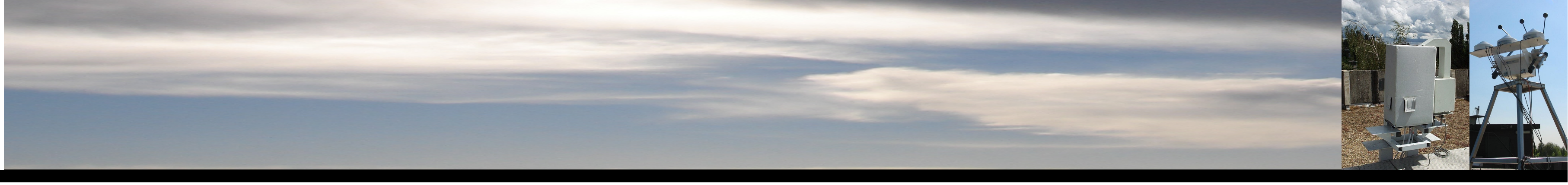

Observed cirrus cloud radiative forcing on surface-level shortwave and longwave irradiances

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State of the art

ISCCP D-series data

Cumulative surface CRF$_{SW}$ and CRF$_{LW}$ (W m^{-2}).

Cirrus (0.13) -3.6 1.1	Cirrostratus (0.06) -7.2 1.7	Deep convective (0.03) -5.8 0.7
Altocumulus (0.10) -3.1 2.2	Altostratus (0.08) -8.2 3.6	Nimbostratus (0.02) -3.4 1.3
Cumulus (0.13) -5.5 5.3	Stratocumulus (0.12) -13.2 7.3	Stratus (0.02) -2.6 1.2

Pressure: 50, 440, 680, 1000

Cloud Optical Thickness: 0, 3.6, 23, 379

Passive remote sensing : ISCCP

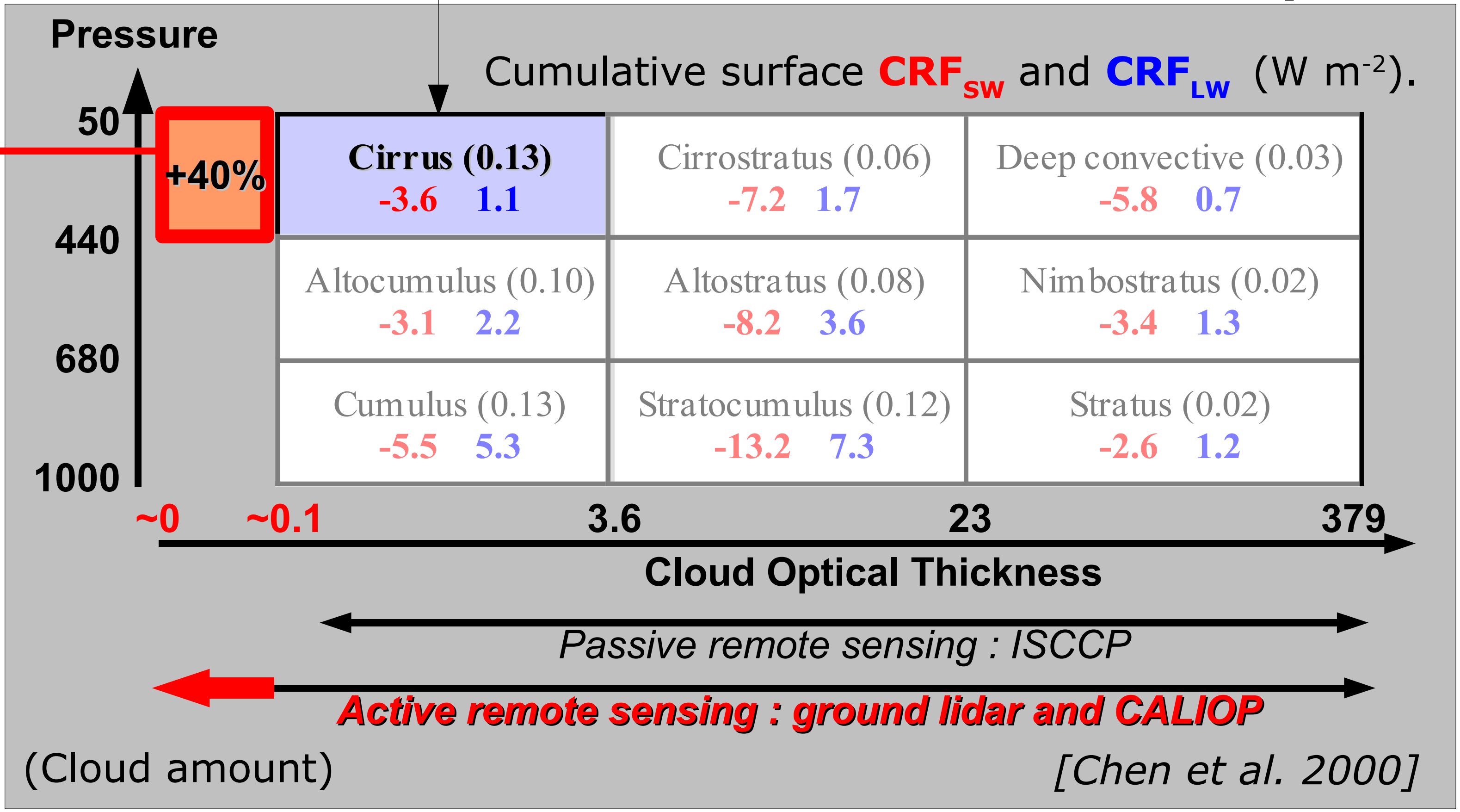
(Cloud amount)

