

Integrated modelling with XBeach

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Mitigation measures during storms



(a) Petten



(b) Petten

Confidence interval creation

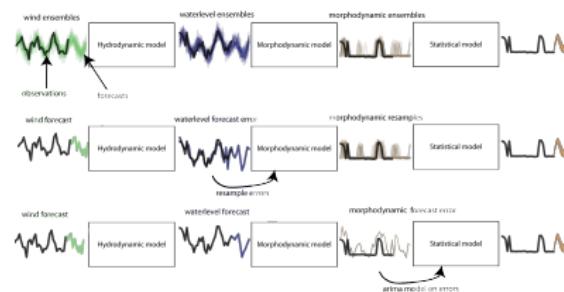


Figure: Confidence interval calculations

Groundwater nourishment interaction



(a) Basement in Ter Heijde



Geplaatst op: 05-02-2010 om 09:35 uur

Kustversterking oorzaak wateroverlast Ter Heijde

De werkzaamheden voor de kustversterking bij Ter Heijde waren de oorzaak van de tijdelijke stijging van het grondwater. Hierdoor werden in de dagen voor Kerstmis de bewoners van de Evertsenstraat, de Kornhaerstraat en de Karel Doormanweg in Ter Heijde verrast door opkomend grondwater in hun kelders en kruipruimtes. Dit blijkt uit het onderzoek dat Projectbureau Delflandse Kust heeft laten uitvoeren door een onafhankelijk ingenieursbureau.

(b) Westland news

Goal

Make XBeach exchange data while running with other models.

1 Developments in integrated modelling

2 Model coupling howto

3 Applications

4 Discussion

1 Developments in integrated modelling

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Challenges in integrated coupling

- Setup
- Calibration
- Domain mapping (terminology,etc.)
- Numerical issues
- Software architecture

1 model

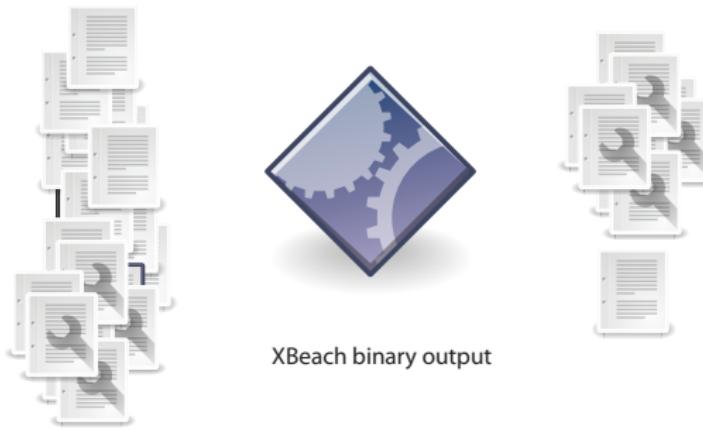
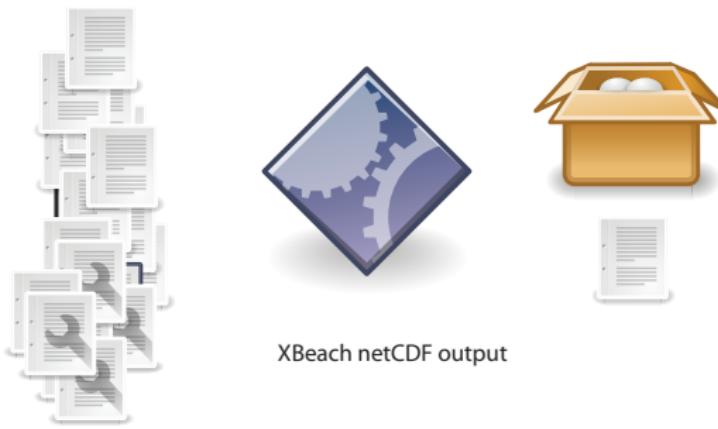


