Institute of Coastal Research
Research Unit 1: System Analysis and Modelling

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Modeling the mercury cycle

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Mercury pollution - a global concern

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„Mercury is one of the ***top ten chemicals of major public health concern*** *and is a substance which disperses into and remains in ecosystems for generations, causing severe ill health and intellectual impairment to exposed populations."*

WHO Director-General Dr. Margaret Chan
Signature of the Minamata Convention on Mercury

Our aim: Linking emissions to exposure

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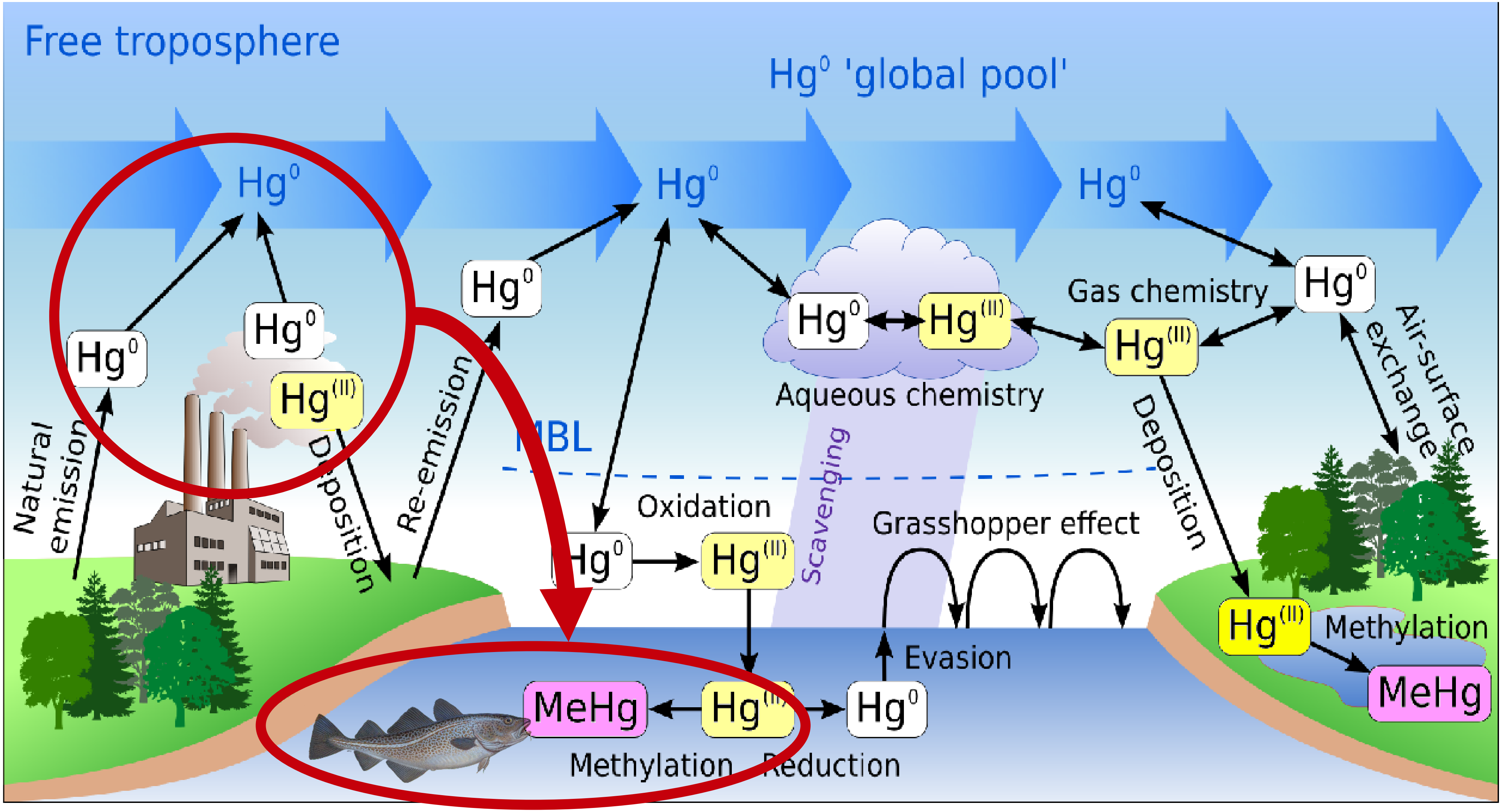

Our aims

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- Representing all relevant processes

  To model the complete mercury cycle we need to implement all chemical, physical, and biological processes that affect transport, transformation (e.g. speciation, complexation, particle partitioning), and bio-accumulation of mercury.

- Scale overarching high resolution model

  The global mercury cycle includes processes that range from hemispheric (e.g. atmospheric transport) to local scale (e.g. bio-accumulation, resuspension). With our high resolution 3d hydrodynamic model we are able to reproduce processes ranging from 1 m to several 1000 km.

- Closing the link between emissions and exposure

  In order to support the successful implementation of the UN Minamata Convention on Mercury it is necessary to close the link between atmospheric emissions and methylmercury exposure in sea food. This is something current 3d hydrodynamic mercury models are unable to do.

