
Girolamo Cardano's Meteorological Predictions: Hippocratism, Weather Signs, Winds, and the Limits of Astrology

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The subject of meteorology was central to Girolamo Cardano's thought. It held together his encyclopedism by tying the celestial realm to the sublunary world and human action. Meteorology, for Cardano, links abstract knowledge to the practical and operative. While many of his Aristotelian predecessors understood weather prediction as distinct from meteorology as a natural philosophical field, Cardano's profound interest in conjectural arts and probabilistic reasoning led him to tie causal explanations to methods of forecasting future conditions of the air and their effects on humans, especially regarding health and disease. While it might be expected that Cardano would have emphasized astrological tools for weather forecasting, instead he went in a different direction, namely, embracing the ancient tradition of weather signs and revising Aristotelian theories of winds. At the end of his career, which he mostly spent writing commentaries on Hippocratic writings, he integrated his understanding of weather signs with Hippocratic rules of prognosis, revising traditional understandings of the causes of winds.

1. Introduction

During the Renaissance, calendars, almanacs, and *practicae* offered annual predictions for the weather. These forecasts, based on astrological formulations, formed a highly circulating, popular genre. Since Gustav Hellmann's

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studies, written a century ago, scholars have recognized these writings as the product of a flowering publishing activity (Hellmann 1921; Pettegree 2010, pp. 335–38; Green 2012, pp. 109–50; Barnes 2016, pp. 25–33.) Annual forecasts, however widespread and popular, nevertheless, represent only part of Renaissance understandings and practices of weather forecasting, which over the course of the sixteenth century became increasingly integrated with natural philosophy. This integration was not seamless. Accurate forecasts were difficult to achieve, and competing theories derived from medical, astrological, and poetical traditions were not readily synthesized. Girolamo Cardano's consideration of weather prediction illustrates one approach to this reconciliation that spurred him to develop novel natural philosophical theories regarding winds as he reevaluated Aristotle, Ptolemy, and Hippocrates.

2. Weather Signs

The field of meteorology formed part of natural philosophy in the Middle Ages and the Renaissance. It largely focused not on predicting the weather but explaining it, following Aristotle's *Meteorology*, which gave little heed to forecasting (Martin 2011, pp. 11–14). The discussion of weather signs in the *Meteorology* is sparse. The few considerations of this theme that are found in the work focus on signs' relation to causal explanation. For example, in the section on earthquakes, signs are used as evidence of the tremors' material and efficient causes (Mandosio 2013). As a result, many pre-modern discussions of weather prediction are found outside of the writings that reflect natural philosophical instruction in meteorology. During the Middle Ages, the most elaborate and diffuse theories of weather prediction were astrological, as exemplified by Al-Kindi's *De mutatione temporum*, and therefore part of mathematical studies rather than philosophy (Jenks 1983; Al-Kindi 2000).

Astrological works, however, were not the only vector for the transmission of techniques of weather forecasting. Weather signs form the subject matter of a coherent genre of ancient writings, which poets, encyclopedists, and philosophers pursued. These collections list the sky's appearances or behavior of animals, along with the rising and settings of constellations that mark the seasons and served as potential indicators for changes in the weather (Taub 2003, pp. 37–69). Hesiod's *Works and Days* is the earliest extant work that addresses this topic. It advises that Boreas, a northerly wind, signals rain when it brings clouds (lines 552–53). Additionally, it put forward several signs regarding the correspondence between constellations and weather. The collection, *On Weather Signs*, attributed to Theophrastus, is perhaps the longest ancient example written in prose. Aratus used these signs as the subject of the second book of his didactic poem *Phaenomena*. Aratus' poem greatly influenced the Roman literary world: Virgil borrowed and transformed portions of it in the *Georgics*; there are three extant Latin

translations of it; Pliny integrated portions of it in his *Natural History*; and scholia attributed to Theon of Alexandria transmitted it (Wilkinson 1969, pp. 234–42; Miles 1980, pp. 100–103; Gee 2013, pp. 39–48). Similar lists of signs are found in Ptolemy's *Tetrabiblos* (2.13) and the Aristotelian *Problemata* (e.g., 26,8.941a1-20; 26,61.946a33-947b2). These works, while providing rules for predicting the weather, did not typically discuss the physical causes of these signs, although at times the authors seem to presume connections either between the motions of the heavenly bodies and the weather or between animals' instincts and changing meteorological conditions. Many signs, especially in the work attributed to Theophrastus, are based on the appearance of the sun and moon, signs that were generally considered more reliable than animals' behaviors (Theophrastus 2007, p. 85). Even Ptolemy's discussion of weather signs in the *Tetrabiblos* (2.13) omits consideration of their causes.

The tradition of weather signs appears throughout the Middle Ages. Pliny's *Natural History* fueled debates about weather prediction in Bede's time and during the Carolingian period (Eastwood 2007, pp. 170–77). Virgil's *Georgics* had a near continuous tradition. In the middle of the thirteenth century, Bartholomew of Messina translated the Theophrastean *On Weather Signs*. His translation is extant in ten manuscripts, most of which identified Aristotle as the author (Schmitt 1971, p. 292). A few scholastic works showed some interest in these signs. Albertus Magnus, for example, discussed animals as weather signs in his *De animalibus* (Martin 2019). Nicole Oresme disputed weather signs in his questions on the *Meteorology* (Oresme 2021). Nevertheless, the tradition of weather signs largely fell outside the scope of the curricula of medieval universities and thus for the most part beyond the most prominent traditions of natural philosophy. By the fifteenth century, at least a few practical manuals listed these weather signs. For example, Roberto Valturio's *De re militari* enumerated weather signs, some of which were taken from the *Georgics*, in the section on naval matters (Valturio 1483, sigs. &5v–&11r). By the late Middle Ages, learned discussions and practices of weather prediction were almost entirely astrological and showed little interest in traditional weather signs (Lawrence-Mathers 2019, pp. 66–172).

