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GUIDANCE COMMITTEE CREST

15 January 2016, Oostende

Activity 1: MULTI-SCALE MODELLING TOOL

met de steun van

Activity 1:
Multi-scale Modelling Tool

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Partners: KATHOLIEKE UNIVERSITEIT LEUVEN, UNIVERSITEIT GENT, museum, waterbouwkundig LABORATORIUM

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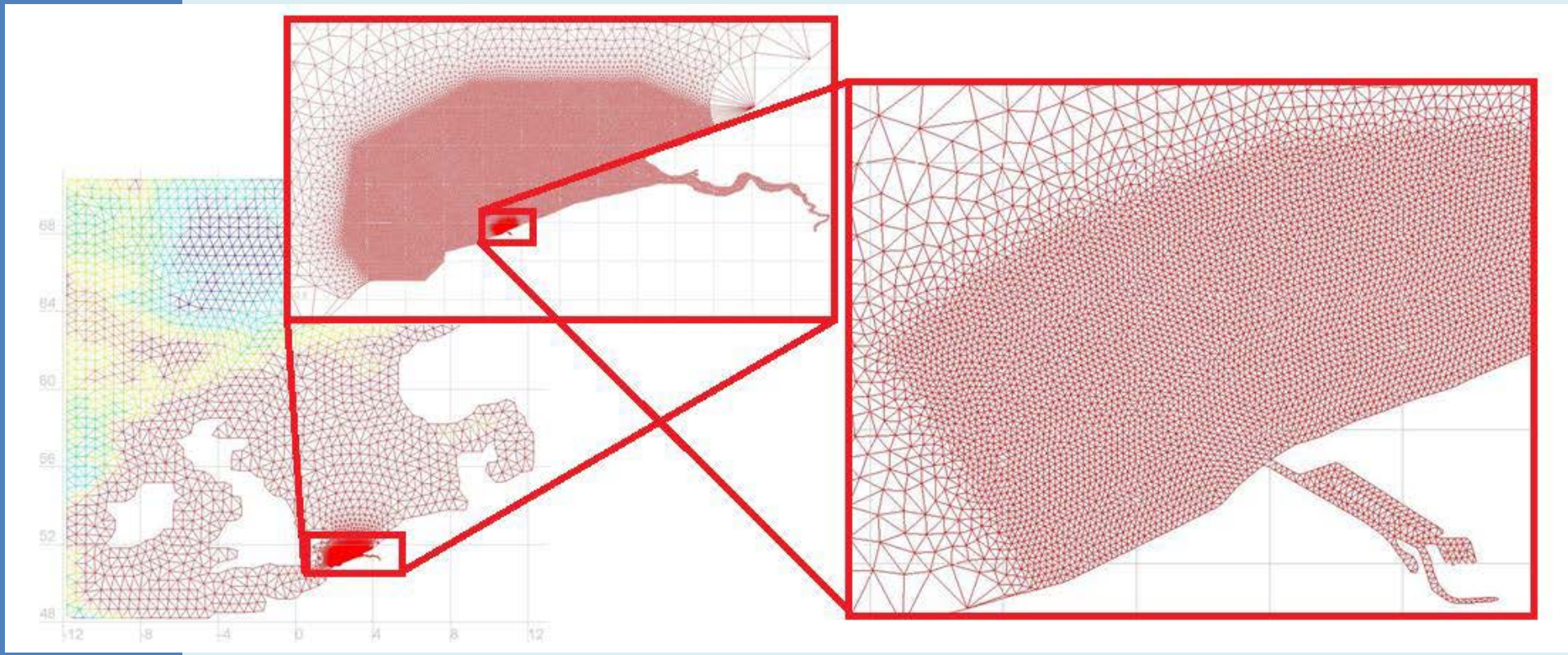
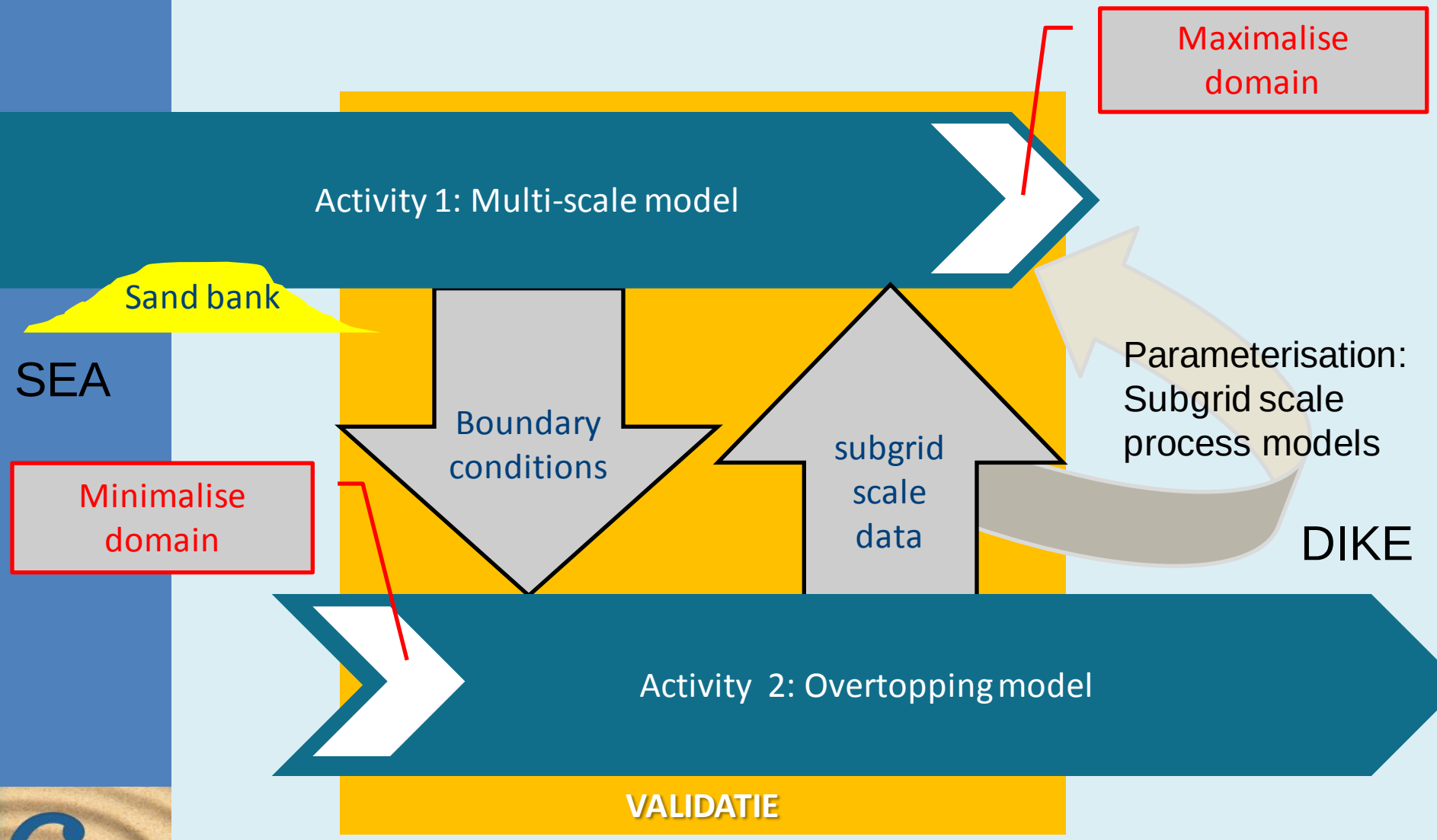
Multi-scale model TELEMAC (KULeuven)



