The role of the mean relative humidity on the dynamics of shallow cumuli - LES Sensitivity experiments

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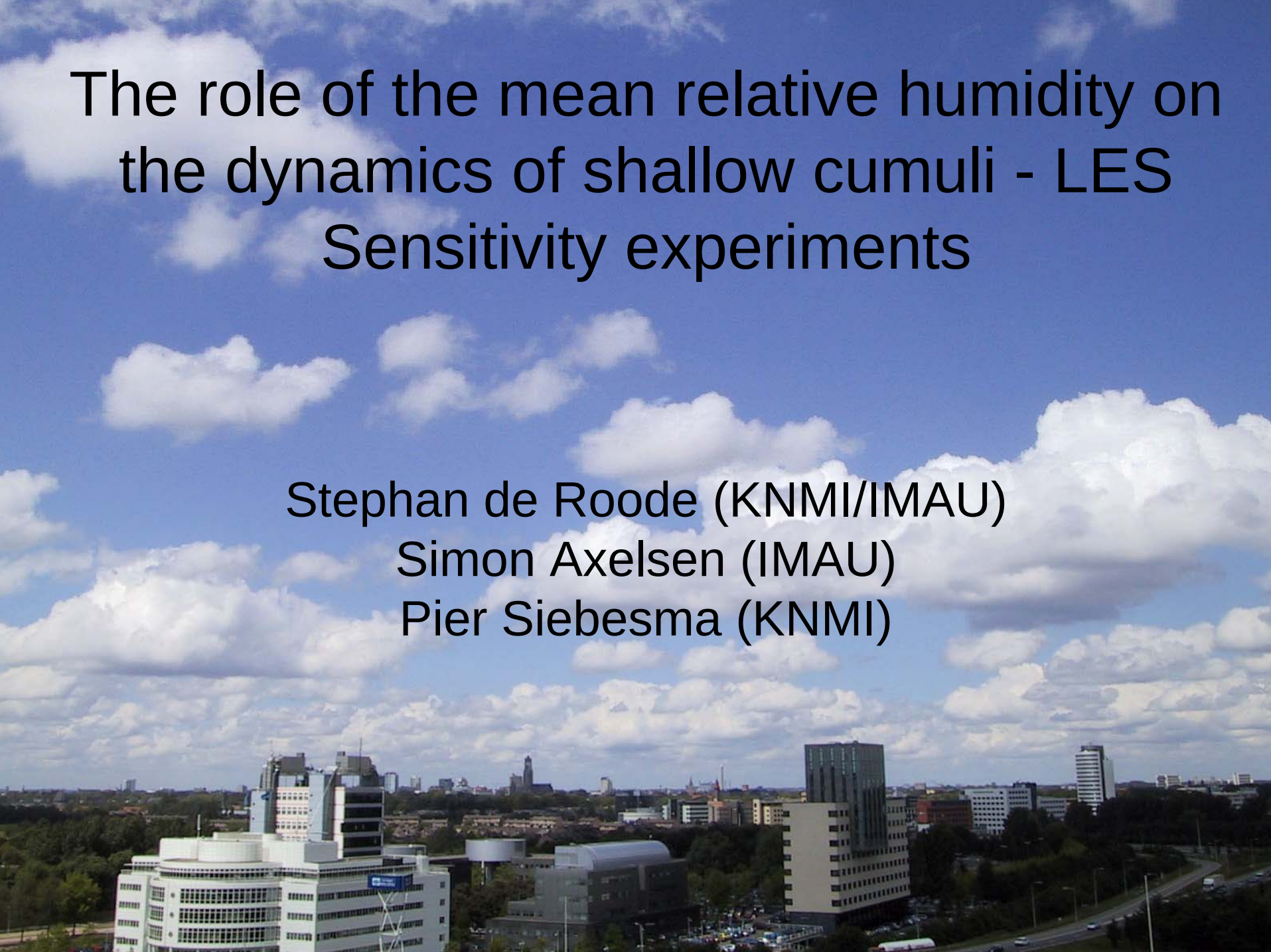
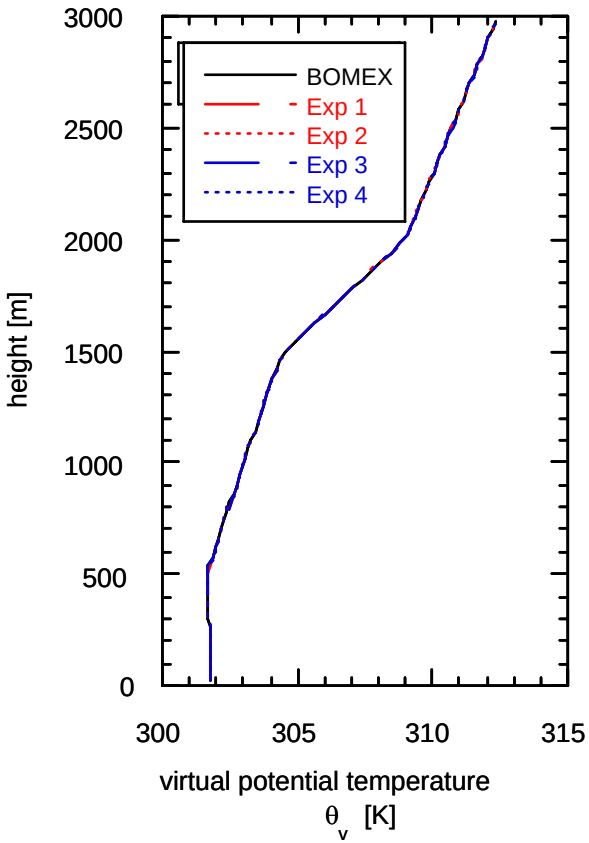


