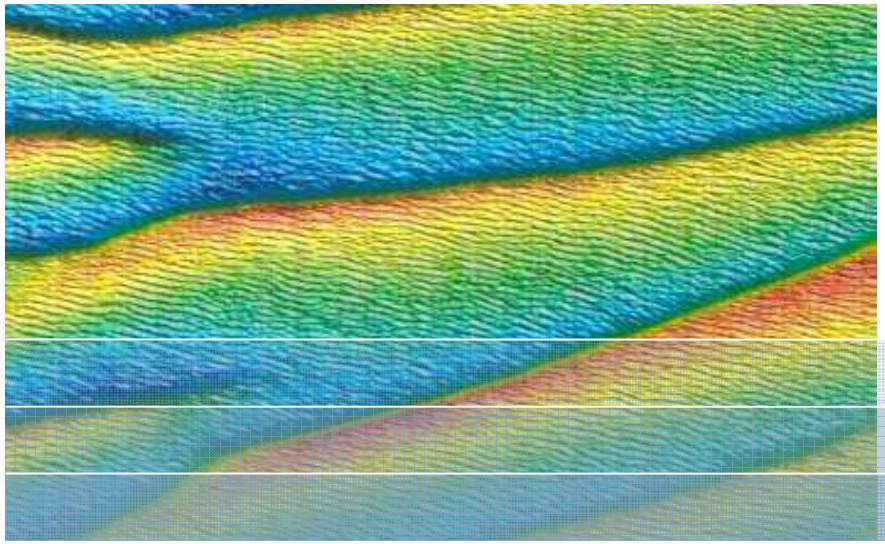


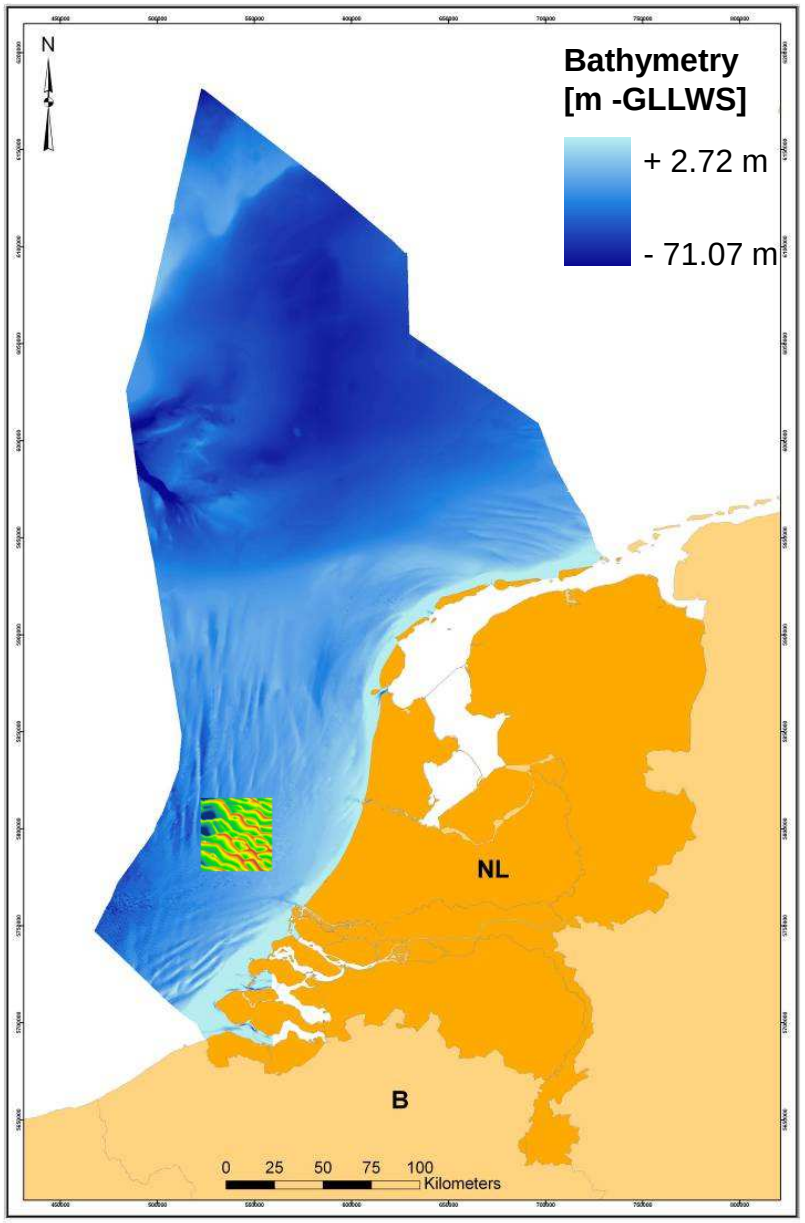
Deltares
Enabling Delta Life

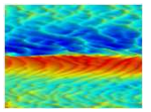
Quantitative seabed dynamics from bathymetric time series and shipping risk assessment, Netherlands Continental Shelf

Deltares
Thaiënne A.G.P. van Dijk

NSHC32, Dublin
22nd of June 2016

Relevance of seabed dynamics



- Dynamic bedforms 
- Safe navigation
- Monitoring and maintenance policies (risk-based resurveying, dredging, nourishments)
- Offshore and coastal engineering (wind farms, cables & pipe lines, nature-based solutions)

Bathymetry NCS (TNO, 2004)

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Relevance of seabed dynamics

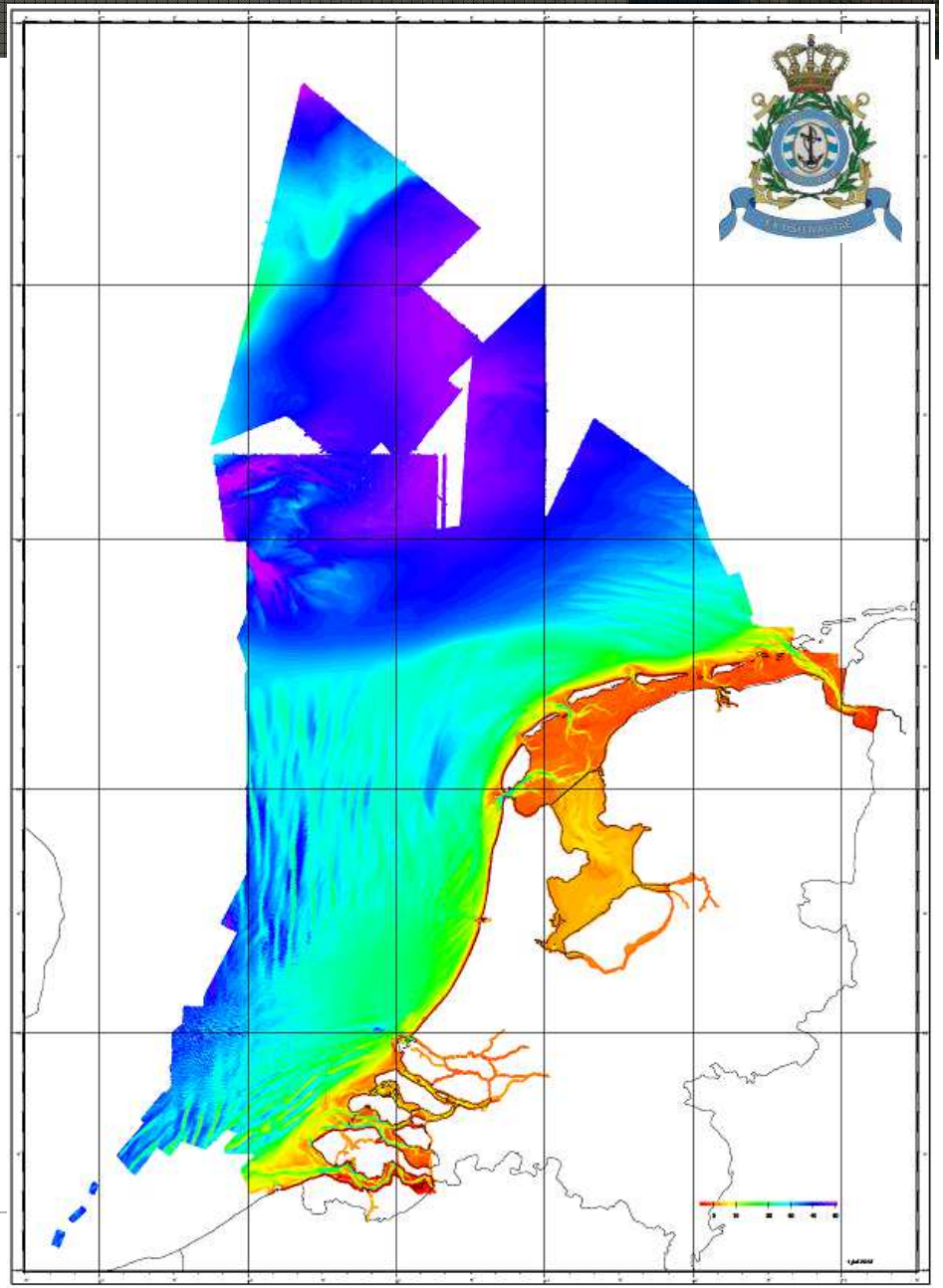
MSC Napoli, off the coast of Devon, UK (with explosives)

- Shipping: critical water depths
  - Safety
  - Environment
  - Large economic benefit transport: 15 cm extra draught
  - Marine Spatial Planning: e.g. adjustment traffic separation schemes (TSS)