Figure: Single model with input and output files

1 model, standardised output



XBeach netCDF output

Figure: Output standardisation

Offline coupling

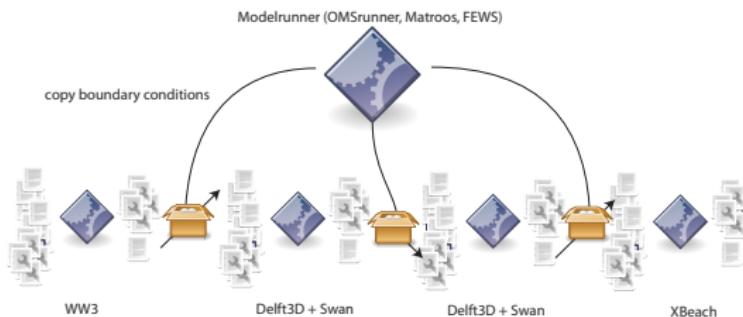


Figure: Lots of models, coupled offline

Online coupling

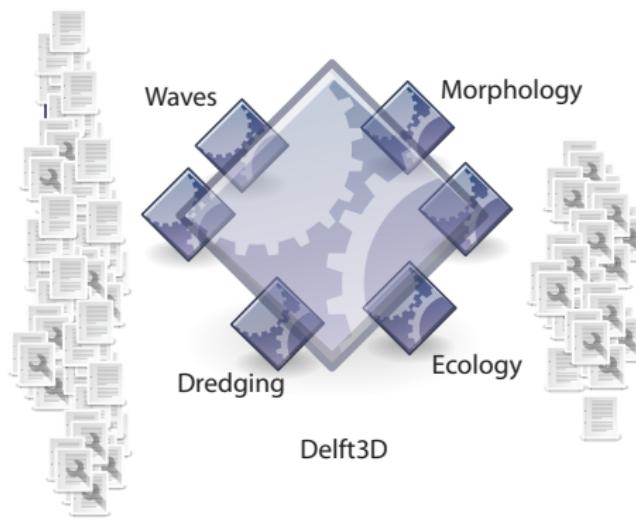


Figure: Monolithic architecture of old Delft3D

Online coupling

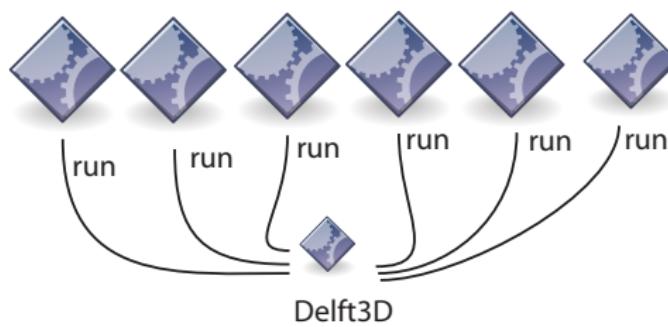


Figure: Current architecture of Delft3D

Modelling Frameworks

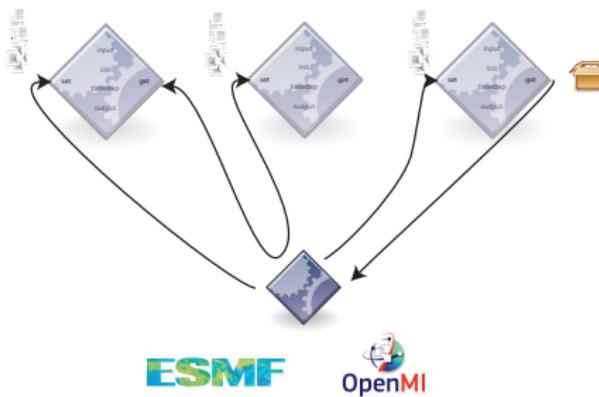


Figure: libxbeach as a OpenMI and ESMF component

Modelling Frameworks

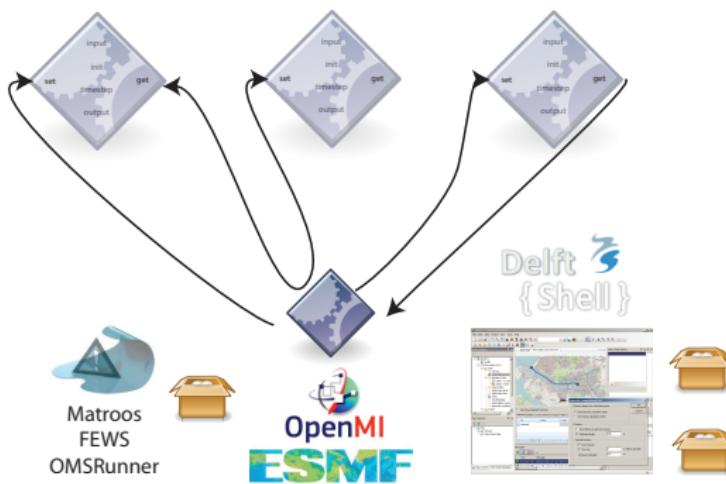


Figure: Integrating models in Deltarès environment

Modelling Frameworks

