Royal Netherlands Institute for Sea Research

NCK Theme Day
Remote Sensing of the Coastal Zone
Utrecht, 25 January 2013

Optical and radar remote sensing of the intertidal zone

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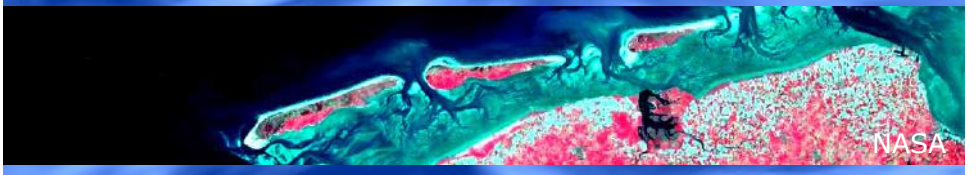


Intertidal ecology

- (Estuarine) intertidal zone
  - Very productive zone
  - Harsh and dynamic environments, large gradients
- Opportunities for remote sensing
  - Structuring of benthic biota
    (physical or biological factors or biophysical interactions?)
  - Resilience
    (responses to change/ human impacts?)

Intertidal ecology

Sediment type

habitat

ecosystem engineering

Benthic (micro)algae

Benthic animals

habitat

ecosystem engineering

food

?

food

Radar satellite remote sensing

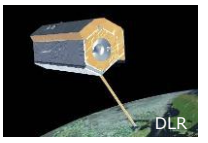
Radar (SAR) configuration

- Polarisation *qp*
- Radar wavelength λ
- Angle of incidence θ_i

Environment/biology

- Epibenthos (e.g.,shellfish)
- Sediment
- Surface water
- Interstitial water
- Salinity, temperature
- Local slope θ_s
- Vertical roughness *RMSz*
- Horizontal roughness *L*
- Dielectric constant ε

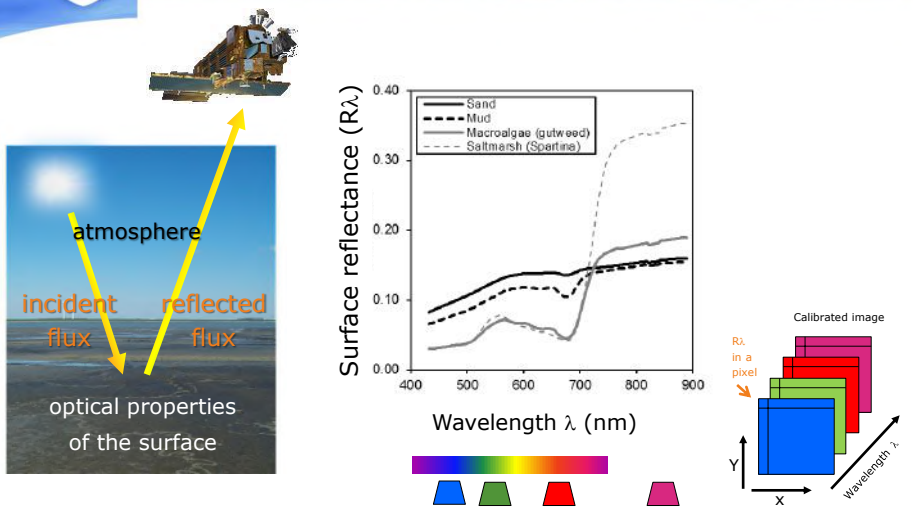
Backscatter σ^0



$\sigma^0 = f\,(qp, \lambda, \theta, RMSz, L, \varepsilon)$

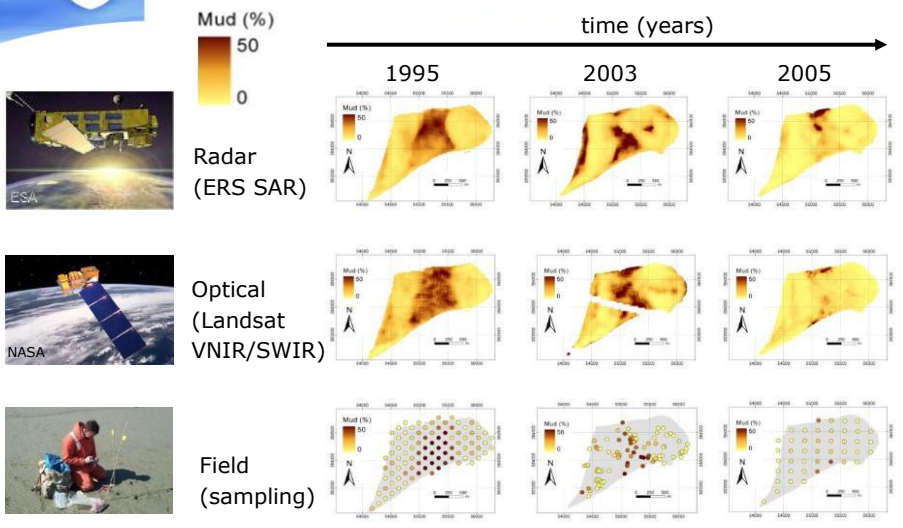
Van der Wal et al. (2005), Remote Sensing of Environment

