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

GEWEX UTCC PROES

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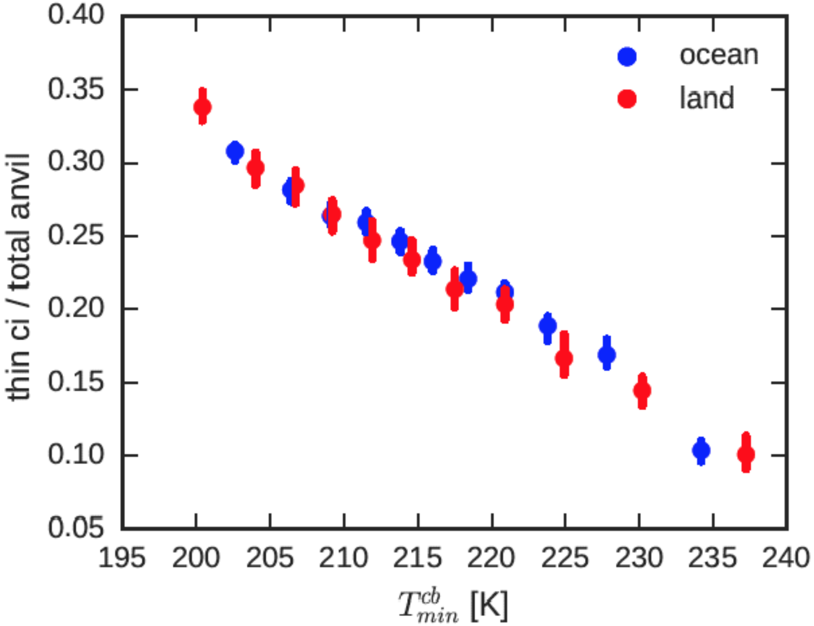
UCLA JIFRESSE

NASA Jet Propulsion Laboratory
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 (ε<0.5) increases as min CTT within convective core decreases.

(Protopapadaki et al., ACP 2017)

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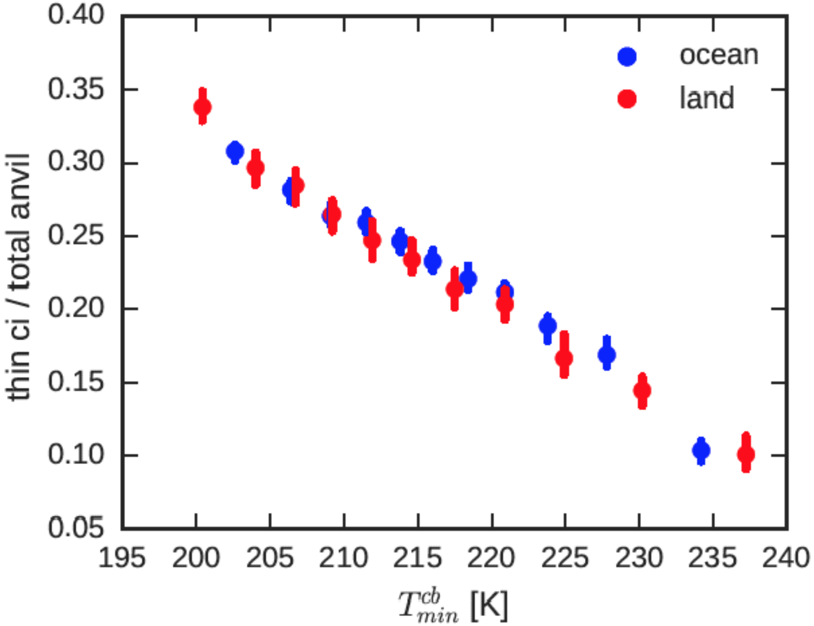

stronger → weaker

(Protopapadaki et al., ACP 2017)

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

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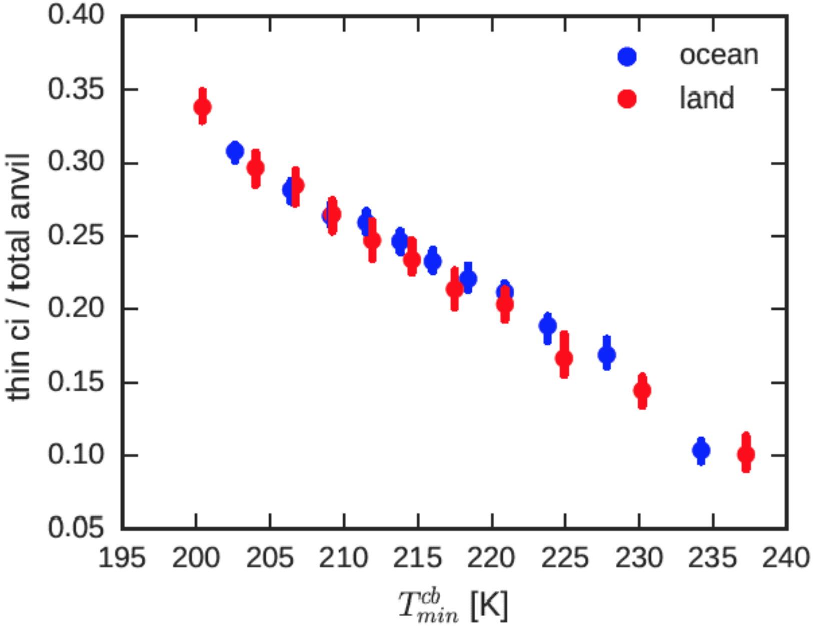

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- Stronger convective cores associated with larger fraction of thin cirrus coverage.

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

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 AIRS-CloudSat-ISCCPCT to find “Mature Stages”

During Mature Stage
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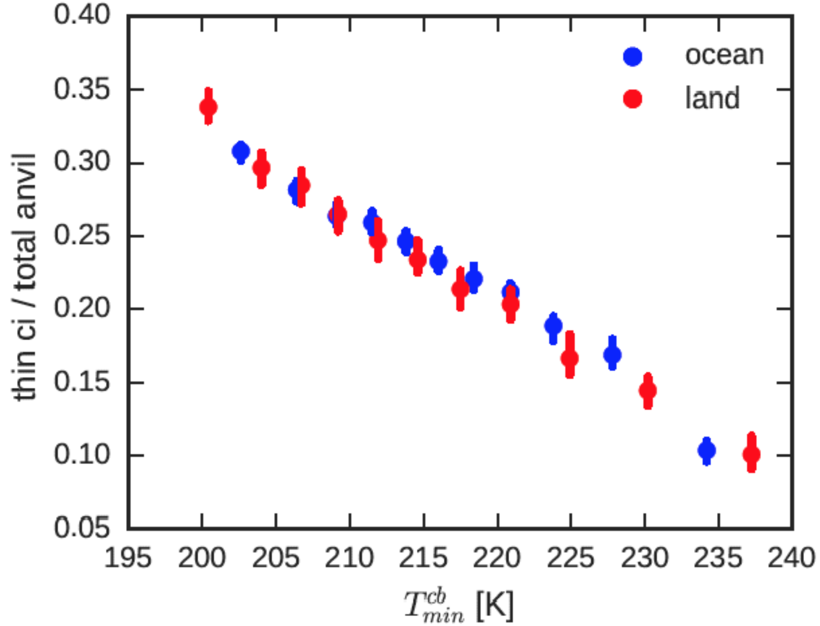

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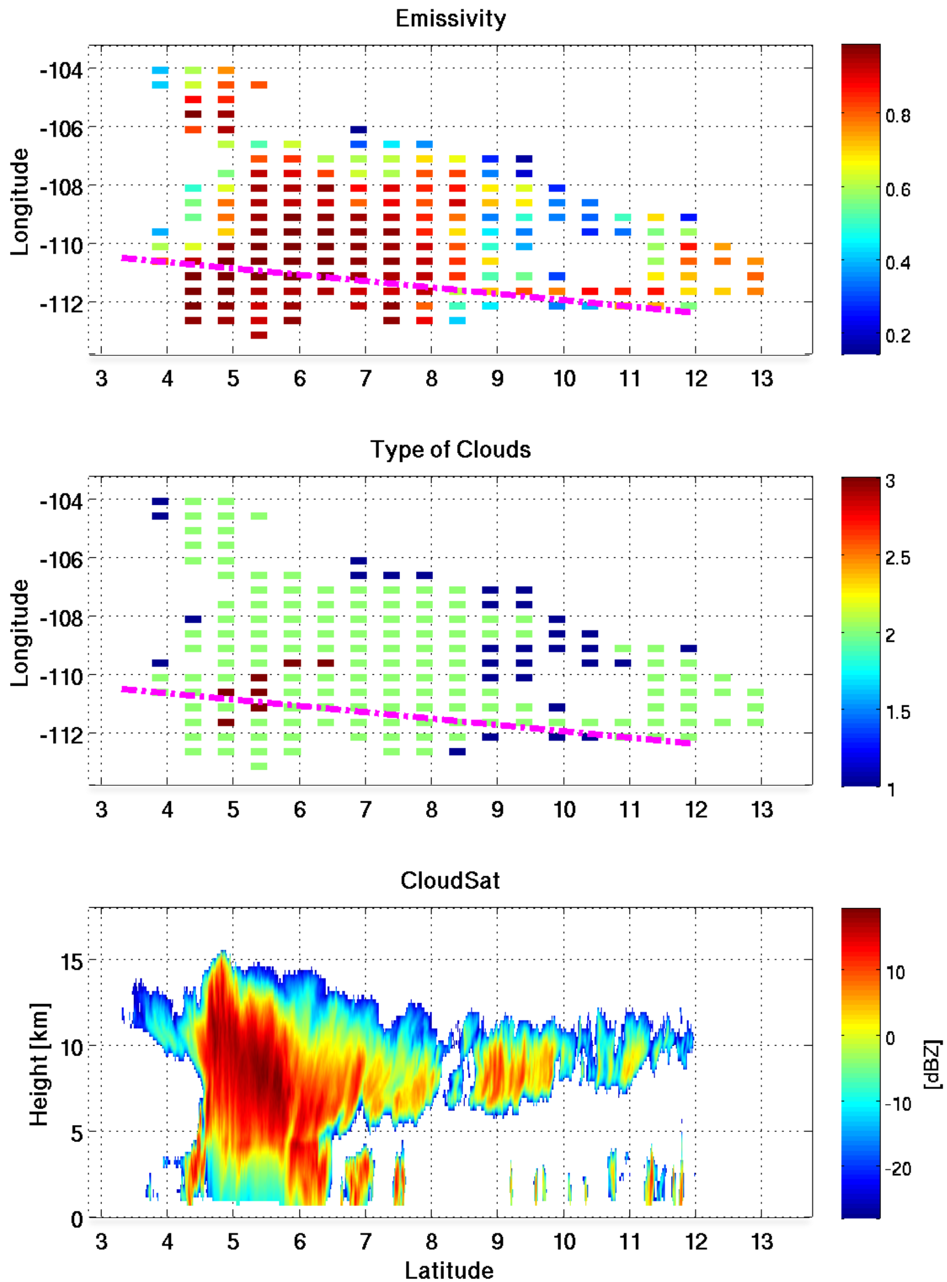
Can we see similar tendency based on AIRS-CloudSat?

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

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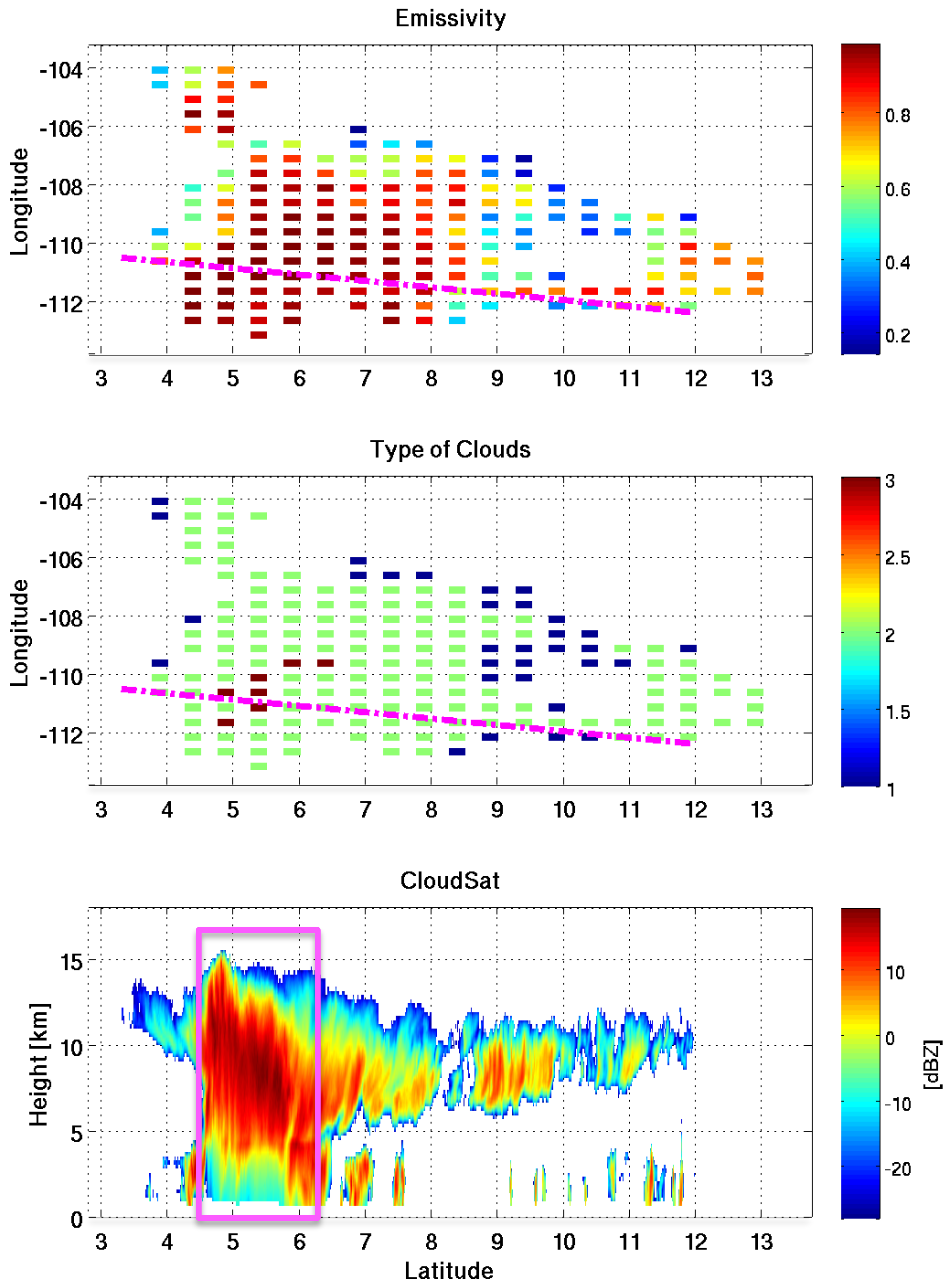
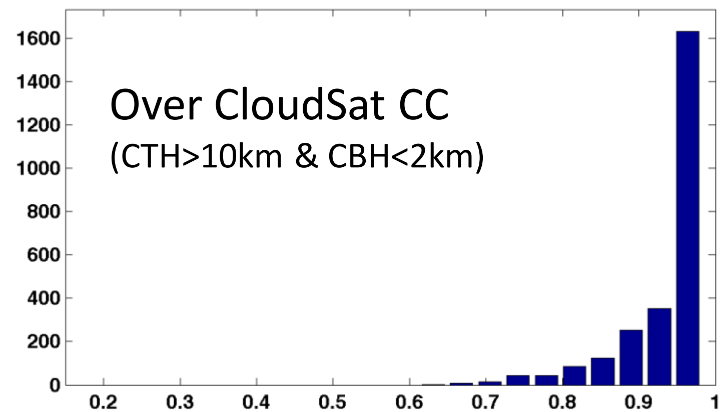


