An evaluation of simulated cloud properties by a two-moment cloud microphysics scheme (CAMS) by observations from SoWMEX/TiMREX

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Objective

- To evaluate and improve the Chinese Academy of Meteorological Sciences (CAMS) two-moment cloud microphysics scheme.

Observation data

Case 1: IOP8 during the SoWMEX/TiMREX

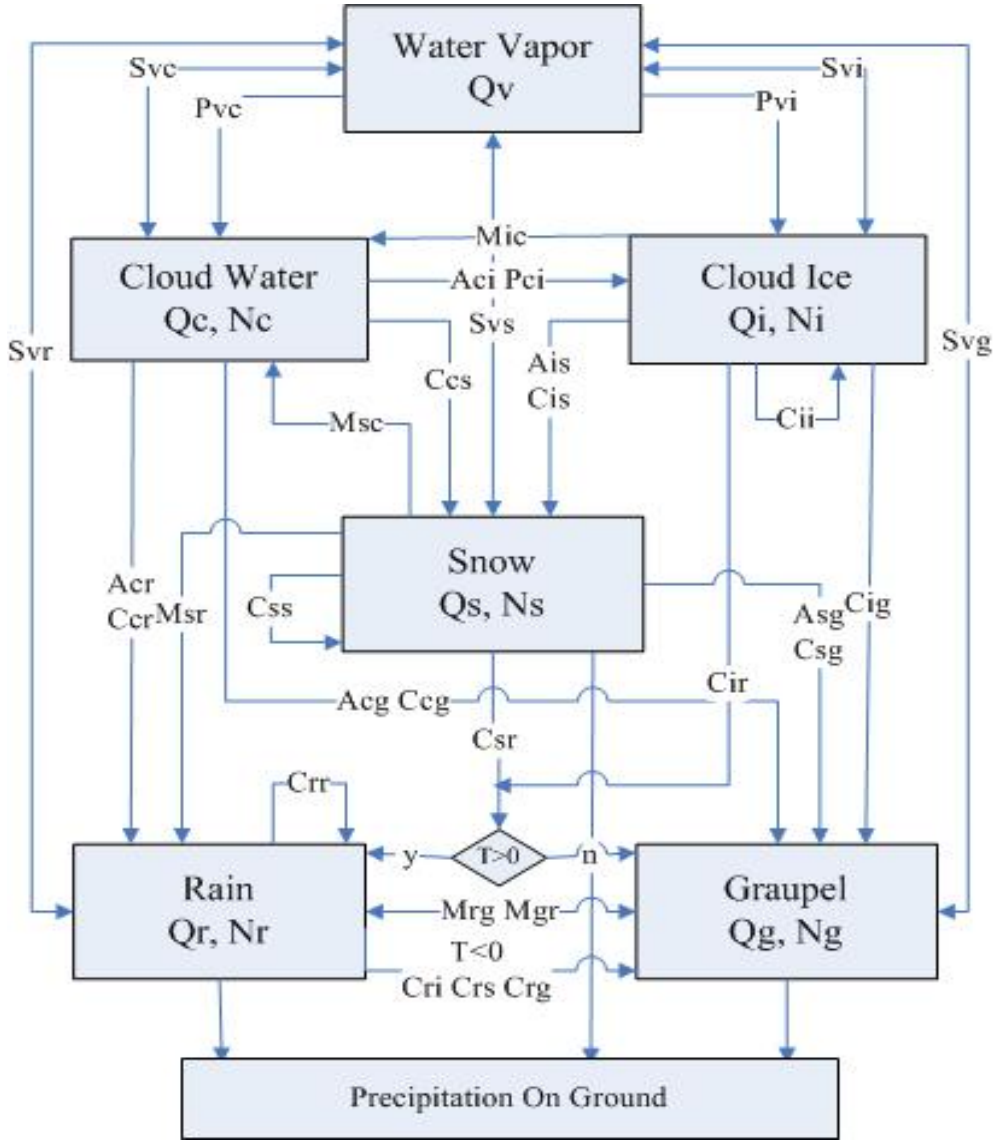
Time: 14 June 0000UTC to 15 June 0000UTC

Analysis region: S-POL (22.53N,120.43E)±100km

Case 2: Typhoon Morakot 2009

Time: 7 Aug. 0000UTC to 8 Aug. 0000UTC

In addition to water vapor, five bulk cloud species are predicted (two water clouds, three ice clouds).
Both mixing ratio and number concentrations are predicted for each cloud species.
Over 32 processes are included in the scheme.

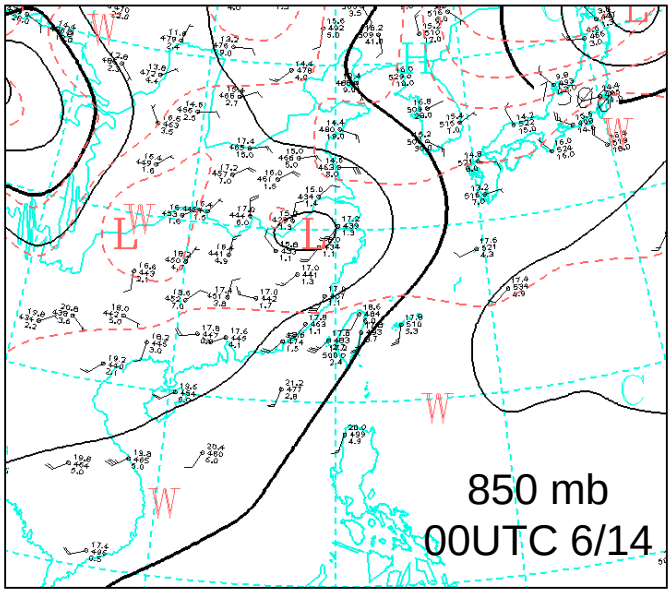


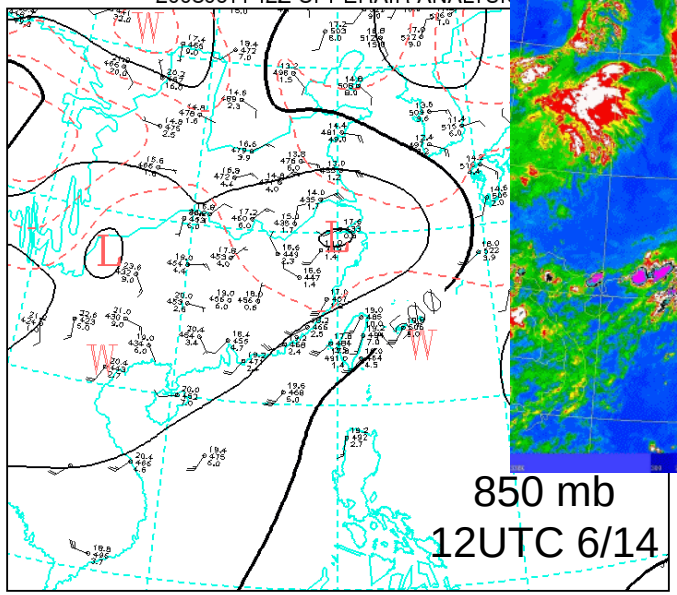
CAMS cloud microphysics scheme flow chart

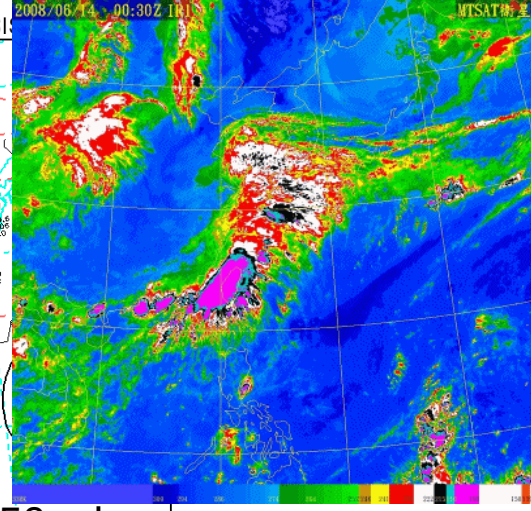
IOP8 during the SoWMEX/TiMREX

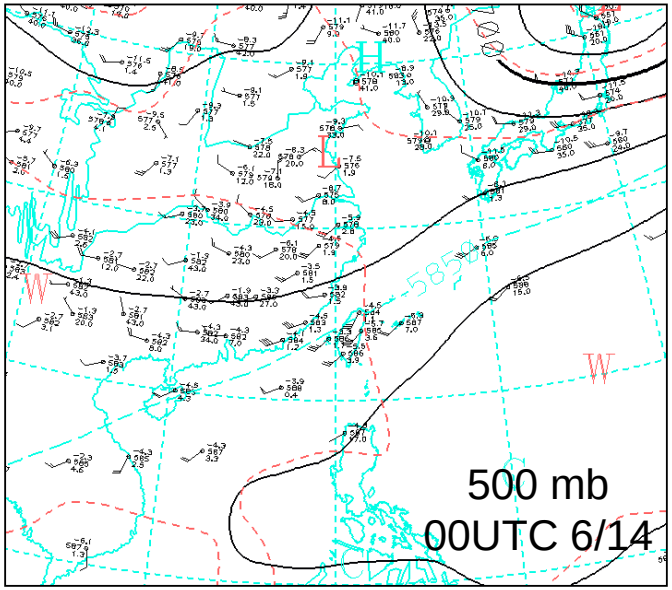
Time: 14 June 0000UTC to 15 June 0000UTC

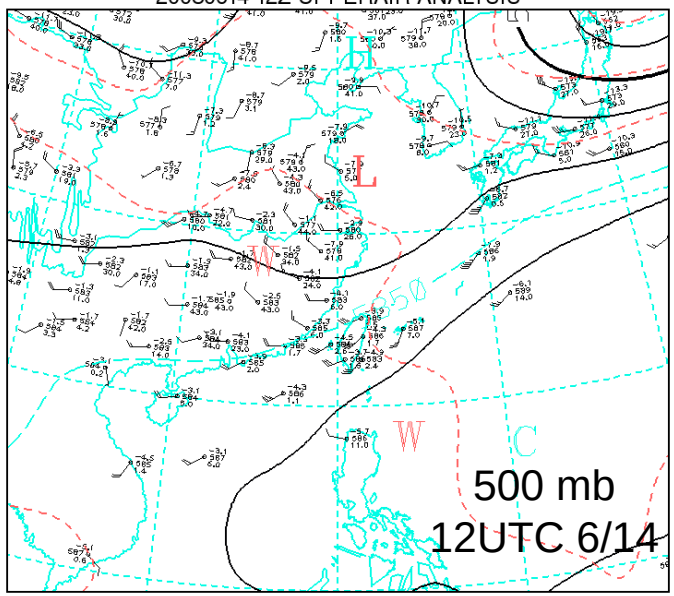
Analysis region: S-POL (22.53N,120.43E)±100km



