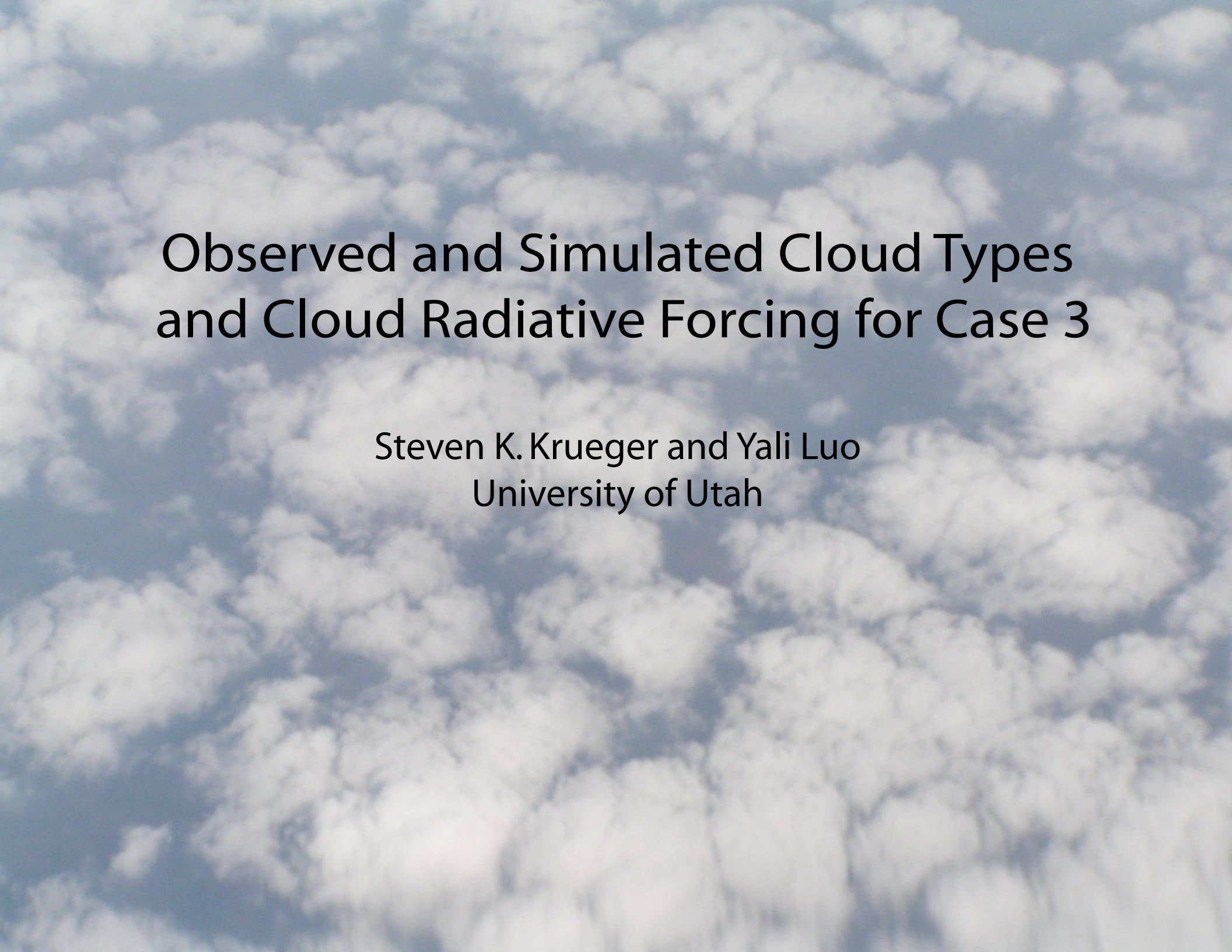


Observed and Simulated Cloud Types and Cloud Radiative Forcing for Case 3

Steven K. Krueger and Yali Luo
University of Utah

Points to make

- We should use more of the available cloud-scale observations to evaluate CRMs.
- Many retrievals take considerable effort to use.
- We need to evaluate and be aware of the uncertainties in the retrievals.

Improving CRM physics for use in SP

- What will be the mechanism in the framework of a STC?
  - Improvement of current model?
  - Replacement with another model?
- How will candidate CRMs or CRM parameterizations be evaluated?
  - In SCM mode?
  - In GCM mode?

Introduction

Goal: Evaluate clouds in models (CRM, SCM, GCM) in a way that dissects TOA CRF and cloud amount into cloud type contributions.

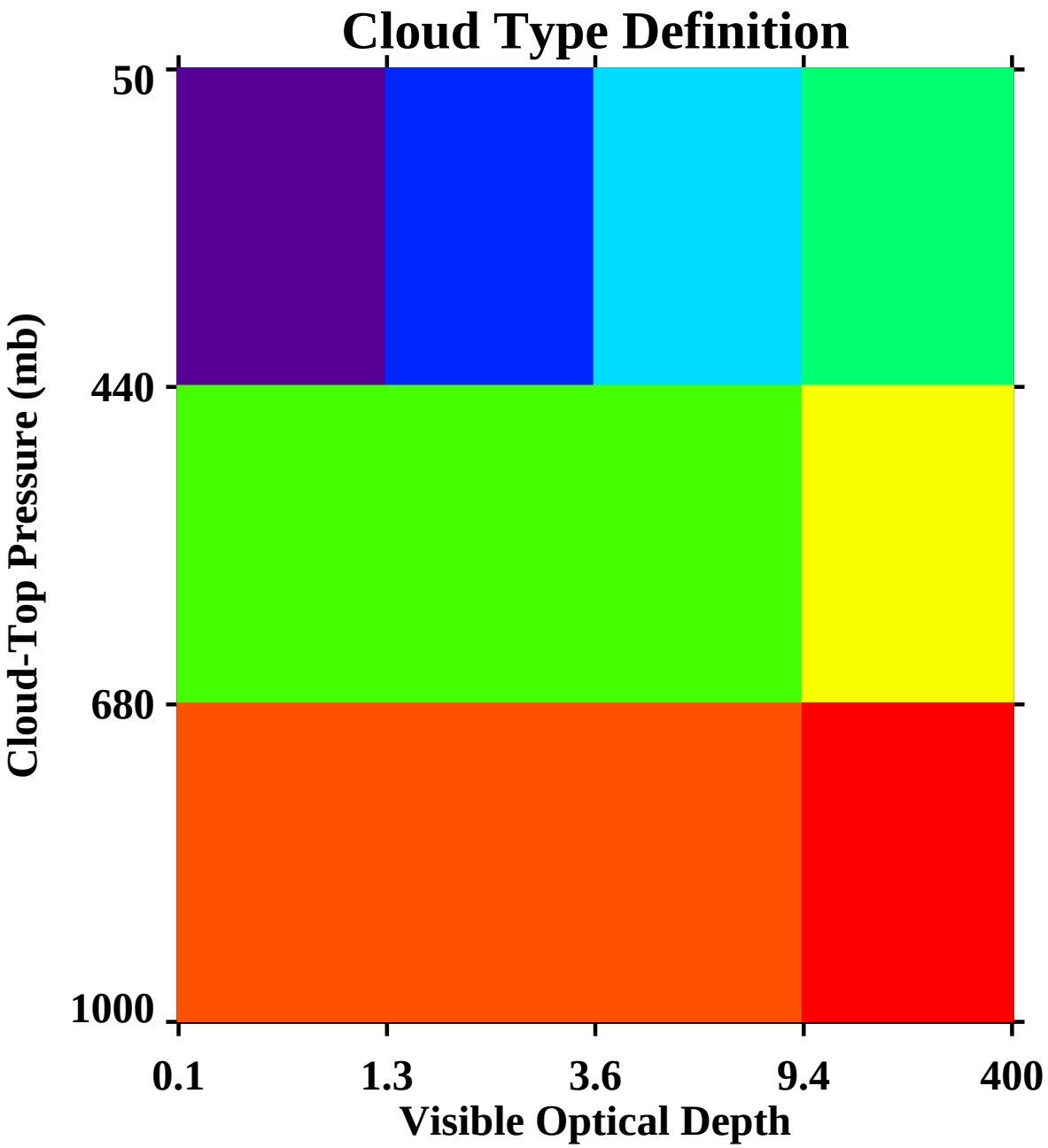
Motivation:

CRF and cloud amount alone do not give many clues about the causes of differences between models and observations.

ISCCP Cloud Types

- Each ISCCP cloud type produces essentially the same (overcast) CRF at a given location and time.

- CRF $= \sum_{i=1}^{n} (\text{CRF})_i (\text{cld amt})_i$


Cloud Type Definition
50
440
680
1000
Cloud-Top Pressure (mb)
0.1
1.3
3.6
9.4
400
Visible Optical Depth

Case 3

- Case 3: SGP summer 1997 SCM IOP:

- Dominated by deep convection and cirrus; also shallow cumulus.

Minnis Cloud Products

- Pixel-level retrievals over CART; half-hourly: 15,000 pixels/hr
- Broadband LW flux and SW albedo.
- Optical depth and cloud top temperature (pressure).
- day: VISST
- night: SIRS

MMCR

- At Central Facility: 100 pixels/hr

- Measurements: Highest echo heights

UCLA/CSU Cloud-System Resolving Model

- 512 km domain; sampled every 5 minutes every 2 km: 3000 pixels/hr

- Fu-Liou RT code.

