

OGF 26. april 2018

Minitsunami fra skip

John Grue

Matematisk institutt, UiO

Foto: Tore Henning Larsen

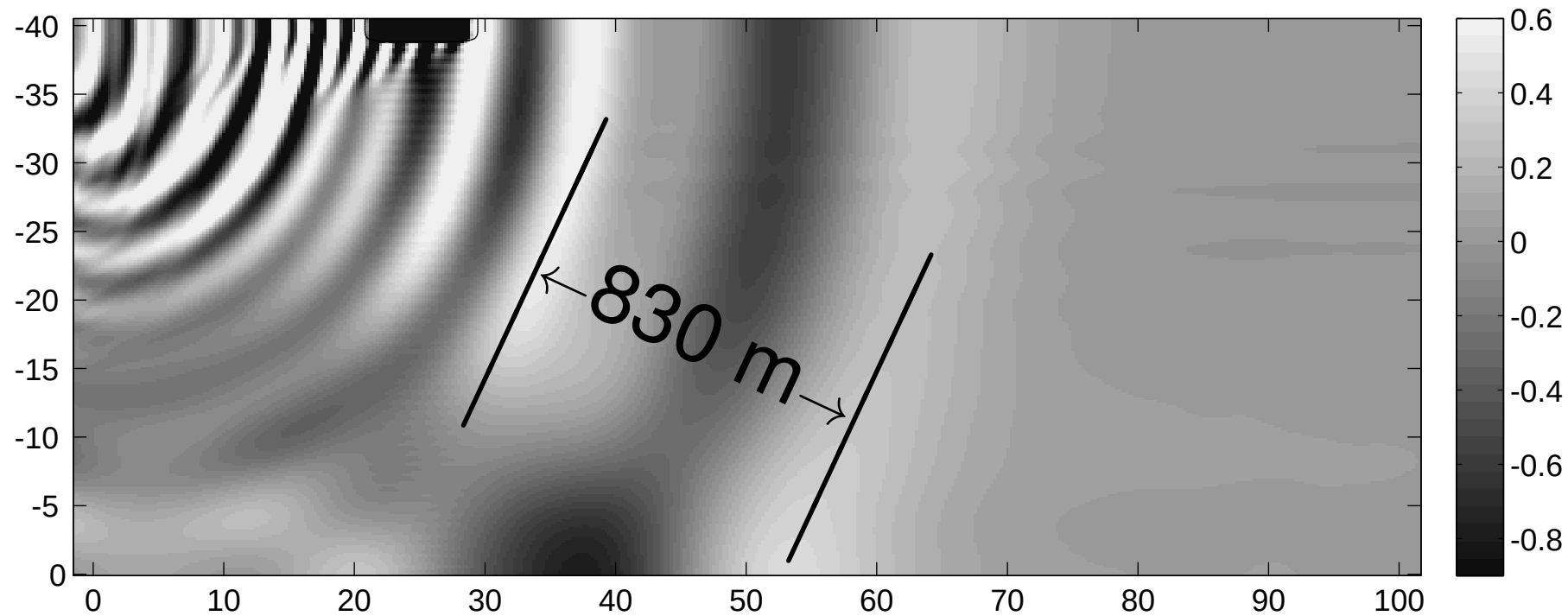






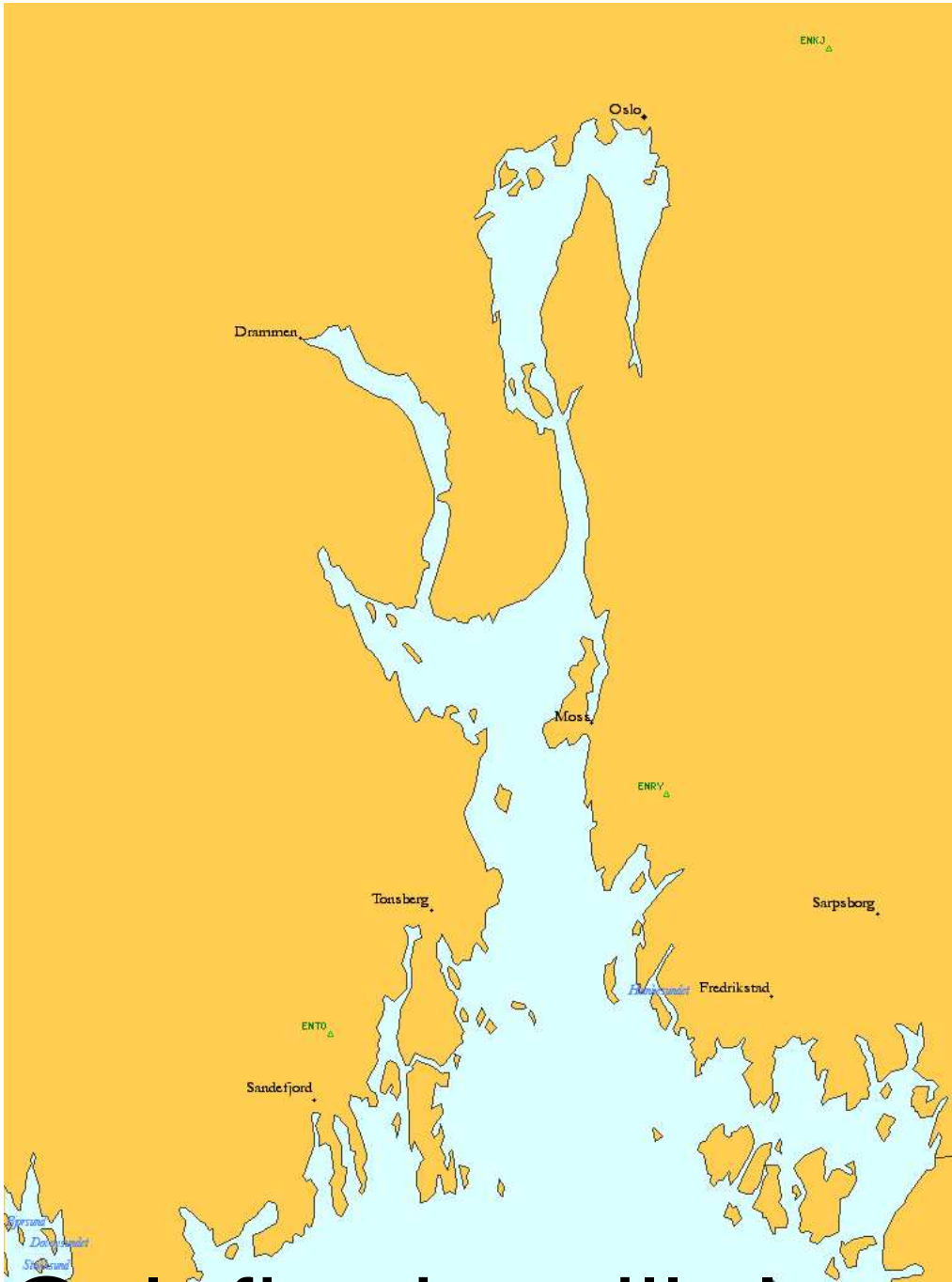






Beregning, Grue, J. Fluid Mech. 2017

Hvor er vi?



Oslofjorden, ill: Internet

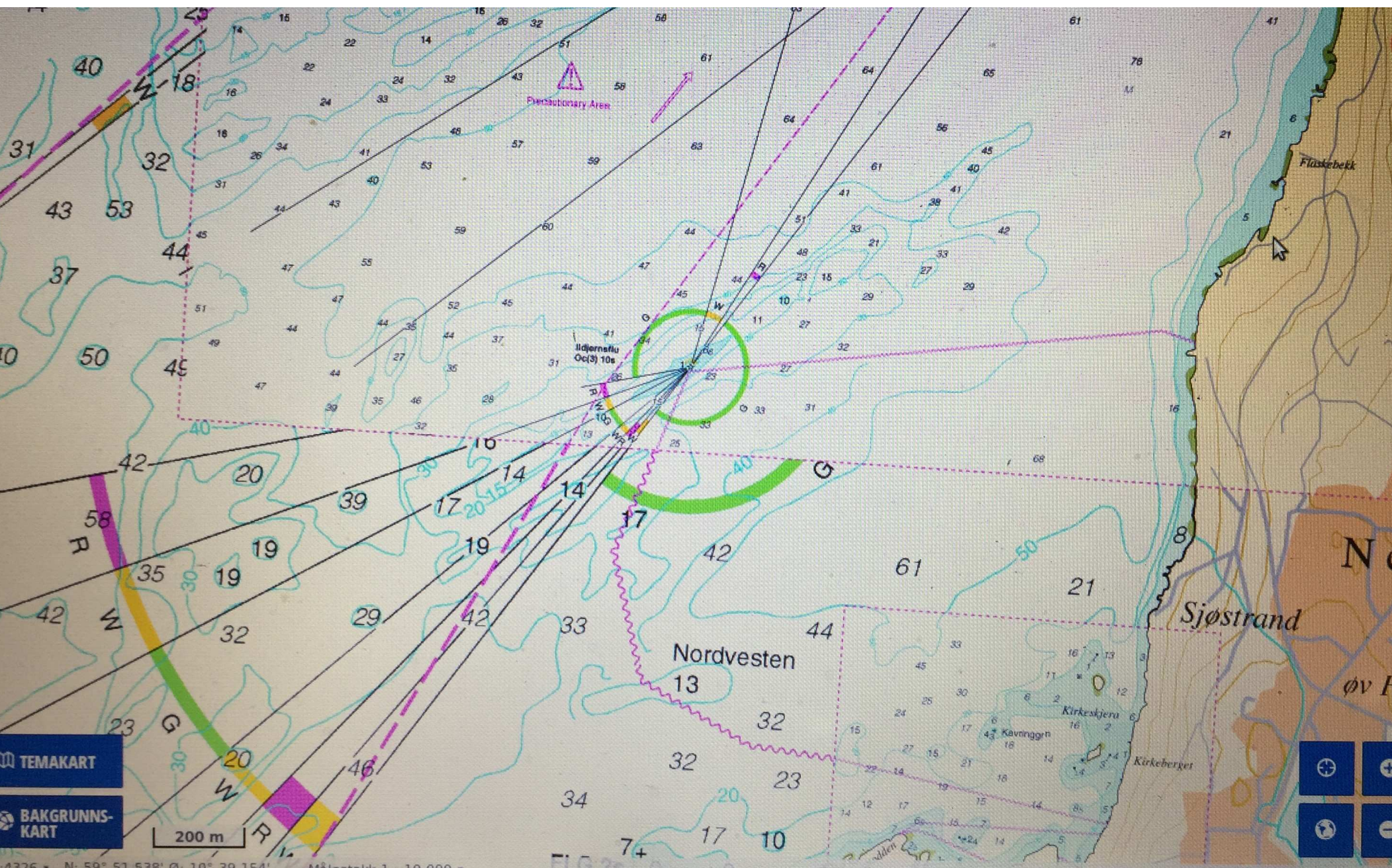


Oslo

* Ildjærnsflu/
Flaskebekk

Drammen

Oslofjorden, ill: Internet



Kilde: Yggdrasil temakart

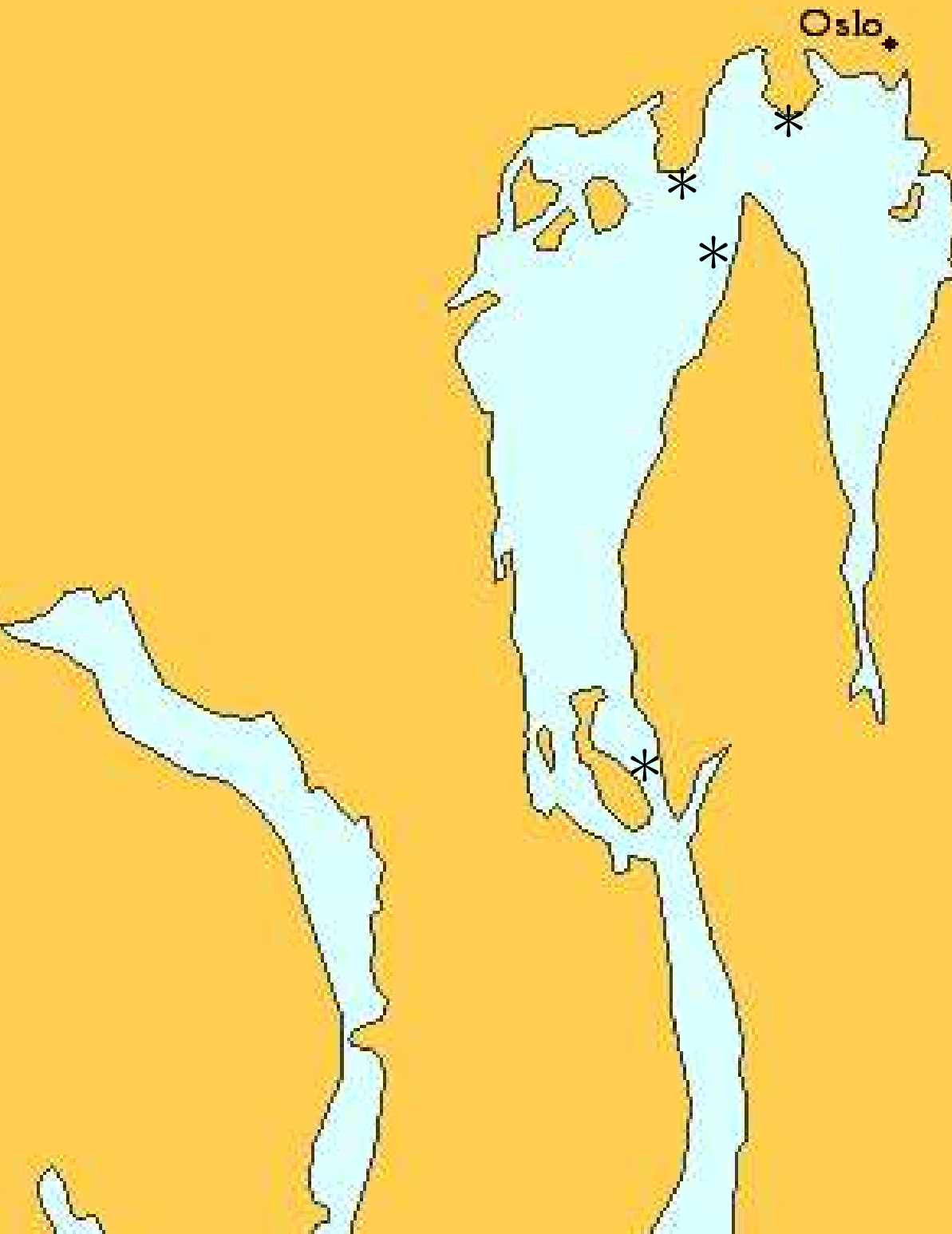


Obs. Flaskebekk

- bølgehøyde i havn: 1 m
(1,4 m rek.)
- foran båt
- ny erosjon
- kun Magic / Fantasy

Plan

1. Observasjoner
2. Film
3. Tsunamigenerering
4. Beregninger



Hvor?

Huk

Snarøya

Flaskebekk

Askholmene

Flere steder

Bølgeperiode

Fantasy 10,3m/s

DFDS 8,6m/s

Magic 7,8m/s

Magic 10m/s

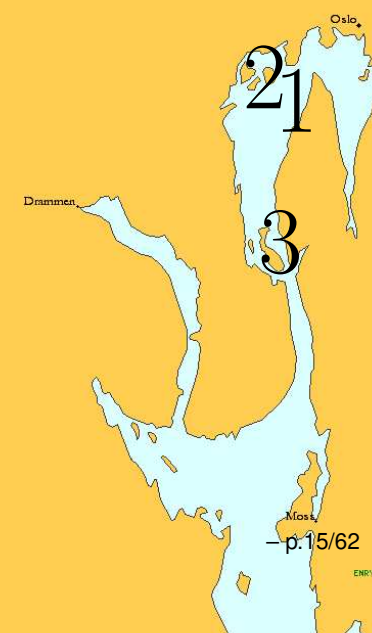
Pos 1

Pos 1

Pos 2

Pos 3

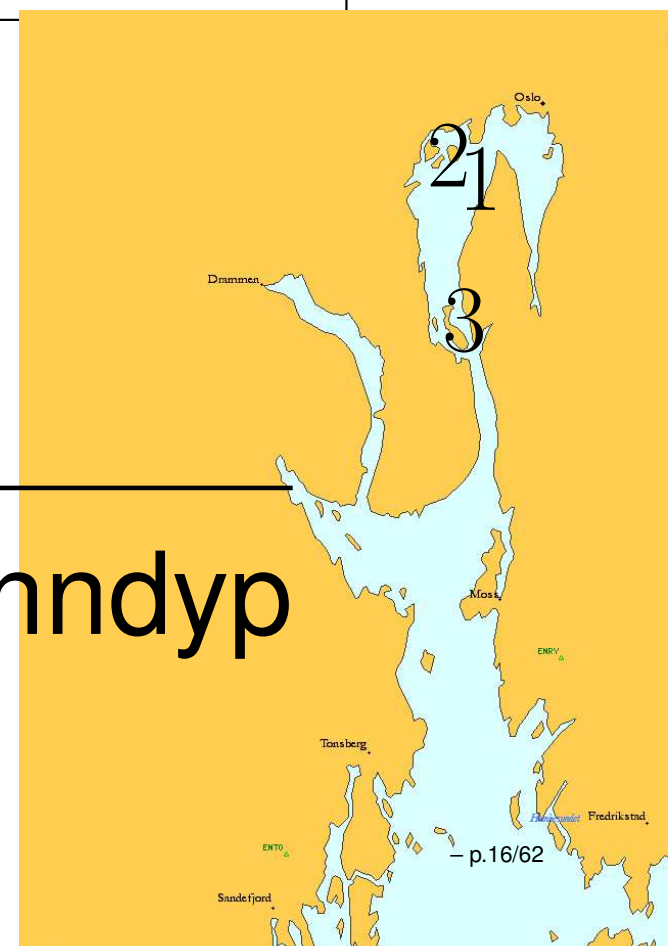
inn-inn	ut-ut	inn-inn	ut-ut	inn-inn	ut-ut	inn-inn	ut-ut
34 s	36 s	26 s	34 s	58 s	57 s	35 s	30 s
32 s	-	34 s	-	49 s	40 s	29 s	34 s
13 s	-	-	-	64 s	-	46 s	36 s



