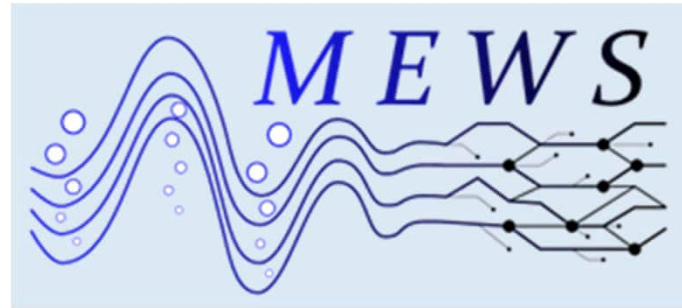
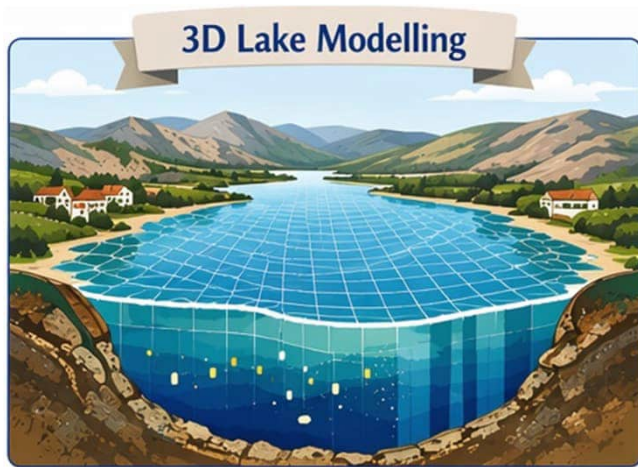


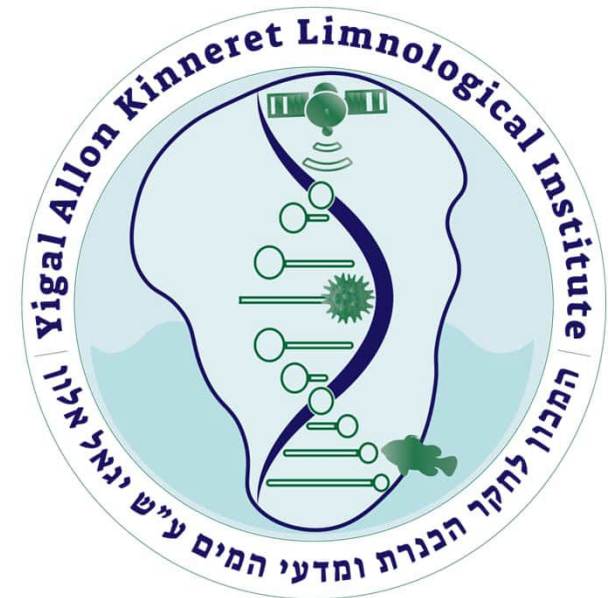


Kinneret team updates



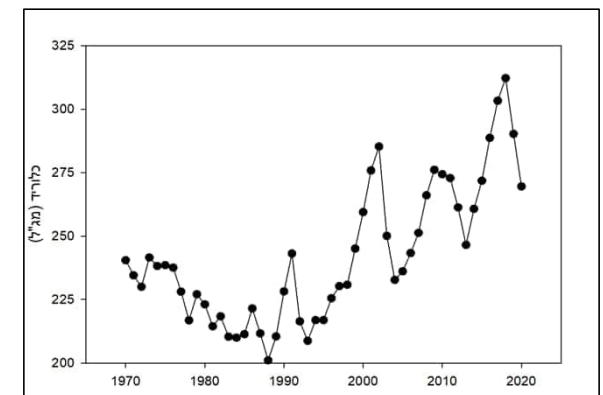
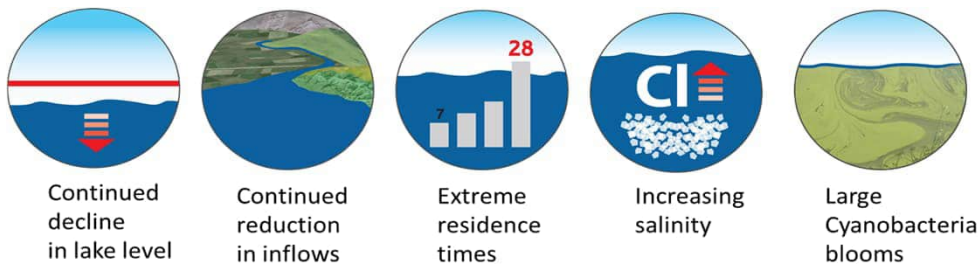
Yael Amitai
Gideon Gal
Shajar Regev
Ioannis Keramidas

Denmark
May 2026



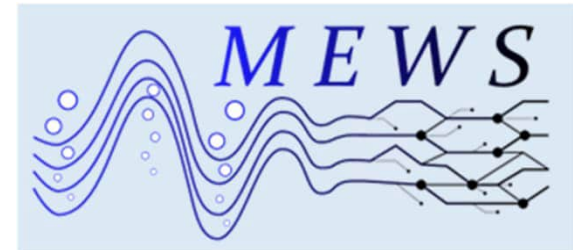
Stakeholder (Israel water authority) scenarios

- Multi-year drought scenarios - inflow-intake realizations
- Extreme high inflow events - changes to the ecosystem and water quality
- Tzalmon artificial inflow of desalinated water - evaluation to understand its potential impact
- Risk assessments - Toxic Cyanobacteria Blooms, Lyngbya Blooms (odor and taste issues), Salt balance (unknown submerged springs)



Papers ideas for the Kinneret case

1. Localization of blooms (especially on the eastern coast) - why it appears there? Discharges location or internal wave activity?
Experiments to explain (example below)
2. The impact of lake level on internal waves activity>nutrients availability>algal blooms
3. Heat waves. Short versus long. They come with calm winds. Favorable for cyanobacteria? (Gideon)
4. A series of droughts years effect on the lake (Shajar)
5. 1D-3D - Methodological paper.



Hydrological modelling of Lake Kinneret Watershed

Elad Ben-Zur, Haim Gvirtzman, Gideon Gal, Yaron Be'eri-Shlevin

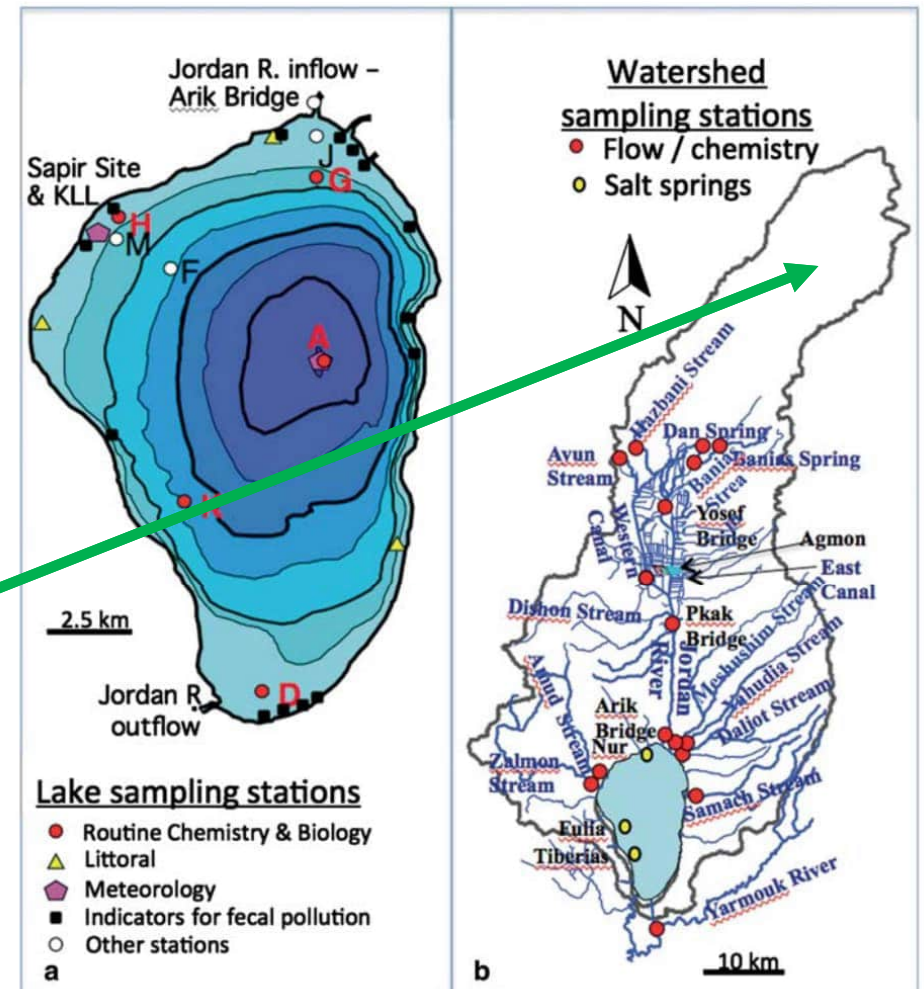
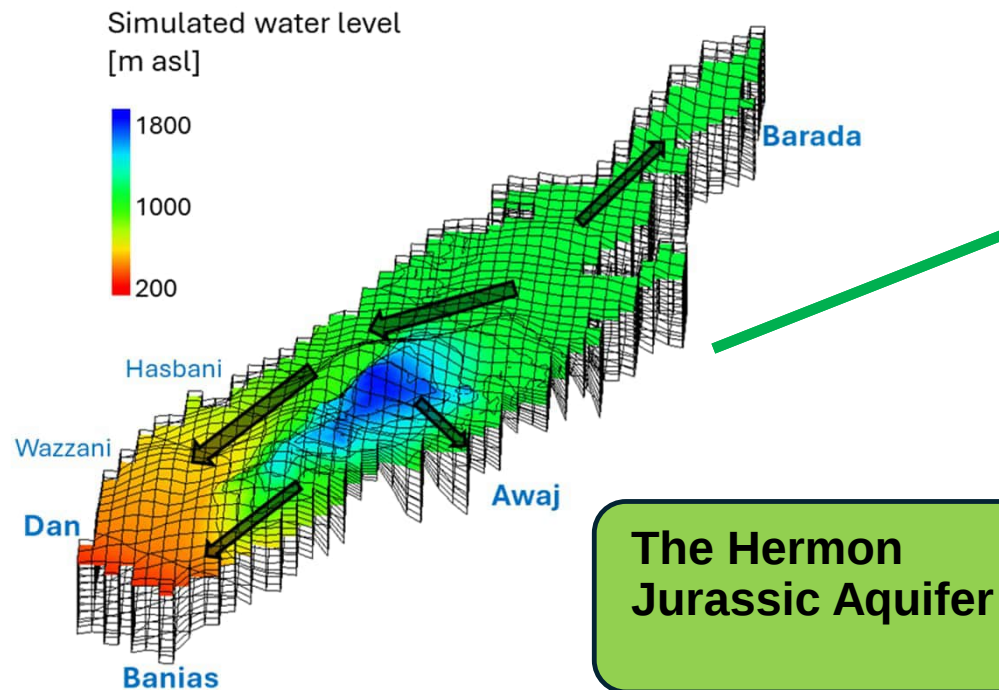
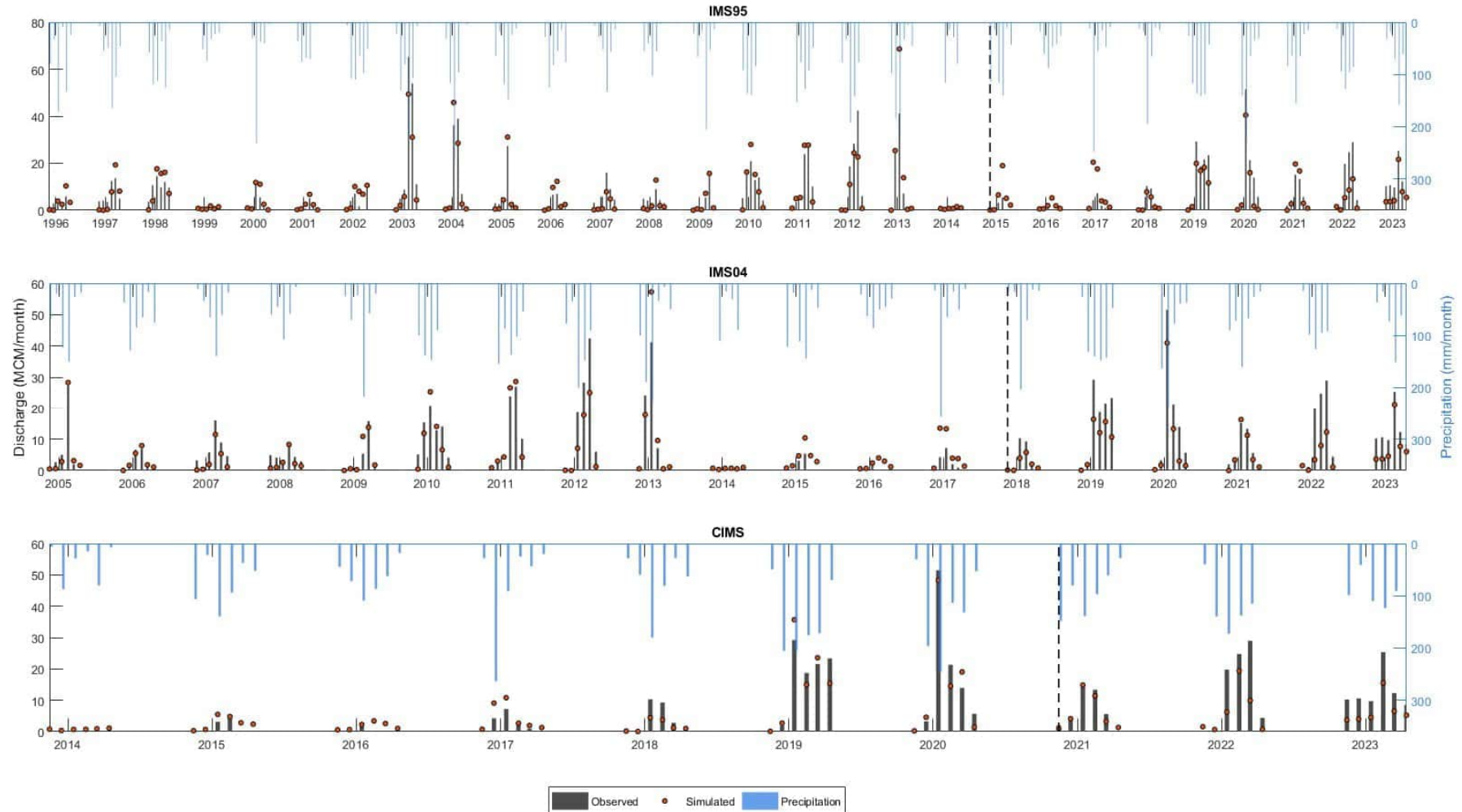
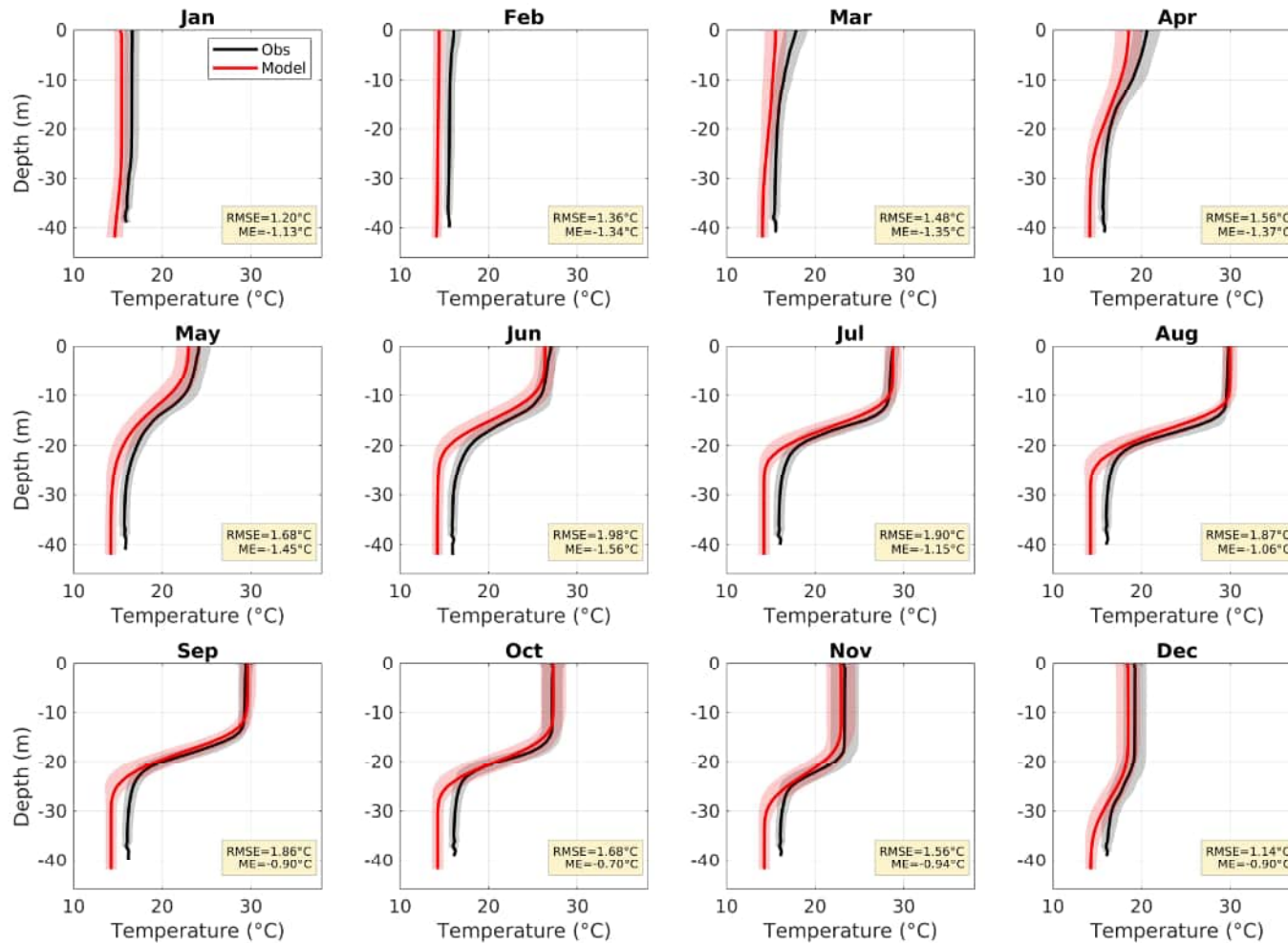


