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# Identification and frequency of atmospheric circulation patterns causing spring frost in the northern French vineyards using the objective version of the Hess-Brezowsky classification

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The possible impacts of climate change at small spatial scales are still very little known. The knowledge of the climate risks at small scales is yet essential for agricultural activities and productions like vine growing, because of their serious economic impacts. Because of their relatively high latitude, the vineyards of the northern Half of France are subjected to spring frost, which can cause serious damages e.g. in the Champagne area on April the 8th, 2003. A detailed study of the variability and frequency of spring frost events in four vineyards (Loire Valley, Champagne, Burgundy and Alsace) was carried out within the framework of the RICLIM-CNRS 2663 multidisciplinary Research Group “Climate Risks” and was supported by the research program TERVICLIM (ANR-JC07-194103) and by the MAIF Foundation (program about air-mass circulation dynamics and climate risks).

The northern Half of France is included in the Cfb type of climate (according to the Köppen’s classification) of northwestern and central Europe. However, the combined effects of the latitude, the continentality and the topography involve varied regional climates. Among the four studied wine-producing areas, the Loire Valley area is the warmest, the Champagne area is the coolest in summer, and eastern Burgundy and especially Alsace are the most subjected to the continentality effect (highest annual temperature oscillation and highest rainfall amounts in summer). Therefore, these areas are not equally subjected to the frost risk. Spring is a key season for the vine growing and during frost-producing weather patterns, northern France is subjected to a high spatial variability of temperature at regional and local scales. During the period 1960-2007, the number of spring frost day events was three times as high in Colmar (Alsace) than in Saumur (Loire Valley). Among the four wine-producing areas, Alsace records the most hard and frequent frosts in early spring, while the Champagne area records the latest frosts (until June). In the Loire Valley area, frost is rare as early as April. The combined effects of the continentality and the topographical features of the Upper Rhine Graben explain the hard frosts in early spring at Colmar, but also higher temperature at Colmar than at Reims from April. The Champagne area is the most exposed to frost-producing North-Westerly and Northerly atmospheric circulations in late spring (e.g. on May the 5th, 1996: minimum temperature of -1°C at Reims / Champagne and +3.8°C at Colmar).

The identification and frequency of atmospheric circulation patterns causing spring frost (daily minimum temperature below 0°C) and hard frost (daily minimum temperature below -5°C) were carried out using the objective computational version of the 29-type Hess and Brezowsky Grosswetterlagen system of classifying European synoptic regimes (James, 2007). Minimum temperature data were got from the Meteo-France database (Climathèque), for the spring months (March, April and May) and for the period 1960-2007, at the weather stations of Saumur (Loire Valley), Reims (Champagne), Dijon (Burgundy) and Colmar (Alsace). More than 40

The results about hard frost days occurring at least at one of the four reference weather stations show that 74