



department

SedNet conference 2013

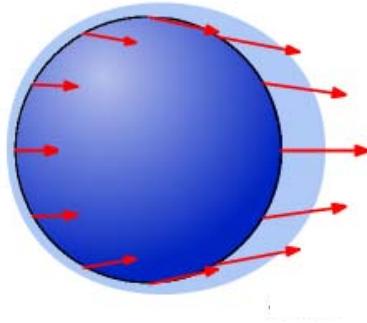
Mobility and
Public Works

How the tides changed in the Schelde-estuary
under influence of natural changes and human
interference

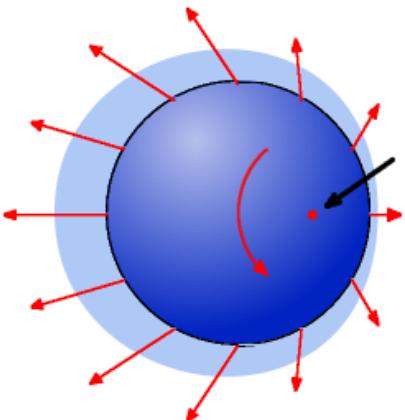
Ir. Yves Plancke & Ir. E. Taverniers
Lisboa, 6-9 November 2013

How the tides...

Gravitational attraction earth – moon



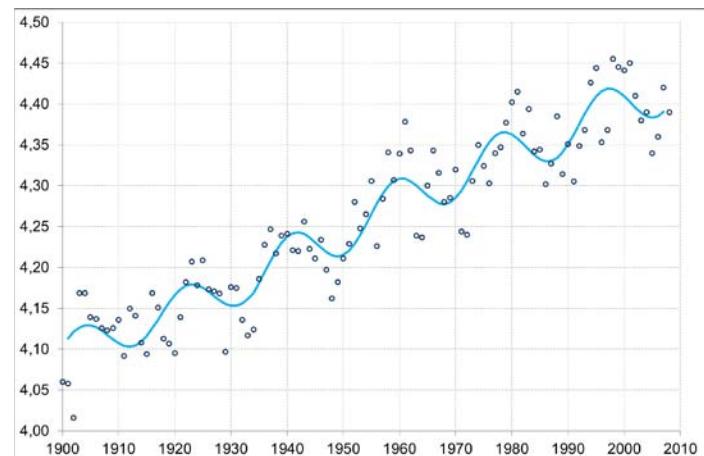
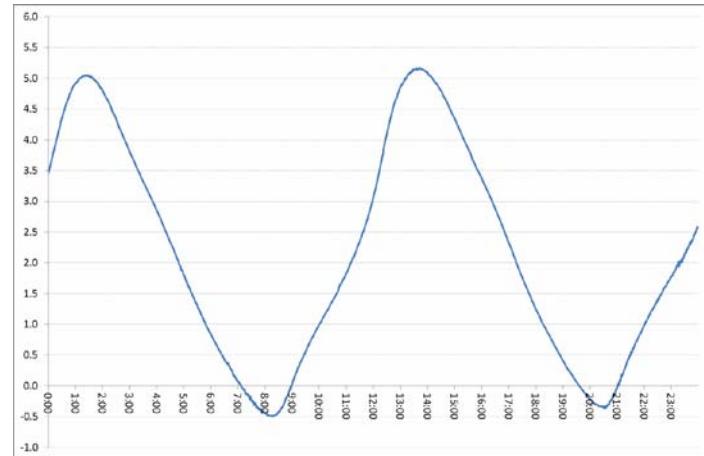
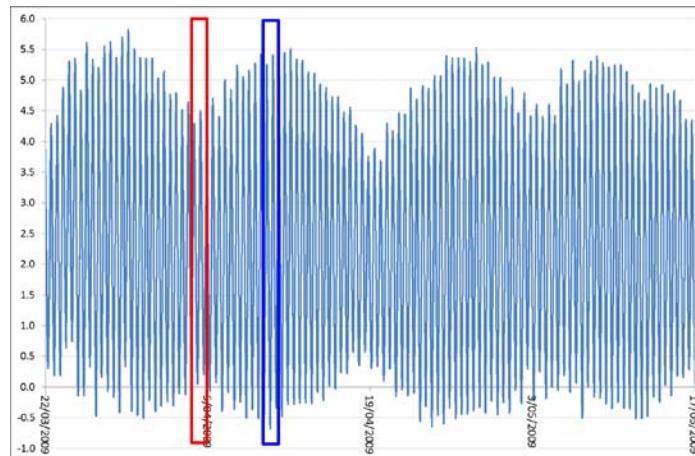
Centripetal acceleration around barycenter



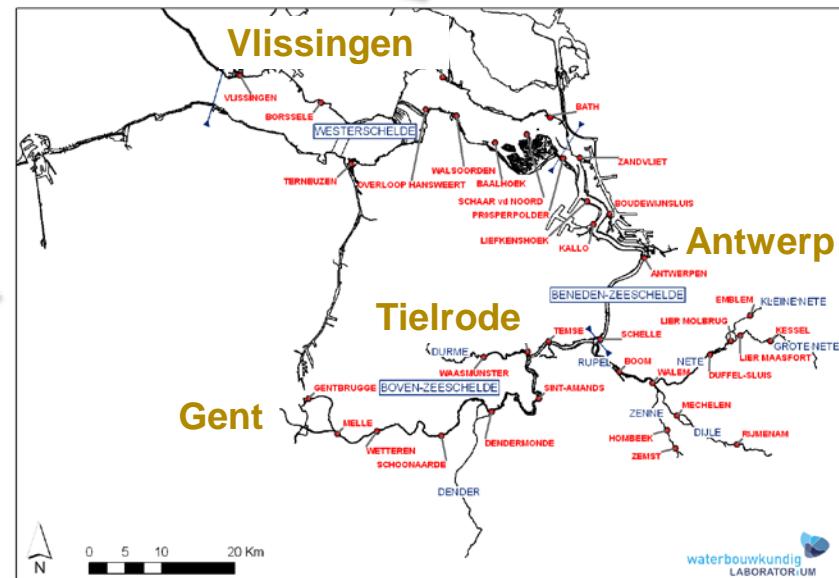
- Tide generating forces
 - Moon
 - Sun (46% of M-E)
- Variations due to:
 - Elliptical orbits
 - Inclinations
 - Continents
- Predictable (harmonic analysis)

Temporal variations

- Semi-diurnal (12h25)
- Diurnal inequality (24h50)
- Spring-neap cycle (14 days)
- Nodal cycle (18,6 years)



- ... in the Schelde-estuary ...

