Special Sessions

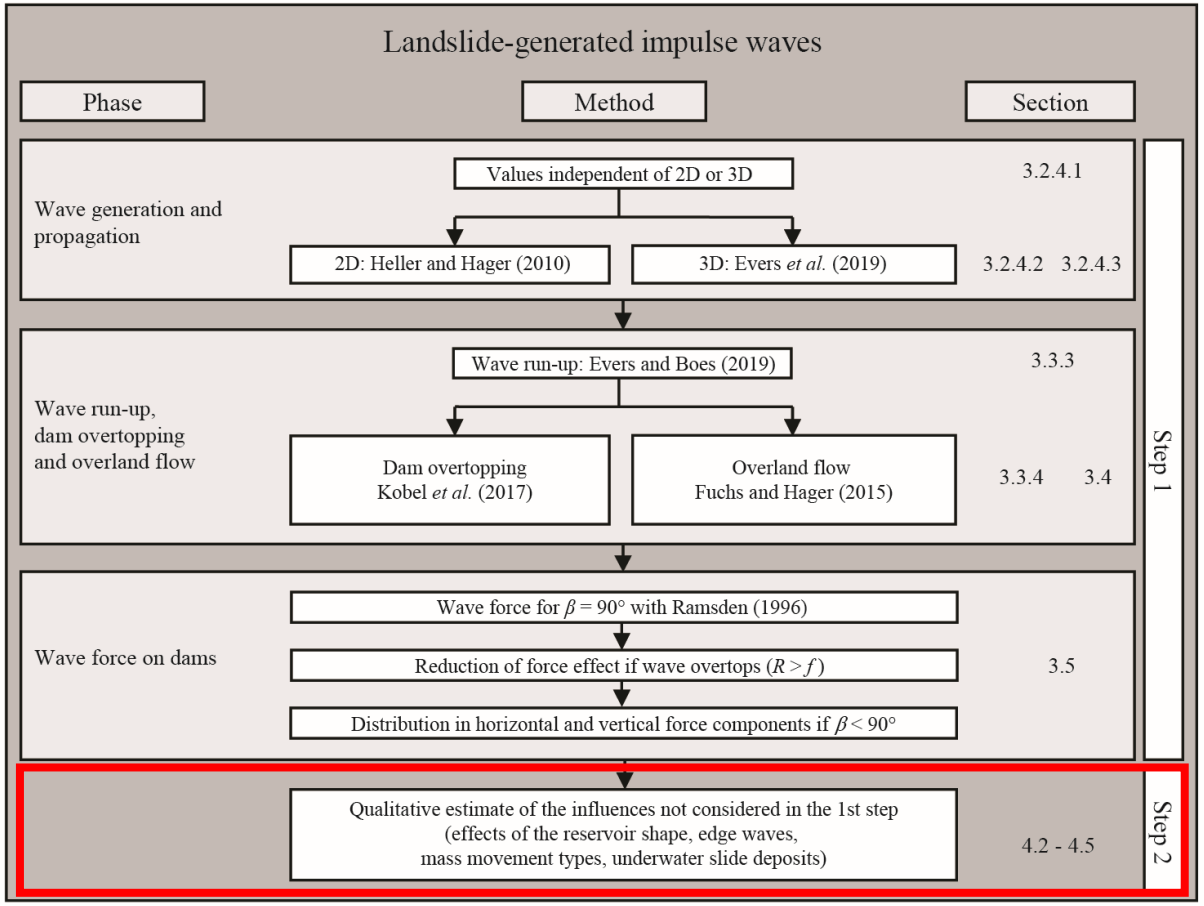
Workshop «LANDSLIDE-GENERATED IMPULSE WAVES IN RESERVOIRS»

Manual Step 2: Water body geometry, Edge waves, Sensitivity

Frederic Evers

ETH Zurich

Computational procedure – Overview



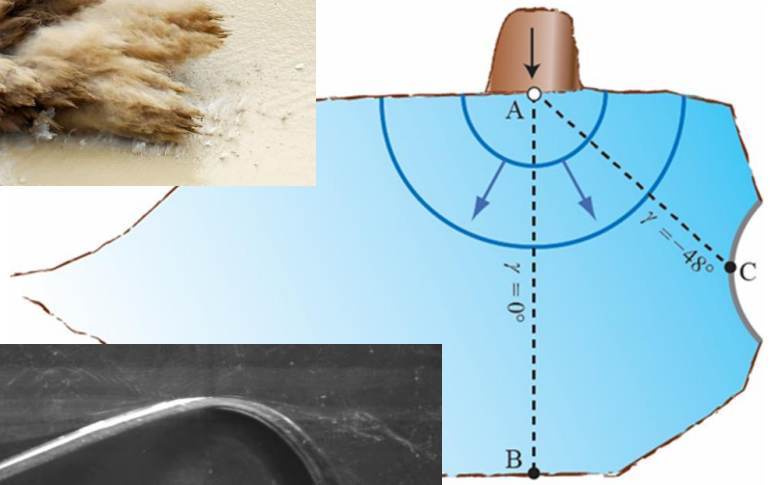
→ «Step 2»

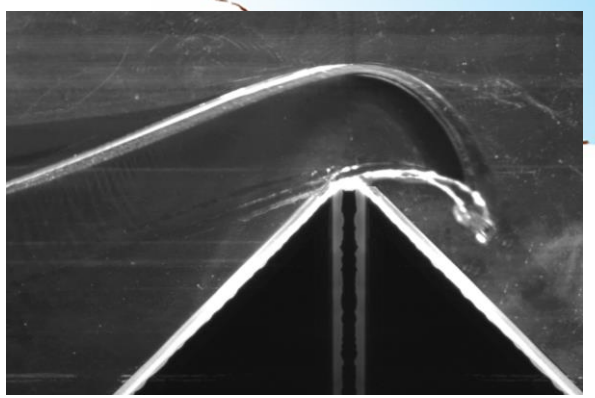
Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

«Step 2» – Outline

- Reservoir shape
- Edge waves
- Mass movement types
- Sensitivity and uncertainty