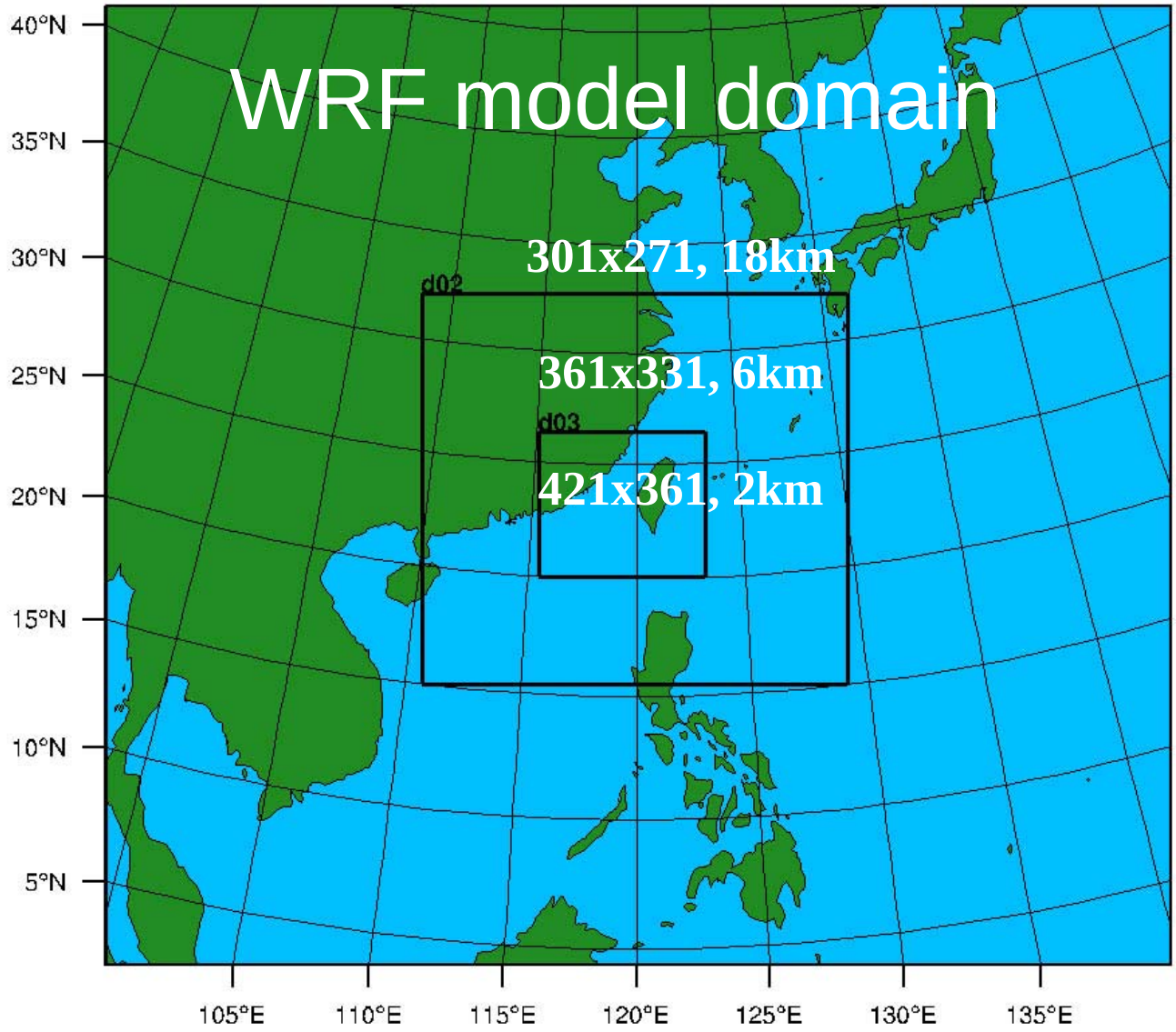






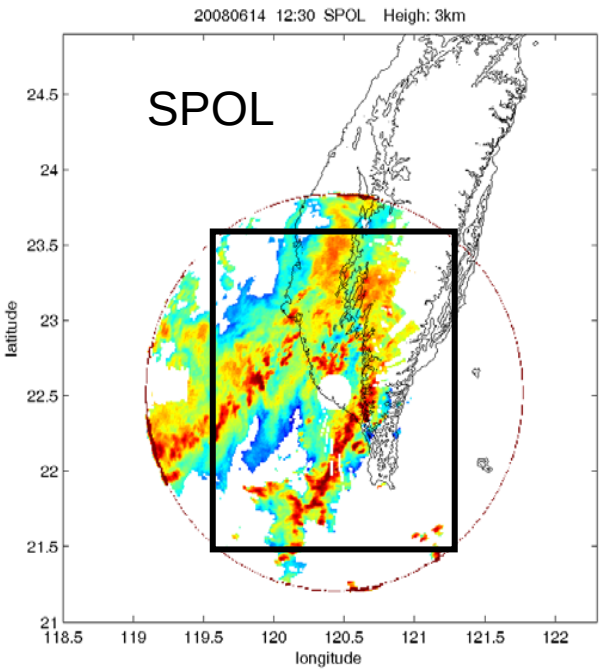


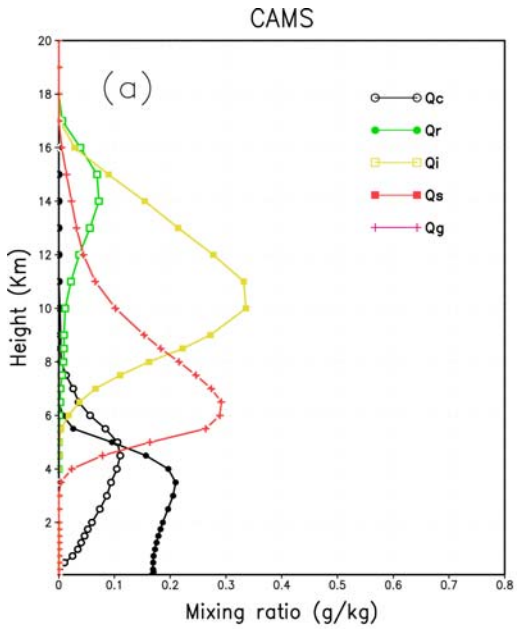
850hPa and 500hPa map (left: June 14 0000UTC; right: June 14 1200UTC)

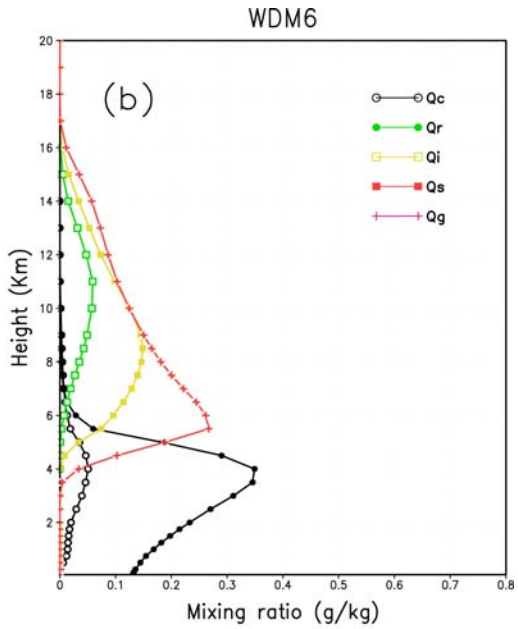


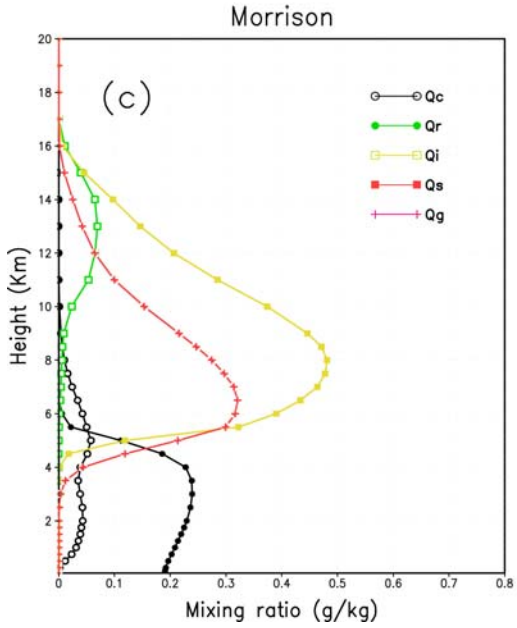
Domains (301x271, 18km; 361x331, 6km; 421x361, 2km)
Time: 0000 UTC 14 - 0000 UTC 15 June 2008

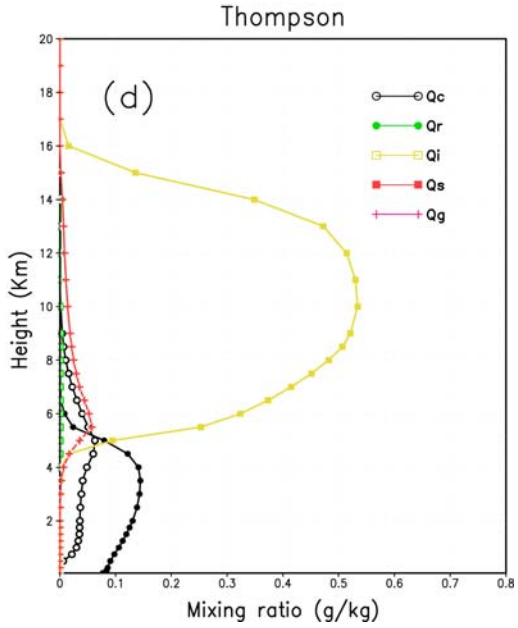
Mean profiles averaged in the period of 12-24 UTC, June 14 and the area boxed below



