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INFLUENCE OF LOCAL *VS*. REGIONAL SETTINGS ON GLACIATION PATTERNS IN THE FRENCH ALPS

ABSTRACT: COSSART É., *Influence of local* vs. *regional settings on glaciation patterns in the French Alps*. (IT ISSN 0391-9838, 2013).

To complement the work led by glaciologists, geographers should explain the distribution of glaciers at different scales. Indeed, various local effects can interfere with regional climatic parameters to generate variations in glacier sensitivity. In this paper, we propose a method to explore the influences of various parameters (topography, relative location, topoclimate, etc.) on glacierisation, at two complementary scales (regional and local). Firstly, the level of equilibrium line altitude (ELA) of 217 glaciers located in the French Alps is explained by coupling a F-test on the influence of region belonging with a multiscalar principal component analysis (PCA). Secondly, the variables identified as influencing the ELA at a local scale (longitude, curvature and incoming solar radiation) are integrated into a geographically weighted regression (GWR) to predict the altitude of instantaneous glacierisation (AIG) at any given point. AIG is then mapped all over the French Alps, and partial correlation maps between AIG and explanatory variables are also provided. Finally, it is useful to identify the structures of spatial organisation, which show a subdivision between glaciers evolving under the influence of a humid climate (Belledonne-Grandes Rousses and Mont-Blanc), and other glaciers, set in drier conditions, and where local effects (curvature and incoming solar radiation) partly compensate for the low-level of precipitation.

KEY WORDS: Glaciers, Equilibrium line altitude, Local settings, Geographically weighted regression, The French Alps.

INTRODUCTION

Studies related to global warming provide a wealth contemporary research for physical geographers. This is particularly true in Alpine environments where global change directly affects the cryosphere and in turn the availability of such a major natural resource as water. As a consequence, glaciers are observed, monitored and mapped, through two distinct approaches.

On the one hand, glaciologists have compiled long-term records in many specific places: they acquire very precise geometric measurements to quantify mass-balances of glaciers and model the relationships between glaciers and climate. Mass-balance modelling is furthermore required by all specialists of mountainous environments as glaciers are a unique proxy of poorly-documented climate at high altitudes (Ohmura & *alii*, 1992), and are also a proxy for palaeoclimate reconstructions (Federici & *alii*, 2008, 2012; Mîndrescu & *alii*, 2010). However, one problem is that glacier distribution is also affected by non-climatic factors (Arnold & *alii*, 2006), so that measurements and modelling provided from one single glacier are not necessarily representative at regional scales, especially because each glacier may be characterised by its own sensitivity (Kuhn & *alii*, 1985; Braithwaite & Zang, 2000; Chenet & *alii*, 2010). This problem is particularly relevant in the French Alps, where surveyed glaciers were often chosen at the end of the 19th century not in terms of their scientific interest, but in terms of their accessibility.

On the other hand, geographers have highlighted that the consequences of climate change on glaciers can be highly variable due to local settings (topography, aspect, glacier position, etc.; Carrivick & Brewer, 2004; Evans, 2006 a & b; Carrivick & Chase, 2011; Cossart, 2011). In turn, geographers try to explain glacier distribution at various spatial scales. At the local scale, a first global model of local asymmetry of glaciation has been defined (Evans & Cox, 2005), but «*understanding of glacier distribution remains qualitative rather than quantitative*» (Evans, 2006a). Indeed, glaciation levels are sensitive to local settings, which were identified in early glacier surveys (Rabot, 1902): they correspond to factors that can create glaciation asymmetry at scales ranging from one to tens of kilometres, such as snow-drift (Evans & Cox, 2005), snow-avalanching (Cossart, 2011), shading effects (Evans, 2011),

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