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Das Wasserforschungsinstitut
des ETH-Bereichs

Remote sensing of tipping lakes

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RESETlakes in a nutshell

- The 6th IPCC assessment report (2021) emphasizes the risks related to tipping points
- October 2022: ESA tipping point workshop at the International Space Science Institute (ISSI), aiming *to advance knowledge about tipping elements and their irreversibility* using EO data
- White papers appear in a special issue of Surveys in Geophysics, currently three published
- February 2024: ESA invitation to tender for four tipping point projects
- RESETlakes starts in December 2024, lasting three years
- Work programme:
  - M1-M6: Which tipping points, which features? (science requirements)
  - M7-M12: Which EO products, which models? (method development)
  - M13-M36: Two analyses on tipping points and uncertainties

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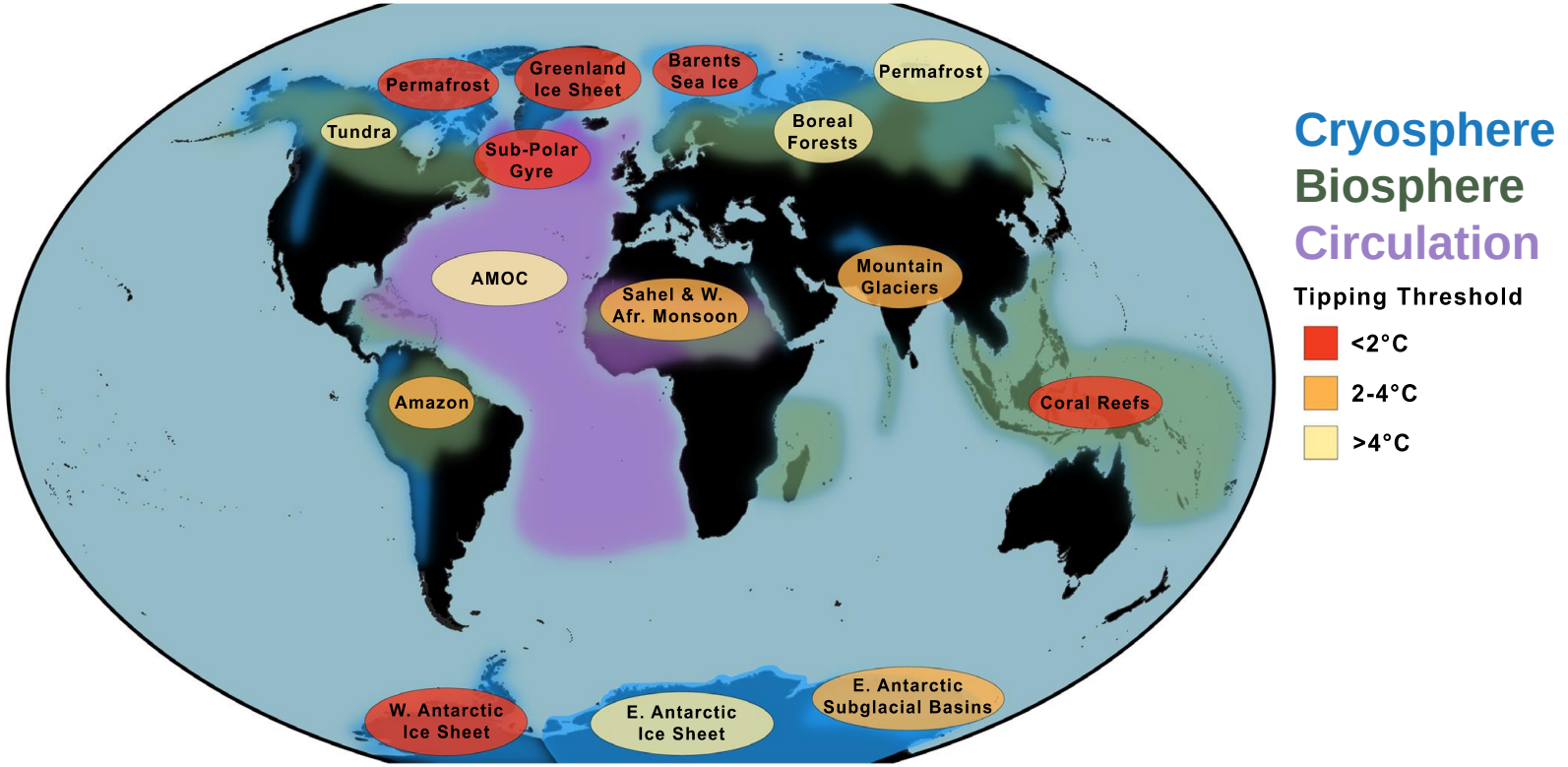
Definitions

- A *tipping point* is a critical threshold beyond which a system reorganises, often abruptly and/or irreversibly
- These *abrupt changes* take place over a few decades or less, persist for a least a few decades, and cause substantial impact on human and/or natural systems
- A *tipping element* is a component of the Earth system that is susceptible to a tipping point

