Weekly Summary

Economics of Climate Change

February 23, 2024

The Role of Geospatial Analysis in Understanding Climate Variables and Their Impacts

The analysis of how climate-related acute physical events affect the economy must consider their unique aspects: brief duration and specific localization. Geographic Information Systems (GIS), for which three case studies are shown, are instrumental in this analysis.

The sudden intensity and granularity of the impact of climate physical events[1] largely differ from the variables most commonly used in economic analysis. Economists have been used to quarterly or monthly frequency and, at most, regional data. However, the climate-related indicators are available at a much higher spatial resolution and frequency. Therefore, against this background, two alternative approaches emerge to combine or integrate climate and economic variables: reducing the "climate" granularity to accommodate it to that of economic variables or exploring data from the economic sphere with granularity comparable to that of geolocated events.

For either approach, Geographical Information Systems (GIS) stand at the forefront of technology for managing and interpreting the spatial data that shapes our understanding of the physical world. These systems allow for inputting, storing, analyzing, and ultimately, mapping of inherently spatial data. Historically, the collection of such spatial data was predominantly conducted through meticulous ground surveys and comprehensive census. However, nowadays, the advent of remote sensing devices has revolutionized the methods by which this data is generated, marking a pivotal shift towards more advanced and less intrusive means of data acquisition.[2]

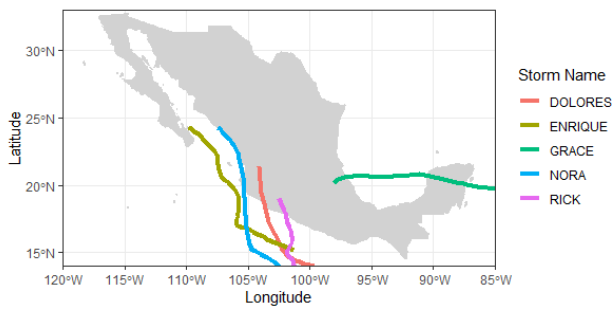
The utilization of GIS and its diverse data formats unlocks a wide range of benefits, particularly in the domain of economic analysis. The granular insight afforded by GIS data could enhance the precision and depth of economic studies, allowing researchers to dissect and understand the complex interplay of geographic variables on economic outcomes. Moreover, GIS facilitates the introduction of new sources of exogenous variation, serving as instrumental variables that can be leveraged, for example, to untangle causality in economic models. This capability not only enriches the analytical toolkit available to economists but also paves the way for novel insights and discoveries that were previously unattainable.

In what follows, three illustrative cases in which the use of geospatial data enhances climate analysis are delineated: tropical cyclones, in Mexico, and drought events and GHG analysis, in Spain.

[1]: Physical risks, either acute (event-driven, e.g. tropical cyclones) or chronic (long-term shifts in climate patterns, e.g. chronic heat waves) are becoming relevant for economic analysis because of their increasing frequency and severity as a consequence of climate change. In this regard, acute weather events (droughts, heat waves, storms, floods) seem to be a perfect fit when thinking about the application of geospatial data in economics.

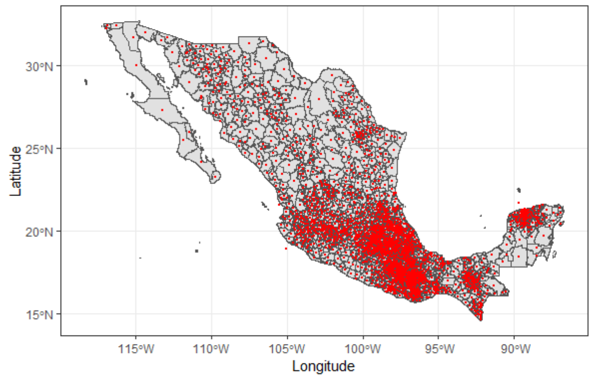
[2]: Regarding GIS, two primary data formats can be distinguished: rasters and vectors. The raster format organizes spatial information across a regular grid, with each cell (commonly referred to as a pixel) assigned a specific value that denotes a particular characteristic of that location. This method excels in capturing the continuous variation of phenomena such as elevation or temperature across a landscape. On the other hand, the vector format assigns values to irregularly shaped polygons and meticulously noting the coordinates that delineate these entities. This format is particularly adept at detailing discrete features like roads, boundaries, and other landmarks, providing a clear and precise representation of spatial relationships.

