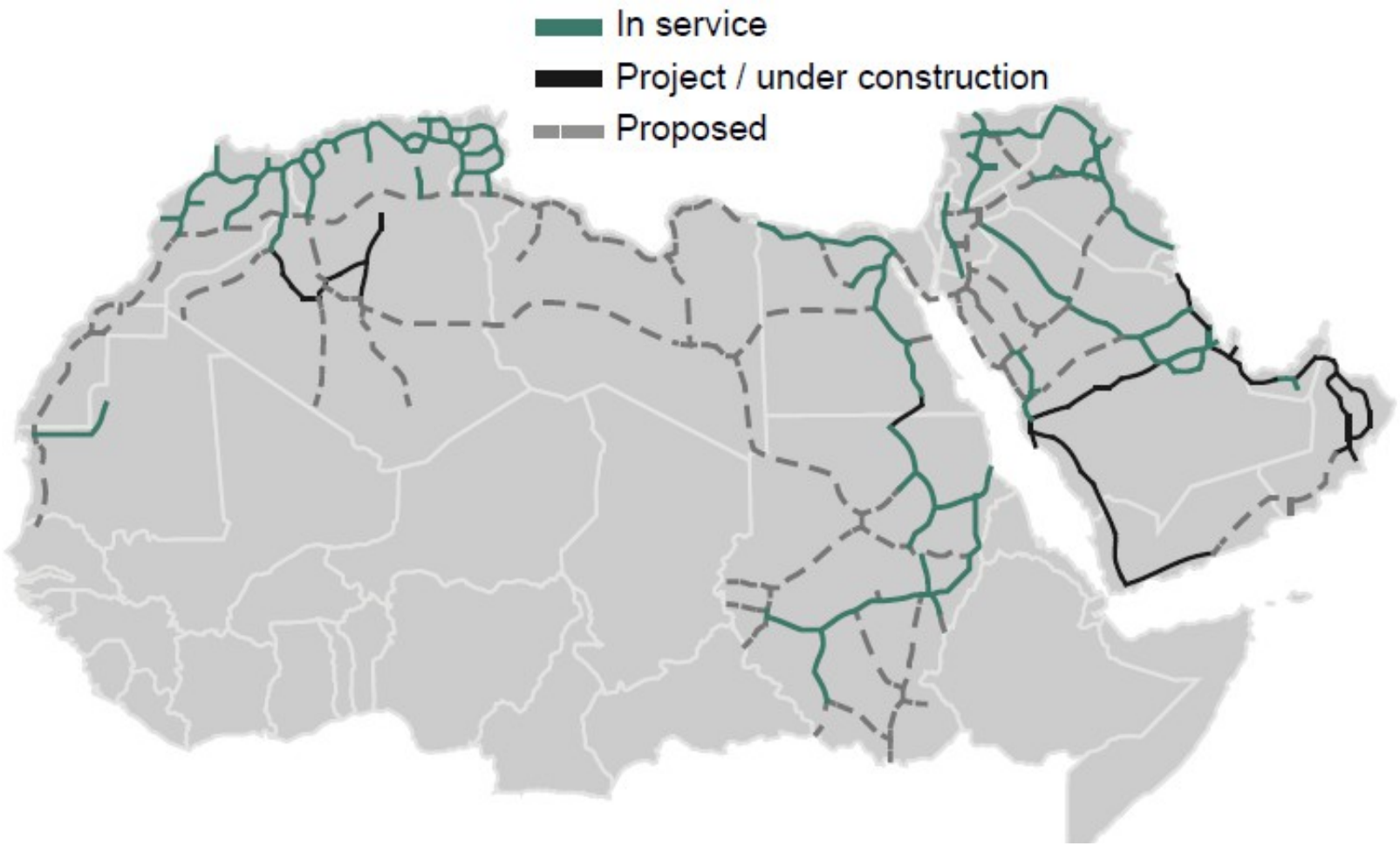
POLITECNICO DI TORINO

Modelling sand motion and protection systems

Luigi Preziosi

Progetti



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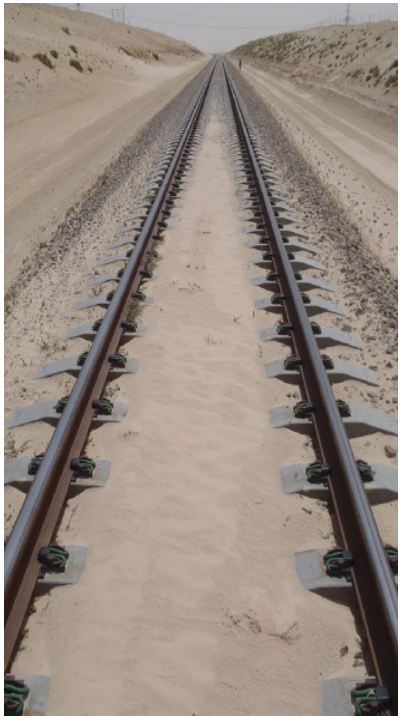
Problems



Ballast contamination

Problems

Communication balise covering

- **Running train derailments**
- **Parked train trapping**
- **Asymmetric consumption of wheels and rails**

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Problems

“We have to clean the track form sand every night”
El Pais, 6 febbraio 2015

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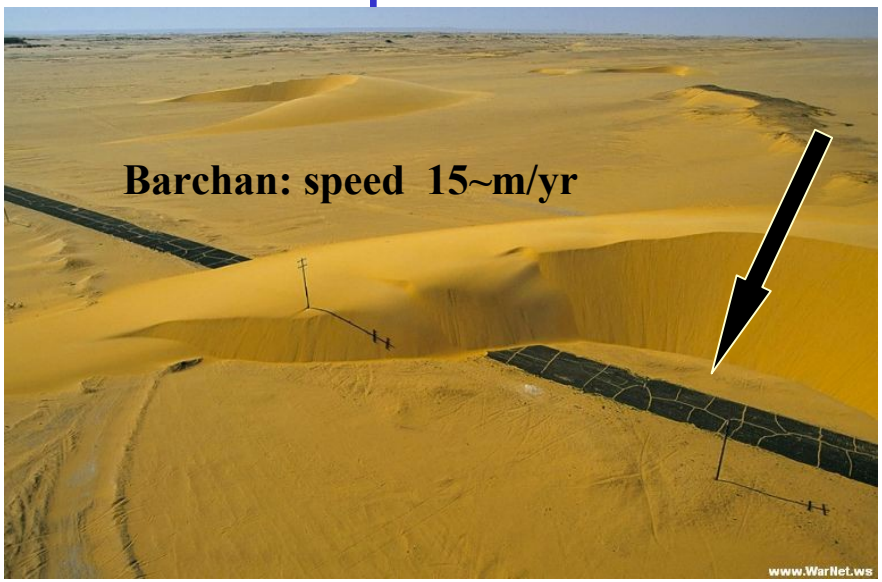
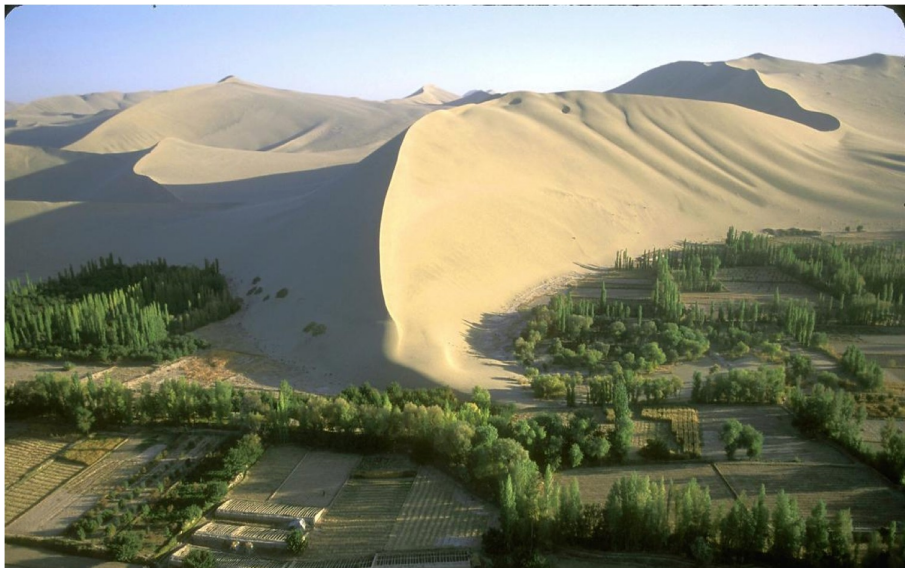
Problems





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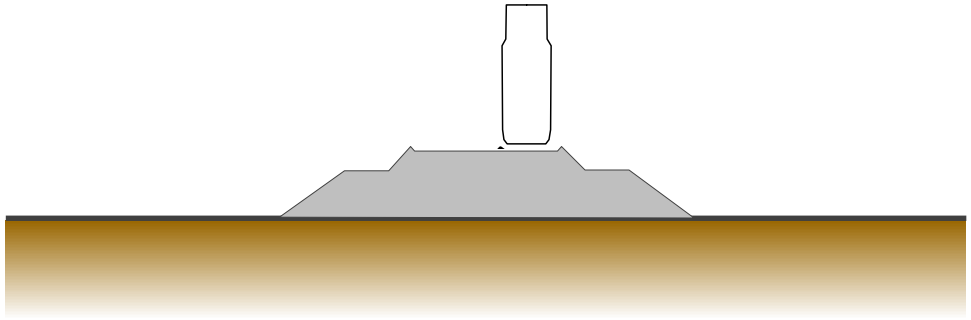
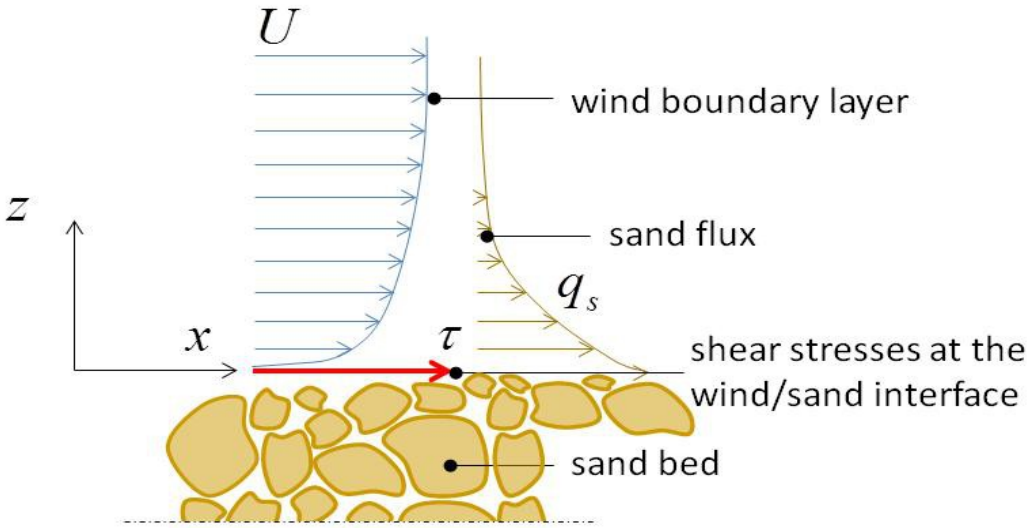
Standard protection systems



