Examining cloud-scale processes using LEM, an comparison with aircraft measurements

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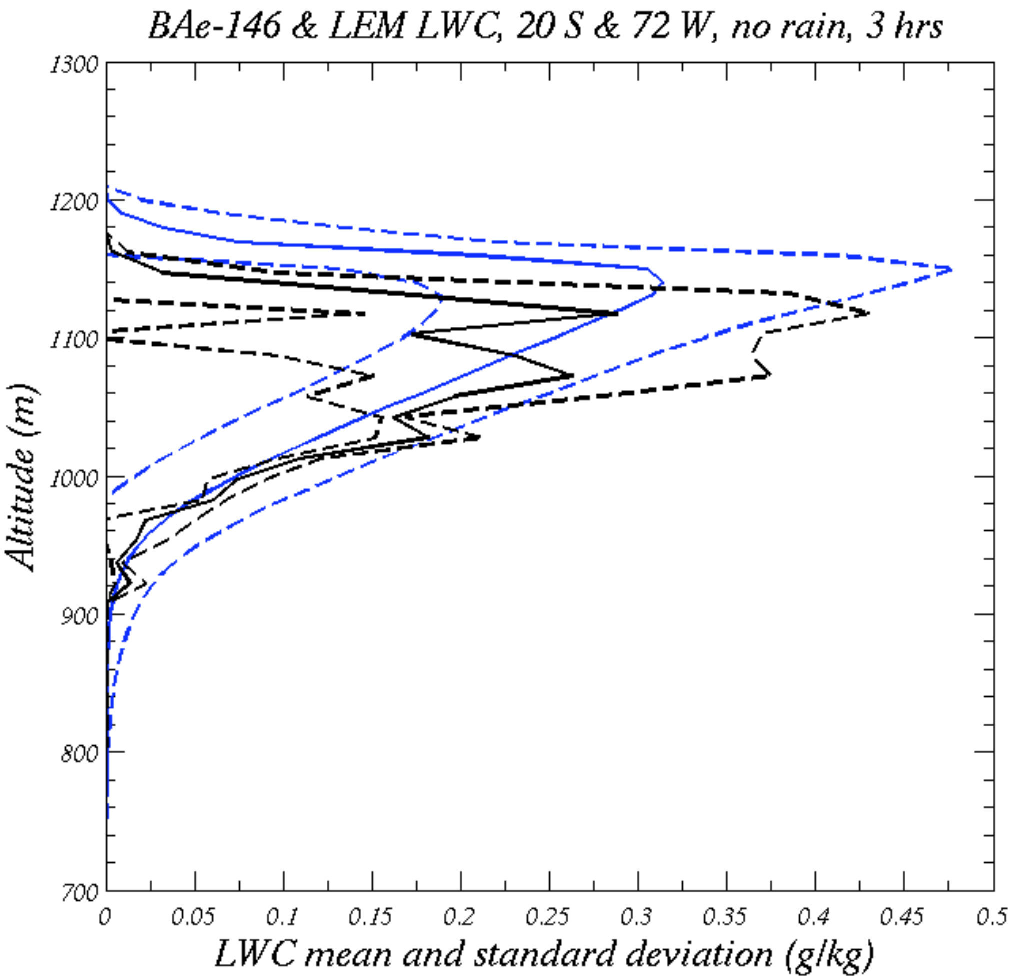
Introduction

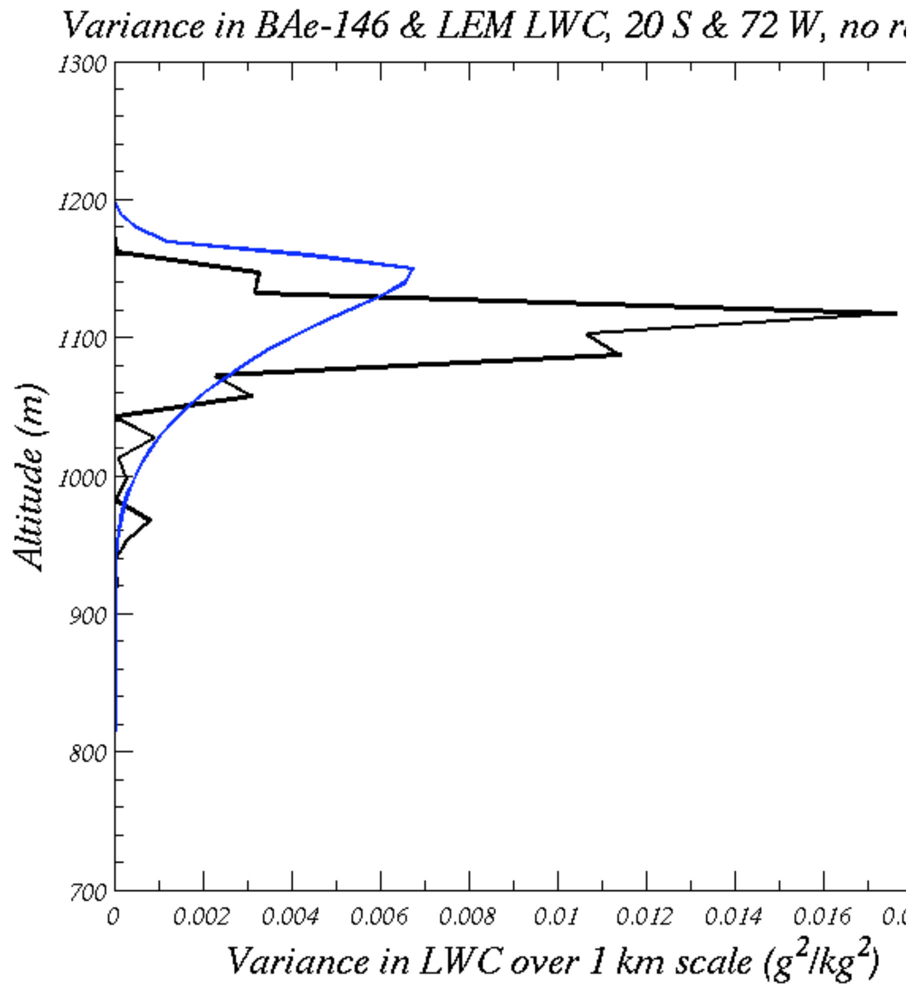
- Investigating the interaction between clouds, precipitatio aerosols and cloud radiative properties over the SE Pacifi
- Using the UK Met Office Large Eddy Model to examine t marine stratocumulus clouds
- The LEM is run using temperature and humidity profiles measured by the BAe-146 research aircraft and dropsond during the VOCALS field campaign (so far at 20 south an 72 & 79 west during flight B420 on 13th November 2008)
- The simulations are compared to the measurements of Liquid Water Content from the BAe-146
- Then studying the influence of different factors on the mo cloud tops, liquid water paths and outgoing radiation

