# Quantifying the Effects of Downward Longwave Radiation on Low Clouds

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Spring CERES Science Team Meeting

4-29-20

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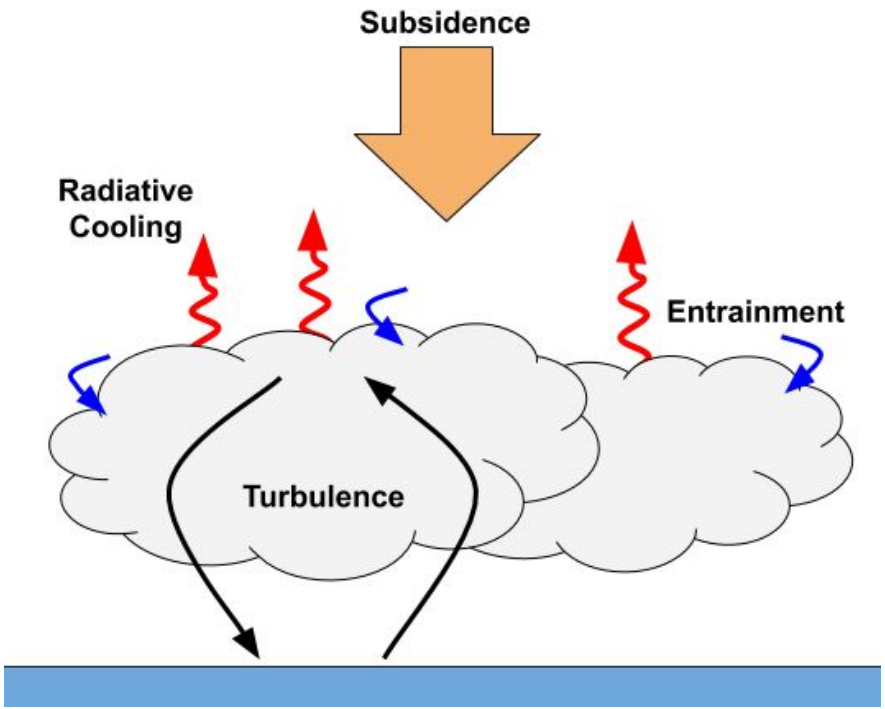
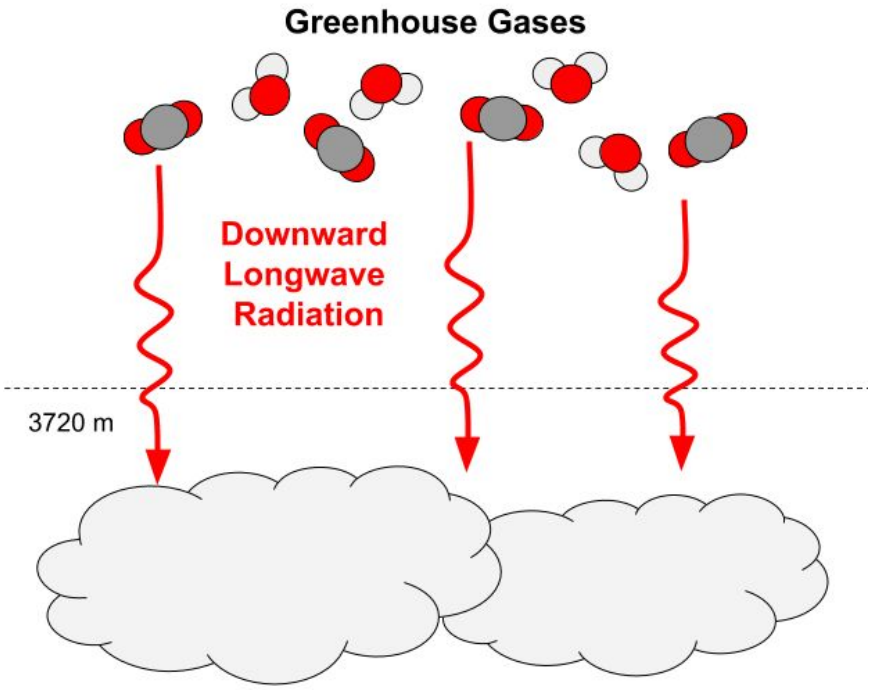
# What Sustains Low Clouds?