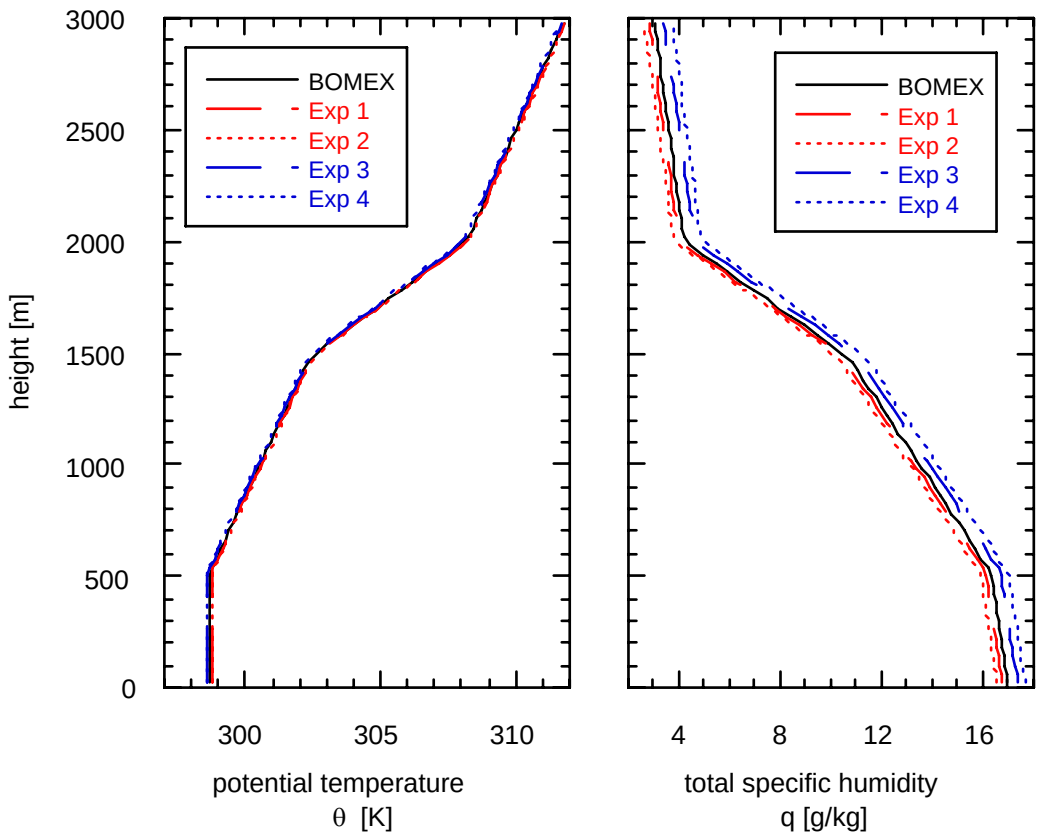
Large-eddy simulation -

The BOMEX shallow cumulus case



	BOMEX
$\overline{w'\theta'}_{z=0}$ Km/s	0.008
$\overline{w'q_t'}_{z=0}$ (g/kg)m/s	0.052

LES sensitivity experiments - Set-up analogous to Derbyshire's EUROCS deep convection case

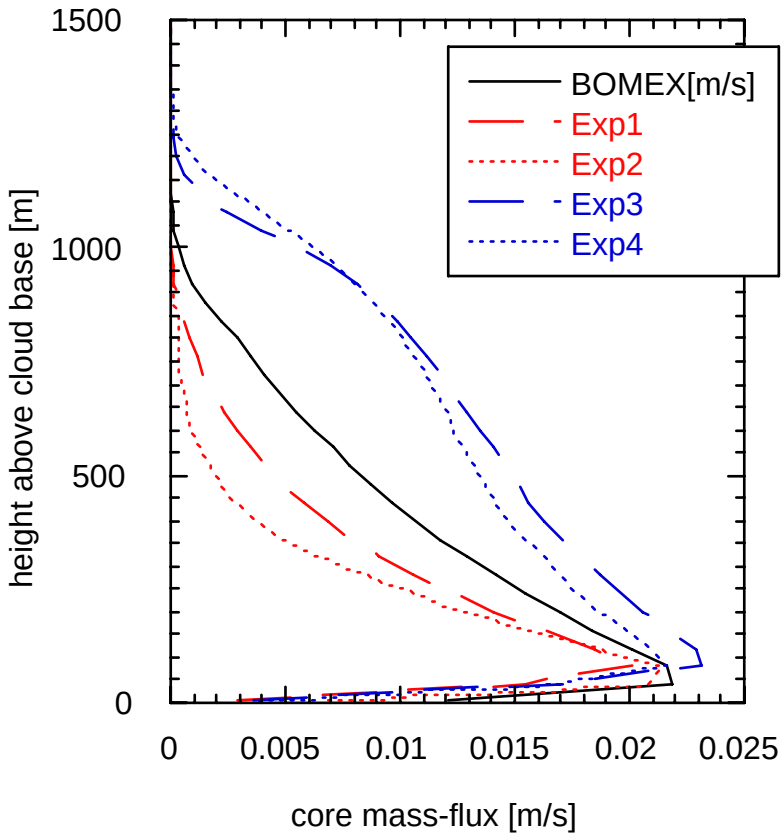


$$\theta_v = (\theta + \delta\theta)[1 + 0.61(q + \delta q)]$$

	δθ [K]	δq [g/kg]
BOMEX		
Exp 1	0.04	-0.2
Exp 2	0.07	-0.4
Exp 3	-0.07	0.4
Exp 4	-0.13	0.7

