Contrasting observed atmospheric responses to tropical SST warming patterns

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Mackie et al., 2021: 10.1029/2020JD033564

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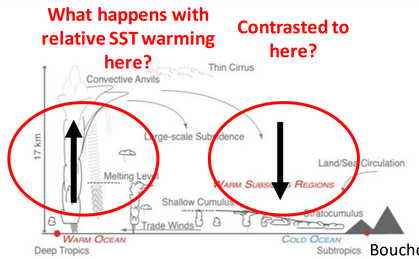
1.

Two **contrasting scenarios** of relative SST warming in regions of either ascending or descending air (e.g. Zhou et al., 2016, 2017; Ceppi and Gregory, 2017; Andrews and Webb, 2018)



Boucher et al., 2013

Mechanism: relative SST warming in

Ascending regions: warm, moist air lofted to upper troposphere
-> remote effects possible

Descending regions: temperature inversion -> low clouds
-> local effects only

As described in Andrews and Webb, 2018

This study:
- evaluate **observational evidence** of this hypothesized mechanism
- quantify the **local effect on TOA radiation budget**

2.

Data: NASA *AQUA* *1° x 1°, 30S-30N, ocean only 2002-2016*

1. ***AIRS:*** temperature and humidity profiles
2. ***CERES SYN1deg:*** TOA broadband radiation flux, cloud fraction
3. ***ERA-Interim:*** vertical velocity at 500 hPa (ω_{500})

Method

Each month, calculate mean SST in regions of strong* ascent or descent relative to tropical ocean mean (using ω_{500}) i.e.

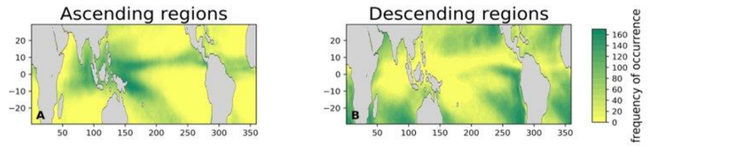
$\Delta T_{up} = T_{\text{ascending region mean}} - T_{\text{tropical mean}}$

Subset other variables in the same region e.g. OLR_{up}

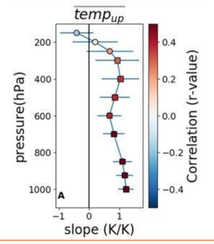
*strong = greater than median for that month, following method of Zhou et al., 2016

3.

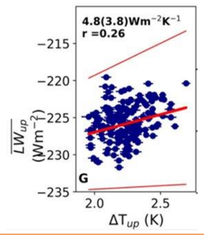
Heat map of how often grid points selected in each region



Plot type 1
At each pressure:
Correlation between monthly mean ΔT_{up} (or ΔT_{down}) and e.g. mean air temperature in ascending regions ($temp_{up}$)

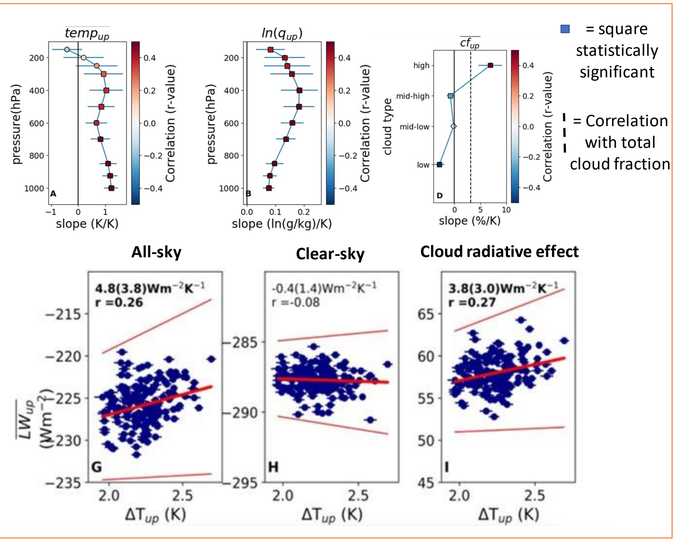


Plot type 2
Scatter plot between monthly mean ΔT_{up} (or ΔT_{down}) and mean e.g. OLR in ascending regions (LW_{up})



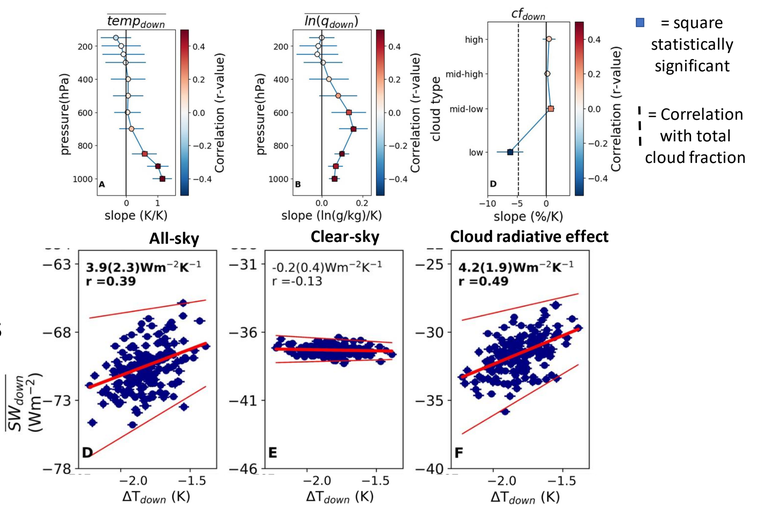
4. Key results: when ascending regions warm relatively

- Temperature increases up to ~300 hPa
- Specific humidity changes throughout troposphere
- Decrease in low cloud, increase in high cloud
- No significant shortwave effects (not shown)
- Strong decrease in OLR, from clouds



5. Key results: when descending regions warm relatively

- Temperature increases up to ~850 hPa
- Specific humidity increases up to ~650 hPa
- Strong decrease in low cloud
- No significant longwave effects (not shown)
- Strong decrease in RSR, from clouds



6.

We find good observational evidence of contrasting atmospheric responses to relative SST warming in regions of strong ascent or descent

Strong ascent:
Strong longwave effect from increase in high clouds

Strong descent:
Strong shortwave effect from increase in low clouds

Study uses data from two **independent, co-located** datasets, which give a consistent picture

Open questions & next steps:
- Remote effects?
- TOA impact of prolonged relative warming?
- How do CMIP6 models compare?