Is there a trend in cirrus cloud cover due to aircraft traffic?

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# What's so special about contrail (condensations trail) clouds?

➢ Aircraft induced contrails and cirrus clouds impact longwave and shortwave radiation (mainly longwave)

➢ These clouds have a net positive radiative effect

➢ IPCC forcing for cirrus is very uncertain (What do they really do?)

➢ Regional forcing may be more significant than a global mean

➢ Contrails and aircraft induced cirrus clouds affect the diurnal temperature. This is the temperature difference between the warmest and coolest parts of the day.

What were they trying to learn?

➤ **To identify trends that can possible be related to aircraft traffic based on satellite observations of cirrus clouds**

➤ **Used ISCCP data over a 16 year period**

➤ **Even though they took a global approach, they focused on the region viewed by METEOSAT (Meteorological Satellite)**

➤ **Do these clouds affect the global mean radiative forcing and if so, is it a symptom of global warming due to anthropogenic factors (aircraft)**

How Do They Measure Cirrus Cloud Cover?

➢ **Use ISCCP datasets for cirrus clouds.**
  - **The dataset is derived from a combination of _visible_ and _IR_ information**
  - **Results are only in the day**

Notice parts of world with the most % of Cirrus Clouds
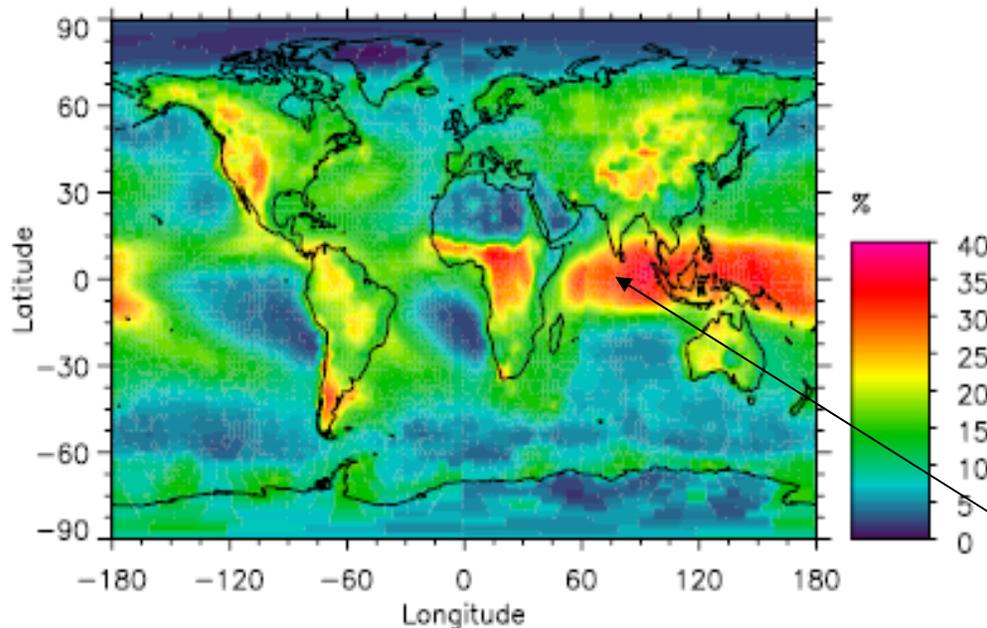
Fig. 1. Global map of average cirrus cover based on ISCCP VIS/IR data for the period 1984–1999 (in % cloud cover).
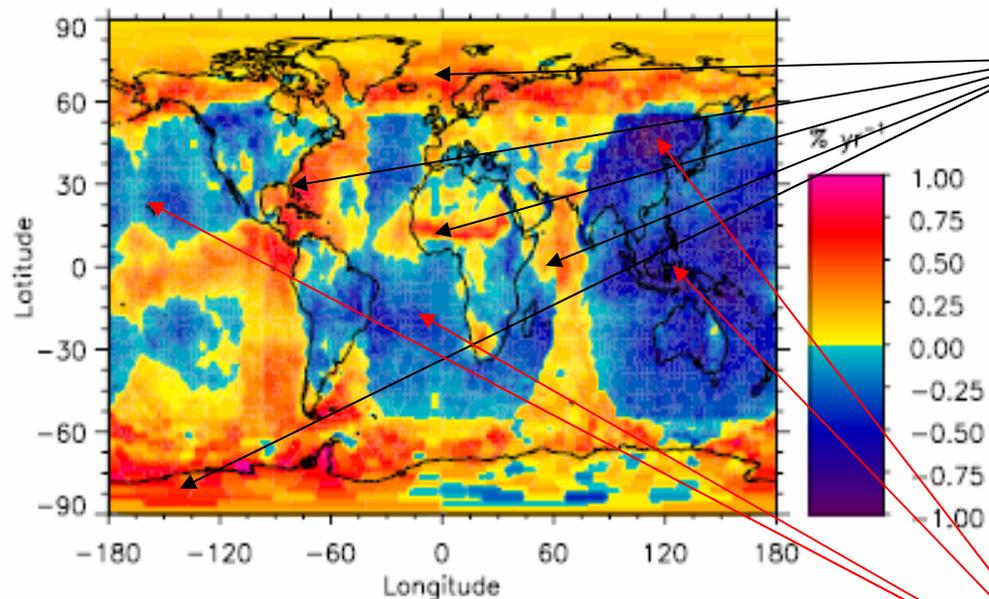
<u>**Why such a discrepancy in cloud cover Of cirrus?**</u>