- LW cooling at cloud top
- Turbulence
- Entrainment



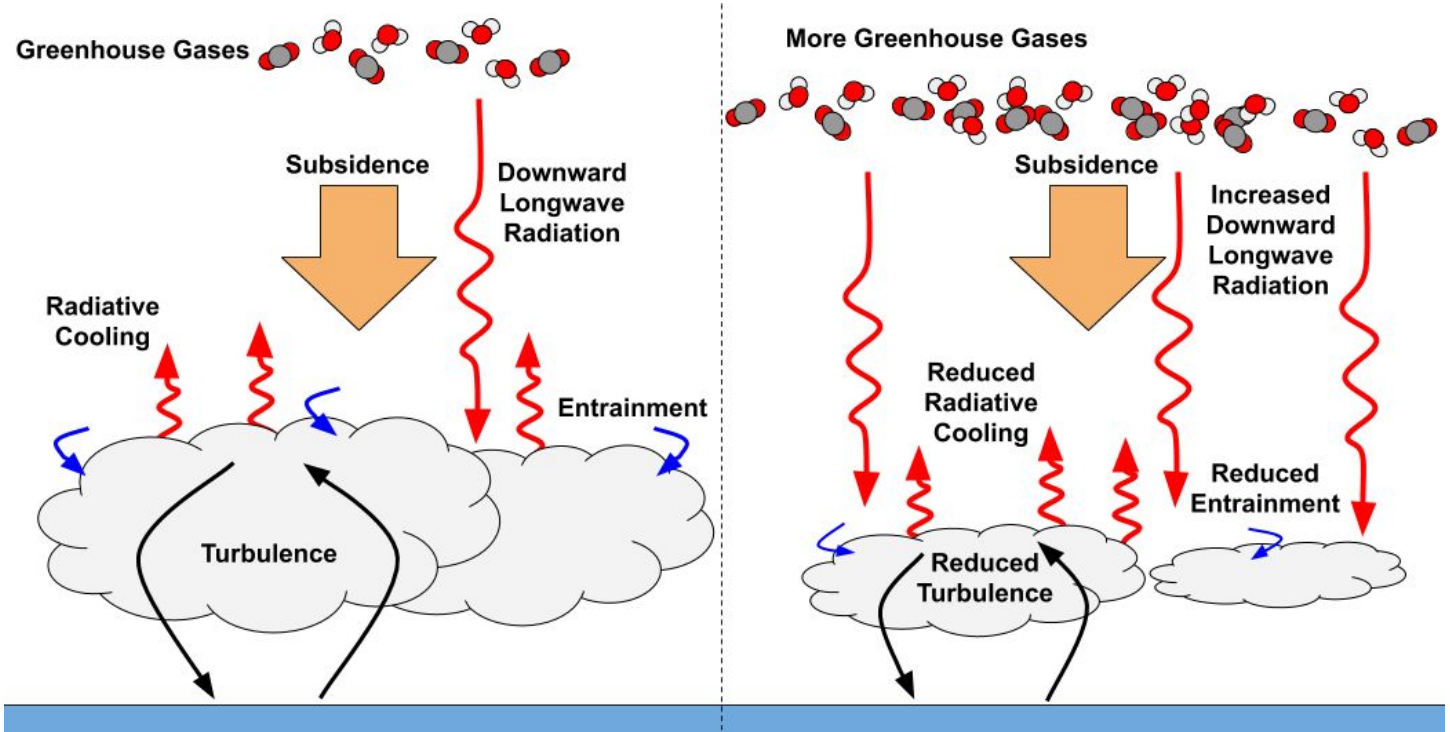
# Question

- Greenhouse gases are increasing
- Atmosphere is more emissive
- Increasing downward longwave radiation
- **How does increased downward LW radiation affect low clouds?**



# Hypothesis

Increasing downward LW radiation → reduces cloud top cooling

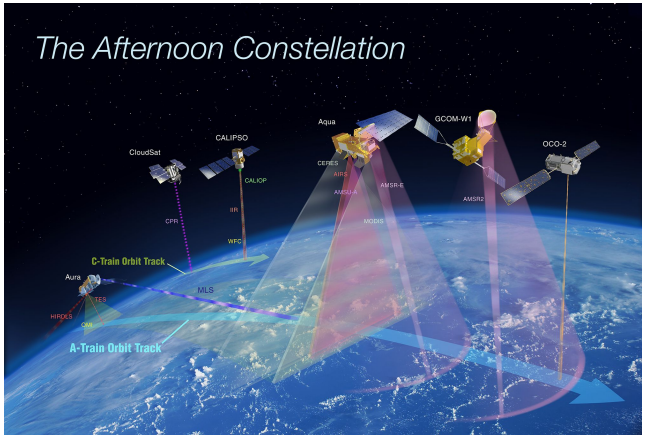


# Data Product

A dataset was needed with:

- Vertical irradiance profiles (MODIS, CALIPSO & CloudSat)
- Ability to observe multilayer clouds (CALIPSO & CloudSat)

A-Train Integrated CALIPSO, CloudSat, CERES, and MODIS Merged Product (C3M)



# C3M Variables

| | |
|---|---|
| SSF-60b | Estimated inversion stability |
| CCCM-12 | Cloud group area percent coverage |
| CCCM-13 | Cloud layer top level height |
| CCCM-15 | Cloud layer base level height |
| CCCM-77 | Temperature Profile |
| CCCM-89 | LW downward flux profile enhanced MODIS (CALIPSO CloudSat) |

# Low Cloud Regions

- Northeast Pacific:
  15-35°N, 120-140°W

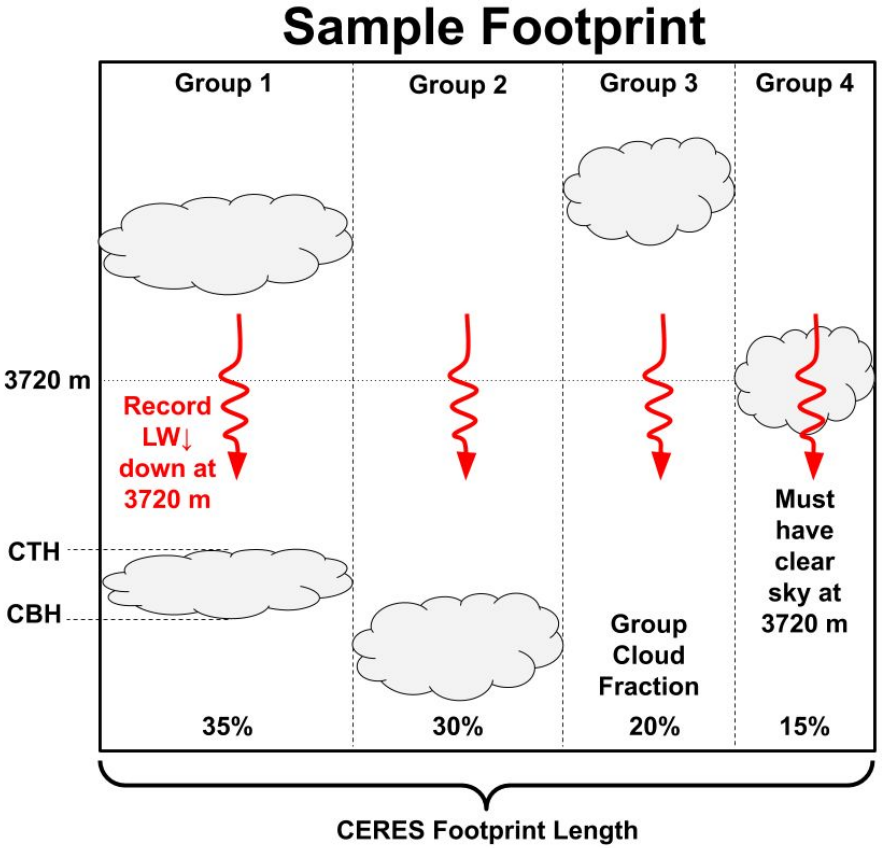
- Southeast Pacific:
  10-30°S, 75-95°W

- Daily data from:
  1/1/2007 – 12/31/2010

- Night-time only footprints
  = 230,277

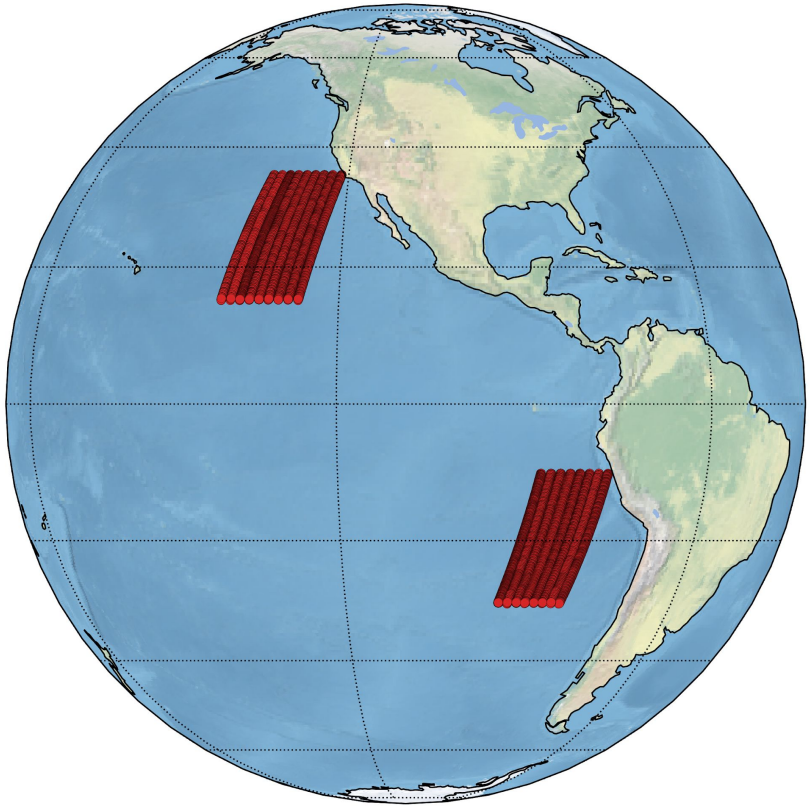
# Organizing Cloud Properties

- Low cloud top and base heights were recorded for each group
- Footprint average low cloud top and base heights were weighted by each group's cloud fraction
- Only the first layer below 3,270m was recorded



# Organizing Tracks

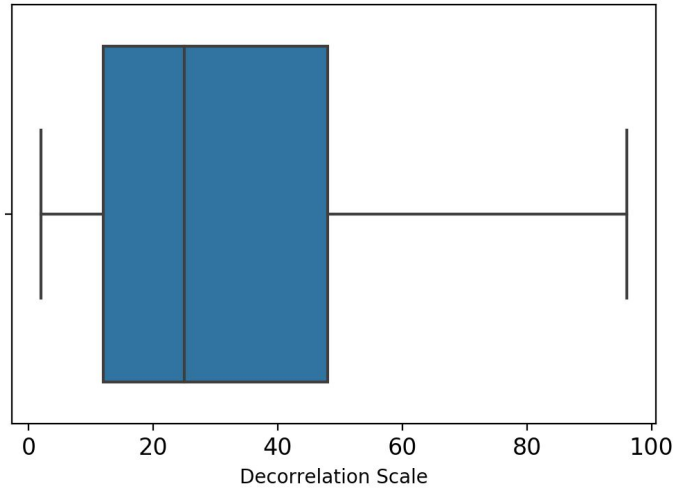
- Data was then organized into “tracks”
- Each “track” contains about 100 adjacent footprints
- **How do we know if the same cloud is being measured across multiple footprints?**