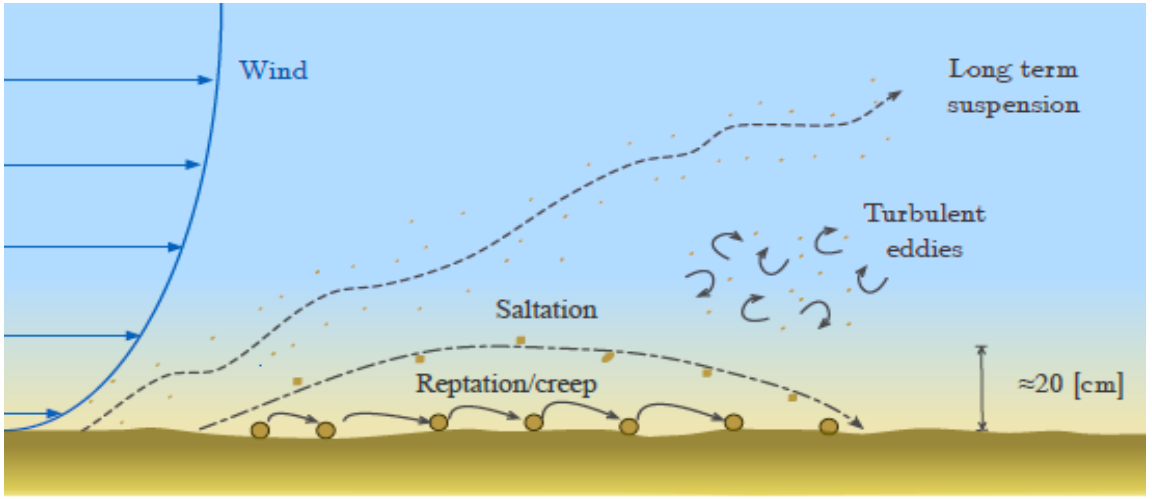
Phenomenological observation

- **Erosion**



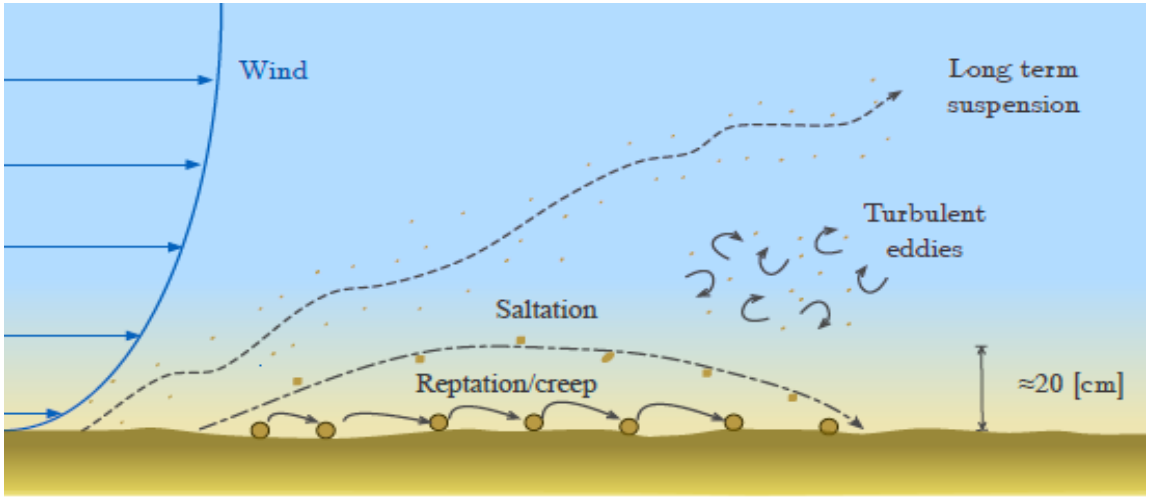
Osservazione fenomenologica

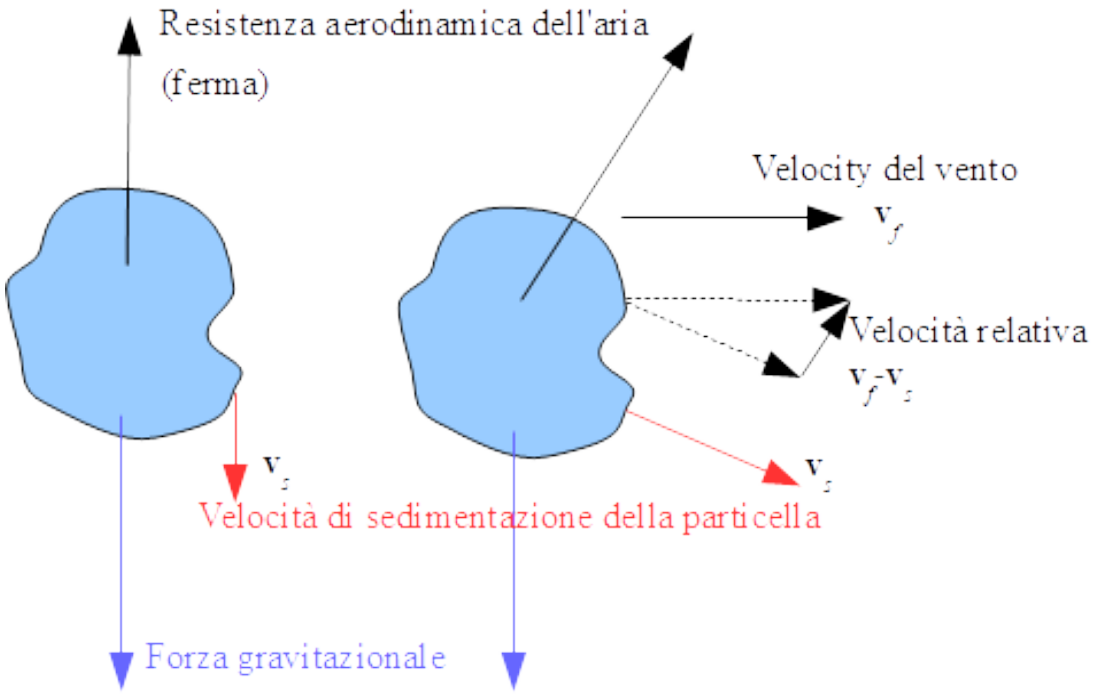
- **Erosion**
- **Transport**



Phenomenological observation

- **Erosion**
- **Transport**
- **Sedimentation**





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Phenomenological observation

- Erosion
- Transport
- Sedimentation
- Sand structure interaction

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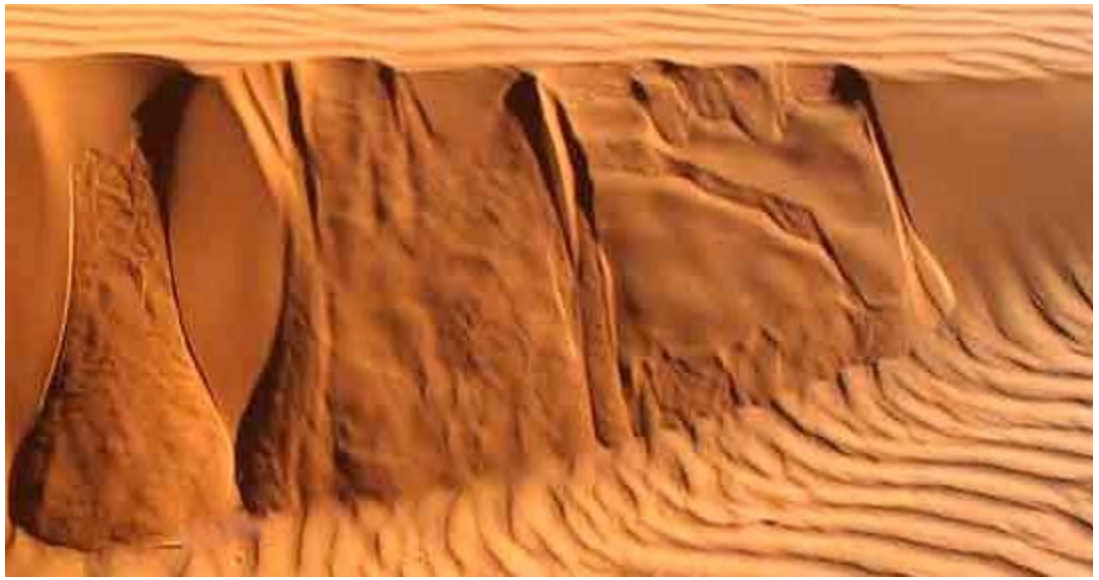
Osservazione fenomenologica

- Erosion
- Transport
- Sedimentation
- Sand structure interaction
- Sand avalanches



Osservazione fenomenologica

- **Erosione** — Il vento interagisce con il terreno ed erode la sabbia
- **Trasporto** — Il vento trasporta la sabbia
- **Sedimentazione** — La sabbia sedimenta

