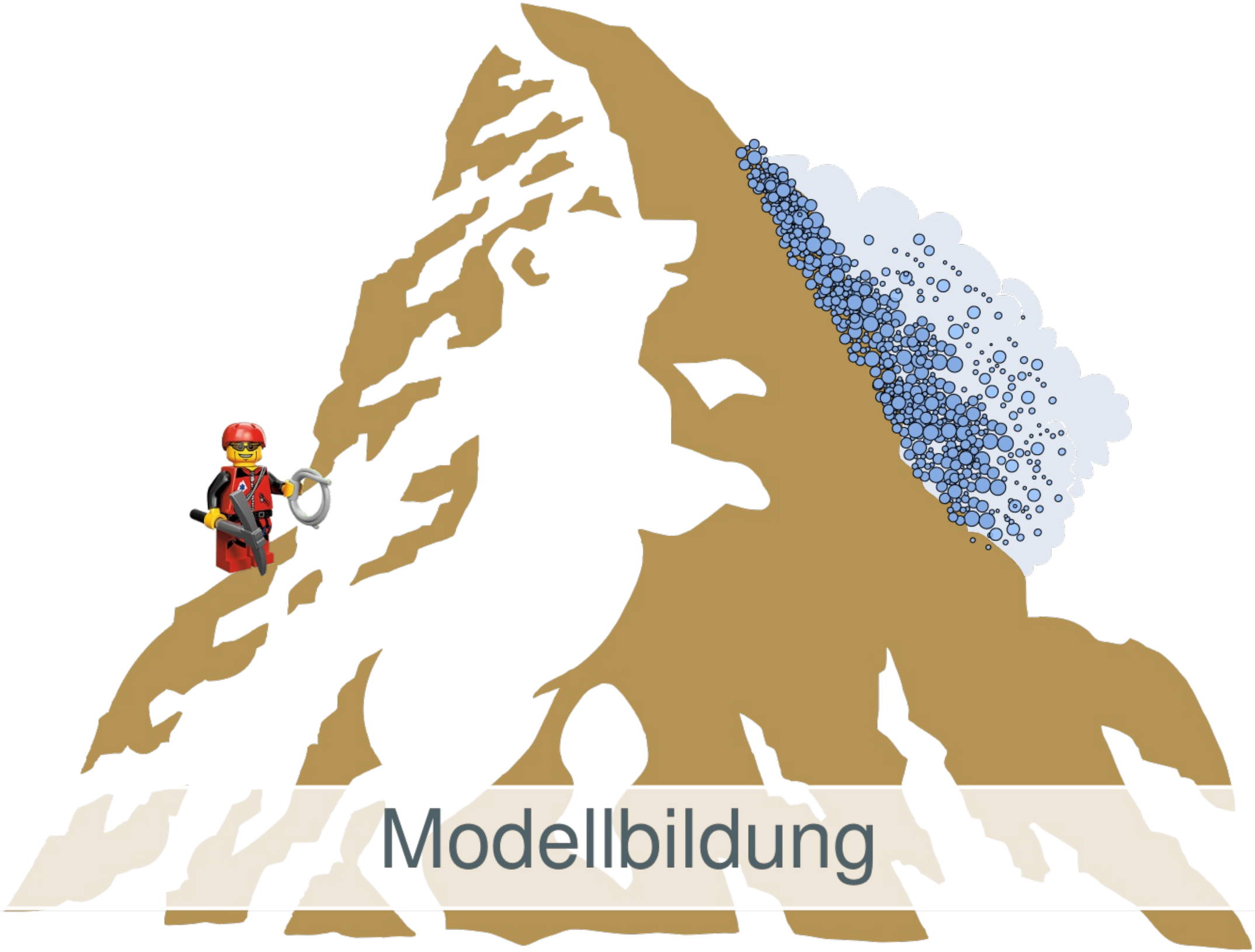
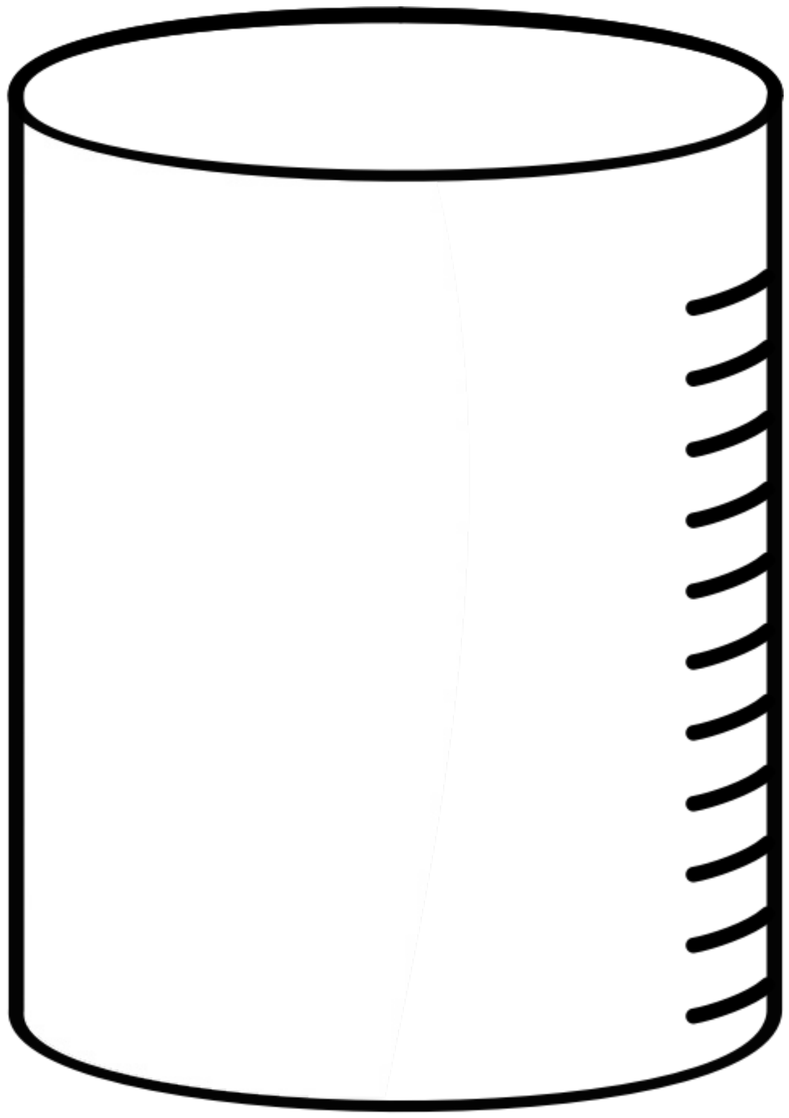
Phil.Alp 2016

Matthias Rauter

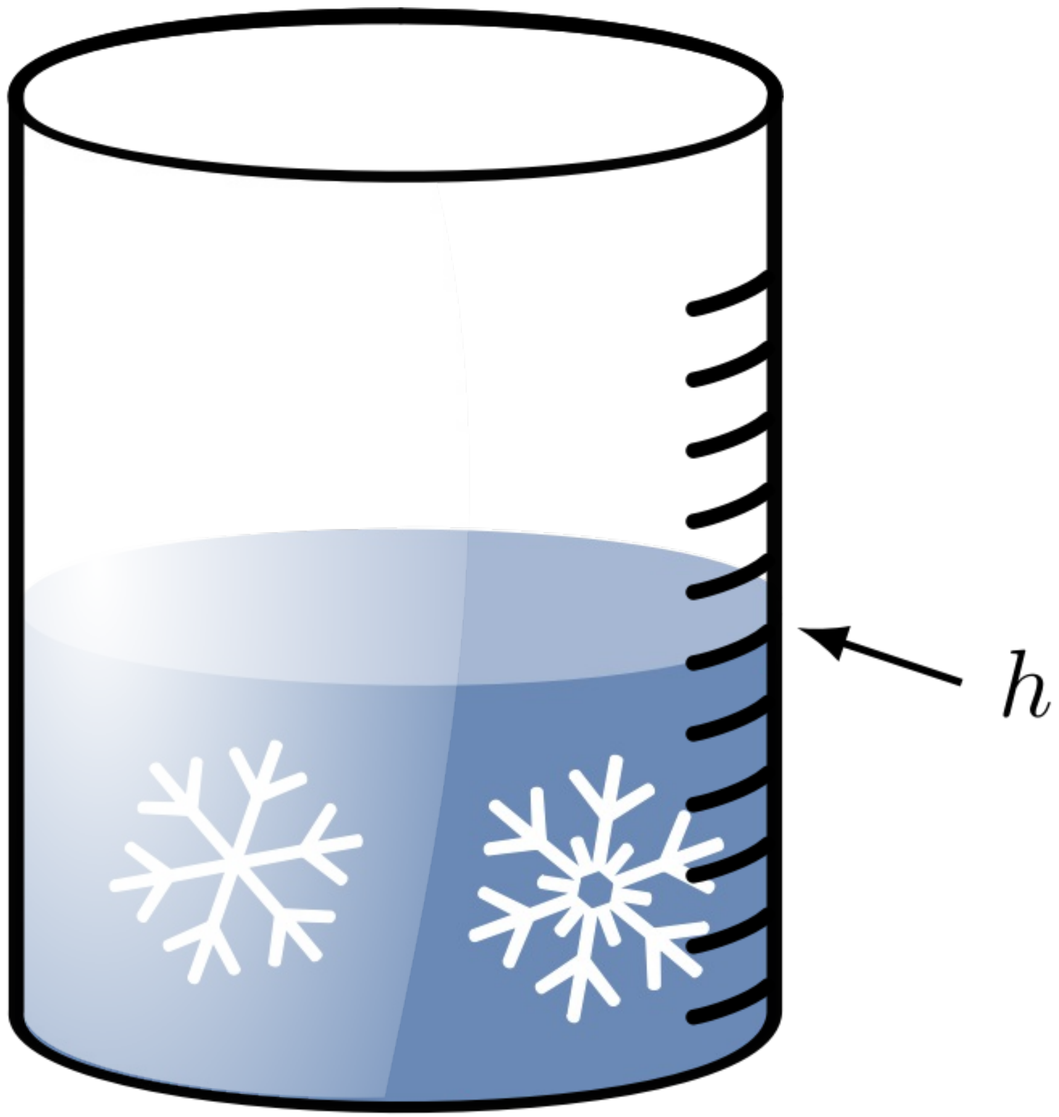
Ein neues Sohlreibungs-modell für Lawinen



