HAVSMANUALEN 2 & 3

From scientific knowledge to solid actions (2018–)

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pro litore

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HANGÖ STAD

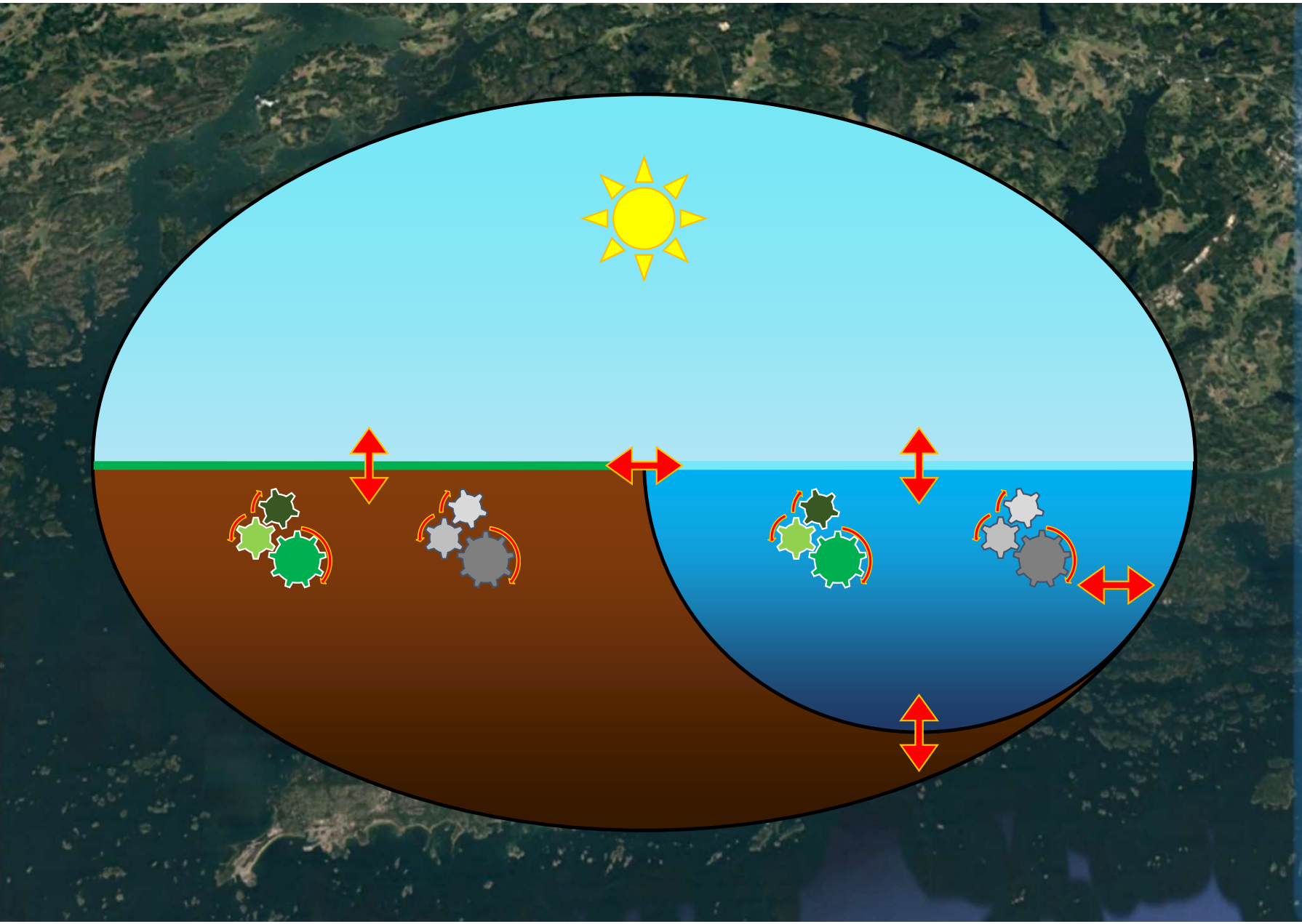
PROGRAMMET FÖR EFFEKTIVERAT VATTENSKYDD

OUTLINE

1) PERSPECTIVE (10')
- The coastal filter
- Indicators
- Spatiotemporal variation
- Ecological baselines

2) METHODOLOGY (5')
- Spatiotemporal scope
- Data collection
- Data interpretation

3) APPLICATIONS | cases (5')
- Sustainable management
- GHGs in coastal waters

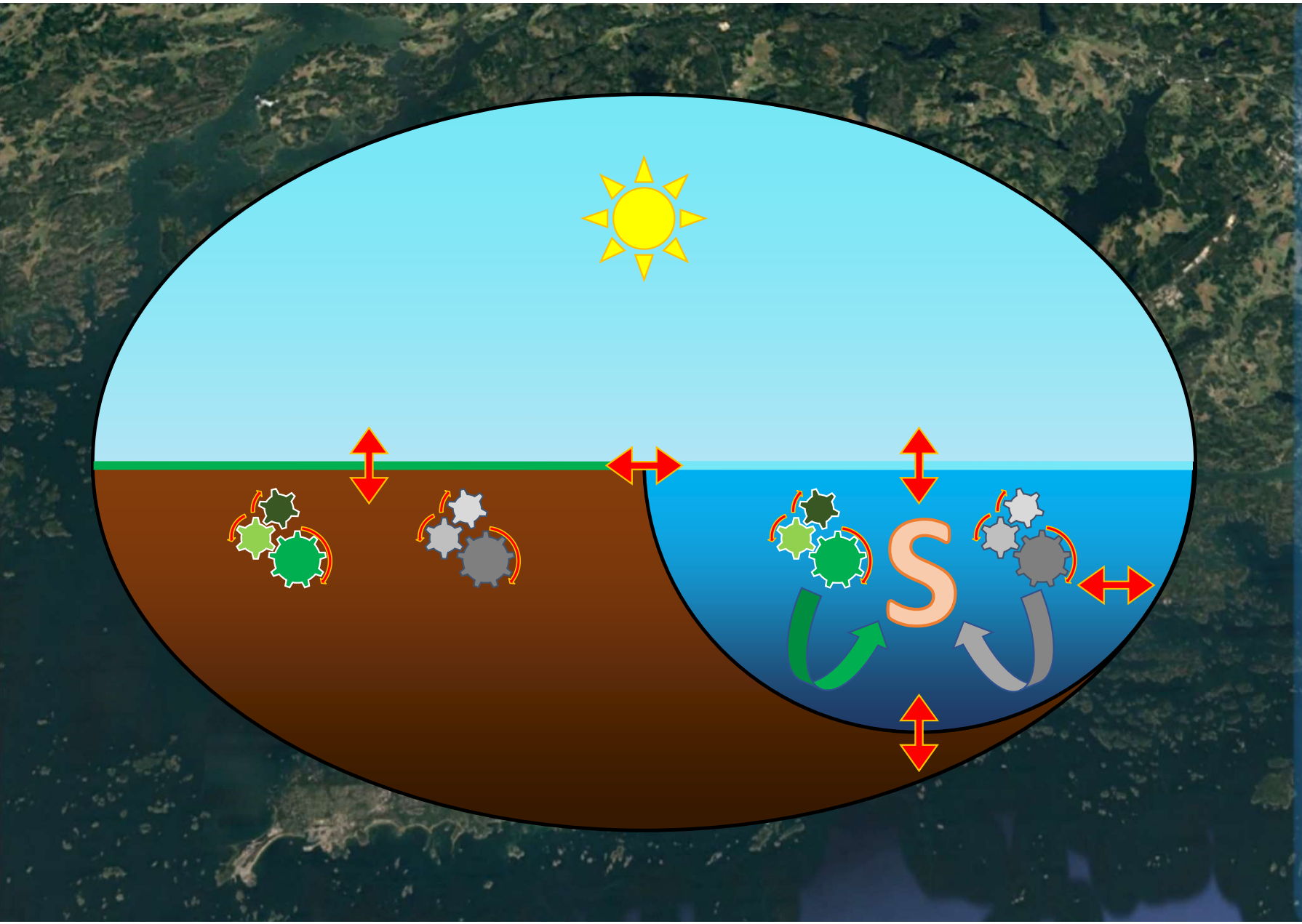


PERSPECTIVE

Carbon and nutrients
- dissolved
- particulate

Coastal waters (coastal filter)
- transportation
- transformation

→ important environments
→ influential environments
for the open sea and climate



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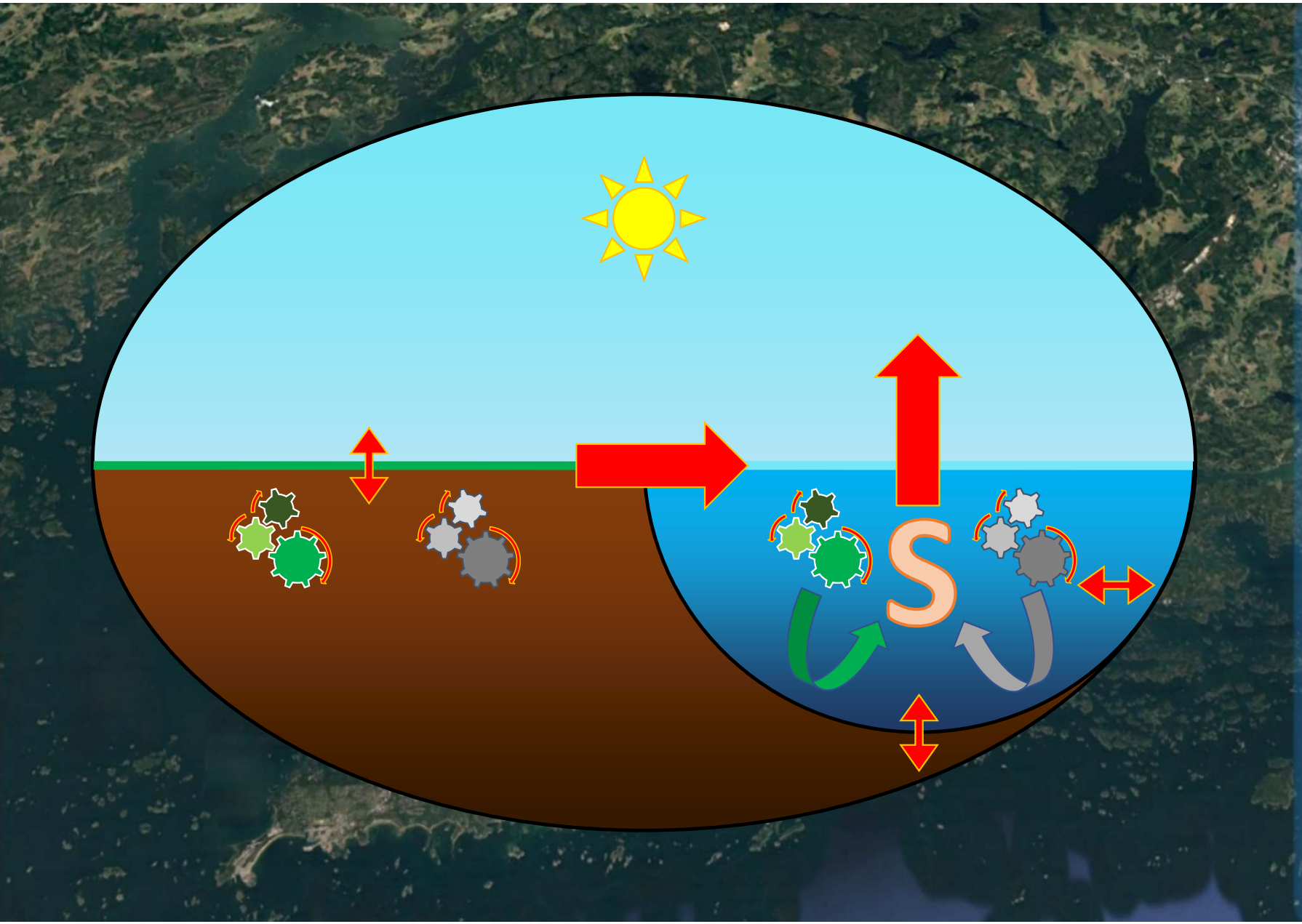
Loading status depends on
- fluxes [double arrows]
- biochemical conditions [green wheels]
- physical conditions [gray wheels]

Status indicators (e.g.)
- dissolved organic matter
- turbidity
- chlorophyll *a*



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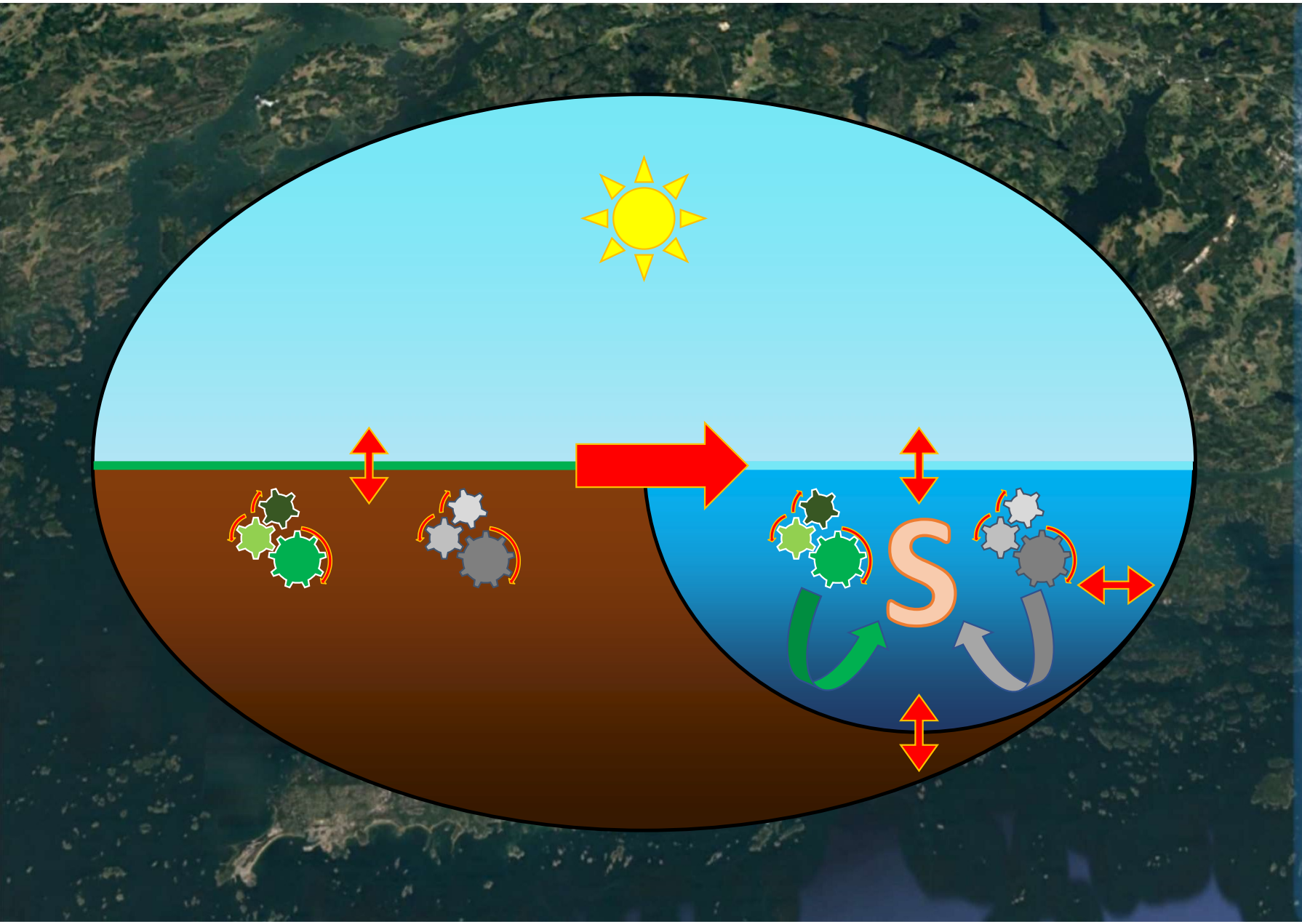

