Policy Outlook
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Evaluating Working Group (WG) II's Contribution to the IPCC's Fourth Assessment Report (AR4)

Executive Summary

In its Summary for Policymakers (SPM), which was approved on April 6, IPCC WG II's presents three types of findings:

- statements based on observations of current conditions,
- projection of future impacts based on modeling, and
- generalized statements about adaptation and vulnerability.

WG II finds that natural systems, both physical systems, such as snow and ice cover, and biological systems, such as bird migration, have responded to the warming of the past century. They also find emerging evidence that human systems, such as agricultural practices, are also responding to warming. Neither conclusion is controversial, since there is ample evidence that both natural and human systems have adapted to past climate change. WG II accepted WG I's conclusion that the warming of the last 50 years can be attributed to human activities, and extends that conclusion by attributing the changes in natural systems to human activities. The Marshall Institute has questioned the basis for WG I's conclusion,[1] and by extension, questions the attribution of observed changes in natural systems to human-induced climate change.

The bulk of WG II's SPM is devoted to projections of future impacts based on assumptions about future climate change. Some of these findings are qualitative, based on simple logic, and relatively robust. For example, if it gets warmer, there will be a continuation in the changes in natural systems that have been observed over the last century. However, the other qualitative findings, and all of the quantitative findings, are based on modeling. These findings are derived from a four step approach:

1. The IPCC's SRES scenarios[2] were used as input to a climate model.
2. The output from the climate model was used as a prediction of future climate.
3. The predicted future climate was used as input to an empirical impact model, e.g., river run-off as a function of rainfall and temperature.
4. The difference between the output of the impact model and current conditions was assumed to be the impact of climate change.

Each of these steps is so fraught with uncertainty or unrealistic assumptions that the outputs of the exercise are meaningless.

- The SRES scenarios are baseline scenarios, i.e., they assume that no overt action is taken to control greenhouse gas emissions. This is an unrealistic assumption since a variety of actions are currently being taken to control greenhouse gas emissions, some voluntary, some mandatory, and those in the future will be shaped by new knowledge. If, as some scientists conclude, the

world is about to enter a cooling period, greenhouse gas emission controls could be rescinded.

- None of the climate models used by the IPCC has been independently validated. In fact, in its contribution to AR4, WG I does not discuss model validation, but uses a less demanding term: evaluation. Validation requires that a model be tested against an independent set of data. Evaluation involves discussing whatever information the model builders choose to use in support of their model. Even using the lower standard of evaluation, WG I finds that major problems exist in the design of climate models.

- Most impact models are empirical models based on an analysis of historical data. Empirical models are excellent tools, but their accuracy is limited to the range of conditions in the data used in their development. Their accuracy for conditions significantly outside that range is unknown. The temperature and rainfall conditions projected by climate models for the late 21st century are often well outside the range of conditions covered by impact models.

- The comparison of projected conditions to current conditions assumes that current conditions are well known and that they represent what future conditions would be without climate change. Both assumptions are questionable. In some cases, e.g., agricultural productivity in developed countries, the assumption that present condition is known is valid. In other cases, e.g., species extinction rate, the assumption is not valid, because the data on current conditions is either nonexistent or suspect.

  The assumption that without climate change future conditions will be the same as current conditions is incorrect in many cases. All projections of future climate are based on the assumption that the world, particularly the developing world, will use large amounts of fossil fuels and significantly raise atmospheric concentrations of CO_2. If this occurs, it will result in significant economic development in what today are underdeveloped countries, and those countries being far better equipped to address climate change impacts than they are today. It will also mean that they will be able to adopt lower carbon technologies, continuing the decarbonization trend that has been in progress since 1850.

  The projection of future conditions also does not address the benefits of technology or take into account likely adaptations. Many projections are based on the so-called "dumb farmer" assumption, that farmers (and society in general) will continue following the same practices even if the climate changes. WG II acknowledges that a wide array of technology and adaptation options is available, but emphasizes only the barriers to their use. This is an overly negative assessment. Society has a long history of adapting to changing climate, and there is no reason to believe that it will not continue to develop and apply the necessary technology to adapt to future changes in climate, whether they are warming or cooling.

