

# Drivers of residual circulation in energetic tidal estuaries (such as the Wadden Sea)

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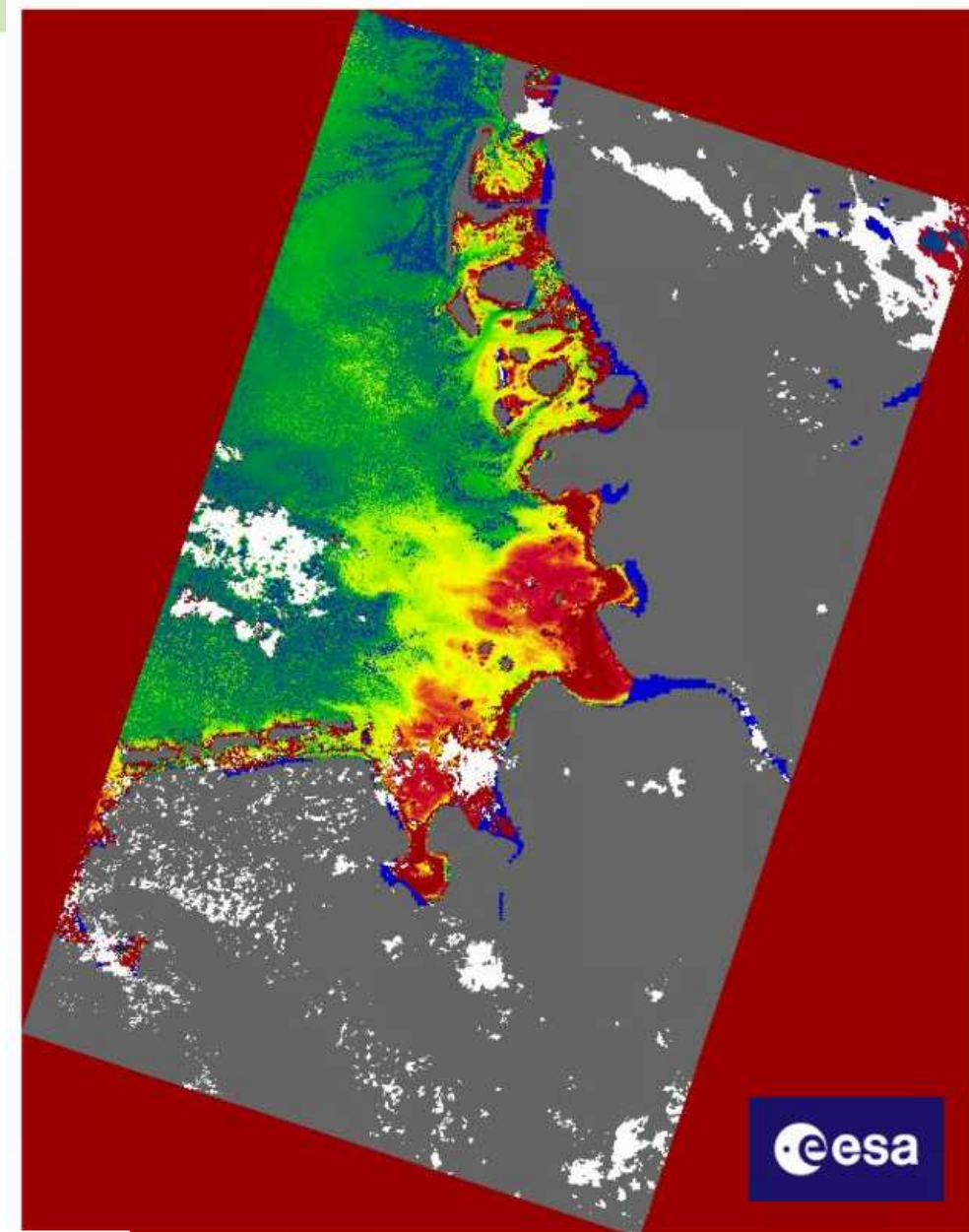
total\_susp [g/m<sup>3</sup>]



esa

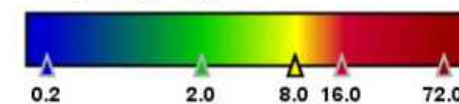
Suspended matter concentrations are substantially increased in the Wadden Sea of the German Bight, without having significant sources at the coast.

Why ?



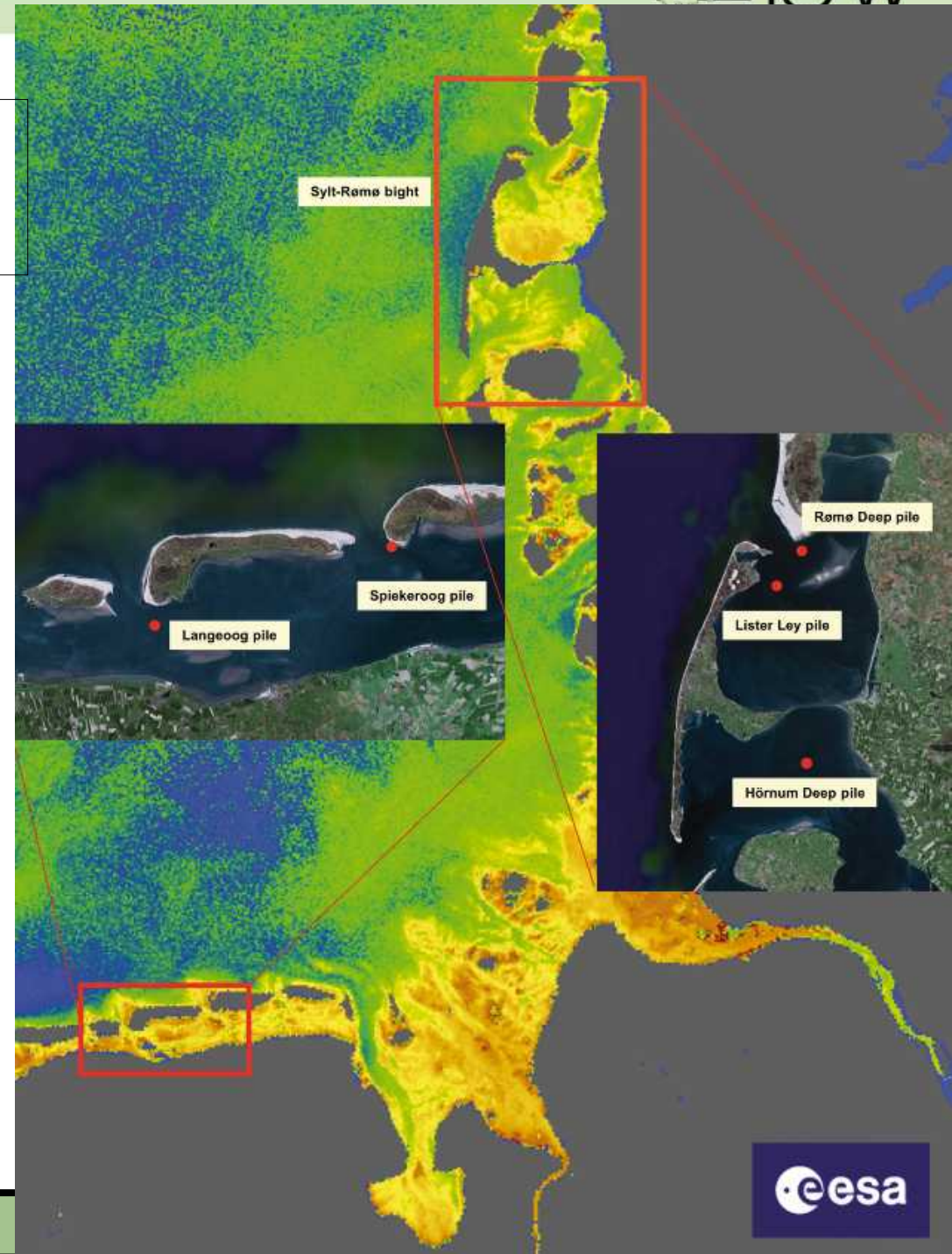
Total suspended matter from MERIS/ENVISAT on August, 12, 2003.

