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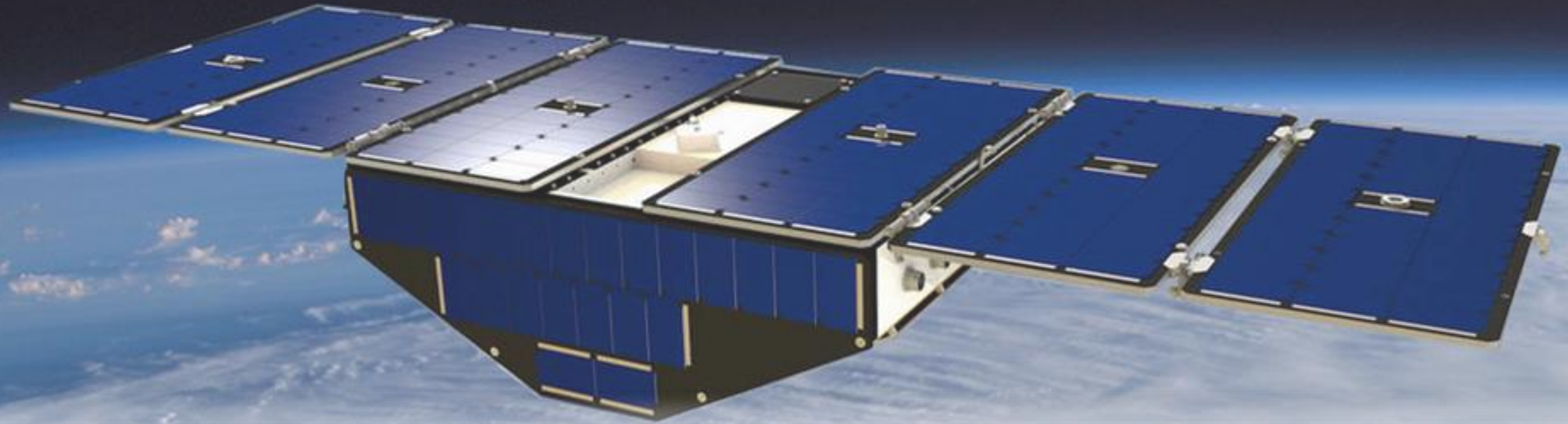

Deep learning in spaceborne GNSS-R:
Recent methodologies and atmospheric products

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EGU General Assembly 2022
Atmospheric and Environmental Monitoring with Space-Geodetic Techniques
and Contributions to Extreme Weather Studies (G5.2)
23.05.2022, Vienna

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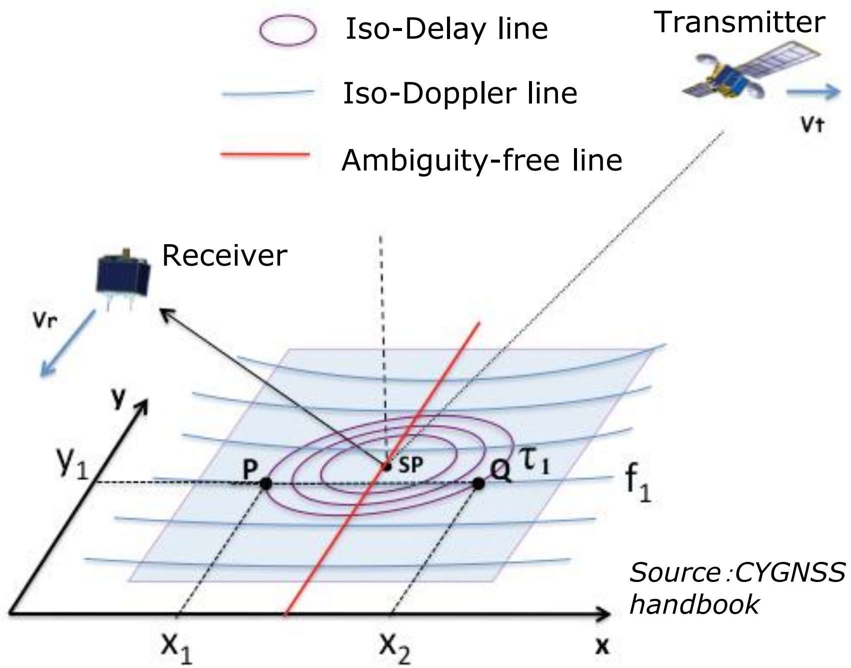
Deep learning in spaceborne GNSS-R

