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Addressing Concerns on Climate Change Science:

Excerpts from IPCC Summary of Policymakers

NOAA Research
March 15, 2001

CLIMATE CHANGE SCIENCE CONTENTIONS AND EVIDENCE

The comments below place the write-up "Climate Change Science Contentions and Evidence" into context. First, the basis of the broad scientific understanding is summarized. Second, the current scientific understanding of the points raised in the document are paired with the corresponding viewpoint of the recent assessment of the scientific understanding summarized by the Intergovernmental Panel on Climate Change (IPCC).

A. Context

- The issues raised in the write-up are familiar ones. They were addressed in the IPCC report and represent a small segment of topics that were comprehensively examined in the 1000+-page IPCC report: "Climate Change 2001: The Scientific Basis". As such, the topics listed are an incomplete description of the climate change phenomenon.

- The references cited are a <u>very</u> small fraction of the scientific literature utilized by the IPCC. Therefore, the IPCC assessment took the larger and wider view of scientific information upon which to base its statements, which reflect the understanding as of 2001.

- The IPCC report was peer reviewed twice, by over 300 worldwide experts and the review process was overseen independently by 20+ editors drawn from the international research community.

- The IPCC assessment was prepared by 122 authors and 516 contributors, all attributed, along with their institutions worldwide; this contrasts with the write-up.

Therefore, the up-to-date assessment of the broader perspective of the worldwide community in climate science, with the scientific procedures of review and publications being a cornerstone, is recommended and the source of sound, independent, and comprehensive information about the climate system.

B. Specific Pairing of the Points in the Write-up to the Conclusions of the IPCC.

The direct quotes from IPCC are provided in blue ink. Other comments are given in italics.

Global Warming Trends:

CONTENTION: The world has been warming rapidly in the last two decades, averaging 1.3 degrees centigrade since 1979. Sophisticated computer models (General Circulation Models [GCMSs]) show dramatic future warming over the next 100 years.

(SPM p. 2)

The global average surface temperature has increased over the 20th century by about 0.6°C.

The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ±0.2°C (Figure 1a). This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects. The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.

