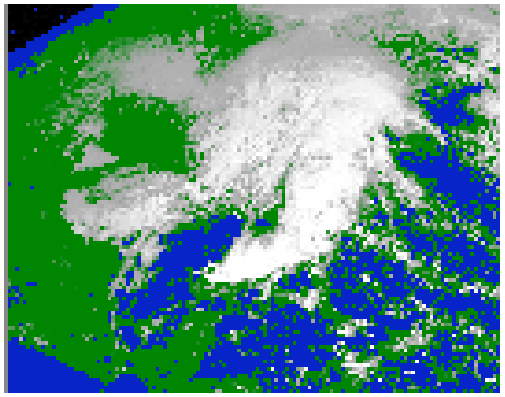


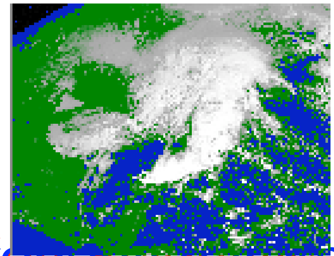
GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

- Mandate: Improve representation of extratropical layer clouds in global models

- Uniqueness: Mandate includes improvement of boundary layer, cirrus, convective, and some polar clouds

- Problem: Not quite certain what is really wrong with extratropical layer clouds in global models

- Approach: Simulation of real world storm cases with a suite of atmospheric models



GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

Key science questions identified by Working Group 3

operly parameterized, and are there specific threshold scales important to

•

•

•

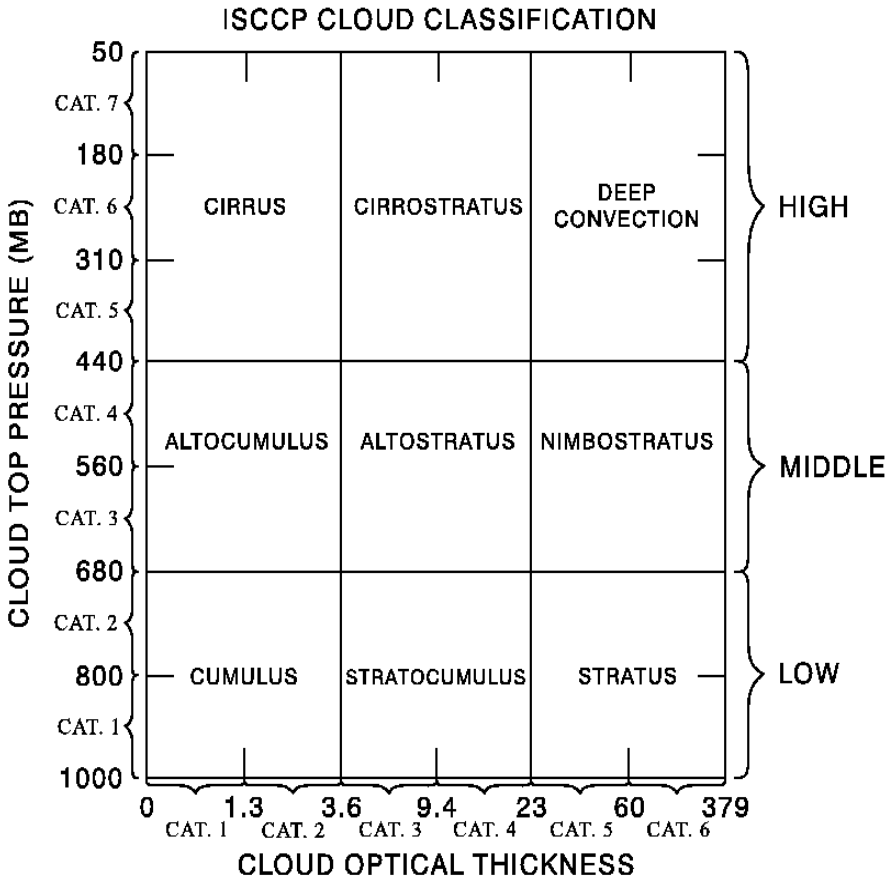
•

•

W3C Publications

What is wrong with global model midlatitude layered clouds?

An evaluation of climate and weather model cloud radiative properties



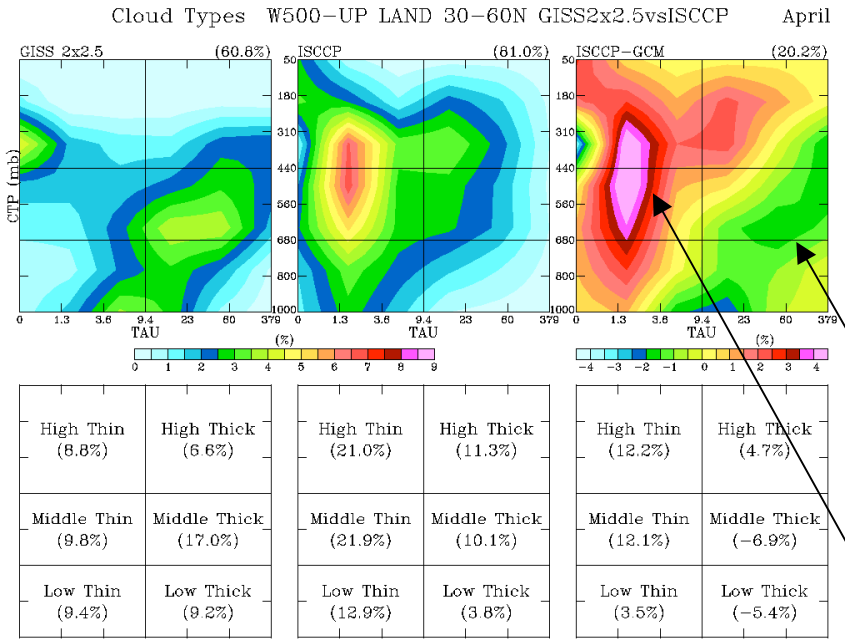
* GISS climate and ECMWF weather model were evaluated

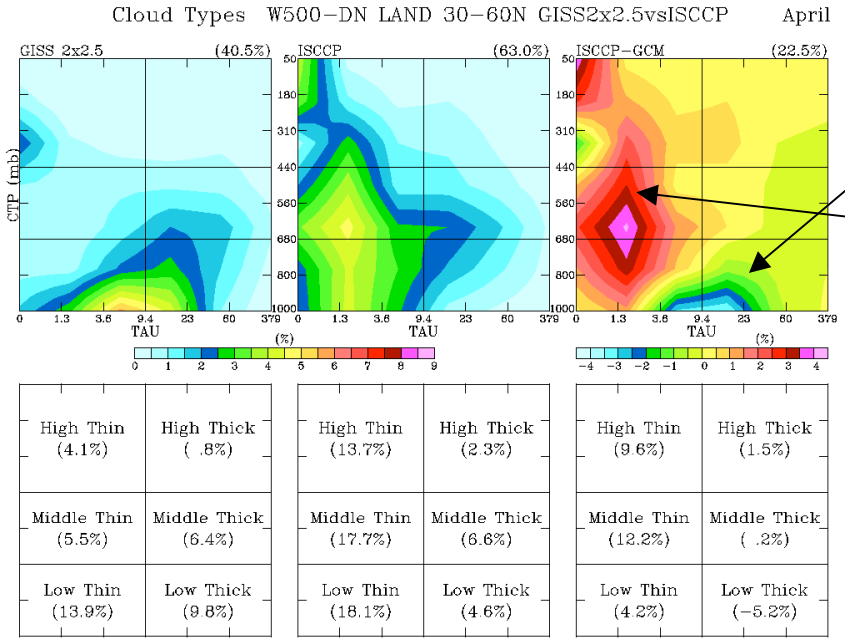
* Monthly distributions of optical depth and top pressure were compared to ISCCP retrievals

* Analysis was done separately for upward and downwards 500mb vertical velocity and for land and ocean locations

Tselioudis and Jakob 2002

GISS GCM 2x2.5x32
APRIL LAND 30-60N



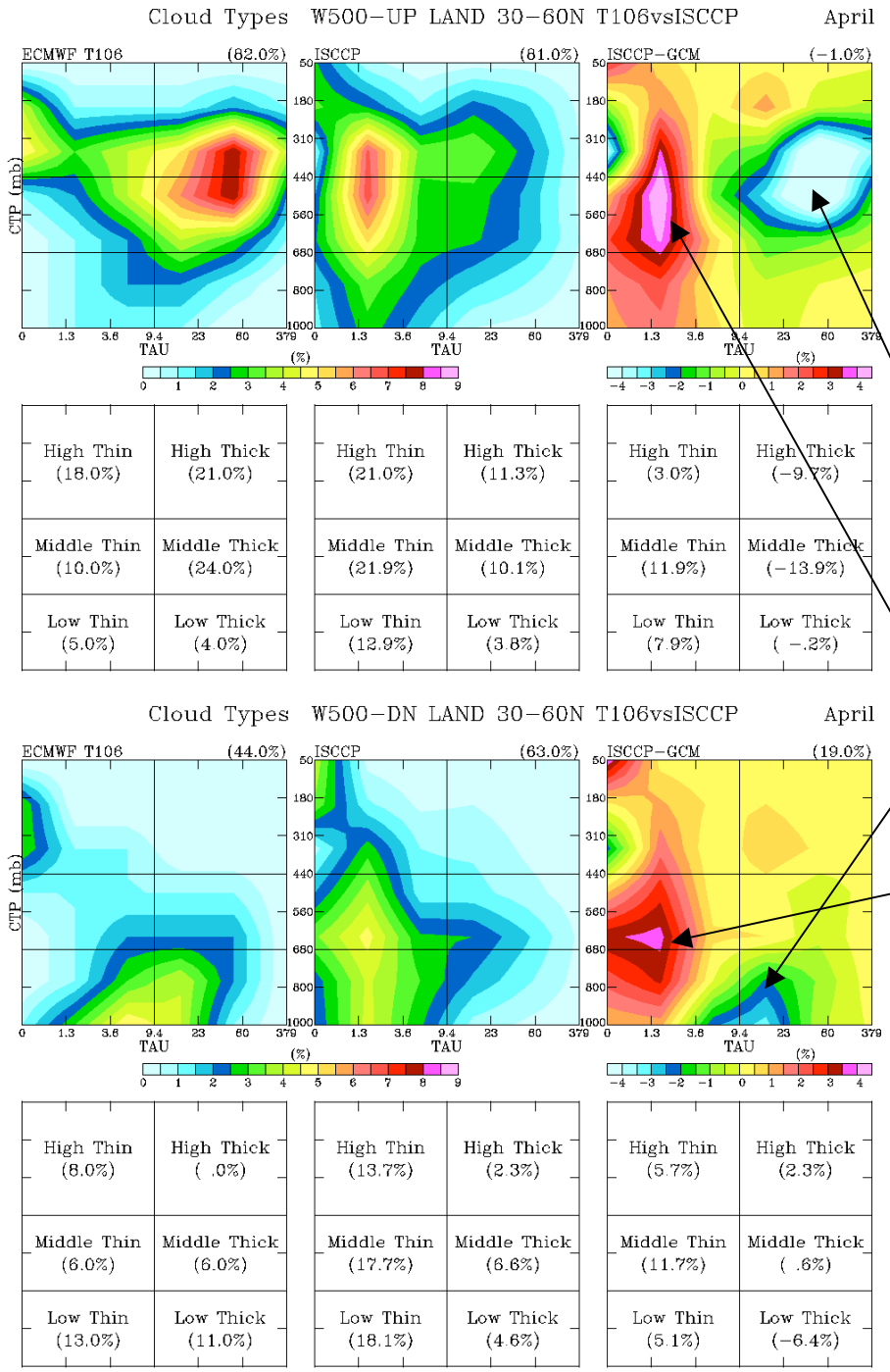


* GCM is missing ~ 20% and 22% cloud cover in the two regimes

* GCM clouds in all regimes are too optically thick

* GCM has too few high and midlevel thin clouds

Tselioudis and Jakob 2002



ECMWF GCM T106

APRIL LAND 30-60N

* GCM is missing 19% cloud cover in the W-DN regime

* GCM clouds are too optically thick in all regimes

* GCM is missing middle and low thin cloud in al regimes

Tselioudis and Jakob 2002

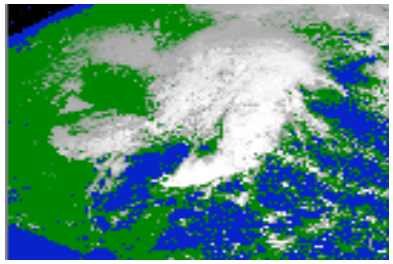
What should be fixed in global model midlatitude layered clouds?

- Cloud optical depths are too large in both upward- and downward-moving air regimes. Cloud water content is overestimated in the water budget calculations or cloud vertical extents are too large.

- Cloud covers are too small in downward-moving air regimes. Boundary layer may be too dry or subsidence too strong.

- Cloud top heights are too low in downward-moving air regimes. Turbulent mixing or shallow convection may be too weak.

