

## Introductory Course Delft3D-WAQ

Water quality modelling, introduction and concepts

WAQ\_Topics\_02 WAQ\_Introduction\_03



#### **Deltares software**

	NL III NEWS BLOG CAREERS SEARCH Q. 203
Deltares	Areas of expertise Software Academy Facilities About us Contact
9	Software Simulation Products and Solutions
Support	Direct to a software product pope
tores offers support on a number of software ducts. Direct to the support-section of a product:	Choose your product
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Martine Constant Sector	Paral Discussions Series
Download your software product	Our experts as well as our clients apply, our software stimulation products and solutions in more than 140 countries in a great variety of commercial projects and research studies. This has resulted in much expertise and in-depth knowledge in an extensive field of applications.
	Simulation software products, such as the <u>Delh3D Flexible Mesh Sume</u> (Delh3D FN) for modeling of coastal waters, estuarter, invert, takes, nurd and watera neese, and <u>DrChest Filing</u> for the design of restarting water, are especially designed for Consultants / Engineers, off the shelf ovailable, and you can easily order these products waters in a <u>software Bellevers in</u> . In addition, we offer various solutions to focus on specific target groups. For Operational Forecasters, we
John the Open source community	provide complete information and fereasting systems using <u>Deth-REWS</u> in combination with any required simulation product. For Policymakers, the combination of the Touch Tolde with our simulation products, such as <u>Deth30</u> and <u>Policymakers</u> , the presenting solutions is a social relevant issues, as differed enemnents dedicated viewers that can be combined with our simulation products for interactive applications.
ertified Delft3D	To train and educate users, several Serious Games and Apps are available. The latest Serious Games can be found on this <u>page</u> .
nodelling centre	For an overview of all our software simulation products and solutions, dick here.
Delft3D Certified Hodelling Centres	E Simulation Products
	Defra 3D Flexible Mesh Suite The Bett3D Freik reisa Suite (Drata Pri) the accessor of the structures central 6-48 Suite, freikautures central 6-48 Suite central 6-48 Suite cent
Acua: gaming	D-Sheet Piling B-Sheet Piling to tool used to design retioning water and hortonating loaded piles, B-Sheet Piling. WANDA Simulation of Nadat and particular free, B-Sheet Piling.
Want to know more?	All simulation products
$\bigcirc$	Solutions  Proceeding system (Deft-FEWS) Deft-FFWSUE on open date honding pictorm winding workpool on a flood  Proceeding of the system of the
	forecasting and wonting system designed to provide you with bits functionality, which is used in
Downlood Team/Ilewer for Remote sport	

& Serious Games and Apps

ort of the Future Serious

Sustainable Delta gam

Given the uncertainties about the fuwhat constitutes a sustainable water https://www.deltares.nl/en/software/:

Simulation products

Solutions

•Serious Games and Apps

•Web and Touch Table applications

Toolboxes

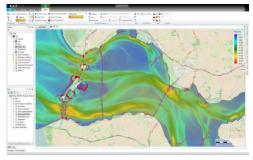
# Deltares

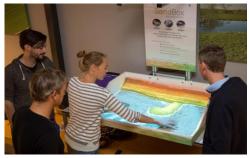
### Why we develop software

#### **Open source community:**

- 21.000+ persons
- 214 countries
- 400-500 sessions per day

#### **Specialist advise**

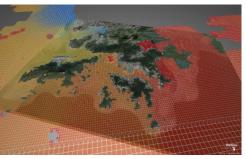




Research

#### **Knowledge sharing**

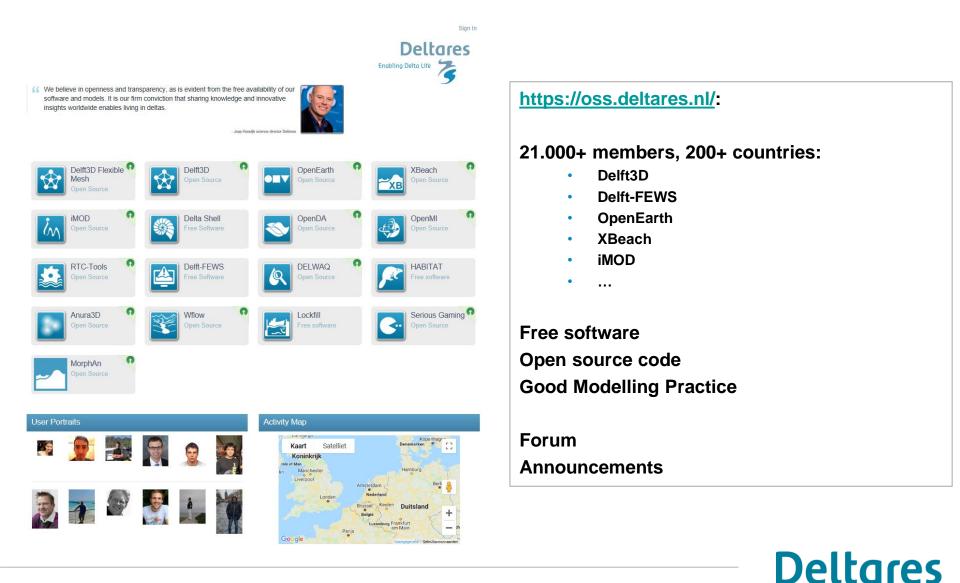




#### Collaboration



#### **Open Source & Free Software**

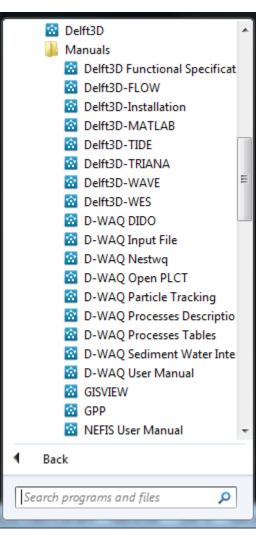


#### User manuals

D-Water Quality comes with a set of nine manuals

Where to look?

Getting started  $\rightarrow$  D-WAQ User Manual Process details  $\rightarrow$  D-WAQ Process Description Advanced input  $\rightarrow$  D-WAQ Input File



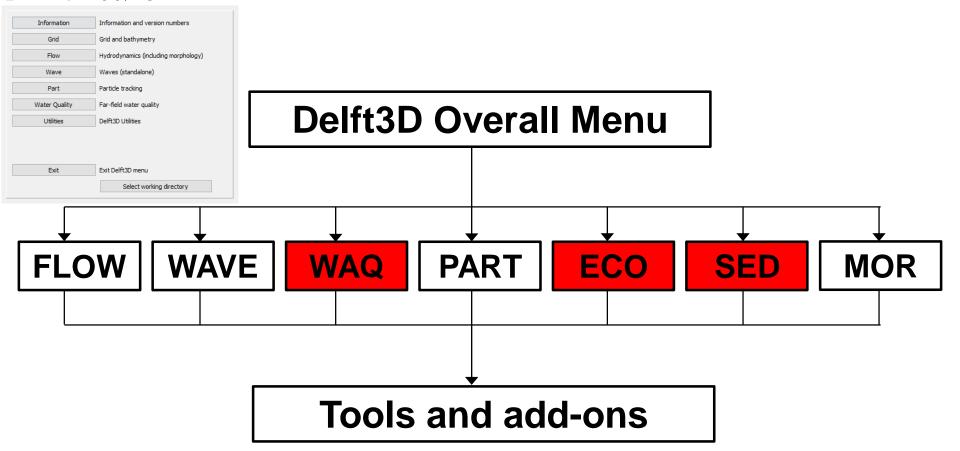
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### **Overview of topics (1)**

- functional specifications Delft3D-WAQ
- water quality modelling, introduction and concepts
- steps in water quality modelling
- transport modelling and numerical aspects
- Process Library Configuration Tool
- water Quality Processes:
  - oxygen BOD, processes and formulation
  - nutrients, cycles of nitrogen, phosphorus and silicon
  - general introduction on algae growth
- exercises

#### **Delft3D system overview**

🔯 Delft3D 4.03.02 - [.../Thracian\_Sea\_input/waq] - 🗆 🗙

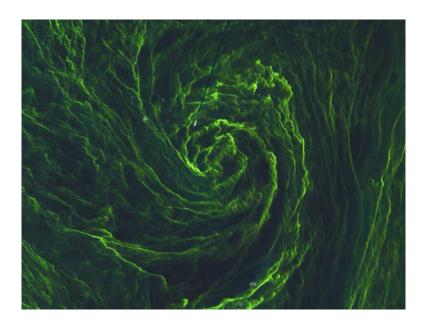


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### Issues in Water Quality Modelling (1)

- Quantitative aspects water management
  - drinking water, flooding (dikes, dams, etc.)
- Salinity (affects ecosystem)
- Bacterial pollution
- Organic material (BOD, COD)
- Nutrient enrichment (eutrophication)
- Algae blooms
- Oxygen depletion



Source: ESA Sentinel-2A



### Issues in Water Quality modelling (2)

- Aesthetic criteria (taste, colour, smell)
- Sediment plumes
- Toxic substances
- Thermal pollution
- Radioactive pollution



CREDIT: AP PHOTO/KIN CHEUNG



### Issues in Water Quality modelling (3)

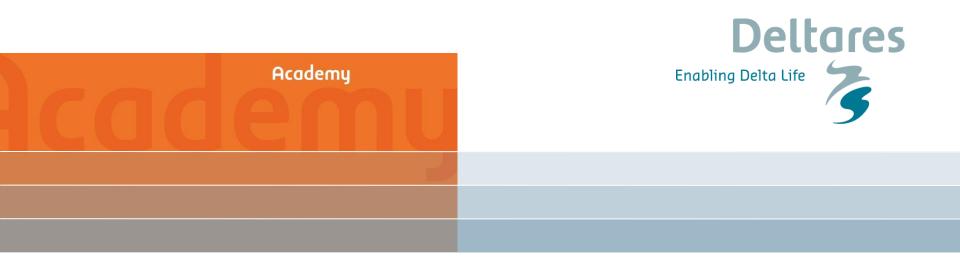
- Concentration of substances (compared to water quality objectives)
- Distribution of pollutants (how does a discharge of pollutants influence water quality)
- Effect of changes (Environmental Impact Assessment)





