Transport processes that cause tsunamis and are caused by tsunamis

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Outline

Process that cause tsunamis:

$\rightsquigarrow$ Submarine landslides

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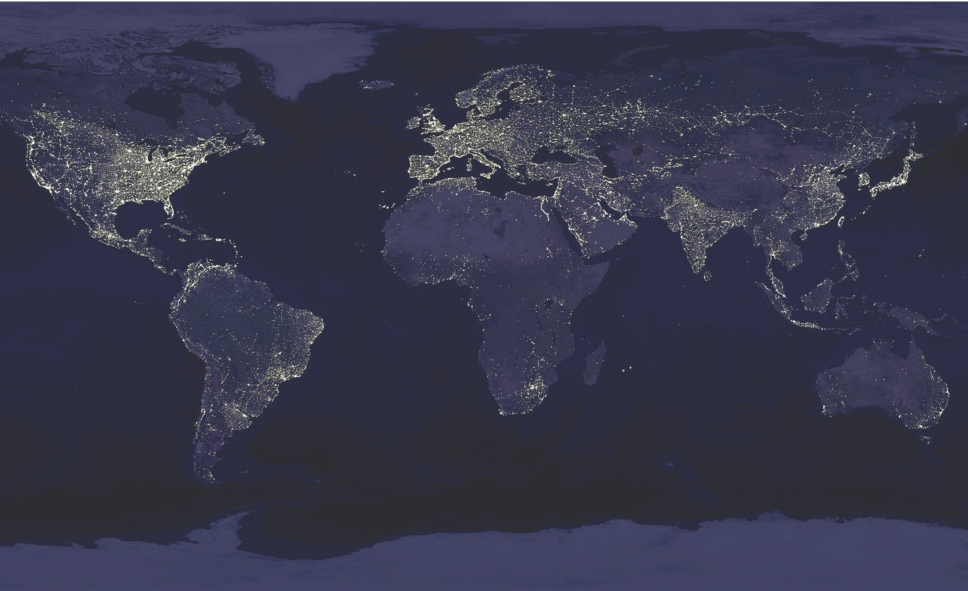
Process that cause tsunamis:

$\rightsquigarrow$ Submarine landslides

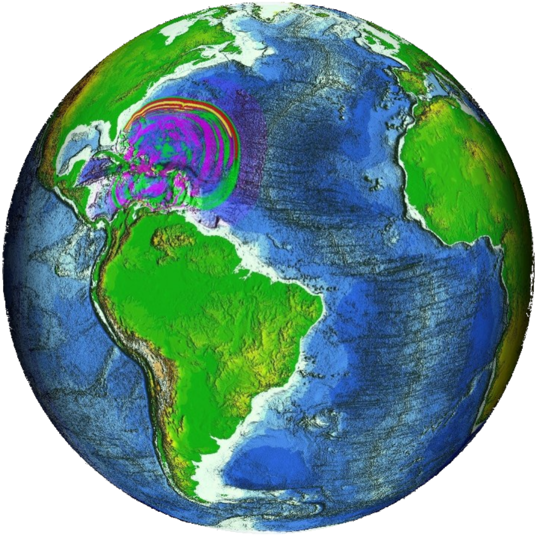
Process that is caused by tsunamis:

$\rightsquigarrow$ Sediment transport

General

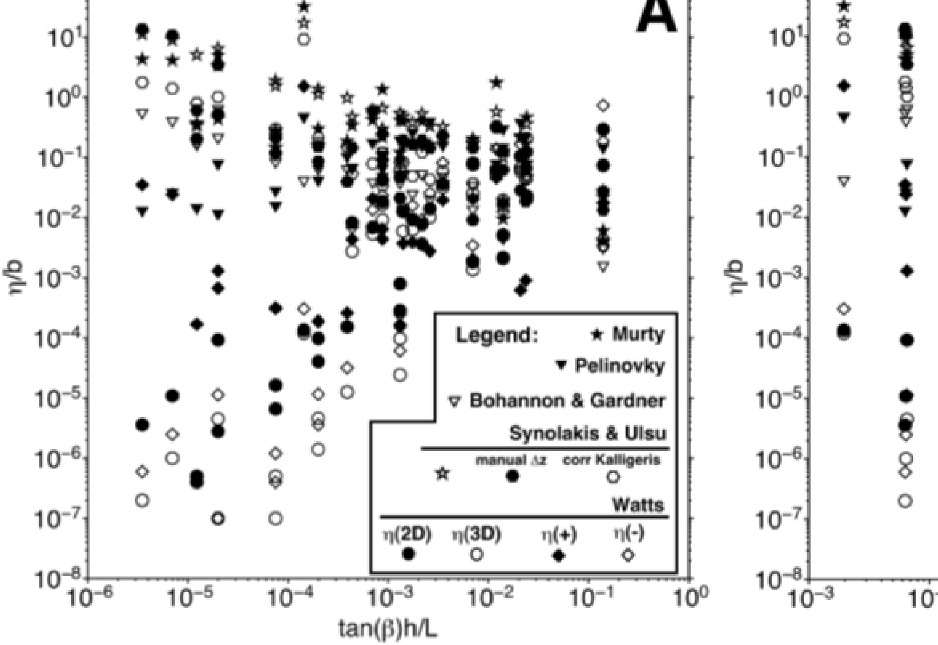


General

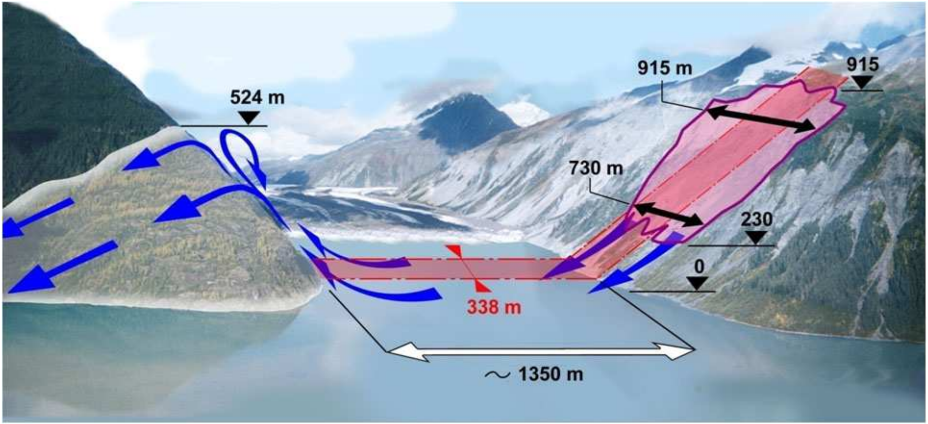


General

Submarine landslides


A
Legend:
Murty
Pelinovky
Bohannon & Gardner
Synolakis & Ulsu
manual Δz
corr Kalligeris
Watts
η(2D)
η(3D)
η(+)
η(-)
η/b
tan(β)h/L

Submarine landslides



iSALE

Simplified **A**rbitrary **L**agrangian **E**urlerian

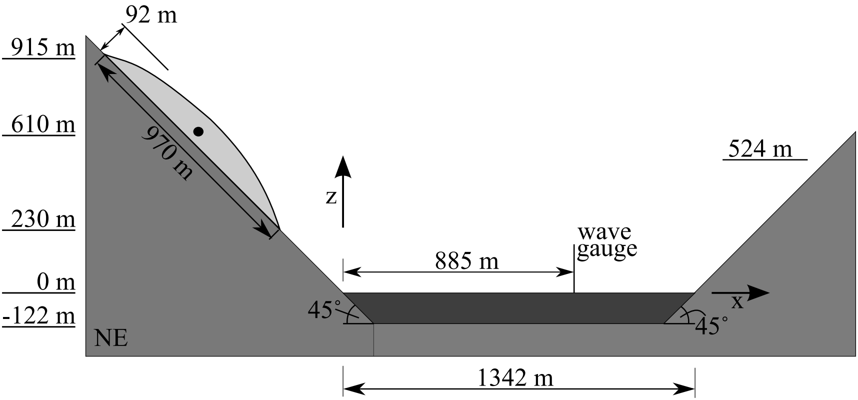
Submarine landslides

iSALE

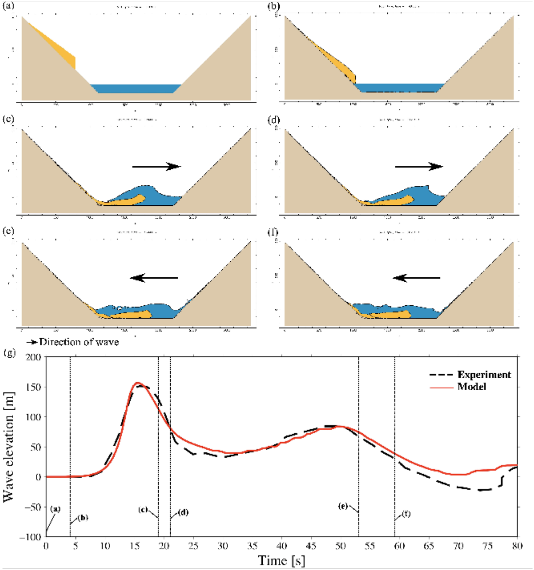
Simplified **A**rbitrary **L**agrangian **E**urlerian

