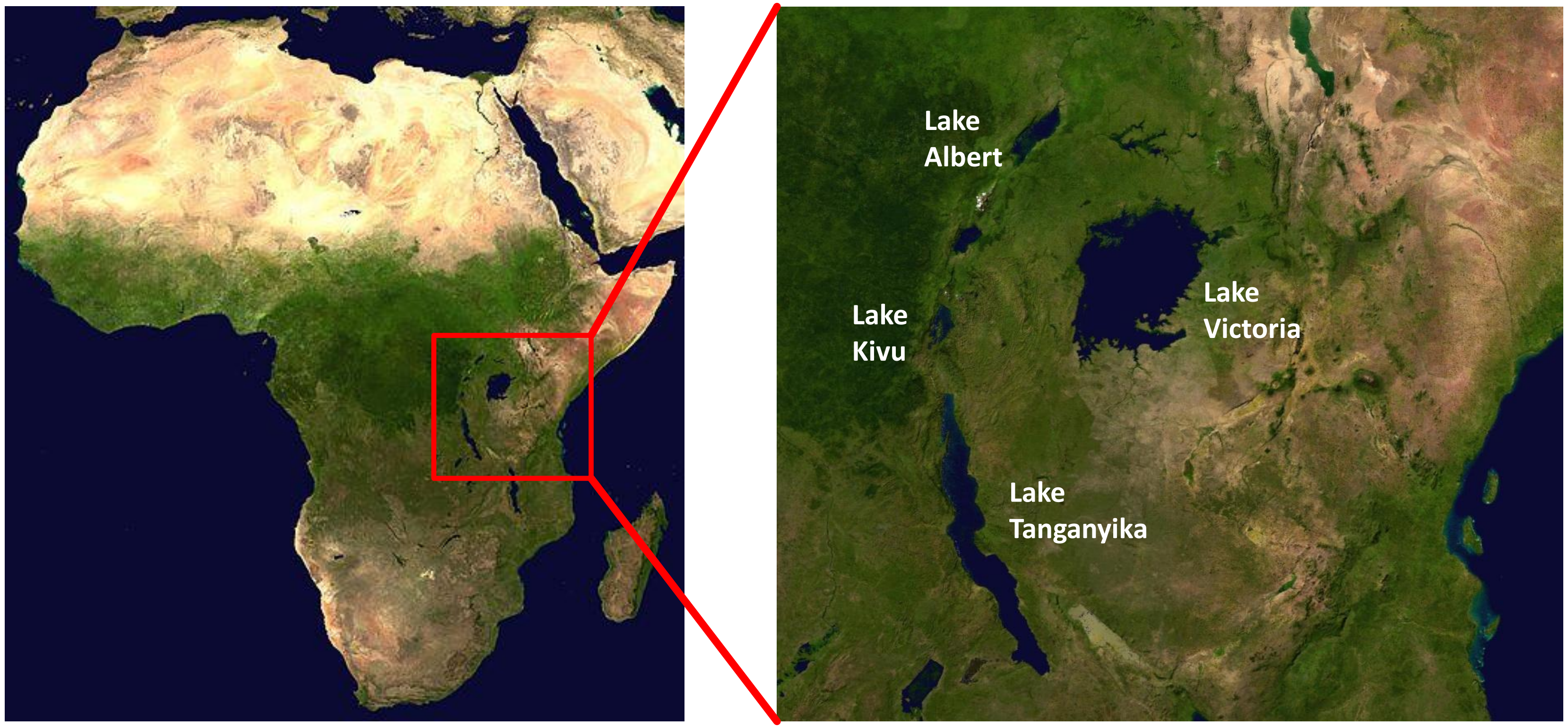
Early warnings of extreme thunderstorms over Lake Victoria

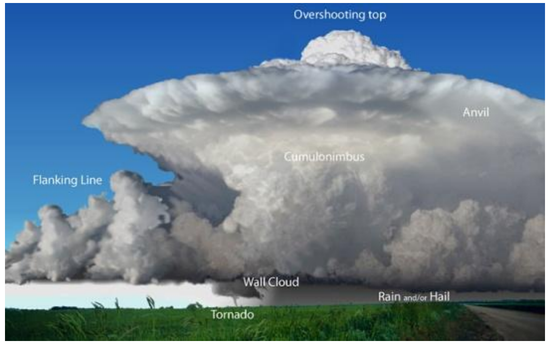
Wim Thiery, Lukas Gudmundsson, Kristopher Bedka, Fred Semazzi, Stef Lhermitte, Patrick Willems, Nicole Van Lipzig & Sonia Seneviratne

The African Great Lakes

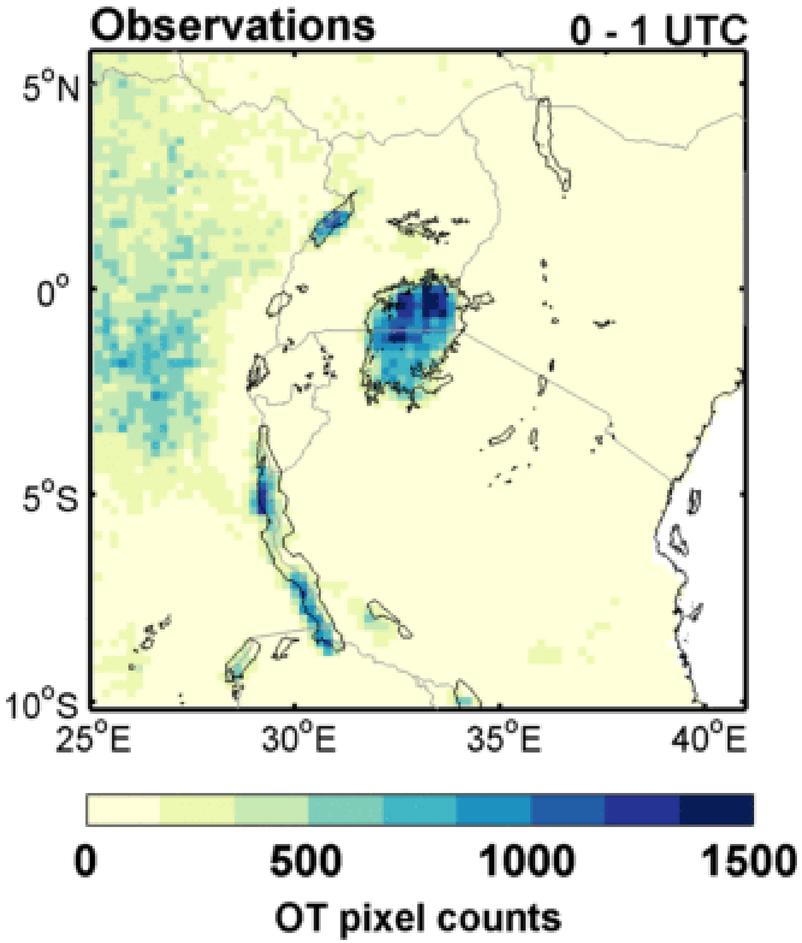


(source: NASA)

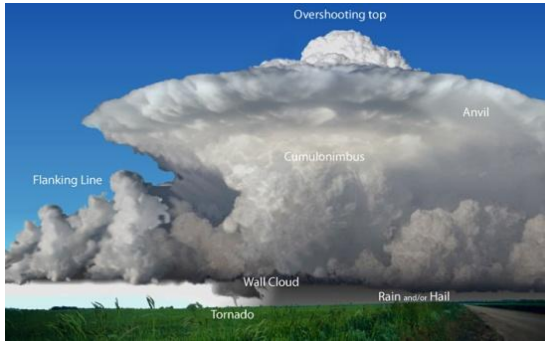
Motivation and objectives



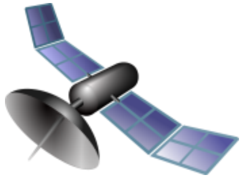
(severe-wx.pbworks.com)

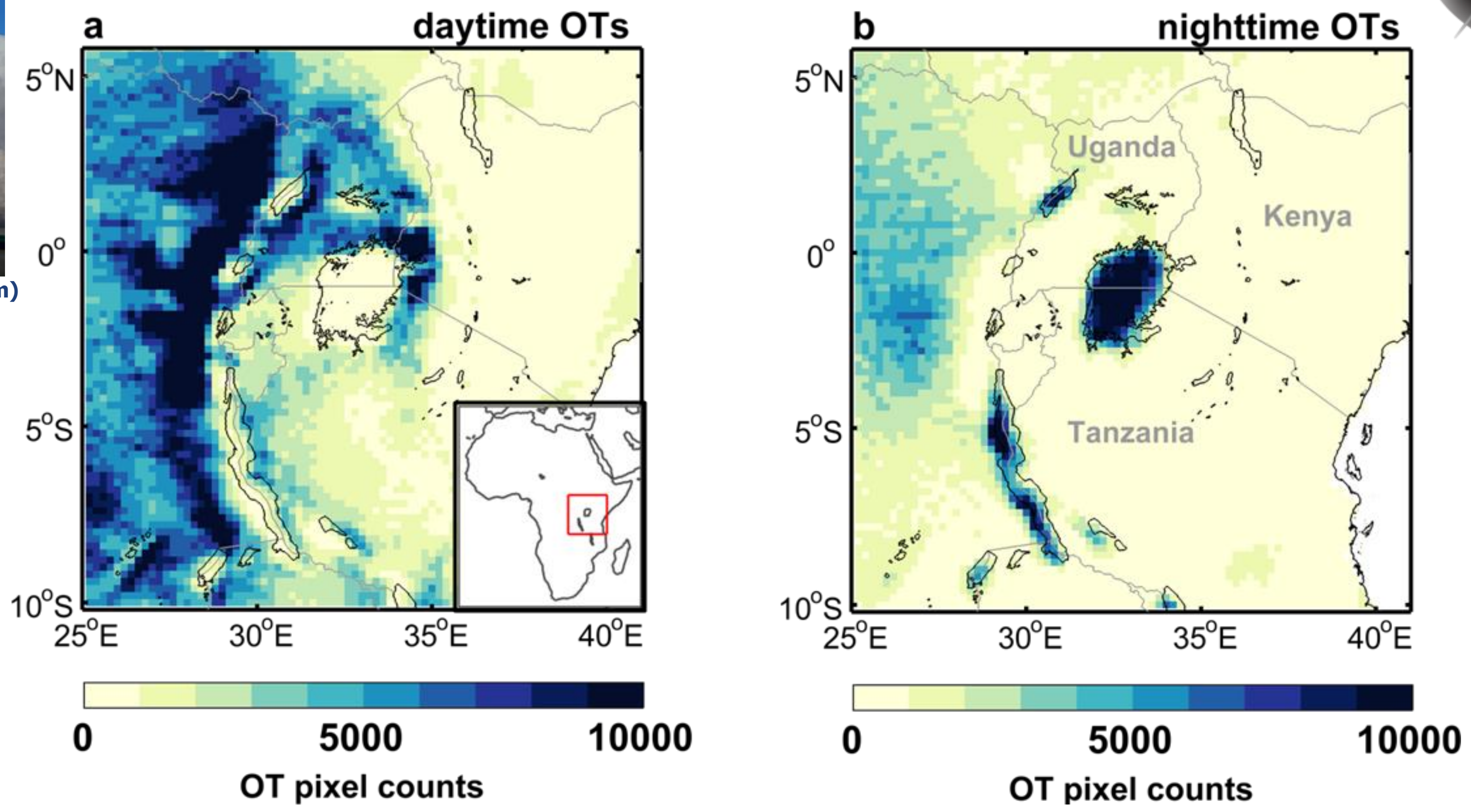


Motivation and objectives



(severe-wx.pbworks.com)





clear lake imprint on thunderstorm occurrence

(Thiery et al., 2017 ERL)

