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FWO VLAANDEREN

Understanding the performance of FLake over the African Great Lakes

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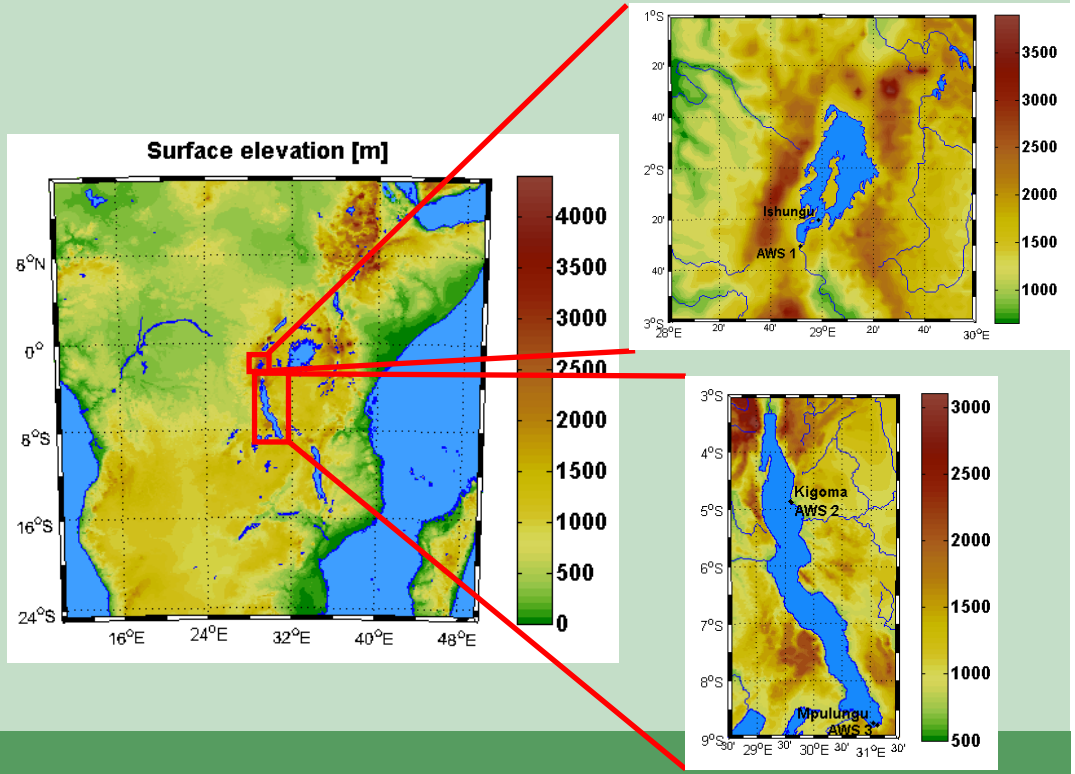
Motivation & Objectives

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



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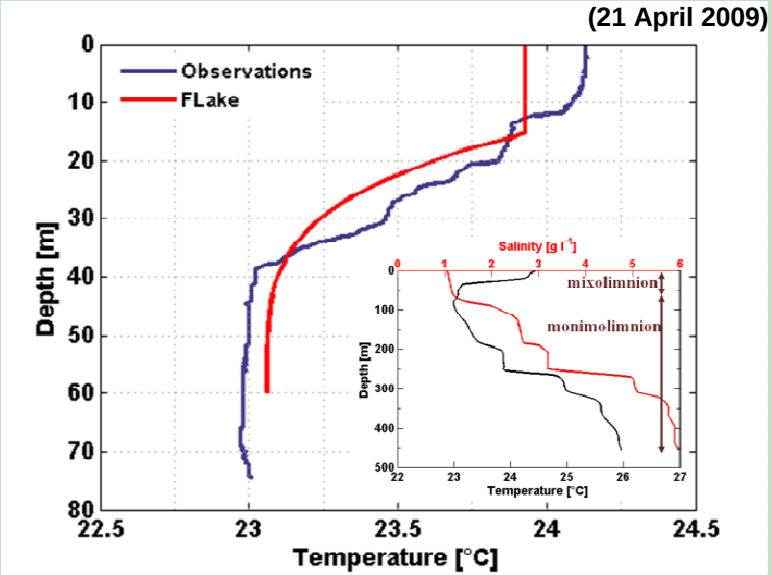
Method: FLake configuration

- FLake model (Mironov, 2008):
  - 1D, two-layer bulk model
  - mixed layer: uniform T
  - thermocline: self-similarity of T-z curve

- FLake standalone configuration:
  - artificial lake depth 60m (100 m)
  - initialisation: climatological profile January
  - spin-up untill convergence (9 – 30 yr)
  - no active sediments
  - wind velocity tuned cfr. AWS Kivu: + 1 m s^{-1} (+ 2 m s^{-1})
  - *k* tuned cfr. obs: 0.32 m^{-1} (0.09 m^{-1})



AWS control

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Method: data correction

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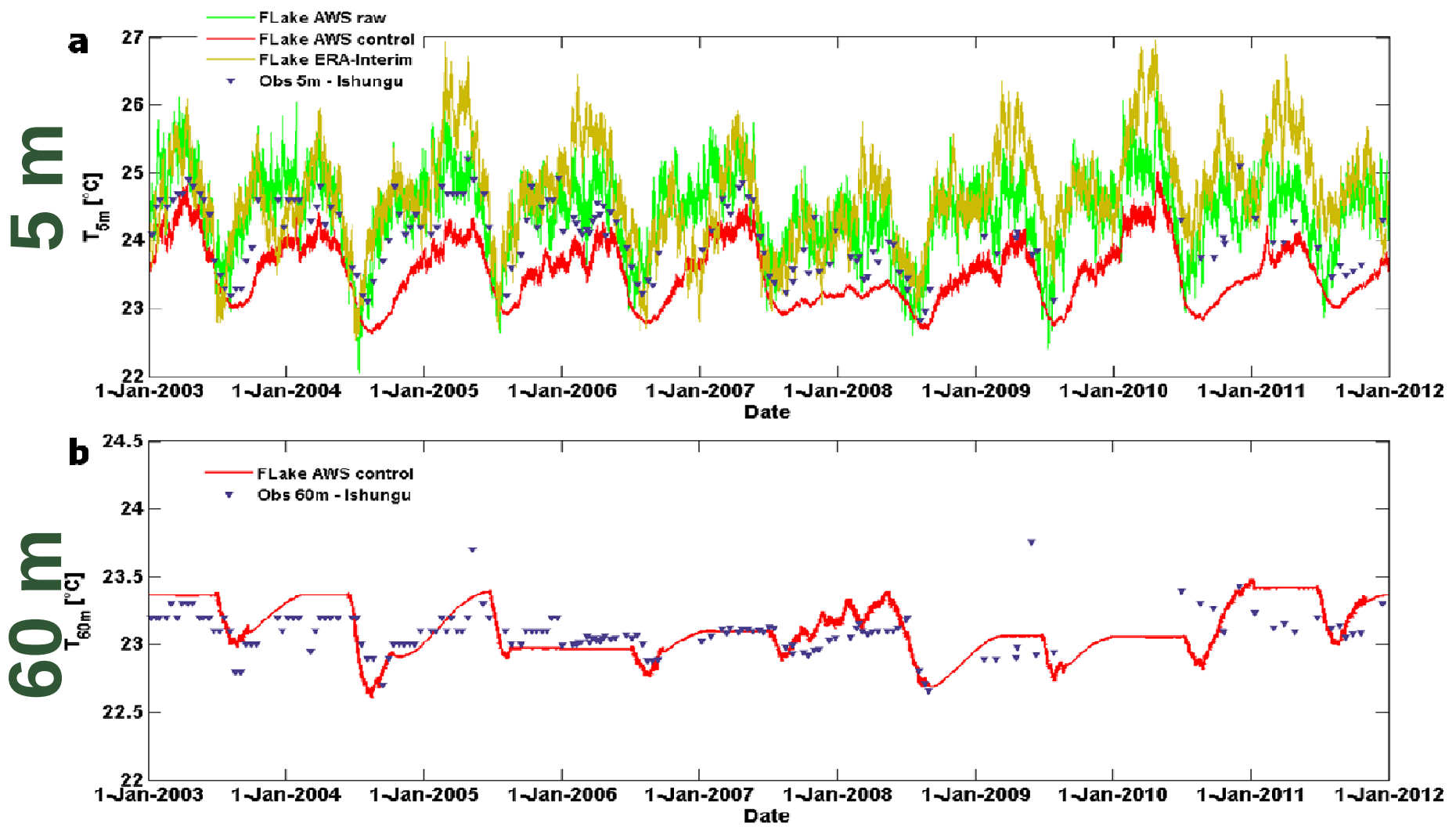
Results: Ishungu