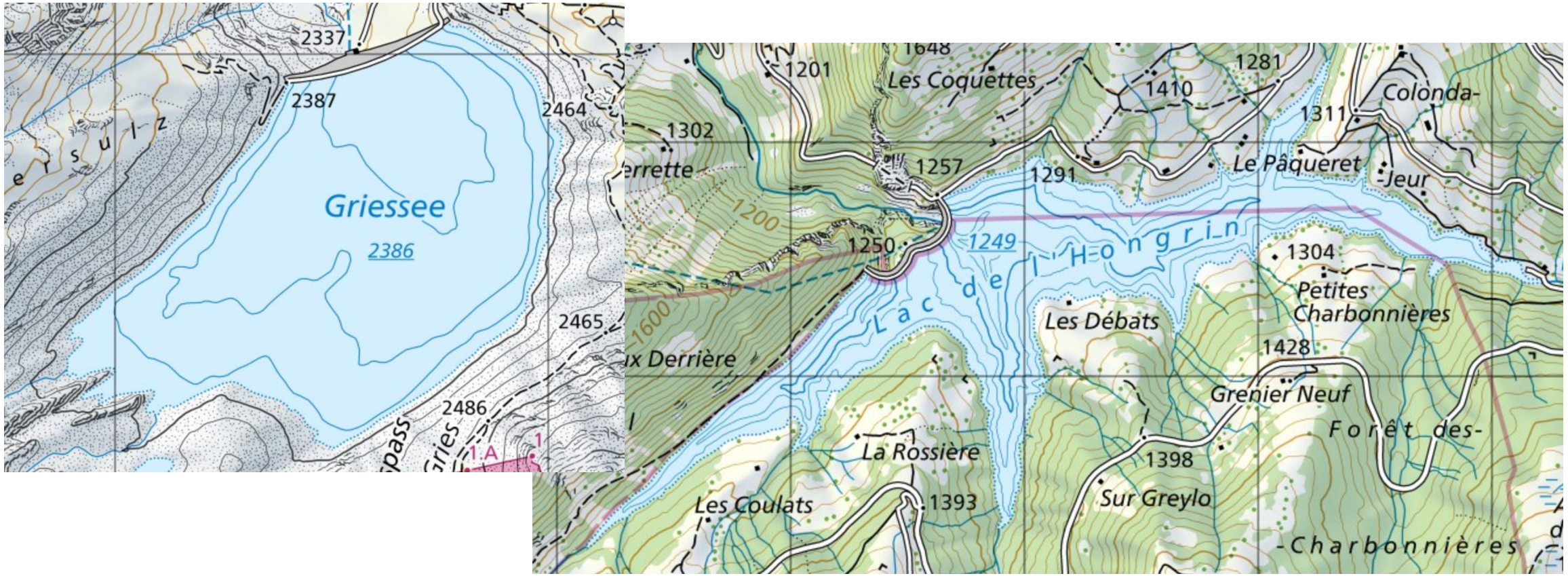




Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

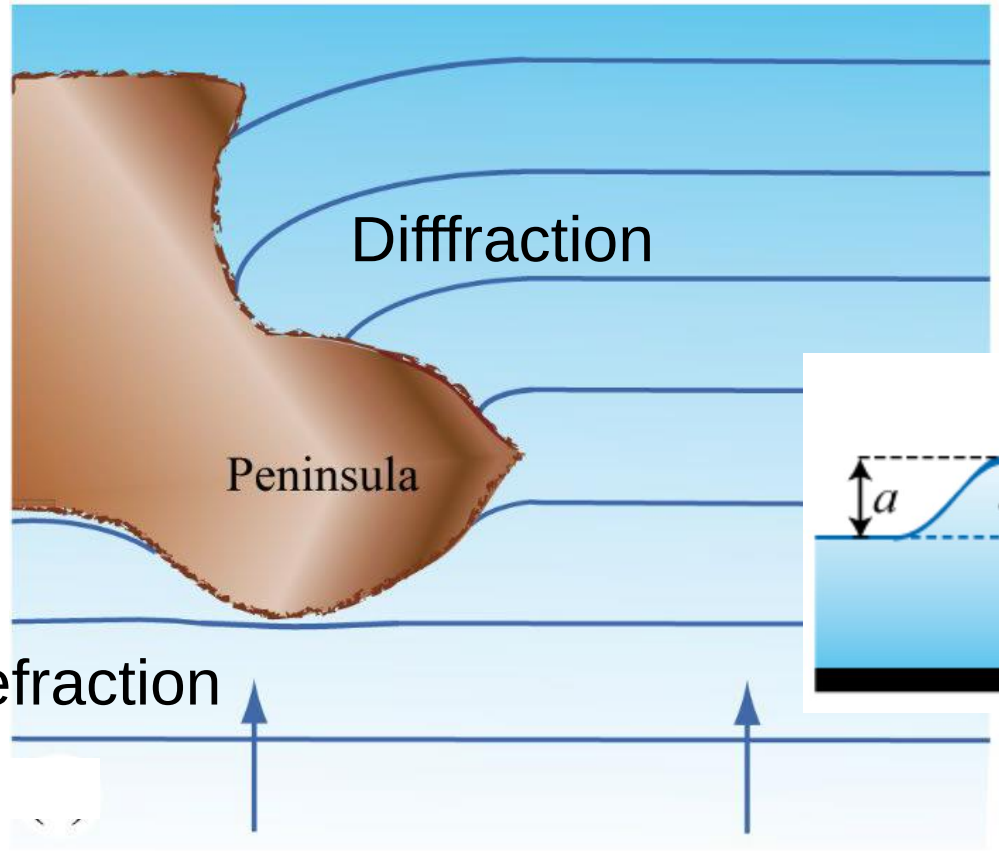
Reservoir shape

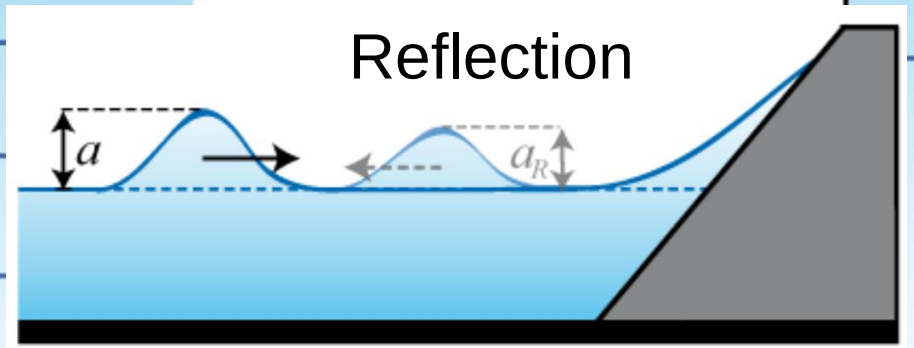


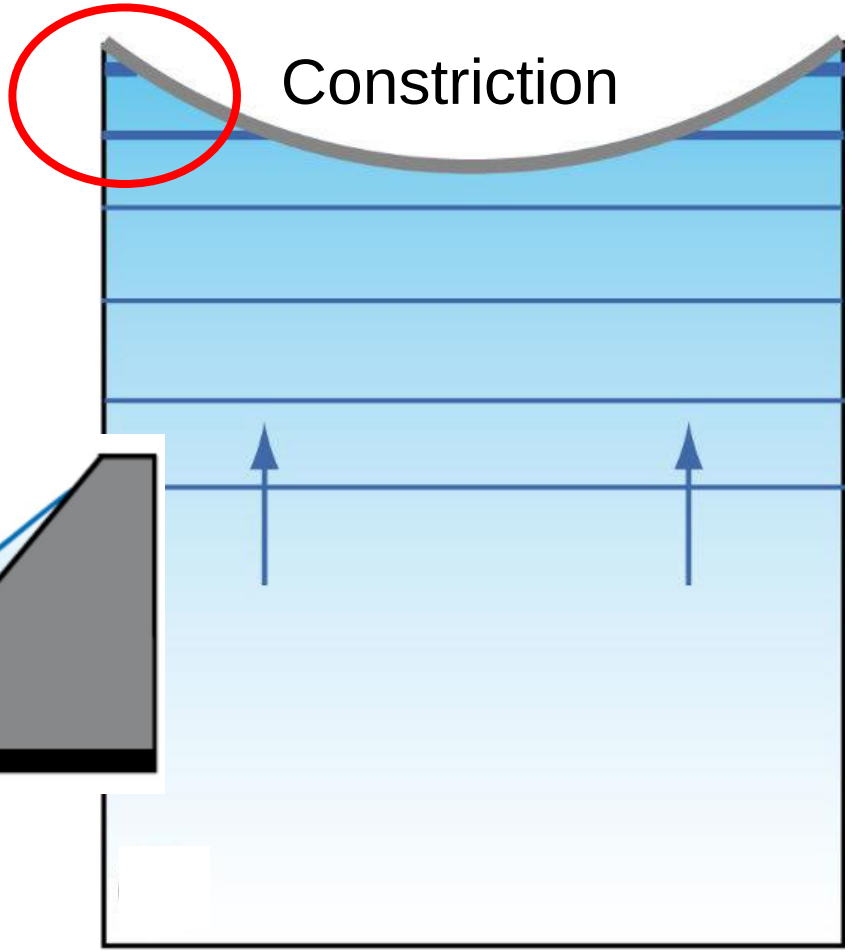
Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