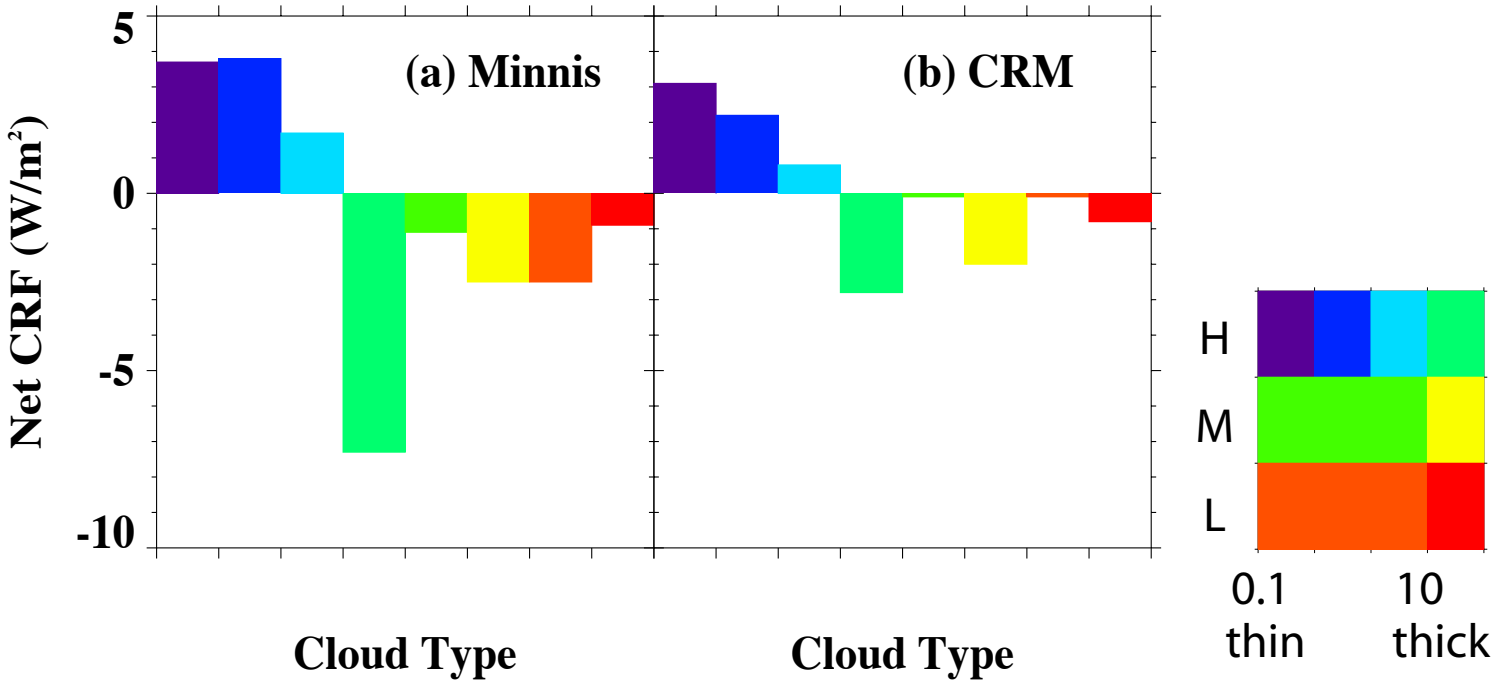
- ISCCP cloud typer program (M. Webb and S. Klein)

Cloud Radiative Forcing

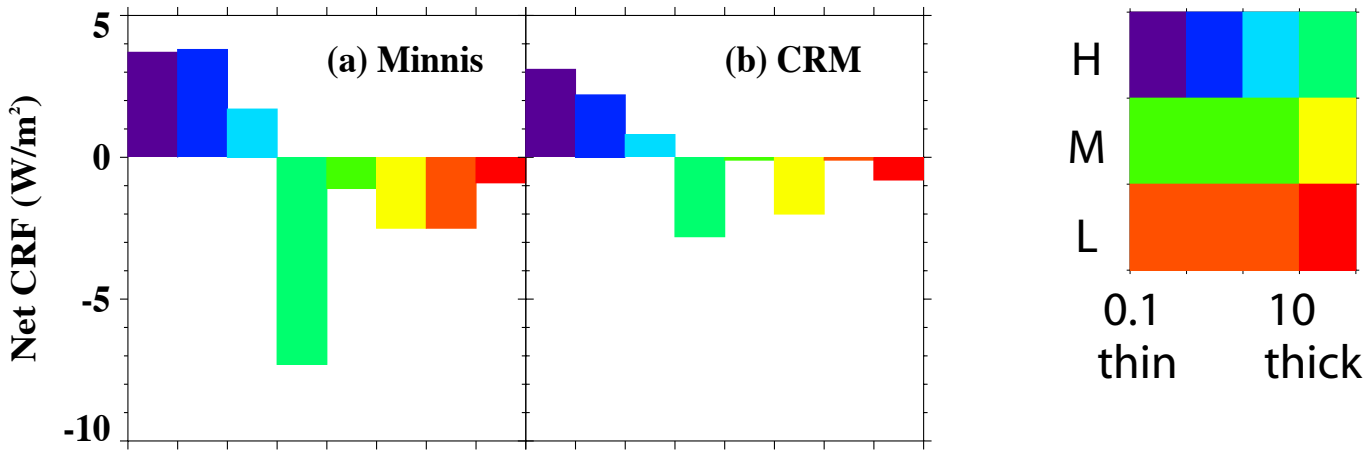
(W m^{-2})

	LW CRF	SW CRF	Net CRF
Minnis	38	-44	-6
CRM	29	-29	0

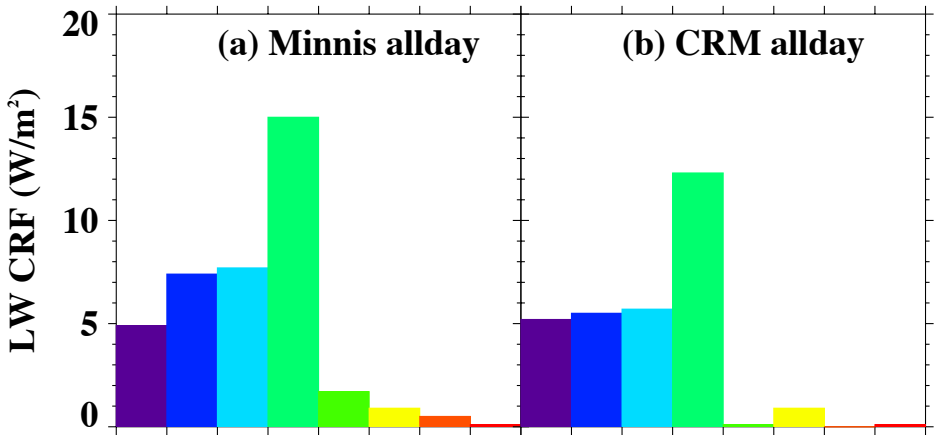
Net CRF

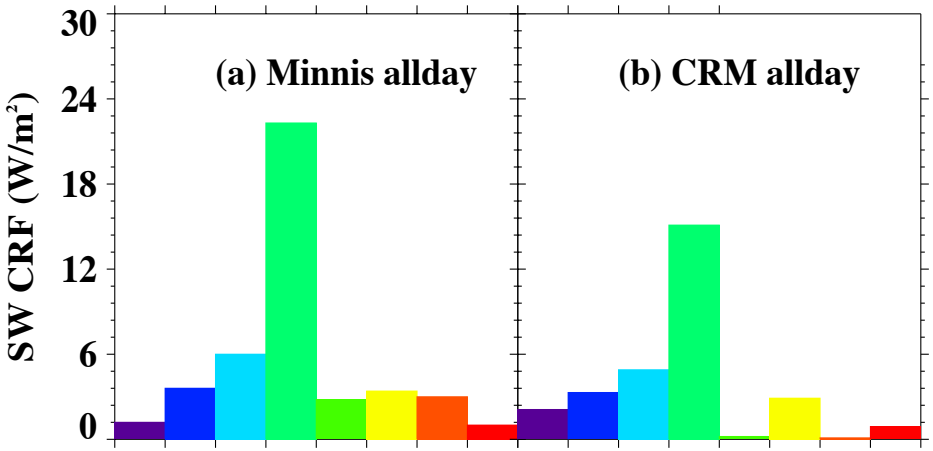

(a) Minnis
(b) CRM
Net CRF (W/m²)
5
0
-5
-10
Cloud Type
Cloud Type
H
M
L
0.1
thin
10
thick

