


# Modeling Bottom Stress Distribution in the Venice Lagoon



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# Bottom Stress and Sediment Transport

- The bottom stress is main forcing factor for erosion and deposition processes
- The bottom stress is composed of both current and wave action
- Wave-Current interaction enhances the bottom stress of both contributions
- Both contributions are important in the Venice lagoon



# Simulations carried out

- Application of the circulation and the wave model for schematic test cases
- Simulation of currents only due to tidal action
- Simulation of Scirocco and Bora events
- Computation of wave-current interaction

# Bottom stress due to currents only

## Currents

$$\tau_c = \rho c_D u_b^2 \quad \text{bed shear-stress}$$

$$c_D = \frac{\kappa^2}{\ln^2\left(\frac{z_0 + 0.5h}{z_0}\right)} \quad \text{drag coefficient}$$

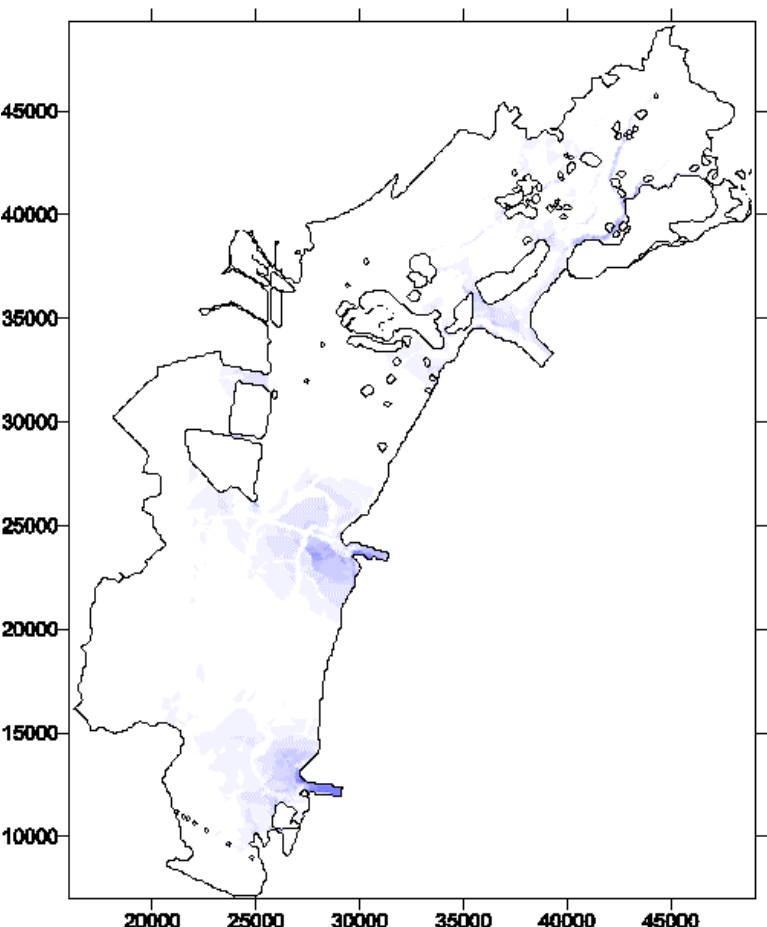
$u_b$  current velocity in bottom layer

$\kappa$  Von Karman constant       $h$  layer depth

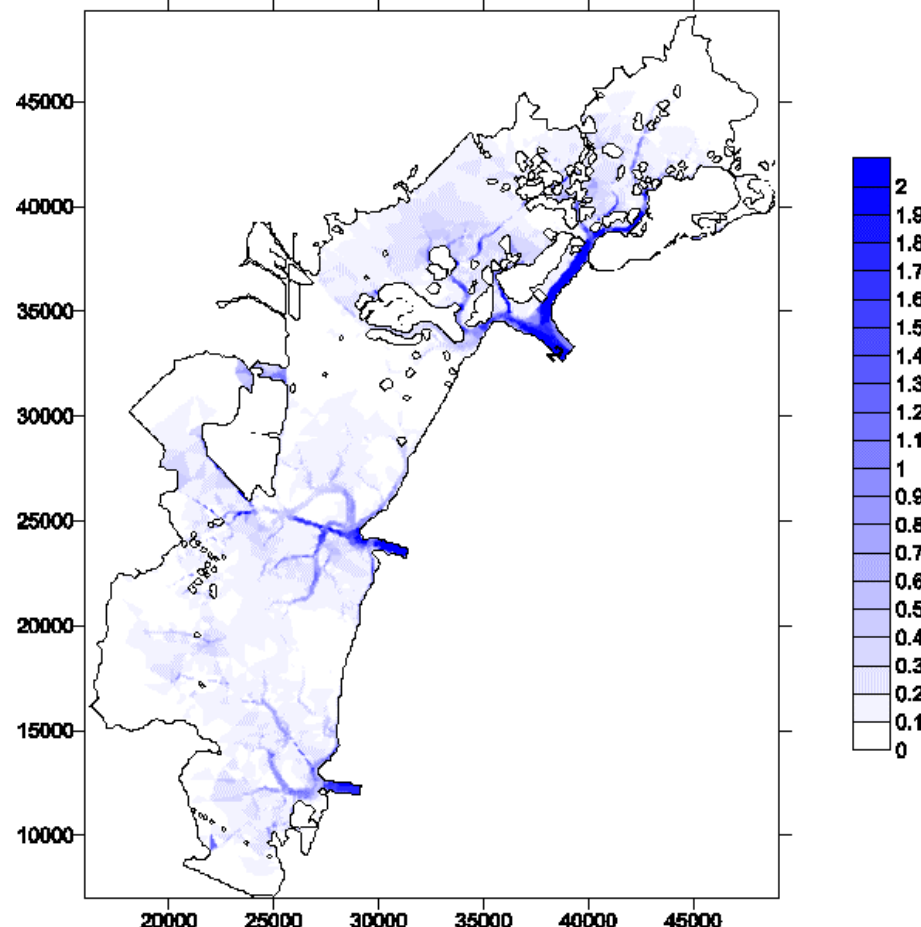
$z_0$  bed roughness length       $\rho$  density of water

# No wind – only current

b37sum E (NO WIND)