Figure 1. **TRACKED STORMS IN MEXICO IN 2021 (FILTERED WITH EM-DAT)**



Source: BBVA Research using IBTrACS (NOAA).

Figure 2. **CENTROIDS FOR MEXICAN MUNICIPALITIES**



Source: BBVA Research

A. Data on tropical cyclone tracks are employed to create a proxy that quantifies the frequency and intensity of such cyclones. Since wind speed is a widely accepted measure for assessing exposure to tropical cyclones, a Maximum Sustained Winds (MSW) metric is calculated for each federal state. The data is sourced from the International Best Track Archive for Climate Stewardship (IBTrACS), which documents storm paths at six-hour intervals. To ensure only the more severe tropical cyclones are included in the analysis, the EM-DAT database serves as a screening tool (Figure 1 presents the recorded storm tracks in Mexico for the year 2021).

Note that to effectively convert spatio-temporal data into a conventional time series for distinct spatial points, it is necessary to first spatially interpolate the storm tracks, so that locations and intensity from storms are available at a finer resolution. This means, transitioning from discrete 6-hour data points to a “continuous” track with 15-minutes data points. Finally, using the centroids of each municipality as reference (**Figure 2**), the tropical cyclone information is imputed to each municipality. The final outcome is a continuous time series of MSW for each Mexican municipality, which can be aggregated at geographical level and frequency to meet the requirements of conventional economic analysis. The final MSWs variable can be used as a proxy to correctly estimate the potential effects tropical cyclones may have on Mexican federal states.

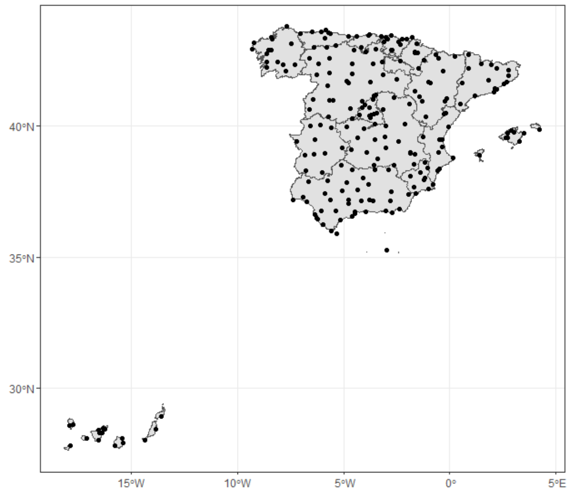
B. Use of geospatial data to analyze droughts in Spain, events characterized by prolonged periods of low precipitation and high temperatures. Quantifying the features of droughts, including their intensity, magnitude, and spatio-temporal extent, is challenging. However, the Standardized Precipitation Evapotranspiration Index (SPEI), developed by the Centro Superior de Investigaciones Científicas (CSIC), is recognized as the reference metric in scholarly research for this purpose.[3]

The publication of historical series for the SPEI typically experiences a delay. However, leveraging geospatial techniques enables the calculation of a near-real-time estimate of this index (i.e. extending the SPEI from 2022 until today). The Spanish Meteorological Agency (AEMET) supplies daily-updated, georeferenced data from its network of meteorological stations across Spain (as illustrated in **Figure 3**). Through spatial interpolation, it is possible to infer values at locations where data is not directly sampled, utilizing the measurements from nearby sites. This process facilitates the computation of the two SPEI inputs at the pixel level

[3]: The SPEI is a multiscalar drought index based on climate data which determines the onset, duration and magnitude of drought episodes. This index is computed as the difference between precipitation and potential evapotranspiration, which is finally standardized using the historical mean and standard deviation. Overall, and under global warming conditions, the SPEI can identify an increase in drought severity associated with both higher water demand or water supply shortages. These characteristics make the SPEI emerge as an ideal proxy to estimate the potential economic consequences of droughts events on an economy.