CYGNSS -
Cyclone Global Navigation Satellite System

- Initial dedicated GNSS-R constellation for ocean wind speed determination
- 8 Low Earth Orbiting microsatellites
- Each satellite can track 4 GNSS signals at most -- 32 wind measurements per second
- Approx. revisit time: 2.8~7.2 hours
- Designed wind speed retrieval accuracy: 2 m/s
- Cost-effective
- High spatiotemporal resolution

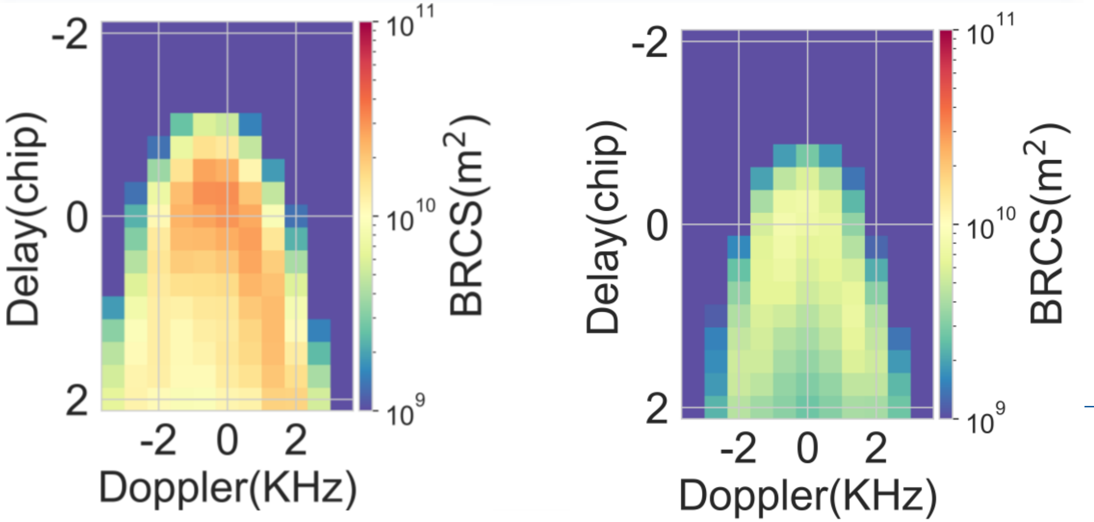


Source :CYGNSS handbook

Delay-Doppler Map (DDM)