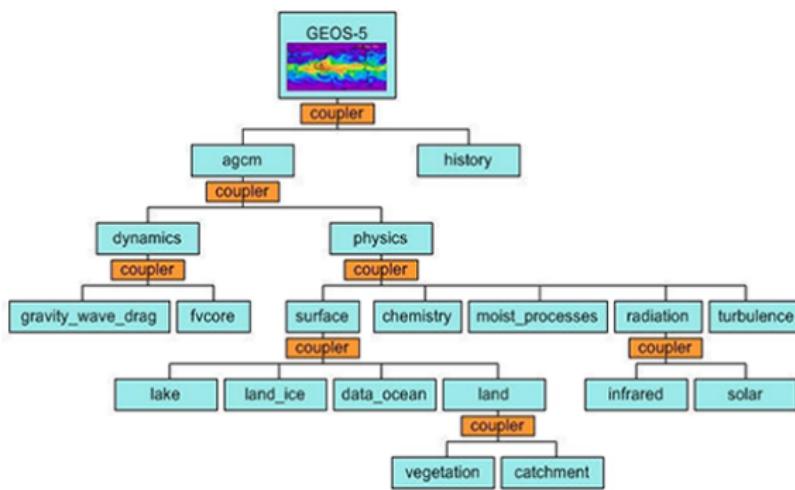


Figure: Integrating models in NASA environment

What have we learned?

Old	New
Mediocre, large scope	Narrow scope, supreme
Closed	Open (api + source)
Share data through files	Share data in memory
Own file format	Standard files
Program	Library

XBeach

Lines of Code = 17,685

Person-Years (Person-Months) = 4.08 (49.00)

Total Estimated Cost to Develop = EUR 551,603
(excluding tests)

Non intrusiveness

Non intrusiveness

How to connect XBeach to other models without any code creeping into XBeach?

5 step plan

- 1** Make a library
- 2** Allow for introspection
- 3** Solve language barriers
- 4** Stick to your domain
- 5** Write tests

