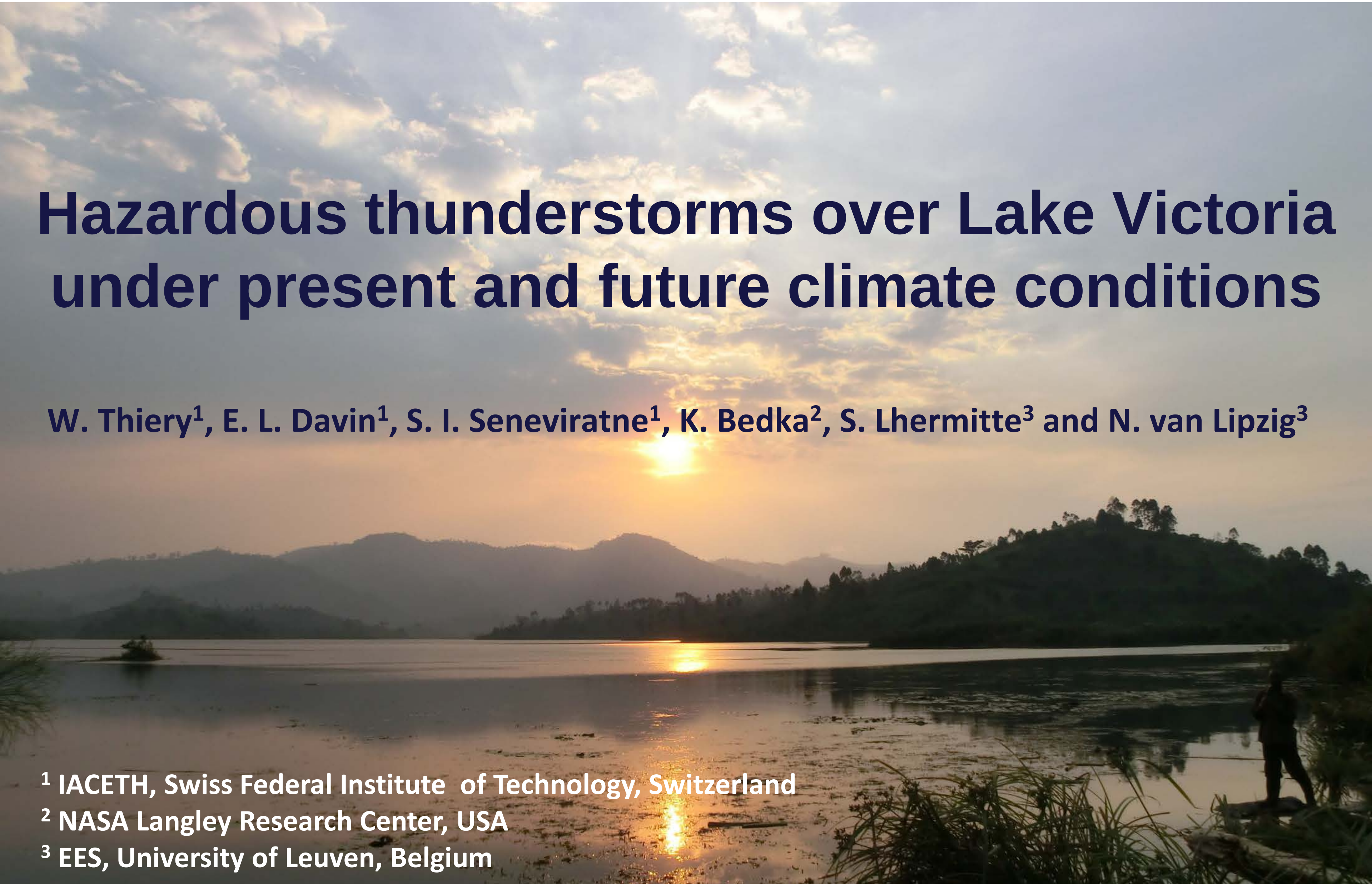
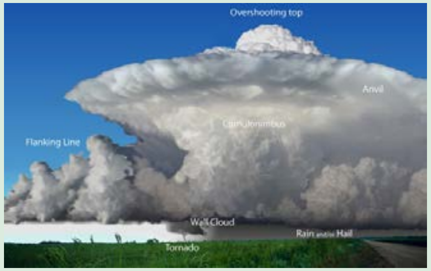


Hazardous thunderstorms over Lake Victoria under present and future climate conditions

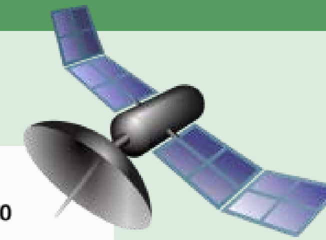
W. Thiery[1], E. L. Davin[1], S. I. Seneviratne[1], K. Bedka[2], S. Lhermitte[3] and N. van Lipzig[3]

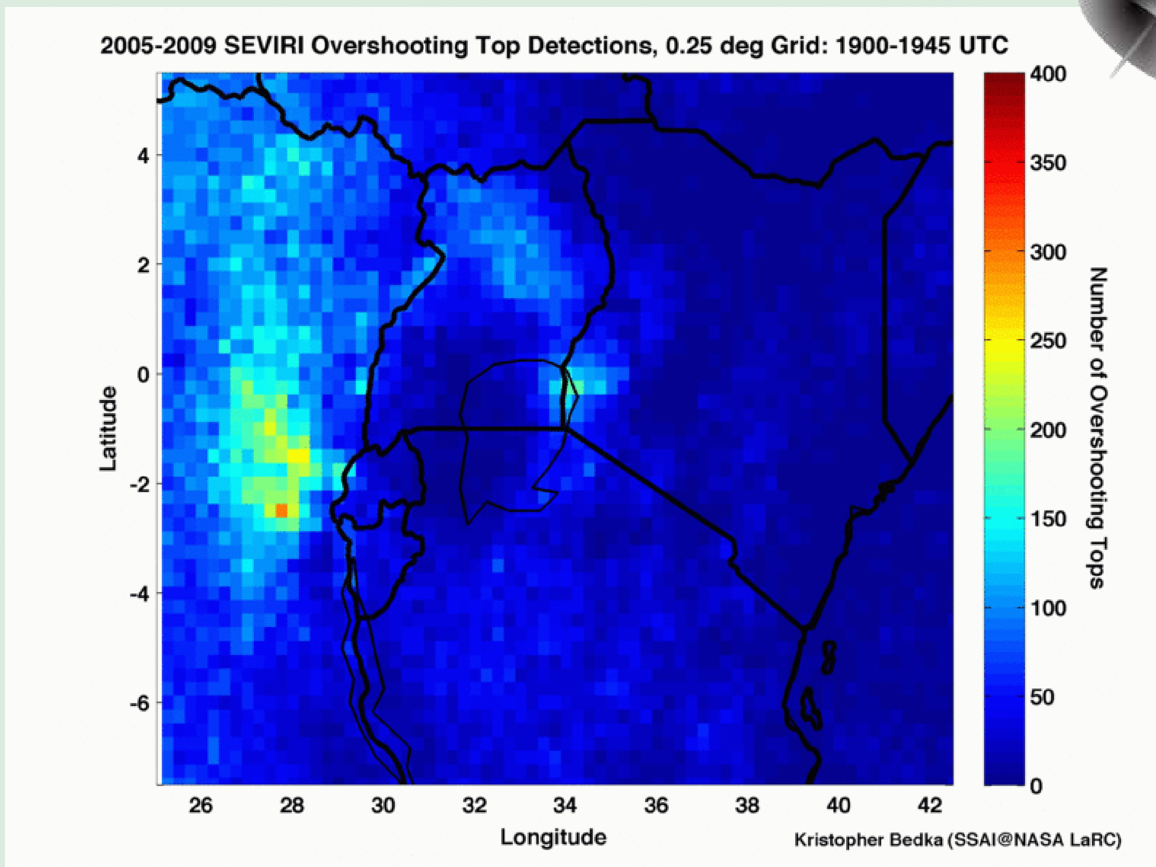
[1] IACETH, Swiss Federal Institute of Technology, Switzerland
[2] NASA Langley Research Center, USA
[3] EES, University of Leuven, Belgium

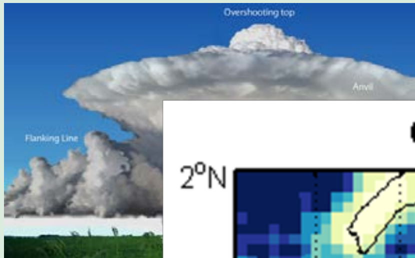
Motivation and objectives



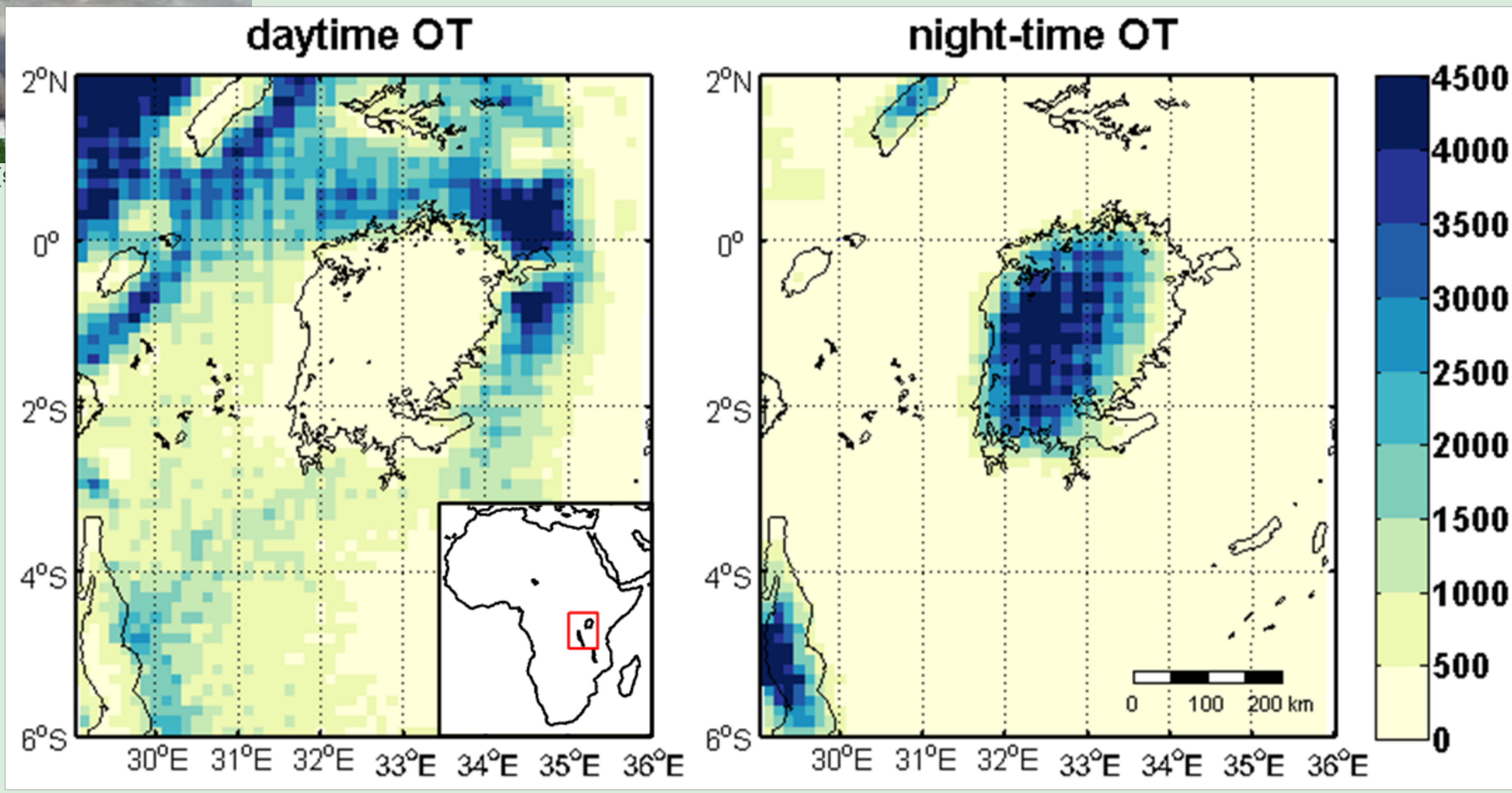
(severe-wx.pbworks.com)







(s



clear lake imprint on thunderstorm occurrence

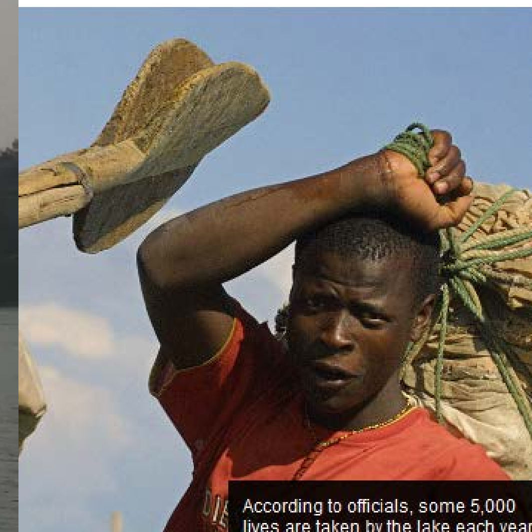
Motivation and objectives

Lethal weather on 'world's most dangerous lake'

From **Errol Barnett,** CNN

January 17, 2013 -- Updated 1448 GMT (2248 HKT)

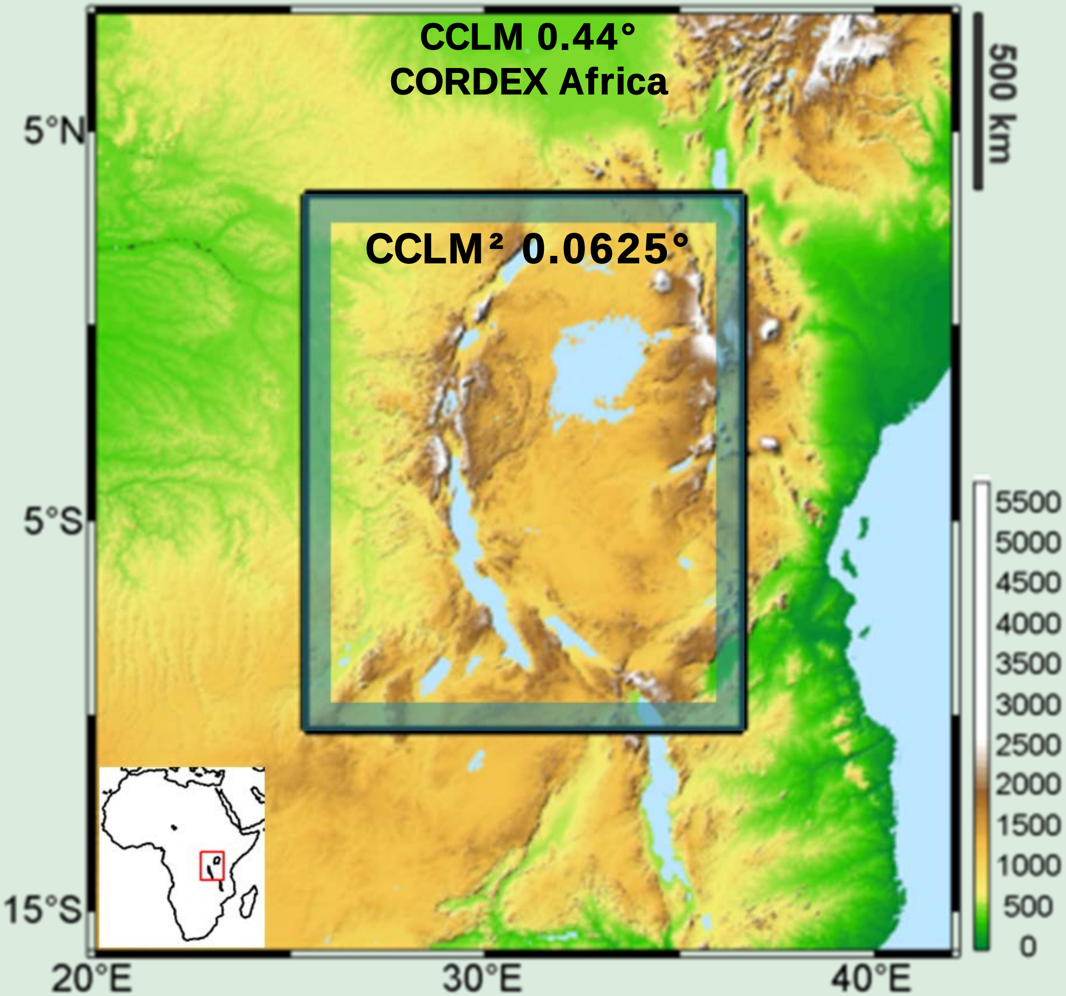
(Lake Kivu)

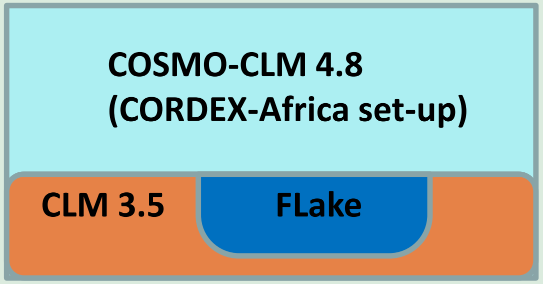


(www.cnn.com)

model skill? **future climate change?**

CCLM² model setup





(Davin and Seneviratne, 2012)

“RC[illegible]” (199[illegible]-200[illegible])


How well does our model perform?