  La sabbia si accumula
- **Interazione con le strutture** — Il flusso del vento e della sabbia viene modificato dalle strutture
- **Svalangamento** — La sabbia scivola

  La superficie evolve

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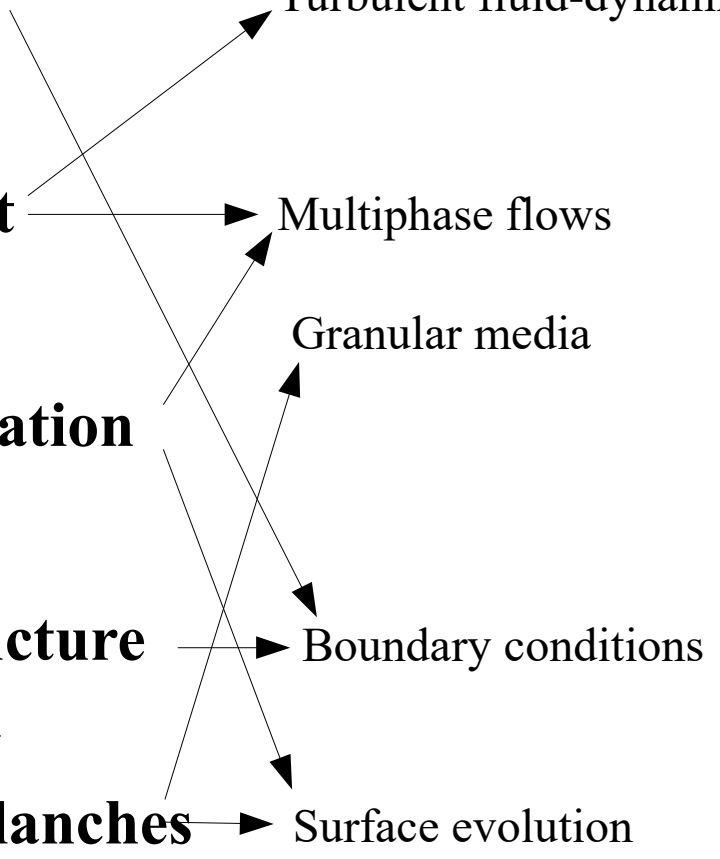
Mathematical modelling

- **Erosion**
- **Transport**
- **Sedimentation**
- **Sand structure interaction**
- **Sand avalanches**



$$\begin{cases} \nabla \cdot \overline{u}_f = 0 \\ \dfrac{\partial \overline{u}_f}{\partial t} + \overline{u}_f \cdot \nabla \overline{u}_f = -\dfrac{1}{\rho_a}\nabla \overline{p} + \nabla \cdot [(\nu_a + \nu_t)\nabla \overline{u}_f] \\ \dfrac{\partial k}{\partial t} + \nabla \cdot (\overline{u}_f k) = \nabla \cdot [(\nu_a + \nu_t)\nabla k] + P_k - \gamma \omega k \\ \dfrac{\partial \omega}{\partial t} + \nabla \cdot (\overline{u}_f \omega) = \nabla \cdot [(\nu_a + \nu_t)\nabla \omega] + P_\omega - C_\omega \omega^2 \end{cases}$$

$$\begin{cases} \dfrac{\partial \rho_f}{\partial t} + \nabla \cdot (\rho_f \mathbf{u}_f) = 0\,, \\ \rho_f \left(\dfrac{\partial \mathbf{u}_f}{\partial t} + \mathbf{u}_f \cdot \nabla \mathbf{u}_f \right) = -\phi_f \nabla p + \nabla \cdot \mathbf{T}_f + \rho_f \mathbf{g} - \mathbf{m}\,, \end{cases}$$

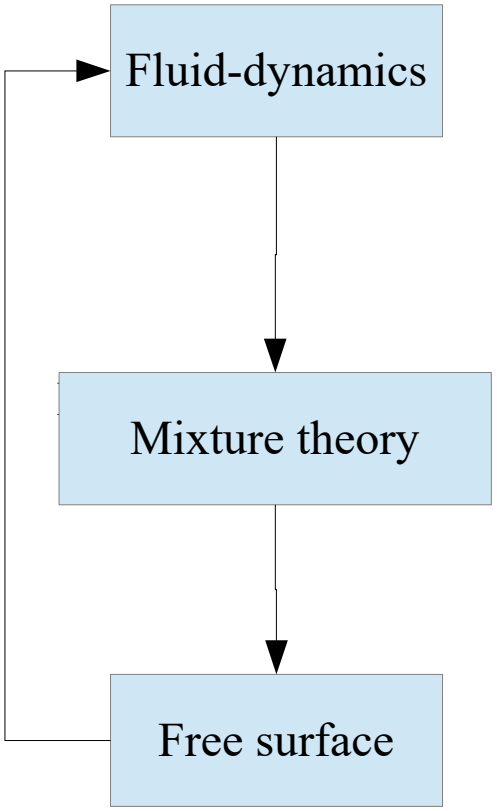
$$\begin{cases} \dfrac{\partial \rho_s}{\partial t} + \nabla \cdot (\rho_s \mathbf{u}_s) = 0\,, \\ \rho_s \left(\dfrac{\partial \mathbf{u}_s}{\partial t} + \mathbf{u}_s \cdot \nabla \mathbf{u}_s \right) = -\phi_s \nabla p + \nabla \cdot \mathbf{T}_s + \rho_s \mathbf{g} + \mathbf{m}\,, \end{cases}$$

$$q_s = \frac{w_{ej} \alpha \hat{\rho}_f}{g d} \hat{\beta} \left(u_*^2 - u_{*,t}^2 \right)_+$$

$$\frac{\partial h}{\partial t} = \nu \nabla \cdot \left[\frac{(|\nabla h| - \tan \bar{\theta})_+}{\sqrt{1 + |\nabla h|^2}} \frac{\nabla h}{|\nabla h|} \right] + q\,,$$

Modellizzazione matematica

- **Erosion**
- **Transport**
- **Sedimentation**
- **Sand avalanches**



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$$\begin{cases} \dfrac{\partial \rho_s}{\partial t} + \nabla \cdot (\rho_s \mathbf{u}_s) = 0 \,, \\ \rho_s \left(\dfrac{\partial \mathbf{u}_s}{\partial t} + \mathbf{u}_s \cdot \nabla \mathbf{u}_s \right) = -\phi_s \nabla p + \nabla \cdot \mathbf{T}_s + \rho_s \mathbf{g} + \mathbf{m} \,, \end{cases}$$

$$\begin{cases} q_s = \dfrac{w_{ej} \alpha \hat{\rho}_f}{g d} \hat{\beta} \left(u_*^2 - u_{*,t}^2 \right)_+ \\ \dfrac{\partial h}{\partial t} = \nu \nabla \cdot \left[\dfrac{(|\nabla h| - \tan \bar{\theta})_+}{\sqrt{1 + |\nabla h|^2}} \dfrac{\nabla h}{|\nabla h|} \right] + q \,, \end{cases}$$

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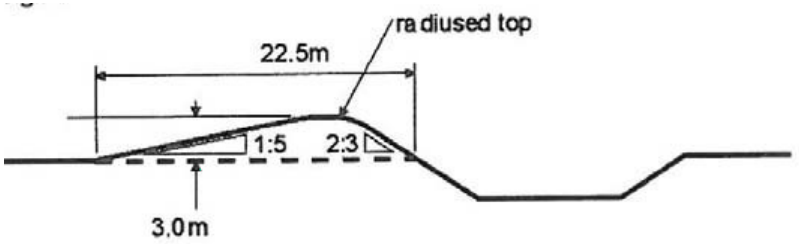
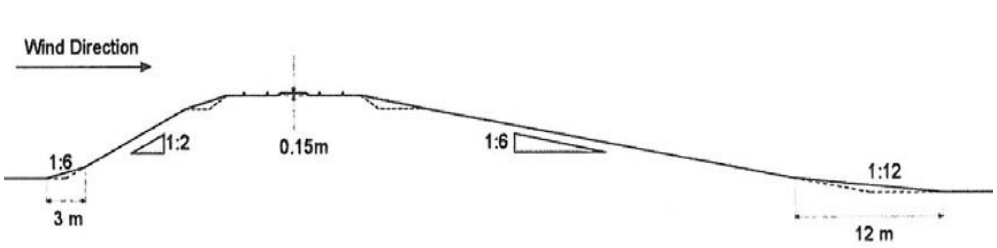
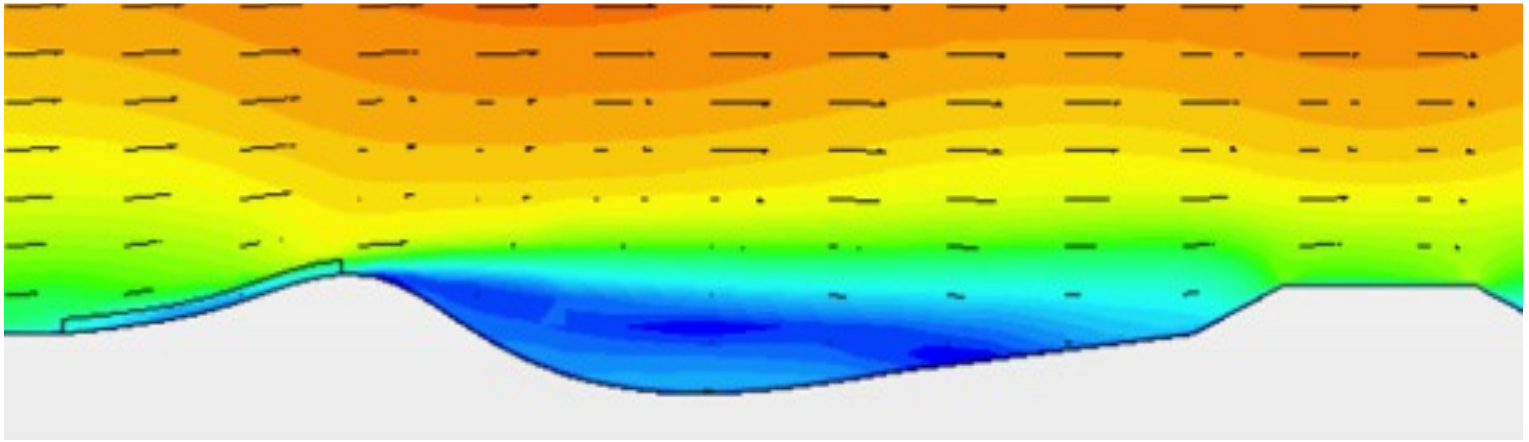
Fluid-dynamics