total\_susp [g/m<sup>3</sup>]

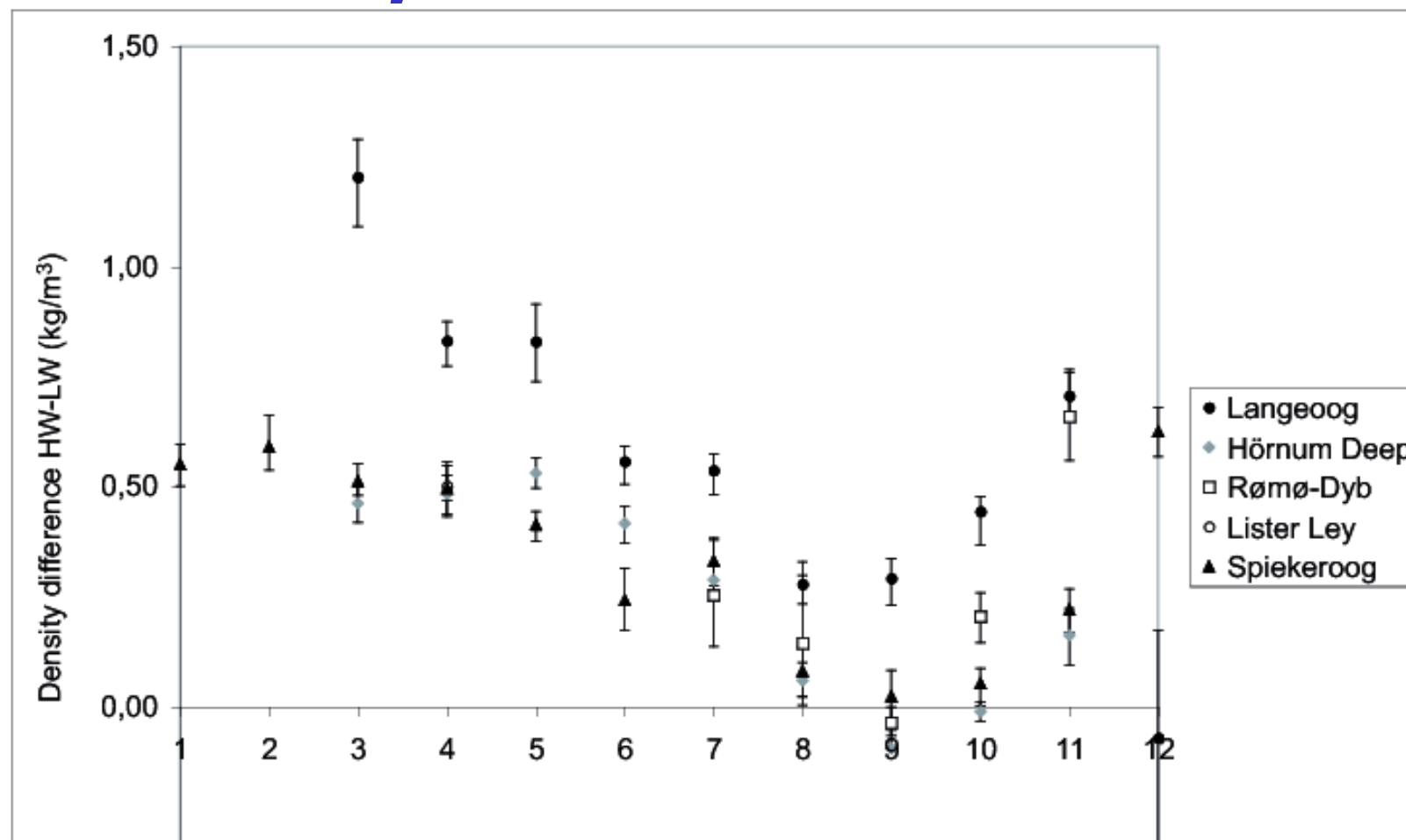


How can we approach this  
with observations ?

Locations of five  
automatic  
monitoring poles in the  
Wadden Sea of the  
German Bight, recording  
temperature and salinity,  
(and thus density).

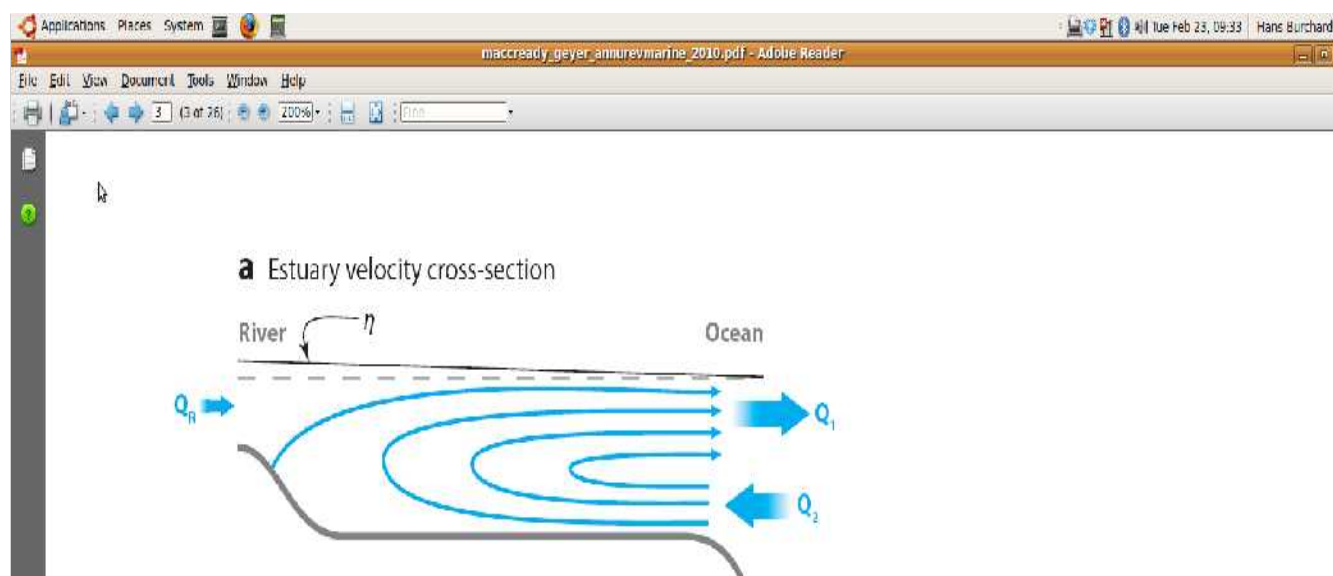


# Density difference HW-LW



Wadden Sea water is generally less dense than the open sea water.