Wave-shore interaction



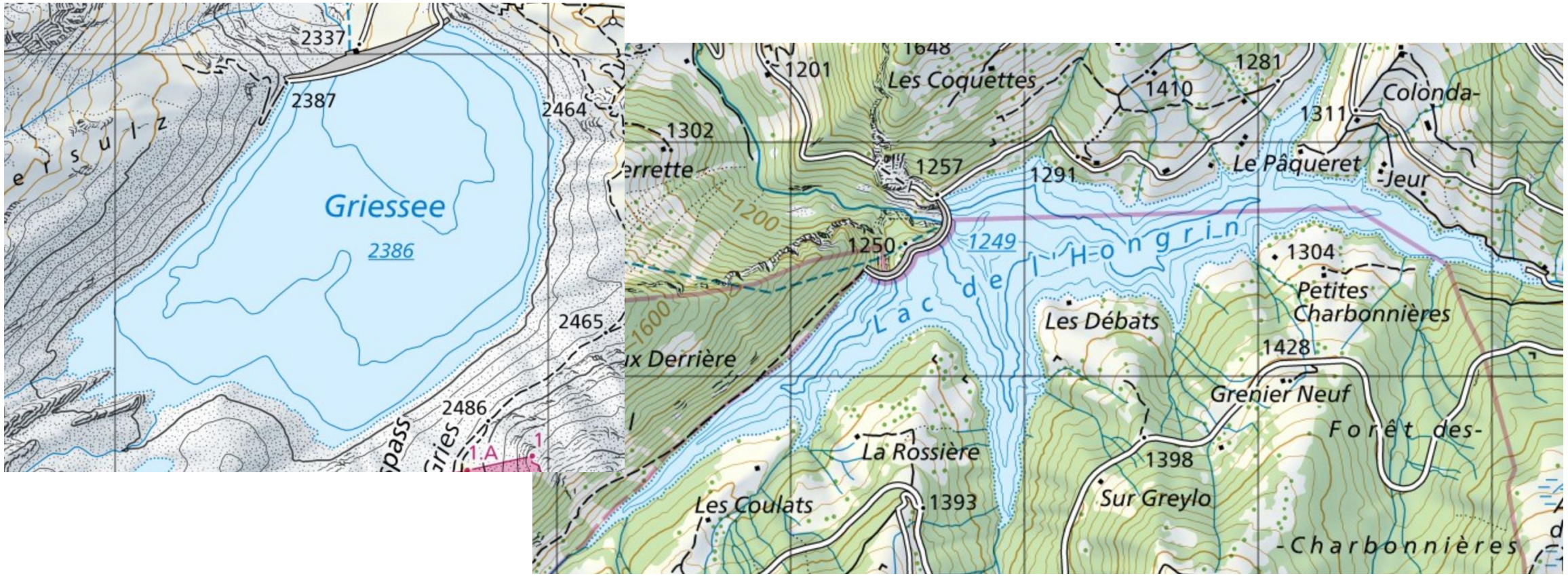




Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

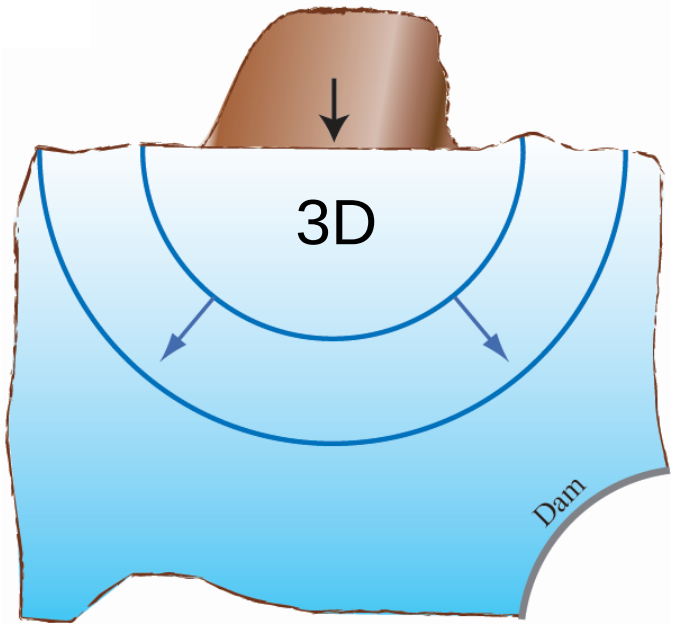
Reservoir shape

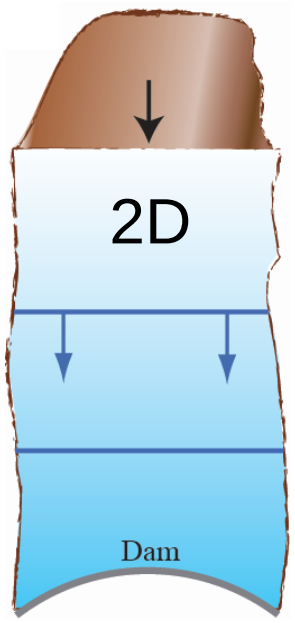


Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

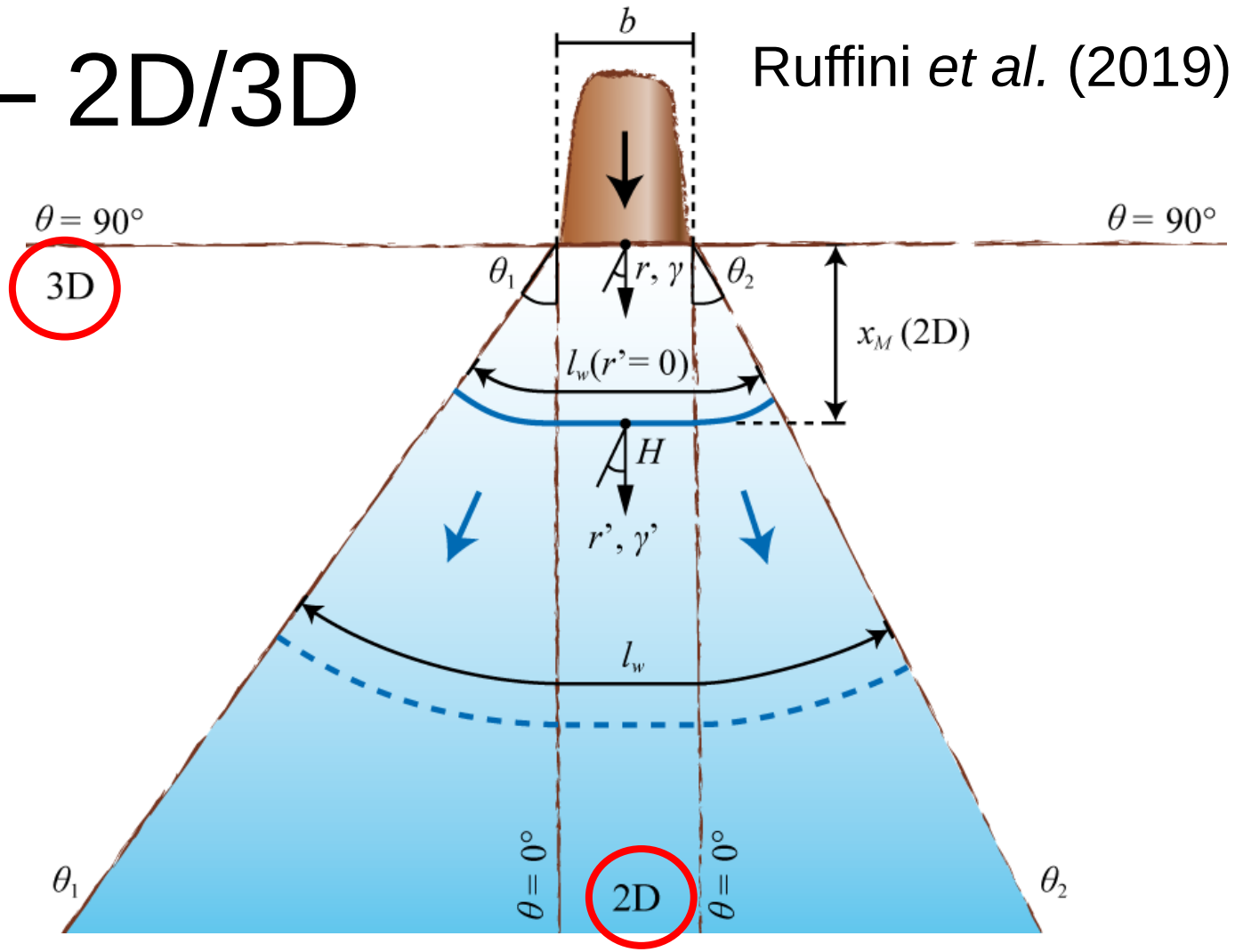
Laboratory of Hydraulics, Hydrology and Glaciology

