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Highly Persisting Patch Formation Areas and Their Interannual Variability in the Gulf of Finland, the Baltic Sea.

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Outline

1. Introduction
2. Spatial domain
3. Calculation scheme + methods
4. Results
5. Conclusions

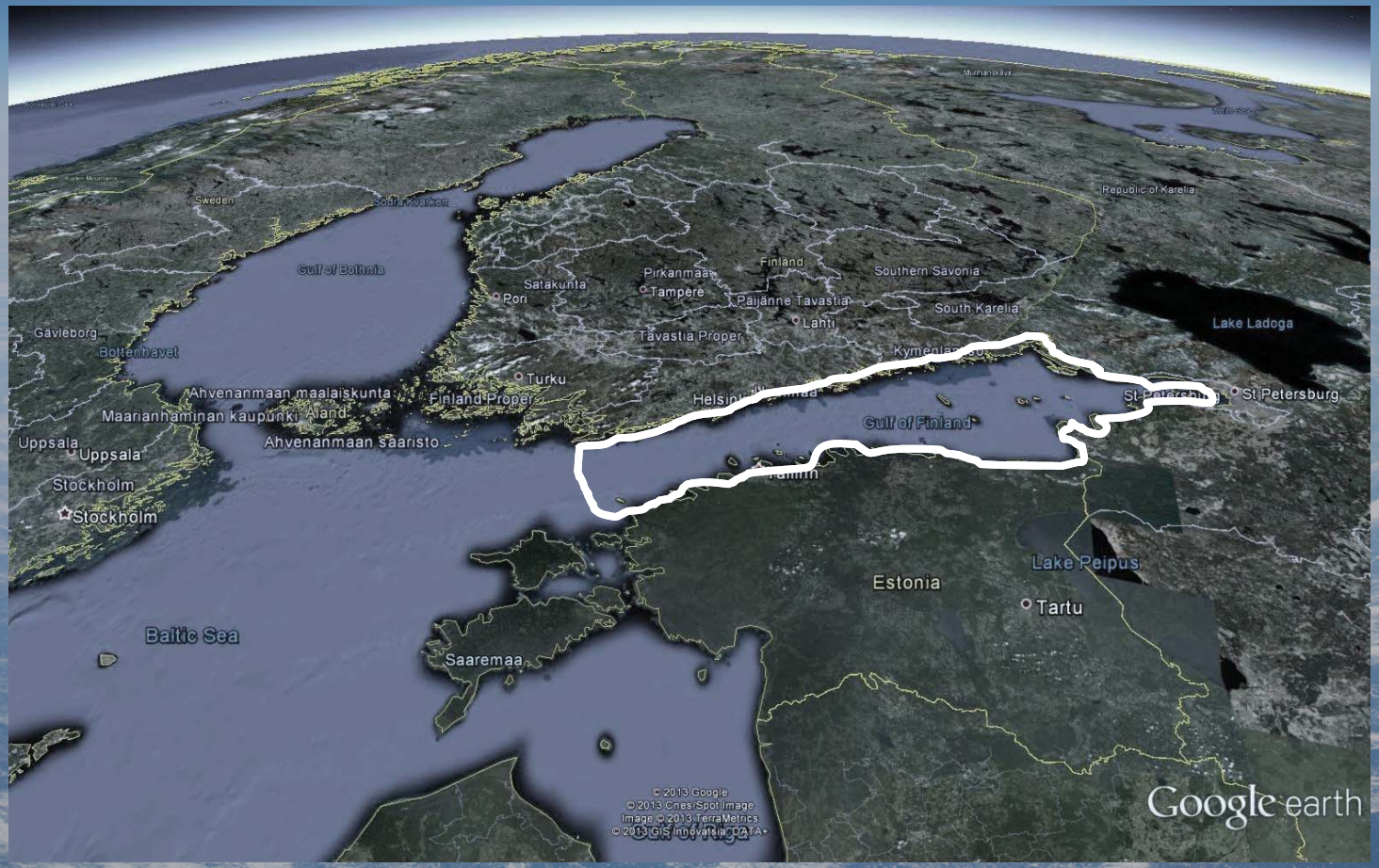
Introduction

- Under normal conditions, the sea surface layer is extremely heterogeneous across different spatial and temporal scales.

- Variations in concentrations of natural biochemical or substances of anthropogenic origin may deeply influence the underlying ecosystems.

- The impact of such variations in concentration (referred to as *patches*) may have positive or negative impact.
  - ➢ Negative impact is often of anthropogenic origin:
    - Dredging
    - Dumping
    - Discharge of pollutants
    - Aquafarming

Spatial domain



- Estuarine area which shows extremely complex dynamics
- High proportion of vertical motions of water masses [Leppäranta and Myrberg, 2009]
- Frequently hosts up- and downwelling phenomena [Lehmann and Myrberg, 2007]
- Extremely dense ship traffic throughout the year.

Calculation scheme

- We explore a convenient way to identify areas of natural increase in concentration of substances on the sea surface, by means of the recently developed measure of the **Finite Time Compressibility** (FTC).

- This measure is retrieved starting from geometrical properties of conveniently defined patches of floating matter, which are tracked through their drifting on the sea surface, under the combined effect of winds and currents.

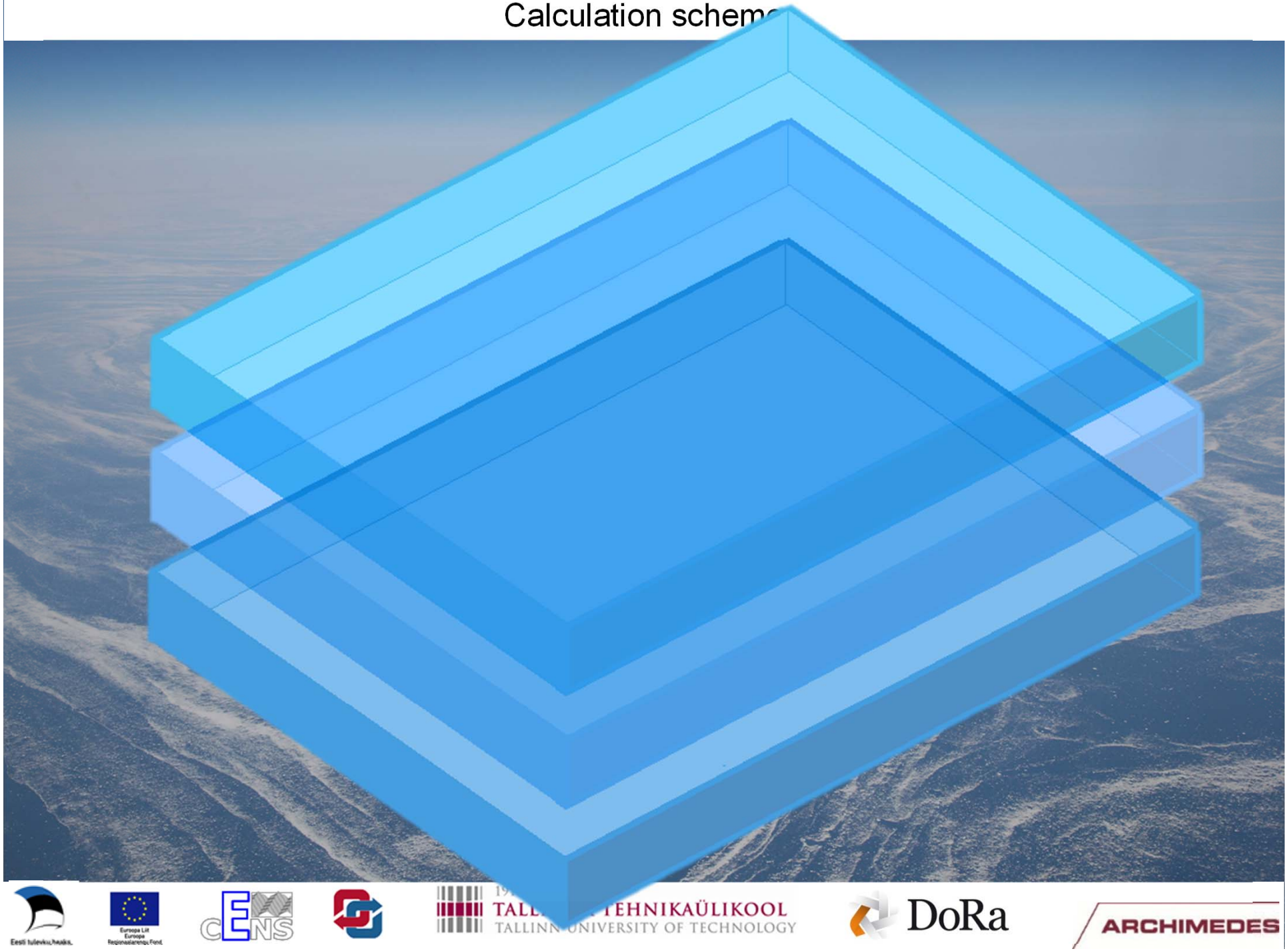
- Key foundation for this measure is to account for time correlations of the realistic flows.

