Past and future changes of moisture transports into the convective areas of the tropical atmospheric circulation

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INTRODUCTION

- large scale atmospheric circulation important driver of the global water cycle
- carries and distributes moisture and energy
- thus determines precipitation regionally
- how will associated moisture transports change in a warmer climate?

DATA

Use of high space resolution quasi-instantaneous data (unlike many other such studies, which apply time or space averages)

- ω, **U** and **V**, q, pressure information
- $\approx 0.5°$, ≈ 30 vertical levels, $6h$ time intervals
- reanalysis (ERAint) 1989 -2008
- two IPCC scenarios from ECHAM5-model 1960-1989: C20, A1B 2070-2100: C21

METHOD, step 1

Define regions of ascending and descending air motion (ASC and DESC)

- based on monthly mean and instantaneous ω (indicated by subscripts i and m)
- results in one ASC/DESC mask per time step

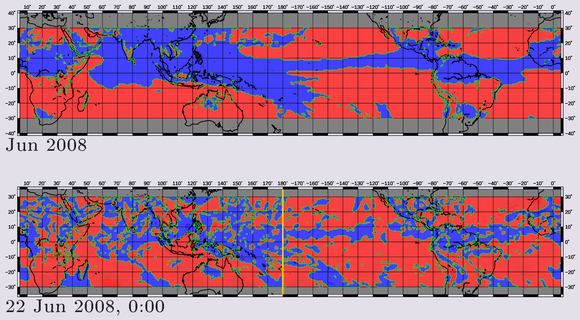

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Fig.1: Examples of a monthly mean and instantaneous ω field, blue: upward, red: downward, green line indicates boundary across which transports are calculated

- instantaneous masks exhibit highly irregular pattern
- ASC_m not physically consistent with instantaneous wind and humidity fields

METHOD, step 2

Calculate moisture transport (MT) across boundary

- linking wind vectors with water content
- along all boundary segments (horizontally and vertically)
- applying mean and instantaneous values

RESULTS

Vertical profiles

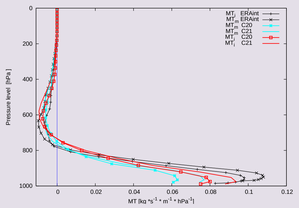


Fig.2: Vertical profiles of horizontal MT into ASC

- In-/outward pattern in accordance with Hadley Cell
- Profiles from EH5 and ERAint similar
- Lower level inward and mid level outward MT increase with warming

Changes of percentiles of vertical transports

- Shape follows mean MT
- 99%tile experiences strongest increase
- Means higher moisture supply during extreme precipitation events

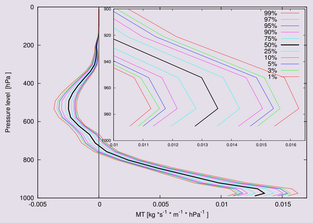
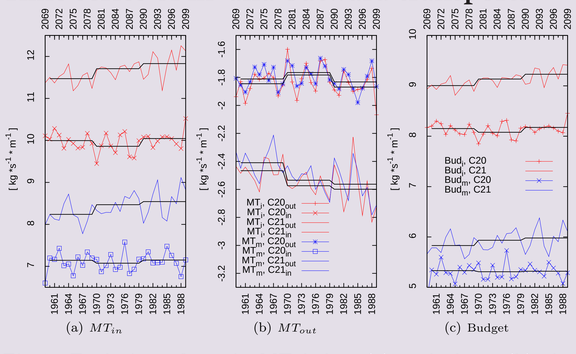


Fig.3: Vertical structure of the difference of percentiles of MT.

Time series of in- and outward transports



(a) MT_{in} (b) MT_{out} (c) Budget

Fig.4: Evolution of yearly MT below (a) and above (b) the reversal level (at which $MT = 0$). (c) time series of the yearly mean budget. Black lines indicate decadal means.

RESULTS (continued)

Changing frequency and extent of the ascending regions.

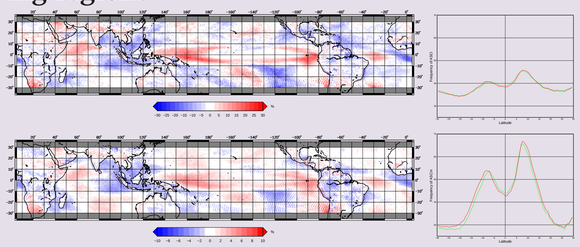


Fig.5: Change of percentage of time steps a grid box belongs to ASC from the instantaneous vertical wind C21 - C20, top: from ASC_i, bottom: ASC_m. Red (blue) indicates a box belongs to ASC more (less) frequently. Note the different scale of the colour bar. Right column: Zonal mean percentage a grid box belongs to ASC_i/ASC_m. Green denotes C21, red C20.

- ITCZ much more pronounced in ASC_m
- widening of extent of ASC_m in response to warming
- slight or no change of extent of ASC_i

SUMMARY

- Masks of ASC_i show a very irregular pattern
- Increase for MT into ASC found at lower and out of ASC at mid levels
- MT budget increases despite of this counteracting
- Increase is most pronounced at high percentiles of MT_i events
- Different answers from ASC_i and ASC_m whether ITCZ extends in response to warming
- MT towards land intensify, but no distinct circulation changes were found
- Moisture budgets of land areas increase

References

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RESULTS (continued)

MT towards tropical land areas

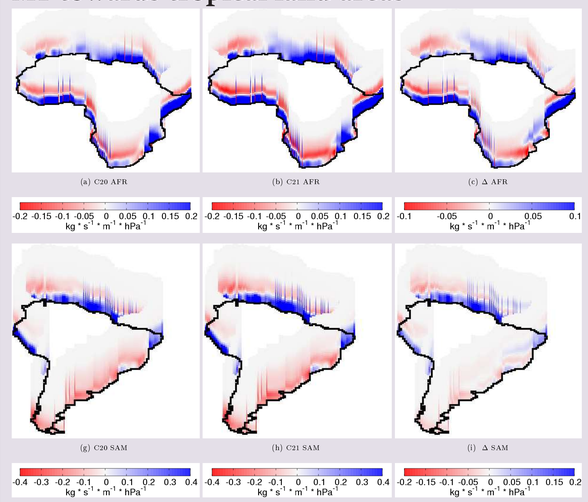

Fig.6: MT_{wall} across shorelines of Africa and South America. Left column: in C20, second column: in C21, right column: C21-C20. red colours: landward MT, blue: seaward MT.

- land- and seaward MT intensify, but rarely change in sign
- intensification of circulation strength and of the hydrological cycle, but generally no change of pattern

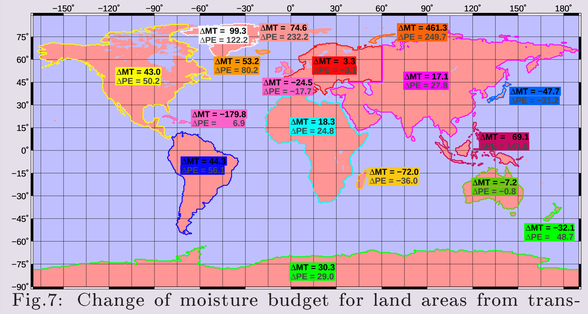

Fig.7: Change of moisture budget for land areas from transports and precipitation - evaporation, C21 - C20

- most land areas get wetter
- sign from P-E and MT consistent in most areas
- 4 times daily MT may be biased by diurnal cycle (not shown)

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