

A central graphic for the ATMOS 2021 mission. It features a globe with a grid overlay. A satellite is shown in orbit above Europe. Surrounding the globe are several circular insets showing various atmospheric data visualizations, including wind patterns and temperature profiles. The text 'ATMOS 2021' is prominently displayed in the center of the globe.

# ATMOS 2021

## 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**

→ ATMOS 2021 - ESA ATMOSPHERIC SCIENCE CONFERENCE

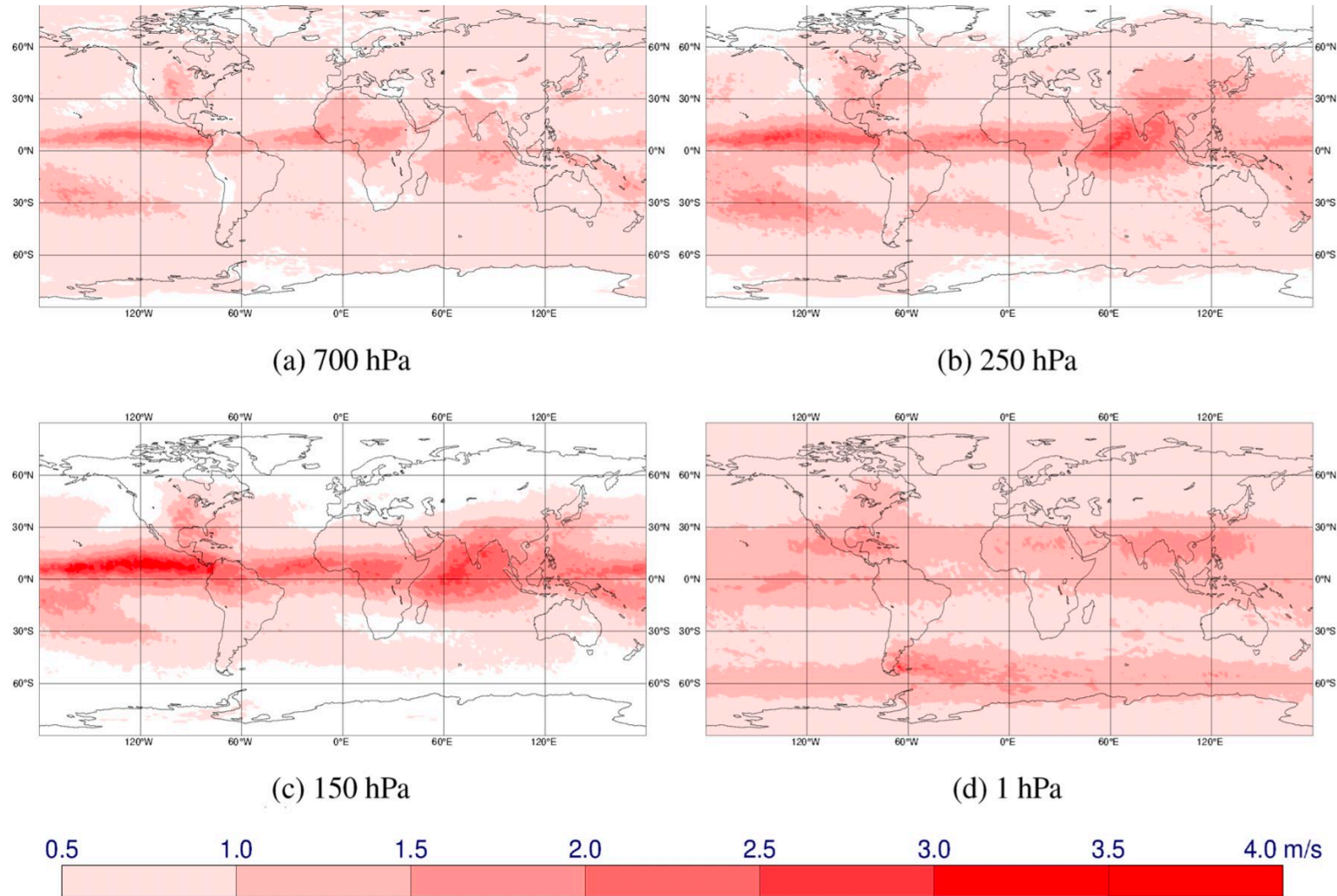
25.11.21

Stratospheric Winds from Aeolus and Loon Balloons. Contact: [bley@tropos.de](mailto:bley@tropos.de)