Fig. 32.1 Location maps of monitoring stations in Lake Kinneret and its watershed. **a** Lake Kinneret (symbol legend below map). **b** Watershed (symbol legend above map). Additional explanations: *KLL*—Kinneret Limnological Laboratory. *Other stations*—stations *F*, *M* are used for sedimentation flux measurements, *J* for occasional biological measurements, and *Arik* for pesticides. *Littoral stations*—shallow water stations for occasional biology and chemistry measurements

Hydrological modelling of Lake Kinneret Watershed: new results



3D Model vertical validation



Root Mean Square Deviation

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}$$

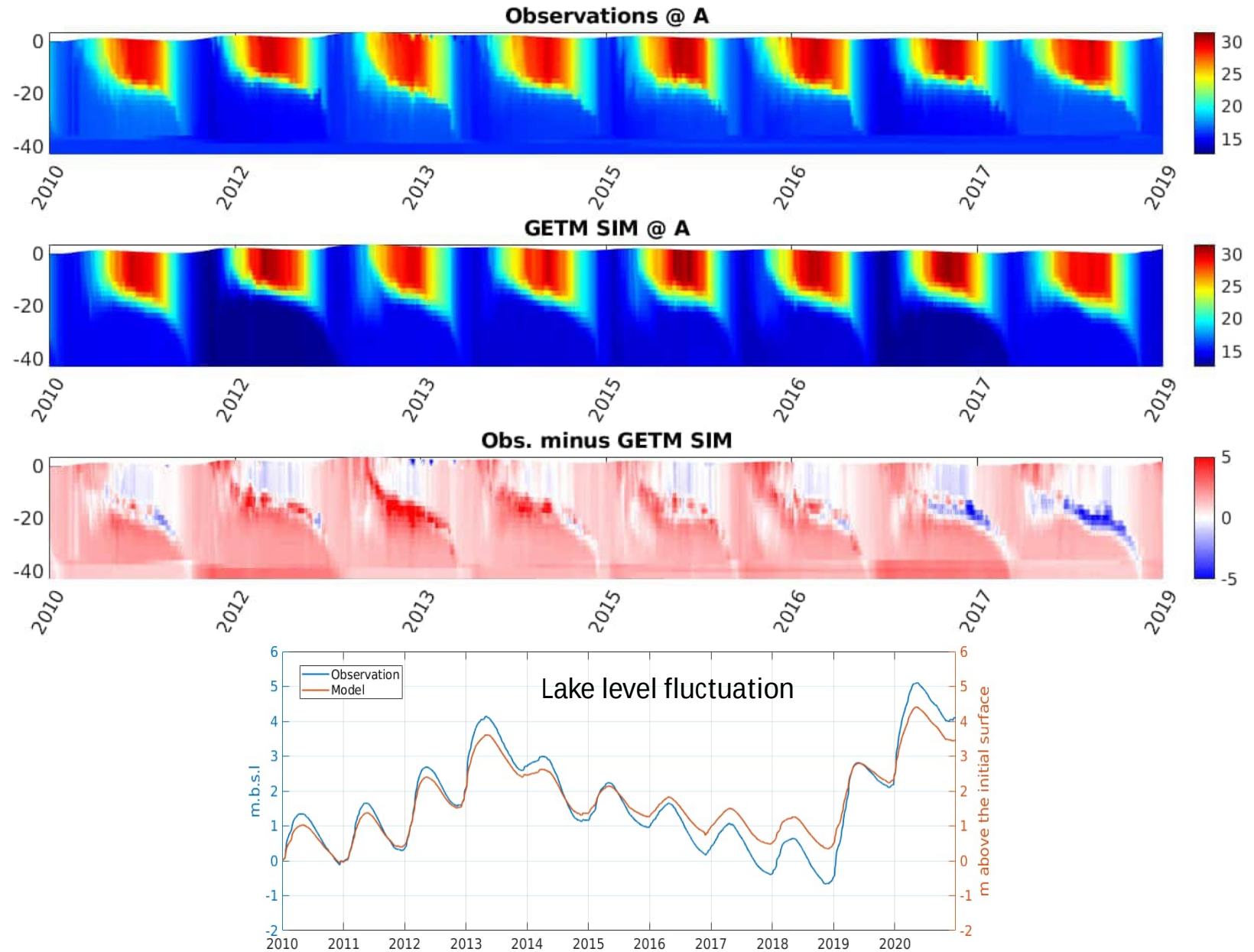
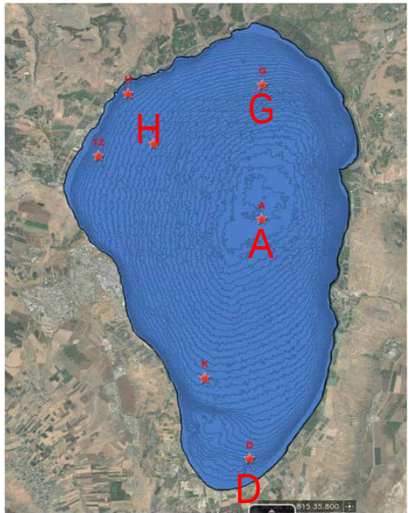
Mean Error

$$ME = \frac{1}{N} \sum_{i=1}^N (M_i - O_i)$$

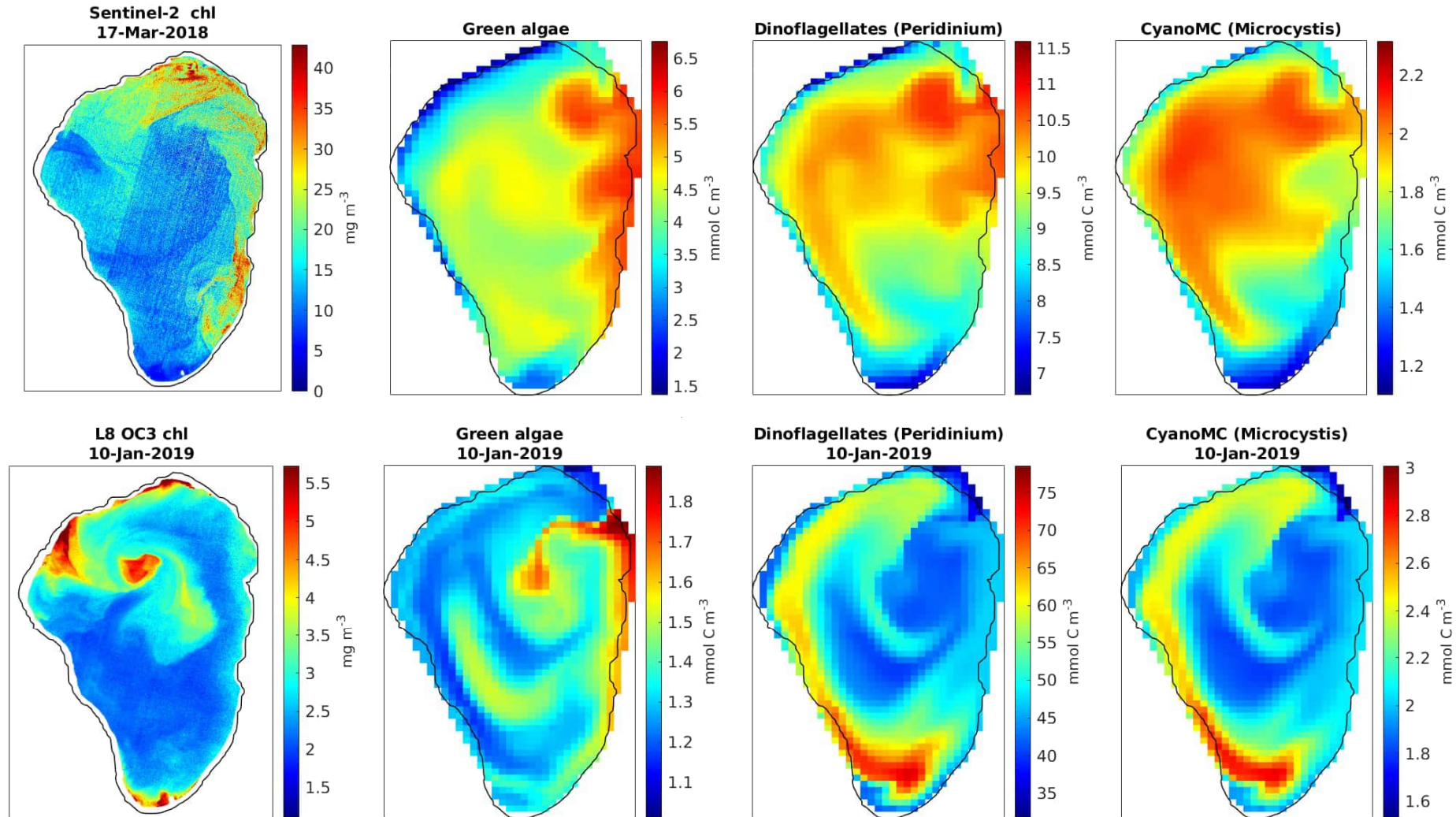
M_i – modeled value at time i

O_i – observed value at time i

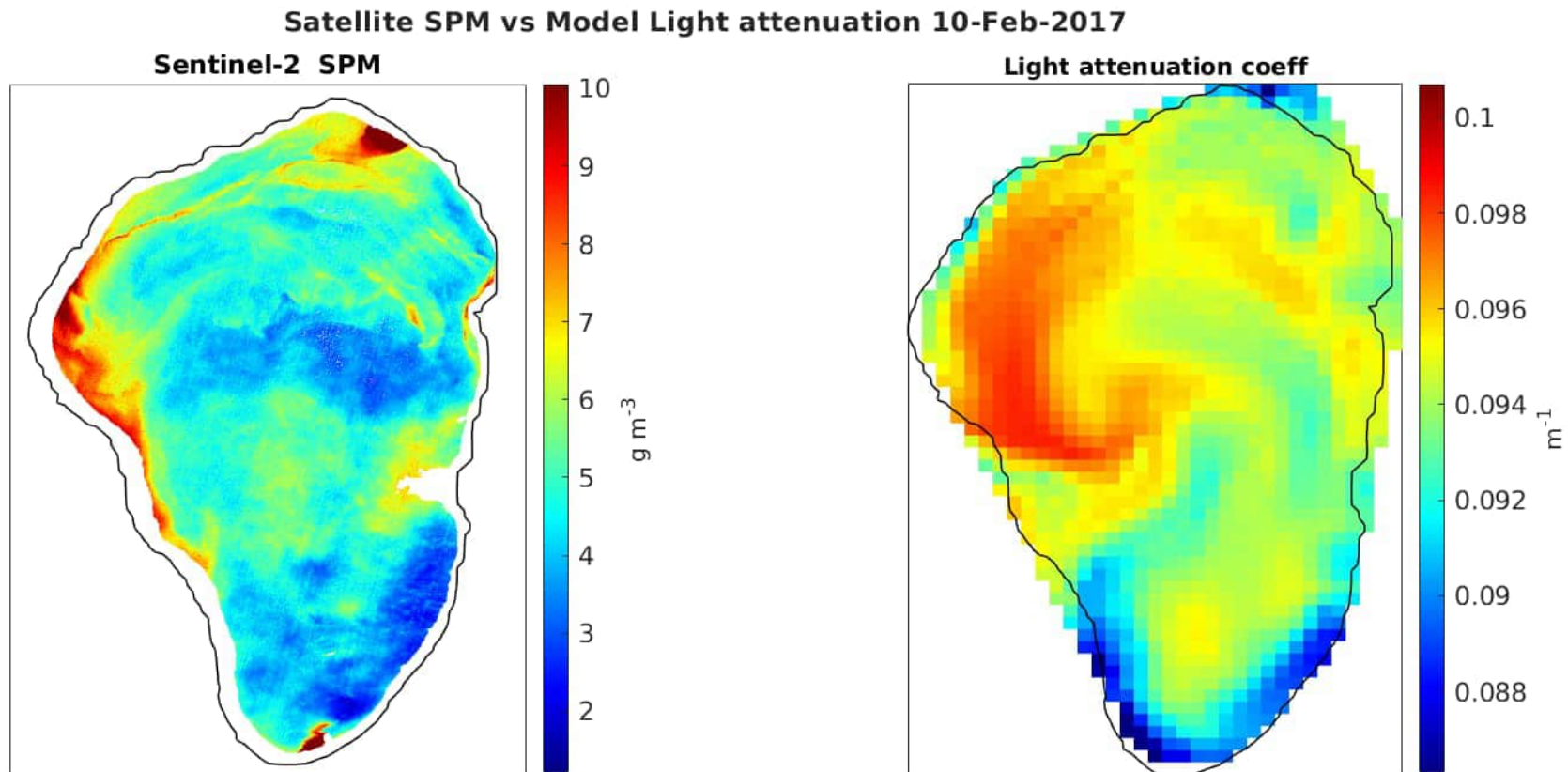
Temperature profiles sampled in station A (the deepest monitoring st. in the lake) vs. modelled profiles



