RESOLUTION OIV-VITI 517-2015

OIV GUIDELINES FOR STUDYING CLIMATE VARIABILITY ON VITIVINICULTURE IN THE CONTEXT OF CLIMATE CHANGE AND ITS EVOLUTION

THE GENERAL ASSEMBLY,

At the proposal of Commission I "Viticulture",

CONSIDERING point E.1 of the OIV Strategic Plan 2012-2014, which foresees to ”Develop a common method for evaluating the impacts of climate change on viticulture (choice of indicators according to the objective researched, parameters recommended to be studied)”,

CONSIDERING the many works presented during the meetings of its expert groups and particularly the "Viticultural environment and climate change" Expert Group, as well as the contribution of the "Oenology" Commission,

CONSIDERING Resolution OIV-VITI 423-2012 on OIV guidelines for vitiviniculture zoning, and especially the part concerning the climate level,

CONSIDERING that a number of recent effects of climate change have already been observed and some more are expected in the future, according to the scenarios of the Intergovernmental Panel on Climate Change (IPCC),

CONSIDERING that data which are currently available or in the process of being developed require a standardised methodology so that a comparison can be made between different countries,

CONSIDERING that more data are needed in order to adjust the management strategies to new situations,

CONSIDERING the study of an OIV Grant from Argentina, initiated in 2009 and delivering interesting results in terms of methodology of study and results obtained,

DECIDES to adopt the following guidelines for studying the effects of climate variability on vitiviniculture in the context of climate change:

OIV guidelines for studying (parameters of) climate variability on vitiviniculture in the context of climate change and its evolution

Introduction

As a fundamental component of the vitivinicultural "terroir", climate largely affects the vine physiology, agronomic characteristics (performance, composition of the grapes, wines or other vine unfermented products) and the final quality of its products.

Therefore, if the main characteristics of the products obtained are to be maintained, the study of climate variability is necessary in order to adjust the applied techniques to each observed or expected change. The vine-growing regions are prone to variations in climate on different temporal and spatial scopes. The tools for a spatial and temporal analysis of climatic conditions and the classification of climates are given in detail in the adopted Resolution OIV-VITI 423-2012 on vitivinicultural zoning on a climate level. In the present resolution, the methodology for studying climate variability to date, as well as in different future scenarios, is provided. It enables the assessment of the effects of climate change on viticulture, and of the possible consequences for the characteristics of wines and/or other vine products.

In order to be able to assess the importance and magnitude of modifications that climate change of recent decades has brought to global vitiviniculture, as well as the projections for the middle and the fast-approaching end of the 21st century, the OIV decided to establish a methodology and several criteria, so that these scientific assessments are adapted to the vitivinicultural sector and are as accurate as possible, before proposing strategies to adapt to these present or possible future changes.

Proposed methodology step by step (4 steps are proposed):

Step one: define the period of the study

Studies on climate change in vitiviniculture may seek to:

1. Assess climate change already observed together with its consequences for vitiviniculture; and
2. Foresee climate change which is yet to come as well as assessing how vitiviniculture will be impacted by these changes.

Within the framework of climate change already observed, studies are based on recorded climate and vitivinicultural data (e.g. modification of phenology), as well as oenological data (e.g. changes in grape, must and wine composition, according to final outcome).

Time series should be of long duration to reveal “climate” effects: minimum of 30 years (climate normals as defined by the World Meteorological Organization) with regard to temperature and precipitation, and 20 years for studies based on future simulations and 30 years for models in the past are recommended. Historical data (climate or vitivinicultural) over very long periods are of particular interest.

Within the framework of climate change which is yet to come, studies rely on climate models in order to make projections on climate variables (temperature, precipitation, etc.) for different time frames. Considering the scientific work reported by the Intergovernmental Panel on Climate Change (IPCC), 20 years intervals between dates commencing around 2050 and extending to 2100 or beyond should be used. Additional dates or periods can of course be used, as well as other climate derived variables such as the changes in spring frosts, hailstorms, gales or days of “heatwave” close to the time of harvest. In a second phase, these climate variables projections are coupled with vitivinicultural models in order to anticipate the consequences for vine cultivation and wine production. They may be followed by recommendations for adaptation of plant material (varietal or clonal adaptation, rootstock), of vitivinicultural techniques, and/or of the planting of vineyards so as to adapt vitiviniculture to these new climate conditions.

The most comprehensive studies on climate change in vitiviniculture analyse both past and future climate change but it is possible to assess the observed changes separately.

