Frequency of Deep Convective Clouds and Global Warming

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State of art climate models are closely tied to the Clausius Clapeyron relationship, which predicts a 7% increase in the total water vapor per K of warming

Held, I.M. and B.J. Soden (2006) “Robust Responses of the Hydrological Cycle to Global Warming”, J.Climate, v.19, 5686-5699

“... the major Climate Models predicted

… a decrease in the strength of the Hadley Ciculation

... 2%/K increase in precipitation

… with global warming

2%/K * 0.13 K/decade = 0.3%/decade increase in precipitation
with global warming

We use 5 years of AIRS data to try to find out how Nature responds to clobal warming.

Outline

→ Source of of the data

Deep Convective Clouds (DCC)

Frequency of DCC and mean surface temperature

DCC and Global Warming

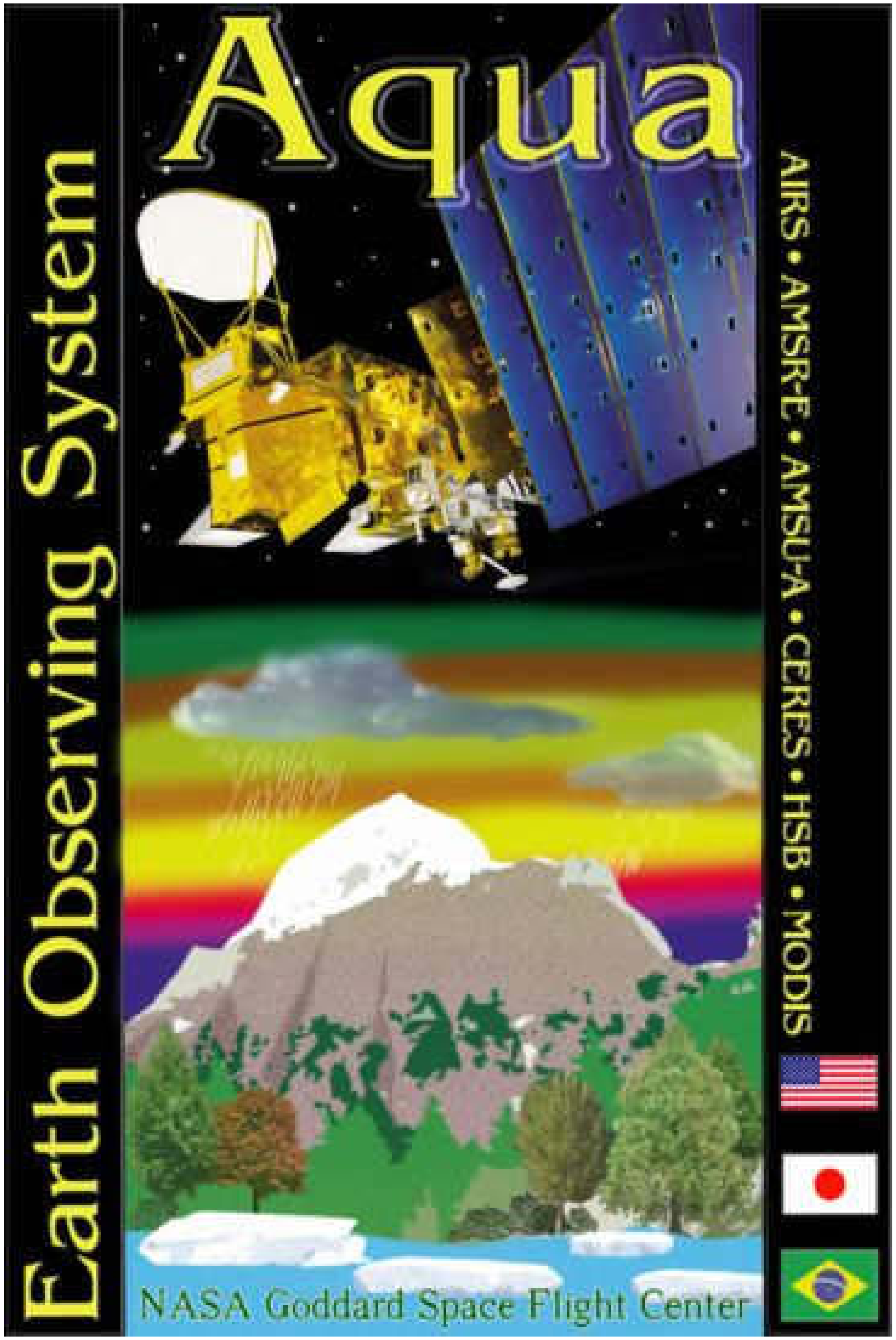
Precipitation and DCC

Conclusion

GRL doi:10.1029/2008GL034562
GRL doi:10.1029/2006GL029191

AIRS/AMSU/HSB

Spacecraft:	**EOS Aqua**
Instruments:	**AIRS, AMSU, HSB, MODIS, CERES, AMSR-E**
Launch Date:	**May 4, 2002**
Launch Vehicle:	**Boeing Delta II Intermediate ELV**
Mission Life:	**5 years**



AIRS Project Objectives

1. **Support Weather Forecasting**
2. **Climate Research**
3. **Atmospheric Composition and Processes**