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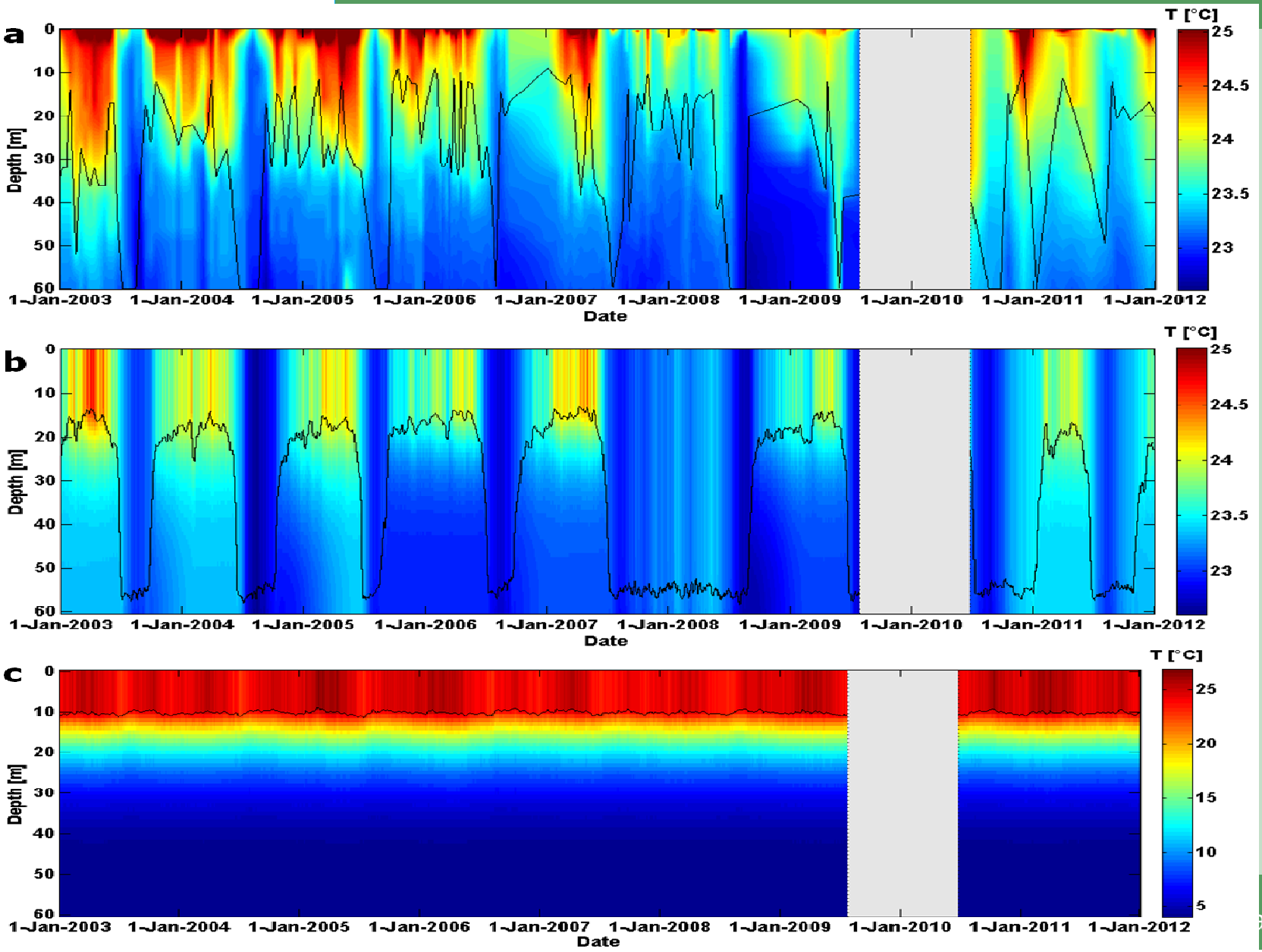
Results: Ishungu

Obs

AWS

EI



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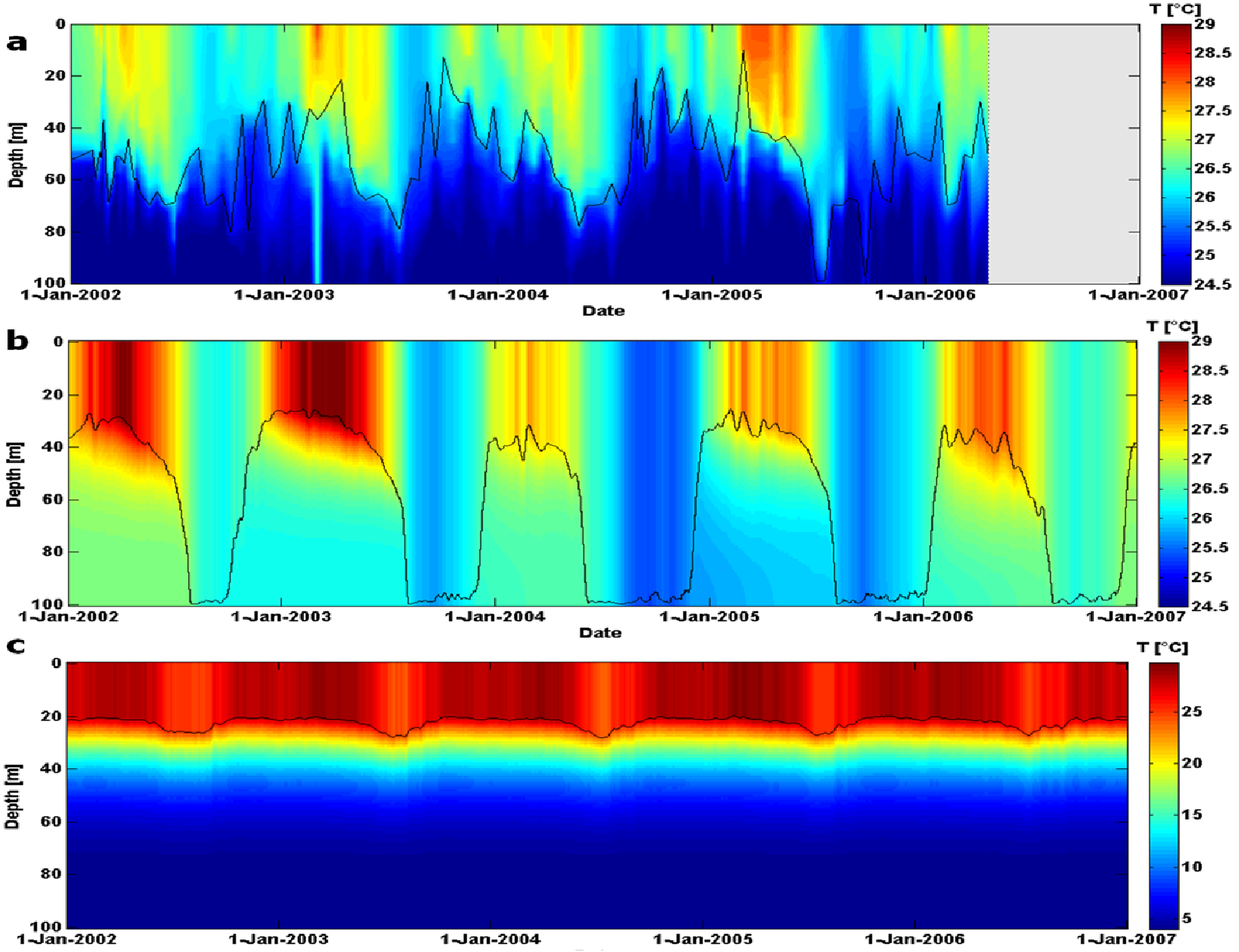
Results: Kigoma

