THE INTEMPERATE NATURE OF WEATHER AND THE WITCH-HUNT

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ABSTRACT. During the early modern period, the widespread witch-hunt and the fires of the stakes have been a common answer to any climatic severity. Nowadays, decisions drawn upon climate projections may drastically affect world's poor countries. The weather is extremely complex. Its variables interact in an irregular and unpredictable way. Climate predictions stem from computational models that present certain scenarios as being plausible. Due to the significant uncertainty, such projections cannot be regarded as forecasts.

KEY WORDS. Climate, witch-hunt, Medieval Warm Period, Little Ice Age, Inquisition, uncertainty, self-similarity.

PROLOGUE

The brandisht Sword of God before them blaz'd
Fierce as a Comet: which with torrid heat,
And vapor as the Libyan air adust,
Began to parch the temperate Clime.
Milton, *Paradise Lost* (12: 633-39)

In recent years, every weather swing, most of them disasters like excessive rain, floods, waves of cold or heat, tropical storms, hurricanes, lack of snow and its excess have been blamed on human induced greenhouse gases. Anyhow, the destructive working of the natural hazards caused by various climatic factors that take place on different temporal and spatial scales are part of our days gone by. The history of climate is a dark page overshadowed by unknown factors and uncertainty; it warns us not to expect climate to be constant, and reminds us that the climate and the environment of every period of history should be considered unique. "Climate is the most awkward unknown factor for many environmental historians [1]."

Back in time, the weather extremes had no news coverage. Solar eclipses and comets, earthquakes and volcanic eruptions were often interpreted "as signs of divine anger against human sins [2]." When the Great Storm of

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1170 in England flatten crops and floods swept away people and buildings, inundating fens, only a Crusade against God's enemies could placate his anger. As the fifteenth century progressed and the weather turned cooler, damper and more erratic across much of Europe, the common response to climate deterioration were fires of the stakes. Witches were burned for causing severe thunderstorms, hurricanes, hailing, droughts, floods, snowstorms and crop diseases.

LOOKING BACK

There is mounting evidence that the years from the ninth to perhaps mid-fifteenth centuries were the warmest spell of the interval called "Medieval Warm Period", at least during some seasons of the year in some regions [3]. Studies on agriculture history have concluded that the high medieval period benefited from a more advantageous climate than any time before or since. During several centuries of the Medieval Warm Period, long, hot summers led to an almost unbroken string of good harvests, with growing urban and rural populations. It coincides with the expansion of Vikings settlements in the North Atlantic. "The existence of 750-1500 year-old tundra in the forefield of Werenskioldbreen shows that the Viking Age included a warm period that certainly lasted longer and was, probably, more intense than the warming of the climate witnessed during this century [4]." According to the oral traditions like sagas and various palaeoenvironmental indications, Norse (Vikings) seafarers enjoyed a nice and pleasant life on the west coast of Greenland. The warmer climate, clear skies, lower incidence of storms and constant winds made it easier for them to colonize the uninhabited lands of the Faeroe Islands, Iceland and Greenland [5]. In the historical treatise *Gesta Hammaburgensis Ecclesiae Pontificum* written by Adam of Bremen (1075-1080), there are remarks about the discovered island with grapes which yield excellent vine and plenty with wild wheat [6]. Like sagas, historical documents are not always trustworthy sources for events of the past. Some point out to etymological mistakes and imply that it was all about the good meadows to keep cattle [7]. "Farmsteads with dairy cattle, pigs, sheep and goats were prevalent in Iceland and along the southern coast of Greenland [8]."

