Global warming hypotheses can be cast as probabilistic predictions for future temperatures. The first modern such ensemble predictions were that of Broecker (1975), whose temperature anomaly outside his CO₂ growth scenario—which he overestimated—by interpolating his table of temperature as a function of CO₂ concentration and projecting the current trend into the near future. For the current observation of 389 ppm, Broecker’s equilibrium assumption—anomaly prediction relative to pre-industrial is 0.15 °C, or about 0.75 °C relative to the base value. His neglect of lag in the response to changes in radiative forcing was partially compensated by his low sensitivity of 2.4 °C, leading to a slight overestimate. Simple linear extrapolation of the current trend since 1973 yields an estimate of 0.5 ± 0.3 °C (net warming of 0.85 °C) for anthropogenic global warming with a normal distribution of random natural variability.

To evaluate an extreme case, we can estimate the prediction Broecker would have made if he had used the Lindzen & Choi (2009) climate sensitivity of 0.5 °C. The net post-industrial warming by 2012 would have been 0.21 °C, for an expected change of 0.09 °F from the base value. This is the temperature to which the Earth would be expected to warm if the observed warming since the 19th century were exactly due to random natural variability that coincidentally mimicked Broecker’s anthropogenic climate change prediction for the past 36 years.

Assumptions made outside the scientific literature can also be cast into predictions for 2012 temperatures, for example Campy’s (2007) “inertial oscillation” model, which projects a temperature of 0.86 °C warming by 2012, and Easterbrook’s (2010) claim of global cooling can be extrapolated to a 2012 value of -0.4 °C (net warming of -0.72 °C).

All contracts in the current market ensembles are consistent with net warming from pre-industrial temperatures. They are also capable of distinguishing the level of acceptance of the various global warming hypotheses, even by their respective proponents. Moreover, they can provide an approximate estimate of future warming and climate variability that is weighted according to level of risk taken on by those providing the estimates, while filtering out the opinions of individuals unwilling to accept any financial risk associated with being wrong.

Weather Derivatives

Weather derivatives came into use in the late 1990s, partly in response to the strong El Niño of 1997–1998. It was primarily driven by the utility industry, whose annual margins are highly dependent on climate. Monthly and seasonal temperature contracts began trading on the Climate Market Exchange in 1999. These consist of Heating Degree Day (HDD) and Cooling Degree Day (CDD) contracts for various US, Canadian, European, and Japanese cities. HDD and CDD are two metrics that are intended to represent heating and cooling costs, respectively. The daily HDD is used in the winter, and the difference is between that day’s mean temperature and 65 °F. The index is summed over the course of days 2010 through 2012 for the period of the contract. CDD is calculated analogously. For the CME contracts, these indices are simplified to make use of published daily high and low temperatures.

HDD = \sum_{x} \max(0, |T_d - 65|) °F

CDD = \sum_{x} \max(0, |T_d - 65|) °F

These quantities have no rigorous physical meaning, but are strongly correlated to energy consumption and are widely used to settle derivative contracts.

Intra-market contracts are entered into primarily for risk management. For example, a natural gas distributor in Texas can enter into a contract to buy gas during the month of May. If the actual temperature is lower than expected, the distributor can sell the gas to the utility at a convenient time. The utility can then use the gas to generate electricity. On the other hand, the utility can buy gas during the month of June to sell to the distributor at a convenient time. The distributor can then use the gas to generate electricity. In this way, the utility can manage its inventory of gas and the distributor can manage its demand for gas.

Weather futures contracts are a way to hedge against weather-related risks. For example, a manufacturer of outdoor furniture can enter into a contract to sell furniture during the month of June. If the actual temperature is lower than expected, the manufacturer can sell the furniture to the retailer at a convenient time. The retailer can then sell the furniture to the consumer at a convenient time. The manufacturer can then use the furniture to generate income. On the other hand, the retailer can buy furniture during the month of July to sell to the manufacturer at a convenient time. The manufacturer can then use the furniture to generate income. In this way, the retailer can manage its inventory of furniture and the manufacturer can manage its demand for furniture.

Binary Ensembles

All 17 contracts in the newly-opened Intra-market ensemble are consistent with net warming from pre-industrial temperatures. They are also capable of distinguishing the level of acceptance of the various global warming hypotheses, even by their respective proponents. Moreover, they can provide an approximate estimate of future warming and climate variability that is weighted according to level of risk taken on by those providing the estimates, while filtering out the opinions of individuals unwilling to accept any financial risk associated with being wrong.

Climate Futures

Temperature probability distributions (above) can be extracted from the contract prices. (a) PDF of linear regression forecast of National Oceanic and Atmospheric Administration (NOAA) annual average surface temperature anomaly (°F) assuming normal distribution of interannual variability. (b) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (c) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (d) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (e) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (f) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (g) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (h) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (i) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010. (j) Probability distribution function for 2012 summer temperature, as determined by the CME in 2010.

References
