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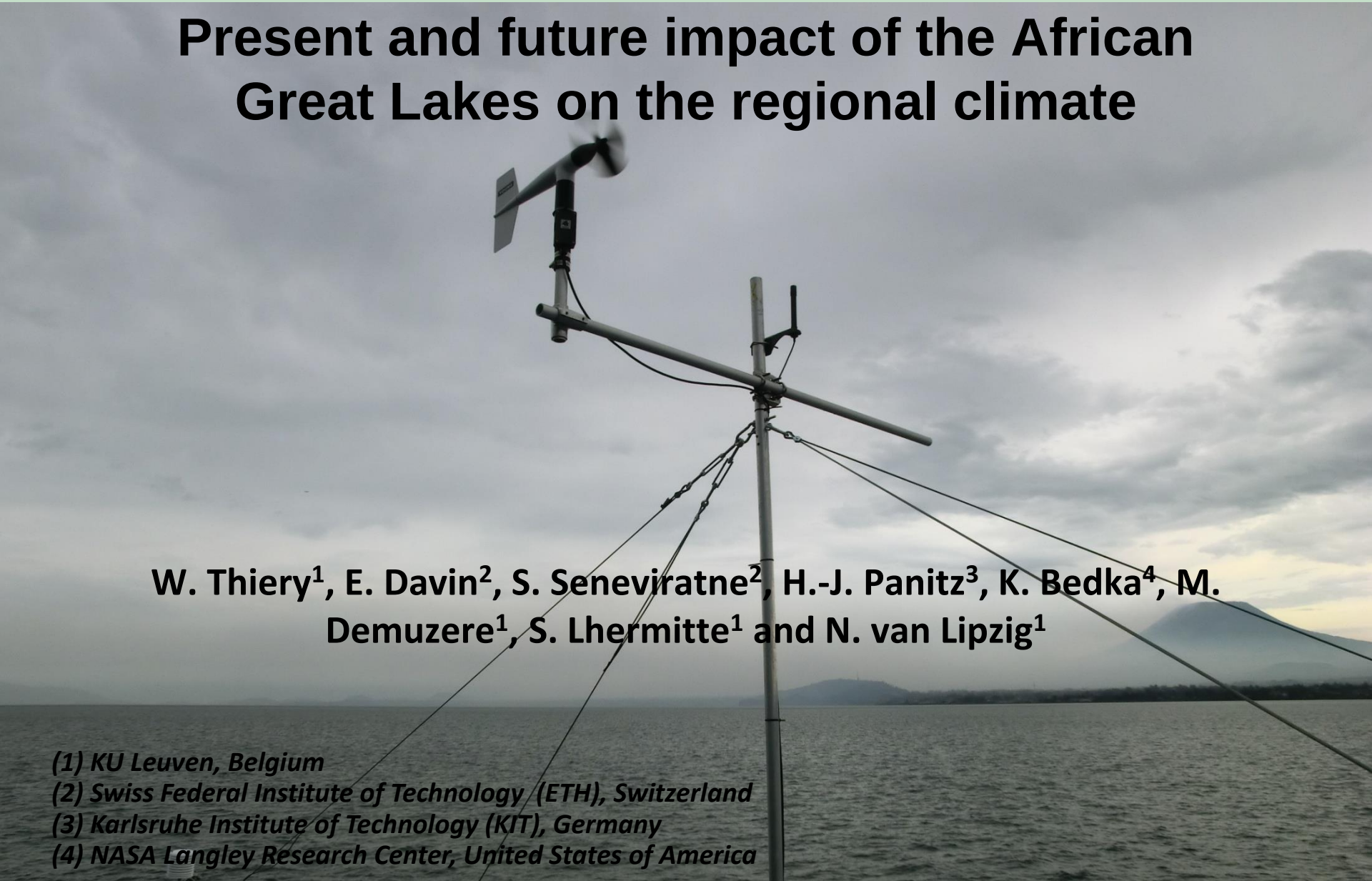
Present and future impact of the African Great Lakes on the regional climate



W. Thiery[1], E. Davin[2], S. Seneviratne[2], H.-J. Panitz[3], K. Bedka[4], M. Demuzere[1], S. Lhermitte[1] and N. van Lipzig[1]

(1) KU Leuven, Belgium
(2) Swiss Federal Institute of Technology (ETH), Switzerland
(3) Karlsruhe Institute of Technology (KIT), Germany
(4) NASA Langley Research Center, United States of America

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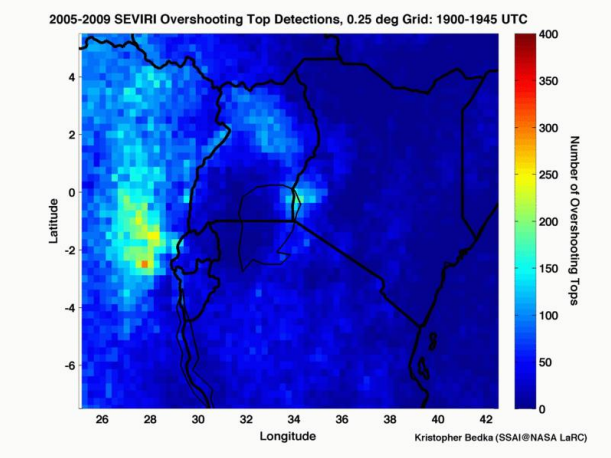
Motivation and objectives



(Bedka, pers. comm.)

Lethal weather on 'world's most dangerous lake'

From **Errol Barnett**, CNN
January 17, 2013 -- Updated 1448 GMT (2248 HKT)

(www.cnn.com)

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Motivation and objectives

(Lake Kivu)

model skill? **impact?** **future climate change?**

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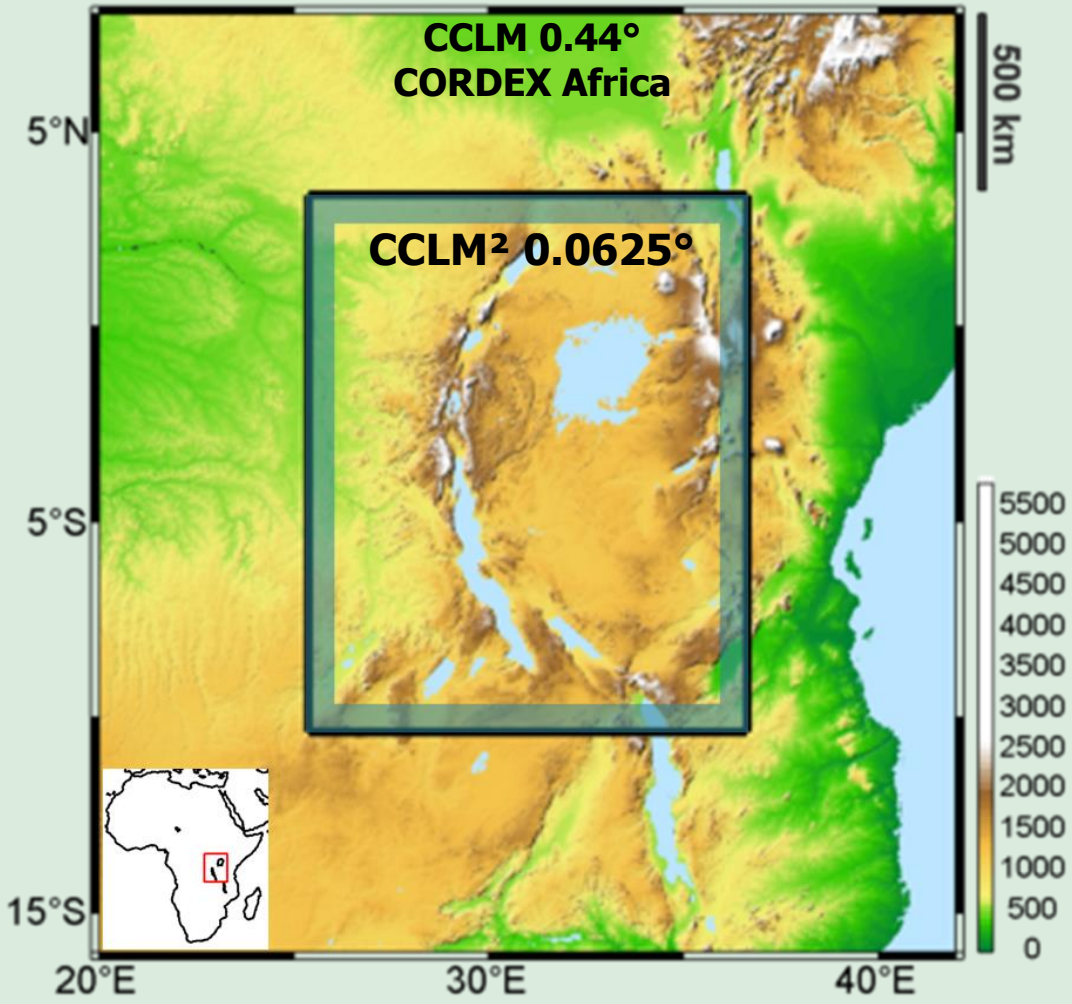
CCLM² model setup



COSMO-CLM 4.8
(CORDEX-Africa set-up)

CLM 3.5 | FLake

"RCP[illegible]" (1979-2[illegible])

How well does our model perform?

