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Testing the representation of the African Great lakes in COSMO's lake module (FLake)

Evaluation, sensitivity and controlling variables

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Motivation & Objectives

- large lakes have a significant impact on regional climate
- even though FLake has become a landmark for lake parameterisation in RCM's (e.g. Mironov et al., 2010; Martynov et al., 2011), it has never been tested for tropical conditions
- test model performance over lake Kivu and lake Tanganyika and understand seasonal & spatial variability
- consortium of biogeochemists and ecologists working on lake Kivu need reliable information on climate change impact on the lake's mixing regime

Sensitivity of a GCM Simulation to Inclusion of Inland Water Surfaces

GORDON B. BONAN

Modeling the impact of global warming on water temperature and seasonal mixing regimes in small temperate lakes

Georgiy Kirillin

Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa

Catherine M. O'Reilly[1]*, Simone R. Alin[1]*, Pierre-Denis Plisnier[2], Andrew S. Cohen[1] & Brent A. McKee[3]

Diffusive methane emissions to the atmosphere from Lake Kivu (Eastern Africa)

A. V. Borges,[1] G. Abril,[2,3] B. Delille,[1] J.-P. Descy,[4] and F. Darchambeau[1,4]

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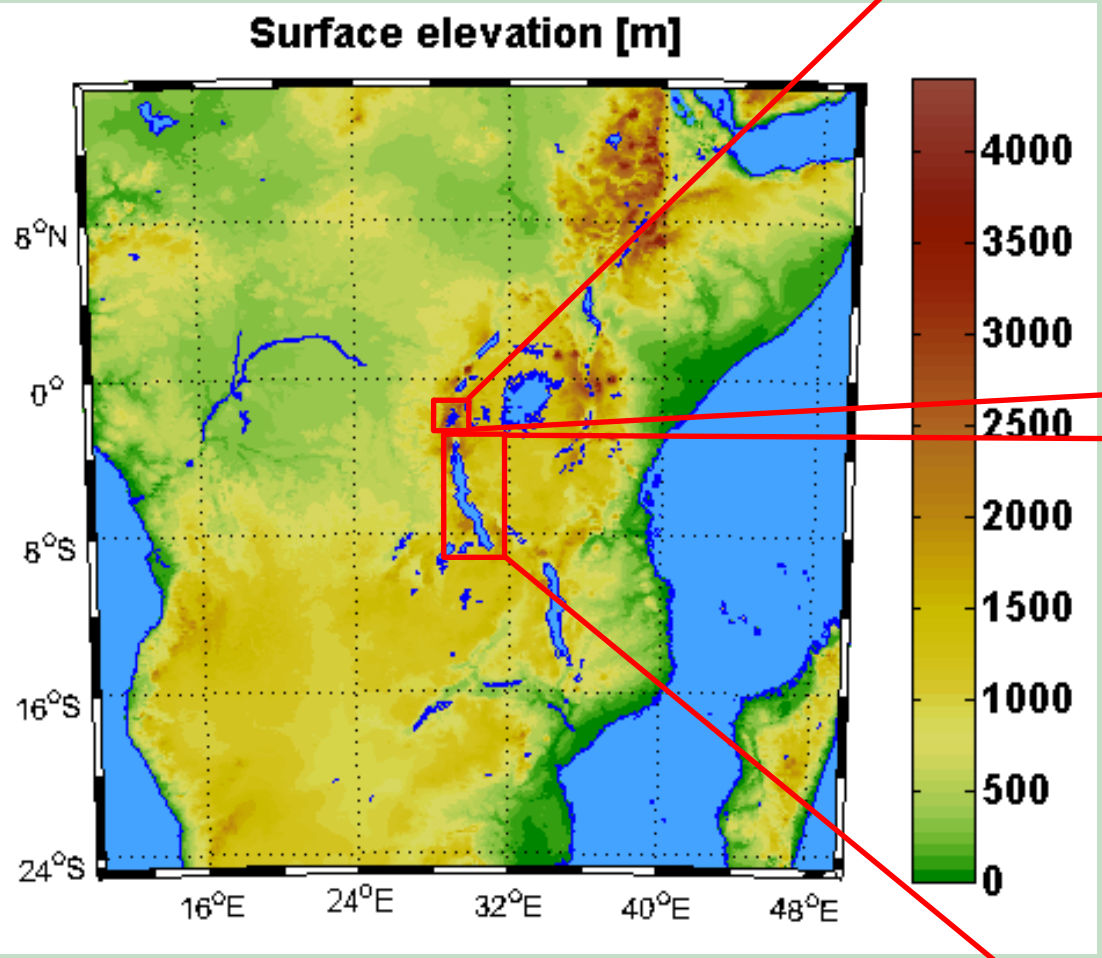
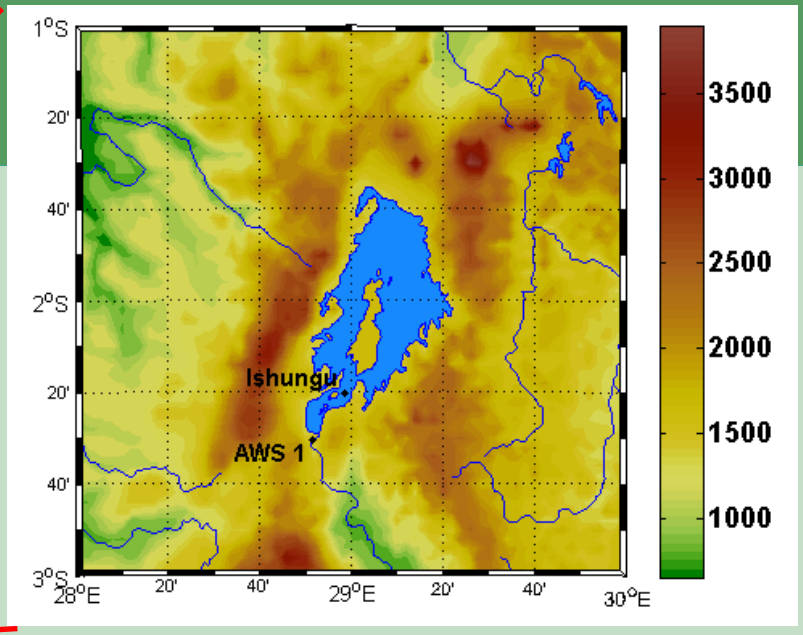
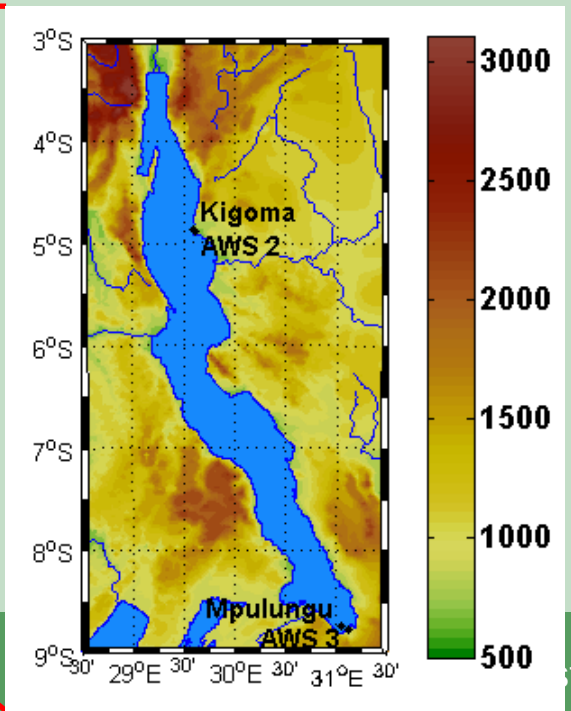
Location







