

Lake hydrodynamic and ensemble modelling

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Training outline

1. Introduction to lake hydrodynamic modelling
2. Introduction to the 1D lake hydrodynamic model FLake
3. Introduction to the R-Package LakeEnsemblR for ensemble modelling

FLake – 1D hydrodynamic model

■ FLake:

- means Freshwater Lake or Fluxes in Lakes
- Was originally called TEMIX in an early version
- is a bulk (not gridded) 1-D hydrodynamic model
- Is written in Fortran, open source
- For more information or to run the model online:
<http://www.flake.igb-berlin.de/>

FLake Home Applications Docs Publications Download External dataset Legacy website Contact [Run FLake Online](#)

FLake-Global


[Input parameters](#) [Output parameters](#)

FLake-Global is an online modelling system that allows you to run the FLake model online and calculate the temperature and mixing pattern in any shallow freshwater lake around the world. A detailed explanation is provided for the [input parameter](#) and [output parameter](#).

FLake-Global can help answer many frequently asked questions about lakes such as "what is the typical surface temperature in the lake ZZ at the day YY of the month XX", "does the lake freeze in winter?" This tool can be of practical interest for researchers looking for information about the lake temperature evolution, fishermen, anglers, divers interested in the vertical position of the thermocline, and anyone who plans to spend holidays at an outlying lake in unpopulated area and wants to know if the water temperature will be good for bathing during that time.

Lake location

Enter the lake coordinates or pick a point representing the lake from the map below



Latitude: Longitude:

Decimal degrees between -90 and 90 Decimal degrees between -180 and 180

Lake characteristics

Introduction

- FLake developed to parameterise lakes in numerical weather prediction (NWP) and climate models
- Extremely fast (ca. 100x faster than gridded models)
- Also runs in stand-alone model for limnol. Studies
- FLake is highly parameterized – little or no calibration
- 3 lake-specific parameters (depth, fetch, transparency)

Introduction

Fun fact:

FLake is used by most European weather services for weather forecasts (Germany, Finland, Sweden, UK, etc)

Overview Download data Quality assessment Documentation

Clear all

Variable ?

At least one selection must be made

▼ Temperature

<input type="checkbox"/> 2m dewpoint temperature	<input type="checkbox"/> 2m temperature
<input type="checkbox"/> Skin temperature	<input type="checkbox"/> Soil temperature level 1
<input type="checkbox"/> Soil temperature level 2	<input type="checkbox"/> Soil temperature level 3
<input type="checkbox"/> Soil temperature level 4	

Select all

▼ Lakes

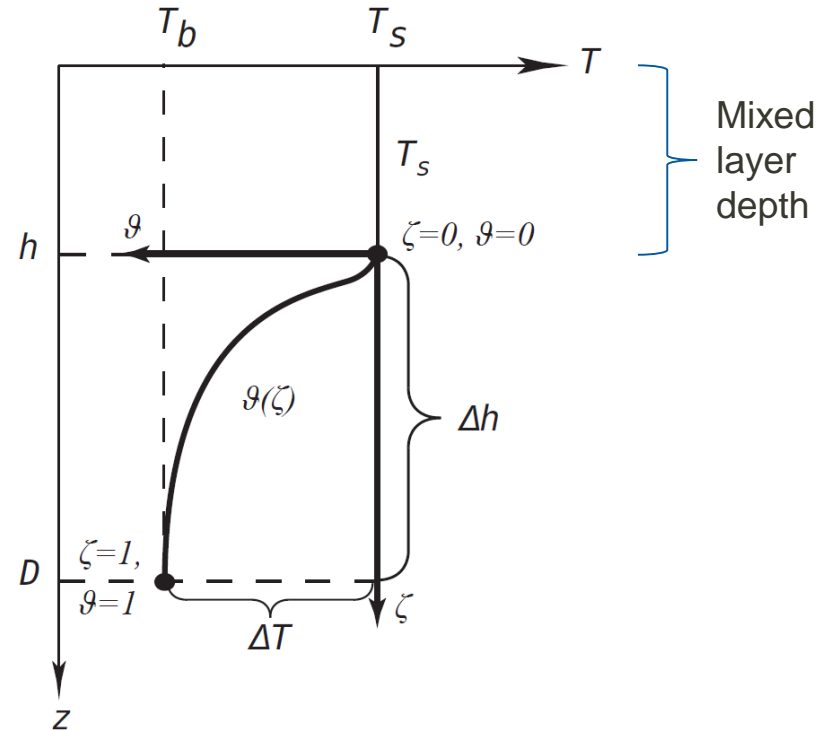
<input type="checkbox"/> Lake bottom temperature	<input type="checkbox"/> Lake ice depth
<input type="checkbox"/> Lake ice temperature	<input type="checkbox"/> Lake mix-layer depth
<input type="checkbox"/> Lake mix-layer temperature	<input type="checkbox"/> Lake shape factor
<input type="checkbox"/> Lake total layer temperature	

