Studies in History and Philosophy of Modern Physics 54 (2016) 9–17

Contents lists available at ScienceDirect

Studies in History and Philosophy of Modern Physics

journal homepage: www.elsevier.com/locate/shpsb

The adventures of climate science in the sweet land of idle arguments

Eric Winsberg *, William Mark Goodwin

University of South Florida, United States

ARTICLE INFO

Article history:
Received 20 May 2015
Received in revised form
26 January 2016
Accepted 8 February 2016
Available online 24 February 2016

Keywords:
Climate Science
Models
Non-linear science
Chaos

ABSTRACT

In a recent series of papers Roman Frigg, Leonard Smith, and several coauthors have developed a general epistemological argument designed to cast doubt on the capacity of a broad range of mathematical models to generate “decision relevant predictions.” The presumptive targets of their argument are at least some of the modeling projects undertaken in contemporary climate science. In this paper, we trace and contrast two very different readings of the scope of their argument. We do this by considering the very different implications for climate science that these interpretations would have. Then, we lay out the structure of their argument—an argument by analogy—with an eye to identifying points at which certain epistemically significant distinctions might limit the force of the analogy. Finally, some of these epistemically significant distinctions are introduced and defended as relevant to a great many of the predictive mathematical modeling projects employed in contemporary climate science.

In a recent series of papers (Frigg, Bradley, Machette, & Smith, 2013a; Frigg, Smith, & Stainforth, 2013b; Frigg, Bradley, Du, & Smith, 2014a, 2014b) Roman Frigg and Leonard Smith, as well as several coauthors, have developed a general epistemological argument designed to cast doubt on the capacity of a broad range of mathematical models to generate “decision relevant predictions” (Frigg et al., 2014a, p. 31). The presumptive targets of their argument are at least some of the modeling projects undertaken in contemporary climate science. The form of their argument is an argument by analogy: they demonstrate that a particular, imperfect mathematical model fails to produce decision relevant predictions of a certain sort, diagnose this failure, then argue that a broad but indeterminate range of additional imperfect modeling projects, with their associated predictions, would fail for the same, or similar, sorts of reasons. The philosophical interest and scientific significance of an argument of this sort depends crucially on its scope: the more modeling projects of scientific or philosophical interest that are subject to doubt on the basis of the argument, the more interesting and important the argument is.

Unfortunately, the scope of their argument is not clear. In some places, they suggest that the quantitative predictive power of all non-linear models is threatened by this argument. If this is their intended scope, then not only would the most basic results of contemporary climate science—that the climate is changing as a result of human activity and will continue to do so—be cast under suspicion, but so too would most scientific modeling endeavors. On the other hand, in places they are more circumspect, merely urging the use of caution in interpreting the “high resolution predictions out to the end of the century” (Frigg et al., 2013b, p. 886) regarding the climate generated by one particular study, and suggesting that scientists and philosophers devote attention to the predictive challenge that they have identified.

In what follows, we first trace and contrast the very different philosophical and scientific implications of the two interpretations—broad and provocative, or narrow and modest—of the scope of their argument. We do this by considering the very different implications for climate science that these interpretations would have. Then, we lay out the analogical structure of their argument, with an eye to identifying points at which certain epistemically significant distinctions might limit the force of the analogy. Finally, some of these epistemically significant distinctions are introduced and defended as relevant to a great many of the predictive mathematical modeling projects employed in contemporary climate science.

* Corresponding author.
E-mail address: eric.winsberg@gmail.com (E. Winsberg).

http://dx.doi.org/10.1016/j.shpsb.2016.02.001

1. The broad and provocative interpretation

In their more provocative moments, the authors claim to have established that the combination of non-linear mathematical models with structural model error is a "poison pill" that "pulls the rug from underneath many modeling endeavors" (Frigg et al., 2013a, p. 479). Since most mathematical models of interest in science are non-linear, and few of them can be expected to be free from all structural model error, it is supposed to follow from their argument, interpreted broadly, that any "probabilities for future events to occur" or "probabilistic forecasts" (Frigg et al., 2013a, p. 479) derived from such models cannot be trusted. Still, all is not lost, because the authors are willing to concede that, "not all the models underlying these forecasts are useless" (Frigg et al., 2014a, p. 57). This is because it is possible for a model that has been shown to be "maladaptive" for "quantitative prediction" (which is presumably what their argument establishes) to be "an informative aid to understanding phenomena and processes" (Frigg et al., 2014a, p. 48). In other words, mathematical models can be qualitatively informative in spite of the fact that they are not quantitatively trustworthy.[1]