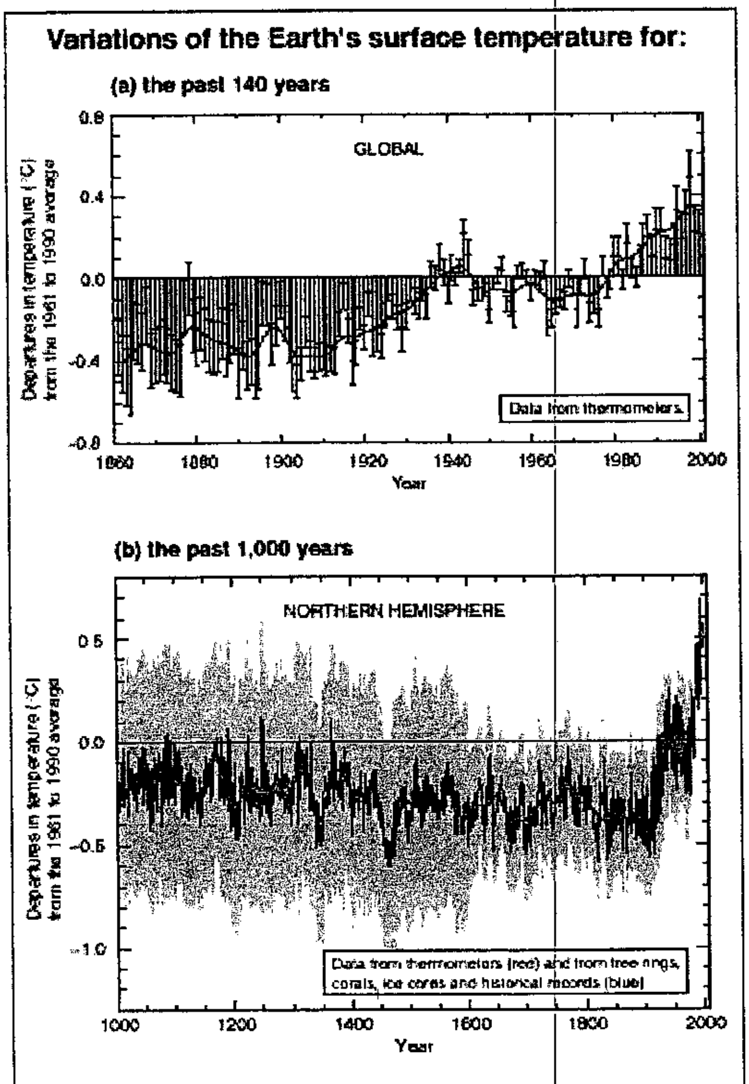

Figure 1: Variations of the Earth's surface temperature over the last 140 years and the last millennium.
(a) The Earth's surface temperature is shown year by year (red bars) and approximately decade by decade (black line, a filtered annual curve suppressing fluctuations below near decadal time-scales). There are uncertainties in the annual data (thin black whisker bars represent the 95% confidence range) due to data gaps, random instrumental errors and uncertainties, uncertainties in bias corrections in the ocean surface temperature data and also in adjustments for urbanisation over the land. Over both the last 140 years and 100 years, the best estimate is that the global average surface temperature has increased by 0.6 □}0.2°C.
(b) Additionally, the year by year (blue curve) and 50 year average (black curve) variations of the average surface temperature of the Northern Hemisphere for the past 1000 years have been reconstructed from "proxy" data calibrated against thermometer data (see list of the main proxy data in the diagram). The 95% confidence range in the annual data is represented by the grey region. These uncertainties increase in more distant times and are always much larger than in the instrumental record due to the use of relatively sparse proxy data. Nevertheless the rate and duration of warming of the 20th century has been much greater than in any of the previous nine centuries. Similarly, it is likely 7 that the 1990s have been the warmest decade and 1998 the warmest year of the millennium.

EVIDENCE: Warming data since 1979 can only be found in earth-based measurements, which are not truly global in reach. Satellite and weather balloon data show no long-term warming. Analyses that show dramatic warming in the last few years conveniently set their start date at 1998, which brings in a one-year spike in world temperatures as a result of an El Nino event, but which excludes the unusually low temperatures of 1992-1994. As for the discrepancy between ground-based temperature measurements and satellite/weather balloon measurements, either there are technical problems with the earth-based measurements, or there is a divergence between ground-level warming and no warming in the upper atmosphere. No computer model has yet been able to explain this discrepancy between the lower and upper atmosphere.

SPM p.2

Temperatures have risen during the past four decades in the lowest 8 kilometres of the atmosphere.

Since the late 1950s (the period of adequate observations from weather balloons), the overall global temperature increases in the lowest 8 kilometres of the atmosphere and in surface temperature have been similar at 0.1°C per decade.

Since the start of the satellite record in 1979, both satellite and weather balloon measurements show that the global average temperature of the lowest 8 kilometres of the atmosphere has changed by +0.05 ±0.10°C per decade, but the global average surface temperature has increased significantly by +0.15±0.05°C per decade. The difference in the warming rates is statistically significant. This difference occurs primarily over the tropical and sub-tropical regions.

The lowest 8 kilometres of the atmosphere and the surface are influenced differently by factors such as stratospheric ozone depletion, atmospheric aerosols, and the El Niño phenomenon. Hence, it is physically plausible to expect that over a short time period (e.g., 20 years) there may be differences in temperature trends. In addition, spatial sampling techniques can also explain some of the differences in trends, but these differences are not fully resolved.

Health Impacts:

CONTENTION: Future warming will cause serious health affects by increasing the spread of tropical diseases.

EVIDENCE: Scientific epidemiological studies show that climate has a minimal impact on the rates of disease transmission and human death. The statistically significant factors are the level of the economic development, infrastructure, access to health care and potable water, and availability of air conditioning.

Health impacts are covered by the IPCC Working Group II, SPM p. 10.

Many vector-borne and water-borne infectious diseases are known to be sensitive to changes in climatic conditions. From results of most predictive model studies, there is medium-to-high confidence (*medium:33-67% and high:67-95%*) that, under climate change scenarios, there would be a net increase in the geographic range of potential transmission of malaria and dengue-two vector-borne infections each of which currently impinge on 40-50% of the world population. **Within their present ranges, these and many other infectious diseases would tend to increase in incidence and seasonality-although regional decreases would occur in some infectious diseases.** In all cases, however, actual disease occurrence is strongly influenced by local environmental conditions, socioeconomic circumstances, and public health infrastructure.