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Method: AWS drives FLake

- Bukavu: *u* corrected, since:
  - land effect biases observations
  - climatology removes extremes large lakes have a significant impact on regional climate
  - trees upwind of AWS

$$u_{lake} = u_{land}\left(\frac{\ln\left(z_{lake}/z_{0,lake}\right)}{\ln\left(z_{land}/z_{0,land}\right)}\right) \approx u_{land}\,1.5$$

- data gaps: replaced by climatology
- *LWin* taken from Era-interim
- for comparison, also an Era-interim simulation was conducted for each location

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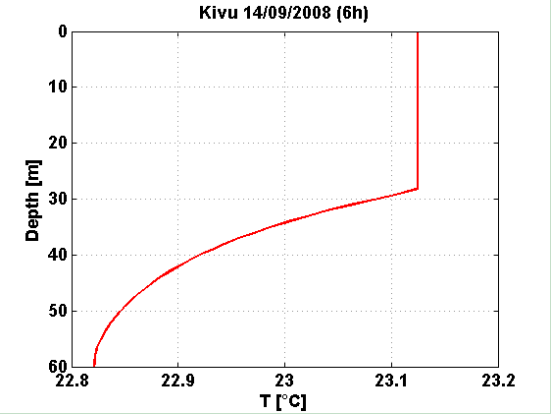
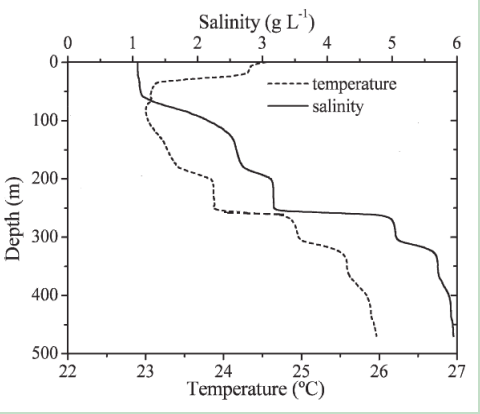
Method: FLake configuration

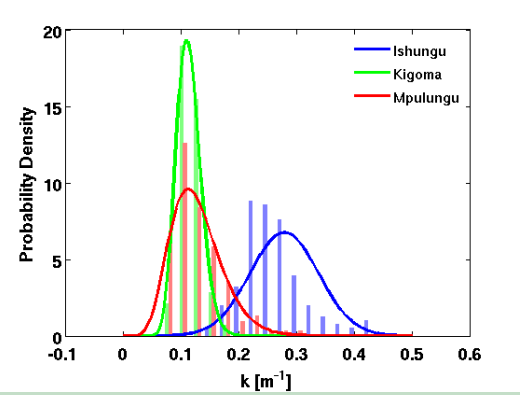
- FLake model:
  - 1D, two-layer bulk model
  - mixed layer: uniform T
  - thermocline: self-similarity of temperature-depth curve





(adapted from Schmid et al., 2010)

- FLake configuration:
  - salinity gradients force lake depth to 60m (100 m)
  - initialisation: climatological profile January
  - spin-up till convergence (9 – 30 yr)
  - *k* = 0.32 m-1 (0.09 m-1), tuned cfr. obs
  - no active sediments



- sensitivity analysis
  - pairwise perturbation of Lake Kivu's time series
  - compare to corresponding seasonal means

Evaluation: Monitoring programs

e.g. Ishungu:

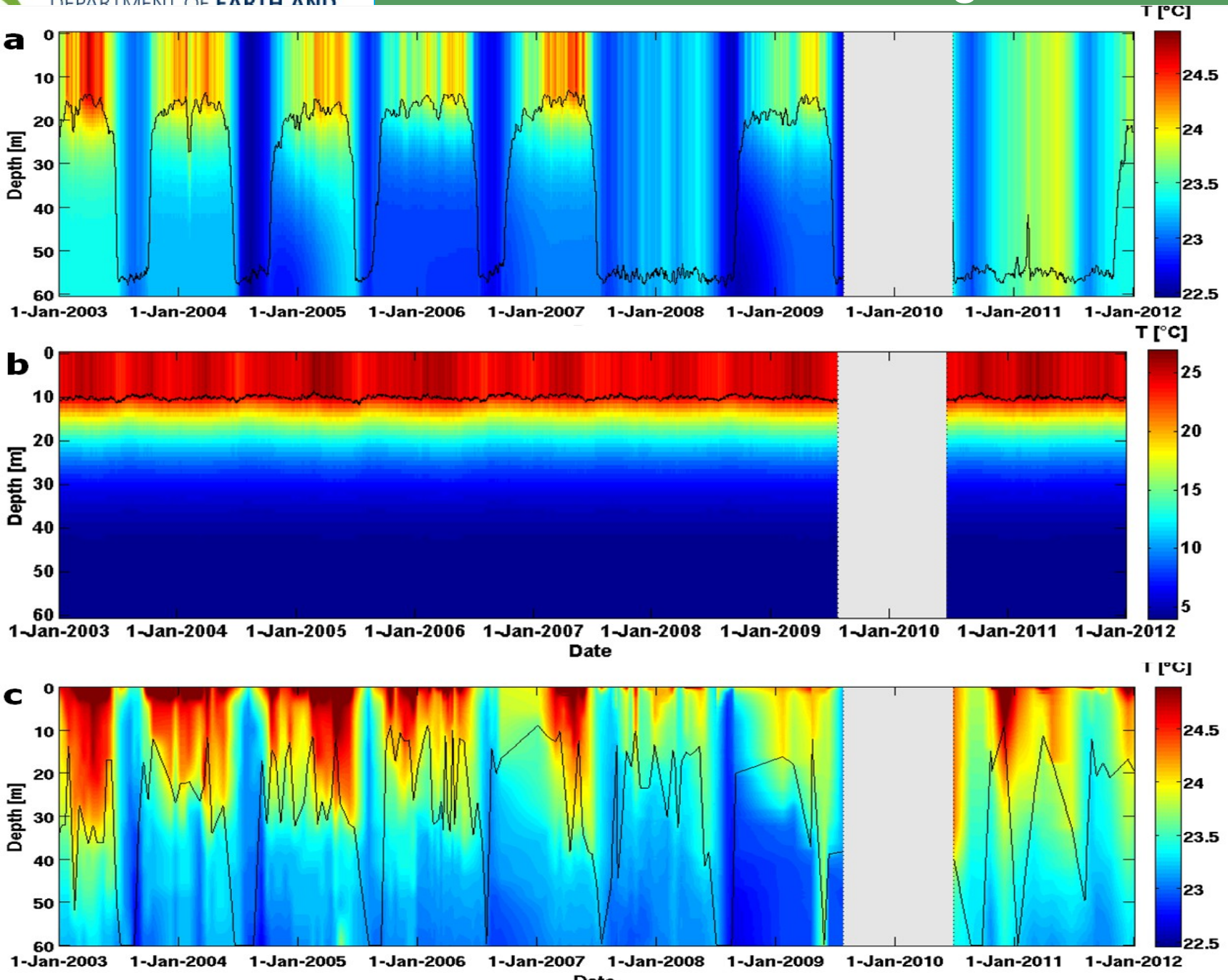
- bimonthly CTD cast since 2003 + cruises
- spline interpolation in vertical and time