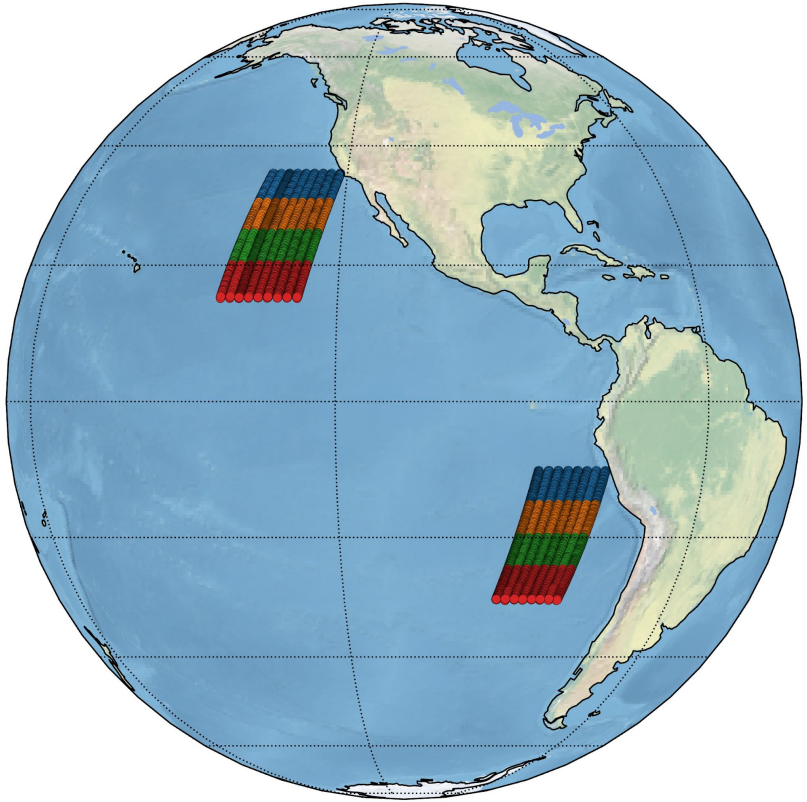


# Decorrelation Scale

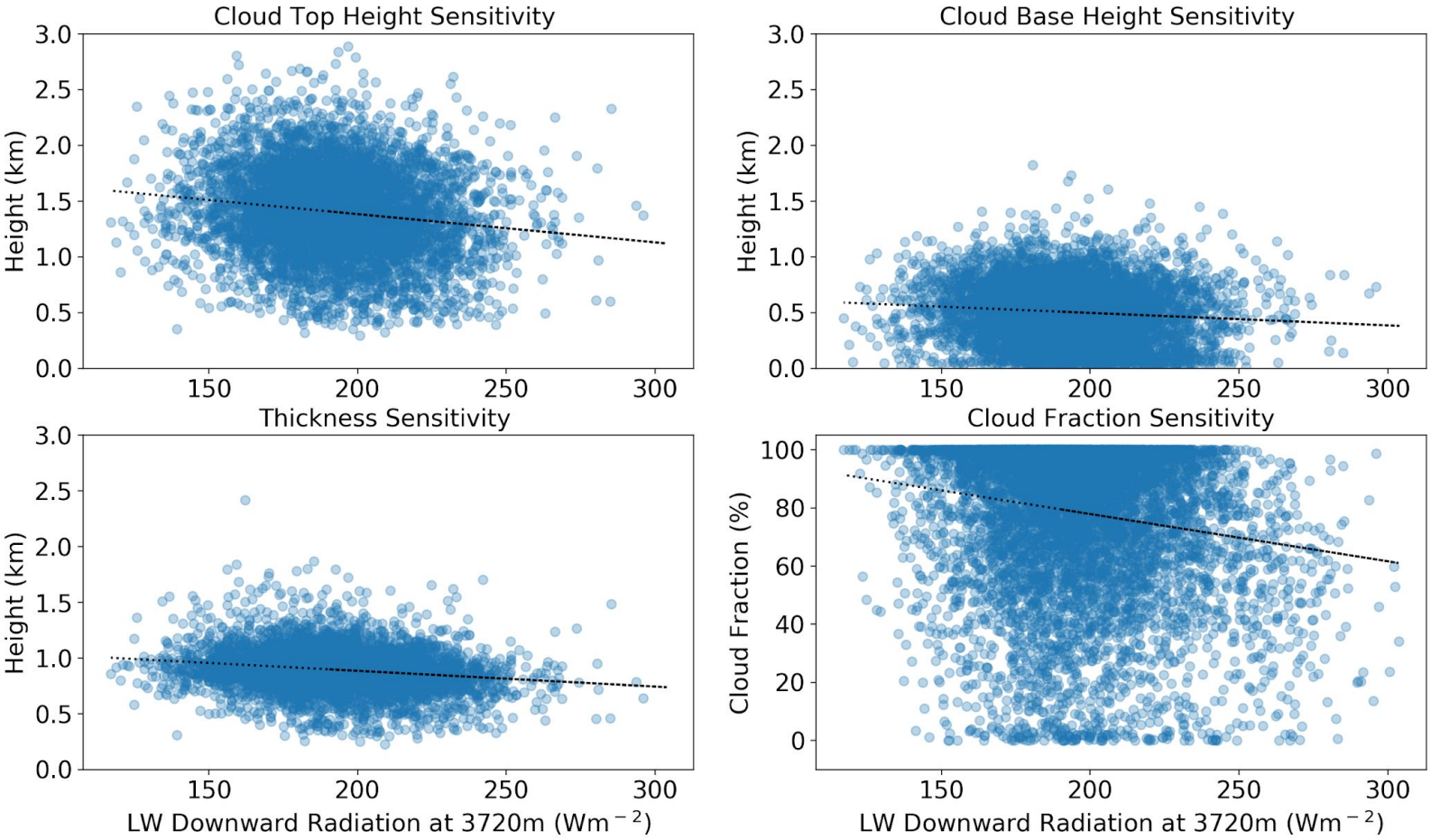
**Decorrelation Scale:** = 5° Latitude (25 footprints)