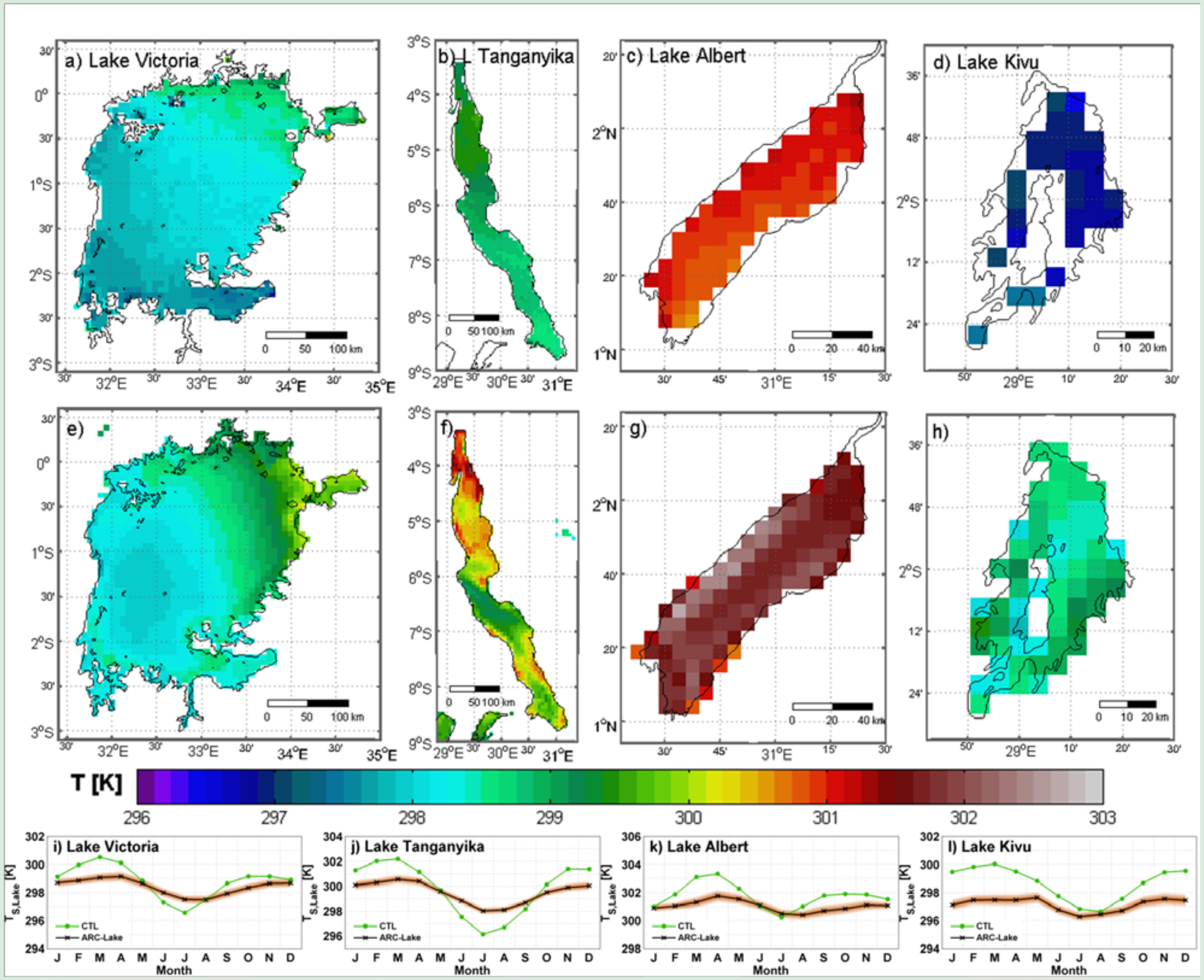
COSMO-CLM 4.8

CLM 3.5 FLake

Evaluation: lake surface temperature

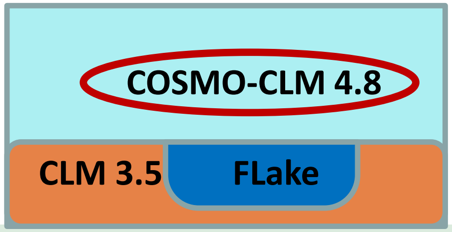
Obs

CTL

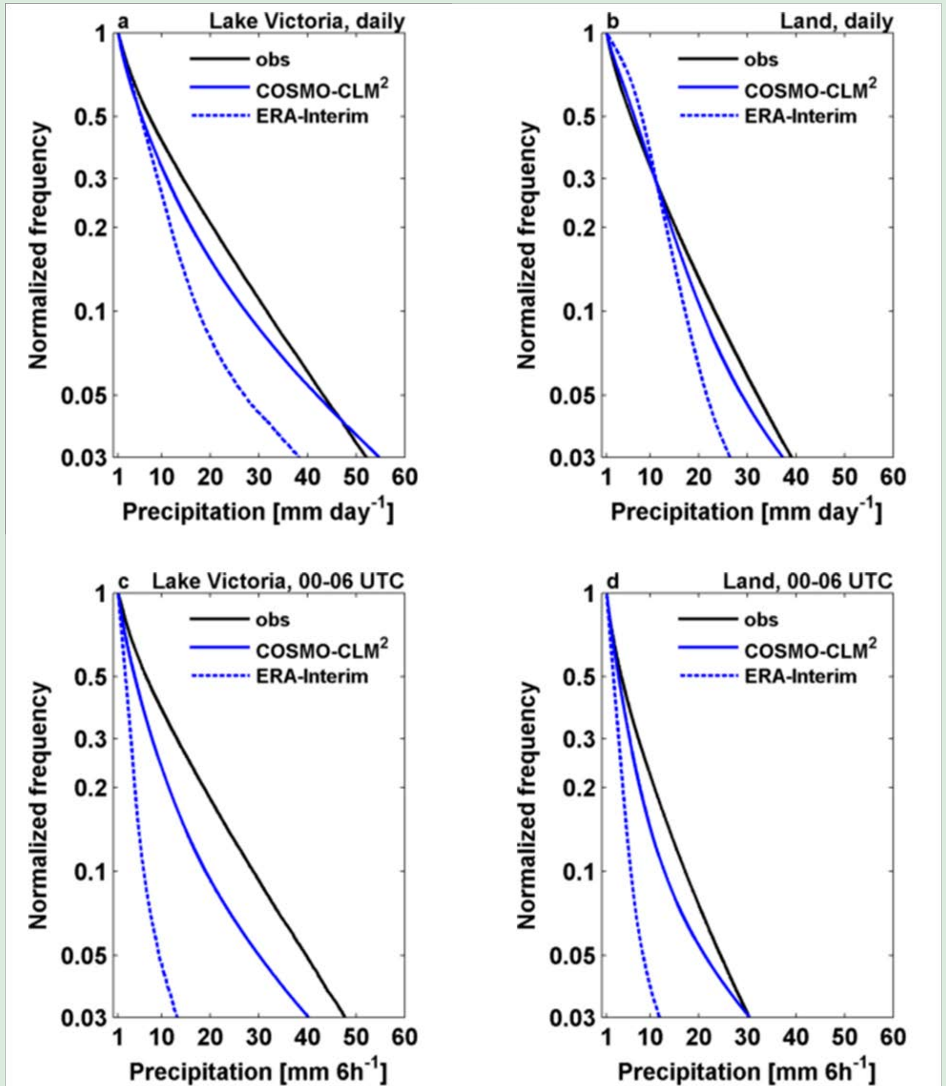


(Thiery et al., 2014 GMD;
2014 TA;
2015 JC)

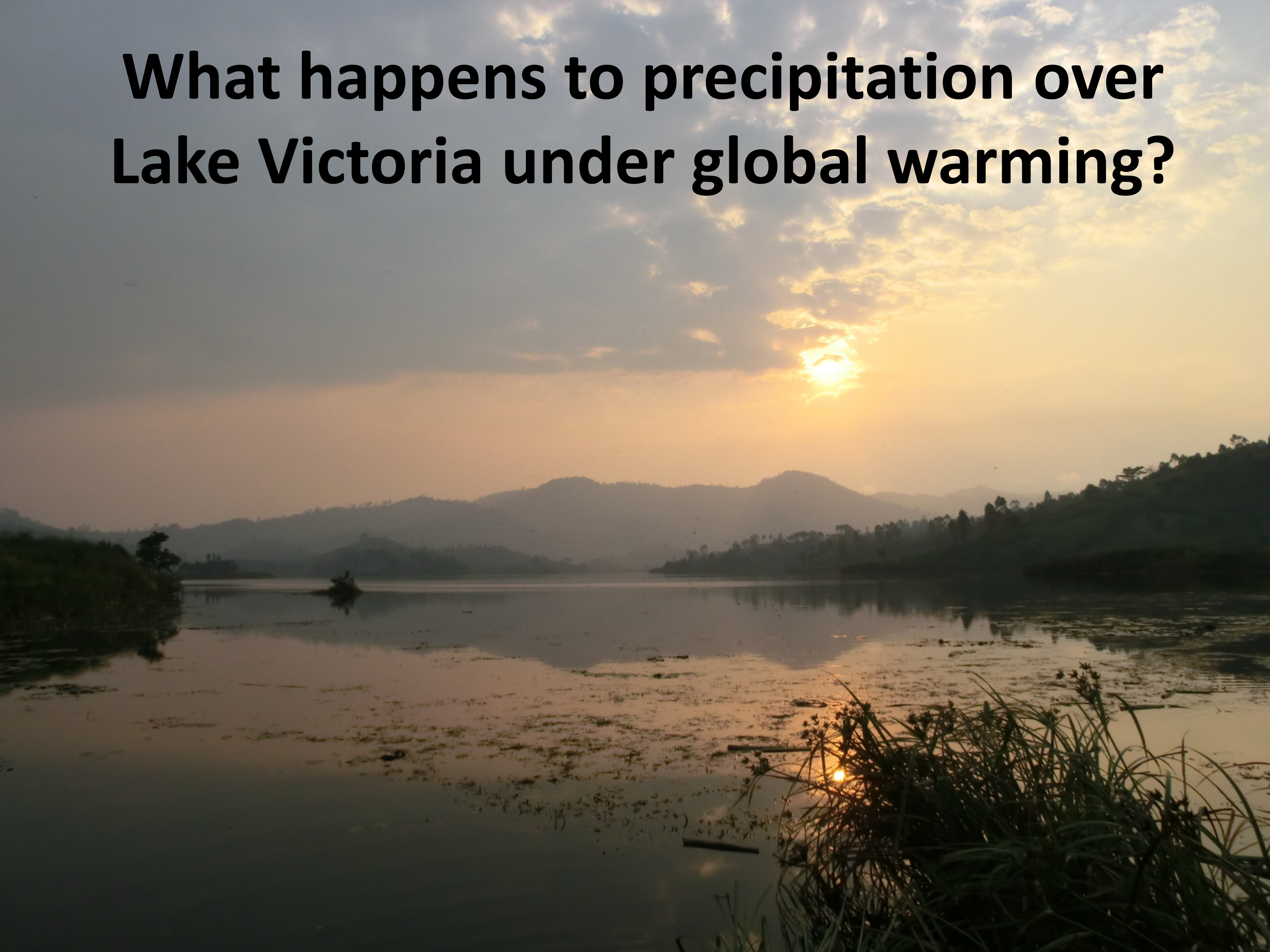
+0.4 °C +1.09 °C +0.9 °C +1.8 °C Bias



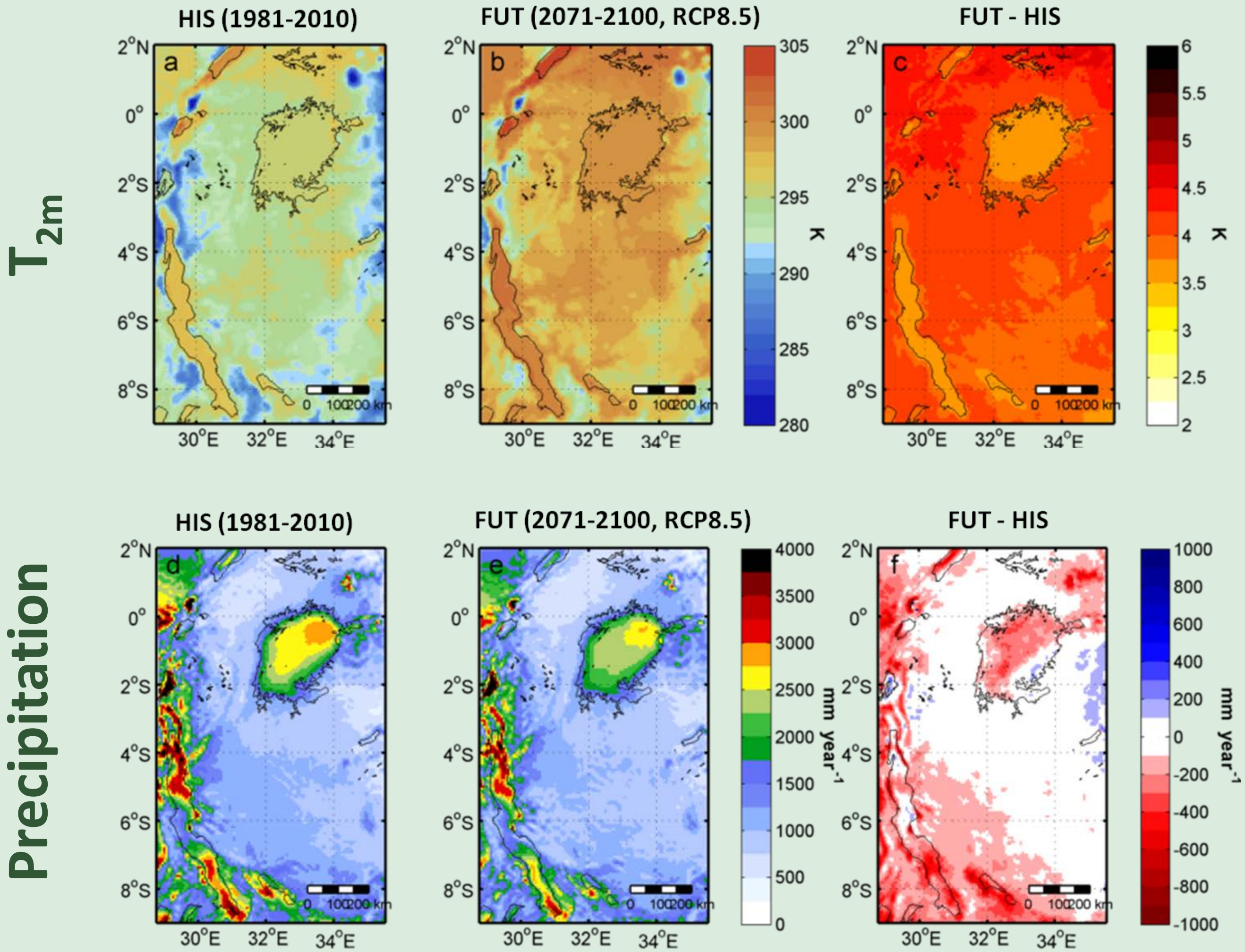
Evaluation: Precipitation



What happens to precipitation over Lake Victoria under global warming?



Climate change



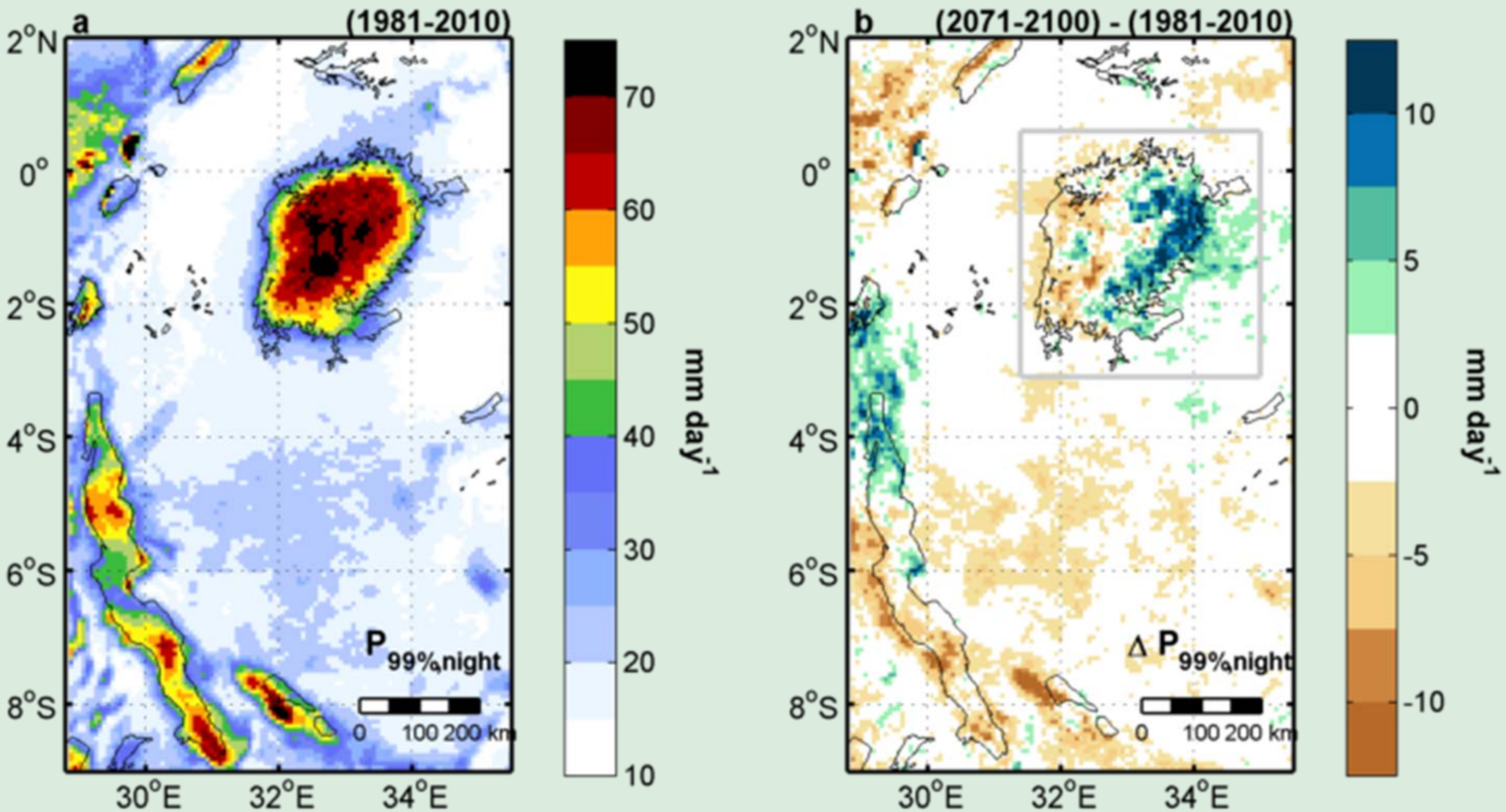
Domain: + 4.16°C
AGL : + 3.74°C

IPCC: + 4.0°C
(+2.4°C - +5.6°C)

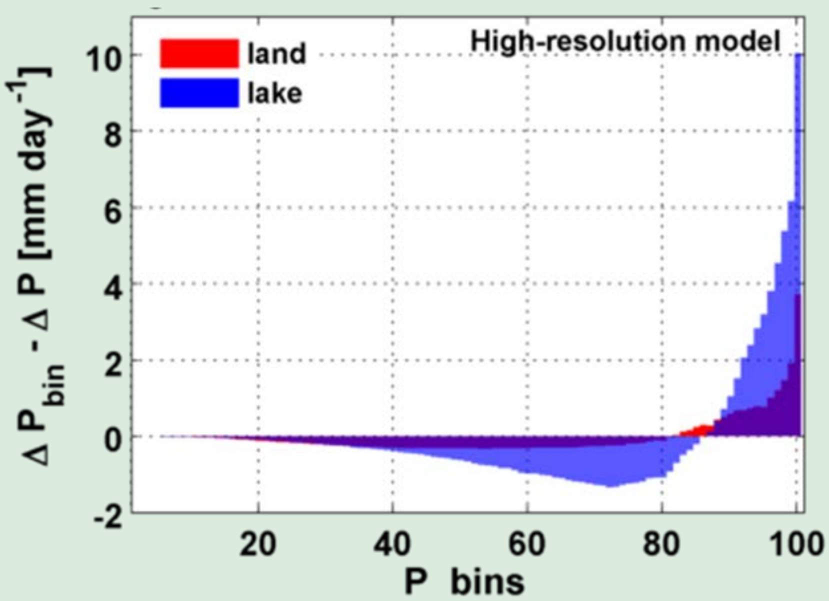
Domain: - 7.95 %
AGL : -7.46 %

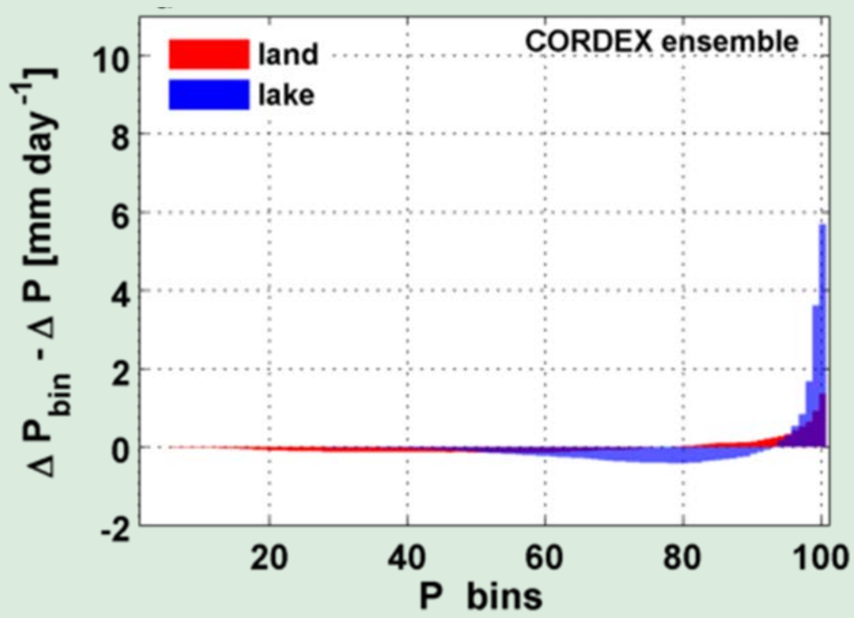
IPCC: + 11%
(-11% - +34%)