A novel multi media mercury model

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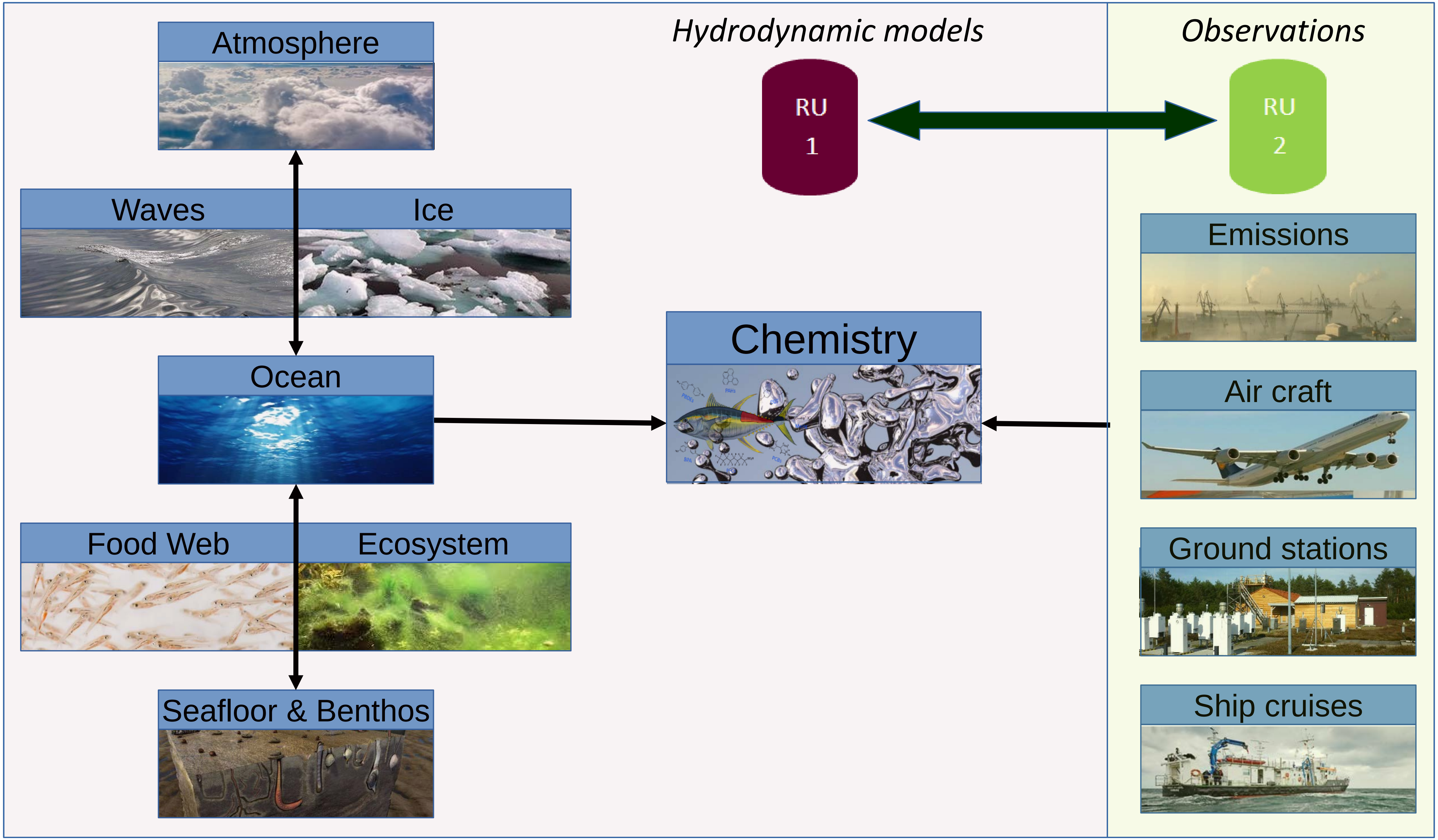

The chemical mechanism

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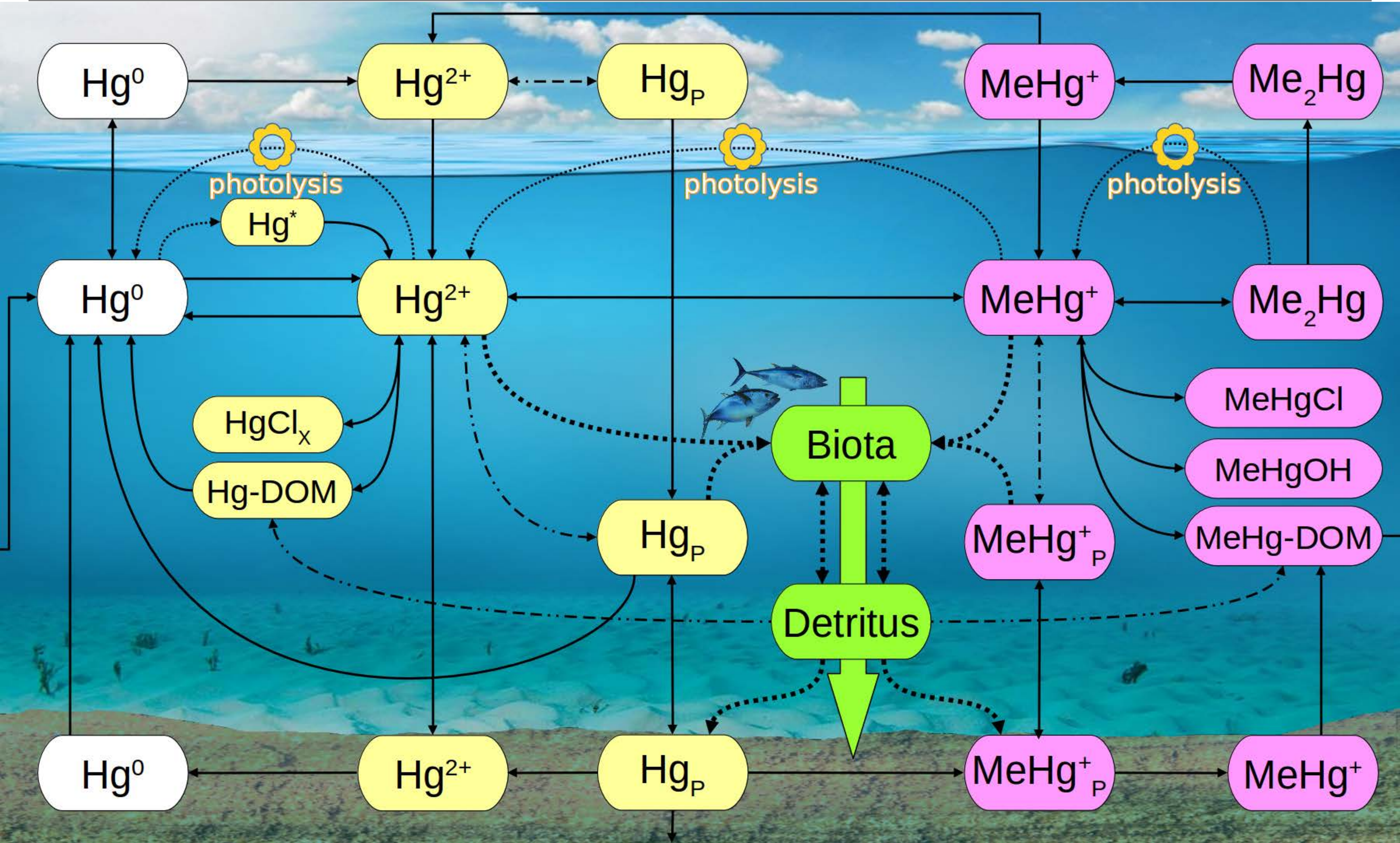

