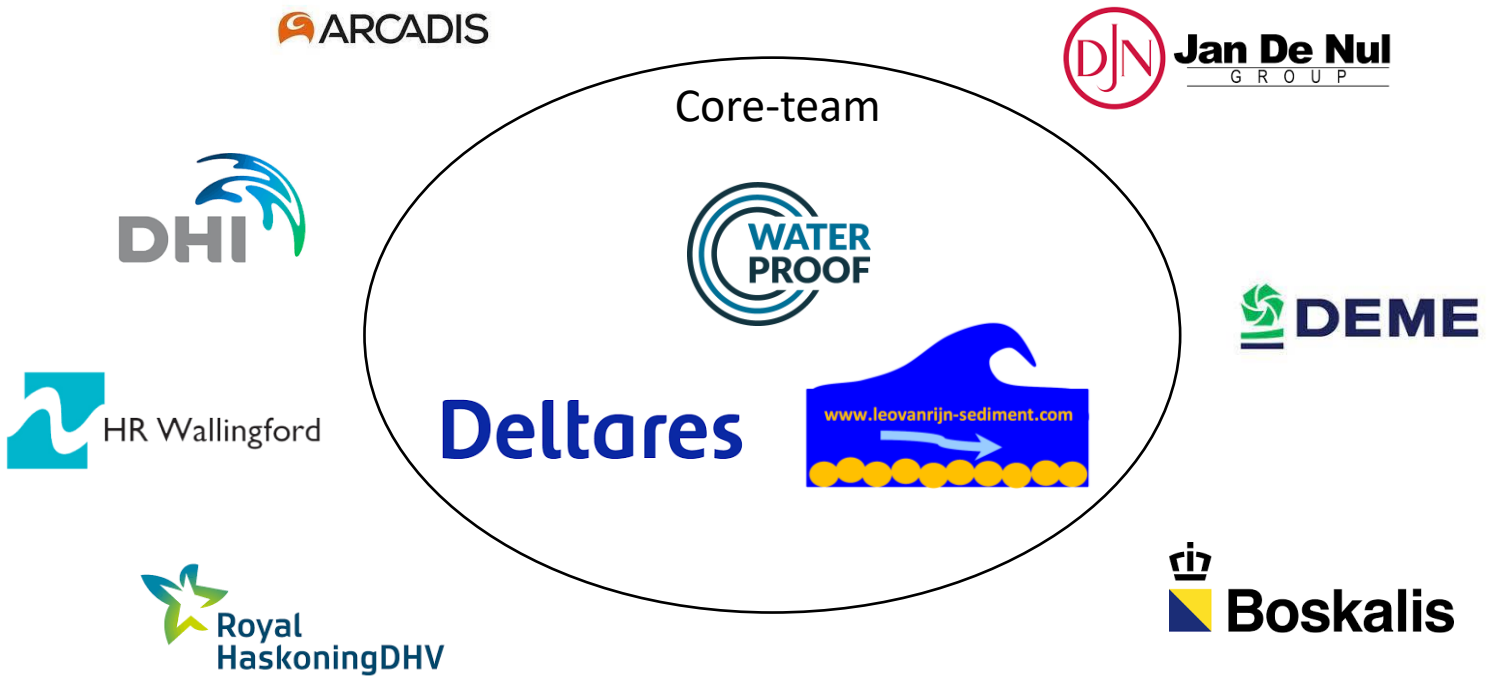
# TKI MUSA: Unravelling the effects of MUd-SAnd mixtures on erosion


Marcio Boechat Albernaz (WaterProof)
Leo van Rijn (LVRSediment)
Roy van Weerdenburg (Deltares)
Luitze Perk (WaterProof)
Bas van Maren (Deltares)
Ymkje Huismans (Deltares)


TKI-MUSA partners:

| | |
|---|---|
| WaterProof | DEME |
| LVRSediment | HR Wallingford |
| Deltares | DHI |
| Jan de Nul | Royal HaskoningDHV |
| Boskalis | Arcadis |

