Studying Changes in PDFs of Selected AIRS channels

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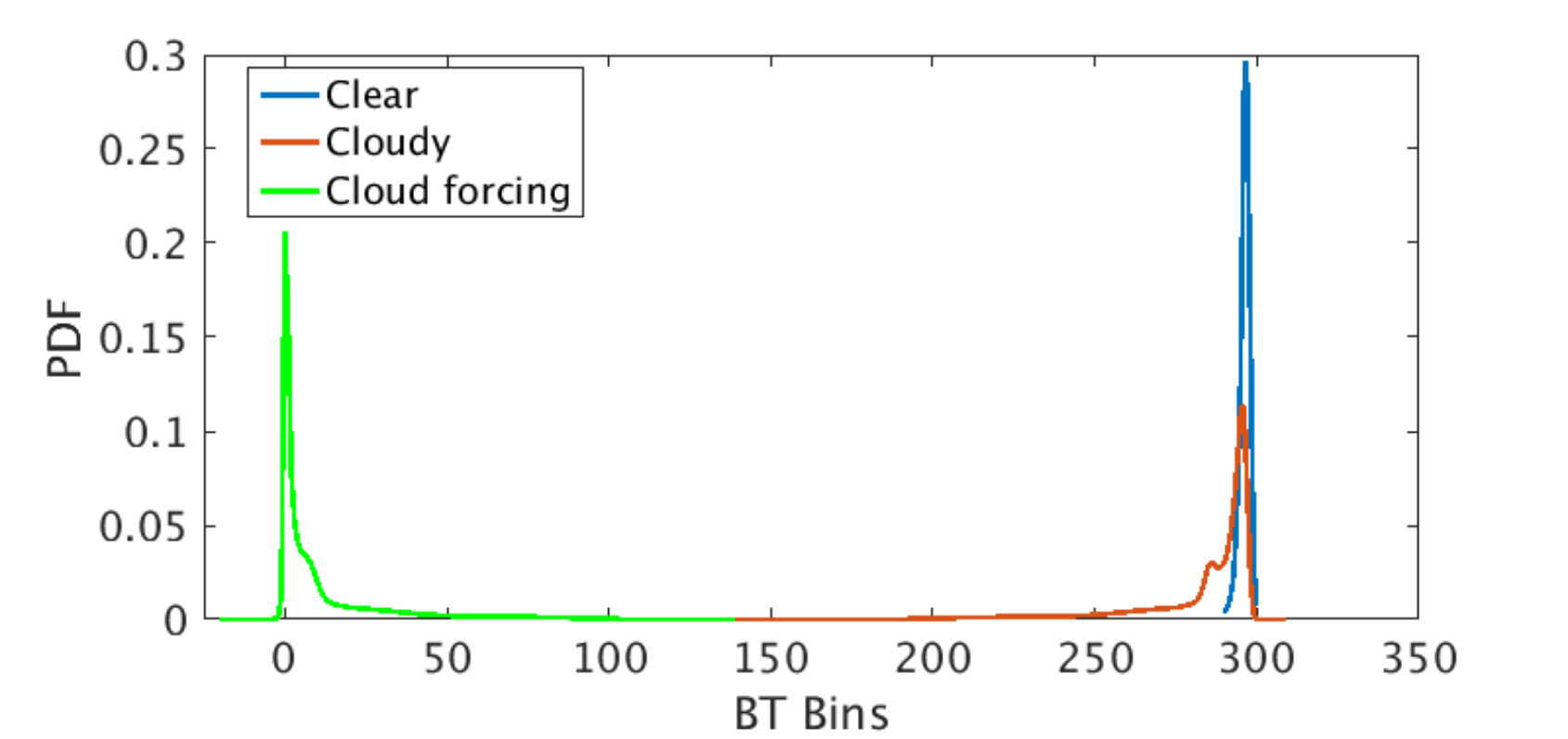
Overview

- AIRS has now made 14 years of high quality TOA radiance measurements
- We have previously shown that the instrument stability is sufficient to determine linear rates surface temp., column CO_2, temp. and wv profiles
- We have also shown that probability density functions (PDFs) of clear sky PDFs can provide insight into non-Gaussian climate variability and stochastic forcing of the atmosphere
- In this talk, we further show how PDFs can provide information on the rate of change that would be missed when looking at changes to mean properties
- We focus on a single channel ($1231 cm^{-1}$), sensitive to surface temp., column water and clouds.
- Observations are allsky, night, over land and ocean

AIRS Obs, Clear Calcs and Cloud Forcing PDFs at the equator

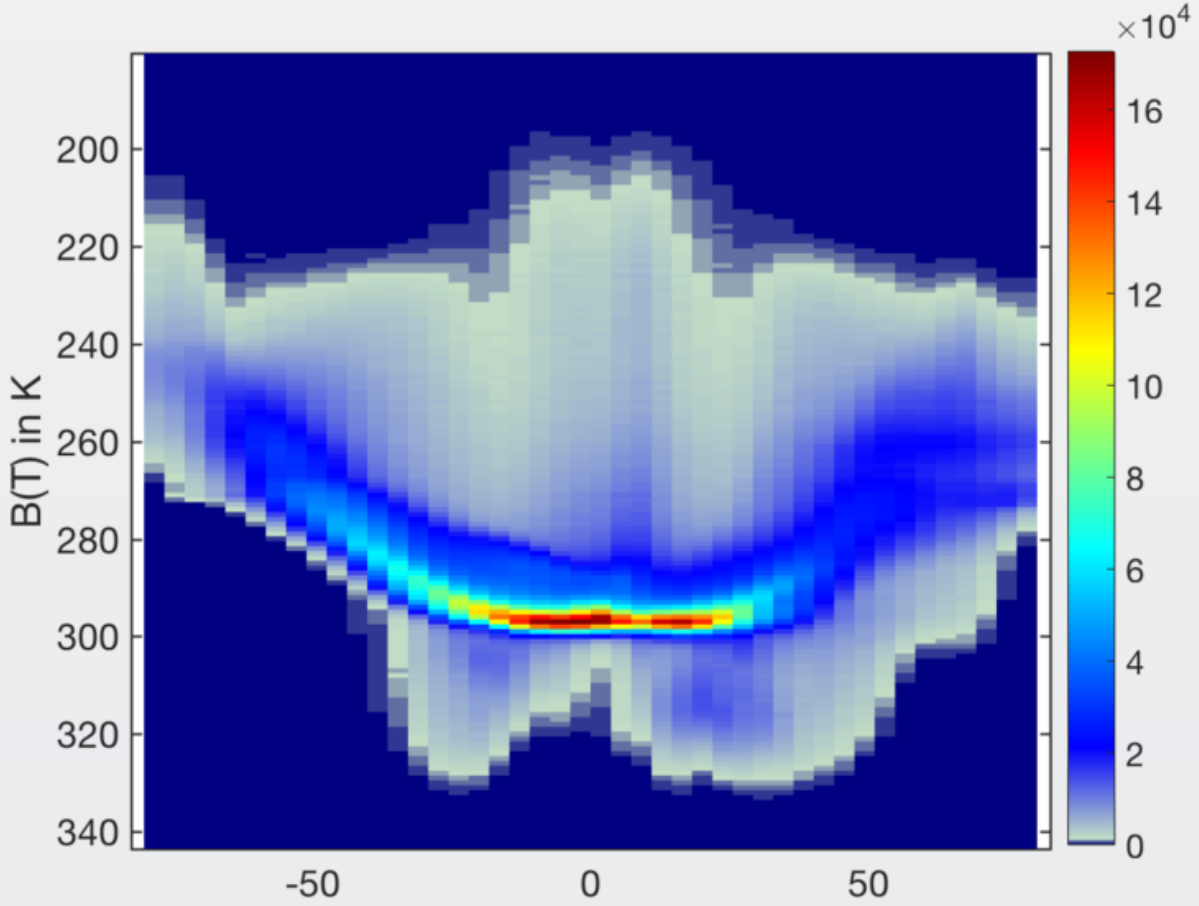
Over ocean, night time



Mean PDF from 13 years of allsky observations from $1231\,cm^{-1}$, all latitudes.

