Supplement of Atmos. Chem. Phys., 25, 6857–6880, 2025
https://doi.org/10.5194/acp-25-6857-2025-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

Relationship between latent and radiative heating fields of tropical cloud systems using synergistic satellite observations

Xiaoting Chen et al.

Correspondence to: Xiaoting Chen (xiaoting.chen@lmd.ipsl.fr)

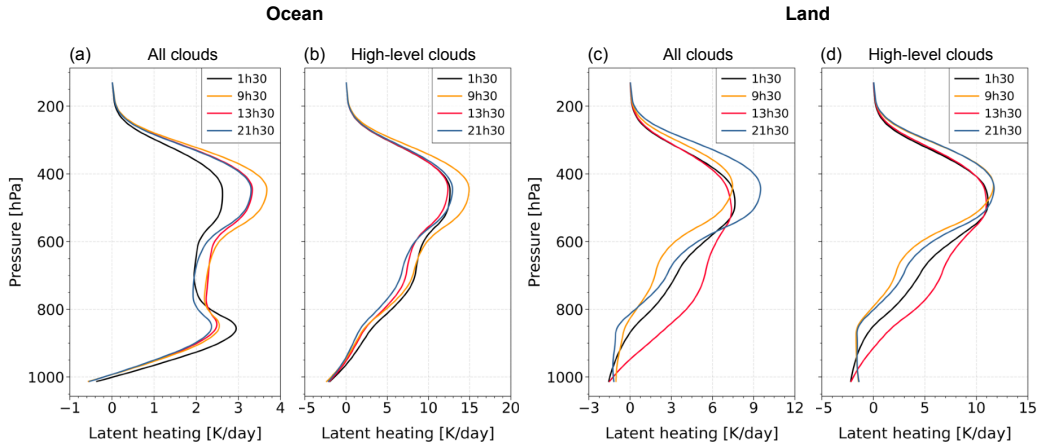

Figure S1. TRMM-SLH LH profiles of precipitating cloud scenes (a,c) and precipitating high-level clouds (b,d) at 4 observation times (1h30, 9h30 AM/PM), separately over ocean (a,b) and over land (c,d), Data are averaged over the TRMM–CIRS collocated data during the period 2008–2013, within 30°N–30°S, with a spatial resolution of 0.5°.

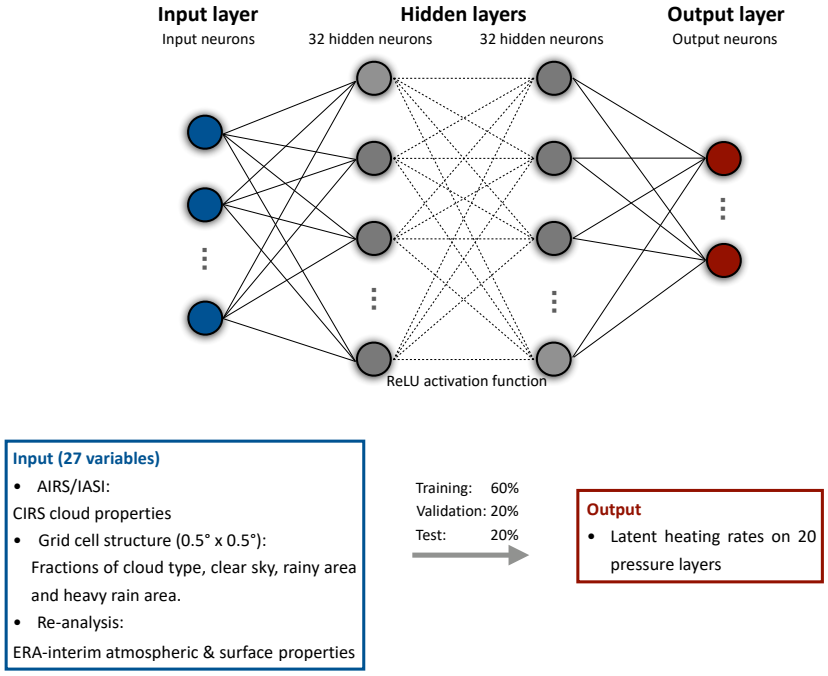

Figure S2. Structure of the ANN used in this study for latent heating retrieval. The network takes 27 input variables and processes them through two hidden layers to predict a latent heating profile within 20 pressure layers as the output. Blue nodes represent input neurons, gray nodes represent hidden neurons, and red nodes indicate the final output neurons.

