22. Österreichischer KLIMATAG

Triggers and consequences of landslide-induced impulse waves – 3D Dynamic reconstruction of the Taan Fiord 2015 tsunami event

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Extreme natural hazards

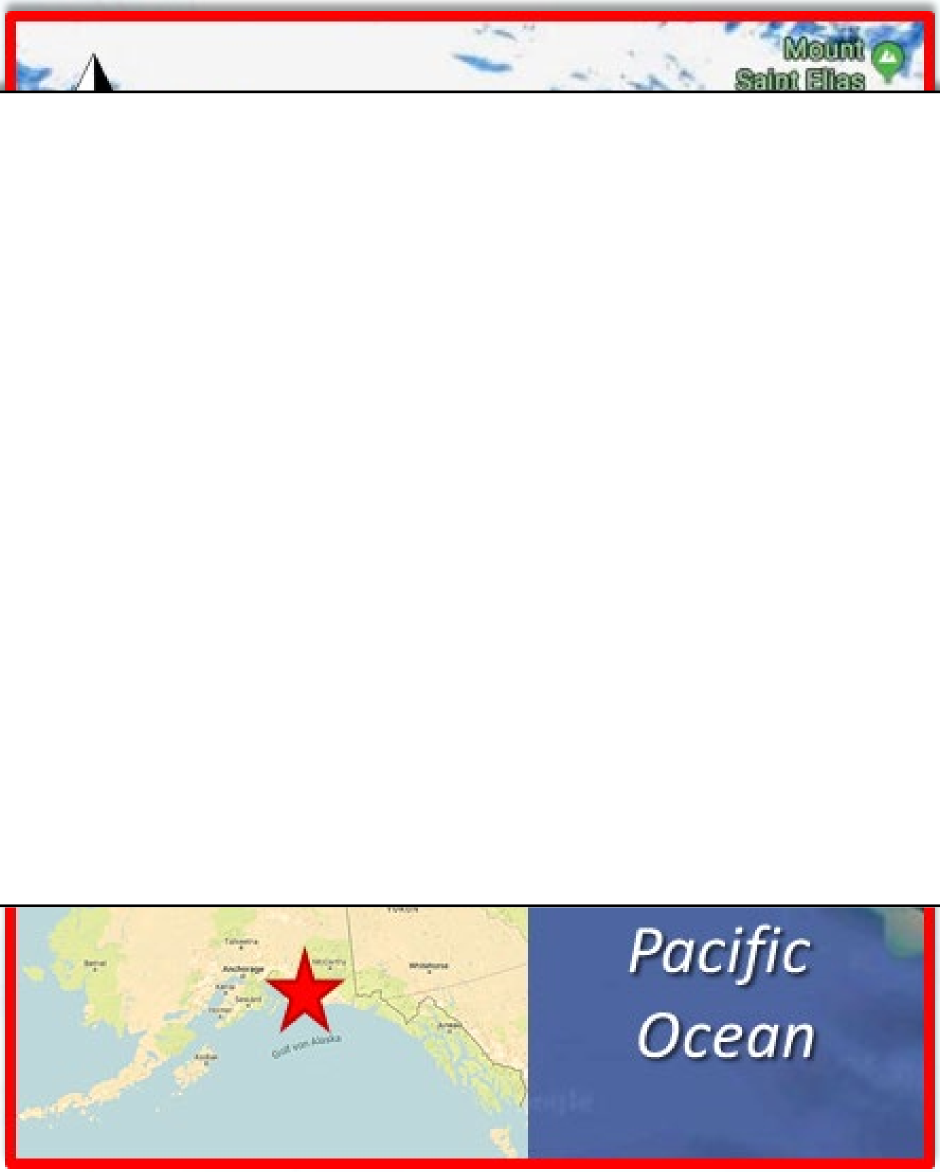
in the context of the ongoing climate change

Research topic:

- Natural multi-hazards
- Catastrophic response to ongoing climate change
- Ice and glaciers retreat in mountain regions:
  → new-formed water basins
  → unstable slope
- Extreme event:
  landslide-induced impulse waves

Recent case study:

- The Taan Fiord landslide-induced impulse wave event 2015



A catastrophic response to climate change:

The Taan Fiord landslide-induced impulse wave event 2015

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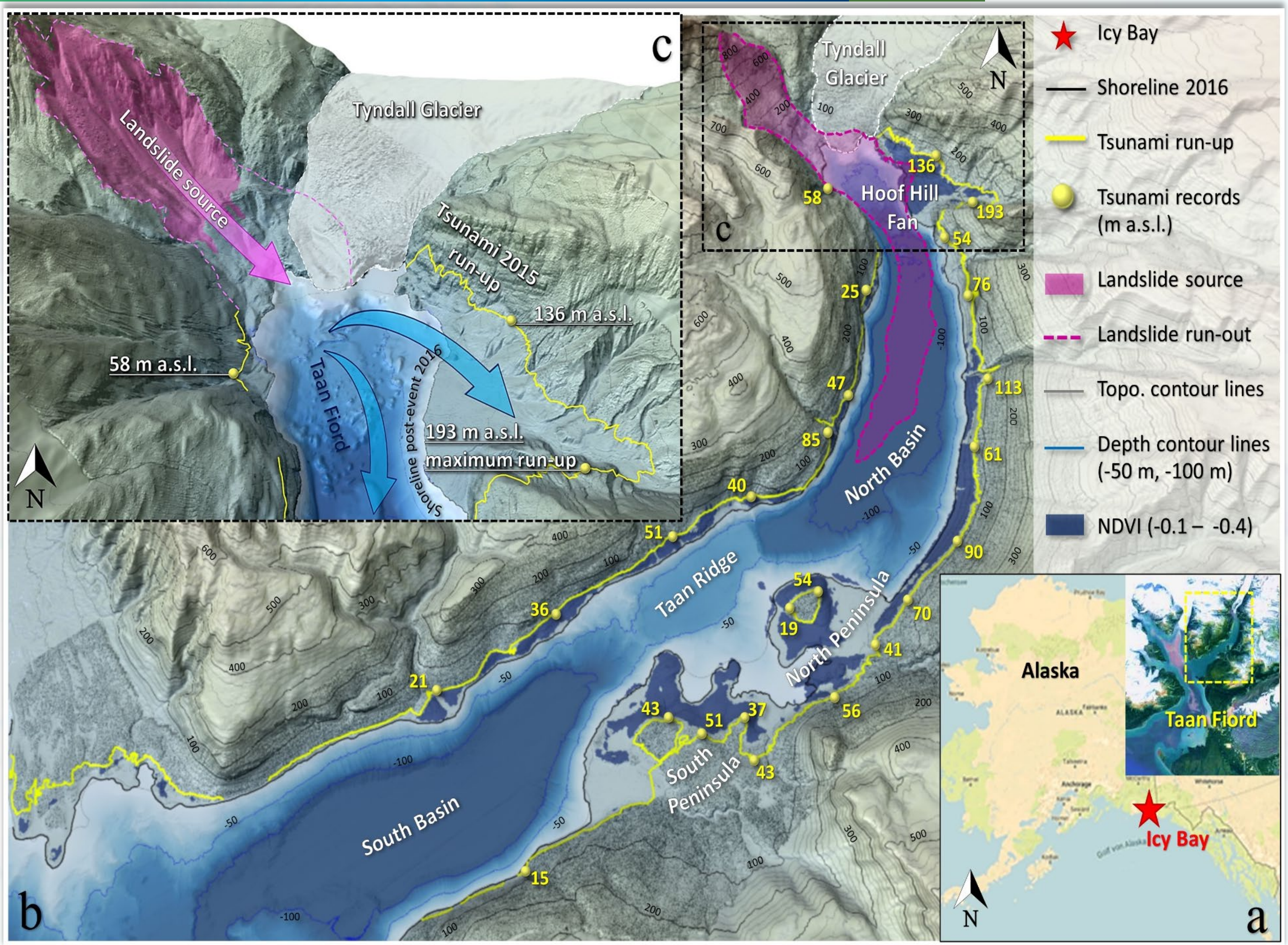
Main objectives:

- Multidisciplinary approach for cascade effect analyses
- Deep understanding of the triggering processes and consequences
- Implications for wave hazard assessment

Methods:

- Geomorphological investigations
- Numerical modelling for wave-dynamics reproduction
- Wave hazard mapping



Geomorphological investigations:

glacier and landslide dynamics (DEMs elaboration)

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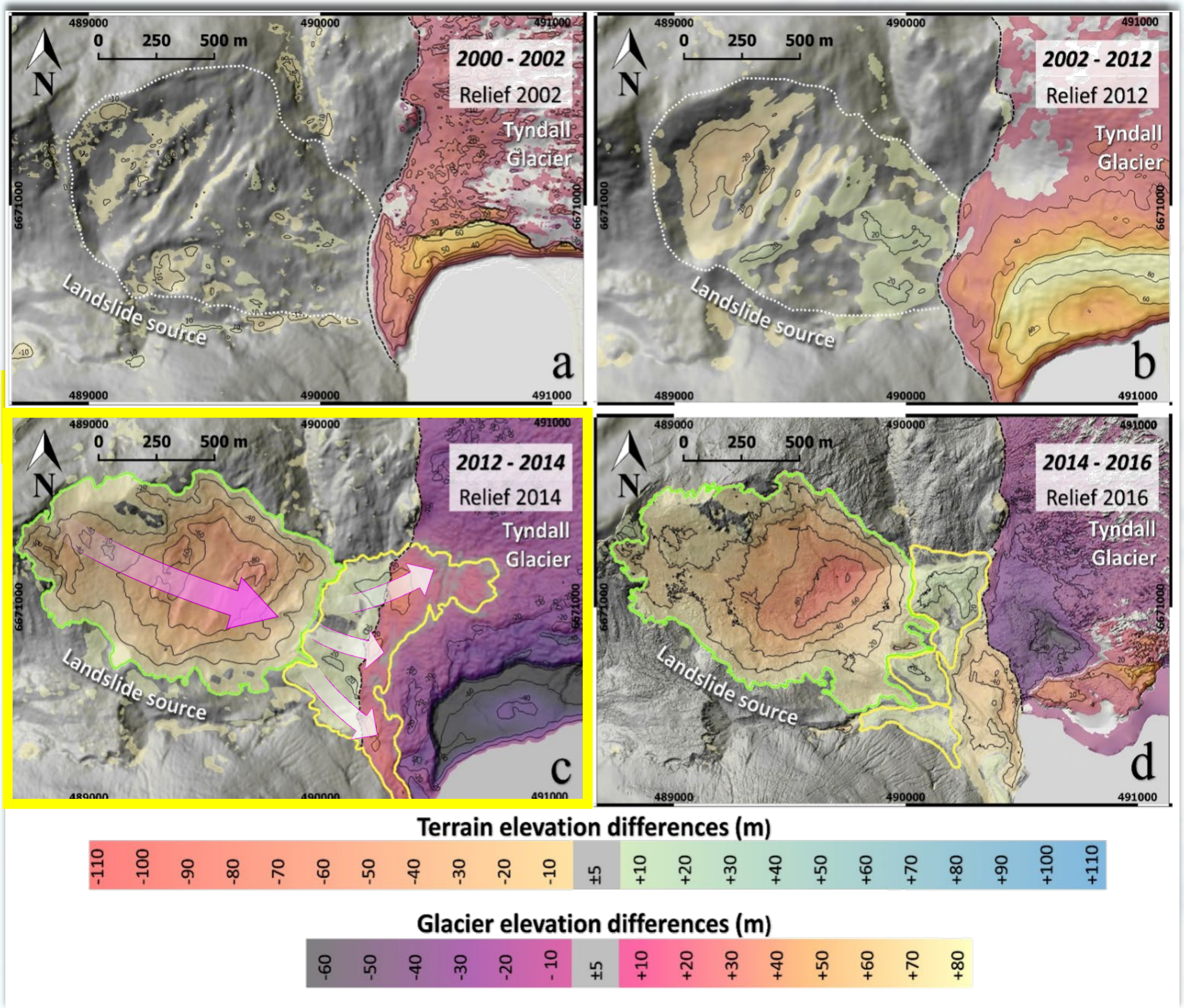