As the twelfth century ended, the climate reversed. Ice crept southward; all over Europe snow fall lower on the mountain slopes, upland trees died. Pack-ice cluttered the coast of Greenland and then tightened an Artic noose to strangle movement [9]. Whatever the reasons, all we know for certain is that Greenland Vikings ultimately faded. When John Cabot (Giovanni Caboto, c.1450-c.1498) got to Greenland in 1497, he found only empty settlements and church records dating several decades back [10]. From the stones, ice and meadows of Greenland the tragic story of the lost

Vikings has finally come to light. Scientists have pieced together an amazing tale of failure. It seems that what triggered the Vikings' downfall was a deterioration of the climate. Ice core indicate that the little ice age closed on them, ultimately causing their crops to fail and their cattle to starve.

Amid all the unknown, climate variations in some parts have been better documented than elsewhere. Such information lend us knowledge that during the warm period vegetation and glacier boundaries were notably higher than today, and grapes were cultivated in England and East Prussia (now largely Poland), where late springs frosts now hinder extensive vineyards. In the *Book of Roger*, the Arabian geographer Muhammad al Al-Idrisi in the twelve century wrote that the ramparts of the Polish Wawel Royal Castle in Krakow were covered in vineyards [11]. Research in the Karkonosze Mountains has shown that the tree line was 600 meters higher in the fourteen century than in the twentieth, and that apricots and melons grew in valleys where they are no longer. "Summer after summer passed with long dreamy days, golden sunlight, and bountiful harvests. Compared with what was to follow, these centuries were a climatic golden age [12]." This period was preceded by a marked, long lasting glacier advance and followed by equally an extensive but shorter advance during the time of cooling of the European climate.

The return of colder climates with very chilly and wet springs and summers heralded the beginning of the "Little Ice Age" (AD 1450-1500). Climatic deterioration brought not only poor harvest, but also a higher risk of landslides, avalanches, glaciers expansion, frosts and floods. Crops diminished and widespread famine followed.

LIGHT WAS RETREATING BEFORE DARKNESS

> Unlike philosophy which merely arouses people and excites them, History (...) permits us to look, as through a mirror, on everything relating to heroism, wisdom, modesty, piety, and human folly.
>
> Jan Dlugosz, *Historia Polonica*

The uses to which magic might have been put included the much feared harmful power to raise storms, conjure mists, and destroy crops by hailstorms and other means [13]. In the beginning, the Christian Church rejected the claim that humans had any power over the climate. Saint Agobard (c. 769-840), Archbishop of Lyon, denounced adscription of hailstorms, tempests and any fruit of the earth damage to magic. In his letter *Contra insulsum vulgi opinionem de grandine et tonitruis* ("Against the foolish belief of the common sort concerning hail and thunder") he dismissed the idea that witches could affect the weather. Agobard wrote as well: "The

wretched world lies under the tyranny of foolishness; things [witches and witchcraft] are believed by Christians of such absurdity as no one ever could aforetime induce the heathen to believe [14]." He condemned the persecution of storm-makers accused of destroying crops by calling up destructive winds, and cautioned people against weather magicians. Yet, regardless of his belief that storms could only raise naturally or by divine power, the fear of the *Temestarii* (witches who specialized in raising violet storms, hail, heavy rains, and crops damage) often led to recurrent lynching of weather "magicians [15]." Already, in 743, during the Carolingian rule the list of superstitions (*indiculi superstitionum)* produced during the sixth and seventh centuries and approved by the Roman Church, condemned the use of weather magic and "rising of storms." In the early 1000's Burchard, bishop of Worms in his *Decretum* or *Collectarium Canonum* (first collection of canon laws) expressed disapproval of "controlling weather" practices or any other form of the pagan traditions that were in league with a mythical race of cloud dwellers from Magonia Land. In this work he included *Canon Episcopi*, one of the most famous and controversial texts in the history of witchcraft. At the time, it looked as if sustaining a skeptical attitude expressed earlier by Saint Augustine of Hippo (400's) that neither Satan nor witches were capable of bringing into play magic of any sort to control the natural world and physical phenomena. He took up the problem of magic condemning all the earlier religions as superstition. In *The City of God* Augustine writes about the practices of "(...) that pernicious and abominable science by which, as the tale goes, one man's crops could be transferred to another land [16]."