Sea-level Rise:

CONTENTION: The melting of ice in polar regions, coupled with an overall warming of the ocean will produce a devastating rise in the global sea level.

EVIDENCE: The only significant threat to a rise in the sea-level is ice cap melting in Greenland and Antarctica. Scientific studies are divided over whether Greenland and Antarctica are experiencing net melting or net accumulation of ice. The U.N.'s Intergovernmental Panel on Climate Change itself has produced 100-year estimates of sea level rises ranging from a 10.6-inch rise to a 2.2-inch decrease, assuming significant global warming. Relationships between increasing temperatures and snow and ice melt, precipitation, and ocean thermal expansion are extremely complex. Much more study is needed in this area.

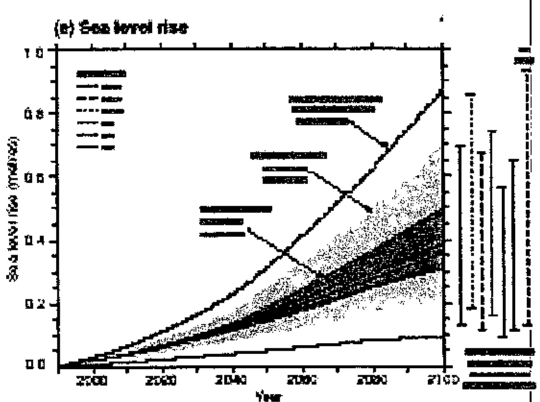

Figure 5: The global climate of the 21st century will depend on natural changes and the response of the climate system to human activities.
Climate models project the response of many climate variables - such as increases in global surface temperature and sea level - to various scenarios of greenhouse gases and other human related emissions. (e) shows the projected sea level response for the simple model when tuned to a number of complex models with a range of climate sensitivities. (Color bars show the range in 2100 produced by several models)

* For clear figure see SPM p.14

Sea level

Global mean sea level is projected to rise by 0.09 to 0.88 metres between 1990 and 2100, for the full range of SRES scenarios. **This is due primarily to thermal expansion and loss of mass from glaciers and ice caps** (Figure 5e). The range of sea level rise presented in the SAR was 0.13 to 0.94 metres based on the IS92 scenarios. Despite the higher temperature change projections in this assessment, the sea level projections are slightly lower, primarily due to the use of improved models, which give a smaller contribution from glaciers and ice sheets.

Drought and Floods:

CONTENTION: Global warming will produce more extreme weather events across the globe, resulting in more flooding in some areas and more droughts in others.

EVIDENCE: Projections of future changes in precipitation from global warming come entirely from computer models, not from actual observation. These models often conflict with one another. There is no global system for actual measurement over time of changes in precipitation levels. Good records do exist in the United States, which show a modest increase in average precipitation over the last century, without any increase in the incident of flooding or droughts.

Table 1: Estimates of confidence in observed and projected changes in extreme weather and climate events.

Confidence in observed changes (latter half of the 20th century)	Changes in Phenomenon	Confidence in projected changes (during the 21st century)
Likely[7]	**Higher maximum temperatures and more hot days over nearly all land areas**	Very likely[7]
Very likely[7]	**Higher minimum temperatures, fewer cold days and frost days over nearly all land areas**	Very likely[7]
Very likely[7]	**Reduced diurnal temperature range over most land areas**	Very likely[7]
Likely[7], over many areas	**Increase of heat index[8] over land areas**	Very likely[7], over most areas
Likely[7], over many Northern Hemisphere mid- to high latitude land areas	**More intense precipitation events[b]**	Very likely[7], over many areas
Likely[7], in a few areas	**Increased summer continental drying and associated risk of drought**	Likely[7], over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	**Increase in tropical cyclone peak wind intensities[9]**	Likely[7], over some areas
Insufficient data for assessment	**Increase in tropical cyclone mean and peak precipitation intensities[b]**	Likely[7], over some areas

7 In this Summary for Policymakers and in the Technical Summary, the following words have been used where appropriate to indicate judgmental estimates of confidence. *virtually certain* (greater than 99% chance that a result is true); *very likely* (90 99% chance); *likely* (66 90% chance); *medium likelihood* (33 66% chance); *unlikely* (10 33% chance); *very unlikely* (1 10% chance); *exceptionally unlikely* (less than 1% chance). The reader is referred to individual chapters for more details.