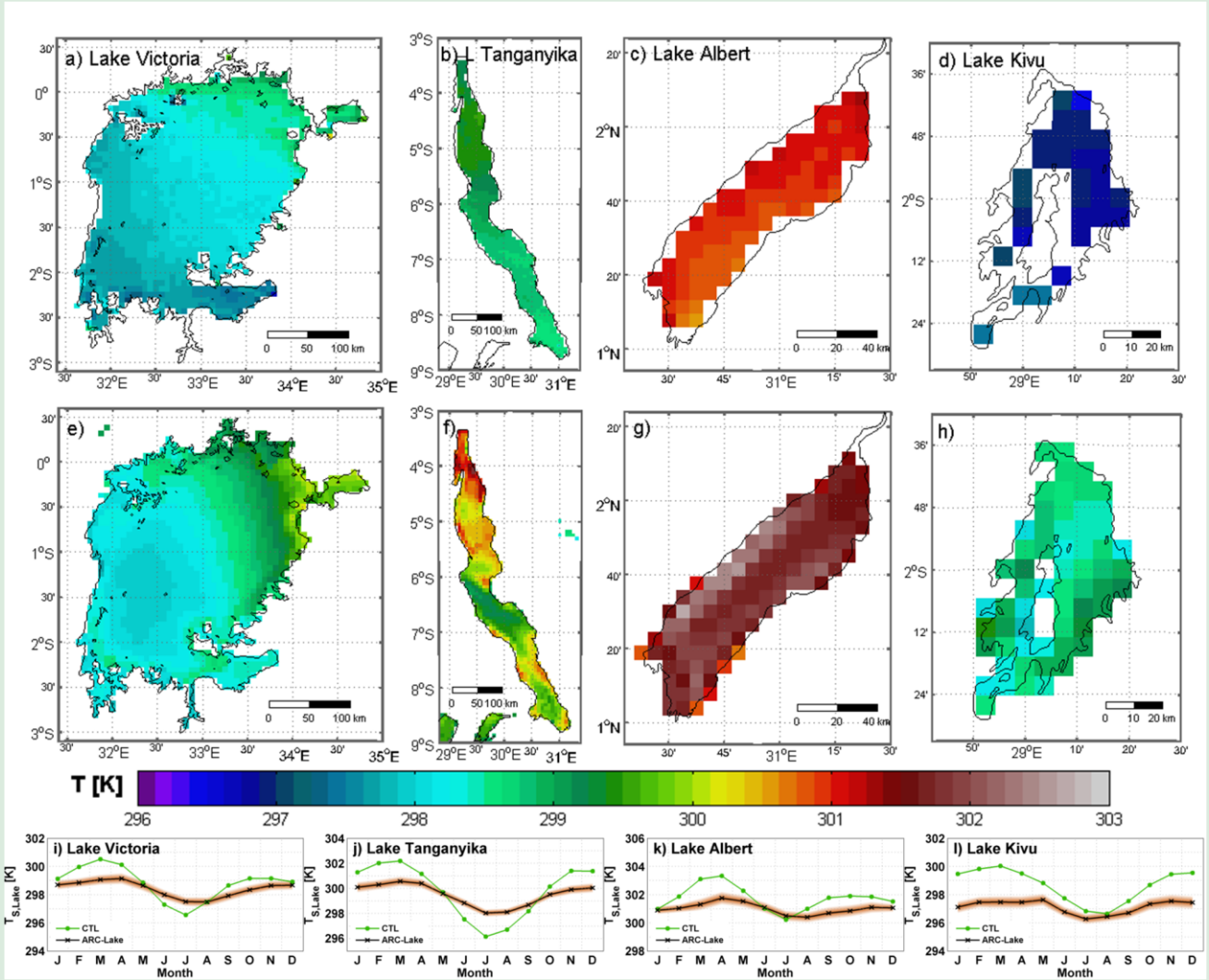
COSMO-CLM 4.8

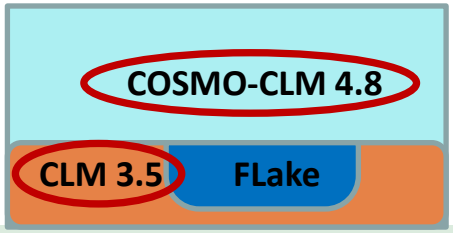
CLM 3.5 FLake

Evaluation: lake temperature

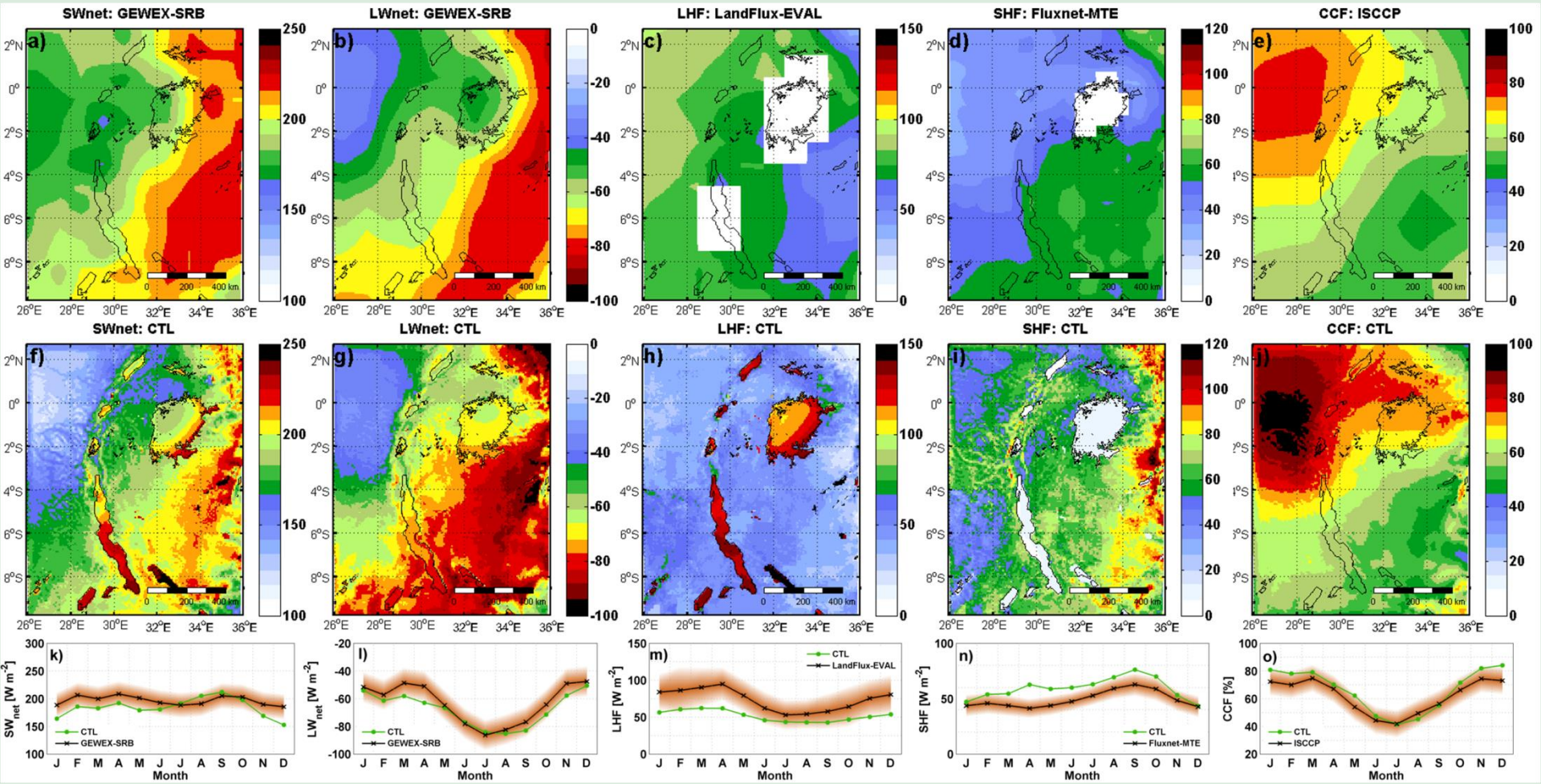
OBS

CTL





Evaluation: SEB and clouds



Impact on the regional climate?

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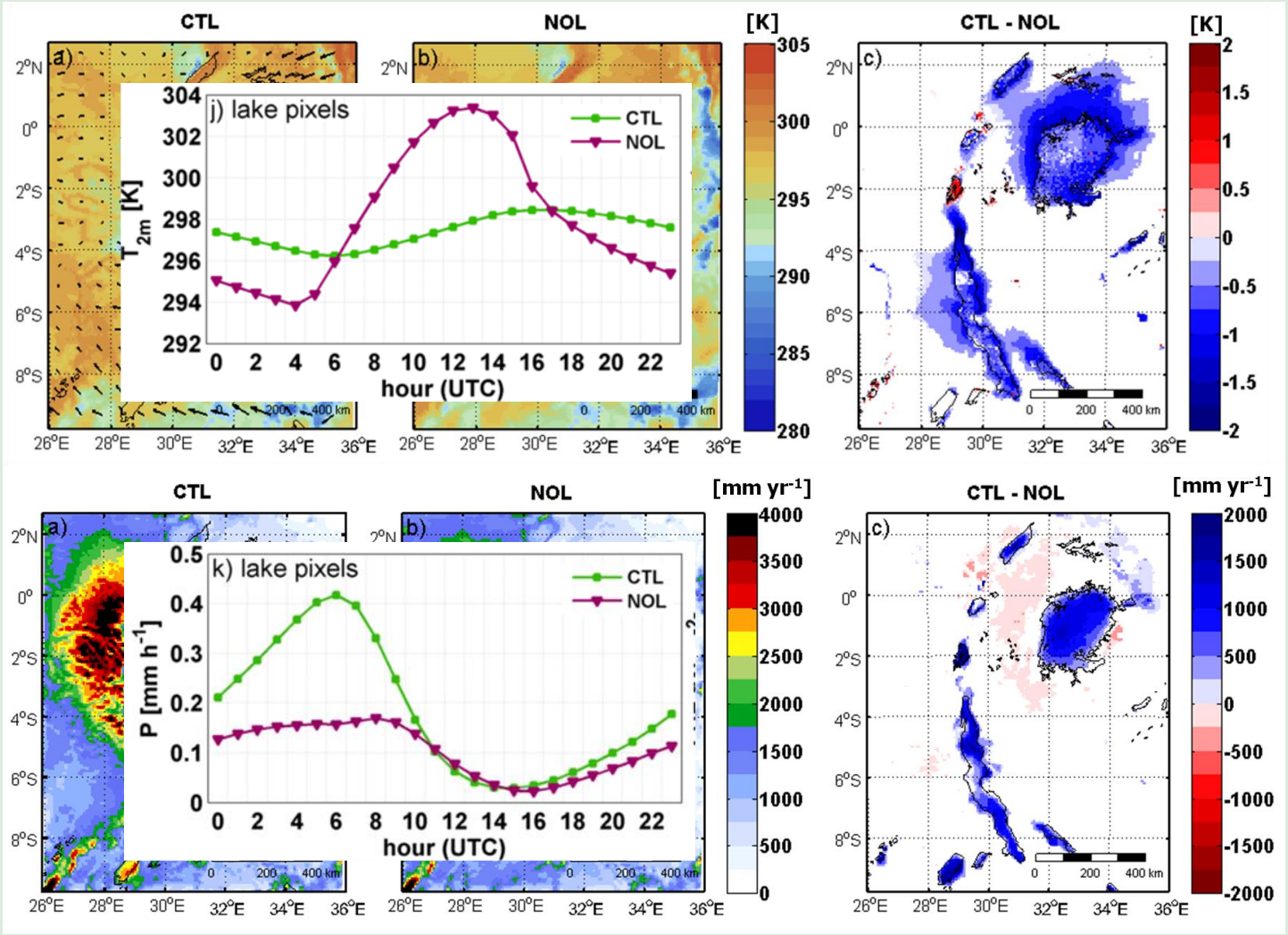
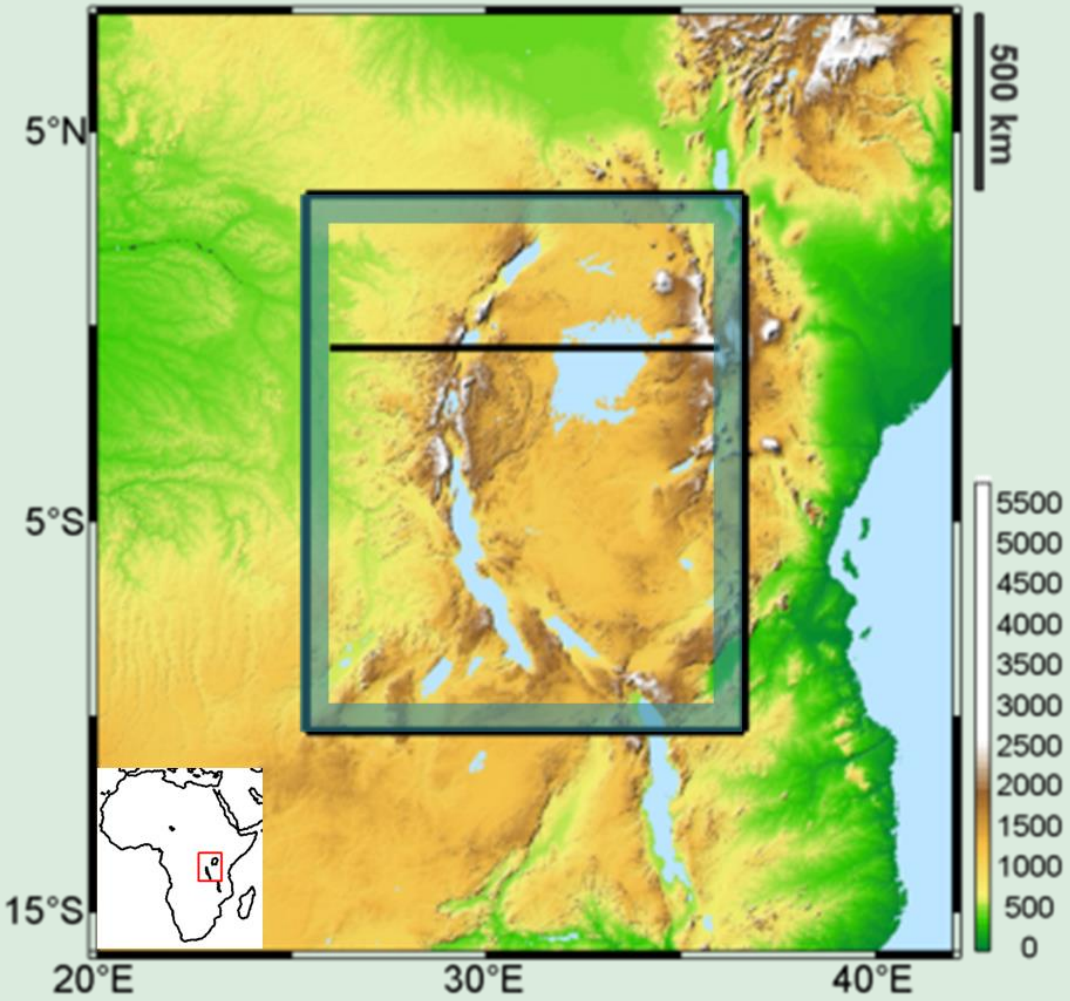
AGL impact on the mean climate

