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CORRESPONDENCE BETWEEN LOCAL AND SCIENTIFIC KNOWLEDGE OF CLIMATE CHANGE

The case of Hutsuls, Northern Romanian Carpathians

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Introduction

Mountain regions provide crucial nature's contributions to highland communities, but also to lower land inhabitants (Schirpke et al. 2019). Despite their essential contributions, mountain areas are particularly vulnerable due to the combination of direct (e.g., extreme weather events, including a steady increase of precipitation) and indirect climate change impacts (e.g., landslides) (Chakraborty 2021; Li et al. 2022). Nevertheless, detecting those impacts is often challenging and efforts based on instrumental data mostly result in coarse predictive models. This is partly so because, in addition to the large heterogeneity in environmental conditions observed in mountain areas, these areas suffer from meteorological data paucity (Gelfan et al. 2017; Hawkins and Sutton 2009; Viviroli et al. 2011).

In the quest to understand climate change impacts in mountain areas, scientists have recently highlighted the potential contributions of local communities, which can provide valuable information (Chaudhary & Bawa 2011; Reyes-García et al. 2016, 2019; Savo et al. 2016). Indeed, the scientific community has started to acknowledge that the perspectives of local communities (defined here as people who have interacted with the surrounding environment for long periods) could provide crucial information on local climate change impacts (Madhanagopal & Pattanaik 2020 and the references within). For instance, climate observations by Ecuadorian mountain communities have helped to select suitable datasets for climatological analysis, providing data otherwise not available (Kieslinger et al. 2019). Local reports of climate change impacts can also enhance our understanding of cascading effects of changes in elements of the atmospheric system (e.g., Garcia-del-Amo 2023; 2024 (2024 refers to chapter 5); Gentle & Thwaites 2016; Ingty 2017; Xenarios et al. 2019). For instance, mountain herders in Nepal note that the scarcity of pastures is generated by extended droughts and lack of snowfall (Aryal et al. 2014). Similarly, Indian mountain farmers,

DOI: 10.4324/9781003356837-4

who mostly rely on rain-fed agriculture, note a reduction in crop productivity due to an overall decrease in precipitation (Shukla et al. 2019).

Despite its richness, to date, local communities' knowledge is rarely taken into account in science and policy fora, for reasons that range from limited accessibility in terms of funding to language barriers (Aryal et al. 2016; Comberti et al. 2016; Matera 2020; Negi et al. 2017). Among the studies on the topic, some have compared climate impacts derived from local knowledge with reports from instrumental recordings, with contrasting results. For example, a study conducted among nomadic Mongolian pastoralists found an alignment between reports of local knowledge and instrumental recordings, local knowledge documenting climate extremes not recorded by instrumental records (Tumenjargal et al. 2020). Conversely, Rakhmanova et al. (2021) found that most of the climate change impacts perceived by the rural dwellers of Western Siberia do not match the measurements by weather stations, arguably because instrumental records are not as specific as local observations. Finally, Shrestha et al. (2019) found a partial overlap between information from the two knowledge systems in Nepal, with convergence on temperature shifts but not on precipitations.

Among the different world regions, understanding of local communities' knowledge on climate change impact is very much neglected in Europe. Indeed, most of the scarce work on local observations of climate change impacts conducted in European mountain ranges has focused on users of ski resorts (e.g., Trawöger 2014 & Wolfsegger et al. 2008 in Austria; Dinca et al. 2014 in Romania, Cholakova & Dogramadjeva 2019 in Bulgaria; Prettenthaler et al. 2022 for a pan-European study), thus ignoring the body of knowledge hold by communities with a long history of interaction with the environment (see García-del-Amo et al. 2023).

To enrich our understanding of climate change impacts in European mountain areas, in this chapter, we explore observations reported by a small ethnolinguistic community and compare them to information obtained from instrumental records in the past 60 years. Specifically, the aims of this work are (1) to document climate change impacts observed by Hutsuls, a mountain community living in Romanian Carpathians; (2) to describe the climatic trends detected through a close-by meteorological station; and (3) to compare data from the local community with those reported by the meteorological station.

Materials & methods

We conducted research in the Carpathians, the second-largest mountain range in Europe, where we worked with the Hutsuls. Recently, the climate of the Carpathians has been examined by several scholars, and particularly through the project "CARPATCLIM, Climate of the Carpathian region", which has analyzed data from hundreds of local meteorological stations until 2010.

