MIKE
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MIKE 21 & MIKE 3 Flow Model FM

Oil Spill Module

Short Description

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MIKE 21 & MIKE 3 Flow Model FM – Oil Spill Module

Accidental oil spills remind us of the dramatic impacts that oil can have on the environment. They also bring into focus, the importance of efficient emergency planning. Oil spills pose serious threats to the marine environment. They also put a lot of pressure on the entities that are responsible for the emergency response and clean-up operations, such as oil companies and national authorities.

This is the background for the Oil Spill Module. The module simulates the weathering and movement of oil represented by discrete particles in a flow field using a so-called Lagrangian approach. It may also simulate the spreading of dissolved oil using advection-dispersion calculations, which are based on the Eulerian approach.

The Oil Spill Module is an add-on module to MIKE 21 & MIKE 3 Flow Model FM. It requires a coupling to the hydrodynamic solver and to the transport solver for passive components (Advection Dispersion module). The hydrodynamic basis is obtained with the MIKE 21 HD FM or MIKE 3 HD FM module.

Application Areas

The Oil Spill Module can be applied in the open sea, coastal areas, estuaries, rivers and lakes. It can be applied in two or three dimensions. However, when considering dissolved oil three dimensions are recommended.

The Oil Spill Module can be applied in studies of e.g.

- environmental impact assessment
- single spill impacts
- clean-up operations
- emergency response systems
- assessment of required amounts of dispersants

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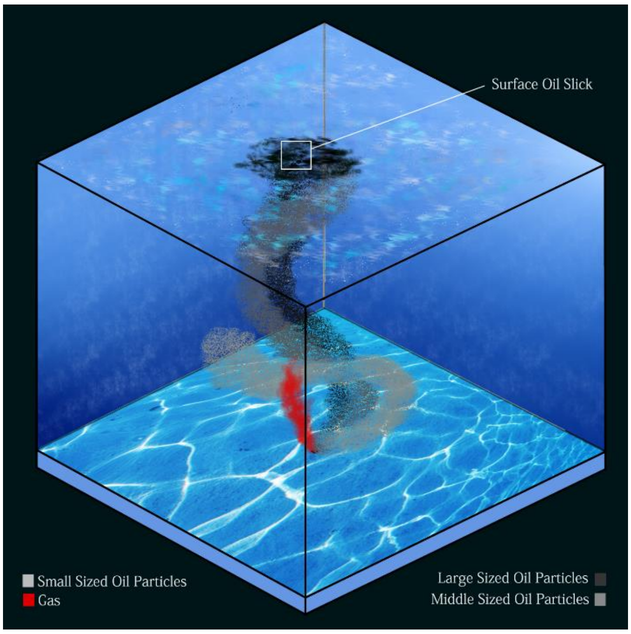
Features

The Oil Spill Module in MIKE 21 & MIKE 3 Flow Model FM includes the following features:

- all weathering processes
- movement of the oil on the surface and in the water column
- movement of dissolved oil independently of non-dissolved oil
- jet from a sub-sea blowout (oil and gas mix)
- the effects of dispersants
- clean-up using booms and skimmers
- stranding with the possibility of re-entering the water
- ice edge interaction with the possibility of re-entering the water



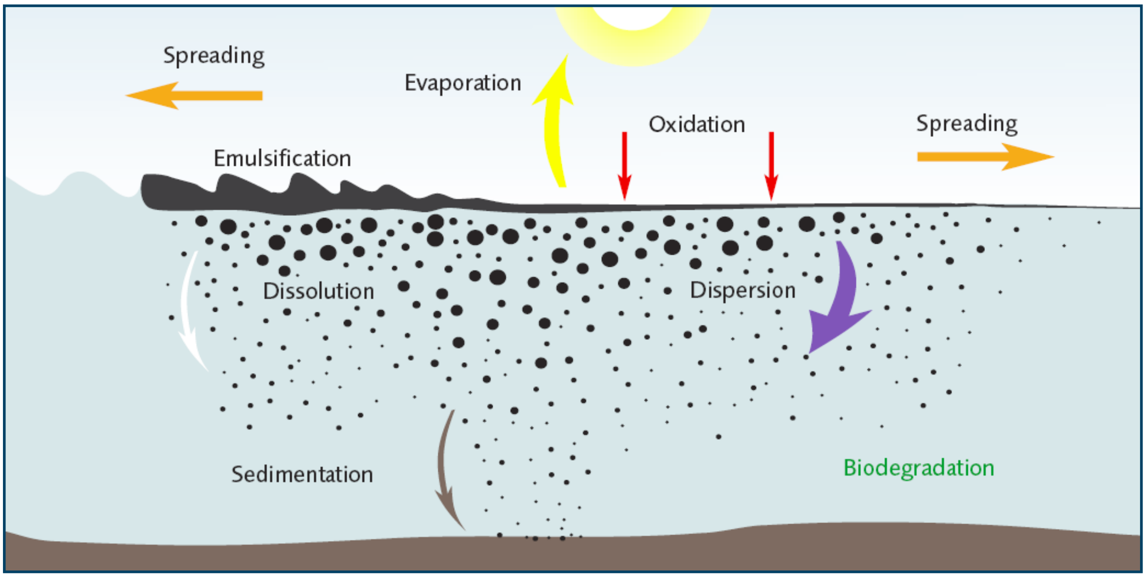
Jet from sub-sea blowout with mix of oil and gas. © DHI