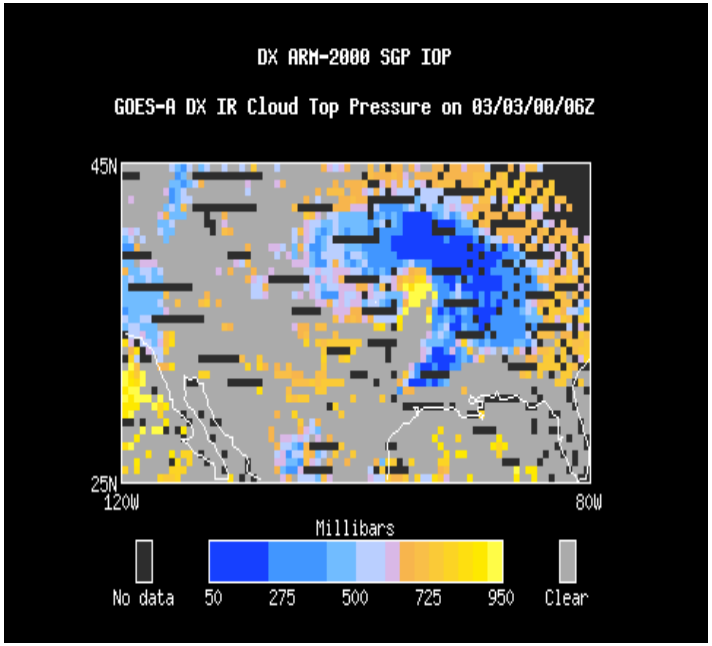
- Increases in resolution from 4 to 2 degrees show great improvements in midlatitude cloud property simulations but further increases to about 1degree show little change



GEWEX CLOUD SYSTEM STUDY
WORKING GROUP 3
EXTRA-TROPICAL LAYER CLOUDS

PRESENT CASE

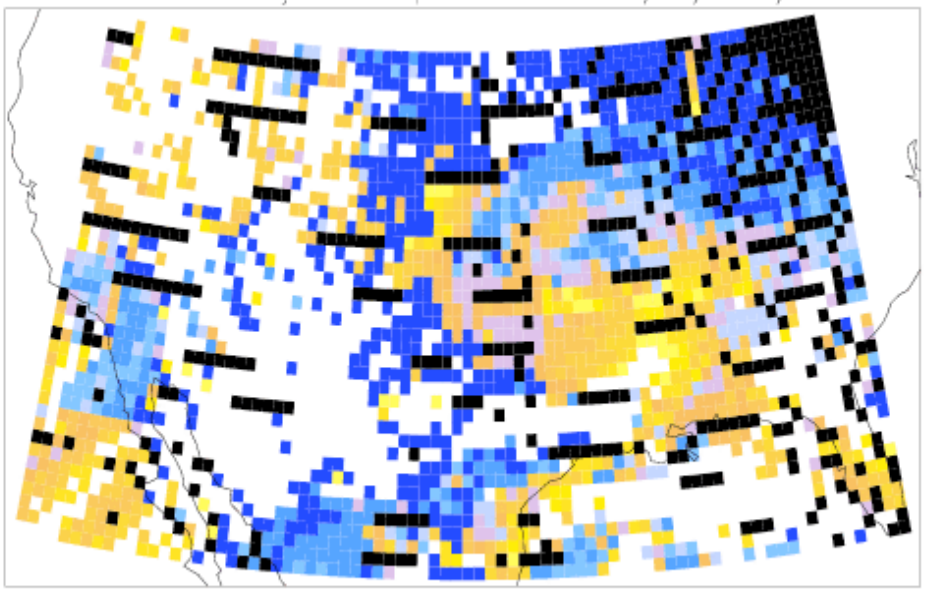
ARM March 2000 IOP

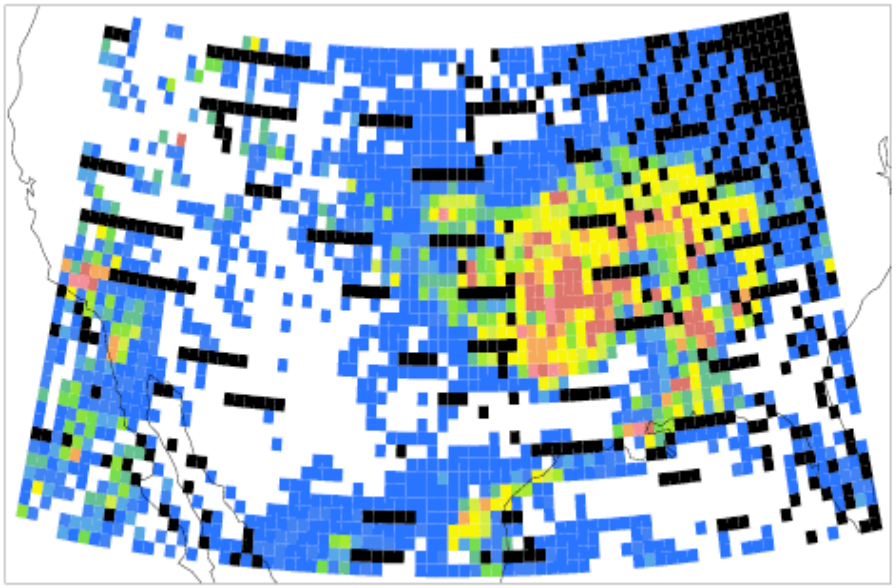


- DIME-based model initialization and evaluation process

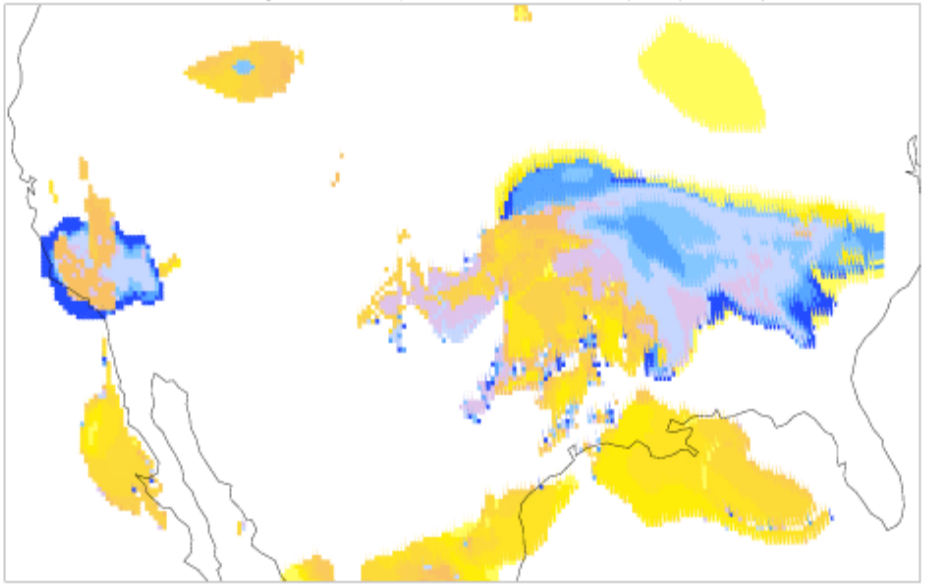
- Evaluation of storm cloud structures from storm-event model simulations and of cloud property statistics from month-long model runs

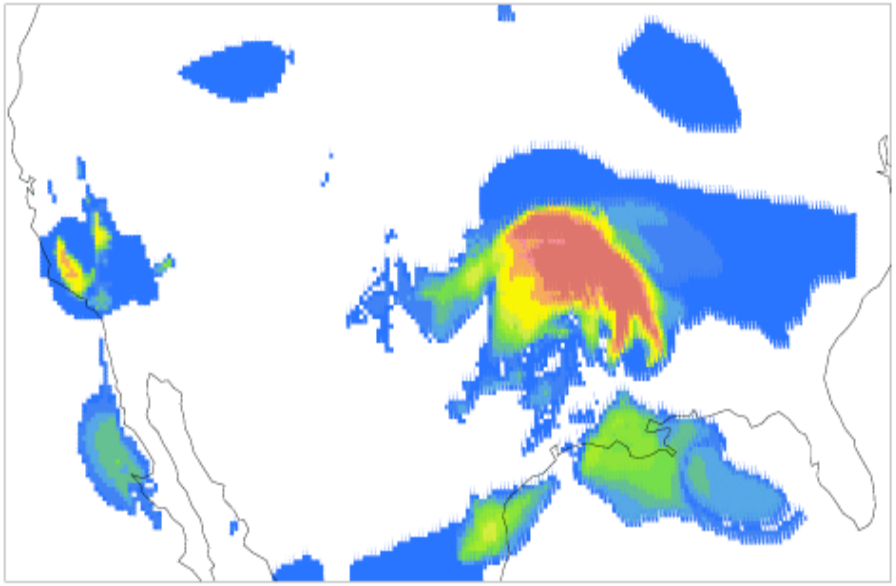
ARM DX VIS-adj Cloud Top Pressure on 03/03/2000/18Z





RAMS VIS-adj Cloud Top Pressure on 03/03/2000/18Z

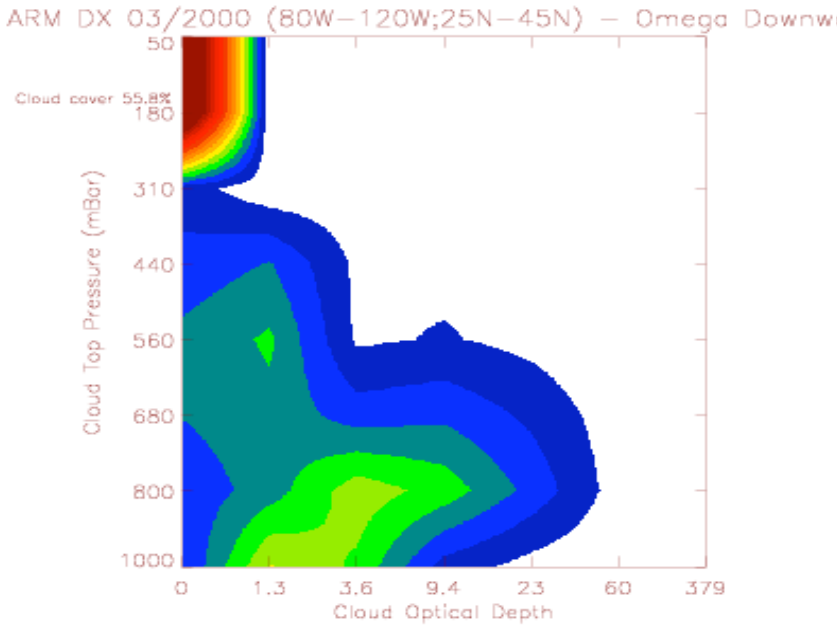


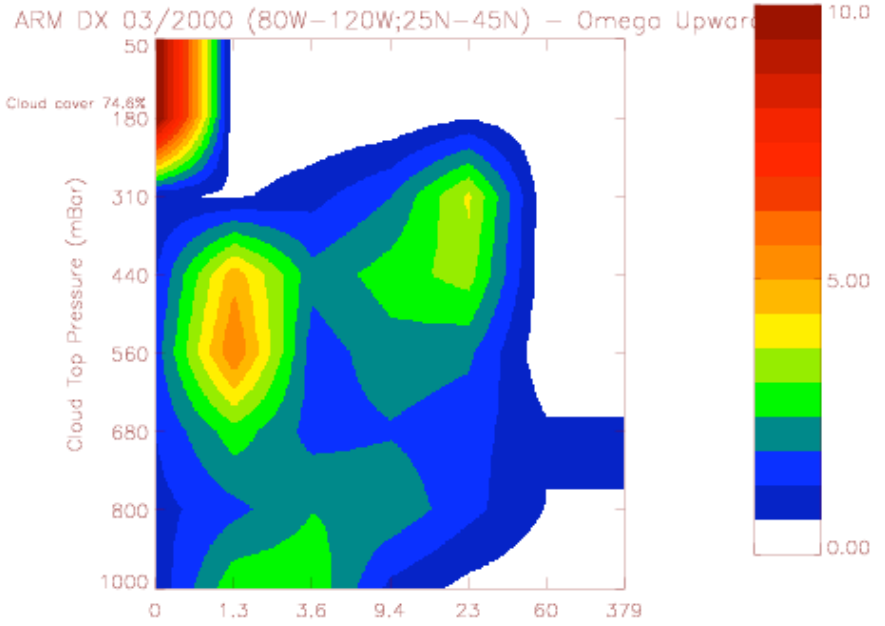


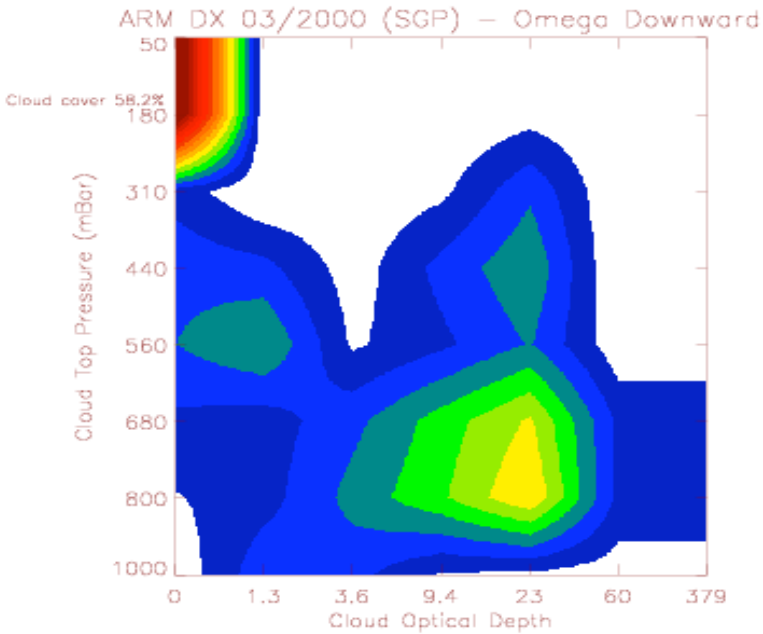
Why the ARM March 2000 IOP case?