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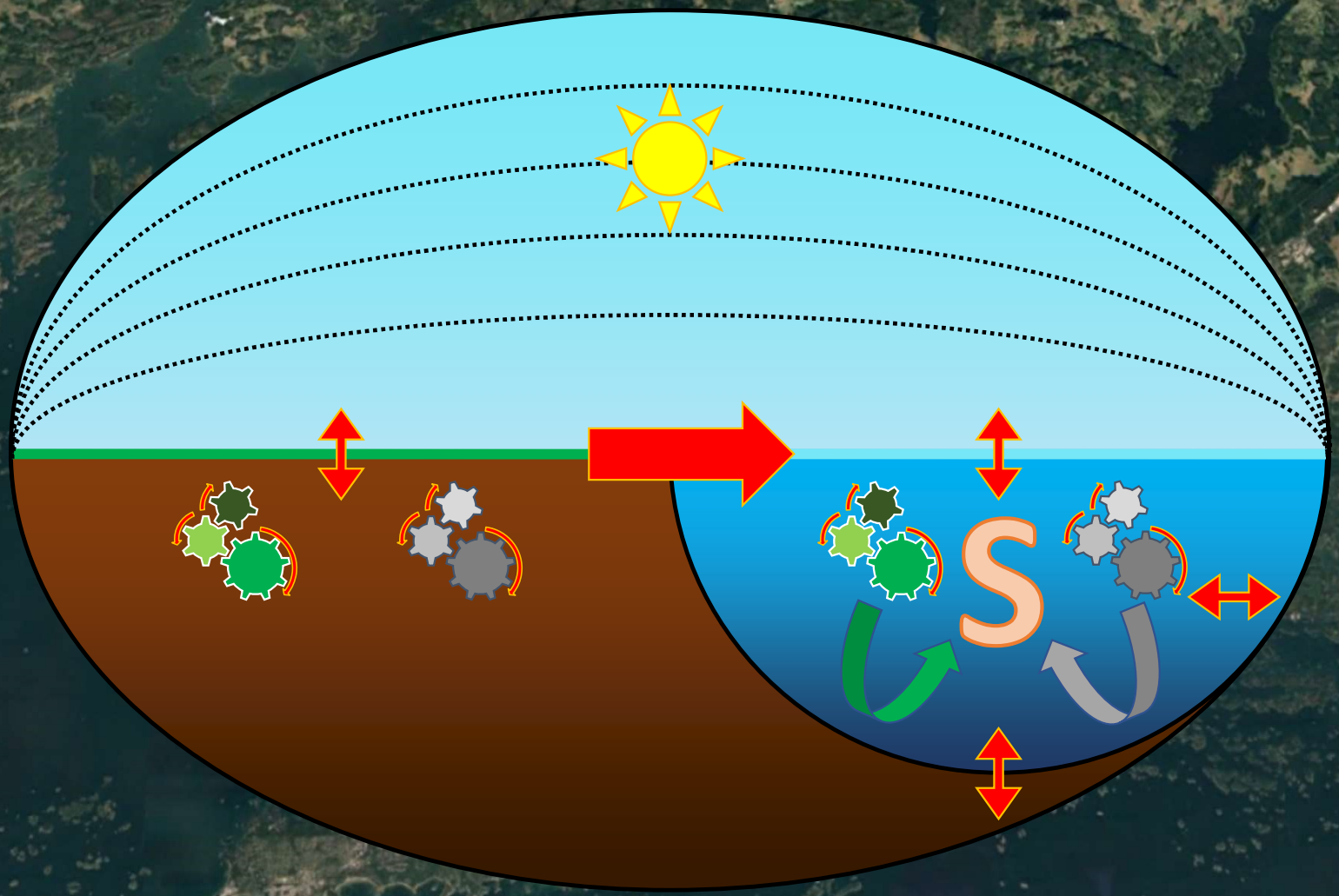

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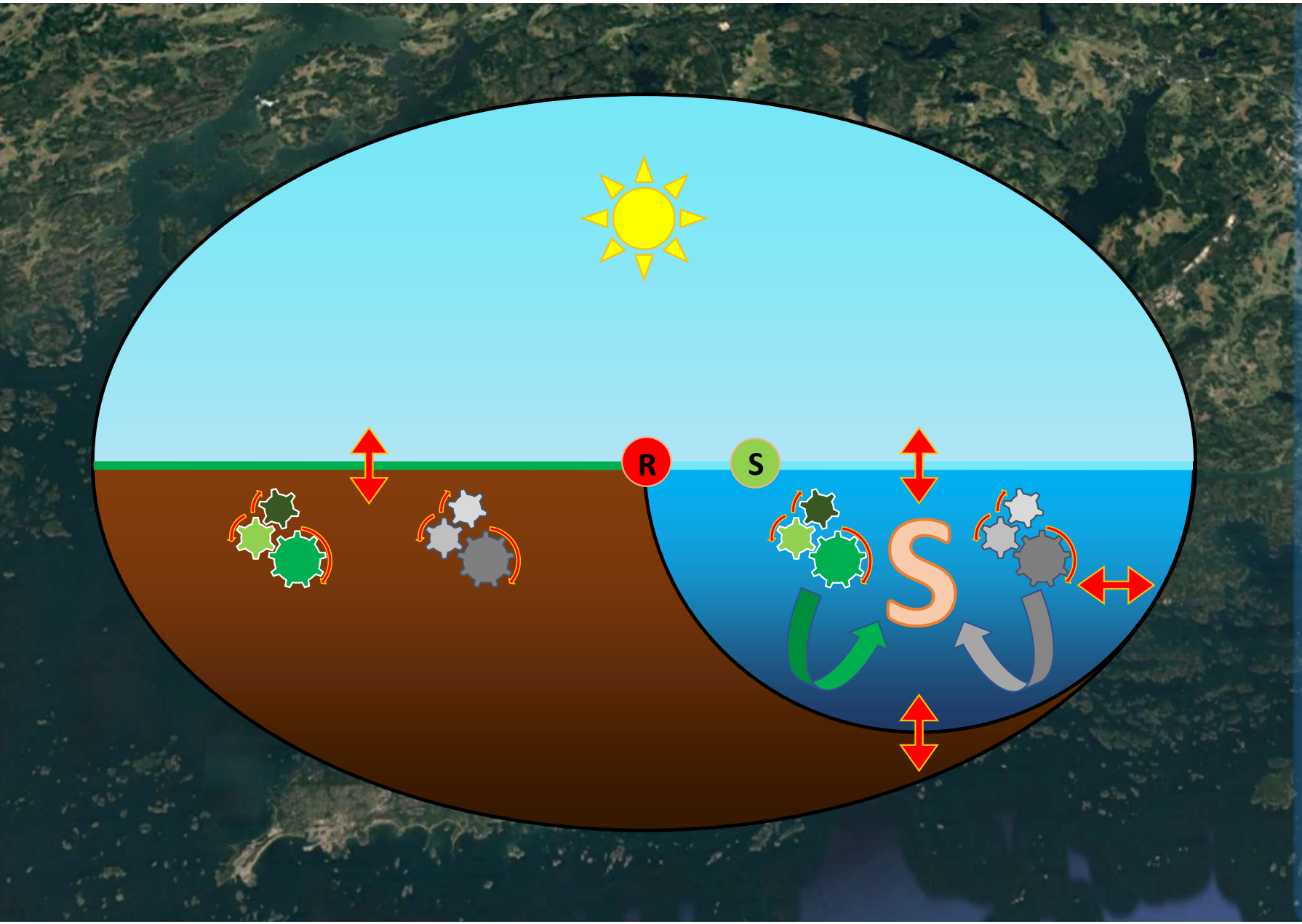

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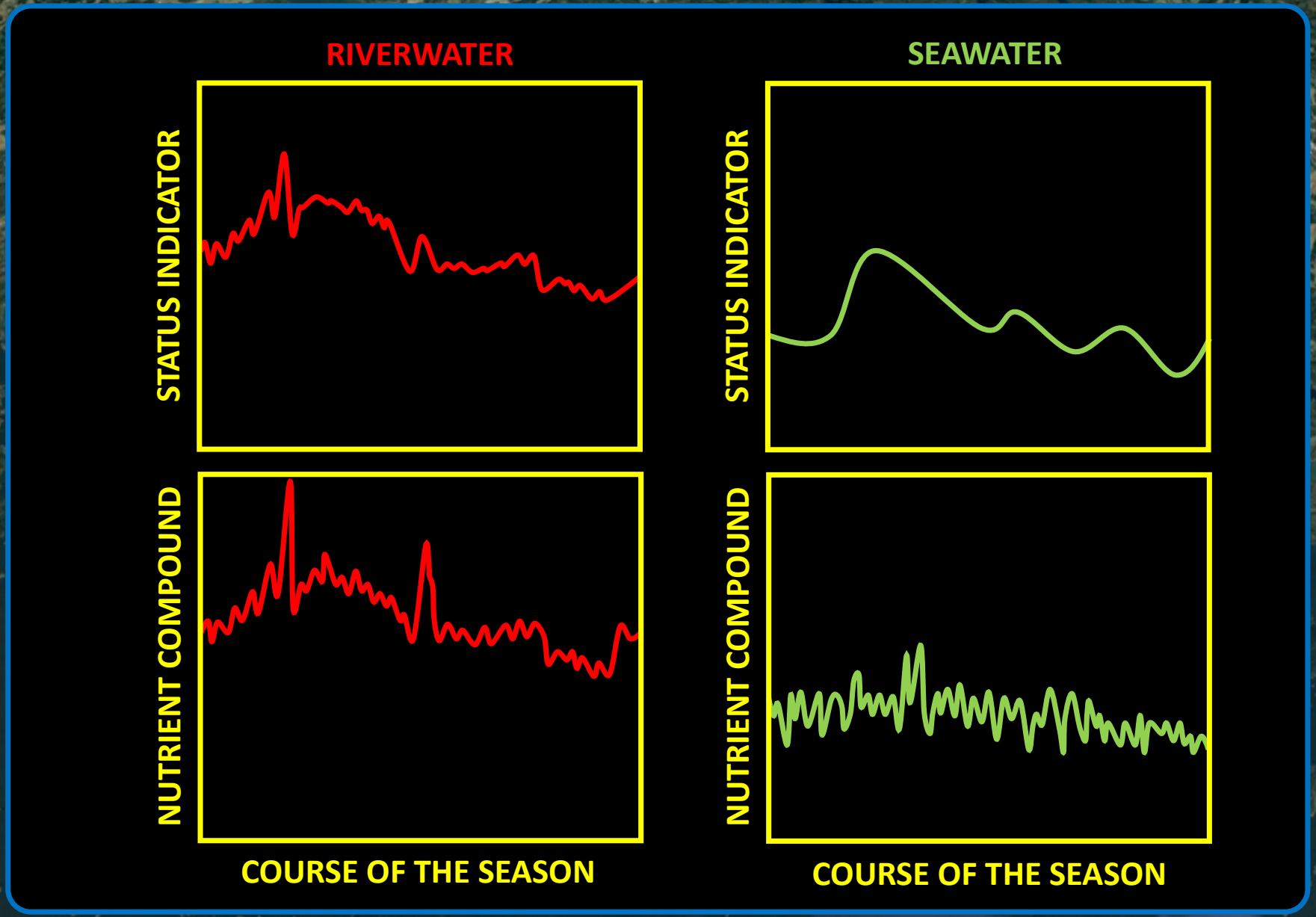


PERSPECTIVE

Carbon and nutrients
- dissolved
- particulate

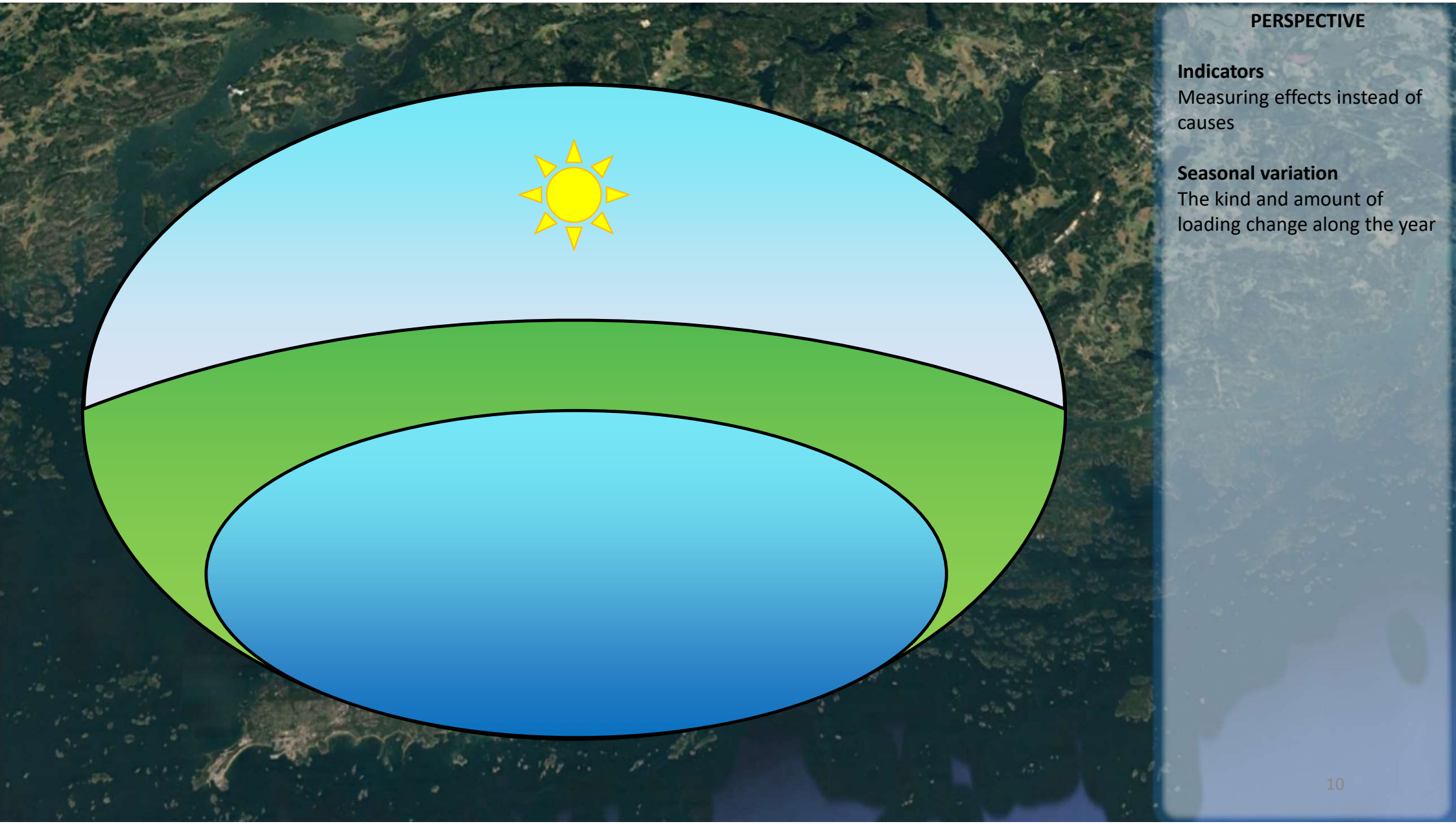
Coastal waters (coastal filter)
- **transportation**
- **transformation**

→ important environments
→ influential environments
for the open sea and climate

Loading status depends on
- fluxes
- biochemical conditions
- physical conditions

Status indicators (e.g.)
- dissolved organic matter
- turbidity
- chlorophyll *a*

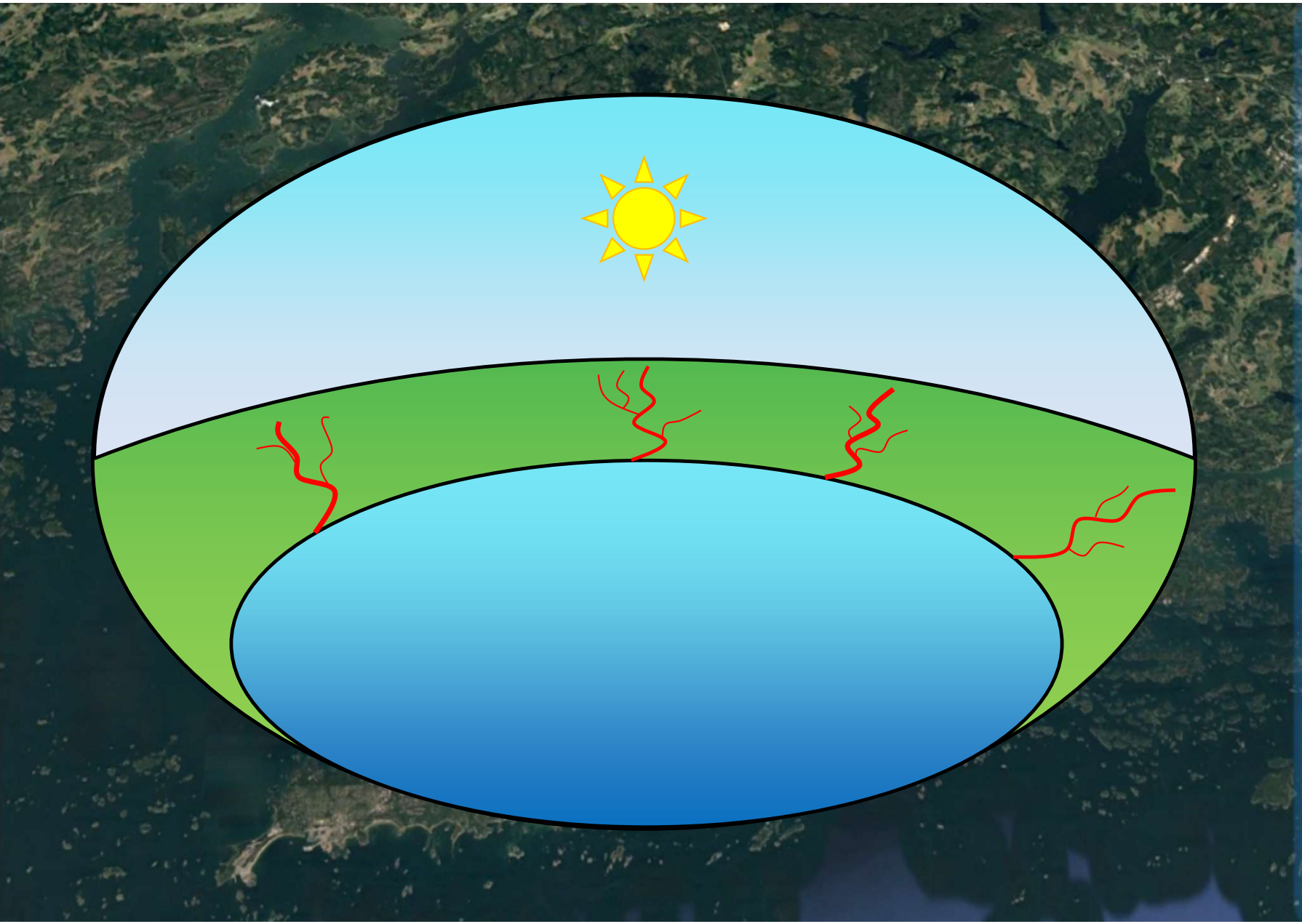
Seasonal variation
- measuring effects
- not the causes



