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# Bias estimation of Doppler radar radial wind observations

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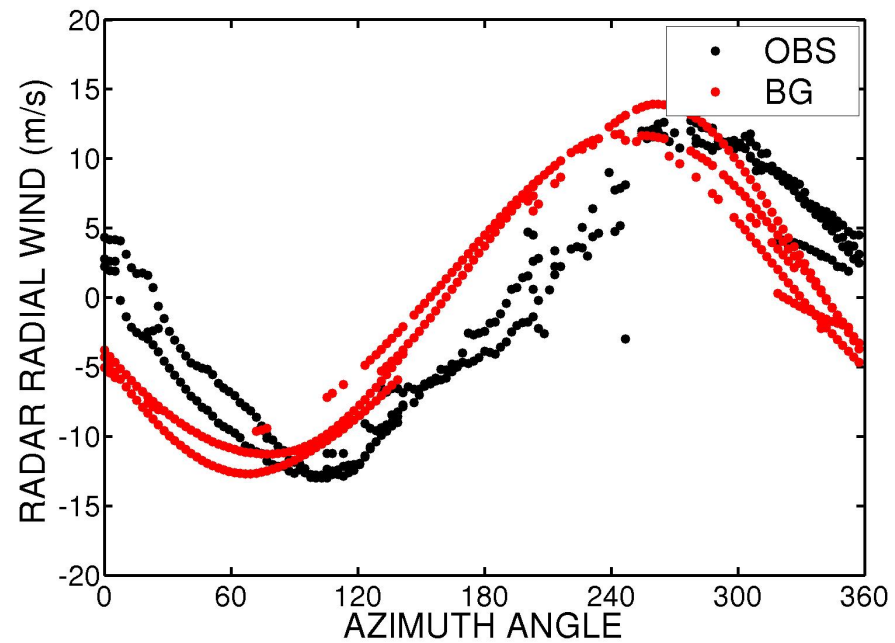
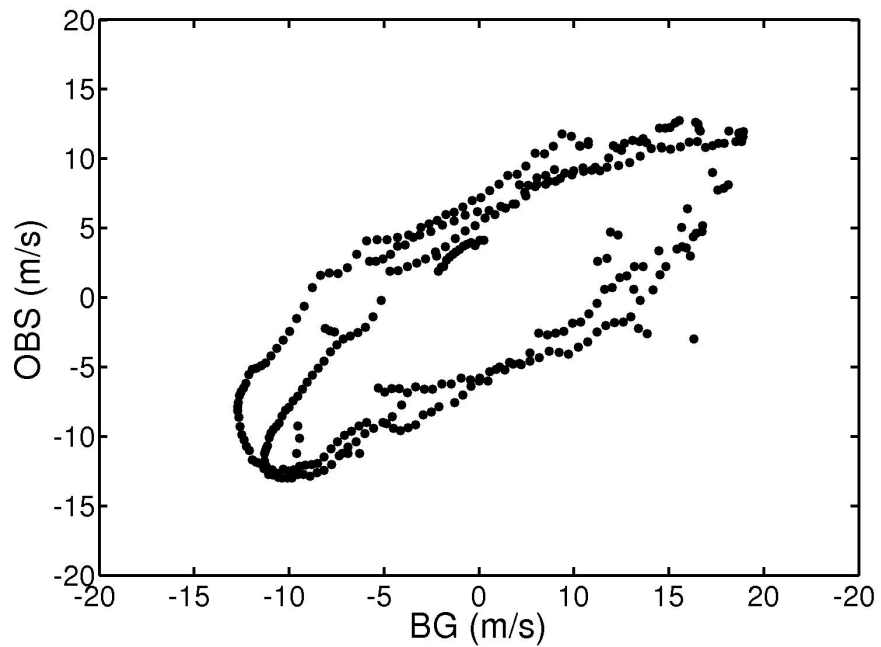
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# Motivation





# Measurement principle

## Doppler radar radial wind:

- is determined from the phase difference between the back-scattered returns from successive radar pulses.
- has a cosine form as a function of azimuth angle, if the wind field is uniform.
  - amplitude of the cosine defines the wind speed
  - phase of the cosine defines the wind direction.

