Thoughts on a new field campaign: quantity of precipitation

Alan Blyth

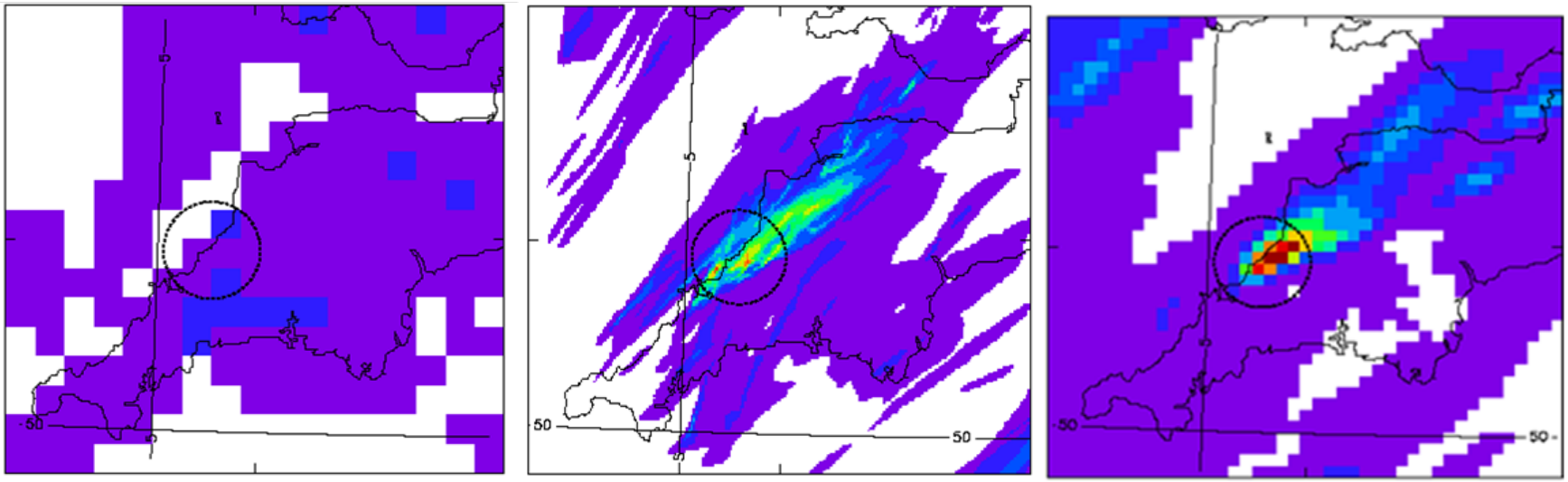
NCAS and University of Leeds

October 27, 2009

High-resolution Met Office UM

- Model represents synoptic and meso-scale controlled convective events well
- Representation of stable lids important and likely to depend on vertical resolution
- On smallest scale – unlikely that location of cells is predictable; cells develop from small cumulus clouds that are not resolved with 1-km model
- Microphysics plays important role: (a) development of precipitation – forecasts of the quantity of precipitation are often poor; (b) evaporation of particles and strength of downdraughts

Boscastle

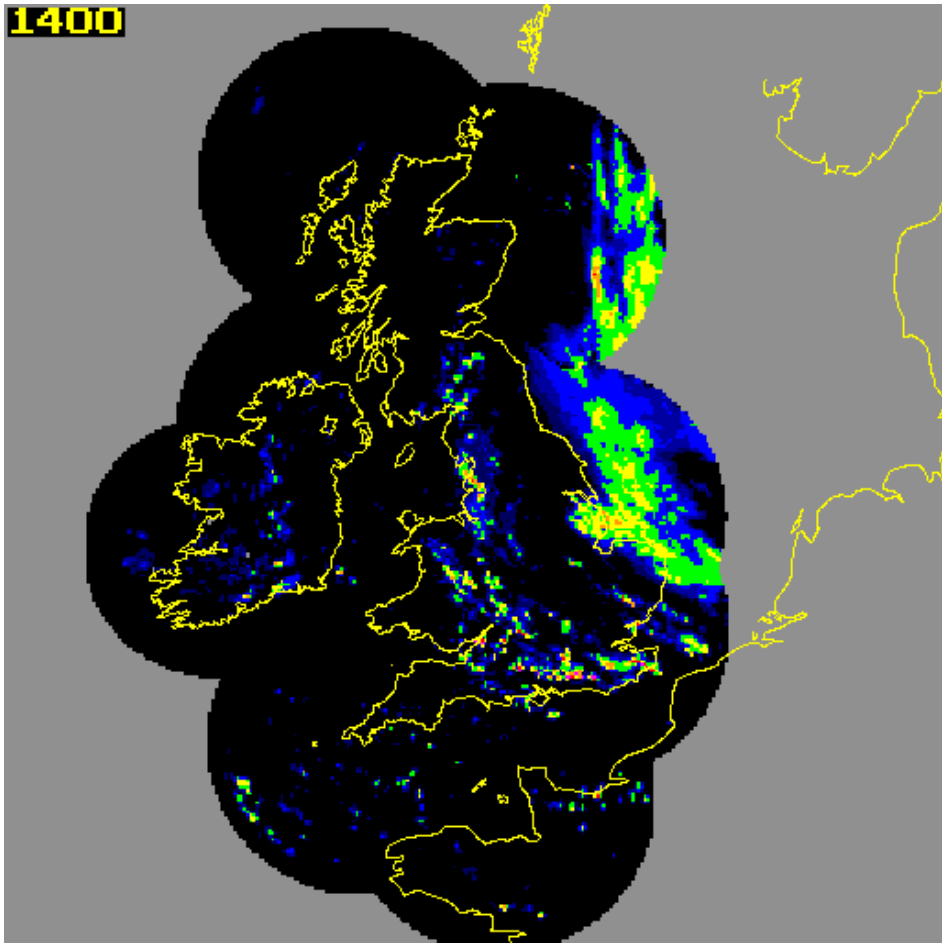


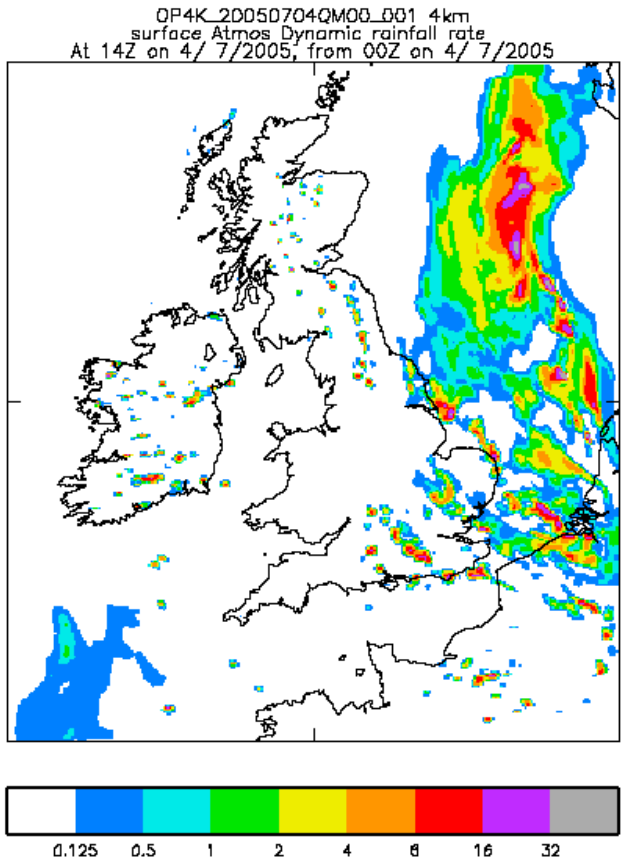
12-km model 1-km model Radar

Peter Clark

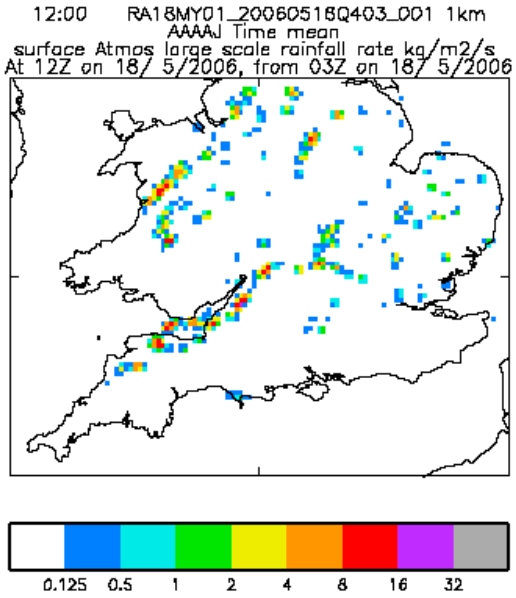
- Over 200 mm of rain was recorded at the head of the Valency river catchment above Boscastle, and peak rates may briefly have reached 400mm hr^{-1}.
- Warm rain is thought to have been important.

4 July 2005

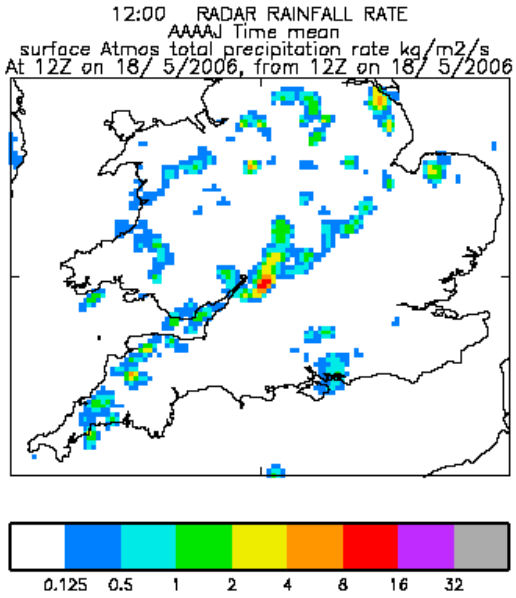

1400


OP4K_20050704QM00_001 4km
surface Atmos Dynamic rainfall rate
At 14Z on 4/ 7/2005, from 00Z on 4/ 7/2005
0.125
0.5
1
2
4
8
16
32

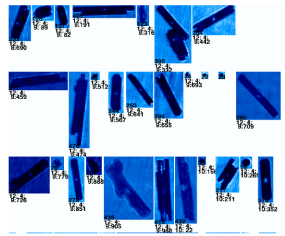
ICE and Precipitation Initiation in Cumulus (ICEPIC) case 18 May 2006



1-km UM



Network radar



Richard Forbes, Richard Cotton and Phil Brown

- **Model predicts:** higher precipitation rates at the upwind end of the convective line
- **Observations show:** broader areas of light precipitation around convective cells; precipitation commences sooner at the upwind end of the convective line; some cells originated over sea
- Clouds penetrated: warm rain and Hallett-Mossop process

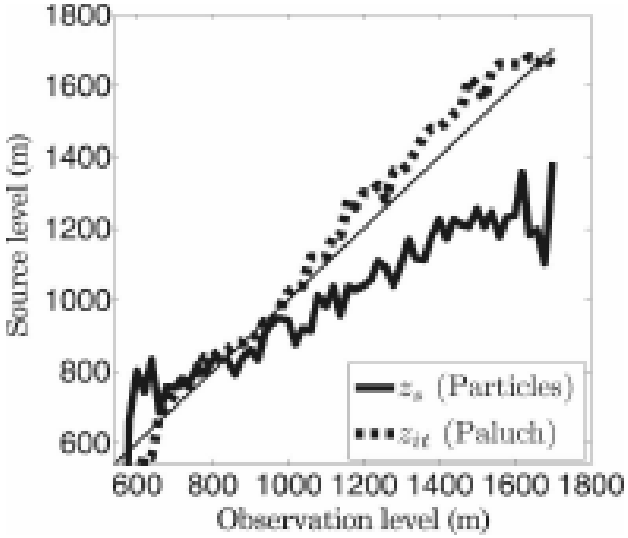
Key Processes

- Entrainment
- Warm rain
- Initiation and development of ice particles and precipitation
- Evaporation, sublimation, melting
- Role of aerosols

