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ADM working group
LONGWAVE ANISOTROPY
A SOLAR ZENITH ANGLE PERSPECTIVE
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PLAN

1. Theme of study
2. Progress
3. Data and Binning
4. SZA Vs LCT bins
5. New binning method
6. Model and validation
7. Future
THEME OF STUDY

Forward scatter
Colder temperature measured

Back scatter
Warmer temperature measured
PROGRESS SINCE LAST CERES SCIENCE MEET

1. Using the **SZA bins** instead of **Local Time Bins**

2. Terra results based on **8 months of Ed 1A** instead of **4 months beta Ed**

3. Validation of model now based on **8 months of Data** instead of **single month**
DATA and BINNING

SSF data from CERES TRMM and Terra

Wavelengths: LW (5-100 µm) & WN (8-12 µm)

Time periods

TRMM - Jan- Aug 1998 (10 km nadir) - Ed 2B (69 days)
TERRA - Jan- Aug 2001 (20 km nadir) - Ed 1A (179 days)

Bin averaging

9 RAA bins (every 20°)  7 VZA bins (every 10°)

4 SOLAR ZENITH ANGLE bins:

1) 0 – 41.41°  
2) 41.41 – 60°  
3) 60 – 75.52°  
4) 75.52 – 90°

Clear sky definition: 0-5% Cloud
Topo and Geo data

Geo types: 5 scene types defined by regrouping IGBP
Forests, Shrub lands, Savannas, Croplands, and Deserts

ETOP05 5´resolution (~10 km) elevation database
(NOAA National Geophysical Data Center/World Data Center for Marine Geology and Geophysics)

Surface topo Variability (SV) = SD of adjacent 3x3 pixels

4 bins using histogram of global SV data:
1) Min (lowest 50%) 2) Low med (50-70%)
3) High med (70-90%) 4) Max (90-100%)
METHODOLOGY

The VZA means are subtracted from bin mean of each RAA bin in a given VZA bin to remove limb darkening effect.

These differences are plotted as a function of VZA and RAA.
LW ANISOTROPY: SZA BINS VERSUS LCT BINS (TRMM)

TRMM 2B: Jan−Aug 1998

LCT BIN=2

Minimum SV

Low medium SV

High medium SV

Maximum SV

LW Radiance: SHRUB LANDS

SOLZ BIN # 2 => 41.41°−60°

Minimum SV

Low medium SV

High medium SV

Maximum SV

CLEAR

LW Rad (Wm⁻²sr⁻¹)

33° S to 33° N
LW ANISOTROPY: SZA BINS VERSUS LCT BINS (TERRA)

Terra 1A: Jan-Aug 2001

LCT BIN=2

FORESTS

SHRUB LANDS

SAVANNAS

CROP LANDS

LW Radiance : Max SV

SOLZ BIN # 2 => 41°-60°

FORESTS

SHRUB LANDS

SAVANNAS

CROP LANDS

LW Rad (Wm⁻²sr⁻¹)

CLEAR

33°S to 33°N
Inferences

1. For both TRMM and Terra azimuthal signal is more conspicuous when binning is done based on SZA instead of LCT.

2. For shrub lands, savannas and Croplands azimuthal signature is more important
COMPARISON OF LW ANISOTROPY FOR 4 SZA BINS

TRMM 2B: Jan–Aug 1998
LW Radiance : Max SV

SHRUB LANDS

SZA bin 1
SZA bin 2
SZA bin 3
SZA bin 4

SAVANNAS

SZA bin 1
SZA bin 2
SZA bin 3
SZA bin 4

CLEAR
LW Rad (Wm\(^{-2}\)sr\(^{-1}\))
33 S to 33 N

SOLZ bin # 1 => 0 – 41.41°
2 => 41.41 – 60°
3 => 60 – 75.52°
4 => 75.52 – 90°
Inferences

Azimuthal signal is strong in SZA bins 2 & 3.

The reason:

Azimuthal signal is based on contrast of shadow which itself depends upon

1. Strength of radiation field

2. Sun’s position => Maximum asymmetry in radiation field

   SZA bin 1: Radiation field is strong but asymmetry is low

   SZA bin 2 & 3: Radiation field is good; asymmetry is high

   SZA bin 4: Radiation field is weak; asymmetry is strong
MODEL

Bin mean assumed to be represent the value at centre location.
Use of linear interpolation.

\[ R (\text{Anisotropic Factor}) = \frac{\pi L}{M} \]

where

\[ L = \text{Radiance (} W / m^2 / \text{sr)} \]

\[ M = \text{Flux (} W / m^2 \) \]

Fluxes are calculated by extrapolating radiances as VZA for CERES SSF data range 0-70°