Obs

AWS

EI



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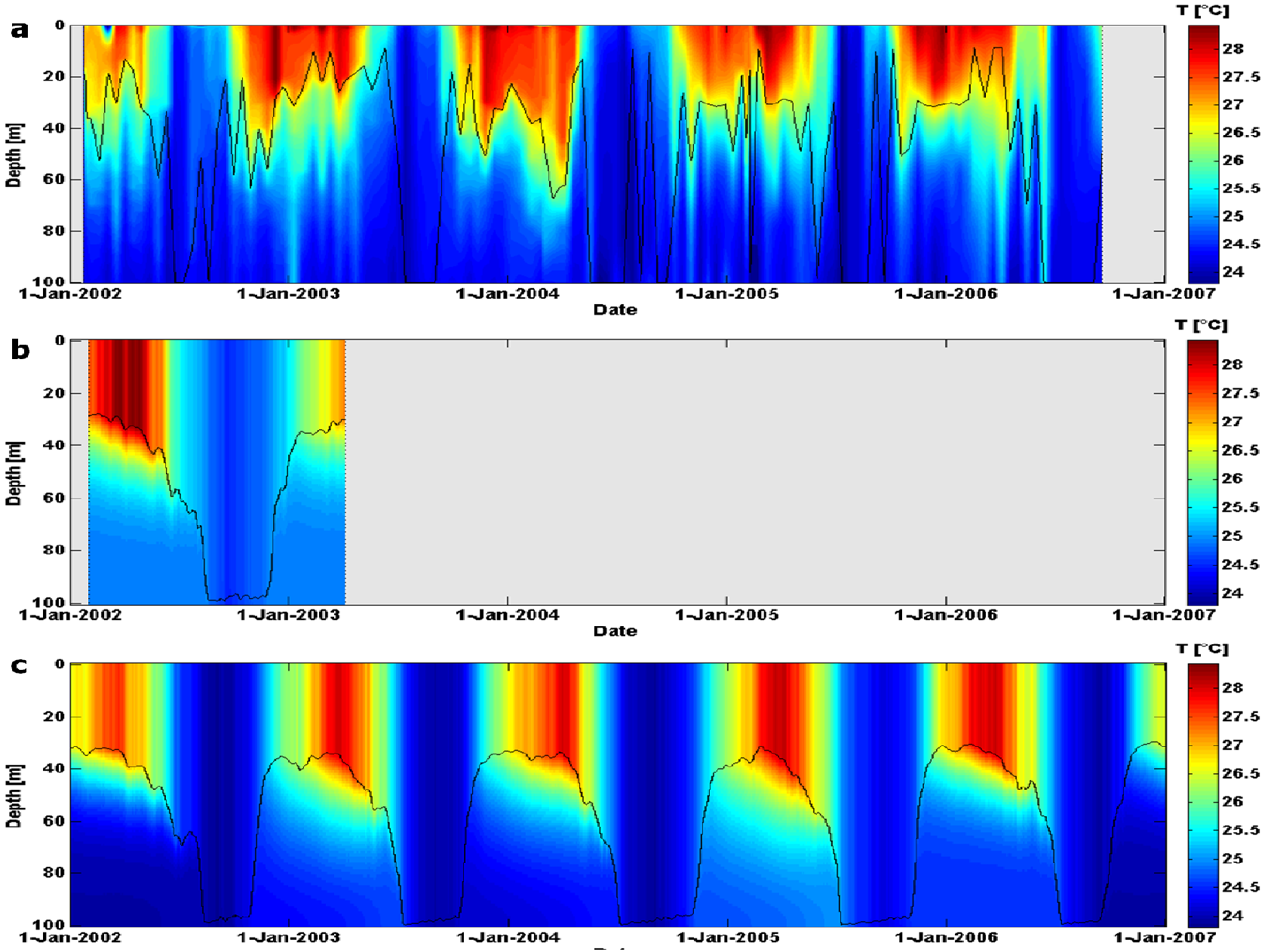
Results: Mpulungu

Obs

AWS

EI



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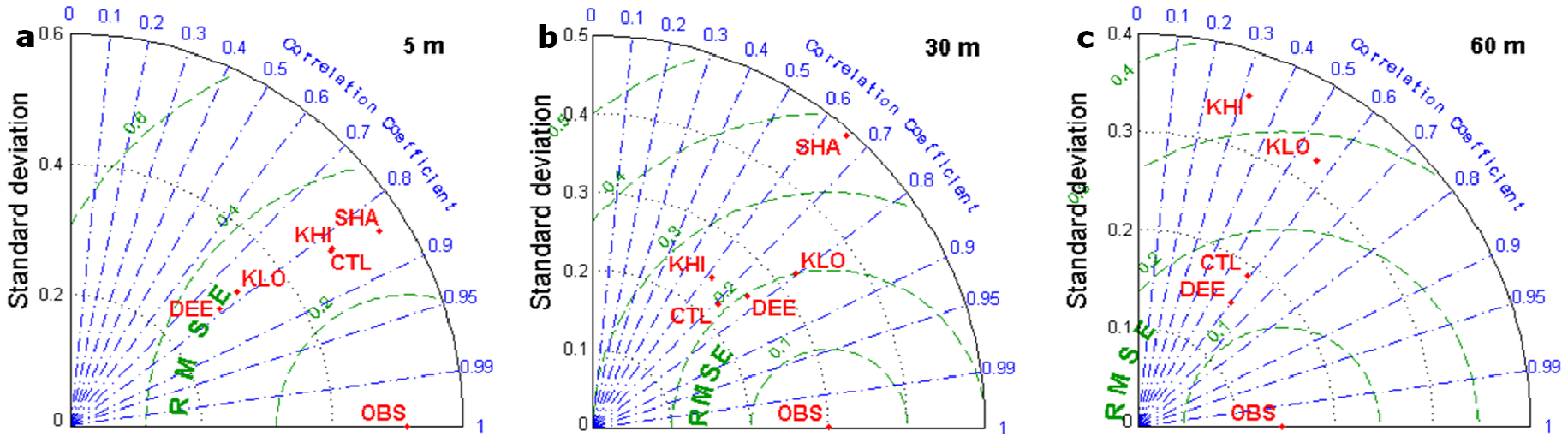
Sensitivity: external parameters

CTL: control
KLO: k = 0.15 m^{-1}
KHI: k = 0.46 m^{-1}
SHA: h_{LAKE} = 30 m
DEE: h_{LAKE} = 120 m



- meromicitc lakes: correct mixing regime is only a delicate equilibrium
- need for careful model configuration
- near-surface temperatures are robust, however