Cloud Issues

Problem	Issues
Entrainment	How are clouds diluted? Size of clouds. Lateral vs cloud-top entrainment
Warm rain	Sometimes aerosols alone; entrainment and mixing, and turbulence important in deeper clouds
Initiation of ice	Some progress associating nucleating ability of specific aerosols. Tricky in field, particularly in convective clouds
Glaciation and development of precip	Hallett-Mossop important; other processes? Rates and types of precip need to be quantified using radar
Role of aerosols	Good progress with models; Measurements needed
Rates of processes in models	Evaporation, sublimation, melting; Measurements needed

Heus et al: LEM study



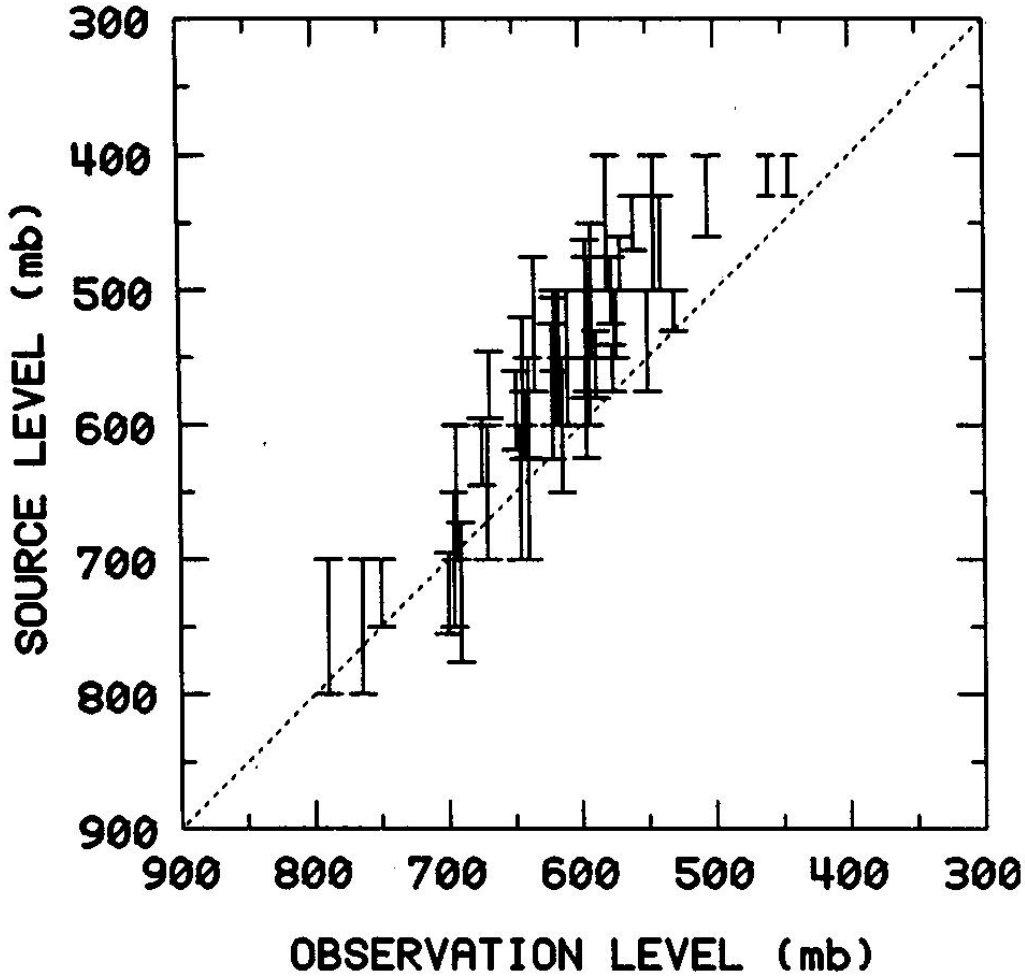
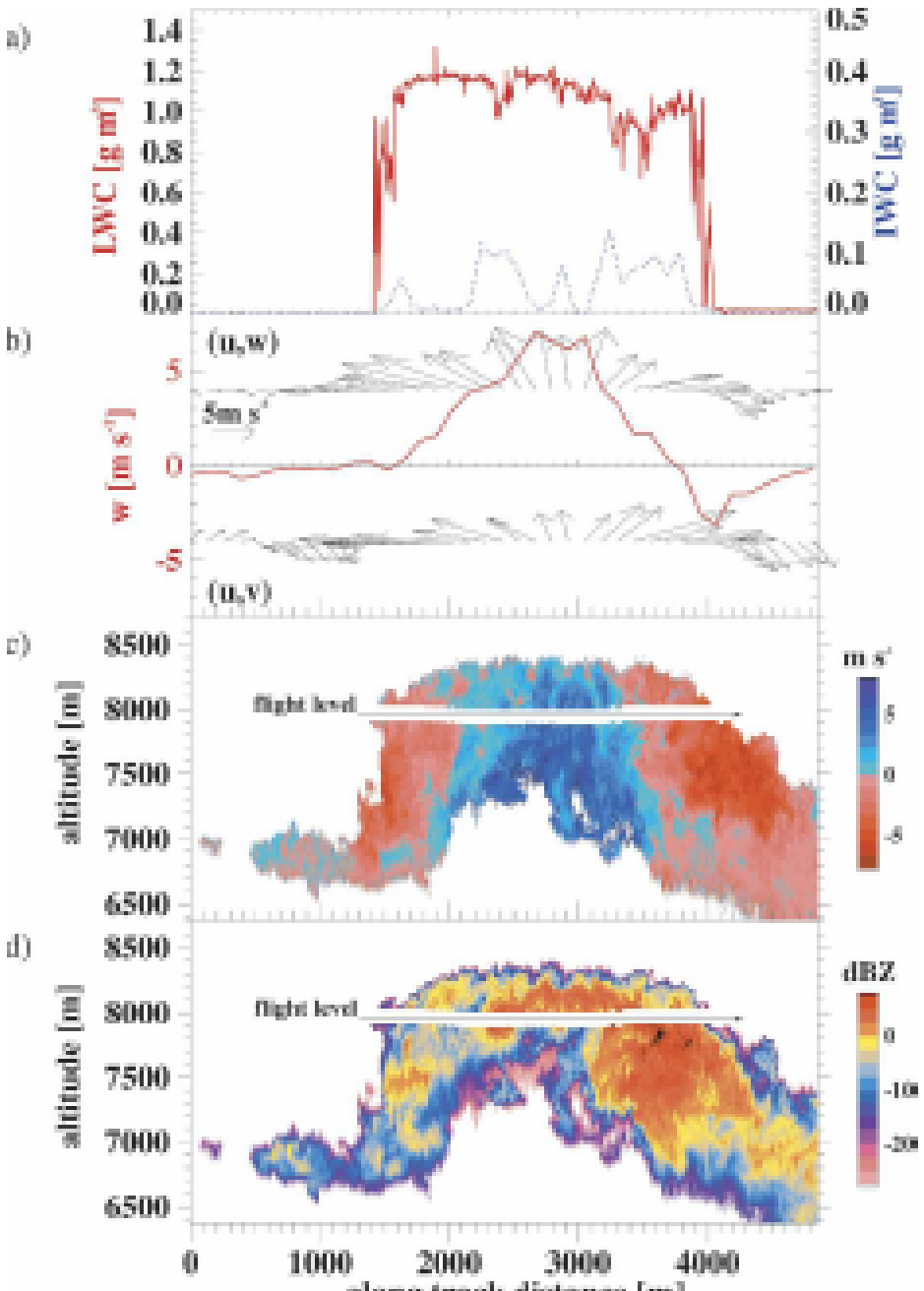
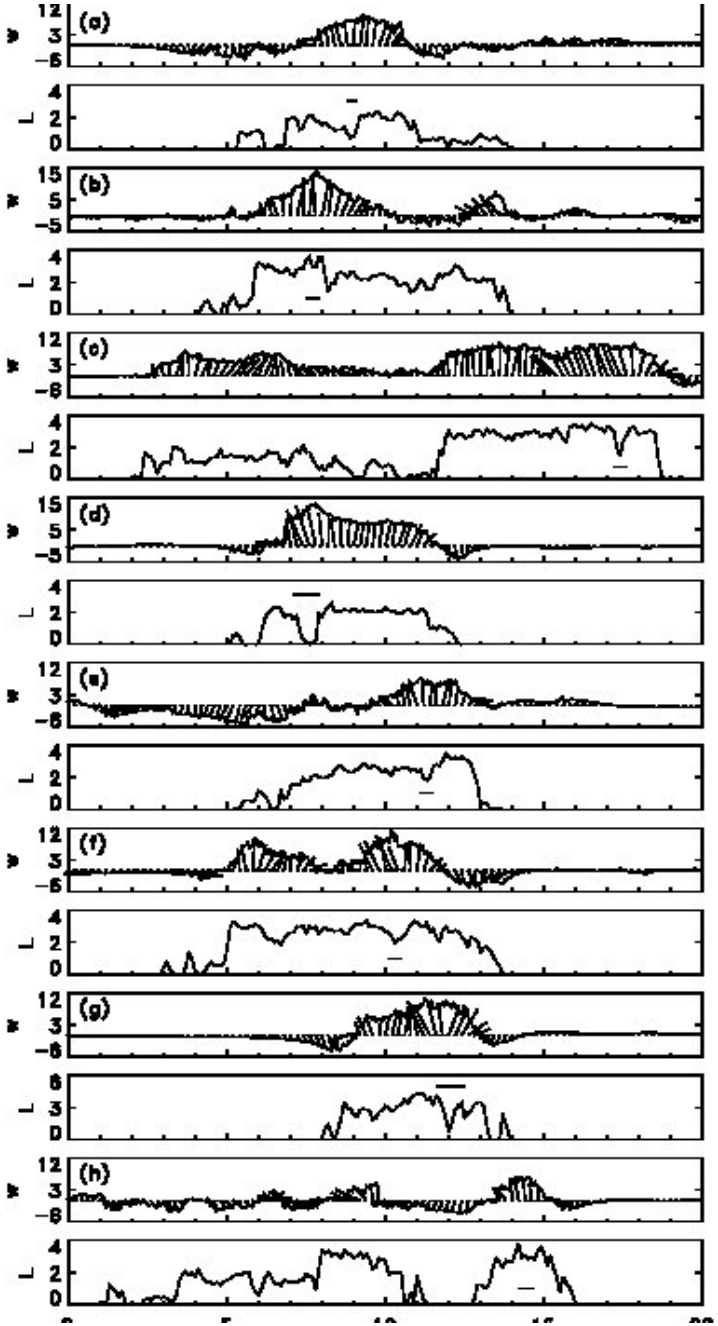


FIG. 10. The source level from which air was entrained into the cloud, as a function of the observation level in the cloud, for 44 cases taken from 44 different regions for which source levels could be determined. The error bars indicate the approximate ranges that are consistent with the observations.

