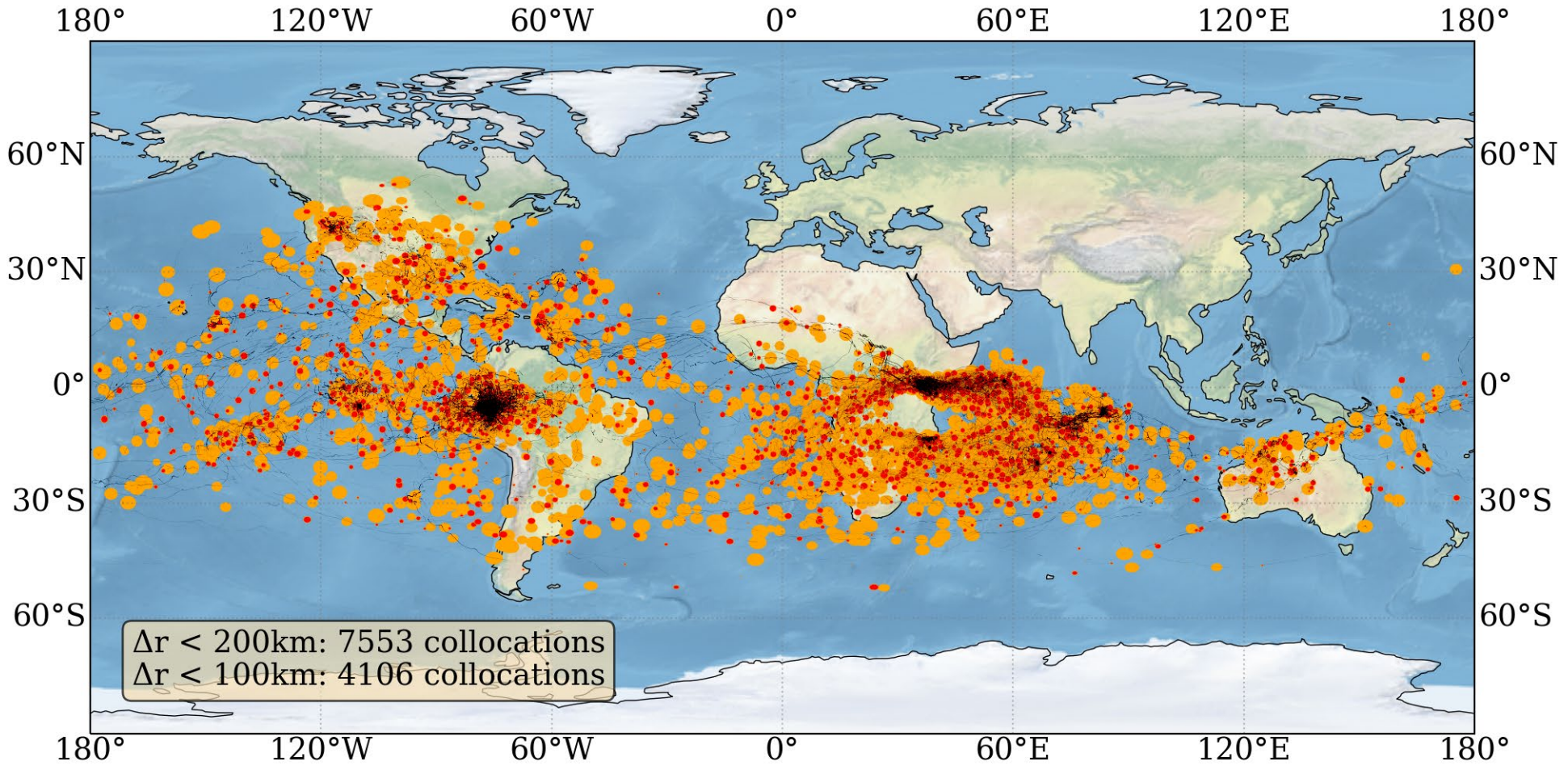
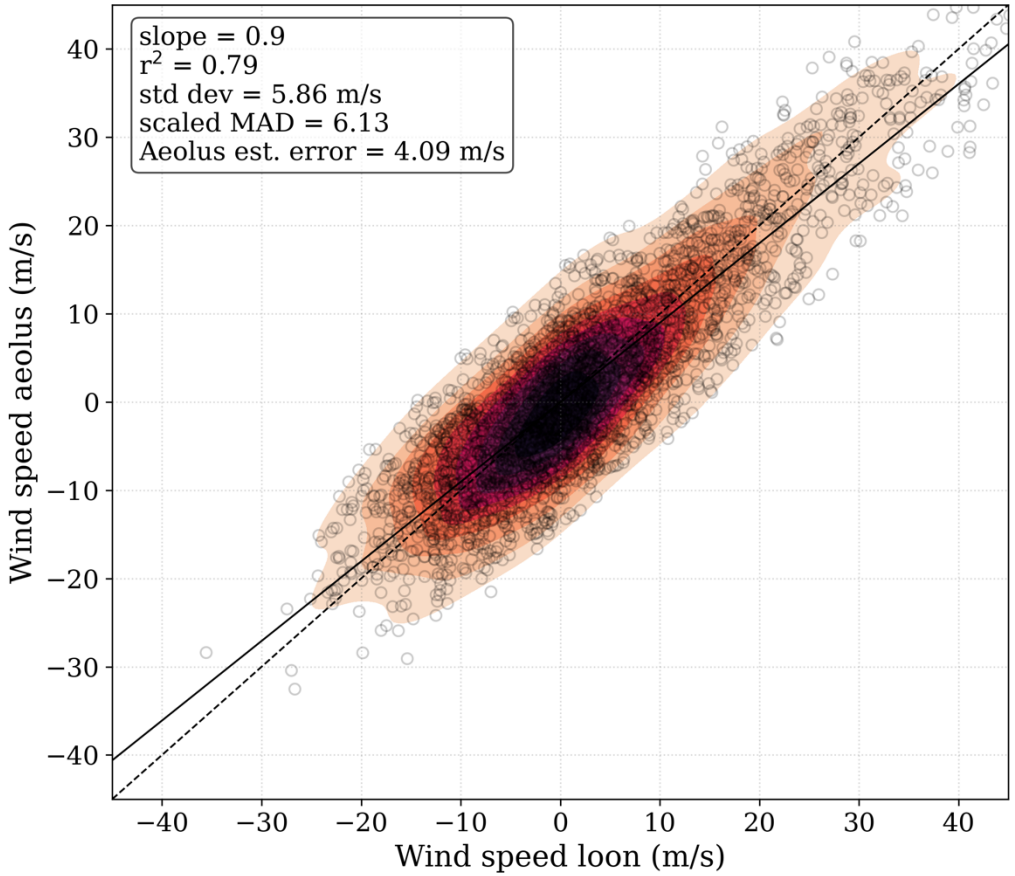