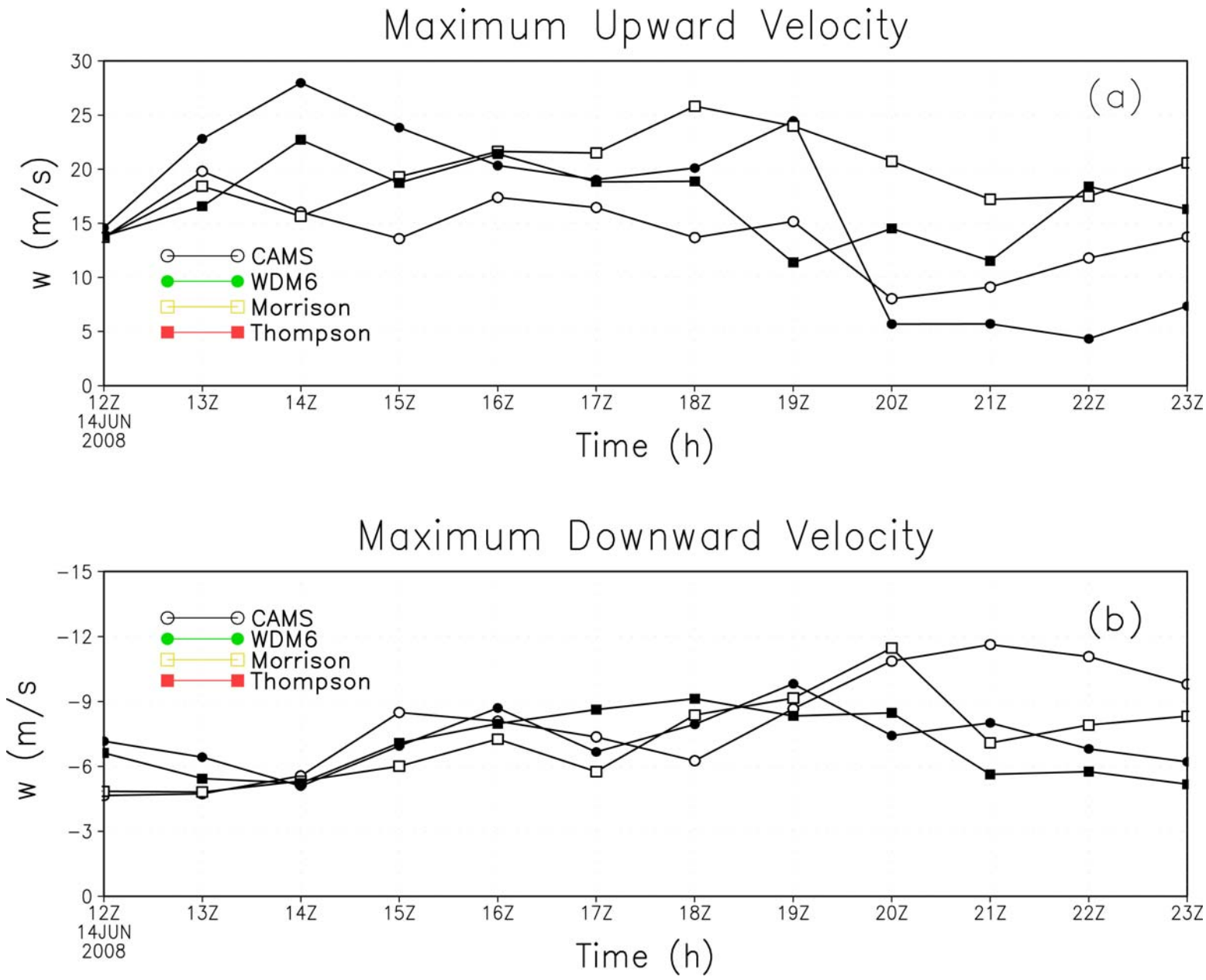




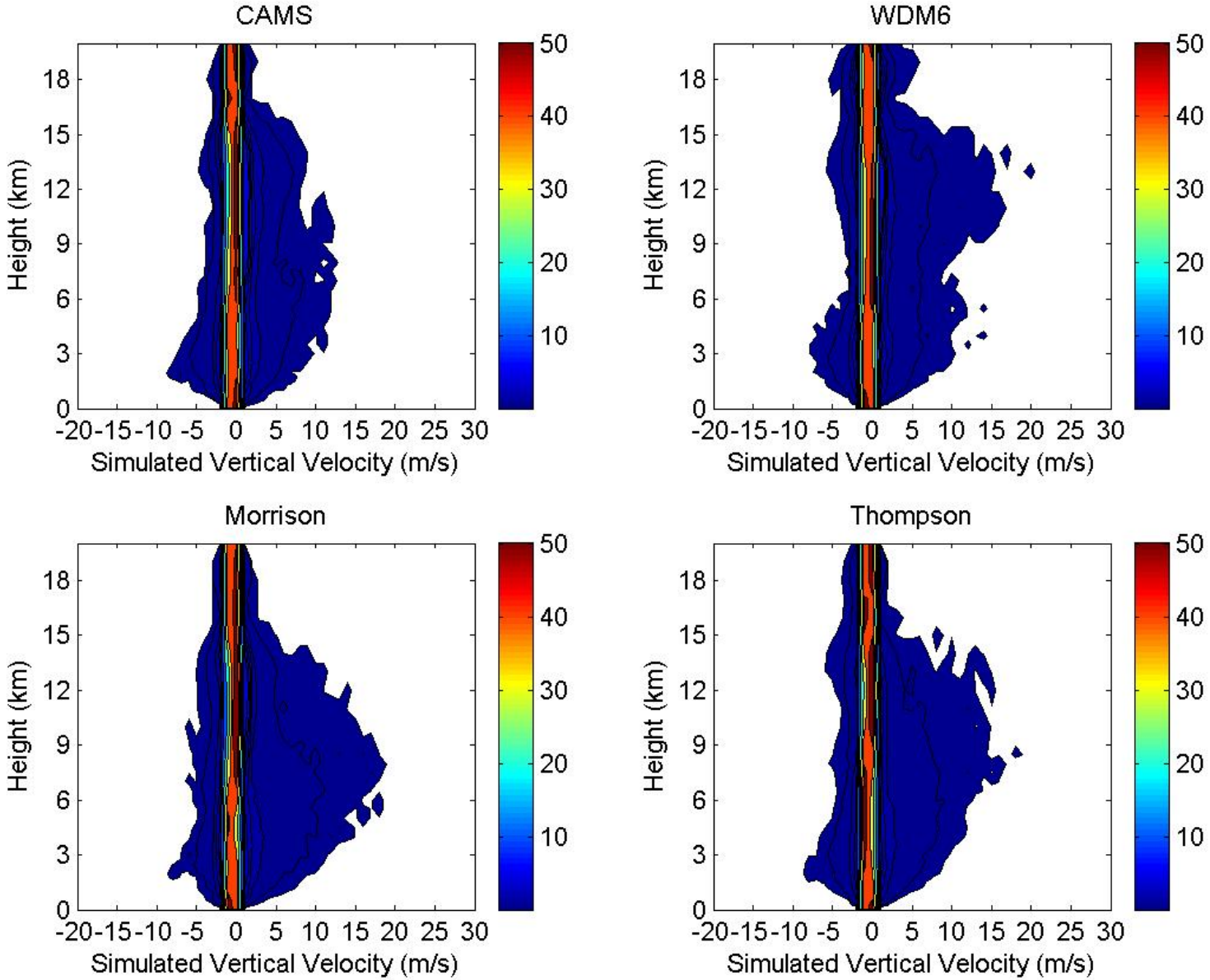




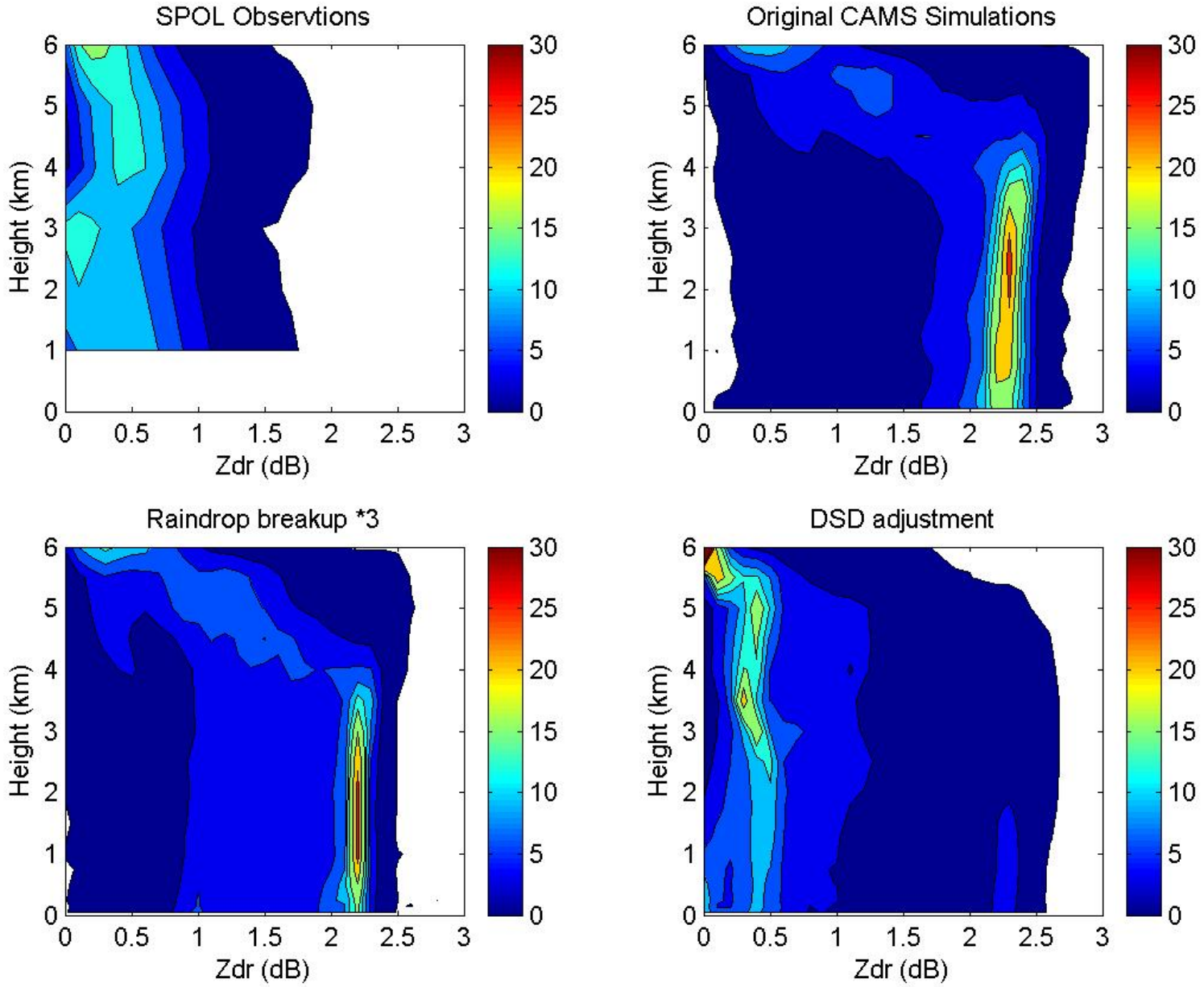
Time-space averaged profiles of mixing ratios in different two-moment schemes



Time series of maximum vertical velocity

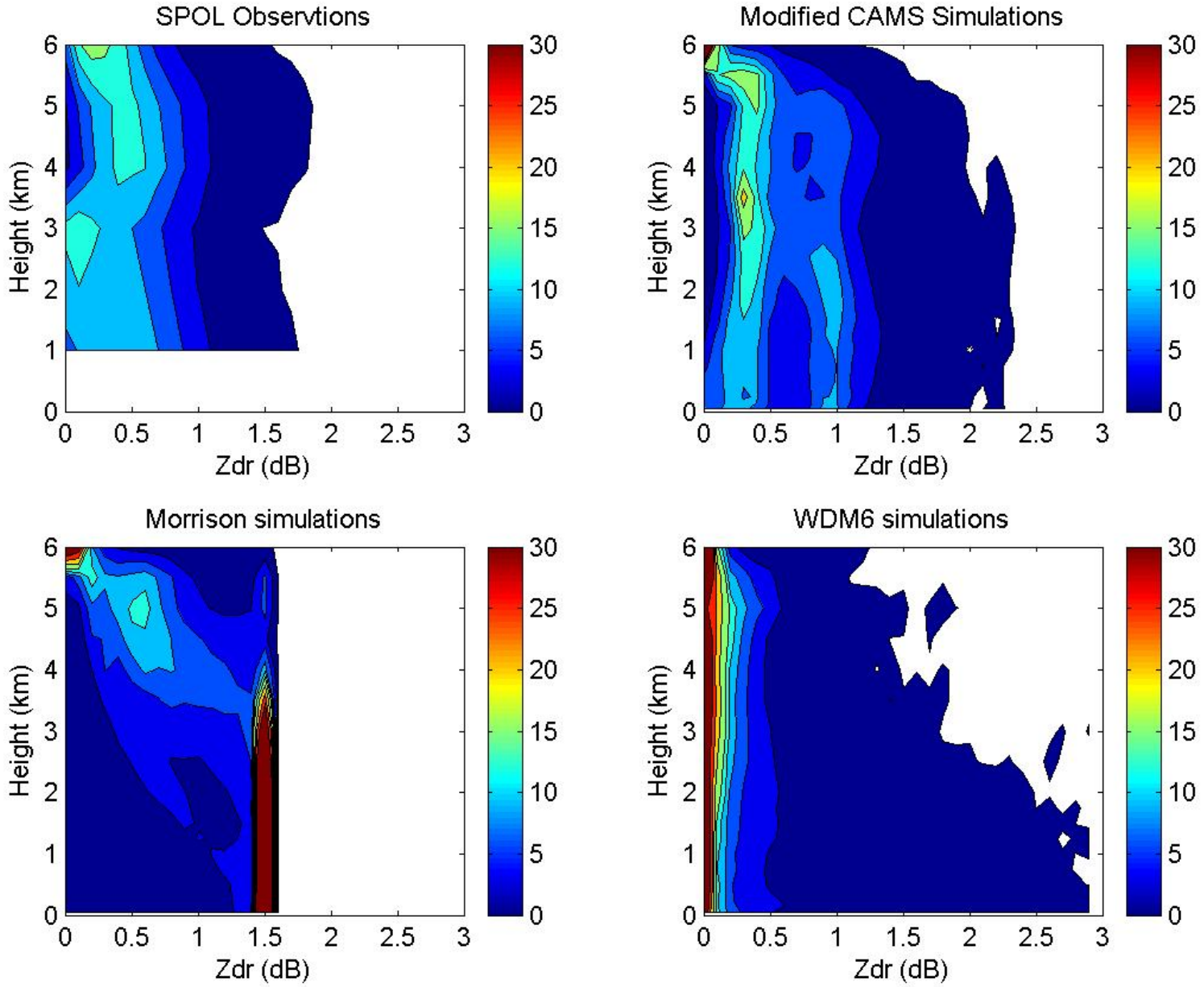


CFADs of maximum vertical velocity
(CAMS at 0614 1500UTC, others at 0614 1700UTC)

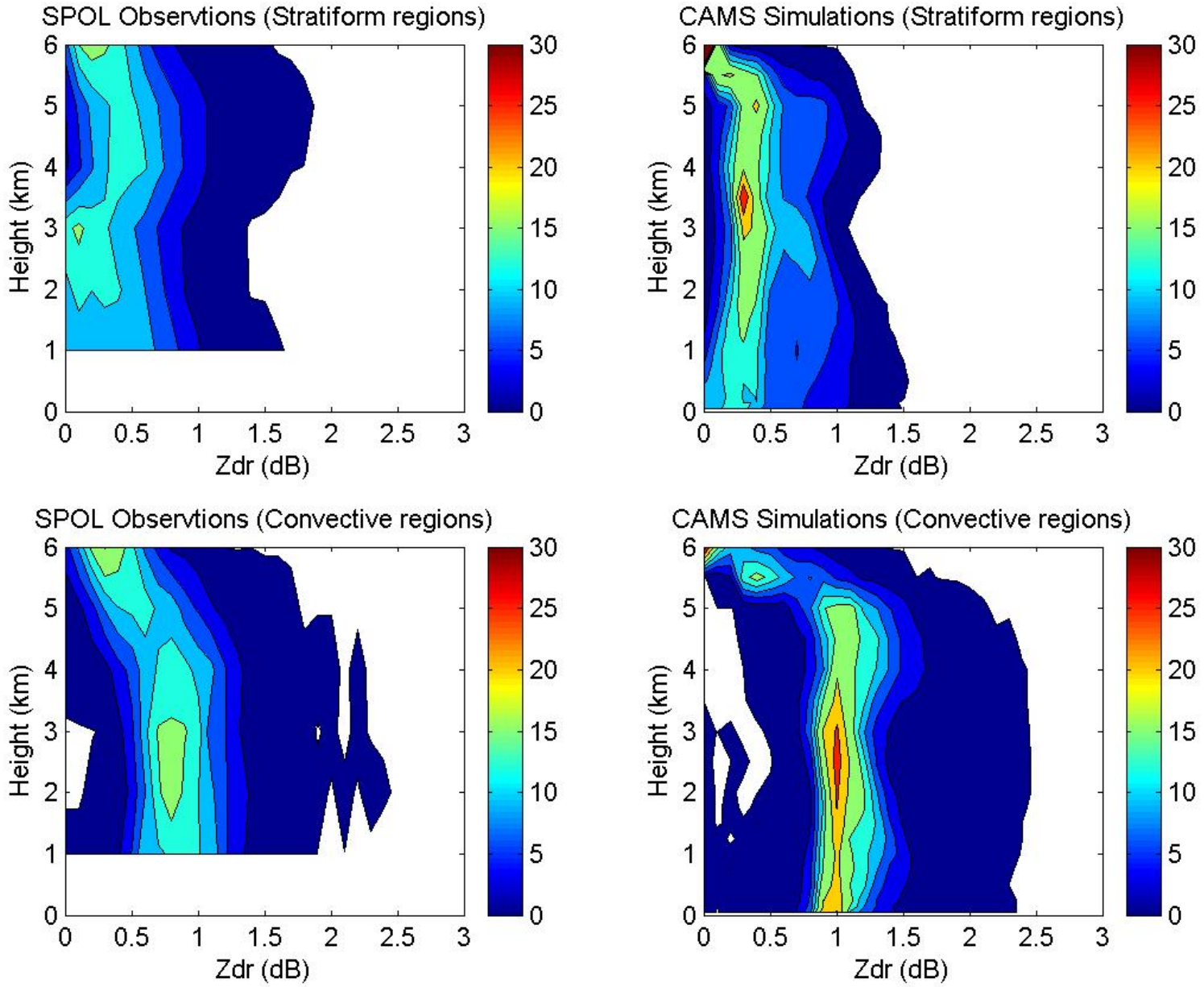


$$D_m = 1.619 \cdot (Z_{dr})^{0.485} \quad \textit{Bringi}\ (2001)$$

SPOL observed and original CAMS simulated Zdr (0614 1500UTC)