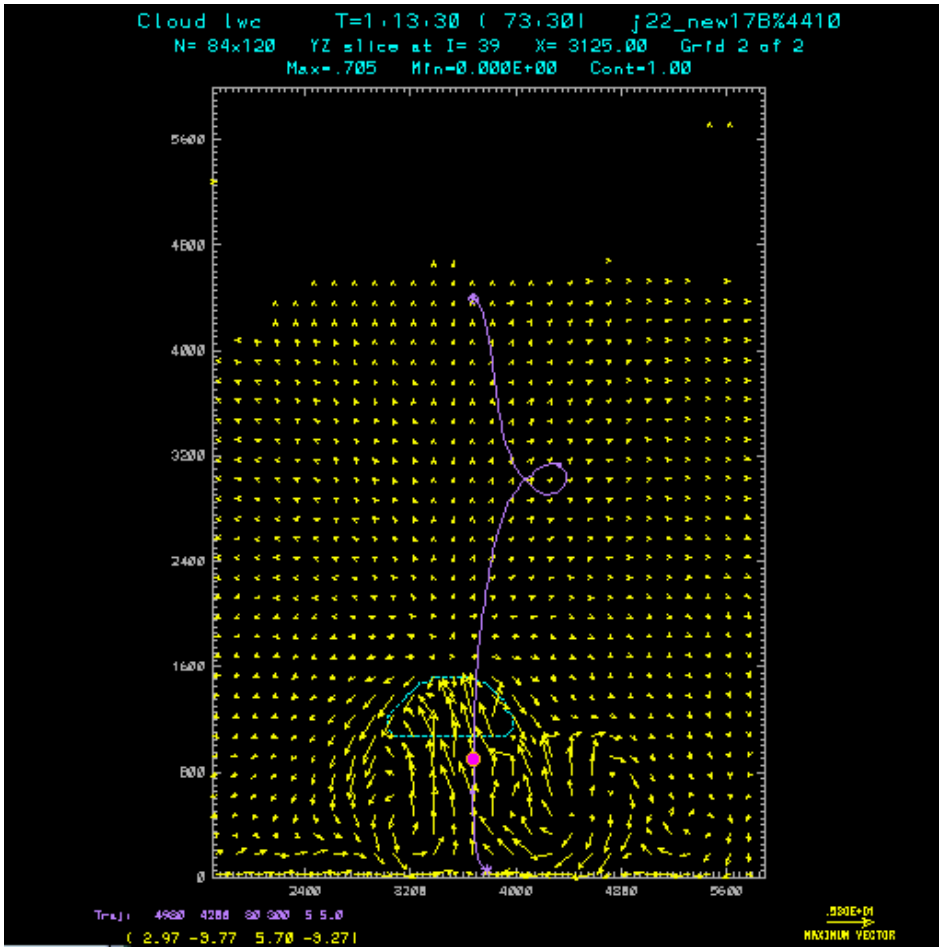
Damiani et al



Reduced LWC in middle of updraft

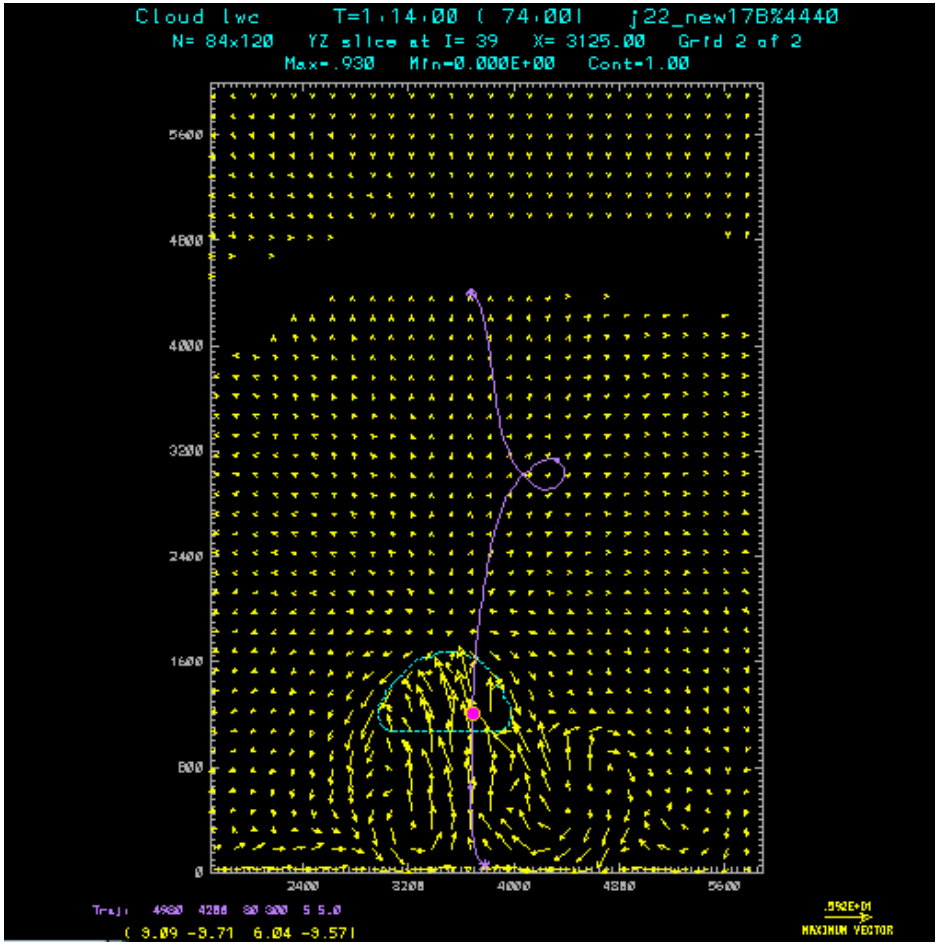


How clouds entrain



Courtesy of Dr. Sonia Lasher-Trapp

How clouds entrain



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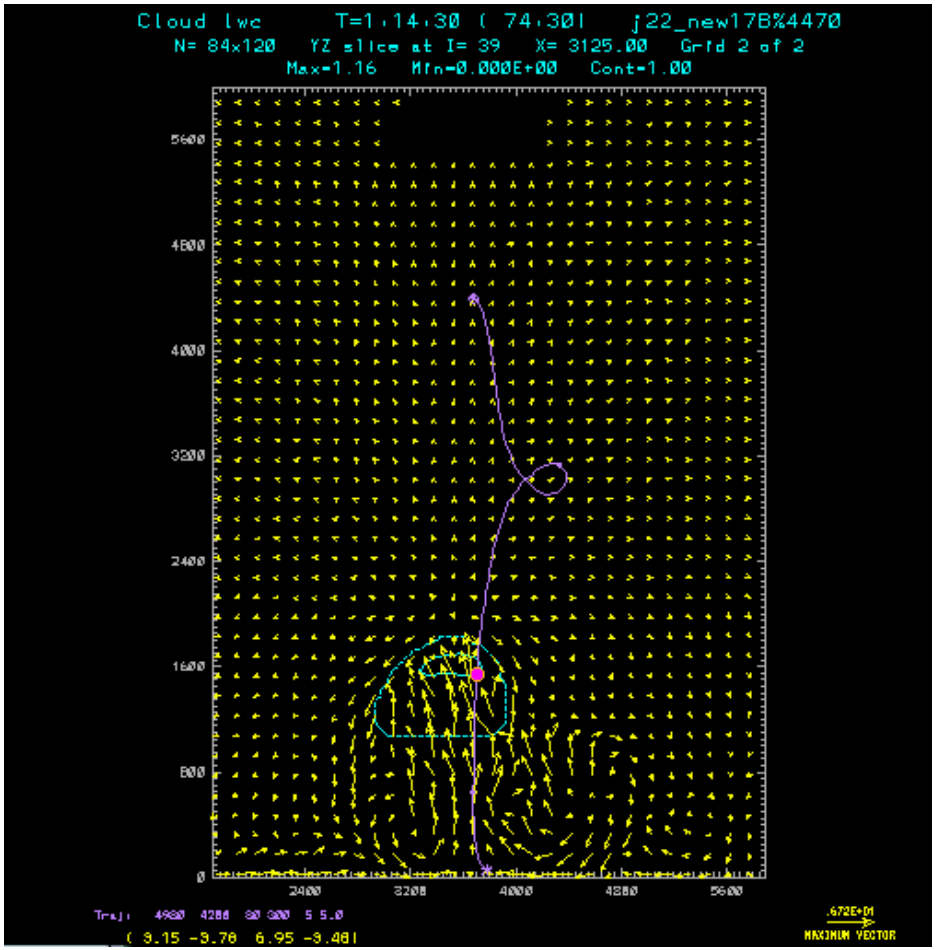

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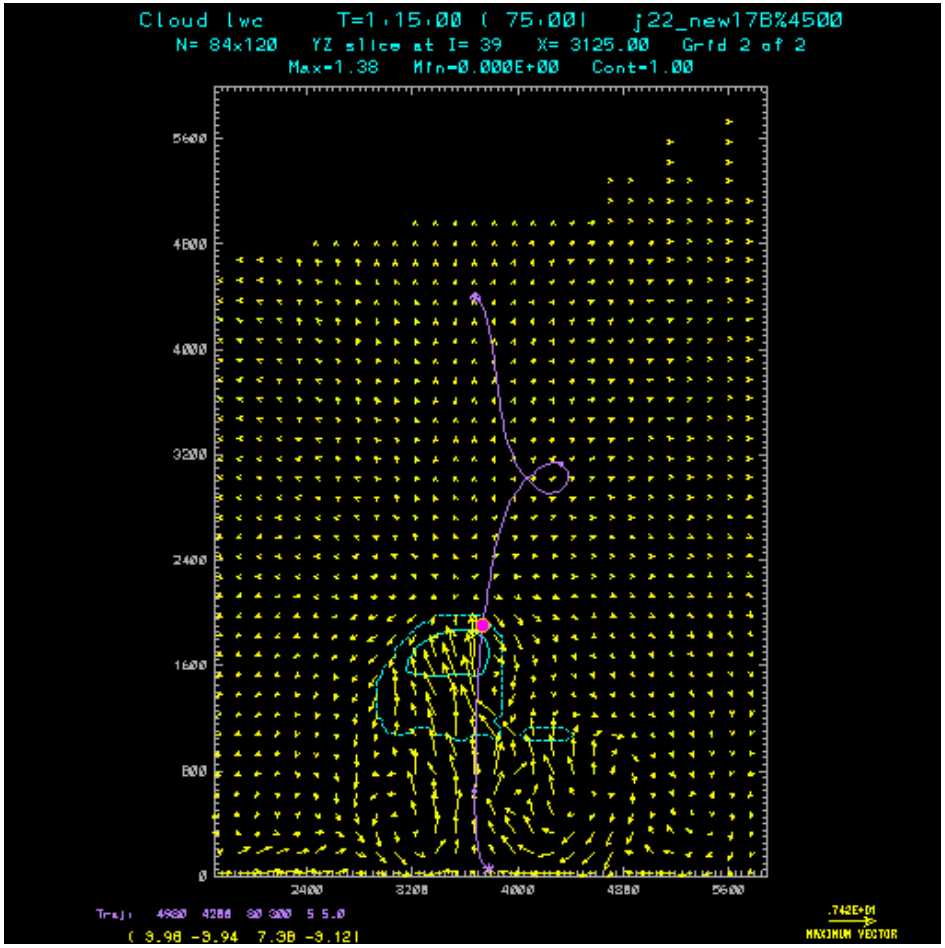

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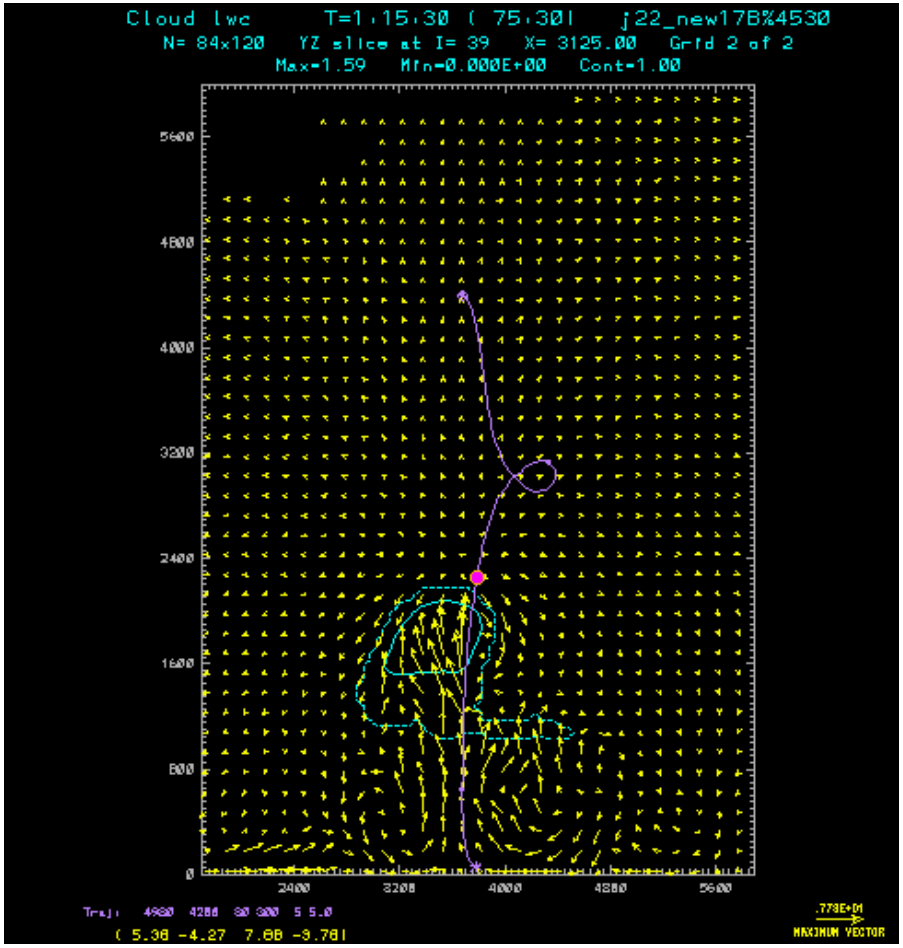
How clouds entrain