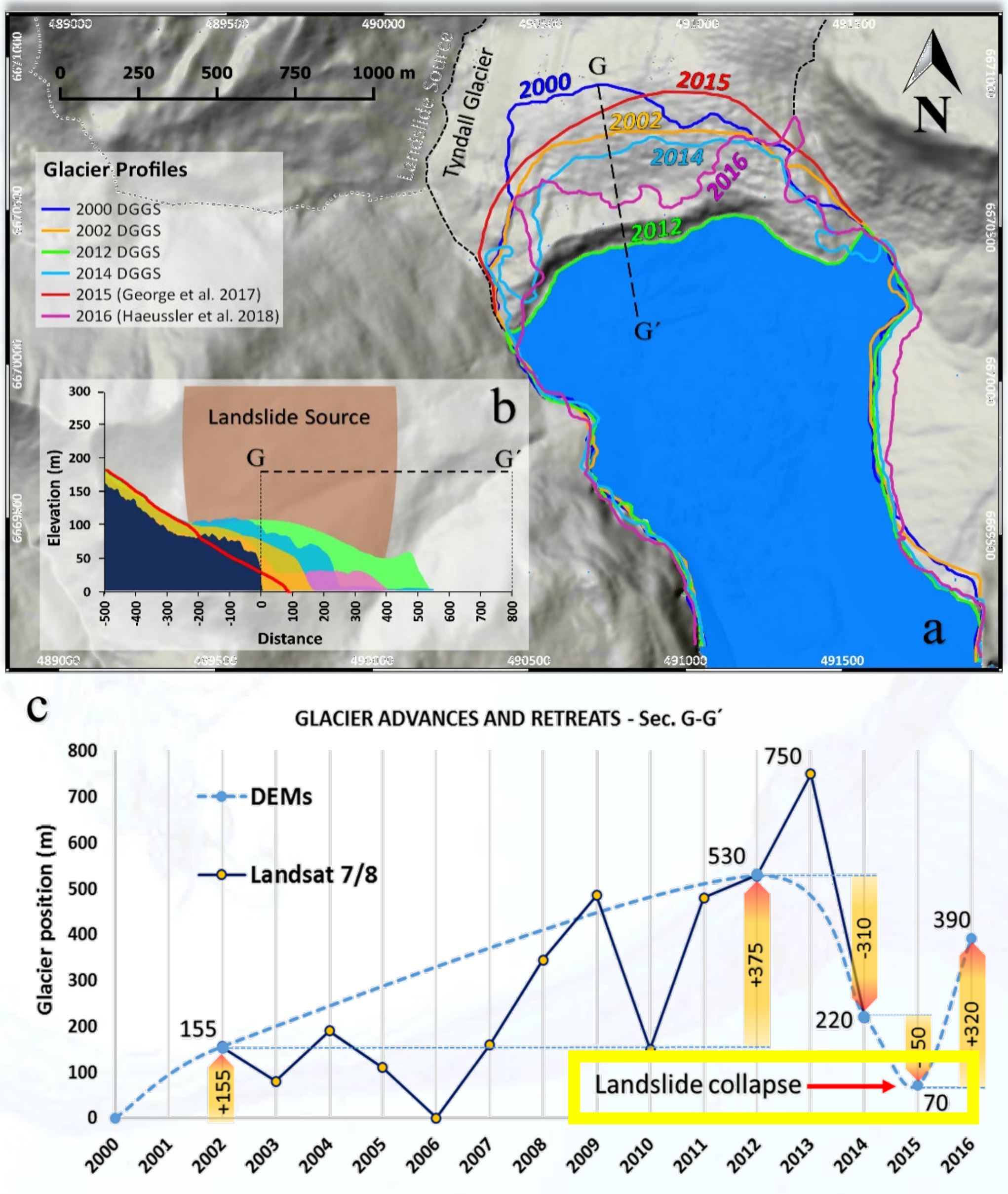

Geomorphological investigations:

a new interpretation and data

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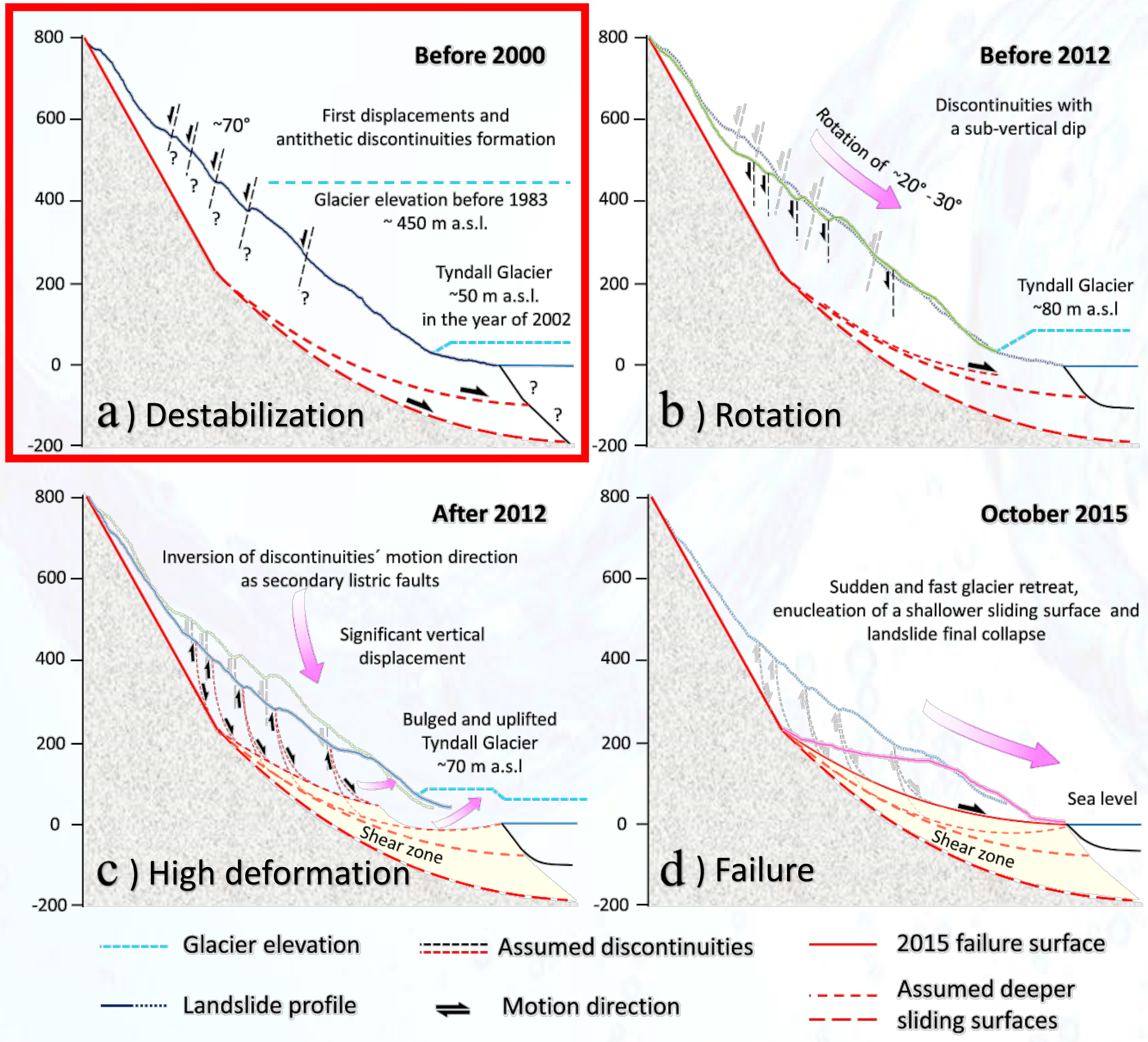


Data	Symbol	Dimension	Value	References
Landslide crown elevation	-	m a.s.l.	830	From this study
Heigth difference between slide crown and toe	L	m	765	From this study
Landslide width	W_d	m	915	From this study
Landslide slope length	L_d	m	~1630	From this study
Landslide max. thickness	S	m	93	From this study
Max. depth of the sliding surface	D_r	m	105	From this study
Landslide centre of mass	-	m a.s.l.	~340	Gualtieri & Ekström (2018)
Landslide impact speed	v_s	m/s	36-45	Highman et al. (2018), Dufresne et at. (2018)
Duration of the sub-aerial sliding process	-	s	~90	Gualtieri & Ekström (2018)
2015 landslide volume onshore	-	Mm^3	23.4	Haeussler et al. (2018)
2015 landslide volume entered in the fiord	-	Mm^3	26.0	From this study
2015 total landslide volume	V_a	Mm^3	49.4	From this study
Impact slope angle	α	°	10-20	George et al. (2017)
Grain density (weakly lithiefied sandstone)	ρ_g	kg/m^3	2150-2650	Highman et al. (2018)
Mean grain density	ρ_g	kg/m^3	2350	Highman et al. (2018)
Grain diameter (onshore)	d	m	0.1-20	Dufresne et at. (2018)
Grain angle of repose	-	°	34	From this study
Grain friction angle	φ_g	°	36-42	From this study
Maximum run-up elevation	-	m a.s.l.	193	Haeussler et al. (2018)
Maximum wave crest elevation	H_w	m a.s.l.	~100	Highman et al. (2018)
Mean water depth (impact area)	h_w	m	~100	Meigs et al. (2006)