PERSPECTIVE

Indicators
Measuring effects instead of causes

Seasonal variation
The kind and amount of loading change along the year



PERSPECTIVE

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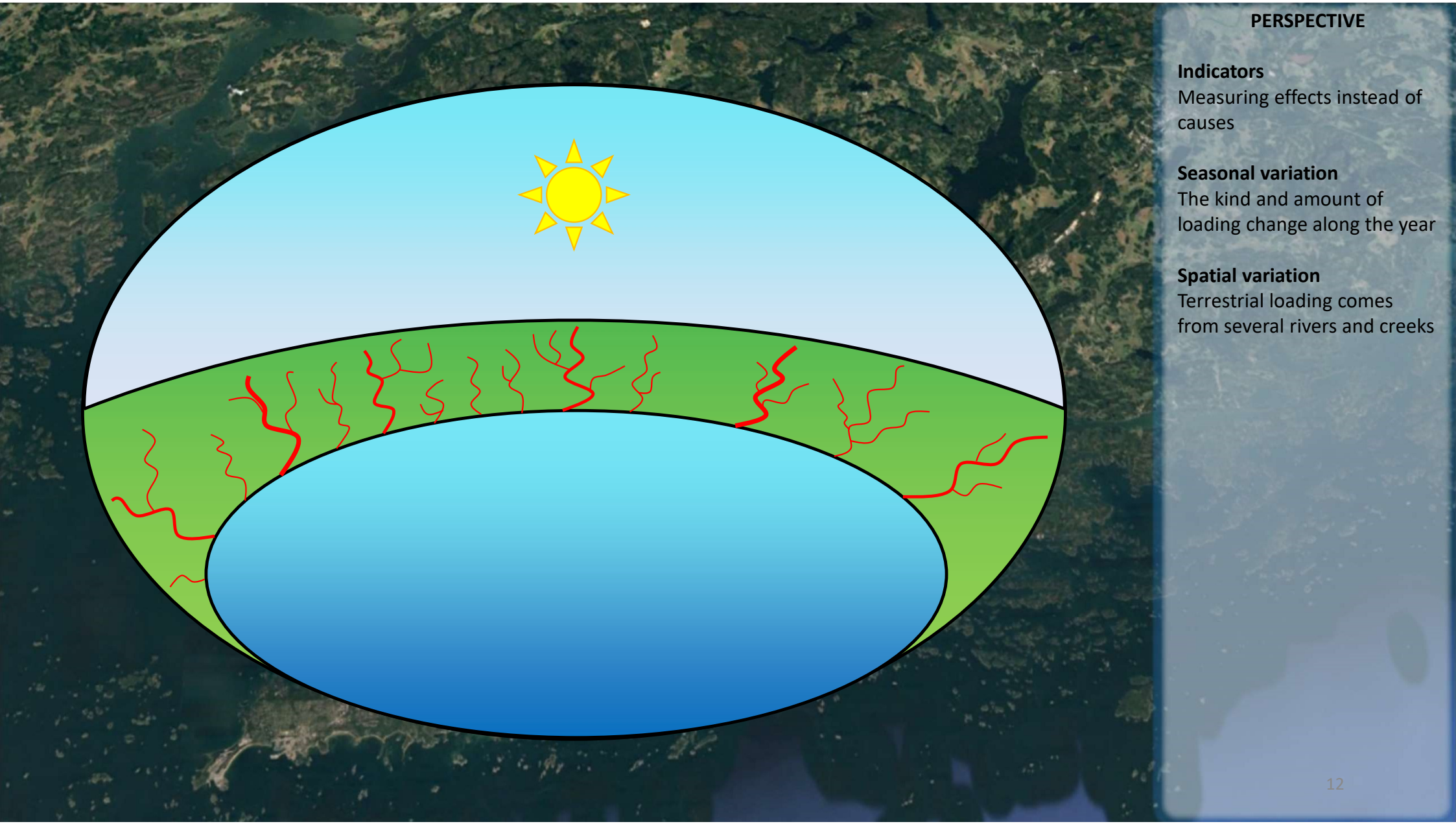
Seasonal variation
The kind and amount of loading change along the year

Spatial variation
Terrestrial loading comes from several rivers

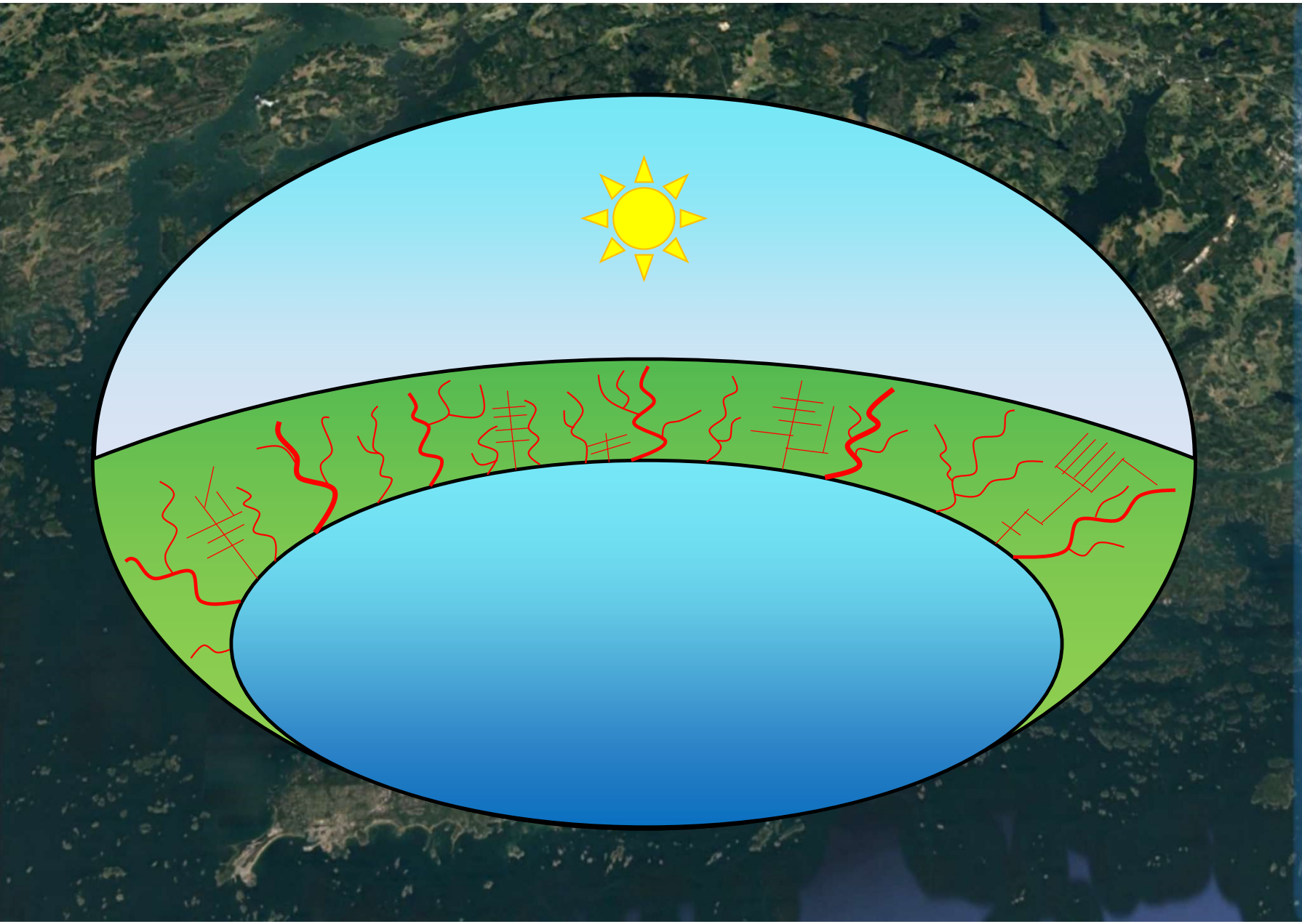


PERSPECTIVE

Indicators
Measuring effects instead of causes

Seasonal variation
The kind and amount of loading change along the year

Spatial variation
Terrestrial loading comes from several rivers and creeks

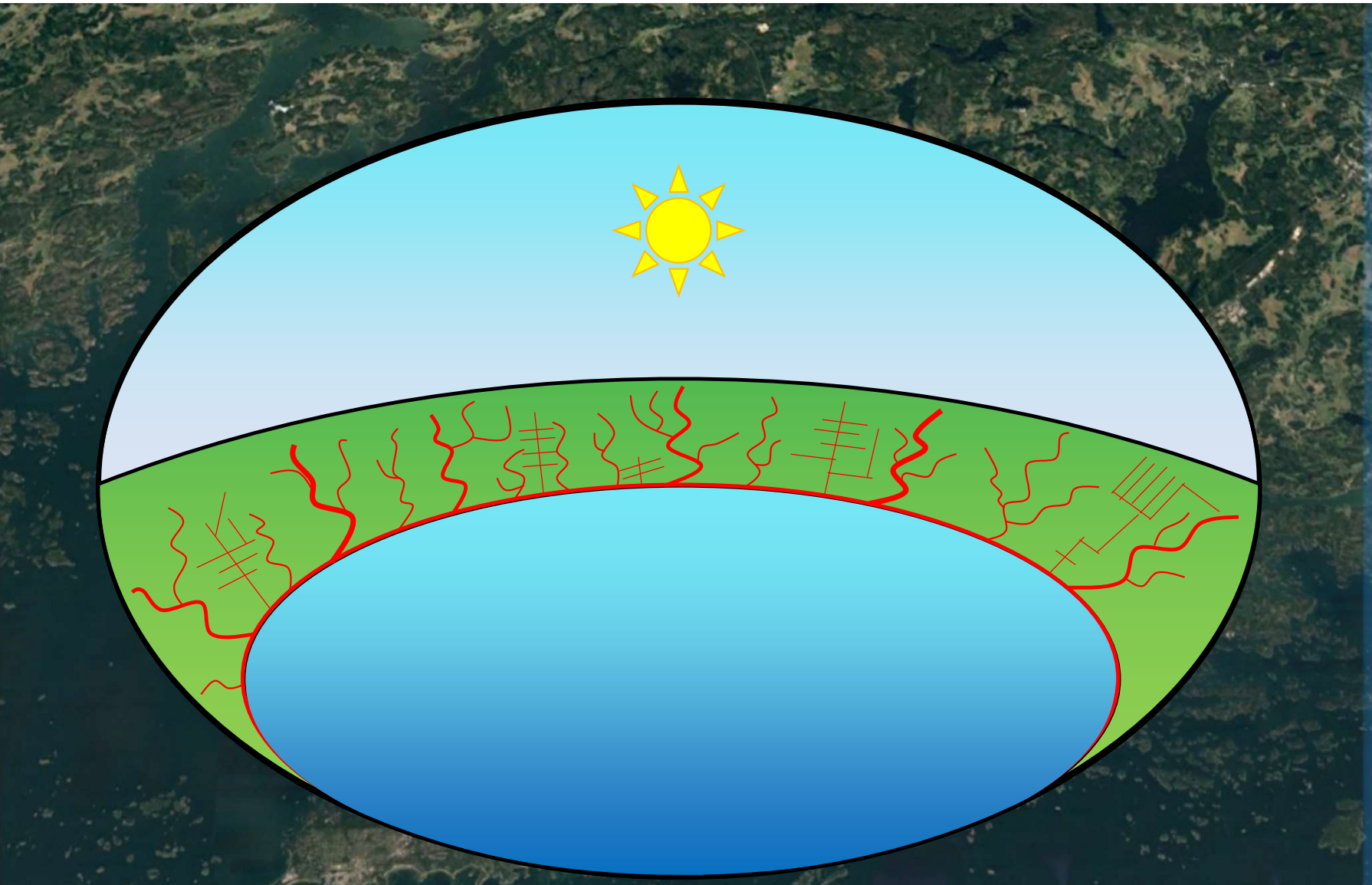


PERSPECTIVE

Indicators
Measuring effects instead of causes

Seasonal variation
The kind and amount of loading change along the year

Spatial variation
Terrestrial loading comes from several rivers, creeks and ditches



PERSPECTIVE

Indicators
Measuring effects instead of causes

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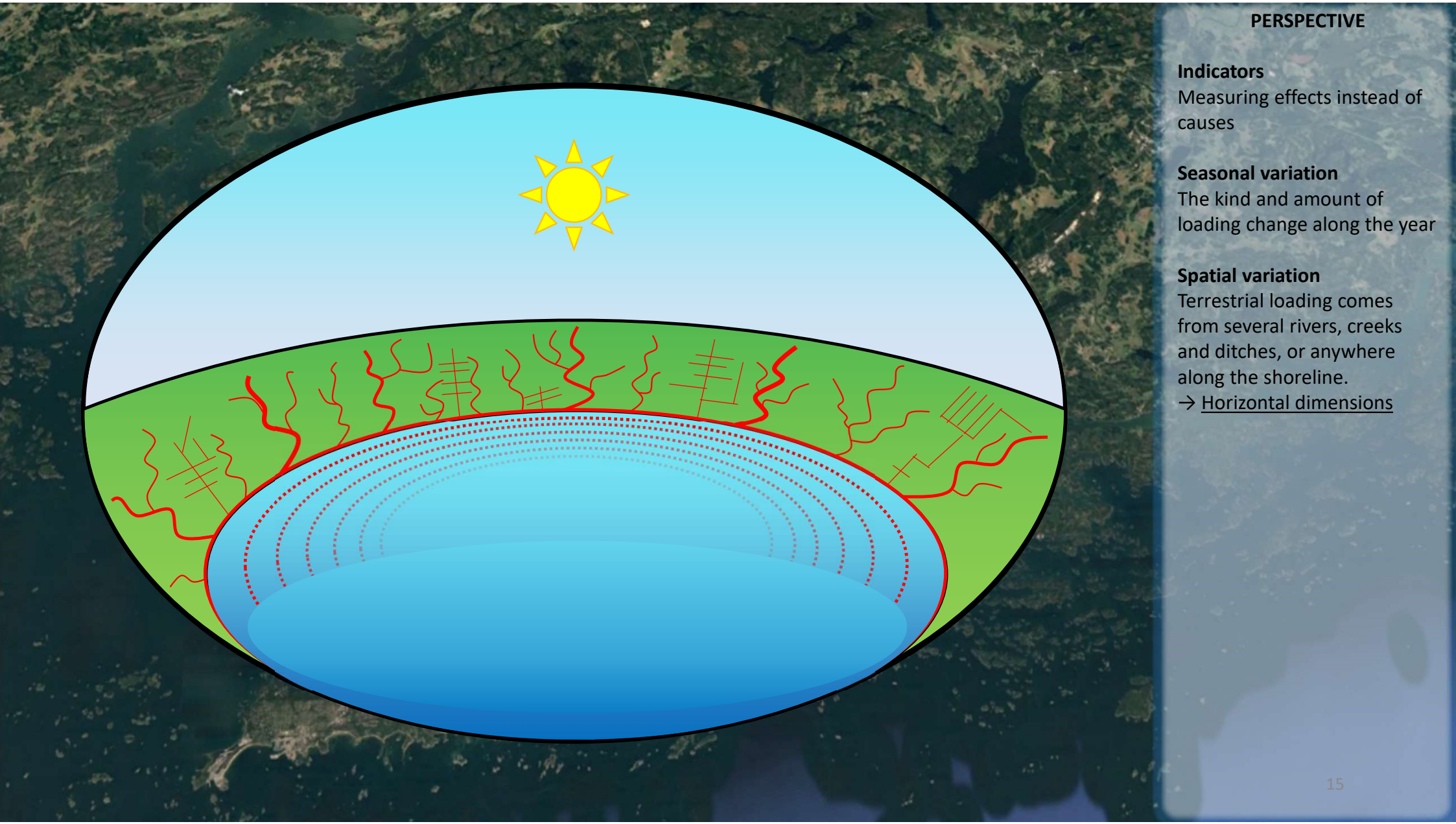
The kind and amount of loading change along the year

Spatial variation
Terrestrial loading comes from several rivers, creeks and ditches, or anywhere along the shoreline.