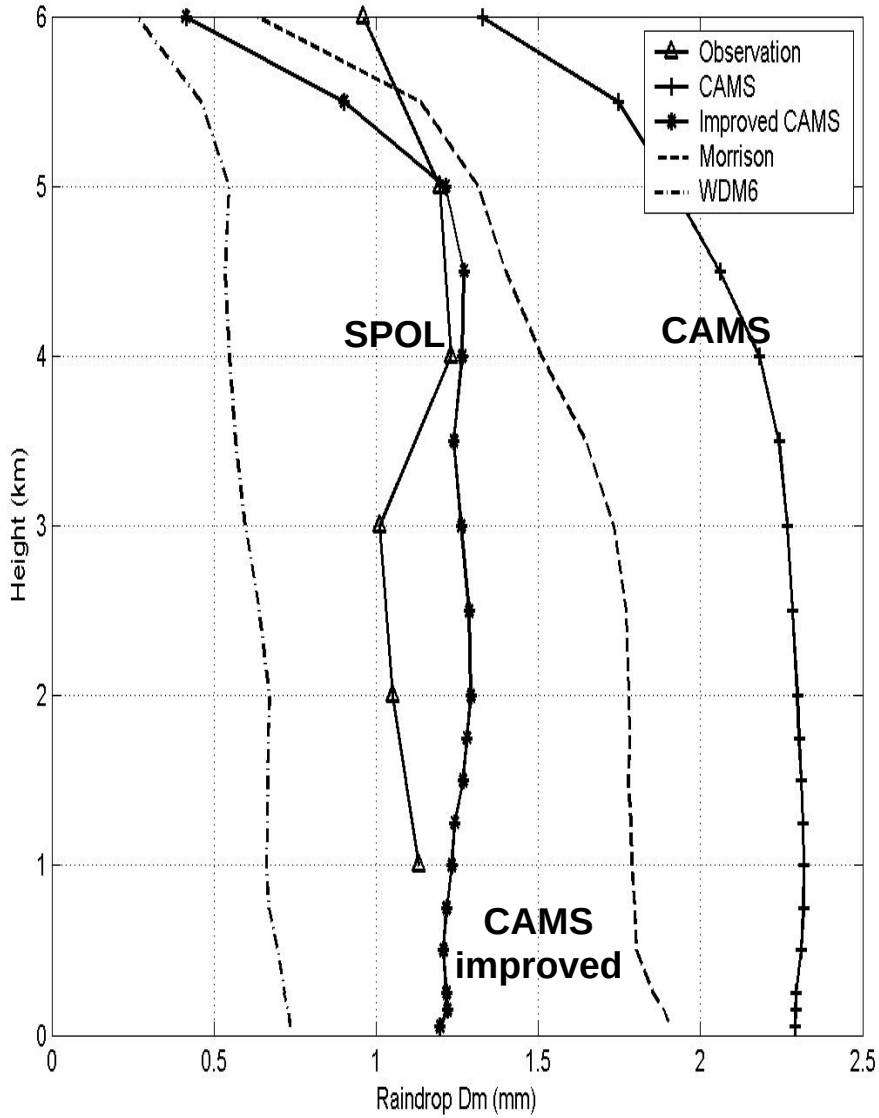
SPOL observed and different schemes simulated Zdr



SPOL observed and CAMS simulated Zdr (stratiform and convective regions)

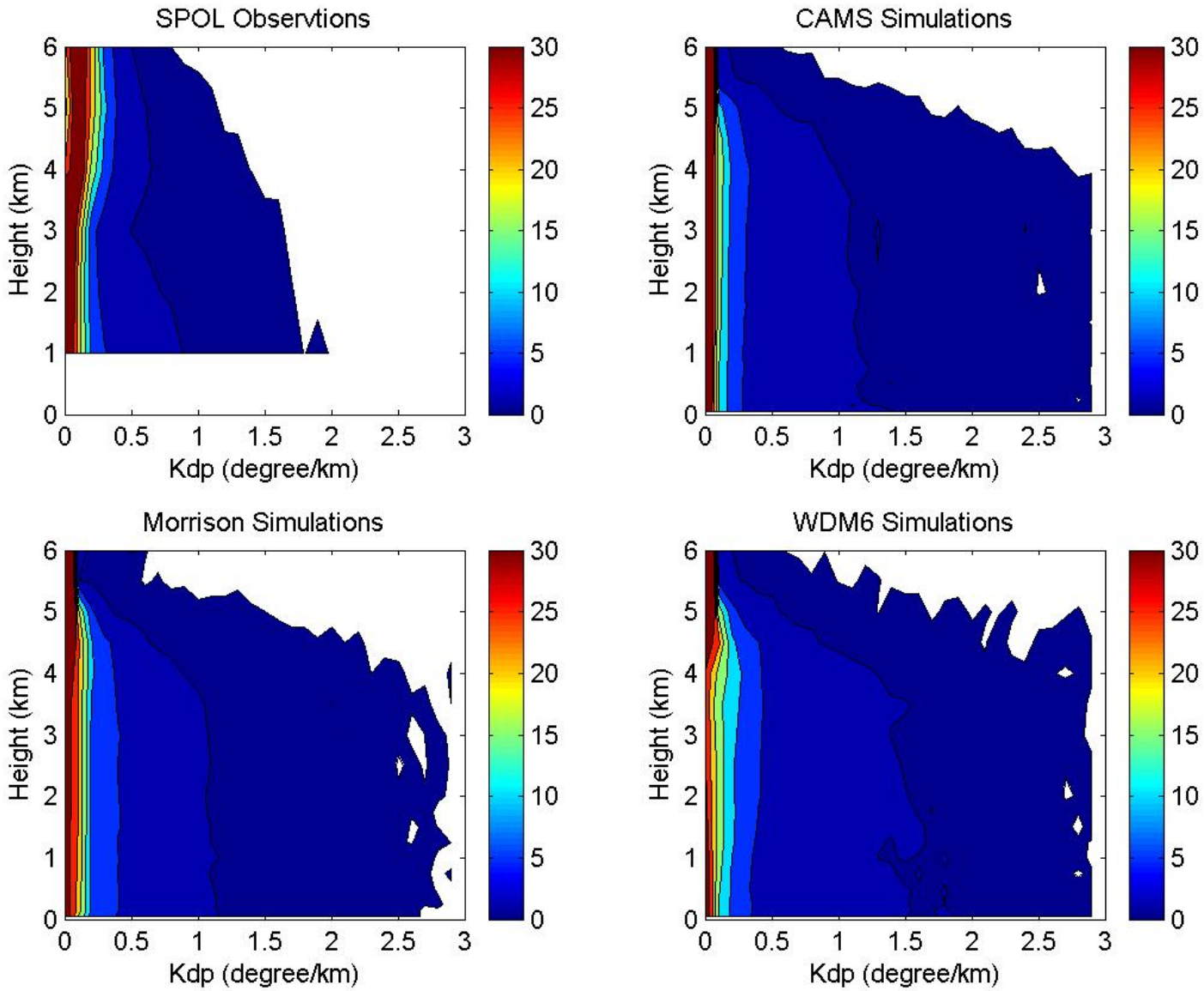
Simulated mean D_m vs SPOL retrieved values

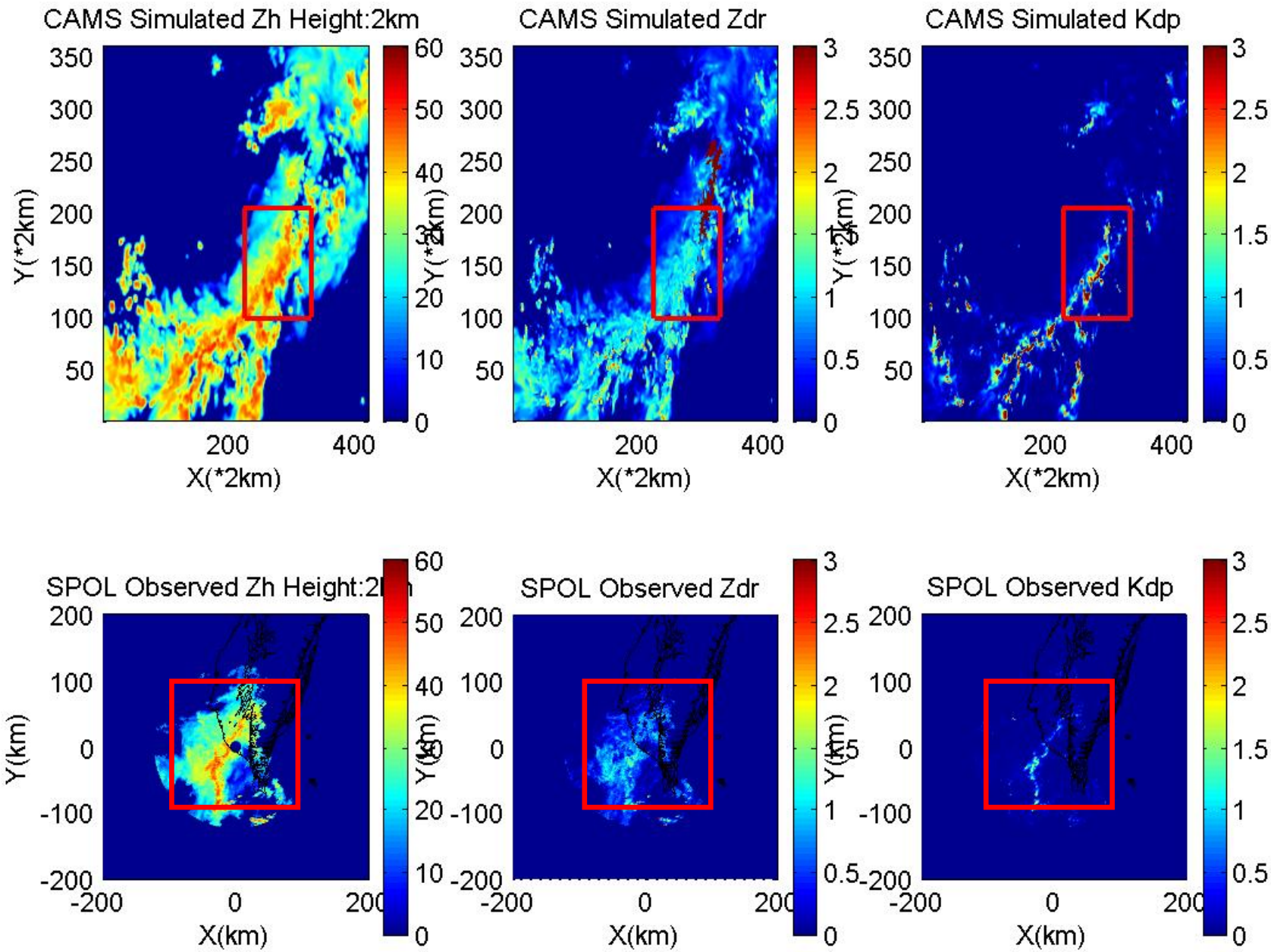
$$D_m = 1.619 \cdot (Z_{dr})^{0.485} \quad Bringi\ (2001)$$