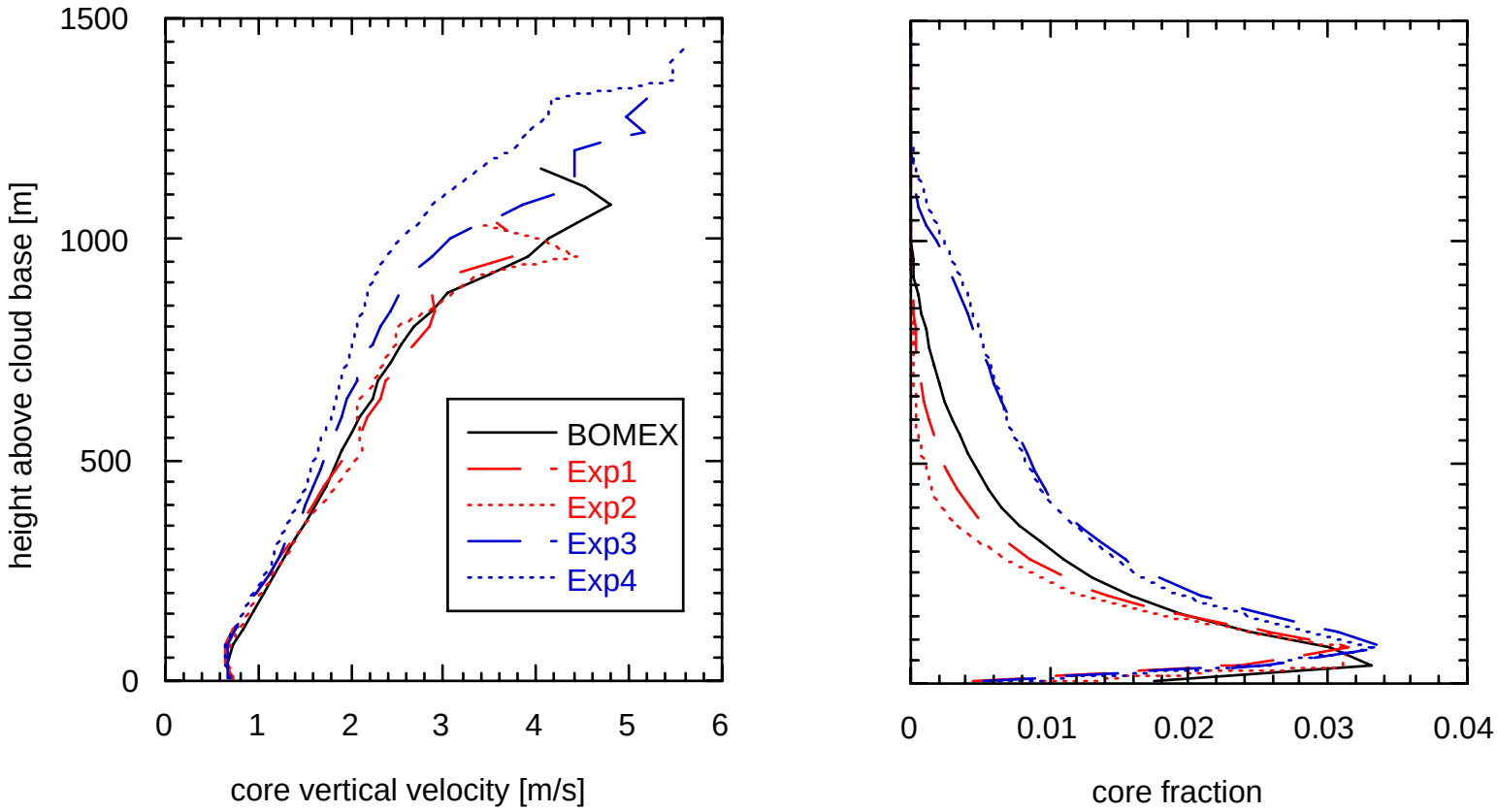
Results for cloud core : mass flux

All averages taken over the 3rd hour



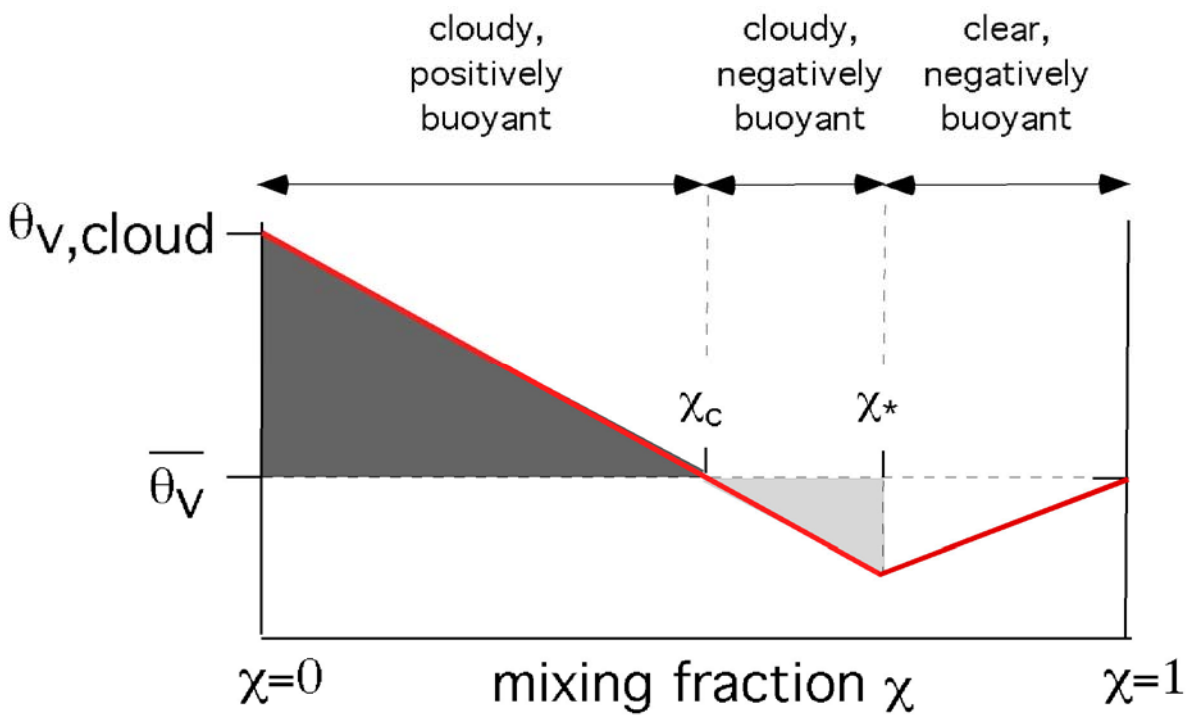
Results for cloud core :

