THE RADIATIVE IMPACT OF OPTICALLY THIN CIRRUS CLOUDS IN THE SHORTWAVE RADIATION BUDGET

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Site Operations & Science Investigations
…. many network partners around the world

MPLNET information and results shown here are the result of efforts by all of our network partners!

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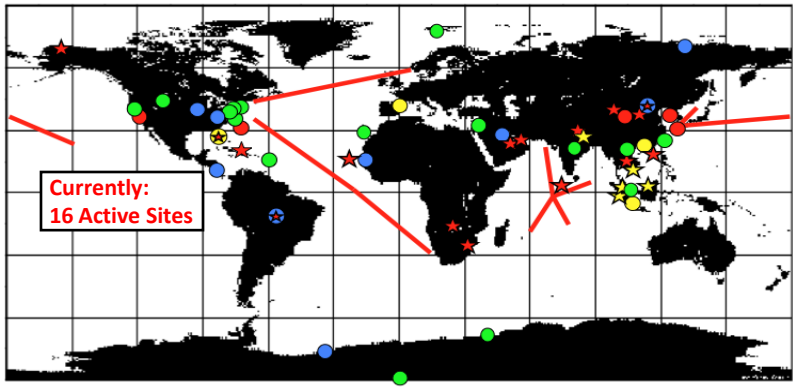
MPLNET Overview

South Pole MPLNET Site:
1999-current

Micro Pulse Lidar
(GSFC Patent)

MPLNET Sites: 2000 - current



* most sites co-located with AERONET

MPLNET: ***8.8Trillion Laser Shots, 59 Mminutes of data and counting…***

- A federated network of micro pulse lidar sites around the world, coordinated and lead from Goddard Space Flight Center
- Co-location with related networks, including NASA AERONET
- Local, regional, and global scale contributions to atmospheric research
- Satellite validation
- Aerosol climate and air quality model validation
- Impact of aerosol & cloud heights on direct and indirect climate effects
- Support for wide variety of field campaigns

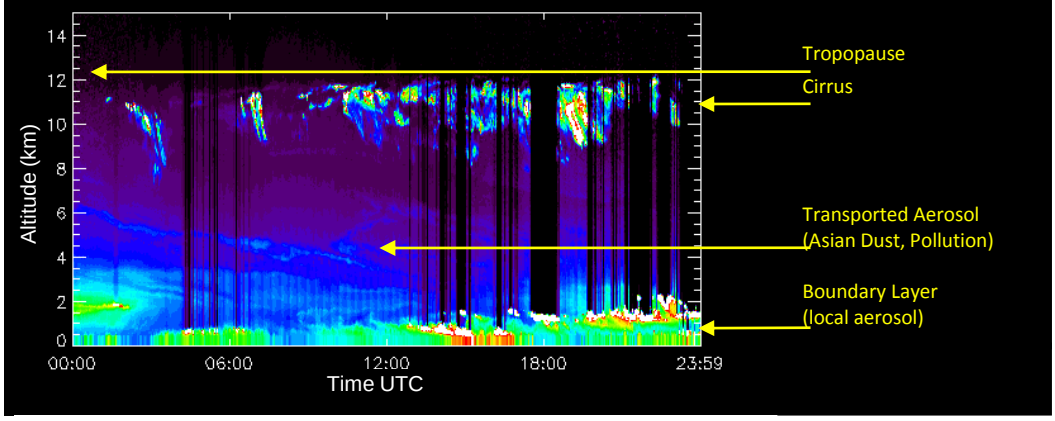
What's New?

- Penang new site August 2014, Barcelona June 2015
- More sites in Africa and in South America
- Ongoing interactions with both Aerocom and ICAP communities (climate and operational air quality modeling)

Investigators, Partners, & Collaborators:

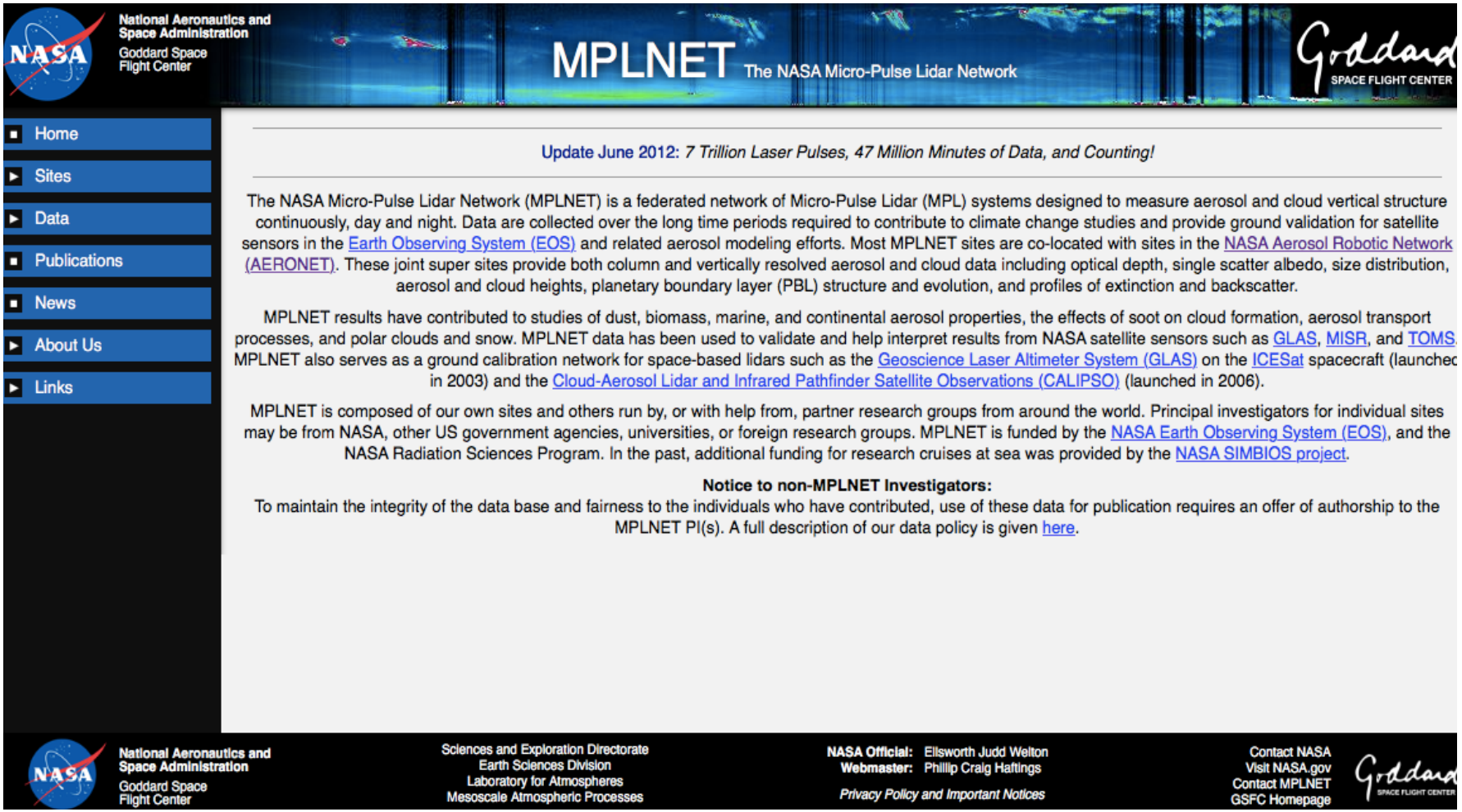
- Principal Investigator: Judd Welton/612
- Brent Holben/618
- Si-Chee Tsay/613
- James Campbell/NRL
- Sebastian Stewart/SSAI/612
- Larry Belcher/SSAI/612
- Simone Lolli/JCET-UMBC/612
- Jasper Lewis/JCET/612
- Phillip Haftings/SSAI/612
- All Network Partners Worldwide

