

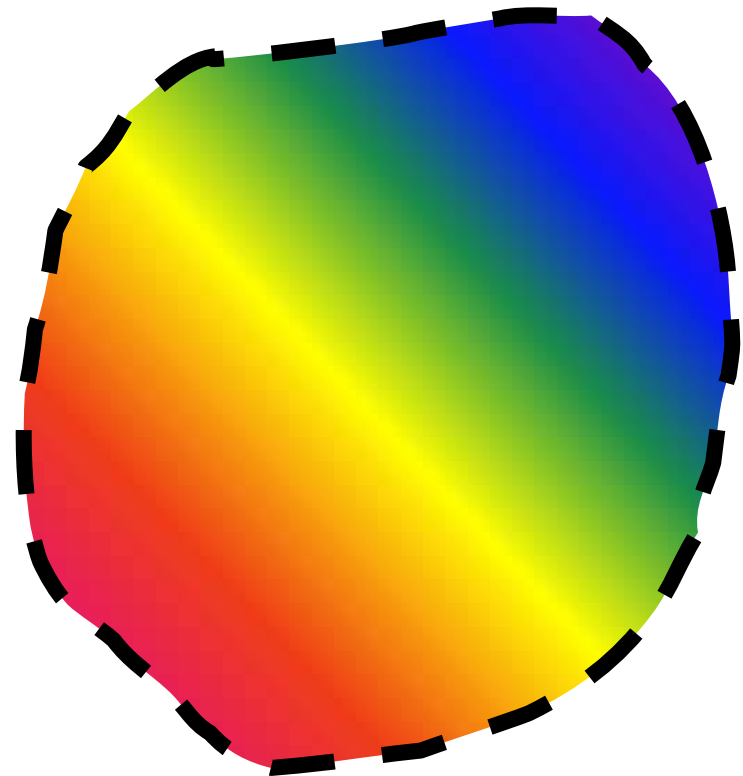


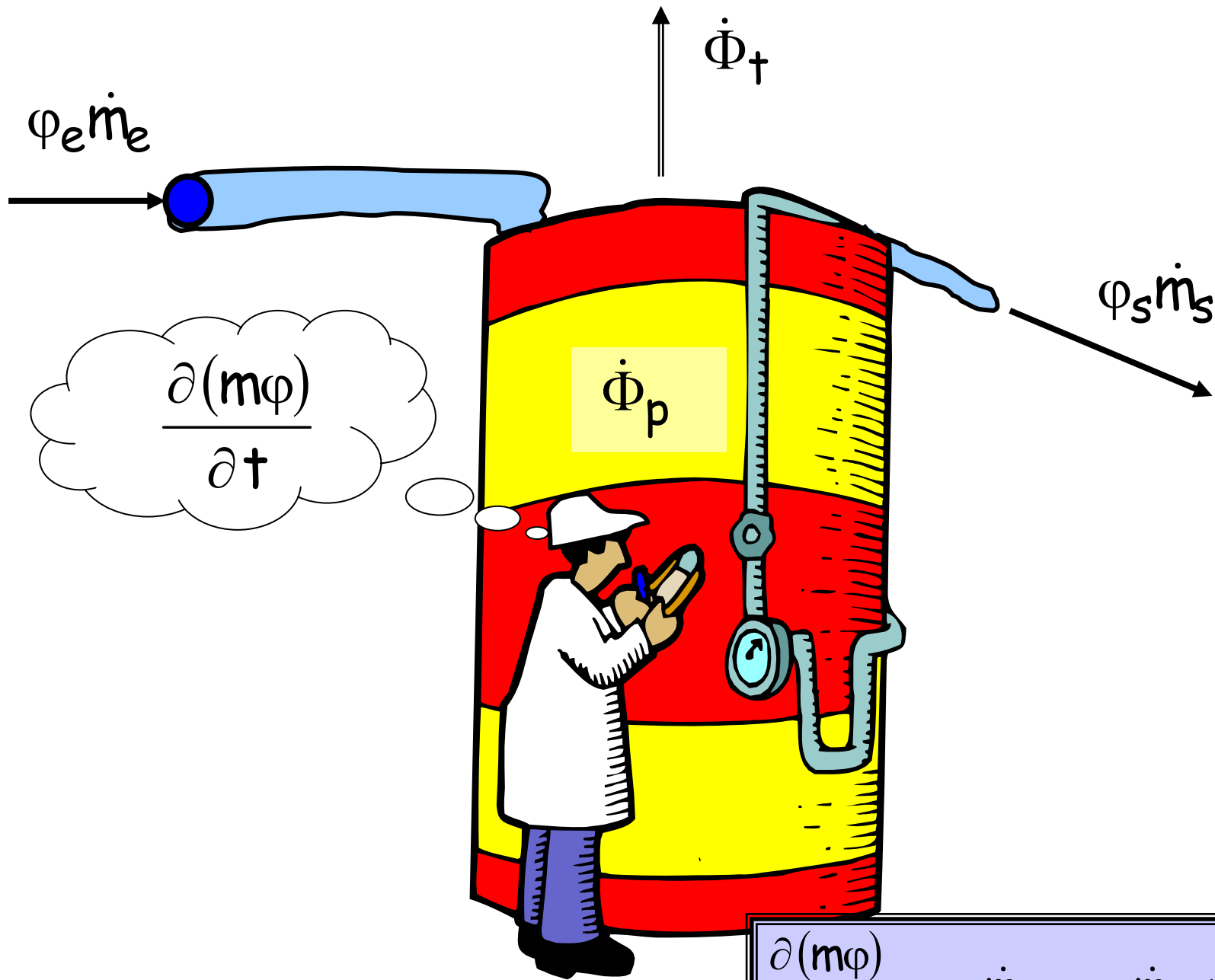
ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

PQI 5776

Fenômenos de Transporte I

Aula 1

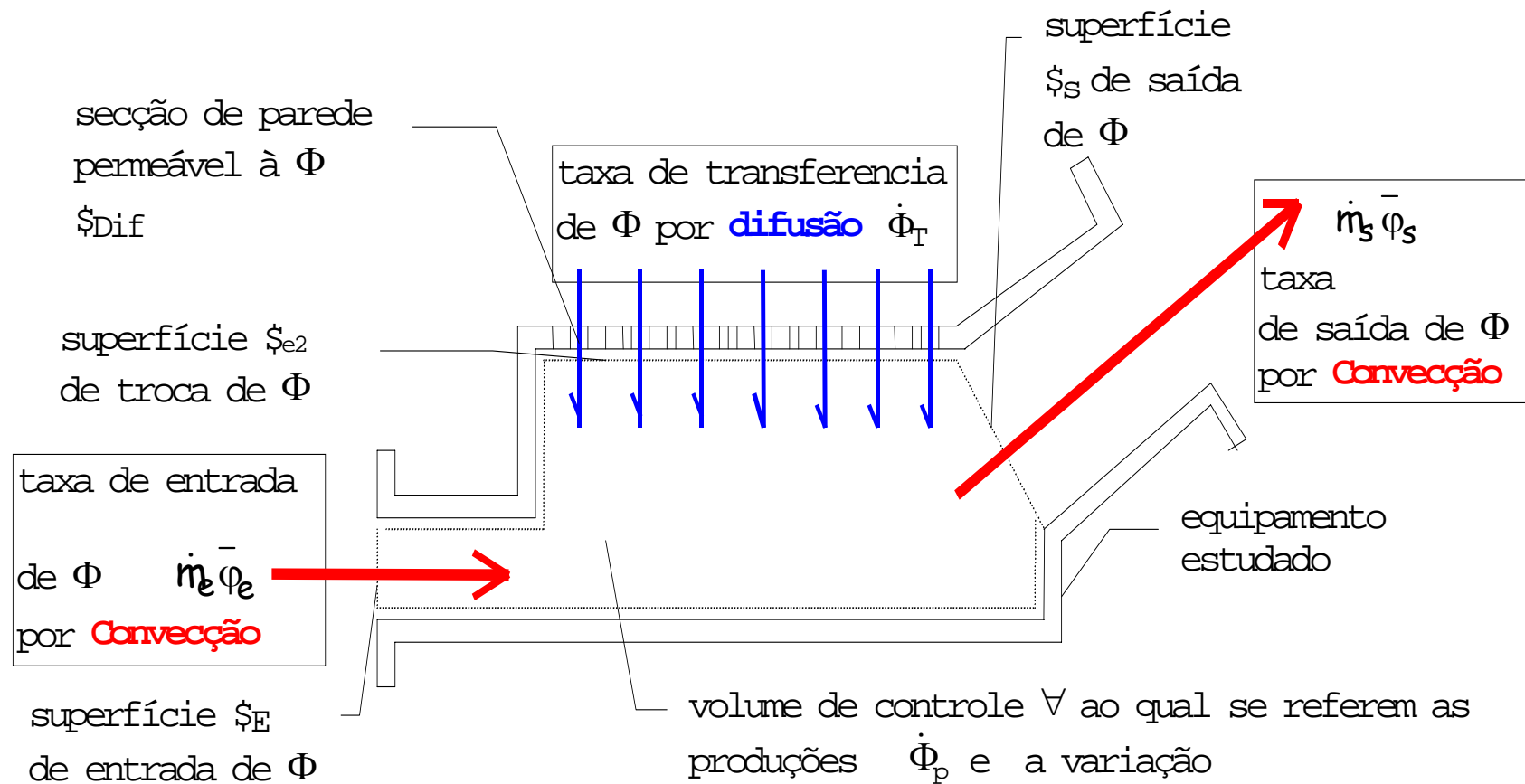




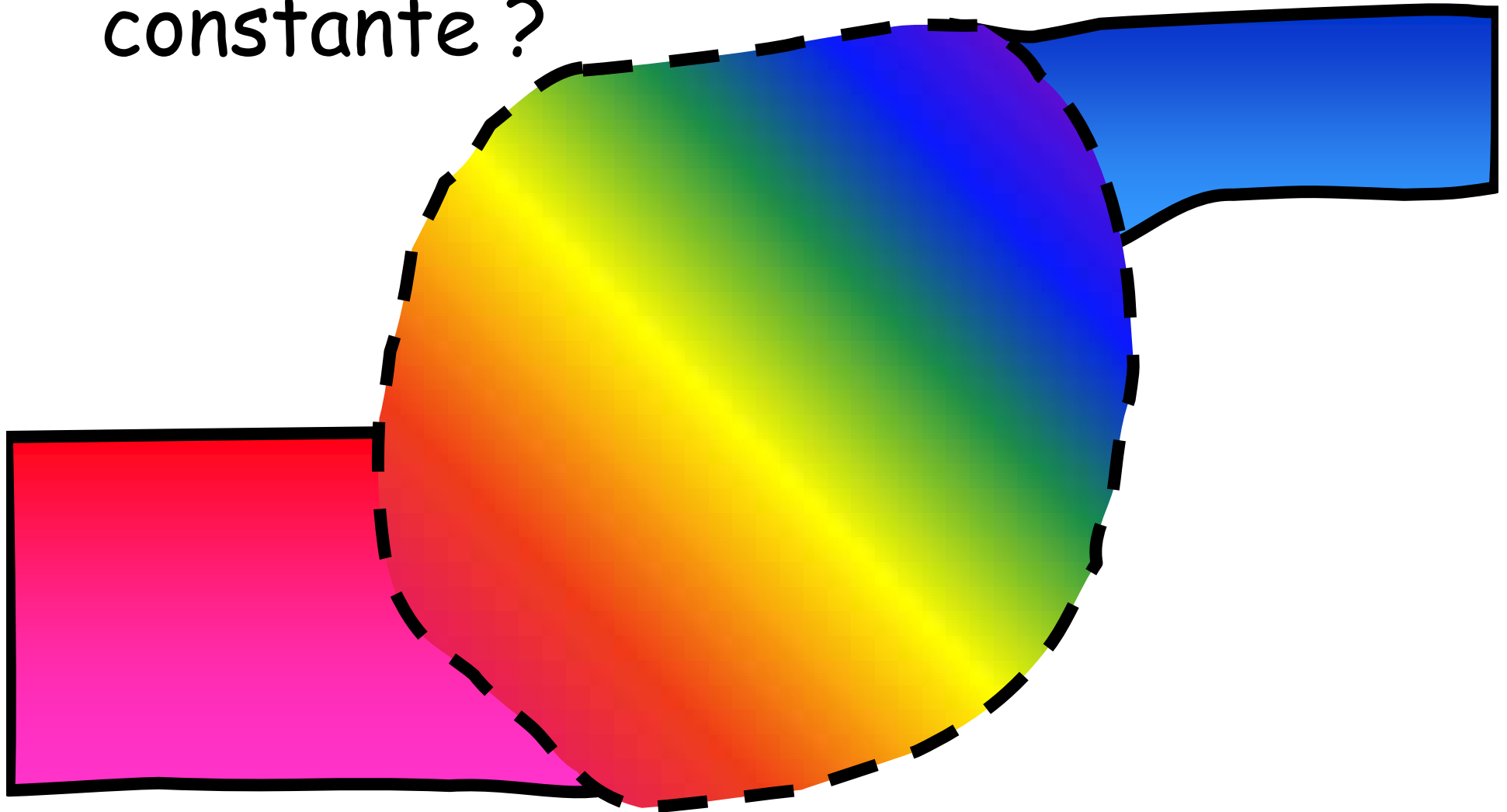
$$\frac{\partial(m\varphi)}{\partial t} = \varphi_e \dot{m}_e - \varphi_s \dot{m}_s + \dot{\Phi}_t + \dot{\Phi}_p$$

figura

$$\frac{\partial (m\varphi)}{\partial t} = \varphi_e \dot{m}_e - \varphi_s \dot{m}_s + \dot{\Phi}_D + \dot{\Phi}_P$$



e se φ não for
constante ?



$$\frac{\partial (\cancel{m\phi})}{\partial t} = \cancel{\phi_e} \dot{m}_e - \cancel{\phi_s} \dot{m}_s + \dot{\Phi}_t + \dot{\Phi}_p$$

variações ?