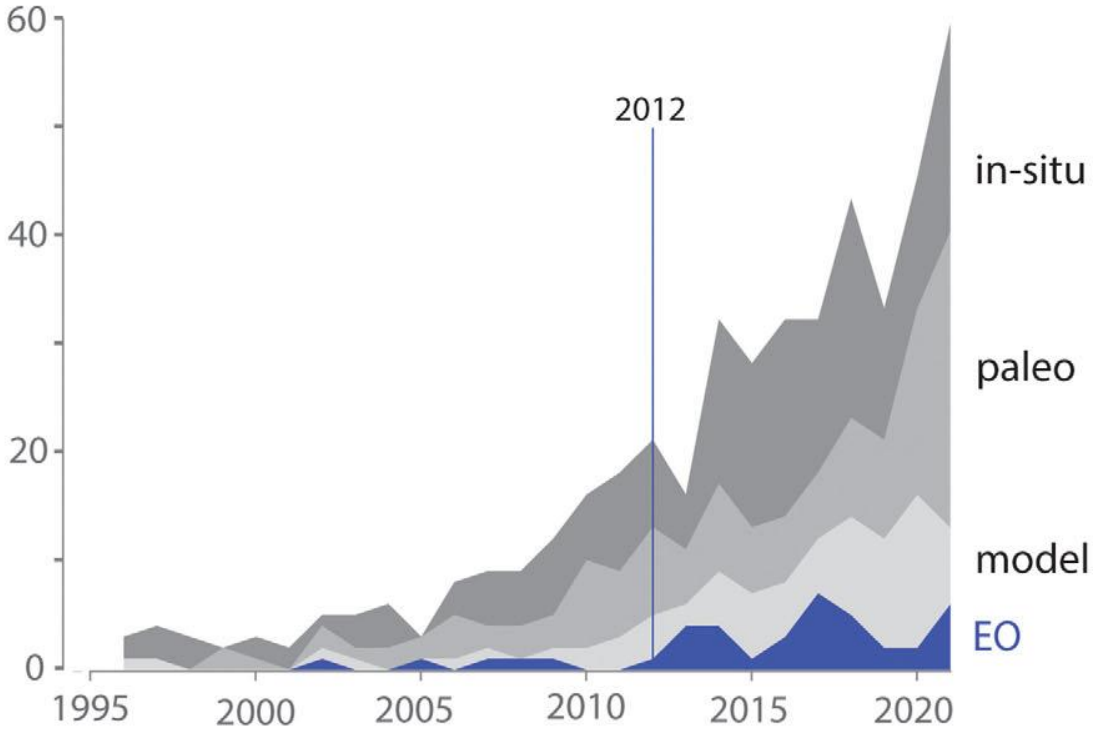
Examples of tipping elements



Lenton, T. M., Abrams, J. F., Bartsch, A., Bathiany, S., Boulton, C. A., Buxton, J. E., ... & Boers, N., Remotely sensing potential climate change tipping points across scales. Nature Communications, 15(1), 343 (2024).

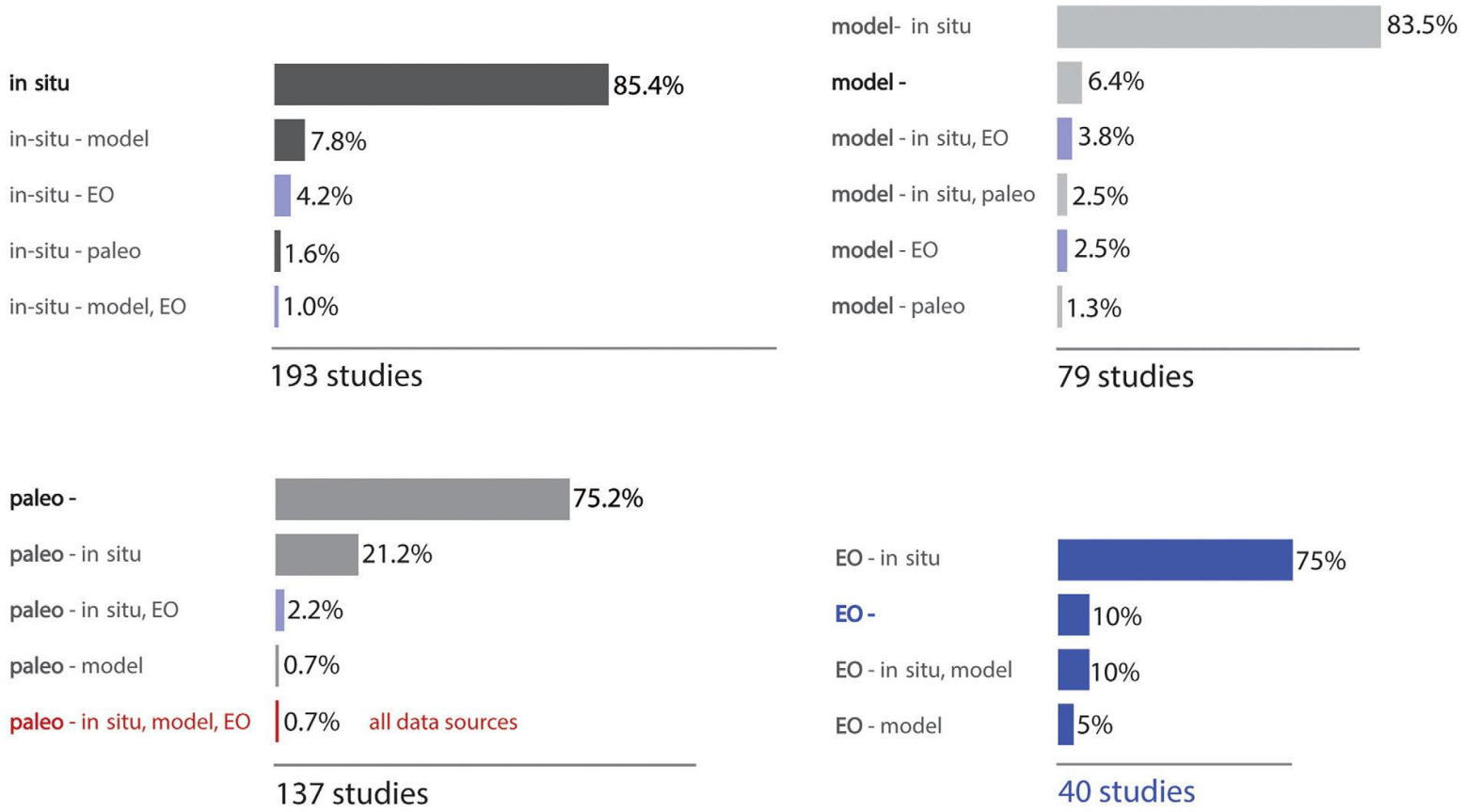
The use of EO in recent literature on lake shifts