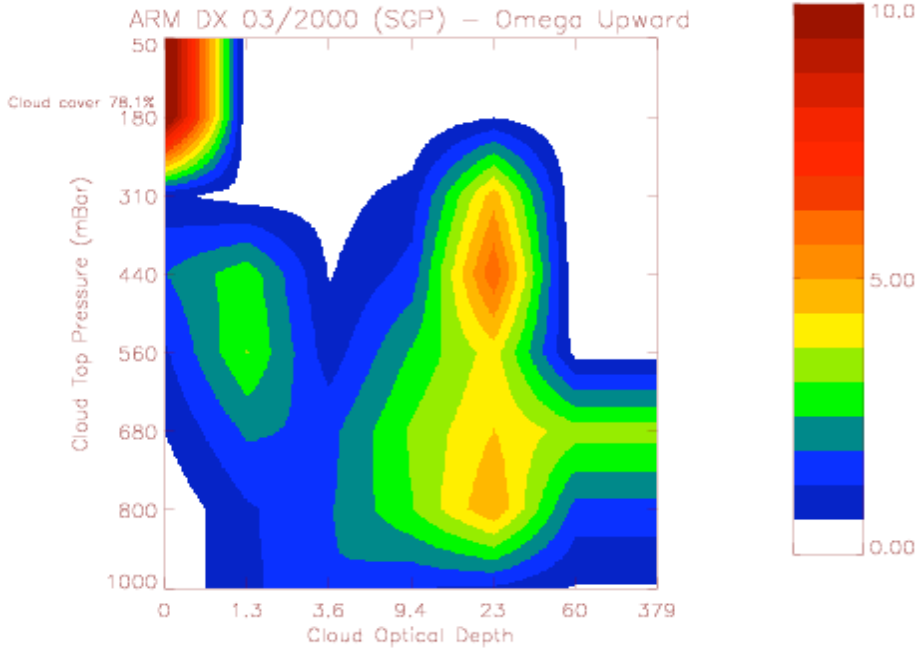
1. Availability of comprehensive long term datasets that allows us to evaluate statistical composites from month-long regional model runs and attempt to relate the results to GCM cloud deficiencies

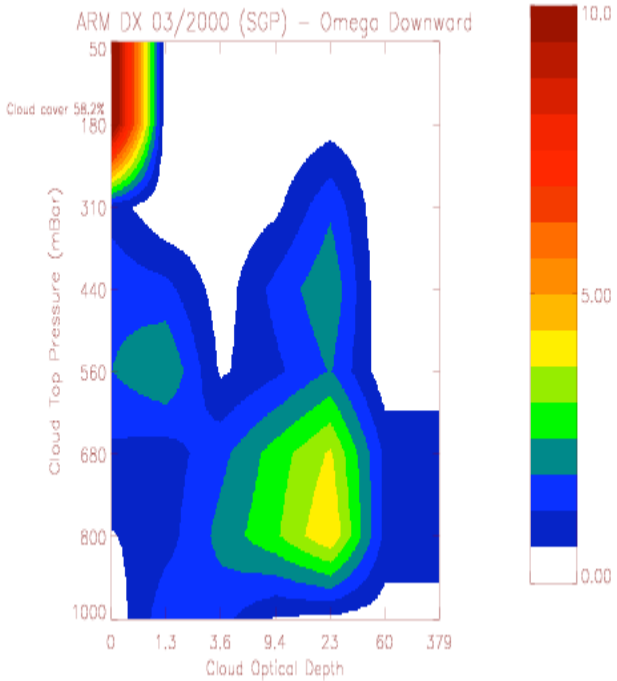
How typical of Continental US are SGP clouds?

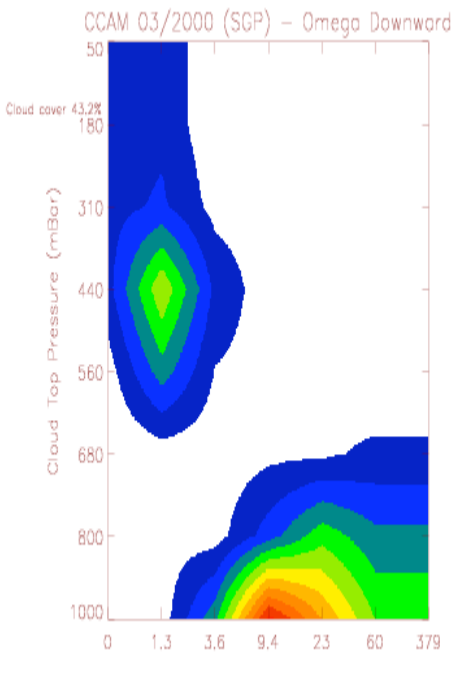


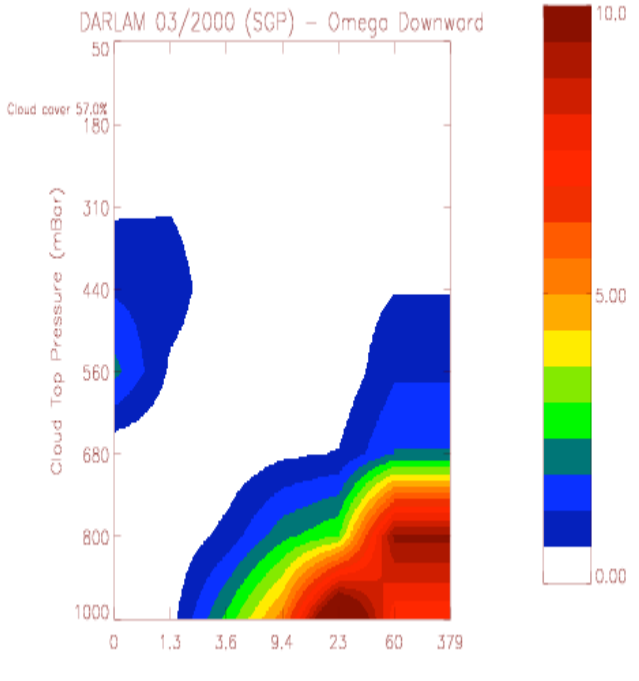


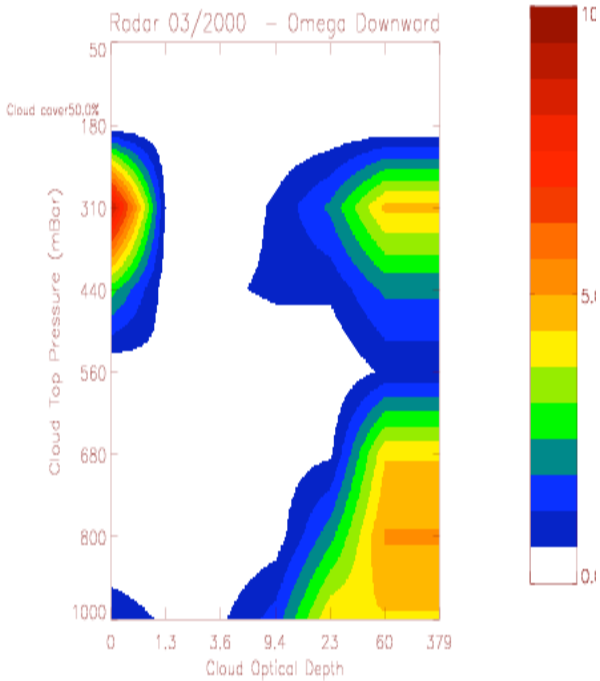


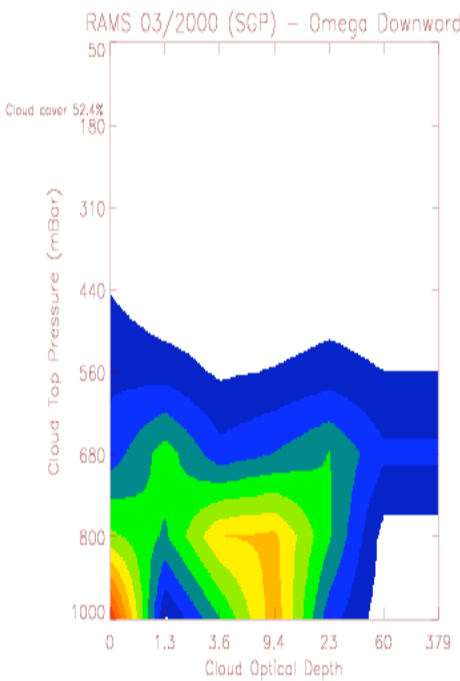


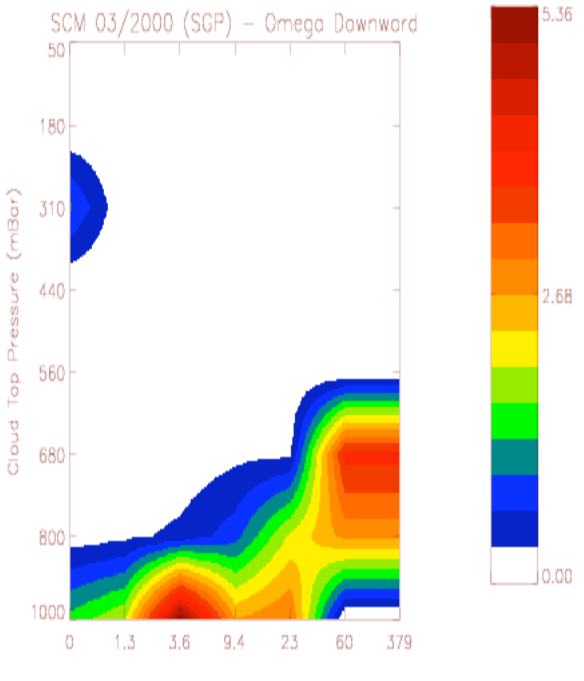

ARM DX 03/2000 (SGP) – Omega Downward
Cloud cover 58.2%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth
10.0
5.00
0.00

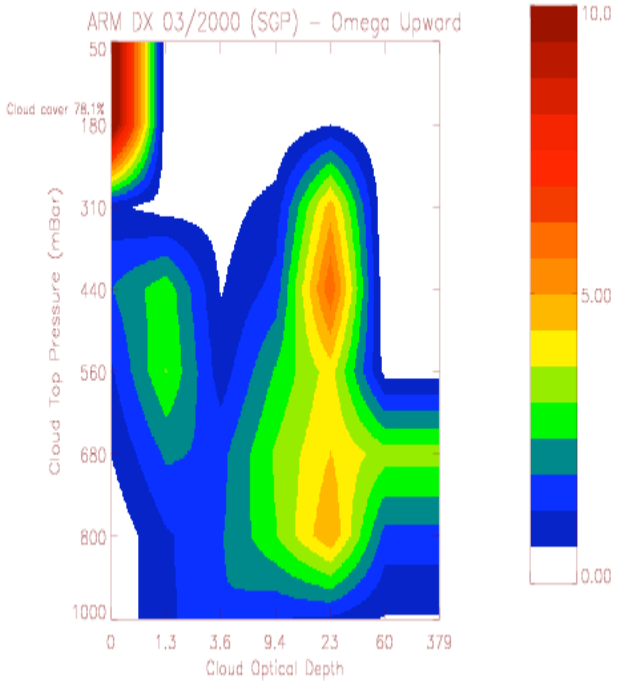

CCAM 03/2000 (SGP) – Omega Downward
Cloud cover 43.2%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379

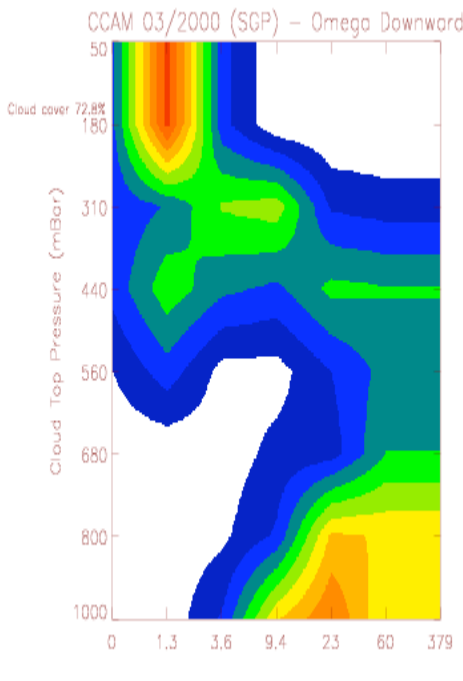

DARLAM 03/2000 (SGP) – Omega Downward
Cloud cover 57.0%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
10.0
5.00
0.00

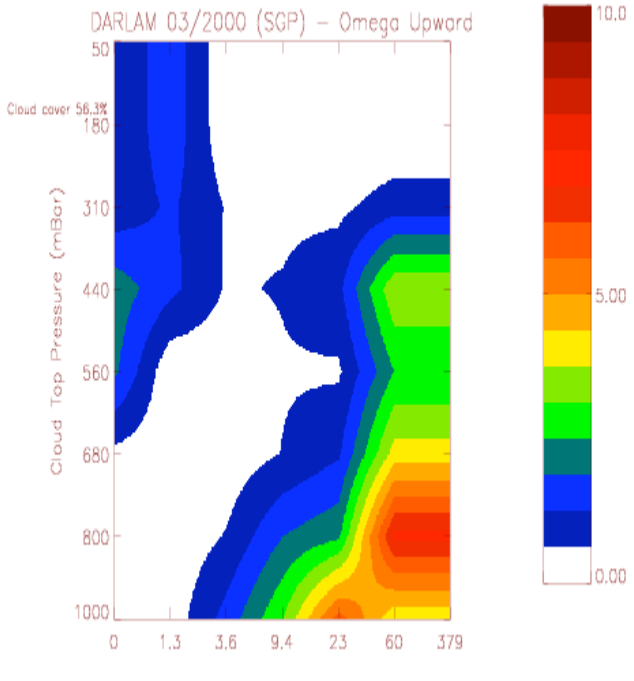

Radar 03/2000 – Omega Downward
Cloud cover50.0%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth

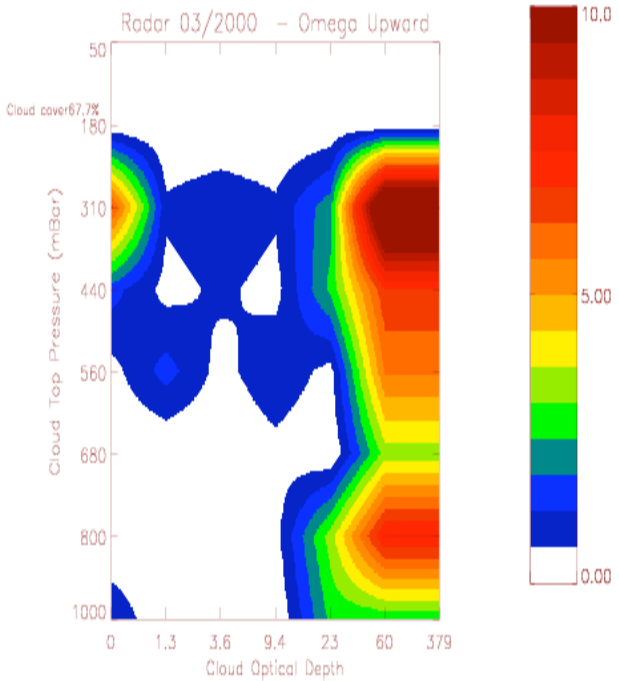

RAMS 03/2000 (SGP) – Omega Downward
Cloud cover 52.4%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth

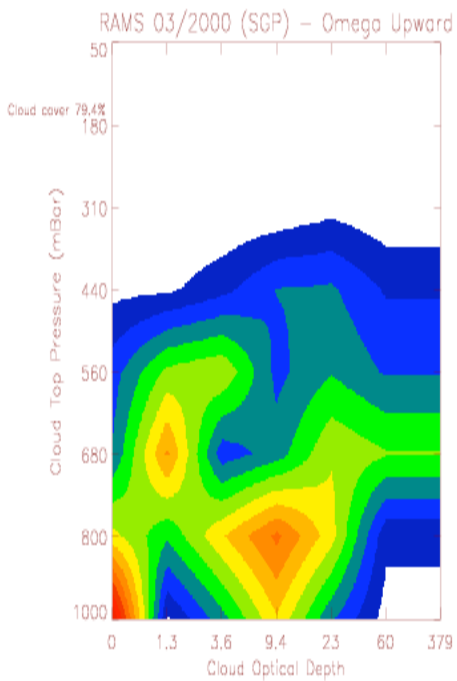

SCM 03/2000 (SGP) – Omega Downward
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
5.36
2.68
0.00

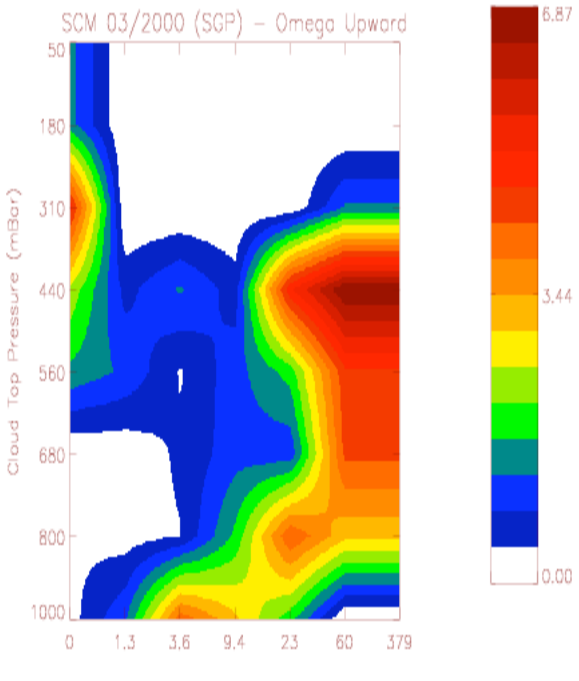

ARM DX 03/2000 (SGP) – Omega Upward
Cloud cover 78.1%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth
10.0
5.00
0.00

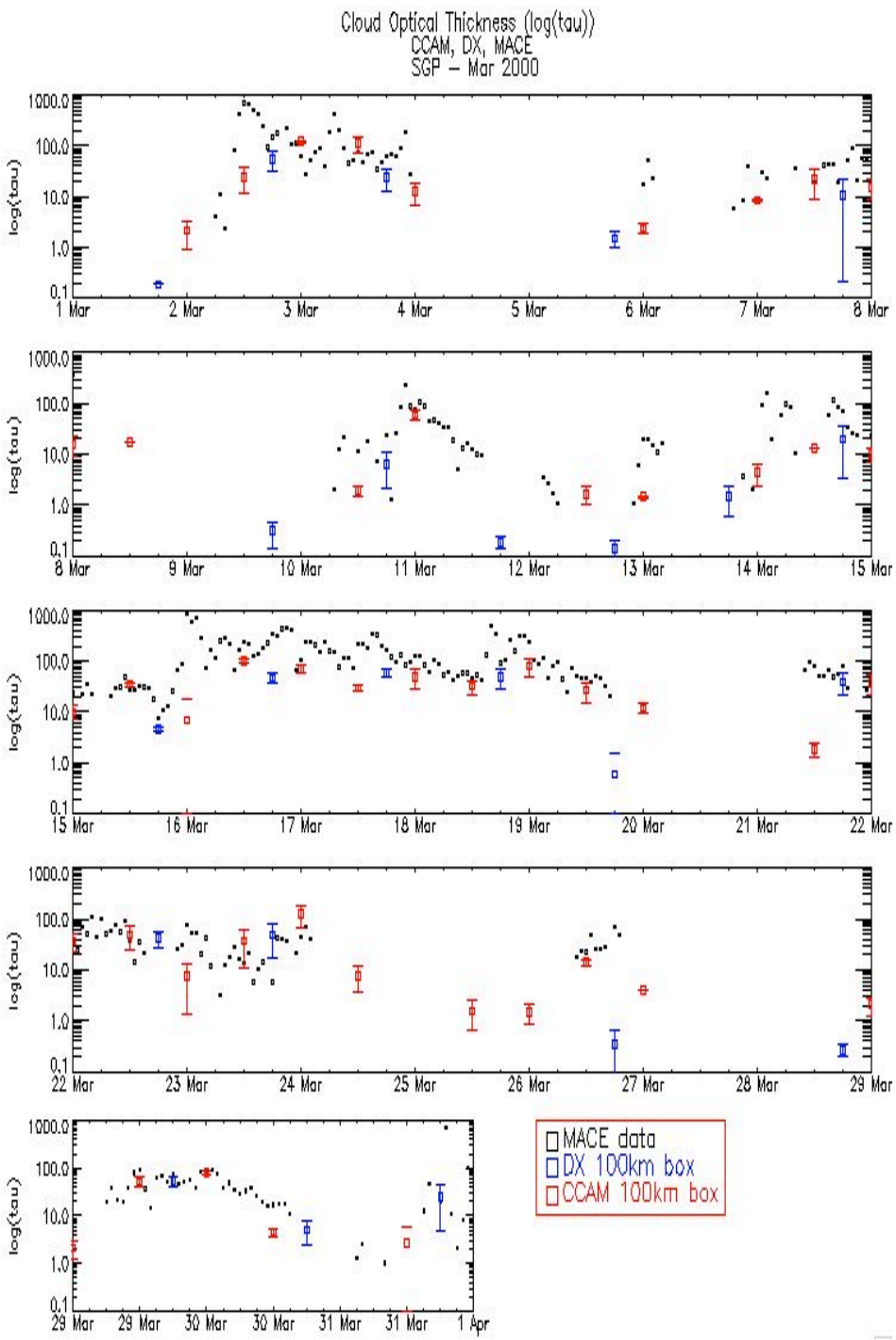

CCAM 03/2000 (SGP) – Omega Downward
Cloud cover 72.8%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379

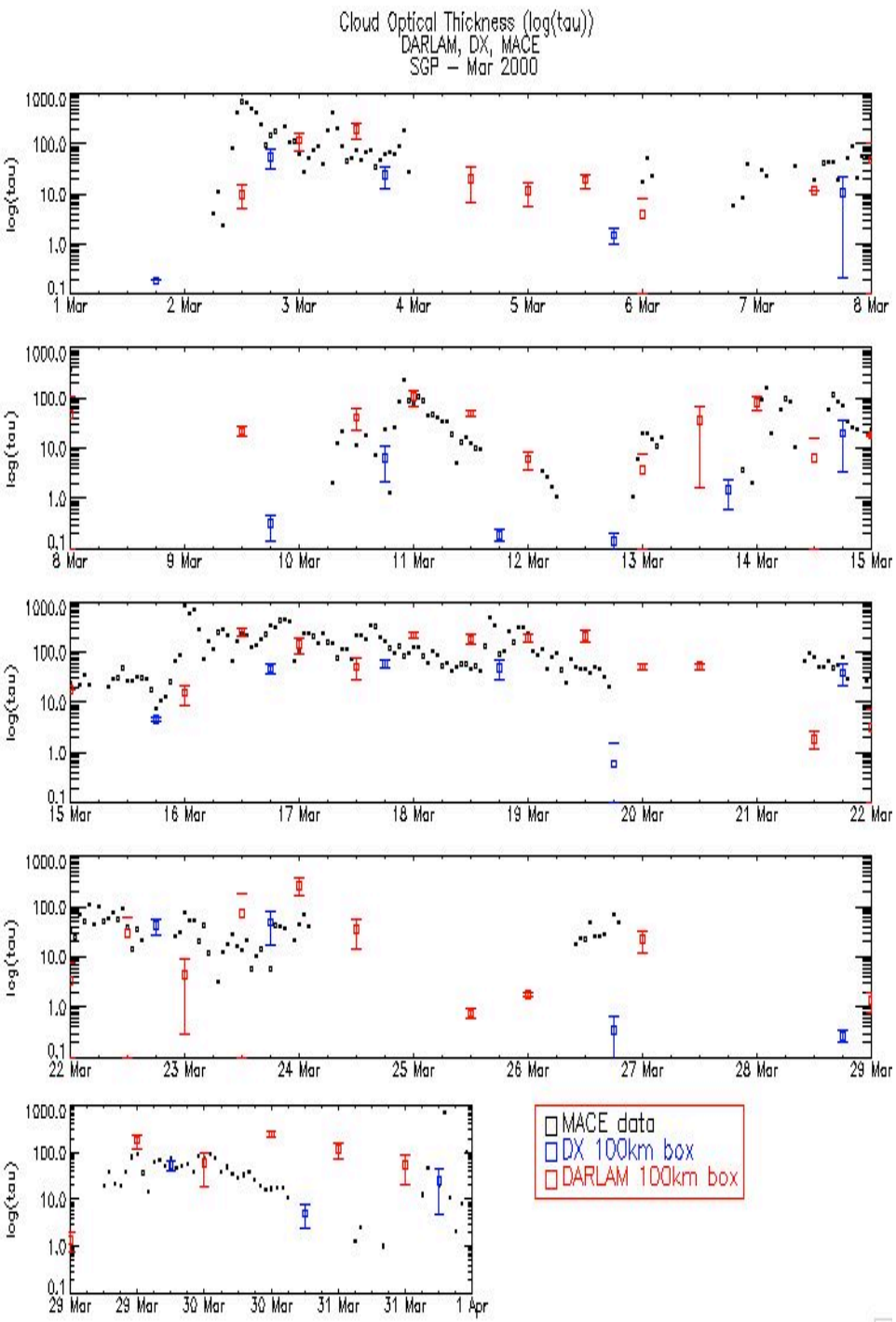

DARLAM 03/2000 (SGP) – Omega Upward
Cloud cover 56.3%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
10.0
5.00
0.00


Radar 03/2000 – Omega Upward
Cloud cover67.7%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth
10.0
5.00
0.00


RAMS 03/2000 (SGP) – Omega Upward
Cloud cover 79.4%
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Depth

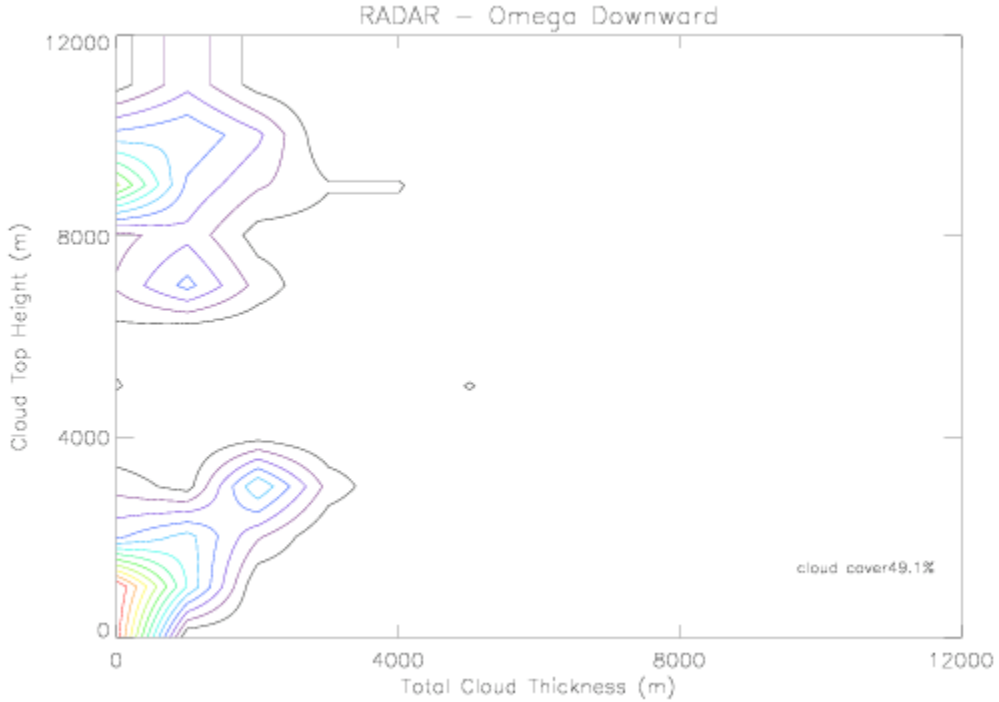

SCM 03/2000 (SGP) – Omega Upward
Cloud Top Pressure (mBar)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
6.87
3.44
0.00