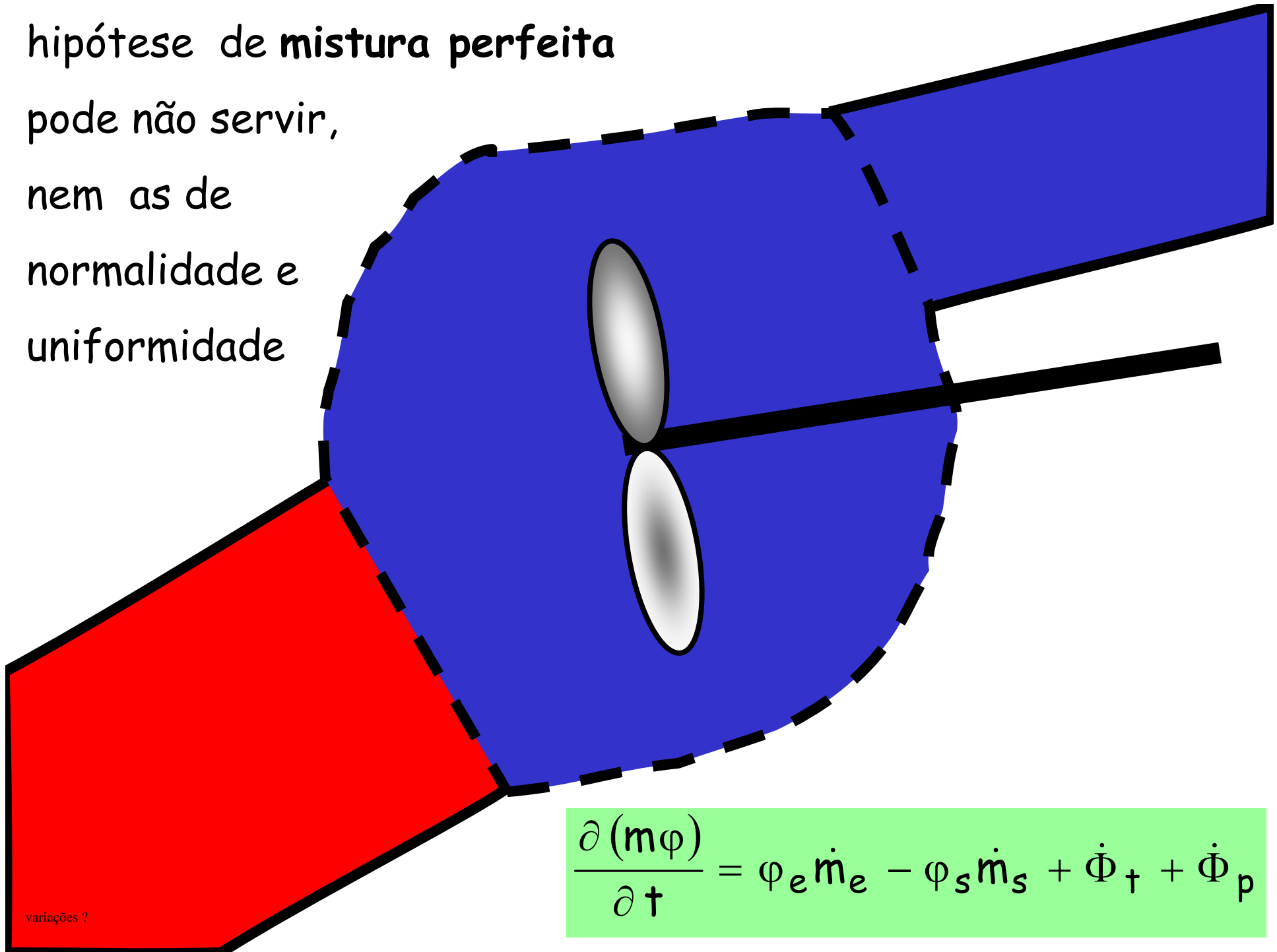
hipótese de mistura perfeita

pode não servir,

nem as de

normalidade e

uniformidade



variações?

$$\frac{\partial (m\varphi)}{\partial t} = \varphi_e \dot{m}_e - \varphi_s \dot{m}_s + \dot{\Phi}_t + \dot{\Phi}_p$$

se não
constante

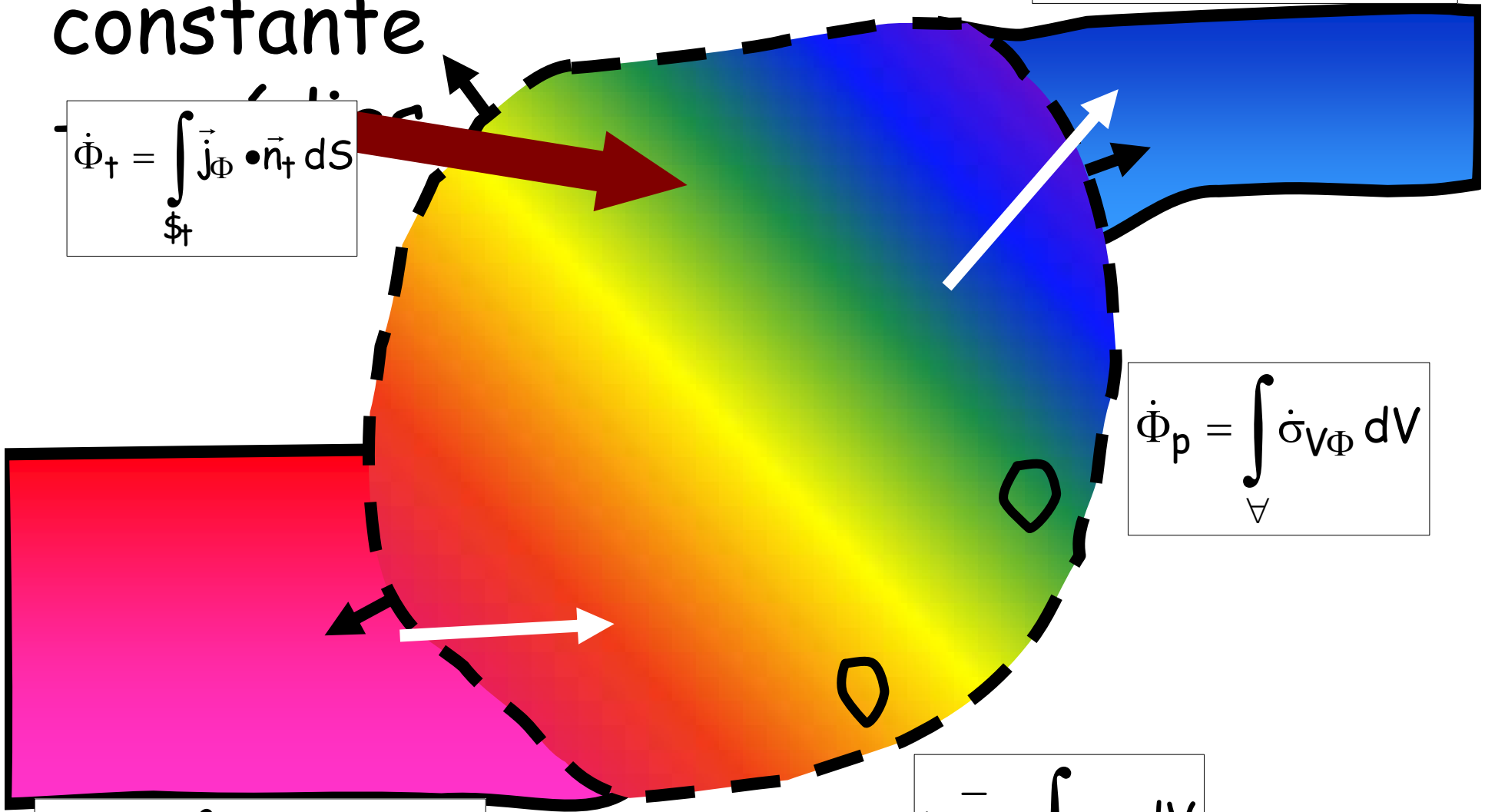
$$\dot{m}_s \bar{\varphi}_s = \int_{\mathcal{S}_s} \rho_s \varphi_s \vec{v}_s \cdot \vec{n}_s dS$$

$$\dot{\Phi}_t = \int_{\mathcal{S}_t} \vec{j}_\Phi \cdot \vec{n}_t dS$$

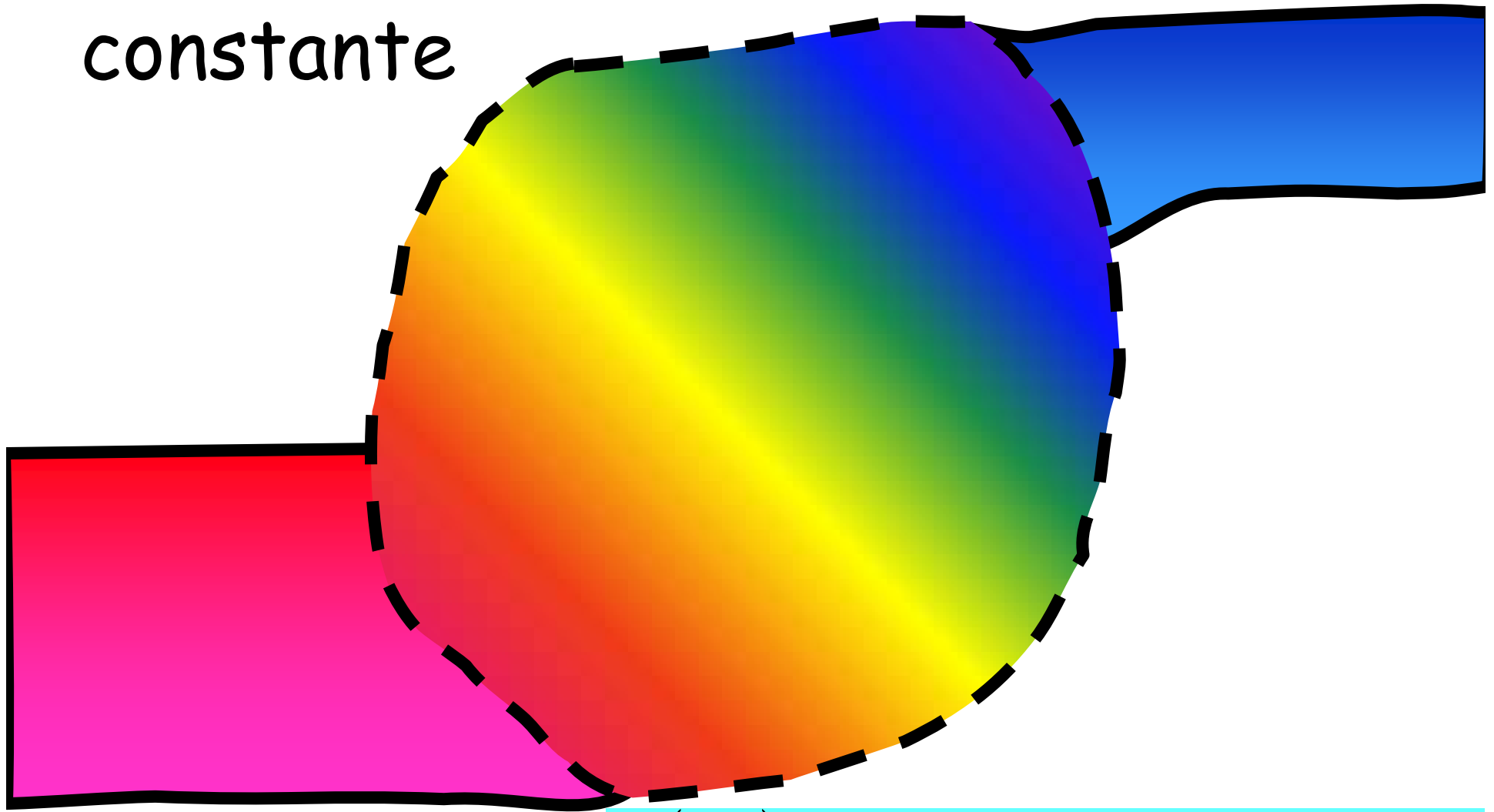
$$\dot{\Phi}_p = \int_V \dot{\sigma}_{V\Phi} dV$$