Modellbildung



Ein einfaches Modell



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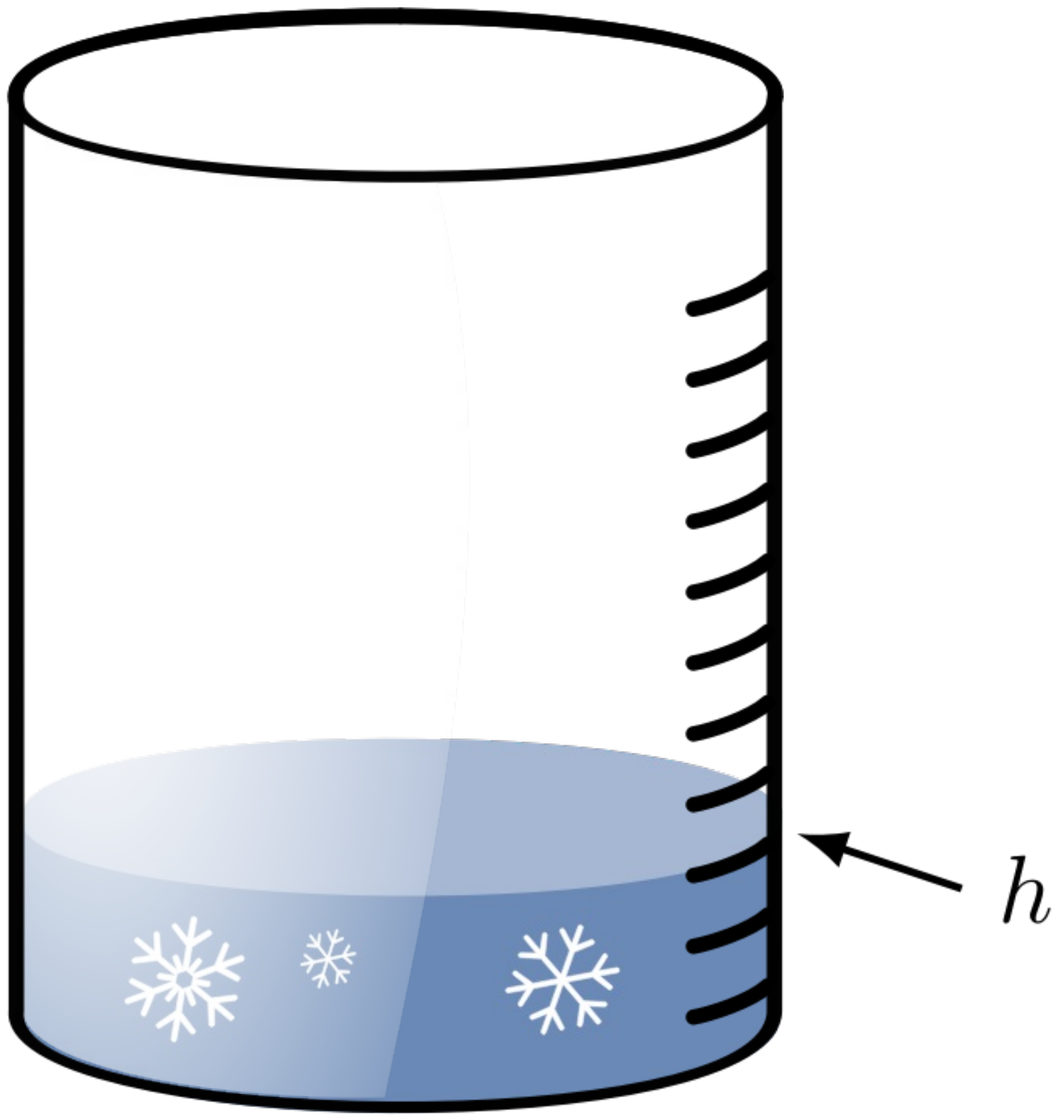
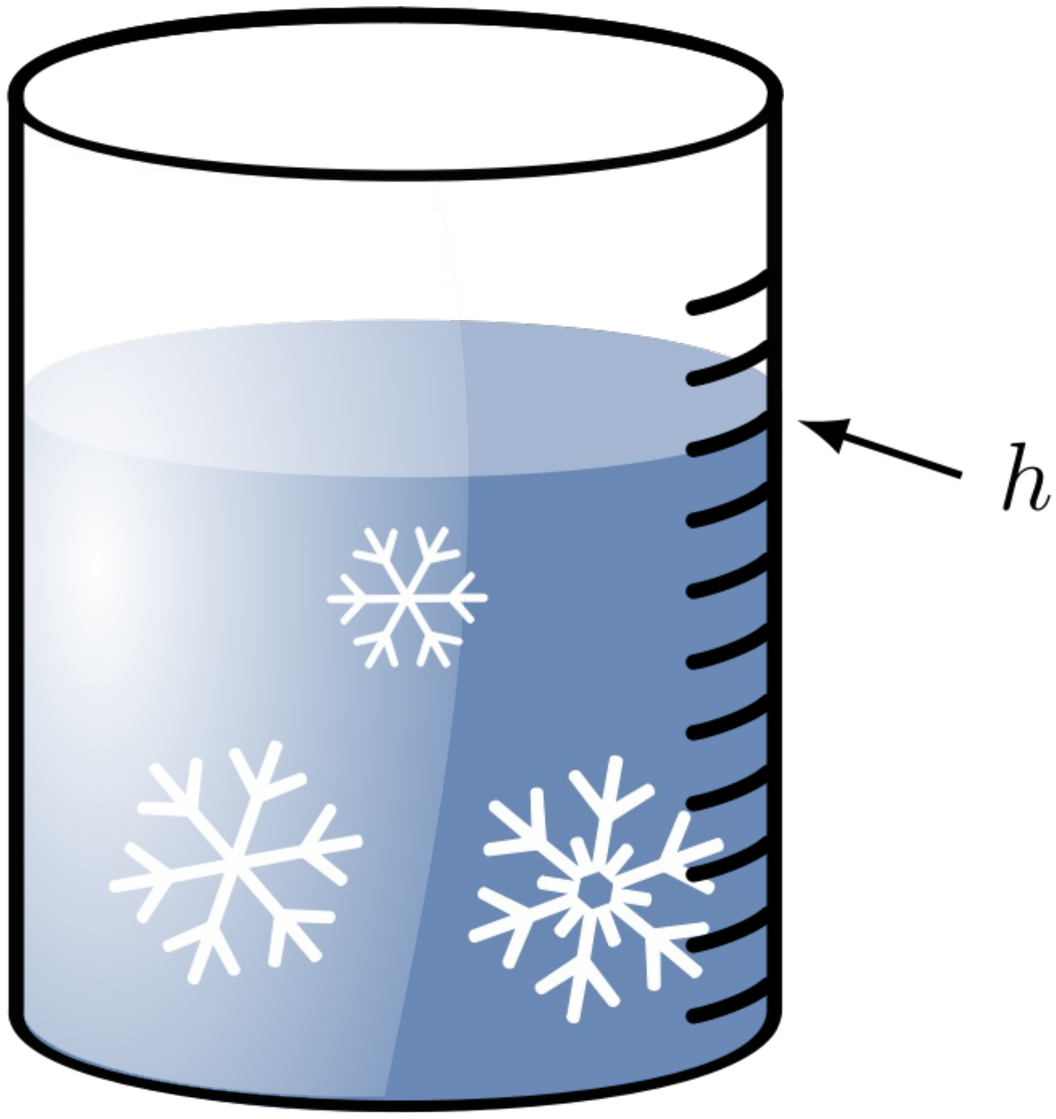
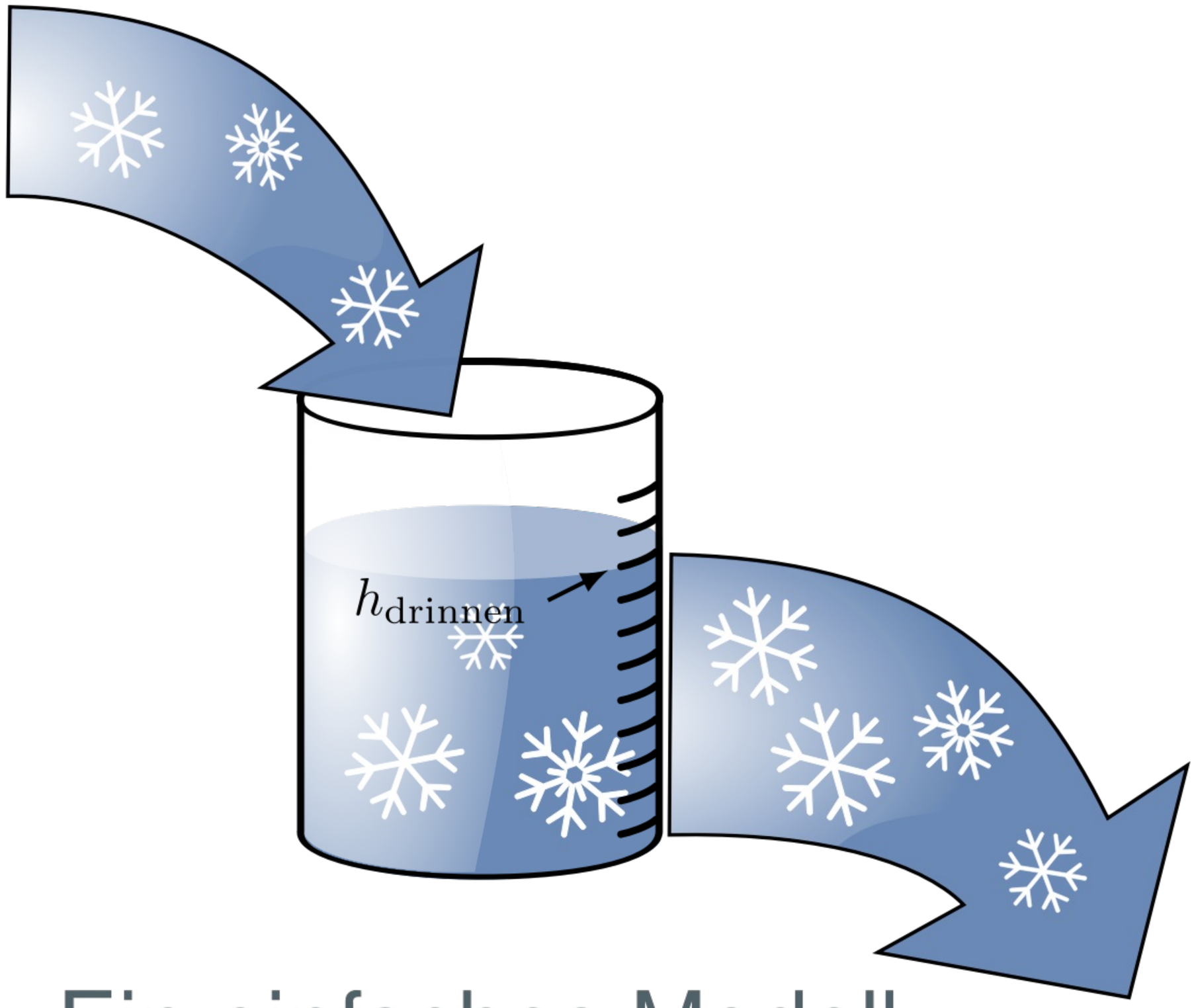