Key processes

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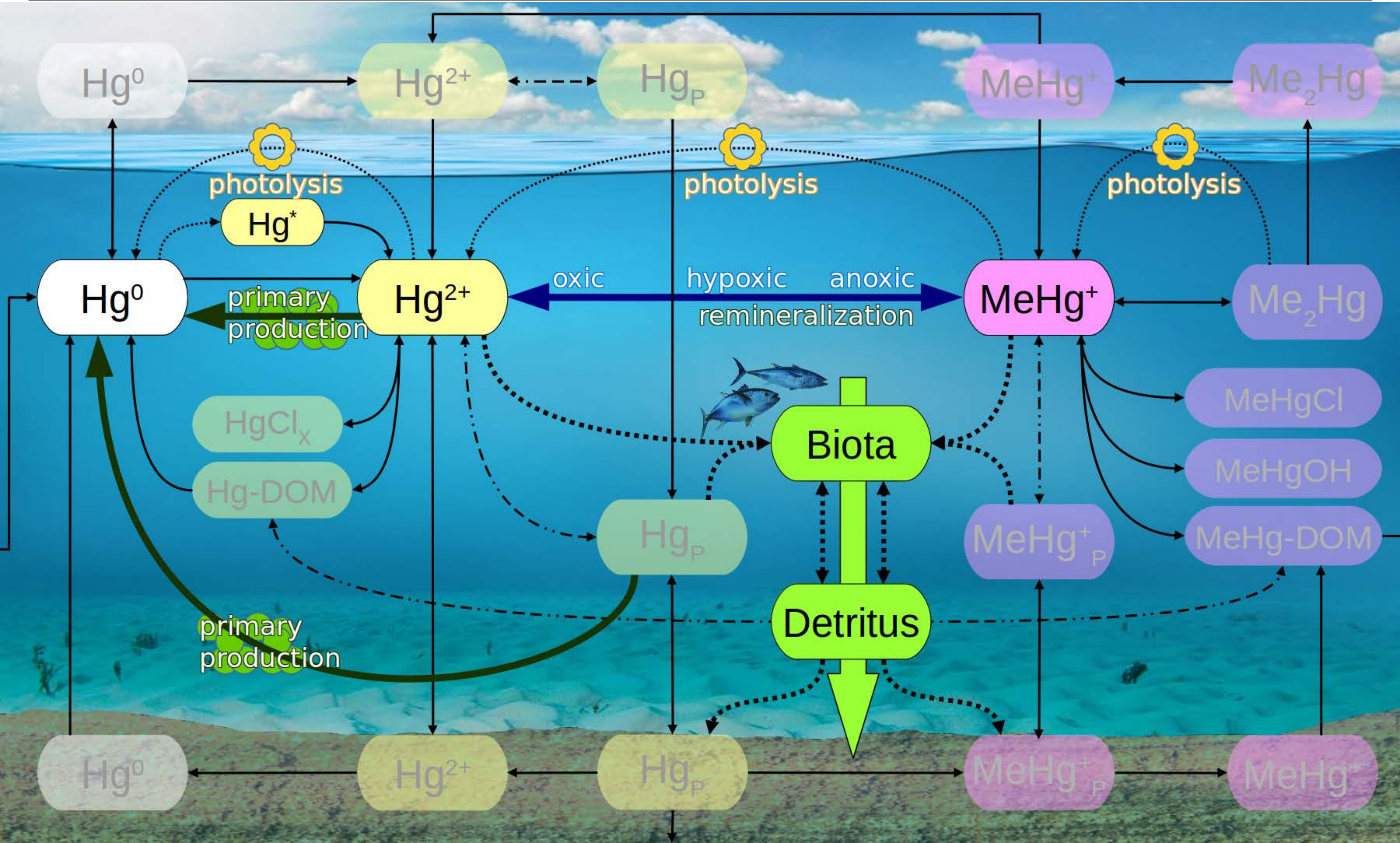

Hg^0 surface seasonality

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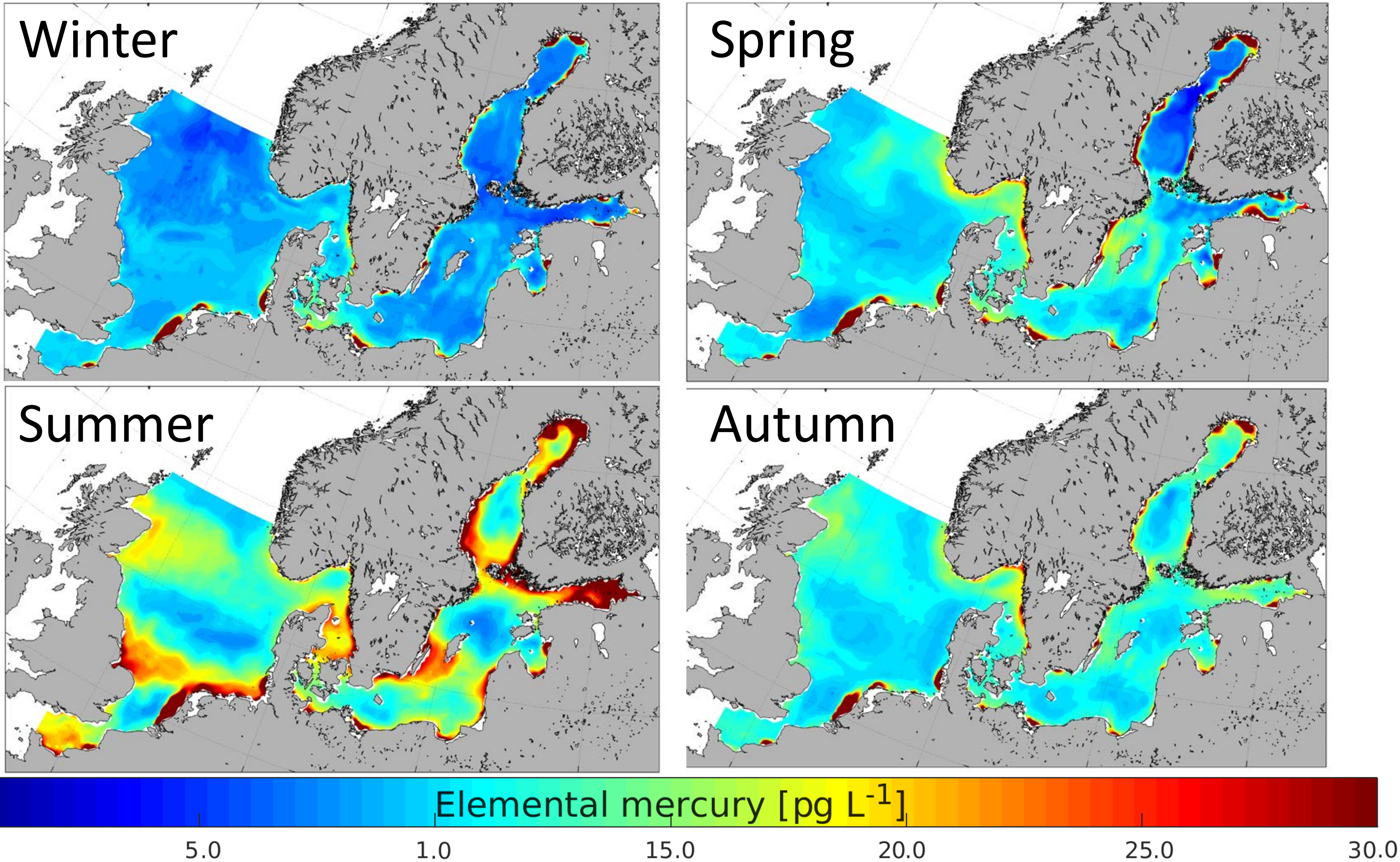