$$\dot{m}_e \bar{\varphi}_e = \int_{\mathcal{S}_e} \rho_e \varphi_e \vec{v}_e \cdot \vec{n}_e dS$$

$$m \bar{\varphi} = \int_V \rho \varphi dV$$



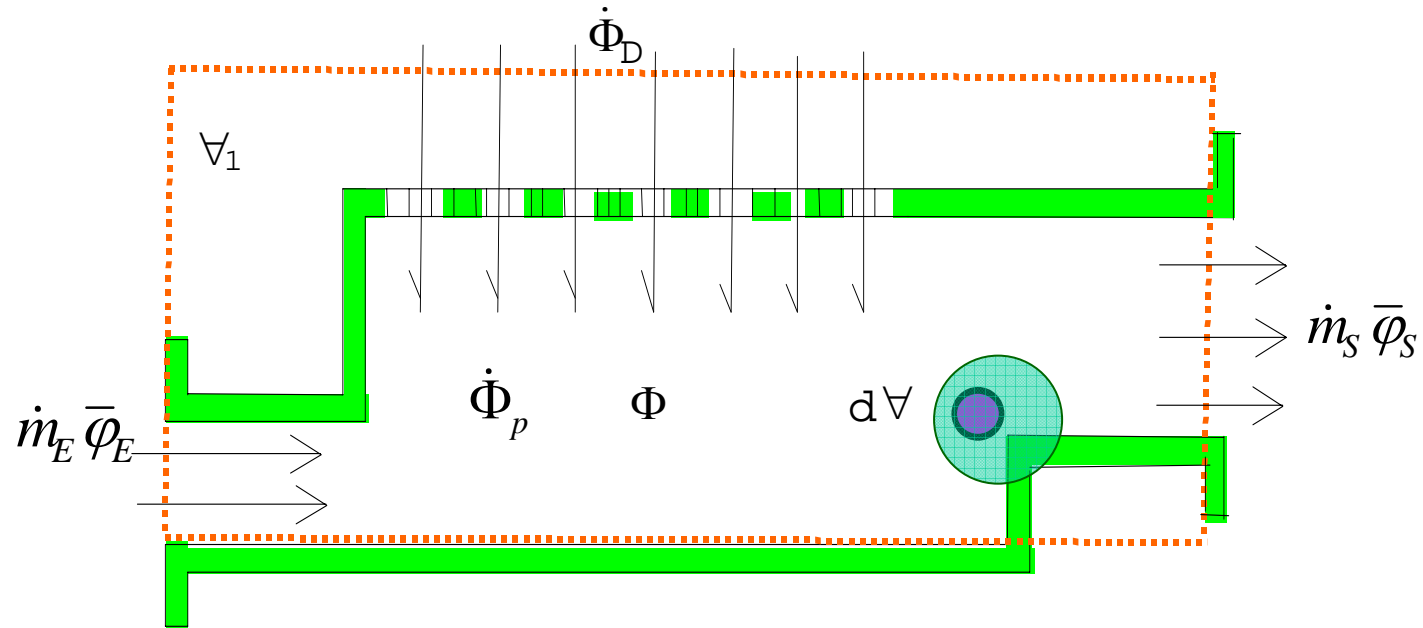
se φ não for
constante



$$\frac{\partial (m\bar{\varphi})}{\partial t} = \bar{\varphi}_e \dot{m}_e - \bar{\varphi}_s \dot{m}_s + \dot{\Phi}_t + \dot{\Phi}_p$$

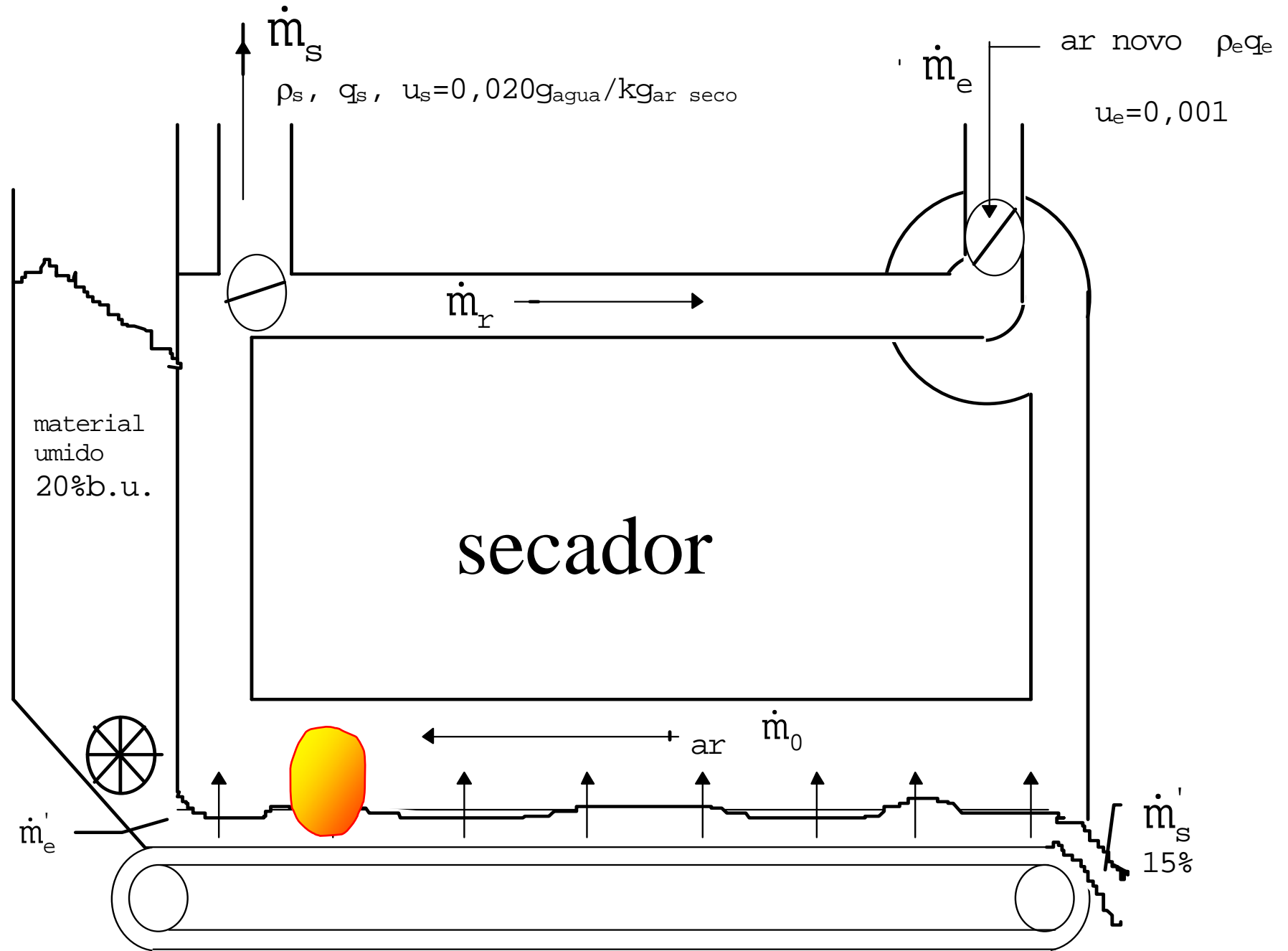
variações ?

$$\frac{d\Phi}{dt} = \dot{m}_E \bar{\varphi}_E - \dot{m}_S \bar{\varphi}_S + \dot{\Phi}_D + \dot{\Phi}_P$$



$$\dot{m} = \bar{\rho} v_b S = \int_{\S} \rho \vec{v} \cdot d\mathbf{S} \quad ; \quad \dot{m} \bar{\varphi} = \bar{\rho} \varphi_b v_b S = \int_{\S} \rho \varphi \vec{v} \cdot d\mathbf{S}$$

$$v_b = \frac{1}{\bar{\rho} S} \int_{\S} \rho \vec{v} \cdot d\mathbf{S} \quad ; \quad \varphi_b = \frac{1}{\bar{\rho} v_b S} \int_{\S} \rho \varphi \vec{v} \cdot d\mathbf{S}$$



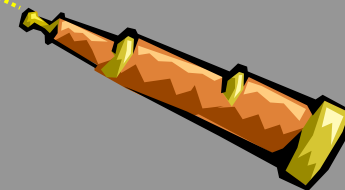
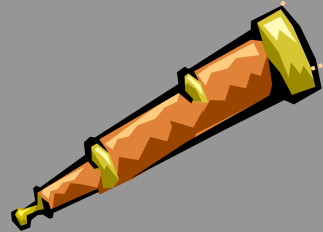
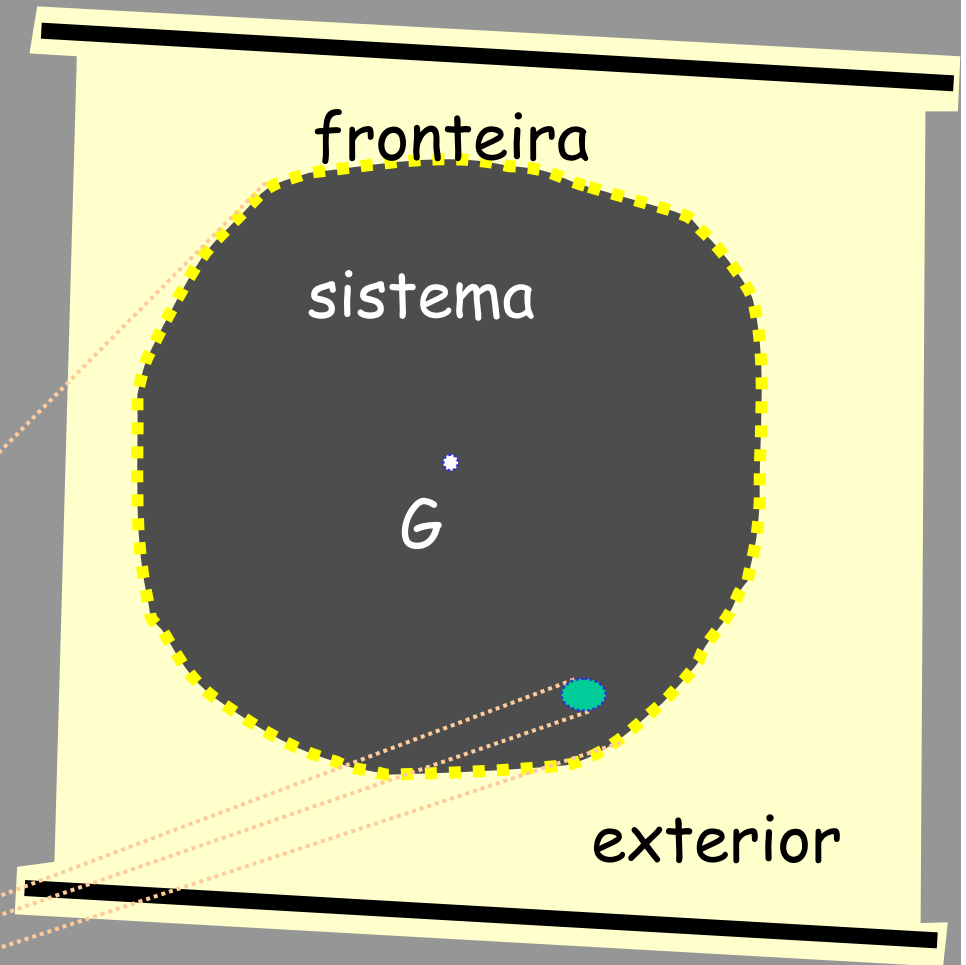
$$\text{macro} = \int \text{micro}$$

$$m = \int_{\text{sist}} dm$$

$$V = \int_{\text{sist}} dV$$

$$m = \int_V \rho dV$$

$$\Phi = \int_V \rho \varphi dV$$



Balanço microscópico de φ :