vertical velocity and core fraction



Mixed parcel diagram -

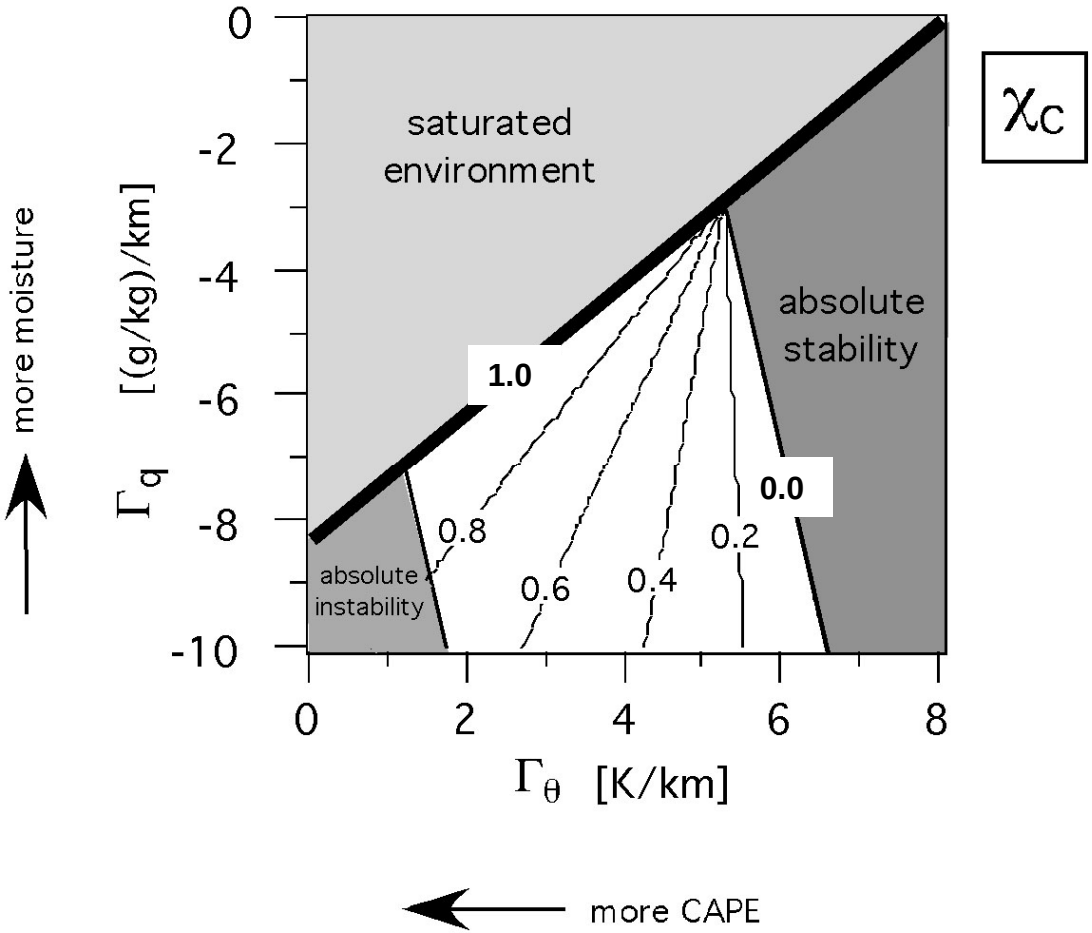
Buoyancy reversal



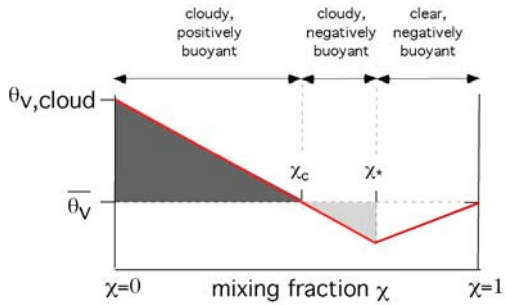
$$\chi = \frac{m_{env}}{m_{cld} + m_{env}}$$

Buoyancy reversal -

Dependency on mean vertical gradients Γ