T_{2m}

Precipitation



Cross section



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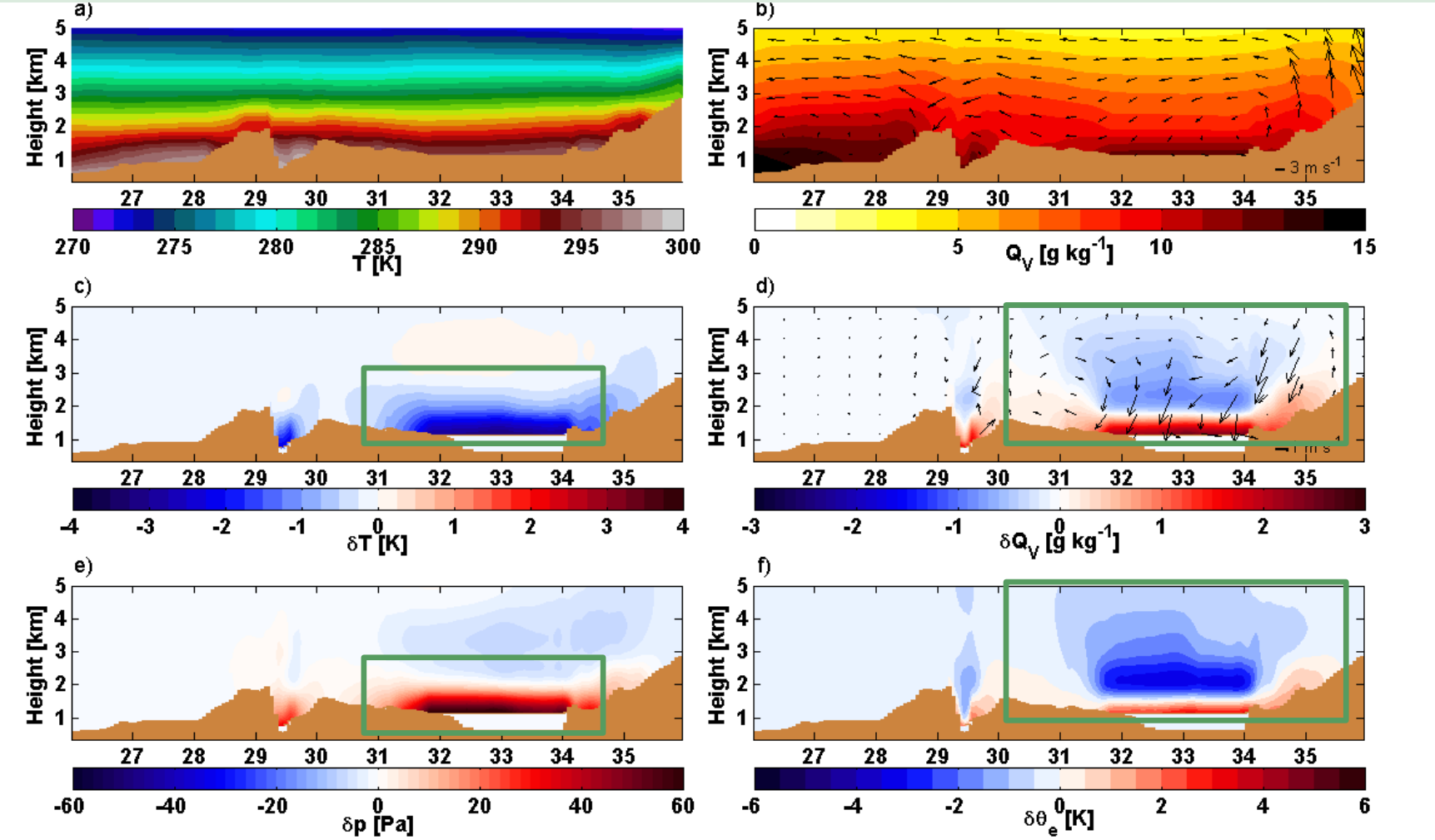
Dynamical response: daytime

CTL

CTL - NOL



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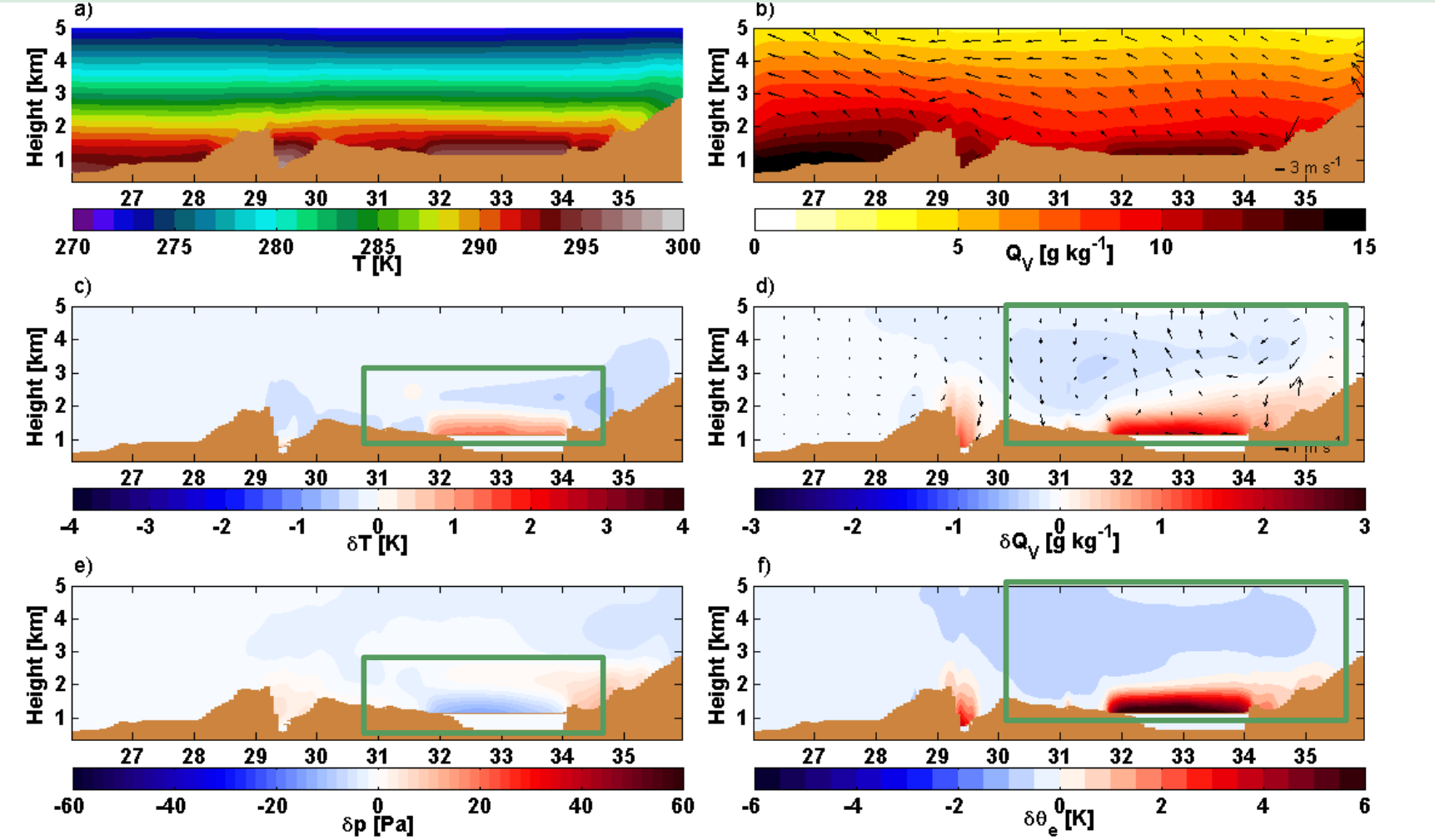
Dynamical response: night-time

CTL

CTL - NOL



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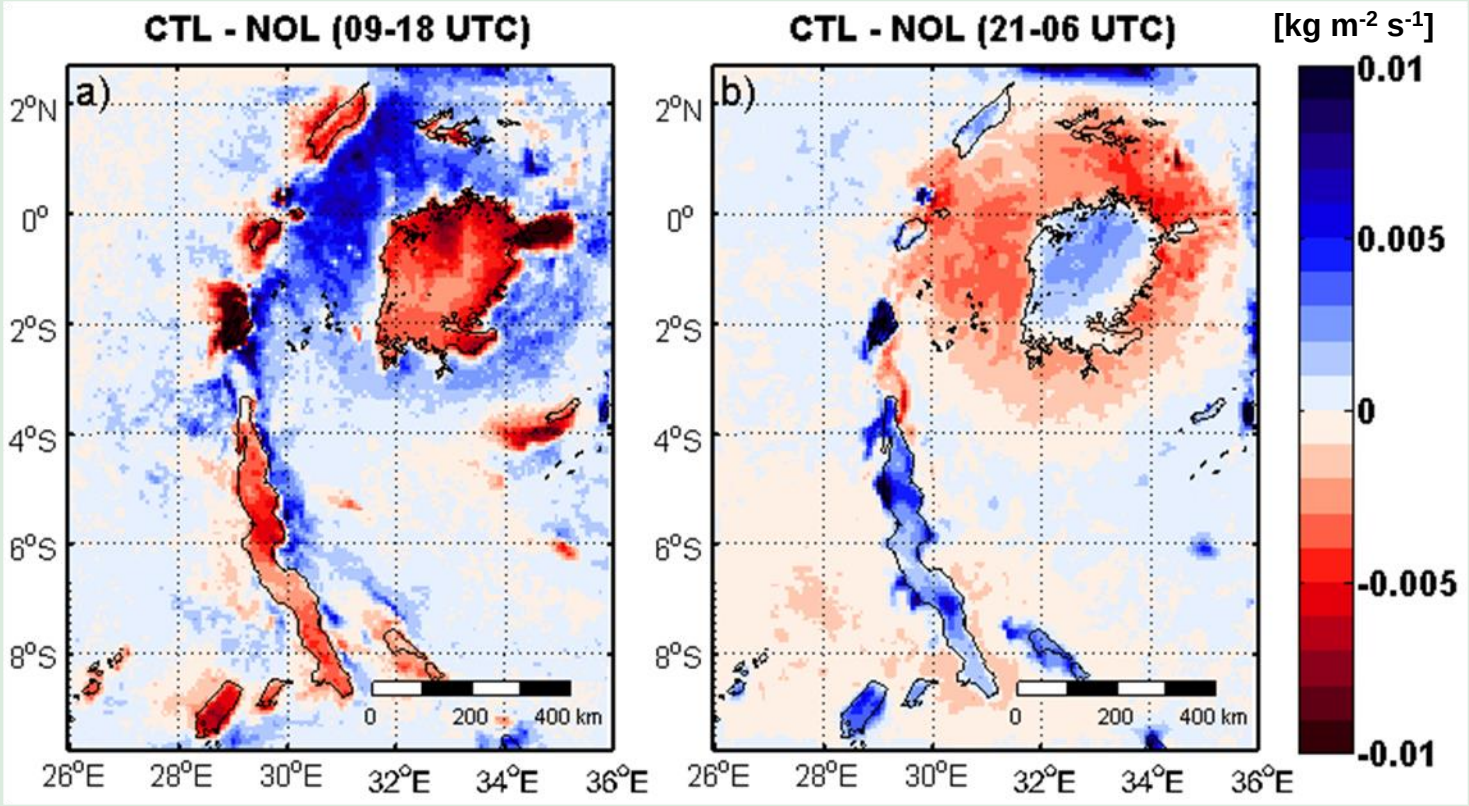
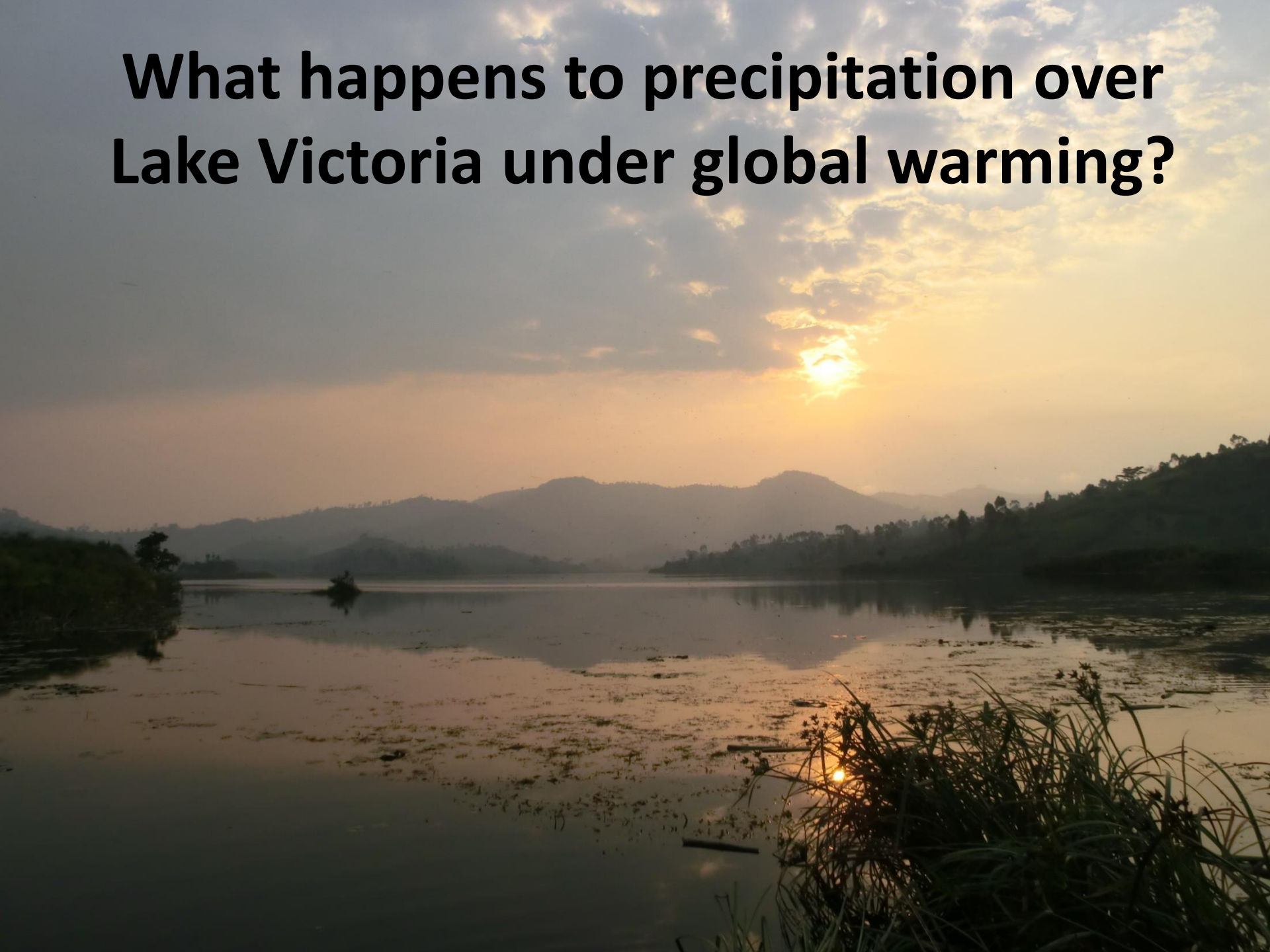
Change in convective mass flux density at cloud base height



What happens to precipitation over Lake Victoria under global warming?