Model phytoplankton groups versus remote sensed Chl

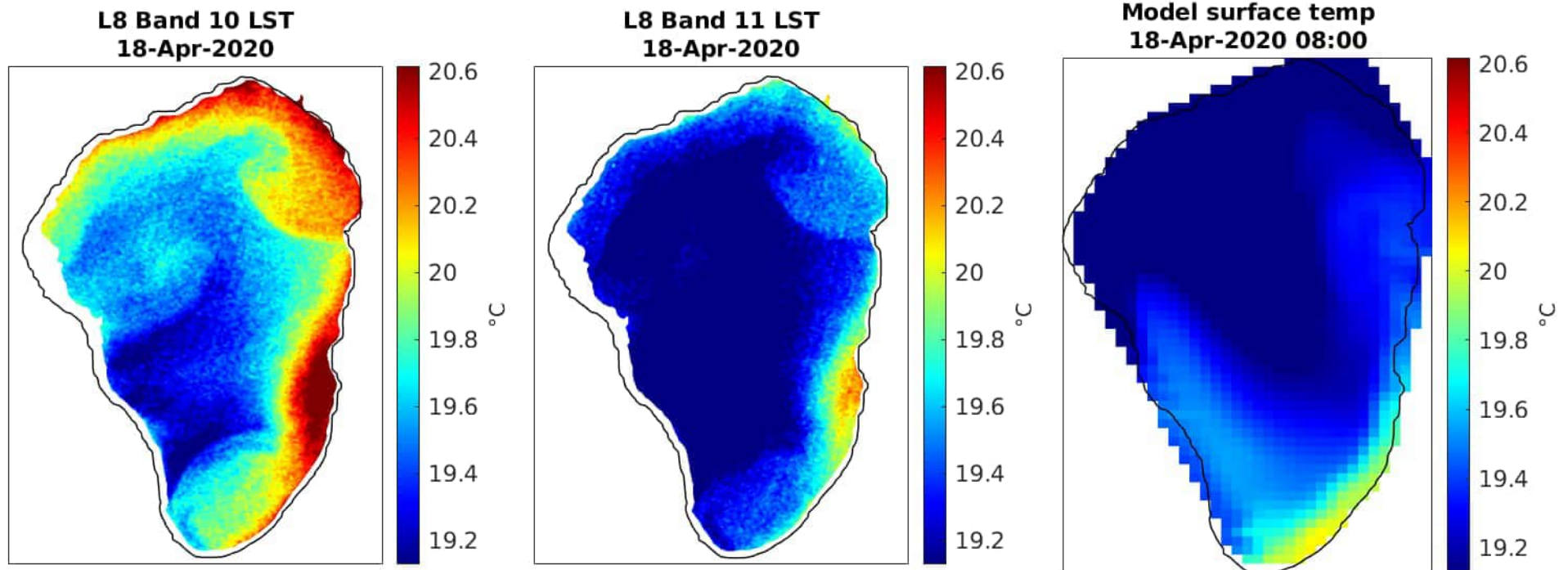


Model light attenuation versus remote sensed Suspended matter



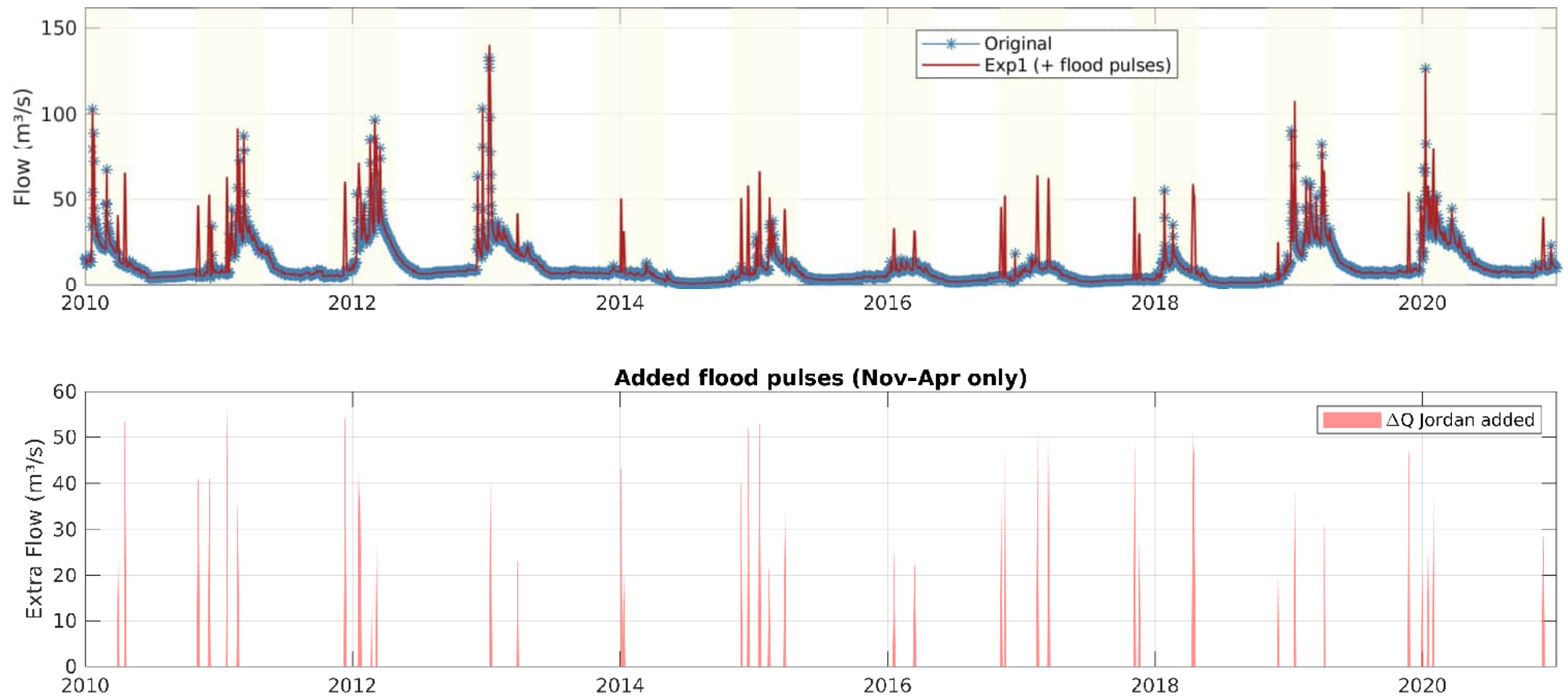
Model surface temp. versus remote sensed temp.

L8 LST vs Model Surface Temperature - Lake Kinneret 18-Apr-2020
Satellite LST = $bt - 273.15$ °C | Model: conservative temperature [°C]

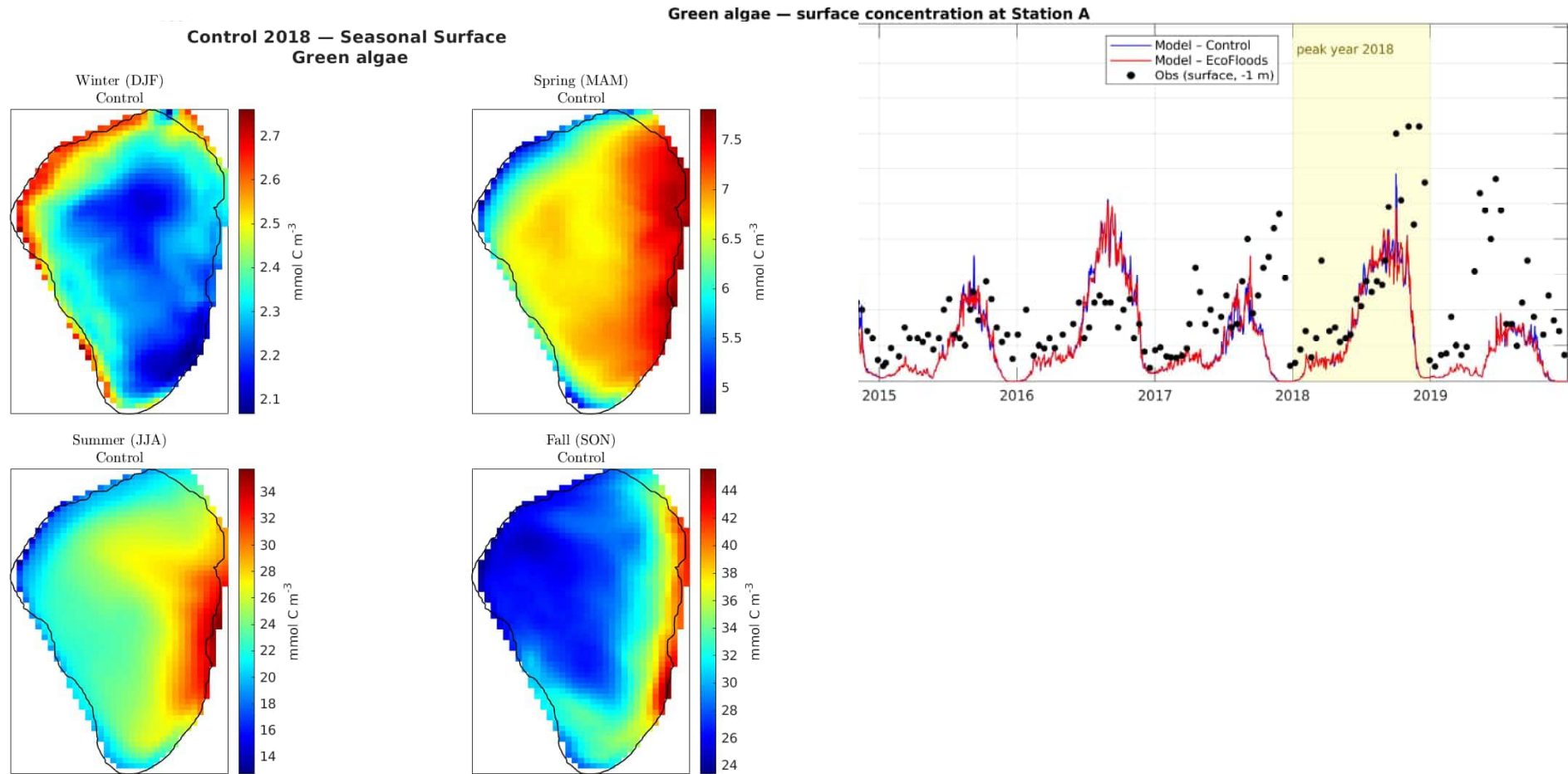


Disadvantage: Remote sensing is only available from ~2010

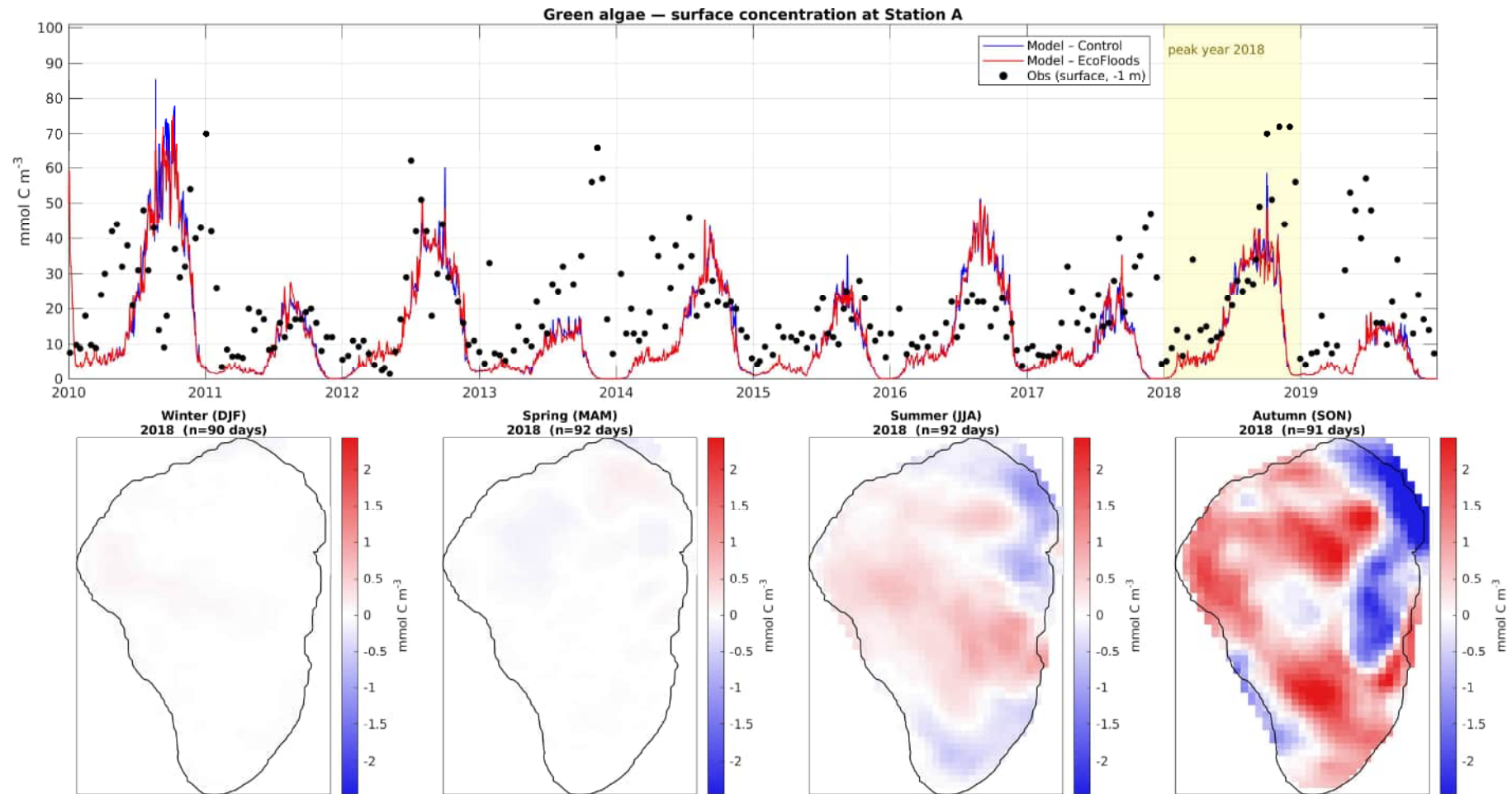
Jordan Floods Experiment – Effect on blooms



Floods in the Jordan experiment – effect on the bloom

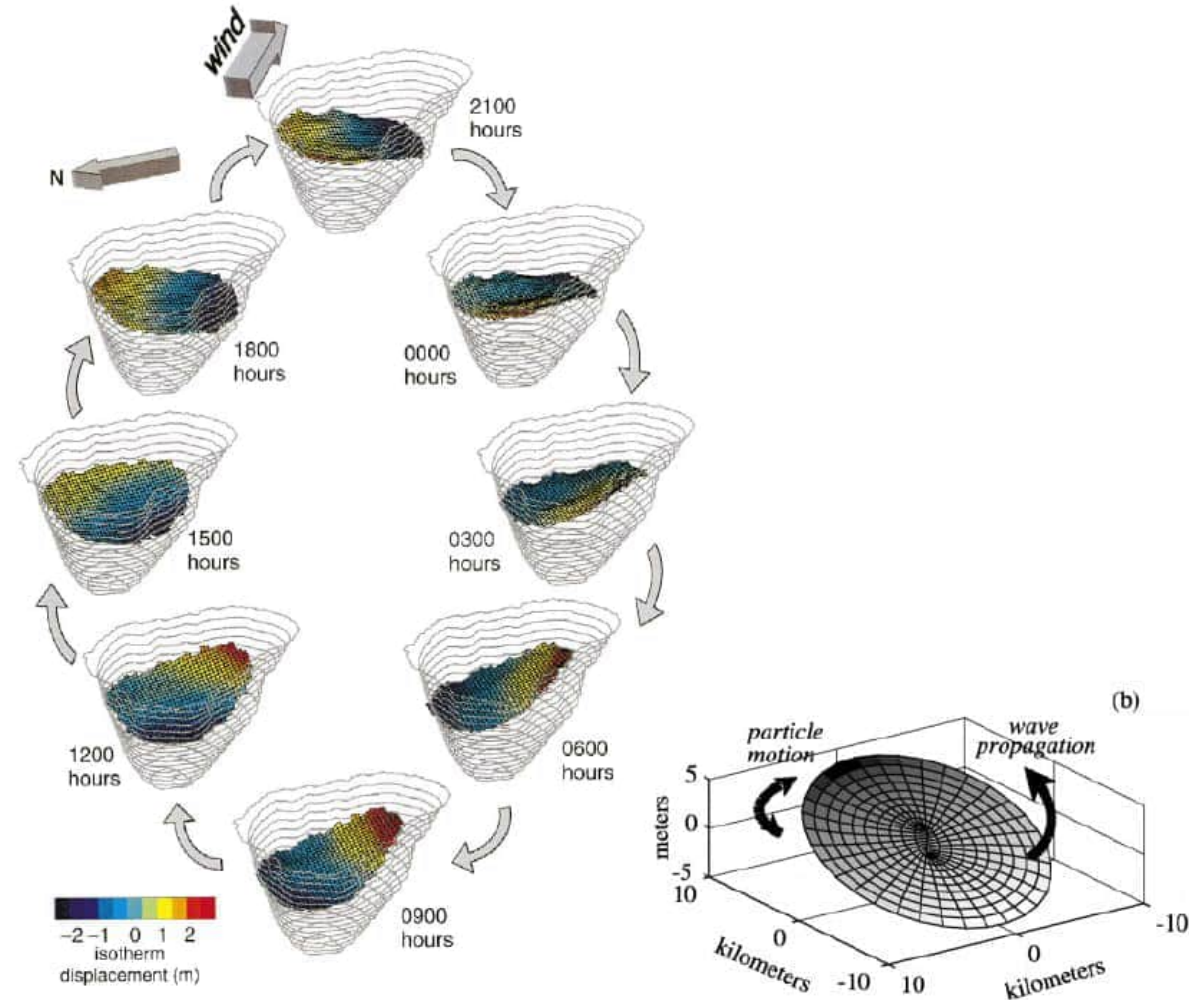


Floods in the Jordan experiment – effect on the bloom



Internal waves

- Due to Earth's rotation, water moves along the shores of the lake.
- This 24-hour Kelvin wave propagates counterclockwise, while water particles oscillate back and forth.
- Internal waves appear as isotherm displacements and are visible in the temperature signal