Cumulative Histogram



AIRS Emissivity

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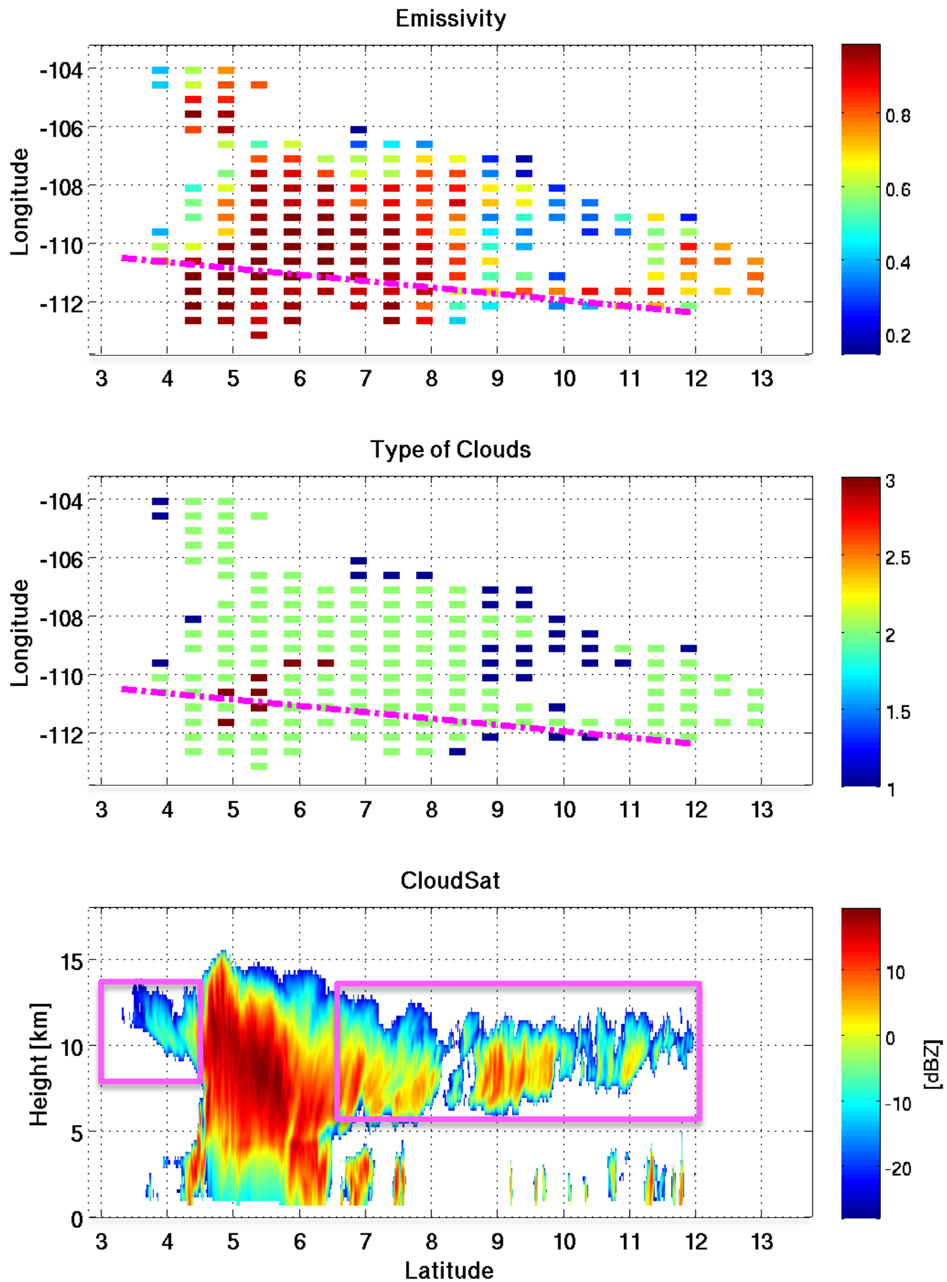

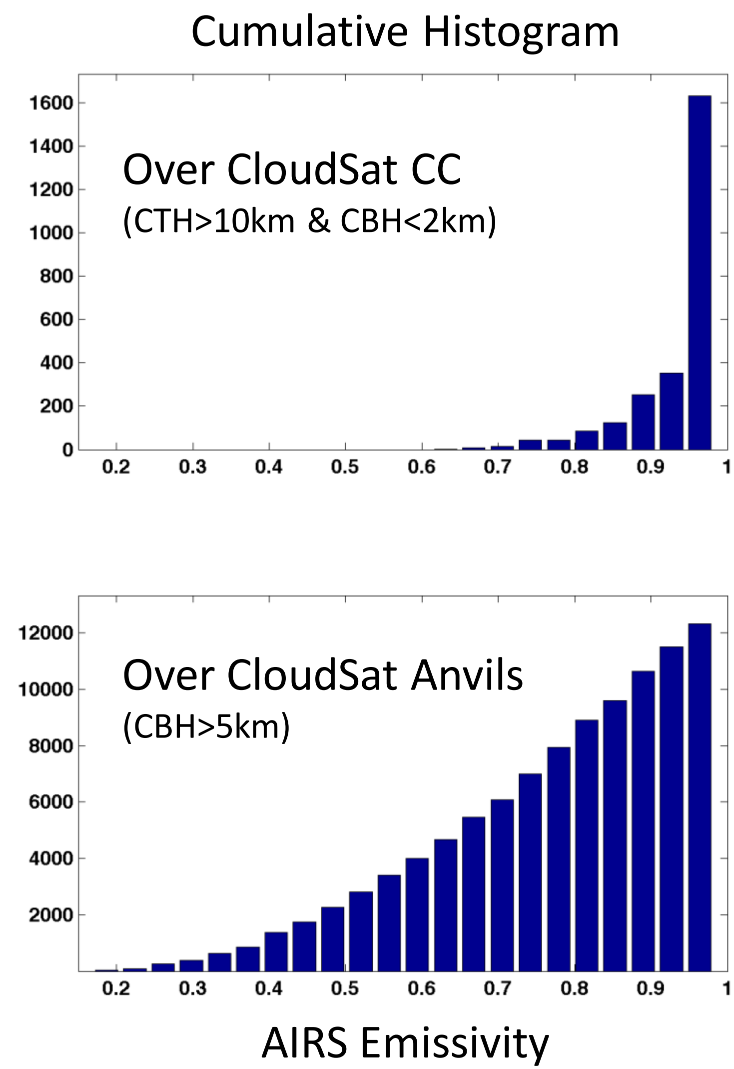

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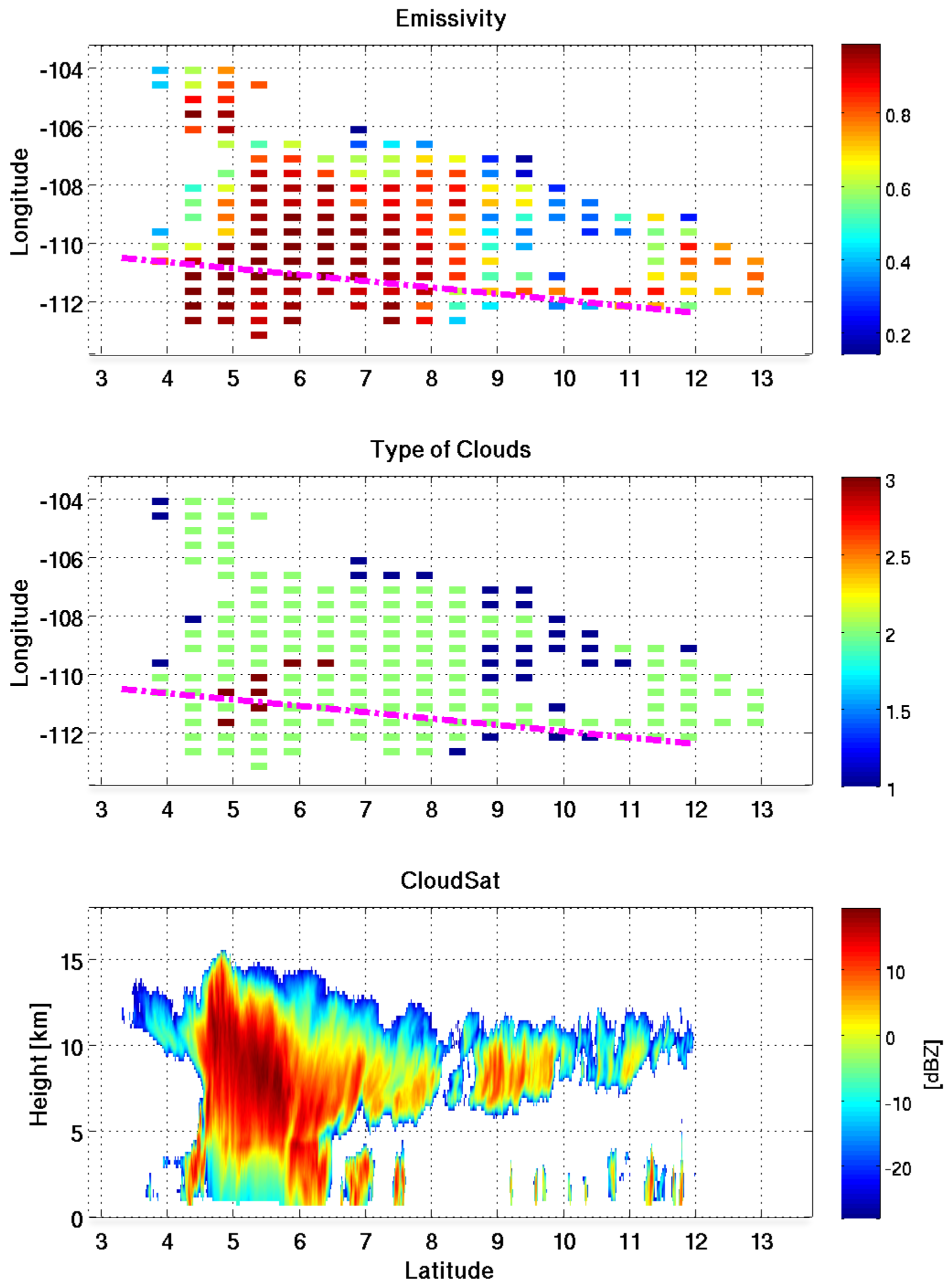