Ein einfaches Modell



Ein einfaches Modell



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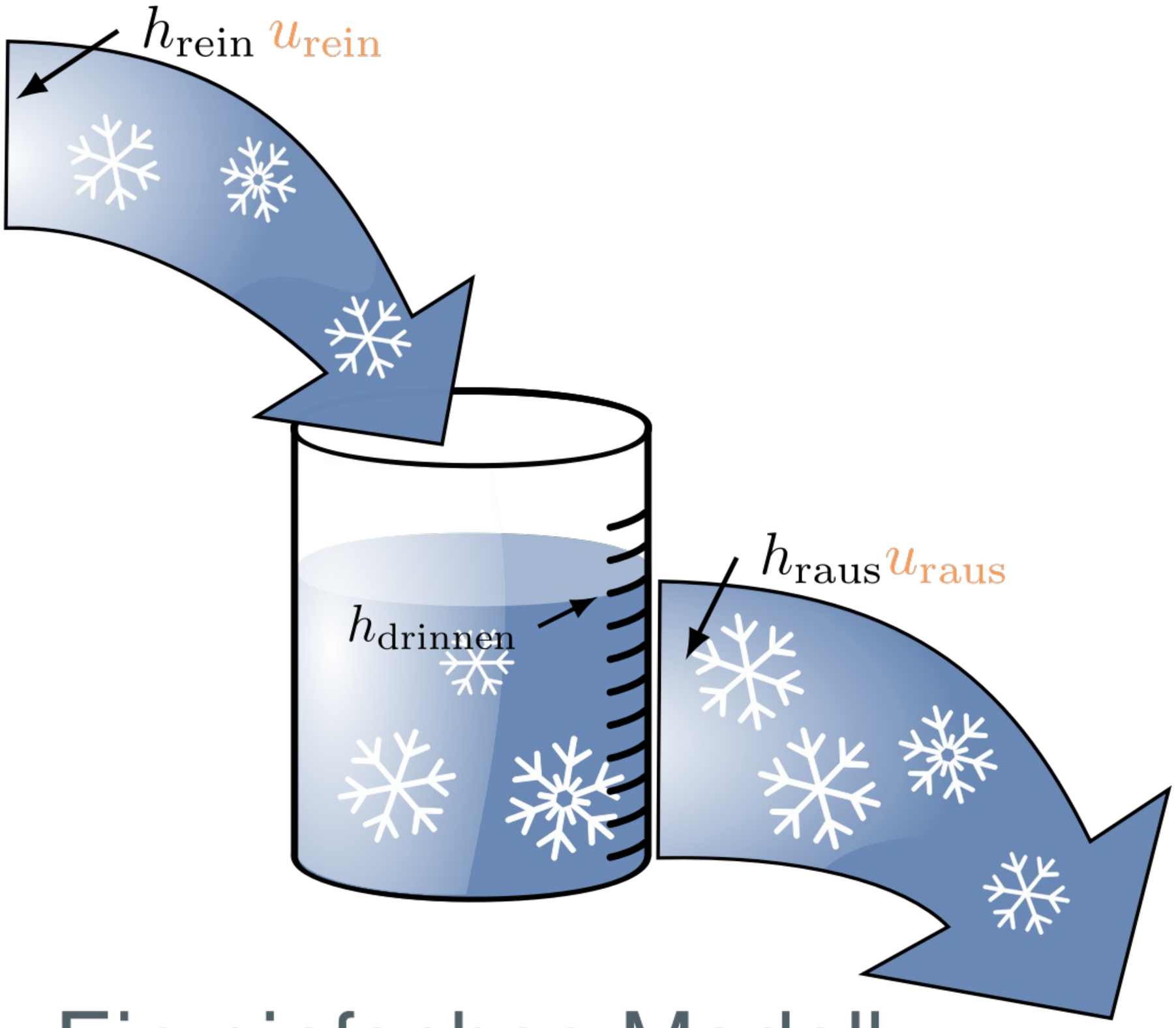

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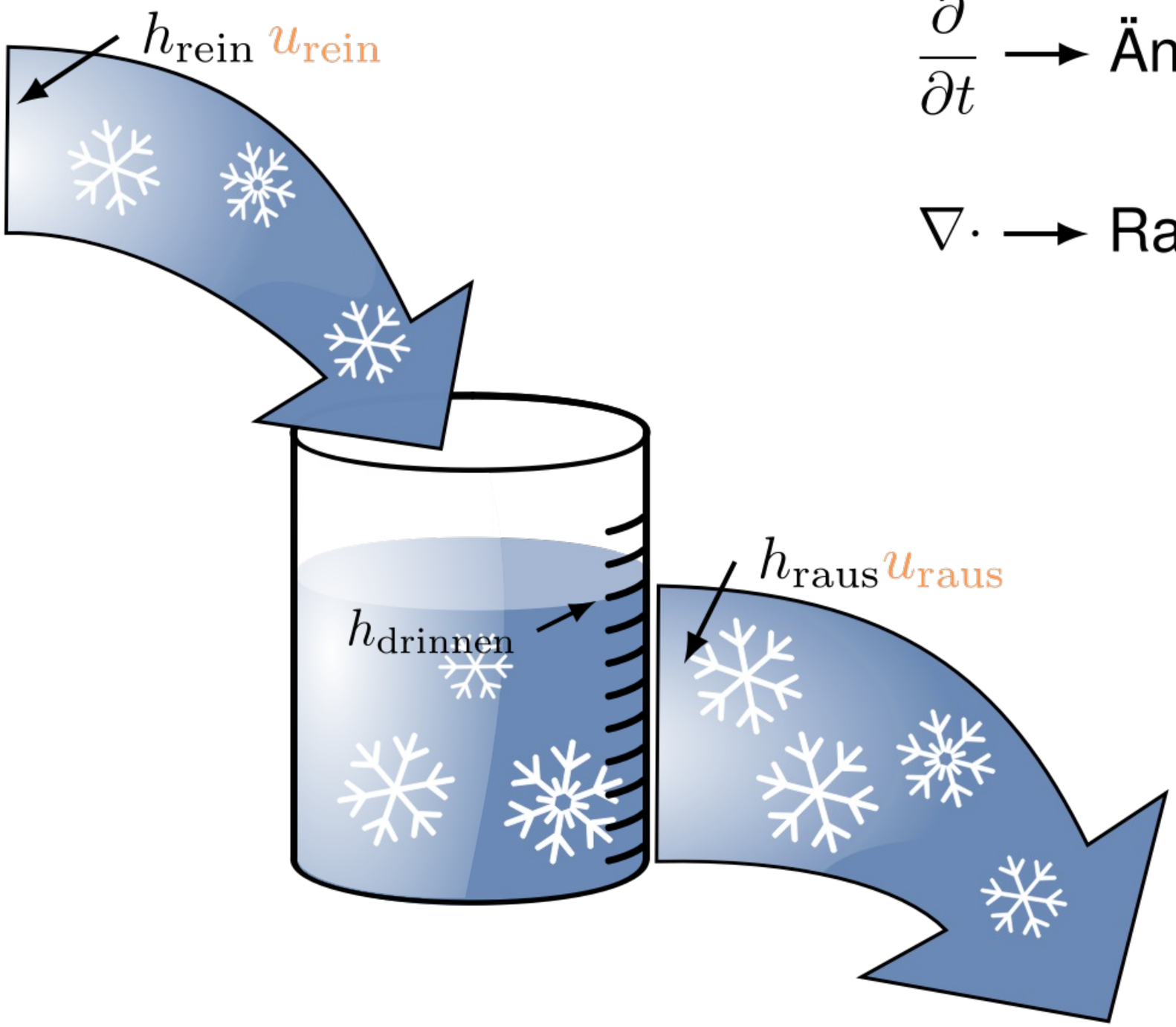
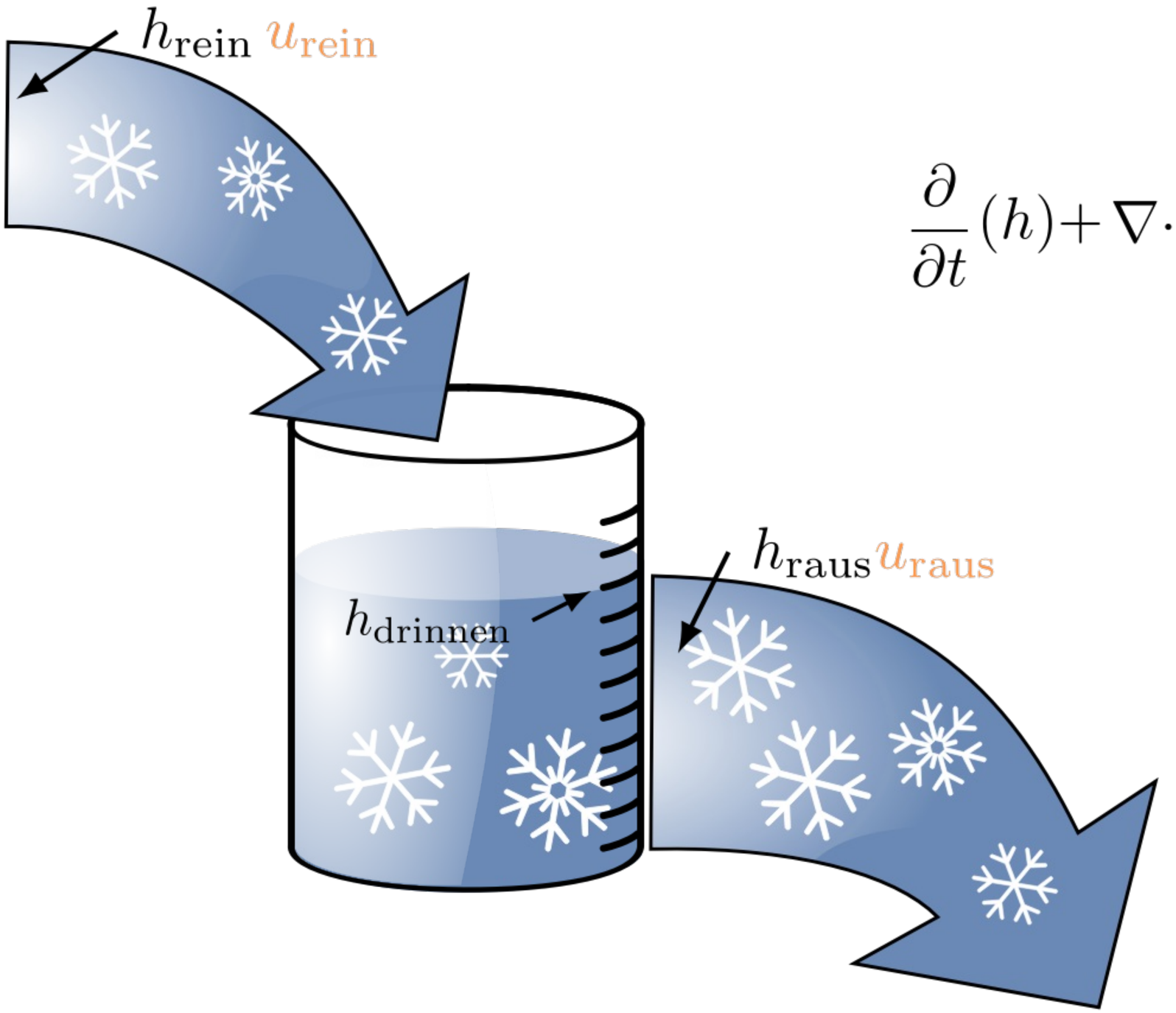


