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

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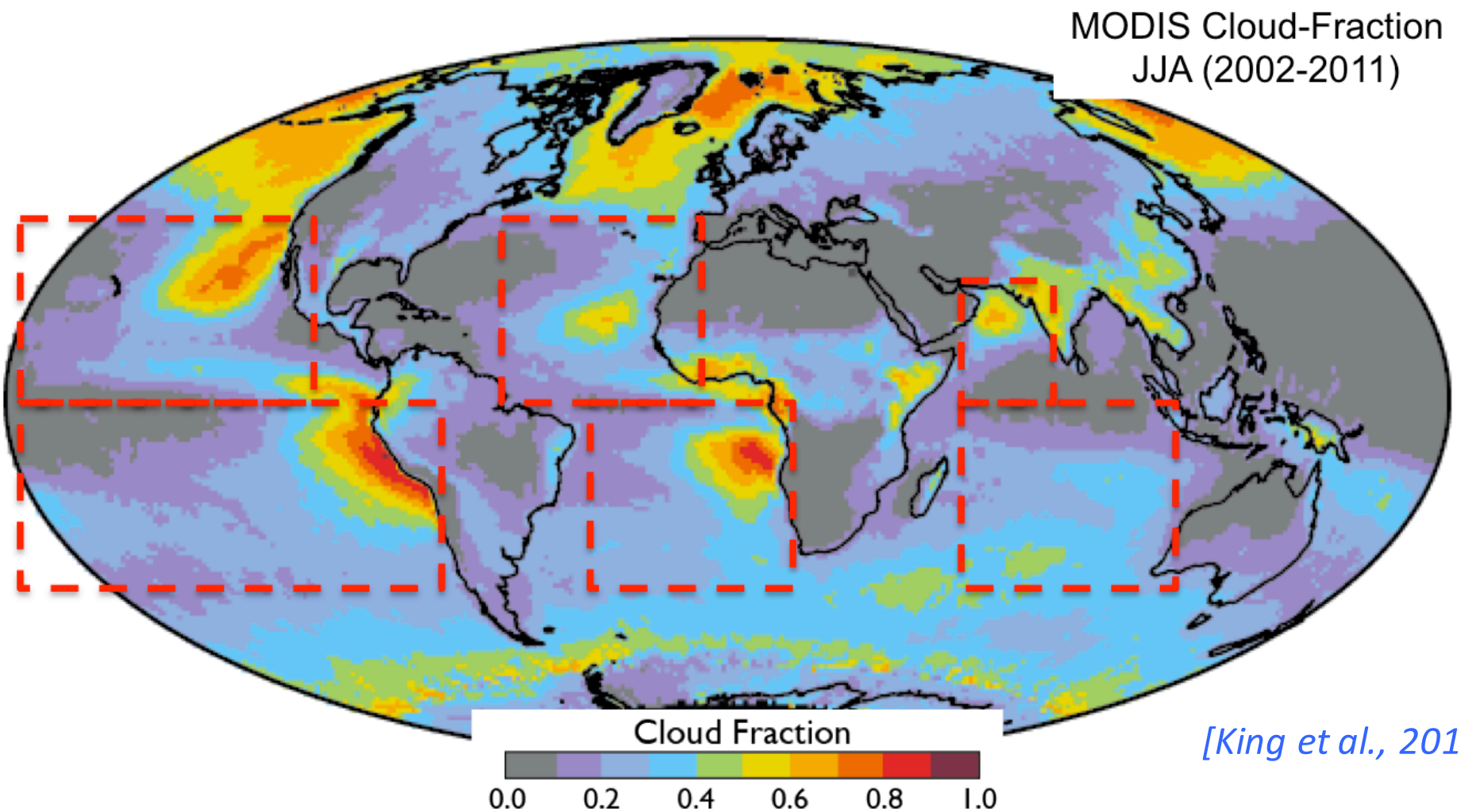
Liquid Water Cloud Fraction – Aqua

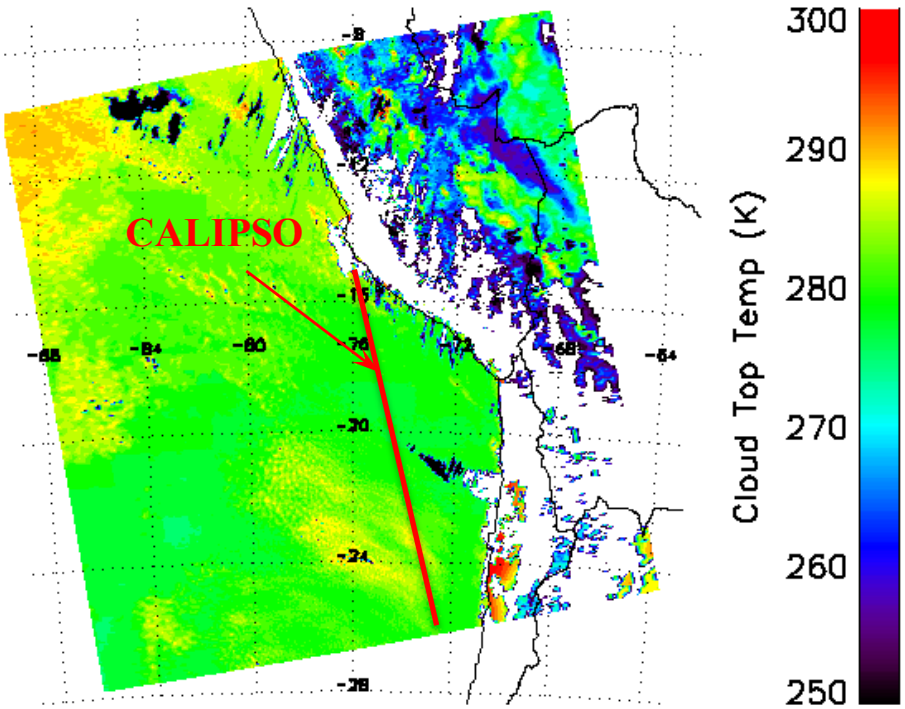


[King et al., 2013]

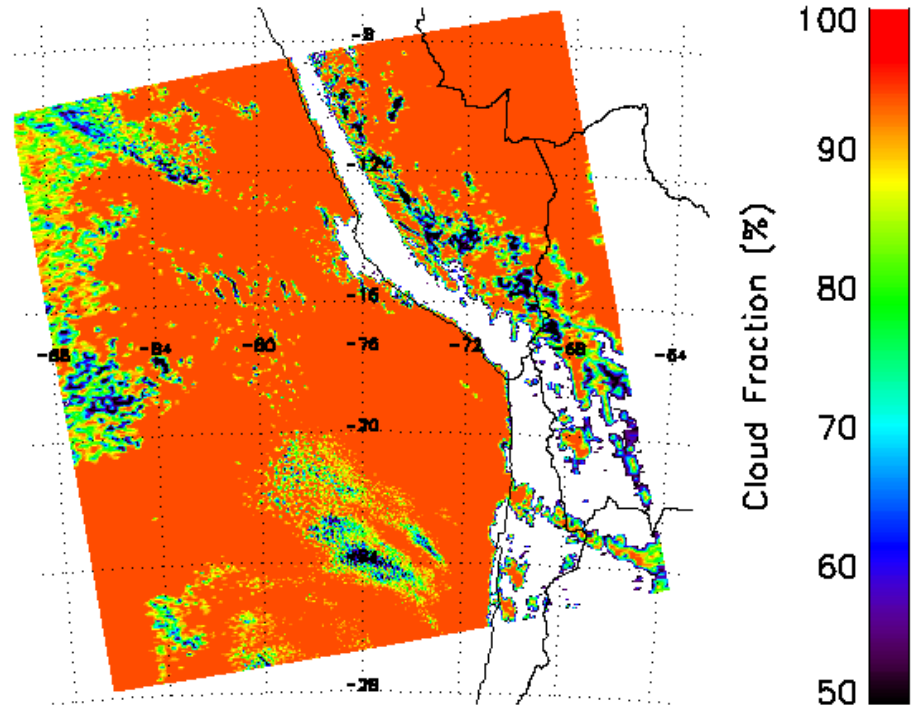
Six selected regions with prevailing boundary layer clouds.