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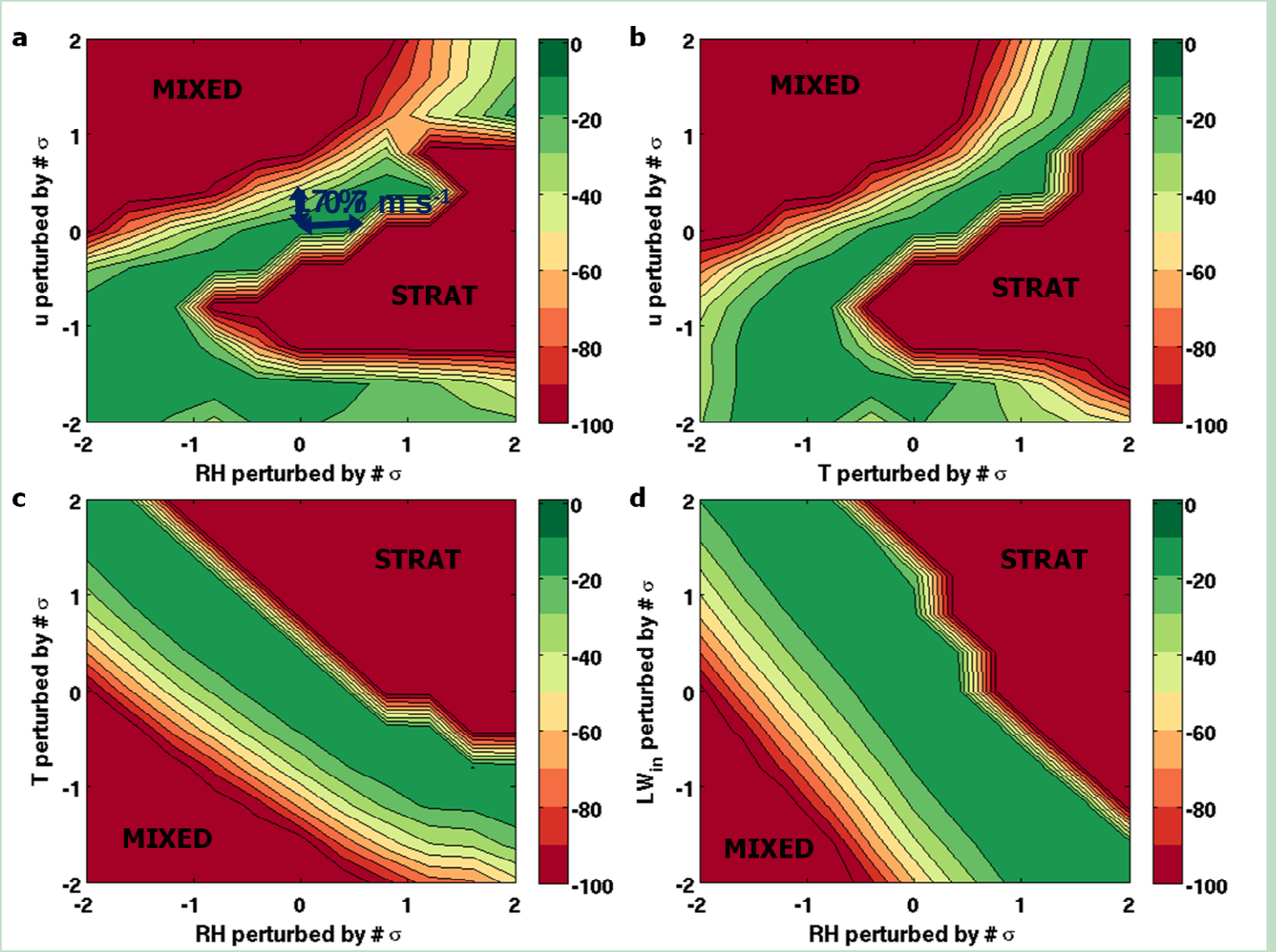
Sensitivity: forcing fields



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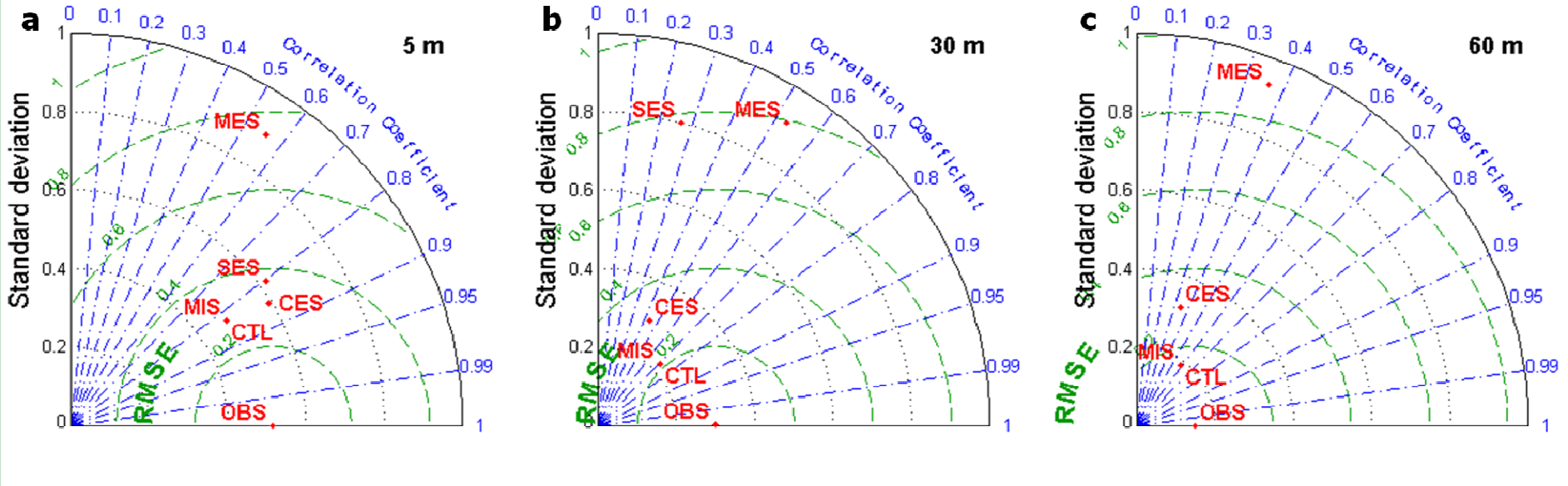
Sensitivity: initialisation

CTL: control
CES: control excl spin-up
MIS mixed incl spin-up
MES: mixed excl spin-up
SES: stratified excl spin-up



- preferred initialisation:
  - climatology including spin-up (CTL)
  - mixed including spin-up (MIS)
  - stratified excluding spin-up (SES)

If no data available

If spin-up not possible

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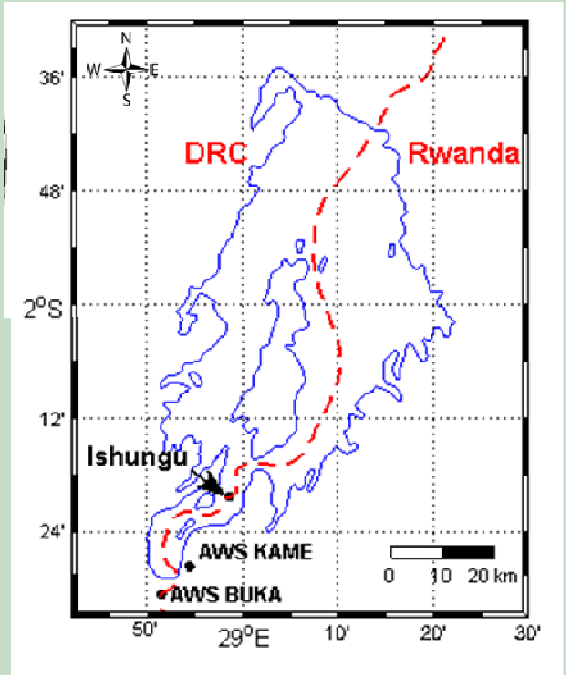
LakeMIP Kivu

- 8 models confirmed, data of 6:
  - Hostetler, LAKEoneD, SimStrat, LAKE, FLake, MINLAKE12
  - (DYRESM, CLM4-LISSS)

- Unified protocol:
  - two main simulations:
    - Freshwater 60m
    - Saline simulation 240m including CO_2 and CH_4
  - two forcing AWSs:
    - Bukavu
    - Kamembe
  - 240m: salinity, CO_2 and CH_4 as forcing data
  - 240m: uniform equation of state (Schmidt et al., 2012)
  - 240m: geothermal heat flux = 0.3 W m^{-2} (Schmidt, 2010)
  - 1 year spin up
  - mean lake's k (= 0.27 m^{-1})
  - sensitivity experiments for k, geothermal heat flux, sediment routine, surface flux schemes and wind velocity
  - ...