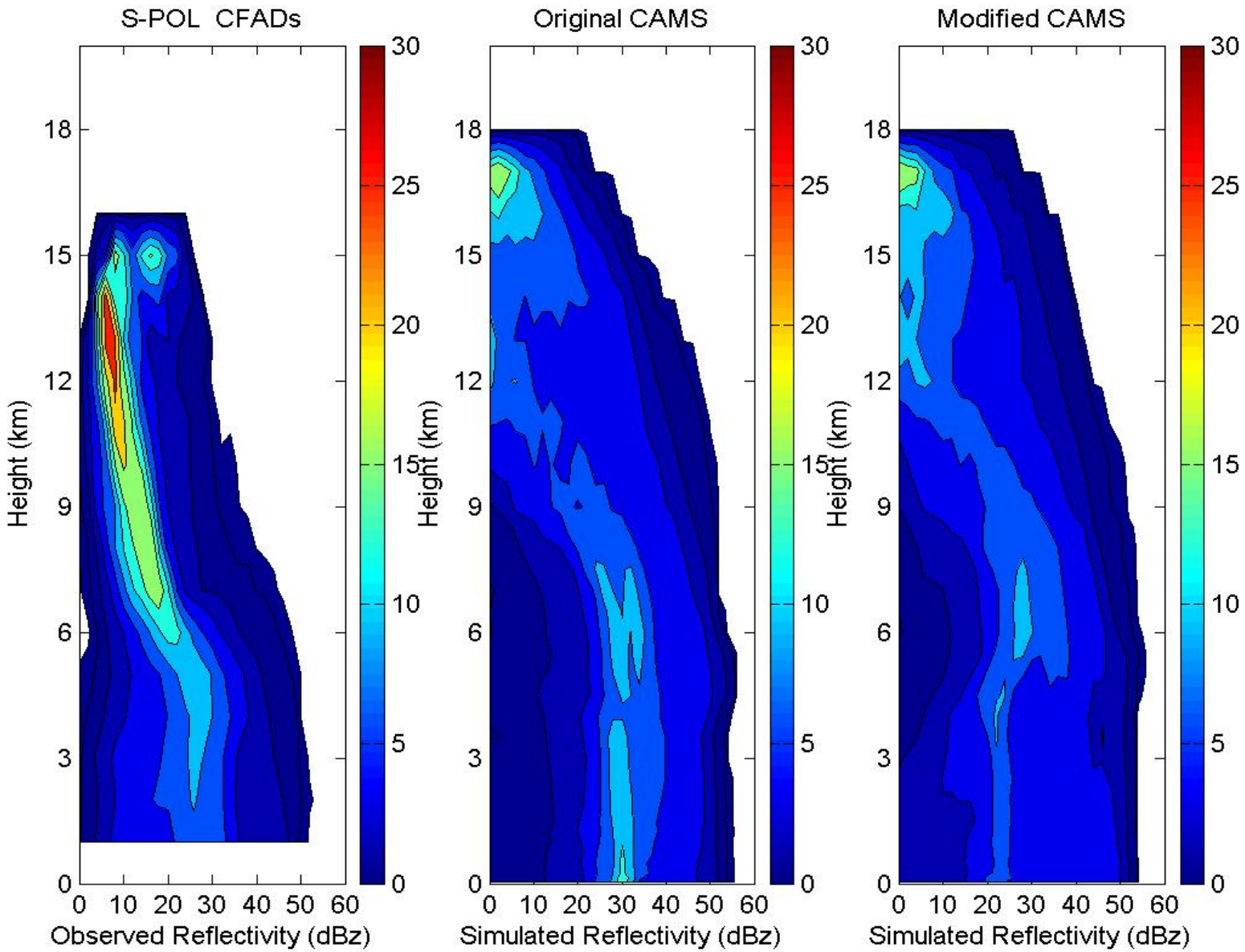
Simulated *Kdp* vs SPOL obs

$$K_{dp} \approx \frac{180}{\lambda} 10^{-3} c \cdot w \cdot (0.062 D_m) \quad Bringi\,(2001)$$

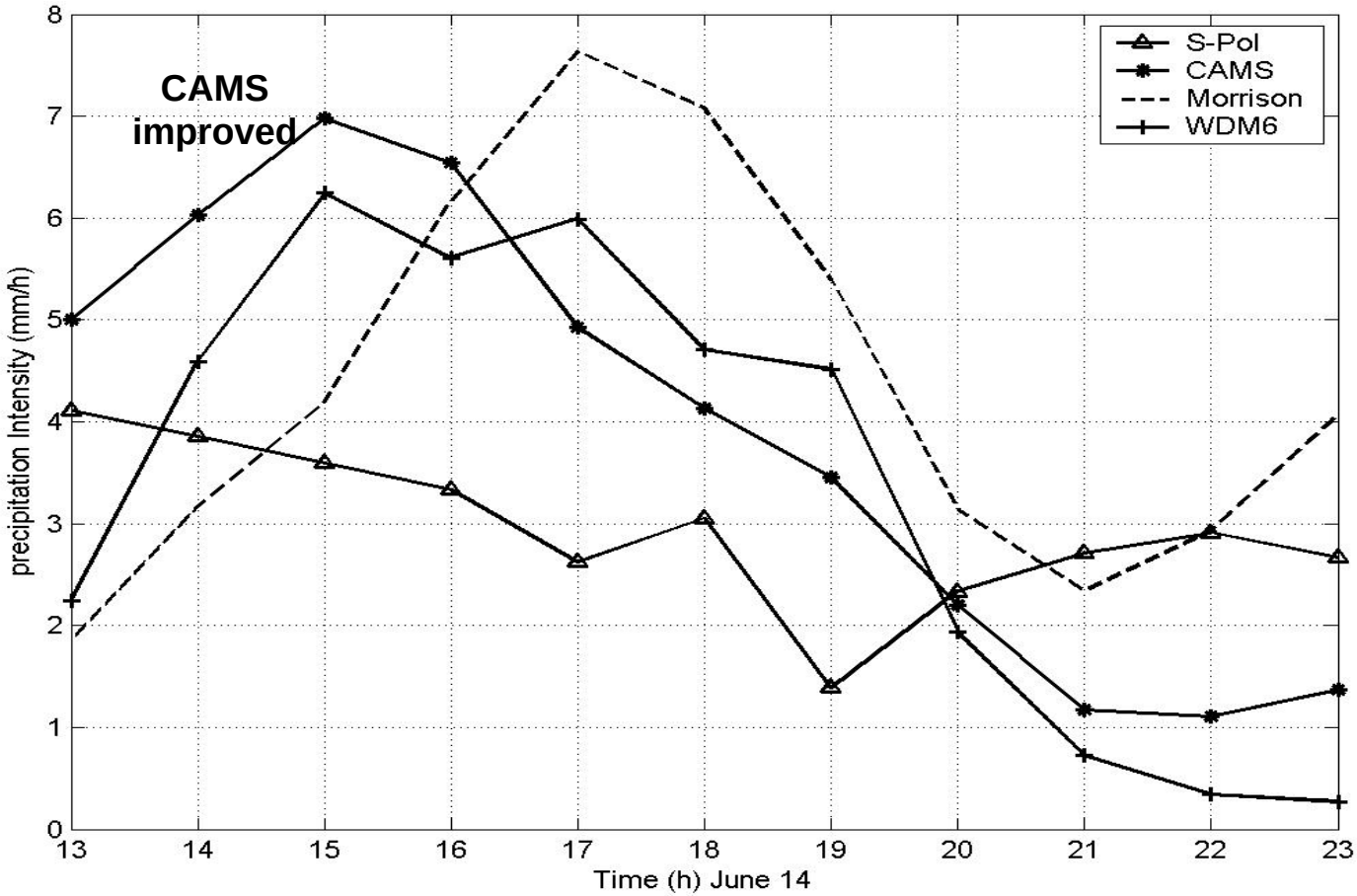




SPOL observed and CAMS simulated Zh, Zdr, Kdp at 2km height (0614 1500UTC)

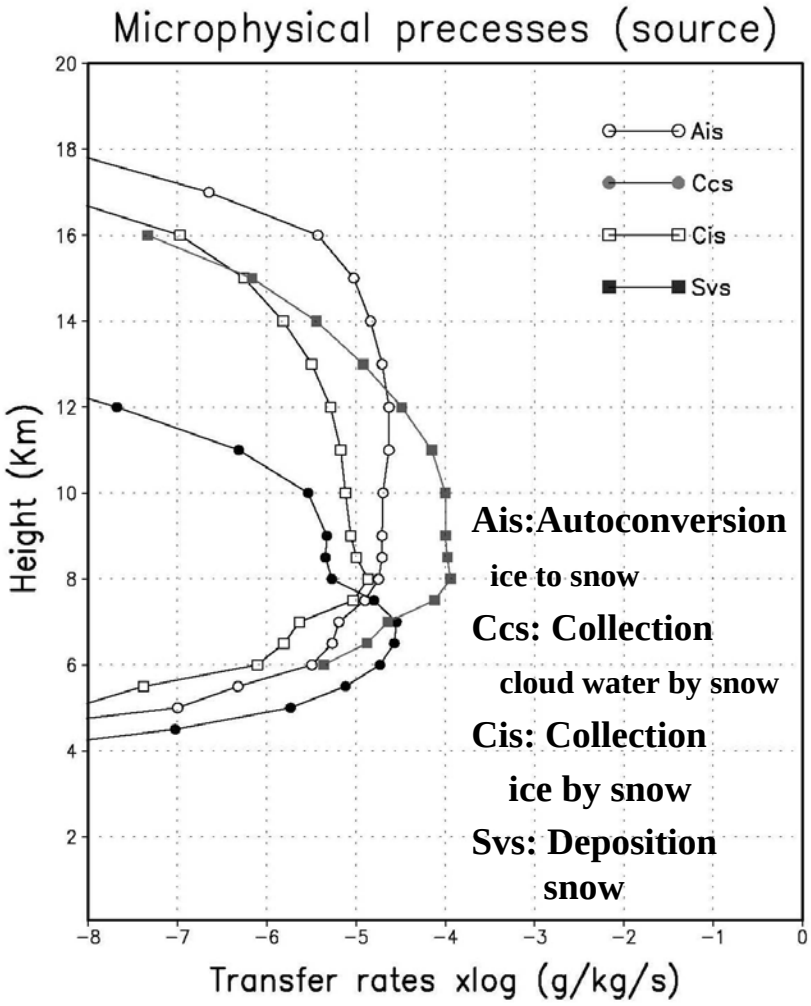


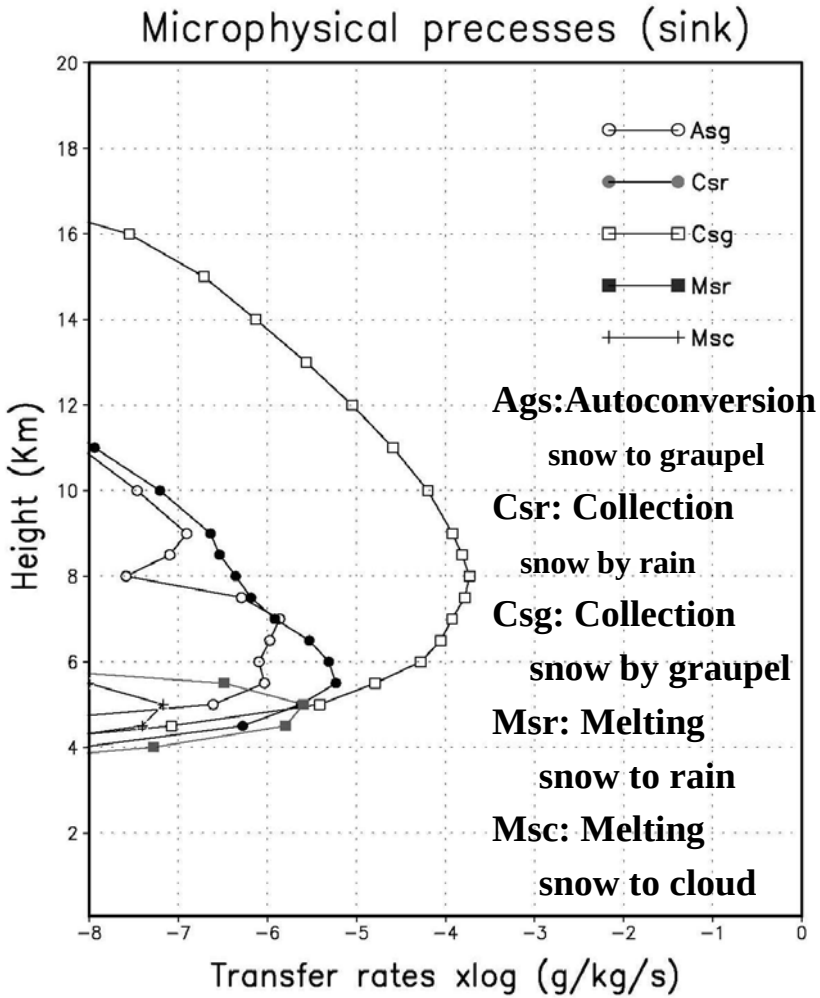
CFADs of SPOL observed and CAMS simulated reflectivity (0614 1500UTC)

