

## Combining SES and ADCP to measure mud transport processes in tide-controlled estuaries

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### Contact

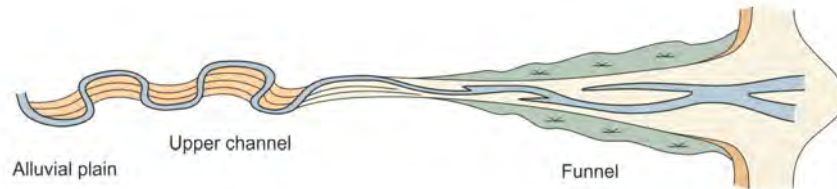
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## Combining SES and ADCP to measure mud transport processes in tide-controlled estuaries

Marius Becker



Christian Maushake

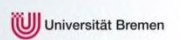


Christian Winter



Alexander Bartholomä

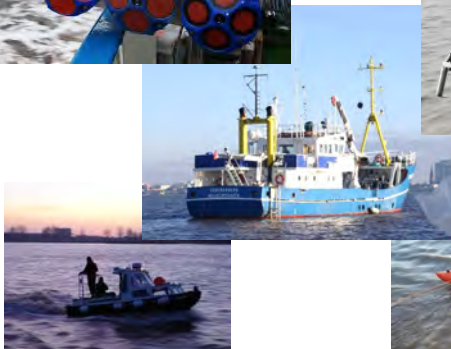
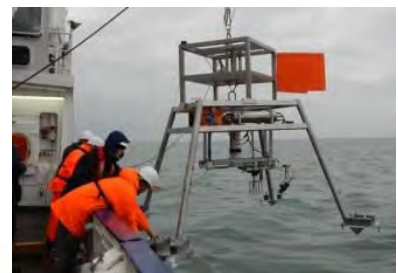
Kerstin Schrottke



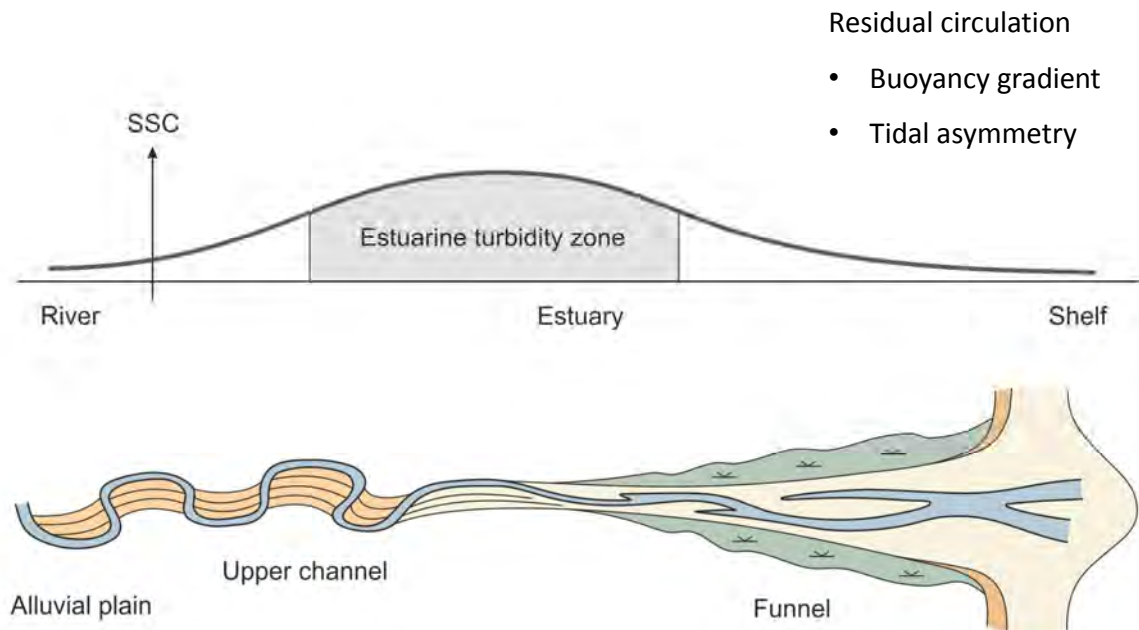
## Combining SES and ADCP to measure mud transport processes in tide-controlled estuaries