**Independent observations: 7994**

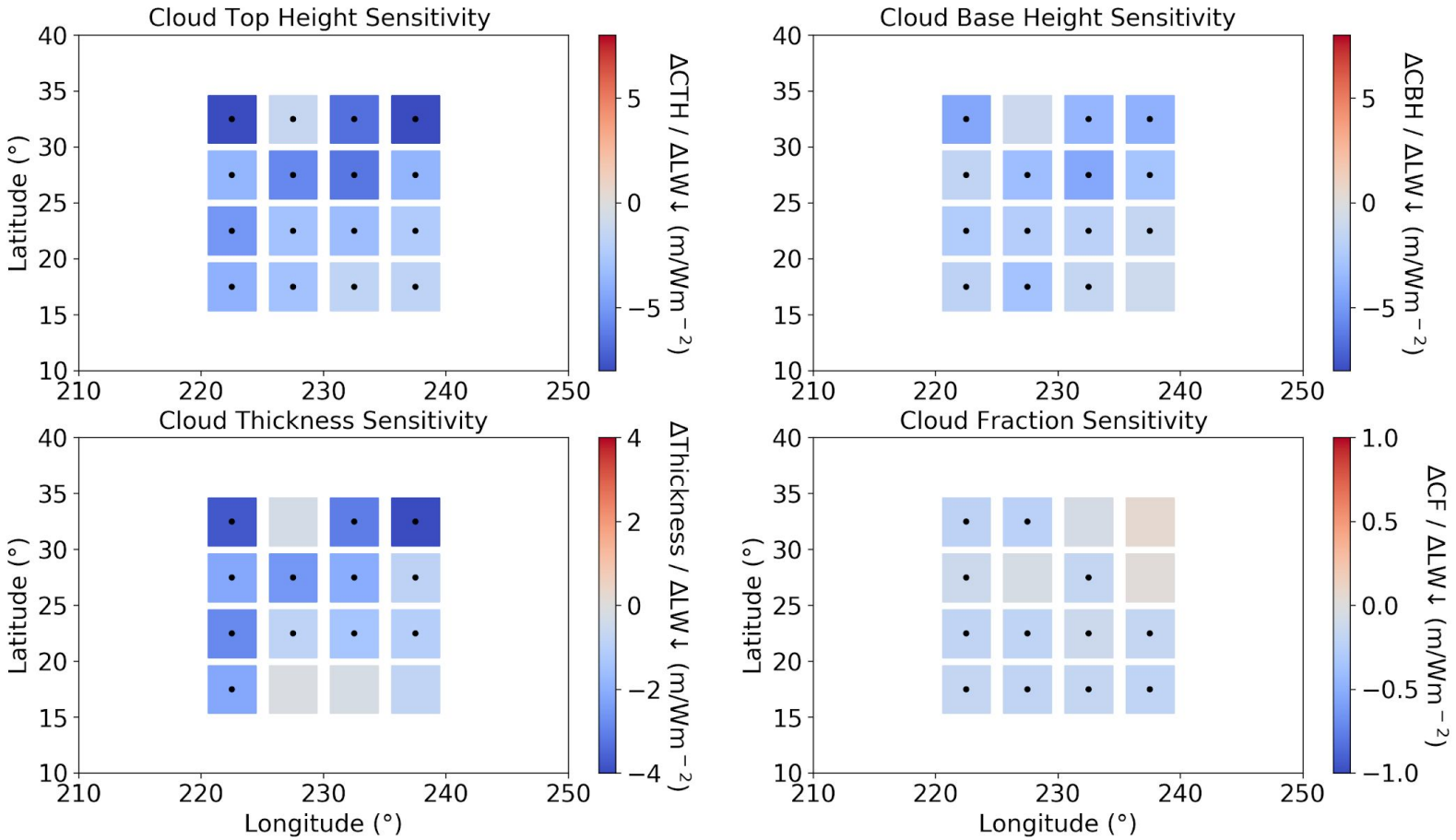


# Low Cloud Properties as functions of Downward Longwave Radiation



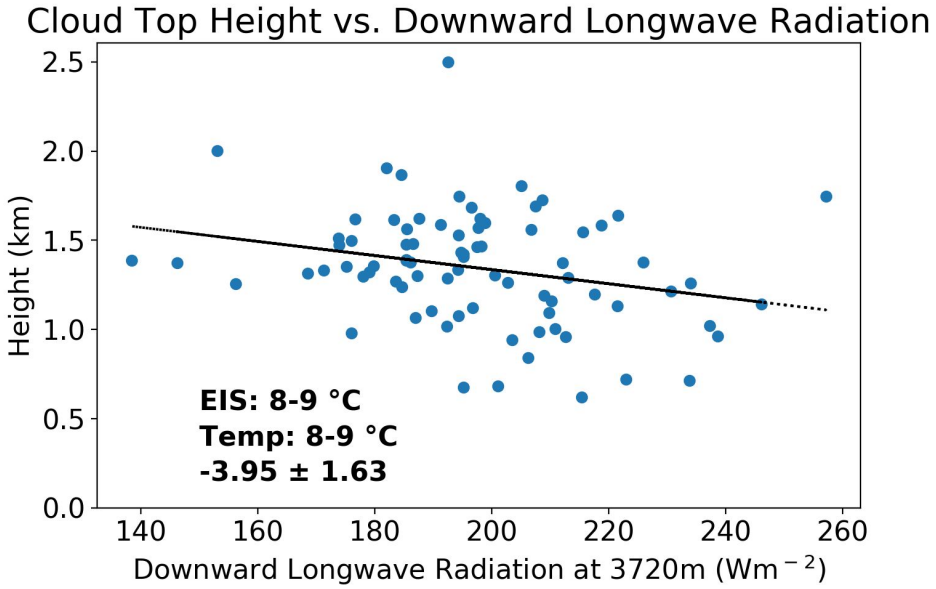
# Low Cloud Properties as functions of LW↓ for Latitude and Longitude