The Hutsuls

We conducted research among the Hutsuls, a mountain ethnolinguistic minority living in the Carpathians, largely on Ukrainian territory, although there are also approximately 15,000 Hutsuls in Suceava County, Romania (Figure 1.1). Hutsuls speak a language of Slavic origin, also named Hutsul, as well as the national languages of the states where they live (Ukrainian or Romanian).

Traditionally, Hutsuls relied on the local environment for their livelihood, which heavily depended on small-scale forestry and farming (Huțuleac 2014; Mattalia et al. 2022; Saghin et al. 2017). In spring (April and May) Hutsuls' main activity is preparing homegardens, and especially seeding potato patches. In summer (June–August), the most important activity for Hutsul communities is haymaking, an activity which they complement with wild berries, mushrooms, and

Figure 1.1 Map of the study area: position of (a) Romania within Europe, (b) Suceava County within Romania, and (c) the upper Suceava Valley and the Selyatin meteorological station in Ukraine, close to the Romanian border. Own modification from https://www.mapchart.net/.

medicinal herbs foraging. Autumn (September and October) is the time for preparing food and feeding reservoirs for winter times while harvesting the last mushrooms. During winter (November–March), Hutsuls slaughter pigs, rarely sheep and calves, and prepare their meat. Despite the importance of these traditional activities, nowadays, young Hutsuls increasingly rely on seasonal jobs abroad, as there is a lack of job opportunities in the upper Suceava Valley (especially in industry and services) and the European Union citizenship has facilitated migration to other countries.

Data collection methods

This work uses both secondary and primary information. Secondary information includes data collected at the meteorological station of Selyatin by two different providers. Primary information includes data obtained from semi-structured face-to-face interviews and focus group discussions (FGD) following the research protocol of the Local Indicators of Climate Change Impacts (LICCI) research project (Reyes-García et al. 2023). Before any data were collected, we requested the Free, Prior, and Informed Consent of all participants (CEEAH 4781).

Climatological data were obtained from two sources. For the period 1961–2009, meteorological records were obtained from CARPATCLIM (through its Ukrainian representative). The project ran between 2010 and 2013 and involved institutions from nine countries of the Carpathian area (see Szalai et al. 2013 for details). Among the selected stations, there was Selyatin, the closest meteorological station to the study area (despite its location in the Ukrainian territory; 47°52′ N lat., 25°13′ E long.; 762 m). In our analysis, we integrated the data obtained from CARPATCLIM and data from an online dataset (https://rp5.ua/Weather_archive_in_Selyatin), which contained data from Selyatin meteorological station for the period 2010–2019. We combined information on the two data sources to generate a unique dataset for the period 1961–2019. Both datasets include three variables: daily temperature (avg, in °C), daily precipitation (sum, in mm), and daily snow cover (sum, in cm). Unfortunately, the second dataset (2010–2019) presents incomplete data about snow cover, thus we could not use them for completing the desired time frame (1961–2019).

Twenty in-depth semi-structured interviews were carried out in June and July 2019 in the upper Suceava Valley (Figure 1.1). Quota sampling was used to select informants from different gender and life stages. Our sample includes 13 women and seven men ranging between 37 and 92 years of age. During interviews, we asked participants to report changes observed in the environment. We started by asking to describe any environmental change observed and then we continued by asking them more precisely about specific elements (e.g., forest, flora; for the full protocol, see

Reyes-García et al. 2023). To avoid biases, the expression "climate change" was not used, but rather we referred to "changes in the environment". The term "weather" was mentioned to elicit changes regarding seasons, temperature, or precipitation. Although interviews covered many environmental changes, here we focus on observations of changes in elements of the atmospheric system (i.e., temperature, precipitation, and seasonal events).

Three FGD with people who did not take part in the semi-structured interviews were organized to validate the information mentioned during semi-structured interviews (Reyes-García et al. 2023). In FGD, we presented the list of changes compiled during semi-structured interviews and asked participants to tell us if they had also observed such changes. After the discussion, for each observed change, the researcher moderating the FGD noted her appreciation of whether participants (1) completely agreed; (2) agreed after the debate; (3) disagreed after the debate; or (4) completely disagreed with the statement proposed by the interviewer.

Interviews and FGD were conducted in Romanian by the first author with the help of a native facilitator. We did not record the interviews but took detailed notes of responses.

Data analysis methods

Secondary data were used to calculate (i) daily and (ii) monthly average temperature, (iii) daily temperature range, (iv) monthly precipitation, and (v) annual snow coverage.