$\frac{\partial}{\partial t}$ → Änderung von Drinnen

$\nabla \cdot$ → Raus minus Rein

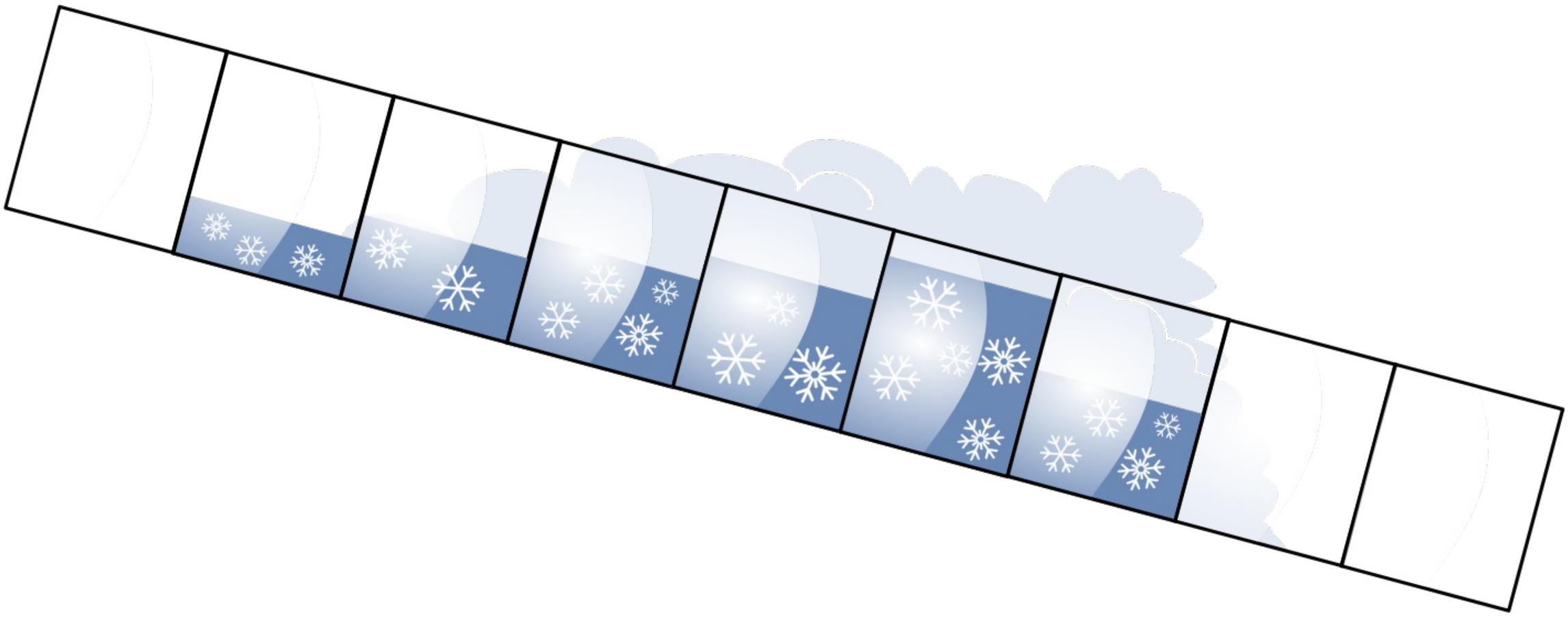
Ein einfaches Modell



$$\frac{\partial}{\partial t}(h) + \nabla \cdot (h\, u) = 0$$

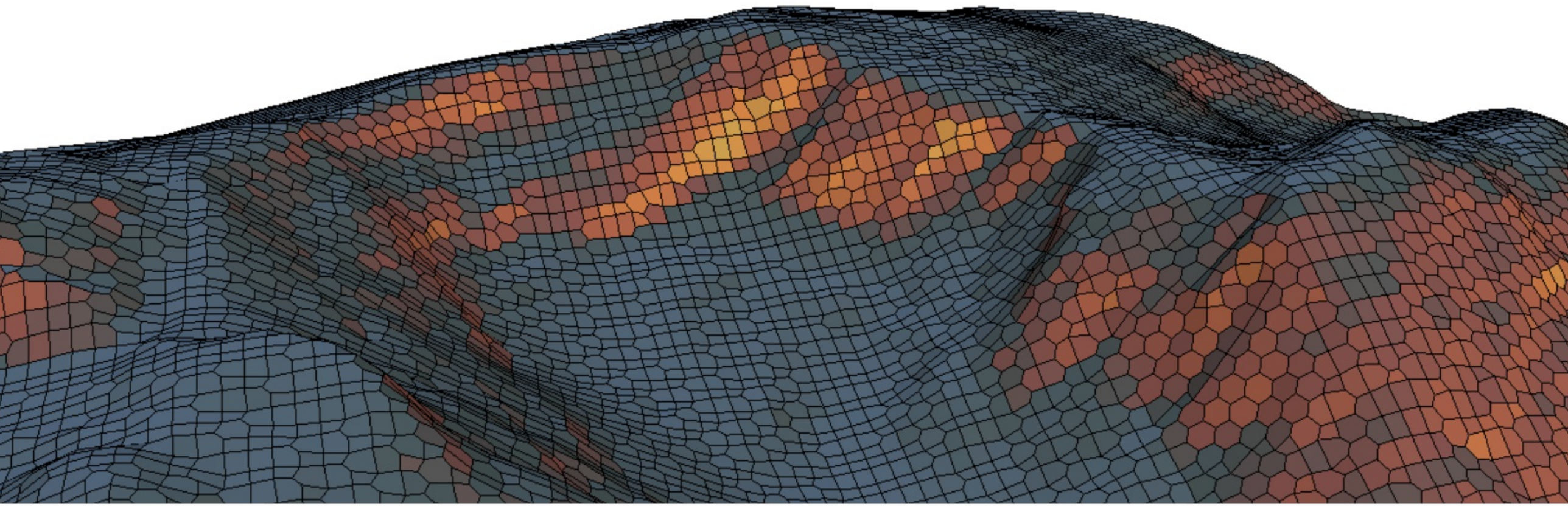
Ein einfaches Modell

$$\frac{\partial}{\partial t}(h) + \nabla \cdot (h\,u) = 0$$



Das Modell bleibt einfach Komplexität durch Auflösung

$$\frac{\partial}{\partial t}(h) + \nabla \cdot (h\,u) = 0$$



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Komplexität durch Auflösung

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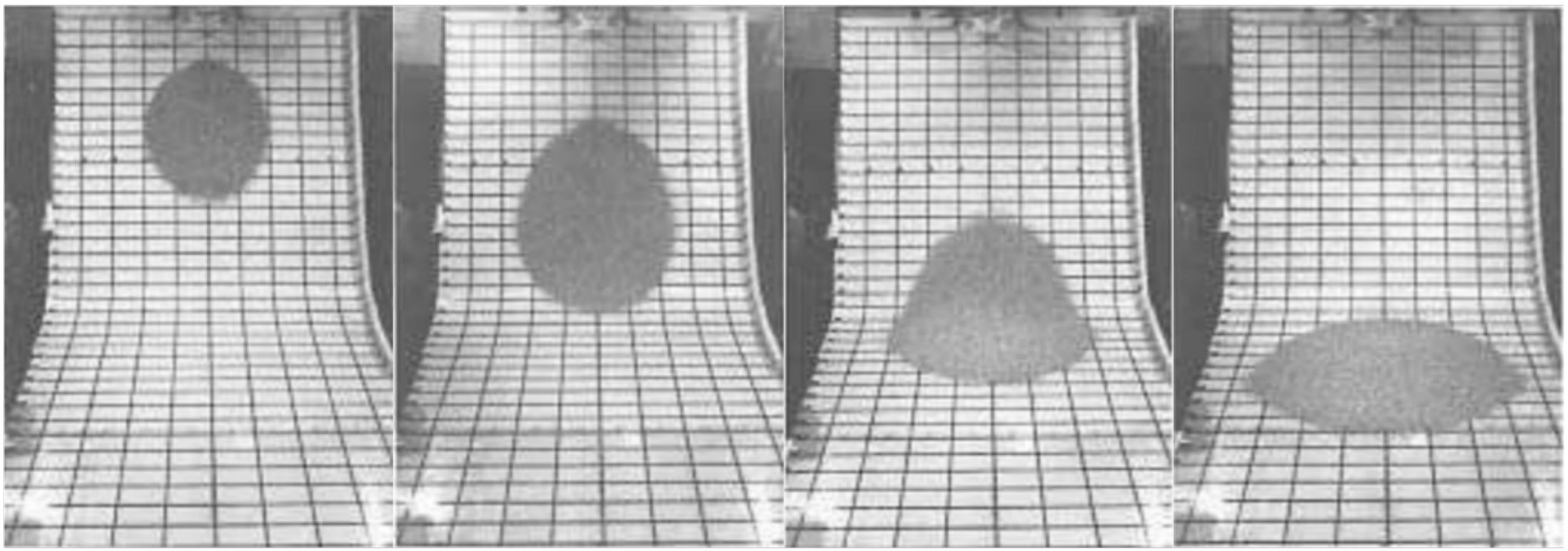
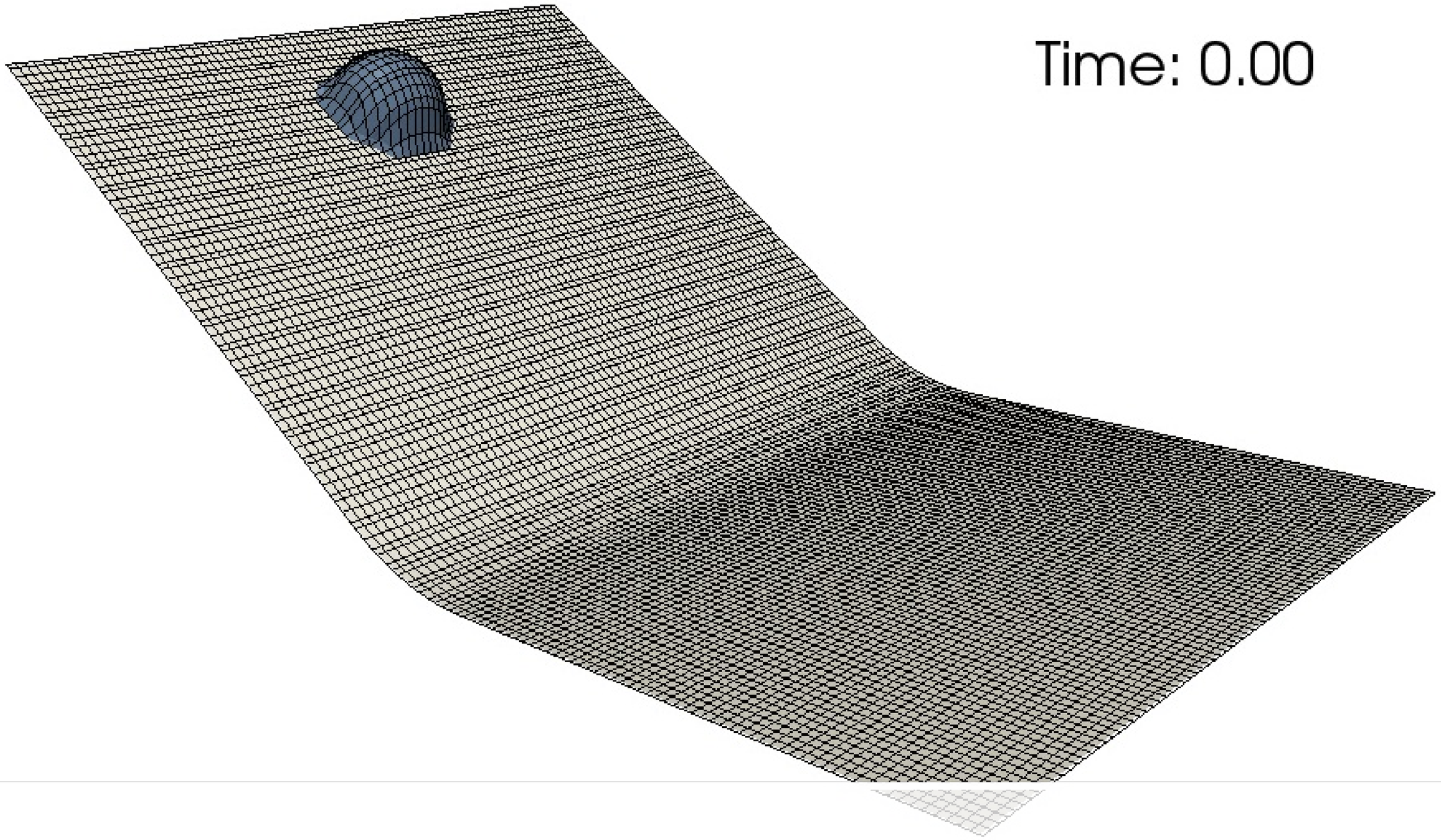
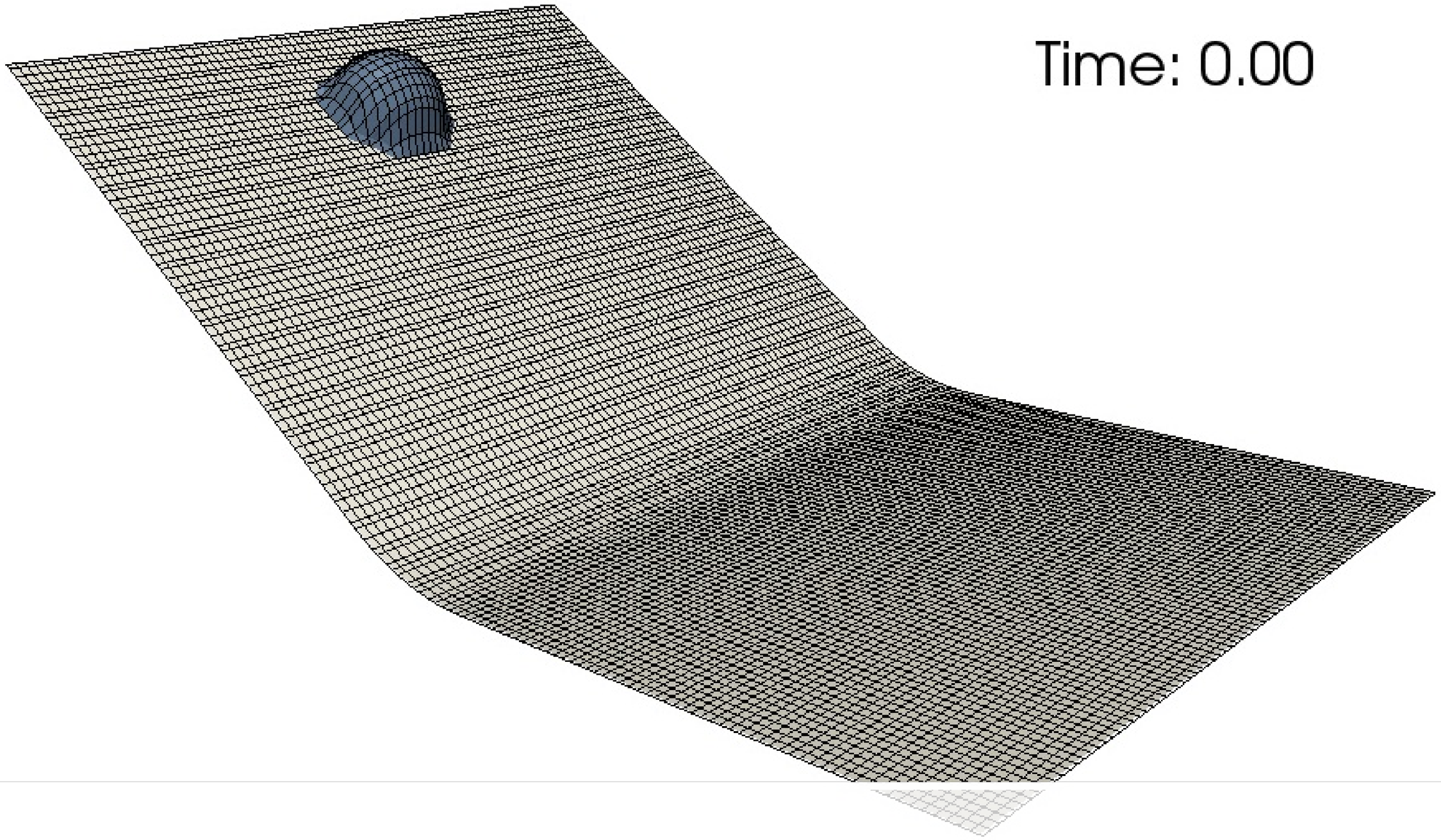