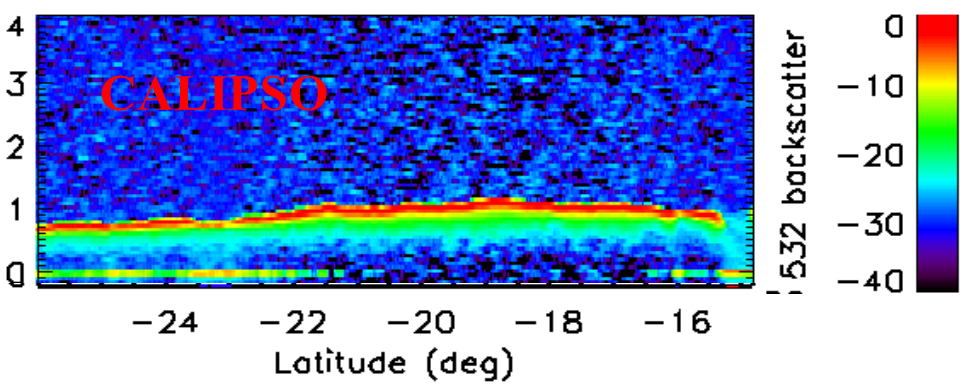
MODIS/CALIPSO Low Cloud Measurement

Cloud-top-temperature (K)



Cloud Fraction (%)





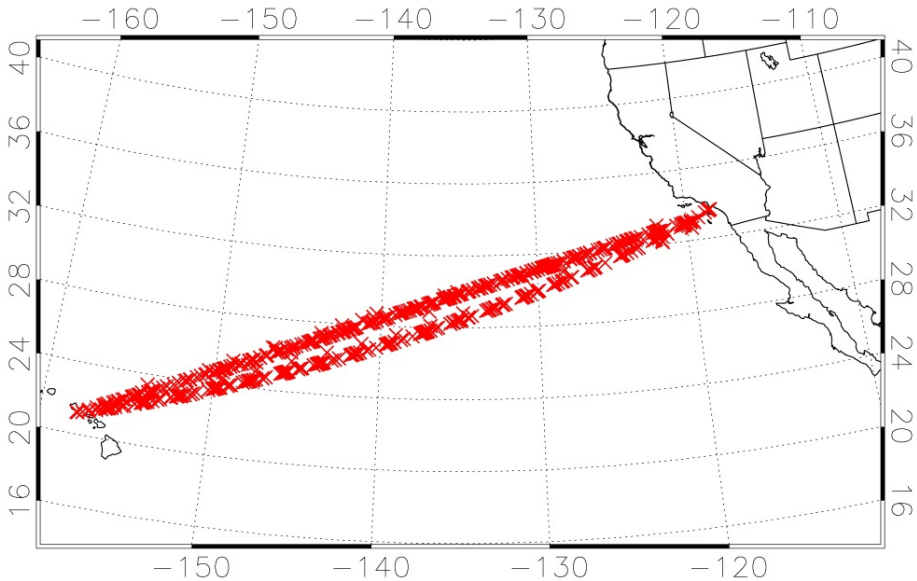
MODIS Lapse-rate Method:

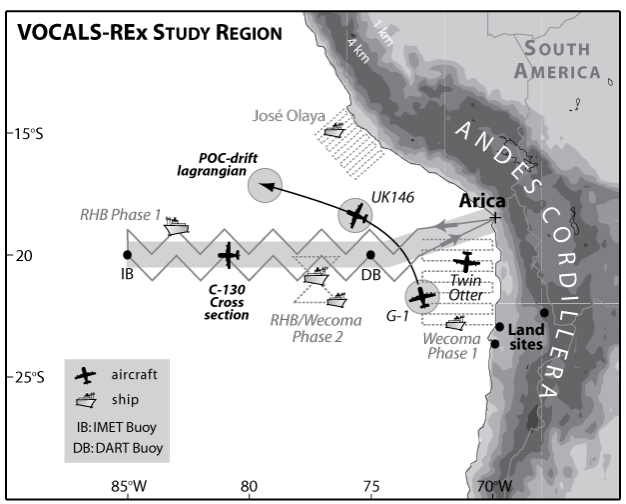
$$CTH = \frac{(SST - CTT) - \delta T}{\Gamma_T}$$

(e.g., Zuidema et al., 2009)

Marine Boundary Layer (Radiosonde)

Marine ARM GPCI Investigation of Clouds (MAGIC)

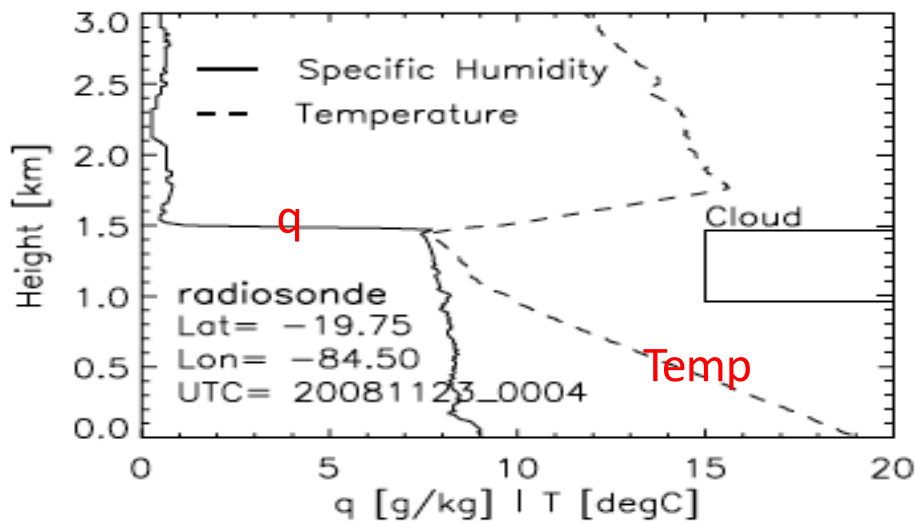




VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment

MAGIC

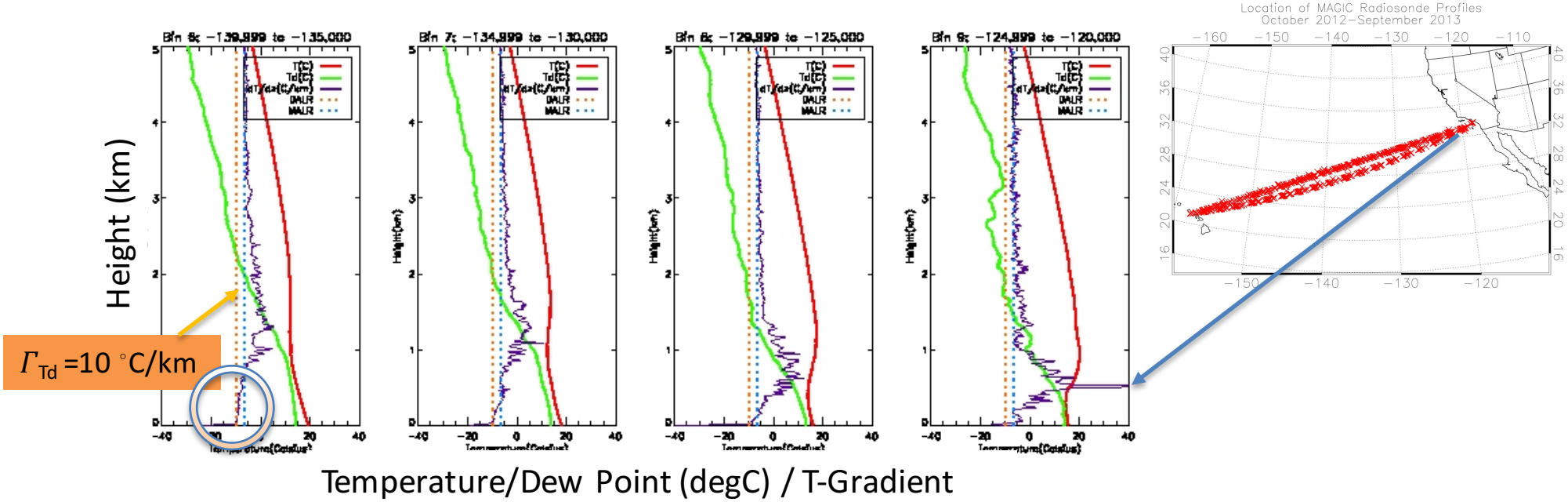
- 20 round trip between
- Los Angeles, CA and Honolulu, HI
- Over 500 radiosonde soundings
- October 2012 - September 2013