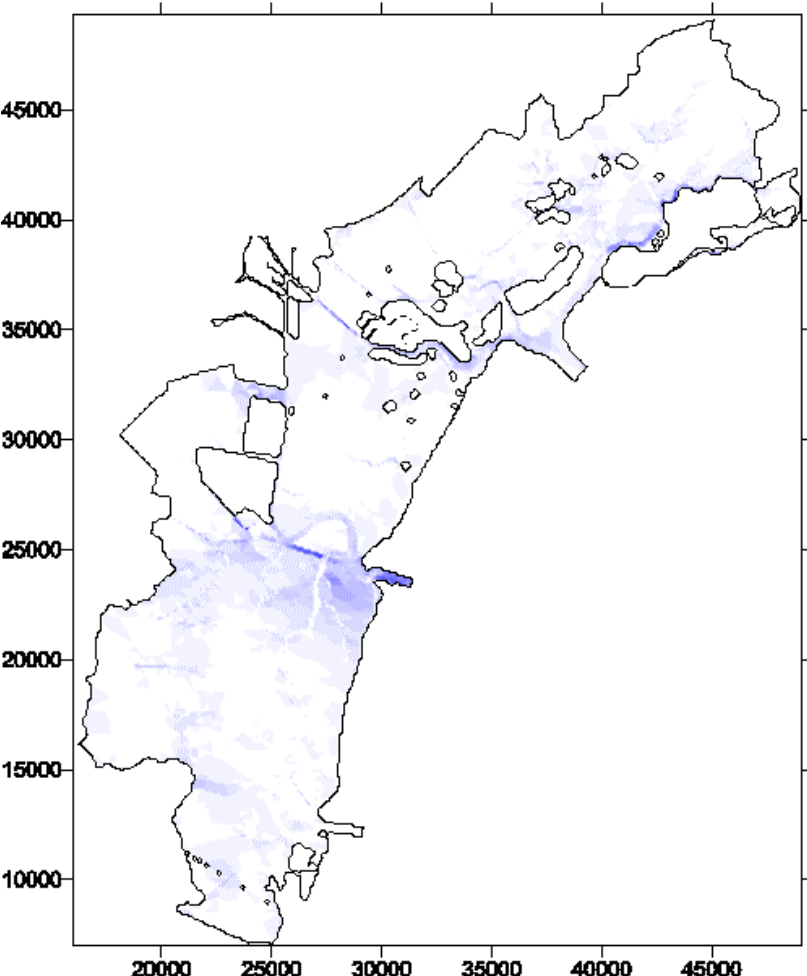


b40sum E

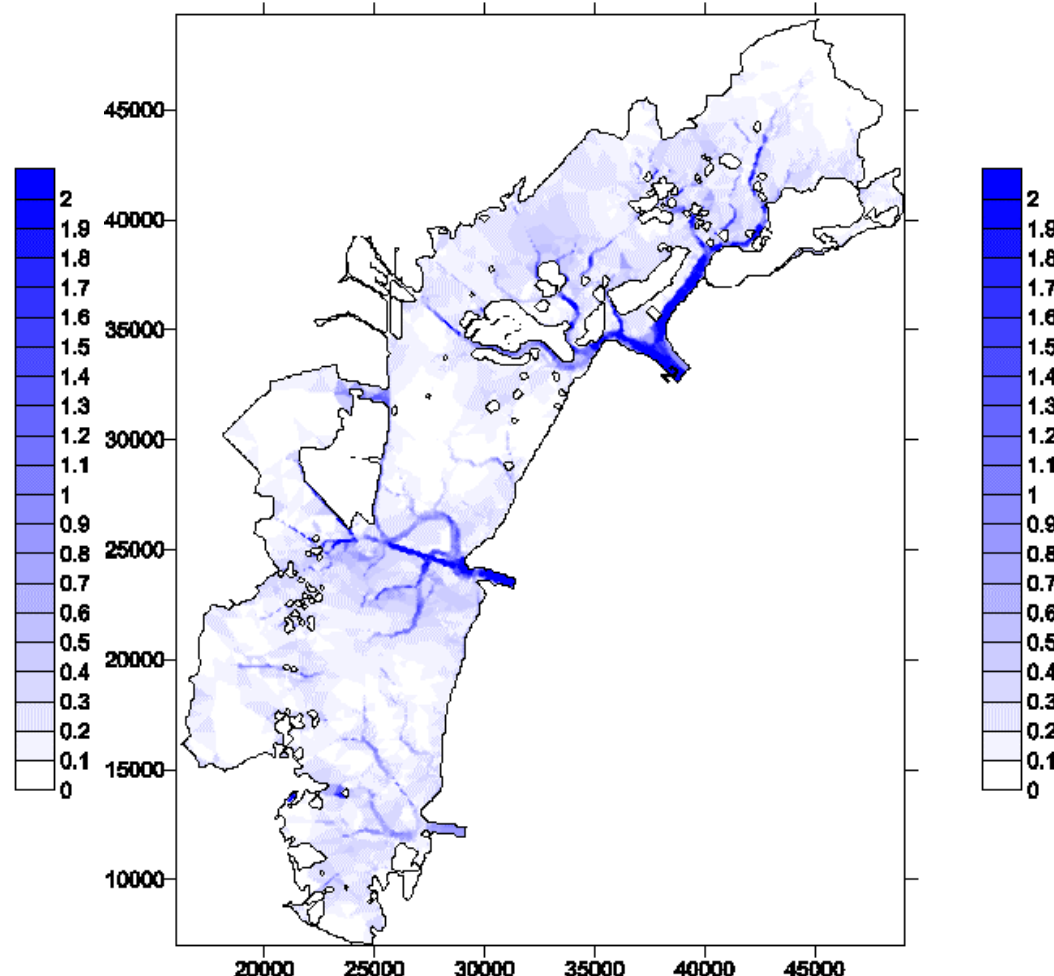


# Scirocco – only current

s37sumD

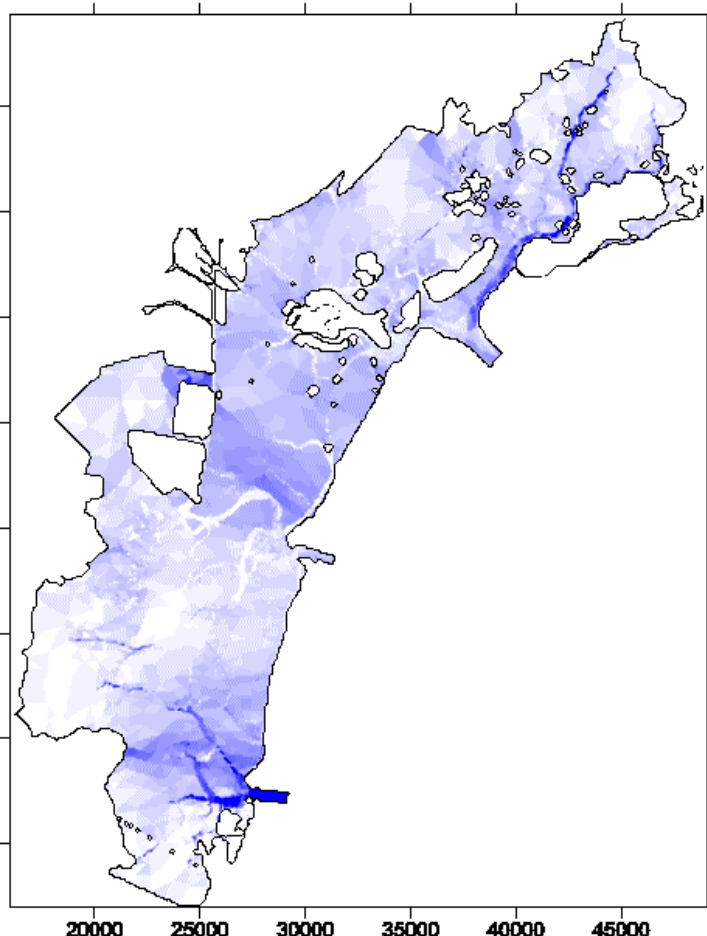


s40sumD

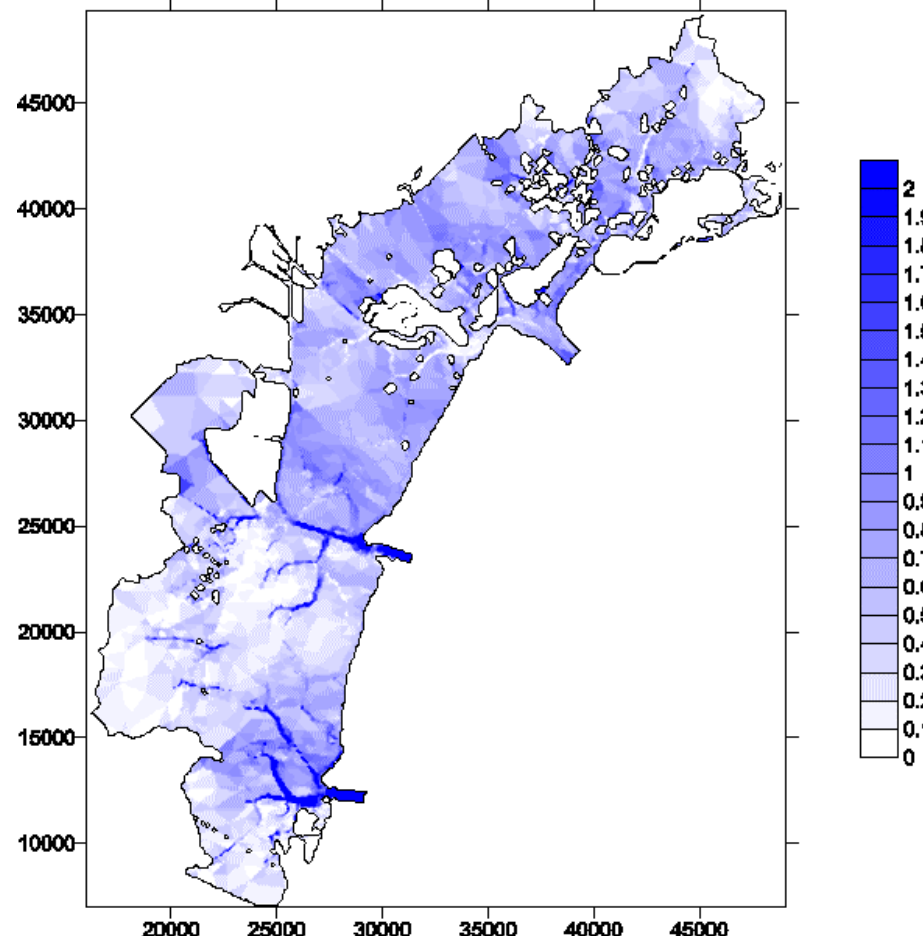


# Bora – only current

b37sumD



b40sum D



# Bottom stress due to waves only

Waves

$$\tau_w = \frac{1}{2} \rho f_w U_w^2 \quad \text{bed shear-stress}$$

