Project 7 – Climate Change

Description

The goal of the project is to map, using a Bayesian Network, the way on which changes in emissions, caused both by natural forces or anthropogenic ones, might influence the rise in the global temperature and consequently modify the frequency/intensity of extreme weather events.

The first step to cover was to identify the key factors that influence the rise of global temperatures in general. Researches state that the three critical factors affecting the temperatures around the globe are: the Greenhouse Effect, Solar Forcing, and Volcanic Forcing. Even if all those factors play a significant role in determining the rise of the temperatures, they don't have the same weight. Solar Forcing is an extremely rare event, but when it happens, it is much more influential than the other two in determining the general temperature level of the globe. This difference is much more evident when considering it in relation to the Volcanic Forcing, that even if it is a natural event as well, its weight is significantly lower. Both Volcanic and Solar forcing depend on natural causes; on the other hand, the Greenhouse Effect is influenced by both human action and nature. One of the principal causes of the Greenhouse Effect is the level of Carbon Dioxide in the atmosphere. This molecule is always present in the atmosphere because it is mostly released by natural elements. However, if the only source of this molecule was nature, it would have been perfectly balanced by the natural cycle. Still, given that also the human action releases Carbon Dioxide in the atmosphere, then it is no longer possible to have a balance. Even if the overall quantity of CO2 released by Anthropogenic Forcing is significantly lower than the CO2 released by Natural Forcing, it is twice as influential. This is because the Carbon Dioxide released by human alters the natural cycle, unbalancing the forces.

The Anthropogenic Forcing is one of the principal causes of the alteration of the overall level of Carbon Dioxide in the atmosphere. However, this forcing is the resultant of three smaller factors, that are all caused by human action; those are:

- Carbon Dioxide Emissions
  It is the level of Carbon Dioxide that is released in the atmosphere by human actions. It comprehends activities such as the production of cement or the burning of fossil fuels like coal, oil, and natural gas.
- Aerosols
  Even if aerosols' presence depends both on natural and anthropogenic causes, the consideration will be mostly about the ones produced by humans. Those are particles able to reflect the sunlight but also the ones that change the composition of the cloud particles, changing the way on which those reflect and absorb the sunlight. Human-released aerosols are in the form of sulfate aerosols that are released with the burning of fossil fuels.
- Changes in Land
  This factor represents the deforestation level. The reduction of the level of the forest is caused by human action. This event has a direct effect on the presence of Carbon Dioxide in the atmosphere, altering the flow of energy between the atmosphere and the land. A high level of changes in lands will have a positive impact on the level of Carbon Dioxide in the atmosphere, increasing its amount.

As Carbon Dioxide emissions have the most significant weight among the other anthropogenic forcing elements, there has been a search for mitigation factors to reduce the level of emissions caused by humans. The model starts by highlighting the significance of public opinion. Public opinion on climate change is seen as a driving force for climate change initiatives at both national and international levels. Treaties on carbon emissions are among the mitigant factors that have been built by various countries and international organizations. Treaties such as the Paris Agreement and the

Kyoto Protocol are encouraging nations to increase their efforts in dealing with climate change. Two significant mitigants policies that are endorsed by the international treaties are Price and Quantity Controls. Price control is a form of government regulation that puts a price on the carbon emission to discourage entities from emitting Carbon Dioxide into the atmosphere. Similarly to Price Control, Quantity Control directly puts a cap on the amount of carbon dioxide emission. The two mitigants are expressed as significant methods to limit the carbon dioxide emission caused by humans.

After having mapped the probability of the rise in temperature, the model uses this data to try to model the possibility of changes in extreme weather events (since the frequency of those events it is not directly related to climate change, the model only considers the possibility of an increase in severity). To do that, four nodes express various scenarios, the increase in severity (and frequency), the decrease in severity (and frequency), not enough data to have a prevision, and the possibility to discern it with the current data.