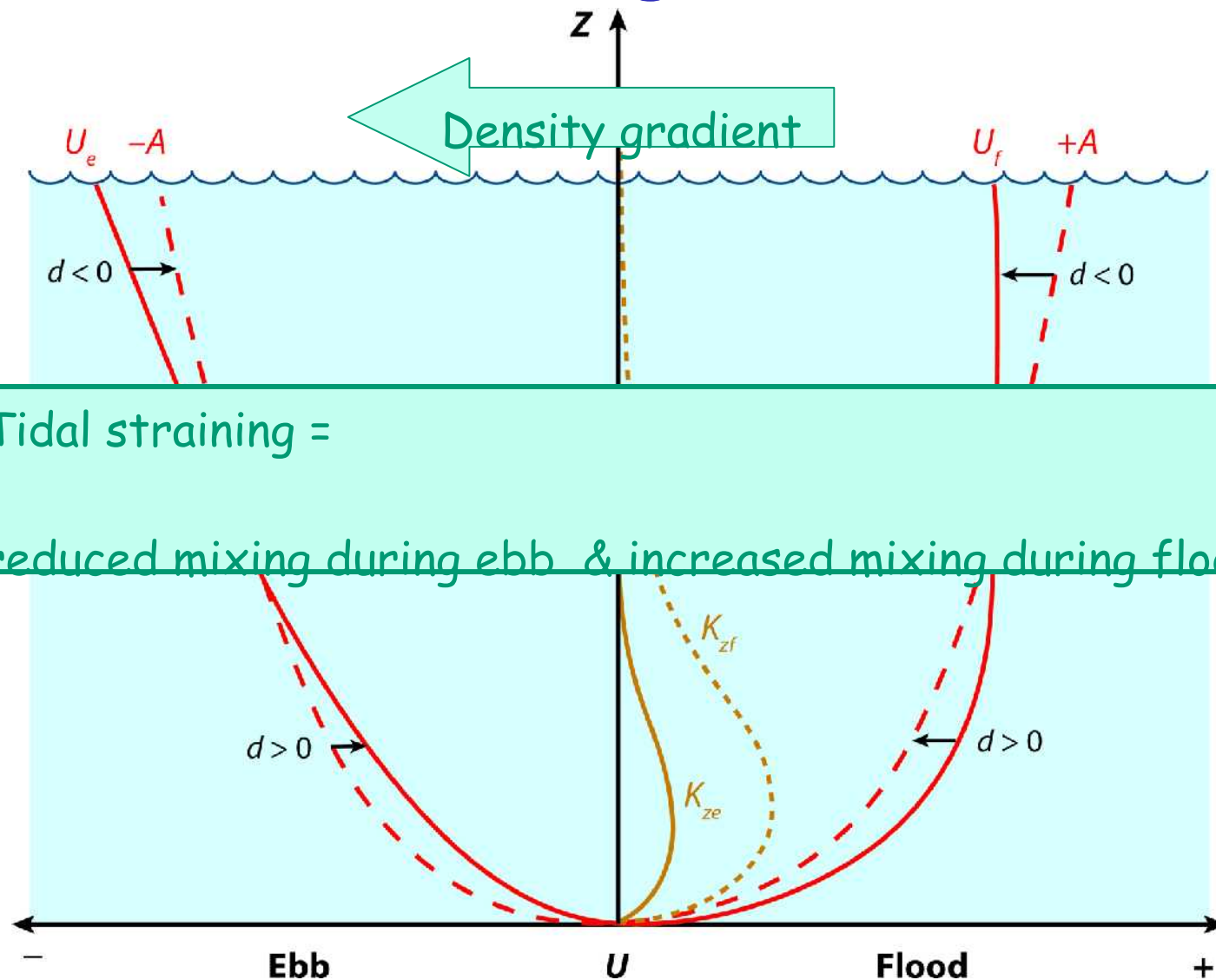
# Gravitational circulation



Zimmerman (1976):

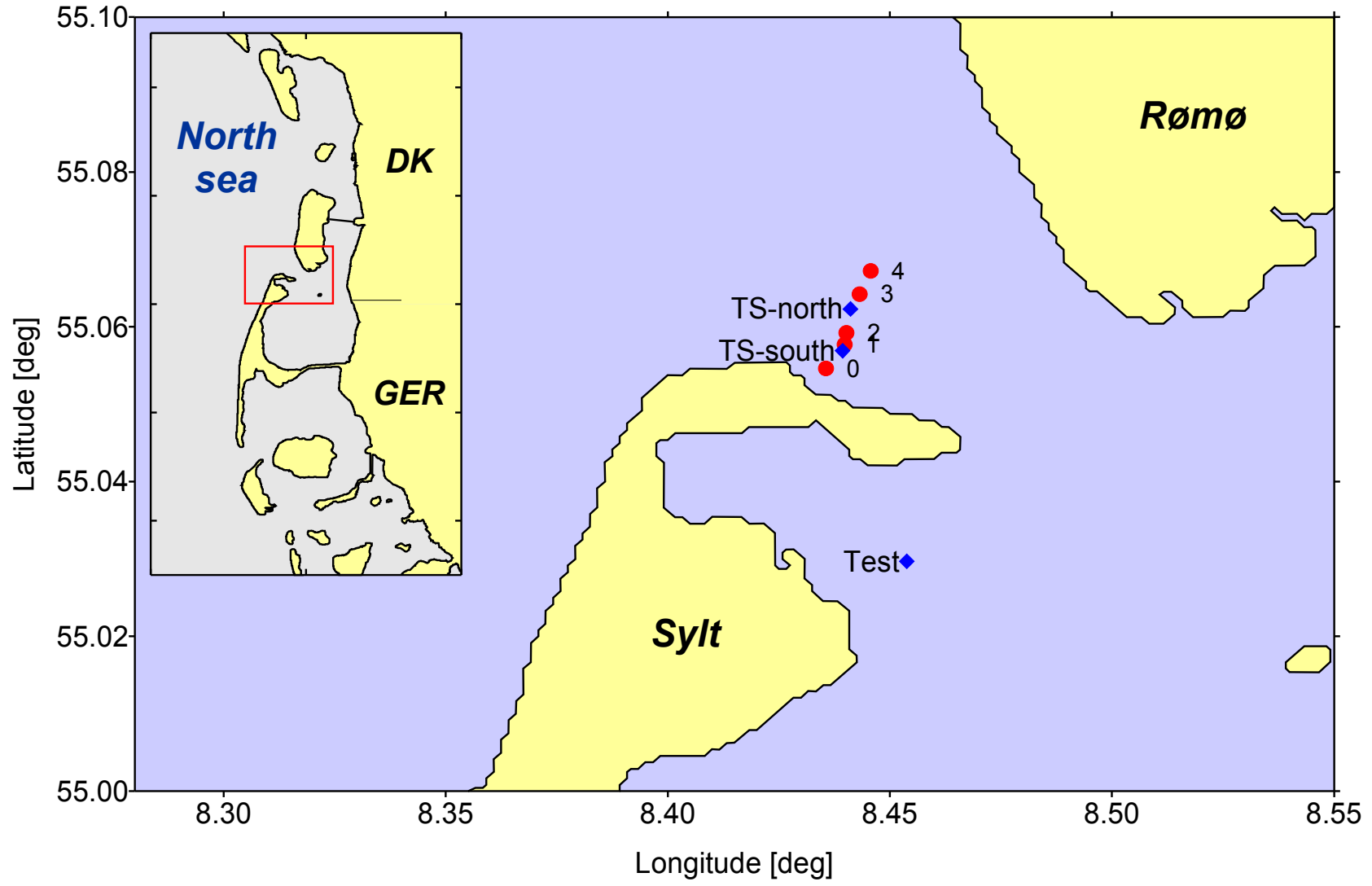
"As been shown by Postma (1954) gravity circulation [...] maybe ignored as a mixing process of importance."