Reservoir shape – 2D/3D





Ruffini *et al.* (2019)

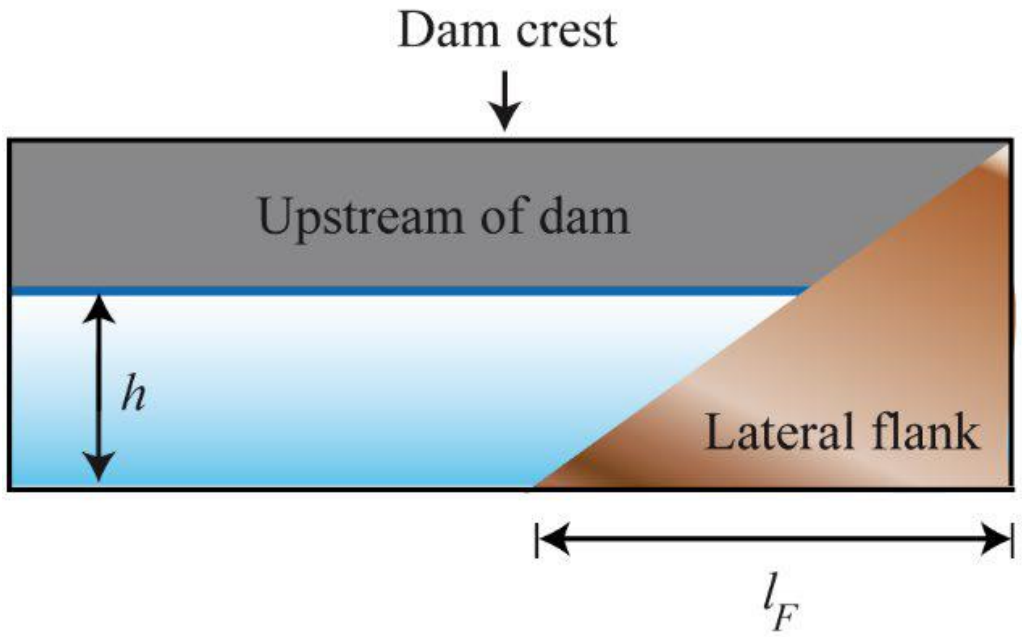


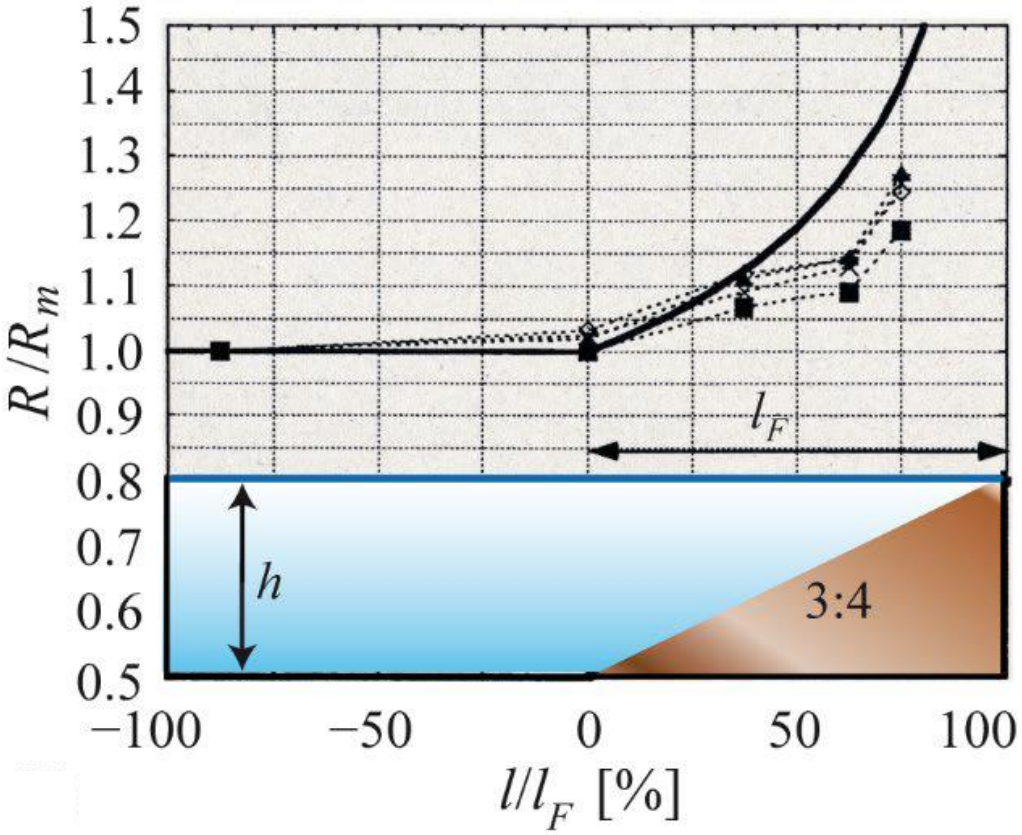
Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

Reservoir shape – Lateral flanks

Müller (1995)