<u>Indian Ocean</u> has 3 covering satellite Instruments: **GMS (east)**
METEOSAT (west)
NOAA-A (in between)

More thin cirrus is detected at slant views which is why more cirrus is detected in the Indian Ocean region

How Do They Measure Cirrus Cloud Cover?

➢ **Determining temporal trends in the ISCCP dataset**
  - **Divided into two 8 year periods, <u>1984-1991</u> and <u>1992-1999</u>**
  - **Trends were taken as the difference between the two periods**
  - **Similar to a linear regression of the yearly mean data in the 16 years**
  - **Focused trend analysis on regions covered by only one satellite in data**

<u>Increase</u>

<u>Decrease</u>

Fig. 2a. Changes in cirrus from ISCCP VIS/IR based on differences between the two periods 1992–1999 and 1984–1991 (in % cloud cover per year).

Focusing on METEOSAT satellite region since it hasn't moved in the whole period of record, thus avoiding the dependence on zenith angles.

Aircraft Impact on Cirrus Cover

➢ **Correlate the estimated trends in cirrus with aircraft flight data**
  - **What data do they use?**
    1. **Global fuel usage**
    2. **NOx emissions and kilometers traveled (determined by TRADEOFF Project for the years of 1992 and 2000 using the FAST model)**
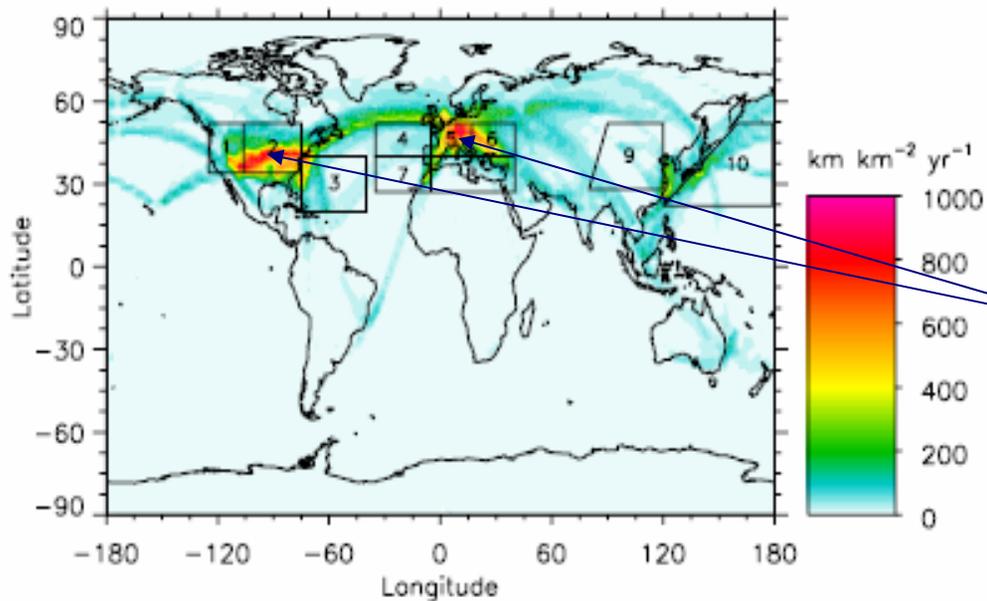
Notice the areas of most traveled aircraft