Make a library

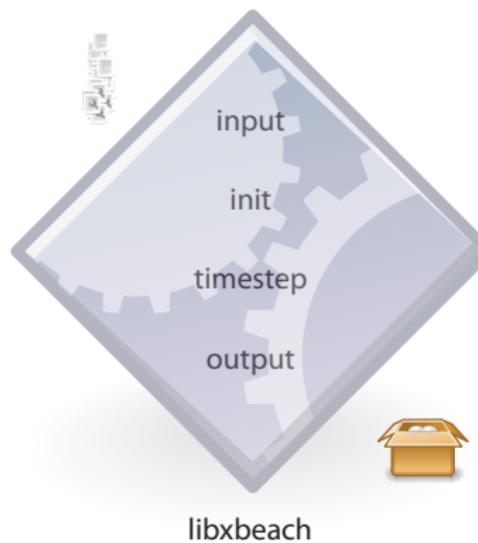


Figure: Internals of XBeach

Introspection

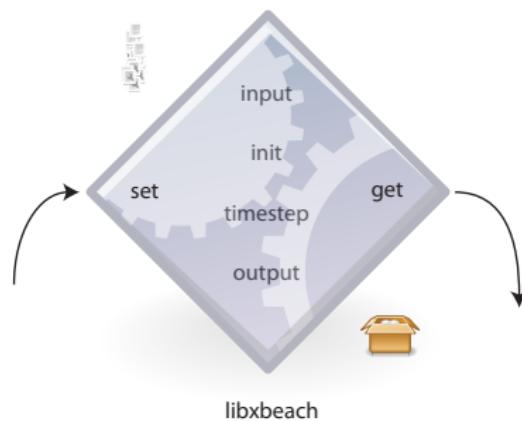


Figure: Internals of libxbeach

Language barriers

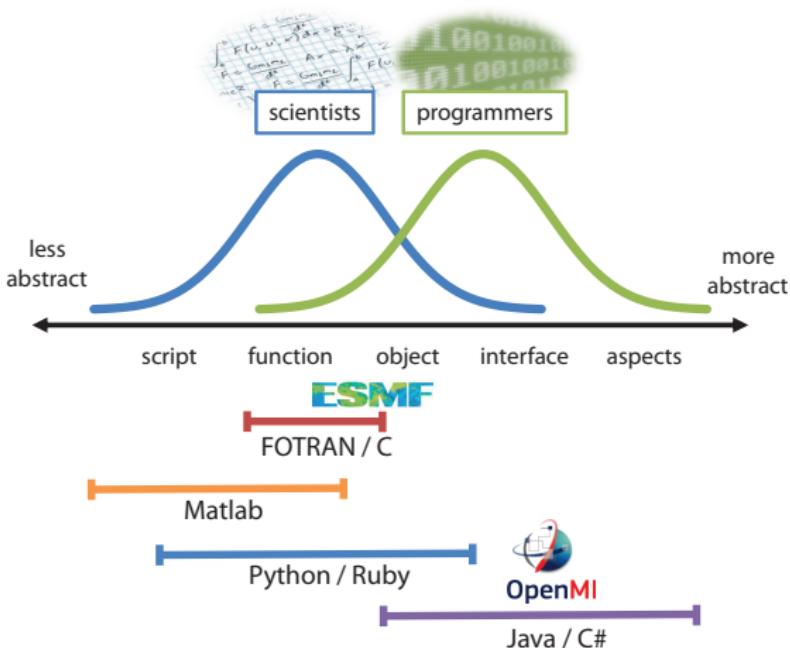


Figure: Abstraction scale with different programming languages and



ESMF vs OpenMI

ESMF	Description	OpenMI 2.0
ESMF_AppDriver	Main program/controller	OpenMI gui + command line runner
ESMF_GridComp	Component with input and output (run, initialize, finalize)	IBaseLinkableComponent
ESMF_CplComp	Maps input to a output state (used for conversion of units, grids, spatial transformation).	SDK / OpenMI Tools
ESMF_State	Connectable input and output items	IBaseExchangeItem / IBaseInput / IBaseOutput
ESMF_Array	Values (arrays, datatype) + attributes (units, spatial information)	IValueDefinition, IBaseExchangeItem, IElementSet
ESMF_Grid	Geospatial representation of connected items	IElementSet
ESMF_Field	Grid with an array, staggering, location	IElementSet, SDK
ESMF_Time	Time management	ITime
ESMF_Calendar	Time management	ITime
ESMF_TimeInterval	Time management	ITime

Figure: OpenMI and ESMF

Implementation effort (lines of code)

Framework	ESMF	OpenMI
library	111	111
language F90,c	29	29
language c,c#	0	65
framework	93	117
coupler	44	0
test	194	189

AGU poster

TU Delft Deltares

Introduction
We show the coupling of the nearshore erosion model XBeach to two modelling frameworks: ESMF and OpenMI. We compare the two implementations and give suggestions for easy model coupling.

Possible applications of coupled XBeach

Reducing the invasiveness of modelling frameworks

XBeach
A two-dimensional model for wave propagation, long waves and mean flow. It can simulate morphological changes of the nearshore area, beaches, dunes and fracturing during storms. (Source: www.xbeach.org)

From XBeach to libX-Beach
The main XBeach program was rewritten to a library (Lib). Making a library resulted in 140 extra lines of code (29 for coupling).