LAGRANGE

EULER

CONVECÇÃO

DIFUSÃO

PRODUÇÃO

$$\rho \frac{D\varphi}{Dt} = \frac{\partial \rho \varphi}{\partial t} + \text{div } \rho \vec{v} \varphi = - \text{div } \vec{j}_{\Phi} + \dot{\sigma}_{\nabla \Phi}$$

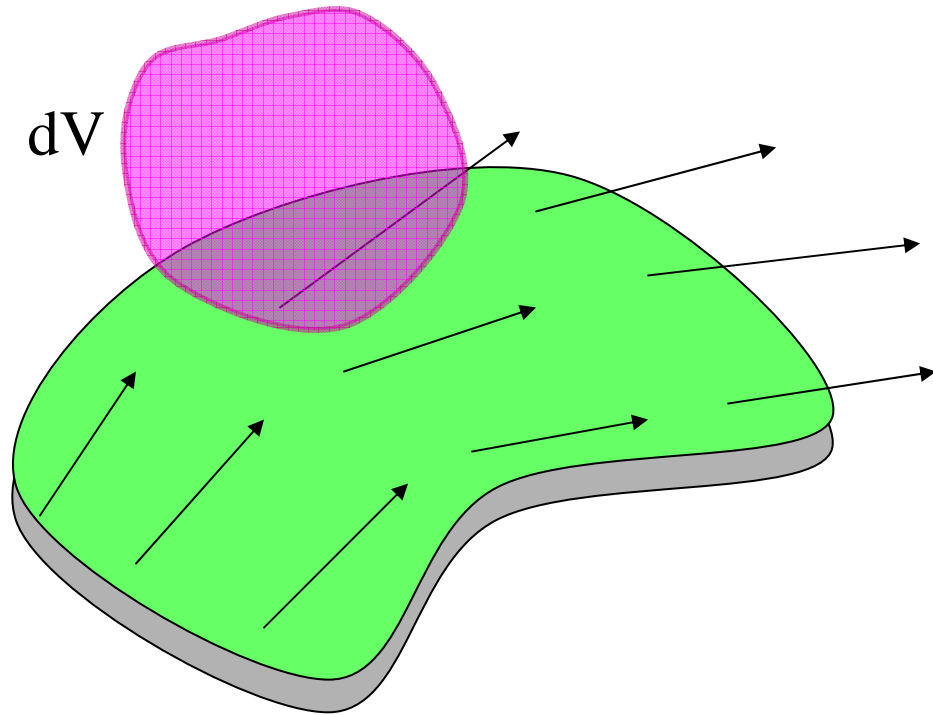
$$\frac{\partial \rho \varphi}{\partial t} + \text{div } \rho \vec{v} = 0$$

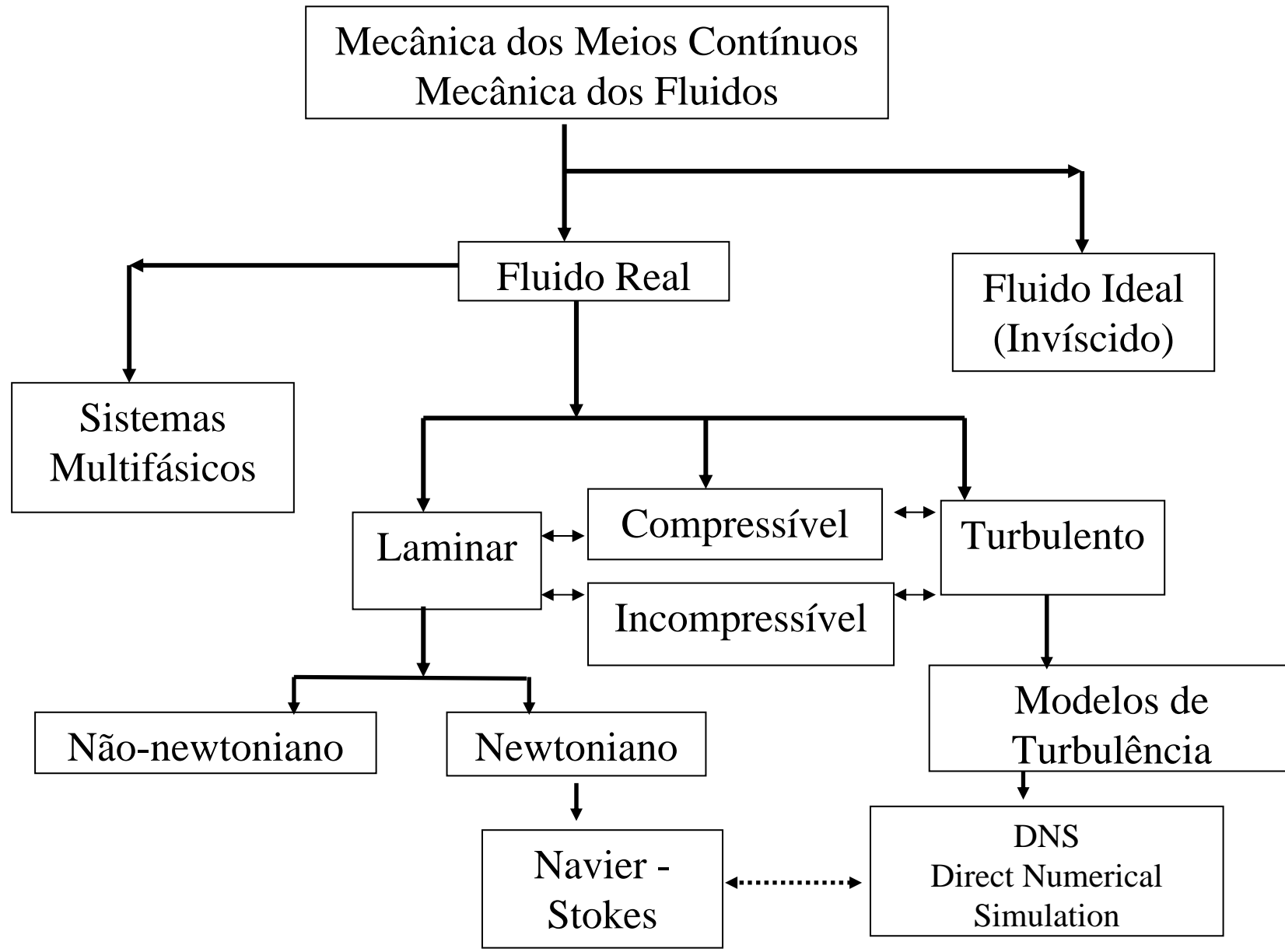
VARIAÇÃO TEMPORAL

ESCOAMENTO

MODELOS E "LEIS"

$$\rho \frac{D\varphi}{Dt} = \rho \frac{\partial \varphi}{\partial t} + \rho \vec{v} \cdot \text{grad } \varphi = - \text{div } \vec{j}_{\Phi} + \dot{\sigma}_{\nabla \Phi}$$





Macroscópico
Equipamento

Mecânica dos
Meios Contínuos

Mecânica
Estatística

Mecânica
Quântica

Taxas: $m\mathbf{v}$, Q , W

Perfil de: \mathbf{v} , T , P , C_A

Radiação,
Cinética

Balances macroscópicos
$$\frac{d\Phi}{dt} = \sum \dot{m}_E \bar{\varphi}_E - \sum \dot{m}_S \bar{\varphi}_S + \sum \dot{\Phi}_D + \sum \dot{\Phi}_P$$

Equações de Conservação
$$\frac{\partial \rho \varphi}{\partial t} + \text{div } \rho \bar{\mathbf{v}} \varphi = - \text{div } \bar{\mathbf{j}}_\varphi + \dot{\sigma}_{\nabla \varphi}$$

Equação de Boltzmann
$$\frac{\partial f_\alpha \psi_\alpha}{\partial t} = - \frac{\partial \bar{r}_\alpha f_\alpha \psi_\alpha}{\partial \bar{r}} + \frac{\partial \psi_\alpha}{\partial \bar{r}} f_\alpha \bar{g}_\alpha + J_\alpha \psi_\alpha$$

Adimensionais e
Coeficientes de Transporte
 \mathbf{f} , \mathbf{h} , \mathbf{k}

Fluxos Difusivos – \mathbf{j}_φ
Newton, Fourier, Fick,...
 $\boldsymbol{\tau}$, \mathbf{q}'' , \mathbf{J}_A