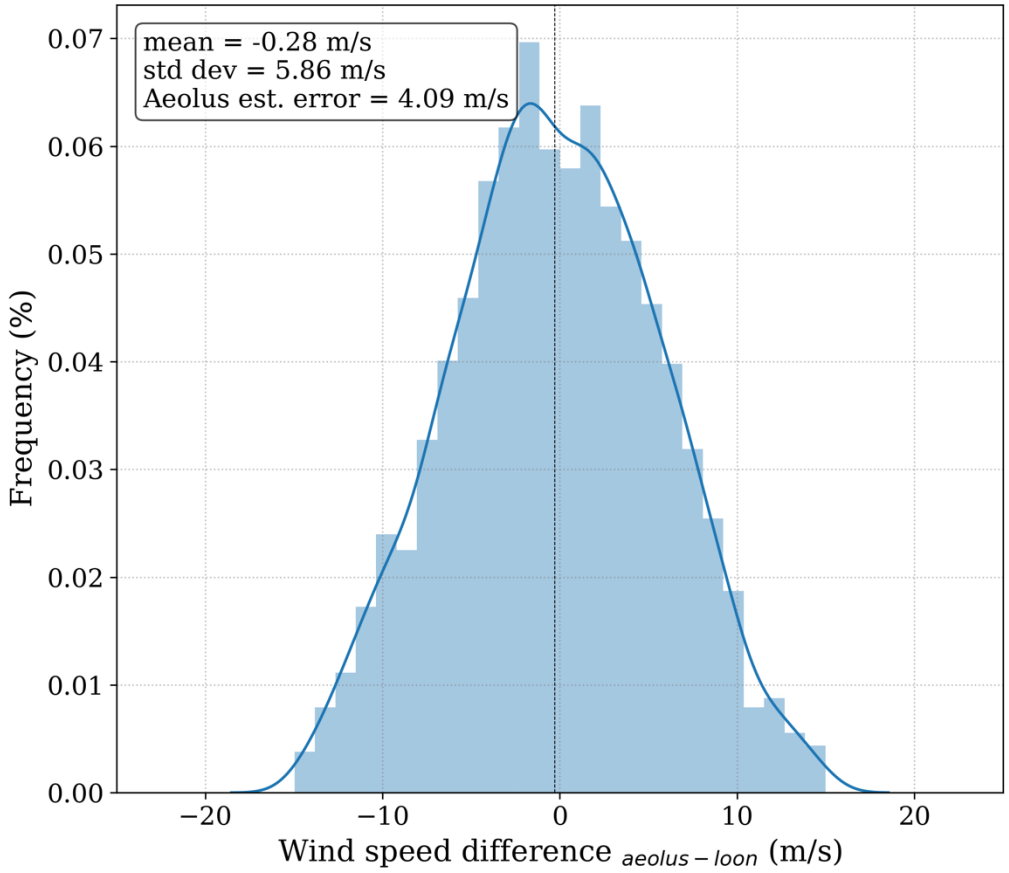