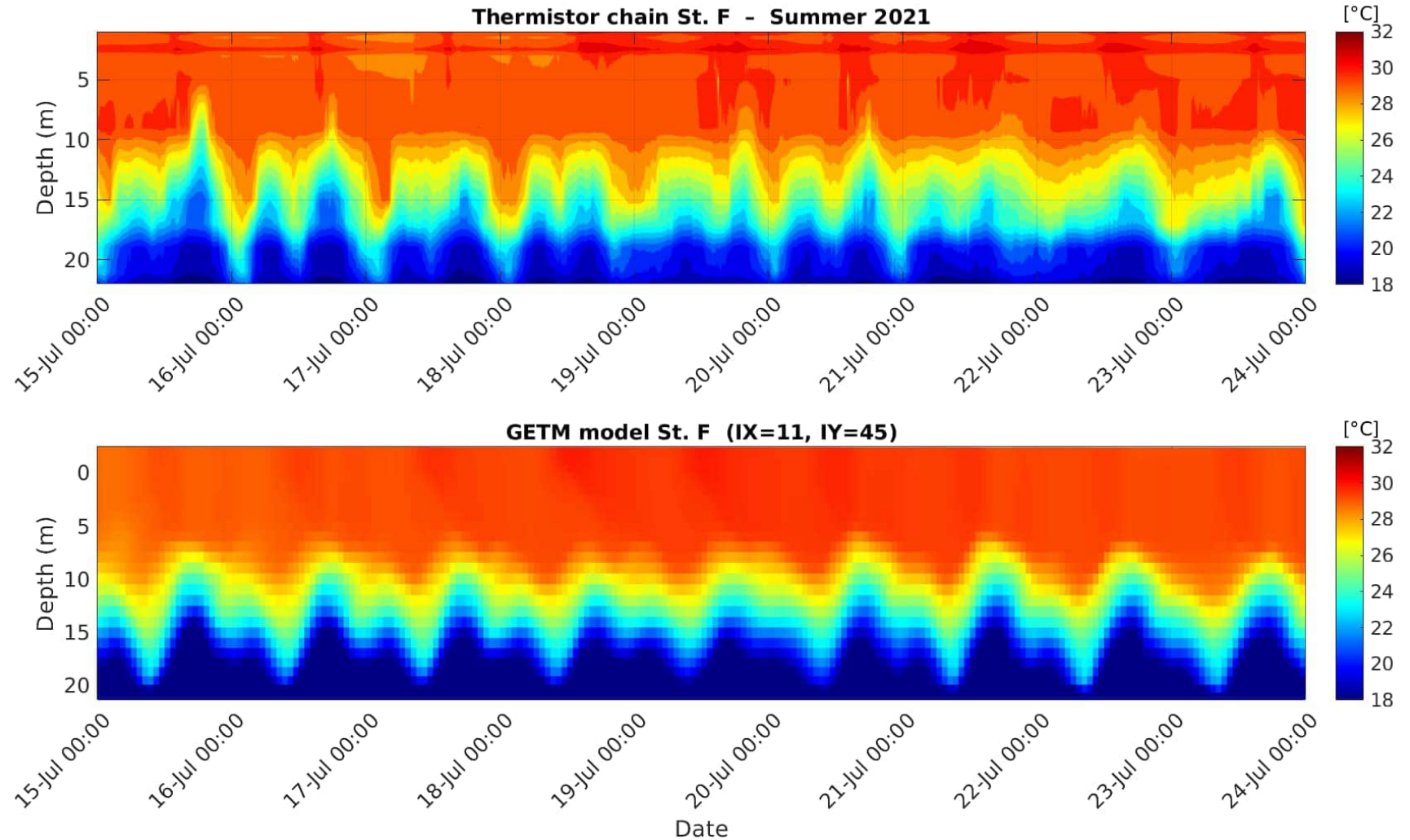
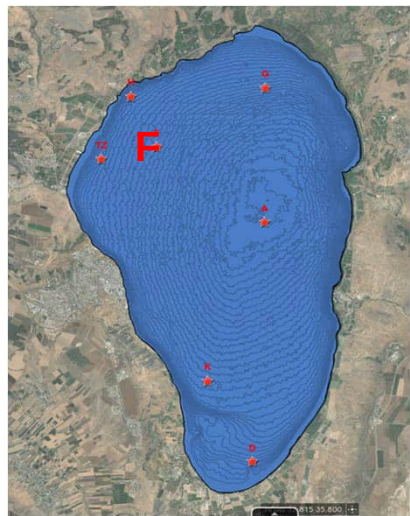


Modeling basin-scale internal waves in a stratified lake

Ben R. Hodges,¹ Jörg Imberger, Angelo Saggio, and K. B. Winters²

Centre for Water Research, The University of Western Australia, Nedlands, Western Australia, Australia 6907

Internal waves in the Kinneret: Model versus Observations



רוחות עזות גרמו לנזקים במיליונים בטיילת בטבריה: "כמו סרט אימה"

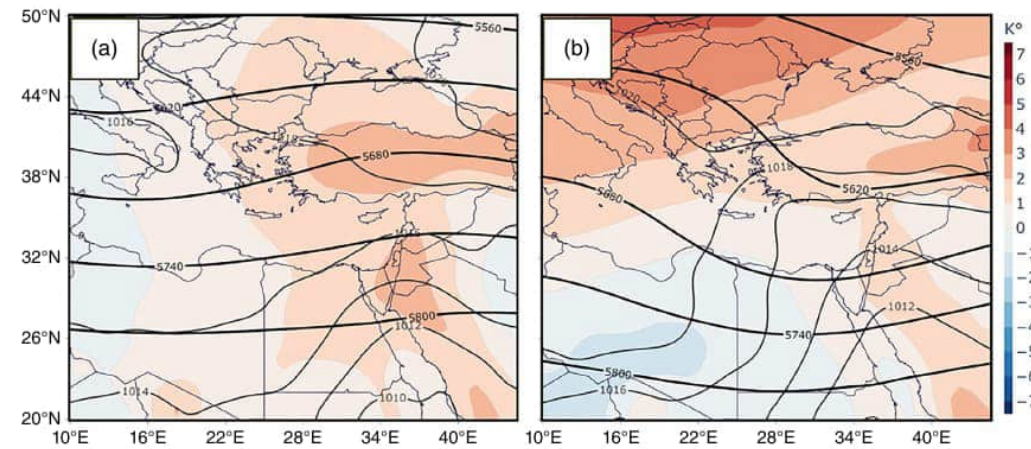
תיעוד: סופה שהתחוללה במהלך הלילה בכינרת גרמה לנזק גדול לטיילת של טבריה: בורות נפערו ברצפה, עצים קרסו ומסעדות הוצפו. יו"ר הוועדה הממונה: "נהיה לי שחור בעיניים, לא האמנתי שהטיילת היפהפייה תיהרס תוך שעות". בחלק מחופי הכינרת התעופפו אוהלים והנופשים פונו מחשש לסיכון חייהם

- Combination of high water-level and strong easterly wind caused huge damage to Tiberia's promenade in the night of May 15, 2022.
- Are we expecting more of these kind of events?
- Can we forecast them correctly?

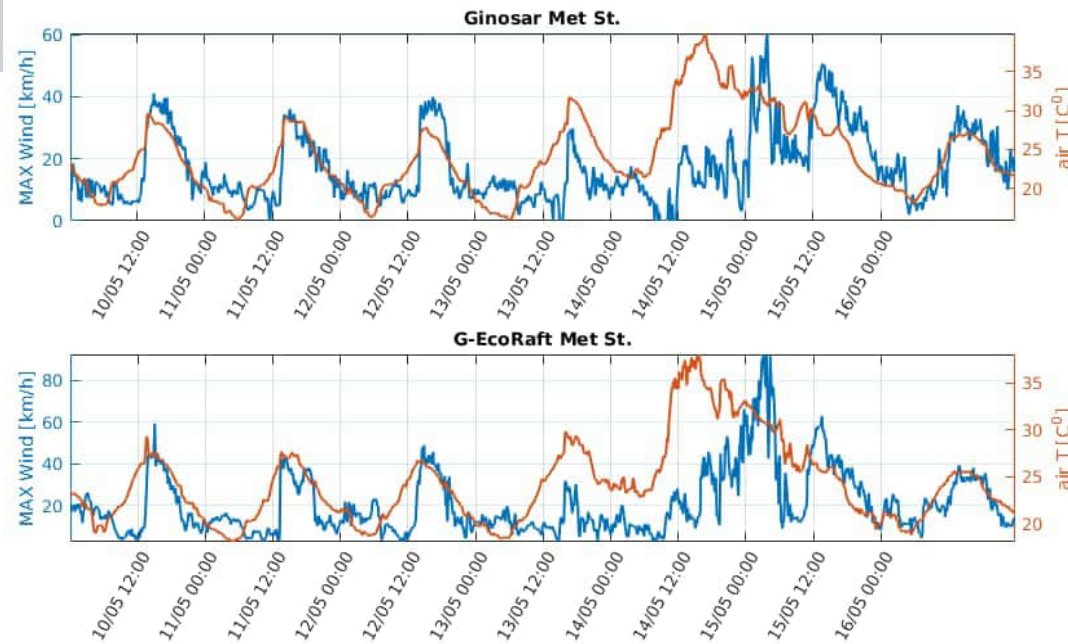
Red Sea Trough

- A tongue of low pressure extends northward from the southern Red Sea toward the eastern Mediterranean.
- Especially typical during transitional seasons, particularly autumn.
- Often not predicted well.

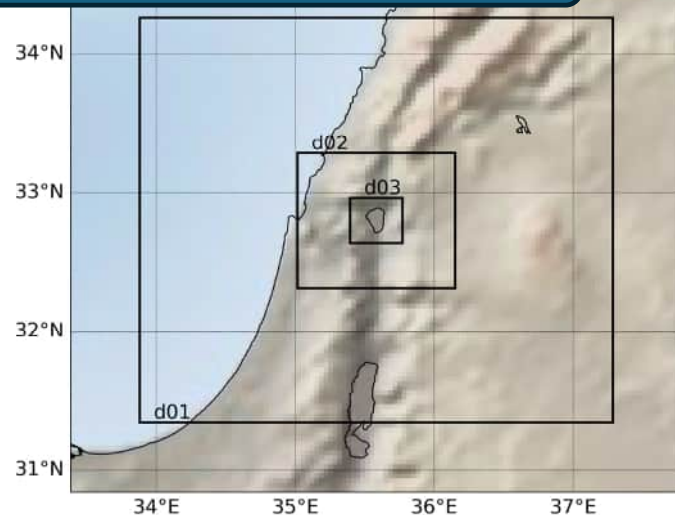
Ziv, et al.
Int. J. Climatol.
(2022)