- Compressible Navier–Stokes equations
- Constitutive and strength models
- Tracking of internal cell interfaces
- Extensively validated for impacts by experiments, other hydrocodes, and field data

Submarine landslides



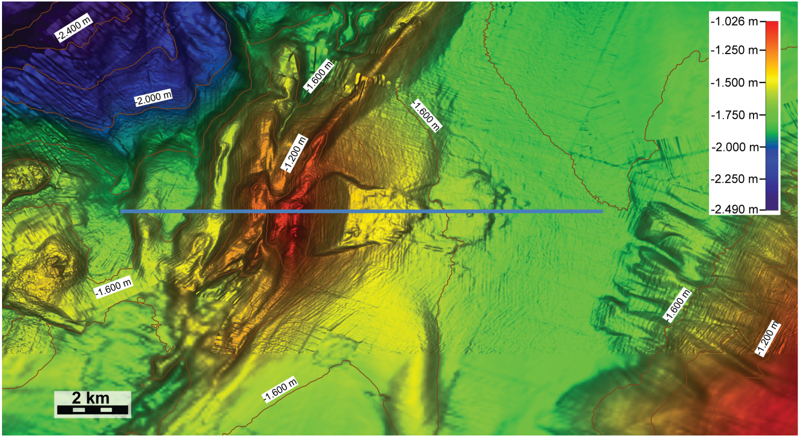
Submarine landslides



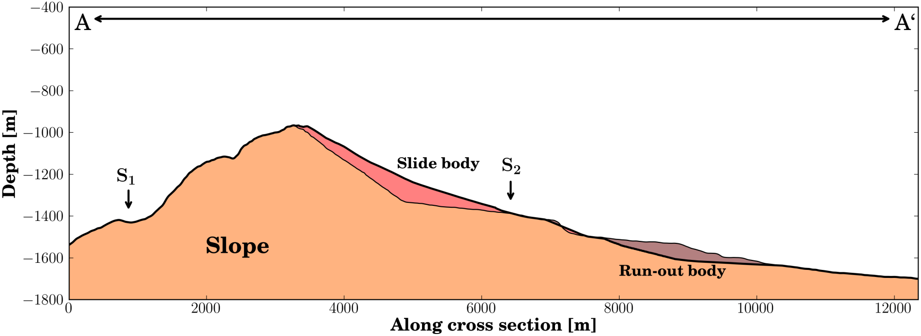
Submarine landslides

Valdes Slide

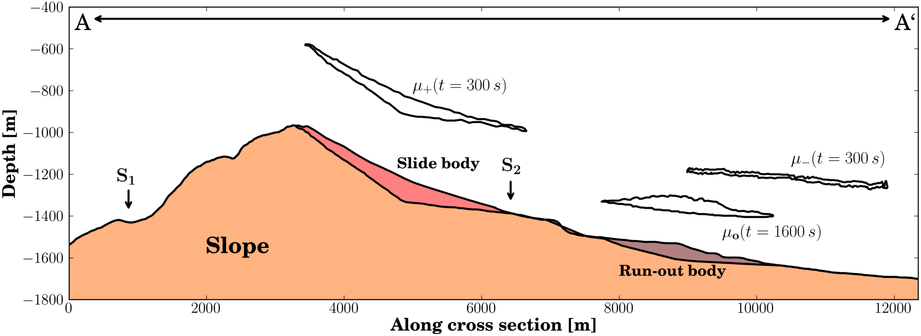
Submarine landslides



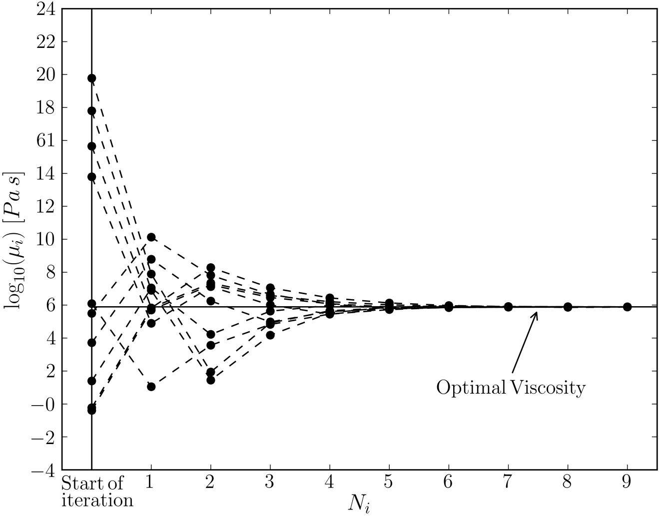
Submarine landslides



Submarine landslides



Submarine landslides



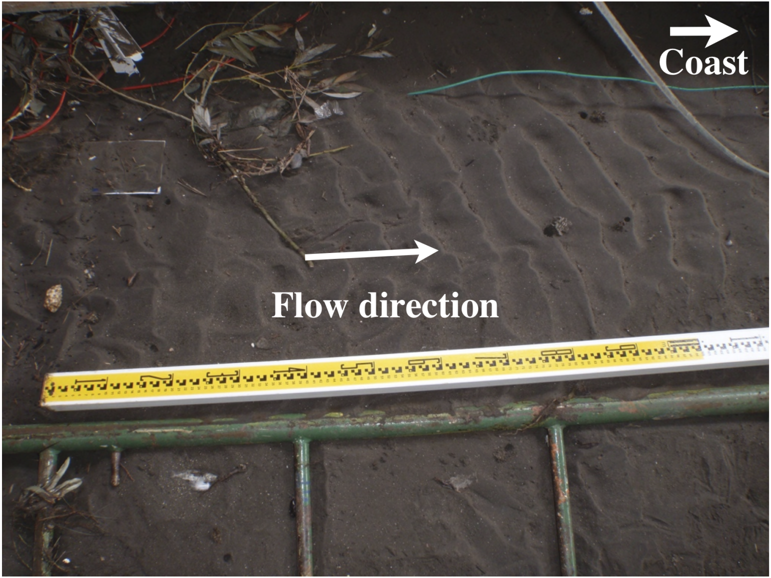
Tsunami deposits

Tsunami deposits

ϕ scale	Size range [mm]	Aggregate name
$-8 <$	> 256	Boulder
-6 to -8	64 - 256	Cobble
-5 to -6	32 - 64	Very coarse gravel
-4 to -5	16 - 32	Course gravel
-3 to -4	8 - 16	Medium gravel
-2 to -3	4 - 8	Fine gravel
-1 to -2	2 - 4	Very fine gravel
0 to -1	1 - 2	Very coarse sand
1 to 0	0.5000 - 1	Coarse sand
2 to 1	0.2500 - 0.5000	Medium sand
3 to 2	0.0125 - 0.2500	Fine dand
4 to 3	0.0062 - 0.0125	Very fine sand
> 4	< 0.0062	Silt, Mud

Tsunami deposits

Tsunami deposits



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Tsunami deposits

Small Grain Sizes

The Honeymoon equations:

The sediment in this domain is thought to be much smaller than the expected fluid structures, which results in a continuum model for particles in suspension and for the fluid. Theoretically there are N different grain-size classes in the domain. The different classes have a volume fraction of $\chi_s(t, \boldsymbol{x})$ with $s = 1, \ldots, N$. Hence, the volume fraction for the fluid is $\chi_0 = 1 - \sum \chi_k$. Furthermore, parameters with over-lines, such as $\overline{\chi}$, are averaged by the Favre method ($\chi' = \chi - \overline{\chi}$). The velocity of each grain-size class is denoted by $u_i^s(t, \boldsymbol{x})$; where a constant grain density is assumed for simplicity. The velocity of the fluid is denoted with $u^f(t, \boldsymbol{x})$. The velocity of the solid phase is $\widetilde{u}_i^s = (\overline{\chi u_i^s}) / (\overline{\chi_s})$ and of the fluid phase, $\widetilde{u}_i^f = (\overline{\chi_0 u_i^f}) / (\overline{\chi_0})$. The velocity fluctuations then become $\Delta u^f = u^f \widetilde{u}_i^f$ and $\Delta u_i^s = u_i^s - \widetilde{u}_i^s$. Using these definitions, the continuity and momentum equations for the fluid and solid phase can be derived. The continuity equation for the fluid phase is:

$$\frac{\partial \rho_f \overline{\chi_0}}{\partial t} + \partial \frac{\rho_f \overline{\chi_0} \widetilde{u}_i^f}{\partial x_i} = 0 \tag{1}$$