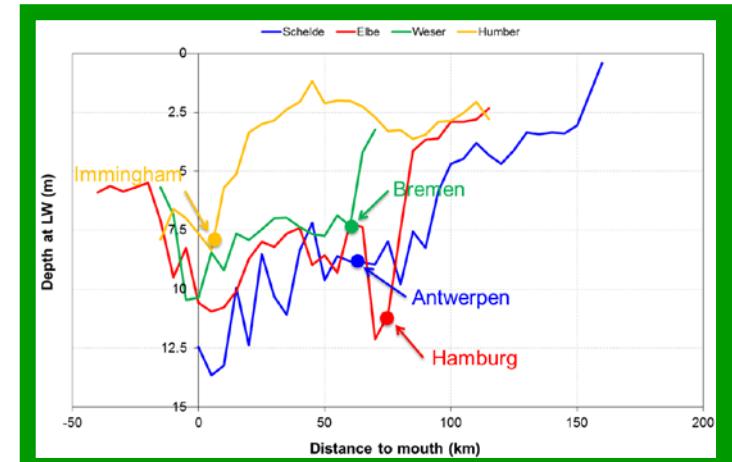
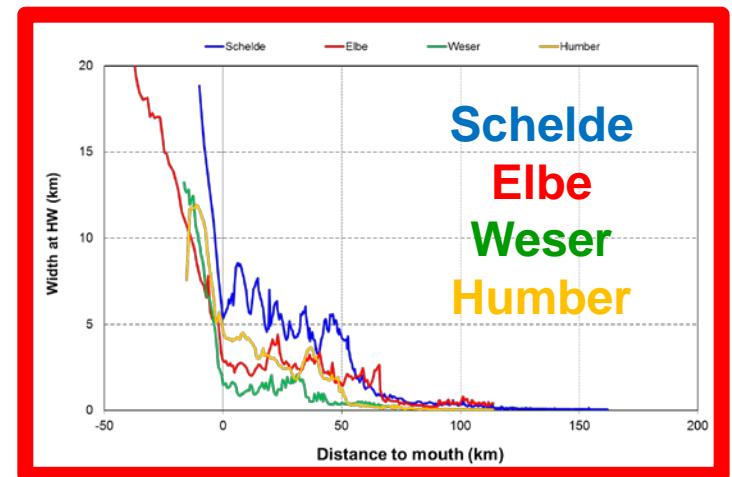
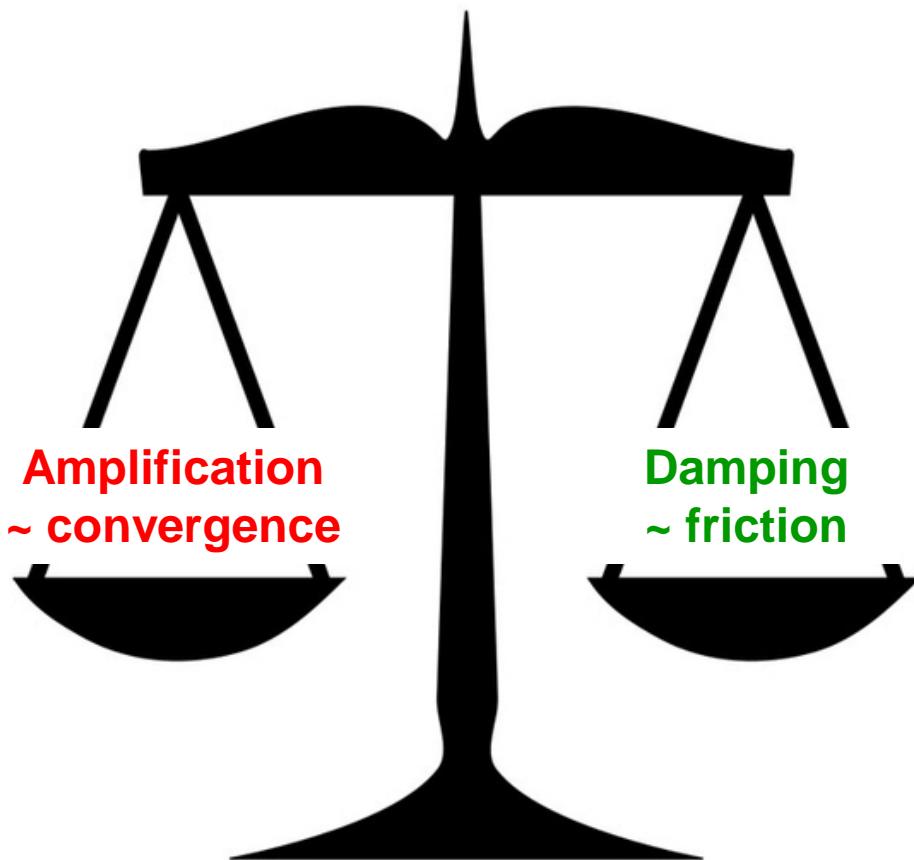