MARUM Coastal Dynamics

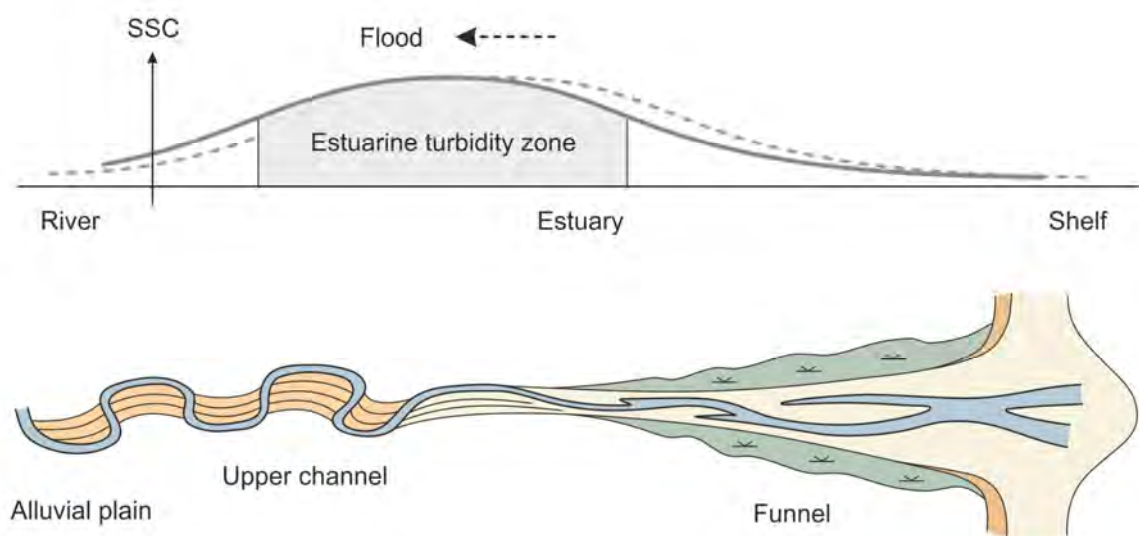
Christian Winter



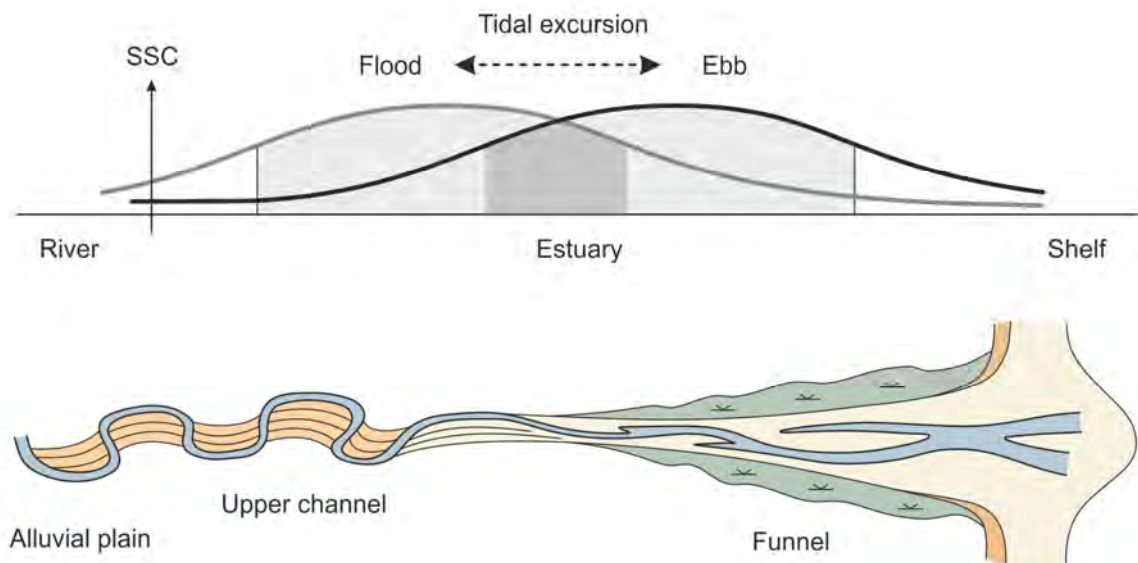
### Trapping of suspended sediments