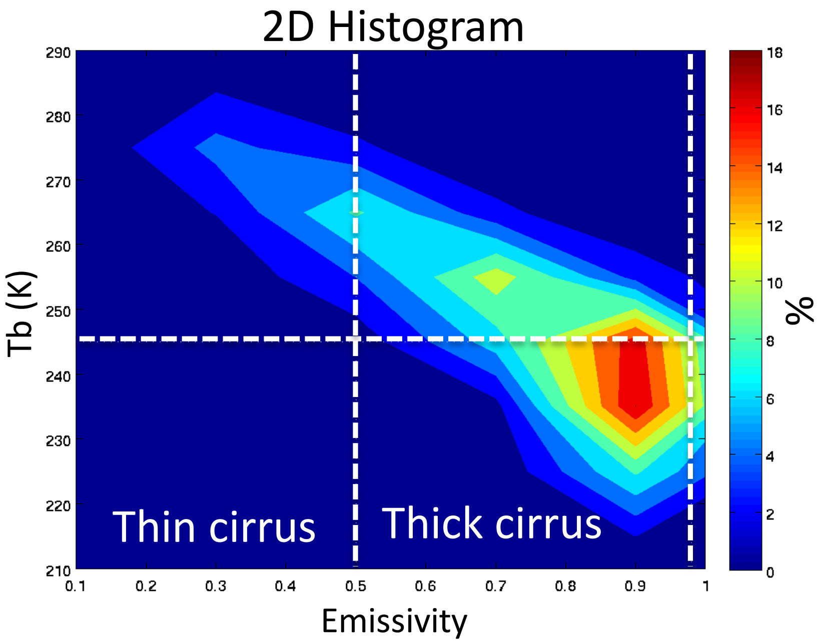

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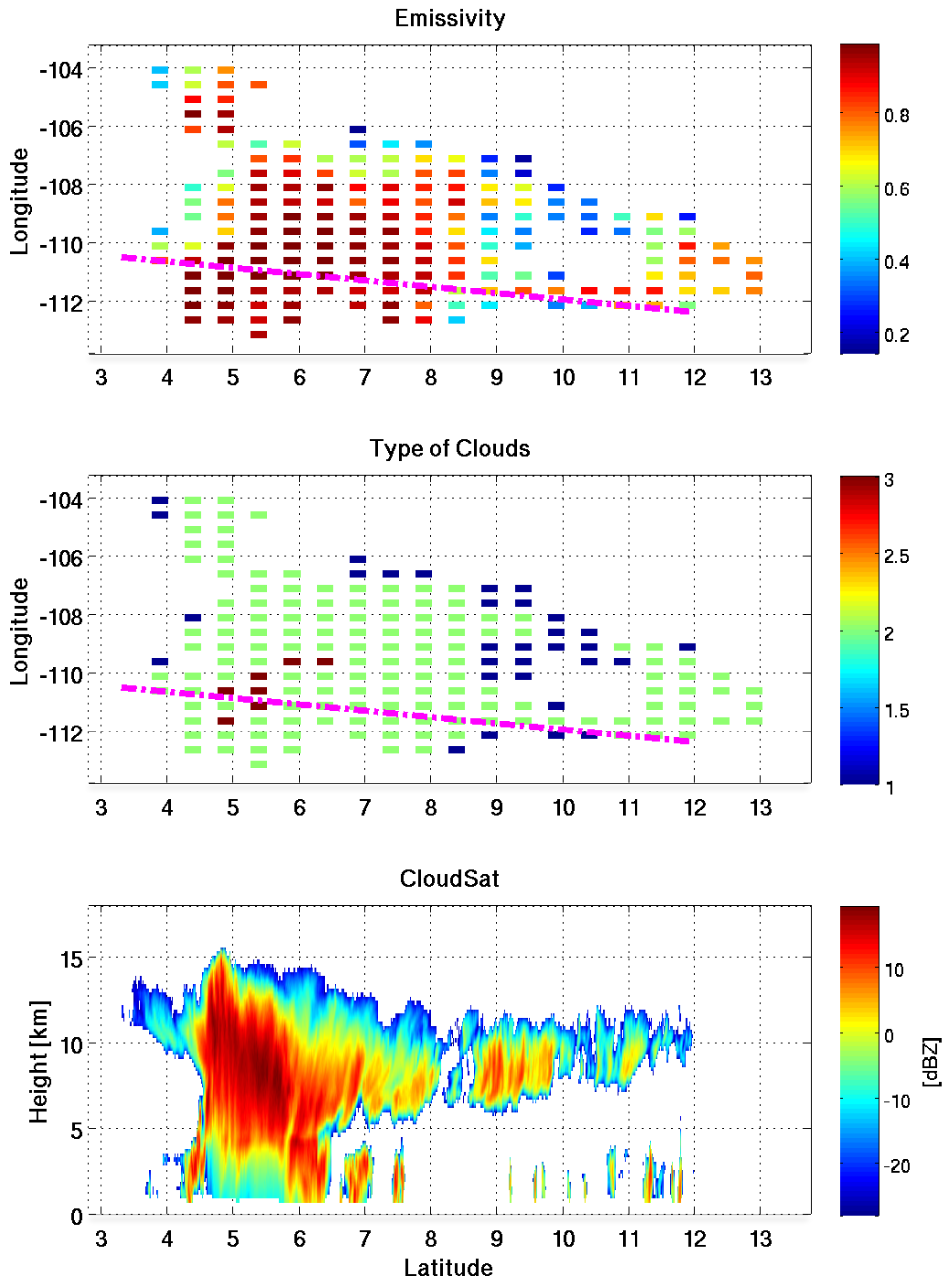
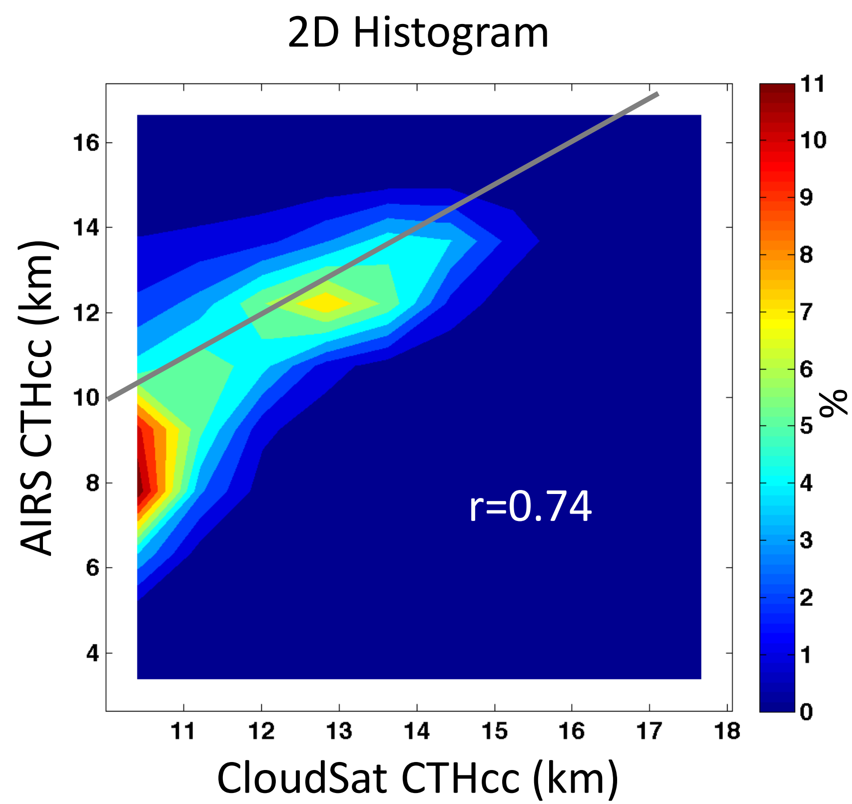




2. Compare Different Proxies of Convective Strength

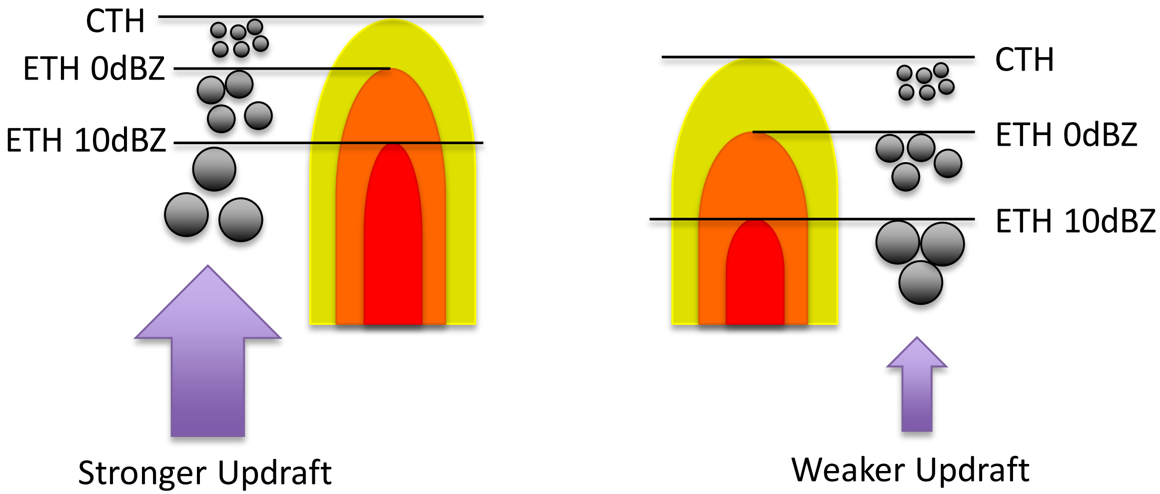
AIRS: T_{min} within convective core (CC)

CloudSat:

CC: CTH>10km & CBH<2km

Proxies: ETH 0dBZ & ETH 10dBZ with in CC

Higher ETH = Stronger Convective Core



Takahashi and Luo (JGR 2014)

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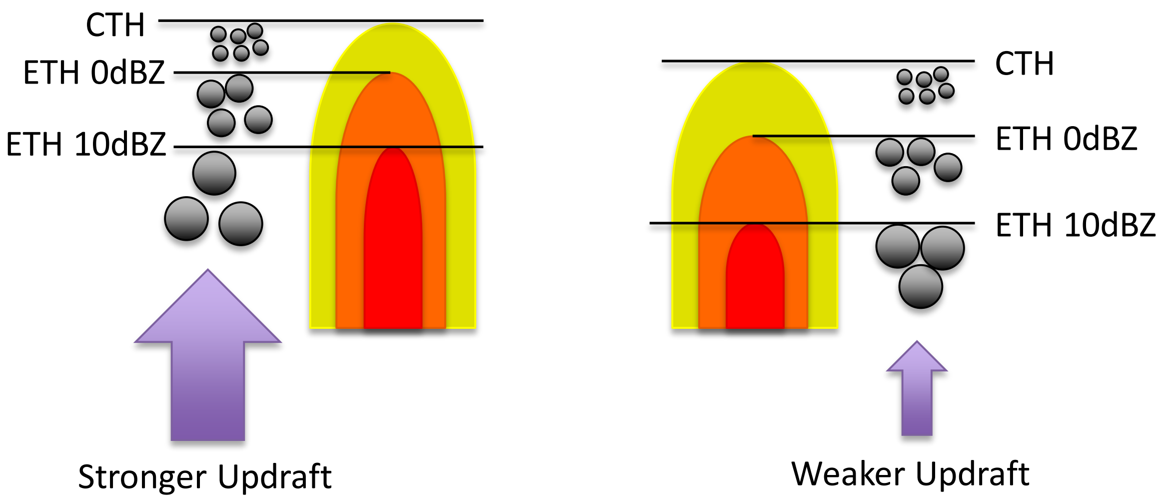

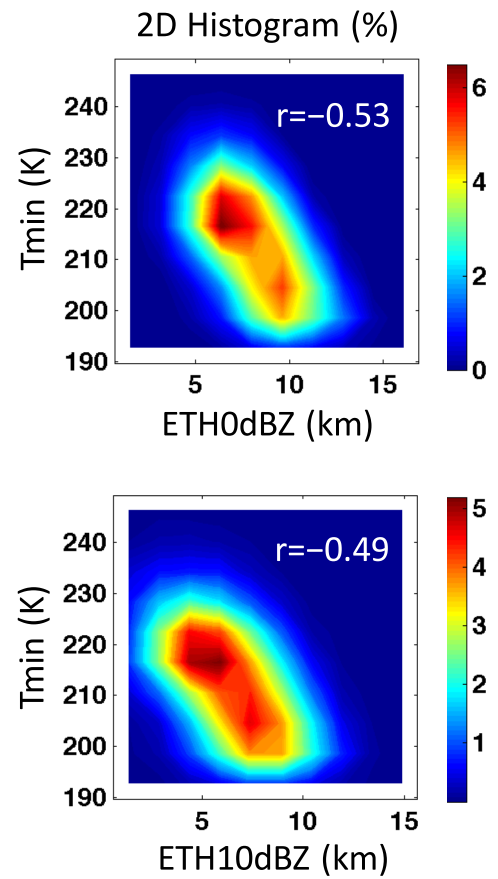

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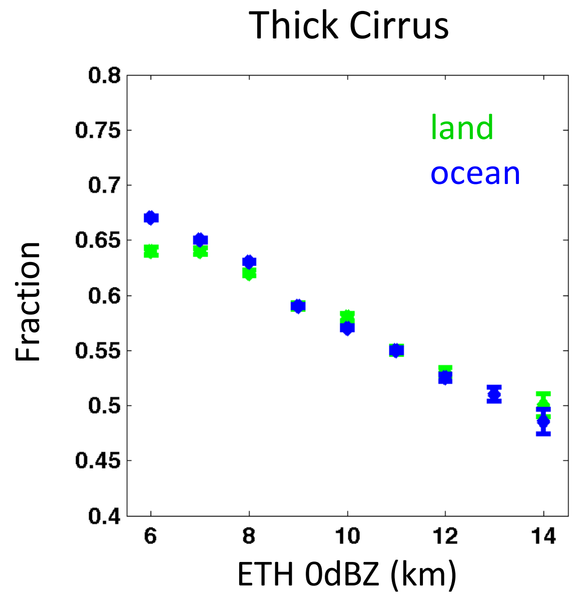