[Chen et al. 2000]

Problematic ?

-3 W m^{-2}, Arctic [Shupe and Intrieri, 2003]
-37 W m^{-2}, Mid Lat. [Dong et al., 2005]
-12 W m^{-2}, Mid Lat. [Mace et al., 2006]

Instantaneous impact



Goal of this study : Quantify regional and global impact of optically thin clouds (typically with COT<0.1) previously not detected by passive remote sensing

Poster session A, n° J3 : ***Toward a global climatology of optically thin clouds derived from networks of ground-based lidars***, presented March 11, 05:30 pm – 08:30 pm.

Objectives

Objectives of this study **:**

- Quantify the mean radiative impact (SW and LW) of high altitude and optically thin clouds on multiple sites at different latitudes (Artic, Midlatitude and Tropical regions) ;

  - **Focus on cirrus cloud with COT<0.1** ;

- Establish the relationship between CRF_{SW} / CRF_{LW} and macrophysical properties of cirrus clouds (cloud optical thickness, cloud base height, cloud temperature) ;

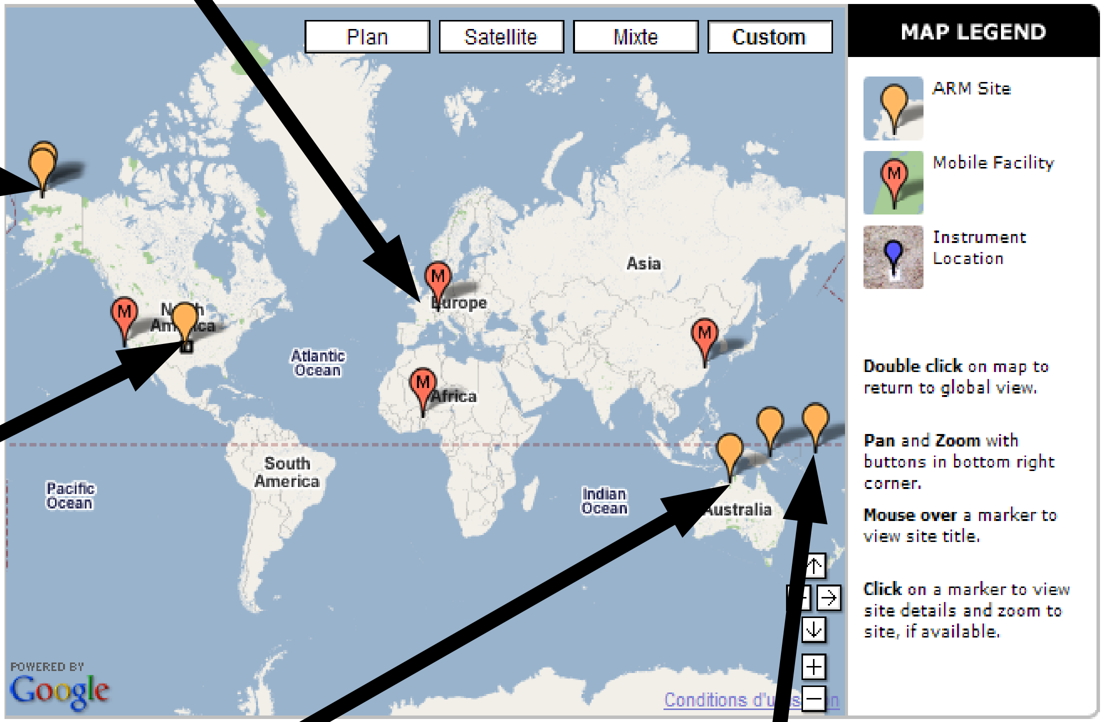
- Estimate the impact of atmospheric humidity (IWV) and aerosol content (AOT) on the CRF (i.e study pristine and turbid atmosphere impact) ;

