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Notes on verification of radar radial winds

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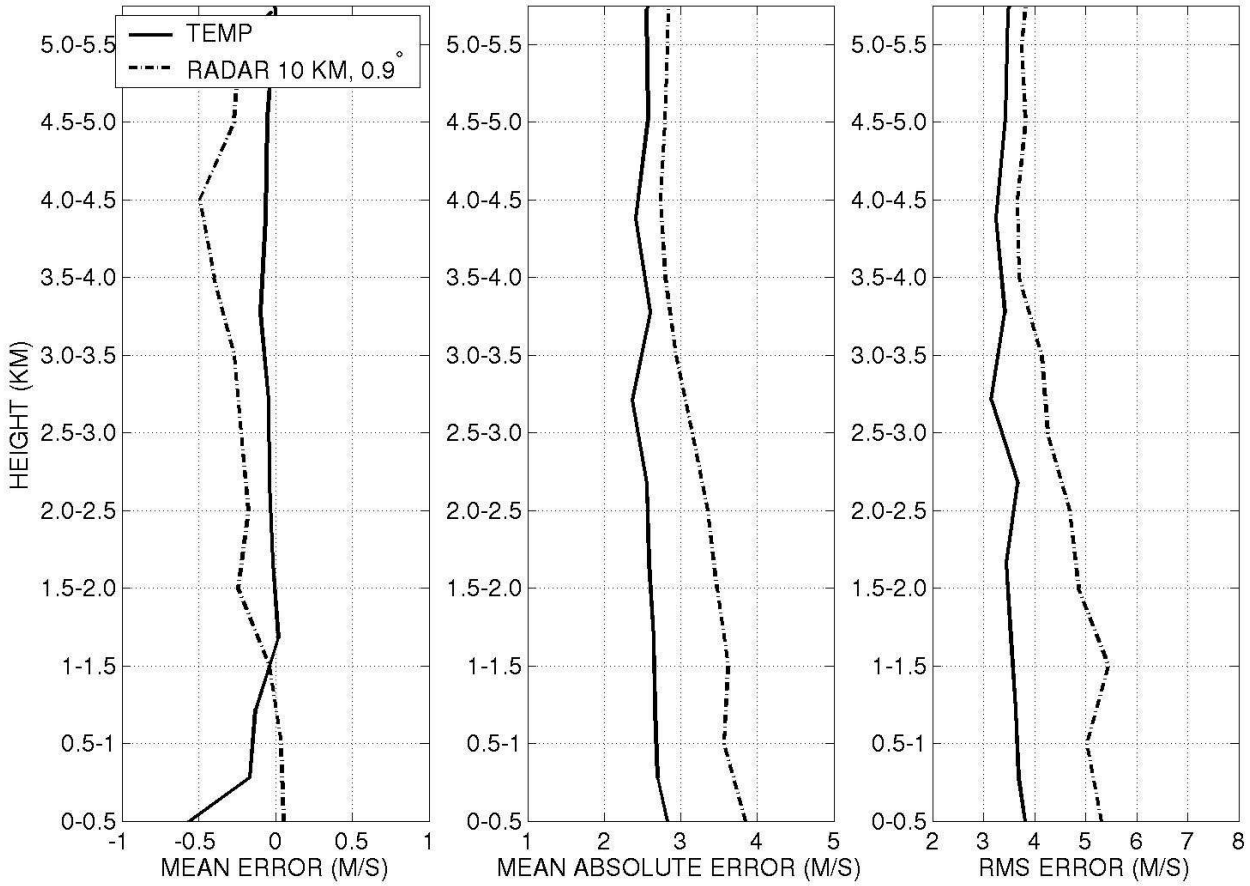
Radar radial wind observation

- Doppler radar measures one component of the wind vector, ie. the radar radial component.
- With constant range and elevation, radial wind has a form of a sine as a function of azimuth angle if an assumption of uniform wind field is made.
- The amplitude of the sine defines the wind speed and and the phase of the sine defines the wind direction.

“Traditional” verification for wind observations



Azimuth dependence in bias

- An important quality aspect for V_r is the azimuth dependence of bias.
- Mixing different azimuth directions in the bias calculation easily results in near zero bias.
- Still, there might be systematic difference between observed and modelled wind direction or wind speed.
- Studying the bias as a function of azimuth angle can reveal those differences.

Simulated uniform windfield (1)

- Assumption of uniform wind field.