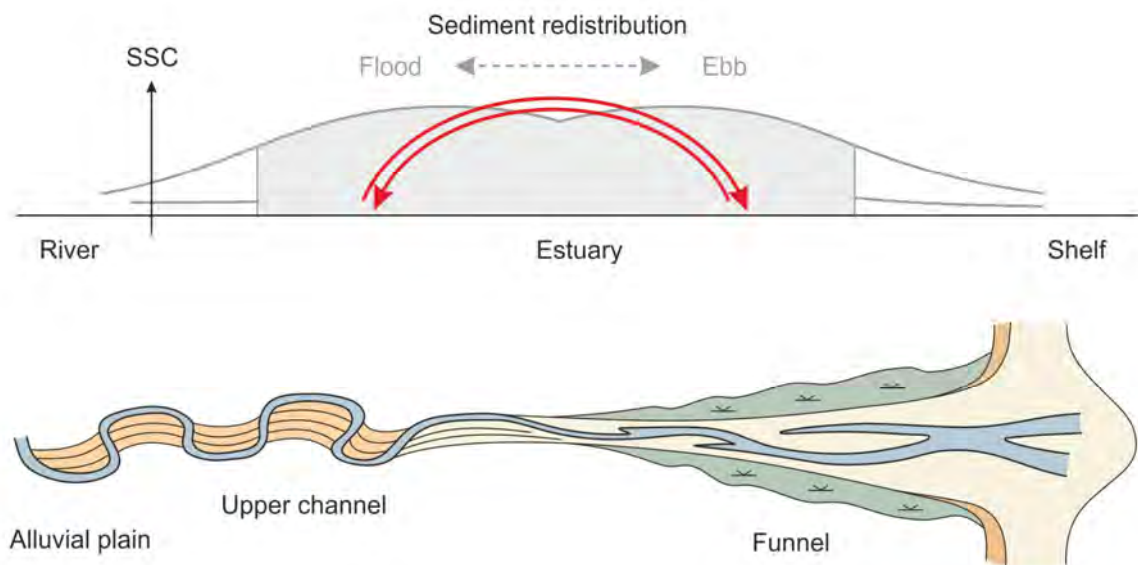
### Tidal excursion



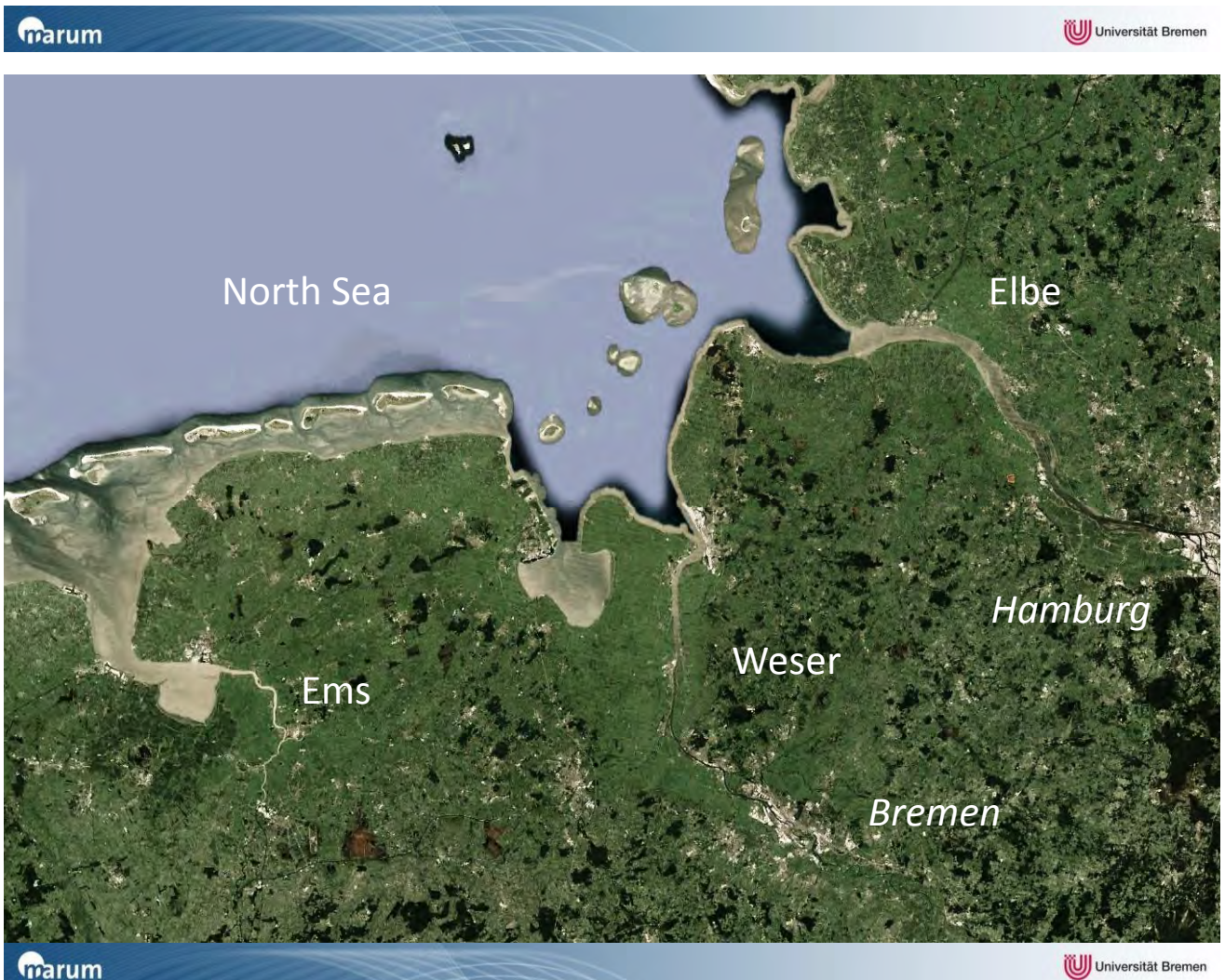
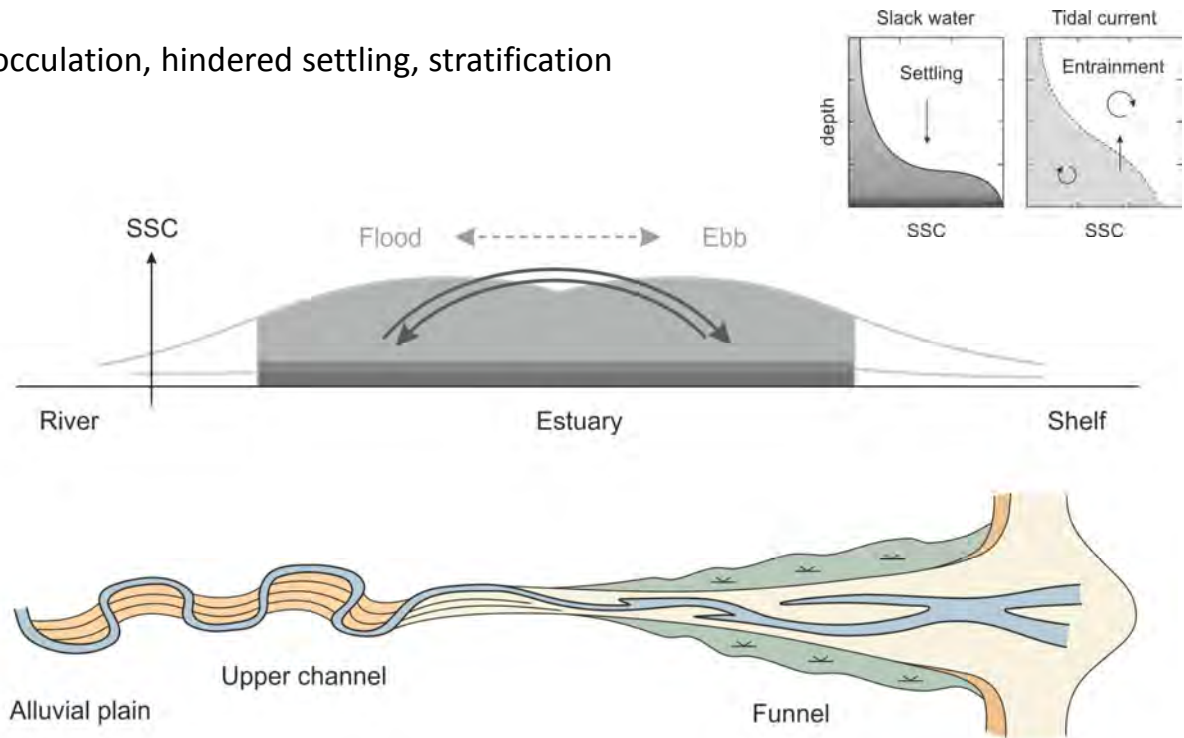
### Tidal excursion