Forwairey, Western Scheldt, 2005 (photo ANP), with dangerous goods

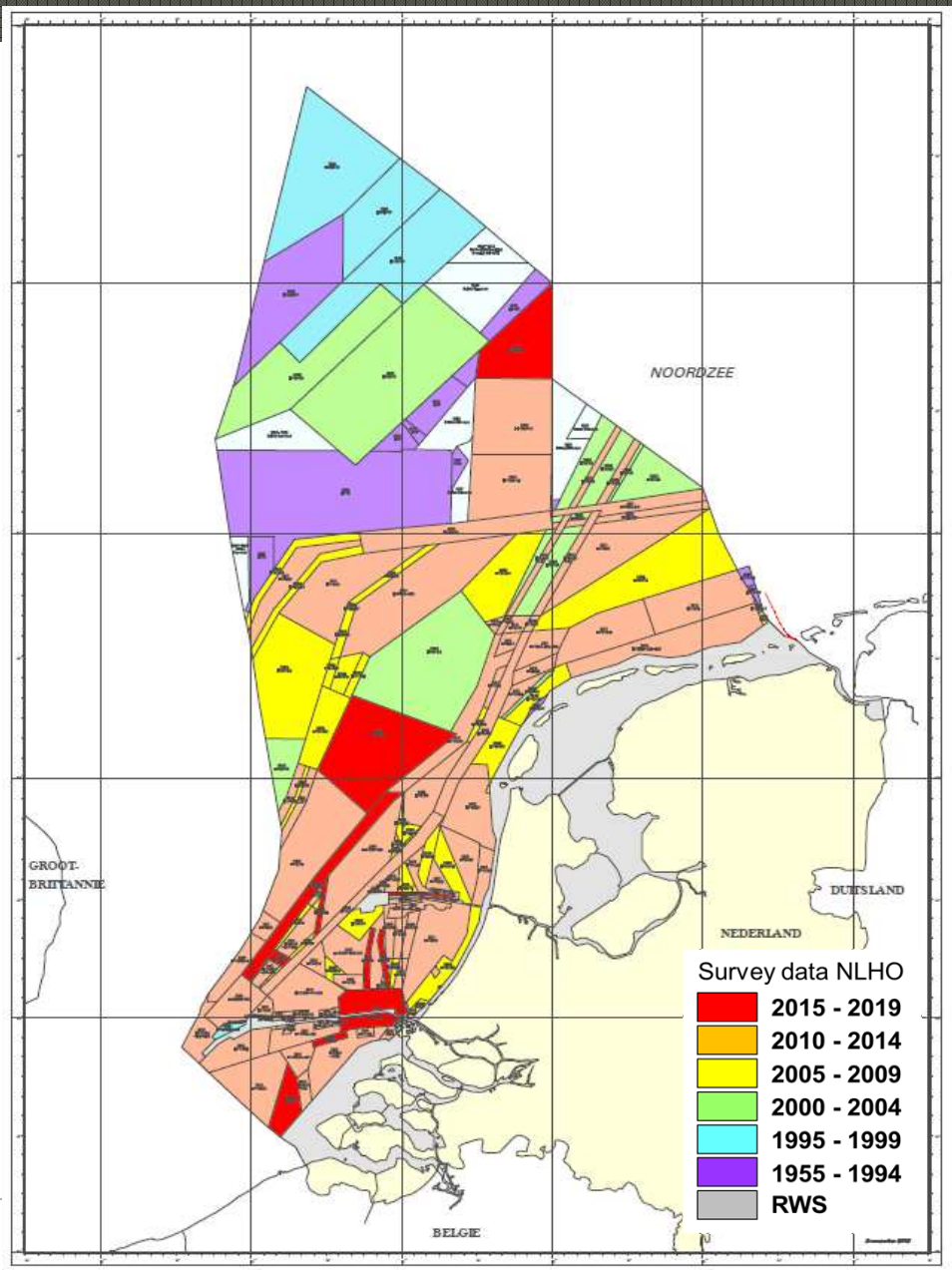
Available data NCS

- All bathymetric data in NLHO's Bathymetric Archive System (BAS)
  - NLHO & RWS
  - SBES & MBES
  - Late 1980s – 2015
- Non-digital data (fair sheets)
- Wrecks/Objects point data set (NLHO & RWS)
- Maritime data (AIS-database)
- Seabed sediments (TNO & Deltares digital map)
- Hydrodynamics (MATROOS-database)

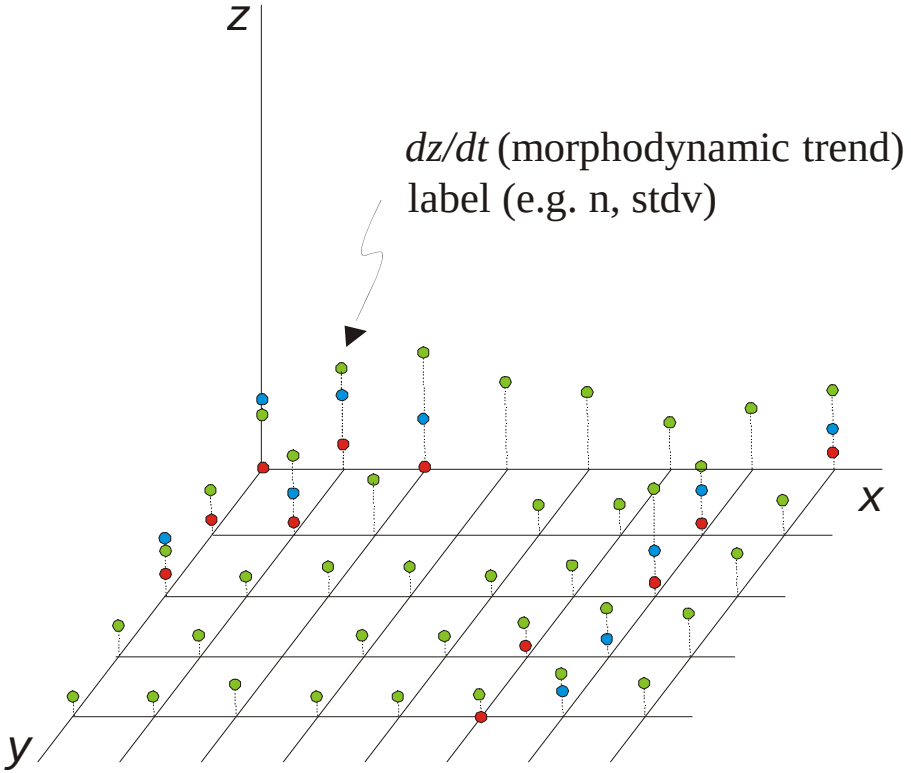


NLHO BAS

Quantification vertical dynamics NCS



- Surveys in time series
- Digital Elevation Models (DEMs) (now online on www.OpenEarth.nl)
- Vertical bed dynamics, *dz/dt* (m/yr)



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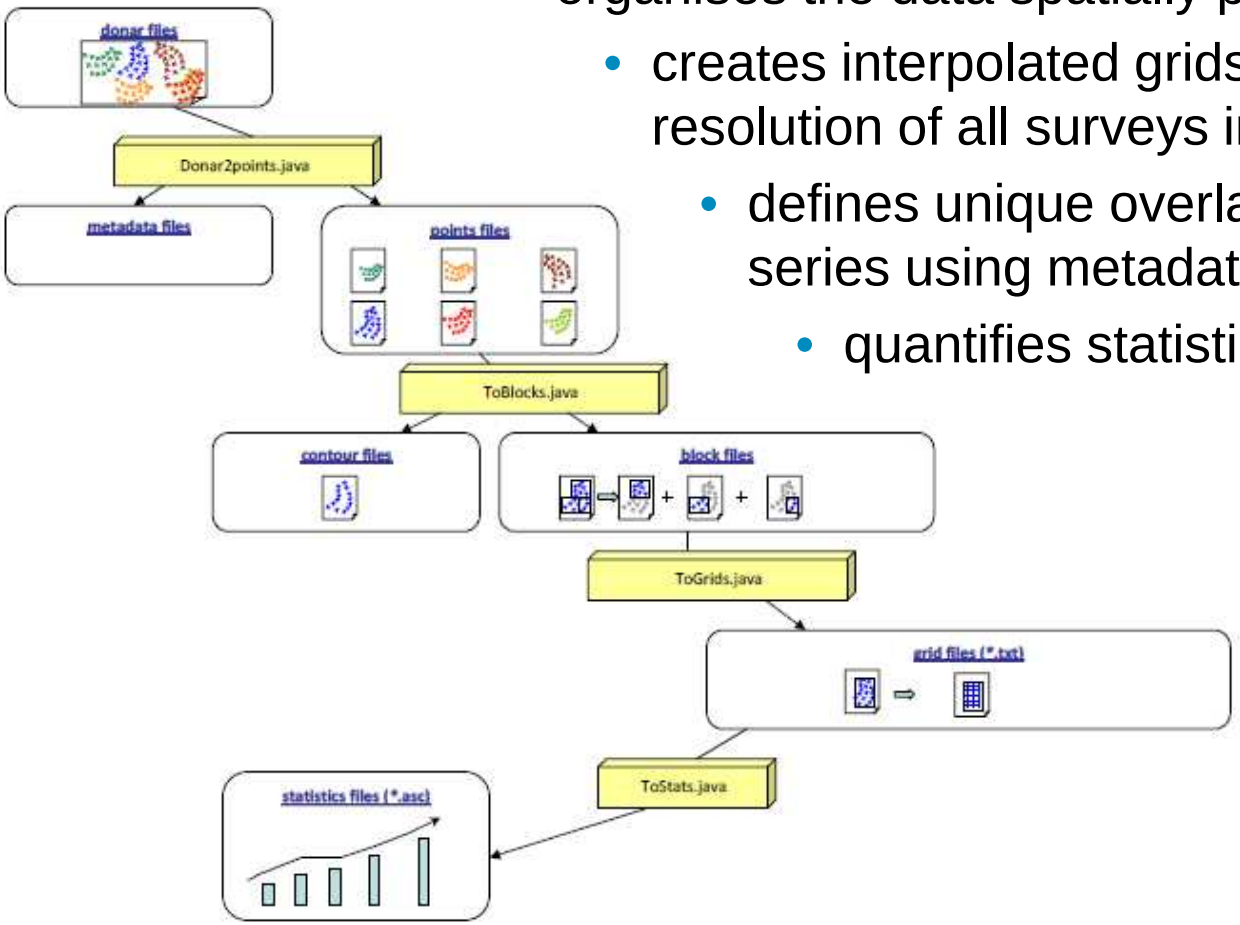
Quantification vertical dynamics NCS

- Fully-automated method for the quantification of vertical bed dynamics. The method can deal with large data sets and high-resolution data.
  - organises the data spatially per survey,
    - creates interpolated grids (DEMs) at user-defined resolution of all surveys in time,
      - defines unique overlaps of surveys in time series using metadata and
        - quantifies statistics per grid node, e.g.
          - mean *z*
          - min *z*, max *z*
          - *dz/dt*



