Exploiting climatic and vegetation information as a support for regional analysis of annual runoff statistics

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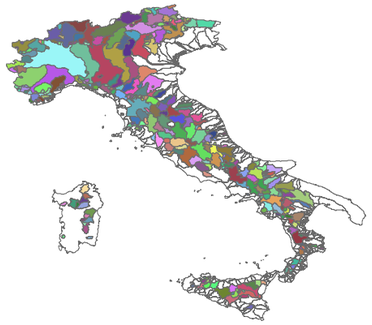
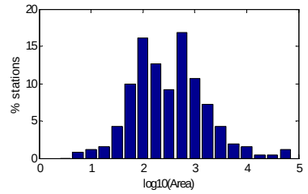
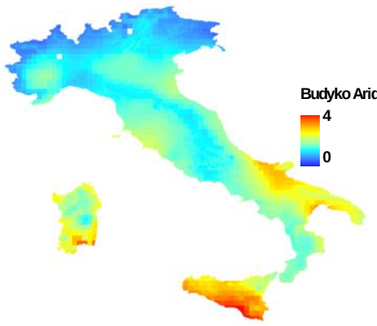


RUNOFF DATA

We selected 261 out of 295 stations where average annual rainfall (*A*) and runoff (*D*) were available. The size of the selected basins ranges from 6 to 70910 km².



CLIMATIC DATA

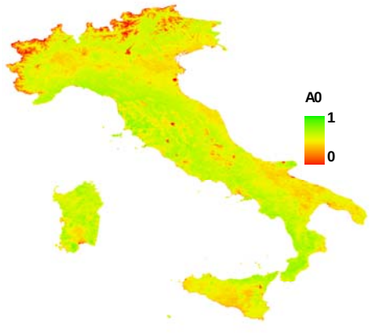


We collected and mapped average annual rainfall, air temperature, net radiation and other derived variables. Here we make use of the Budyko Aridity Index:

$$BAI = \frac{R_n}{\lambda \cdot P}$$

where:
P = annual rainfall (mm)
R_n = net radiation (MJ/m²)
l = lat. heat of vaporization (MJ/kg).

VEGETATION INFORMATION



We obtained from VITO (http://free.vgt.vito.be) 7 years of 10 days MVC NDVI images calculated on SPOT-Vegetation data. We adapted to the NDVI data a two harmonics (12 and 6 months periods) Fourier series:

$$NDVI(t) = A_0 + A_1 \cdot cos\left(\frac{2 \cdot \pi \cdot t}{12} + F_1\right) + A_2 \cdot cos\left(\frac{2 \cdot \pi \cdot t}{6} + 2F_2\right)$$

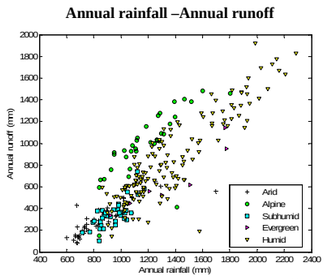
We used the amplitudes (A_i) and phases (F_i) of the Fourier series for producing the climate-vegetation map (see EGU2007-A-08622 for details) and the selection of the classes shown at the left. Once calculated the percent of the area of the basins falling into each class, basins are labelled with the main class name.

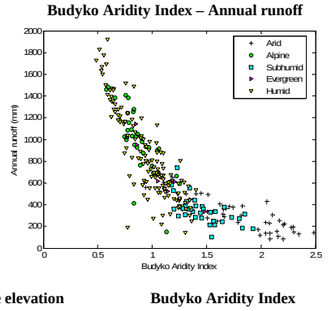
Introduction

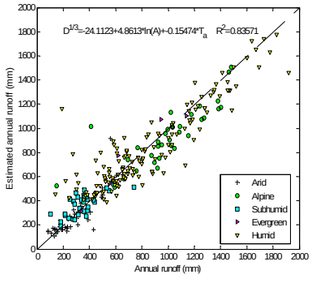
The climate-soil-vegetation interactions controlling the rainfall-runoff mechanisms at different space and time scales play a very important role in regional analysis of hydrological variables. In addition, the availability of spatially distributed remotely sensed information on vegetation and soil moisture dynamics in response to the seasonal water and energy cycles allows a deeper comprehension of the effects of the climate in a region and can support the recognition of homogeneous spatial features.
The relations between climatic parameters and hydrological variables at the basin scale have been investigated with the aim of evaluating in a parsimonious way some physical parameters useful for both climatic characterisation and for supporting statistical models of water resources assessment.
We found good agreement between the climatic indices and the statistics of annual runoff. The relations between annual runoff statistics and NDVI showed up a much complex behaviour. Since the relation between NDVI and rainfall is affected by the well known saturation effect, it is not possible to use NDVI as a surrogate of rainfall in humid areas, where energy limited climatic conditions occur. However, NDVI allows to enforce the climatic characterisation of the study area, as well as to estimate runoff statistics in the basins falling outside the humid regions.