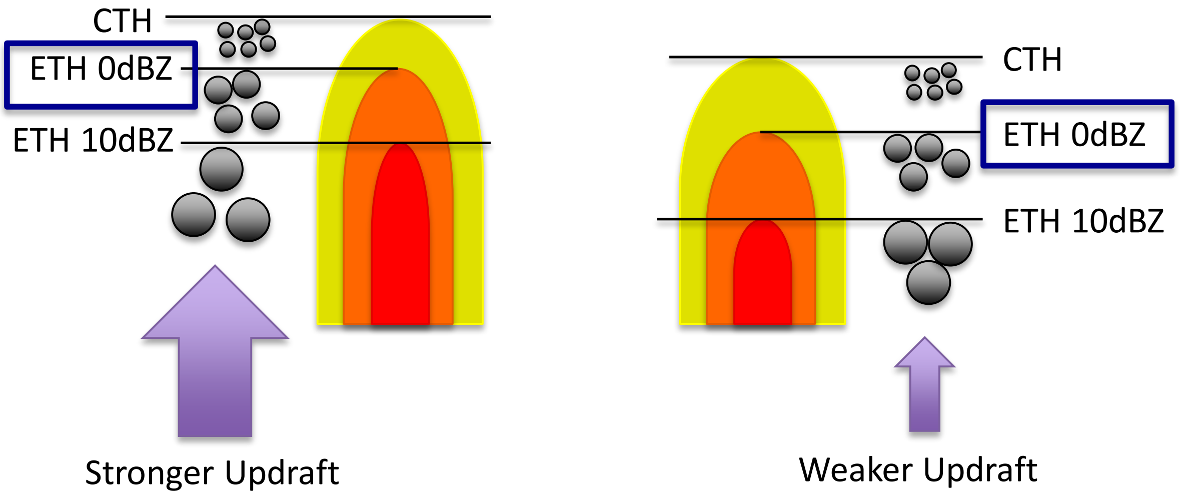

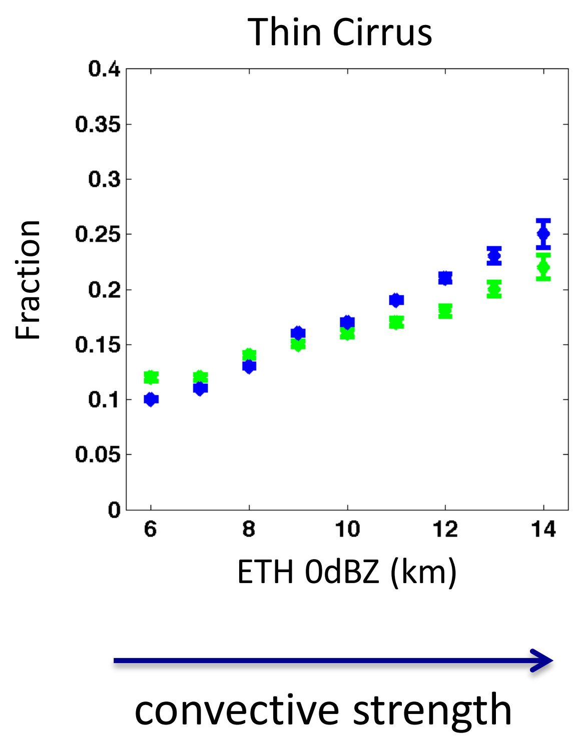

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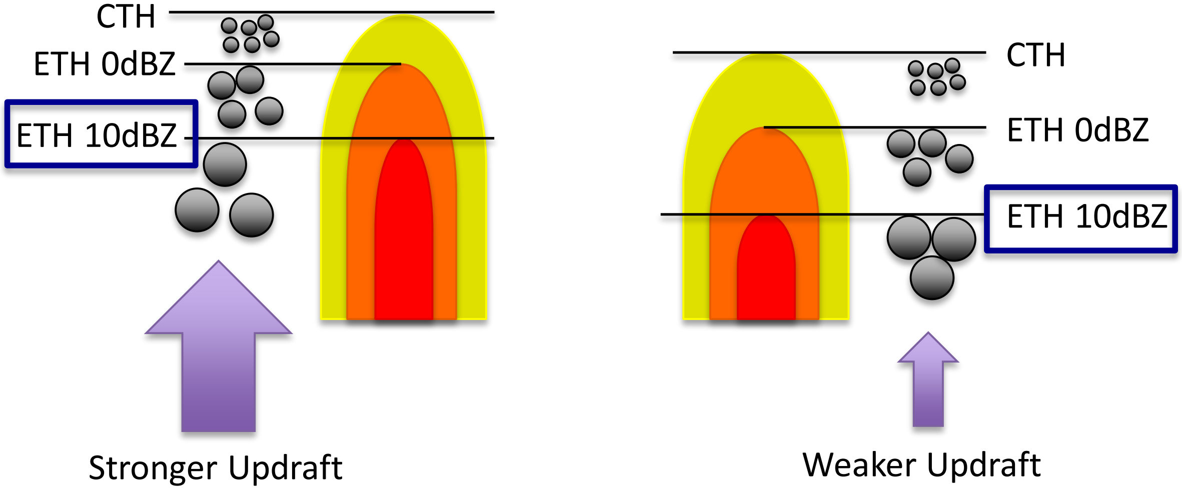

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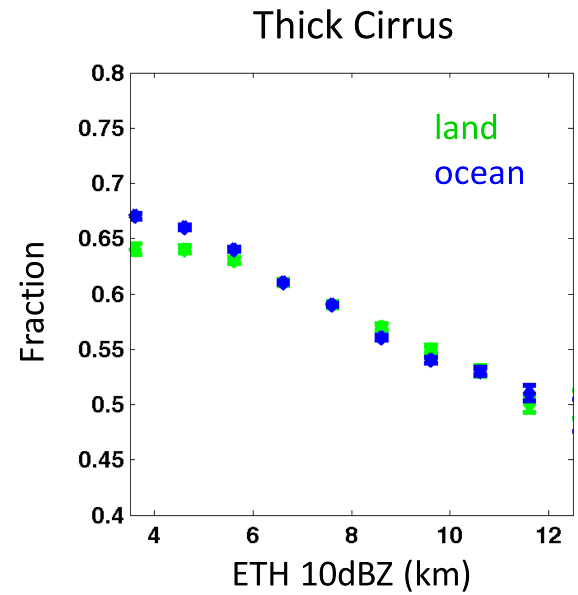

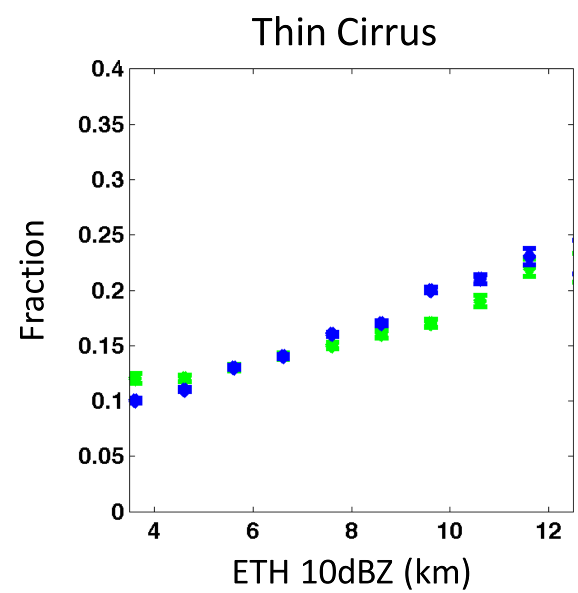

convective strength

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CloudSat:

Proxy: Level of Neutral Buoyancy (LNB)

- LNB_CTH: The highest detrainment level
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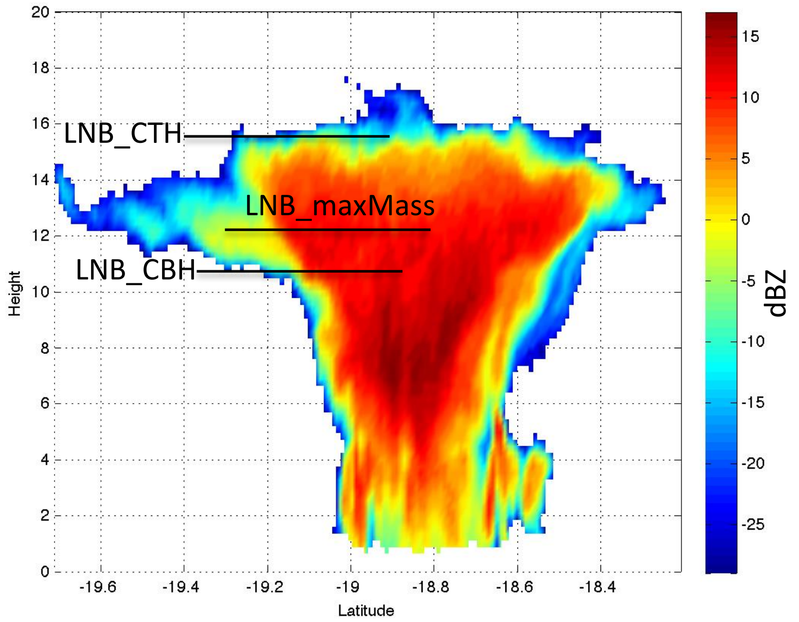

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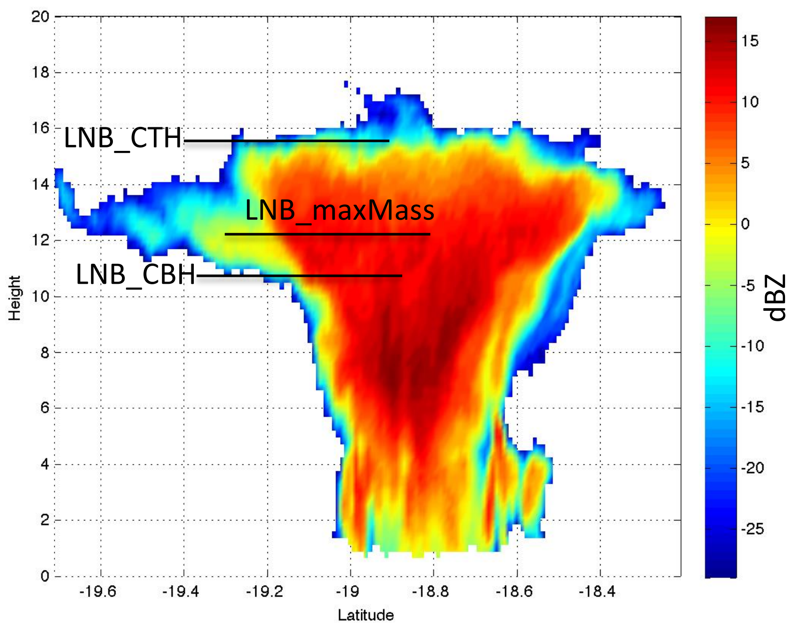
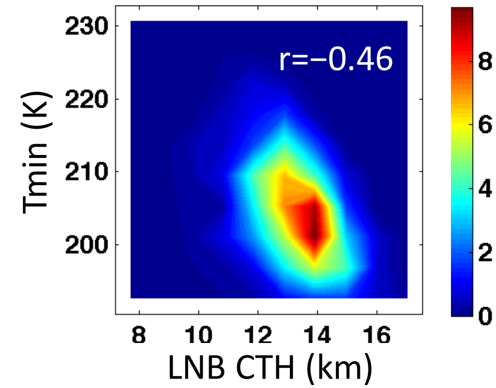
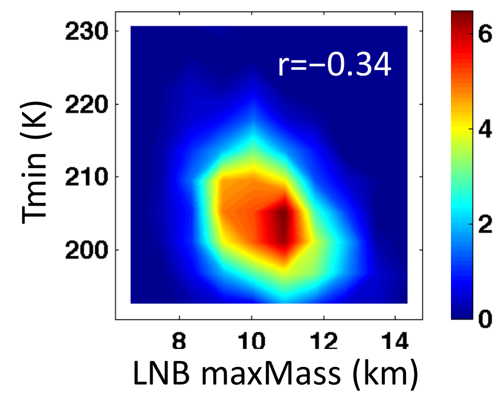
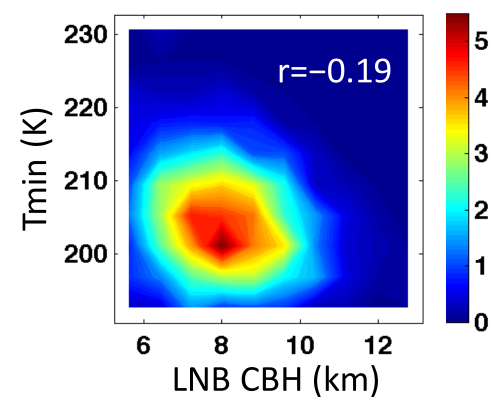


2D Histogram (%)







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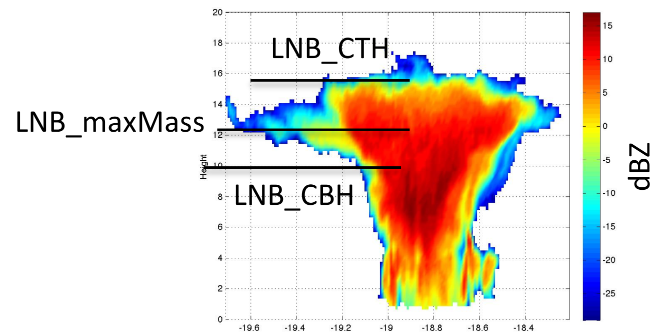
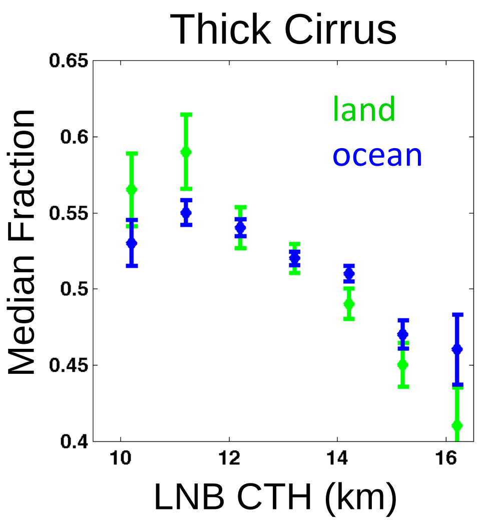
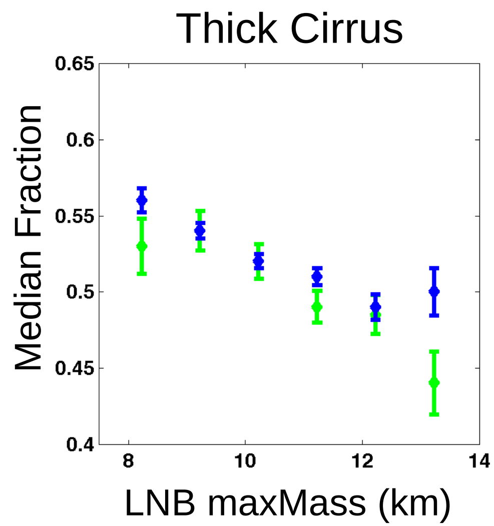
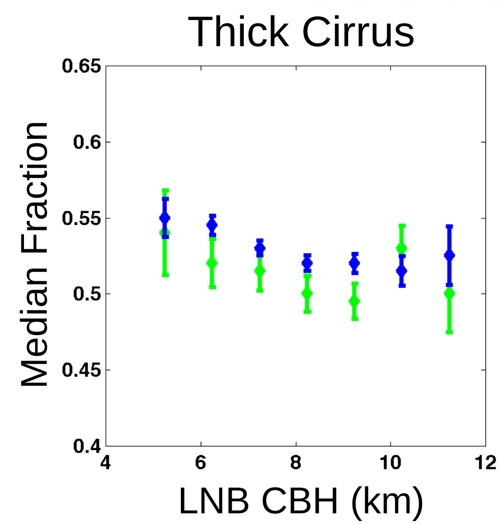
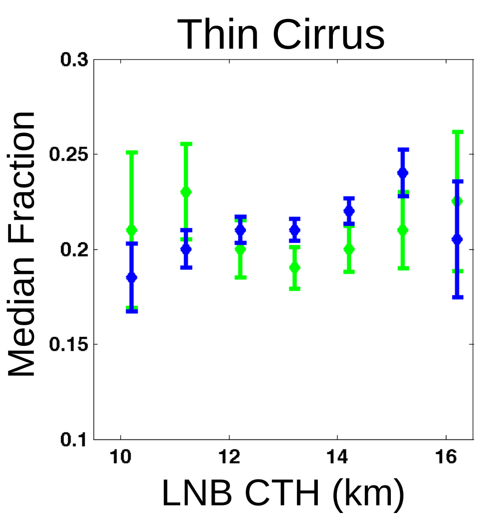
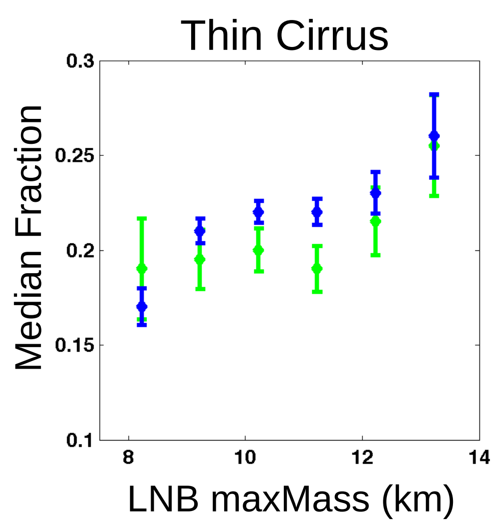


