Towards retrieving critical relative humidity from ground-based remote-sensing observations

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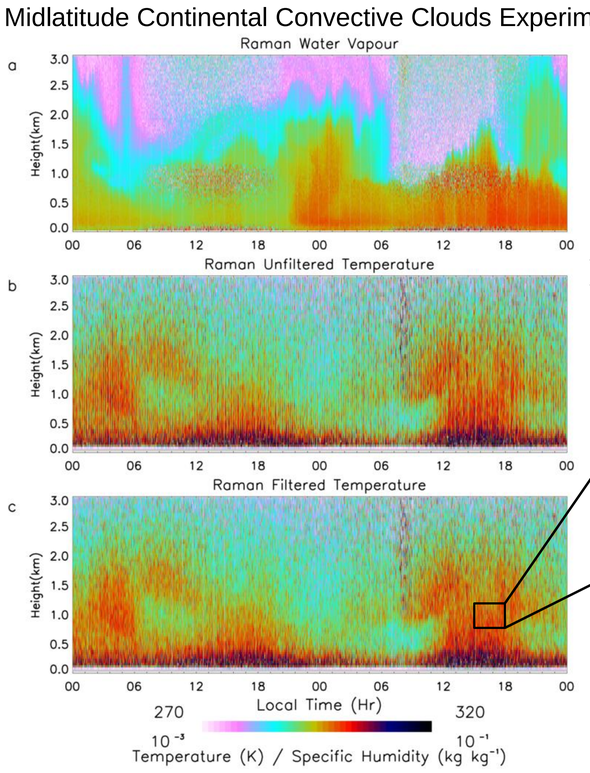
Motivation

- Critical Relative Humidity (RHcrit) is crucial parameter even in state-of-the-art large-scale cloud parameterisations, affecting climate simulations and NWP.
- Very high resolution Raman lidar measurements might allow for the first time to obtain water vapour and temperature variances with sufficient accuracy to constrain diurnal cycle of RHcrit.

Data and Methods

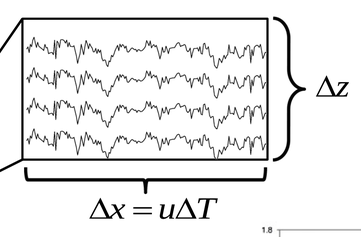
Raman lidar at ARM Southern Great Plains (Oklahoma)

Midlatitude Continental Convective Clouds Experiment (MC3E): 22/04 – 06/06/2011 at SGP

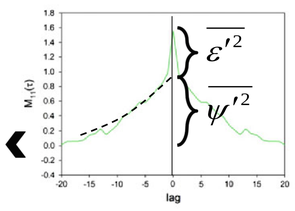


	Microbase	Raman lidar	Mergesond
variable	q_L, q_l	q_v, T	u, v, P
Δt	4 sec	10 sec	60 sec
Δz	30 m	37 m	20-200 m

› Data inherently noisy:
- FFT filtering of HVAC frequency
- Auto-covariance filtering



‹ $ACF(\tau) = \overline{\psi'^2} - k\tau^{2/3}$



From Water Vapour and Temperature Variances to RHcrit

Assumed grid box size:

$$\Delta x = 120km \qquad \Delta z = 100m$$

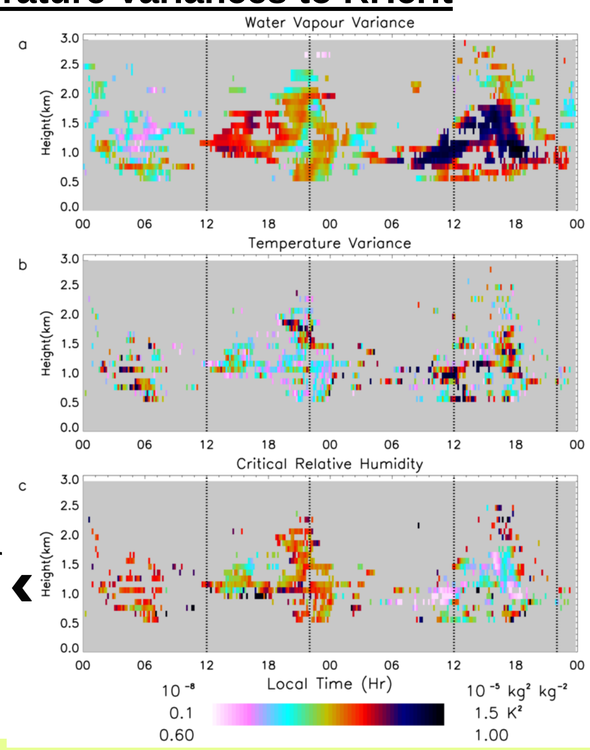
Combined variance of temperature and water vapour ('s-distribution'):

$$\sigma_s^2 = a^2\overline{q_T'^2} - 2ab\overline{q_T'\theta_L'} + b^2\overline{\theta_L'^2}$$

Assuming a triangular distribution:

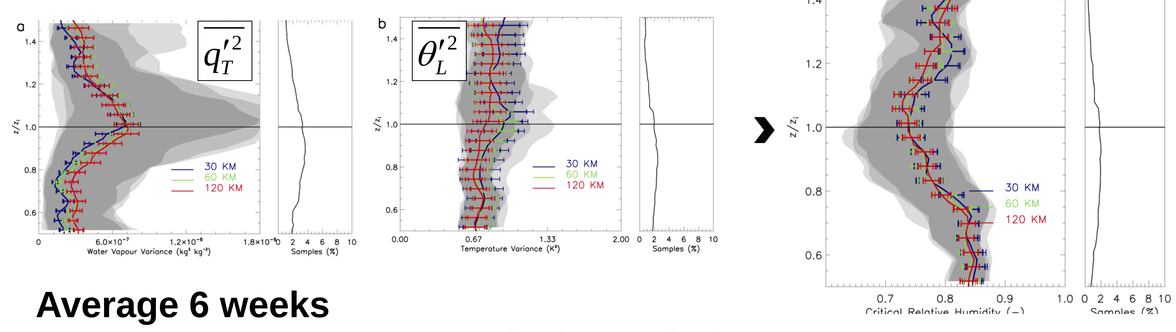
$$RH_{crit} = 1 - \frac{\sqrt{6\sigma_s^2}}{aq_{sat}(\overline{T_L})}$$

Clear diurnal cycle in RHcrit. Lower values near boundary layer top.



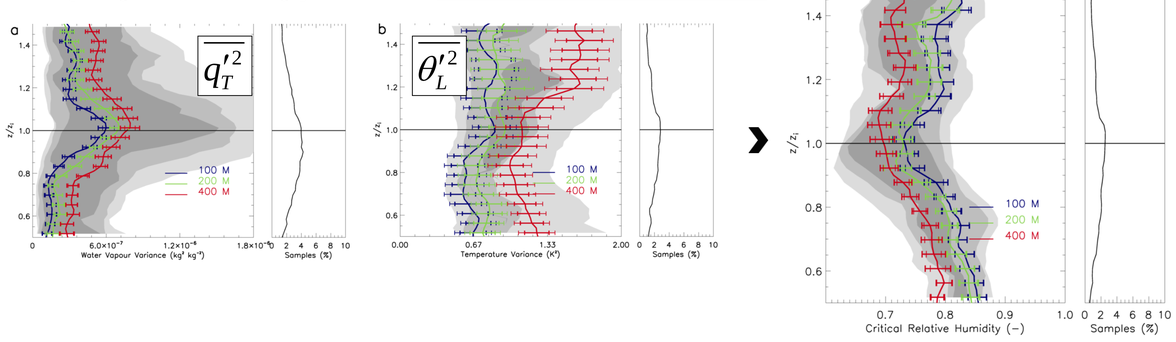
Resolution Dependence Rhcrit

Horizontal Resolution



Average 6 weeks (daytime only)

Vertical Resolution



Temperature variance has larger error bars than water vapour variance

RHcrit can be estimated within about 4 %.

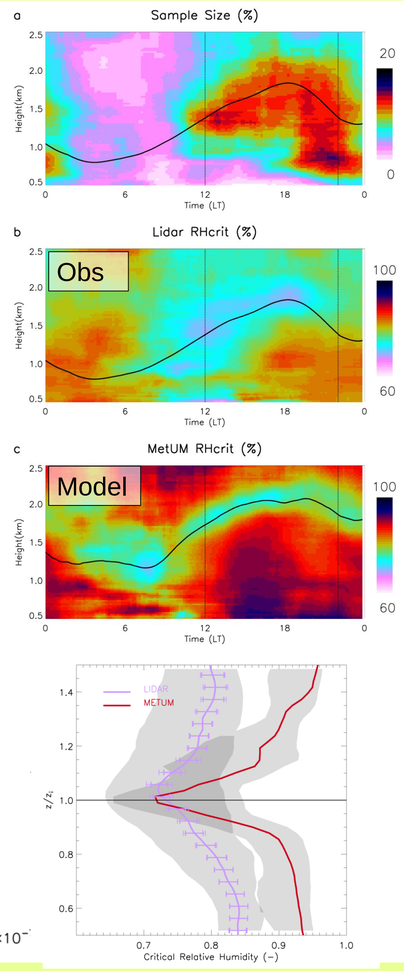
Quadrupling of horizontal resolution has limited impact on RHcrit.
Quadrupling of vertical resolution leads to 4-8 % smaller RHcrit.

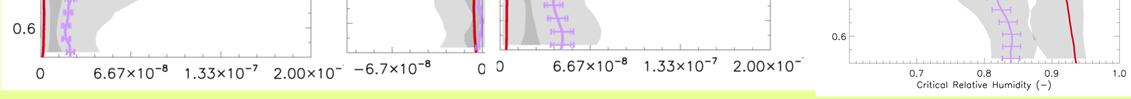
Evaluation RHcrit Parameterisation

Average 6 weeks (daytime only)

Newly implemented parameterisation MetUM:
Use water vapour and temperature (co-) variances from boundary-layer scheme to diagnose RHcrit

- Capable of reproducing diurnal cycle RHcrit
- RHcrit overestimated throughout the day
  → missing gravity waves in model or remaining error variance in obs?
- Larger covariance in MetUM than observed





Conclusions

- **Noise-filtered (co-)variance profiles of water vapour and temperature are of sufficient quality to estimate RHcrit within a few percent.**
- **RHcrit varies largely during the day and is more sensitive to vertical resolution than horizontal resolution for the scales investigated here.**
- **New TKE-based RHcrit parameterisation at Met Office captures diurnal cycle but overestimates RHcrit throughout most of the day.**

Outlook

- **Method will be repeated for longer time periods and different regions (TWP, Europe ...); empirical relations will be established.**
- **Higher temporal sampling rate and lower noise levels in lidar required to obtain estimate of RHcrit for grid lengths smaller than 30 km.**

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The "CAUSES" project is a collaboration between GASS and ASR, led by staff at the Met Office and PCMDI.

Please get in touch if you would like to participate.