### Entrainment, advection, settling



### Flocculation, hindered settling, stratification



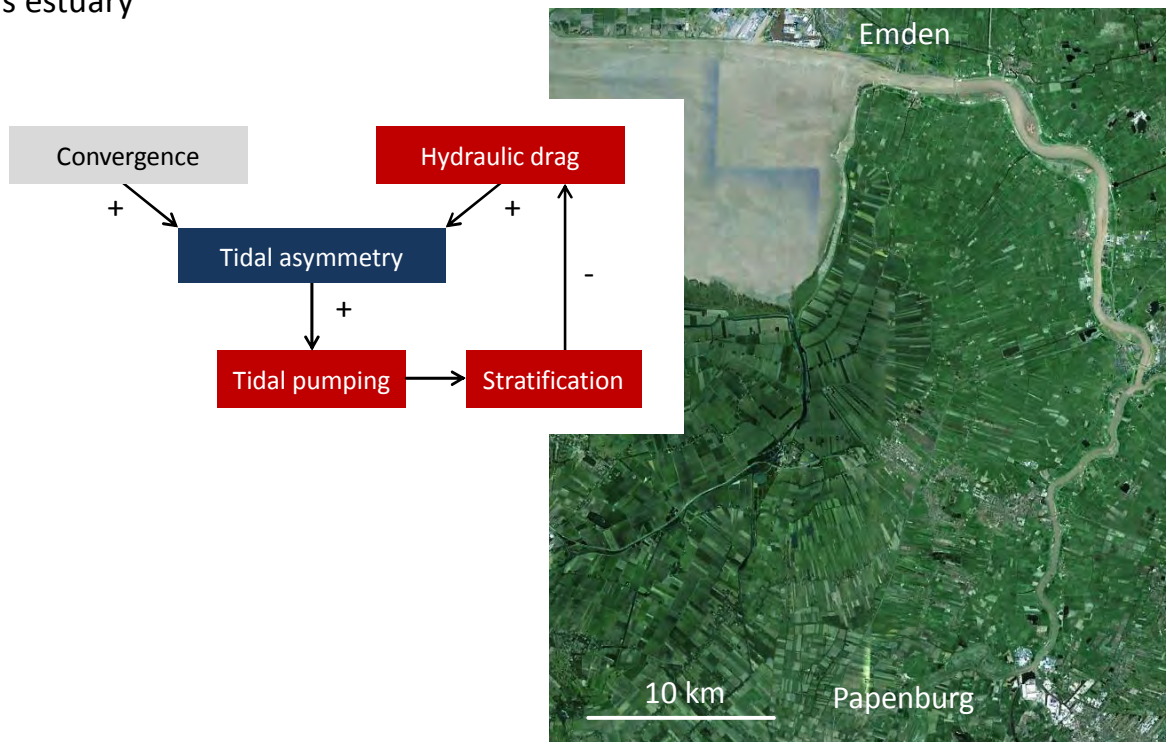
### Ems estuary

- Sediment stratification
- ETM decoupled from salt wedge
- Large scale fluid mud formation

discharge	80 m <sup>3</sup> s <sup>-1</sup>
SSC <sub>ETM</sub>	5 g l <sup>-1</sup>
tidal excursion	15 km
depth	8 m
tidal influence	65 km
tidal elevation	3.5 m