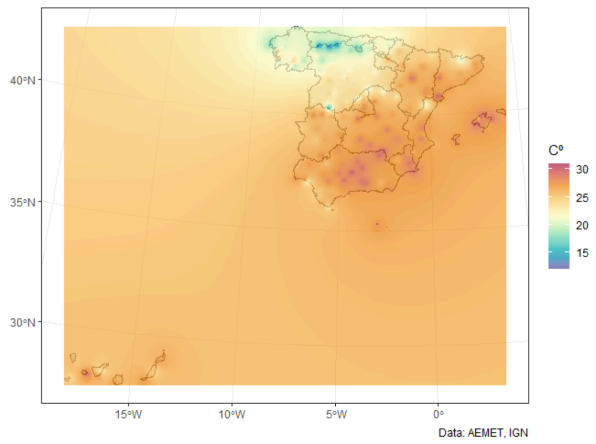
for any selected area, such as Spanish autonomous communities: the mean temperature (depicted in **Figure 4**) and total precipitation. Consequently, this "real-time" SPEI can be calculated (see **Figure 5**), which serves as an effective tool to accurately monitor the duration and intensity of drought conditions with a high degree of geographic precision.

Figure 3. **SPATIAL DISTRIBUTION OF METEOROLOGICAL STATIONS IN SPAIN**



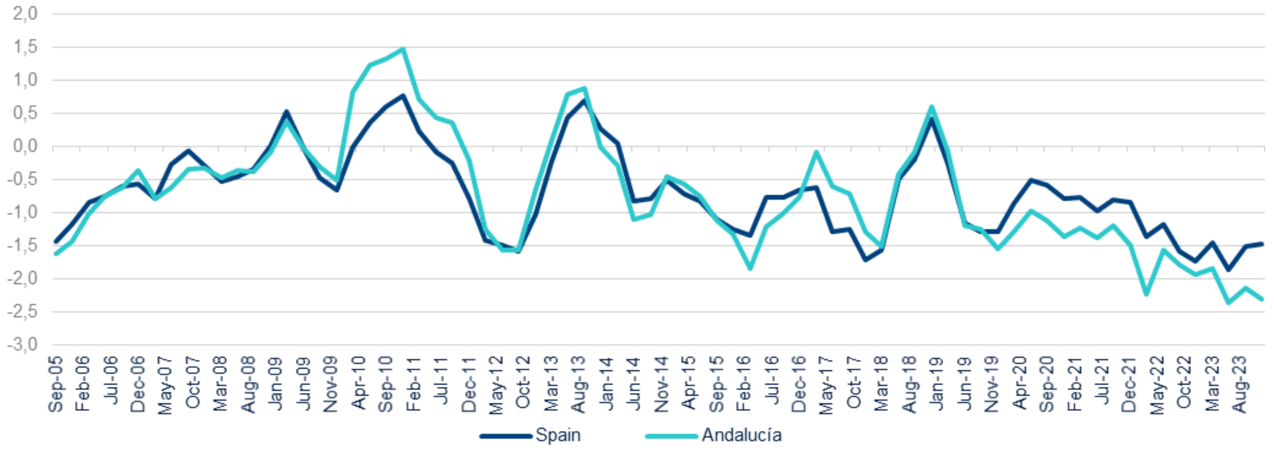
Source: BBVA Research using AEMET.

Figure 4. **RASTER OF INTERPOLATED TEMPERATURES IN SPAIN** (15/08/2023)



Source: BBVA Research using AEMET.

Figure 5. **SPEI DROUGHT INDEX** (SEP. 2005 - DEC. 2023)