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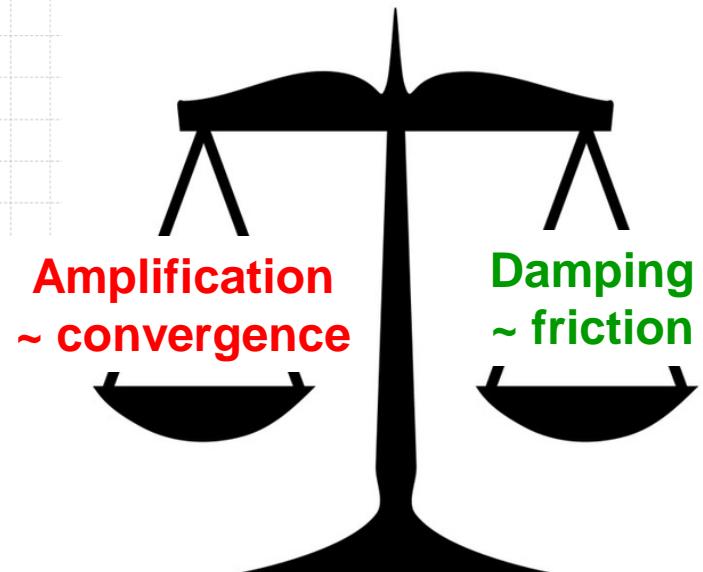
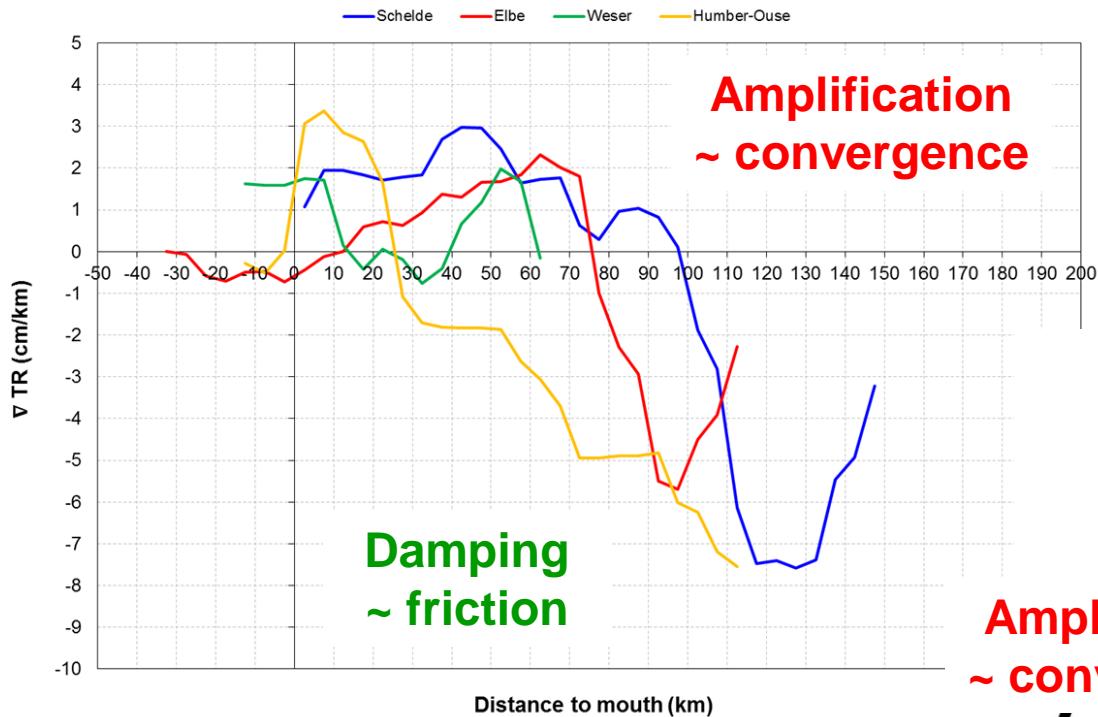
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Tidal propagation: processes

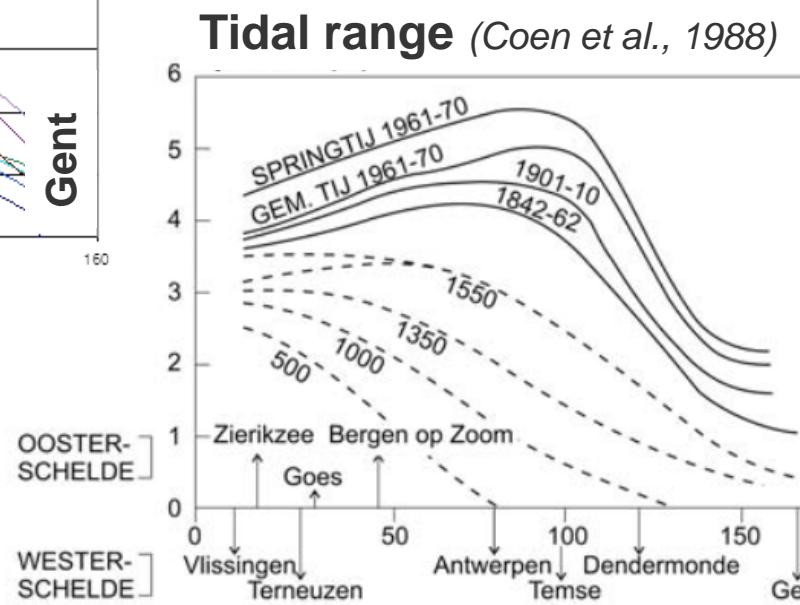
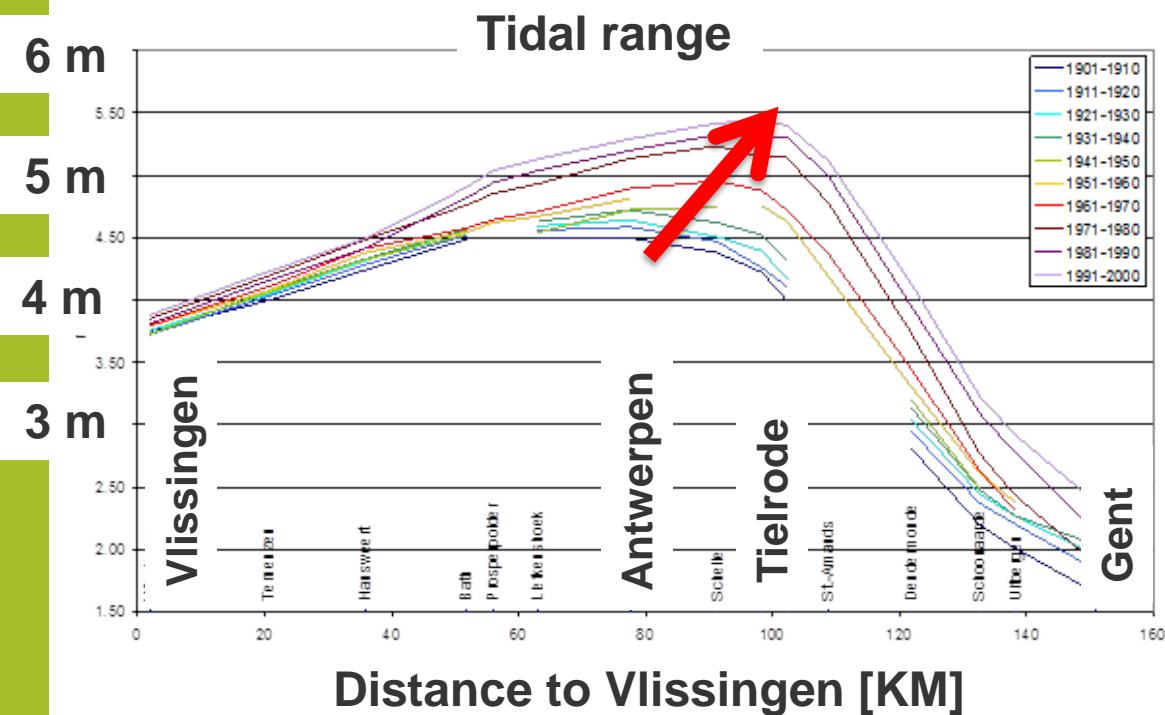