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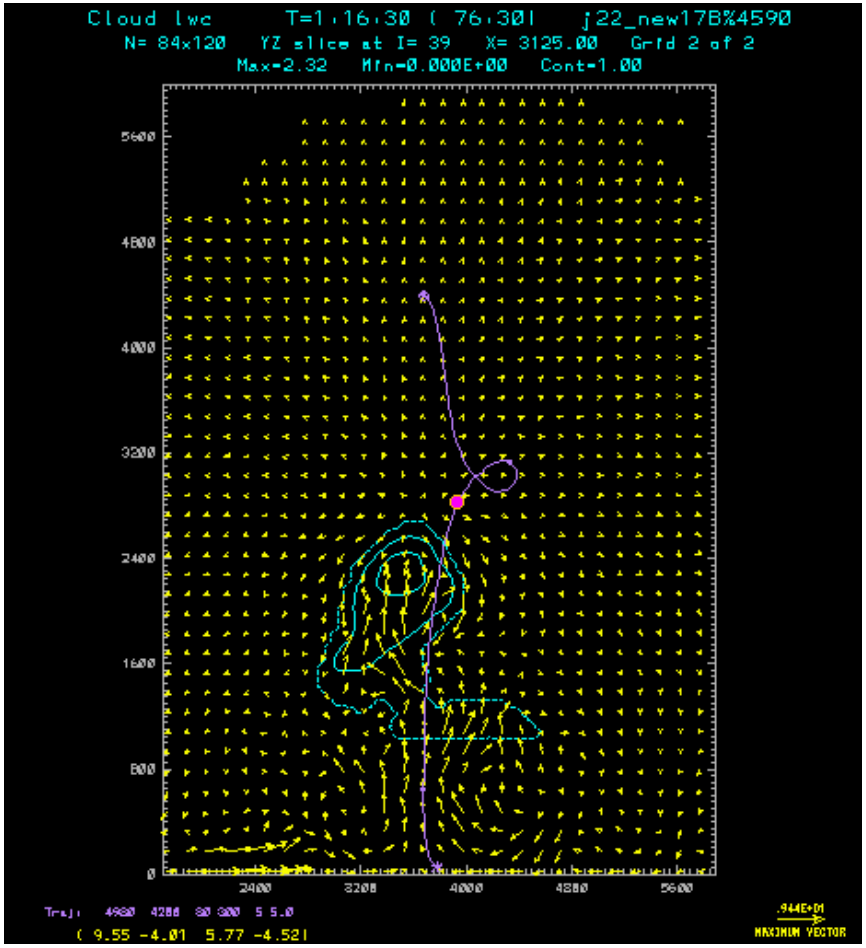
How clouds entrain



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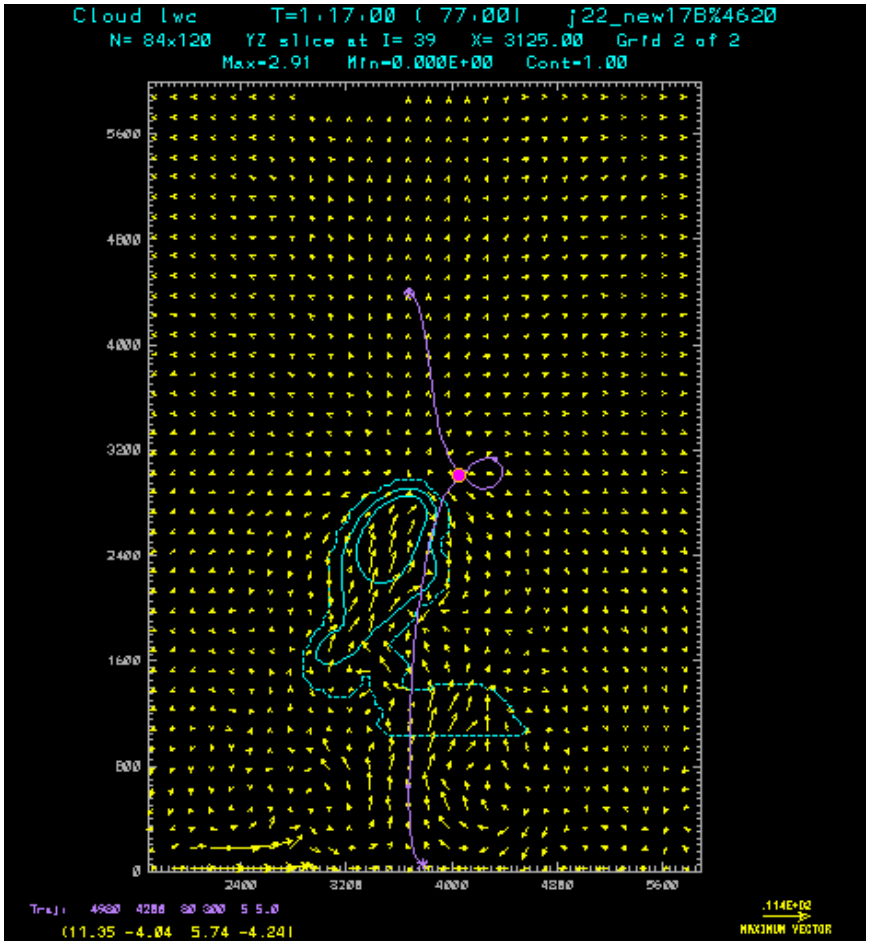
How clouds entrain



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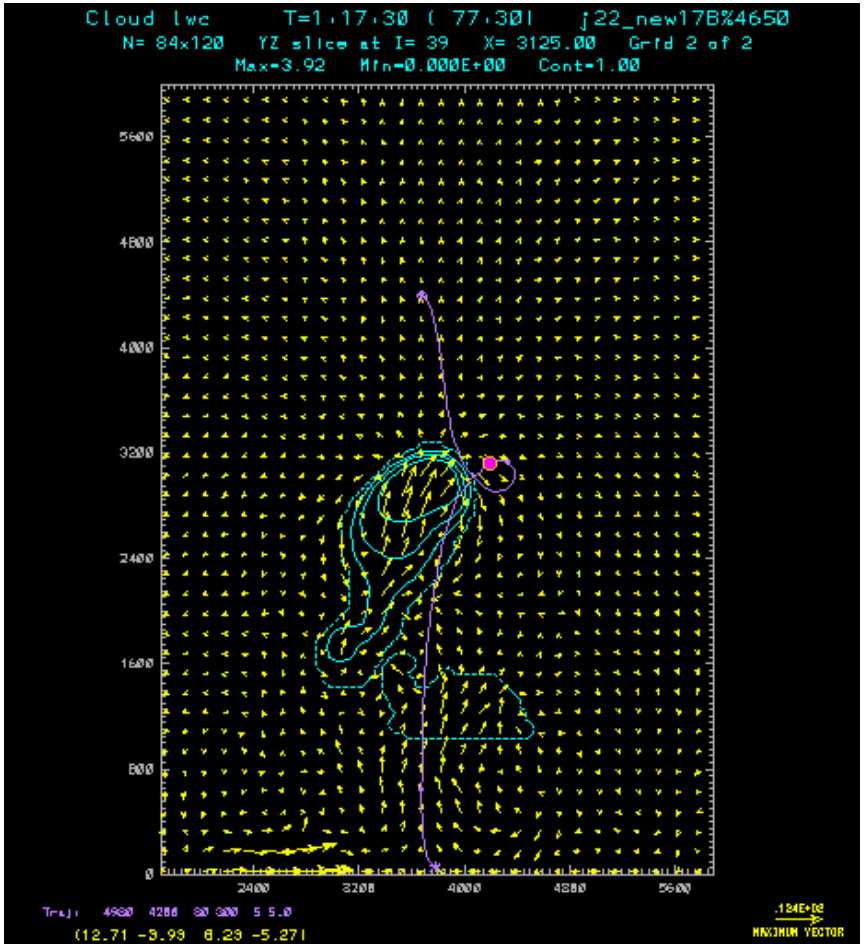
How clouds entrain



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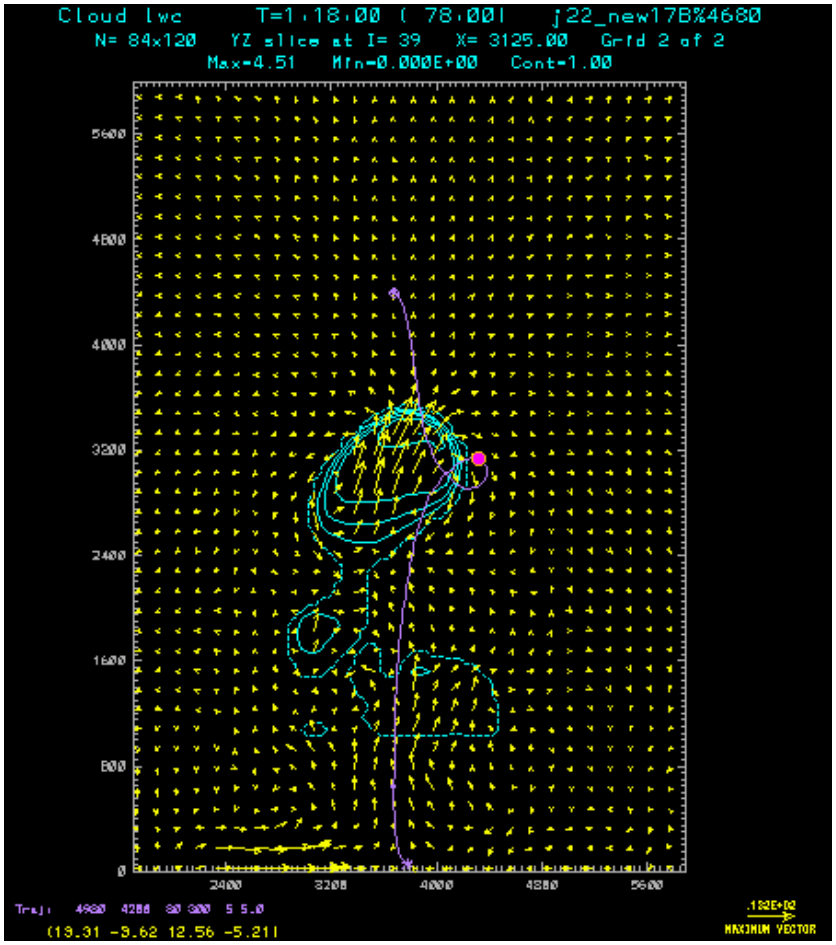
How clouds entrain