$$f_w = 1.39 \left( \frac{A}{z_0} \right)^{-0.52} \quad \text{friction factor}$$

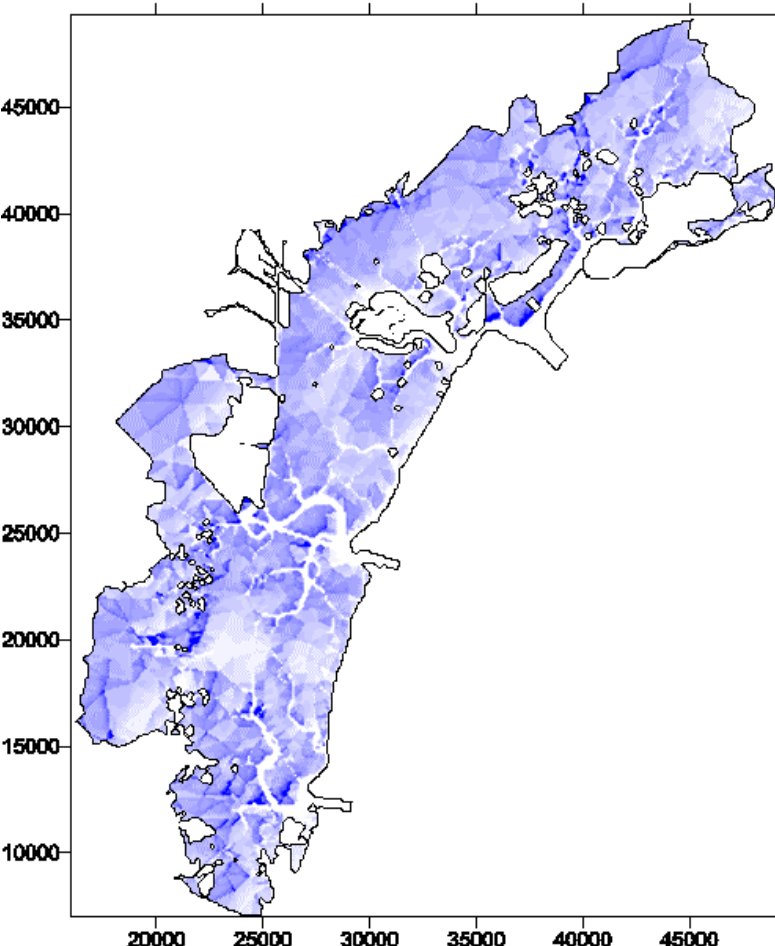
$$A = \frac{U_w T_p}{2\pi} \quad \text{semi-orbital excursion}$$

$U_w$  bottom orbital velocity       $z_0$  bed roughness length

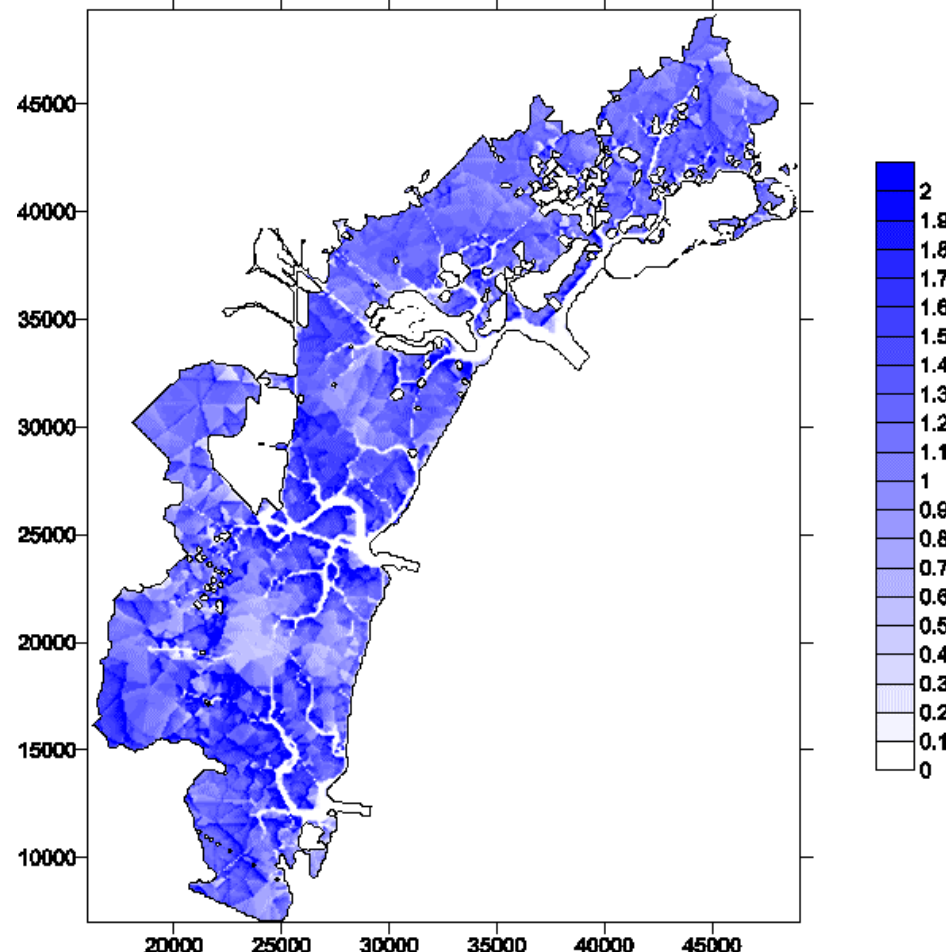
$\rho$  density of water       $T_p$  wave period