Fig. 4. Global map of distance flown with aircraft ($km\ km^{-2}\ yr^{-1}$) in year 2000 in altitude layer 17–19 (9760–11 590 m altitude). Also shown are 10 regions used for trend analysis.
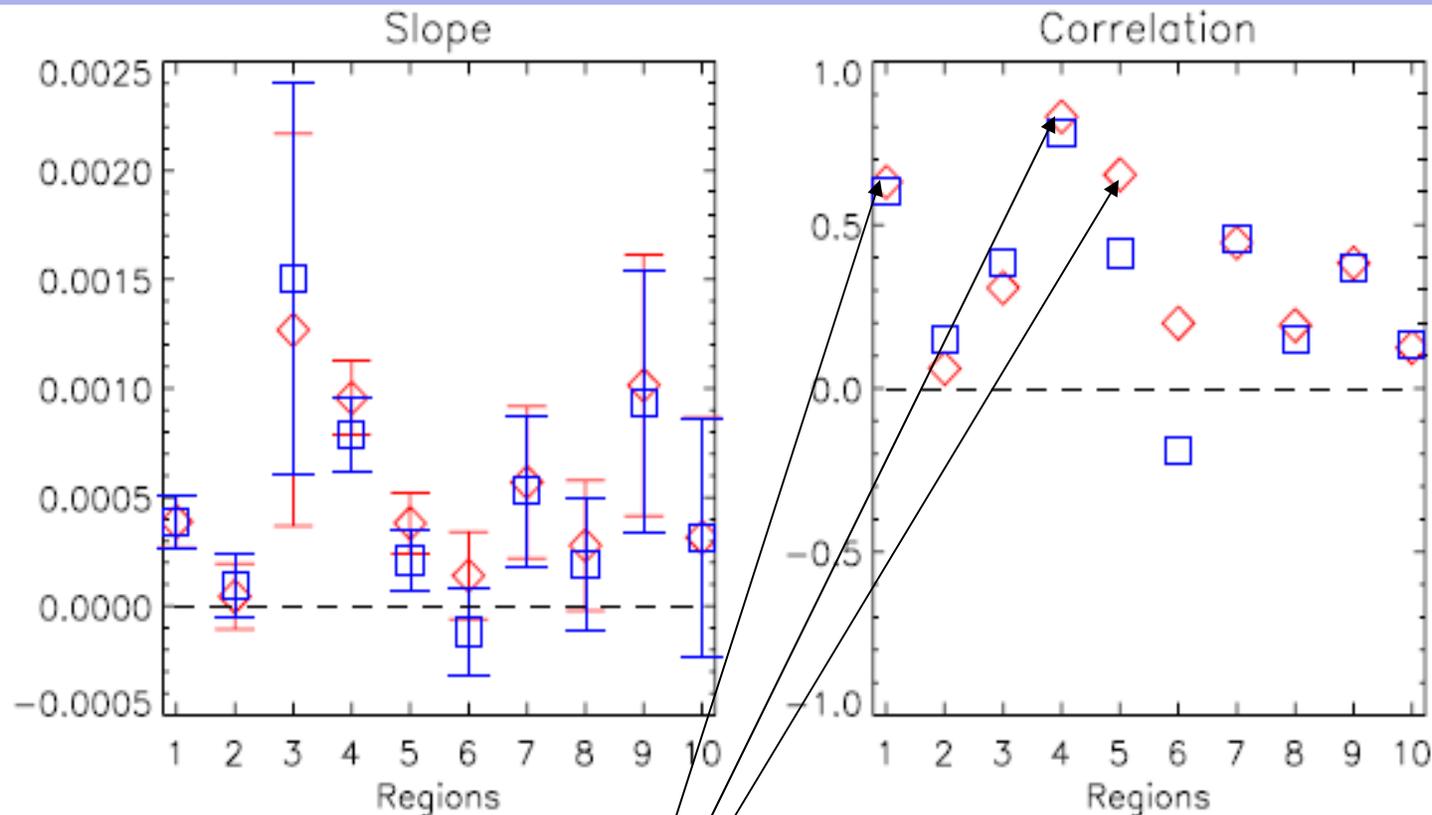
Results? Correlations?