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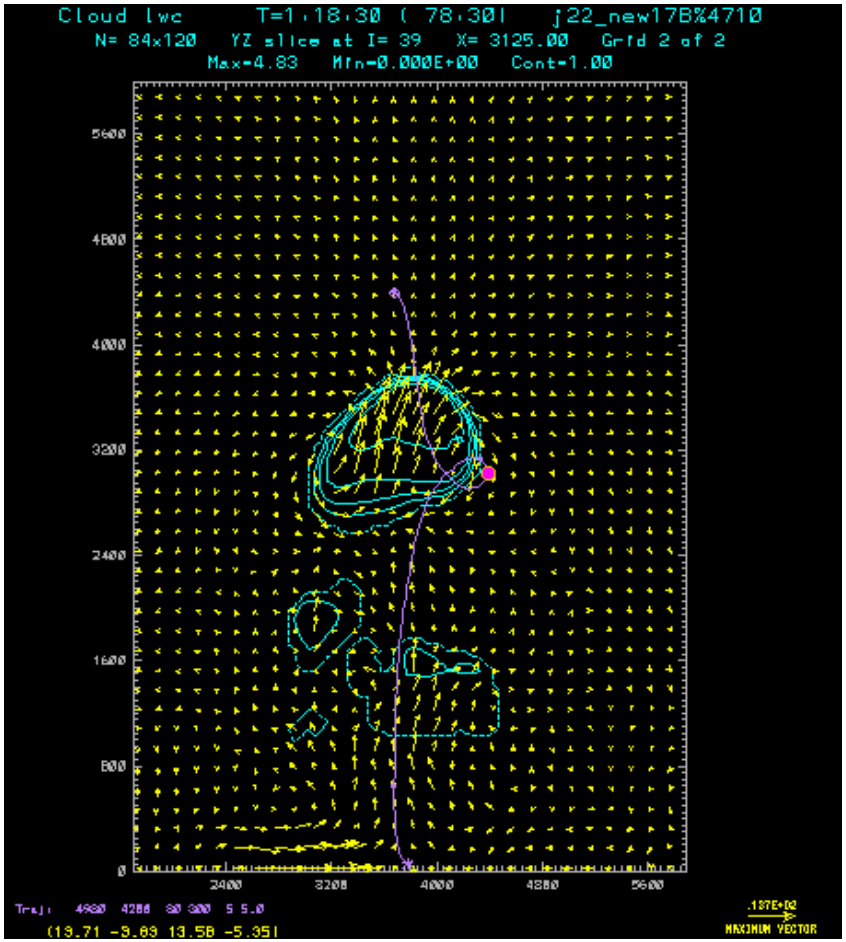

Courtesy of Dr. Sonia Lasher-Trapp

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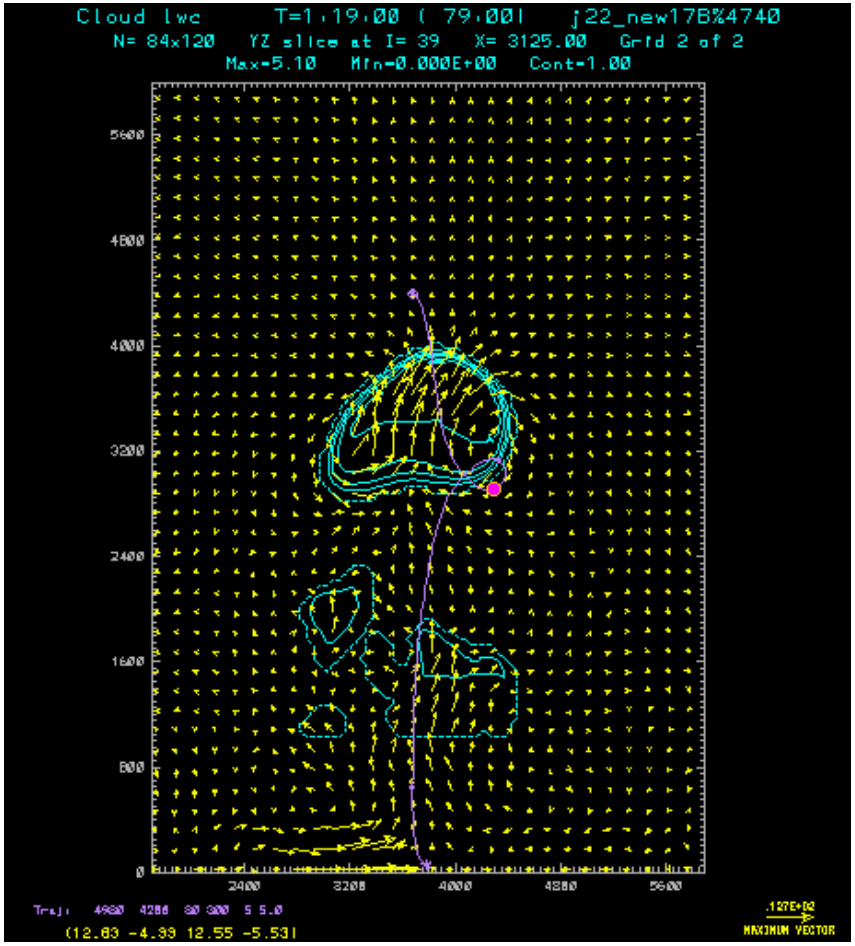

Courtesy of Dr. Sonia Lasher-Trapp

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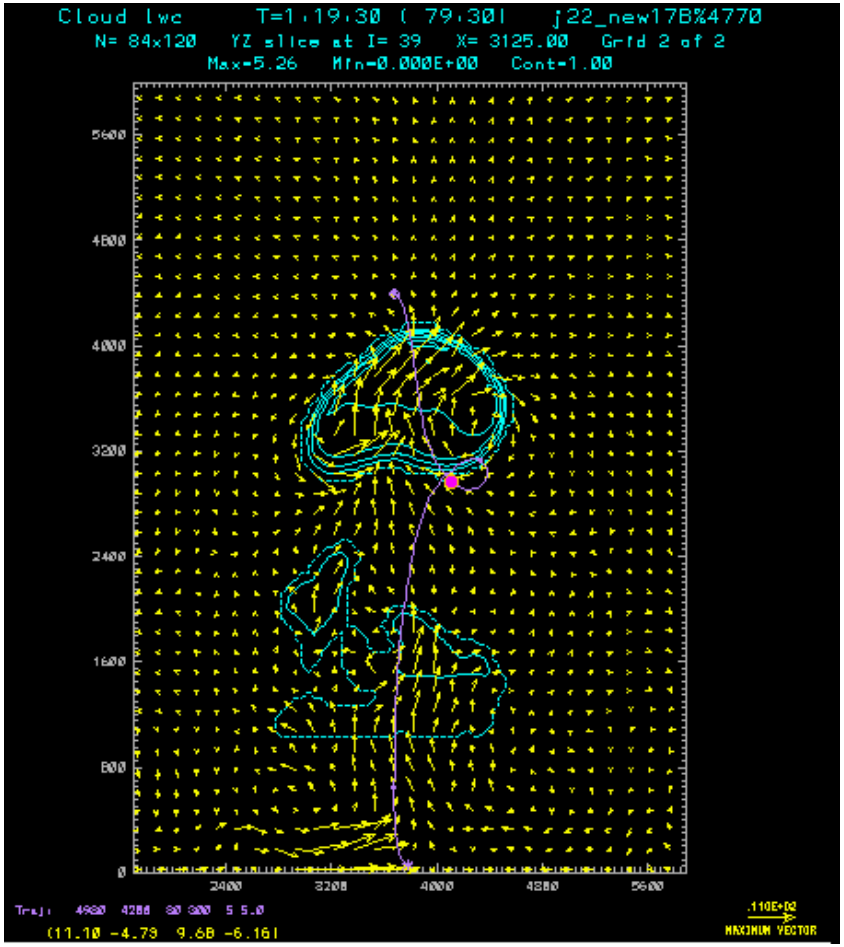

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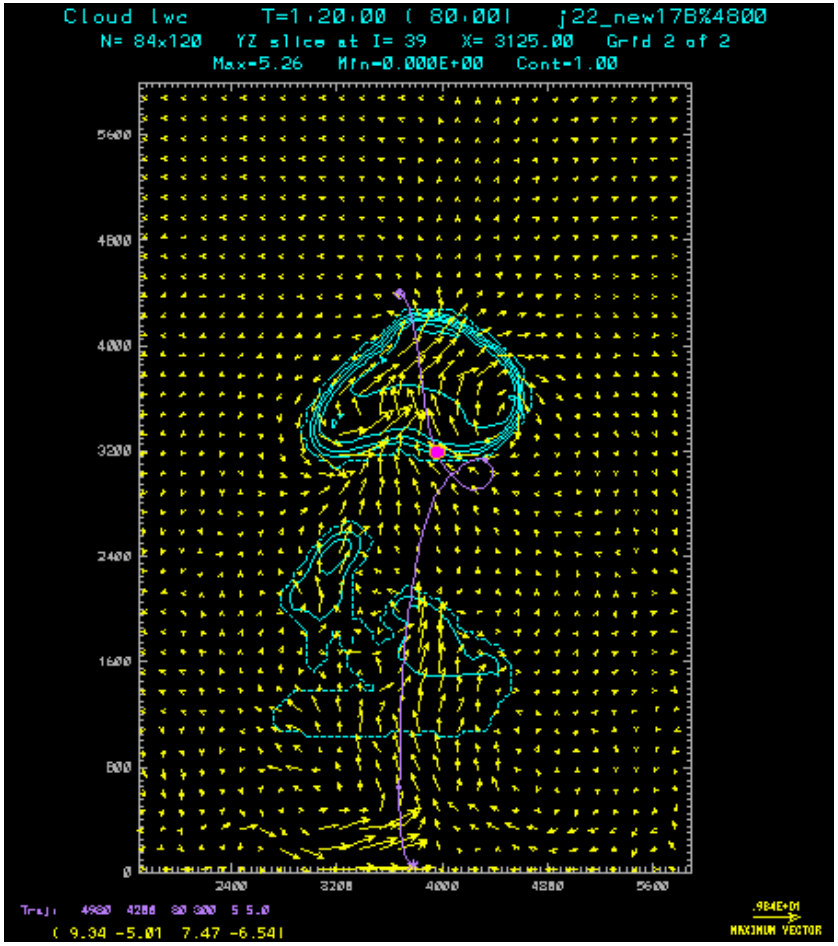

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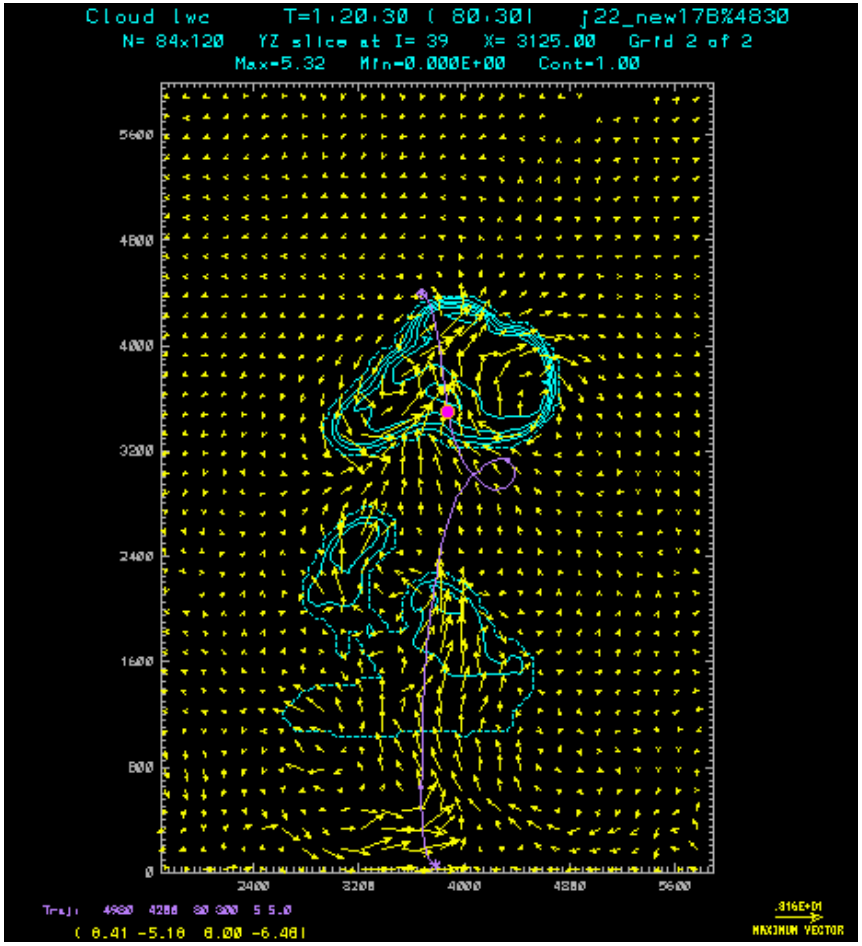

