Climate Change and Its Impacts

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Contents

- Features of climate change sciences and key uncertainties
- Challenges of climate change to sustainable development
- Conclusions and responsive recommendations
Features of Climate Change Sciences and Key Uncertainties
Estimation of annual global energy balance

(1370 → 342 → 288 → 240 W/m²)

FAQ 1.1, Figure 1. Estimate of the Earth’s annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth’s surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. Source: Kiehl and Trenberth (1997).
Greenhouse Effect:

GHG absorbs surface long-wave radiation to warm up the atmosphere, the effect of which is like a “greenhouse”. Without “greenhouse effect”, the Earth surface temperature would be about -18°C instead of the current 15°C.
Climate change is caused by both natural and man-made factors. The IPCC AR4 finds that the warming in recent 50 years is very likely due to human activities.
Panel (a): Natural GHG effect.
Panels (b) and (c): Enhanced “GHG effect” caused by increased CO₂ concentration in the atmosphere.
## Variety and Effects of GHG
(Take 2005 as an example)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Type</th>
<th>Warming effect (%)</th>
<th>Life cycle (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyoto Protocol</td>
<td>Carbon dioxide (CO₂)</td>
<td>63</td>
<td>10¹-10³</td>
</tr>
<tr>
<td></td>
<td>Methane (CH₄)</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Nitrous oxide (N₂O)</td>
<td>6</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Others (HFCₛ⁺PFCₛ⁺SF₆)</td>
<td>&lt;1</td>
<td>1.4-50000</td>
</tr>
<tr>
<td>Montreal Protocol</td>
<td>CFCₛ+HCFCₛ+Halonₛ+others</td>
<td>12</td>
<td>0.7-1700</td>
</tr>
</tbody>
</table>

(IPCC AR4, 2007)
Global Carbon Cycle (2007)

Global emission: CO₂

Atm. + ~3.2 Gt/a

~7.5 Gt/a

~2.5 Gt/a (absorbing 1/3)

Land

~1.8 Gt/a (absorbing 1/4)

Ocean

1 ton C = 3.7 ton CO₂

2007年全球排放约270亿吨CO₂
Changes of GHG Concentrations in the Past 650,000 Years
Changes of Atmospheric GHG Concentrations at Global Level in the Past 10,000 Years

Carbon Dioxide 379 ppm  Methane 1774 ppb  Nitrous Oxide 319 ppb

The 2005 CO$_2$ concentration was higher than that caused by natural changes over the past 650000 years (180-280 ppm). Its growth rate in recent decade was 1.9 ppm per annum, higher than the observed annual average 1.4 ppm. The methane concentration in 2005 was higher than that caused by natural changes over the past 650000 years (320-790 ppb). The growth rate has declined since 1990s. The 2005 nitrous oxide concentration was 319 ppb, higher than the pre-industrial level (270 ppb). It has generally stabilized since 1980.
图3. 1983-2008年全球平均CO₂（a）及其增长率（b）。

图4. 1984-2008年全球平均CH₄（a）及其增长率（b）。

385.2ppm
1797ppb
Since 1750, the global net impact of the anthropogenic activities is warming with an averaged radiative forcing at 1.6\(\text{W/m}^2\), one order higher than the solar radiative forcing (0.12\(\text{W/m}^2\)).
Globally averaged, the planet is about 0.75°C warmer than it was in 1860, based upon dozens of high-quality long records using thermometers worldwide, including land and ocean.
**Warming of the climate system is unequivocal**

The global surface temperature has increased by 0.74°C in the past 100 years (1906~2005). Eleven of the last twelve years rank among the 12 warmest years (1995~2006) in the past 150 years.

In the 20th century, the global sea level rise was estimated to be 0.17 m, with an average rise of 1.8 mm/year in 1961-2003 and 3.1 mm/year in 1993-2003.

Snow cover has declined in most continents, especially in spring and summer.

(IPCC AR4, 2007)
Global mean temperatures are rising faster with time

**Warmest years:**

**Period** | **Rate** | **±**
--- | --- | ---
25 | 0.32 | 0.09
50 | 0.23 | 0.05
100 | 0.13 | 0.03
150 | 0.08 | 0.02

Source: IPCC 4th assessment report, by Dr. Ghulam Rasul
Global surface temperature change over the last 1300 years (relative to 1961-1990)

**AR4:** Average temperature during the second half of the 20th century were likely the warmest 50 years over the last 1300 years.