Keywords *regime shift*, *critical transition* and *tipping point*



Calamita, E., Lever, J.J., Albergel, C., Woolway, R.I., Odermatt, D., 2024. Detecting climate-related shifts in lakes: A review of the use of satellite Earth Observation. Limnol. Oceanogr.

Primary and secondary data sources



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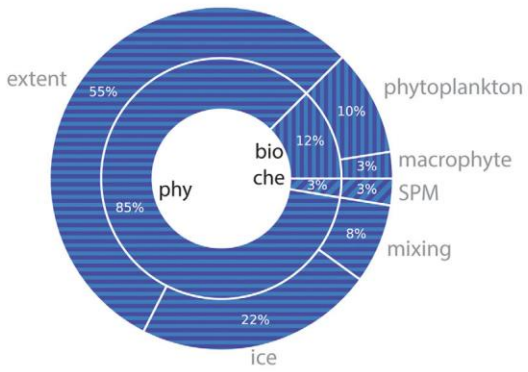
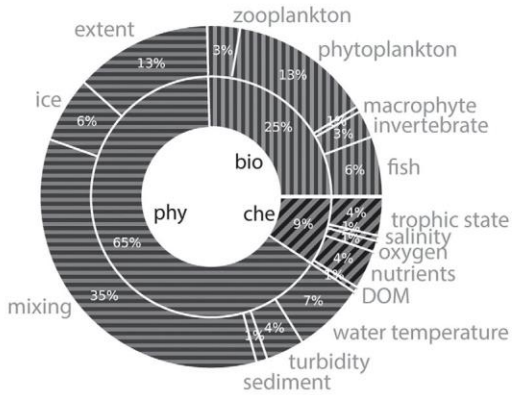
Lake shift indicator variables by data source