Example of MPLNET Level 1 Data: Atmospheric Structure

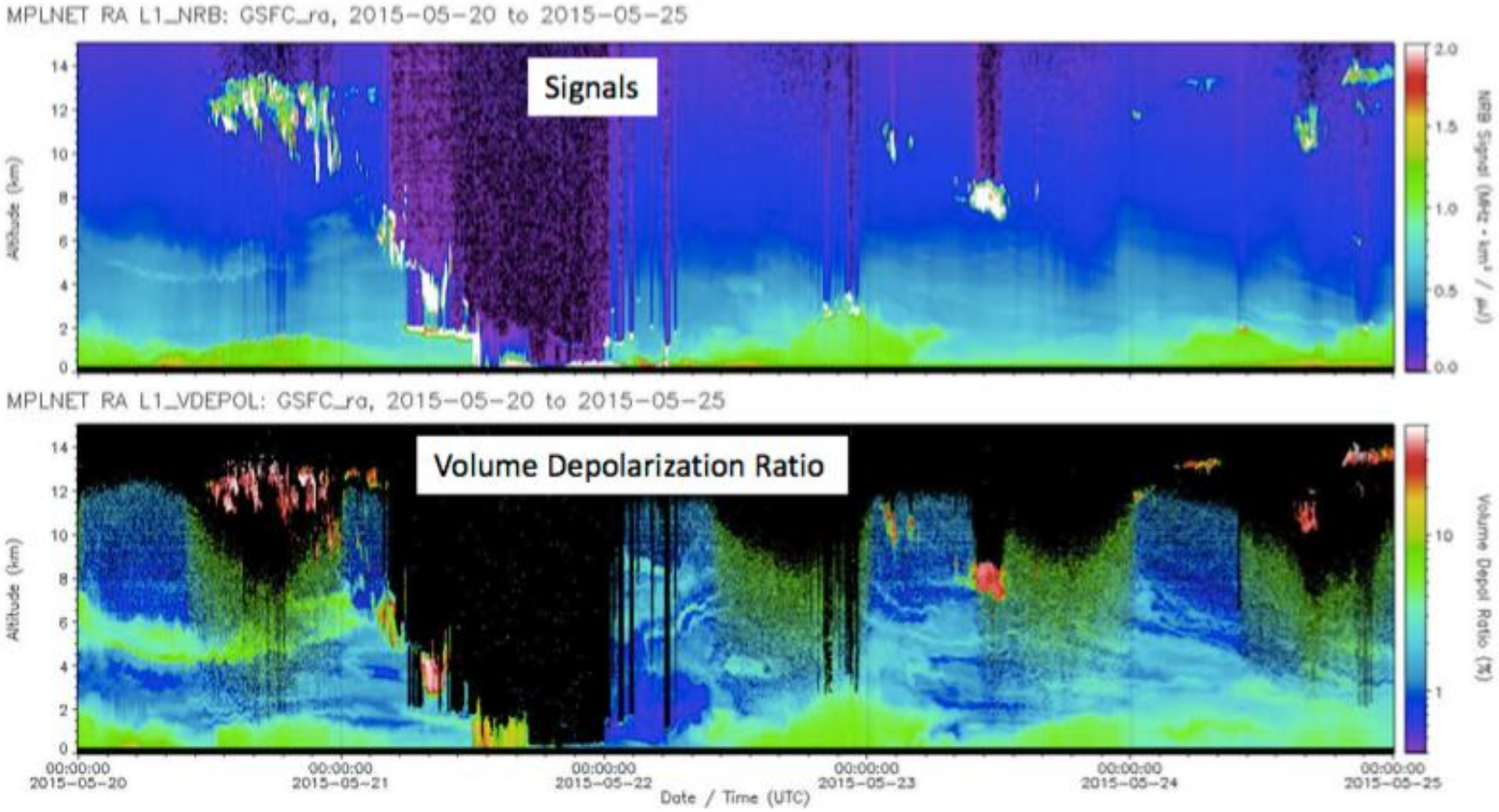


http://mplnet.gsfc.nasa.gov

The New V3 Website
http://kimura.gsfc.nasa.gov



V3 Data May 20 – 24, 2015 GSFC: L1 Signals



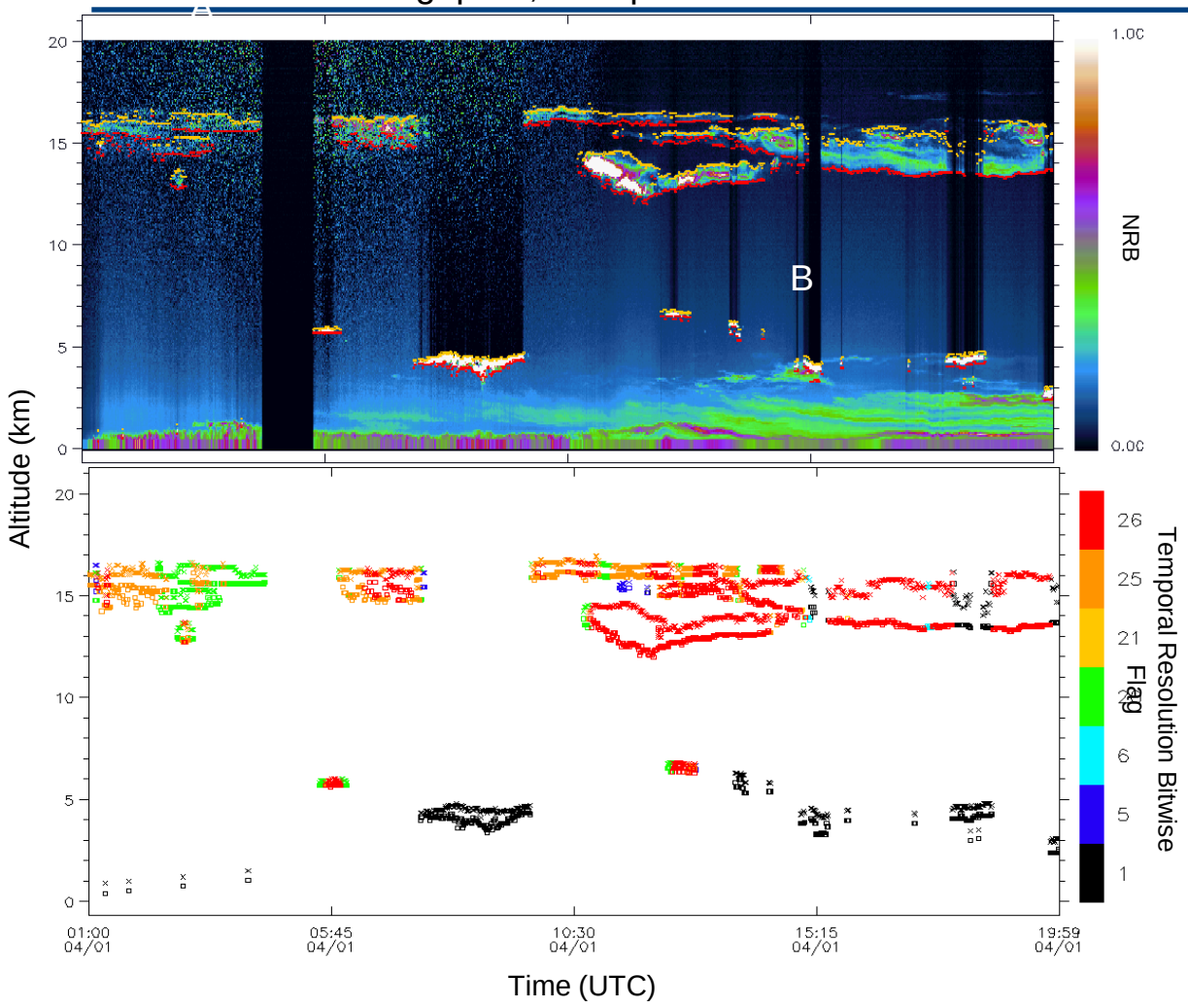
$$NRB(\lambda, R) = \frac{[N_S(\lambda, R) - N_B]T_m^2 T_a^2}{C} R^2$$

Incorporate both older MPLs and new polarized MPLs

New signal averaging scheme:
- running boxcar average, re-gridded to 1 minute
- this applies to all higher level products (-> aerosol retrievals up to cloud edge)

No data acquired (no raw lidar signal data)
instrument status (temps, energy, calibrations)
Failed retrieval (no PBL, Fernald fail, etc)
Specific product screen (ex. L15V_AER)

The new V3 Cloud Algorithm:



- A multi-temporal averaging scheme is used to improve performance in weak signal-to-noise.
- Data flags will indicate the temporal resolution used as well as the number of 1-minute profiles included in the average.
- Other data flags indicate:
  - Cirrus (Ice) clouds
  - Day/Night retrievals
  - Data quality
  - Attenuation limit
  - Retrieval Method (GCDM or UCDM)

MPLNET: Version 3 Update

MPLNET Data Products: Version 2 (2006-current) *nectcdf 3, error propagation from raw data to final product*

Level 1: Lidar Signals, Instrument Diagnostics
Latency: < 1.5 hrs most sites, others next day.
No QA Flags, No QA Screening.

Level 1.5: **L1.5b:** Aerosol, PBL, and Cloud Heights
L1.5a: Aerosol Backscatter, Extinction, Optical Depth,
Lidar Ratio (at AERONET times and 24/7 day-to-night)
Latency: next day. Limited QA Flags, No QA Screening.

Level 2: Same as L1.5 above, except no PBL, aerosol only with AERONET
Latency: X months+ after Level 2 AERONET is available.
QA Screening applied.

MPLNET Data Products: Version 3 (in development) *utilizes GEOS-5 met, all data files netcdf 4 CF Compliant*
Online Data Ordering Too
Subset packaging
other formats: nc3, GALION?