Climate change impact on extremes



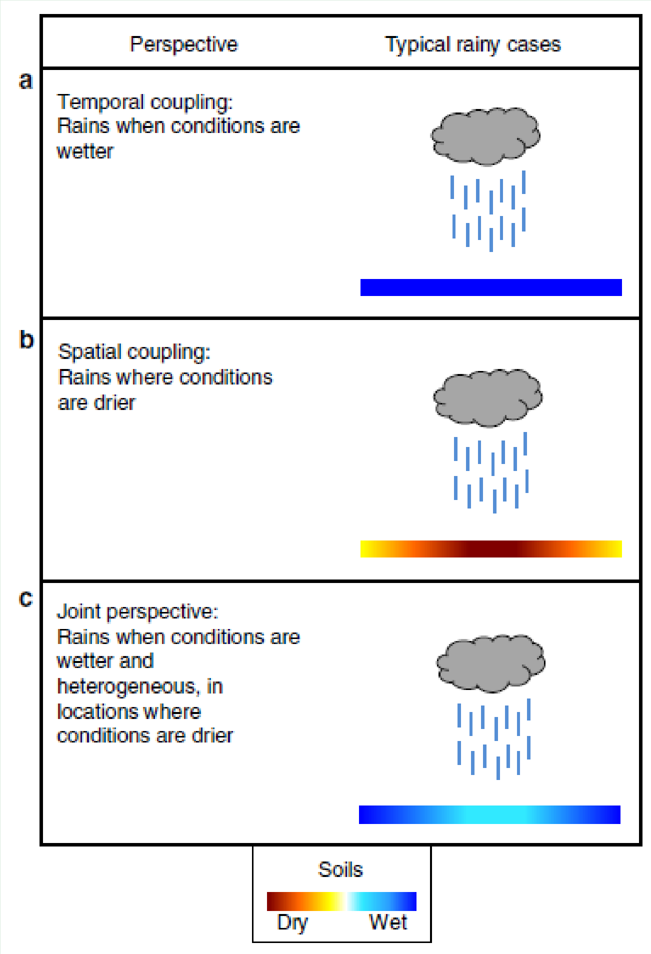
climate change: extreme precipitation





Why? ➔ **First understand extremes in present-day climate**

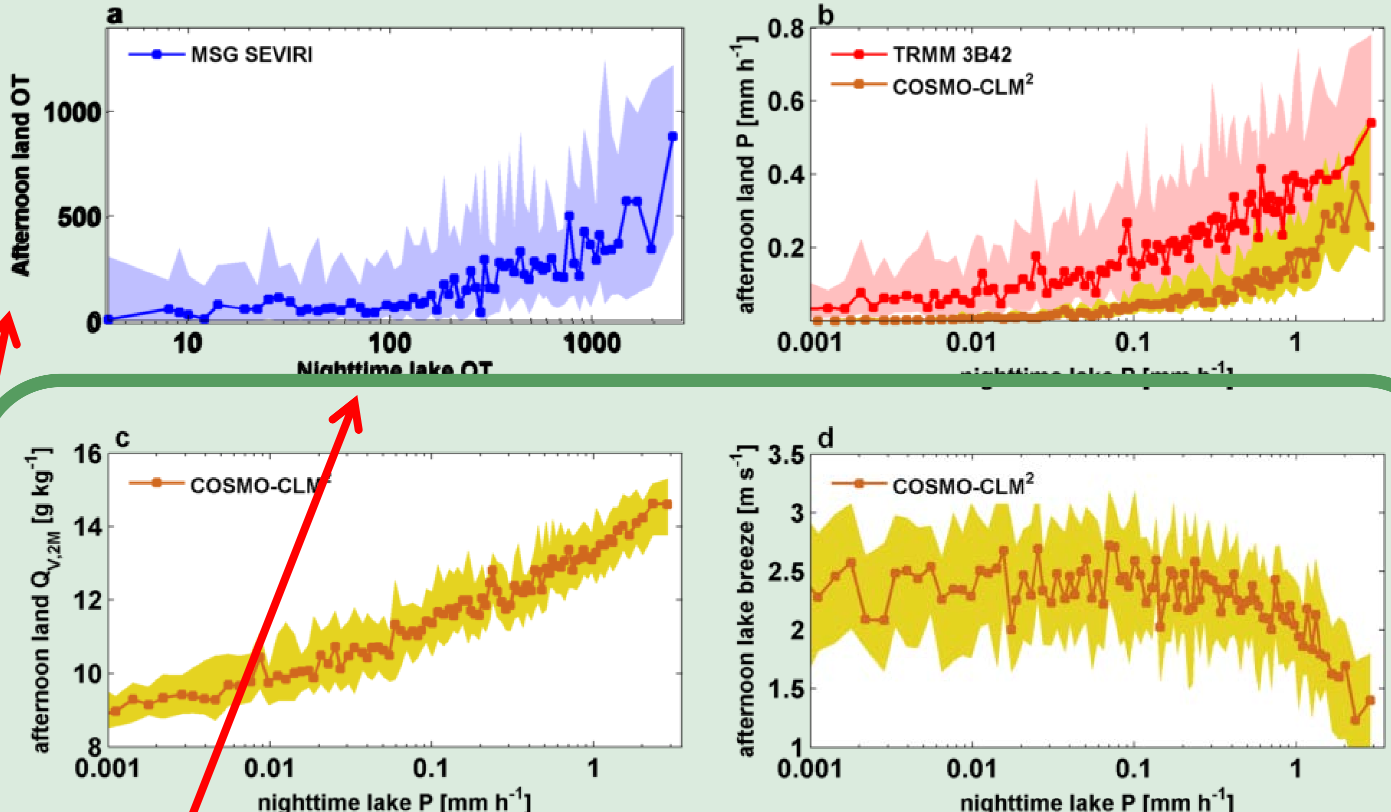
Role of soil moisture for afternoon land rainfall.

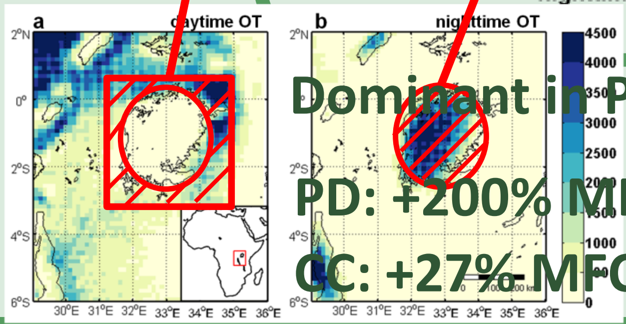


(Guillod et al., 2015 Nat. Comm.)

- Positive temporal coupling might enhance precipitation persistence, while negative spatial coupling tends to regionally homogenize land surface conditions.

Afternoon controls on nighttime thunderstorms





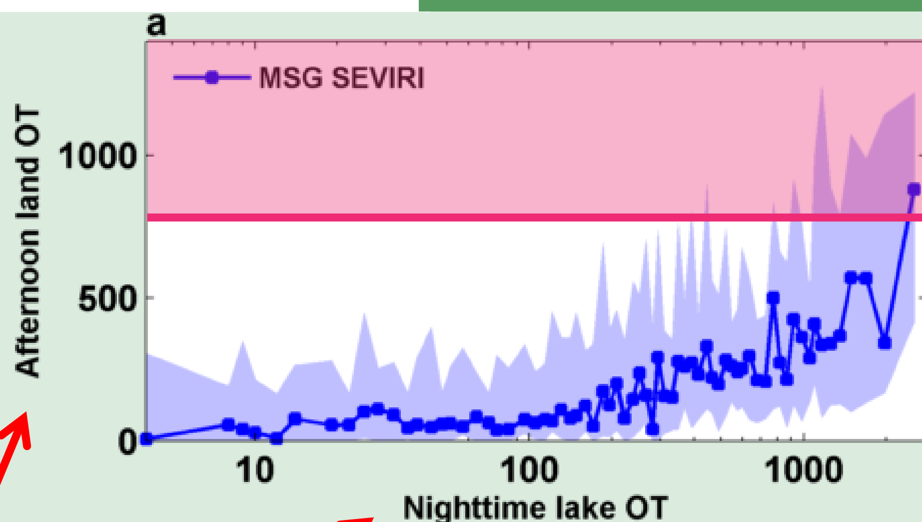
Dominant in PD?

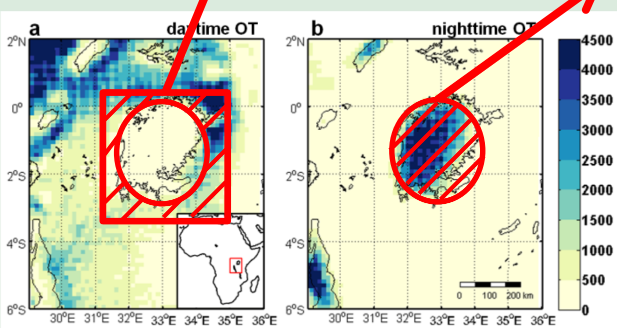
Changing with CC?

PD: +200% MFC during extremes, ¾ due to mesoscale dynamics

CC: +27% MFC entirely due to enhanced moisture content

Towards an early warning system

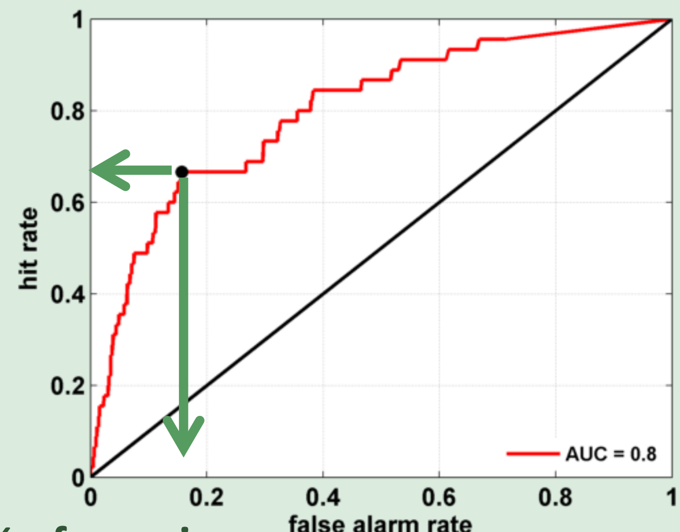




Log. Reg.: “tonight there will be an extreme event” (X% threshold prob.)

Issue warning

Forecast 67% of all events



15% of warnings is a false alarm

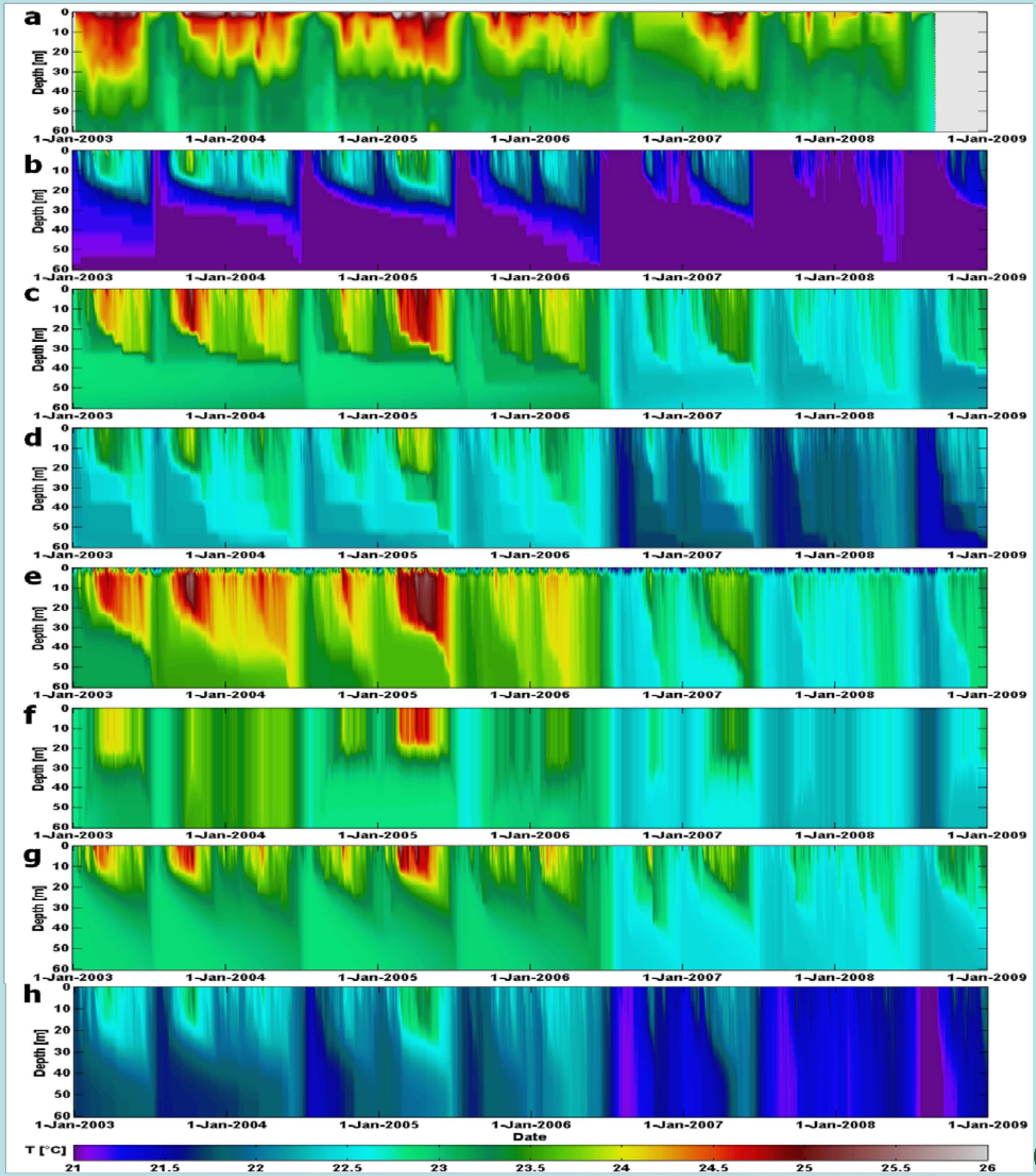
Thank you for your attention

Acknowledgements: FWO, BELSPO

wim.thiery@ees.kuleuven.be

Conclusions

- Extremes and climate change
  - using a high-resolution RCM simulation we project an average precipitation decrease over the AGL
  - despite the average precipitation decrease, LV extremes will become more intense under global warming
  - this result is robust and more pronounced compared to surrounding land
  - Afternoon land precipitation controls nighttime lake precipitation by moistening and cooling the land
  - Clausius-Clapeyron scaling only holds over LV where future evaporation increase ensures moisture availability



observations

Hostetler

LAKEoneD

SimStrat

LAKE

Although T_{bot} is extremely sensitive to extpar and forcing, T_{surf} predictions are robust (Thiery et al., GMD 2014)

FLake

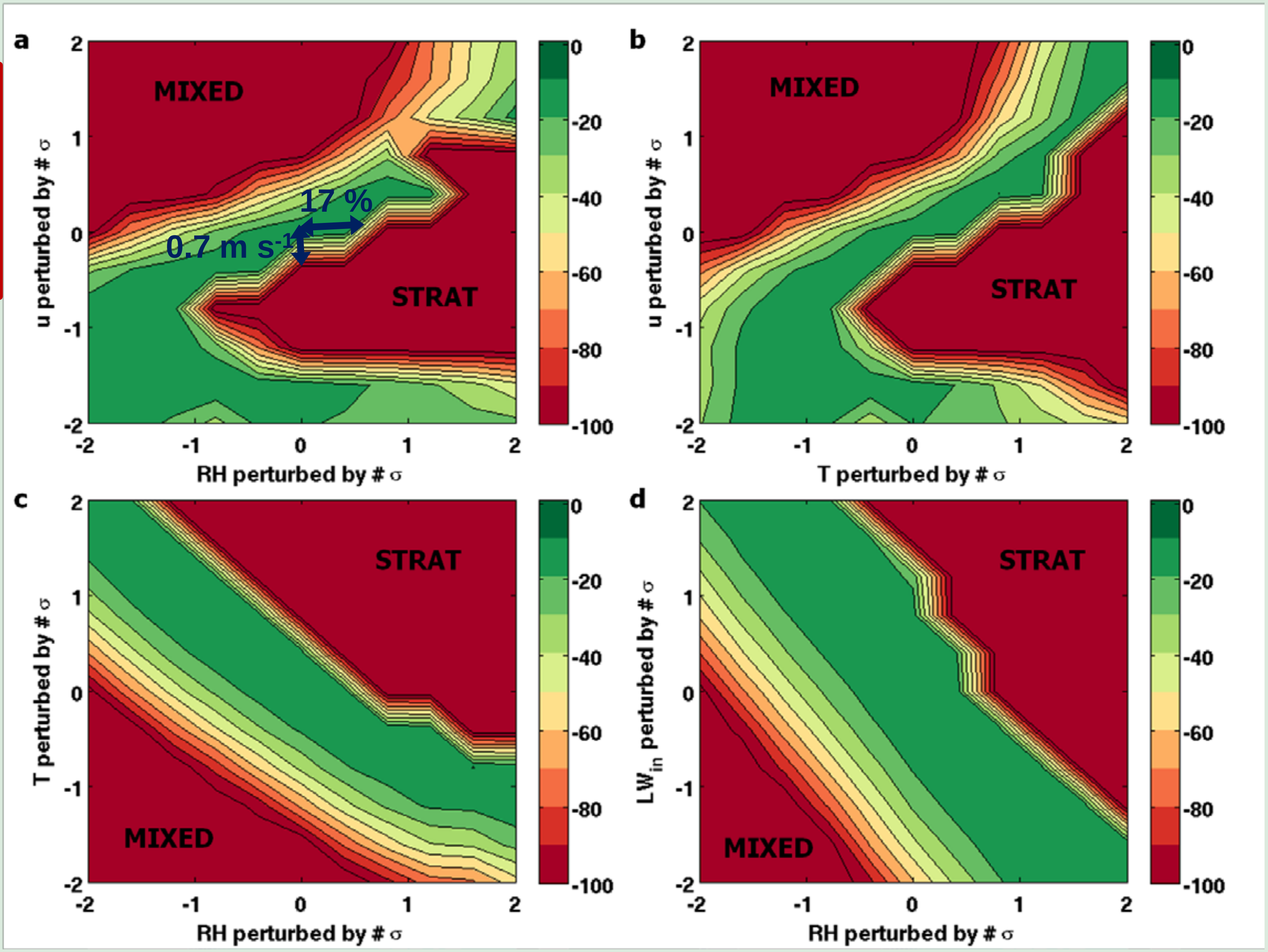
MINLAKE2012

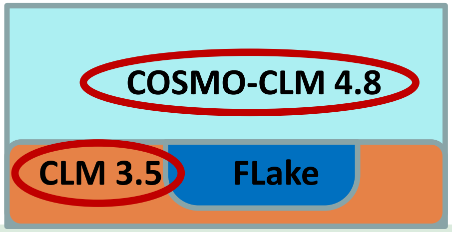
CLM4-LISSS

(Thiery et al., TA 2014)

FLake Sensitivity to forcing fields

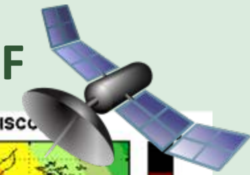
Although T_{bot} is extremely sensitive to extpar and forcing, T_{surf} predictions are robust