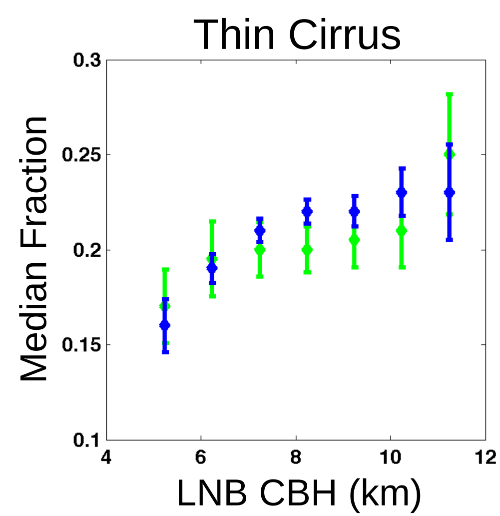












3. Definition of Stages

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

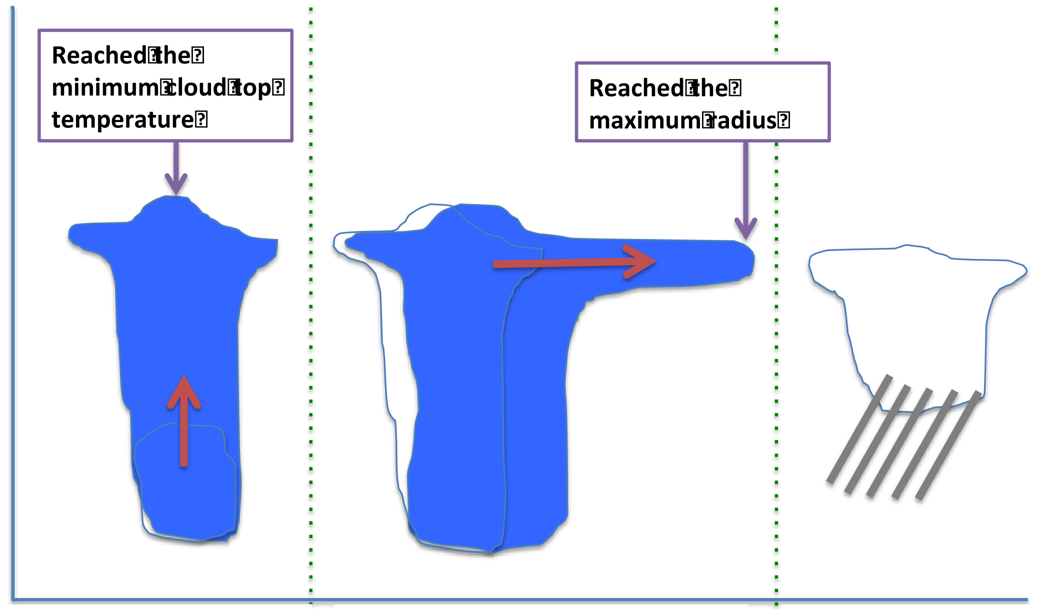
CloudSat: Collocate with ISCCPCT

Growing: Before reaching the min TB

Mature: Between growing and dissipating

Dissipating: After reaching the max radius

(Futyan and Del Genio, J Clim 2007)



Growing Stage: Period of vertical growth

Mature Stage: Period of horizontal expansion

Dissipating Stage: Period of decaying

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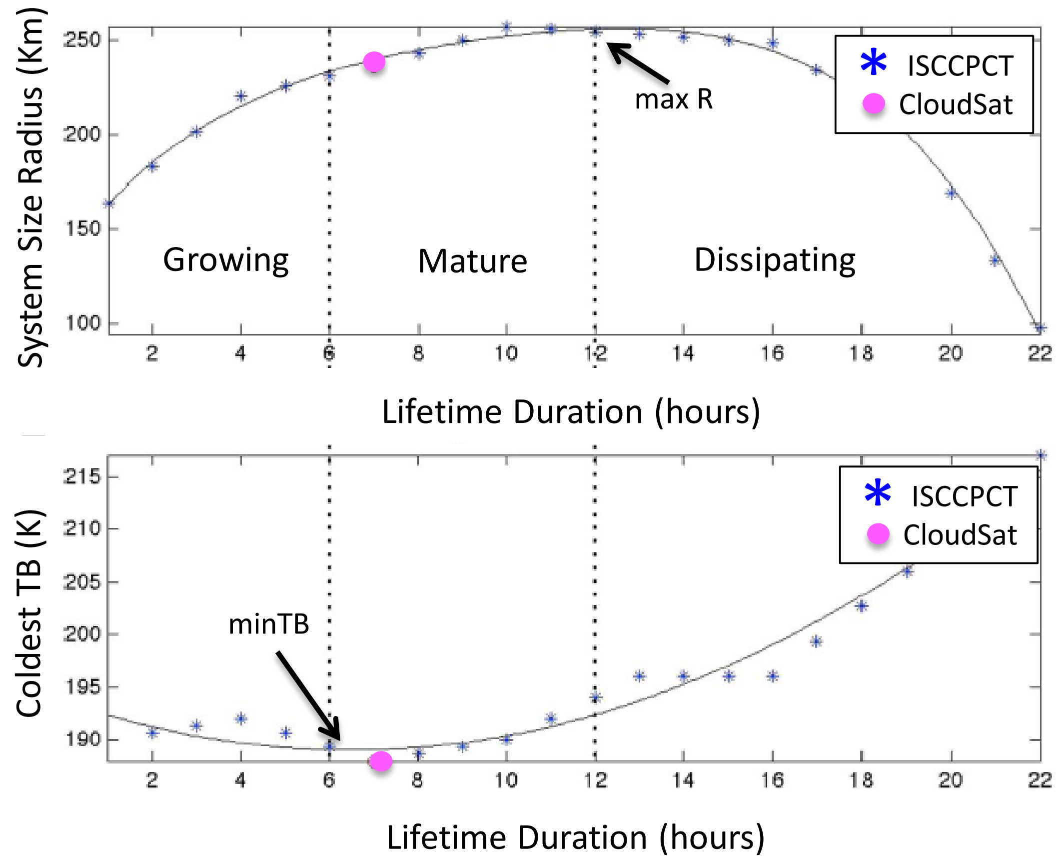

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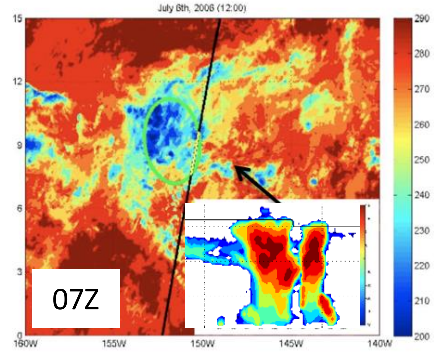

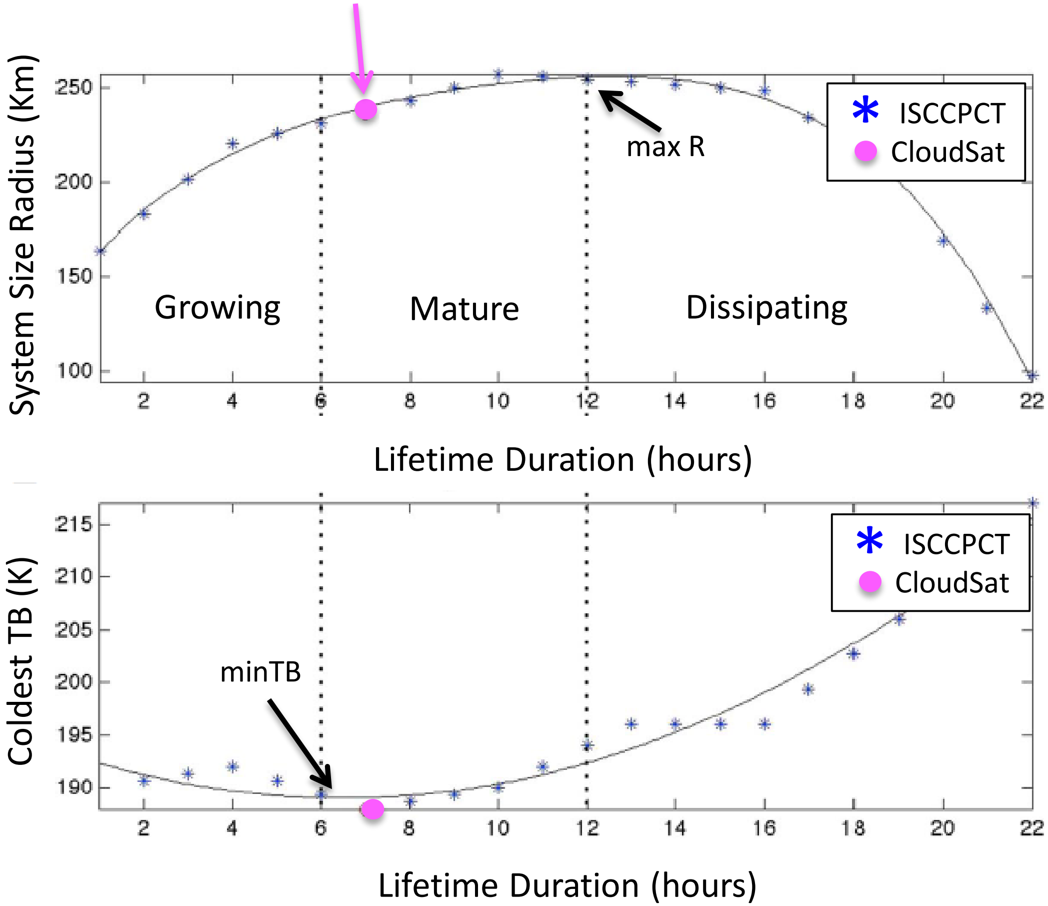

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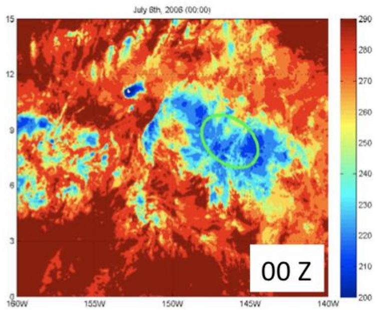

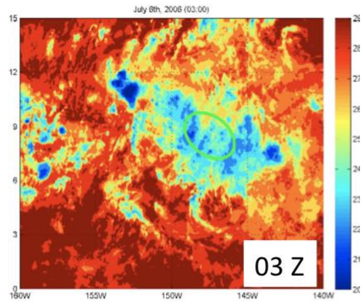

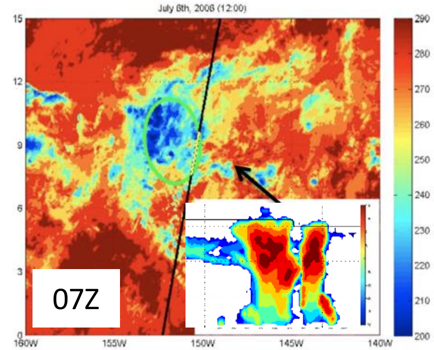

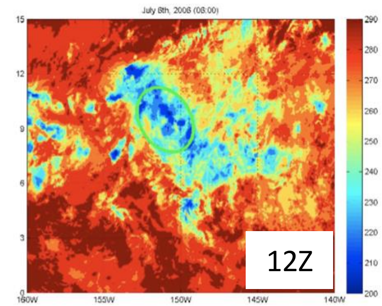

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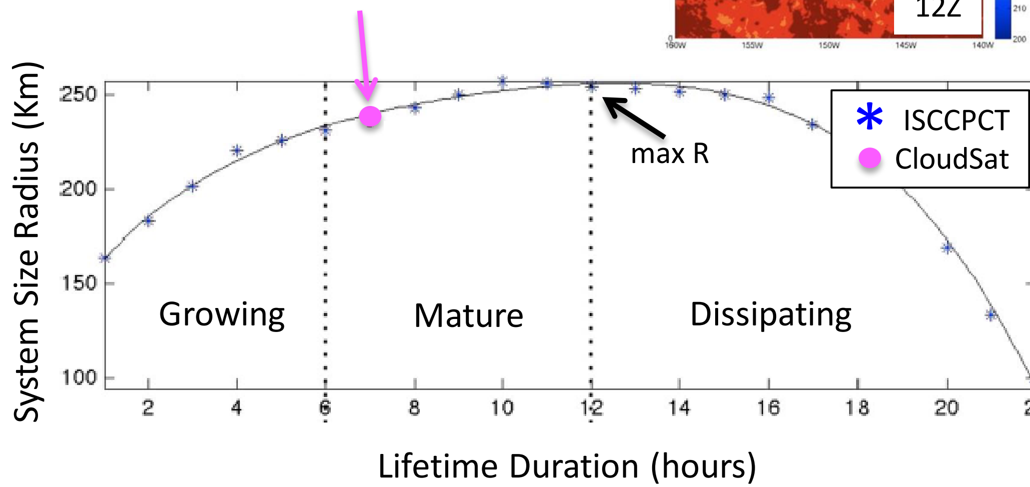