# Tidal straining circulation

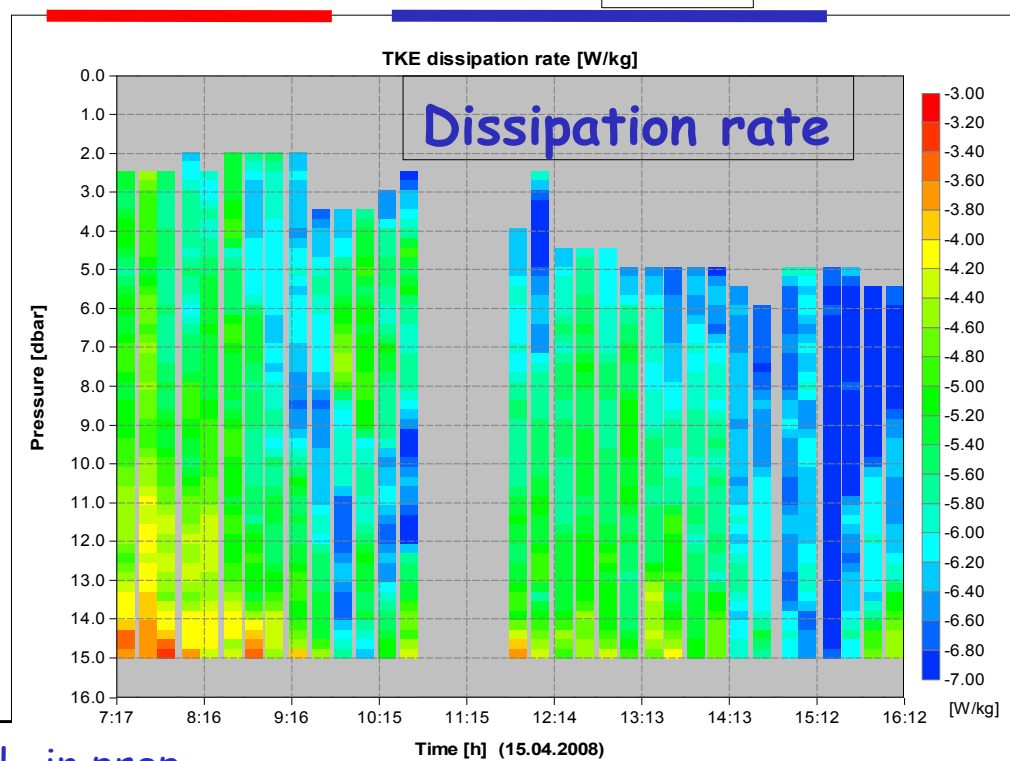
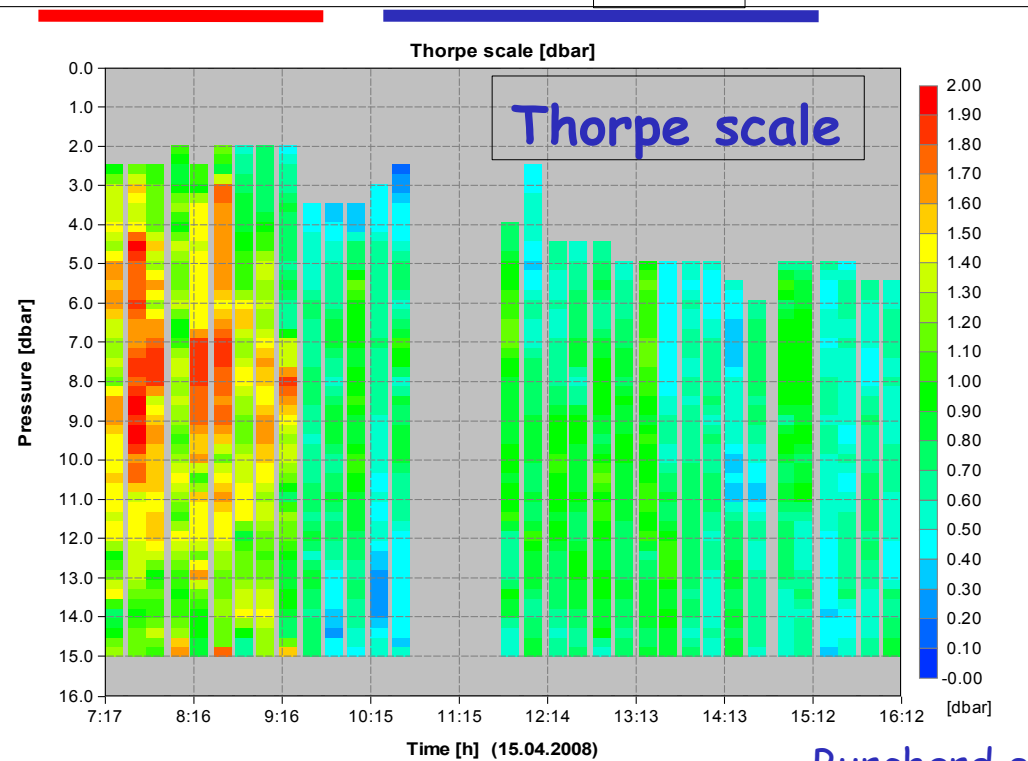
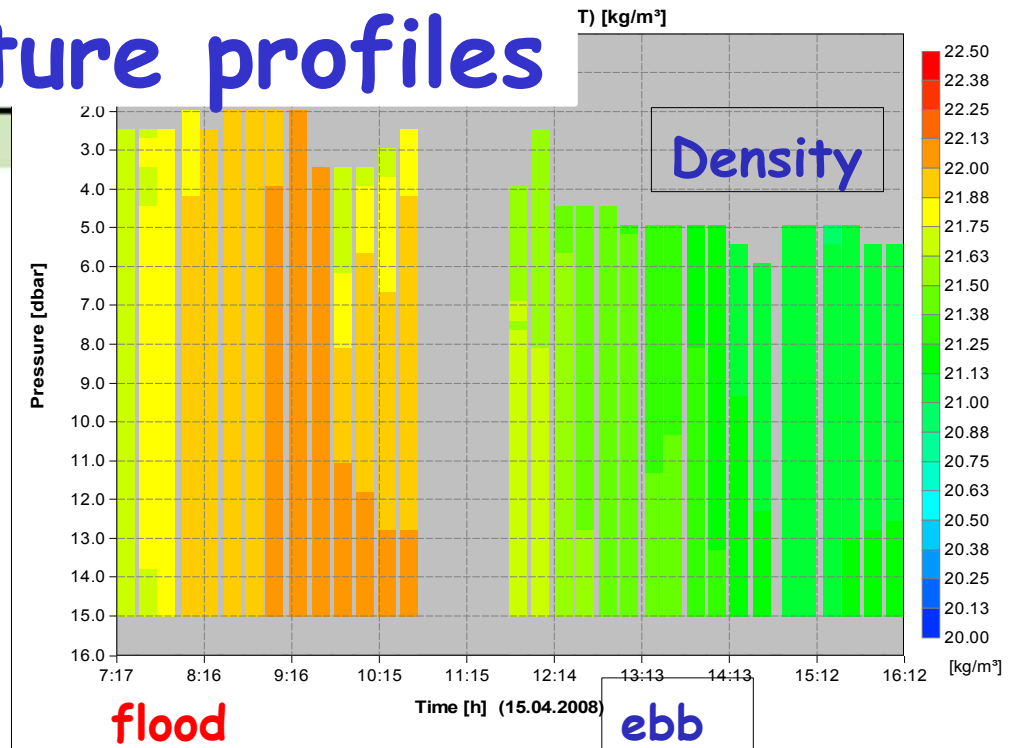
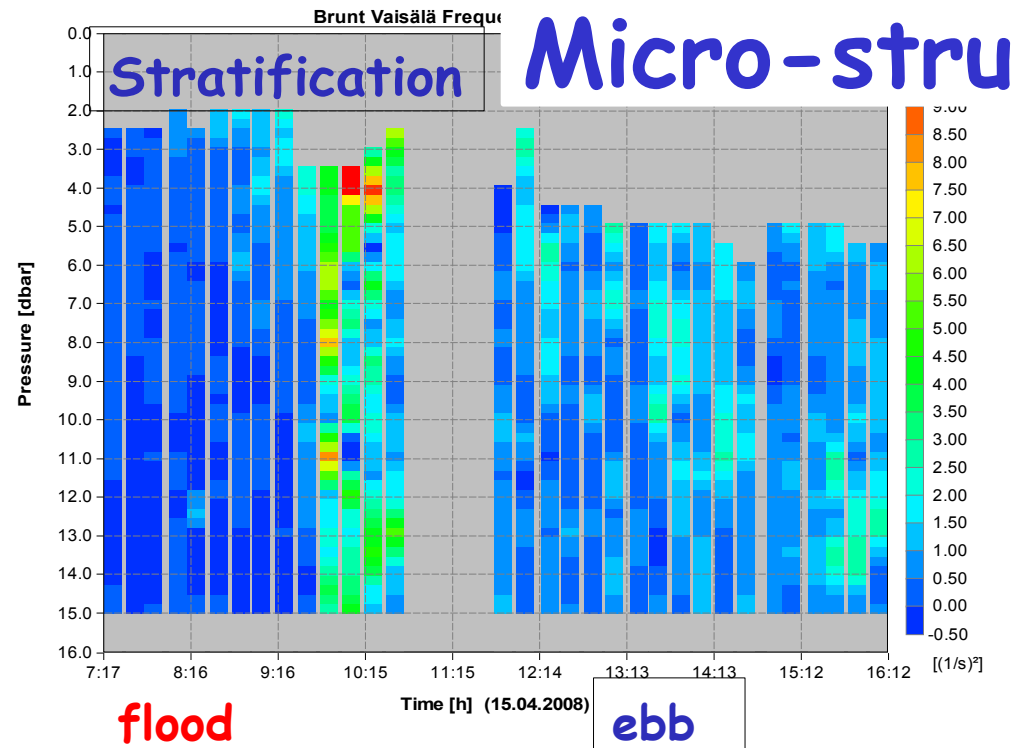