# Scirocco and Bora – only waves

s40sumC

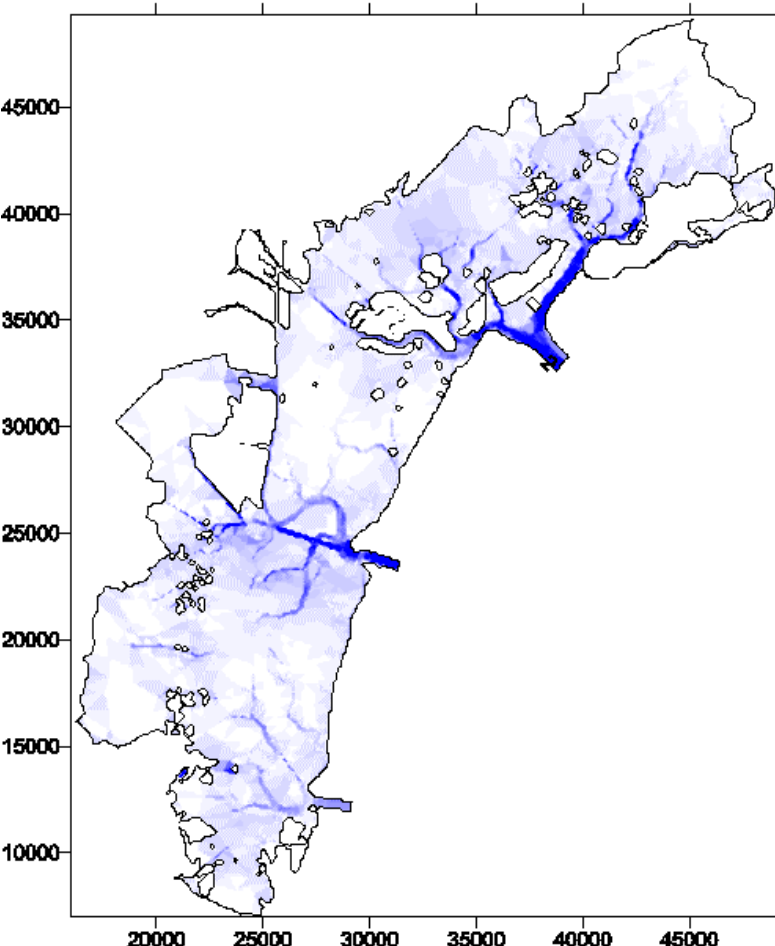


b40sum C

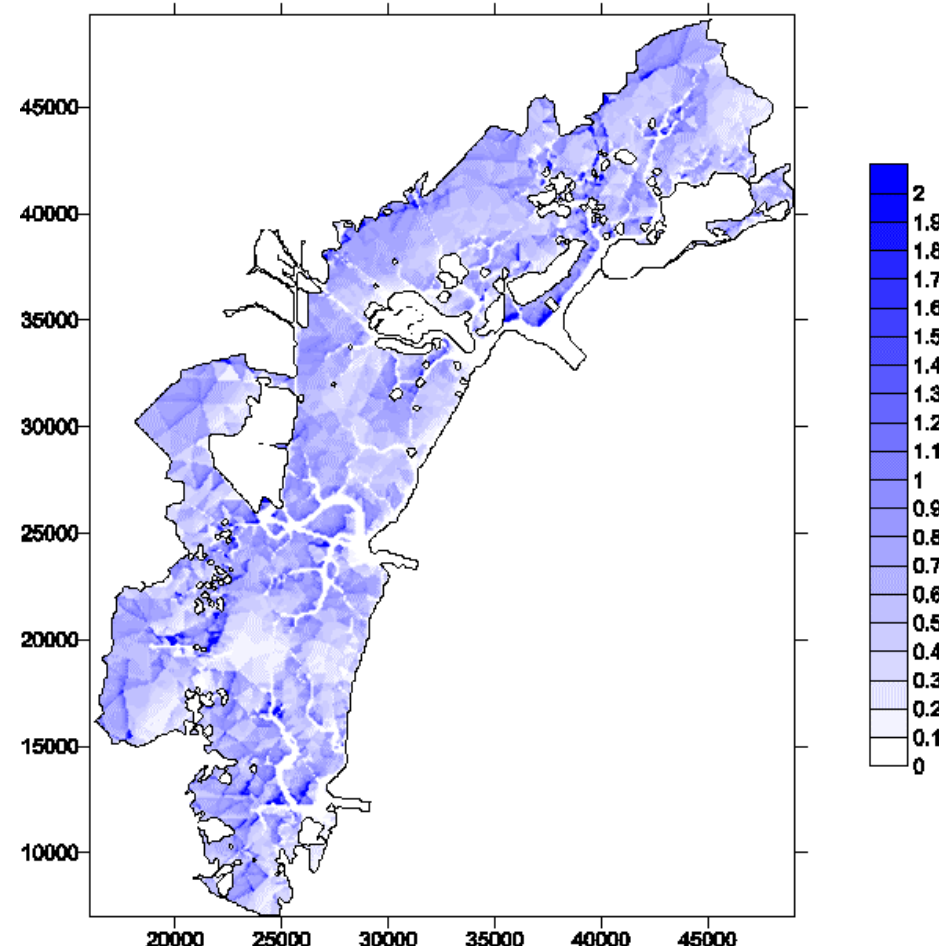


# Bottom stress due to currents and waves: a specular view

s40sumD



s40sumC



# Non linear wave-current interaction

- Various models exist for the description of the interaction
- All models predict an enhancement of the mean shear stress
- Here the empirical formulation of Soulsby is used

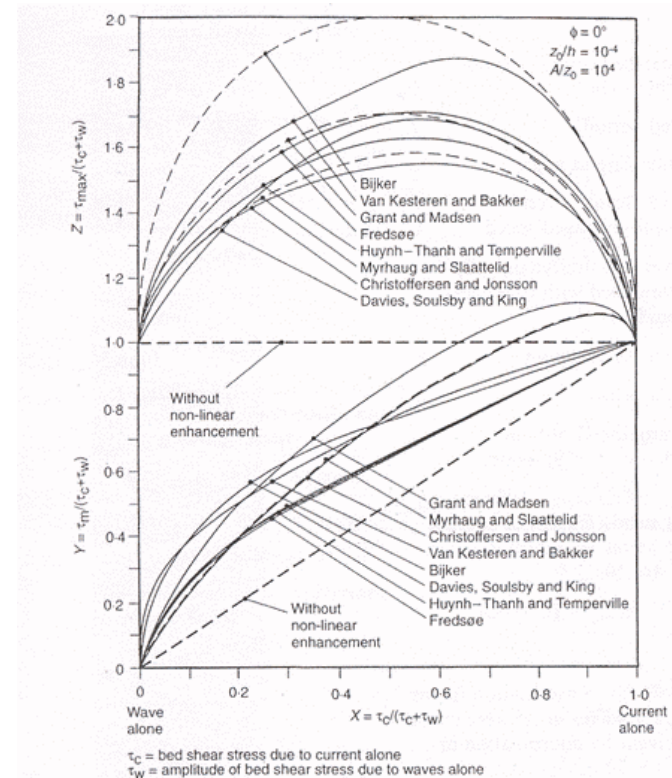
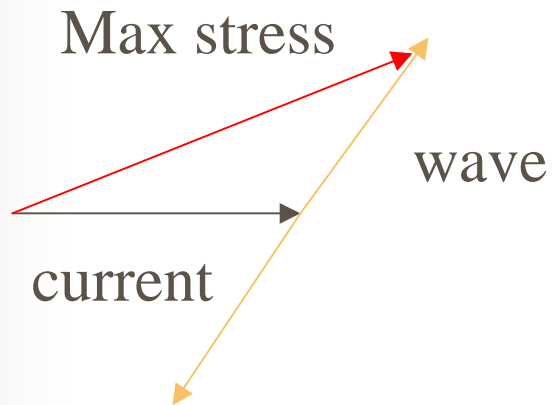


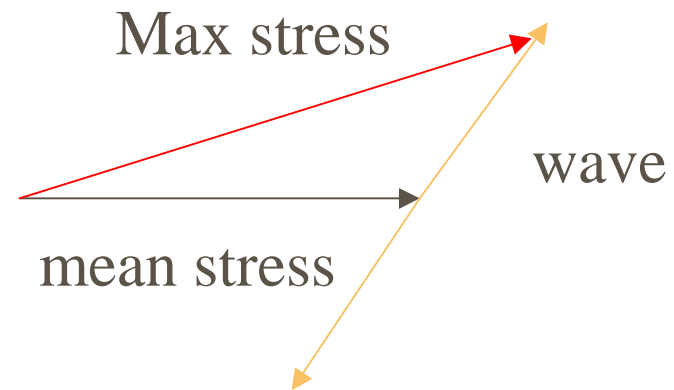
Figure 17. Intercomparison of eight models for prediction of mean ( $\tau_m$ ) and maximum ( $\tau_{max}$ ) bed shear stress due to waves plus a current (reprinted from Soulsby et al. (1993), *Coastal Engineering*, 21, 41–69, by permission of Elsevier Science Publishers, BV)

# Wave-current interaction

No interaction



Wave current interaction





# Bottom stress due to wave-current interaction

Wave-Current Interaction

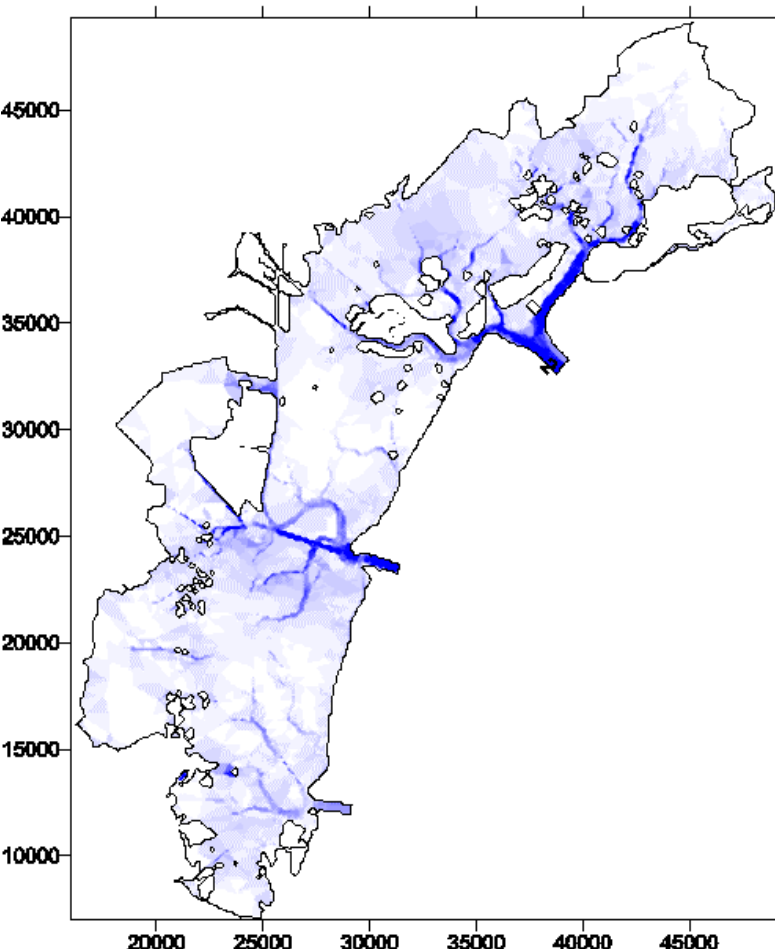
$$\tau_m = \tau_c \left[ 1 + 1.2 \left( \frac{\tau_w}{\tau_c + \tau_w} \right)^{3.2} \right]$$