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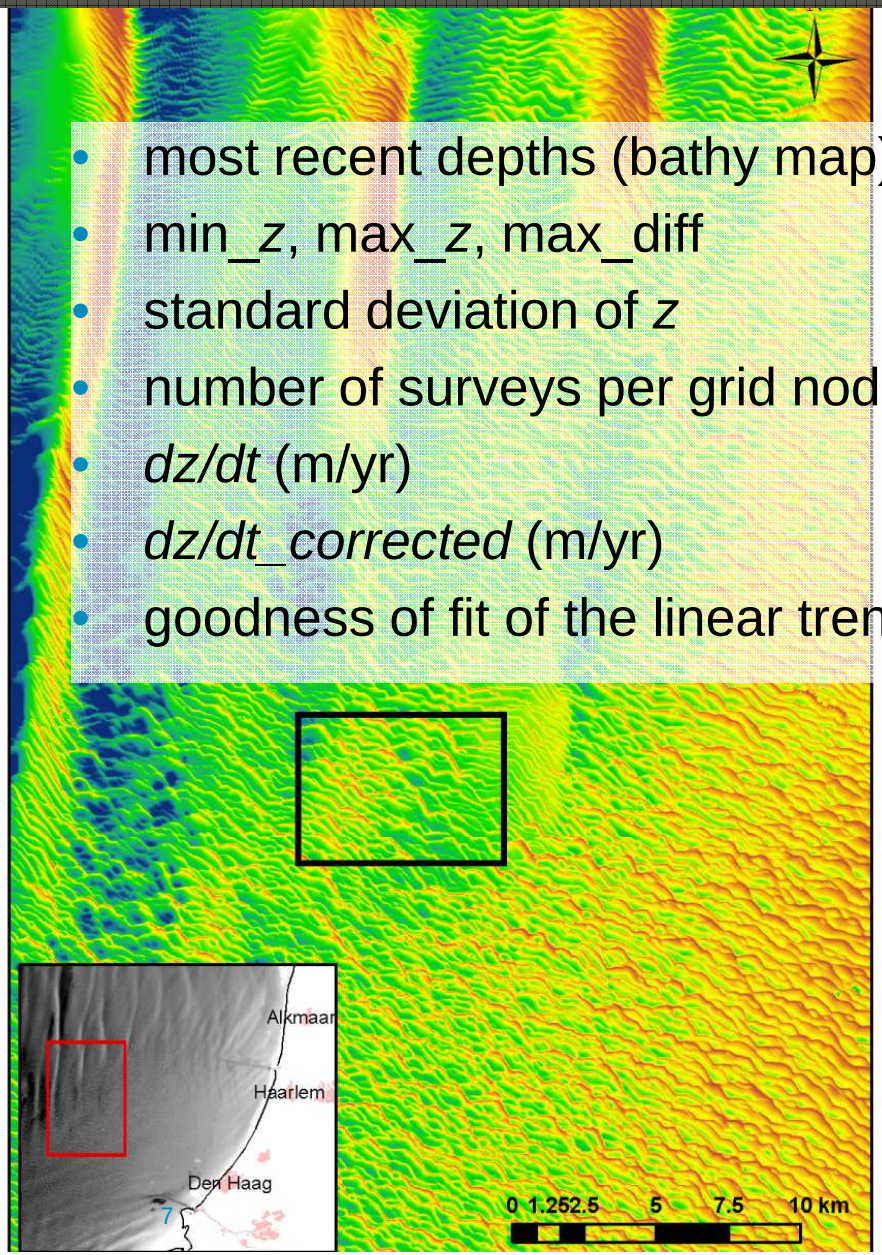
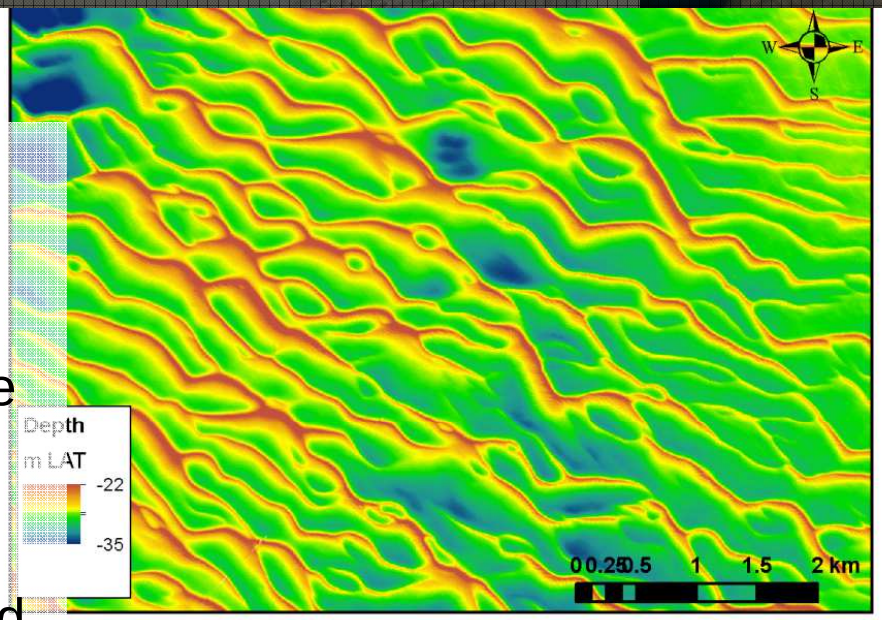
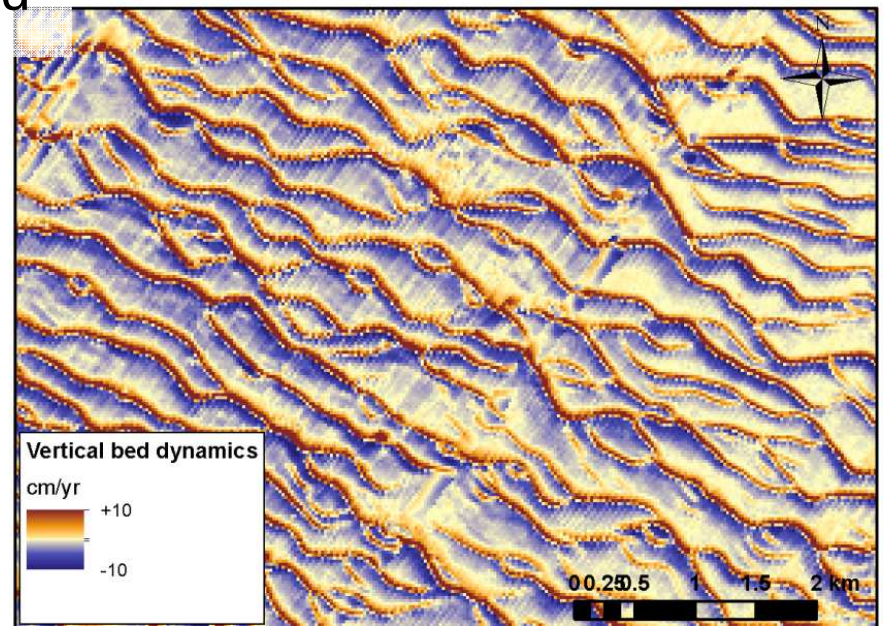
Results: high-resolution statistics (per node)

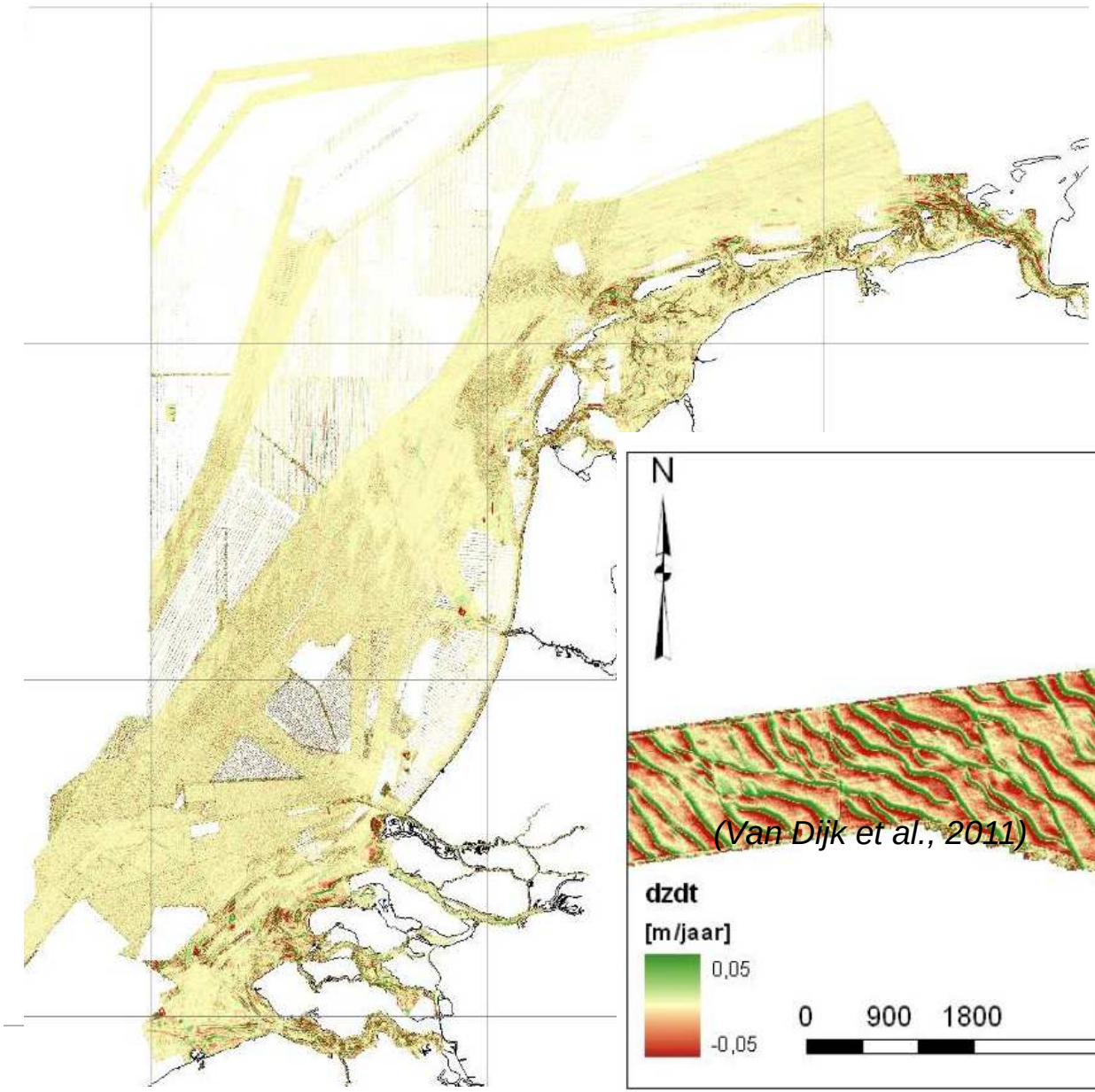
- most recent depths (bathy map)
- min_*z*, max_*z*, max_diff
- standard deviation of *z*
- number of surveys per grid node
- *dz/dt* (m/yr)
- *dz/dt_corrected* (m/yr)
- goodness of fit of the linear trend