Hydrodynamics analysis:

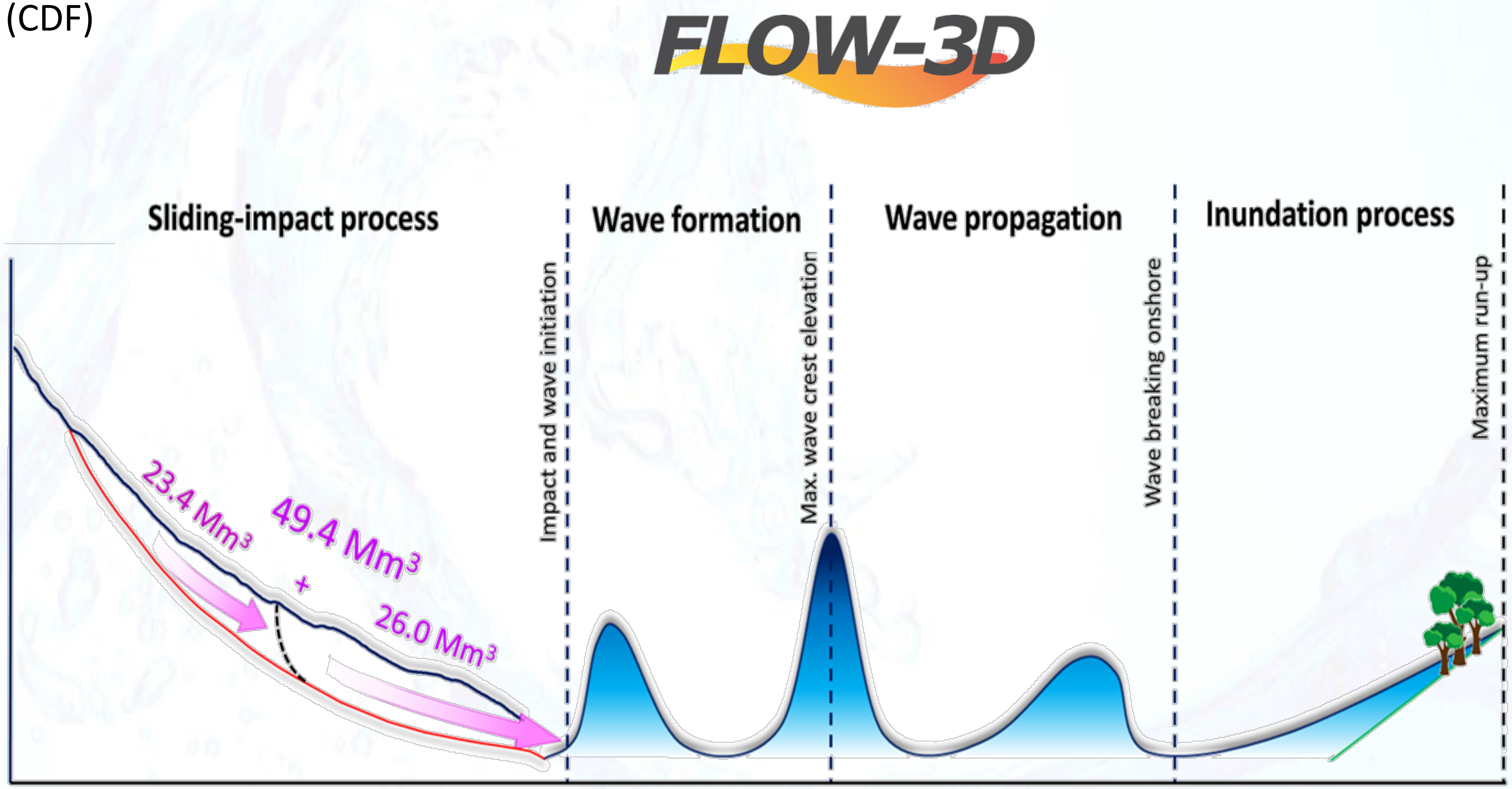
3D numerical modelling (CFD - FLOW 3D)

Numerical method:

- Computational fluid dynamic (CDF)
- RANS Equations
- FVM – mesh based
- 3D approach

Model-concept for impact:

- Dense fluid (26 Mm^3)
- Granular media - slurry ($49.4\ Mm^3$)



Hydrodynamics analysis:

Impact area - near field analysis

Hydrodynamics analysis:

Impact area - near field analysis

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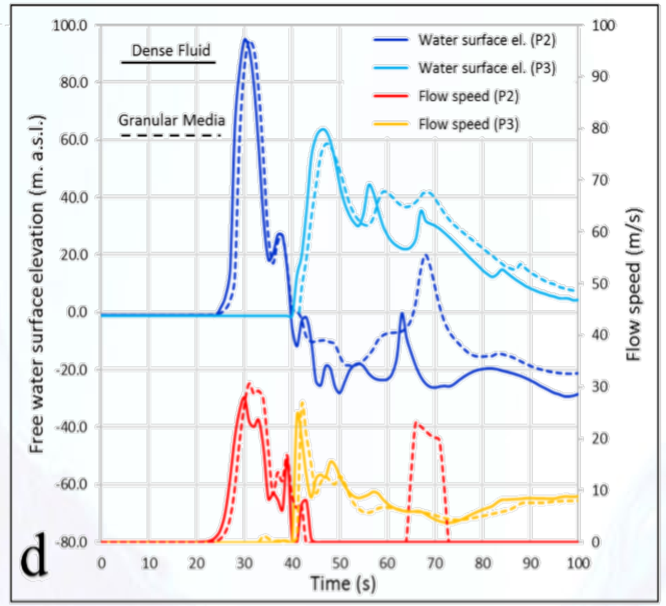
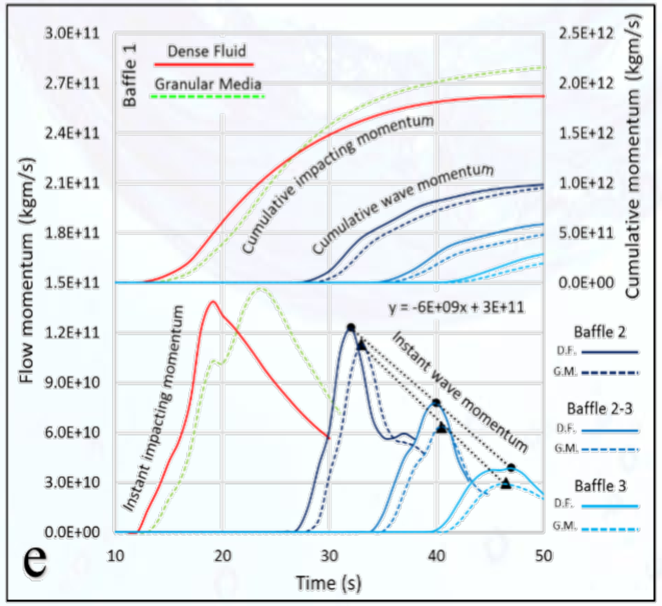
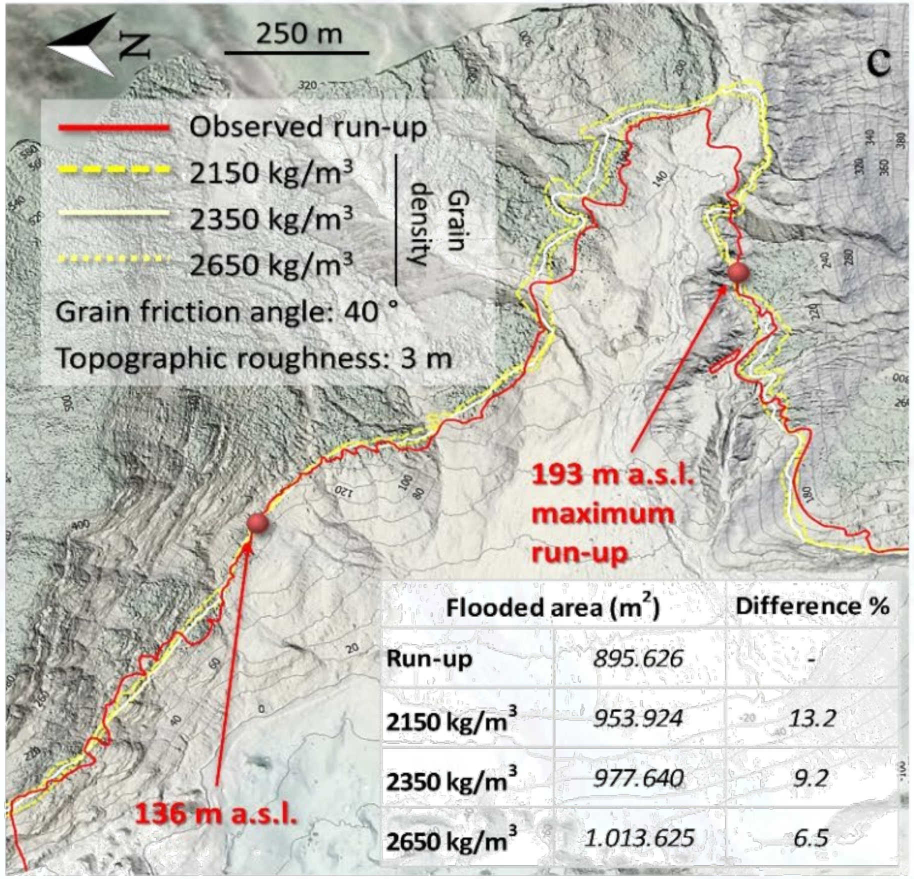
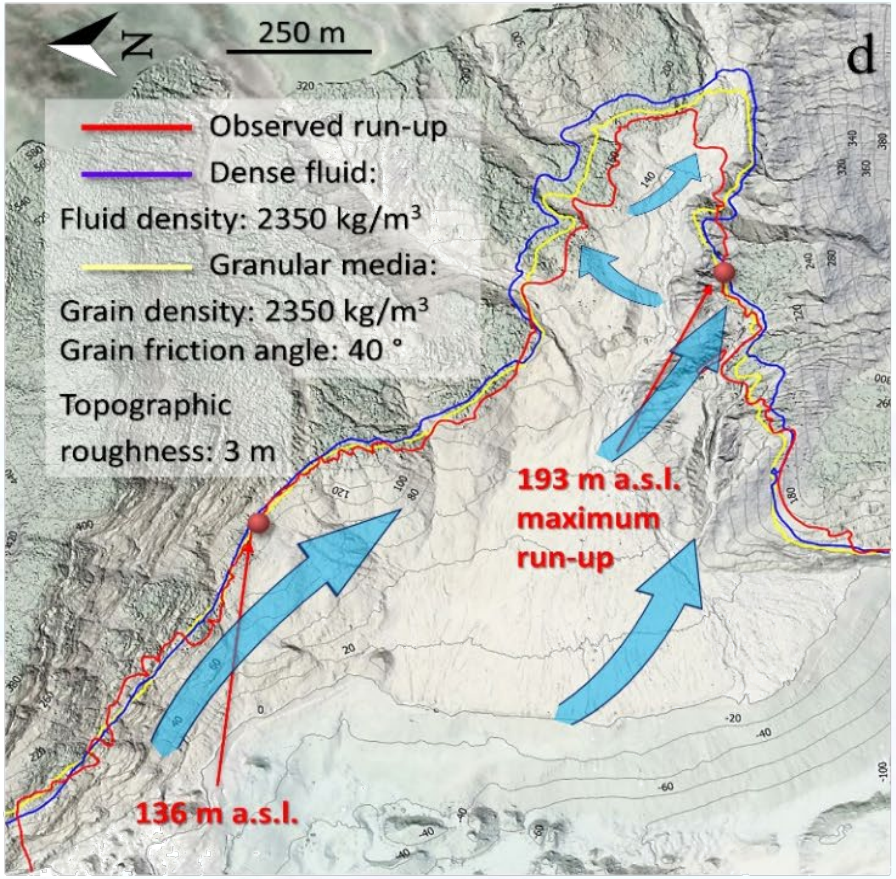