Results: Ishungu

AWS

EI

Obs



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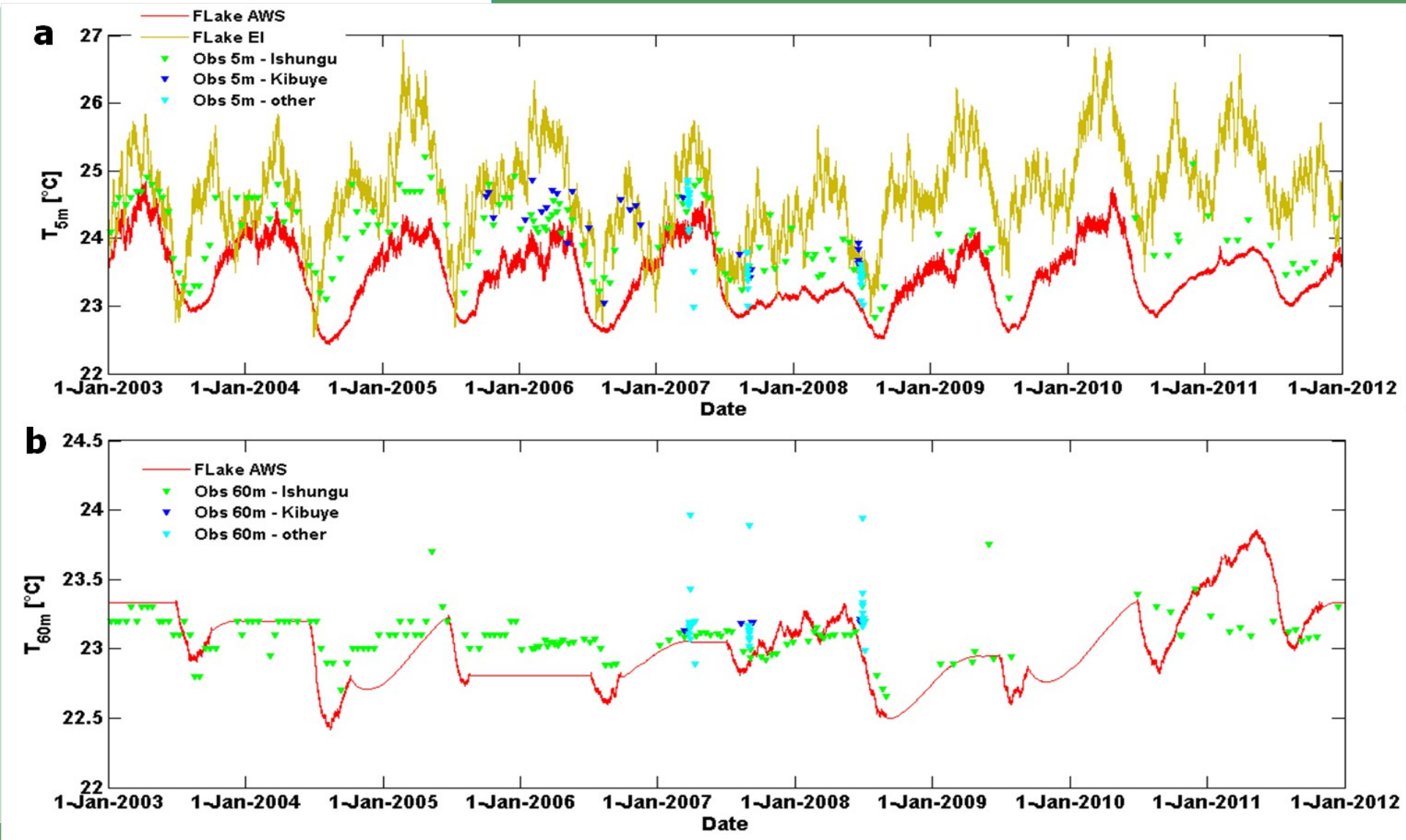
Results: Ishungu