To summarize, WG II's projections of future impacts of climate change are based on the use of the SRES scenarios, which do not take actions to control greenhouse gas emissions into account, in unvalidated climate models, to predict future climate. This projection of future climate is then used in empirical impact models, whose accuracy for extreme conditions is unknown. Impacts are assessed without taking into account that global capacity to respond to climate change will grow over the next century as a result of economic growth, adaptation and improved technology.

If WG II's findings were presented as one scenario in a set of scenarios that also examined the benefits of mitigation and adaptation, they would be an interesting worst case. By presenting only the worst case, WG II paints an overly negative and unrealistic view of the future. Policymakers need to know a possible worst case, but they also need to understand the more likely outcomes. WG II does not provide this information.

Despite adaptation being in WG II's title, and its importance in evaluating response to potential climate change, the WG II SPM's discussion of adaptation is limited to generalities. Some of WG II's key conclusions on adaptation are:

- "Some adaptation is occurring now, to observed and projected future climate change, but on a limited basis." WG II presents a handful of examples, but no indication that these are representative of a larger set of cases.
- "Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions." The climate system will require a long time to approach equilibrium with the increased greenhouse gas concentrations of the 20th century. This will tend to raise global average temperature — actual global temperature will depend on the interplay between greenhouse gas concentrations and the other factors that drive climate.
- "A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood." Vulnerability is the potential for damage. Adaptation can reduce that potential. Adaptation is also useful under current conditions, since it reduces vulnerability to normal climate variability, e.g., high or low temperature extremes. Human societies are well adapted to average climate, but as many examples show, not well adapted to the normal extremes of climate.
- "Vulnerability to climate change can be exacerbated by the presence of other stresses." While this statement is correct, it is misleading in that it implies that climate change is the most important cause of stress in today's world. This is hardly the case. For example, poverty, poor governance, and lack of access to energy supplies are certainly larger concerns in today's world than climate change.
- "Future vulnerability depends not only on climate change but also on development pathway." Development pathways that reduce poverty, provide access to reliable energy supplies, and create democratic institutions, will provide the ability to both reduce emissions intensity and apply adaptation technology.

Introduction

The Summary for Policymakers (SPM) of Working Group II (Impacts, Vulnerability and Adaptation)'s contribution to the IPCC's Fourth Assessment Report was finalized on the morning of April 6, after an all-night session. The SPM, subject to final text editing, is available on the IPCC website, ***www.ipcc.ch***. In an effort to assist the public's evaluation of the strong claims made in the SPM and the subsequent use of the those conclusions by the media and public policymakers, this review will evaluate the methodology used by WG II to arrive at its conclusions. Since many of WG II's findings are based on the conclusions reached by WG I (Science), this review will reiterate, where appropriate, elements of the Marshall Institute's critique of WG I's SPM.[3]

A key element of any IPCC report is its treatment of uncertainty. Very few of WG II's

findings can be subjected to statistical analysis, in most cases, WG II uses expert judgment to assign confidence levels to its findings. The terms used are shown below:

Confidence Scale, chance of being correct

Very High	At least	9 out of 10
High	About	8 out of 10
Medium	About	5 out of 10
Low	About	2 out of 10
Very Low	Less than	1 out of 10

In a few cases, WG II uses the likelihood scale used by WG I. The terms on this scale, which are also assigned using expert judgment, are:

Likelihood Scale, chance of being true

Virtually Certain	>99%
Very Likely	90 – 99%
Likely	66 – 90%
As Likely as Not	33 – 66%
Unlikely	10 – 33%
Very Unlikely	1 – 10%
Exceptionally Unlikely	<1%

While the terms on these two scales seem similar, both WG I and WG II stress that they are not interchangeable.

WG II's SPM presents three types of findings:

- statements based on observations of current conditions,
- projections of future impacts based on modeling, and
- generalized statements about adaptation and vulnerability.

The Marshall Institute's evaluation of each of these types of findings follows.

Observations of Current Conditions

WG II's first finding is:

> Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.[4]

This finding is uncontroversial because there is no dispute that global average surface temperatures rose over the past century. One would expect natural systems, both physical, such as snow and ice cover, and biological, such as bird migration, to respond to warmer conditions. Given the significant questions about the accuracy of temperature measurements,[5] changes in natural systems offer supporting evidence that warming is, in fact, occurring.