**TAR:** Average temperature during the 20th century were likely the warmest 100 years over the last 1000 years.

IPCC AR4, WG1, 2007
Annual precipitation anomalies on land in 1901-2005 (%)

Precipitation has been changing significantly in the most continents

( IPCC AR4, 2007 )
In most land areas, the proportion of heavy precipitation is increasing.

Distribution of the heavy and extremely heavy precipitation (+: increased; -: decreased)

(IPCC AR4, 2007)
Key Uncertainties in climate change sciences

- Natural variability and human activities
- Complexity of climate system
- Lack of data and studies in developing countries
  ~88/5000 (WG1, AR4)
- IPCC WG1 conclusions: most from studies in developed countries
- IPCC WG1 conclusions: some based upon small samples
- IPCC WG1 projections: most based upon climate models

Climate change sciences: rich country club

- Uncertainties can be resolved only by further studies;
- The emergency of combating climate change can NOT be ignored by the existence of uncertainties.
Some Things to Look Forward To….

- **Forcing**: Greenhouse gases are at unprecedented levels, and are forcing the climate to change. Future needs include: Effects of soot? Effects on circulation, precipitation?

- **Beyond global warming**: Discernible human influences on other aspects of climate including heat waves, wind patterns, Arctic sea ice, drought, and more…this is the first ‘earth system’ IPCC report, and much more is needed in future.

- **Commitment**: Already committed to more warming (next few decades), with choices about emissions affecting the longer term more and more. Future needs: A more integrated approach to scenarios, including e.g., land use?

- **Long term**: Sea level rise is inexorable and will continue, and the face of the planet will change. By how much? How fast?

AR5: WG1 in early 2013; WG2, WG3 to follow

Susan Solomon, private communication, 2008
Under a range of GHG emission scenarios, by the end of this century, the global average temperature will increase in a broad range of 1.1°C - 6.4°C. For the low scenario (B1), it will rise from 1.1°C to 2.9°C, and for the high scenario (A1FI), it will rise from 2.4°C to 6.4°C.
There are greater confidence on projected warming patterns and other regional scale characteristics. Warming is greatest over land and at most high latitudes in NH during winter. In contrast, warming is least over the southern oceans and parts of the North Atlantic Ocean.
Projected patterns of precipitation

Since TAR (2001), there is an improving understanding of projected patterns of precipitation. Increase in the amount of precipitation are very likely at high latitudes, while decrease are likely in most subtropical land regions.
On the centennial time scale, the increasing tendency of surface temperature is quite sure. The global warming has caused significant changes in different components of climate system, e.g., snow cover, glacier, sea ice and sea level.

These phenomena were repeatedly confirmed by vast of observations from numerous international research institutes.
Global averaged surface temperature anomaly during 1850~2005 (relative to 1961~1990) (From IPCC AR4, 2007)
A comprehensive review of key climate indicators confirms the world is warming and the past decade was the warmest on record.

More than 300 scientists from 48 countries analyzed data on 37 climate indicators, including sea ice, glaciers and air temperatures.

A more detailed review of 10 of these indicators, selected because they are clearly and directly related to surface temperatures, all tell the same story: global warming is undeniable.
These indicators all increase in a warming world.
These indicators all decrease in a warming world.
The change of surface temperature is NOT increasing in a linear way

- Due to solar and volcanic activities and internal processes and feedback of climate system, there are multi-time scales variations or fluctuations of global climate change.

- What we observed are the consequences of long term change and diurnal, daily, seasonal, annual, decadal and inter-decadal variations.