Observatories

SIRTA (oceanic / continental)
N 48°42'00", E 2°12'28"
Alt. 156 m

ARM NSA, *Barrow* (arctic)
N 71°18'43", E - 156°39'54"
Alt. 0 m

ARM SGP, *Lamont* (continental)
N 36°36'25", E - 97°29'09"
Alt. 318 m



ARM TWP, *Darwin* (oceanic)
S 12°25'26", E 130°53'31"
Alt. 29 m

ARM TWP, *Nauru* (oceanic)
S 00°31'15", E 166°54'57"
Alt. 7 m

Clear-sky references

$CRF_{SW} = SW_{measured} - SWCSM$ $\qquad$ $CRF_{LW} = LW_{measured} - LWCSM$

Clear-Sky periods detected by 3 thresholds

1/ Lidar algorithm *[Morille et al., 2007]* → remove cirrus clouds from the dataset

2/ LongWave flux algorithm *[Dürr and Philipona, 2004]*

3/ ShortWave flux algorithm *[Long and Ackerman, 2000]*

↓ detect low and middle level cloud

↓ hazy cases *[Dupont et al., 2008]*

ShortWave Clear-Sky Model

$$SWCSM = \underbrace{a \times \cos(SZA)^{b} \times c^{1/\cos(SZA)}}_{\text{[Dutton et al. 2001]}} + \underbrace{\Phi_{(AOT,\ IWV)}}_{\text{Corrective function}}$$

[Dutton et al. 2001] Corrective function

a : solar constant adjusted for the Earth-Sun distance for each site
b, **c** : constants adjusted on clear-sky atmosphere and correspond to average scattering of atmosphere for each site

Mean RMS error < 10 W/m²

LongWave Clear-Sky Model

$$LWCSM = \frac{\overbrace{\alpha \times (e/T)^{1/7}}^{\varepsilon_{Brutsaert}}}{\Gamma_{(e,\ T,\ IWV)}} \times \sigma \times \left[\frac{T}{\Pi_{(T)}}\right]^{4}$$

[Dupont et al., 2008]

T : 2m-height temperature (K)
e : water vapor pressure near the surface (hPa)
σ : 5.67×10^{-8} W m^{-2} K^{-4}
α : constant adjusted on clear-sky periods
Γ : proxy for vertical distribution of humidity
Π : proxy for thermal inertia of atmosphere