Optical (satellite) remote sensing



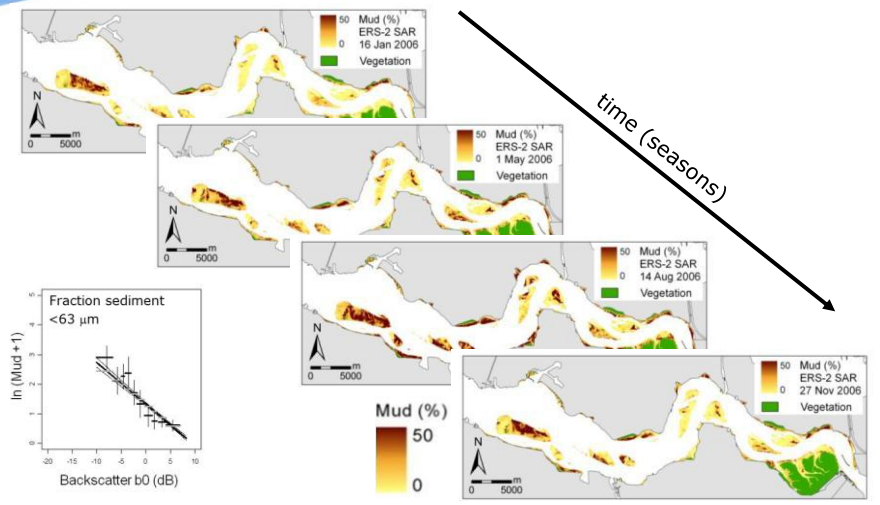
Van der Wal & Herman (2007), Remote Sensing of Environment

Radar and optical remote sensing: sediment



Van der Wal and Herman (2007) Remote Sensing of Environment

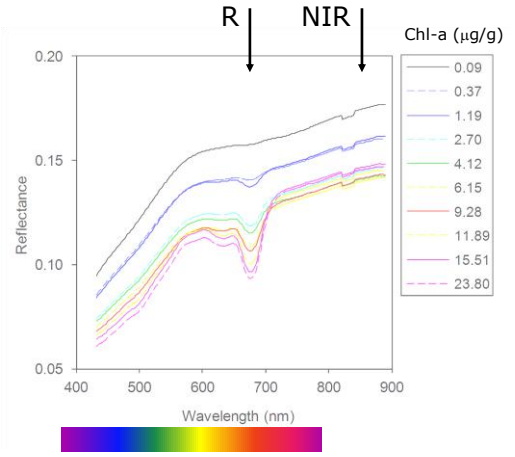
Sediment dynamics (Westerschelde)



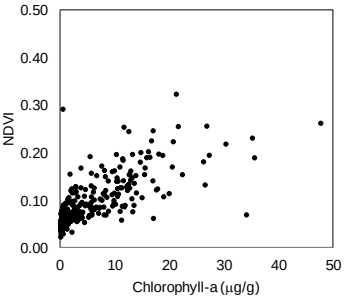
Van der Wal, Van Kessel, Eleveld and Vanlede (2010) Ocean Dynamics

Spectral characteristics of benthic algae

- Benthic microalgae (diatoms) in the sediment

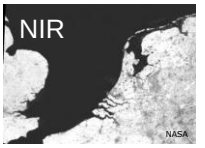


- NDVI = (NIR-R) / (NIR+R)



Van der Wal, Herman, Forster, Ysebaert, Rossi, Knaeps, Plancke, Ides (2008). Marine Ecology Progress Series