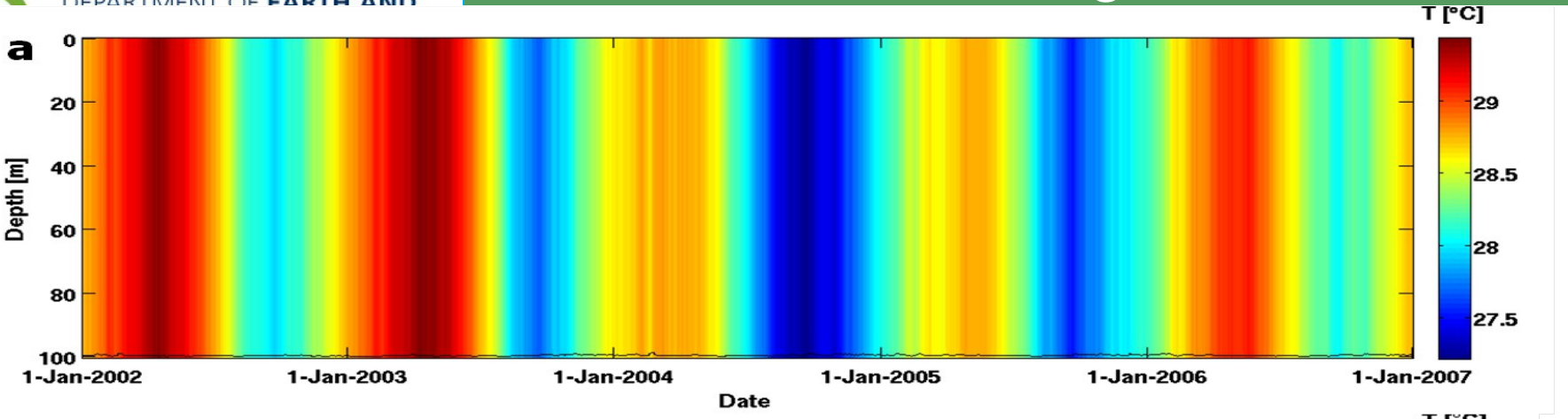


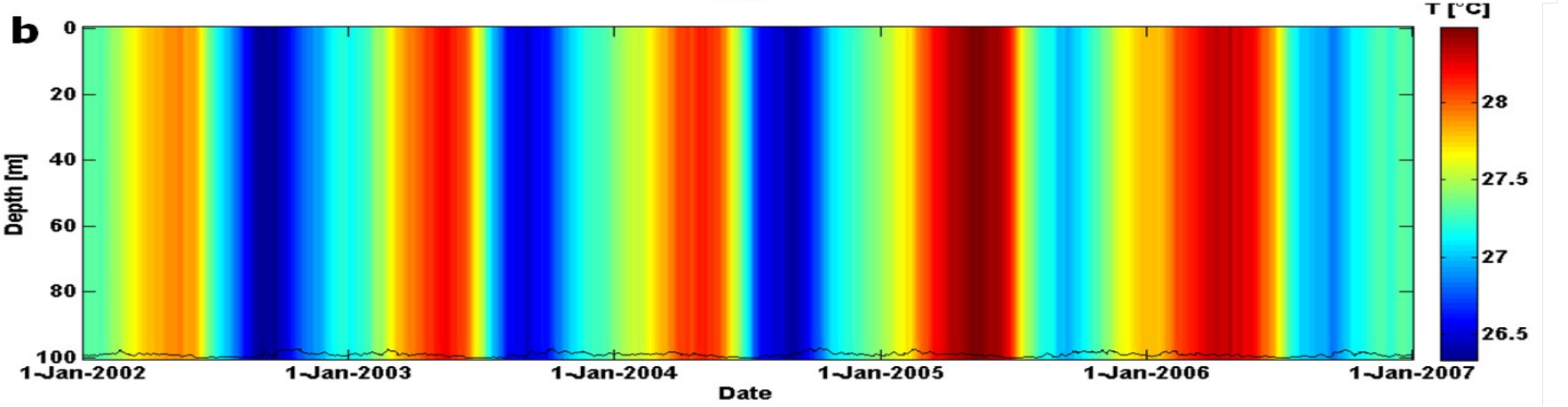
Results: Kigoma

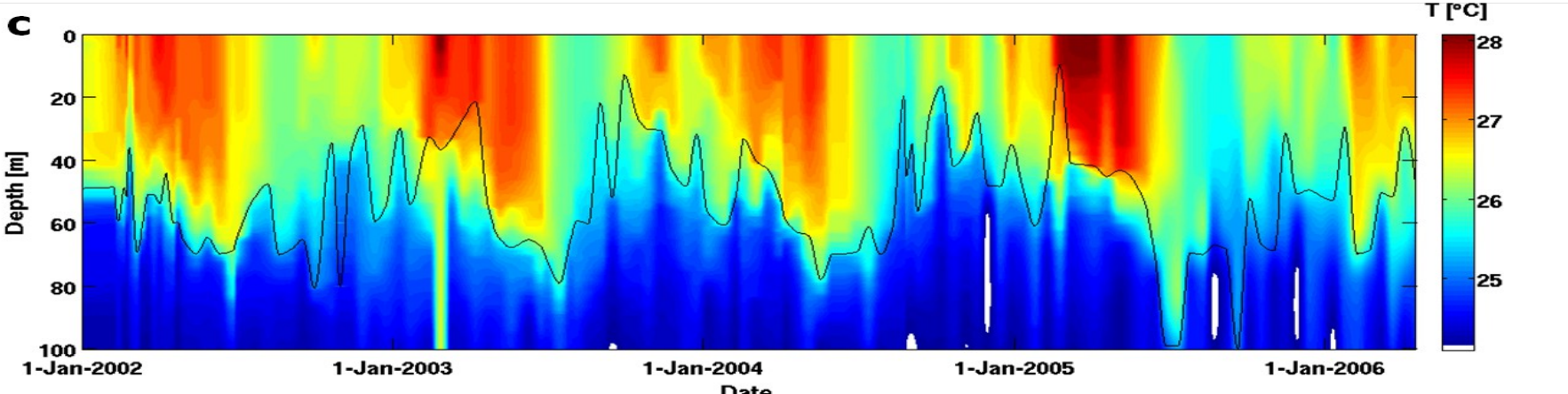
AWS

EI

Obs







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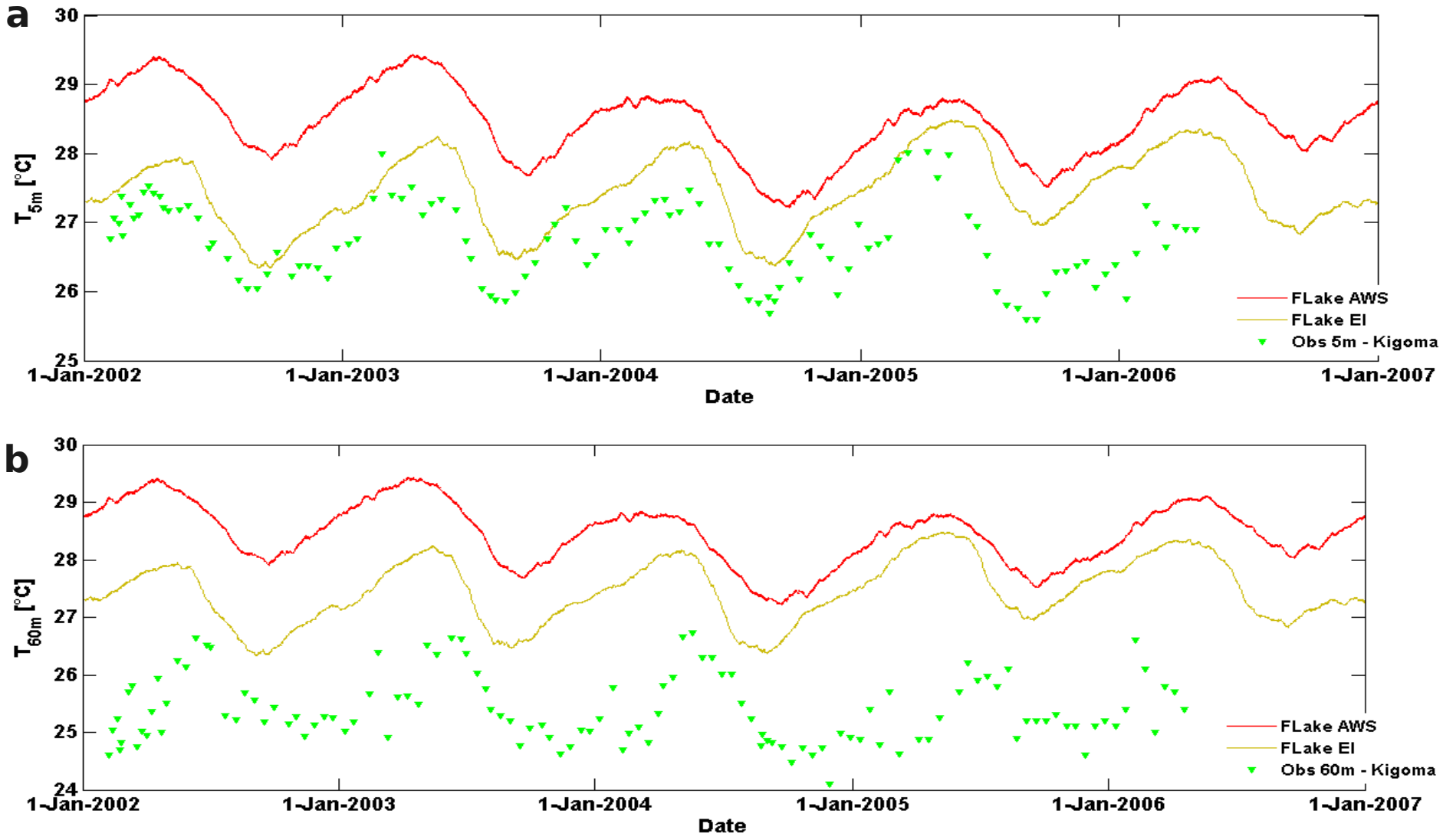