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Extreme Events

Table 1 depicts an assessment of confidence in observed changes in extremes of weather and climate during the latter half of the 20th century (left column) and in projected changes during the 21st century (right column)[8]. This assessment relies on observational and modelling studies, as well as the physical plausibility of future projections across all commonly-used scenarios and is based on expert judgement[7].

<u>Global Warming and Atlantic Hurricanes:</u>

CONTENTION: Global warming will produce an increase in the intensity and frequency of Atlantic hurricanes.

EVIDENCE: These claims are based on computer models rather than physical reality. Based on historical records, the frequency of large, land falling Atlantic hurricanes has dropped despite increased concentrations of carbon dioxide. Long-term trends show either not change or an overall decline in hurricane activity, depending on the period of record. However, there <u>has</u> been a substantial increase in damage to coastal property from hurricanes. This increase is entirely accounted for by increased real estate development along the hurricane-prone American coastlines.

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For some other extreme phenomena, many of which may have important impacts on the environment and society, there is currently insufficient information to assess recent trends, and climate models currently lack the spatial detail required to make confident projections. For example, very small-scale phenomena, such as thunderstorms, tornadoes, hail and lightning, are not simulated in climate models.

<u>El Nino and Global Warming:</u>

CONTENTION: As global warming progresses, El Nino climate events (a prolonged periodic warming of ocean waters off the coast of Peru and related impacts on atmospheric and oceanic circulation) will become more frequent and severe. In the last two decades there have been as many El Nino events as normally would only occur every 2000 years.

EVIDENCE: El Nino events have been a natural component of the earth's climate for thousands of years. Based on data from geological records, there is no evidence that there was more El Nino activity 4,000 to 7,000 years ago when the planet was about 2 degrees centigrade warmer than today. There have been increases and decreases in El Nino events over the centuries, long before increases in manmade greenhouse gas emissions.

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El Niño: Confidence ın projections of changes in future frequency, amplitude, and spatial pattern of El Nıño events ın the tropical Pacıfic is tempered by some shortcomıngs in how well El Niño is sımulated in complex models. **Current projections show little change or a small increase in amplitudé for El Niño events over the next 100 years.** Even with little or no change ın El Niño amplitude, global warmıng ıs likely to lead to greater extremes of drying and heavy rainfall and increase the risk of droughts and floods that occur with El Nıño events in many different regıons

<u>Computer "General Circulation" Models:</u>

CONTENTION: Computer General Circulation Models (GCMs) are the most sophisticated tools available to predict future climate changes. These physically-based models can reproduce past and current climate variability, so future predictions are also reliable over long time scales.

EVIDENCE: There are over 30-GCMs being used worldwide, and their projections vary dramatically. If global climate changes could easily or reliably modeled, the disparities would be small. Furthermore, these large climate models have <u>not</u> been successful in reproducing past climate variations accurately, raising further questions about the reliability of future climate changes.