Motivation and objectives

Lethal weather on 'world's most dangerous lake'

From Errol Barnett, CNN

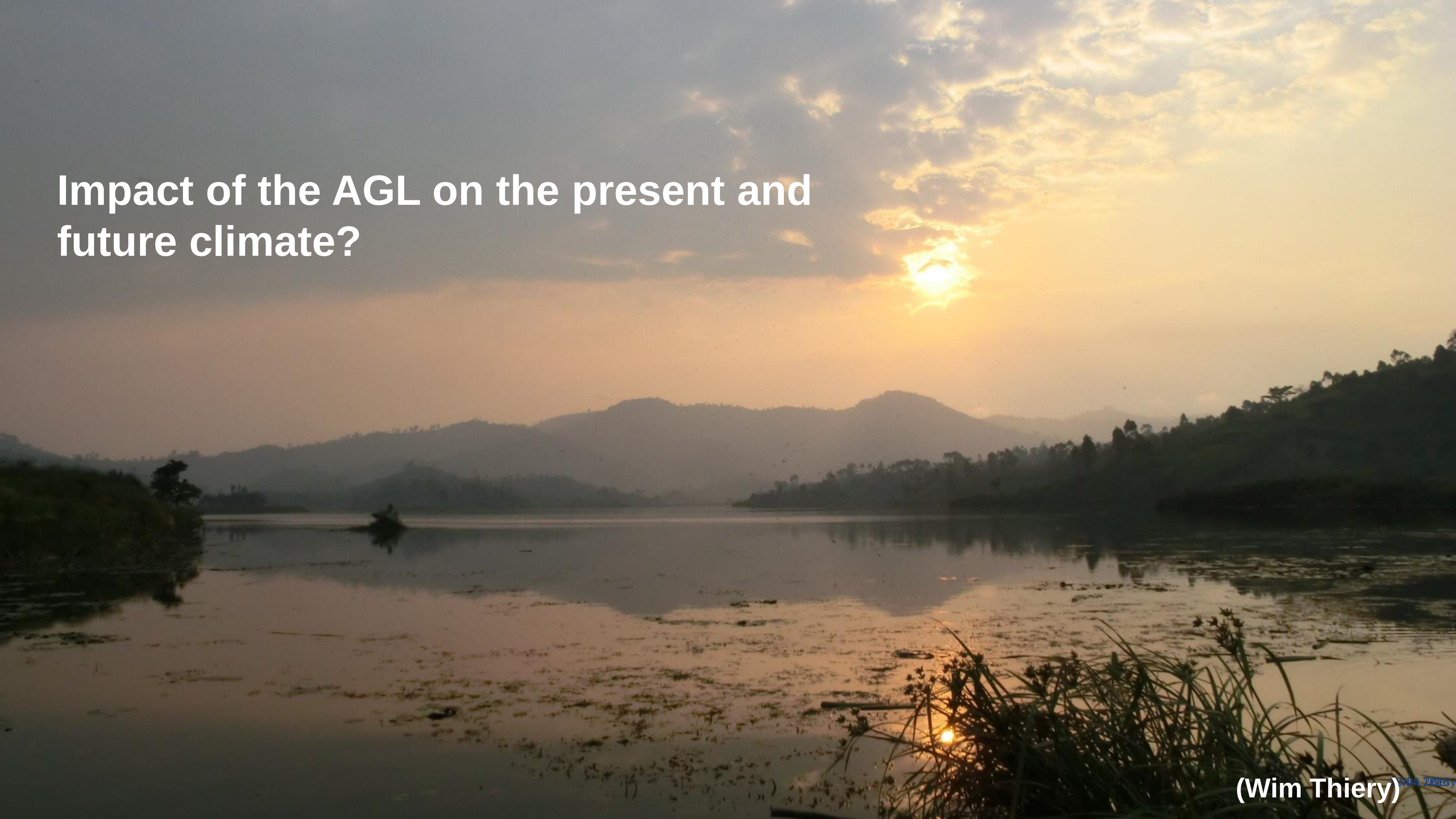
January 17, 2013 -- Updated 1448 GMT (2248 HKT)

(W. Thiery; Lake Kivu)

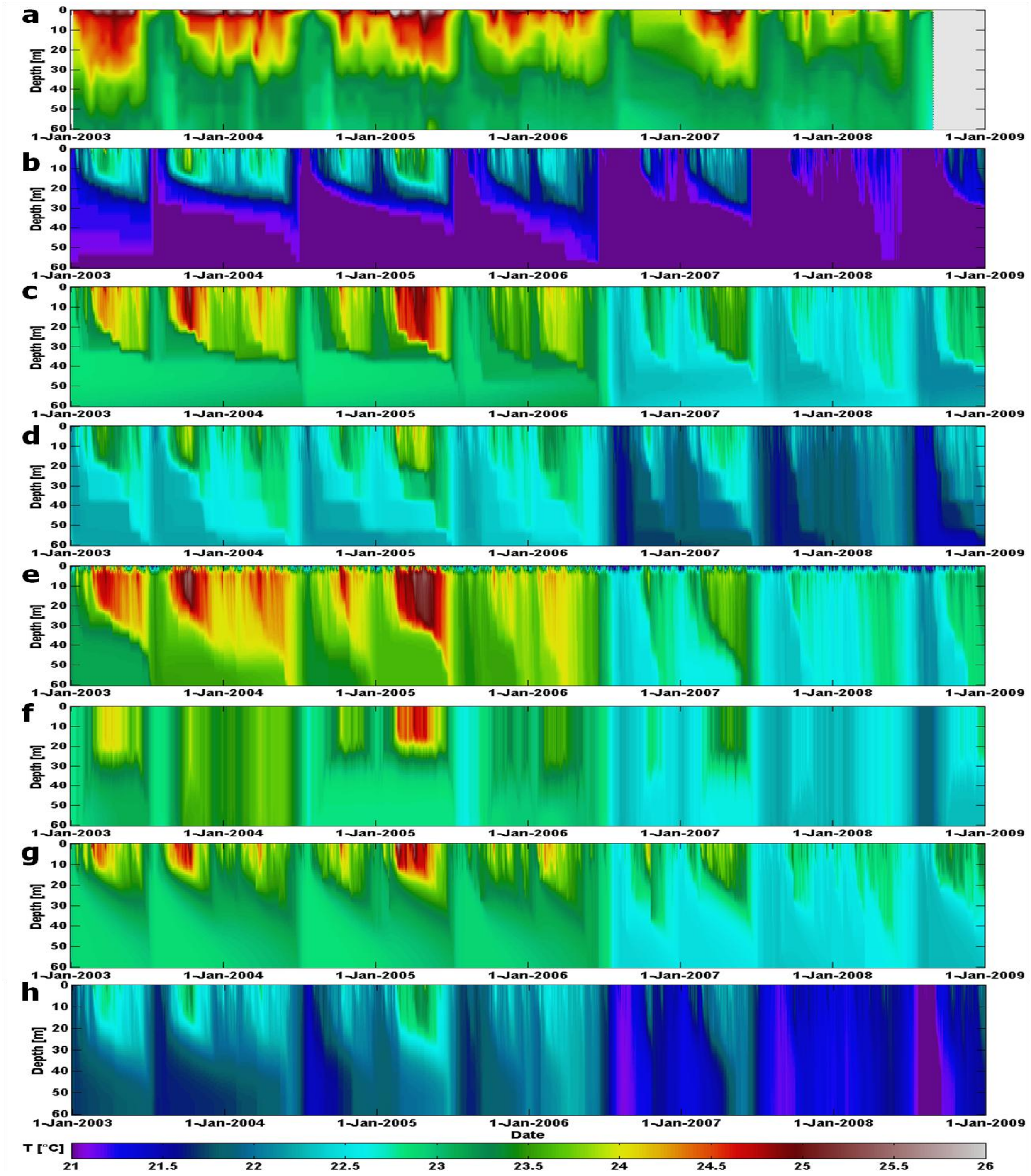
(www.cnn.com)

Impact on climate? **future climate change?** **storm prediction?**

Impact of the AGL on the present and future climate?



(Wim Thiery)