Oil Characterisation

The different types of oil are characterised through a number of key parameters including e.g. density, viscosity, pour point and maximum water content. Additionally, the oil is divided into the following five fractions:

- heavy fraction
- semi-volatile fraction
- volatile fraction
- wax
- asphaltene

Each of these is described through a number of key parameters and weathering constants.



Weathering processes (from Fate of Marine Oil Spills, 2002)

Weathering Processes

The following weathering processes are included in the Oil Spill Module:

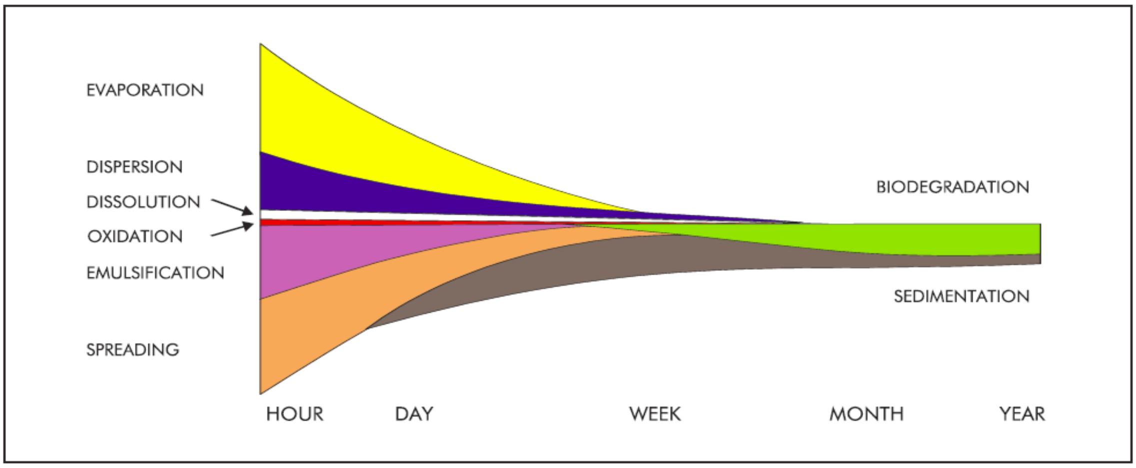
- spreading (viscous, gravity based)
- evaporation
- emulsification
- vertical dispersion (by waves)
- dissolution
- biodegradation
- photo-oxidation

All of these processes and the other features in the Oil Spill Module are handled by a MIKE ECO Lab template. This means that all processes/features may be inspected (and updated if so desired) using the ECO Lab editor (an ECO Lab license is required to use the ECO Lab editor). An illustration of the weathering processes and their time scales are shown above and below.

Environmental Data Requirements

The following environmental data are required for an oil spill simulation:

- Current data in 2D or 3D. These will normally come from a coupled or de-coupled MIKE 21 or MIKE 3 FM simulation.
- Wind data. These are used for calculation of the surface layer drift and Stoke's drift. The wind data are also applied in e.g. the evaporation process.
- Wave data. These are used for the vertical dispersion of the oil. Note that when oil particles are dispersed into the water column no evaporation will take place. This may have an important effect on the amount of oil hitting e.g. a coast.
- Ice data (optional). Oil drifting in ice-infested waters will follow the ice. Also, the weathering processes will be adjusted.



Time scales for weathering processes (from Fate of Marine Oil Spills, 2002)

Solution Technique

The oil spill simulation is executed using the MIKE ECO Lab engine and a MIKE ECO Lab oil spill template. The execution comprises both Lagrangian particle tracking (including weathering processes) and Eulerian advection-dispersion computations of dissolved oil (optional).

An oil spill simulation may either be run as a coupled model together with the MIKE 21 or MIKE 3 Flow Model FM or in the de-coupled mode. In order to save time the de-coupled mode, where flow data from a previous MIKE 21 or MIKE 3 FM simulation are re-used, is normally used.

The spreading of an oil spill is calculated by dividing the oil spill into discrete parcels, termed particles.

The movements of the particles are given as a sum of a displacement determined by the hydrodynamic flow field (and optionally the wind) and a dispersive component as a result of random processes (e.g. turbulence in the water).