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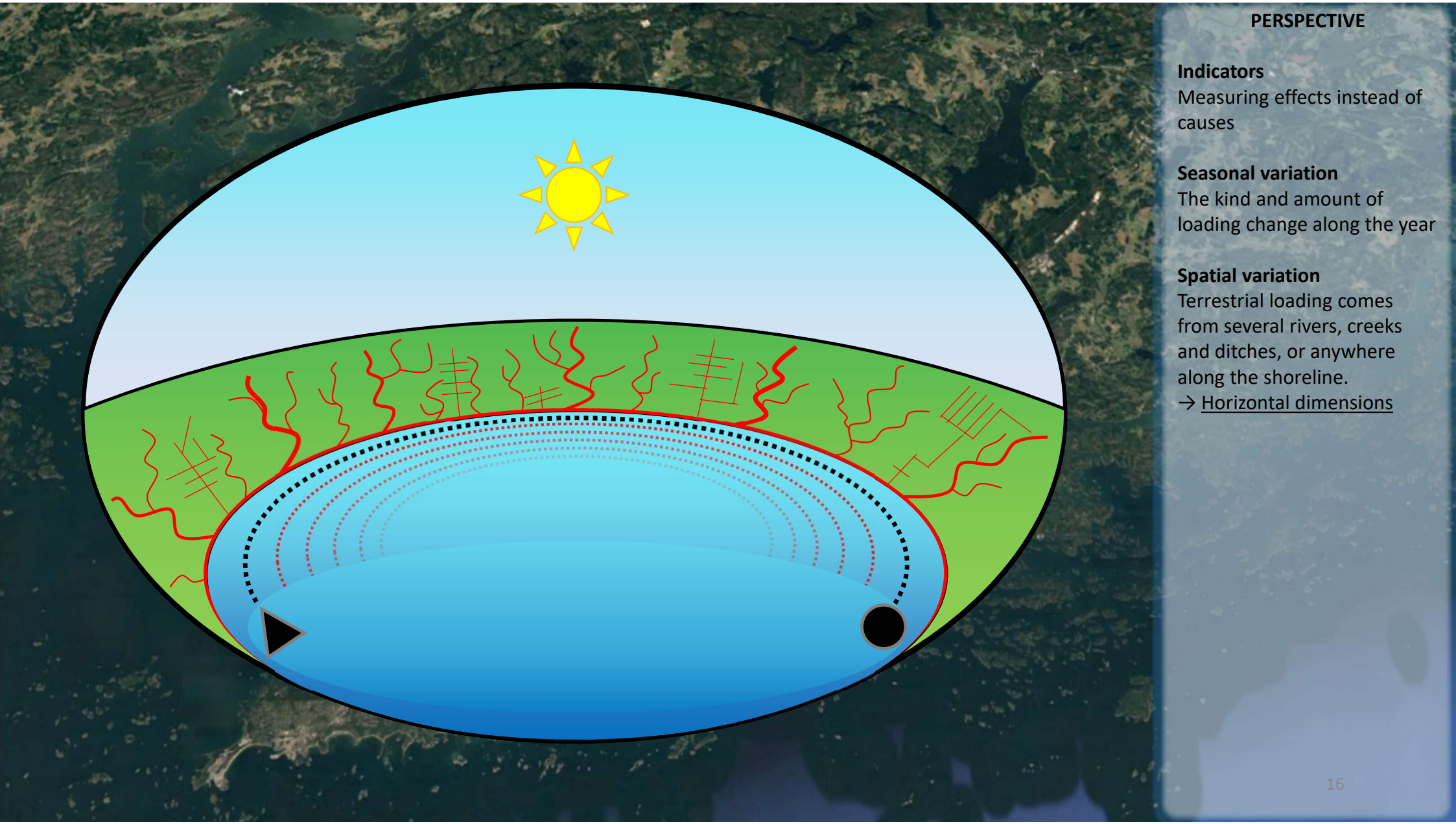
→ Horizontal dimensions



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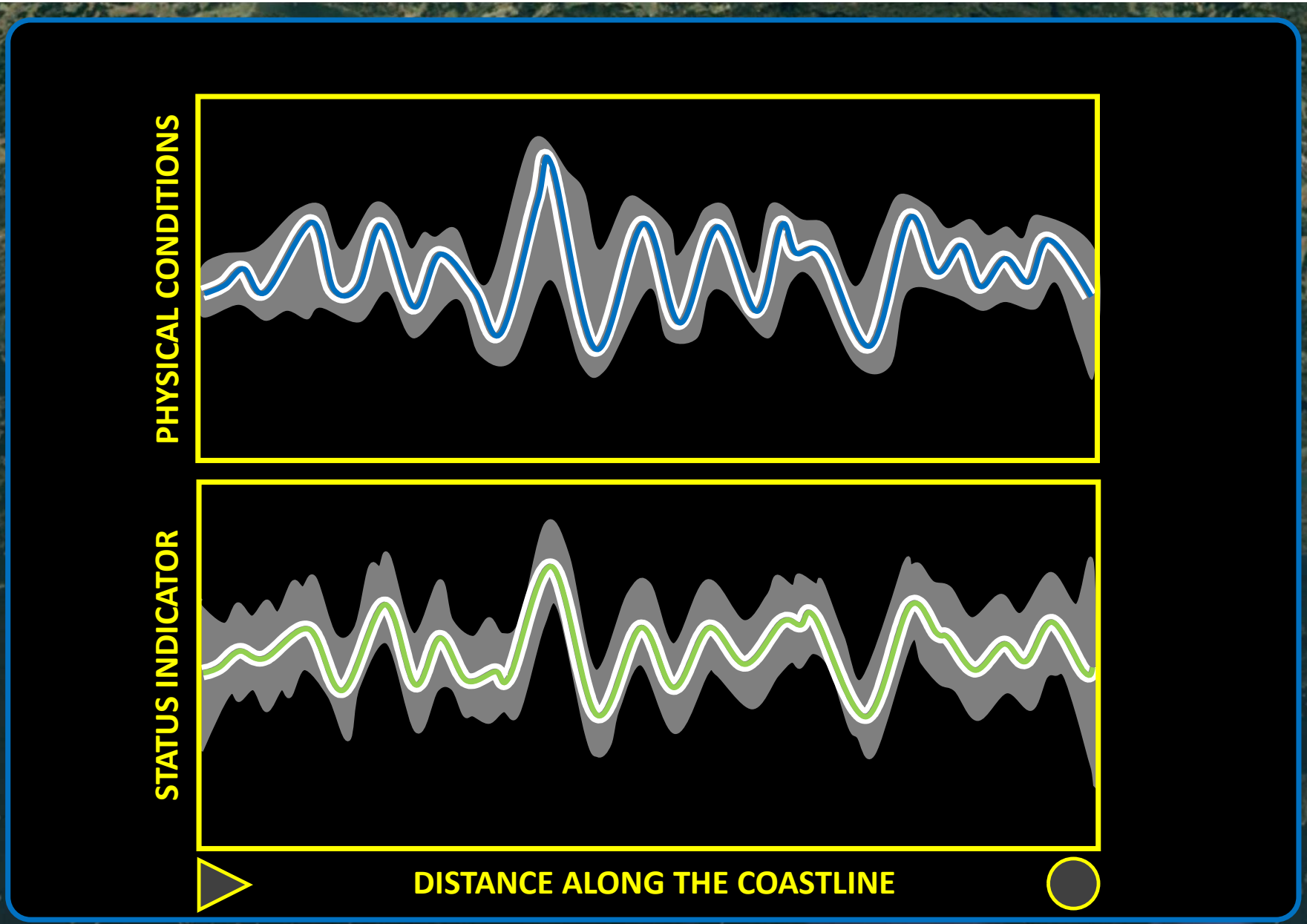

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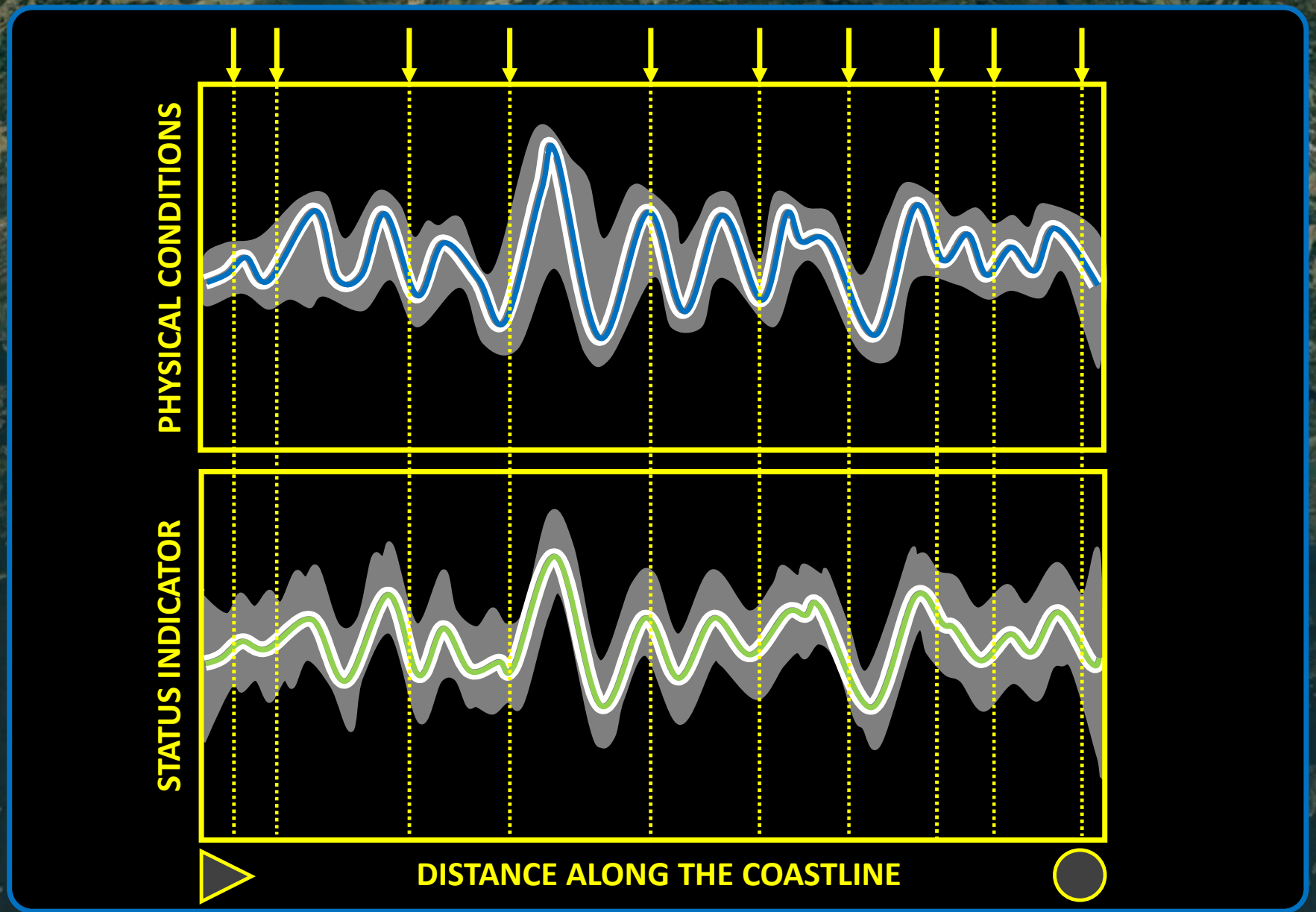

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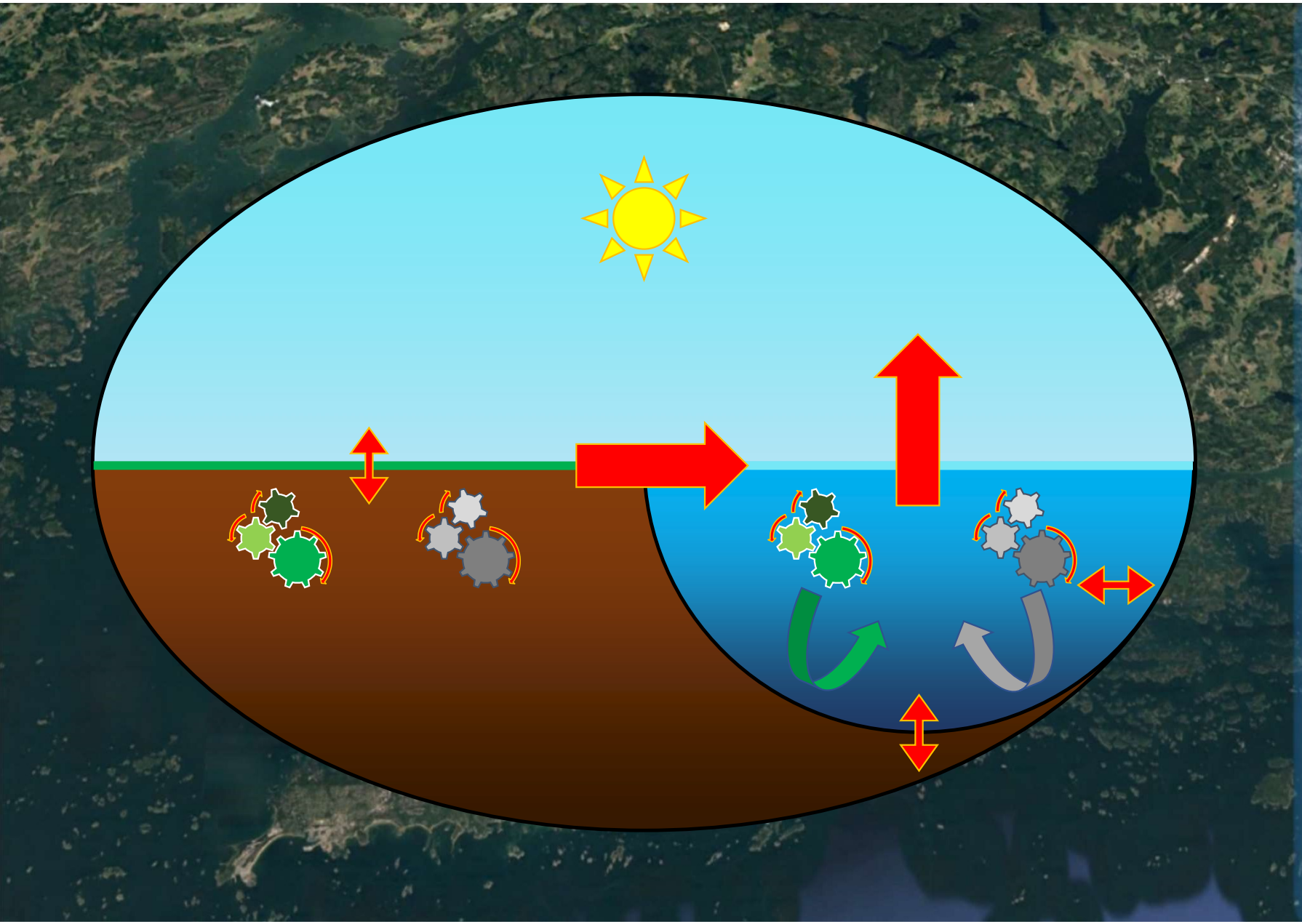
Predicting status
Specific reference values
→ Anomalies
→ Spatial loading gradients



PERSPECTIVE

Indicators
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Seasonal variation
The kind and amount of loading change along the year