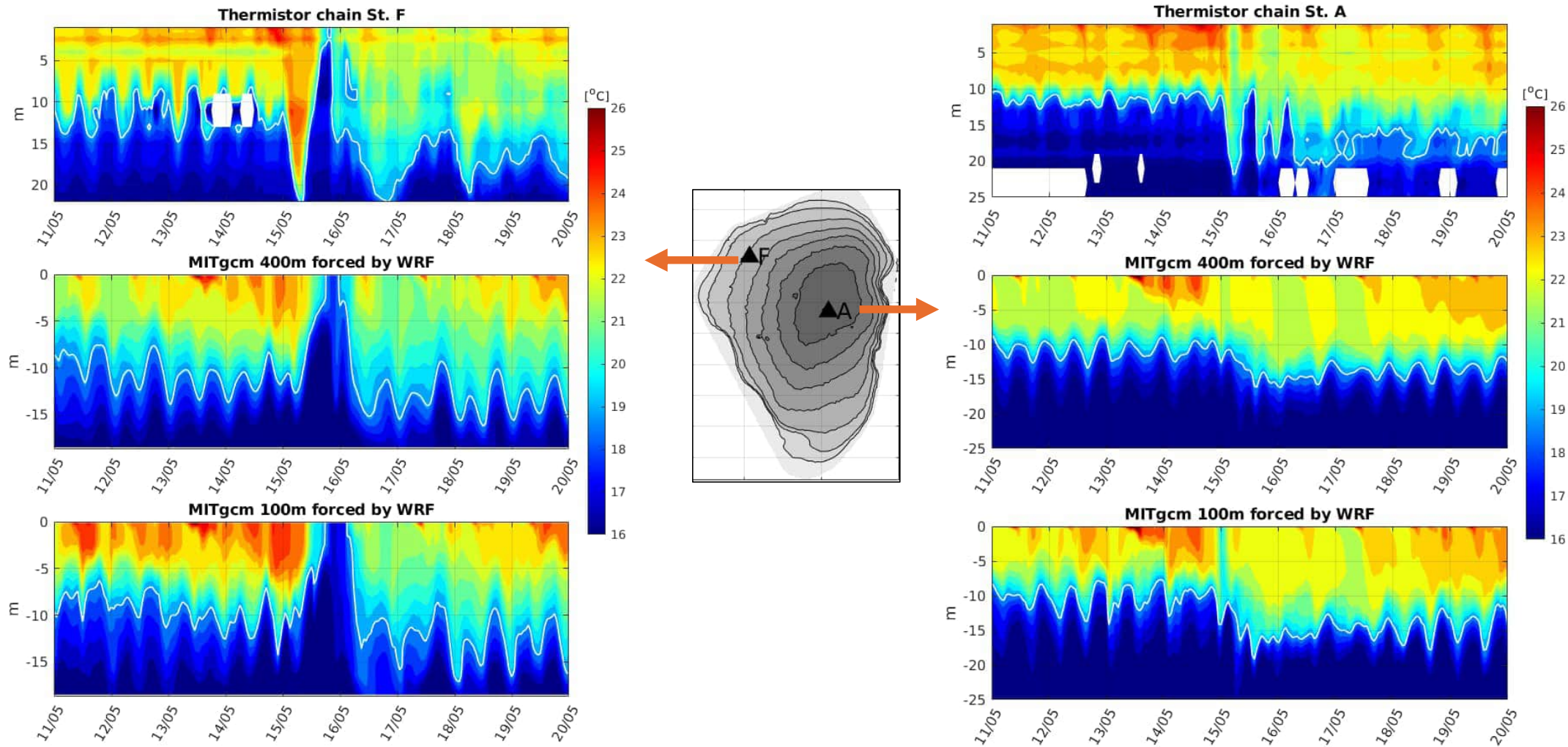
Air temperature and maximal wind



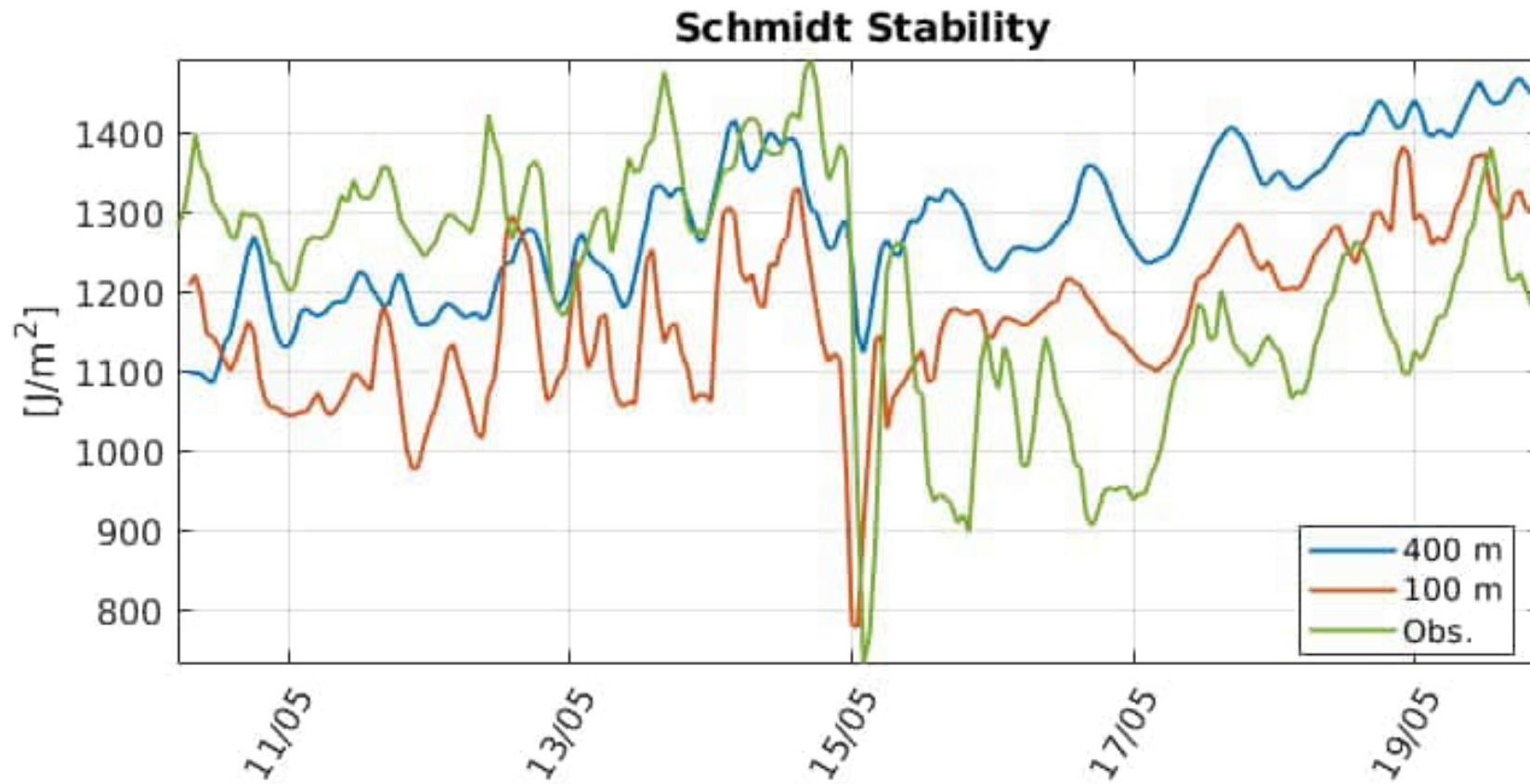
WRF by Dr. Udi Strobach



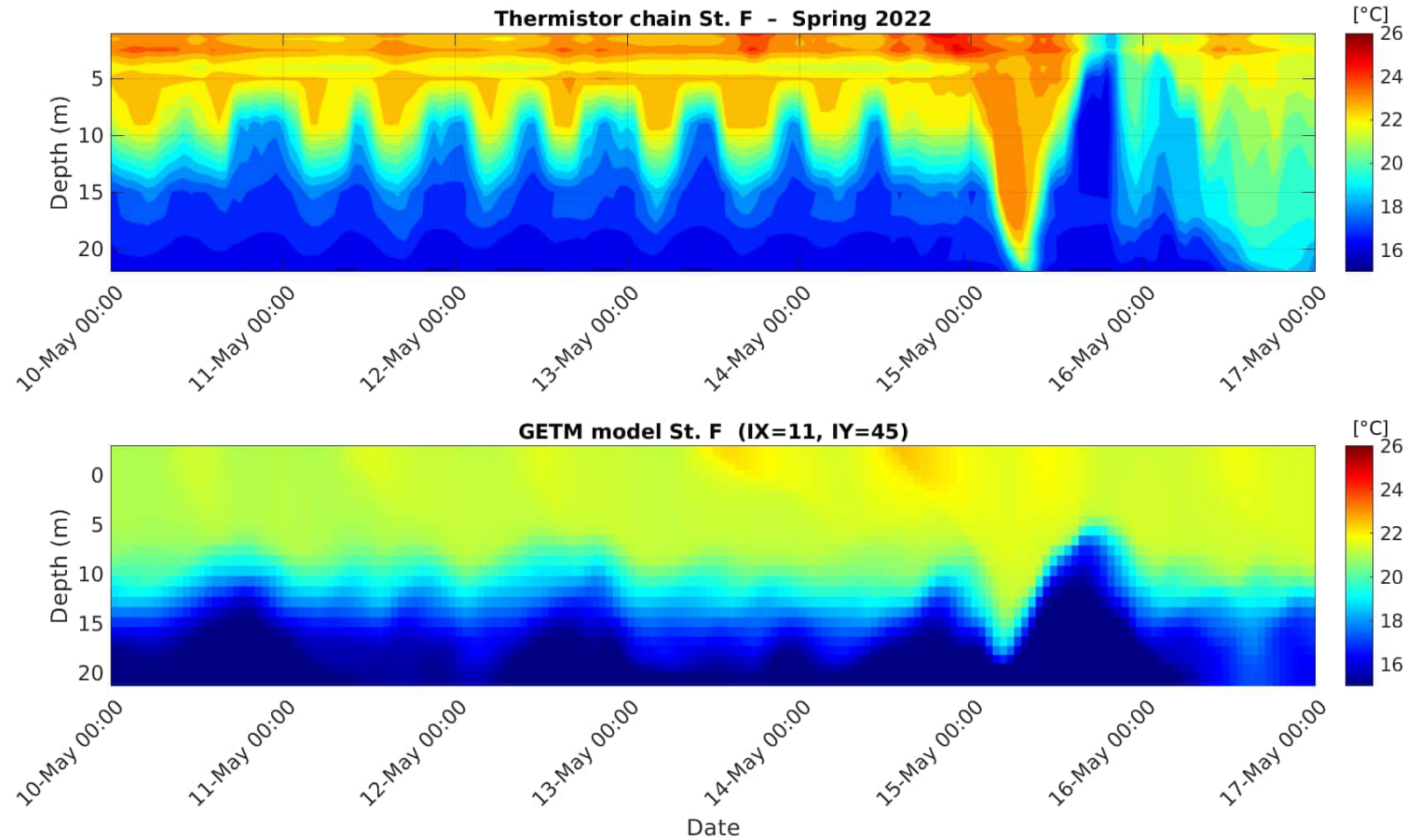
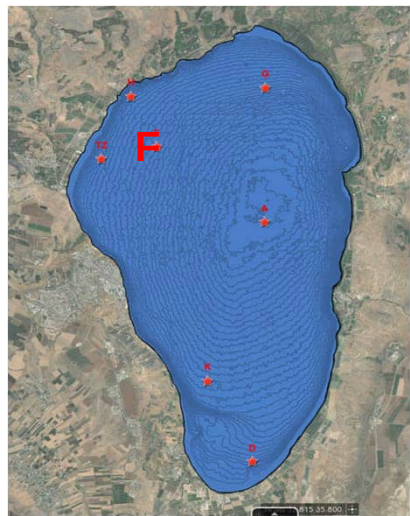
Thermistor Chains (obs.) versus MITgcm (model)



3D simulation (not GETM) of May 2022 storm with WRF forcing



Internal waves in the Kinneret: Model versus Observations



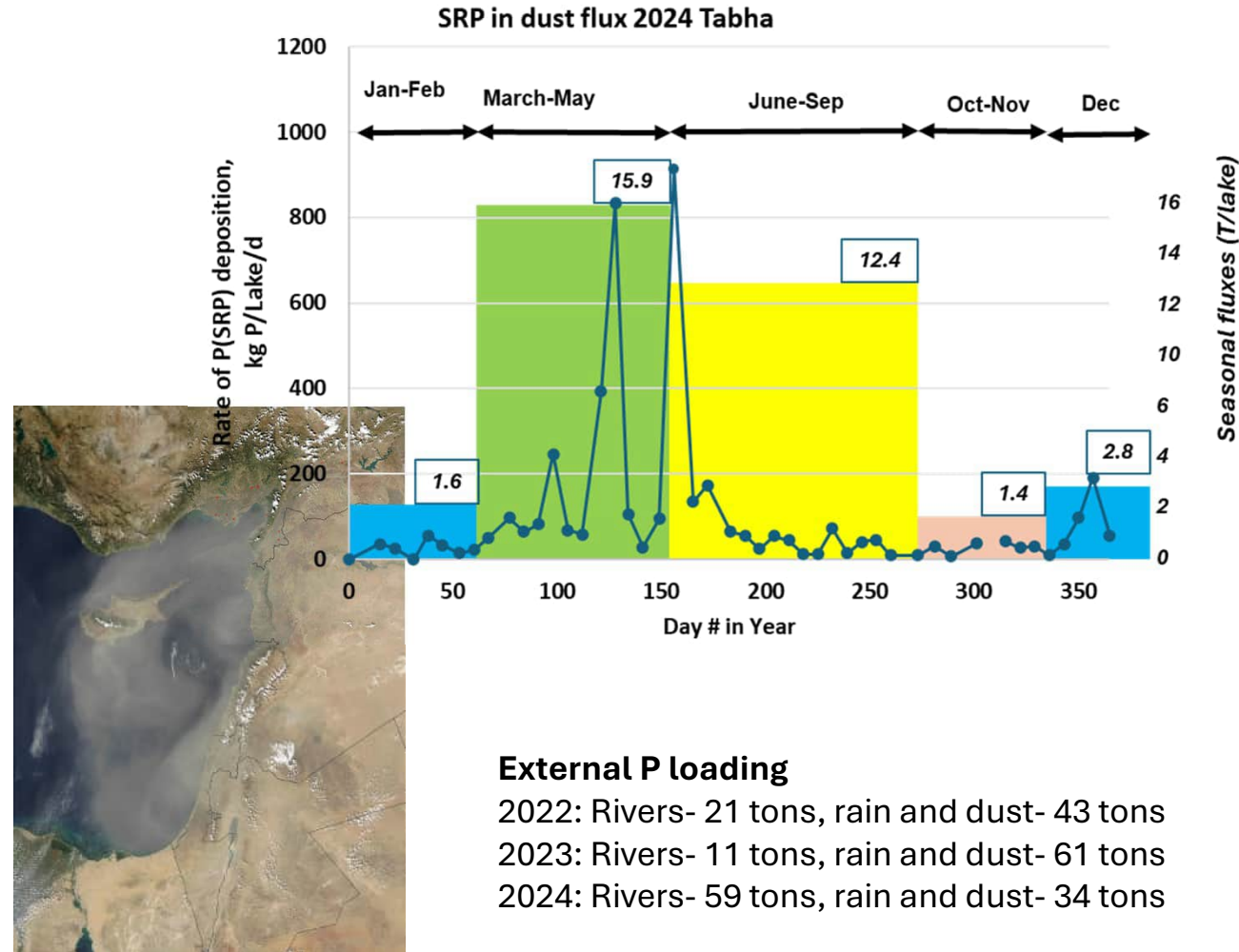
Kinneret modeling challenges

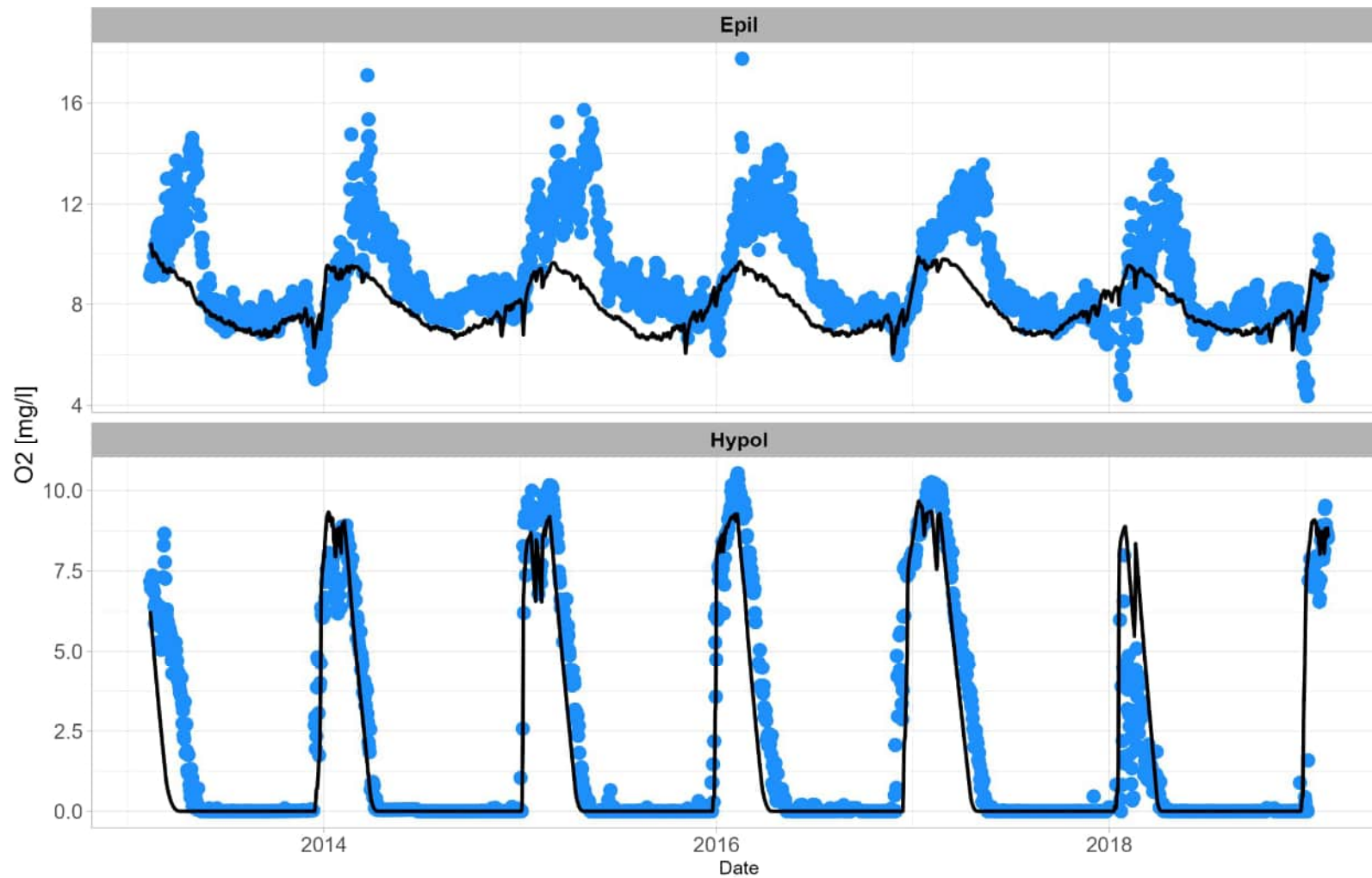
Dust from the atmosphere:

- Spatial variability.
- Inter-annual variability
- P loading – a major source

Climate Projections

- Climate models has low resolution
- Nutrient loading through streams is not modeled in the watershed