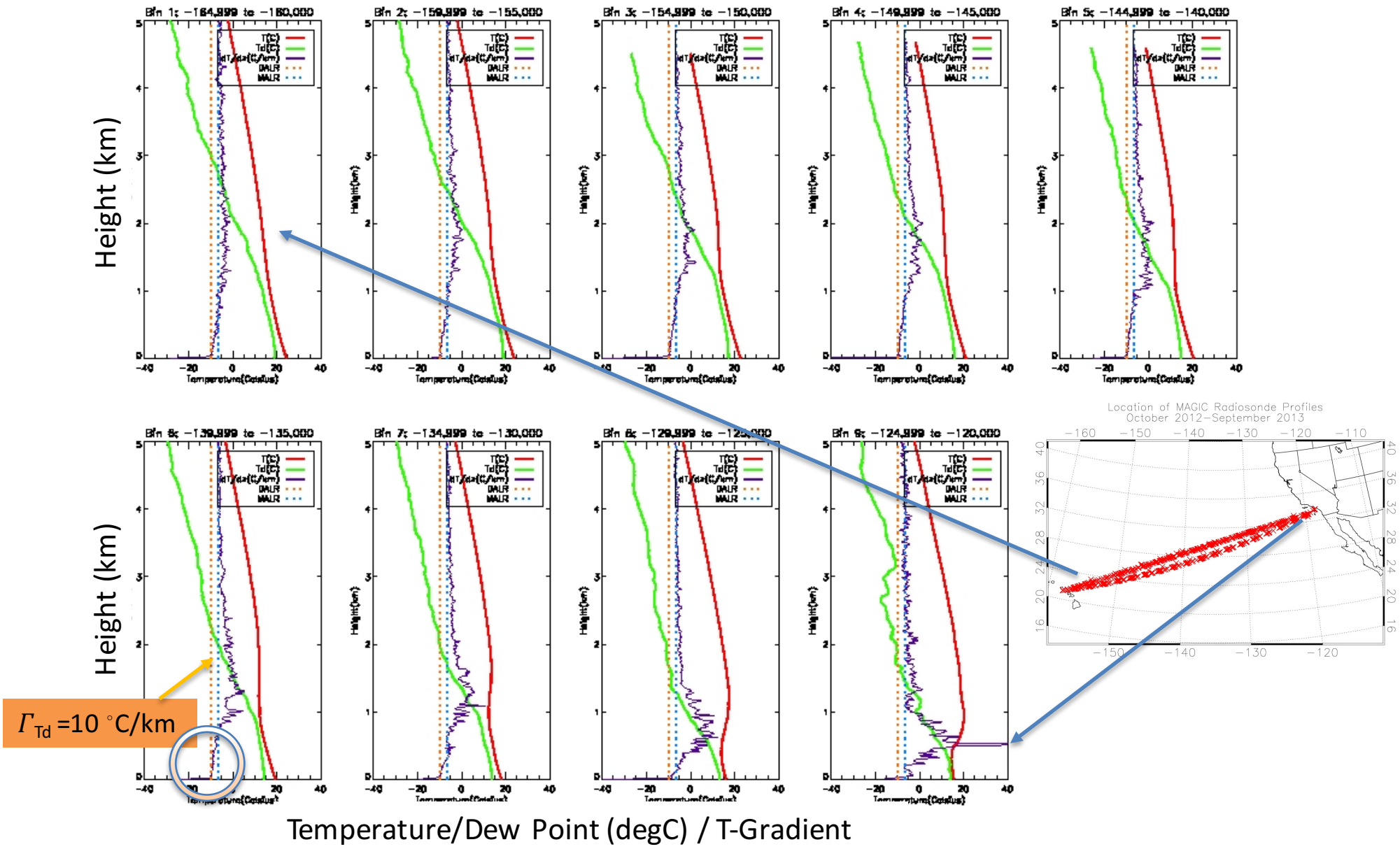
VOCALS-REx

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

MBL Structure along the Transect – MAGIC



MBL Structure along the Transect – MAGIC



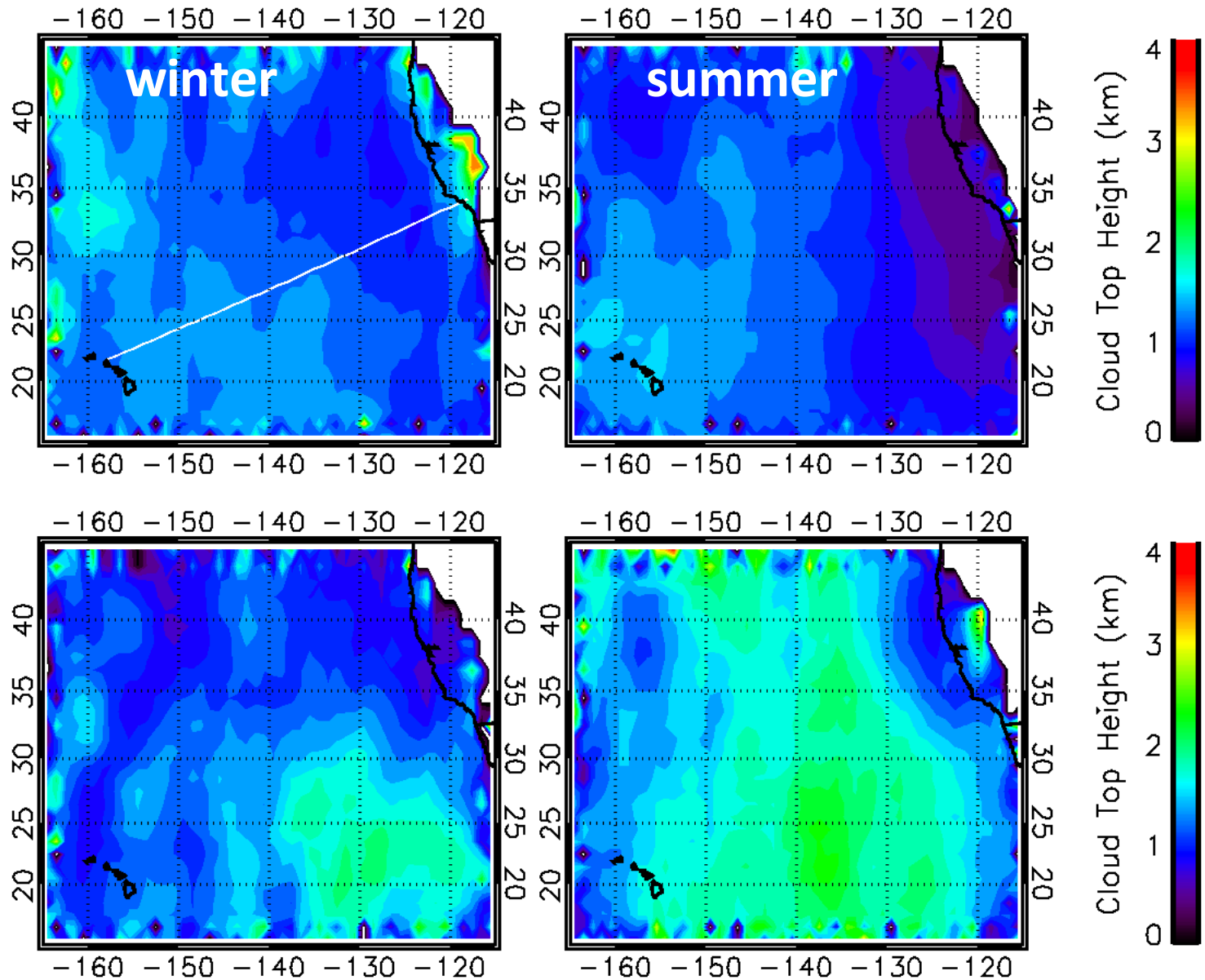
CALIPSO and MODIS-C6 Cloud Top Heights

CALIPSO

