Estimating natural silica fluxes to the coastal zone using a global segmentation

Hans Dürr[1,2], Michel Meybeck[1]

1 UMR Sisyphe, Université Paris VI, France

2 currently at : ESA, Université Libre de Bruxelles, Belgium

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Hans.Duerr@ccr.jussieu.fr, Michel.Meybeck@ccr.jussieu.fr

Towards global pictures of riverine changes

– Geographic Information Systems : combination of multiple informations

– Information layers now available at fine resolutions (1 to 50 km) for most Earth System components (runoff, river network, relief, lithology...) to map past natural river state

– Socio-economic layers (water uses, environmental pressures, water needs) still being developed or available at coarser resolutions

– First global maps of present river state are coming out

Why focus on DSi ?

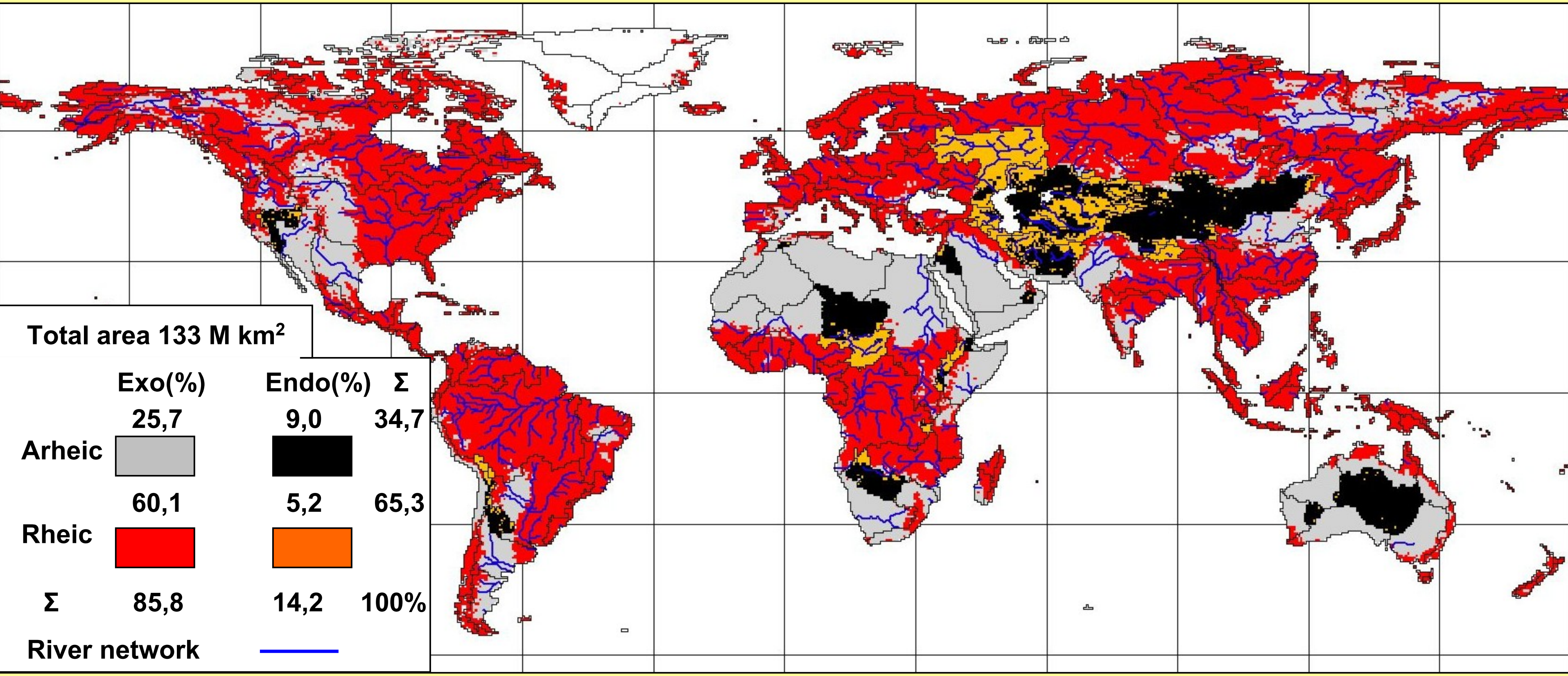
– Importance of marine silica cycle well known and documented