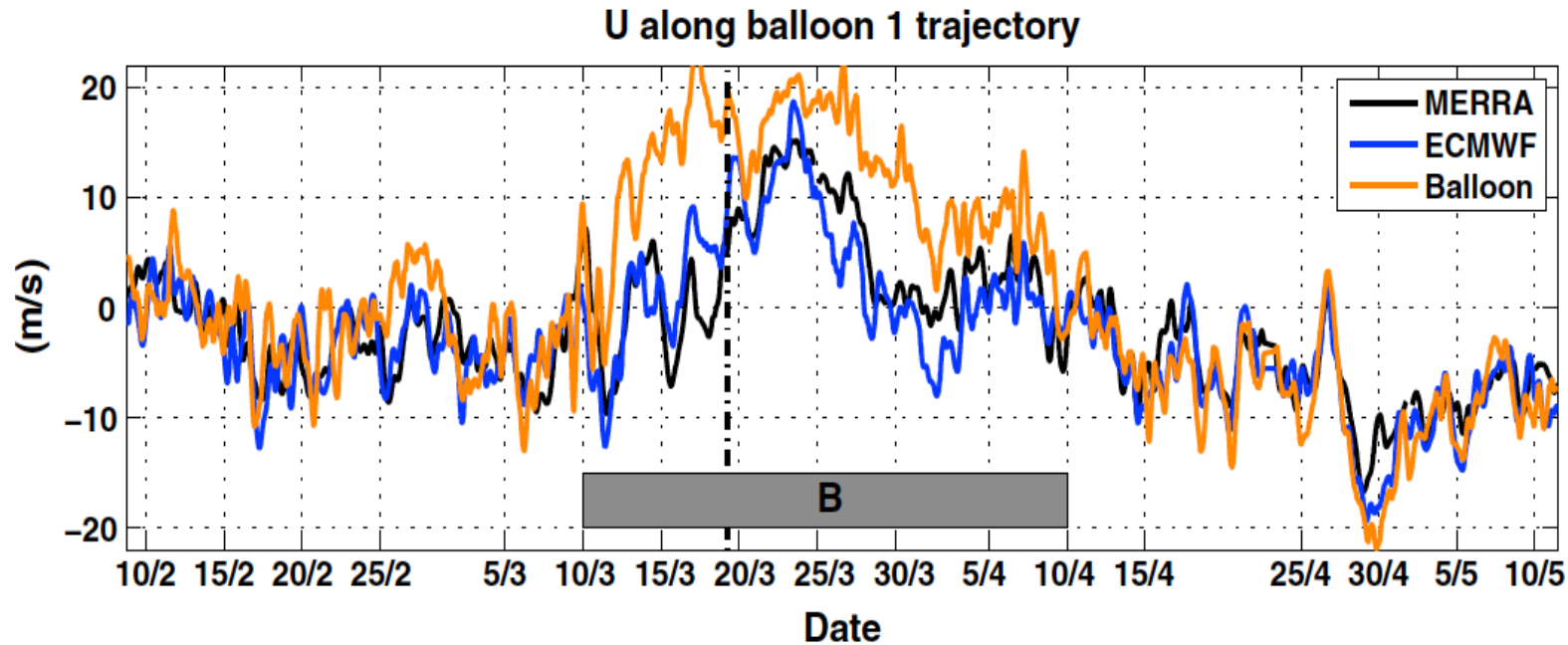


# Introduction

- 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.*



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 opportunities for Aeolus product validation and for quantification of the horizontal representativeness errors of Aeolus winds