[Lang et al.; 1989]

Ein einfaches Experiment



Ein einfaches Experiment



Ein einfaches Experiment

$$\frac{\partial}{\partial t}(h) + \nabla \cdot (h\,u) = 0$$

Wir brauchen Geschwindigkeit!

$$\frac{\partial}{\partial t}(h) + \nabla \cdot (h\,u) = 0$$

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g$$

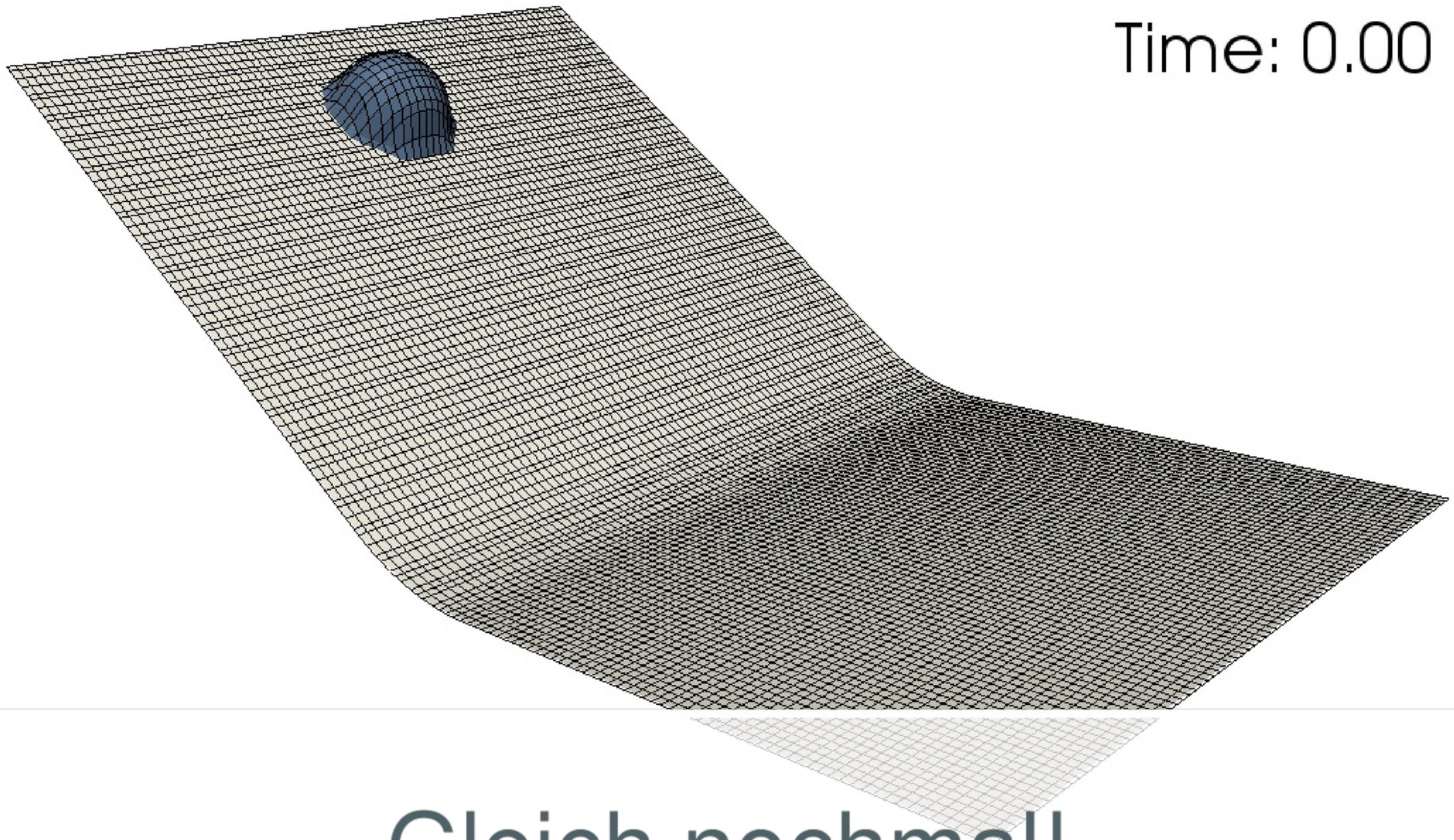
was sich ändert

raus minus rein

Erdbeschleunigung

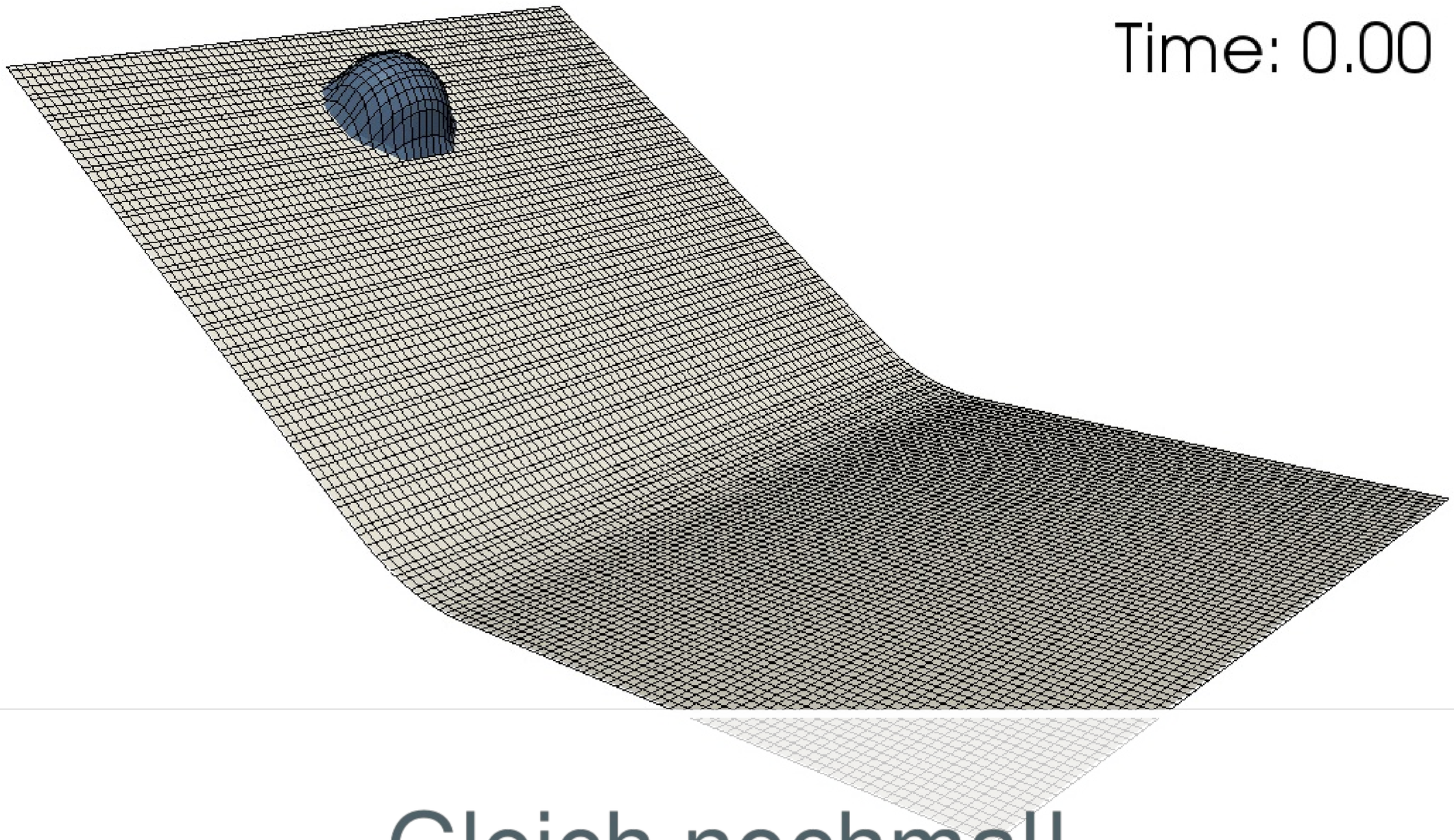
Wir brauchen Geschwindigkeit!