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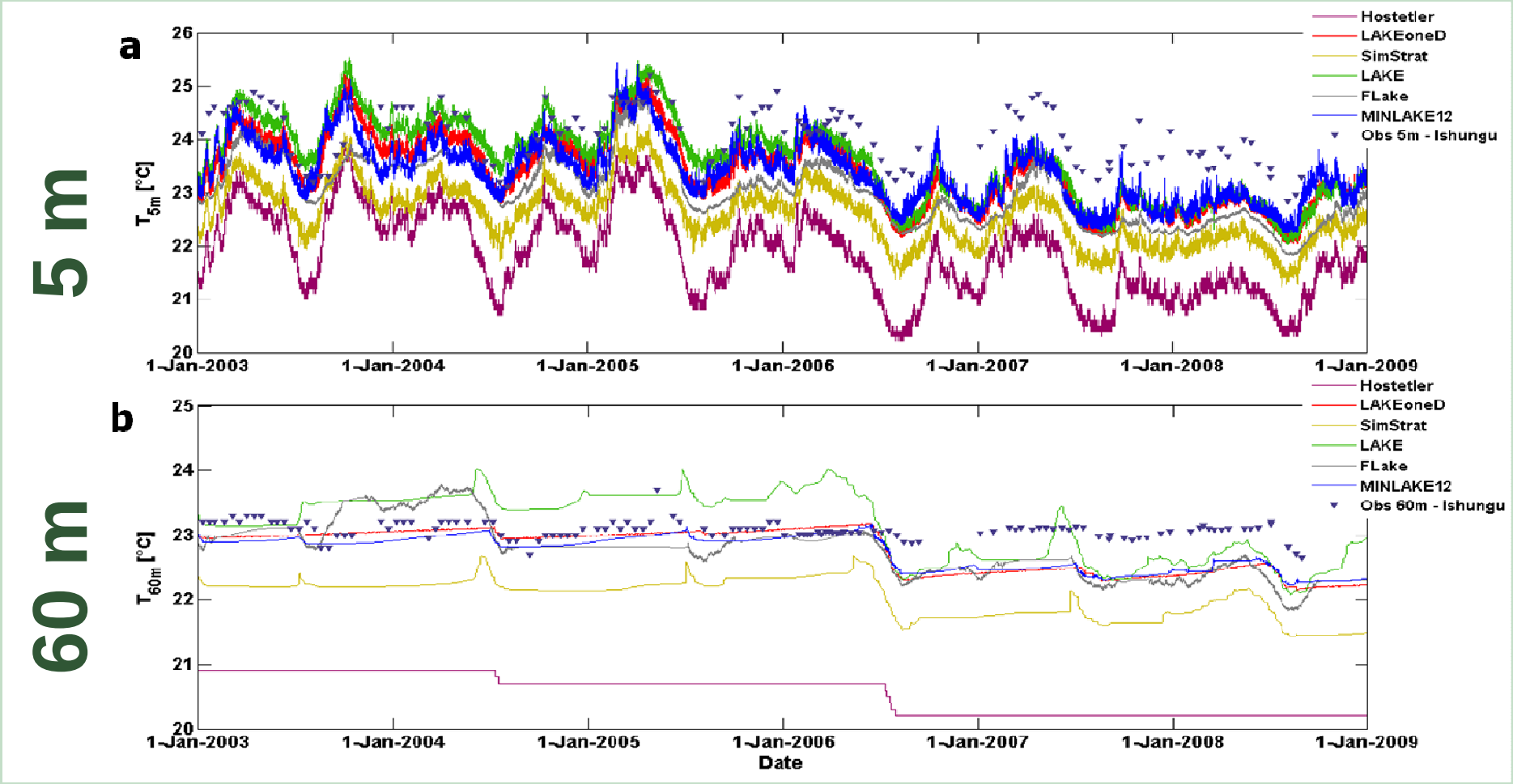
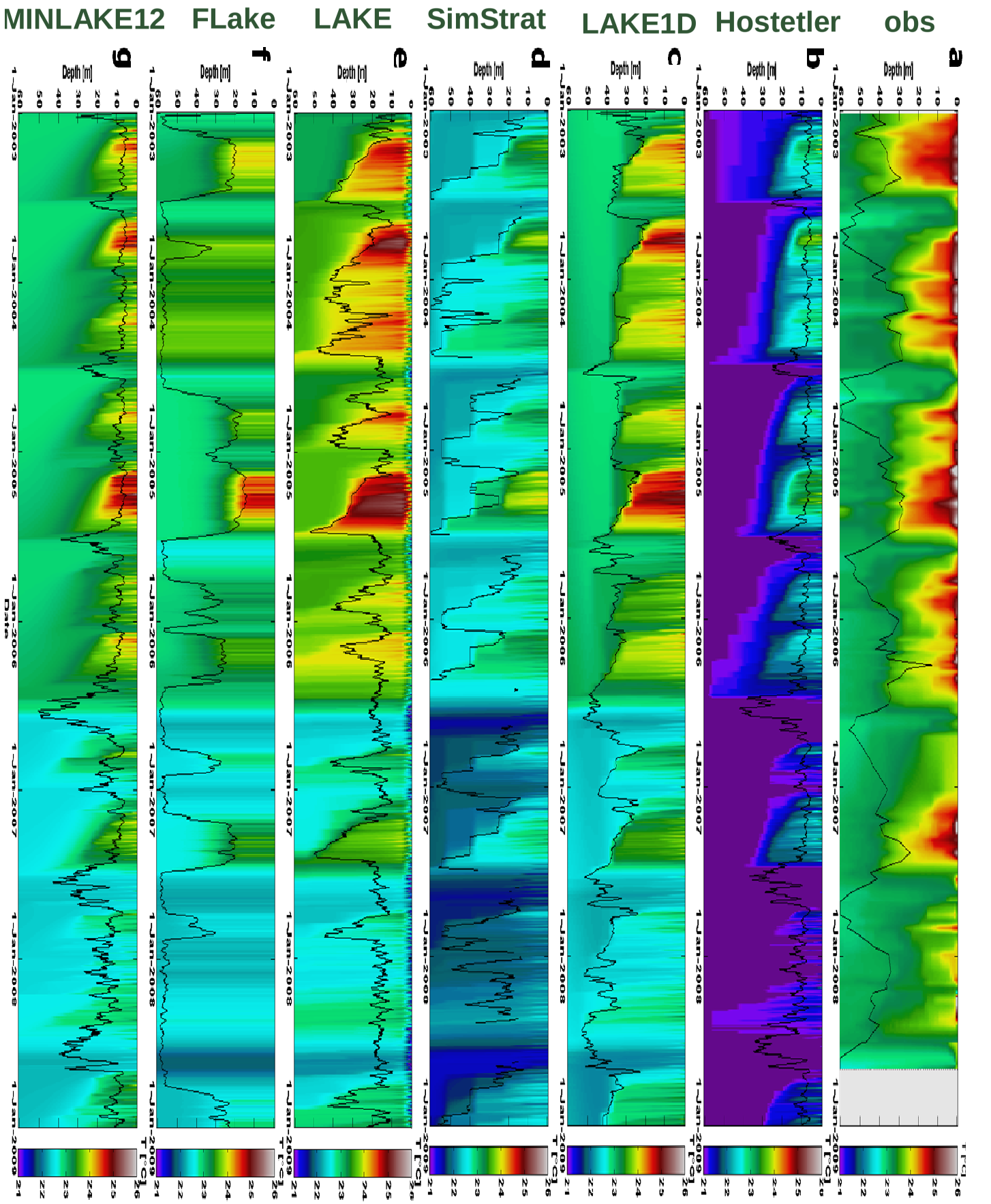
LakeMIP: results




MINLAKE12
FLake
LAKE
SimStrat
LAKE1D
Hostetler
obs
a
b
c
d
e
f
g
Depth [m]
Date
T [°C]
1-Jan-2003
1-Jan-2004
1-Jan-2005
1-Jan-2006
1-Jan-2007
1-Jan-2008
1-Jan-2009