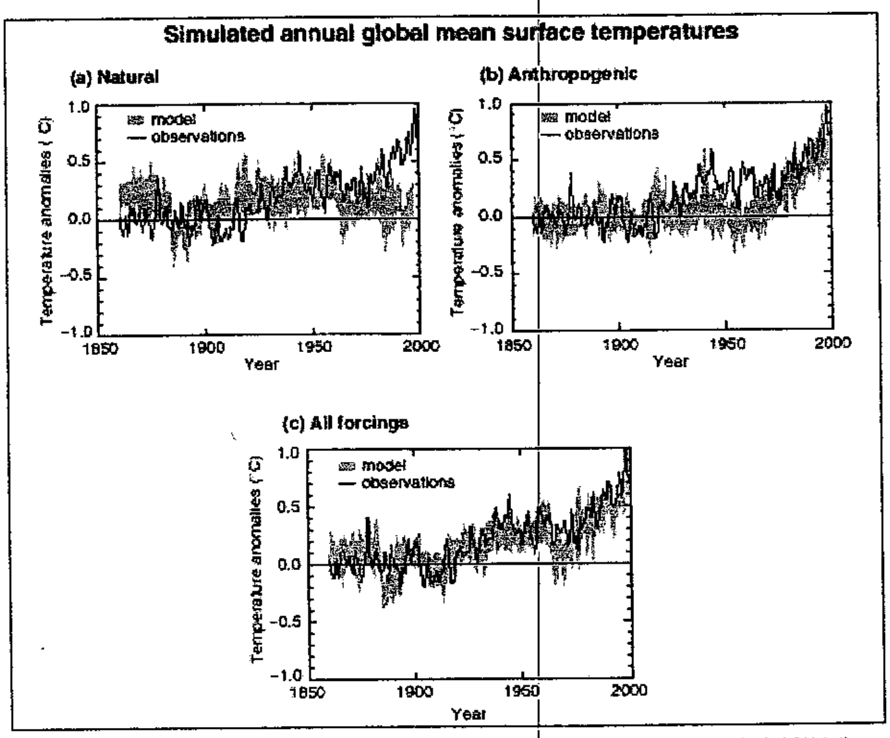

Figure 4: Simulating the Earth's temperature variations, and comparing the results to measured changes, can provide insight into the underlying causes of the major changes.

A climate model can be used to simulate the temperature changes that occur both from natural and anthropogenic causes. The simulations represented by the band in (a) were done with only natural forcings: solar variation and volcanic activity. Those encompassed by the band in (b) were done with anthropogenic forcings: greenhouse gases and an estimate of sulphate aerosols, and those encompassed by the band in (c) were done with both natural and anthropogenic forcings included. From (b), it can be seen that inclusion of anthropogenic forcings provides a plausible explanation for a substantial part of the observed temperature changes over the past century, but the best match with observations is obtained in (c) when both natural and anthropogenic factors are included. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed. The bands of model results presented here are for four runs from the same model. Similar results to those in (b) are obtained with other models with anthropogenic forcing.

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Temperature

The globally averaged surface temperature is projected to increase by 1.4 to 5.8°C (Figure 5d) over the period 1990 to 2100. These results are for the full range of 35 SRES scenarios, based on a number of climate models. The projected rate of warming is much larger than the observed changes during the 20th century and is very likely to be without precedent during at least the last 10,000 years, based on palaeoclimate data.

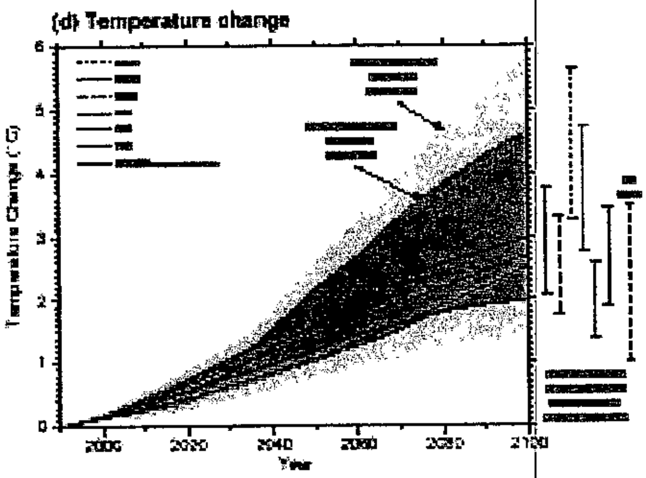

Figure 5: The global climate of the 21st century will depend on natural changes and the response of the climate system to human activities.
Climate models project the response of many climate variables - such as increases in global surface temperature and sea level - to various scenarios of greenhouse gases and other human related emissions. (e) shows the projected temperature response for the simple model when tuned to a number of complex models with a range of climate sensitivities.
(Color bars show the range in 2100 produced by several models)

* For clear figure see SPM p.14

<u>Ice Core Evidence on the CO_2/Global Warming Connection:</u>

CONTENTION: Perhaps the single most convincing argument that an enhanced greenhouse effect will lead to global warming is that in ice core records extending back several hundred thousands years, periods of high global temperatures were associated with elevated atmospheric carbon dioxide levels.