Tidal straining =  
reduced mixing during ebb & increased mixing during flood

# Observational evidence (April 2008)



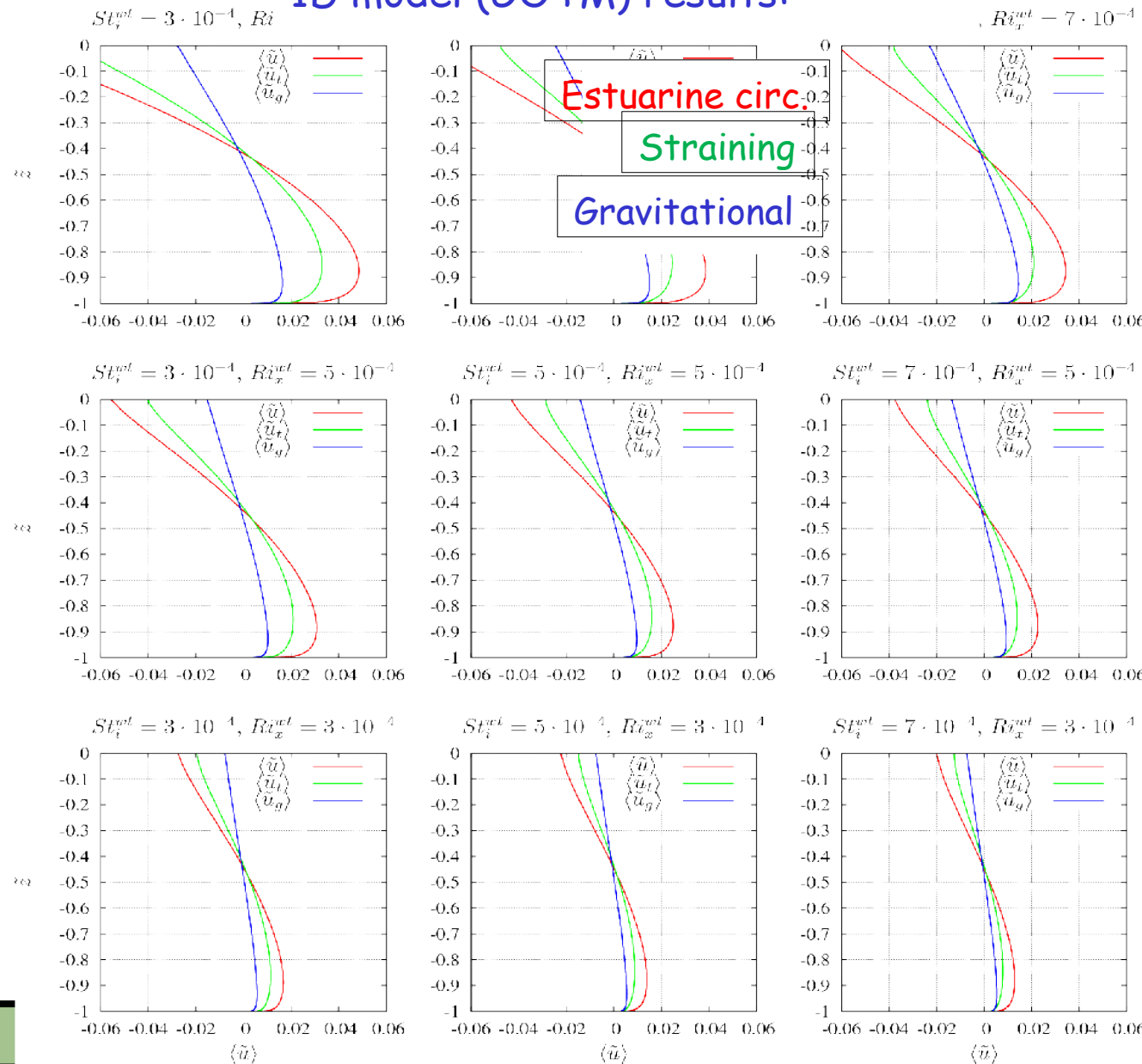
# Micro-structure profiles





# Residual flow profile decomposition

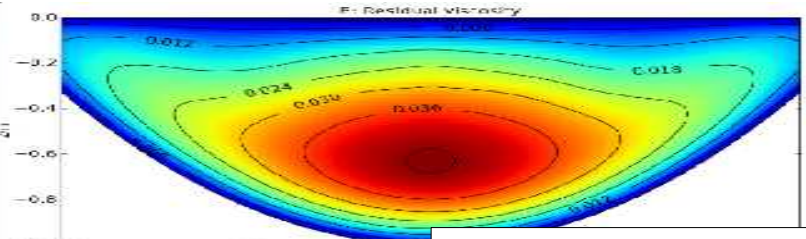
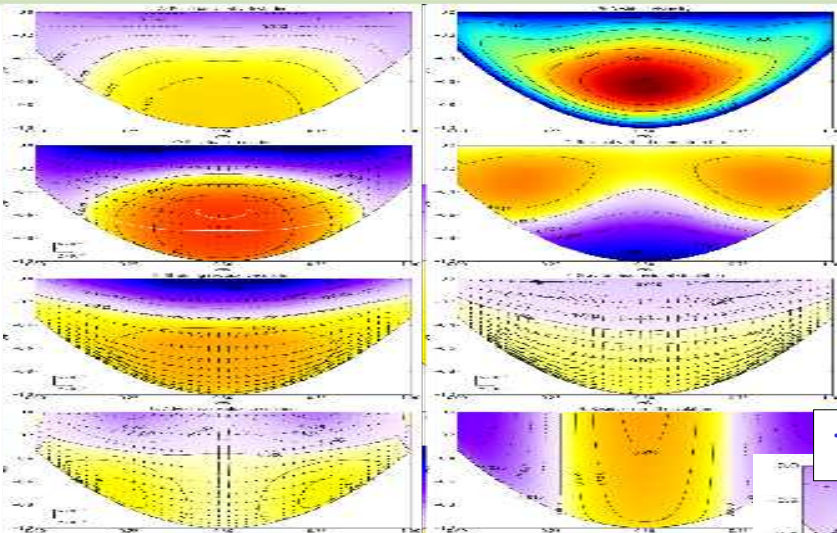
1D model (GOTM) results:



**Result:**  
Tidal straining makes  
about 2/3 of  
estuarine circulation.

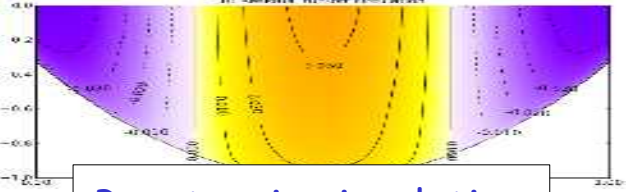