Since WG I concluded that the warming of the past fifty years was very likely (>90% probability, based on expert judgment) due to human activities, WG II concludes that the changes it observes in natural systems also are attributable to human activities, but acknowledges:

> Limitations and gaps prevent more complete attribution of the causes of observed system responses to anthropogenic warming. First, the available analyses are limited in the number of systems and locations considered. Second, natural temperature variability is larger at the regional than the global scale, thus affecting identification of changes due to external forcing. Finally, at the regional scale other factors (such as land-use change, pollution, and invasive species) are influential.

The Marshall Institute questions WG I's attribution of recent warming to human activities, which is based on a comparison of results from unvalidated climate models, using uncertain input data, with a global temperature record of dubious quality.[6] The limitations and gaps recognized by WG II make the attribution of changes in natural systems to human activity even weaker.

WG II also concludes:

> Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.

The comments supporting this finding also are uncontroversial, since a warmer world will affect the human environment, and humans will respond to those changes with appropriate adaptations, e.g., if farmers find that the weather is warmer, they will plant crops earlier.

Projections of Future Impacts Based on Modeling

The bulk of WG II's SPM is devoted to these findings, which are based on assumptions about future climate change. Some of these findings are qualitative and based on relatively simple logic. These findings are relatively robust. For example, if it gets warmer, there will be a continuation in the changes in natural systems that have been observed over the last century. However, the other qualitative findings, and all of the quantitative findings, are based on modeling. These findings are derived from a four step approach:

1. The IPCC's SRES scenarios were used as input to a climate model.
2. The output from the climate model was used as a prediction of future climate.
3. The predicted future climate was used as input to an empirical impact model, e.g., river run-off as a function of rainfall and temperature.
4. The difference between the output of the impact model and current conditions was assumed to be the impact of climate change.

Each of these steps is so fraught with uncertainty or unrealistic assumptions that the outputs of the exercise are meaningless.

- The SRES scenarios[7] are baseline scenarios, i.e., they assume that no overt action is taken to control greenhouse gas emissions. This is an unrealistic assumption since a variety of actions are currently being taken to control greenhouse gas emissions, some voluntary, some mandatory, and those in the future will be shaped by new knowledge. If, as some scientists conclude,[8] the world is about the enter a cooling period, greenhouse gas emission controls could be rescinded.

  Other criticisms of these scenarios include:

  - the scenarios with high CO_2 emission rates, which lead to high levels of temperature rise, are unrealistic,[9] and

  - the scenarios are based on market exchange rates rather than purchasing power parity, which would provide a more realistic comparison of the economies of different nations.[10]

  These and other criticisms of the SRES scenarios led the UK House of Lord Select Committee on Economics to conclude: "There are significant doubts about some aspects of the IPCC's emission scenario exercise, in particular, the high emission scenarios."[11]

- None of the climate models used by the IPCC has been independently validated. In fact, in its contribution to AR4, WG I does not discuss model validation, but uses a less demanding term: evaluation.[12] Validation requires that a model be tested against an independent set of data. Evaluation involves discussing whatever information the model builders choose to use in support of their model. Even using the lower standard of evaluation, WG I finds that major problems exist in the design of climate models, including:

- systematic biases in simulation of the Southern Ocean, which is important for the transfer of heat between the atmosphere and oceans;

- on-going problems in simulating the El Niño – Southern Oscillation (ENSO) cycle, which is a major factor in the Earth's climates;

- poor simulations of precipitation events: "In general, models tend to produce too many days with weak precipitation (< 10 millimeters/day, <0.4 inches/day) and too little precipitation overall in intense events (>10 millimeters/day, >0.4 inches/day)"; and

- substantial uncertainty in the simulation of feedbacks from sea-ice, which are coupled with polar cloud formation and transport of heat through the polar oceans.[13]

Other authors provide more detailed assessments of the shortcomings of climate models.[14]

- Most impact models are empirical models based on an analysis of historical data. William Gray's model,[15] widely recognized as providing the best predictions for hurricane formation in the North Atlantic, is an example of this type of model. Empirical models are excellent tools, but their accuracy is limited to the range of conditions in the data used in their development. Their accuracy for conditions significantly outside that range is unknown. The temperature and rainfall conditions projected by climate models for the late 21st century are often well outside the range of conditions covered by impact models.