The separation of weather signs from causal meteorological investigations began to break down by the beginning of the sixteenth century. While some have linked the tradition of weather signs to folklore, in the Renaissance if it was folkloric it was nevertheless mediated by an erudition informed by humanists' textual investigations (Burnett and Giglioni 2010, p. 276). In 1497, the Aldine press printed Theophrastus's *Opera omnia*, which included the *De signis*. From 1501 to 1528 *De signis* was printed four times in editions, which identified Aristotle as the author,

together with the *Secretum secretorum*, a work that dealt with physiognomy, also a subject that depended on the reading of signs (Schmitt 1971, p. 292). In 1499, Manuzio's press printed Aratus' poems, two translations of them, and the commentary attributed to Theon. Consequently, awareness of the ancient tradition grew immensely in the first decades of the sixteenth century.

Shortly thereafter, Agostino Nifo, and then Girolamo Cardano, began to integrate these works in their natural philosophies. While weather signs might be considered a peripheral topic, a number of important early modern thinkers transmitted and appropriated the tradition. These include Niccolò Tartaglia (1550, sigs. d4r–e3v), Antoine Mizauld (1546), Guglielmo Gratorolo (1552), Giovan Battista Della Porta ([1610] 2000, pp. 71–8, 93–8, 107–8, 159–61), Ulisse Aldrovandi ([1599] 1681, pp. 9–11), and Francis Bacon ([1622] 2007, 12:106–20). Additionally, Giovanni Pico della Mirandola (Mandosio 2013, pp. 180–81), Gianfrancesco Pico della Mirandola (1520), Pietro Pomponazzi ([1516] 1954, pp. 216, 222; Pomponazzi 2011, pp. 86–8, 92), and Caspar Peucer (1553, fols. 255r–257v) discussed weather signs and their relation to divination. Many of these thinkers were actively engaged in astrological writing. Several—namely Nifo, Cardano, Peucer, and Gratorolo—wrote on and practiced medicine and thus were knowledgeable of semiological techniques of medical prognosis as well as of theories that connected epidemic disease to changing conditions of the air, which were prominent in ancient, medieval, and early modern medical writings.

Agostino Nifo integrated weather signs with natural philosophy in his commentary on Aristotle's *Meteorology*, written in 1523, and in a separate work *De verissimis temporum signis*, written in 1526, but not printed until 1540. In a 1531 work on ancient practices of augury, he discussed weather signs based on the activity of birds, distinguishing this practice from the allegedly demonic and illegitimate practices of using avian behavior to predict the outcomes of human endeavors that were widespread in antiquity (Nifo 1534, pp. 109–14). His commentary on Ptolemy's *Tetrabiblos* did not treat the chapters on weather signs (Nifo 1513).

Nifo considered the causes and reliability of weather signs in conjunction with warnings of calamities in his commentary on the *Meteorology*. Like for much of meteorology, determining the causes of weather signs in a complete and definitive fashion was impossible, according to Nifo. He saw his task as collecting, confirming, and at times explaining. He wrote: "I collected [these signs] from good authorities; for some, a reason can be given, for others it cannot, but they are confirmed by observation."¹ He

1. Nifo 1547, fol. 45v: "Ego ex bonis auctoribus collegi, quorum ratio reddi potest in aliquibus, in aliquibus non, sed observatione sunt comprobata."

held that signs based on the sun and moon were both more reliable than animal signs and easier to explain since the same exhalations and vapors that altered the appearance of the luminaries were the material causes of incipient weather (Martin 2019).

In Nifo's *De verissimis temporum signis*, determinations of probable causes of weather signs brought the subject into natural philosophy. While Nifo's natural philosophical explanations derive from Aristotle's *Meteorology*, he extracted the signs from Ptolemy, Aratus, Theon, the *Problemata*, and Pliny. Many explanations are strictly sublunary. For example, dew signals and is responsible for fair weather. Dew's matter, which is rare and thin, is not converted into rain when it evaporates, thereby rendering the upper air free of vapors and clouds. Thus, it is both a sign and a material cause of rainless and clear days (Nifo 1540, p. 26). At times, Nifo invoked astral causes, especially with regard to animals, whom he thought act according to instinct and the heavenly impressions' effects on the air. Additionally, in agreement with Ptolemy's *Tetrabiblos* (2.12), he identified the moon as generating changes in weather, understanding its phases as corresponding to alterations of meteorological conditions (Nifo 1540, pp. 20–23).

3. Cardano's Prognostications

Nifo's attempt to integrate weather signs into natural philosophy, his interest in calamities, and his knowledge of Ptolemaic astrology echo in Cardano's discussions of weather prediction. Unlike Nifo, Cardano rejected traditional readings of Aristotelian meteorology in his attempt to improve weather forecasting. Cardano's interest in meteorology began early and ran throughout his entire career. The subject was central to many ideas that hold together his encyclopedism. It ties the celestial realm to the sublunary world and human action.² Meteorology, for Cardano, links abstract knowledge to the practical and operative. His understanding of the causes of meteorological phenomena connects his natural philosophy to theories of divination and prognostication. Cardano's profound interest in conjectural arts and probabilistic reasoning tied causal explanations to methods of forecasting the future conditions of the air and their effects on humans and their health.