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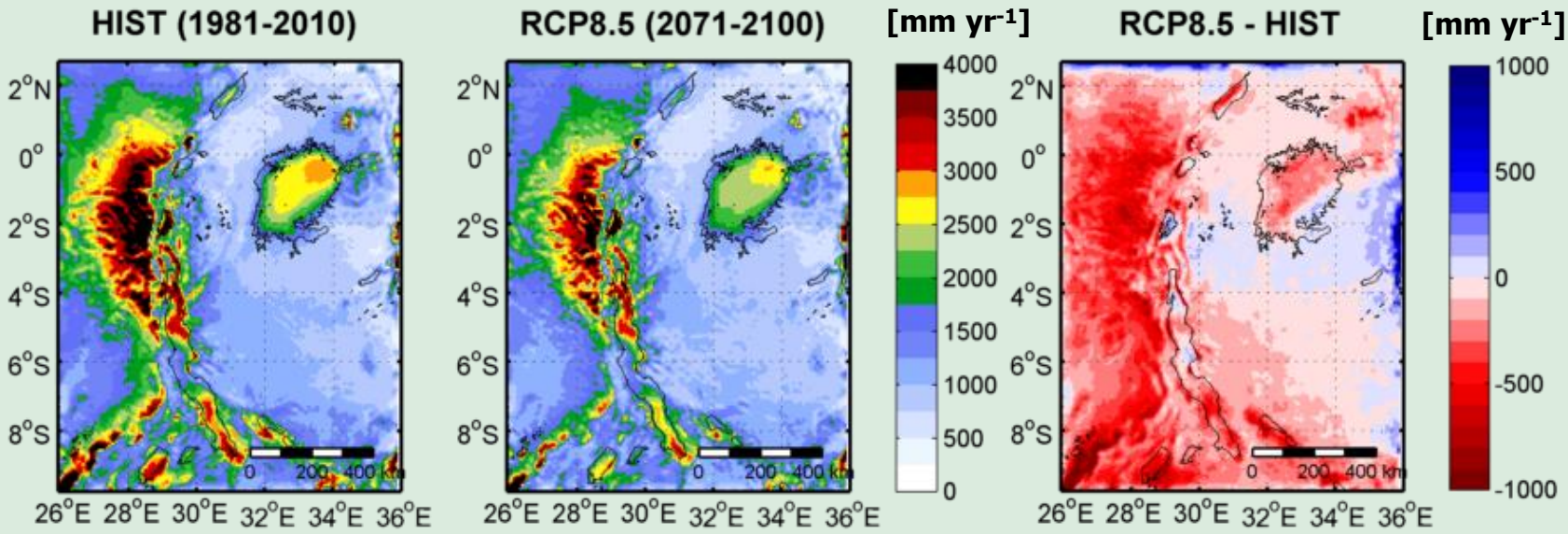
Precipitation under climate change

Precipitation



Domain: - 7.95 %
AGL : -7.46 %

IPCC AR5 (EAF, 14SM-36): + 11%
(-11% - +34%)

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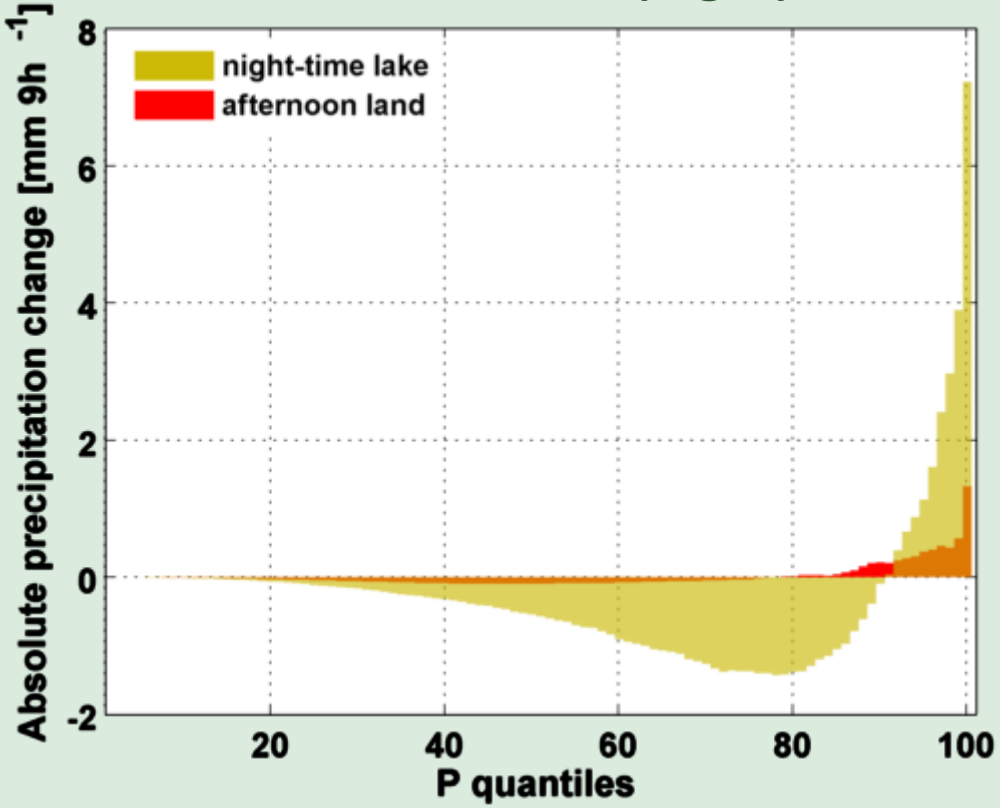
Quantile change: night-time lake precip (LV)

RCP8.5 - HIST (night)



1. robust?
2. why?

“extremes become more extreme” amplified over LV

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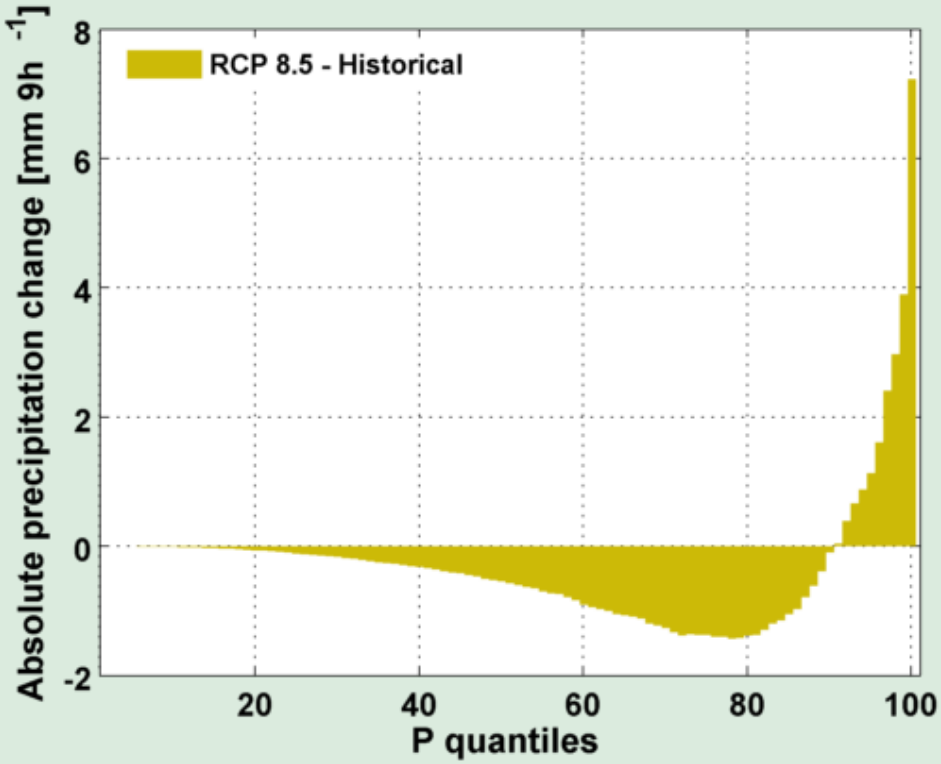
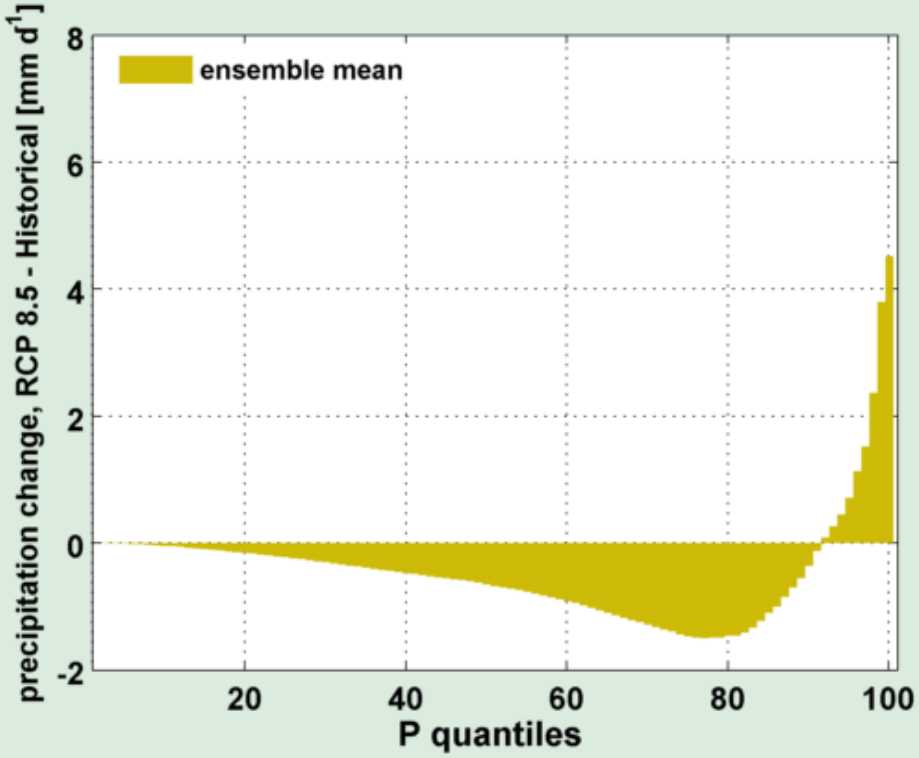
1. Our simulations are robust

CCLM² (lake, night)



CORDEX ensemble (lake, 24h)



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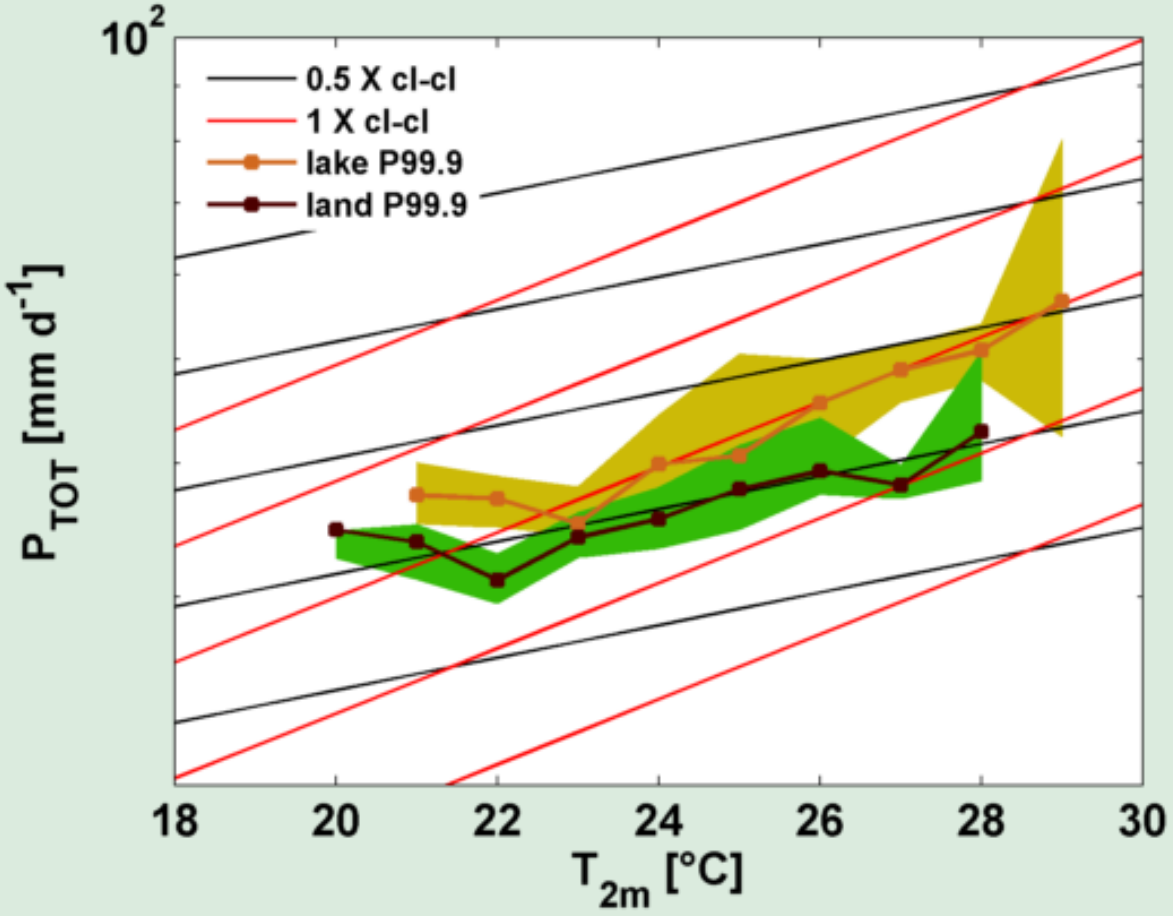
Clausius-Clapeyron scaling