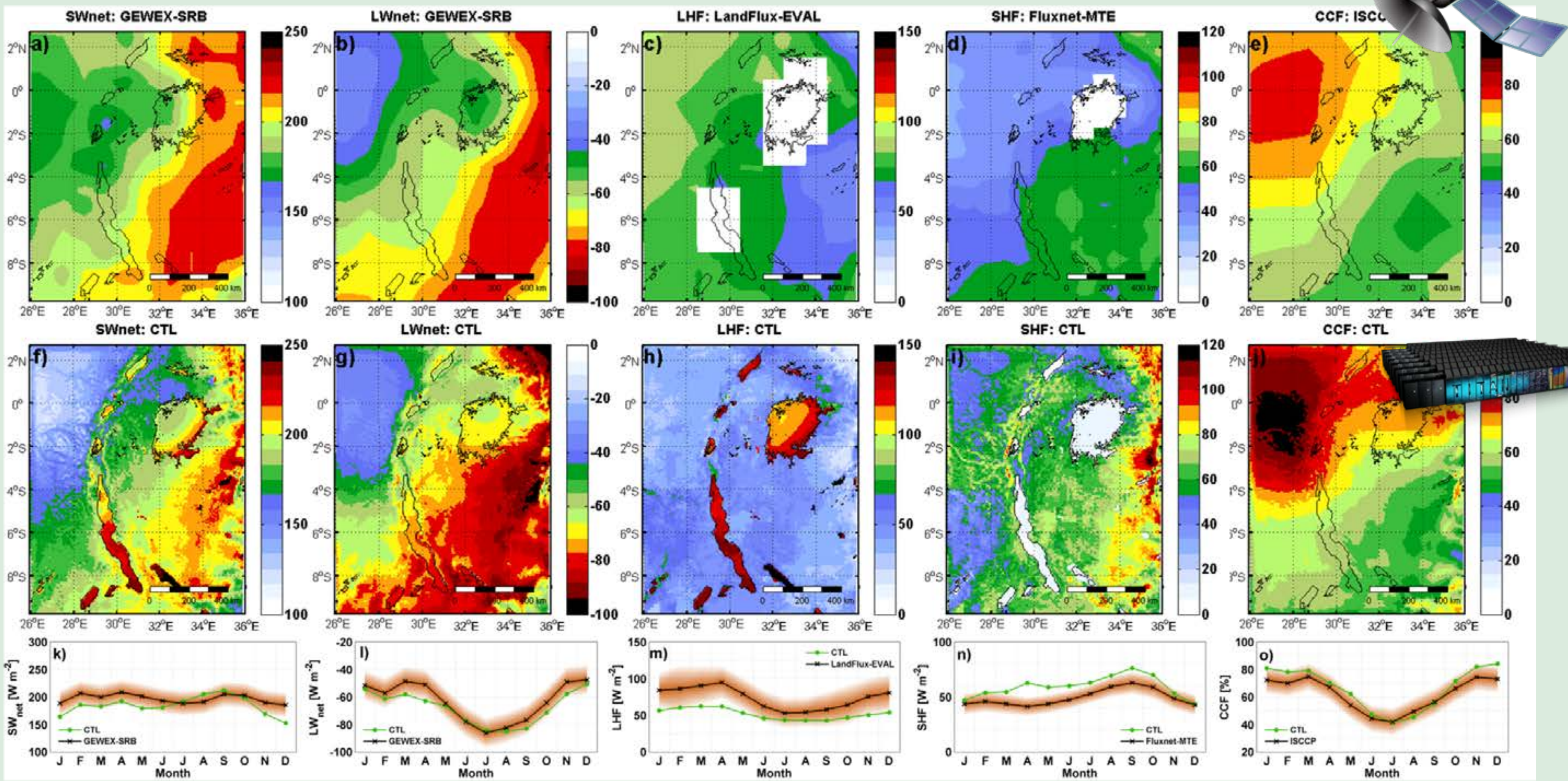
Evaluation: SEB and clouds

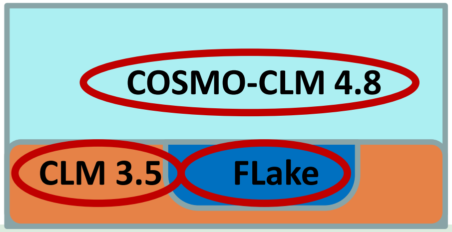
SW_{net} | LW_{net} | LHF | SHF | CCF



Obs

CTL





Evaluation: relative skill

Physical quantity (units)	COSMO-CLM² Bias	COSMO-CLM² RMSE	ERA-Interim Bias	ERA-Interim RMSE	CORDEX Bias	CORDEX RMSE
TRMM 3B42 precipitation (mm yr^{-1})	−261	683	612	881	−717	838
GPCC precipitation (mm yr^{-1})	68	631	941	1160	−389	508
GPCP precipitation (mm yr^{-1})	30	554	903	1069	−427	519
UDEL precipitation (mm yr^{-1})	84	604	957	1167	−373	478
CMORPH precipitation (mm yr^{-1})	−330	712	739	907	−771	973
TRMM 2B31 precipitation (mm yr^{-1})	−273	678	599	873	−730	927
Ensemble precipitation* (mm yr^{-1})	−116	554	757	932	−573	669
GEWEX-SRB SW_{net} (W m^{-2})	−12	22	39	42	−26	33
GEWEX-SRB LW_{net} (W m^{-2})	−5	8	−21	24	1	7
LandFlux-EVAL LHF (W m^{-2})	−22	34	32	35	−27	31
FLUXNET-MTE SHF (W m^{-2})	10	22	−2	15	6	23
ISCCP CCF (%)	4	7	−1	6	3	6
ARC-Lake LSWT Victoria (K)	0.40	0.53	−4.16**	4.52**	−2.70	2.81
ARC-Lake LSWT Tanganyika (K)	1.09	1.16	−7.58**	7.82**	−3.07	3.35
ARC-Lake LSWT Albert (K)	0.90	0.94	—	—	−5.90	5.94
ARC-Lake LSWT Kivu (K)	1.80	1.83	—	—	−4.19	4.19

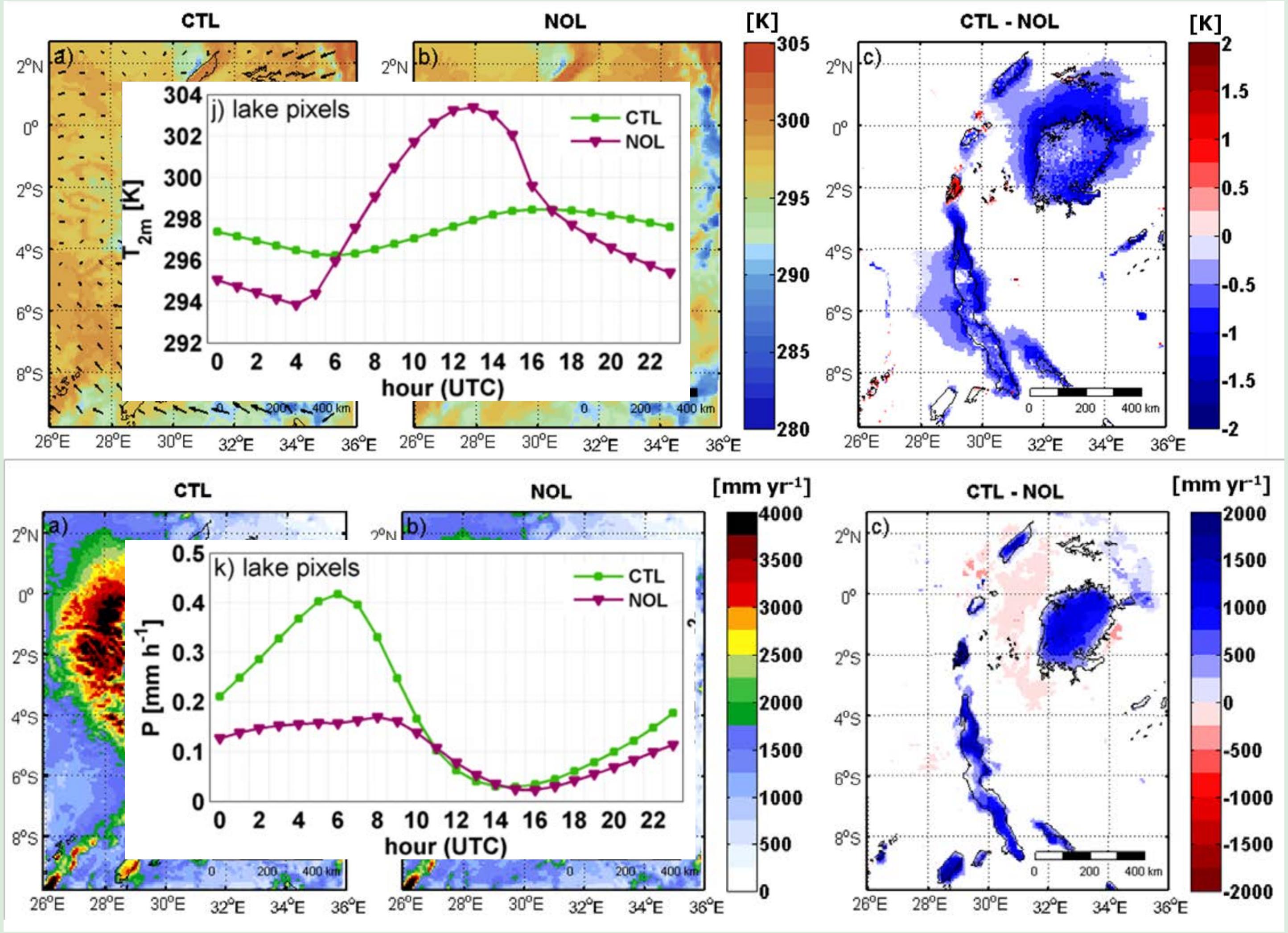
* Average of the six gridded precipitation products.

** Given the coarse resolution of this product and associated limited number of lake pixels, nearest neighbour interpolation was used in this case instead of bilinear interpolation.

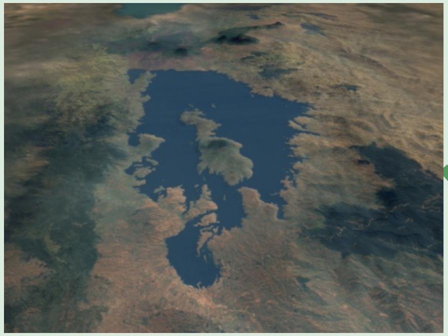
AGL impact on the mean climate

T_{2m}

Precipitation

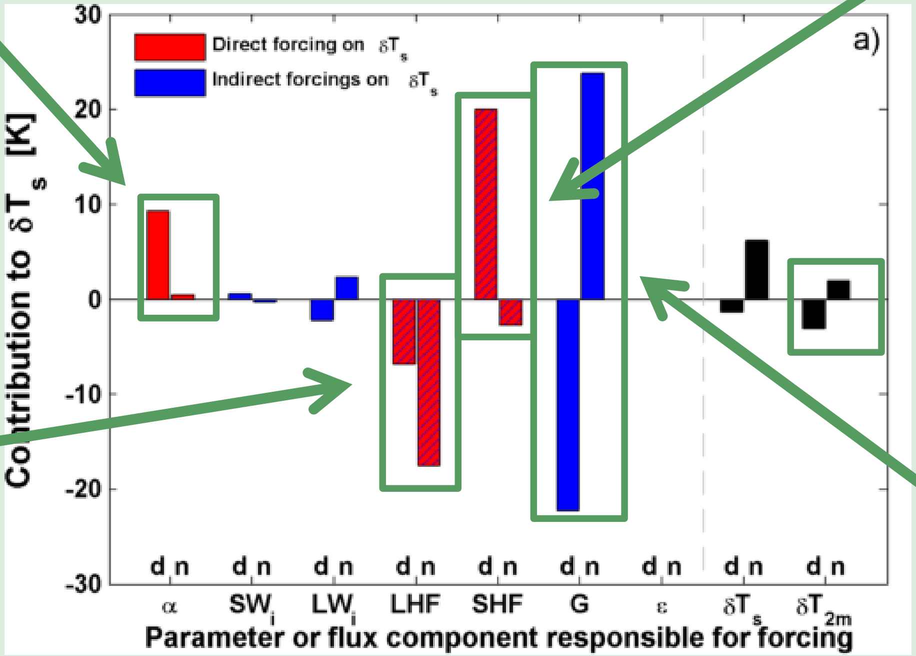


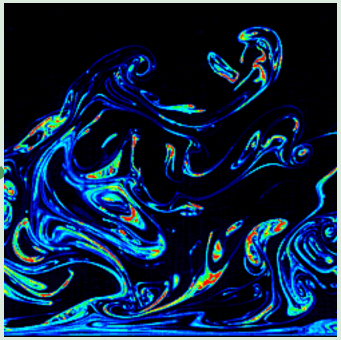
SEB decomposition: day-night contrast



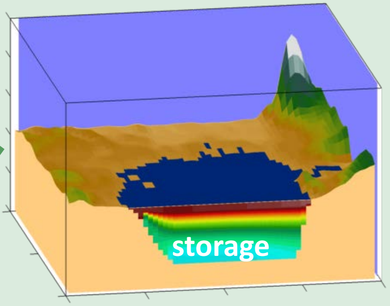
(source: NASA)

(source: SignTech)

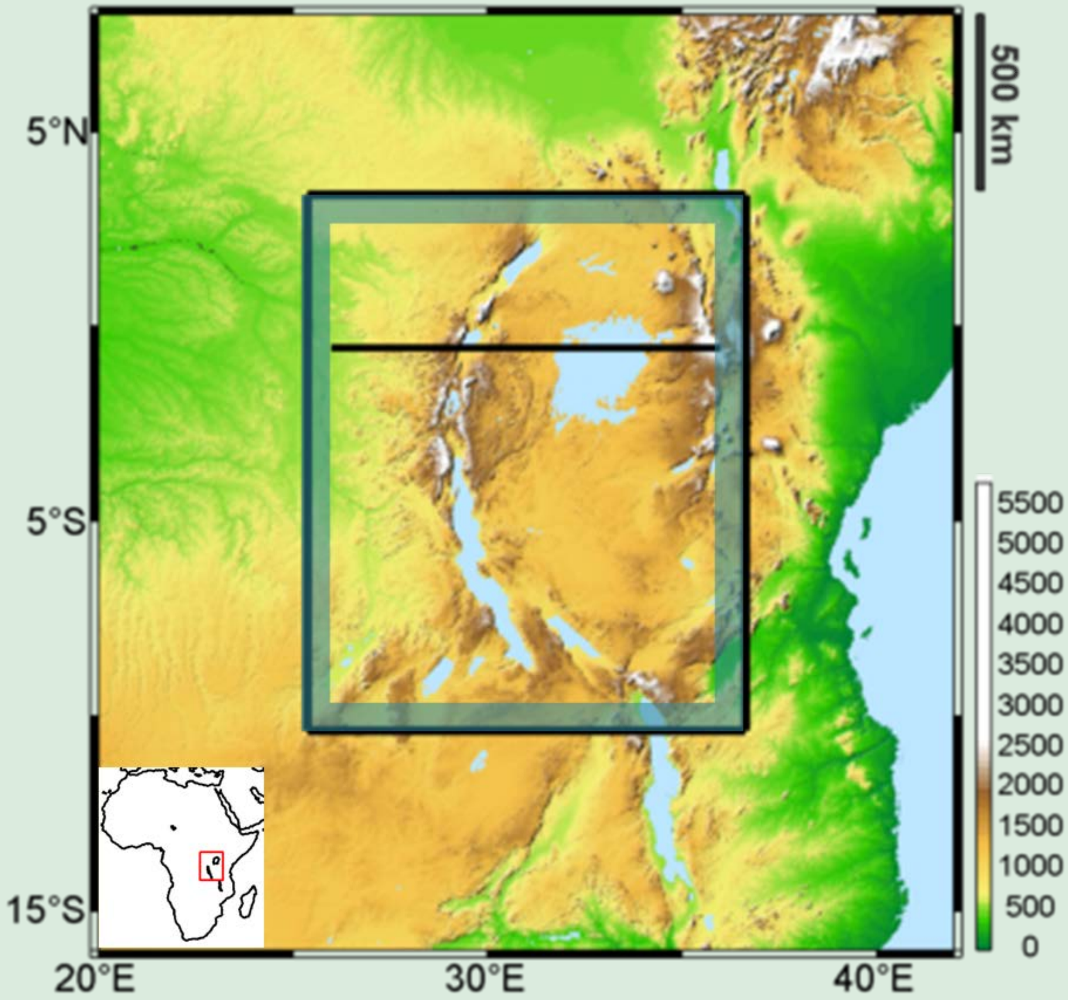




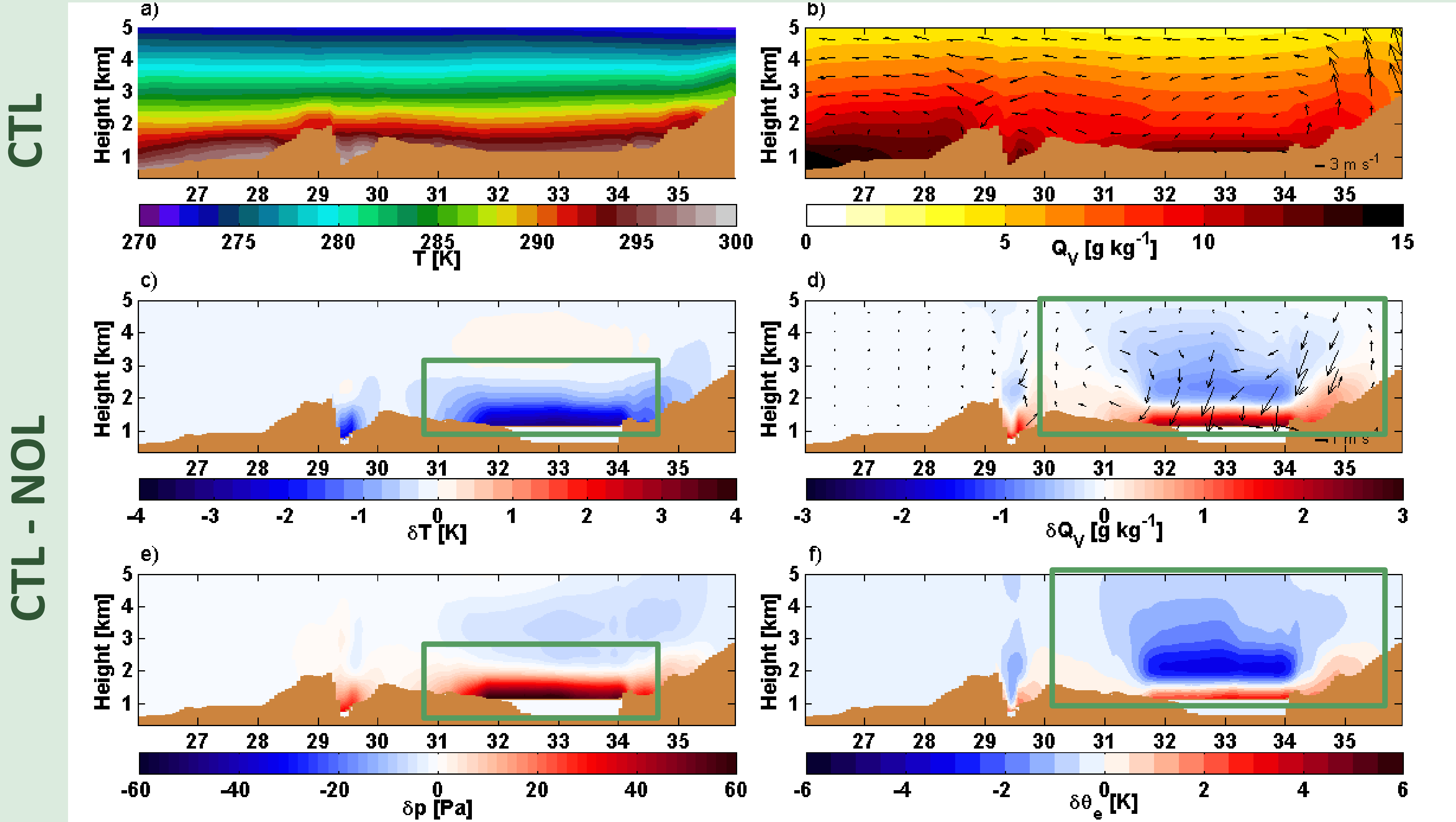
(source: Stanford U.)