Annual Hg budget

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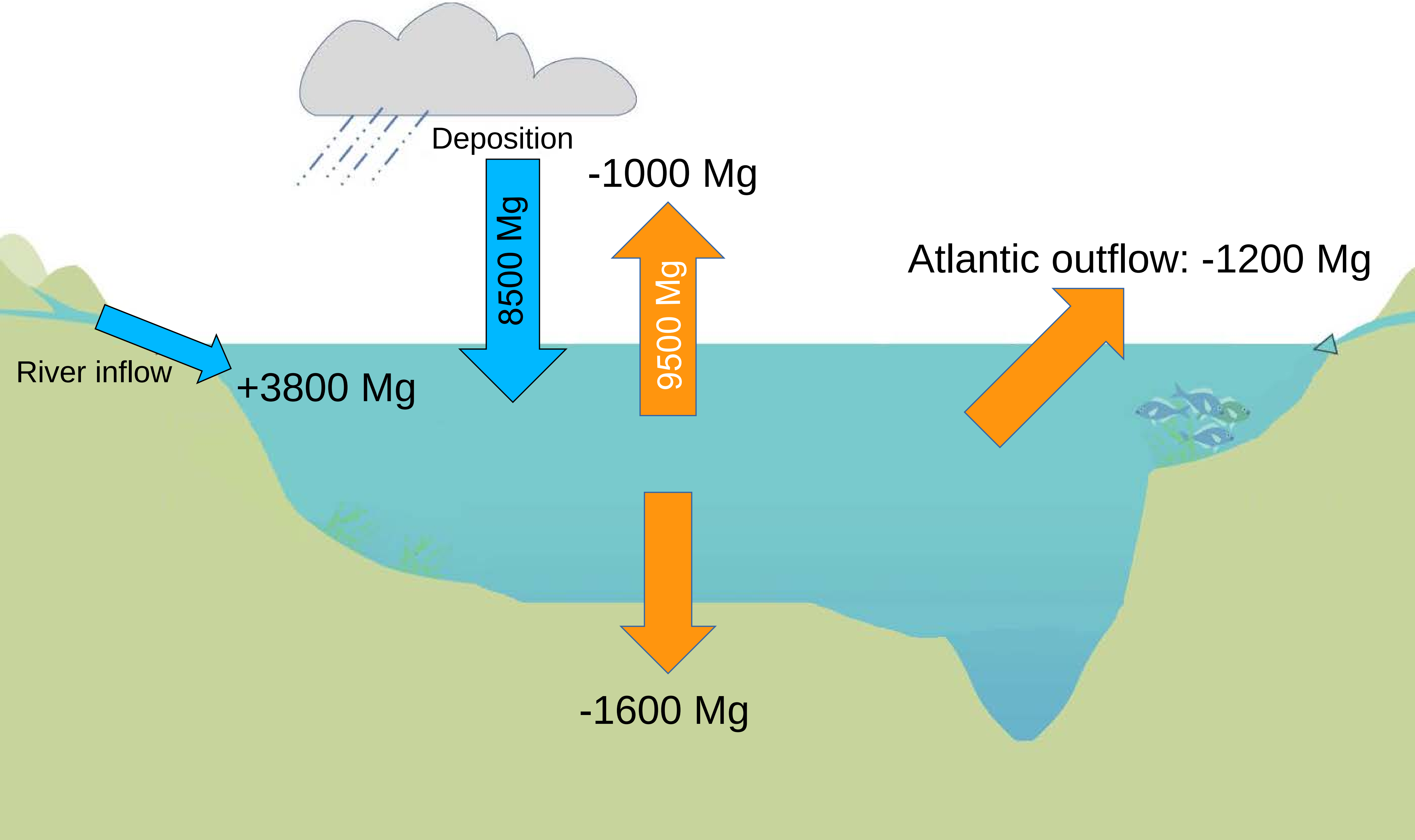