Bølgelengde

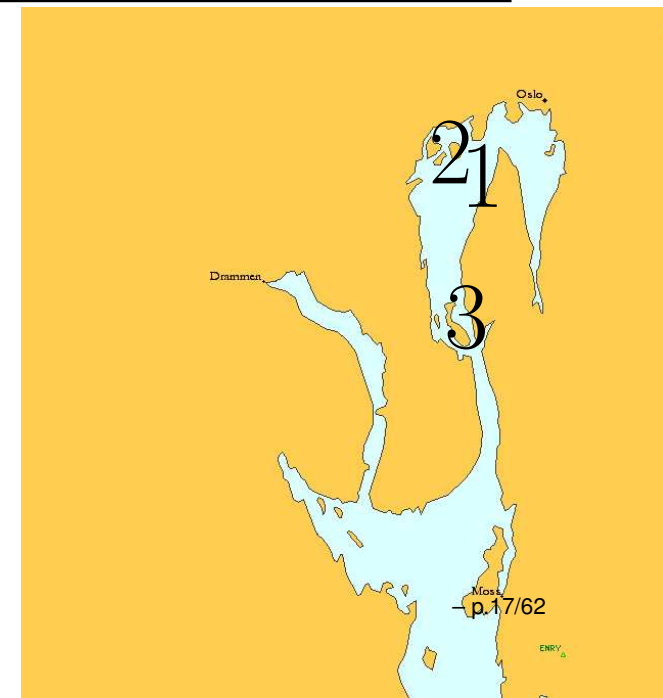
	periode	vanndyp	bølgefart	bølgelengde
pos 1	35 s	60 m	25 m/s	875 m
pos 3	32 s	30 m	17 m/s	540 m
pos 2	60 s	30 m	17 m/s	1000 m

$$\text{Bølgefart} = \sqrt{9.81 \text{ m/s}^2 * \text{vanndyp}}$$

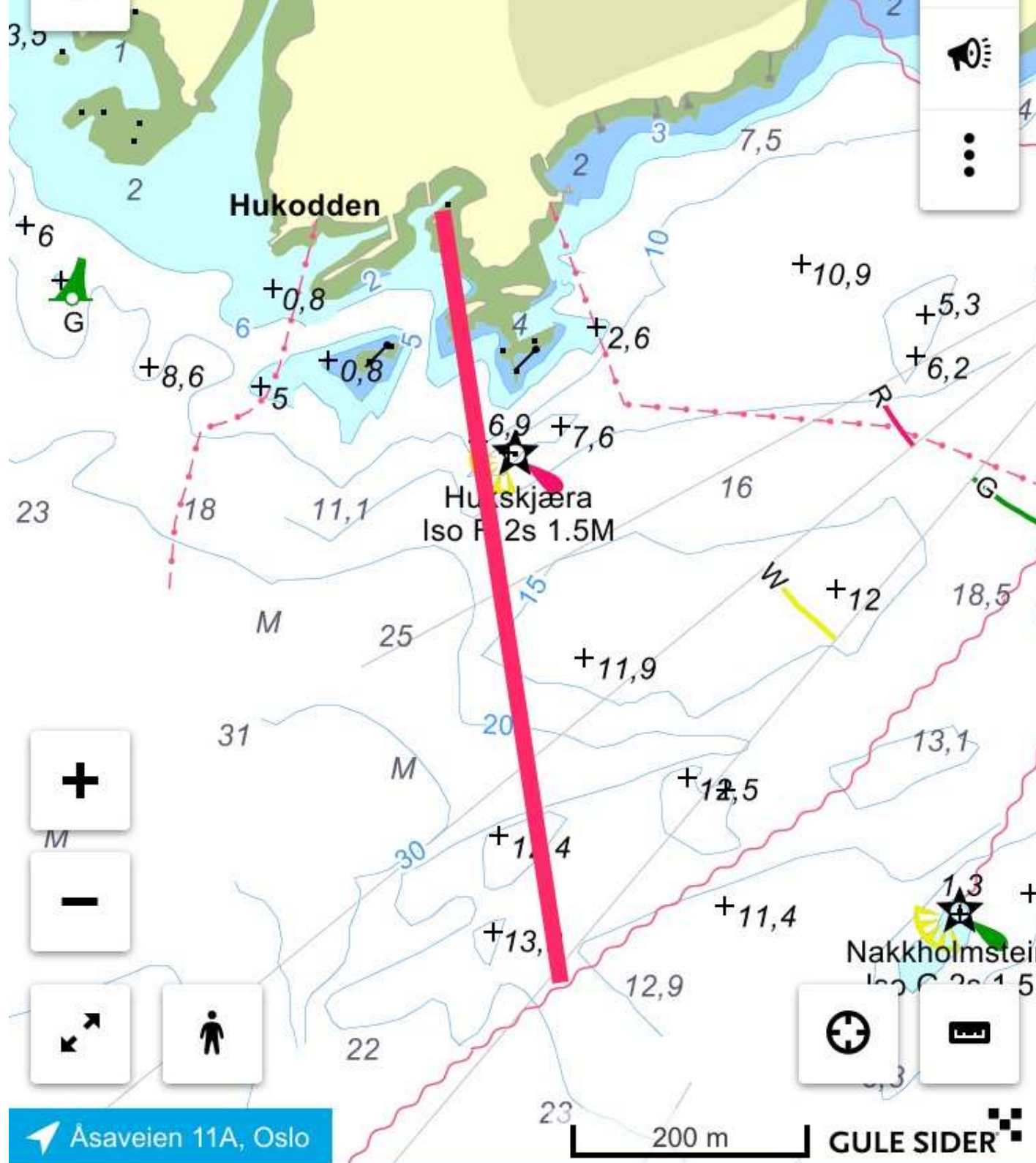


Skipene

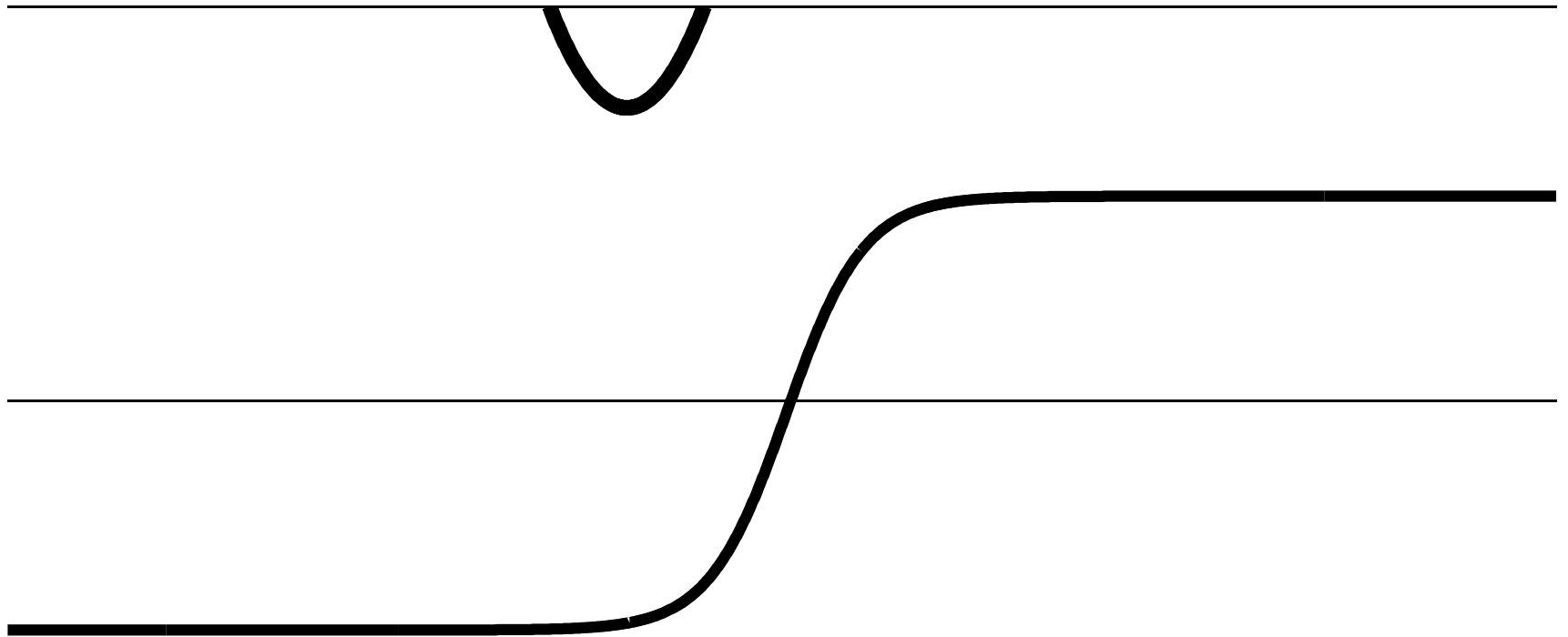
	V_0 (m ³)	l (m)	w_0 (m)	d_0 (m)	knop	År
Magic	36 000	224	35	6.8	22	2007
Fantasy	36 000	224	35	6.8	22	2004
Pearl DFDS	24 700	178	34	6.2	21	2001
Crown DFDS	20 200	171	28	6.4	21.5	1994
Stena Saga	20 500	166	28	6.7	22	1994



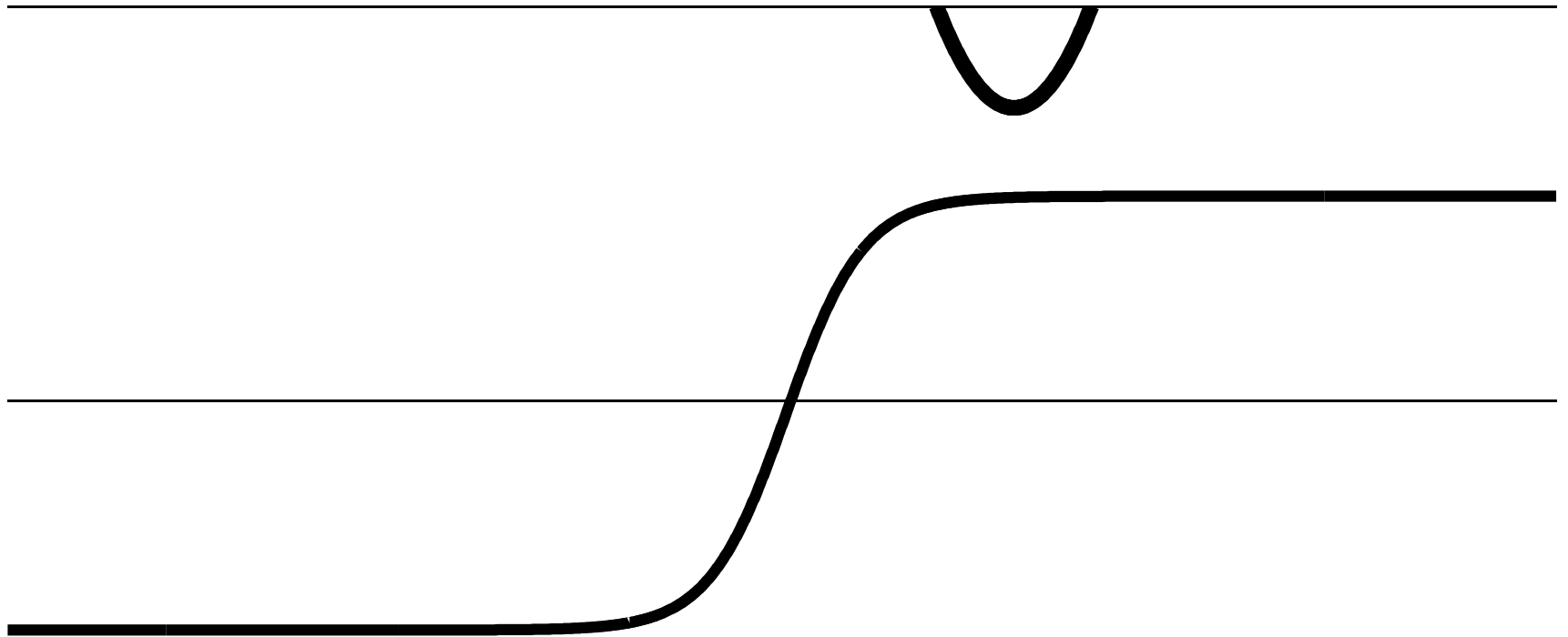




Bølger dannes ved dybdeendring



Bølger dannes ved dybdeendring



Askholmene: fra 80 m til 30 m

Huk: fra 12 m til 32 m

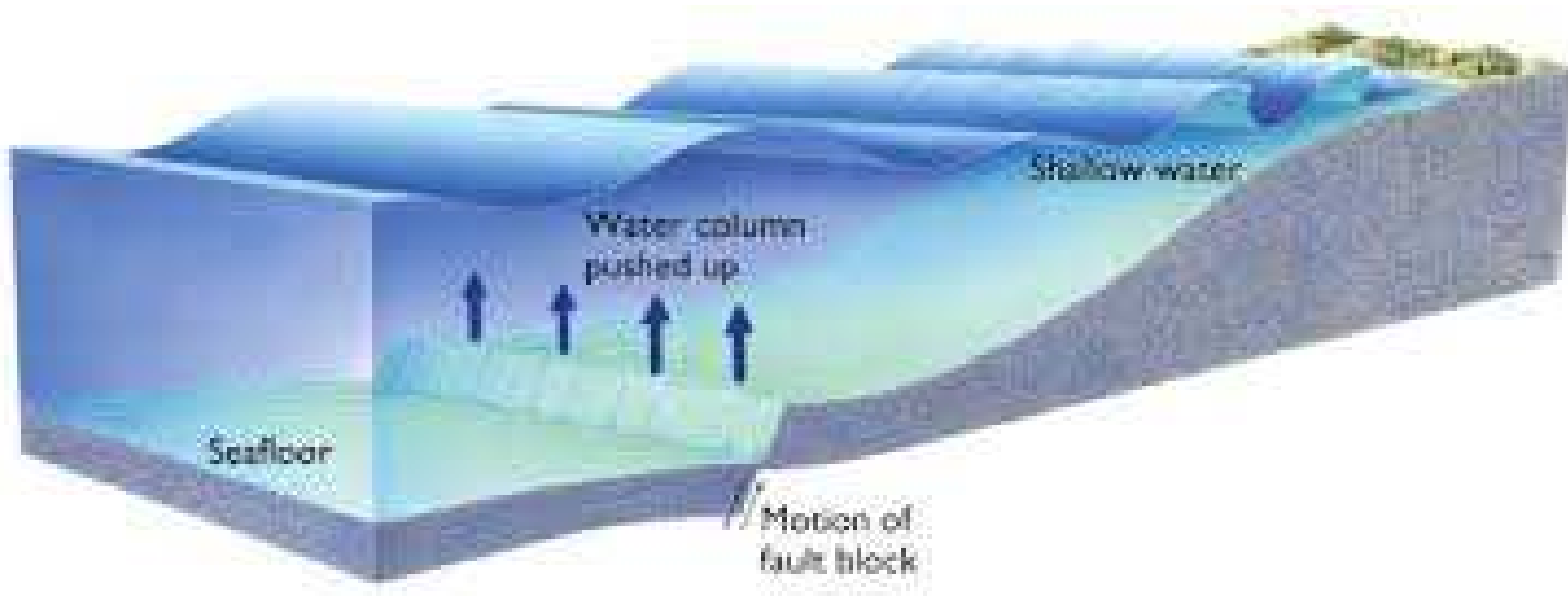
Ildjærnsflu: fra 46 m til 14 m til 46 m



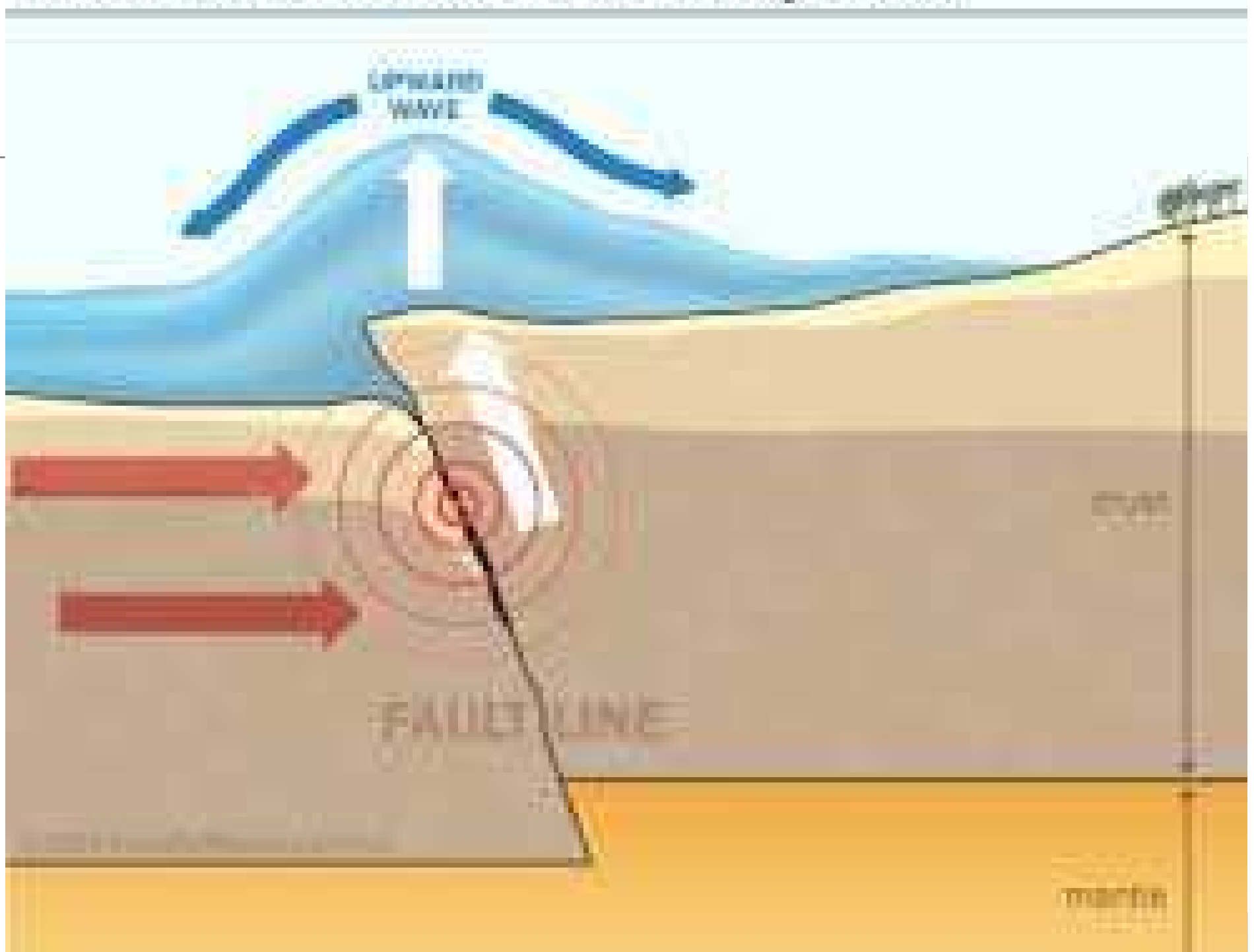
FILM!