CORDEX ensemble (FLake members only)



Thank you for your attention

Thiery, W., Davin, E.L., Panitz, H.-J., Demuzere, M., Lhermitte, S., and van Lipizg, N.P.M.:
The impact of the African Great Lakes on the regional Climate, J. Climate, in review.

Acknowledgements: FWO, BELSPO

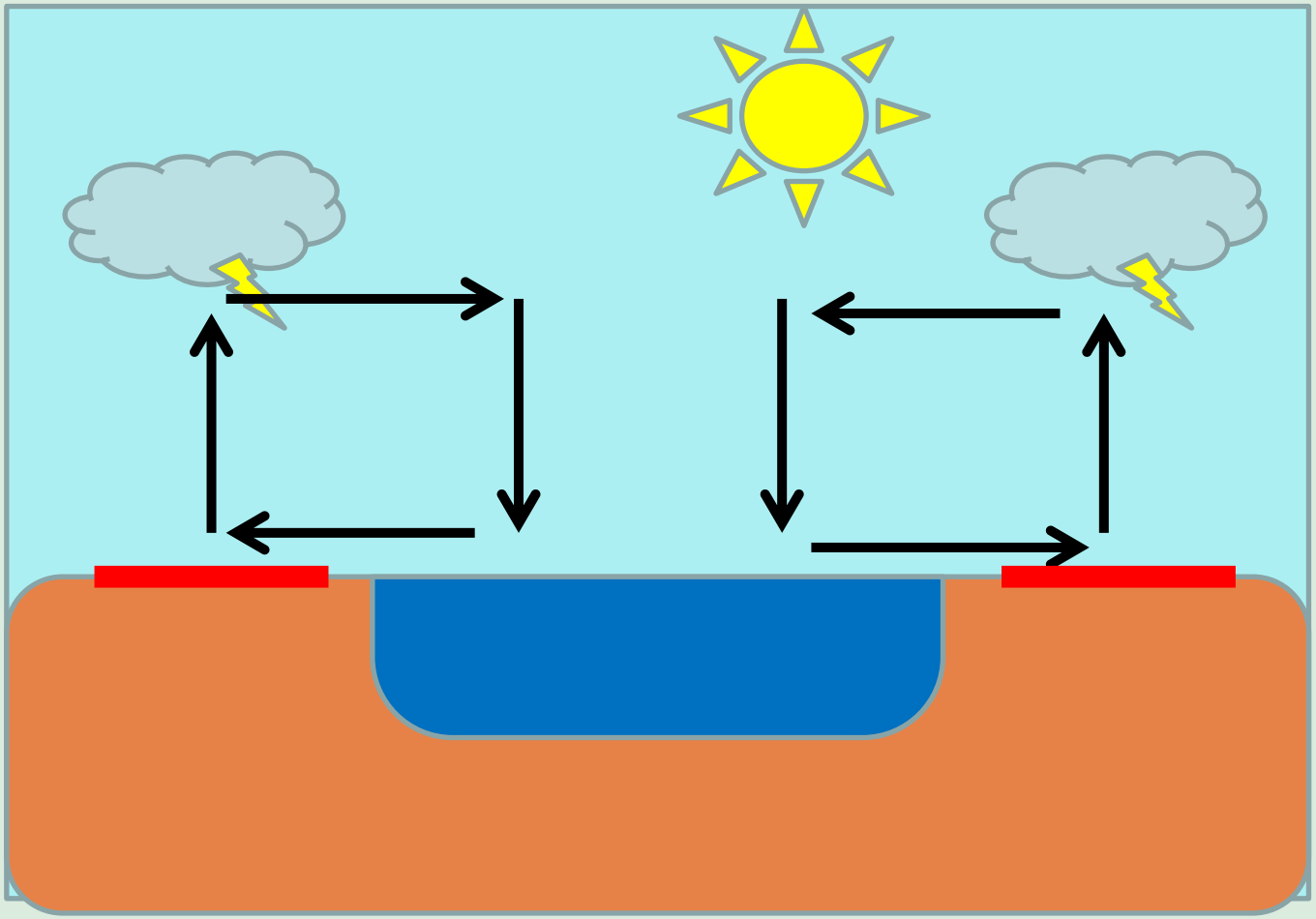
wim.thiery@ees.kuleuven.be

Conclusions

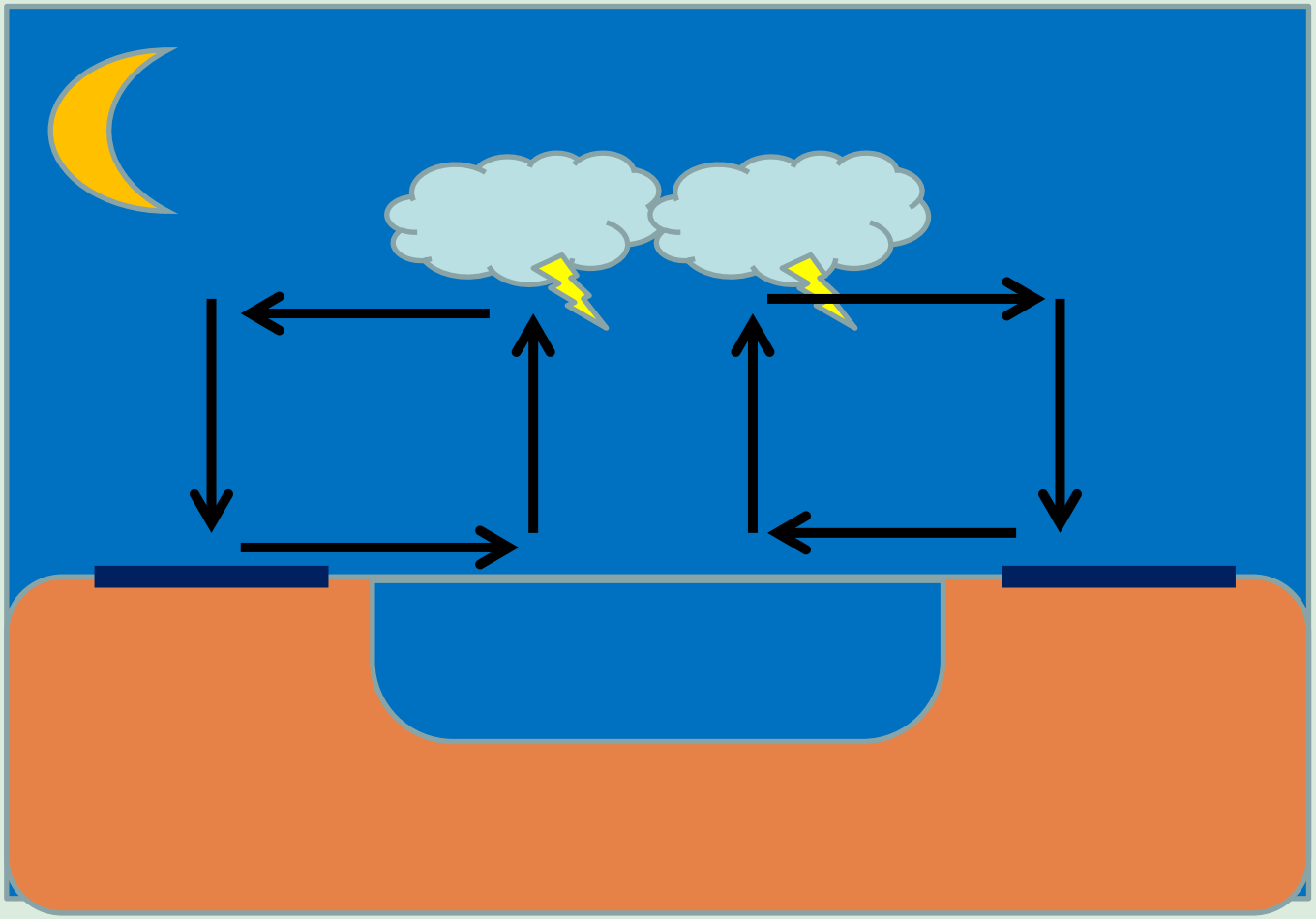
- Mean climate
  - CCLM² 0.0625° simulation outperforms state-of-the art reanalysis and RCM simulation.
  - AGL exert profound influence on near-surface temperature and precipitation…
  - … through its impact on the SEB and mesoscale circulation

- Extremes and climate change
  - LV extremes will become more intense under global warming
  - this result is robust and more pronounced compared to surrounding land
  - reduced divergence is hypothesized as the main cause for triggering extremes
  - future decrease of this gradient is possibly the cause for more intense extremes