Nevertheless, the popular belief in the efficacy of magic was much too strong to be ignored. In fact, the belief in witch power to affect the weather conditions was not confined to the *Tempestarii* (weather makers). Witches struck homes and crops alike, sunk ships, cause tempests, hailstorms and lightning, destroy people and crops. It all began when Pope Lucius III issued *Ad abolendam* (1184) that lay procedures for ecclesiastical trials to deracinate heresy. Although typical weather magic, demons and witch beliefs were in the air, there were not used against anyone except in quite unusual circumstances. Thomas Aquinas admitted the existence of trolls, fairies, demons and other manifestations of devilish powers, but only as intangible beings.

In the Middle Ages, the power of demons, or evil spirits (*daimonion*) were associated usually with fertility, of great importance in agricultural societies living on the edge of subsistence. The relative cooling of the fifteenth century particularly affected the Alpine regions where the periods of frost and snowfalls lengthen, endangering harvests. Felix Hemmerlin (1388-c.1460), provost of Zurich, in his dialogue on nobility blames peasant women for bringing hail and thunder upon land and "calling

storms together by magic." And the higher we go the grater power a demon possesses,

> ... on that broken mountain (...) at whose foot lies the city of Lucerne with its great lake (...) if any man (...) utter any speech (...) or if he casts anything into the water (...) or if he touch or stir the water then forth-with, however clear the sky may be, most furious tempest ariseth in the realm of the clouds followed by the intolerable hail and snow and rain, so as to threaten the very ruin of the lands at this mountain's foot [17].

He also upholds the demon's power to cause any weather misfortune on its own, and not being overshadowed by witches. The imaginary abilities of evil spirits were further stressed by Pierre (Petrus) Mamoris of Limognes, who in his *Flagellum Maleficorum* (1462) gave an impressive description of their altering weather, bringing the sudden tempests or downpour, causing disease or carrying witches through the air [18]. The popular fears of magic were indeed real and significant.

It was only when authorities, bishops, inquisitors, magistrates and lawyers reversed legal procedures that a new idea of witchcraft was embraced. In the troubled early years of his pontificate, Eugenius IV focused his attention on the conundrum of witchcraft and other demonic arts used by the Prince of Darkness. In 1437 he empowers all inquisitors to proceed with inquisitional processes against "heretical depravity" of those Christians who implore demons to regulate the weather provoke tempests and other unspeakable things [19]. As it happened, an anonymous text entitled *Errores Gazariorum* (1437), apparently compiled by the Savoyan inquisitor in charge, let us know the particular methods of causing hail and thunderstorms:

> (...) some convicted members of the sect [Carthars] who have already been burned confessed that storms and bad weather have been commanded by many devils together on the top of a mountain to break up ice (...) carrying the ice during a period of stormy weather through the air with the help of the devil, using their staffs to destroy the crops of their enemies or of certain neighbors [20].

MORS OMNIA SOLVIT

Weather deterioration during the late fourteenth and fifteenth centuries drastically worsened the conditions for agriculture, bringing famine and increasing predisposition to disease. In their wake, the traditional conception of witchcraft was transformed into the idea of a great conspiracy of witches to explain almost all climatic phenomena. Magic and weather control became popular as a sign of heresy. Once the weather conditions became more unstable, with the mix of extremely warm and cold years, often wetter and damper, with "unnatural" severe storms across Europe,

witch-hunt was set in motion. Climate, visible turn for the worse, set off religious enthusiasm and zeal with tremendous folly and irrationality. If there was unseasonable weather, cold or hot, wet or dry, frost or snow, hail or thunder or heavy winds, all these phenomena were attributed to the power of witches. During the spring of 1456 and 1457, an unusual frost destroyed the vegetation in Metz and other places of Lorraine. This unseasonably cold weather was attributed to sorcery, and the young convicted victim was burn on the stake on May 18th [21].