# TKI-MUSA Consortium

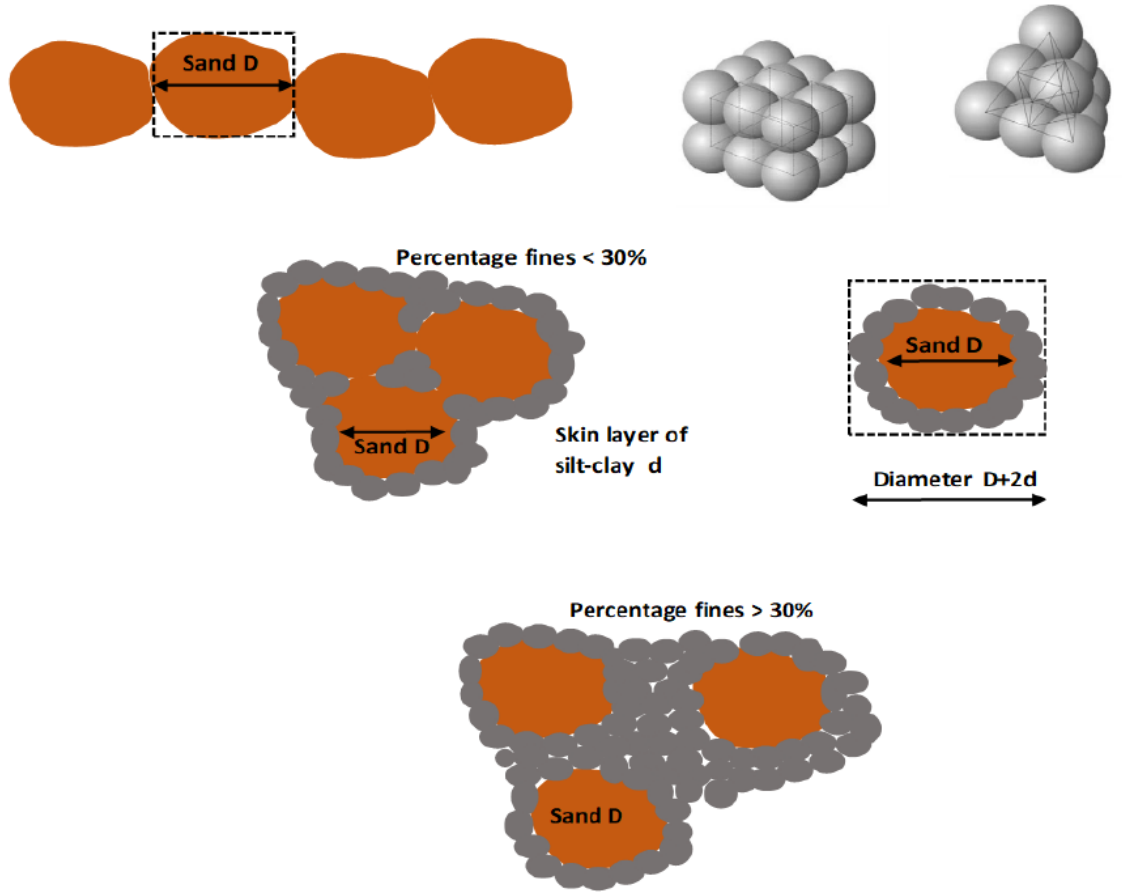



*Students/Guests:*

*Jelmer Korteling (Utrecht University)*
*Wouter Gerats (Utrecht University)*
*Jelle Bulens (Utrecht University)*
*Naika Noheli A. Barrera (DTU – DK)*
*Shadi M. Tawfic (KU – Leuven)*
*Dr Anne Baar (U Hull – UK)*

# Mud-Sand Mixtures

- Sand dominated matrix
  - Sand structure
  - High permeability
- Transitional $P_{fines}$ ~ 30% (van Ledden)
- Mud dominated matrix
  - Clay/Water matrix
  - High cohesion/low permeability



# Mud-Sand Mixtures

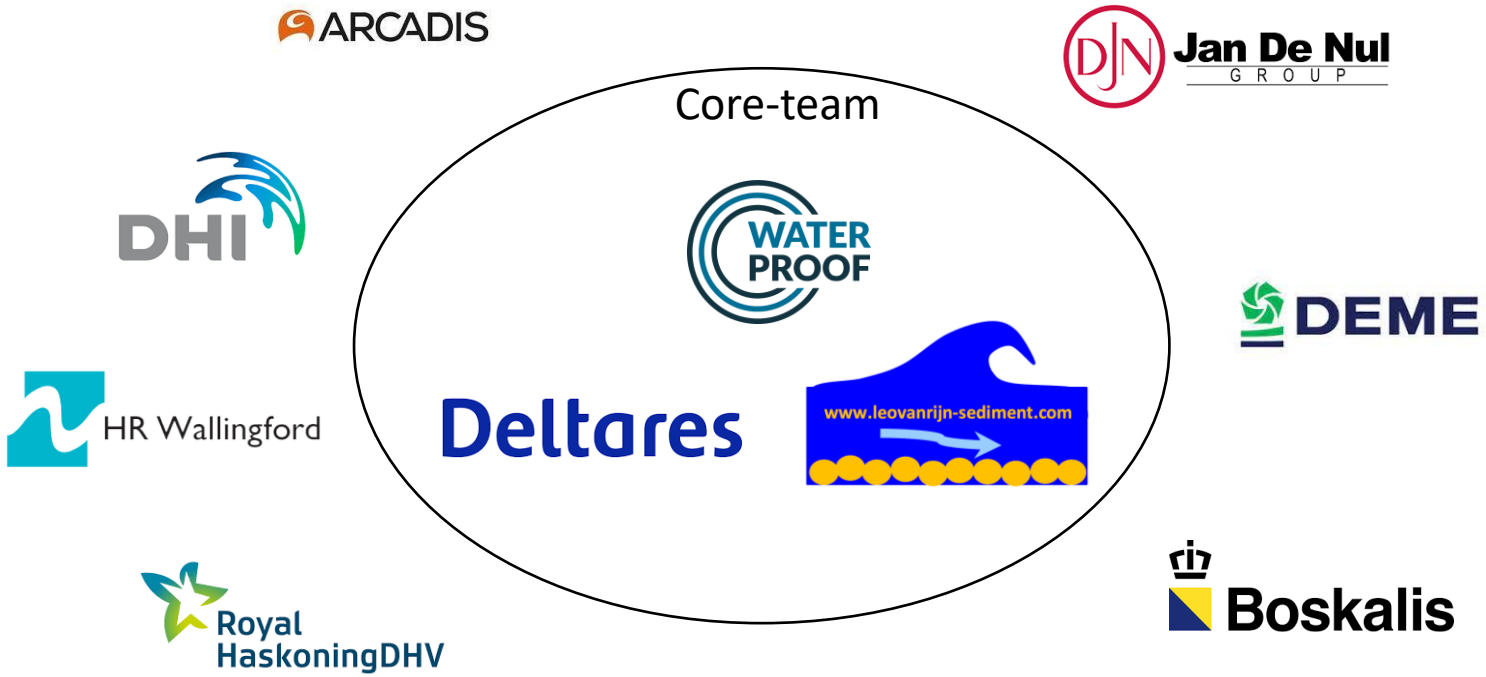
- Problem:
  - Determination erosion ($\tau_{crit}$) and sediment transport
    - Well predicted for pure sand (Shields/Mobility curve)
    - Strong variability for mud
      - Mineral composition/Density
      - Porosity/Permeability/Compaction
    - Mud-Sand mixtures
      - Very difficult to predict
      - Not a simple combination of sand and mud
      - strong interaction between mud and sand fractions