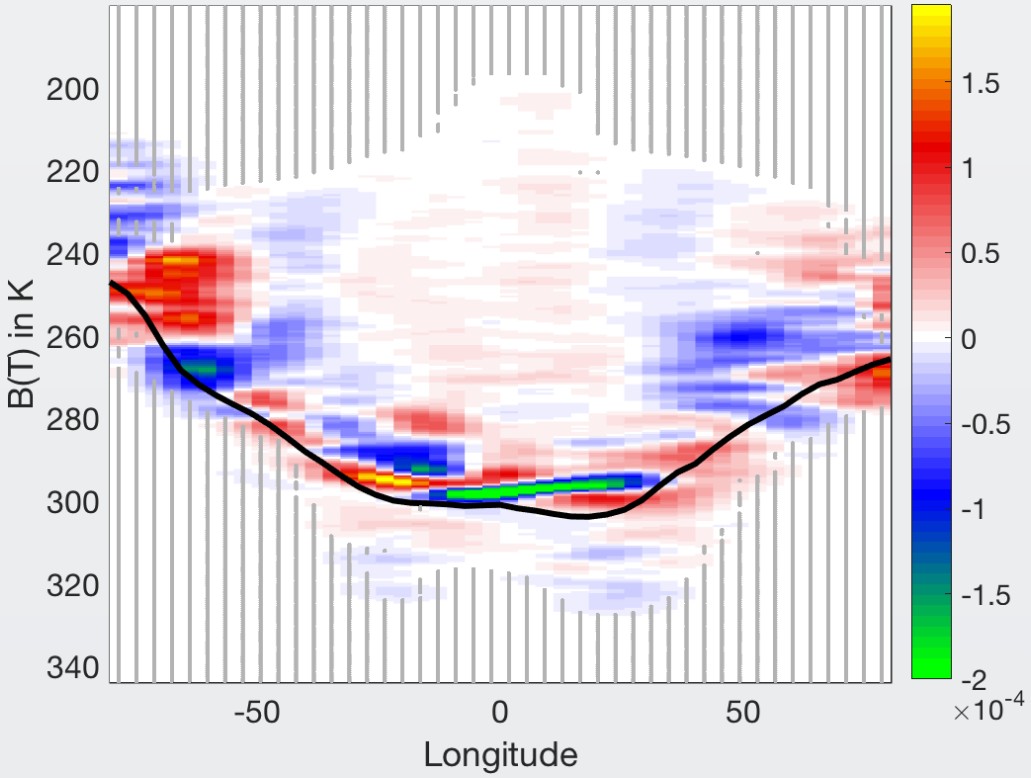
Window channel sensitive to surface temperature, clouds and column water vapor

- PDF scale is indicated by the colorbar. The x and y axes show the latitude and BT bins.



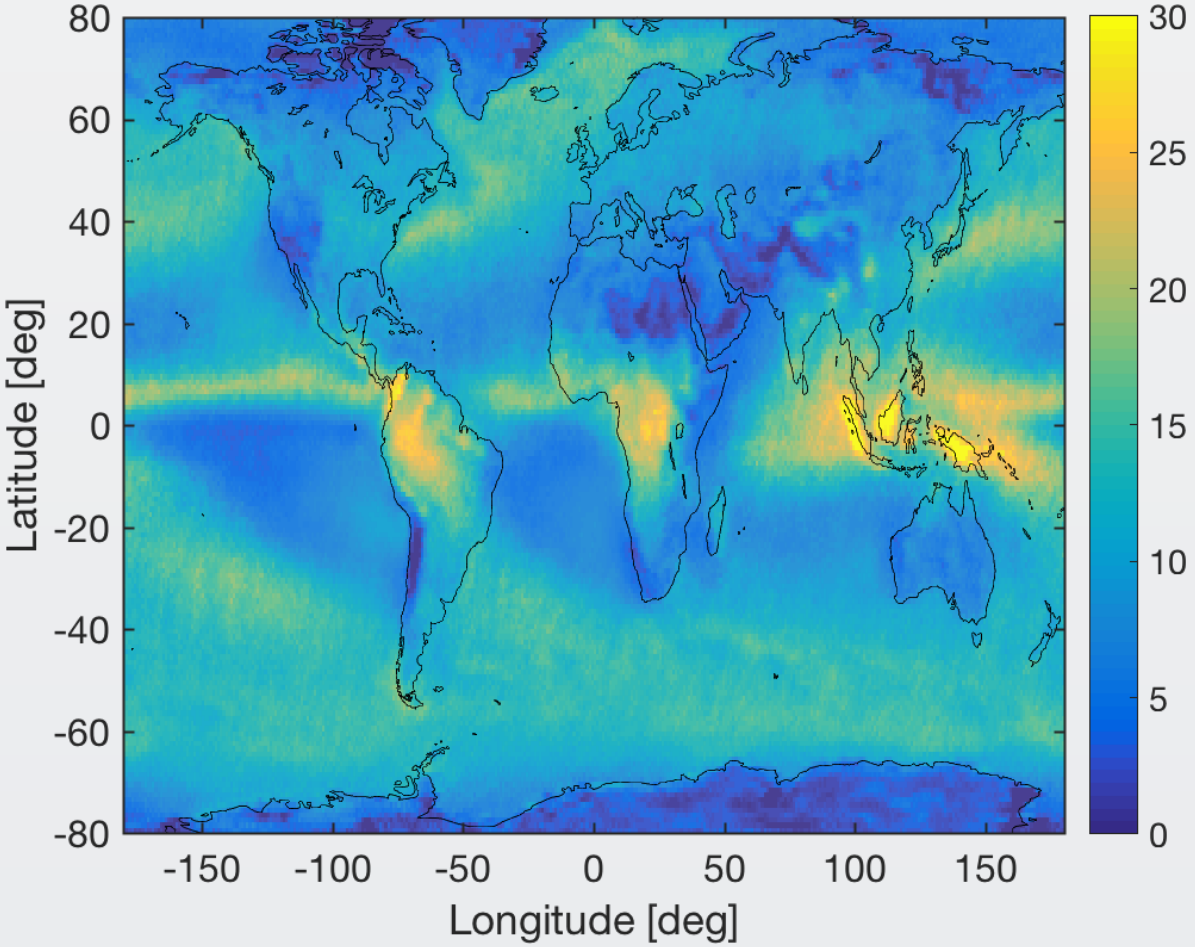
Rate of change in BT PDF for $1231 cm^{-1}$

- Linear rate from regression of $1231 cm^{-1}$ PDF.
- PDF rate shows how occurences of a particular BT range are changing per year.
- Color bar scale shows whether BT is increasing.
- Gray lines are where rate < uncertainty