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g$$



Gleich nochmal!

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g$$



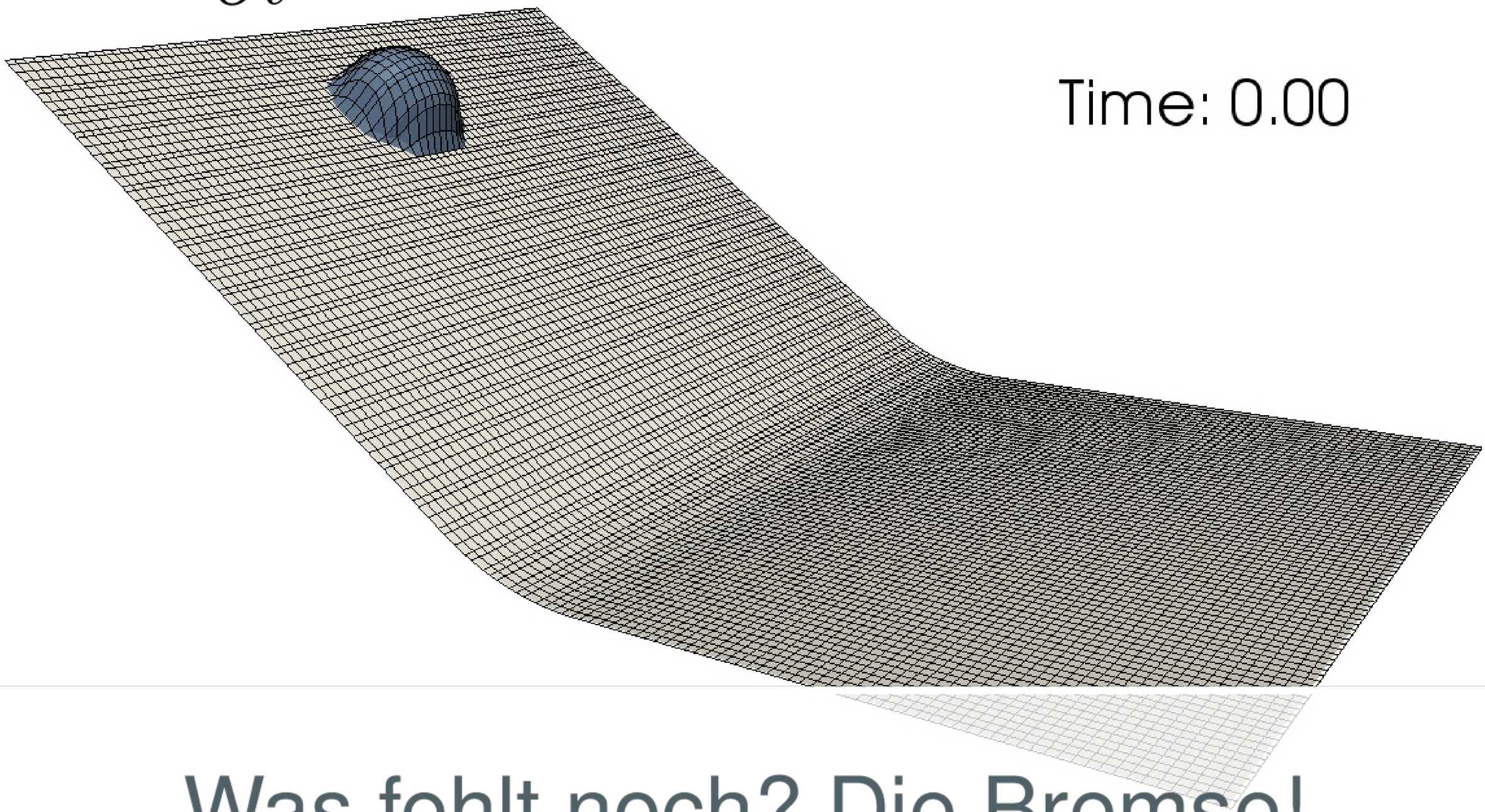
Gleich nochmal!

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g - \tau$$

Sohlreibung

Was fehlt noch? Die Bremse!

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g - \tau$$



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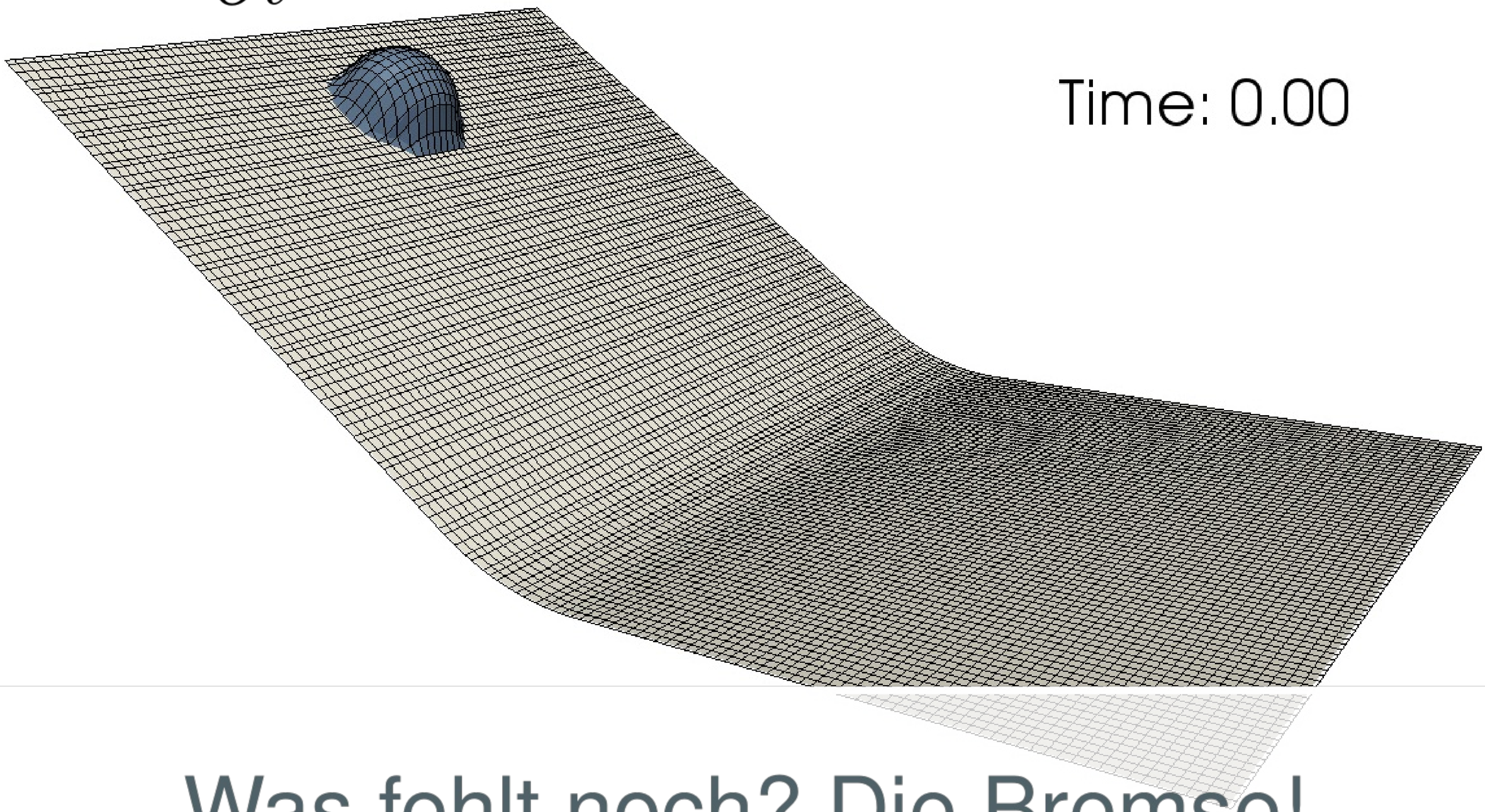
$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g - \tau$$



Was fehlt noch? Die Bremse!

Und die Lawine vom Anfang?

Und die Lawine vom Anfang?

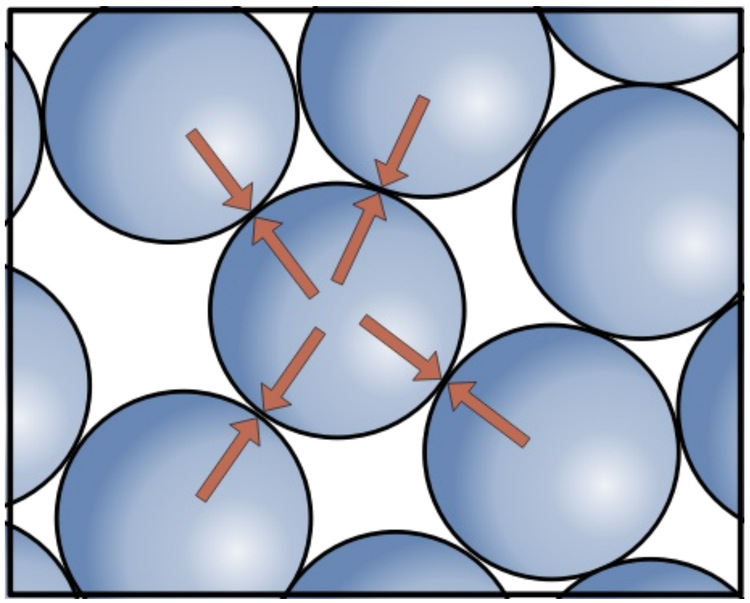
$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g - \tau$$

??

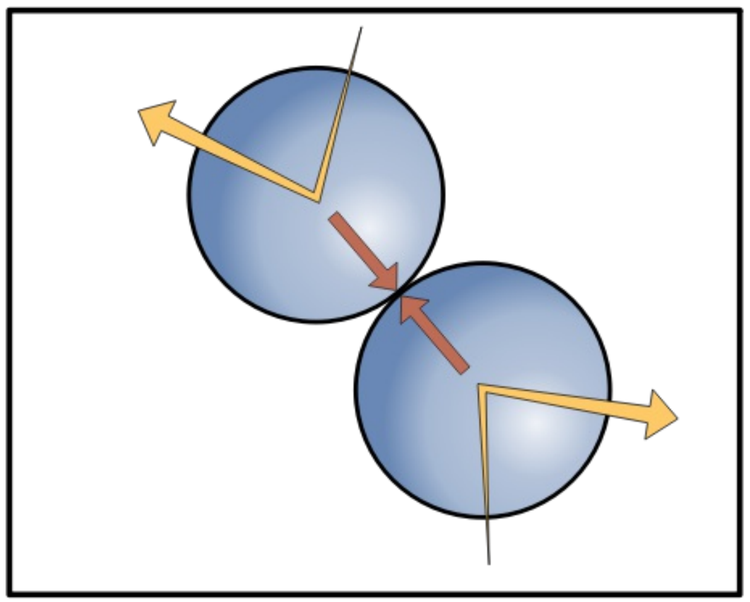
Was bremst eine Lawine?