Level 1: Lidar Signals, Instrument Diagnostics, Volume Depol Ratio
Latency: < 1.5 hrs. QA Flags provided, No QA Screening.

Level 1.5: **Cloud:** Heights, Phase, Thin Cloud Extinction & Optical Depth
Aerosol: Height, Backscatter, Extinction, AOD, Lidar & Depol Ratio
PBL: Height, PBL AOD
Latency: < 1.5 hrs for browse images, data next day. QA Flags provided, No QA Screening.

Level 1.5V: **Cloud:** Heights, Phase, Thin Cloud Extinction & Optical Depth
Aerosol: Height, Backscatter, Extinction, AOD, Lidar & Depol Ratio
PBL: Height, PBL AOD
Latency: **< 1.5 hrs for browse images, data next day. ICAP < 1.5 hrs.** QA Flags provided, QA Screening.

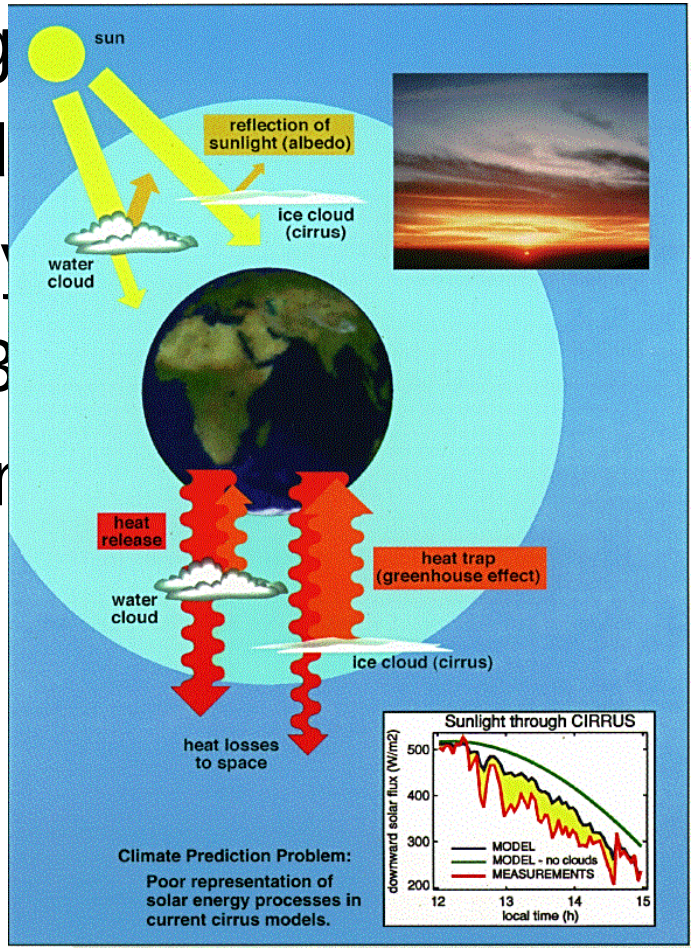
Level 2: Same as L1.5 above.
Latency: X weeks after Level 2 AERONET is available.
QA Flags provided, QA Screening applied.

Cirrus cloud Facts

- High level clouds (>12 Km Mid-Lat) consisting purely of ice crystals
- Ice Super Saturated Regions (ISSR) are potentially cirrus formation regions
- **Homogenous freezing** is probably the dominant freezing mechanism in low temperature / high altitude regimes (< 235 K)
- Cirrus clouds coverage about 20%-30% of the earth surface (up to **70%** in the tropics)

Cirrus Clouds still main source of uncertainty in climate model sensitivity

- Modulators of earth radiation budg
- Quantitative information is needed
  observation, especially on optically
  thin sub-visible clouds (COD<0.03
- Cirrus Clouds net radiative forcin
  - Solar Albedo Effect(**C**)
  - Infrared greenhouse effect(**W**)
  - Which effect is outweighing?



Cirrus Clouds Parameterization

Cloud Extinction Profiles are transformed into IWC and Dge profiles through Heymsfield parameterization

- Power Law depending on temperature

  $Dge(z)=a*exp(b*T)$ a, b depending on T*

- Ice Water Content :