Applied QC

- Rayleigh-clear estimated HLOS error < 8 m/s
- validity flag = 1

Results: Aeolus vs. Loon

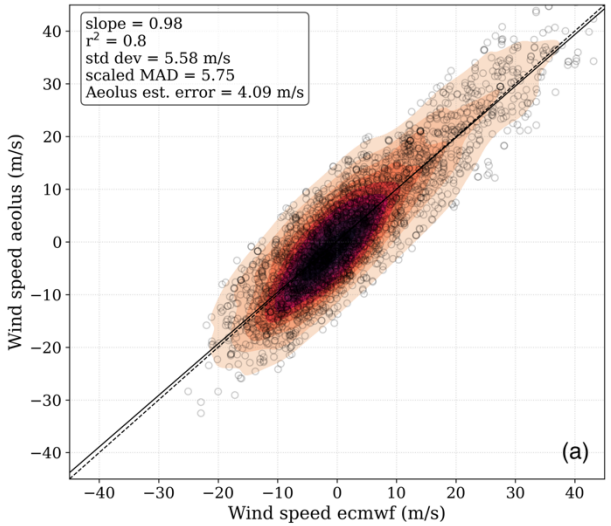


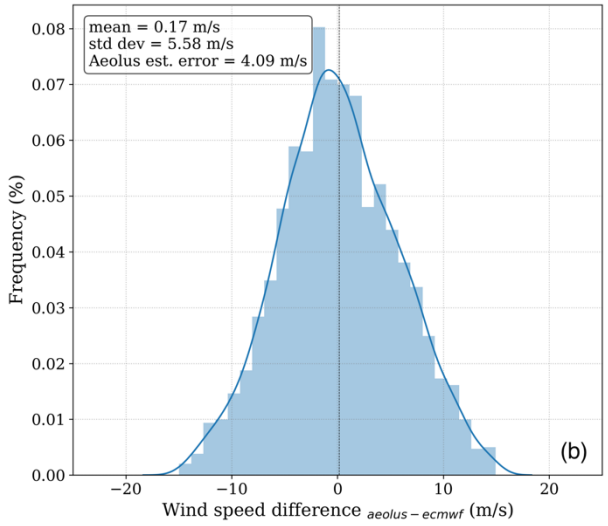


$$HLOS_{Loon} = -u \sin\phi - v \cos\phi$$

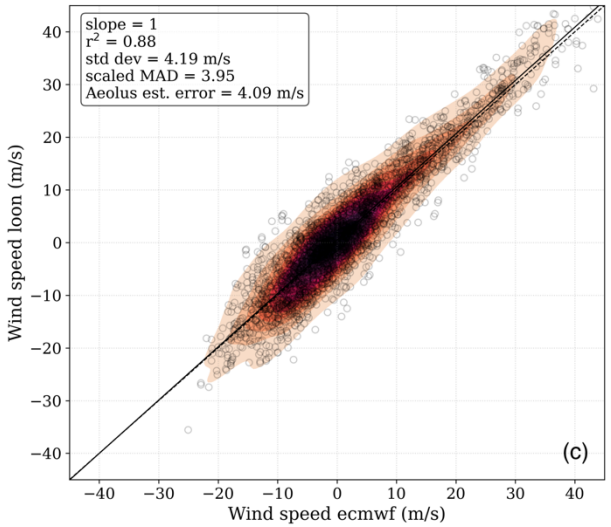
Results: Comparison against ECMWF model winds