In 1470, Jordanes de Bergamo, master of theology at Cortona, reconciling the skepticism of the canon *Episcopi* with the reality of imaginary occult harm wrote: "(...) by the power of the devil *strigae* (*Strega*—witch in Italian) can be changed into cats, (...) and by the power of words and signs the *strigae* themselves can produce hail and rain and things of this kind [22]." Illusion and fantasy turned to the reality accepted equally by common people and educated opinion. The burning times have begun.

Malleus Maleficarum (in Latin, *For the Haut of Witches*) written in 1486 by Heinrich Kramer and Jacob Sprenger, was one of the most famous treatises on witches. However, it is not the book itself that attracted our attention but the introductory Papal Bull opening it. Pope Innocent VIII wrote: "It has indeed come to Our ears... many persons of both sexes... have blasted the produce of the earth, the grapes of vine, the fruits of the trees,... vineyards, orchards, meadows, pasture-land, corn, wheat, and all other cereals [23]." Various humanists and church persons bluntly denied the supposed power of witches. In the year 1500, Erasmus of Rotterdam published a letter in which he spoke of devil contacts as an invention made by the witch prosecutors. He was joined by the young scholar Andrea Alciati (1492-1550) who labeled those trials *nova holocausta*, and by another humanist, Heinrich Cornelius Agrippa (1485-1535). Yet their voices were a "void crying in the wilderness." Though some reformers refuse to recognize that magic was physically impossible since all the weather phenomena lie in the hand of God, nonetheless they took for granted witch persecutions for their evil intentions [24]. The *Malleus* became a handbook for the witch-hunters during the fifteenth, sixteenth and seventeenth centuries, detailing the powers of witches over the "Hailstorms and Tempests, (...) lightning to Blast both Man and Beasts," or storms at sea. Witches were blamed for nearly every problem—any misfortune, bad harvest, famine, plaque, "unnatural" weather, were seen as their fault.

Marcin Biem (c.1470-1540), rector of the Jagiellonian University in Krakow, in the first ever systematic weather report wrote: "After the solar eclipse a severe drought followed almost throughout the whole universe [*Post eclipsim illiam subsecuta fuit magna siccitas per universum fere orben* [25]]." The drought of 1540 was the worst in entire Europe within the last 500 years. Likewise, Renward Cysat (1545-1613) Chancellor in Lucerne who

has quite regularly observed a broad variety of meteorological and environmental data, mentioned snowfalls in summer on the summits surrounding his city. He also reported severe thunderstorms throughout almost the entire month of May in 1613. Martin Luther himself mentioned in his correspondence widespread forest fires during this hot summer and the severe floods of the Saale and Mulde rivers that follow the hot summer of 1545-1546 [26]. The data from Iberian Peninsula that cover the second part of the sixteenth century show large number of events related to odd and severe drop in winter temperatures that affected forest and deteriorated various plant communities [27]. It was during this period that witchcraft accusations reached their peak in England, France, Scotland and Germany.

When an unusually severe thunderstorm hit Central Europe on the 3rd of August 1562, most theologians of all faiths blamed the sinful people for having caused God's fury. In the small Lutheran town of Weisensteig in Germany, sixty three women were burned as witches within one year. Extended witch-hunts took place at the various peaks of the Little Ice Age because a part of society held the witches directly responsible for the high frequency of climatic anomalies and their impacts. Belief in the witch, and the fear it provoke, was enduring. In the second half of the sixteenth century, Johann Linden, canon of St. Simeon church in the city of Trier (Treves) wrote in *Gesta Trevirorum*: "Inasmuch as it was popularly believed that the continued sterility of many years was caused by witches through the malice of the Devil, the whole country rose to exterminate the witches [28]."