Source: Vandenbruwaene et al., 2013

Tidal propagation: processes



... tides changed ... (LT)

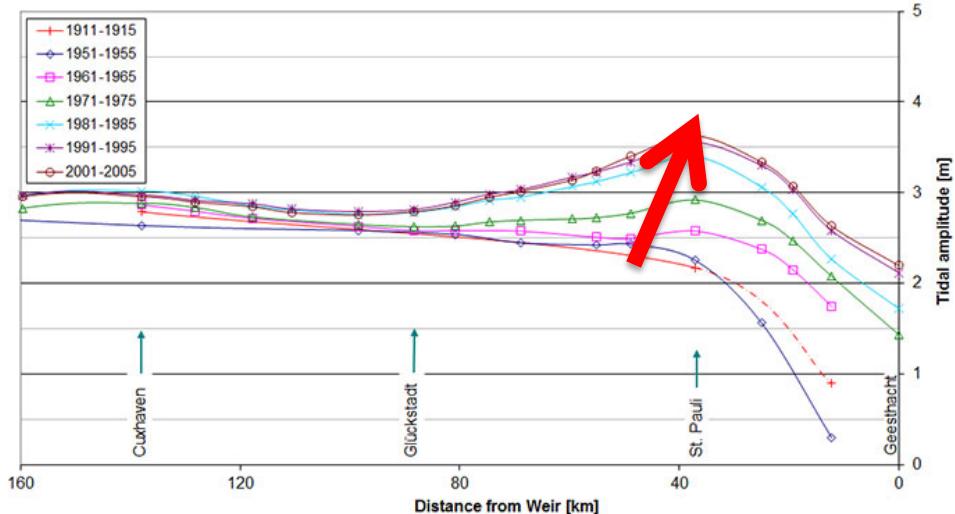




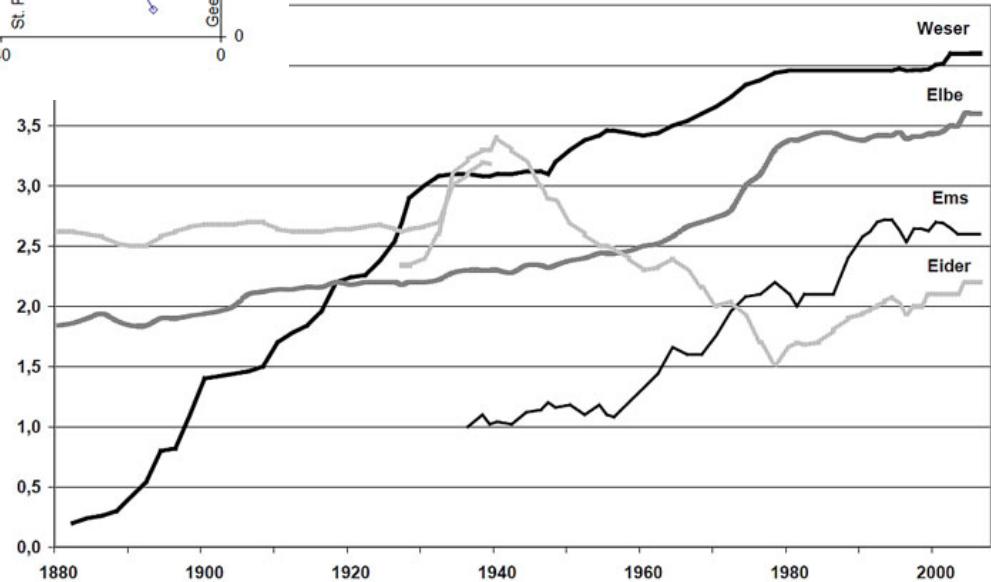
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... but also outside the Schelde!