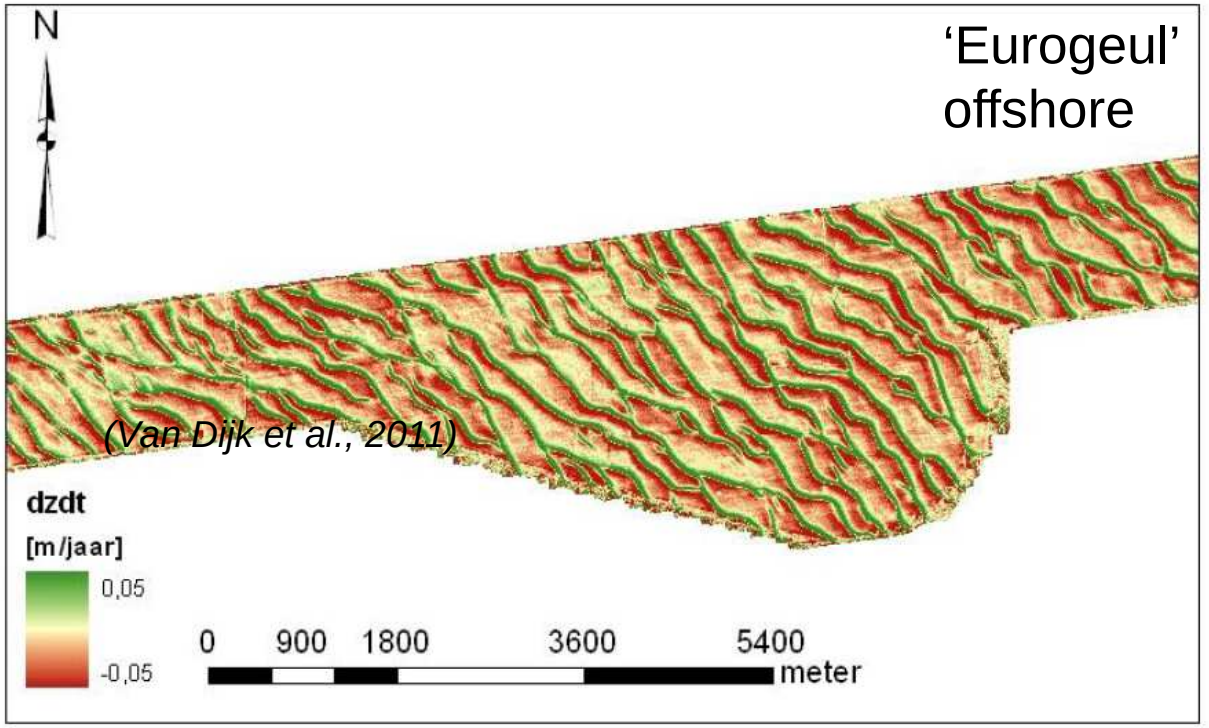




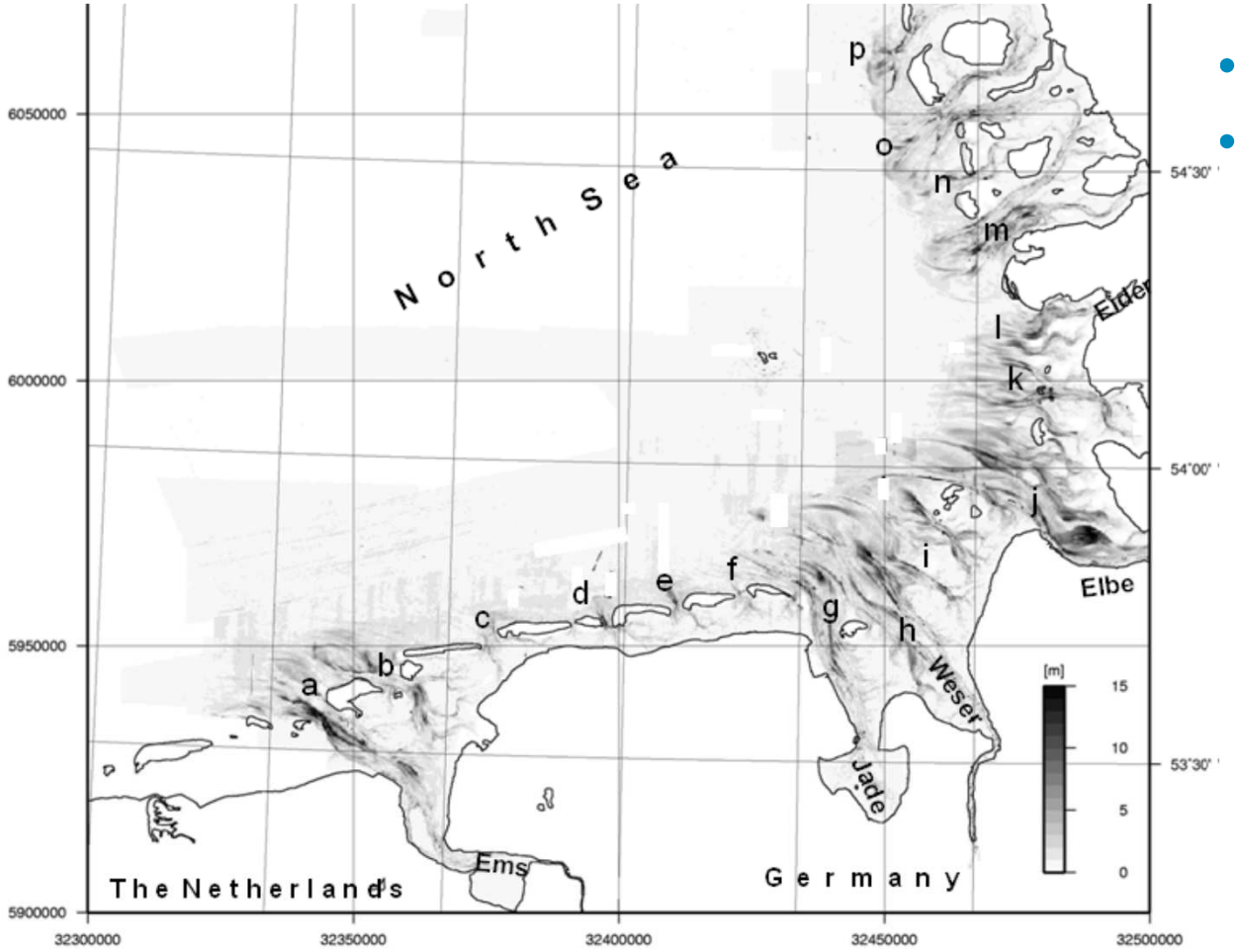
Results: Vertical nodal dynamics NCS (m/yr)



- Coast is dynamic:
  - 25 x 25 km
  - Coastal inlets and tidal-inlet channels
  - estuaries



Comparison to study of German Bight



- Bed elevation range (m)
- data 1982 - 2004

(Winter, 2011)

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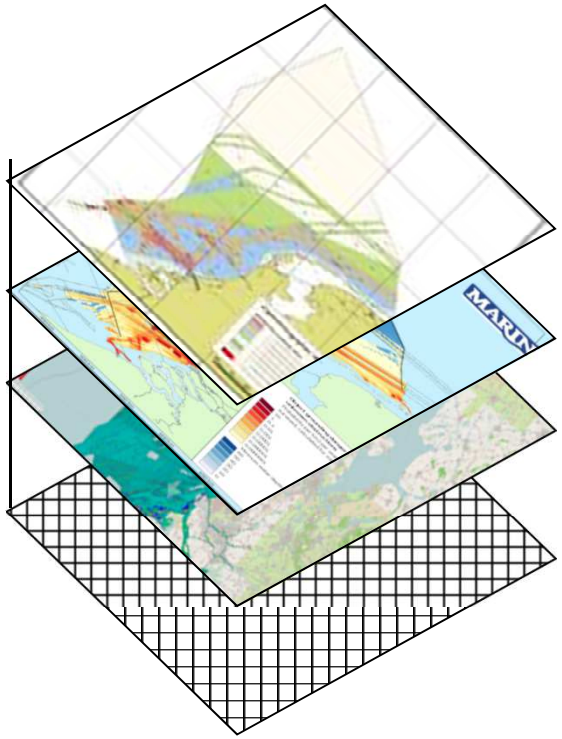
Risk-based resurvey policy

- Aim: validation & optimisation of re-survey policy NLHO



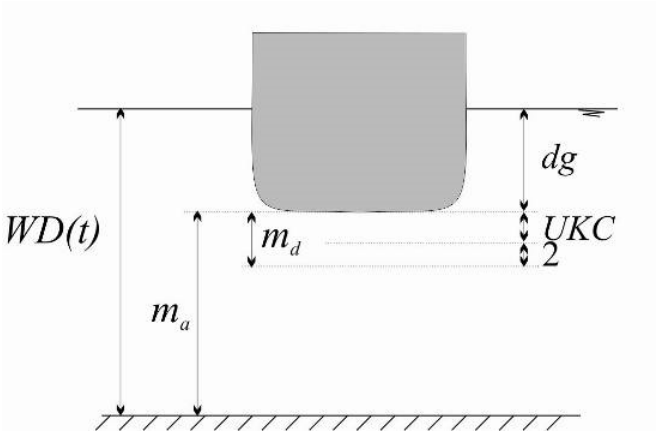
GIS-overlay method:

- re-survey policy
- combined grounding dangers for ships (based on AIS-data)
- morphodynamics (*dz/dt*) as predicted water depths