Observations of environmental changes noted during interviews were categorized according to the hierarchical classification proposed by Reyes-García et al. (2023). Specifically, we classified observations of environmental changes into Local Indicators of Climate Change Impacts (LICCI), which were then organized into "impacted elements" (e.g., mean temperature) grouped by subsystems affected (e.g., temperature).

We compared observations of changes in elements of the atmospheric system with climatic trends derived from instrumental data from the Selyatin meteorological station following the correspondence in Table 1.1.

Table 1.1 Correspondence between climate trends (a) mentioned by Romanian Hutsuls and (b) derived from instrumental data (Selyatin station), for the period 1961–2019

Climate trend reported by Hutsuls	*Climate trend derived from instrumental data*	
	Original variable	*Trend calculation*
Before there was not such a hot temperature	Daily max temperature (°C)	Days/year with a maximum temperature above 25.4°C (equivalent to the 95th percentile).
Winters are milder	Daily temperature (°C)	Average temperature during winter (avg. daily, to avg. monthly, to avg. winter temperature).
Winter can be colder [than it used to be]	Daily min temperature (°C)	Number of days with minimum temperatures <−16.6°C (equivalent to the fifth percentile).
Temperature changes abruptly	Daily max and min temperature (°C)	Number of days with a temperature variation (max temp-min temp) >21°C (equivalent to the 95th percentile).
Temperature is more extreme	Daily max and min temperature (°C)	We defined extreme cold days, days when minimum temperature <−16.6°C (equivalent to the fifth percentile) and extreme hot when maximum temperature >25.4°C (equivalent to the 95th percentile). We calculated the total number of days per decade with extreme cold or hot days.

(*Continued*)

Table 1.1 (Continued)

Climate trend reported by Hutsuls	*Climate trend derived from instrumental data*	
	Original variable	*Trend calculation*
Some days are too cold, some days are too hot	Daily avg temperature (°C)	Unusual months (i.e., “too cold” or “too hot”) were months with temperature variation over the 95th percentile calculated for every month. We calculated the monthly average temperature, then the average for every month, and finally, the variation for each month.
It snows less	Snow cover sum	Sum of cm of snowfall.
It rains more often	Number of days with recorded daily precipitation	We calculated the days in which rain precipitations occurred per year (excluding the winter months, as at this time, it snows).
Seasons do not exist anymore. Now there are only two seasons [Seasons do no longer present the characteristics they used to have]	Daily temperature; daily precipitation	We defined unusual months (i.e., “too cold” or “too warm”), when temperature variations were over the 95th percentile calculated for every month. To determine “unusual months”, we calculated the monthly average temperature, then we calculated the average for every month and the variation for each month of each year 1961–2019. We also calculated seasonal precipitation sum for the years to determine anomalies in it.
Spring comes earlier	Daily snow cover	Date of the last snowfall recorded for each winter.

We are aware that concepts derived from local knowledge may not necessarily overlap with concepts derived from scientific knowledge due to the multifaceted nature of knowledge systems (Barnhardt & Oscar Kawagley 2005; Silvano & Valbo-Jørgensen 2008). Despite these difficulties, and in line with what Tengö et al. (2014) and Fassnacht et al. (2018) have proposed, we argue that the effort to compare evidence derived from different knowledge systems can generate new and important insights to understand the complexity of climate change impacts.

Results

Hutsuls reported several observations of changes in elements of the atmospheric system, including changes in temperature, precipitation, and seasonal events (Table 1.2). In what follows, we describe ten observations of climate change reported by Hutsuls and corresponding trends detected by the meteorological station of Selyatin. We then discuss the level of similarity between data from the two sources.

Changes in temperature

We documented six different observations referring to changes in temperature. The six observations referred either to warmer weather, temperature fluctuations, or more frequent occurrences of extreme temperatures than in the past (see Table 1.2).

Extreme hot temperatures were reported to occur during longer summer periods than in the past. One informant mentioned that *“Before, there were not such hot temperatures [during summer]”* (interview with an Hutsul elder, July 2019). Two out of three FGD agreed on this observation.