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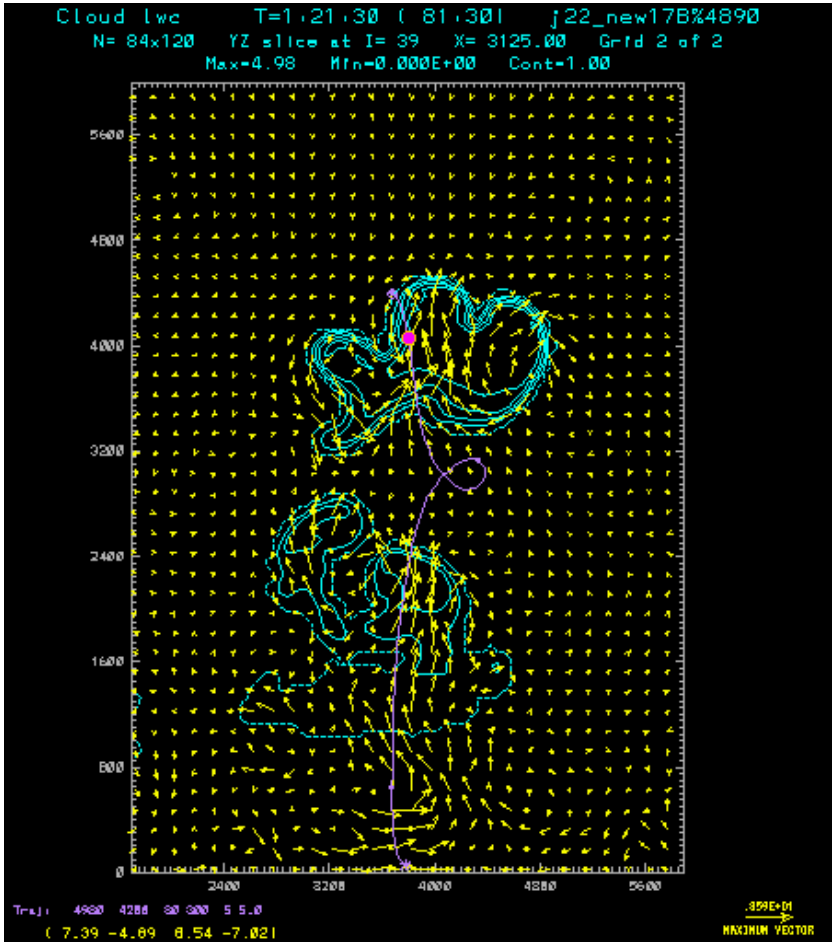
How clouds entrain



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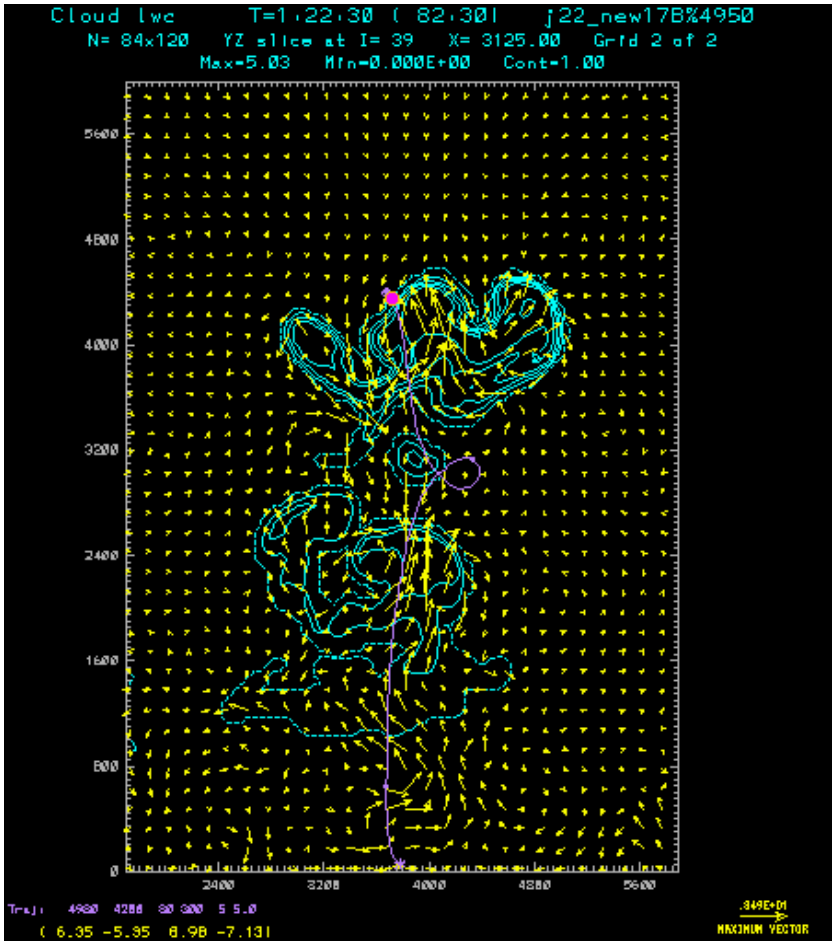
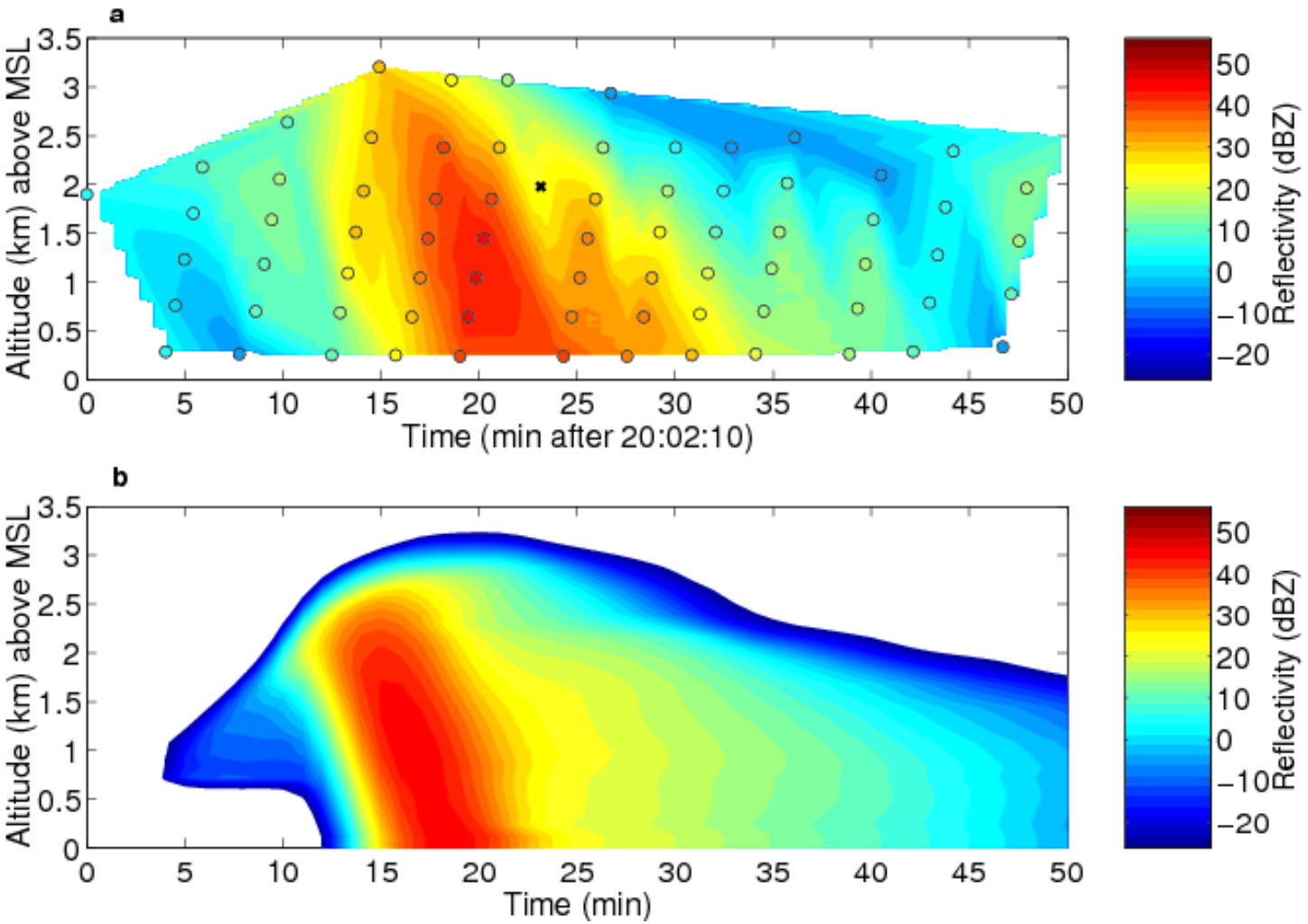
How clouds entrain