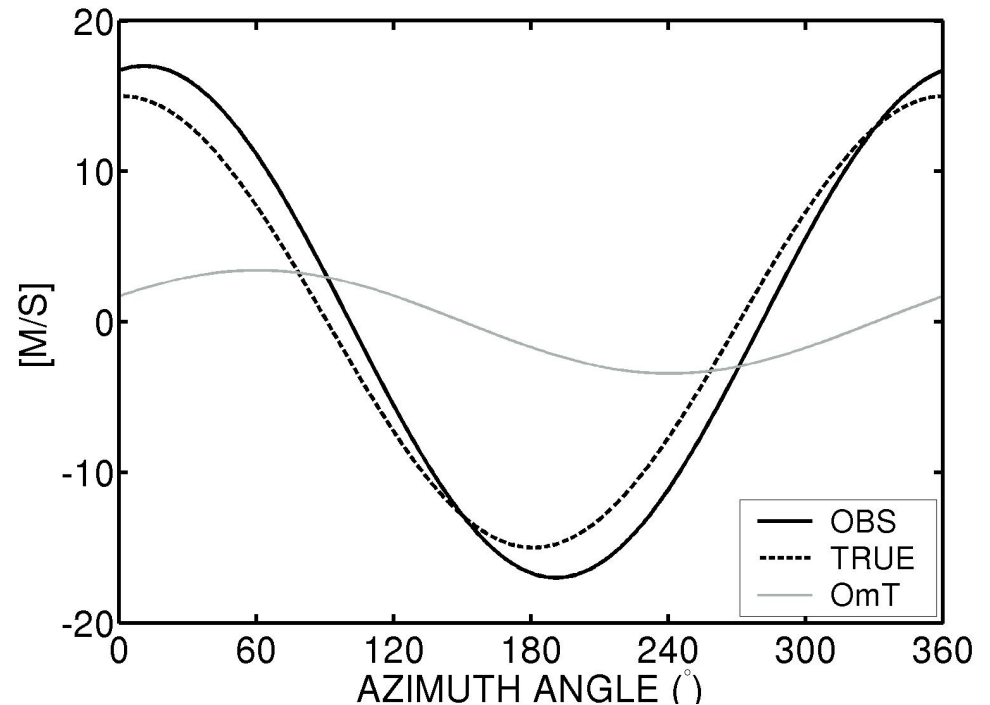


# A conceptual example of the behaviour of the radial wind bias

Obs: 17 m/s from 190°

True: 15 m/s from 180°

- The bias statistic calculated by summing up the individual OmT values is **zero**.





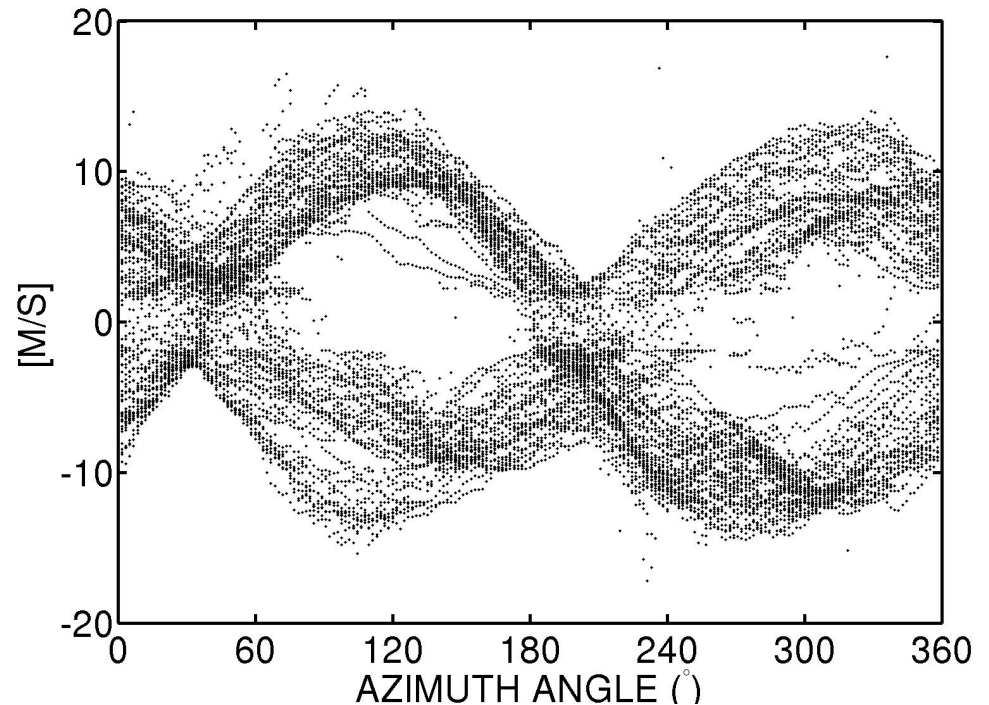
# Behaviour of the radial wind bias

- Non-zero bias statistic is obtained when
  - wind field is not uniform
  - there is no back-scattering in all azimuth directions
  - the radar is unable to measure all azimuth directions due to obstacles
  - the radar measurement is contaminated by non-meteorological echoes like birds, ground clutter etc.