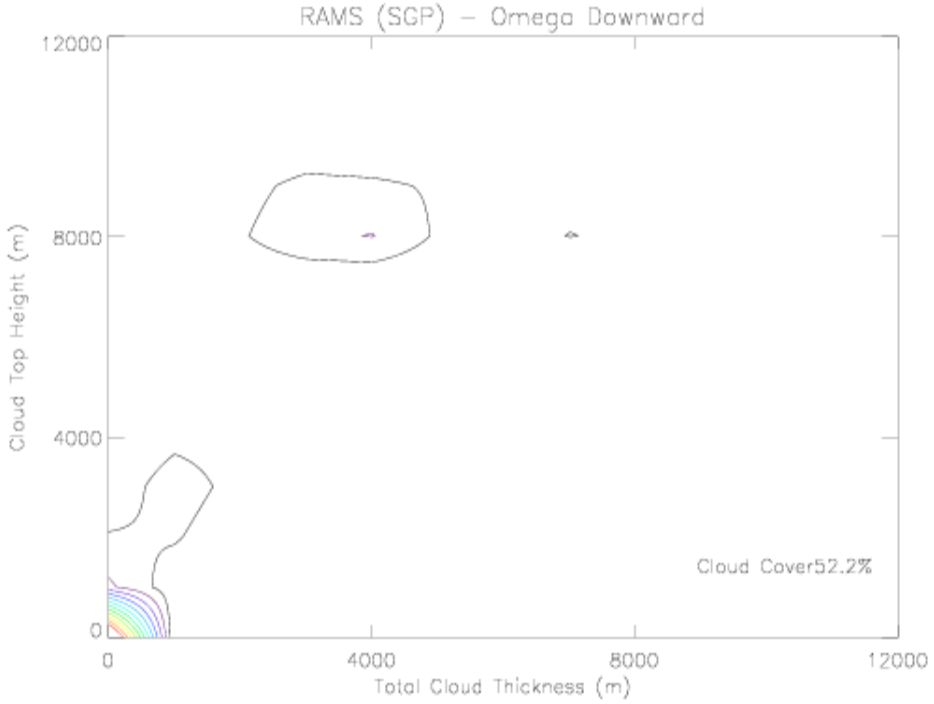

Cloud Optical Thickness (log(tau))
CCAM, DX, MACE
SGP – Mar 2000
log(tau)
1000.0
100.0
10.0
1.0
0.1
1 Mar
2 Mar
3 Mar
4 Mar
5 Mar
6 Mar
7 Mar
8 Mar
9 Mar
10 Mar
11 Mar
12 Mar
13 Mar
14 Mar
15 Mar
16 Mar
17 Mar
18 Mar
19 Mar
20 Mar
21 Mar
22 Mar
23 Mar
24 Mar
25 Mar
26 Mar
27 Mar
28 Mar
29 Mar
30 Mar
31 Mar
1 Apr
MACE data
DX 100km box
CCAM 100km box

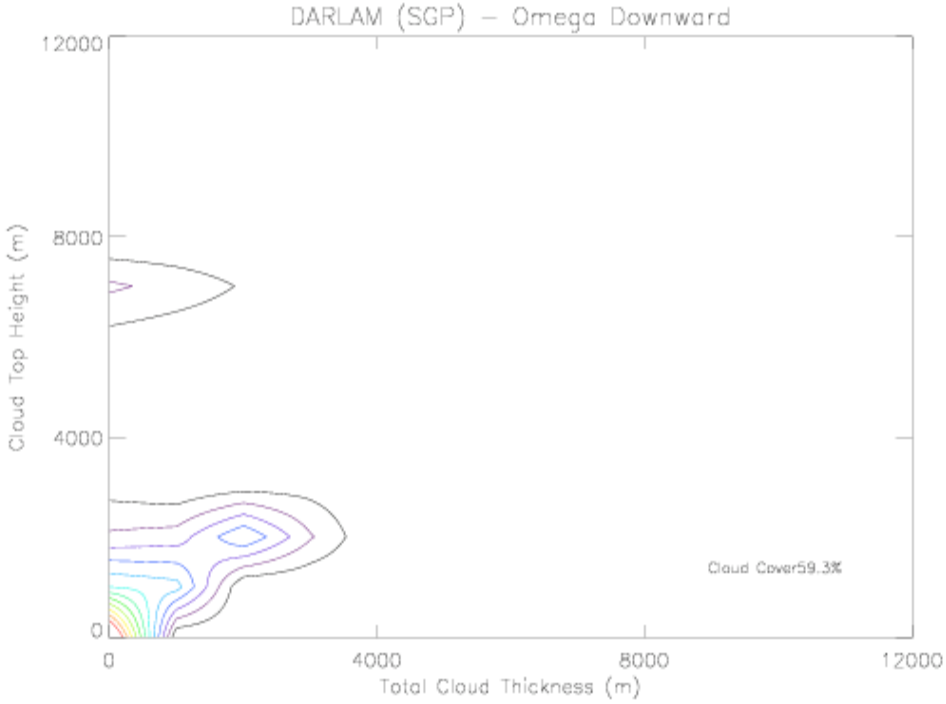

Cloud Optical Thickness (log(tau))
DARLAM, DX, MACE
SGP – Mar 2000
log(tau)
1000.0
100.0
10.0
1.0
0.1
1 Mar
2 Mar
3 Mar
4 Mar
5 Mar
6 Mar
7 Mar
8 Mar
9 Mar
10 Mar
11 Mar
12 Mar
13 Mar
14 Mar
15 Mar
16 Mar
17 Mar
18 Mar
19 Mar
20 Mar
21 Mar
22 Mar
23 Mar
24 Mar
25 Mar
26 Mar
27 Mar
28 Mar
29 Mar
30 Mar
31 Mar
1 Apr
MACE data
DX 100km box
DARLAM 100km box

DZ

W-DOWN

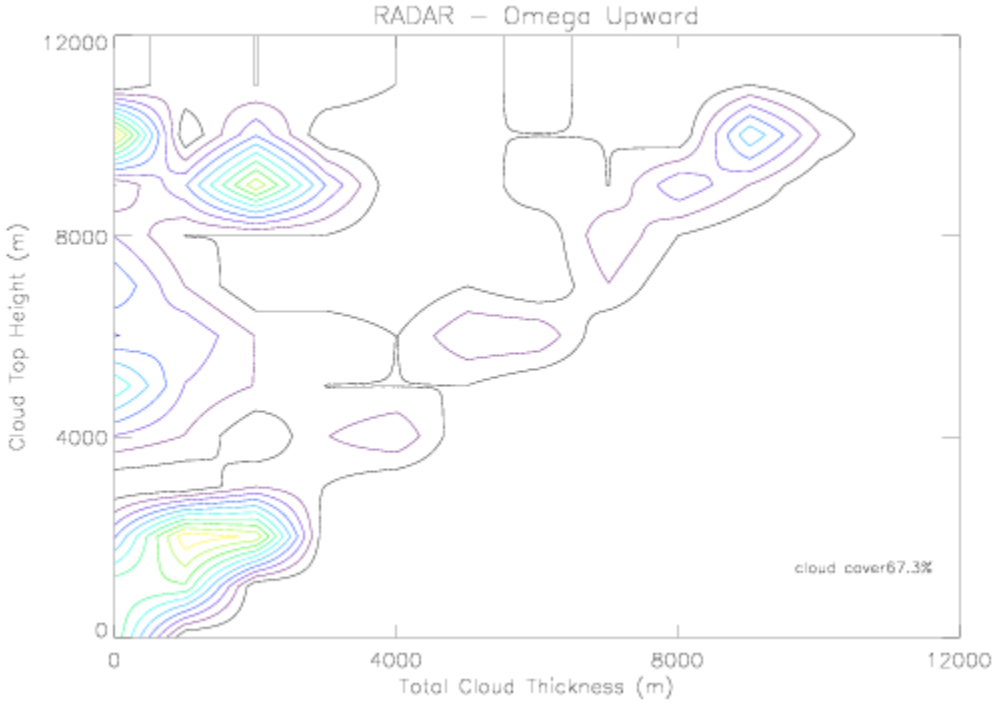

RADAR – Omega Downward
Cloud Top Height (m)
12000
8000
4000
0
0
4000
8000
12000
Total Cloud Thickness (m)
cloud cover49.1%

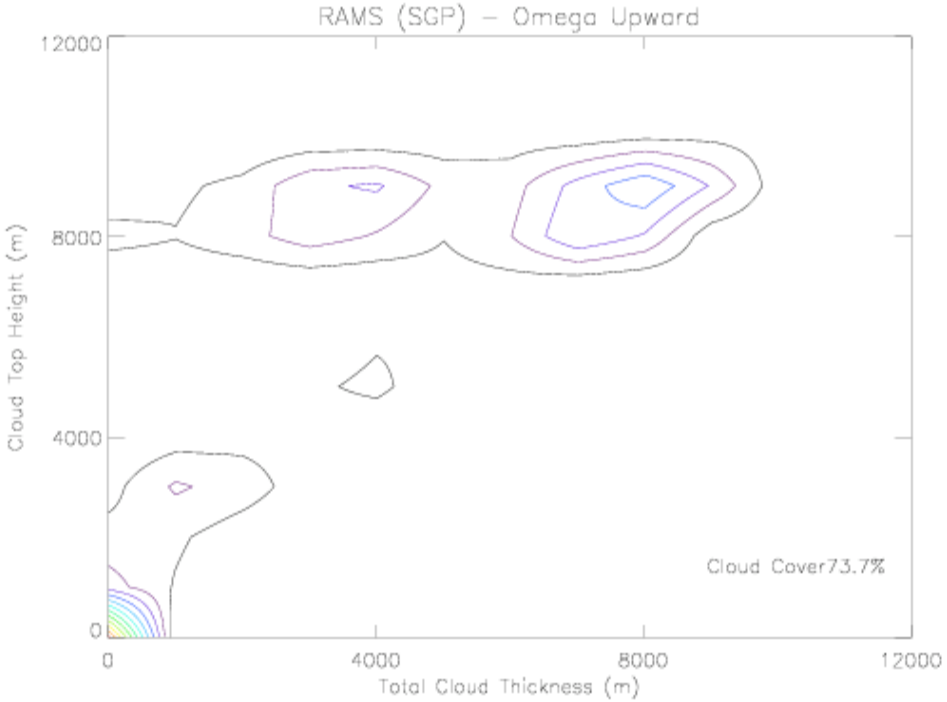

RAMS (SGP) – Omega Downward
Cloud Top Height (m)
12000
8000
4000
0
0
4000
8000
12000
Total Cloud Thickness (m)
Cloud Cover52.2%

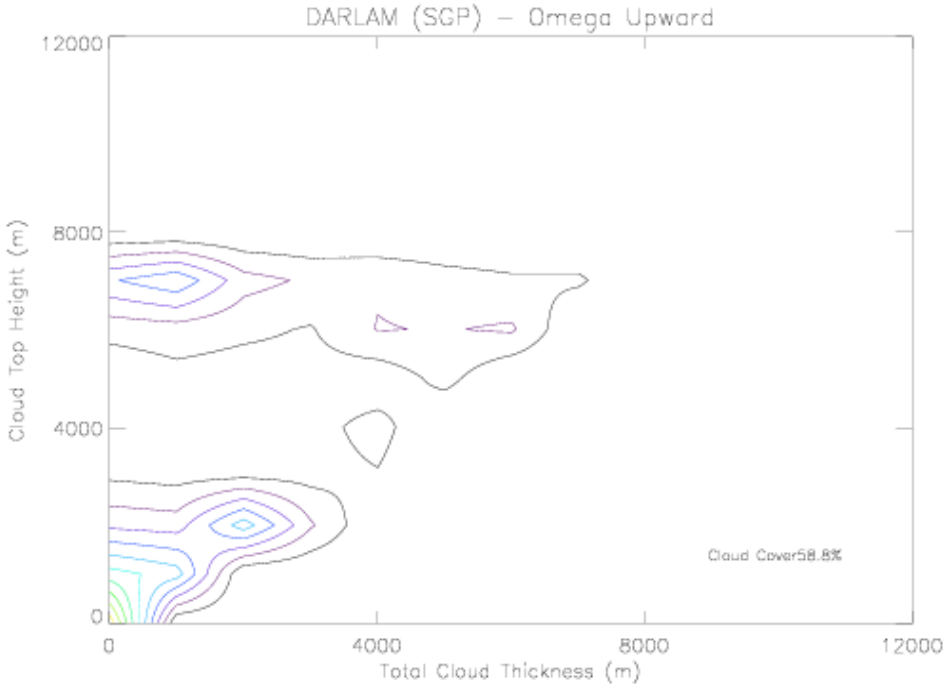

DARLAM (SGP) – Omega Downward
Cloud Top Height (m)
12000
8000
4000
0
0
4000
8000
12000
Total Cloud Thickness (m)
Cloud Cover59.3%

