Atmospheric clear-sky longwave radiative cooling and precipitation

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Introduction

• Clear-sky radiative cooling:
  – radiative convective balance
  – atmospheric circulation

• Earth’s radiation budget
  – Understand clear-sky budget to understand cloud radiative effect

• Datasets:
  – Reanalyses – observing system
  – Satellites – calibration and sampling
Datasets used

- Surface and Top of Atmosphere clear-sky LW flux
- Column integrated water vapour (CWV)
- Reanalyses:
- Satellite data
  - ERBS, ScaRaB, CERES (clear-sky OLR)
  - SMMR, SSM/I V5 (CIWV)
- Combination datasets:
  - SRB Rel. 2(1983-1994)…reanalysis?
  - SSM/I, da Silva, ERA40, Prata (1996) → surface net LWc
- IPCC AR4 models
Links to precipitation

HadGEM - AMIP

![Graph showing the relationship between Precip LH (Wm^-2) and LWcs cooling (Wm^-2)]
Tropical Oceans

- ERA40
- NCEP
- SRB
- HadISST
- SMMR, SSM/I
- SSM/I, Prata

(a) $T_s$ (K)
(b) CWV (kg m$^{-2}$)
(c) SNLc (W m$^{-2}$)

Graphs showing variations in $T_s$, CWV, and SNLc from 1980 to 2005.
Spurious variability in ERA40

- Improved performance in water vapour and clear-sky radiation using 24 hour forecasts.
Surface LWc and water vapour

$$\frac{dLWc}{dCWV} \sim 1.5 \text{ Wkg}^{-1}$$

$$\frac{dCWV}{dT_s} \sim 3 \text{ kgm}^{-2}\text{K}^{-1}$$
Clear-sky OLR with surface temperature:
+ ERBS, ScaRaB, CERES; SRB

Calibration or sampling?
Clear-sky vs resolution

July 2006

% clear-sky pixels vs nadir resolution (km)

- Meteosat-8, 3-hrly Ac<1%
- Meteosat-8, mean, Ac<5%
- Meteosat-8, mean, Ac<1%
- Meteosat-8, mean, Ac<0.5%

ERBE, CERES
Sensitivity study

- Based on GERB-SEVIRI and model simulations of OLR and cloud products over ocean:
  - \( \frac{d\text{OLR}_c}{d\text{Res}} \approx 0.2 \text{ Wm}^{-2}\text{km}^{-0.5} \)
  - Suggest CERES should be biased low by \( \approx 0.5 \text{ Wm}^{-2} \) relative to ERBS
Tropical Oceans

- ERA40
- NCEP

- HadISST
- ERBS, ScaRaB, CERES
- Derived

Surface Net LWc
Clear-sky OLR
Clear-sky Atmos LW cooling
$Q_{LWc}$
Linear least squares fit

- Tropical ocean: descending regime

<table>
<thead>
<tr>
<th>Dataset</th>
<th>( \frac{dQ_{LWC}}{dT_s} )</th>
<th>Slope</th>
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</thead>
<tbody>
<tr>
<td>ERA-40</td>
<td>3.7 ± 0.5 ( \text{Wm}^{-2}\text{K}^{-1} )</td>
<td></td>
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<tr>
<td>NCEP</td>
<td>4.2 ± 0.3 ( \text{Wm}^{-2}\text{K}^{-1} )</td>
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<tr>
<td>SRB</td>
<td>3.6 ± 0.5 ( \text{Wm}^{-2}\text{K}^{-1} )</td>
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<tr>
<td>OBS</td>
<td>4.6 ± 0.5 ( \text{Wm}^{-2}\text{K}^{-1} )</td>
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Implications for tropical precipitation (GPCP)?
IPCC AR4 models: tropical oceans

- SST
- CWV
- Net LWc
- OLRc
IPCC AR4 models: tropical oceans

- $Q_{\text{LWc}}$
- Precip
Conclusions

• Intercomparisons of datasets: clear-sky LW at SFC, TOA, ATM
• Reanalyses: observing system changes
• Satellites: calibration, sampling

• Increase in clear-sky LW cooling of atmosphere of ~3-5 Wm\(^{-2}\)K\(^{-1}\)
• All-sky changes? Models?