Seasonal and Inter-annual Variations of Polar TOA Irradiance and Cloud Cover

Seiji Kato, Norman G. Loeb,
Patric Minnis, Jennifer A. Francis,
Thomas P. Charlock, David A. Rutan,
Eugene E. Clothiaux,
Szedung Sun-Mack, Fred Rose,
and Takmeng Wong
Objectives

• Understand Seasonal variations of TOA SW and LW irradiances over the Arctic and Antarctic.
• Understand Seasonal variations of cloud cover.
• Evaluate trends in the SW irradiance and cloud cover associated with sea ice cover change.
Methods

- Derive the daily mean SW and LW irradiances and cloud cover over 1 degree by 1 degree areas.
- Derive area-weighted mean values over the Arctic (60-90N) and over the Antarctic (60-90S).
- Compute anomalies and estimate trends.
Seasonal Variations, Radiation

Mean SW and LW, Arctic

Mean SW and LW, Antarctic

Irradiance (W m$^{-2}$)

Month

Abs. SW

Ref. SW

LW
Seasonal Variation, NET

![Graph showing seasonal variation in NET]

- Y-axis: Irradiance ($\text{W m}^{-2}$)
- X-axis: Month
- Legend: Arctic (solid line), Antarctic (dotted line)
- Data points indicate the variation in NET throughout the year, with peaks in June (6) and December (12) for both regions.
## Annual Mean TOA Irradiance and Albedo

<table>
<thead>
<tr>
<th>CERES (ERBE)</th>
<th>Arctic (60N – 90N)</th>
<th>Antarctic (60S – 90S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downward Shortwave (W m(^{-2}))</td>
<td>204.2 (201.3)</td>
<td>206.8 (202.5)</td>
</tr>
<tr>
<td>Albedo</td>
<td>0.469 (0.487)</td>
<td>0.566 (0.591)</td>
</tr>
<tr>
<td>Longwave (W m(^{-2}))</td>
<td>201.1 (201.2)</td>
<td>179.8 (179.8)</td>
</tr>
<tr>
<td>Net (W m(^{-2}))</td>
<td>-92.6 (-97.9)</td>
<td>-90.1 (-97.0)</td>
</tr>
</tbody>
</table>
Seasonal Variations, Cloud Cover

![Graphs showing seasonal variations in cloud cover.](image-url)
Seasonal variation
Clouds over Ocean and Land
Comparison with Cloud Occurrence Derived from Ground-based Active Sensors

Day + night clouds over Barrow, AK
March 2000 – Feb. 2004
CERES: CERES cloud algorithm
Radar: Millimeter Cloud Radar
Lasers: micro-pulse lidar Vaisala celometer
Large differences in Radar and Laser-based Cloud Occurrence
Smaller Difference in Cloud Occurrence

Clear day
Cloud Vertical Profile

Day + night clouds

over Barrow, AK
Daytime Trends Over the Arctic

2.0±2.0 W m\(^{-2}\)

0.047±0.041

-0.064±0.055
Nighttime Trend Over the Arctic

3.8±2.2 W m$^{-2}$

-0.024±0.028

-0.024±0.036

0.012±0.032
LW Night Irradiance

Year

Nighttime LW (W m$^{-2}$)

2001 2002 2003 2004
Conclusions

• The daytime cloud fraction over the Arctic from March 2000 through February 2004 increased at a rate of $0.047 \pm 0.041$ per decade.

• The corresponding top-of-atmosphere (TOA) shortwave irradiiances show no significant trend during this period.

• The influence of reduced Arctic sea ice cover on TOA shortwave radiation is reduced by the presence of clouds and compensated by the increase in cloud cover.

• The cloud fraction and TOA shortwave irradiance over the Antarctic show no significant trend during the same period.