Supporting Information

Zickfeld et al. 10.1073/pnas.0908906107

SI Text

SI Materials and Methods ***Selection of experts.*** In choosing the experts (Table 1), we relied upon our own knowledge of the field and our review of recent publications. We also solicited advice from a range of colleagues working in the field. Our objective was to include experts who represent a range of main-stream opinion. We believe the final list achieved the desired balance, while remaining within the constraints of budget and time. Three experts declined to participate when invited and were substituted with other experts from our larger list. When agreeing to participate, all experts were told that although we would list their names and affiliations, we would not identify any specific response with any expert. The process of choosing experts for inclusion in a study like ours is fundamentally different from the process of sampling to estimate some uncertain value such as a physical quantity in the presence of noise, or polling the public to predict the results of an election. The route to scientific truth is not a matter of voting. One of the outliers among the respondents may be correct, and those who appear to be in close agreement may all be wrong.

Elicitation of probability distributions. In eliciting probability distributions, we followed formal elicitation protocols developed for assessing subjective probabilities of experts in the field (1). Such protocols employ procedures designed to minimize common biases that can arise from heuristics and framing effects in the assessment of probabilities. To minimize risk of overconfidence when eliciting the subjective probability distributions, we always began by asking for extreme values (not the "best estimate"), and then posed counter factual questions in an attempt to "spread the tails" and thus counter the effect of the cognitive heuristic of "anchoring and adjustment." Only then did we elicit interior points in the distribution, before finally asking for a median value.

Mean ranking of factors. We computed the mean values of ranks (Table 3) using three different procedures. Under the first procedure, we weighted entries that were ranked first with 1, entries that ranked second with 0.9, etc. We then normalized these numbers such that each expert's entries summed up to the same value, taking into account the fact that sometimes different processes were assigned the same rank, or some experts ranked a greater number of processes than others. In a second strategy we weighted the entries as described above, but did not normalize the values. Thirdly, we used a procedure in which we first counted the number of times one process was ranked first. In the case of equal number of mentions, we considered the times the process was ranked second, then third, and so on. We found that the ranking is not entirely robust with respect to the ordering procedure used. However, for each scenario four sets of processes can be identified whose ranking does not vary across the three ordering procedures.

Simple climate model. To assist the experts in quantifying the global mean temperature changes that might arise for a specific forcing level, we built a simple heuristic aid in the form of a Mathematica® model that solved:

$$c\Delta T'(t) = F(t) - \lambda \Delta T(t)$$

where c is the ocean heat capacity expressed as a time constant, $\Delta T(t)$ is the global mean temperature change over time, $F(t)$ is the net radiative forcing over time, and λ is the climate feedback parameter.

In this Mathematica® model, the forcing is determined from the equivalent CO_2 concentration using the radiative forcing formula given in the Intergovernmental Panel on Climate Change Third Assessment Report (2). The CO_2 concentration was specified according to the three forcing trajectories used in this study. The participants could adjust both the climate sensitivity and the ocean heat uptake with slider bars and view the resulting global mean surface air temperature. In this model, the climate sensitivity is defined as the equilibrium change in global mean surface air temperature for a radiative forcing given by a doubling of atmospheric CO_2 over preindustrial levels, and is inversely related to the feedback parameter λ. If the $2 \times CO_2$ radiative forcing is $F_{2\times CO2}$, the climate sensitivity $T_{2\times CO2}$ is given as:

$$T_{2\times CO2} = \lambda / F_{2\times CO2}$$

We cautioned the experts that the Mathematica® model was only an approximation that would be less and less valid as $\Delta T(t)$ becomes large, so it should be used merely as an aid.

Whereas several experts explored this model, most made no serious use of it in providing their judgments. Several looked up results in their own or other literature, or examined model output. Experts 5 and 10 made runs with their own models during the course of the elicitation.

Other Supporting Information Files

SI Appendix (PDF)

1. Morgan MG, Henrion M (1990) *Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis* (Cambridge University Press, New York).
2. Intergovernmental Panel on Climate Change (2001) *Climate Change 2001: The Scientific Basis. Contributions of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, eds Houghton JT, et al. (Cambridge University Press, New York).

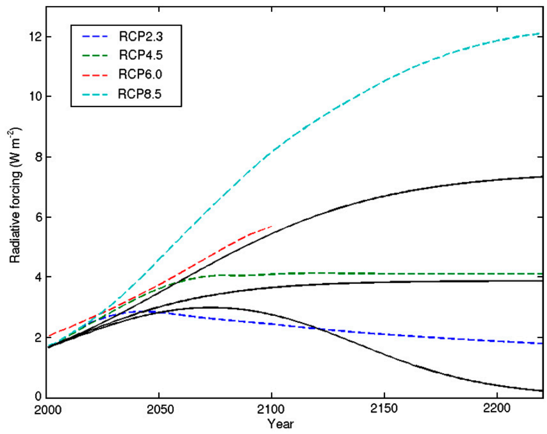

Fig. S1. Comparison of the radiative forcing trajectories used in this study (solid lines) with the representative concentration pathways (RCPs; dashed lines) developed for the Climate Model Intercomparison Project 5 (CMIP5). In 2050, the radiative forcing of our low and medium scenario is at the lower end of the RCP range, whereas the radiative forcing of the high scenario is similar to that of RCPs 4.5 and 6.0. In 2200, the radiative forcing of medium scenario is similar to that of RCP 4.5, whereas the radiative forcing of the low scenario lies below that of RCP 2.6. At the time of revision of this study, the continuation of RCP 6.0 beyond 2100 was not yet available.

