Marine Boundary Layer Lapse-rate and Cloud-top-height Observed from MODIS and CALIPSO Over Subtropical Eastern Oceans

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Liquid Water Cloud Fraction – Aqua

Six selected regions with prevailing boundary layer clouds.

[King et al., 2013]
MODIS/CALIPSO Low Cloud Measurement

Cloud-top-temperature (K)

Cloud Fraction (%)

MODIS Lapse-rate Method:

\[ CTH = \frac{(SST - CTT) - \delta T}{\Gamma_T} \]

(e.g., Zuidema et al., 2009)
Marine Boundary Layer (Radiosonde)

Marine ARM GPCI Investigation of Clouds (MAGIC)

- 20 round trip between Los Angeles, CA and Honolulu, HI
- Over 500 radiosonde soundings
- October 2012 - September 2013

VOCALS-REx

- 20° S (SE Pacific)
- Over 200 radiosonde soundings
- October - December 2008

VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment
MBL Structure along the Transect – MAGIC

\[ \Gamma_{td} = 10 \, ^\circ C/km \]
MBL Structure along the Transect – MAGIC

\[ \Gamma_{Td} = 10 \text{ °C/km} \]
CALIPSO and MODIS-C6 Cloud Top Heights

**CALIPSO**

Dec 2012 – Feb 2013 (winter)

**MODIS-C6**

June – Aug 2013 (summer)
CTH from Coincident MODIS and CALIPSO

MODIS C6 vs CALIPSO CTH (single-layer, <5km)

Time:
Dec 2012 – Feb 2013 (winter, blue)
June – Aug 2013 (summer, red)

Range:
15 °N – 45 °N, 115°W – 165 °W
MODIS Cloud Top Height along the Transect

**winter**

**summer**
Low Cloud Properties

MODIS
Cloud Fraction

winter

summer

CALIPSO
Cloud Thickness

winter

summer
MBL Lapse Rate \( (\Gamma_T) \)

\[
\Gamma_T = -\frac{CTT - SST}{CTH}
\]

- \( CTT \) = MODIS CTT
- \( SST \) = Sea surface temp (ERA-I)
- \( CTH \) = CALIPSO CTH
MBL Lapse Rate - Transect over NE Pacific

MODIS C6 (ATBD)
Monthly mean in Aug.
Courtesy of Richard Frey
MBL Lapse Rate - Transect over NE Pacific
Cloud Top Temp. vs. Inversion Base Temp. ($T_{IVB}$)

Near-Coincident MODIS vs. Radiosonde (VOCALS)

\begin{align*}
Y &= -0.02 + 0.99X \\
\text{Corr} &= 0.729 \\
\text{Sigma} &= 0.13 \\
\# \text{ pairs} &= 50
\end{align*}

\begin{align*}
Y &= -1.11 + 1.04X \\
\text{Corr} &= 0.805 \\
\text{Sigma} &= 0.11 \\
\# \text{ pairs} &= 48
\end{align*}

CTT > 0 °C
CF > 90%
Near-Coincident: 300km, 3hrs
MODIS-CTT vs. MAGIC-T_{IVB}

CTT > 0 °C
CF > 90%
Longitude [-118°W, 140°W]
Near-Coincident: 300 km, 3hrs

CTT – Single Footprint

CTT_{min} – 5x5 Footprint
MODIS-CTT vs. MAGIC-$T_{IVB}$

CTT > 0 °C
CF > 90%
Longitude [-118°W, 140°W]
Near-Coincident: 200 km, 2hrs
Summary and Conclusions

- MODIS Collection 6 CTH shows significant improvement over Collection 5.
- CALIPSO and radiosonde observations show an increase in CTH and cloud thickness from stratocumulus near shore westward to the trade-wind regimes over the subtropical eastern Pacific.
- Significant seasonal variations of LR ($\Gamma_T$) and CTH are observed near shore of south California, but much less near Hawaii.
- Large longitudinal variation of MBL LR from $\sim 8 \, ^\circ C/km$ over the stratocumulus region to $\sim 4.5 \, ^\circ C/km$ over the trade-cumulus regime. This need to be considered in the future MODIS CTH retrieval.
- MODIS C6 overestimate CTH in the stratocumulus regimes likely due to the underestimated LR used in the retrieval.
- MODIS C6 underestimate the CTH over higher cloud regimes such as the trade cumulus regions.
- MODIS CTT measurements are highly consistent with radiosonde inversion base temperature over the overcast stratus regime but become less reliable over the broken cloud regime.
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• MODIS data: L1 & Atmospheric Archive and Distribution System (LAADS) Distributed Active Archive Center (DAAC) from GSFC

• CALIPSO data These data were obtained from the NASA Langley Research Center Atmospheric Science Data Data Center.

• ECMWF/ERA-interim data

• VOCALS & MAGIC (DOE-ARM) radiosonde data