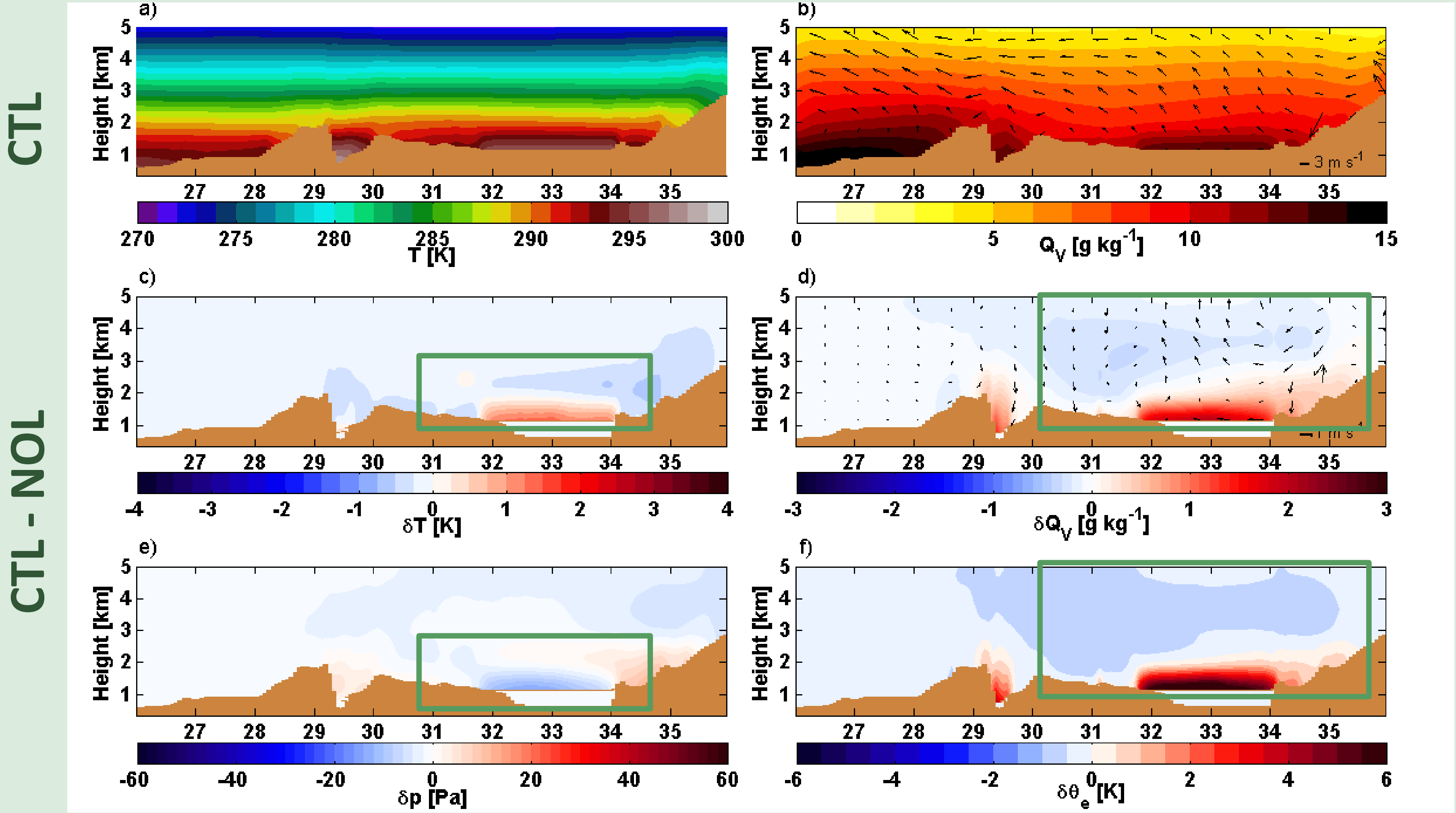
Cross section



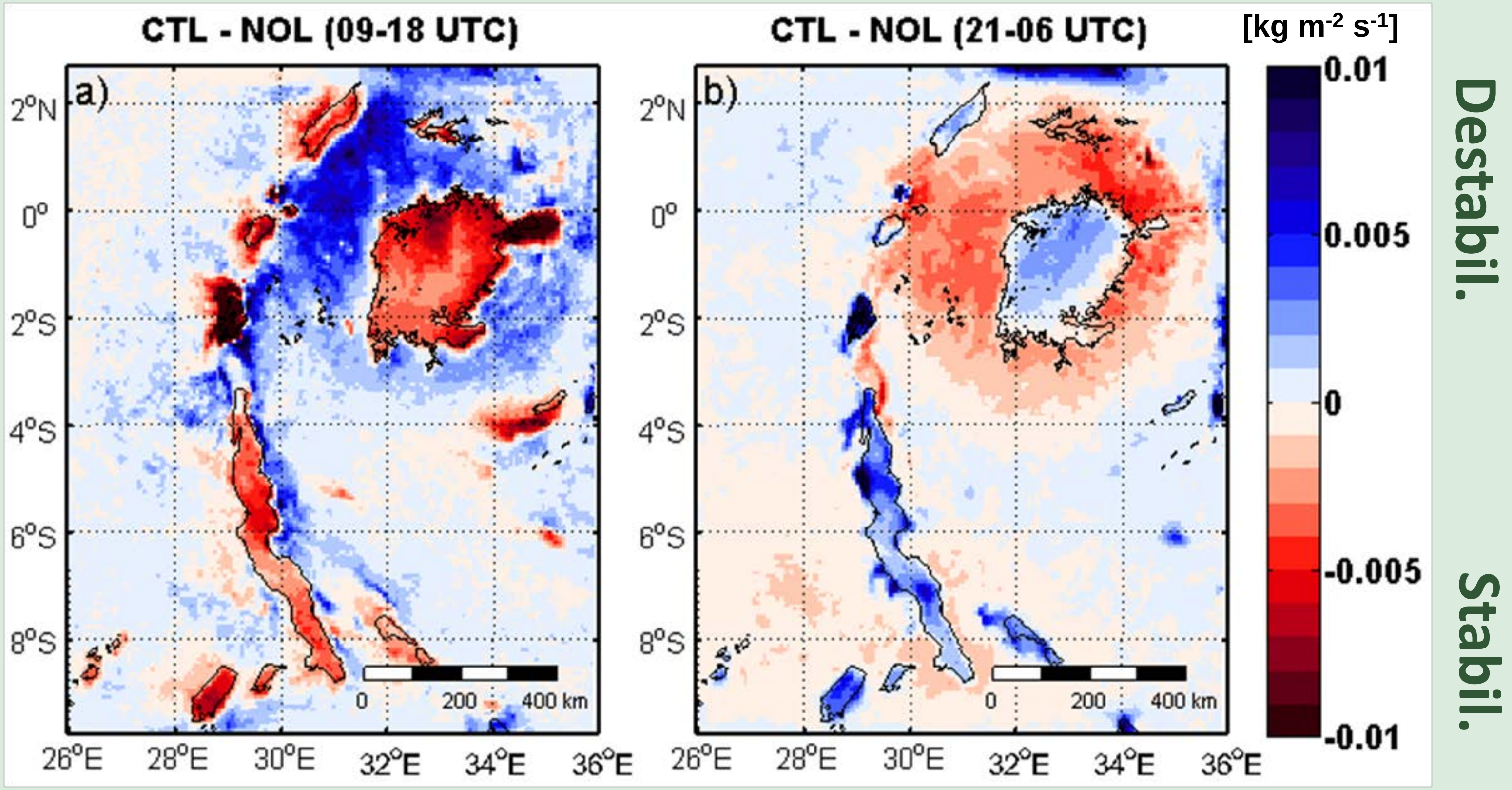
Dynamical response: daytime



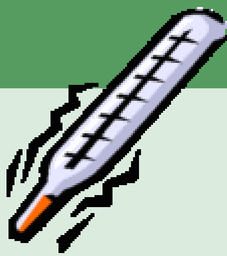
Dynamical response: night-time

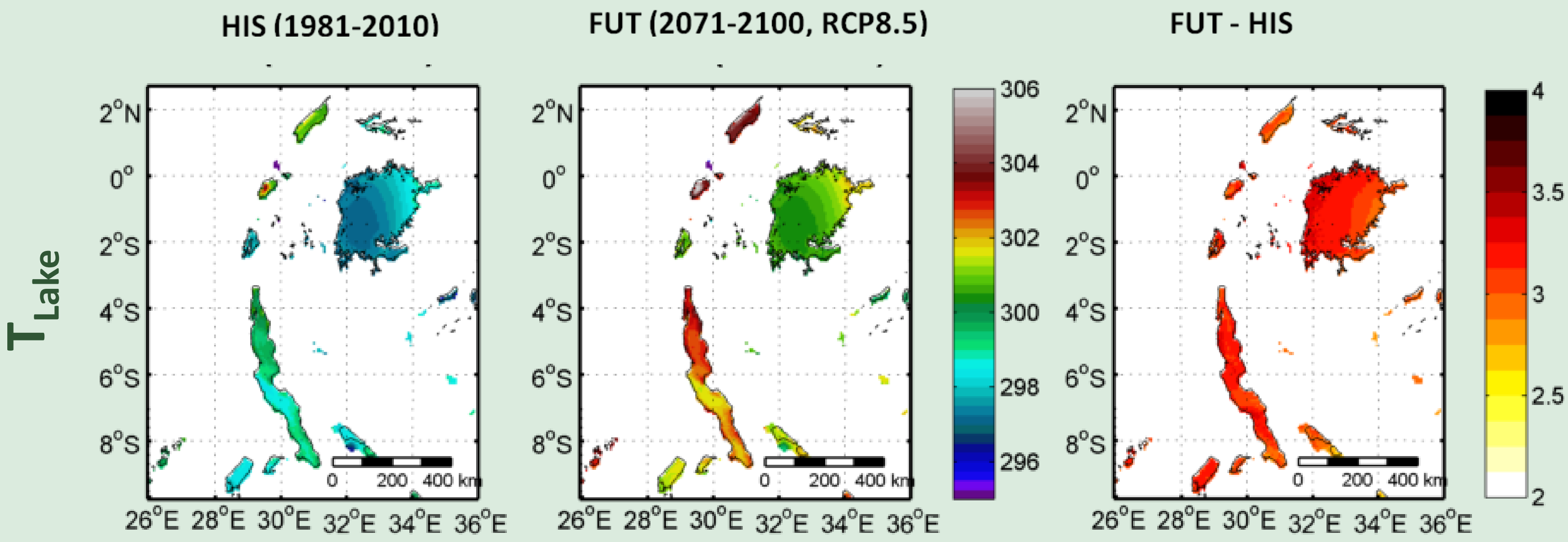


Change in convective mass flux density at cloud base height



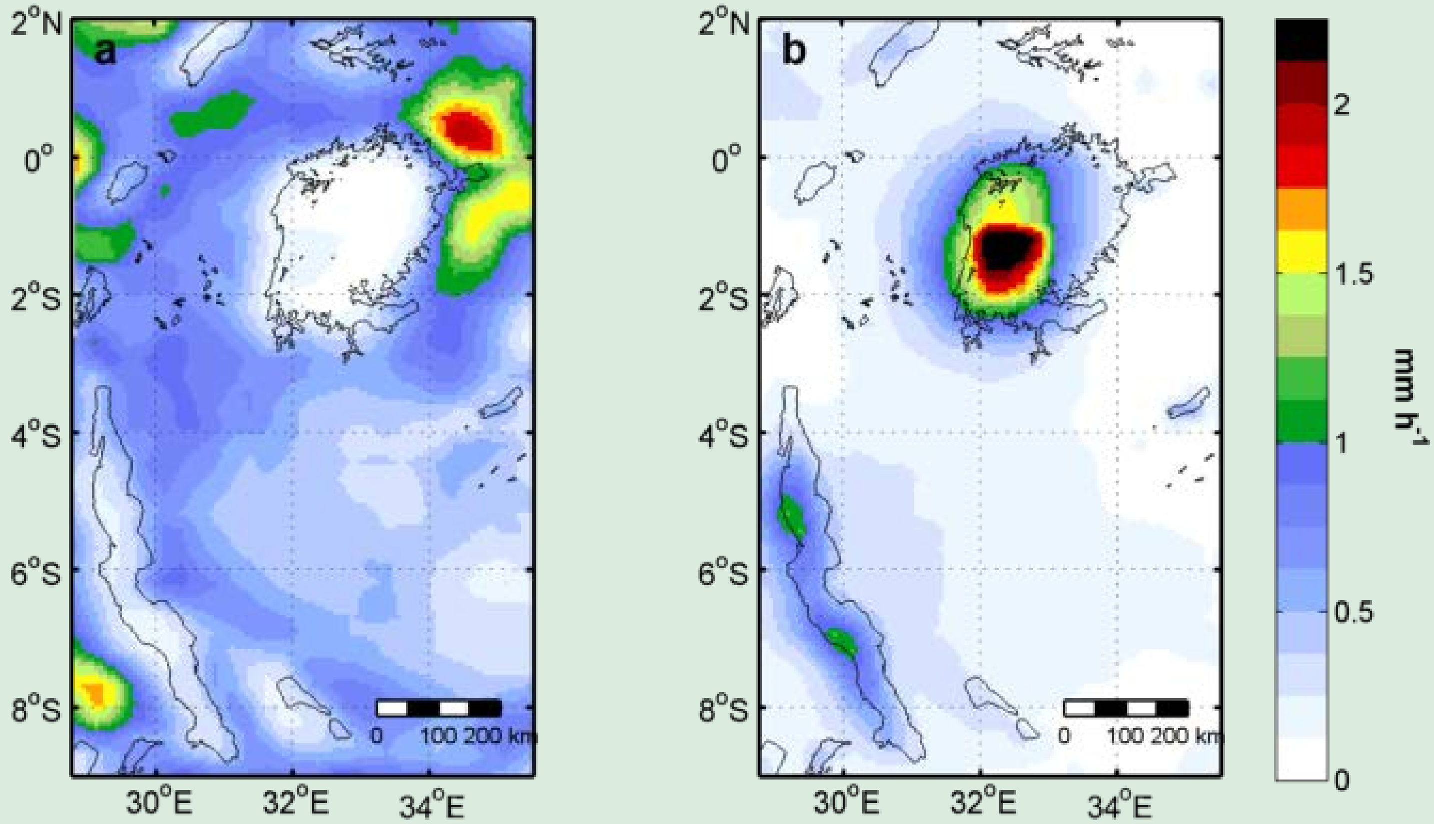
Climate change: lake temperature



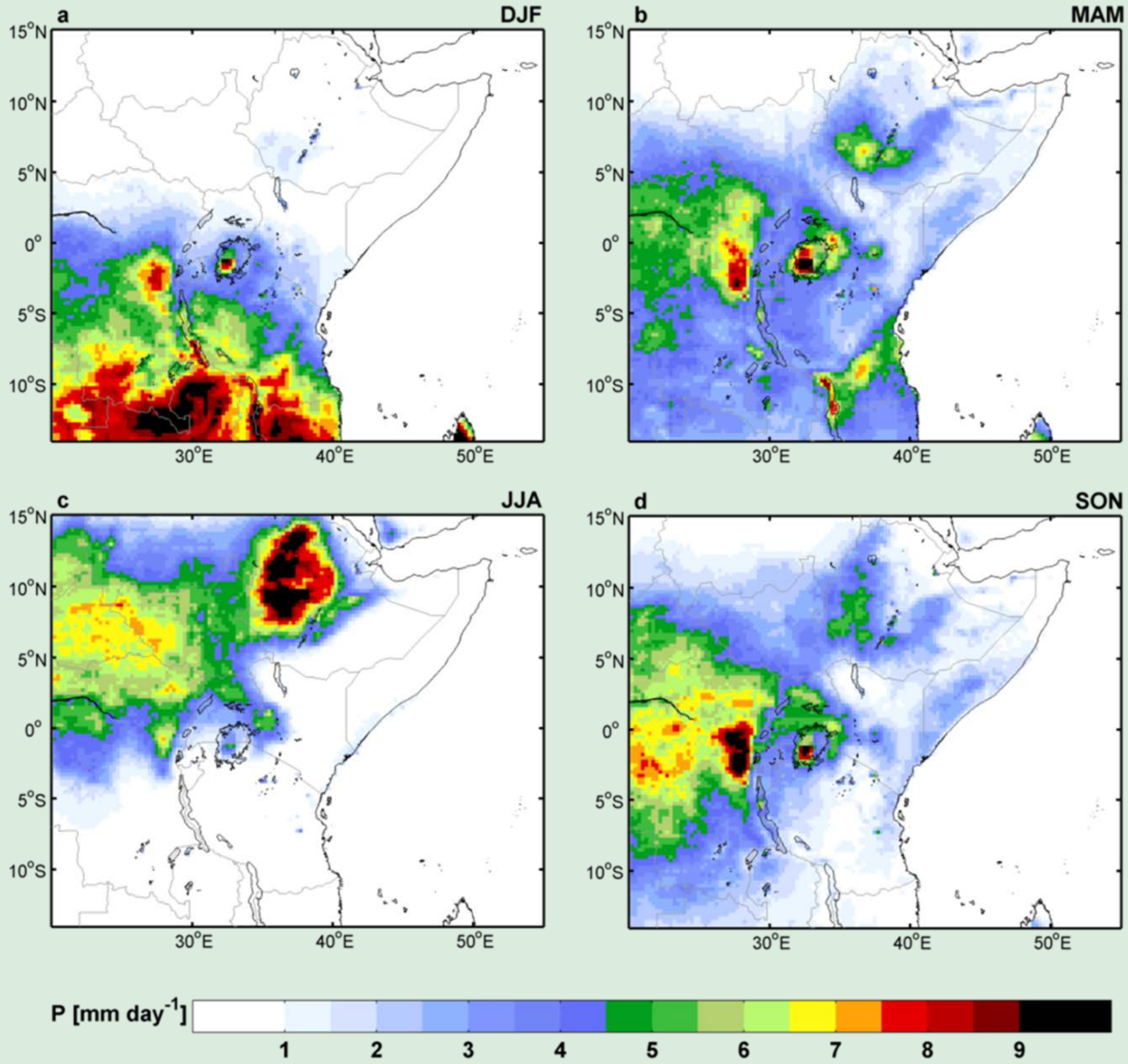


Future mixed layer warming by far exceeds seasonal variability.
This has massive implications for ecosystem functioning