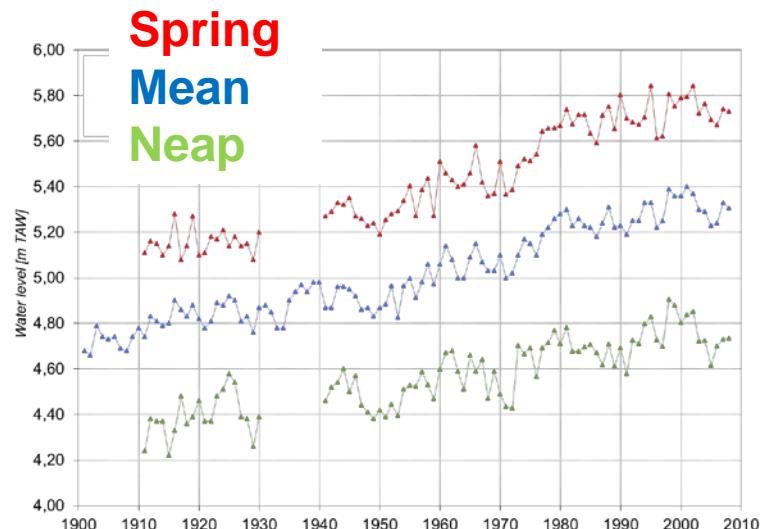


Source: Tide toolbox

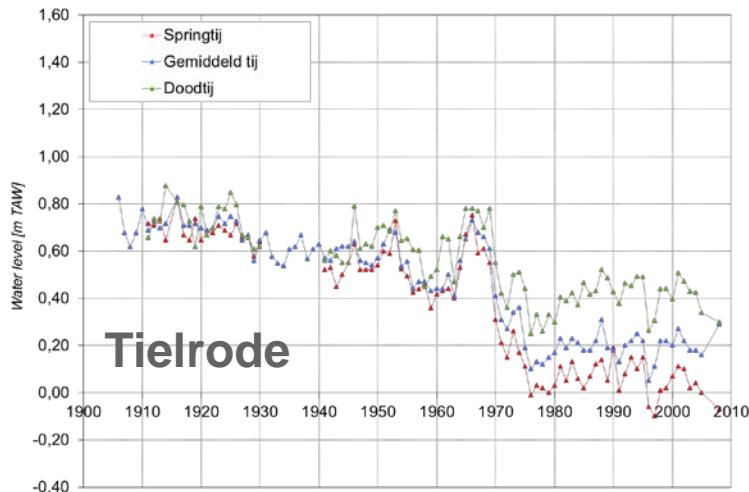
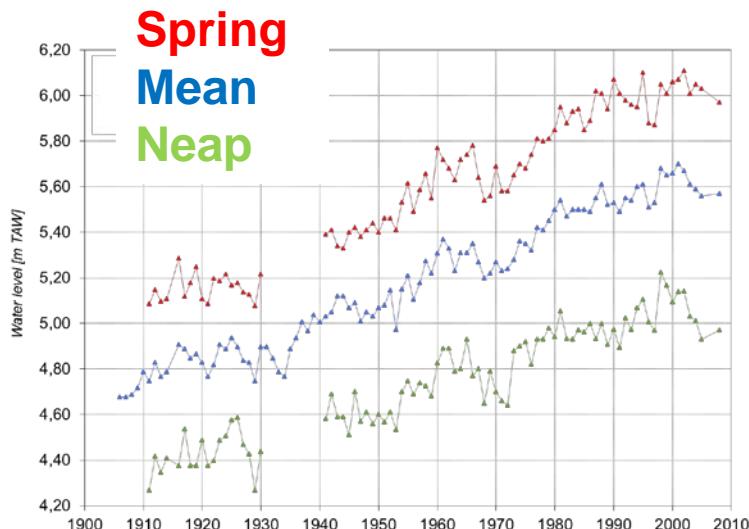
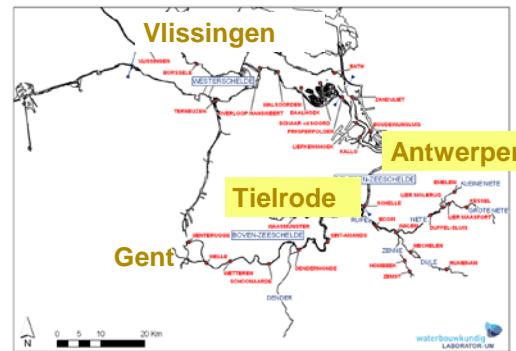
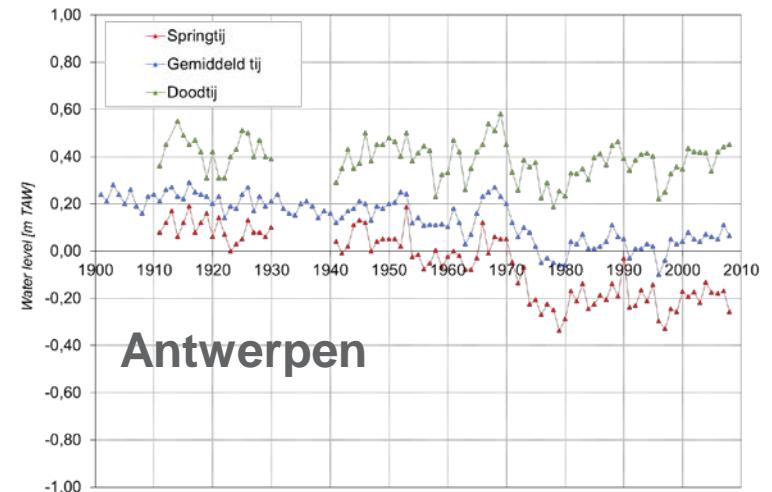