Fig. 5. Results of spatial regression analysis between trends in cirrus cloud amount from ISCCP VIS/IR and aircraft traffic density, for the slope in (% yr^{-1})/(km km^{-2} yr^{-1}) and the correlation coefficient. Temporal trends have been determined from differences between two 8 year periods, and from linear regression, and traffic data are taken from the region encompassing layers 17–19 (9760–11 590 m altitude).

Found a higher correlation for Regions 1 (**western US**), 4 (part of **NA Flight Corridor**, 5 (**western Europe**)

Assumption: Change in the area covered by cirrus in a region (dA) is proportional
(by a factor *b*) to the change in aircraft flight distance (dL) over a unit of time
dA = *b*dL

Results? Correlations?

◇ — Trends from 2 periods
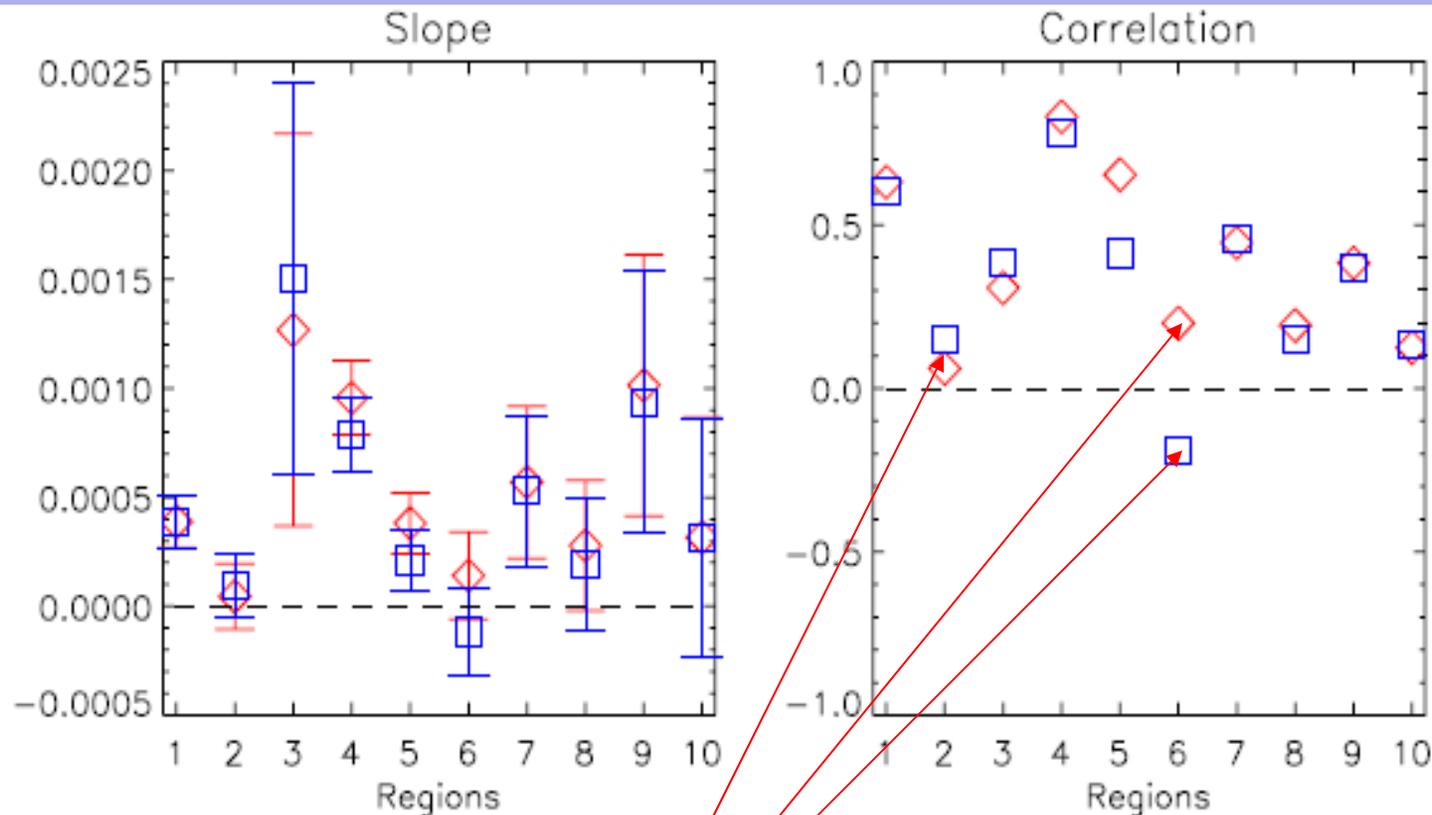☐ — Trends from regression