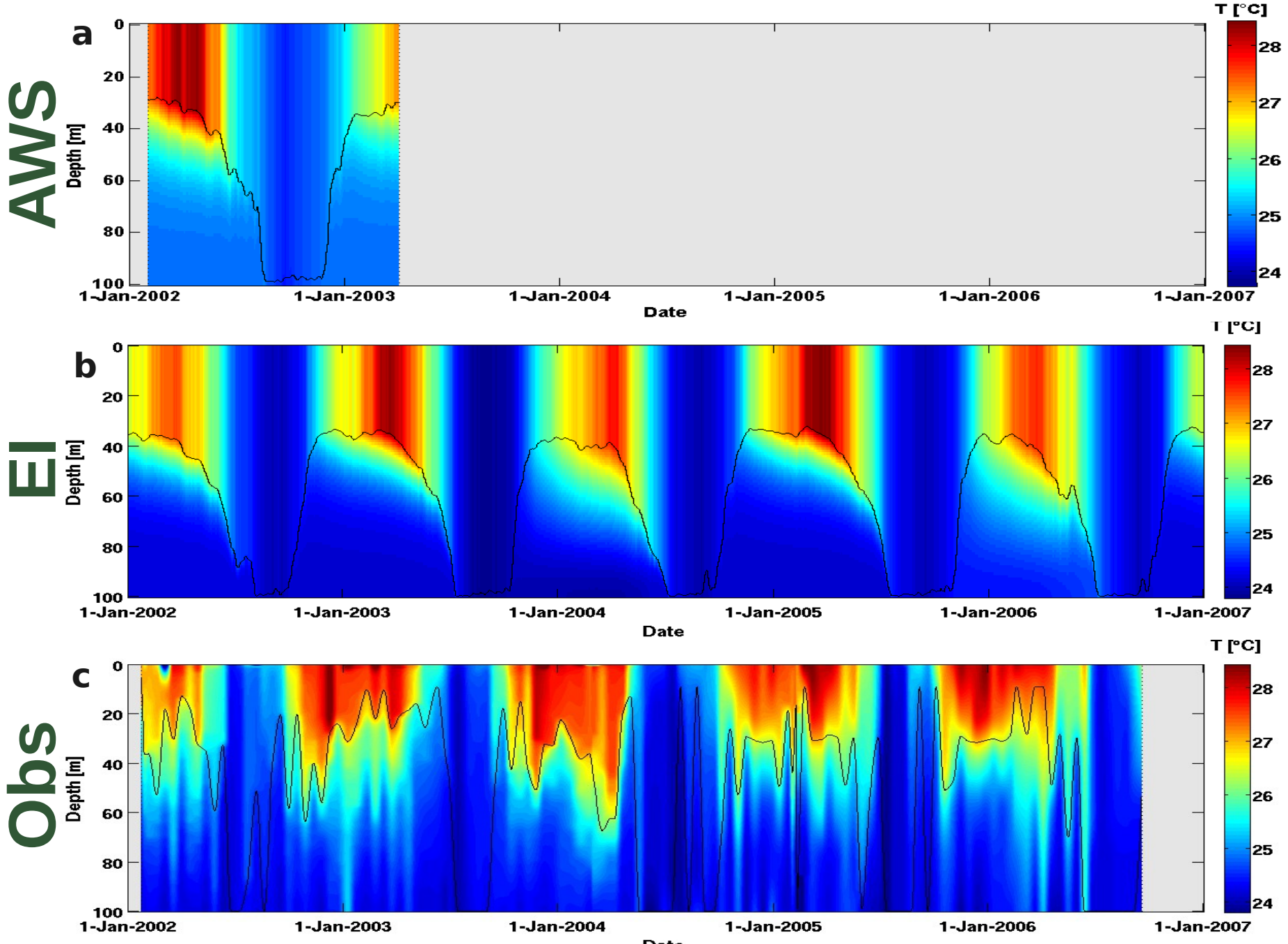
Results: Kigoma



Results: Mpulungu



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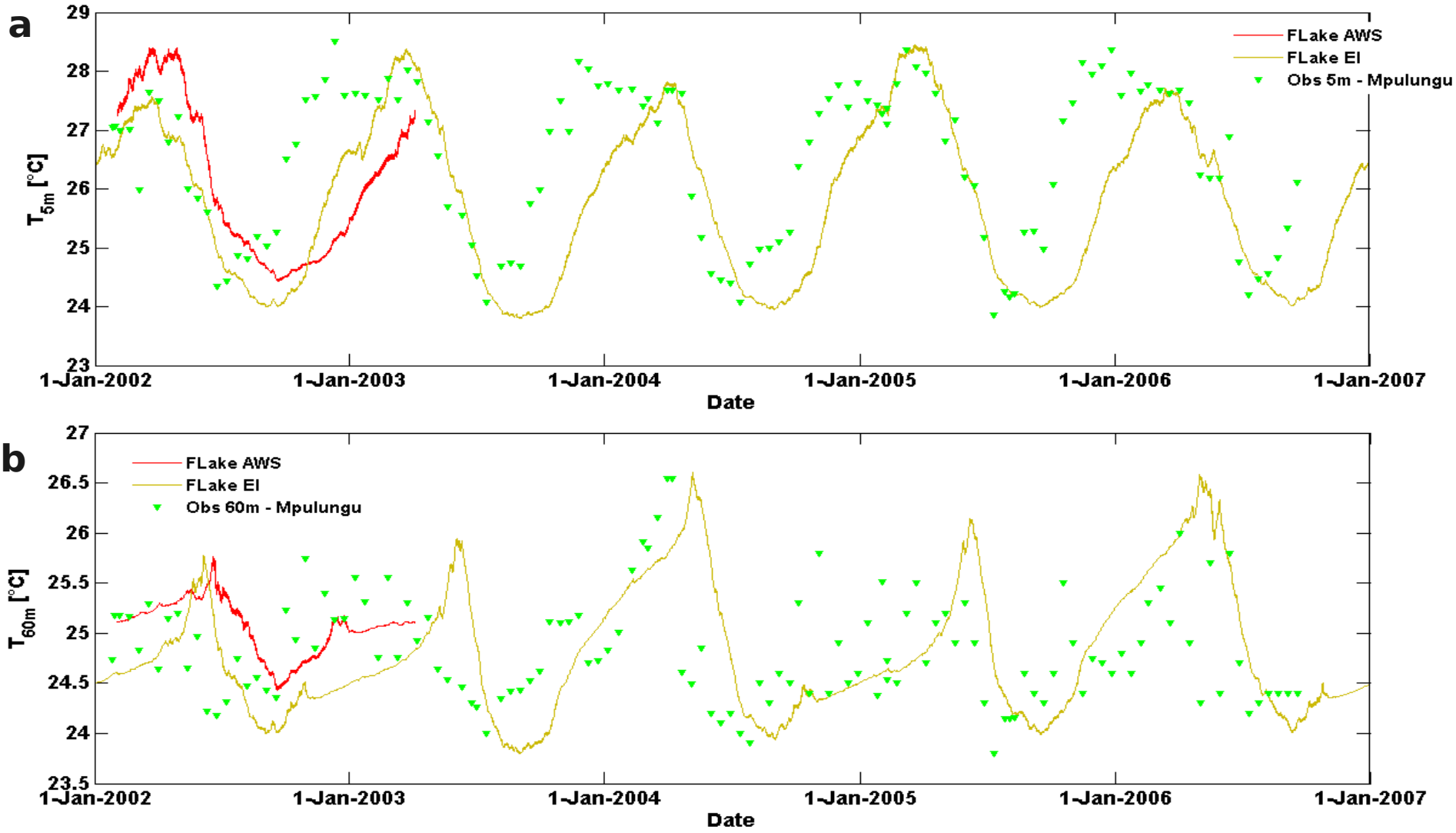
Results: Mpulungu