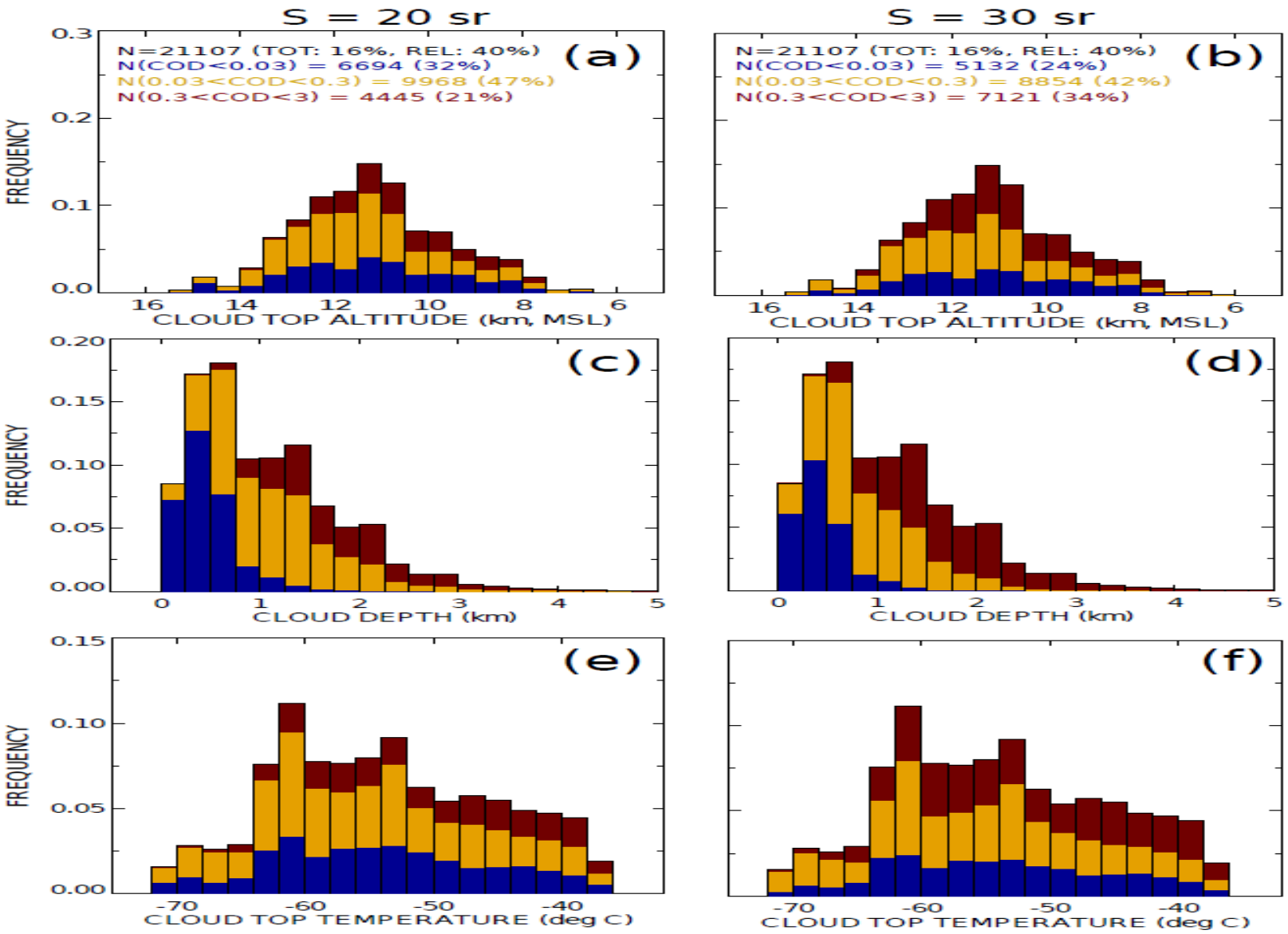
  $$IWC(z)=\alpha(z)*0.303*Dge(z)$$

- Cloud Net Radiative Forcing

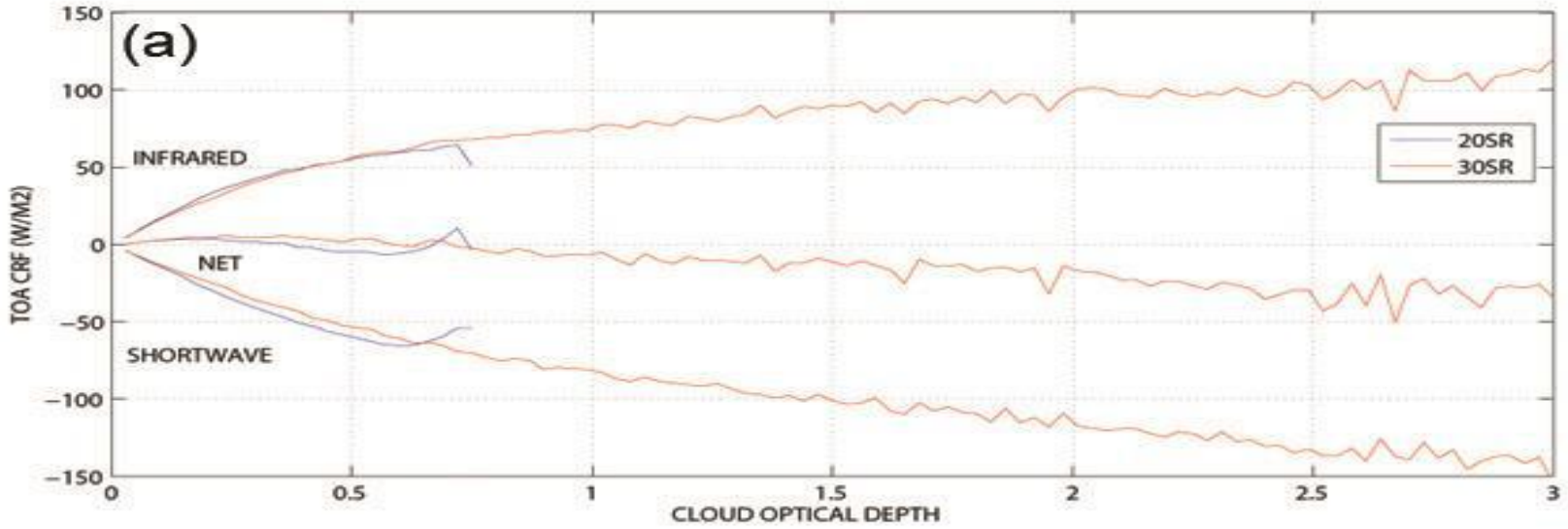
  $CRF^{net}=CRF^{sw}+CRF^{lw}$ with $CRF^{sw,lw}=F_{cl}^{sw,lw}-F_{clr}^{sw,lw}$