Spatial variation
Terrestrial loading comes from several rivers, creeks and ditches, or anywhere along the shoreline.
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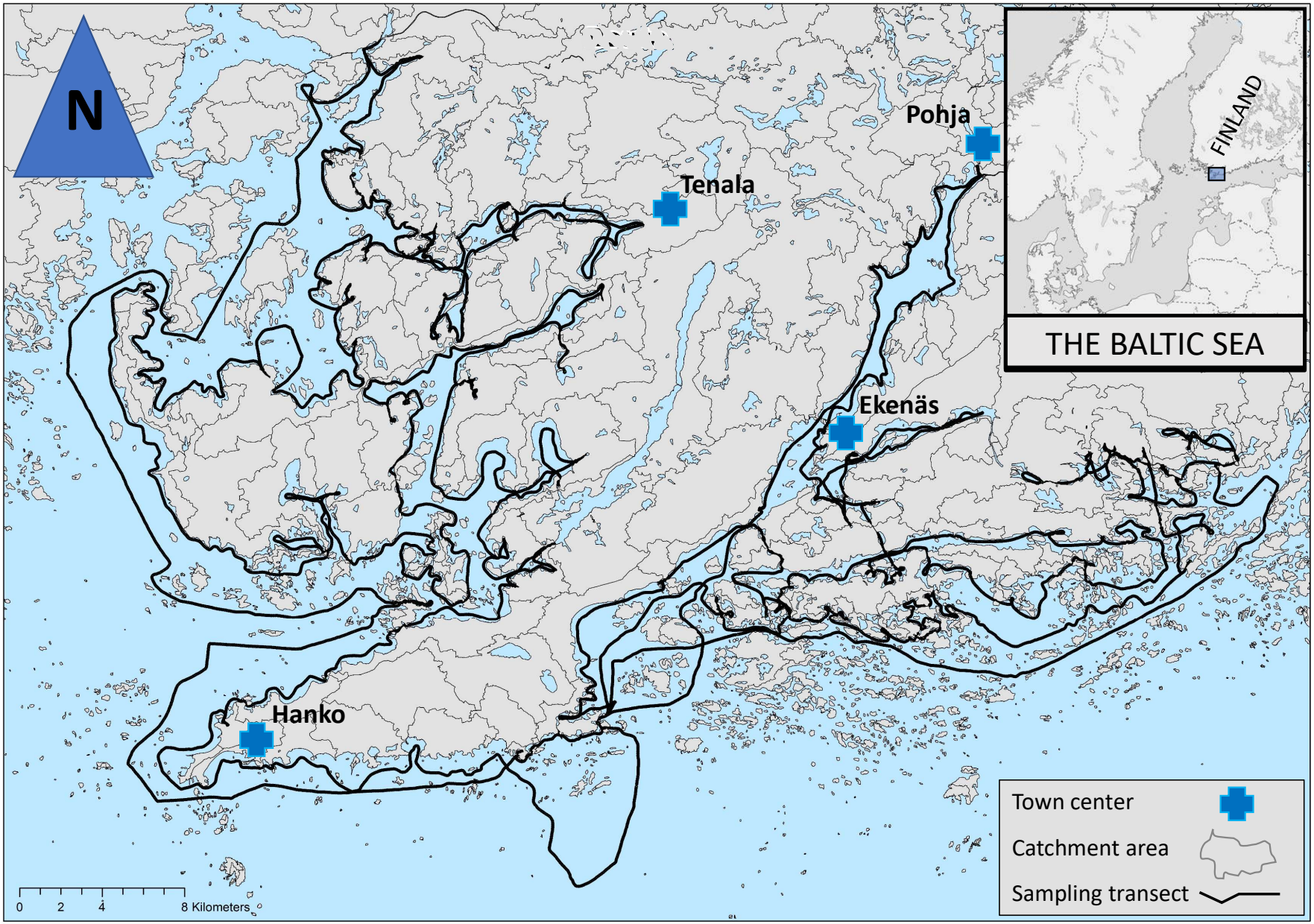
Predicting status
Specific reference values
→ Anomalies
→ Spatial loading gradients
→ Hotspots of GHGs



METHODOLOGY

Physical conditions
- Horizontal and vertical mixing of water masses
- Climate, weather, season

C, N, P and particle loading are manifested as
- chlorophyll *a*
- dissolved organic matter
- turbidity
- greenhouse gases

depending on
- each other
- the physical environment
- the relative loading level

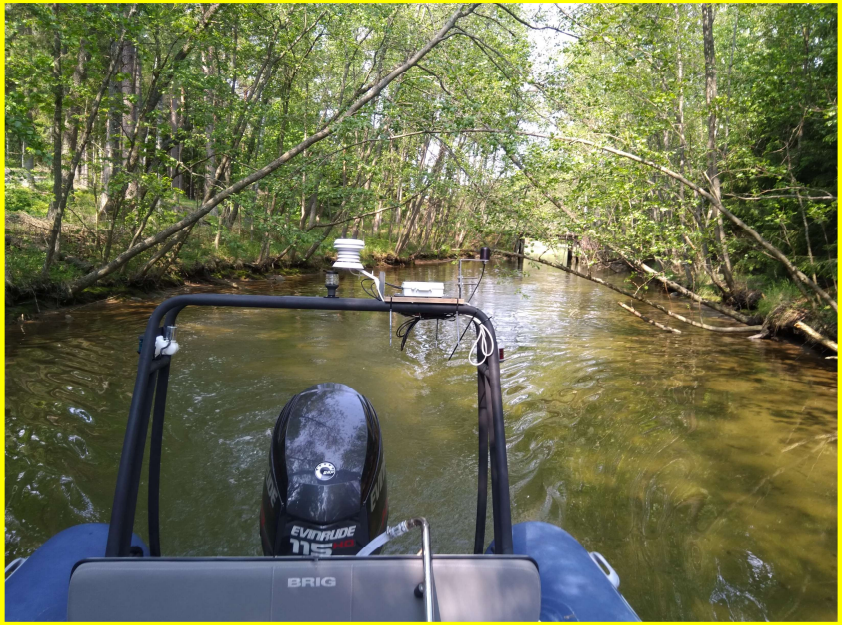
Measuring variation
- Defining reference values
- Analysis of anomalies
- <u>Environmental status decreases towards the source of loading</u>

<u>Mappings</u>
- 500 NM transect
- 17 rounds 2018-2020
- 20,000 obs. per round
- Ancillary data

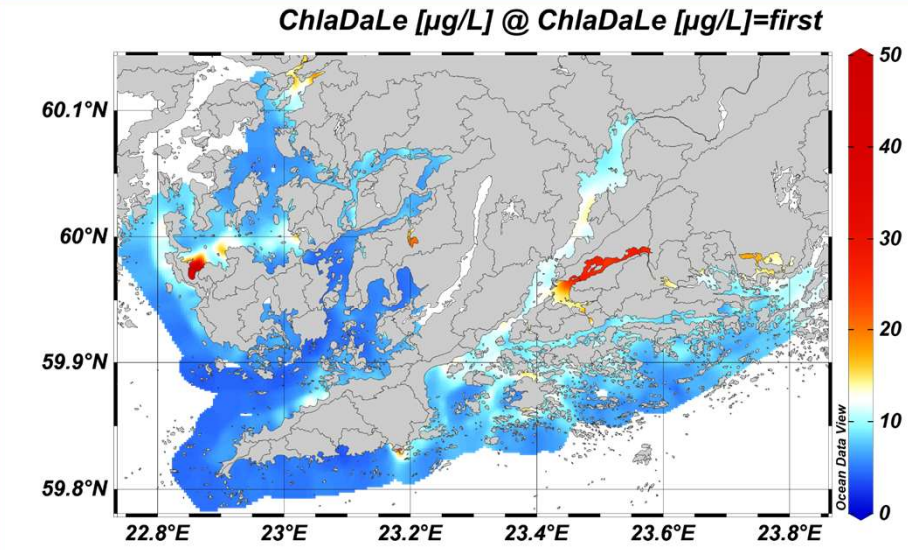
Method	Type	Variable	Unit	2018(A)	2019(A)	2019(B)	2019(C)	2019(D)	2019(E)	2019(E)	2019(F)	2019(G)	2019(H)	2019(I)	2019(J)	2020(A)	2020(B)	2020(C)	2020(D)	2020(E)
CONTINUOUSLY LOGGED	TAG	Date	YYMMDD	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Time	hhmmss	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Latitude	WGS84	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Longitude	WGS84	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	AIR	Air pressure	mbar	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		PAR	µmol m^{-2} s^{-1}				X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Air temperature	°C				X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Air humidity	%				X	X	X	X	X	X	X	X	X	X	X	X	X	X
	WATER	Water temperature	°C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Conductivity	µS cm^{-1}	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Turbidity	NTU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Chlorophyll *a*	µg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Phycocyanin	µg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		fDOM	QSU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		O_2	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		pH		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		pCO_2	µatm						X	X	X	X	X	X	X	X	X	X	X	X
		CH_4	nmol L^{-1}												X	X	X	X	X	X
	CALCULATED (E.G.)	Oxygen saturation	%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Total dissolved solids	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Salinity		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		CDOM	QSU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Total alkalinity	meq L^{-1}						X	X	X	X	X	X	X	X	X	X	X	X
		HCO_3	µmol kg^{-1}						X	X	X	X	X	X	X	X	X	X	X	X
		CO_3	µmol kg^{-1}						X	X	X	X	X	X	X	X	X	X	X	X
		OH	µmol kg^{-1}						X	X	X	X	X	X	X	X	X	X	X	X
		Revelle							X	X	X	X	X	X	X	X	X	X	X	X
		ΩCa							X	X	X	X	X	X	X	X	X	X	X	X
		ΩAr							X	X	X	X	X	X	X	X	X	X	X	X
		PAR attenuation CFC	m^{-1}				X	X	X	X	X	X	X	X	X	X	X	X	X	X
DISCRETE WATER SAMPLES	EMPIRICALLY MODELLED (E.G.)	Dissolved inorganic nitrogen	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Total dissolved nitrogen	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Total nitrogen	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Dissolved inorganic phosphorus	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Total dissolved phosphorus	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Total phosphorus	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Dissolved inorganic carbon	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Dissolved organic carbon	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					
		Total organic carbon	mg L^{-1}	X	X	X	X	X	X	X	X	X	X	X	X					