Tsunamigenerering

Tektonisk tsunami



Kilde: Internett

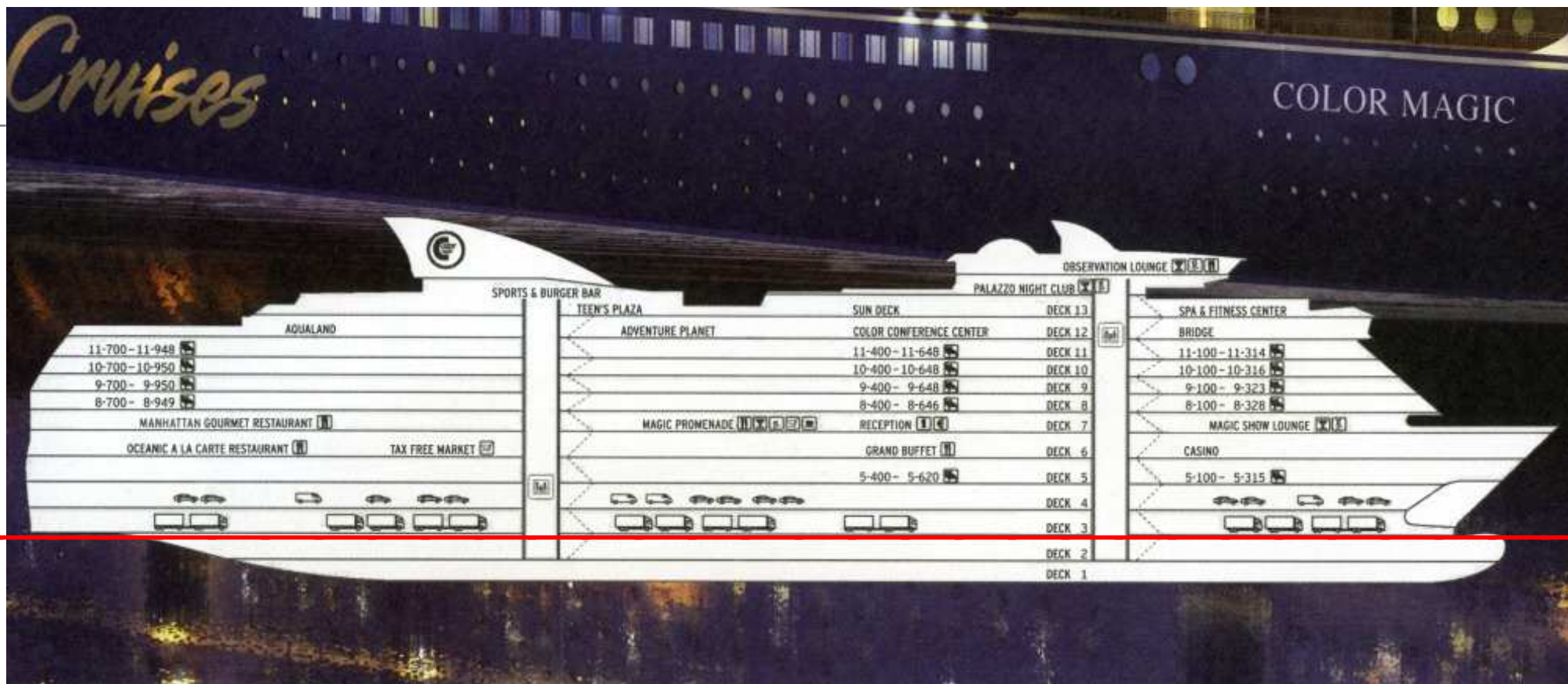


Kilde: Internett



HD WALLPAPERS

Lengde $\sim$ 210 m, bredde 35 m, dypgang 6.8 m
(Bilde: Internett)



COLOR MAGIC FACTS

Gross registered tons:	75 100 tons
Length:	224 meters
Width:	35 meters
Decks:	15
Magic Promenade length:	163 meters
Magic Promenade height:	9 meters, 3 decks
Main engine power:	42 400 horsepower
Maximum speed:	22.3 knots
Passengers:	2 700
Passenger cabins:	1016
Cars:	550
Lane meters:	2 320 meters



Palazzo Night Club



Oceanic à la Carte Restaurant



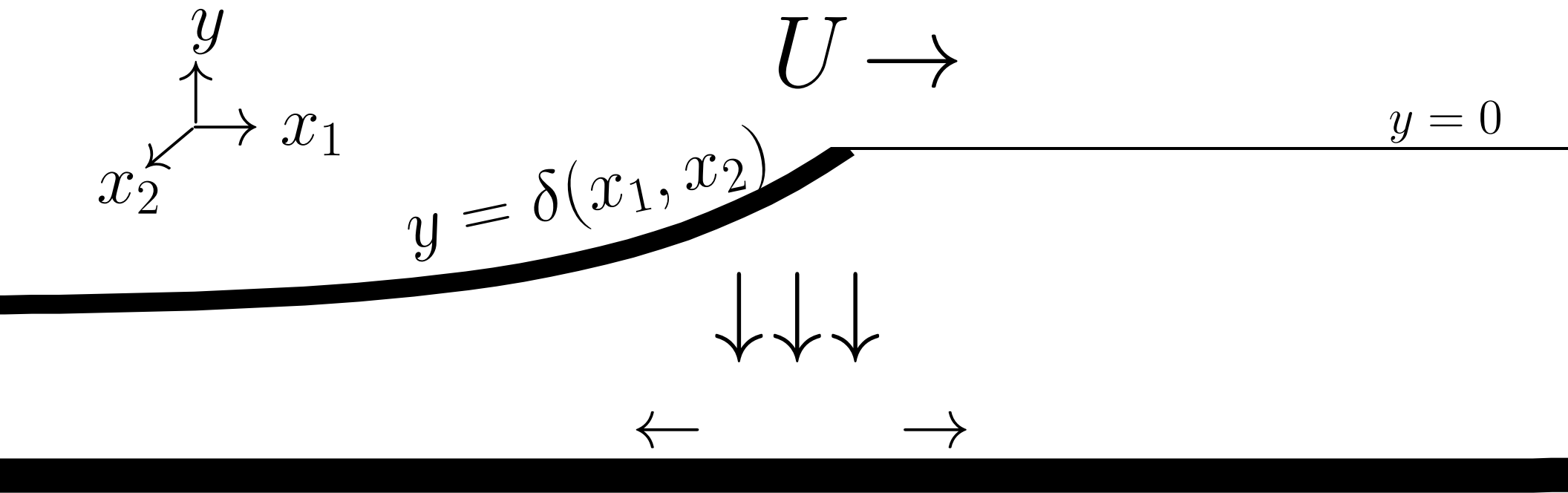
Magic Show Lounge



Magic Promenade

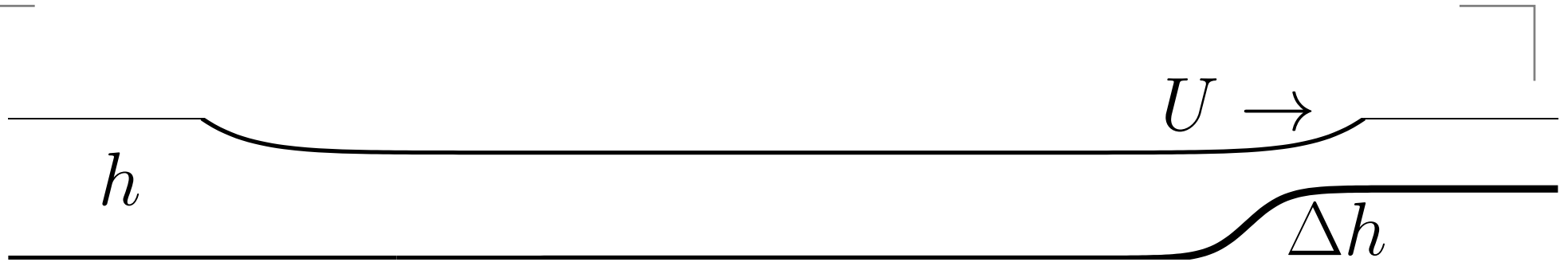
Lengde ~ 210 m, bredde 35 m, dypgang 6.8 m
(Bilde: Internett)



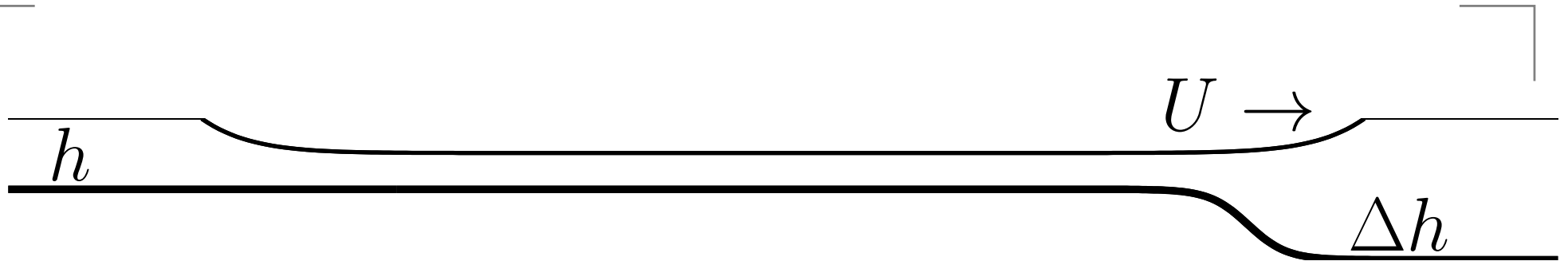


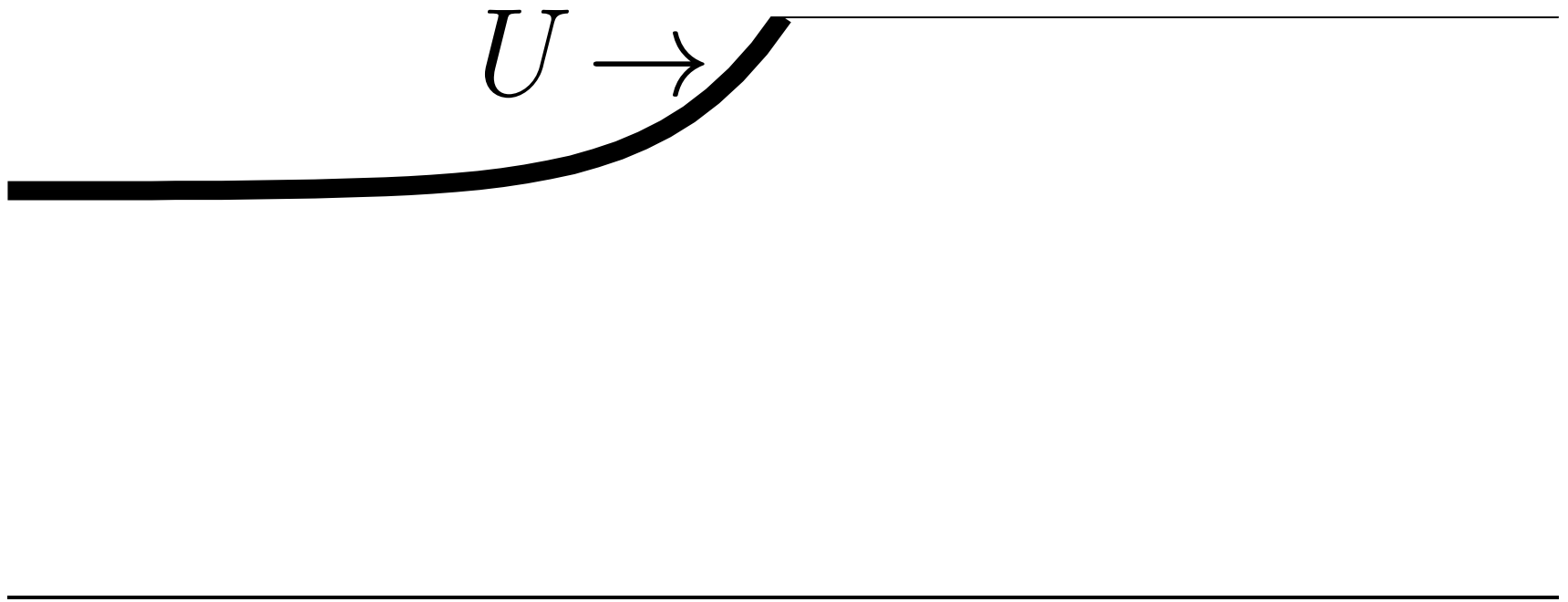
$$V_{0,F} = -U \frac{\partial \delta}{\partial x_1} \text{ (normalhastighet ved SKROG)}$$