- The comparison of projected conditions to current conditions, the basis for determining the impacts of climate change, assumes that current conditions are well known and that they represent what future conditions would be without climate change. Both assumptions are questionable. In some cases, e.g., agricultural productivity in developed countries, the assumption that present condition is known is valid. In other cases, e.g., species extinction rate, the assumption is not valid, because the data on current conditions is either nonexistent or suspect.

The assumption that without climate change future conditions will be the same as current conditions is incorrect in many cases. All projections of future climate are based on the assumption that the world, particularly the developing world, will use large amounts of fossil fuels and significantly raise atmospheric concentrations of CO_2. If this occurs, the use of those large amounts of fossil fuels will result in significant economic development in what today are underdeveloped countries. That economic development will result in those countries being far better equipped to address climate change impacts than they are today. It will also mean that they will be able to adopt lower carbon technologies, continuing the decarbonization trend that has been in progress since 1850.[16]

The projection of future conditions also does not address the benefits of technology (hardware, software and know-how) or take into account likely adaptation. Many projections are based on the so-called "dumb farmer" assumption, that farmers (and society in general) will continue following the same practices even if the climate changes. In a subsequent section of the SPM, WG II acknowledges that wide arrays of technology and adaptation options are available, but emphasizes only the barriers to their use. This is an overly negative assessment. Society has a long

> history of adapting to changing climate, and there is no reason to believe that it will not continue to develop and apply the necessary technology to adapt to future changes in climate, whether they are warming or cooling.

To summarize, WG II's projections of future impacts of climate change are based on the use of the SRES scenarios, which do not take actions to control greenhouse gas emissions into account, in unvalidated climate models to predict future climate. This projection of future climate is then used in empirical impact models, whose accuracy for extreme conditions is unknown. Impacts are assessed without taking into account that global capacity to respond to climate change will grow over the next century as a result of adaptation and improved technology.

It is interesting to consider this approach in light of the IPCC's definition of scenarios. In its Special Report on Emissions Scenarios, the IPCC stated:

> Scenarios are images of the future, or alternative futures. They are neither predictions nor forecasts. Rather, each scenario is one alternative image of how the future might unfold. A set of scenarios assists in the understanding of possible future developments of complex systems.[17]

If WG II's findings were presented as one scenario in a set of scenarios that also examined the benefits of mitigation and adaptation, they would be an interesting worst case. By presenting only the worst case, WG II paints an overly negative and unrealistic view of the future. Policymakers need to know a possible worst case, but they also need to understand the more likely outcomes. WG II does not provide this information.

WG II summarized its findings in highly abbreviated form in Table SPM-1. All of these findings are assigned high confidence, i.e., in the expert judgment of the WG II authors, they have about 8 out of 10 chances of being true. The following is an evaluation of these "soundbites," which are likely to be widely quoted.

- "Hundreds of millions of people exposed to increase (sic) water stress"

  All projections show increasing numbers of people living in water stressed countries, even without climate change. Climate change is projected to make that situation worse. However, 90% of water is used for agriculture, and most of that water is used in inefficient ways. Technology for improving the efficiency of water use in agriculture is available, e.g., drip irrigation, which can cut the amount of water needed for irrigation by as much as 60% while increasing crop yields and reducing the need for fertilizer and agricultural chemicals.[18] These systems are more expensive than sprinkler or flood systems, but with additional development, will become affordable in much of the world.

- "Up to 30% of species at increasing risk of extinction (with 1.5-2.5°C temperature rise)" and "Significant (more than 40%) extinctions around the globe (at still higher temperature rise)."[19]

  The first part of this finding is sufficiently imprecise to allow almost any interpretation, since increased risk is undefined. The second part of the statement is more precise and highly alarming. However, it is an example of the use of impact models, in this case very poorly designed impact models, for situations well outside the data range for which they were developed.

