Relationships between Convective Strength and Anvil Development based on AIRS-CloudSat

GEWEX UTCC PROES

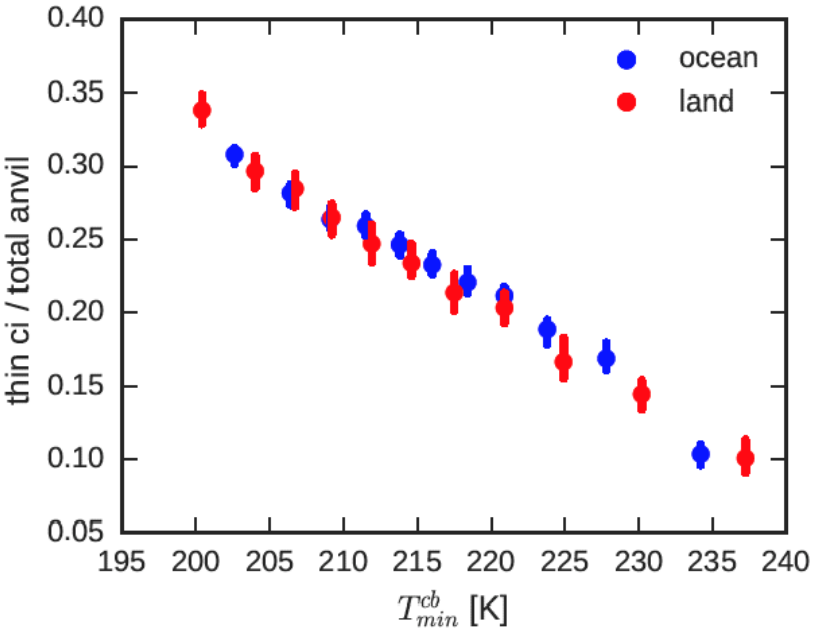
Hanii Takahashi*, Sofia Protopapadaki, Claudia Stubenrauch, Z. Johnny Luo, and Graeme Stephens

*Joint Institute for Regional Earth System Science and Engineering, University of California, Los Angeles, California
*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California

© 2017 California Institute of Technology

Introduction: Convective Strength vs. Thin Cirrus from AIRS

During Mature Stage
(fraction of CC btw 0.1-0.3%)

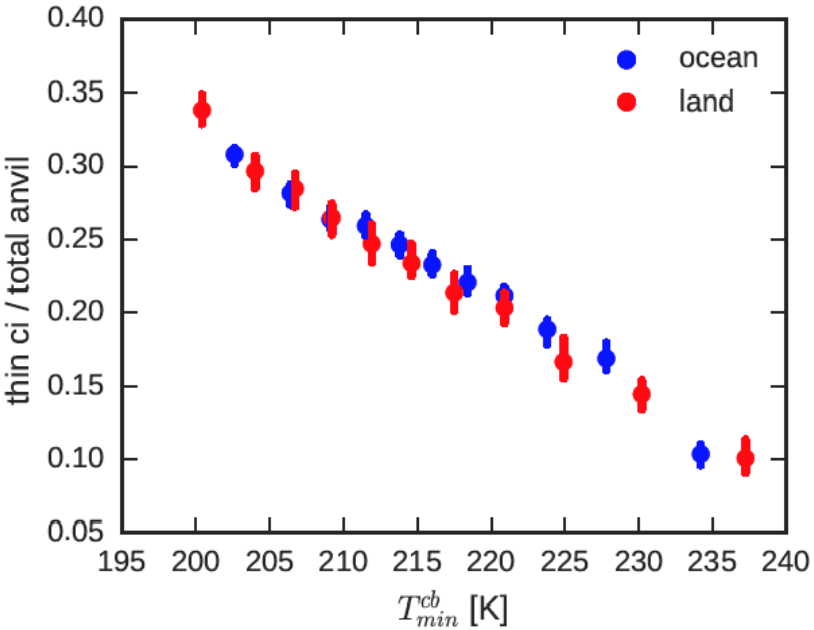


The fraction of thin cirrus increases as minimum temperature within convective core decreases.

(Protopapadaki et al., ACP 2017)

Introduction: Convective Strength vs. Thin Cirrus from AIRS

During Mature Stage
(fraction of CC btw 0.1-0.3%)



stronger → weaker

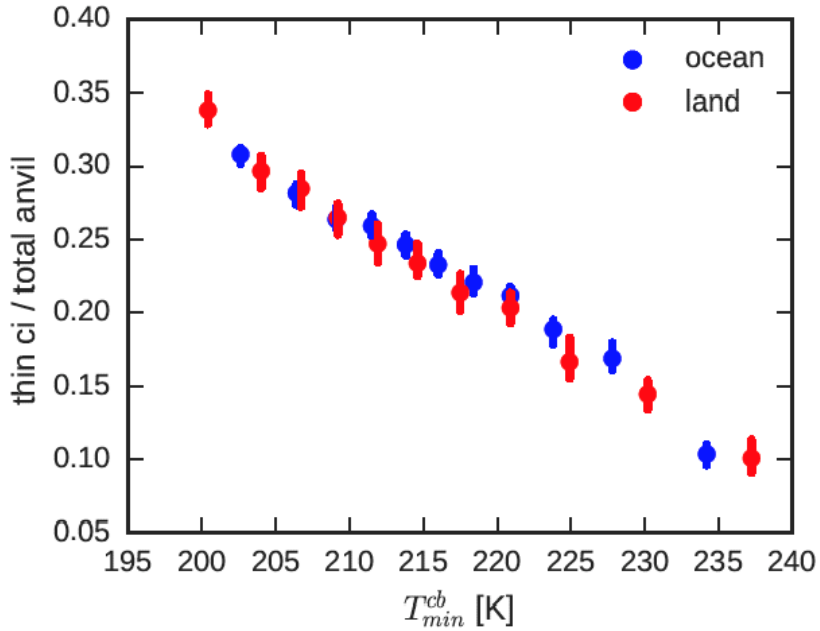
(Protopapadaki et al., ACP 2017)

The fraction of thin cirrus increases as minimum temperature within convective core decreases.

- Stronger convective cores associated with larger fraction of thin cirrus coverage.

Introduction: Convective Strength vs. Thin Cirrus from AIRS

During Mature Stage
(fraction of CC btw 0.1-0.3%)



stronger → weaker

(Protopapadaki et al., ACP 2017)

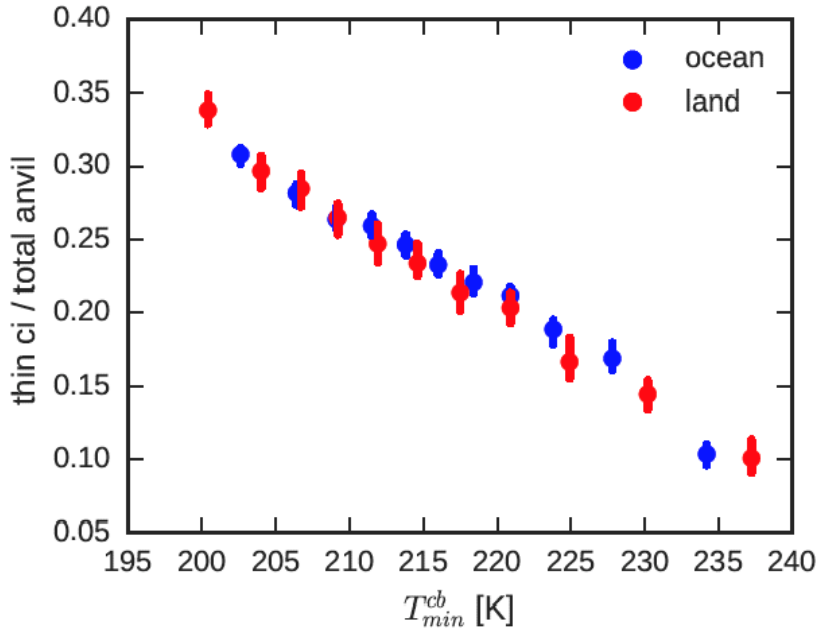
The fraction of thin cirrus increases as minimum temperature within convective core decreases.

- Stronger convective cores associated with larger fraction of thin cirrus coverage.

more convective ➔ more **Thin** Cirrus ➔ more UT warming ➔ less convective : Negative Feedback

Introduction: Convective Strength vs. Thin Cirrus from AIRS

During Mature Stage
(fraction of CC btw 0.1-0.3%)



stronger → weaker

(Protopapadaki et al., ACP 2017)

The fraction of thin cirrus increases as minimum temperature within convective core decreases.

- Stronger convective cores associated with larger fraction of thin cirrus coverage.

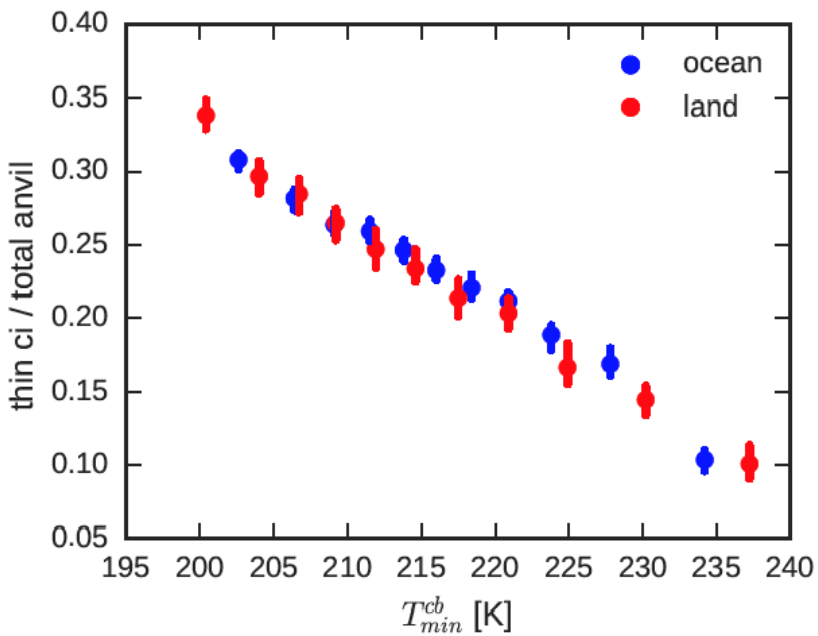
more convective ➔ more **Thin** Cirrus ➔ more UT warming ➔ less convective : Negative Feedback

Higher SST ➔ colder CTT ➔ more **Thin** Cirrus
(Cirrus-Detrainment-Temperature Feedback, Chou and Neelin 1999)

Motivation: To test the relationship between convective strength and fraction of cirrus using AIRS-CloudSat collocation dataset.

1. Collocate AIRS and CloudSat
2. Use different proxies of convective strength from CloudSat
3. Collocate ARIS-CloudSat-ISCCPCT to find “Mature Stages”

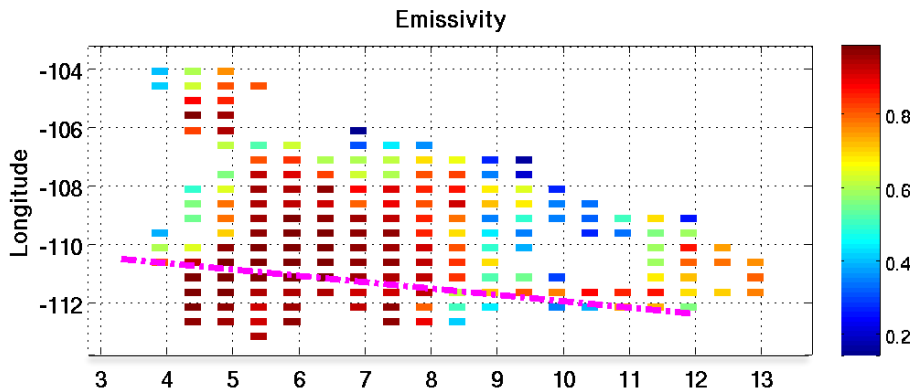
During Mature Stage
(fraction of CC btw 0.1-0.3%)



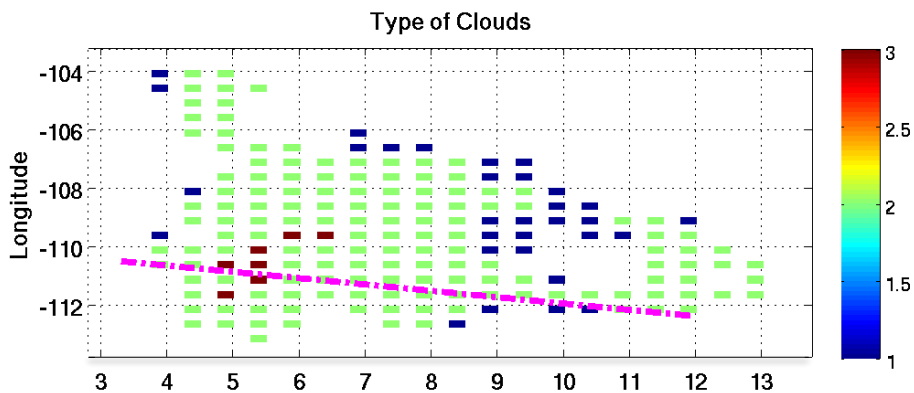
(Protopapadaki et al., ACP 2017)

Can we see similar tendency based on AIRS-CloudSat?