Latest Prediction: 12 year life
= year 2014

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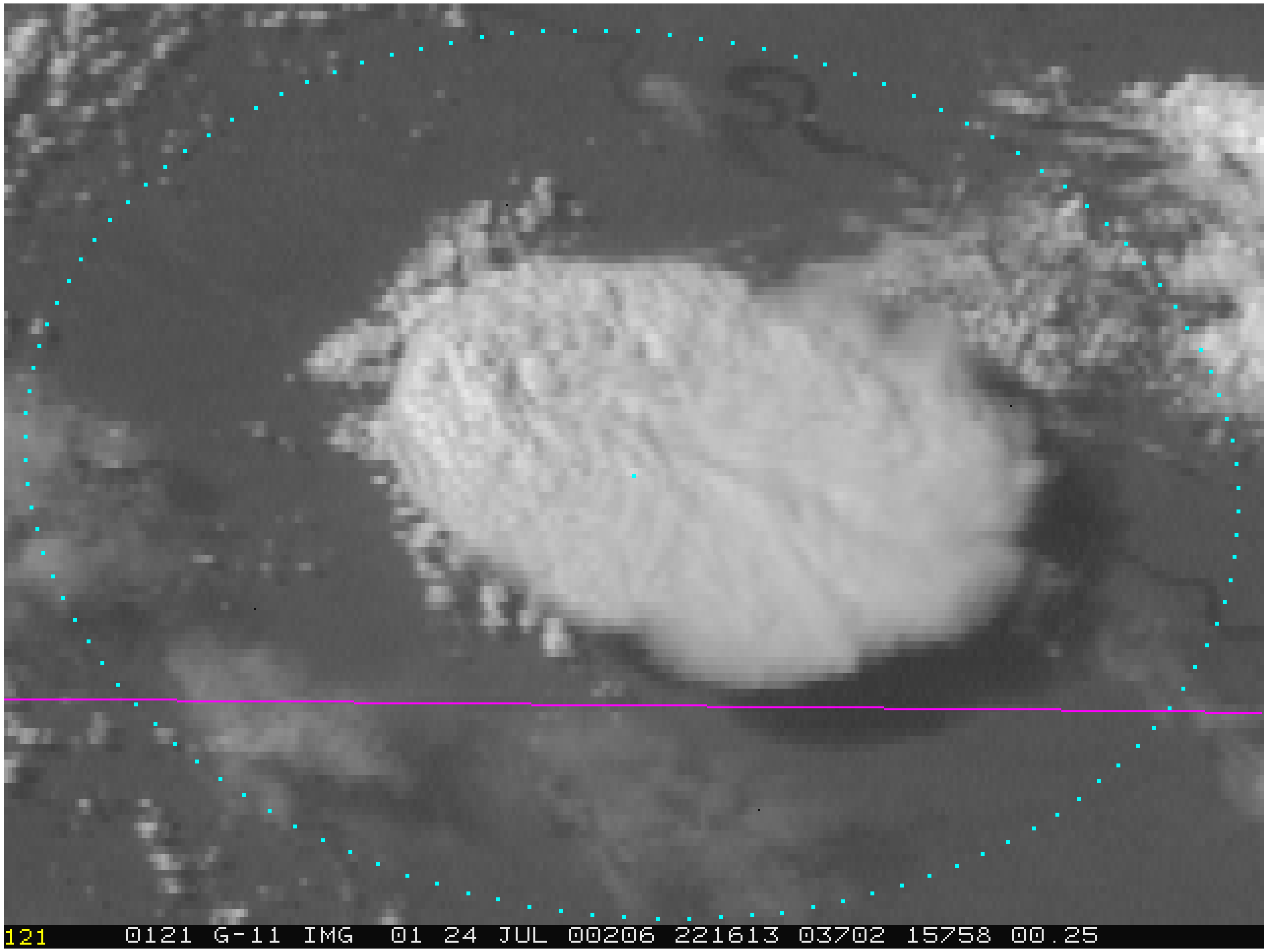
DCC were discovered using GOES data.
Reynolds (1986) and Purdom (1991) correlated
DCC with severe storms and extreme precipitation