DZ

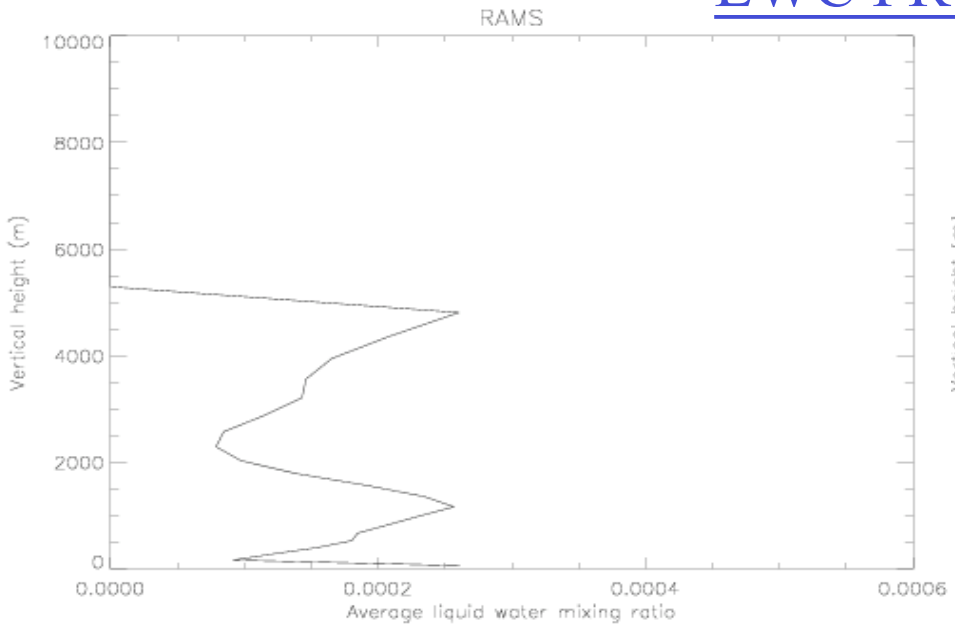
W-UP

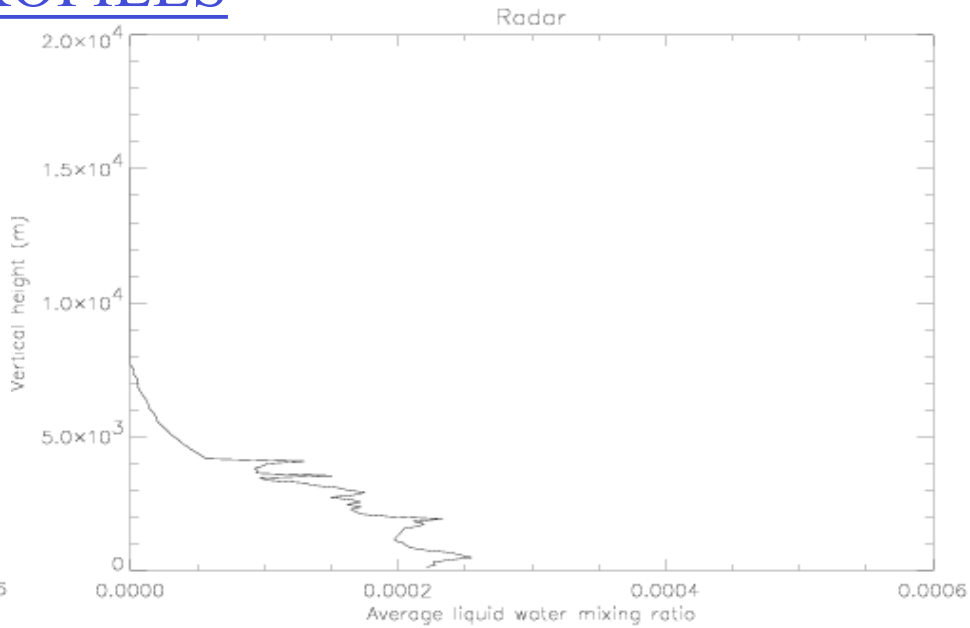

RADAR – Omega Upward
12000
8000
4000
0
Cloud Top Height (m)
0
4000
8000
12000
Total Cloud Thickness (m)
cloud cover67.3%

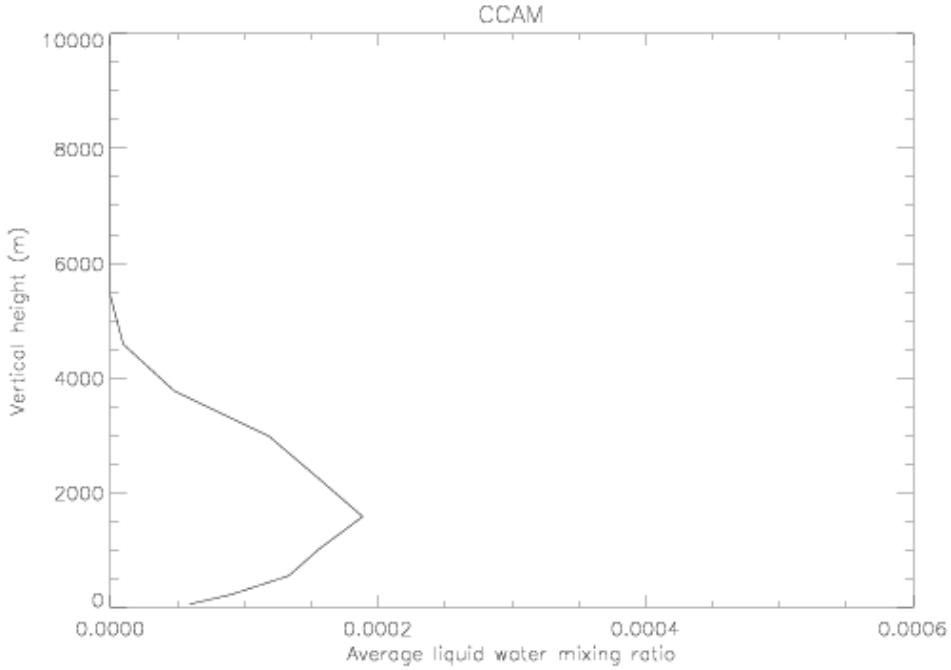

RAMS (SGP) – Omega Upward
12000
8000
4000
0
Cloud Top Height (m)
0
4000
8000
12000
Total Cloud Thickness (m)
Cloud Cover73.7%

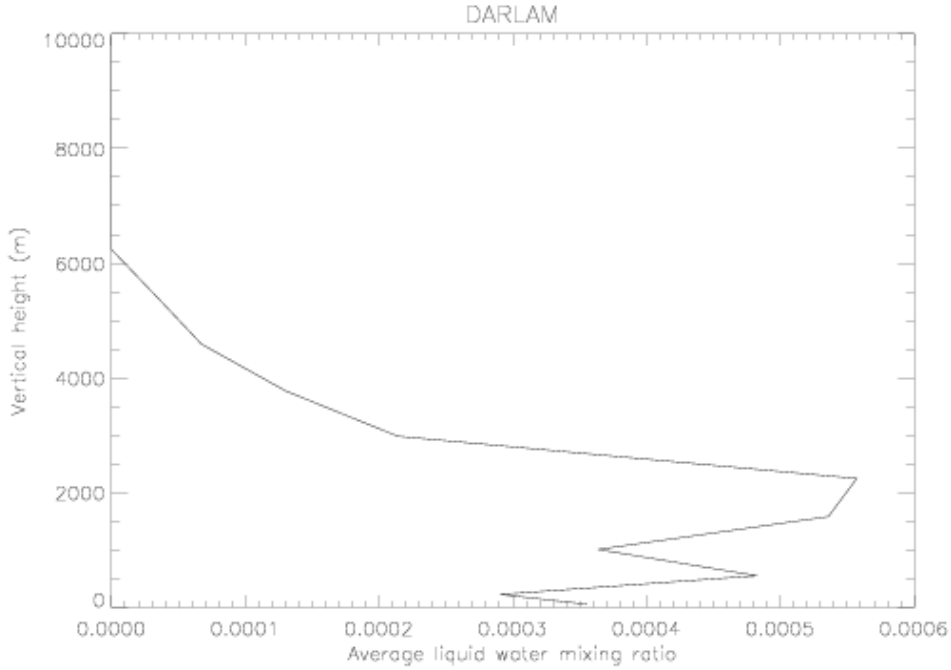

DARLAM (SGP) – Omega Upward
12000
8000
4000
0
Cloud Top Height (m)
0
4000
8000
12000
Total Cloud Thickness (m)
Cloud Cover58.8%