observations

Hostetler

LAKEoneD

SimStrat

LAKE

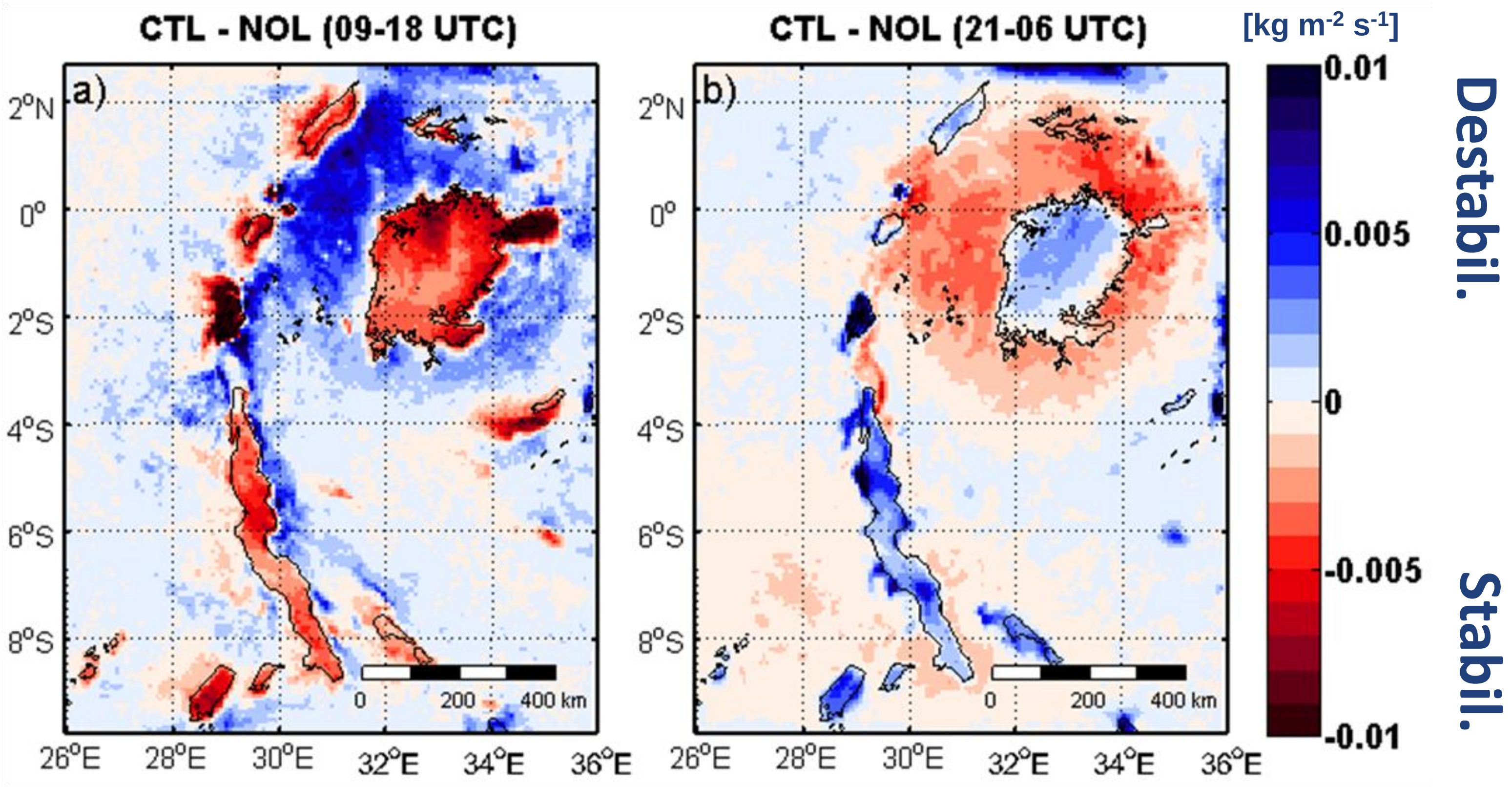
FLake

MINLAKE2012

CLM4-LISSS

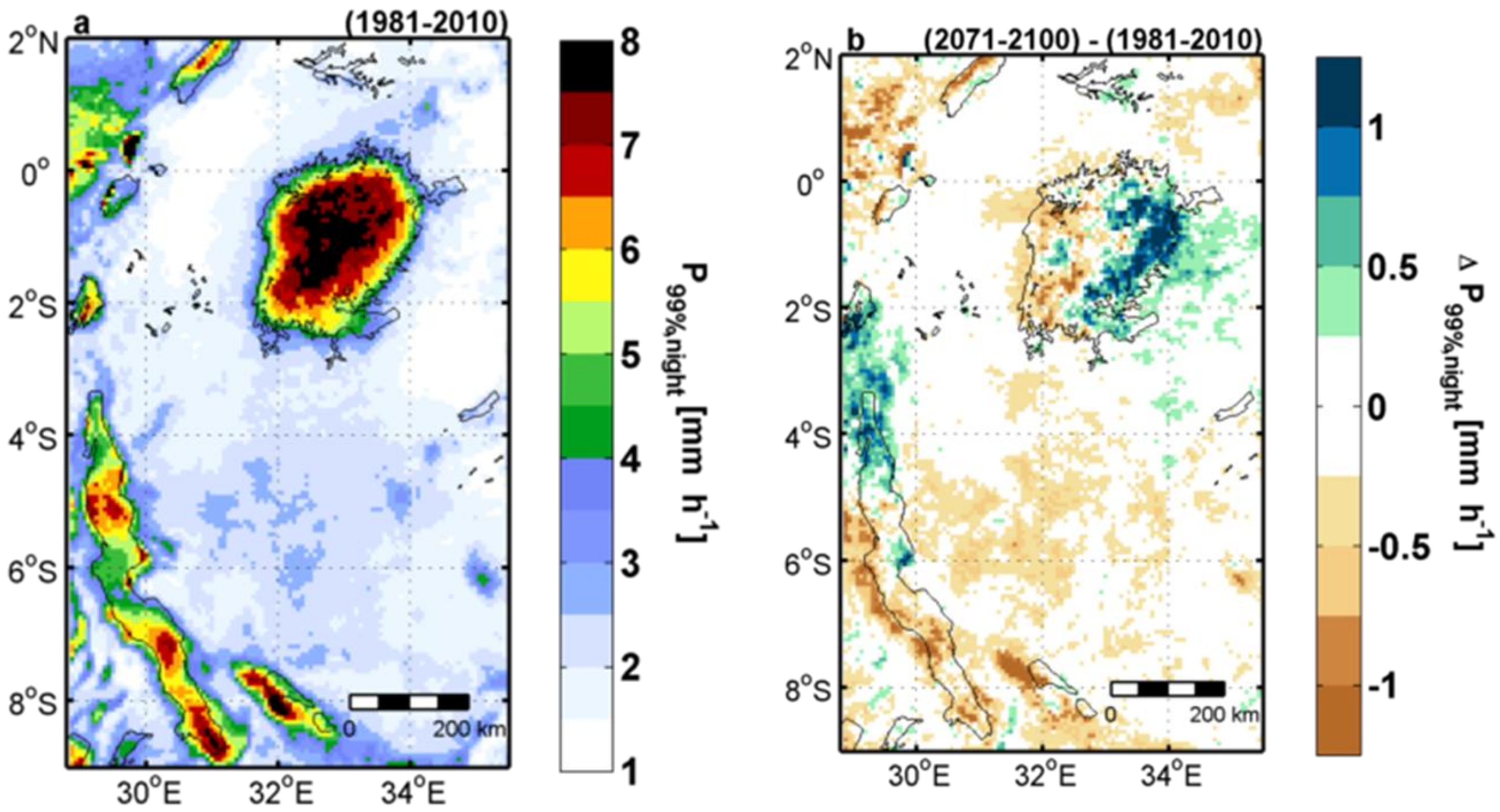
(Thiery et al., 2014 TA)

Convective mass flux density at cloud base height



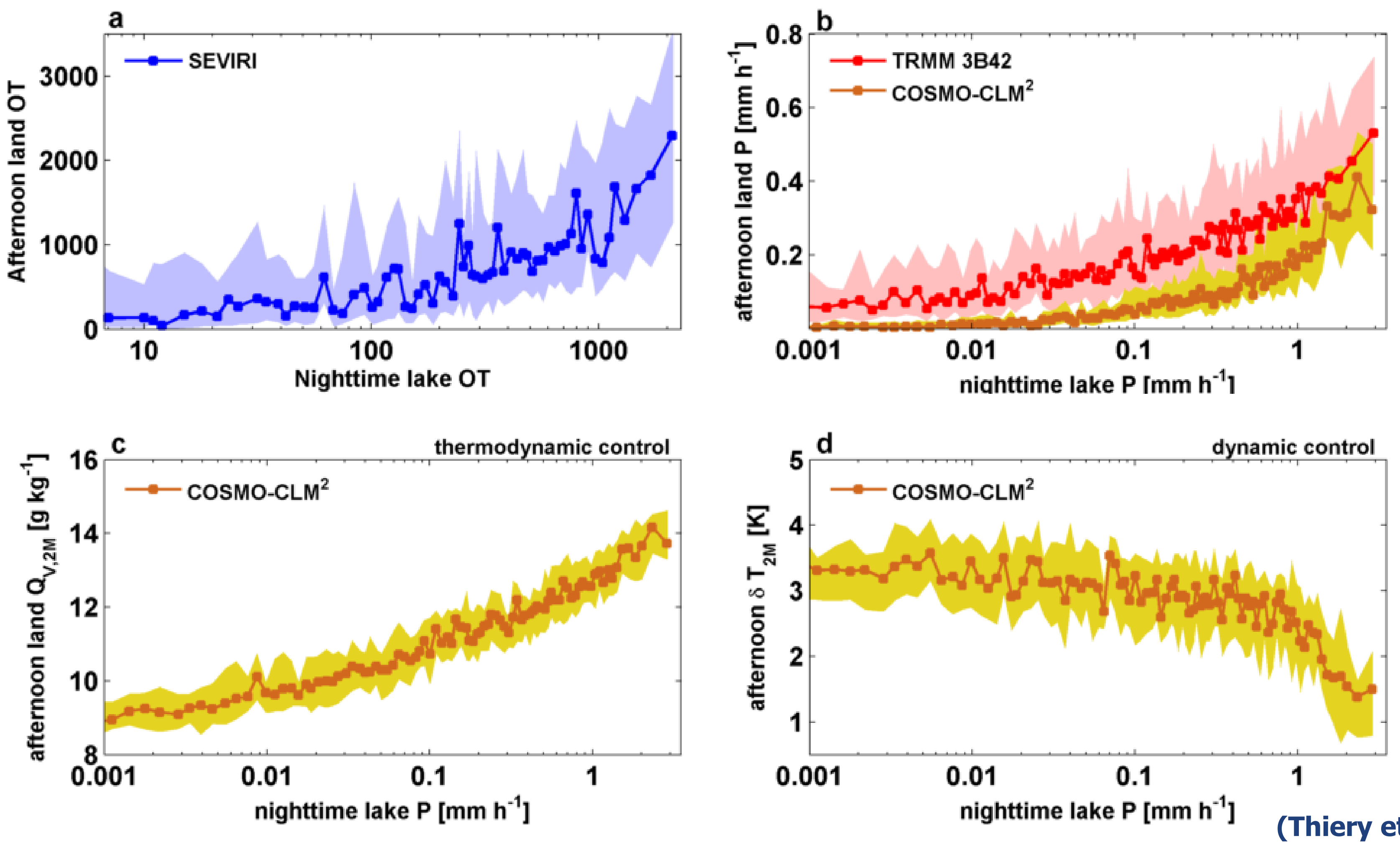
(Thiery et al., 2015 J Clim)

Climate change: extreme precipitation



(Thiery et al., 2016 Nature Comm.)

Afternoon controls



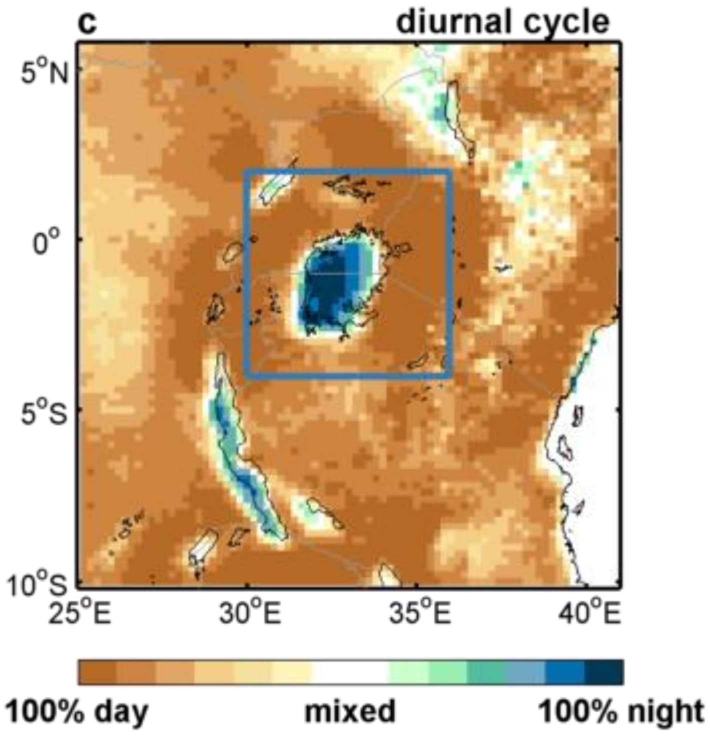
(Thiery et al., 2016 Nature Comm.)

Towards an early warning system?

