

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 |
| hoose product 👻 | |
| 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

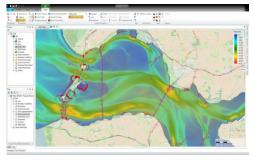
Deltares

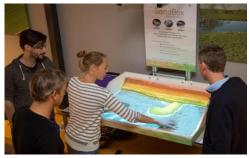
Why we develop software

Open source community:

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

Specialist advise

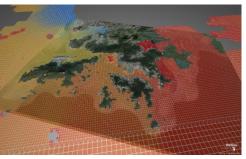




Research

Knowledge sharing

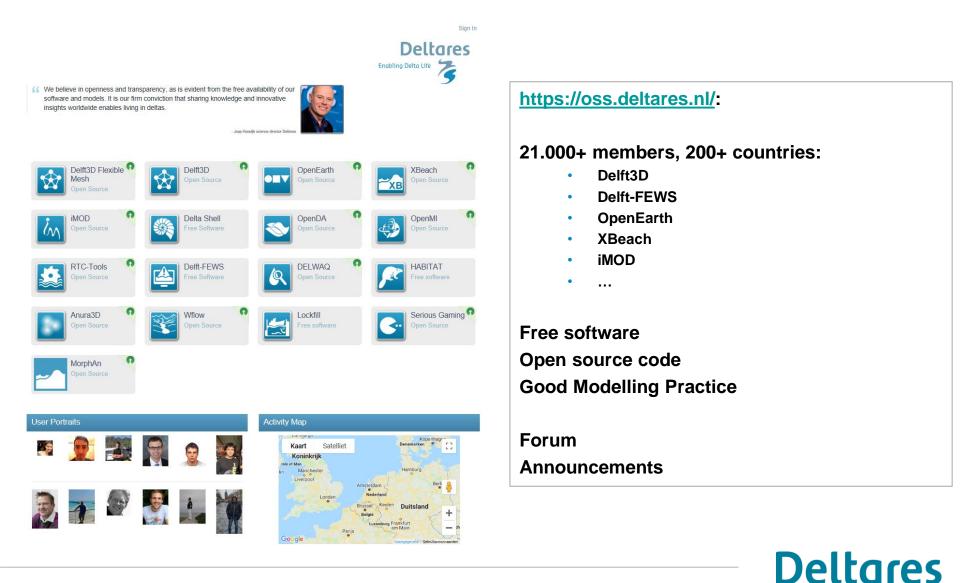




Collaboration



Open Source & Free Software

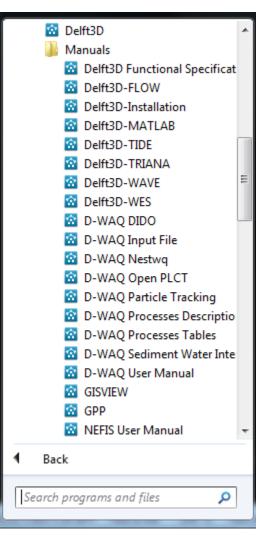


User manuals

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



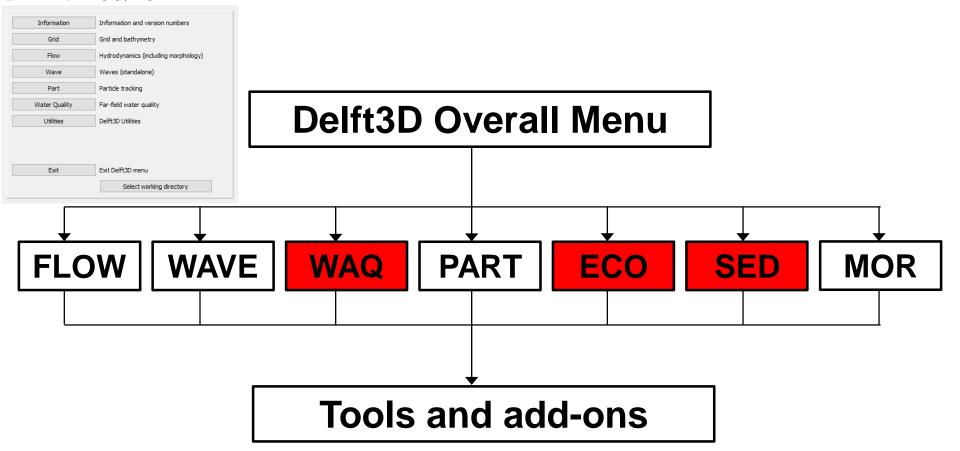
Deltares

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] - 🗆 🗙

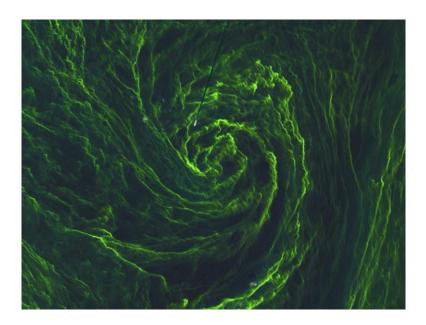


THE AN UN

Deltares

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)

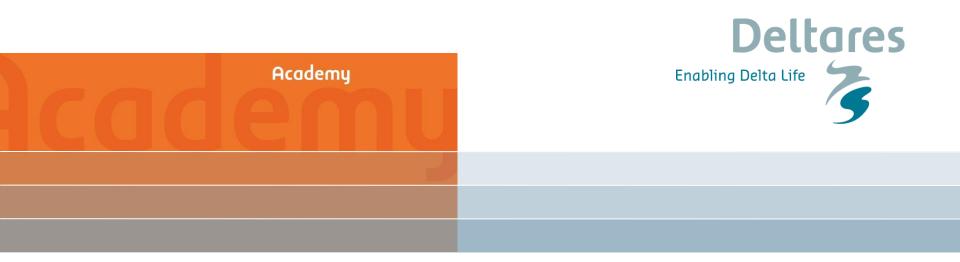
- Concentration of substances (compared to water quality objectives)