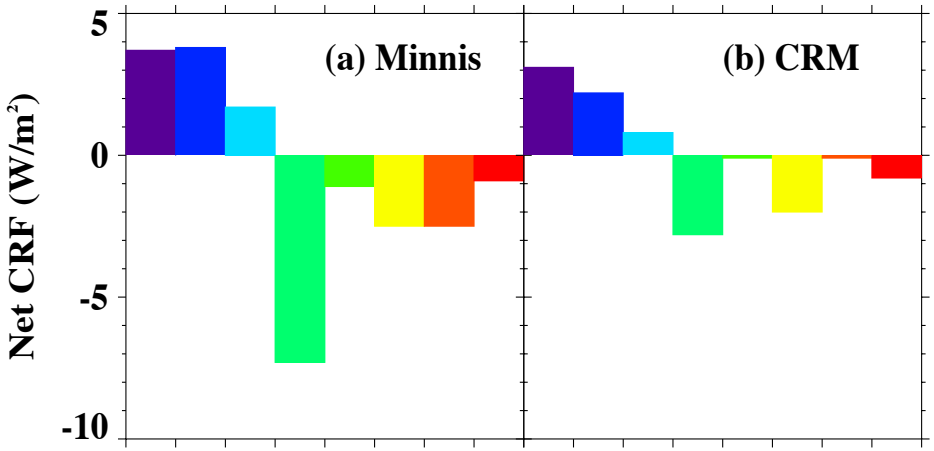
Net CRF = LW CRF - SW CRF

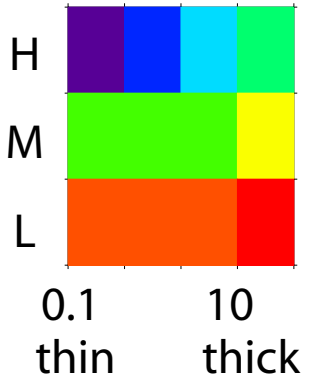


Net CRF = LW CRF - SW CRF

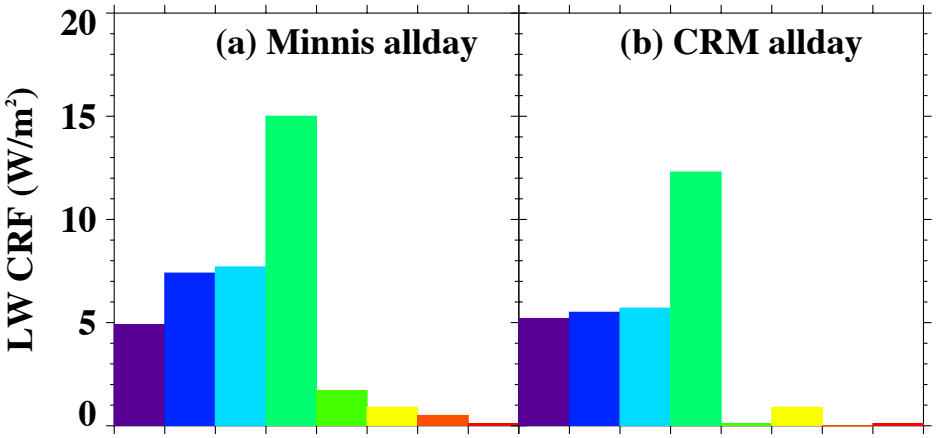


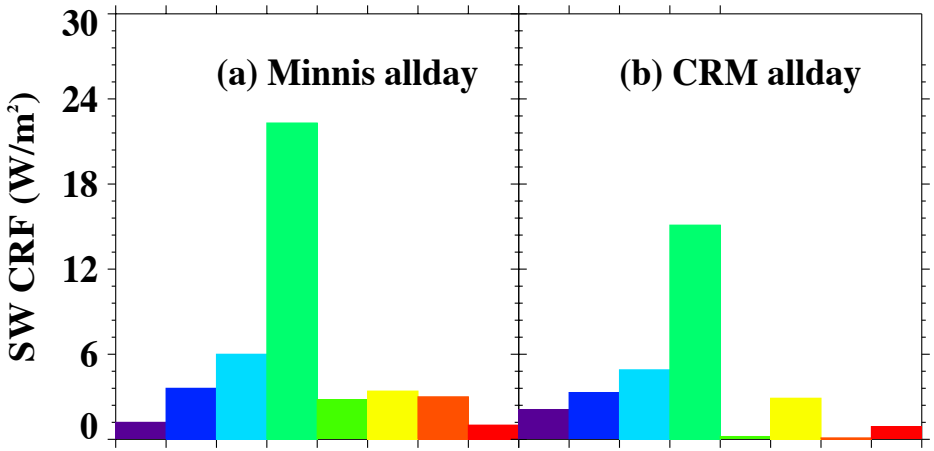




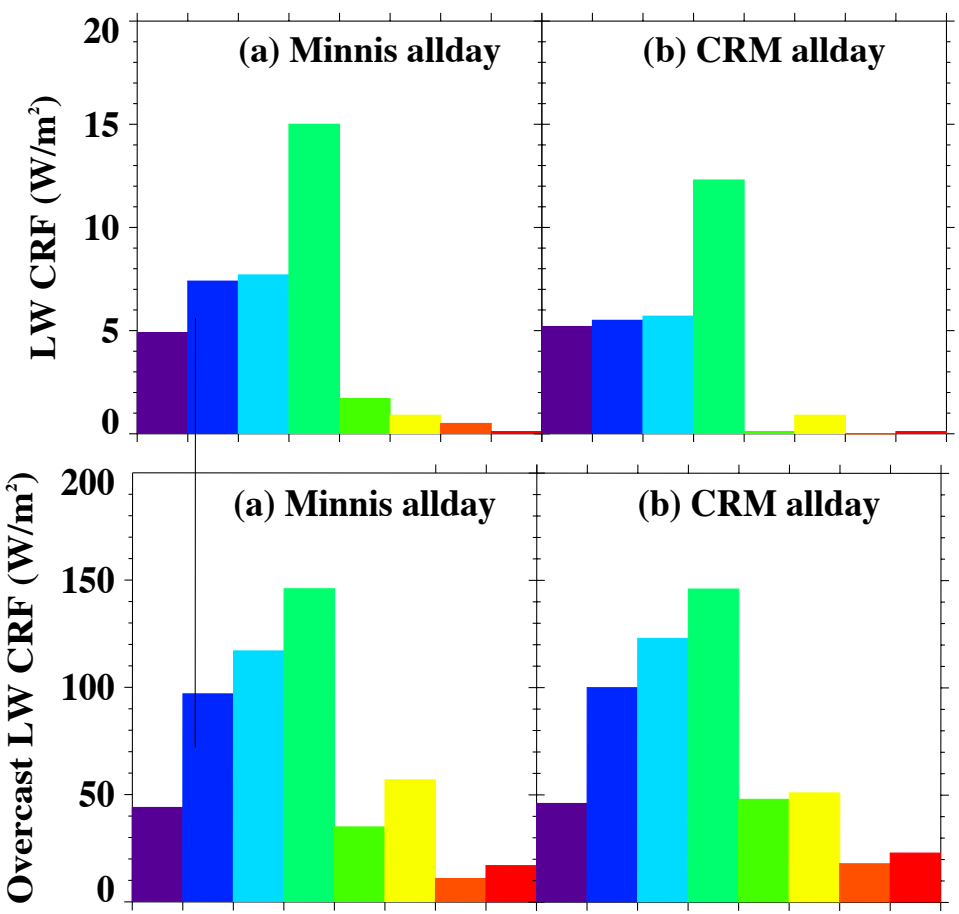


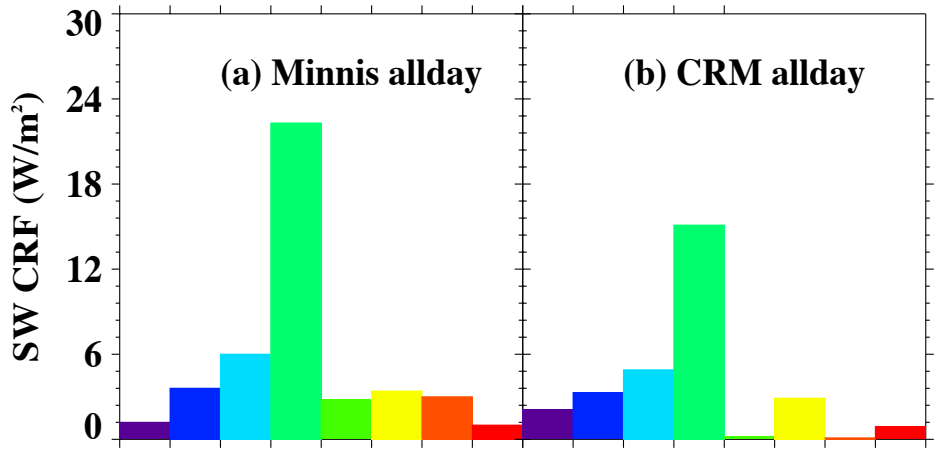
CRF(i) = CRF_{ovc}(i) x Cloud Amount(i)

