Condensation - Mass Flux Connection in Shallow Cu Clouds

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Objective:

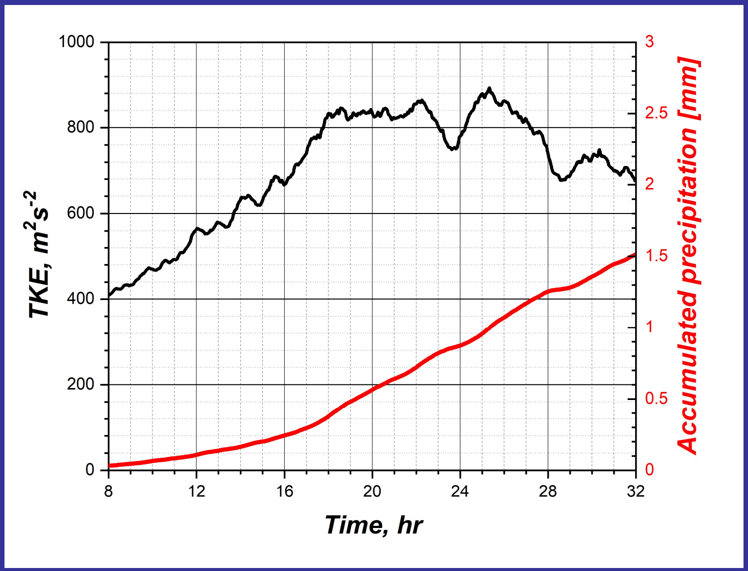
- Evaluating correlations between phase transition rates (CR/ER) and up/down mass/buoyancy flux
- Finding relationships between CR/ER and upward mass flux (MFP)

LES model and Simulations

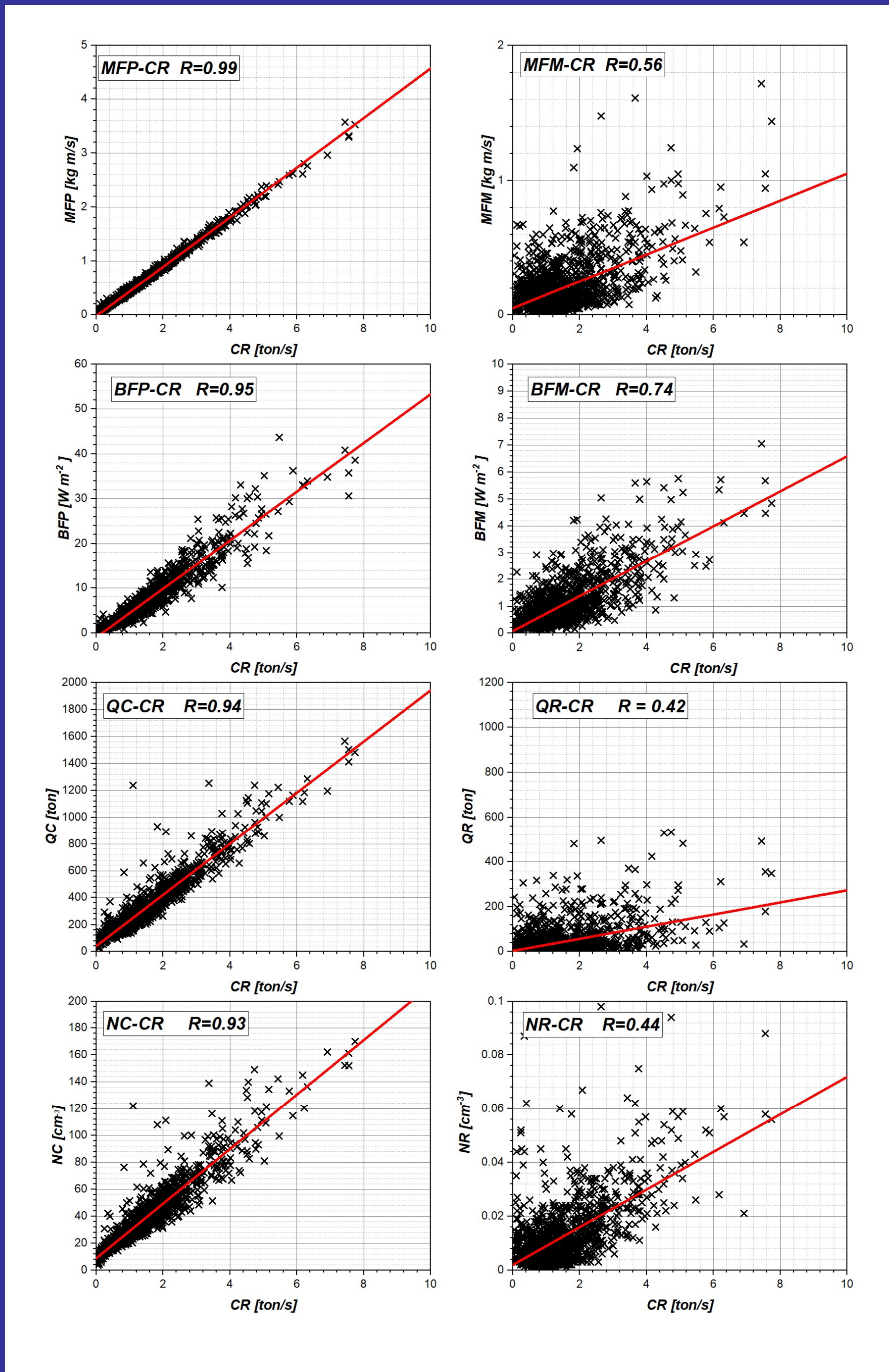
SAM-BM: SAM Bulk Microphysics (BM)