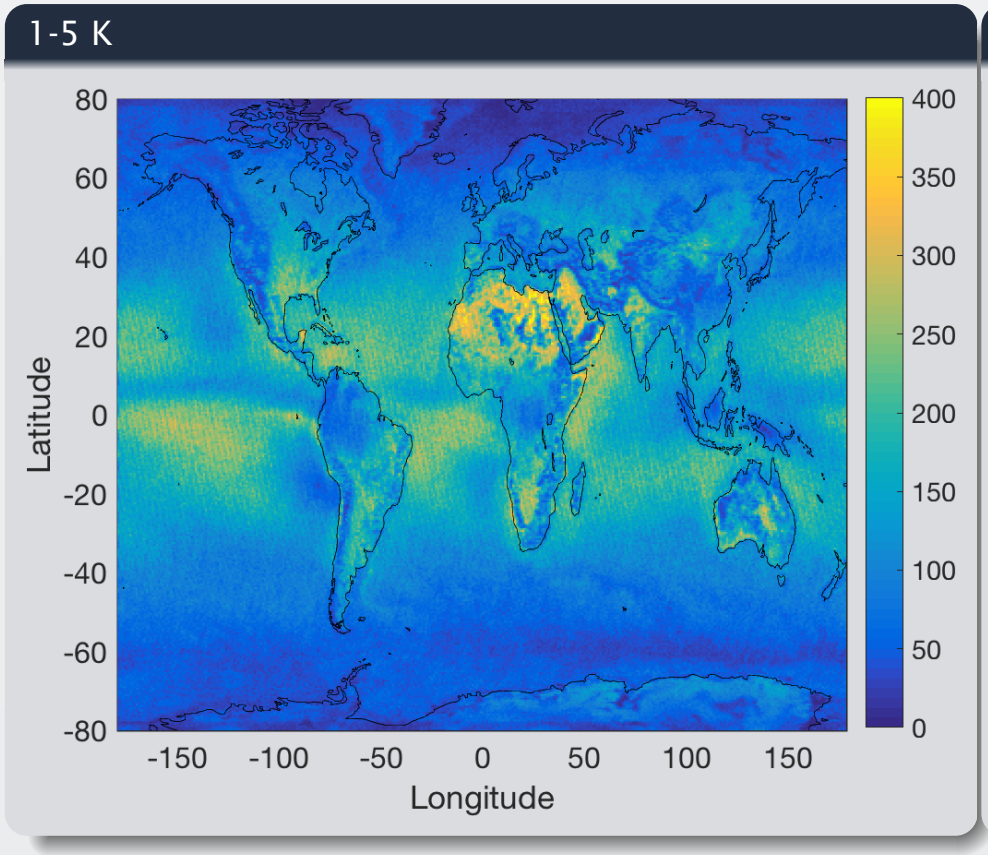
Cloud radiative effect

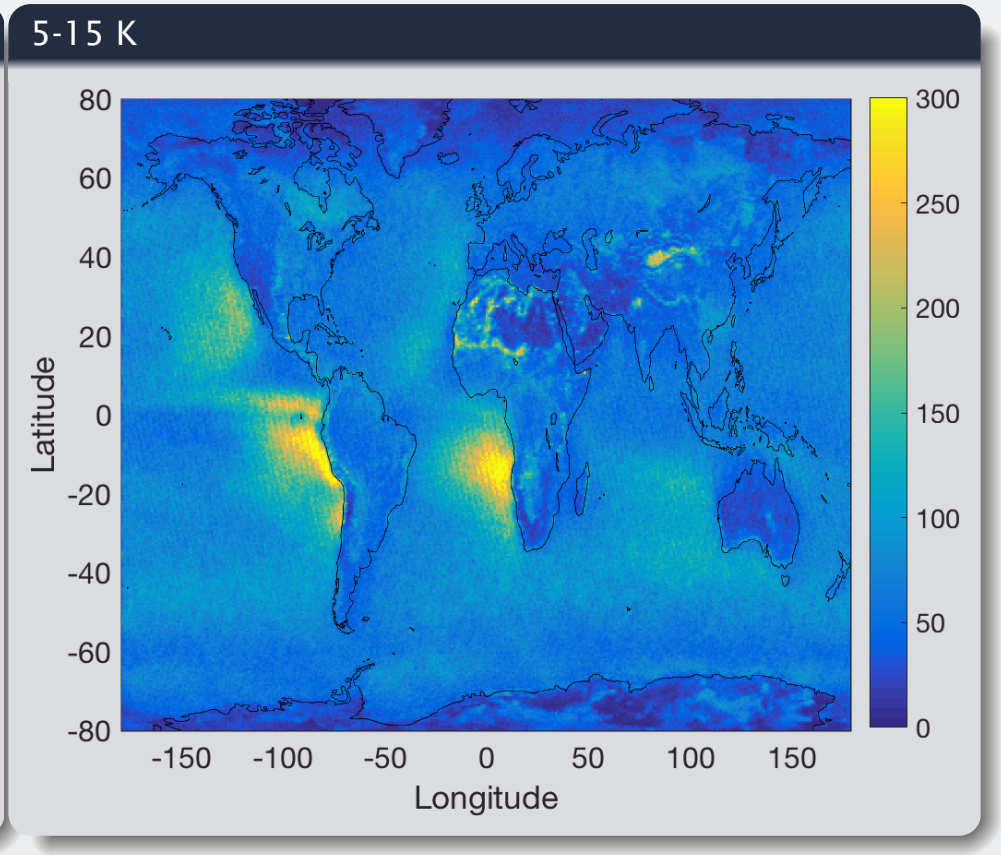
- Mean cloud forcing over 13 years.
- Clear Calculated Bt - Obs using ERA.
- Averaged on 1x0.5 degree grid.



Observation count for cloud forcing ranges

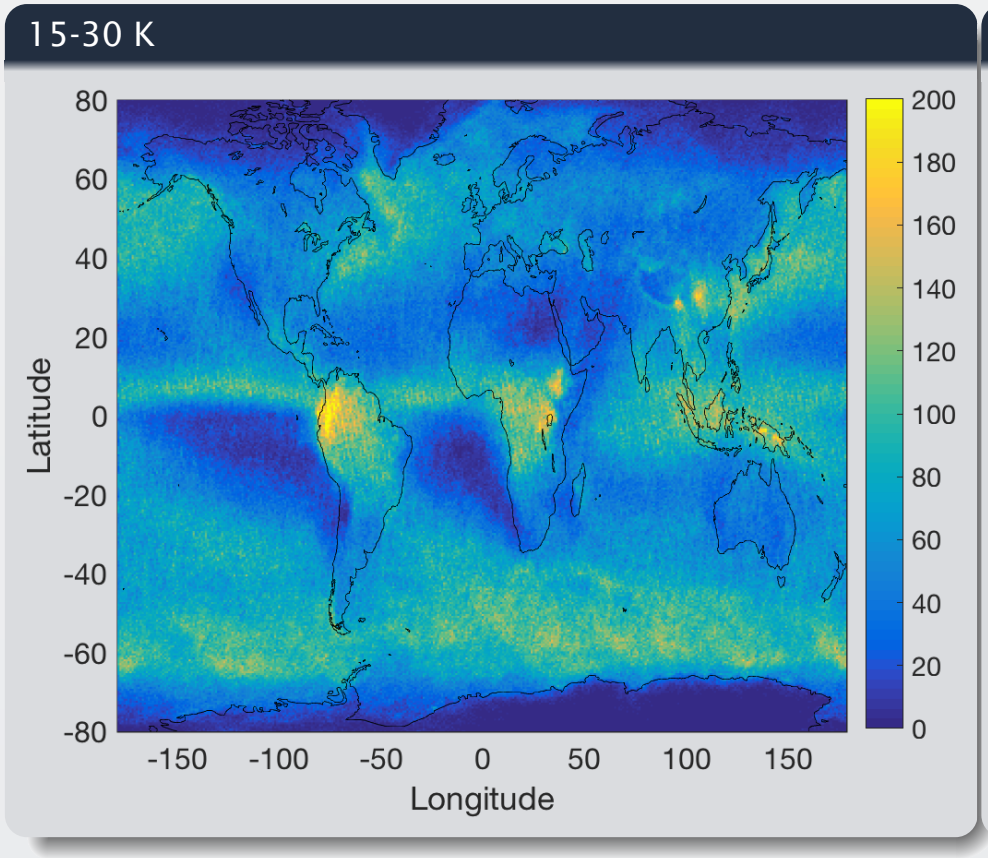
- Observations per pixel.
- 1% of data over 13 years.