1. AIRS and CloudSat Collocation (200606-201104)



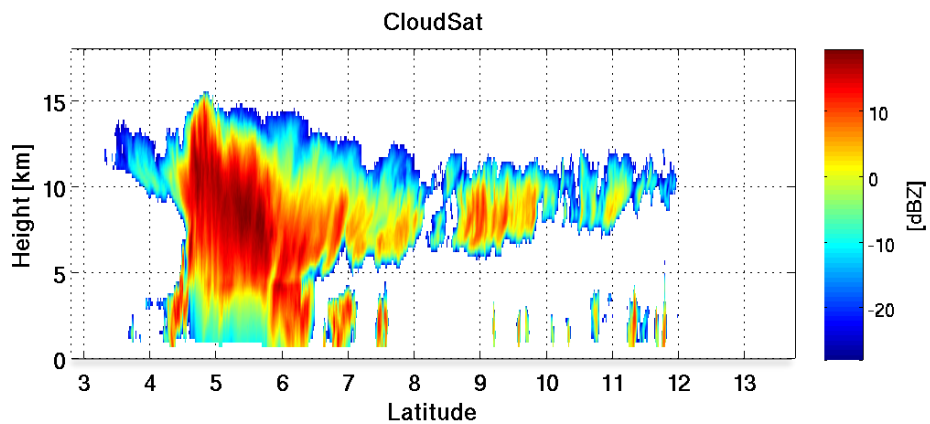
footprint of CloudSat



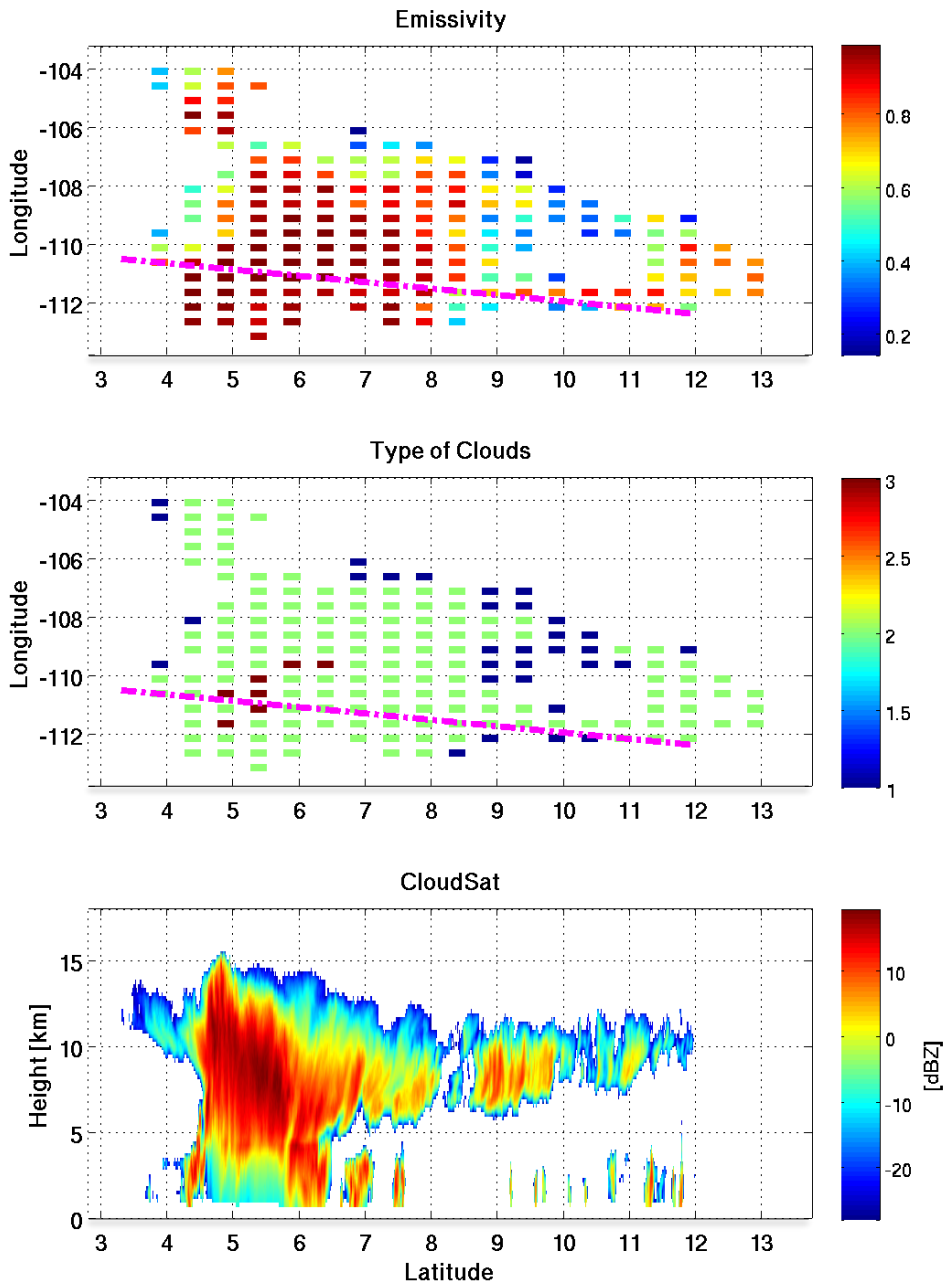
Convective Core: emissivity >0.98

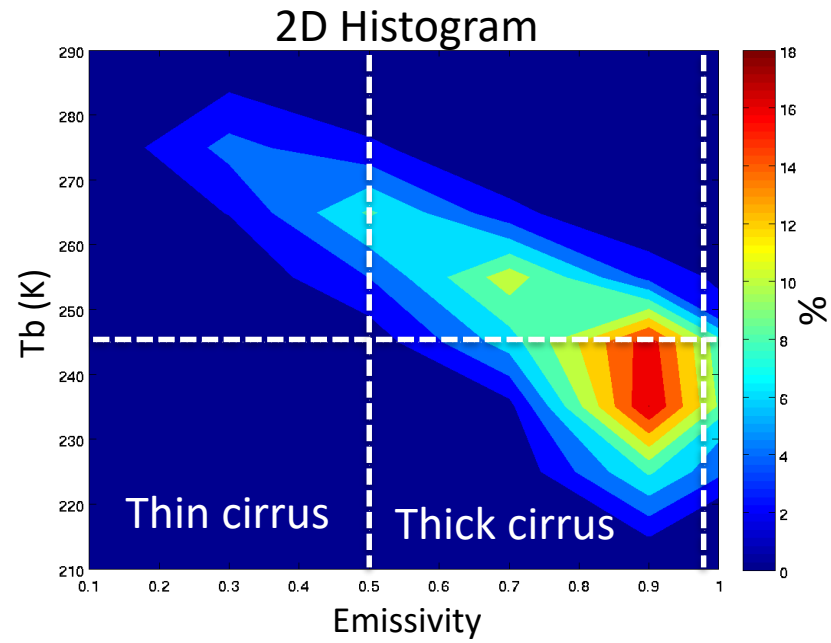
Thick Cirrus: 0.5<emissivity <0.98

Thin Cirrus: emissivity <0.5

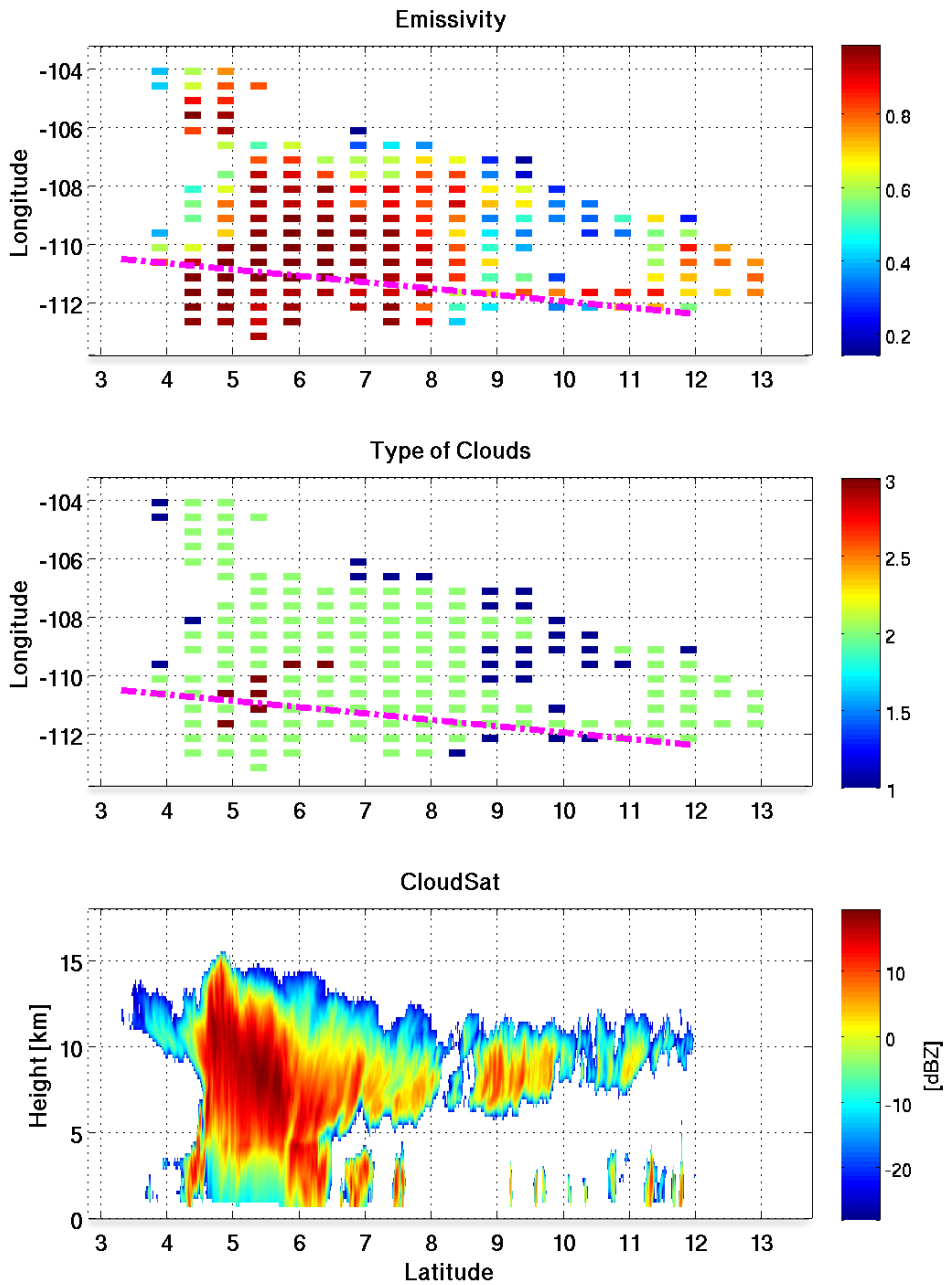


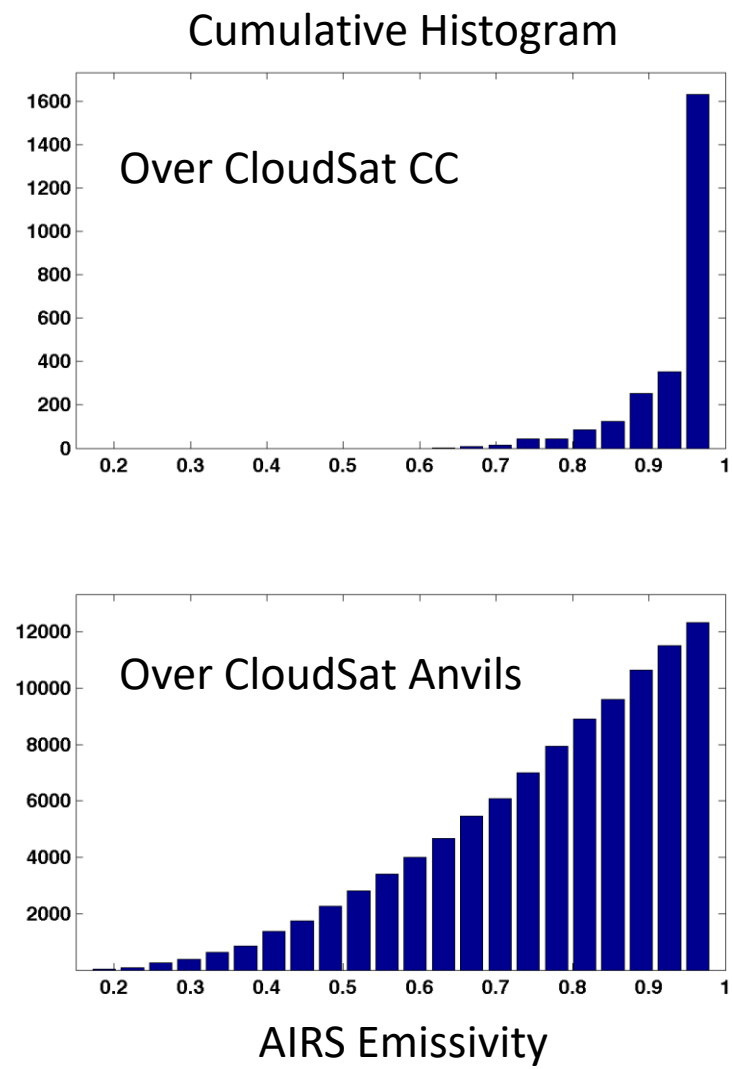
1. AIRS and CloudSat Collocation (200606-201104)