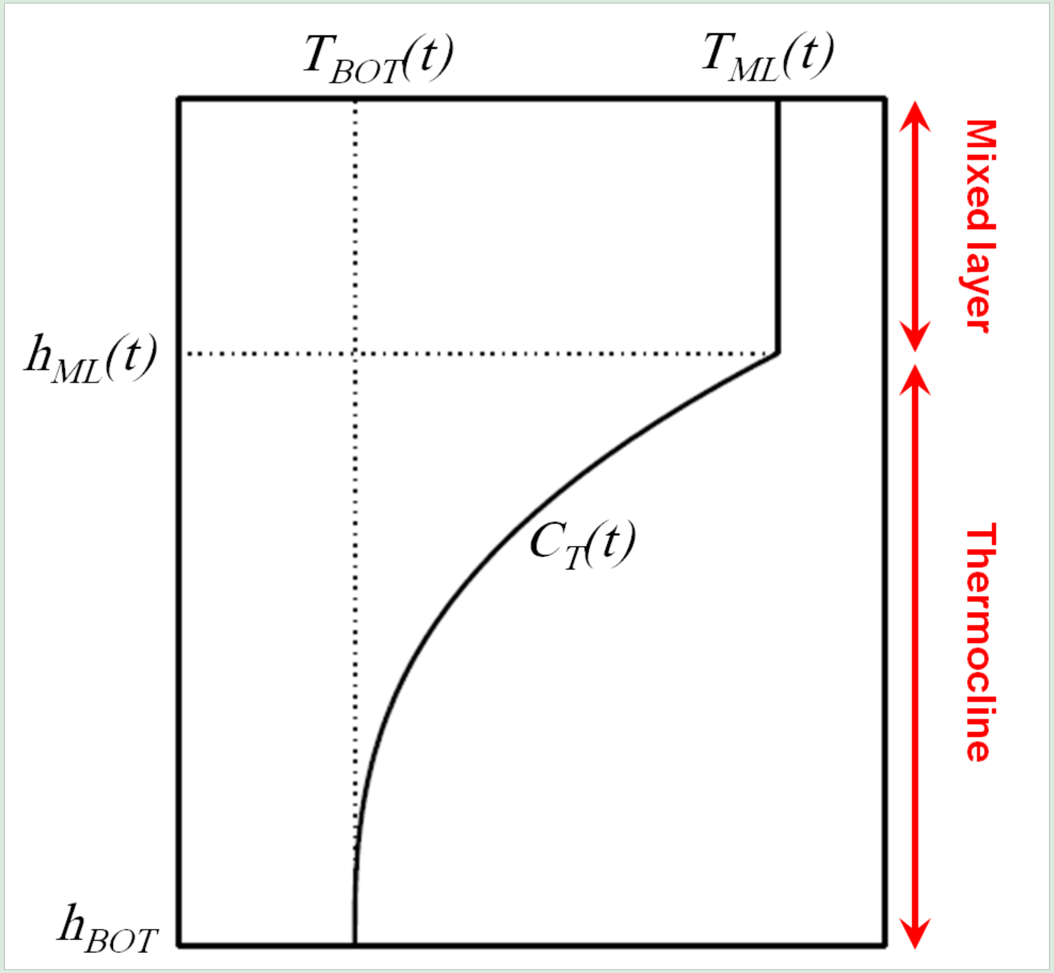
TRMM average precipitation



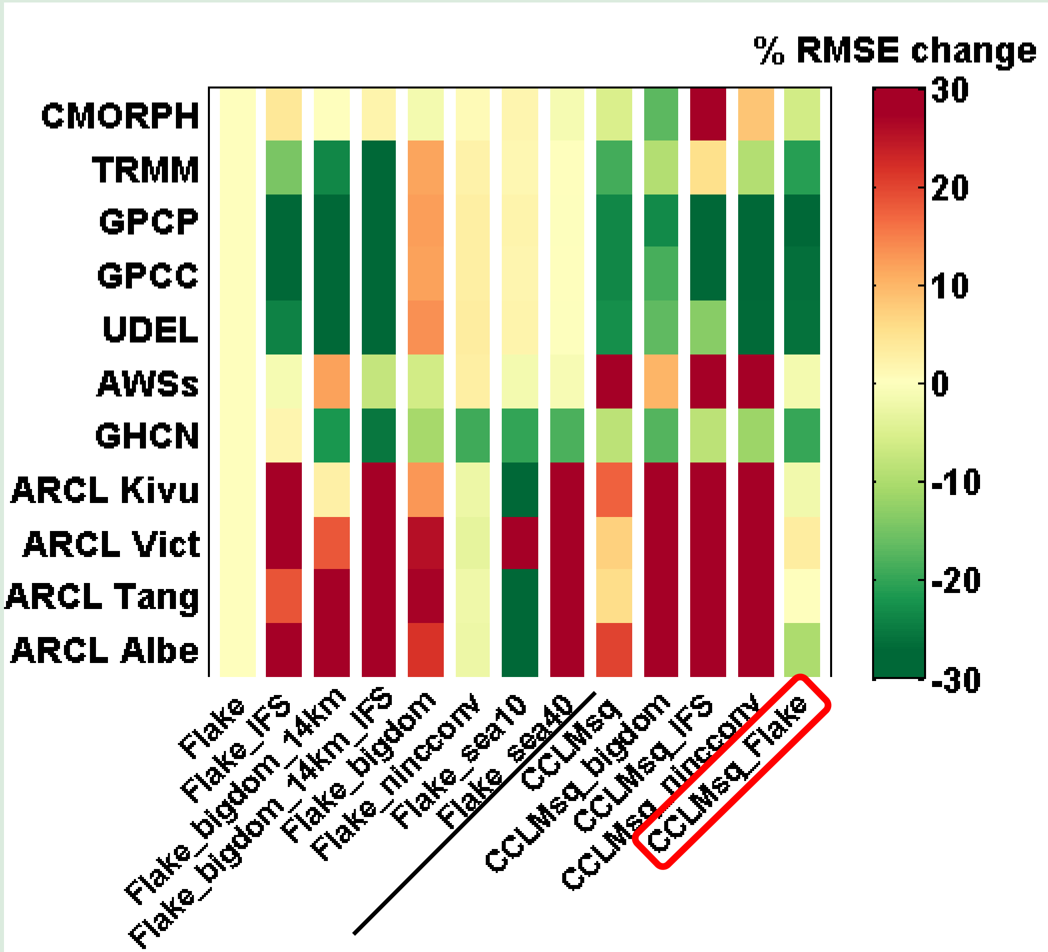
Climate of East Africa



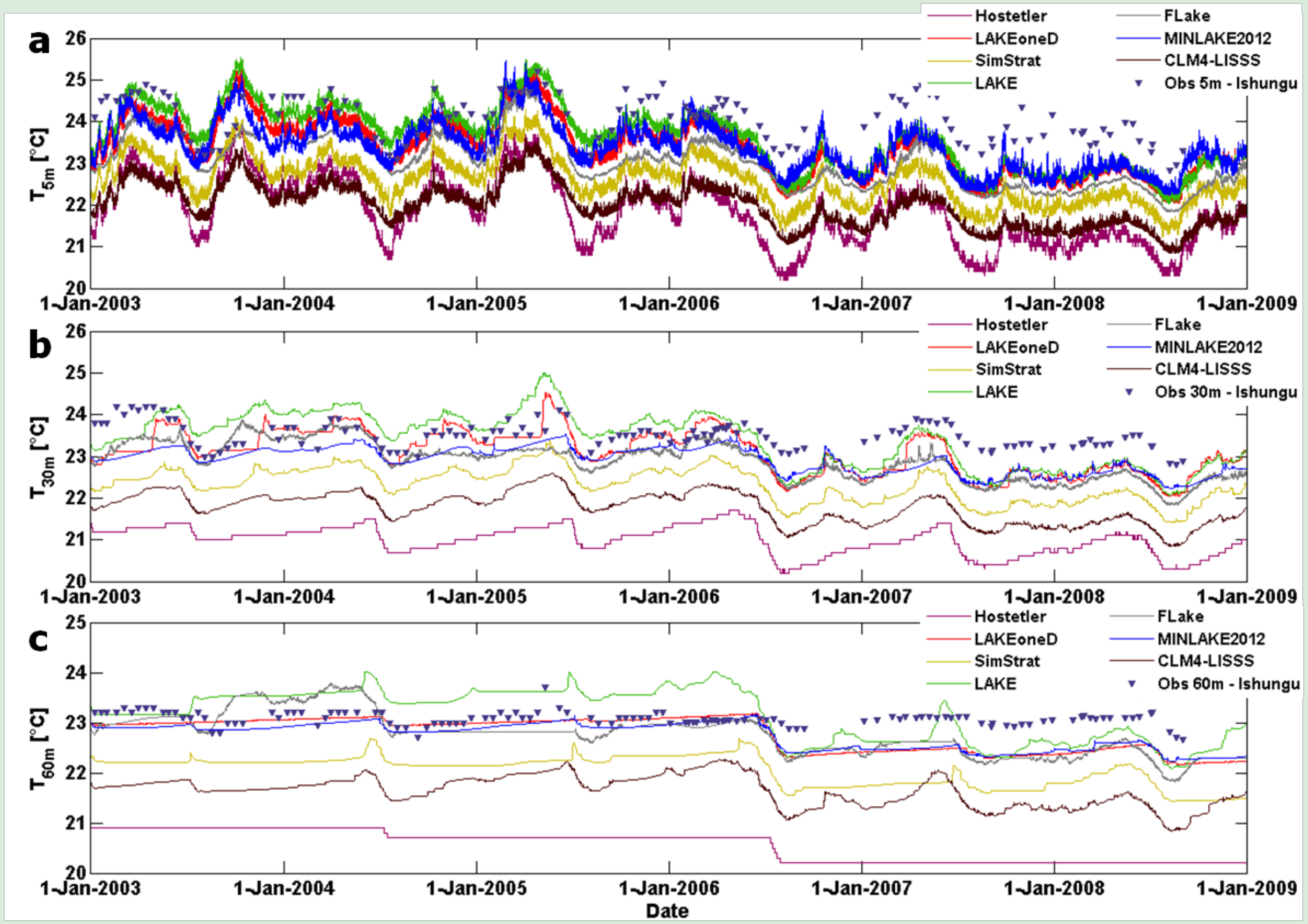
FLake structure



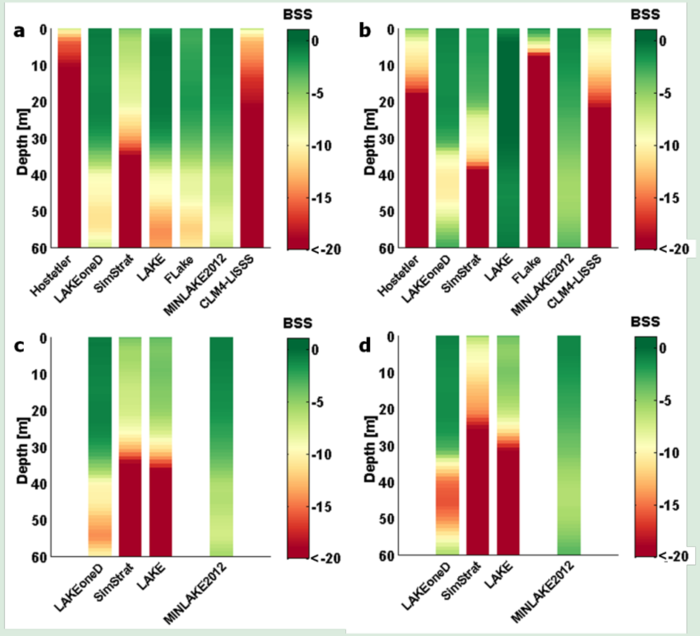
Comparing skill of different configurations