- High values of divergence at a certain location aren't enough for strong patch-formation processes to take place → they take some time.

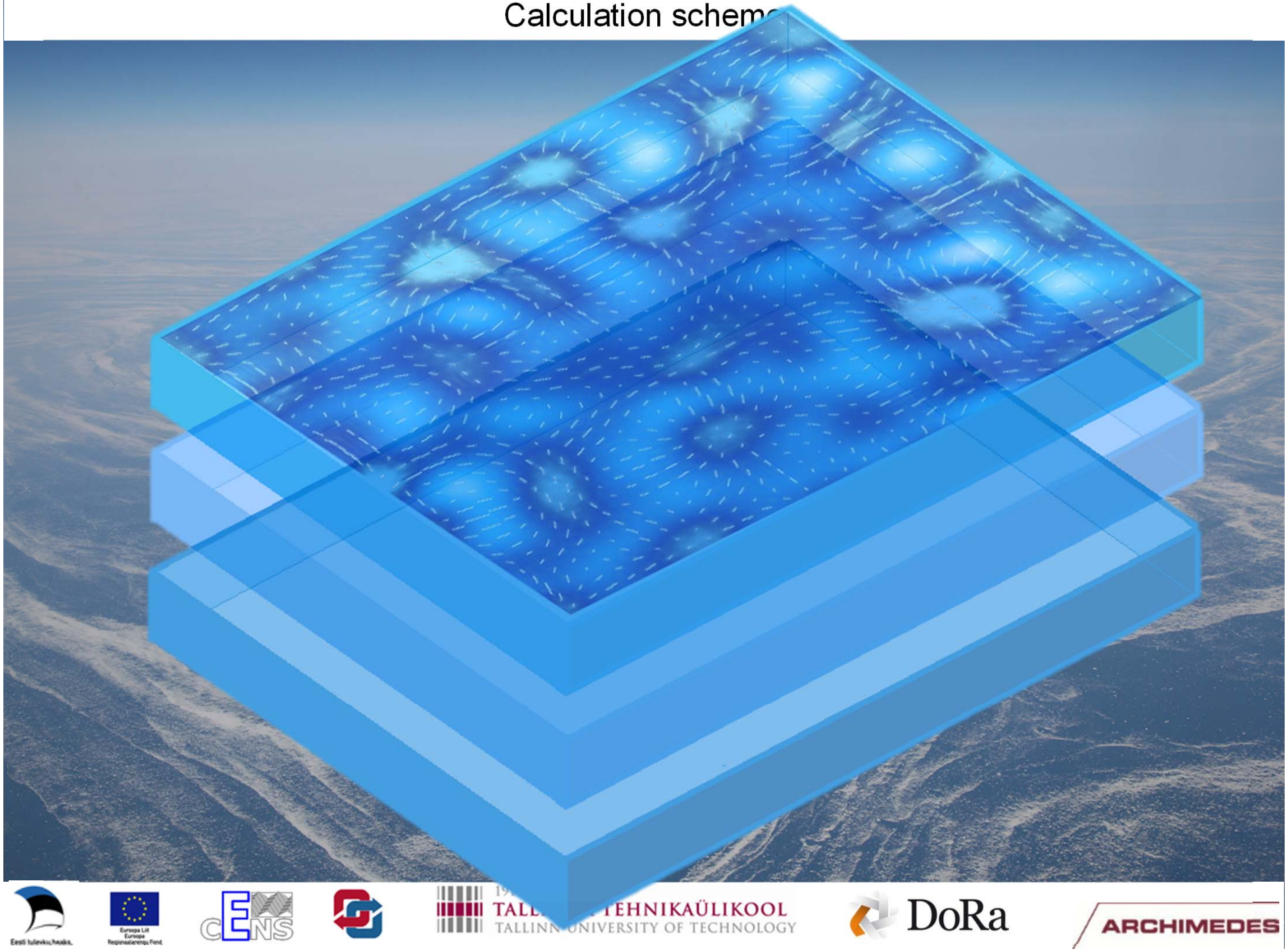
- Such processes become effective if the area of high divergence **moves together with the flow.**

- The measure of FTC has the same basic properties of flow compressibility but is able to **integrate the contributions of moving areas of high divergence** to the patch-formation process.

Calculation schem



Calculation schem



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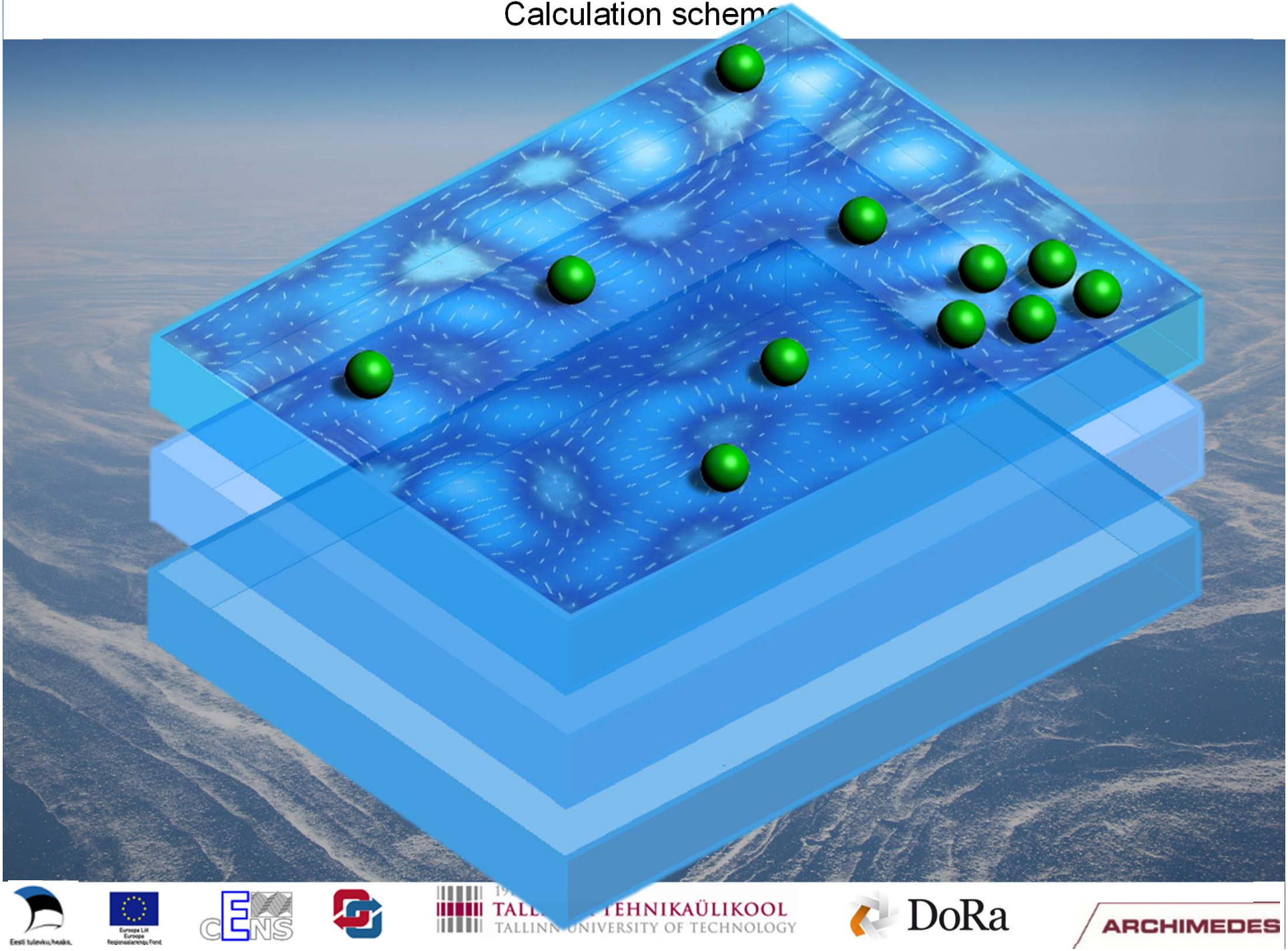