The Different Factors

- Precipitation
- Reduced Cloud Condensation Nuclei (CCN) number density, and hence larger cloud droplets
- Reduced surface temperature and hence heat fluxes
- Some initial vertical mixing of the temperature and humid profiles around the inversion, to represent the entrainment warm dry air at the cloud tops (CCN is not changed)
- (In general a reduction in the amount of cloud results in le outgoing shortwave radiation, but more outgoing longwave radiation)

Measured (black) and model (blue) profiles of Liquid Water Conte
(LWC g kg^{-1}) and variance in LWC (g^2 kg^{-2}) over one km scales at 7





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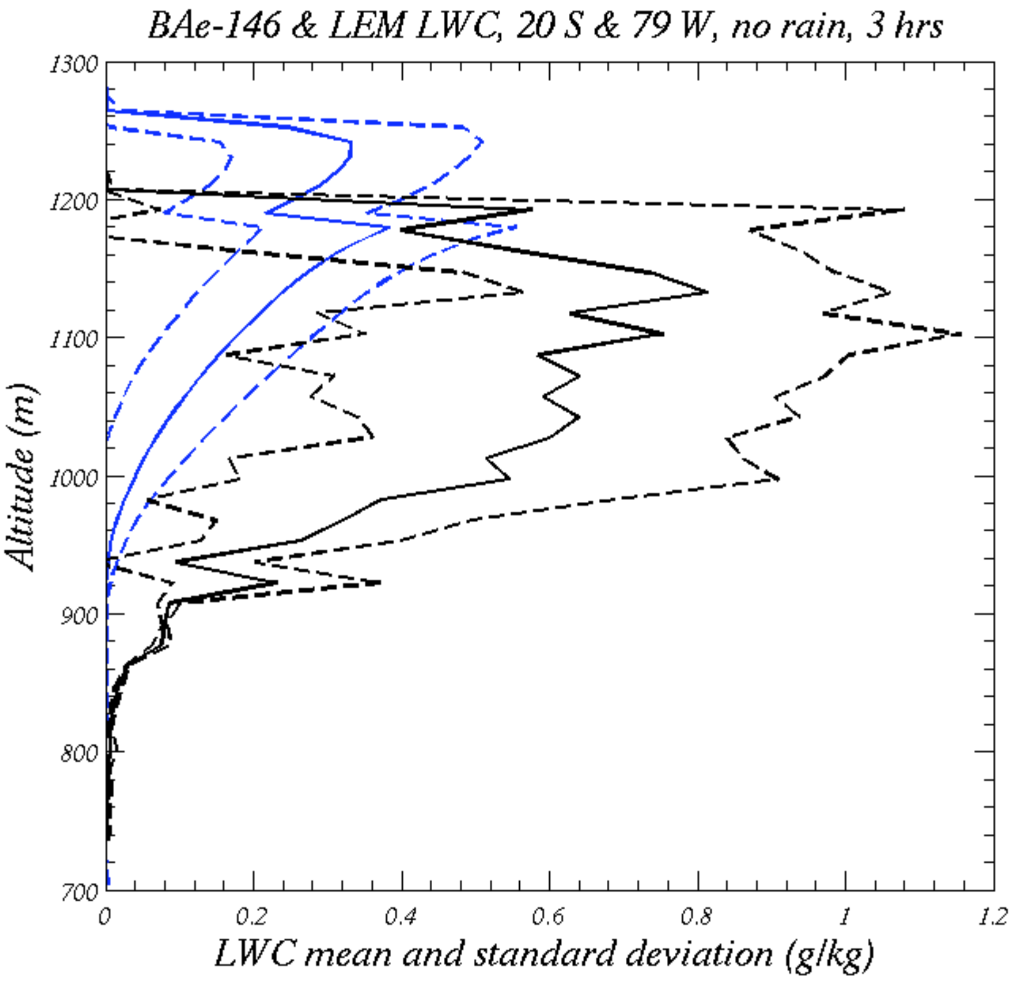
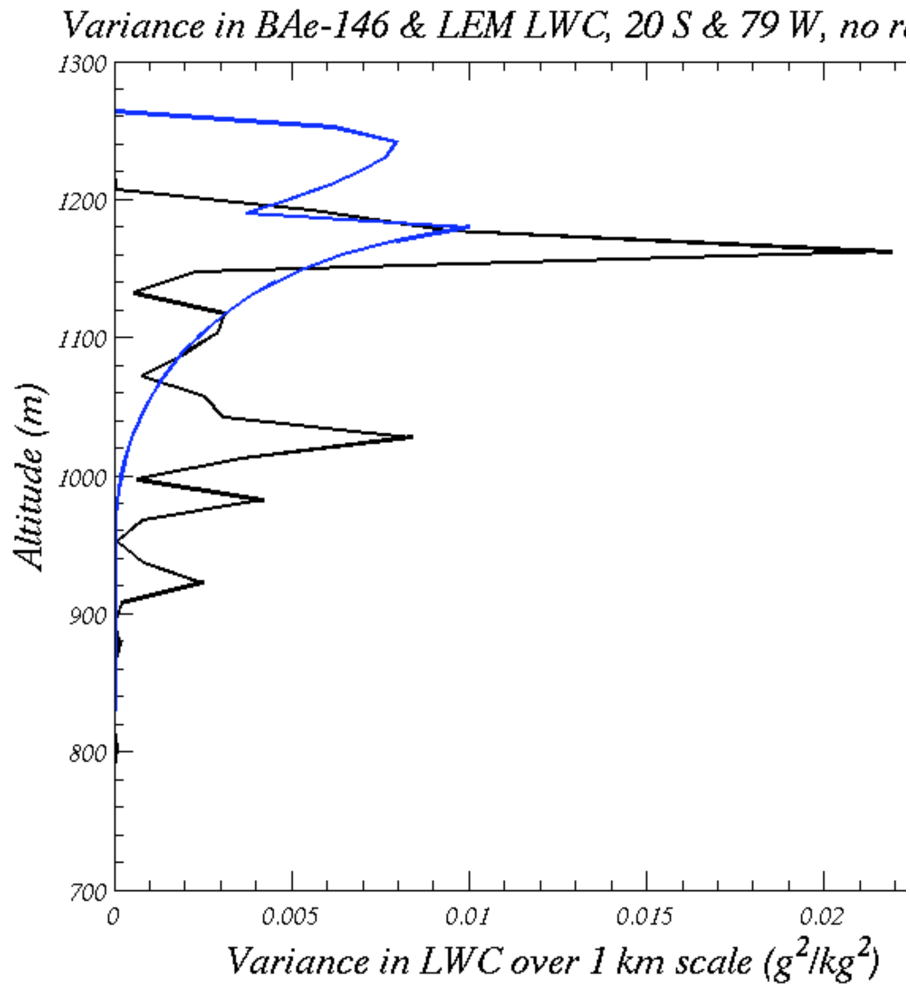
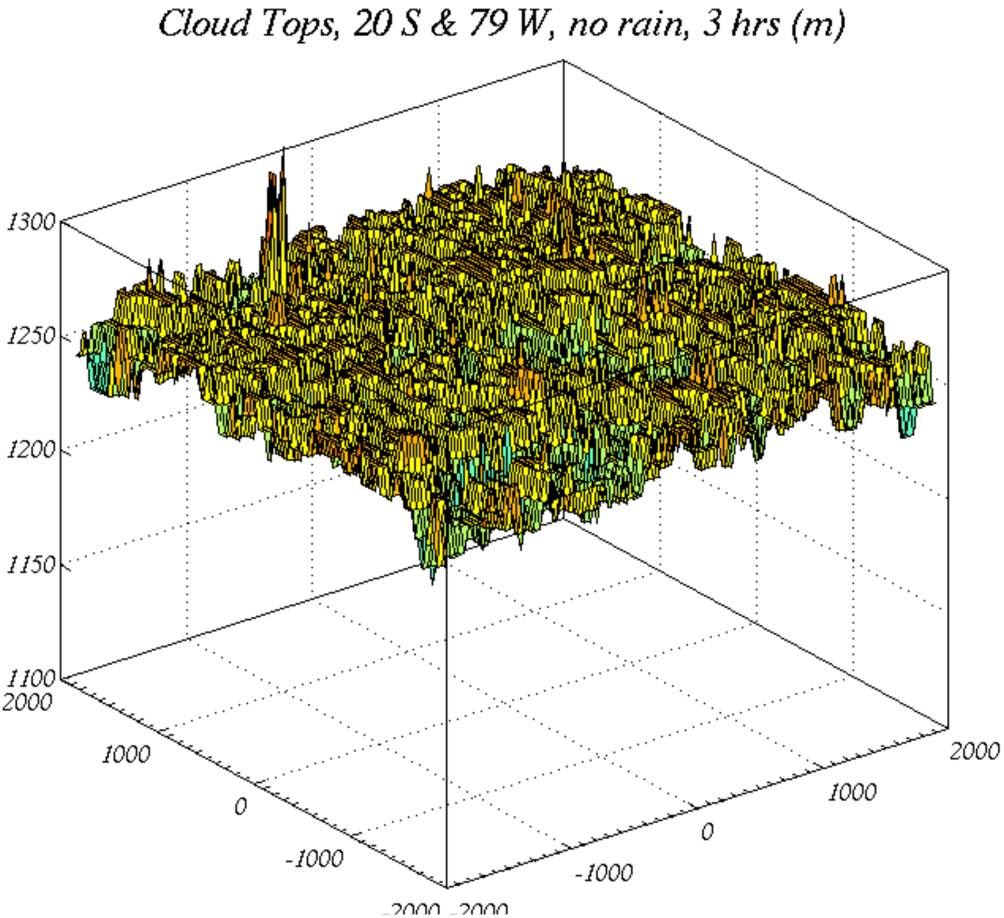
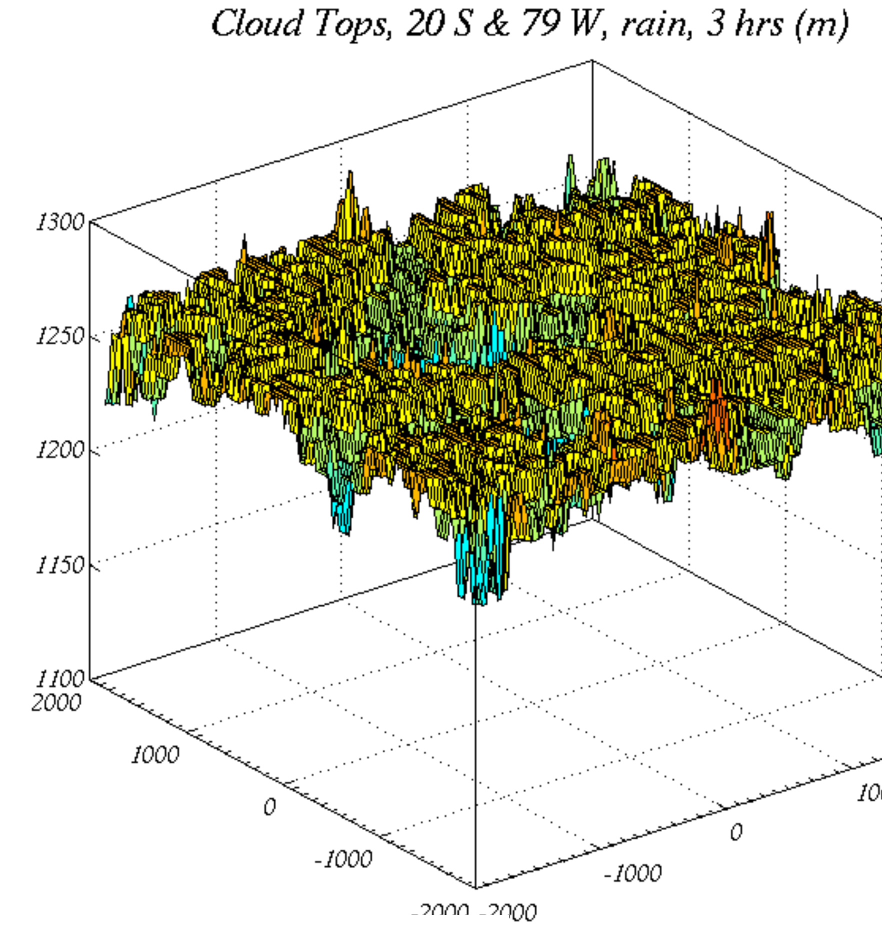
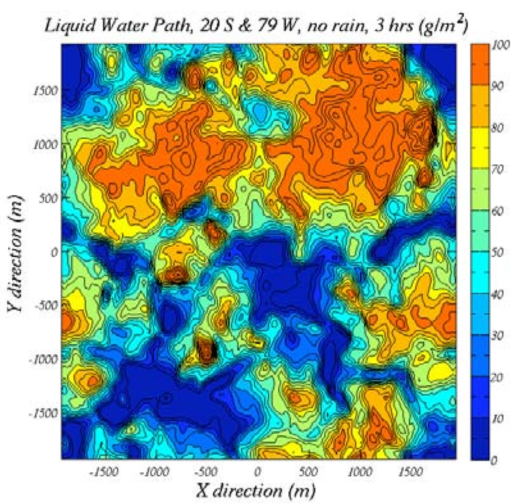
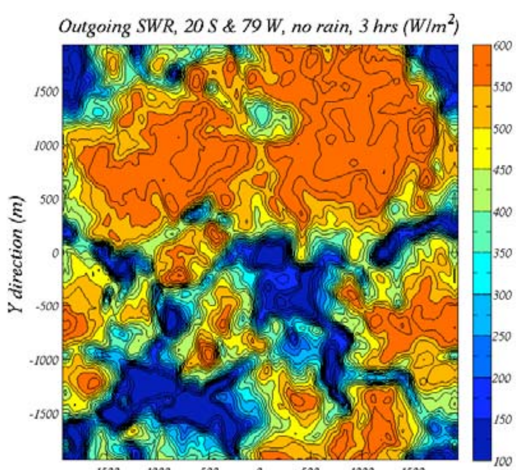