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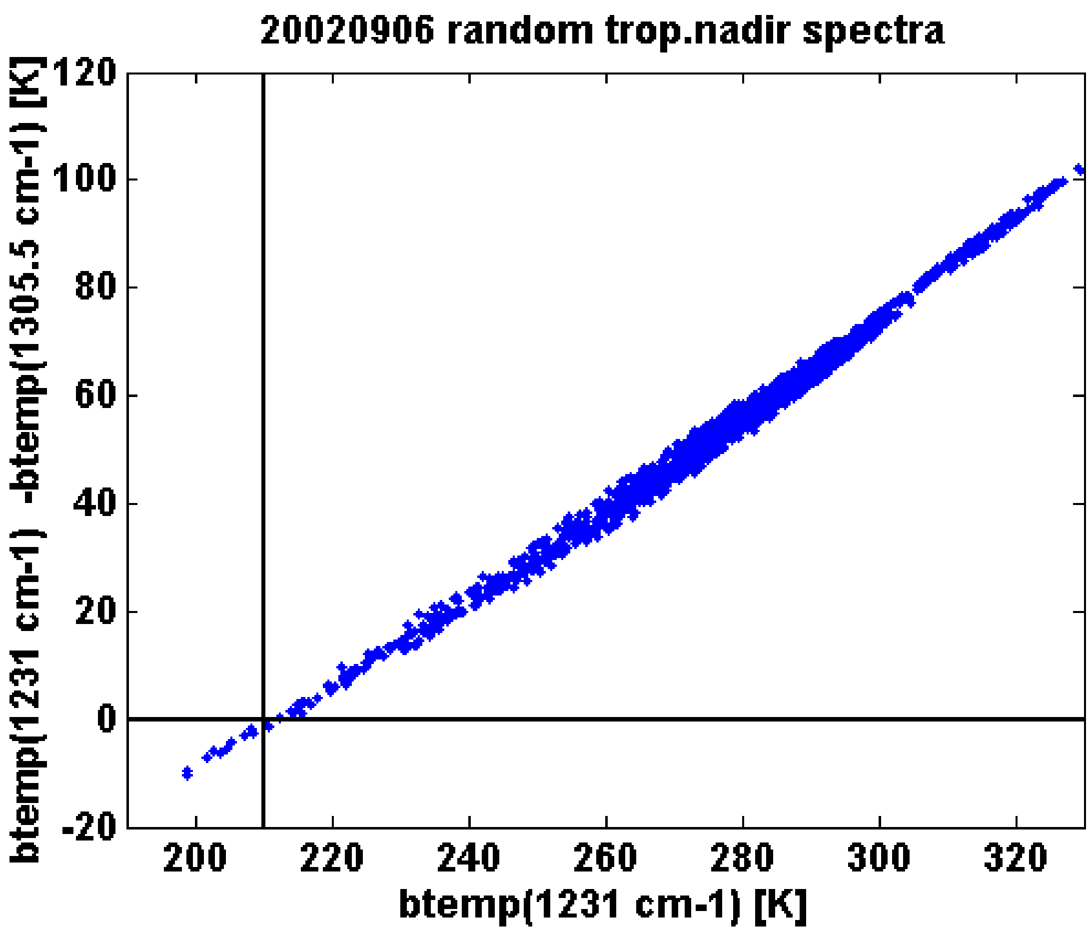
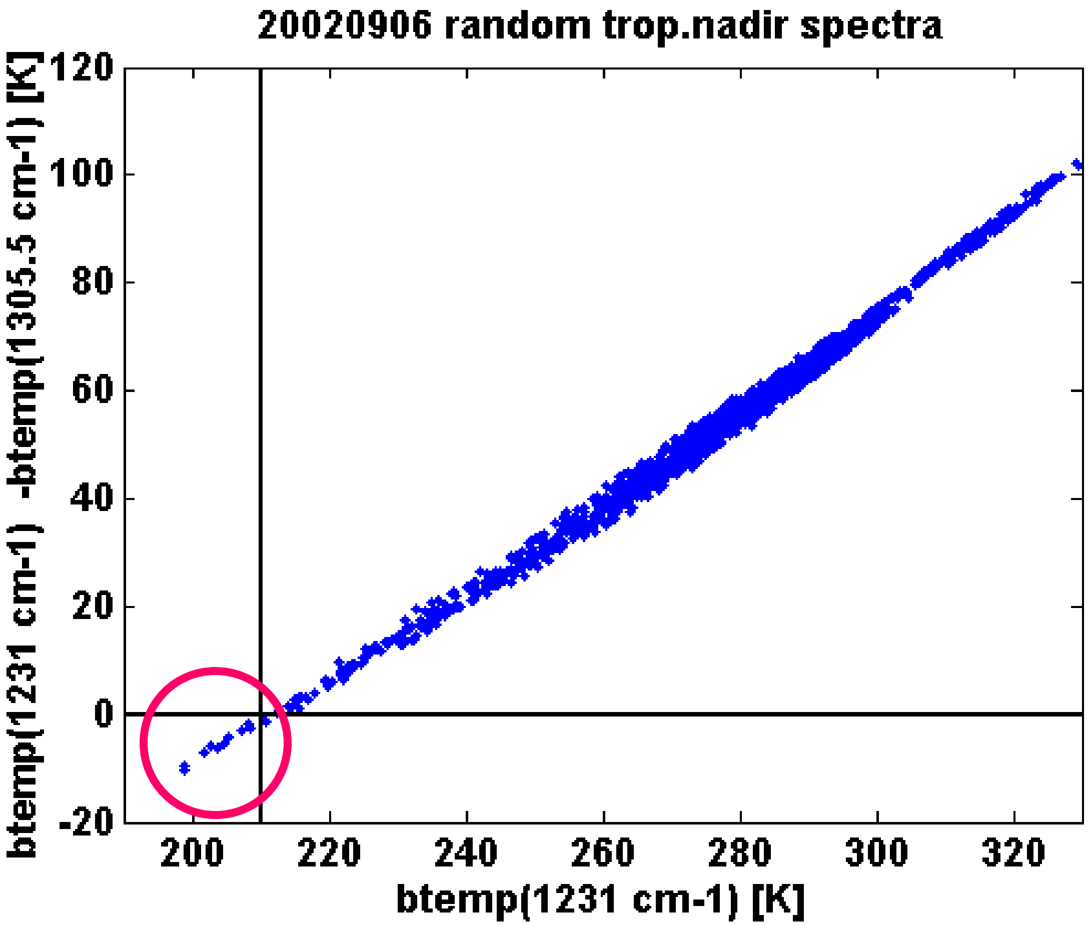
The depth of the strong waterline at 1305.5 cm-1 vers. the brightness temperature in the 1231 cm-1 window channel