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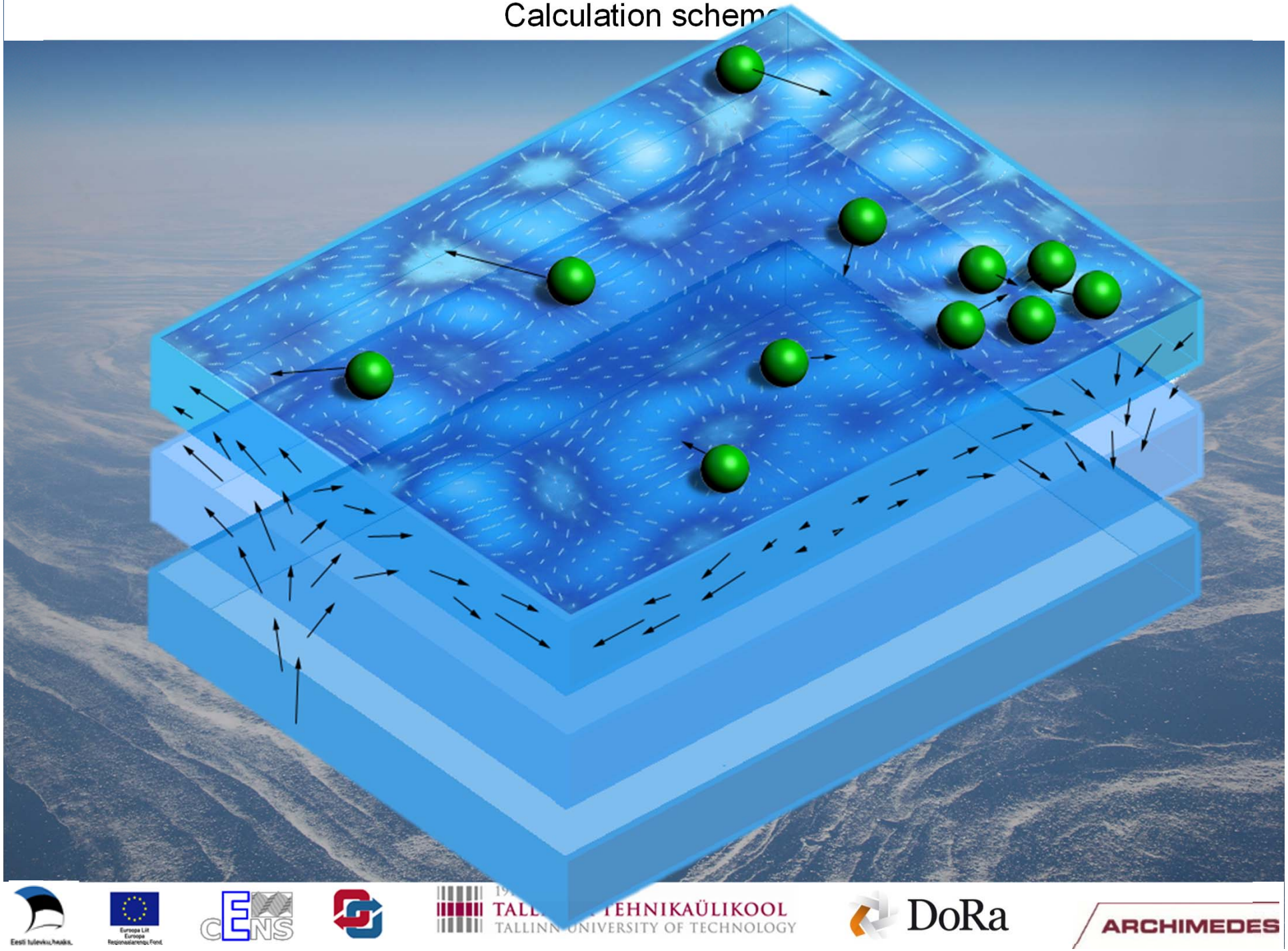

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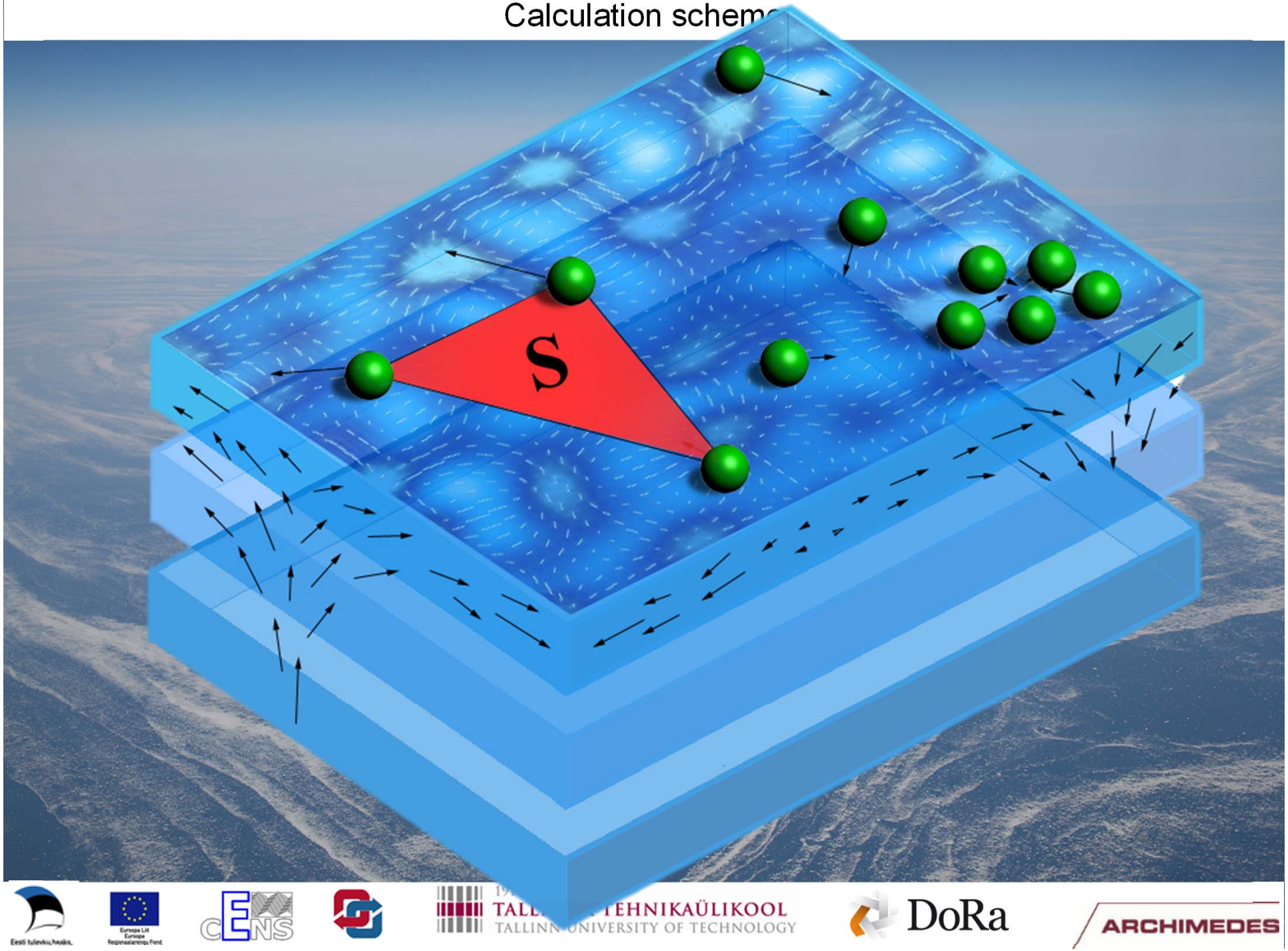