Tides: up-estuary

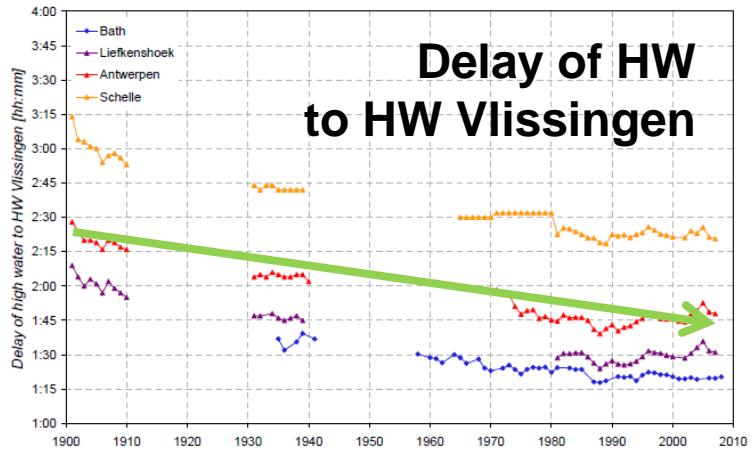
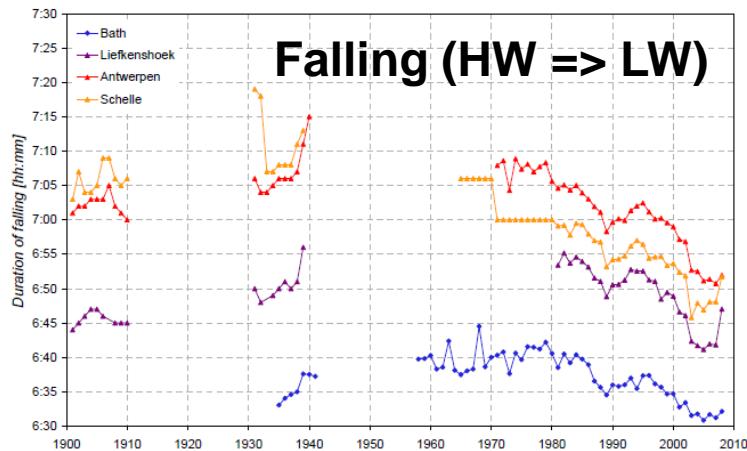
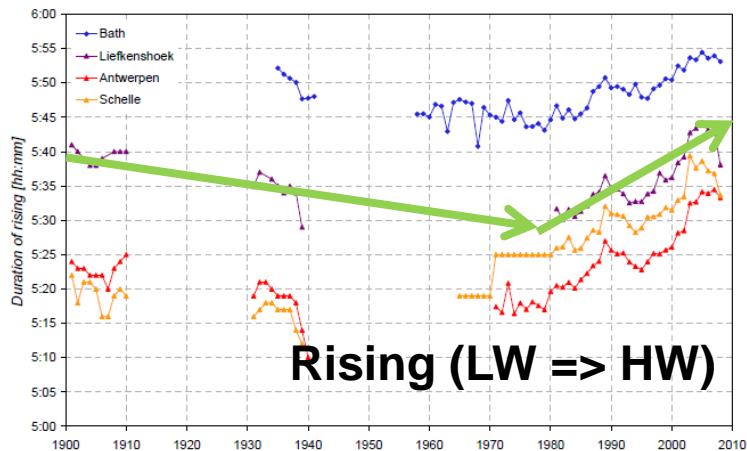
High water



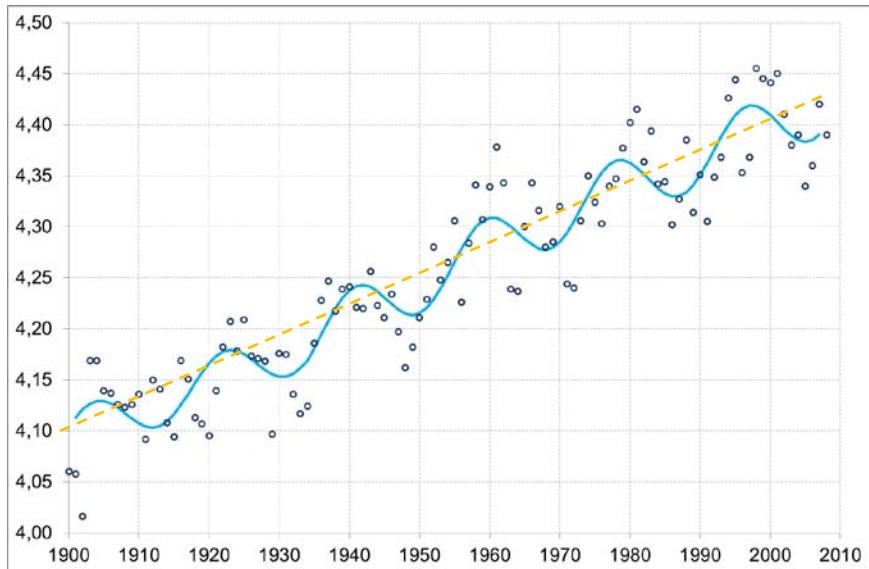
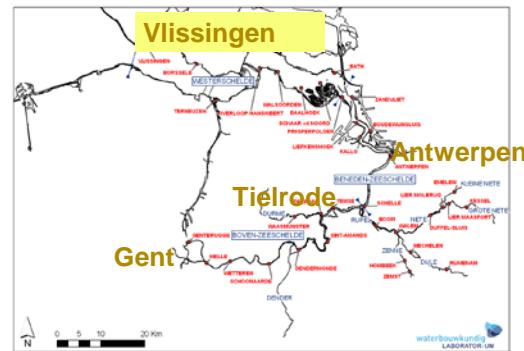
Low water



Tides: up-estuary

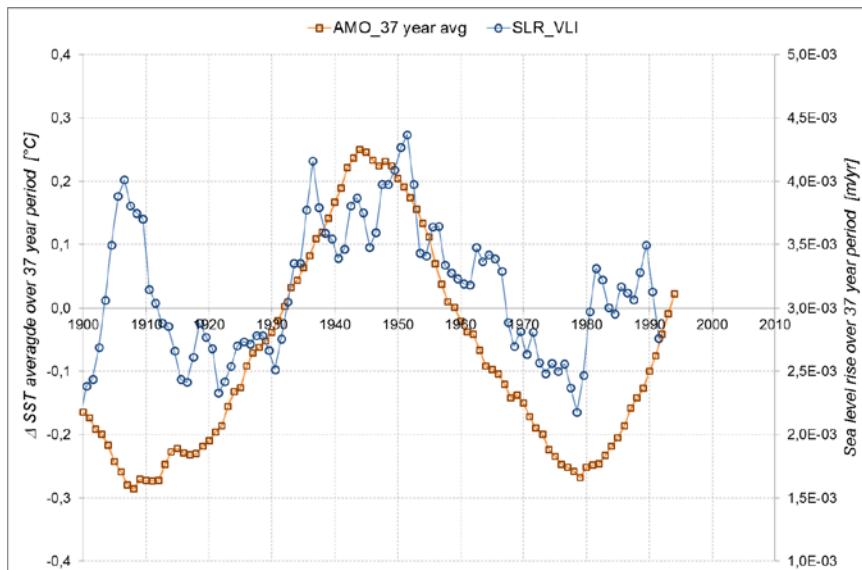


- ... natural changes and human interference.