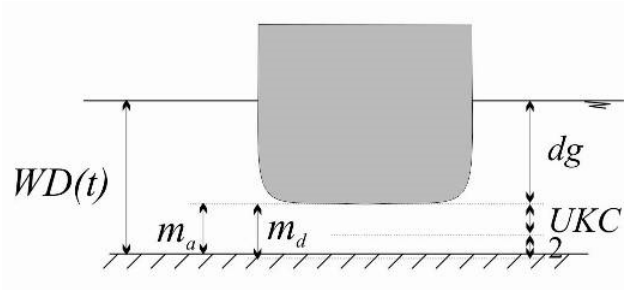
Risk-based resurvey policy

- AIS data
- 1x1 km

- Regular grounding

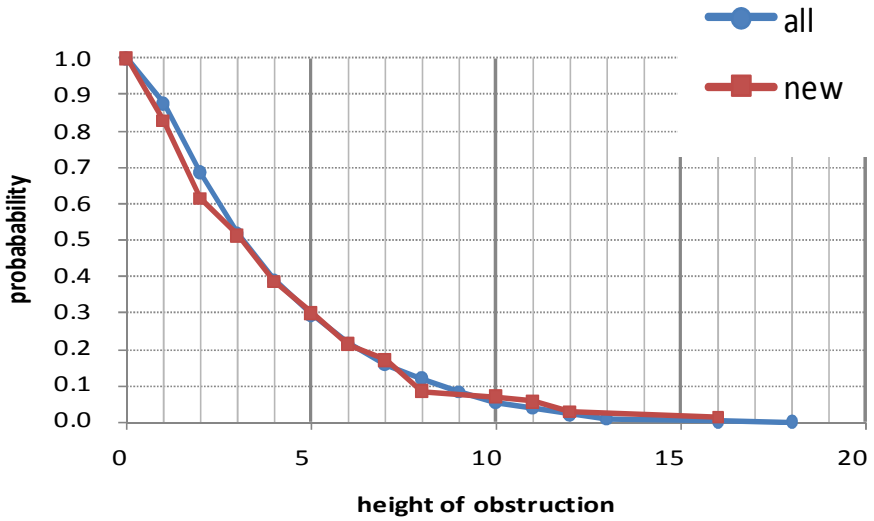


- If $m_a > m_d$, danger = 0
- If $m_a < 0$, runs aground



- Probability of running aground

- Object grounding

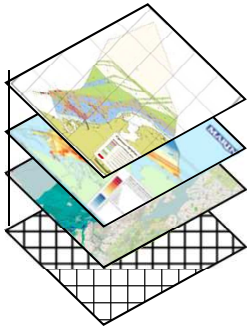


- All known objects
- New known objects

↓

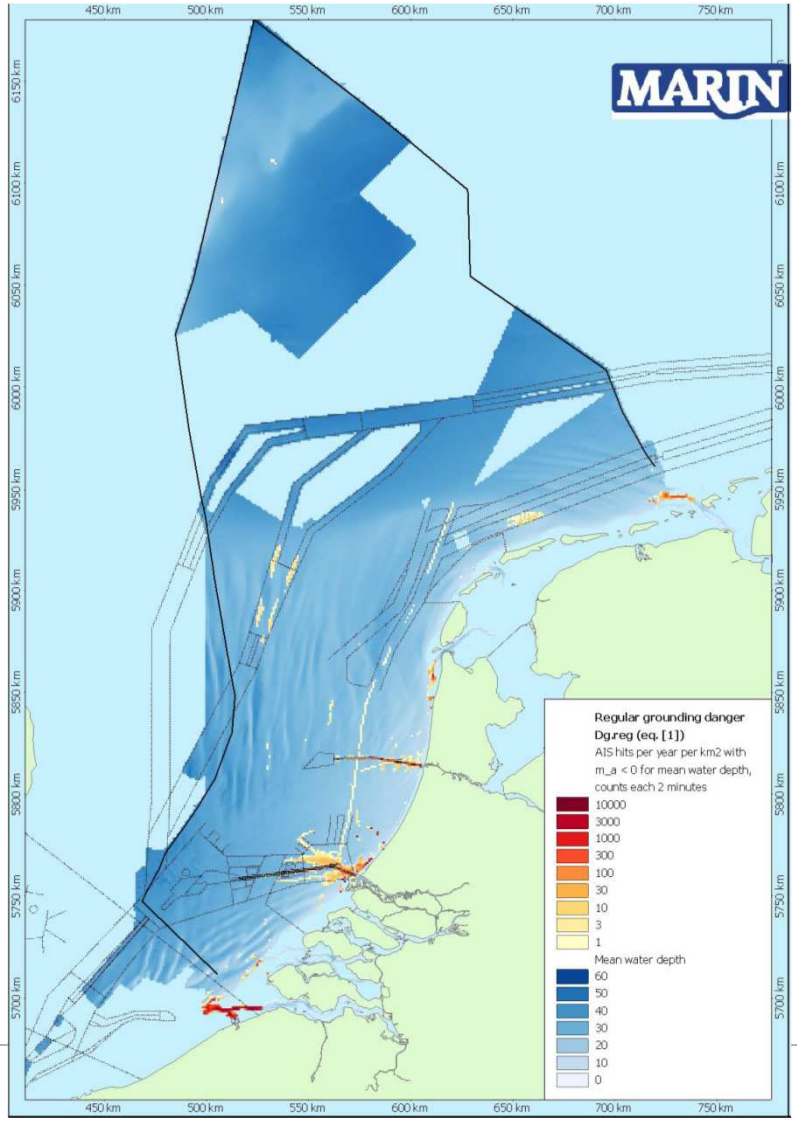
- Unknown objects

Risk-based resurvey policy

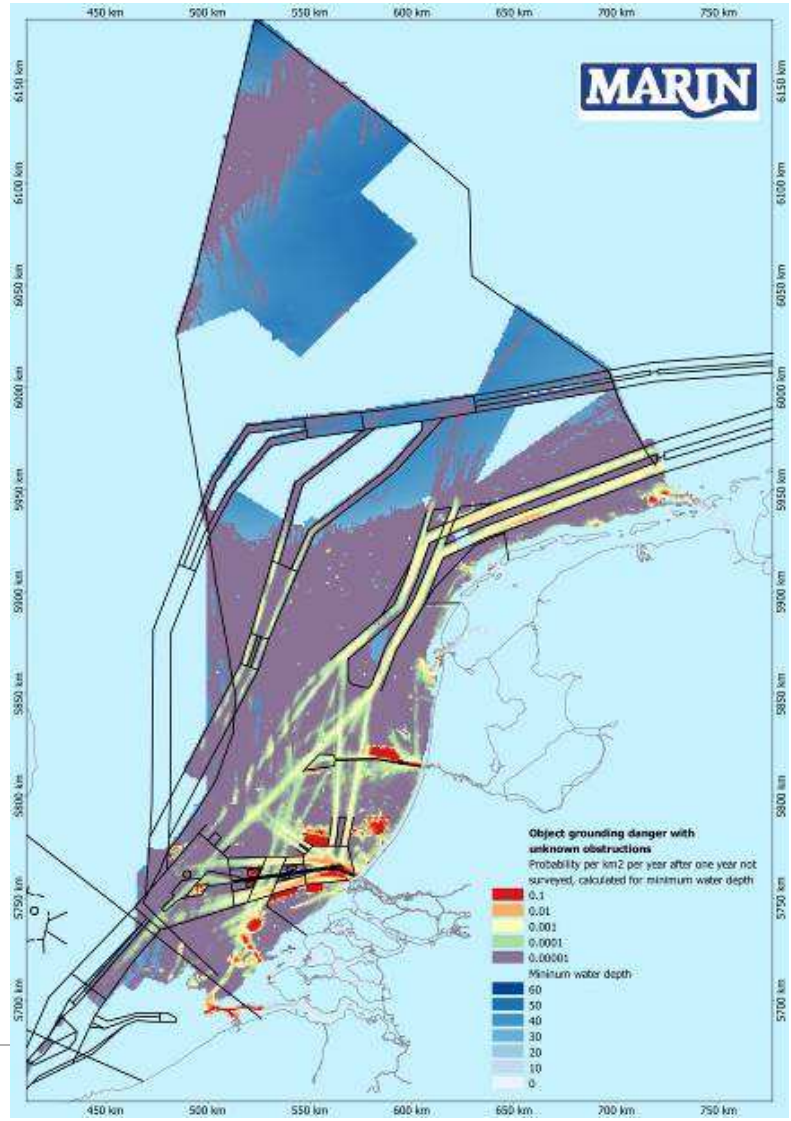


- 1x1 km

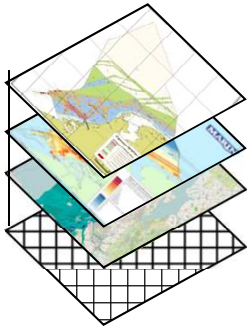
- Regular grounding

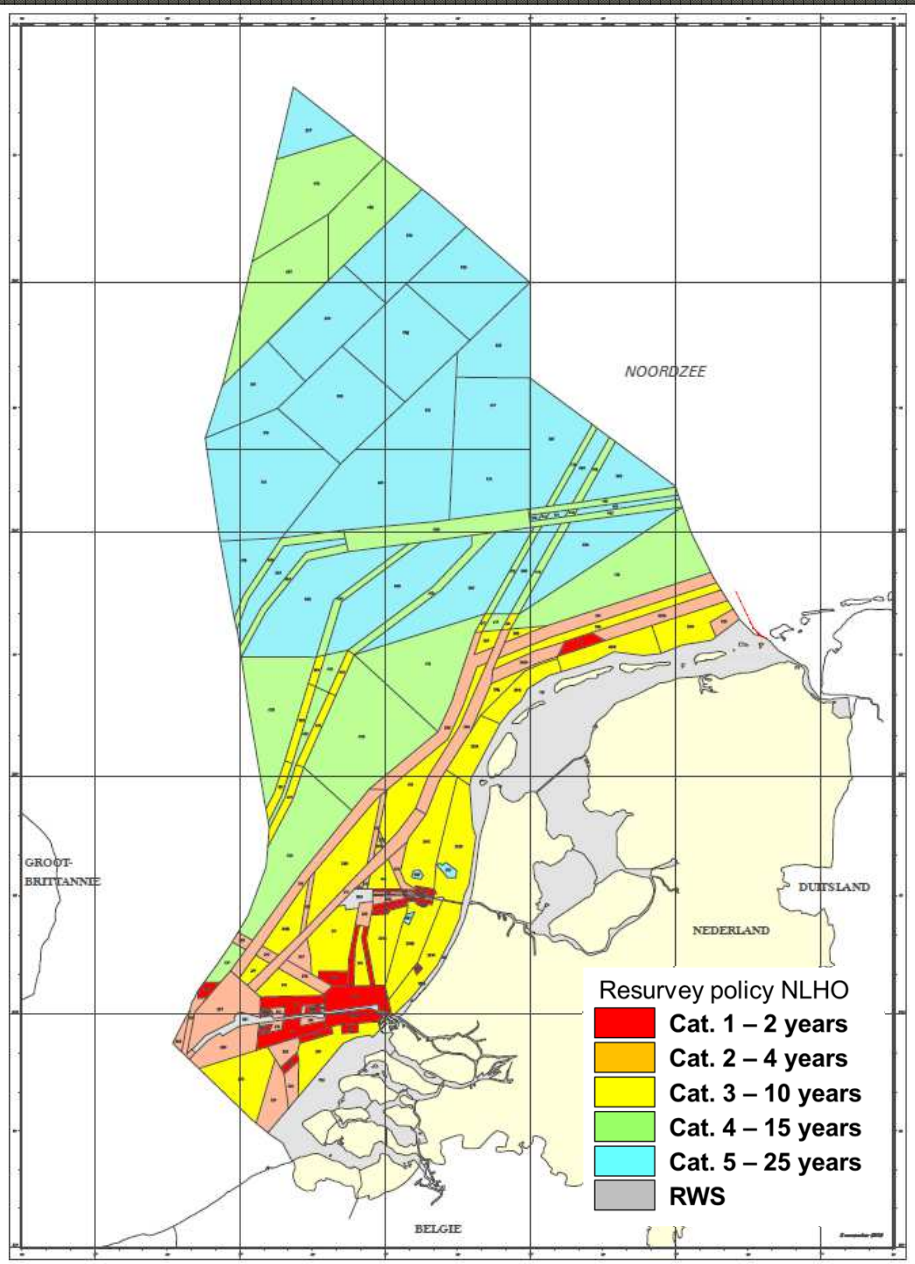


- Object grounding



Risk-based resurvey policy





- NLHO's resurvey policy for the NCS, 2015

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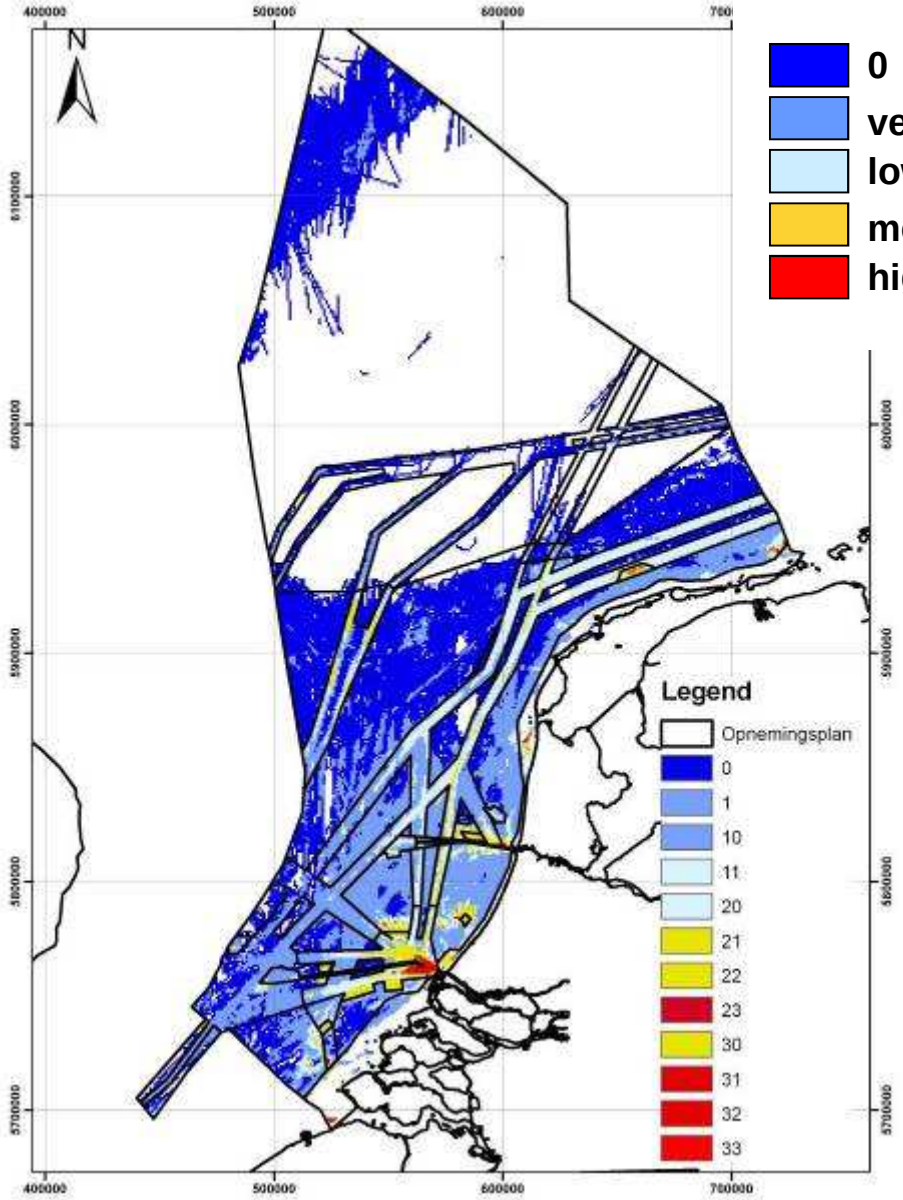
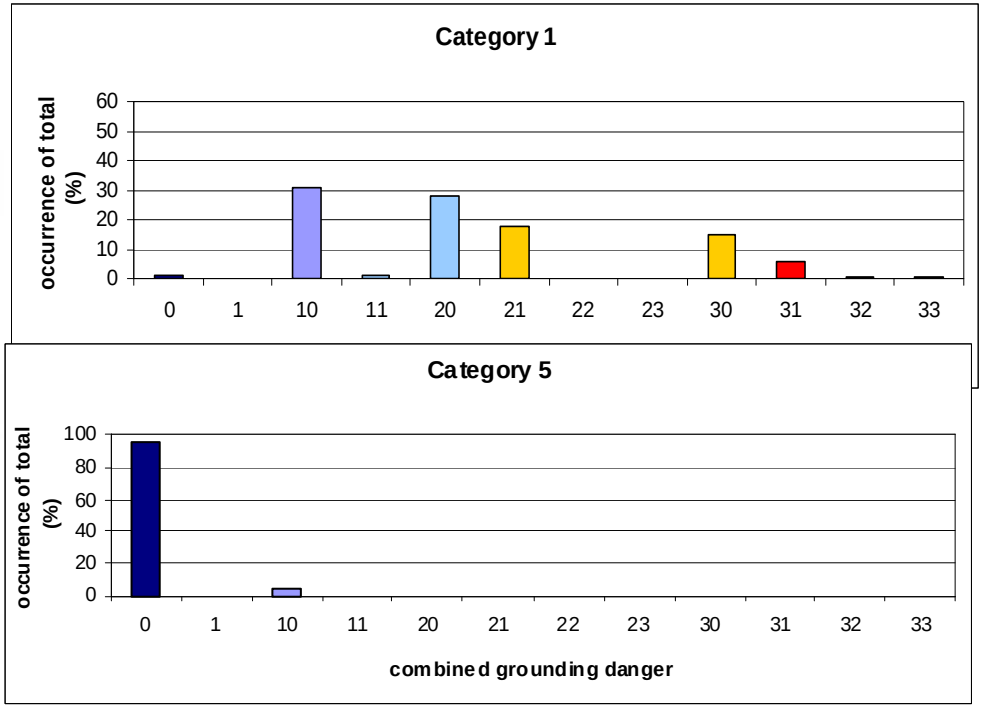
Risk-based resurvey policy

CAT 1 – at least every 2 years
CAT 2 – 4 years
CAT 3 – 10 years
CAT 4 – 15 years
CAT 5 – 25 years



