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WORKSHOP ON CLOUD PHYSICS AND CLIMATE

23 November - 20 December 1985

FLORIDA DEEP CONVECTION
(Part 3)

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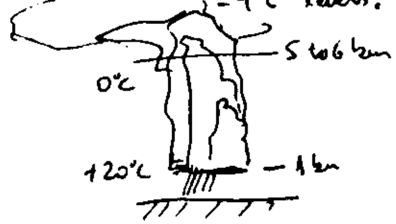
LECTURE 3. FLORIDA DEEP CONVECTION

MICROPHYSICS

References: Hallett et al 1978, Q.J.R.M.S p.631
Lamb and Hallett 1987, QJRMS p 935

Aircraft observations. Repeated penetrations between -5°C and -9°C levels:



1) New towers have no ice (<0.1 liter^{-1})
2) Within 5 minutes >10/liter graupel present; not correlated with updraft or with LWC
3) Cloud droplets >25 μm diameter present
Rain drops >0.5 mm dia. present
4) Vapor-grown crystals observed at times

Process:
Proto-ice rimes with cloud droplets ① → splinters (H-M) produced ② → splinters collected by supercooled raindrops; freeze ③ → graupel grows by further riming → more splinters produced providing feedback to ①
Graupel falls out and melts at lower levels.
(Origin of proto-ice uncertain.)


etc.

Model: - cf. next page
- results Fig 7., Figs 2, 3
∴ Multiplication factor of ~10^2 possible in 5 min.

$$\frac{dn_s}{dt} = J_s - J_{dl} = S_g n_g - S_{dl} n_s$$

(production; removal by drops)

$$\frac{dn_g}{dt} = J_{dl}$$

n_s - conc. of splinters
n_g - conc. of grpl
n_{dl} - conc of drops

$S_{dl} = n_{dl} \pi r_{dl}^2 v_{dl} E_{dl}$ — sweep-out by drops

$S_g = n_{25} \alpha \pi r_g^2 v_g E_g$ — production per grpl.

$\alpha = 0.005 - 0.02$

n_{25} – conc. of droplets $d > 25 \mu m$

$\frac{1}{S_{dl}} = \tau_r$ time const. for removal

$\frac{1}{S_g} = \tau_p$ time const for production

α - splinter production efficiency

DYNAMICS

Mesoscale convergence over the peninsula demonstrated via numerical model:
Pielke 1974, M.Wea.Rev. p115-139
Ulanski and Garstand 1978, I & II, J.Atm.Sci. p1047-1069

Three-dimensional cloud-scale model:
Tripoli and Cotton, 1980 J.Appl.Meteor. p.1037-1063
(uses parameterized microphysics)

RADAR OBS.

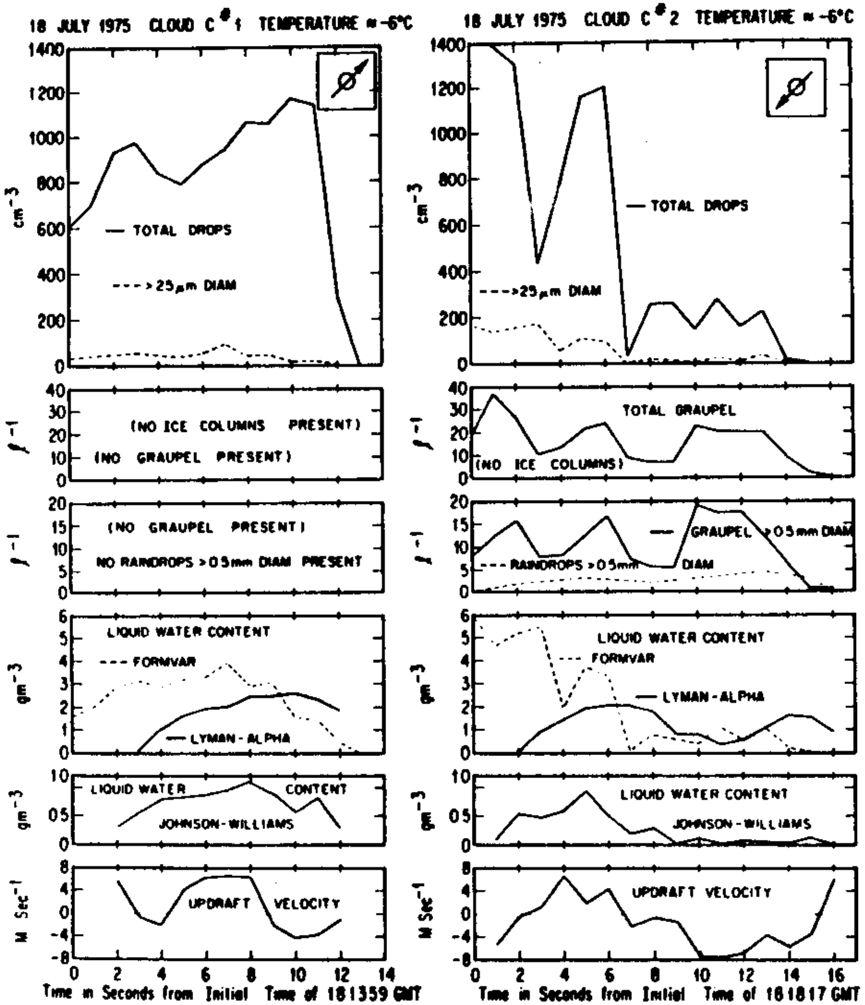
Lopez et al. 1984 M.Wea.Rev. p.56-75
Gagin et al 1985 J.Atm.Sci. p.84-94