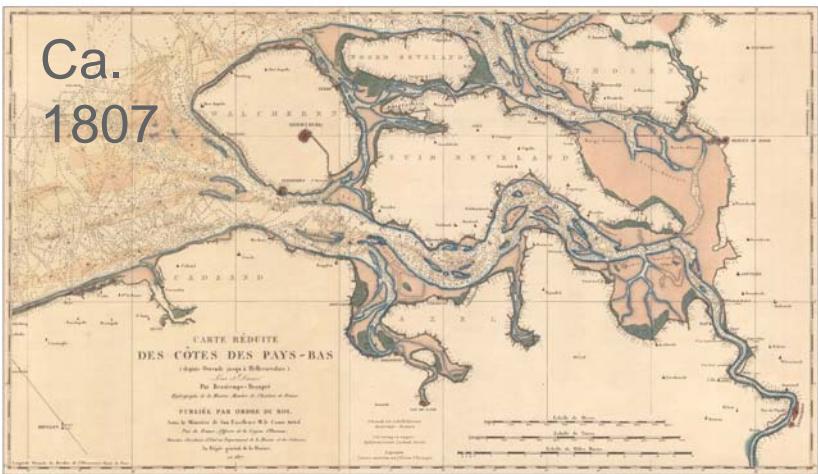


Sea level rise
18,6 year nodal cycle

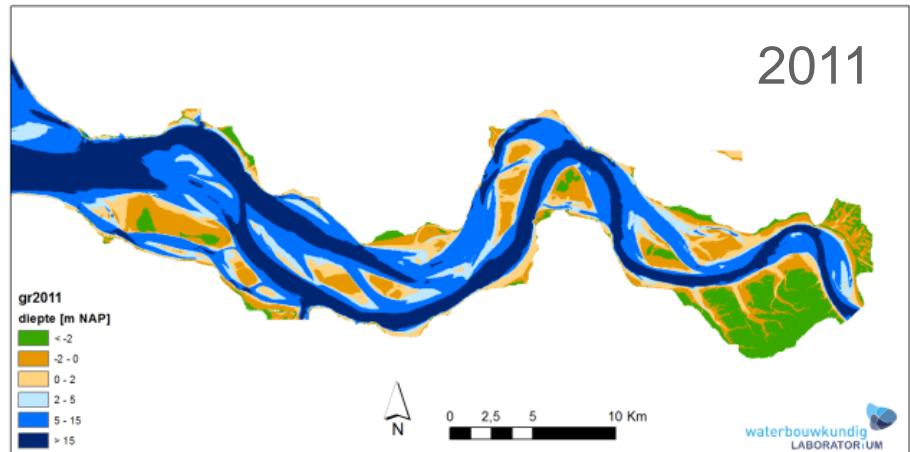
Atlantic
Multidecadal
Oscillation



... natural changes and human interference.

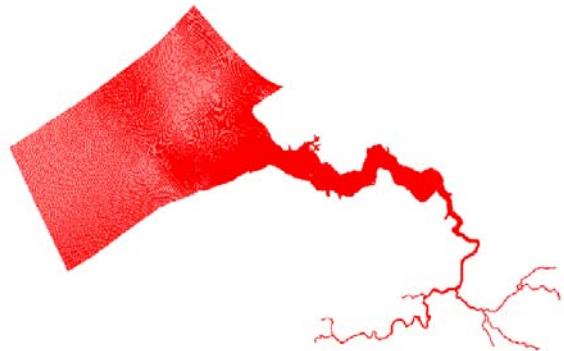


- Sea level rise
- Poldering
- Sediment extractions
- Channel enlargement
- Canalisation
- Hard bordering