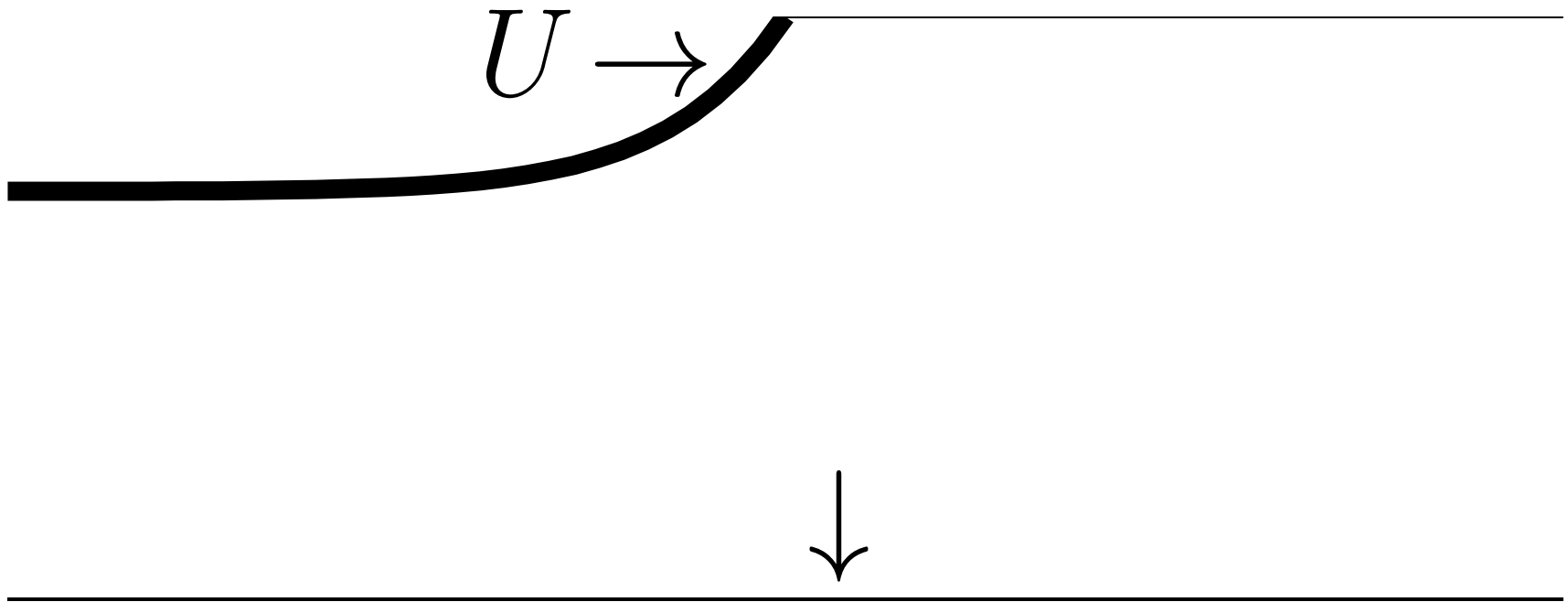
Skip passerer dybdeendring Δh

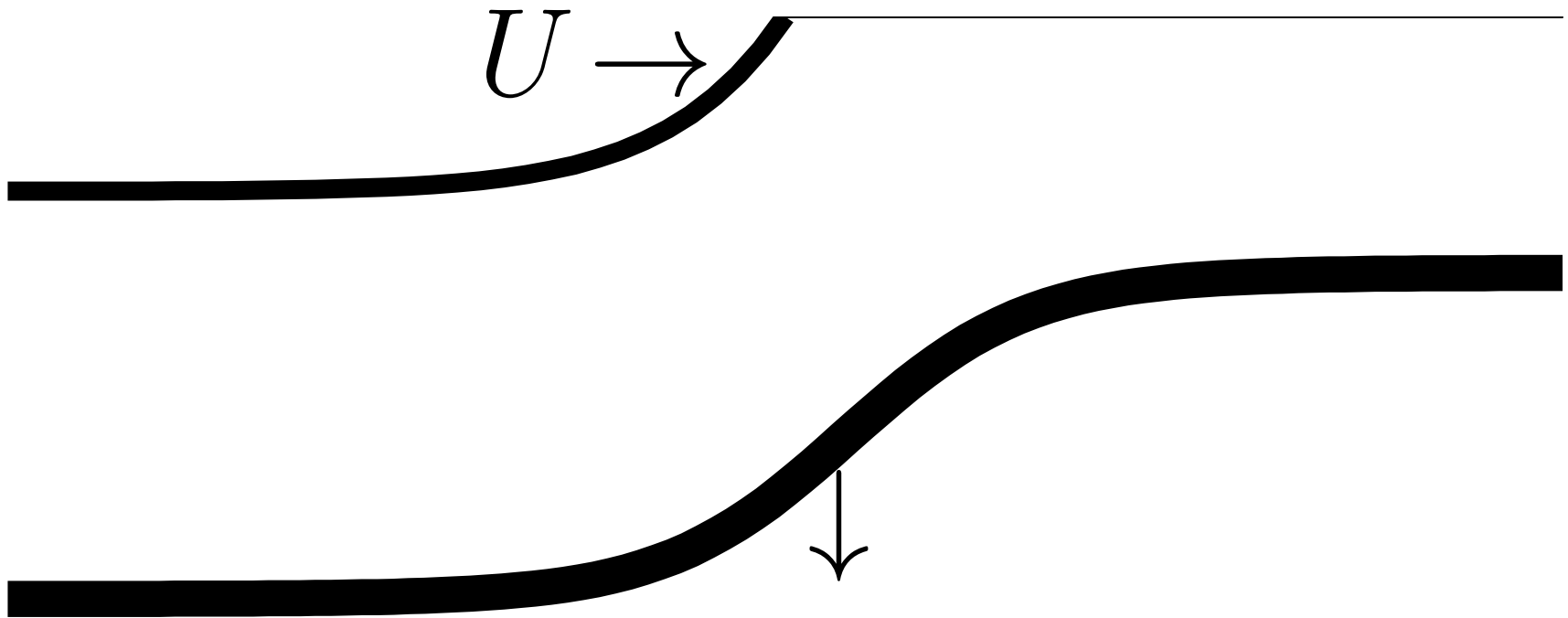


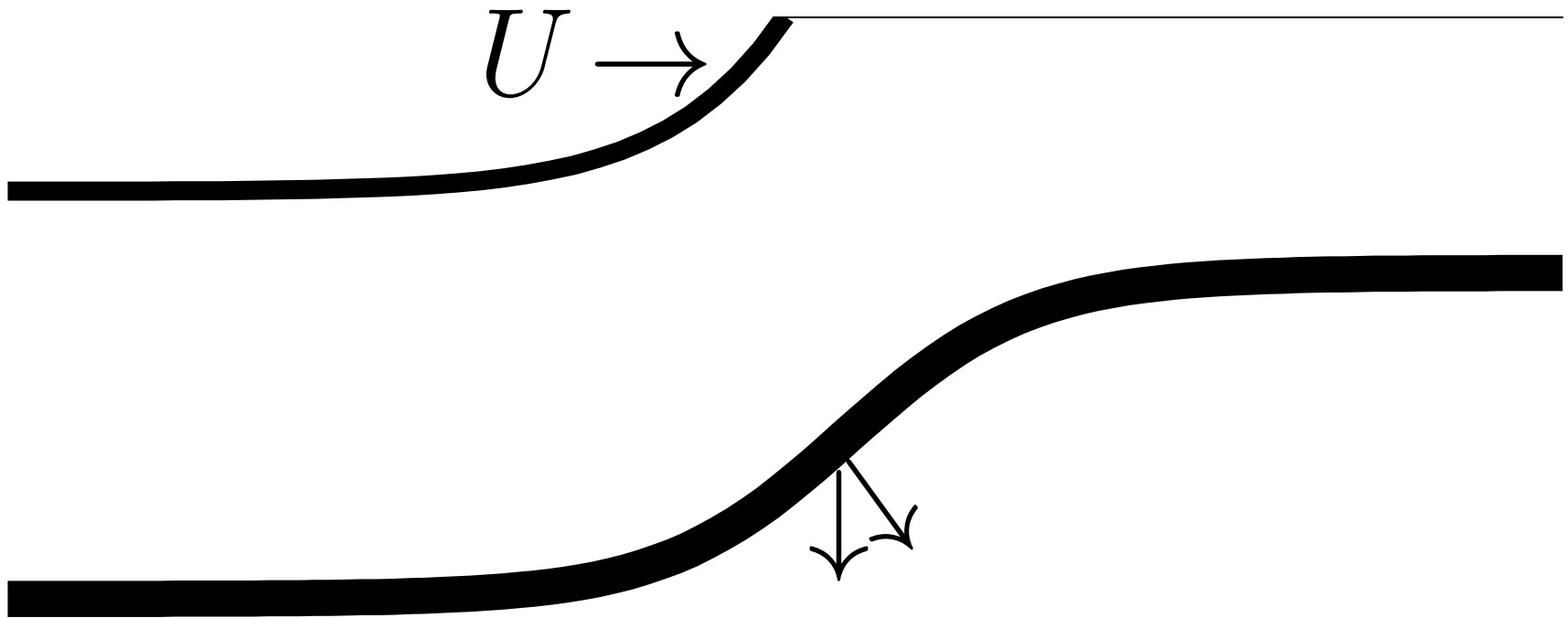
Skip passerer dybdeendring Δh

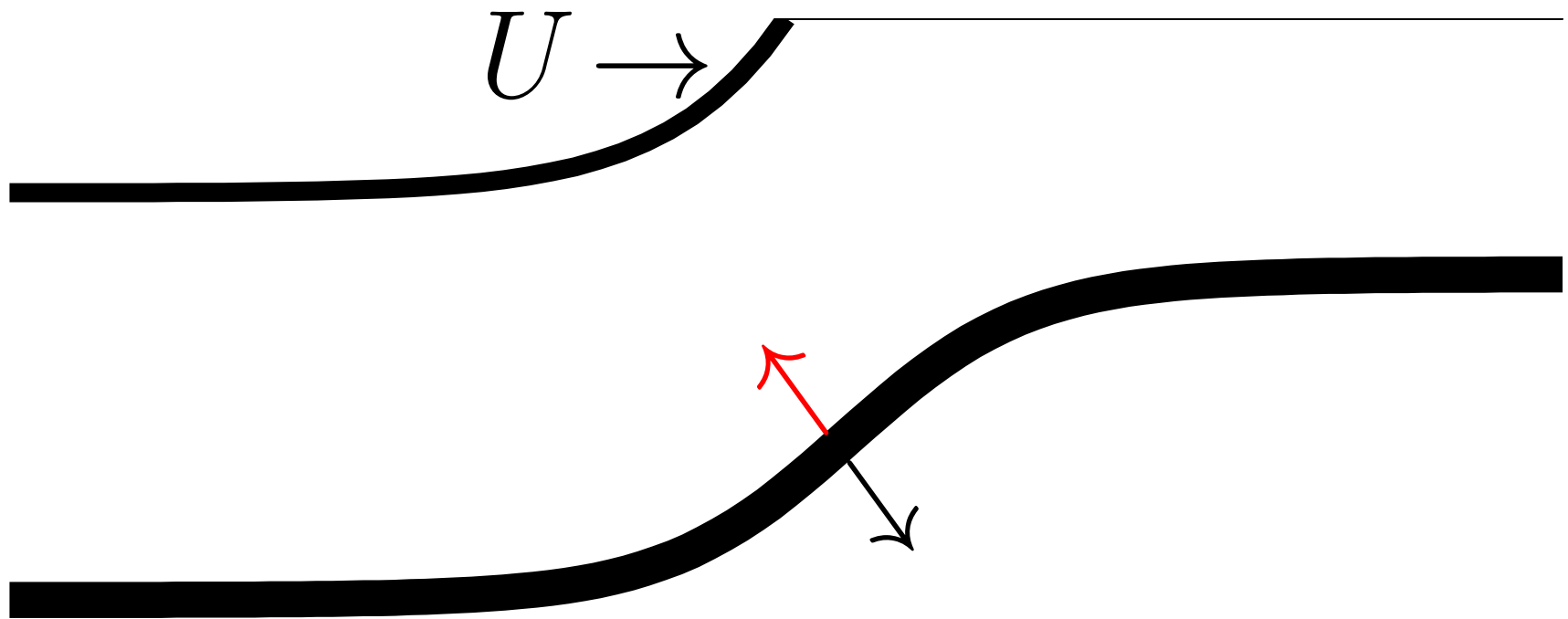


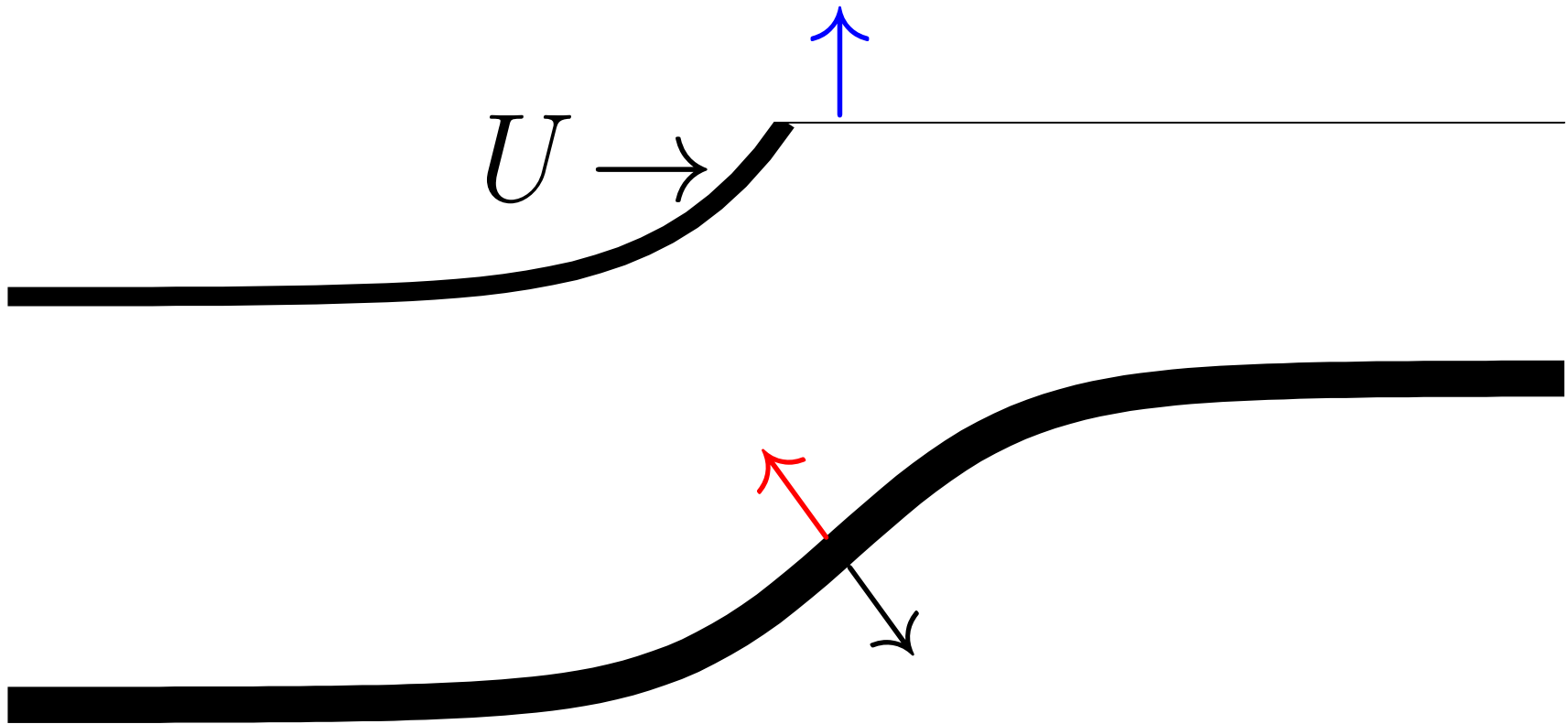




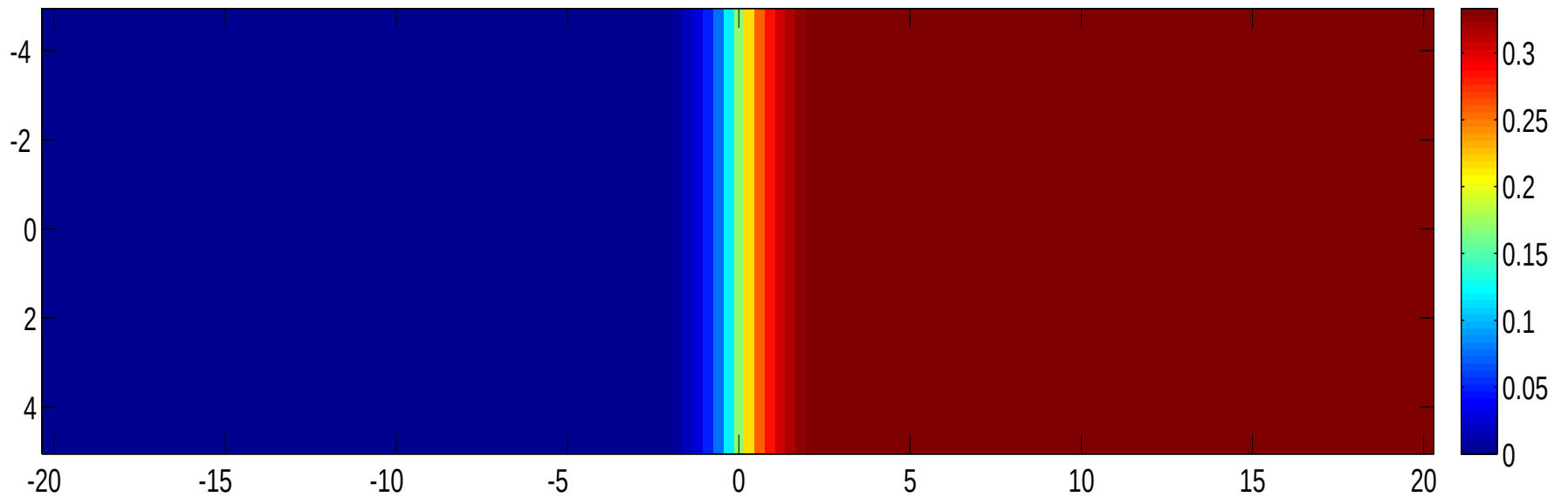








Dybdeendring



dybdeendring

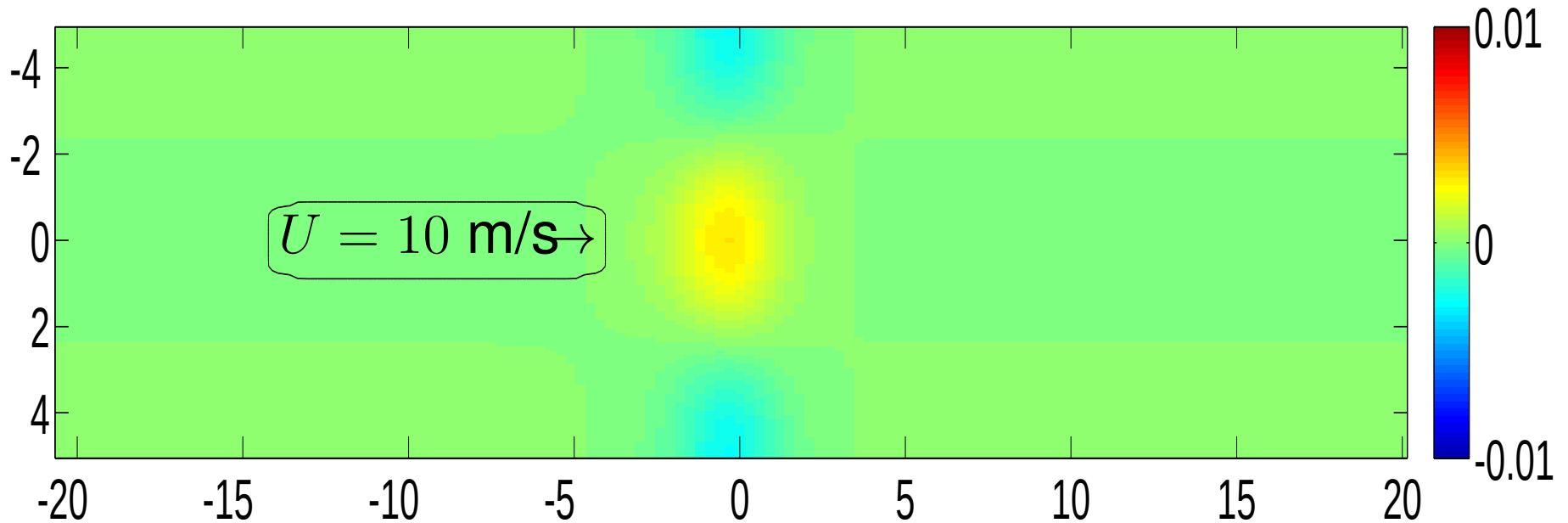
$$h = 21 \text{ m}$$

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 10$$

V_1 m/s



dybdeendring

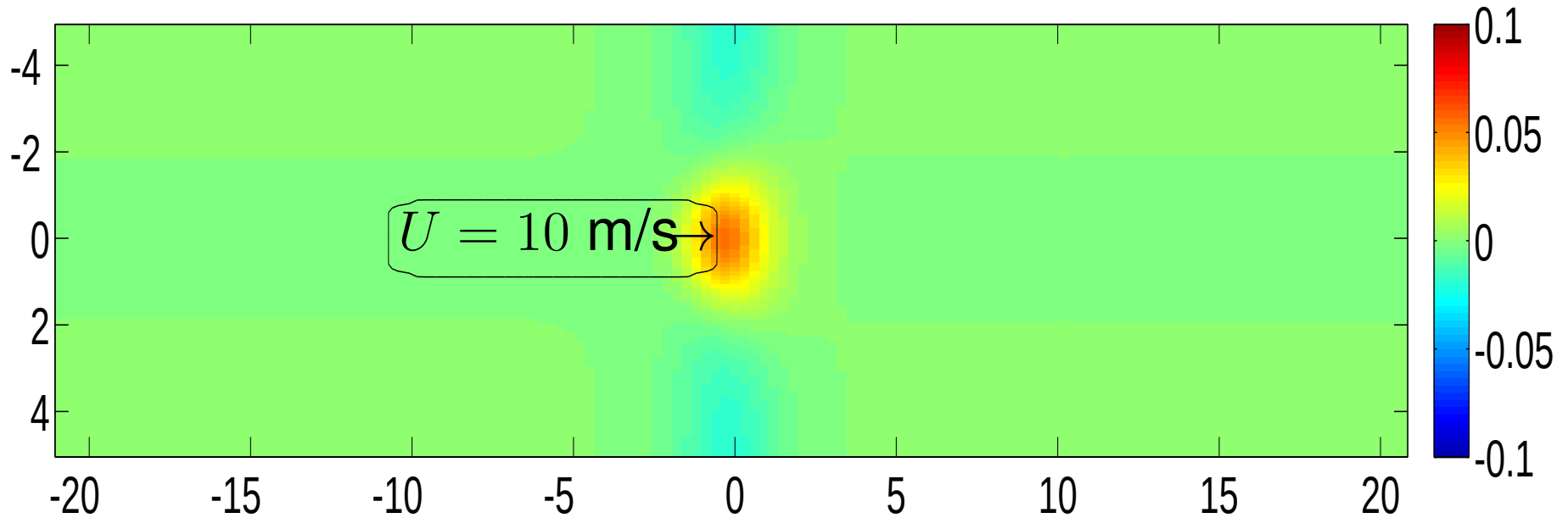
$$h = 21 \text{ m}$$

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 15$$

V_1 m/s



dybdeendring

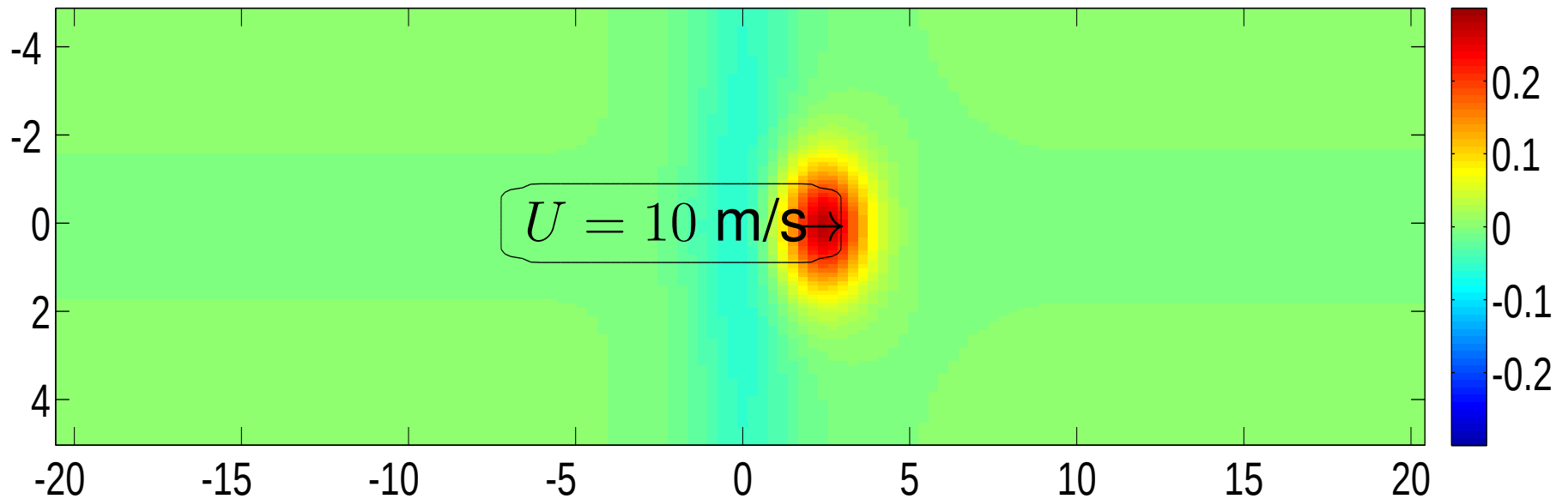
$$h = 21 \text{ m}$$