Step two: define the spatial scope of the study

The temporal resolution of the study is directly dependent on the data spatial resolution. When the latter is too large, it makes irrelevant the use of these data related to small or time intervals. It is highly recommended that both scopes are congruent.

It is important to recognise the fact that, in addition to the regional level (macroclimate), climate variability also affects vineyards at the mesoclimate and microclimate (plant) levels.

The finer scope of the study is always related with a higher resolution of the model simulations. Naturally, the cost will be higher for studies with a finer scope.

From the perspective of adaptation to global climate change, knowledge of local climates is very important: spatial differences brought about by local conditions (topography, pedology, etc.) may be of the same magnitude as, or even greater than, the change simulated for the coming decades.

Step three: choose the climatic and vitivincultural variables

In order to carry out studies on climate change, climate variables, periods of reference, agro climatic indices, phenological, physiological and phytopathologic variables should be used. Also, biological variables and oenological variables may be used.

Climate variables

Climate variables may be calculated on a daily, monthly or yearly basis. For coupling between climate projections and phenological models, it is often essential to work with daily intervals in order to have sufficient accuracy in the forecasts.

- Average temperature[1] ;
- Maximum temperature;
- Minimum temperature ;
- Precipitations;
- Radiation;
- Potential Evapotranspiration [2](ETP);
- Vapour pressure deficit (VPD) daily maximum.
- Cold hours during winter or dormant period.

Reference periods

- Year;
- Month;
- Phenological stages and reference indices: April to September (included) for hemisphere North and October to March (included) for the southern hemisphere. It is suggested to use these reference periods in order to allow comparison between vitivinicultural regions.
- Grape maturity period: from veraison to harvest;
- Hydrological periods. Hydrological summer (growing season; May-October; in

northern hemisphere) and hydrological winter (off-season; November-April in northern hemisphere). In and out of season precipitation and potential evapotranspiration are important variables to judge the water balance of vineyards and recommend management strategies. In order to complete the list of compound climate variables, one should distinguish between total precipitation and total evapotranspiration in the hydrological summer and hydrological winter. The latter information is particularly important in order to trace changes in off-season water use and replenishment of soil water content. It would be desirable to have information on organic matter content and soil water holding capacity. However these data have a high spatial variability and cannot be represented for entire regions.

Agroclimatic indices

- Huglin's Heliothermic Index (HI index)
- Winkler's Growing Degree Days (GDD)
- Gladstones' Biologically Effective Degree Days (BEDD)
- Jones' Average Growing Season Temperature (AvGST)
- Water balance based indices such as the Drought Index (DI) or the direct method, amongst others. If the study aims at assessing the sole consequences of climate, a soil water holding capacity from 100 to 200 mm is relevant.
- Cool night index (CI).
- Days in the vegetative period where there is a risk of freezing
- Maximum temperature in the vegetative period, and particularly in the period prior to harvest
- Selianinov index [(∑P/Winkler Index) x 10]. Effectiveness of precipitation in the growing season.

The calculation of many indices presented here can be found in resolution OIV-VITI 423-2012. Spatial structure of climate change and its impacts within and between vitivinicultural areas might be assessed through the zoning methodology presented in resolution OIV-VITI 423-2012

In the case of viticulture studies under tropical climates, characterized by a

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viticultural climate with intra-annual variability, where more than one growing season with one or more harvests per year are frequent, the same climatic variables or indices and the same periods for the proposed rates can be used (at the same time) for the southern hemisphere and the northern hemisphere, which will allow comparisons with other regions of the world.

In addition, it is important to complete the climate characterization also taking in count other calculated indices for periods corresponding to bioclimate and vine phenology inside tropical climates, where the vine has a shorter growth cycle. For tropical regions with several consecutive vine growing cycles throughout the year, indices for potential successive periods of 4 months (average cycle duration between budburst and harvest) throughout the year can be calculated.

Phenological variables

Phenology is an excellent indicator for assessing the effect of climate change on vines:

- Date of bud burst (50% of buds at Baggiolini's stage C)
- Date of flowering (50% of flowers at the "anthesis" stage)
- Date of veraison (50% of berries starting to ripen)
- Date of maturity.

Technical variables

- Date of harvest according to grape use (wine, table grapes and other products and purposes). OIV also recommend to use this date when it is possible.