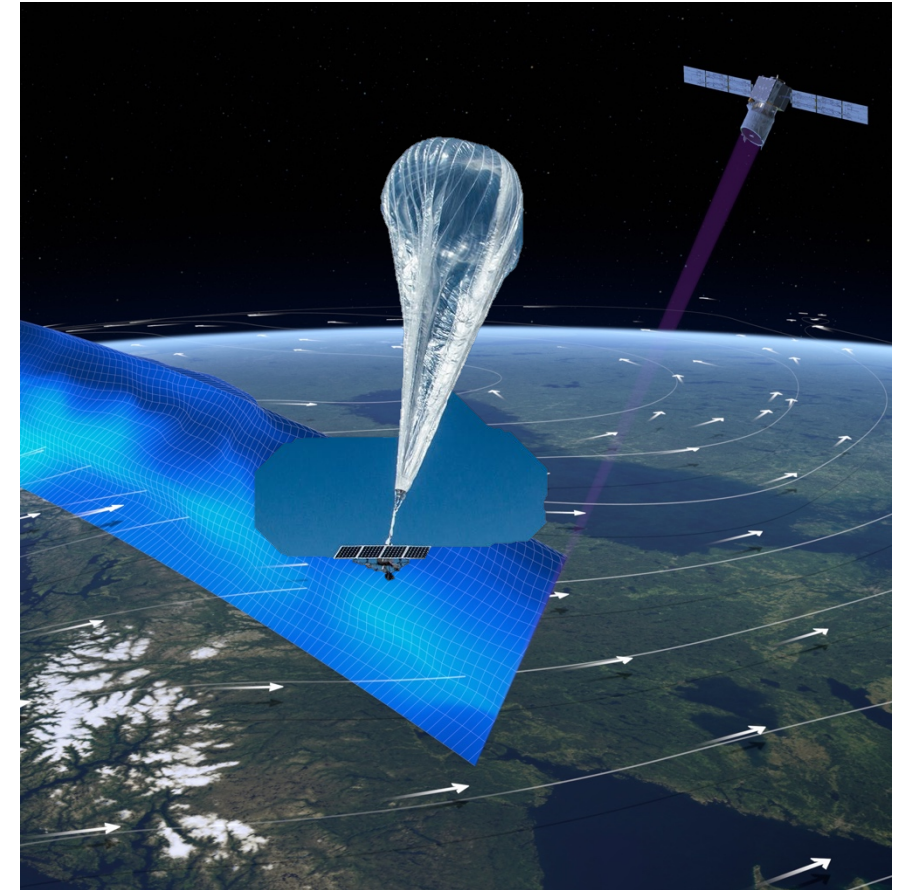


# Introduction

- 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

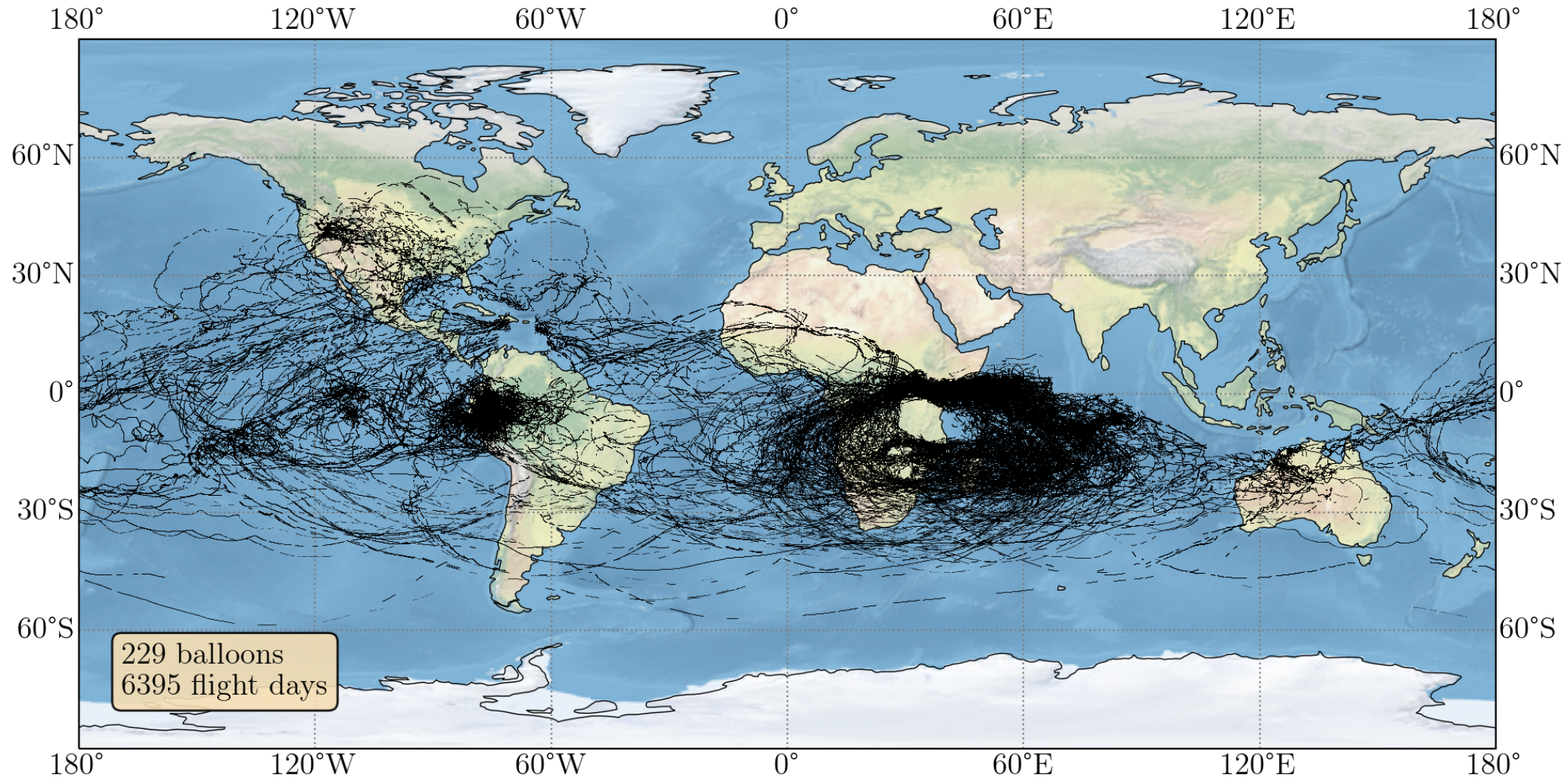