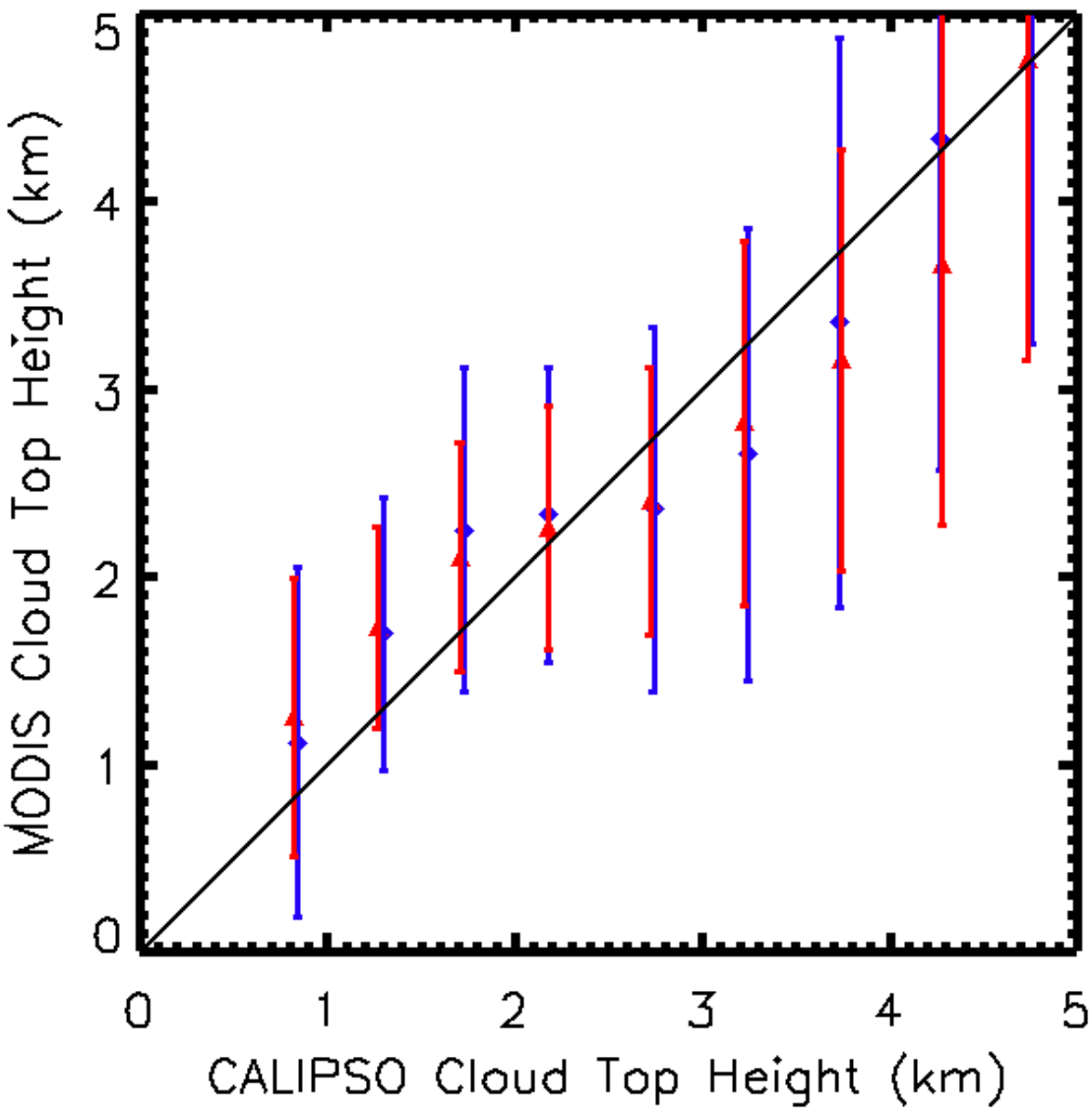
Dec 2012 – Feb 2013 (winter)

June – Aug 2013 (summer)

MODIS-C6



CTH from Coincident MODIS and CALIPSO

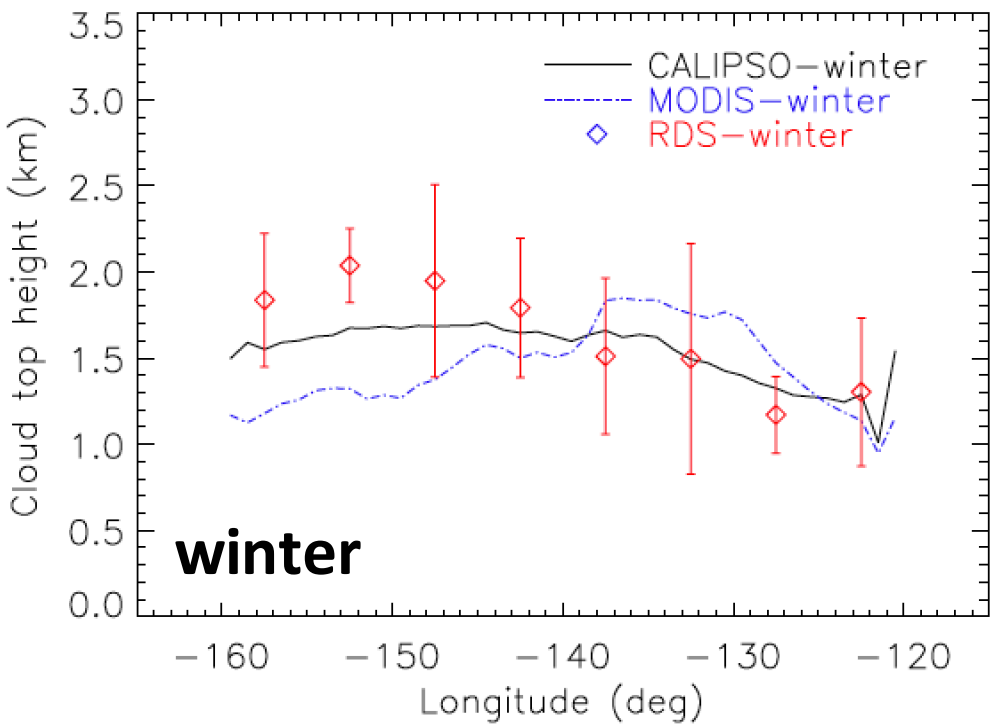


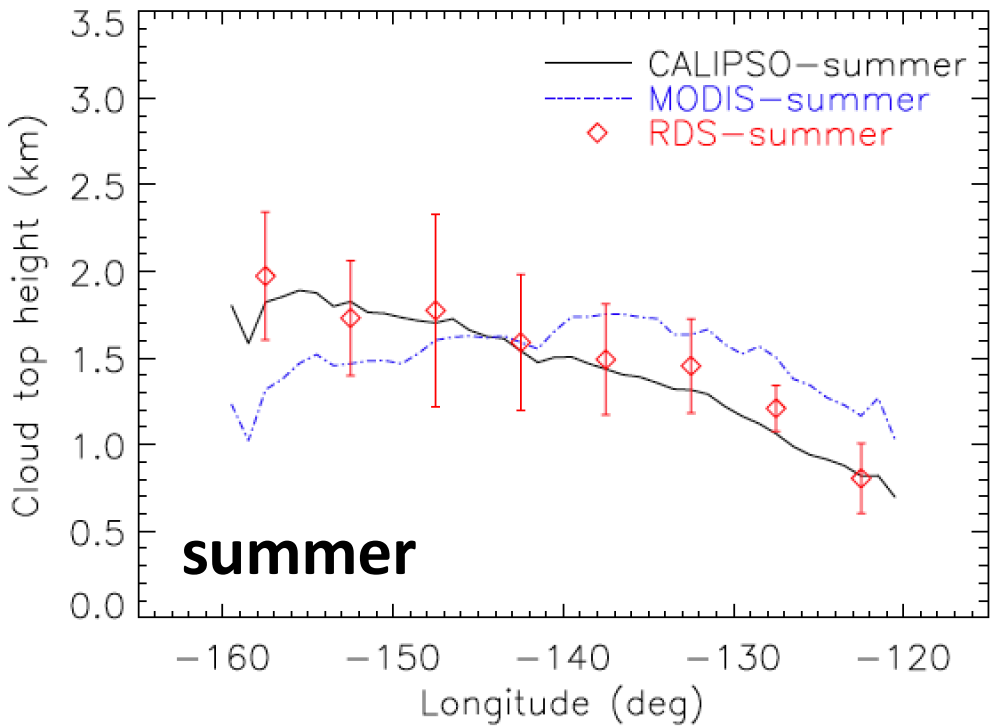
MODIS C6
vs
CALIPSO CTH (single-layer, <5km)