In 1597, King James VI of Scotland in his book entitled *Daemonology, in Forme of a Dialogue* claimed that witches "can raise storms and tempests in the air either upon sea or land..." In fact, this monarch held it blasphemy *not* to believe in the ability of these evil powers to raise storms. Few years earlier, in the German city of Trier, a Dutch scholar has been forced by the prosecutors to retract his protest against all the witchcraft superstition. "I do revoke, condemn, reject and repudiate (...) That neither devils nor witches can raise tempests, rain, hailstorms, and the like, and the things said about these are mere dreams [29]."

Then again, not all learned followed the hysteria that swept the sixteenth and seventeenth century Europe. In 1529, a little known Franciscan friar, Martin de Castañeda, in his brief treatise on witchcraft wrote:

> The conjurers and their conjurations of clouds and tempests are so public in this kingdom that there is no town that doesn't have one on a public payroll (...). This error is so shameless that they offer to ward off all hailstorms for that year (...). Anyone with normal intelligence can recognize these acts are vain, evil, superstitious, and diabolical. The madness, simplicities and idiocies that they explain are to be laughed at, and even be scorned [30].

Nine years later, after the Navarre witchcraft outbreak and the popular demand to burn them all, the inquisitor Valdeolitas was sent to explain more intelligent people that the destruction of harvests and other disasters came either from the bad weather or from God himself, rather than from demonic witches. In 1610, the Spanish ecclesiastic Pedro de Valentia, following the skeptic path, held up the opinion that acts confessed by witches were imaginary tales—a result of unspeakable horrors of persecutions.

Later on, by the end of the eighteen century, Gilbert White, English cleric and naturalist, in *Natural History of Selborne* [31], the most popular work of natural history before Darwin's *Origin of Species* (1859), pointed out the divergence between the desire to see the world as unchanged and unchanging, and the meteorological data that suggest that the case is otherwise. He put in the picture two "unusually hot and dry" summers of 1781 and 1783. The latter "was an amazing and portentous one and full of horrible phenomena" (265). White's letters contain "many particulars concerning some of the great frost and a few respecting some very hot summers" (253). The unusual heat of the summer of 1781 turned trees into a "decaying state" and the excessive moisture of the previous months gave way to drought. The summer of 1783 was, in White's words, full of harbingers of imminent apocalypse:

> for besides the alarming meteors and tremendous thunder-storms that affrighted and distressed the different countries of this kingdom, the peculiar haze, or smokey fog, that prevailed for many weeks in this island, and in every part of Europe, and even beyond its limits, was a most extraordinary experience, *unlike anything known within the memory of man* (383 n.)

White did not know that is has been a volcano eruption behind this atmospheric condition. Nowadays, historical climatology provides information about natural climate change and variability of past weather and climatic extremes. It teaches us that "Climate shapes the theatre in which human existence—the history of human race—takes place, sets borders for that which can happen on the earth, but certainly does not (...) compose the text for the development drama of mankind [32]."

THE UNCOMFORTABLE CONSEQUENCES OF RANDOMNESS

The issue whether the number and severity of "extreme events" has increased as a result of the enhanced greenhouse effect is highly controversial. It gets rather contentious because the devastating future scenarios come not from measurements but from computer models. These models are just models, and as such a "caricature" of the real world, to use the famous description of the Polish mathematician, Mark Kac (1914-1984).

Therefore, they cannot reflect all the features of the behavior of natural systems. For practical reasons, it is absolutely insignificant if we deal with deterministic chaos or with models where the stochastic factor enters continuously. The idea that uncertainty is set only at the beginning goes back to the American theoretical physicist and mathematician J. W. Gibbs (1839-1903), who assumed that while knowing the initial conditions, the future development of system is totally deterministic. Randomness and stochasticity do not replace regularities in the hierarchical pattern of special and/or temporal variations in natural systems [33]. Any kind of regularities can be incorporated into a stochastic model without exclusion of random elements. The bottom line is that models make an enormous range of assumptions. Whether all the assumptions and parameter adjustments collectively really add up to a realistic representation of the atmosphere is open to conjecture (current climate models do not model "natural" climatic variations very well). Thus, all those predictions are based on best guesses.