Unstructured mesh

Hydrodynamics (TELEMAC)
Waves (spectral model TOMAWAC)
Morphodynamics (TELEMAC 3D / SISYPHE 2DH)

Interaction Activities 1 & 2



WP **A1.1**: Spectral Wave Model innovation

- A1.1.1: Long wave generation (+ FHR)
- A1.1.2: New dissipation terms (🡐 A1.2.1)
  - Physics-based bottom friction
  - New wave turbulence dissipation
- A1.1.3: Coupling to 3D hydrodynamics
  - Boundary condition generation: wave reconstruction (adding phase information) + profiles (*U, C, k, ε, …*)
- A1.1.4: Add missing features (+ LNH / HRWallingford + PhD ParisTech)
  - Roller equation (cf. XBeach)
  - Undertow (cf. Xbeach & SWAN (Komijani & Monbaliu, 2014))
  - Wave reflection (cf. SWAN)

Implementation in TOMAWAC

WP **A1.2**: Hydrodynamics & Sediment Transport model innovation

- A1.2.1: 3D RANS
  - Wave-induced bottom shear (🡐 KUL IRO)
  - Wave induced turbulence
  - A1.2.2: 3D sediment transport
  - New bedload/sheetflow formulation(s) (+KUL IRO)
- A1.2.3: Upscaling to 2DH
  - 3D 🡒 2DH RANS / Non-hydrostatic SWE
  - 3D 🡒 2DH sediment transport
    - Transport capacity under waves & currents

Implementation in TELEMAC-SISYPHE v7.1 (Jan.2016)

WP **A1.3**: Morphodynamics

- A1.3.1: Validation of wave-sediment interaction
  - Simulation of flume experiment(s) ← KUL IRO
- A1.3.2: Short-term wave impact
  - Lab flume (long waves): comparison with OpenFOAM
  - Field experiment: comparison with Xbeach (FHR?)
- A1.3.2: Medium-term (max. 1 year) morphodynamics
  - Application of TELEMAC-SISYPHE-TOMAWAC to the Belgian Coast (mixed sediments!)
  - Simulation of (recent) historical events (← SA1)
  - Scenarios proposed by end user group
- A1.3.3: Climate change scenarios (← SA2 ← end users?)

Comparison with other models (FHR, KBIN)

Complementary research on (fluid) mud: BRAIN.be INDI67 project

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Small scale (“storm impact”) validation

- Wave flume experiment
- Field experiment

➔ Activity 2

Major Innovations

- Improved physics:
  - Accounting for:
    - energy loss by sediment transport
    - wave generated turbulence
  - More processes in spectral wave model
    - Long waves, rollers, undertow, refraction
  - Reduction of empiricism

Methodology:

process model development in small-scale model

(IRO PhD, MSc thesis, … : OpenFOAM, FENST2D)

➔implementation in TELEMAC

(KUL: 2 PhDs + 3 postdocs & FHR)

tested with small scale applications at different grid resolutions

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Major Challenges

- Validation of the new process models
- Coupling of the large-scale and fine-scale onshore models:
  - Exchange of interface boundary conditions
    - spectral ↔ resolved wave characteristics
    - turbulence
- Optimization of computational effort:
  - Best location of the interface?
  - Grid structure and resolution

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Contributing institutes

- UGent (/KU Leuven):
  - OpenFOAM: sediments (1.2.1+1.3.1) & long waves (1.3.2)
- FHR:
  - XBeach (1.3.1+ 1.3.2)
  - TELEMAC (1.1.1 long waves, 1.3.3 & 1.3.4)
- KBIN:
  - COHERENS (1.3.3 & 1.3.4)
  - Climate Change scenario's (1.3.4)
- KU Leuven: (all tasks)
  - OpenFOAM
  - TELEMAC

Expected Output

MODELLING TOOL(S)

- Innovation in (open-source) models:
  - Improved physics ➔ WP A2 + WP A3
- Guidelines for optimal scales:
  - model application limits
  - mesh structure + time step(s)
  - (morphological acceleration methodologies?)
- Boundary condition generation for fine-scale onshore wave models ➔ WP A2
- Model generated data ➔ WP A3

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Dank voor uw aandacht !

Vragen ?

Original timing & funded (!) MM

	KU Leuven	Year 1		Year 2		Year 3		Year 4	
	total/ subactivity	M1-6	M6-12	M1-6	M6-12	M1-6	M6-12	M1-6	M6-12
WP A1.1 Hydrodynamics: waves and currents									
1.1.1 Introducing long wave generation for coastal applications	4	2	2						
1.1.2 New friction model for wave dissipation	5	2.5	2.5						
1.1.3 Coupling waves and 3D currents	10	2.5	2.5	3	2				
	19								
WP A1.2 Hydrodynamics & Sediment Transport									
1.2.1 From RANS to wave averaged hydrodynamic & sediment transport modelling	10	2	2	3	3				
1.2.2 3D sediment transport modelling (UGent: 7 MM)	15		2	7	4	2			
1.2.3 Upscaling and parameterization from 3D to 2DH	6					3	2	1	
	31								
WP A1.3 Validation of morphodynamics									
1.3.1 Validation of small-scale wave-sediment interaction	6					3	3		
1.3.2. Validation of short-term wave impact	4						1	3	
1.3.3 Validation of medium-term morphodynamics	9						2	4	3
1.3.4. Climate change scenarios	6							2	4
	25								
Total MM	**75**	9	11	13	9	8	8	10	7