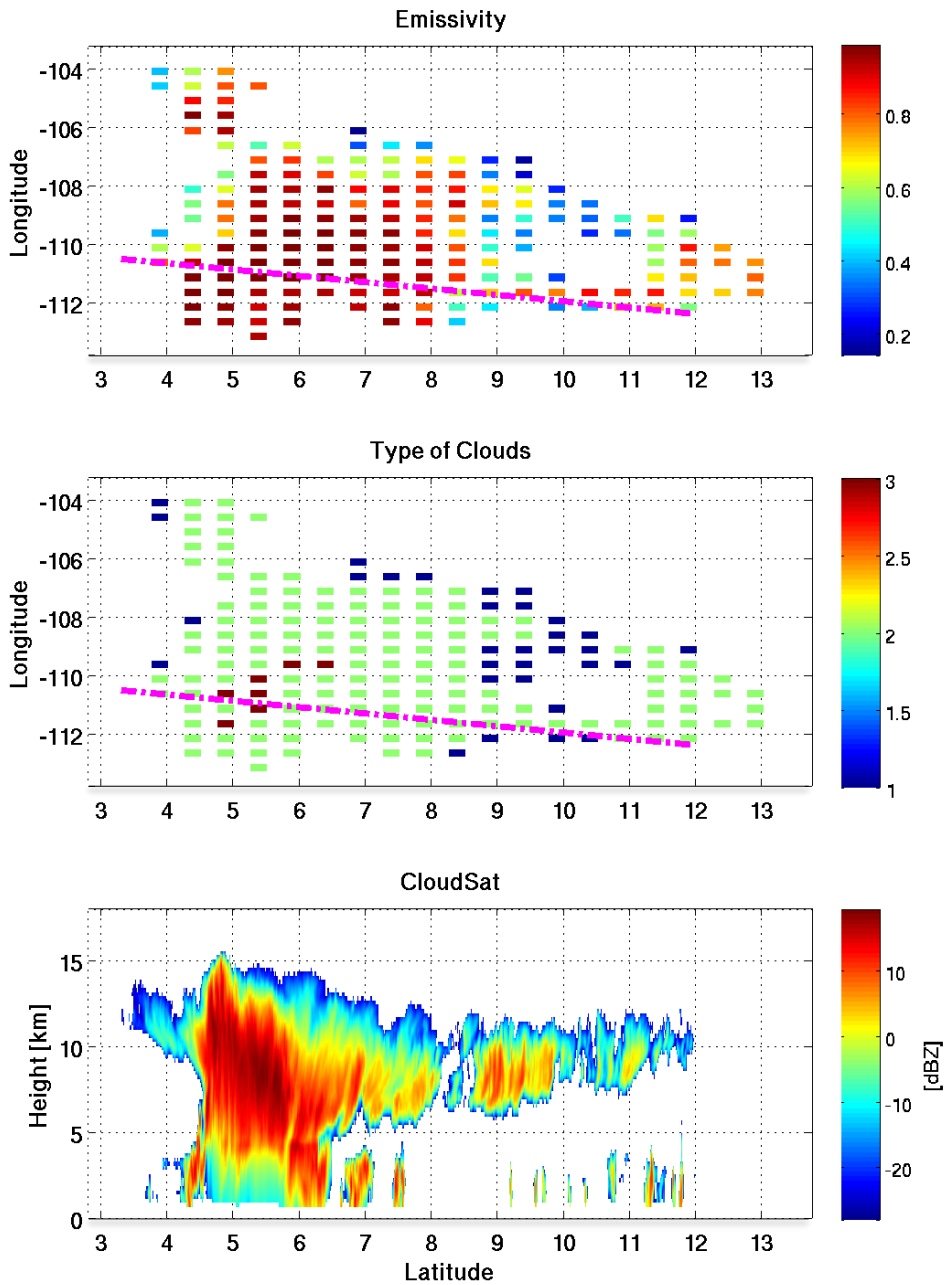


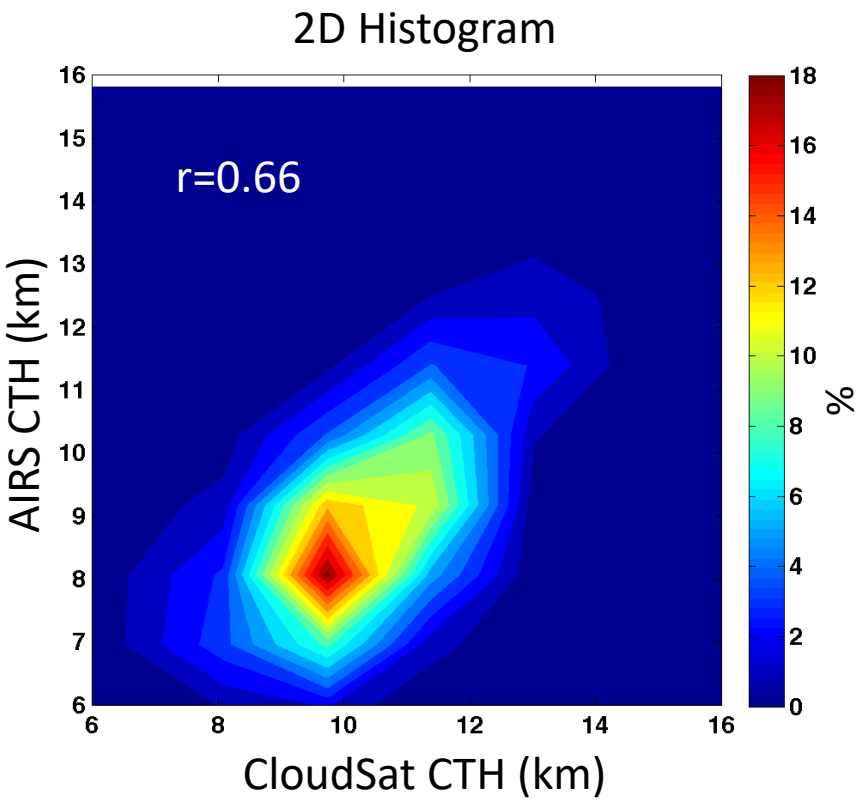
1. AIRS and CloudSat Collocation (200606-201104)



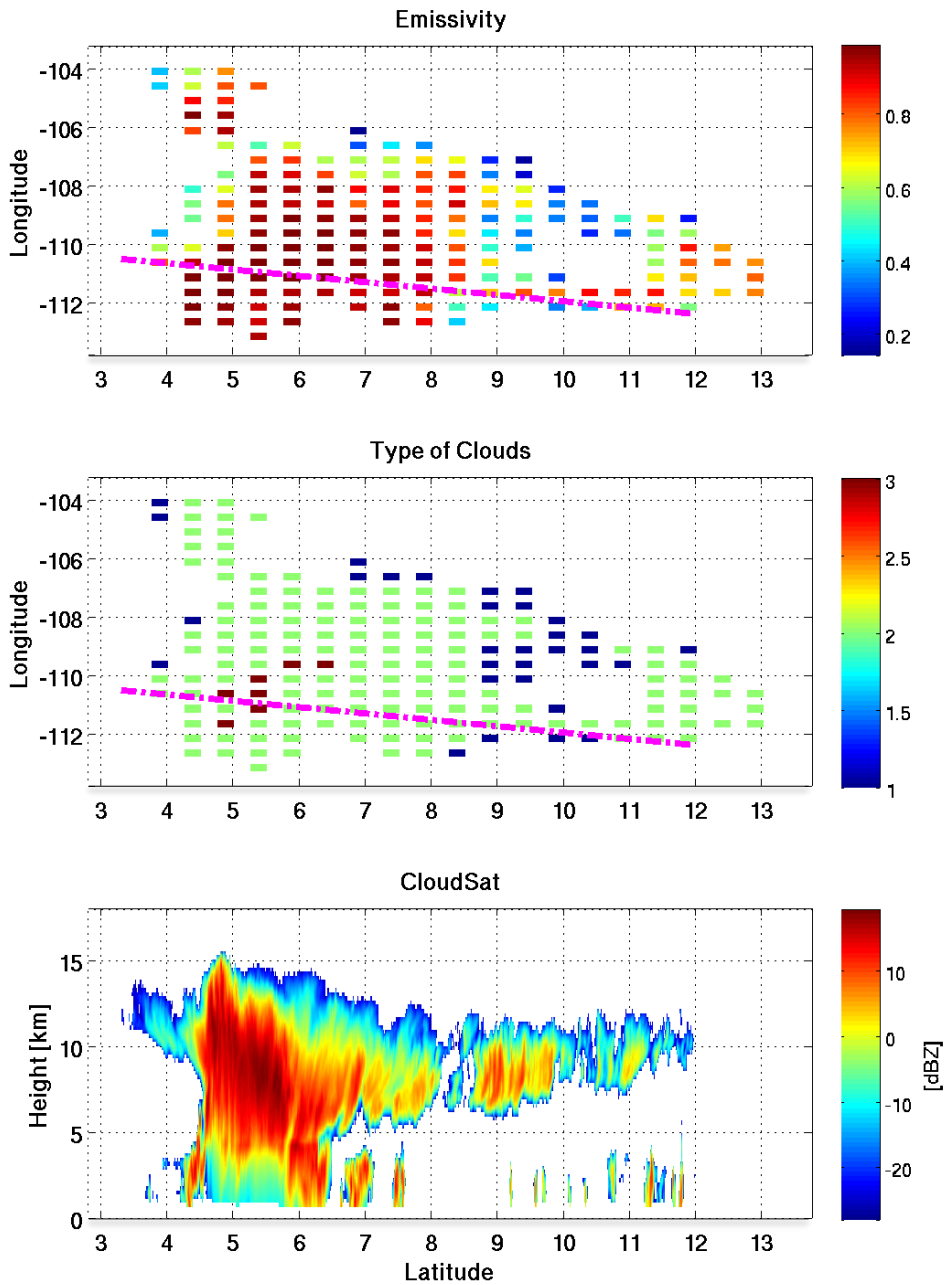


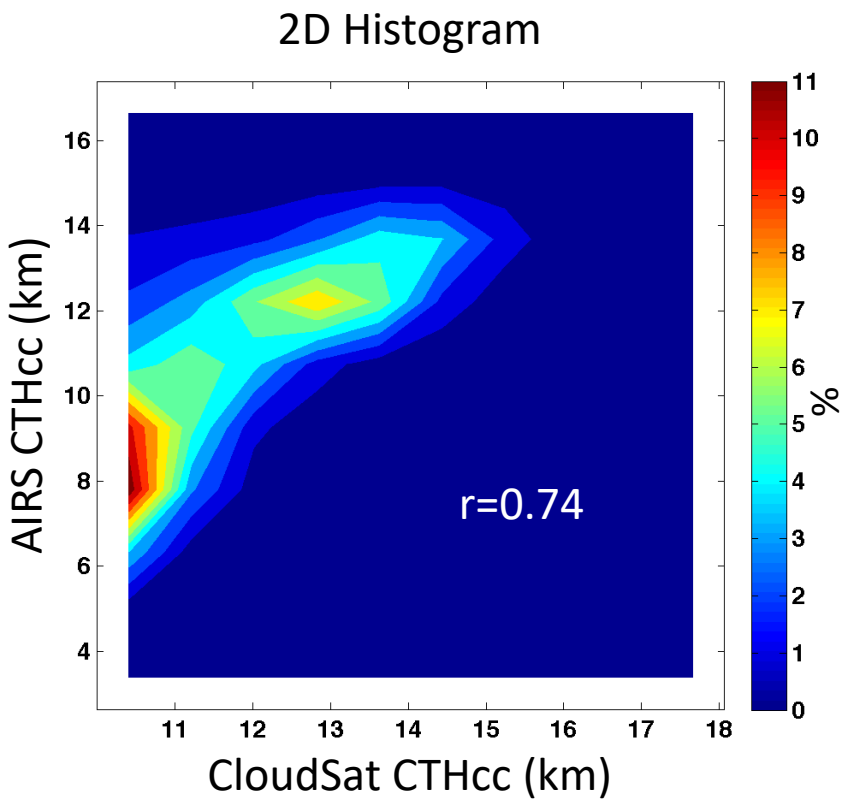
1. AIRS and CloudSat Collocation (200606-201104)





1. AIRS and CloudSat Collocation (200606-201104)



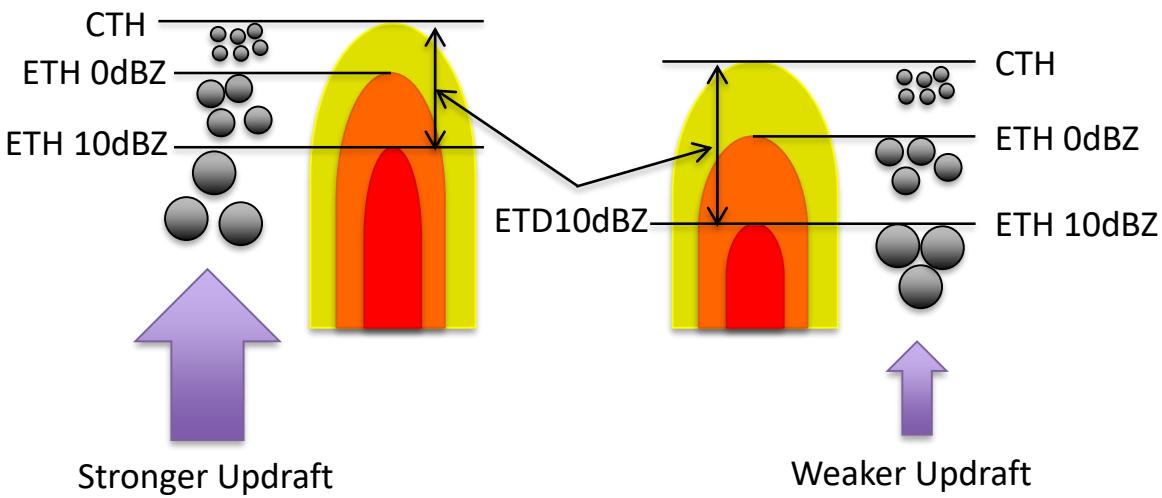


2. Compare Different Proxies of Convective Strength

AIRS: T_{min} within convective core

CloudSat:
Convective Core: CTH>10km & CBH<2km
Proxies: ETH (0 & 10dBZ), ETD (CTH-ETH)

