Comparison of everything with everything (CEWE) at the CESAR site:
An update of TARA CEWE for assessing the applicability of contemporary EDR retrievals for precipitation profiling Doppler radar

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Comparison of everything with everything (CEWE) at the CESAR site
CESAR Science Day, June 17th, 2015

Outline

• Ultra Fast wind SensOrs project
• Research question
• What is TARA CEWE?
• Contemporary turbulence retrieval methods
• Preliminary conclusion from TARA CEWE
• Back to the details
• Conclusions
• Outlook
Ultra Fast wind SensOrs project

The UFO project. A solution to mitigate weather hazards and increase airport capacity.

WVs and weather hazards can be monitored under all weather conditions by using UFO scanning radars and lidars.
Ultra Fast wind SensOrs project

We would like to improve wind vector/turbulence intensity retrievals and improve wake vortex monitoring.

- Improve wind retrievals
- Improve turbulence retrievals
- Improve lidar/radar technology

Evaluation of contemporary methods
New methods?
Evaluation of contemporary methods

Do eddy dissipation rate retrievals work for precipitation profiling Doppler radar?, CESAR Science Day, June 18th, 2014
Research question

We would like to improve wind vector/turbulence intensity retrievals and improve wake vortex monitoring.

Evaluation of contemporary methods

Research question:

Do the contemporary turbulence retrievals work for a precipitation profiling radar?
What is TARA CEWE?

TARA: Transportable Atmospheric Radar
CEWE: Comparison of Everything with Everything

- CESAR instrument data interpolated to TARA grid.
- Website to investigate scatter density plots. http://taracewe.ewi.tudelft.nl/ (> 1 million scatter density plots)
- BIG DATA!
- 140 days from TARA
- ~80 parameters from meteorological supersite instruments: BSRN, IDRA, Sonics, surface fluxes, TARA, tower instruments.
What is TARA CEWE?

http://taracewe.ewi.tudelft.nl/
Example 1: validation of TARA wind retrieval algorithm

c = 0.97
y = 1.22e+01 +9.05e-01 x

c = 0.94
y = 1.89e-01 +1.09e+00 x
What is TARA CEWE?

http://taracewe.ewi.tudelft.nl/
Example 2: validation of TARA and IDRA reflectivities

\[ c = 0.98 \]
\[ y = 2.64 \times 10^{-1} + 9.94 \times 10^{-1} x \]
What is TARA CEWE?

http://taracewe.ewi.tudelft.nl/

Example 3: Does 180m sonic anemometer work when it rains?

- Fill fraction is the fraction of data that passes a quality filter.
- Data is filtered when there are fill values or spikes occur.
Contemporary turbulence retrieval methods

Turbulence intensity retrieval
- Turbulence is quantified by the Eddy dissipation rate (EDR)
- Assumption on homogenous isotropic frozen turbulence
Contemporary turbulence retrieval methods

**Turbulence intensity retrieval**
- EDR can be derived from velocity measurements from radar, lidar or sonic anemometers.

**Power spectrum**
\[ E(\kappa) = C \varepsilon^{2/3} \kappa^{-5/3} \]

**Structure function**
\[ D_{LL}(r) = \langle [v(x + r) - v(r)]^2 \rangle = C_2 (\varepsilon r)^{2/3} \]

**Variance**
\[ \sigma^2 = \frac{3}{2} C \varepsilon^{2/3} \left[ \kappa_1^{-2/3} - \kappa_2^{-2/3} \right] \]

Contemporary turbulence retrieval methods

Turbulence intensity retrieval from radar

- Radar Doppler velocity variance / spectral width is a combination of factors:

\[ \sigma_v^2 = \sigma_d^2 + \sigma_0^2 + \sigma_\alpha^2 + \zeta_I^2 \sigma_t^2 \]

Radar Doppler spectral width / Radar Doppler mean velocity variance

Homogeneous isotropic turbulence

Stratification important

- Strong turbulence: \( \zeta_I \sigma_I \gg \sigma_d, \sigma_0 \)
- Moderate turbulence: \( \zeta_I \sigma_I \approx \sigma_d, \sigma_0; \zeta_I = ? \)
- Light turbulence: \( \zeta_I \sigma_I \ll \sigma_d, \sigma_0 \)

- Turbulence intensity too small to measure.

\( \sigma_I < \sigma_{I, \text{measurable}} \)

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Preliminary results from TARA CEWE

Validation of TARA EDR vs Sonic EDR at 180 m lever with BIG DATA

- Small scale effects (DSD, drop inertia) on retrieved EDR mitigated by using a large footprint (10 min. scale).
- Comparison of EDR from vertically profiling radar (TARA) shows good agreement with sonic anemometer on June 21\textsuperscript{st} 2012 in a convective mixed boundary layer.
- Comparison of EDR fails on January 19\textsuperscript{th} 2012 in nocturnal boundary layer.
Comparison of everything with everything (CEWE) at the CESAR site

Back to the details

- Correction for terminal fall is problematic
Back to the details

• Solution: use wind speed for analysis instead of vertical velocities.
Back to the details

EDR from wind speeds, instead of vertical velocities works better
Conclusion

• Terminal fall speed correction causes large errors in the standard deviation of vertical velocities. But not always.
• Typical processing (e.g. O’Connor (2010) using vertical velocities) is not suitable for TARA.
• Alternative EDR processing using full wind speeds seems more reliable.

Outlook

• Updated version of TARA CEWE with new processing.
• Parametric turbulence model for simulation of radar observables. Optimal estimation based retrieval of DSD and turbulence intensity.
Questions?

Foto from Charlotte van den Arend
References/ further reading


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Backup-slide: Cabauw research site

Atmospheric Profiling between 180 m and ~ 15 km.

Tower with sonic anemometer at 180 m. (and other levels)

TARA (S-band RADAR) measures the vertical Doppler velocities at Cabauw. 330 m
Backup-slide: different EDR methods

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Backup-slide: TARA quicklooks