XBeach + OpenMI
For OpenMI a C# wrapper around XBeach was written (80 lines). The OpenMI component contains 117 lines of code. An XBeachComponent (117 lines), Unit tests (10 lines) and a test (10 lines).

XBeach + ESMF
An ESMF component (93 lines) and a coupler were created (44 lines) and tests (194 lines).

Frameworks

ESMF:
It is a modeling framework, composed of several components. Components are coupled through a common interface. Components can be distributed over different machines. Components can be developed independently. Components can be exchanged between models. Components can be exchanged between models.

OpenMI:
It is a modeling framework, composed of several components. Components are coupled through a common interface. Components can be distributed over different machines. Components can be developed independently. Components can be exchanged between models.

Coupling in 5 steps:

- Make a library (lib) or a shared object (so) exposing the initialisation, step, finalise and run time loop. Then call us well call you!
- Allow introspection: Make all your data structures public. Make all your variables public. Make all your functions public. Extra points if you do not use global arrays.
- ESMF: Create a configuration, programming interface, and a shared object. Make sure the configuration file is well documented. Make sure the configuration file is well documented.
- Language barriers: Use the appropriate tools. Pfft or not, _binding others.
- Stick to your domain: Keep a clear separation between domains (the example separates land from ocean, land from sea).

Barrier island during a storm

Delphi3D → XBeach → Delphi3D

2D inundation after breach

Literature

Dierk, M. et al. (2010) An exploratory investigation on the invasiveness of environmental modeling frameworks.
Held, C., et al. (2004) Architecture of the Earth System Modeling Framework. *Geosci. Model Dev.*, 7, 551–564. <http://dx.doi.org/10.5194/gmd-7-551-2004>
Hoogendoorn, H.R.A. (2010) Linking Data, Models and Tools: An Overview.

micore
www.micore.eu

OpenEarth
www.openearth.eu

Download this poster and more:
<http://bit.ly/agu2010>

www.deltares.nl

Figure: Poster presented at AGU conference. See
<http://bit.ly/AGU2010>

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Application of coupled XBeach

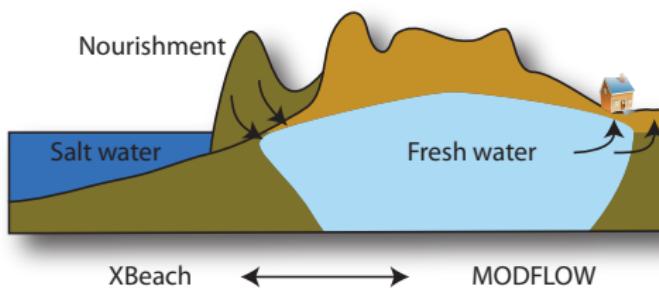


Figure: Application

Application of coupled XBeach

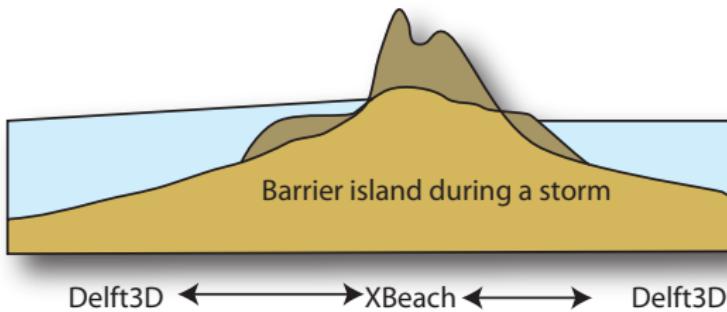


Figure: OpenMI and ESMF

Other applications

- SWASH integration
- Stranded ship modelling
- Swimmer simulator

Other applications

- Integration into Delta Shell
- Export to FEWS-pi
- R coupling for data assimilation/sensitivity analysis
- Matlab coupling for simple experiments

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Call for applications

Please use this in Msc projects.

ESMF as a basis

ESMF as a base for fortran model coupling

OpenMI on top of ESMF