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 20$$

V_1 m/s



dybdeendring

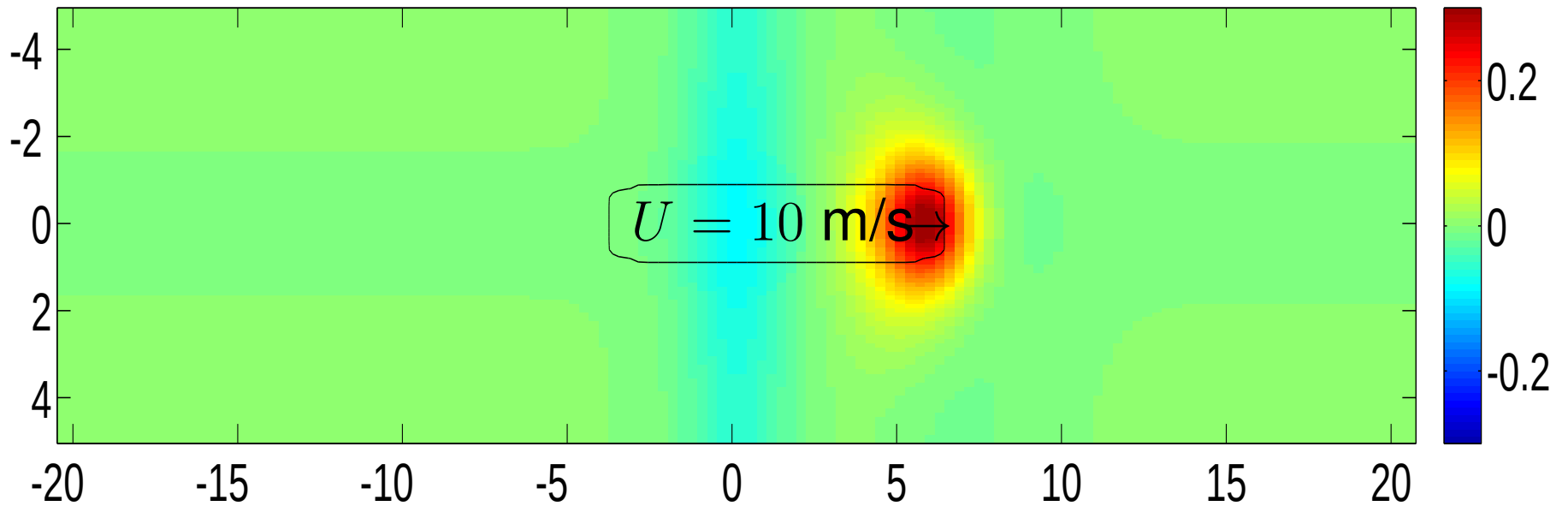
$$h = 21 \text{ m}$$

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 25$$

V_1 m/s



dybdeendring

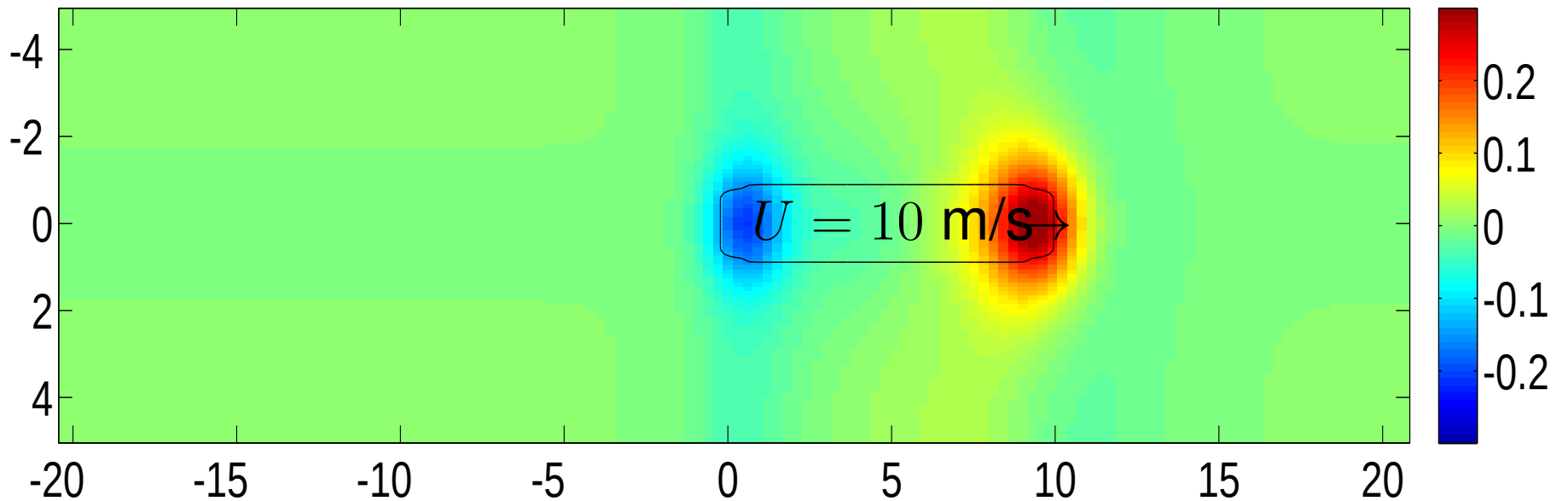
$$h = 21 \text{ m}$$

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 30$$

V_1 m/s



$$h = 21 \text{ m}$$

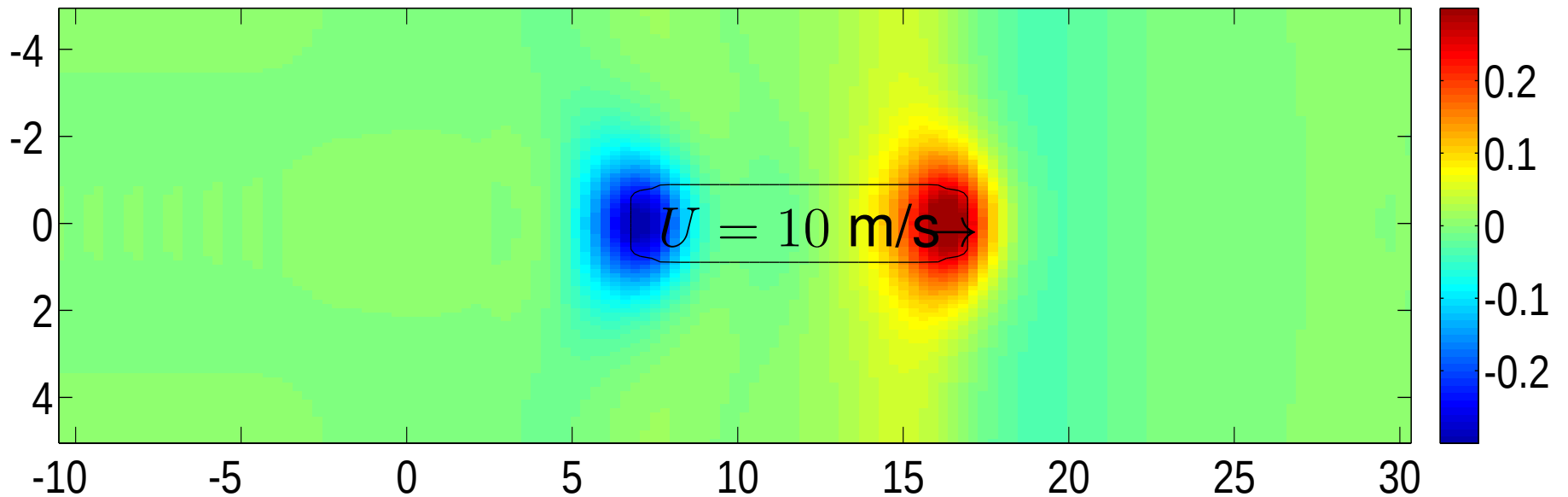
dybdeendring

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 40$$

V_1 m/s



$$h = 21 \text{ m}$$

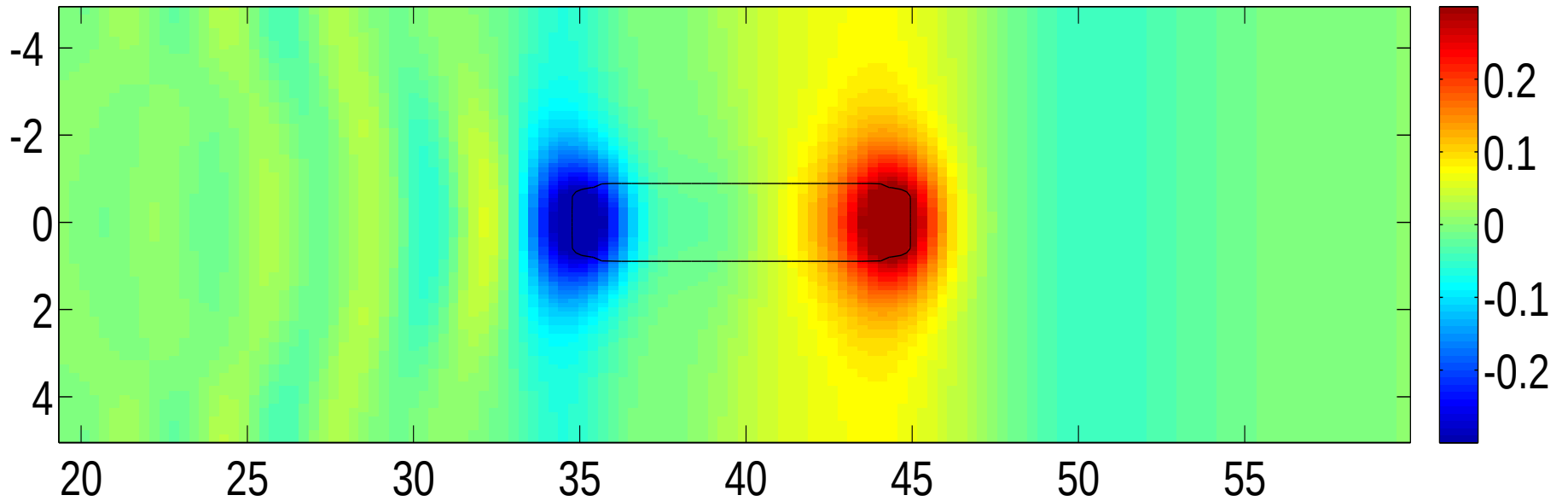
dybdeendring

$$h - \Delta h = 14 \text{ m}$$

Vertikalhastighet

$$t\sqrt{g/h} = 80$$

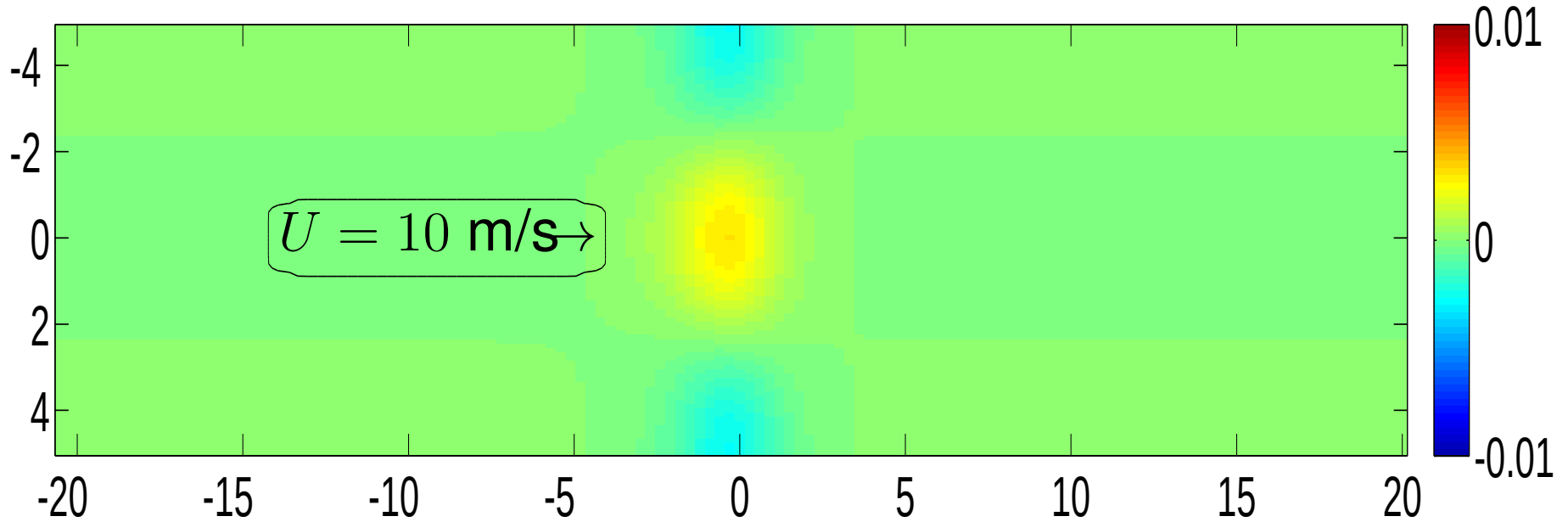
V_1 m/s