Fig. 5. Results of spatial regression analysis between trends in cirrus cloud amount from ISCCP VIS/IR and aircraft traffic density, for the slope in (% yr^{-1})/(km km^{-2} yr^{-1}) and the correlation coefficient. Temporal trends have been determined from differences between two 8 year periods, and from linear regression, and traffic data are taken from the region encompassing layers 17–19 (9760–11 590 m altitude).

Why are Regions 2 and 6 weak with correlation?

One possible reason is advection, predominantly eastward from regions 1 and 5 into
The neighboring regions 2 and 6.

Conclusions:

Found indications that cirrus <u>cloud amount increases</u> have accompanied an <u>increase in air traffic</u> in the 16 year period (1984-1999) contrasting with a general negative trend

- Relationship between cirrus cloud amount and aircraft density is <u>uncertain</u> and they <u>cannot draw firm conclusions</u> or quantify the effect with high certainty
- Results may still be influenced by natural variability, climate change, and other anthropogenic impacts

Find that the <u>strongest influence</u> on cirrus clouds occurs in parts of the regions with the <u>highest aircraft traffic</u>

<u>Conclude that cirrus from aircraft can potentially contribute to global warming over the last few decades!</u>

What's The Bottom Line?

• **Global mean** radiative forcing change due to an aircraft effect on cirrus = **0.03 W/m^2**

To explore the range of radiative forcing they used two other estimates for radiative impact of cirrus:

Table 2. Radiative forcing (Wm^{-2}) due to aircraft induced cirrus (year 2000), adopting the global cirrus cover derived from the METEOSAT regions (in Table 1).

Adopted radiative impact of cirrus (Wm^{-2} per 1% cloud cover)	Lower limit	Best estimate	Upper limit
0.06 (Marquart et al., 2003)	0.01		
0.12 (Myhre and Stordal, 2001)		0.03	
0.20 (Boucher, 1999)			0.08

Problems / Room for Error?

• Need to derive a global estimate to include all parts of the world (not just 10 regions)

• Only have aircraft data for 1991/1992 and 2000 and made assumptions on the evolution from 1984 to 1991/1992

• Used monthly means for the cirrus clouds estimates

Possible Improvements

- Could use <u>daily</u> data instead of monthly means

- Take into account <u>advection</u> of aircraft induced cirrus

- Supplement satellite data with <u>ground observations</u> somehow

- Use <u>actual</u> flight path data instead of relying on models (Gather information from airline industries)

May be more work, but it would tell us more