Lake breeze



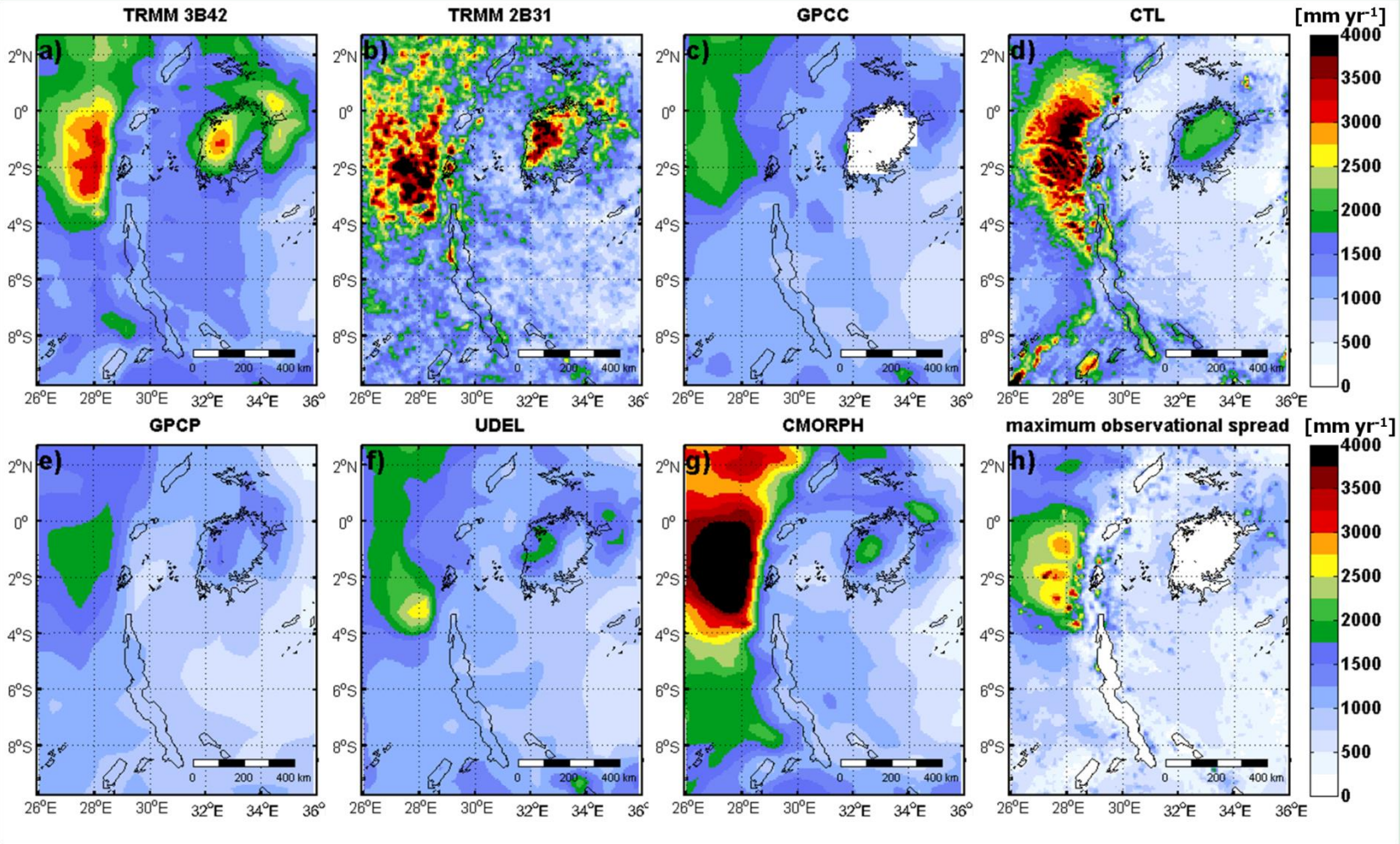
Land breeze



COSMO-CLM 4.8

CLM 3.5 FLake

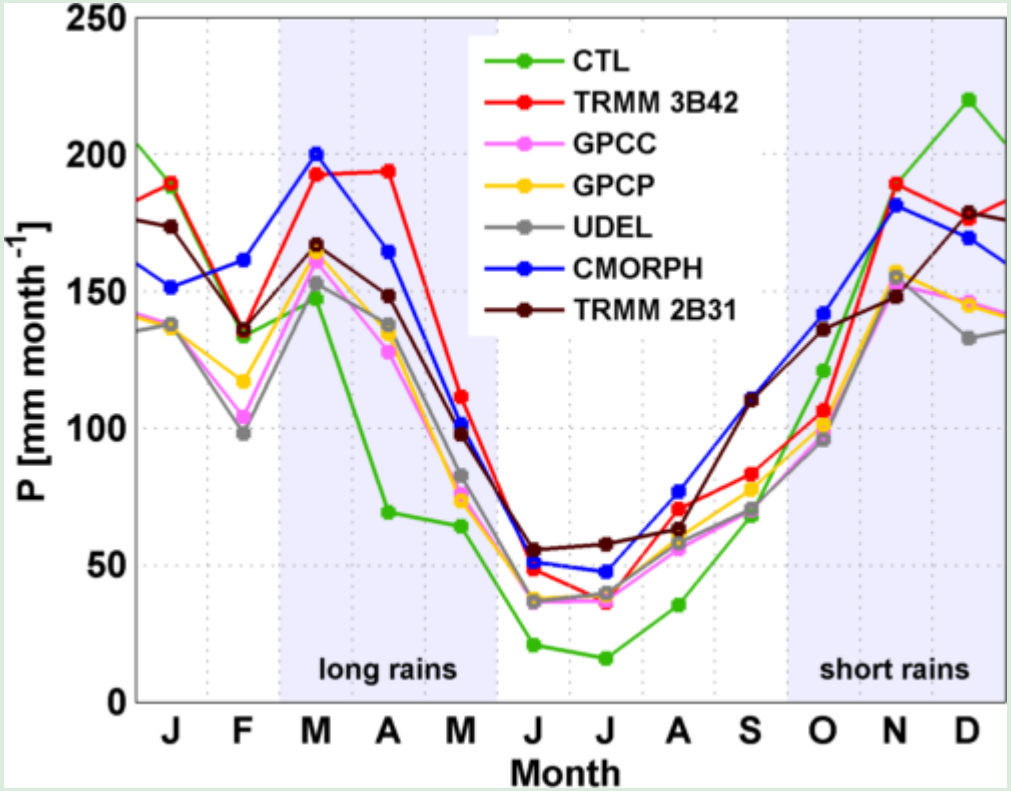
Evaluation: precipitation



COSMO-CLM 4.8

CLM 3.5 FLake

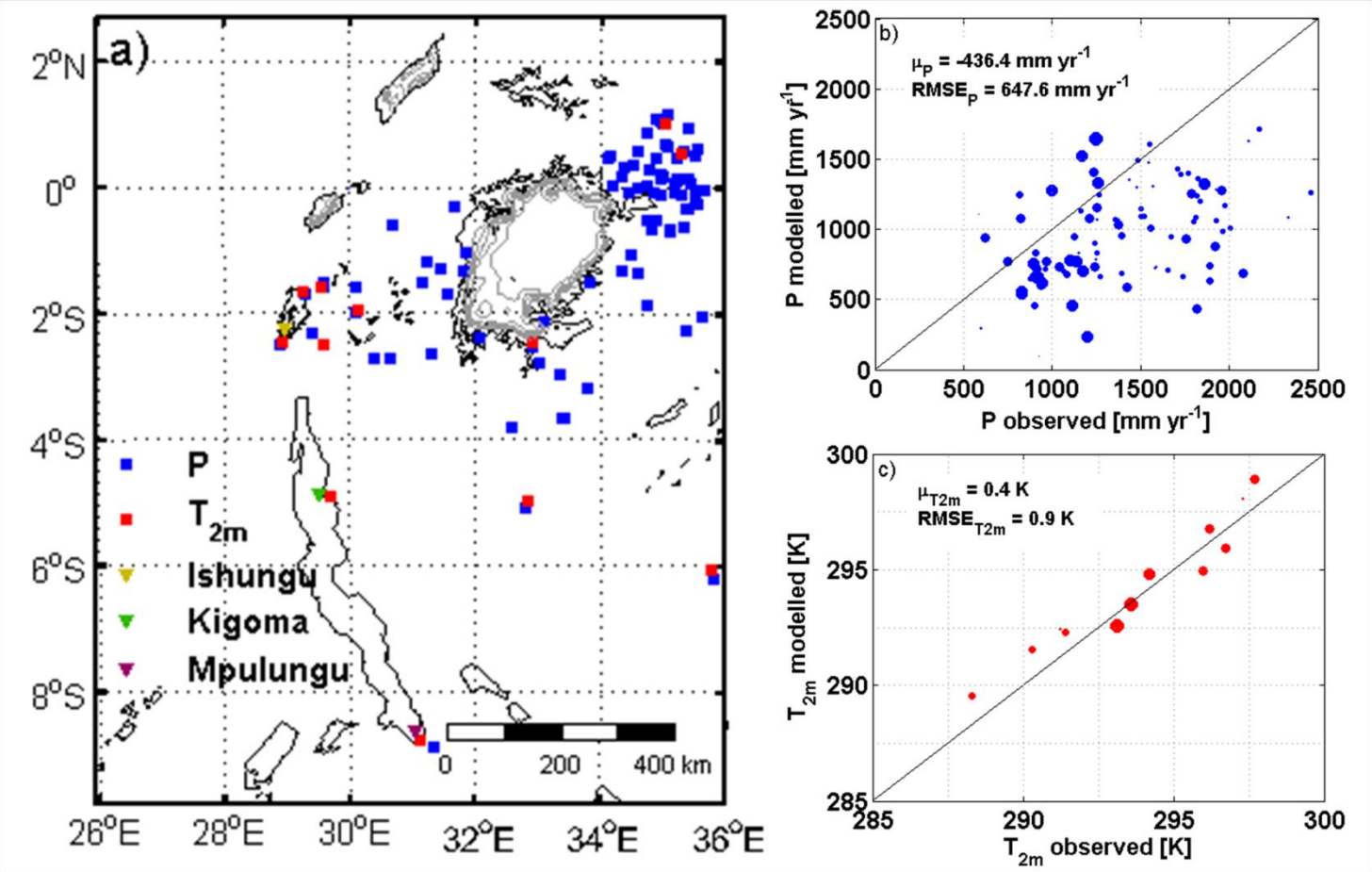
Evaluation: precipitation

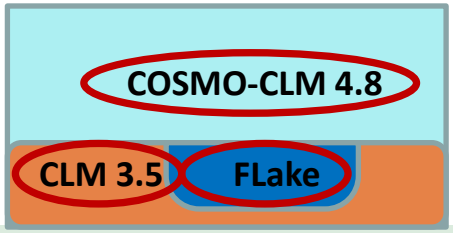


COSMO-CLM 4.8

CLM 3.5 FLake

Evaluation: precipitation





Evaluation: precipitation

CTL ERA-Interim CORDEX

Physical quantity [Units]	COSMO-CLM²		ERA-Interim		CORDEX	
	bias	RMSE	bias	RMSE	bias	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 6 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.

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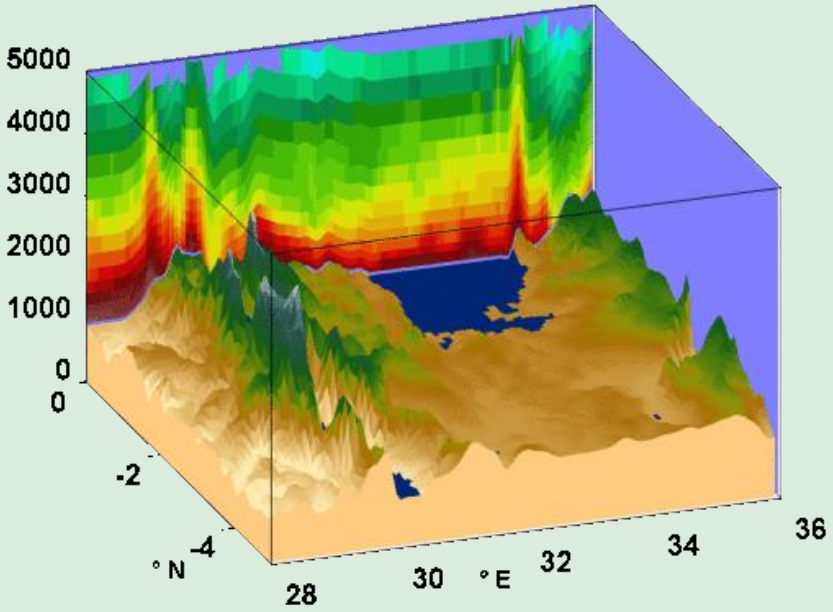
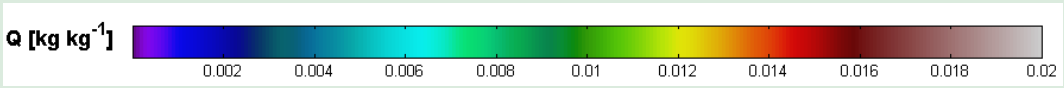
Added value of our simulations



"CTL"



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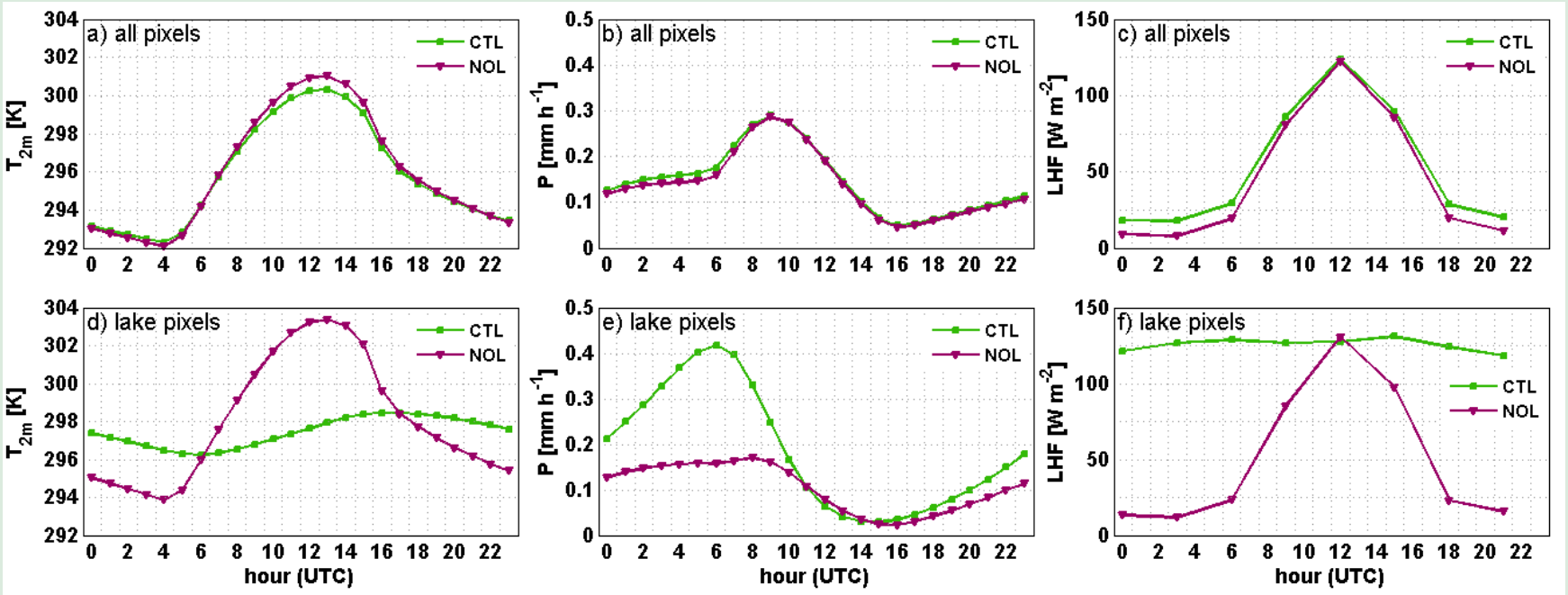
AGL impact on the diurnal cycle