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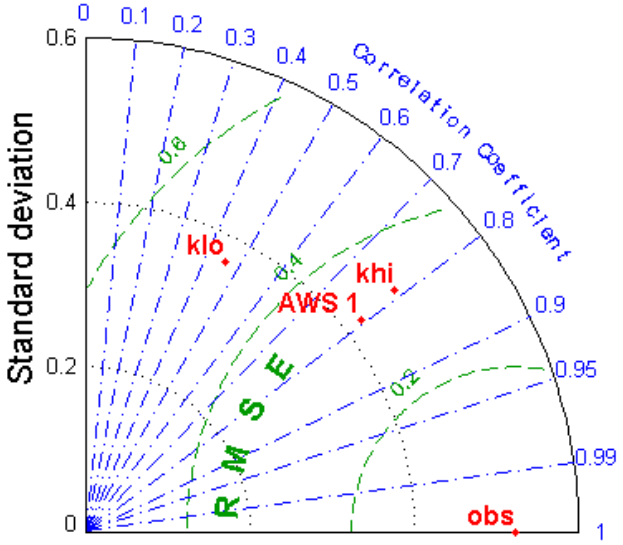
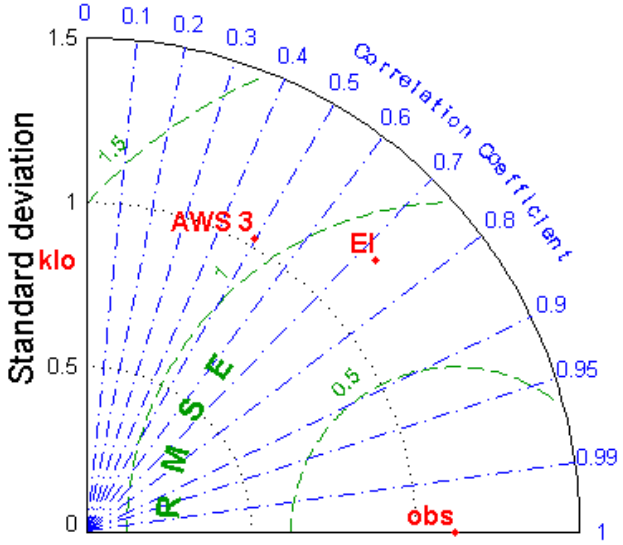
Sensitivity to configuration

Ishungu



Mpulungu



Not shown:
- EI (Ishungu)
- *uuncorr* (Ishungu)
- high *k* (Mpulungu)

- correct mixing regime is only a delicate equilibrium
- necessicity for reliable input data and careful model configuration
- reason: absence of an abyssal in FLake which would act as a heat buffer

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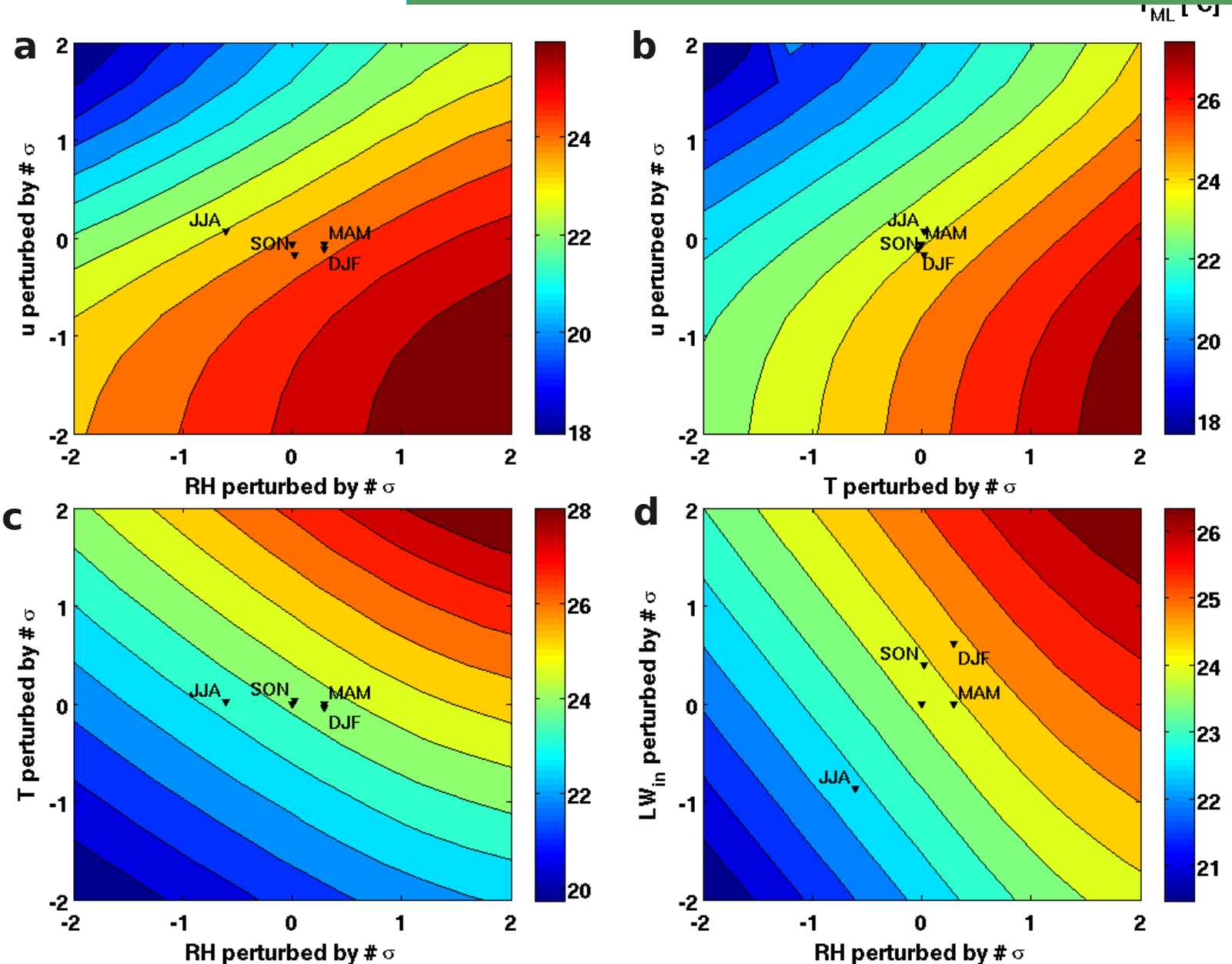
Mean TML for pairwise perturbed input variables, 2002-2008