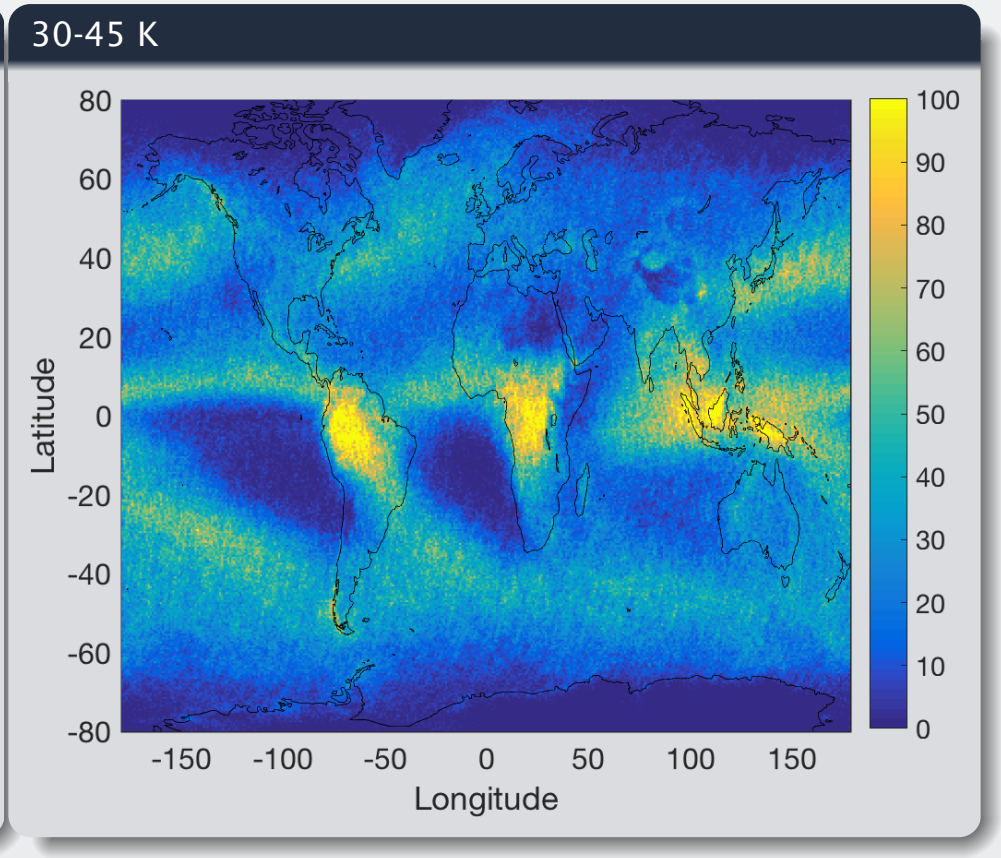




Observation count - continued

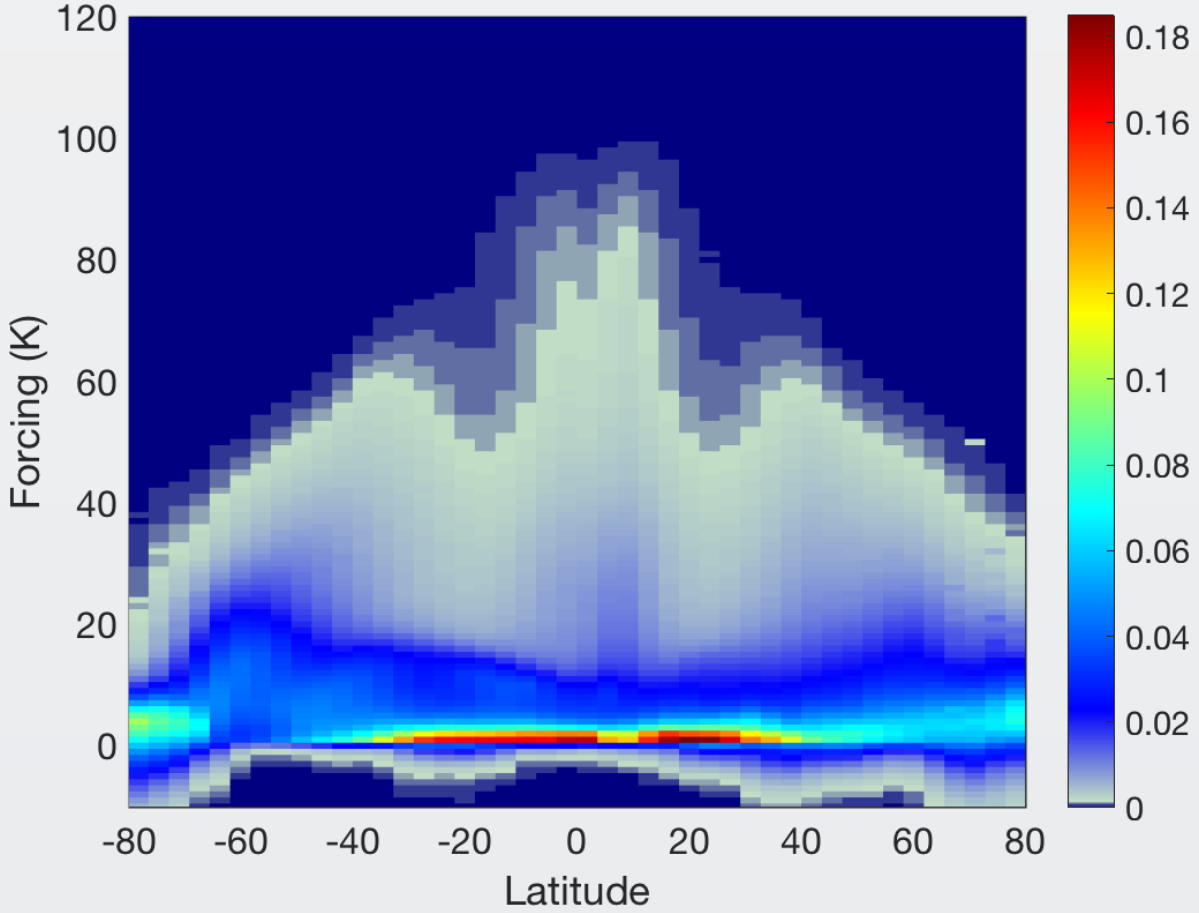
- Observations per pixel.
- 1% of data over 13 years.