BG wind 15 m/s from South:

$v_{r\,bg} = 15\ cos\ \phi$

OBS wind 17 m/s from South:

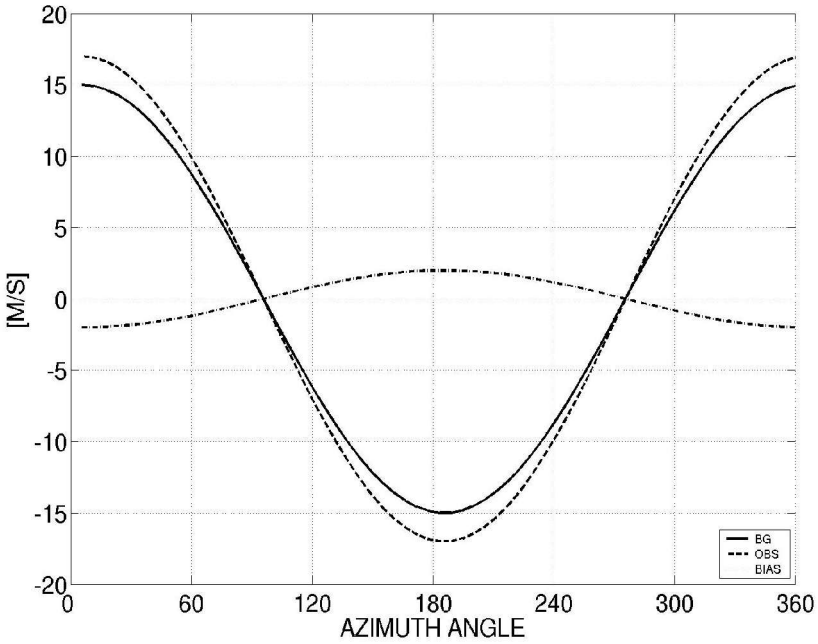
$v_{r\,obs} = 17\ cos\ \phi$

- BIAS = BG – OBS

$BIAS_{min}$ = -2 m/s

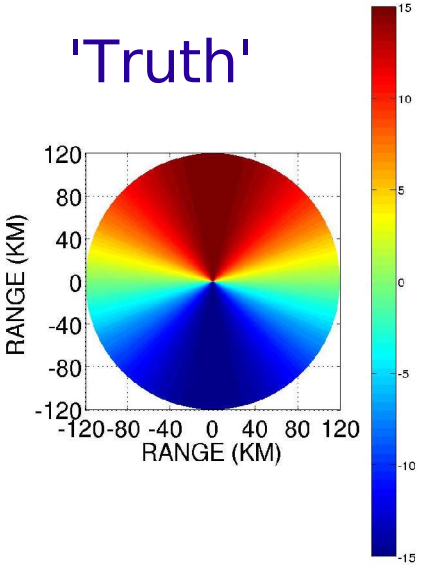
$BIAS_{max}$ = 2 m/s

! $BIAS_{averaged}$ = 0 m/s

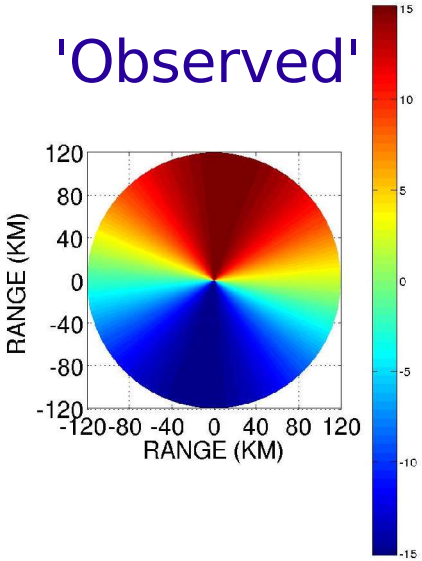


Simulated uniform wind field (2)

'Truth'



'Observed'