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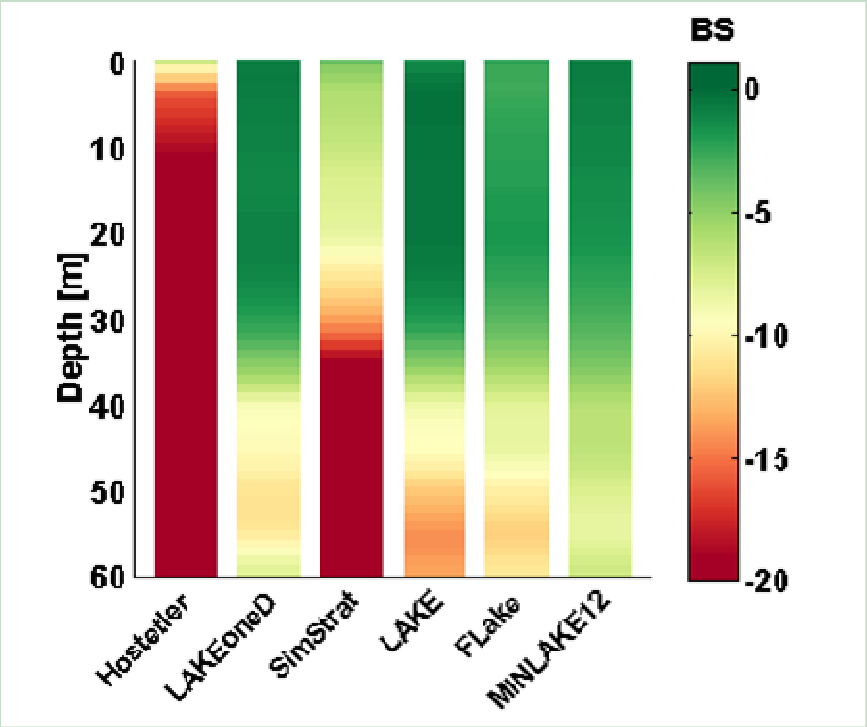
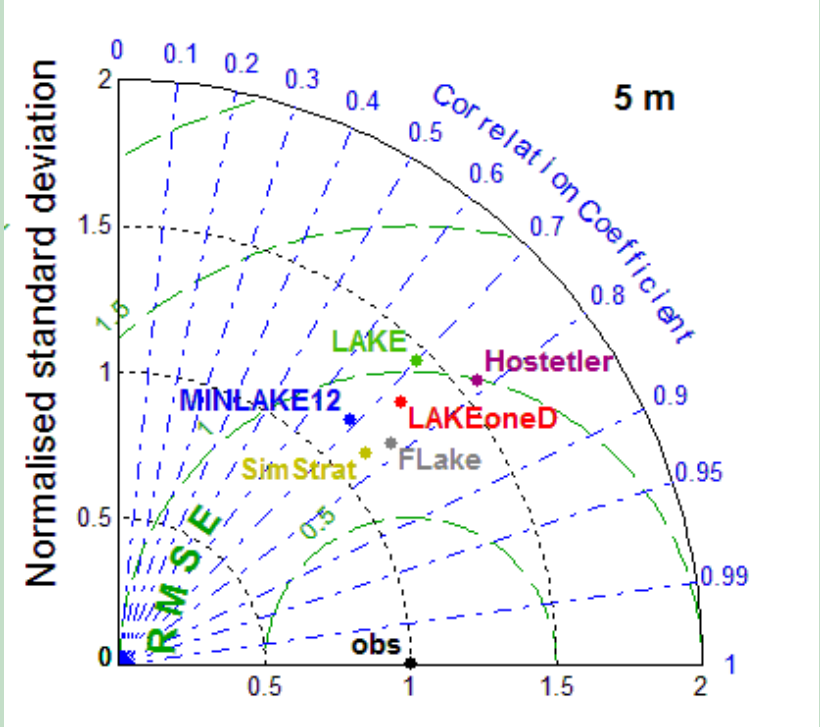
skill scores





- FLake shows good skill in the control simulation, but very low skill in most sensitivity experiments
- cfr. nonlinear response

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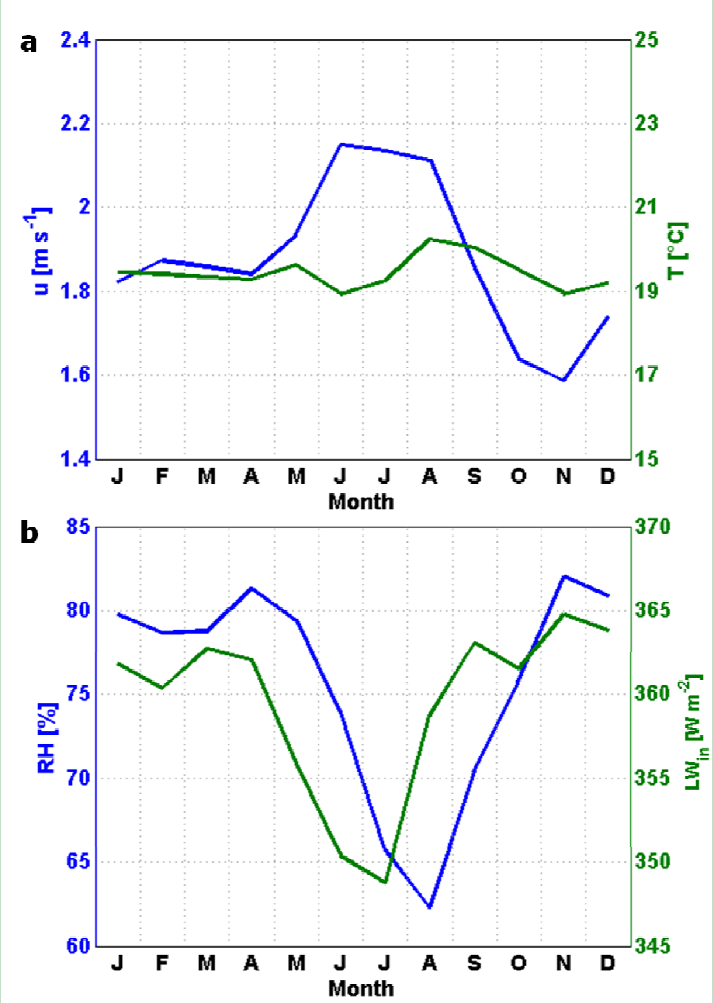
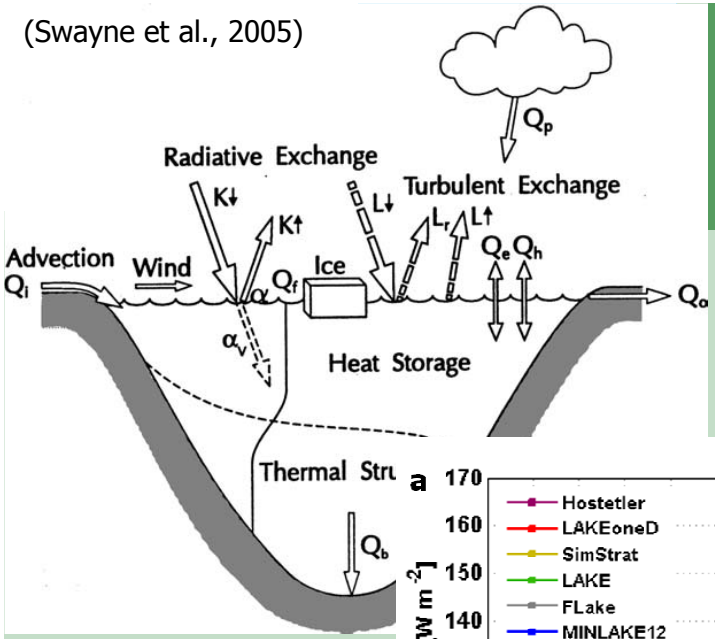
Mixing seasonality controls?