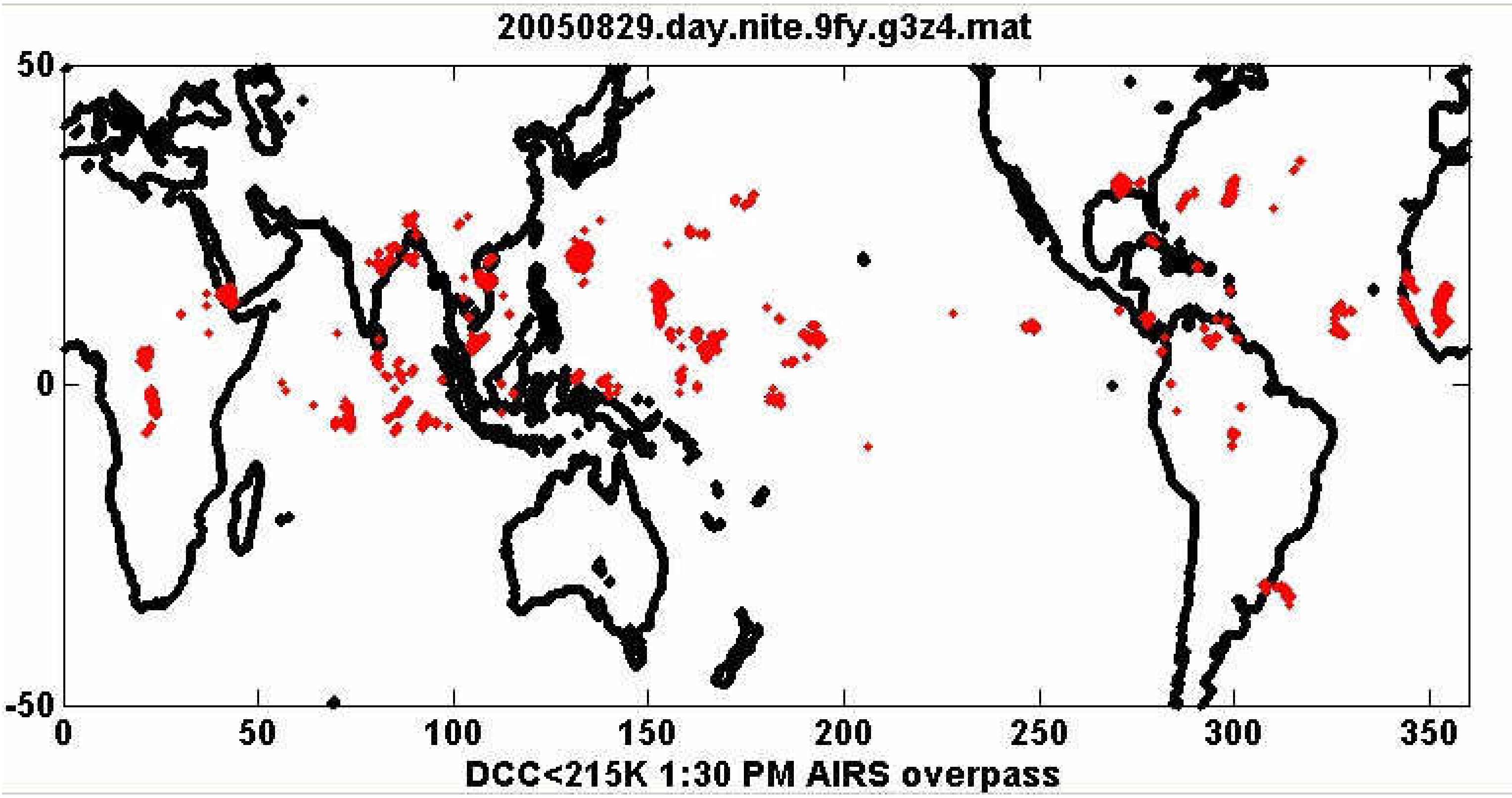


We define a DCC as any spectrum where bt1231-bt1305<0 at the tropical latitudes. This is equivalent to bt1231<215 K.