$$\tau_{\max} = [(\tau_m + \tau_w \cos \Phi)^2 + (\tau_w \sin \Phi)^2]^{0.5}$$

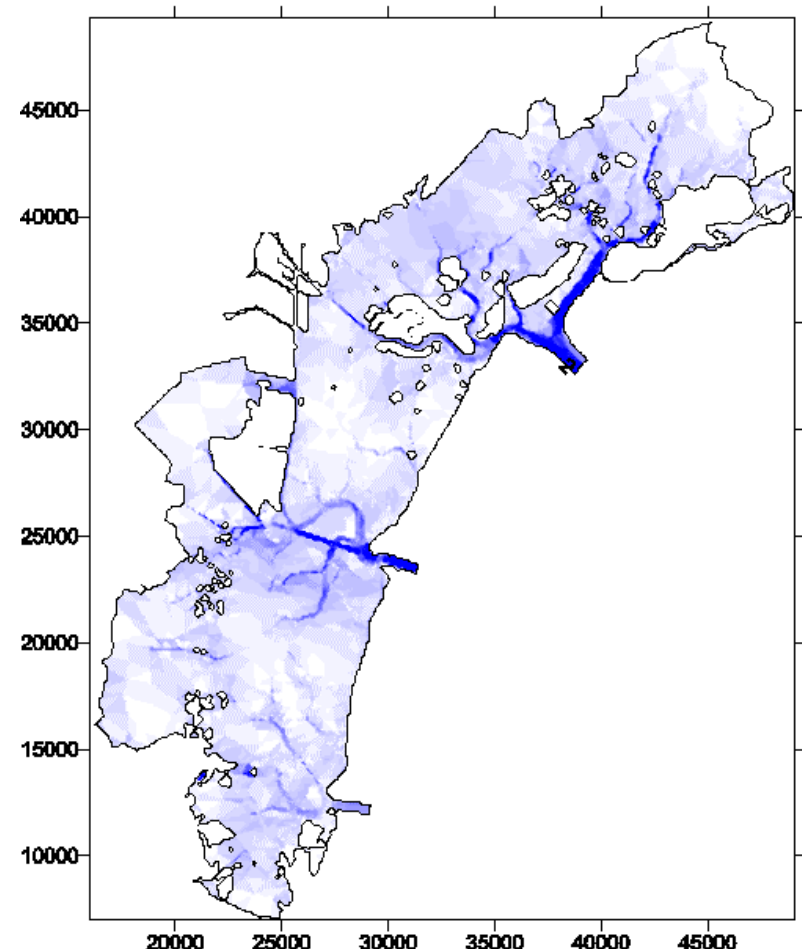
$\Phi$  angle between current and waves

# Mean shear stress: enhancement due to non linear interaction (Scirocco)

s40sumD

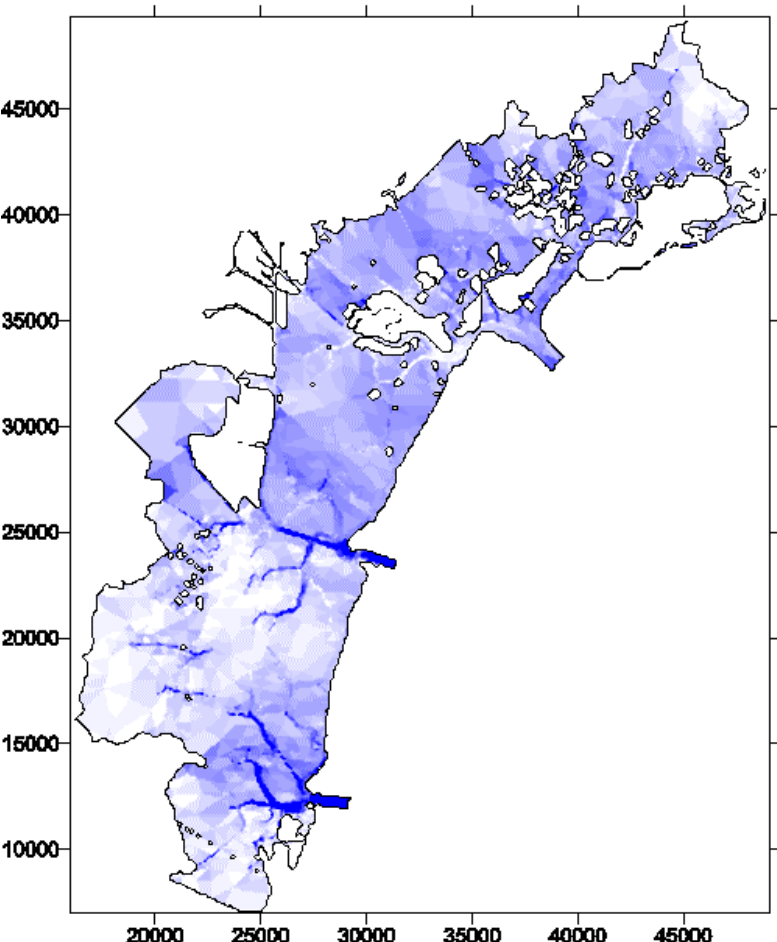


s40sumF

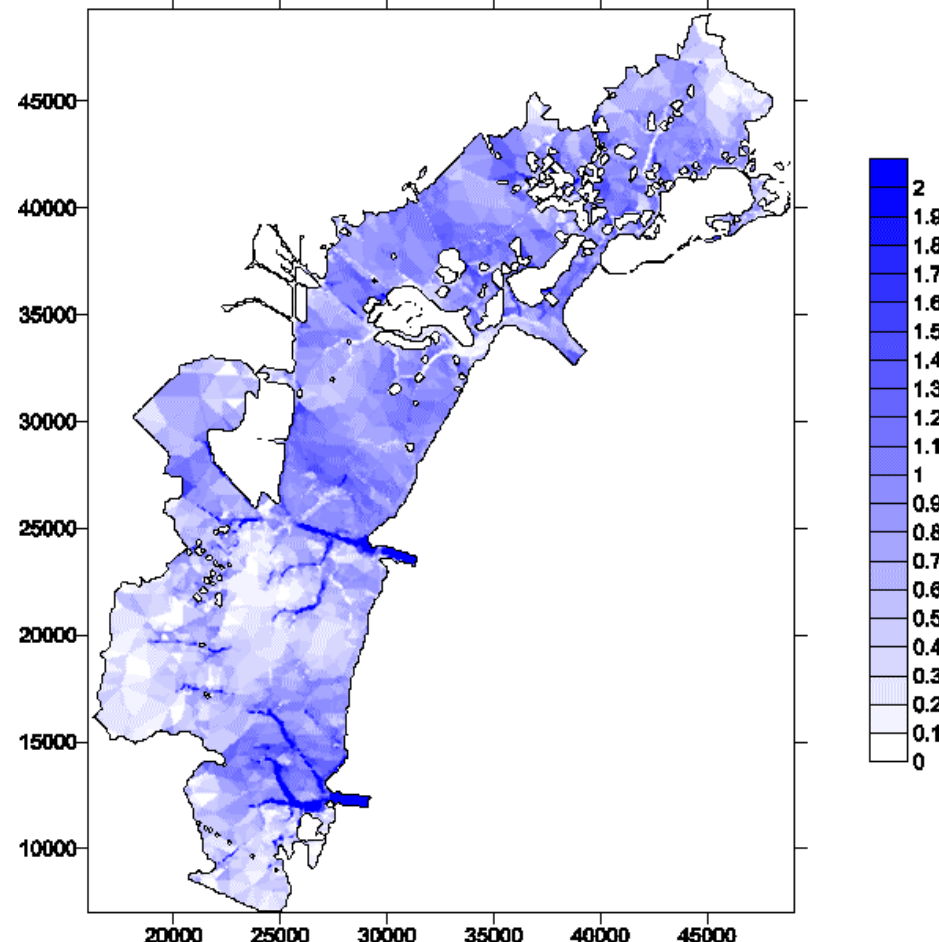


# Mean shear stress: enhancement due to non linear interaction (Bora)

b40sum D