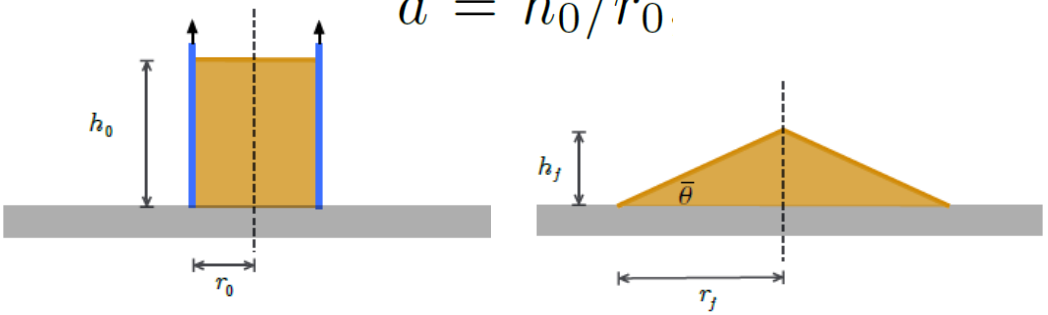
POLITECNICO DI TORINO

Sand sliding

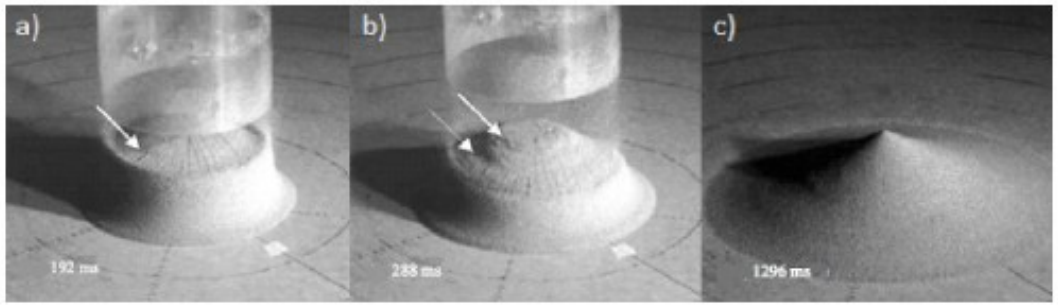
$$\frac{\partial h}{\partial t} = \nu \nabla \cdot \left[\frac{(|\nabla h| - \tan\bar{\theta})_+}{\sqrt{1+|\nabla h|^2}} \frac{\nabla h}{|\nabla h|} \right] + q \,,$$