μ , k , D_{AB} , κ_T , δ

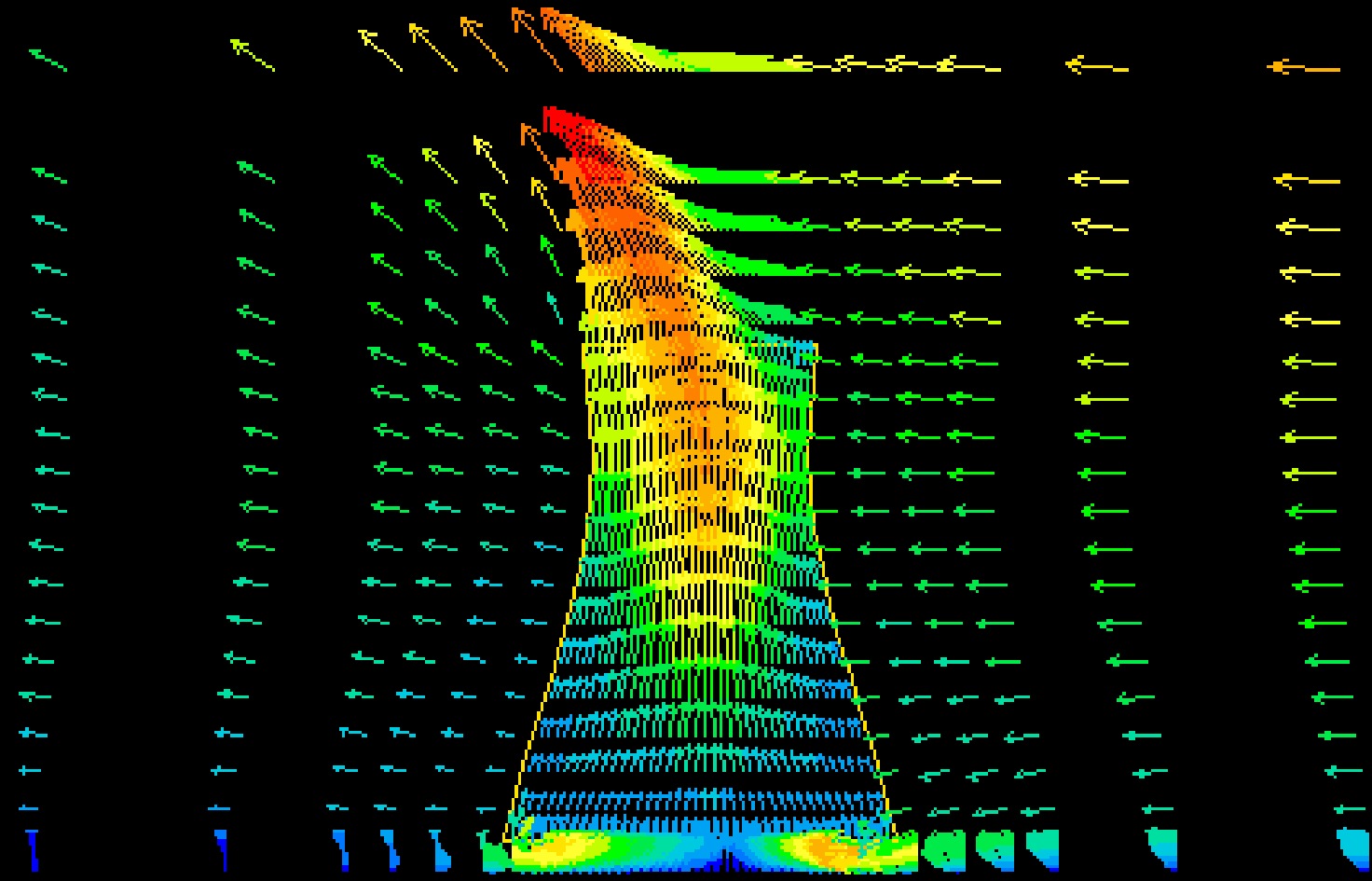


Dimensão L e Caminho livre médio λ
Número de Knudsen – $Kn = \lambda/L$

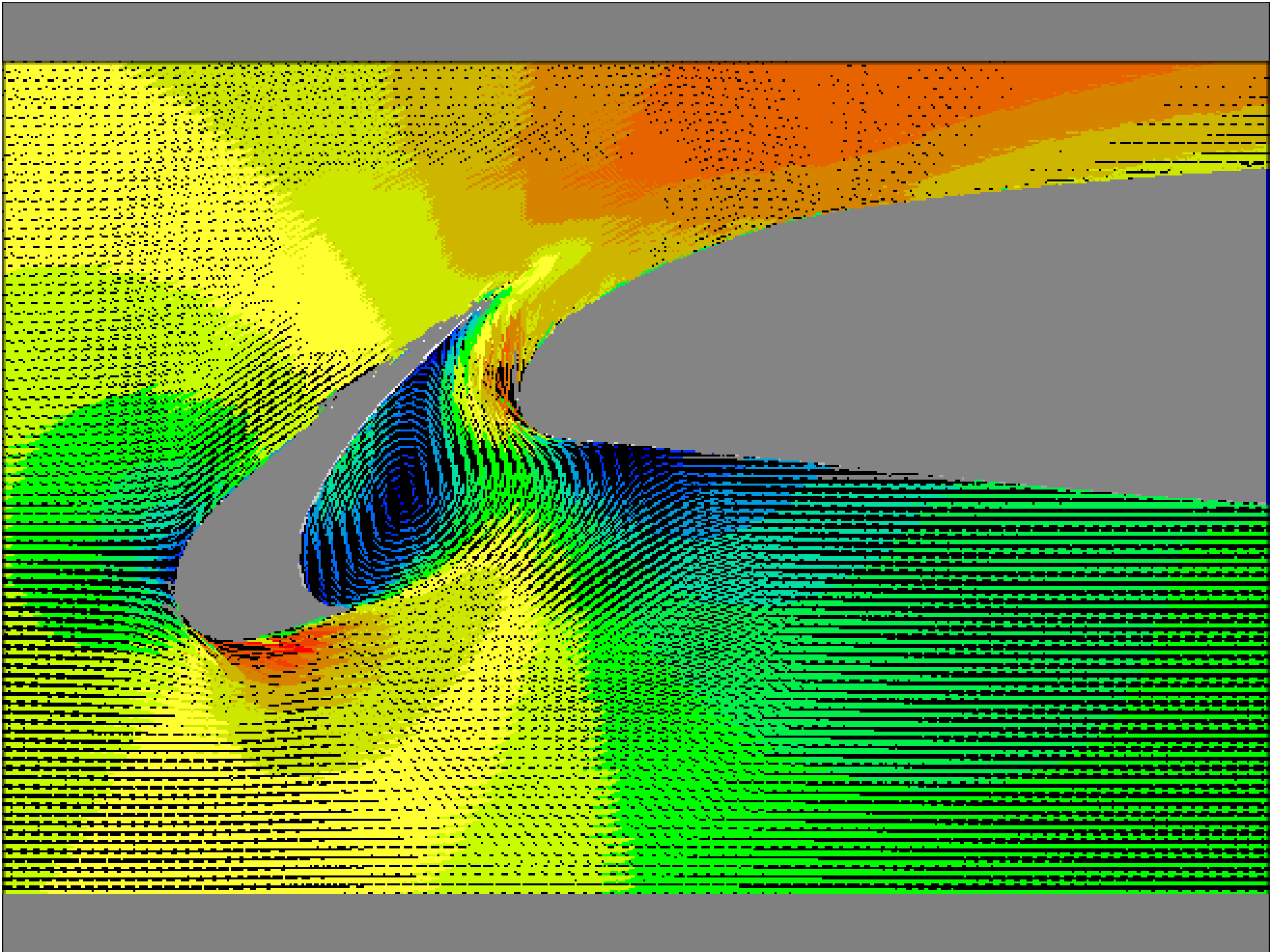
COOLING TOWER SIMULATION

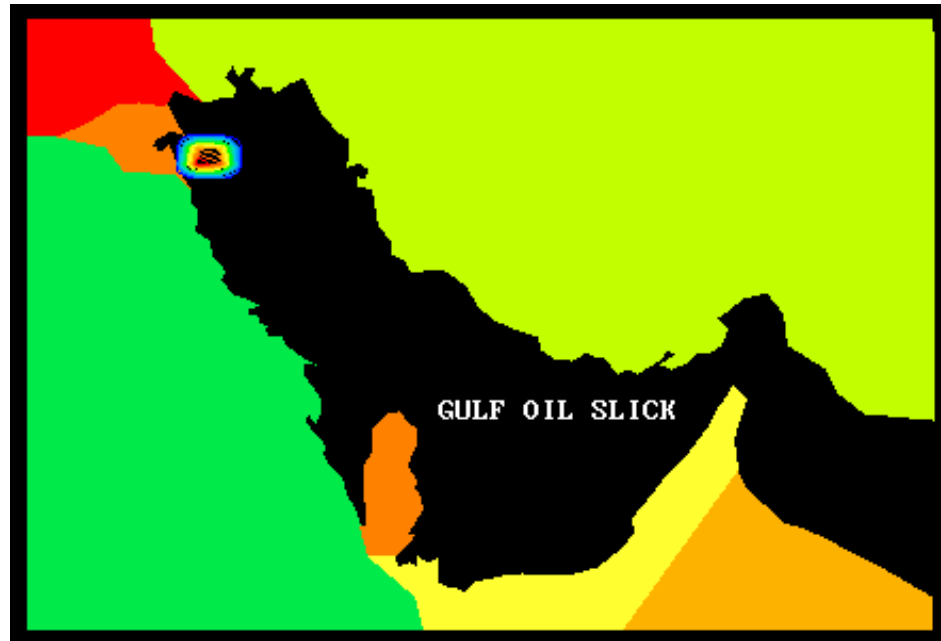


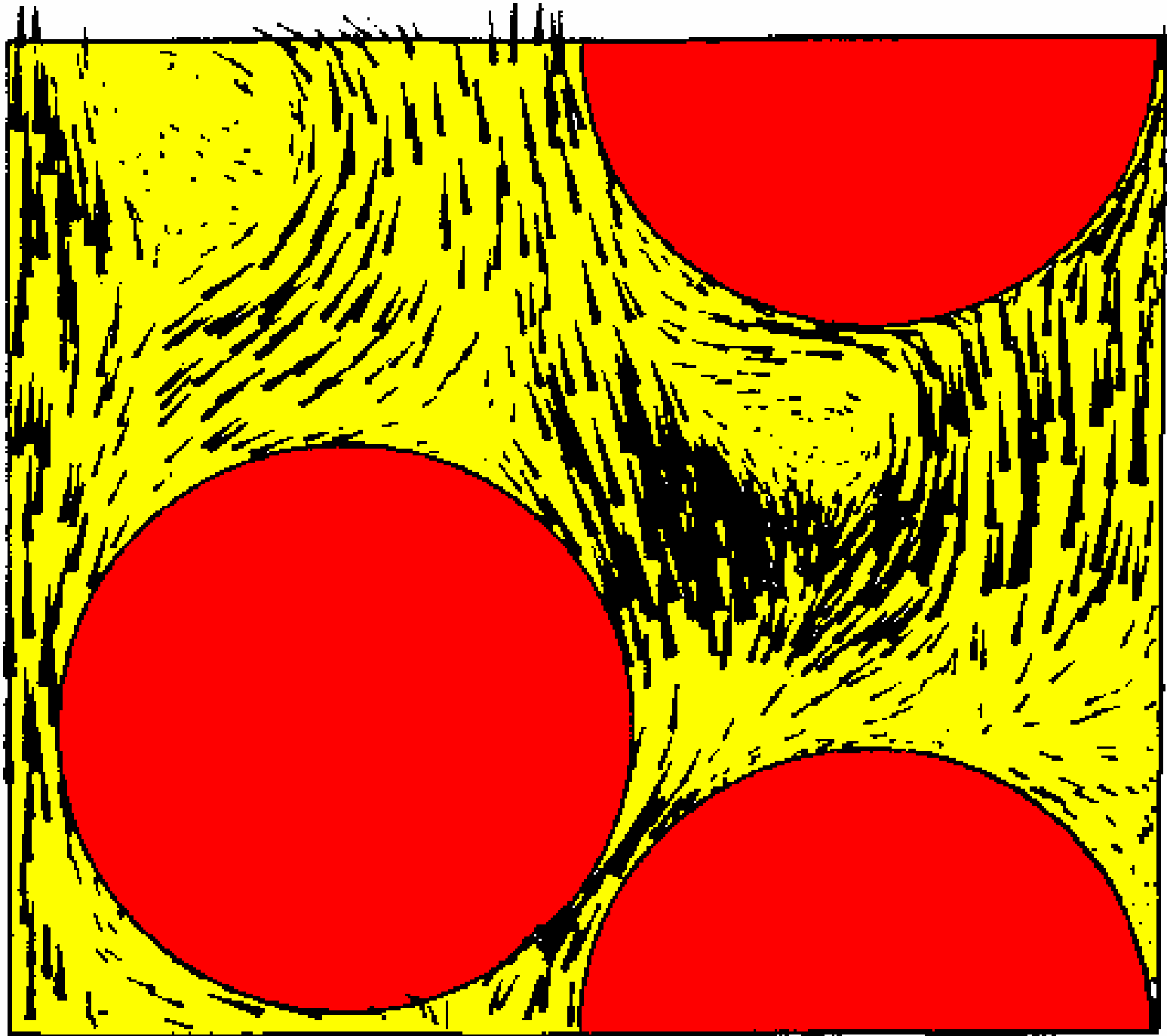
<--- wind 1.5m/s at 10m



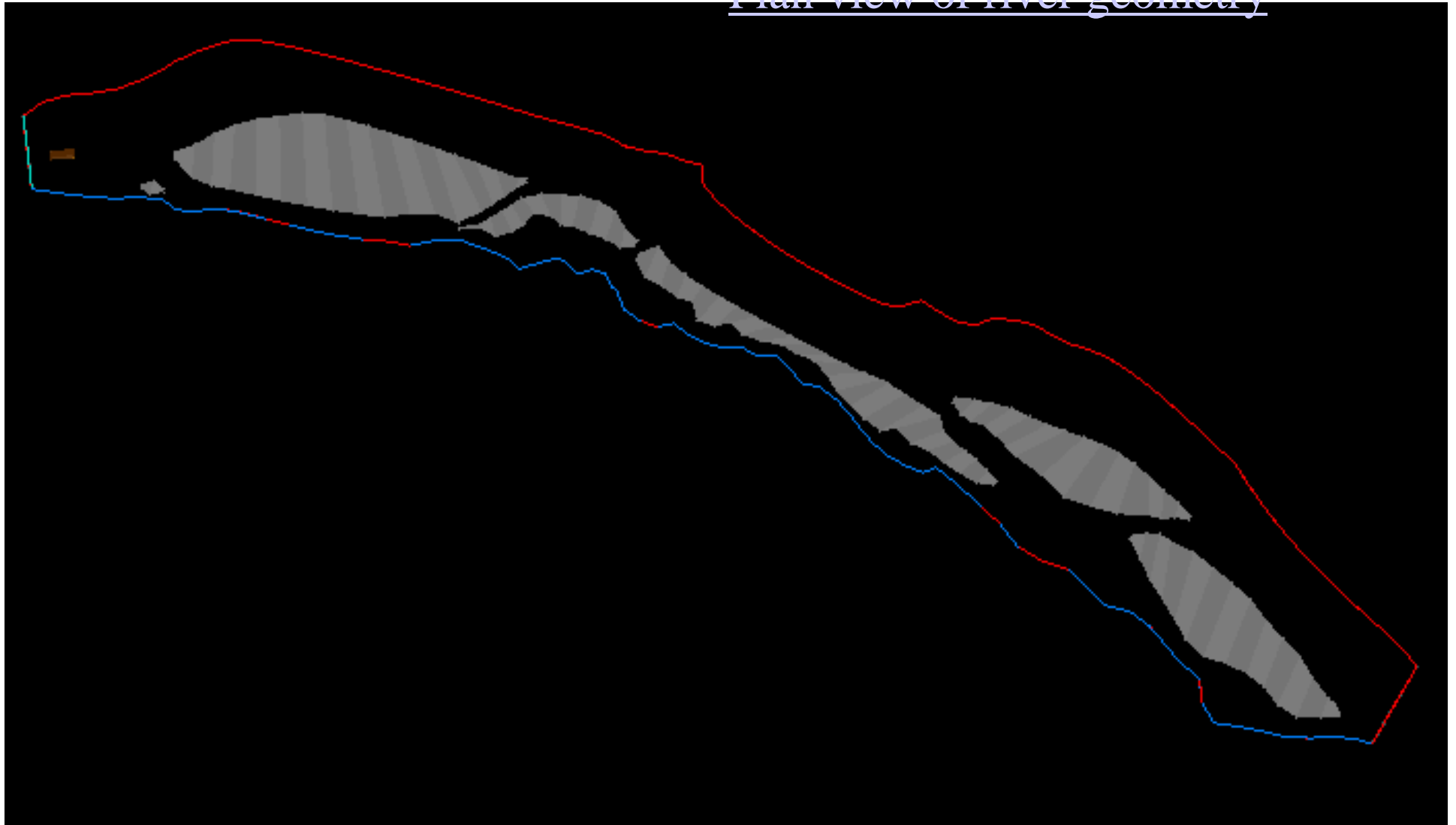
→ : 7.31 m/s. Min : 1.9599E-02 Max : 5.8843E+00