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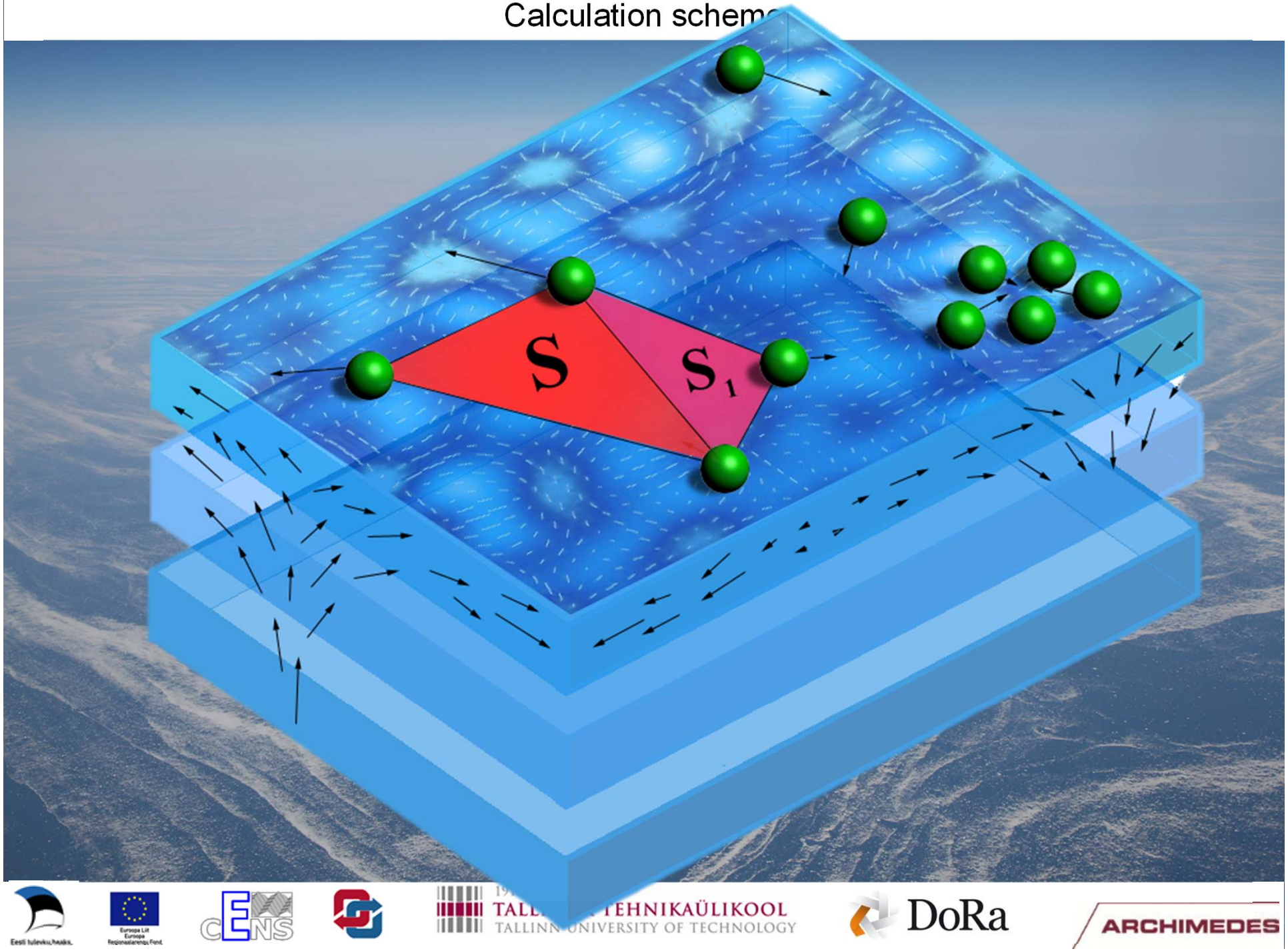

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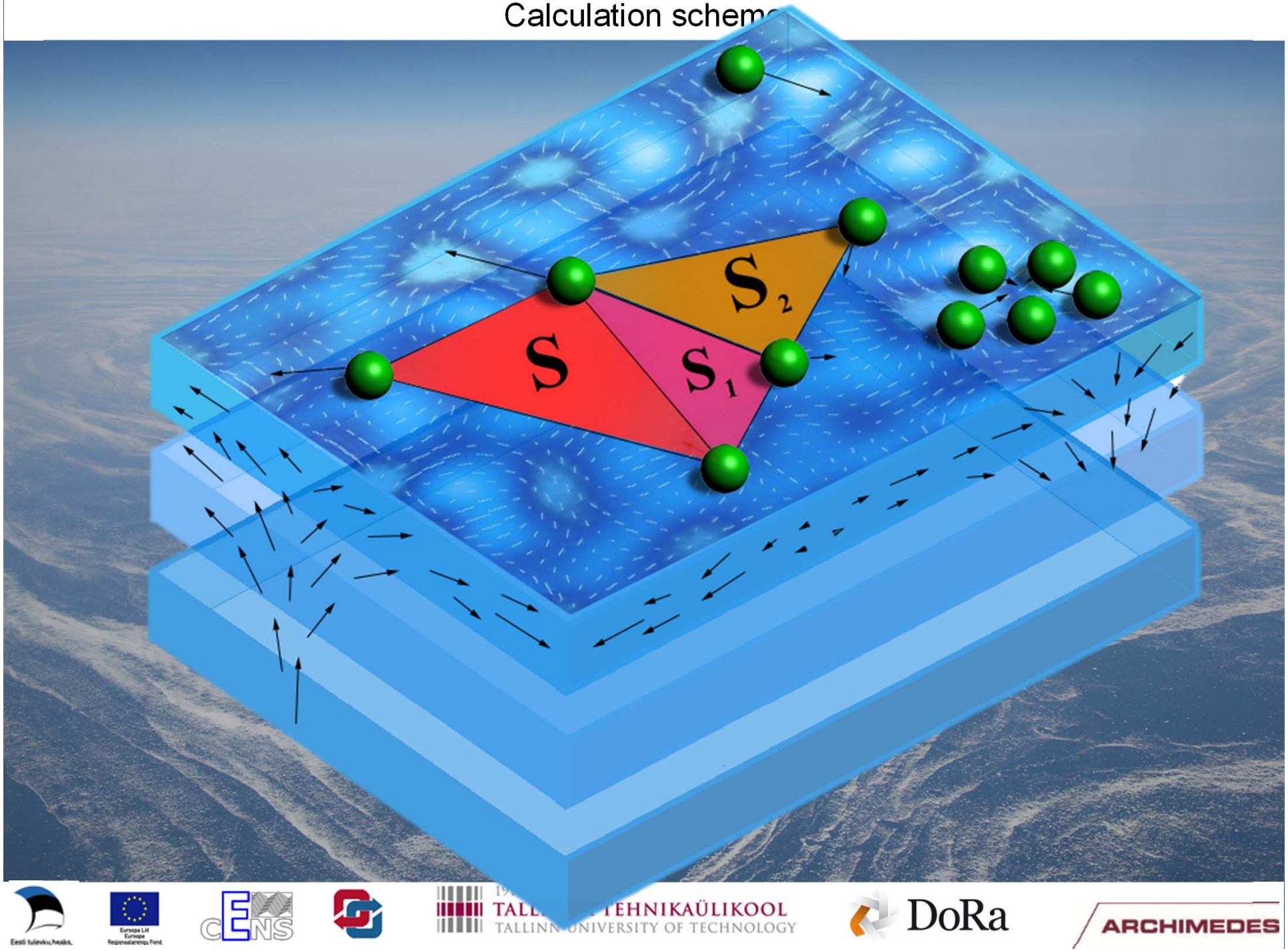