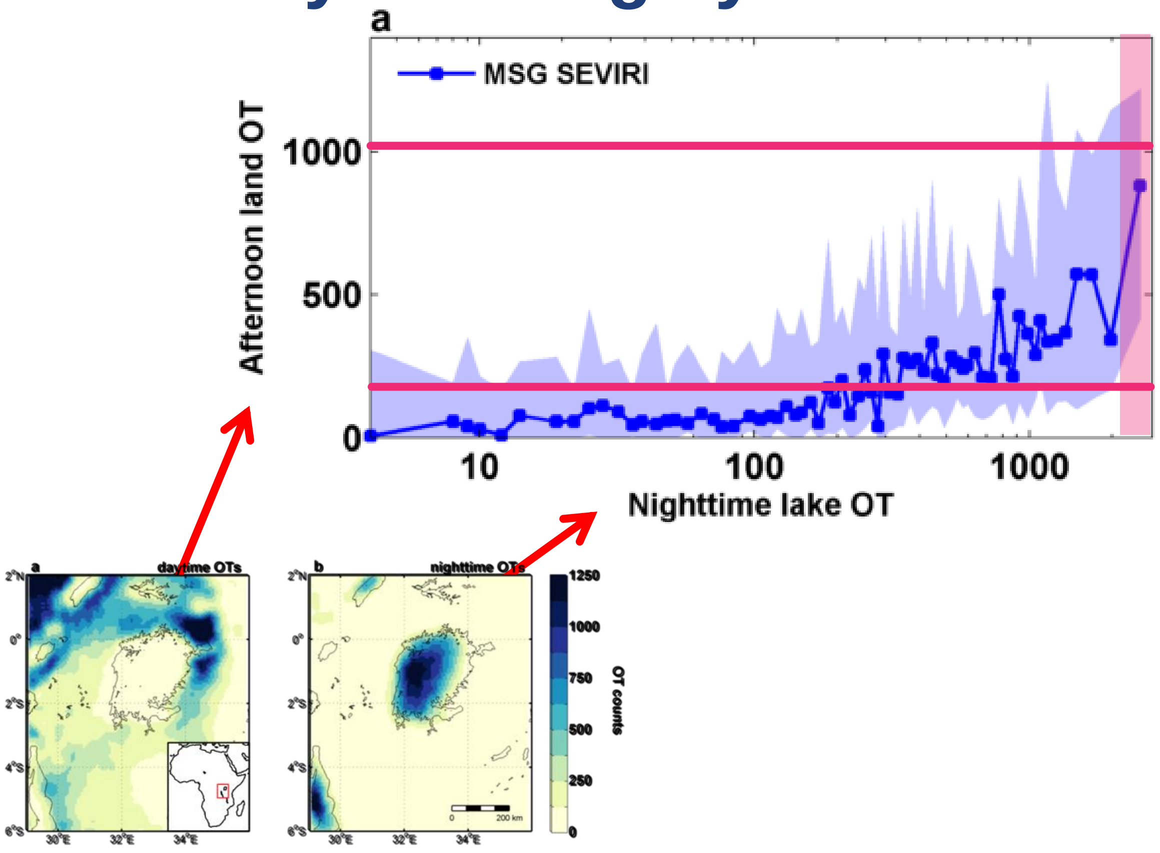
(Wim Thiery)

Methods: proof of concept

- Logistic regression
- Binary predictant:
  - ‘nighttime lake OTs > 99th percentile’
- Predictor:
  - ‘afternoon land OTs’
  - ‘nighttime lake OTs’ (i.e. persistence forecast)
- Model parameters
  - Lead time = 7h
  - Aggregation time = 6h
    ➔ night = 22-09 UTC; day = 10-15 UTC
  - Land pixel selection = square



Towards an early warning system



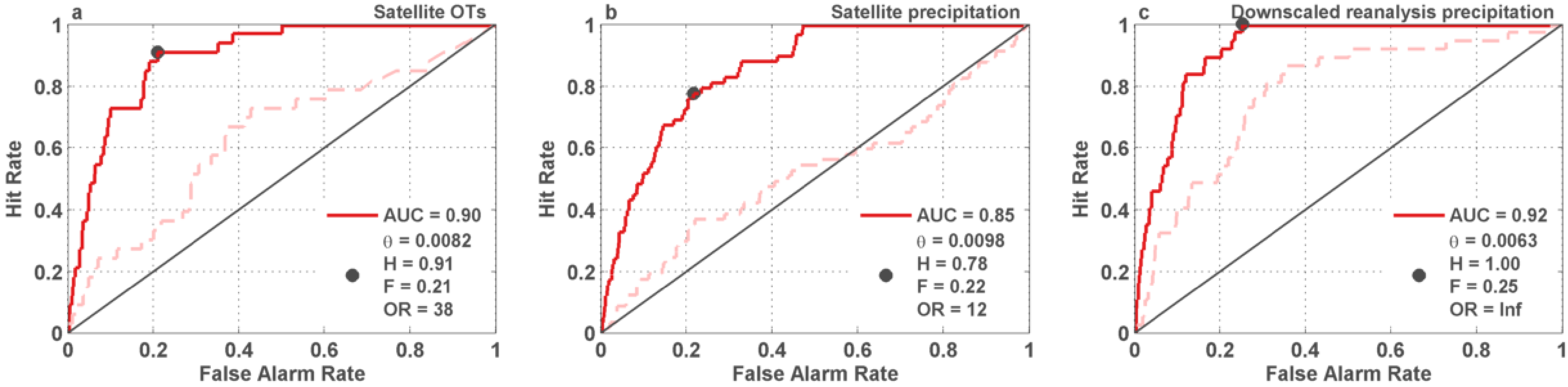
Log. Reg.: "tonight there will be an extreme event" (X% threshold prob.)

Issue warning

Assess skill

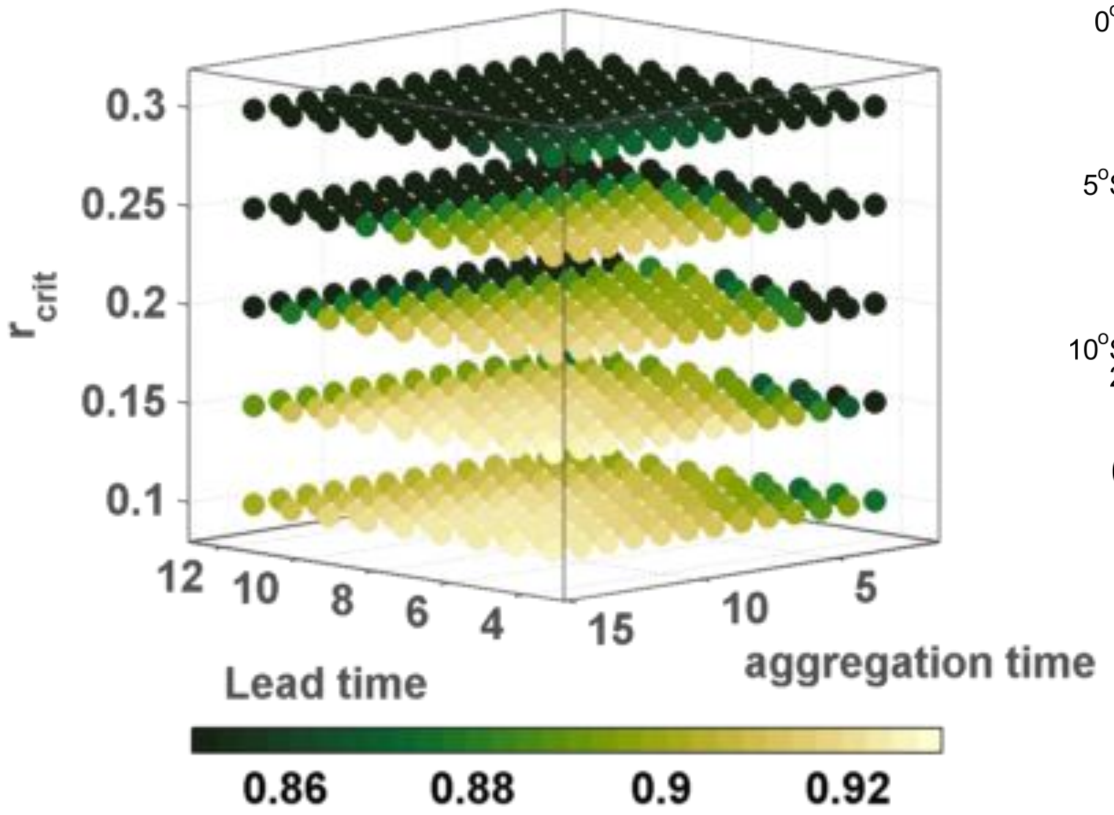
(Thiery et al., 2017 ERL)

Results: Proof of concept storm predictability

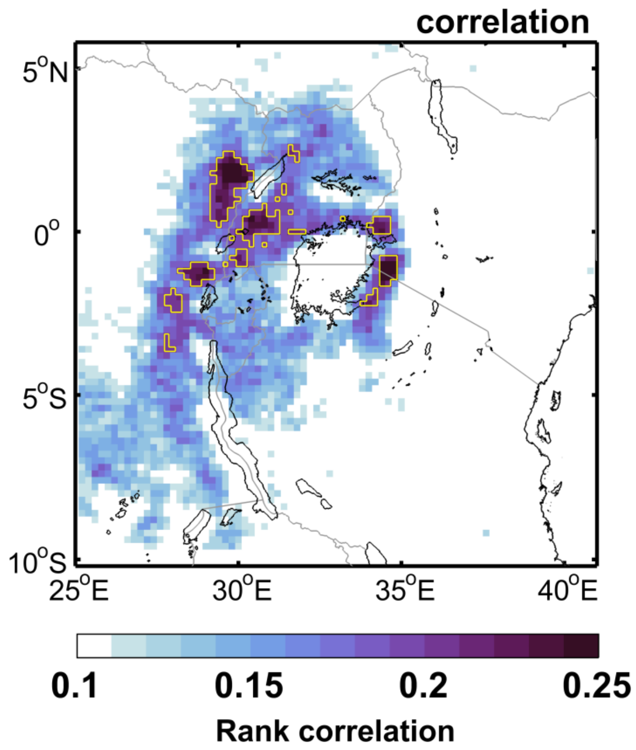


(Thiery et al., 2017 ERL)

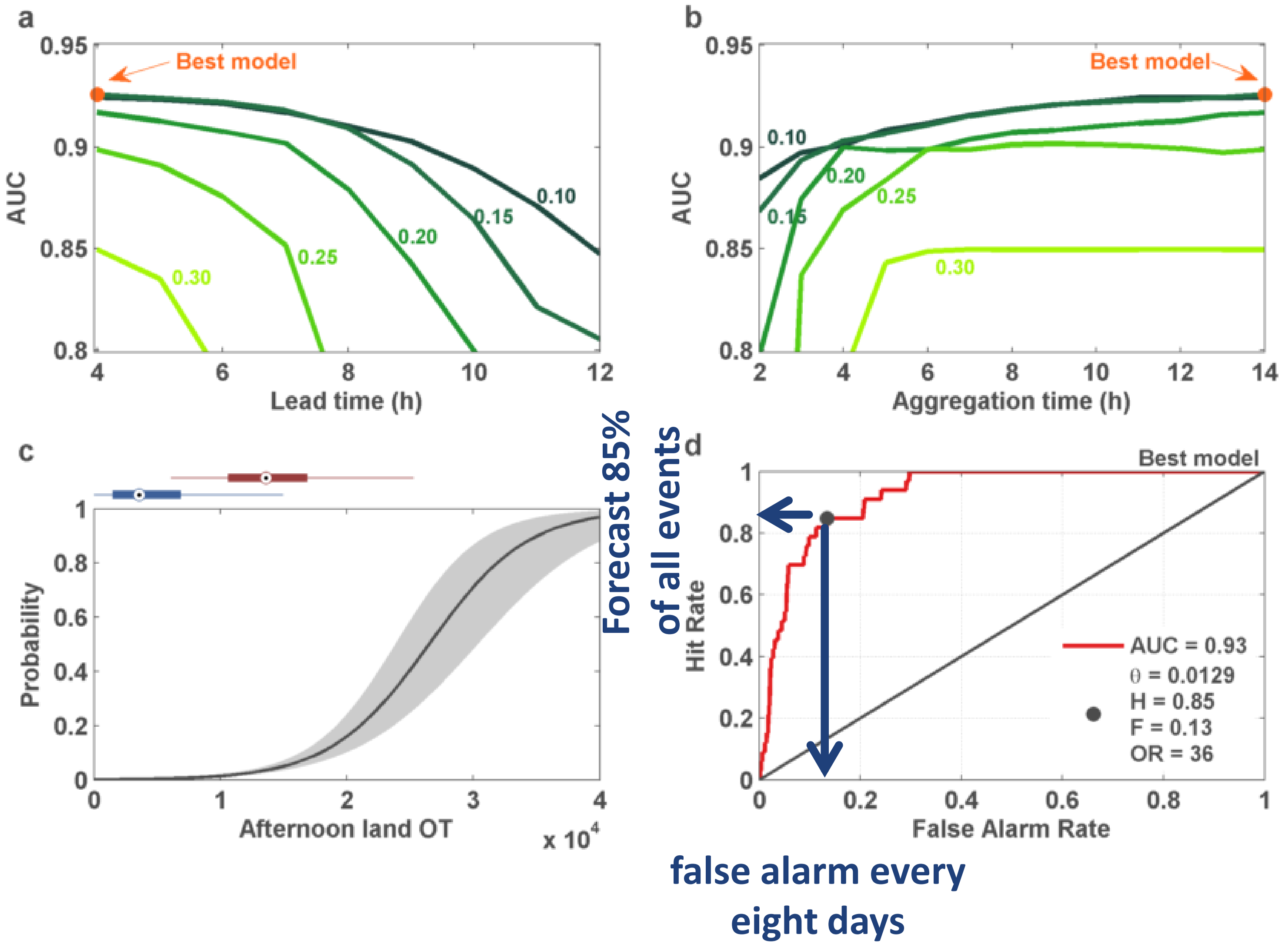
Methods: optimization



AUC



Results: optimization



(Thiery et al., 2017 ERL)

sign in | become a supporter | subscribe | search | jobs | dating | more | International edition

theguardian

UK world sport football opinion culture business lifestyle fashion environment tech travel | browse all sections

home › world › africa | middle east cities development europe US americas asia australia