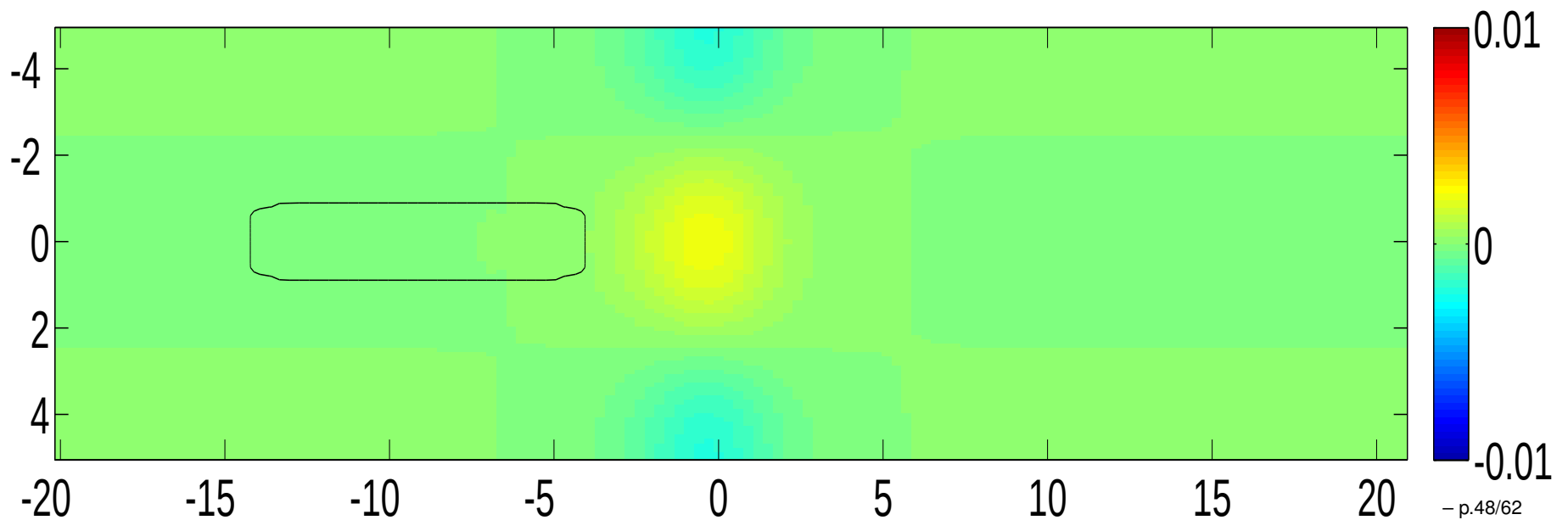
$$t\sqrt{g/h} = 10$$

Vertikalhastighet

m/s



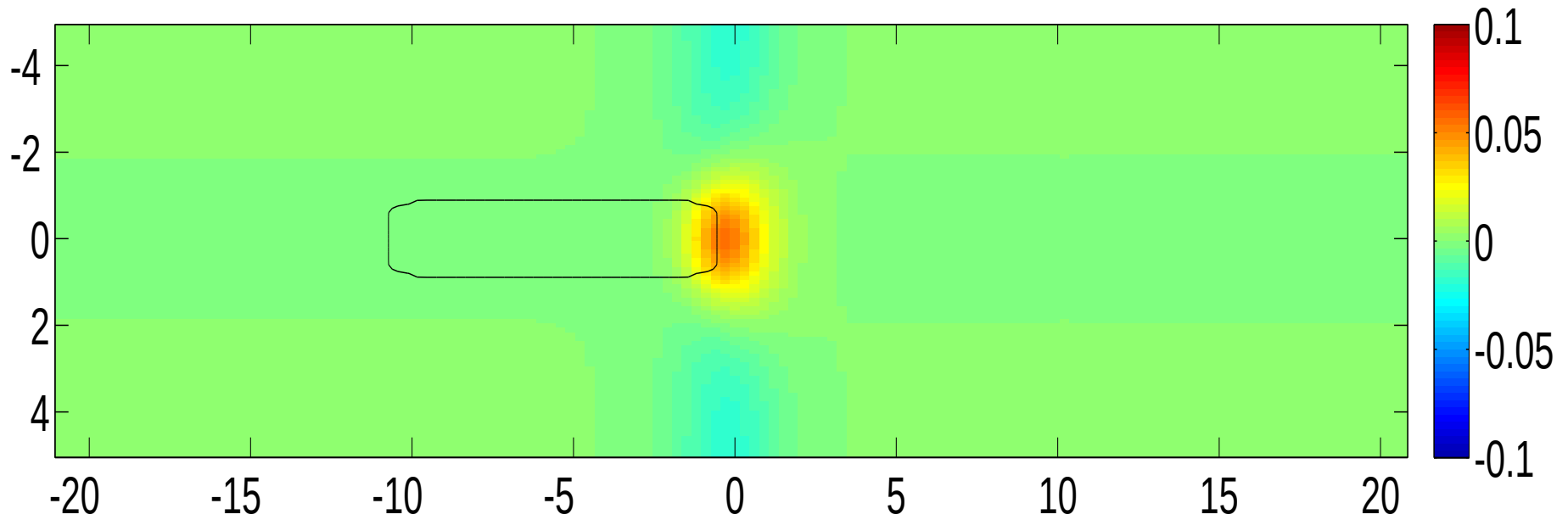
Bølgehevning i meter



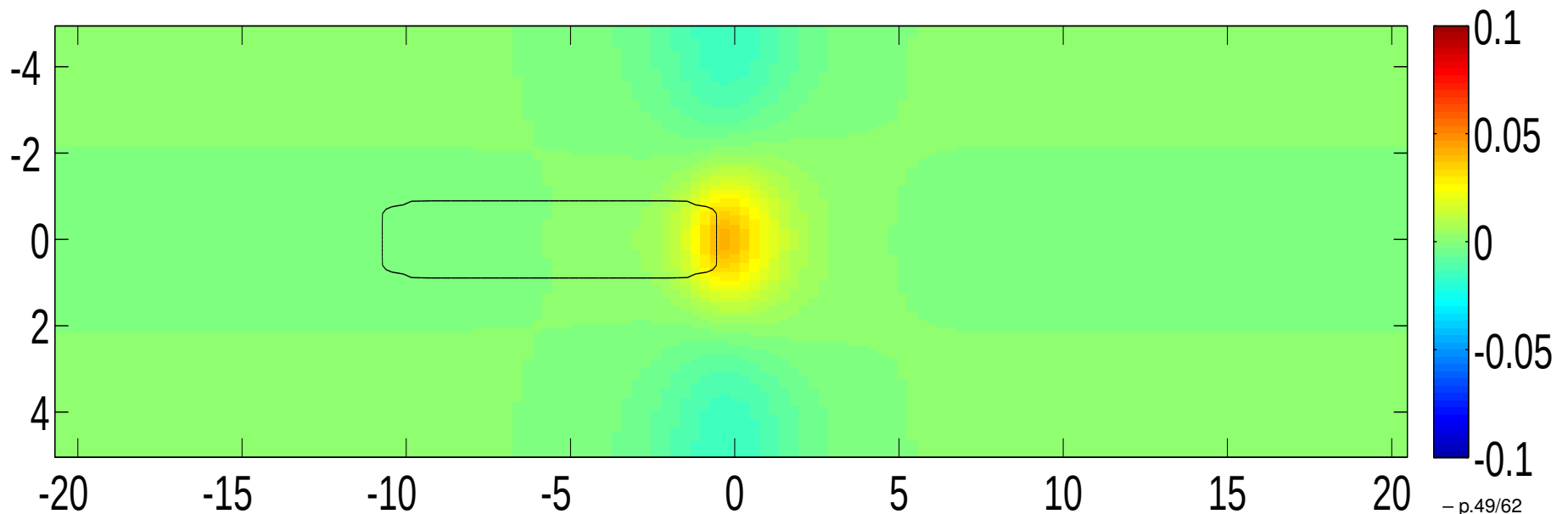
$$t\sqrt{g/h} = 15$$

Vertikalhastighet

m/s



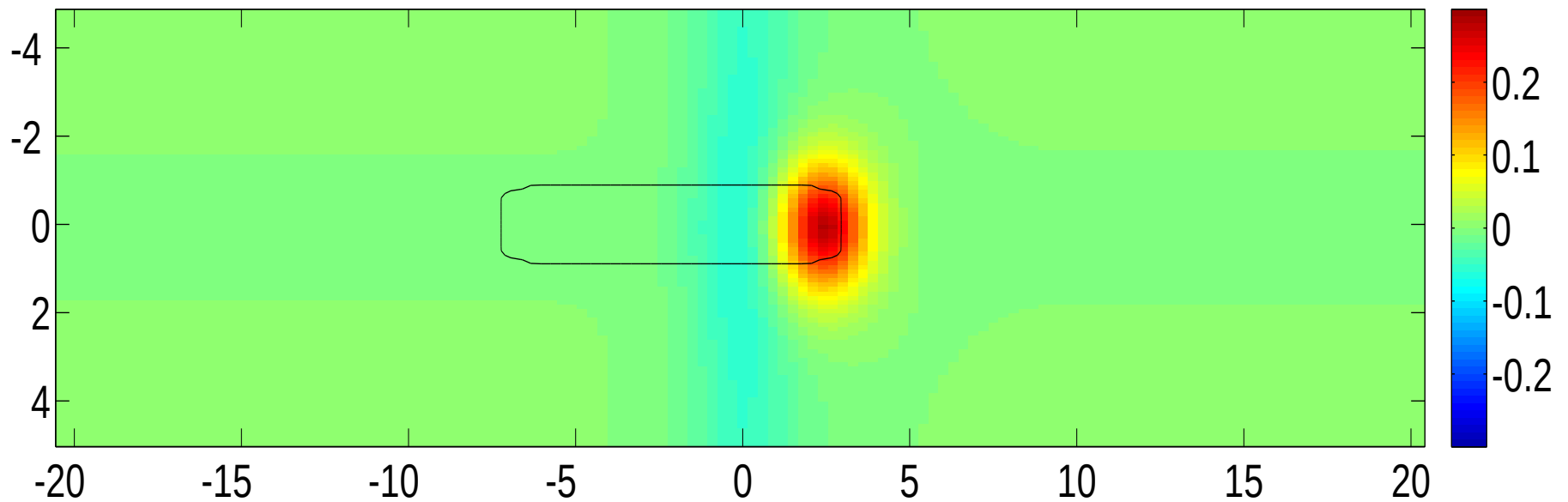
Bølgehevning i meter



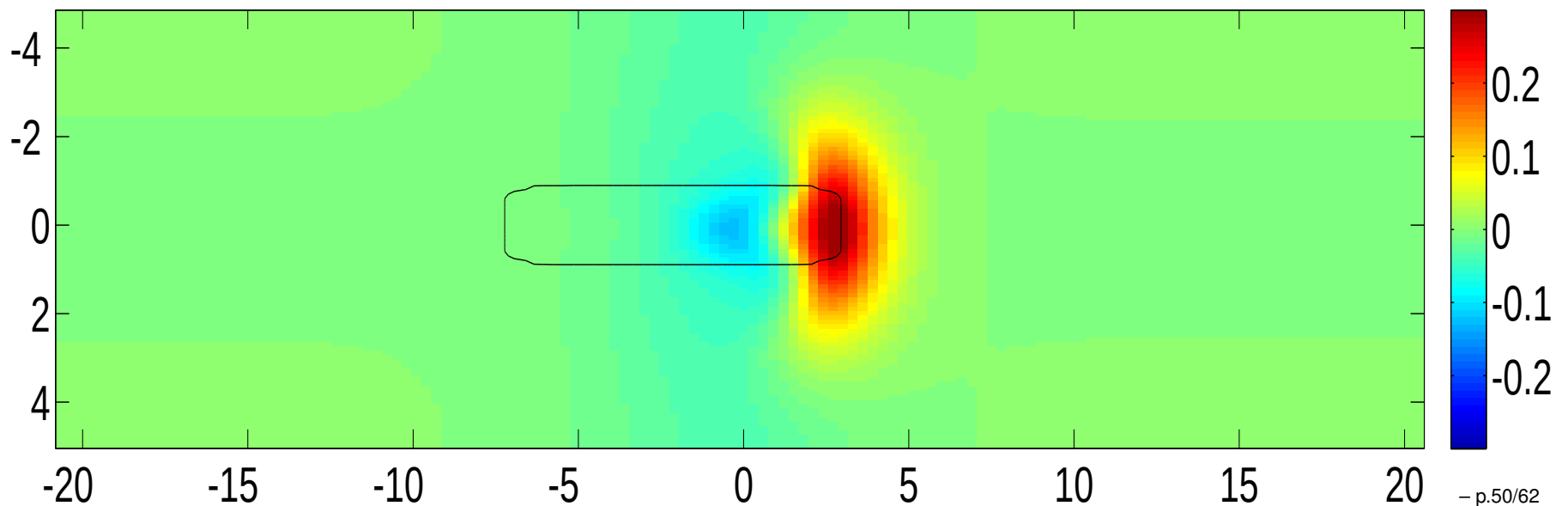
$$t\sqrt{g/h} = 20$$

Vertikalhastighet

m/s



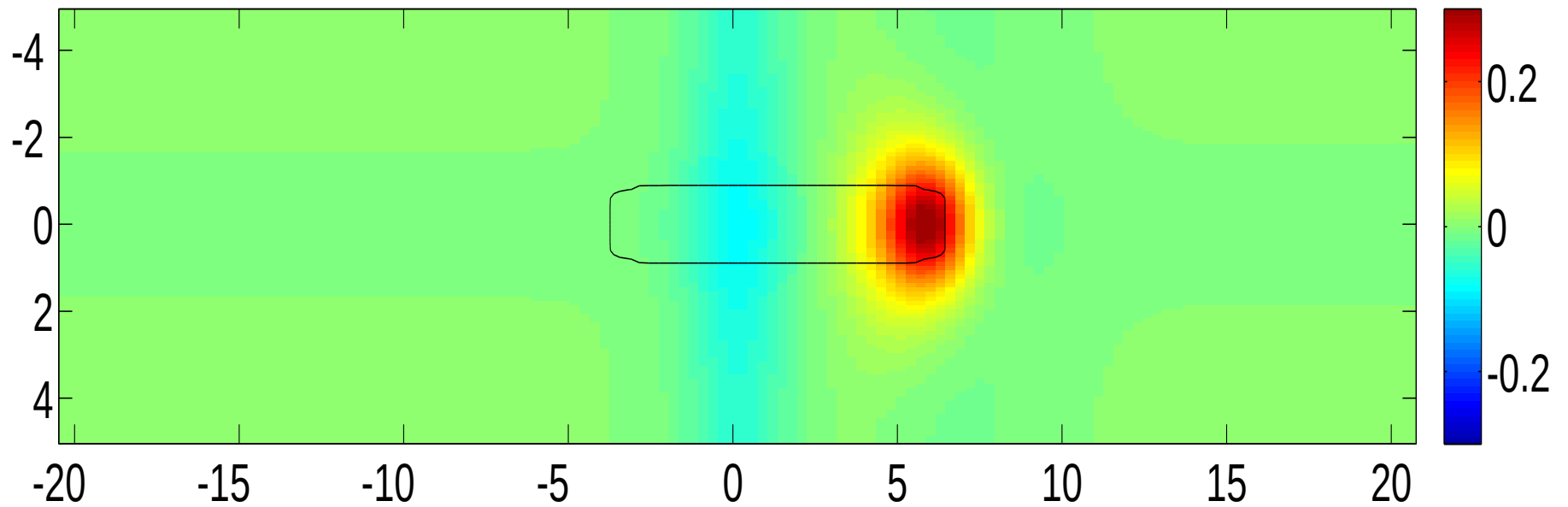
Bølgehevning i meter



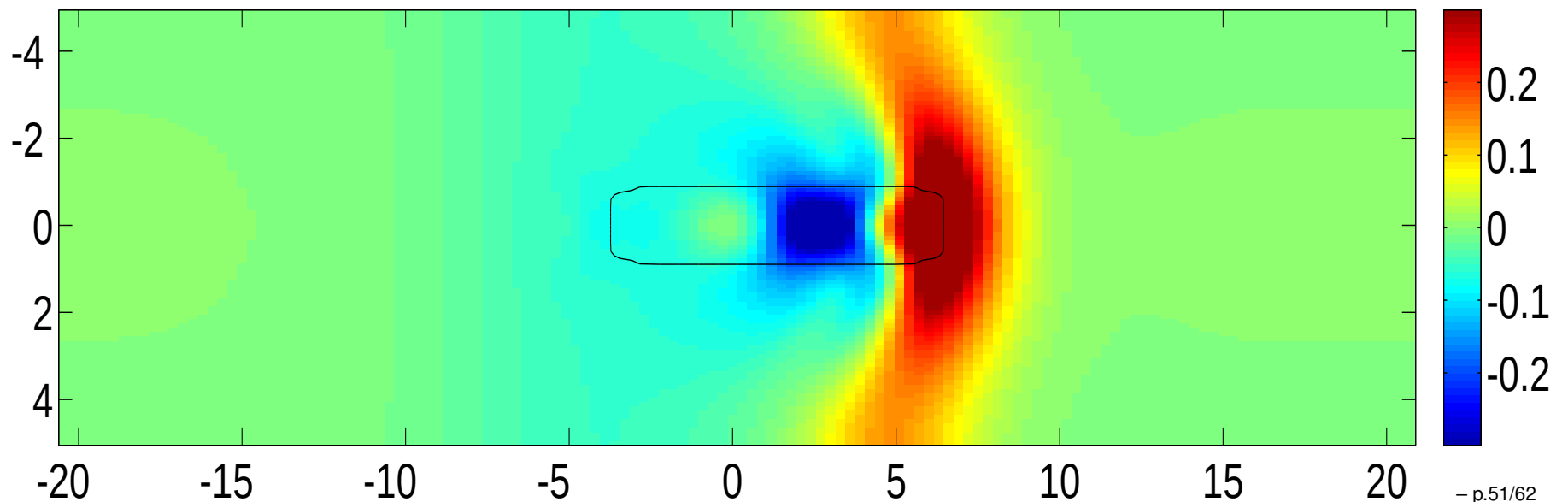
$$t\sqrt{g/h} = 25$$

Vertikalhastighet

m/s



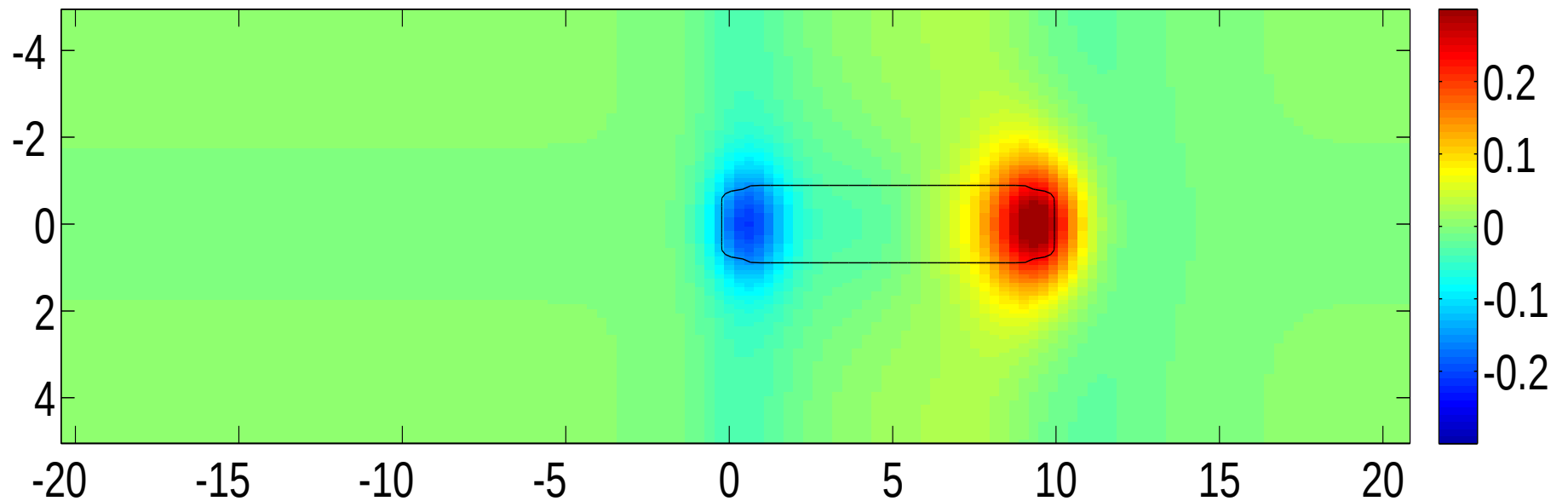
Bølgehevning i meter



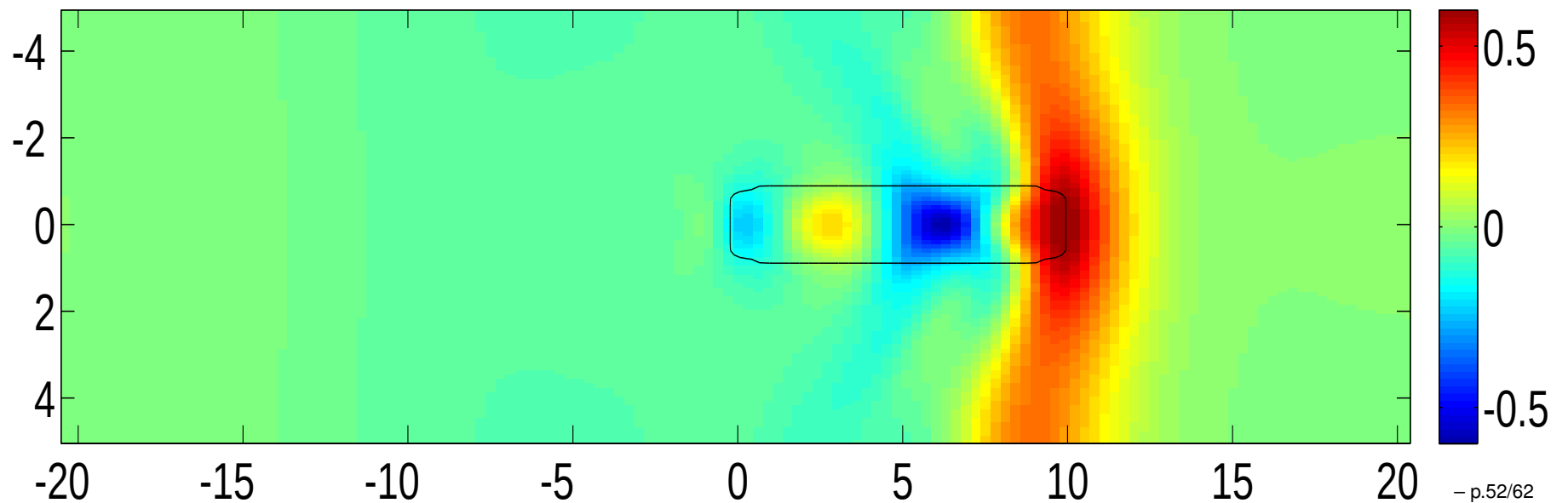
$$t\sqrt{g/h} = 30$$

Vertikalhastighet

m/s