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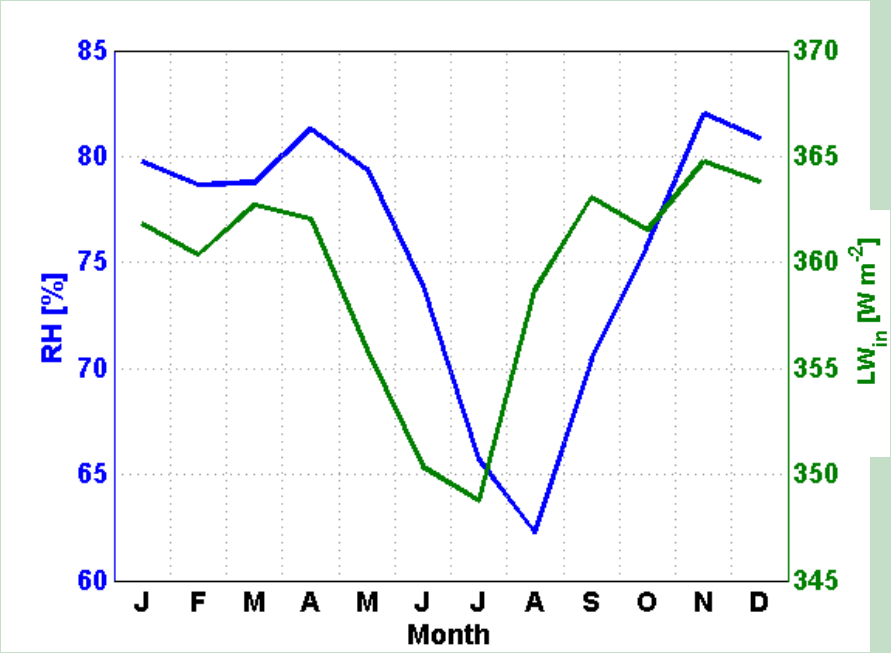
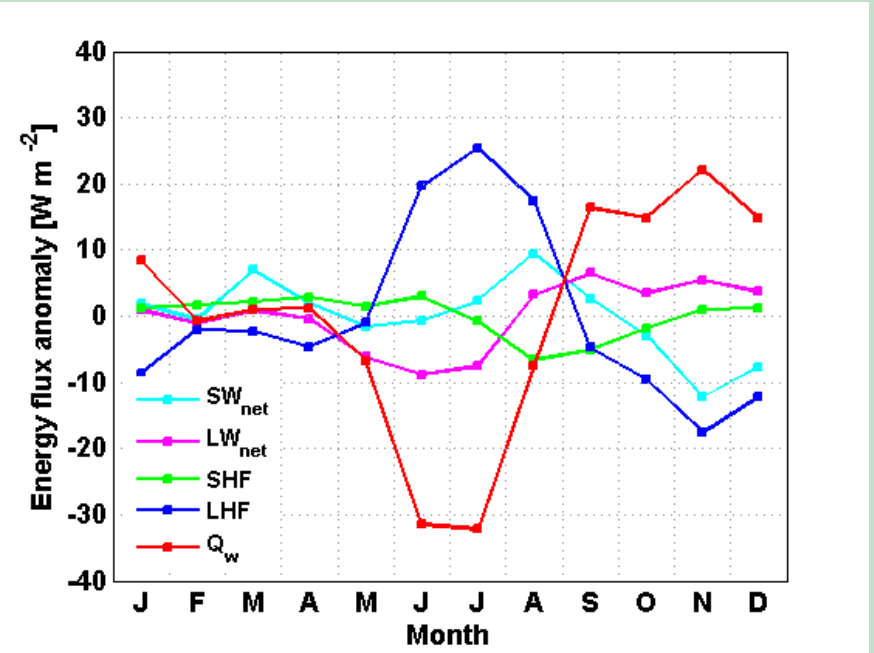
Seasonal mixing caused by...?





- in lake Kivu, interseasonal *RH* and *LWin* variability, rather than *u or T*, causes dry season mixing
- dry season: enhanced evaporation; less energy input; less stratified
- *u* triggers deep mixing

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Conclusions and outlook

- conclusions
  - FLake reproduces lake Kivu's thermal structure
  - Tanganyika: good results in S, less in N
  - lake Kivu's mixing regime is regulated by *RH* and *LWin* seasonality
  - necessity for long spin-up time & artificial lake depth
  - reliable input data and careful configuration are crucial

- outlook
  - LakeMIP Kivu
  - water and energy balance from AWS
  - CCLM-FLake 2001-2012: Era-interim & CORDEX (~0.0625°) + evaluation
  - CCLM-FLake 2071-2100: CORDEX (~0.0625°) + attribution