$$\frac{\partial}{\partial t}(h\,u) + \nabla \cdot (h\,u\,u) = h\,g - \tau$$

Reibung



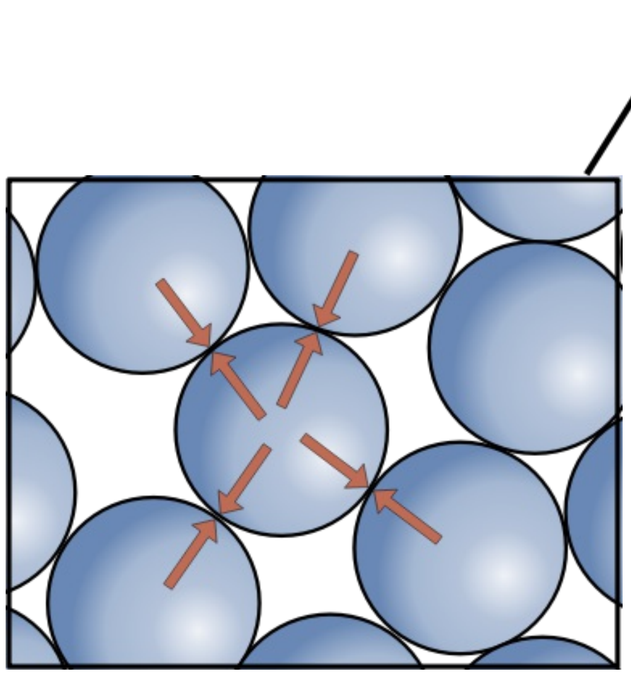
Kollisionen

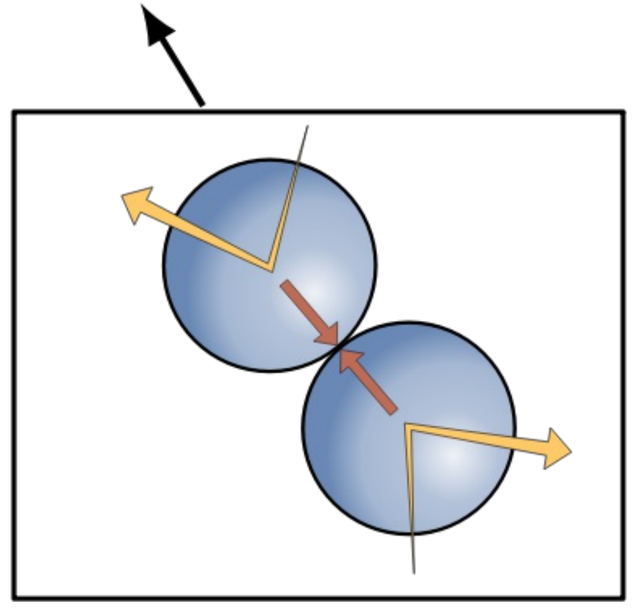


Was bremst eine Lawine?

Wie oft? Wie stark? Statistik

$$\tau = \mu\,\sigma + \frac{\rho\,g}{\chi}\,\frac{u^2}{h^2}$$

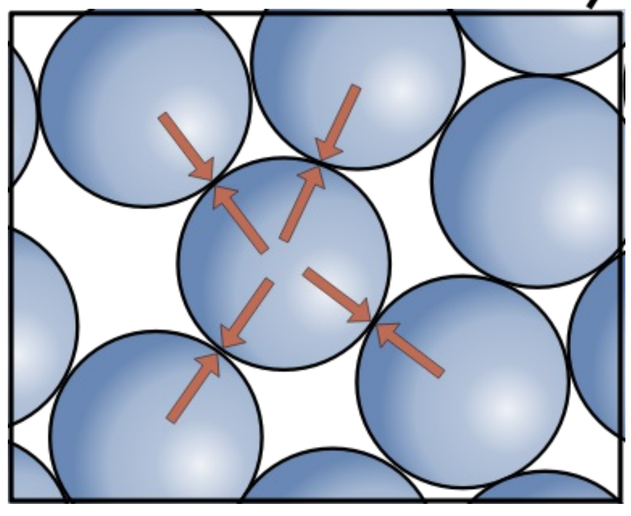


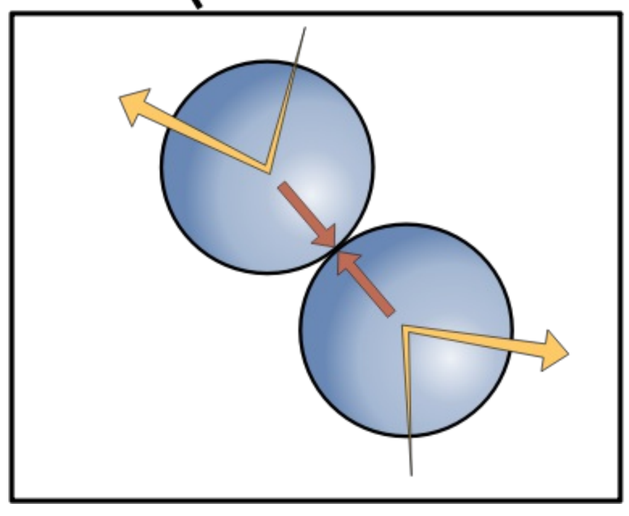


Kinetic Theory

Voellmy (1955) $\tau = \mu\,\sigma + \dfrac{\rho\,g}{\xi}\,u^2$

Kinetic Theory $\tau = \mu\,\sigma + \dfrac{\rho\,g}{\chi}\,\dfrac{u^2}{h^2}$

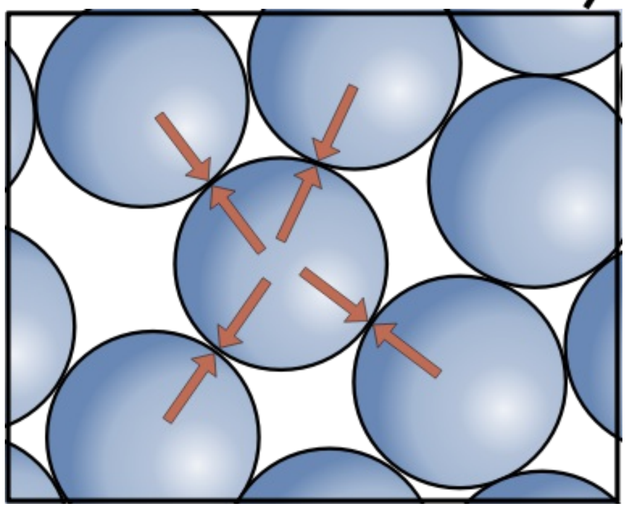


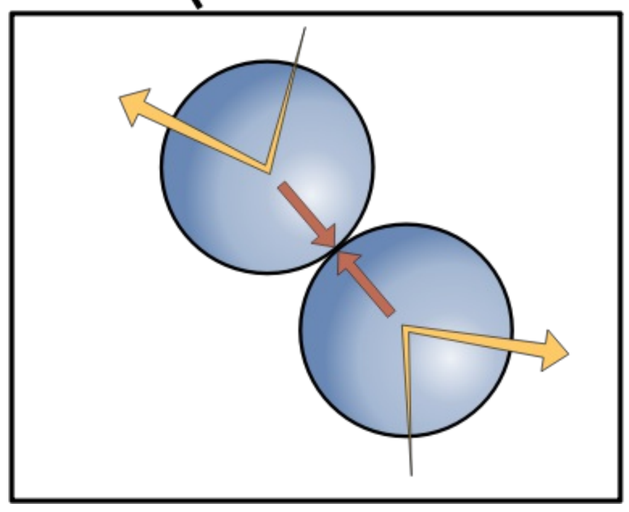


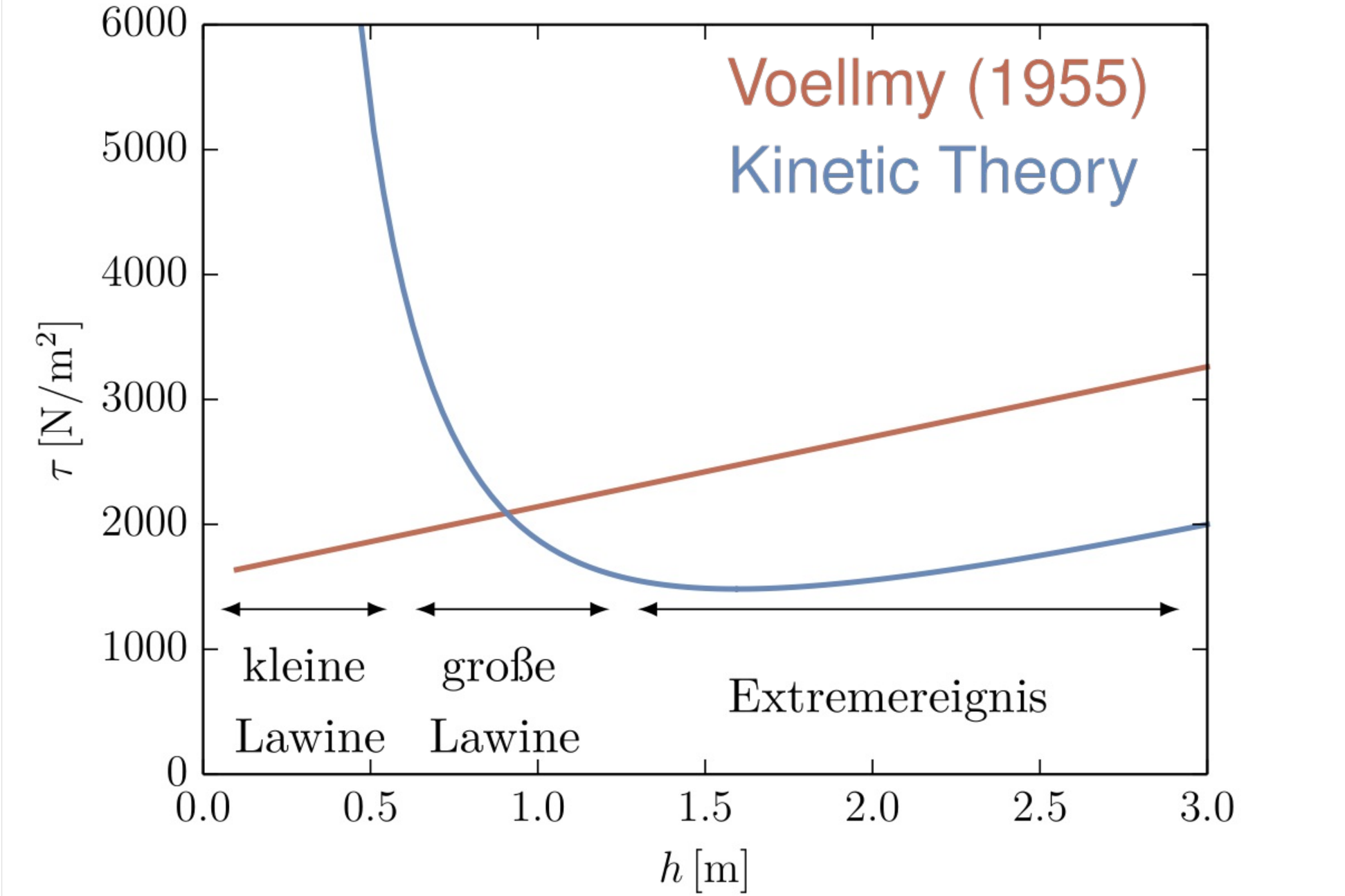
Voellmy (1955) $\tau = \mu\,\sigma + \frac{\rho\,g}{\xi} u^2$

neu!