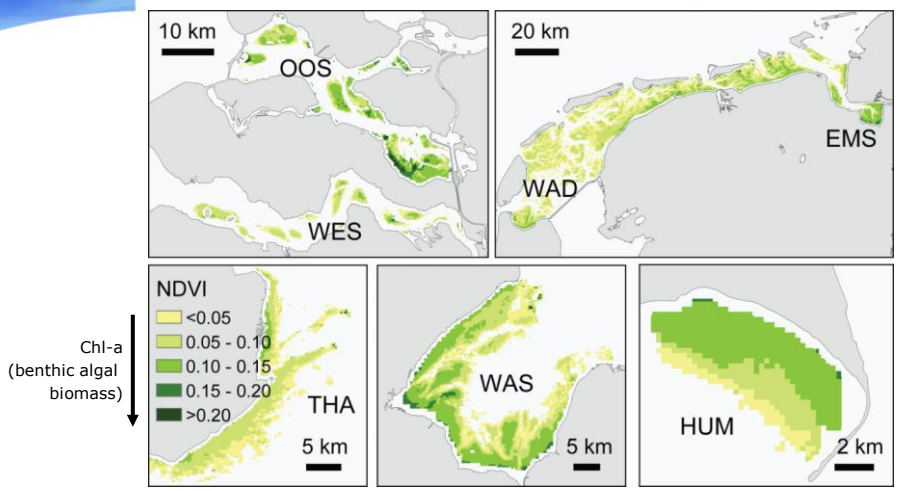
Benthic (micro)algal biomass



- Daily MODIS Aqua 2002-2008 (>2100 images, 250 m resolution)
- 7 estuaries / coastal lagoons
- High quality pixels only (e.g., atmospheric correction, no clouds)
- NDVI as proxy for benthic algae (no surface water, no land, no seagrass/saltmarsh)

Van der Wal, Wielemaker-van den Dool & Herman (2010). Ecosystems.

Benthic (micro)algal biomass (2002-2008)

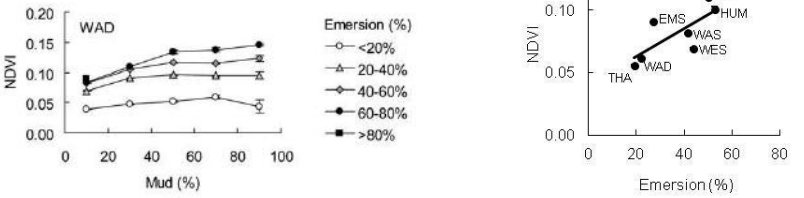


Van der Wal, Wielemaker-van den Dool & Herman (2010). Ecosystems.

Benthic (micro)algae: structuring in space

- Spatial variation in NDVI is largely (62%) explained by:
  - emersion duration (photosynthesis, vertical migration)
  - mud content of the sediment

… both ***within*** and ***across*** ecosystems



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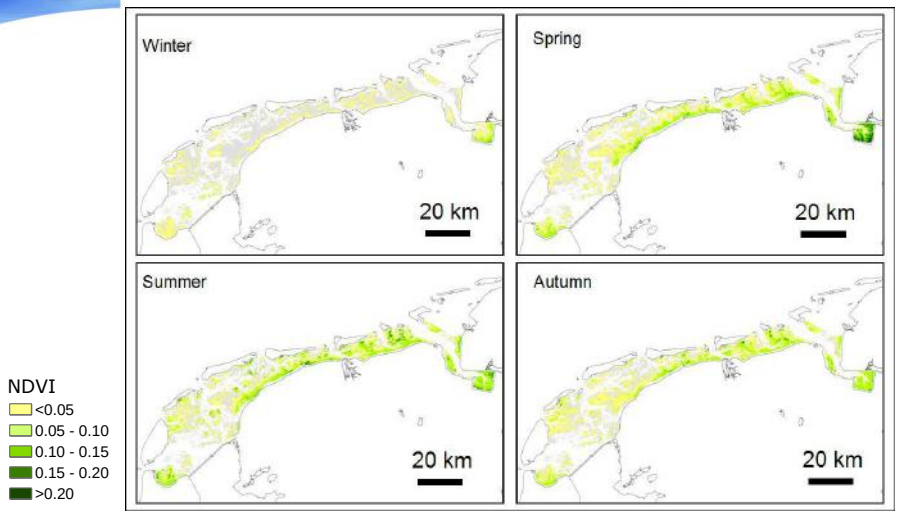
Benthic (micro)algae: seasonal variation



Van der Wal, Wielemaker-van den Dool & Herman (2010). Ecosystems.

Benthic (micro)algae: year-to-year variation

		NL - south		NL - north		UK		
		Westerschelde	Oosterschelde	Wadden Sea	Ems-Dollard	Humber	Wash	Thames
NL - south	Westerschelde		P<0.001	P<0.01	P<0.01			
	Oosterschelde	P<0.001		P<0.1	P<0.05			
NL - north	Wadden Sea	P<0.01	P<0.1		P<0.001			P<0.001
	Ems-Dollard	P<0.01	P<0.05	P<0.001				P<0.05
UK	Humber							
	Wash							
	Thames			P<0.001	P<0.05			

Monthly anomalies (deviations from longterm monthly means) in NDVI:

- show synchrony among Dutch ecosystems
- correlate with waves (-), temperature (+) and for UK-N also air frost (-)

Van der Wal, Wielemaker-van den Dool & Herman (2010). Ecosystems.