Dec – Jan – Feb

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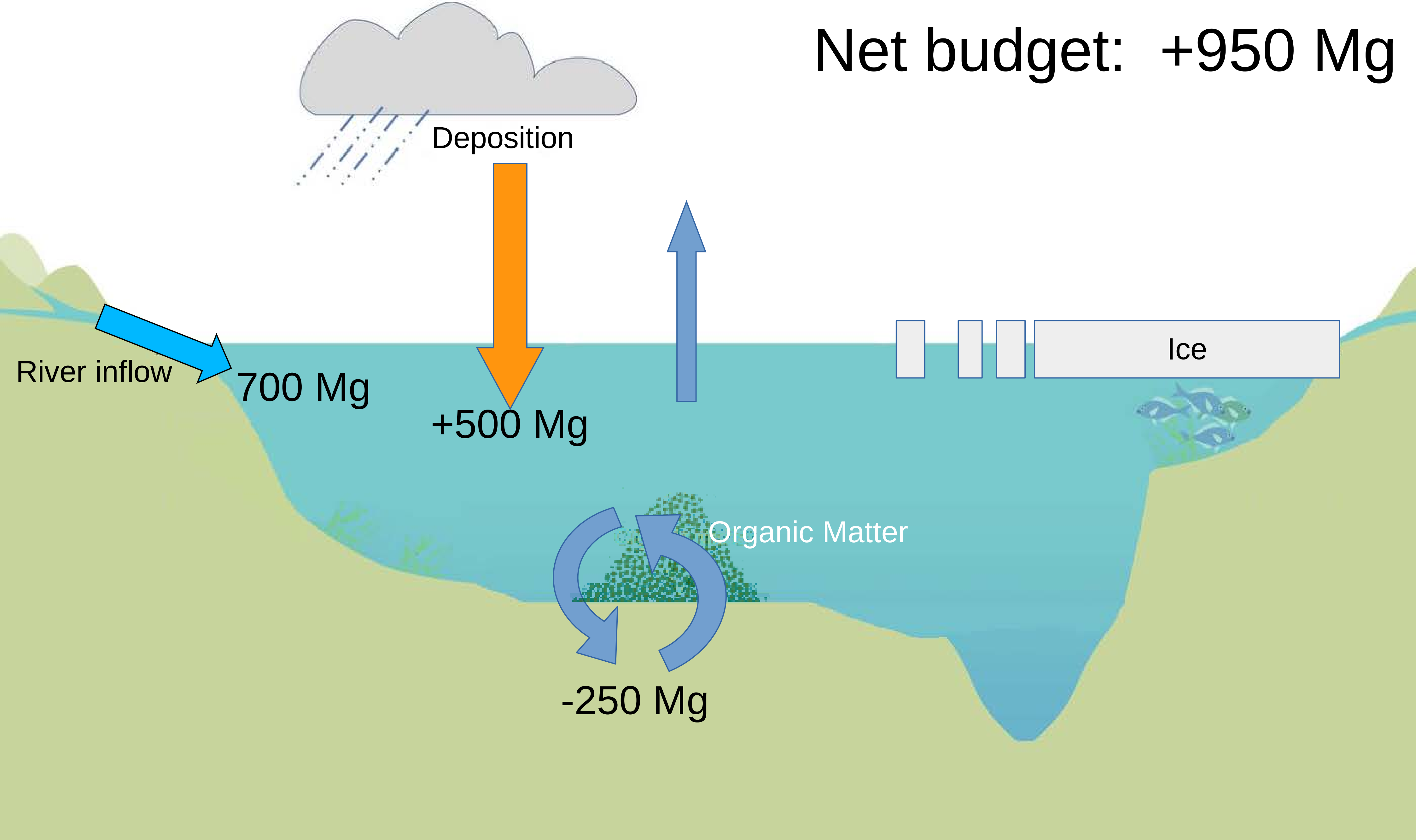
Net budget: +950 Mg



Mar – Apr – May

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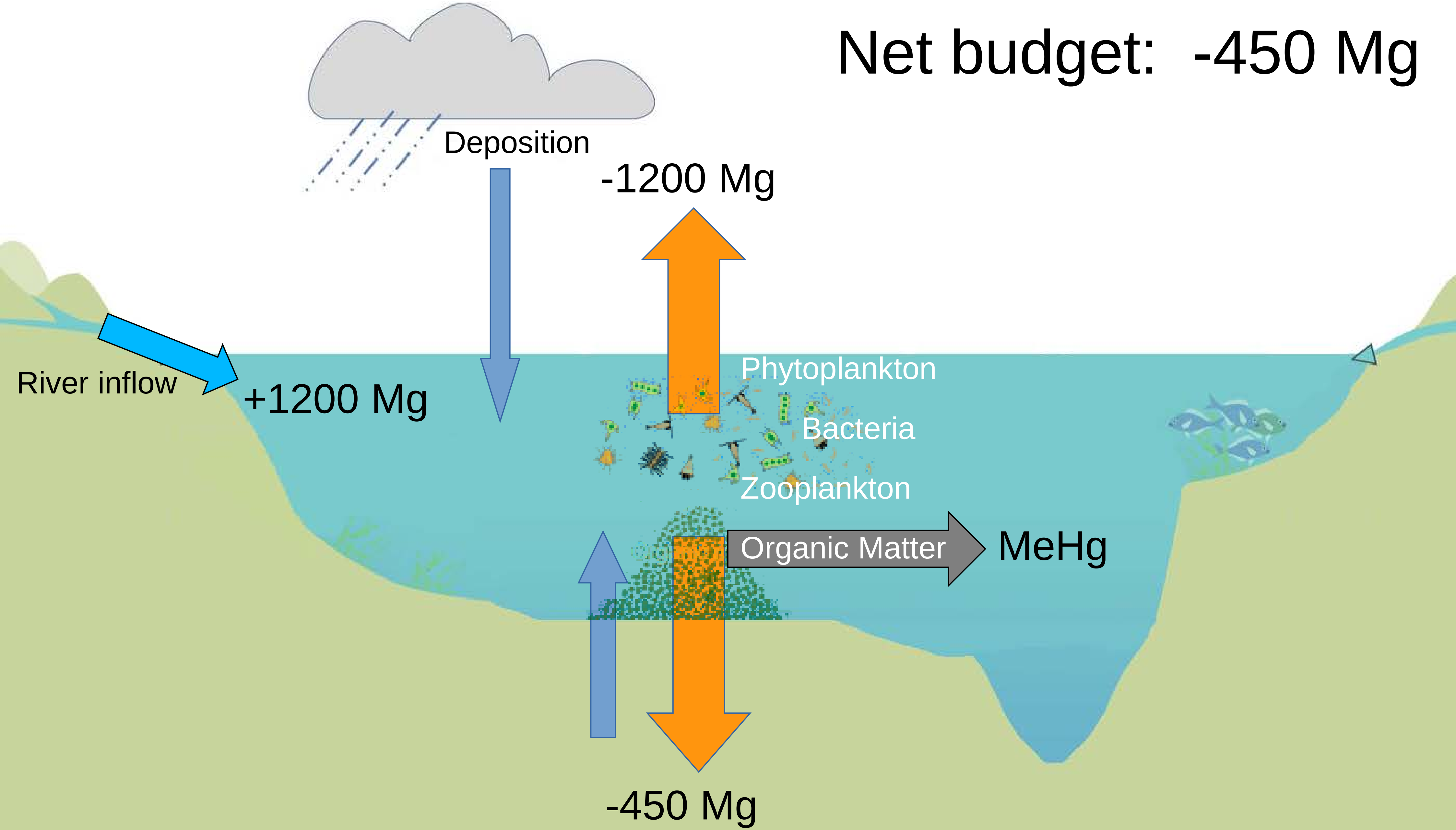
Net budget: -450 Mg