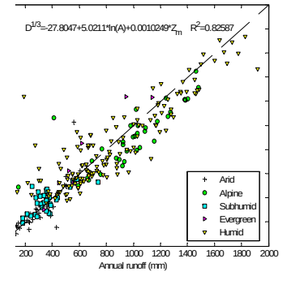
ESTIMATION OF AVERAGE ANNUAL RUNOFF BY MEANS OF CLIMATIC INFORMATION

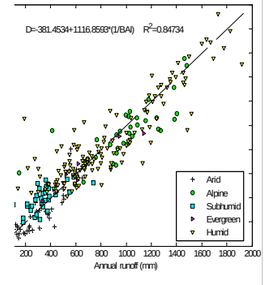
We carried out multiple linear regressions for the estimation of *D* in Ungauged Basins. Working on smaller regions we recognised that the most effective relations can be determined working on $D^{1/3}$ and $ln(A)$. The spreading in the relation between *A* and *D* is mainly caused by the alpine basins. It is possible to improve the reconstruction by using information related to such basins, e.g. catchment elevation (Z_m, R^2=0.82) or average annual temperature (T_a, R^2=0.83). The relation between BAI^{-1} (which resembles the aridity index $AI=A/PET$) and *D* gives R^2=0.84.



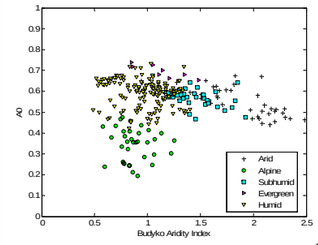




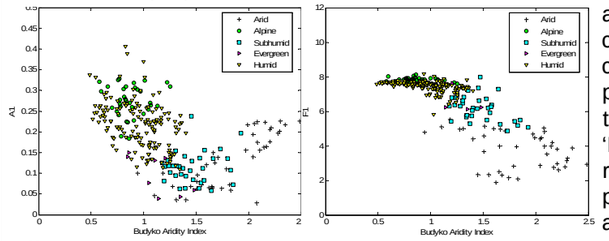


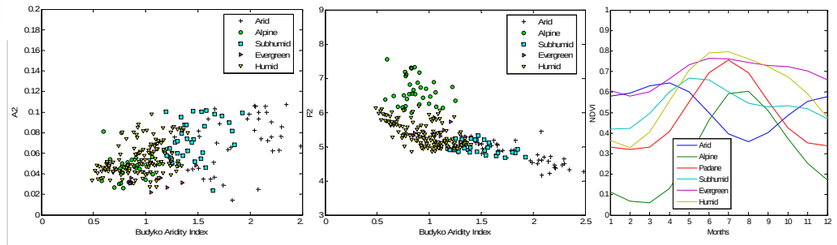


RELATIONS BETWEEN VEGETATION AND CLIMATIC INFORMATION



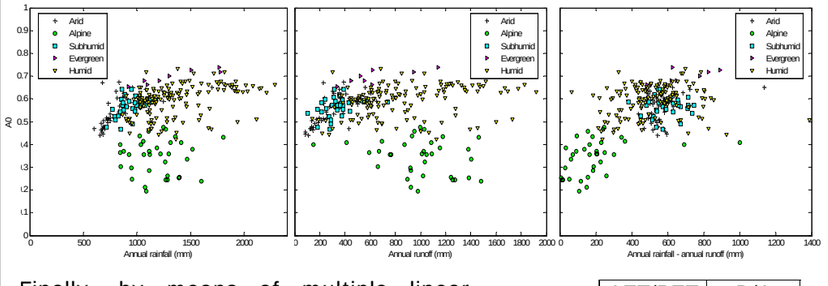
In the subsequent plots the vegetation A_i and F_i parameters averaged over the basins are plotted against the *BAI*. Even operating the basins' classification without considering any climatic information and without checking for homogeneity, the groups of basins in each class have quite homogeneous vegetation and climatic features. The average NDVI curves for each class are also presented. Note that no mainly 'Padane' basin resulted in this part of the analysis.





RELATIONS BETWEEN VEGETATION AND THE AVERAGE WATER BALANCE

As reported in literature, NDVI undergoes to saturation effect in energy limited climatic divisions. Hence it is not possible to use NDVI for estimating *A* and, as a side-effect, *D*. Better results can be achieved in a rough evaluation of average annual actual evapotranspiration (*AET*), which can be roughly estimated as *AET=A-D*.



Finally, by means of multiple linear regressions based on the percent of each class in the basins, we estimated the average *AET/PET* and *D/A* ratios. The results are reported in the table. The alpine basin demonstrate problems of rainfall underestimation.

	AET/PET	D/A
Semiarid	0.34	0.33
Alpine	0.07	0.94
Padane	0.65	0.37
Subhumid	0.47	0.27
Evergreen	0.49	0.45
Humid	0.44	0.63