Image: <https://x.company/projects/loon/>

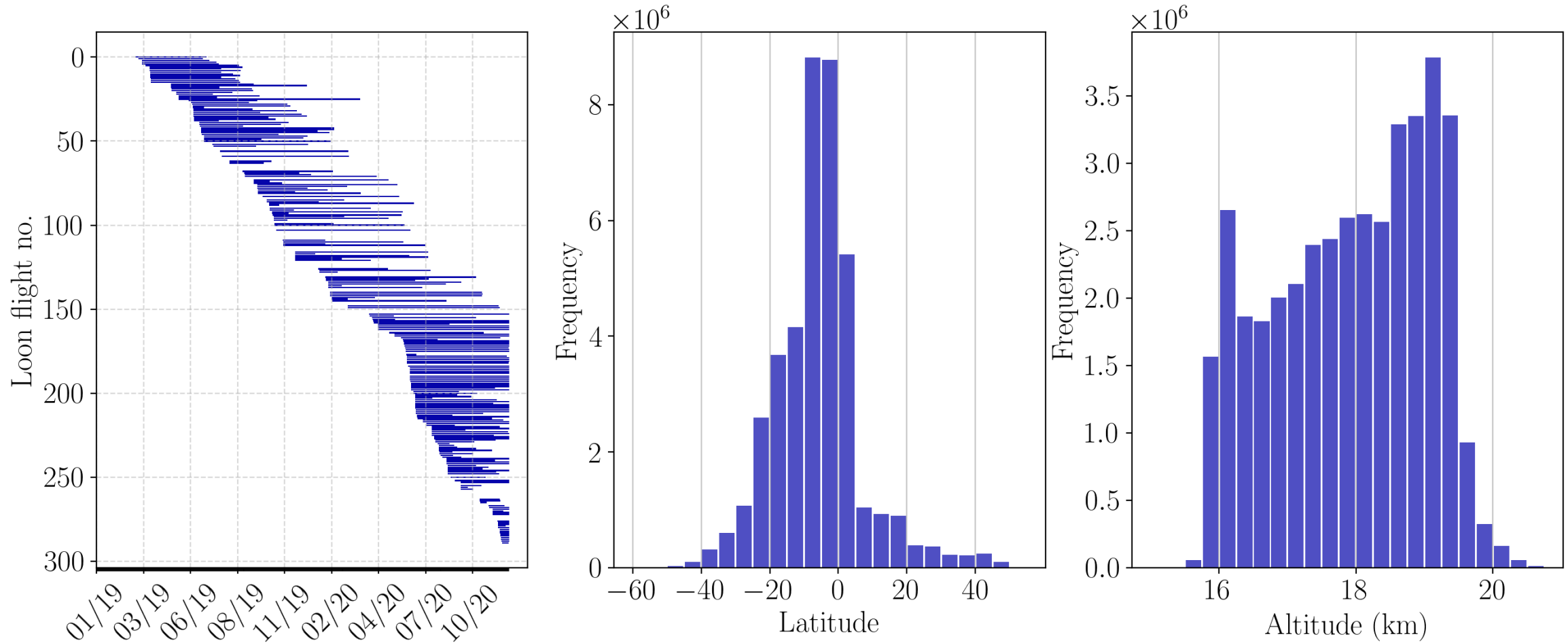




# Data: Loon trajectories March 2019 – December 2020

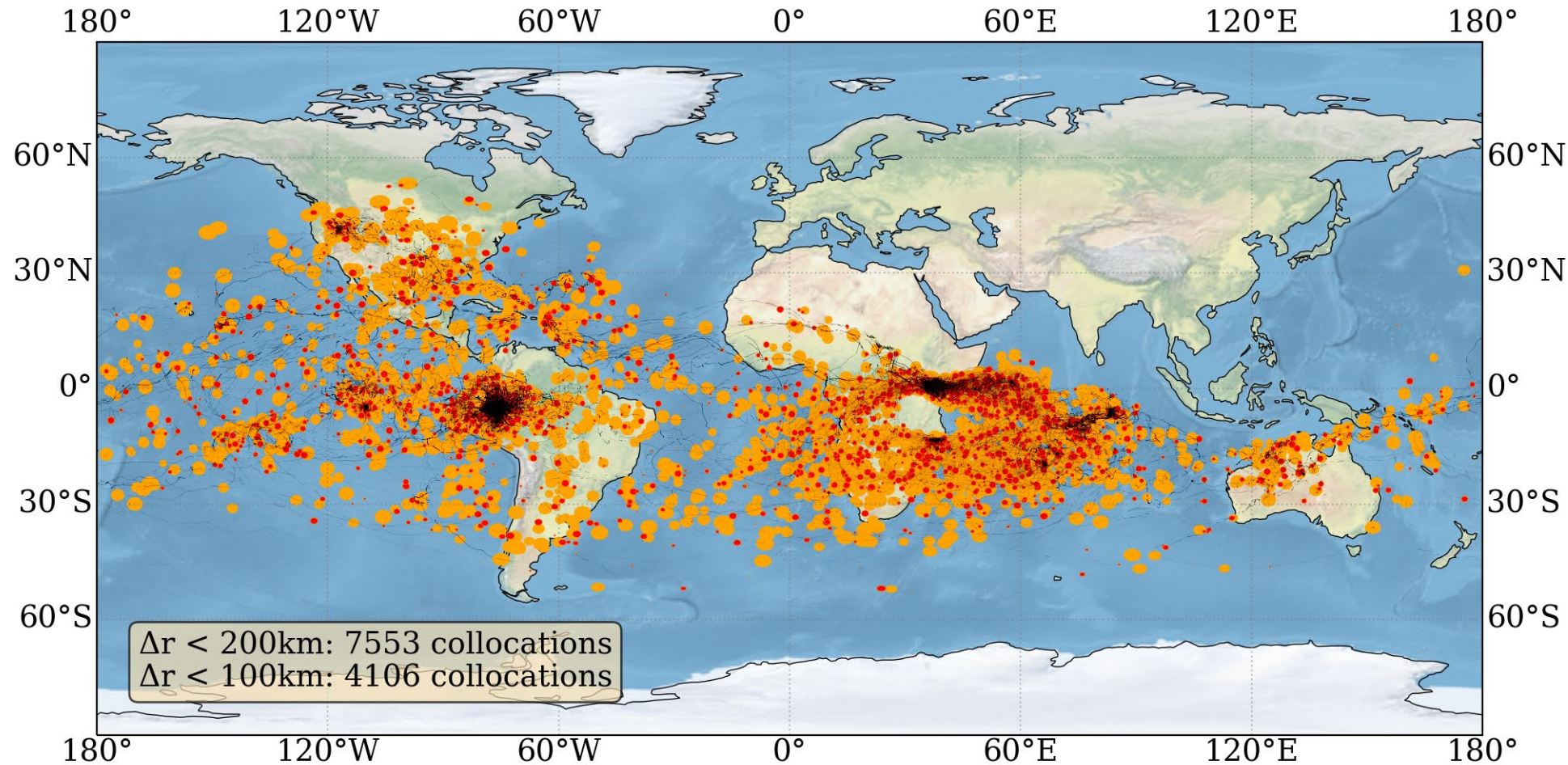