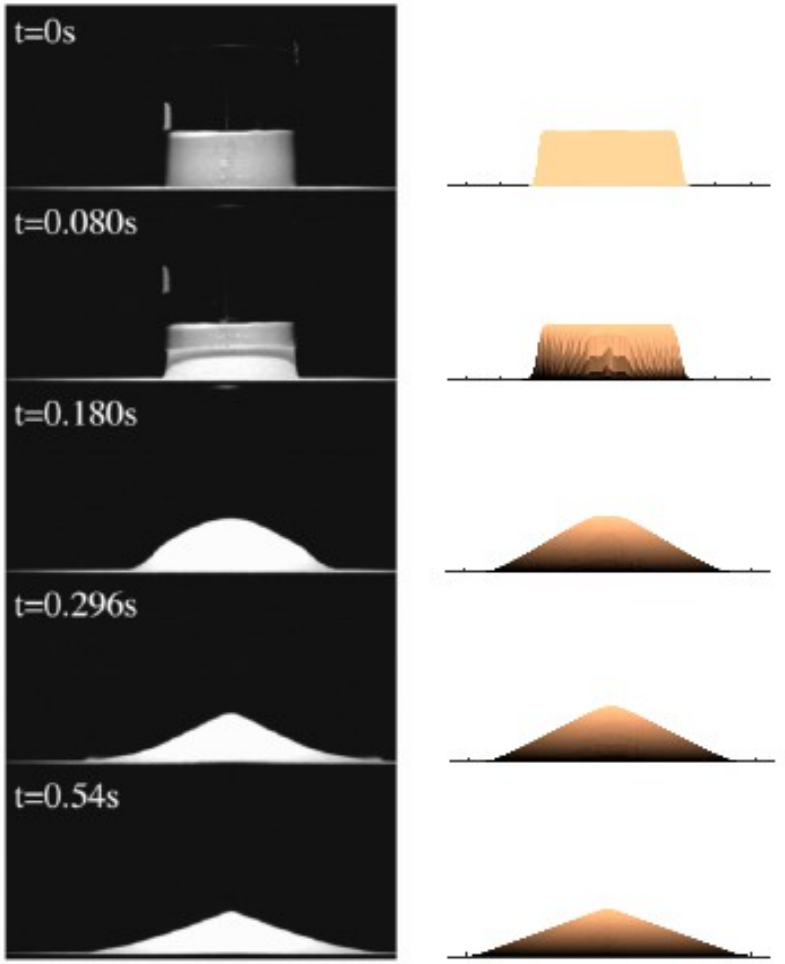
Sand sliding

$$a = h_0/r_0$$



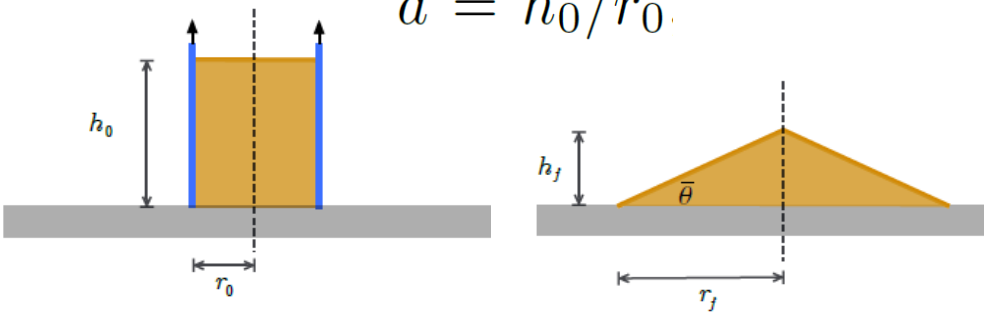
a > 0.74



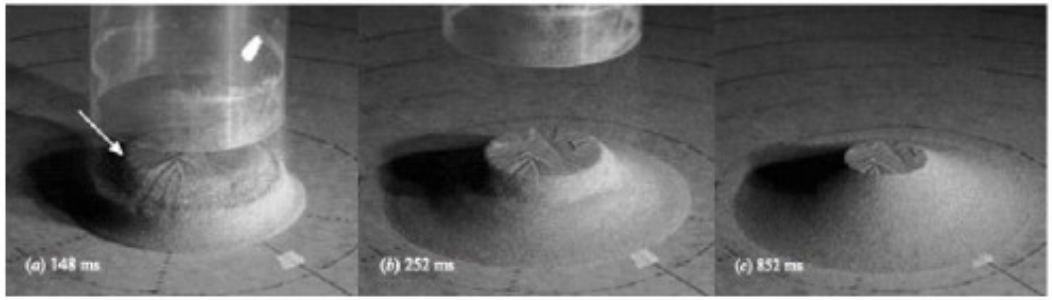


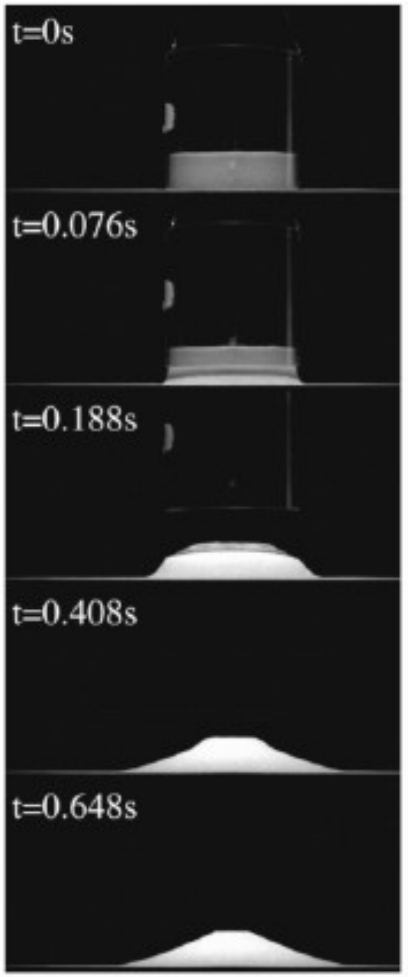
Sand sliding

$$a = h_0/r_0$$

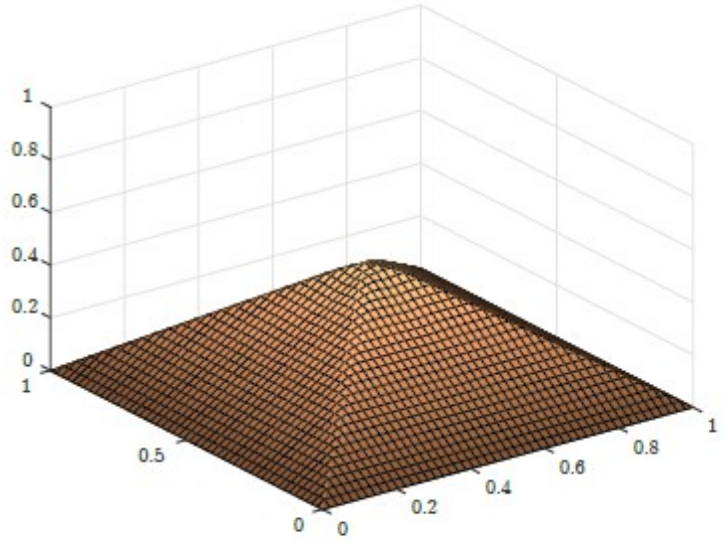


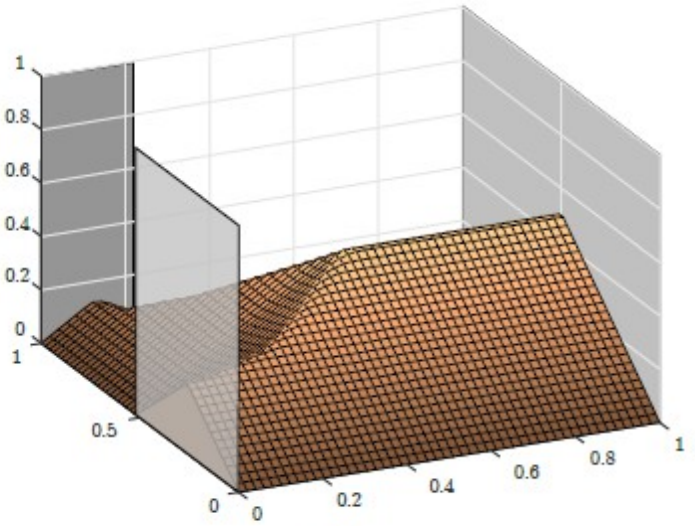
a < 0.74



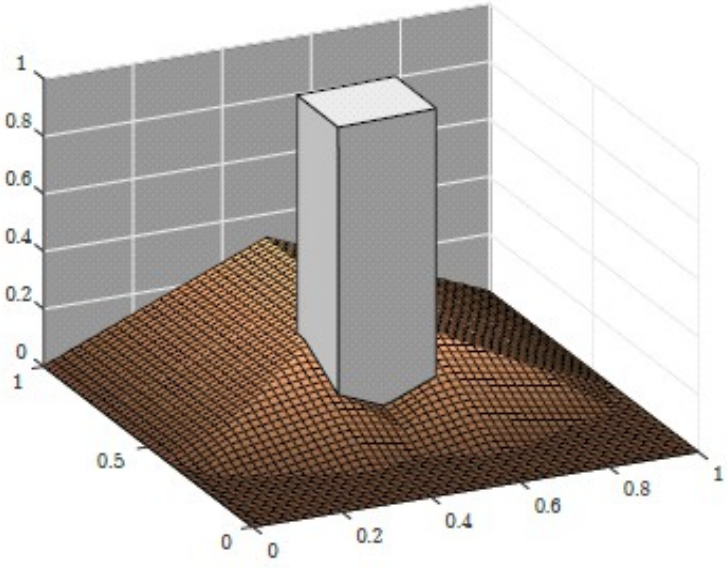


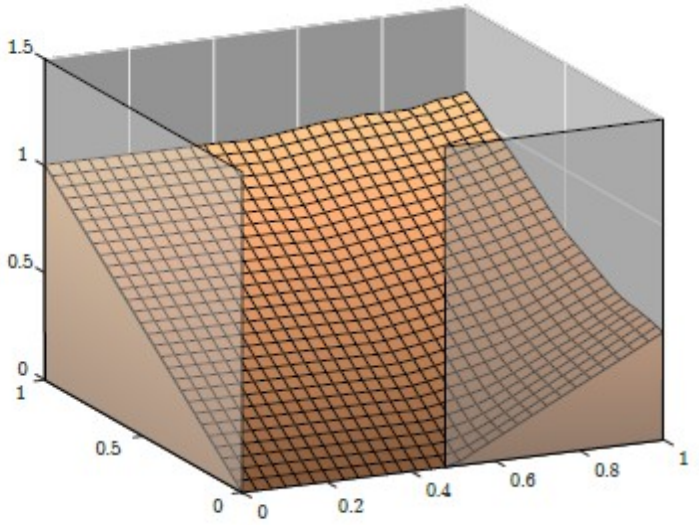
Sand sliding





(a)





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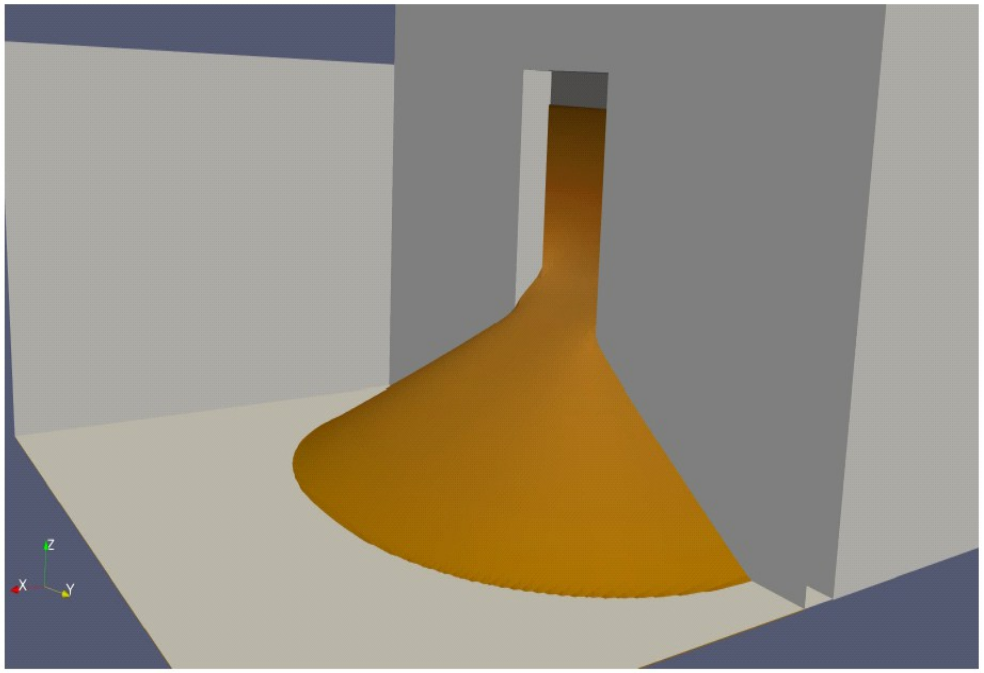
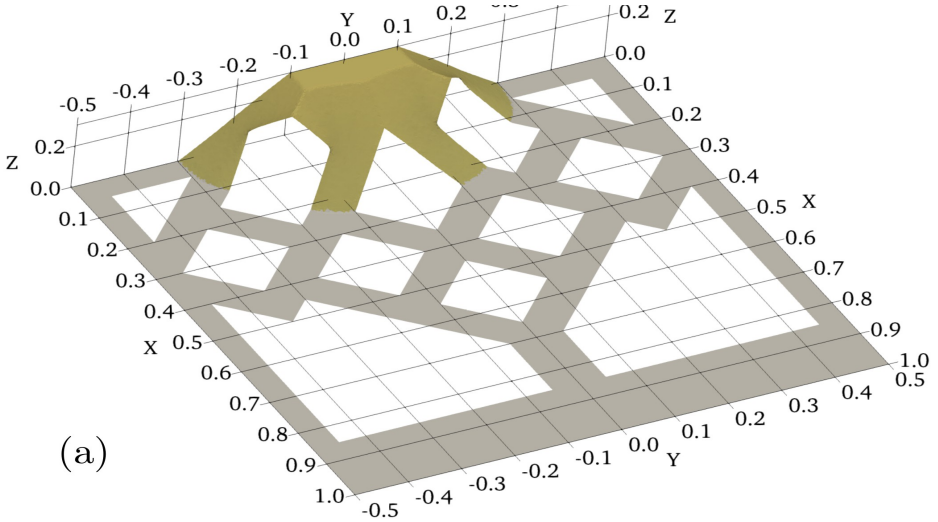
Sand sliding





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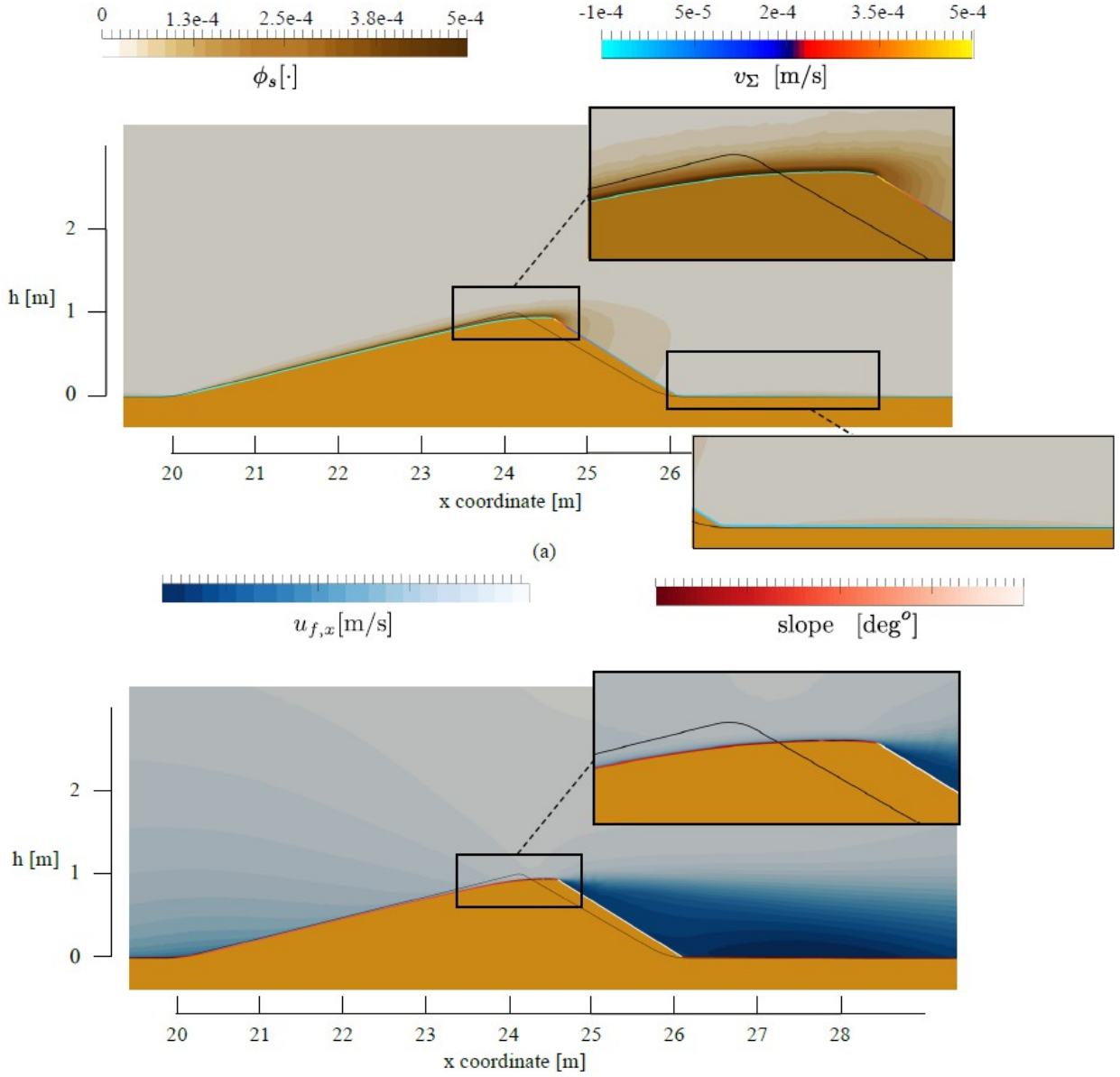
Dune motion