Higher ETH and Shorter ETD
= Stronger Convective Core

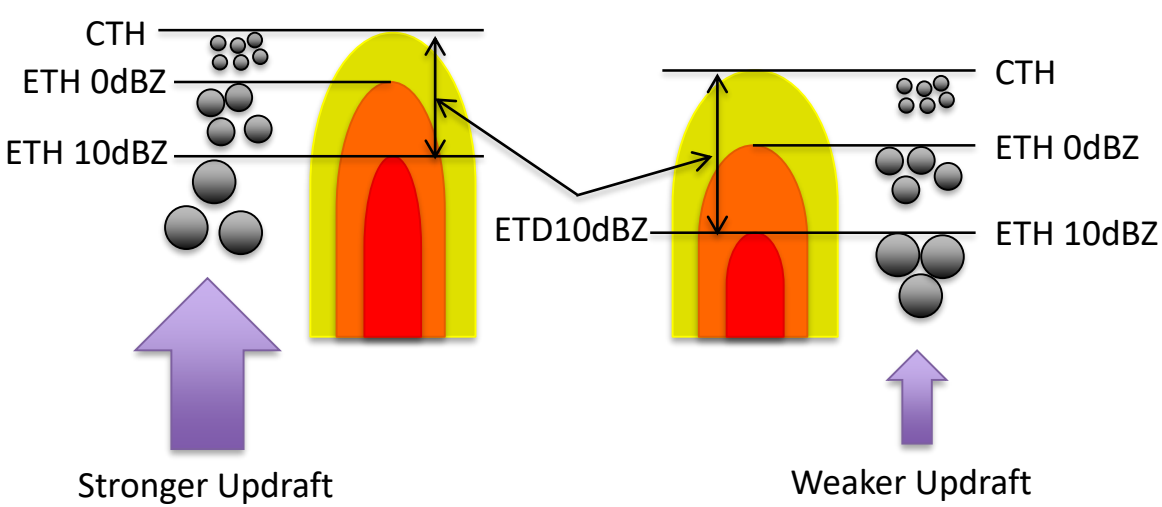


Takahashi and Luo (JGR 2014)

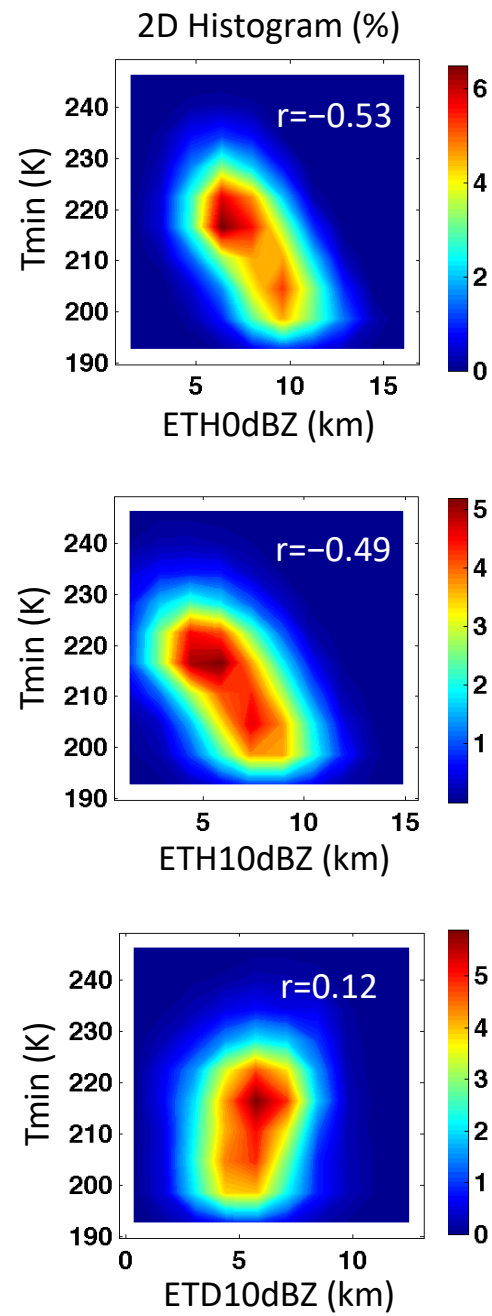
2. Compare Different Proxies of Convective Strength

AIRS: T_{min} within convective core

CloudSat:
Convective Core: CTH>10km & CBH<2km
Proxies: ETH (0 & 10dBZ), ETD (CTH-ETH)

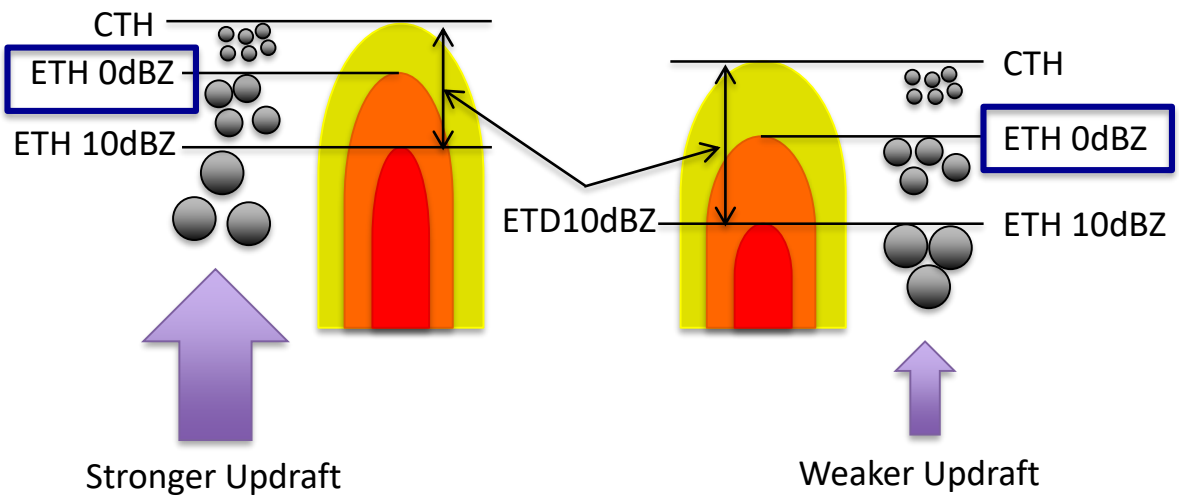


Takahashi and Luo (JGR 2014)

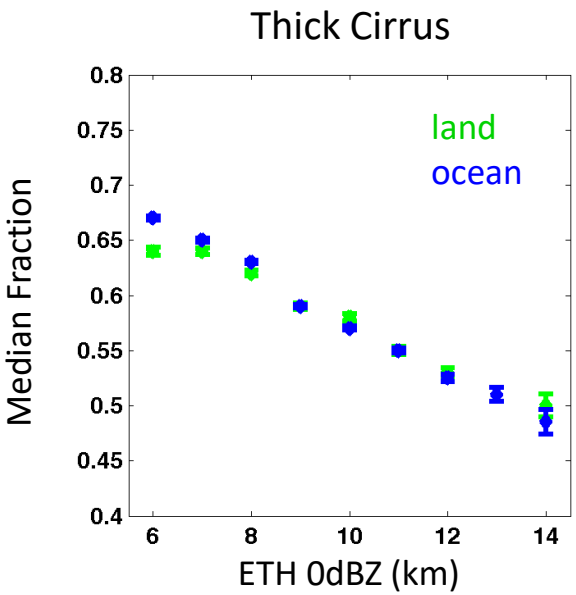


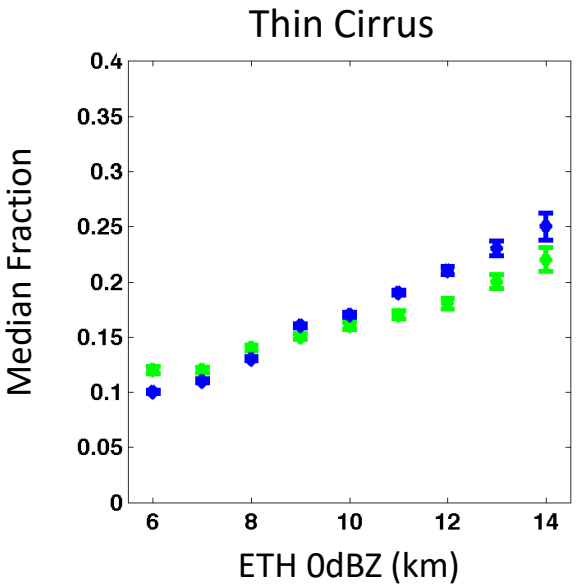
2. Compare Different Proxies of Convective Strength

- Thick cirrus decreases but thin cirrus increases with convective strength during mature stage.



Takahashi and Luo (JGR 2014)

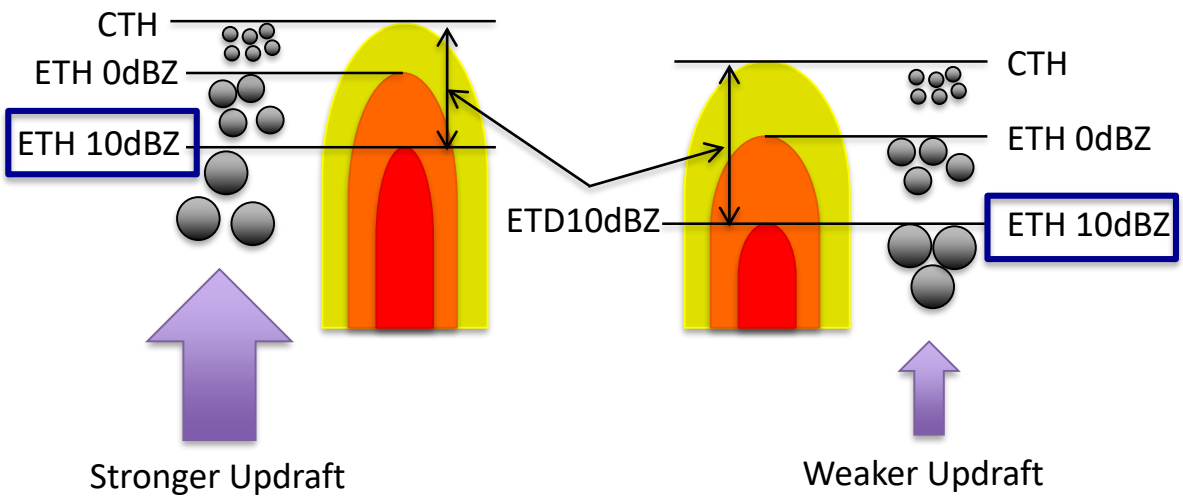




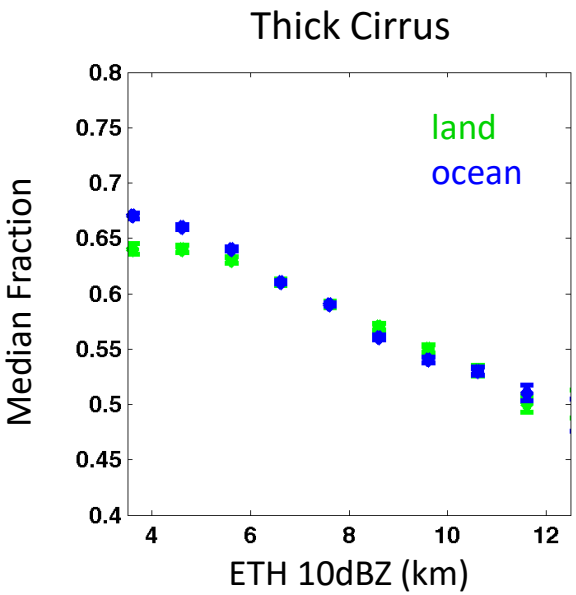
convective strength

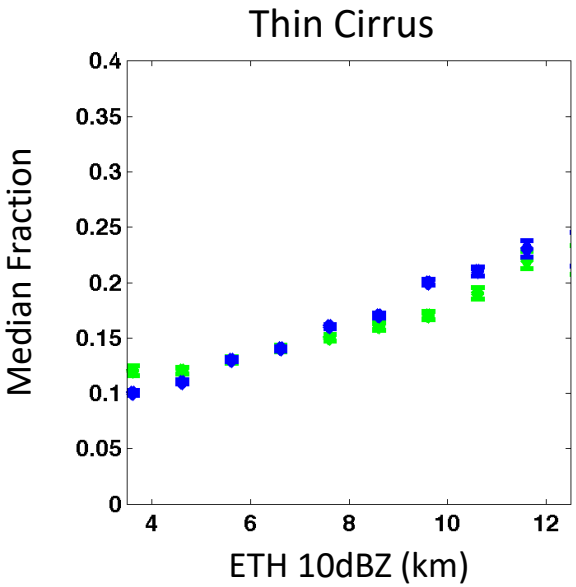
2. Compare Different Proxies of Convective Strength

- Thick cirrus decreases but thin cirrus increases with convective strength during mature stage.