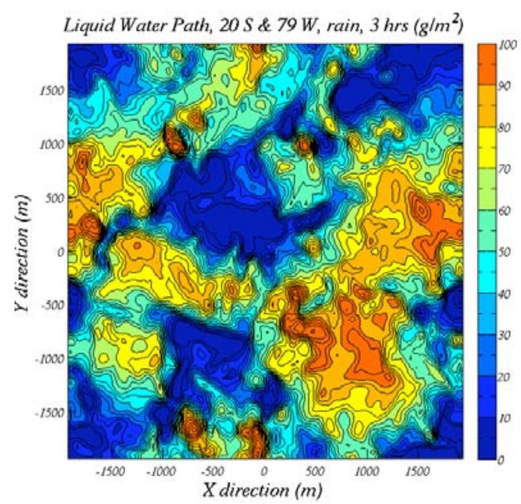


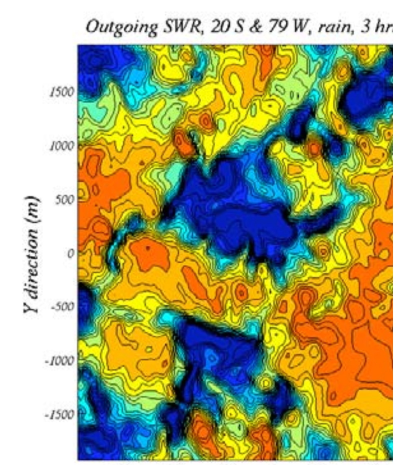

Cloud Tops, 20 S & 79 W, no rain, 3 hrs (m)
1300
1250
1200
1150
1100
2000
1000
0
-1000
-2000
-2000
-1000
0
1000
2000