# Data: Aeolus Loon collocated measurements





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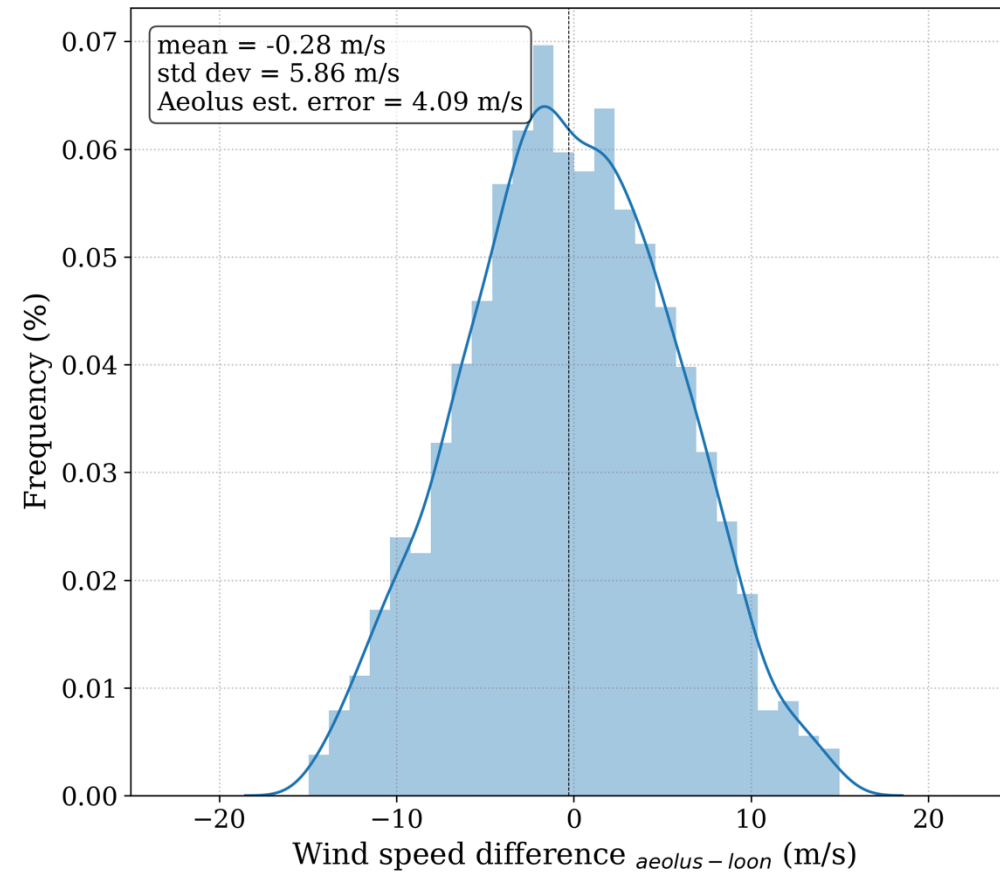
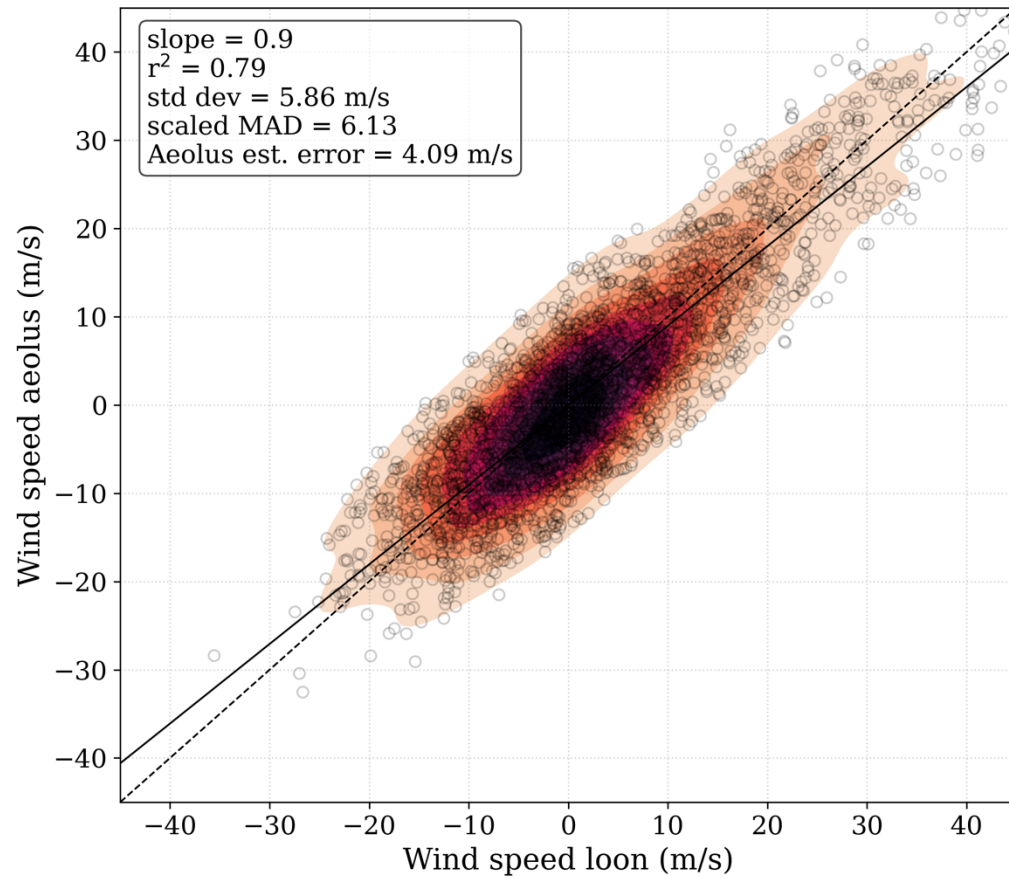