Meteorology
Weatherwatch

Scientists devise early thunderstorm alerts for fishermen in Africa

Team develops storm warning system based on satellite observations in hope of reducing boating deaths on Lake Victoria

48 3

Kate Ravilious

@katerav

Tuesday 29 August 2017 21.30 BST

Most popular

I asked Tinder for my data. It sent me 800 pages of my deepest, darkest secrets

Lady Lucan found dead at London home after being reported missing

Alabama Republican Senate primary: Roy Moore defeats Trump-backed Luther Strange

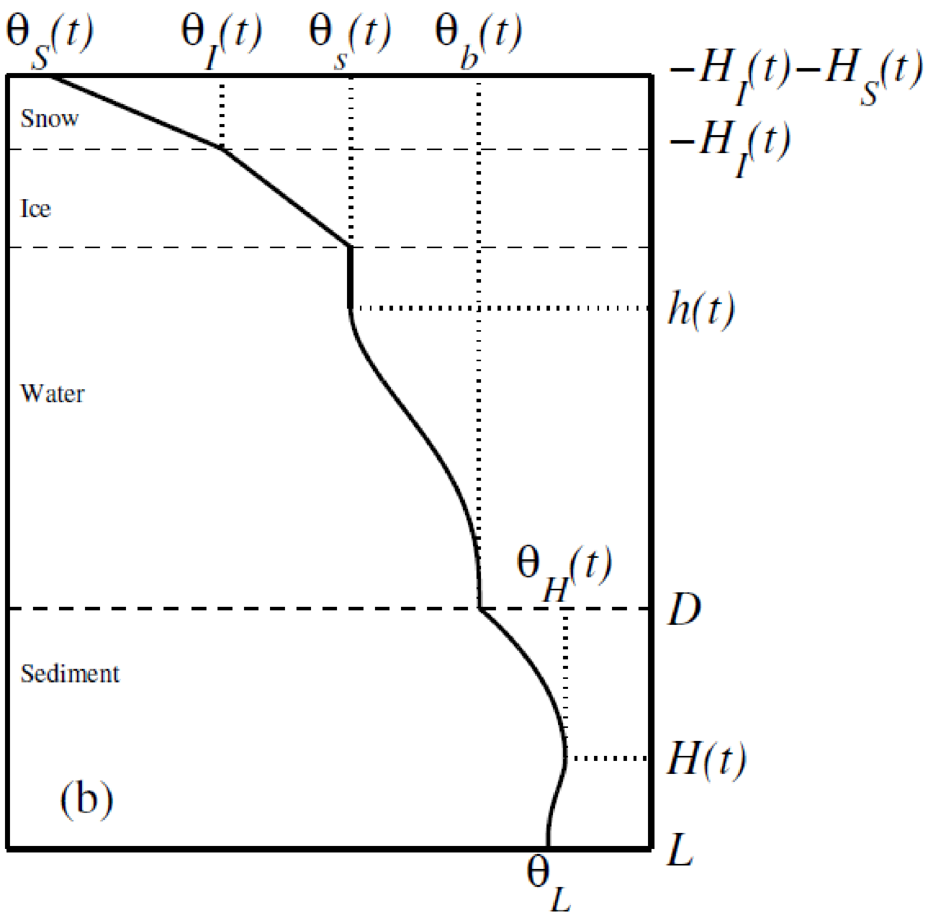

(Photo: Tomaz Kunst / Shutterstock)

Towards FLake2.0

Added value for lake, weather and climate modelling

Wim Thiery, Georgiy Kirillin, Victor Stepanenko & Dmitrii Mironov

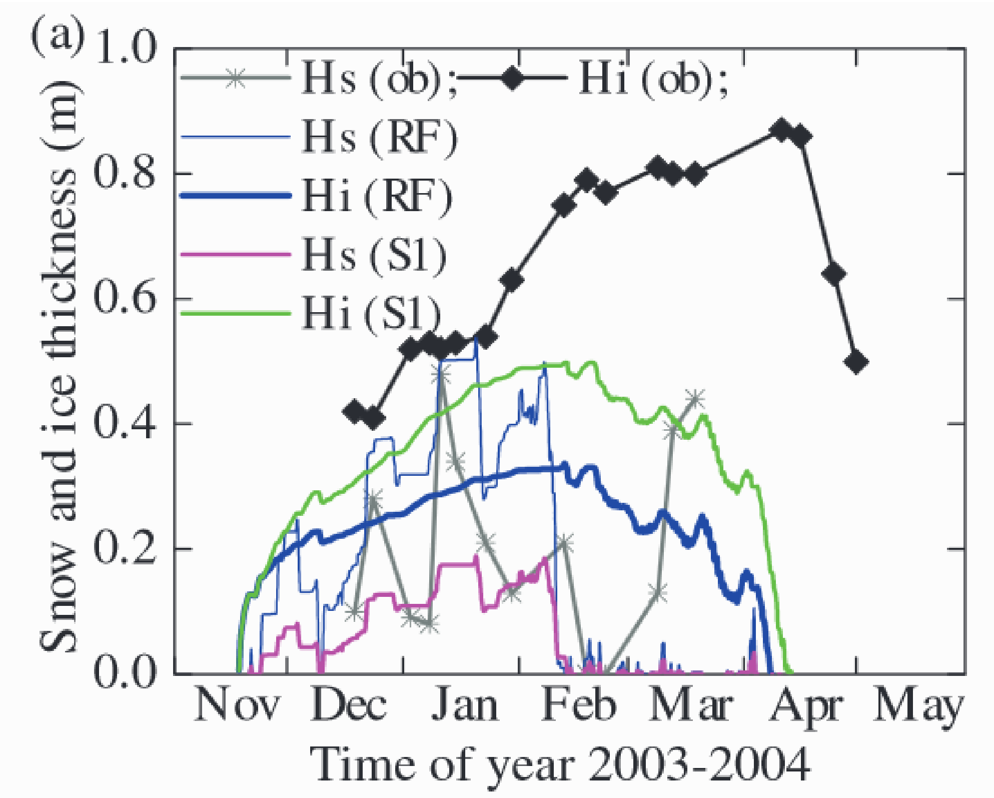
FLake1.0



(Mironov, 2008)

Issues

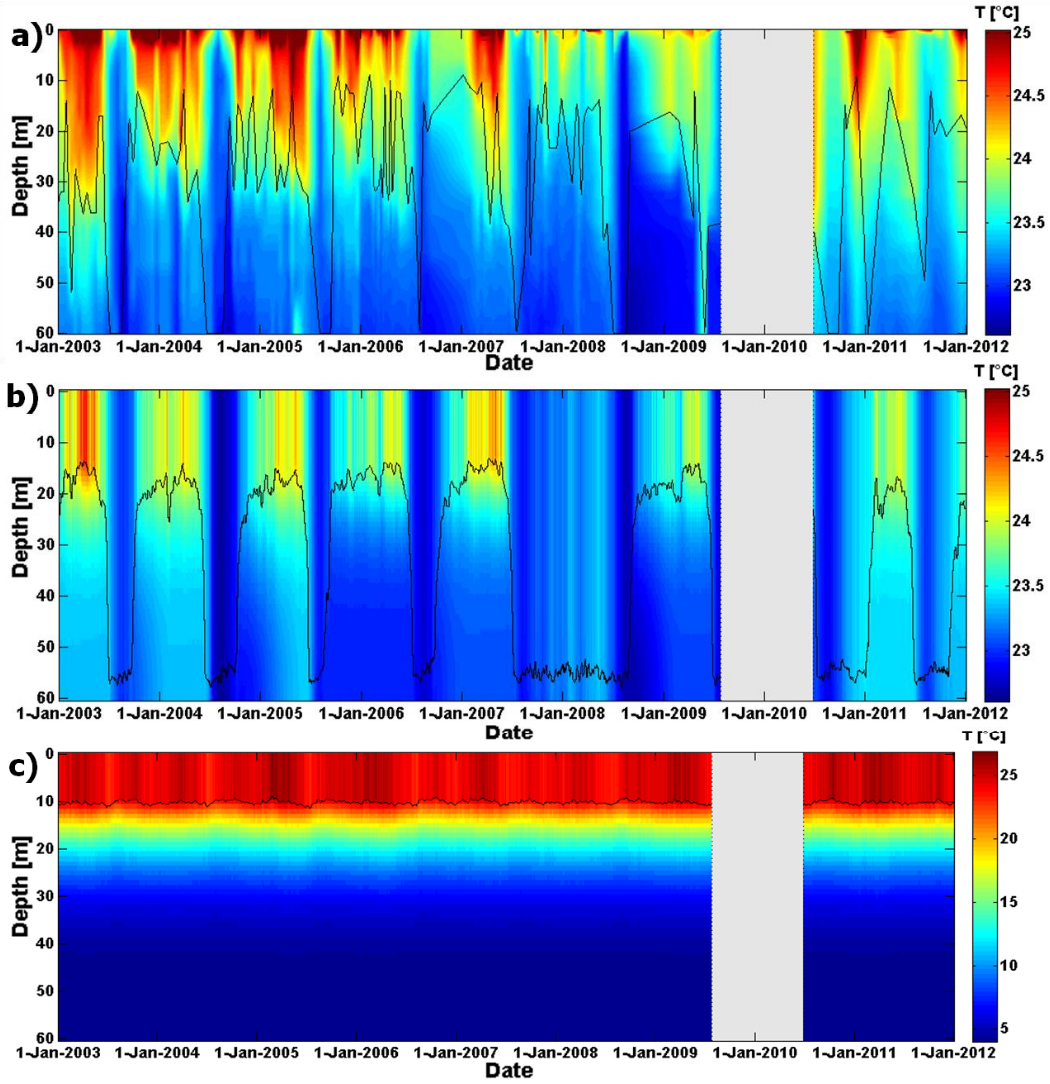
- Ice on/ice off dates



(Semmler et al., 2012; see also Stepanenko et al.,2014 GMD)

Issues

- Ice on/ice off dates
- An inconvenient attractor



(Thiery et al.,2014 GMD)

Issues

- Ice on/ice off dates
- An inconvenient attractor
- Thermodynamics only
  - No GHGs

nature geoscience ARTICLES
PUBLISHED ONLINE: 20 JULY 2015 | DOI: 10.1038/NGEO2486