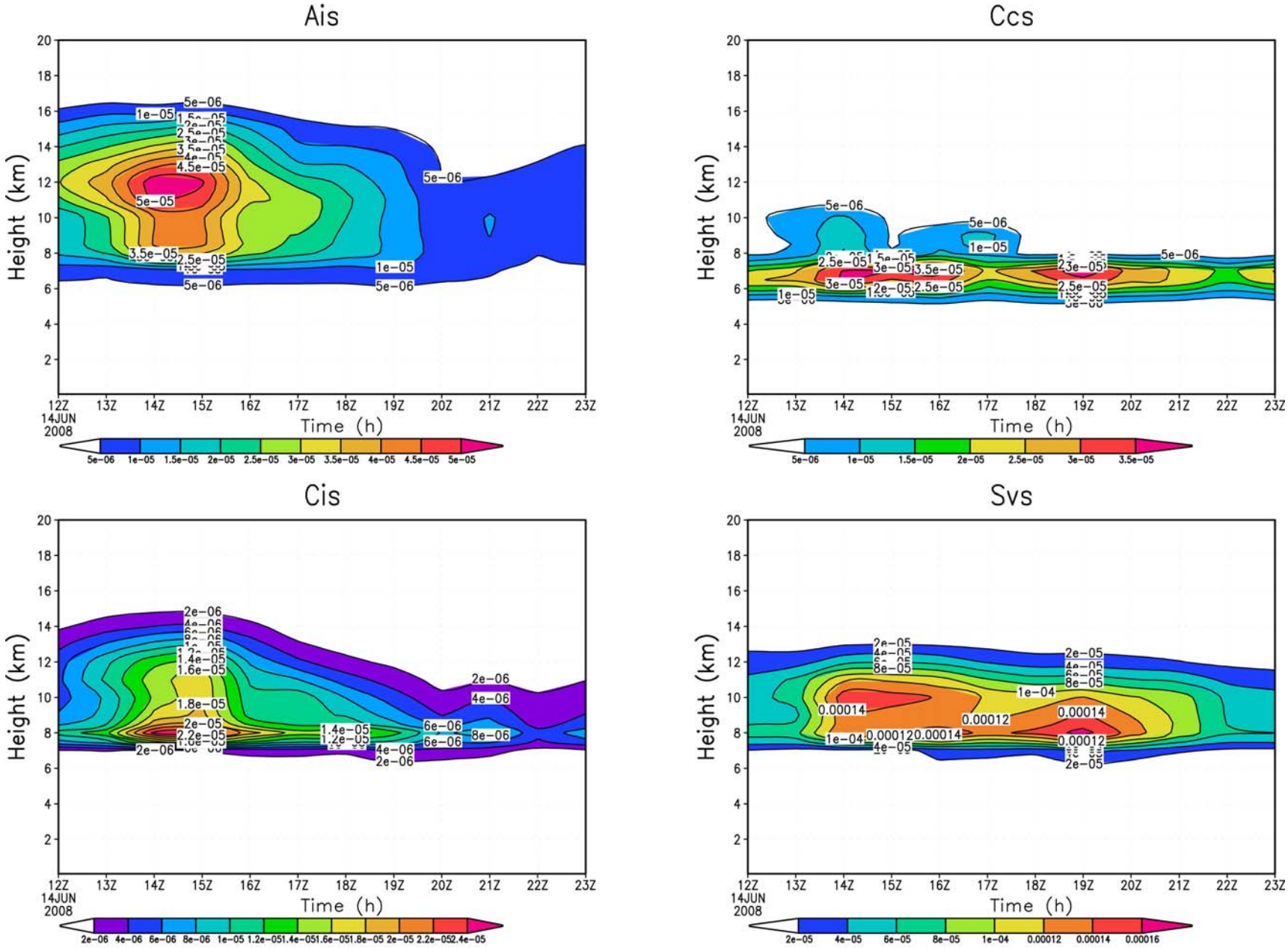


Time series of precipitation intensity

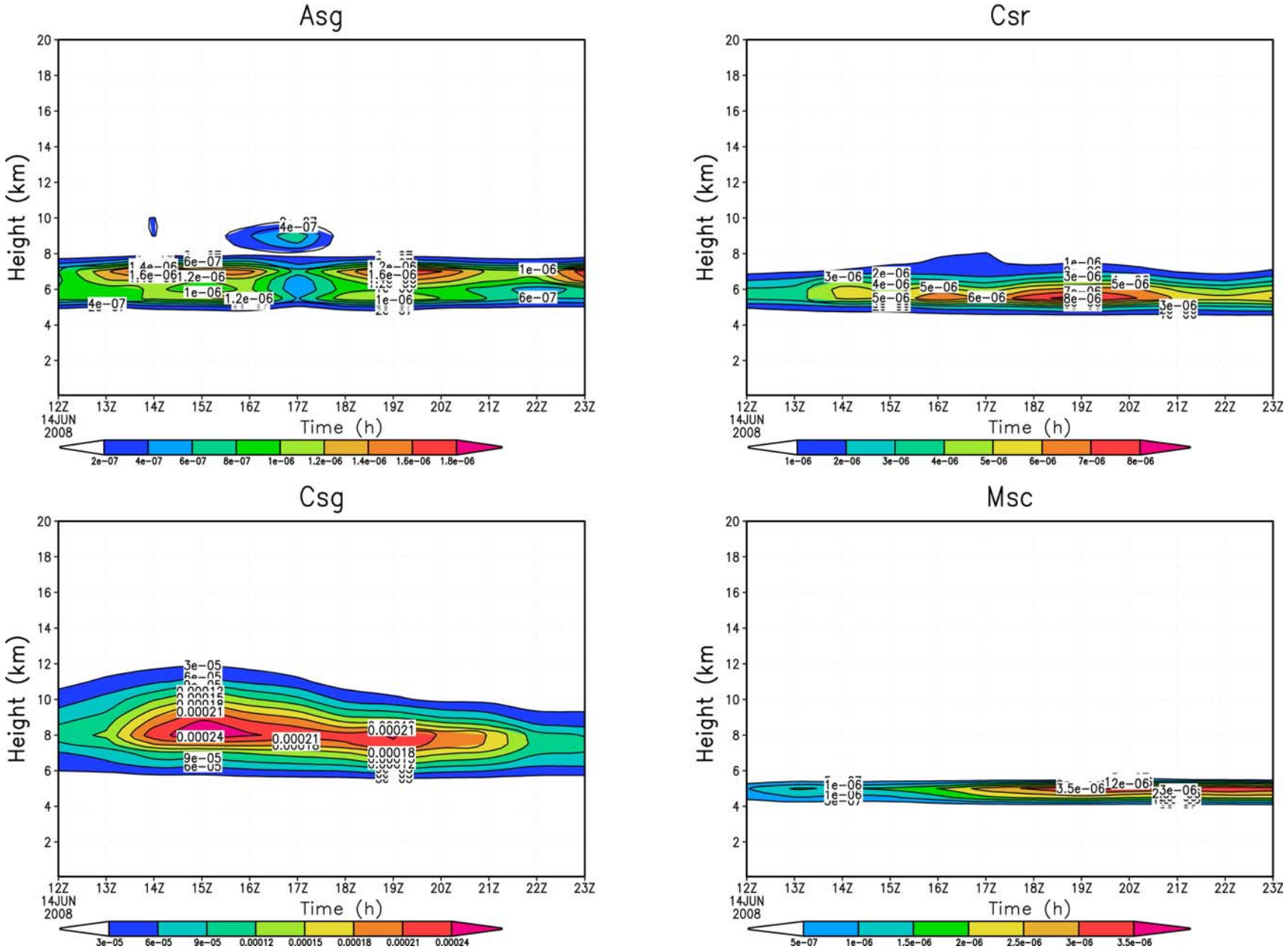
Profile of the time-space mean snow microphysics processes



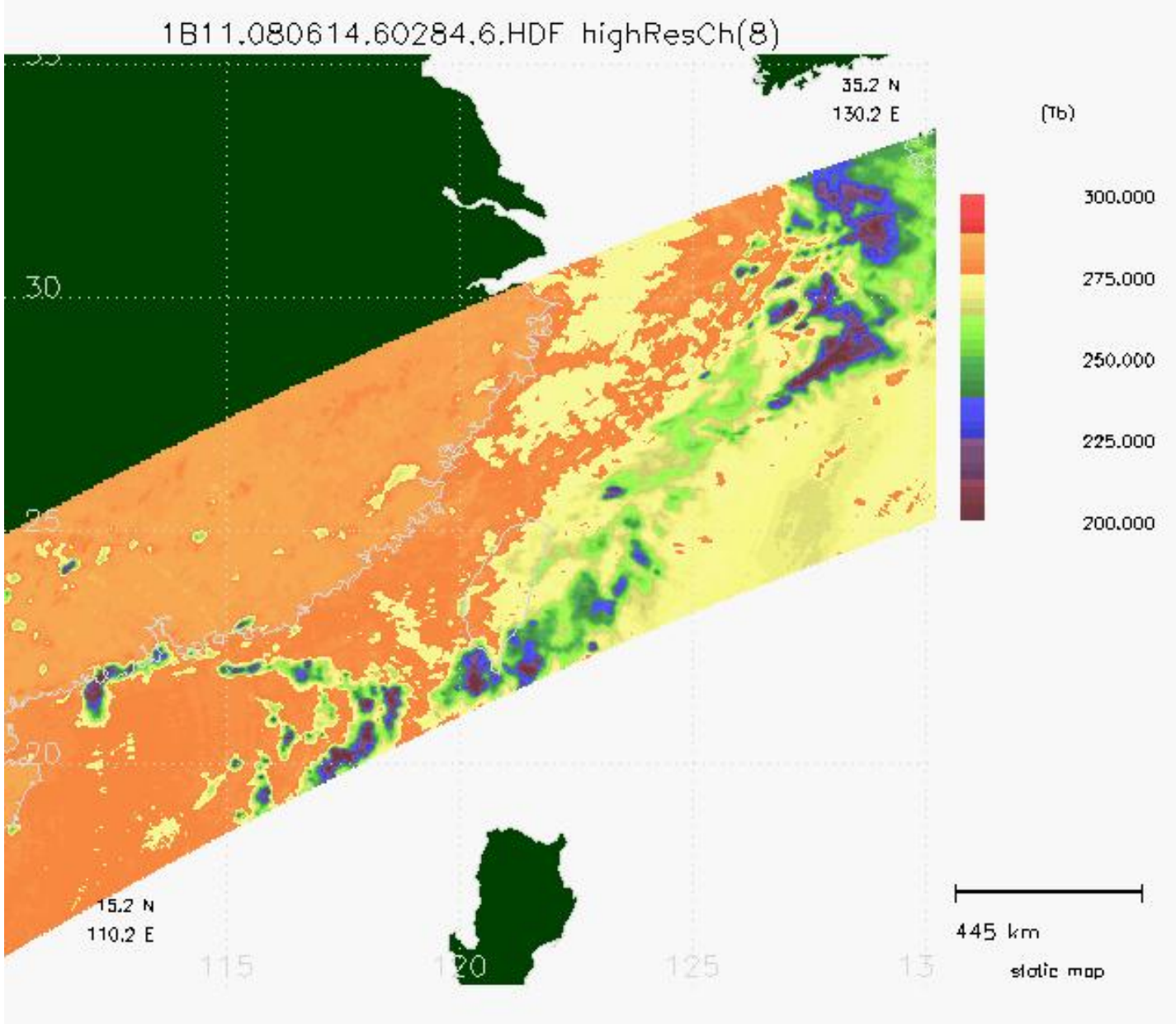




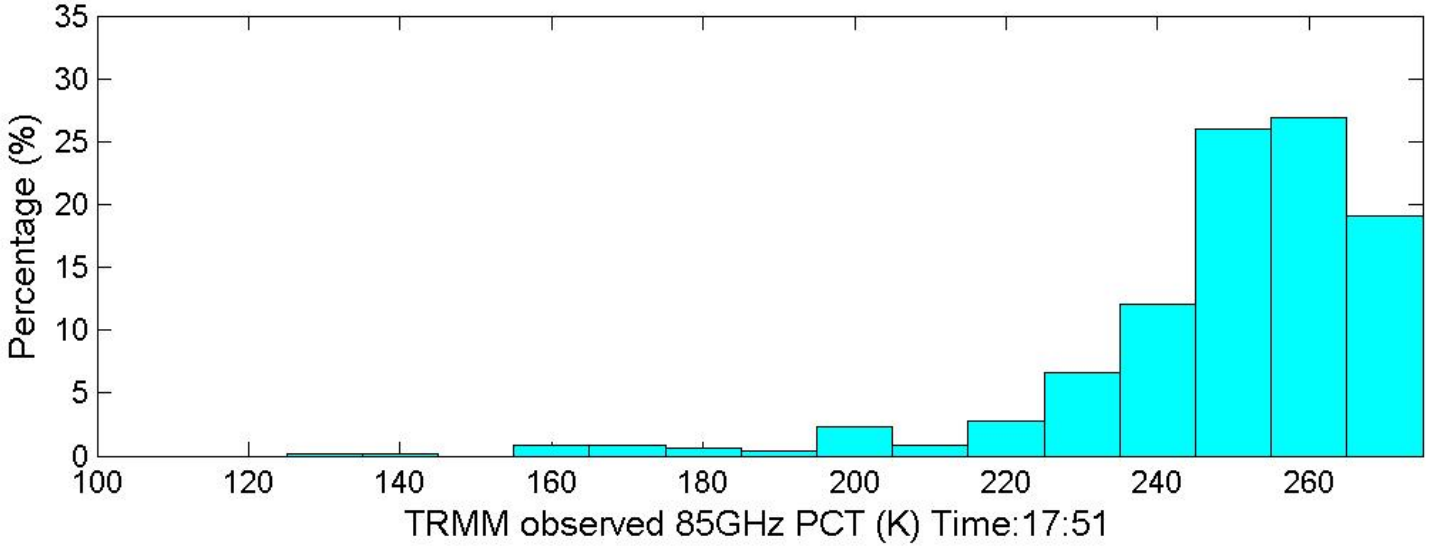
Evolvement of the snow microphysics processes (source)