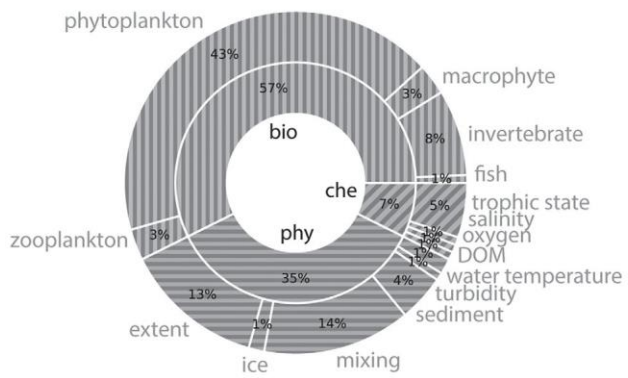
A - Earth Observation



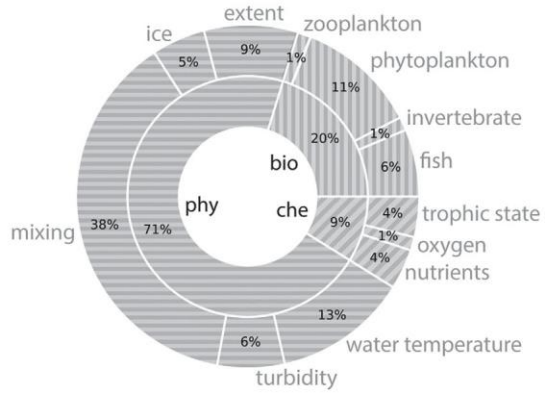
B - In situ



C - Paleo



D - Model



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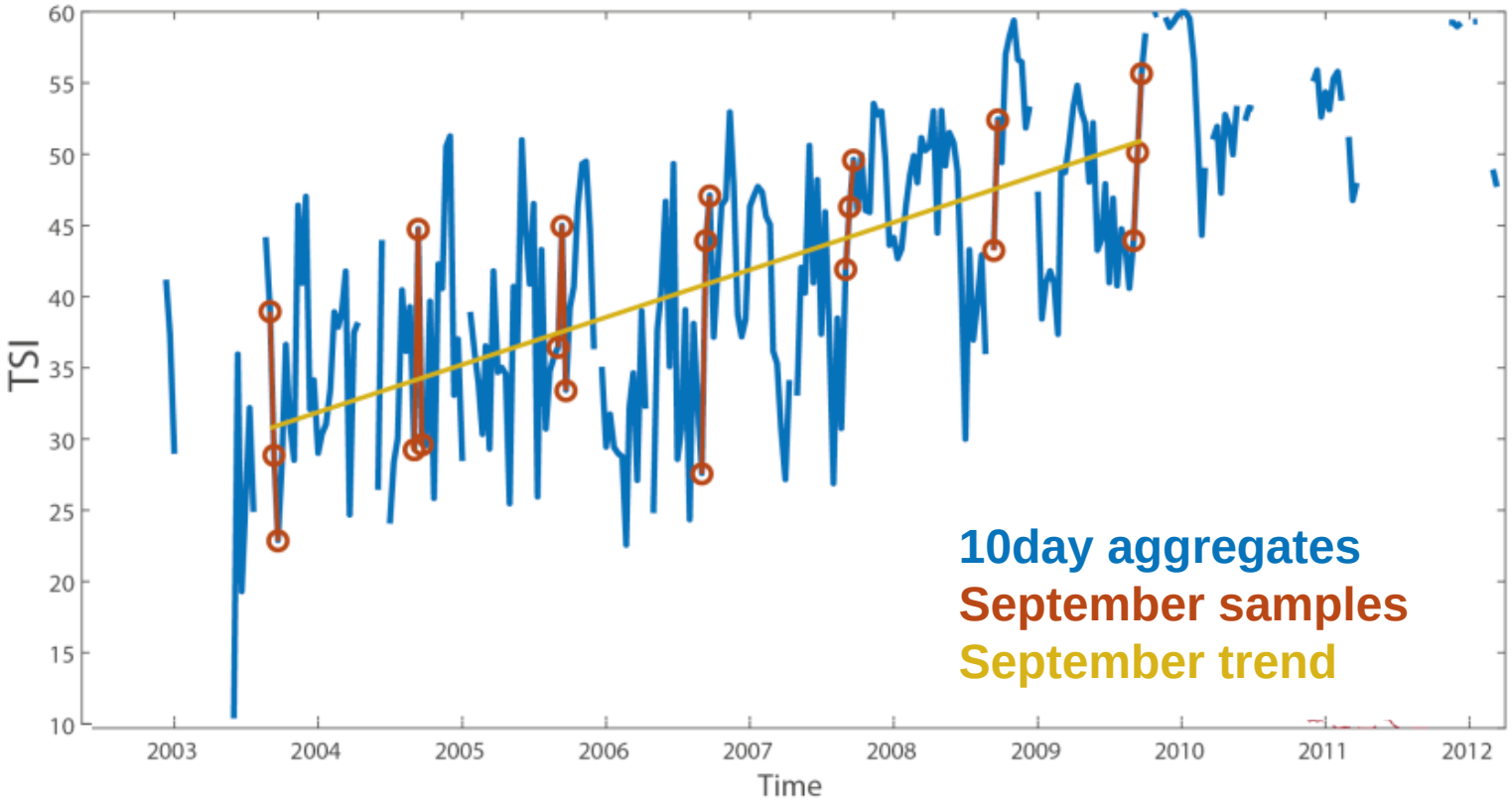
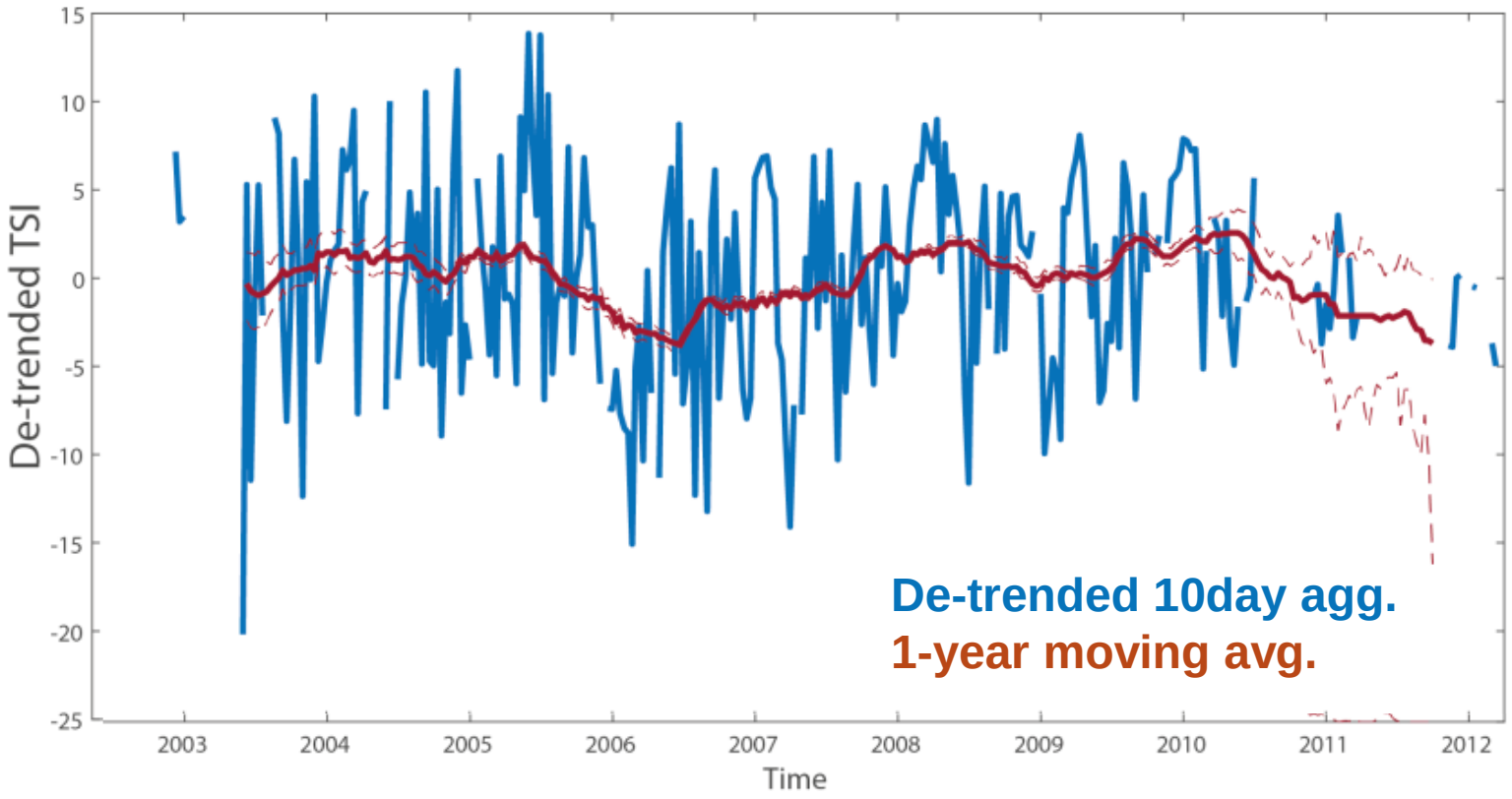
Identifying tipping points: CGLS TSI time series, Toshka Lakes



