Why?
Science is an economic investment by the public. We will be managing Earth’s climate until civilization moves elsewhere. We currently have no natural or international climate observing system, nor a plan to create one. Should we invest in one? Is it worth it?
What is the economic value of an advanced climate observing system? How would you estimate it?
We have a few tractable estimates of the economic value of weather prediction for severe storms, hurricanes, floods and droughts. Climate scientists often say that the results from their research “will inform societal decisions with trillion dollar impacts”.

But is this statement verifiable in any way? How could we quantify these estimates and trace them in any way?

How?
The uncertainty of societal decisions on climate change is strongly affected by the uncertainty in the future predictions of climate change. For example, the 95% confidence bound for equilibrium climate sensitivity is a factor of 4 (IPCC, 2013). Climate sensitivity defines the relationship between an increase in carbon dioxide in the atmosphere and the amount of global surface air temperature change. Studies of the economic impacts of climate change (International Social Cost of Carbon Memo, 2010, hereafter SCC) suggest a quadratic relationship of the amount of global temperature change and the magnitude of economic impacts.

In this case the factor of 4 uncertainty in climate sensitivity causes a factor of 16 uncertainty in long term economic impacts, which leads to inefficient and uncertain solutions for climate change.

Society (and climate science) views past climate change through two sets of “fuzzy” lenses. The first is natural variability in the climate system which acts as noise to confuse early signals of anthropogenic climate change. The second is uncertainty in our observations of climate change, including shifting calibration of instruments or orbit sampling uncertainties. Figure 2 below shows an example of these uncertainties for observing one of the critical measures of climate sensitivity: changes in the amount of global mean solar energy reflected back to space by clouds as climate changes.

In this study we use a baseline scenario of a societal trigger when 95% confidence is reached for a global average temperature increase of 2.5ºC, and an advanced full climate observing system begins in 2020. All initial calculations use a simple switch from higher to lower emissions-scenarios.

Conclusion: An advanced higher accuracy climate observing system would return $50 for every $1 invested in the improved observations

Table 1 summarizes the results, and shows a NVP of $12 Trillion U.S. dollars for the nominal 1% discount rate. While the CLARREO example of advanced accuracy has been used in this initial estimate, society would never base a decision on any one set of instruments, so this economic value is the trend as that of an advanced full Climate Observing System, which CLARREO would be a key part of. If we estimate that such a system would cost 4 times the current investment in world climate research of about $480b, then over 30 years, the additional cost in NVP would be about 1.5% of the benefits shown in Table 1. Every $1 invested returns $50. We also examined sensitivity of the results to the assumed baseline parameters by changing the warming rate from 0.2°C to 0.5°C per decade for the societal decision triggers by systematic confidence required (80 to 99%) and the severity of the emissions reduction scenario (moderate or severe). In all cases, the economic value remained within about 30% of the values in Table 1. The results of this study have been published in the journal of Environment, Science, and Decisions (Cook et al., 2013). Future developments of this framework will use recent updates in the social cost of carbon estimates, additional mitigation costs, and improved realism of societal decision triggers and consider the uncertainties of additional key climate change observations including sea level, aerosol forcing, and carbon cycle.

References
US Government’s Social Cost of Carbon Memo, 2010

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What is the Correct Levels of National Investment in Climate Science?

Table 1

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>CLARREO Example</th>
<th>NVP</th>
<th>Decision Accuracy</th>
<th>NVP</th>
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<td>1.03 $17.7 T</td>
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<tr>
<td>10%</td>
<td>$3.5 T</td>
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<td>1.03 $3.5 T</td>
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</table>

Before we discuss the results, we need a quick version of Economics 101. First, the global Gross Domestic Product (GDP) per year is about $70 Trillion U.S. dollars. Second, economics calculations use a concept called Net Present Value (NPV) to equate investments and revenue over long intervals. To do this, the Discount Rate is used, which varies in the SCC, 2010 report from 5% to 3%. The effect of using the nominal 3% Discount Rate is that the economic benefits gained in the future are discounted by 3% per year, so that benefits gained 50 years from now are “discounted” by a factor of 1.03^50, or a factor of 4.4. This means that economic benefits 80 years into the future are decreased by a factor of 4.4, while benefits 100 years into the future are decreased by a factor of 4. Finally, the recent financial crisis affected worldwide GDP by a few percent. This is similar to the economic impacts of climate change in the second half of this century, which are expected to range from 0.5% to 5% of GDP per year depending on climate sensitivity and the amount of warming realized. Therefore future climate change impacts can range from $0.4T to $3.5T per year.

Results

Given these results, what would an advance of 15 to 20 years in climate change knowledge mean in terms of economic impacts of climate change? The schematic below shows how to test such a concept. The concept uses the climate accuracy framework from Wielicki et al. 2013 developed for the CLARREO mission, and combines it with the SCC, 2010 estimates of future climate impacts for varying levels of warming, and the DICE 2009 integrated assessment model (Nordhaus, 2008) which links models of climate physics, economic development, and economic impacts. The schematic below shows the dependence of economic impacts from climate change on societal decision points, which are in turn dependent on the accuracy of climate observations.

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Figure 4

The DICE model is run for 100s of simulations varying climate sensitivity (SCC, 2010 distribution), natural variability realizations, and emissions scenarios.