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





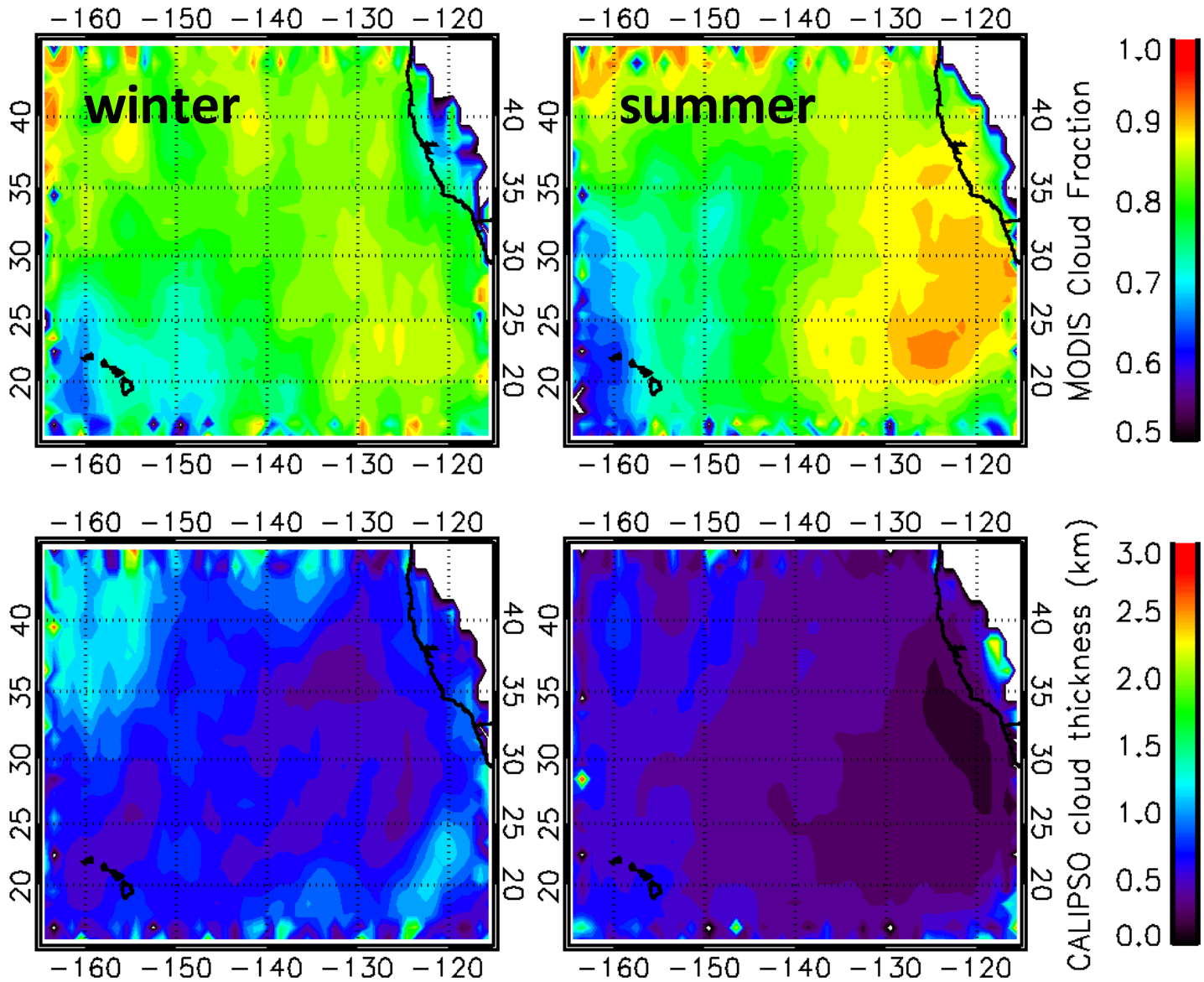
Low Cloud Properties

MODIS

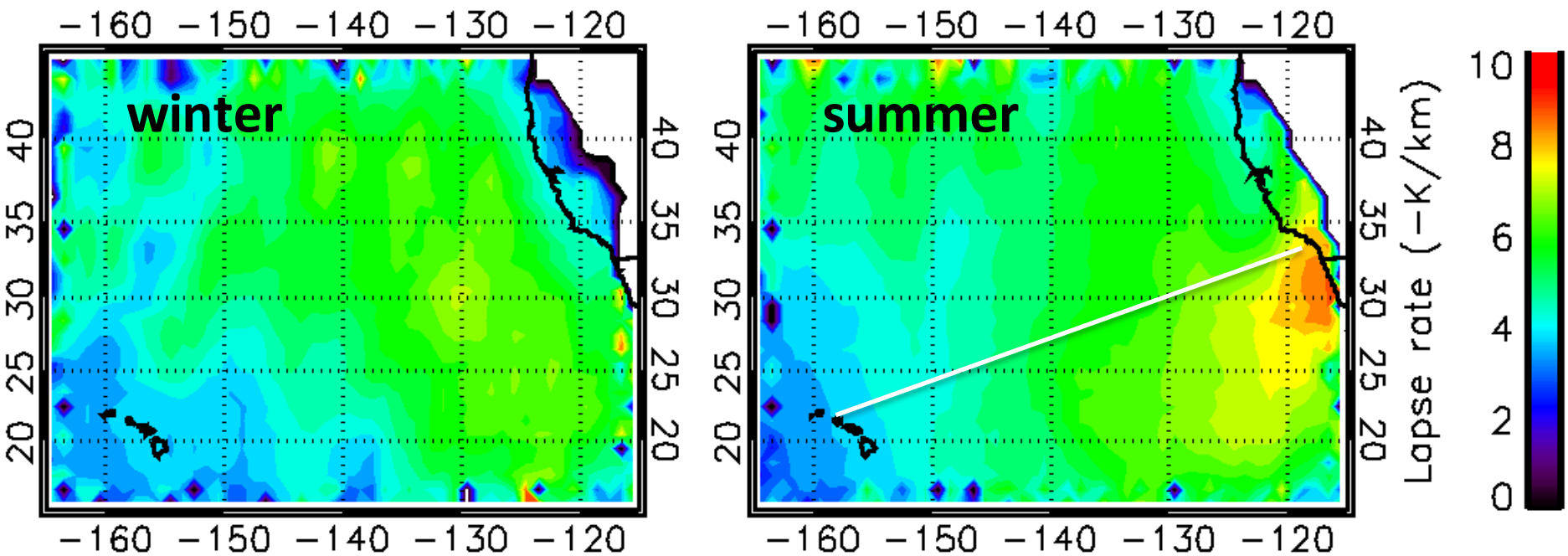
Cloud Fraction

CALIPSO

Cloud Thickness



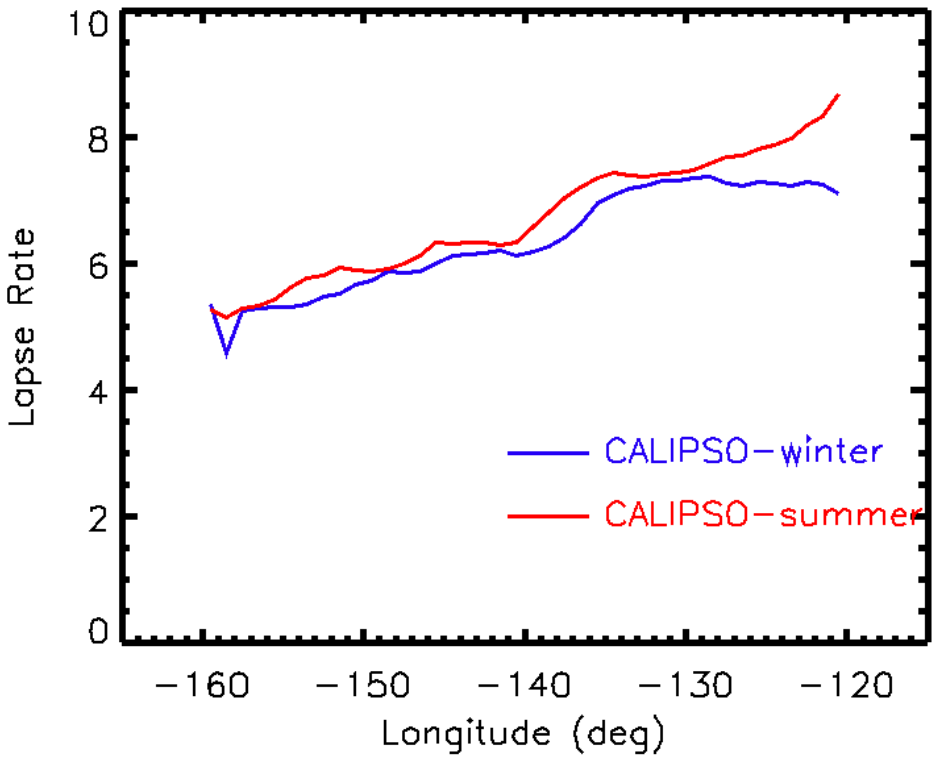
MBL Lapse Rate (Γ_T)