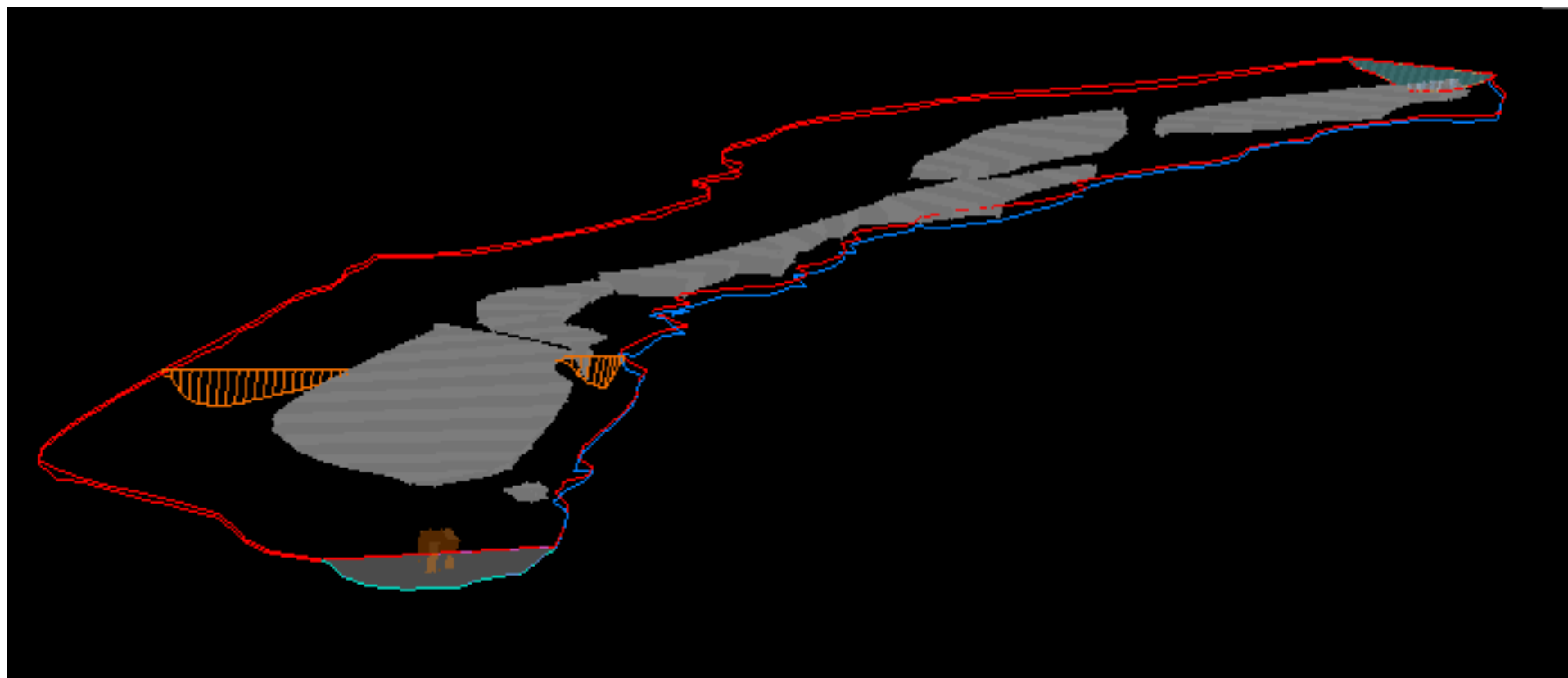




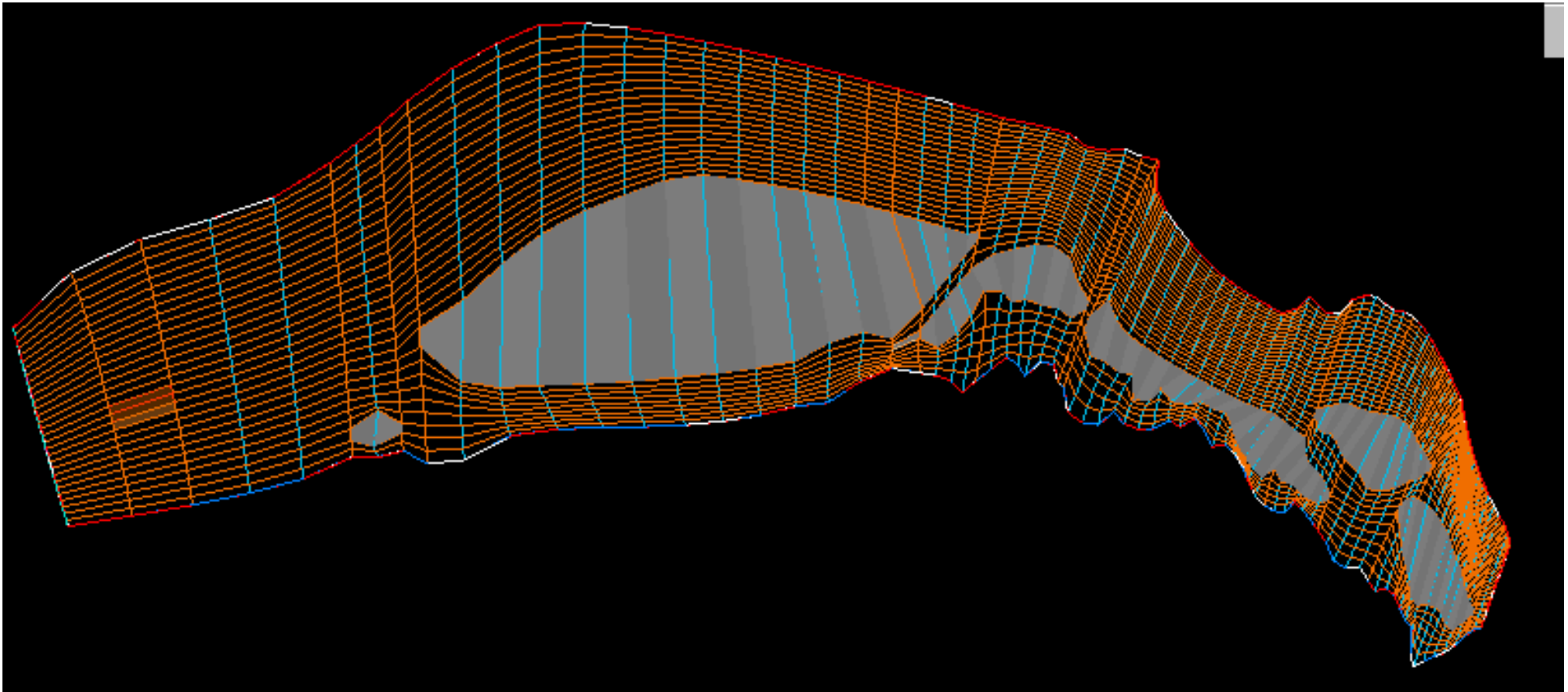
Plan view of river geometry



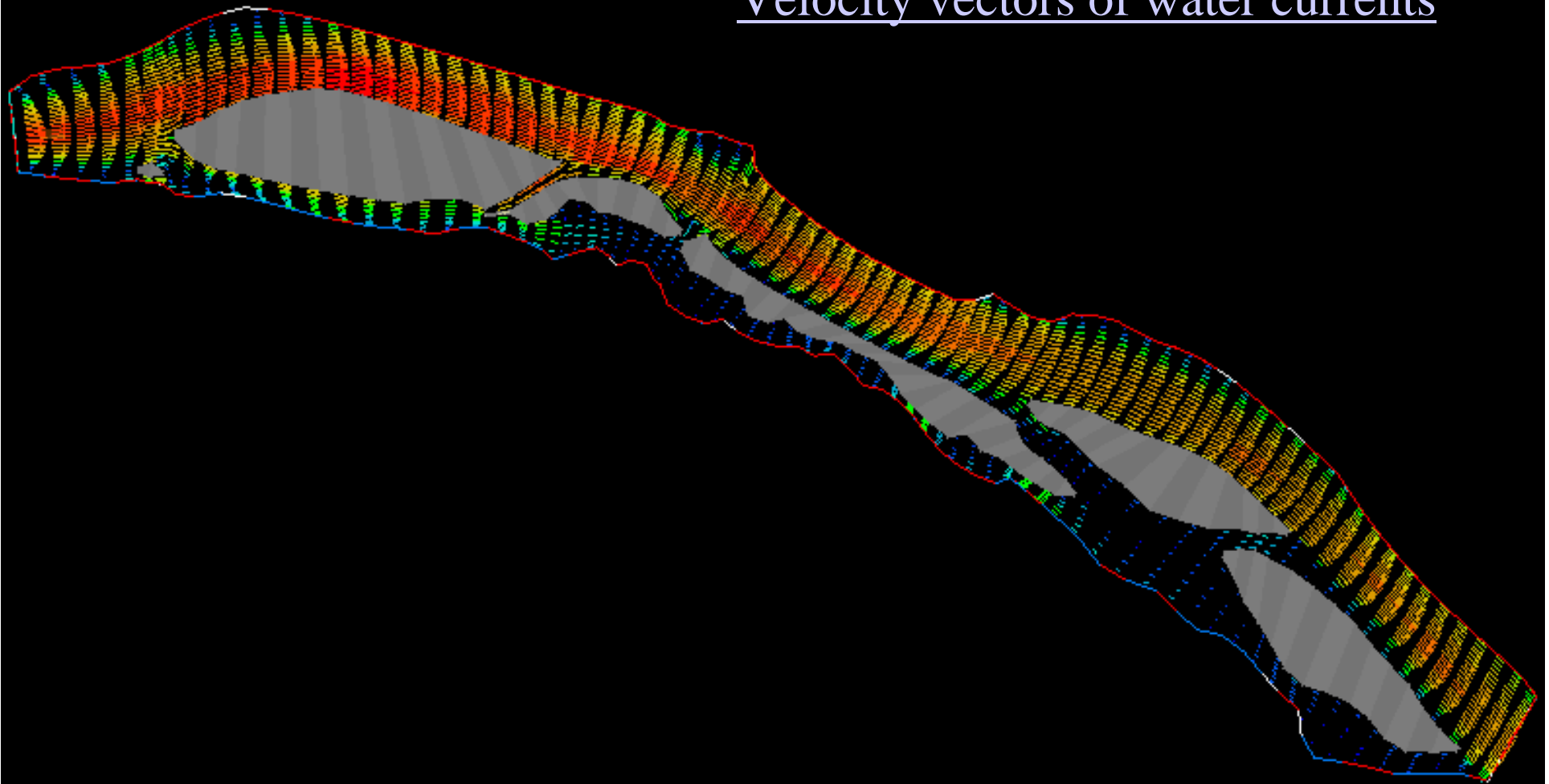
River bathymetry



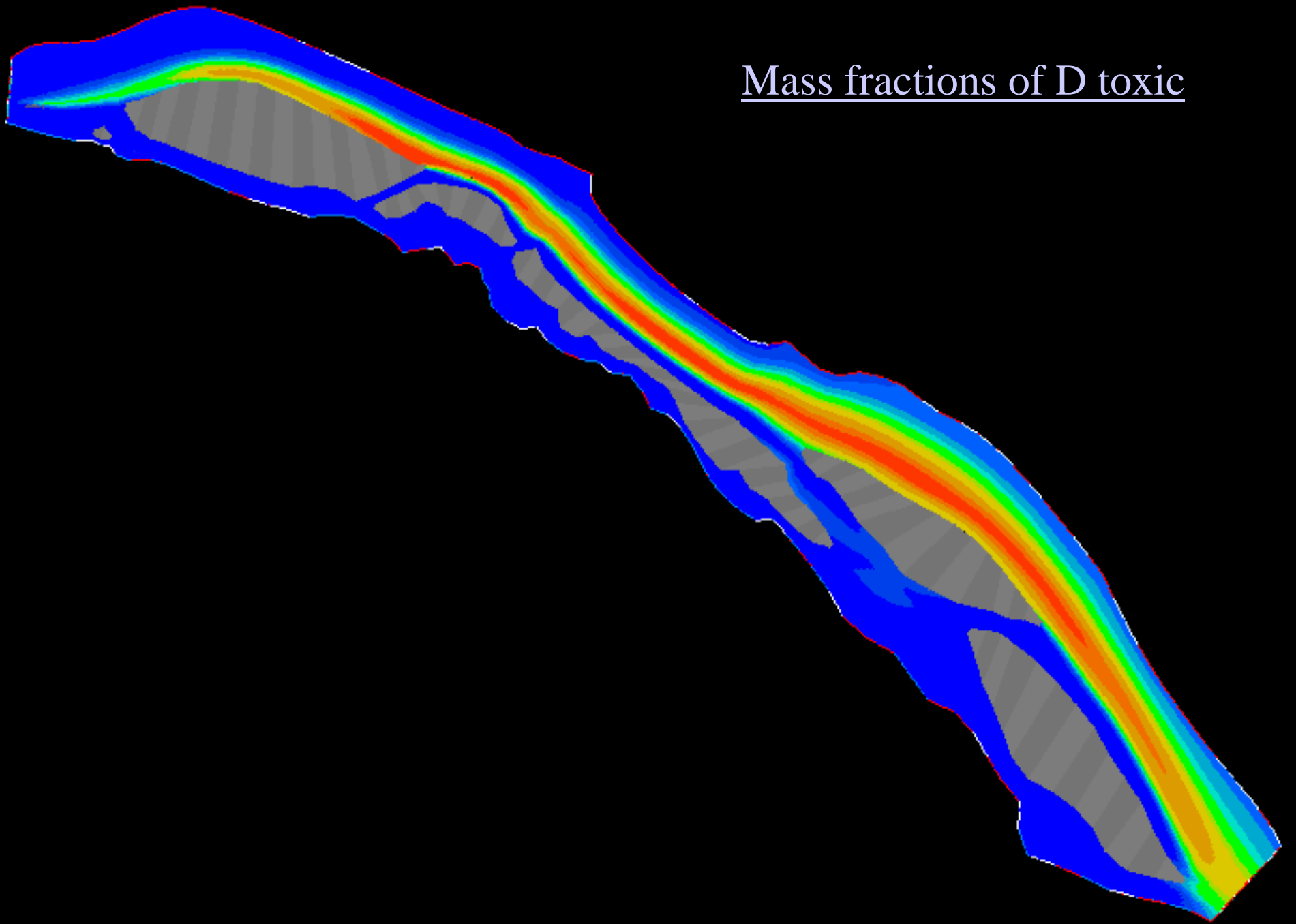
Plan view on computational grid



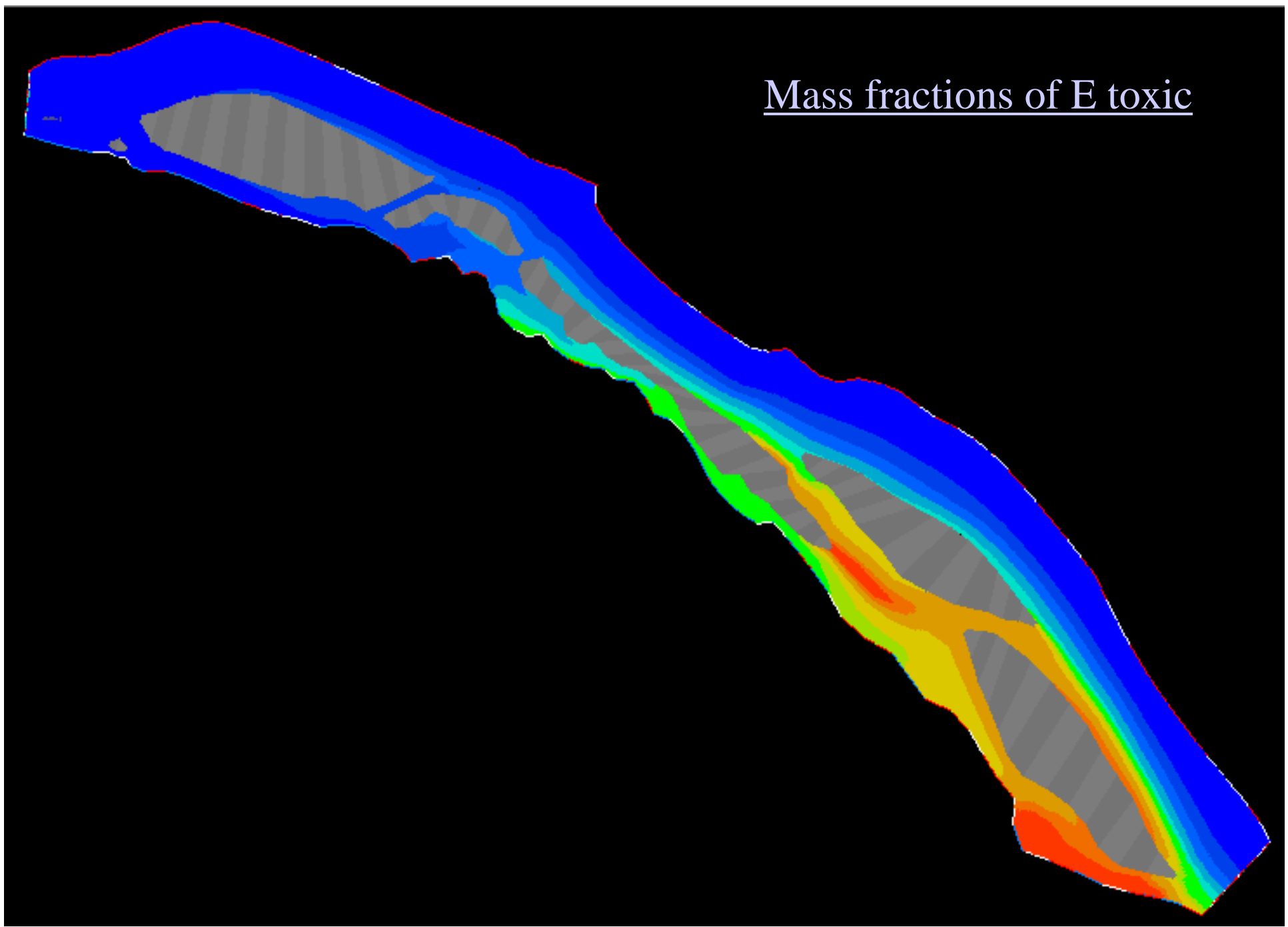
Velocity vectors of water currents



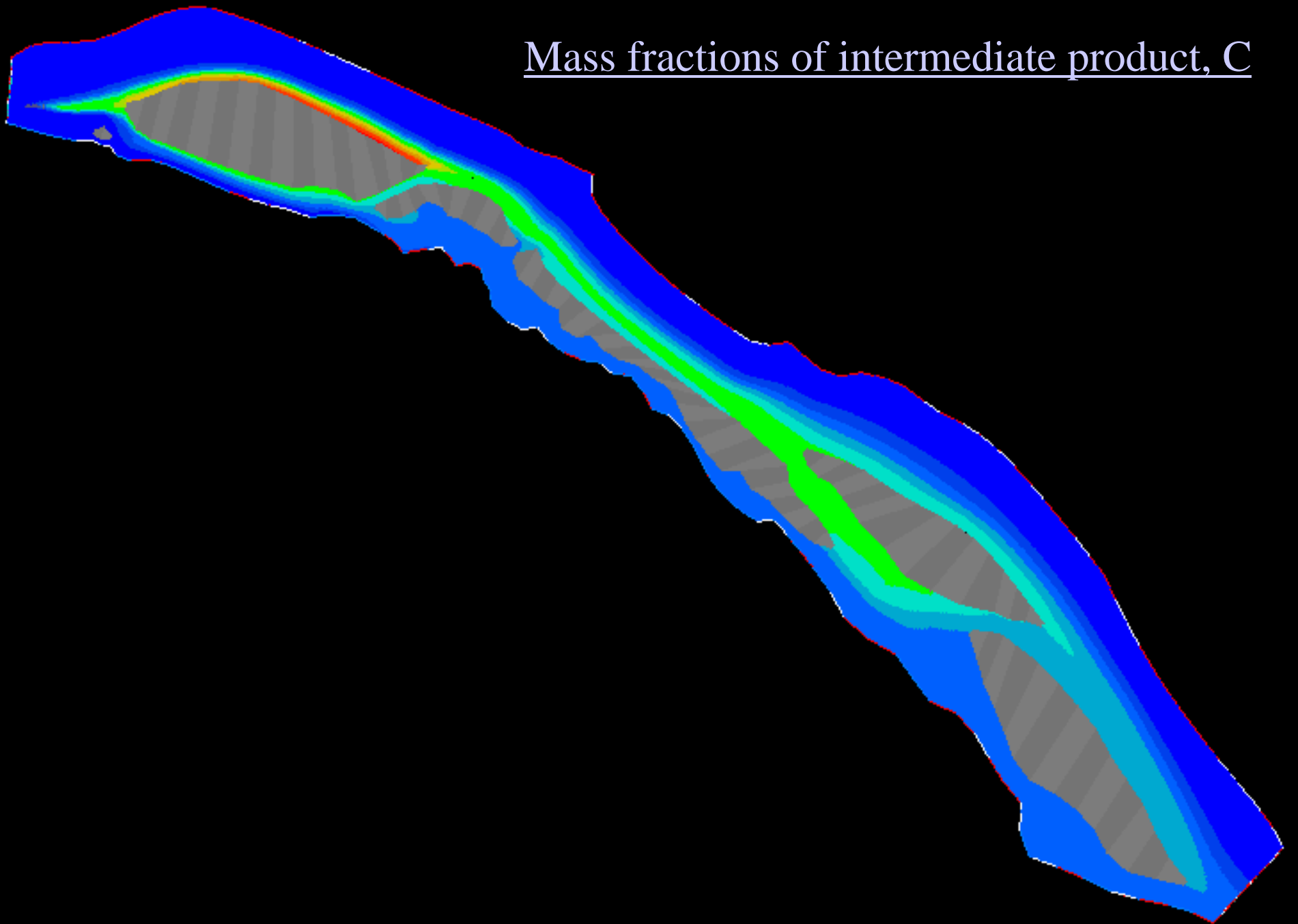