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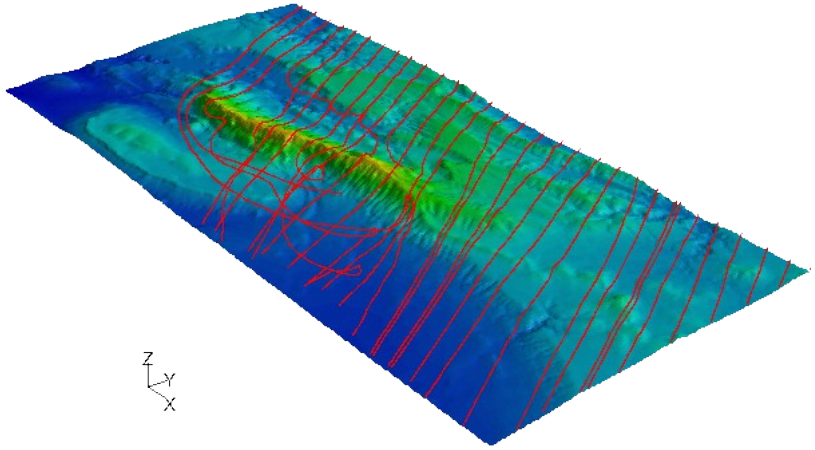
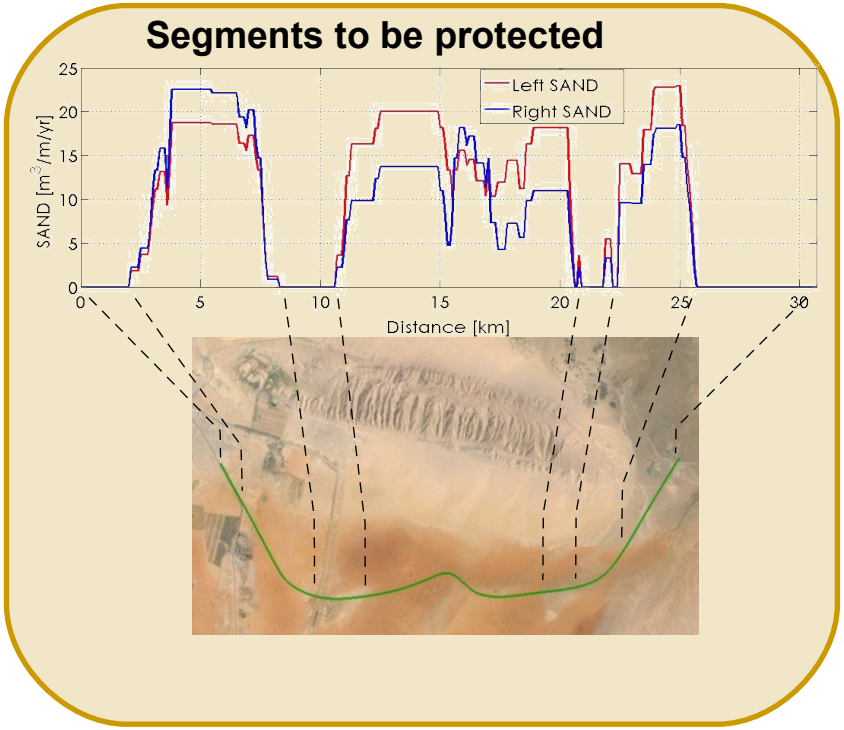
Sand drift assessment





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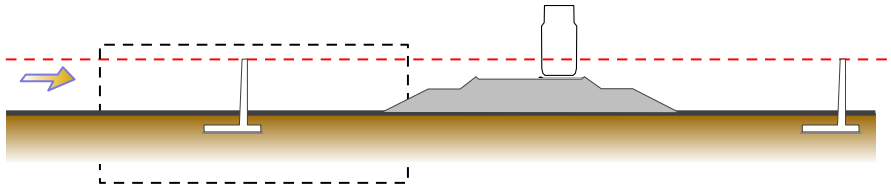
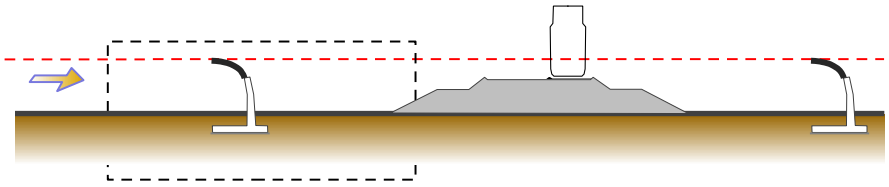
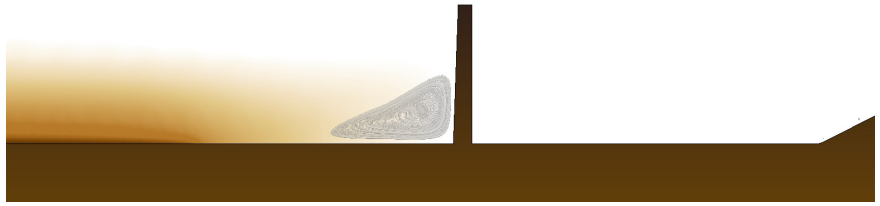
Simulation of protection systems

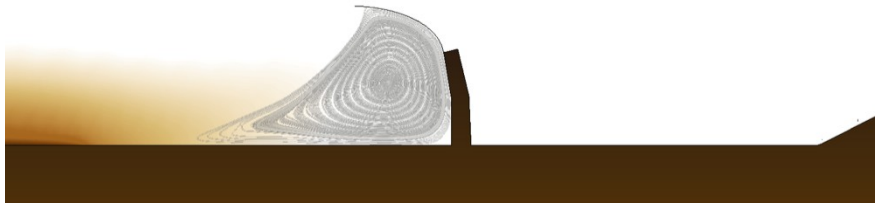
vertical wall

SMaRT barrier









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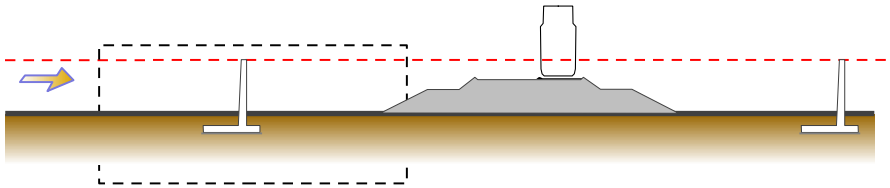