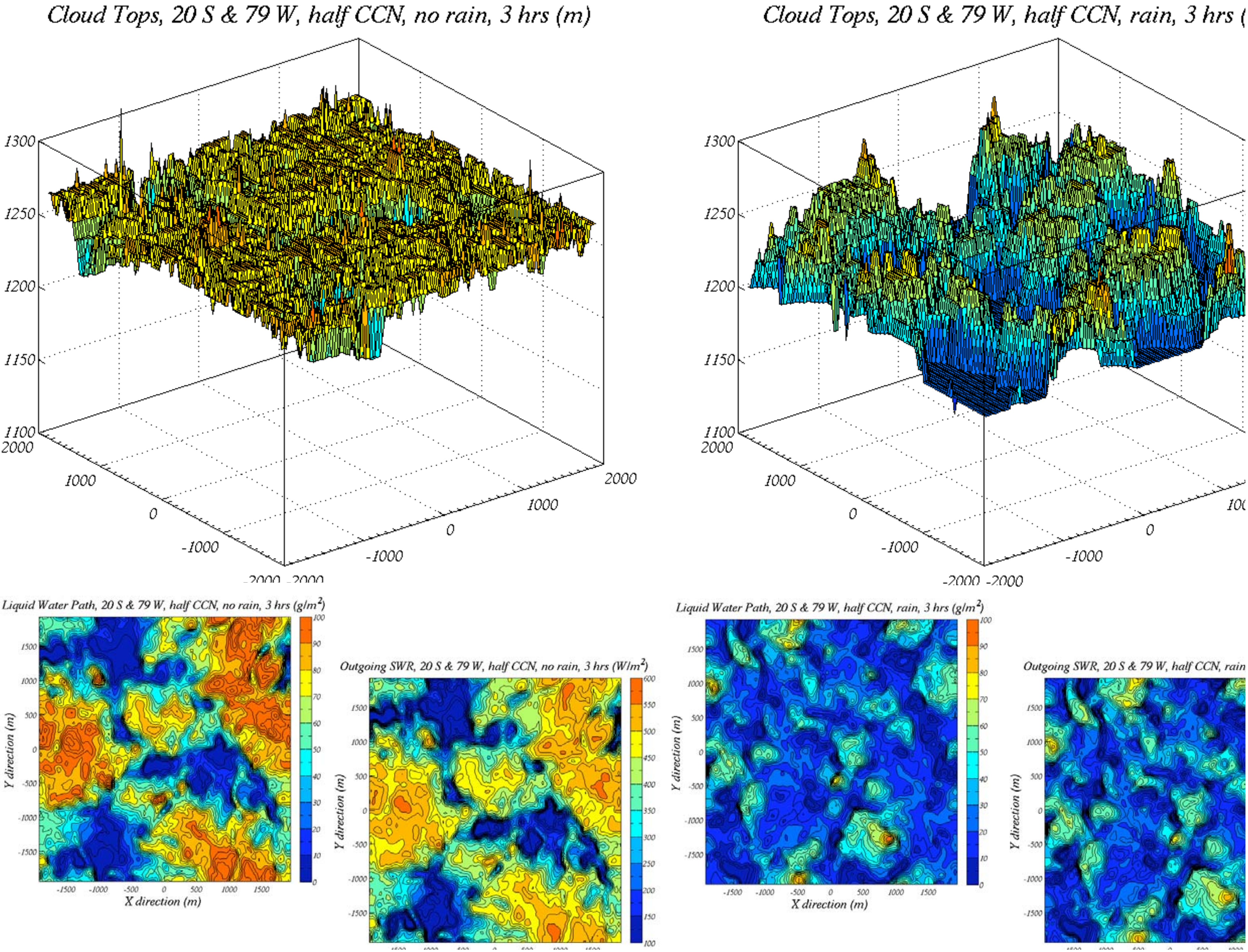

Cloud Tops, 20 S & 79 W, rain, 3 hrs (m)
1300
1250
1200
1150
1100
2000
1000
0
-1000
-2000
-2000
-1000
0


Liquid Water Path, 20 S & 79 W, no rain, 3 hrs (g/m^2)
Y direction (m)
X direction (m)

