CLIMATE CHANGE AND ASIA: IMPACTS AND RESPONSE

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Outline

- Climate change in ten slides
- IPCC and UNFCCC
- Impacts of climate on Asia – overview
- Asia's rise (and fall?)
- Impacts on food grains esp. rice
- Mitigation and adaptation
- All eyes on Paris

Climate Change

- Primarily anthropogenic (human induced)
- CO2 main greenhouse gas (GHG)
- Climate change is about ‘stocks’ of GHGs (accumulated amount in the atmosphere) not about ‘flows’ (emissions per year)
- 71% of cumulative emissions from 1850-2000 were by US (30%), EU (27%), Russia (8%), Japan (4%), Canada (2%)

The Greenhouse Effect (1)

- The warming of the atmosphere by heat reflected from the earth is called the greenhouse effect.
- The greenhouse effect actually makes the earth habitable. Without the greenhouse effect, the earth would be much colder (- 180^{o}C)!
- Main greenhouse gases (GHGs) in the atmosphere include CO_2 , CH_4, N_2O, CFCs.
- Increased concentration of GHGs causes more heat to be retained in atmosphere, more heat to be reflected back to the earth surface and rise in average global temperatures (global warming).

The Greenhouse Effect (2)

- The ‘natural’ greenhouse effect warms the temperature of the atmosphere to 15 ^{o}C at the Earth’s surface.
- This natural warming allows water to exist on the Earth’s surface, the basis of life support.
- The problem is of “too much” warming due to human interference/activities.
- Also, the earth goes through cooling/warming cycles, but again the pace and scale of human interference is the problem.

Climate Change Then…

IPCC 4th Assessment (February 2007):

"Warming of the climate system is **unequivocal**, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"

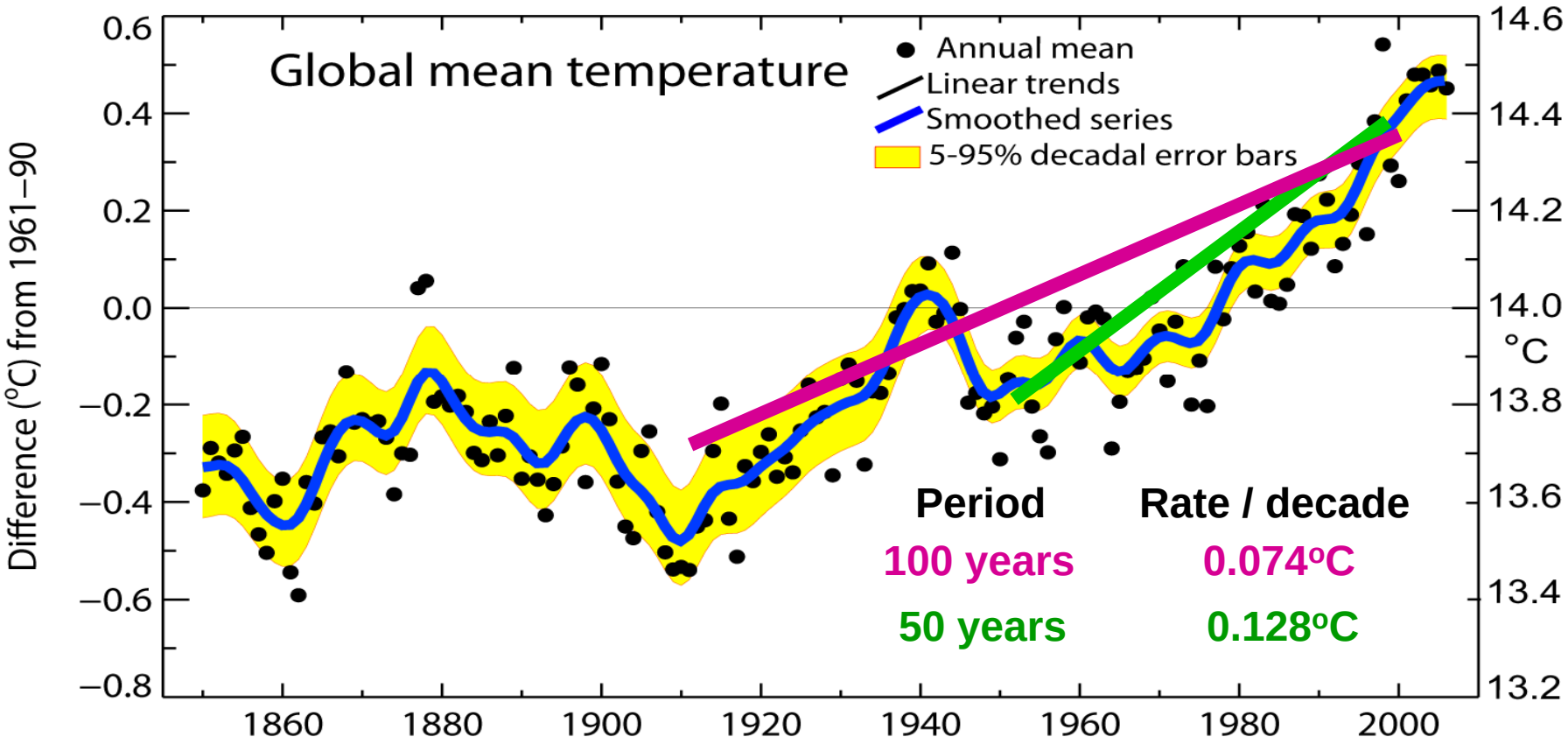
Source: IPCC, *Climate Change 2007: The Physical Science Basis, Summary for Policymakers*