Gilarranz, L.J., Narwani, A., Odermatt, D., Siber, R., Dakos, V., 2022. Regime shifts, trends, and variability of lake productivity at a global scale. Proceedings of the National Academy of Sciences 119, e2116413119.

Identifying tipping points: CGLS TSI time series, Toshka Lakes



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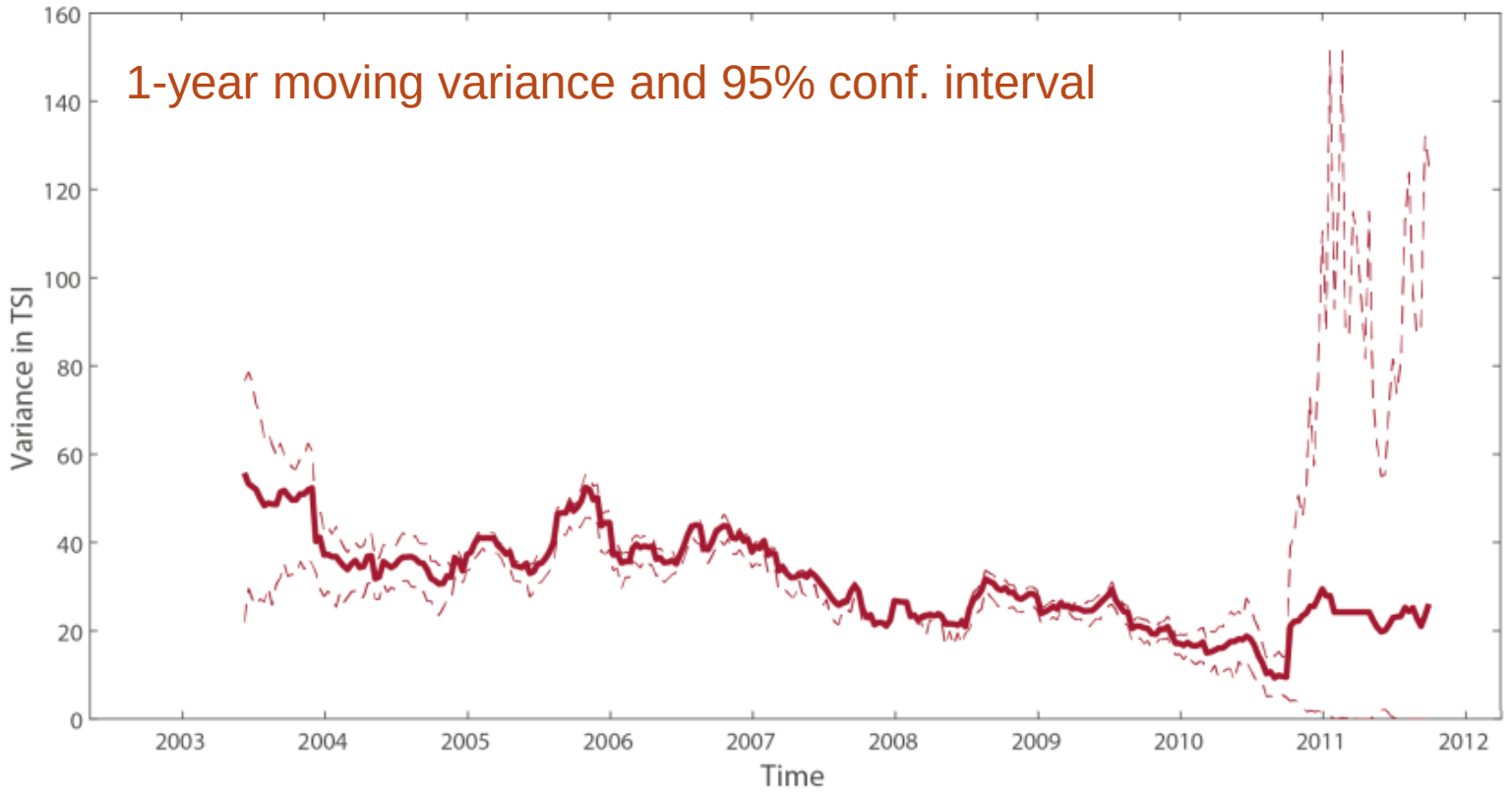

