RADI.jl

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Abstract

RADI.jl is a Julia implementation of RADI: the 1-D Reaction-Advection-Diffusion-Irrigation Diagenetic Sediment Module. Here, we define the variables and the equations used in this implementation. So far, only one solute (dissolved oxygen) and one solid (particulate organic carbon) are included and documented here.

1 Parameters

1.1 Time

Time units are always in ???

- T is the total time that the model runs for.

- dt is the time resolution (i.e. the interval between each timestep).

- t refers to a specific modelled point in time (i.e. timestep).

The model therefore runs from time 0 to T in intervals of dt.

1.2 Sediment column

1.2.1 Structure

Depth units are always in metres.

- Z is the total thickness of the sediment column being modelled.

- dz is the depth resolution (i.e. the height of each model layer).

- z refers to a specific modelled depth within the sediment.

The model layers are therefore at depths within the sediment from 0 to Z in increments of dz, where 0 represents the interface between the surface sediment and overlying seawater.

1.2.2 Overlying water

1.2.3 Sediment properties

The depth-varying porosity (ϕ) is parameterised following Boudreau [1996]:

$$\phi = \phi_\infty + (\phi_0 - \phi_\infty)\exp(-\beta z) \tag{1}$$

where $\phi_\infty = 0.74$, $\phi_0 = 0.85$ and $\beta = 33$ [Boudreau, 1996]. The corresponding "solid porosity" is:

$$\phi_s = 1 - \phi \tag{2}$$

Following Archer et al. [2002], the surface sediment bioturbation coefficient B_0 is:

$$B_0 = 0.0232F^{0.85} \tag{3}$$

This propagates down through the sediment following:

$$B_z = B_0\exp(-z/\lambda_b)[\texttt{oxy}]/([\texttt{oxy}] + 0.02\,\mu\text{M}) \tag{4}$$

where λ_b is the characteristic depth of 0.08 m, following Sayles et al. [2001].

The rate constant for organic matter degradation (k_z) is:

$$k_z = 80.25B_0\exp(-z) \tag{5}$$

2 Variables

2.1 Porewater solutes

- Dissolved oxygen: `oxy`.

2.2 Solids

- Particulate organic carbon: `poc`.

3 Master equation

For each modelled variable v:

$$v_{t+1} = v_t + R(v_t) + A(v_t) + D(v_t) + I(v_t) \tag{6}$$

where:

- v_t is the concentration of the variable v at timestep t at a specific depth in the sediment (z).

- $R(v_t)$ quantifies the effect of **reactions** on v from t to $t+1$.

- $A(v_t)$ quantifies the effect of **advection** on v from t to $t+1$.

- $D(v_t)$ quantifies the effect of **diffusion** on v from t to $t+1$.

- $I(v_t)$ quantifies the effect of **irrigation** on v from t to $t+1$.

4 Reaction

Biogeochemical reactions for both solutes and solids are modelled as:

$$R(v_t) = r(v) \, dt \tag{7}$$

where $r(v)$ is the net rate at which v is being consumed (negative r_v) or created (positive r_v) by biogeochemical reactions.

4.1 Organic matter degradation

Organic matter degradation affects dissolved oxygen (`oxy`) and particulate organic carbon (`poc`):

$$r(\texttt{poc}) = -k_z[\texttt{poc}] \tag{8}$$

$$r(\texttt{oxy}) = r(\texttt{poc}) \cdot \phi_s/\phi \tag{9}$$

where the rate constant k_z was defined in Eq. (5), and porosity coefficients ϕ and ϕ_s in Eqs. (1) and (2) respectively.

5 Advection

6 Diffusion

7 Irrigation

References

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