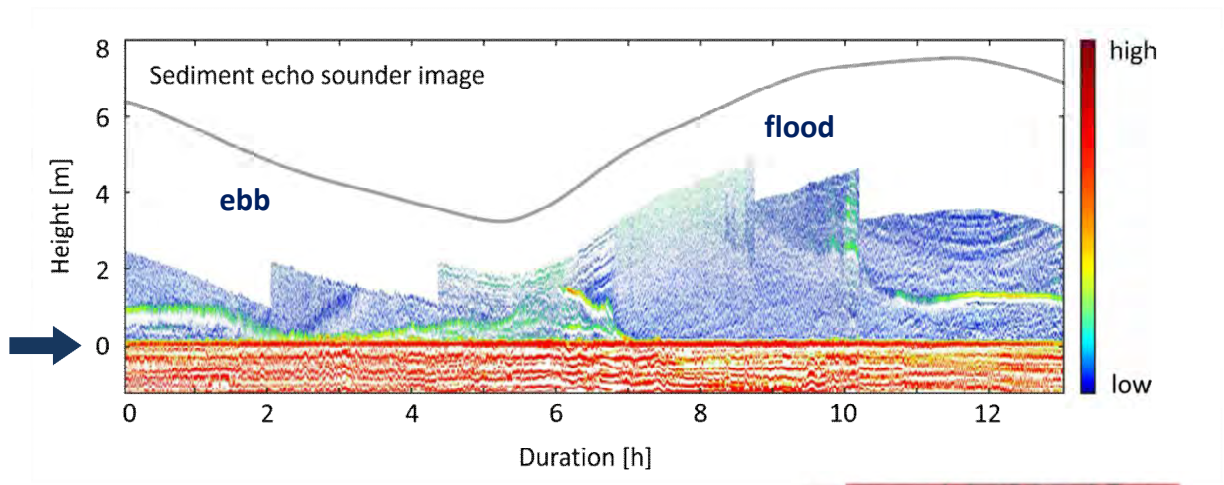
### Ems estuary



following Winterwerp et al. (2013a, 2013b) OD and others



Ems, tidal cycle: sediment stratification

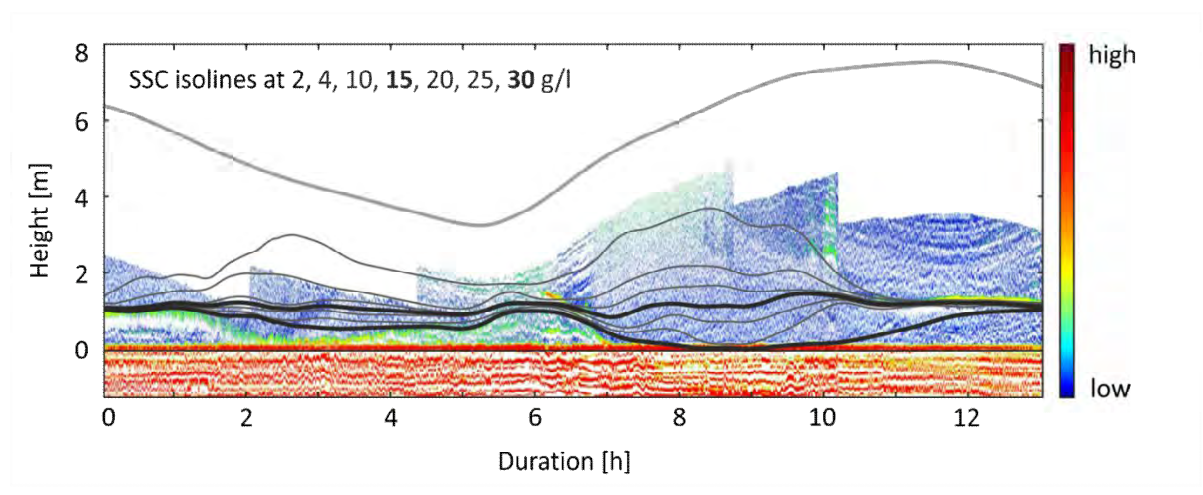


Tidal asymmetries ...

- sediment stratification



Ems, tidal cycle: SSC

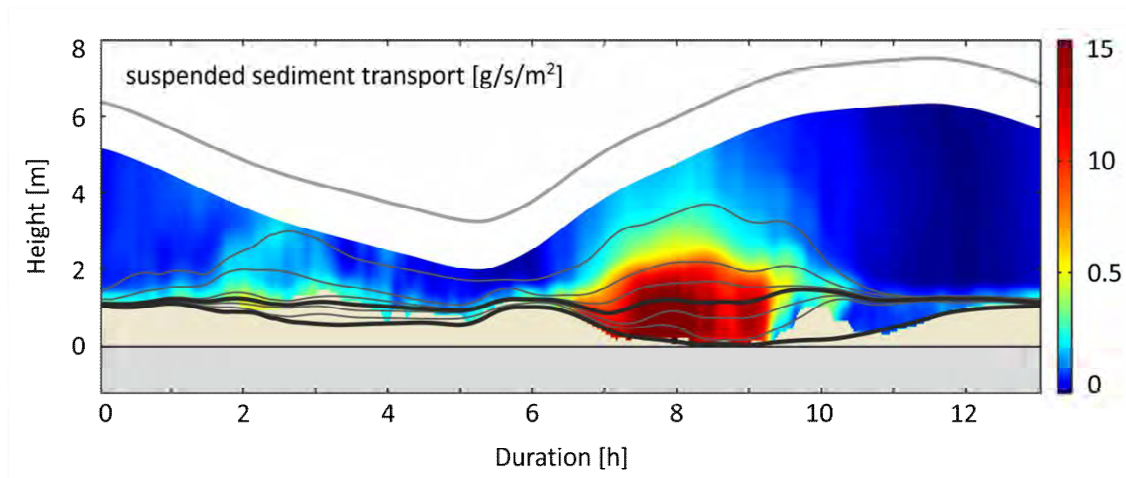


Tidal asymmetries ...

- sediment stratification
- entrainment



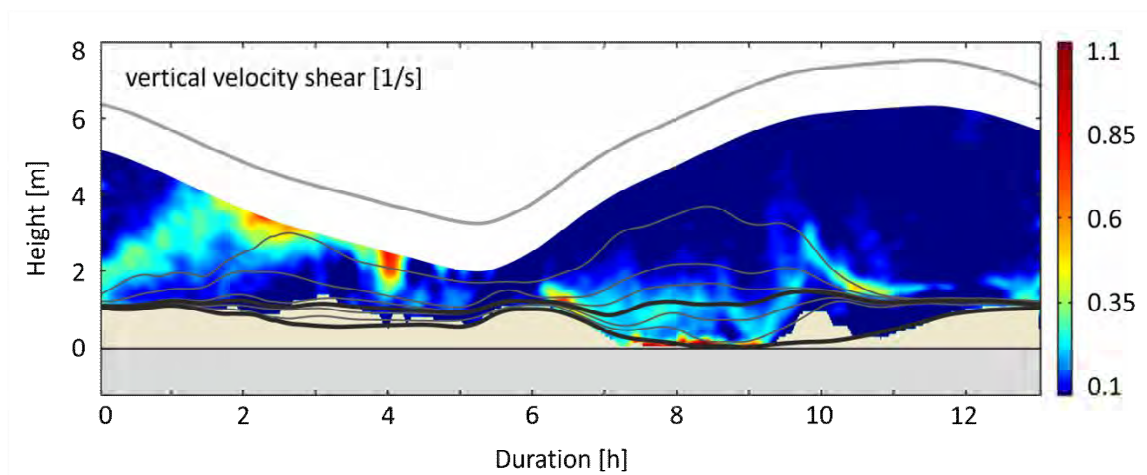
## Ems, tidal cycle: sediment transport



Tidal asymmetries ...

- sediment stratification
- entrainment
- transport

## Ems, tidal cycle: velocity shear



Tidal asymmetries ...

