Abstract

Towards a typology of global river systems:
some concepts and examples at medium resolution

Global change generates growing interest (i) in the structural and geographical organisation of the continental surfaces (geographers, geomorphologists, geologists, Earth System Science, paleoclimatologists), (ii) for factors of lithological control determining chemical and detrital erosion on the continents and geospatialised estimates of global natural fluxes from land to the oceans (hydrogeologists, geochemists), (iii) for a segmentation and a typology of the coastal system when addressing questions like productivity, eutrophication or fisheries management. River systems play a determining role for these questions.

We develop their typologies using different tools and by potential river basin (dry surfaces) or active basins, taking runoff into account. The principal factors controlling global natural fluxes (lithology, relief, runoff, structure of the drainage network) are mapped at a minimum resolution of 30 minutes (0,5°), and are re-aggregated following different spatial scales, per river and coastal basins. In a second step, they have been aggregated following different organisation types between continents, regional basins, ocean basins, global areas with internal (endorheic) or external (exorheic) drainage.

Various datasets available to the scientific community at the targeted resolution and at global scale are used and correlated for our purposes. They include a surface runoff model calibrated with station data, global discharge data, the landmass organisation in potential river networks and basins, global topography data, climate data – rainfall, temperature, climate zones, soil distribution data / potential vegetation and data on distribution of the contemporary human population.

The lithological composition of the continental surface of the globe is of primary importance for the organisation of terrestrial material fluxes in the rivers on the continents. A spatialised database of 17 lithological types adapted to river transfers is established in digital form using the Geologic World Map (UNESCO), combined with the Soil Map of the World (FAO), the World Map of Hydrogeological Conditions (UNESCO) and multiple regional sources. Certain types of lithology are grouped and other especially considered such as quaternary rocks, loess, dunes or alluvial deposits, all three bearers of information.
The distribution of the different lithologies on different continents, with regards to ocean basins or regional seas, is first considered without presence of water, then taking into account lithologies weighted by runoff. In certain river basin or coastal basins large differences between the two distributions are observed.

A map of the ‘water towers of the world’, combining relief and runoff, allows to identify regions important for the control of global sediment fluxes to the oceans. Combination with the distribution of human population permits to evaluate the pressure on these regions.

Additionally to their great spatial heterogeneity, river systems also present great temporal variability of river fluxes. This is further illustrated by a study of daily fluxes of suspended material and certain of their temporal characteristics (flux duration curves). The global typology we develop will allow mapping of the results of these new metrics.

In order to facilitate studies of interactions between continents and oceans, a segmentation of the coastal zone into 140 segments has been established, based on combined criteria (natural limits of continents / oceans / regional basins, coastal morphology, submarine relief, runoff distribution, and, sometimes, coastal currents and tectonic features). As defined the coastal segments and basins have a maximum homogeneity for both land and ocean attributes. For each segment and its associated catchment basin we present the main characteristics (lithology, relief, runoff, population) as well as applications for water, sediment, and nitrogen budgets.

Our tools and the various aggregations and segmentations permit to propose indicators of the structure and the heterogeneities of river systems on the globe, illustrated in particular by the Nile basin.

One of the principal results of this work is the spatial analysis of the relations between continents and oceans taking into account global river systems. Direct inputs to oceans are actually limited by ‘Mediterranean type’ regional seas (such as the Mediterranean Sea, Black Sea, Gulf of Mexico, China Sea) or other regional basins (e.g. Persian Gulf or Adaman Sea). Open oceans are only exposed to the pressure of half the population of the globe : the other half is filtered by the regional seas.

These approaches and the tools developed will further promote regionalisation studies of land and oceans models within the Earth System context.