Weak Points of the Model

Trying to design a Bayesian network to analyze different types of scenarios regarding climate change using AgenaRisk is a non-trivial task. A changing climate can be expected to lead to changes in climate and weather extremes. But it is challenging to associate a single extreme event with a specific cause such as increasing greenhouse gases because a wide range of extreme events could occur even in an unchanging climate and because extreme events are usually caused by a combination of factors. Despite this, it may be possible to make an attribution statement about a specific weather event by attributing the changed probability of its occurrence to a particular cause (i.e., an increase in average temperature). According to many scientific papers, we have low confidence in attribution of any detectable changes in tropical cyclone activity to anthropogenic influences (due to uncertainties in historical tropical cyclones record, incomplete understanding of physical mechanisms, and degree of tropical cyclone variability). Furthermore, scientists observed that, while there is likely not a change in frequency of tropical cyclones, there is a likely increase in mean maximum wind speed (but possibly not in all basins) and in heavy rainfall associated with tropical cyclones.

Another crucial weak point is related to the nature of the model itself. In fact, in deterministic qualitative models, the main problem is the system incapability to handle contradicting impacts of two different variables. Our case's main challenge is to estimate the weights in the effects of two or more variables converging in the same child node (Pourret et al., 2008).

A climate change model has as a starting point the physical relationships between various parameters, usually dictated by physical principles. This requires accurate knowledge of the source processes, the properties, and the propagation of the singles variables. In addition to this, it is essential to highlight the subjectivity of experts' judgment and disagreement between multiple experts that make really difficult the choice of the data to use in modeling such events (Vogel, 2014).

Designing the structure of the model, building the connections between the nodes, and finding data regarding the parameters is a straightforward task. On the other hand, finding the interconnection between nodes and how one parameter affects the others is generally a hard task to accomplish. It is possible to identify several weak points for each of the nodes that make up the model. One example is that “Public Opinion” regarding a subject is generally hard to assess. However, disregarding this inconveniency, it is really hard to measure the way on which it affects the probability of “Treaties on Carbon Emissions.” This is because, while the public opinion may vary widely from one year to the other, international treaties are long-term commitments (usually non-binding) by nations to behave in a certain way, which means that their ratification is not bound by the public opinion and is actually influenced by many other factors (i.e., international relations), that were not taken in consideration.

Test Scenarios

In order to test the accuracy of the model, two different scenarios were tested. The first one has the aim to check the possible changes in frequency and intensity of a hurricane (extreme weather event) without the human impacts.