# Bias estimation method (1)

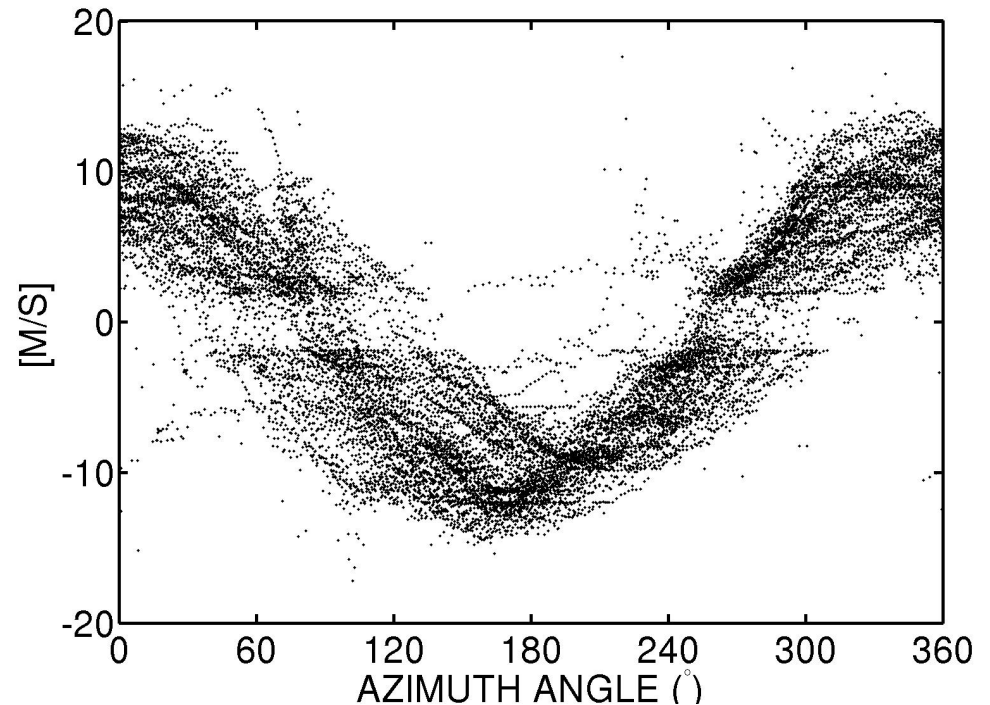
- Wind direction varies from day to day and from radar to radar.
- No unique reference, such as  $u$  and  $v$ .
- To make observations comparable, an arbitrary reference direction is chosen.





## Bias estimation method (2)

- Rotation angle  $\Delta\Phi$ : difference between the reference and the model wind direction.
- Azimuth angle corresponding to observation is rotated by adding  $\Delta\Phi$  to it.
- With the rotation, nominal wind direction is the same for all observations.