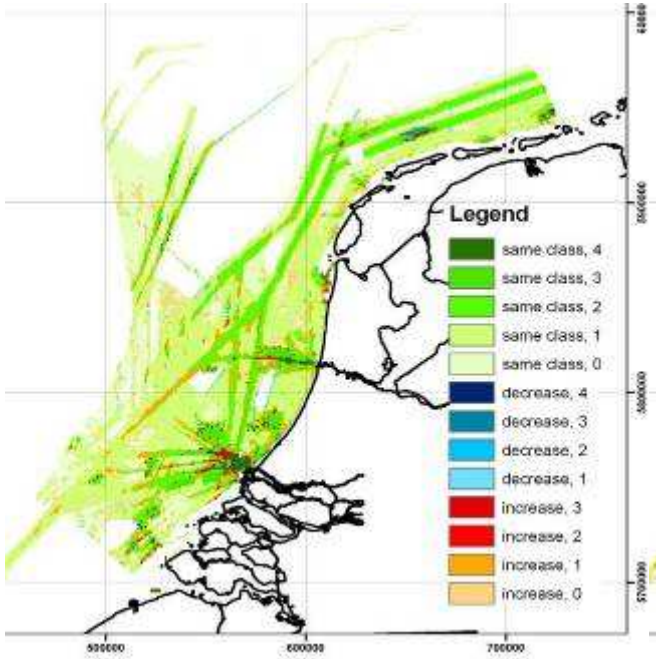
- Combined grounding dangers
- Validation
- Ideally, few classes per category



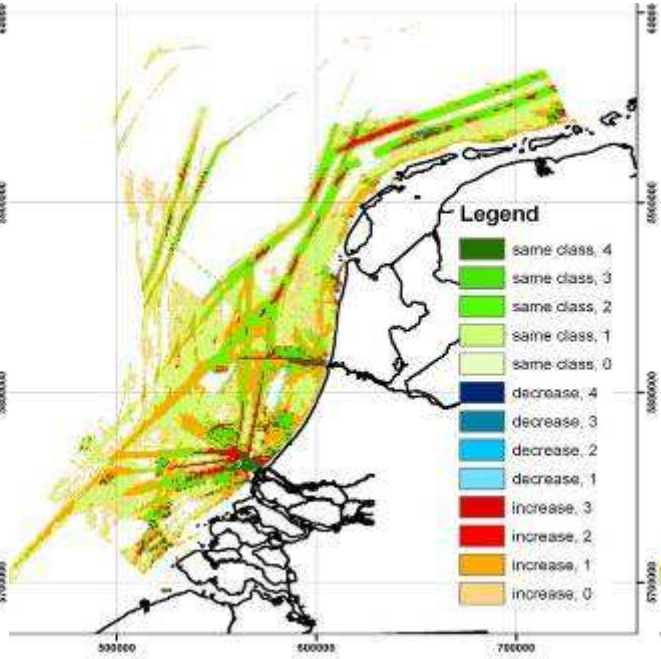
Risk-based resurvey policy

- Development of combined grounding danger in the future based on predicted water depths identifies when areas need to be re-surveyed

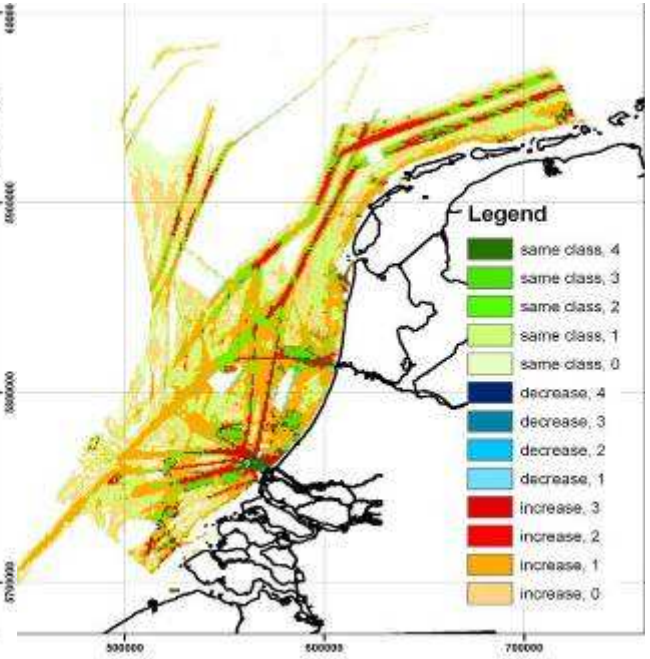
2010 to 2011



2010 to 2015



2010 to 2020



(Van Dijk et al., 2011)

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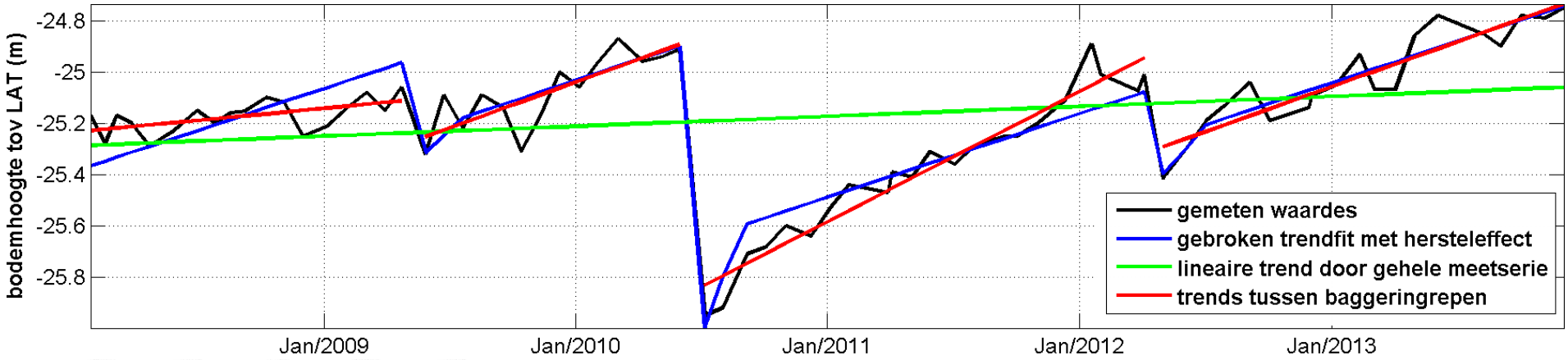
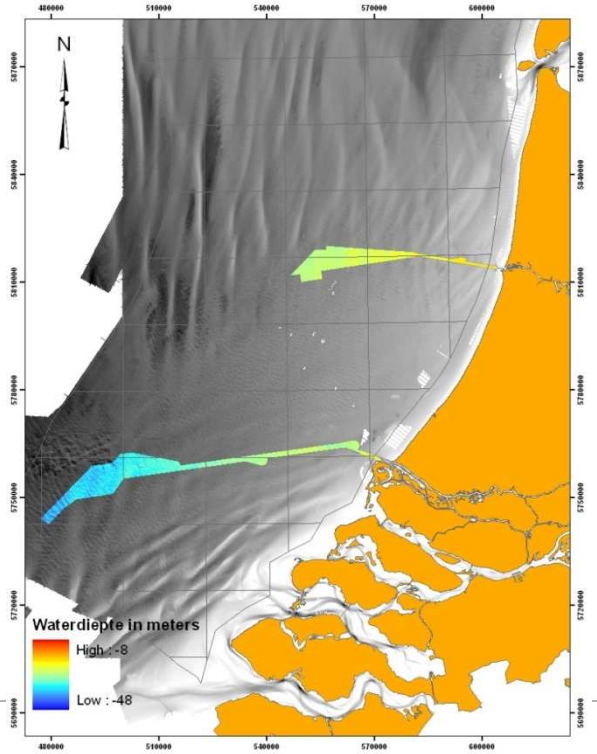
Vertical nodal dynamic trends in dredged areas





- Automated detection of dredging operations
- Nodal dynamic trends in between dredging operations (red lines) correspond well to autonomous trends in bed level
- Broken trend line algorithm (blue line): fits through increased bed level rise after dredging; applies one trend in each part
- *dz/dt* through entire time series (green line) is not valid in dredged areas