Cardano spent significant intellectual energy on meteorology and the related although not well-defined field of weather forecasting (Grafton 1999, pp. 146–47). His first published writing, *Pronostico* (1534), forecast the "state of the air" for the following decades. In 1538, he composed *De supernis*, which treated the "substance, motion, light and apparent magnitudes of the heavens, the rainbow, hail, comet, air, earthquake, wind, tide,

2. For Cardano's encyclopedic method, see Ingegno 1980, pp. 272–317.

cloud, frost, snow and lightning,” a set of subjects that combined the traditional topics of meteorology with considerations of the celestial bodies.³ *De subtilitate*, first printed in 1550, made Cardano's thought famous among northern European audiences. The encyclopedic work contains lengthy discussions of meteorological explanations and prognostications. These topics are found in earlier and subsequent writings. He discussed weather predictions in the astrological volume, *Libelli duo*, first printed in 1543, and in his 1554 commentary on Ptolemy's *Tetrabiblos*. The section of Cardano's *Problemata* on natural philosophical topics, which he began in 1550, treats winds, rains, and climate (Cardano 1663 2:630–34; Cardano 2004, pp. 88–9). While *De supernis* remained unpublished, it was perhaps recycled in *De rerum varietate*, a companion to *De subtilitate* (Cardano 2004, p. 71).

As Cardano's focus shifted to medicine in the 1560s, his interest in meteorology remained strong. The 1563 *De providentia ex anni constitutione* relates changes in the air to disease (Cardano 1663, 5:15–28). Winds, airs, and disease are prominent subjects in Cardano's Hippocratic commentaries, especially on the *Aphorisms* (1564) and *Airs, Waters, Places* (1570). The commentary on *Airs, Waters, Places* puts forth a theory of the origins of winds—a topic that he wrote about in a non-extant work (*De origine ventorum*)—their effects and qualities, in addition to theories about the relation between changes in the air and disease (Siraisi 1997, pp. 128–31; Cardano 1663, 1:e4v; Maclean 2009, pp. 151–52, n68).

His earliest published writing, *Pronostico* (1534), reveals how understandings of weather can assist practical and utilitarian aspects of human knowledge. In his view, changes in the air affected both individual lives and the march of history (Grafton 1999, pp. 38–50; Ernst 1999). The title page of the pamphlet, written in a vernacular prose peppered with Latin words, offers a general judgment for the years 1534 to 1550, although in fact Cardano's predictions extend beyond that interval.⁴ After establishing astrological premises and conjectures for the dates of the apocalypse and next ecumenical councils, Cardano addressed “the conditions of the air” (*de statu aeris*), meaning weather and climatic conditions in a broad sense (Ernst 1999, pp. 464–67). Using the positions of planets, presence of comets, celestial signs, storms, and lightning, he conjectured about the air's general state: for the most part it will be wet from 1534 to 1564 (Ernst 1999, pp. 465–67).

3. Cardano 2004, p. 133: “de coeli substantia, motu, luce magnitudine cuiusque eorum quae apparent, de iride, grandine, cometis, areis [sic], terr[ae]motu, ventis, aestu maris, nimbis, pruina, nive, fulgure.”

4. The text is found in Cardano 1534. The pagination refers to that of the edition in Ernst 1999.

Many prognostications regard extremes and calamities. For example, Cardano predicted that in 1535 rapidly mutating air would provoke “sudden rains, pestilential diseases, earthquakes, corruption of the air, and the death of great men.”⁵ That year differs little from much of the 1530s and 1540s, a period that will suffer “many and infinite diseases” linked to corrupt air (1537); numerous storms (1538); many wars, massacres, and much poverty (1539); “tragedy” and “devastation” (1541); widespread death of the *popolo minuto* from hunger (1542); “scarcity” and the rise of new leaders (1544); great winds and wars (1545); strange diseases (1546); dangerous frosts (1547 and 1548); and more wars (1550) (Ernst 1999, pp. 465–67).

Cardano’s pessimistic vision for society’s future accompanies his concerns about the rapidly changing air that is at fault for the rough times ahead. Meteorological phenomena—floods, droughts, comets—are inextricably tied to plagues, famines, wars, and political revolutions that will define humanity’s future. The brief chapter, “On Particular Conditions of the Air,” is similarly focused on extreme events. Conceding that there is not enough space to provide all prognostications, he forecast specific months marked by heavy rains, strong winds, droughts, as well as “horrid comets, strange signs, and the appearance of daily stars and frightening things,” thereby emphasizing the ominous and the risk of natural disasters.⁶

Cardano’s emphasis on calamities and inclement weather in his *Promostico* fits with this popular genre, which he perhaps mimicked in his effort to improve his economic and professional standing (Grafton 1999, pp. 47–8). Regardless of the motivations behind his first printed work, Cardano provided instruction on obtaining “knowledge of the qualities of the air” through tracing the positions of the planets in *De restitutione temporum*, which together with *De supplemento almanach* formed *Libelli duo*. These two works set forth rules for making astrological predictions. The final chapters of the 1547 version relate the planets’ zodiacal position to propitious and dangerous meteorological phenomena. Saturn in the northern portion of Aries signals the corruption of the air; Jupiter in the same location predicts serene air. The noxious is counterbalanced by the salubrious, and storms by tranquil weather (Cardano 1547, fols. 43v–44r). Cardano supplied additional rules for weather prediction based on conjunctions,

5. Cardano 1534, sig. A3v: “1535. Aere molto diverso & pioggie inopinate, malathie pestilential, terremoti, segni celesti, corruptione d’Aere, & morte de grandi homini.”

6. Ernst 1999, p. 467: “Comette horrende & segni strani apparitione de diurne stelle & cose spaventose cosi te direi ... saranno non solum acque copiosissime & pioggie largissime ...”

retrograde motion, planets' absides, and the angles between planets and the sun (Cardano 1547, fols. 45r–46r).