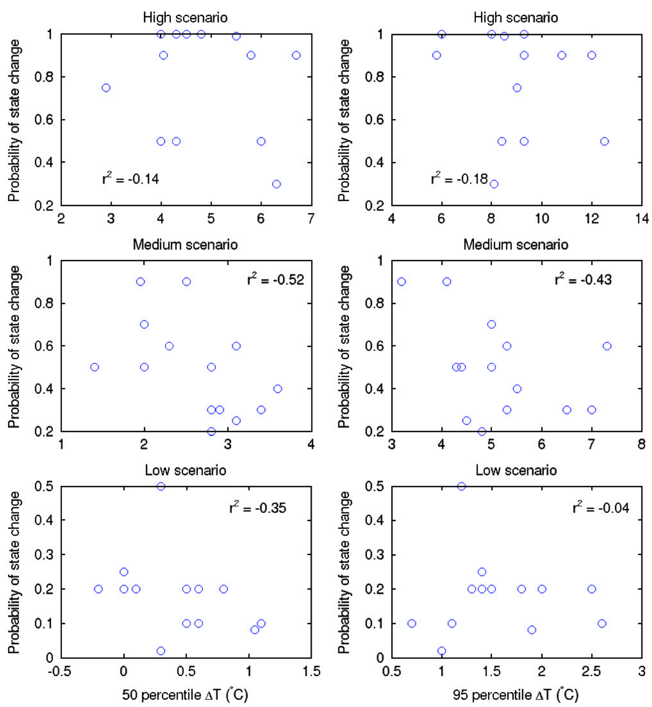

Fig. S2. Linear regression of the probability of state change against global mean surface air temperature change in 2200 for the low (*Lower*), medium (*Center*), and high (*Upper*) radiative forcing scenarios. The regression was done for the 50 percentile (*Left*) and 90 percentile (*Right*) of the experts' probability distributions of global men temperature change. No significant correlation is calculated between the two quantities.

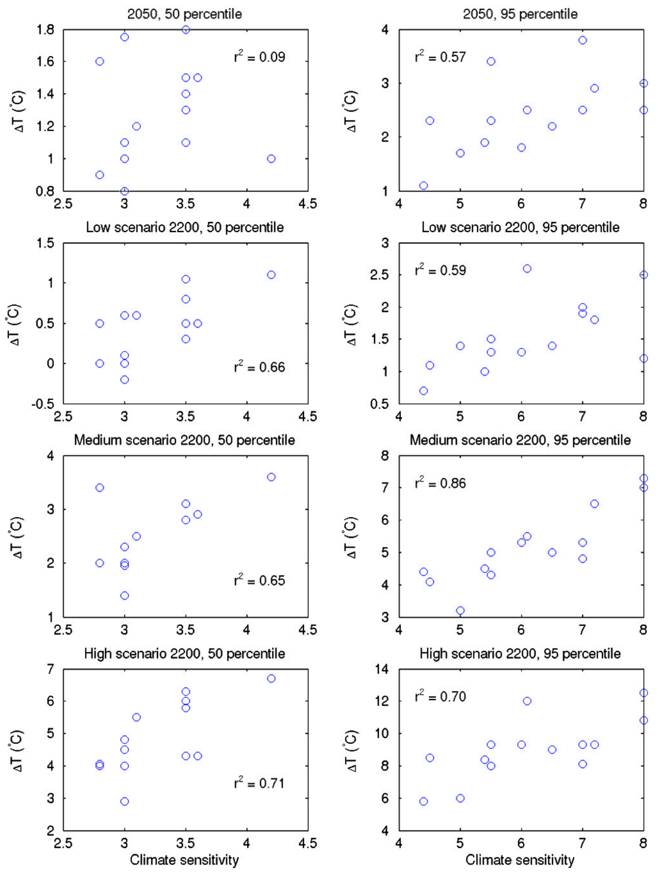

Fig. S3. Linear regression of global mean surface air temperature change against climate sensitivity in 2050 (top row) and 2200 for the low (2nd row), medium (3rd row), and high (bottom row) radiative forcing scenarios. The regression was done for the 50 percentile (*Left*) and 90 percentile (*Right*) of the experts' probability distributions of global men temperature change and equilibrium climate sensitivity.