Jun – Jul – Aug

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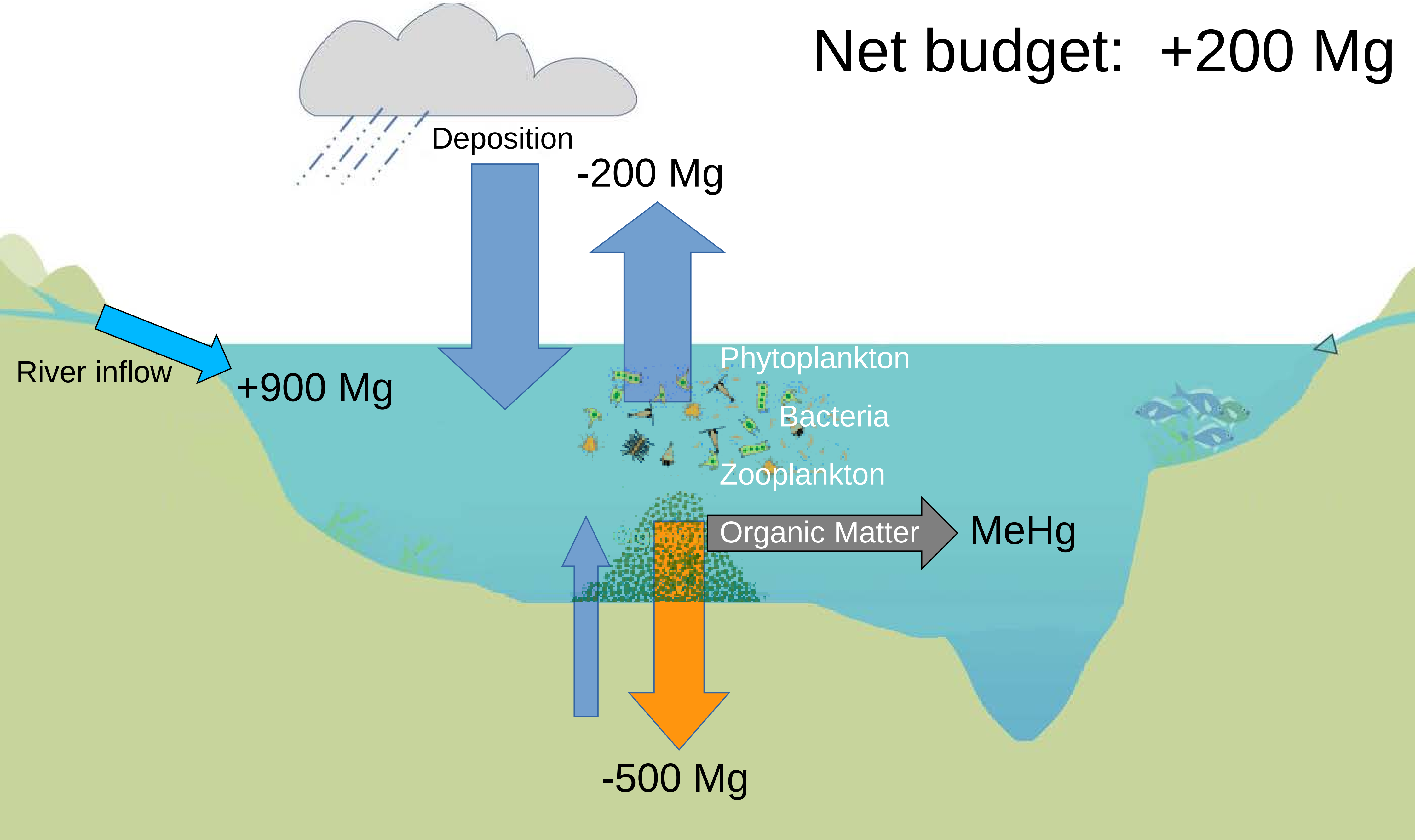