In a recent report, the Geological Science Committee of the Polish Academy of Science firmly reminds us that the climate of our planet is influenced by "the Earth's yearly revolution around the sun, thermics, changes in ocean waters flow, air mass movement, mountain massif position, their uplift and erosion in time perspective, as well as changes in the continents position as a result of their permanent wandering [34]." Acting as an unpredictable practical joker, nature might perform conjuring tricks with our opinion of the physical world.

Stochastic models (used when continuous randomness is involved)—even the most symmetric—exhibit the possibility of large excursions from the actual state. The simplest, most popular and, for probability people, most beautiful, continuous time and continuous paths stochastic model is Brownian motion, although symmetric and recurrent, can produce very large displacements, positive or negative. Roughly speaking Brownian motion is characterized by Gaussian symmetric distribution and independency of its increments in nonoverlapping intervals. In climate topics there is large unstructured uncertainty generated by external factors, and not by humans. In addition, things complicate because the stochastic mechanism behind them is not autonomous (since models depend intrinsically on time factor). Any serious analysis and subsequently predictions must be given in terms of probability of occurrence in specific results; hence, if the model is practically unknown, these predictions are fuzzy and dimmer with an increasing time horizon. Many stochastic models are recurrent, yet recurrence time can be quite large.

To find out if there is a real change in tendencies in some well defined stochastic models like Brownian motion with drift (adding some time function to the original symmetric Brownian Motion), represents a pretty

difficult part of stochastic analysis. The problem was studied carefully, for example, by Albert Shiryaev [35], a distinguished Russian mathematician, student and colleague of A. Kolmogorov, one of the greatest scientists of the twentieth century. There is no fast procedure to make such detection. It is by far much more complex in only partially observed and blurred phenomena like climate.

If we analyse our solar system, its stability can be fragile, and here the subsistence of mankind does not matter. This subject stems in many problems of nonlinear behavior of systems—one of the central problems in mathematics.

Any climatic phenomena seem to exhibit some kind of self-similarity, meaning the same patterns reappear in any time scale if properly renormalized. This kind of studies are very popular in many sciences and, in our opinion, underdeveloped in climate issues, where political discourse makes real scientific approach dim. "Scaling occurs in probability theory since Cauchy (1853) and Paul Pierre Lévy (1886-1971). It occurs in turbulence since Richardson (the 1920s) and Kolmogorov (1941) [36]." Various researchers in social and other sciences misunderstand the law of large numbers and misuse Gaussian distribution arising from the central limit theorem. As Mandelbrot stated: "The law of large numbers and the central limit theory are not universal truths that one can rely upon in model making. There are special properties that characterize cases of exceptional simplicity that defy mild or slow randomness [37]." The use of stable stochastic processes that generalize simpler ones becomes more and more popular since they are able to explain any kind of self-similarity [38].

EPILOGUE

The weather is extremely complex; it involves dozen of measurements such as temperature, humidity, wind speed and cloud cover. These variables interact in irregular and unpredictable ways. There is no doubt that the science behind the "climate topic" is far from settled; for instance, meteorological cloud related factors are poorly understood, and many cosmic effects are omitted from climate models. We do not simply refer to the well-known Schrödinger's expression that "nature resists imitations through models [39]," but to the fact that models entries can hardly be observed or estimated. For such reason, an uncritical faith in human-made models has created many of the problems now threatening the planet. The wholesale reliance on scientific progress is untenable and myopic.

Humans indeed have been affecting the environment ever since they first started landscaping and manipulating fire. They pollute, change vegetation, deforest entire areas, and although these actions may have been affecting regional temperatures, climate sensitivity remains un-

known. The earth goes through cycles of warming and cooling independently of both radioactive and anthropogenic influences [40]. So Hamlet said: "things standing thus unknown shall live behind me."

NOTES

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