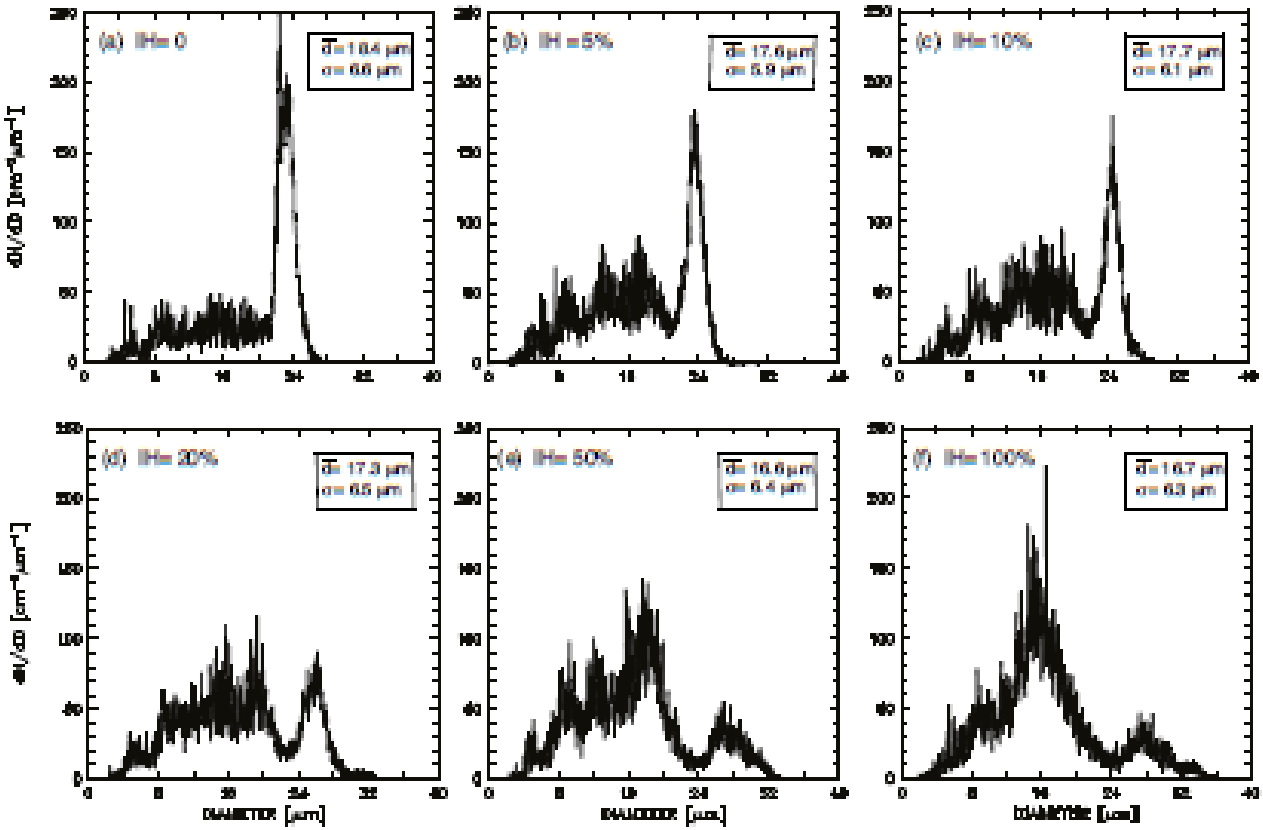
Courtesy of Dr. Sonia Lasher-Trapp

Warm rain process



Jason Lowenstein, Yahui Huang, Stewart Davies

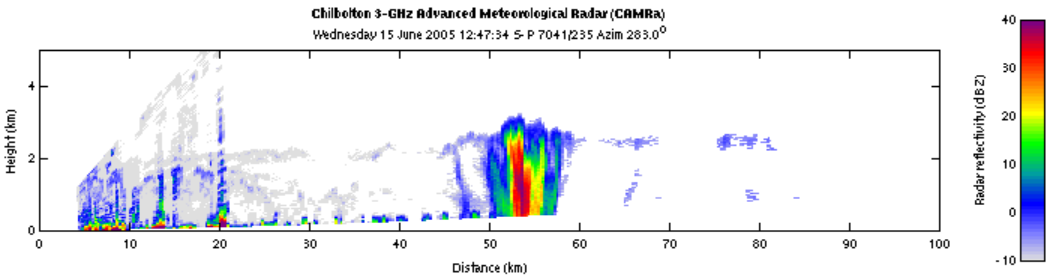
Entrainment important for warm rain

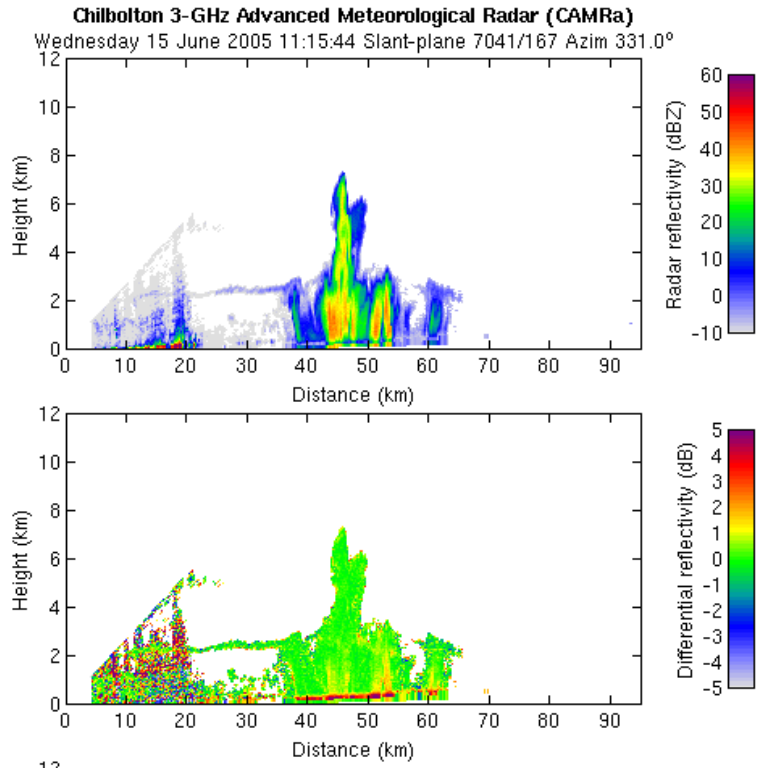


Lasher-Trapp et al. (2005)

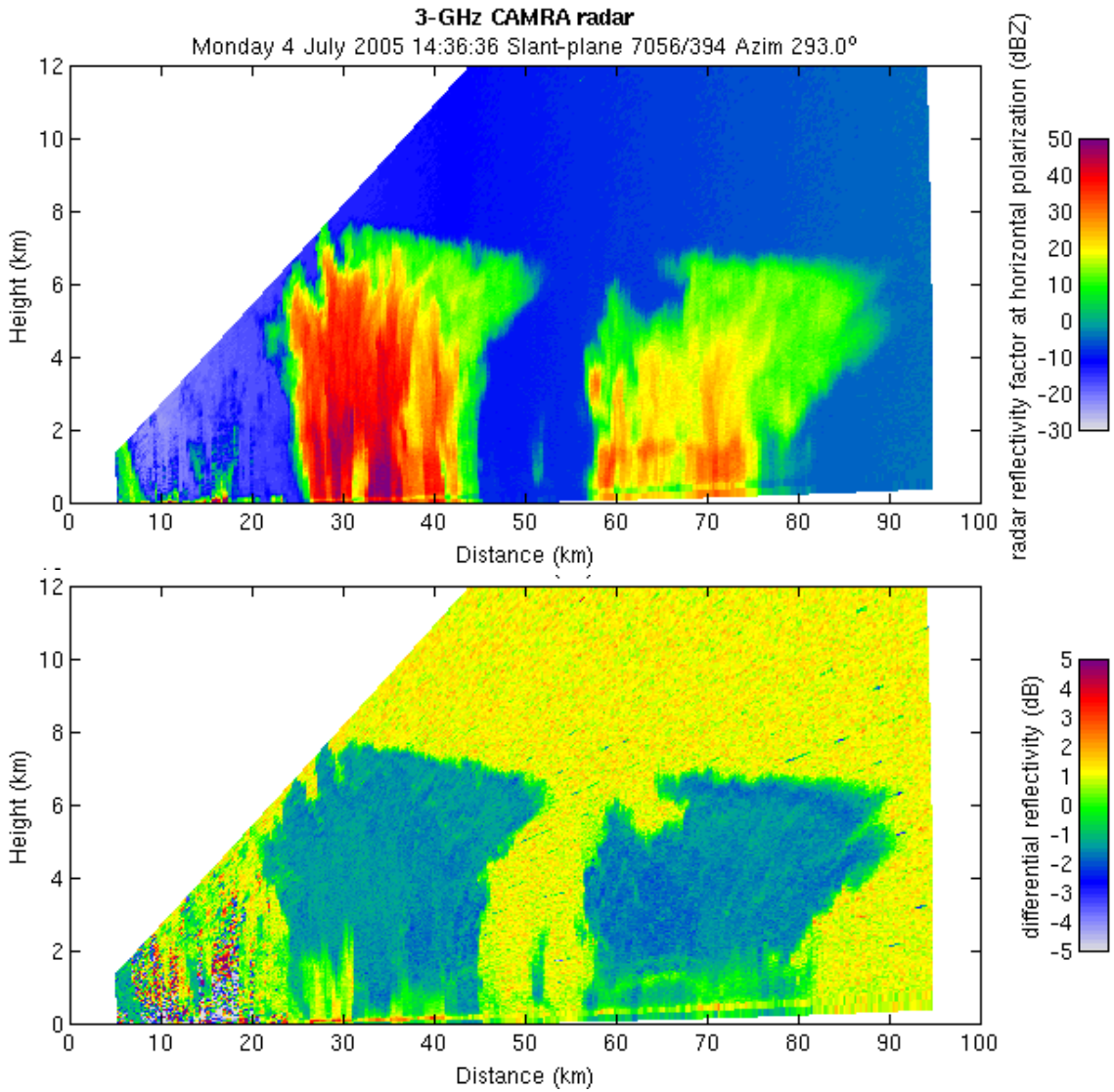
Warm rain important for ice processes in deep convection