Globally significant greenhouse-gas emissions from African inland waters

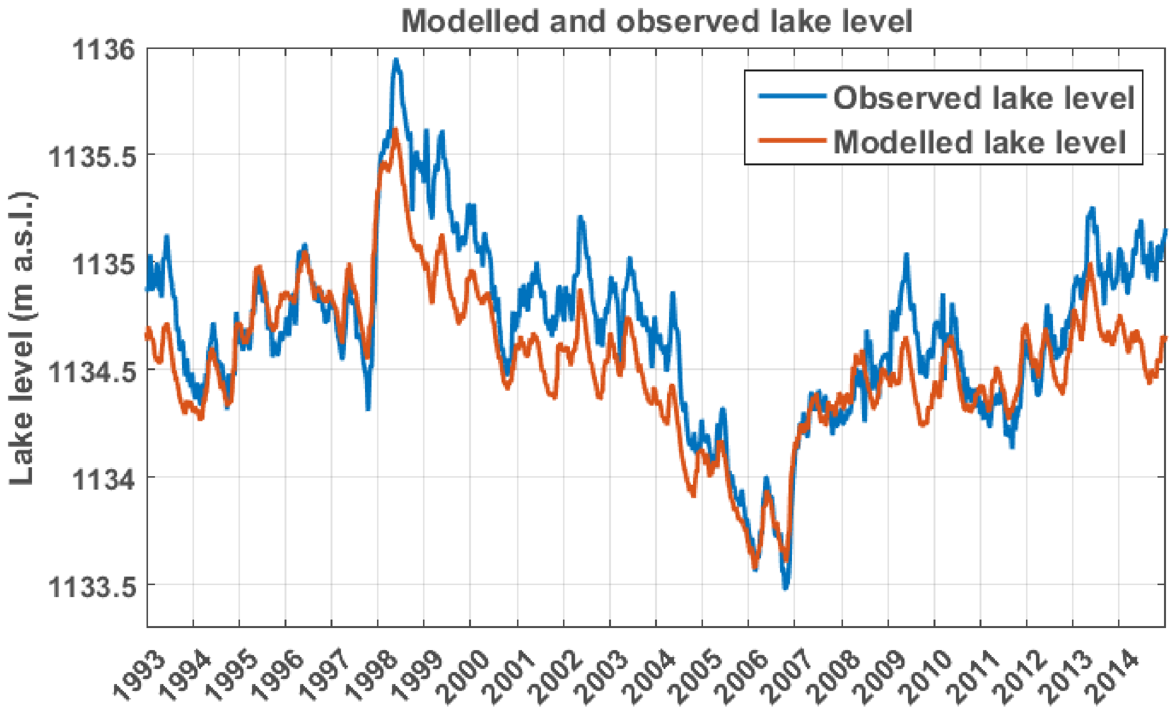
Alberto V. Borges[1*], François Darchambeau[1], Cristian R. Teodoru[2], Trent R. Marwick[2], Fredrick Tamooh[2,3], Naomi Geeraert[2], Fredrick O. Omengo[2], Frédéric Guérin[4], Thibault Lambert[1], Cédric Morana[2], Eric Okuku[2,5] and Steven Bouillon[2]

Carbon dioxide emissions to the atmosphere from inland waters—streams, rivers, lakes and reservoirs—are nearly equivalent to ocean and land sinks globally. Inland waters can be an important source of methane and nitrous oxide emissions as well, but emissions are poorly quantified, especially in Africa. Here we report dissolved carbon dioxide, methane and nitrous oxide concentrations from 12 rivers in sub-Saharan Africa, including seasonally resolved sampling at 39 sites, acquired between 2006 and 2014. Fluxes were calculated from published gas transfer velocities, and upscaled to the area of all sub-Saharan

(Borges et al., 2015 Nat Geo)

Issues

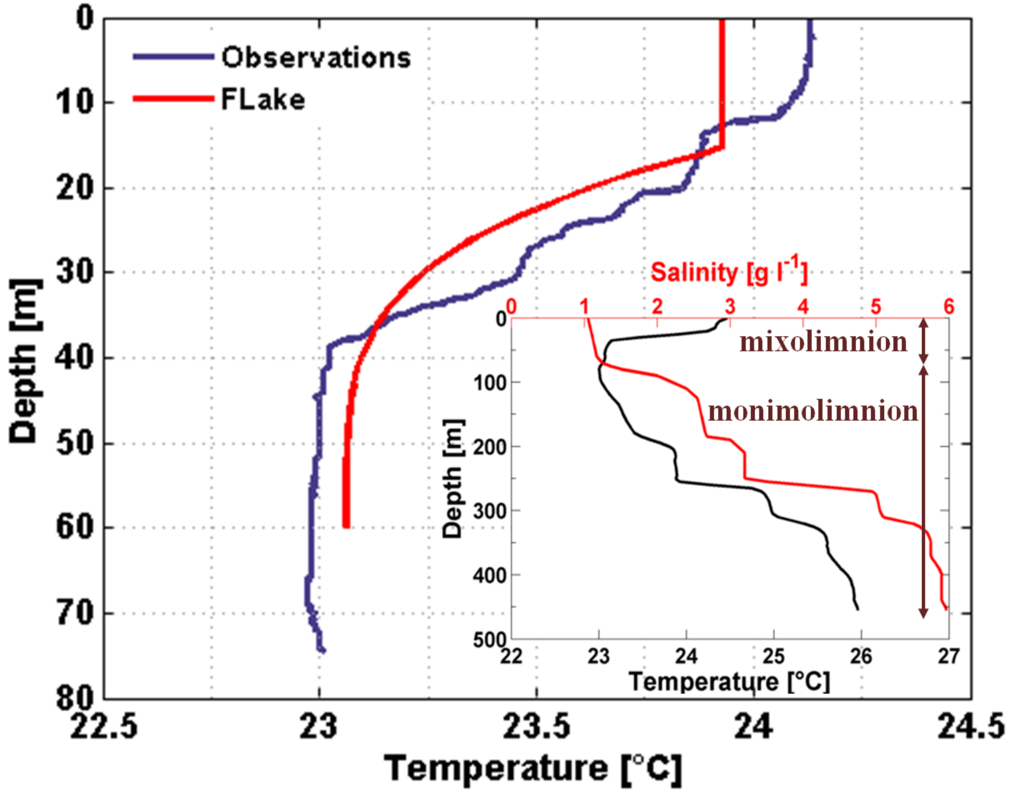
- Ice on/ice off dates
- An inconvenient attractor
- Thermodynamics only
  - No GHGs
  - No Water Balance



(Vanderkelen et al., in prep.)

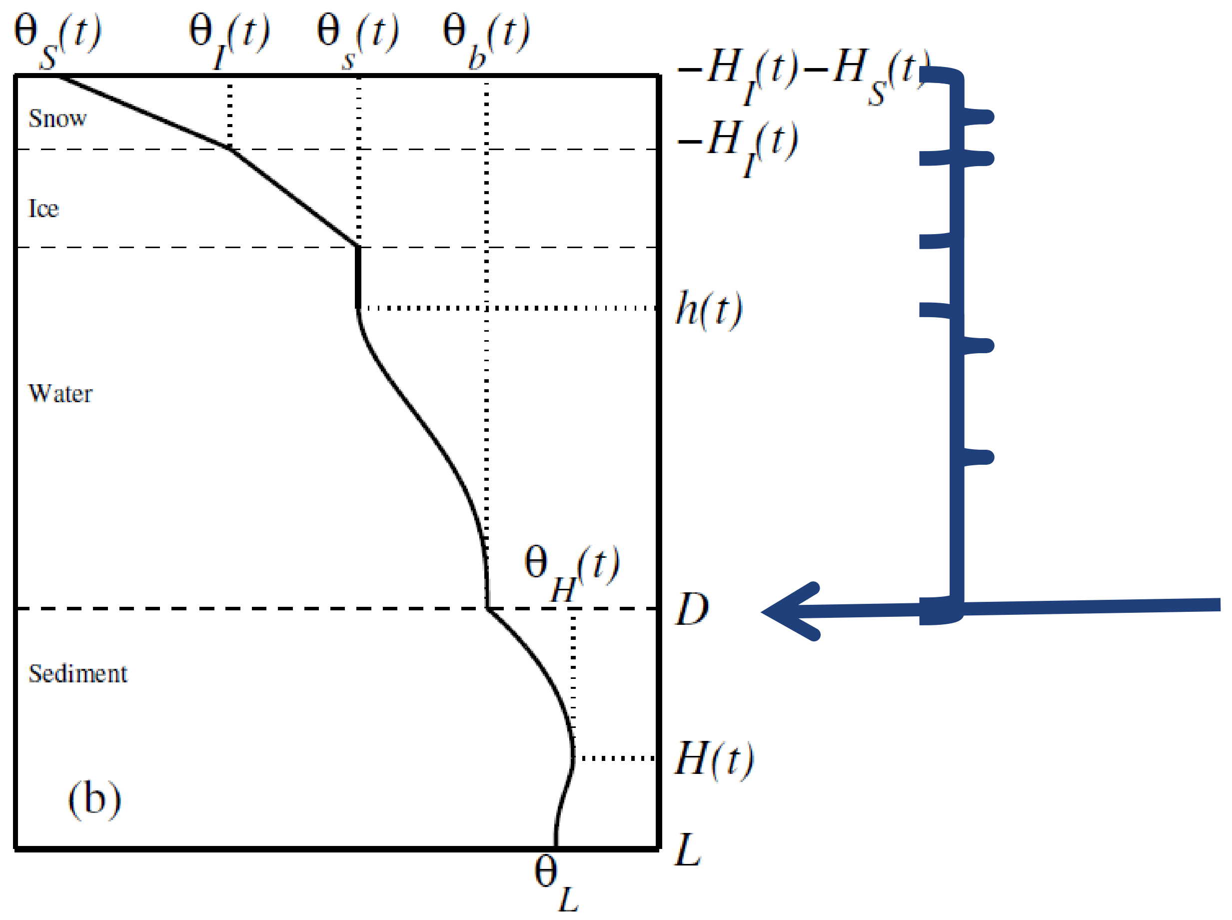
Issues

- Ice on/ice off dates
- An inconvenient attractor
- Thermodynamics only
  - No GHGs
  - No Water Balance
- Deep lakes
- Freshwater only



(Thiery et al.,2014 GMD)

Towards FLake2.0



1. thermocline **[Georgiy]**
2. GHG module **[Victor]**
3. data assimilation **[Dmitrii]**
4. water balance? **[Wim]**
5. snow? **[Dmitrii]**

1. Thermocline representation: the idea

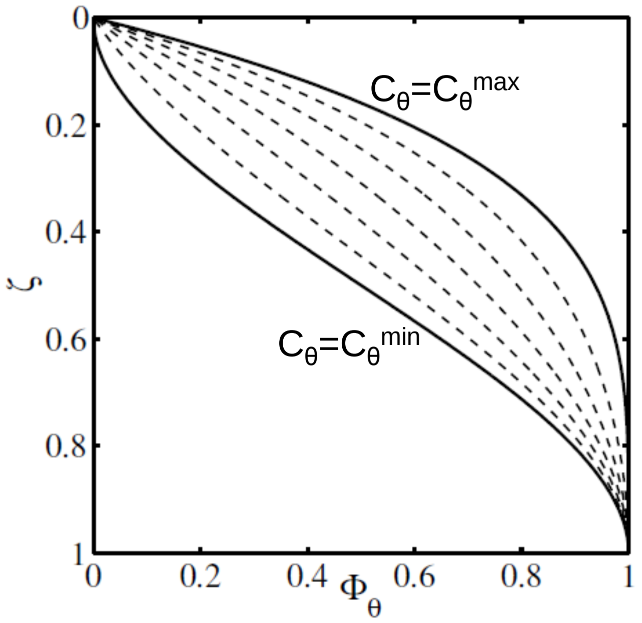


Figure 5: The fourth-order polynomial approximation of the shape function $\Phi_\theta(\zeta)$ with respect to the temperature profile in the thermocline. The curves are computed from Eq. (55) with seven different values of the shape factor C_θ ranging from $C_\theta = C_\theta^{min} = 0.5$, lower solid curve, to $C_\theta = C_\theta^{max} = 0.8$, upper solid curve, $\Delta C_\theta = 0.05$ apart.