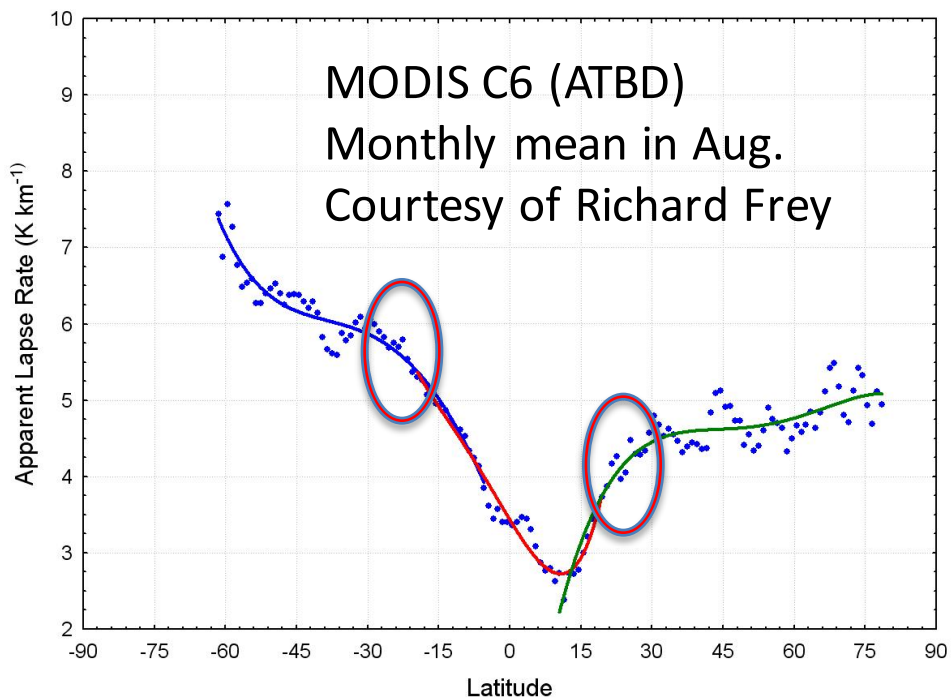


$$\Gamma_T = -\frac{CTT - SST}{CTH}$$

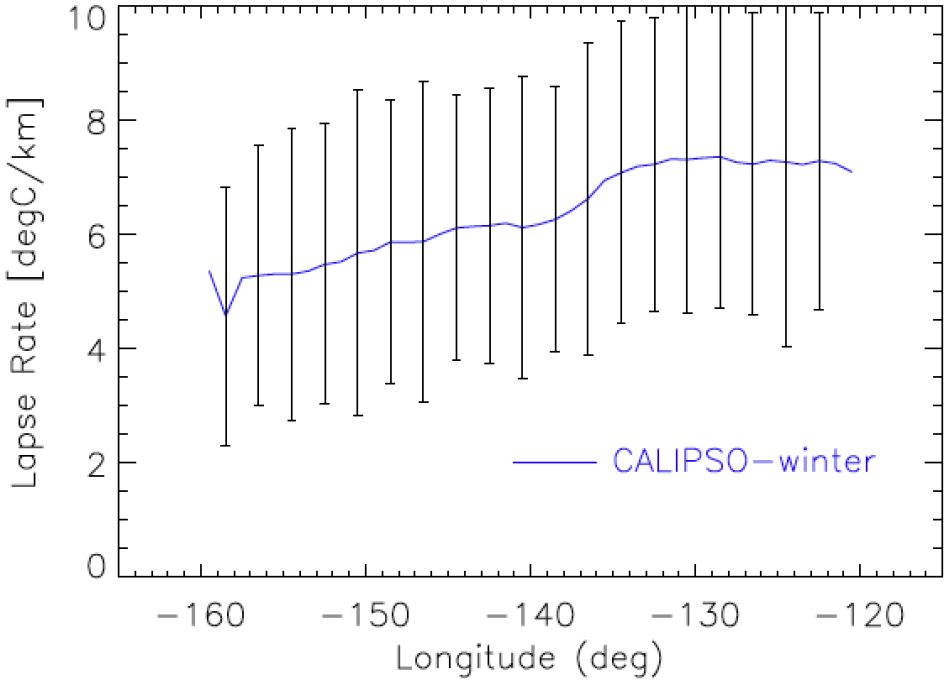
CTT = MODIS CTT
SST = Sea surface temp (ERA-I)
CTH = CALIPSO CTH

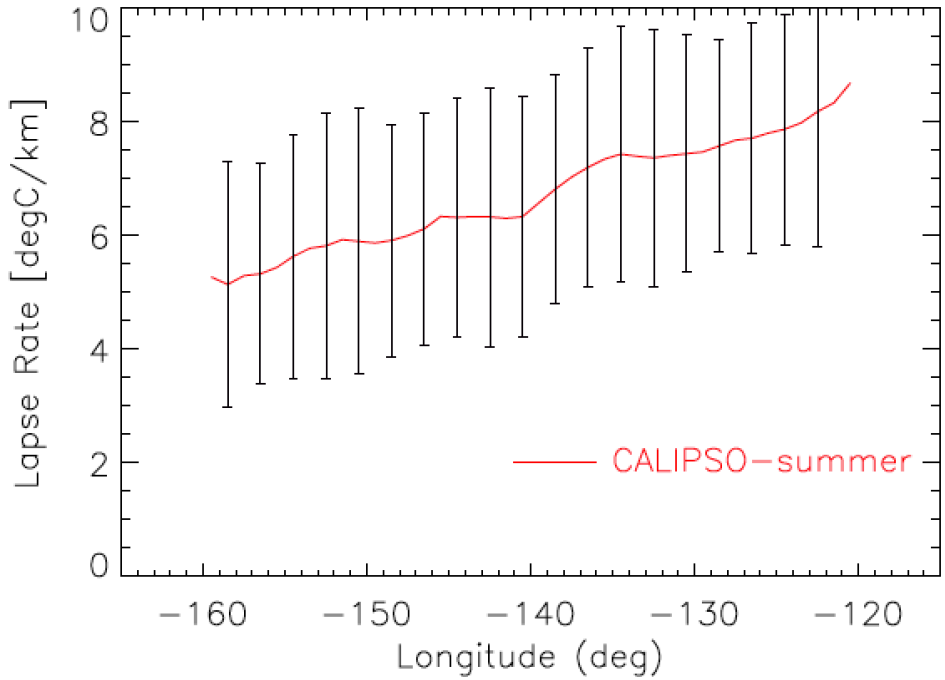
MBL Lapse Rate - Transect over NE Pacific