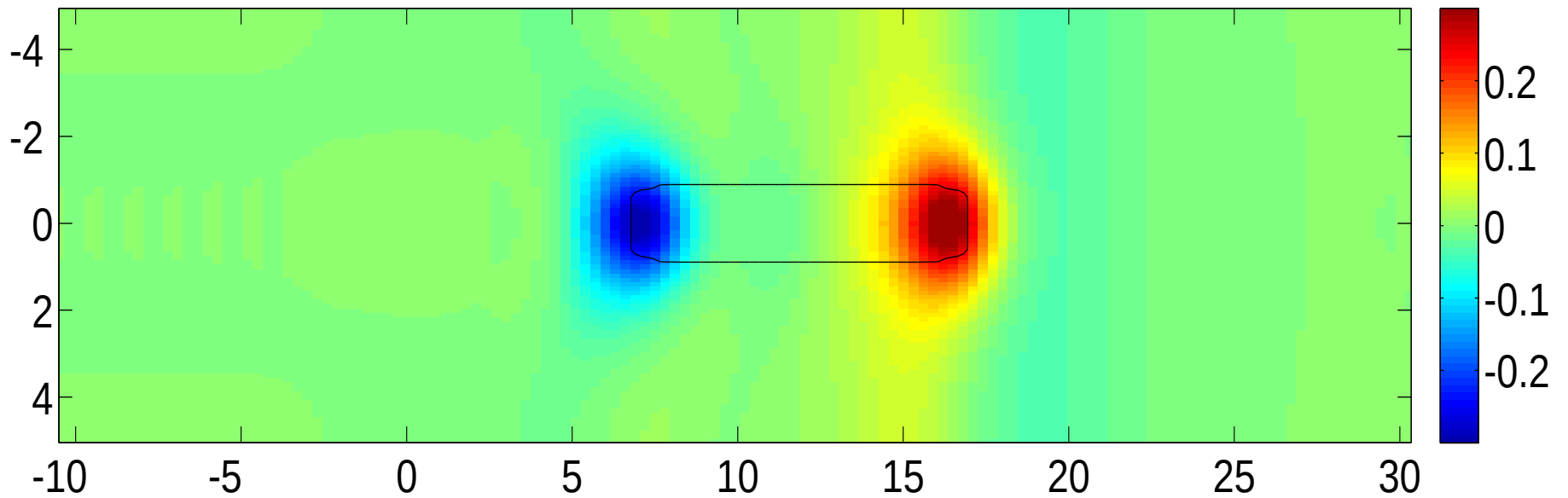
Bølgehevning i meter



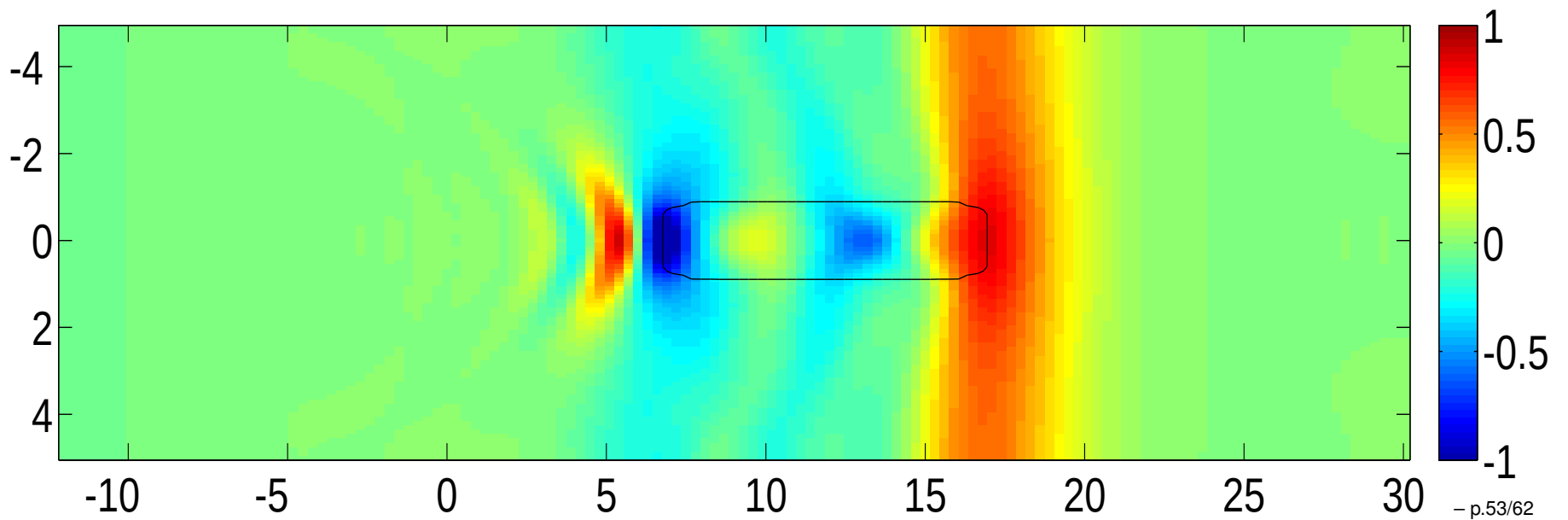
$$t\sqrt{g/h} = 40$$

Vertikalhastighet

m/s



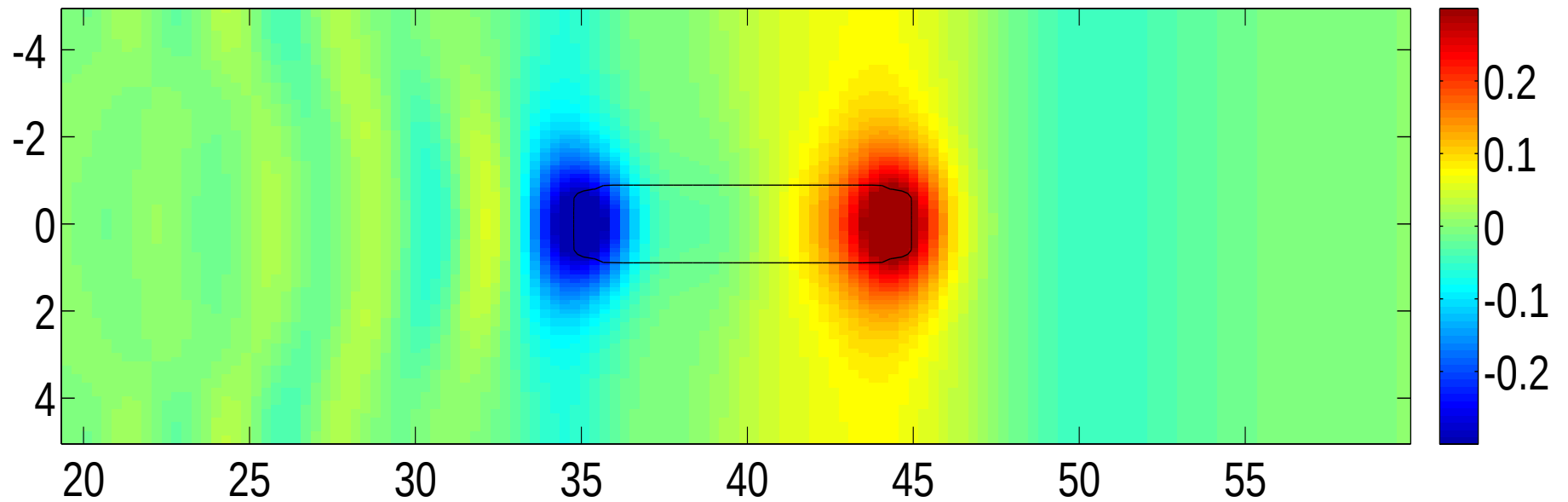
Bølgehevning i meter



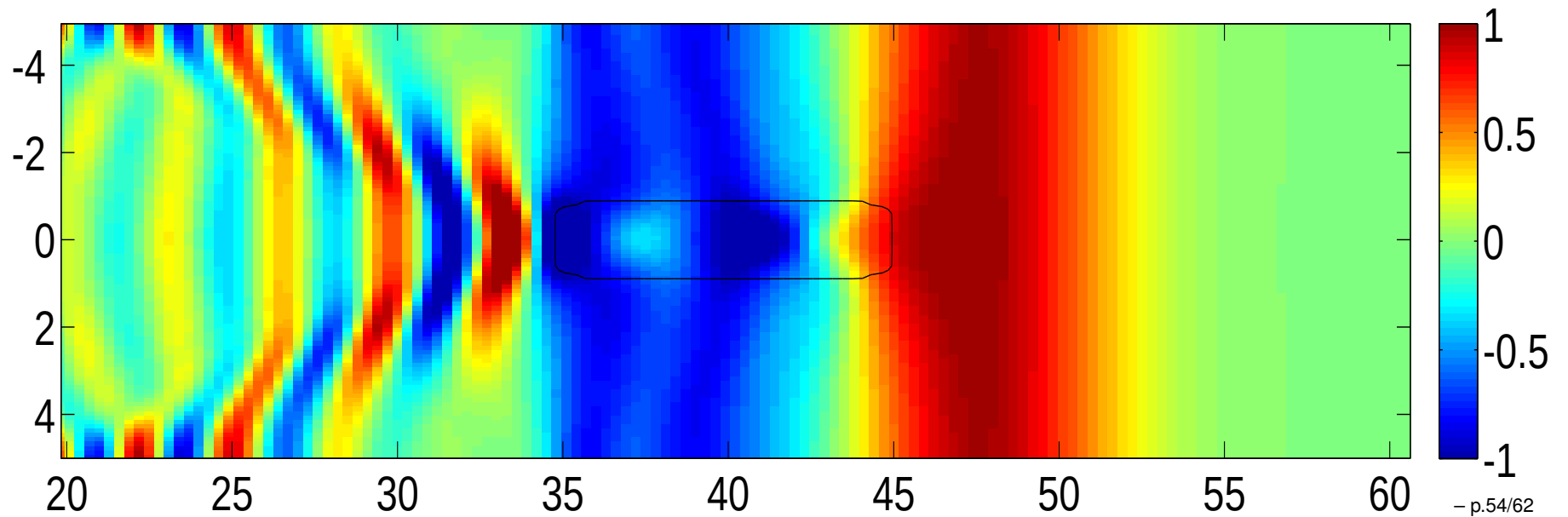
$$t\sqrt{g/h} = 80$$

Vertikalhastighet

m/s



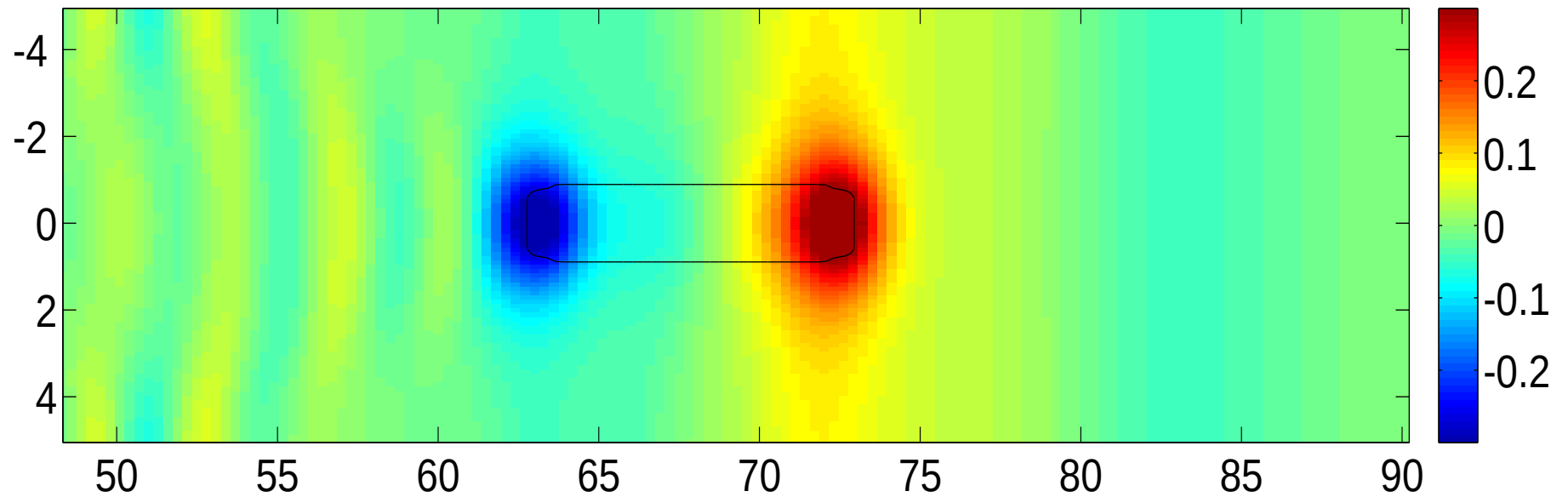
Bølgehevning i meter



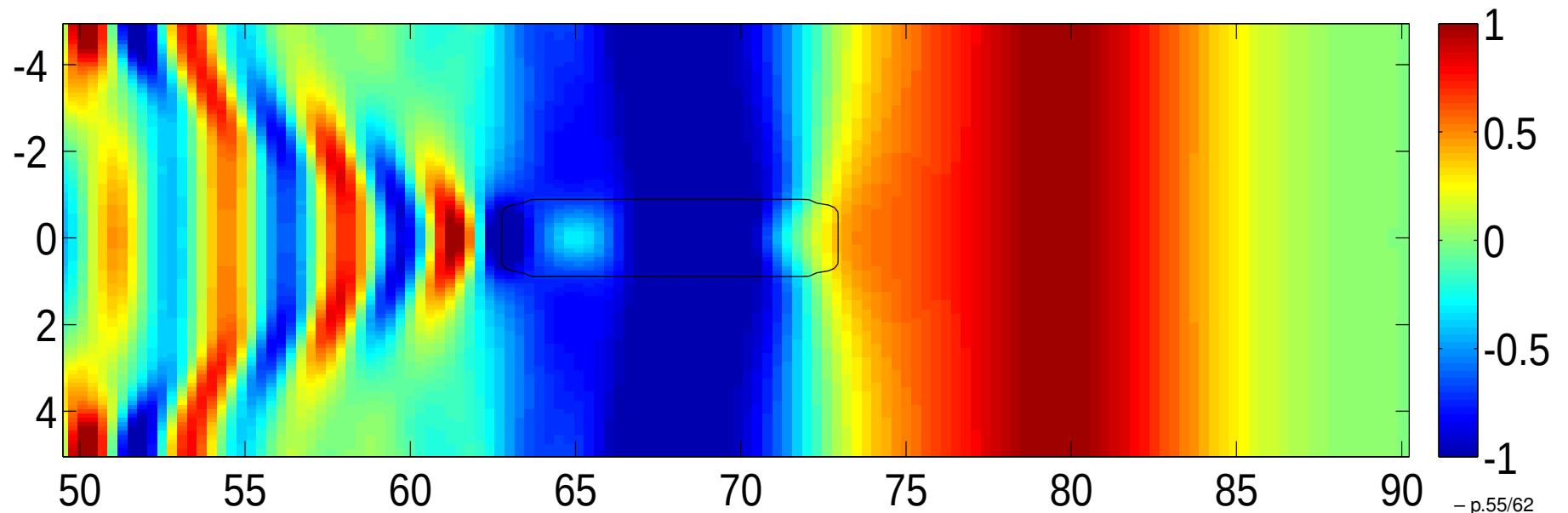
$$t\sqrt{g/h} = 120$$

Vertikalhastighet

m/s



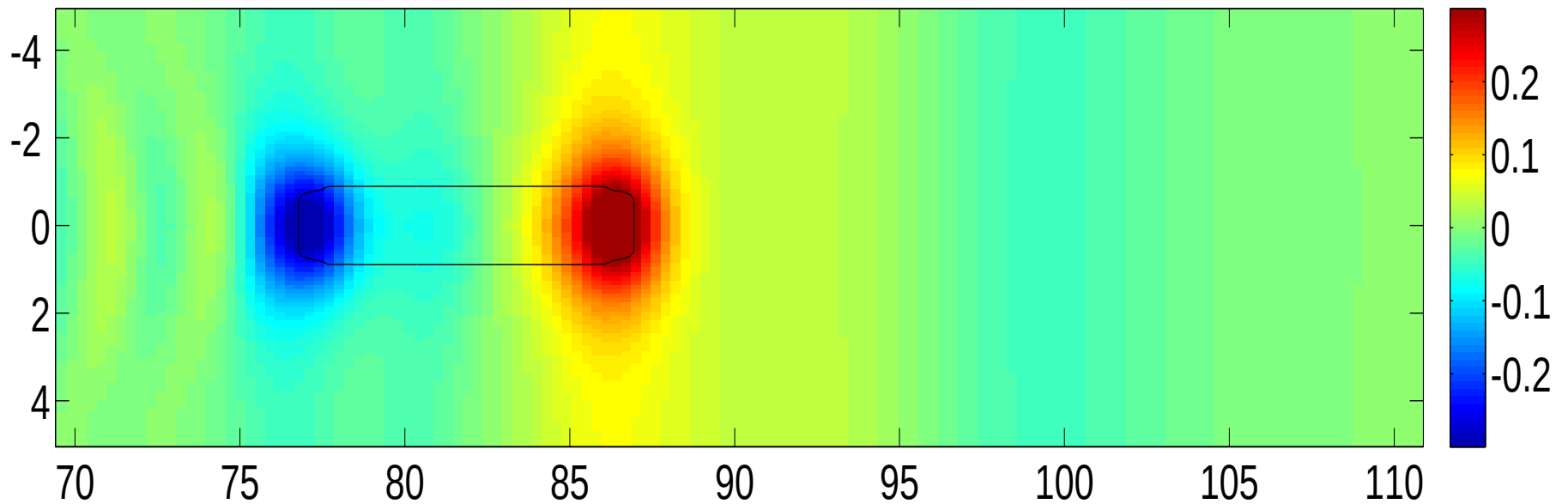
Bølgehevning i meter



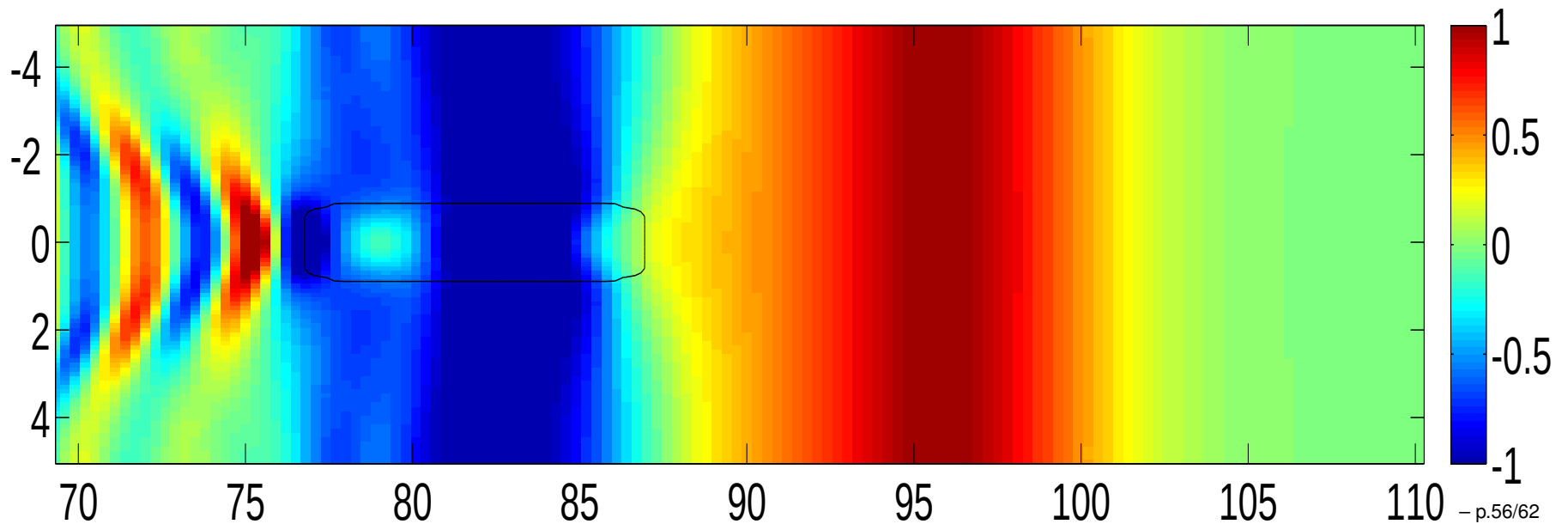
$$t\sqrt{g/h} = 140$$

Vertikalhastighet

m/s

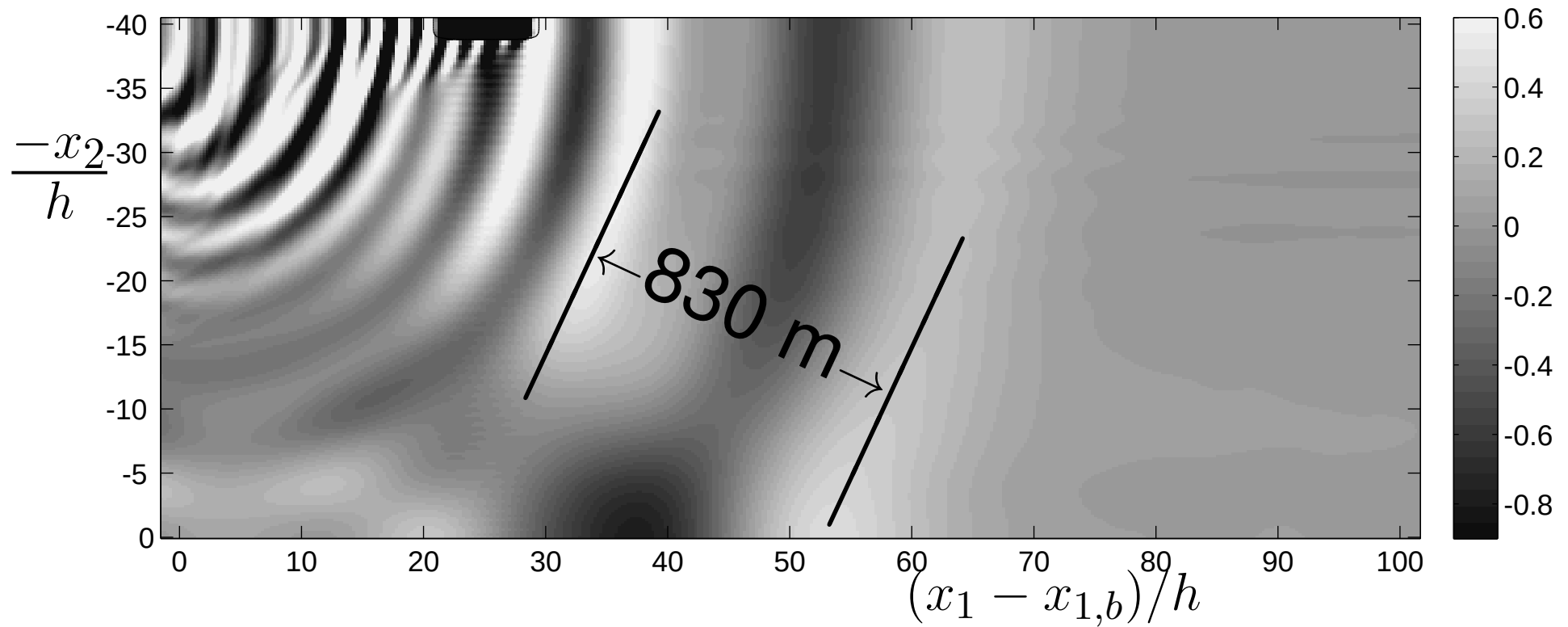


Bølgehevning i meter



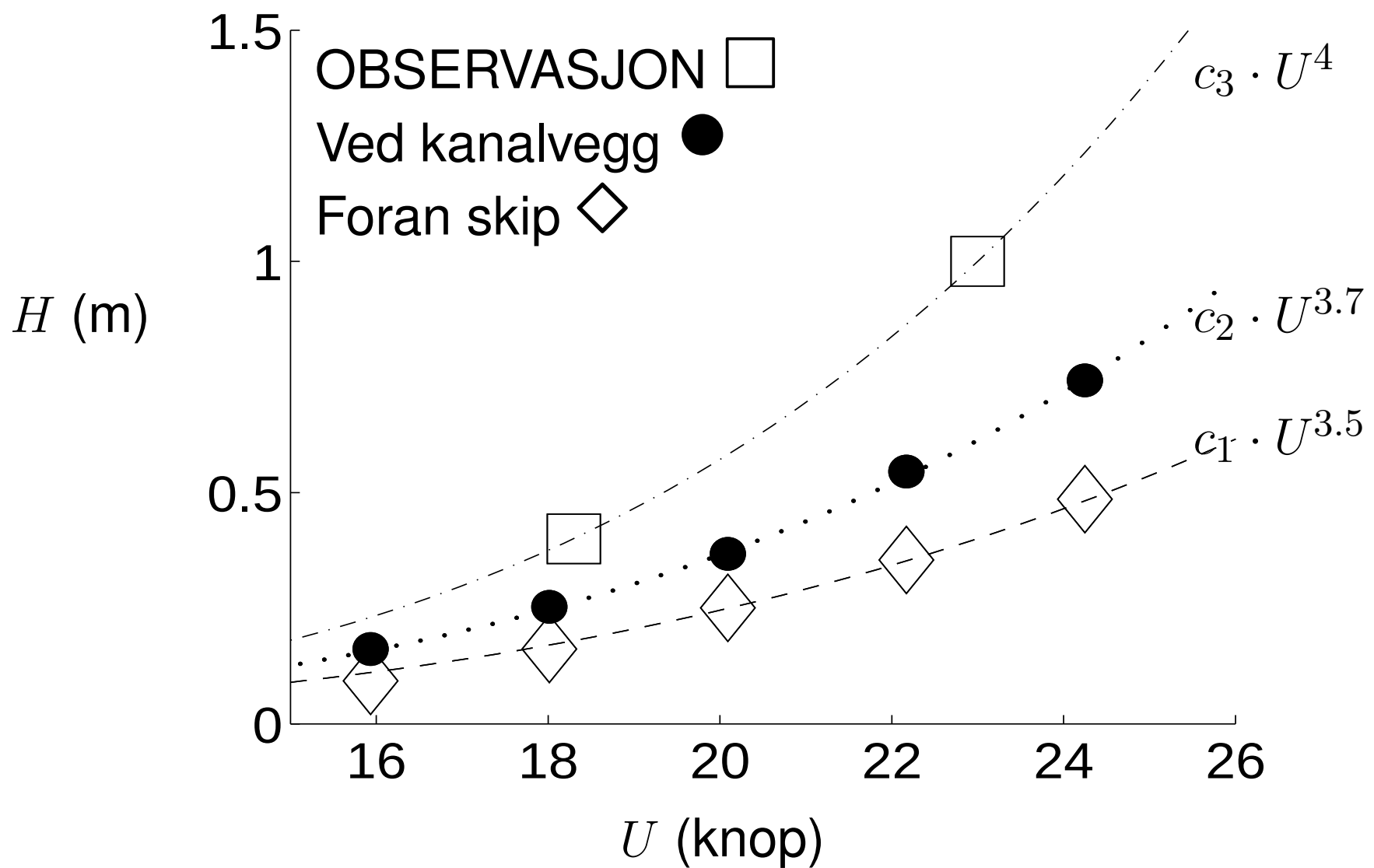