T_{2m} | precipitation | LHF

All pixels

Lake pixels



SEB decomposition

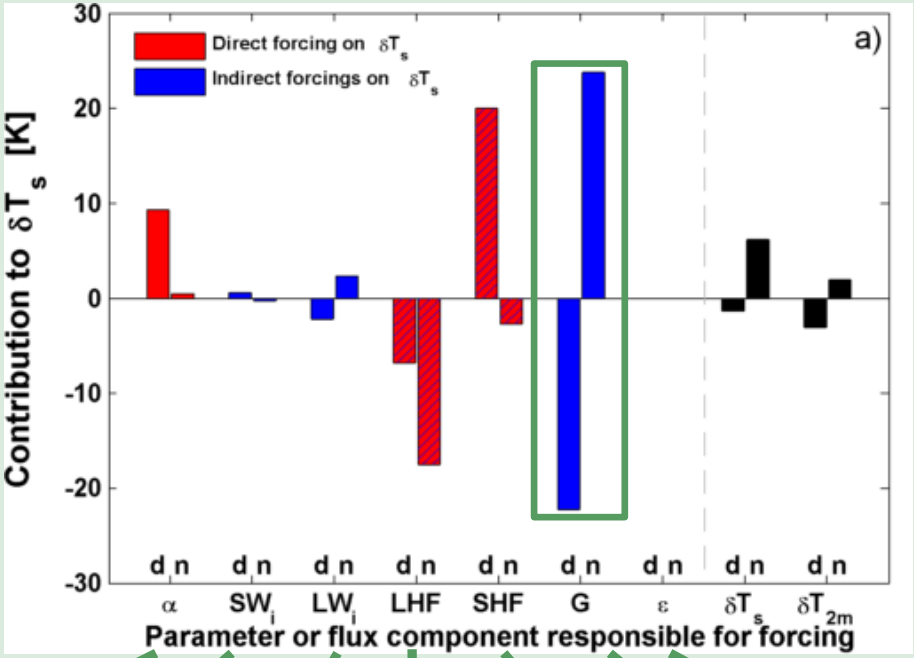
$$\epsilon\sigma T_s^4 = (1-\alpha)SW_{in} + LW_{in} - LHF - SHF - G$$

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

(Akkermans, Thiery & van Lipzig, JC 2014)

SEB decomposition: day-night contrast

Lake pixels



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

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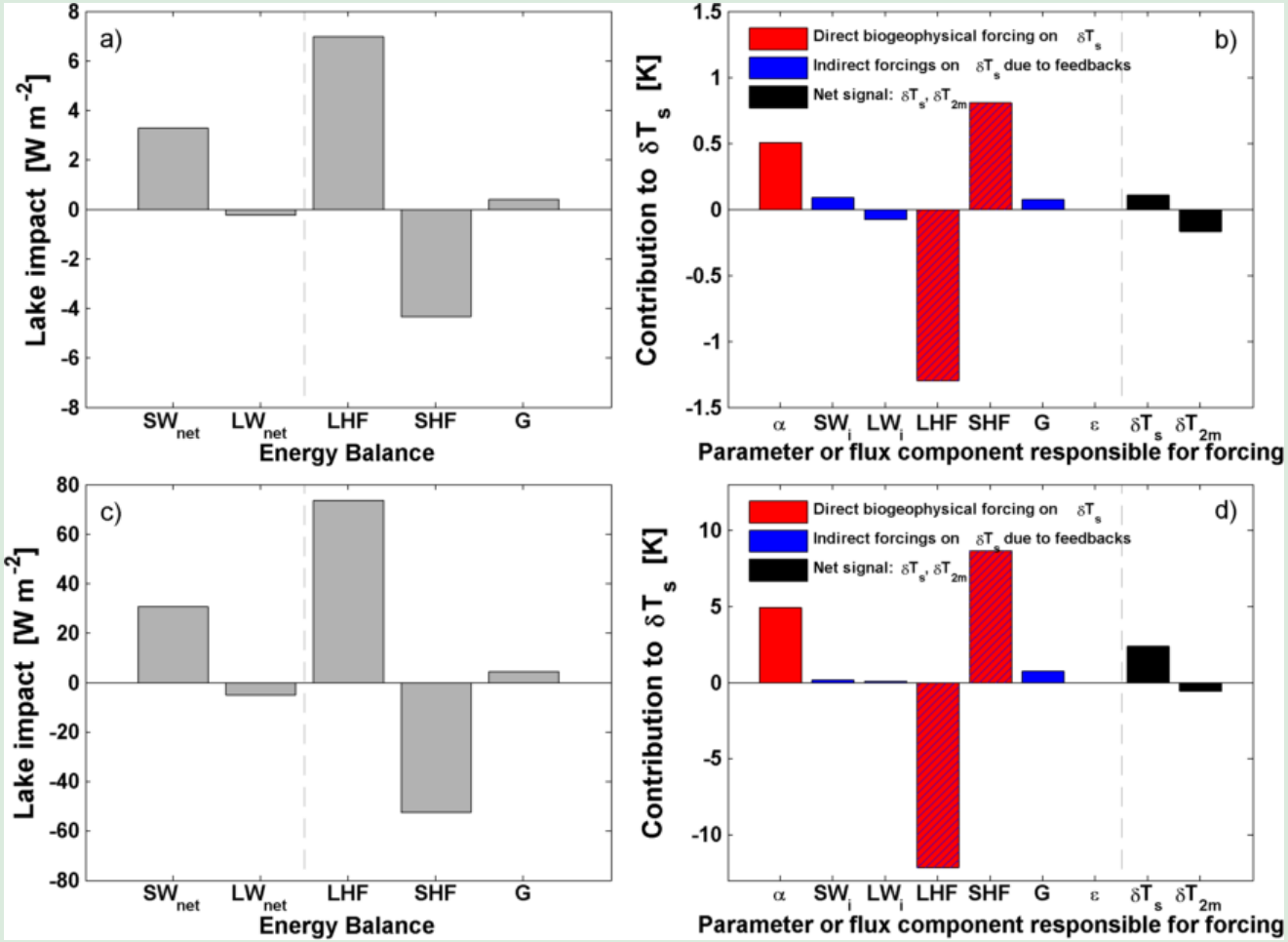
SEB decomposition

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

All pixels

Lake pixels



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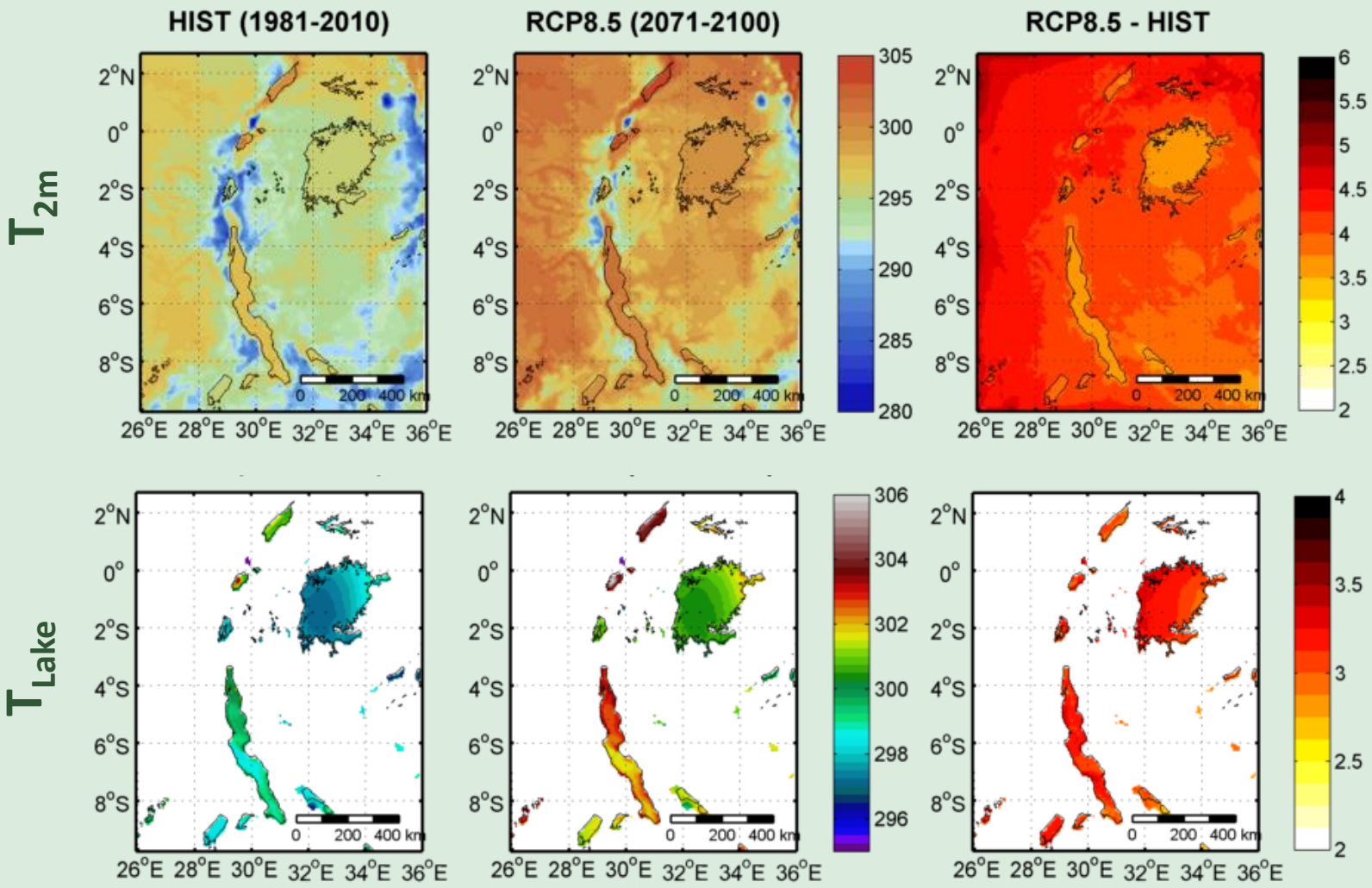
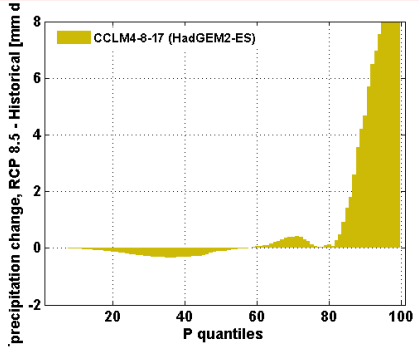
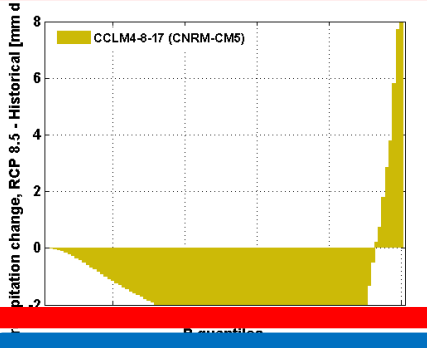
Climate change: temperature [K]

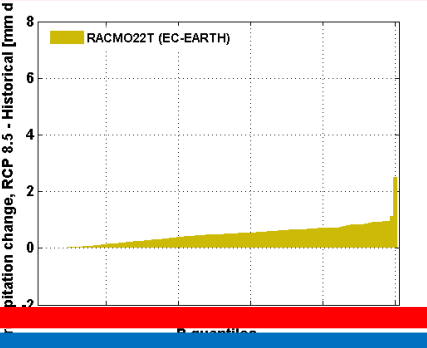


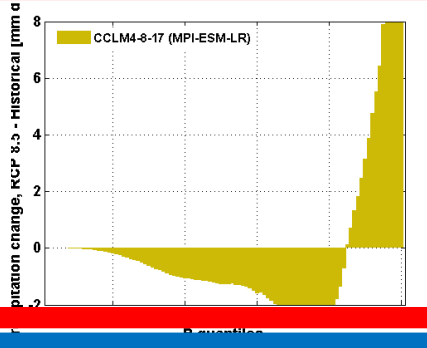
Domain: + 4.16°C
AGL : + 3.74°C

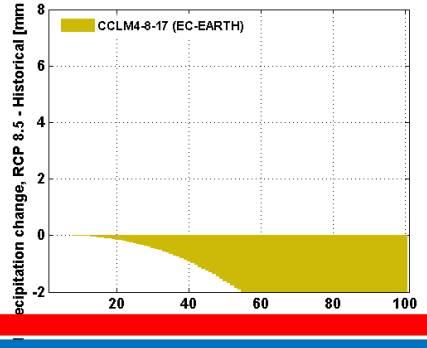
IPCC AR5 : + 4.0°C
(+2.4°C - +5.6°C)