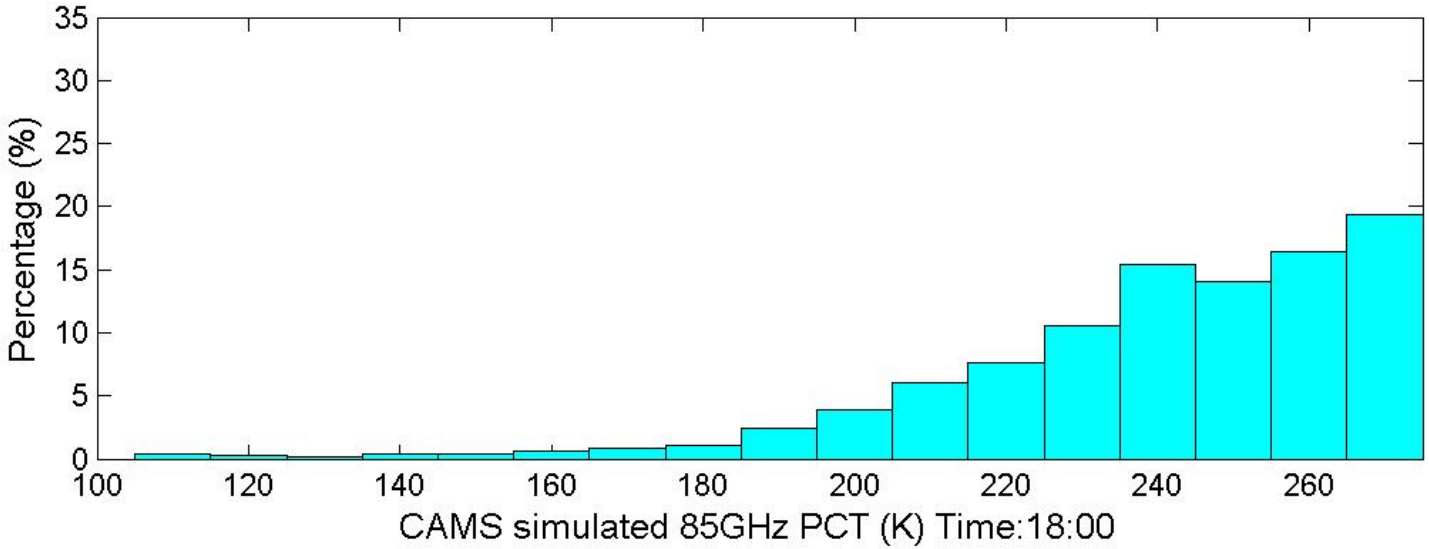


Evolvement of the snow microphysics processes (sink)



TRMM-TMI observed 85GHz Tb-vert (14 June 1751UTC)

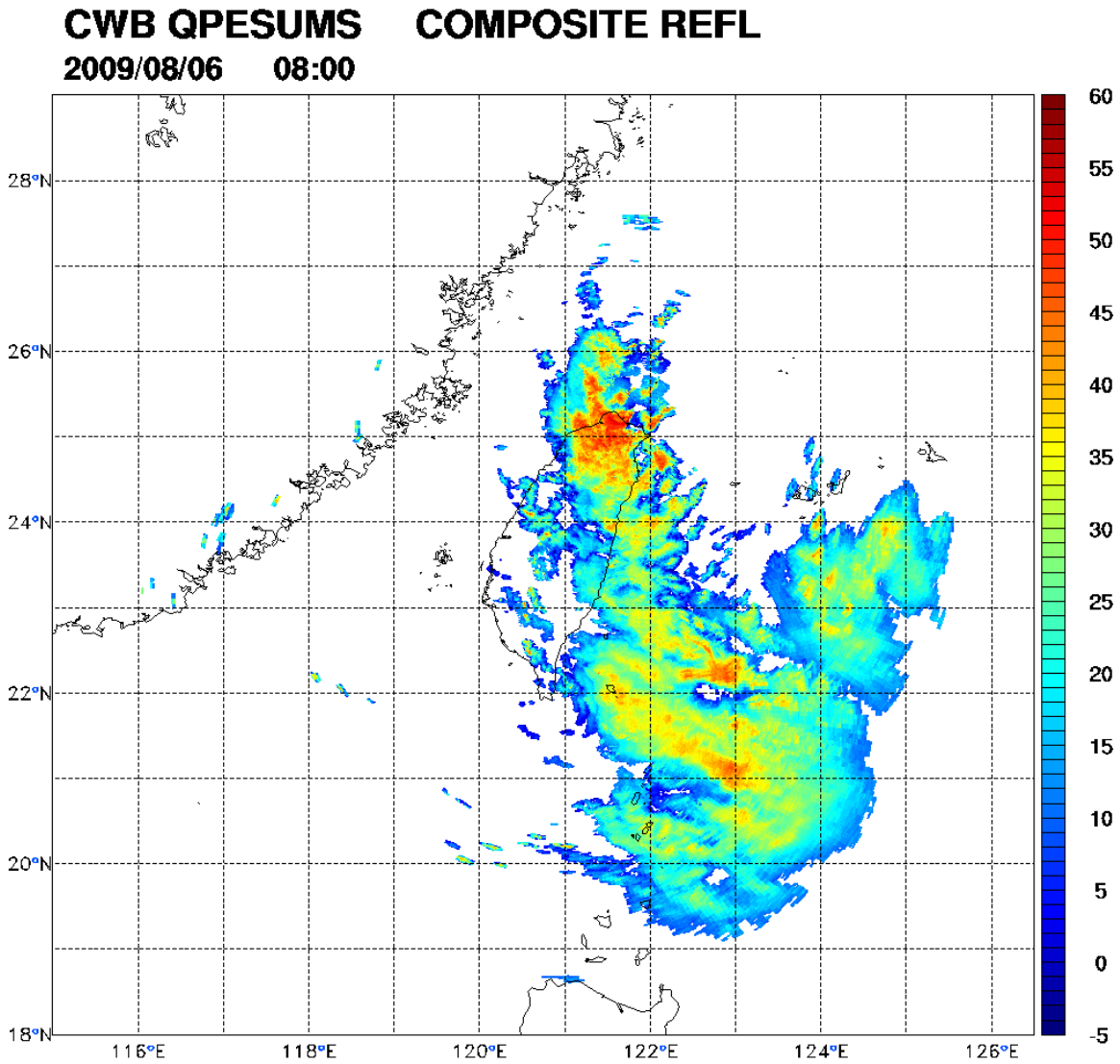




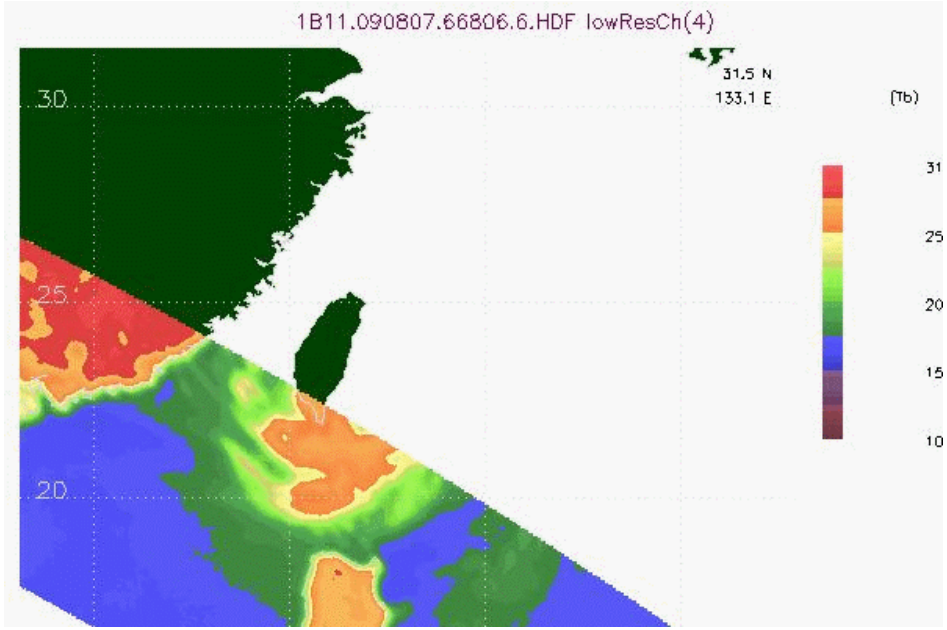
TRMM observed and CAMS Simulated 85GHz PCT PDF (14 June 1800UTC)

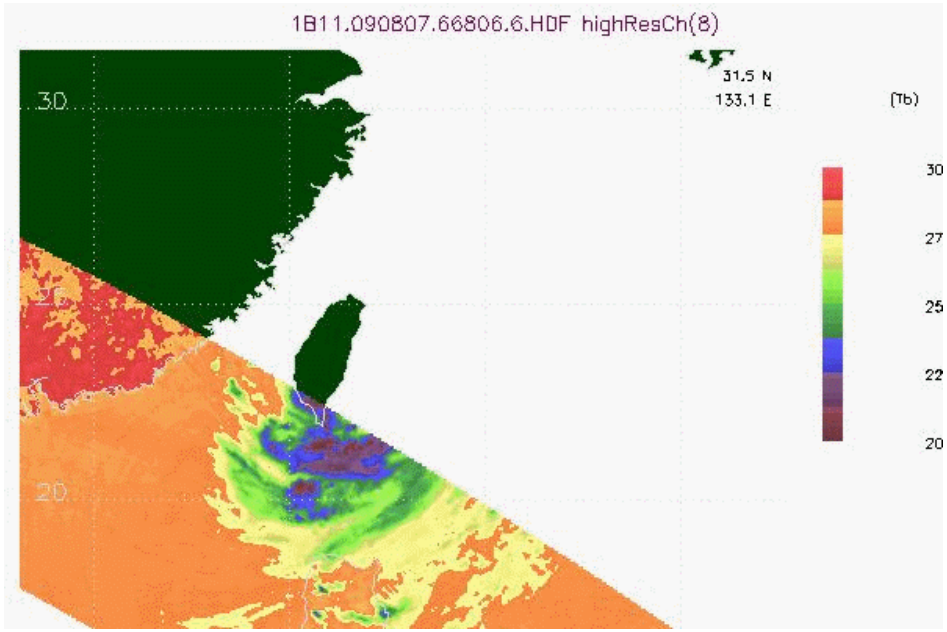
Typhoon Morakot 2009

Time: 7 Aug. 0000UTC to 8 Aug. 0000UTC



Ground-based radar observed reflectivity（dBz）

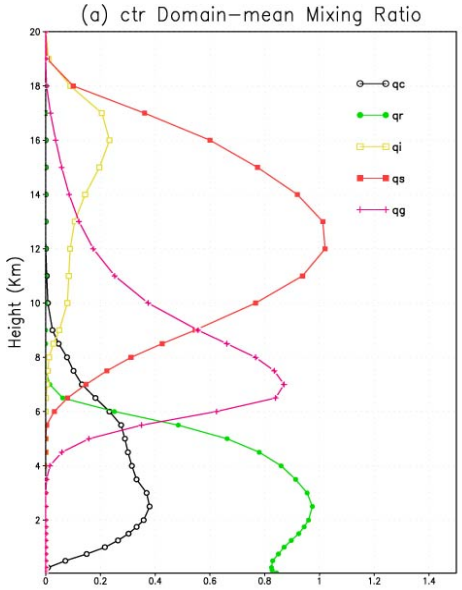


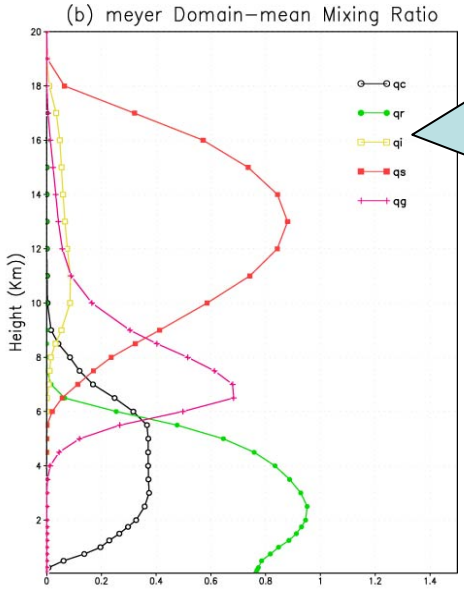


- TRMM-TMI observed 19-GHz (upper) and 85-GHz Tb (down)

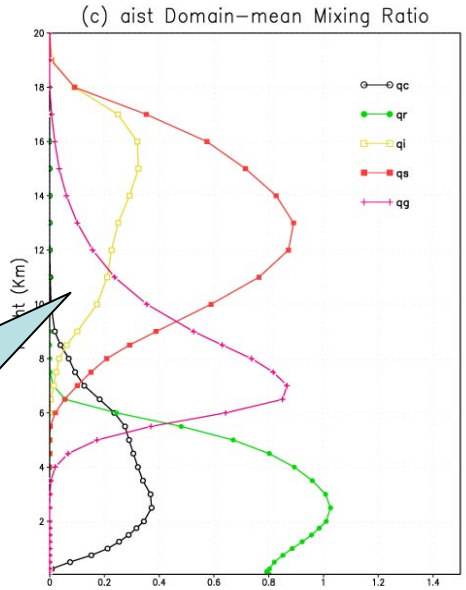
- Time（UTC）:
  2009 0807 05:08
  2009 0808 04:13
  2009 0808 20:45

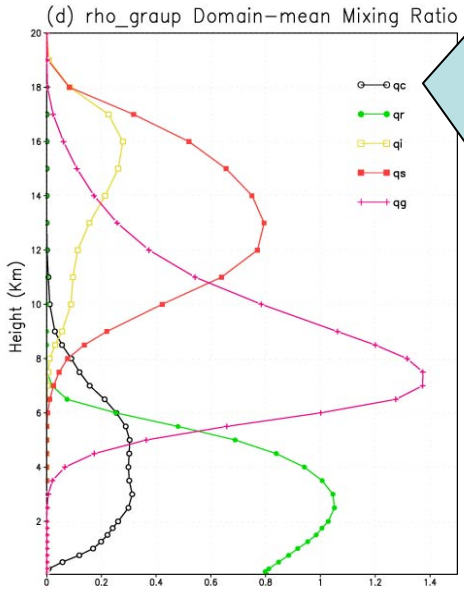
- Control experiment (a)
- Ice nucleation with Meyer (b)
- Double the time of autoconversion from ice to snow (c)
- Graupel density changed from 0.12 to 0.4 (d)