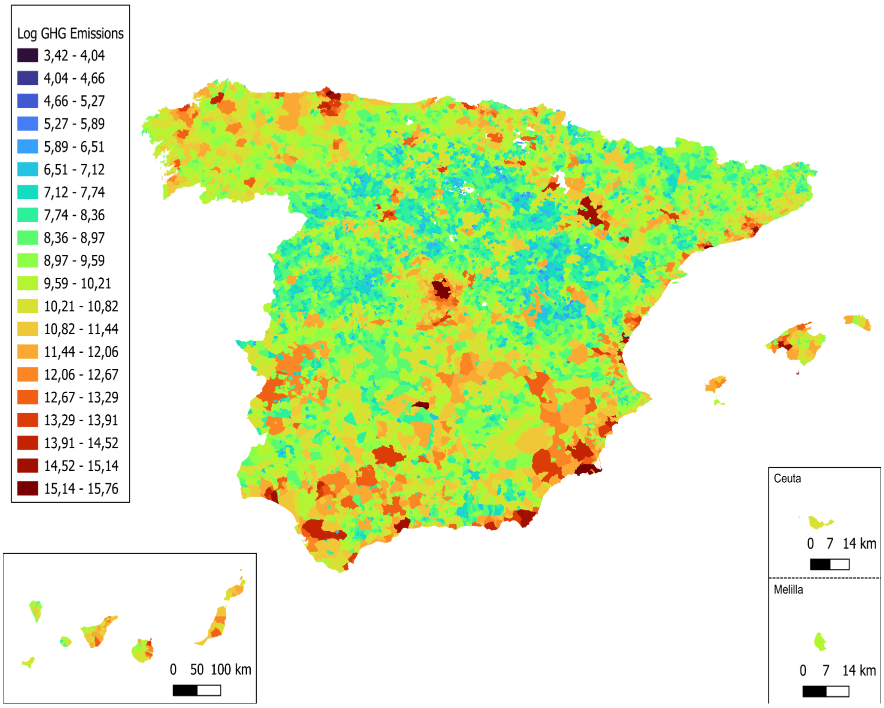


Source: BBVA Research.

C. GIS data also finds application in the detailed analysis of atmospheric pollutants. In Spain, for instance, greenhouse gas (GHG) emissions can be monitored at the municipal level through the Emissions Database for Global Atmospheric Research (EDGAR), a creation of the Joint Research Centre (JRC). This database meticulously charts emissions over 0.1º by 0.1º grid cells, employing spatial proxies for precise emission attribution. These emissions are subsequently aggregated into municipalities by BBVA Research. These spatial proxies include, but are not limited to, the locations of energy production and manufacturing plants, transportation networks (including roads and shipping lanes), as well as population densities of both humans and livestock, and land utilized for agriculture, which may change over time.

This approach allows EDGAR to offer a sophisticated perspective on emission, providing detailed insights tailored to the specificities of different geographic areas. An illustration of this is **Figure 6, which showcases the spatial distribution of GHG emissions across Spain.**[4] According to this data, the municipalities with the highest emission levels include Carreño in the Principality of Asturias, Madrid in the Community of Madrid, Puertollano in Ciudad Real, Tarragona, and Cartagena in Murcia, highlighting the diverse sources and concentrations of GHG emissions within the country.

Figure 6. **GHG EMISSIONS IN SPAIN, TONS OF SUBSTANCE** (2021)



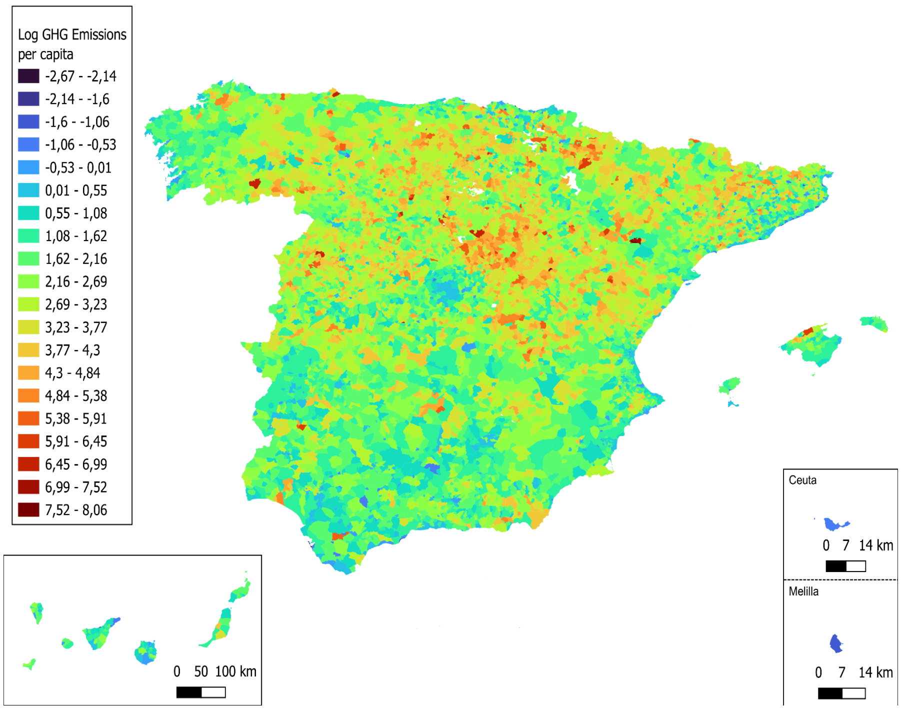
Note: Logarithmic scale.
Source: BBVA Research from Emissions Database for Global Atmospheric Research (EDGAR).