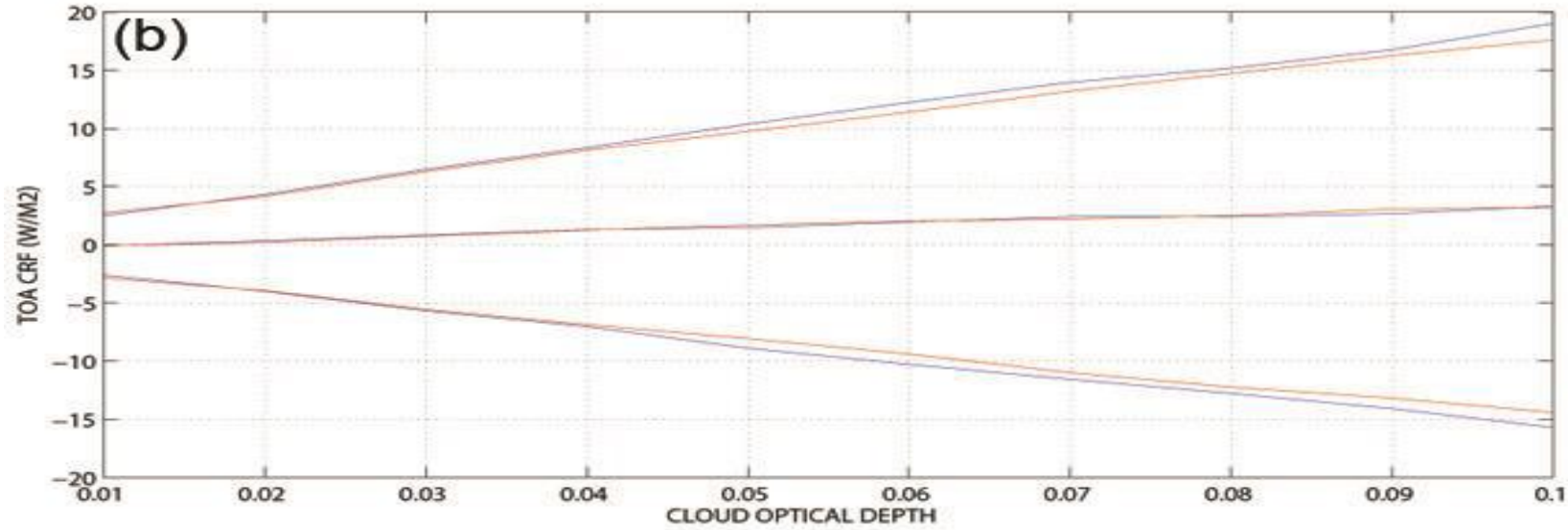
*T profile is retrieved from Dulles WMO radiosounding network site