The movement of dissolved oil is calculated using the advective-dispersion formulation in the transport solver in MIKE 21 & MIKE3 FM.

Input

Input data to the Oil Spill Module are divided into a number of groups:

- environmental data (currents, wind, wave and ice)
- current profile specification near surface and bottom (optional)
- dispersion coefficients
- oil characteristics for the five fractions including weathering constants
- gas characteristics, if sub-sea blowout
- spill location, depth, duration and amount
- blowout characteristics
- boom and skimmer specifications
- possibility of oil re-entering the water after being stranded (depending on type of coast, e.g. sandy beach or vertical rocks)
- initial conditions
- boundary conditions

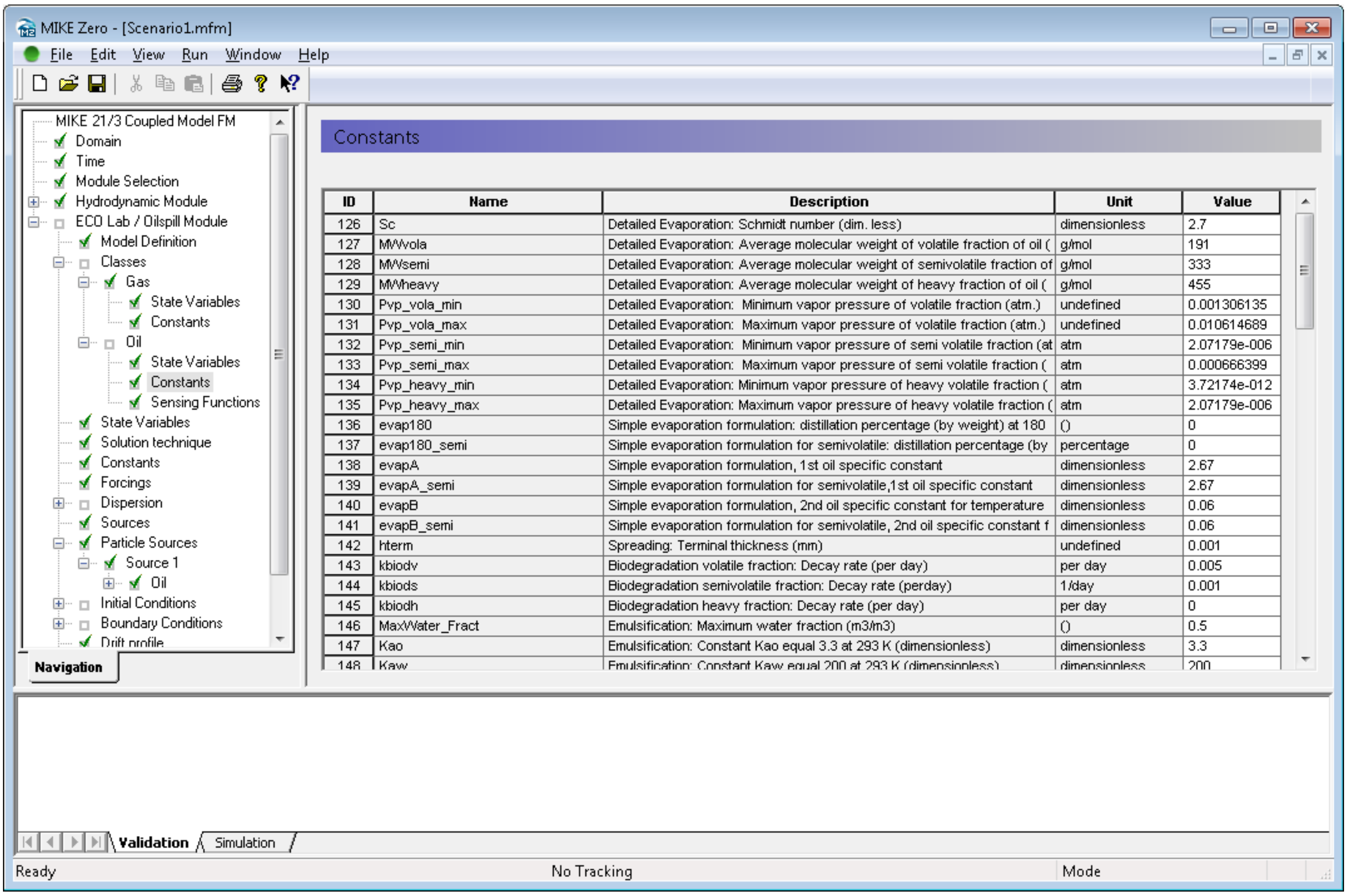
The oil spill may be specified as an instantaneous spill (at the outset of the simulation) or as a spill continuing for some time. The location may be fixed or moving.