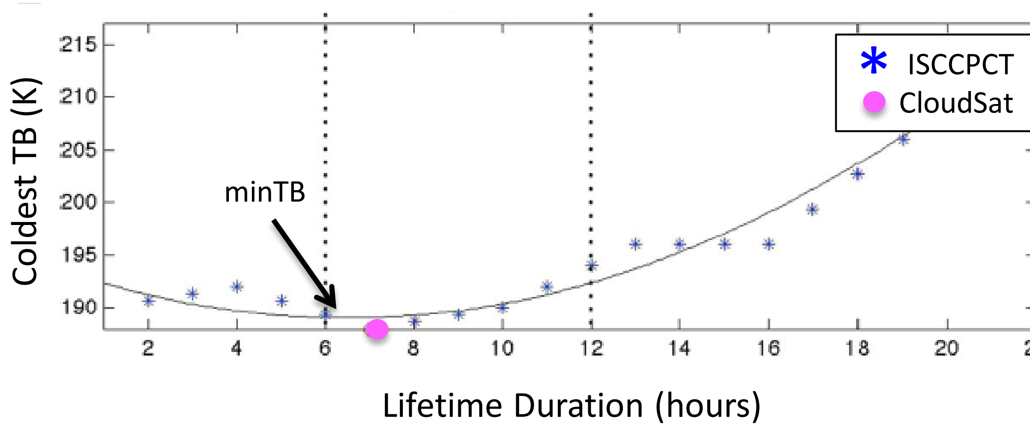

Takahashi and Luo (JGR 2014)

3. Definition of Stages

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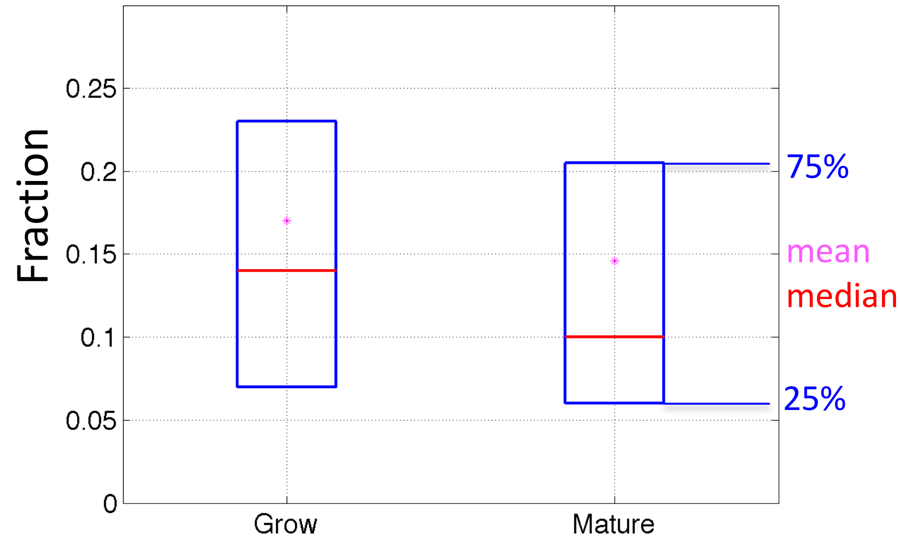
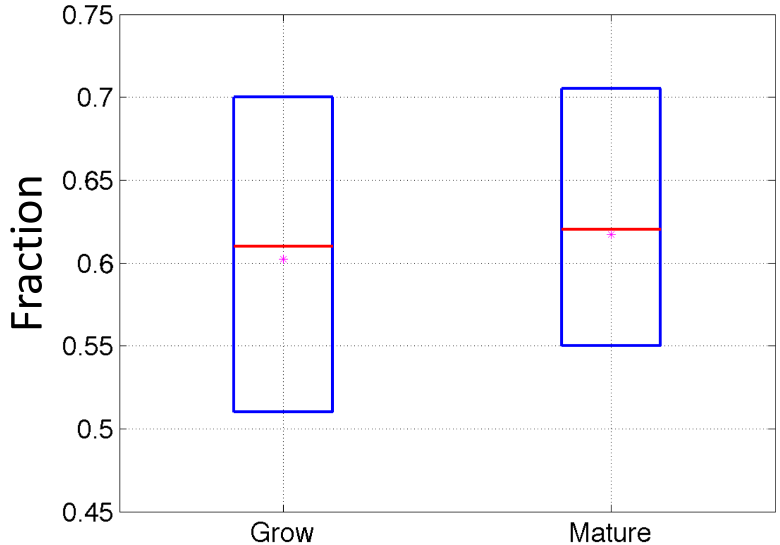
CloudSat: Collocate with ISCCPCT

- CC decreases and Cirrus increases as cloud ages.

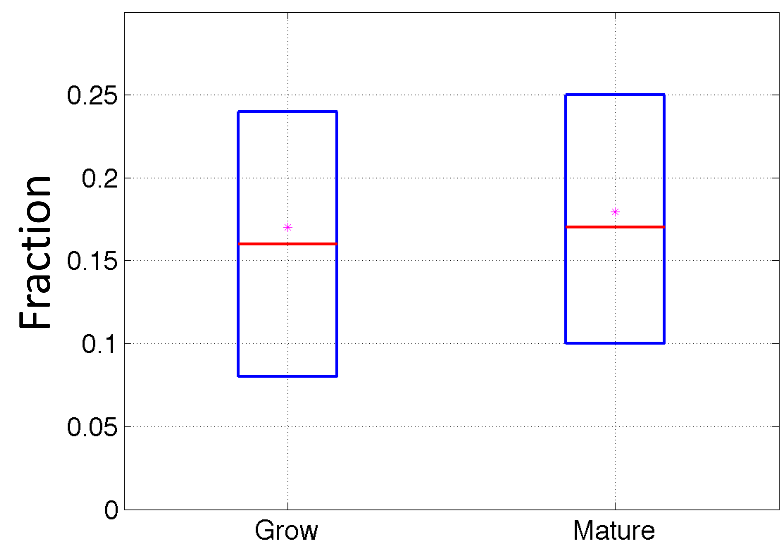
Convective Core (ε>0.98)



Thick Cirrus (0.5<ε<0.98)



Thin Cirrus (ε<0.5)



3. Definition of Stages

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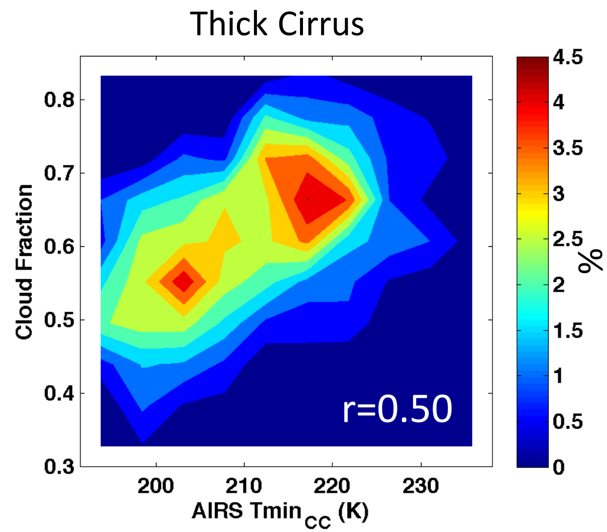
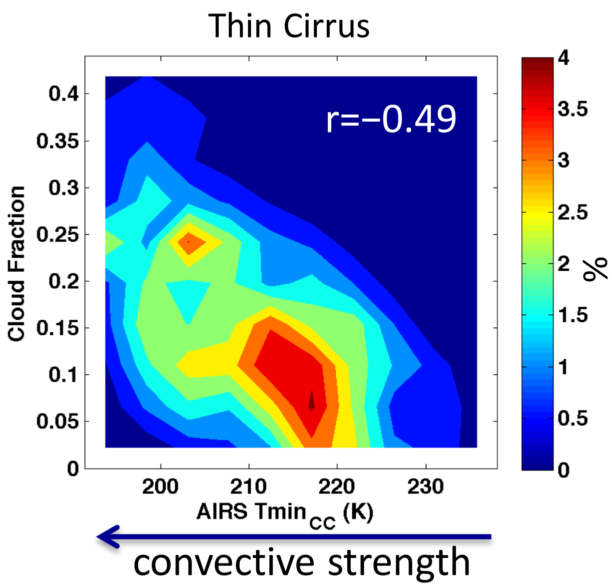
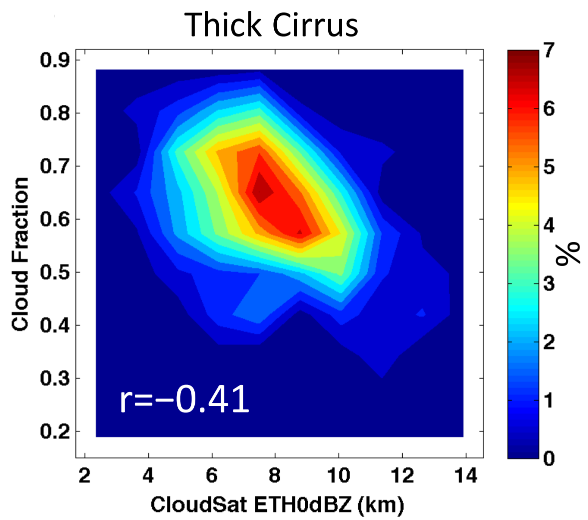
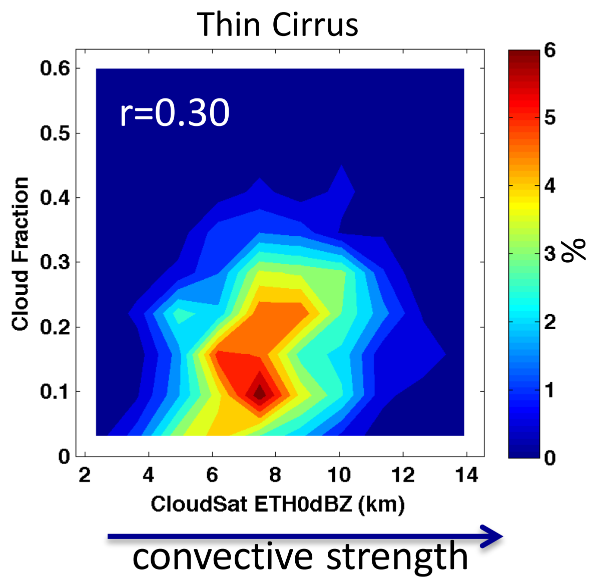
(CC frac bw 0.1-0.3)





Mature
(CloudSat+ISCCPCT)





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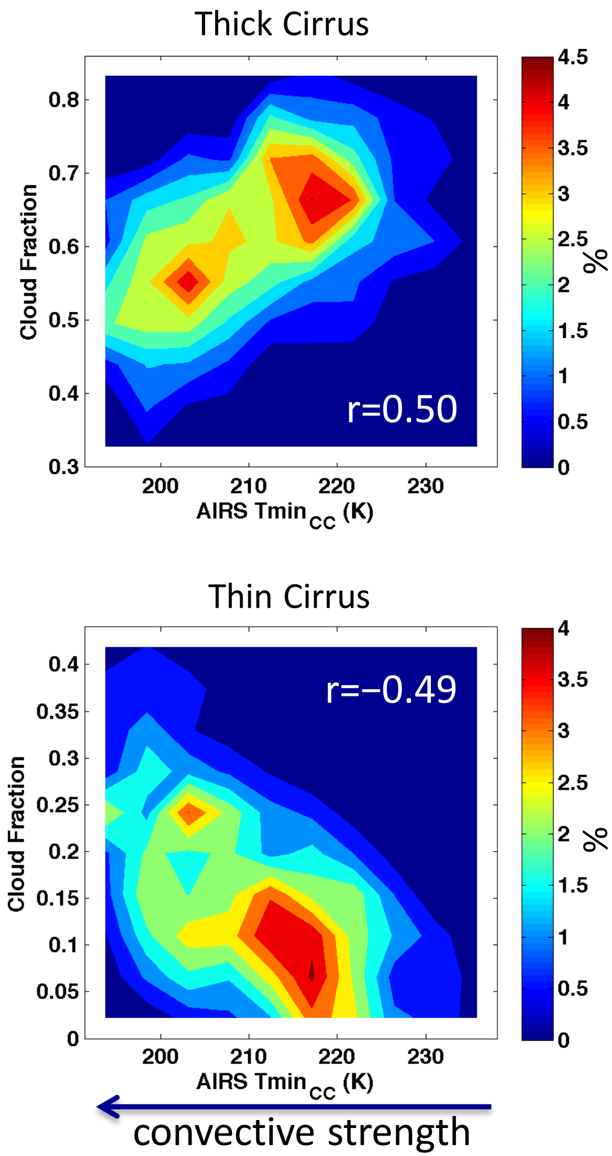