Select all

FLake is also in ERA5 reanalysis

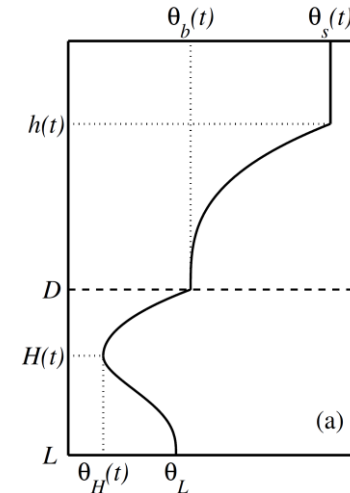
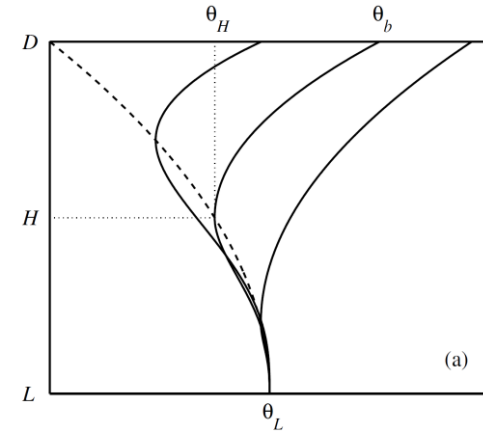
Water column

- Two layers: 1) homogeneous mixed layer, 2) thermocline
- T-profile based on 'self-similarity'
- = dimensionless, universal shape
- Output variables:
 T_s , T_m , T_b , h_{mix} , shape factor
- T-profile can be calculated from these (perl script)



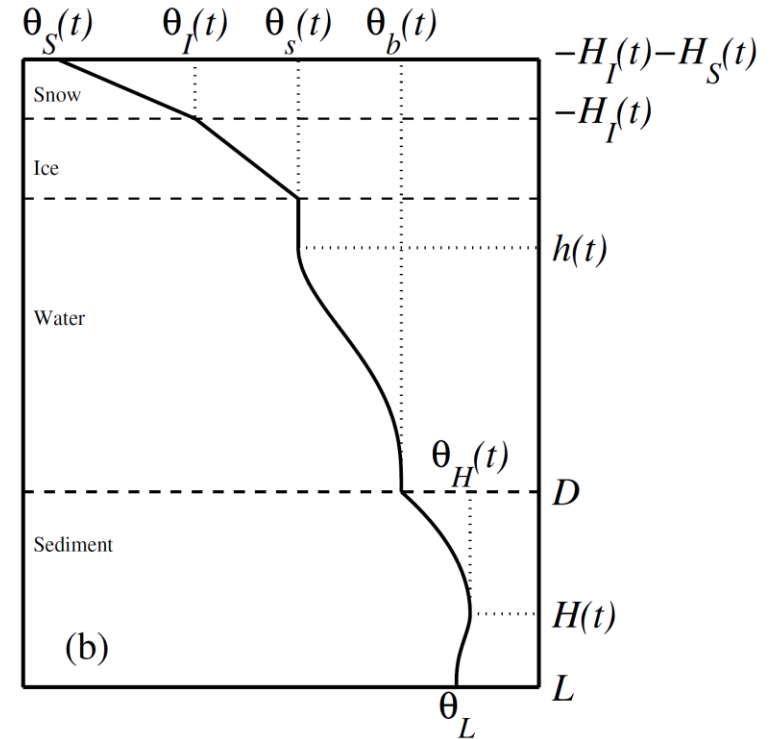
Sediment module

- Flake also models heat storage in sediment
- Sediment heating of water column
- Uses self-similar T-profile in sediment
- Most relevant for lakes < 5 m deep
- Sediment module can be switched off



Ice and snow modules

- Flake contains a simple but effective ice module
- Bulk (non gridded) approach with self-similar parametric representation of T-profile in ice and snow
- Snow module is not really tested → generally don't use it, but testers are welcome!