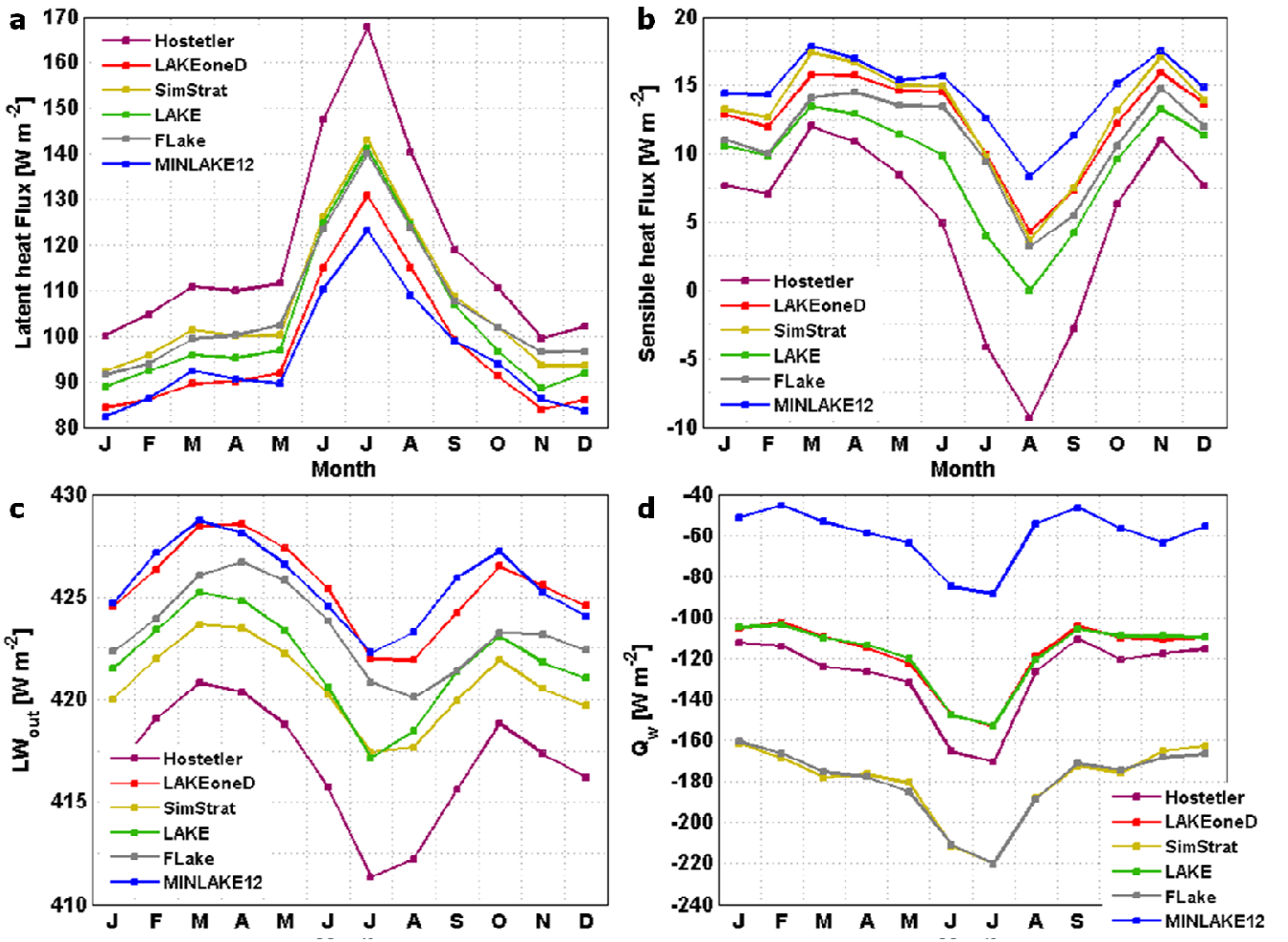
Surface energy budget

(Swayne et al., 2005)



$$SW_{net,VIS}(z) = SW_{in}(1-\beta)(1-\alpha_s)\,e^{-kz}$$

$$SW_{net,NIR} + LW_{in}(1-\alpha_L) = LW_{out} + LHF + SHF + Q_w$$



Conclusions & outlook

- conclusions
  - FLake reproduces lake AGL's thermal structure …
  - … when correcting for *u* (and *k*)
  - nonlinear response to deficiencies in input data and model configuration leading to regime switches
  - 5 m temperature however much more robust
  - Compared to other models, FLake shows good skill, but only for one default simulation!
  - lake Kivu's mixing regime is regulated by *RH* and LW_{in} seasonality

- outlook
  - surface energy balance study from AWS
  - CCLM-FLake 2001-2012: Era-interim + evaluation
  - CCLM-FLake 2071-2100: CORDEX (~0.0625°) + CC attribution


Thank you for your attention!
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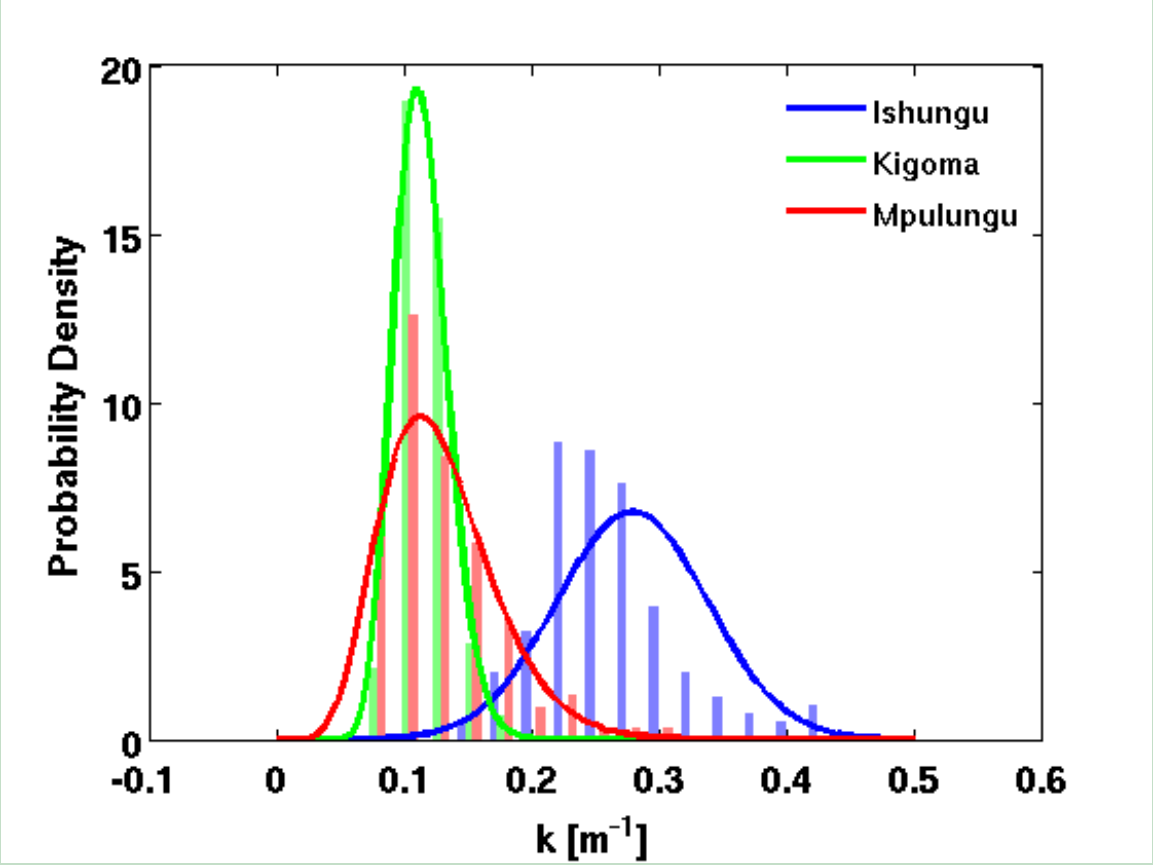
Method: FLake configuration



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Method: FLake configuration

	Ishungu Basin	Kigoma	Mpulungu
General characteristics			
Lake	Kivu	Tanganyika (northern basin)	Tanganyika (southern basin)
Latitude	2°20' 25'' S	4°51' 16'' S	8°43' 59'' S
Longitude	28°58' 36'' E	29°35' 32'' E	31°2' 26'' E
Altitude (m a.s.l.)	1463	768	768
Depth (m)	120	600	120
Number of CTD casts	174	119	126
Water transparency			
Number of secchi depths	163	114	124
Average k (m^{-1})	0.28	0.11	0.13
σ_k (m^{-1})	0.06	0.02	0.05
Minimum k (m^{-1})	0.15	0.07	0.06
Maximum k (m^{-1})	0.46	0.17	0.31
Vertically averaged scores for control run			
σ_T (°C)	0.30	0.70	0.67
(relative to $\sigma_{T,obs}$ (°C)	0.32	0.49	0.65)
$RMSE_c$ (°C)	0.22	0.59	0.89
r	0.71	0.51	0.05
BS	-0.13	-9.63	-1.81