Kinetic Theory $\tau = \mu\,\sigma + \frac{\rho\,g}{\chi} \frac{u^2}{h^2}$

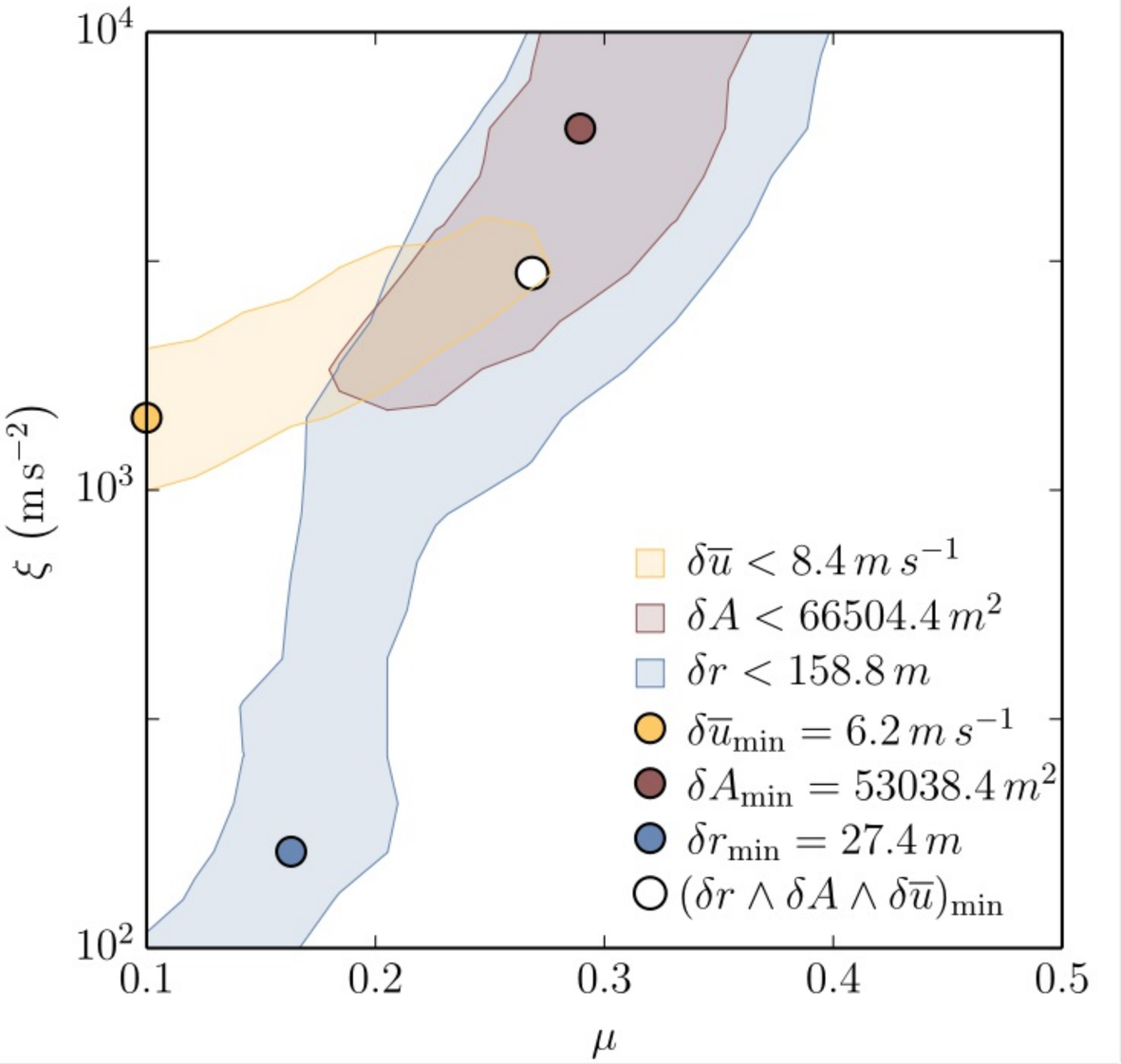




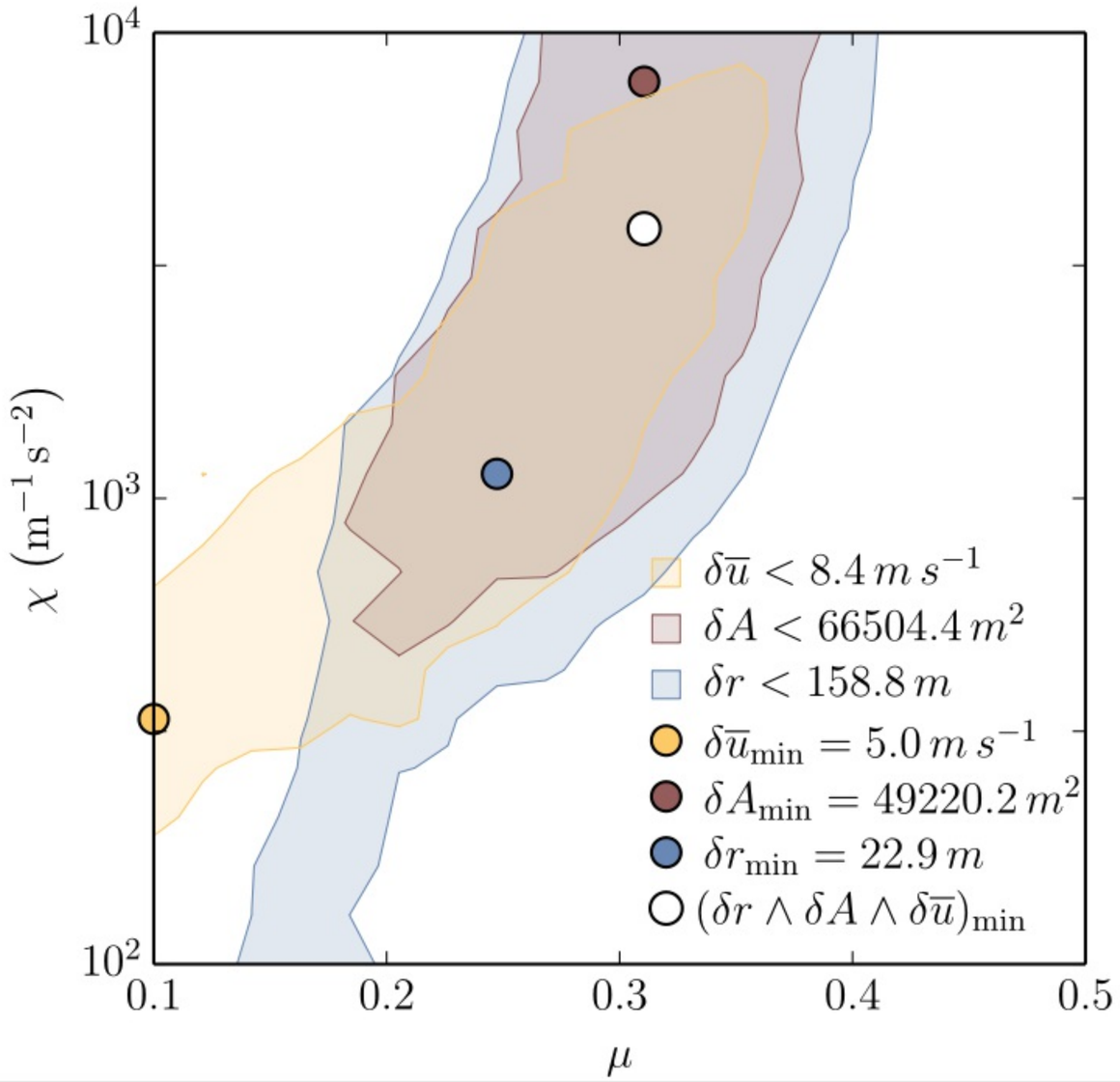


Abhängigkeit von der Höhe

Voellmy (1955)



Kinetic Theory



gleiche Parameter - viele Lawinen

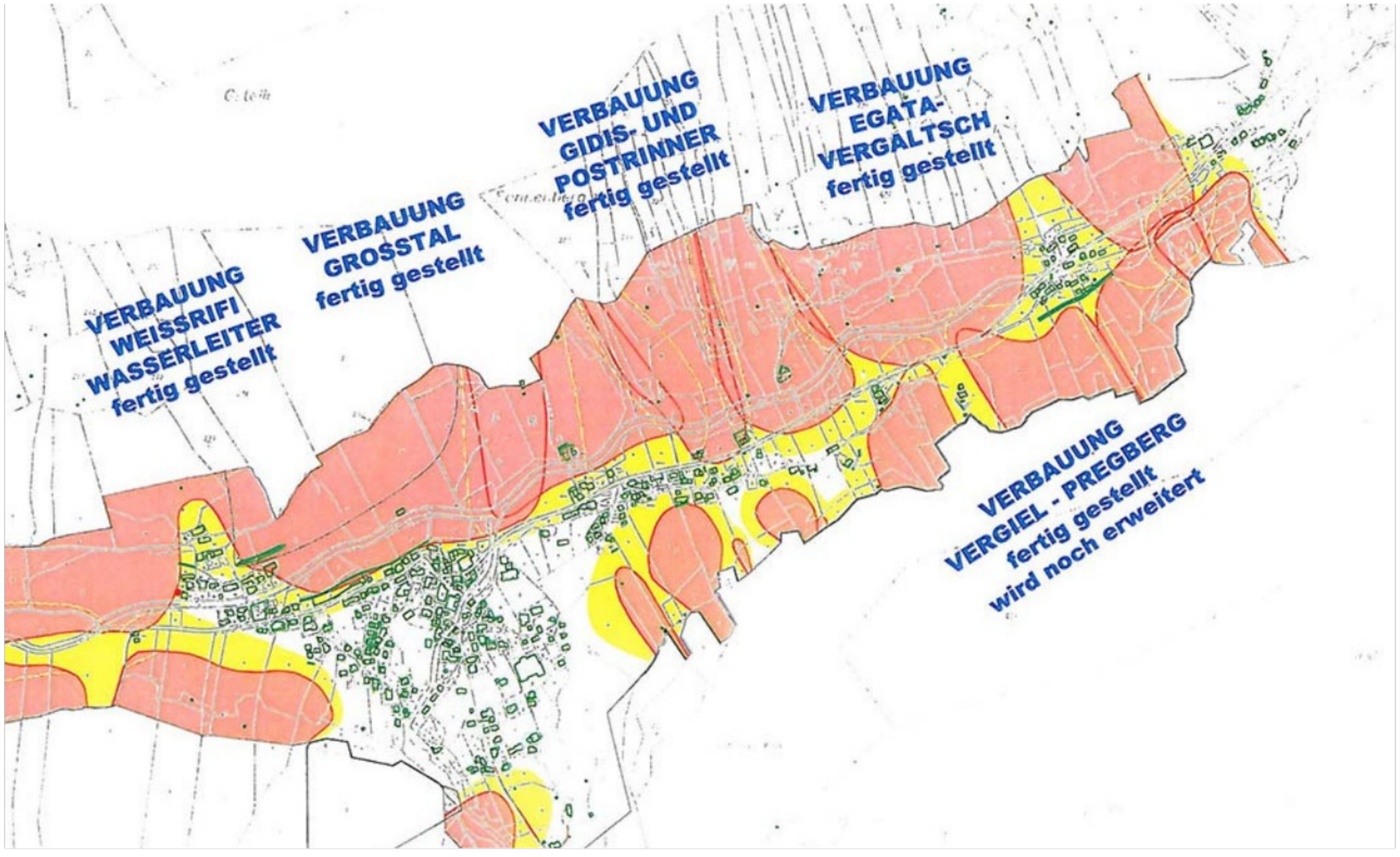
Galtür 1999 [dpa]

Was bringts? Schutz der Bevölkerung

Schneebrücken bei Zermatt [S. Margreth]

Was bringts? Effektive Maßnahmen

Gefahrenzonenplan Galtür



Was bringts? Siedlungsplanung

Mit freundlicher Unterstützung von:

BFW.

IGT

SLF

Vielen Dank für Ihre Aufmerksamkeit!