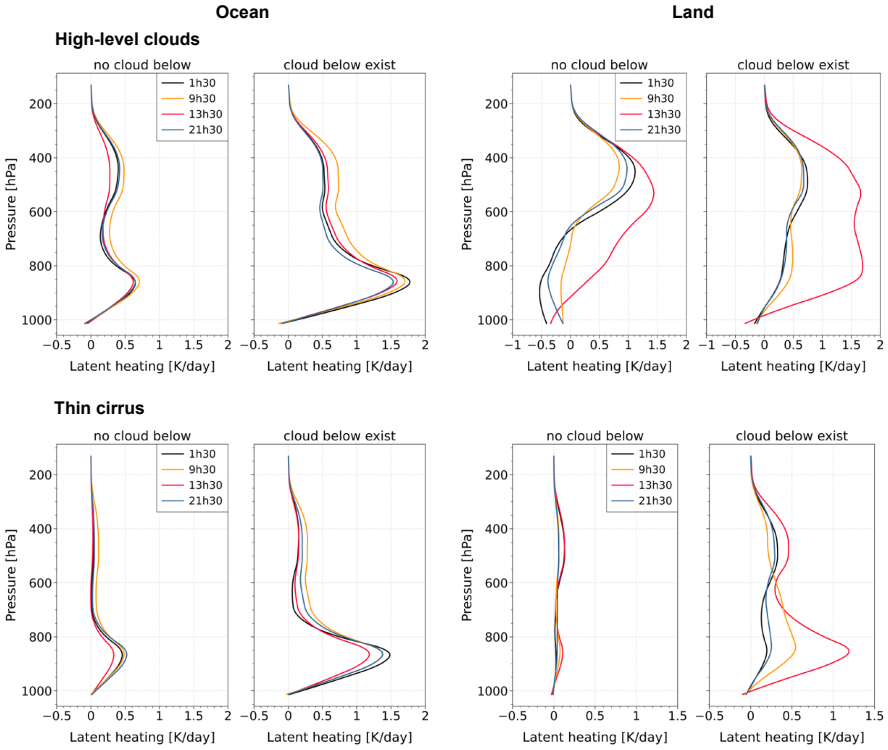

Figure S3. TRMM-SLH LH profiles of non-precipitating high-level clouds (top panels) and thin Cirrus (bottom panels) at 4 observation times (1h30, 9h30 AM/PM), considering the absence or presence of underlying lower clouds (no cloud below, cloud below exist) from CIRS-ML, separately over ocean (left) and over land (right). Data are averaged over the TRMM–CIRS collocated data during the period 2008–2013, within 30°N–30°S, at a spatial resolution of 0.5°.