The momentum equation for the fluid phase is:

$$\frac{\partial \rho_f \overline{\chi_0} \widetilde{u}_i^f}{\partial t} + \frac{\rho_f \overline{\chi_0} \widetilde{u}_i^f \widetilde{u}_j^f}{\partial x_j} = -\overline{\chi_0} \frac{\partial \overline{P^f}}{\partial x_i} + \frac{\partial T_{ij}^{fT}}{\partial x_j} + \rho_f \overline{\chi_0} g_i + \sum_s \left(\beta \overline{\chi_s} \left(\tilde{u}_i^f - \tilde{u}_i^s \right) + \beta \nu_T \frac{\partial \overline{\chi_s}}{\partial x_i} \right) \tag{2}$$

The momentum equation for the solid phase is:

$$\frac{\partial \rho_s \overline{\chi_s} \widetilde{u}_i^s}{\partial t} + \frac{\rho_s \overline{\chi_s} \widetilde{u}_i^s \widetilde{u}_j^s}{\partial x_j} = -\overline{\chi_s} \frac{\partial \overline{P^f}}{\partial x_i} + \rho_s \overline{\chi_s} g_i - \beta \overline{\chi_s} \left(\tilde{u}_i^f - \tilde{u}_i^s \right) + \beta \nu_T \frac{\partial \overline{\chi_s}}{\partial x_i} \tag{3}$$

with T_{ij}^{fT} representing fluid stresses and P^f, the fluid pressure. For the fluid stresses, a respective turbulence-closure model, such as $k - \epsilon$, needs to be applied. Finally, the continuity equation for the solid phase is:

$$\frac{\partial \rho_s \overline{\chi}}{\partial t} + \partial \frac{\rho_s \overline{\chi} \widetilde{u}_i^s}{\partial x_i} = 0 \tag{4}$$

With the presented framework, the advection-diffusion equation becomes:

$$\frac{\partial \rho_s \overline{\chi_s}}{\partial t} + \frac{\partial}{\partial x_i} [(\tilde{u}_i - w_s \delta_{j3}) \rho_s \overline{\chi_s}] = \frac{\partial}{\partial x_i} \left(\frac{\nu_T}{\sigma_k} \frac{\partial \rho_s \overline{\chi_s}}{\partial x_i} \right) \tag{5}$$

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AFP/ Jiji Press

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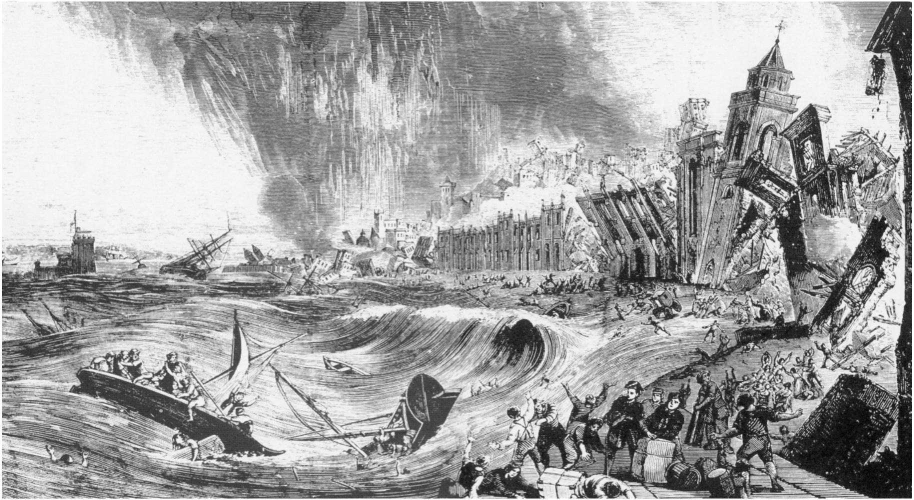
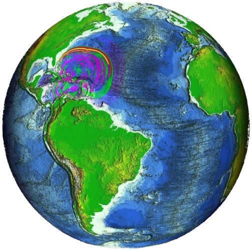


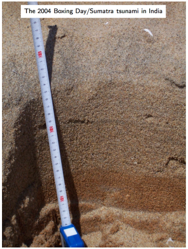
Tsunami deposits

Tsunami deposits

Motivation



$\Longrightarrow$



$\Longrightarrow$

Tsunami deposits