Cardano concluded by pointing to the usefulness of knowing these mutations, confirming astrology's status as a "*scientia naturalis*." According to Aristotelian categorizations, "*scientia*" was typically reserved for knowledge confirmed by syllogistic deduction. In this instance, for Cardano, "*scientia naturalis*" refers to something akin to conjectural knowledge. He wrote that "from these matters, it is clear that a wise person can attain much of use from this discipline (*scientia*), just like from medicine, about the preservation of health, and [just like] from nautical knowledge, about the well-being of ships, since astrology is in every aspect a *scientia naturalis*."⁷ Thus, he presented weather prediction as a tool for maintaining health and safety, replacing the gloom of the *Pronostico* with at least a limited amount of optimism. In his view, the "wise" can profit from astrology. His comparison of astrology to medicine and piloting, disciplines that provide informed if imperfect guides to future action, underscore its conjectural character, despite its being a *scientia naturalis*.

4. The Limits of Astrological Weather Forecasts for Cardano

Cardano's contention that astrology is a *scientia naturalis* must be weighed in relation to his epistemology and notion of conjecture. Standard accounts of medieval and Renaissance Aristotelianism emphasize that *scientia* referred to certain, universally true propositions that conform to the standards of syllogistic demonstration. Nevertheless, there were many exceptions among Aristotelians, and not all the content of natural philosophy met such high epistemological standards. Renaissance Aristotelians frequently treated portions of the field of meteorology, due to its difficulty and irregularity, as provisional and conjectural (Martin 2009). In his commentary on Ptolemy's *Tetrabiblos*, Cardano outdid many Aristotelians and reversed the epistemological hierarchy between mathematical and philosophical fields. By 1560, Cardano considered Ptolemy, along with Hippocrates and Plotinus, to have surpassed all others' brilliance (Siraisi 1997, p. 119).

Cardano's commentary criticized elections and interrogations as being un-Ptolemaic, yet the work is not a simply an attempt to purify astrology from Arabic-writing authors. Even Cardano's position toward interrogations was ambiguous (Hasse 2016, pp. 258–61). Moreover, he repeatedly praised Haly Rodoan, whom he considered the most successful, if imperfect, expositor of the *Tetrabiblos* (Cardano 1554, pp. 157, 197, 213, 261,

7. Cardano 1547, fol. 46v: "Ex his apertum est, sapientem multum utilitatis consequi posse ex hac scientia, velut ex Medicina, circa sanitatis conservationem, & ex Nautica, circa navis salutem, cum Astrologia sit undequaque scientia naturalis."

263). Furthermore, when it came to weather predictions, Cardano believed the discipline's failings stemmed more from the deficiency of Peripatetics than from the Islamicate astrological tradition.

Following Ptolemy, Cardano wrote that the celestial bodies' motions and influences on the sublunary world "are necessary" and "proceed according to divine law and order," yet it is not possible to have certain knowledge of their effects on sublunary bodies because these terrestrial and aerial substances "are composed out of matter that is inconstant and always in flux."⁸ This outlook had a number of proponents in medieval writings dealing with medicine or astrology. For example, Pietro d'Abano, whose *Conciliator* Cardano knew well, denied that there could be certain predictions (*certain pronuntiones*), such as those based on the moon's phases, about the course of either a chronic or acute disease because of the disorder (*disordinatio*) of the underlying matter.⁹ Similarly, Thomas Aquinas, in an examination of whether the heavens determine the outcomes of events on earth, responds that the heavens' powers are limited by matter's dispositions and grossness, which are accidental and therefore not necessary (Thomas Aquinas 1952, pars 1 q. 115, a. 6, 1:544).

Accordingly, in *De rerum varietate*, the prediction of the sun's path, which is most reliable (*certissimum*), is contrasted with divinations of other fields, namely "medicine, agriculture, navigation, physiognomy, and astrology."¹⁰ These fields' conjectures are prone to error, but they nonetheless each have "their own rationale," (*suam rationem*) based on natural causes.¹¹ Consequently, these fields "have always been considered to be nearly divine" even if they depend on an understanding of nature.¹² According to Cardano, the combination of theoretical knowledge, based on nature, and the absence of determinism in the sublunary world make

8. Cardano 1554, p. 25: "Motus quidem coelestium corporum & influxus eorum in hae inferiora sempiternus est, & ordine procedit ac lege divina, necessariusque est. Verum non ita ut a superioribus procedunt, sic ab inferioribus recipiuntur, sed ut fortuita & mutabilia & quae evitari, perverti, augeri, ac minui possint, non quidem superiorum corporum causa, nam ipsa ut dixi sunt immutabilia & necessariam habent actionem in hae inferiora, sed merito inferiorum ipsorum quae inconstanti materia ac semper fluente composita sunt." For an analysis of this passage, see Giglioni 2003, p. 51.

9. Pietro d'Abano 1548, fol. 5r: "Quod propter materiei eventus diversitatis inordinationem." For the relation of this passage and Pietro's views on medical astrology, see Cooper 2013, p. 545. For Cardano's reading of Pietro, see Giglioni 2008.

10. Cardano 1557, pp. 911–12: "Ergo ea relictia, dicemus rursus divinationem esse scilicet in quibusdam artibus, Medicina, Agricultura, Nautica, Physionomia, & Astrologia."

11. Cardano 1557, p. 912: "Quinimo unaqueque ars suam habet divinandi rationem."

12. Cardano 1557, p. 912: "ut hae artes divinae quasi semper habitae fuerint."

divination useful but not perfect.¹³ Cardano's espousal of the imperfect usefulness of conjectural knowledge resonates with Ptolemy's pronouncement at *Tetrabiblos* (1.2) but also with the lengthy tradition of describing medicine as a conjectural art (Maclean 2002, pp. 72–4; Fidora 2013, pp. 522–26). Texts that circulated under Galen's name suggested that medicine was conjectural and its outcomes uncertain because of the actions of healers, even if medicine's principles were stable ([Pseudo] Galen 1821–1833, 1:114–15). François Valleriole, a contemporary of Cardano who taught medicine at Turin, used the uncertainty of medical practice to argue that medicine is a conjectural art (Valleriole 1576, p. 239).