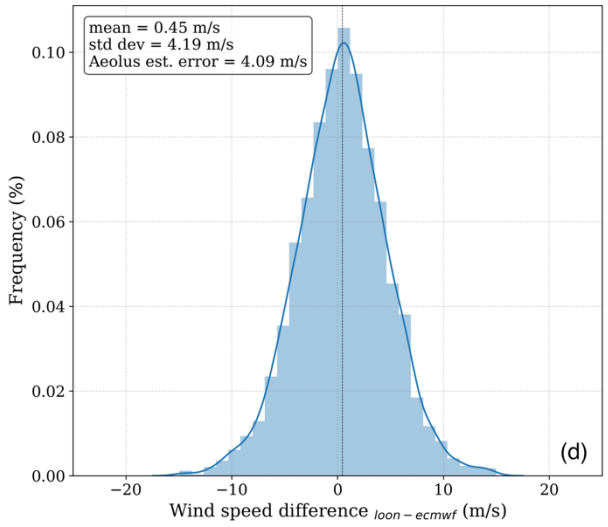
Aeolus vs. ECMWF





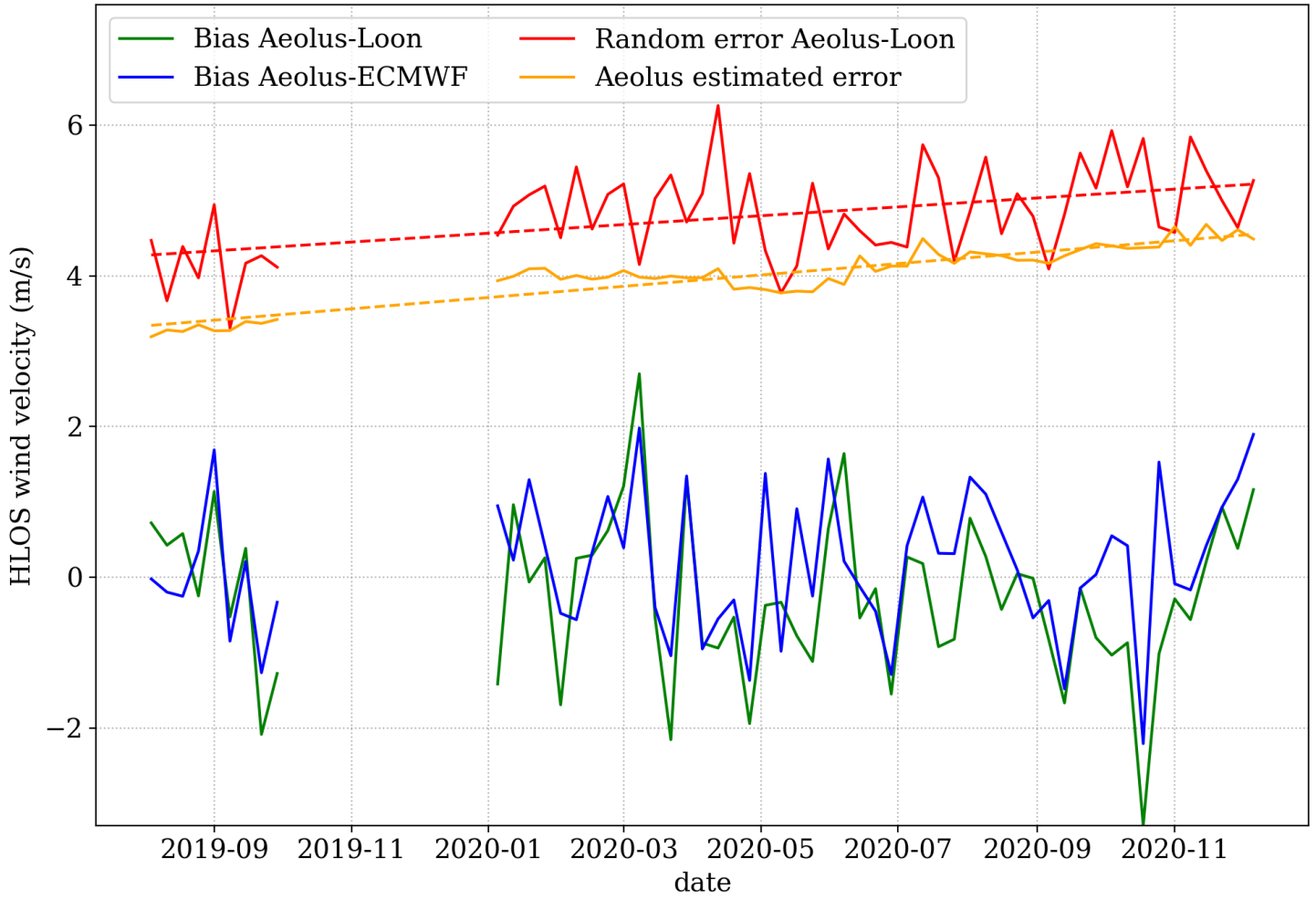
Loon vs. ECMWF





- ECMWF model wind = u,v vector winds converted to HLOS and reprojected to Aeolus observation scale