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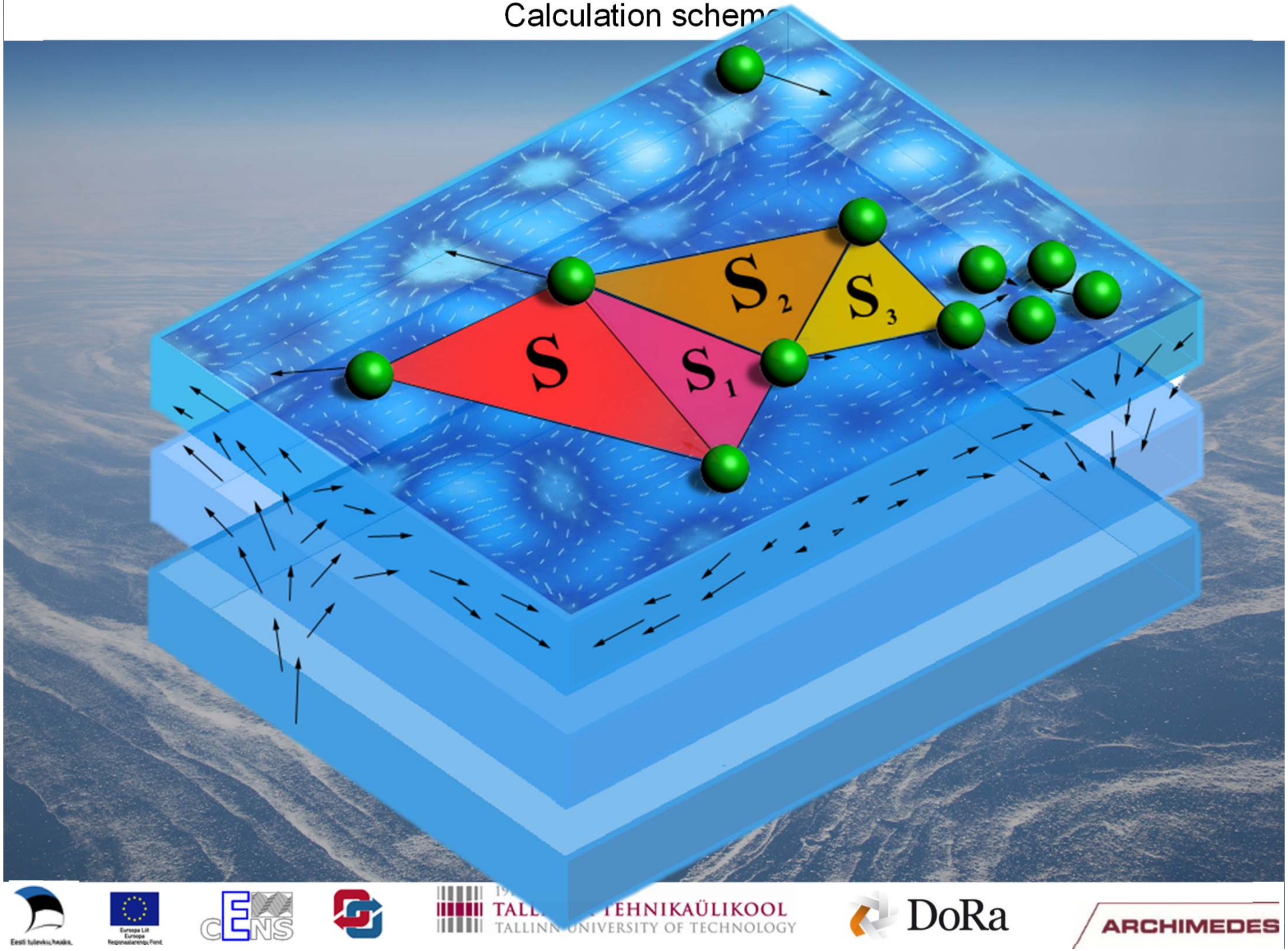
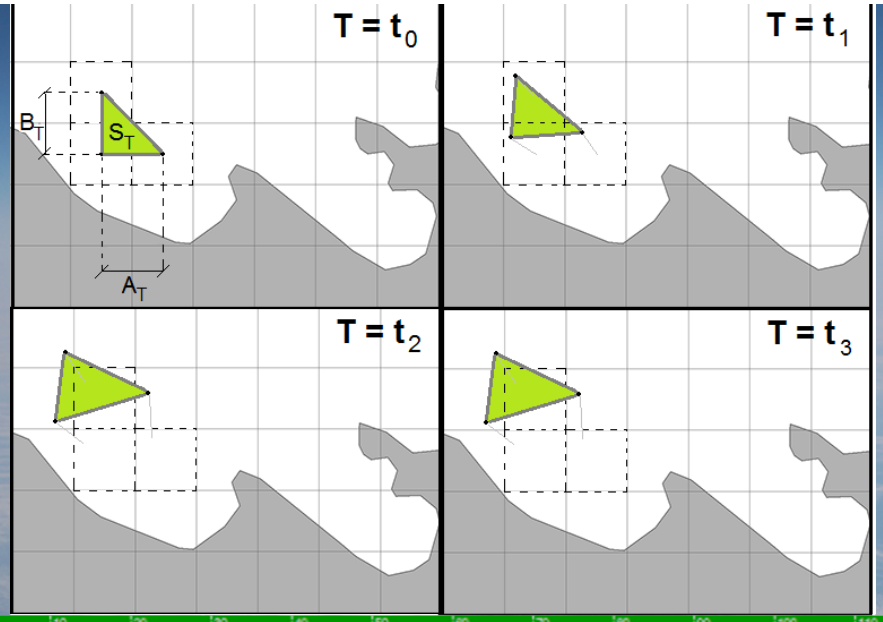
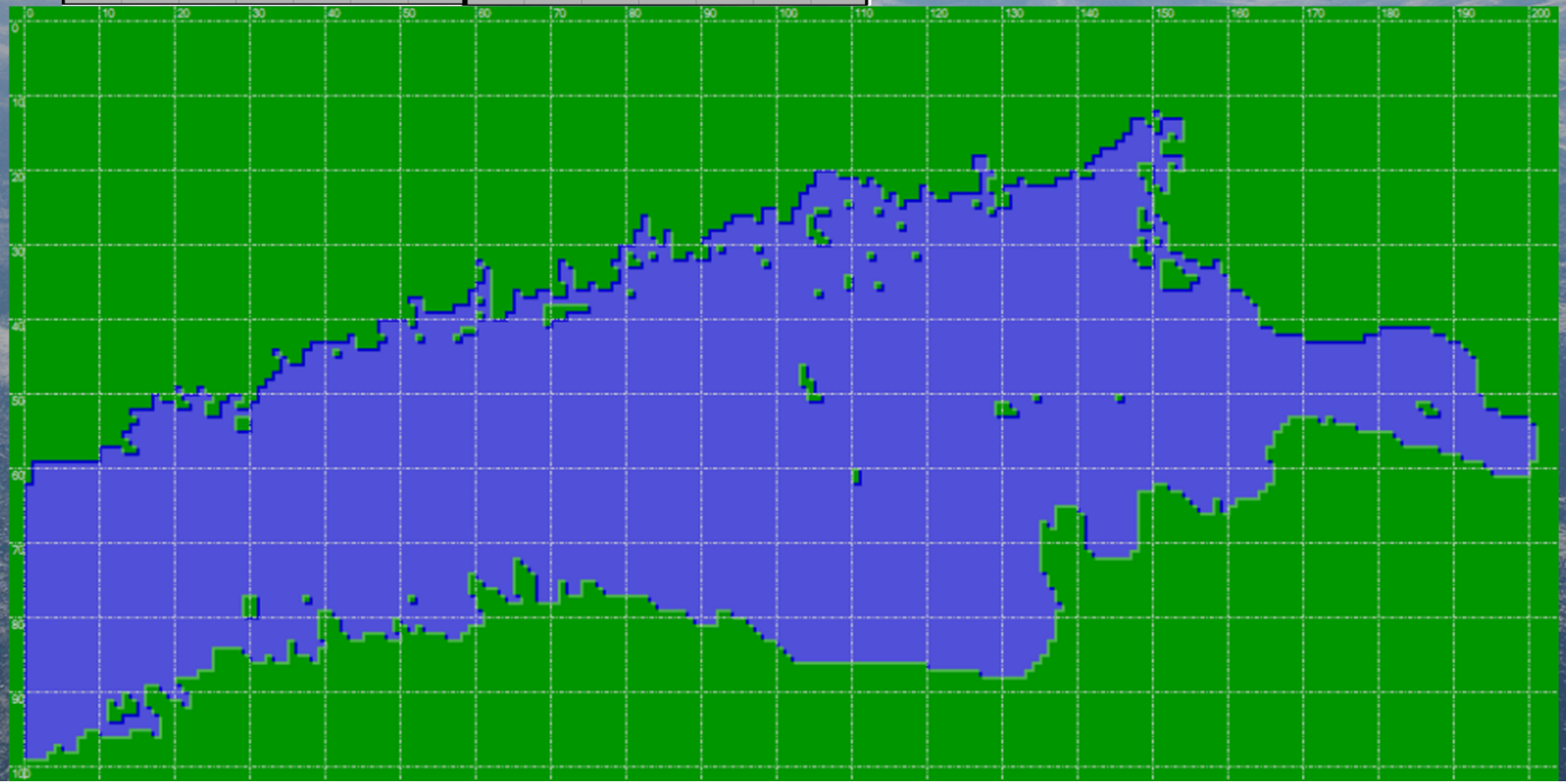