(Van Dijk et al., 2014)

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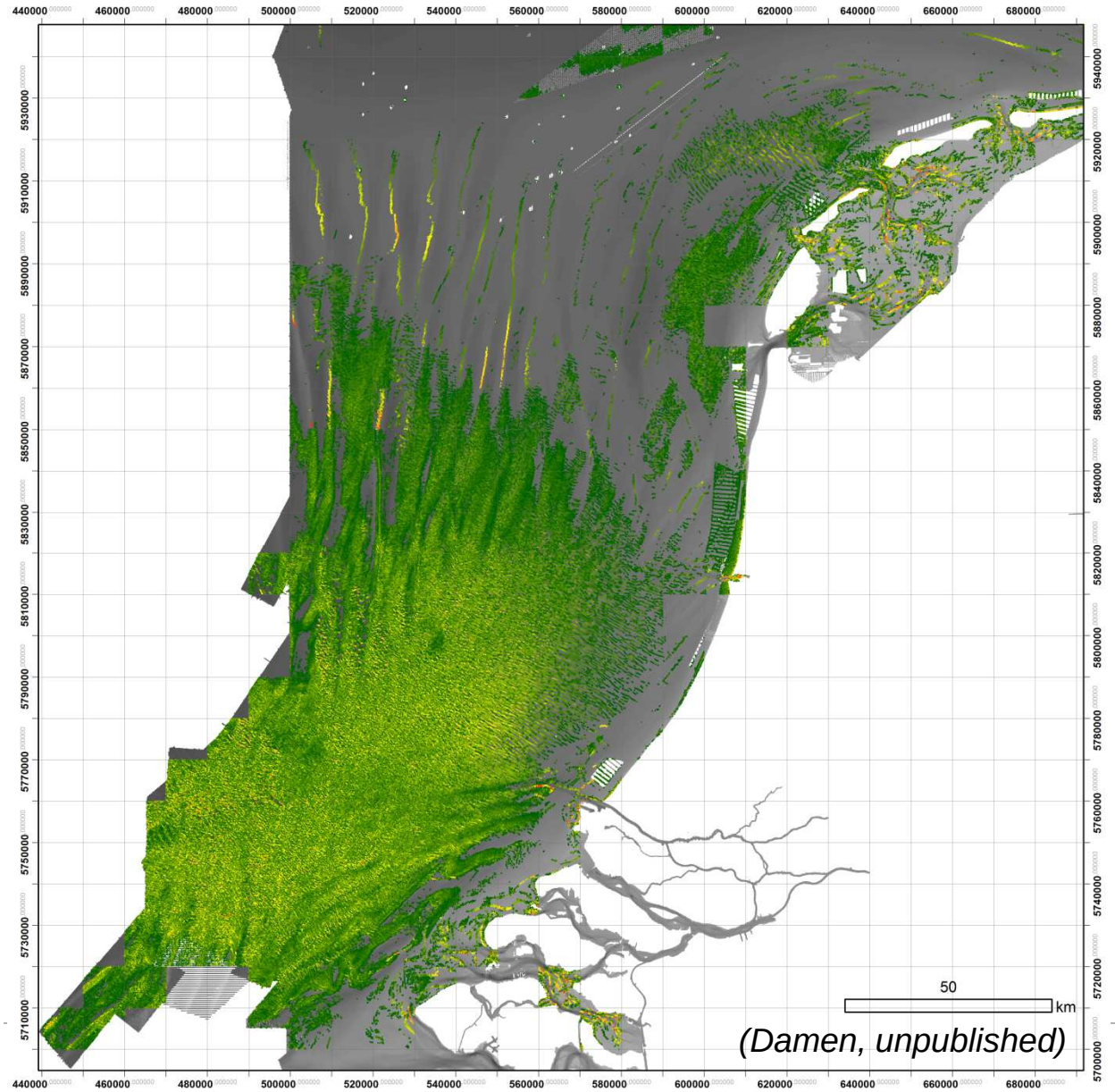
Dynamics of individual bedforms



- NWO-STW project “SMARTSEA”
  U Twente & TU Delft
  3 PhD students
  (2014-2018)
- Sand wave dynamics & resurvey policy
- Environmental controls
- Quantified precisions

Koninklijke Marine
Ministerie van Defensie

Rijkswaterstaat
Ministerie van Verkeer en Waterstaat

UNIVERSITY OF TWENTE.

TU Delft

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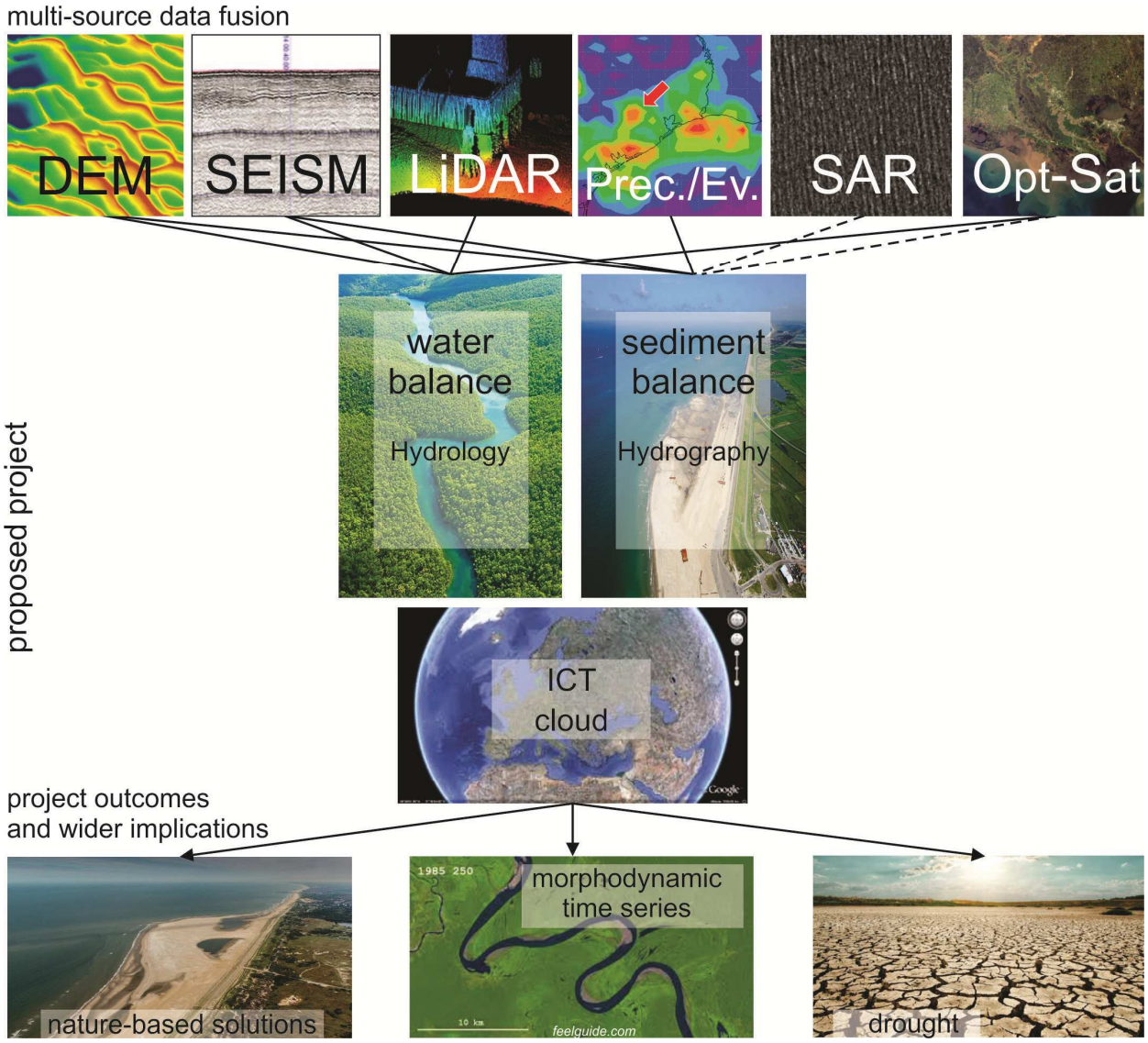
Data fusion in hydrology and hydrography



- NWO ALW Topsector Water Call Proposal
- 2 PhD, 1 post-doc
- TU Delft & UTwente
- 23rd of June 2016

TU Delft

Van Oord
Marine ingenuity

UNIVERSITY OF TWENTE.

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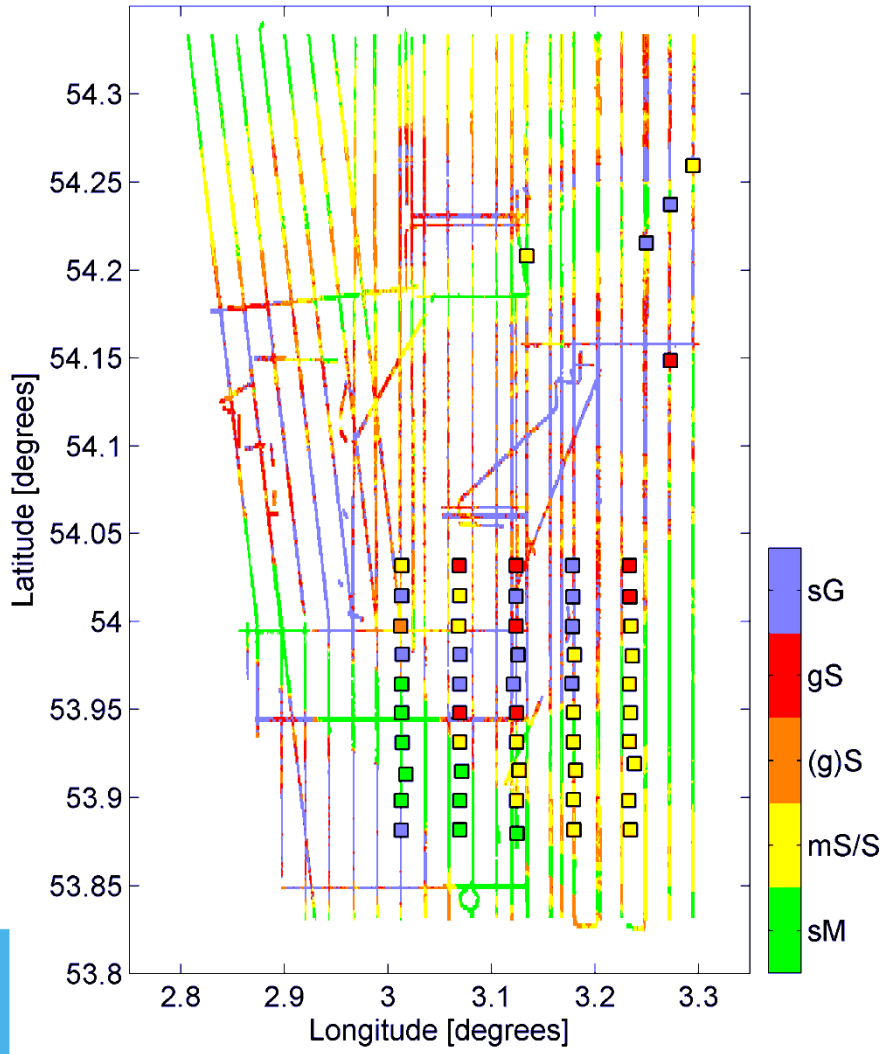
MBES knowledge network NLds