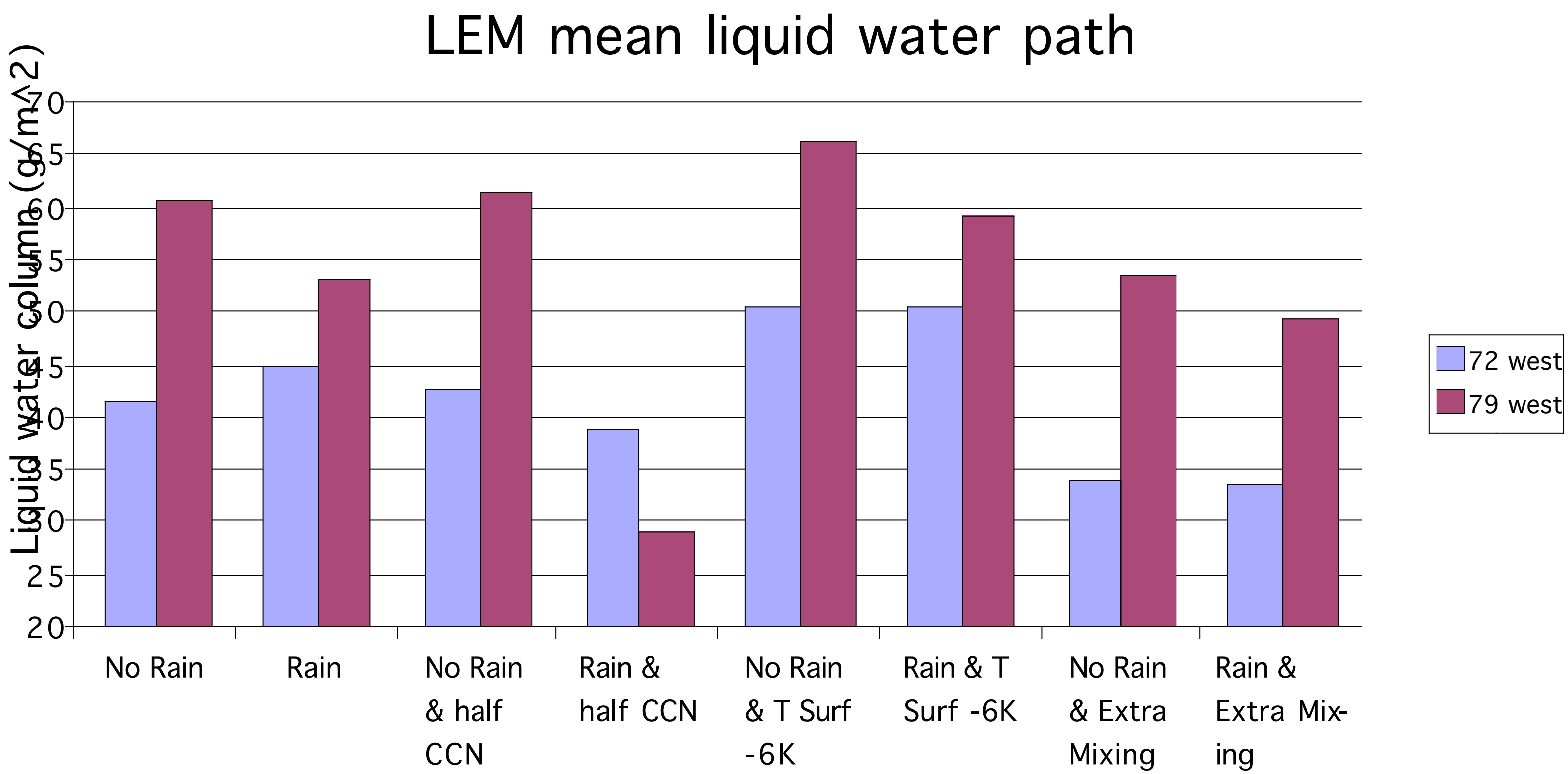

Outgoing SWR, 20 S & 79 W, no rain, 3 hrs (W/m^2)
Y direction (m)


Liquid Water Path, 20 S & 79 W, rain, 3 hrs (g/m^2)
Y direction (m)
X direction (m)