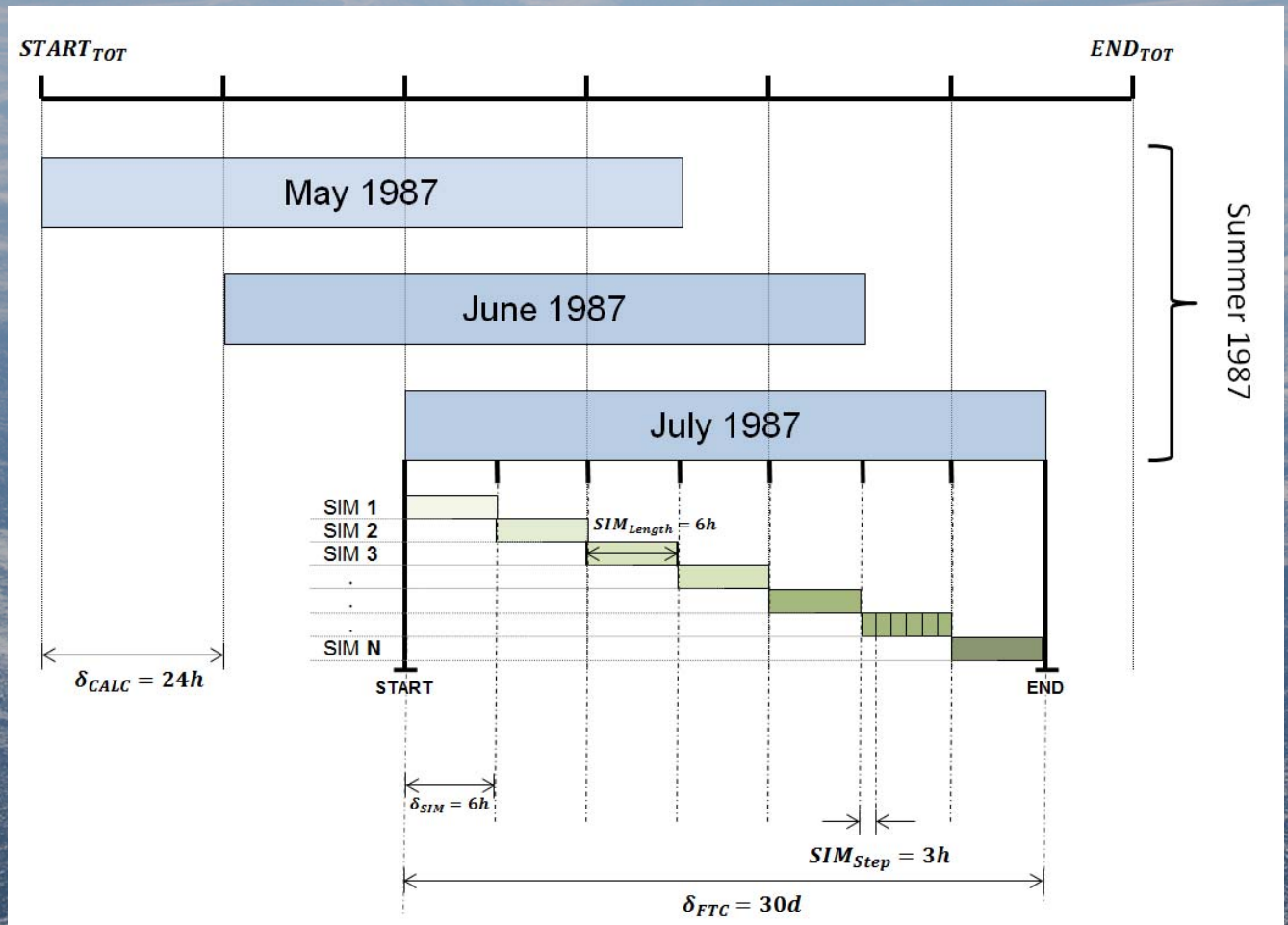
$$C_{ftc} = \frac{2dS_{rms}}{dA_{rms}+dB_{rms}} \quad \in [0,1].$$

Rapid and significant increase in concentration occurs when this value **exceeds the threshold of ~0.7**



Calculation scheme

- Our analysis relies on the output of OAAS ocean model [Andrejev and Sokolov, 1989]
- Spatial resolution 1NM - Temporal resolution 3 hours.
- 161600 vector information /day.