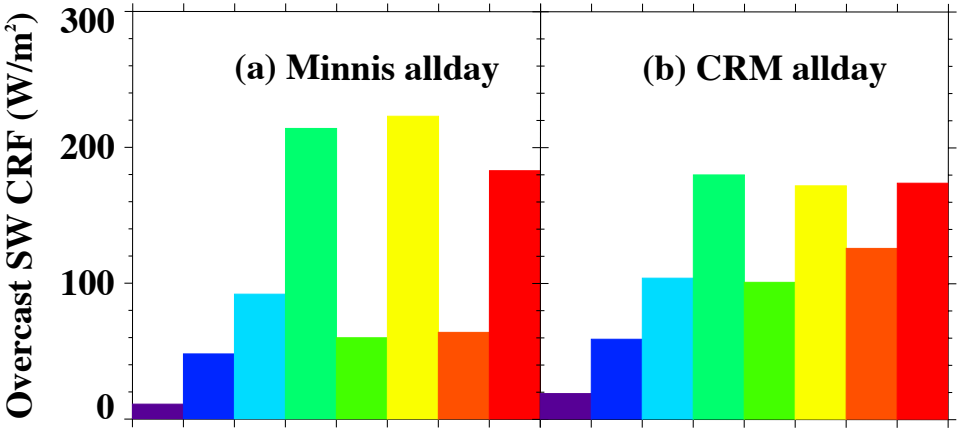




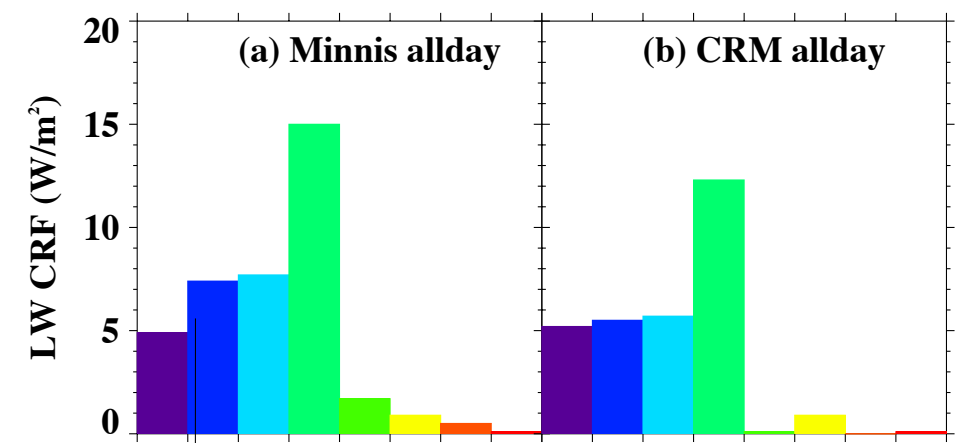
CRF(i) = CRF_{ovc}(i) x Cloud Amount(i)

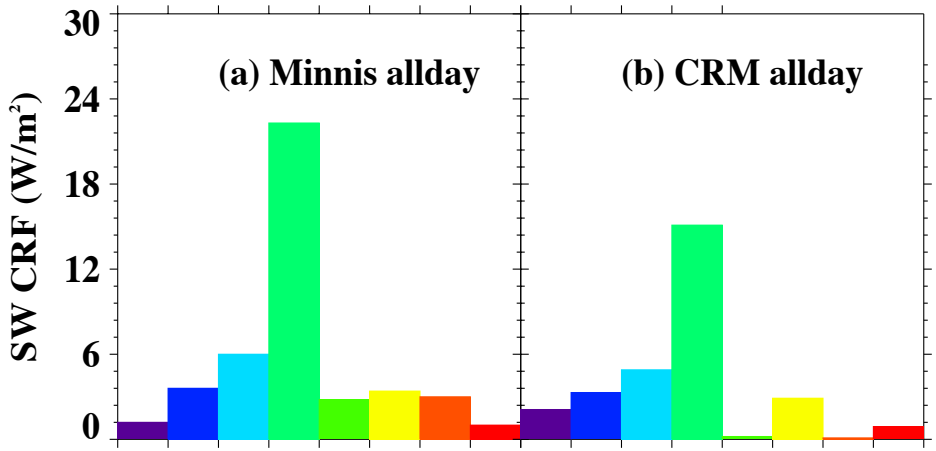


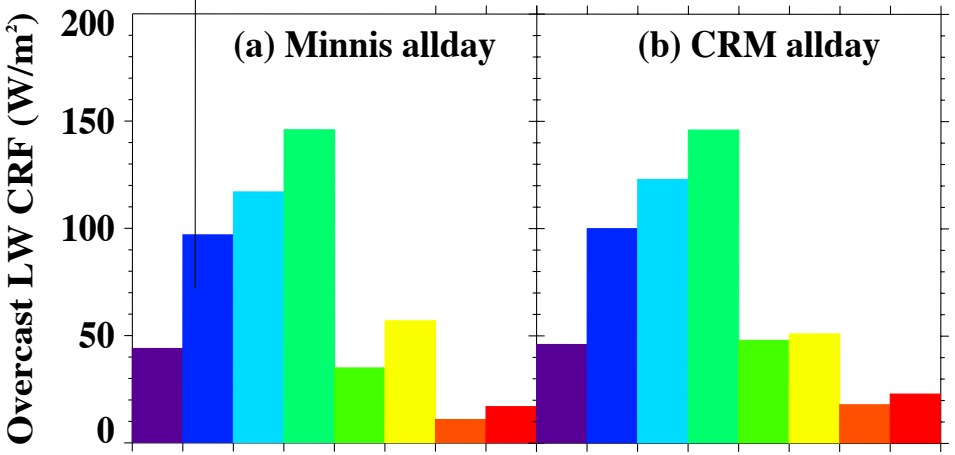


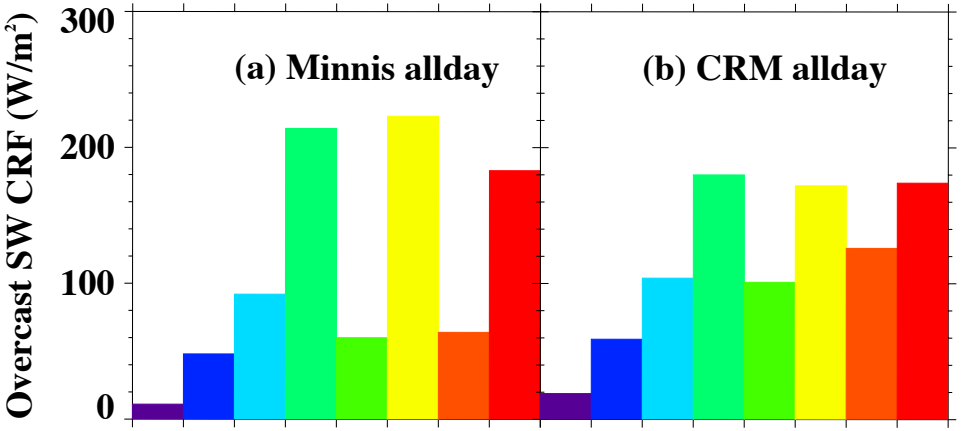


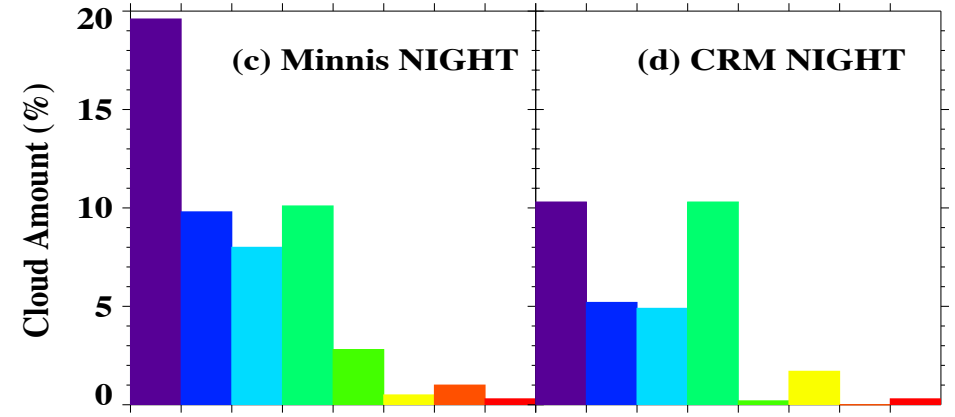
CRF(i) = CRF_{ovc}(i) x Cloud Amount(i)