- Importance?
  - Overall lack of knowledge about mud-sand mixtures
  - Mud vs Sand research – often distinct worlds
  - Input parameter for Numerical Models (e.g. Parteniades-Krone, Van Ledden and Van Rijn)
  - Mud and Sand are often treated apart or without interaction
  - Sedimentation tools (e.g. SEDTUBE) developed only for sand

# MUSA Goals

- Collect and characterize sediment samples with various mud-sand percentages and mud characteristics
- Quantify erosion & deposition parameters
- Improve knowledge and predictions tools

# TKI-MUSA Consortium



# TKI-MUSA Consortium

Siltation
Sediment transport
Morphodynamics
Engineering
Numerical models

ARCADIS

Jan De Nul GROUP

Core-team

DHI

WATER PROOF

DEME

HR Wallingford

Deltares

www.leovanrijn-sediment.com

Royal HaskoningDHV

Boskalis

Dredging
Excavation
Siltation
Operations

# TKI-MUSA Consortium

**Strong points**

Deltares

Large and established knowledge centre
Reference in Coastal Engineering
Developer/Owner of Delft3D

LC van Rijn

FOLLOW

Consultant www.leovanrijn-sediment.com
Verified email at leovanrijn-sediment.com - Homepage

sediments coastal dynamics river dynamics coastal erosion

UU, etc)

www.leovanrijn-sediment.com

WATER PROOF

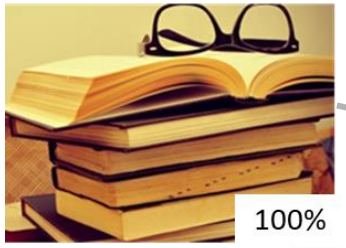
| TITLE | CITED BY | YEAR |
|---|---|---|
| Sediment transport, part I: bed load transport<br>LC Van Rijn<br>Journal of hydraulic engineering 110 (10), 1431-1456 | 4027 * | 1984 |
| Principles of sediment transport in rivers, estuaries and coastal seas<br>LC Van Rijn<br>Aqua publications 1006, 11.3-11.4 | 3146 | 1993 |
| Sediment transport, part III: bed forms<br>LC Van Rijn<br>Hydraulic Engineering 110 (12) | 1232 | 1984 |
| Unified view of sediment transport by currents and waves. I: Initiation of motion, bed roughness, and bed-load transport<br>LC Van Rijn<br>Journal of Hydraulic engineering 133 (6), 649-667 | 1079 * | 2007 |

# TKI-MUSA Consortium

| | Weak points | Selected strong points |
|---|---|---|
| Deltares | Less cost-effective<br>Difficulties in lab and field<br>Low flexibility | Expertise<br>Funding/Management<br>Analysis (detailed)<br>Models/tools developments |
| www.leovanrijn-sediment.com | Solo (very) senior consultant (but no lack of energy!)<br>Not enough resources and lack of facilities | Contact with industry/partners<br>Life-time expertise<br>Analysis (pragmatic)<br>Models/tools developments |
| WATER PROOF | Too small/young to pursue large fundings for R&D<br>Not enough hands and resources to expand the analyses, models/tools improvements and outreach | Practical execution/Budget friendly<br>Lab facilities & boats available<br>Integrated field, lab, models expertise<br>Flexibility (to work with Leo!) |

# Overview

**Literature**



100%

**Knowledge gaps**
→ What to measure?

**Flume**



90%

**Erosion**
> Sediment characteristics
> Erosion flow only & flow + waves
> Influence pebbles and shells
> Influence fluffy top layer