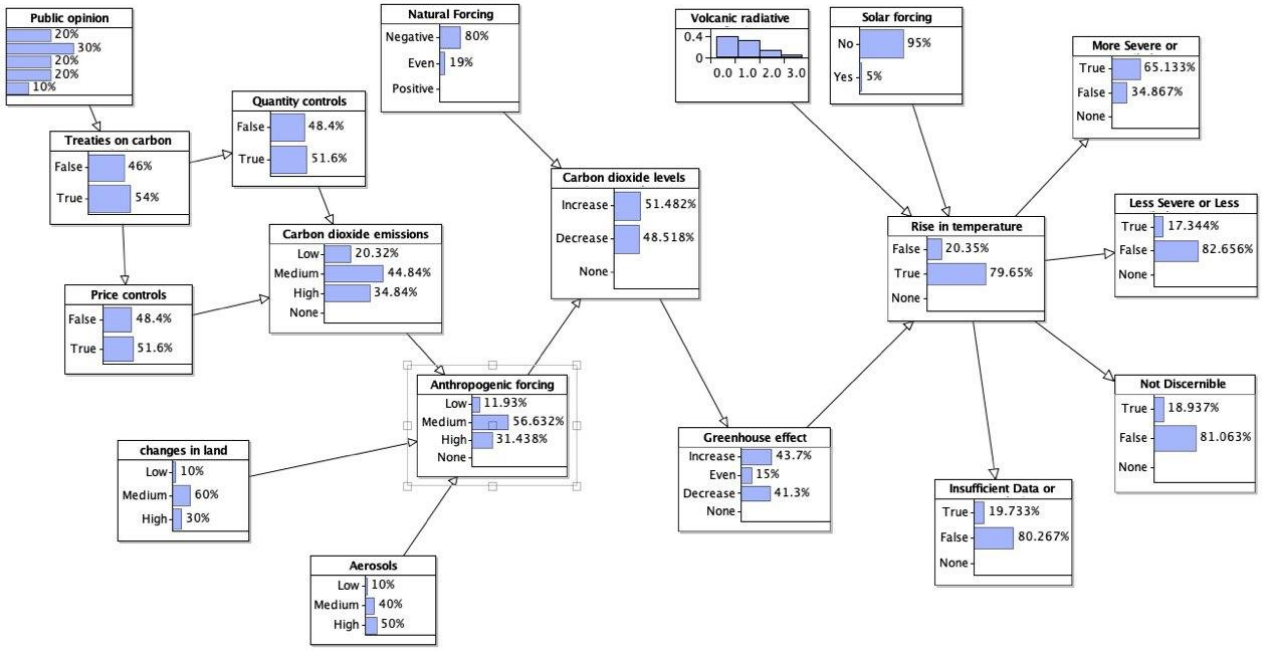

Image 1. Basic scenario of the model, with no given observation.

Considering the basic scenario of the model in the picture above (Image 1), without any given observation, it is possible to compare it with the one on which we assume a “Low” anthropogenic forcing. In the proposed case (Image 2), it is clear how removing the human factor from the picture causes a probable reduction of having a more severe event (-1,3%), with a consequent increase in the chances of having a less severe event (+2,82%). On the other hand, reducing the anthropogenic forcing adds a lot of uncertainty to the model, because it removes a sensible amount of data. Due to the limitations described above, this causes an increase both on the Non-Discernible node (+2,64%) and the Insufficient Data (+2,61%).

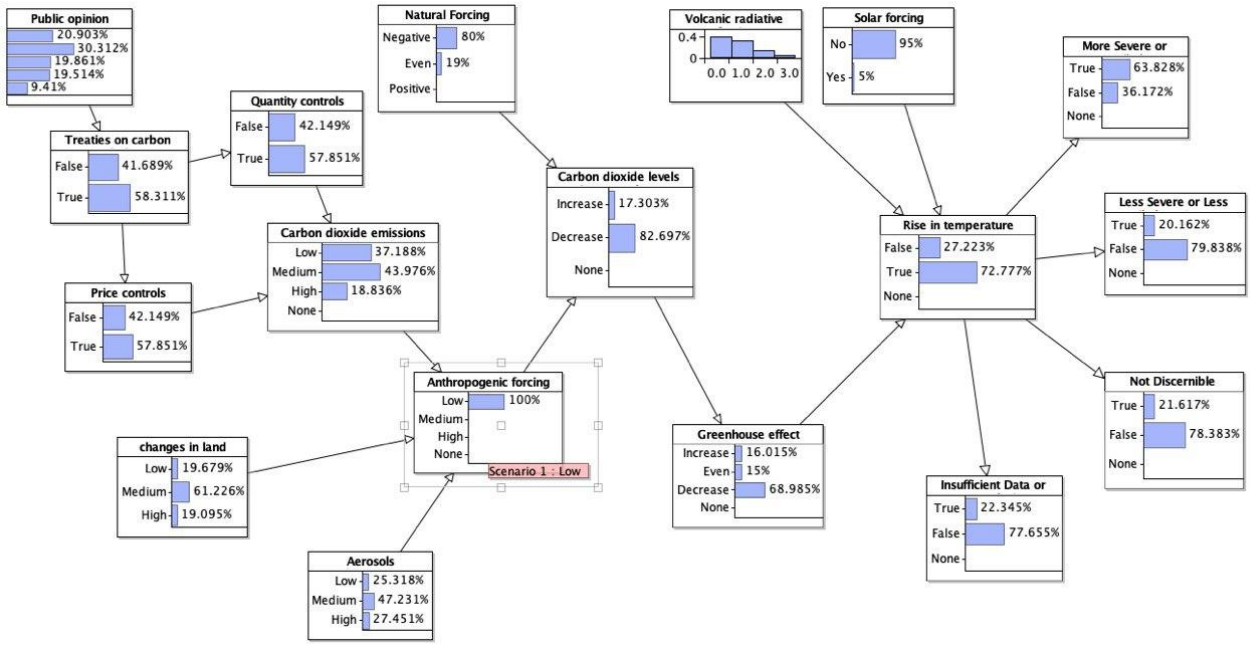

Image 2. Scenario on which the human impact is zero or extremely limited.