2012 DAYTIME GSFC AT GLANCE

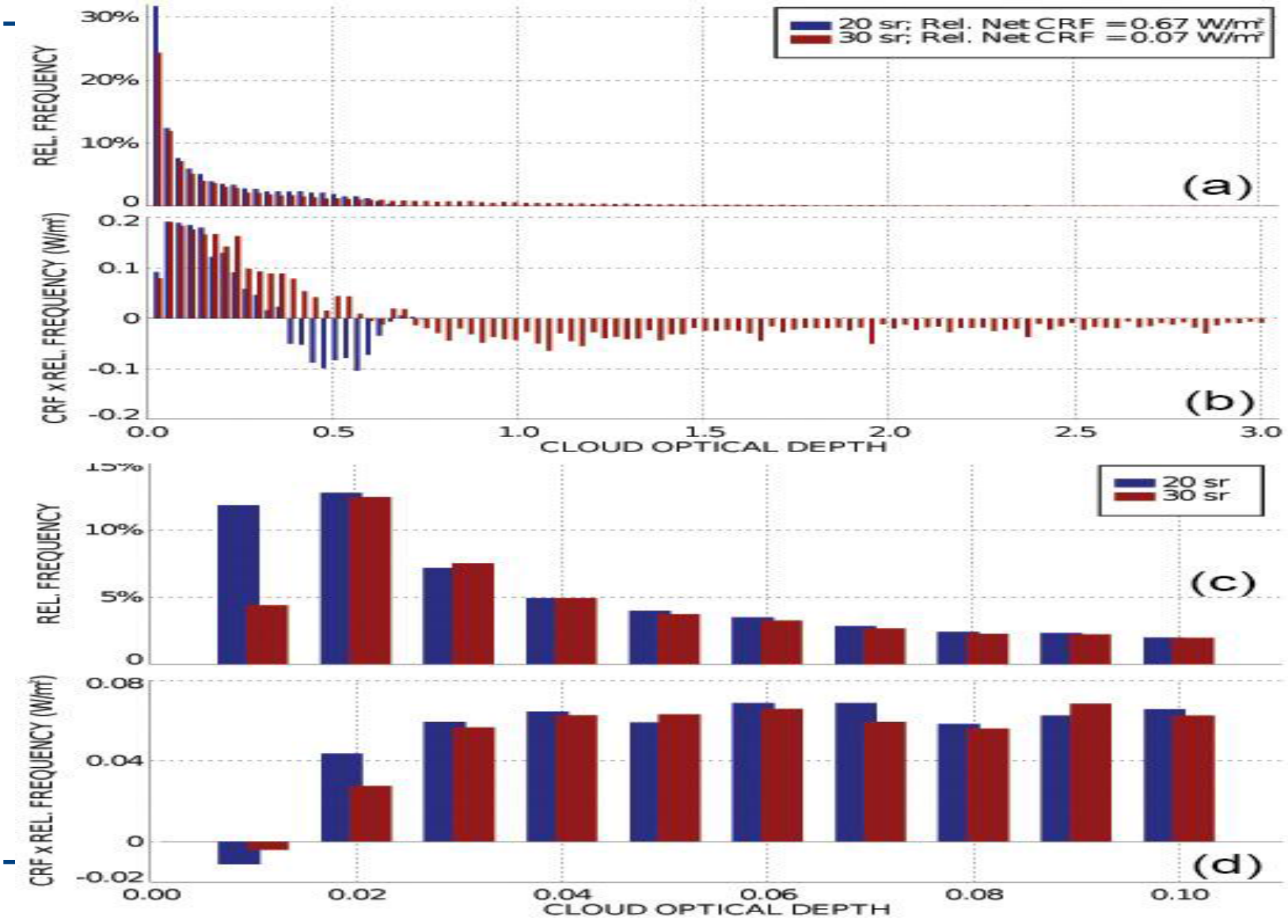


Net Radiative Forcing vs. COD

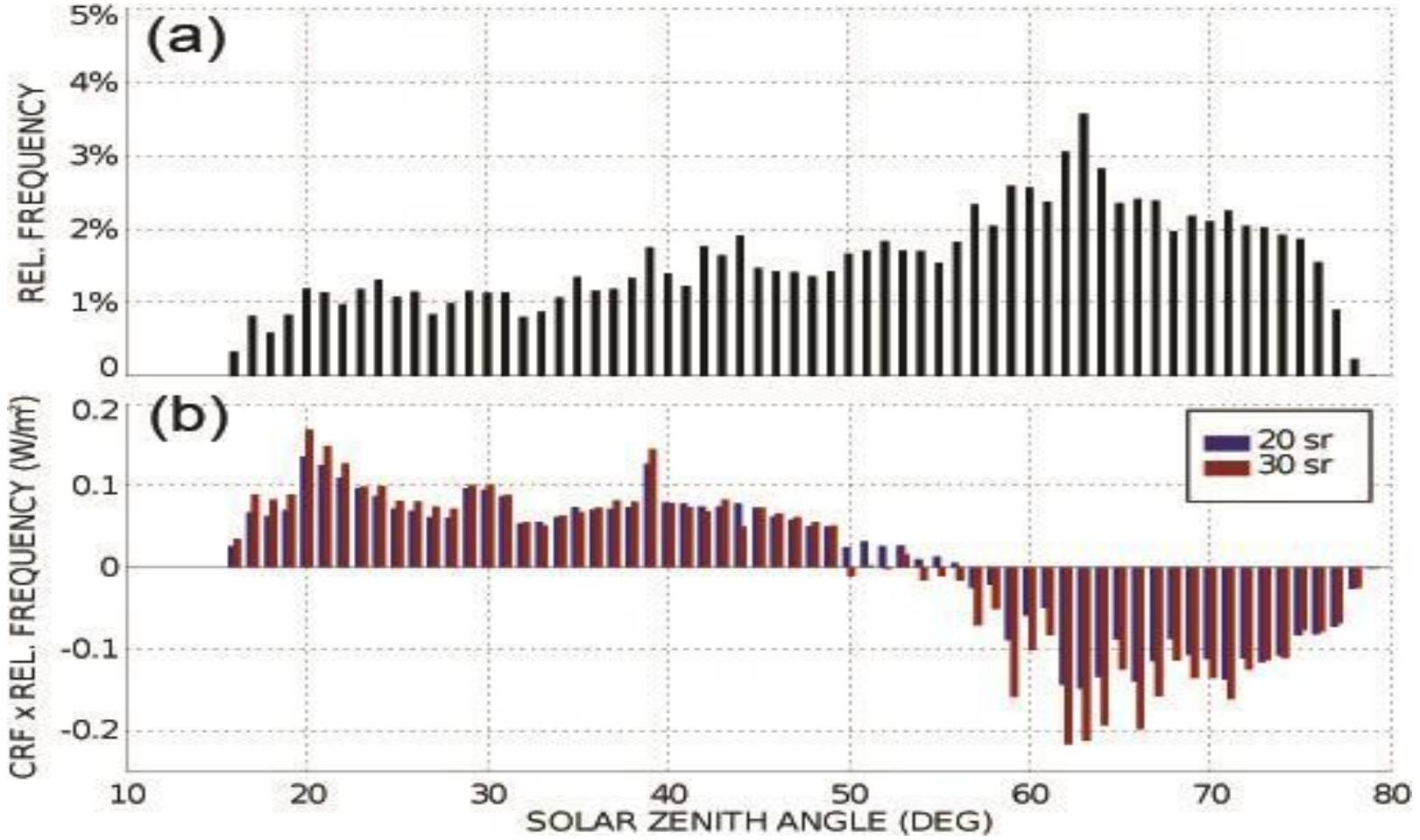




NORM DAYTIME NET FORCING

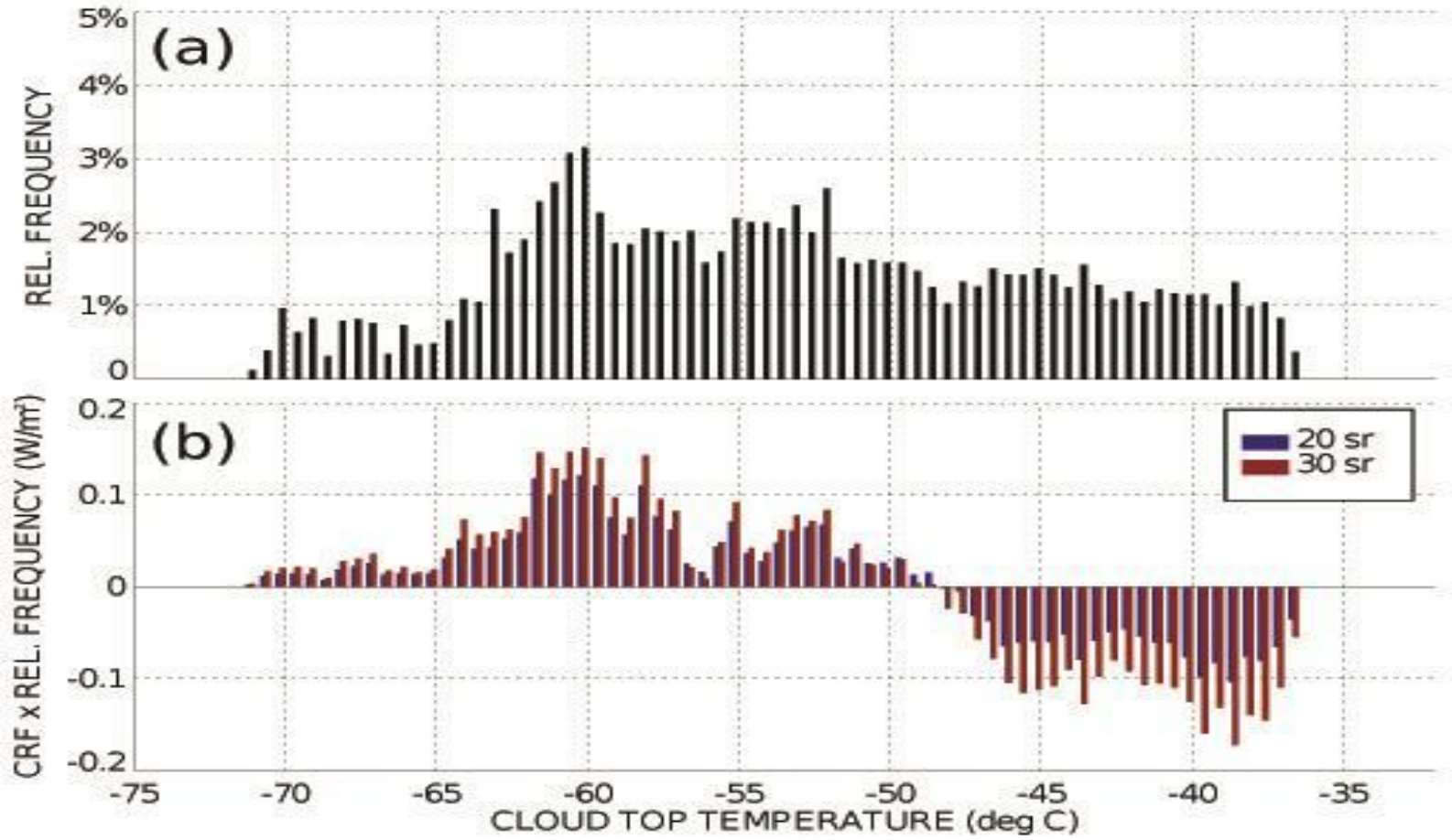


Net RF vs. SZA



Existence of a gradient in forcing with latitude ?

Net RF vs. Cloud Top



-37 C threshold to distinguish ice cloud