Bølgehevning $\frac{\eta}{h} \cdot 10^2$

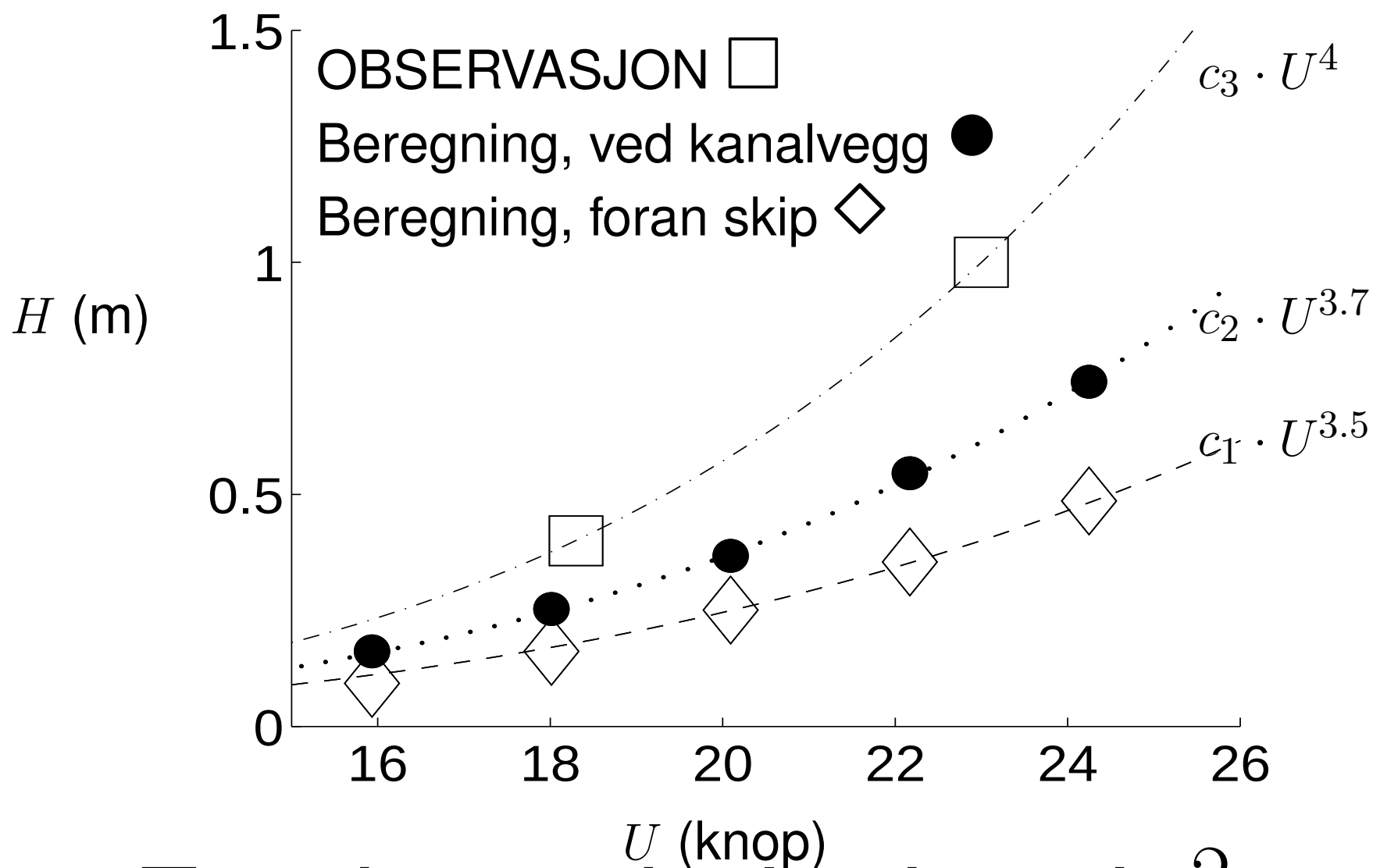


Modellberegning i kanal. $Fr = 0,58$ ($U=10$ m/s).
Grue (JFM, 2017).

bølgehøyde



bølgehøyde



$$\text{Erosjon} \sim \text{bølgehøyde}^2$$

Konklusjon

1. Minitsunami dannes når skip passerer dybdeforandring.
2. Strømningen ved skipets baug og akter justerer seg til nytt sjøbunnsnivå. Danner vertikalhastighet på overflaten.
3. Effekten sterk nok til å danne et kort tog av oppstrømsbølger med lengde 0.5-1 km, kamlengde ~ 3 km, bølgehøyde ved land opptil 1,4 m.
4. Bølgehøyde vokser som U^4 . Erosjonen vokser som U^8 .
5. Observasjoner flere steder i Norge og internasjonalt.
6. Referanse: J. Grue, Journal of Fluid Mech., 2017.