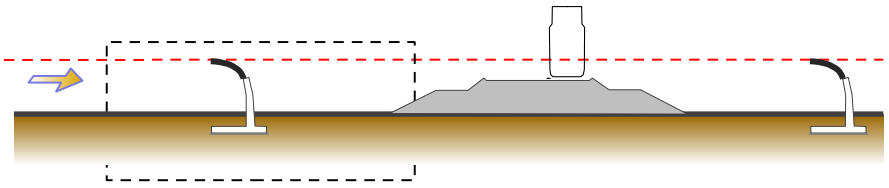

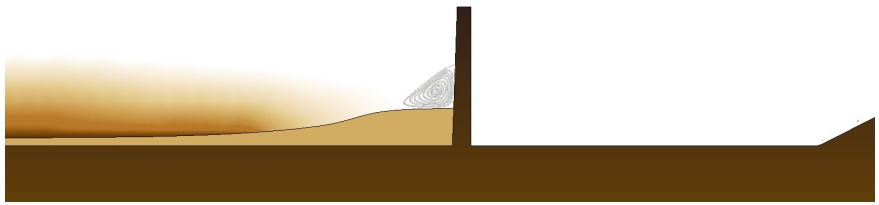

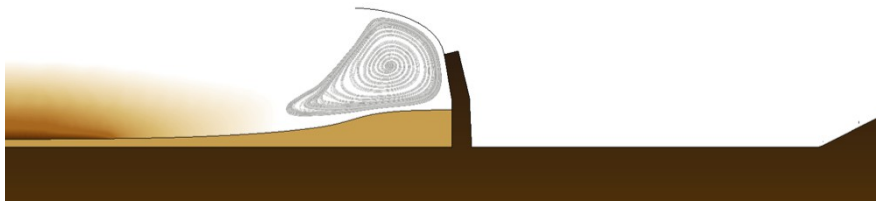

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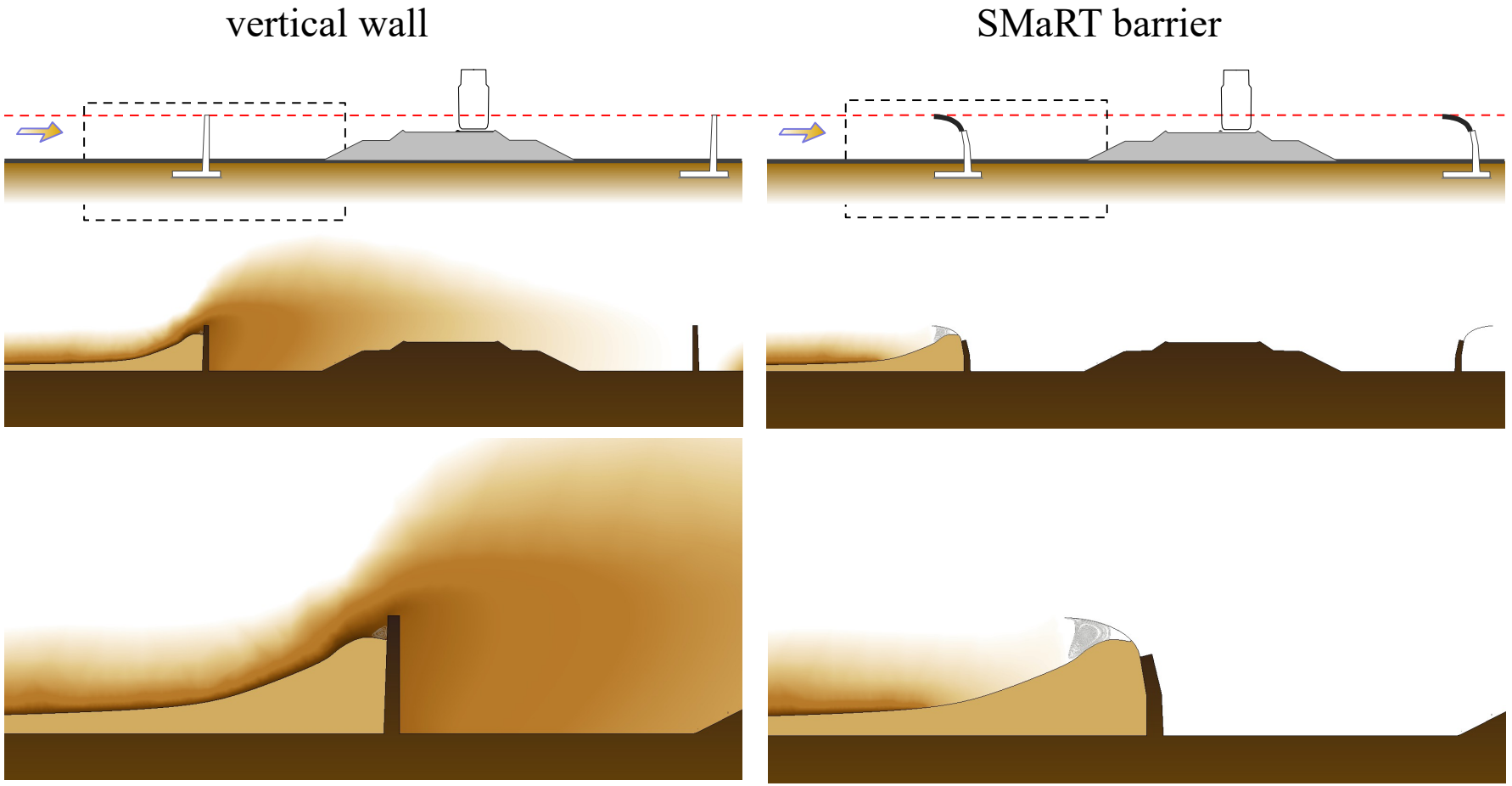
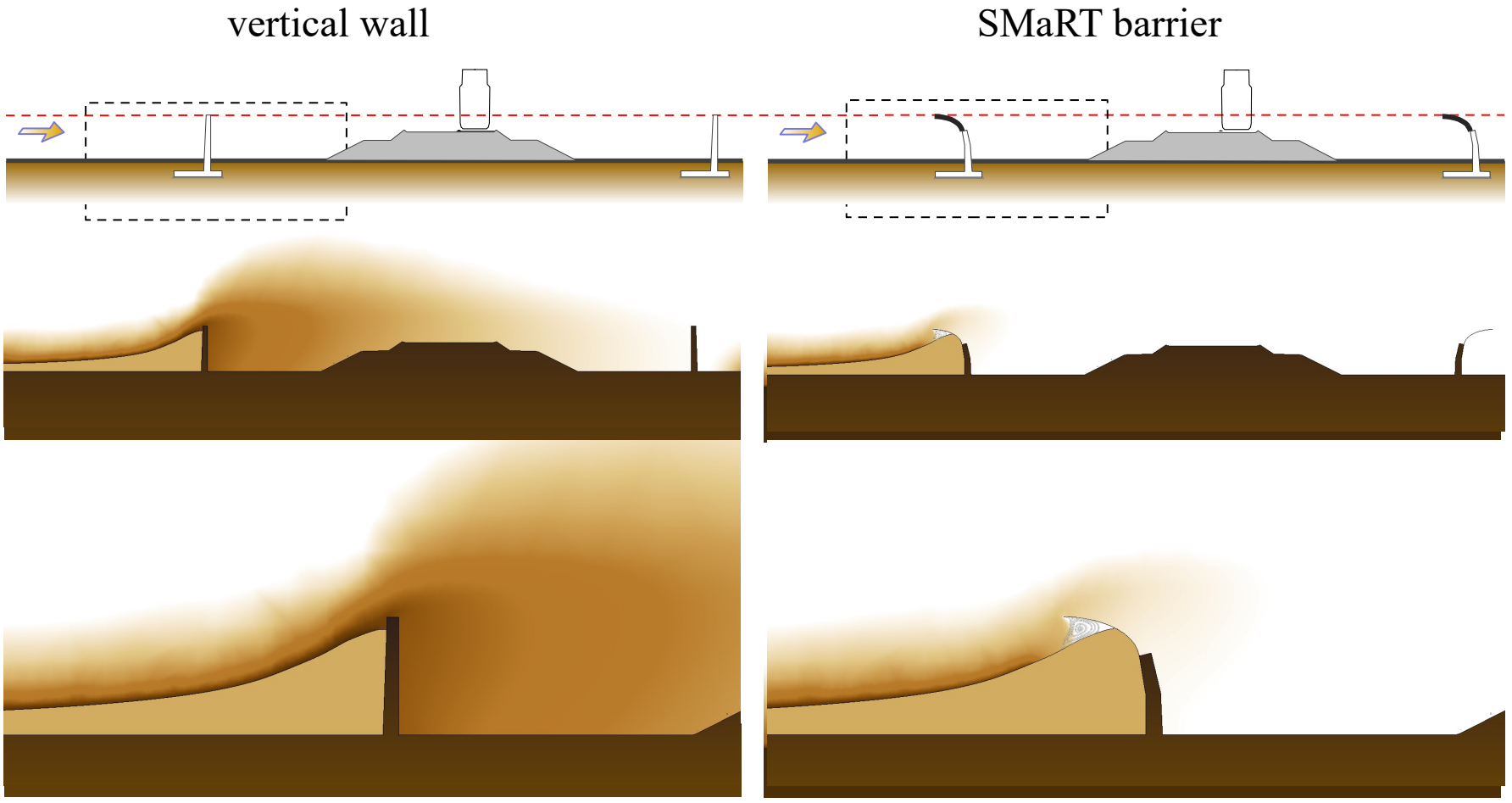
Simulation of protection systems



POLITECNICO DI TORINO

Simulation of protection systems



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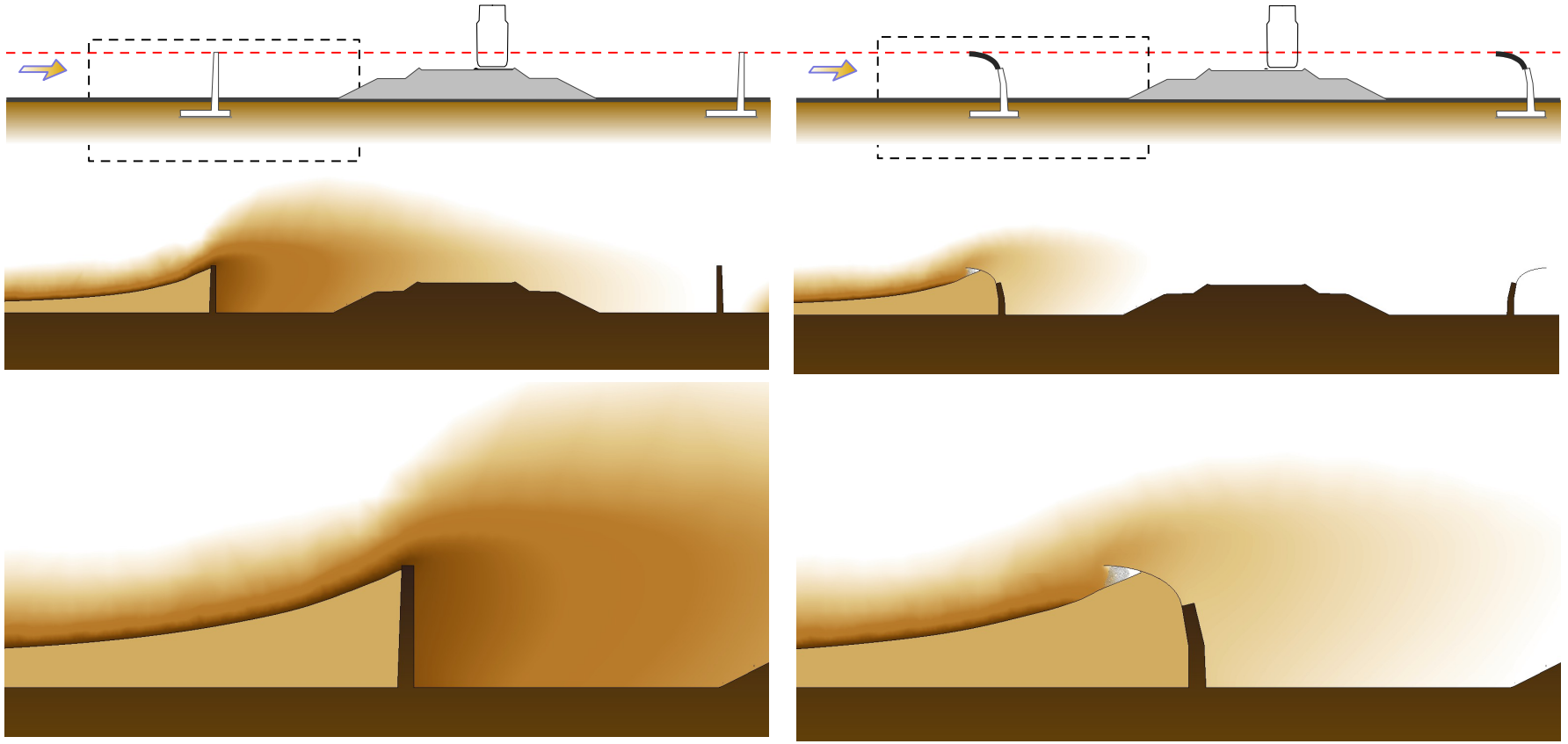
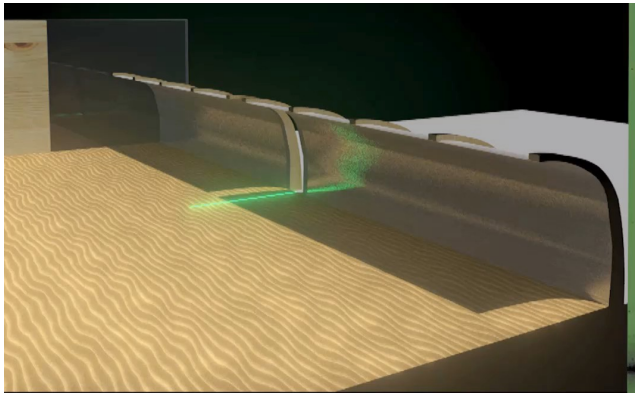
Simulation of protection systems