- MBES bathymetry
- Bed classification of sea-bed sediments based on MBES backscsatter

- Cleaver Bank
- MBES 2013-2015



(Snellen et al., 2015)

Conclusions

- Hydrographic time series allow for the quantification of seabed dynamics
- Bed dynamics are relevant to calculating grounding dangers (risk assessments) and resurvey policies
- Bathymetric time series are highly valuable to both applied and scientific projects
- Initiatives for data and results availbility online are important
- storing MBES backscatter would be a great step forwards (NLds)

Further information

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Netherlands

References to the literature in this presentation:

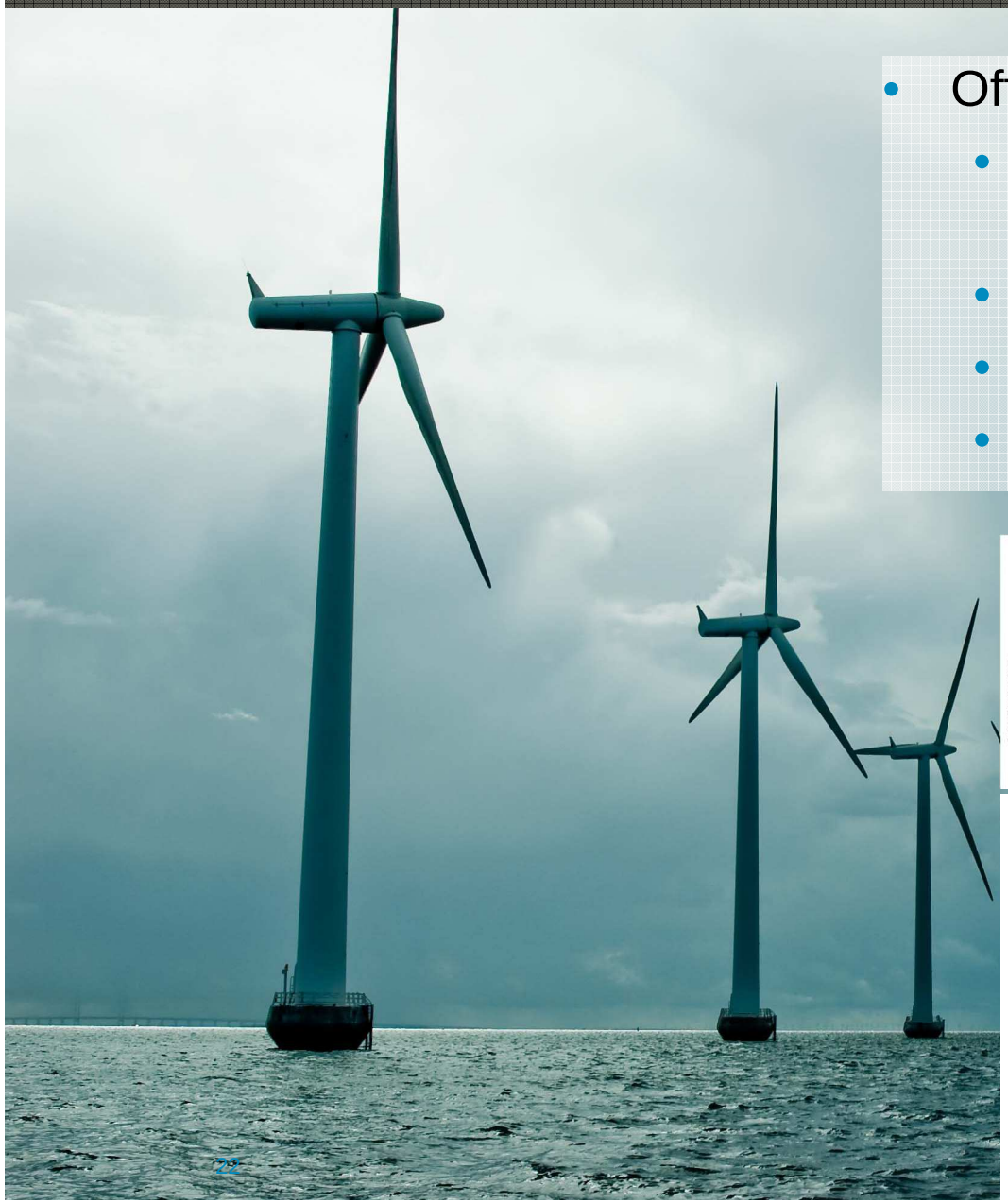
Snellen, M., Siemes, K., Janmaat, J. and Simons, D.G. (2015). The effect of bathymetric measurement uncertainties on multibeam echosounder sediment classification. Proceedings of the Institute of Acoustics, 37: 273 – 280.

Van Dijk, T.A.G.P., C. Van der Tak, W.P. De Boer, M.H.P. Kleuskens, P.J. Doornenbal, R.P. Noorlandt and V.C. Marges (2011). *The scientific validation of the hydrographic survey policy of the Netherlands Hydrographic Office, Royal Netherlands Navy*. Deltares, Report 1201907-000-BGS-0008: 165 pp. http://kennisonline.deltares.nl.

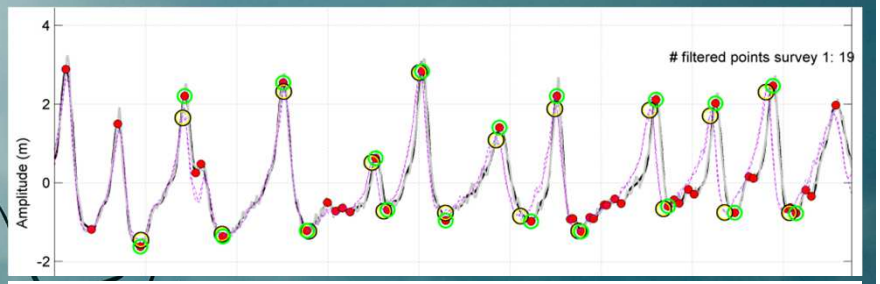
Van Dijk, T.A.G.P., Vermaas, T. and Hijma, H.P. (2014). KPP Onderzoek Bodemdynamiek 2014. Deltares report 1209377-010-ZKS-0001 (in Dutch), 47 pp.

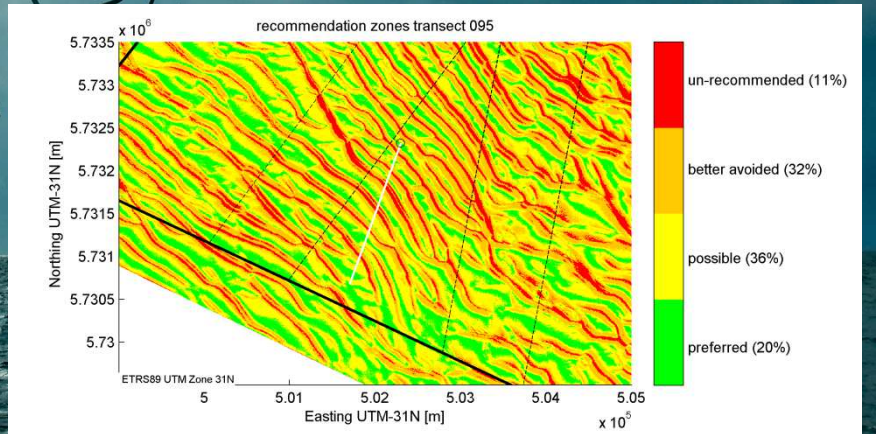
Winter, C. (2011). Macro scale morphodynamics of the German North Sea coast. *Journal of Coastal Research* SI 64(Proceedings of the ICS2011, Poland): 706 - 710.

Applications of sea bed dynamics

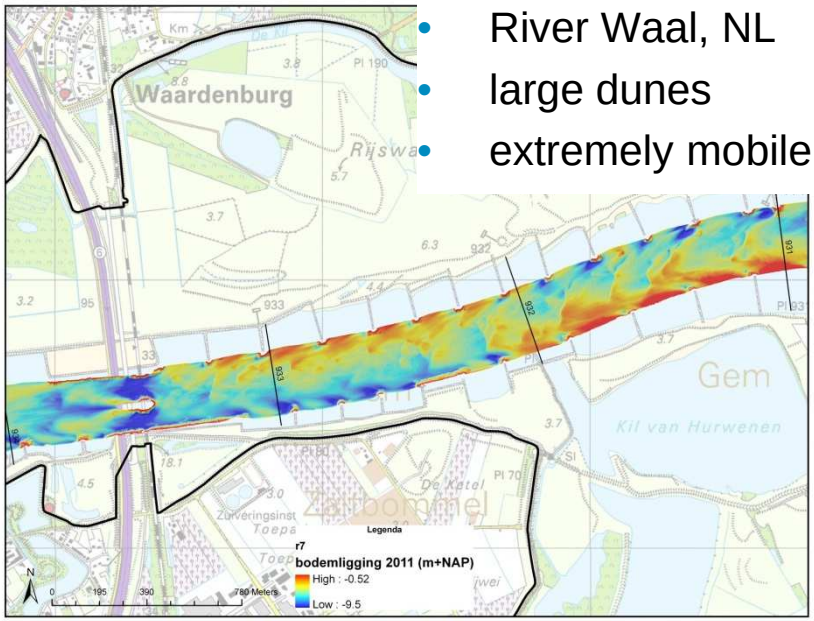


- Offshore and Coastal Engineering
  - Offshore wind farms: design and construction
  - Pipelines and cables
  - Anchors of rigs
  - Coastal constructions





River beds



- River Waal, NL
- large dunes
- extremely mobile

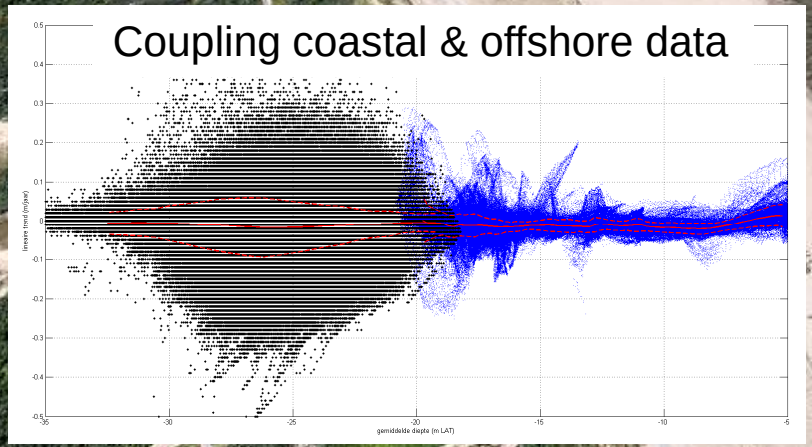
- Safe and economic navigation at critical water depths (in-land shipping)
- Monitoring and maintenance policies (charting, dredging, nourishments)

River IJssel, NL, 2015 (*rtvoost.nl*)

Nature-based solutions

- Mega-nourishment "Zandmotor" (20 Mm^3)
- Redistribution of sand by tide, waves and wind

Coupling coastal & offshore data



- National applied research programme (KPP) Morphodynamic modelling
- Monitoring campaign
- Nature Coast

  multidisciplinary science project: 6 universities,15 PhD students

www.haagsetijden.nl