Mean RMS error < 2 W/m²

=> Clear-sky parameterizations directly fit to observed data

Observed CRF_{SW}

$$CRF_{SW} = SW_{measured} - SW_{clear\text{-}sky\ reference}$$

Observed cirrus cloud radiative forcing for shortwave flux (W m^{-2})				
	SIRTA Palaiseau, 48°N	ARM SGP Lamont, 36°N	ARM TWP Nauru,0°S	NSA SGP Barrow,71°N
Cirrus occurrence (%)[1]	49,0	25,6	43,2	3,2
CRF_{SW}	-28 (-13,7)[2]	-32 (-8,2)[2]	-38 (-16,4)[2]	-25 (-0,8)[2]
Standard deviation	72,0	64,0	65,0	41,0
Standard error	10,0	11,0	6,6	7,3
Relationship between CRF_{SW} and COT (slope in W m^{-2} COT^{-1})				
All atmosphere	-130,7 ± 5.1	-122,8 ± 9,7	-123,2 ± 5	-201,5 ± 8,9
Turbid atmosphere	-121,1 ± 4 (-8 %)	-117,3 ± 5 (-5 %)	-114,8 ± 5 (-7 %)	-114,4 ± (-43 %)
Pristine atmosphere	-146,1 ± 4 (+11 %)	-137 ± 8 (+11 %)	-157,6 ± 4 (+28 %)	-237,4 ± (+17 %)

[1] *Cirrus present in lidar observations*

[2] *Mean impact multiplied by the cirrus occurrence*

Average sensitivity of CRF_{SW} to COT is more important for Artic region (-200 W m^{-2} COT^{-1}) than for Midlatitude region (-130 W m^{-2} COT^{-1}) due to low IWV. The mask effect of atmosphere below the cloud ranges from -5 % to -40 % for Midlatitude and Arctic region respectively.

Note : At ARM TWP Darwin, we find a mean shortwave radiative impact of cirrus clouds of ~-24 ± 7 W m^{-2} and a slope of -440 ± 5 W m^{-2} COT^{-1} for the period between May and October 2005.

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Observed CRF_{LW}

$$CRF_{LW} = LW_{measured} - LW_{clear\text{-}sky\ reference}$$

Observed cirrus cloud radiative forcing for longwave flux (W m^{-2})				
	SIRTA Palaiseau, 48°N	ARM SGP Lamont, 36°N	ARM TWP Nauru, 0°S	NSA SGP Barrow, 71°N
Cirrus occurrence (%)[1]	49,0	25,6	43,2	3,2
Mean impact	6,6 (3,2)[2]	8,9 (2,3)[2]	0,8 (0,3)[2]	5,5 (0,2)[2]
Standard deviation	9,9	7,7	6,5	7,0
Standard error	1,9	1,8	1,0	2,7
Relationship between CRF_{LW} and LW_{cirrus}				
CRF_{LW}/LW_{cirrus}	0,24	0,28	0,03	0,4
Mean IWV, *cm*	1,4	1,5	4,7	1,1

[1] *Cirrus present in lidar observations*
[2] *Mean impact multiplied by the cirrus occurrence*

Instantaneous CRF_{LW} is more important in Artic and Midlatitude region (5-9 W m^{-2}) than in Tropical region (1 W m^{-2}). Sensitivity of CRF_{LW} to LW_{cirrus} ranges from 40%, 26% to 3%, for Artic, Midlatitude and Tropical sites respectively.

<u>Note</u> : At ARM TWP Darwin data, we find a mean longwave radiative impact of cirrus clouds of ~ +5 W m^{-2}.