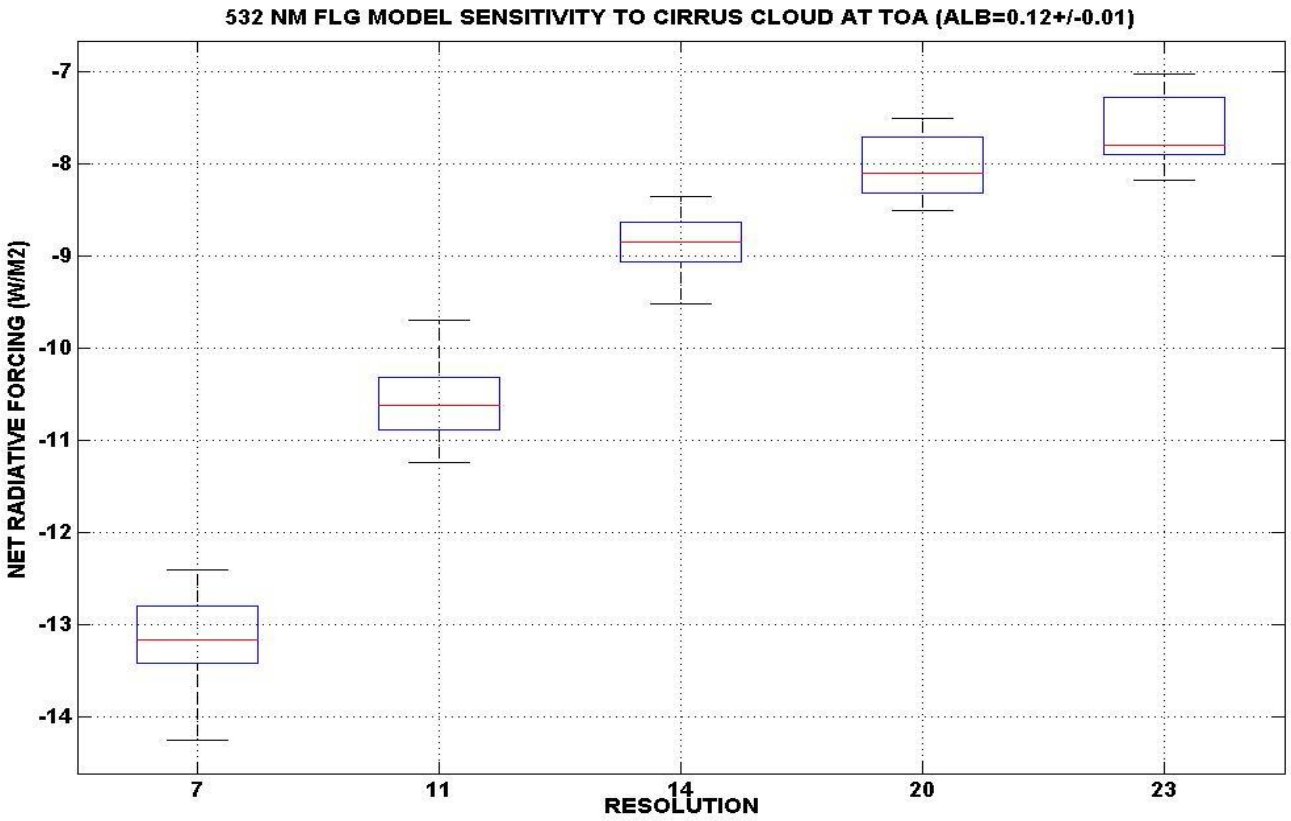
What to take home

- MPLNET furthers our understanding of global cloud physical processes => analysis over the last decade showed that **optically-thin cirrus clouds are the most common cloud type.**

- Cloud forcing likely varies with **latitude** and **season**, with cirrus clouds exerting less positive forcing and eventually net TOA **cooling** during daytime.

=> Increase ***thermal gradients*** and ***baroclinicity*** in summer

What about FLG sensitivity? Are the results reliable?



Lolli, Madonna, Rosoldi, Pappalardo, Welton, 2016, in progress

Thank you

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