Takahashi and Luo (JGR 2014)

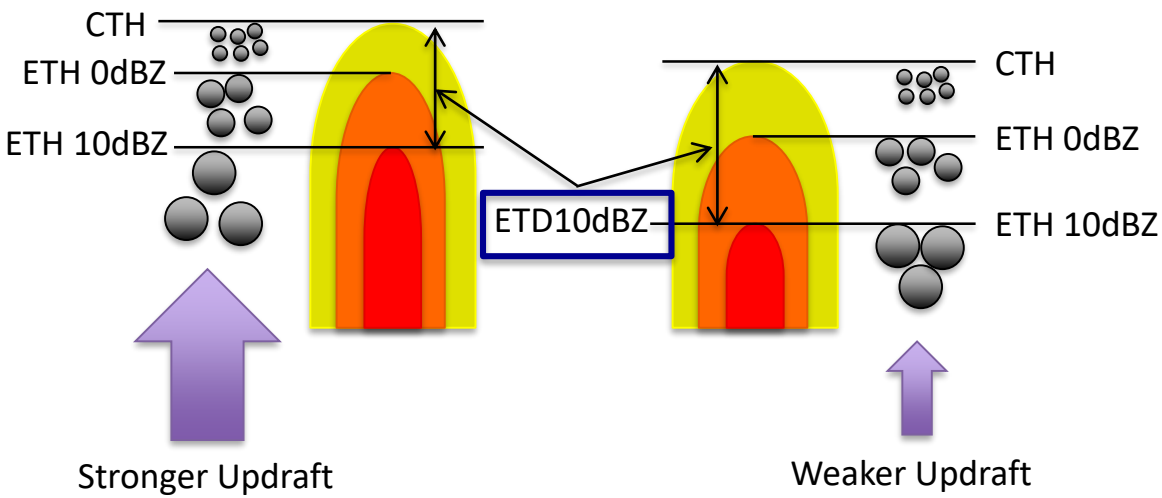




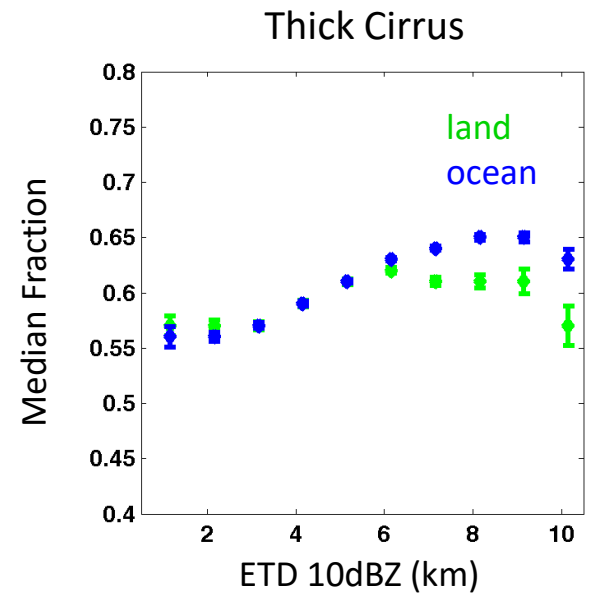
convective strength

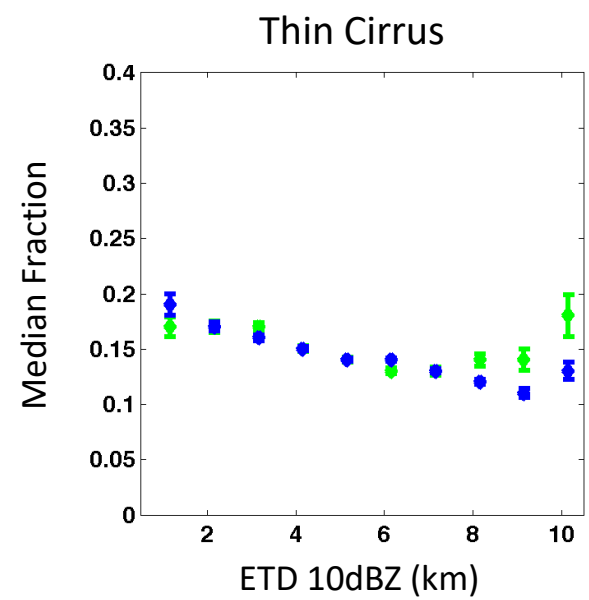
2. Compare Different Proxies of Convective Strength

- Thick cirrus decreases but thin cirrus increases with convective strength during mature stage.



Takahashi and Luo (JGR 2014)





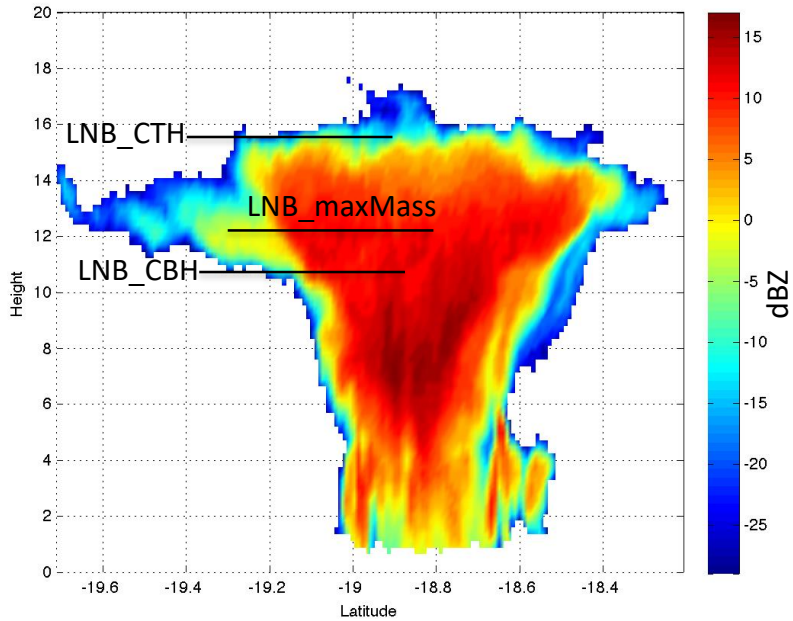
convective strength

2. Compare Different Proxies of Convective Strength

AIRS: T_{min} within CC

CloudSat:
Proxies: Level of Neutral Buoyancy (LNB)

- LNB_CTH: The highest detrainment level
- LNB_maxMass: The max mass detrainment level
- LNB_CBH: The lowest detrainment level



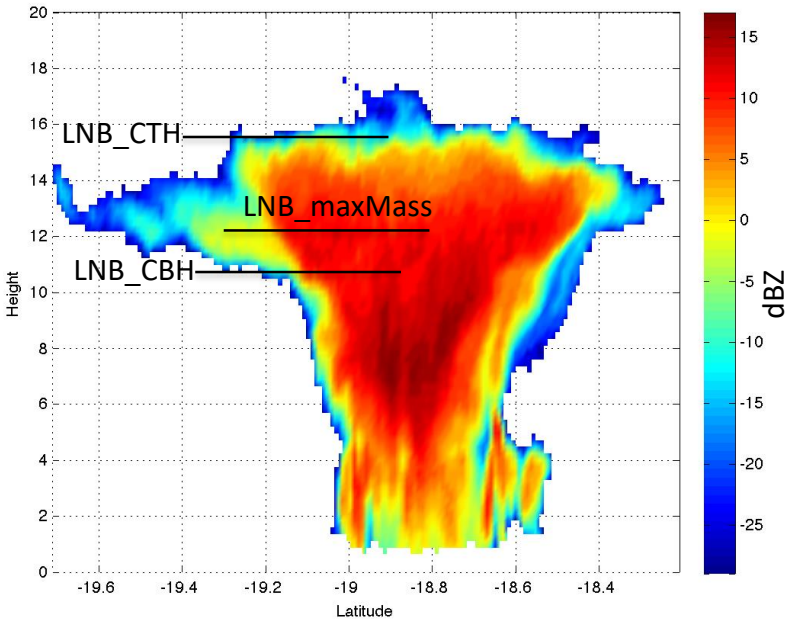
Takahashi and Luo (GRL 2012)

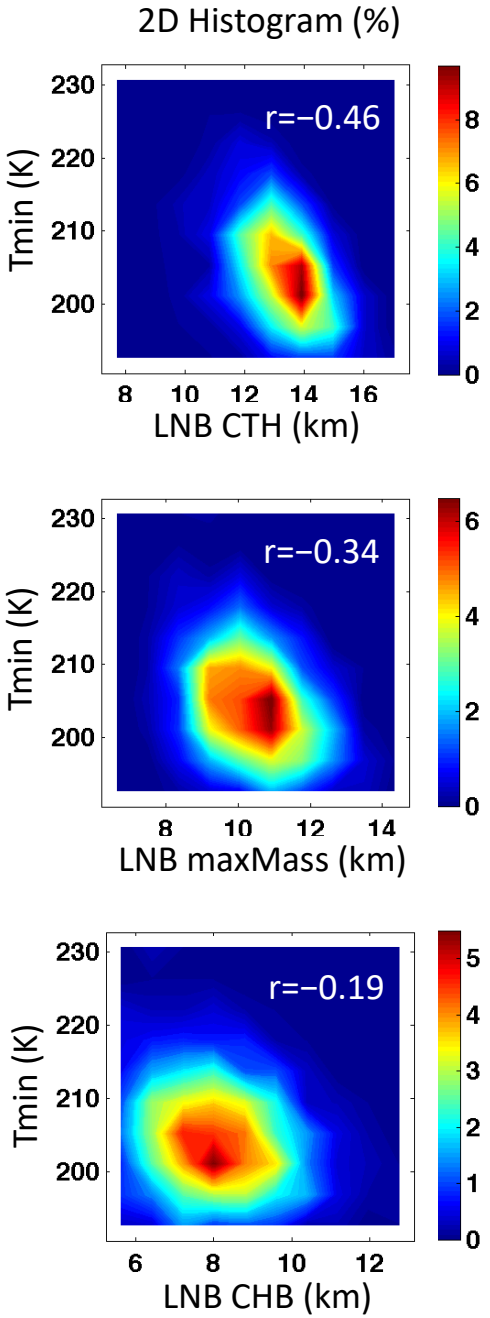
2. Compare Different Proxies of Convective Strength

AIRS: T_{min} within CC

CloudSat:
Proxies: Level of Neutral Buoyancy (LNB)

- LNB_CTH: The highest detrainment level
- LNB_maxMass: The max mass detrainment level
- LNB_CBH: The lowest detrainment level

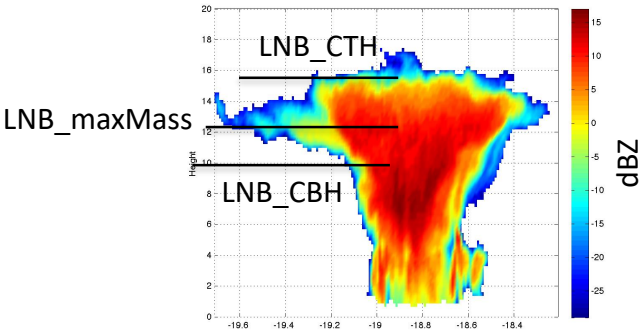


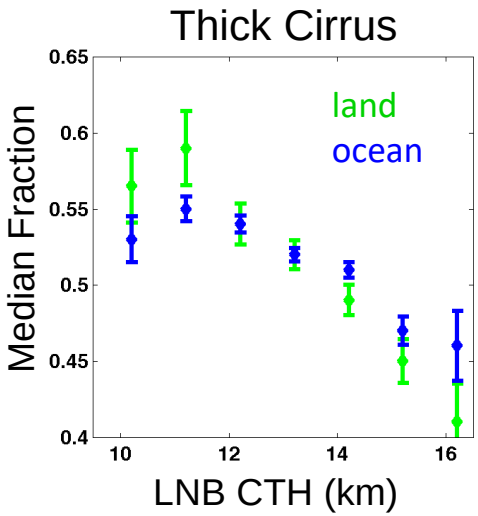


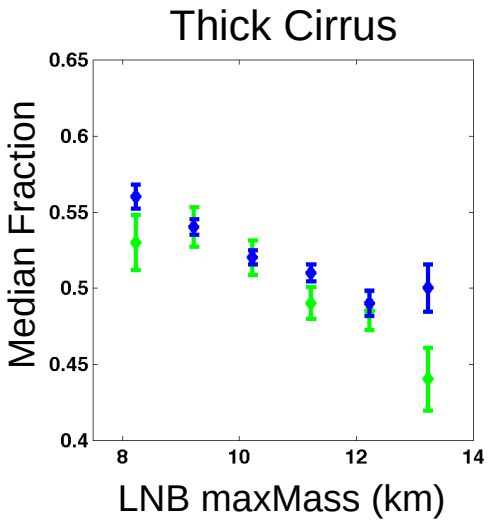
Takahashi and Luo (GRL 2012)

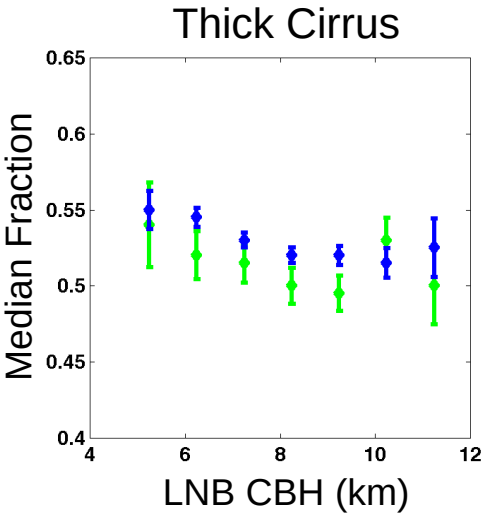
2. Compare Different Proxies of Convective Strength

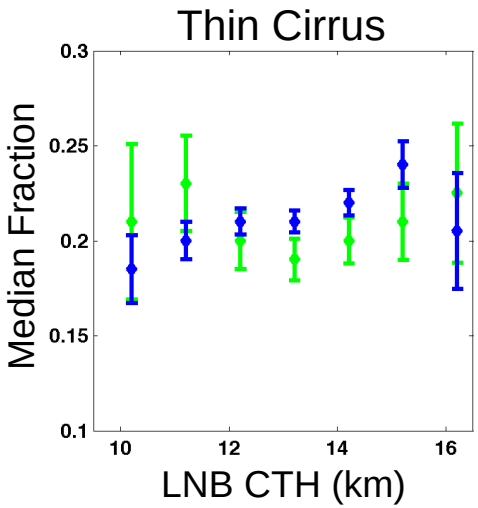
- Thick cirrus decreases but thin cirrus increases with convective strength.