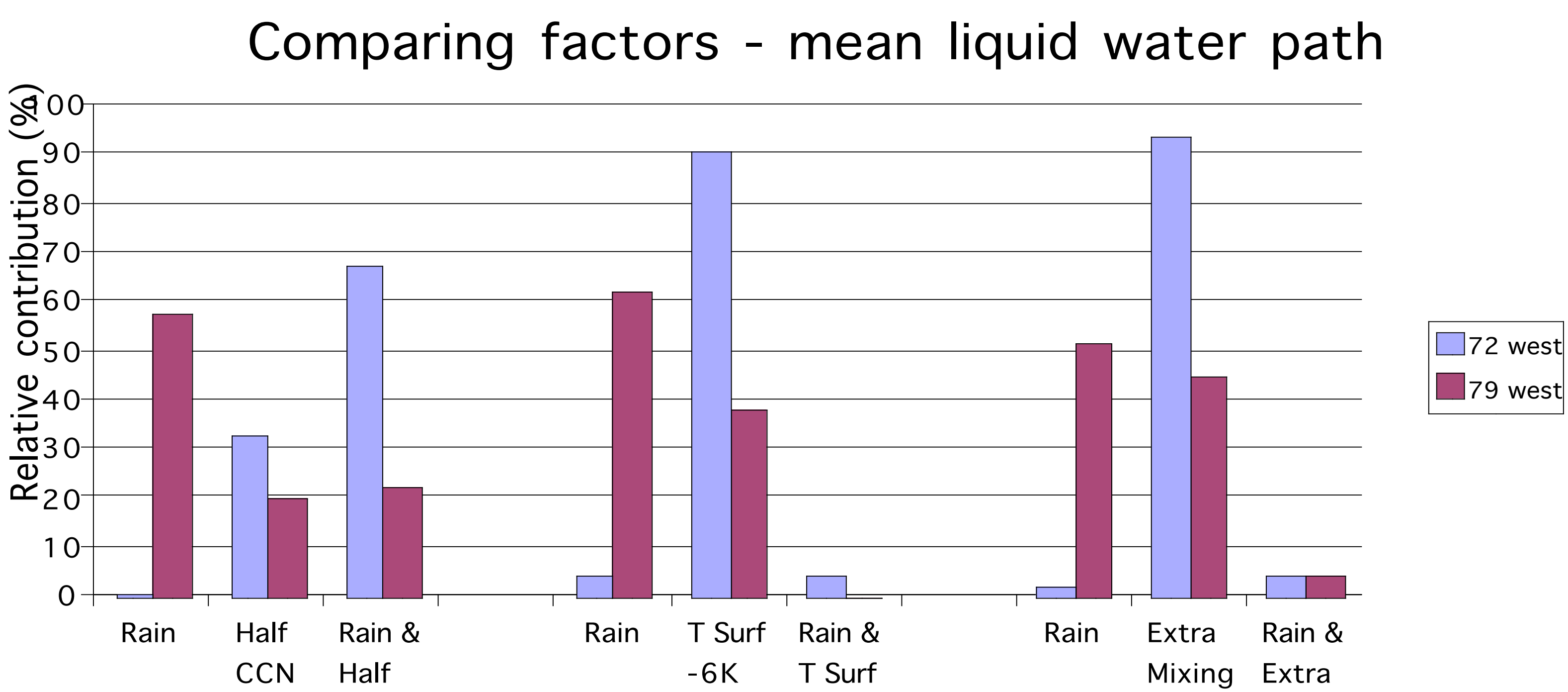

Outgoing SWR, 20 S & 79 W, rain, 3 hr
Y direction (m)



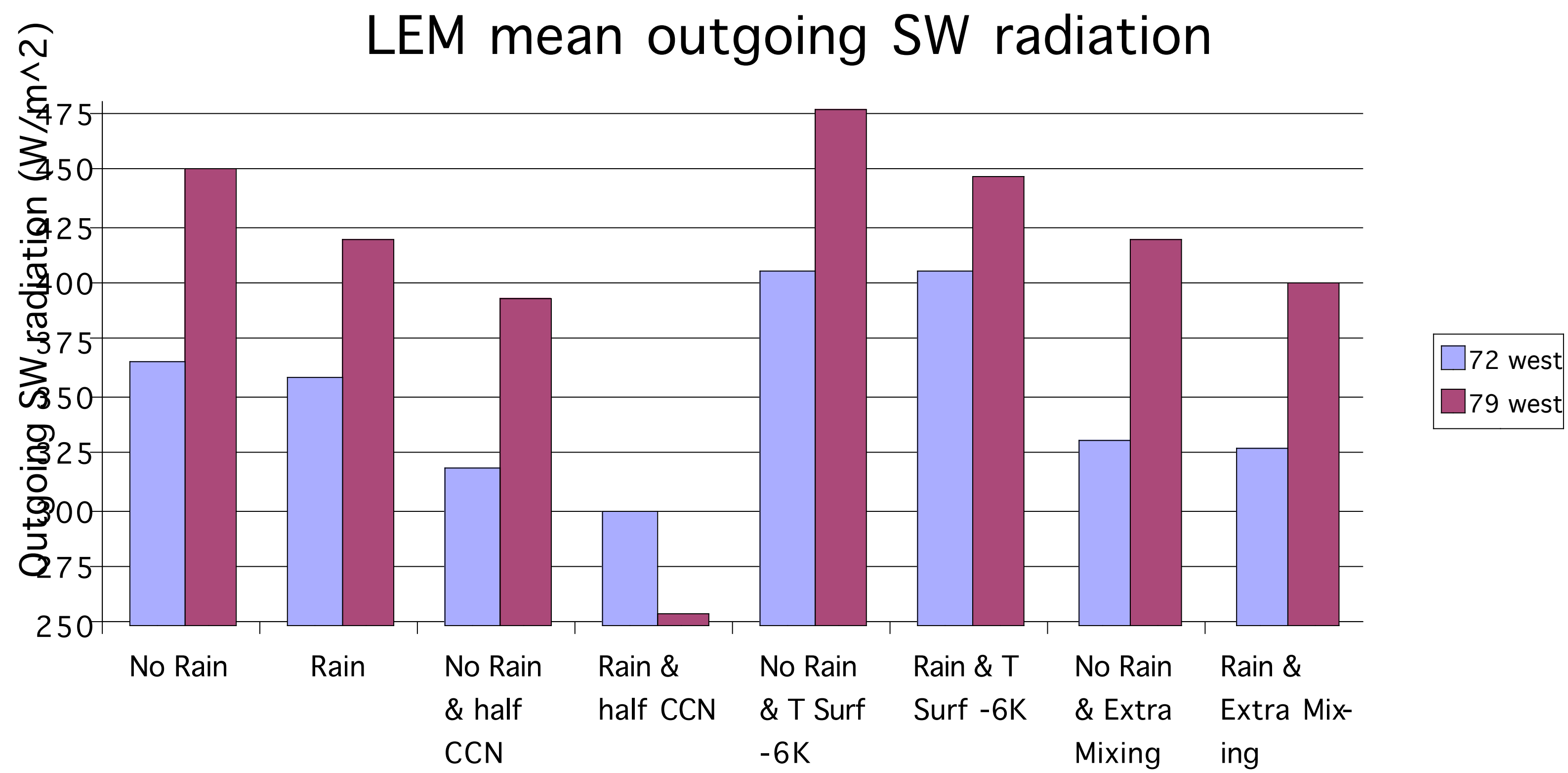
Cloud Tops, 20 S & 79 W, half CCN, no rain, 3 hrs (m)
Cloud Tops, 20 S & 79 W, half CCN, rain, 3 hrs (
Liquid Water Path, 20 S & 79 W, half CCN, no rain, 3 hrs (g/m2)
Outgoing SWR, 20 S & 79 W, half CCN, no rain, 3 hrs (W/m2)
Liquid Water Path, 20 S & 79 W, half CCN, rain, 3 hrs (g/m2)
Outgoing SWR, 20 S & 79 W, half CCN, rain
X direction (m)
Y direction (m)