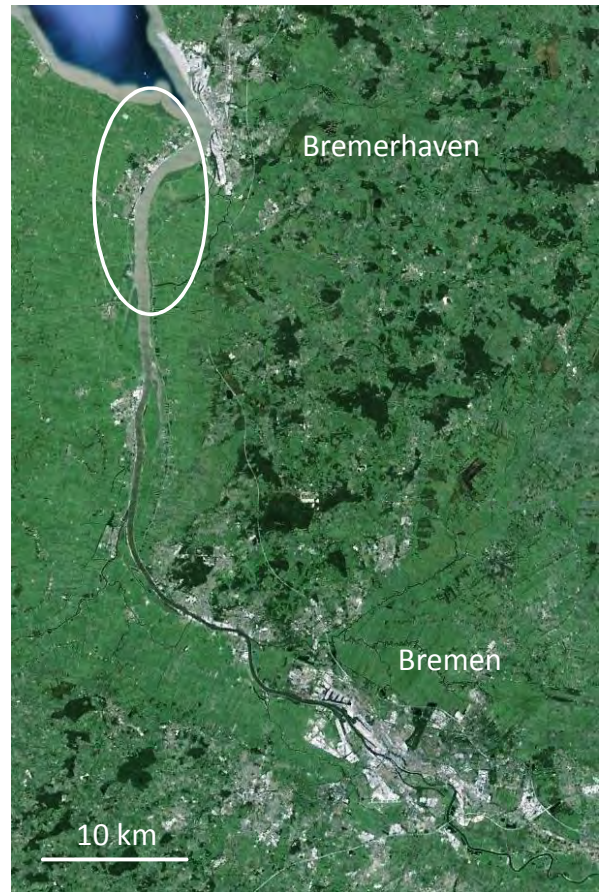
- sediment stratification
- entrainment
- transport



### Weser estuary

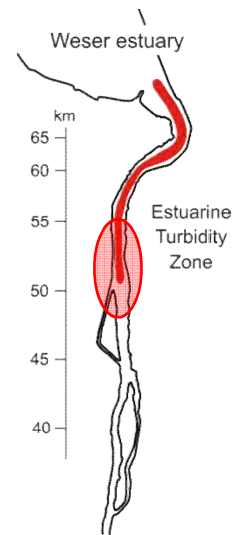
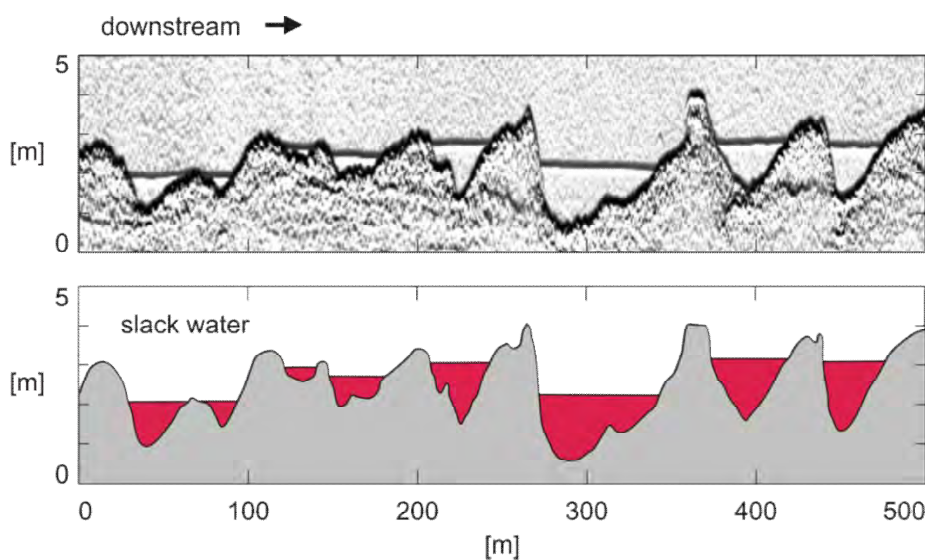
discharge	350 m <sup>3</sup> s <sup>-1</sup>
SSC <sub>ETM</sub>	0.25 g l <sup>-1</sup>
tidal excursion	15 km
depth	12 m
tidal influence	70 km
tidal elevation	3.5 m

- periodically stratified (salt)
- ETM near tip of salt wedge



### Fluid mud in dune troughs

#### Slack water



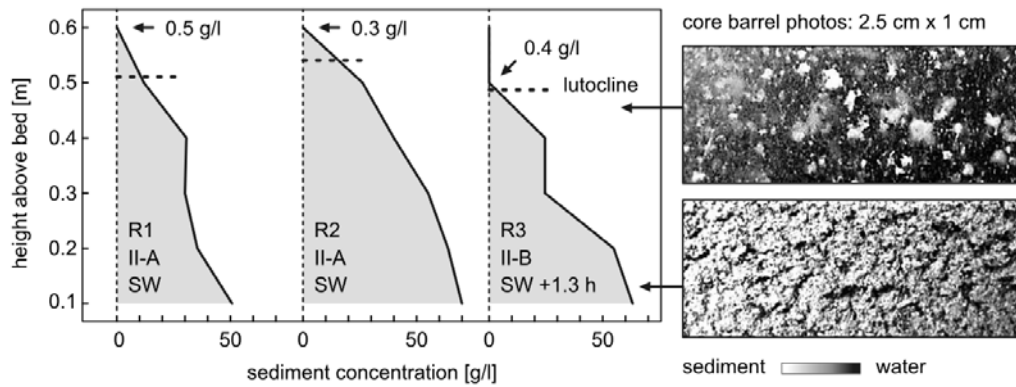
Becker et al. (2013) JGR



Fluid mud in dune troughs

Slack water

- Gravity cores: 20 g/l - 70 g/l, large mud floccs (< 2.5 mm)
- Layer thickness: max. 2 m, gelling point, fluid mud