Table 1.2 Observations of change in elements of the atmospheric system reported by Hutsuls, level of agreement in Focus Group Discussion (FGD), and matching with records from Selyatin meteorological station

Subsystem	*Local observation*[a]	*FGD agreement*[b]	*Matching with instrumental recordings*
Temperature	Before there was not such a hot temperature.	2/3	Yes
	Winters are milder; there are no cold winters anymore.	2/3	Yes
	Winter can be colder [than it used to be]	3/3	No
	Temperature changes abruptly	3/3	No
	Temperature is more extreme	3/3	Partial
	Some days are too cold, some days are too hot	3/3	Yes
Precipitation	It snows less	3/3	N.D.
	It rains more often	3/3	N.D.
Seasonal events	Seasons do not exist anymore; now there only two seasons	3/3	Yes
	Spring comes earlier	1/3	Yes

[a] Local observation refers to the textual observation reported by Hutsuls.
[b] FGD: Focus group discussion carried out with Hutsuls.

This observation also partially matches with instrumental data, as the meteorological station of Selyatin recorded that the number of days with temperatures above 25.4°C is increasing (Figure 1.2A). For instance, if we compare the first (1961–1980) and the last two decades of analysis (2000–2019), we observe an increase of 0.4°C (from 27°C to 27.4°C) in the average temperature of the hot days. We also observe an increase in the number of days characterized by extreme temperature, from 279 days during the 1961–1980 period to 419 days during the 2000–2019 period (+33%).

Despite the overall trend, the last decade is characterized by alternating hot summers with few days with temperatures above 25.4°C. For instance, in 2012 and 2015, the meteorological station recorded 35 and 33 days, respectively, with a temperature above 25.4°C, while in 2014, only three days with temperatures in that range were recorded. In 2018 no day with a temperature above 25.4°C was recorded.

A commonly mentioned change, validated in two of three FGD, was the general temperature increase during winter. In informants' words: "*Winters are milder*". The Hutsuls call "winter" the period of the year when the ground is covered by snow. Typically, winter was considered to start in November and end in late March or early April (although snowfall can occur from the beginning of October to late April). Informants reported that winters were more rigid in the past, with frosting for several months. The trend of wilder winters reported by Hutsuls corresponds with the trend found when analyzing instrumental data. Thus, according to data from the meteorological station, during the period 1961–2019, there was a temperature increase of 2°C during the months of November–March (being 1961–1970 and 2010–2019 avg winter temperatures respectively equal to −3.9 and −1.9°C). The increase has been more remarkable since the 1990s (Figure 1.2B), with unusually warmer winters in 2019 and 2014.

Hutsuls also mentioned that, although winters are generally milder, there are also some peaks of unusually cold temperatures with some extremely cold winter days, even colder than in the past. Despite these observations, the analysis of instrumental data reveals that extremely low temperatures in winter are not as common as in the past. For instance, in the last decade (2010–2019), there

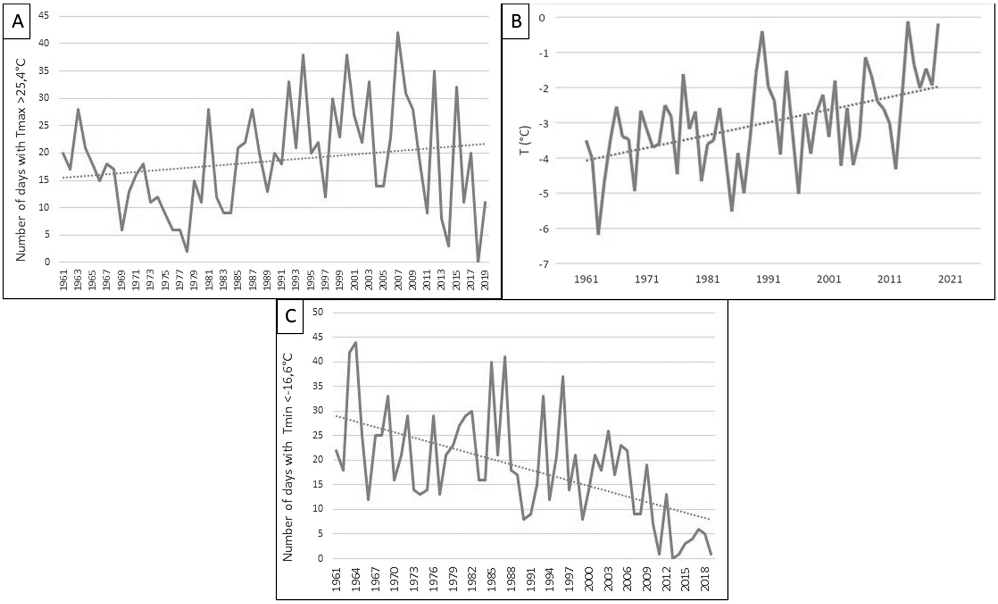

Figure 1.2 Changes in temperature during the period 1961–2019, derived from instrumental data. (A) Number of days/year with extremely high temperatures. (B) Average temperature during winter. (C) Number of days with extremely low temperatures.