Table S1. Individual experts' ranking of factors influencing uncertainty in transient climate response for the medium forcing scenario

Factor		Expert													
	Mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Atmospheric convection and precipitation	10				3	4	4			2					
Cloud radiative feedbacks	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deep water formation (e.g., oceanic convection)	5	5	4	2					2		4		1		4
Horizontal/isopycnal mixing	11			4	4				3			5			
Ice and snow albedo feedback on land	3	6	3		5	3		2			3	3	1	2	3
Lapse rate feedback	8	2				5	4	3			2		2		
Large-scale atmospheric circulation incl. meridional heat transport	14		2	5						3					
Mesoscale/submesoscale ocean eddies	13			2	4										
Wind-driven and thermohaline ocean circulation	6			4		2			2			2	1		4
Sea-ice albedo feedback	2	6	3	3	3			2		3	3	4		2	2
Soil moisture	12		5				3							4	
Vegetation-albedo feedback	7		3	6		4	3			4			3	2	
Vertical/diapycnal mixing	9	4		2	2		5		3					4	
Water vapor feedback	4	3	6			4		3	1		2		2	3	
Carbon cycle feedbacks						3	2								

The mean ranking was computed according to the first procedure described in *SI Text*.

Table S2. Individual experts' ranking of factors influencing uncertainty in transient climate response for the high forcing scenario

Factor	Mean	Expert 1	2	3	4	5	6	7	8	9	10	11	12	13	14
		AA				AA		AA	AA		AA		AA		
Atmospheric convection and precipitation	13				4	4				2					
Cloud radiative feedbacks	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deep water formation (e.g., oceanic convection)	7	5	2	3					2		4		1		2
Horizontal/isopycnal mixing	12				5				3						4
Ice and snow albedo feedback on land	2	6	3		3	3		2			3	4	1	4	5
Lapse rate feedback	9	2				5		3			2		2		
Large-scale atmospheric circulation incl. meridional heat transport	11		2							3		3			
Mesoscale/submesoscale ocean eddies	14			3	5										4
Wind-driven and thermohaline ocean circulation	6					2			2			2	1		2
Sea-ice albedo feedback	8	6	5	2				2			3			6	
Soil moisture	10		6				4			3				7	
Vegetation-albedo feedback	5		4			4	4			3			3	2	3
Vertical/diapycnal mixing	4	4		3	2		3		3					5	4
Water vapor feedback	3	3	7			4		3	1		2		2	3	
Carbon cycle feedbacks						3	2								

"AA" indicates the ranking is the same as in Table S1.

Table S3. Individual experts' ranking of factors influencing uncertainty in transient climate response for the low forcing scenario

Factor	Mean	Expert 1	2	3	4	5	6	7	8	9	10	11	12	13	14
				NA		NA		NA	AA		AA	AA		AA	
Atmospheric convection and precipitation	10						3			2					
Cloud radiative feedbacks	1	2	1		4		1		1	1	1	1	1	1	5
Deep water formation (e.g., oceanic convection)	4	5	4		5				2		4		3		2
Horizontal/isopycnal mixing	13								3			5			
Ice and snow albedo feedback on land	3	6	3		1						3	3	1	2	4
Lapse rate feedback	8	3					3				2		2		
Large-scale atmospheric circulation incl. meridional heat transport	12		2							3					
Mesoscale/submesoscale ocean eddies	14														
Wind-driven and thermohaline ocean circulation	5				2				2			2	3		2
Sea-ice albedo feedback	2	6	3		3					1	3	4		2	1
Soil moisture	11		5				2							4	
Vegetation-albedo feedback	7		3				2						4	2	3
Vertical/diapycnal mixing	9	1					4		3					4	
Water vapor feedback	6	4	6						1		2		2	3	
Carbon cycle feedbacks							5								

"AA" indicates the ranking is the same as in Table S1, and "NA" means "no answer."

Table S4. Individual experts' ranking of factors influencing uncertainty in equilibrium climate sensitivity

Factor	Mean	Expert 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Atmospheric convection and precipitation	9	4		5		4				2					
Cloud radiative feedbacks	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deep water formation (e.g., oceanic convection)	11										4		1		4
Horizontal/isopycnal mixing	12														
Ice and snow albedo feedback on land	2	5	3	4	3	3		2	4		3	3	1	2	3
Lapse rate feedback	5	3		5		5		3	5		2	5	2		
Large-scale atmospheric circulation incl. meridional heat transport	8		2	6	2					3					
Mesoscale/submesoscale ocean eddies	12														
Wind-driven and thermohaline ocean circulation	10			6		2							1		4
Sea-ice albedo feedback	3	5		2	2			2	3		3	2		2	2
Soil moisture	7		4				3		2			4		4	
Vegetation-albedo feedback	6	6	6	3		4	3						3	2	
Vertical/diapycnal mixing	12														
Water vapor feedback	4	2	5	5		4		3	1		2	5	2	3	
Carbon cycle feedbacks						3	2								