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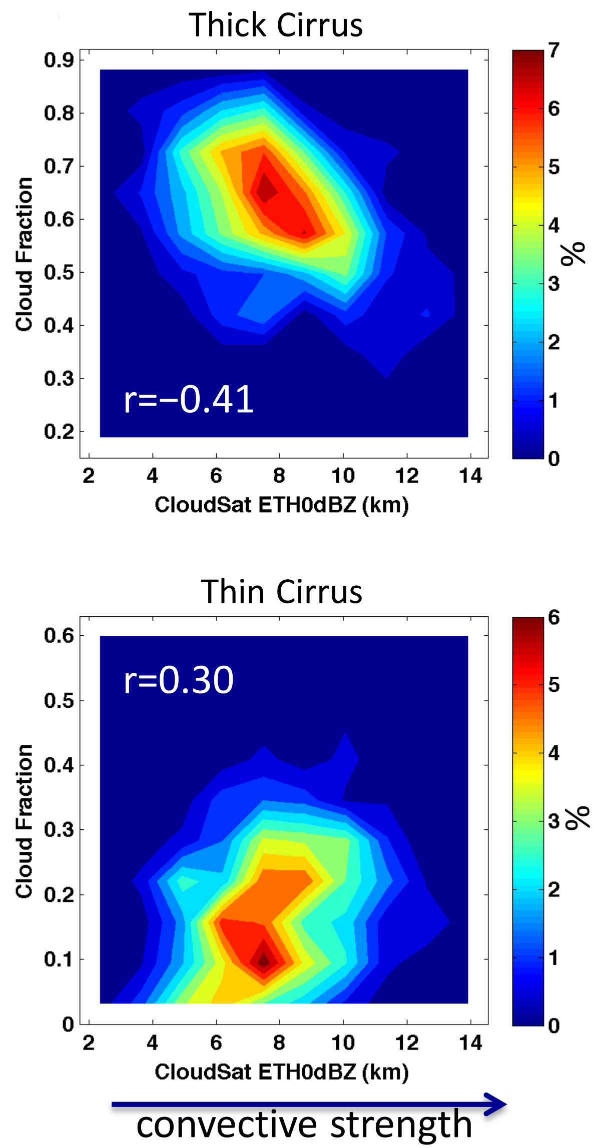
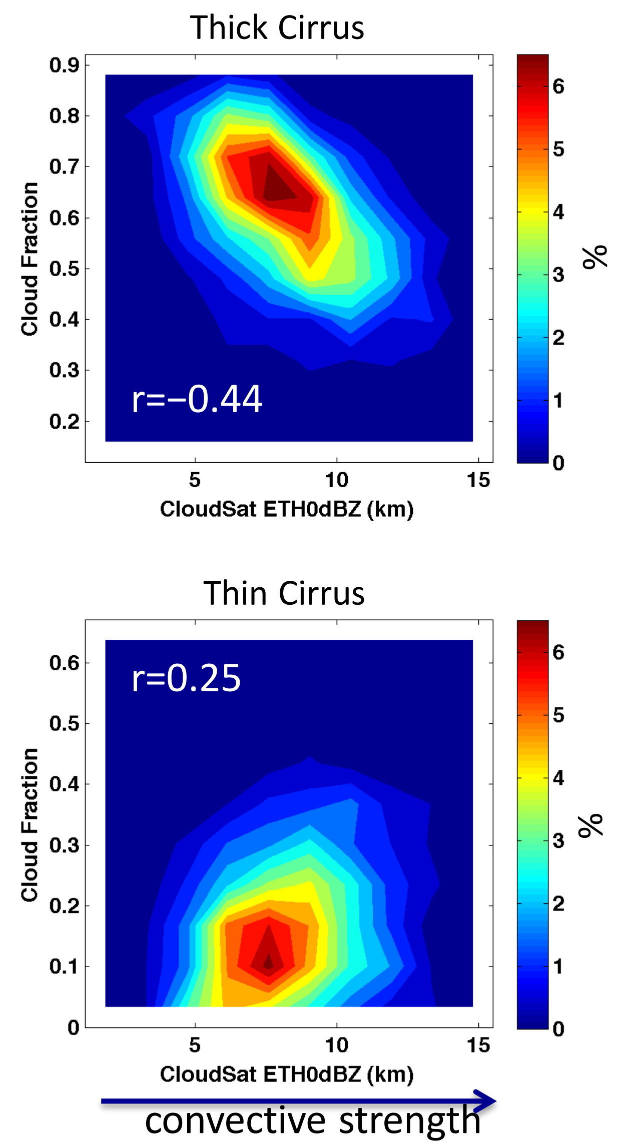


Growing
(CloudSat+ISCCPCT)



Conclusion and Discussion:

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

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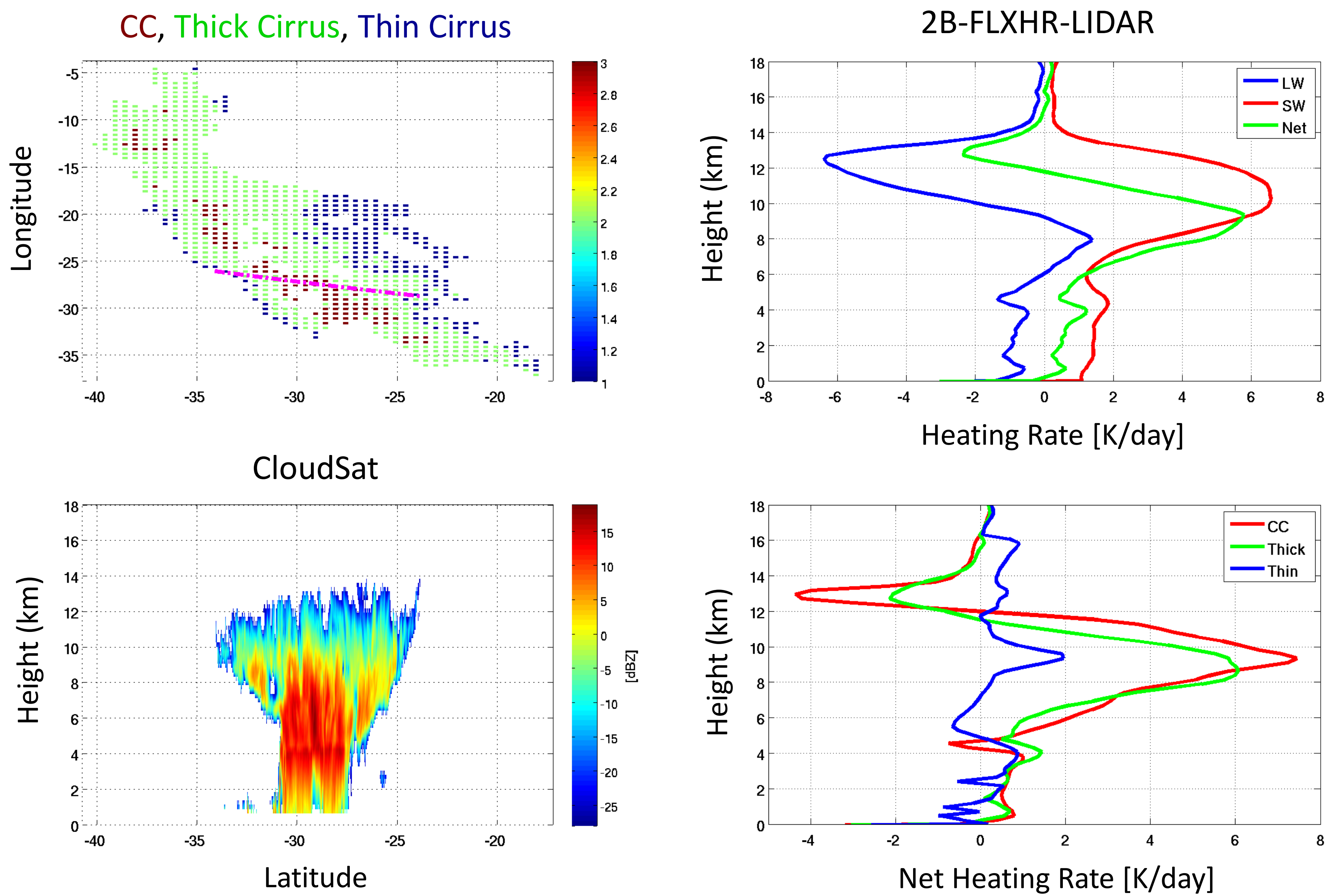
more convective → more **Thin** Cirrus → more UT warming → less convective : Negative Feedback

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:



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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

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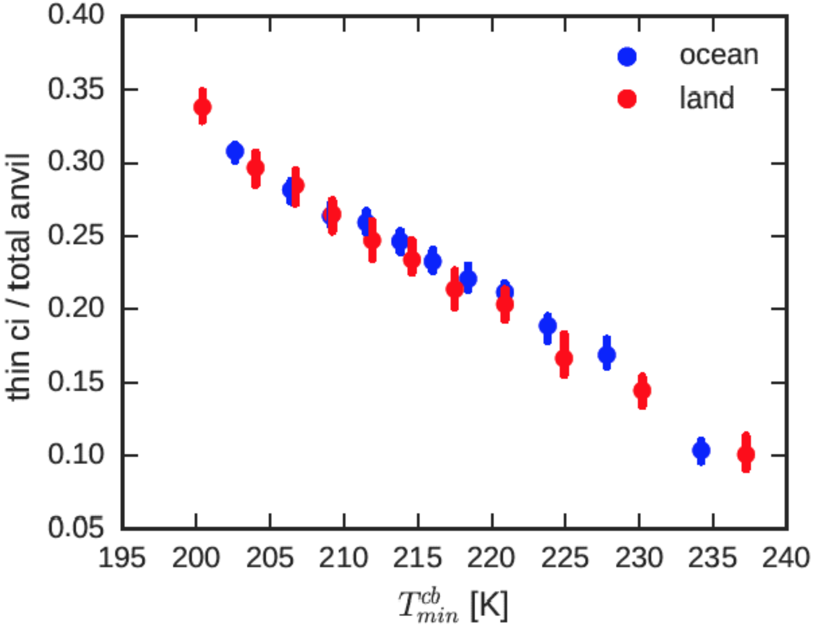
Motivation:

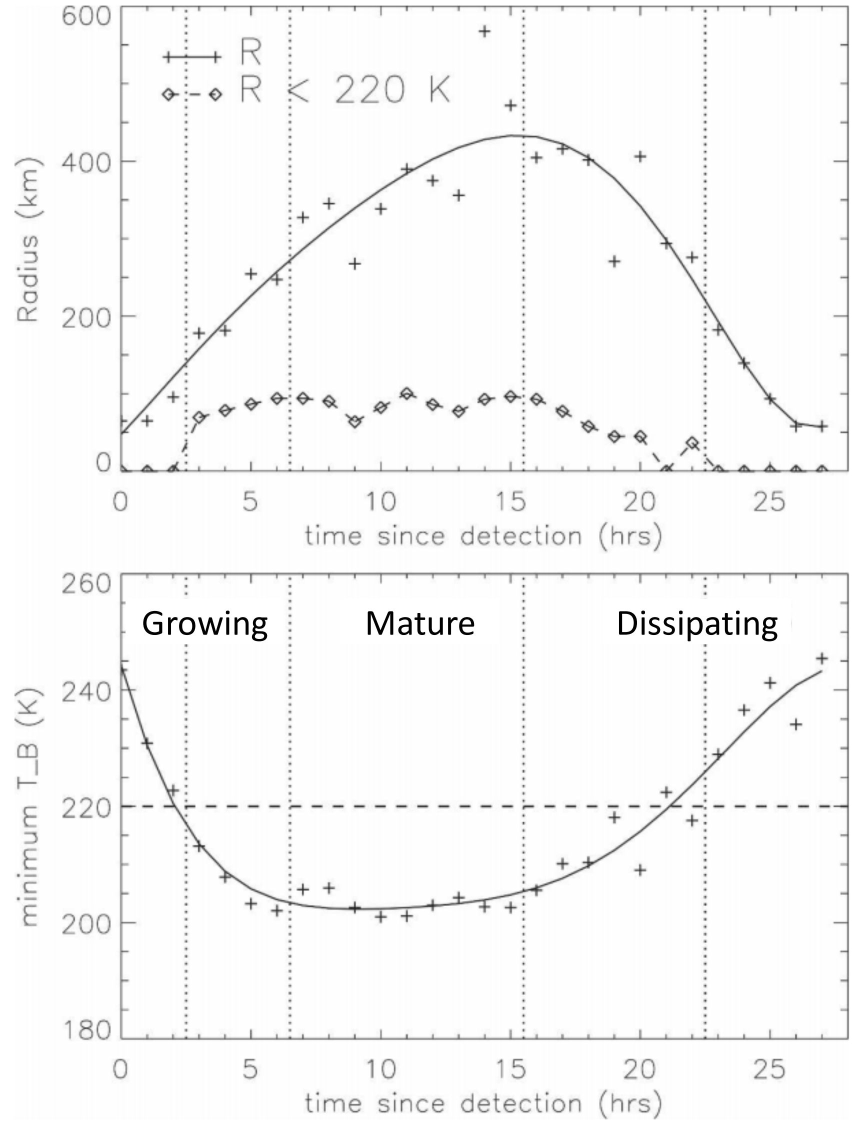
During Mature Stage
(fraction of CC btw 0.1-0.3%)



stronger → weaker

younger → older

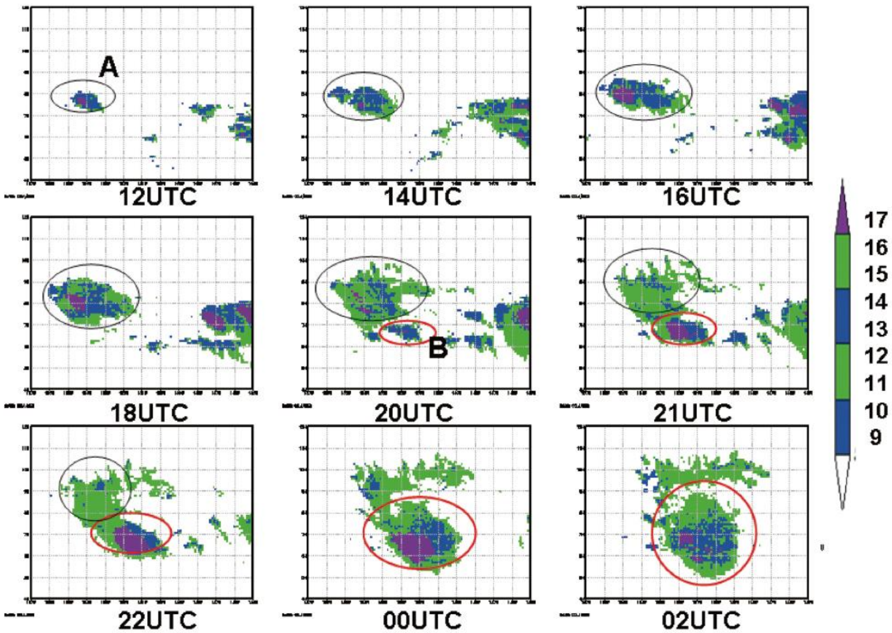
(Protopapadaki et al., 2017)