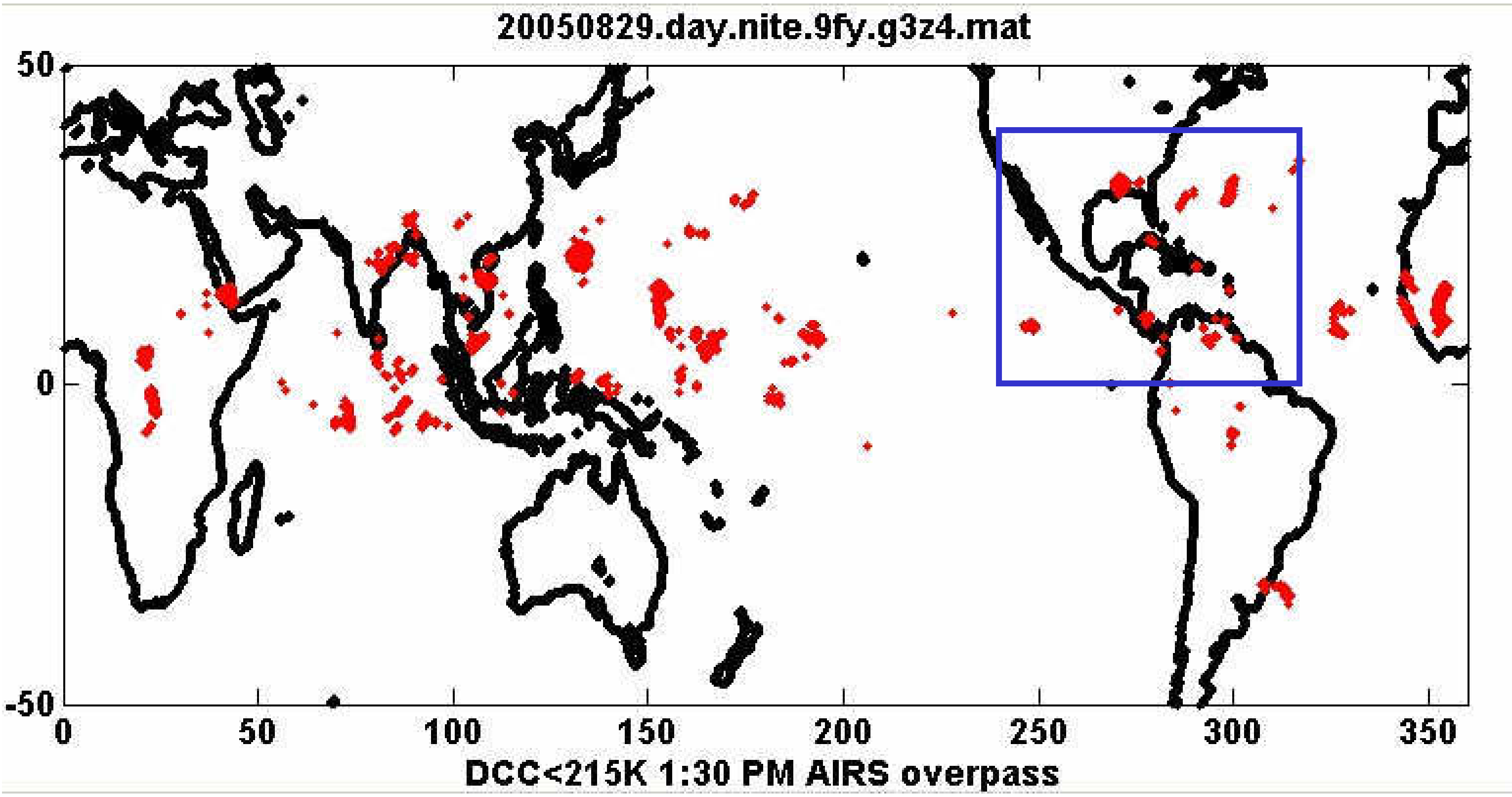
Every day AIRS identifies about 10,000 DCC, about 55% at night, 45% during the day

Most DCC are found in clusters with more than 50 DCC in a 2 x 2 degree box



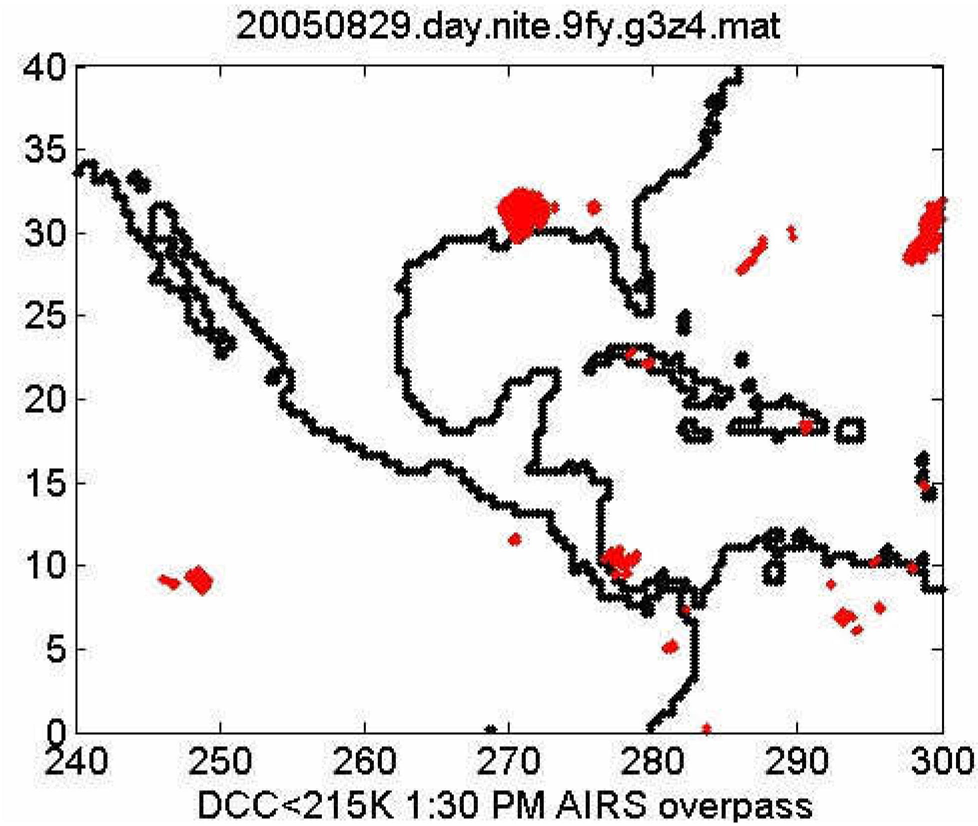
DCC on 20050819 during the 1:30 AM orbits.