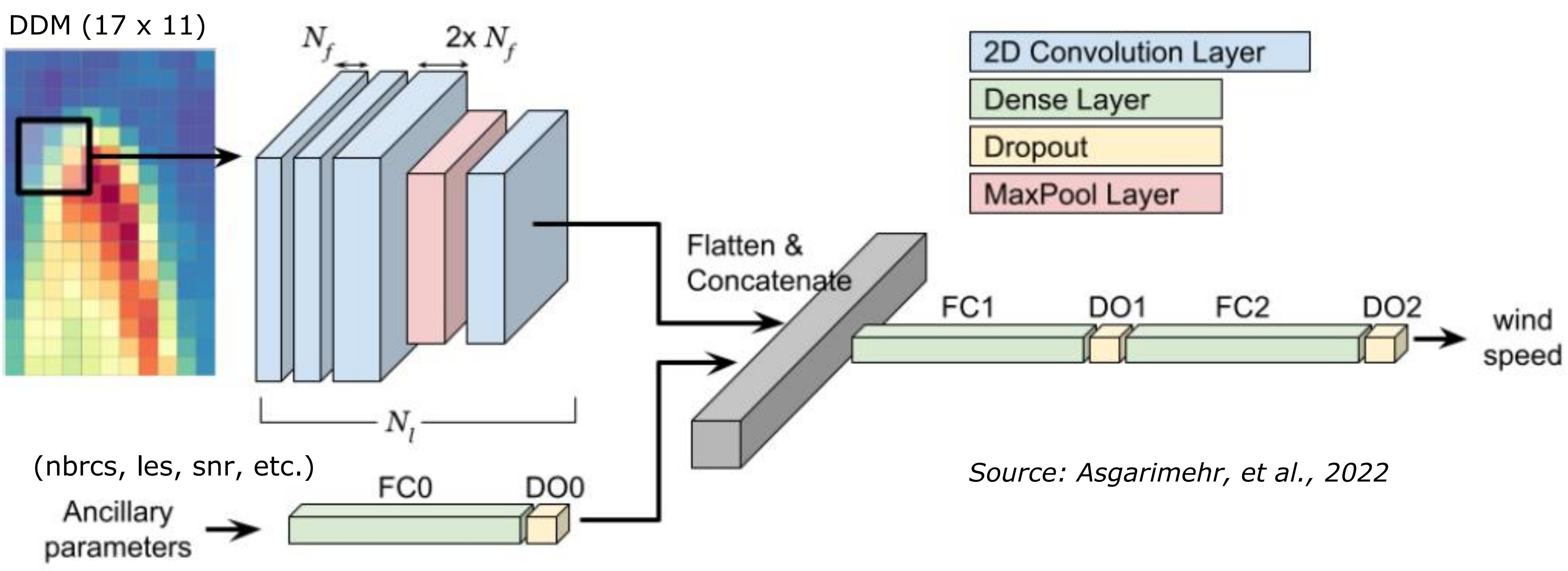
Wind speed: 2.68 m/s

Wind speed: 12.90 m/s

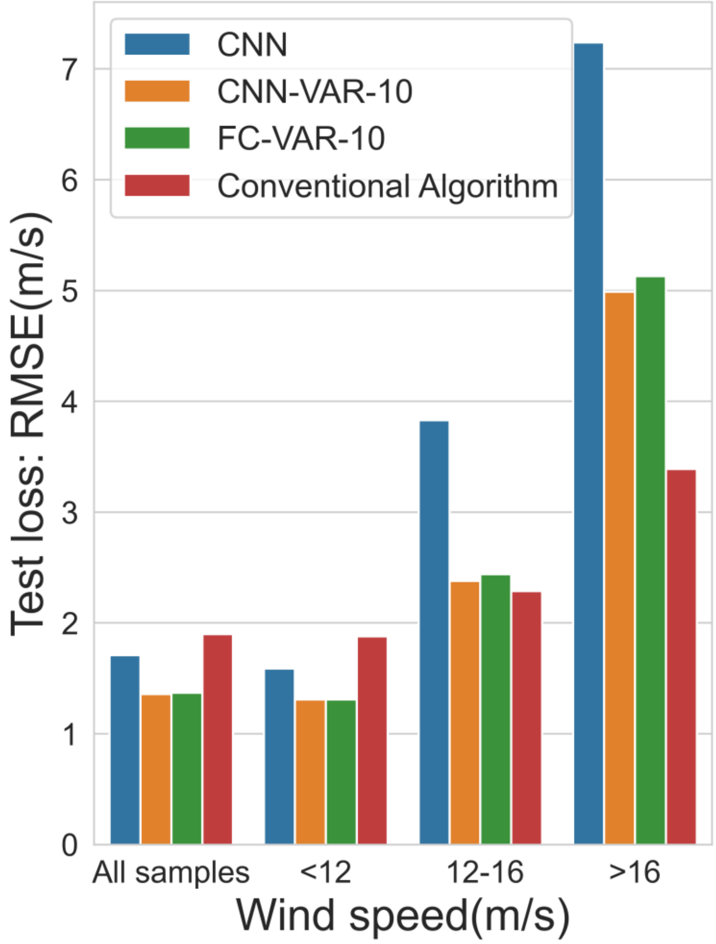


Deep learning in spaceborne GNSS-R -- Model

CYGNSSnet



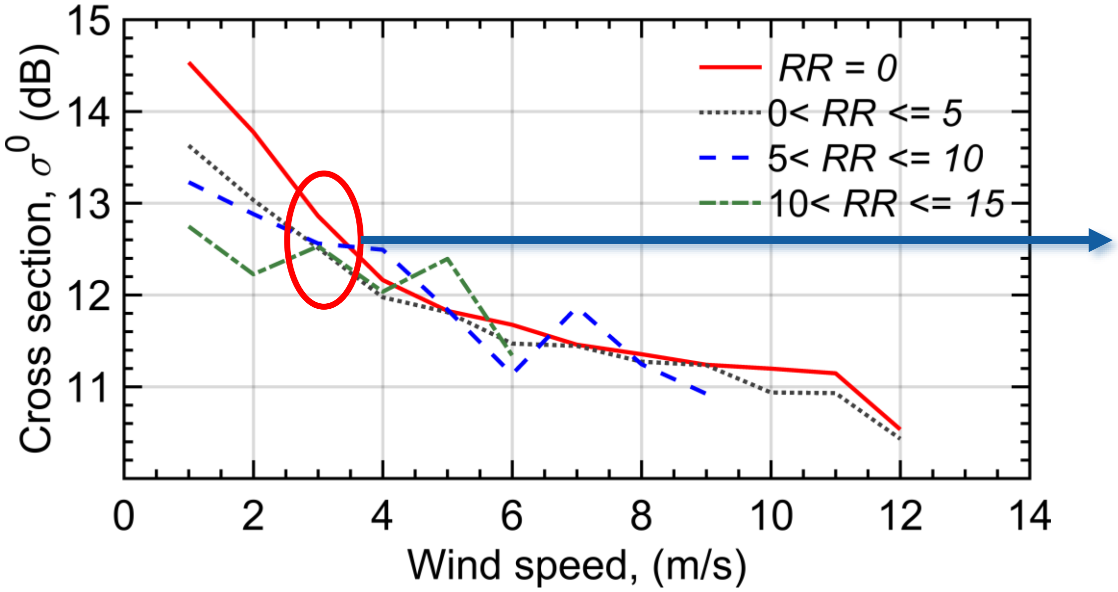
Source: Asgarimehr, et al., 2022