χ_c

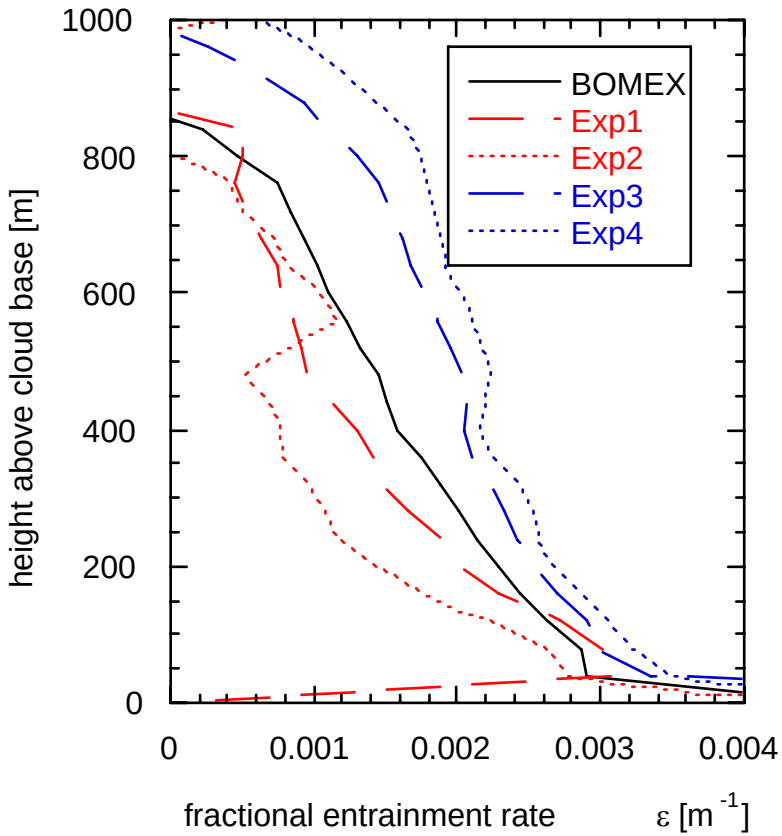


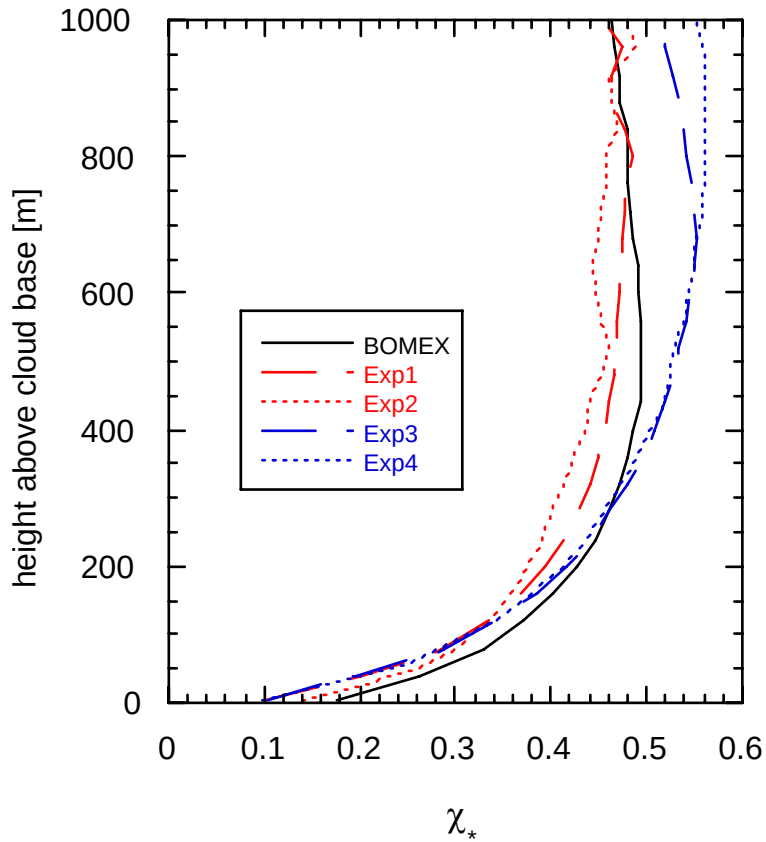
$$\Gamma_\theta = \frac{\partial \bar{\theta}}{\partial z} \quad , \quad \Gamma_q = \frac{\partial \bar{q}}{\partial z}$$

De Roode, 2004

χ and fractional entrainment rate.