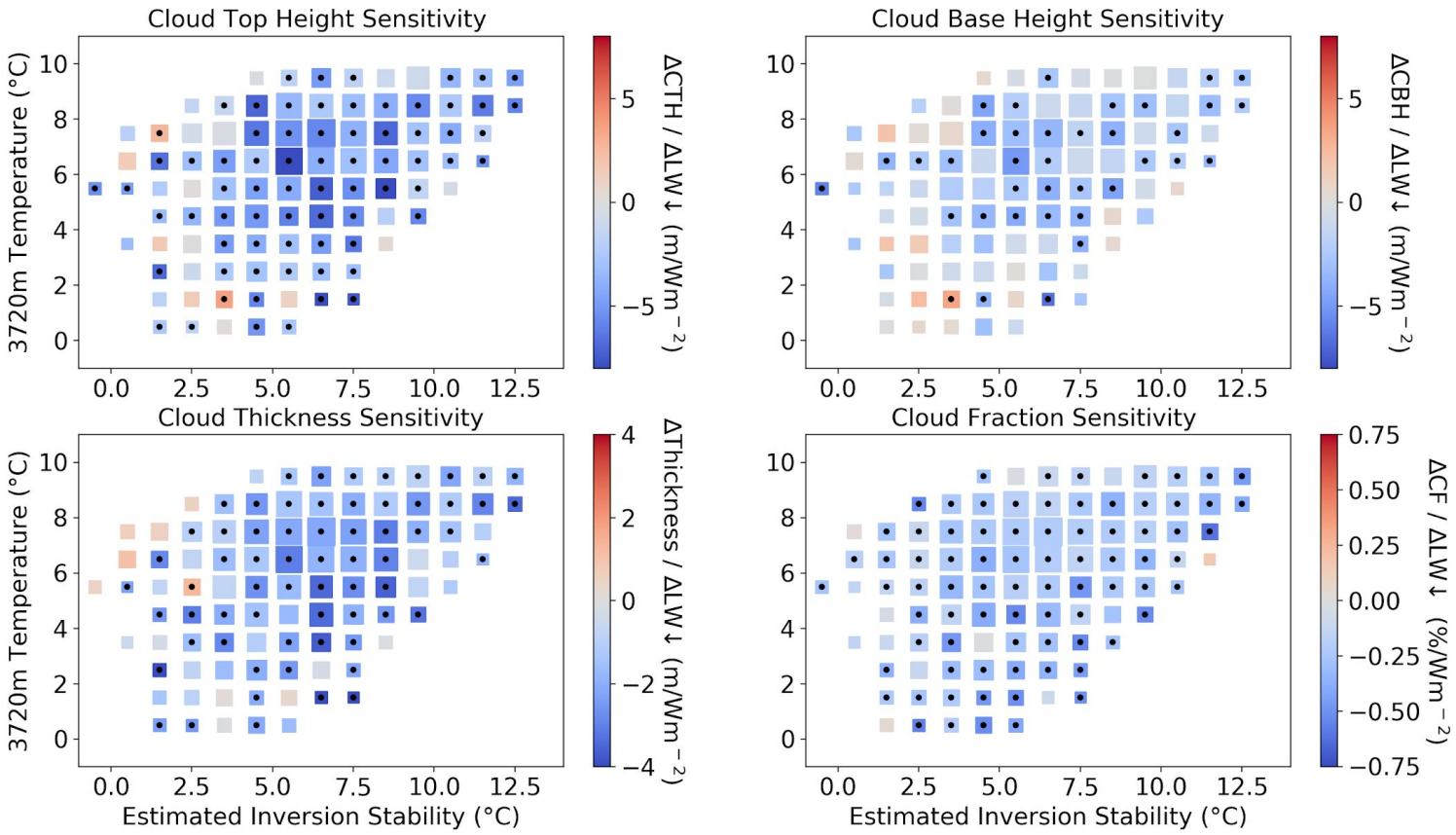

How do we know low clouds are *only* changing due to LW↓?