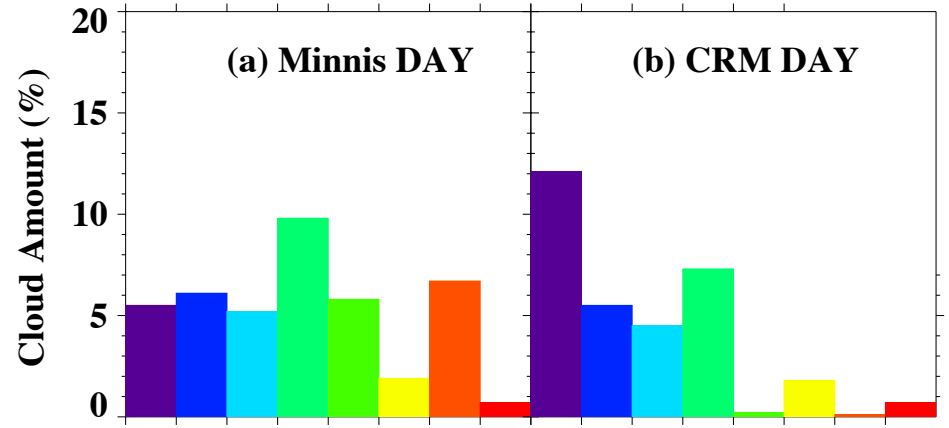


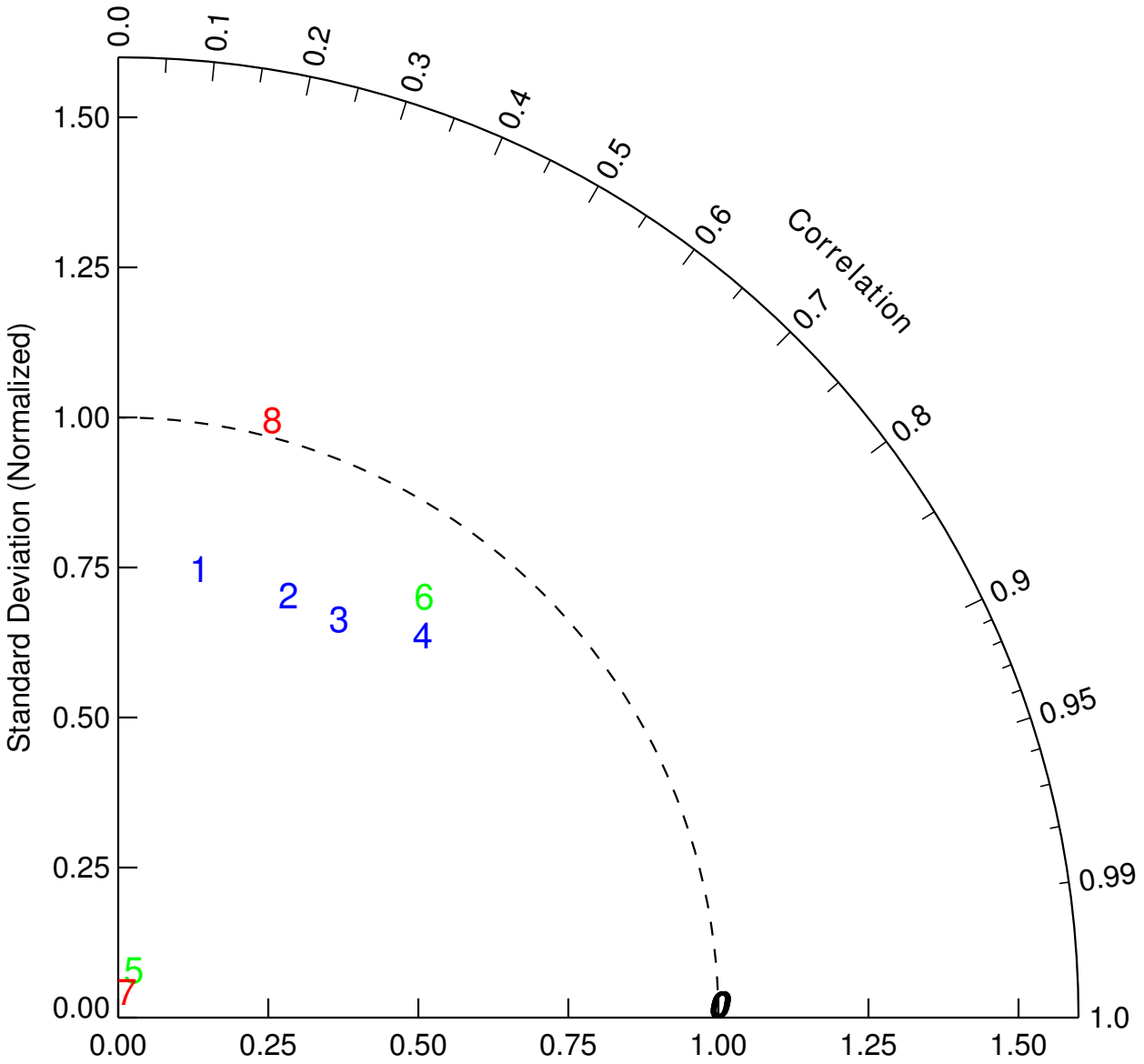




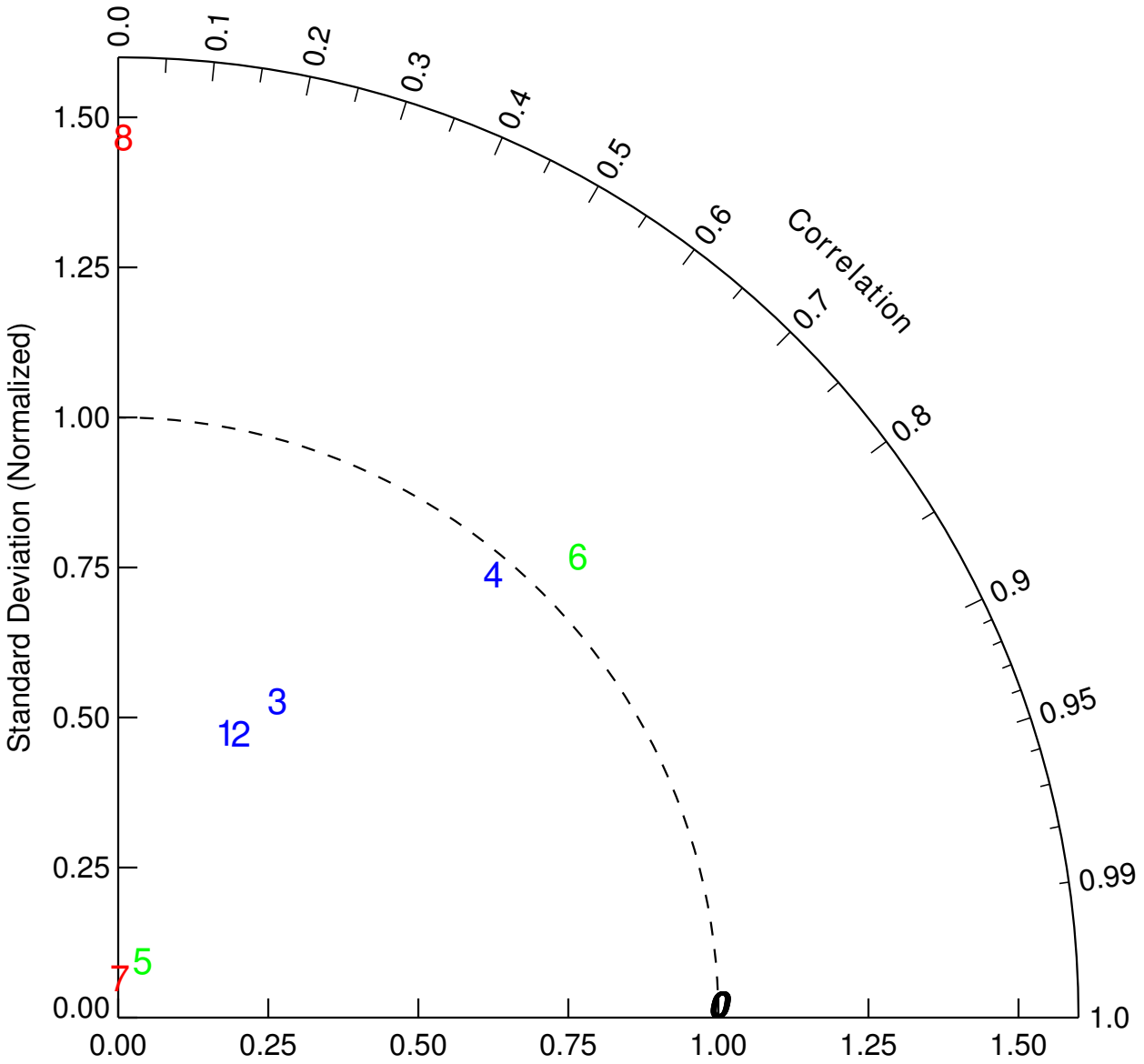




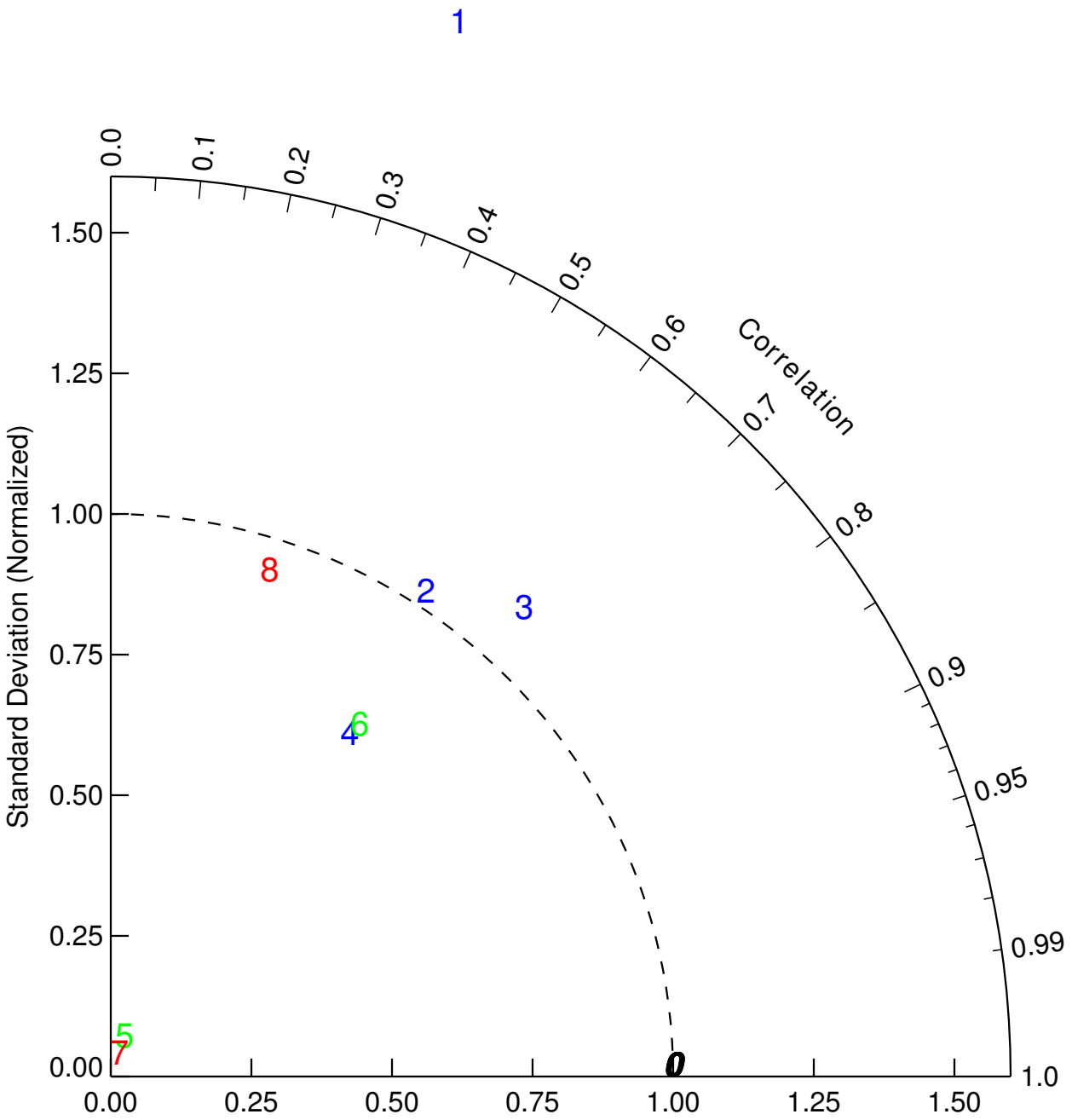




Case 3 (SCM Summer 1997 IOP): ABC Cloud Types Amount



Case 3 (SCM Summer 1997 IOP): ABC Cloud Types Amount



Case 3 (SCM Summer 1997 IOP): ABC Cloud Types Amount

Summary

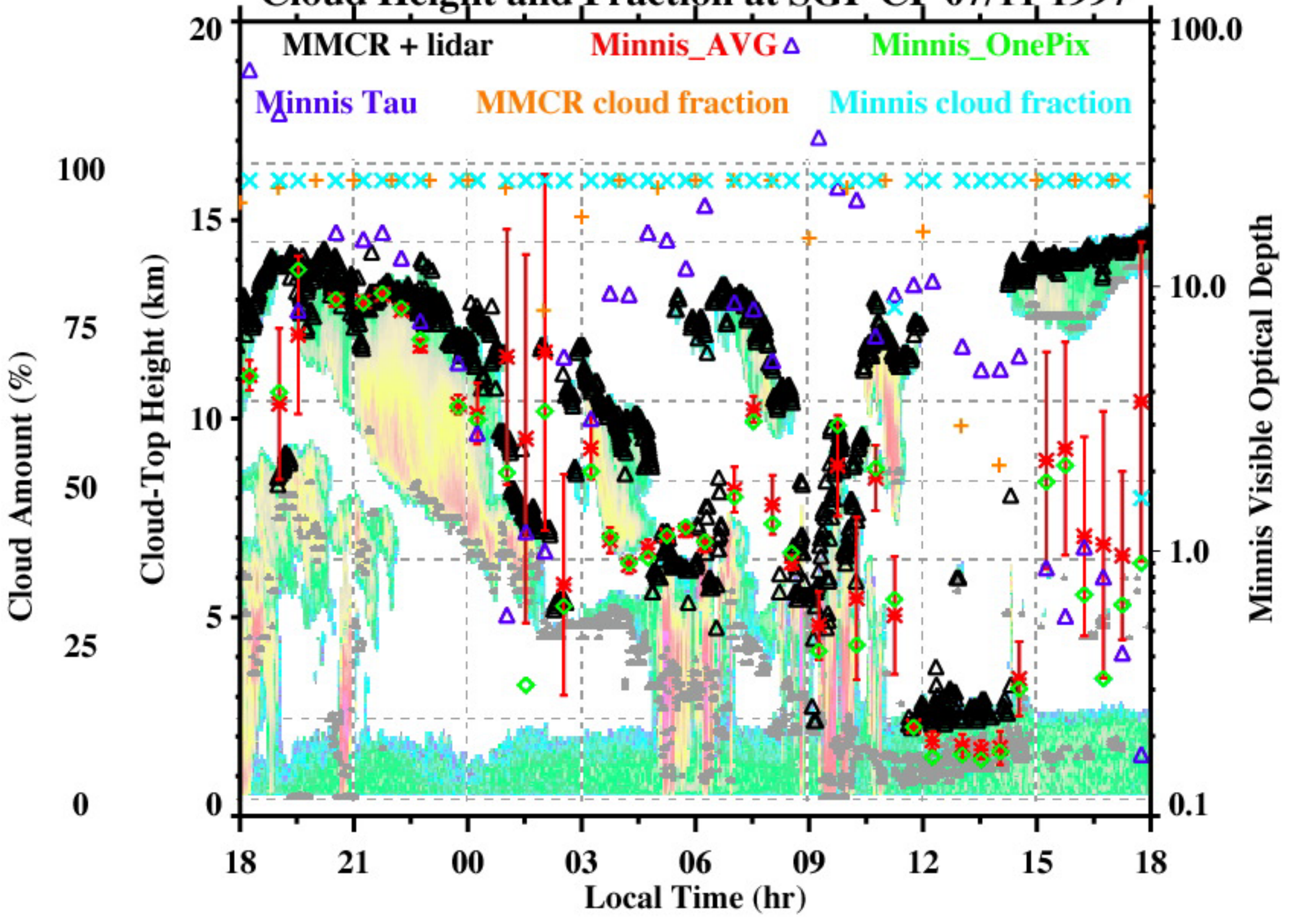
1) The CRM simulation reproduced the predominance of high clouds, but underestimated cloud occurrence at all levels during the selected subperiods compared to the MMCR.