Δh=100 m; Δz=40 m; L ~ 51 km 512x512x100

RICO : Trade wind shallow Cu

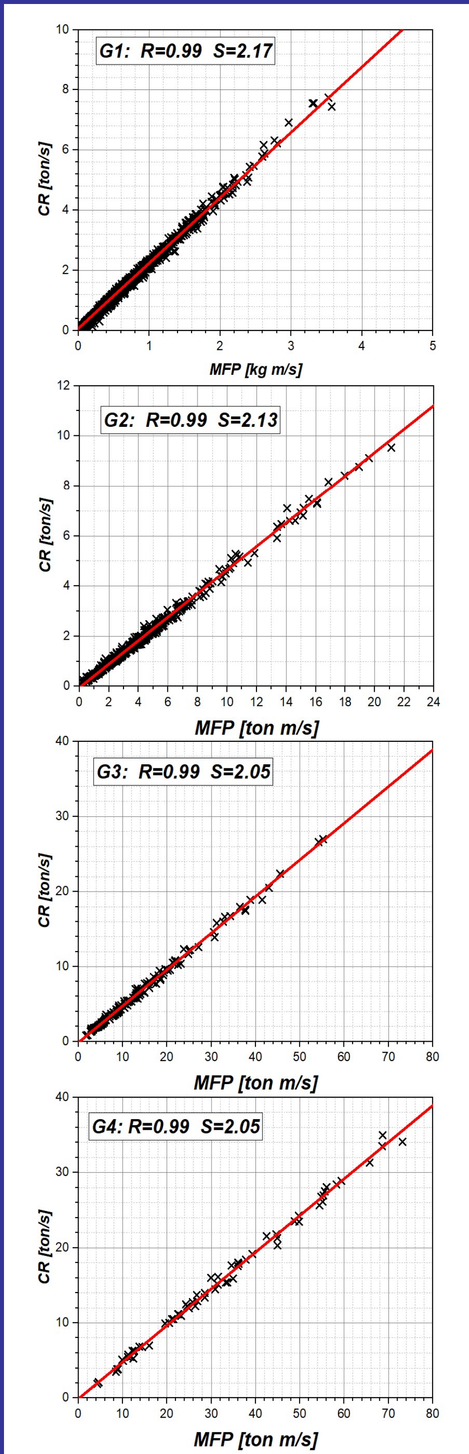


8-32 hours
2031 clouds
Four Groups G1-G4



CR correlations

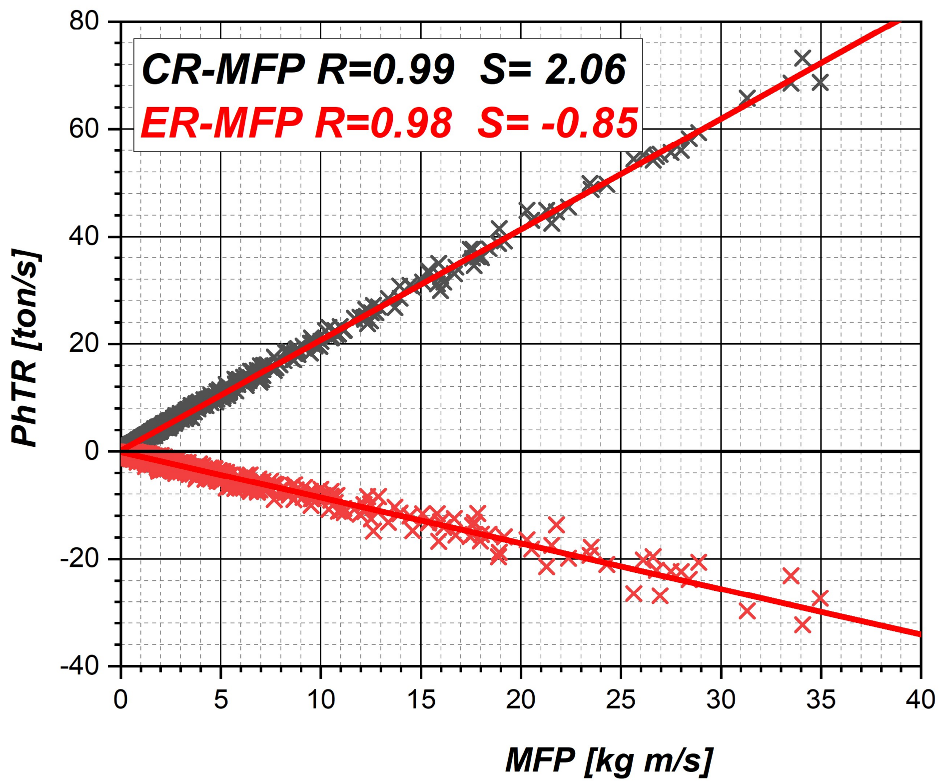
CR-MFP R=0.99
CR-BFP R=0.95
Low R's for downward fluxes



Correlation between condensation rate (CR) and upward mass flux (MFP)

Four Groups G1-G4
R=0.99

High correlation with MFP, both for condensation and evaporation rates



$$\frac{dq_l}{dt} = \alpha_{les}\rho_a W$$

$\alpha_{les} = 2.06 \times 10^{-6}$ [s^{-1}] for $q_v > q_{vs}$

$\alpha_{les} = -0.85 \times 10^{-6}$ for $q_v < q_{vs}$.

Lagrangian air parcel model

$$\frac{dS}{dt} = A_1 W - A_2 S R_i$$

Supersaturation equation

$$S_{qs} = \frac{A_1 W}{A_2 R_i}$$

Quasi-steady solution for S

$$S = \kappa S_{qs}$$

Kappa-- supersaturation in "quasi-steady" units

$$\frac{dq_l}{dt} = \kappa \alpha_{qs} \rho_a W \qquad \alpha_{qs} = \frac{A_1}{A_3}$$