For Cardano, divination offers reasonable conjectures that conform to human reason but reflect a world that is not fixed and can be manipulated through prudential foresight. Even if disease and material dispositions lead to situations that the stars cannot overcome, an understanding of the general causes can allow for skillful, prudent self-preservation. The heavens generate the general causes, but the singular effects (plagues, wars, famines) are not determined because the proximate causes found in terrestrial qualities are more powerful than celestial ones. Moreover, astrological predictions are in no way certain since nature, coupled with the complexity and number of the stars, defies complete human understanding. Or as Guido Giglioni puts it, “man's knowledge is the precarious mirroring of a precarious world” (Giglioni 2003, p. 46).

Although Cardano's list of divinatory arts in *De rerum varietate* does not mention weather prediction, in *De subtilitate* he identified it as “the most noble part” of “the most beautiful knowledge of the natural world.” He wrote:

But the most noble part of it [i.e., philosophy] is that which teaches to have foreknowledge (*praecognoscere*) of the nature of the seasons and the temperament (*temperies*) of the air: for [it is] useful to farmers, sailors, merchants, and emperors, in short, it is both pleasing and salutary to the entire human race.¹⁴

Weather prediction's usefulness is presented as multifarious, yet it resonates with medicine and its terminology. Prediction concerns the “temperament of the air,” originally a medical term that is found in Galen, and it is potentially “salutary” (Galen 1821–1833, 1:530) Furthermore,

13. For divination's centrality to Cardano's reflections on nature, see Céard 1977, pp. 229–51; Giglioni 2003. For Cardano's probable predictions related to weather forecasting, see Maclean 2002, p. 184.

14. Cardano 1550, fol. 261r: “Verum nobilissima pars est illius quae temporum naturam praecognoscere docet & aeris temperiem. Utilis nanque Agricolis, Nautis, Mercatoribus, Imperatoribus: denique omni humano generi tum iucunda tum salutaes.”

these predictions reveal future “constitutions of the air,” a term widely linked to disease and epidemics. While it might be expected that Cardano would then reveal astrological tools for weather prediction as he had in *Libelli duo*, instead he went in a different direction. He embraced the ancient tradition of weather signs, which he had not addressed in his earlier astrological works. This choice was a harbinger of the dissatisfaction he later expressed about predictions of the weather based on the positions of celestial bodies in the zodiac, as he held that these weather signs were beyond astrology’s scope (Cardano 1578, p. 313).

Cardano’s treatment of these signs in *De subtilitate* highlights his engagement with tradition. It also reveals his desire to treat the science of conjecture in relation to medicine and cosmology.¹⁵ After enumerating the traditional categories of weather—fair weather, winds, clouds, rains, and storms—he recounted the signs of winds that derive from “natural decrees” (*ex naturalibus decretis*) (Cardano 1550, fol. 261v). These signs are similar in character, although not identical, to those found in the Theophrastean and Aratean tradition. Among the indications of winds, he counted risings of the moon and sun, protuberances on the moon, and cloudiness covering the Asses, two stars in Cancer. A lengthy quotation from Virgil’s *Georgics* on animal signs forms the entirety of the section on storms. A second passage from the *Georgics* on the appearance of the sun and clouds presents more indications (Cardano 1550, fols. 261v–62v).

The discussion of signs leads into the consideration of extreme weather experienced firsthand by Cardano or reported by recent authorities: Poggio Bracciolini (1380–1459), Georgius Agricola (1494–1555), and Olaus Magnus (1490–1557). Cardano—aiming to limit the astonishment created by forceful winds and accounts of raining frogs and lemmings—offered naturalistic explanations and historical context: winds were stronger and thus floods were more frequent in antiquity. Yet, he still maintained that these extreme phenomena are “monsters” (*monstra*) and prodigious (Cardano 1550, fols. 262v–63v).¹⁶ The prodigious nature of forceful winds stems from their hot and dry qualities as well as from astrological efficient causes. They arise from the influence of Mercury and Mars and of “more powerful constellations” (Cardano 1550, fol. 263r). Thus, for Cardano, such meteorological phenomena are indicators of omens and indicated by the stars but explicable through sublunary causes.¹⁷

15. For the role of natural signs in the *De subtilitate*, see Maclean 1984.

16. For Cardano’s efforts to limit wonder’s power in natural philosophy, see Park and Daston 2001, pp. 164–67.

17. For Cardano’s view on signs and *ostenta*, including those related to weather, see Céard 1977, pp. 247–48.

The air's intermediary role is particularly evident in subsequent treatments of the seasons' and weather's effects on epidemic disease. Basing himself on the Hippocratic *Aphorisms* and the first book of the Aristotelian *Problemata*,¹⁸ two works that treat the question with great "subtlety," Cardano addressed the predictive signs of plagues (Cardano 1550, fol. 263v; Cardano 1560, p. 1004). In the 1560 edition of *De subtilitate*, he explained that the most reliable sign—rainy, windless, hot, humid ends of spring—is both cause and sign, as it renders the constitution of air hot and moist, qualities that indicate and provoke corruption. Other, less reliable signs—eclipses, comets, and fiery appearances—derive from the heavens or upper regions of the air. Cardano, however, cast doubt on their dependability, as Italy was free from plagues from 1524 to 1559 despite the comet of 1531 and numerous eclipses during the years from 1539 to 1551 (Cardano 1560, pp. 1004–5).