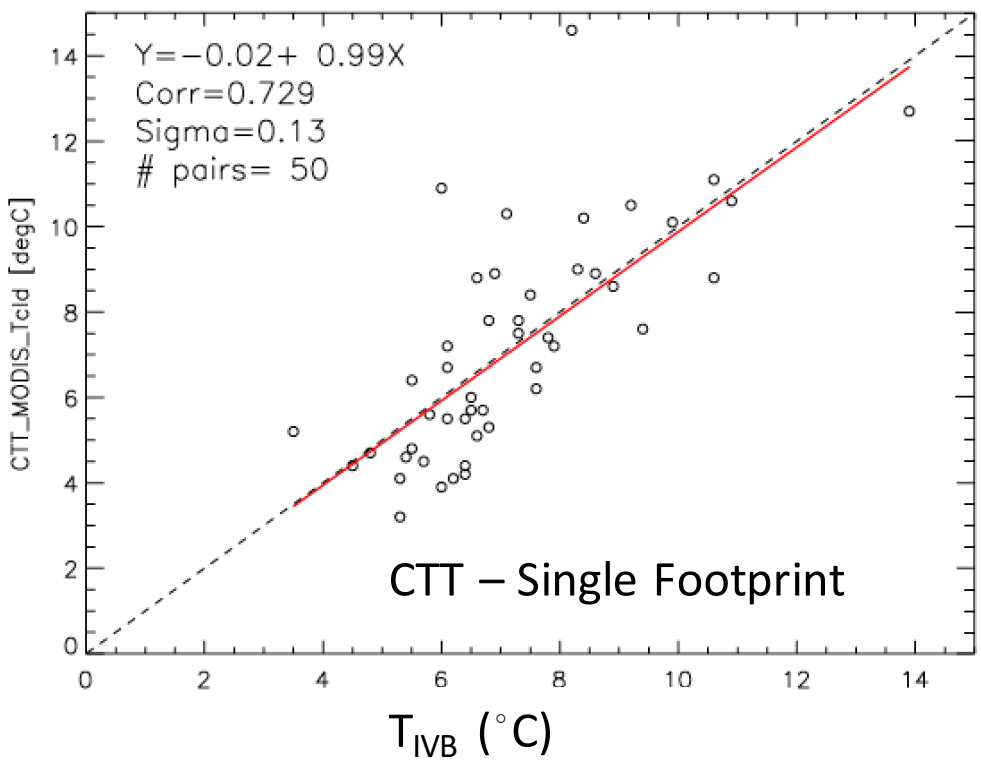
MBL Lapse Rate - Transect over NE Pacific

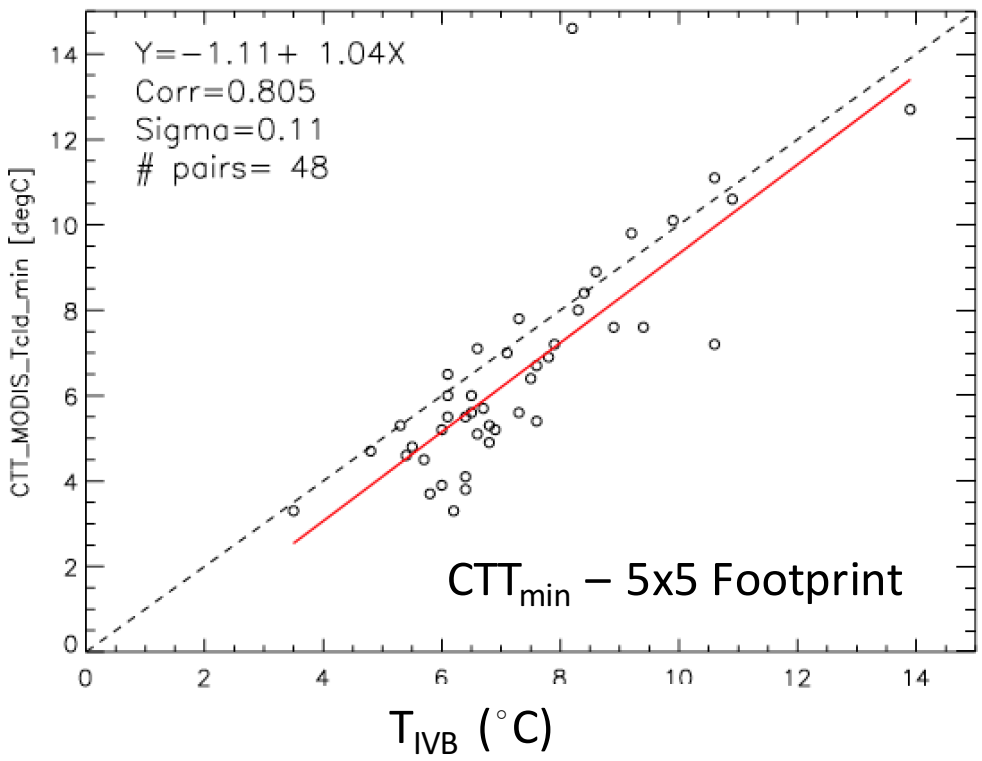




Cloud Top Temp. vs. Inversion Base Temp. (T_{IVB})

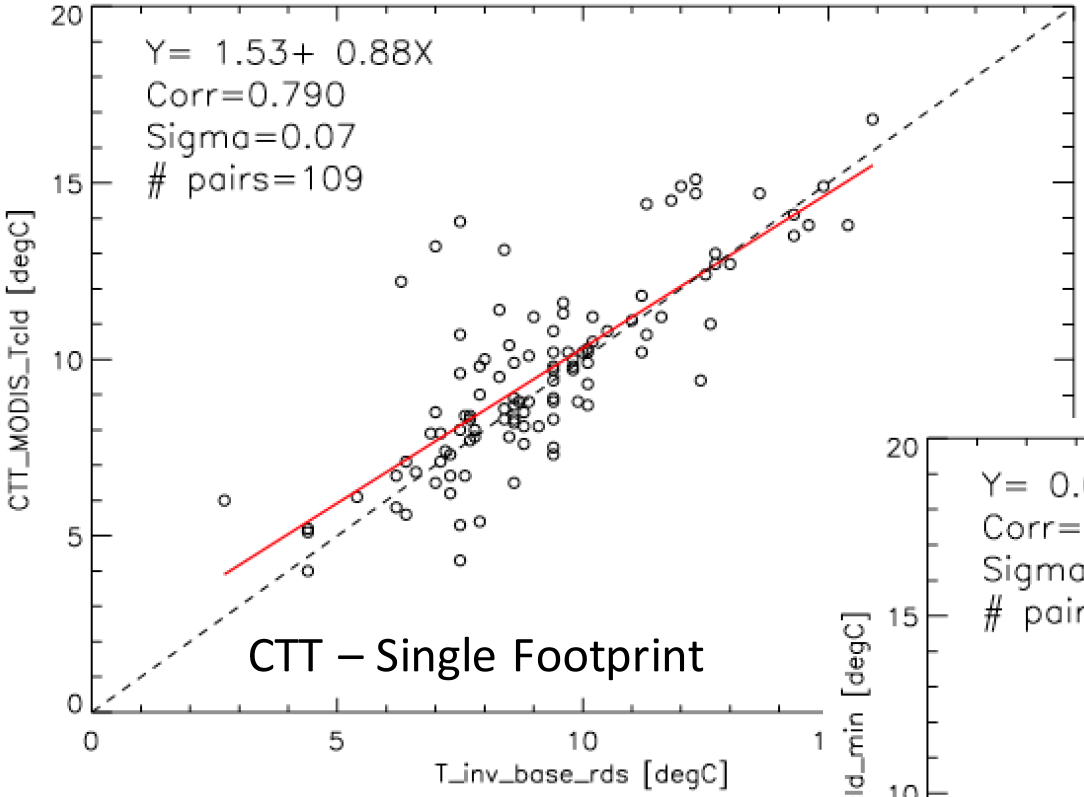
Near-Coincident MODIS vs. Radiosonde (VOCALS)