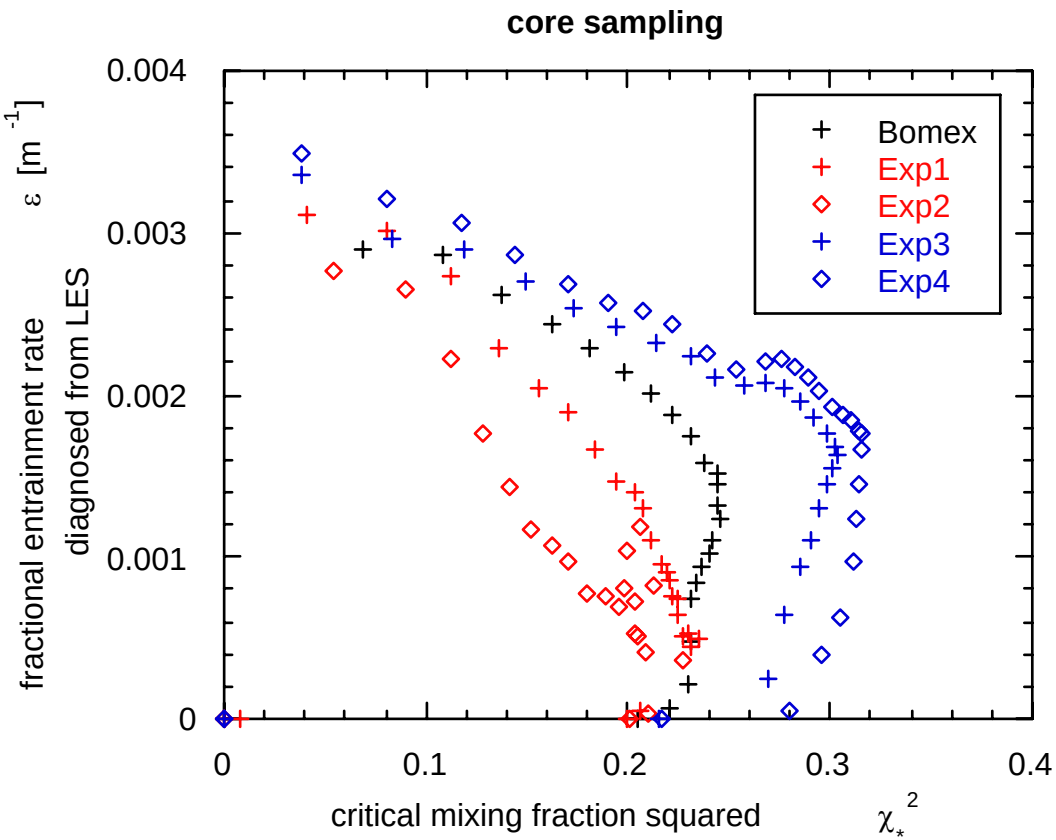
Diagnosis from LES results.





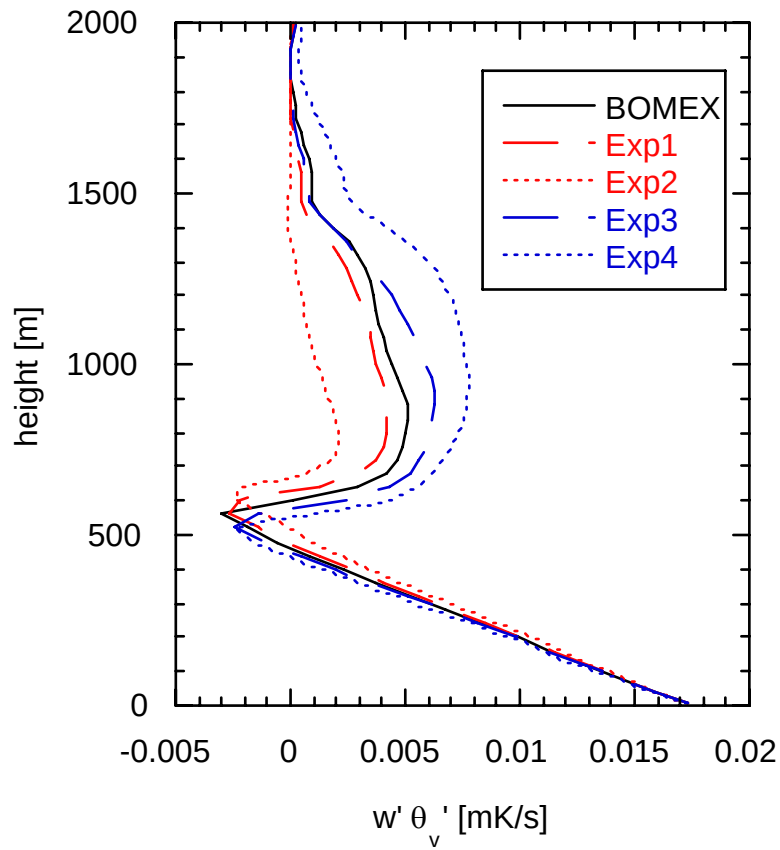
Kain & Fritsch parameterization- Assume flat PDF for χ