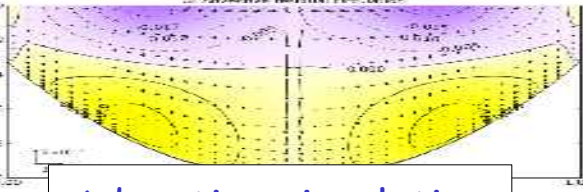
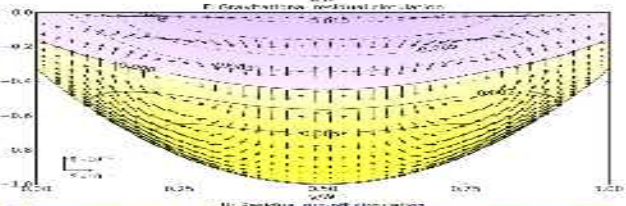
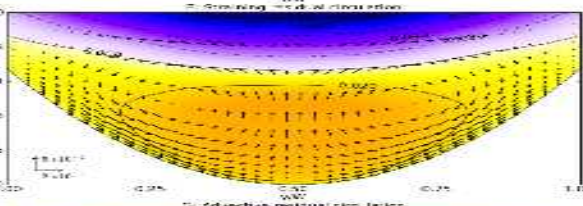
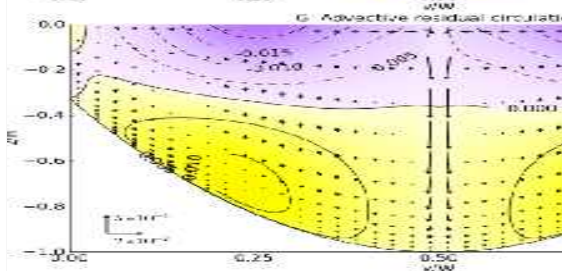
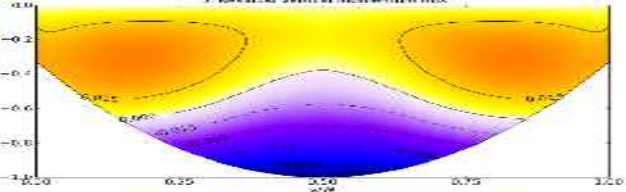
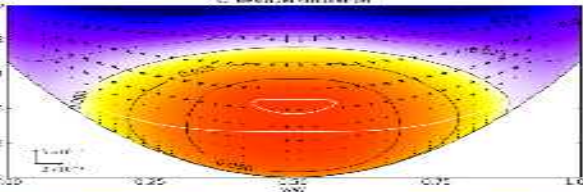
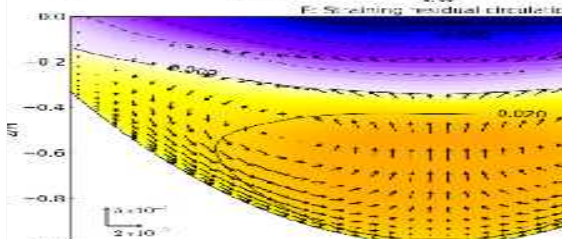
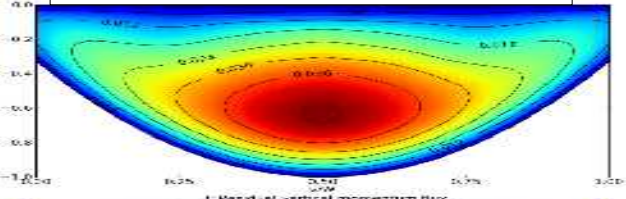
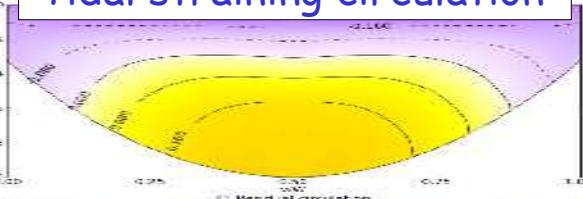
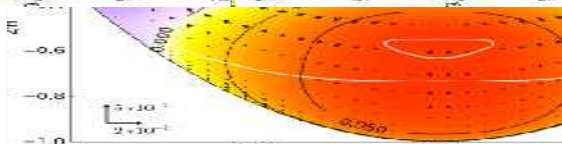
## Circulation in transverse estuary