Model	CNN	CNN-VAR-10	FC-VAR-10	Conventional Algorithm
Observable input (per sample)	1 ddm	1 ddm + 10 Ancillary parameters	10 Ancillary parameters	Derived from CYGNSS L2 data

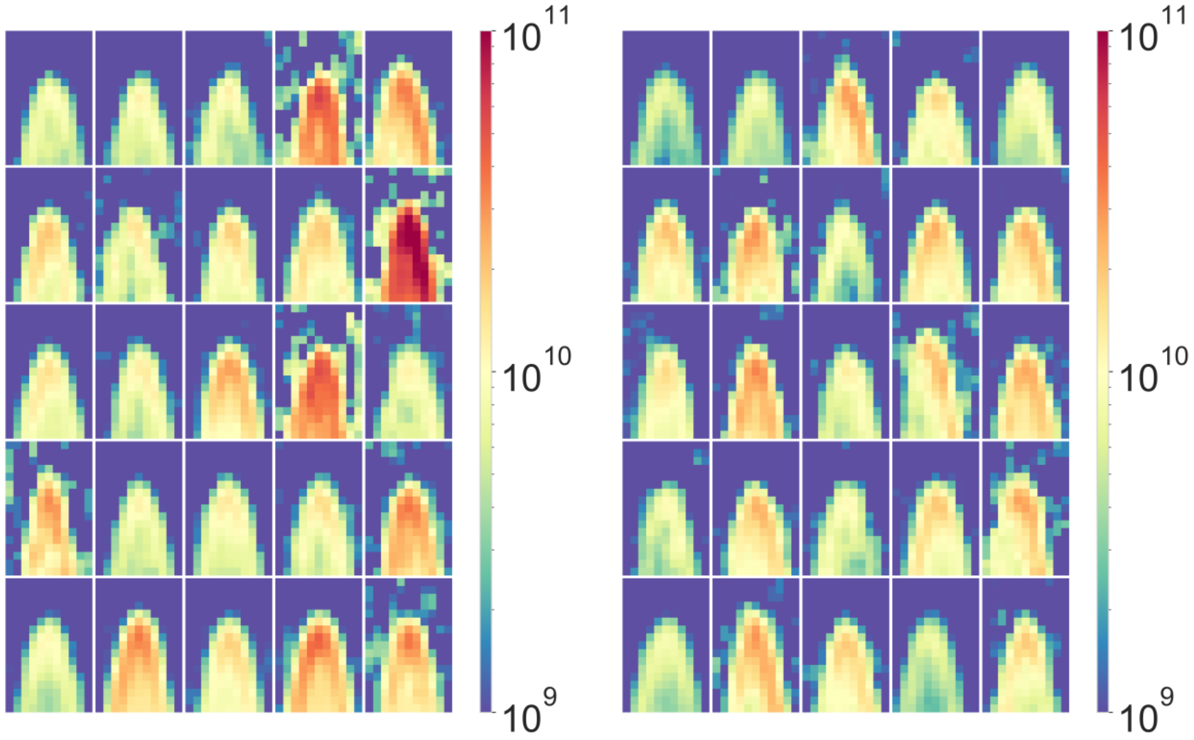
Deep learning in spaceborne GNSS-R -- Rain Effect