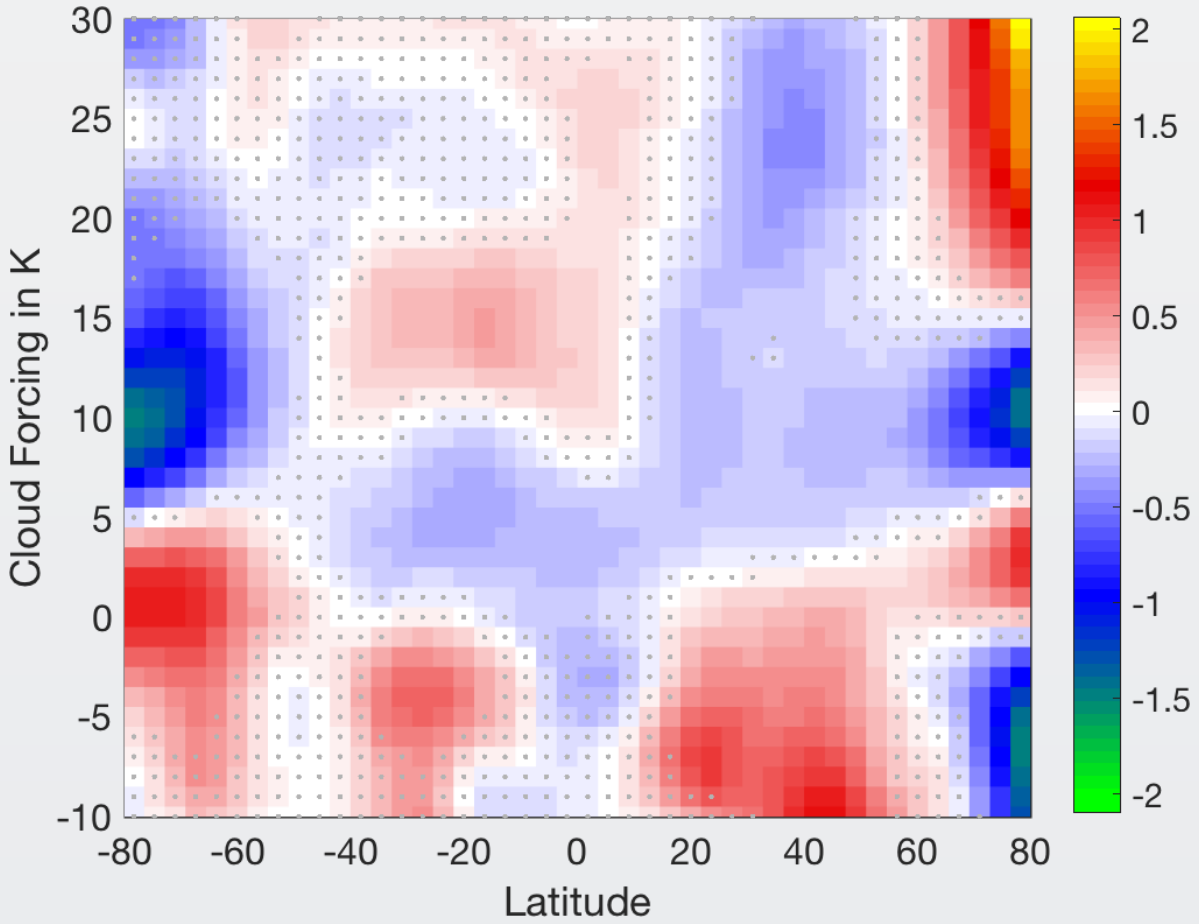
Mean Cloud Forcing over 13 years, zonal average

- Color bar indicates PDF value.
- Large values indicate deep convective clouds.
- Values near zero indicate clear sky.



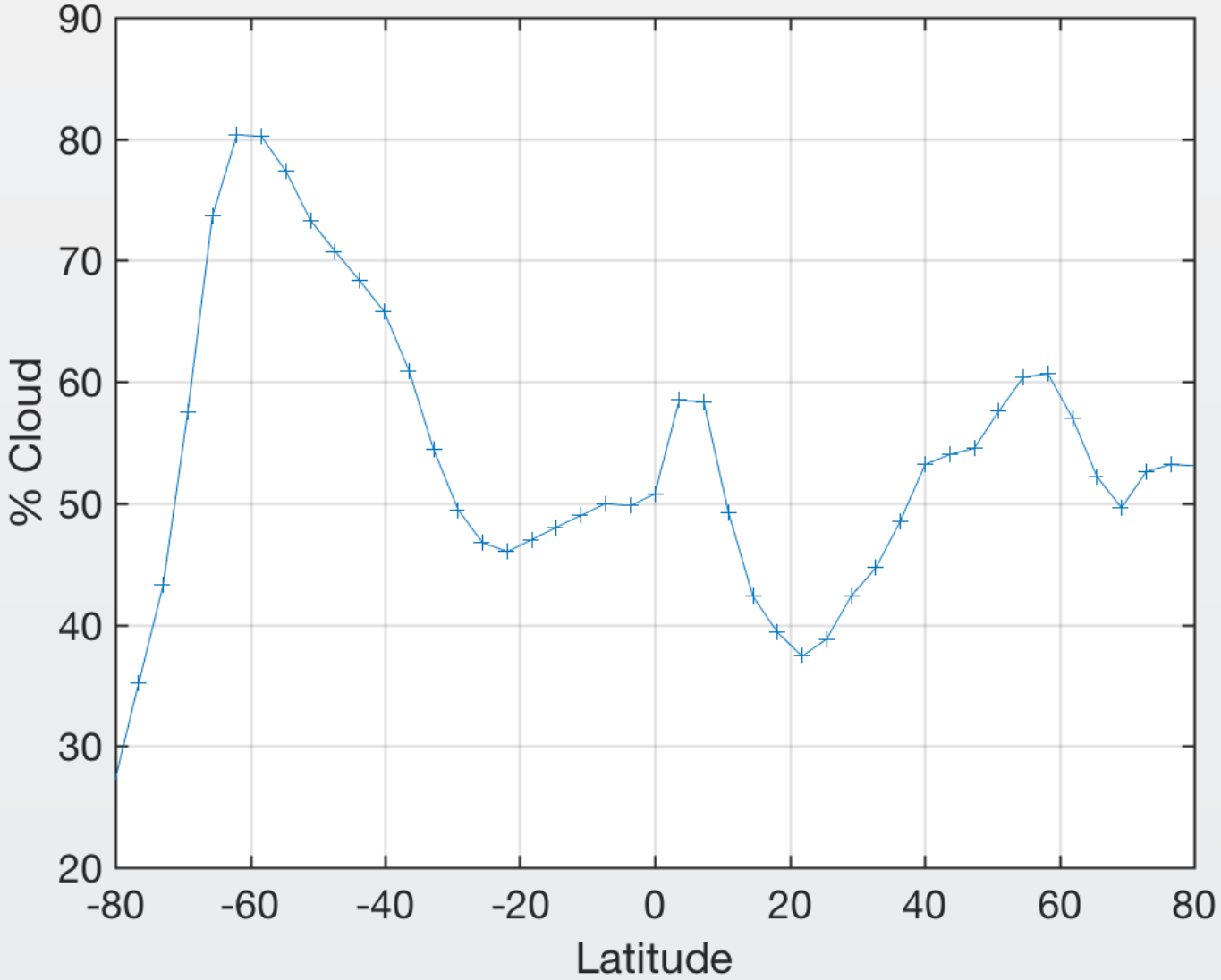
Percent rate of change in cloud forcing ($1231 cm^{-1}$).