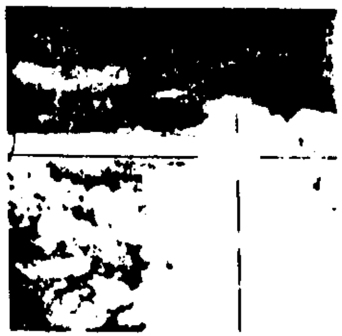
Objective tracking of individual cells
Trends between maximum height of cloud and
- max. reflectivity
- total duration of precip.
- max. area of precip.
- max. rate of rainfall volume ($m^3 hr^{-1}$)
- max. rainfall volume precipitated

all power-law relationships.

SEEDING

Concept of dynamic seeding effect - Simpson
Randomized experiments I & II
Statistical analyses - Woodley
Positive result but not statistically significant
Physical hypothesis: difficulties with high natural ice concentrations due to "secondary" mechanism, with propagation of effect from buoyancy aloft to cloud-base increase of moisture flux





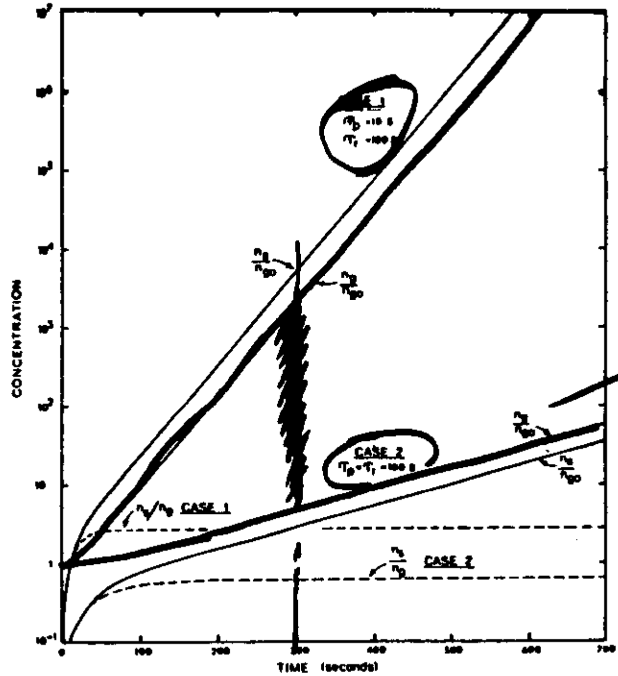


Figure 7. The evolution with time of the number concentrations of secondary splinters (n_s) and graupel (n_g) for two cases of the conceptual model (see text). τ_p represents the time constant for splinter production, τ_r that for removal of the splinters by supercooled drops.