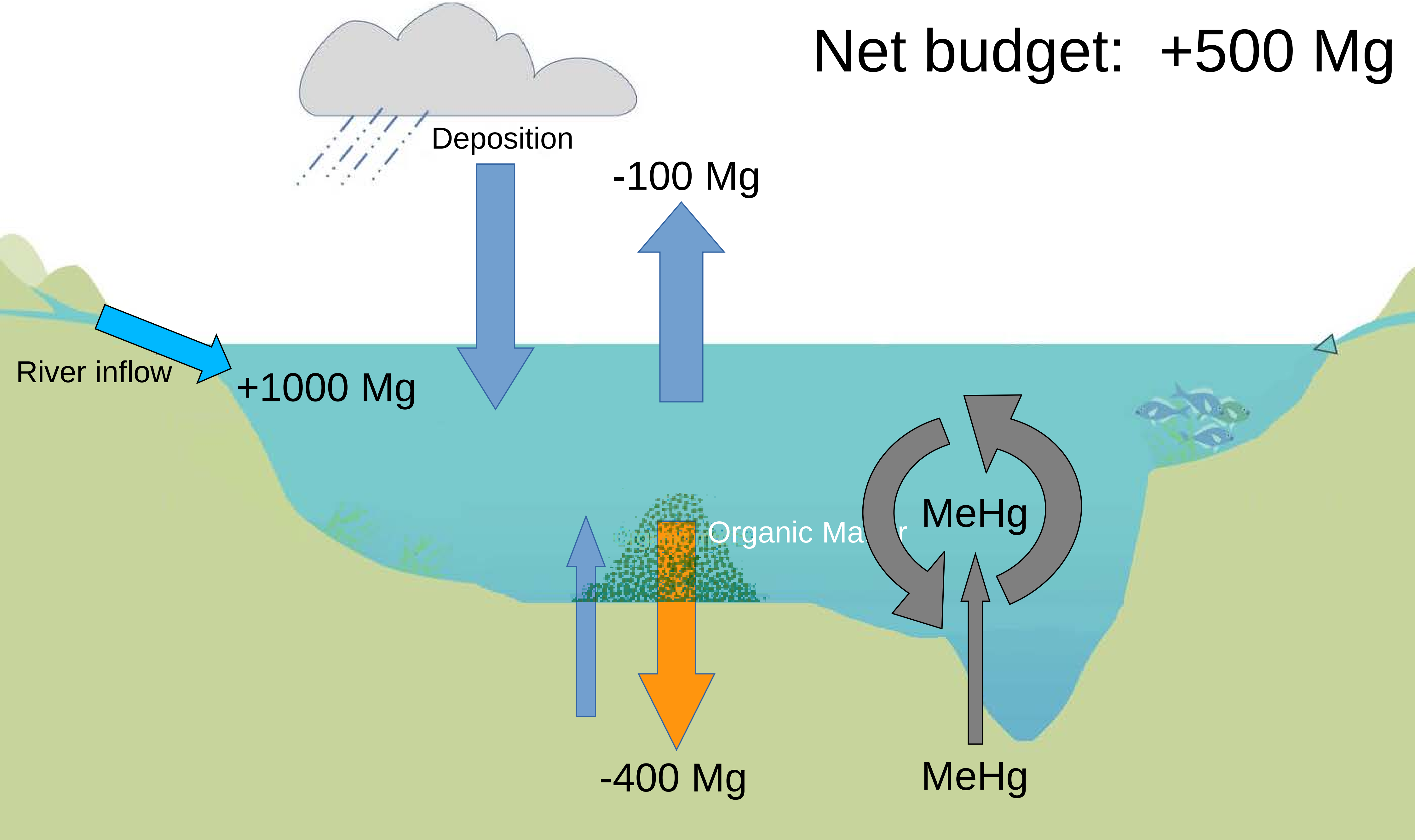
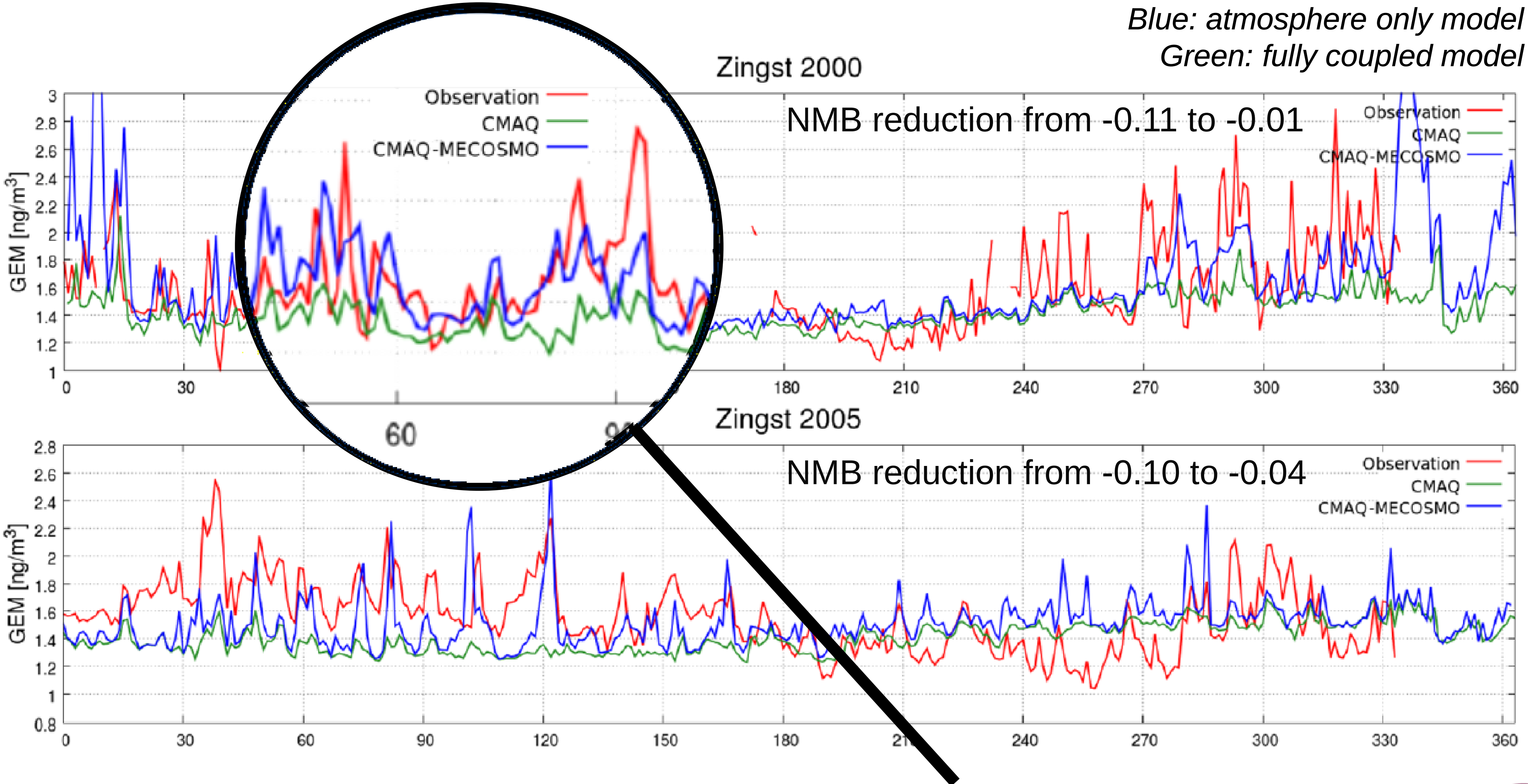