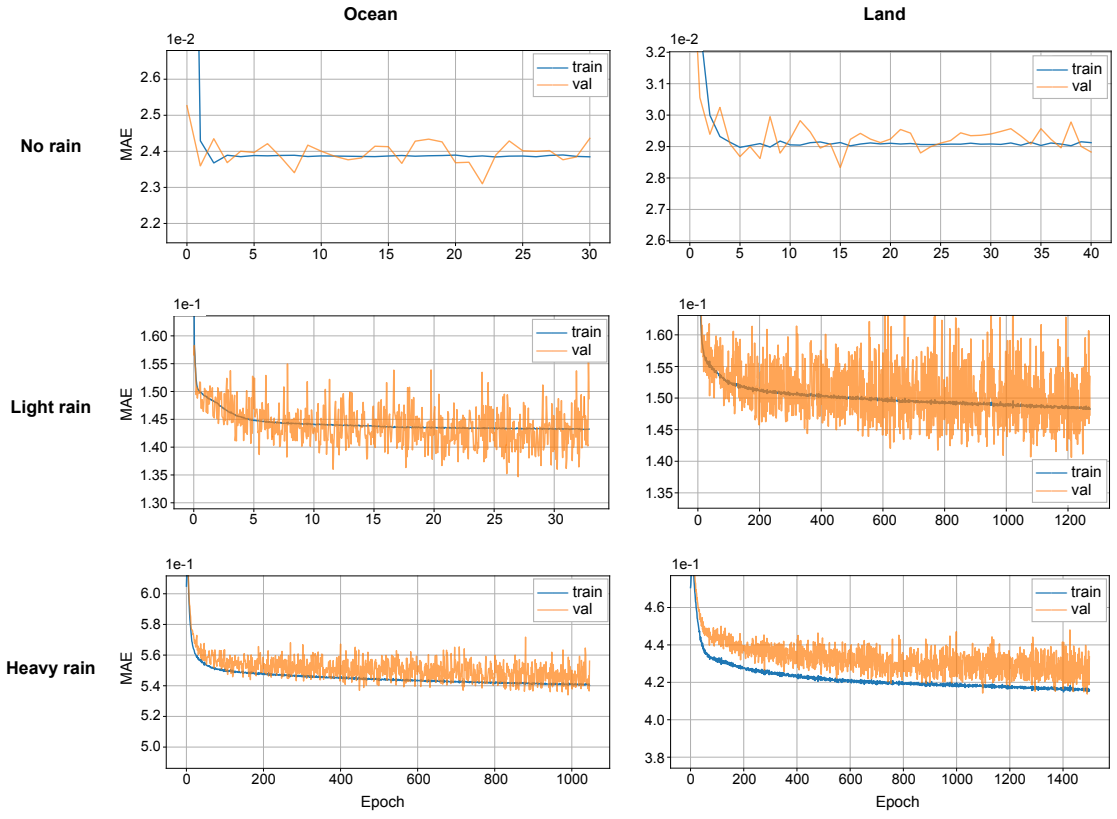

Figure S4. Mean absolute error (MAE) as a function of iterations (epochs) for high-level clouds, categorized by three rain intensities (top to bottom: no rain, light rain, heavy rain) over ocean (left) and land (right). ANN regressions were trained on collocated AIRS–TRMM data.

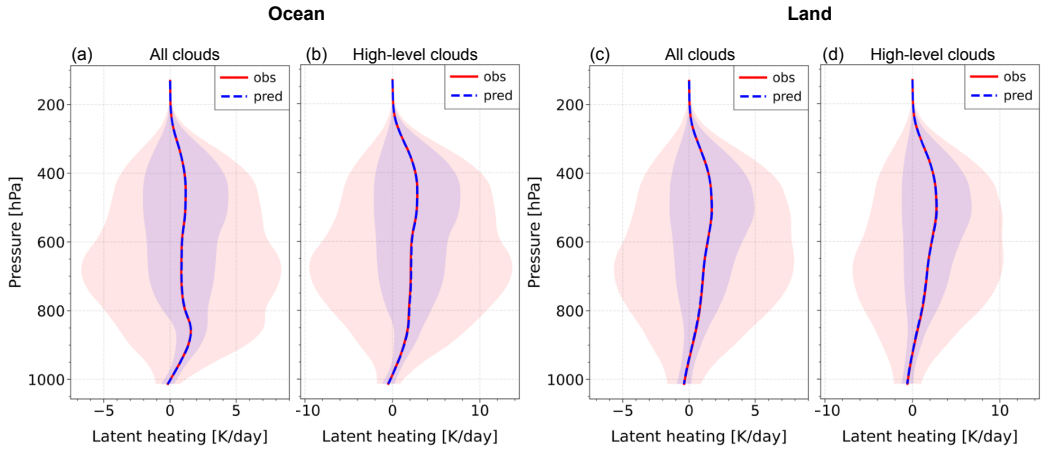

Figure S5. Average and range of predicted (dashed) and observed (solid) latent heating (2004–2013) for (a,c) all cloud scenes and (b,d) high-level clouds 1h30 AM/PM (AIRS), separately over ocean (a,b) and over land (c,d), within 30°N–30°S, with a spatial resolution of 0.5°. Models were trained on collocated AIRS–TRMM. Shaded areas indicate ±67.5 % of the standard deviation, which corresponds to quartiles.

