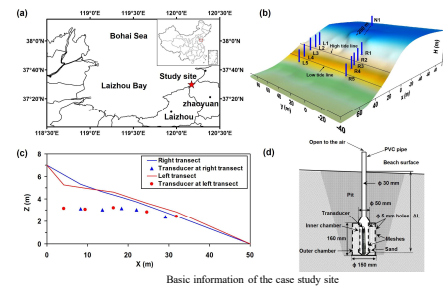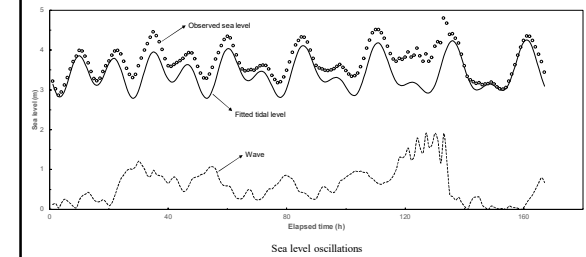EGU General Assembly 2020

Wave effect from sea level dynamics on density-dependent groundwater flow at a sandy beach

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May 2020

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Basic information of the case study site

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Sea level oscillations

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Mathematical model

$$\beta\phi\frac{\partial S}{\partial t} + \beta S_p S\frac{\partial \psi}{\partial t} + \phi S\frac{\partial \beta}{\partial t} = \frac{\partial\left(\beta\delta K\frac{\partial\psi}{\partial x}\right)}{\partial x} + \frac{\partial\left(\beta\delta K\frac{\partial\psi}{\partial z}\right)}{\partial z} + \frac{\partial\left(\beta^2\delta K\right)}{\partial z}$$

$$\phi S\frac{\partial c}{\partial t} = \beta\left[\nabla\cdot(\phi S\tau D_m\nabla c) + \nabla\cdot(\mathbf{D}\nabla c)\right] - \mathbf{q}\cdot\nabla c$$

$\beta_i = (1.0+\varepsilon c_i) = \rho_i/\rho_0$ ϕ = porosity S = soil moisture ratio

$\delta = (1.0-\xi c) = \mu_0/\mu$ ψ= pressure head   Kx and Kz: hydraulic conductivity

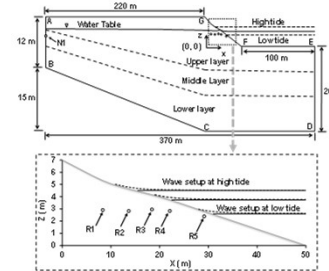q: Darcy velocity   D: dispersivity coeff. tensor c_1 and c_2: concentration
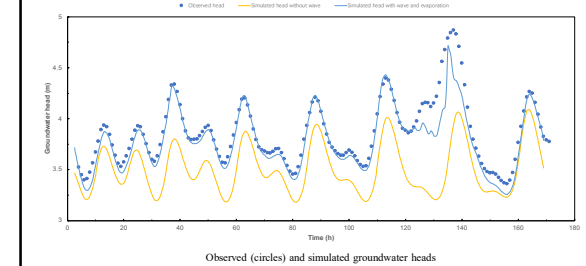

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Numerical model

$$E_g = \frac{\rho_a}{R_{air}}(q_g - q_a)$$
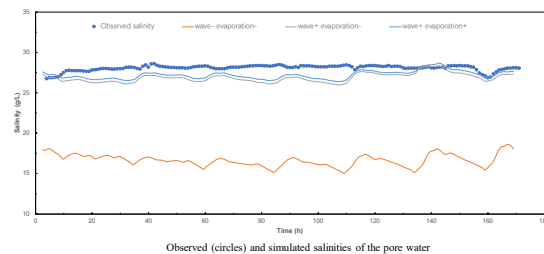
$$(qc - \beta\phi SD\cdot\nabla c)\cdot\vec{n} = 0$$

Eg: evaporation flux
ρa: air density
Rair: aerodynamic resistance
qg: surface specific humidity
qa: air specific humidity
q: Darcy flux vector
c: solute concentration
$\beta_i = (1.0+\varepsilon c_i) = \rho_i/\rho_0$
ϕ = porosity
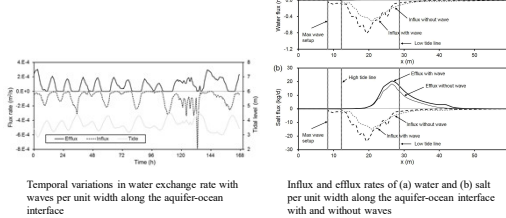S = soil moisture ratio
D: dispersivity coeff. tensor

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Observed (circles) and simulated groundwater heads

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Observed (circles) and simulated salinities of the pore water

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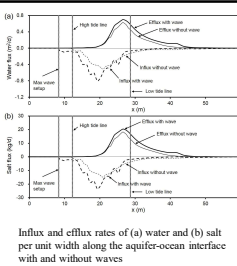
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Temporal variations in water exchange rate with waves per unit width along the aquifer-ocean interface

Influx and efflux rates of (a) water and (b) salt per unit width along the aquifer-ocean interface with and without waves

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Calculated SGD components. Note: Q_f means fresh groundwater discharge and Q_R means recirculated seawater

Seaward boundary condition	SGD (m²/d)	Q_f(m²/d)	Q_f/SGD	Q_R (m²/d)	Q_R/SGD
Combined waves and tides	7.37	0.08	1.1%	7.29	98.9%
Tides only	5.66	0.13	2.3%	5.53	97.7%