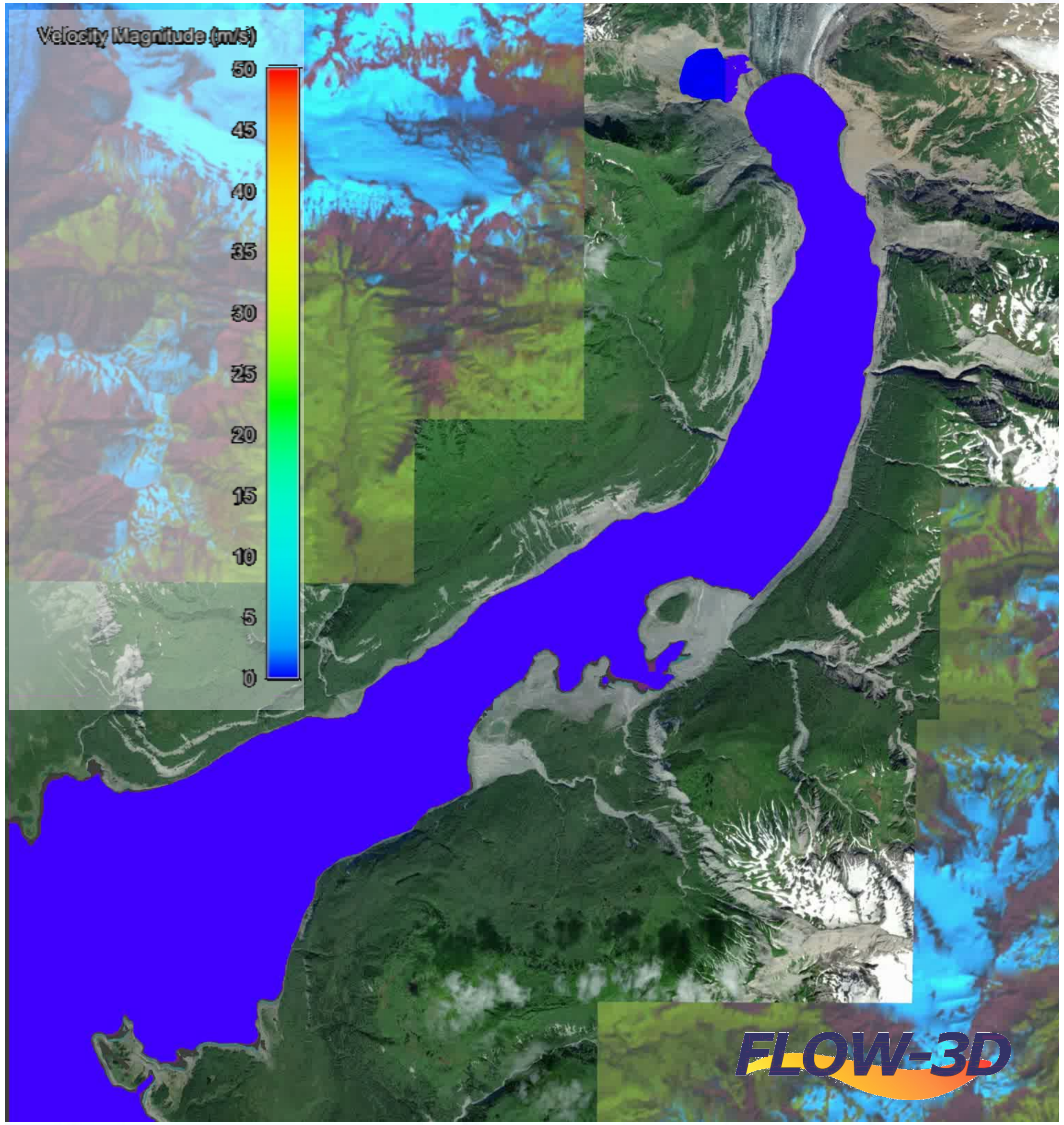


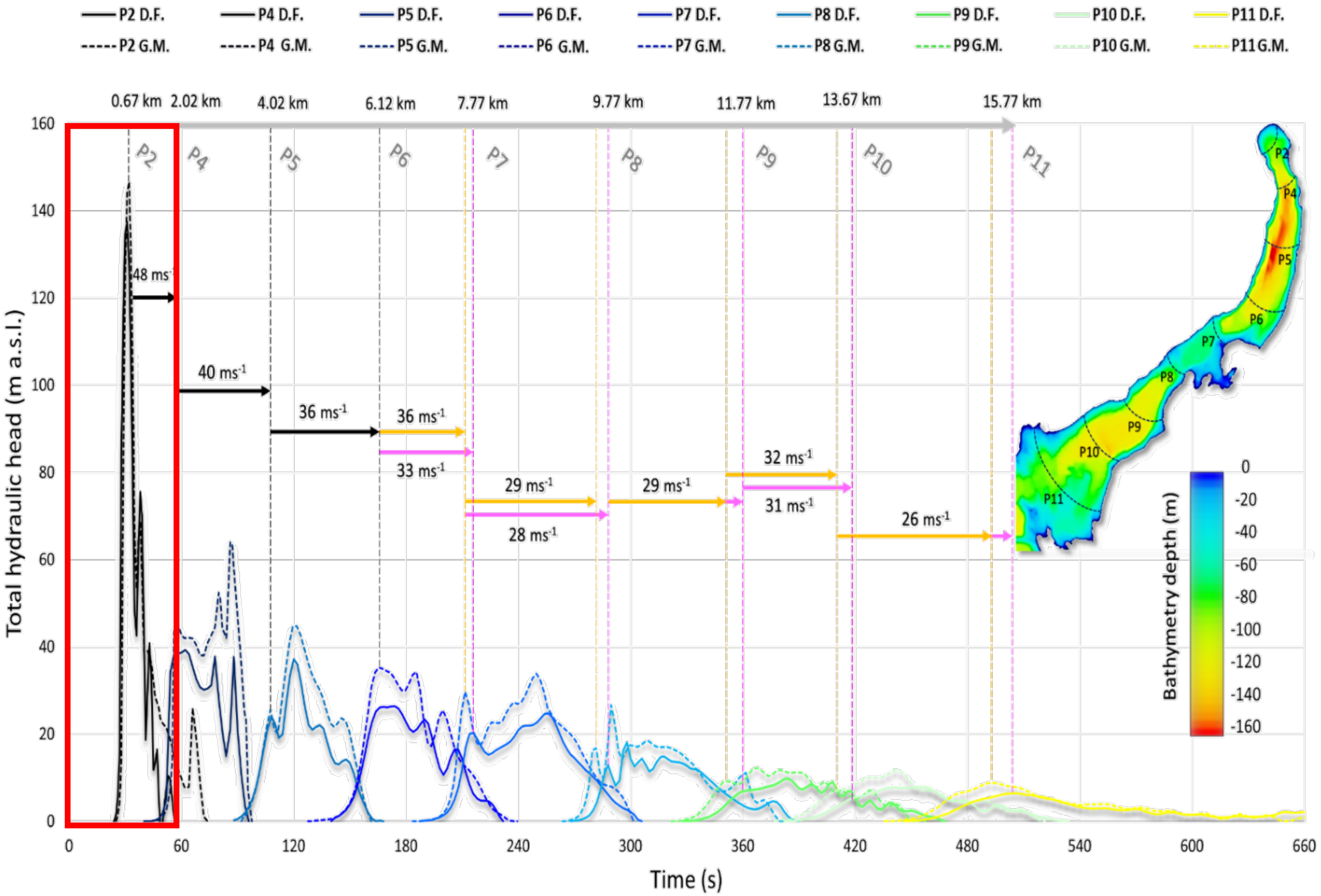
	Flooded area (m²)	Difference %
Run-up	895.626	-
2150 kg/m³	953.924	13.2
2350 kg/m³	977.640	9.2
2650 kg/m³	1.013.625	6.5