Mass fractions of D toxic



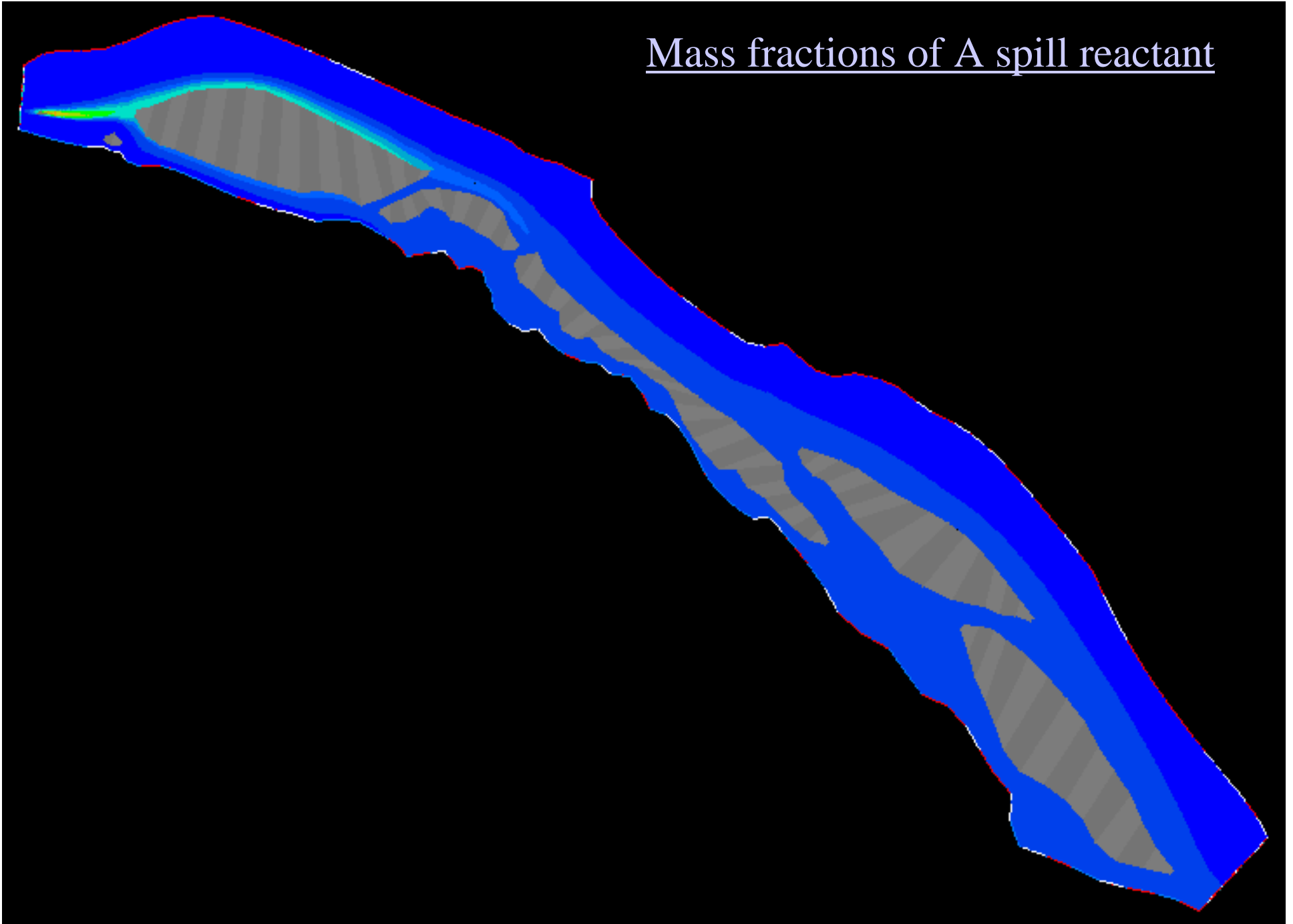
Mass fractions of E toxic



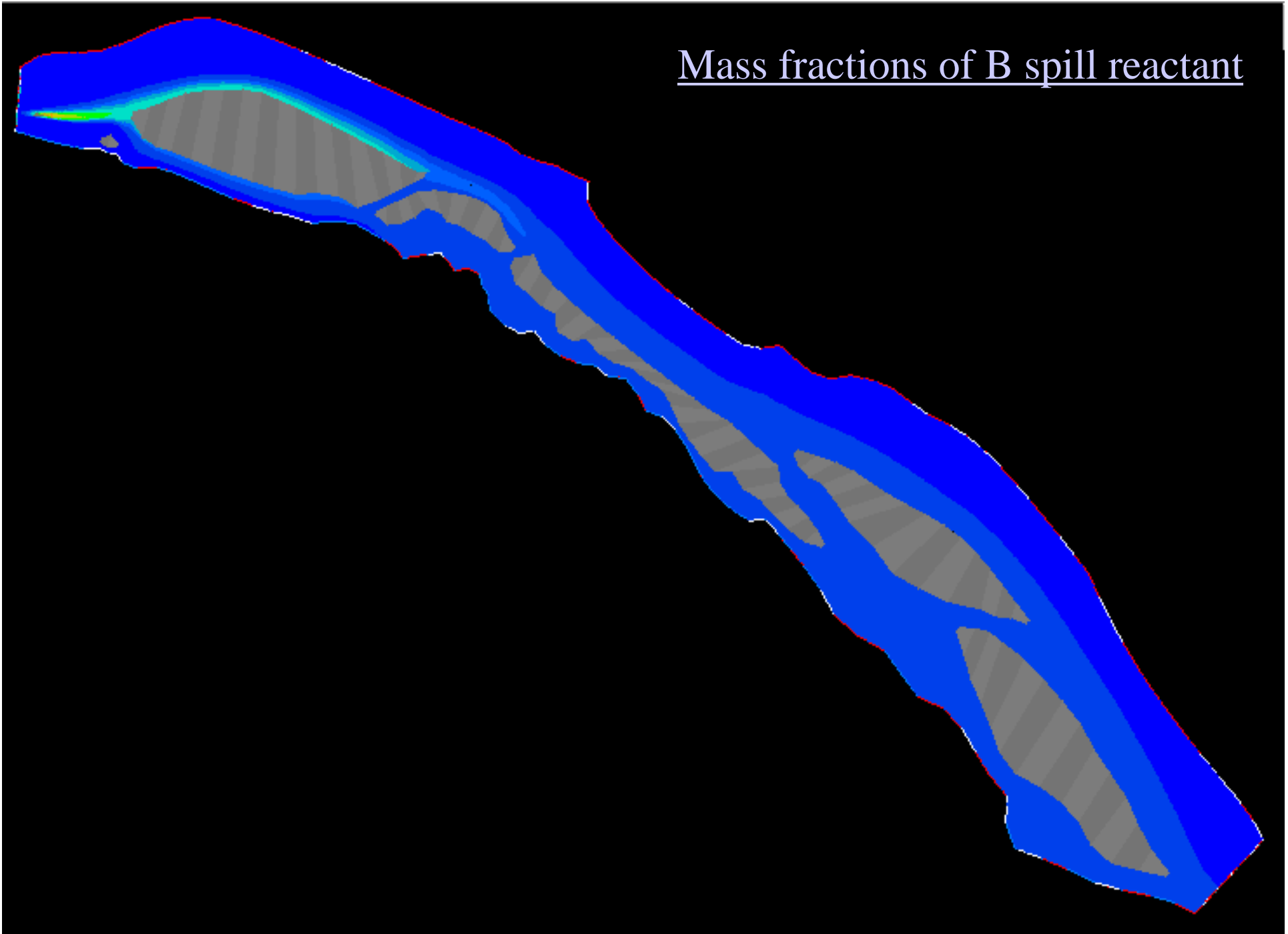
Mass fractions of intermediate product, C

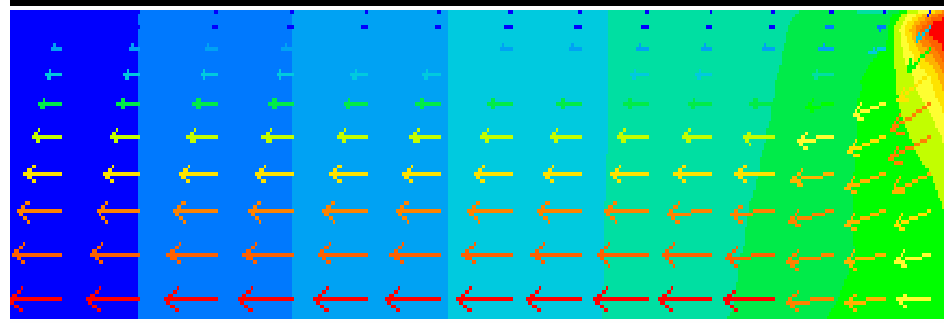


Mass fractions of A spill reactant

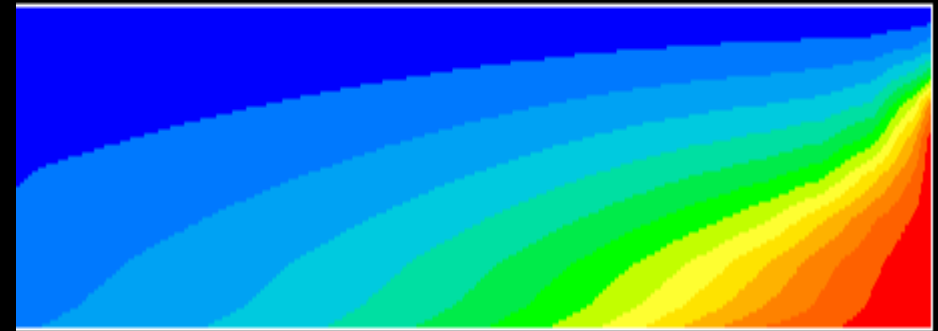


Mass fractions of B spill reactant

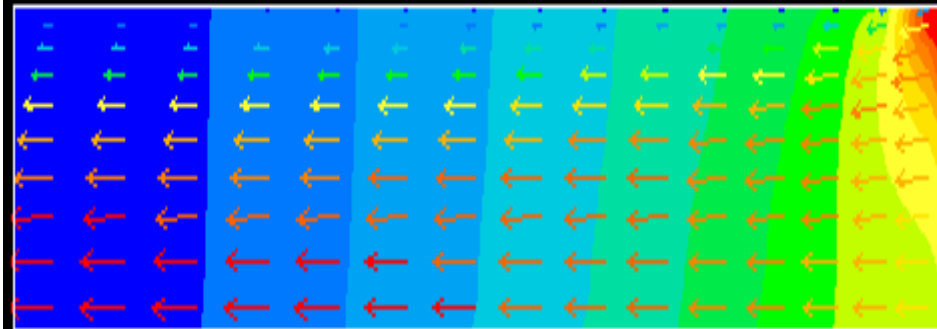