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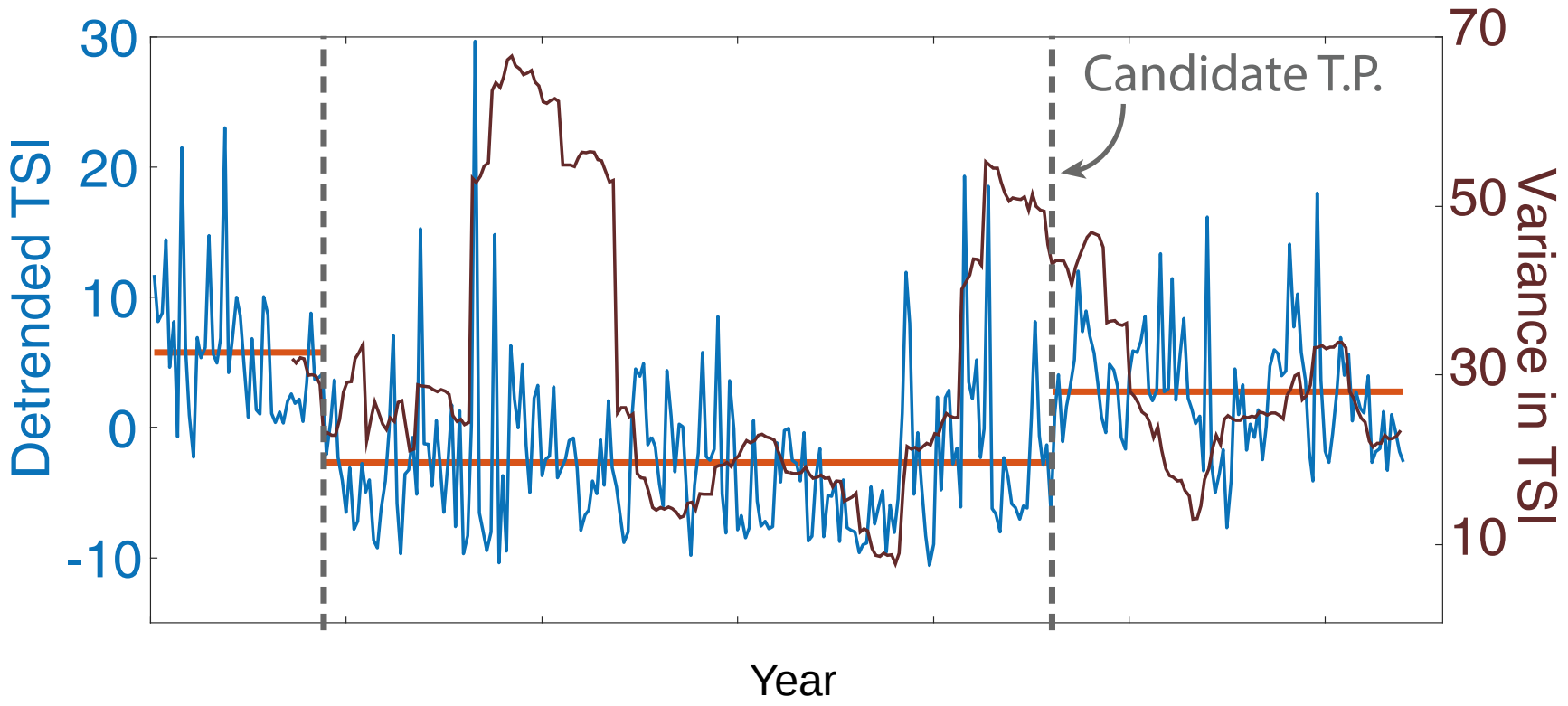
Identifying tipping points: Shift in level and variance, Lake Thertar