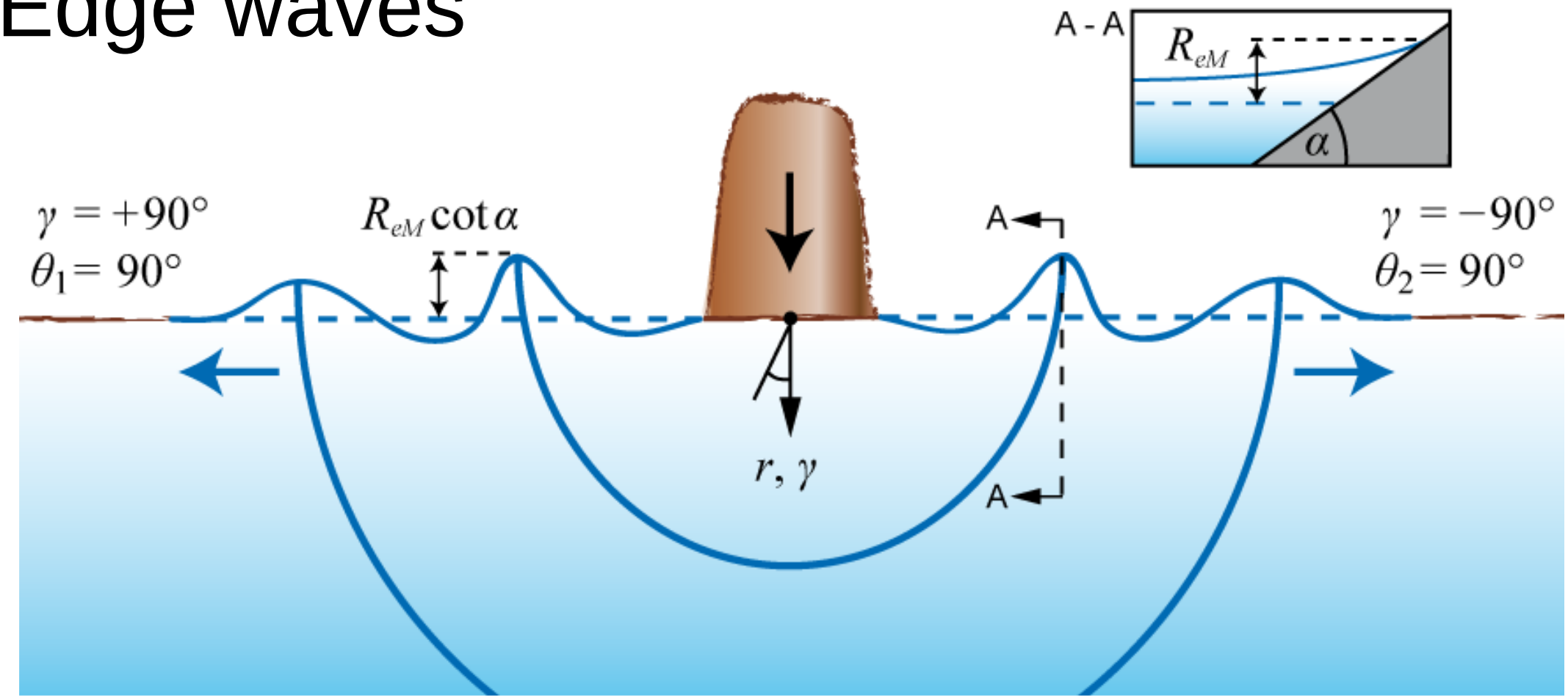




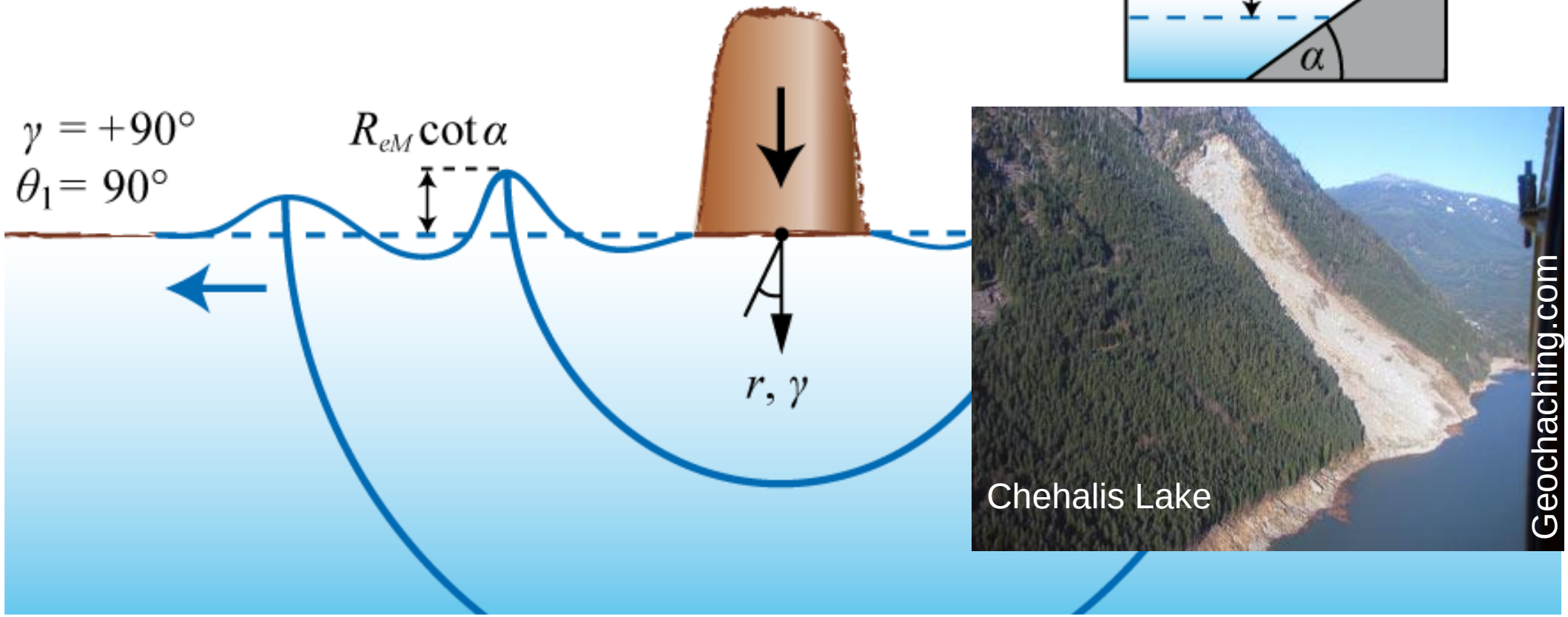
Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

Edge waves


A - A
R_{eM}
α
$\gamma = +90°$
$\theta_1 = 90°$
$R_{eM} \cot \alpha$
A
$\gamma = -90°$
$\theta_2 = 90°$
r, γ
A