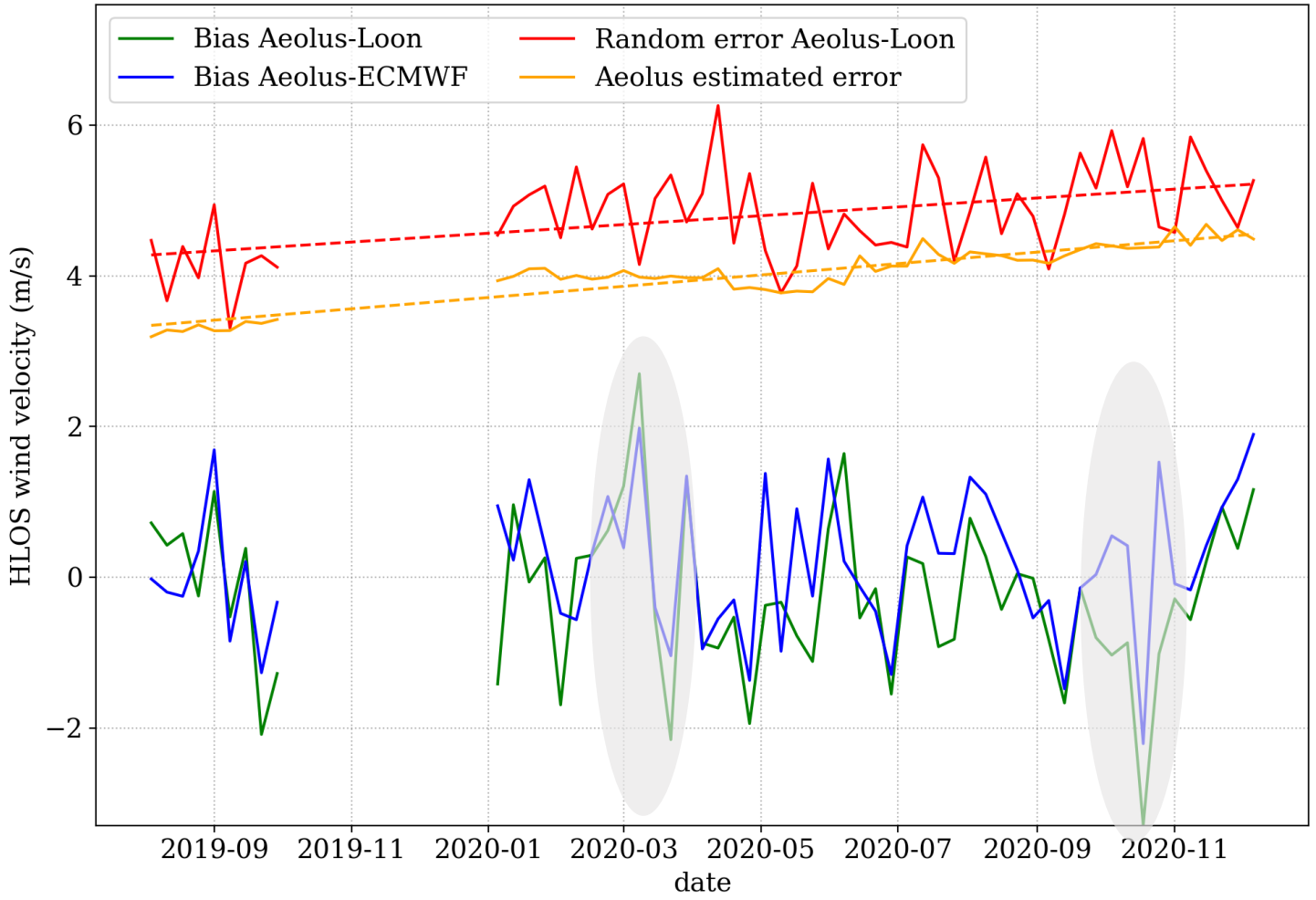
Results: Time series of wind biases and random errors