- Distribution of pollutants (how does a discharge of pollutants influence water quality)
- Effect of changes (Environmental Impact Assessment)





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

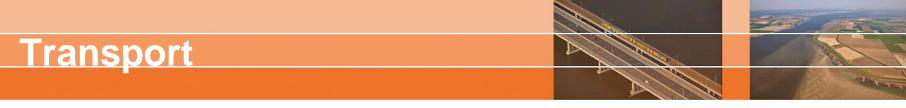
- changes by transport
- changes by processes (physical / chemical)
- changes by sources / discharges

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

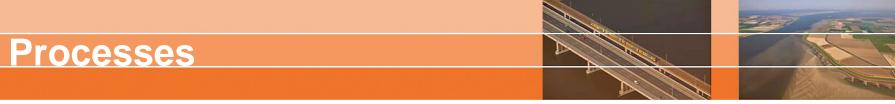




$$M_{i}^{t+\Delta t} = M_{i}^{t} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{T} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{P} + \Delta t \left(\frac{\Delta M}{\Delta t}\right)_{S}$$

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)

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

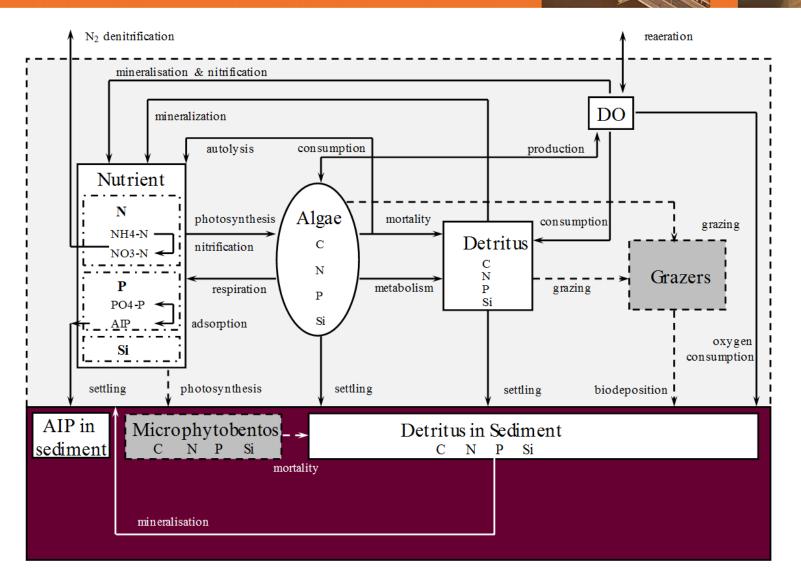


Important ecological processes

| 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



veuldres

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