Hydrodynamics analysis:

whole fiord - far field analysis

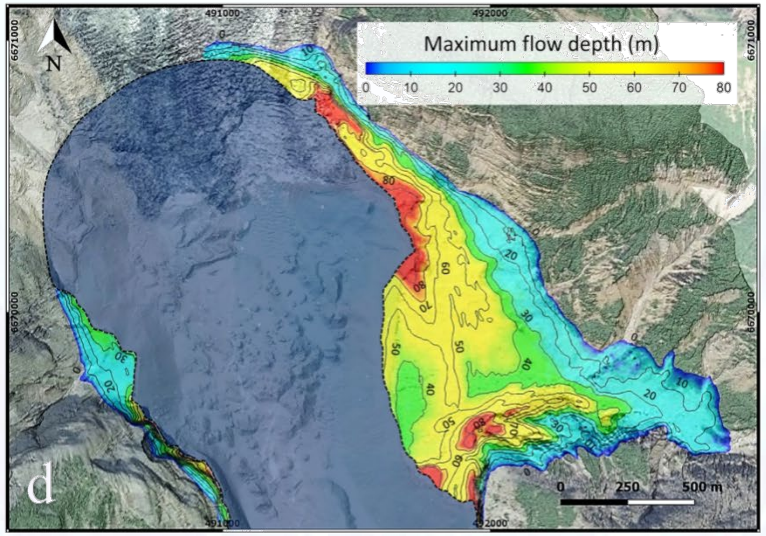


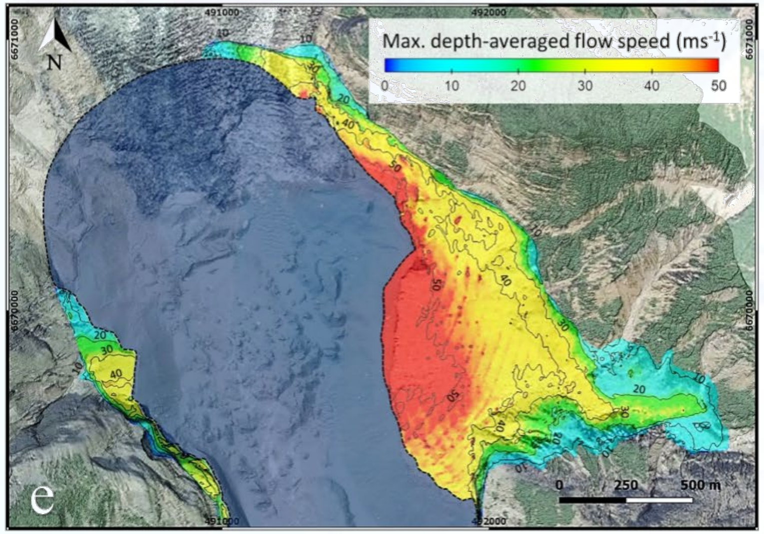


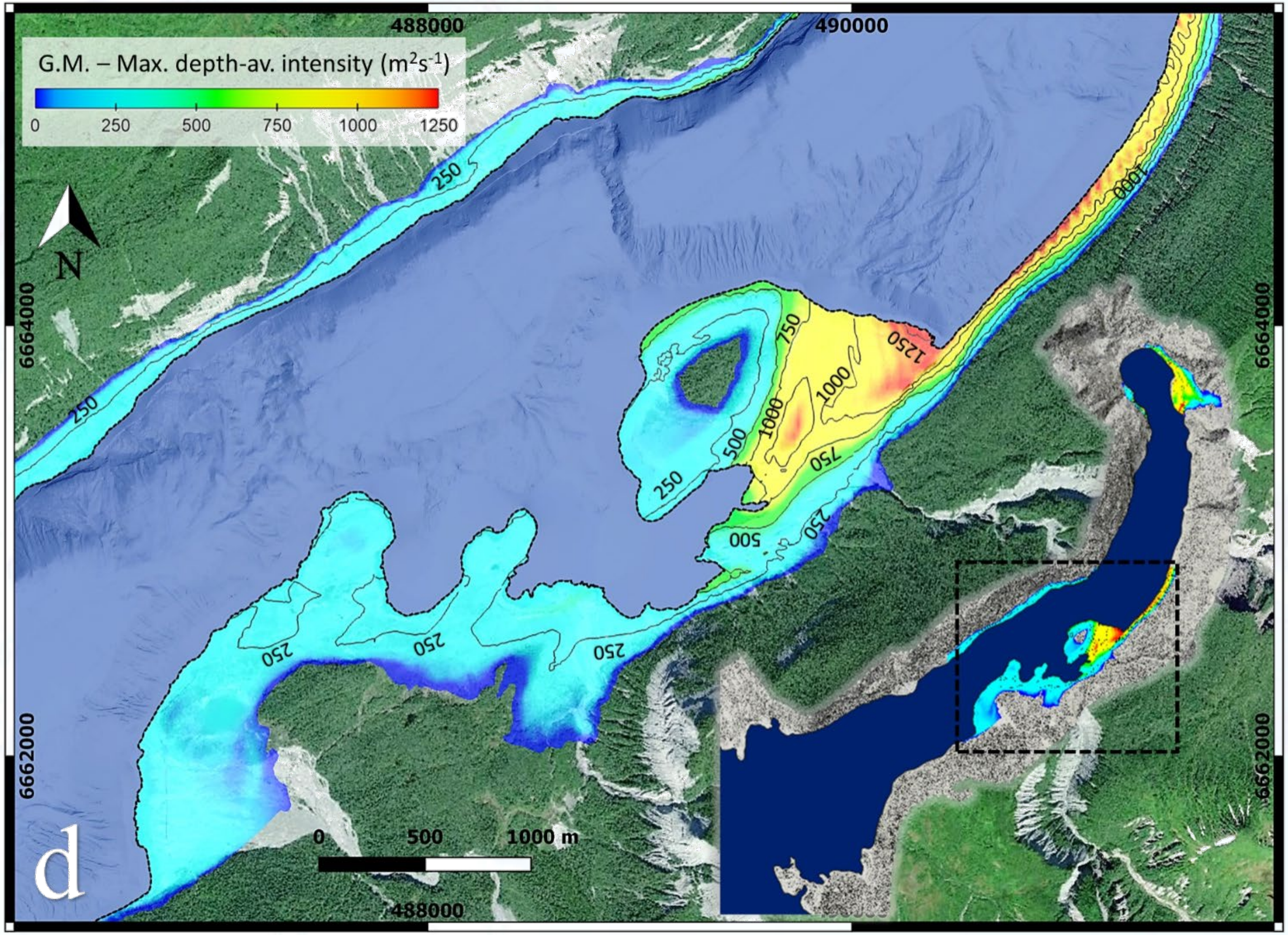
Wave hazard mapping:

a potential tool for wave hazard assessment

Wave hazard maps for the granular media concept







Conclusions and implication
for wave hazard in natural basins

Findings:

- The creeping-motion of the landslide related to the glacier dynamics
- Fast ice retreat as possible trigger of landslide failure
- Both models concepts unable the wave-dynamics reproduction

Implications:

- Numerical modelling approaches suitable for hazard analysis
- Maps out of the hydrodynamics models as useful tool for wave hazard assessment in mountain regions

Research project sponsored by the University of Innsbruck Doctoral College in Natural Hazards in Mountain Regions

Doctoral College: UIBK_Natural_Hazards

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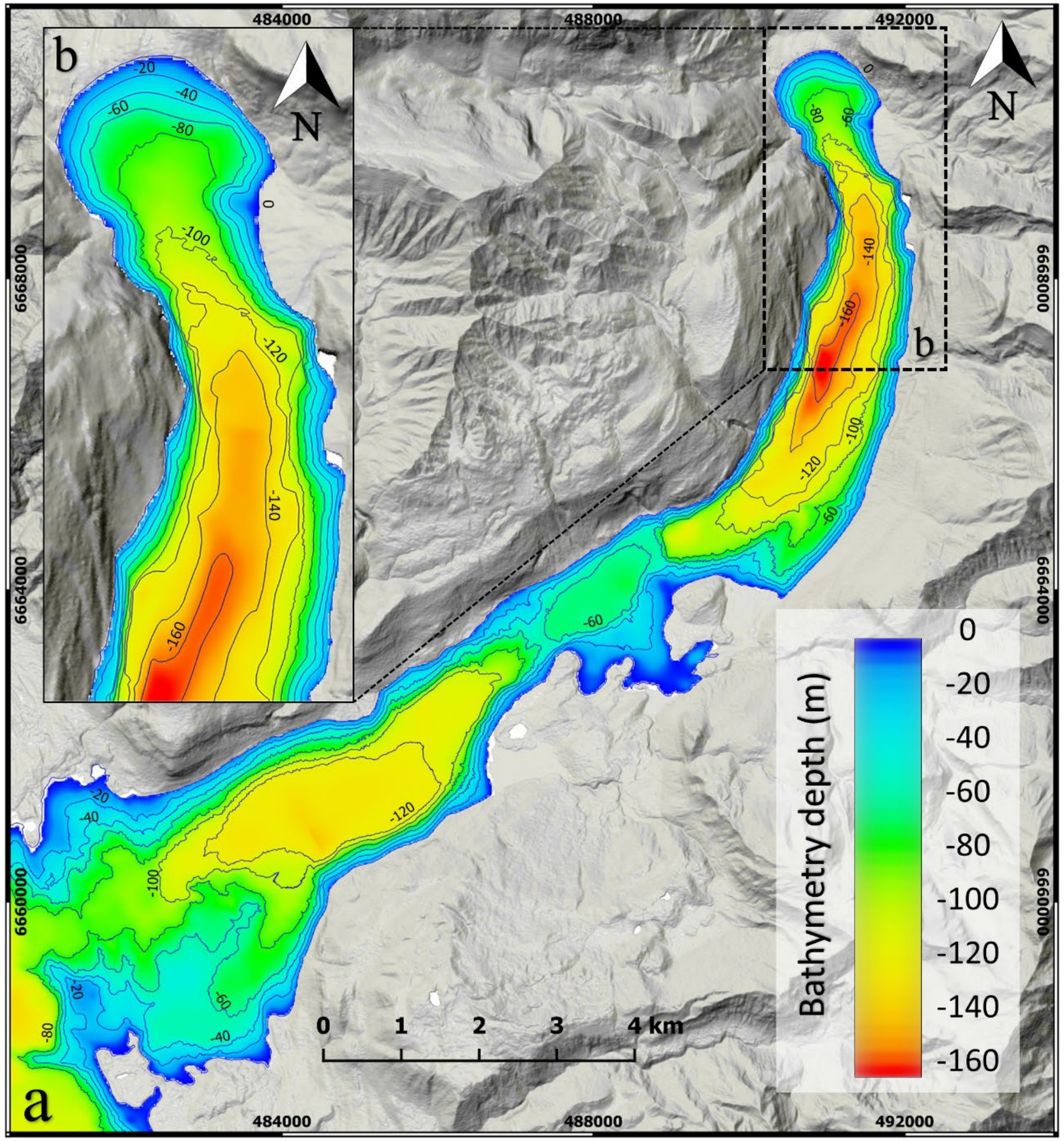
3D Dynamic reconstruction of the Taan Fiord 2015 tsunami event