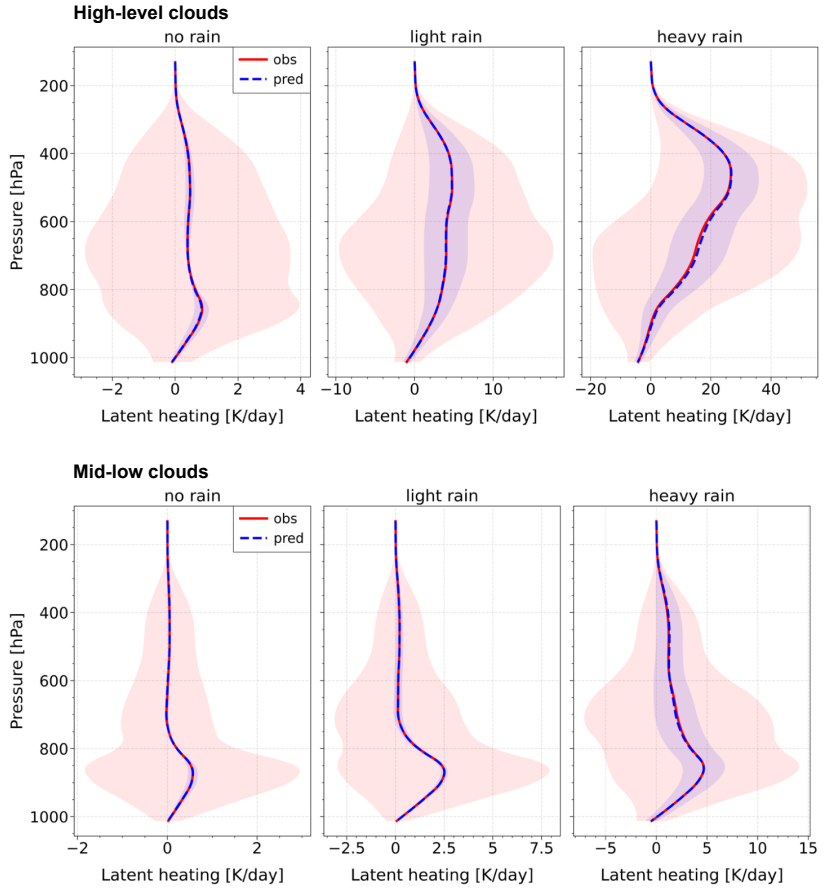

Figure S6. Average and range of predicted (dashed) and observed (solid) LH rates (2004–2013) of high-level clouds (top panels, same as the upper panels of Fig. 3, but with independent X-axis tick labels) and mid-low level clouds (bottom panels), for different rain rate intensities (no rain, light rain and heavy rain) over both ocean and land, within 30°N–30°S, with a spatial resolution of 0.5°. Models were trained on collocated AIRS–TRMM. Shaded areas indicate ±67.5° of the standard deviation, which corresponds to quartiles.