2) The CRM simulation reproduced the overcast LW and SW CRFs of various cloud types obtained from the satellite observations.
3) Both the Minnis data and the CRM simulation suggest that the net CRF of the optically thin high level clouds had a warming effect at the TOA while the other cloud types had a cooling effect. The thick high cloud had the most significant cooling effect.

Future

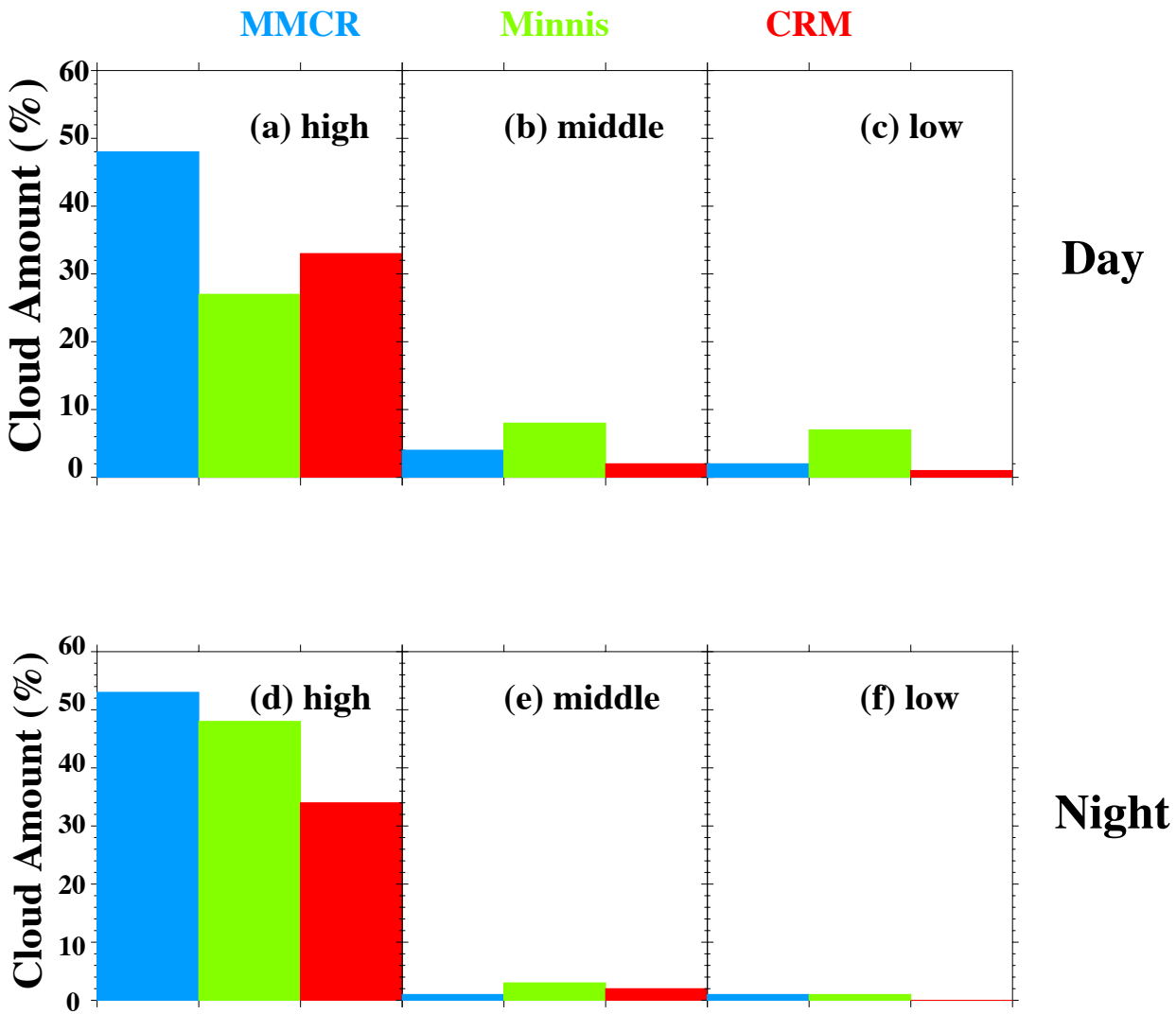
- Identify ISCCP cloud regimes (coexisting cloud types)
- Link ISCCP cloud types/regimes to MMCR/CRM cloud profiles.
- Evaluate surface CRF.