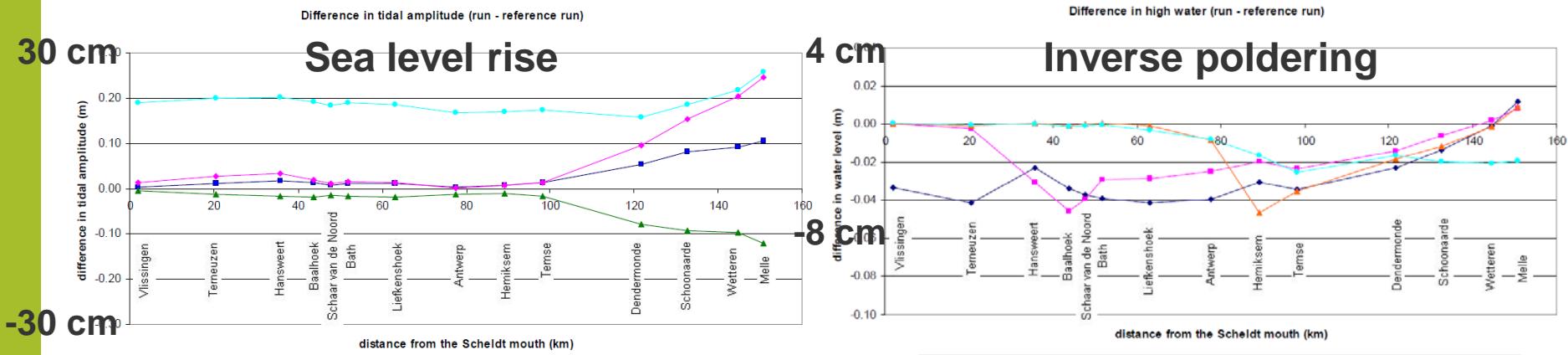


Human interference

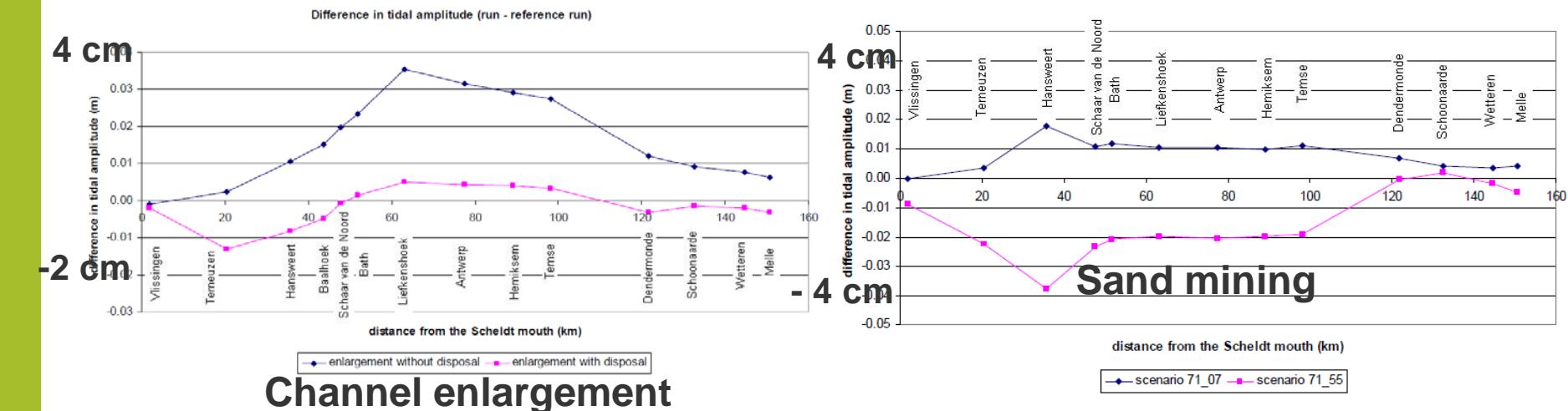
- Numerical models (1D, 2D)
- Initial effect of individual measures
 - **Sea level rise**
 - **Inverse poldering**
 - **Channel enlargement (with/without extraction)**
 - **Sand mining**
 - **Changes in fresh water discharge**
 - **Canalisation**
- Analysis of water level and tidal volumes



Human interference

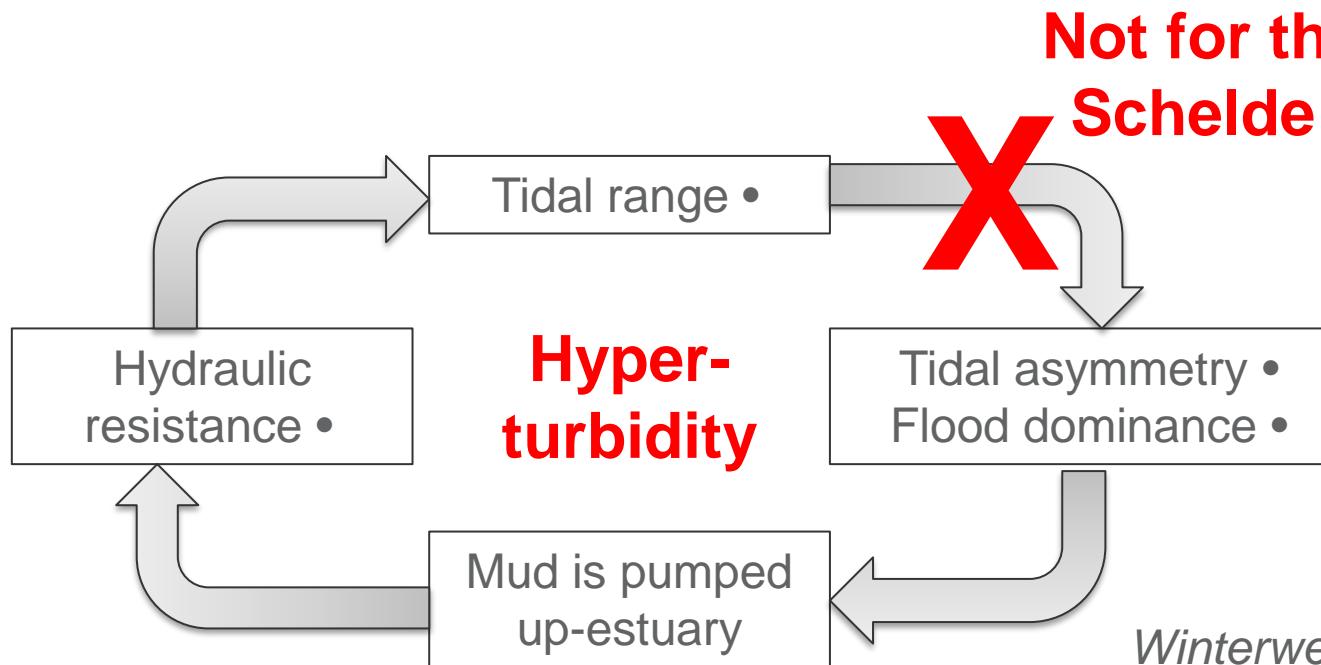


Sum of individual initial effect of measures • real evolution



Tides ↔ sediments?

- Tides (asymmetry) ~ residual sediment transport
- Sediment ~ hydraulic resistance



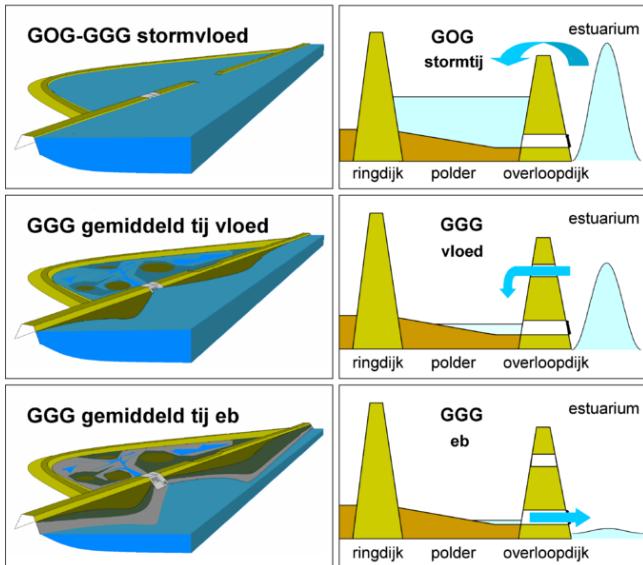
Winterwerp, 2013

Conclusions

- Gradual increase HW ~ sea level rise + human activities
- Stepwise decrease of LW ~ human activities
- Importance of morphological evolutions (indirect effect)
=> important increase of tidal range + maximum up-estuary
- Similar evolution in other estuaries (Elbe, Weser, Loire,...)

- Future challenges (~ “morpho-system” services):
 - **Reduction high water level ~ inundations**
 - **Reduction tidal dynamics ~ safety + ecology**
 - **Measures creating “win-win”-situations**
 - **“Global” measures with effects in whole estuary**

Measures: present and future



Source: cCaspar, 2012



**Crucial to strive for
win-win-situations !**

... or doing more with less!

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