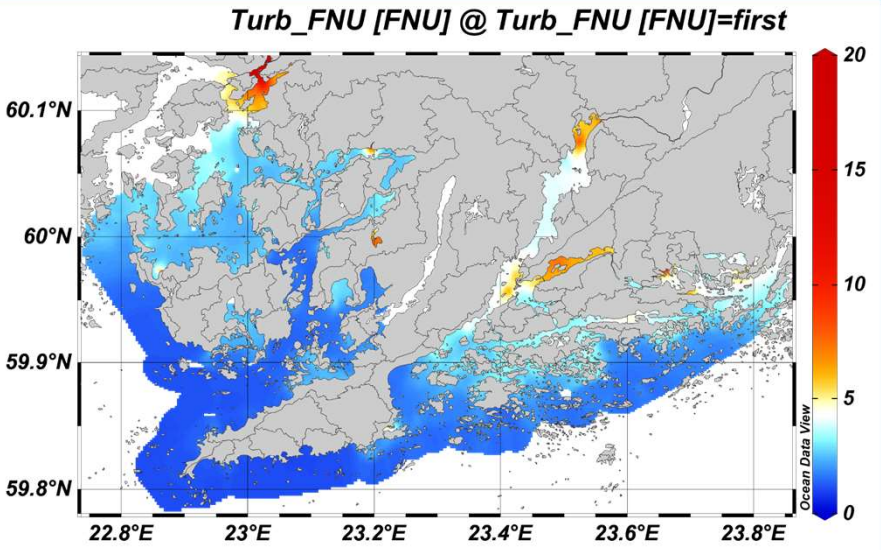

BRIG
EVINRUDE
115


TEMPERATUR
SALTHALT
SYRE
PH
GRUMLIGHET
KLOROFYLL - a
LOST ORGANISKT MATERIAL
Raymarine


EVINRUDE
115
BRIG


EVINRUDE


ChlaDaLe [µg/L] @ ChlaDaLe [µg/L]=first
60.1°N
60°N
59.9°N
59.8°N
22.8°E
23°E
23.2°E
23.4°E
23.6°E
23.8°E
50
40
30
20
10
0
Ocean Data View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59.9°N
59.8°N
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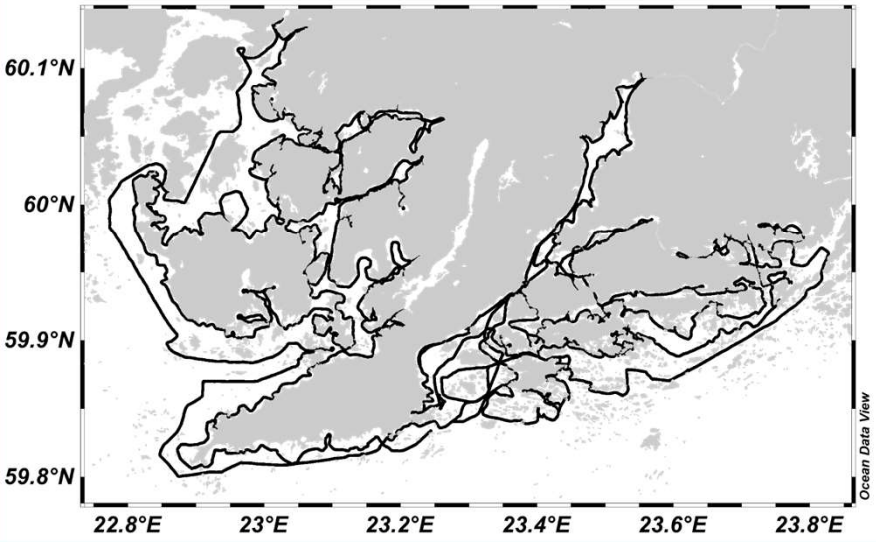
23°E
23.2°E
23.4°E
23.6°E
23.8°E
20
15
10
5
0
Ocean Data View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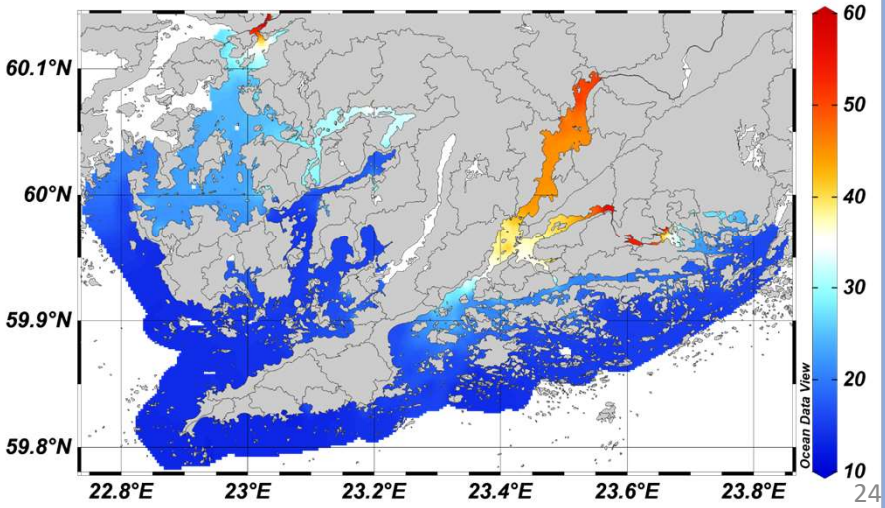
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60
50
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30
20
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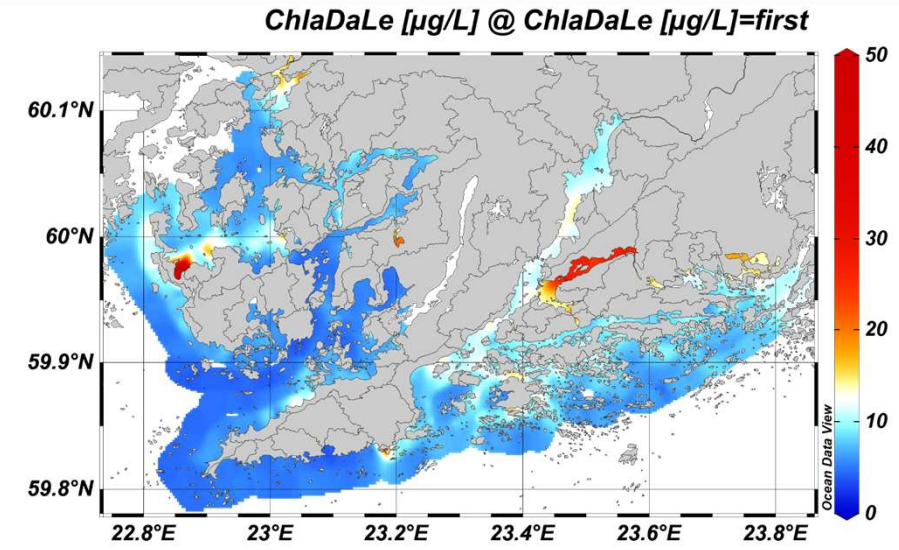
Ocean Data View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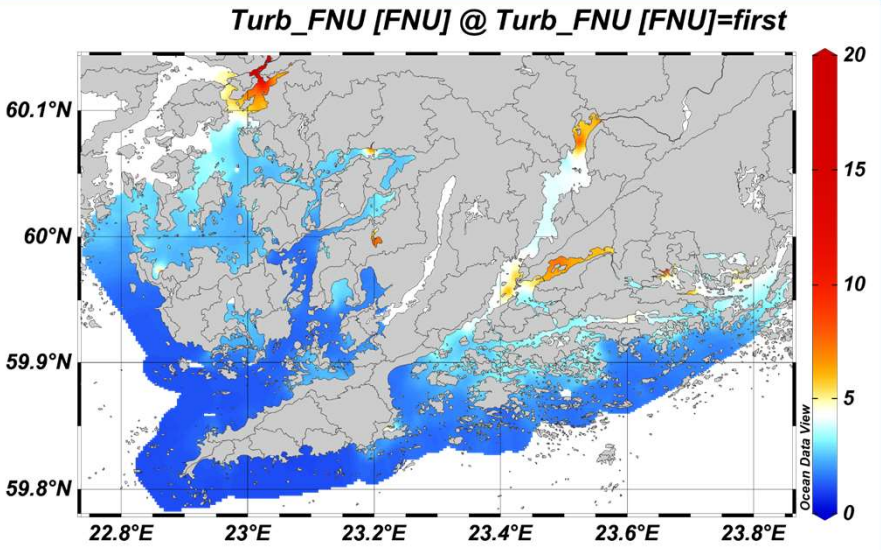
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59.9°N
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23°E
23.2°E
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23.8°E
20
15
10
5
0
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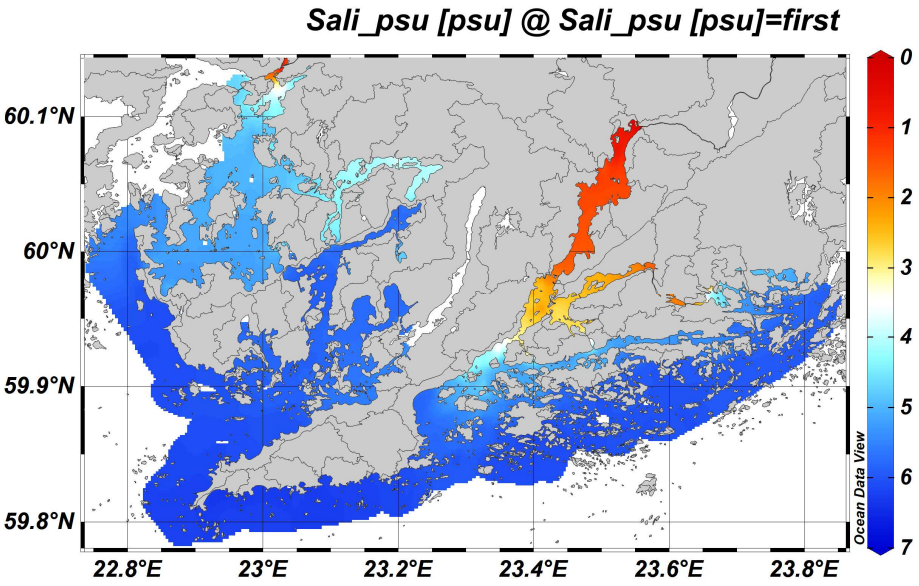
Sali_psu [psu] @ Sali_psu [psu]=first
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60°N
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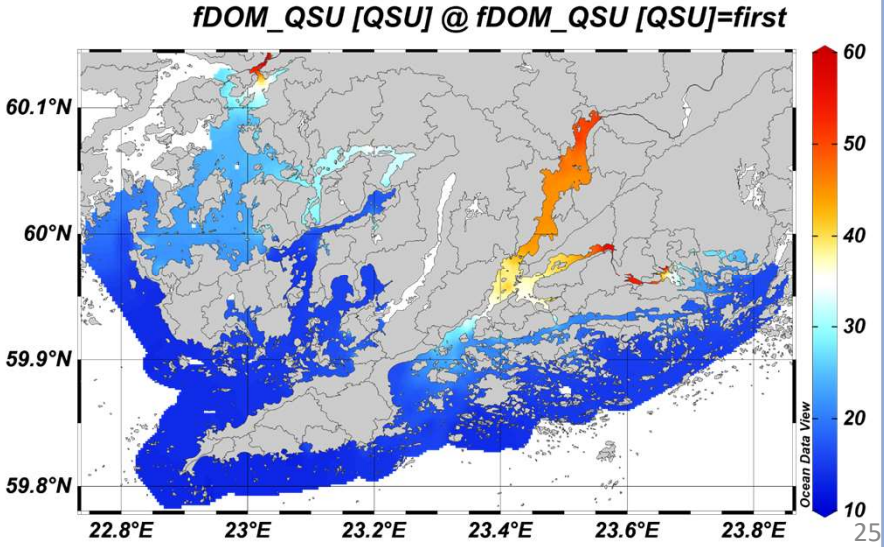
23°E
23.2°E
23.4°E
23.6°E
23.8°E
0
1
2
3
4
5
6
7
Ocean Data View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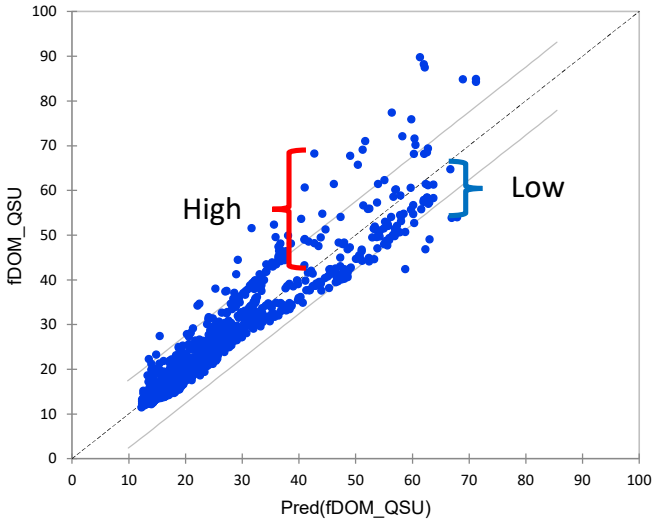
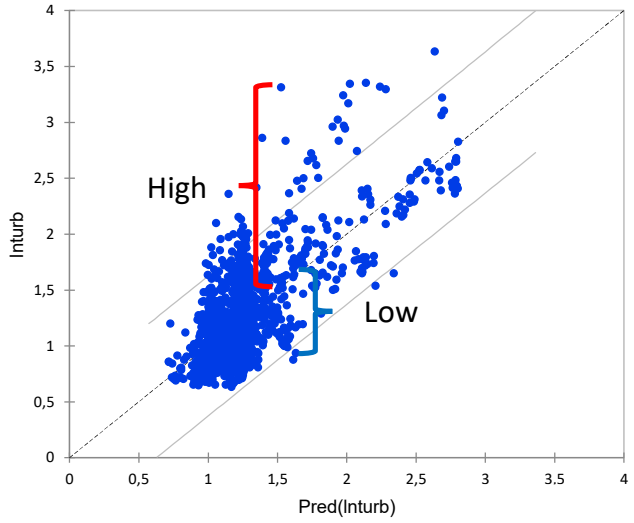
23.8°E
60
50
40
30
20
10
Ocean Data View

Fluorescent DOM (95 %)



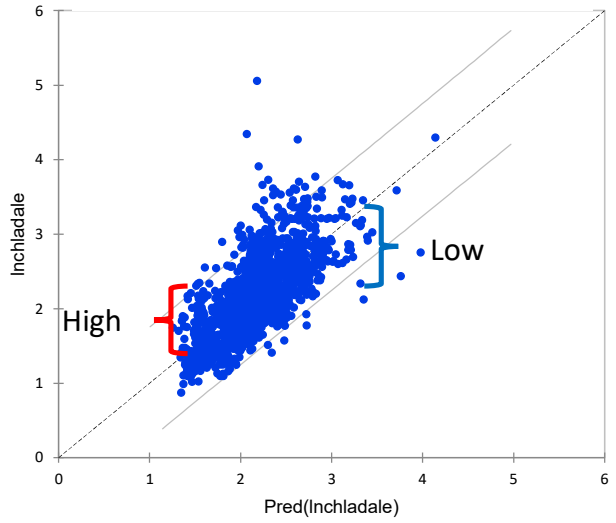
Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Week	0.856	0.184	4.660	**<0.0001**	0.496	1.216
Sali_psu	-0.398	0.124	-3.219	**0.001**	-0.640	-0.155
TempCels	0.295	0.175	1.686	0.092	-0.048	0.637
Week*Sali_psu	-1.241	0.253	-4.912	**<0.0001**	-1.737	-0.746
Week*TempCels	-1.160	0.294	-3.943	**<0.0001**	-1.737	-0.583
Sali_psu*TempCels	-0.653	0.226	-2.890	**0.004**	-1.096	-0.210
Week*Sali_psu*TempCels	1.426	0.334	4.269	**<0.0001**	0.771	2.081

Turbidity (75 %)



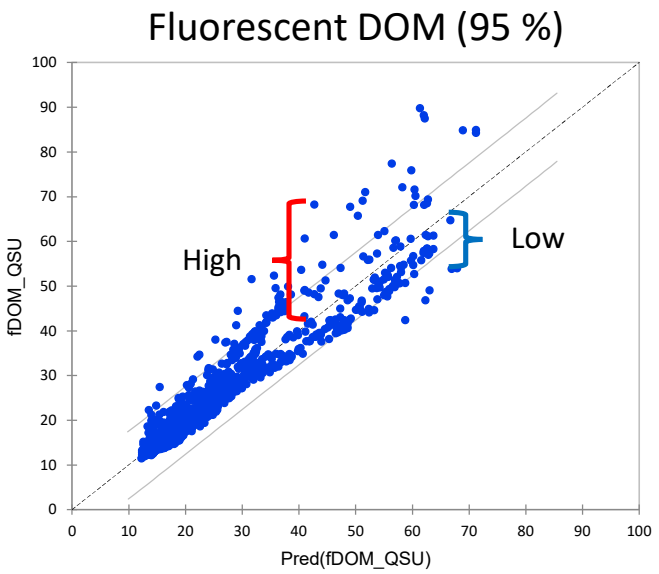
Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Week	0.673	0.327	2.056	**0.040**	0.031	1.314
Sali_psu	-0.689	0.218	-3.166	**0.002**	-1.116	-0.262
TempCels	0.211	0.280	0.754	0.451	-0.338	0.759
Week*Sali_psu	-1.413	0.457	-3.092	**0.002**	-2.310	-0.517
Week*TempCels	-1.907	0.507	-3.762	**0.000**	-2.901	-0.912
Sali_psu*TempCels	-0.459	0.379	-1.211	0.226	-1.203	0.285
Week*Sali_psu*TempCels	2.711	0.596	4.549	**<0.0001**	1.542	3.880

Chlorophyll *a* (72 %)



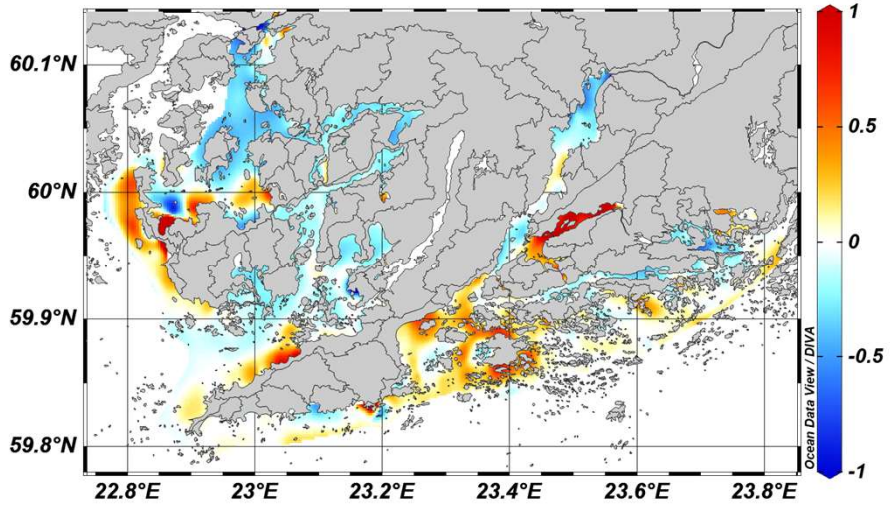
Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Week	4.021	0.947	4.248	**<0.0001**	2.164	5.878
fDOM_QSU	2.923	0.747	3.914	**<0.0001**	1.458	4.388
Sali_psu	2.881	0.538	5.356	**<0.0001**	1.826	3.937
Turb_FNU	2.362	2.026	1.166	0.244	-1.613	6.336
TempCels	-1.074	1.009	-1.065	0.287	-3.053	0.904
Week*fDOM_QSU	-2.899	0.807	-3.591	**0.000**	-4.482	-1.315
Week*Sali_psu	-5.731	0.734	-7.811	**<0.0001**	-7.170	-4.292
Week*Turb_FNU	-4.096	2.400	-1.707	0.088	-8.805	0.612
Week*TempCels	1.083	1.207	0.897	0.370	-1.285	3.450
fDOM_QSU*Sali_psu	-0.476	0.480	-0.992	0.322	-1.418	0.466
fDOM_QSU*Turb_FNU	-2.064	2.019	-1.022	0.307	-6.025	1.897
fDOM_QSU*TempCels	2.914	0.722	4.037	**<0.0001**	1.498	4.331
Sali_psu*Turb_FNU	-1.129	0.408	-2.766	**0.006**	-1.930	-0.328
Sali_psu*TempCels	1.792	0.635	2.824	**0.005**	0.547	3.037
Turb_FNU*TempCels	5.721	1.999	2.861	**0.004**	1.799	9.643
Week*fDOM_QSU*Sali_psu	2.208	0.700	3.155	**0.002**	0.835	3.581
Week*fDOM_QSU*Turb_FNU	4.124	2.443	1.688	0.092	-0.668	8.916
Week*fDOM_QSU*TempCels	-2.675	0.771	-3.470	**0.001**	-4.188	-1.163
Week*Sali_psu*Turb_FNU	3.909	0.587	6.659	**<0.0001**	2.757	5.060
Week*Sali_psu*TempCels	0.000	0.000				
Week*Turb_FNU*TempCels	-3.511	2.306	-1.523	0.128	-8.034	1.012
fDOM_QSU*Sali_psu*Turb_FNU	1.019	1.090	0.935	0.350	-1.118	3.157
fDOM_QSU*Sali_psu*TempCels	-1.745	0.779	-2.240	**0.025**	-3.274	-0.217
fDOM_QSU*Turb_FNU*TempCels	-6.666	2.043	-3.263	**0.001**	-10.674	-2.658
Sali_psu*Turb_FNU*TempCels	-2.569	0.601	-4.272	**<0.0001**	-3.748	-1.389
Week*fDOM_QSU*Sali_psu*Turb_FNU	-3.526	1.181	-2.986	**0.003**	-5.842	-1.209

Where, when and how much does carbon, nutrient and particle loading deviate from their <u>normal</u> level as predicted by the environmental conditions and manifested as status indicators?



Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Week	0.856	0.184	4.660	**<0.0001**	0.496	1.216
Sali_psu	-0.398	0.124	-3.219	**0.001**	-0.640	-0.155
TempCels	0.295	0.175	1.686	0.092	-0.048	0.637
Week*Sali_psu	-1.241	0.253	-4.912	**<0.0001**	-1.737	-0.746
Week*TempCels	-1.160	0.294	-3.943	**<0.0001**	-1.737	-0.583
Sali_psu*TempCels	-0.653	0.226	-2.890	**0.004**	-1.096	-0.210
Week*Sali_psu*TempCels	1.426	0.334	4.269	**<0.0001**	0.771	2.081

Where, when and how much does carbon, nutrient and particle loading deviate from their <u>normal</u> level as predicted by the environmental conditions and manifested as status indicators?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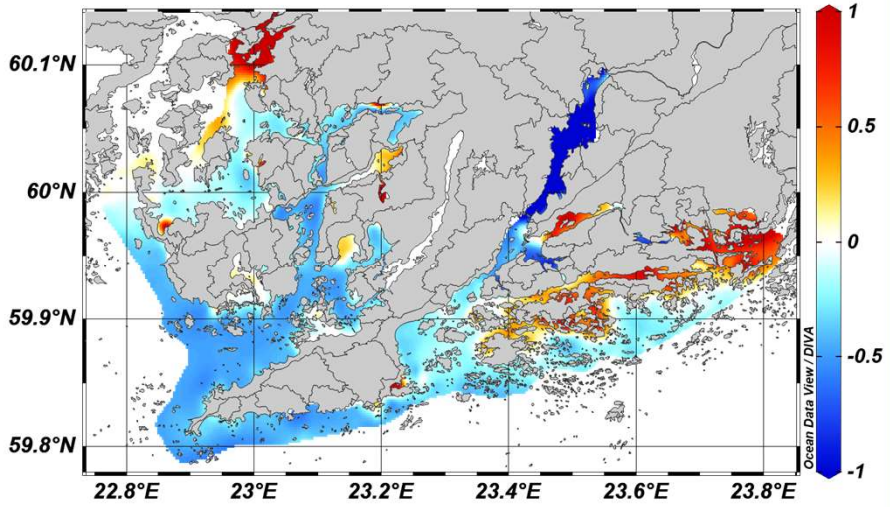
59.9°N
59.8°N
22.8°E
23°E
23.2°E
23.4°E
23.6°E
23.8°E
1
0.5
0
-0.5
-1
Ocean Data View / DIVA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59.8°N
22.8°E
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23.8°E
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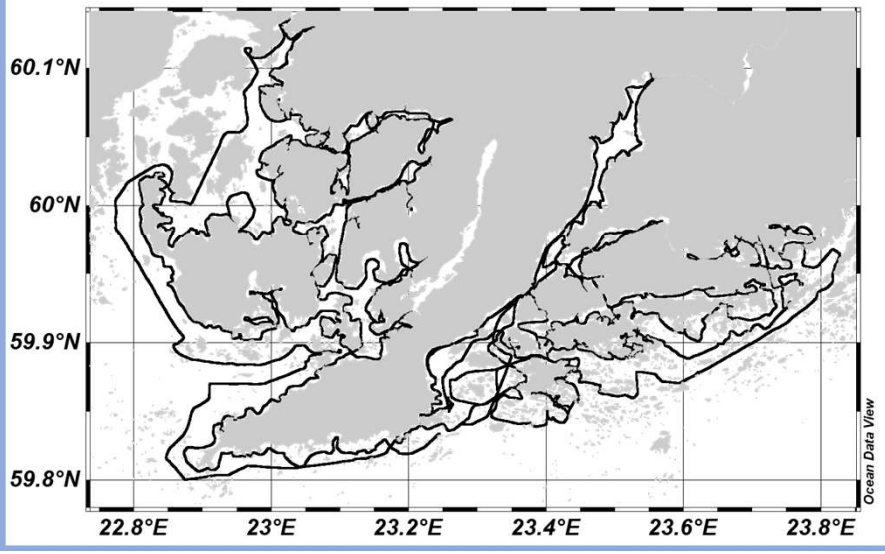
Ocean Data View / DIVA


60.1°N
60°N
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22.8°E
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23.6°E
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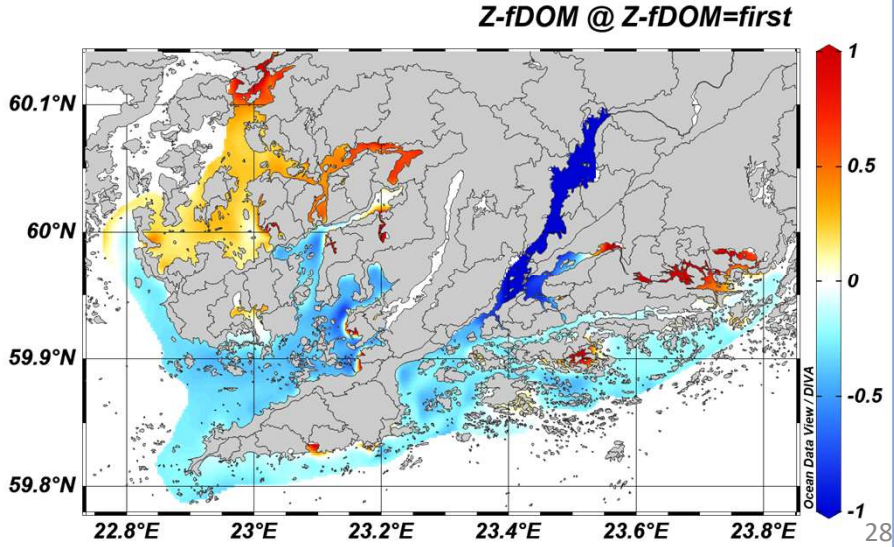
Ocean Data View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23.6°E
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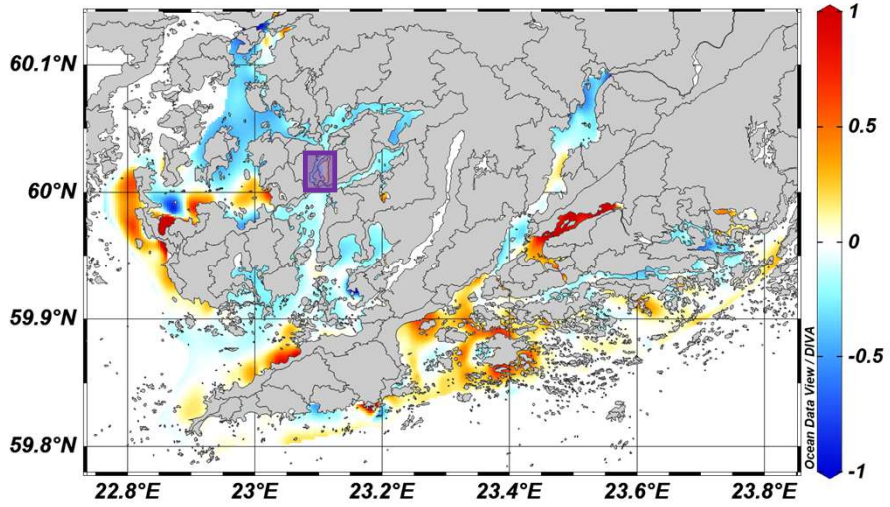
Ocean Data View / DIVA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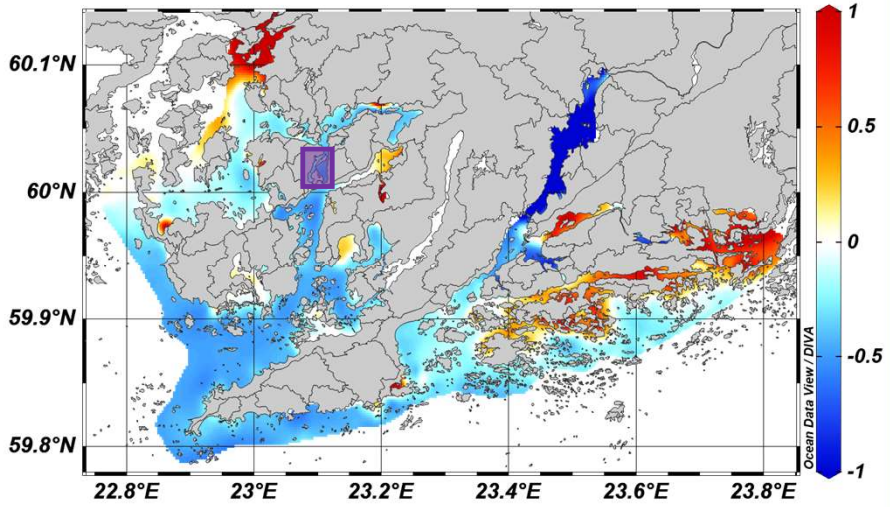
Ocean Data View / DIVA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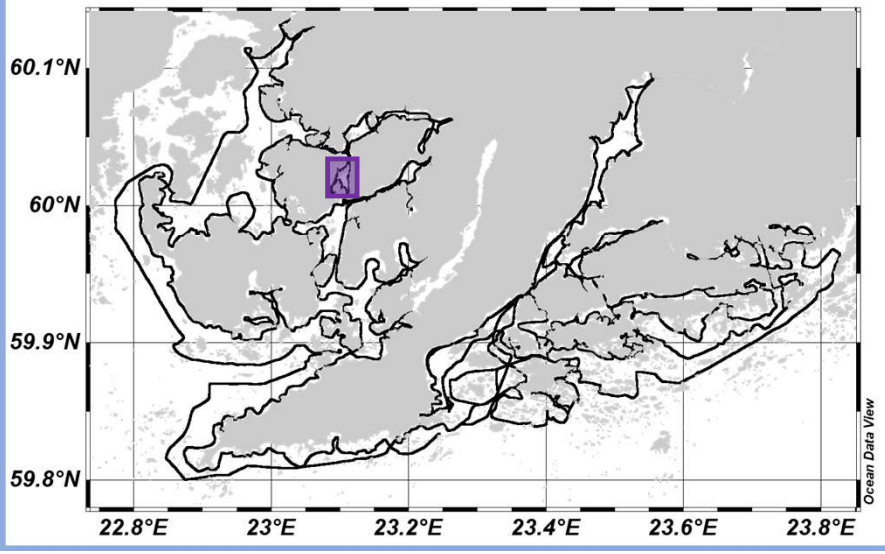
Ocean Data View / DIVA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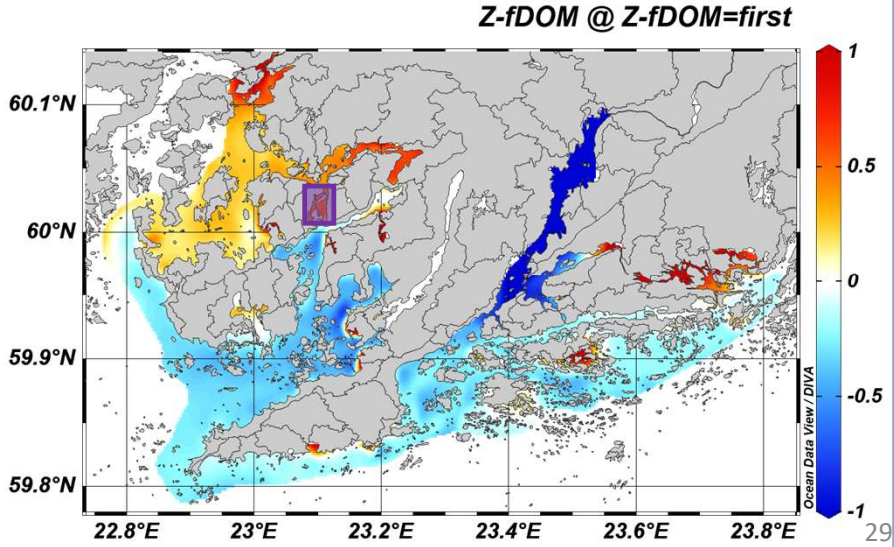
Ocean Data View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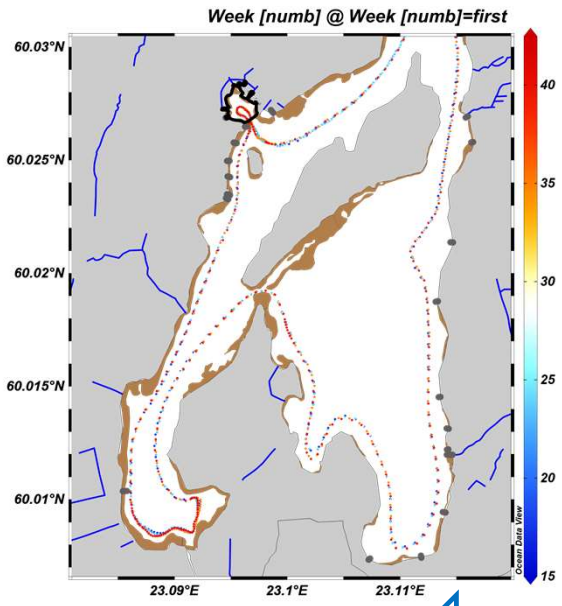
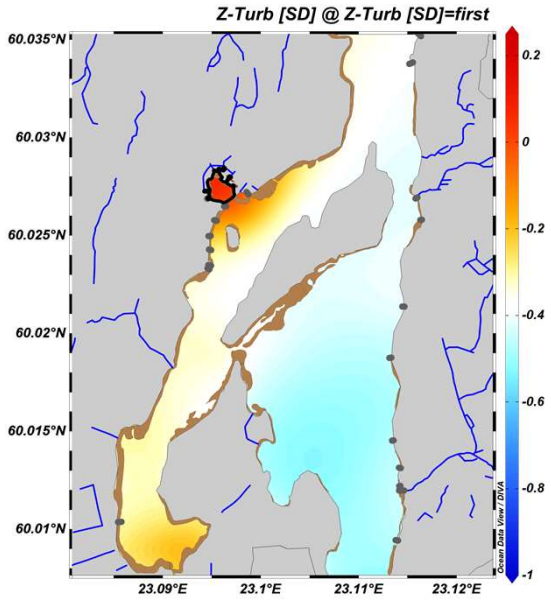
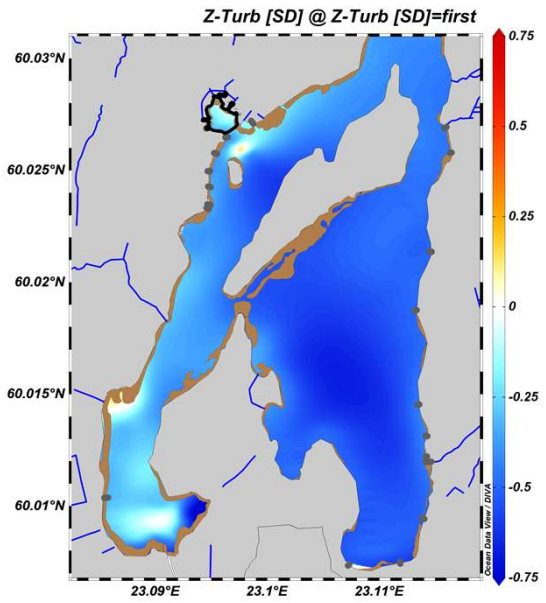
-0.5
-1
Ocean Data View / DIVA

SURVEY → TARGET → FOLLOW UP





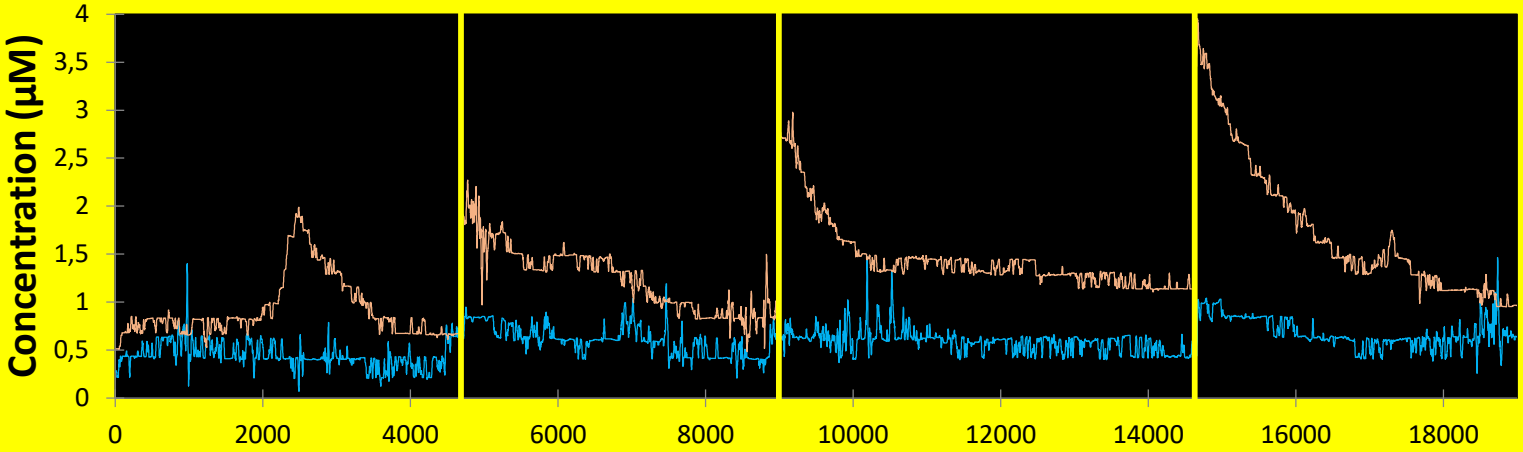


VALIDATION/EVALUATION

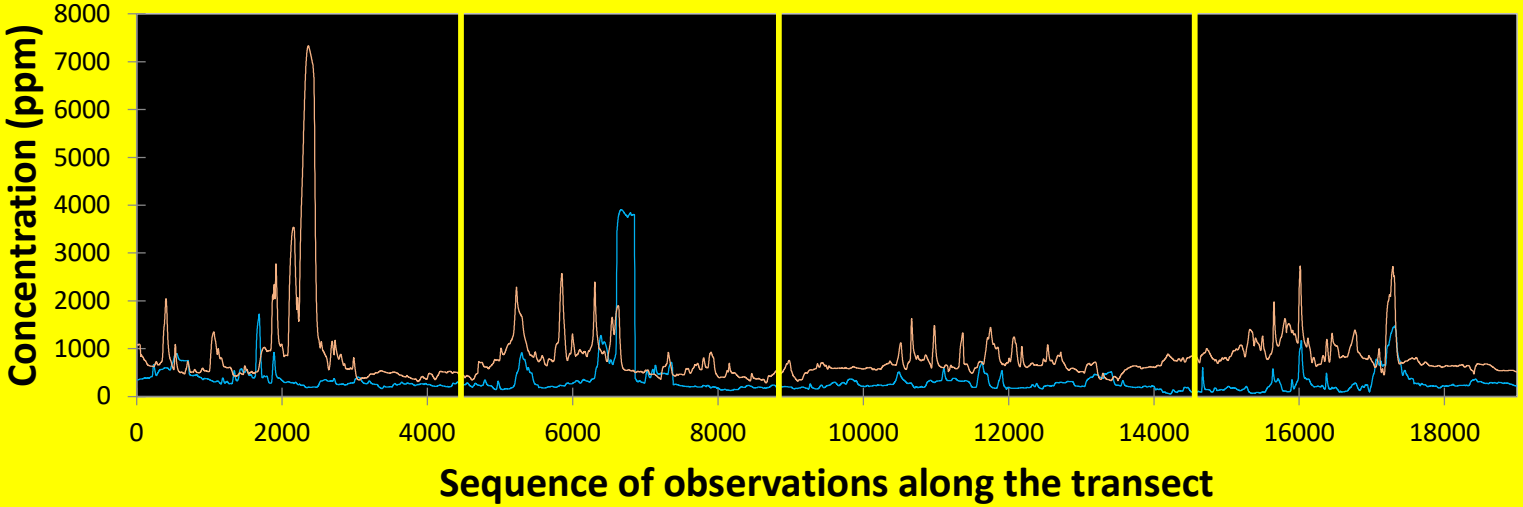
- Agricultural profitability & climate impacts
- Aquatic ecosystem health & climate impacts

⇒ WIN-WIN-WIN-WIN solutions?