5. Winds and Weather Prediction

For Cardano, winds, with their effects on the air's constitution, form an essential link between the universe's structure and prognostications. His commentary on Ptolemy's *Tetrabiblos* stresses the centrality of the wind to changes in weather. It also points to marred understandings of the wind that undermine astrology's ability to predict the weather. In particular, the blame lies on Aristotle's failure to give a satisfying account for winds. With respect to Ptolemy's understanding of the new moon's effects on weather, he wrote:

[Ptolemy] calls this tract subtler than the preceding one, since (as we said) changes in the weather happen from winds. The theory (*ratio*), causes, origin, accidents, [and] qualities of winds are so abstruse, so varied, changing, and uncertain (*incertae*) that Aristotle, even though the greatest investigator into nature, dared to put forward nothing other than that wind is made of the hot and dry exhalation. But anyone can justly doubt whether this is completely true.¹⁹

18. Although portions of the *Problemata* are no longer considered to be by Aristotle but by later Peripatetics, in the Renaissance debates about the work's authorship were inconclusive. Cardano, like many of his contemporaries, considered the *Problemata* authentic. See Blair 1999, pp. 179–80, Martin 2016a, pp. 23–5.

19. Cardano 1554, p. 166: "Quam tractationem praecedente subtiliorem appellat, quoniam ut diximus mutatio temporum ex ventis contingit. Ventorum ratio, causae, origo, accidentia, qualitates tam abstrusae sunt, tam variae, mutabiles, incertae, ut Aristoteles alio quin maximus naturae indagator, nihil aliud proferre ausus sit quam quod ventus sit exhalatio calida & sicca: Quod an plane omnino verum sit, merito quisque possit dubitare."

Cardano illustrated the rapid mutability of the weather as evidence for the difficulty of meteorology and the inadequacy of astrology. While it might be raining in Gallarate, only a mile away in Campo di Cardano the weather is serene. Cardano rhetorically asked how there can be an art of conjecture subtle enough to take into account these small distances (Cardano 1554, p. 166; Grafton 1999, p. 147). While astrology might not be able to predict such fine distinctions, it does not mean the field is useless. Just as medicine cannot cure without fail, it should not be spurned as an art. But it does mean that astrometeorology, seemingly dependent on Aristotelian natural philosophy, is defective. Cardano wrote:

This part of astrology is defective, which treats wind and rains, since in that [Peripatetic] philosophy the causes and rising of winds, from which rains come, are not only completely uncertain but not even one Peripatetic has dared to try, as they fill huge volumes with their trifles, disputing each other, not taking up arguments from the matters themselves, but worshipping the words of Aristotle as if they were God's.²⁰

In his analysis of *Tetrabiblos* 2.13, in the 1578 version of the commentary, where he discussed signs derived from the appearance of the sun and moon, Cardano repeated his view that astrometeorological prediction is difficult. He wrote that “general matters not only of weather but war, plagues, earthquakes, droughts are most difficult, varied, ambiguous, and only can be diagnosed obscurely.”²¹ It is for this reason that Ptolemy added these chapters on weather signs that are “as if not according to the art” of astrology.²² He advised the reader to consult Pliny for a more detailed discussion (Cardano 1554, p. 191; Cardano 1578, pp. 313–14; Pliny, *NH* 18.78–90). Here, Cardano reiterated that the difficulty stems from the wind's role in causing changes in weather. Therefore, in order to improve predictions, a better understanding of winds is needed, and for this Cardano directed the

20. Cardano 1554, p. 167: “Atque ea de causa haec pars in Astrologia manca est quae de ventis agitatque imbris, quod in ipsa philosophia naturali causae ventorum atque ortus a quibus imbres proveniunt non solum omnino incertae sint, sed ne unus peripateticus quidem vel tentare ausus sit, cum tamen ingentia volumina nugis suis repleant, diglandiantes invicem, non ex ipsis rebus argumenta sumentes: Sed verba Aristotelis tanquam Dei venerantes.”

21. Cardano 1578, p. 313: “Generales enim res non solum temporum, sed bellorum, pestis, terraemotuum, penuriae sunt difficillimae, variae ancipites, & quae non nisi obscure dignoscuntur.”

22. Cardano 1578, p. 313: “Ea de causa hoc caput, & alia ex antecedentibus, quasi non ex arte hic adiecit.”

reader to *De rerum varietate*, where he developed an alternative to the theory presented in Aristotle's *Meteorology* (Cardano 1578, p. 315). In this case, Cardano's unhappiness with the present state of astrology is not the result of Islamicate authors' reading of Ptolemy but rather derives from the insufficiency of Aristotelian natural philosophy.

6. The Theory of Winds in *De rerum varietate*

Humanists had questioned Aristotle's material cause for winds. In the 1520 *Examen vanitatis*, Gianfrancesco Pico della Mirandola attempted to undermine philosophy by highlighting the lack of agreement among philosophers. The subject of meteorology figures prominently, a consequence of the field's varying and inexact conclusions. Gianfrancesco Pico noted that Anaximander believed wind to be a flow of air caused by the sun moving or melting its smallest parts; the Stoics held that wind is flowing air that moves by fate (*sortitum*); Metrodorus of Chios theorized that winds are made of a watery vapor burnt by the sun and pushed by divine spirits (Pico 1520, fol. 20v). Gianfrancesco Pico added Aristotle's view that maintained, in opposition to Anaximander, Metrodorus, and the Stoics, that wind is not air or wet vapor but a dry terrestrial exhalation. This inability to find agreement was but another reason to doubt philosophy, for Gianfrancesco Pico. Vitruvius, an author Cardano knew well, also presented an alternative to Aristotle's exhalations, holding that winds are a wave of air (Martin 2016b, p. 271). These humanist musings trickled down to Aristotelians. Nifo, for example, considered and dismissed Anaximander's and the Stoics' views regarding winds (Nifo 1547, fols. 45v–46r).