BRCS responds to precipitation with a drop in its value at Low wind speed (<4 m/s)



Source: Asgarimehr, et al., 2018

DDMs of low wind speed



Data fusion with precipitation

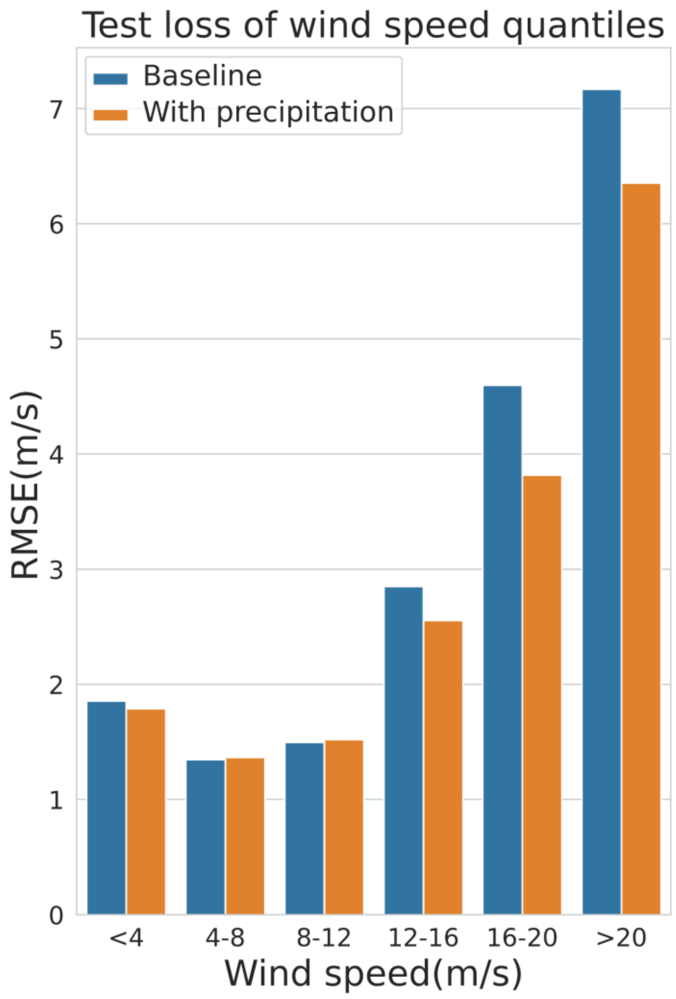
Baseline update:

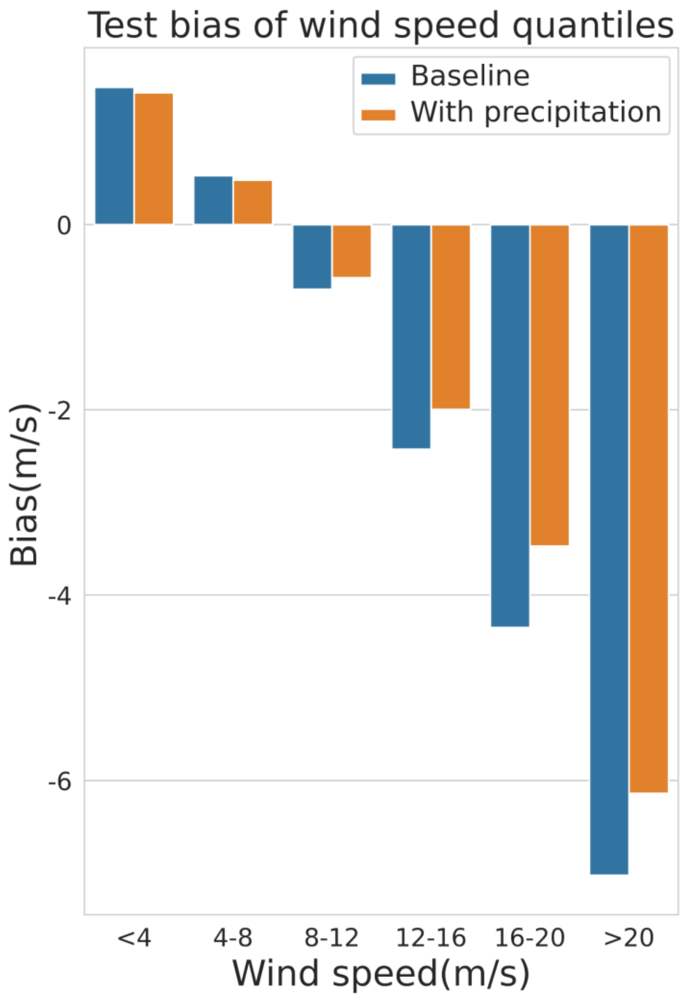
Dataset version: v3.0

Input DDM: 4 per sample

Input ancillary parameters: 23 per sample

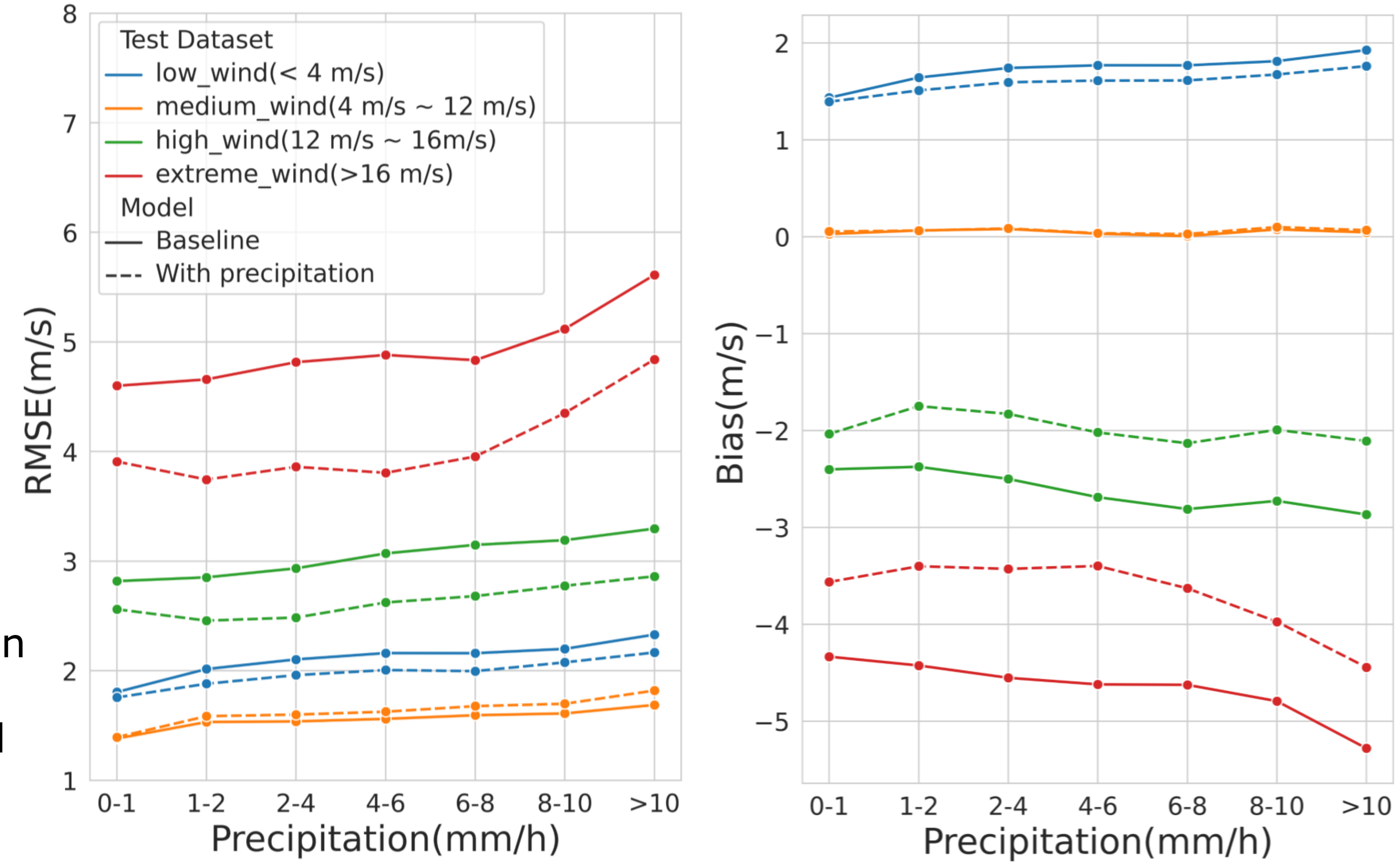
Additional input: GPM precipitation





Data fusion with precipitation -- Results

Precipitation quantile loss and bias for test samples at different winds peed



Model trained with precipitation data performed better when wind speed is low(<4m/s) and higher(v>16m/s)

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Conclusion

- CyGNSSnet shows a significant improvement in the general RMSE (28%) compared to the baseline winds derived from the algorithm based on minimum variance estimations.
- However, reaching MVE accuracy is still a challenge at higher winds.
- Deep learning offers the capability of correcting the effects dictated by the data.
- Data fusion with GPM precipitation data can correct the effect of precipitation and improve the wind speed predictions, especially at low wind speed (<4m/s) and extreme wind speed(>16m/s).

Future work

- Improve current model performance at medium wind speed (4~12 m/s)
- Investigate other potential error source such as swell
- Addressing the unbalanced data
- Combination of physics-based and deep learning methods

References:

Asgarimehr, Milad, et al. "GNSS reflectometry global ocean wind speed using deep learning: Development and assessment of CyGNSSnet." *Remote Sensing of Environment* 269 (2022): 112801.

Asgarimehr, Milad, et al. "Remote sensing of precipitation using reflected GNSS signals: Response analysis of polarimetric observations." IEEE Transactions on Geoscience and Remote Sensing 60 (2021): 1-12.

Asgarimehr, M., Zhelavskaya, I., Foti, G., Reich, S., & Wickert, J. (2019). A GNSSR geophysical model function: Machine learning for wind speed retrievals. IEEE Geoscience and Remote Sensing Letters, 17(8), 1333-1337.

Asgarimehr, Milad, et al. "Can GNSS reflectometry detect precipitation over oceans?." Geophysical research letters 45.22 (2018): 12-585.

Asgarimehr, Milad, Jens Wickert, and Sebastian Reich. "TDS-1 GNSS reflectometry: Development and validation of forward scattering winds." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 11.11 (2018): 4534-4541.

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Thank you!

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