Most DCC are found in clusters with more than 50 DCC in a 2 x 2 degree box



DCC on 20050819 during the 1:30 AM orbits.

Hurricane Katrina at its peak contained over 400 DCC



cyan=1:30 AM red=1:30 pm overpass

Hurricanes Katrina overpass of New Orleans 2005/08/29

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We analyze the data in terms of the DCC frequency, i.e. the DCC count divided by the number available spectra.

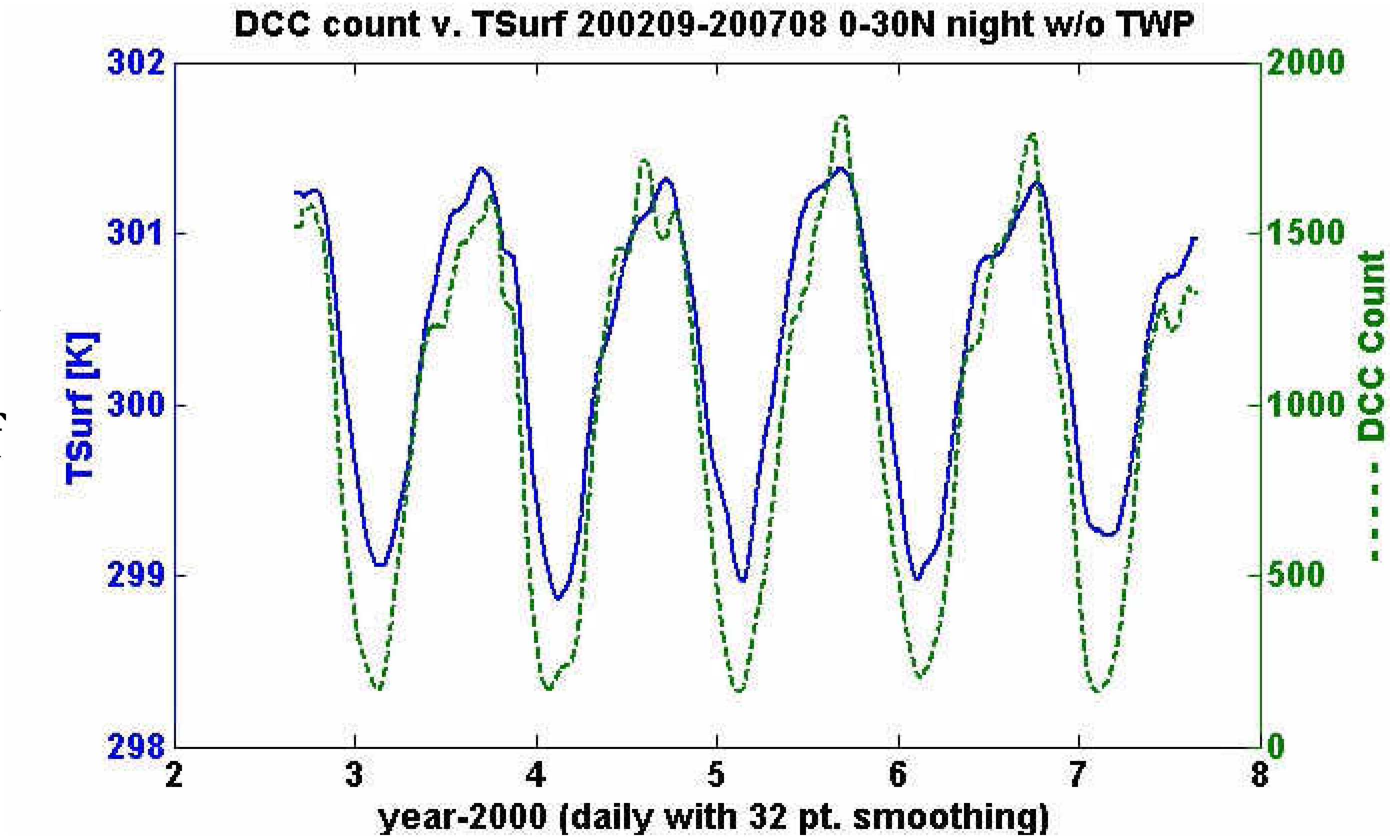
The DCC frequency for the tropical oceans is approximately 1% for the 1:30 pm EOS Aqua orbit.