From GHG footprint to intensity per capita. When controlling for population size within each municipality, as depicted in Figure 7, the analysis reveals a significant shift in the perception of pollution levels. Cities previously identified as having high Greenhouse Gas (GHG) emissions, including Madrid, Barcelona, Valencia, Zaragoza, Málaga, and Cartagena, demonstrate a reduced intensity of GHG emissions in per capita terms. The distinction between northern and southern regions becomes evident when adjusting for population size within a given municipality. This observation suggests that the notably higher GHG footprint in a substantial proportion of southern municipalities can be attributed partly to the population density in these areas (in addition to other relevant factors as sectoral composition).[5]

[4]: GHG emissions are represented using the logarithmic scale. This scale allows for a large range of data points to be displayed without small values being compressed down into the bottom of the distribution.
[5]: This difference is founded on sectoral disparities and from the fact that the focus of this analysis is on emissions produced rather than consumed.

GHG intensity by income: similar distribution to that of the absolute footprint. Ultimately, refining the evaluation metrics to quantify emissions as tons of GHG per euro of average income per capita for each municipality, yields an analysis that closely aligns with the initial findings **(as shown in Figure 8)**. This demonstrates that the relationship between income distribution and produced emission distributions is more alike, as opposed to that of population size and emissions. However, it is observed that the situation in the southern regions is somewhat more adverse, due to the income disparity between the north and south, even though the difference in the graph appears subtle. This strong correlation indicates that municipalities with higher average incomes per capita tend to be the principal contributors to GHG emissions in Spain, as it is where major economic activity takes place. Nevertheless, this research can be enhanced using consumption instead of income, and focusing on the emissions related to households' consumption (demand side) instead of produced emissions (supply side, influenced by economic activity and sectoral composition)[6]. This represents a promising avenue for future investigation, which will be pursued in collaboration with the Big Data cluster.

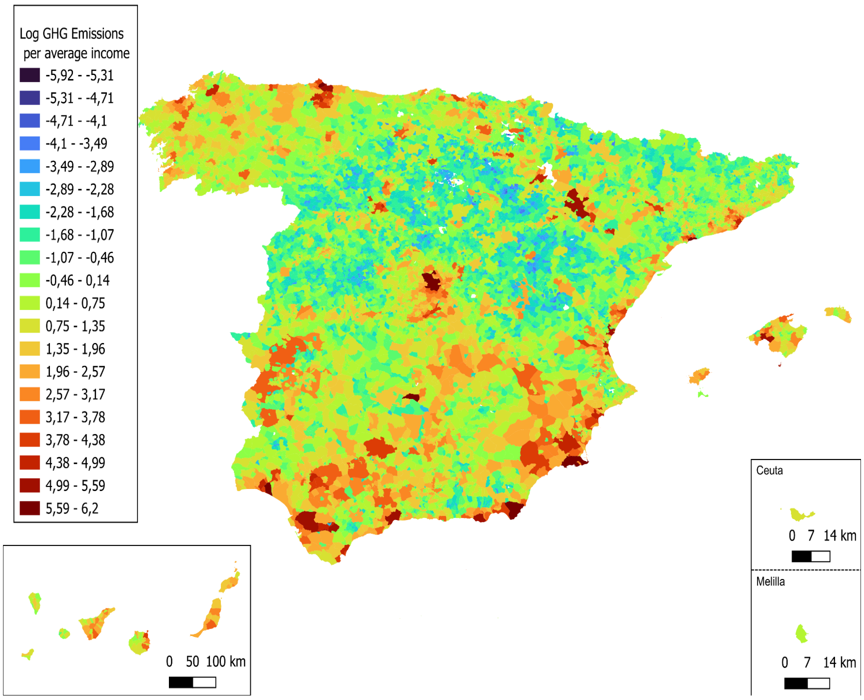
Figure 7. **GHG EMISSIONS PER CAPITA IN SPAIN, TONS PER PERSON** (2021)