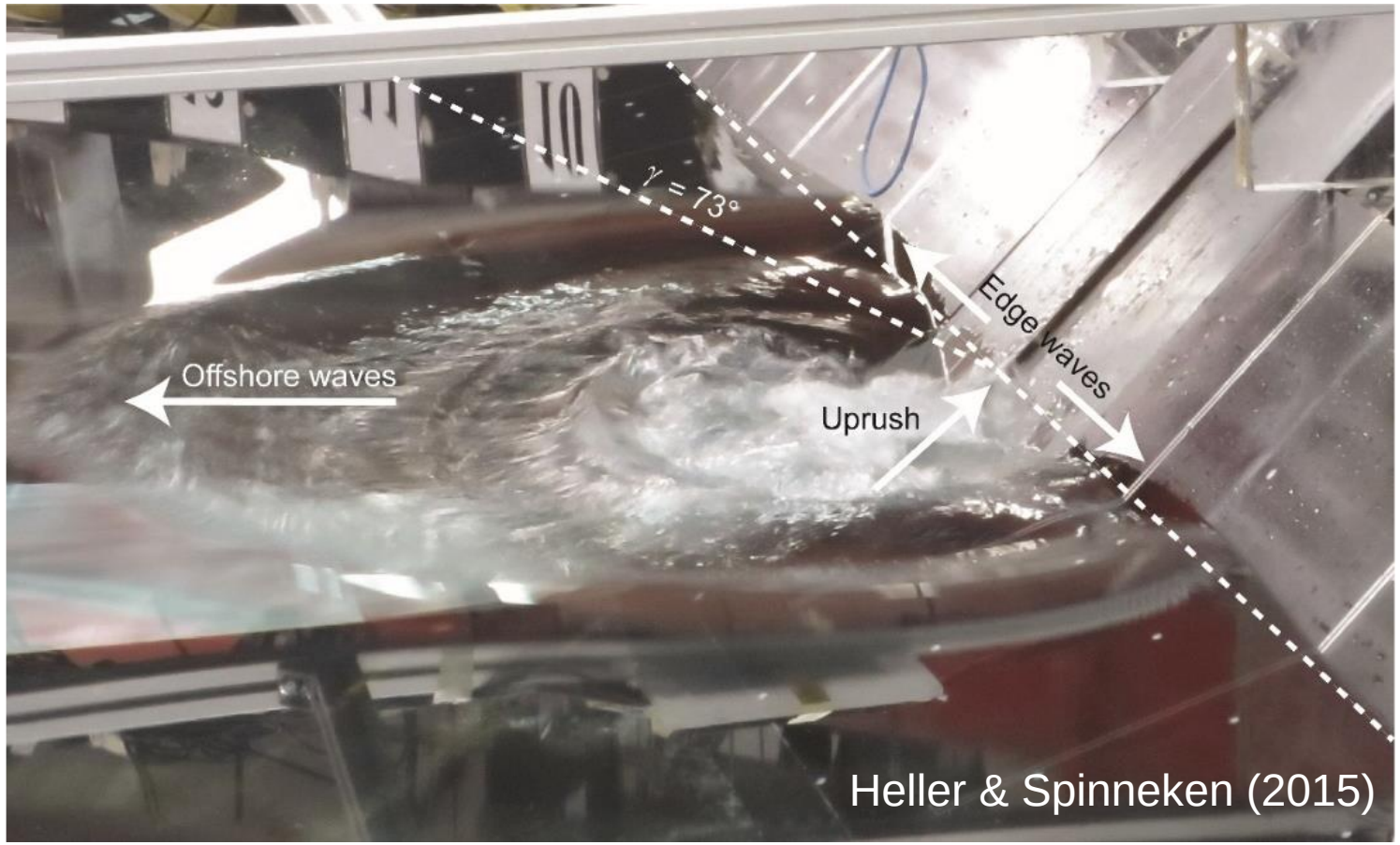
Edge waves



Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

Edge waves - Experiment



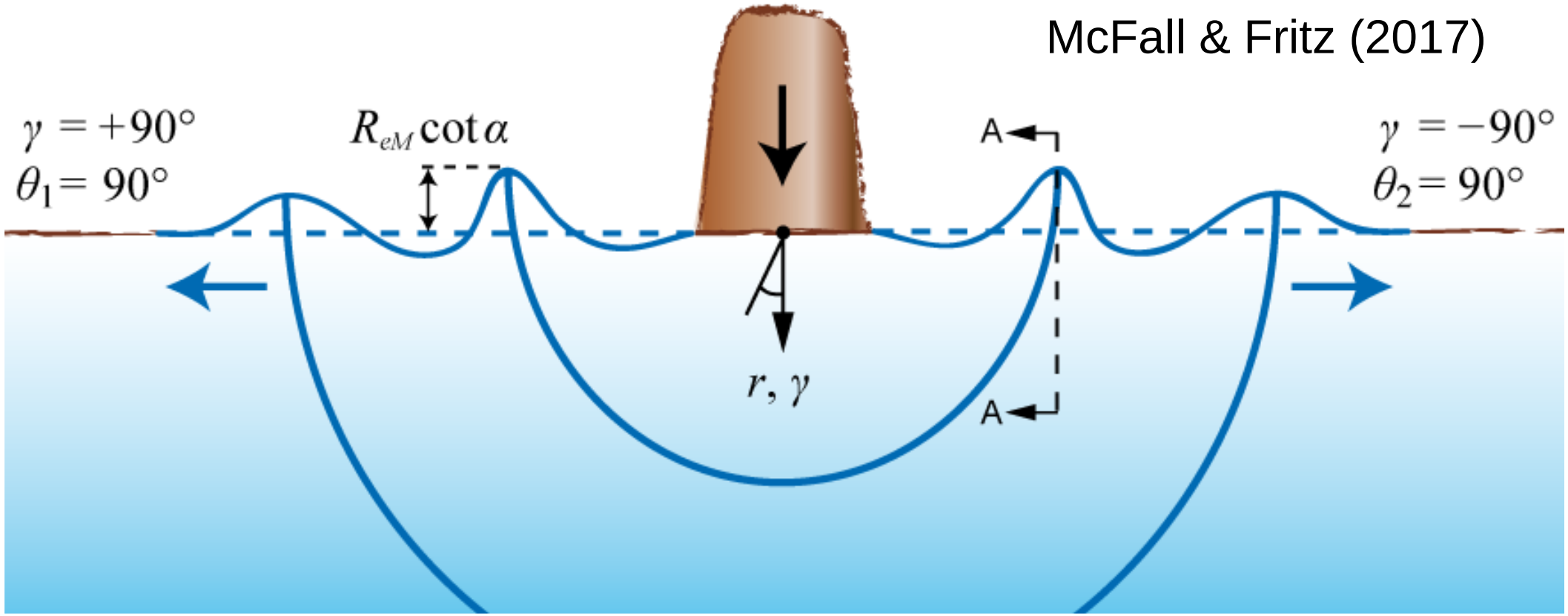
Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

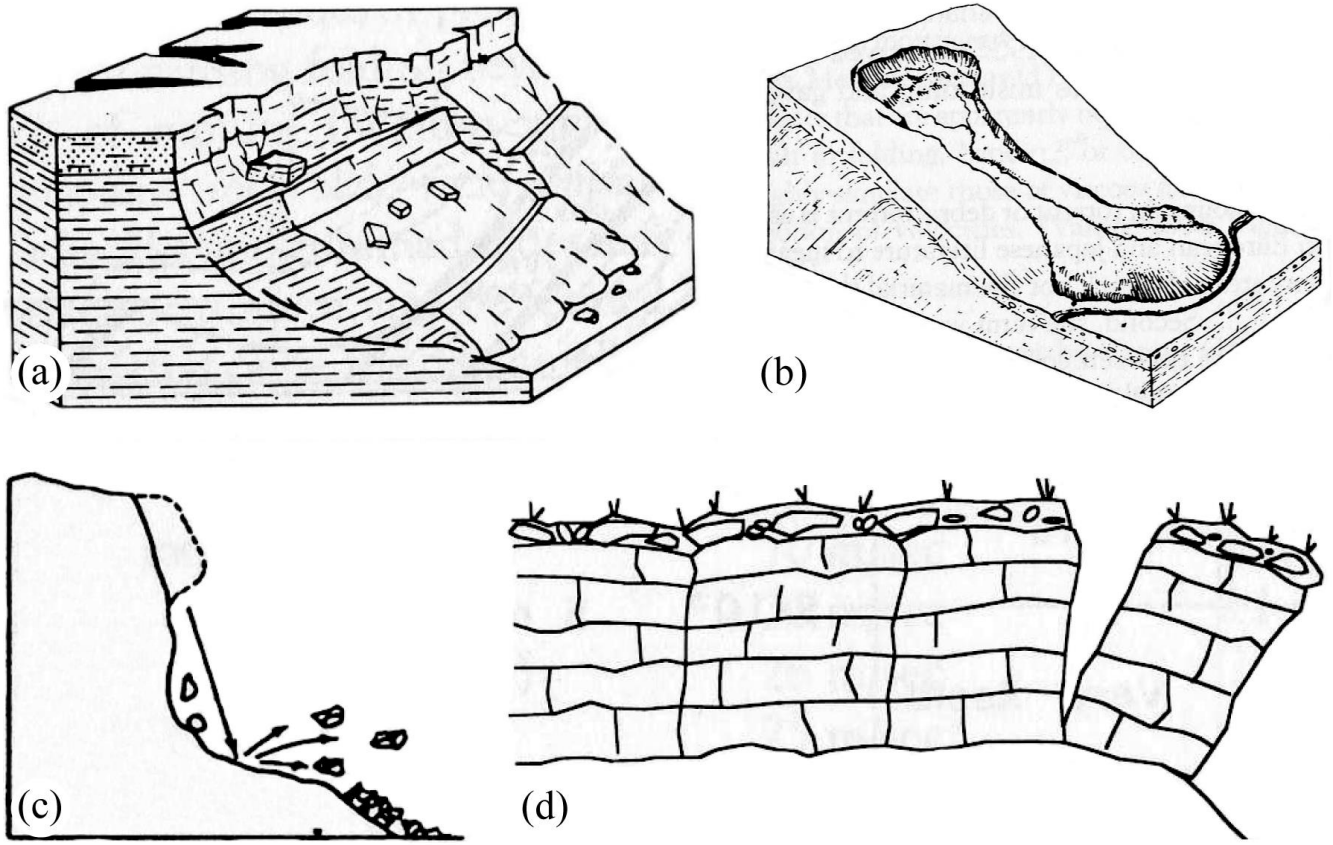
Edge waves

Heller & Spinneken (2015)