The second test to the model is aimed at checking how a reduction in the Carbon Dioxide emissions impacts on the rise in temperature. In order to do that, it has been inserted in the model an observation which states that the level of emissions is 'Low' to check if it has significant changes in climate change. The main difference from the previous test is that Carbon Dioxide emissions is not the only source of Anthropogenic Forcing, meaning that all the others remain unaltered (Image 3).

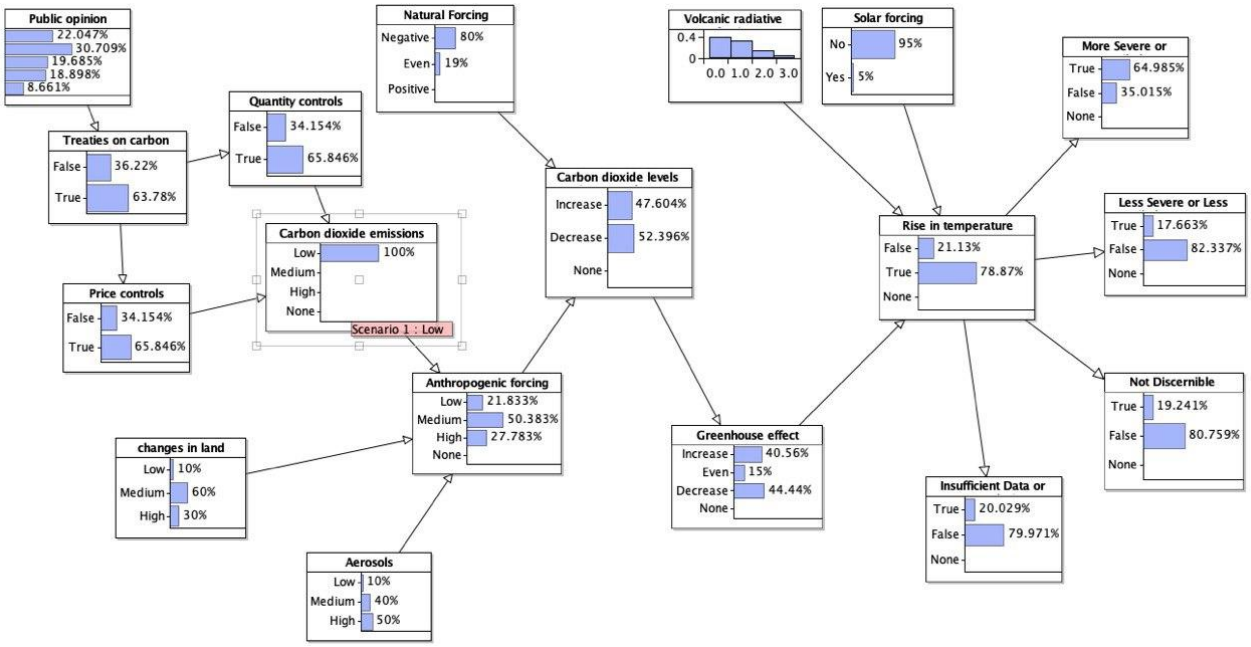

Image 3. Scenario with Low levels of Carbon Dioxide Emissions.

It is clear how a significant reduction in emissions has a direct effect on the probability of not having an increase in temperature (+0,78%). However, since human action is not limited to those emissions, the impact is lower than the scenario on which we assumed low Anthropogenic Forcing (+6,87%). This demonstrates how Carbon Dioxide emissions are only a small part of the many different causes of this shifting on temperature, and that the natural forces still play a fundamental role in the climate change scenario.

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