**Field**




90%

**Fall velocities**
> validation method van Rijn
> Comparison different measurement techniques

**Analysis**




15%

**Improved formulations**
> erosion
> density
> settling

**Numerical models**



5%

**Engineering tools**



0%

**Data-base**



50%

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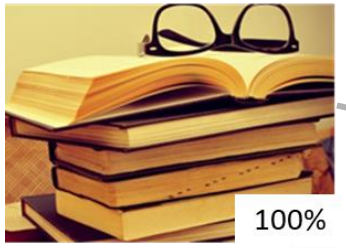

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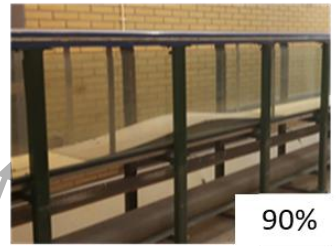

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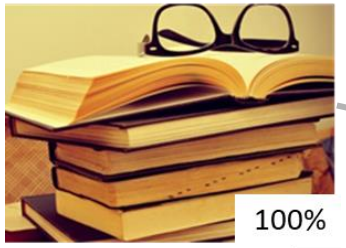


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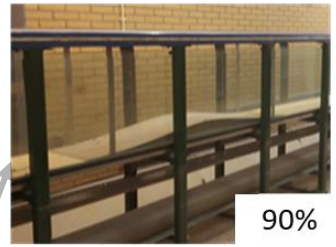


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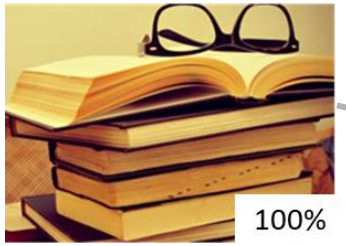

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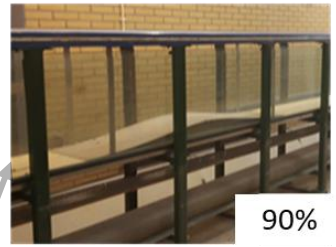

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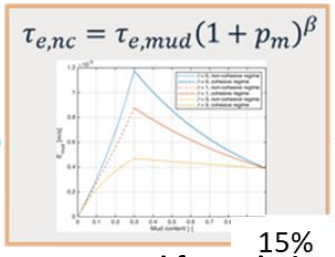


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**Data-base**



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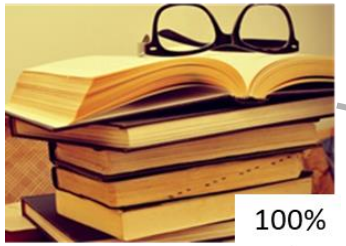

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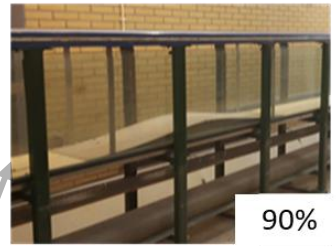

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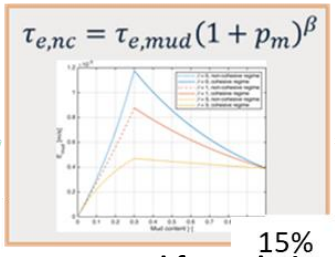


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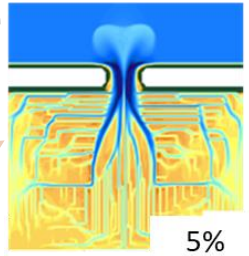

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**Engineering tools**

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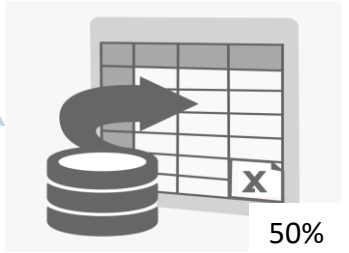
**Data-base**



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# Sediment Sampling


Scheldt


Plym Estuary


Noordpolderzijl (Wadden Sea)