$\varepsilon = \varepsilon_0 \chi_*^2$ (Bretherton et al. 2004)

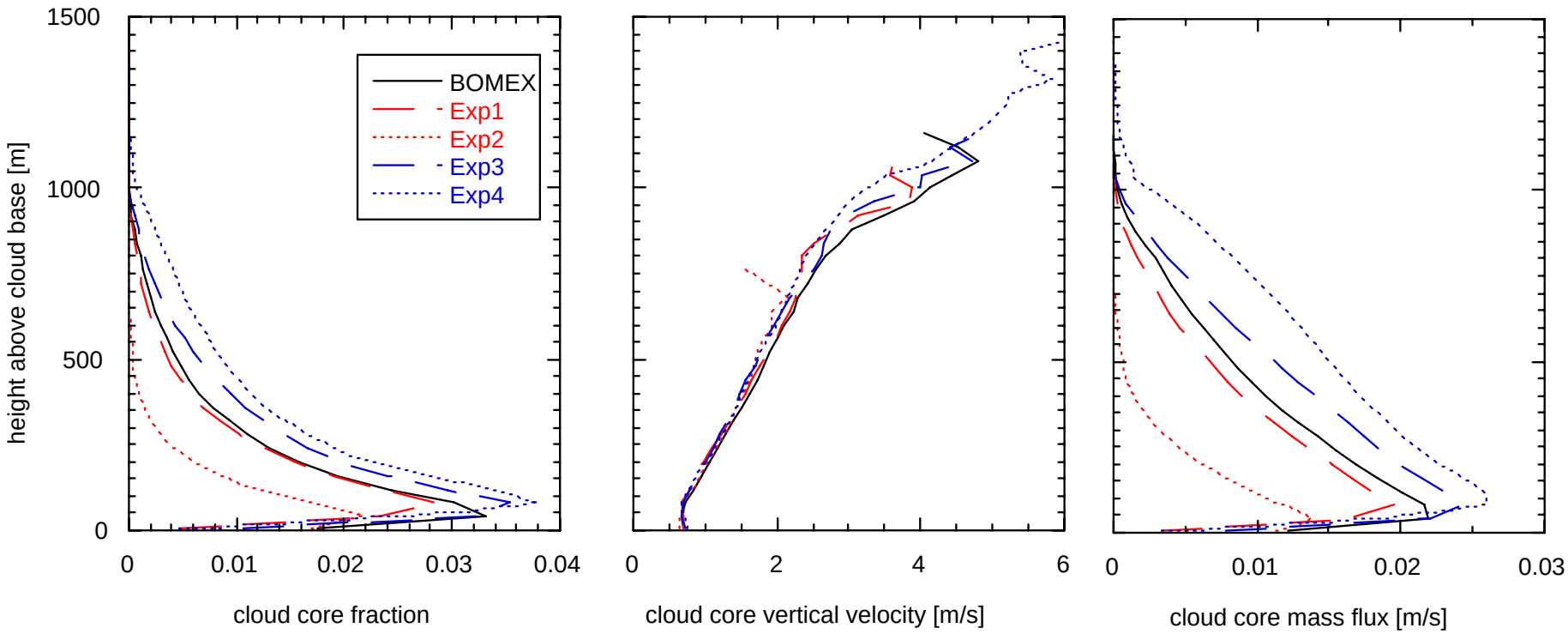


Bowen ratio, convective velocity scale w_* and mass-flux

	$w'\theta'_0$ x 1000 [Km/s]	$w'q'_{v0}$ x 10^{-5} [m/s]
BOMEX	8.0	5.2
Exp 1	9.9	4.2
Exp 2	13.6	2.1
Exp 3	6.1	6.2
Exp 4	4.2	7.3



Bowen ratio, convective velocity scale w_* and mass-flux



Conclusions

- Set I - Change relative humidity, but keep mean buoyance the same

  Cloud fraction changes =>

  Mass flux changes

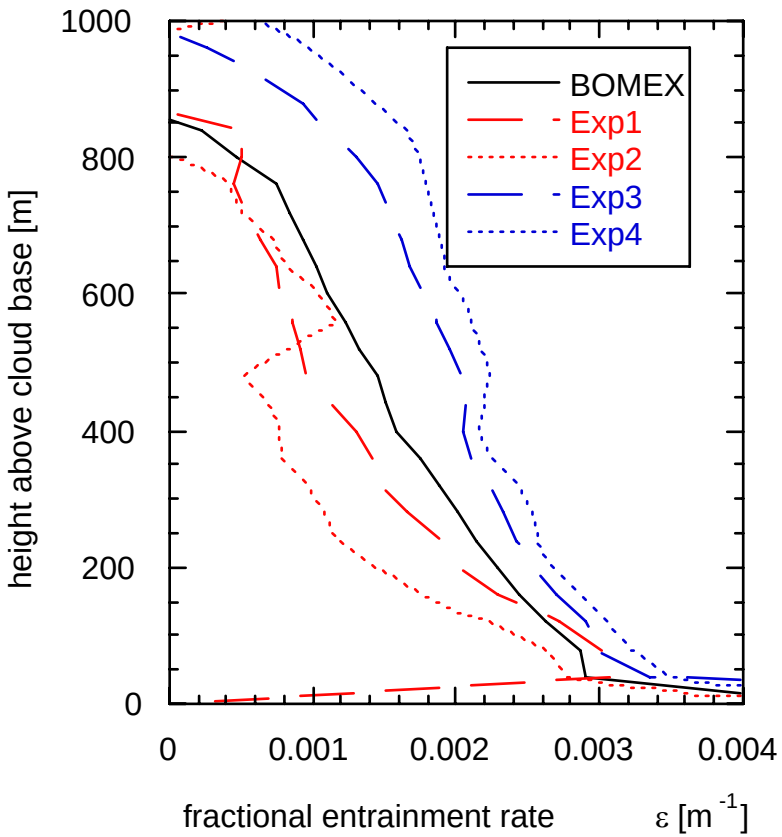
- Set II - Change Bowen ratio, but keep surface buoyancy flux the same