– Increased awareness of the importance of the terrestrial silica cycle

– Existing budgets (results between 7,7 – 13,1 mg/L global mean DSi) rarely use typological approaches

– Regionalised silica inputs are needed to enhance global ocean models

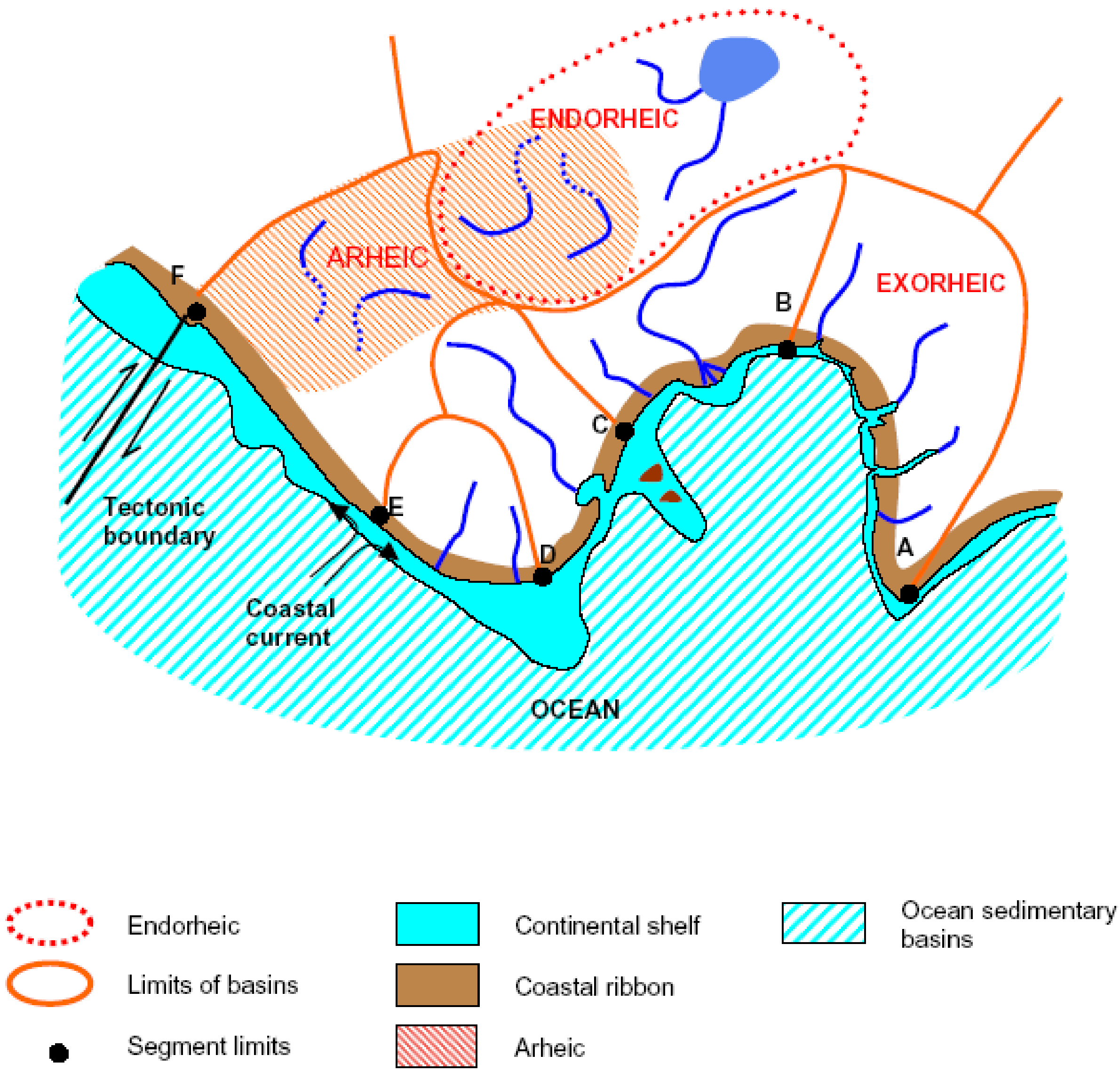
Organisation of the continental surfaces by water into major units



River network : Vörösmarty et al. 2000 a & b, modified and adapted ; Runoff : Fekete et al. 2002

- **COSCAT approach (~150 coastal segments defining coastal catchments), focused on general land to ocean connexion**

Topology of coastal segments



Limits of coastal segments: A coastal morphology (e.g. cape), B runoff gradient, C coastal morphology (Island Chain), D coastal morphology (widering shelf), E current divergence, F plate tectonics.