## Applied QC

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



# Results: Aeolus vs. Loon

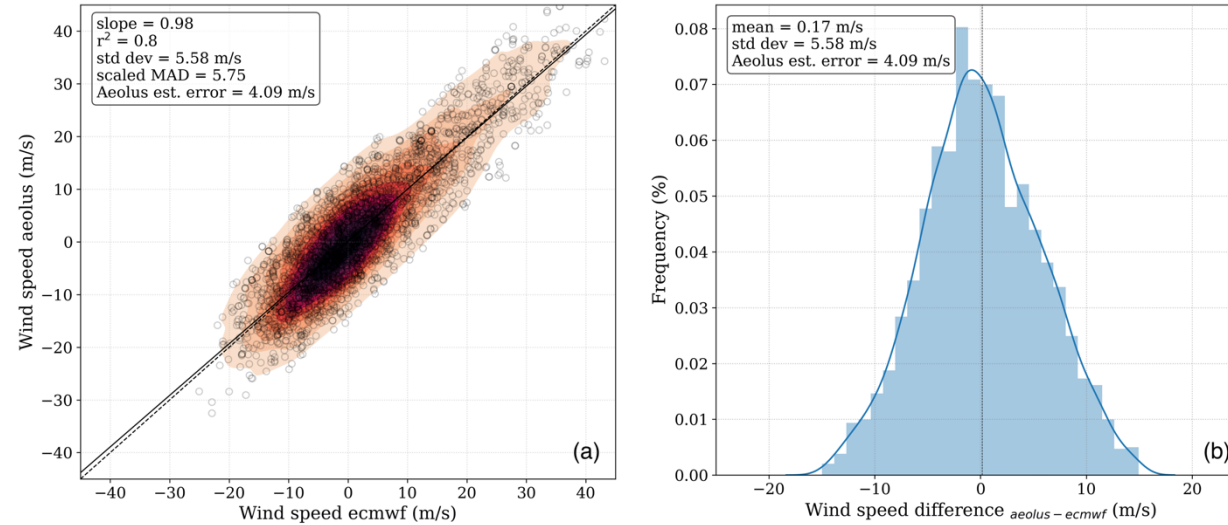


$$HLOS_{Loon} = -u \sin\phi - v \cos\phi$$



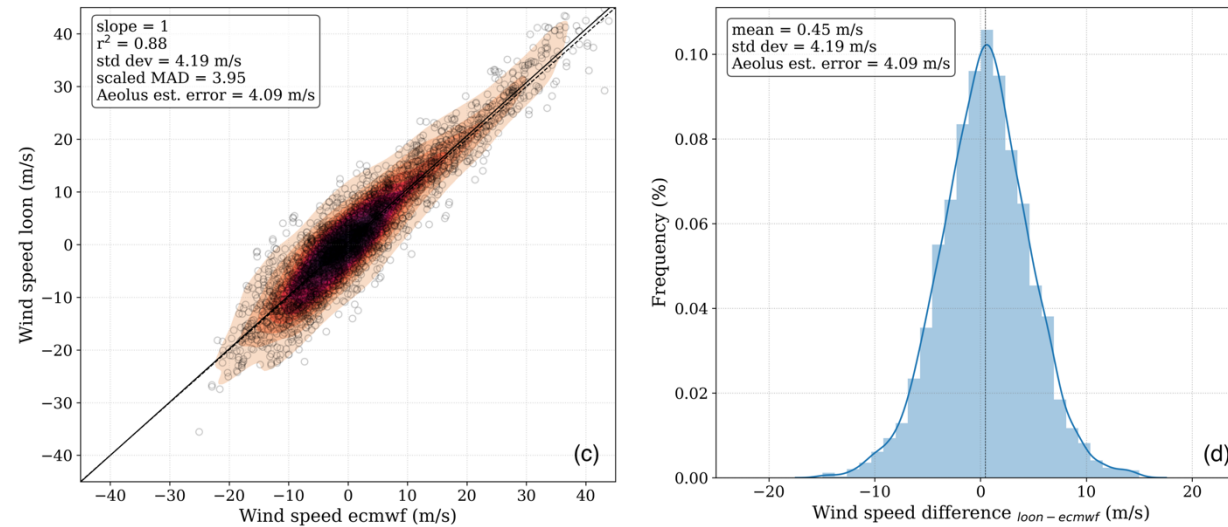
# Results: Comparison against ECMWF model winds