# Using Constraints

- EIS and 3720m temperature have big impacts on cloud properties
- Cloud properties were binned by EIS and 3720m Temperature in 1°C x 1°C grids
- The linear regression was calculated for each bin



# Low Cloud Properties as functions of LW↓ for EIS and 3720m Temperatures




| ΔCTH/ΔLW↓ | ΔCBH/ΔLW↓ | ΔTh/ΔLW↓ | ΔCF/ΔLW↓ |
|---|---|---|---|
| -3.72 +/- 0.54 m/Wm$^{-2}$ | -1.91 +/- 0.38 m/Wm$^{-2}$ | -1.80 +/- 0.26 m/Wm$^{-2}$ | -0.25 +/- 0.03 %/Wm$^{-2}$ |

# Results

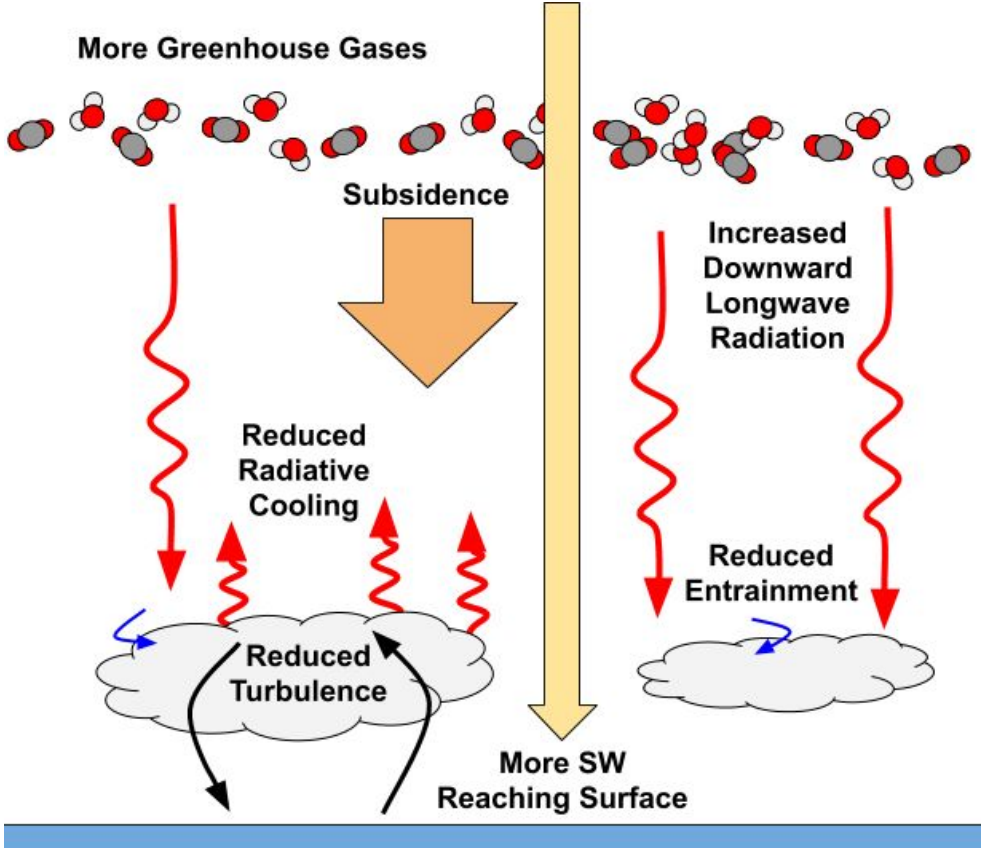
Found that with increasing LW↓:

- Low cloud top heights are decreasing
- Low cloud base heights are decreasing
- Low clouds are thinning
- Low cloud fraction is decreasing

| | |
|---|---|
| **ΔCTH/ΔLW↓** | -3.72 +/- 0.54 m/Wm$^{-2}$ |
| **ΔCBH/ΔLW↓** | -1.91 +/- 0.38 m/Wm$^{-2}$ |
| **ΔTh/ΔLW↓** | -1.80 +/- 0.26 m/Wm$^{-2}$ |
| **ΔCF/ΔLW↓** | -0.25 +/- 0.03 %/Wm$^{-2}$ |

# Conclusion

- Increased greenhouse gases…
- Increases downward LW…
- Reduces cloud fraction and thickness…
- Allows more incoming SW to reach Earth's surface…
  Further warming the surface



Thank you!