# Lateral structure of estuarine circulation



Tidal straining circulation

Gravitational circulation



Advective circulation

Barotropic circulation

# GETM

General Estuarine Transport Model



WHO'S ONLINE

We have 3 guests online

NEWSFLASH

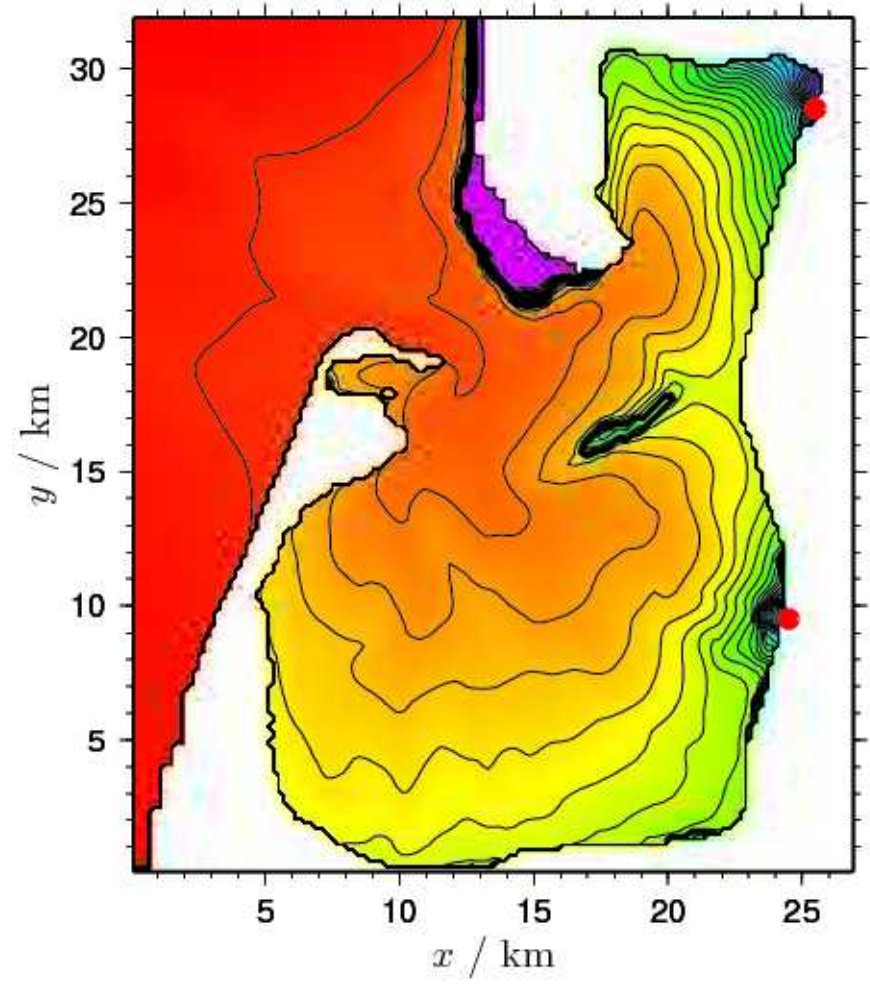
The new GETM web page

## Approach:

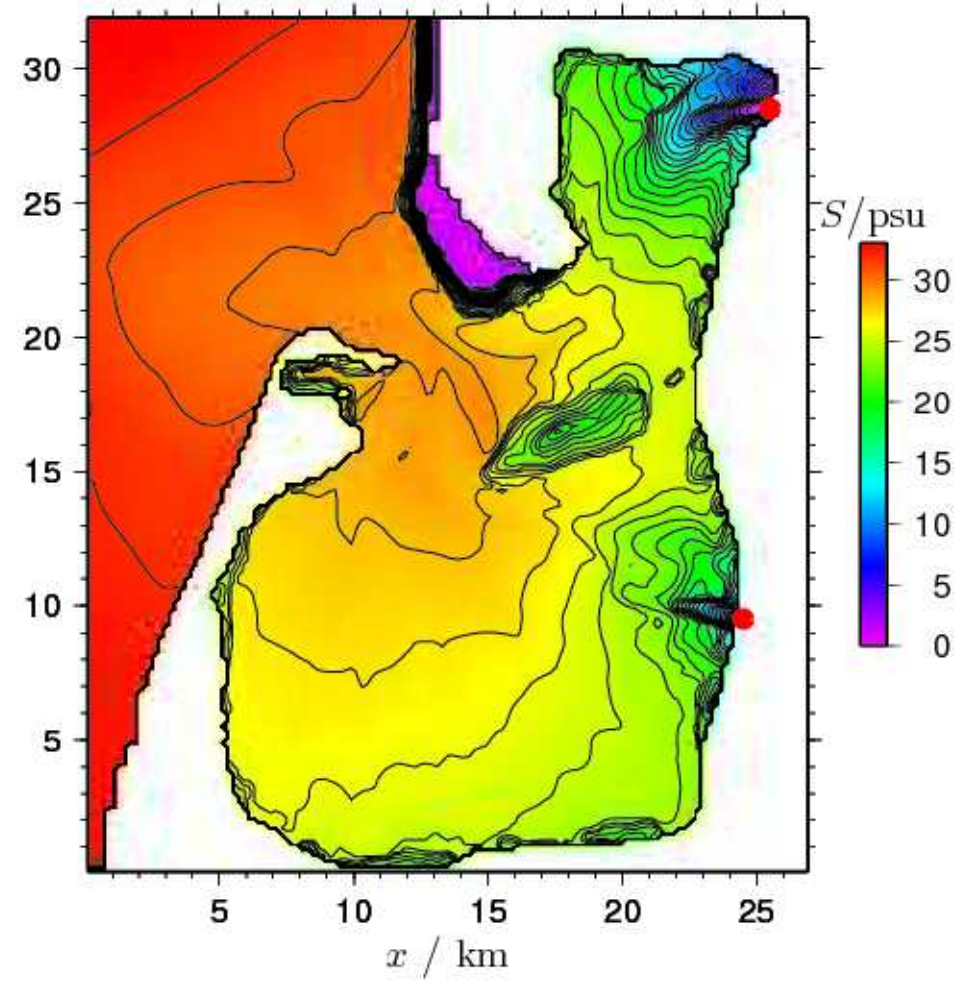
1. Simulating a closed Wadden Sea basin (Sylt-Rømø bight) with small freshwater-runoff and net precipitation.
2. Spin up model **with variable** and **with constant density** until periodic steady state.
3. Then initialise both scenarios with const. SPM concentration.
4. Quantify SPM content for control volume.