to graupel is thus seen to approach a constant value in each case, depending upon the respective time constants. Particularly noteworthy is that multiplication factors of O(10^3) arise in times less than five minutes in case 1, the case with the higher splinter production rate. Although the basic trends shown in Fig. 7 are intuitively reasonable, it is well recognized that the assumptions, primarily of constant S_g and S_{di}, impose limitations which prohibit direct application of this simple conceptual model to the real atmosphere. Nevertheless, the concept of 'in situ' multiplication based on the scavenging of secondary splinters by large supercooled drops is seen to be potentially powerful and could well be the basis for the actual multiplication of graupel in Florida cumuli. This further implies that the evolution of the ice phase in such clouds in general depends intimately upon the prior and independent evolution of the liquid phase.

It should be noted that weak to moderate updraught speeds (up to several metres per second) are favoured for the optimum conversion of liquid water drops to new graupel

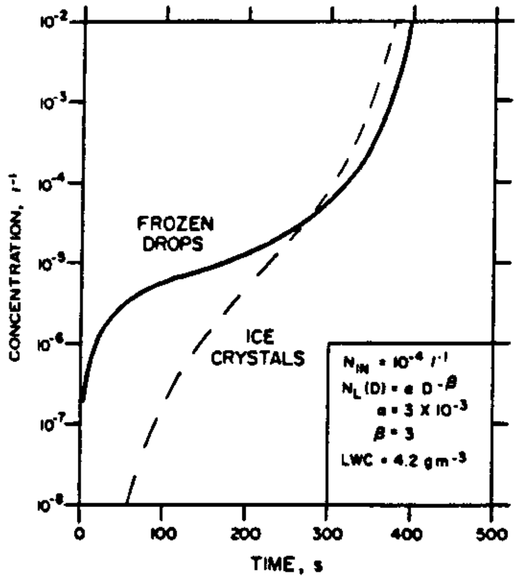


Fig. 2. Model output of the evolution of ice for the case of a high raindrop concentration.

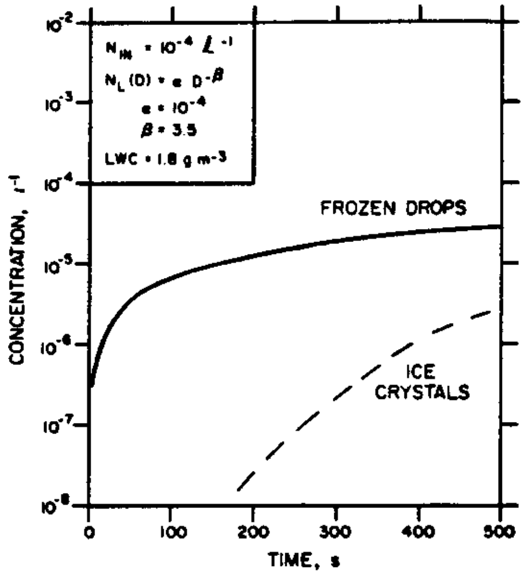


Fig. 3. Model output of the evolution of ice for the case of a reduced concentration of raindrops.

VI. REFERENCES

Foster, T and J. Hallett, 1982: A laboratory investigation of the influence of liquid water content on the temperature dependence of secondary ice production during soft hail growth. Proceedings of Conference on Cloud Physics, Chicago, Nov. 1982.

Hallett, J., and S.C. Mossop, 1974: Production of secondary ice particles during the riming pro-

Lamb, D., J. Hallett and R.I. Sax, 1981: Mechanistic limitations to the release of latent heat during the natural and artificial glaciation of deep convective clouds. Q. J. Roy. Meteor. Soc., 107, 935-954.

Locatelli, J.D. and P.V. Hobbs, 1974: Fall speeds and masses of solid precipitation particles. J. Geophys. Res., 79, 2185-2197.