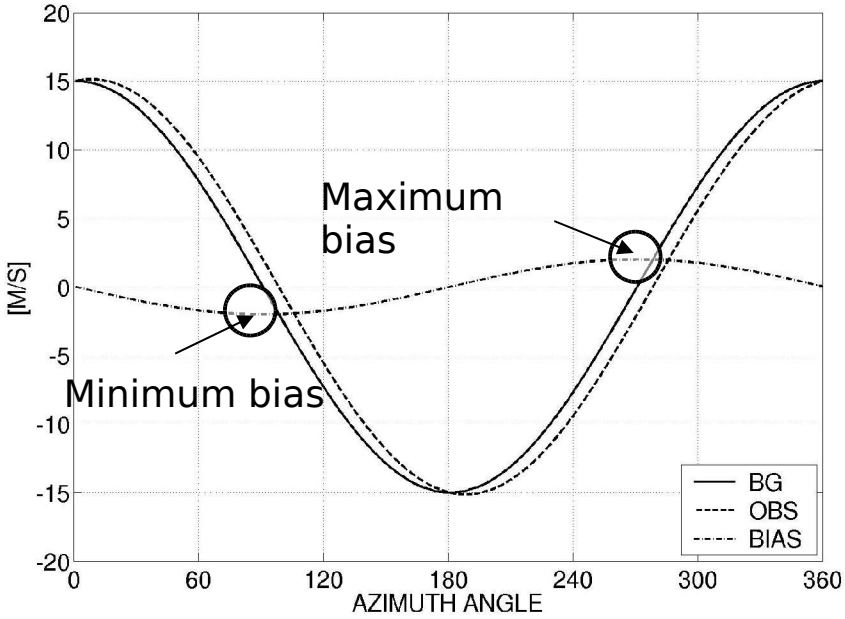


$V_r = u \sin\varphi + v \cos\varphi$

$BIAS_{max} = 2$ m/s

$BIAS_{min} = -2$ m/s

! $BIAS_{average} = 0$ m/s



$u_{bg} = 0$ m/s
$v_{bg} = 15$ m/s

$|V_{bg}| = 15$ m/s
$d_{bg} = 180^o$

$u_{obs} = 2$ m/s
$v_{obs} = 15$ m/s

$|V_{obs}| = 15.13$ m/s
$d_{obs} = 187.6^o$

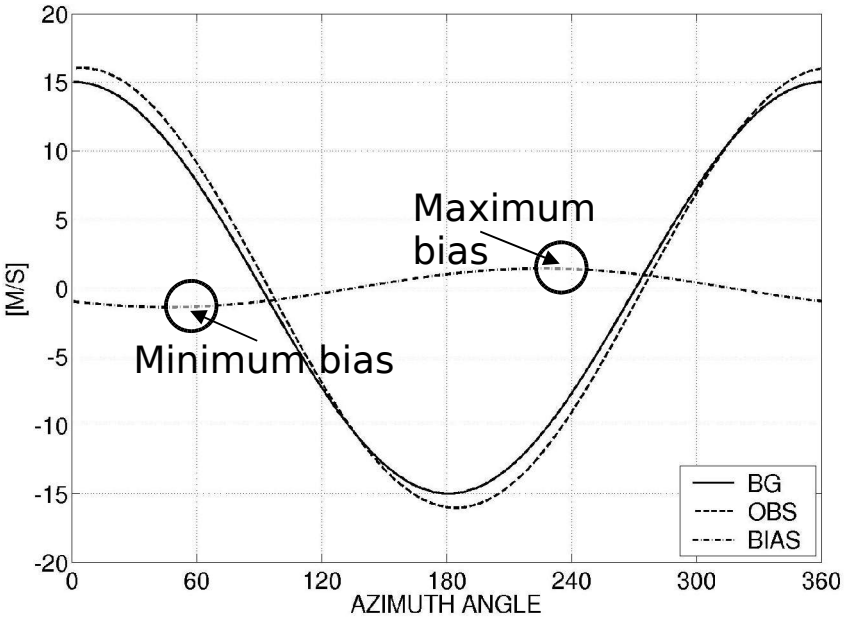
Simulated uniform wind field (3)

u_{bg} = 0 m/s
v_{bg} = 15 m/s

$|V_{bg}|$= 15 m/s
d_{bg} = 180°

u_{obs} = 1 m/s
v_{obs} = 16 m/s

$|V_{obs}|$= 16.03 m/s
d_{obs} = 183.6°



$BIAS_{max}$ = 1.41 m/s
$BIAS_{min}$ = -1.41 m/s
! $BIAS_{average}$ = 0 m/s

Defining bias

- Rotate the true wind direction so that the nominal wind direction is always the same, for example South.
- If the uniform wind field assumption is valid:
  - Bias as a function of azimuth is:

$$BIAS = V_{r\,bg} - V_{r\,obs} = (v_{bg} - v_{obs})\cos\phi - u_{obs}\sin\phi$$

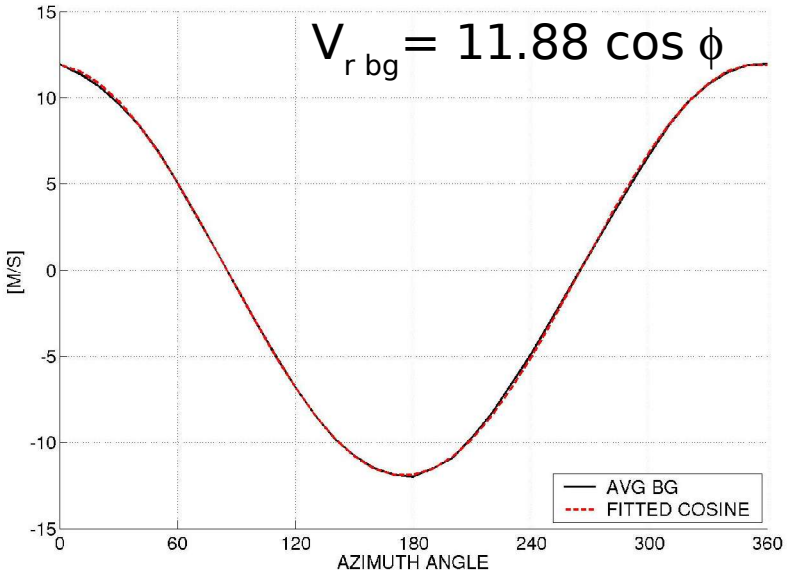
  - It is possible to calculate the bias in wind speed and direction.