- Rates form linear regression of cloud forcing over 13 yrs
- Color scale indicates percent change in PDF per year
- Regions with dots have uncertainty greater than rate



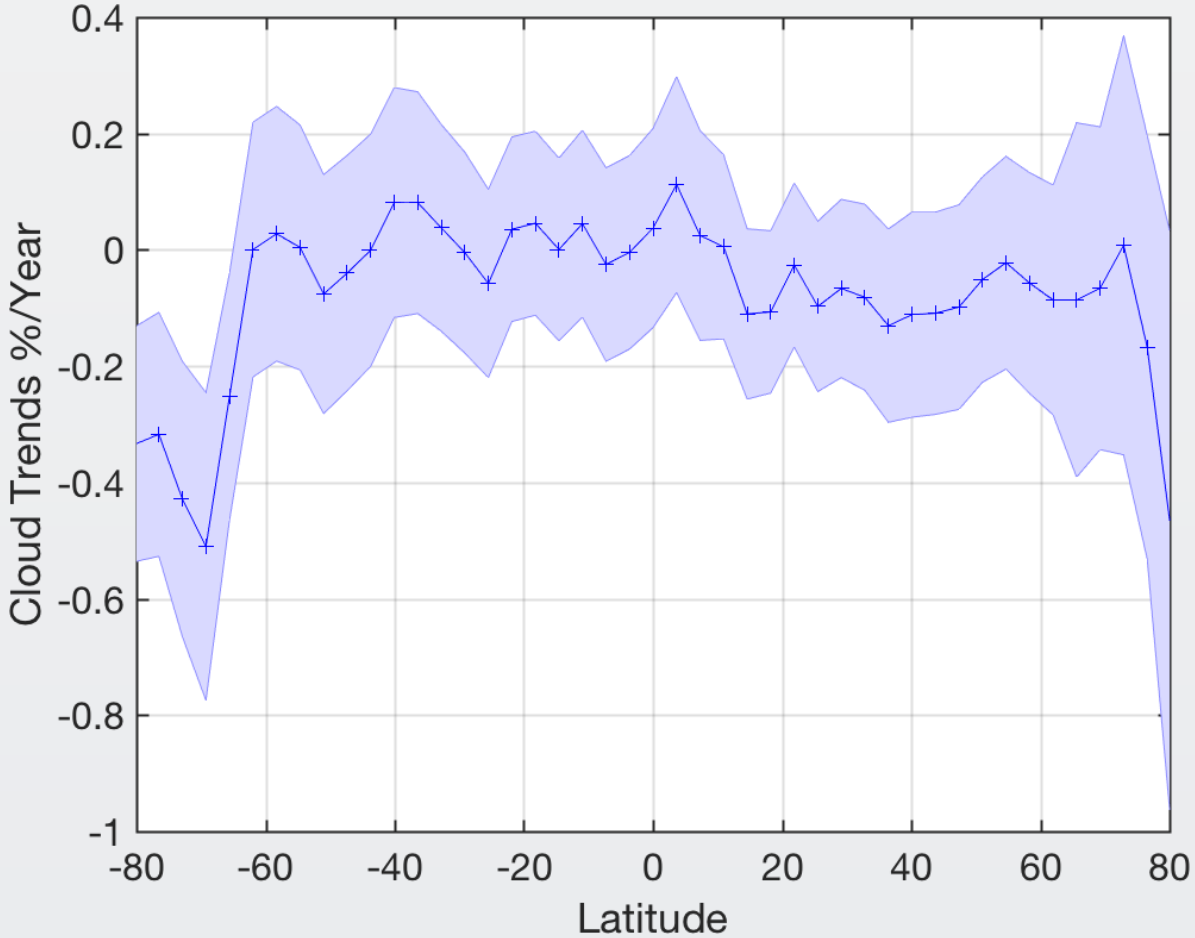
Mean Total Cloud Fraction over 13 years

- Sum of cloud forcing PDFs from 5K to maximum



Percent rate in change of cloud fraction

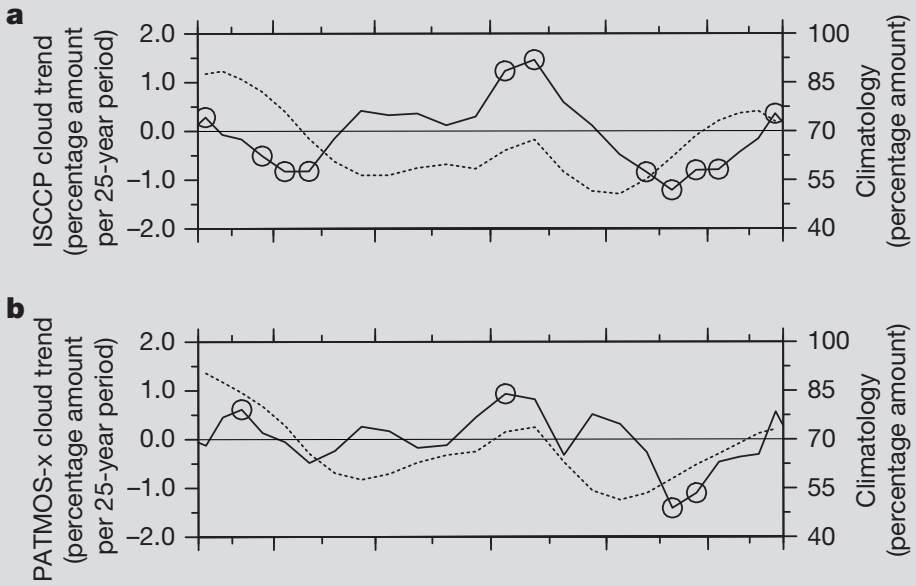
- Sum rate of change in cloud forcing from 5 K to maximum
- Uncertainty from linear regression



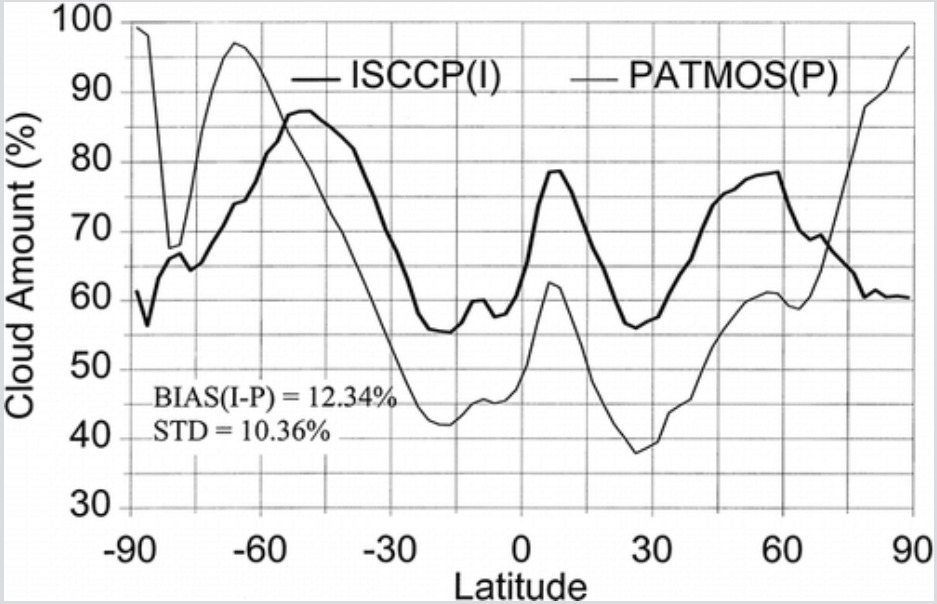
Imager determination of cloud fraction

- ISCCP = count how many cloudy 5 km pixels there are in a 280 km region, seen by satellite? http://isccp.giss.nasa.gov/cloudtypes.html
- PATMOS : from AVHRR, cf from tests using IR/NR/VIS channels (Foster et. al., Remote Sens. 2016, 8(5), 424; doi:10.3390/rs8050424)

Norris (Nature 2016)