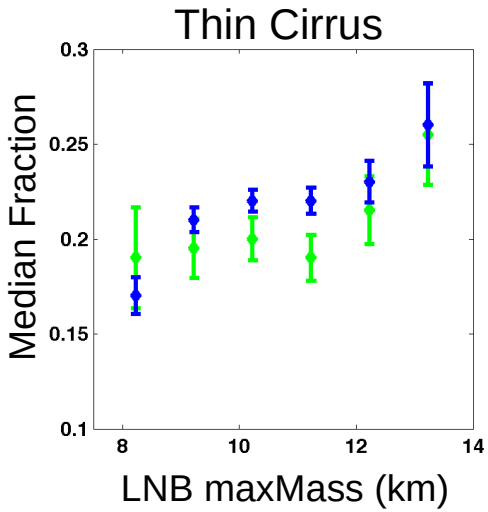


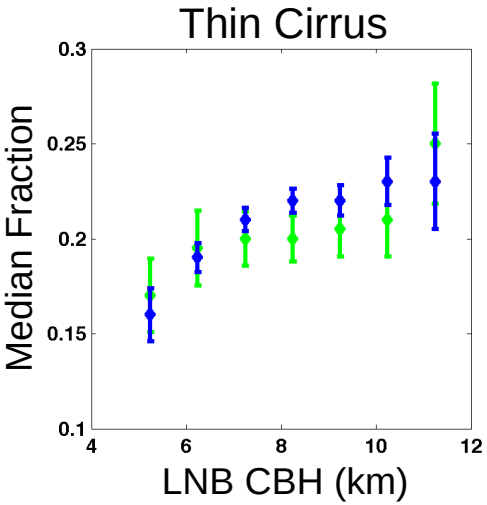












3. Definition of Stages

AIRS: Fraction of CC btw 0.1-0.3% (Mature Stage)

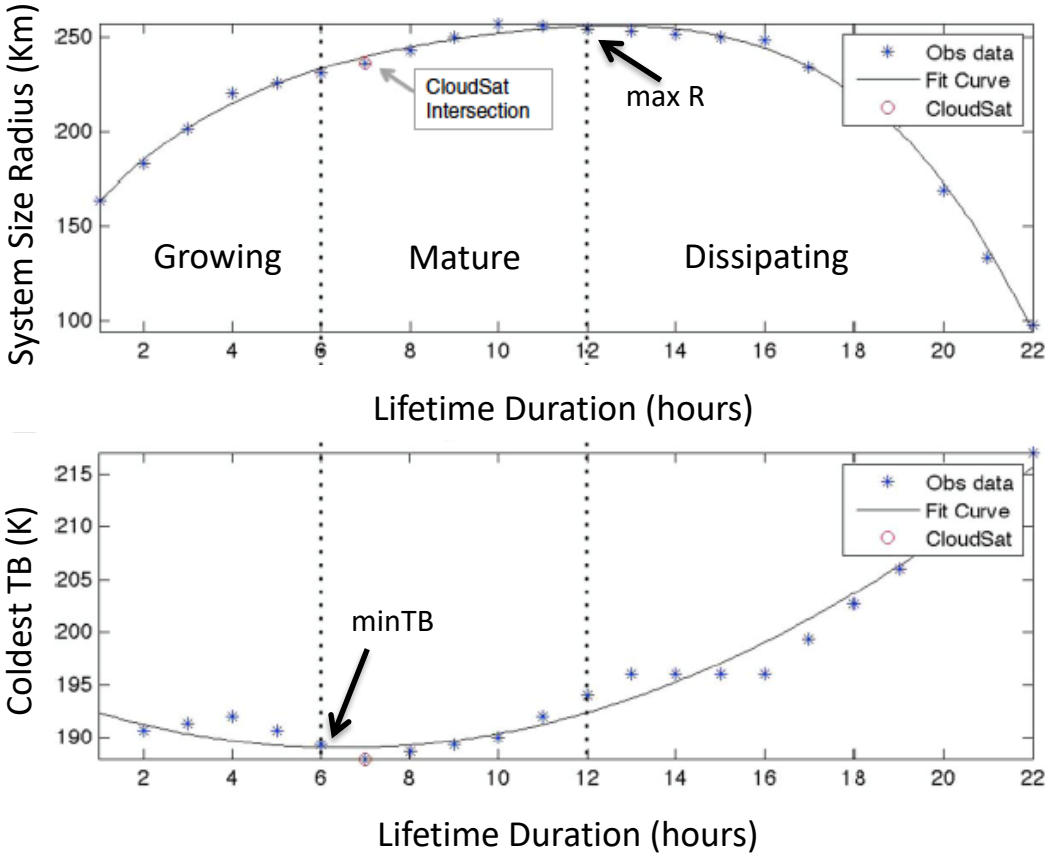
CloudSat: Collocate with ISCCPCT

Growing: Before reaching the mim TB

Mature: Between growing and dissipating

Dissipating: After reaching the max radius

(Futyan and Del Genio, J Clim 2007)



Takahashi and Luo (JGR 2014)

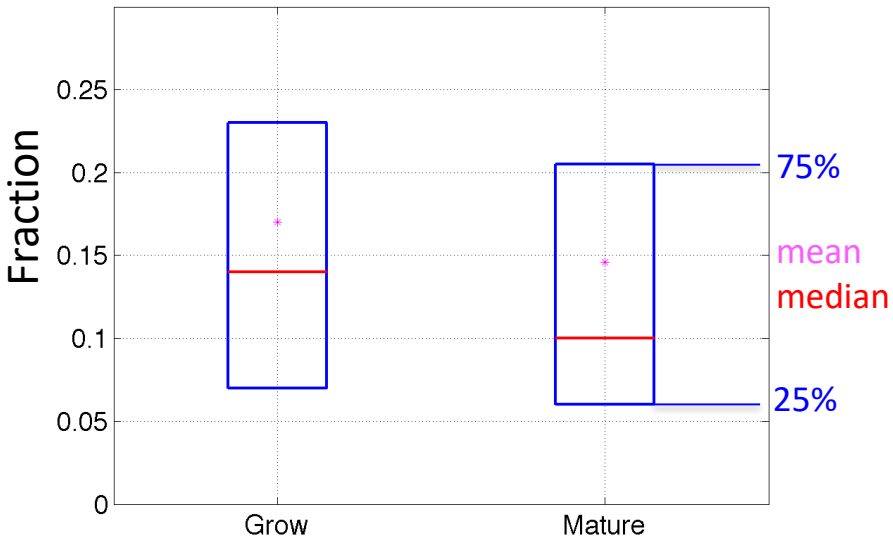
3. Definition of Stages

AIRS: Fraction of CC btw 0.1-0.3%

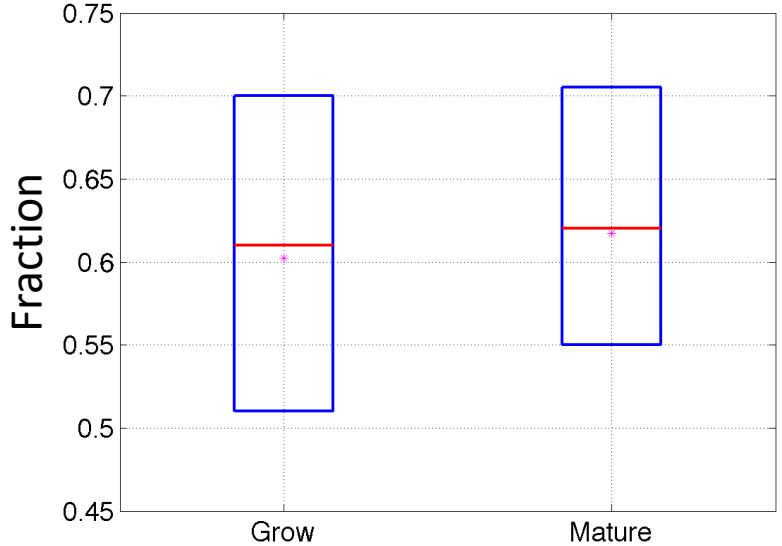
CloudSat: Collocate with ISCCPCT

- CC decreases and Cirrus increases as cloud ages.

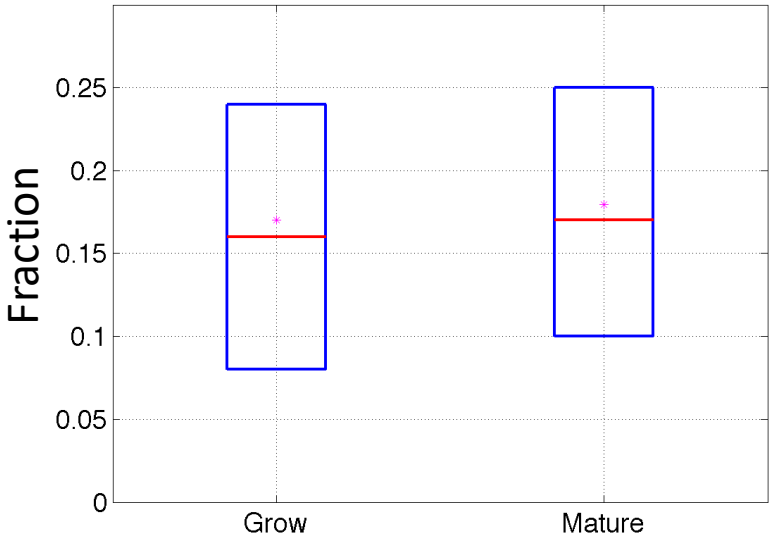
Convective Core (ε>0.98)



Thick Cirrus (0.5<ε<0.98)



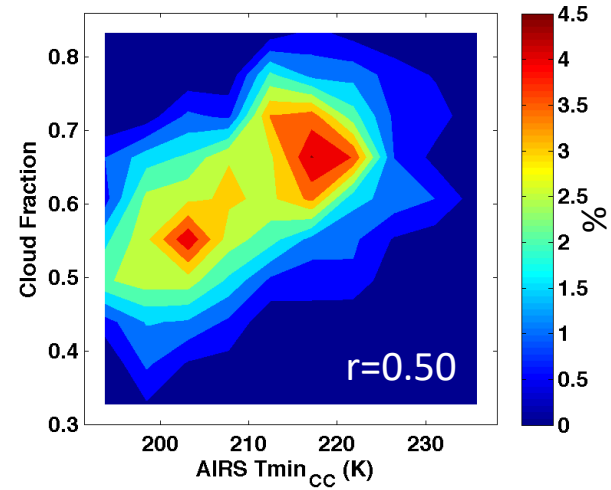
Thin Cirrus (ε<0.5)



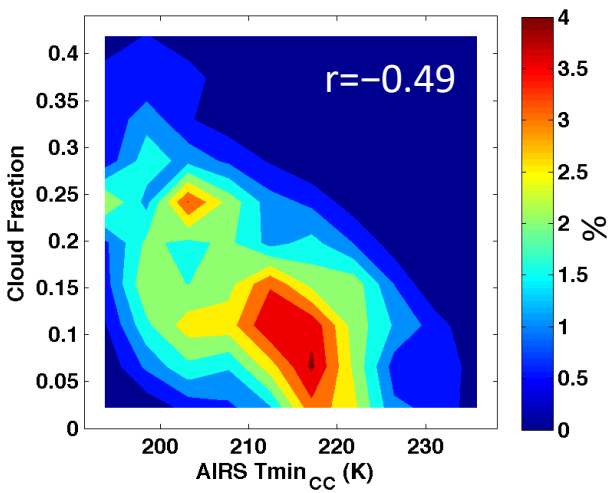
3. Definition of Stages

Mature
(CC frac bw 0.1-0.3)

Thick Cirrus

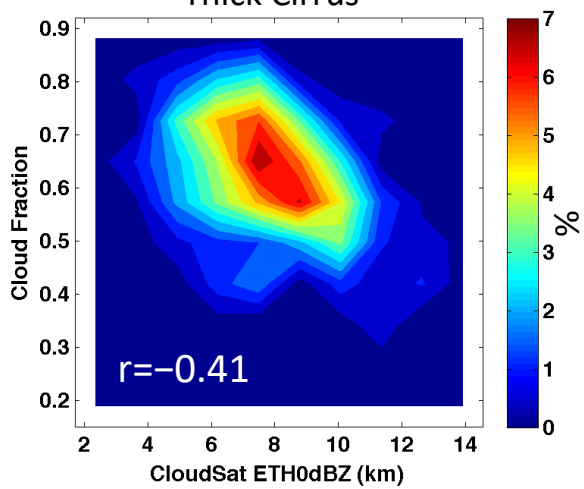


Thin Cirrus

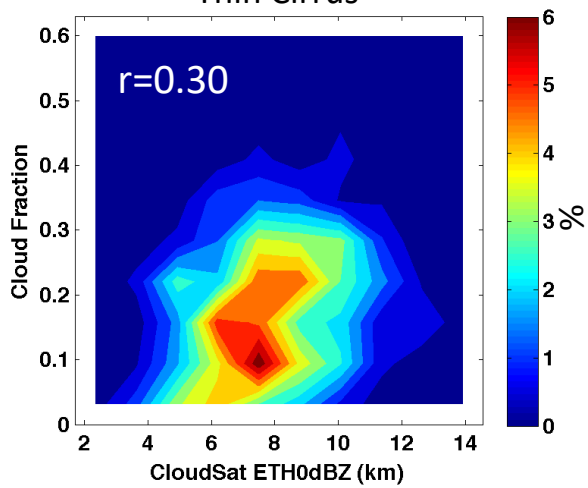


Mature
(CloudSat+ISCCPCT)

Thick Cirrus



Thin Cirrus

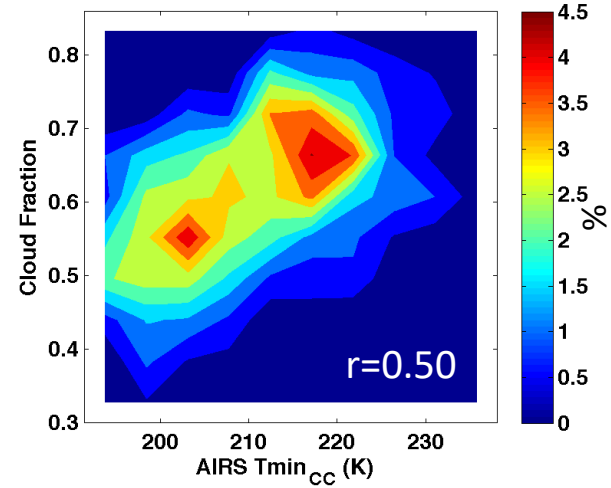


3. Definition of Stages

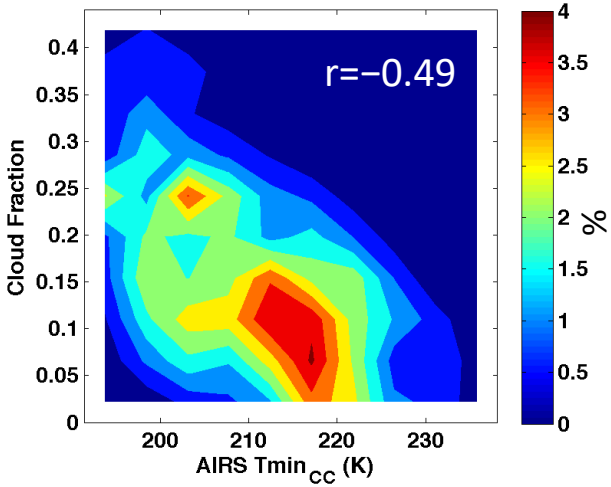
- Thick cirrus decreases but thin cirrus increases with convective strength.