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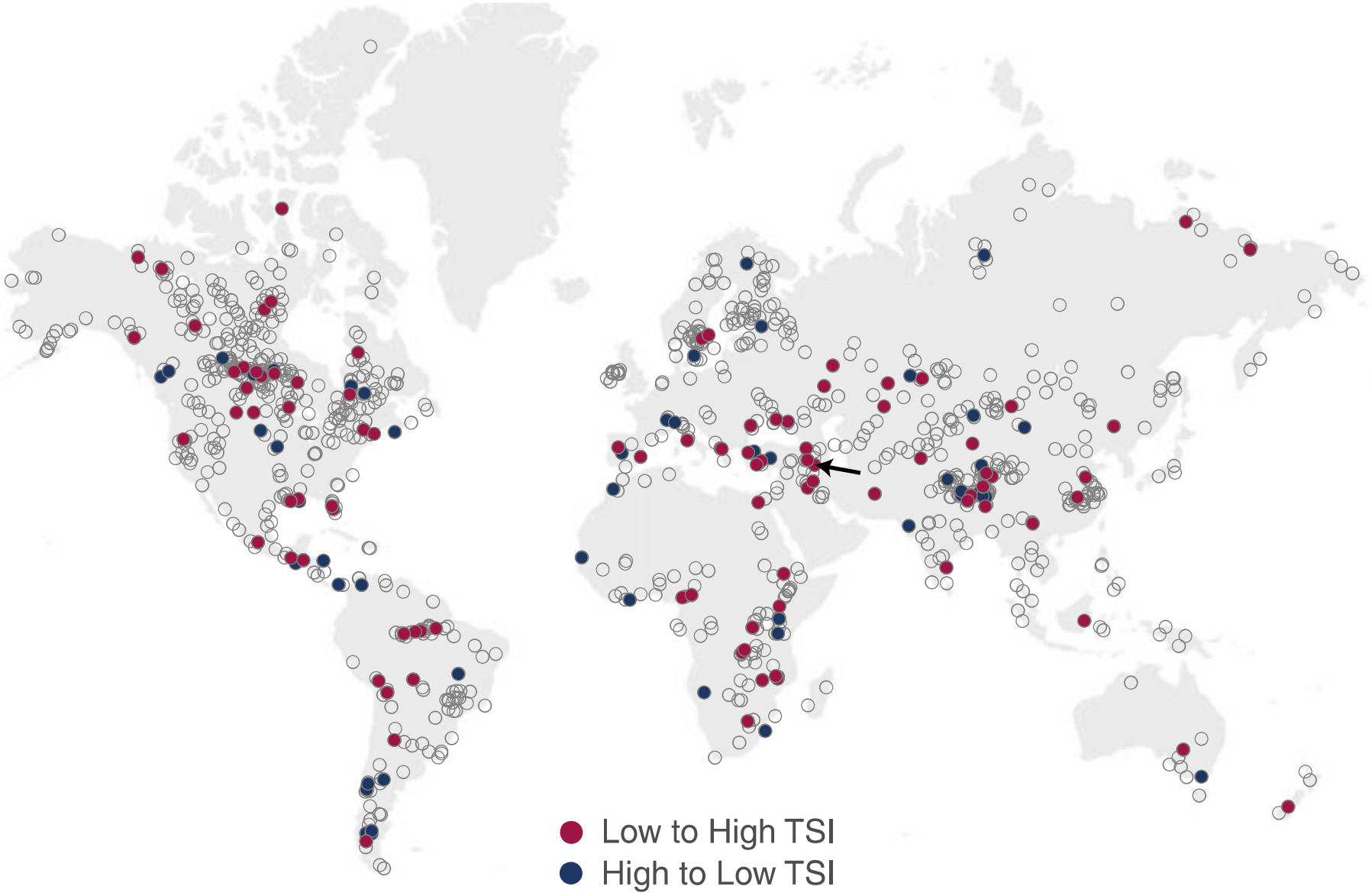
Candidate tipping points, 2002-2012