Retrieval Aspects

- Cloud detection
- Cloud-top pressure/height
- Cloud optical thickness


Cloud Height and Fraction at SGP CF 07/11 1997
MMCR + lidar
Minnis_AVG
Minnis_OnePix
Minnis Tau
MMCR cloud fraction
Minnis cloud fraction
Cloud Amount (%)
Cloud-Top Height (km)
Minnis Visible Optical Depth
Local Time (hr)
100
75
50
25
0
20
15
10
5
0
100.0
10.0
1.0
0.1
18
21
00
03
06
09
12
15
18

Cloud Amount Comparison



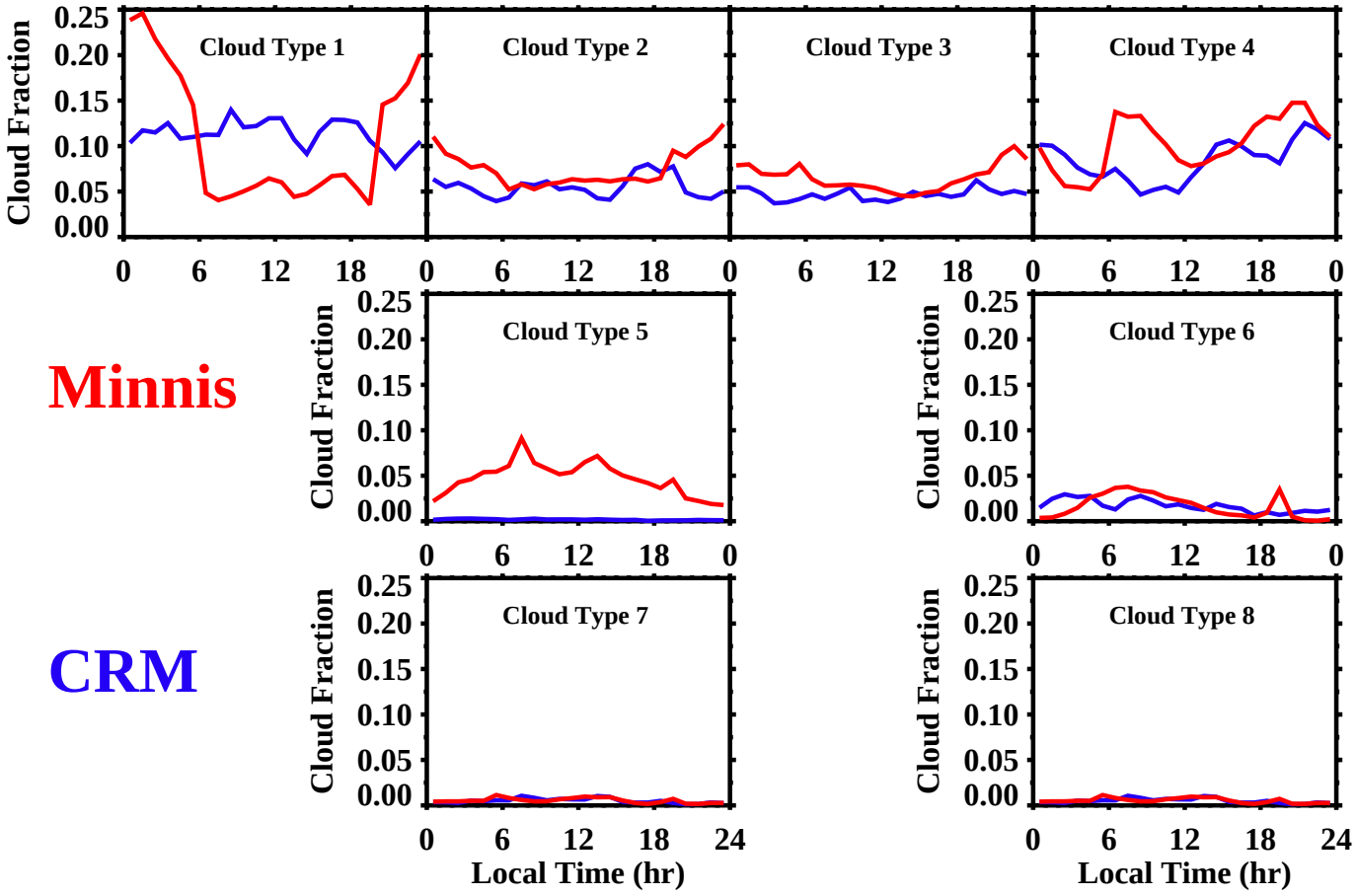


Figure 16. The fraction of various cloud types from the Minnis (red lines) and the CRM (blue lines) composited at each hour of day during the selected subperiods.

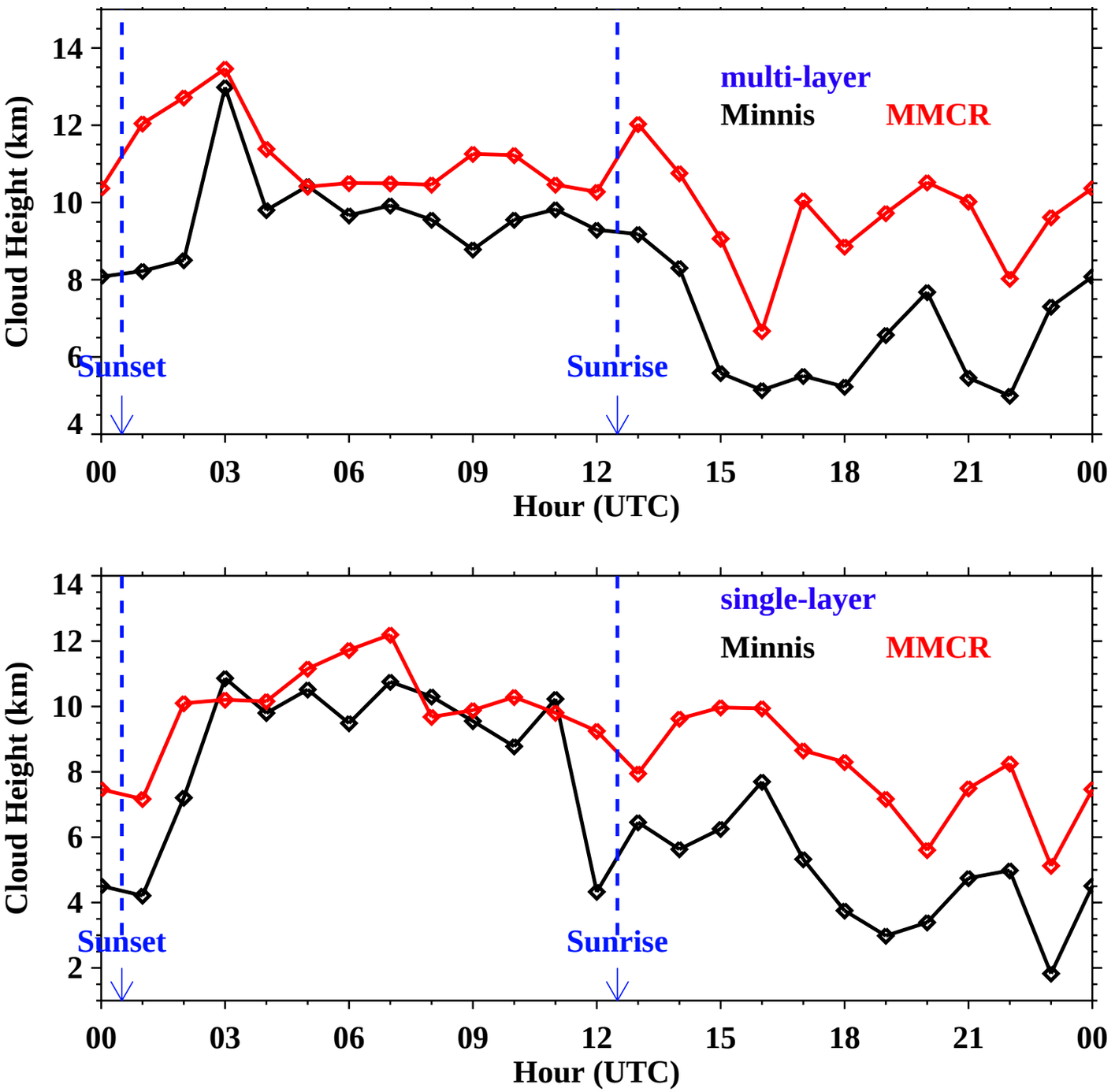


Figure 9. Comparison of MMCR cloud-top height (red) with Minnis effective cloud height (black) for multi-layer clouds (upper panel) and single-layer clouds (lower panel).