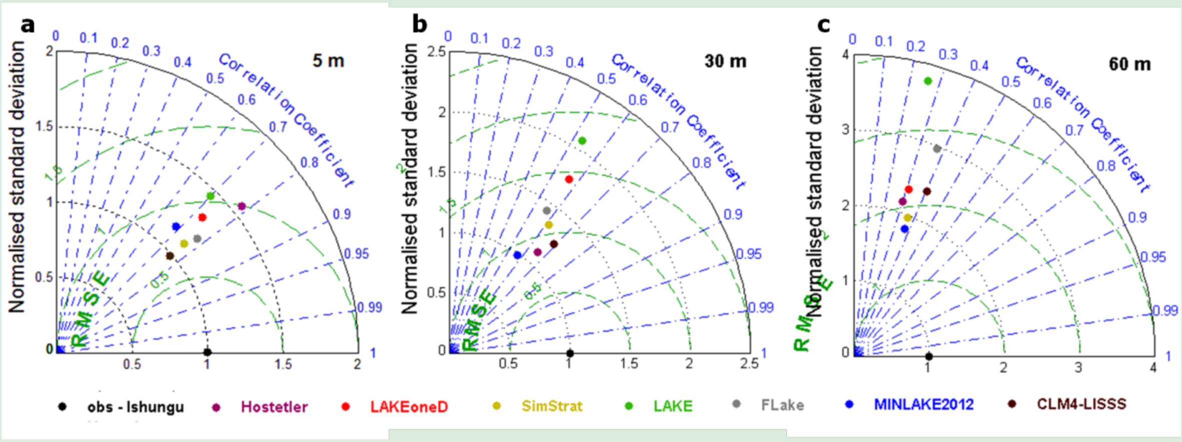


LakeMIP T05, T30, T60

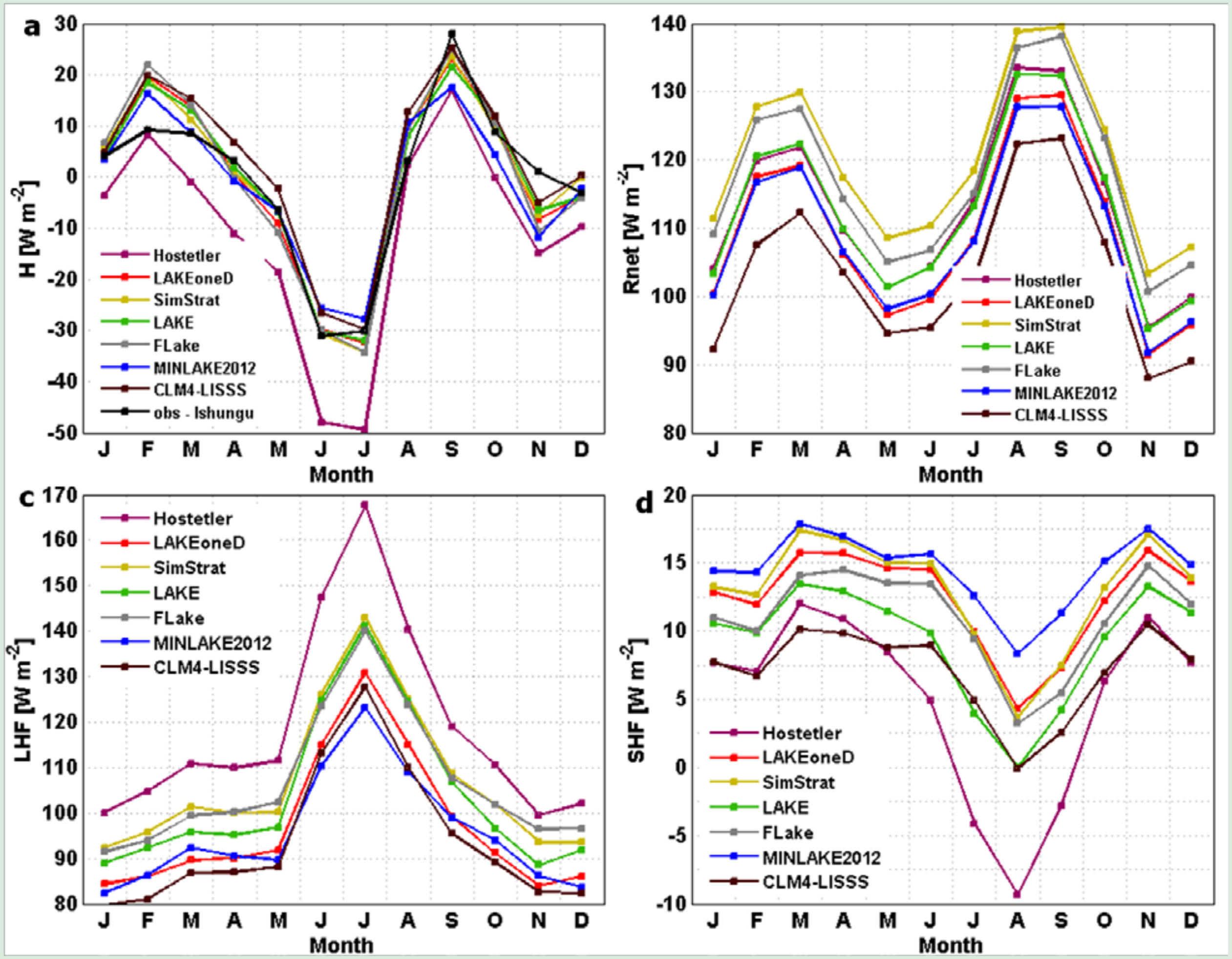


LakeMIP BSS and Taylor

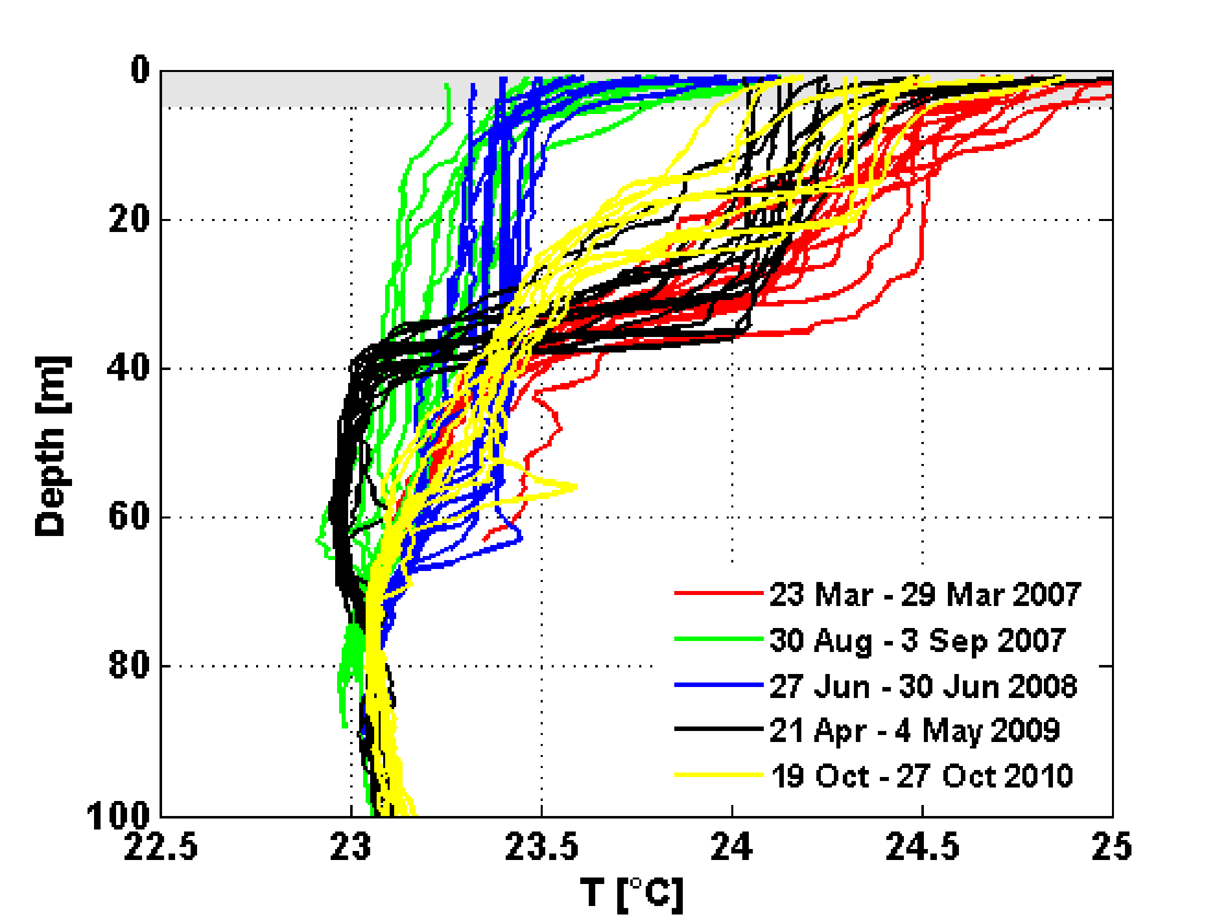




LakeMIP understanding



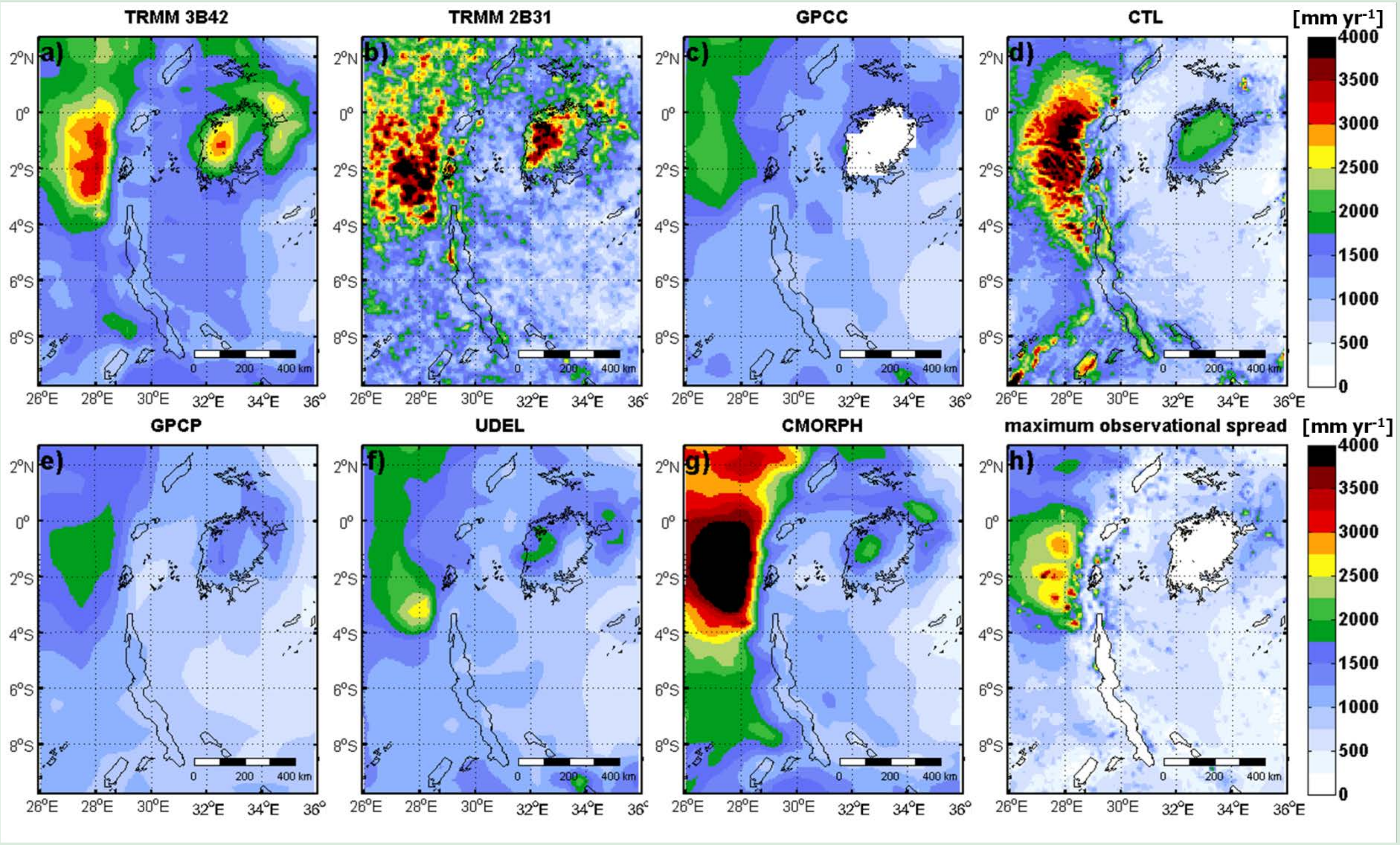
LakeMIP space versus time

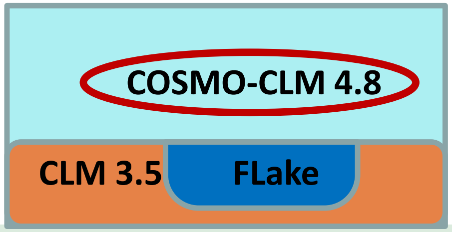


COSMO-CLM 4.8

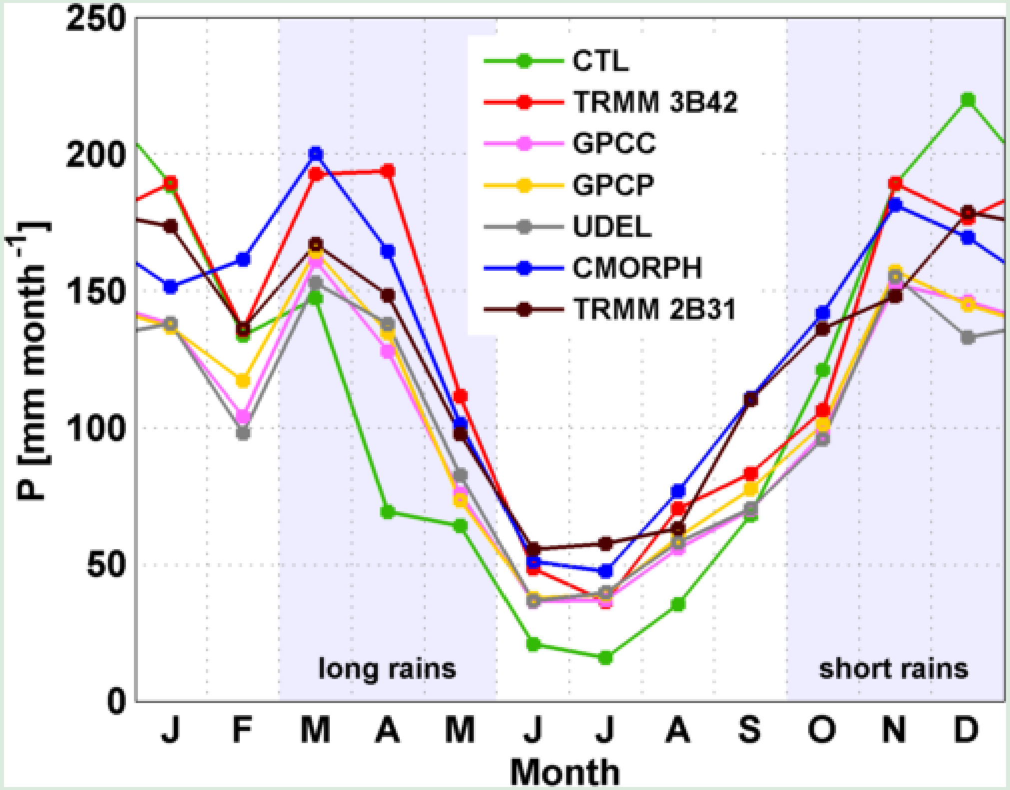
CLM 3.5 FLake

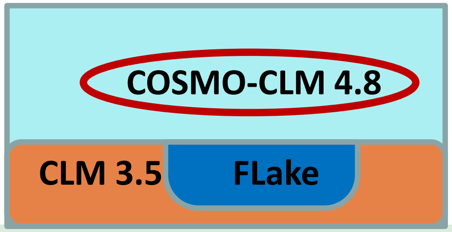
Evaluation: precipitation



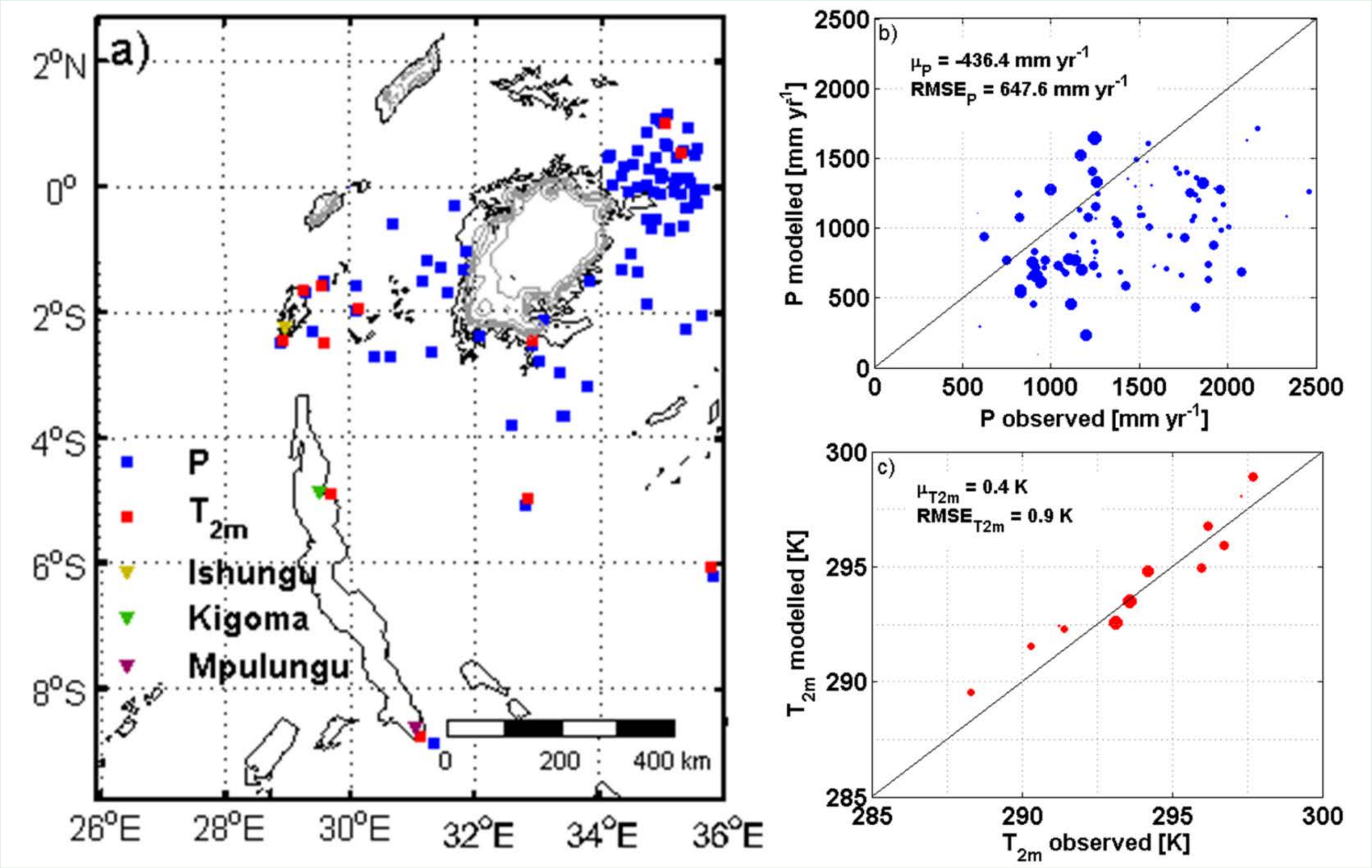


Evaluation: precipitation





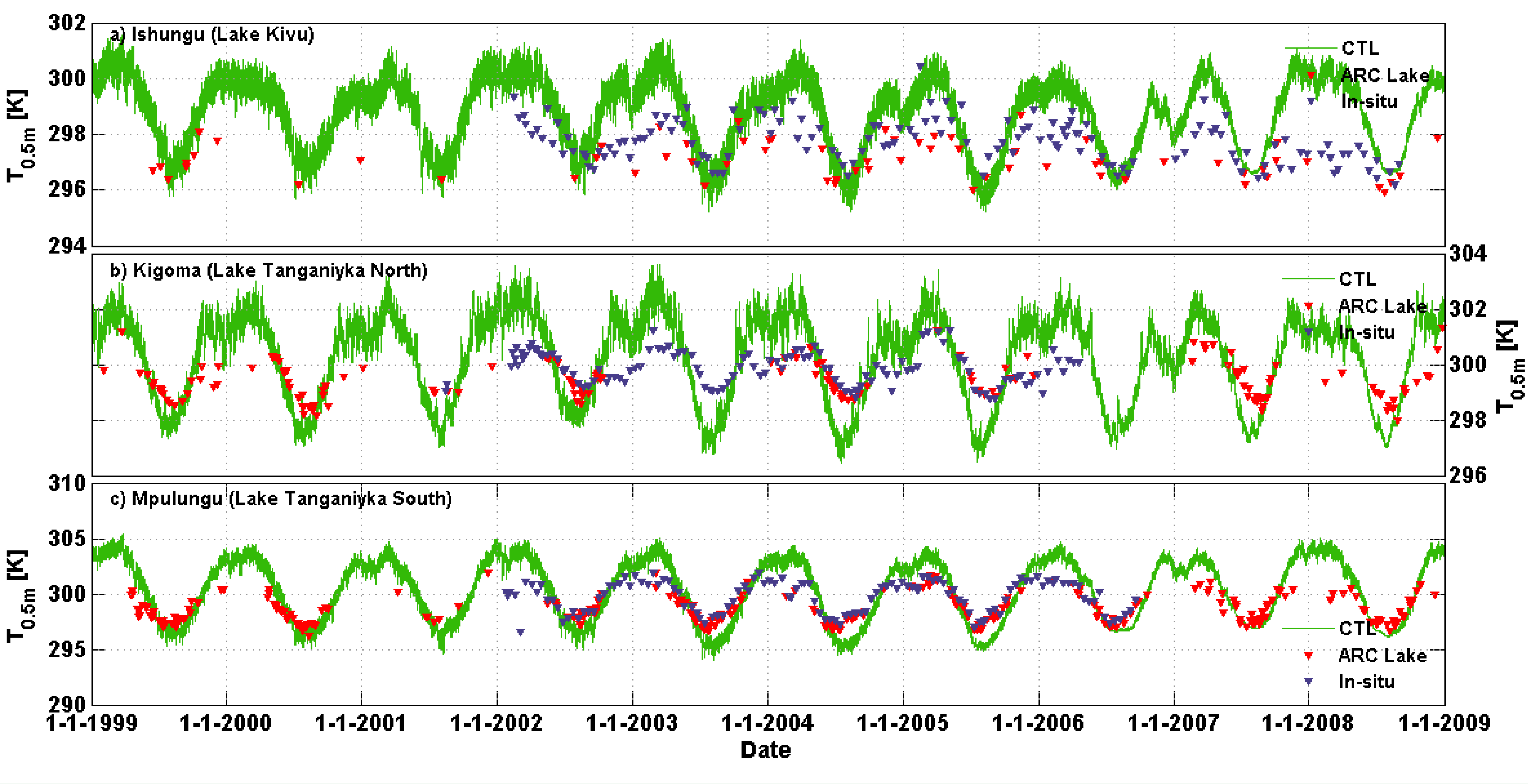
Evaluation: precipitation



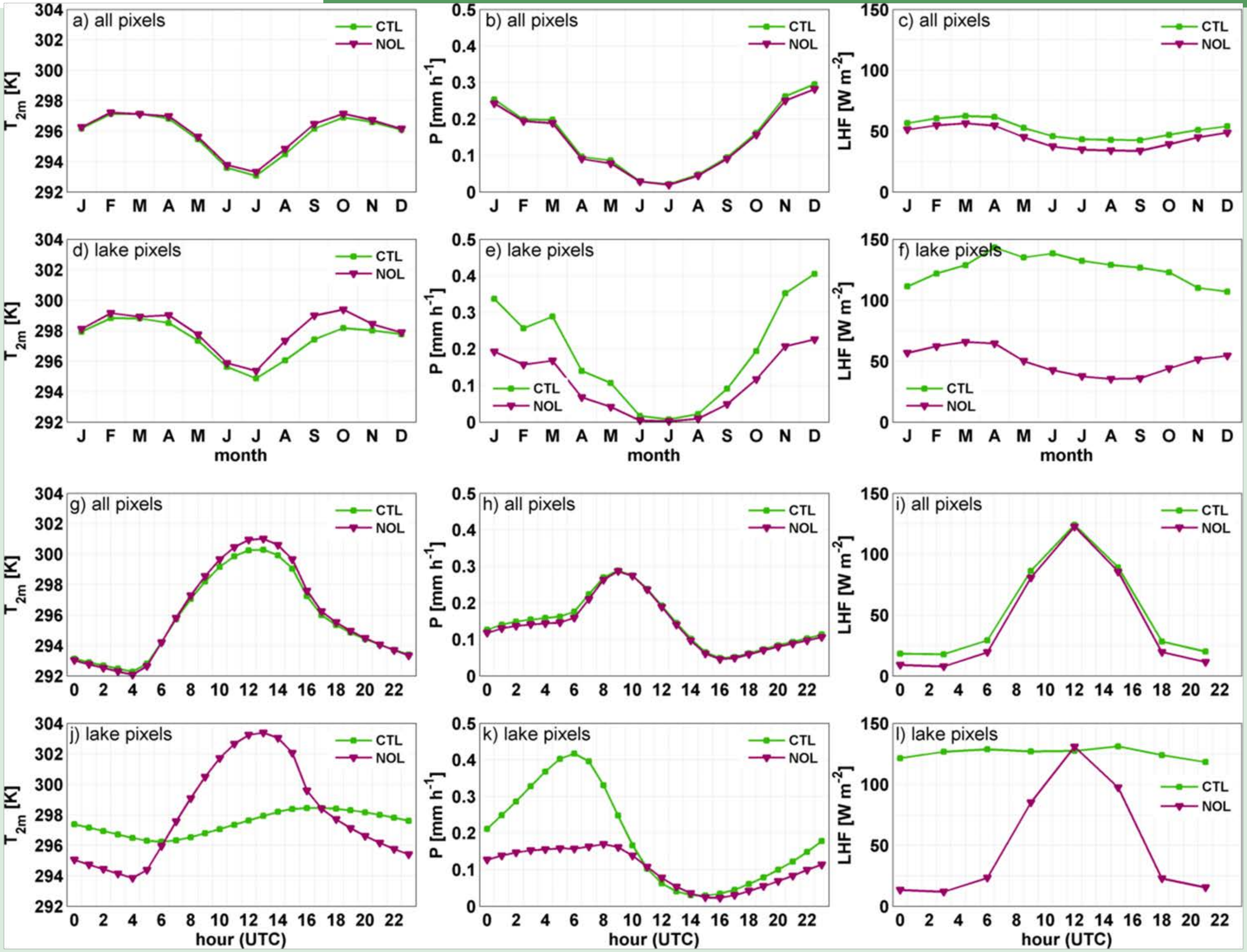
COSMO-CLM 4.8

CLM 3.5 FLake

Evaluation: lake temperature



Impact: seasonal and diurnal

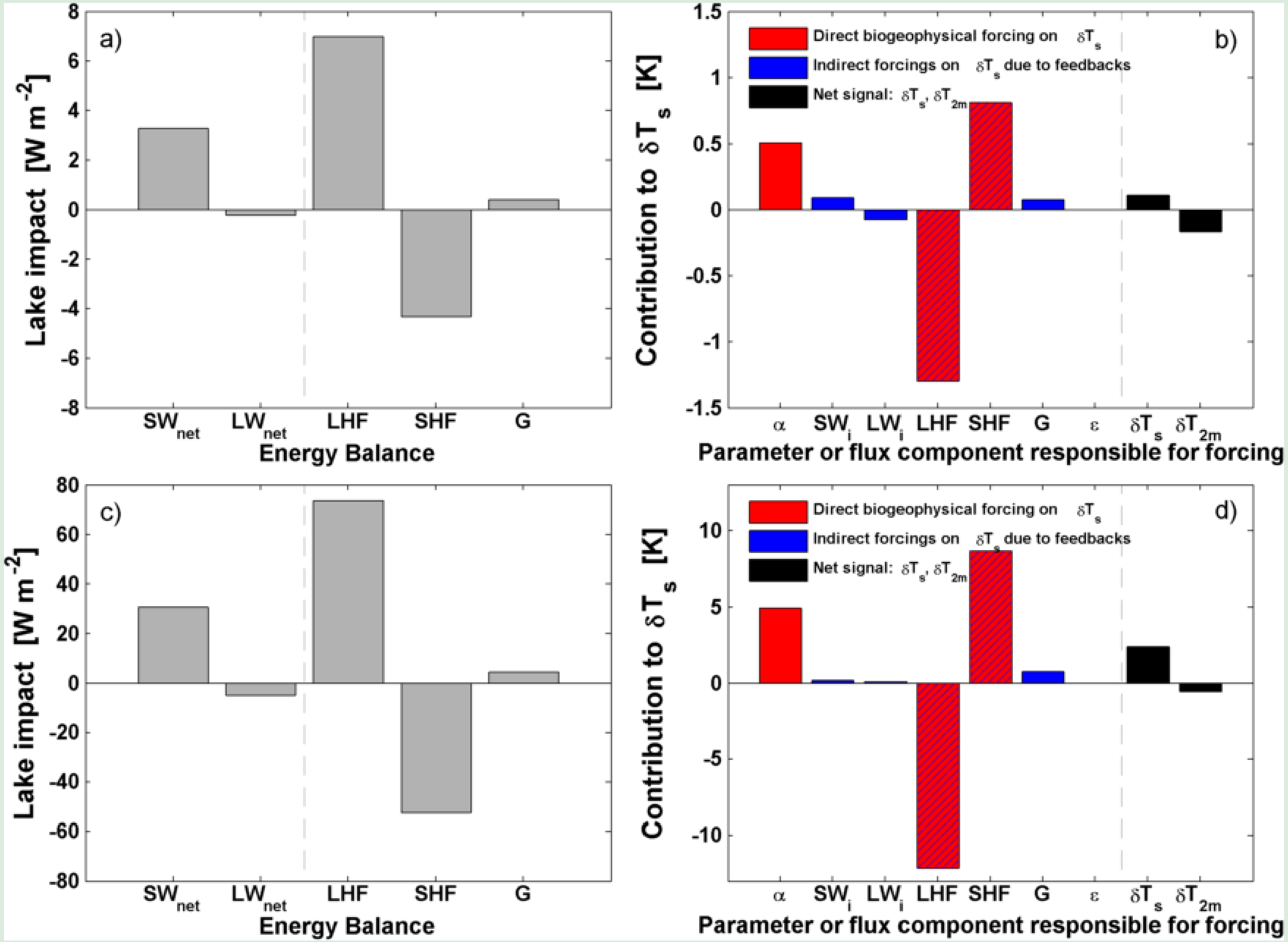


SEB decomposition

$$\delta T_s = \frac{1}{4\epsilon\sigma T_s^3}(-SW_{in}\delta\alpha + (1-\alpha)\delta SW_{in} + \delta LW_{in} - \delta LHF + \delta SHF - \delta G - \sigma T_s^4\delta\epsilon)$$