Cardano gave the first chapter of the first book of *De rerum varietate* the title "The Universe, Comets, Theory (*ratio*) of Winds." Here, just as in the final chapter of the later editions of *De subtilitate*, the cyclical weather changes are tied to climatic diversity and the cosmos as a whole (Cardano 1560, pp. 1230–64). In agreement with what he wrote in his commentary on the *Tetrabiblos*, he proposed multiple deviations from Aristotle. A significant deviation is found in his theory of comets.

Despite maintaining the connections between comets and changes in weather, Cardano undermined traditional explanations for comets' relation to epidemics, violence, and political upheaval. Unlike Aristotle, he held that comets are supralunary. Round and of a mixed nature, partly like the sun, partly like stars, they are illuminated by reflections from the sun's, planets', and stars' rays. The sun's rays generate the tail, in a manner similar to the formation of rainbows (Cardano 1557, pp. 3–4). Cardano maintained that only a few comets are observed, a consequence of their feeble light. Rather, most comets pass unseen, since we notice them "only when

the air is thinnest.”²³ Sightings of comets therefore coincide with other phenomena that immoderately thin air causes. These phenomena include winds that lead to the death of infirm individuals; dryness in the air that brings on famines, plagues, and violence; and rainstorms that signify that the air has returned to its natural state (Cardano 1557, pp. 5–6). While comets are signs, the state of the air and the presence of rain are proximate causes and direct indicators. Cardano’s critiques of Aristotle’s theory of winds immediately follow the passage in which he explained his theory of comets.

In *De rerum varietate*, Cardano attacked Aristotle’s theory of winds. He contended that air and vapors—wet in nature and frequently mixed together—are the wind’s matter, a fact supported by the presence of persistent winds that accompany seas and rivers. The air possesses a natural global motion, circling from east to west while the sun “stirs up” (*excitat*) vapors as it moves. In addition to the air’s natural motion, there are “a thousand ways” that wind is generated (Cardano 1557, p. 16). These includes the force (*impetus*) of the stars that moves the air, “as if shaken and vibrated” like when a whip cracks;²⁴ and the sea’s generation of vapor from the crashing of waves (Cardano 1557, p. 20). Winds’ motion partially depends on regular astral motions, which send air down from the higher regions of the air to the lower one. Matter’s various dispositions and the earth’s irregular geological and oceanic features increase the diversity of winds and their qualities (Cardano 1557, p. 17). A refined understanding of these various causes can improve forecasting the weather, according to Cardano.

7. Weather, Winds, and Disease in Cardano’s Hippocratic Commentaries

Cardano extended his attack on Aristotle’s theory of winds in his Hippocratic commentaries, products of his tenure at Bologna as professor of medicine (1562–1570). Like *De varietate rerum*, his commentary on *Airs, Waters, Places* argued that the air’s perpetually westward motion causes winds (Cardano 1570, p. 7). He posited that air is contiguous with the sphere of the moon, which displaces the air, oceans, and the sea as it circles the earth. Accordingly, air, just as comets and shooting stars supposedly do, moves from east to west, following the moon’s path. Cardano added that had Aristotle known the tides’ motion he would have agreed that the air also perpetually moves (Cardano 1570, p. 7). Just as he argued in his

23. Cardano 1557, p. 20: “Nec si fiat, semper videtur, sed tantum cum aer tenuissimus est.”

24. Cardano 1557, p. 17: “Mouetur autem aer ab astrorum impetu, quasi concitato atque vibrato: velut cum virga vibratur, & stridet.”

commentary on the *Aphorisms*, Cardano held that vapors often accompany moving air, endowing it with specific characteristics and qualities (Cardano 1564, col. 216; Cardano 1570, p. 8). The astrological indicators of winds—conjunctions and oppositions of Jupiter and Mars—are an additional sign that winds arise when the air's natural motion intensifies (Cardano 1570, p. 7). Despite Cardano's enumeration of the causes and kinds of winds, complete understanding is elusive. The final category he listed are winds that are "fortuitous and generated by some kind of chance."²⁵

The general solution, while initially seeming to correct Aristotle, turns its target on those who interpret him as believing that "wind is only the motion of exhalation or the hot and dry exhalation." Cardano pointed out that the Aristotelian *Problemata* described wind as "the motion of air, or abundant moisture," and explained that the air's continual motion makes tall buildings drafty.²⁶ Furthermore, the *Problemata* supported Cardano's view that comets and shooting stars move with the air and likens alternating winds to the sea's ebb and flow at straits.²⁷ Consequently, Cardano's Hippocratic conception of winds corresponds not to Aristotle's *Meteorology* but to the *Problemata*, a work that he admired greatly. He wrote in *De subtilitate*:

Almost more divine is how medicine considers the disposition of the seasons to predict bodily health and the kinds of disease, with which especially Hippocrates has dealt in the third part of his *Aphorisms*, and Aristotle in the first part of his *Problemata*, with an extraordinary degree of subtlety.²⁸

Cardano's determination of wind's matter held ramifications for prognostication. The contention that wind consists not of terrestrial exhalations but rather air or vapors, or mixtures of them, conforms both to Hippocratic rules about wind differences' effects on health and to the *Problemata* (26,50.946b4–9). Later Renaissance commentators, such as

25. Cardano 1570, p. 10: "Ultimo loco sunt fortuiti & casu quodam geniti."

26. Cardano 1570, pp. 8–9: "Errant in interpretando illius dicta: nam ipsi putant quod velit ventum solum esse exhalationis motionem seu materiae humidae vel siccae. ... at ille dicit ibidem (Problemata. 35. [now numbered as 25,34] quod ventus est commotio aeris, vel redundantis humoris" Cf. Aristotle, *Problemata* 25,22.940a3–15; 25,34.944a25–30.