LWC PROFILES

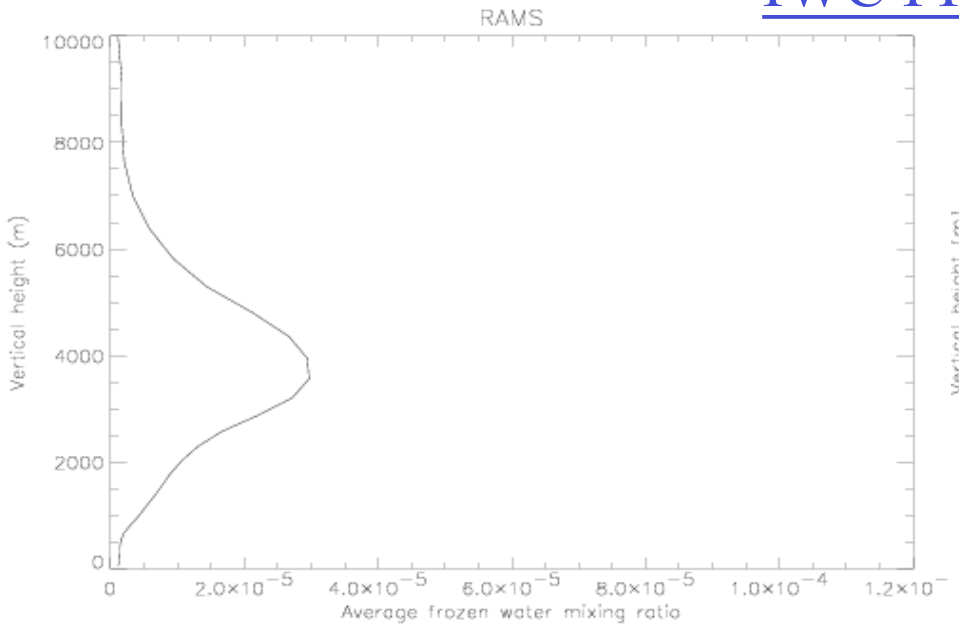


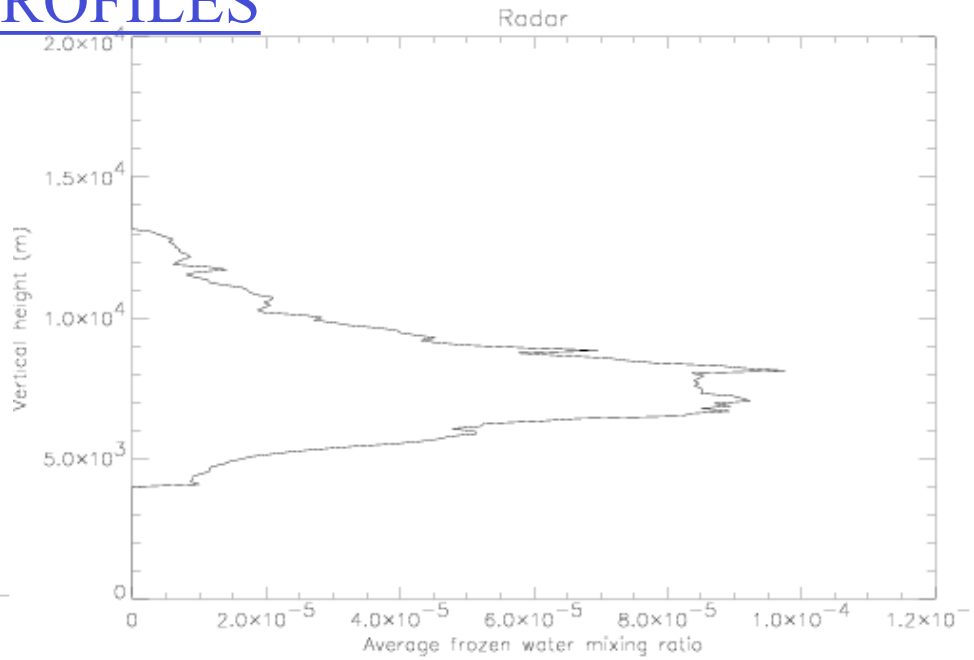


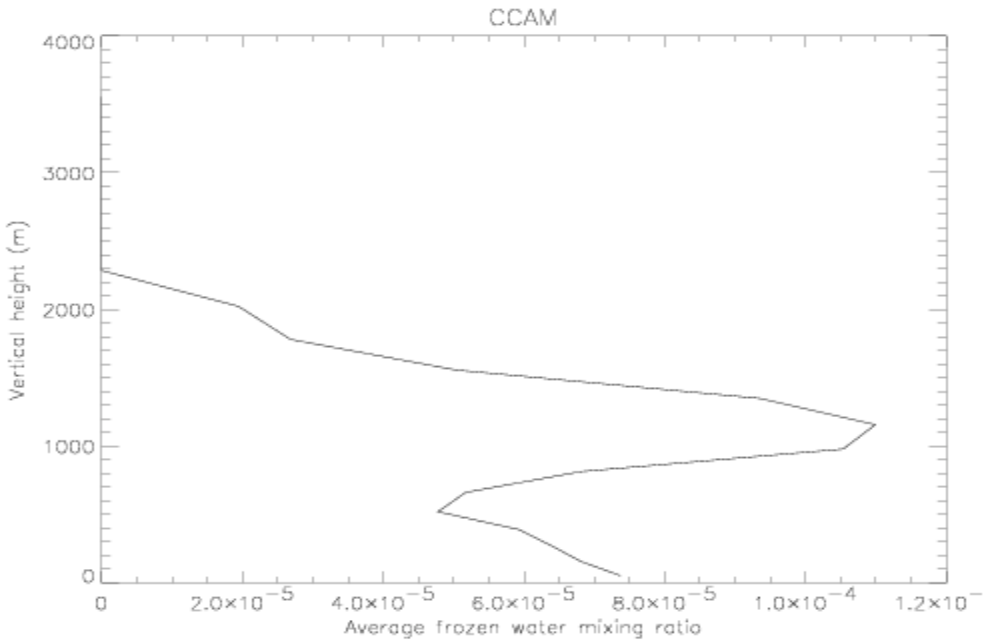


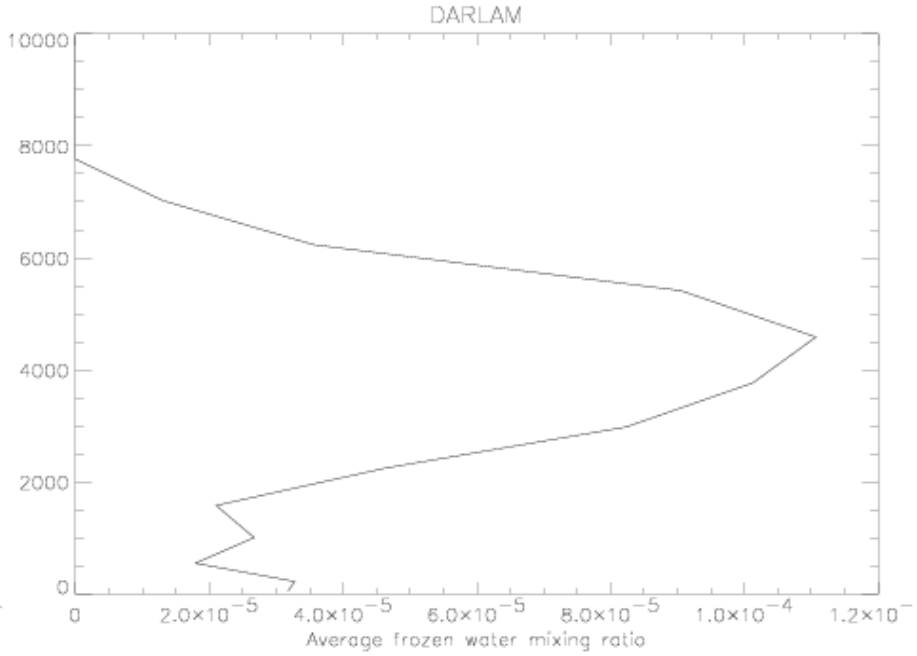


IWC PROFILES





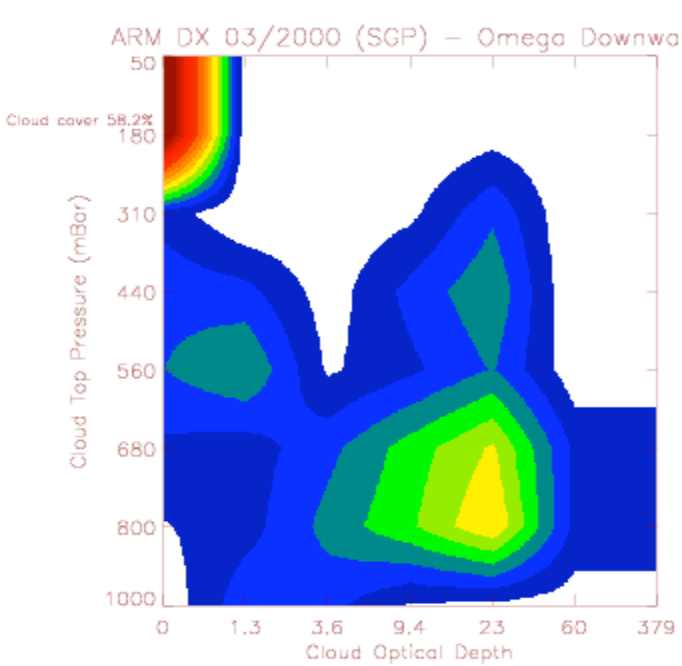


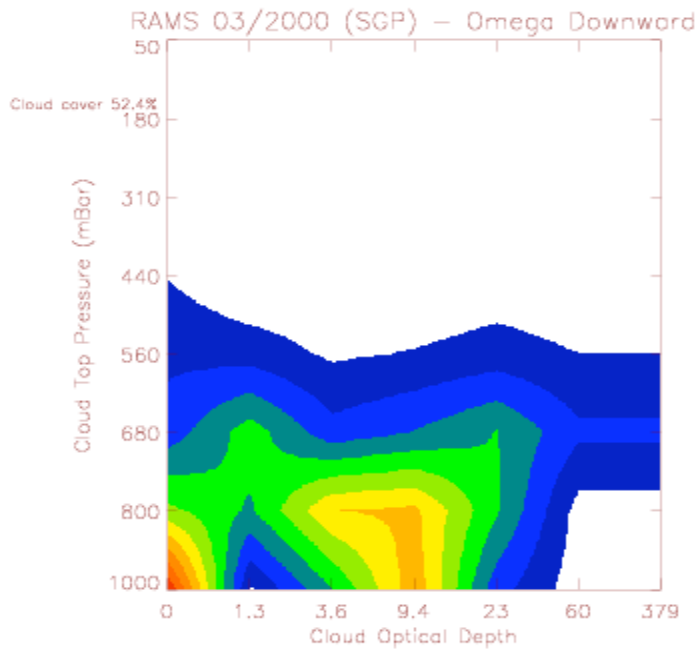


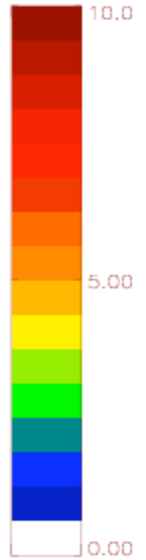
Leads and Clues

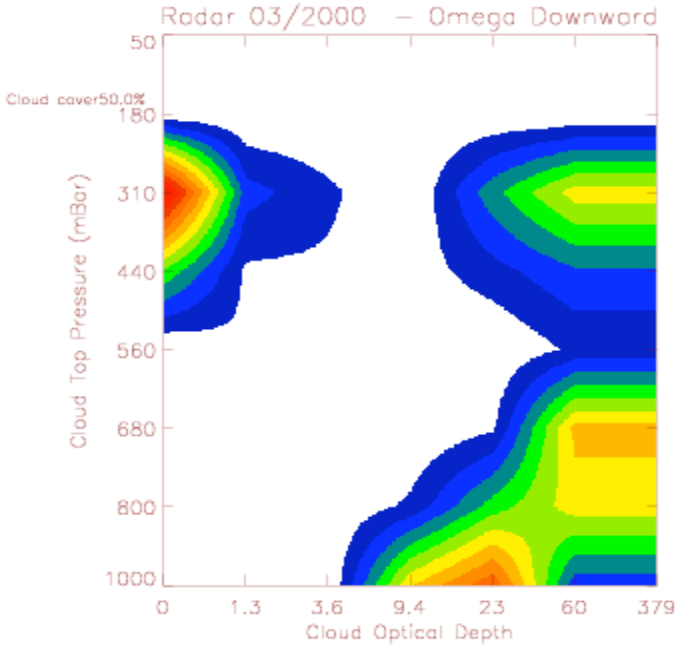
- Ice concentrations may be the reason for GCM prediction of large midlatitude cloud optical thickness values
- Need to resolve the relative role of ice microphysics and subgrid scale atmospheric dynamics in model prediction of ice contents