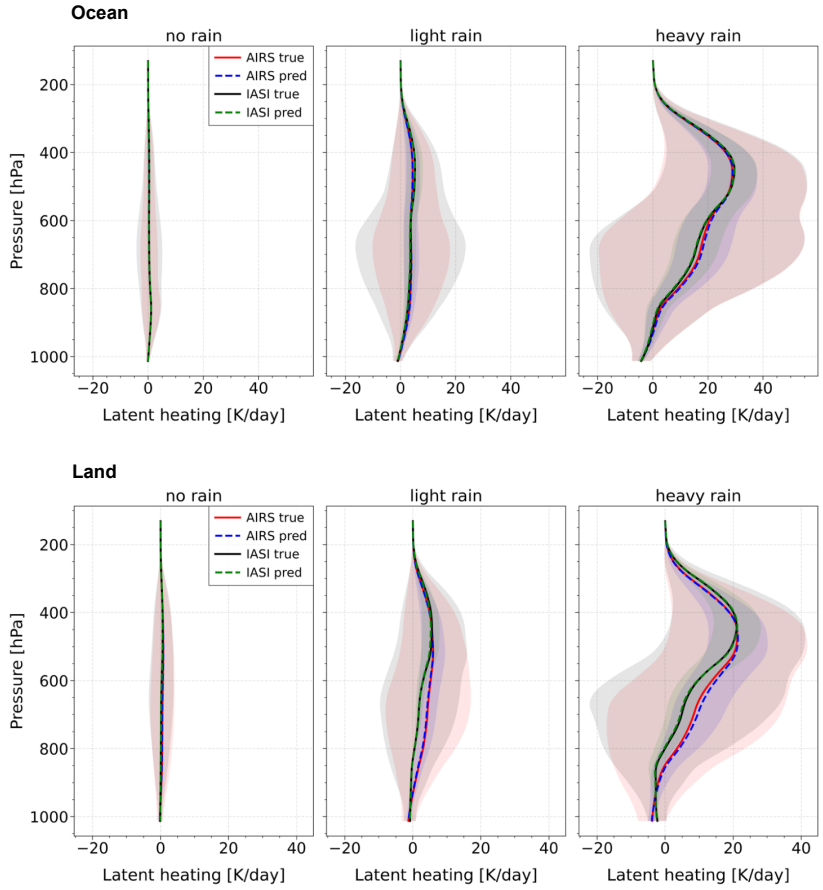

Figure S7. Average and range of predicted and observed LH rates for high-level clouds with different rain intensities (no rain, light rain and heavy rain), over ocean (top panels) and land (bottom panels), separately for AIRS and IASI, within 30°N–30°S, at a spatial resolution of 0.5°. Models were trained on collocated AIRS–TRMM and IASI–TRMM. Shaded areas indicate ±67.5° of the standard deviation, which corresponds to quartiles.

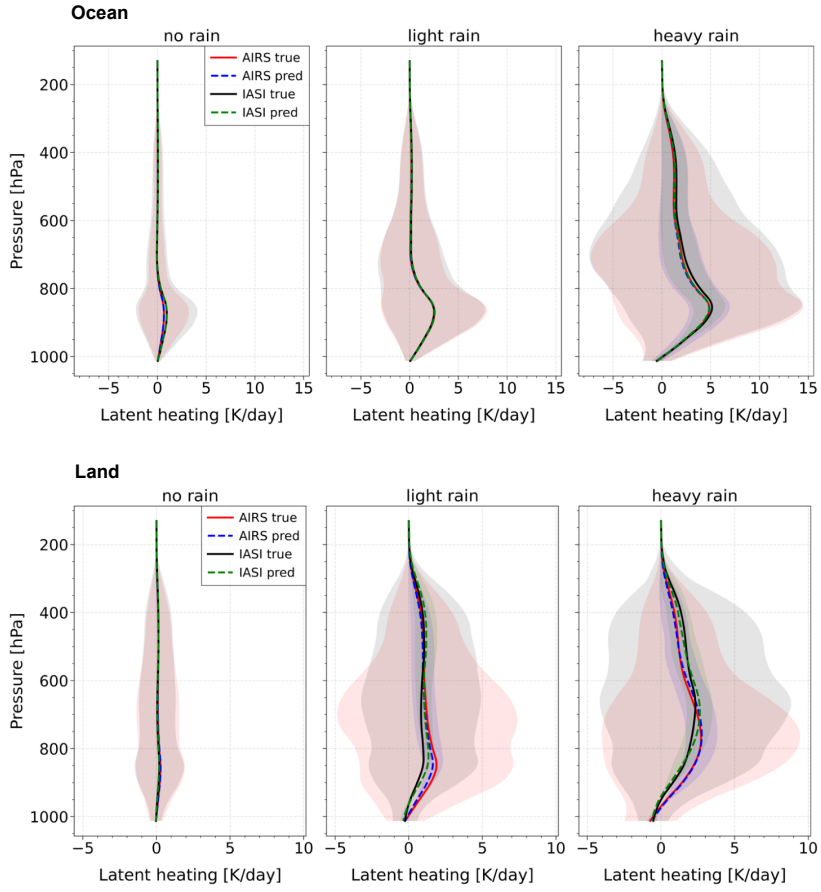

Figure S8. Average and range of between predicted and observed LH rates for mid-low level clouds with different rain intensities (no rain, light rain and heavy rain), over ocean (top panels) and land (bottom panels), separately for AIRS and IASI, within 30°N–30°S, at a spatial resolution of 0.5°. Models were trained on collocated AIRS–TRMM and IASI–TRMM. Shaded areas indicate ±67.5° of the standard deviation, which corresponds to quartiles.