- The total tendency of climate warming does NOT exclude the cold spells in certain areas and periods of time.
Averaged air temperature increased by 1.1°C, BUT the temperature over Southwest China decreased by 0.45°C.
April 2010: warmest after 1880

Global averaged surface temperature in April 2010 was 0.76°C higher than 20th century, BUT air temperature over China was 1.2°C lower than normal.
Combined global land and ocean annual surface temperatures for 2010 tied with 2005 as the warmest such period on record at 0.62°C above the 20th century average.
# Global Top 10 Warmest Years (Jan-Dec)

<table>
<thead>
<tr>
<th>Year</th>
<th>Anomaly ° C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0.62</td>
</tr>
<tr>
<td>2005</td>
<td>0.62</td>
</tr>
<tr>
<td>1998</td>
<td>0.60</td>
</tr>
<tr>
<td>2003</td>
<td>0.58</td>
</tr>
<tr>
<td>2002</td>
<td>0.58</td>
</tr>
<tr>
<td>2009</td>
<td>0.56</td>
</tr>
<tr>
<td>2006</td>
<td>0.56</td>
</tr>
<tr>
<td>2007</td>
<td>0.55</td>
</tr>
<tr>
<td>2004</td>
<td>0.54</td>
</tr>
<tr>
<td>2001</td>
<td>0.52</td>
</tr>
</tbody>
</table>
State of the Art Understanding of key Scientific Issues of Climate Change

- Global climate change is featured by total tendency of warming and fluctuation in surface temperature variations;
- The global climate warming during the past 100 years was unequivocal and undeniable;
- The latest observation suggests: Global climate warming has NOT stopped or reversed;
- The argument and uncertainties of climate change sciences should NOT slow down or halt the international action addressing for climate change.
Challenges of Climate Change to Sustainable Development
THE NATURE OF PROJECTED IMPACTS:

e.g. Crop Yields

SAR and TAR: Yields projected to decrease throughout the Tropics and Sub-tropics, but increase at High Latitudes:

AR4: Examination of response ranges under varying conditions, including adaptation: (maize and wheat yields)
THE NATURE OF PROJECTED IMPACTS: e.g. Water

SAR and TAR: Projected decreases in Mid and Lower latitudes (single model):

AR4: used multiple models to indicate uncertainty:

[Map showing projected changes in annual runoff (mm yr⁻¹)]

- High latitude increases
- Decreases over some dry regions
- Percentage changes uncertain in desert regions
- Changes less reliable in lower latitudes, e.g. monsoon regions
OBSERVED EFFECTS OF CLIMATE CHANGE

Weather-Related Economic Damages Have Increased
Approximately 20-30% of species assessed so far are likely to be at increased risk of extinction if increases in global average temp. exceed 2-3°C.

Globally, the potential for food production is projected to increase with 3°C increase in global average temp., but above this it is projected to decrease.

Any temp. increases below 2°C are likely to have negative effects on health.

Even temp. increases below 2°C are likely to cause the changes of the intensity, frequency and location of extreme events. If increases in global average temp. exceed 2-3°C, winter precipitation would significantly increase and snow cover would decrease, with frequent floods in many regions.
### 2°C warmer than pre-industrial times

#### Global mean annual temperature change relative to 1980-1999 (°C)

<table>
<thead>
<tr>
<th>Continent</th>
<th>Temperature Change</th>
<th>Impact/Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td>2°</td>
<td>Semi-arid / arid areas increase by 5 to 8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional people with increased water stress</td>
</tr>
<tr>
<td>ASIA</td>
<td>3°</td>
<td>2 to 5% decrease wheat and maize in India</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 to 12% decrease rice in China</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crop yield potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up to 2 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up to 7 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional people at risk of coastal flooding each year</td>
</tr>
<tr>
<td>AUSTRALIA / NEW ZEALAND</td>
<td></td>
<td>Annual bleaching of Great Barrier Reef</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,000 to 5,000 more heat related deaths per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Murray-Darling River flow -10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreasing water security in south and east Australia and parts of east New Zealand</td>
</tr>
<tr>
<td>EUROPE</td>
<td>2°</td>
<td>+5 to +15% in Northern Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+10 to +20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 to -25% in Southern Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-5 to -35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+2 to +10% in Northern Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+10 to +25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wheat yield potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+3 to +4% in Southern Europe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 to +20%</td>
</tr>
</tbody>
</table>

1. Reference 1
2. Reference 2
3. Reference 3
4. Reference 4
5. Reference 5
6. Reference 6
7. Reference 7
8. Reference 8
9. Reference 9
10. Reference 10
11. Reference 11
12. Reference 12
Heat-wave days have increased in summer, especially since 1998, the number of days over 35°C is significantly higher than average. 2010 peaked by 9.6 days.
Over the past more than 50 years, the number of typhoons landed on China has not been significantly increased or decreased.
Over the past 50 years and more, the tropical cyclones tend to become more intense at the time of landing on China.
Super typhoon "Saomai" landed mainland China on 10 August 2006.