COSCAT approach :
(i) fixed segment boundaries allow easy description and mapping at coarse resolution
(ii) all land to ocean fluxes can be reported in the same format

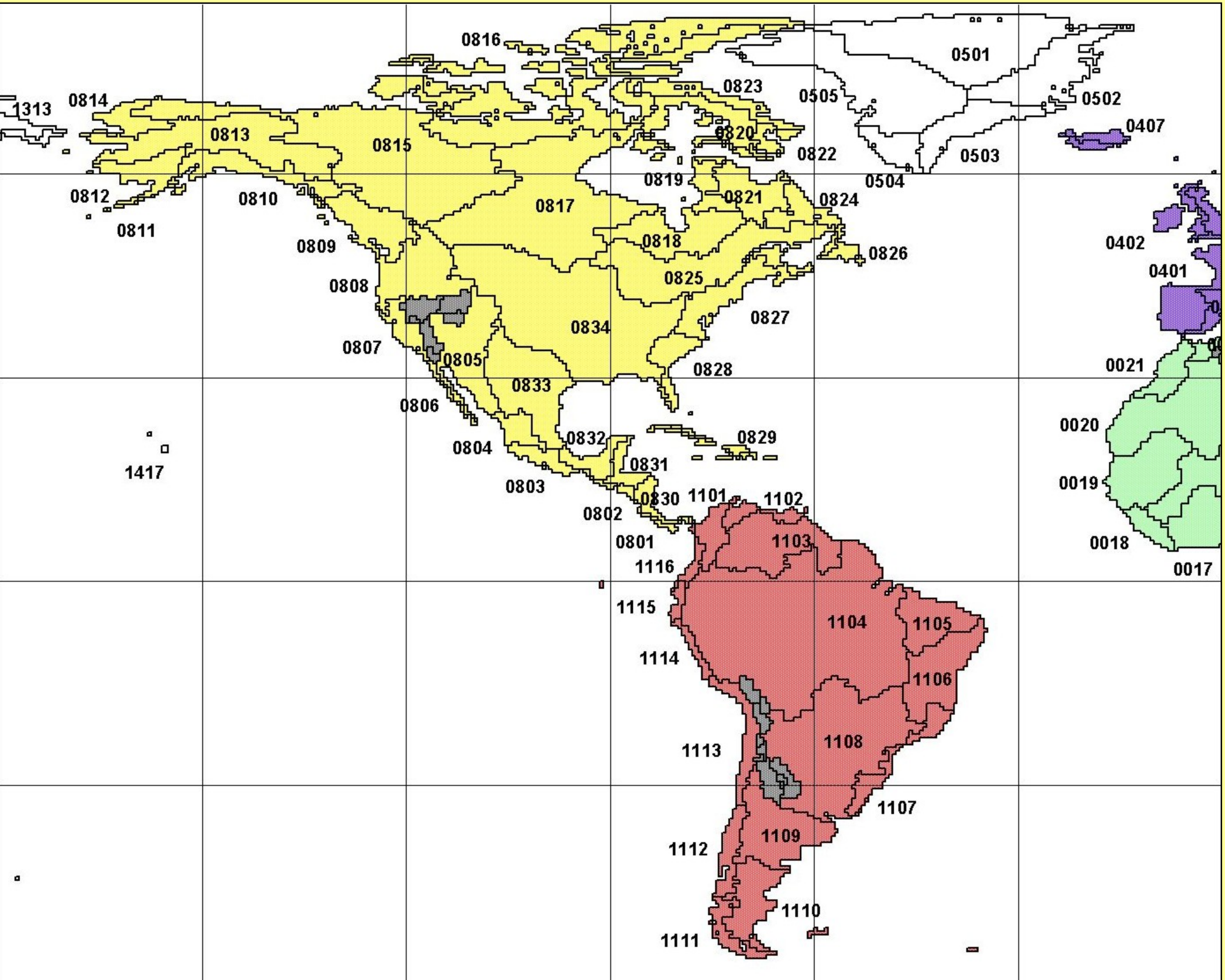
Typical coastal segments and coastal basin :

Mean average depth : 360 km;
only 13 basins > 1 000 km

Median length : a little over 2 000 km

Meybeck et al. 2005 (Global Biogeochemical Cycles, submitted)