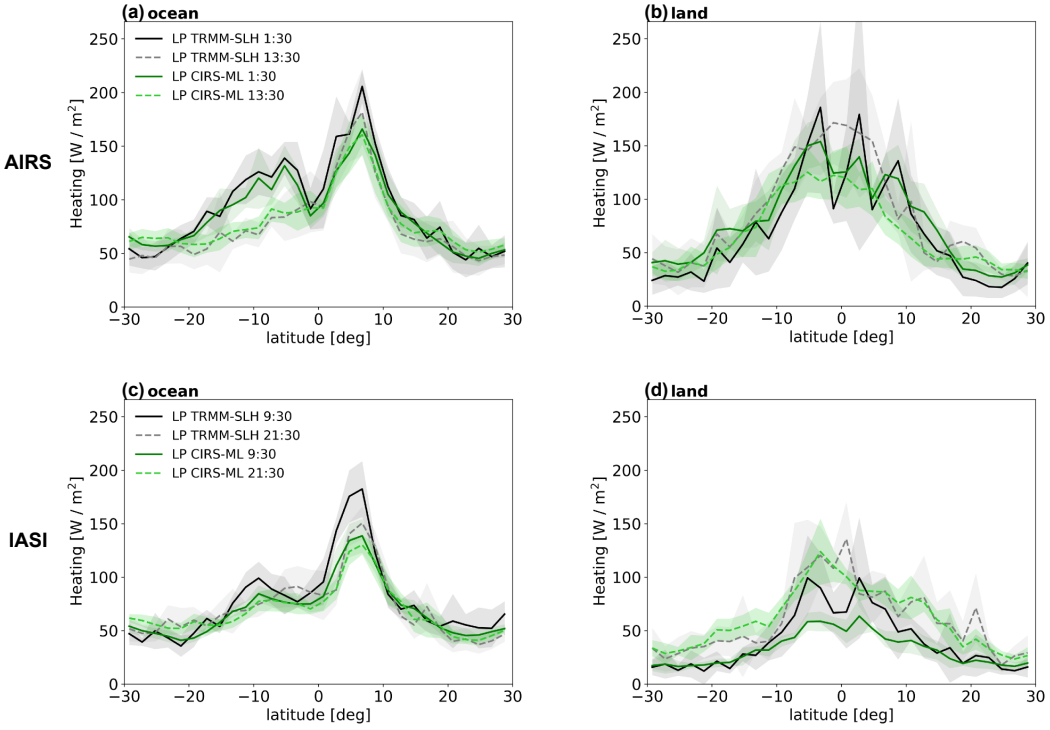

Figure S9. Zonal averages of vertically integrated LH (LP) of collocated data (a) at 1:30 AM and PM over ocean, (b) at 1:30 AM and PM over land, (c) at 9:30 AM and PM over ocean, (b) at 9:30 AM and PM over land. Black solid lines: TRMM LP for AM observations. Gray dashed line: TRMM LP for PM observations. Dark green solid line: LP from ML regression using AIRS or IASI as inputs for AM observations. Light green dashed line: LP from ML regression using AIRS or IASI as inputs for PM observations. Shaded areas correspond to inter-annual variabilities. The latitude intervals are 2°, and the time period is 2008-2013.