"Saomai" landed on Cangnan county of Zhejiang province with a pressure of 920 hPa at its centre and the maximum wind speed of 60m/s (wind force 17).
Heavy precipitation events have been increased. The recent 20 years were the period of higher frequency of floods over the Yangtze River and the Huaihe River after 1950s.
Shalan town of Heilongjiang Province in 2005

Huaihe River basin in 2008

Jinan of Shandong Province, 2007
Regional drought was aggravated, particularly in the 8 out of the recent 20 years in North China. The drought was the most serious one since 1886 in terms of coverage, severity and frequency.

Changes of annual drought index (CI) across the country in 1951-2006.
Glaciers

alluvium

oasis

desert
Glacier retreated significantly.

By 2050, China’s glaciers will be lost by half (within the total period of 350 years).
Namtso Lake: 4,720m, highest saltwater lake in the world

The water level has increased by 7m since 2005.
小冰期（LIA）以来的变化
1962年以来连续退缩过程

《中国西部环境演变评估》，2002
Glacier No.1 in the up stream of Urumuqi River in Mt. Tianshan Mountains 2004
Glacier No.1 in the Headwater of Urumuqi River, Tianshan Mountains

Summer 2007

Glacier change in decades
Global warming is likely to have the biggest effect on agriculture, and crop yield is likely to decrease in many regions. In China agriculture will be facing three outstanding problems:

- **Yield fluctuation is likely to increase**
  - 5-10% reduction in output

- **Layout and Structure will change**
  - Changes in cropping system and crop variety

- **Cost and investment will increase**
  - Increase in fertilizer, pesticide and weedicide.
Till 2030, crop yield in China is likely to decrease by 5-10%, and three main crops all show a decrease in yield. (mainly due to temperature increase, intensification of flood and drought, and water shortage etc.)
Sharp drop of groundwater resources

Changes of natural groundwater resources in Hexi Corridor (in 100 million cubic meters)

<table>
<thead>
<tr>
<th>Decade</th>
<th>1950s</th>
<th>1960s</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heihe River</td>
<td>35.4</td>
<td>32.4</td>
<td>27.9</td>
<td>26.1</td>
<td>20.8</td>
</tr>
<tr>
<td>Shiyanghe River</td>
<td>15.8</td>
<td>12.0</td>
<td>9.8</td>
<td>8.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Shulehe River</td>
<td>13.9</td>
<td>13.3</td>
<td>11.5</td>
<td>9.3</td>
<td>8.1</td>
</tr>
<tr>
<td>Total</td>
<td>65.1</td>
<td>46.9</td>
<td>49.2</td>
<td>44.1</td>
<td>35.8</td>
</tr>
</tbody>
</table>

As compared with 1950s, the groundwater resources of Hexi Corridor was decreased by 45% in 1990s, and it was decreased by 41% in Heihe river, by 56% in Shiyanghe river, and by 42% in Shulehe river.
Contradictions between supply and demand for water resources are likely to increase in China.

Possible increase in water shortage amount in some regions or river basins across China in 2030 (95% probability)

In drought years water shortage will worsen in regions like North China and Northwest China.
Inter-Decadal Variation of Summer Precipitation in China

- Further northward migration of summer precipitation in China?
- Contribution of natural variability and anthropogenic forcing?
Over the past 30 years, China's coastal sea level has increased by about 0.09 meters, slightly higher than the global average. This, plus frequent typhoons and storm surges, has made increasing adverse impacts on coastal areas. Rising sea-water temperatures and ocean acidification have caused coastal ecosystem degradation.
Sea level will continue to rise in the future

The trend of China's coastal sea level rise will exacerbate in the future, and by 2050 it will increase by 0.13-0.22 meters relative to 2000. Estuarine ecosystems and coastal economy will be affected; marine ecosystems such as mangroves and coral reefs will degrade; sea level rise and extreme events will exacerbate ocean disasters such as storm surge, red tide, saltwater intrusion, salination, etc.; Shanghai, Guangzhou and other coastal big cities will be subject to the direct threat of sea level rise.
China is one of countries of world who experiences the most severe weather-induced disasters

All of disasters of the world in China:

Typhoon, torrential rain (snow), lightning, drought, high wind, hail, thick fog, haze, dust storm, high temperature, heat wave, low temperature, freezing occur from time to time;

And weather-induced landslide, mud-rock flow, mountain torrent, as well as marine disasters, biological disasters, forest and prairie fires, . . . . . . .