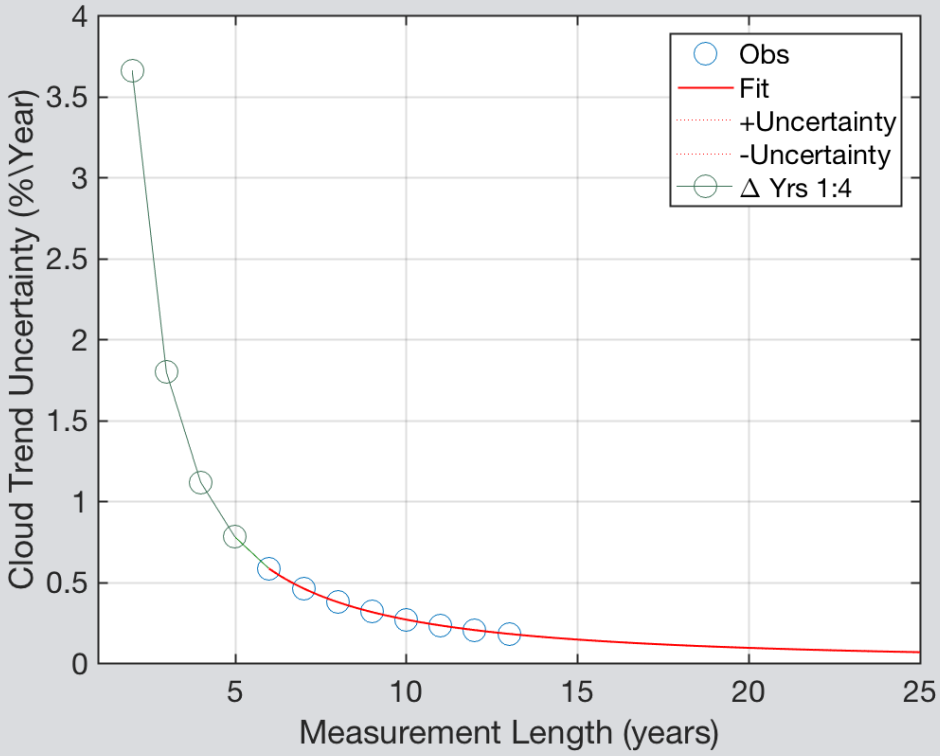
Stowe (JGR 1997)



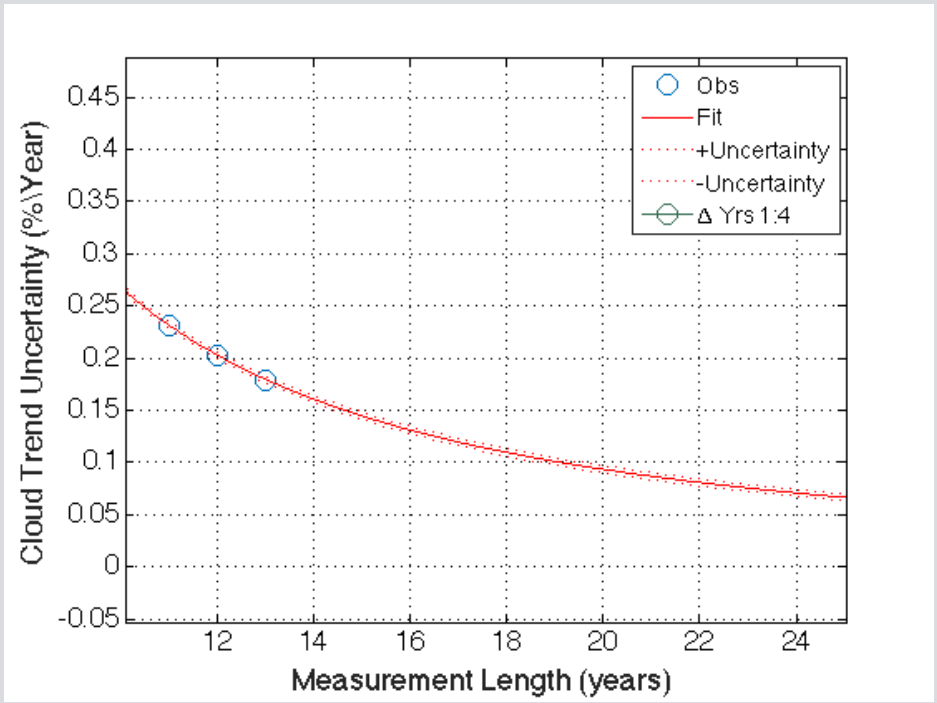
Reduction of Uncertainties over Time

- Linear regression errors decrease with longer data sets
- We calculate the regression errors for 1-13 year linear fits and extrapolate to 25 years

25 years



Zoom to last 15 years

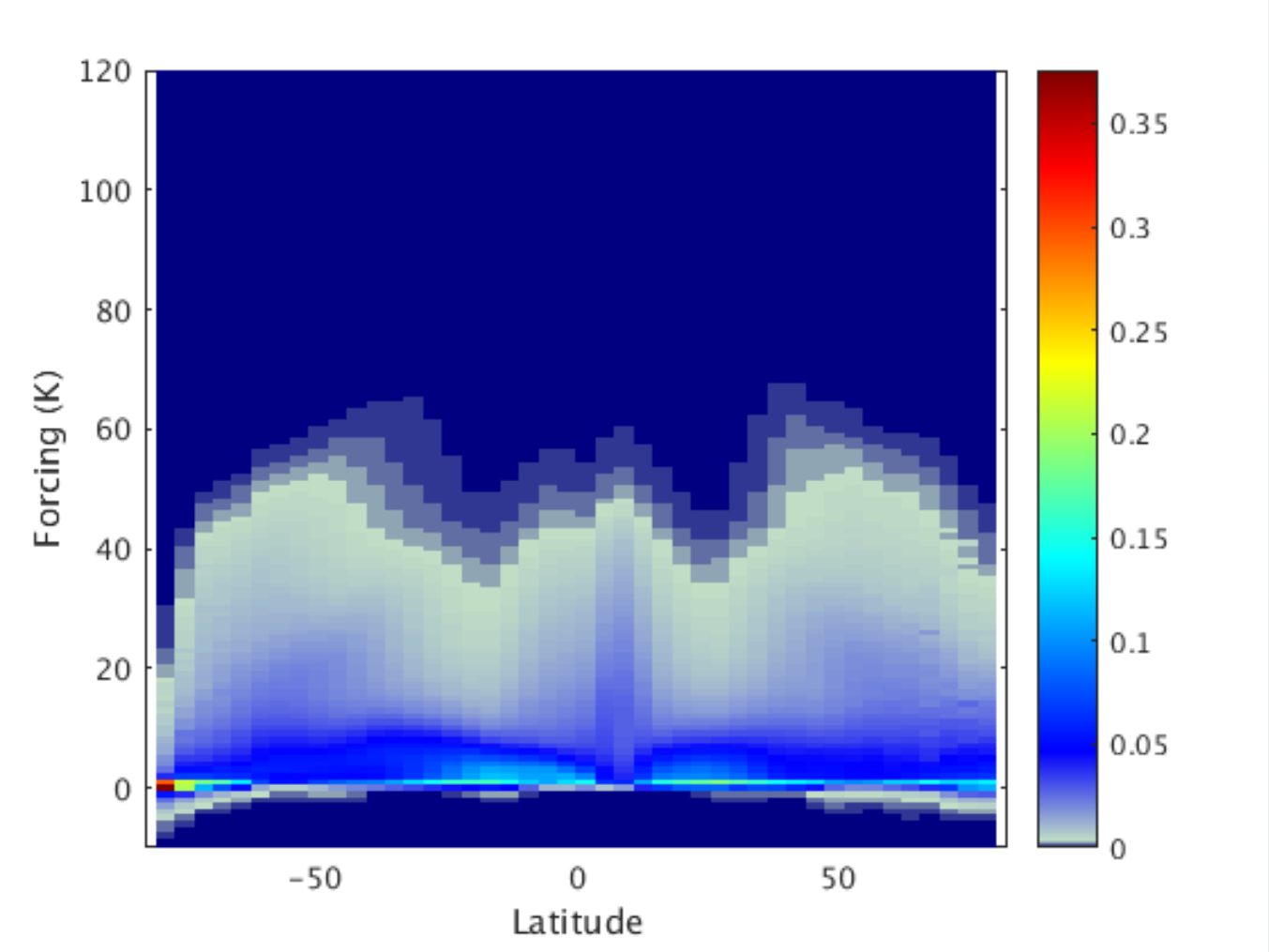


Conclusions

- AIRS can give you high-quality pseudo-veritcal cloud percent changes, and we are starting to reach climate level measurements
- Linear rates of cloud forcing can be used to obtain cloud fraction rate dependence on latitude and level
- Longer term IR observation records should lead to higher accuracy
- Introduced a simple and easily implemented definition of partial cloudiness that agrees with eg ISCCP and PATMOS
- Preliminary results, more work needed