Sep – Oct – Nov


Net budget: +500 Mg
Deposition
-100 Mg
River inflow
+1000 Mg
Organic Ma r
MeHg
-400 Mg
MeHg

Ocean feedback into atmosphere

Blue: atmosphere only model
Green: fully coupled model



__Bieser, J.__ & Schrum, C. 2016. Impact of marine mercury cycling on coastal atmospheric mercury concentrations in the North- and Baltic Sea region. Elementa 111.
Sprovieri, F., Pirrone, N., __Ebinghaus, R.__, Weigelt, A., et al., 2016. Atmospheric mercury concentrations observed at ground-based monitoring sites globally distributed in the framework of the GMOS network. Atmos. Chem. Phys. 16, 11915-11935.

MeHg average seasonality (20yrs)

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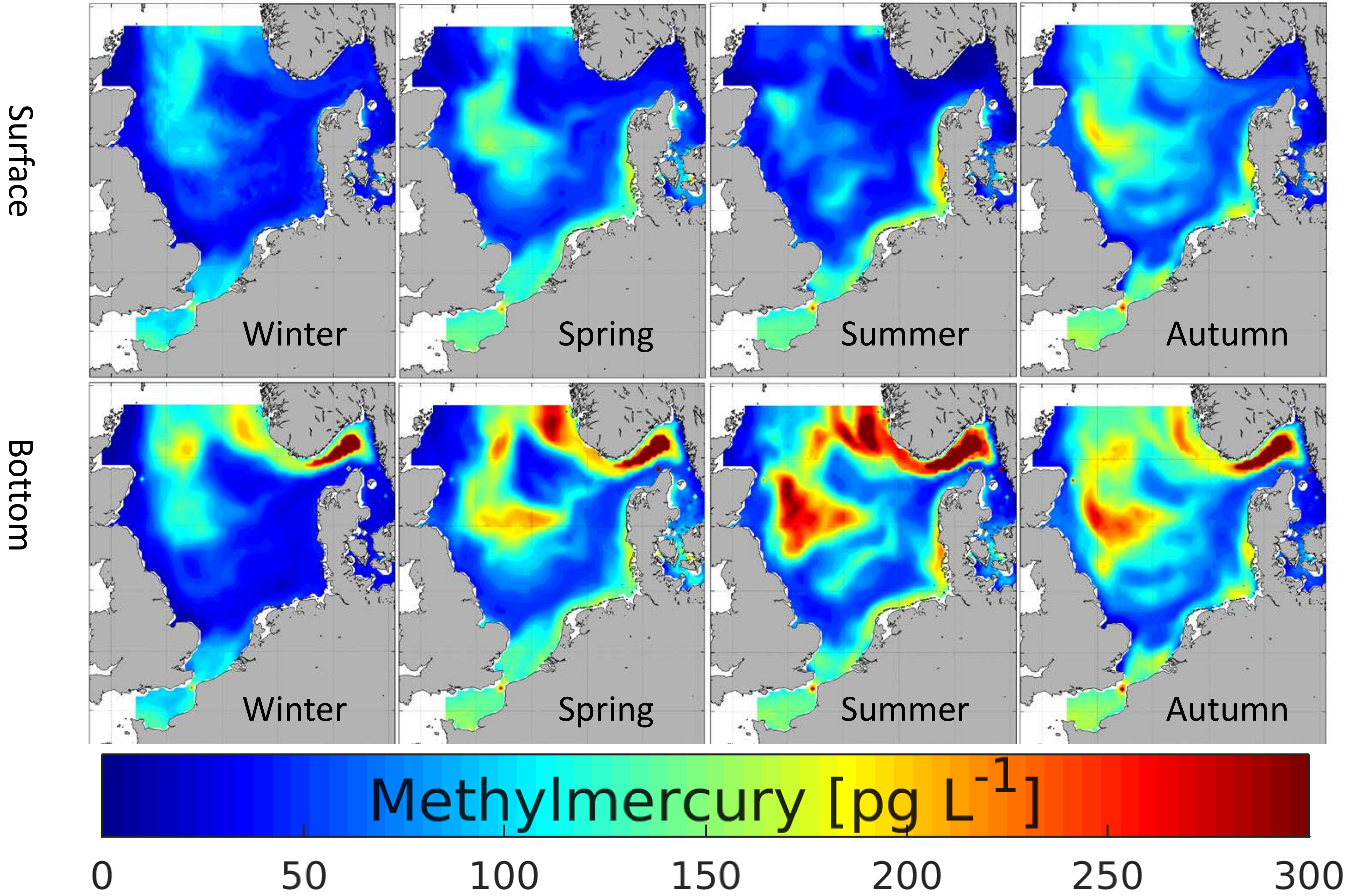


International cooperation
& Knowledge transfer

- UNEP and Minamata Convention

  UNEP Global Mercury Assessment Report 2018 including regionalized mercury models

- EU-FP7 Project GMOS

  Global Mercury Observation System

- EU-H2020 Project ERA-PLANET

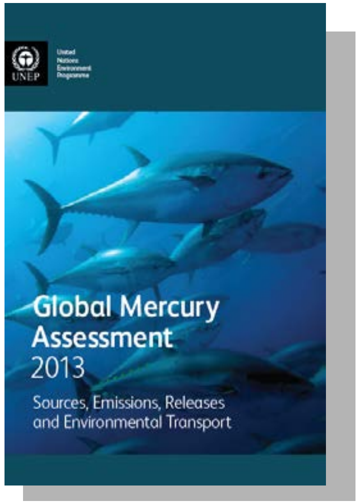
  The European network for observing our changing planet

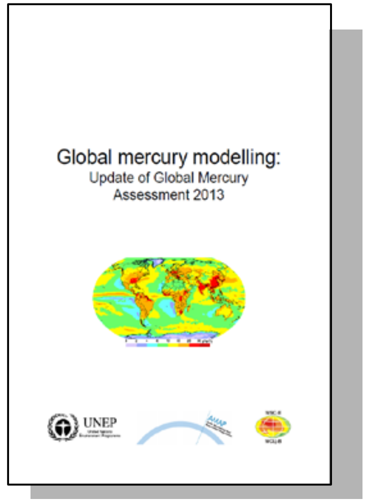
- MMTF – Mercury Modelling Task Force

  International Hg model inter-comparison

- Swedish Environmental Agency

  Modeling the impact of historical dumping sites in the Baltic Sea





***Bieser, J.**, De Simone, F., Gencarelli, C., Geyer, B., Hedgecock, I., Matthias, V., Travnikov, O. & Weigelt, A. 2014, "A diagnostic evaluation of modeled mercury wet depositions in Europe using atmospheric speciated high-resolution observations", Environ. Sci. & Pollut. Res. 21 (16), 9995-10012.*

***Bieser, J.**, Slemr, F., Ambrose, J., Brenninkmeijer, C., Brooks, S., Dastoor, A., …, Pirrone, N. 2017. Multi-model study of mercury dispersion in the atmosphere: Vertical and interhemispheric distribution of mercury species. Atmos. Chem. Phys. 17 (11), 6925-6955.*

*Jinskra, M., Sonke, J.E., Obrist, D., **Bieser, J.,** Dommergue, A., Olivier, M., Lund, C., Martin, L. Plant mercury pump controls seasonal and diurnal variations in global atmospheric mercury. Nature Geoscience, accepted for publication.*

***UNEP/AMAP**, Global Mercury Assessment 2018 – Draft Technical Background Document. available online: wedocs.unep.org/handle/20.500.11822/21553.*

Conclusions

- A novel multi media mercury model

  The MECOSMO modeling framework is the first and only fully coupled 3d hydrodynamic atmosphere – ocean – ecosystem model for mercury.

- Improved understanding of air-sea exchange dynamics

  Based on temporal and spatial high resolution modeling we are able to explicitly resolve the cross-compartmental mercury exchange.

- Feedback of ecosystem on organic and inorganic mercury cycle

  We find that ecosystem processes (i.e. primary production, remineralization, biological pump) are key for understanding the global mercury cycle.

- Closing the link between emissions and exposure

  Based on the presented modeling system we are now able to determine the sources for methylmercury exposure and predict the impact of emission changes. Thus, supporting the implementation of the UN Minamata Convention on Mercury.