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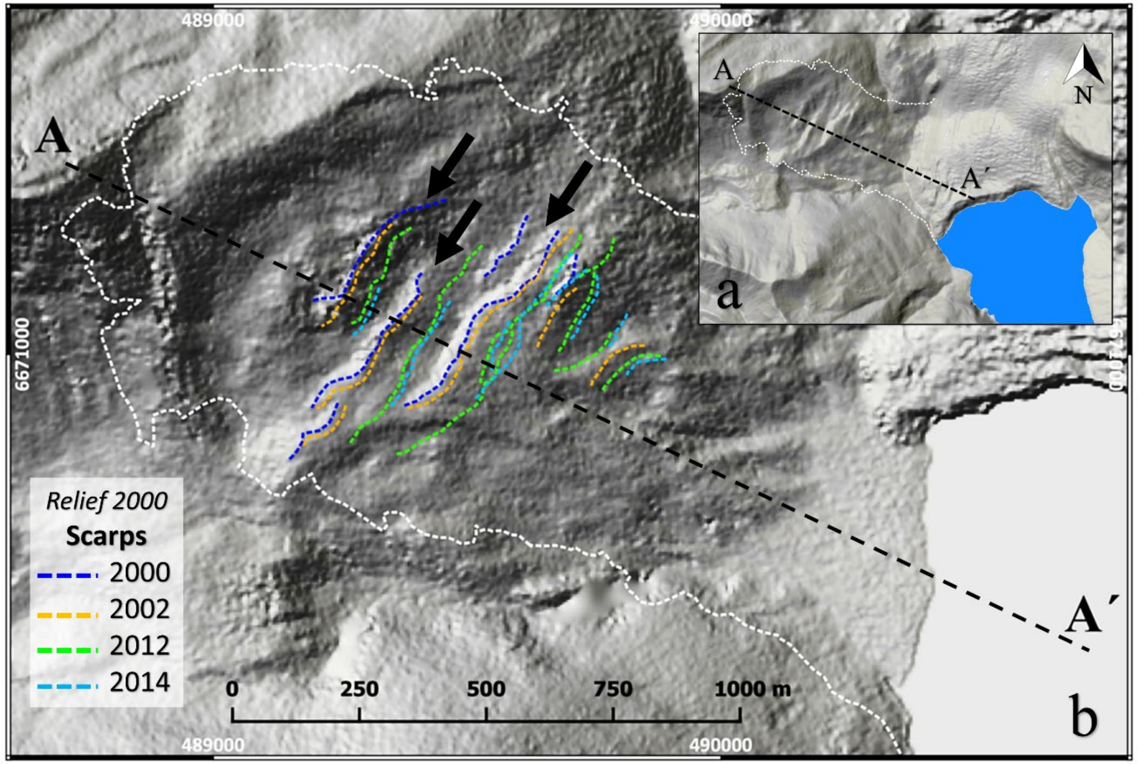

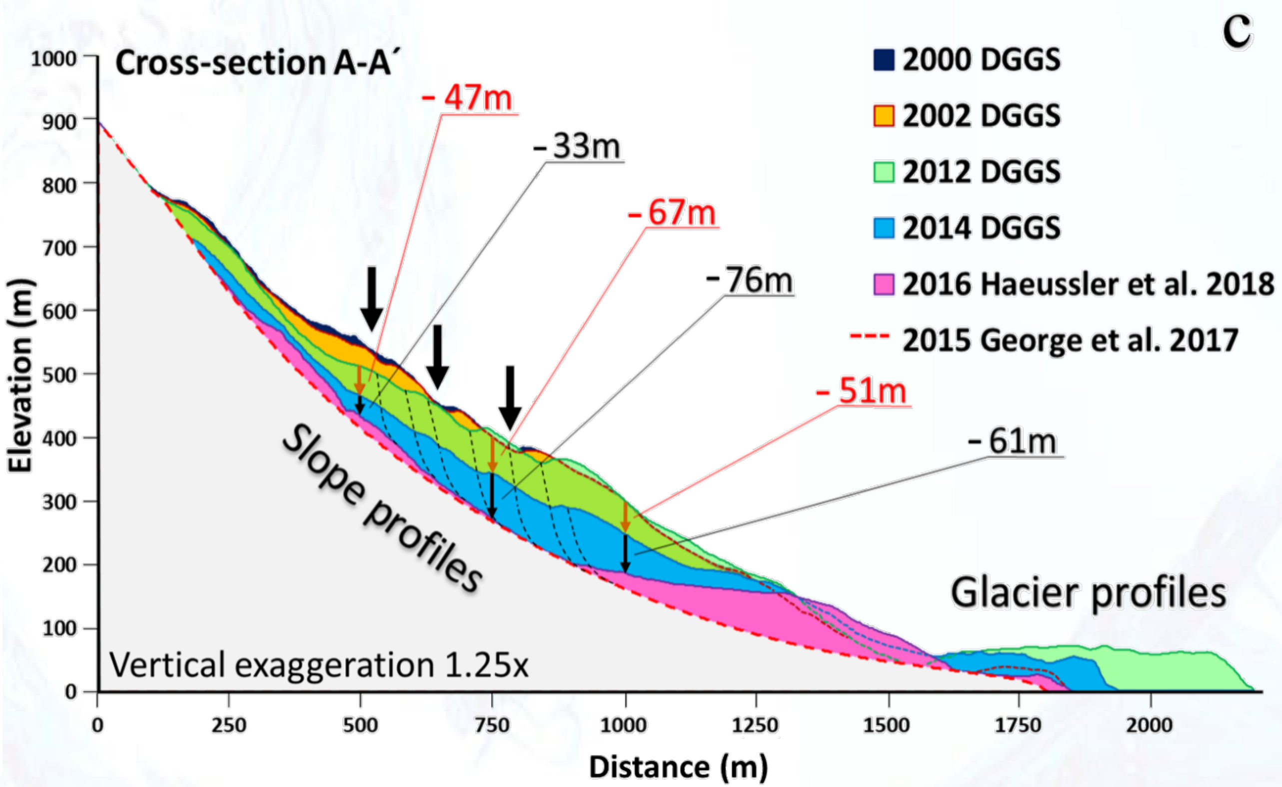

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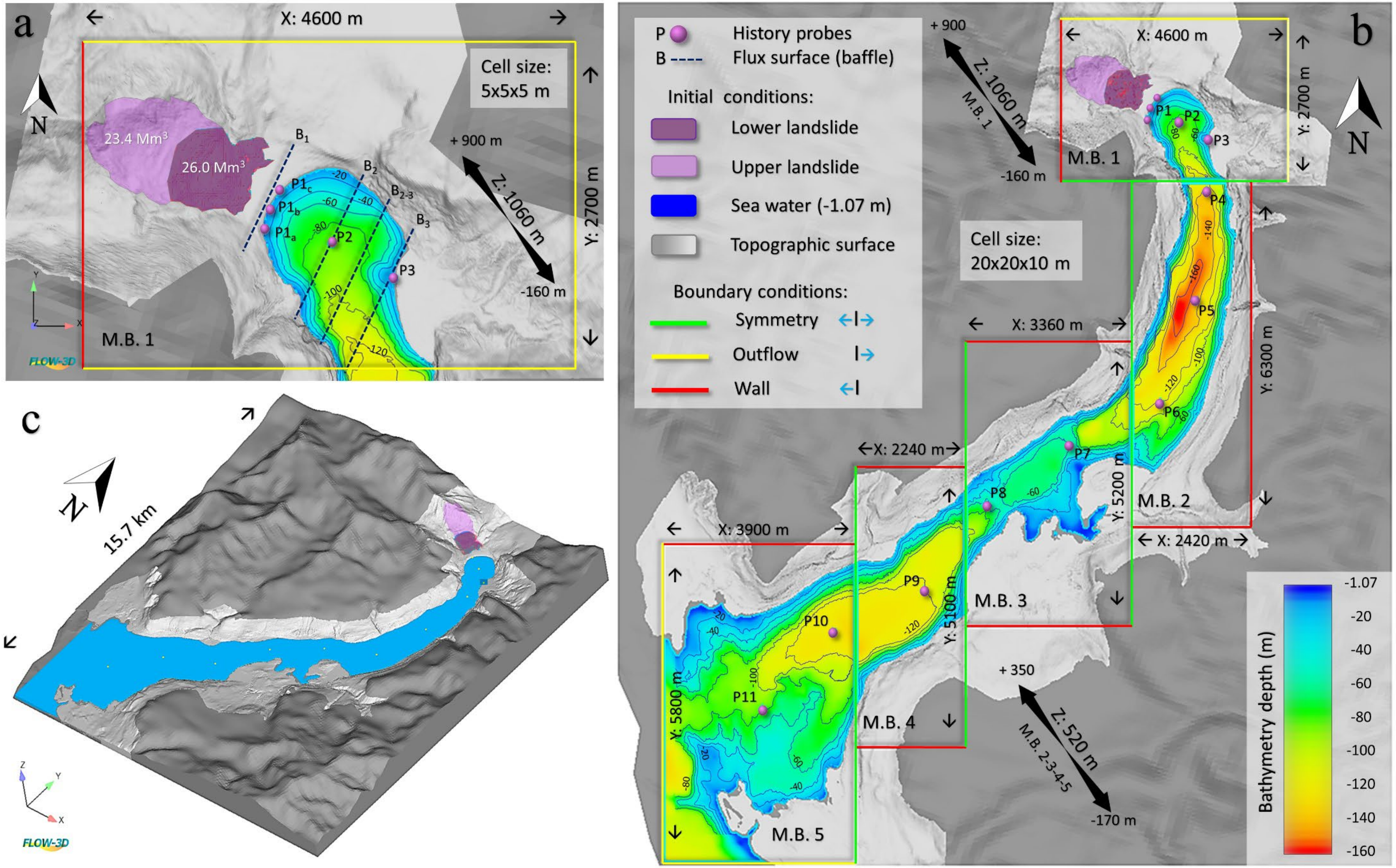
◉ Granular Flow in Liquid (Slurry)

Granular Flow Properties

Global vent coefficient	0.02	
Close packing volume fraction	0.63	
Mechanical jamming volume fraction		
Loose packing volume fraction	0	
Average grain diameter	0	m
Grain density	0	kg/m^3
Fluid density	0	kg/m^3
Fluid viscosity	0	kg/m/s
Multiplier in packing drag	1	
Multiplier in threshold packing velocity	1	
Friction angle		degree(s)
Angle of repose	34	degree(s)
Minimum volume fraction of granular phase		
Grain restitution coefficient	0.7	