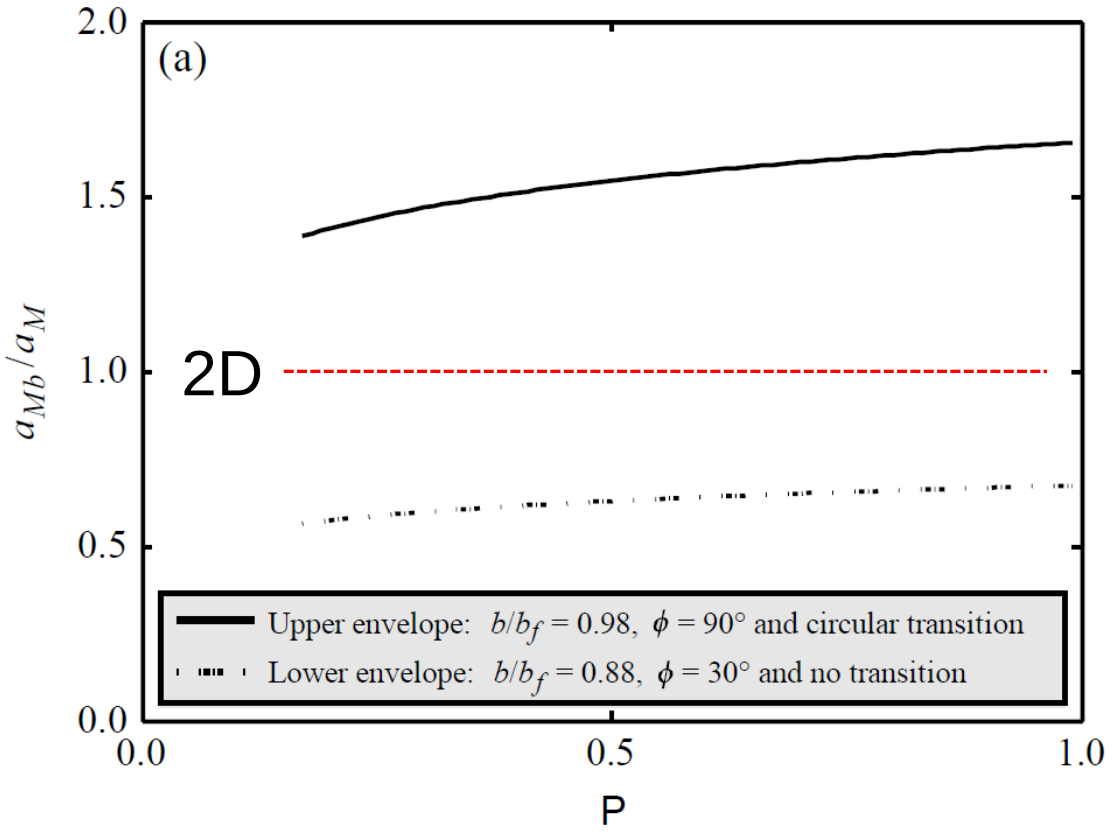
McFall & Fritz (2017)