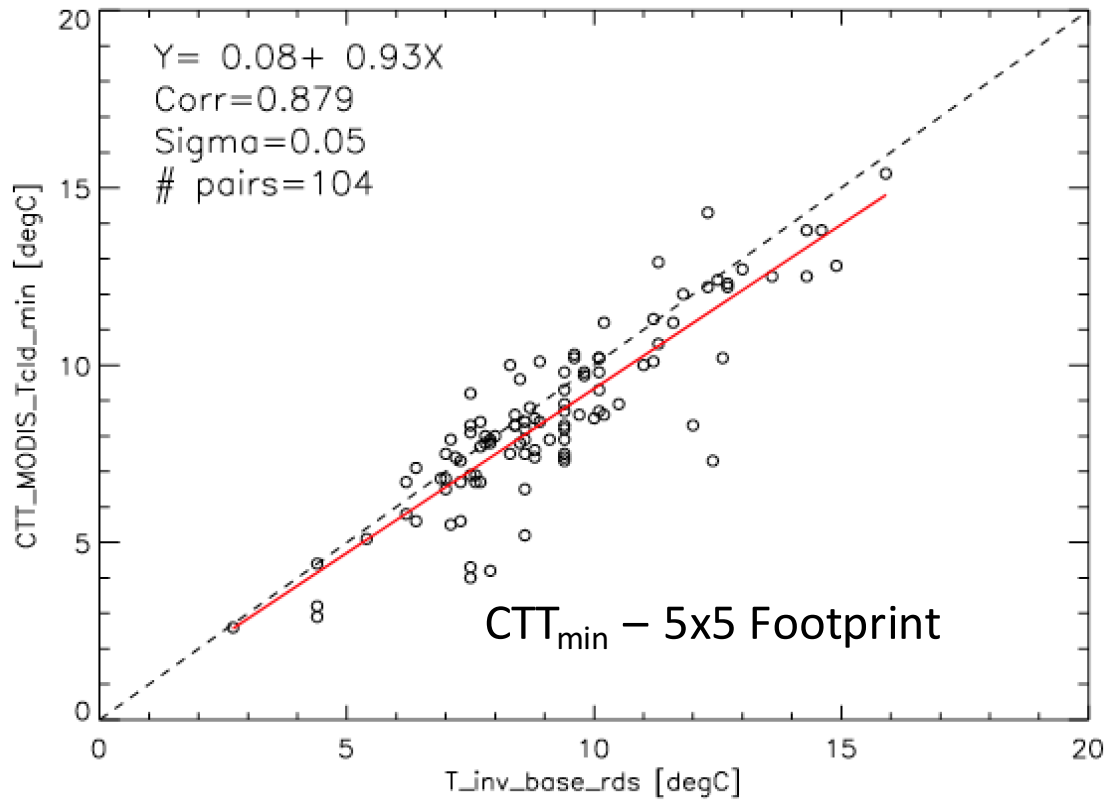




CTT > 0 °C
CF > 90%
Near-Coincident: 300km, 3hrs

MODIS-CTT vs. MAGIC-T_{IVB}





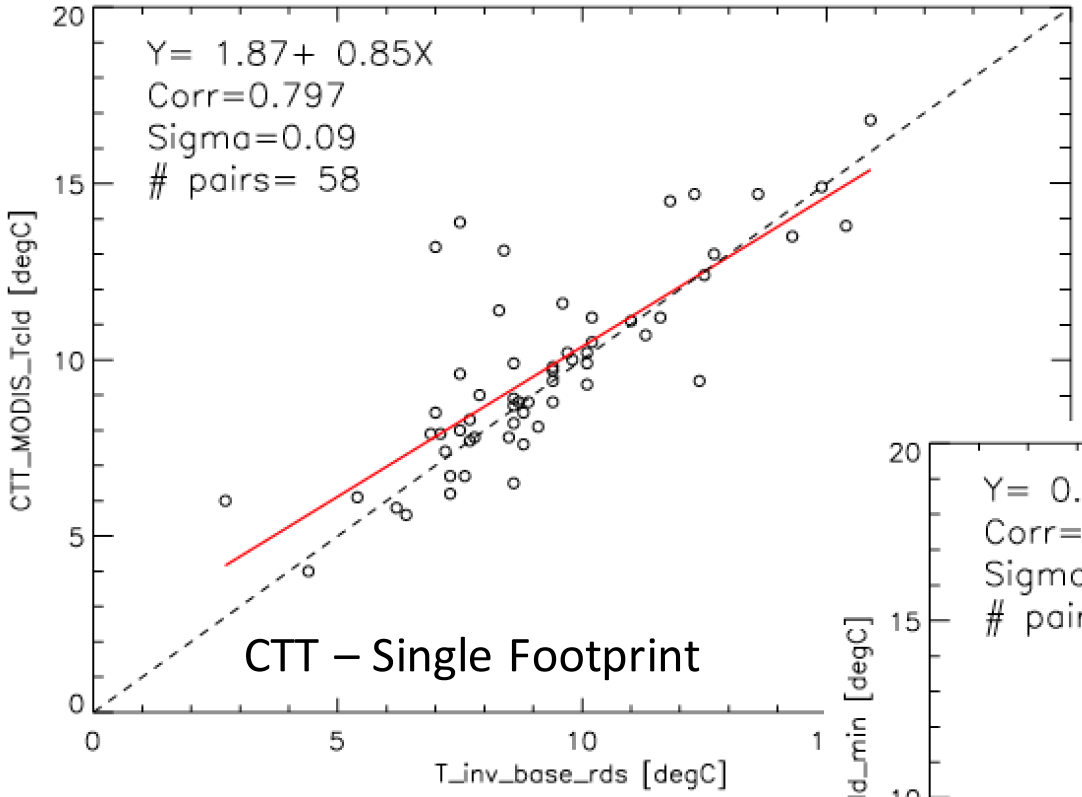
CTT > 0 °C

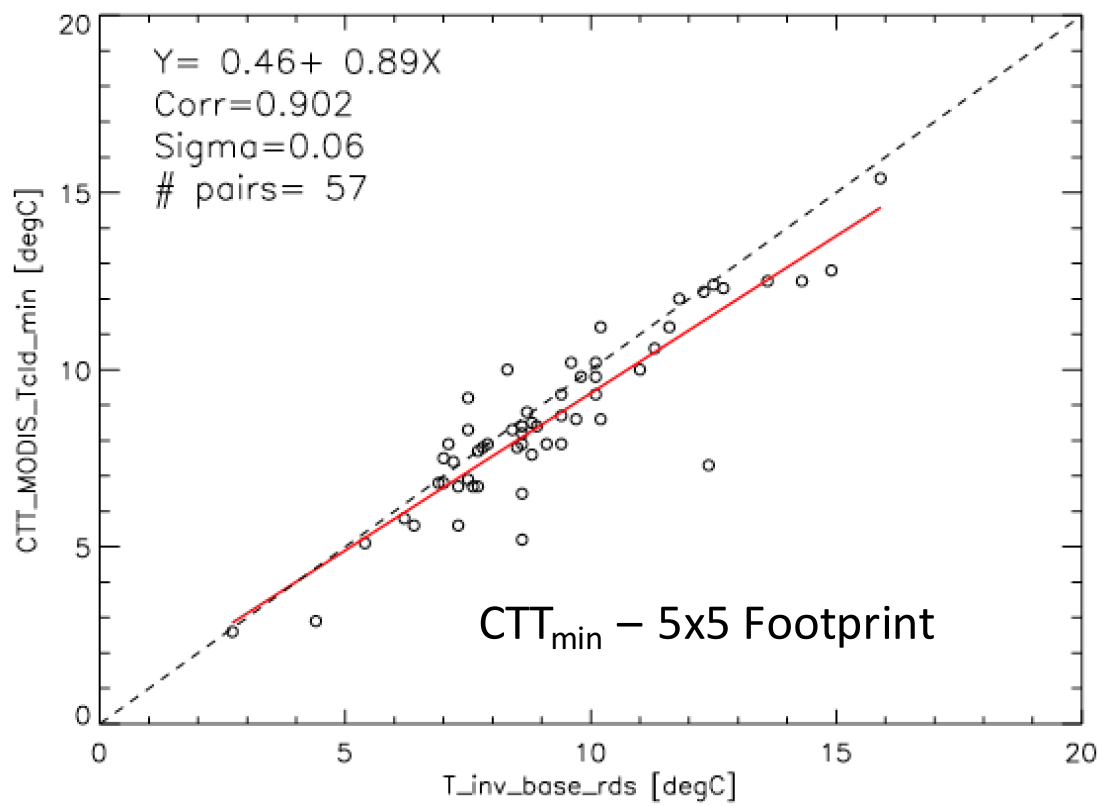
CF > 90%

Longitude [-118°W, **140°W**]

Near-Coincident: 300 km, 3hrs

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 (Γ_T) and CTH are observed near shore of south California, but much less near Hawaii.
- Large longitudinal variation of MBL LR from ~ 8 °C/km over the stratocumulus region to ~4.5°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.

Acknowledgements

- Supported by NASA-NNX14AK17G, special thanks to Dr. Ramesh Kakar.
- 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 Center.
- ECMWF/ERA-interim data
- VOCALS & MAGIC (DOE-ARM) radiosonde data

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