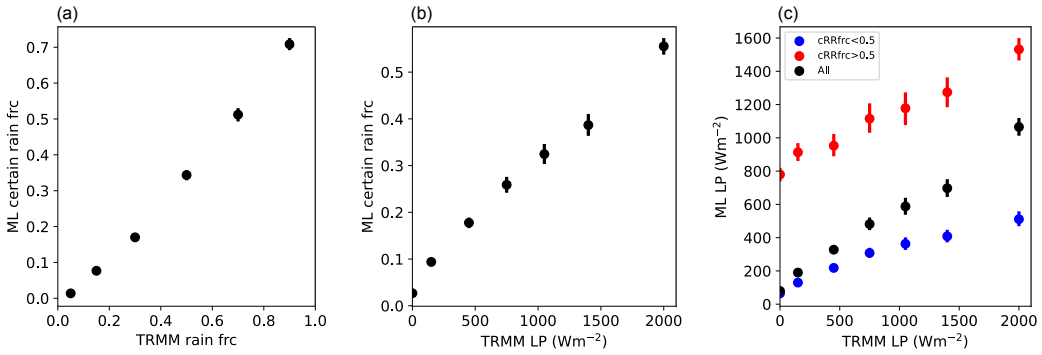

Figure S10. Average relationships for high-level clouds between (a) CIRS-ML certain rain fraction and TRMM rain fraction, (b) CIRS-ML certain rain fraction and TRMM-SLH LP and (c) CIRS-ML LP and TRMM-SLH LP for all and for cases with CIRS-ML certain rain fraction < 0.5 and > 0.5. Statistics of collocated data over ocean 30°N–30°S, over the time period from 2004–2013.

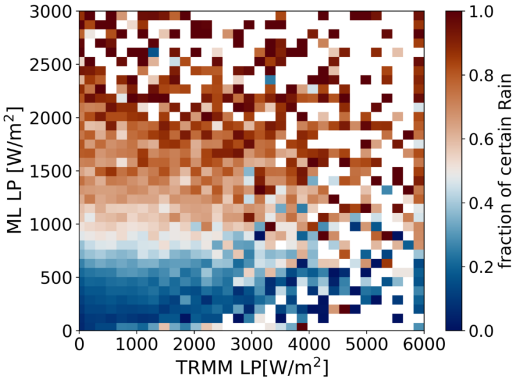

Figure S11. Averages of CIRS-ML certain rain fraction as function of TRMM-SLH LP and CIRS-ML LP of high-level clouds over the ocean, from collocated data for the period 2004-2013, spanning 30°N to 30°S, at a spatial resolution of 0.5°S. Each square corresponds to an interval of 75 W m^{-2} in ML LP and 150 W m^{-2} in TRMM-SLH LP.

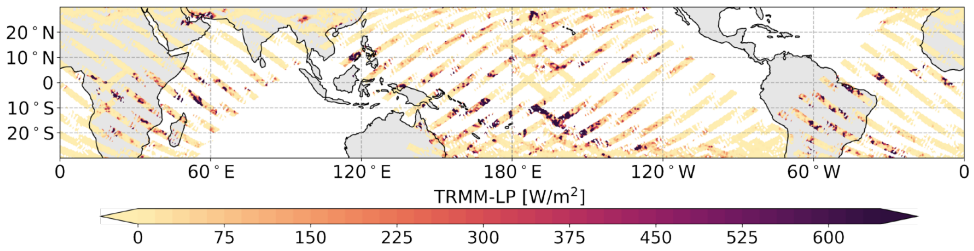

Figure S12. Maps of vertically integrated LH during La Niña (JAN 2008), within 30°N–30°S, at a spatial resolution of 0.5°. Data from TRMM-SLH, at 1h30 AM/PM (AIRS).