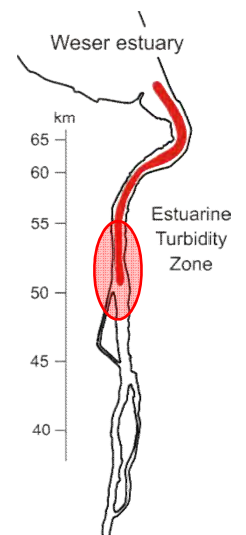
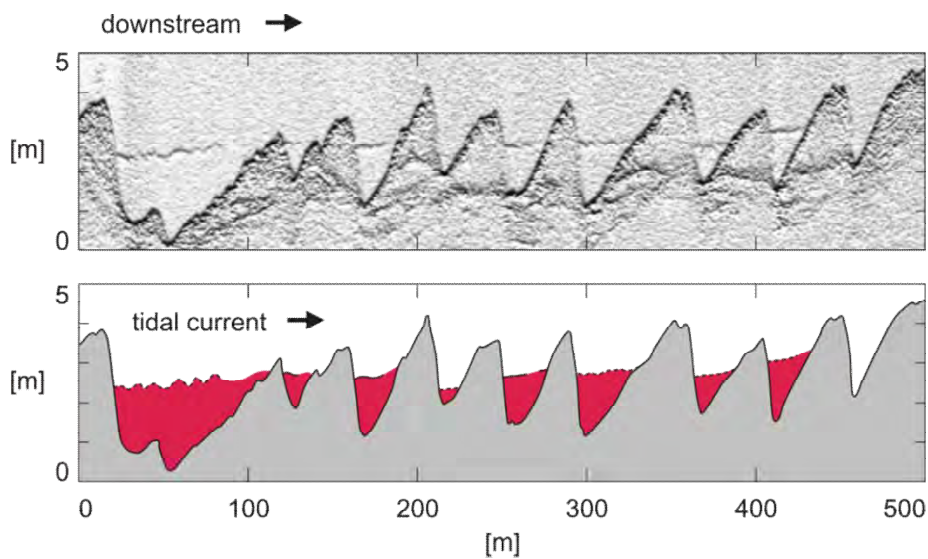


Becker et al. (2013) JGR



Fluid mud in dune troughs

Early ebb phase

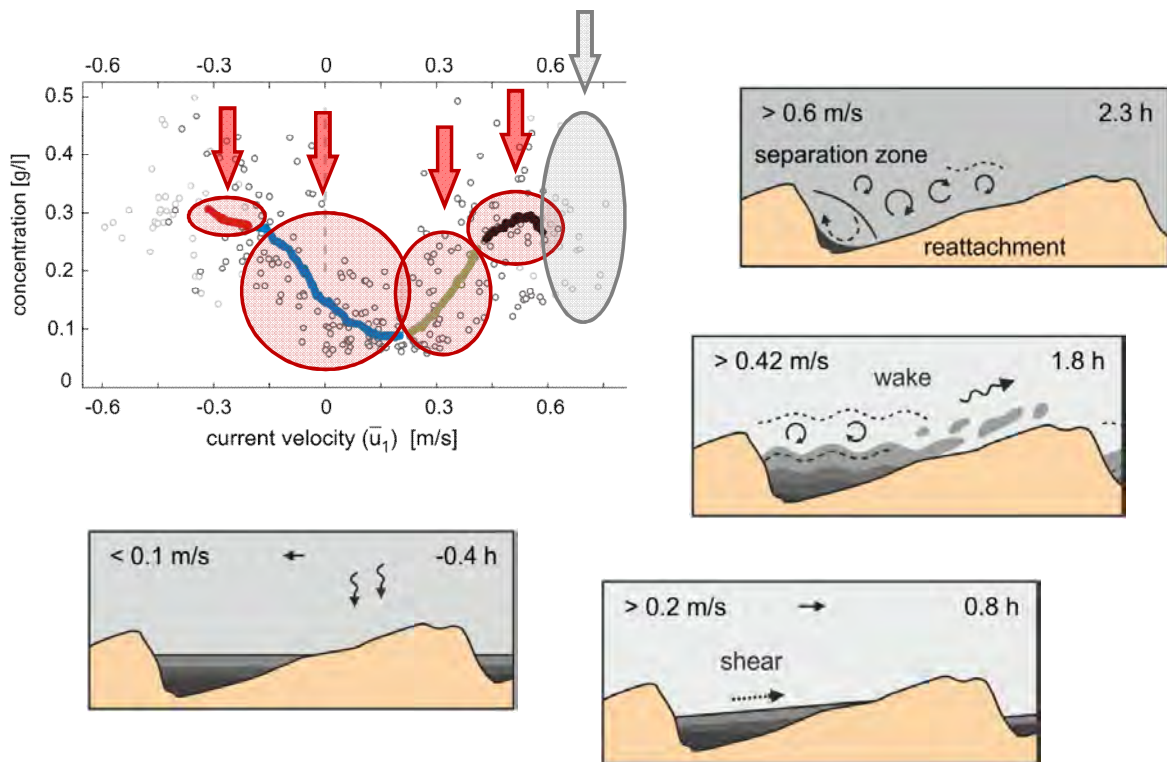


- Entrainment: inclination, internal waves

Becker et al. (2013) JGR



Fluid mud in dune troughs



Becker et al. (2013) JGR



Fluid mud entrainment

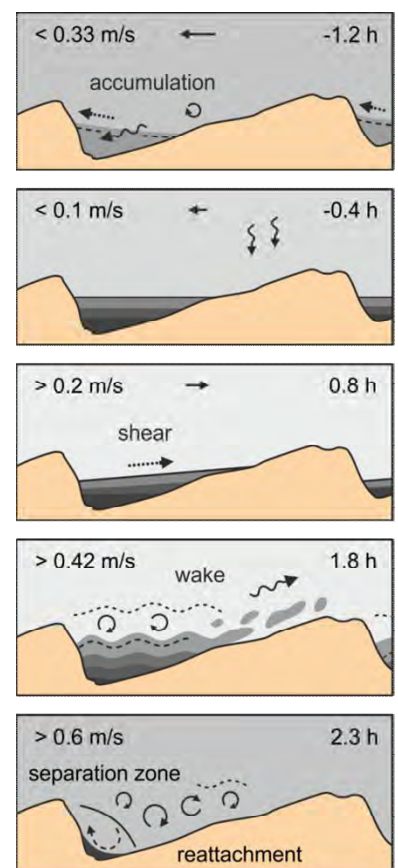
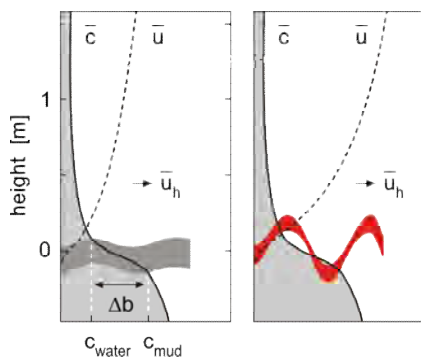
Gradient Richardson Number ( $Ri_g$ )