METHANE



CARBON DIOXIDE

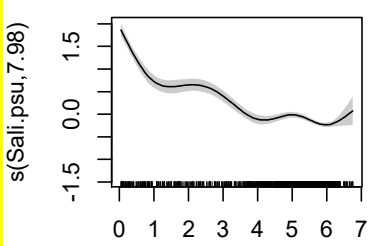


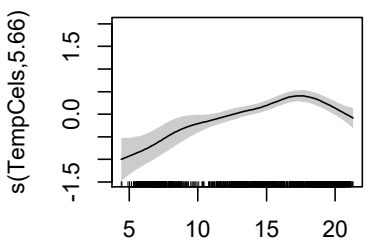
RESULTS

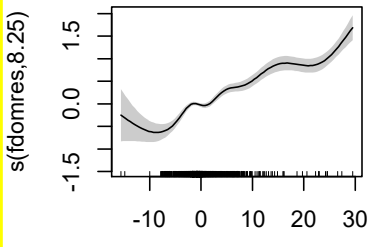
Scale
Coastal waters are characterized by high concentrations of GHGs

Variation
Spatial (horizontal)
Seasonal
Diurnal (methane)

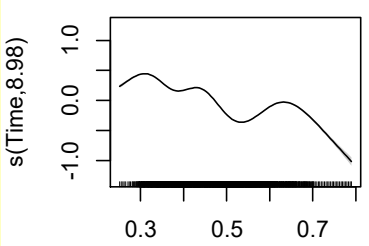
CARBON DIOXIDE

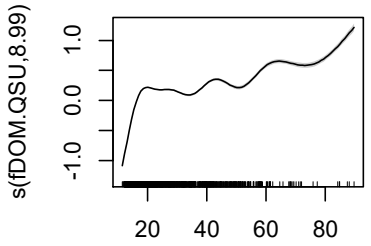


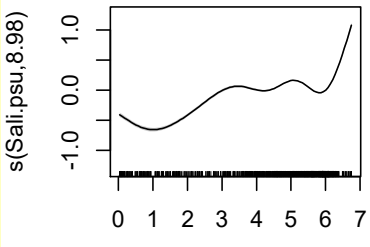


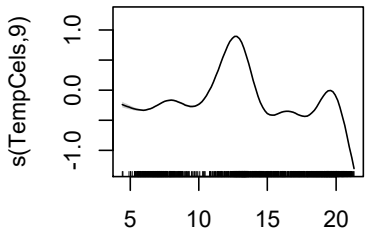


METHANE









RESULTS

Scale

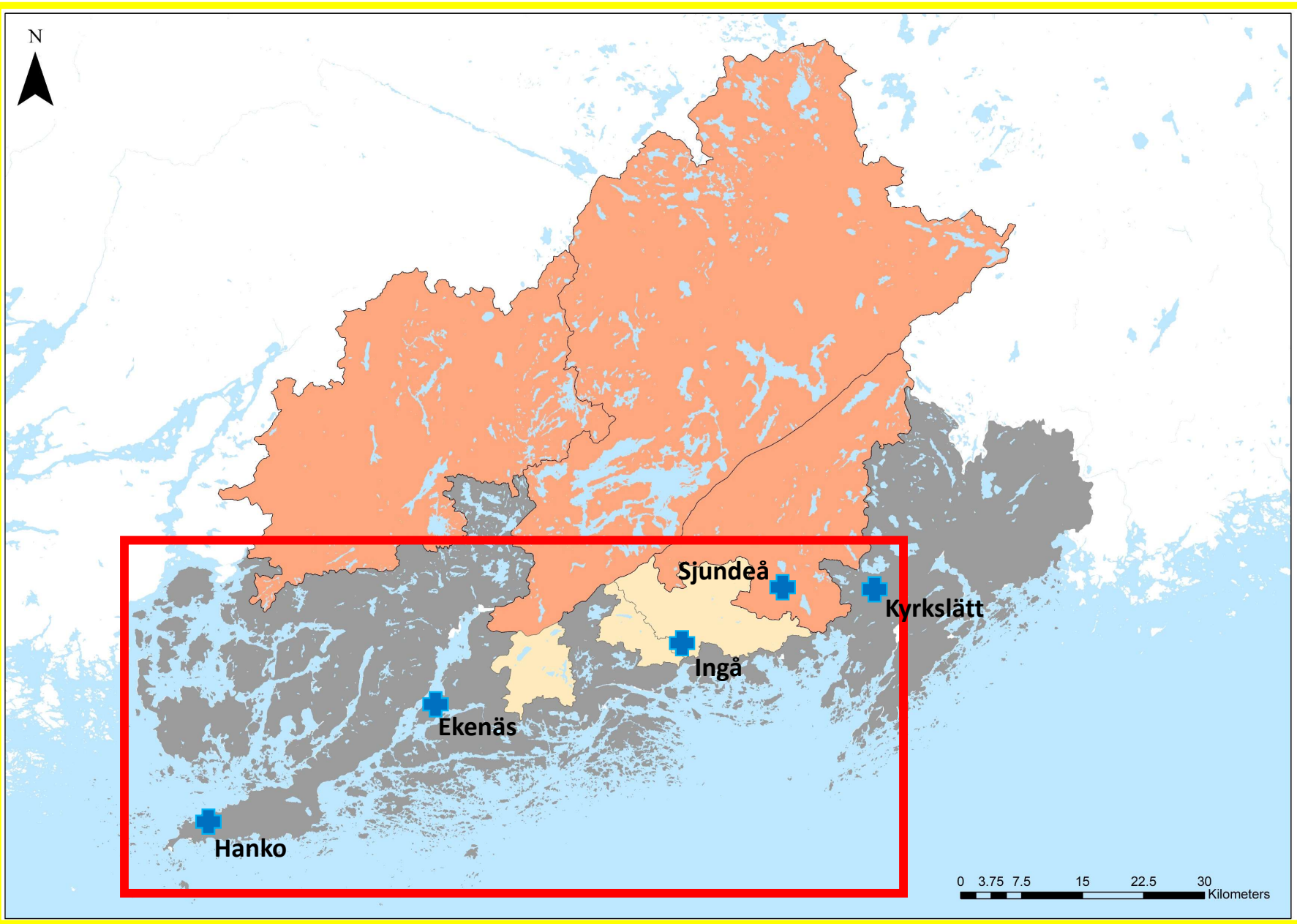
Coastal waters are characterized by high concentrations of GHGs

Variation

Spatial (horizontal)
Seasonal
Diurnal (methane)

Environmental conditions (a preliminary hypothesis)

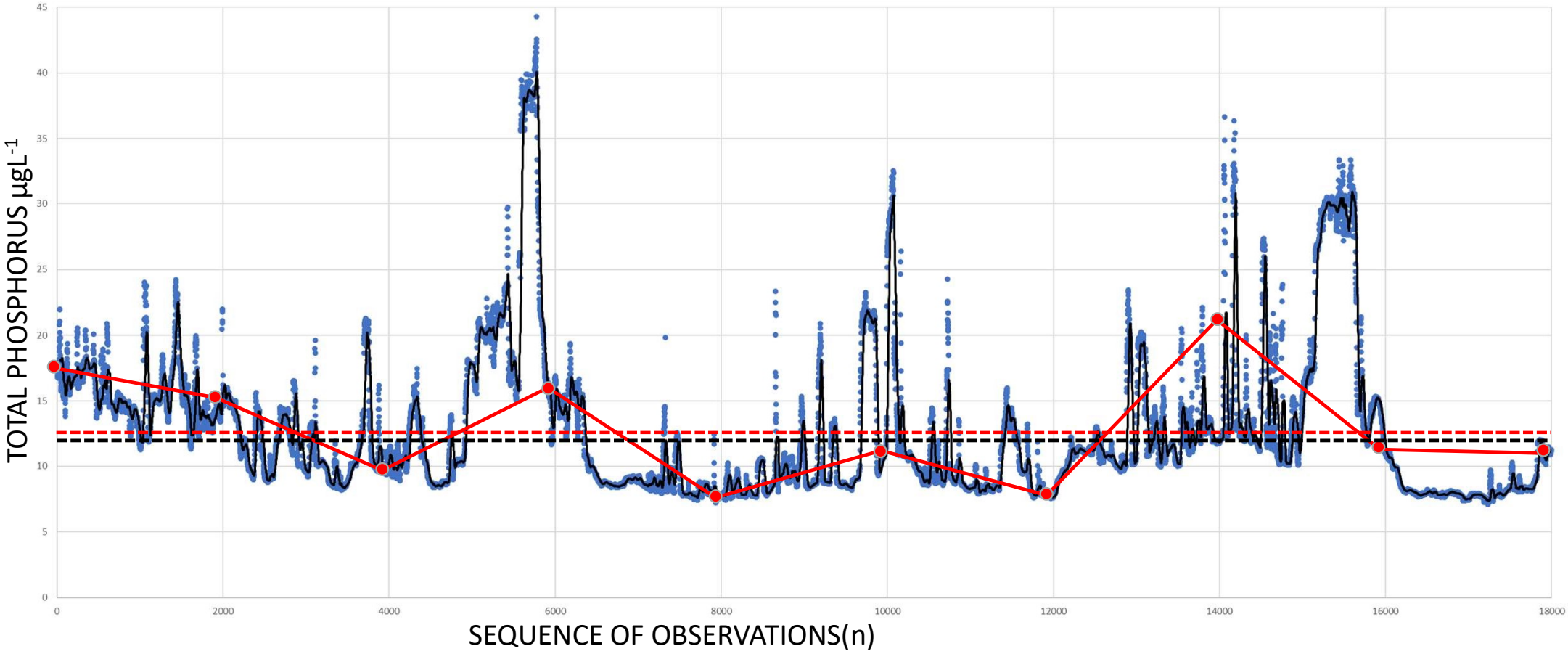
- Fuelled by terrestrial loading
- Facilitated by specific physical conditions



FUTURE DIRECTIONS

Havsmanualen 3 (2021-)

- Direct runoff/larger area
- At least 3 more years
- General evaluation of environmental impacts
- Macrophyte communities
- Analysis of land use
- Patterns and processes of GHG production (vertical profiling and diurnal sampling in hotspot areas)


TOTAL PHOSPHORUS µgL-1
45
40
35
30
25
20
15
10
5
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
SEQUENCE OF OBSERVATIONS(n)
REAL TREND
DISCRETE WATER SAMPLES
TRENDLINE FOR DISCRETE WATER SAMPLES
PREDICTION BASED ON EMPIRICAL MODEL
AREAL MEAN FOR DISCRETE WATER SAMPLES
AREAL MEAN FOR MODELLED DATA

ACADEMIC RESEARCH

Scheinin M & Asmala E. 2020. Ubiquitous patchiness in chlorophyll *a* concentration in coastal archipelago of Baltic Sea. Front Mar Sci. https://doi.org/10.3389/fmars.2020.00563

Asmala E, Virtasalo J, Scheinin M, Newton S, Jilbert T. Role of particle dynamics in processing of terrestrial nitrogen and phosphorus in the estuarine mixing zone. Limnol Oceanogr (minor revisions)

Almén A-K, Lindén A, Engström-Öst J, Karell P, Scheinin M. A quantitative basis for context-sensitive trophic state assessment in sheltered coastal waters. Ecol Appl (in review)

Olofsson M, Almén A-K, Jaatinen K, Scheinin M. Temporal escape - adaptation to eutrophication by *Skeletonema marinoi*. Biol Lett (in review)

Gunko R, Rapeli L, Scheinin M, Vuorisalo T, Karell P. How accurate is citizen science? Evaluating the public's assessments of coastal water quality. Environ Sci Pol (in review)

Asmala E. & Scheinin M. Methane and carbon dioxide in coastal waters. Manuscript

Heinänen S & Scheinin M. Macrophyte community composition as a bioindicator. Manuscript

DELIVERABLES

Environmental management

- **Cost-efficient, scalable and dublicable tool for**
  - **targeting**
  - **monitoring**
  - **evaluating**
- **End users**
  - **Regional**
    - **SW Finland**
  - **Municipal**
    - **Hanko**
    - **Raseborg**
    - **Ingå**
    - **Sjundeå**
    - **Kyrkslätt**

Academic research

- **Publications**
- **Platform for**
  - **Information**
  - **Logistics**
  - **Outreach**

TAKE-HOME MESSAGES

Land areas have a huge impact on coastal waters, and thereby, on the climate.

Local stress, local effects, local solutions.

Environmental management can and should be mutually beneficial for the land, the sea and the air, from ecological and economical perspectives, alike.

BACKGROUND

Coastal filter determines the fate of carbon and nutrients

Coastal ecosystems alter carbon and nutrient pools on their way from land to sea via multiple biogeochemical processes. The main pathways through this coastal filter are *bypassing*, *transformation*, *retention* and *removal*.

The ecological status of coastal waters

Carbon, nutrient and particle loading drive the *status* of coastal waters by altering e.g. *trophic state*, *acidity*, *carbon balance* and *light climate*. Elevated freshwater input due to climate change can intensify this loading.

Central indicators for local anthropogenic impacts

In inshore waters, ecosystem state, functioning and services are mainly disrupted by *local human influence*. This calls for spatiotemporally detailed data on associated indicators, with attention to parallel, *non-local influences*.

AIMS AND MEANS

Environmental contextualization in high resolution

Indicators for carbon, nutrient and particle loading are surveyed in high spatiotemporal resolution and extent in parallel with capturing prevailing physical settings, thus siting the indicator values in their *environmental context*.

Hanko and Raseborg as a model area

Indicator values unmasked from external influences such as freshwater input, background loading or weather give a detailed view of local anthropogenic impacts on the coastal waters of the Hanko and Raseborg municipalities.

Deliverables for sustainable management

Spatial patterns for the context-sensitive indicator values are used for *locating* hotspots of human influence, subsequent *targeting* and *implementation* of sustainable management actions, and *monitoring* their outcomes.

THANK YOU

From scientific knowledge to solid actions

CONTACT INFORMATION

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Ville Wahteristo
Environmental protection director
City of Hanko
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00 358 40 16 93 523

SvJ BERGSRÅDINNAN SOPHIE VON JULINS STIFTELSE

pro litore

HANGON KAUPUNKI
HANGÖ STAD

PROGRAMMET FÖR EFFEKTIVERAT VATTENSKYDD

HAVSMANUALEN 2 & 3

From scientific knowledge to solid actions

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BERGSRÅDINNAN SOPHIE VON JULINS STIFTELSE

pro litore

HANGON KAUPUNKI
HANGÖ STAD

PROGRAMMET FÖR EFFEKTIVERAT VATTENSKYDD