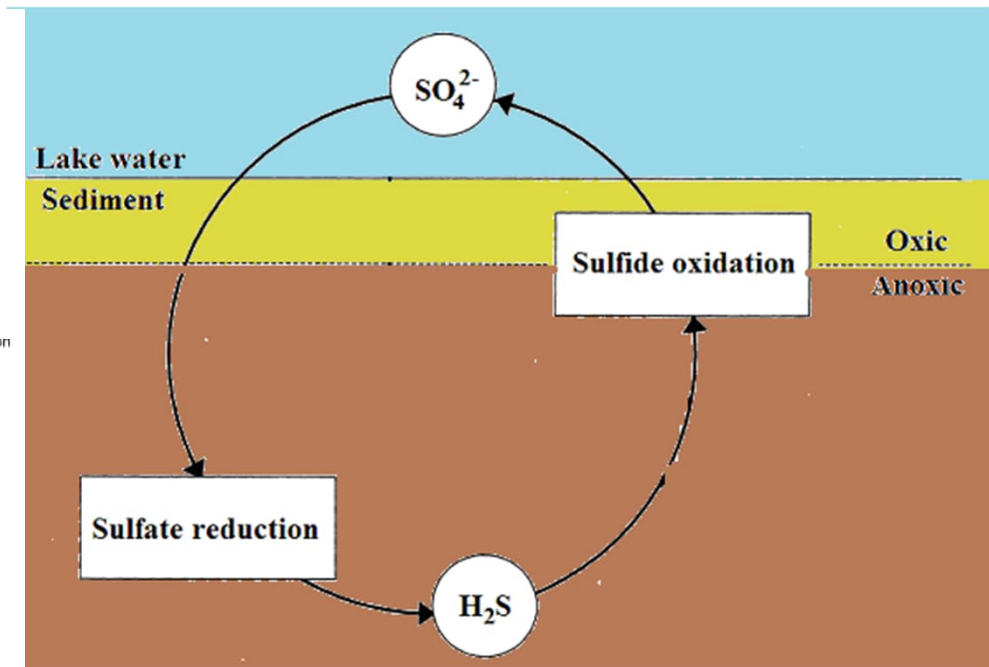
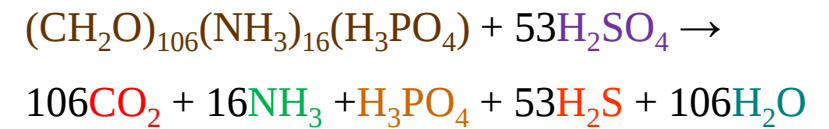
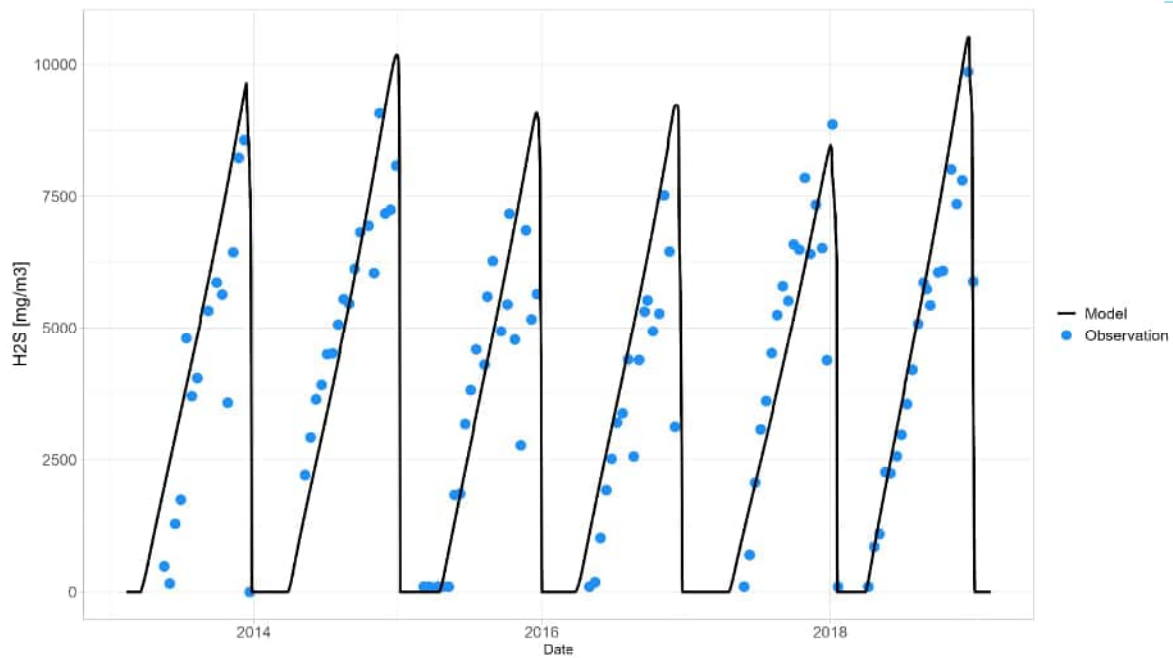


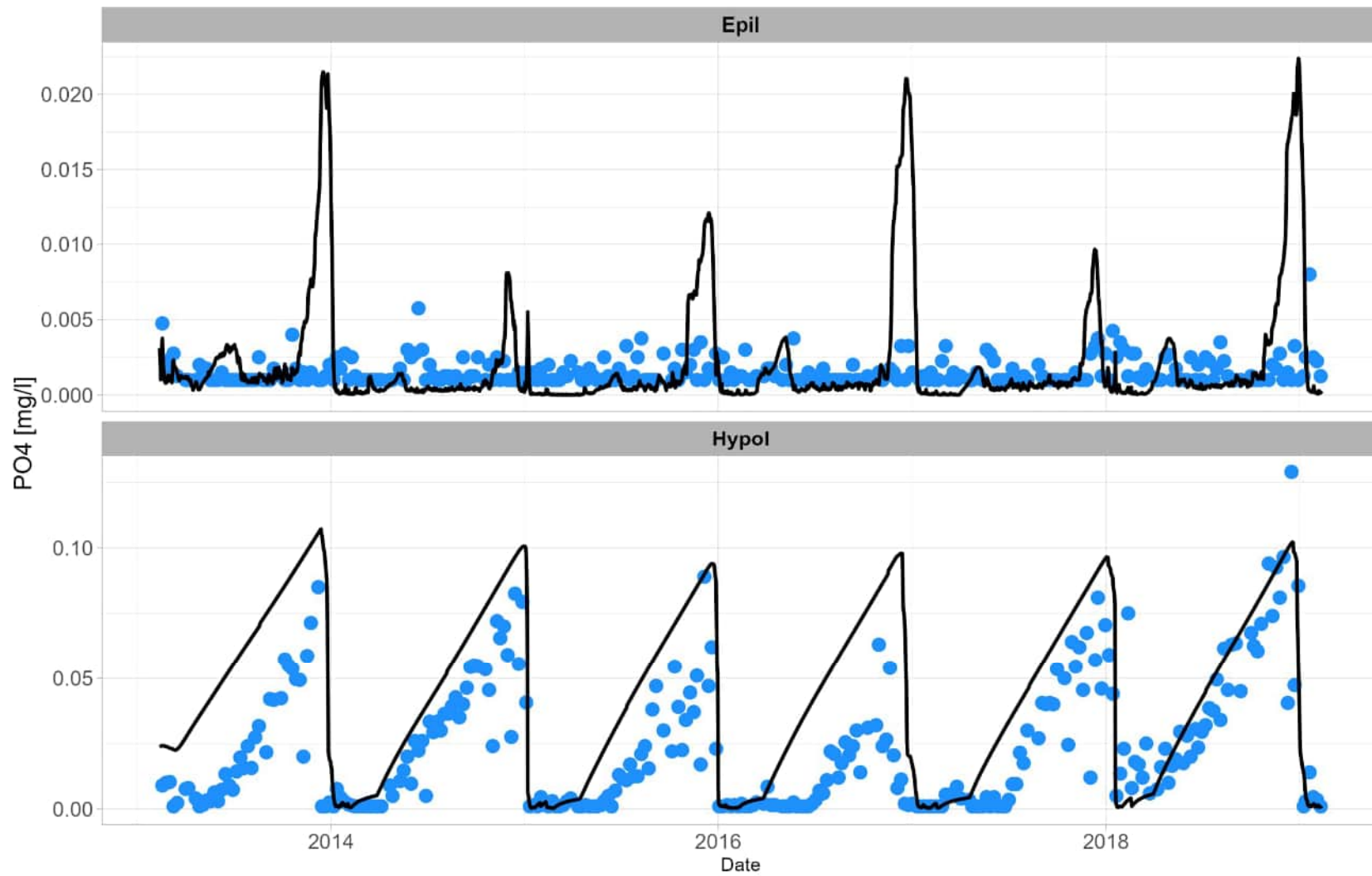


1D Model Calibration

Oxygen

Modelling Hydrogen sulfide (H₂S)