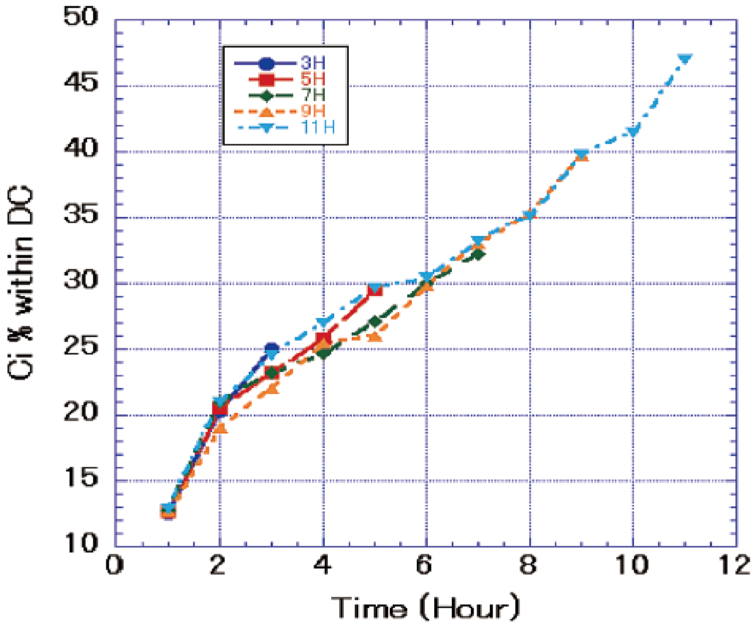


(Futyan and Del Genio., 2007)

Motivation:

Convective Core Cirrus

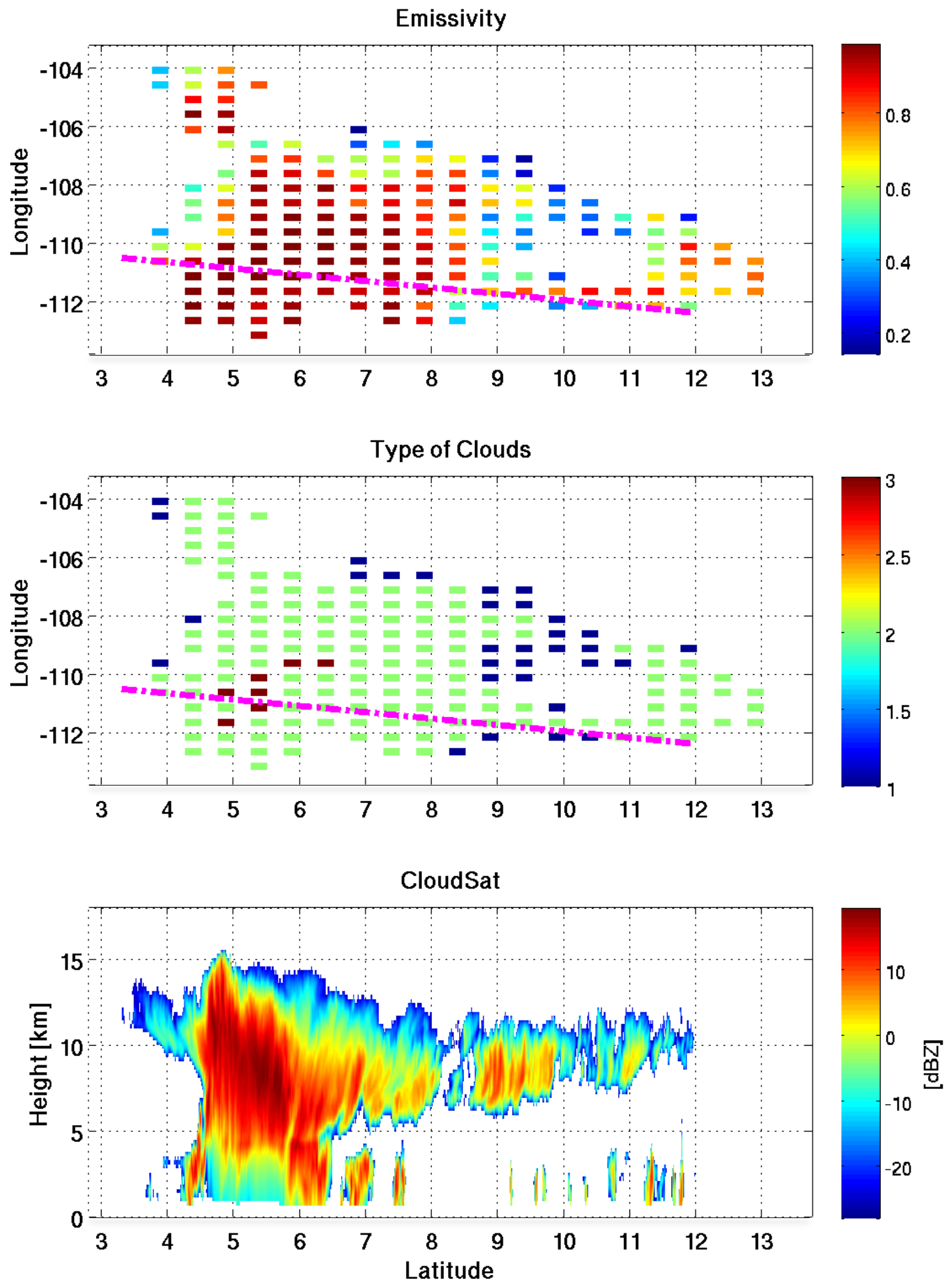


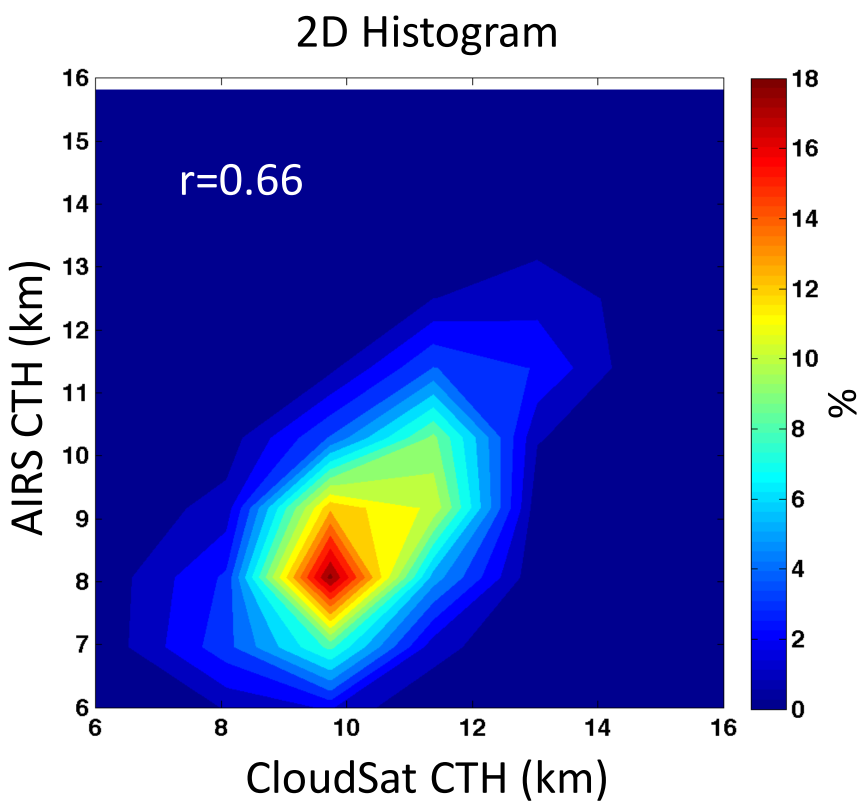


(Inoue et al., 2009)

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

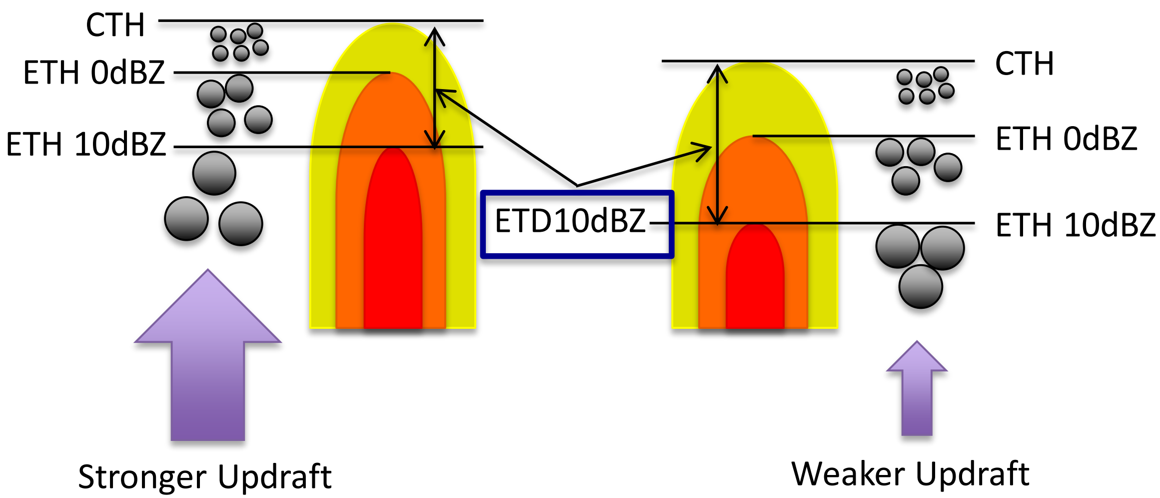
1. AIRS and CloudSat Collocation (200606-201104)



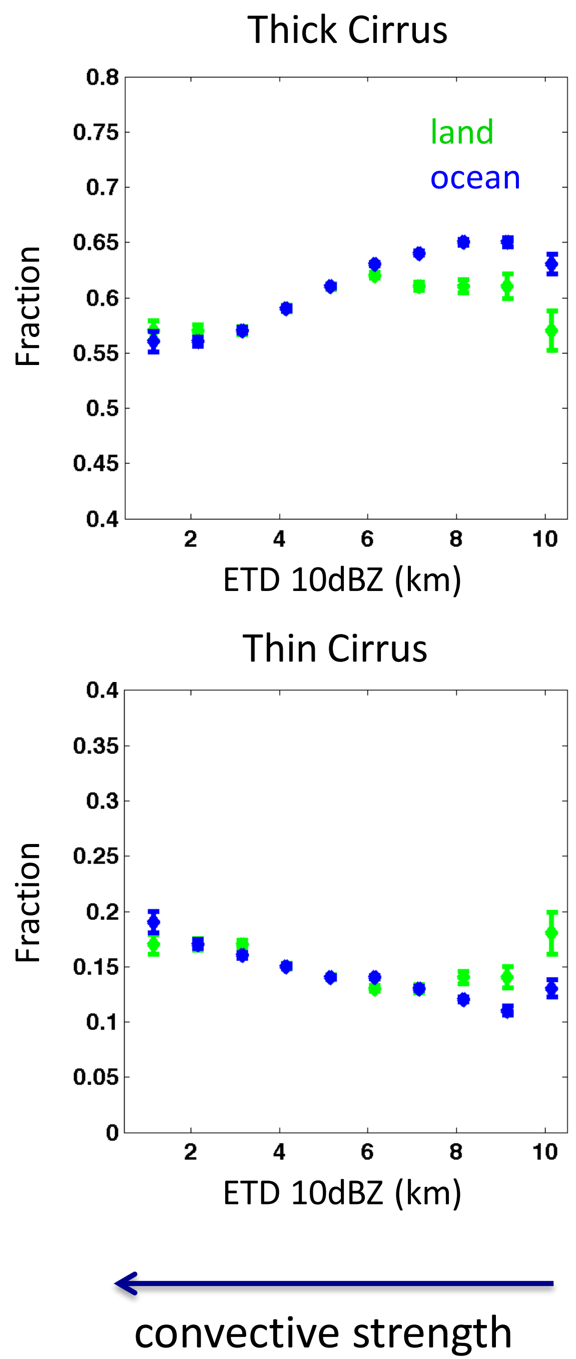


2. Compare Different Proxies of Convective Strength

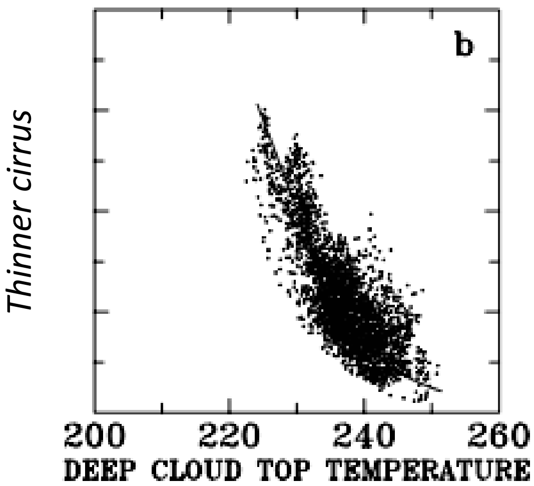
- Thick cirrus decreases but thin cirrus increases with convective strength during mature stage.



Takahashi and Luo (JGR 2014)



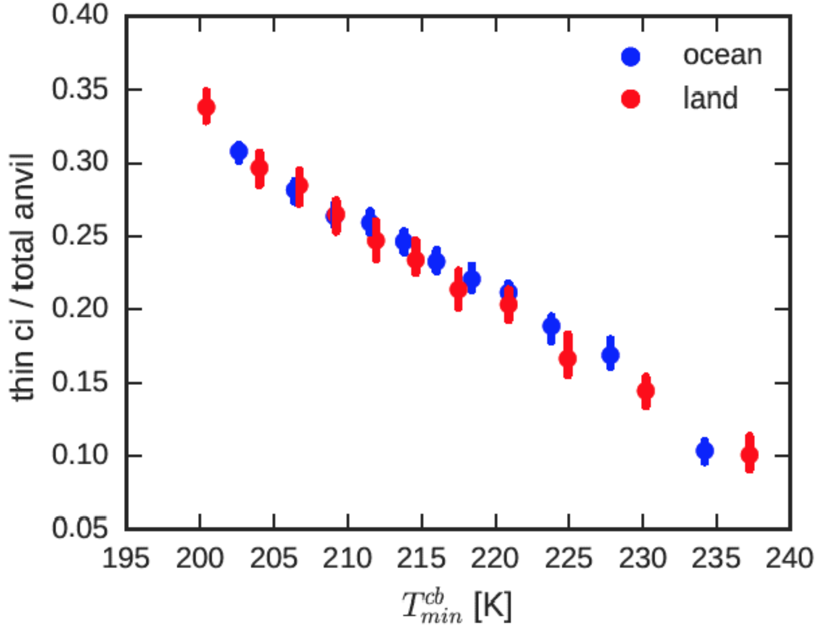
Introduction: Convective Strength vs. Thin Cirrus from AIRS



(Chou and Neelin., GRL 1999)

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 (ε<0.5) increases as min CTT 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)