Experiments with real data

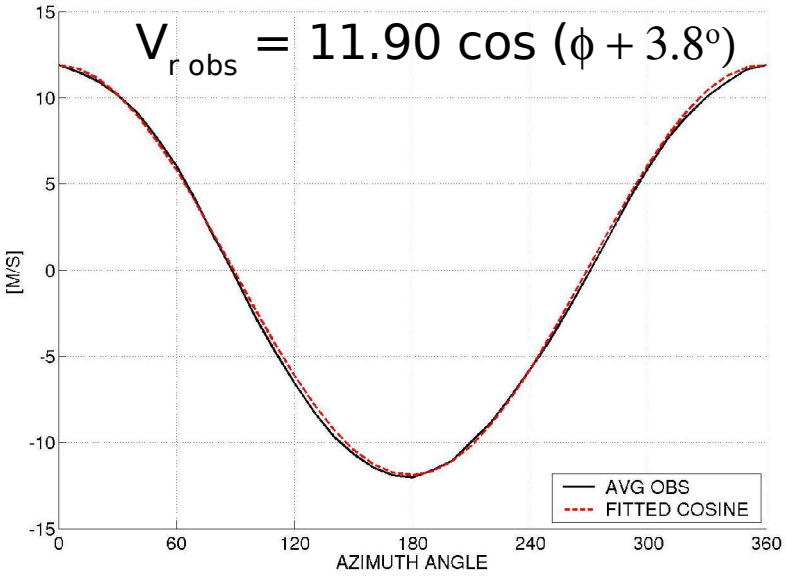
- One month data set, 1 025 000 V_r observations and their model counterparts.
  - Raw observations are averaged to superobservations with 10 km resolution.
  - Model counterparts are calculated from HIRLAM model with 9 km horizontal resolution.
  - The wind direction is rotated so that the nominal wind direction is always South.

Average V_r and fitted cosine

Model Bg



Observed



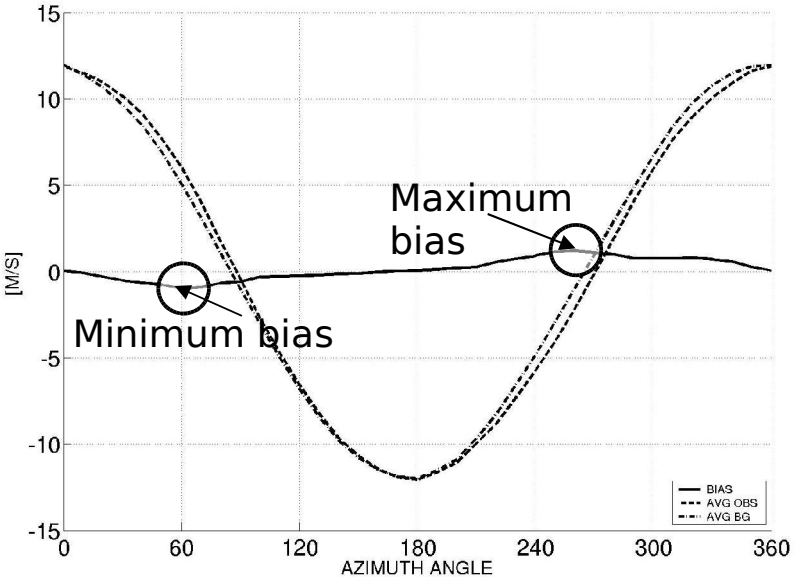
Bias as a function of azimuth angle

- Maximum bias 1.19 m/s
- Minimum bias –0.98 m/s

- Bias estimated from the fitted cos-curves:

  Bias in wind speed 0.02 m/s

  Bias in wind direction 3.8^{o}



Summary

- Verification of radar radial winds needs special attention.
- Mixing different azimuth directions in the bias calculation easily results in near zero bias even though there is systematic difference in the wind speed or/and wind direction.
- Studying the bias as a function of azimuth angle can reveal those differences.

Open questions

- What is the best method to compare the quality of radar radial winds and traditional (u, v) wind observations?