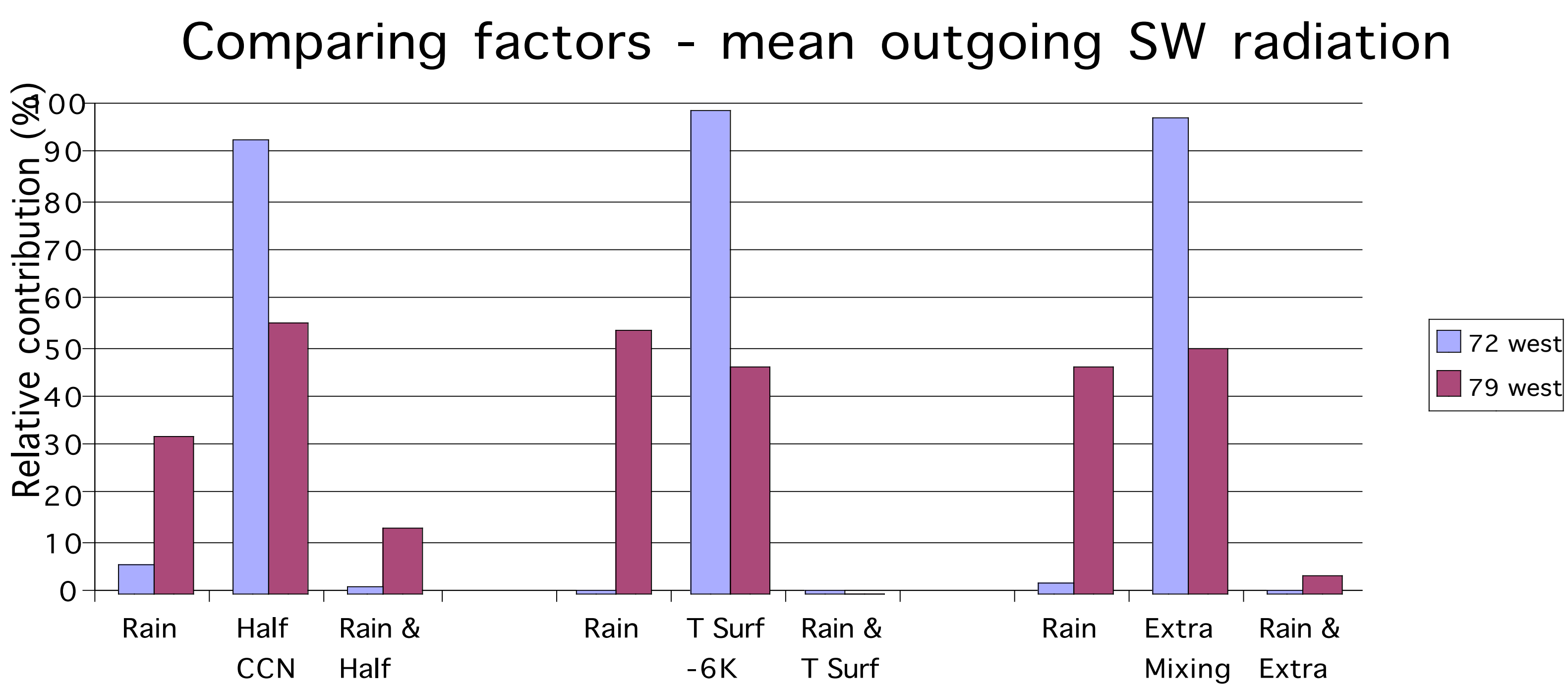


LEM mean liquid water path
Liquid water column (g/m^2)
70
65
60
55
50
45
40
35
30
25
20
No Rain
Rain
No Rain & half CCN
Rain & half CCN
No Rain & T Surf -6K
Rain & T Surf -6K
No Rain & Extra Mixing
Rain & Extra Mix-ing
72 west
79 west



Comparing factors - mean liquid water path
Relative contribution (%)
100
90
80
70
60
50
40
30
20
10
0
Rain
Half CCN
Rain & Half
Rain
T Surf -6K
Rain & T Surf
Rain
Extra Mixing
Rain & Extra
72 west
79 west


LEM mean outgoing SW radiation
Outgoing SW radiation (W/m^2)
475
450
425
400
375
350
325
300
275
250
No Rain
Rain
No Rain & half CCN
Rain & half CCN
No Rain & T Surf -6K
Rain & T Surf -6K
No Rain & Extra Mixing
Rain & Extra Mix-ing
72 west
79 west


Comparing factors - mean outgoing SW radiation
Relative contribution (%)
100
90
80
70
60
50
40
30
20
10
0
Rain
Half CCN
Rain & Half
Rain
T Surf -6K
Rain & T Surf
Rain
Extra Mixing
Rain & Extra
72 west
79 west

Results

- The model clouds are a good match to the measurements at 72 we but are too high and have too little liquid water at 79 west
- Precipitation leads to lower cloud tops, reduced liquid water path (LWP) and outgoing shortwave radiation (OSR), and increased outgoing longwave radiation (OLR) and cloud variance (in most of tl cases), but there is little precipitation in the 72 west model runs
- Reducing the CCN makes little change the cloud without precipitati though OSR is reduced and OLR increased because of the fewer larger droplets, but with precipitation and the responses of the clouc and outgoing radiation are much greater
- Reducing the surface temperature and heat fluxes by 6 K raises the cloud tops, increases LWP and OSR, and reduces OLR
- Applying some initial vertical mixing reduces the amount of cloud, lowering the cloud tops, reducing LWP and OSR, and increasing OL