Introduction
The Framework for Aquatic Modeling of Earth System (FrAMES) is a spatially and temporally explicit multi-scale (local through global) hydrological/biogeochemical modeling scheme (Wolffheim et al., 2008). FrAMES is an ongoing interdisciplinary project, modeling varying aspects of river flux response to changing environmental conditions. Here we present a new component within this framework, a spatially explicit sediment flux model.

Methodology
We expand the BQART sediment flux model from point (river outlet) to distributed (pixel) scale by integrating it into the WBMin continental hydrology model (an integral part of the FrAMES scheme).

The BQART/WBM model
An analytical model describing the empirical relationship between basin geomorphology, climatology, geology, human characteristics and long-term sediment flux (Syvitski and Milliman, 2007; Fig. 1):

\[ Q_s = wBQ^{0.31}A^{0.85}RT \]  

(Eq. 1)

where

- \( w \) - long-term Average Suspended Sediment load (kg/s)
- \( Q_s \) - long-term Average Discharge (m³/s)
- \( A \) - contributing Area (km²)
- \( R \) - maximum Relief [km]
- \( T \) - long-term average Temperature [°C]

\[ B = I(A - T_s)E_s \]  

(Eq. 2)

where

- \( I \) - Anthropogenic Factor: \( \text{POP} \times \text{GDP} \)
- \( E_s \) - Anthropogenic Factor: \( / \text{POP} \times \text{GDP} \)
- \( T_s \) - Sediment Trapping by reservoirs

\[ Q_s = \frac{\psi Q_d}{Q} \]  

(Eq. 3)

where

- \( Q_d \) - Daily Discharge (m³/s)
- \( \psi \) = 0.763(0.99995)

Figure 1. Flowchart of the sediment flux module in the BQART/WBM model.

The BQART/WBM model is a spatially explicit model describing varying components of the global hydrological cycle (Wisser et al., 2010). BQART was integrated as a new component in the WBMin platform to allow spatially explicit calculations of sediment flux at a global scale (the BQART/WBM model).

As BQART is a basin-outlet model, BQART/WBM consider each pixel as a local outlet of its upstream contributing area.

The BQART/WBM model has two phases. The first phase generate the long-term average temperature and discharge values (illustrated in the 'Preprocess' frame in Fig. 1) needed for calculating Average long term Sediment Flux (\( Q_s \); Eq. 1). The second phase calculate the Daily Sediment Flux (\( Q_s \)) values with the Psi model (Eq. 3).

BQART/WBM make use the Daily Discharge (\( Q \)) and Reservoirs Capacity (to determine \( T_s \); Eq. 2) modules of WBMin (Fig. 1).

Results
The BQART/WBM model is still in development and yet to be fully validated. We present two yearly-averaged (1976 and 2000) global-scale sediment flux maps from a daily 49 years test-run (1960-2009 at 30 minute spatial resolution).

Some notable differences between the two maps:
- Higher sediment flux in Africa’s major rivers (Nile and Zaire/Congo) in 1976;
- Higher sediment flux in Northern Asia (Ob River) in 2000;
- Higher sediment flux in the Middle-East (Tigris-Euphrates system) in 1976;
- Higher sediment flux at the lower Colorado River in 1976;

Applications and future development
Distributed sediment flux predictions are useful for a wide array of scientific and engineering applications (e.g. carbon cycle predictions and infrastructure design).

The BQART/WBM model will soon be applied with higher spatial resolution and will be used to test scenarios of future environmental changes (e.g. climate, land-use). In the next couple of years we intend to further develop the model by adding a bedload sediment transport component and introduce more physically-based equations to better account for the spatio-temporal variability of the sediment transport processes.

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References


Figure 2. Two yearly-averaged global Sediment flux maps (1974 and 2000) derived from a daily 49 years test run (1960-2009 at 30 minute spatial resolution).

Figure 3. Flowchart of the sediment flux module in the BQART/WBM model.

Population 
Density
GDP
Anthropogenic Factor (I)
Ice Cover
Lithology
Reservoirs Capacity
Distributed sediment flux component
Sediment Trapping (T)
Long term average Temp. (T_s)
Daily Temperature
Daily Discharge
Precipitation & daily updates
Preprocess & daily updates
Input
Intermediate layer calculated by the model
Output layer
Parameter connection with daily update
Parameter connection which are constant in time
WBMin model
Daily Sediment Load (Q_d)
Long term average Sediment load (Q_s)
Reservoirs
Combined area (A)
WBM model