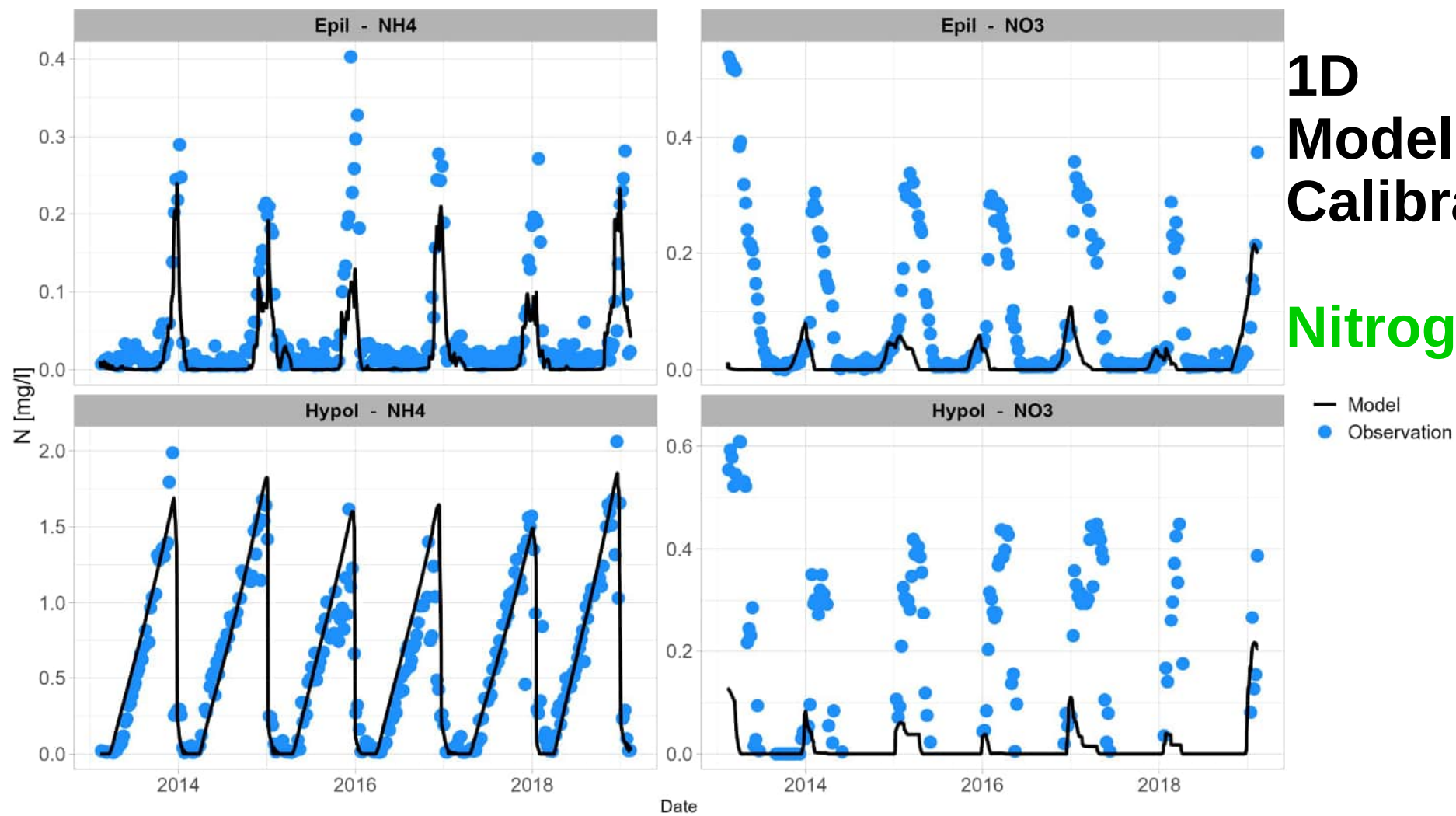




1D Model Calibration

Phosphorus

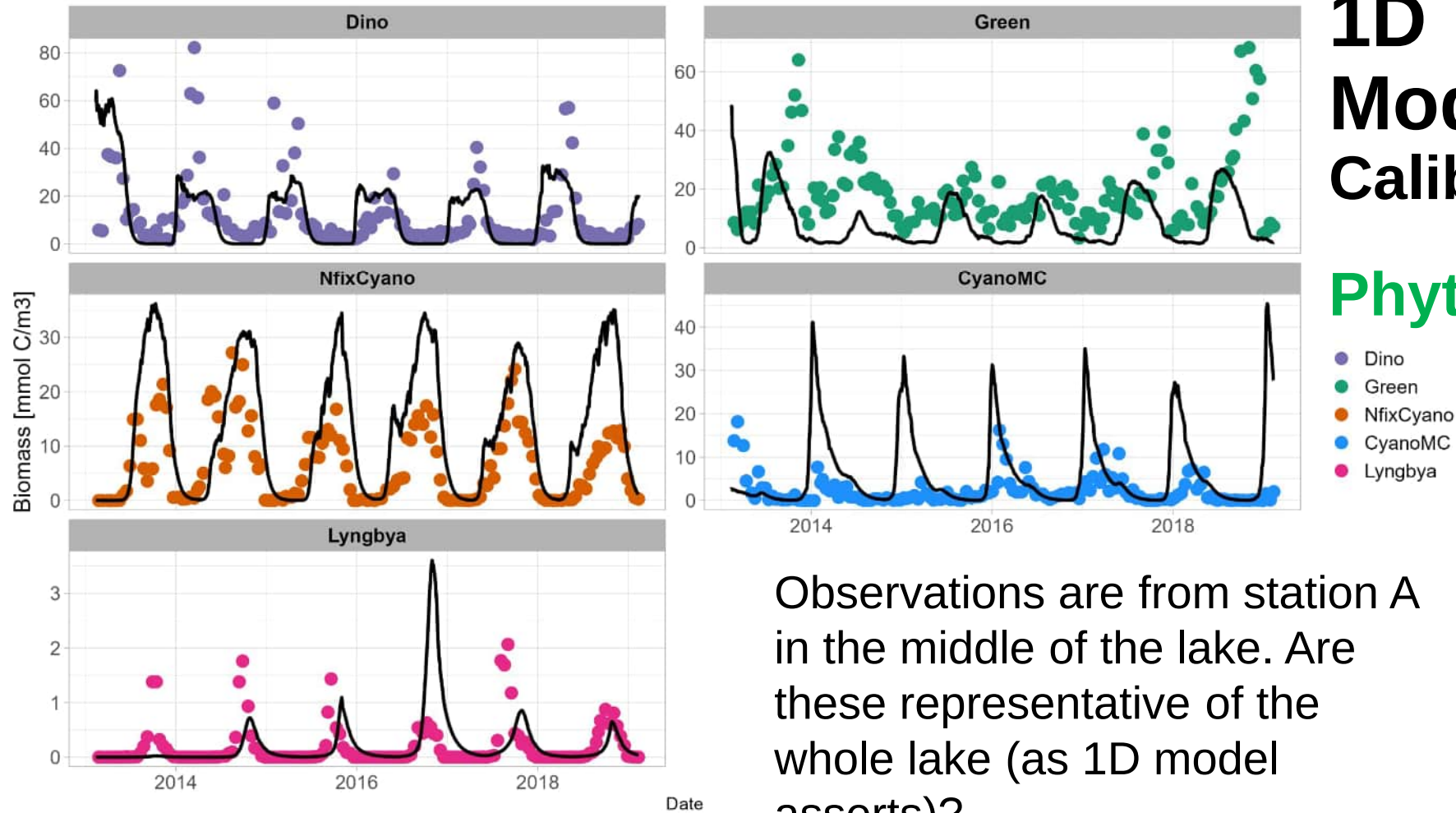
— Model
● Observation



**1D
Model
Calibration**

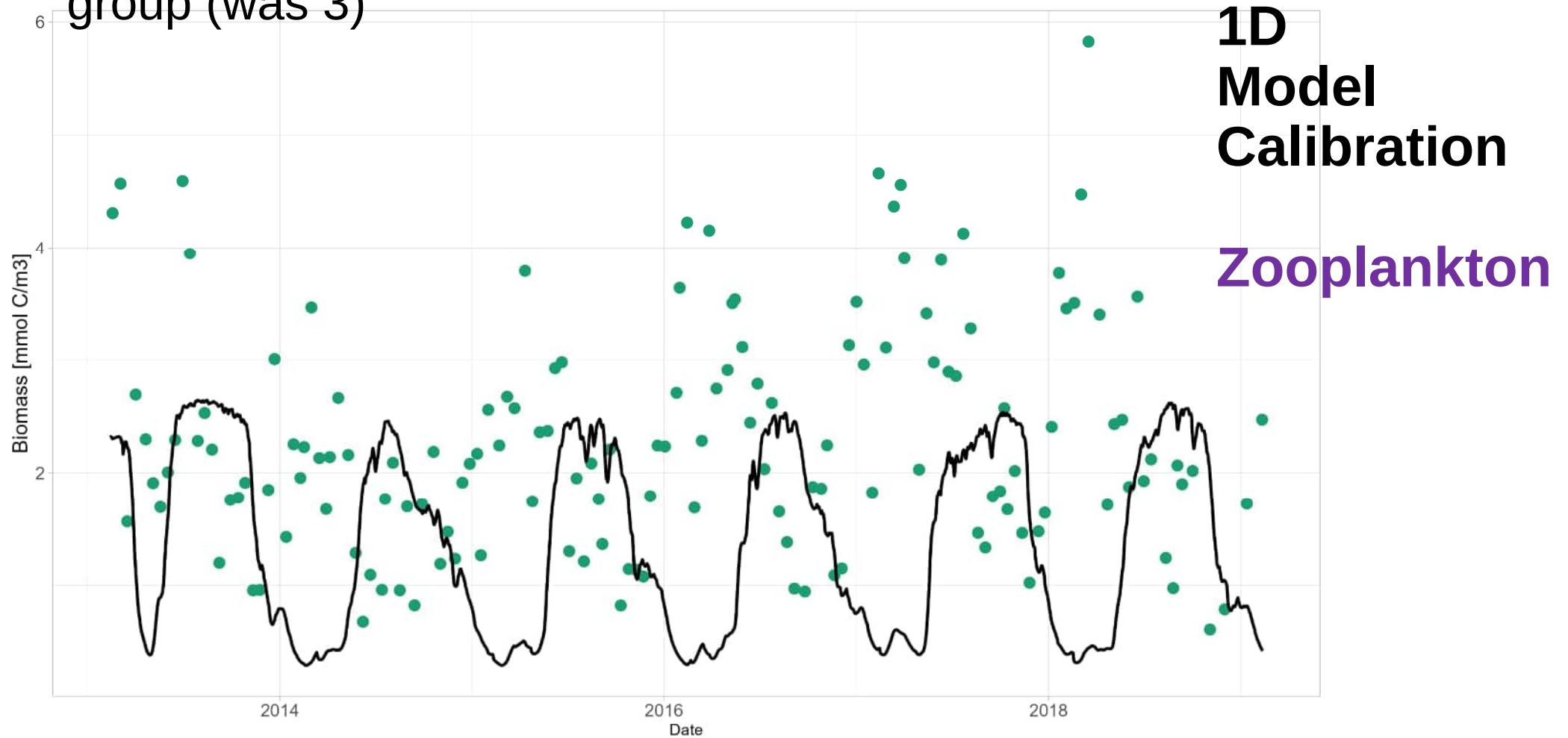
Nitrogen

1D Model Calibration Phytoplankton

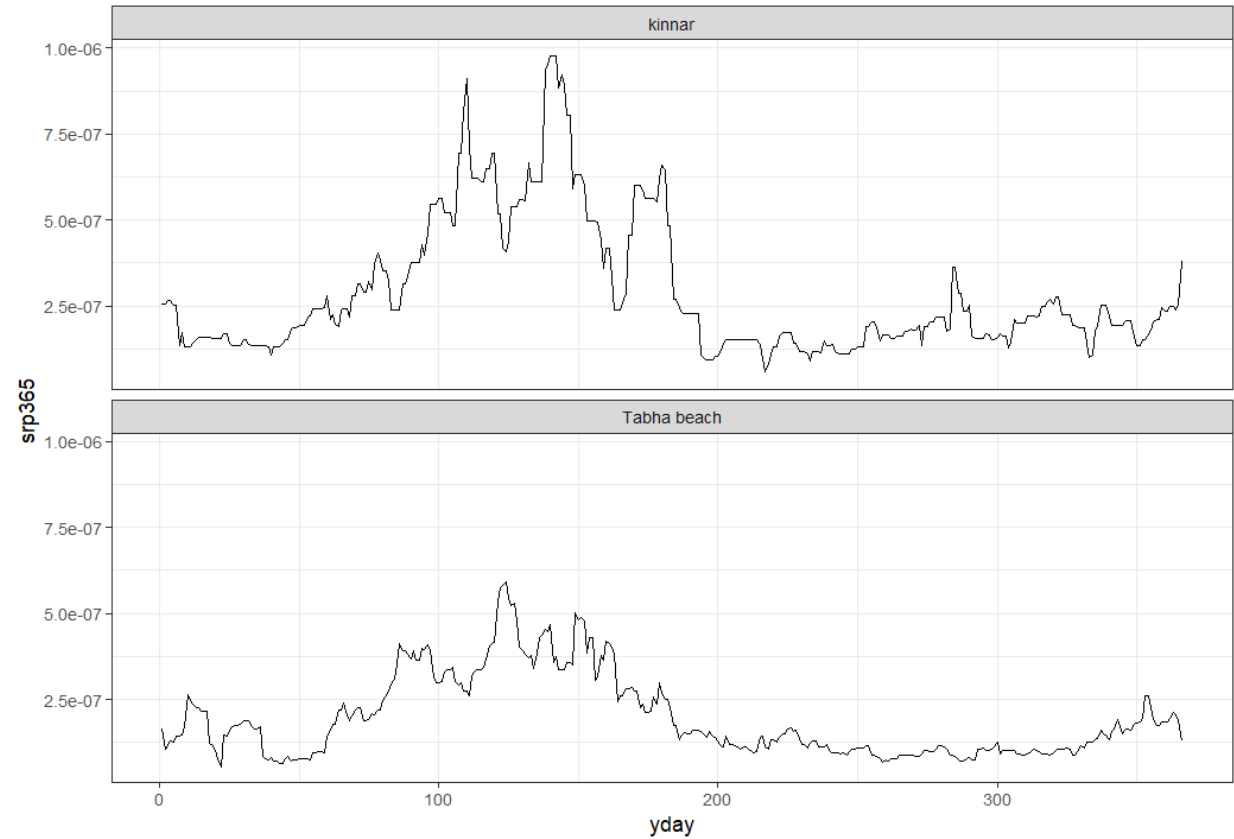


Observations are from station A in the middle of the lake. Are these representative of the whole lake (as 1D model asserts)?

Decided to switch to 1 Zooplankton
group (was 3)



Dust deposits

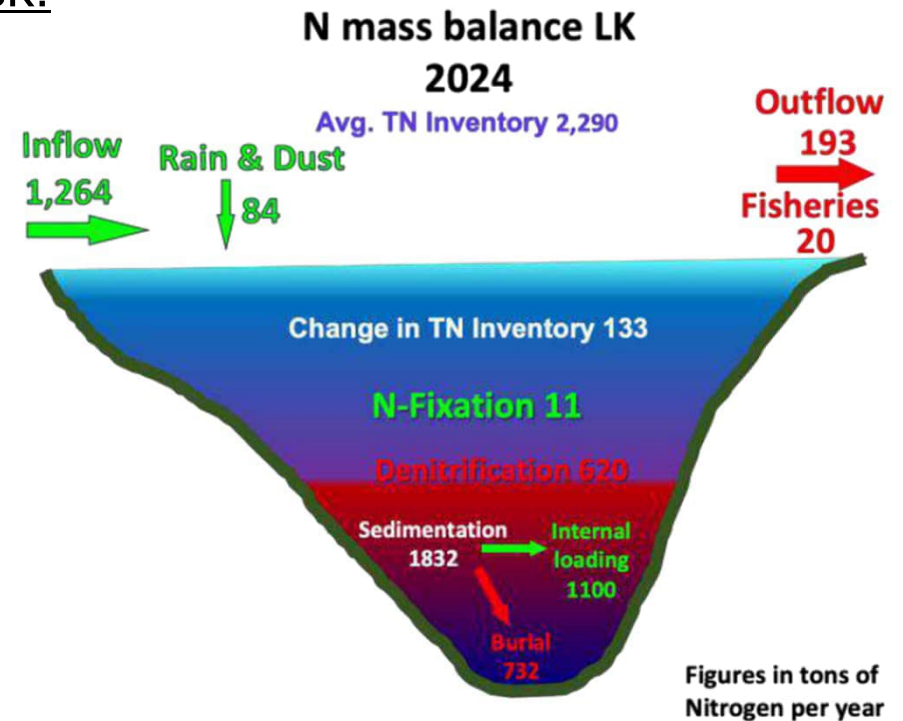
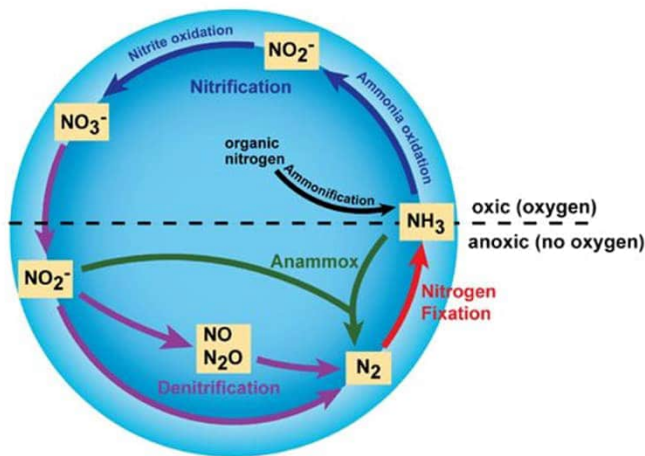


How can we implement in PyGETM?

Mass balance

Mass balance in the 1D proved to be a difficult task:

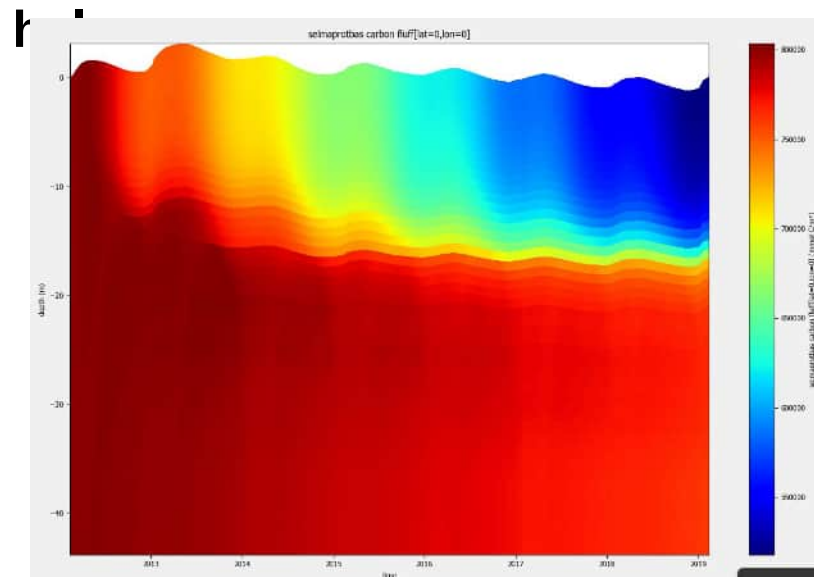
- Volume and area calculation
- Must define all streams with nutrients
- repair_state: true
- Lake level changes also sediment inventory
- Mass balance calculation is not concluded yet



Can the model determine what is the main nitrogen removal process – Denitrification or Anammox ?

Nitrification rate + C:N:P ratio of sediment can be adjusted so both options are possible.

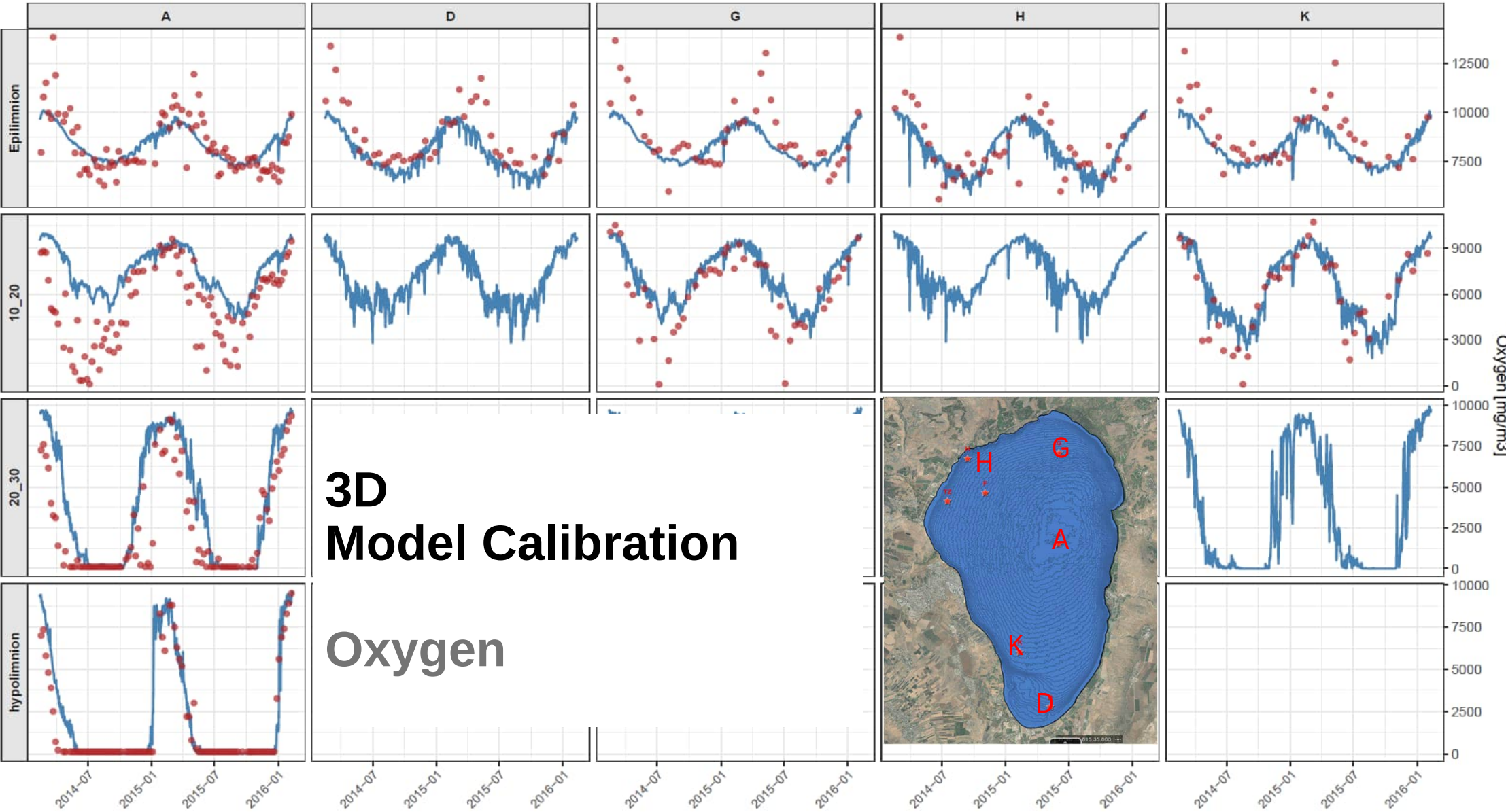
Some data of N:P and organic:inorganic P in the sediment exists - might