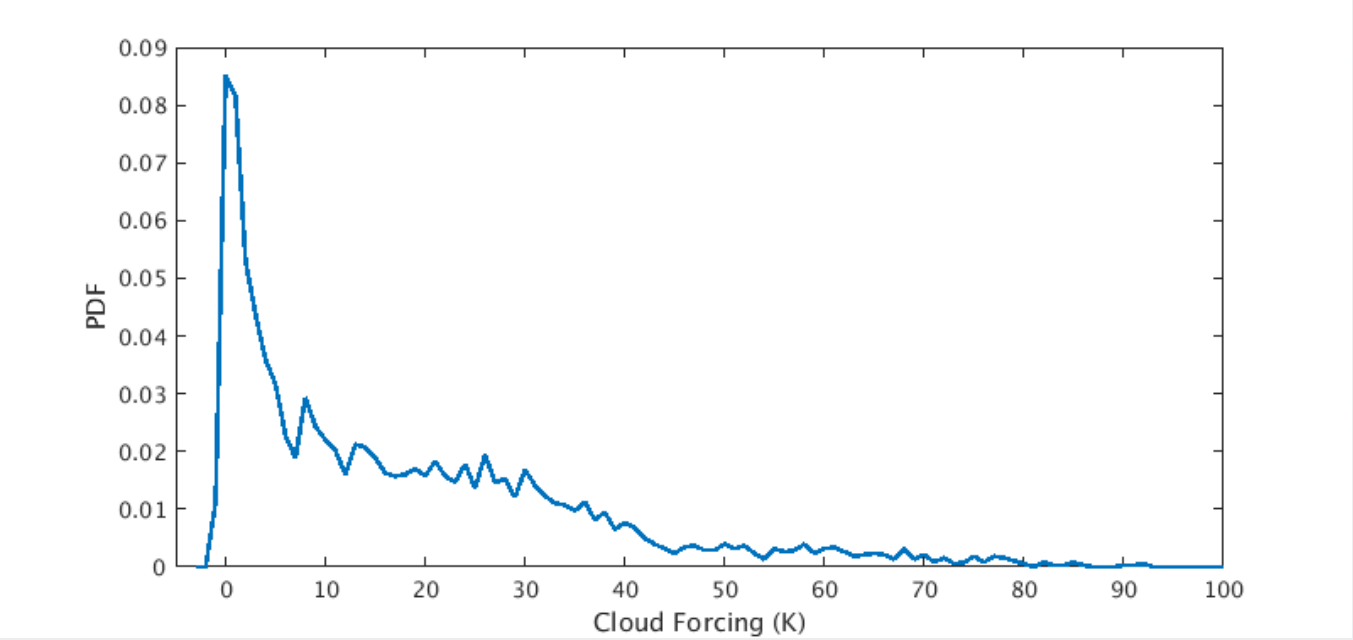
Cloud Forcing PDF with ERA Calcs, Ocean Only

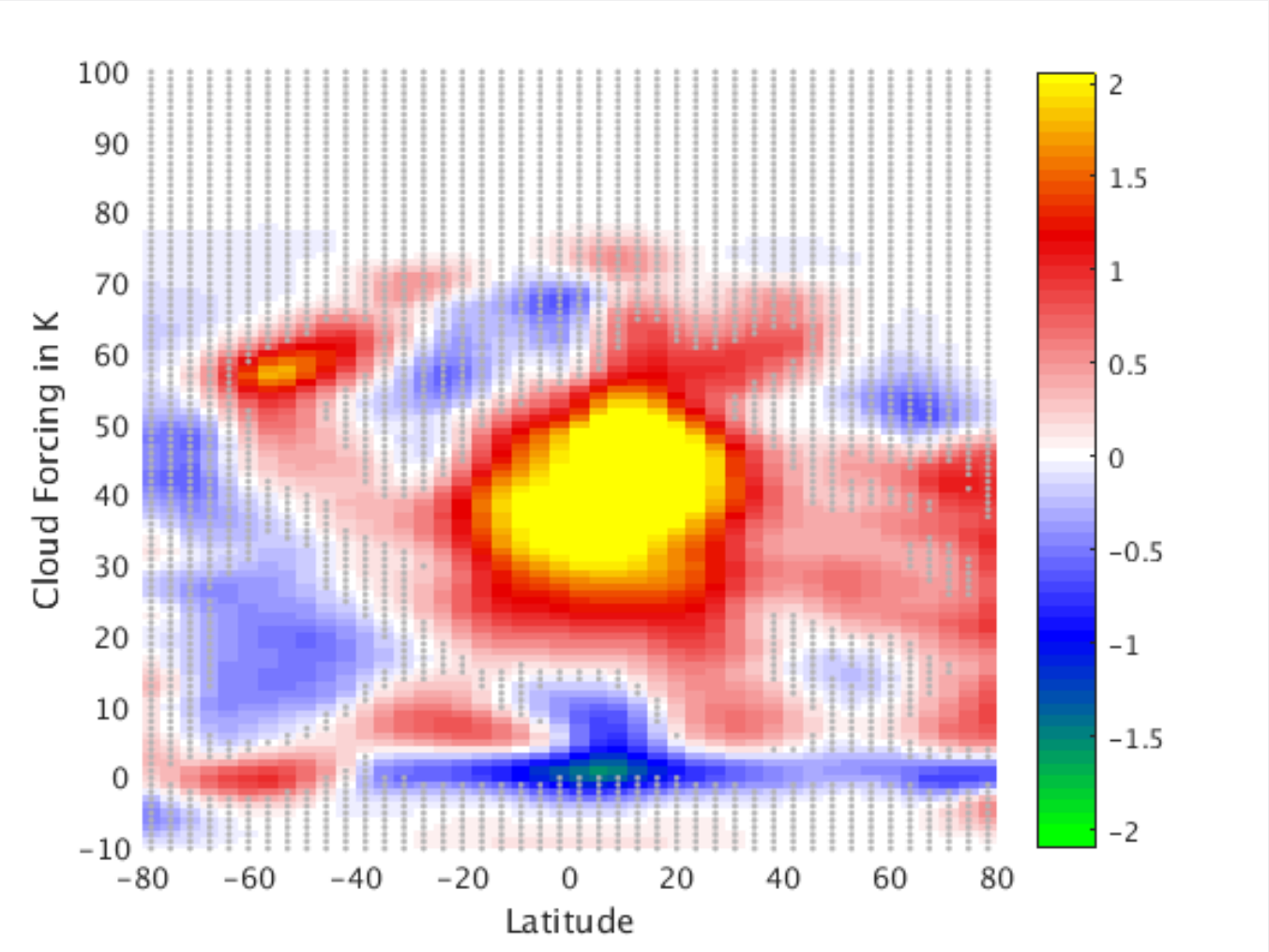
- Shows much less negative forcing over oceans



Cloud forcing PDF at equator, ERA Calcs, one month

- Sum of these PDF values gives the cloud fraction.



Cloud forcing rates, ERA Calcs, ocean only

- Shows high clouds increasing over tropics and northern mid-lat.