Now one might wonder what the implications of taking this conclusion seriously would be for contemporary climate science. How much of what climate scientists claim to know about the state of the current climate and its future possible trajectories would be undermined should one accept the strong reading of this argument? Though a precise answer would depend crucially on a more detailed parsing of the qualitative vs. the quantitative predictions of models, it is safe to say that much of what climate scientists claim to know would have to be regarded as untrustworthy. The authors seem aware of this risk because in the very paragraph where they consider whether or not "science [is] embroiled in confusion," they include a footnote with the reassuring claim that this, "casts no doubt on the reality or risks of anthropogenic climate change, for which there is evidence from both basic physical science and observations" (Frigg et. al., 2014, p. 48)[2]. However, according to the IPCC, establishing the reality of anthropogenic climate change requires, both detecting and attributing climate change. Detecting a change in the climate, based on observations (of roughly the weather), requires determining that "the likelihood of occurrence by chance due to internal variability alone … is small" (Bindoff et al., 2013, 872). This, in turn, requires an estimate of internal variability, generally derived from a "physically based model" (Bindoff et al., 2013, 873). Furthermore, going on to attribute the detected change to a specific cause (such as human activity) typically involves showing that the observations are, "consistent with results from a process-based model that includes the causal factor in question, and inconsistent with an alternate, otherwise identical, model that excludes this factor" (Bindoff et al., 2013, 872). Indeed the authors of the IPCC report are quite clear that, "attribution is impossible without a model" (Bindoff et al., 2013, 874). And the reasons for this are ones that should be quite familiar to philosophers of science: establishing or evaluating causal claims requires deciding how a system would have been different had things been otherwise; furthermore, in complex systems where multiple causal factors are at play, there is no 'basic physical science' that is capable of answering these modal questions. As the IPCC authors put it:

> We cannot observe a world in which either anthropogenic or natural forcings are absent, so some kind of model is needed to set up and evaluate quantitative hypotheses: to provide estimates of how we would expect such a world to behave and to respond to anthropogenic and natural forcings.
> (Bindoff et al., 2013, 873).

Even if one takes the view of the IPCC to be controversial, and one thinks as Frigg et al say, that "there is evidence from both basic physical science and observations," for the reality of anthropogenic climate chance, it does not follow that undercutting model-based evidence—the only evidence that exists for identifying the relative strength of contributors to current changes in climate—"casts no doubt on the reality or risks of anthropogenic climate change." Undercutting some of the evidence obviously casts some doubt. The broad reading of the argument, in other words, is quite provocative. It doesn't just undermine prediction about regional climate in a hundred years; it undermines the most basic conclusions of contemporary climate science, at least as those conclusions are now established.

2. The narrow and modest interpretations

While it would certainly be earthshaking if this argument had managed to establish that most of contemporary mathematical science was "embroiled in confusion" or "maladaptive," the sheer implausibility of such a result suggests looking for a narrow, more modest reading of the scope of the argument. In their more modest moments, the authors do characterize the scope of their argument more narrowly, but they do this in two distinct ways. In some cases they infer from the precision and locality of a prediction that it must be subject to doubt on the basis of their argument, but in other cases they suggest that the applicability of their argument depends on how a probabilistic prediction was generated from the underlying mathematical model. Ideally, the class of modeling projects subject to doubt by this argument *identified by the details of the content of their predictions* and the class subject to doubt *in virtue of their method of generation* would line up, and it would be obvious why they line up. Whether this is so is something that will be considered after these two ways of characterizing the scope have been explicated.

The authors repeatedly use the same example when they want to establish the applicability of their argument to the sorts of modeling projects in which climate scientists are actually engaged. The example is the United Kingdom Climate Projections 2009 project, or UKCP09, which aspires to produce decision relevant "high-resolution forecasts of twenty-first-century climate" (Frigg et al., 2013b, p. 887). From the fact that UKCP09 forecasts, "the hottest day in August in a particular year" (Frigg et al., 2013a, p. 490) or "the temperature on the hottest day in central London in 2080," it is supposed to follow that their argument is "not just a hobbyhorse for academic philosophers" (Frigg et al., 2014a, p. 50). Evidently, it is the fact that the UKCP09 project assigns probabilities to climate variables in relatively small regions far off in the future that makes it obvious that this modeling project falls within the scope of their argument.[3] Indeed, regional climate projections are not generally considered to be as trustworthy as their global counterparts, and UKCP09 is not cited in the latest Working Group I report from the IPCC. However, if these authors are right, there is a new, in principle, argument establishing the impossibility of the kinds of projections that this group hopes to

[1] They also acknowledge that there might be some cases where some quantitative insight can be derived from such models, perhaps by switching to "non-probability odds." See (Frigg et al., 2014a, p. 57) and (Frigg et al., 2013a, p. 490).

[2] They are also clear, at least at some points, that climate models fall within the scope of their argument: "The problems arise if models are non-linear and imperfect …[w]ithout question, climate models have both of these properties" (Frigg et al., 2013a, p. 488).

[3] The authors characterize these sorts of predictions as predictions of "finely defined specific events" (Frigg et al., 2013b, p. 888), which seems to conflict with their characterization as climate variables (cf. Werndl, forthcoming).