  In one of the most widely publicized studies of the impact of climate change on species extinction, C.D. Thomas and

18 co-authors predicted that 15-37% of the 1100 species with limited range they studies would be "committed to extinction" by 2050 as a result of projected climate change.[20] Temperature rise as low as 0.8-1.7°C was projected to commit about 18% of these species to extinction. This result does not stand up to comparison with the recent past. As Kueter pointed out, if species were that vulnerable to temperature rise, biologists should have been able to identify a significant number of species that became extinct as a result of the temperature rise of the 20th century.[21] In their paper, Thomas, *et al.* report that the climate change of the 20th century has been implicated in the extinction of only *one* species, a Costa Rican tree frog, and even in this case, other factors also were at work. Additionally, Thomas, *et al*. and other authors who predict wholesale species extinction do not take into account the beneficial aspects of projected climate change on species survival. Idso, *et al.*[22] document the ability of plants and animals to adapt and flourish under conditions of a simultaneous rise in temperature and CO_2 concentration. Climate change, whether natural or human-induced, will have both positive and negative effects on species around the globe.

WG II's model-based projections of species extinction are not supported by actual observation and experimentation. In the real world, plants and animals prove far more able to survive than they do in computer simulations.

- As temperatures rise above 3°C, "Productivity of all cereals decreases in low latitudes" and "Cereal productivity to decrease in some mid- to high-latitude regions."

This is an example of a conclusion that does not take improved technology or adaptation into account. The text of the SPM points out:

> Adaptations such as altered cultivars and planting times allow low and mid- to high latitude cereal yields to be maintained at or above baseline yields for modest warming.

But this is only part of the story. It has long been realized that more heat resistant crops were an important adaptation technology, and that these crops could be developed either by traditional plant breeding methods or with the improved techniques available through genetic engineering. If projected climate change occurs, shifts in rainfall patterns are more likely to be a threat to agriculture than increased temperature. As discussed above, improved technology, such as drip irrigation, offers a practical response to that threat too.

- "Millions more people could experience coastal flooding each year."

The text of the SPM indicates that this prediction is for the 2080s. This projection assumes that no steps are taken to control greenhouse gas emissions, ignoring the fact that such steps, some voluntary, some mandatory, are now being taken and more are planned for the future.

If sea level rise continues, as it has since the end of the last ice age, there will, in fact, be flooding in areas that are now inhabited. Adaptation in this case means either building dikes and other protections against the sea, as the Dutch have done, or "planned retreat," recognizing that some coastal areas will not continue to be suitable for human

habitation. Even taking WG II's projection at face value, 75 years gives society a long time to decide on and implement a strategy.

- "Increasing burden from malnutrition, diarrheal, cardio-respiratory and infectious diseases."

The section on human health in this and earlier WG II reports steadfastly refuse to recognize the connection between rising energy use and improved living conditions, which translate into longer and healthier lives.[23] It is well documented in IEA and other studies[24] that most of the future growth in fossil fuel use and CO_2 emissions will come from what are now developing nations, and that this will result in higher per capita GDP. If these countries have reasonable governance, that increased wealth should result in better social services and public health facilities, which would address all of these problems. Use of modern energy sources also would directly address one of these concerns. Much of the respiratory disease in poor countries is the result of using traditional fuels (wood, charcoal and dung) in open fires which leads to high levels of indoor air pollution, sickening or killing millions of women and children each year.

This latest report from WG II finally accepts the evidence that projected climate change will *not* cause a significant increase in malaria and other vector-borne diseases. WG II's latest conclusion on this issue reads: "Changed distribution of some disease vectors." The text of the SPM does not provide any more detail, stating that "Climate change is expected to have some mixed effects, such as the decrease or increase of the range and transmission potential of malaria in Africa."

WG I's SPM included a table of projected changes weather and climate extremes during the 21st century. WG II assumed that these extremes will occur and produced a table of the impacts, positive and negative, that could result.

Some of the extremes projected by WG I, e.g., fewer cold days and nights and more warm days and nights, are obvious results of the projected rise in average temperature. Others, such as changes in precipitation patterns, which would result in drought in some areas, are extrapolations of trends noted in the 20th century. However, the final two, (1) intense tropical cyclone (hurricanes and typhoons) activity is *likely*[25] to increase, and (2) increased incidence of extreme high sea level (excluding tsunamis) is *likely*, do not fit into either of these categories.