Applied QC

- Outliers filtered out, if difference > 15 m/s

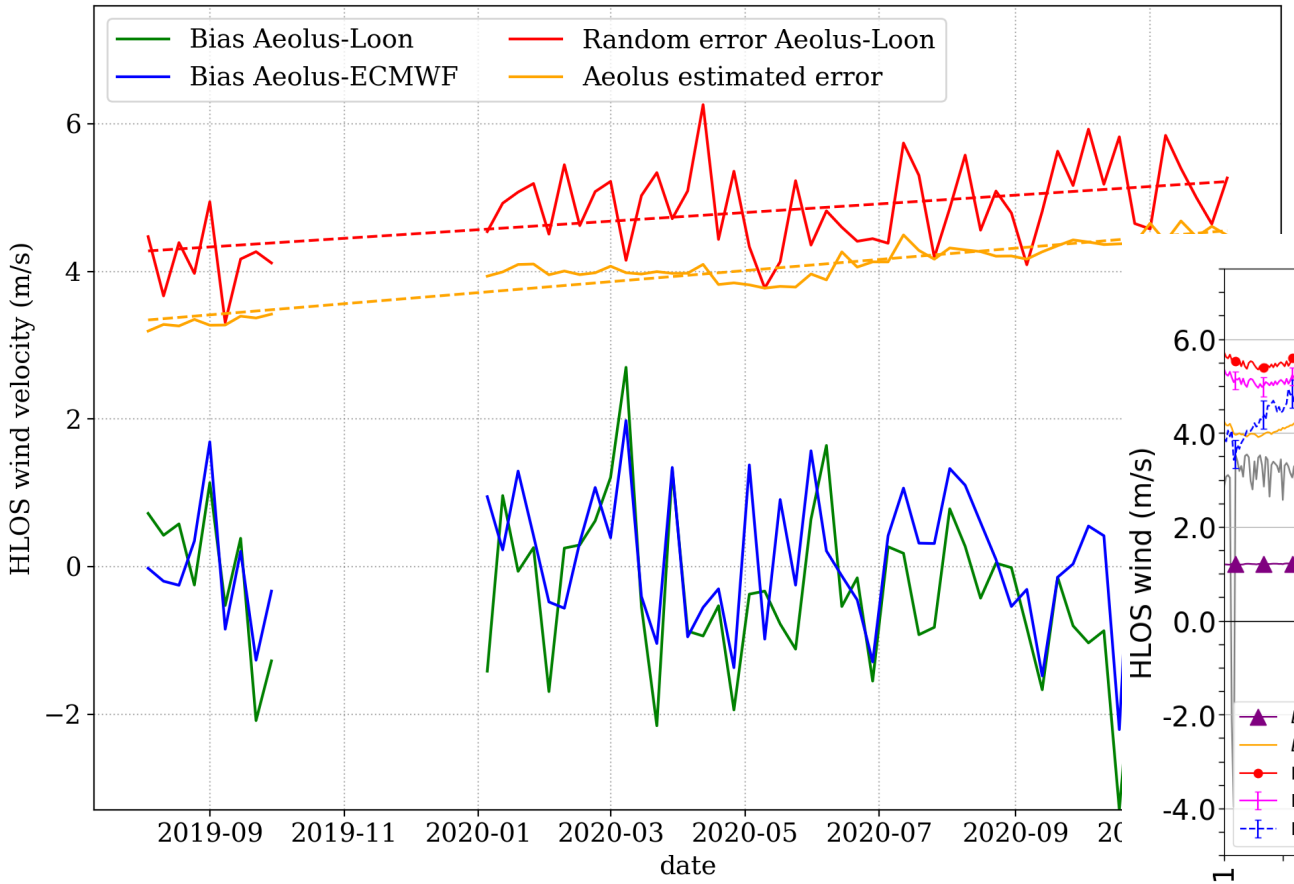
Results: Time series of wind biases and random errors