$$\frac{dC_\vartheta}{dt} = \mathrm{sign}(\dot{h}) \frac{C_\vartheta^{max} - C_\vartheta^{min}}{t_*}, \qquad (1)$$

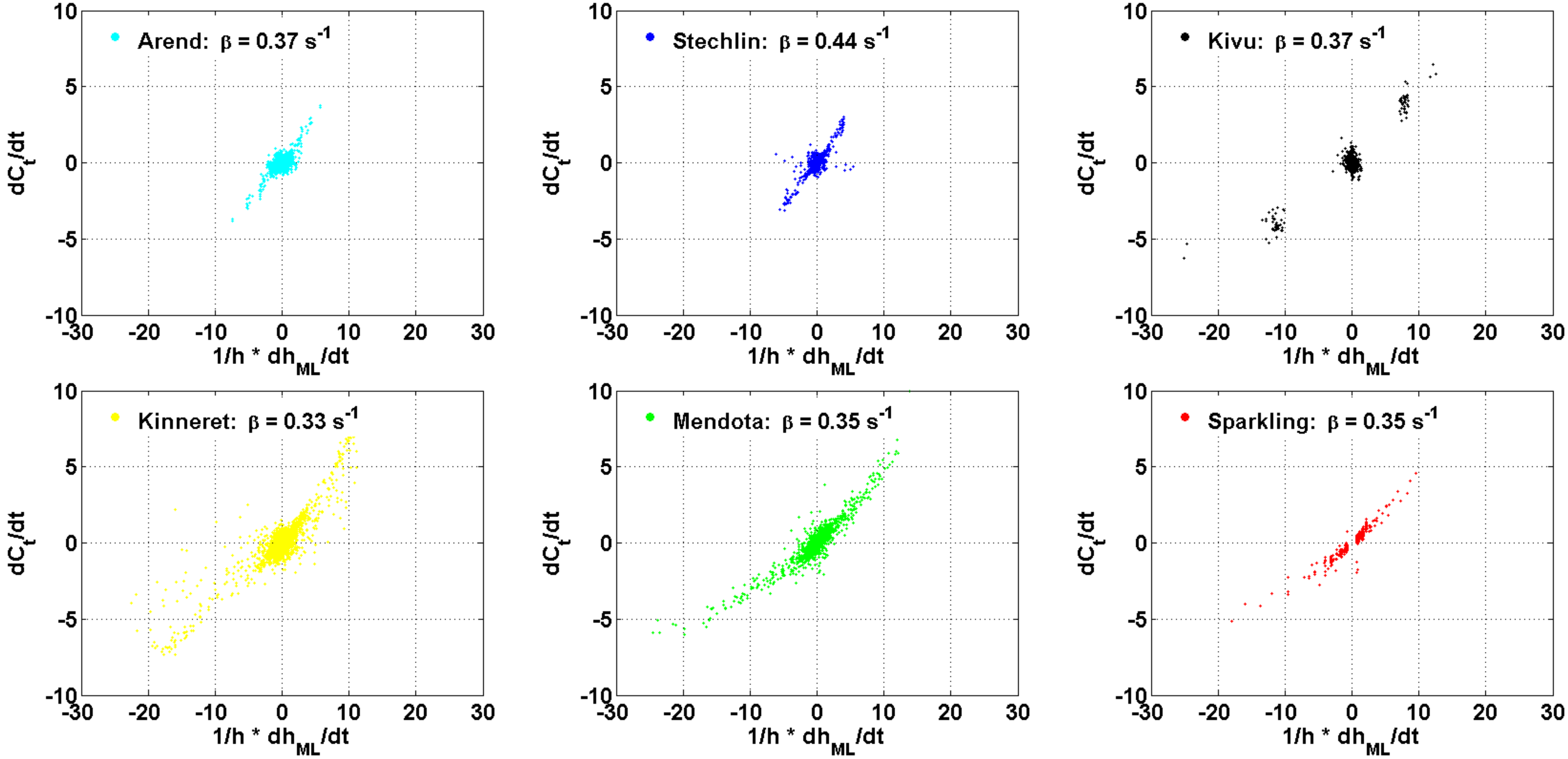
with a characteristic time scale

$$t_* = \frac{\Delta h^2 \bar{N}}{C_{rc} U_*^2}. \qquad (2)$$

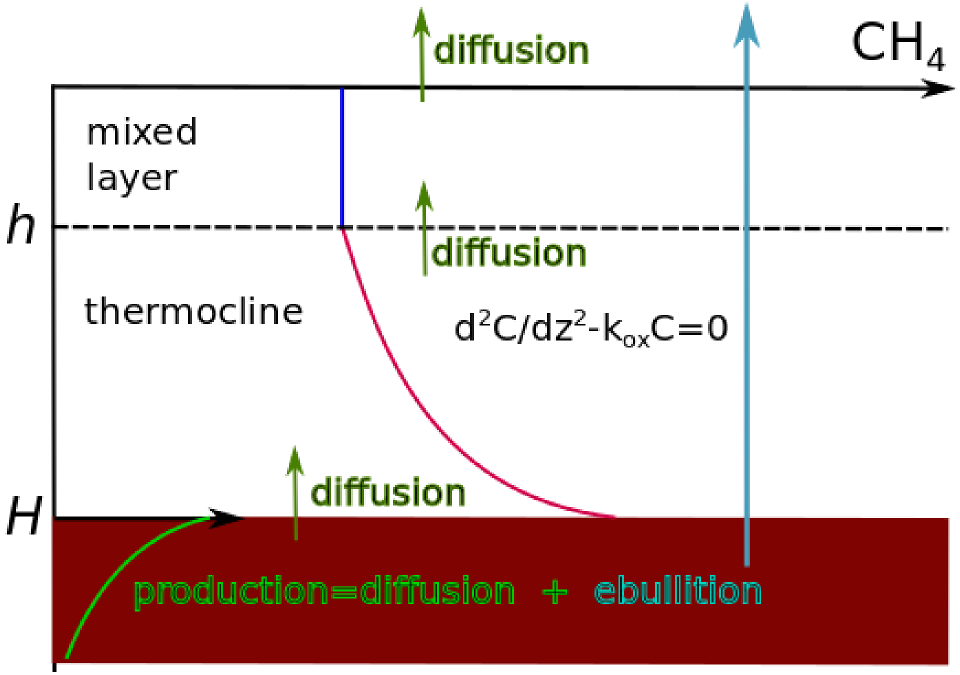
where $\dot{h} = dh_{mix}/dt$ is the entrainment rate, $\Delta h = (D - h_{mix})$ is the thickness of the lower stratified layer (thermocline), $\bar{N} = \Delta h^{-1} \int_{h_{mix}}^{h_{mix}+\Delta h} N dz$ is the mean buoyancy frequency

$$\frac{dC_\vartheta}{dt} \propto \dot{h} \frac{C_\vartheta^{max} - C_\vartheta^{min}}{\Delta h},$$

1. Thermocline representation: testing on data



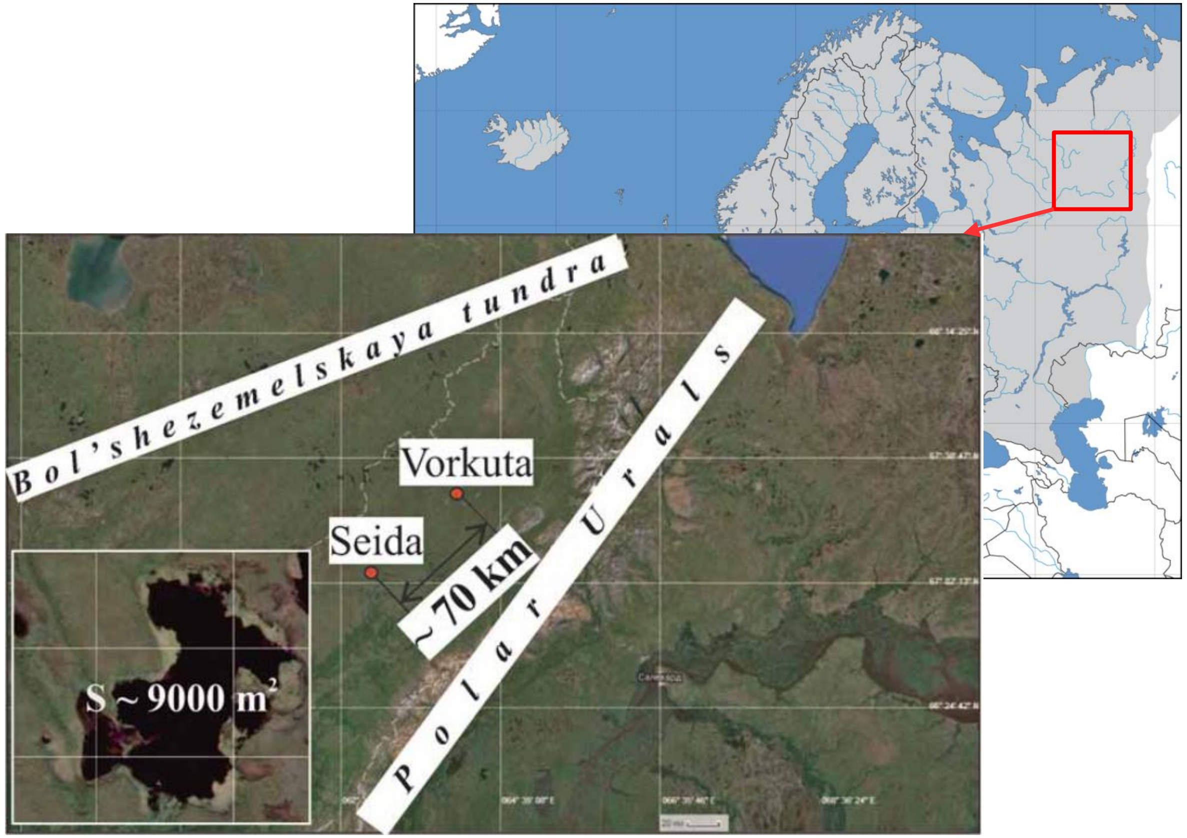
2. GHG module: simple methane model



- Stationary equations (dC/dt=0) in the mixed layer, thermocline and sediments
- Diffusive gas exchange at the water-atmosphere interface
  - ➔ (Heiskanen et al., 2014)
- Analytical solution
  - ➔ computationally very simple model
- Input variables: h, u*, w*, T_bot, T_ML

2. GHG module: validation

- Lake Seida
  - Thermokarst lake
  - S = 0.9 ha
  - Depth = 1.1 – 2.6 m
  - No vegetation
- Observations: UEF
  - (Lind et al., 2009; Marushchak et al., 2016)
  - CH4: floating chambers & subsurface gas collectors