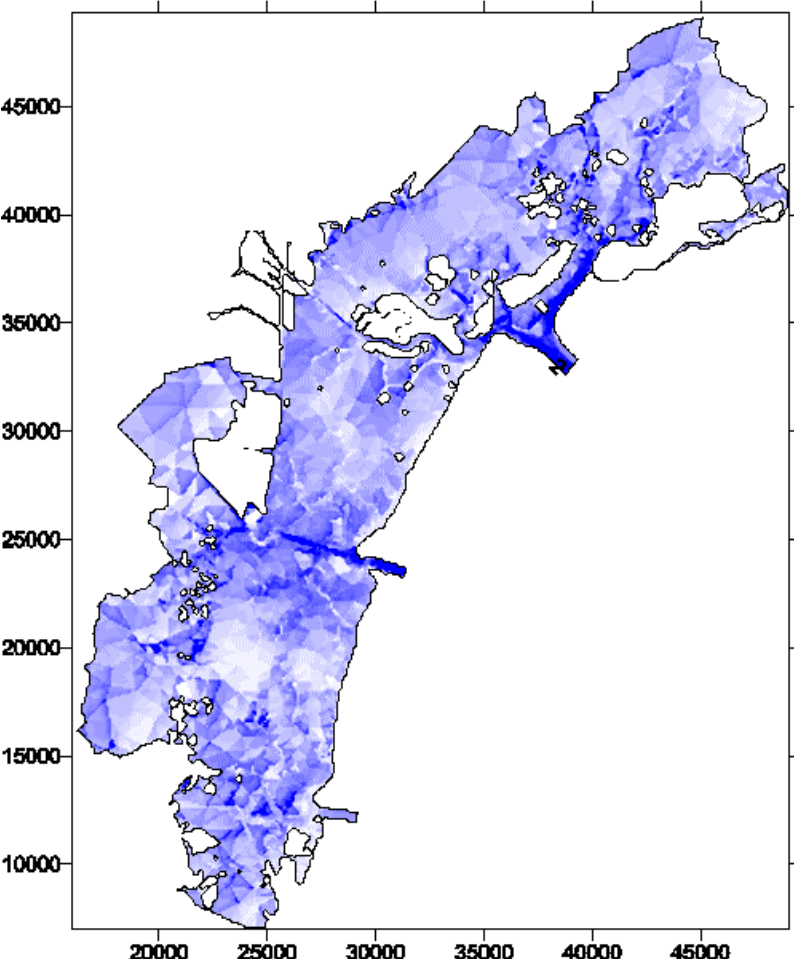


b40sum F

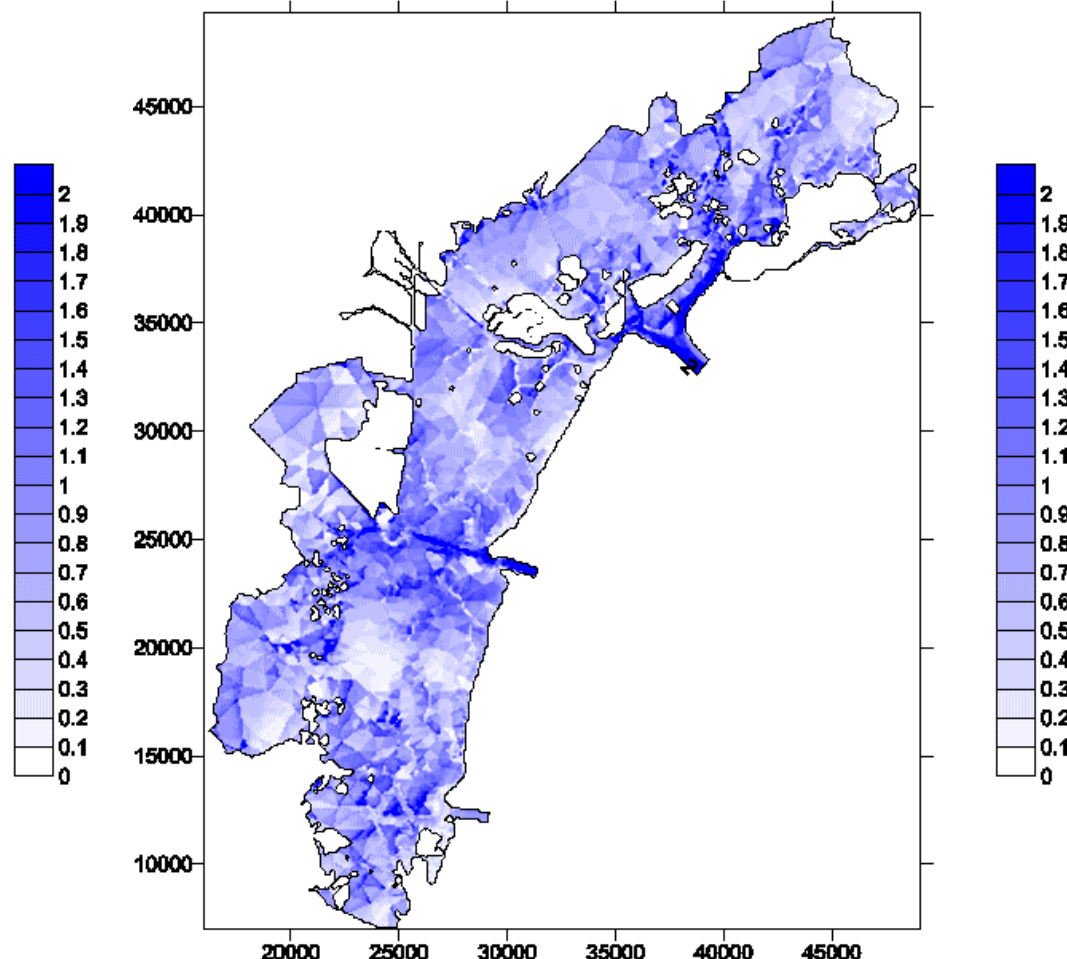


# Maximum shear stress: enhancement due to non linear interaction (Scirocco)

s40sumG

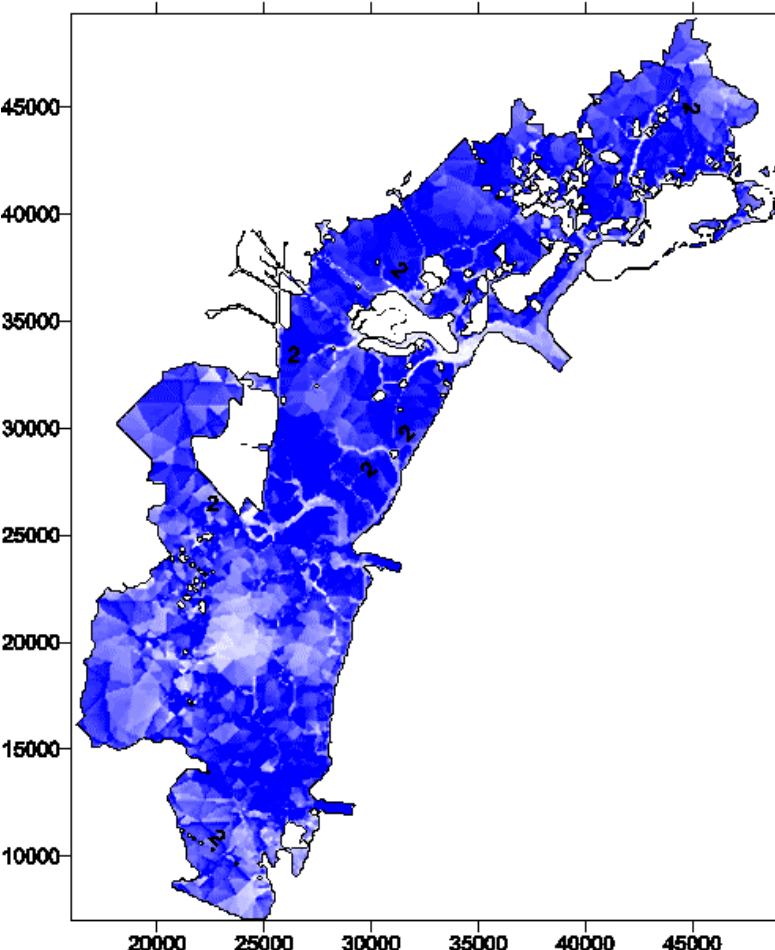


s40sumH

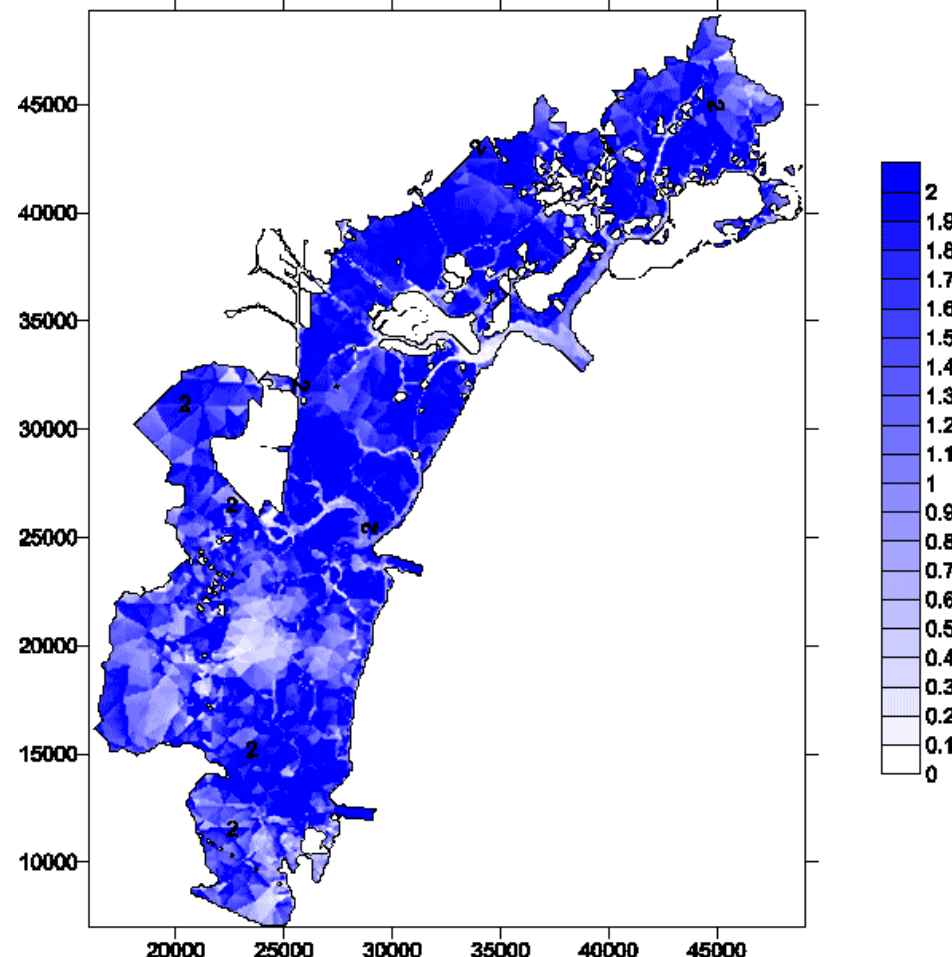


# Maximum shear stress: enhancement due to non linear interaction (Bora)

b40sumG (onde+corrente)