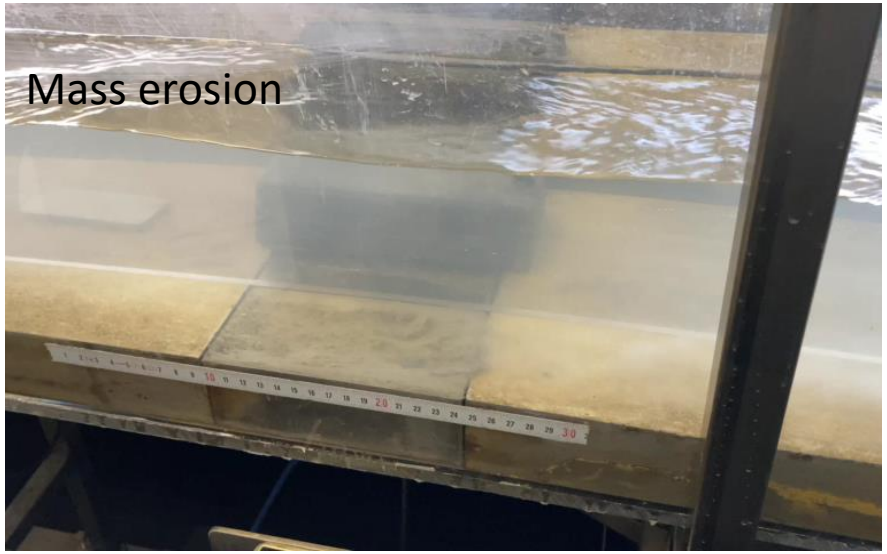

Western Scheldt


Western Scheldt


Western Scheldt

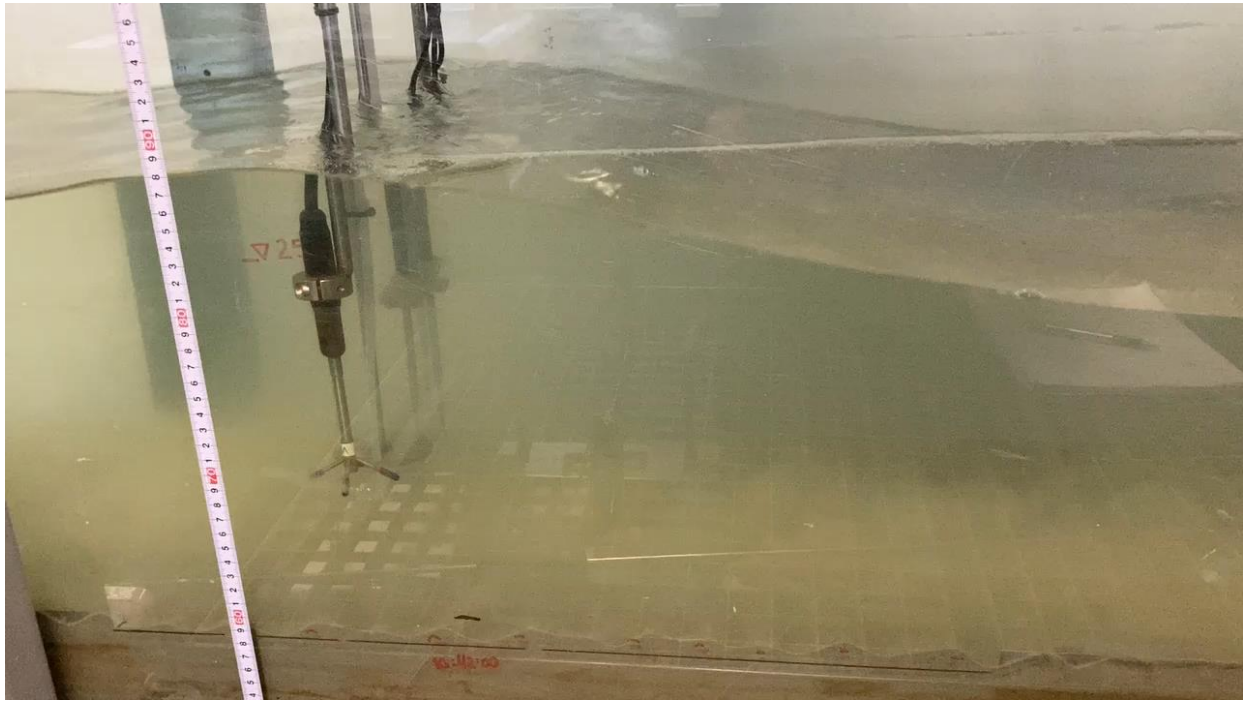
# Flume experiments

- Determine critical shear stress ($\tau_{crit}$)
  - **Surface erosion** ($\tau > \tau_{crit,se}$)
    - Several layers of particles are put into motion near the surface.
    - Grooves start to form on the surface.
  - **Mass erosion** ($\tau > \tau_{crit,me}$)
    - Sudden release of large quantities of bed material,
    - Sediment can be suspended over the entire water column.



# Flume Experiments

- Wave-current experiments
- Controlled mixtures of sand/mud
- Aim: Sediment transport/concentrations



# Flume Experiments

- Notebook vs Notebooks & not on the (note)books

# Settling velocity & sediment characterization

- 1-day at Holwerd Pier
  - Water sampling over c.a. tidal cycle
  - In-situ analyses of Piranha and LabsFLOC2
  - LISST and Aquadopp