CR linear function of mass flux

LES vs Theory

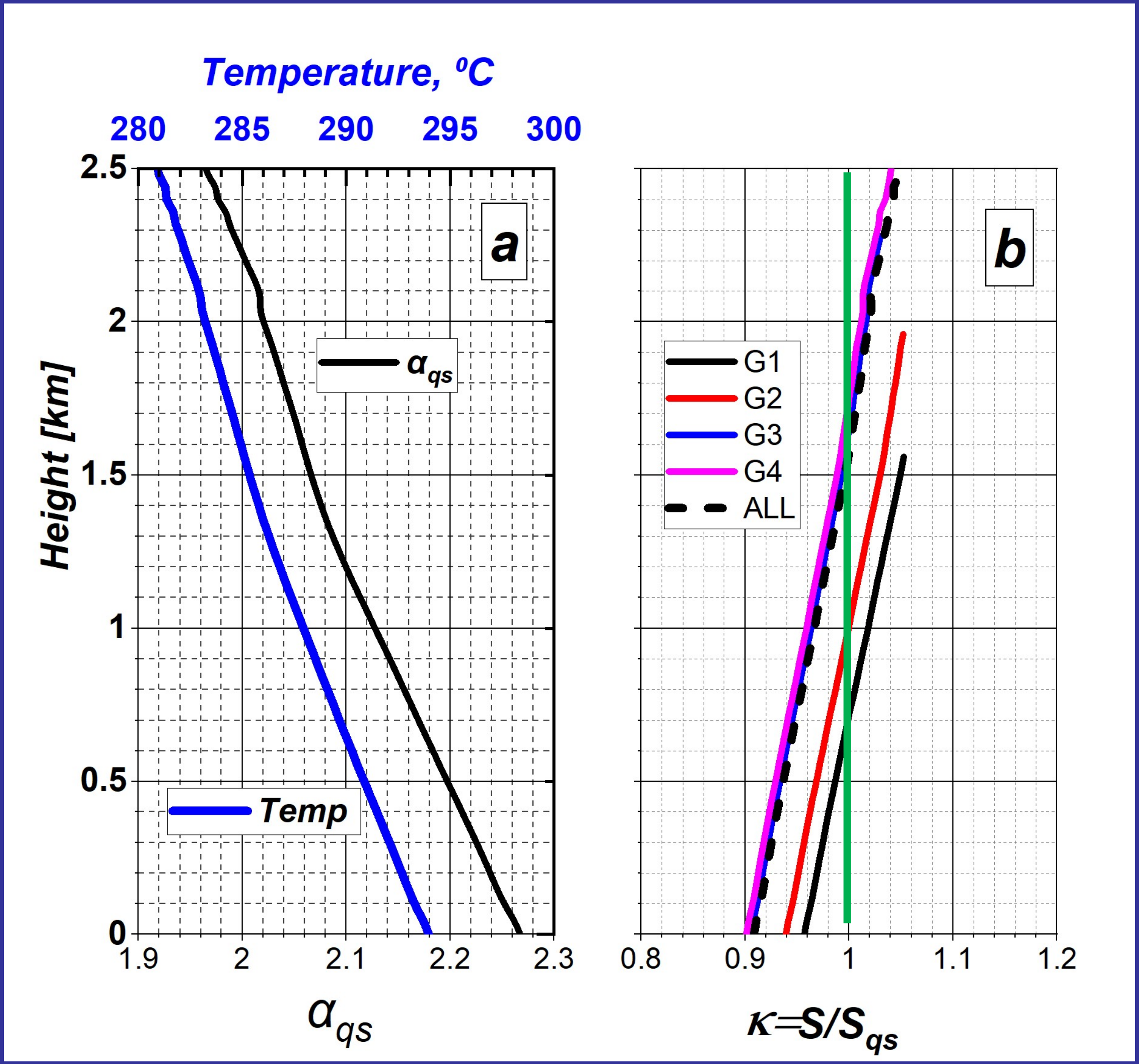
$$\frac{dq_l}{dt} = \alpha_{les}\rho_a W \qquad \frac{dq_l}{dt} = \kappa\alpha_{qs}\,\rho_a W$$

$$\kappa = \alpha_{les}/\alpha_{qs}$$

LES vs Theory

Case	G1	G2	G3	G4	All
LES	2.17	2.13	2.052	2.048	2.06
QS	2.20	2.17	2.15	2.14	2.09
Error, %	1.4	1.9	4.8	4.5	1.5

Kappa profiles - a tool to explore supersaturation in clouds



Conclusions

1. Phase transition rates are highly correlated with upward mass flux (R=0.99)
2. Linear dependence of CR on MFP is supported by condensation theory
3. Linear fit can form a basis for parameterization of latent heat release in NWP models
4. It also implies that supersaturation in clouds, on average, is close to its "quasi-steady" value