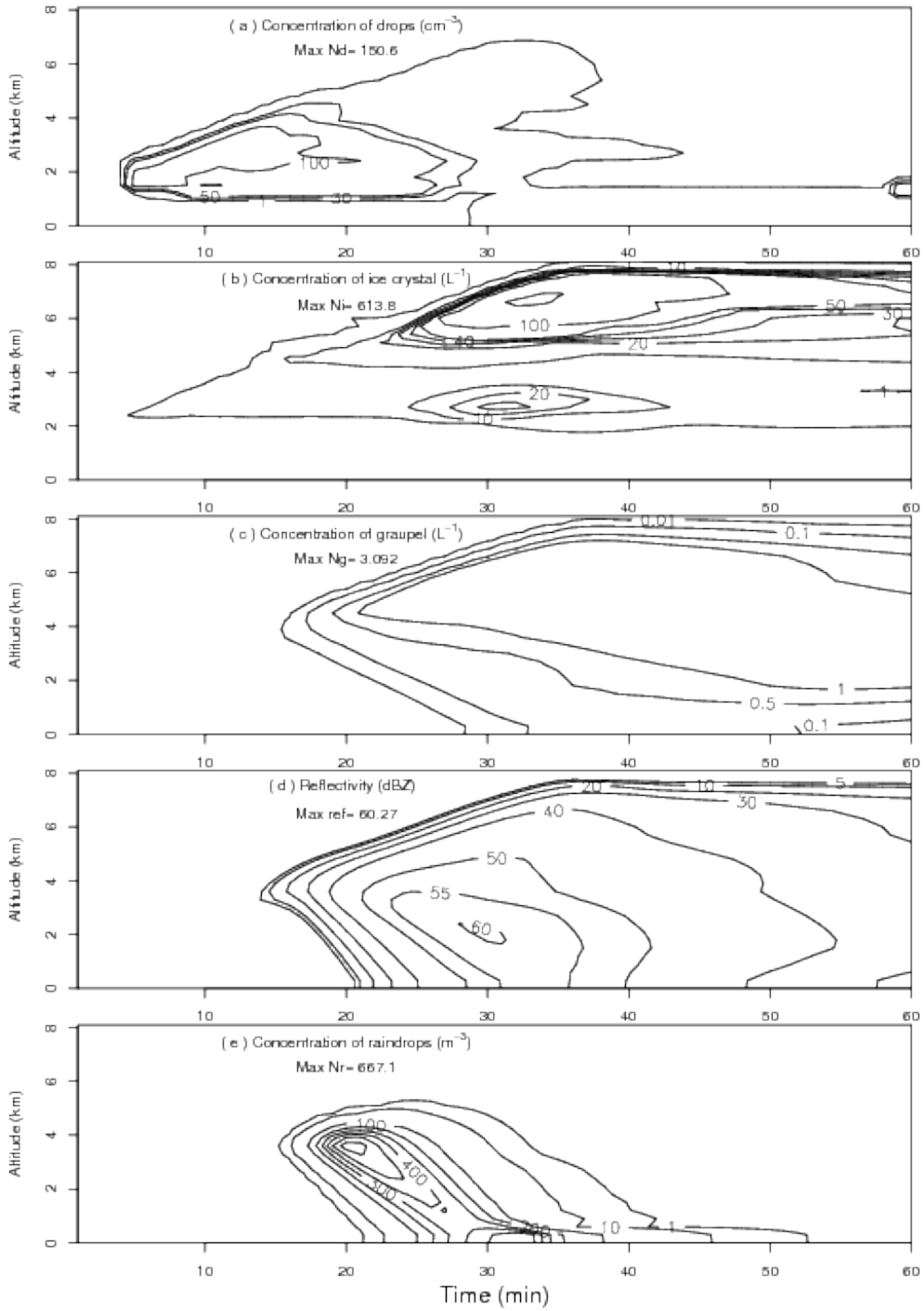
0 deg C level: 2.9 km





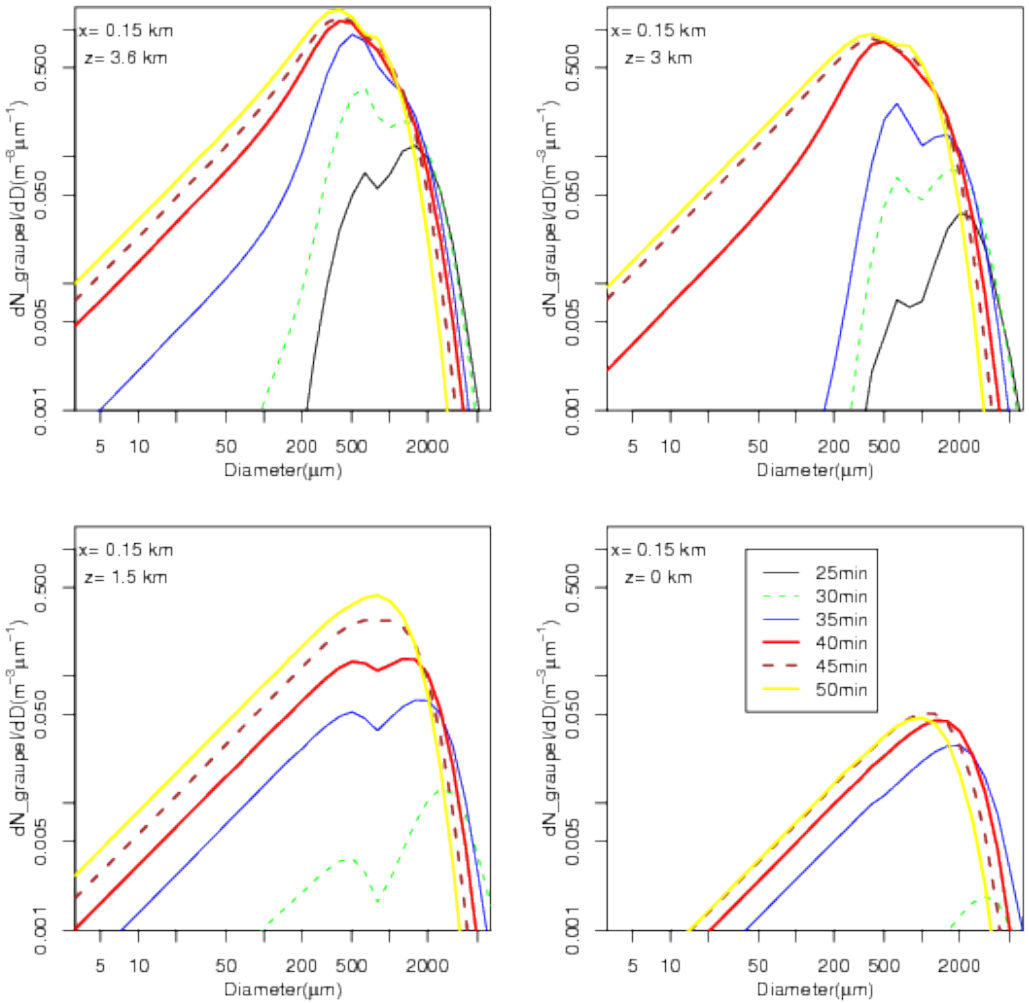
Ice and Precipitation: 4 July 2005, CSIP





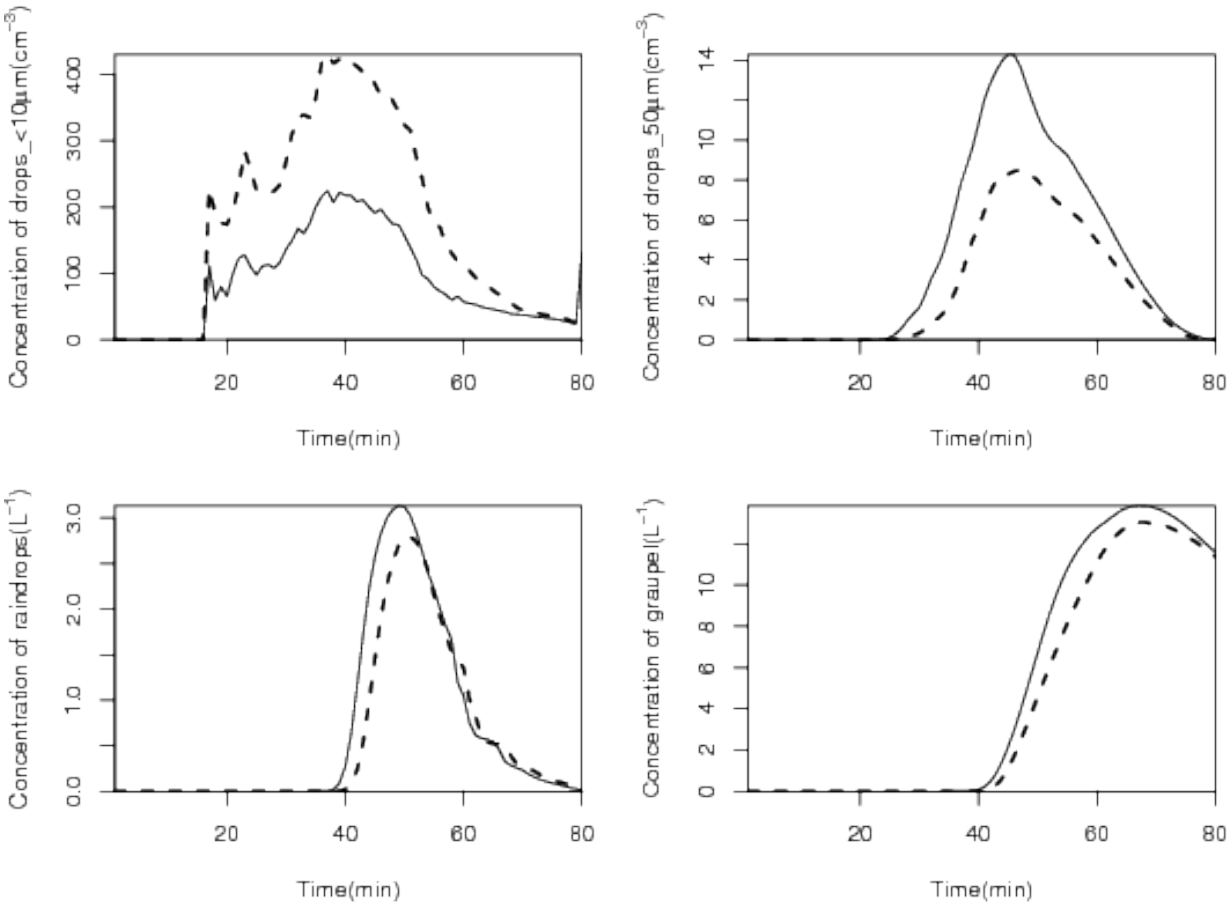
MAC3 model: *Yahui Huang*

Particle size distributions



MAC3 model: *Yahui Huang*

Influence of Aerosols



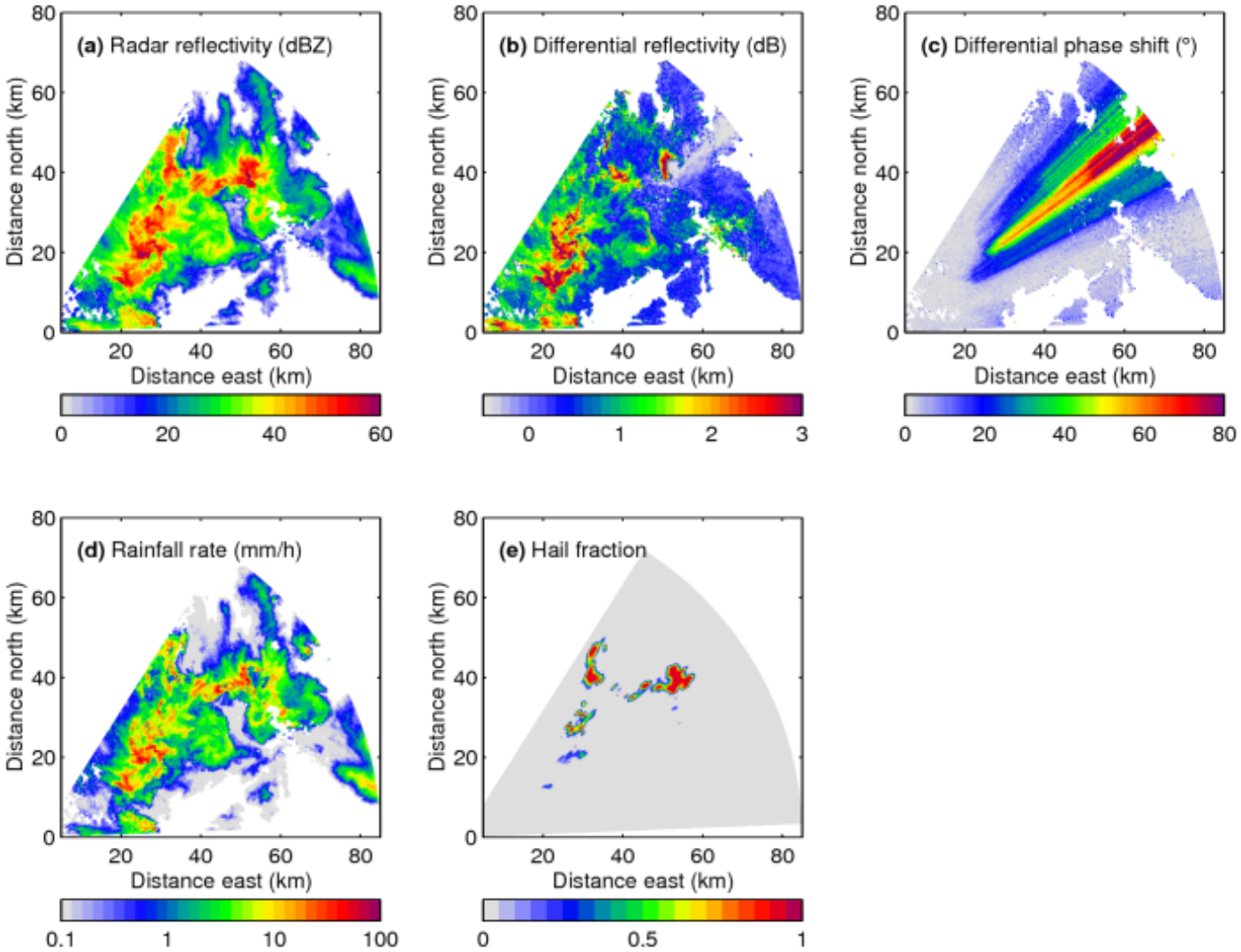
MAC3 model: *Yahui Huang*

UK Met Office CONSTRAIN project

Field campaign with BAe 146 off NW of Scotland.

- **Ice nucleation:** Introduce a prognostic aerosol source of IN?
- **Growth and loss of ice mass to pristine ice or snow:** depends on v_t and PSD assumptions.
- **Conversion of liquid droplets to ice:** Initiation of ice
- **Ice/snow melting rates:** Control latent heating rates
- **Autoconversion from ice to snow:** Requires understanding of the aggregation of ice
- **Ice/snow precipitation rates:** depend on v_t and m relations and PSD representation
- **Graupel:** collection processes, deposition/sublimation and melting.
- **PSD:** makes assumptions about numbers of small ice crystals ($d < 100\ \mu$m).

Retrieving the properties of rain and hail - Robin Hogan



Future Project

- **Behaviour of convergence lines:** humidity structure; persistence; air flow; behaviour of clouds in convergence lines
- **Microphysical processes, thermodynamics and interaction with dynamics in convective storms:**
  - entrainment and detrainment;
  - formation and development of ice
  - quantity of precipitation; formation and development of warm rain and graupel
  - evaporation of solid and liquid particles
  - role of aerosols
- **Two connected study areas:** SW peninsula of England and over Chilbolton radar
- New cloud physics instruments on the aircraft; mobile radar; S-PolKa?
- Improved modelling capability (UM; WRF; ADDEM aerosol model; LEM with bin microphys, etc)

Discussion groups

- Groups of 4-6. Mix up - not all people from same group please.
- Raporteur; Presenter; Critic.
- Use laptop so we have saved file and summary can be shown tomorrow.
- Use rooms: Saloon, Board room and King's
- Issues:
  - Next field campaign after COPS
  - Field campaign in S England
  - Modelling projects
- Questions to consider:
  - What questions still need to be addressed with current data?
  - What measurements are missing?
  - What modelling has to be done?
  - Next project?
  - Model development?