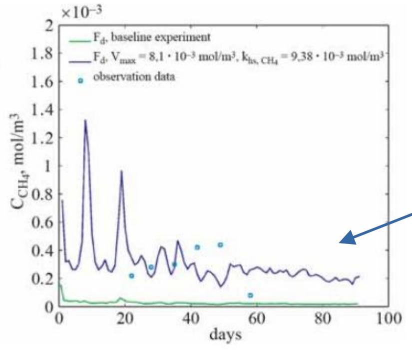


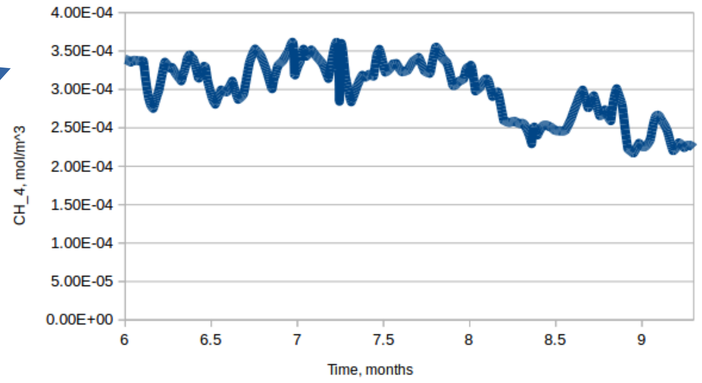
2. GHG module: CH_4 concentration and fluxes (Jul – Aug 2007)

Obs & LAKE (Guseva et al., 2016)

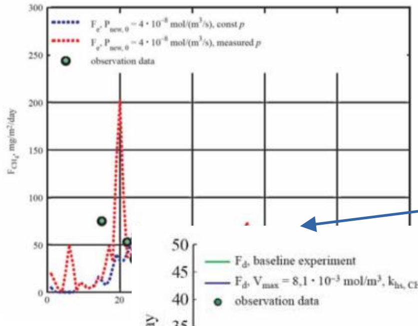
FLake

Surface CH4 concentration

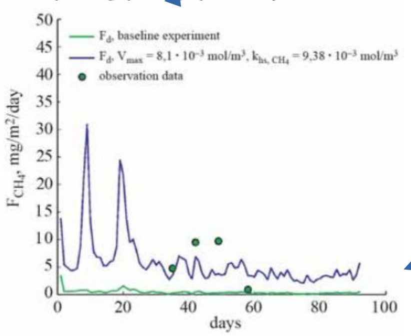


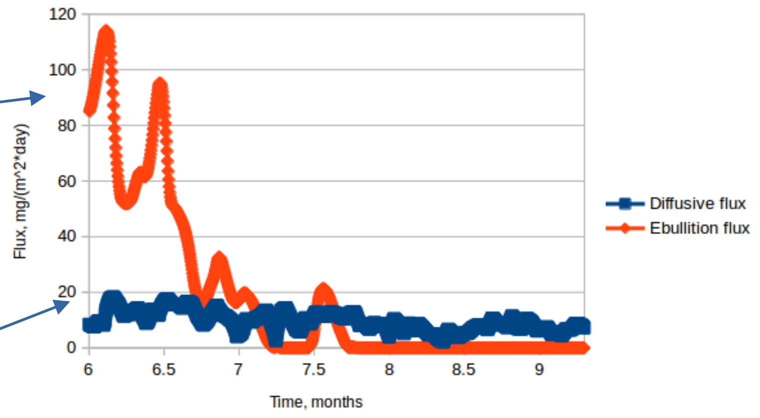


Bubble flux



Surface diffusion flux





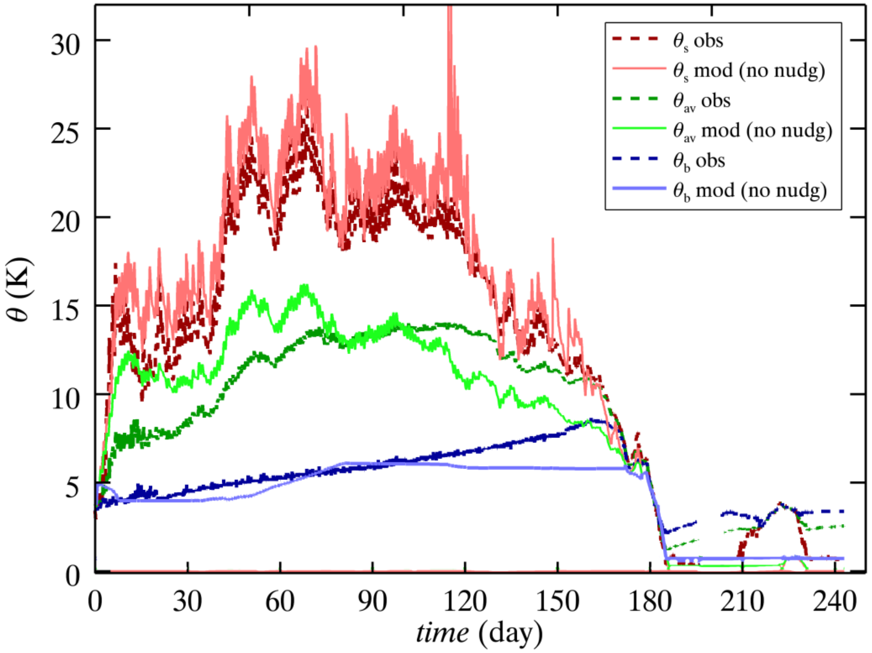
3. Data assimilation: decision tree

cice_obs =

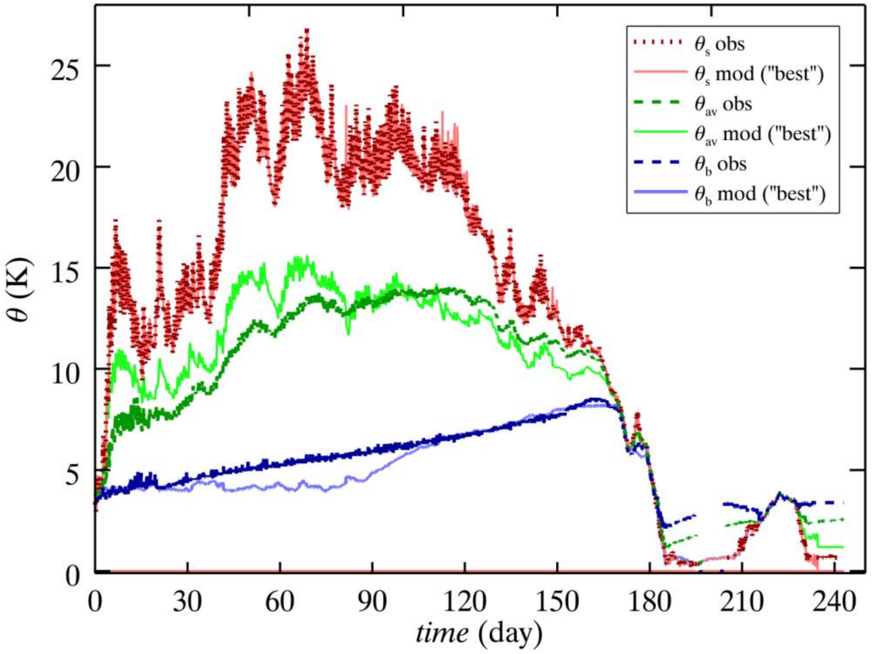
'ice'	**'noice'**	**'nodata'**
There is ice in the forecast ⇒ do nothing No ice in the forecast ⇒ create new ice No observational data on θ_s are assimilated if ice is present	There is ice in the forecast ⇒ remove ice Nudge θ_s data if available ($\langle W \rangle$ and $\langle W\theta \rangle$ should be provided, a negative $\langle W\theta \rangle$ indicates no data)	Nudge θ_s data if available ($\langle W \rangle$ and $\langle W\theta \rangle$ are provided) Do nothing if there are no θ_s data ($\langle W\theta \rangle$ is negative)

3. Data assimilation: test on Valkea-Kotinen

No Nudging

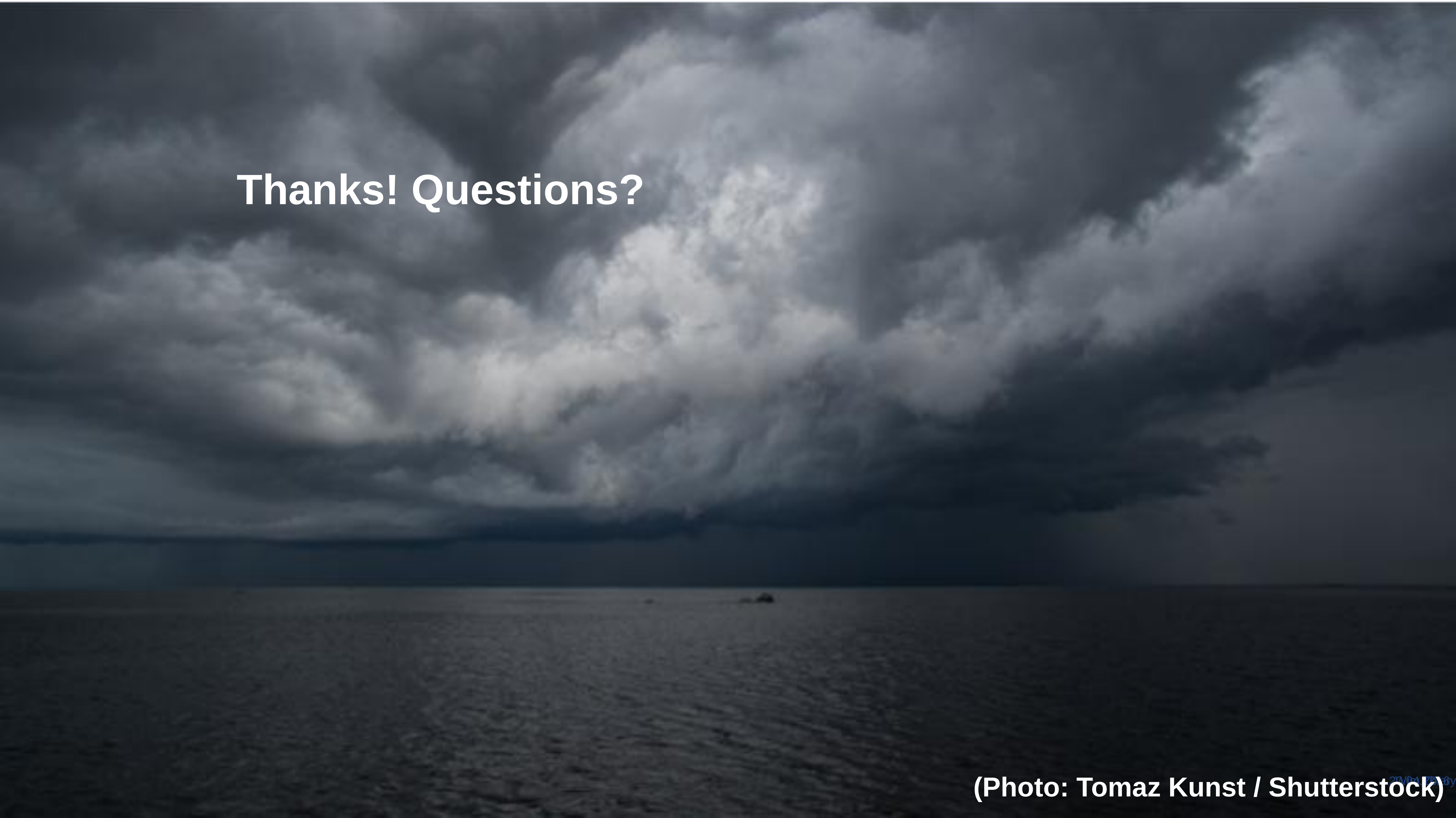


Nudging



Outlook: what will still be missing

- Surface layer stratification
- Hypolimnion
- Equation of state dependence on salinity
- Precipitation effects on temperature
- Charnock parameter dependency on fetch
- Horizontal circulation



Thanks! Questions?

(Photo: Tomaz Kunst / Shutterstock)