151 exorheic Coastal Segments



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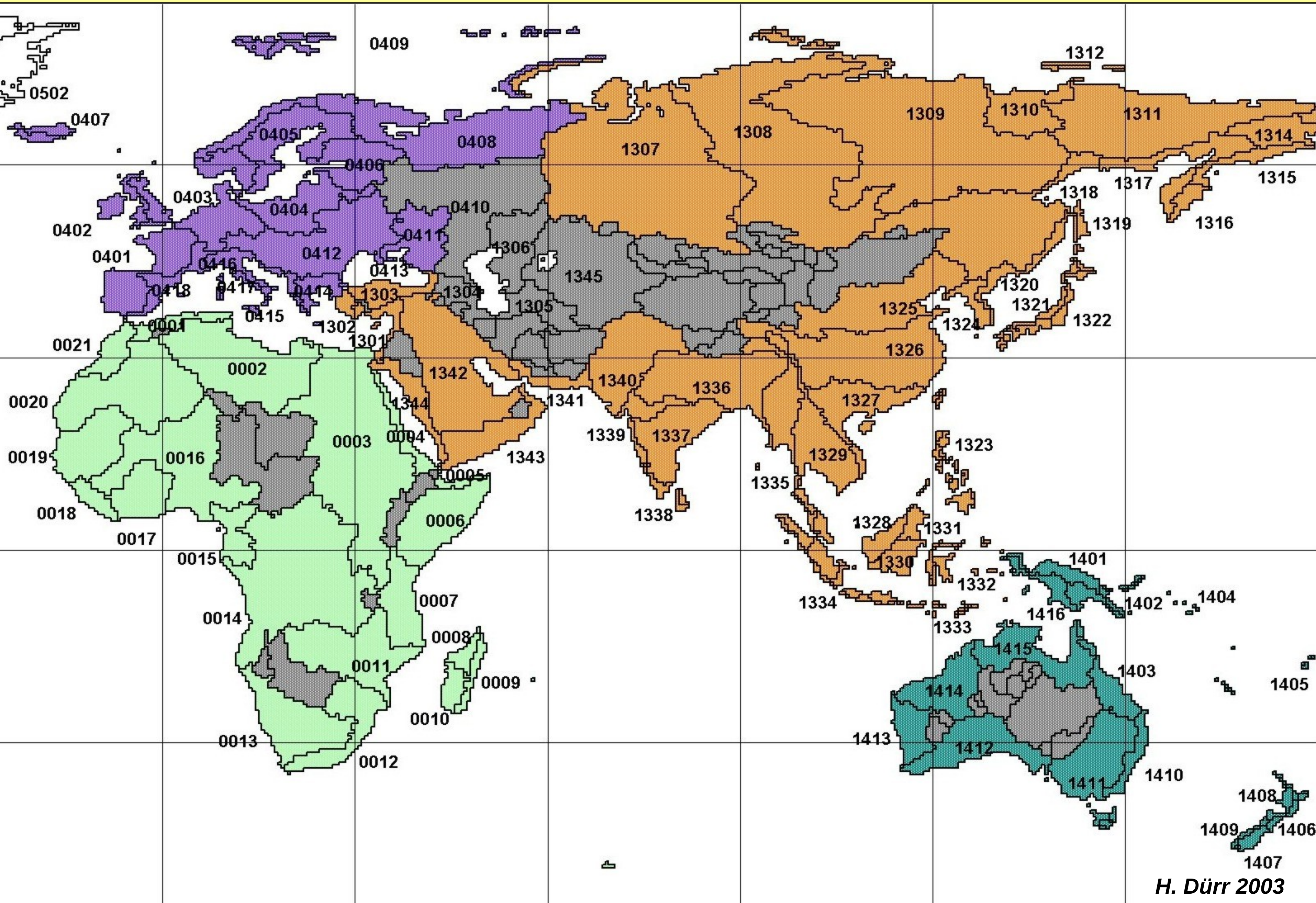

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Database for DSi estimate

- major world rivers SiO_2 concentration with minimum human impacts (reservoirs avoided) as in Gems GLORI and PRISRI (Meybeck unpublished) revised, particularly taking into account the first set of analyses made :

  - USA reported in Clarke (1924)
  - miscell. reported in Livingstone (1963)
  - Japan, Thailand, Indonesia, Sri Lanka :
    Kobayashi (1959 – 1966)