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Conclusions & Perpectives

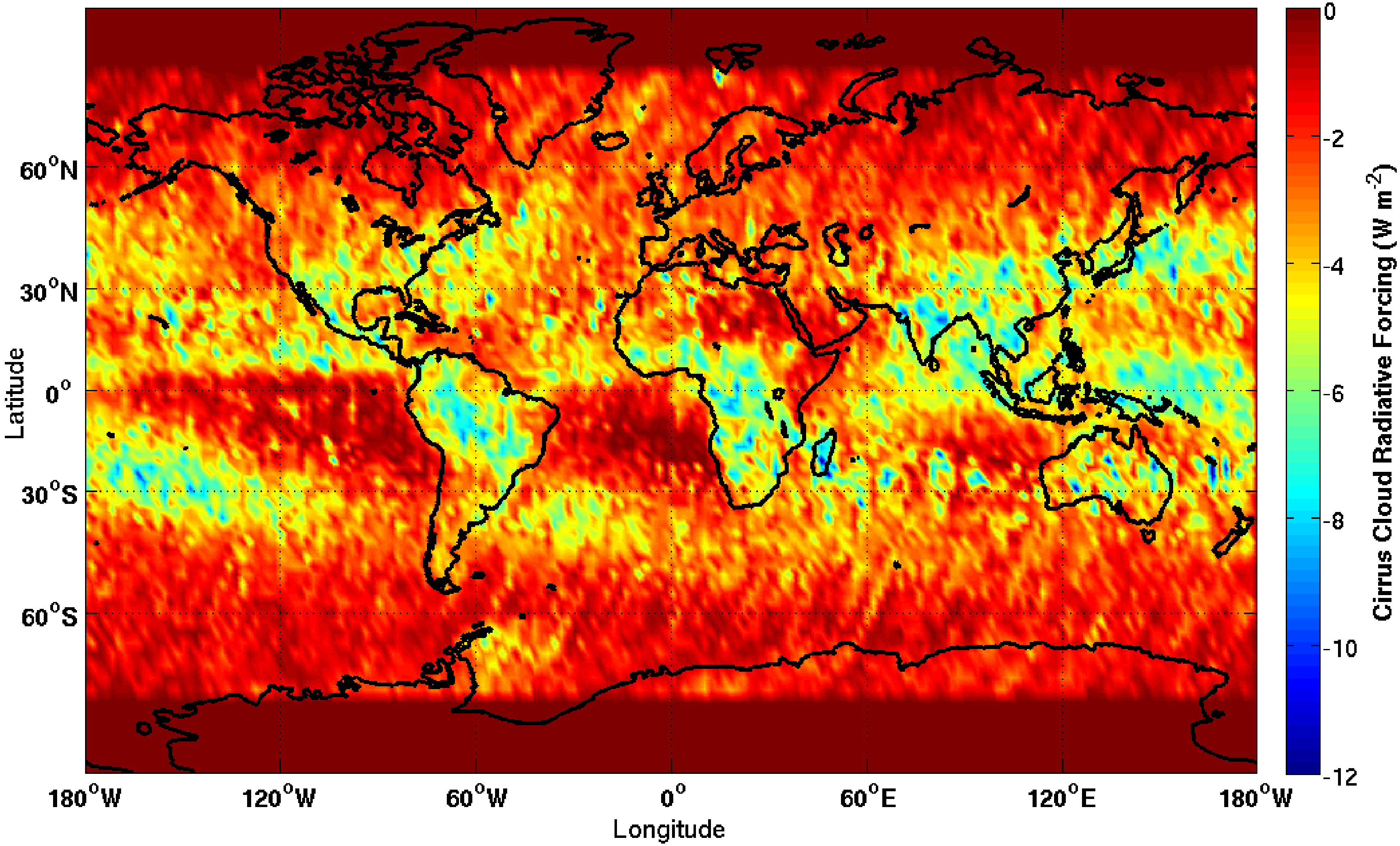
- Average instantaneous radiative effect of high altitude clouds :
  - **CRF_{sw}** is about **-30 W m^{-2}**
  - **CRF_{LW}** ranges from **1 to 9 W m^{-2}**
- The **significant coverage of cirrus clouds** (25% and near 45 % in Midlatitude and Tropical region respectively) increases the **contribution of these clouds** to the total radiation budget compared to other types of clouds.
- Average sensitivity of *CRF_{sw} to COT* ranges from **-130** to **-200** W m^{-2} COT^{-1} (-40 % to +30 % for turbid and pristine atmospheres respectively).
- Relationship between *CRF_{LW} and LW_{cirrus}* ranges from **3 to 40 %** and strongly depends on the atmospheric humidity.
- Cirrus clouds detected by lidar but not by passive instruments (**COT<0.1**) have a mean impact near **-5 and +1.1 W m^{-2}** for SW and LW fluxes respectively.
- Future work consists in applying the relationships between cirrus cloud radiative forcing and macrophysical properties of these clouds to global scale (data provided by CALIPSO).

Poster session A, n°K3 : ***Observed cirrus cloud radiative forcing on surface-level shortwave and longwave irradiances***, presented March 11, 05:30 pm – 08:30 pm.

Goal ....

Ground-level cirrus cloud radiative forcing for SW irradiances at global scale

Preliminary results, Calipso data, lvl1 v1



Thank you for your attention...

... questions