The IASI DCC frequency (9:30 am orbit) is also about 1%.

The diurnal samples at 1:30 AM, 9:30 AM, 1:30 PM and 9:30 PM show little day/night variability in extreme convection in the tropical oceans.

DCC count is highly correlated with the mean zonal SST

Zonal mean TSurf



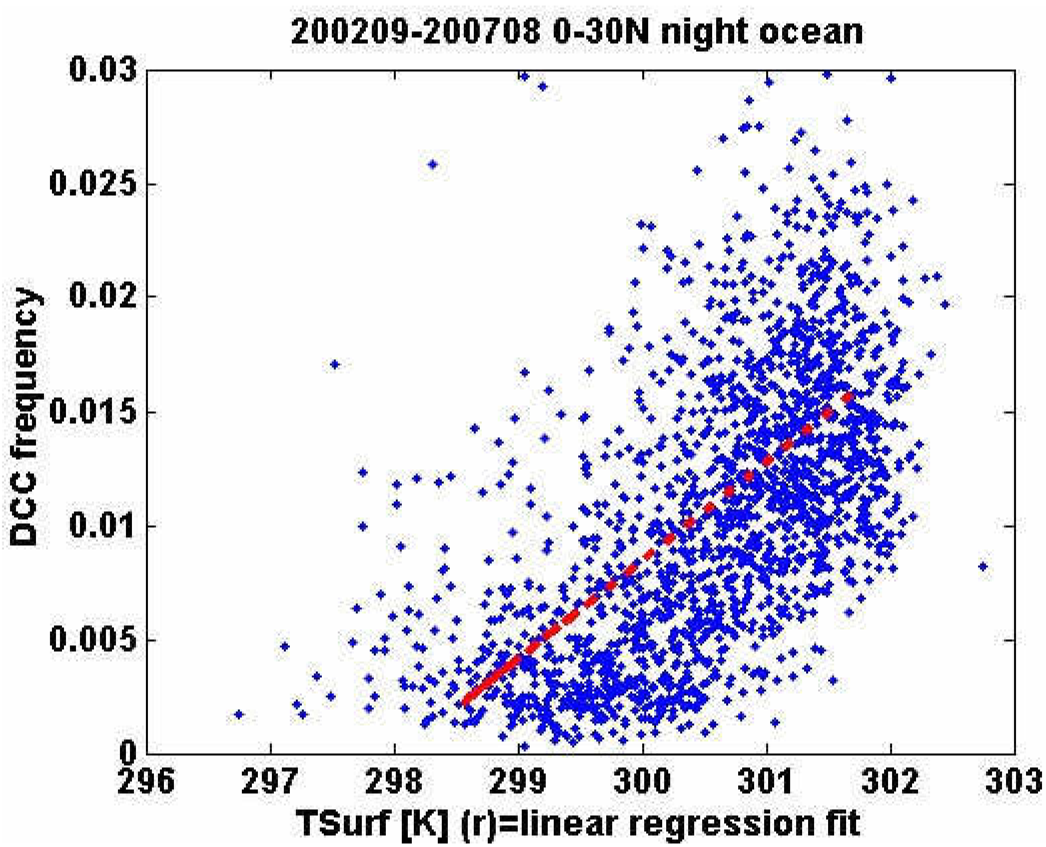
DCC count

For night 0-30N the correlation is 0.62

Aumann et al. 2007 GRL

We use the seasonal change in the temperature of the ocean as a free global experiment to evaluate how Nature responds to a global change in surface temperature with a change in the frequency of DCC

DCC frequency correlation with TSurf results in a DCC frequency sensitivity of 48%/K



Aumann et al. GRL doi:10.1029/2008GL034562

The DCC frequency sensitivity uncertainty was evaluated by breaking up the data into four independent groups.

	Five year mean DCC frequency	DCC frequency / TSurf correlation	sensitivity [fraction/K] with TWP		Five year mean DCC frequency	DCC frequency / TSurf correlation	sensitivity [fraction/K] without TWP
0-30N day	**0.0085**	**0.611**	**0.45**		**0.0058**	**0.603**	**0.56**
night	**0.0105**	**0.622**	**0.48**		**0.0066**	**0.610**	**0.52**
0-30S day	**0.0062**	**0.661**	**0.48**		**0.0027**	**0.591**	**0.37**
night	**0.0073**	**0.678**	**0.29**		**0.0035**	**0.592**	**0.35**

DCC is a process which occurs with a frequency which is a function of the mean zonal surface temperature.

Nature responds to a increase in the surface temperature by increasing the DCC frequency by 45%/K .