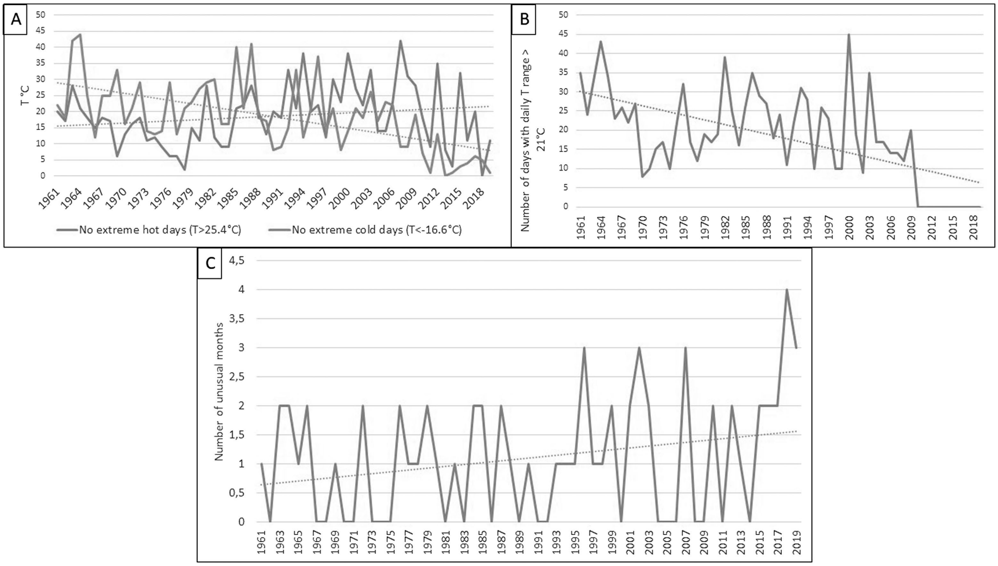

Figure 1.3 Changes in temperature during the period 1961–2019, derived from instrumental data. (A) Number of days with extreme temperature per decade. (B) Number of months with extreme average monthly temperature per decade. (C) Number of months with unusual temperature. See Table 1.1 for definitions.

were 137 fewer days (about 85%) characterized by temperature below −16.6°C than in the period 1961–1970 (Figure 1.2C).

All FGD agreed on the observation that temperature changes more abruptly now than in the past. This observation is relevant because it affects Hutsuls' ability to forecast weather. In their own words: "The weather is becoming increasingly strange". This observation matches with results of the analysis of instrumental data, which show an increase in extremely hot days after the 1961–1979 period and a decrease in extremely cold days during the 2010–2019 period, which has been also unusual in relation to the low number of extremely hot days (Figure 1.3A).

Another change mentioned by Hutsuls during semi-structured interviews, and validated by all FGD, was that nowadays extremely hot and extremely cold days are more frequent than in the past. In their own words: "*Temperature is now more extreme*". The analysis of instrumental data suggests that the last decade (2010–2019) has the lowest number of days with extremely cold temperatures (*n* = 41) recorded during the period. Indeed, instrumental data suggest that the last decade has experienced the lowest number of days with extreme temperatures since the 1960–1969 decade (Figure 1.3B). The 1990–1999 decade had the highest number of extremely hot days (*n* = 273). We consider that there is a partial overlap between Hutsul reports and instrumental records. Indeed, on the longer term (e.g. for older Hutsul participants) this represents an increasing trend of the number of days with extreme temperatures compared to the period before 1990.

In the same line, Hutsuls also reported that "S*ometimes is too cold and sometimes is too hot*", an observation that matches Hutsul's collective memory regarding the weather and the perception of the current climate. All FGD agreed on this observation. By this observation, the analysis of monthly temperature trends for the period 1961–2019 reveals a decadal increase in the number of months characterized by unusual temperatures (Figure 1.3C). Overall, instrumental data shows that the decade 2010–2019 registered the highest number of months with unusual temperatures within our temporal series (*n* = 18).

Precipitation

Hutsuls reported two observations regarding changes in precipitation, one referring to snowfall and the other to rainfall. Hutsuls reported that snowfall is less abundant than it used to be, an observation that was validated in the three FGD. Although the instrumental recordings that would allow a comparison with this observation are incomplete, particularly in the years 2008–2019 (Figure 1.4A), they suggest a decreasing trend, which will be in the same line as the local observations.