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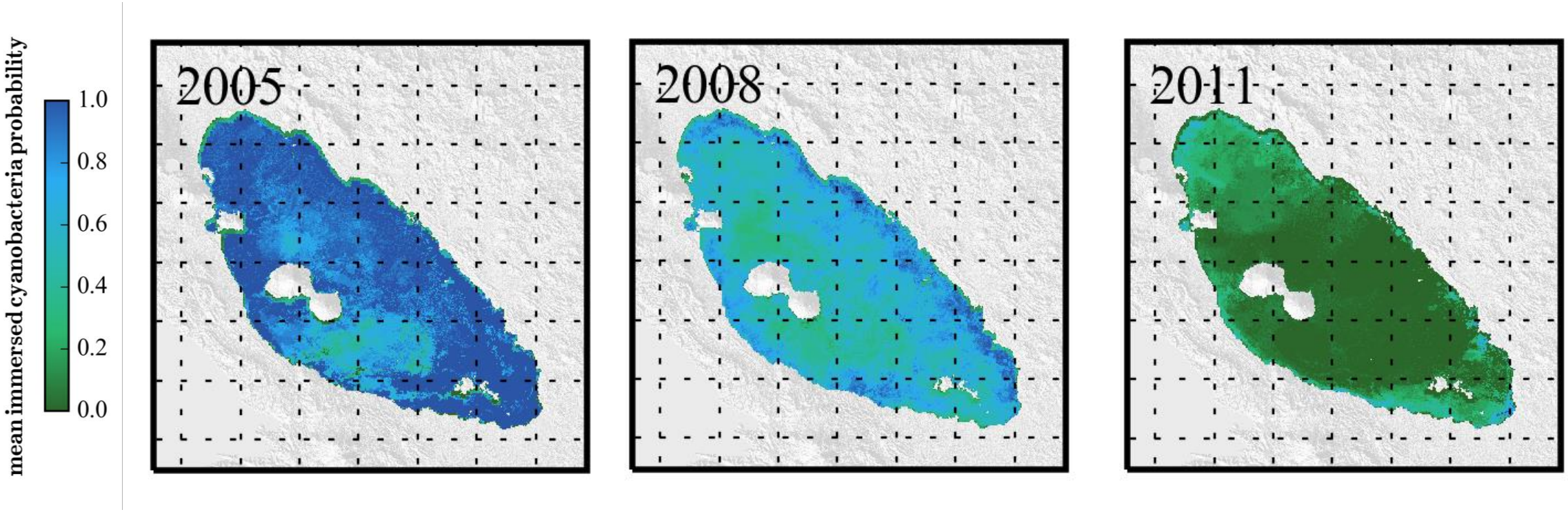
But what are these TSI signals representative of?

1) Direct changes in trophic state



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But what are these TSI signals representative of?

2) Resposes to shifts in water quantity

Toshka Lakes, September 11, 2002

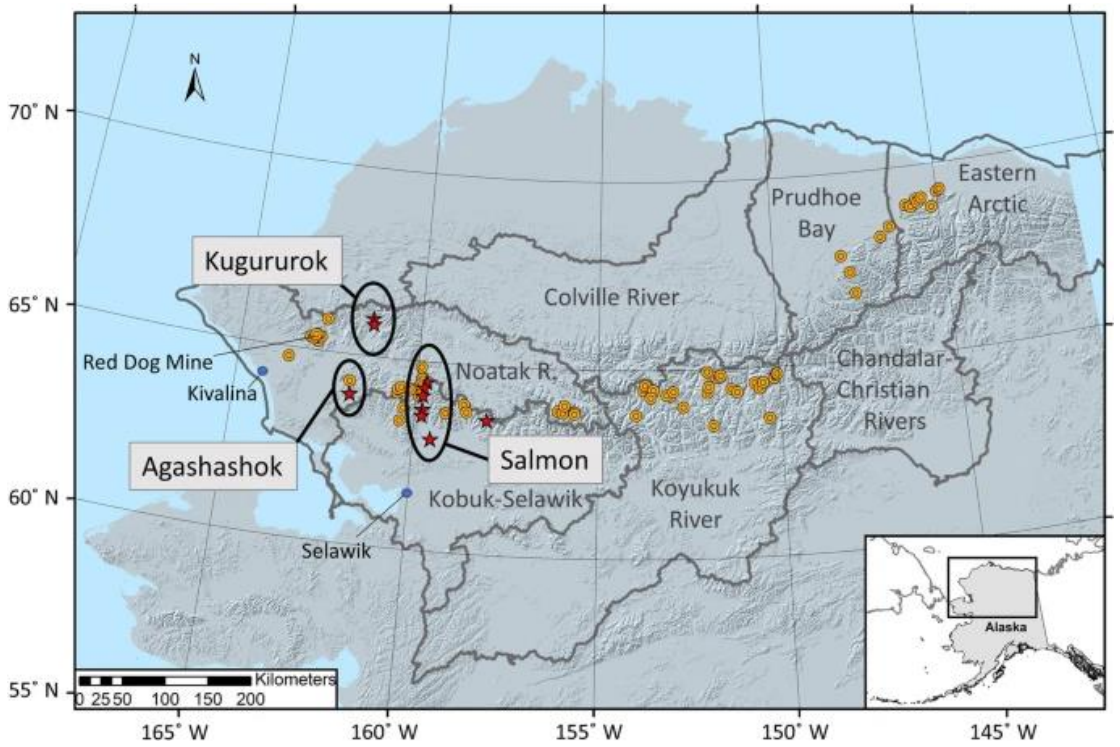
Toshka Lakes, June 21, 2012

Images from https://earthobservatory.nasa.gov

But what are these TSI signals representative of?

3) “Sentinel” resposes to alterations in the catchment

Kutuk River, Alaska



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Summary of main expectations of RESETlakes

- Analyses of combined CCI products and custom EO products can better inform on causality, initial and reorganised state
- Longer EO timeseries and modelling can reveal the persistence of tipping elements
- Models enable assessments of the impacts of tipping points