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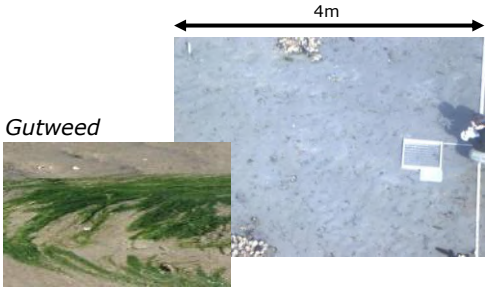
Benthic macroalgae (seaweeds)

Argus-BIO camera
Building with Nature,
Galgeplaat (Oosterschelde):
Monitoring nourishment

Small scale experiment
Collaboration NIOZ, IMARES, Deltares



Gutweed

Van der Wal, Van Dalen, Wielemaker-van den Dool, Ysebaert and Dijkstra (2013), submitted

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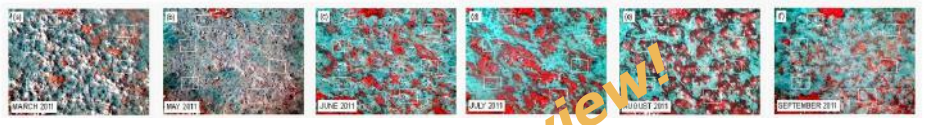
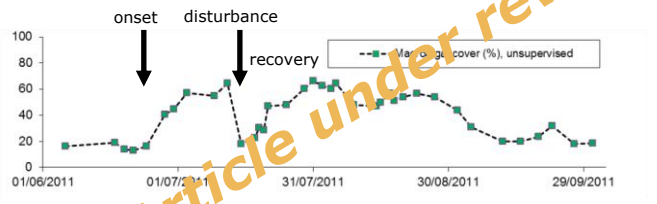
Classification of benthic macroalgae





Unsupervised classification: macroalgal cover

… more results…

Van der Wal, Van Dalen, Wielemaker-van den Dool, Ysebaert and Dijkstra (2013), submitted

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Yearly airborne hyperspectral surveys

Van der Wal, Herman, Forster, Ysebaert, Rossi, Knaeps, Plancke, Ides (2008). Marine Ecology Progress Series

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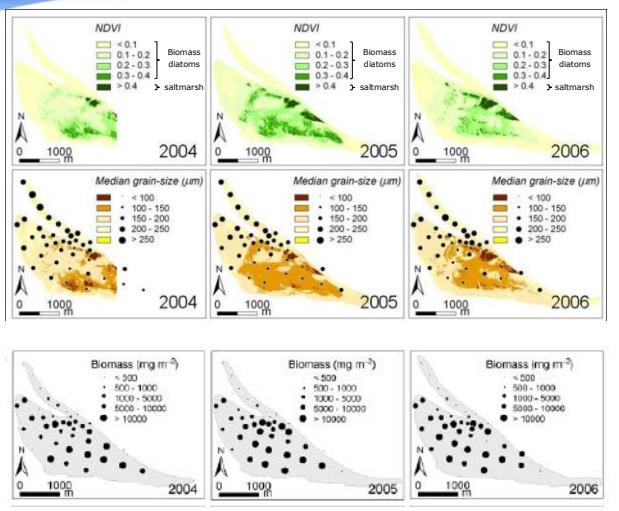
Food, sediment and benthic animals



Hyperspectral surveys: Microalgae (food)

Sediment

In situ sampling: Benthic macrofauna (animals)

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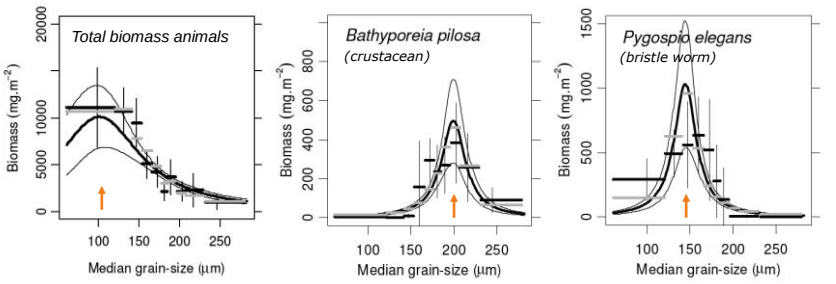
Benthic animals: response models