Mature (CC frac bw 0.1-0.3)

Thick Cirrus

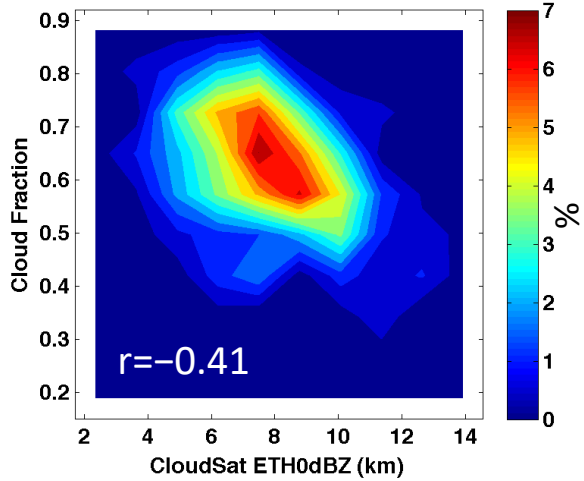


Thin Cirrus

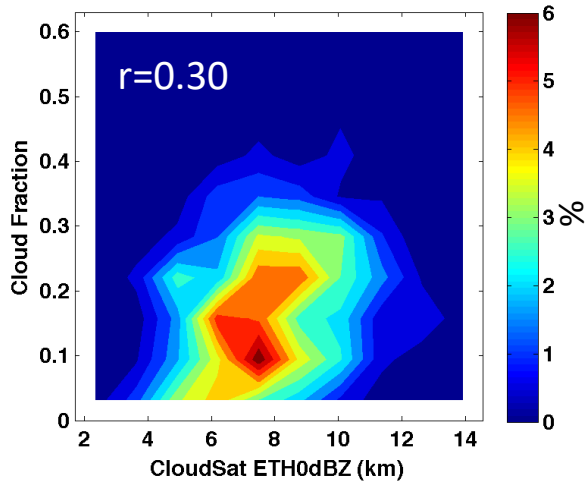


Mature (CloudSat+ISCCPCT)

Thick Cirrus

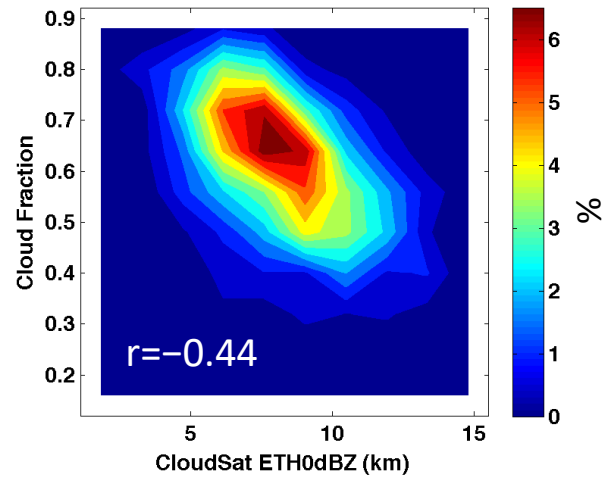


Thin Cirrus

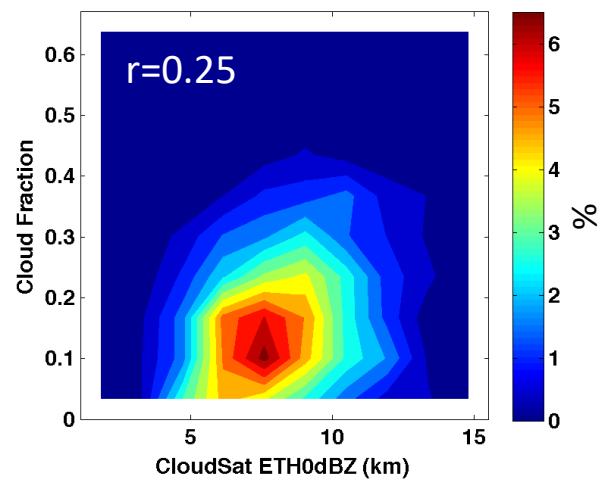


Growing (CloudSat+ISCCPCT)

Thick Cirrus



Thin Cirrus



Conclusion and Discussion:

- The tendency of thick cirrus decreases but thin cirrus increases with convective strength is robust.

Conclusion and Discussion:

- The tendency of thick cirrus decreases but thin cirrus increases with convective strength is robust.

more convective ➔ more **Thin** Cirrus ➔ more UT warming ➔ less convective : Negative Feedback

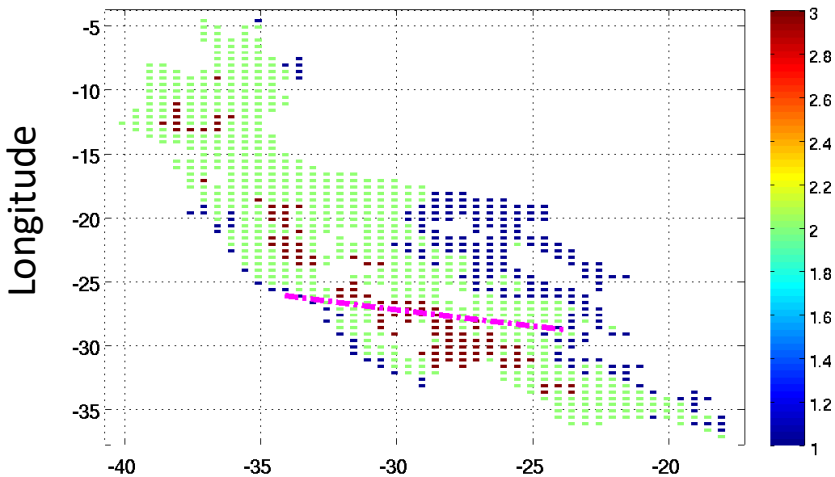
more convective ➔ less **Thick** Cirrus ➔ less UT warming ➔ more convective : Positive Feedback

more convective ➔ less **Thick** Cirrus ➔ more UT warming ➔ less convective : Negative Feedback

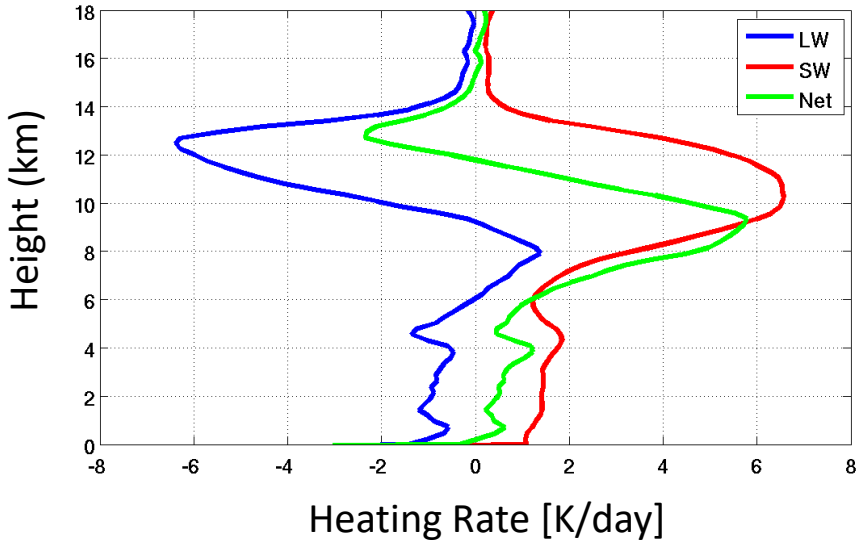
Which feedback plays larger role?

Conclusion and Discussion:

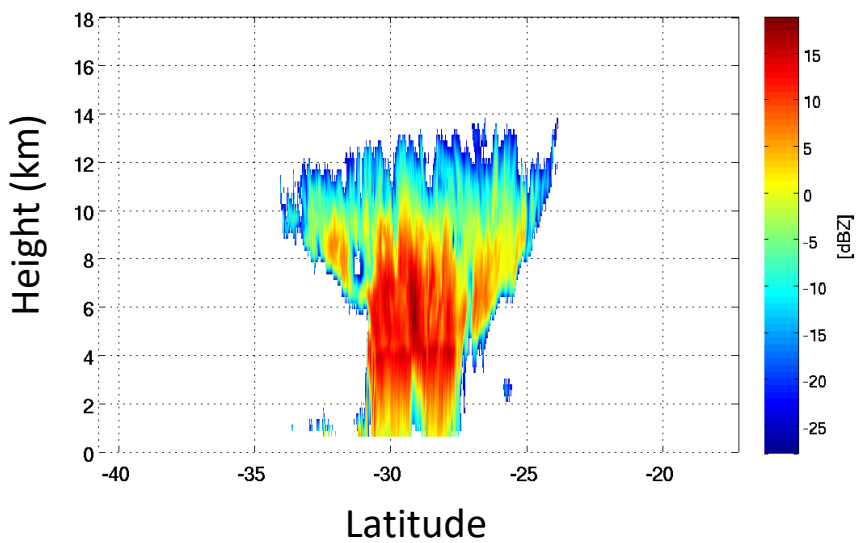
CC, Thick Cirrus, Thin Cirrus

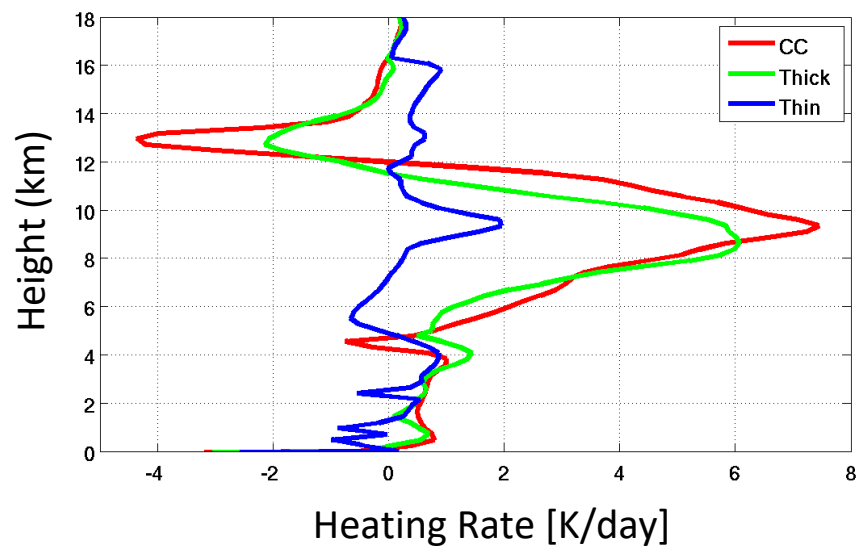


2B-FLXHR-LIDAR



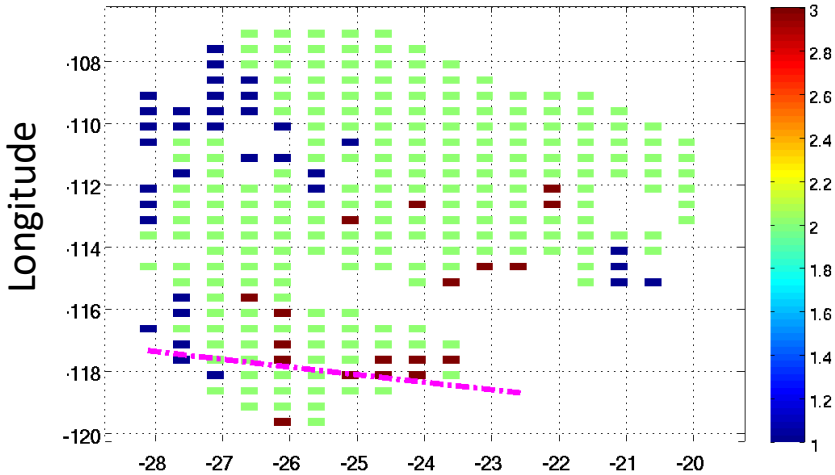
CloudSat



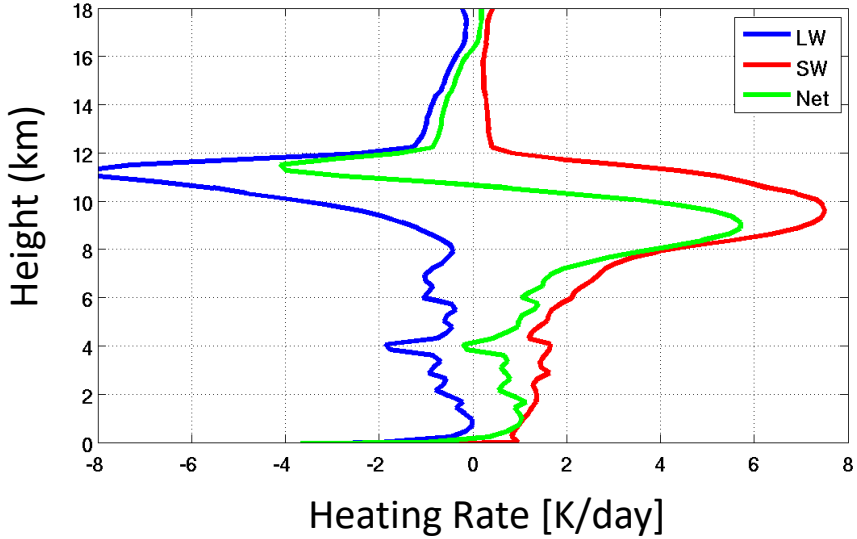


Conclusion and Discussion:

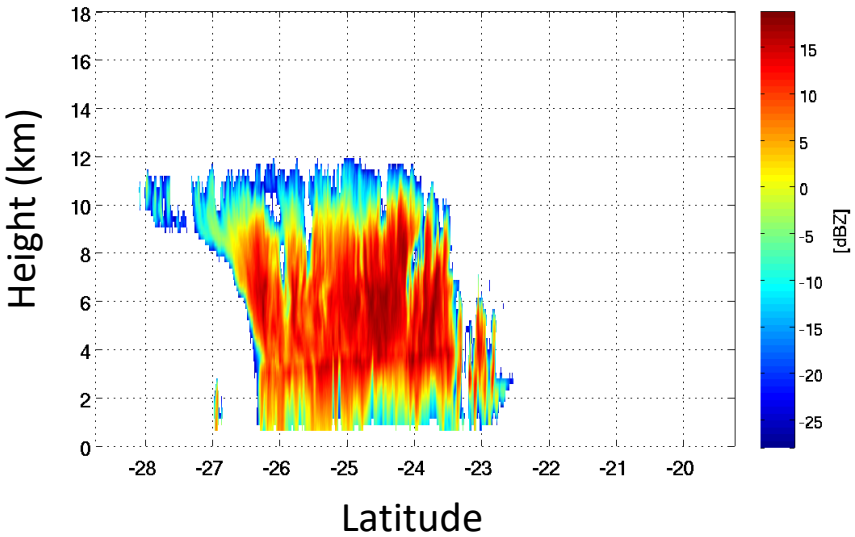
CC, Thick Cirrus, Thin Cirrus

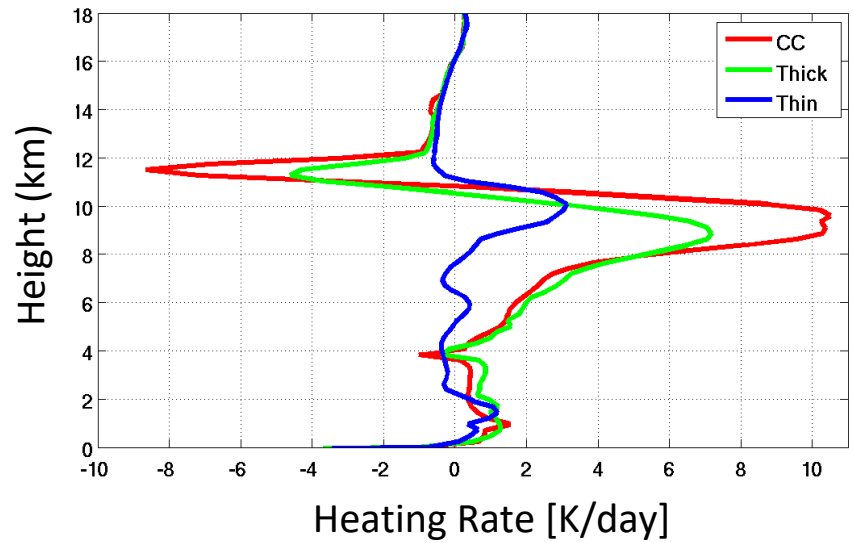


2B-FLXHR-LIDAR



CloudSat





References:

Futyan, J. M., and A. D. Del Genio, 2007: Deep convective system evolution over Africa and the tropical Atlantic, J. Clim., 20, 5041–5060.

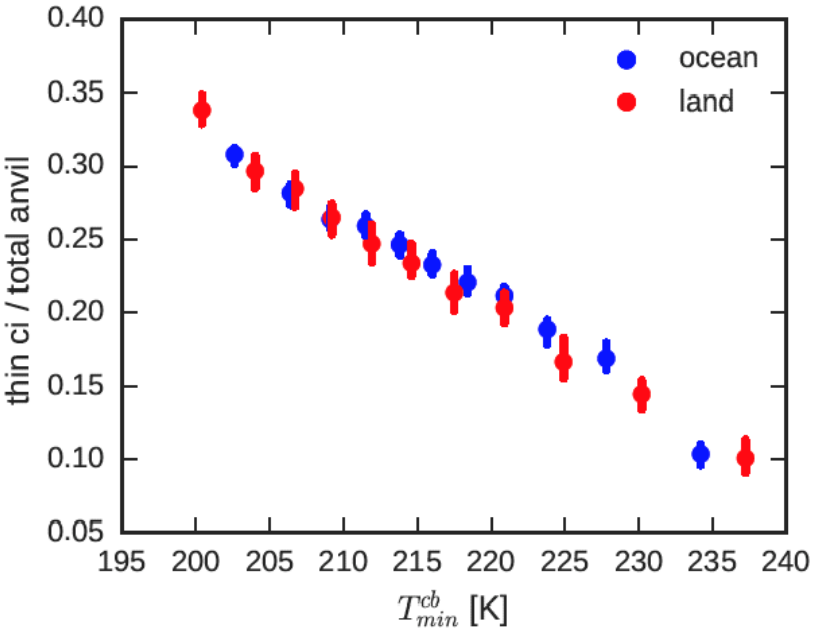
Takahashi, H. and Z. J. Luo, 2014: Characterizing Tropical Overshooting Convection from Joint Analysis of CloudSat and Geostationary Satellite Observations, J.Geophys. Res. Atmos., 119, 112-121, doi:10.1002/2013JD020972.

Takahashi, H. and Z. Luo, 2012: Where is the level of neutral buoyancy for deep convection? Geophys. Res. Letts., 39, L15809, doi:10.1029/2012GL052638

Protopapadaki, S. E., Stubenrauch, C. J., & Feofilov, A. G., 2017: Upper Tropospheric Cloud Systems Derived from IR Sounders: Properties of Cirrus Anvils in the Tropics. Atmos. Chem. Phys., 17, 3845–3859, doi:10.5194/acp-17-3845-2017

Motivation:

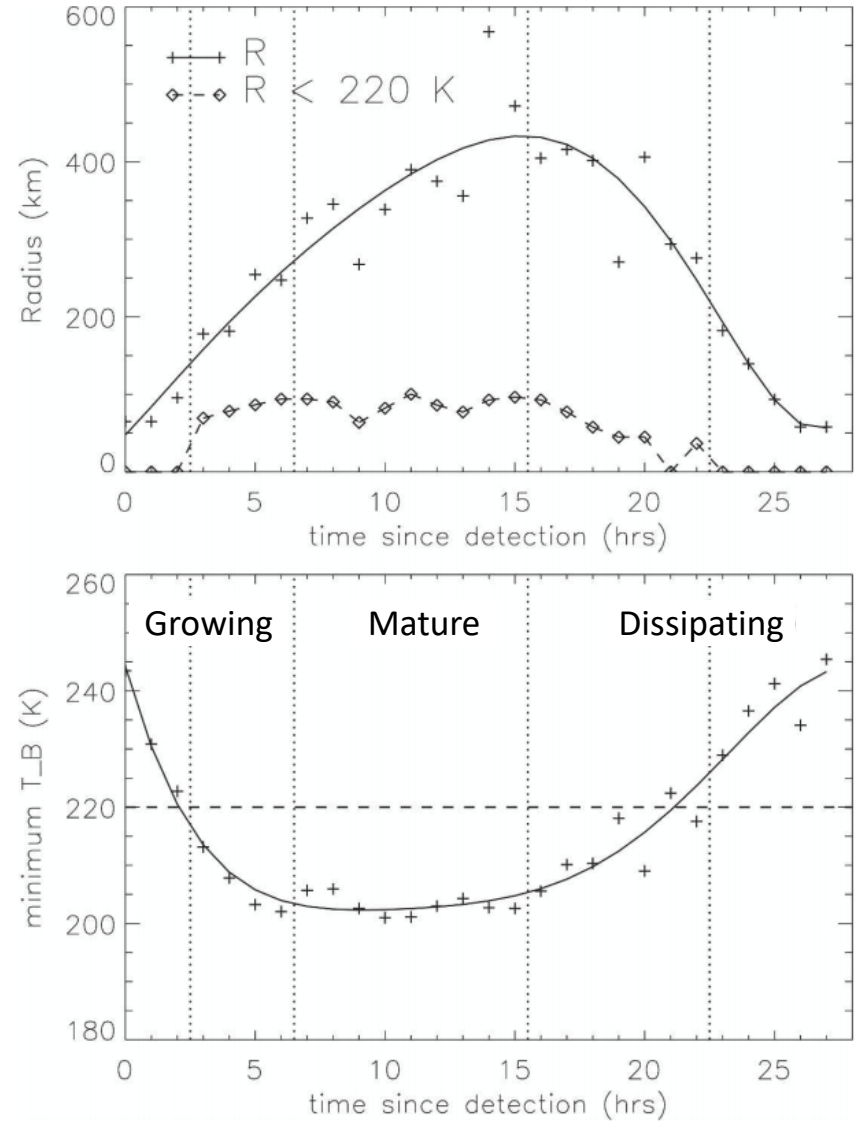
During Mature Stage
(fraction of CC btw 0.1-0.3%)



stronger → weaker

younger → older

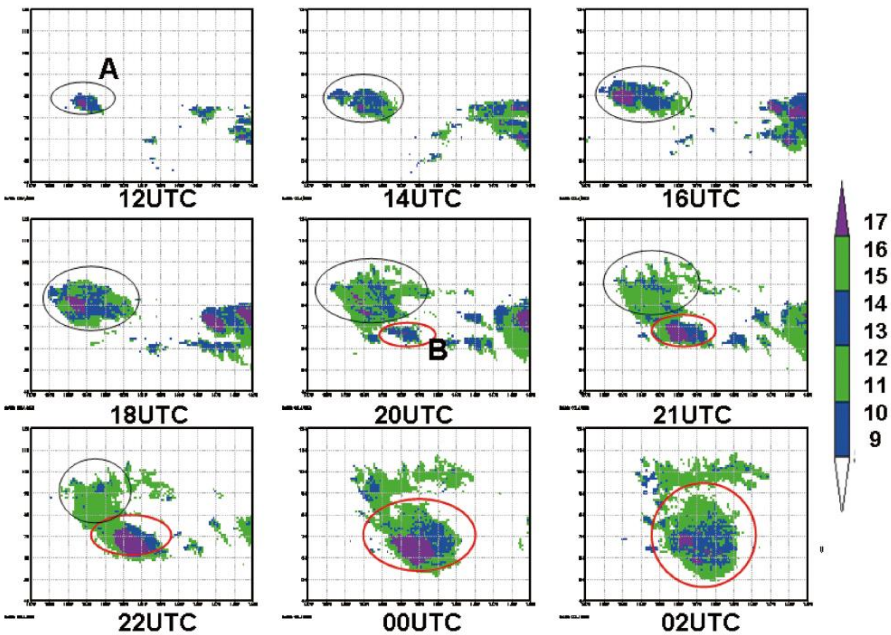
(Protopapadaki et al., 2017)

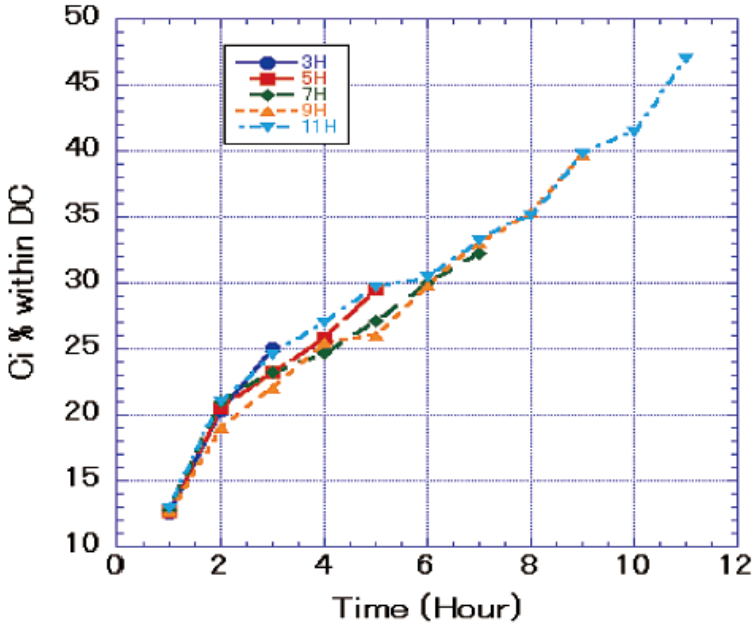


(Futyan and Del Genio., 2007)

Motivation:

Convective Core Cirrus

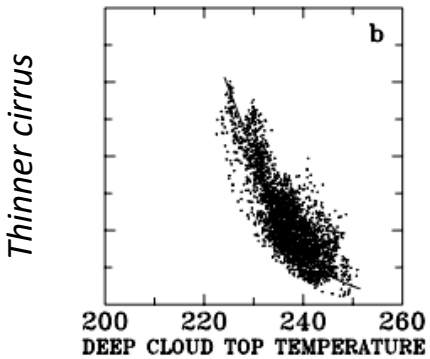




(Inoue et al., 2009)

- Cirrus fraction start to increase as the convective system ages.

Introduction: Convective Strength vs. Thin Cirrus from AIRS



(Chou and Neelin., GRL 1999)