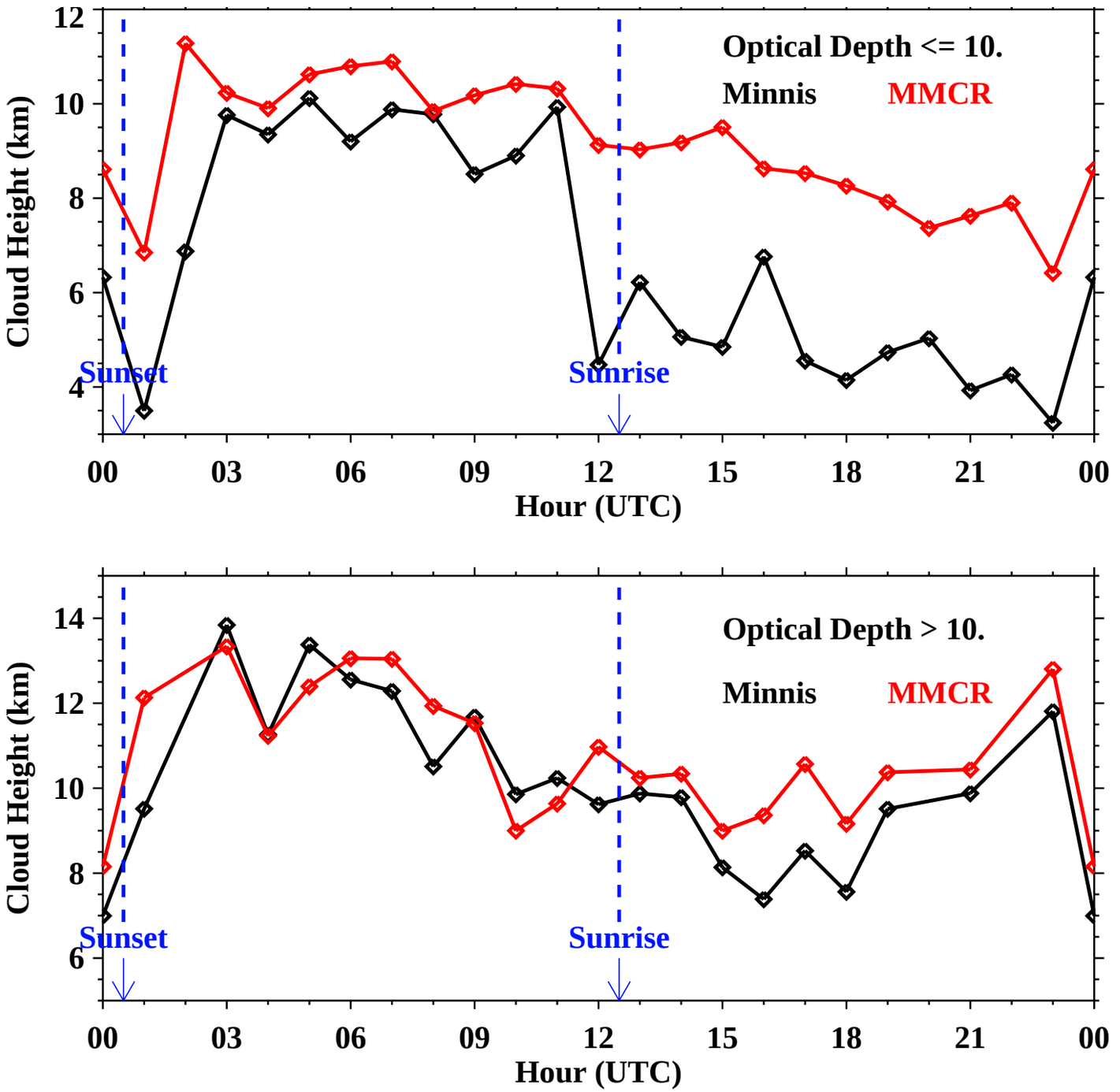
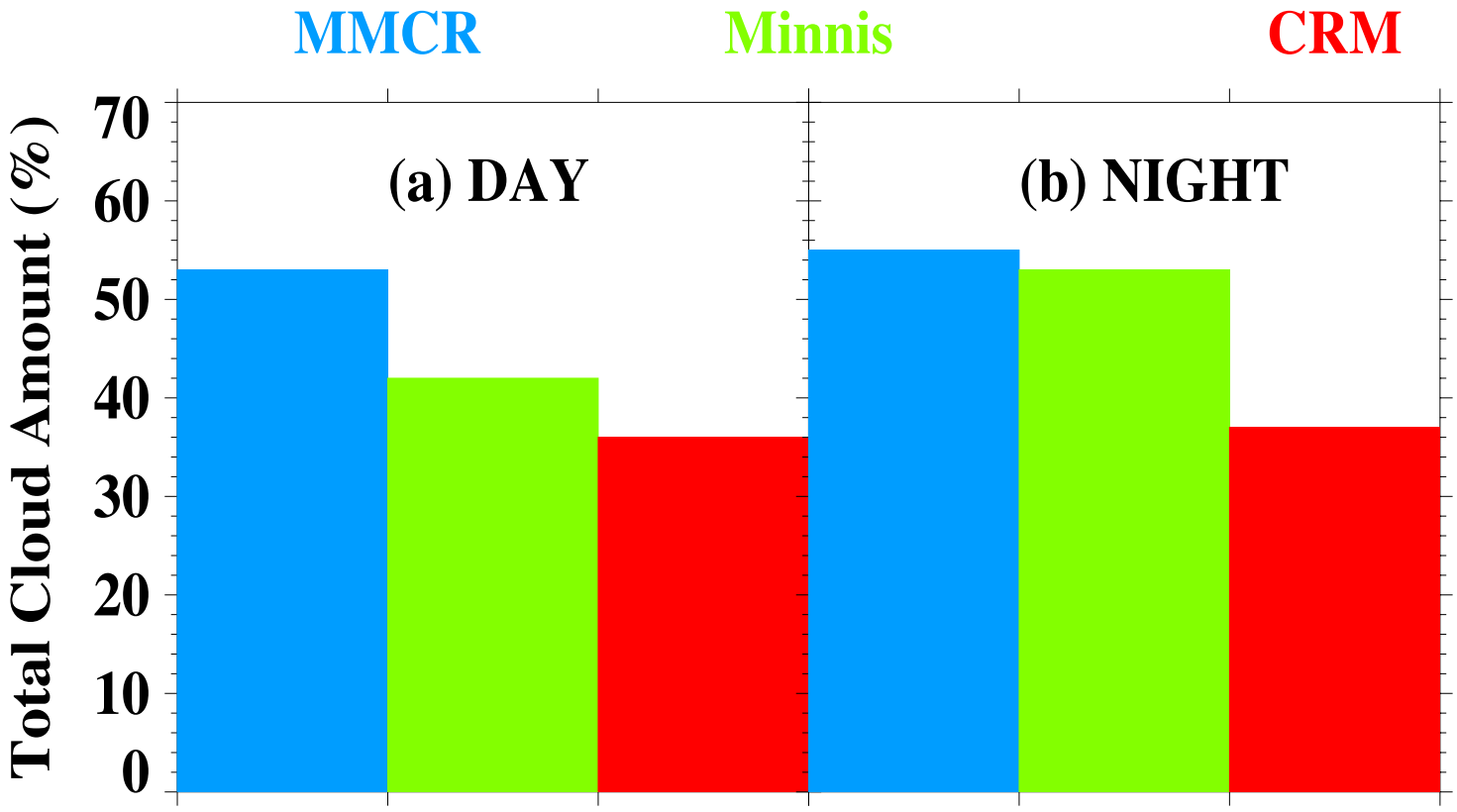


Figure 8. The MMCR and Minnis cloud heights composited at each hour of day. Upper/lower panel is for thin/thick cloud with optical depth /less/greater than 10.

Summary

1) The satellite deduced cloud heights are mostly the same as the radar observations during nighttime but underestimated during daytime of the IOP.
2) Some thin high clouds were missed and some were misclassified as lower-level clouds by the satellite retrieval used during daytime. As a result, the daytime high cloud amount is underestimated by Minnis by 20% compared to the MMCR.

Cloud Amount Comparison



Cloud-top Height Frequency: Minnis vs MMCR