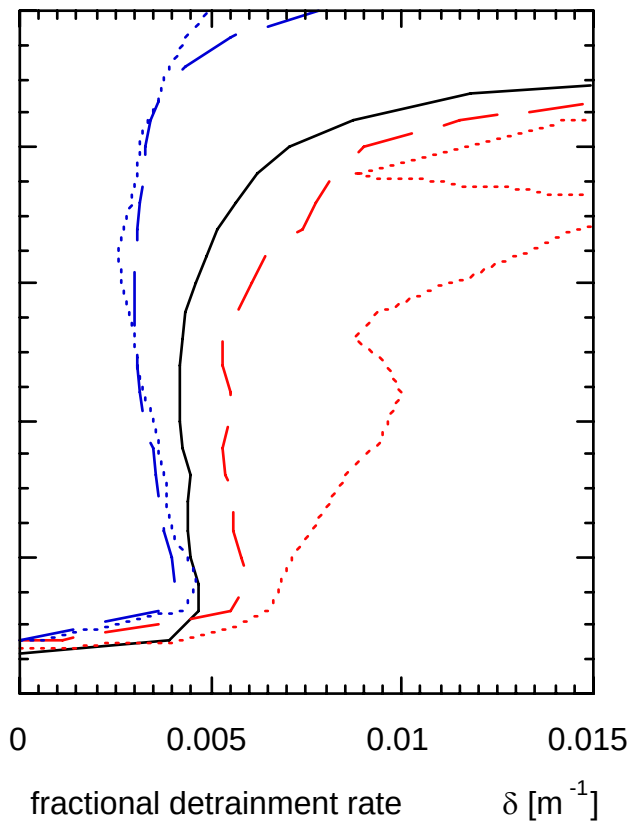
  Cloud fraction changes =>

  Mass flux changes (also at cloud base)

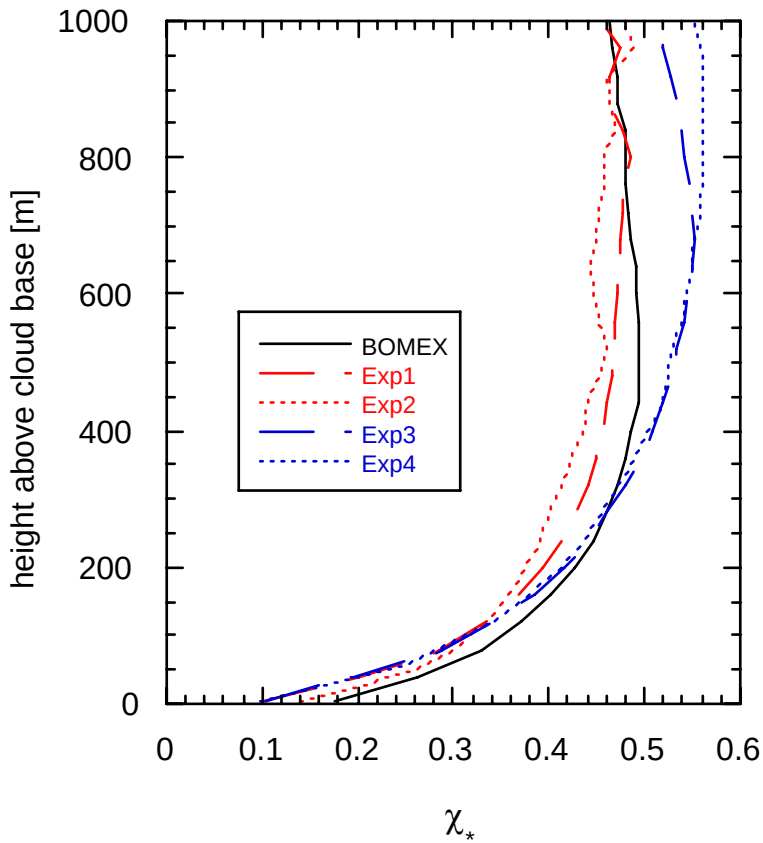
Results for cloud core :

fractional entrainment and detrainment





χ_* from LES


1000
800
600
400
200
0
height above cloud base [m]
0
0.1
0.2
0.3
0.4
0.5
0.6
χ_*
BOMEX
Exp1
Exp2
Exp3
Exp4