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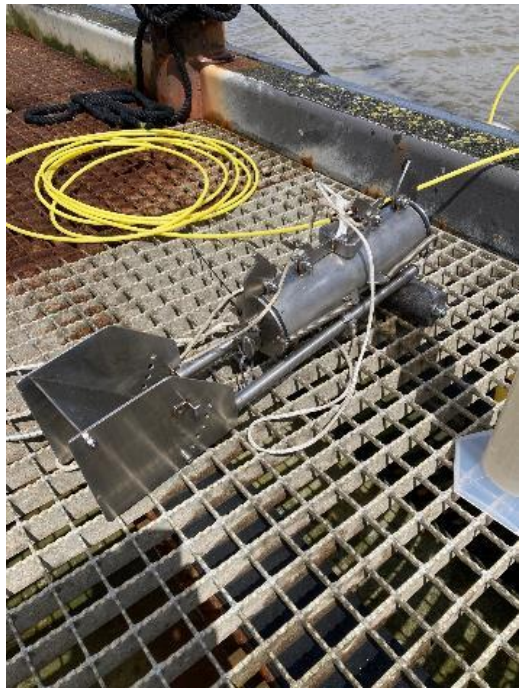
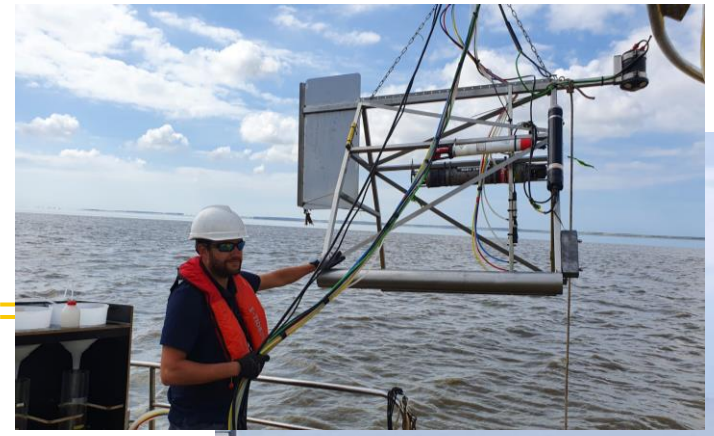
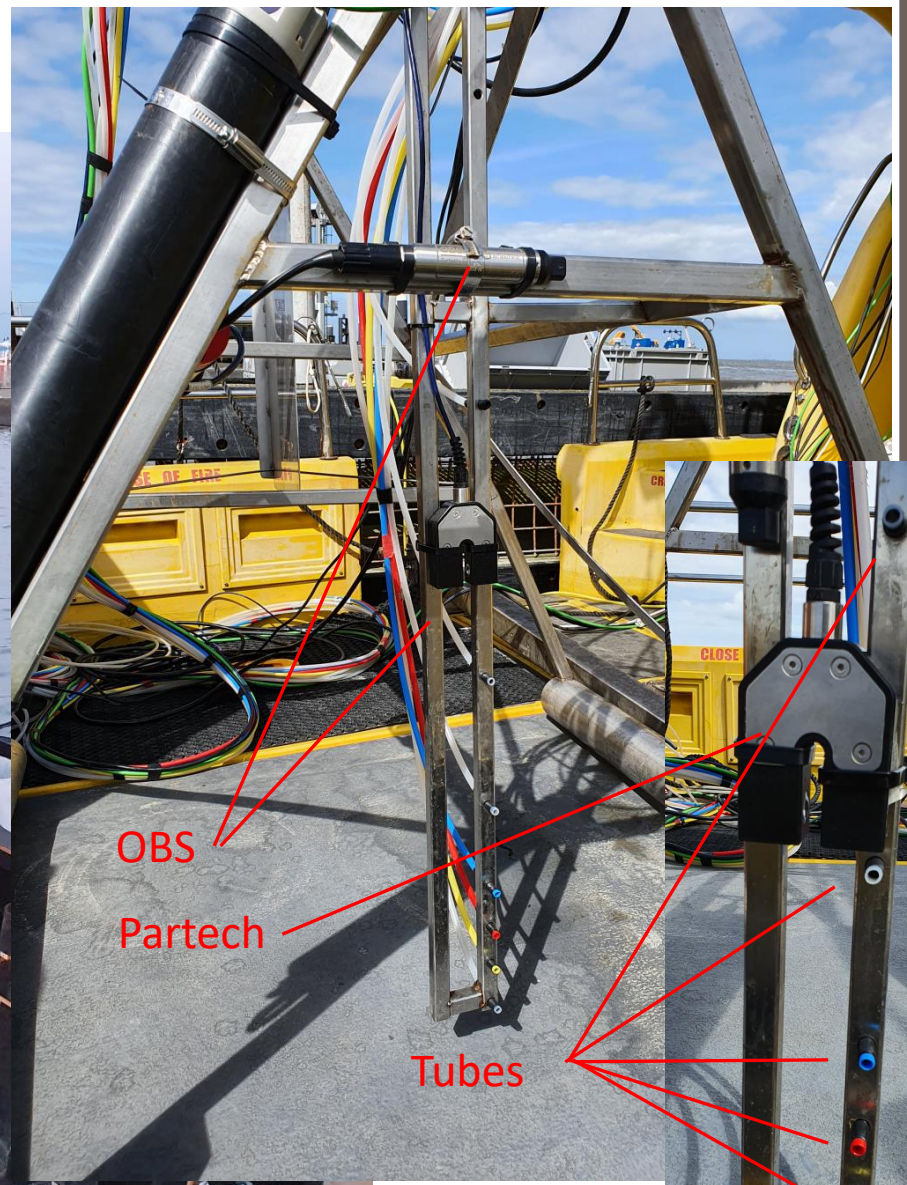