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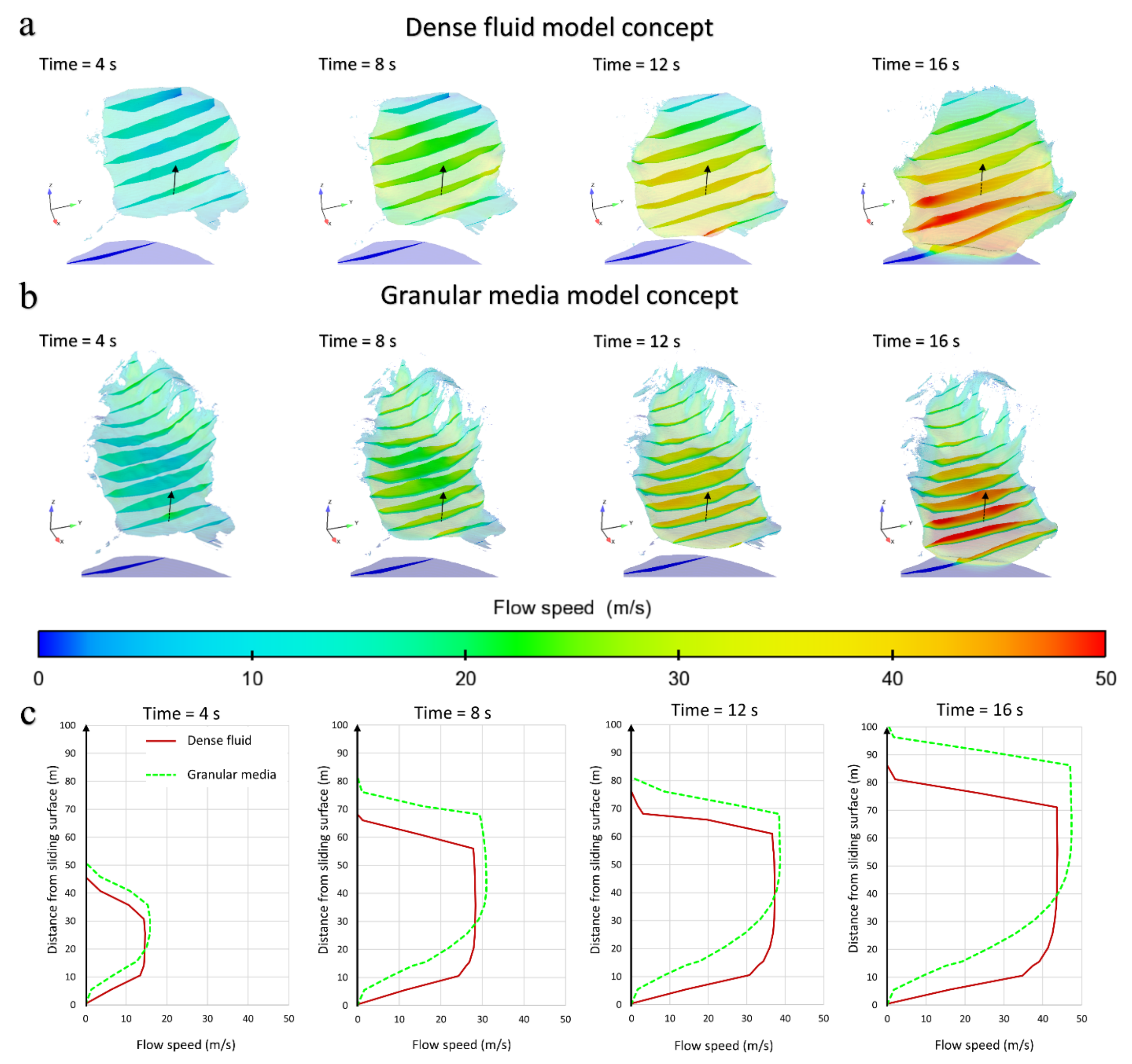

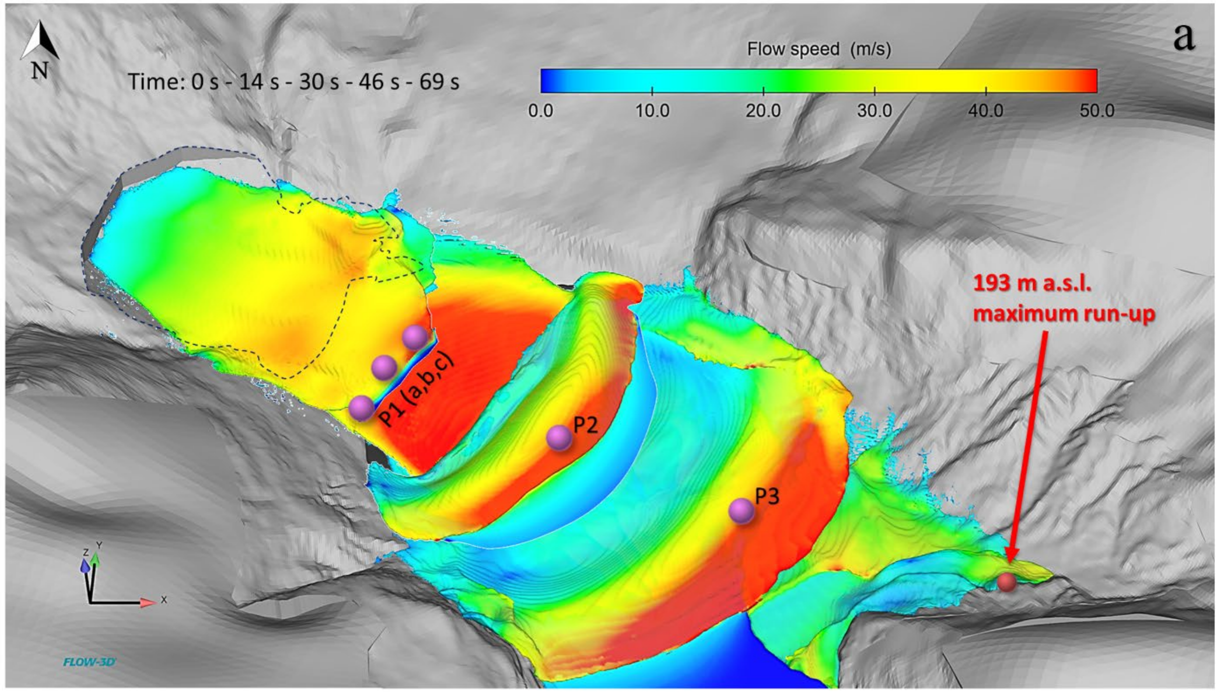

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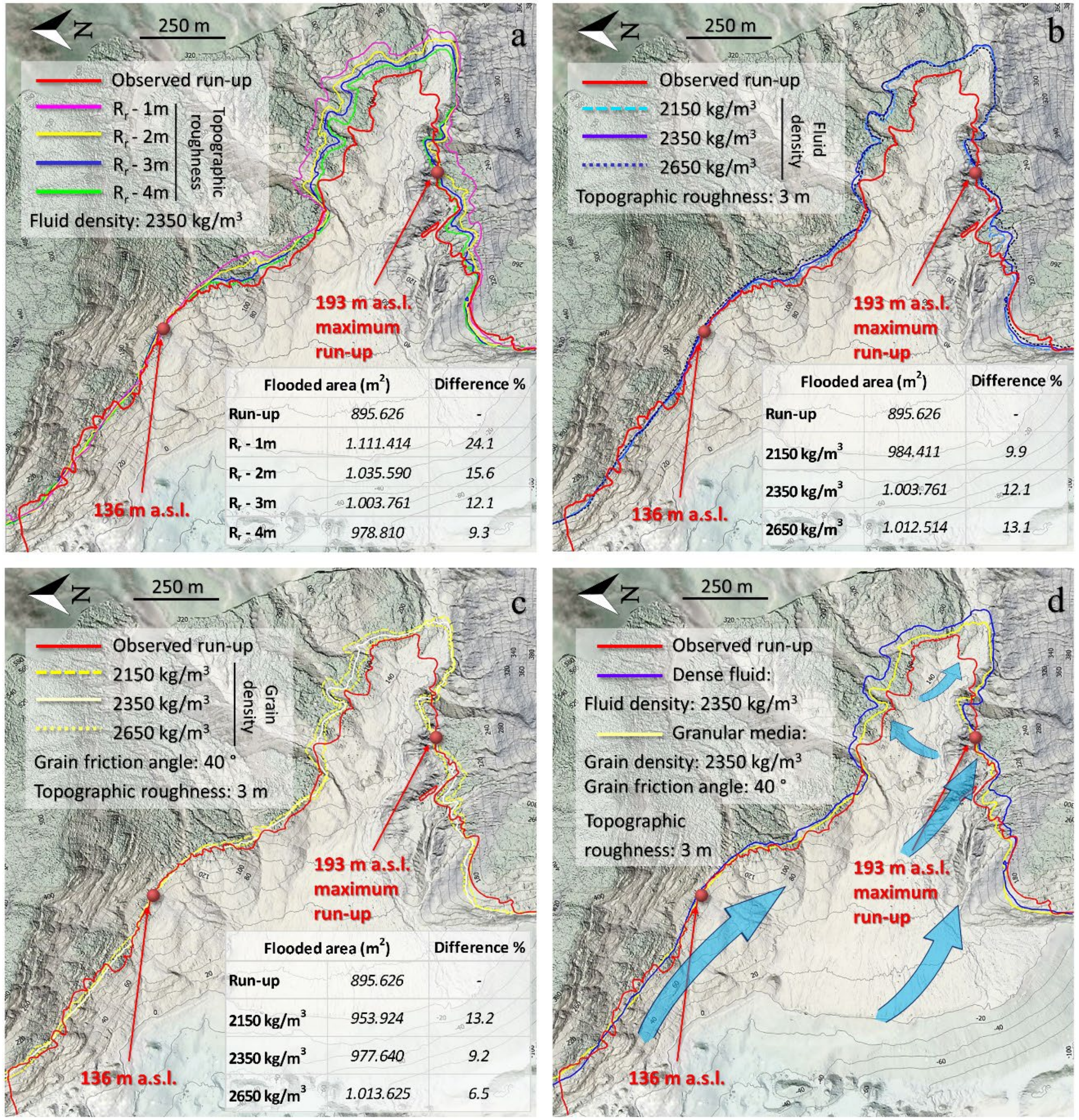

	Flooded area (m²)	Difference %
Run-up	895.626	-
R_r - 1m	1.111.414	24.1
R_r - 2m	1.035.590	15.6
R_r - 3m	1.003.761	12.1
R_r - 4m	978.810	9.3

	Flooded area (m²)	Difference %
Run-up	895.626	-
2150 kg/m³	984.411	9.9
2350 kg/m³	1.003.761	12.1
2650 kg/m³	1.012.514	13.1