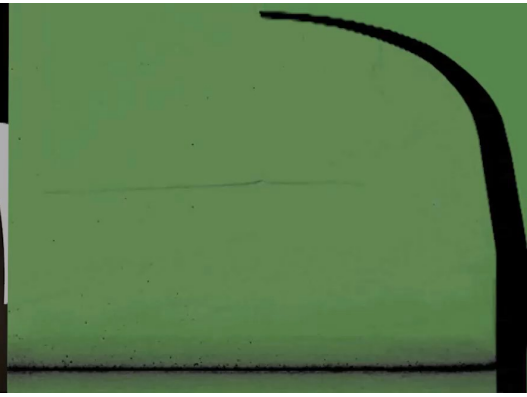
vertical wall

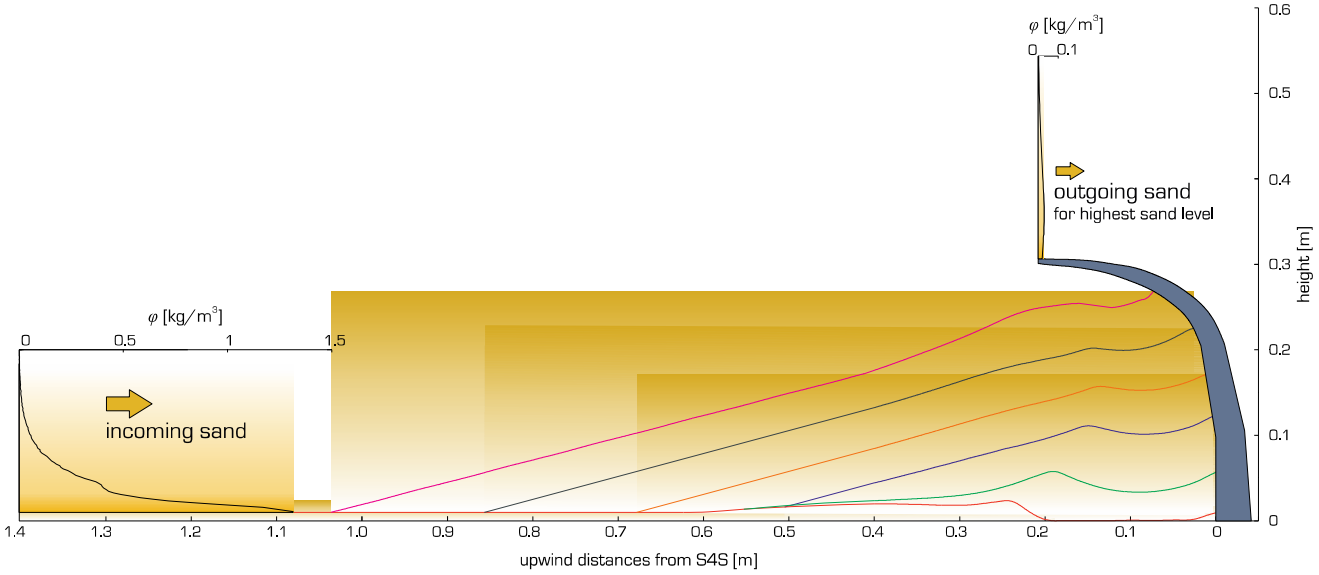
SMaRT barrier



Experimental validation







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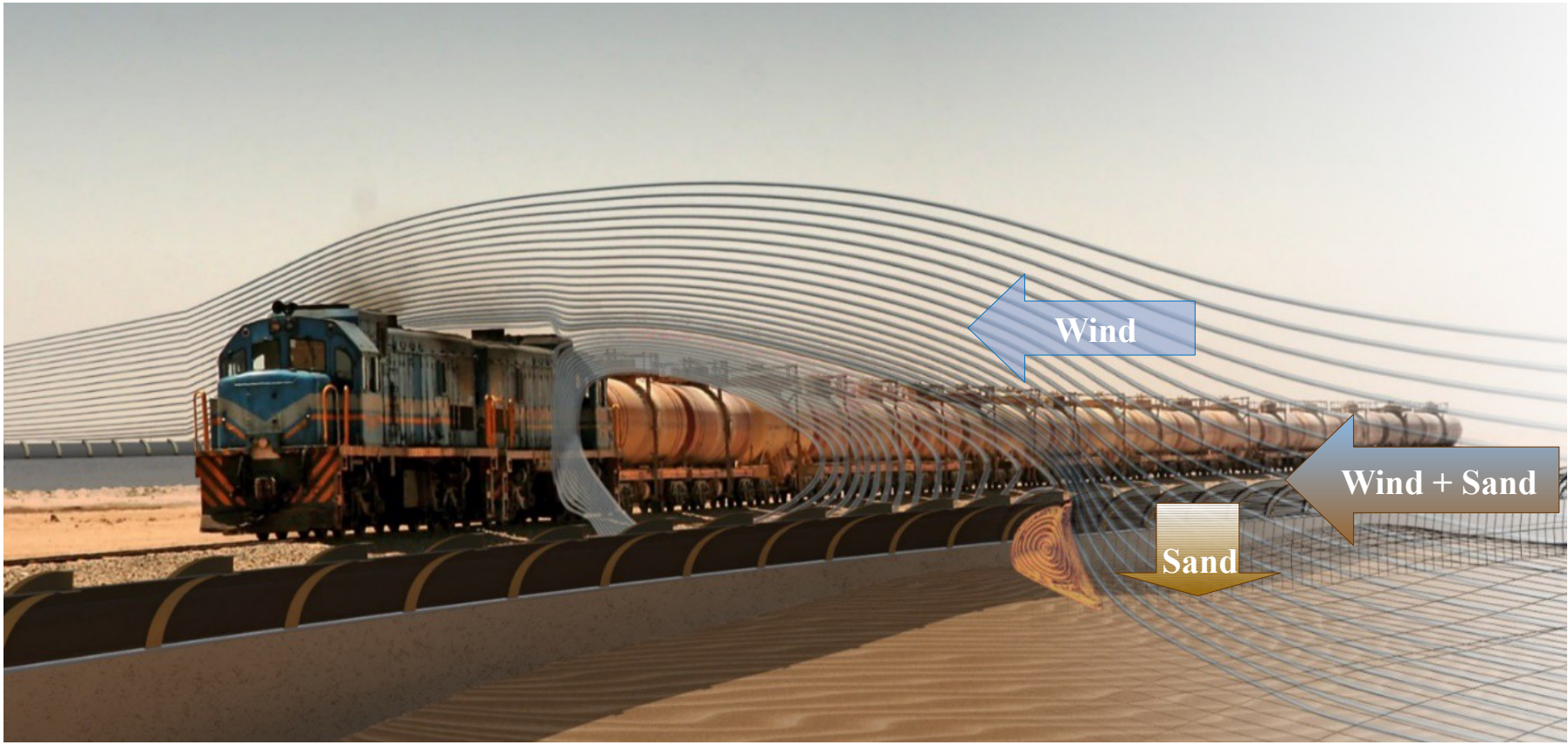
Shield 4 Sand

International patent of a Sand Mitigation System

SMaRT System, PCT/IT2015/000129

S4S Shield for Sand

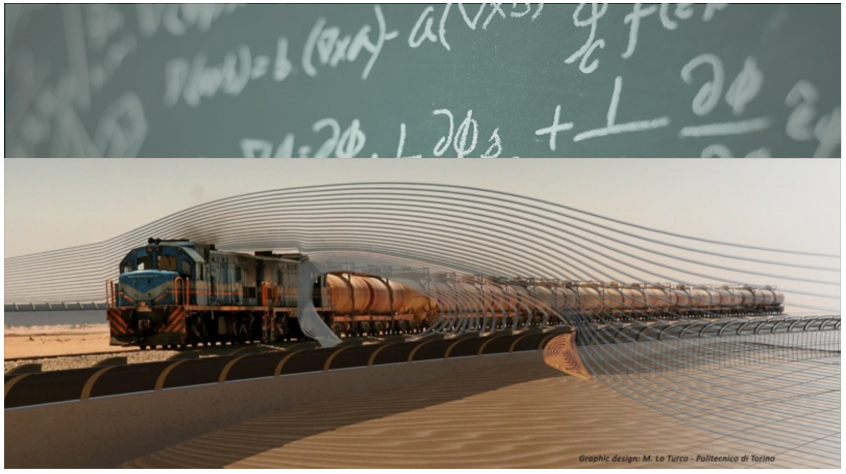


POLITECNICO DI TORINO

Multidisciplinarietà

Geomorfologo

Ingegnere del vento e delle strutture



Modellizzazione matematica

High performance computing