## Aeolus vs. ECMWF



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

## Loon vs. ECMWF





# Results: Time series of wind biases and random errors

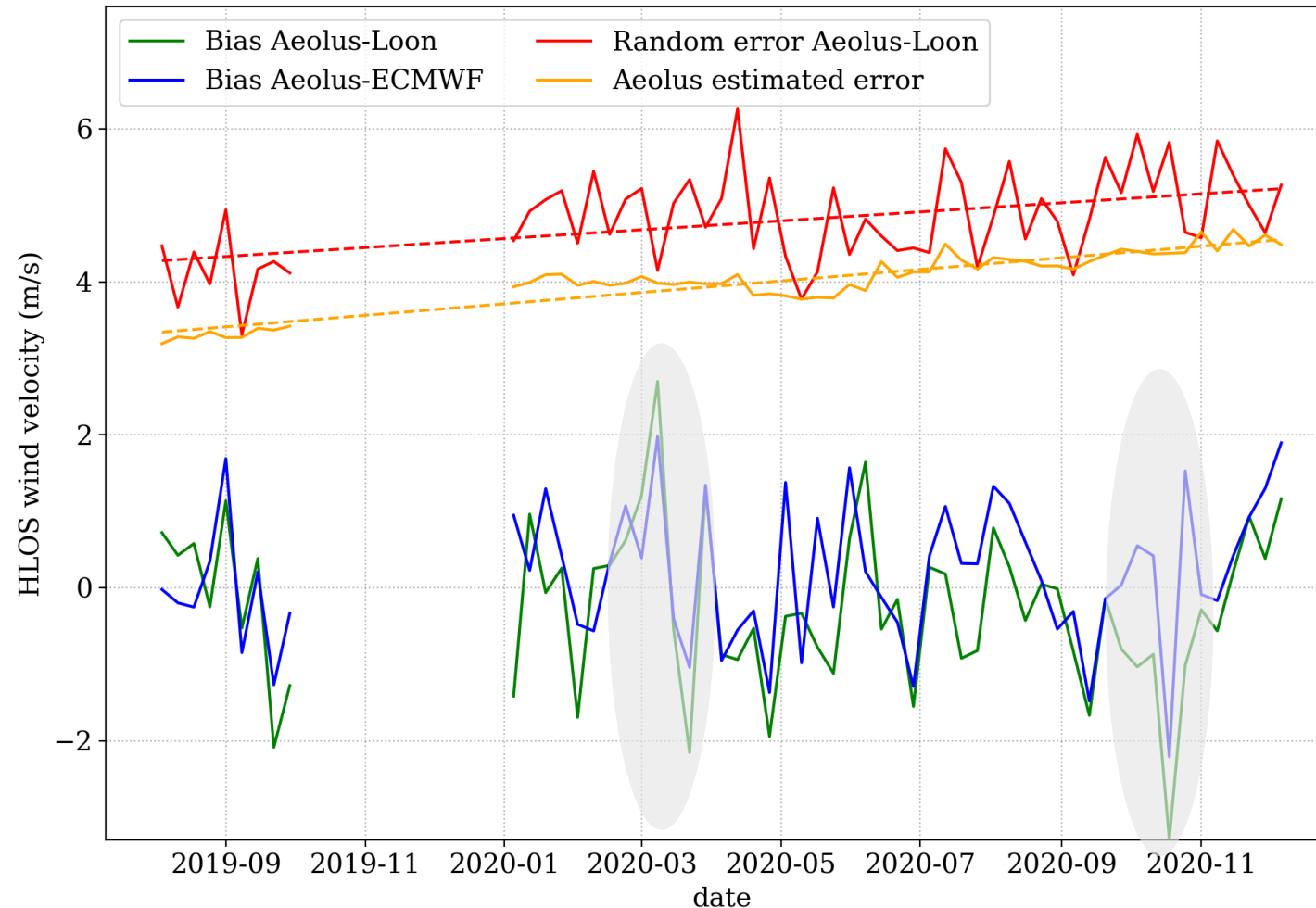


## Applied QC

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



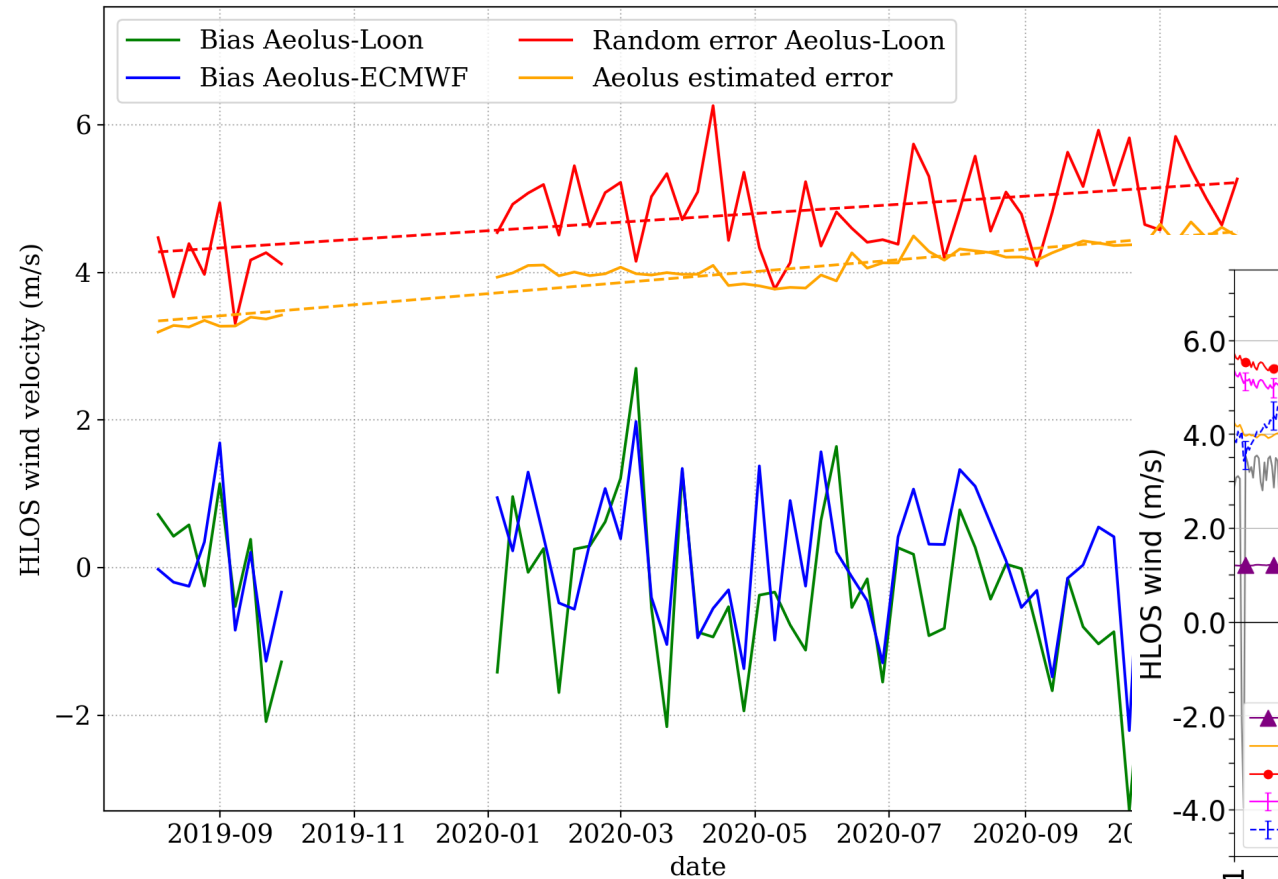
# Results: Time series of wind biases and random errors