Note: Logarithmic scale.
Source: BBVA Research from Emissions Database for Global Atmospheric Research (EDGAR) and Instituto Nacional de Estadística (INE).

[6]: The relationship between income and consumption is a fundamental concept in economics, reflecting a positive and high correlation: as income increases, consumption rises. This correlation is grounded in the principle that higher income provides individuals with greater purchasing power, allowing them to spend more on goods and services. Thus, income could be considered a proxy of consumption in this case.

Figure 8. **GHG EMISSIONS PER AVERAGE INCOME IN SPAIN, TON SUBSTANCE PER AVERAGE INCOME PER CAPITA (2021)**



Note: Logarithmic scale.
Source: BBVA Research from Emissions Database for Global Atmospheric Research (EDGAR) and Instituto Nacional de Estadística (INE).

In addition to the three cases above described, the possibilities of enhancing research in the field of economics using geospatial data are immense. Among them, it is worth highlighting the following examples:

- Augmenting income growth measures granularity using nighlights (example I, example II)
- Impacts of infrastructures on regional economic growth (example I, example II)
- Deforestation analysis (example I)
- Other types of physical risks such as floods (example I)

Concluding, geospatial information could play a pivotal role in comprehending the occurrences, timings, and reasons behind events, especially in understanding how and to what extent communities are and might be affected by climate change. Armed with this insight, actions can be initiated. This encompasses trying to evaluate climate change impacts, calculating losses and damages, or formulating efficient mitigation tactics, all of which are inherently linked to specific geographic locations. Hence, geospatial data is helpful for aiding policymakers in making informed decisions that are consistent with government objectives and bolster national adaptation strategies and mitigation measures.

Highlights of the Week

- **Global | Four US financial giants retreat on climate actions amid political pressure.** JPMorgan, Pimco, BlackRock and State Street withdraw from Climate Action 100+ groups following Republican pushback. The moves also highlight a growing split between the largest US-based asset managers, which are under intense pressure from Republicans over climate issues, and those elsewhere. Smaller competitors and European firms have largely stuck with various climate coalitions.
- **Europe | Despite COP28 pledge, France keeps fossil fuels subsidies for farmers.** At COP28 last December, France's former minister for energy transition announced they were very happy to support the Dutch initiative to remove subsidies for fossil fuels. But, just two months later, France has abandoned plans to phase out tax breaks on agricultural diesel in efforts to appease its increasingly disgruntled farmers.
- **US | Biden administration is said to slows early stage of shift to electric cars.** In a concession to automakers and labor unions, the Biden administration intends to relax elements of one of its most ambitious strategies to combat climate change, limits on tailpipe emissions that are designed to get Americans to switch from gas-powered cars to electric vehicles, according to three people familiar with the plan.
- **Global | Countries draw battle lines for talks on new climate finance goal.** Developed and developing countries are gearing up for heated discussions over the size of the goal and who should provide money for it. Governments are drawing their battle lines over what a new global climate finance goal should look like as talks face time pressure for a decision to be made.

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ENQUIRIES TO:
BBVA Research: Azul Street, 4. La Vela Building – 4th and 5th floor. 28050 Madrid (Spain).
Tel. +34 91 374 60 00 y +34 91 537 70 00 / Fax (+34) 91 374 25
www.bbvaresearch.com