All of this disasters have significant impacts on economic and social development, people’s life, ecosystems and environment.
Each year affected population by meteorological disasters is about 600 millions, affected farmland more than 33 million hectares. In the early 2008, low temperature, sleet, snow and freezing weather caused an economic loss of 151.6 billion yuan.

Annual change of direct economic losses caused by meteorological disasters in China

177.9 billion yuan averaged over 1990–2005

200.3 billion yuan in 2006

234.2 billion yuan in 2007
China is one of countries of world who experiences the most severe weather-induced disasters.

Global warming make a lot of lost for China.

In recent years, global climate is continuously warming and various extreme weather and climate events have become more frequent, resulting in increasing losses and influences.

According to statistics, 70% of natural disasters are induced by weather.

Each year, economic losses caused by meteorological disasters account for 2-3% of GDP that year.
Projected severe weather events become more frequent in China in the 21st century

- Hot days in the summer are likely to increase in some areas, while the frequency of warm winter and hot summer will increase;
- Precipitation increase will mainly occur in more frequent heavy precipitation events;
- Typhoon and strong convective weather are likely to become more intense.
- Increased instability of *agricultural production*
- Increasingly serious problem of *water resources*
- Significant retreat of *glaciers*
- Greater *risks* in operating safely major engineering projects
- Economically developed coastal areas are subject to the threat of *sea-level rise*

- *biological diversity*
- *Human health*
- *Industry, tourism, finance, ……*

- *Politics, economy, diplomacy, national Security……*
Climate Change Policies can make a difference

- Major policies and measures by government are required:
  - RD&D efforts
  - Investments in new technologies
  - Tax credits
  - Standard setting
  - Technology development and transfer
  - Market creation and development

- An effective carbon-price signal could realize significant mitigation potential

- Linking sustainable development with climate change policies provide governments the opportunity to avert the possible climate threats

- An effective climate change strategy will require the integration of development, equity and sustainability
Non-Climate Change Policies can significantly contribute to Mitigation

Changes in lifestyles and behaviour patterns can contribute to CC mitigation—occupant behaviour, cultural patterns, consumer choices in buildings

– reduction of car usage and efficient driving, improved urban planning and more availability of public transport

– behaviour in industrial organizations

- **Macro-economic policy**: taxes, subsidies, other fiscal policies, structural adjustment
- **Trade policy**: “embodied carbon”, removing barriers for low-carbon products, domestic energy sources
- **Energy security policy**: efficient energy use, domestic energy sources (low- high carbon)
- **Access to modern energy**: bio-energy, poverty tariffs
- **Air quality policy**: clean fuel
- **Bank lending policies**: lending for efficiency/ renewable energy, avoid lock-in into old technologies in developing countries
- **Insurance policy**: Differentiated premiums, liability insurance exclusion, improved conditions for green products
Conclusions and responsive recommendations
Suggestions

- It is imperative to **improve scientific levels** of projection and predictions, to actively address the effects of climate change on economic and social sustainable development, to take adaptive measures to mitigate negative impacts, and to make full use of opportunities created by climate change for the development of some areas or sectors to ensure socioeconomic sustainable development.
It is imperative to take mitigative measures to control and reduce emissions of pollutants and greenhouse gases, thus mitigating the rate and extent of climate change at the root.
It is imperative to fully play the role of scientific and technological advance and innovation, and to improve institutional mechanisms for addressing climate change and weather-induced disasters.
It is imperative to extensively make international exchange and cooperation, to deal with the relationship between economic growth, social development and environmental protection, and to enhance the capacity of sustainable development.
Thank you