Modelling tips

- Depth:
 - use mean depth to best model surface temp and ice
 - use max depth if you want a whole profile
 - truncate at 50-60 m (liquid bottom) in very deep lakes, switch off sediments
- Sediments: use for shallow lakes, doesn't seem to harm in moderately deep lakes, switch off in deep lakes
- Calibration or adjustment of profile relaxation time parameter (`c_relax_C`) is advisable (not necessary in new FLake)
- Always set depth, transparency, fetch to lake specific values

Exercise

1. Open the `rappbode.nml` configuration file in the flake folder (eg with notepad++)
2. Open a shell (eg PowerShell or bash) and `cd` (change dir) to the flake folder.
Run flake with the command `.\flake rappbode.nml` (windows) or `./nixflake rappbode.nml` (linux)
3. Open the result file `rappbode_flake.rslt`, and inspect the output.
4. Now follow the same routine and run flake for Lake Erken
5. In Rstudio, open and run through the R-script “`post_process_flake.R`”
6. Adjust some parameters in the `.nml` configuration files and rerun the model (hint you can switch parameters on/off by adding/removing the comment marker “!” at the line beginning.
What is the effect of changing:
 - extinction coefficient (esp bottom temperature and mixed layer depth),
 - `c_relax_C`,
 - the water depth
 - Switching sediments on/off
7. Run flake online for either of the lakes (<http://www.flake.igb-berlin.de/model/run>)

Ensemble modelling

- Ensemble modelling means running several model simulations with different models and/or inputs and/or parameters
- Why? – fill out this form to find out: <https://forms.gle/5HLGBMcQ92pzafAL9> (link also on https://github.com/shatwell/LakeEnsemblR_intro)

☰ README.md

Hydrodynamic and ensemble lake modelling

📅 October 13, 2022


🕒 9:00-13:00

👤 Tom Shatwell (tom.shatwell@ufz.de), Karsten Rinke (karsten.rinke@ufz.de)

📁 Material

🏠 Homepage

📄 OA journal article on the LakeEnsemblR R-package



Description

This training module will provide an introduction into lake hydrodynamic modelling. After a short introductory presentation we will apply the 1D lake model [FLake](#) to an example waterbody. After learning how to apply one hydrodynamic model, we will dive into ensemble modelling with the [R package "LakeEnsemblR"](#) that has been developed within the GLEON modelling group. Learn how to set up multiple lake models for your lake physical system, how to calibrate your models and explore model uncertainty.

What will this workshop cover?

- Introduction to hydrodynamic modelling of lakes
- Introduction to the FLake model
- Introduction to LakeEnsemblR package:
 - Why use ensembles? (link to the [introductory exercise](#))

here

Ensemble modelling: LakeEnsemblR R package

Who's who?