	AWS1	AWS2	AWS3
Location			
Corresponding evaluation site	Ishungu	Kigoma	Mpulungu
Latitude	2°30' 27'' S	4°53' 15'' S	8°45' 59''
Longitude	28°51' 27'' E	29°37' 11'' E	31°6' 25''
Altitude (m a.s.l.)	1570	777	782
Setup of this study, after corrections			
Start of observation	1 Jan. 2003	1 Jan. 2002	2 Feb. 2002
End of observation	31 Dec. 2011	31 Dec. 2006	4 Apr. 2003
Meteorological averages			
T (°C)	19.4	24.5	24.1
RH (%)	76	70	58
u ($m\ s^{-1}$)	1.9	0.3	2.6

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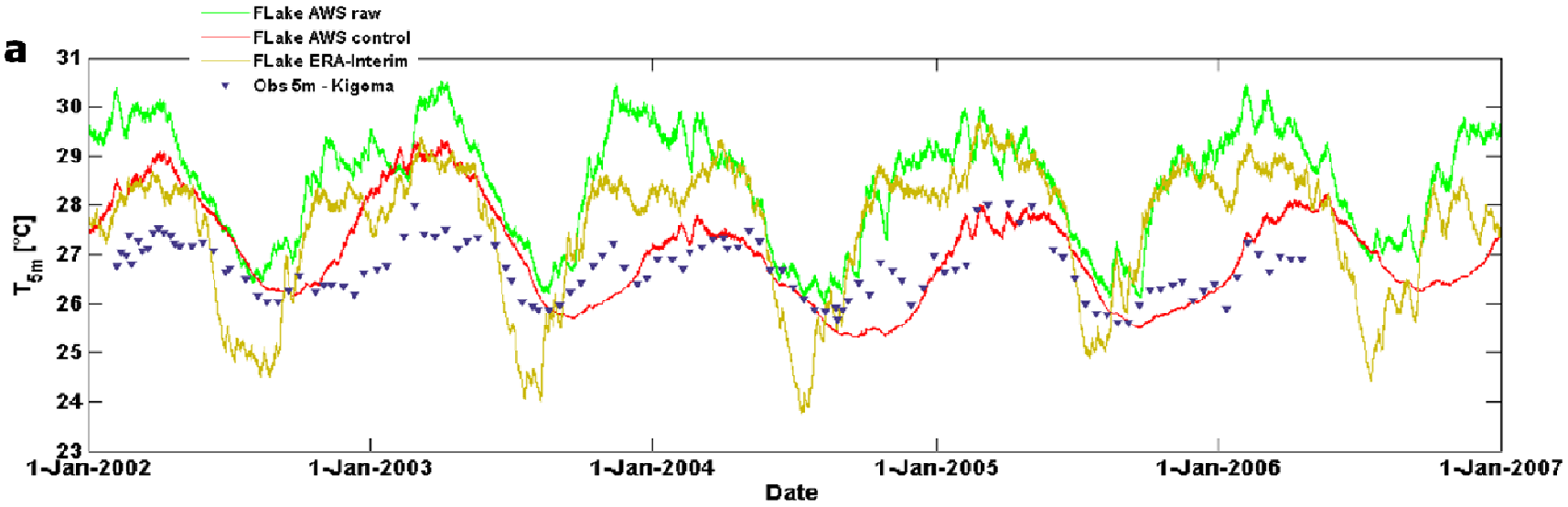
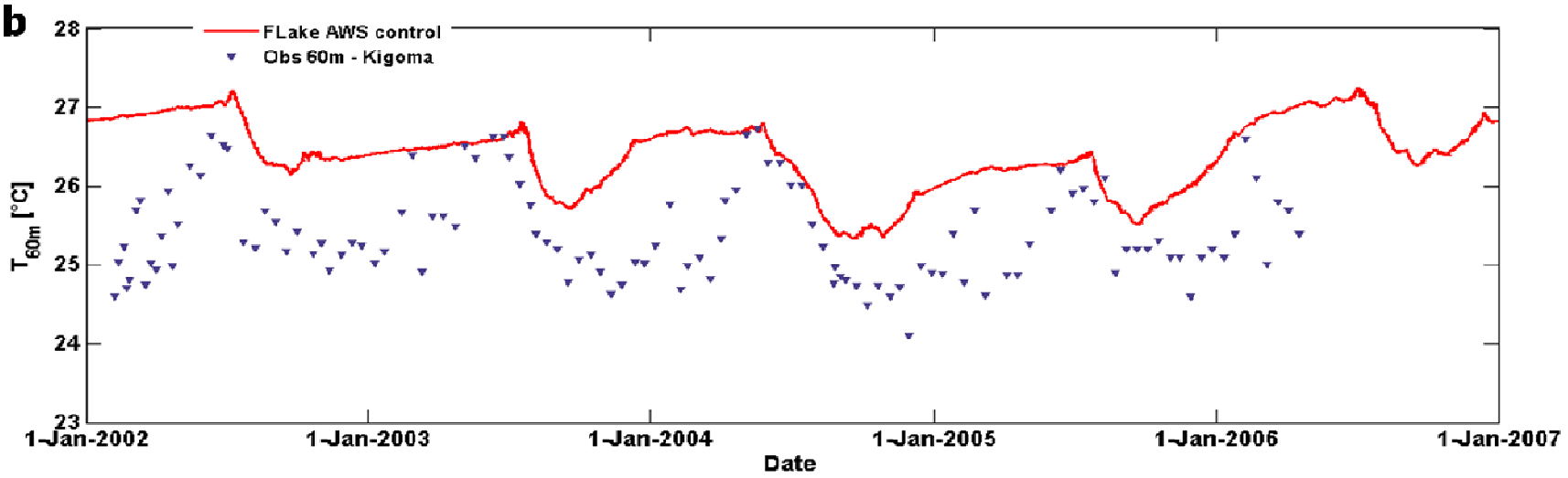
Results: Kigoma

5 m



60 m



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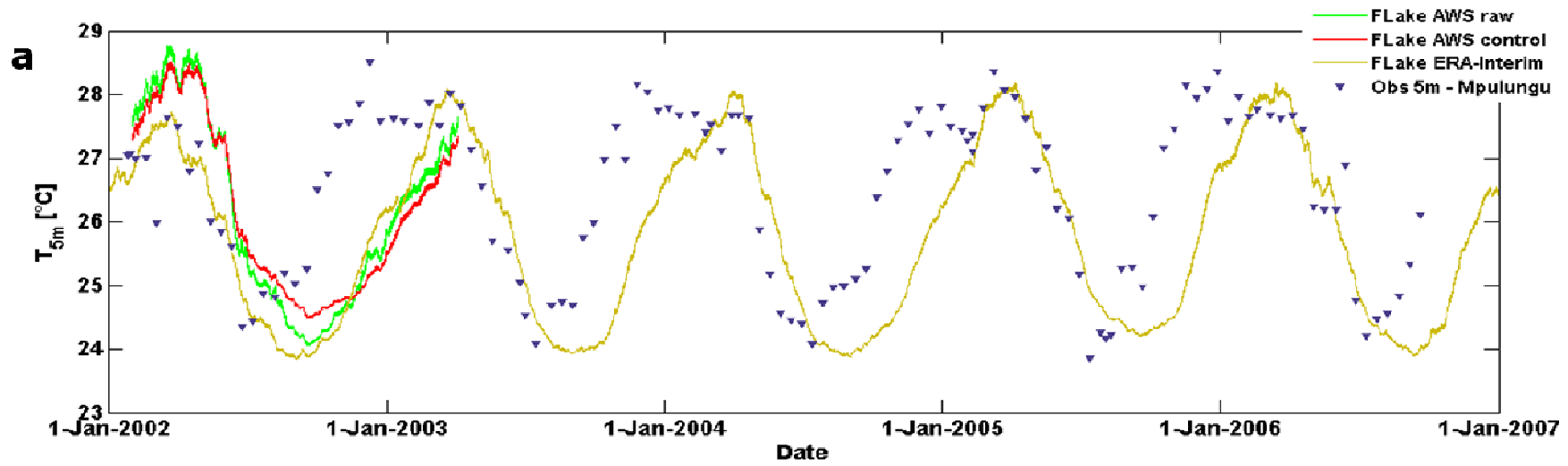
Results: Mpulungu

5 m



60 m