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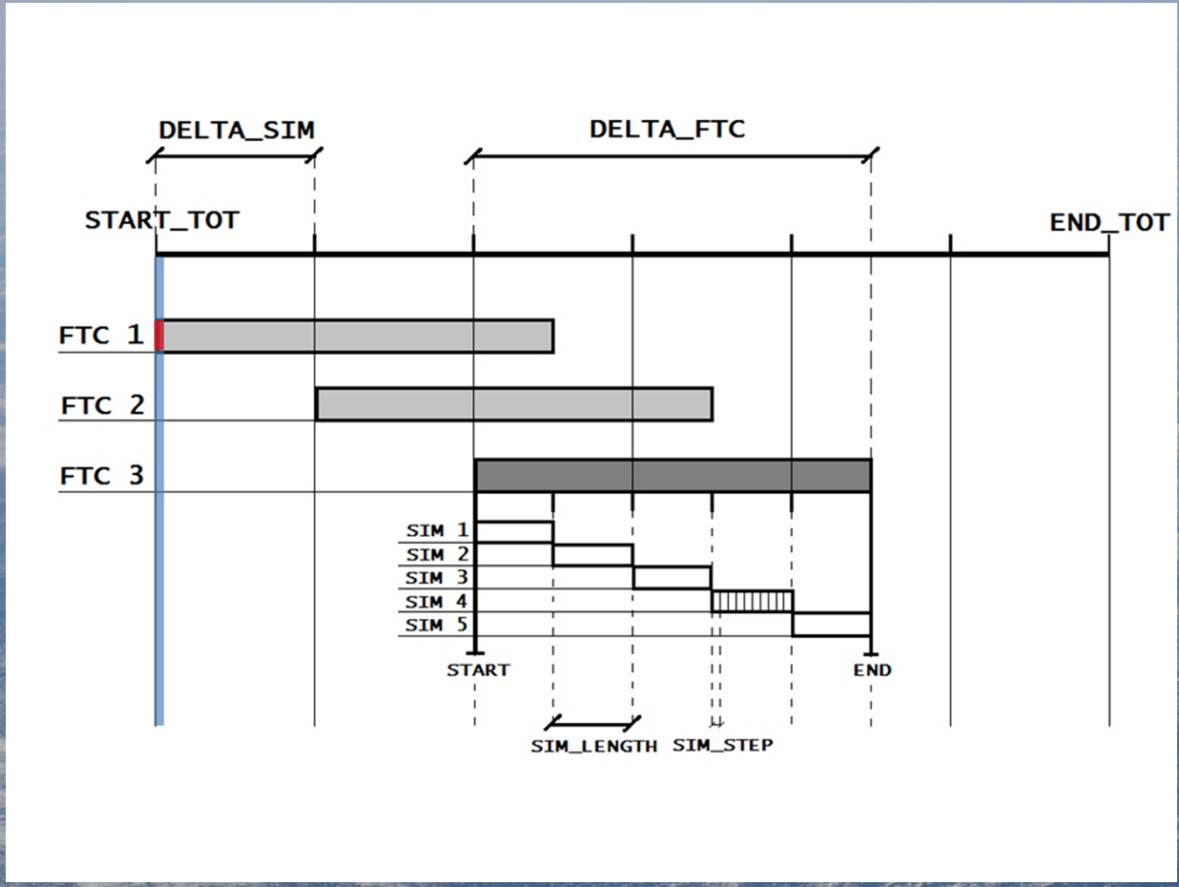
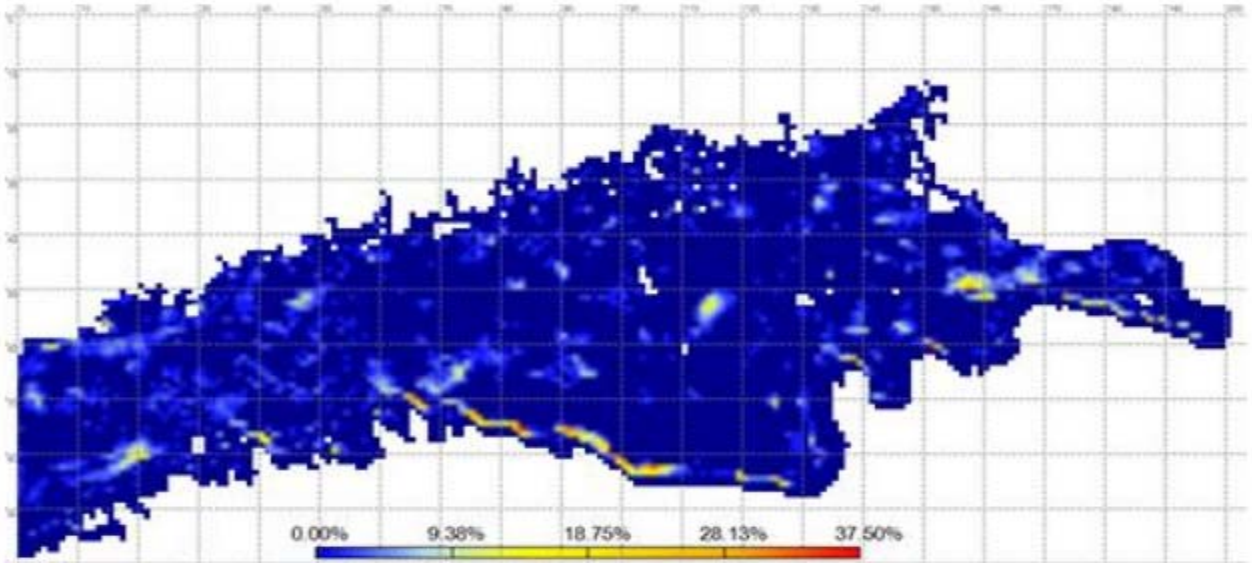