# Field: Erosion and Sediment Transport

- 4-days measurement near Holwerd (4 sites)
  - Water/sediment sampling over c.a. tidal cycle
  - Measurement of flow/waves
    - Aquadopp/ADV
    - 2x ADCP (1 on vessel, 1 on frame)
    - Pressure sensor
    - CTD
  - Measurement of sediment concentrations
    - 2x OBS + 1x Partech (Optical Backscatter)
    - ADV (Acoustic Backscatter)
    - LISST (LISST-ST) TU-Delft
    - Sampling via tubes and pumps
  - Bed composition/density
    - Van Veen samples




ADCP
Aquadopp
LISST
ctd


OBS
Partech
Tubes

# Field: Erosion and Sediment Transport

# Field: Erosion and Sediment Transport

- The challenges!

And the reasons for some gaps in the data

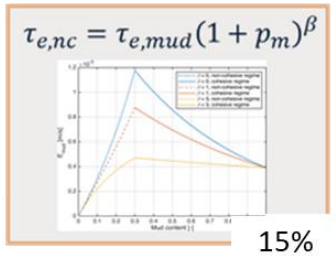
# Field In-kind Contributions

- Andy Manning (HRW) – Pier day
- Roy (Deltares) – 2 days measurements
- Ana Colina (Deltares) – 2 days measurements
- Huub (BOSKALIS) – 2 days measurements
- Mark (BOSKALIS) – sample processing
- Pauline (DEME) – sample processing
- Tijs (DEME) – 2 days measurements
- Meike (WP/UU) – 2 days measurements

# Products overview

**End products to:**

**Analysis**

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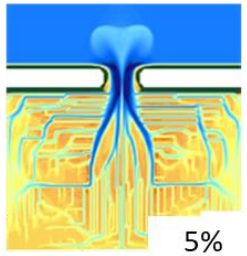
**Improved formulations**

Fundamental research
In-depth knowledge
Report and publications

ARCADIS
HR Wallingford
DHI
Royal HaskoningDHV

**Numerical models**



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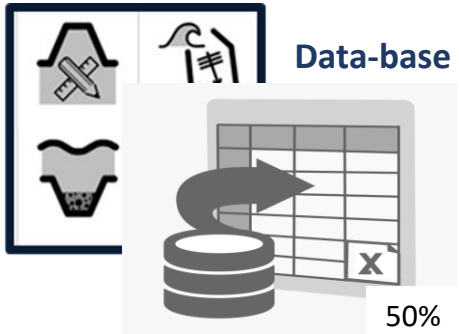
Improvement of models:
Delft3D/MIKE21

Deltares
DHI

ARCADIS
Royal HaskoningDHV
HR Wallingford

**Engineering tools**



**Data-base**

Development of engineering tools
Sampling and analyses guidelines

Quick-scans and site characterization
Look up tables

Boskalis
DEME
Jan De Nul GROUP

ARCADIS
Royal HaskoningDHV

# WIKI

https://publicwiki.deltares.nl/display/TKIP/DEL112+-+MUSA

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Deltares TKI Projects

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SPACE SHORTCUTS
Bestandslijsten

CHILD PAGES
TKI Projects Home
DEL112 - MUSA
1. Literature analysis
2. Laboratory experiments
3. Field measurements
MUSA Deliverables

Space tools

Pages / TKI Projects Home

## DEL112 - MUSA

Created by Lidian Lenssinck, last modified by Roy van Weerdenburg on 25-07-2022

Estuaries and tidal basins form the transition zones between land and sea. They contain important habitats for flora and fauna and are extensively used by people, like for navigation. For ecological and navigational purposes, it is important to understand and predict the evolution of channels and shoals, including sedimentation rates and the composition of the bed sediments. The bed material of large estuaries and tidal basins largely consists of mixtures of mud and sand, with predominantly sandy channels and mainly muddy intertidal areas. The interaction between sand and mud, in combination with currents and waves, leads to complex dynamics in these areas, with migrating channels and shoals

Much is known about the behaviour of the individual sediment fractions, but the knowledge and understanding of sand-mud interaction remains limited, as do the available tools and models to accurately predict the bed evolution and sediment transport rates in sand-mud areas. Existing models, like the ones by Van Ledden (2003), Soulsby & Clarke (2005) or Van Rijn (2007) have only limitedly been verified with observations due to a lack of good quality observational data. Also, none of the available approaches cover the complete spectrum of sand-mud interaction, which includes settling, erosion processes, and bed shear stresses due to waves and currents. Therefore, in practice, sand- and mud fractions are often treated separately. This decoupled approach limits the predictive capacity of numerical models, and therefore the understanding of impact of human intervention such as deepening of channels and port construction on maintenance dredging volumes and other morphological changes.