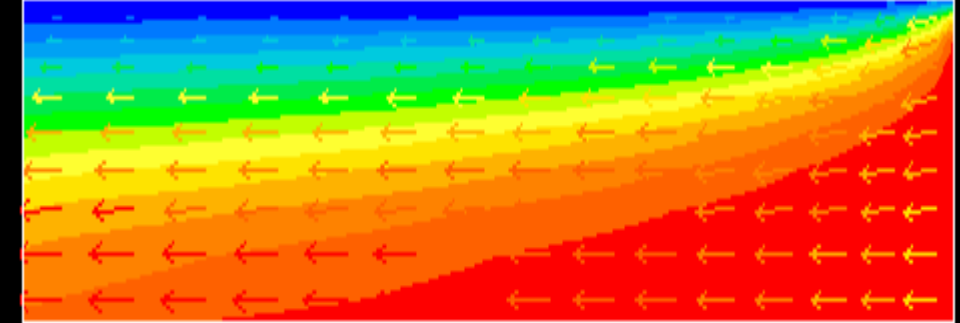
DILATANT FLUID \rightarrow 12.3 Vector ■ 0.8 ■ 8.2



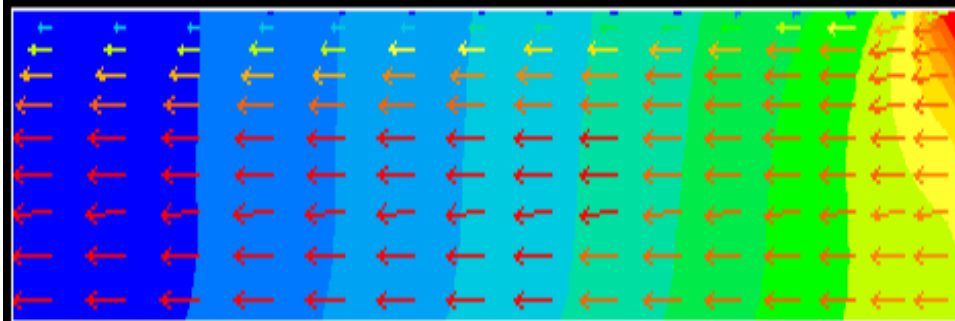
DILATANT TEMP ■ 0.6 ■ 8.6



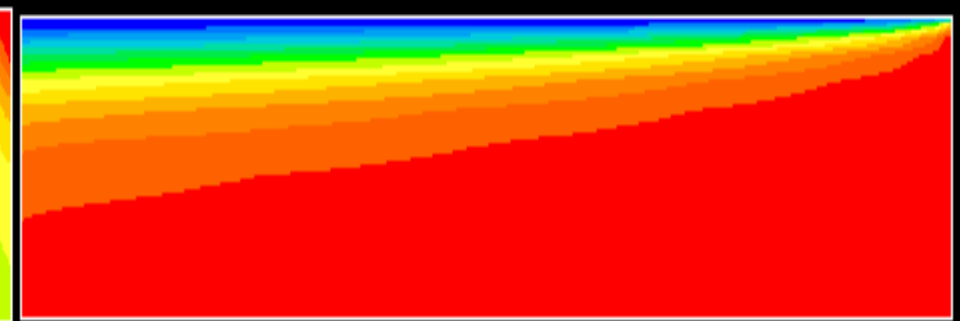
NEWTONIAN FLUID Vector ■ 0.7 ■ 7.0



NEWTONIAN \rightarrow 11.6 Vector ■ 0.7 ■ 7.0



PSEUDOPLASTIC \rightarrow 11.4 Vector ■ 0.9 ■ 5.9



PSEUDOPLASTIC TEMP ■ 1.1 ■ 9.0