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Parametrization of vineyard's physiology and phenology with the crop model IVINE

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The numerical crop growth model IVINE (Italian Vineyard Integrated Numerical model for Estimating physiological values) was developed at the dept. of Physics, Univ. of Torino to simulate grapevine phenological and physiological processes. The boundary conditions required by IVINE are hourly meteorological data related to: air temperature and relative humidity, atmospheric pressure, wind speed, downward radiation, soil temperature and volumetric water content and/or water moisture potential relating to the two soil layers considered (80 cm). Among those values, the more relevant are: air temperature and soil moisture. Other inputs required are initial conditions and parameters characterizing geography (longitude and latitude), soil texture, and grapevine variety, as well as information relating to cultivation interventions (main pruning, grape bunches thinning). Among the principal IVINE outputs, there are: the main philological stages (dormancy exit, bud-break, fruit set, veraison, and harvest), the leaf development, the yield, the berry sugar concentration, and the predawn leaf water potential. The IVINE requires to set some experimental parameters depending on the cultivar. IVINE model works including theoretical physically based equations for processes such as water balance and photosynthesis, and empirical equations for others. Seven main phenological phases can be identified: exit from dormancy period, bud-burst, flowering, fruit-set, beginning of ripening, veraison and harvest (the timing of this phase greatly depends on the variety of the grapevine, as well as on the choices of the winemaker). Exit from dormancy phase is evaluated using summed chilling units, while for bud burst summed growing degree hours are used, and for flowering and fruit set summed growing degree days (GDD), always starting from the previous phase. The phases of the beginning of ripening, veraison and harvest are determined by the model through a combination of GDD and critical thresholds on the sugar content of the berries, depending on the grapevine variety chosen. The leaf area index (LAI) is calculated from the bud-burst to the veraison in function of some parameters, the temperature, and the soil water content. The quantity of sugar in the berries (in °Brix), which is an excellent indicator of berry maturity and quality, depends on some parameters and uses double sigmoid with values depending on air temperature. The yield is regulated by photosynthesis, using some empirical parameters. Regarding the model sensitivity to the boundary conditions, the phenological phases are almost linearly anticipated by an increase of temperature, while the sugar content of the berries increases non-linearly with temperature, stabilizing around its maximum value; the LAI and the yield show non-linear increases with soil moisture. Long-term simulations carried out in Italian territory show, in the period 1980-2010,

significant trends in almost all physio-phenological variables, as well as a reduction in interannual variability, correlated with the climate change still ongoing.

IVINE model performances depend on the quality of input data: the use of experimental data measured not far from the vineyard could improve the quality of the simulation, even if the model seems able to account for the interannual variability of the meteorological conditions, which reflects in the pheno-physiological trends interannual variability.