

## SUPPLEMENTARY INFORMATION

### Timeline of Some Notable Developments and International Applications of Scenarios in Climate Research

Note: This timeline highlights some notable developments in the creation and use of emissions and climate scenarios. The entries are illustrative of the overall course of model-based scenario development and application described in this Perspective and do not provide a comprehensive account of all major scenarios and significant studies or assessments which have employed them.

Year	Scenario Development	Notable Applications	Context and Institutional Developments
1896			Arrhenius publishes initial quantification of temperature effects of rising CO <sub>2</sub> concentrations based on a “scenario” of global coal consumption. <sup>1</sup>
1960			Publication of first robust evidence that CO <sub>2</sub> is increasing in the global atmosphere, and faster than Arrhenius expected. <sup>2</sup>
1967	Climate sensitivity investigated using a radiative-convective model of the atmosphere. <sup>3</sup>		
1969	Coupled ocean-atmosphere GCM is developed with realistic Earth geography and oceanic and atmospheric processes. <sup>4</sup>		
1970s	Predecessors of contemporary global scenarios used in “futures studies” exploring the long-term sustainability of natural resources. <sup>5-8</sup>		
1979			The First World Climate Conference recognizes climate change as a serious problem and calls on the world’s governments “to foresee and prevent potential man-made changes in climate that might be

			adverse to the well-being of humanity.”
1980s	Scenarios become mainstream in futures research and are applied to other issues such as oil scarcity; initial explorations of the implications of global energy needs for future CO <sub>2</sub> emissions, concentrations, and climate. <sup>9-11</sup>		
1980			World Climate Research Program (WCRP) is established to determine the predictability of the climate and the impacts of human activities on the climate system. It plays a significant role in climate model development and coordination with the IPCC and the integrated assessment and impact research communities.
1983			WMO/UNEP/ICSU conference at Villach, Austria, presents some of the earliest results of impact studies on agriculture and ecosystems using GCM-based climate scenarios. <sup>12</sup>
1985			A second conference in Villach concludes that increasing concentrations of greenhouse gases, if not mitigated, would lead in the first half of the 21 <sup>st</sup> century to a rise of global mean temperature greater than in any period of human history. <sup>13</sup>
1988	Time-dependent (transient)		

	GCM simulations of climate response to three alternative scenarios of atmospheric concentrations conclude that the signal of anthropogenic climate warming would soon emerge from the noise of natural variability. <sup>14</sup>		
1988			Intergovernmental Panel on Climate Change (IPCC) is established.
1990	First IPCC scenarios (SA90) published describing four possible futures with assumptions ranging from high economic growth and fossil fuel use with high emissions to an accelerated policy scenario with low emissions. <sup>15</sup>	IPCC First Assessment Report released: The Report's impact assessment uses analogue climates and equilibrium climate model experiments.	Second World Climate Conference calls for establishment of an international climate change convention and Global Climate Observing System.
1991		Impact studies published <sup>16</sup> based on the transient climate scenarios of ref 14.	
1992	IPCC publishes six new scenarios (IS92) reflecting new developments such as the London Amendments to the Montreal Protocol, new population scenarios, and updates on tropical deforestation. The scenarios span a wide range of "business as usual" assumptions (i.e., in the absence of climate policy). <sup>17</sup>		
1994	An IPCC approved evaluation of IS92 recommends an open scenario process using multiple models, incorporation of economic restructuring in Eastern Europe and the former Soviet Union, and exploration of alternative economic development pathways. <sup>18</sup>	IPCC approves technical guidelines for impact assessment including information on applying scenarios. <sup>19</sup>	
1995		Intercomparison of	

		global vegetation model results using equilibrium GCM 2xCO <sub>2</sub> scenarios is published. <sup>20</sup>	
1995	MAGICC/SCENGEN (SCENario GENerator) software allows non-specialists to make use of climate scenarios. <sup>21</sup>	IPCC Second Assessment Report impact volume relies primarily on equilibrium climate experiments, with some studies based on transient climate model runs.	
1996		Programs of country studies on impacts, adaptation and vulnerability conducted worldwide. <sup>22</sup>	
1998			IPCC Data Distribution Centre ( <a href="http://www.ipcc-data.org/">http://www.ipcc-data.org/</a> ) established to increase availability of climate scenarios for use in impact research.
1998	Database and review of more than 400 scenarios of global and regional greenhouse gas emissions and their main driving forces - population, economy, energy intensity, and carbon intensity – is published. <sup>23</sup>	IPCC's first regional assessment of impact, adaptation, and vulnerability published, includes regional socio-economic baselines, and assesses impact results based on IS92 scenarios. <sup>24</sup>	
1999	IPCC approves "Special Report on Emissions Scenarios" developed through an open process using multiple integrated assessment models. Scenarios are based on a combined approach using		

	qualitative narratives and quantitative projections to explore the range of GHG emissions in the absence of explicit climate policies. <sup>25</sup>		
2000	Climate scenarios based on GCM projections for IS92 emissions are pattern-scaled to represent climates under SRES emissions to assist in interpreting impacts based on earlier IS92 projections and in anticipation of new SRES-forced climate model simulations. <sup>26</sup>		
2001	Comprehensive multi-model assessment of SRES-based mitigation pathways to stabilize CO <sub>2</sub> concentrations. <sup>27</sup>	IPCC Third Assessment Report released: most impact results assessed in the report are based on IS92 scenarios.	
2001		A socio-economic scenario framework for vulnerability assessment based on SRES is developed by the United Kingdom Climate Impacts Programme for use in regional and national climate impact assessment studies. <sup>28</sup>	
2004	GCM-based regional projections of seasonal temperature and precipitation changes based on SRES forcing provided to authors of the IPCC Fourth Assessment Report. <sup>29</sup>		
2005	Emissions scenarios start to cover mitigation options for non-CO <sub>2</sub> GHGs. <sup>30</sup>	Scenarios from the Millennium Ecosystem Assessment	

		explore implications of climate change for ecosystems, land-cover changes and human well-being. <sup>31</sup>	
2006			Aspen Global Change Institute workshop initiates planning for new scenario process. <sup>32</sup>
2007	IPCC expert meeting discusses plans for research community to develop new scenarios and options for "representative concentration pathways" to span the full range of business as usual and climate policy scenarios. <sup>33</sup>	IPCC Fourth Assessment Report released. WG I (physical science basis) evaluates new model results and WG II (impacts, adaptation, and vulnerability) assesses research based on earlier SRES and IS92 scenarios.	The Integrated Assessment Modeling Consortium (IAMC) is established to foster integrated assessment research, coordinate with the climate modeling and impact research communities, and serve as a point of contact with users of scenario research.
2007	An assessment published by the US Climate Change Science Program explores how four different radiative forcing stabilization pathways can be achieved by a diverse range of socioeconomic and technological development scenarios. <sup>34</sup>		

2009	The IAMC releases the Representative Concentration Pathways (RCPs) to the climate modeling community starting the “parallel phase” of new scenario process. Database at <a href="http://www.iiasa.ac.at/web-apps/tnt/RcpDb">http://www.iiasa.ac.at/web-apps/tnt/RcpDb</a> .		World Climate Conference 3 discusses development of capacity to respond to the needs of users of climate information worldwide.
2009	The United Kingdom releases national probabilistic climate projections (UKCP09). Regional climate projections are expressed in terms of likelihood rather than as scenarios. <sup>35</sup>		

2009	Probabilistic methodology refined and extended by in ENSEMBLES project, which also includes new "peak and decline" stabilisation simulations with Earth System Models. <sup>36</sup>		
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