Mossop, S.C., 1978: The influence of drop size distri-

Tripoli and Cotton, J. Appl. Meteor. 1980 p1037
Florida convection.

into a downdraft throughout the region.

of the downdraft region. This updraft appears to be

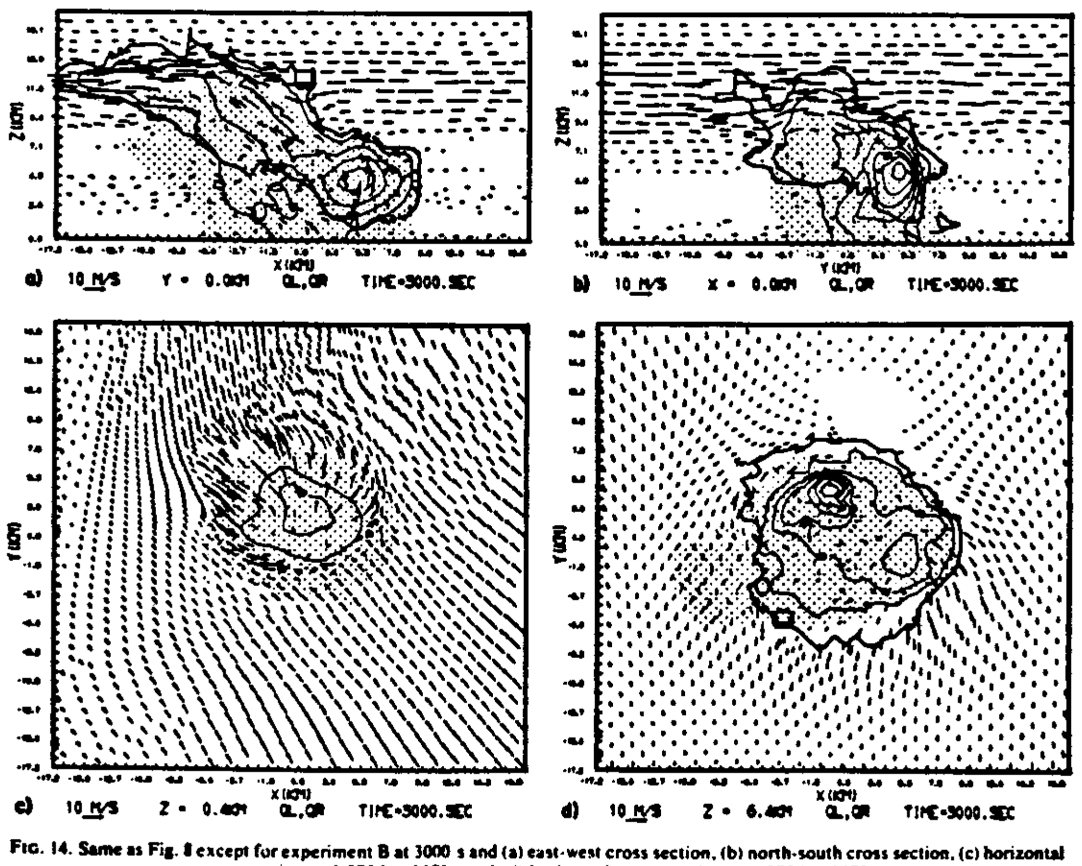


FIG. 14. Same as Fig. 8 except for experiment B at 3000 s and (a) east-west cross section, (b) north-south cross section, (c) horizontal cross section at 0.375 km MSL, and (d) horizontal cross section at 6.375 km MSL.