The IPCC has not made a cause and effect statement for these paleoclimate data

EVIDENCE: New scientific studies have shown that higher CO_2 levels began <u>after</u> not before temperature increases. Understanding the interaction between the ocean and the atmosphere explains this phenomenon. Warmer water holds less dissolved carbon dioxide than cooler water. Therefore, as the atmosphere warms, the ocean warms and then releases additional CO_2 into the atmosphere. While this added CO_2 in the atmosphere may enhance the greenhouse effect, thus helping to fully bring the earth out of an ice age, the added CO_2 did not initiate the warming, but occurred as a result of it.

Sun/Climate Link with Global Warming:

CONTENTION: Increased emissions of manmade greenhouse gas emissions has led to temperature increases of 0.7 degree centigrade (about 1 degree Fahrenheit) over the last 100 years.

SPM p. 10

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

There is a longer and more closely scrutinised temperature record and new model estimates of variability. The warming over the past 100 years is very unlikely to be due to internal variability alone, as estimated by current models. Reconstructions of climate data for the past 1,000 years (Figure 1b) also indicate that this warming was unusual and is unlikely to be entirely natural in origin.

Most of these studies find that, over the last 50 years, the estimated rate and magnitude of warming due to increasing concentrations of greenhouse gases alone are comparable with, or larger than, the observed warming. Furthermore, most model estimates that take into account both greenhouse gases and sulphate aerosols are consistent with observations over this period. The best agreement between model simulations and observations over the last 140 years has been found when all the above anthropogenic and natural forcing factors are combined, as shown in Figure 4c. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed.

In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.

EVIDENCE: The 0.7 degree centigrade increase in global temperature since 1900 has not been a continual increase. Earth-based temperatures rose rapidly from 1900 to the mid 1930s, held constant until the late 1970s, and have since been measured (by ground-based measurements) as resuming a modest warming trend. Most of the temperature increase since 1900 occurred in the first third of the century, a time when manmade greenhouse gas emissions were low. Obviously, the earth has undergone dramatic swings in temperatures, long before the industrial revolution or even the rise of man. Changes in solar activity appear to be the main source of warming early in the century. Using historical sunspot data, more recent satellite solar radiation measurements, chemical data from tree rings, and other sources a reliable record of solar out put has been reconstructed for the past 400 years. Changes in this solar out put data is a close match to changes in global temperatures over this same period. Other factors also play a role, including volcanic activity and changes in greenhouse gas concentration in the atmosphere (both natural and manmade). But the single closet correlation appears to be changes in solar activity.

SPM p. 2

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely 7 to have been the largest of any century during the past 1,000 years. It is also likely 7 that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year (Figure 1b). Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.

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Natural factors have made small contributions to radiative forcing over the past century.

The radiative forcing due to changes in solar irradiance for the period since 1750 is estimated to be about +0.3 Wm^{-2}, most of which occurred during the first half of the 20th century. Since the late 1970s, satellite instruments have observed small oscillations due to the 11-year solar cycle. Mechanisms for the amplification of solar effects on climate have been proposed, but currently lack a rigorous theoretical or observational basis.

Coral Bleaching and Global Warming:

CONTENTION: Massive coral bleachings occurred during 1998, the hottest year in the last six centuries. Together, rising global temperatures and rising levels of carbon dioxide are the primary cause, which will wipe out most of the coral in the world's oceans by the end of this century.

EVIDENCE: Coral bleaching occurs when corals expel a symbiotic algae that the corals rely on to survive. When this occurs, the corals die and lose their color. Bleaching occurs when the corals become environmentally stressed, through exposure to high water temperatures, increased level of toxic chemicals, or increased sediments in the water column. The main sources sediments in coastal waters comes from coastal development. The main source of toxic chemicals is man-made water pollution. Neither have any link with climate change. The primary sources of rapid temperature rises in water that stressed coral reefs in 1998 was unusually strong 1997-1998 El Nino event.

Coral reef bleaching is covered by the IPCC Working Group II. SPM p. 10

Impacts on higly diverse and productive coastal ecosystems such as coral reefs, atolls and reef islands, salt marshes and mangrove forests will depend upon the rate of sea level rise relative to growth rates and sediment supply, space for and obstacles to horizontal migration, changes in the climate-ocean environment such as sea surface temperatures and storminess, and pressures from human activities in coastal zones. Episodes in coral bleaching over the past 20 years have been associated with several causes, including increased ocean temperatures. Future sea surface warming would increase stress on coral reefs and result in increased frequency of marine diseases. (High confidence:67-95%).