## Surface salinity at high and low water

Surface salinity at high water

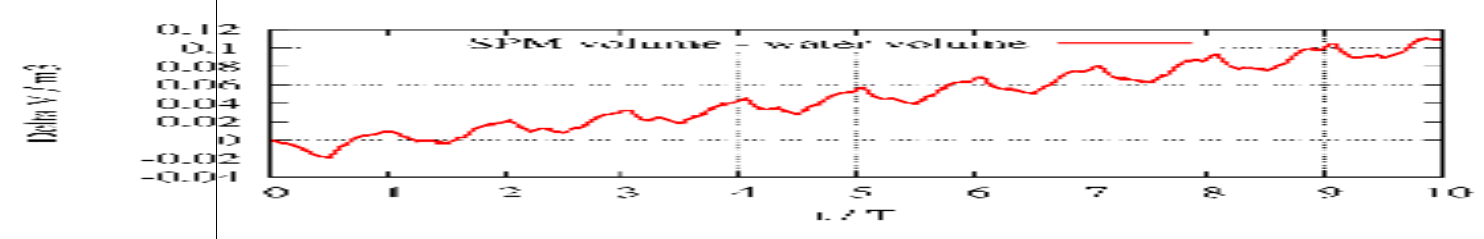
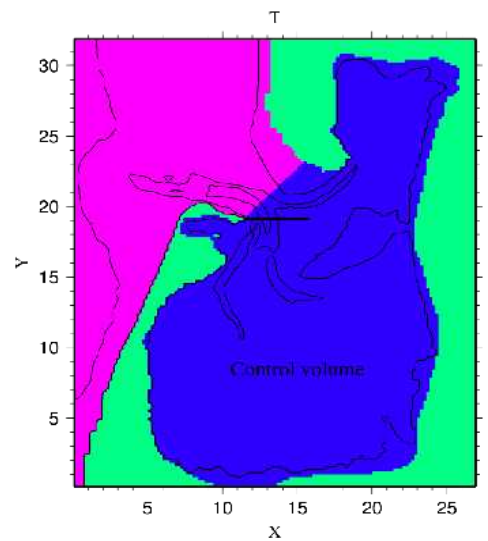
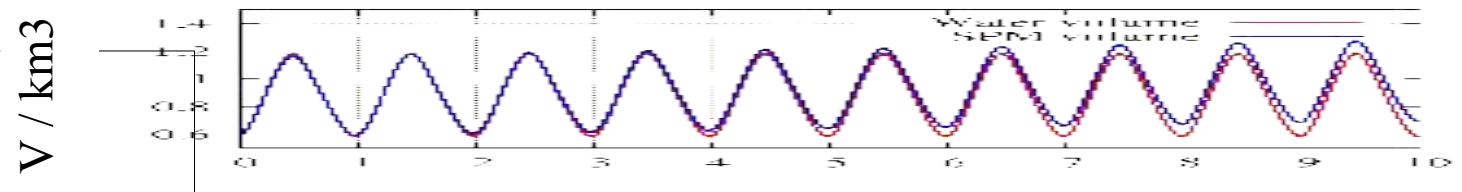


Surface salinity at low water



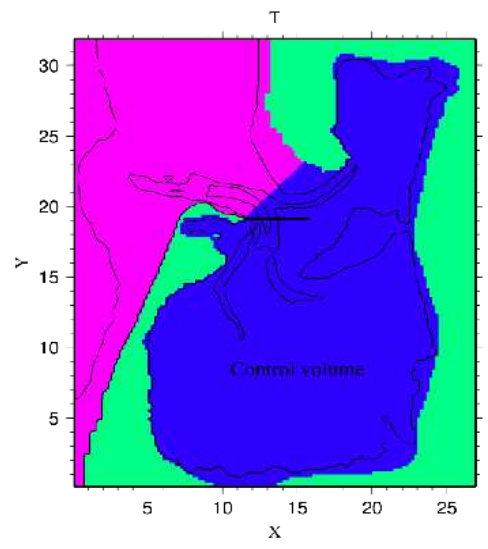
# Total water and SPM volume

With density differences

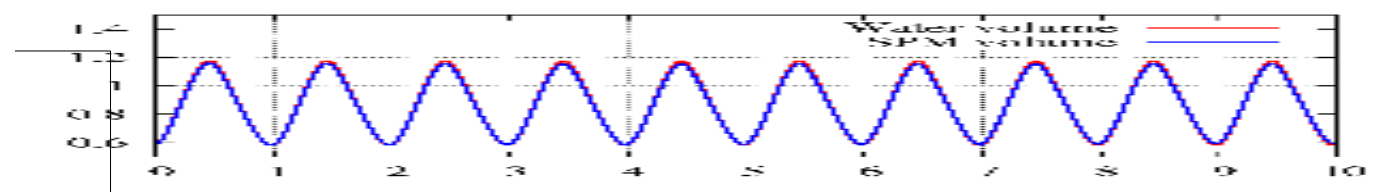


# Total water and SPM volume

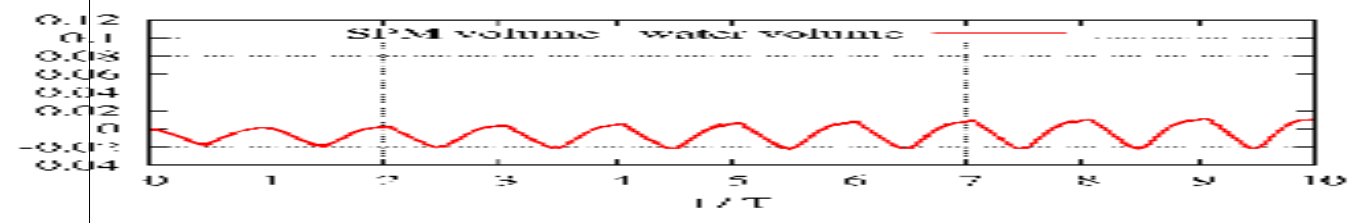
Without density differences



V / km<sup>3</sup>



Delta V / m<sup>3</sup>



## Conclusions

For tidally energetic estuaries, tidal straining is the dominant process in generating estuarine circulation.

In the Wadden Sea, tidal straining has the potential to generate landward suspended matter transport.

This has implications on nutrient transport into the Wadden Sea. □ Presentation by Justus van Beusekom

This theory leads to a new hypothesis:

~~The Wadden Sea is the major recipient of rain.~~  
to keep the Wadden Sea floor  
in sync with sea level rise.