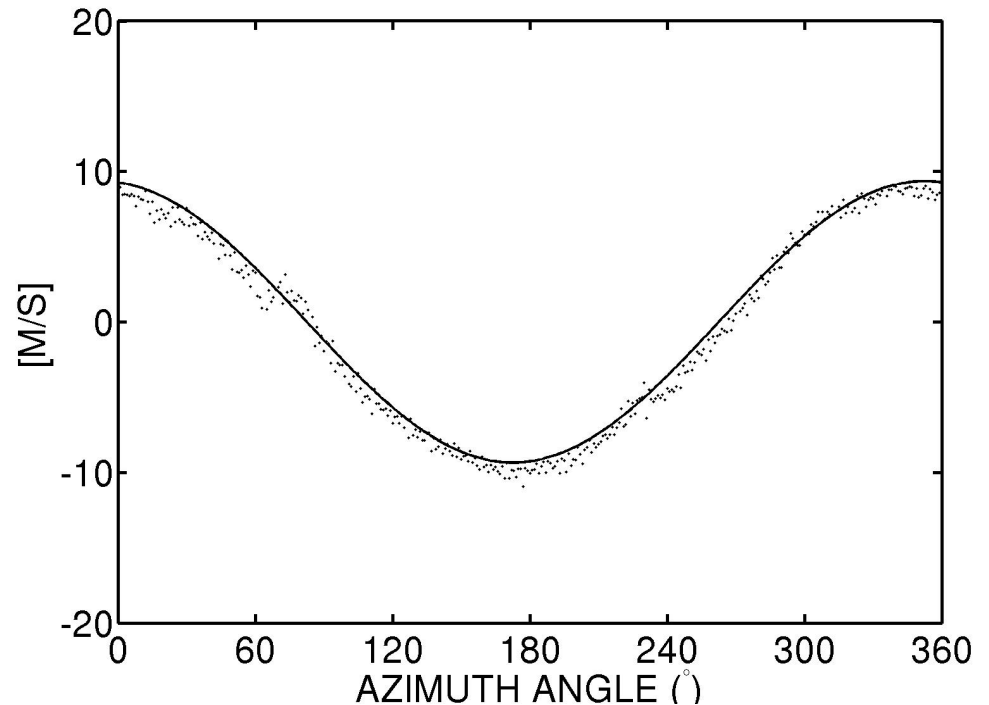


## Bias estimation method (3)

- Calculate an azimuth bin average.
- By least-squares fitting

$$v_r = v_h \cos(\delta - \Phi)$$

to the bin averaged observations, estimates for horizontal wind speed and direction are obtained.







# Demonstration of the bias estimation method

- One-month data set (January 2002), ca 533 000 superobservations and their model counterparts.
- Unambiguous velocity interval  $\pm 48$  m/s.
- Raw observations are averaged to superobservations with 10 km resolution in range and  $1.7^\circ$  in azimuth.
- Model counterparts are calculated from HIRLAM model with 9 km horizontal resolution.
- The reference wind direction used in the rotation is  $180^\circ$ .



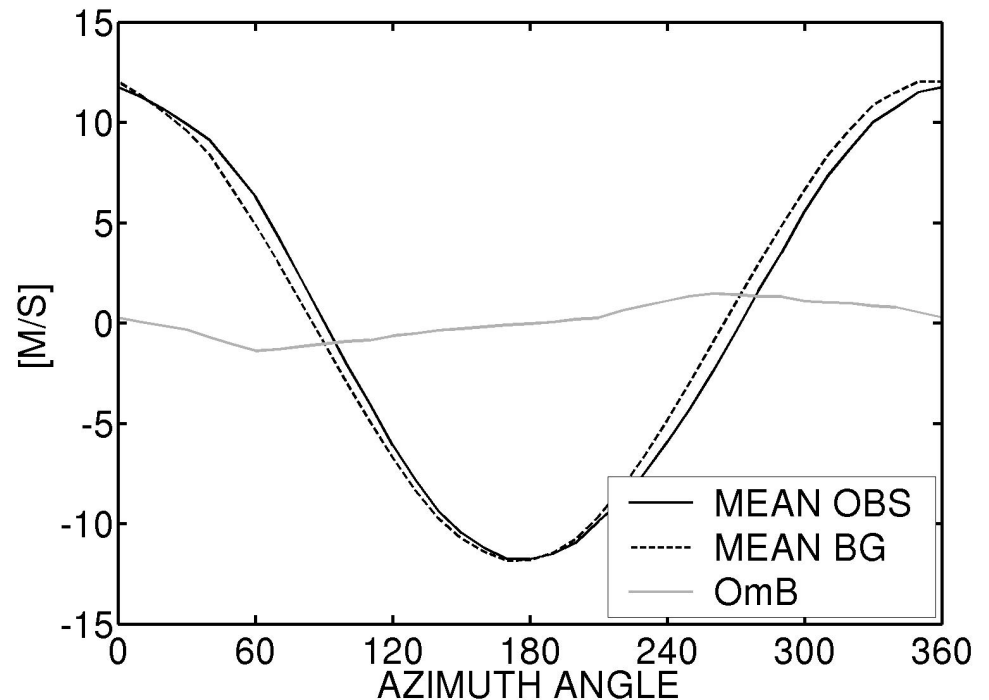
# WMO requirements for upper air wind measurements

- The wind speed bias must be less than 1 m/s and the wind direction bias must be less than  $5^\circ$  for wind speeds less than 15 m/s and less than  $2.5^\circ$  for higher winds.