- Concentration gradient versus velocity gradient

$$\overline{Ri}_g = -h \Delta b / \bar{u}_h^2$$

$$\Delta b = g(\rho_0 - \rho_L) / \rho_0$$

$$Ri_g = 1.3 > 0.25$$



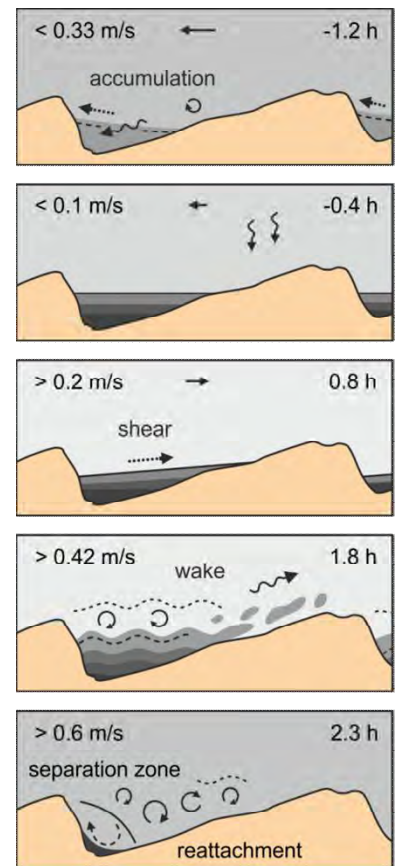
Becker et al. (2013) JGR



Fluid mud entrainment

Gradient Richardson Number ( $Ri_g$ )

- Concentration gradient stable regarding growth of shear instabilities
- Entrainment induced by advection of turbulent stresses generated at the dune crest

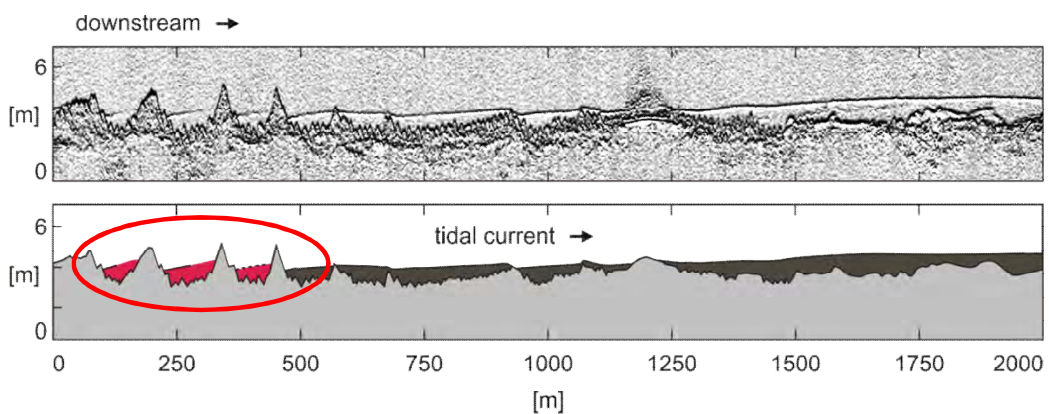


Becker et al. (2013) JGR



Fluid mud entrainment

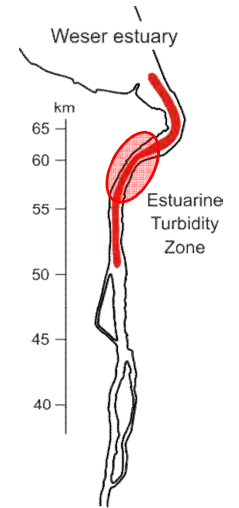
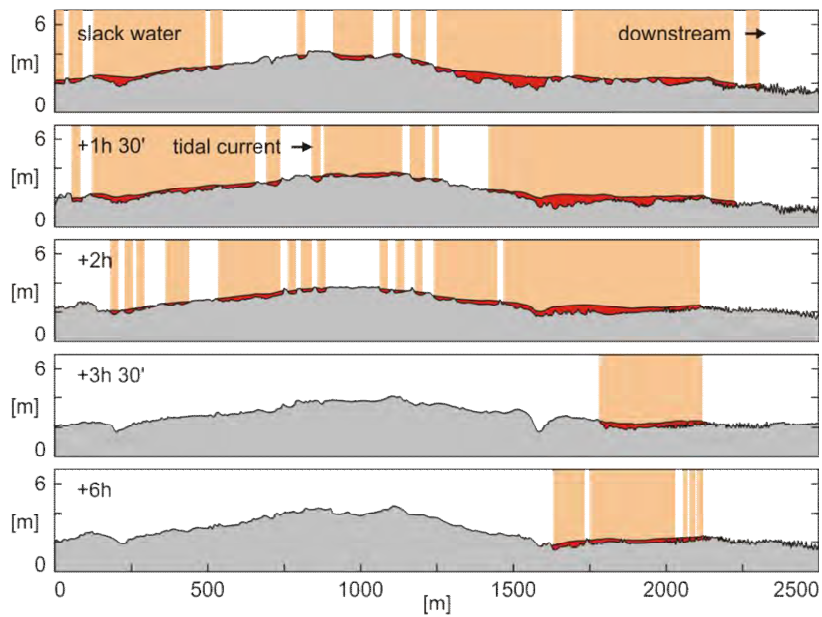
Entrainment of fluid mud in dune troughs: 2 h after slack water



Becker et al. (2013) JGR



Mobile mud, only partly entrained during one tidal phase



### Summary