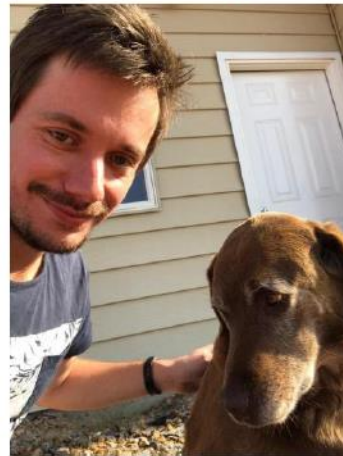
 #LakeEnsemblR

Jorrit
package mastermind



Hannes
coding genius

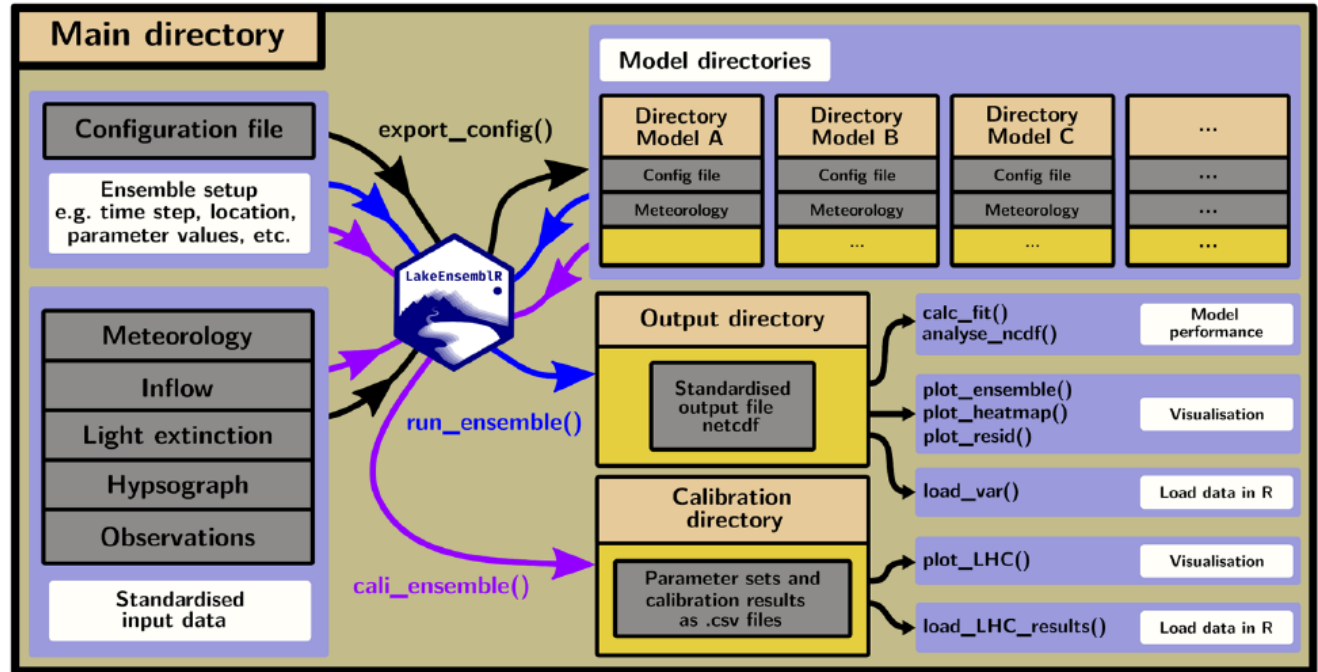
Robert
living compiler



Tadhg
fearless leader

LakeEnsemblR

- open-source and open access R package (GNU 2.0 license)
- models: R-packages that contain executables for macOS, Windows & Linux
- standardized workflow



LakeEnsemblR

- Models:



Two-layer
representation

Numerical
weather
predictions



1D energy
balance
approach

Ecosystem
modeling



1D k- ϵ
turbulence
model

Lake
turbulence
studies

SIMSTRAT

1D k- ϵ
turbulence
model

Lake
turbulence
studies

MyLake

1D heat
equation

Ecosystem
modeling

- Calibration:

- Latin Hypercube Sampling
- Markov-Chain Monte Carlo
- Different algorithms for constrained optimization using the FME package

LakeEnsemblR: support

- walk-through: vignette in R and wiki
<https://github.com/aemon-j/LakeEnsemblR/wiki>
- example configuration files:
https://github.com/aemon-j/LER_examples

Branch: master

Go to file Add file Code

robertladwig committed 33d8f2e 31 minutes ago 22 commits 1 branch 0 tags

LakeErken	Addition Lake Erken example files	2 months ago
LakeGiles	initial examples	2 months ago
LakeMendota	error Pa to mbar	32 minutes ago
Langtjern	Updated yaml file	last month
LoughFeeagh	initial examples	2 months ago
images	updated readme	2 months ago
.DS_Store	updated readme	2 months ago
LICENSE	Initial commit	2 months ago
README.md	updated readme	2 months ago

README.md

LER_examples

Collection of example setups to run the LakeEnsemblR package (<https://github.com/aemon-j/LakeEnsemblR>).

LakeEnsemblR is a suite of tools for running an ensemble of lake models using standardised input data. Lake models currently incorporated are [Freshwater Lake Model \(FLake\)](#), [General Lake Model \(GLM\)](#), [General Ocean Turbulence Model \(GOTM\)](#) (lake-branch), [Simstrat](#), and [MyLake](#).

Installation

You can install LakeEnsemblR from Github with:

```
# install.packages("devtools")
devtools::install_github("aemon-j/LakeEnsemblR")
```

aemon-j / LakeEnsemblR

Code Issues Pull requests Actions Projects Wiki Security Insights

Home

Jørnt Meeman edited this page on Jun 5 - 21 revisions

Welcome to the LakeEnsemblR wiki!

LakeEnsemblR (LER) is a collaborative project across many countries and hydrodynamic model developers and users. Our goal is to develop an R package that:

1. Facilitates easy setup and configuration of model files
2. Allows the running of all models provided with standardised input files
3. Standardises model output and provides tools for convenient post-processing in R
4. Calibration routines to improve model performance by automatically adjusting selected meteorological scaling factors and model parameters
5. Aggregate and allow for ensemble averaging to account for different sources of uncertainty between models

Configuration

Simulation

LakeEnsemblR

Pages

Find a Page...

Home

2. Setting up LakeEnsemblR

3. Running LakeEnsemblR

4. Post Processing the results from LakeEnsemblR

FAQ

Lake Models

Package structure

What is a NetCDF file?

Exercise

1. Open the Rstudio project “LakeEnsemblR_intro.Rproj”. In Rstudio, open “InventWater_LakeEnsemblR.R”. **Finally, open “InventWater_LakeEnsemblR.pdf”** in your pdf viewer.
2. We will now go through the R-script together and run LakeEnsemblR. You can also go through the pdf document and execute the associated commands in the R-script at your own pace.