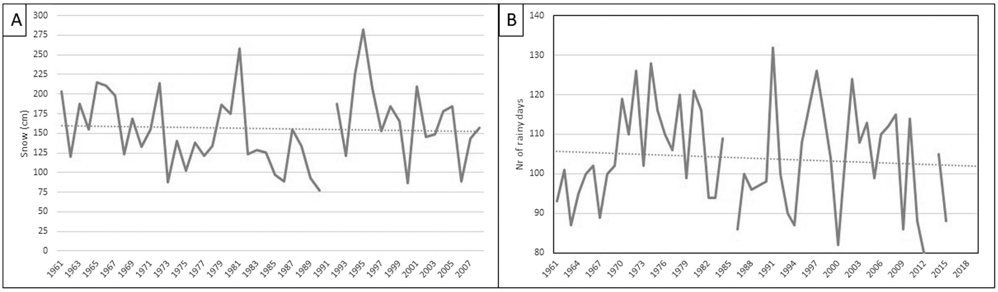

Figure 1.4 Changes in precipitation during the period 1961–2019, derived from instrumental data. (A) Snowfall during winter months. (B) Number of rainy days per year.

Hutsuls also reported that rainfall is more frequent nowadays than in the past, an observation also agreed in the three FGD. Again, data from the meteorological station of Selyatin were insufficient to determine the number of rainy days during the period 2010–2019 as data from the years 2013, 2016, 2017, and 2018 were not complete. However, the general trend seems to be decreasing, although the number of rainy days appears to be increasingly variable since the 1990s (Figure 1.4B).

Seasonal events

During semi-structured interviews, Hutsuls reported two main changes in seasonal events, namely that seasons, as they used to distinguish them, do not exist anymore and that spring comes earlier now than in the past.

During interviews, respondents mentioned that "*Seasons do not exist anymore*". Other people said that "*Now, there are only two seasons*", referring to the difference between summer and winter, and implying that the seasons shift abruptly between these two, with spring and autumn not being well-defined anymore. The three FGD agreed on this observation, which also seems to be in consonance with changes in temperature and precipitation documented through instrumental recordings. As mentioned, instrumental data show that winter temperature (avg T −3°C) is increasing and that snow precipitations are decreasing (Figure 1.5A). In the dataset analyzed, 2011 was characterized by the driest winter since 1961.

Spring average temperature (7.8°C) was relatively stable over the period 1961–2019, although precipitations experienced a slightly increasing trend. Spring precipitation presented an unusual peak in 2012, corresponding to the heavy rains recorded on May 27th, which resulted in 968 mm of rain in 12 hours (Figure 1.5B). Summer trends (avg T 14.6°C) indicate a slight increase in temperatures,

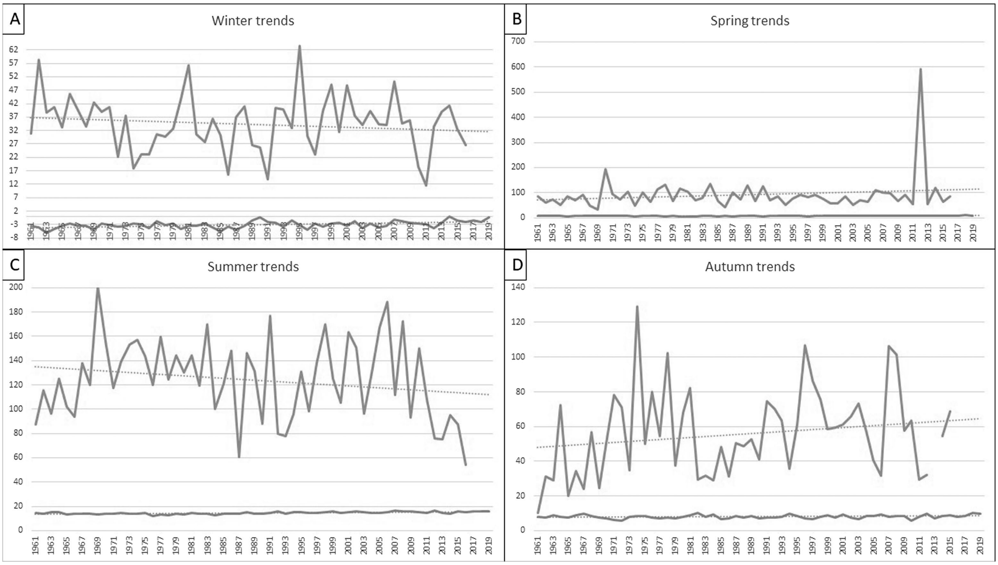

Figure 1.5 Seasonal trends of temperature T (°C) and precipitation PP (mm) recorded by the Selyatin meteorological station during the period 1961–2019. Each year is represented with a point in the graph corresponding to the monthly average seasonal temperature (lower blue lines) and precipitation sum (upper orange lines).