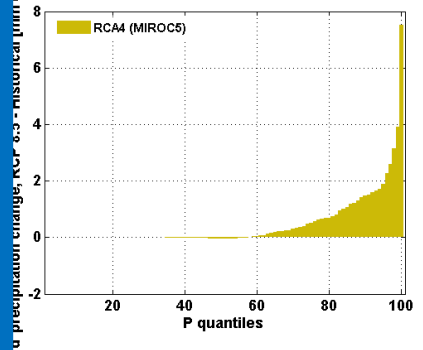

CCLM4-8-17 (HadGEM2-ES)
P quantiles

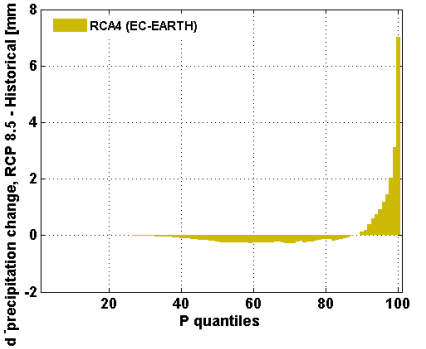

CCLM4-8-17 (CNRM-CM5)
P quantiles

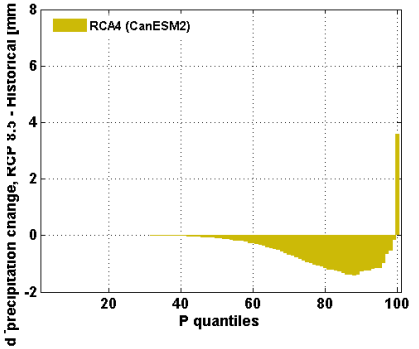

RACMO22T (EC-EARTH)
P quantiles

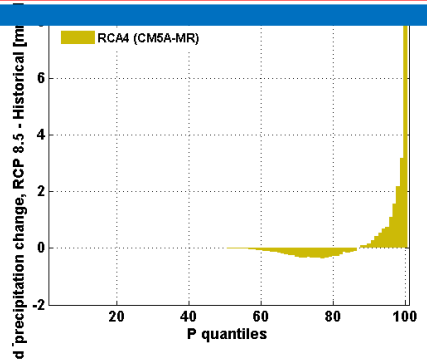

CCLM4-8-17 (MPI-ESM-LR)
P quantiles

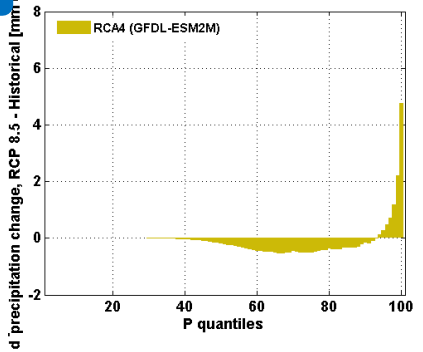

CCLM4-8-17 (EC-EARTH)
P quantiles

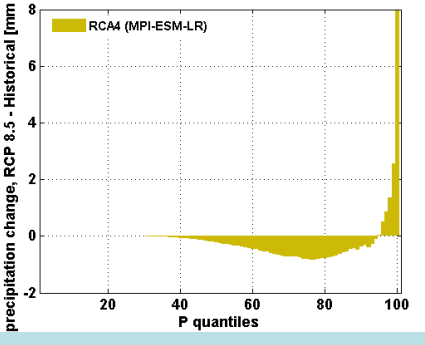

RCA4 (MIROC5)
P quantiles

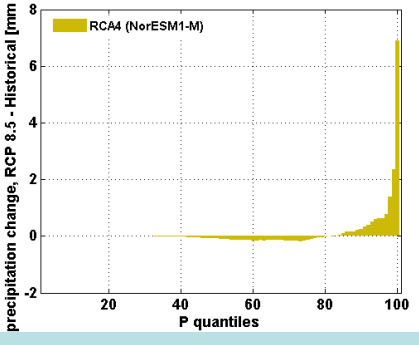

RCA4 (EC-EARTH)
P quantiles

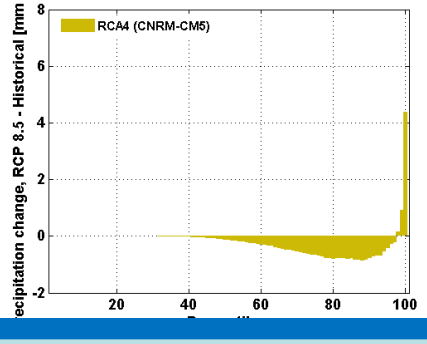

RCA4 (CanESM2)
P quantiles

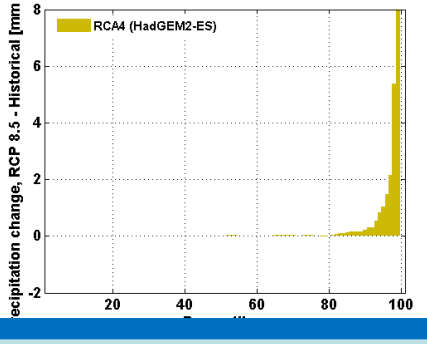

RCA4 (CM5A-MR)
P quantiles


RCA4 (GFDL-ESM2M)
P quantiles


RCA4 (MPI-ESM-LR)
P quantiles


RCA4 (NorESM1-M)
P quantiles


RCA4 (CNRM-CM5)
P quantiles


RCA4 (HadGEM2-ES)
P quantiles

FLake

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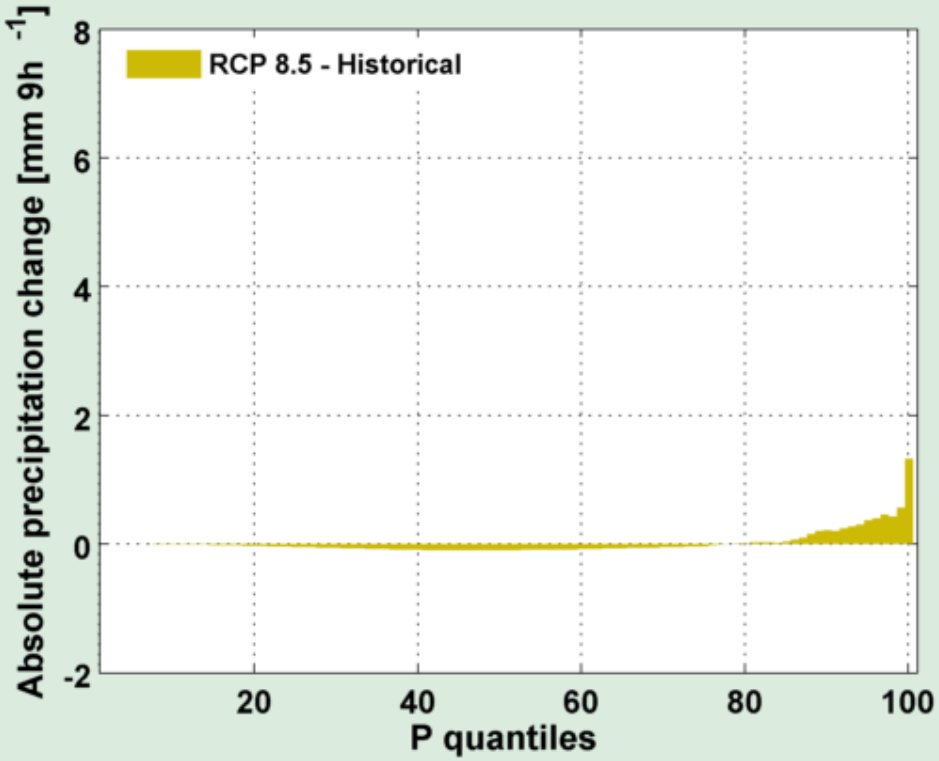
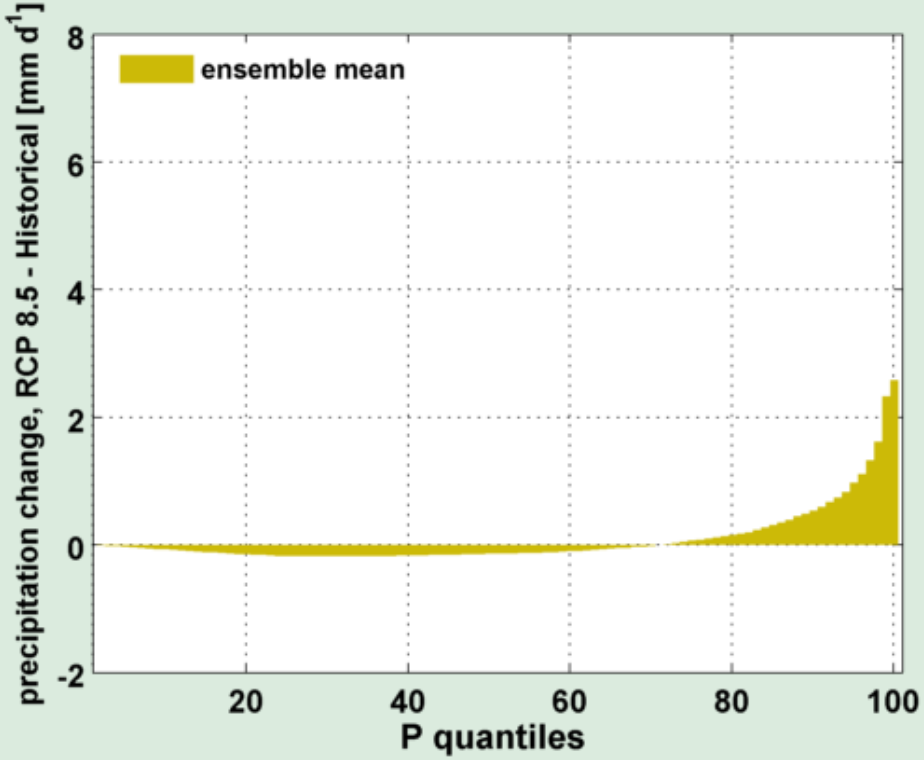
Less happening during over land

CCLM² (land, day)



CORDEX ensemble (land, 24h)



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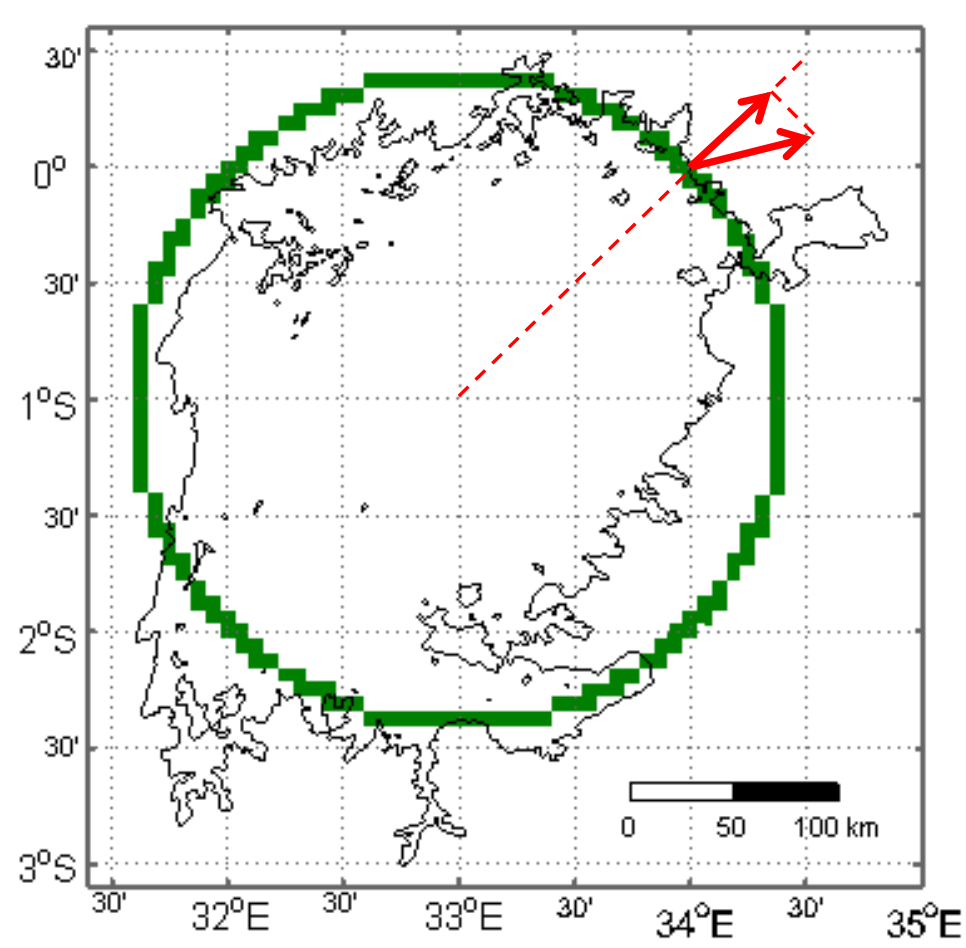
"Lake breeze strength"



Temperature gradient, now and in the future

CCLM² (daytime temperature contrast binned from night-time lake precipitation)