- about > 200 documented rivers, area 10^5 to 6.4 10^6 km^2

- discharge and drained area :
  Gems GLORI + UNH (Vörösmarty et al. 2000 a, b – river network; Fekete et al. 2002 – UNH-GRDC combined discharge & runoff)

Silica budget

- The total area and runoff for each segment is documented from UNH

- On each segment the documented basins are identified, the extrapolation to the rest of the undocumented coastal basin is made according to various criteria but always on the basis of concentration x discharge (<u>not</u> yields x area) since the runoff budget is ‘known’ on each segment (if not we would have taken yields x area)

- **documented average silica taken as representative of the missing part of the segment (particularly if many small / medium rivers documented)**

- **average silica for selected small / medium rivers on the segment avoiding the very large (and heterogeneous in terms of climate / lithology) rivers (e.g. Ob, Yenisei, Mekong, Ganges, …)**

N.B.: the extrapolated silica is often different from the documented one

- **silica from rivers outside of the documented segment (e.g. Mahakam used in N Borneo)**

- **for undocumented segments : estimated silica based on expert judgement taking into account (i) climate effect, (ii) lithology, (iii) lake trapping**

The total of documented + extrapolated fluxes are calculated then the average

$$\text{concentration} = \frac{\Sigma\ \text{flux}}{\Sigma\ Q}$$

and

$$\text{yields} = \frac{\Sigma\ \text{flux}}{\Sigma\ \text{area}}$$

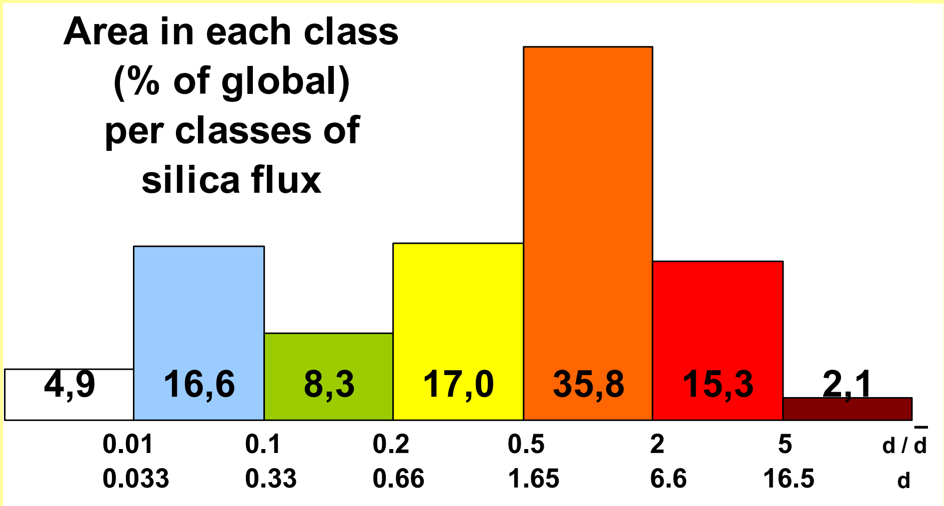
then reaggregated into ocean basins, continents, regional seas …

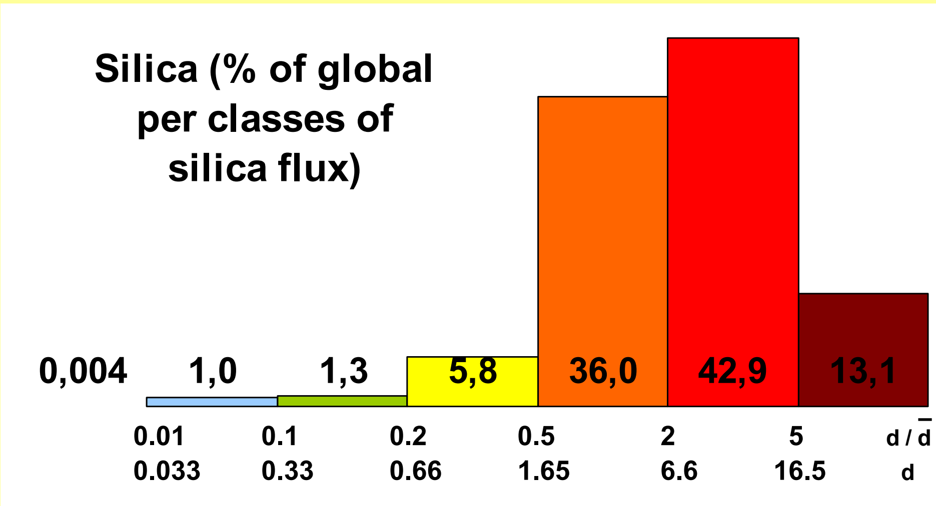
➡ **56,7 % of the global continental exorheic surfaces,**
58,6 % of the global exorheic discharge and
51,1 % of the global silica flux to the coastal zone