27. Cardano 1570, p. 8; Aristotle, *Problemata*, 26,23.942b16–19; 26,4.940b16–20.

28. Cardano 1550, fol. 263v: "Sed quasi divinius, quo medicina meditatatur per has constitutiones temporum, salubritatem corporum & morborum genera praedicere, de quibus maxime Hippocrates in tertia Aphorismorum parte, & Aristoteles in prima problematum tractaverunt, mirum quanta subtilitate." Revised translation from Cardano 2013, 2:811.

Lodovico Settala, also noted the numerous similarities between *Airs, Waters, Places* and the *Problemata*, in efforts to reconcile Hippocrates and Aristotle (Martin 2016a). The winds are crucial to health since they are responsible for the greatest changes in the air, bringing rains or clear skies (Cardano 1570, pp. 217–18). Cardano emphasized the differences in the qualities and powers of winds, which change according to region and direction depending on their sources and mixtures of vapors and air (Cardano 1570, p. 218).

This understanding of variations in the wind's matter allowed Cardano to propose general rules about its effects on health, in essence extracting weather signs from the *Aphorisms*. Since *On the Sacred Disease* maintained that the sacred disease arose from great changes in the wind, Cardano contended that Auster and Aquilo, southerly and northerly winds, are contrary in their geographic origins as well as in their powers. The southerly wind “heats and moistens everything, and even darkens the sun, and the moon and stars;” it disturbs the air, human bodies, and “all crops, rivers and wells, and the sea and springs.”²⁹

In his reading of the *Aphorisms*, Cardano argued that predictions of winds should be made based on the “inspection of stars.” What is key to forecasting is not stellar or planetary positions but whether the stars can be seen clearly. This rule parallels his understanding of comets and also traditional weather signs based on the sun's and moon's appearances. Faded stars during calm weather, an effect of murky air, signals the descent of winds from the upper region of the air, in agreement with the theory that Cardano had put forward in *De rerum varietate* (Cardano 1564, cols. 218–19). Once again, he presented weather signs as central to prognosticating, confirming Anthony Grafton's and Nancy Siraisi's assessment that “in his writings on medical theory and practice, Cardano showed remarkable restraint on the subject of medical astrology” (Grafton and Siraisi 2001, p. 77).

While in the Hippocratic *Aphorisms* both southerly and northerly winds are responsible for diseases, Cardano emphasized northerly winds' healthful purging actions, thereby creating a polarity between Auster and Aquilo. This division corresponded to the experiences of late-medieval and early modern Italians, as plagues typically were most severe during hot summers (Cohn 2003, pp. 145–75). Cardano in his commentary on the Hippocratic *Epidemics* interpreted the description of an outbreak characterized by “carbuncles” in the Thessalian city of Crannon as establishing a general rule

29. Cardano 1564, cols. 218–19: “Auster vero calefacit & humectat omnia, atque obtenebrat etiam solem & lunam & sidera. ... inquit aerem & humana corpora turbat Auster, sed & omnia sata, flumina & puteos.”

about prognosticating plagues and putrefaction based on Auster's hot and wet temperament (Cardano 1663, 10:331). Cardano used these passages from the Hippocratic corpus to create seven categories of wind that have varying degrees of healthiness, with Boreas representing a range of north-easterly winds (Cardano 1564, col. 221). Recognizing the winds, their qualities, and their classifications therefore potentially enables accurate forecasts for both weather and health.

8. Conclusion

Cardano's elaboration of the connections between disease and the conditions of the air that result from the seasons, rains, and winds aided his desire to predict and prognosticate. While presenting himself as an antagonist of Aristotle, in particular of his theory that winds are composed of terrestrial exhalations as found in the *Meteorology*, Cardano identified another Aristotelian text, the *Problemata*, as an alternative authority. Cardano was not alone among sixteenth-century thinkers who preferred the *Problemata*. For example, the humanist scholar Juan Luis Vives (1493–1540) lamented that scholars ignored the *Problemata* and *History of Animals*, two most useful writings in his view, and instead concentrated on Aristotle's natural philosophical works, including the *Meteorology*. He accused scholastics of having chosen their texts randomly rather than by using critical judgment (Vives 1555, 1:410). Although Cardano gave no philological or historical rationale for why texts within the Aristotelian corpus presented conflicting ideas or for why the theories of the *Problemata* were to be preferred over those found in the *Meteorology*, like Vives, he was open to critical reevaluations of the Aristotelian *Corpus*.

The *Problemata* had been central to the field of medicine ever since Pietro d'Abano composed his commentary on it (Siraisi 1970). Cardano esteemed the *Problemata* for its subtlety and for its similarities to the Hippocratic writings that he prized so greatly. Like Hippocratic treatises, the *Problemata* connected aerial alterations to health and disease. Moreover, the *Problemata*'s affirmation of the winds' connection to the movements of shooting stars and comets bolstered Cardano's belief in a chain that links the heavens to the air and to human events. In this manner, Cardano, like Nifo before, sought to bring weather prediction into the causal sphere of natural philosophy. But for Cardano, traditional Aristotelian understanding of the winds had to be revised.

After praising the ancient tradition of weather signs in *De subtilitate* and pointing out the inadequacies of astrological prediction of weather in his commentary on the *Tetrabiblos*, he sustained that the Hippocratic accounts of the stars' rising, qualitative descriptions of the season, and arrival of winds provided tools for explaining and predicting epidemic disease.

The best causal account of the winds, the carriers of changing weather, derives from observed signs and the *Problemata*. Its dictums support the idea that the constant movement of the air combined with vapors account for the variety of winds and weather conditions. Leaving behind much of the astrometeorological tradition, Cardano sought methods for predicting weather and epidemic disease that required revising theories of the origin and cause of winds. In doing so, he molded traditions of weather signs according to his conception of cosmology and natural philosophy and in agreement with his readings of Hippocrates and the *Problemata*.

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