INPUT TO MODEL:
Latitude, Longitude, VZA, RAA, SZA, Cloudiness fraction
VALIDATION of WN Azimuthal model

Match within 15° coincident VIRS and Geostationary 10.7 μm in 1° gridded radiances

- VIRS from SFC data set
- Geostationary from GGEO data set, Meteosat, GMS, GOES-8 (Jan-Aug 1998)
- clear-sky (cloudiness < 5%) based on VIRS analysis

Compare Azimuthal model to limb darkening model

Azimuthal model \( R = F (VZA, RAA, SZA, \text{geo}, \text{topo}) \)

Limbmodel \( R' = F (VZA, \text{geo}) \)

\[ \text{error}_{az} = \frac{\text{GGEO}_{rad} - \text{VIRS}_{rad}}{\text{GGEO}_{rad}} \cdot \frac{\text{R}_{GGEO}}{\text{R}_{VIRS}} \]

\[ \text{error}_{limb} = \frac{\text{GGEO}_{rad} - \text{VIRS}_{rad}}{\text{GGEO}_{rad}} \cdot \frac{\text{R'}_{GGEO}}{\text{R'}_{VIRS}} \]
1998 Jan–Aug: Clr sky rad: RMS errors for matched data METEOSAT 6–7 and VIRS

![Graph showing RMS errors for different azimuthal bins]

RMS ERRORS (W m⁻² sr⁻¹)

MEDIUM & MAXIMUM SV

AZIMUTHAL BINS
1998 Jan–Aug: Clr sky rad: Bias errors for matched data
METEOSAT 6–7 and VIRS

[Graph showing bias errors for different data sets]
1998 Jan–Aug: Clr sky rad: # of Pairings for matched data METEOSAT 6–7 and VIRS
New Binning Method

To reduce noise in individual azimuthal bins, make courser stratification

3 SOLAR ZENITH ANGLE bins:
1) 0 – 48°  2) 48 – 70.1°  3) 70.1 – 90°

3 bins using histogram of global SV data:
1) Min (lowest 50%)  2) Med (50-80%)
3) Max (90-100%)

Geo types: 3 scene types
1) Forests  2) Savannas + Croplands
3) Deserts + Shrub lands

Clear conditions: 0-5% clouds
New binning: 3 SZA, 3 Scenes and 3 SD bins
1998 Jan–Aug: Clr sky rad: RMS errors for matched data
METEOSAT 6–7 and VIRS

![Graph showing RMS errors for Clr sky rad between 1998 Jan–Aug. The graph compares RMS errors for different azimuthal bins, with two lines indicating different error categories.](image-url)
1998 Jan–Aug: Clr sky rad: RMS errors for matched data
GMS and VIRS
1998 Jan–Aug: Clr sky rad: RMS errors for matched data GOES–8 and VIRS

![Graph showing RMS errors for different azimuthal bins. The graph shows two lines, one for Umb and another for Umb + Adm, with RMS errors measured in W m⁻² sr⁻¹. The x-axis represents azimuthal bins, ranging from 1 to 9, and the y-axis represents RMS errors.]
1998 Jan–Aug: Clr sky rad: Bias errors for matched data METEOSAT 6–7 and VIRS
1998 Jan–Aug:Clr sky rad: Bias errors for matched data
GMS and VIRS
1998 Jan–Aug: Clr sky rad: Bias errors for matched data
GOES–8 and VIRS

![Graph showing bias errors for matched data between GOES–8 and VIRS.](image)
1998 Jan–Aug: Clr sky rad: # of Pairings for matched data
METEOSAT 6–7 and VIRS

**Diagram Description:**
- The graph shows the number of pairings of METEOSAT and VIRS over azimuthal bins.
- The x-axis represents the azimuthal bins, ranging from 1 to 9.
- The y-axis represents the number of pairings, ranging from 0 to 1200.
- The peak in the graph occurs around bin 6, indicating the highest number of pairings.

**Graph Details:**
- Title: 1998 Jan–Aug: Clr sky rad: # of Pairings for matched data
- Subtitle: METEOSAT 6–7 and VIRS

**Graph Analysis:**
- The data suggests a significant concentration of pairings around the central azimuthal bins, particularly around bin 6.
1998 Jan–Aug: Cir sky rad: # of Pairings for matched data
GMS and VIRS
1998 Jan–Aug: Clr sky rad: # of Pairings for matched data
GOES–8 and VIRS
Conclusions

1. Binning by SZA demarcates azimuthal signal better

2. Validation for 8 months data of VIRS and G GEO shows that azimuthal correction is indeed needed for high SV and possibly for medium SV bins
FUTURE

1. Revalidate the results with some other data set possibly.

2. Inclusion of azimuthal model in LW ADM for high SV.