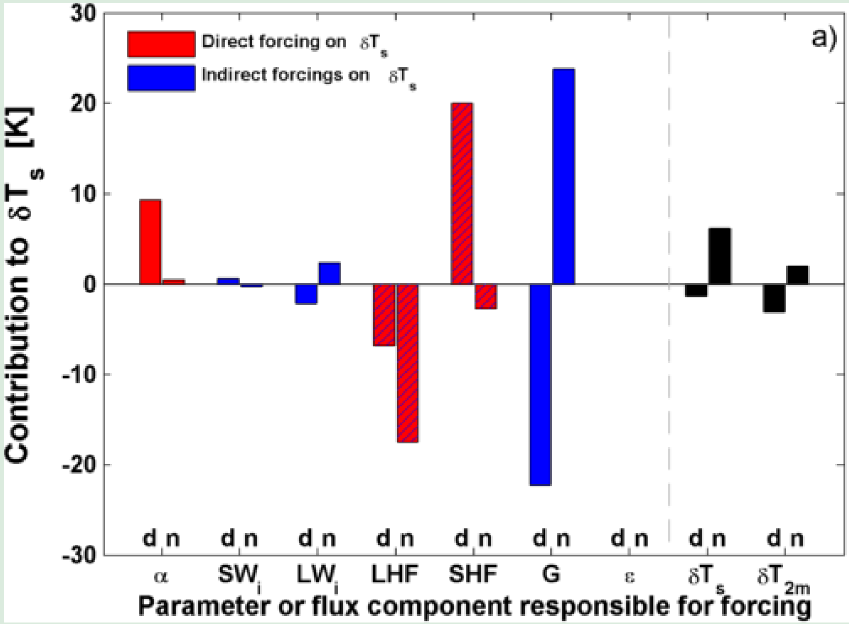
All pixels

Lake pixels

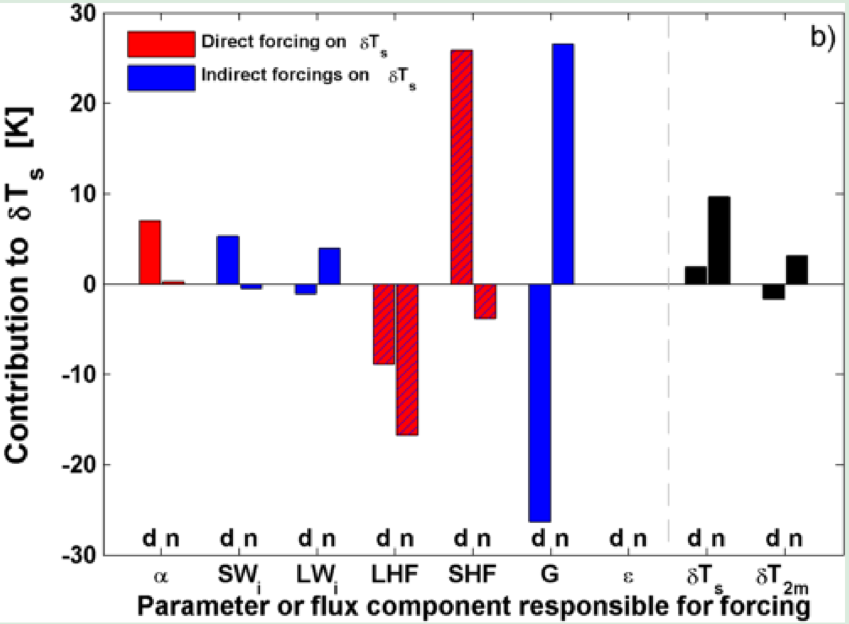


SEB decomposition: Lake Kivu versus other lakes

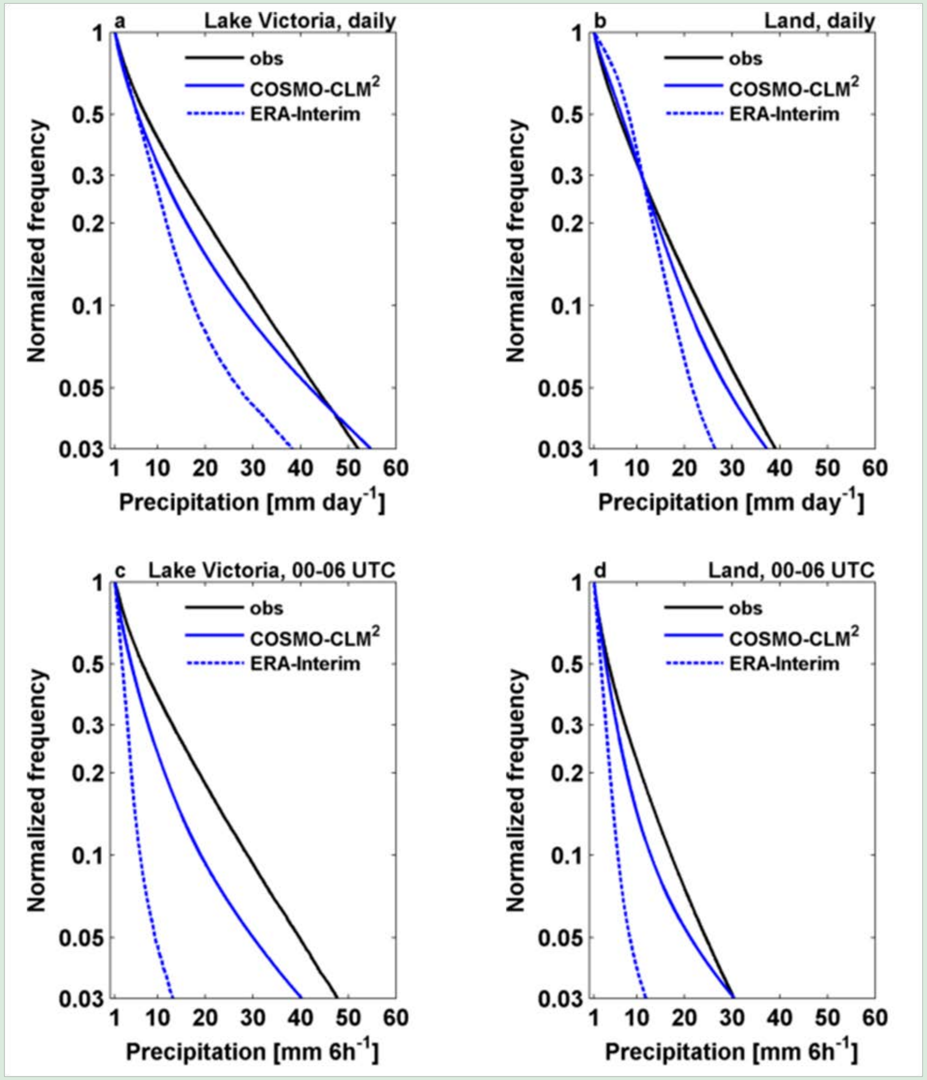
Lake pixels



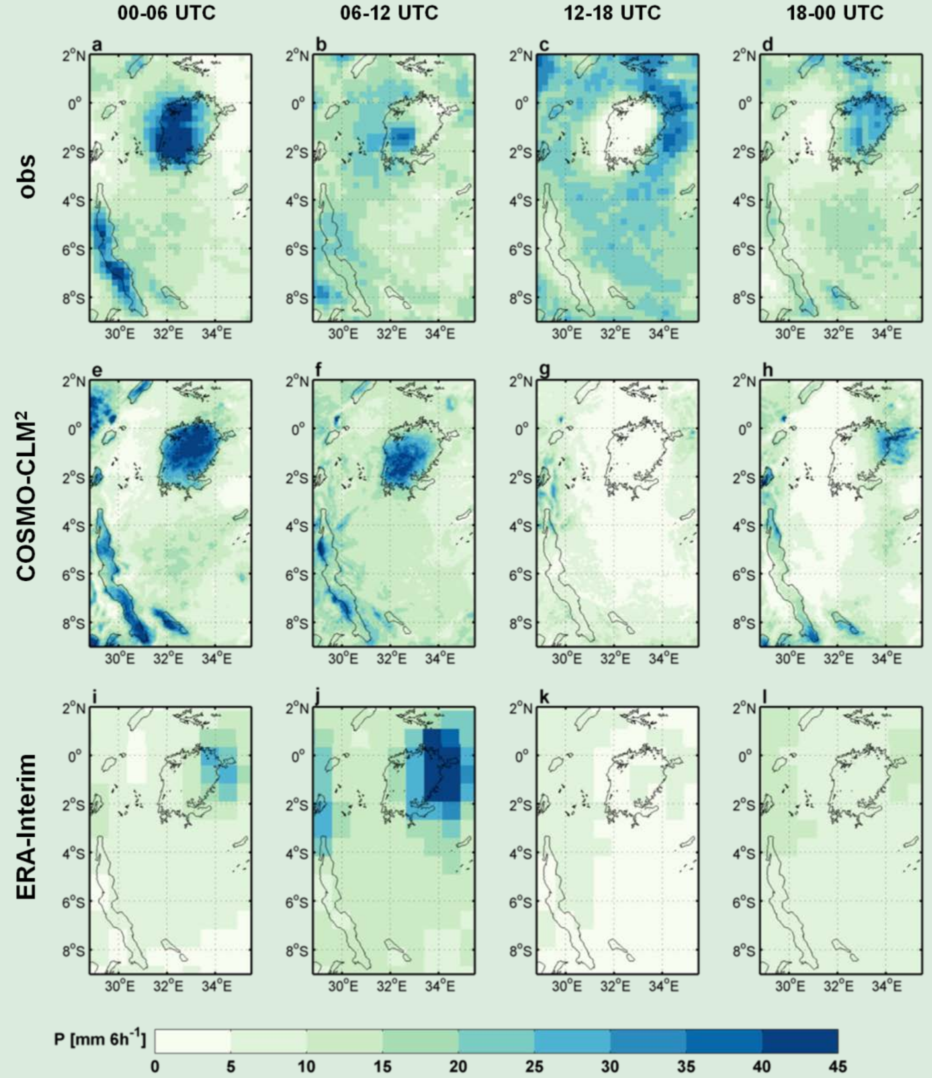
Lake Kivu



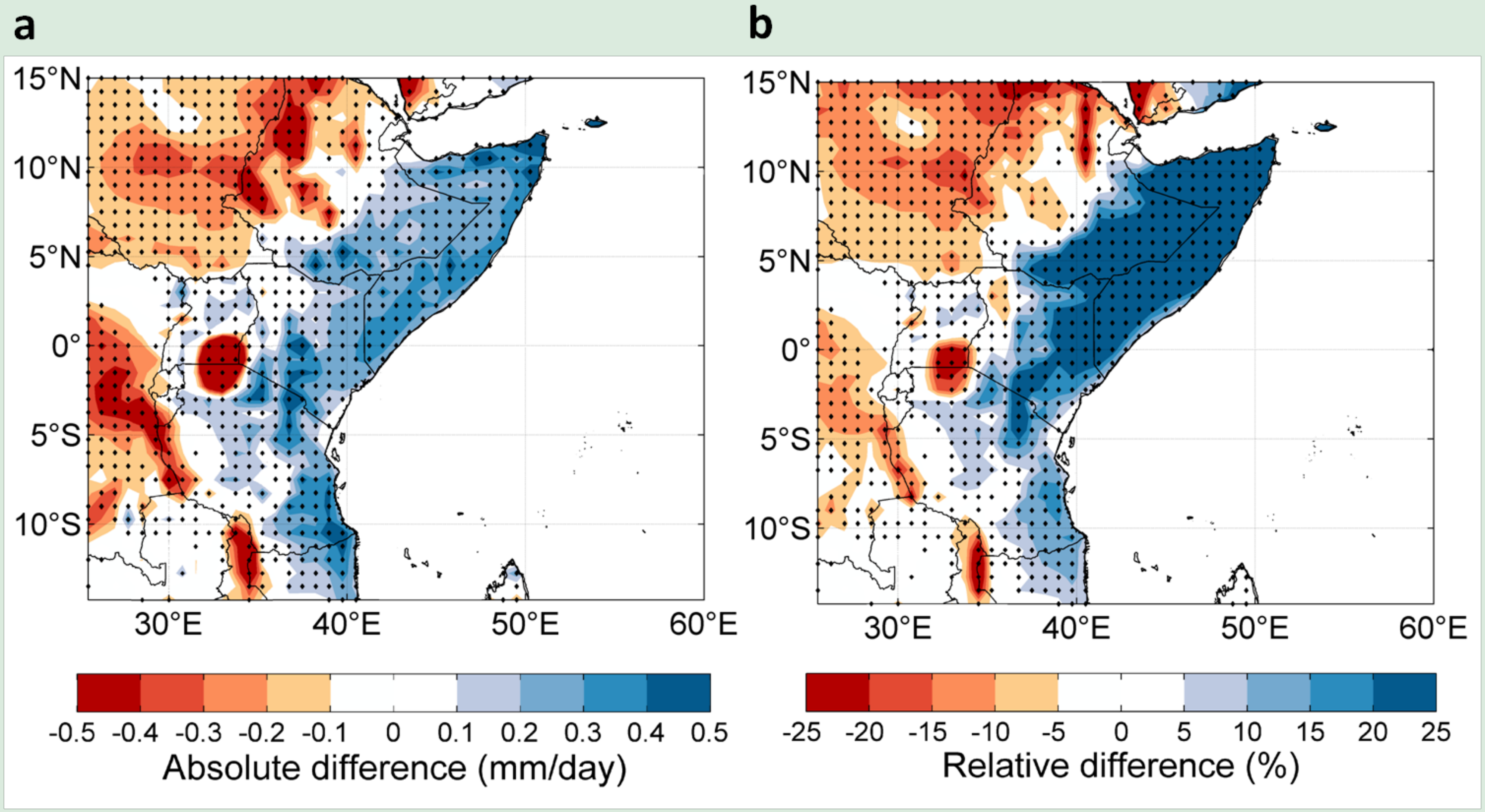
Evaluation: survival plots



Evaluation: extreme precipitation

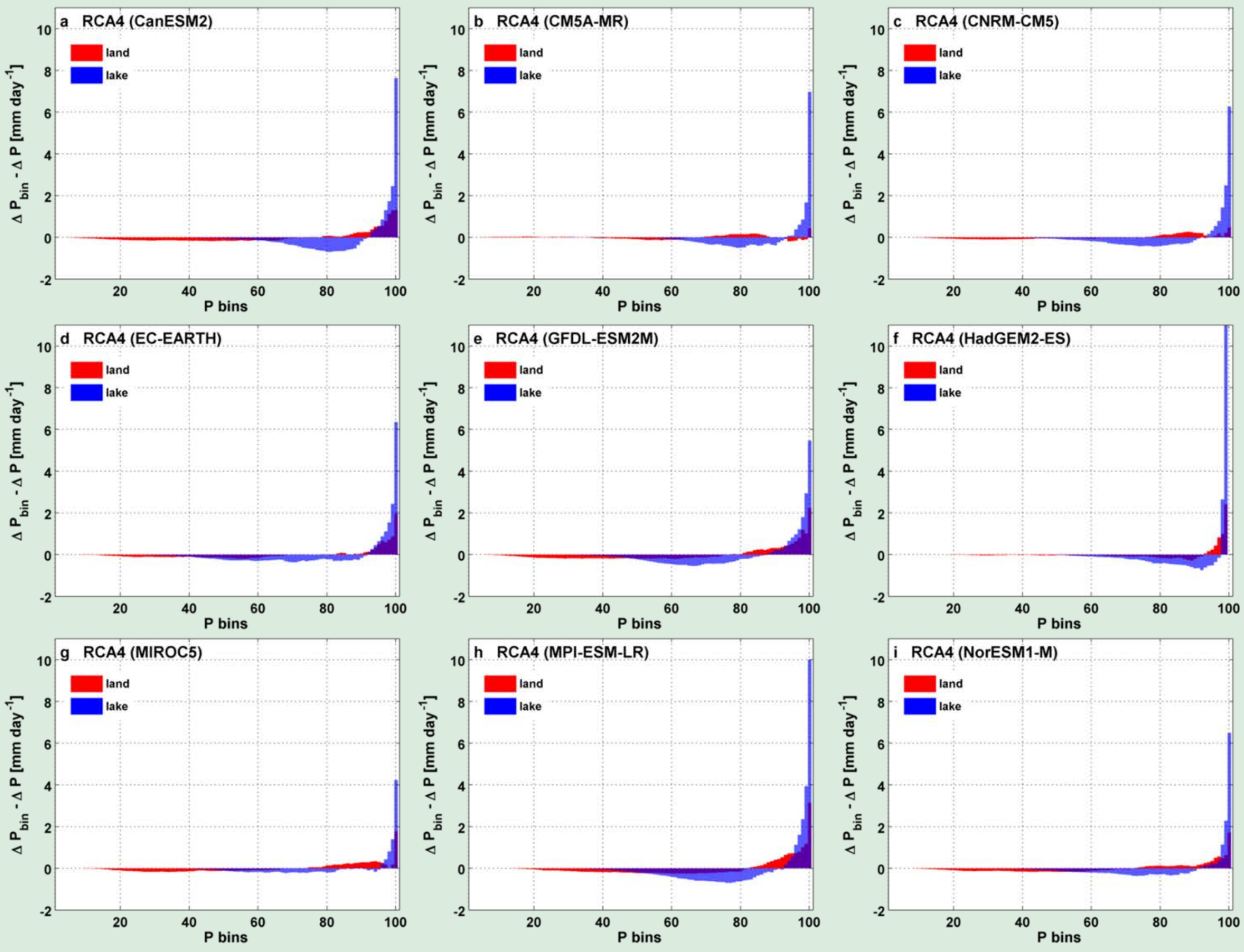


CORDEX ensemble: evidence for over-lake precipitation decrease

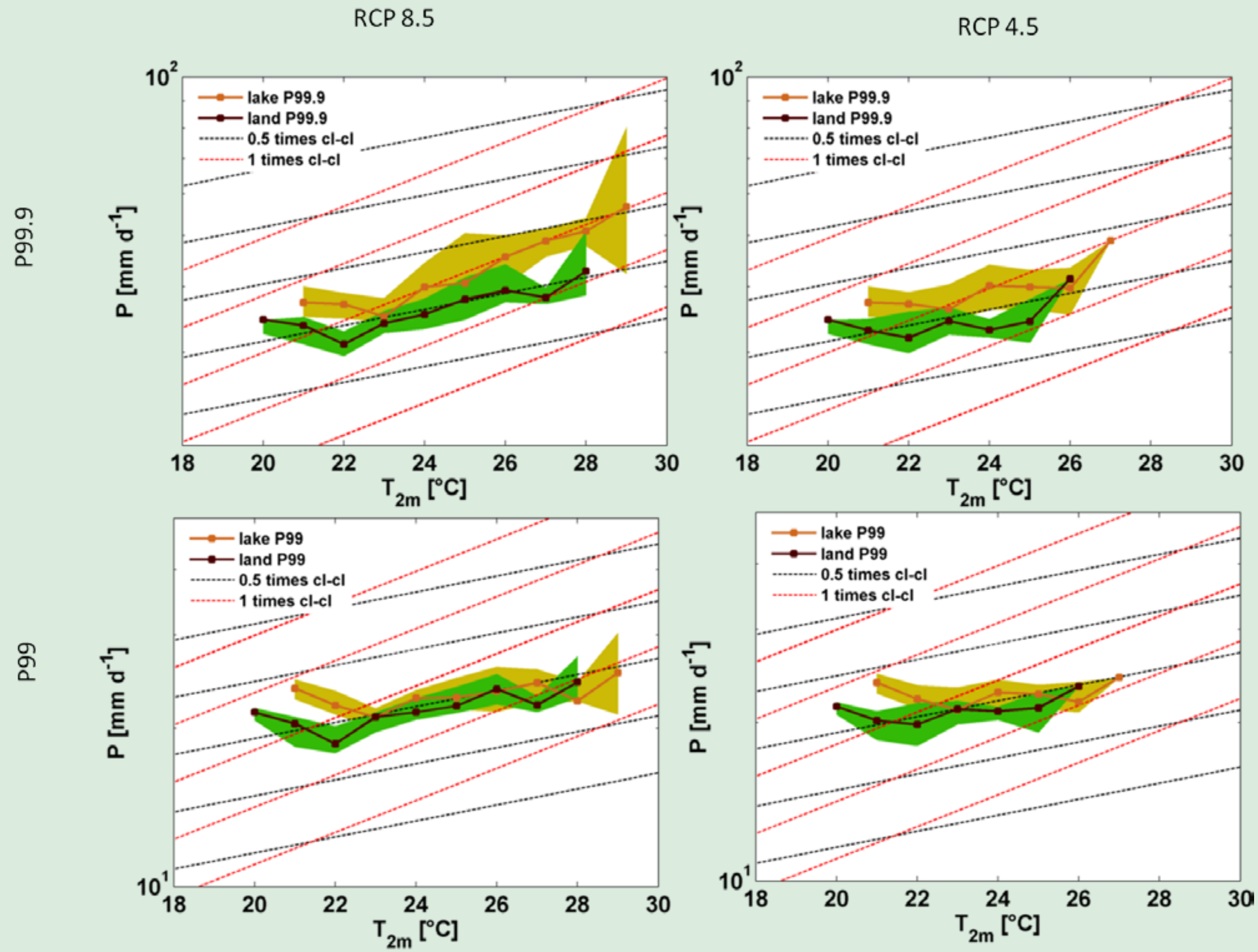


(Courtesy: Niels Souverijns)

CORDEX ensemble: “CCLM² projections are robust”

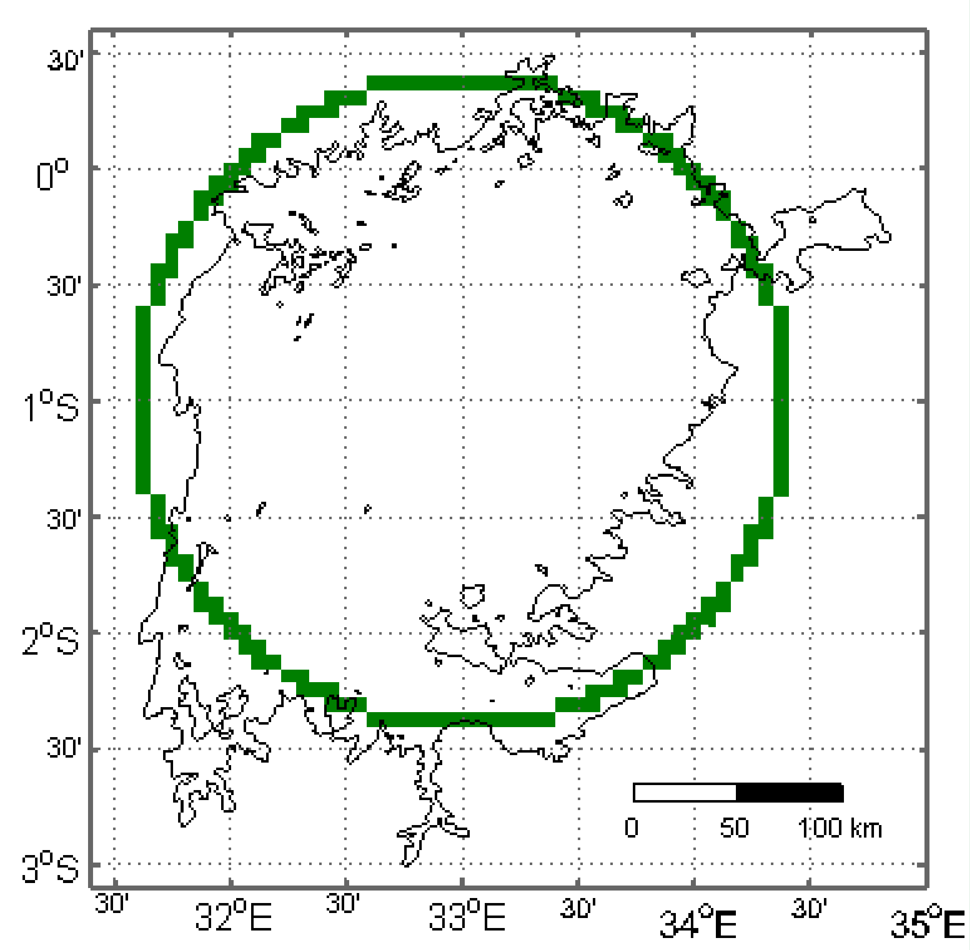


Sensitivity to scenario and percentile choice



Scaling over the lake twice as strong compared to land for P99.9 under RCP8.5

“Lake breeze strength”



FLake: improved stratification