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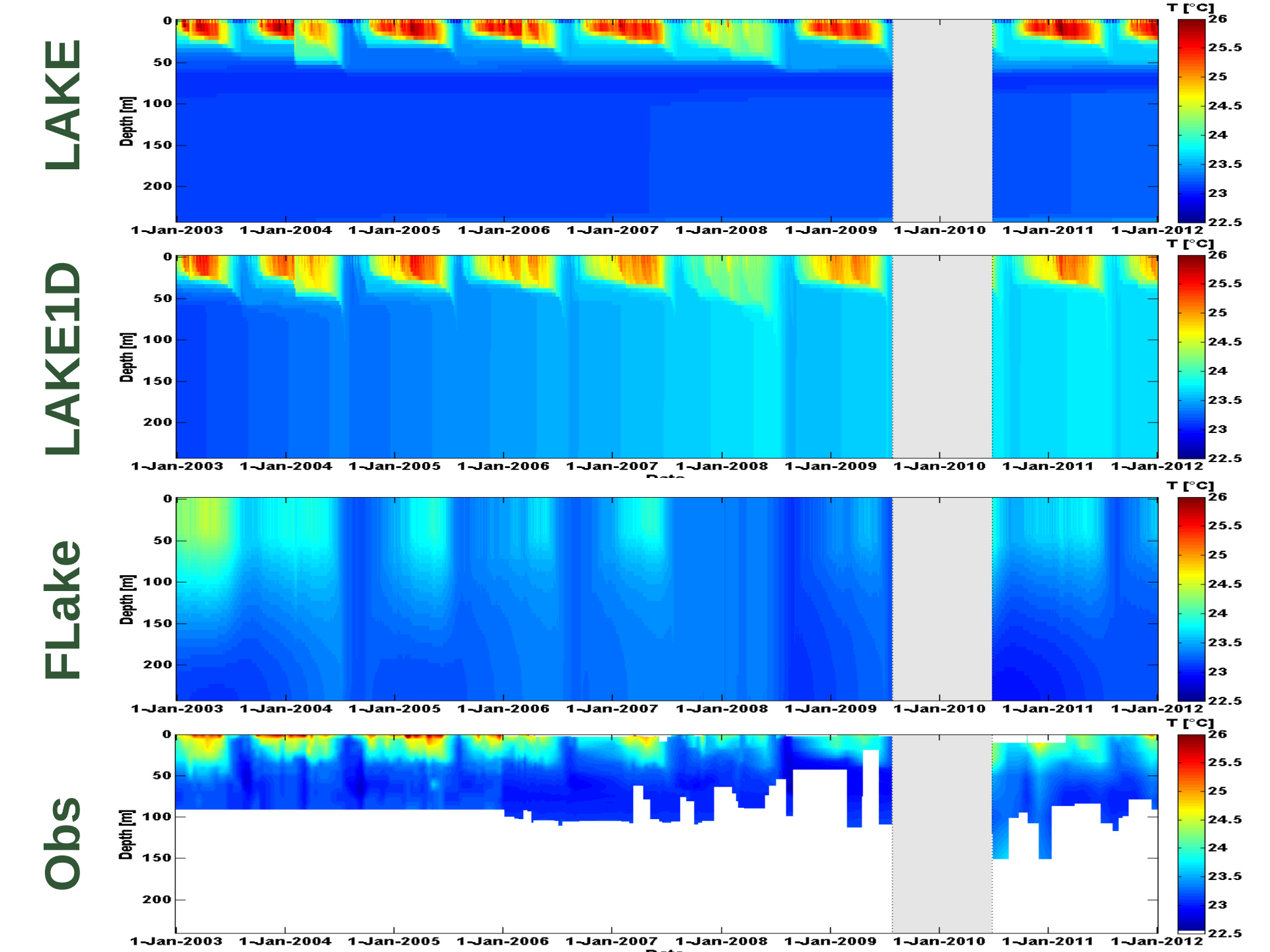
LakeMIP Kivu

- Unified protocol:
  - mean lake's depth (= 240m) + 60m
  - mean lake's k (= 0.27 m-1)
  - mean lake's geothermal heat flux (= 1.09 W m-2 ; Newman, 1975)
  - salinity forcing data
  - ...

- 5 models confirmed, preliminary results of 3:


LAKE
LAKE1D
FLake
Obs
Depth [m]
T [°C]
0
50
100
150
200
22.5
23
23.5
24
24.5
25
25.5
26
1-Jan-2003
1-Jan-2004
1-Jan-2005
1-Jan-2006
1-Jan-2007
1-Jan-2008
1-Jan-2009
1-Jan-2010
1-Jan-2011
1-Jan-2012

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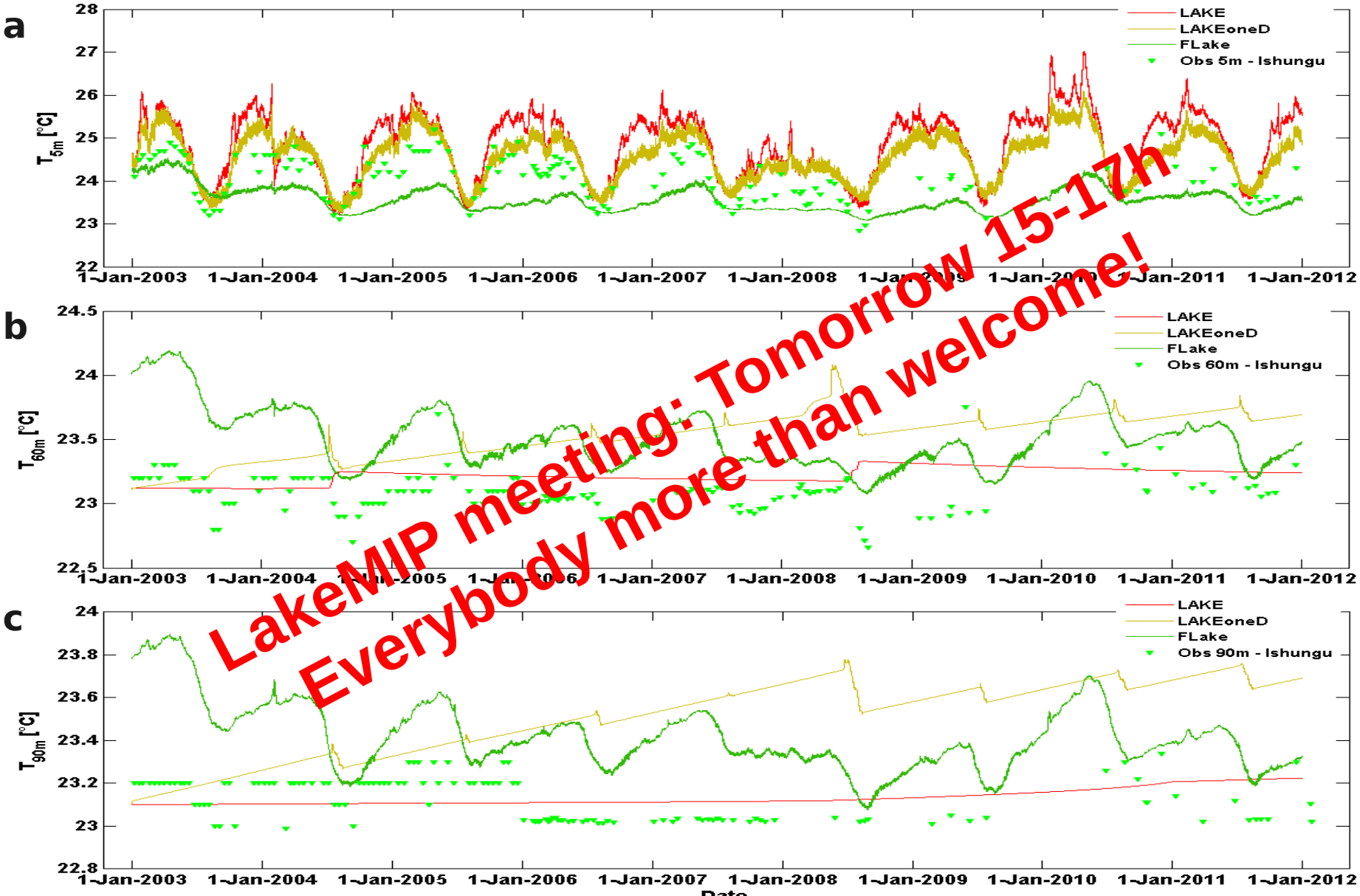
LakeMIP-Kivu: results



Thank you for your attention

Acknowledgements: FWO, BELSPO

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