The projection of more intense tropical cyclones is an extrapolation from the claim that hurricane intensity has increased in the North Atlantic since the 1970s. This conclusion has been challenged in the scientific literature.[26] It is not supported by a historical comparison prepared by William Gray, widely recognized for having developed the best predictive model for hurricane formation in the North Atlantic.[27]

WG I notes that incidence of extreme high sea level closely follow the changes in average sea level. Presumably they are the result of storm activity in a raised sea level situation. Since projections of increased intense storm activity are questionable, this conclusion is also questionable.

As in the case of its projections of the impacts of average climate change, WG II does not take adaptation into account when considering the impacts of extreme events. Adaptation to hot weather often involves avoiding strenuous activity during the hottest part of the day, and has no direct cost. Less cold weather will be a benefit and generate savings in terms of less cold weather mortality, longer growing seasons, and lower heating costs. Adaptation to changing precipitation

patterns would involve redesigning water collection systems and changing agricultural practices. Adaptation to more intense tropical cyclones, were they actually to occur, would involve construction of stronger buildings and redesigning infrastructure. Adaptation to increased incidence of extreme high sea level would probably involve moving away from the most vulnerable areas. Most adaptation steps will involve direct costs, and all will involve indirect costs. However, these steps will provide benefits in terms of improved tolerance of normal weather and climate variability.

WG II's summary conclusion, which actually appears in a different section of the SPM, reads:

> Impacts of climate change will vary regionally but, aggregated and discounted to the present, they are very likely to impose net annual costs which will increase over time as global temperatures increase.

Again quoting WG II's SPM:

> This Assessment makes it clear that the impacts of future climate change will be mixed across regions. For increases in global mean temperature of less than 1 to 3°C above 1990 levels, some impacts are projected to produce benefits in some places and some sectors, and produce costs in other places and other sectors. It is, however, projected that some low latitude and polar regions will experience net costs even for small increases in temperature. It is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2 to 3°C. These observations re-confirm evidence reported in the Third Assessment that, while developing countries are expected to experience larger percentage losses, global mean losses could be 1-5% Gross Domestic Product (GDP) for 4°C of warming.

WG II also reviews the literature projecting the cost of climate damages.

> Many estimates of aggregate net economic costs of damages from climate change across the globe (i.e., the social cost of carbon (SCC), expressed in terms of future net benefits and costs that are discounted to the present) are now available. Peer-reviewed estimates of the social cost of carbon for 2005 have an average value of US$43 per tonne of carbon (tC) (US$12 per tonne of carbon dioxide) but the range around this mean is large. For example, in a survey of 100 estimates, the values ran from US$-10 per tonne of carbon (US$-3 per tonne of carbon dioxide) up to US$350/tC (US$96 per tonne of carbon dioxide).

These figures are interesting because the average, $12/tonne of carbon dioxide, is much lower than the typical cost of mitigation efforts, >$25/tonne of carbon dioxide. The results are highly dependent on the discount rate chosen, a topic that WG II's SPM considers only in the most general terms:

> The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses and discount rates. It is very likely that globally aggregated figures underestimate the damage costs because they cannot include many non-quantifiable impacts. Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time.

And as usual in IPCC reports, concern is expressed about the most vulnerable portions of society. However, there is no discussion of the cost that these portions of society will bear if uneconomical climate policies were adopted:

> It is virtually certain that aggregate estimates of costs mask significant differences in impacts across sectors, regions, countries, and populations. In some locations and amongst some groups of people with high exposure, high sensitivity, and/or low adaptive capacity, net costs will be significantly larger than the global aggregate.

Adaptation and Vulnerability

Despite being topics in its title, and their importance in evaluating response to potential climate change, WG II's SPM has only limited coverage of adaptation and vulnerability (slightly over three pages out of the twenty-four page SPM), and most of that limited discussion is generalities. WG II's key conclusions are:

- Some adaptation is occurring now, to observed and projected future climate change, but on a limited basis.

WG II presents a handful of examples, but no indication that these are representative of a larger set of cases.

- Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions.