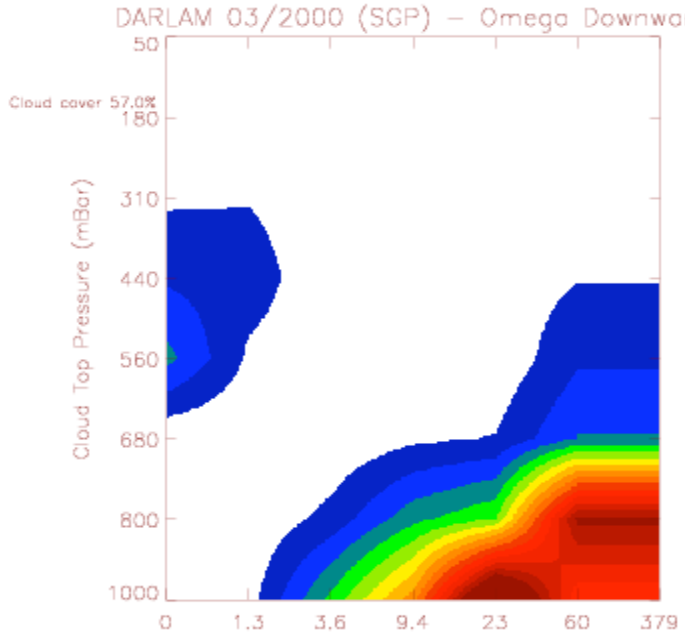
TAU-PC Histograms W-DOWN

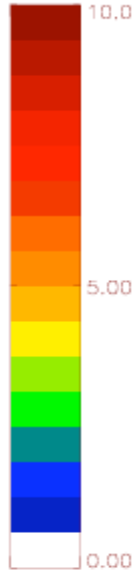




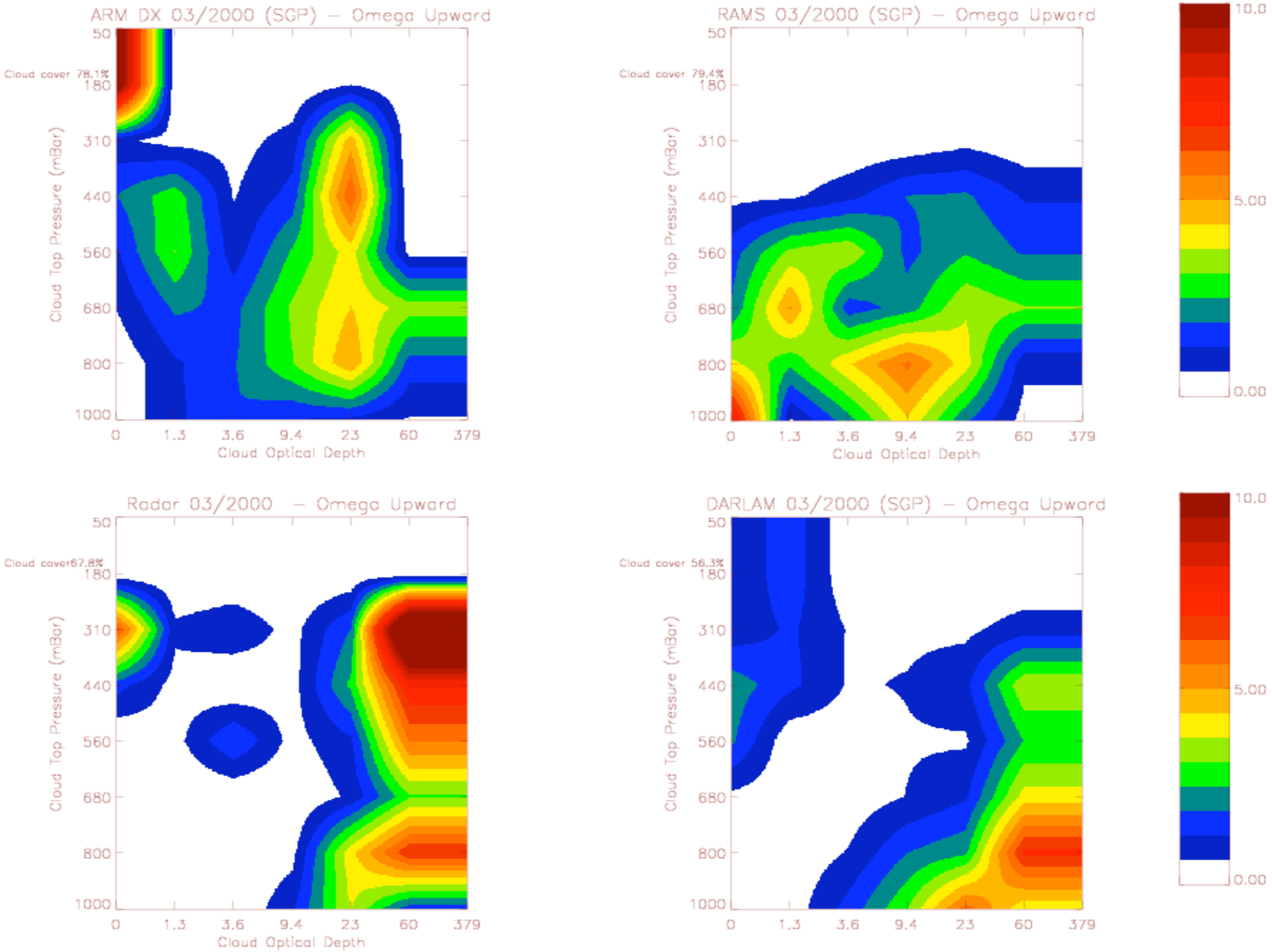


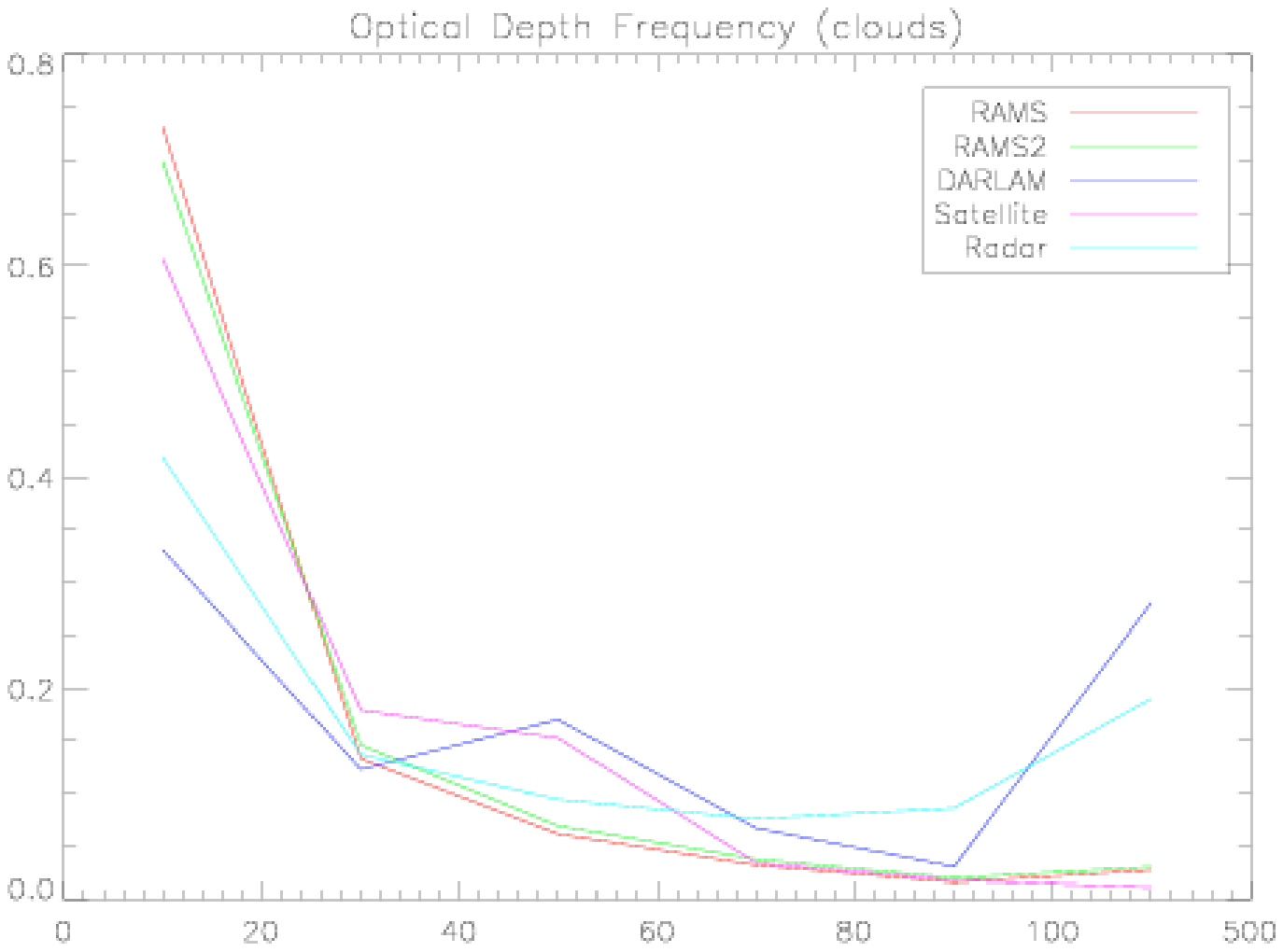


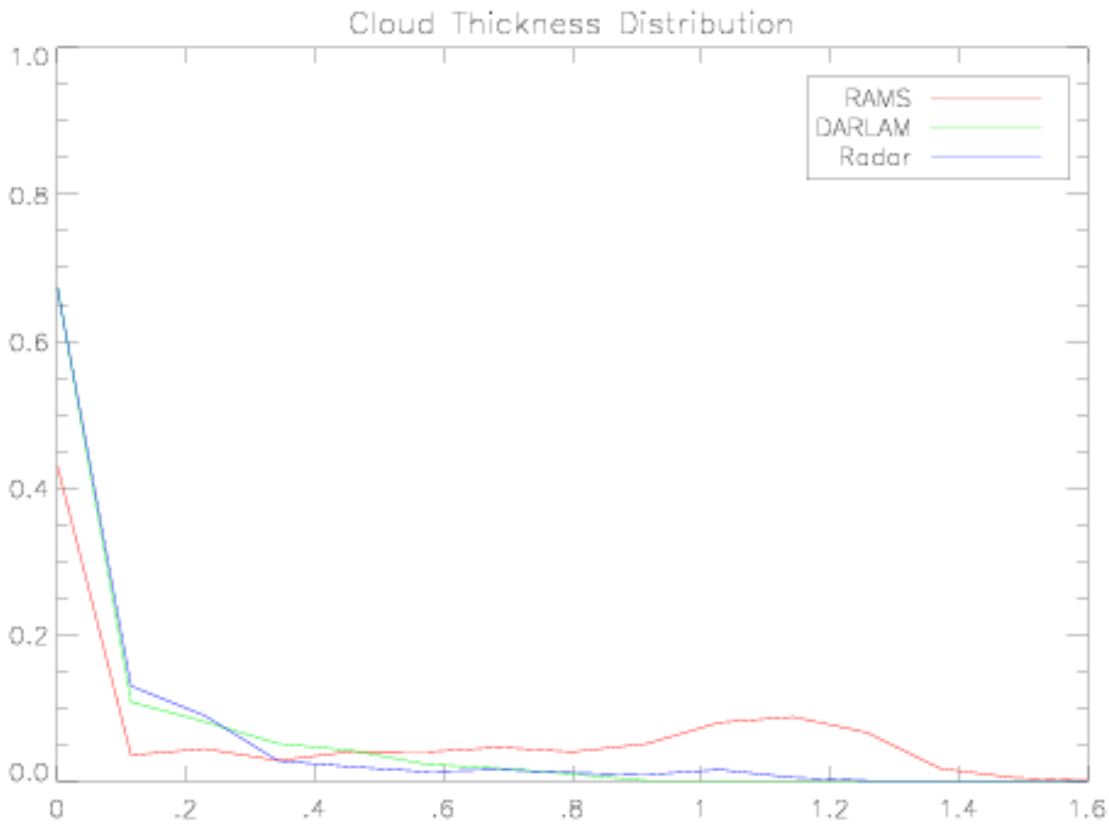


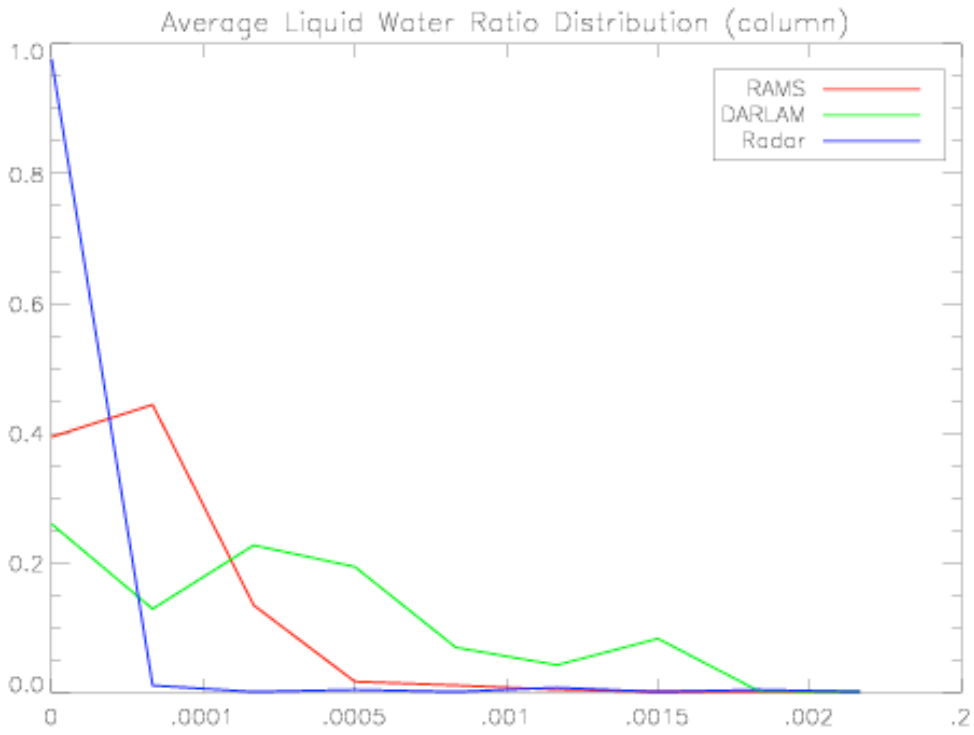


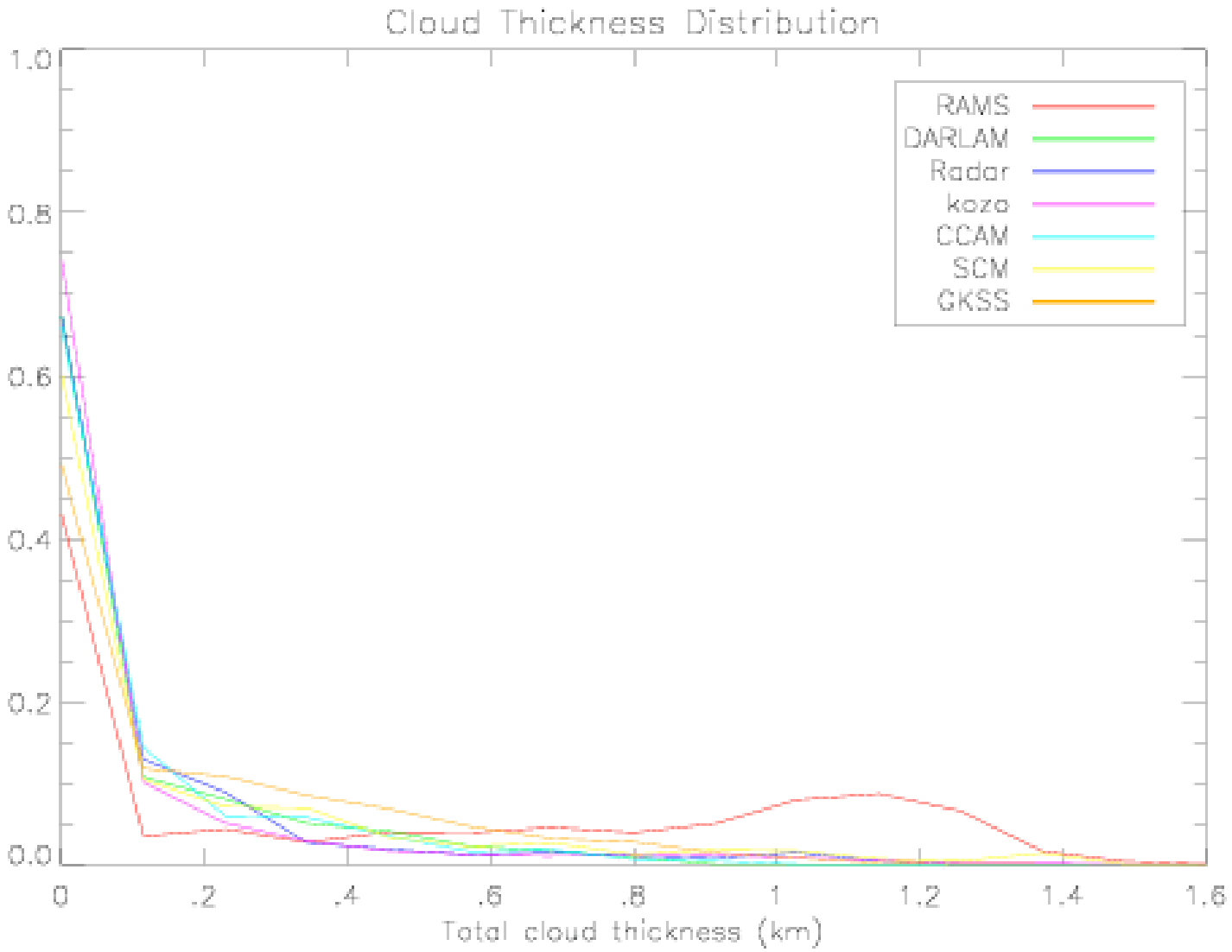
TAU-PC Histograms W-UP




Optical Depth Frequency (clouds)
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
500
RAMS
RAMS2
DARLAM
Satellite
Radar


Cloud Thickness Distribution
RAMS
DARLAM
Radar
1.0
0.8
0.6
0.4
0.2
0.0
0
.2
.4
.6
.8
1
1.2
1.4
1.6


Average Liquid Water Ratio Distribution (column)
RAMS
DARLAM
Radar
1.0
0.8
0.6
0.4
0.2
0.0
0
.0001
.0005
.001
.0015
.002
.2


Cloud Thickness Distribution
1.0
0.8
0.6
0.4
0.2
0.0
0
.2
.4
.6
.8
1
1.2
1.4
1.6
Total cloud thickness (km)
RAMS
DARLAM
Radar
koza
CCAM
SCM
GKSS