Gagin 1985 J. Atm. Sci., p. 84

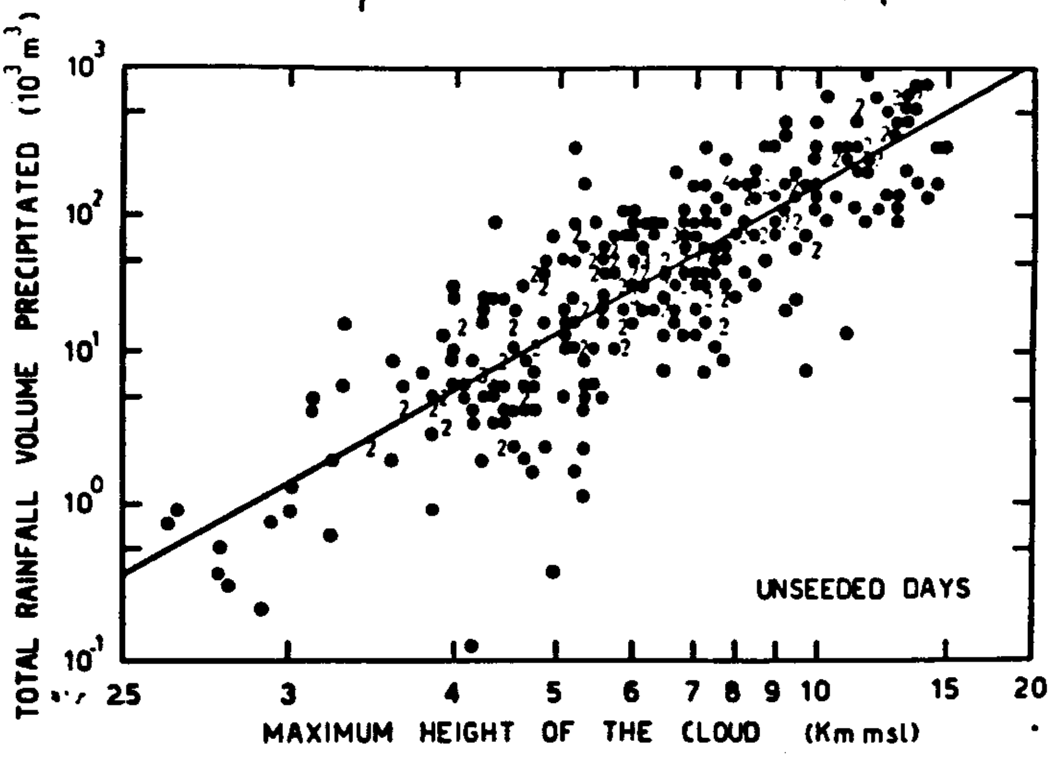


Fig. 4a.

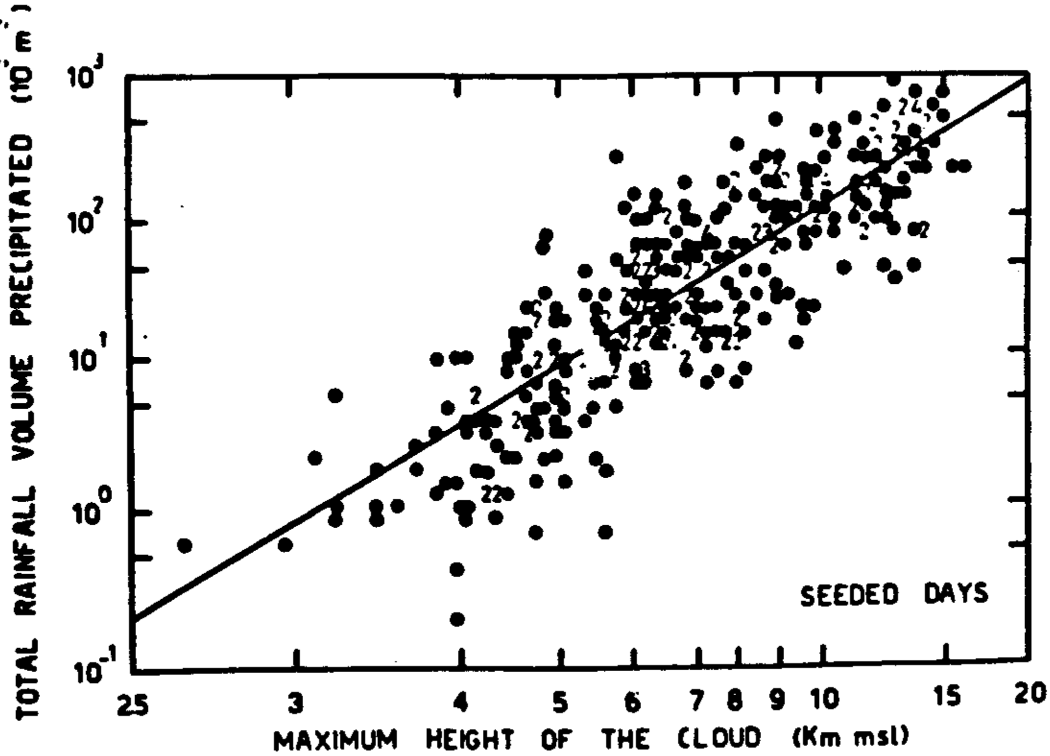


Fig. 4b.