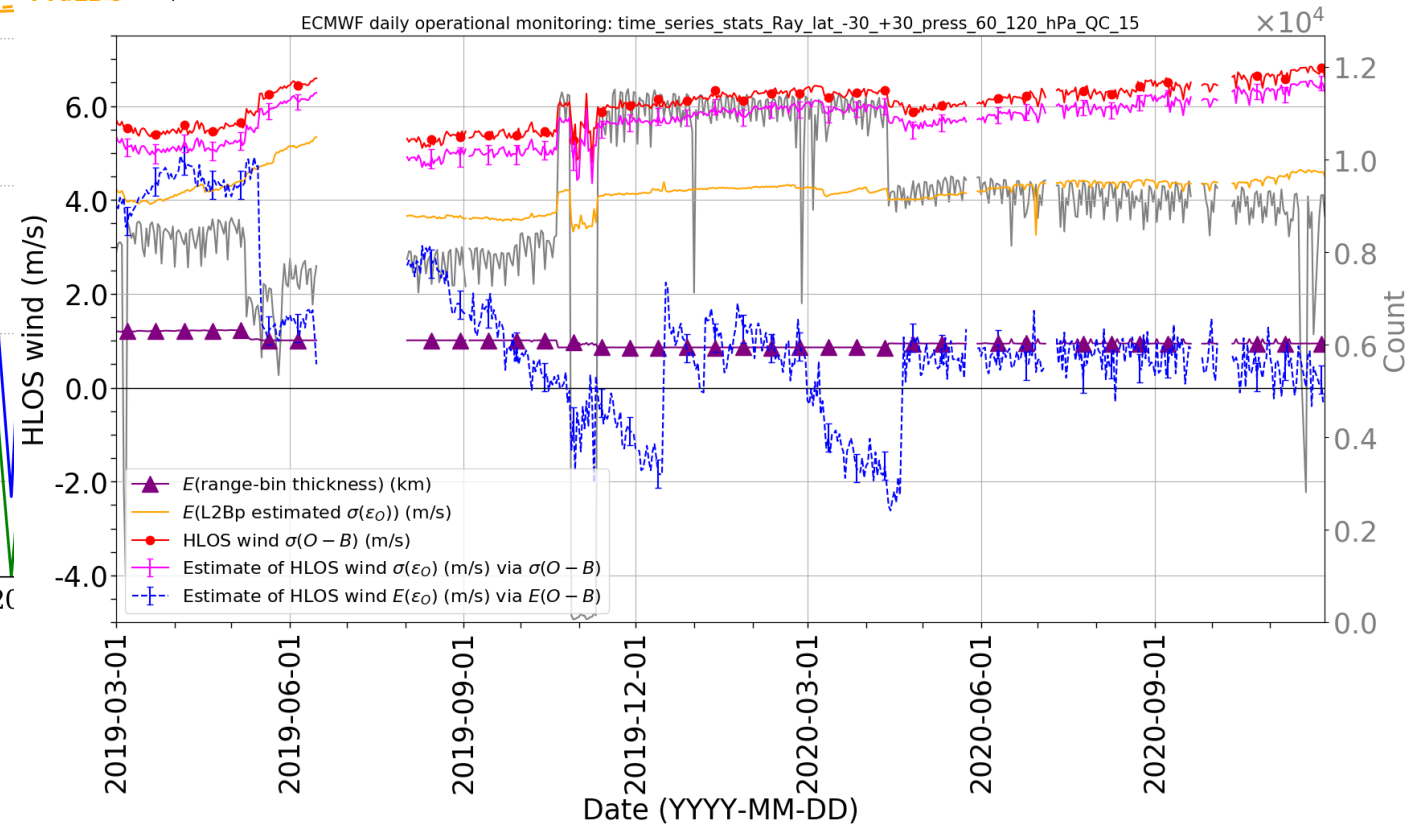
## Applied QC

- 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



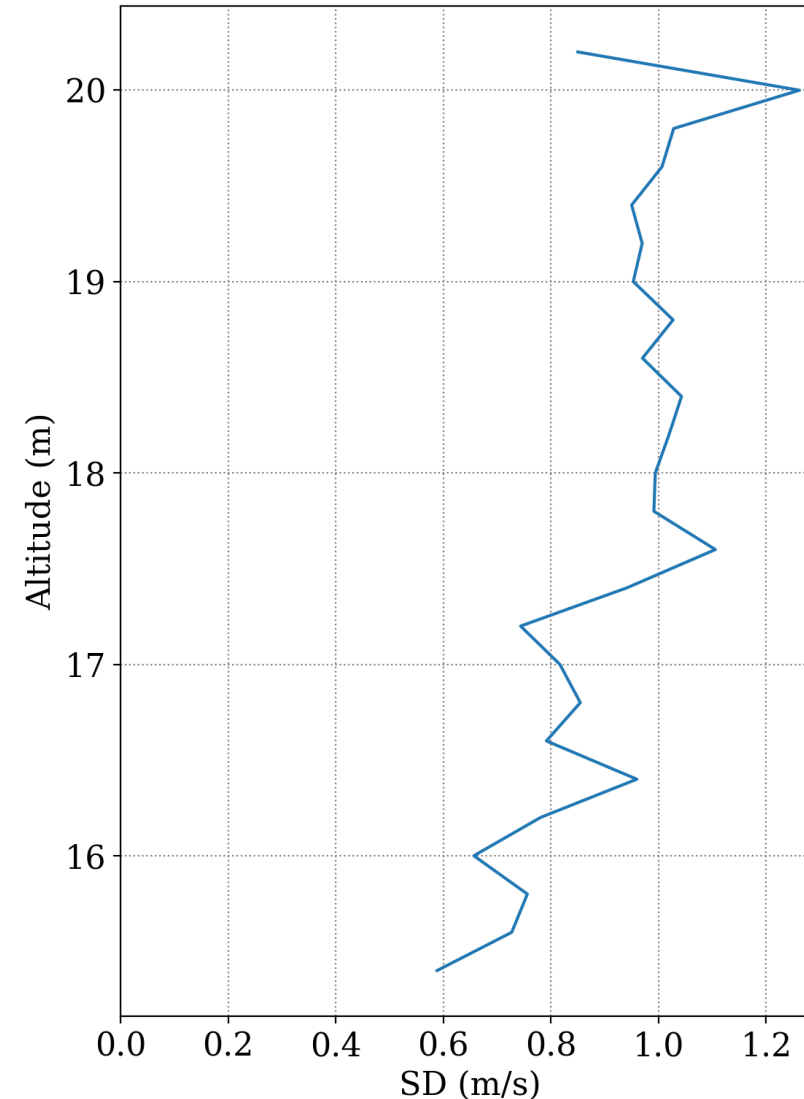
- Results from ECMWF monitoring for 30S-30N and 60-120 hPa (*Courtesy of M. Rennie*)



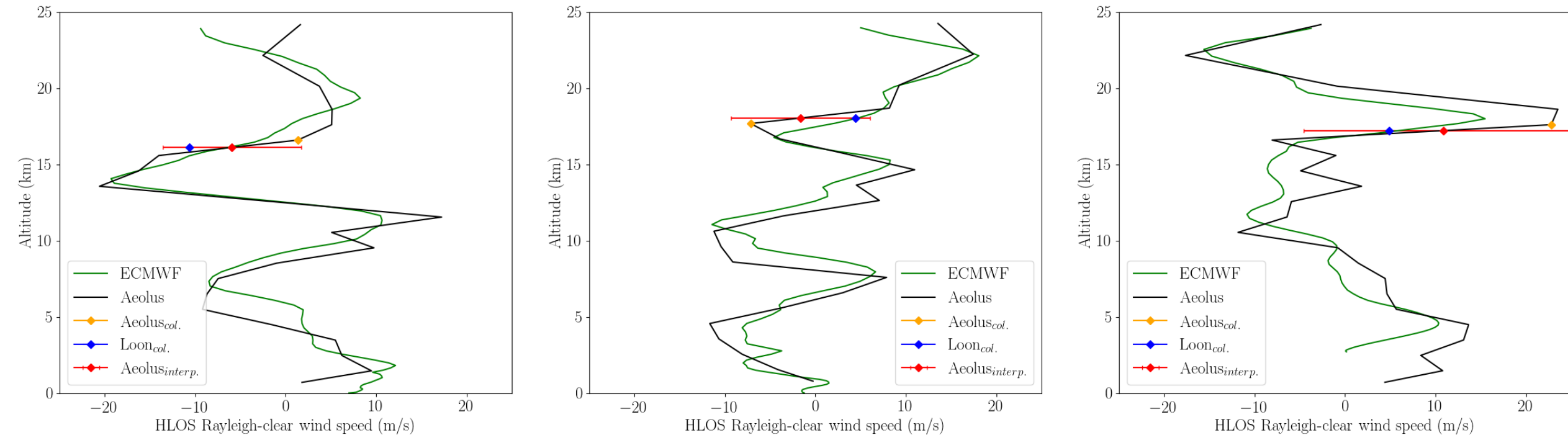


# Results: Representativeness errors

- 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 constraints are found in the vertical range.



# Results: Representativeness errors



- 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



A large, white, ribbed stratospheric balloon is being inflated by a large, black, metal structure. The balloon is suspended by ropes and is positioned in the center of the frame. The structure is made of a complex network of metal beams and cables. In the background, there are trees and a blue sky with white clouds. In the foreground, there are two people looking at the balloon. One person is wearing a blue shirt and the other is wearing a black jacket. There is also a solar panel on the ground.

# Thank you!