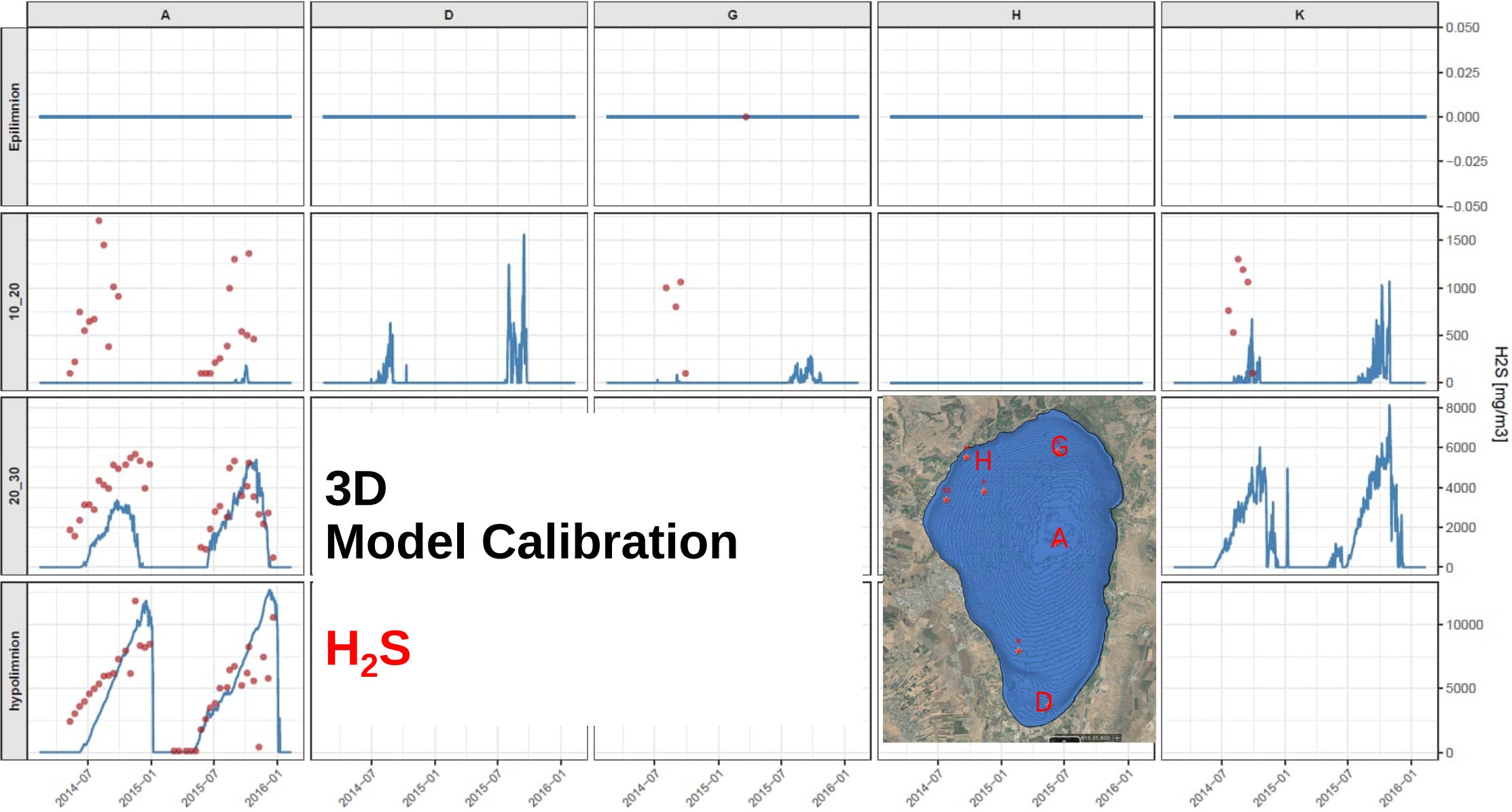
In Lake Kinneret we assume infinite inventory of sediment that can be mineralized. So:

- Sediment initial conditions is crucial.
- Sediment C:N:P is important
- Spin-up time is several years

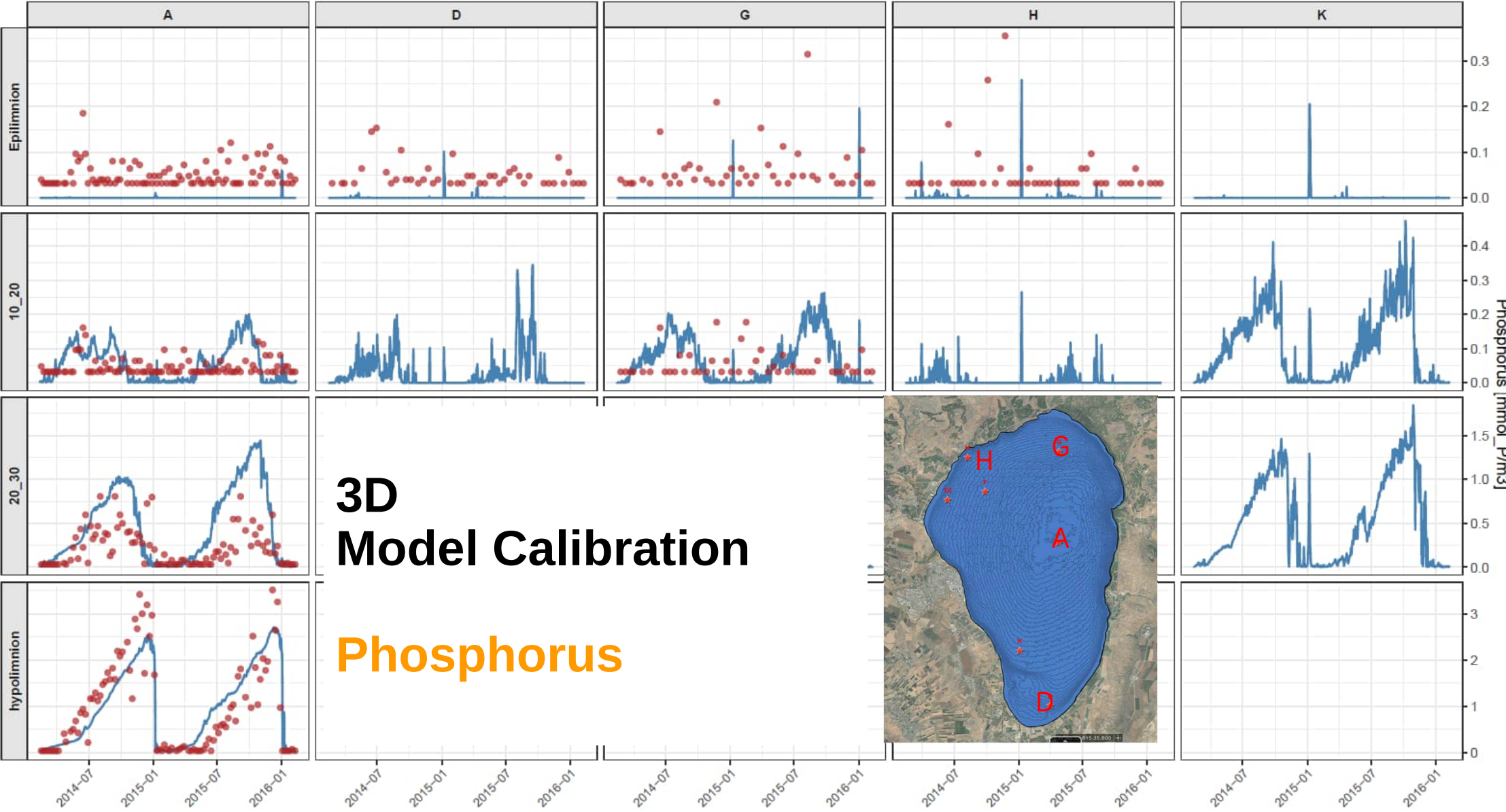
Oxygen



H2S

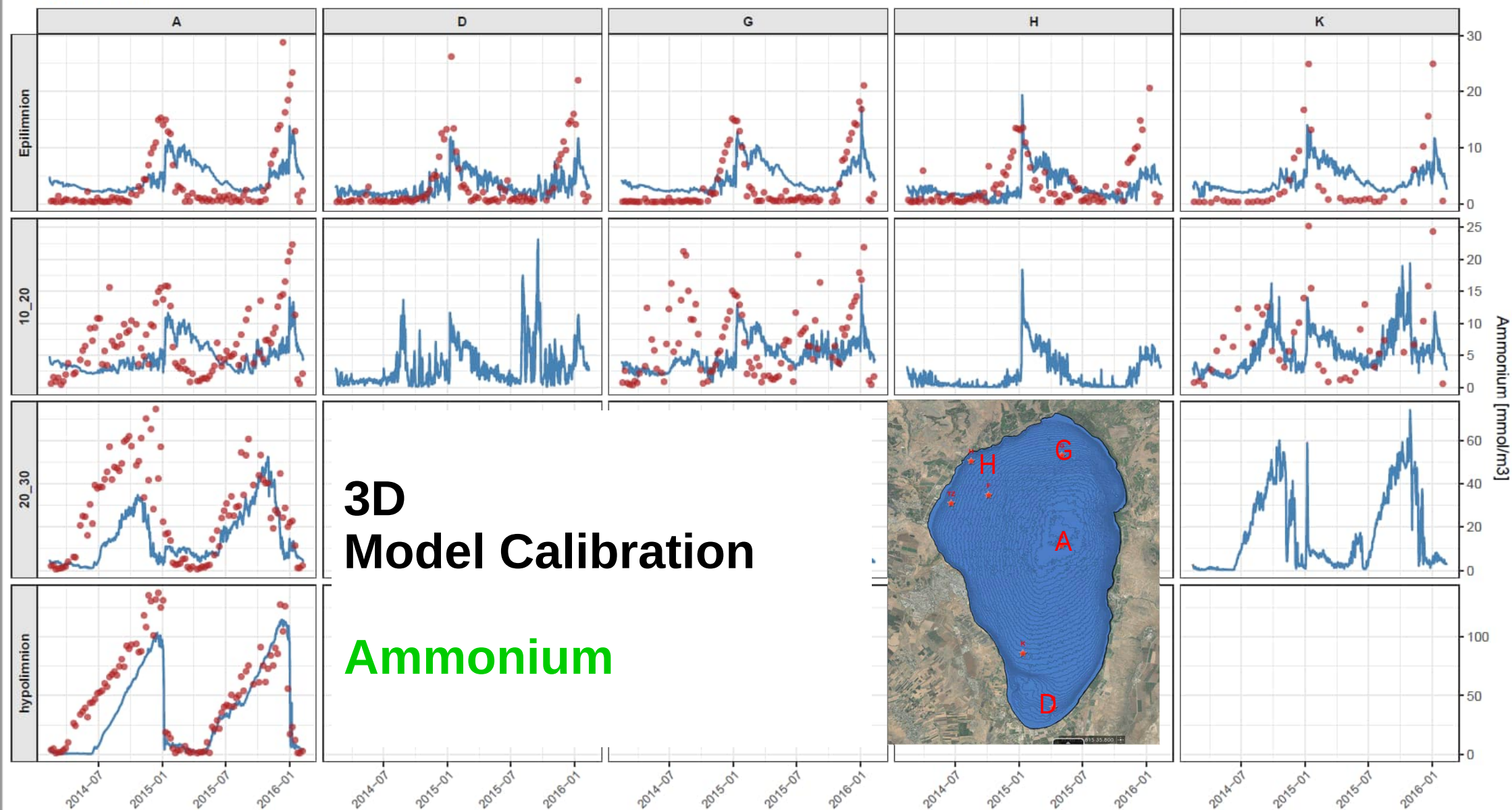


Phosphorus

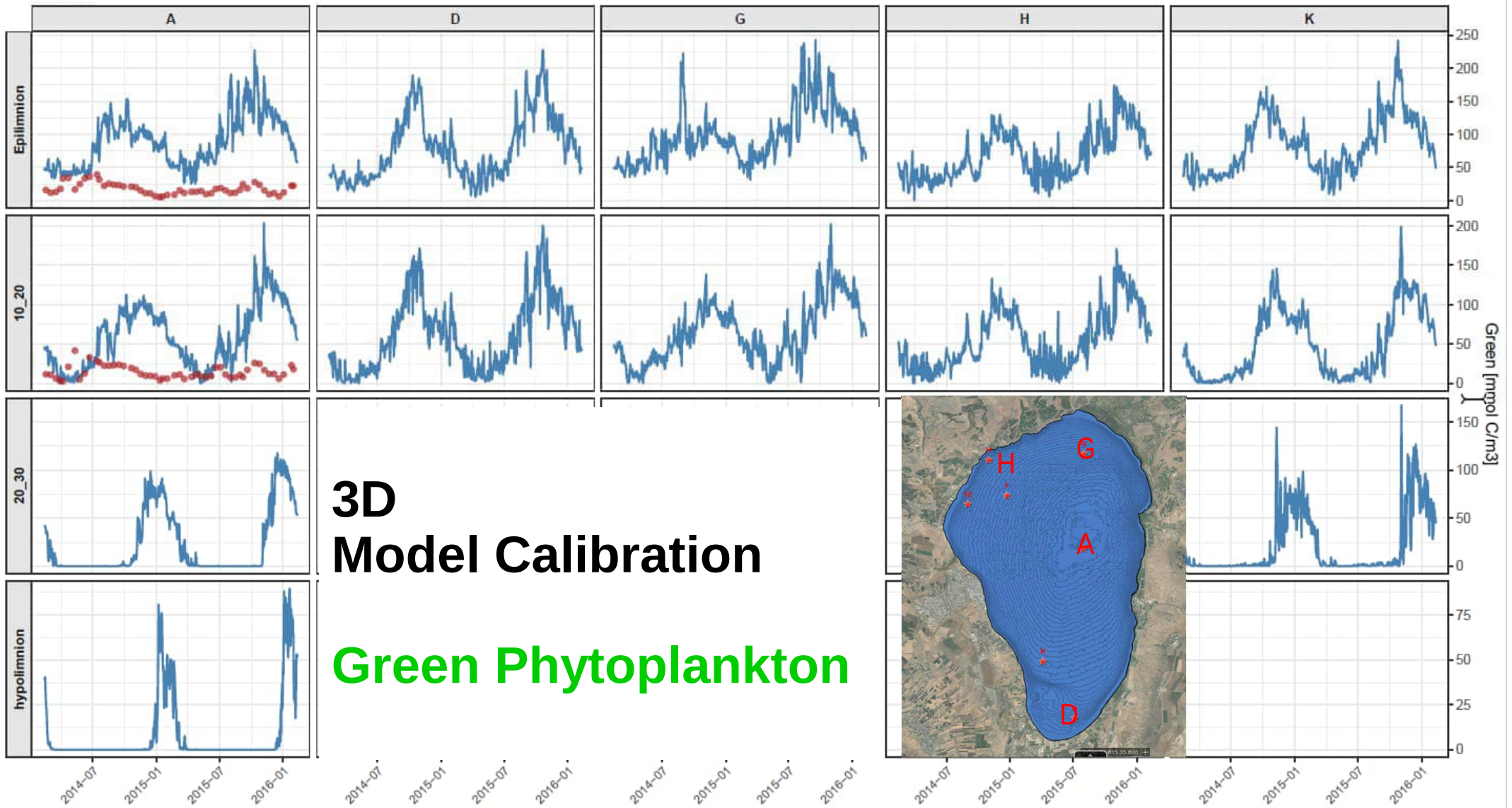


Ammonium

Highlight text



Green



3D Model Calibration

Transferring ecology calibration
from 1D to 3D is
not plug-and-play 🙄
But a good start.