OIV member countries are strongly recommended to identify and create long series using observations of dates of 50% flowering and 50% veraison, given their relevance in assessing the impact of climate change on vine behaviour. These observations should be carried out on as many vine varieties as possible. The dates of harvest have the disadvantage of being influenced by criteria other than the climate (style of wine, sanitary state of grapes, etc.). Nevertheless, over long historical series it is easier to have access to data on dates of harvest than on dates of flowering and of veraison.

Physiological variables

These variables are depending on all the production systems.

a. Yield/ha or pruning weight (e.g. Ravaz index).

b. Water status of the vine (e.g. isotopic discrimination C method through δ13C, leaf or stem water potential measurements). Water status of the vine may be determined by measuring the isotopic discrimination of carbon-13 of the must at ripeness (δ13C). OIV member countries are recommended to build databases of this criterion in order to assess the development of the impact of climate change on the water supply conditions of the vine taking in account the eventually irrigation. Given the effect of the soil's water reserve on this criterion, the must samples should always be taken from the same plots of land.

c. Observations with respect to other physiological problems (e.g., wilting, and berry shrivel).

Phytopathologic variables

The climatic changes lead to modifying the behavior of pathogens and parasites which could develop more cycles and generations during the year. It is possible to evaluate the effects of climatic changes through the examination of the historical data available, about the parasite presence and how it changes during the cycle with reference to territorial level. In relation to the climate the development of epidemics and diseases can be examined for their variations during spring and summer.

Variables relating to grape and wine composition

Climate change is accompanied by a change in grape and wine composition. It is possible to assess the impact of climate change on grape and wine composition as well as modelling the impact of climate change to come. Each data series (values should be expressed by reference units) is specific to a variety refers to zone production, where necessary agronomic interventions haven't been implemented.

Table grapes

- sugar concentration
- total acidity
- berry weight
- pH

Wine grapes

- sugar concentration.
- total acidity
- berry weight
- pH

When possible, it may be interesting to assess the organic acid (malic and tartaric acid) content of the grape, as well as the aromatic compound and polyphenol or rest of berries compounds. It also important to take into account phytosanitary aspects.

Wine composition

- Alcohol
- pH
- Total acidity

Step four: choose the climatic models and the scenarios of the study

Climate change projections are performed mostly within the framework of the Coupled Model Intercomparison Project (CMIP). They consist in climate simulations by means of several types of models of ranging complexity. Several models runs are performed on basis of various global scenarios. These scenarios account for several possible evolutions of socio-economic, land use, gas and aerosols emissions trajectories, leading to a range of radiative forcing accounted for climate models. According to these scenarios, climate models produce various and divergent climate trajectories at long term (2100). The IPCC third (2000) and fourth (2007) assessment reports were based on the so-called Special Report on Emissions Scenarios (SRES) set of scenarios, while the fifth report (2013) analysed climate models output under the so-called Representative Concentration Pathway (RCP) set of scenarios. In each experiment, one might identify two extremes and an intermediate scenario, leading to respectively moderate, very high or intermediate global warming.

It is recommended to evaluate climate projection impacts on viticulture using these three groups of scenarios, especially to assess climate impact at long term (end of the 21st century or later). Indeed, at mid-term (2050) moderate changes, though not

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neglictible, according to scenarios are simulated. However, mid-term climate projections diverge strongly, for a same scenario, according to the climate model. It is therefore recommended to compare several models outputs for mid-term assessment of climate change impacts on vitiviniculture.

Agroclimatic modelling using daily or shorter time step climate data, as well as climate change assessment at meso- to micro- spatial scales (i.e. within a winegrowing regions) require high resolution spatial data to provide relevant outputs for vitiviniculture. Whilst global climate models used in the CMIP experiments simulate climate at a low spatial resolution (around more than 100 km of more), higher spatial resolution can be reached through regional models (i.e. dynamical downscaling) or through statistical method (i.e. statistical downscaling). Such methods allow to provide hourly to daily data operational for agroclimatic modelling and climate change impact within vitivinicultural regions.

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[1] In order to be able to compare the average temparature with long historical series, it will be calculated as the arithmetic mean between the minimum temperature and the maximum temperature even if, in absolute terms, the integration of the temparature over the day, based on hourly data, would give a more precise average.

[2] Also addressed as Reference Evapotranspiration (ET_0.) Guidelines to calculate ET_0 are provided by the Food and Agriculture Organisation (FAO) in *Allen, R.G, Pereira, L.S., Raes, D., Smith, M., 1998. Crop evapotranspiration: guidelines for compunting crop water requirements. Food and Agriculture Organization (FAO), Rome Italy, 300p.*