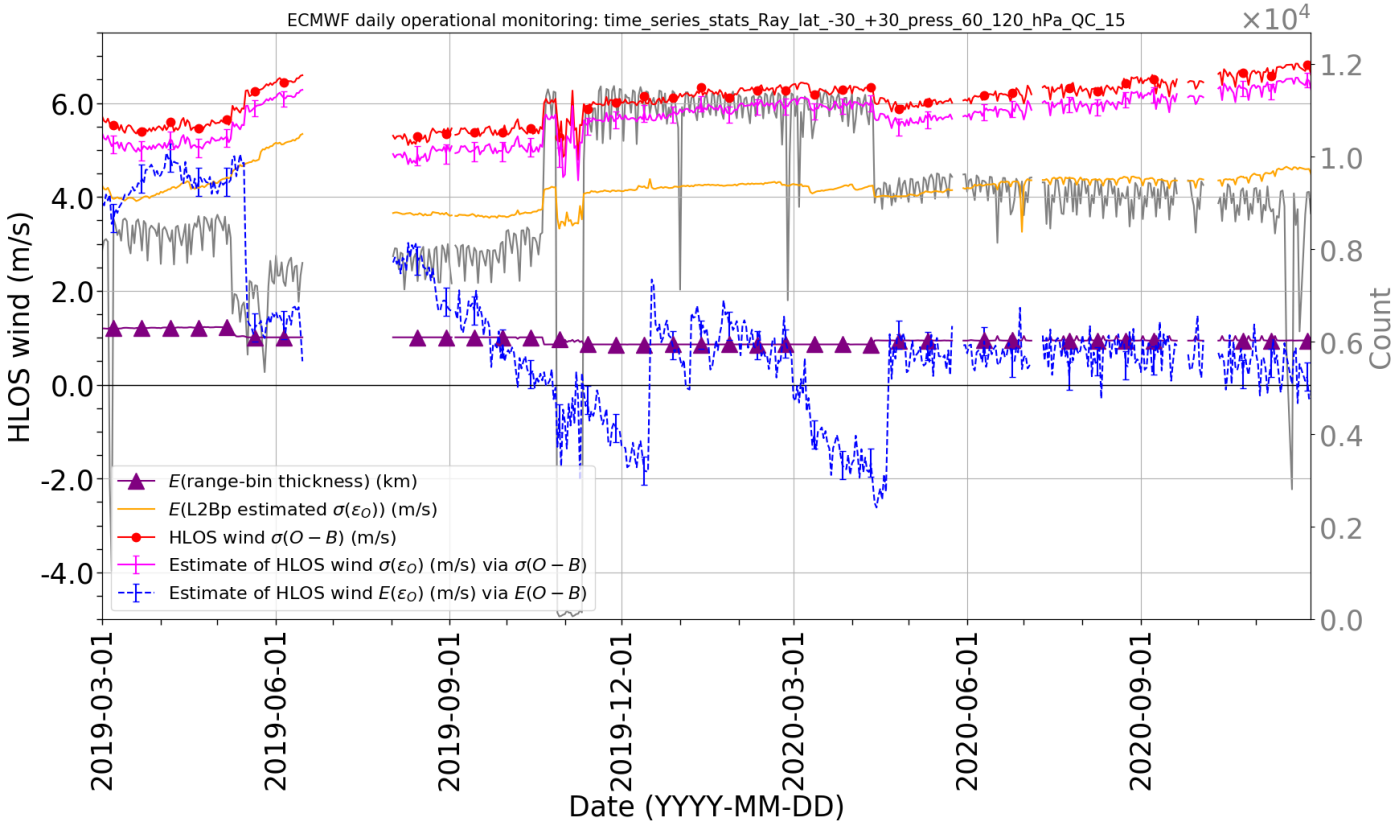
Applied QC

- Outliers filtered out, if difference > 15 m/s
- Largest systematic biases in March and October 2020

Results: Time series of wind biases and random errors



- Results from ECMWF monitoring for 30S-30N and 60-120 hPa (*Courtesy of M. Rennie*)