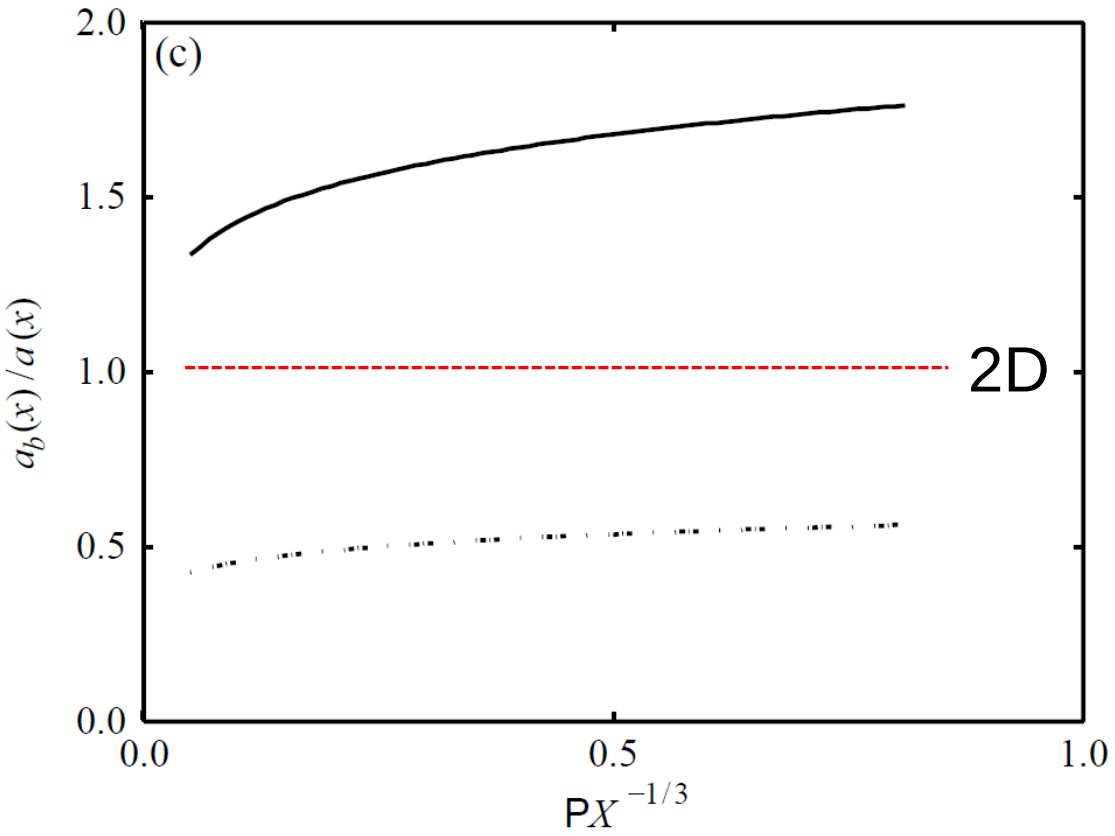


Mass movement types



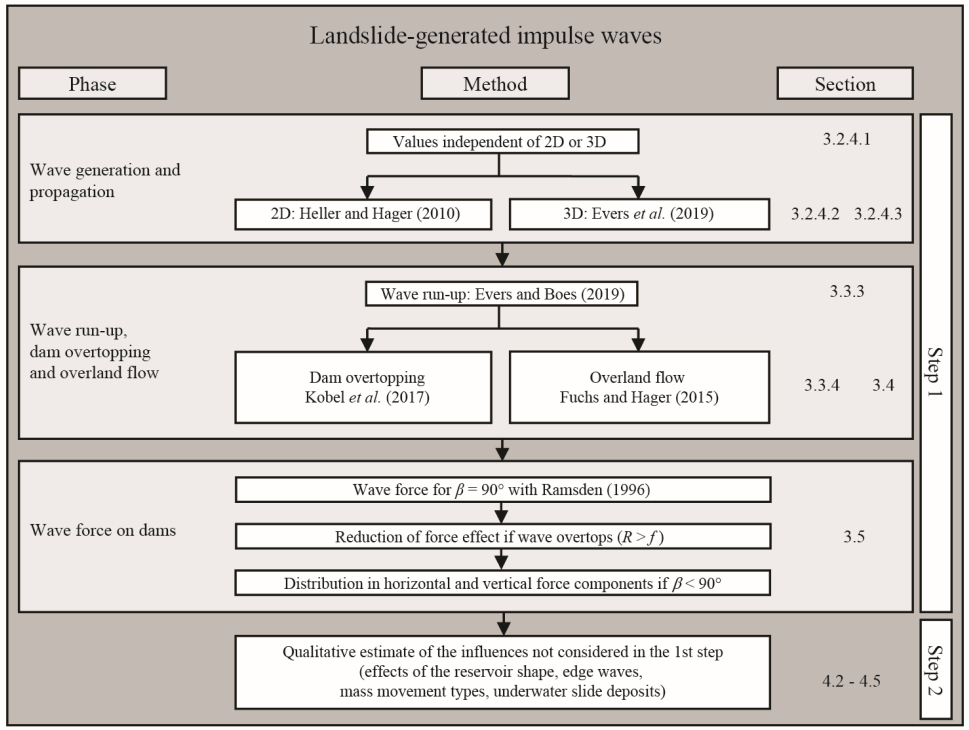
Mass movement types – Granular vs. Block





Heller & Spinneken (2013)

Sensitivity: V_s

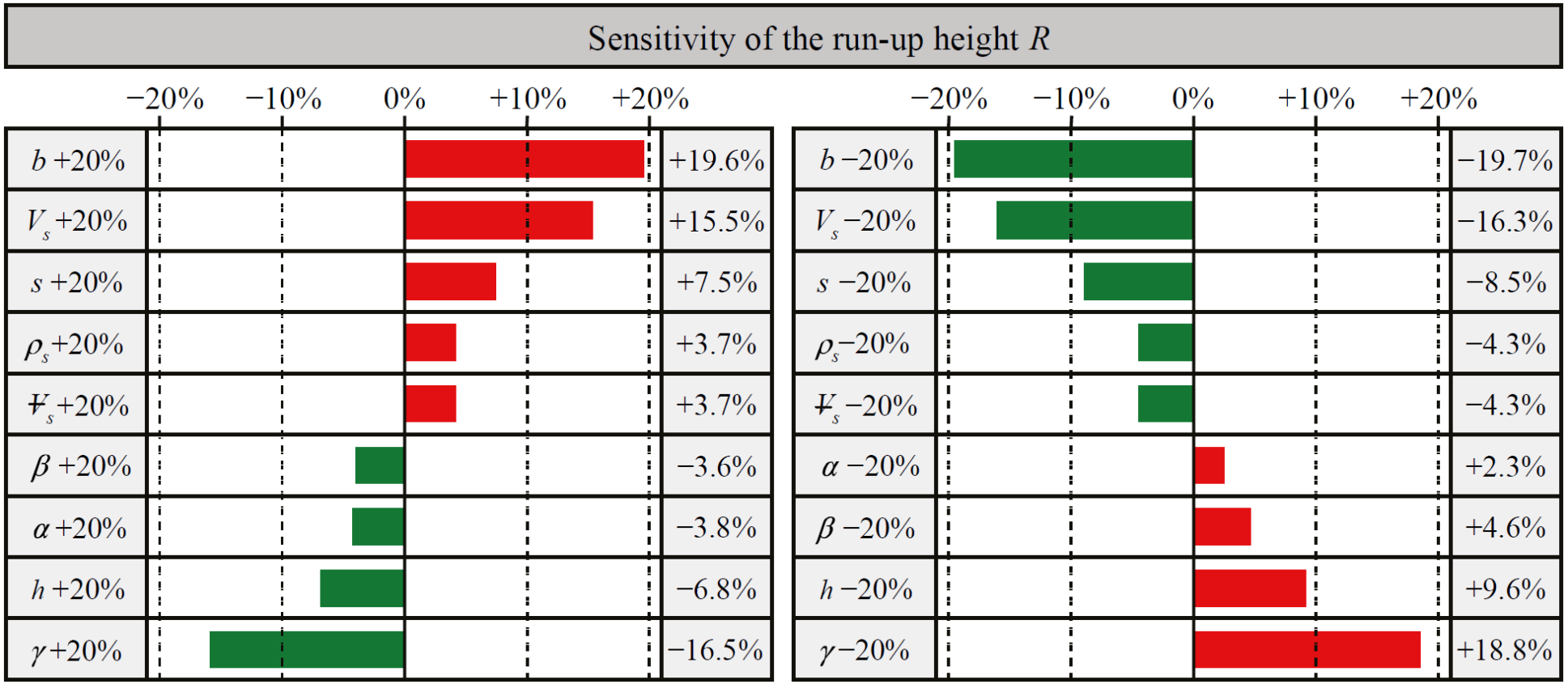


Term	Change	Relation
Slide impact velocity	V_s +20%	
Slide Froude number	F +20%	$F \sim V_s$
Impulse product parameter	P +20%	$P \sim F$
Impact radius	r_0 +3.8%	
Initial first wave crest amplitude	$a_{0,c1}$ +9.5%	$a_{0,c1} \sim P^{1/2}$
First wave crest amplitude	a_{c1} +15.5%	
Run-up height	R +15.6%	

Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology

Sensitivity: all parameters



Experimental scatter

Term	Symbol	Equation	Scatter
Maximum wave height (2D)	H_M	Eq. (3.13)	±30%
Streamwise distance of H_M (2D)	x_M	Eq. (3.14)	±50%
Wave period of H_M (2D)	T_M	Eq. (3.15)	±50%
Wave celerity (2D)	c	Eq. (3.17)	±15%
Wave height (2D)	H	Eq. (3.19)	±30%
Wave period (2D)	T	Eq. (3.20)	±100%
First wave crest amplitude (3D)	a_{c1}	Eq. (3.29)	+25%, −45%
First wave trough amplitude (3D)	a_{t1}	Eq. (3.30)	+40%, −25%
Second wave crest amplitude (3D)	a_{c2}	Eq. (3.31)	+50%, −60%
First wave crest celerity (3D)	c_{c1}	Eq. (3.32)	+10%, −15%
Second wave crest celerity (3D)	c_{c2}	Eq. (3.33)	+15%, −25%
First wave period (3D)	T_1	Eq. (3.34)	+15%, −10%
Run-up height	R	Eq. (3.36)	±20%
Overtopping volume per unit length dam crest (rigid dam)	V	Eq. (3.38)	±30%
Maximum overtopping flow depth (rigid dam)	d_0	Eq. (3.39)	±10%
Wave overtopping duration (rigid dam)	t_O	Eq. (3.40)	±10%

Conclusions «Step 2»

- Step 1 assumes simplified/idealized conditions
- Deviations from idealized conditions → Under-/Overestimation
- Safety allowance becomes necessary
- Additional topics: Ice cover, Underwater landslide deposits

Schweizerisches Talsperrenkomitee
Comité suisse des barrages
Comitato svizzero delle dighe
Swiss Committee on Dams

Laboratory of Hydraulics, Hydrology and Glaciology