are documented

Distribution of silica yields in exorheic basins

- Hot spots & hyperactive areas :
Areas in which the area specific fluxes are 5 or 10 times the average for the considered spatial domain





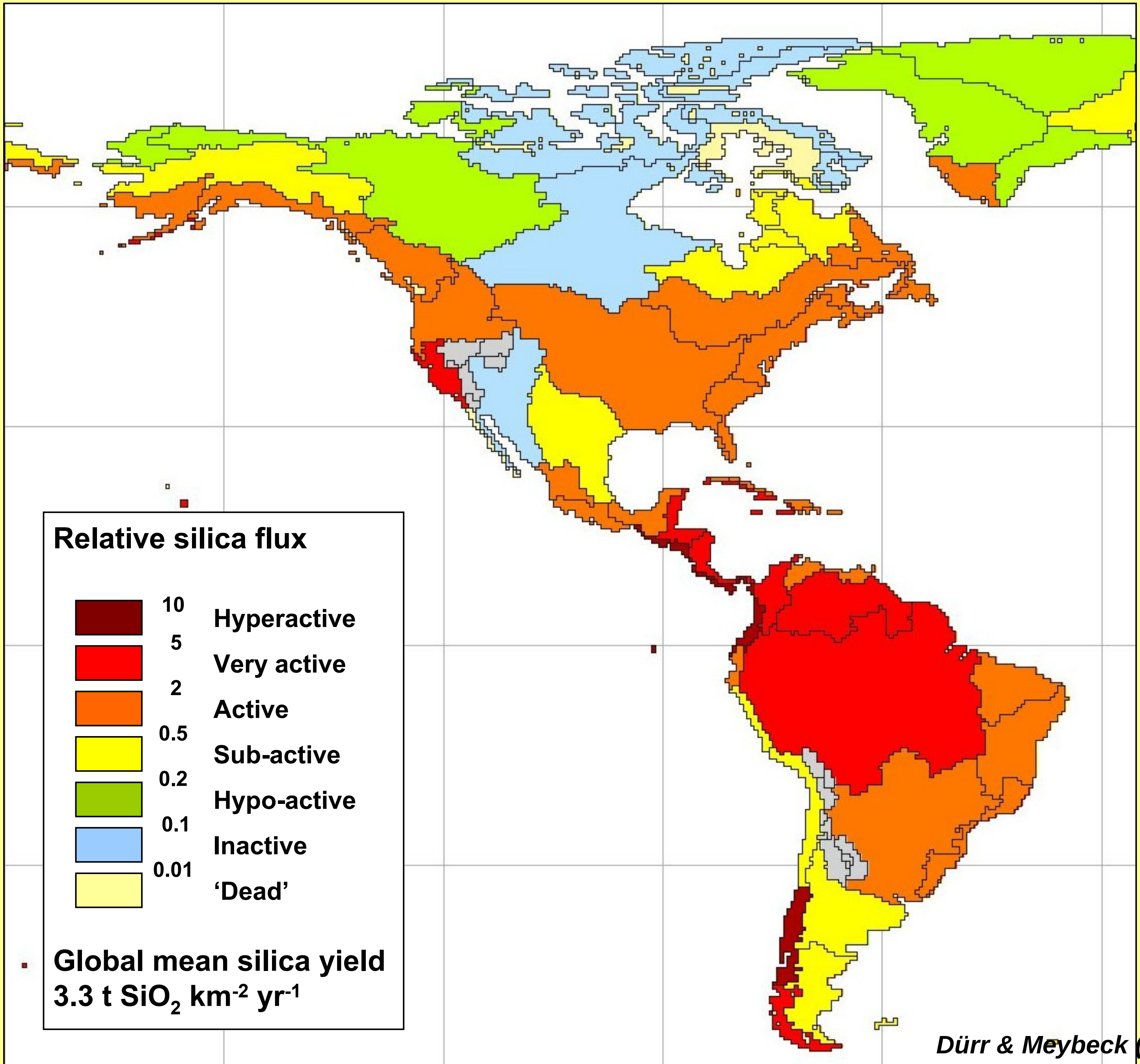
(115 M km^2, n=160, global mean yield 3.3 t DSi km^{-2} yr^{-1})