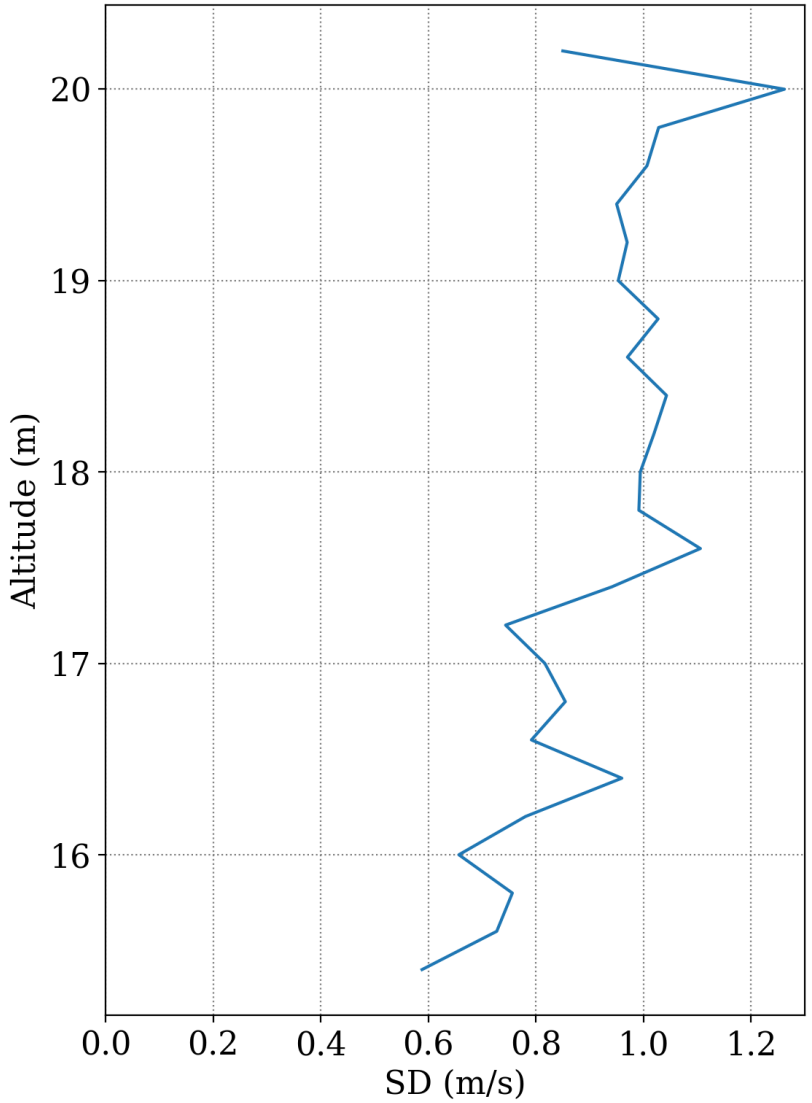


Results: Representativeness errors

→ Standard deviation of Loon winds 200 km centred around the actual Aeolus observation

→ Considering the random errors, Aeolus Rayleigh-clear winds provide a realistic representation of the wind variability in the UTLS

→ For the UTLS region, bigger contrainst are found in the vertical range.



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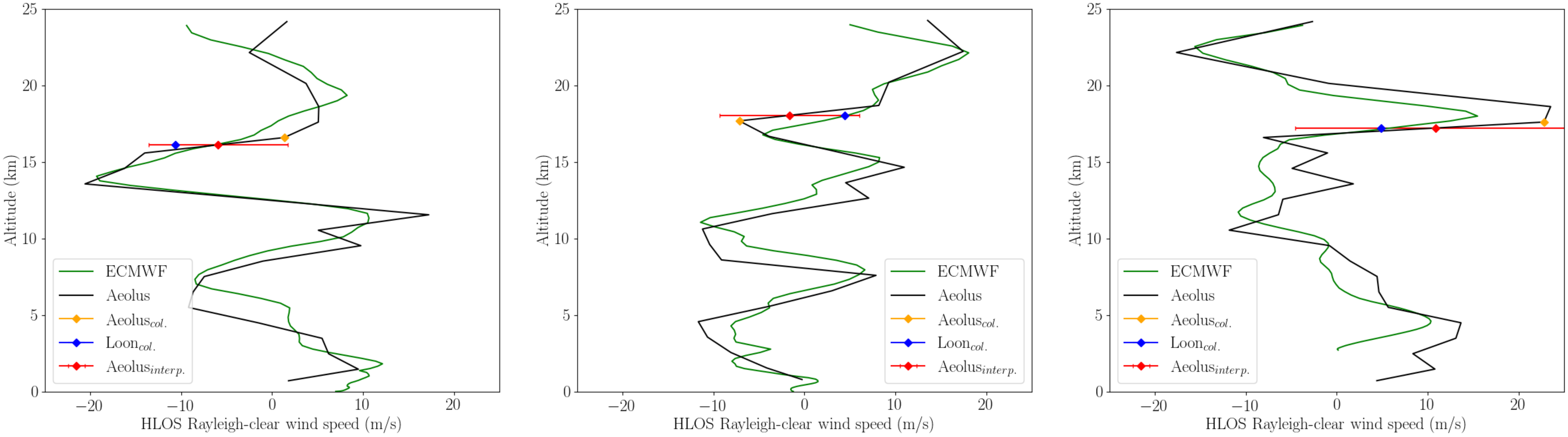

→ Vertical bin resolution of Aeolus profiles as limiting factor for mapping vertical wind shear
→ One HLOS result represents the mean of the 1km range bin
→ Interpolation can improve the results

Conclusion

→ Loon balloons provide unique dataset for regions of high impact and where almost no other independent observations are available

→ Aeolus observations provide a relatively good view on the horizontal variability of the wind velocity in the UTLS

→ However, the random errors have increased significantly over the analyzed time period

→ In order to quantify the vertical representativeness, collocated radiosonde observations are needed


Thank you!