Ice content reduce evidently, snow and graupel contents reduce slightly



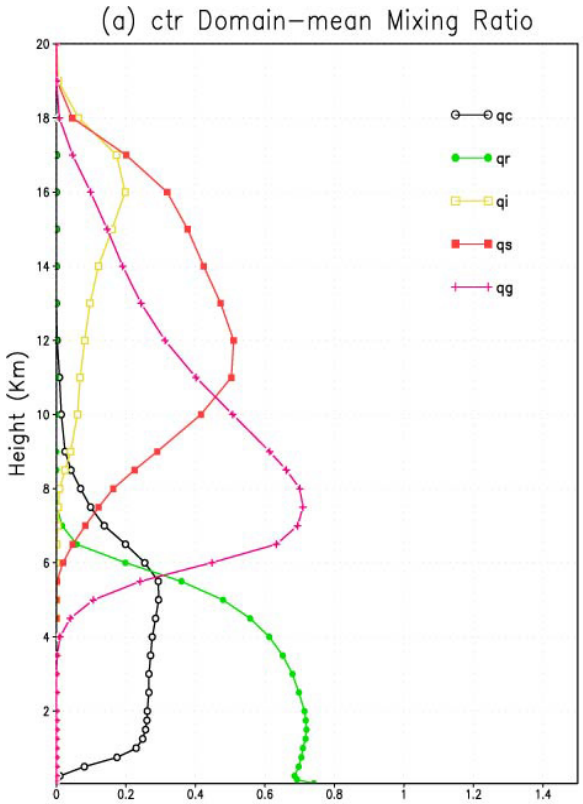


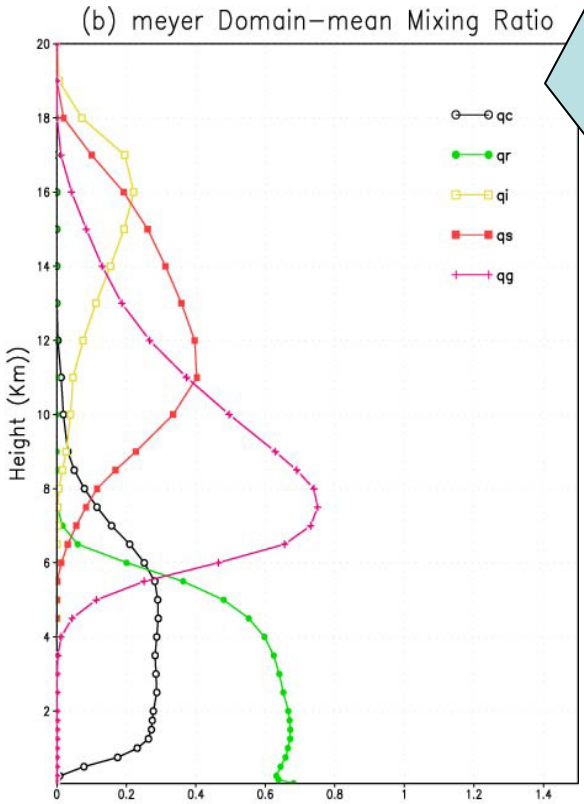
Graupel diameter reduce, terminal velocity reduce（accumulation）induce the graupel evidently increase

Ice increase, snow reduce a little

(22-23.5N,119-120.5E) area-averaged mixing ratios

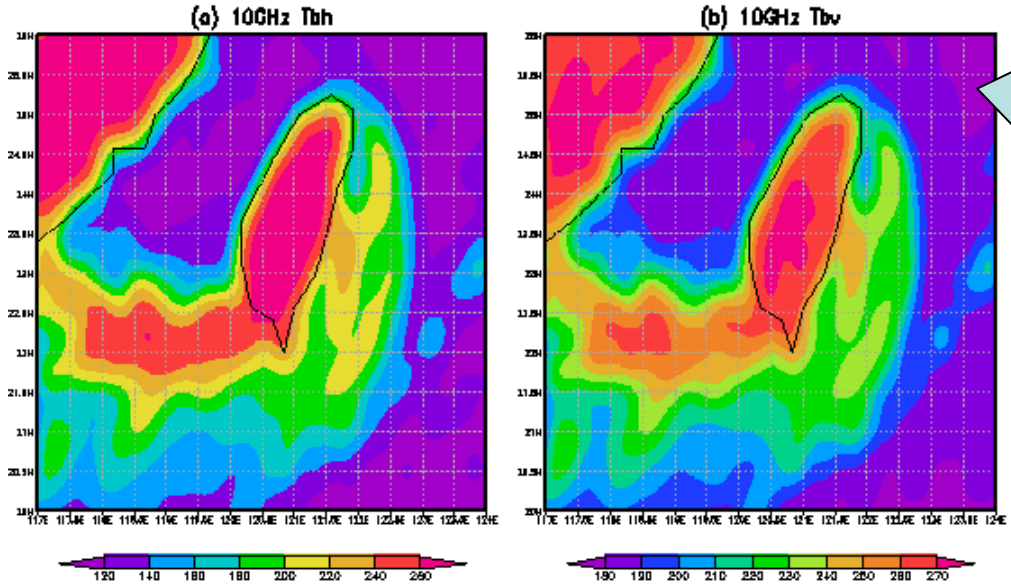
- Ice deposition（Svi）(1000/p)**0.8



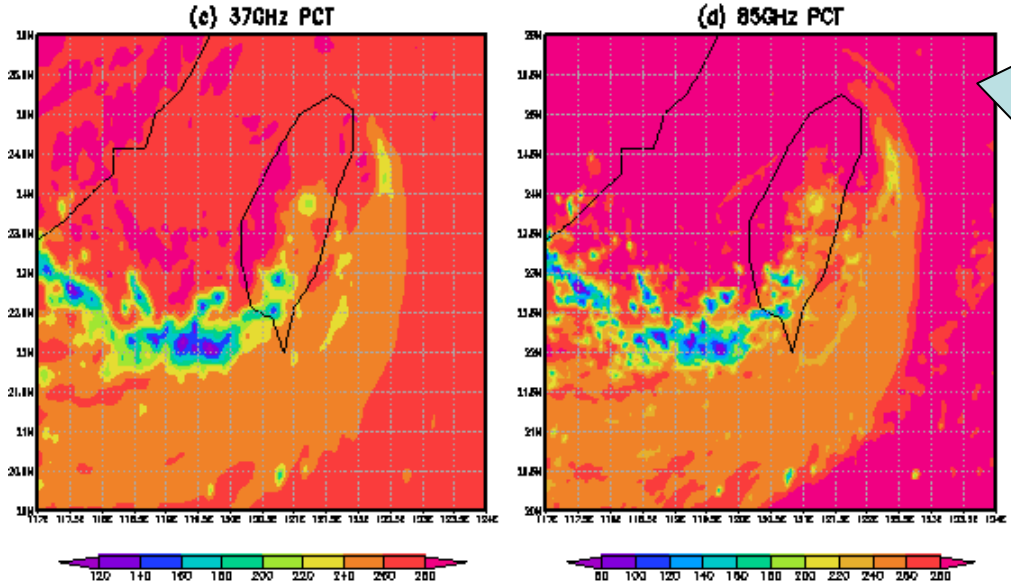


Ice deposition reduce ↓ →water vapor expend ↓ →supersaturation of ice ↑ →number of ice nucleation ↑ →ice content ↑（ice size smaller）→latent heating ↑ → supersaturation of ice ↓ →dynamic equilibrium, autoconversion slower → snow content reduce

(22-23.5N,119-120.5E) area-averaged mixing ratios （Time:0807 13h）



10GHz低频亮温主要受低层水相粒子吸收的影响，亮温高则表示液相水含量多



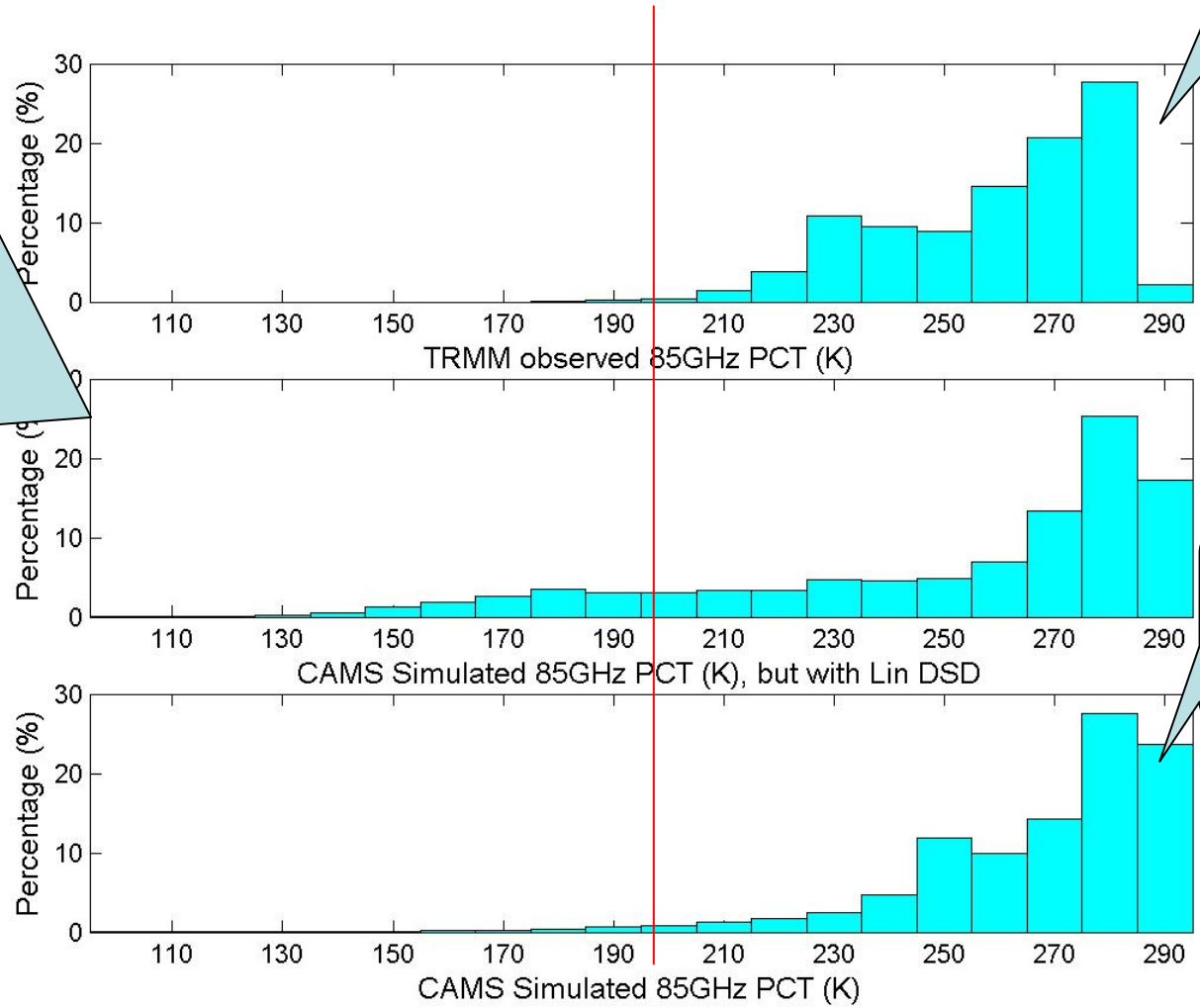
85GHz高频亮温主要受高层冰相粒子散射的影响，亮温低则表示冰相粒子含量多

CAMS simulated TRMM-TMI Tb（K）Time:0807 20h

单参数方案模拟值＜200K的出现频率偏高(模拟亮温偏低较多)，表示模拟的冰粒子散射偏强，这是多数单参数方案的缺点(没有粒子数浓度的预报)，在进行微波数据仿真时需注意

观测值＜200K的出现频率很低

CAMS模拟值＜200K的出现频率也较低



TRMM observed and CAMS simulated 85GHz PCT

（upper：TRMM，middle: CAMS but with one-moment input，lower：CAMS Time:0808 04h）

Conclusion

- This study first shows that simulated DSD of raindrop in two-moment microphysics cloud schemes are quite different from observations. Modifications are made to get better results based on the SPOL polarimetric radar observations.
- The CAMS scheme tends to overestimate radar reflectivity above the freezing level and underestimate microwave TB at ice-scattering frequency (85.5 GHz). Too much snow/graupel amounts are the most likely reason.

  Sensitivity experiments are performed (increasing the autoconversion time of cloud ice to snow; lowering the ice nucleation; lowering the depositional growth rate of ice) to reduce the precipitation ice contents.

Thanks a lot !

谢谢！