In the MUSA-research project, a consortium* of contractors, consultants and research organizations join forces to increase the understanding of the dynamics of sand-mud mixtures through flume tests and field measurements. The developed knowledge, insights and data will be incorporated in engineering tools and in numerical modelling software. The four-year project (2020-2023) consists of the following activities:

- Literature analysis
- Laboratory experiments
- Field measurements
- Development and improvement of formulations on sand-mud dynamics
- Development of engineering tools
- Implementation of formulations in numerical software

The project started in May 2020 and will end at the end of 2023. In the current stage of the project (Summer 2022), multiple activities are going on: the laboratory experiments are being processed and reported by WaterProof and HR Wallingford, field experiments are carried out in de Wadden Sea and the first analyses by Leo van Rijn and Deltares are starting up.

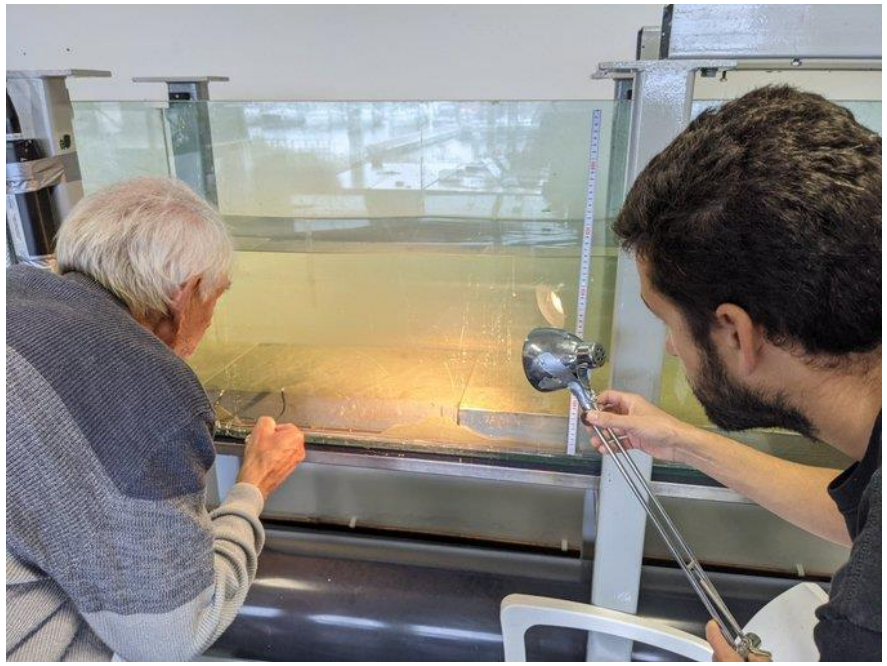
** the TKI-MUSA consortium consists of WaterProof, Leo van Rijn Sediment Consultancy (LVRS), Jan de Nul, DEME, Boskalis, HR Wallingford, DHI, Royal HaskoningDHV, Arcadis and Deltares.*

[DEL112 - MUSA - TKI Projects - Deltares Public Wiki]

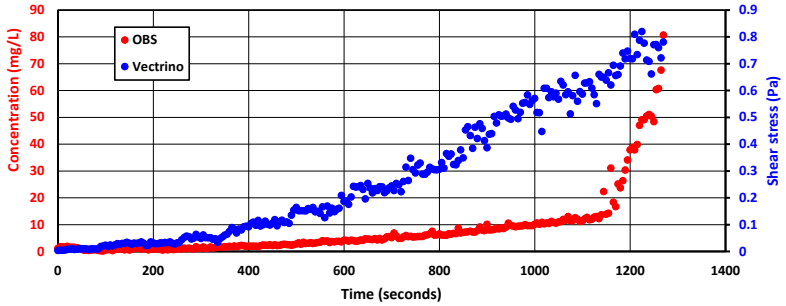
# Project challenges!

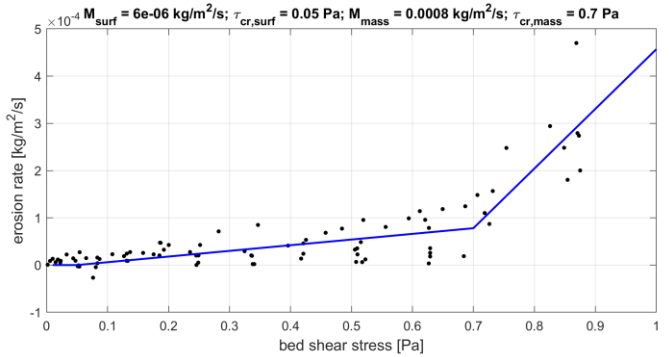
- 2 years project with multi-country/institutes (physical) collaboration during COVID-19
- Various levels of bureaucracy/procedures that made the spin-up and planning difficult
  - “Learn by doing” vs Schedule
- Different “quality” levels and data needs during the project

Method Van Rijn



Method Deltares



# TKI-MUSA

Our recipe for success:

- We took advantage of the best from each partner
- True cooperation scheme
- Flexibility and communication (core team)
- Focus on end-user products, e.g. tools, guidelines
- Aim for novel applied science
- Great and integrated core team

50L Barrels! Quiz:
What's the weight the 3
hard workers had to carry over the dike to the van?