Van der Wal, Herman, Forster, Ysebaert, Rossi, Knaeps, Plancke, Ides (2008). Marine Ecology Progress Series

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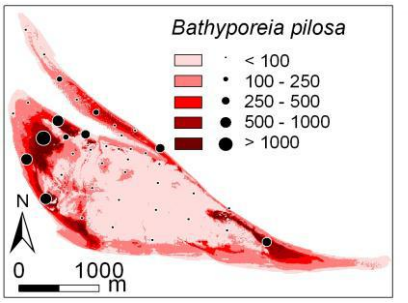
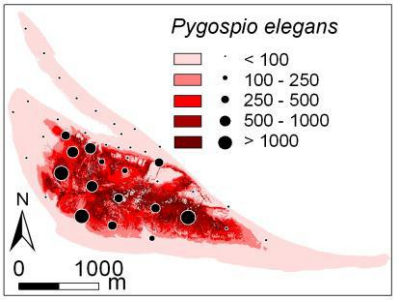
Benthic macrofauna: spatial prediction

Predicted (remote sensing) mg/m^2

Observed (field) mg/m^2





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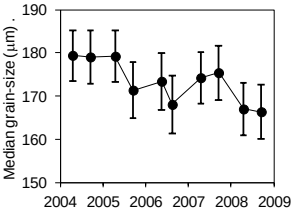
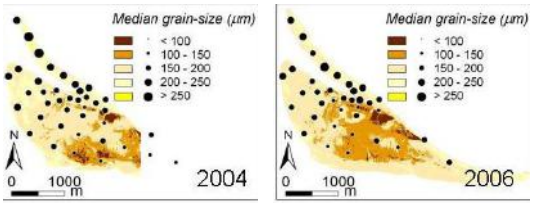
Benthic macrofaunal community change

Sediment fining





Van der Wal, Herman, Forster, Ysebaert, Rossi, Knaeps, Plancke, Ides (2008). Marine Ecology Progress Series

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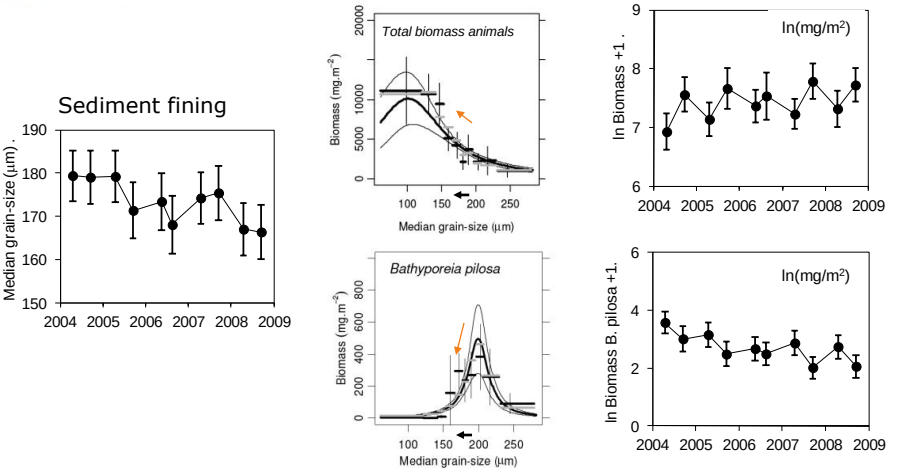
Benthic macrofaunal community change



Van der Wal, Herman, Forster, Ysebaert, Rossi, Knaeps, Plancke, Ides (2008). Marine Ecology Progress Series
Van der Wal, Forster, Rossi, Hummel, Ysebaert, Roose, Herman (2011). Marine Pollution Bulletin.

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Conclusions

- Remote sensing reveals spatial structuring of
  - (micro)algae: by emersion duration and mud content (*MODIS Aqua satellite*)
  - macroalgae: by *Lanice (pole camera)*
  - macrofauna: by microalgae and sediment (*airborne hyperspectral surveys*)
- Correlations suggest tight coupling, but not in all cases causal relations!
- Remote sensing supports efficient synoptic hindcasting/forecasting of benthos in response to environmental change or human impact (e.g., changes in temperature, storminess, sediment grain-size)

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Thank you for your attention!

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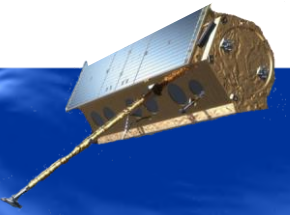

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