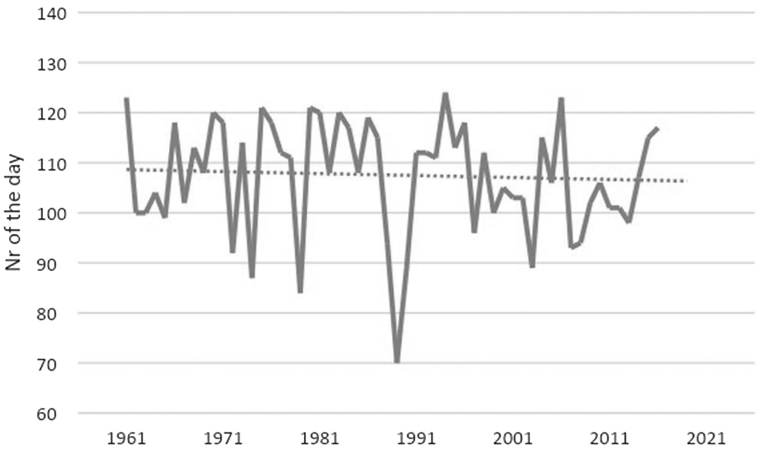

Figure 1.6 Latest day of snow cover according to the Selyatin meteorological station. Day 100 corresponds to April 9th.

with the summer of 2012 characterized by an exceptionally hot temperature and a severe decline in summer precipitations (Figure 1.5C). Autumn trends (avg T 8.1°C) show slightly increasing temperatures and decreasing rainfall, thus resembling more to summer trends (Figure 1.5D). Beyond general trends, in the last decade, the meteorological station of Selyatin recorded three unusual warm seasons (2012, 2018, 2019). Thus, changes in the main characteristics of each season detected by the closest meteorological station are in line with Hutsuls' observations that seasons are now blurred and sometimes hard to be distinguished. For instance, winters are getting milder thus resembling autumns, and autumns are becoming warmer and drier, like late summers.

Informants participating in semi-structured interviews also mentioned that "*Spring comes earlier*", although there was a certain level of disagreement with this trend. Indeed, only participants in one FGD agreed on the trend and several informants mentioned that spring can come earlier or later than in the past, depending on the year. However, the observation overlaps with instrumental data, which shows an advancement of the last day of snow cover, which corresponds to the beginning of spring (Figure 1.6).

Discussion

We present ten changes in elements of the atmospheric system reported by Hutsuls. Out of these, six showed similar trends to data gathered in the closest meteorological station, two were not aligned, and two could not be assessed due to gaps in instrumental data. In this discussion, we comment on this comparison and discuss the potential to combine Hutsul knowledge with instrumental data for enriching our understanding of climate change impacts in European mountain areas.

Before discussing these results, we want to highlight two caveats that might affect them. First, we acknowledge that we used convenient sampling to select study participants, for which our sample might not be representative of the entire Hutsul population of the upper Suceava Valley. Second, the instrumental dataset used is not fully complete (especially concerning precipitation), limiting our ability to make comparisons.

Climate change impacts reported by Hutsuls resemble those reported by other mountain communities

The first important finding of this work is that changes reported by Hutsuls (e.g., warmer temperatures, precipitation decrease, changes in seasonal events) have also been observed in other mountain areas of the world (see, for instance, Babai 2024; Fuchs et al. 2024; Garcia-del-Amo 2024). For example, Cuni-Sanchez et al. (2018) in Kenya and Pandey (2019) in Nepal find a general increase in the mean temperature and a decrease in rainfall, and farmers in Himalayan and South African highlands mountain report an increase in winter temperature (Basannagari and Kala 2013; Rankoana 2016; Sujakhu et al. 2016). Increased frequency of cold and hot temperatures was also found among farmers in the Ecuadorian Andes (Córdova et al. 2019; Postigo 2014), although several other studies only report an increase in extreme heat – but not cold – events (e.g., Meena et al. 2019). As Hutsuls, Ethiopian mountain cereal farmers, Pakistani yak and goat herders, and Mexican horticulturalists have also noticed unusual hot temperatures (Joshi et al. 2013; Kassie et al. 2013; Sánchez-Cortés & Chavero 2011). Changes in precipitation have also been mentioned by subsistence Himalayan and Andean farmers (Gurgiser et al. 2016; Joshi et al. 2019). Changes in seasonality have been reported by potato growers in Bolivia and by mixed farmers in India (Boillat & Berkes, 2013; Meena et al. 2019).