The climate system takes a long time to equilibrate because of the large thermal inertia of the oceans. In fact, the climate system probably is never in equilibrium because changes in the drivers of climate change over a shorter period of time than is needed to establish equilibrium. The climate system will require time to approach equilibrium with the increased greenhouse gas concentrations of the 20th century. This will tend to raise global average temperature — actual global temperature will depend on the interplay between greenhouse gas concentrations and the other factors that drive climate. WG II has focused only on the effect of greenhouse gases in drawing this conclusion.

- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.

Vulnerability is the potential for damage. Adaptation can reduce that potential. For example, if farmers plant more heat resistant crops, the potential damage from high temperature is reduced. Adaptation is also useful under current conditions, since it reduces vulnerability to normal climate variability, e.g., high or low temperature extremes. Human societies are well adapted to average climate, but as many examples show, are not well adapted to the normal extreme of climate.

- Vulnerability to climate change can be exacerbated by the presence of other stresses.

While this statement is correct, it is misleading in that it implies that climate change is the most important cause of stress in today's world. This is hardly the case. For example, poverty, poor governance, and lack of access to energy supplies are certainly larger concerns in today's world than climate change. The IPCC's charge is to focus on climate change, but it would be refreshing if occasionally they put climate change in its appropriate place on the world's list of problems.

- Future vulnerability depends not only on climate change but also on development pathway.

This statement comes closer to putting the threat of climate change in the correct perspective than the last. Development pathways that reduce poverty, provide access to reliable energy supplies, and create democratic institutions will provide the ability to both reduce emissions intensity and apply adaptation technology.

- Sustainable development can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways.

WG II uses the Brundtland Commission definition of sustainable development, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Volumes have been written trying to explain what this definition means, but there are no generally accepted procedures for defining whether a development step is sustainable or not. There is general agreement that sustainable development is a balance between concerns about the environment, economic development, and social justice. However, these objectives may be contradictory. For example, economic development may drive a country to use indigenous energy resources, rather than importing energy. In the case of China and India, this means using large amounts of coal, driving up their CO_2 emissions. Does using indigenous resources and providing local employment, but increasing CO_2 emissions, make development in China and India more or less sustainable? WG II's SPM does not address this or similar issues.

Notes

1. George C. Marshall Institute, 2007: Working Group (WG) I's Contribution to the IPCC's Fourth Assessment Report (AR4): A Critique. ***www.marshall.org/pdf/materials/515.pdf***.
2. The SRES scenarios are documented in the IPCC Special Report on Emission Scenarios (SRES) published in 2000.
3. George C. Marshall Institute, 2007: Working Group (WG) I's Contribution to the IPCC's Fourth Assessment Report (AR4): A Critique. ***www.marshall.org/pdf/materials/515.pdf***.
4. Unless otherwise referenced, this and all other quotes in this report are from the April 6, 2007 version of the WG II SPM posted on the IPCC website.
5. For a discussion of the uncertainties in estimates of global average temperature, see: Balling, R, 2003: The increase in global temperature: What it does and does not tell us. ***www.marshall.org/article.php?id=170***.
6. George C. Marshall Institute, 2007: Working Group (WG) I's Contribution to the IPCC's Fourth Assessment Report (AR4): A Critique. ***www.marshall.org/pdf/materials/515.pdf***.
7. The SRES scenarios are documented in the IPCC Special Report on Emission Scenarios (SRES) published in 2000.
8. Gray, W.M., 2006: Hurricanes and climate change. ***www.marshall.org/pdf/materials/461.pdf***.
9. See for example: Ausubel, J., 2002: Does Energy Policy Matter? ***www.marshall.org/article.php?id=7***.
10. See for example an exchange of letter between Castles and Henderson and the Chair of IPCC and presentations at IPCC technical expert meetings raising this point, ***www.lavoisier.co.au/paper/articles/IPCCissues.html***.
11. House of Lords Select Committee on Economic Affairs, 2005: The Economics of Climate Change. ***www.publications.parliment.uk/pa/Id200506/Idselect/Ideconaf/12/12i.pdf***

12. WG I Final Draft, 2007: Chapter 8, Climate Models and their Evaluation. Available on the web at ***www.junkscience.com/draft_AR4***

13. *Ibid.*, Executive Summary, Pg. 3-6.

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