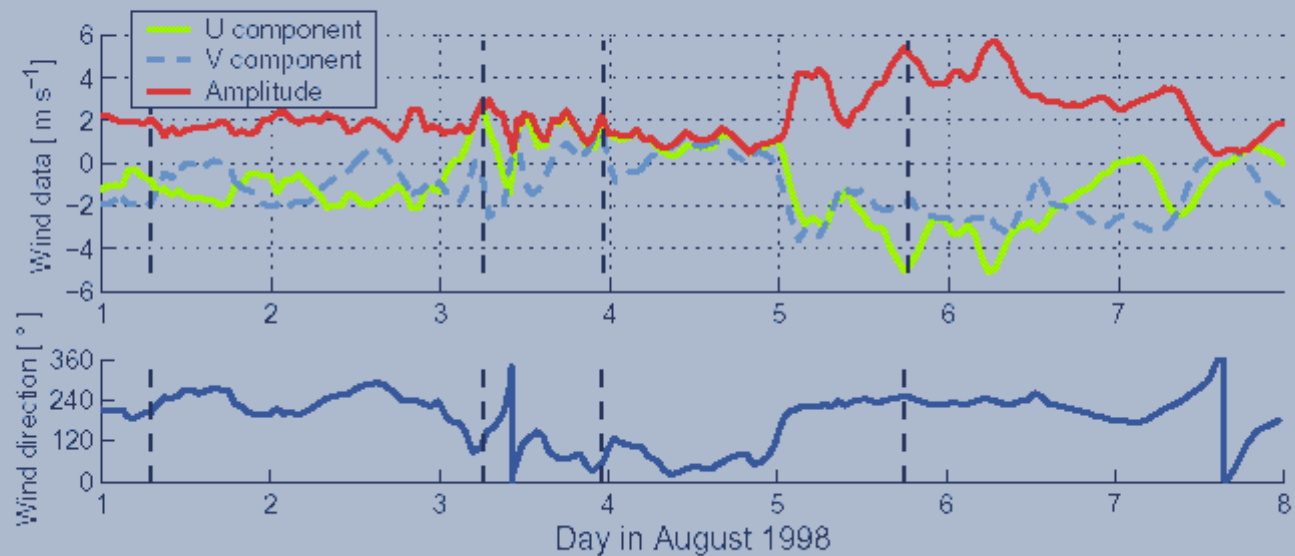


b40sumH

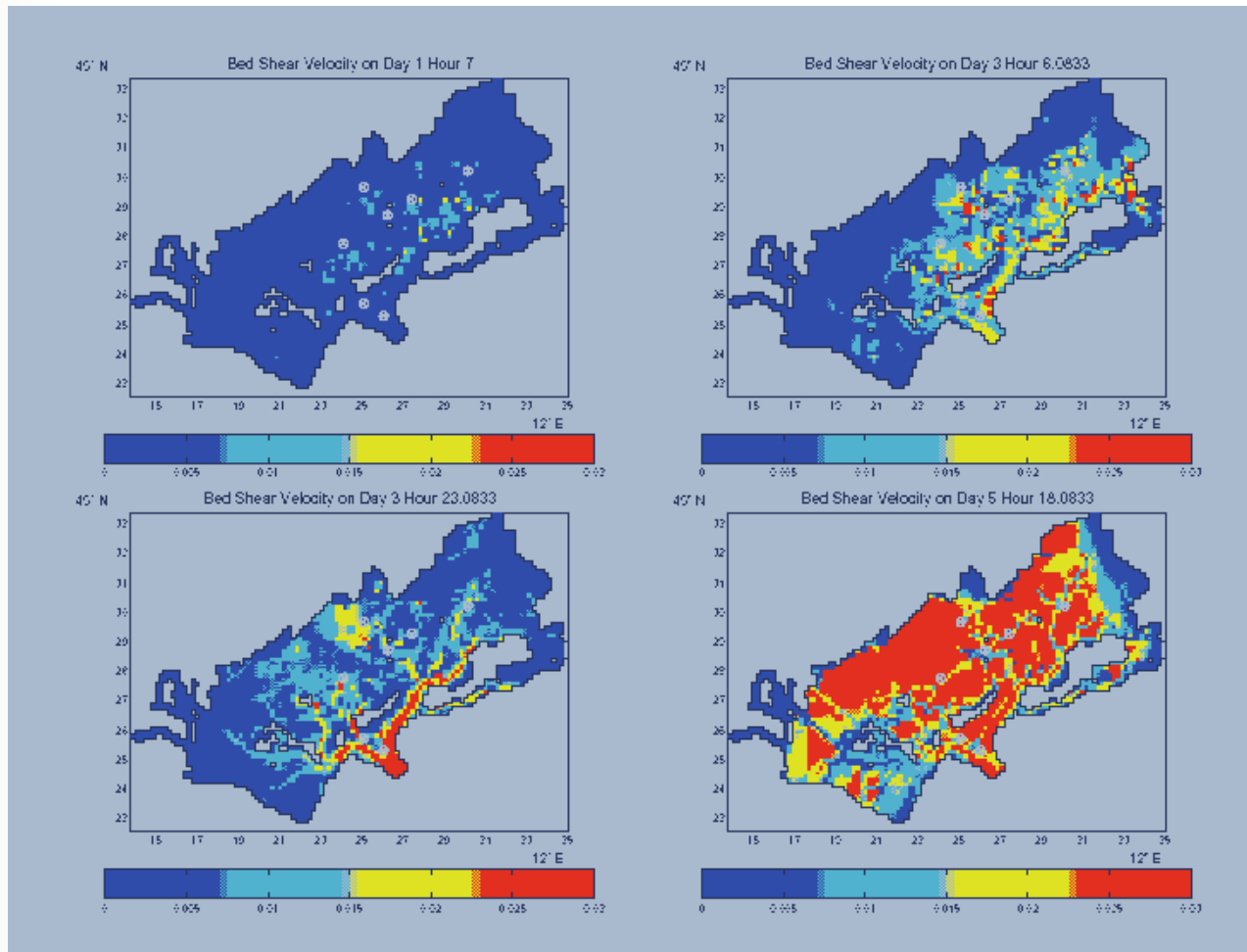


# F-ECTS field campaign - wind

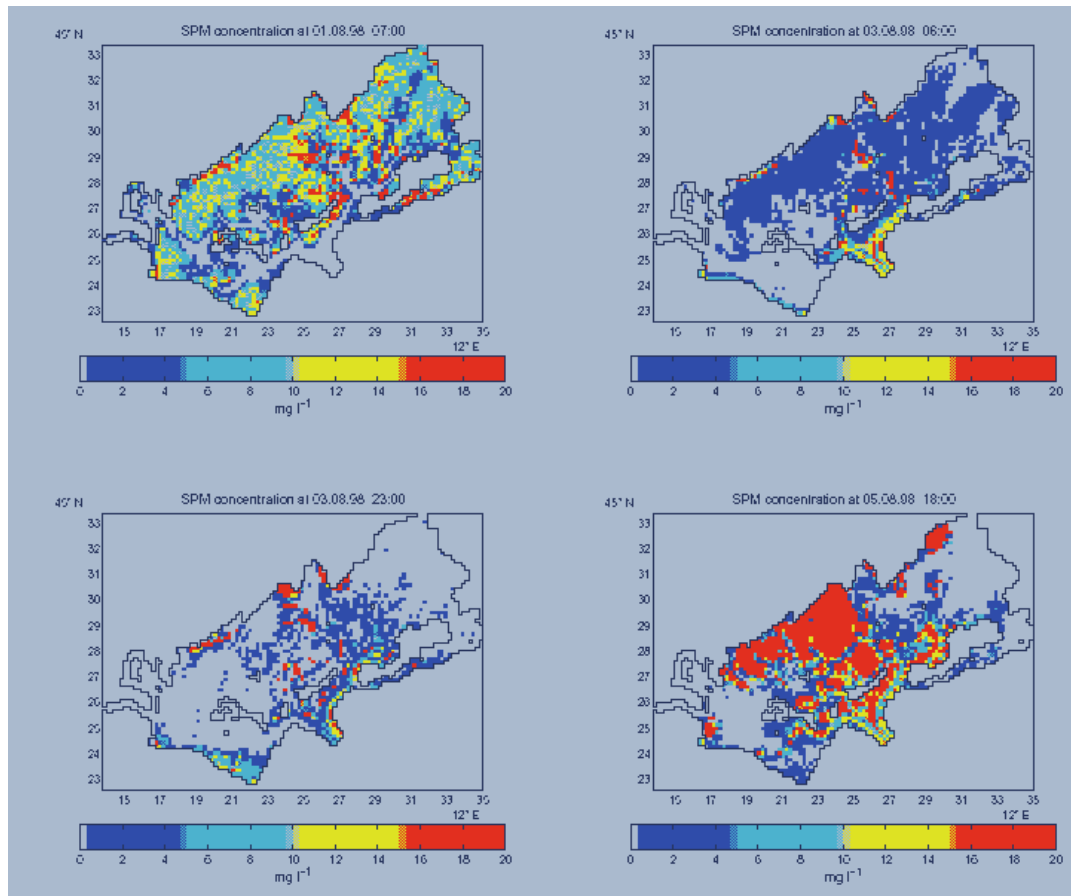
Wind velocity and direction



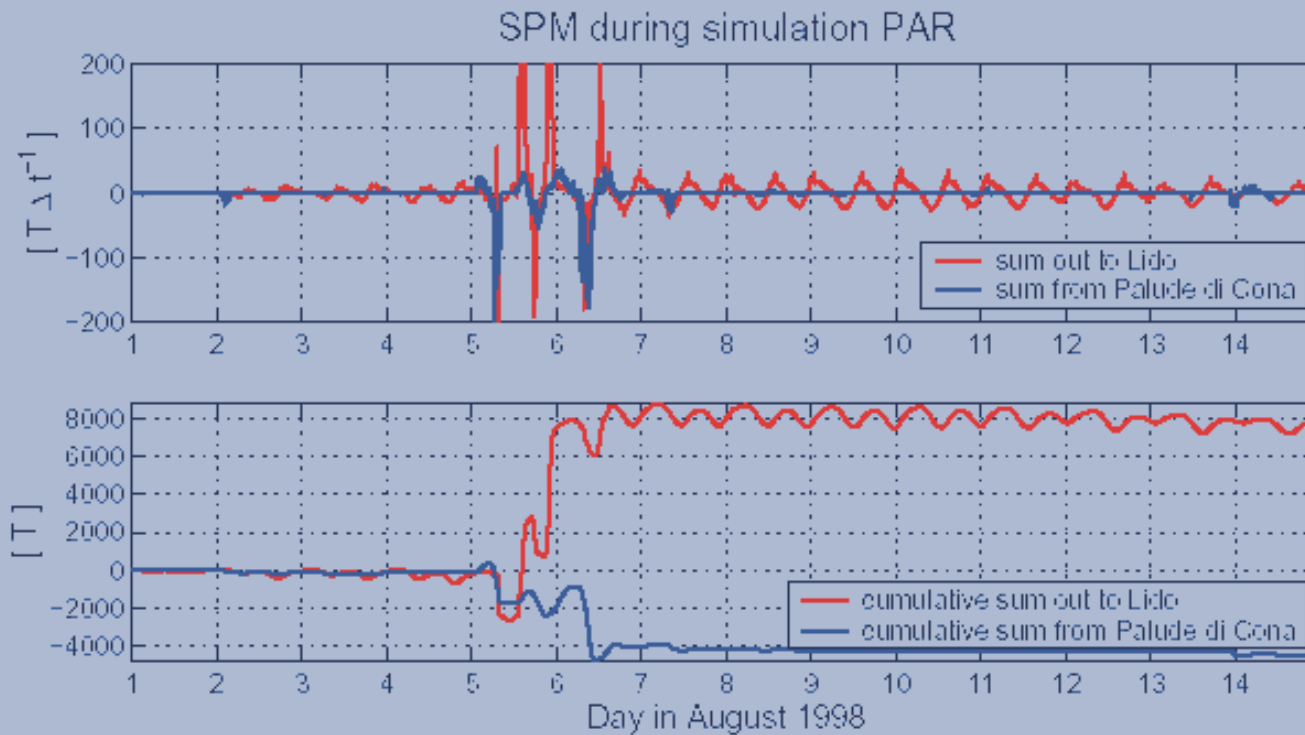
# Bottom stress computed



# SPM concentration computed



# Outgoing SPM-fluxes through Lido inlet





# Conclusions

- Shear stress due to waves is an important factor in the Venice Lagoon
- Currents dominate the channels and waves the shallow areas
- Short periods of strong wind events might dominate the sediment budget of the Venice Lagoon