We derive an important insight from such similarities. Climate change might result in similar impacts across mountain ecosystems of the Earth. These impacts seem to be generally characterized by increased temperatures and decreased precipitations. This is in line with the ideas that mountains are particularly affected by climate change impacts (Schirpke et al. 2019) and calls for urgent management strategies (Chakraborty 2021; Li et al. 2022; Lurgi et al. 2012). Considering the high climatic variability and instrumental data paucity in mountain areas, the changes perceived by local populations can inform the development of resource managers on tailoring management strategies to face the current climatic crisis.

Local climate change impacts reported by Hutsuls mostly align with instrumental data

The second main finding of this work refers to the general match between Hutsuls' reports of changes in elements of the atmospheric system and reports from data from the meteorological station. Six out of eight observations of climate change impacts reported by Hutsuls are similar to those recorded by the meteorological station of Selyatin. Moreover, Hutsuls' observations of extreme temperatures are also in line with findings from several studies analyzing instrumental data in the Carpathian Mountains (Bartholy & Pongrácz 2007; Birsan et al. 2019; Spinoni et al. 2015). This match reinforces the idea that communities depending on nature are particularly prone to perceive the impacts of climate change, and thus provide essential knowledge, particularly in context where no other data sources are available (e.g., Gentle & Maraseni 2012; Pearce et al. 2012; Shukla et al. 2019). Instrumental recordings can provide precise and frequent data on temperature and precipitation for long periods. However, they are potentially subject to data gaps, such as those derived from technical or human errors, or breakage of instruments due to weather conditions or wild fauna and flora interactions. For example, in the Selyatin station there were gaps concerning rainfall amount and, in a couple of cases, also concerning temperature. While we do not know the exact reasons for these data gaps, the case exemplifies the importance of finding alternative data sources in mountain regions.

It is interesting to notice that while Hutsuls' reports of increased incidence of unusual hot periods, milder winters, and decreased snowfall amount are aligned with scientific observations and projections (Birsan et al. 2014; Micu 2009), the reports of an increase in extremely cold events differ with scientific records, which show a robust reduction of such events (Birsan et al. 2014). We can think of several explanations for this mismatch. For example, the average annual temperature rise may have affected the overall perception of extreme "cold" temperatures. Another possible reason for the mismatch could be the different scales and sensibility of the two knowledge systems. Considering Hutsuls' main activity (mixed farming), they may be more sensitive to the climate in certain periods of the year. Thus, it is possible that Hutsuls particularly noticed an increase in the frequency of the rains during spring and summer, which are crucial for haymaking, which would contrast with instrumental data that records an overall decrease in rainy days on a monthly or annual basis. These local reports are crucial as climate policies are often planned at national and global scales, neglecting the peculiarity of specific areas and particularly the heterogeneity of mountain regions.

Conclusions

We found several instances of overlap between Hutsuls' reports of climatic changes and meteorological records, particularly concerning changes in temperature and seasonal events. This overlap supports the idea that different knowledge systems bring synergic insights to our understanding of local climate change impacts for which considering insights of both knowledge systems could lead to better contextualized, and potentially more efficient, climate adaptation plans. Following previous work on the topic, we propose a blended approach, combining both data from meteorological stations and mountain communities' reports of climate change as the basis for co-developing climate policies.

Acknowledgments

We thank the participants of the first LICCI partner workshop: Rosario Carmona, Daniel Babai, Leneisja Jungsberg, and Priyatma Singh for supporting and fostering the writing process of this chapter. We are grateful to Yurii Nabyvanets and CARPATCLIM for sharing the dataset of Selyatin and to Angela for her linguistic facilitation in the field. We also thank Camilla Dibari, Marco Moriondo and Giacomo Trombi for their suggestions for data analysis. This project received funding from the European Research Council under a Consolidator Grant (FP7-771056-LICCI) and contributed to the "María de Maeztu Unit of Excellence" (CEX2019-000940-M).

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