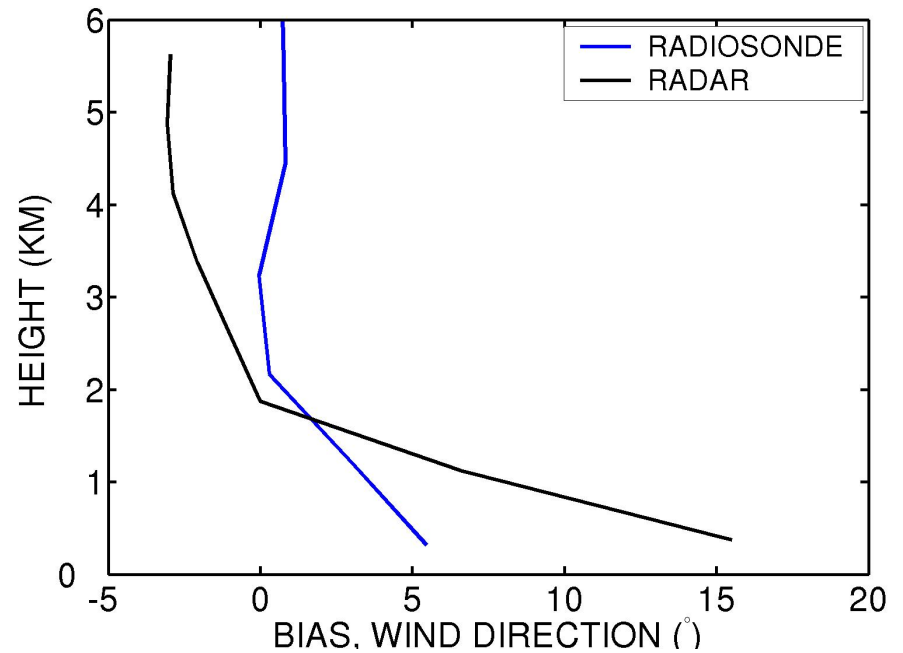
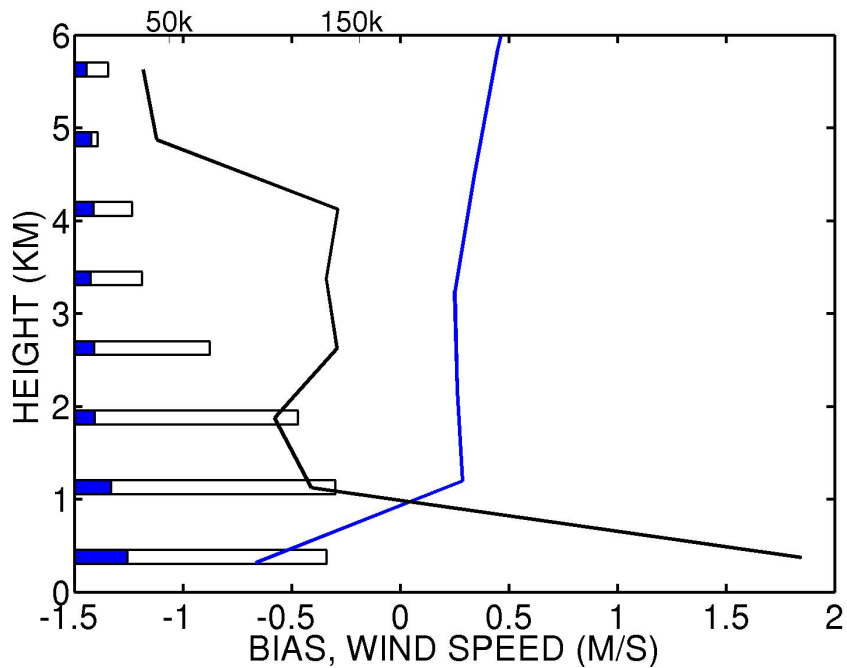
# Verification for the whole data set

- Amplitudes are nearly the same. The obtained wind speed bias is 0.03 m/s.
- Phase difference indicates systematic difference in the wind direction. The obtained wind direction bias is  $4^\circ$ .





# An intercomparison of the bias estimates with radiosonde wind bias





# Summary

- The introduced method enables estimation of the bias in wind speed and direction for Doppler radar radial wind observations.
- The bias in Doppler radar winds is within the limits of the WMO requirements above the altitude of 1.5 km.
- Bias estimation method is useful for example in model validation.