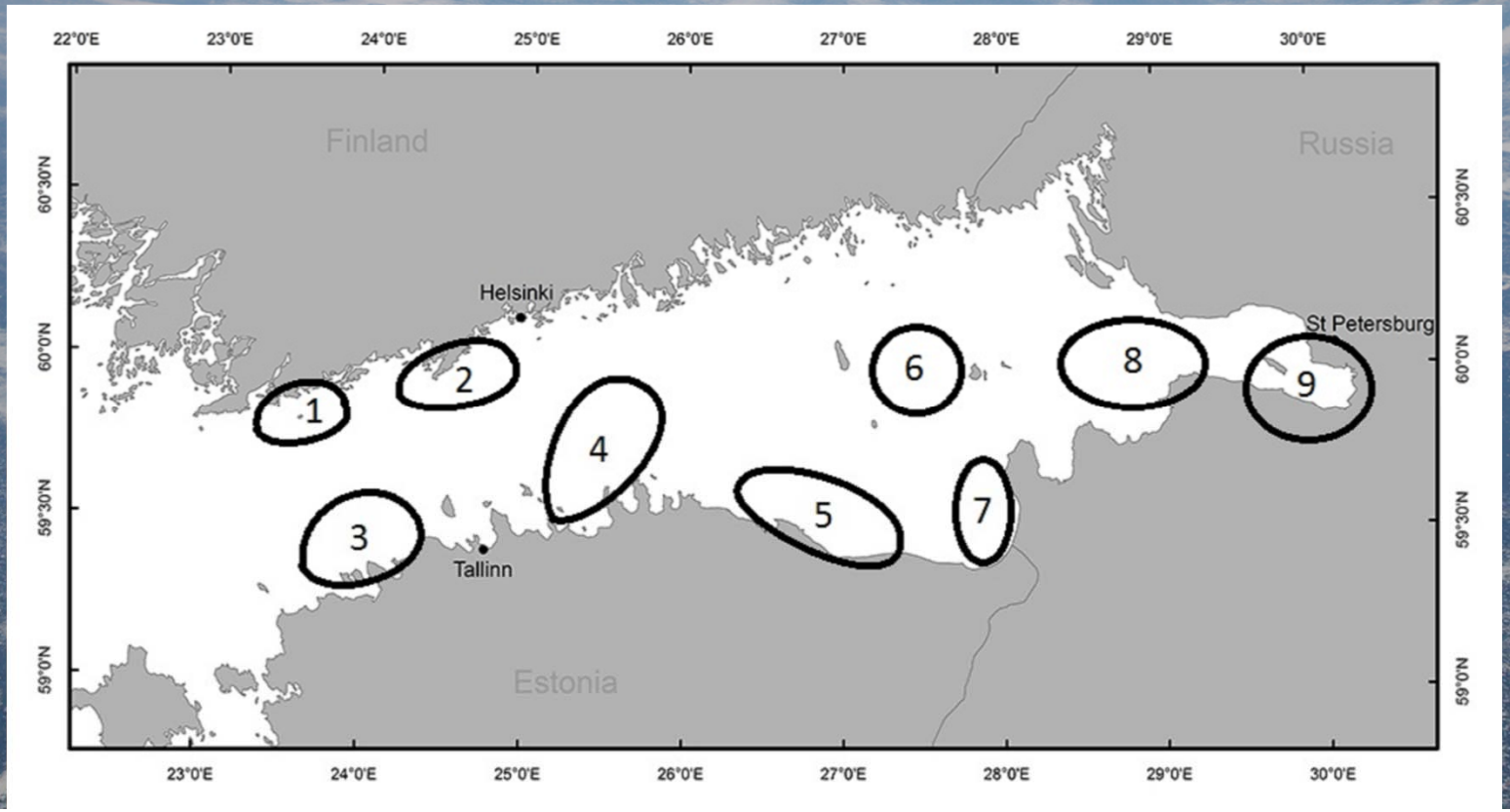


- Resulting maps for each batch are scanned for areas where the local value of FTC exceeds the threshold of 0.7, which is the point after which patch formation starts to occur.
- For each batch, we produce a persistency map.
- Each wet grid cell of such persistency maps represents the percentage of time during which that very grid cell showed FTC ≥ 0.7, over the considered time span.
- By performing a large number of FTC batches, we obtain at this step a large set of persistency maps, which will be grouped together depending on their overall length.
- Data analysis is produced over this set.

Results

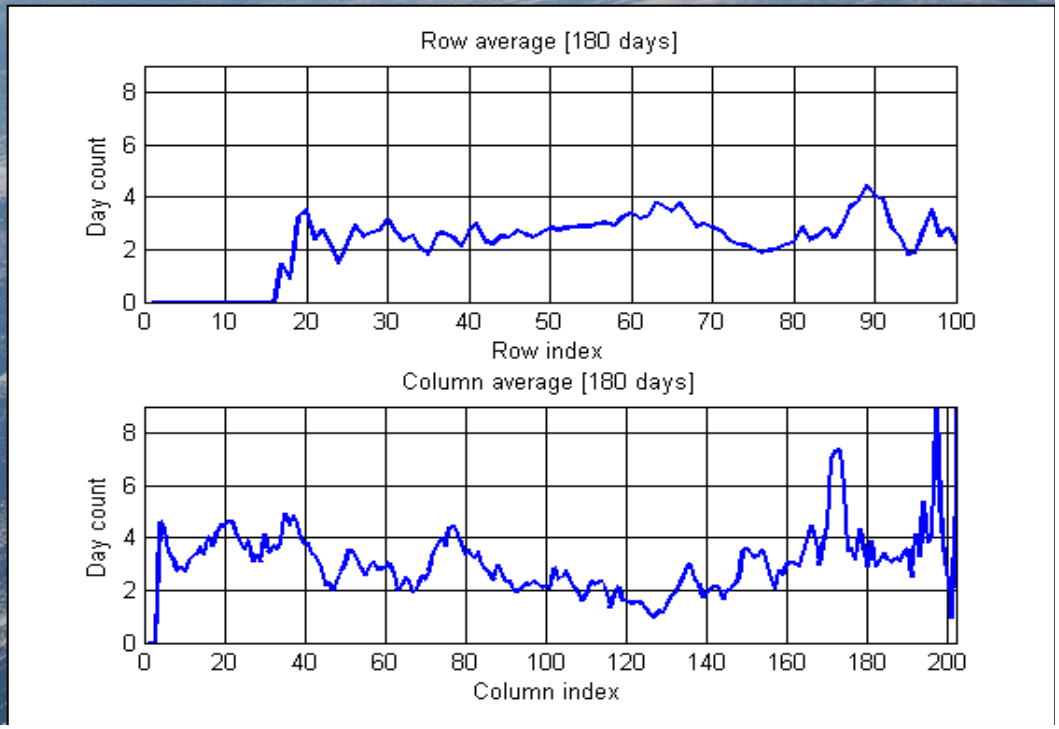
- Averaging instantaneous values of FTC over a long time allows us to identify and focus only on those areas that systematically show heavy clusterization potential.
- Averaging over 90 or 180 days long batches of maps smoothens out many local features which show up only on individual maps.

- The resulting averaged distributions show several areas of appreciable size which host
  above-clustering-threshold values of FTC in the Gulf of Finland.



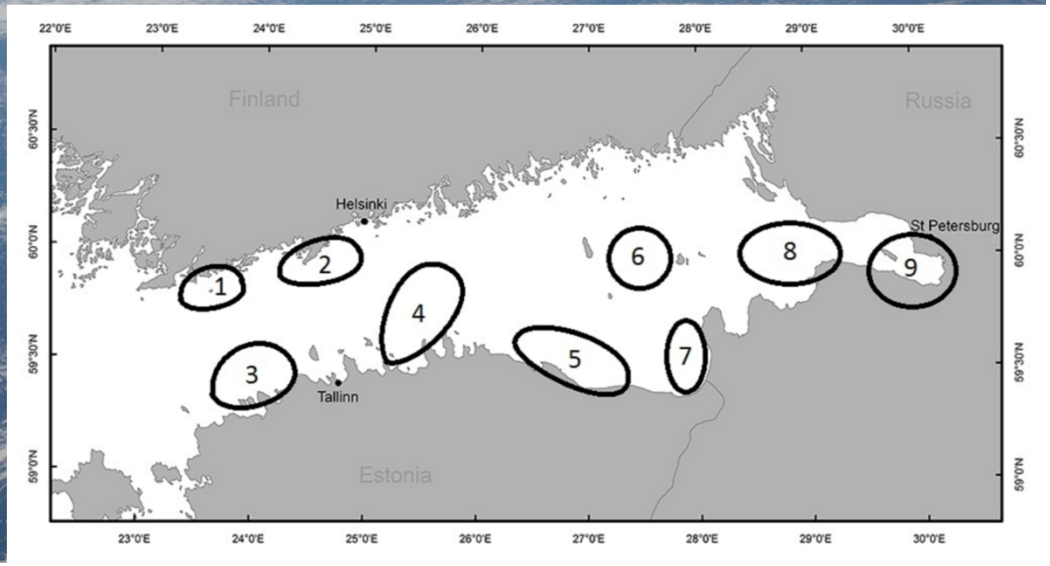
Results

- Some of these areas show this characteristic for over one third of the time.
- They are concentrated along coastal regions, mostly along the southern coast of the Gulf.
- One of these areas is located in the central part of the Gulf, between the islands of Gogland, Bolshoy Tyuters and Moshchny.
- Vertically averaged profiles confirm this asymmetry, implying that the patch formation processes are more likely to occur in the southern parts of the Gulf.
- The presence of area 8 is evidently connected with a persistent area of convergence of the overall cyclonic circulation of the gulf with the voluminous fresh water inflow due to the river Neva.



Conclusions

- We presented an approach to the problem of detection of areas of natural patch-formation.
- This approach matches convergence areas and Lagrangian drift of the forming patches
  in the surface layer.
- We highlighted a rich pattern of possible patch-formation regions in the Gulf of Finland.
- Detected areas show low interannual variations of their basic properties, even if no evident strong pattern can be seen at this stage.
- Several of the nine distinguished areas match the corresponding locations of frequent downwelling regions.
- Some of them are located in a central area of the Gulf, possibly indicating long-term convergence areas of surface currents.




Thank you