Source: CMEMS





## **Concept of Delft3D-WAQ**

#### How do we model water quality?

WAQ\_Introduction\_03

#### <u>Concept</u>

#### Two main components:

- 1. **Transport of substances:** in the water column is computed using advection-dispersion equation.
- 2. Ecological processes: concentrations of the state variables are determined by ecological processes meaning numerous physical, chemical and biological reactions

Administrate the mass balance of a substance in a segment Components of the mass balance

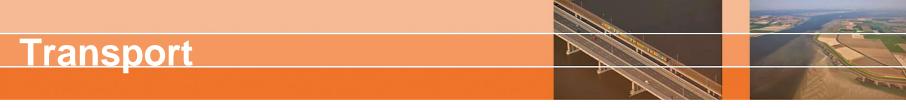
- changes by transport
- changes by processes (physical / chemical)
- changes by sources / discharges

To proceed one step in time, solve for each segment:

$$M_{i}^{t+\Delta t} = M_{i}^{t} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{Tr} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{P} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{S}$$

- Tr: change due to transport
- P: change due to processes
- S: change due to sources

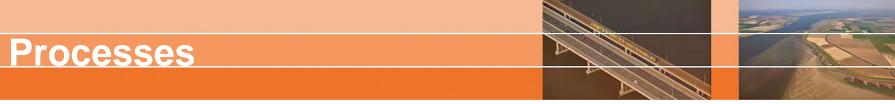




$$M_{i}^{t+\Delta t} = M_{i}^{t} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{T} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{P} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{S}$$

Derived from hydrodynamic model (e.g. Delft3D-FLOW or SOBEK) both advective and dispersive transport





Physical: reaeration, settling, resuspension

- Chemical: denitrification, decay of organic matter
- Biological: algae growth

Processes can

 remove a substance from or add a substance to the system (denitrification)

•convert a substance (nitrification  $NH_4^+ \rightarrow NO_3^-$ , settling IM1  $\rightarrow$  IM1S1)

$$M_{i}^{t+\Delta t} = M_{i}^{t} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{Tr} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{P} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{S}$$

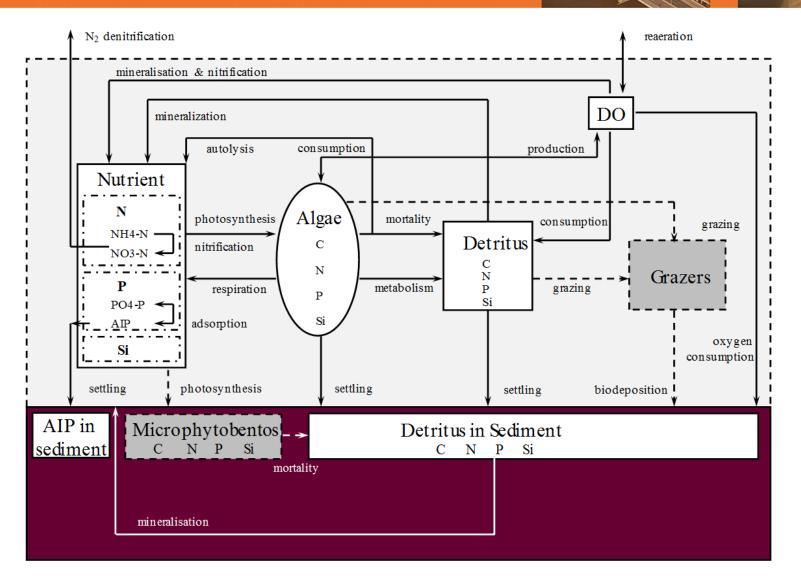


## Important ecological processes

Process type	Process
Phytoplankton processes	Primary production
	Respiration
	Mortality
Nutrient cycle	Decomposition of porticulate organic matter
	Decomposition of particulate organic matter
	Nitrification
	Denitrification
	Burial
	Uptake of inorganic nutrients
	Autolysis
	Mineralization
	Sedimentation of adsorbed inorganic phosphorus (AIP)
	Adsorption/desorption of orthophosphate
Oxygen dynamics	Reaeration
	Respiration
	Oxygen production (primary production)
Energy availability	Extinction of light
Others	Settling
	Decomposition of particulate organic matter



#### Important ecological processes



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### Sources / discharges

Waste loads River loads Boundary loads Diffusive loads (atmospheric deposition)



$$M_{i}^{t+\Delta t} = M_{i}^{t} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{Tr} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{P} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{S}$$



## Mass and concentrations in a segment