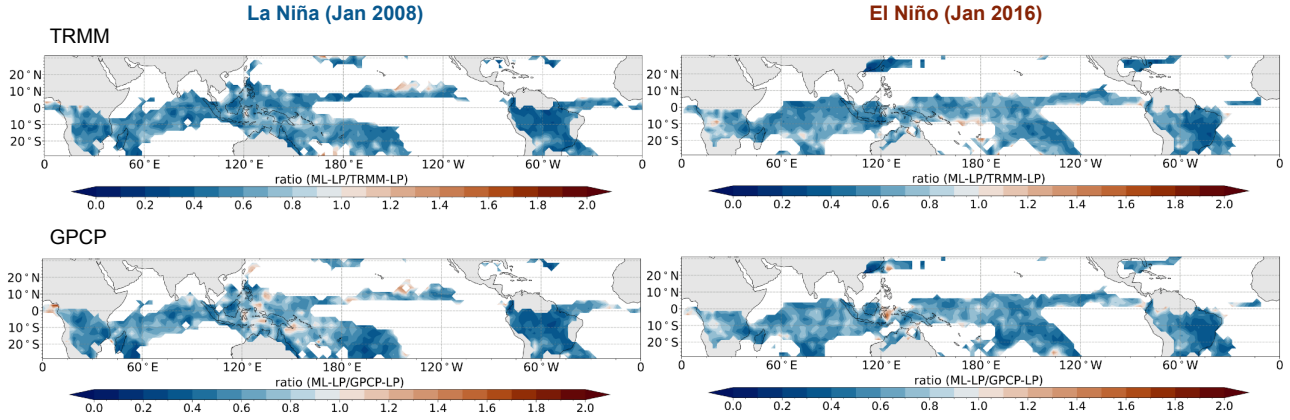

Figure S13. Ratio between the vertically integrated latent heating (LP) from CIRS–ML (at 1:30 LT) and the LP estimated from daily precipitation data from TRMM (upper panels) and GPCP (lower panels). The ratios (CIRS–ML LP / TRMM LP or GPCP LP) are shown for La Niña (JAN 2008) and El Niño (JAN 2016), over the region 30°N–30°S, at a spatial resolution of 2.5° × 2.5°. Since very small TRMM LP values could lead to unrealistic ratios, we apply a threshold of 50 W m^{-2} to filter out these cases.

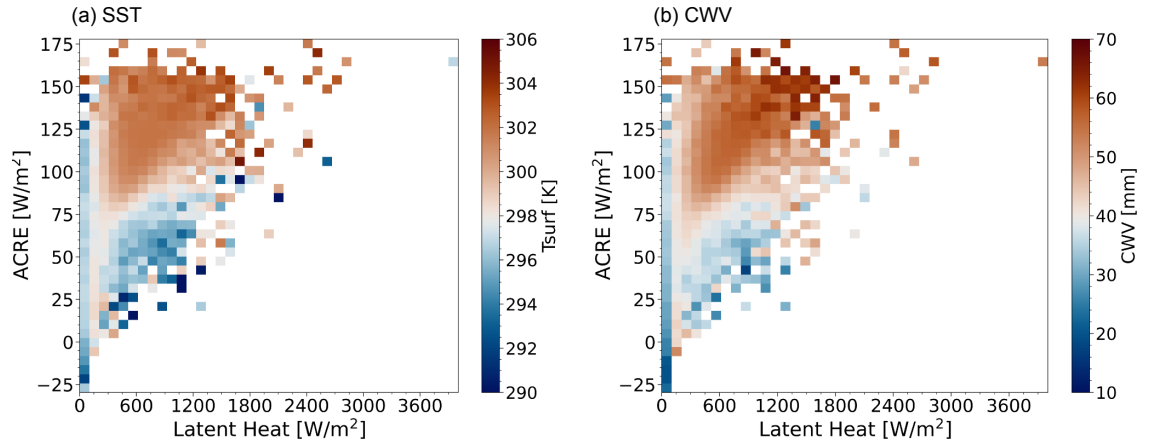

Figure S14. Averages of (a) SST and (b) CWV as function of LP and ACRE released by precipitating UT clouds over the ocean, for the period 2004-2013, spanning 30°N to 30°S, at a spatial resolution of 5°. LP and ACRE are from CIRS–ML, while SST and CWV are from ERA-Interim at 1:30 AM/PM local time. Each square corresponds to an interval of 75 W m^{-2} in ML LP and 5.25 W m^{-2} in ACRE.

Table S1. Validation MAE (K day^{-1}) for the prediction of LH rates using models over different rain intensity classes.

Scene	Ocean / Land	No Rain	Light Rain	Heavy Rain
AIRS				
high-level clouds	ocean	0.024	0.146	0.552
	land	0.029	0.150	0.427
mid-low clouds	ocean	0.008	0.032	0.085
	land	0.008	0.042	0.058
IASI				
high-level clouds	ocean	0.027	0.158	0.541
	land	0.022	0.138	0.387
mid-low clouds	ocean	0.012	0.033	0.089
	land	0.007	0.043	0.065