	Flooded area (m²)	Difference %
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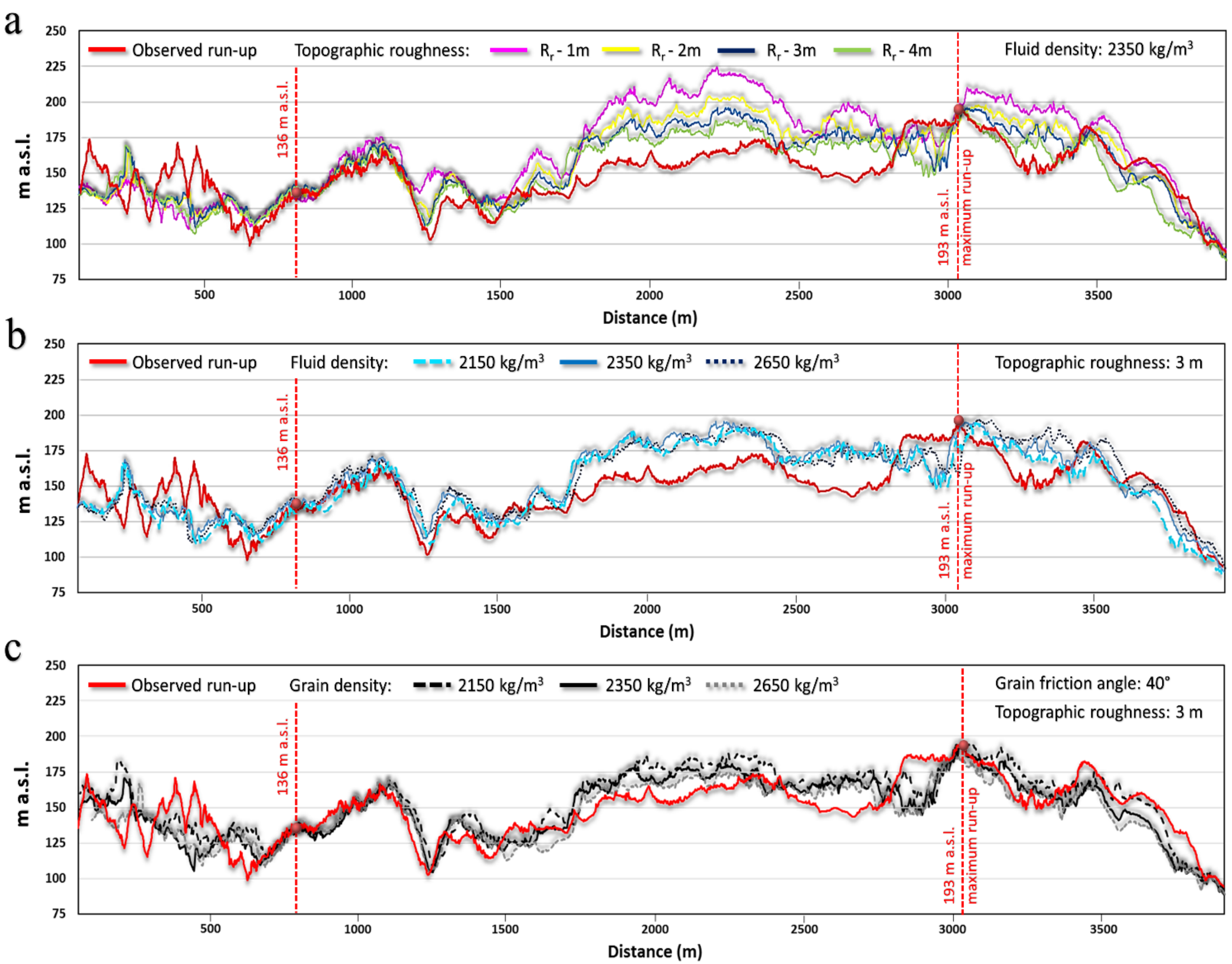

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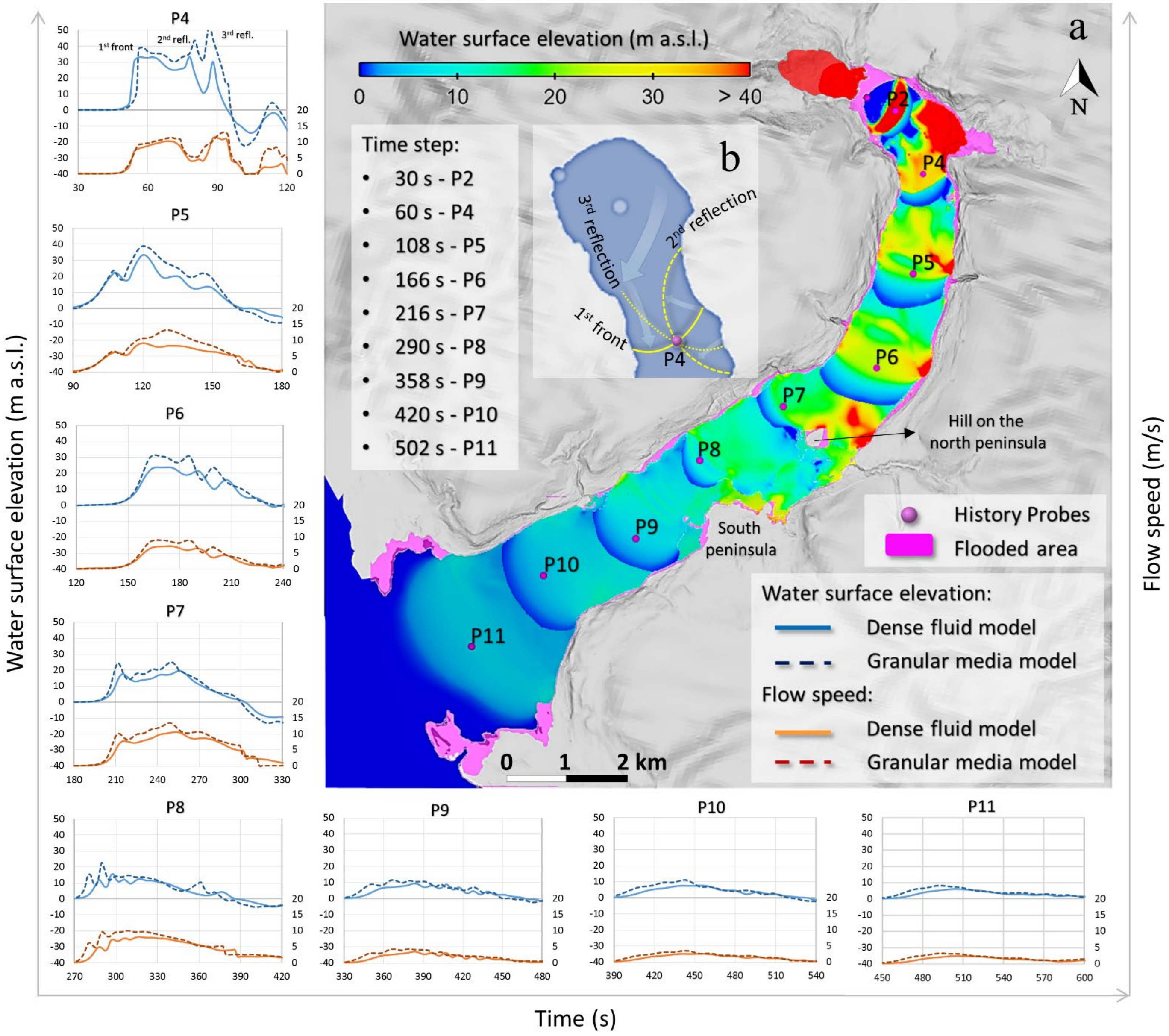

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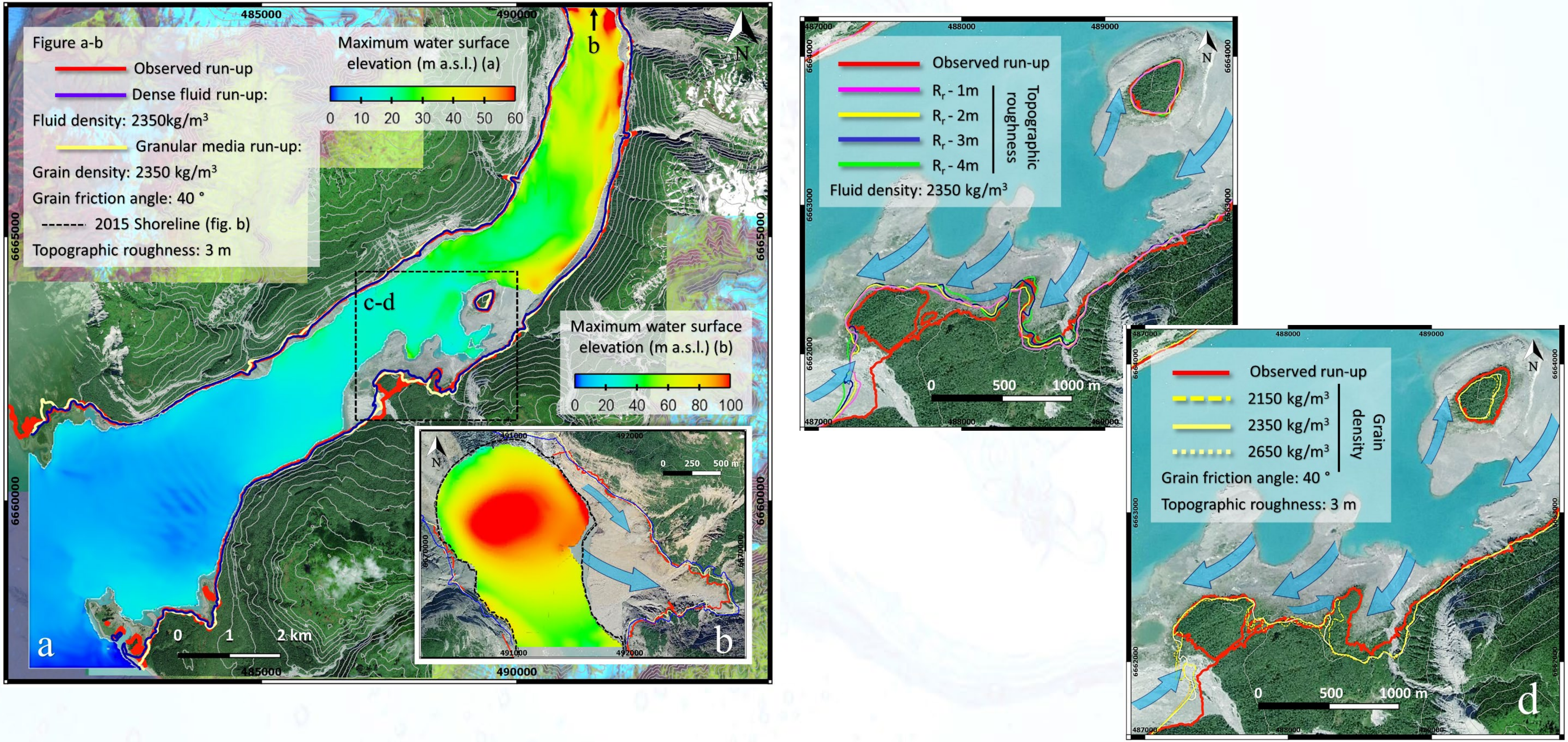

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Wave hazard maps for the dense fluid concept

Wave hazard maps for the granular media concept