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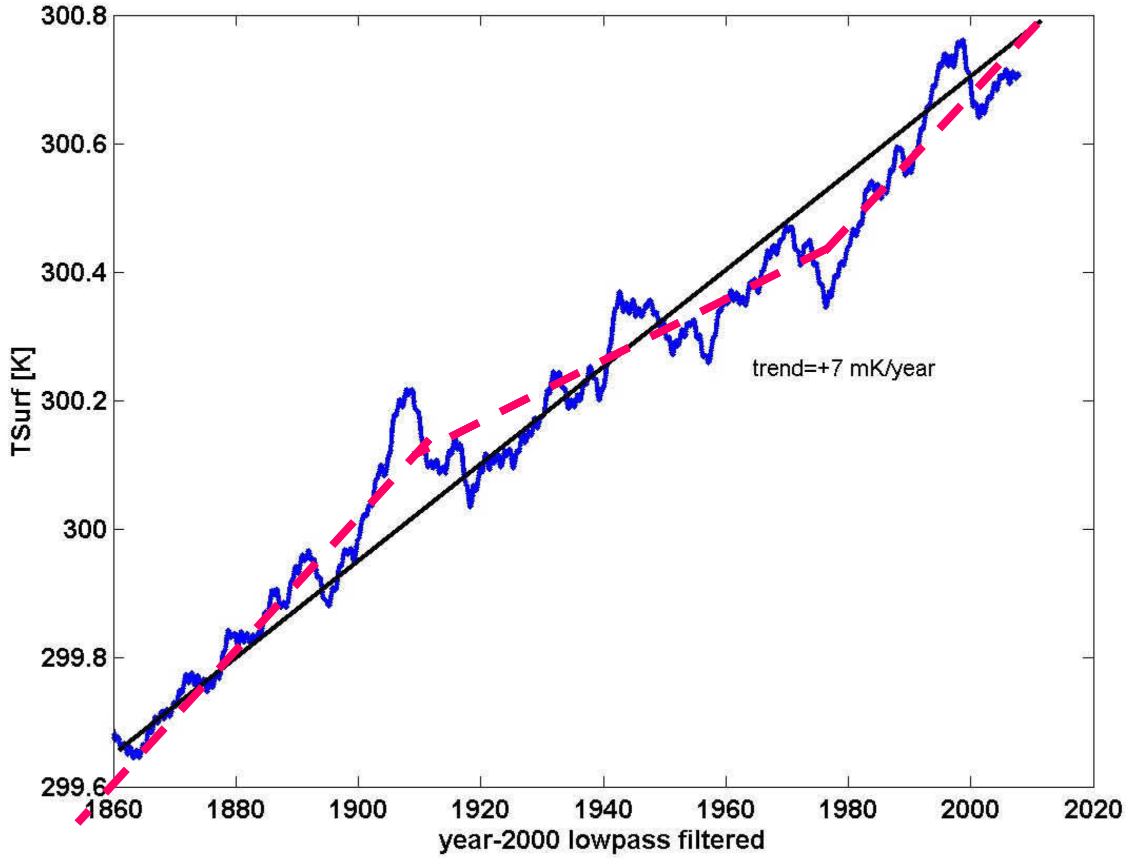
The multi-decadal increase in the temperature of the global oceans is 0.13K/decade

Tropical Western Pacific



+0.13 K/decade based on IPCC (2007)

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Expected changes with global warming

The mean DCC frequency sensitivity is (+45±15) %/K

Global warming is +0.13 K/decade

Combine the two equations to predict the increase in DCC frequency

(+45±15) %/K * 0.13K/decade = (+6±1.5) %/decade

The frequency of severe storms increased with the currenty observed global warming at the rate of 6%/decade.

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AMSRE on the EOS Aqua spacecraft measure rain rate.

Tropical ocean mean rain rate: 0.12 mm/hr

The rain rate at the DCC identified by AIRS is obtained from AMSRE

DCC are correlated with the most intense rain events.

Mean Rain rate at AIRS DCC matchups with AMSRE: 3 mm/hr

DCC cover about 1% of the tropical oceans.

DCC contribute 25% to the tropical ocean mean rainfall.
(3 mm/hr * 0.01 area = 0.030 mm/hr compared to total of 0.12 mm/hr

A 6%/decade increase in the DCC frequency increases total precipitation from DCC alone from 0.030 mm/hr to 3 mm/hr * 0.01*1.06 = 0.032 mm/hr

The increase is 0.002 mm/hr per decade

0.002 mm/hr / 0.12 mm/hr mean = + 1.7%/decade.

The major Climate Models predicted
an increase of 0.3%/decade increase in precipitation
with global warming

AIRS data: +1.7%/decade increase precipitations.

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SSMI data:
Wentz (2007): +1.5%/decade increase in precipitation.

The major Climate Models predicted
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AIRS data: +1.7%/decade increase precipitations.

SSMI data
(Wentz 2007) +1.5%/decade increase in precipitation.

The climate models respond to global warming with a factor of five less precipitation then is derived from two independent sets of observations

Conclusions

Deep Convective Clouds (DCC) form in large clusters.

Intense hurricanes are clusters of 400 or more DCC

Nature responds to global warming with an increase in strong convective activity. The frequency of DCC increases with global warming at the rate of 6%/decade.

The increased frequency of DCC with global warming alone increases precipitation by 1.7%/decade.

Conclusions

State-of-art climate models respond to global warming

with only a 0.3%/decade increase in precipitation

with a decrease in deep convective activity.

The parametrization of Climate Models needs to be tuned to more closely emulate the way Nature respond to global warming.

www.jpl.nasa.gov/airs