- 56,0 % of the silica flux to the coastal zone occur in 17,4 % of exorheic area where silica flux exceeds 2 times the world average

- 2,3 % of silica originate in 29,8 % of exorheic area where silica flux is less than 1/5 of the world average

Dürr & Meybeck (in preparation)

Coastal Zone Segmentation: Silica yields per segment



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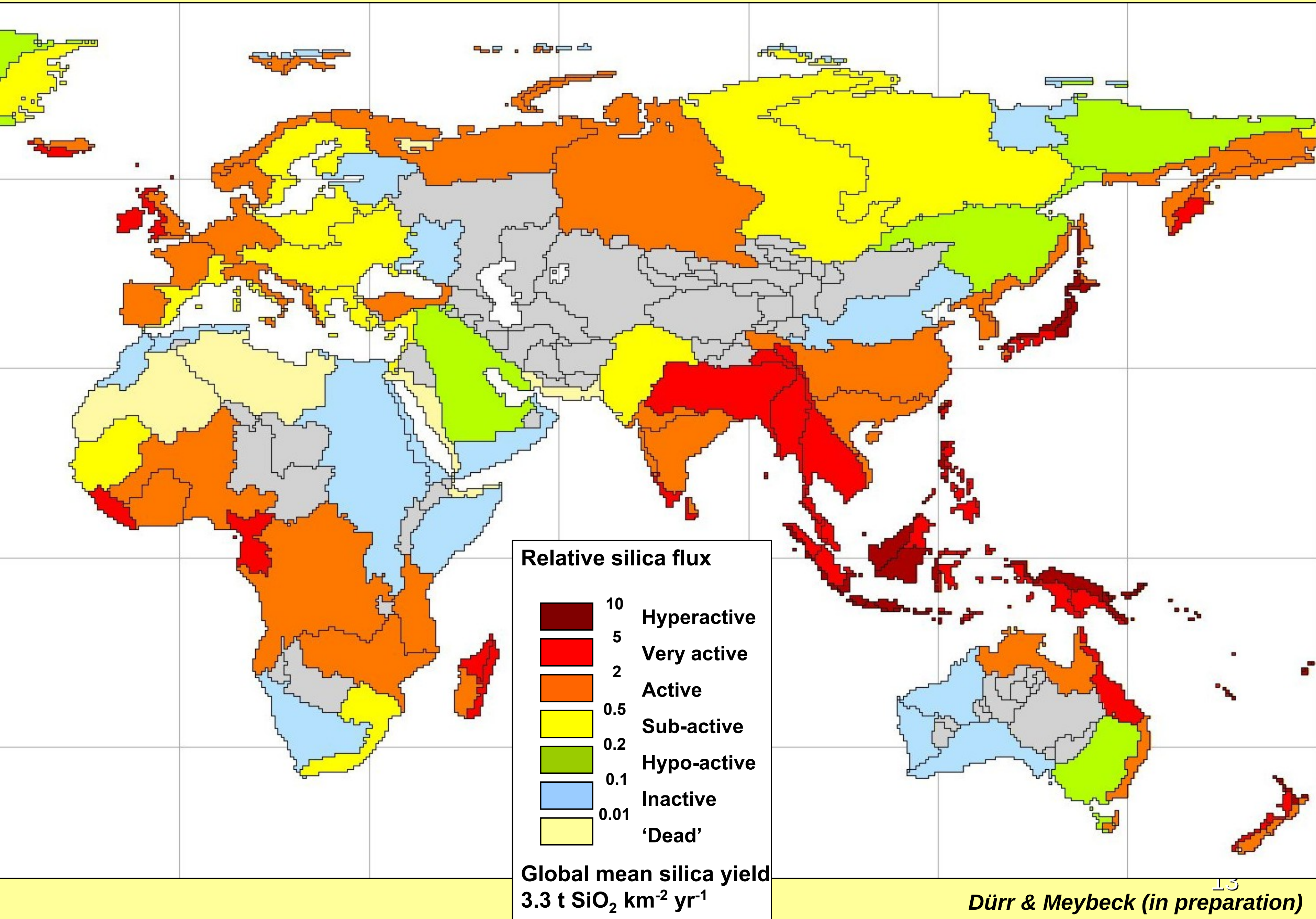
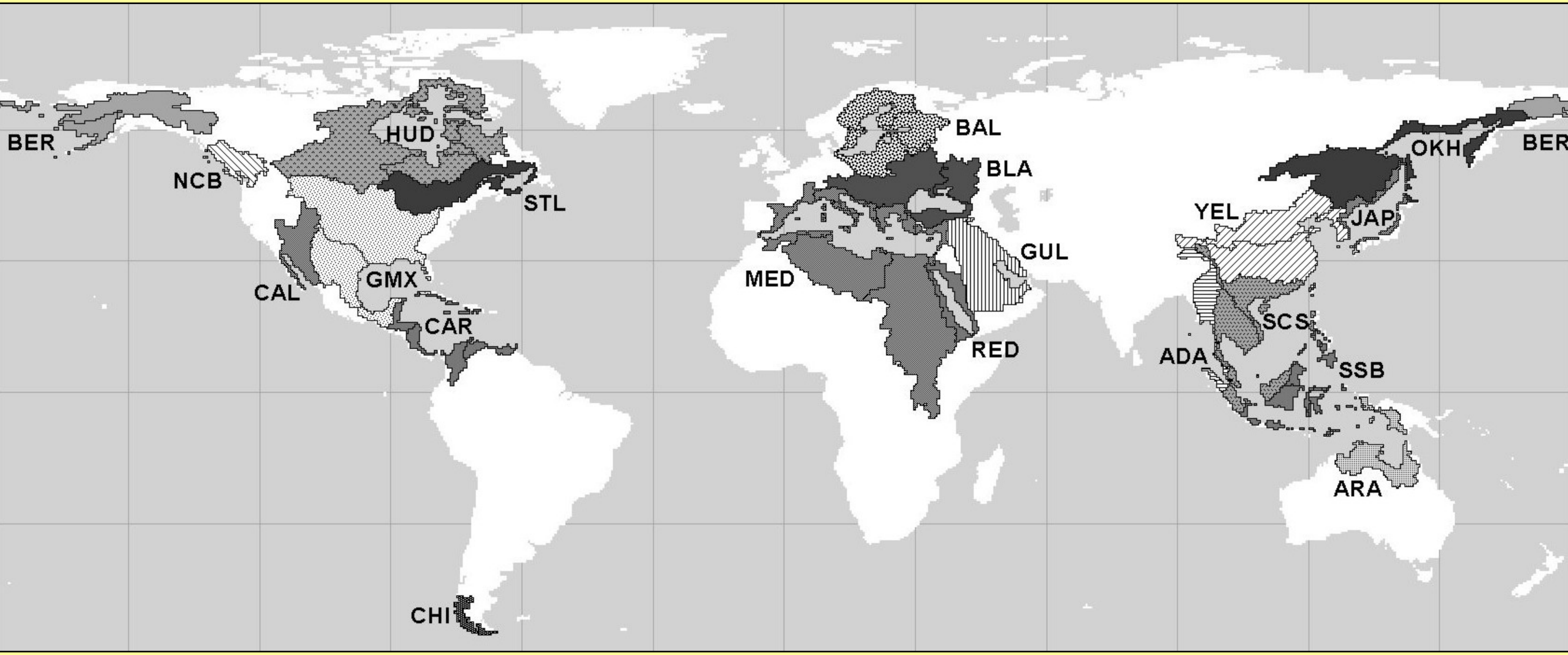


Dürr & Meybeck (in preparation)

Catchment basins of regional seas



- 38,6 % of the exoheic continental area
- 37,4 % of the total exorheic runoff
- 49,2 % of the total population linked to exorheic drainage

- 33,1 % of total exorheic DSi fluxes

} intercepted by regional seas basins

Meybeck & Dürr (Marine Chemistry, in preparation)

Conclusions

- **Global Silica budget based on existing data extrapolated to regional basins :**

  - global mean concentration : 9,5 mg/l SiO_2
  - ~ 1/3 of DSi is retained by the macrofilter of regional seas

- **High fluxes : high runoff, tropical climate on sensitive lithologies :**

  < 20 % of area responsible for > 50 % of natural silica yield