Output

A number of output types are available:

- 2D-maps or 3D maps (the latter only when running the Oil Spill Module in a 3D domain) containing the instantaneous value (as mass, area concentration of volume concentration) or the statistical value (min, mean, max, time average or cell average) of all oil parameters. These parameters include (among many):
  - total mass excluding water
  - total mass including water
  - oil slick thickness (2D only)
  - amount stranded incl. and excl. water (2D only)
  - time of first arrival (2D only)
- Mass budget as a time series. This is useful for identifying how the weathering processes affects the oil.
- Particle tracks and particle properties. These are useful for illustrating the spreading of the oil spill. An example is shown below.

Visualisation of oil trajectories and current field on Google Earth background

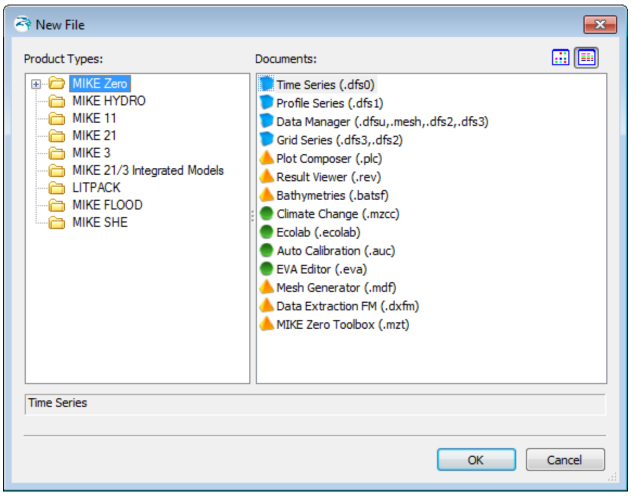


Graphical user interface of the Oil Spill Module showing weathering constants

Graphical User interface

The MIKE 21 & MIKE 3 Flow Model FM, Oil Spill Module is operated through a fully Windows integrated Graphical User Interface (GUI) and is compiled as a true 64-bit application. Support is provided at each stage by an Online Help System. A screen shot of the GUI is shown on the next page.

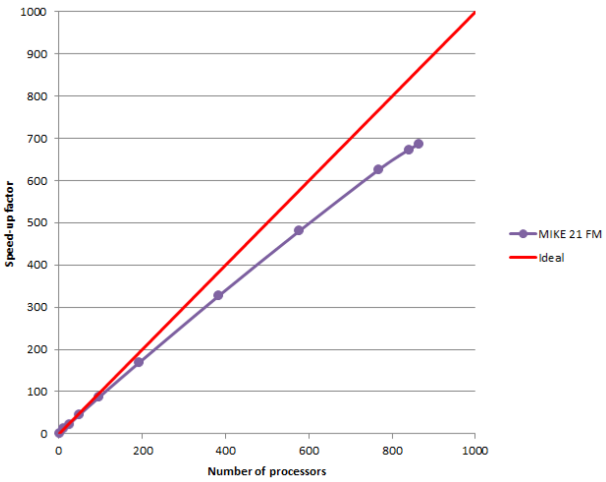
The common MIKE Zero shell provides entries for common data file editors, plotting facilities and a toolbox with utilities as the Mesh Generator and Data Viewer.



Overview of the common MIKE Zero utilities

Parallelisation

The computational engines of the MIKE 21/3 FM series are available in versions that have been parallelised using both shared memory (OpenMP) as well as distributed memory architecture (MPI). The result is much faster simulations on systems with many cores.



MIKE 21 FM speed-up using a HPC Cluster with distributed memory architecture (purple)

Hardware and Operating System Requirements

The MIKE 21 & MIKE 3 Flow Model FM, Oil Spill Module supports Microsoft Windows 7 Professional Service Pack 1 (32 and 64 bit), Windows 8.1 Pro (64 bit), Windows 10 Pro (64 bit) and Windows Server 2012 R2 Standard (64 bit). Microsoft Internet Explorer 9.0 (or higher) is required for network license management as well as for accessing the Online Help.

The recommended minimum hardware requirements for executing the MIKE 21 & MIKE 3 Flow Model FM, Oil Spill Module are:

Processor:	3 GHz PC (or higher)
Memory (RAM):	4 GB (or higher)
Hard disk:	160 GB (or higher)
Monitor:	SVGA, resolution 1024x768
Graphic card:	64 MB RAM (256 MB RAM or higher is recommended)

Support

News about new features, applications, papers, updates, patches, etc. are available here:

www.mikepoweredbydhi.com/Download/DocumentsAndTools.aspx

For further information on MIKE 21 & MIKE 3 Flow Model FM software, please contact your local DHI office or the support centre:

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Documentation

The MIKE 21 & MIKE 3 Flow Model FM models are provided with comprehensive user guides, online help, scientific documentation, application examples and step-by-step training examples.

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