Climate Change Now…

IPCC 5th Assessment (2014):

- "Warming of the climate system is **unequivocal**, and many of the observed changes are unprecedented over decades to millennia
- The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased
- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850
- In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years"

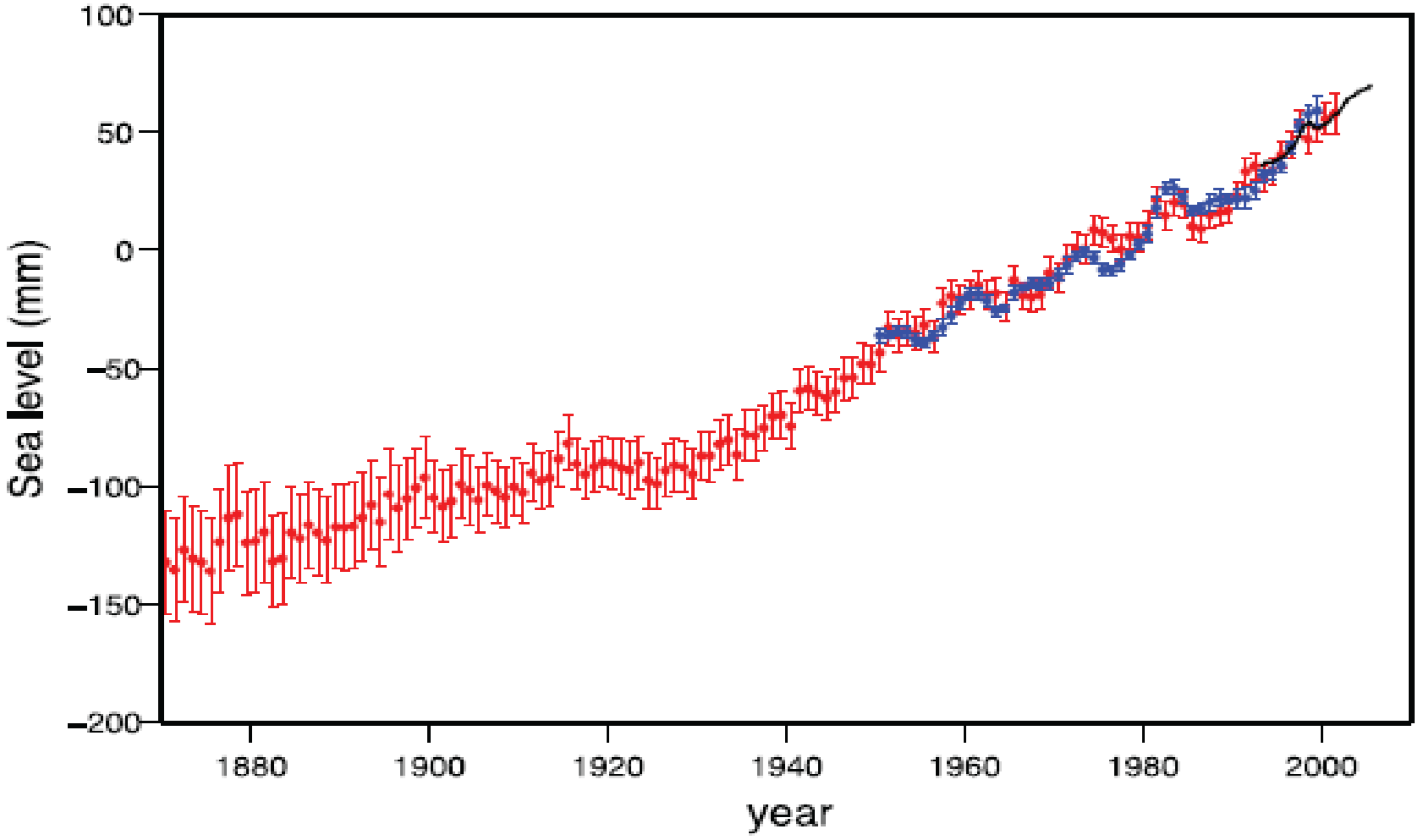
Changes in global average surface temperature



Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

Source: IPCC

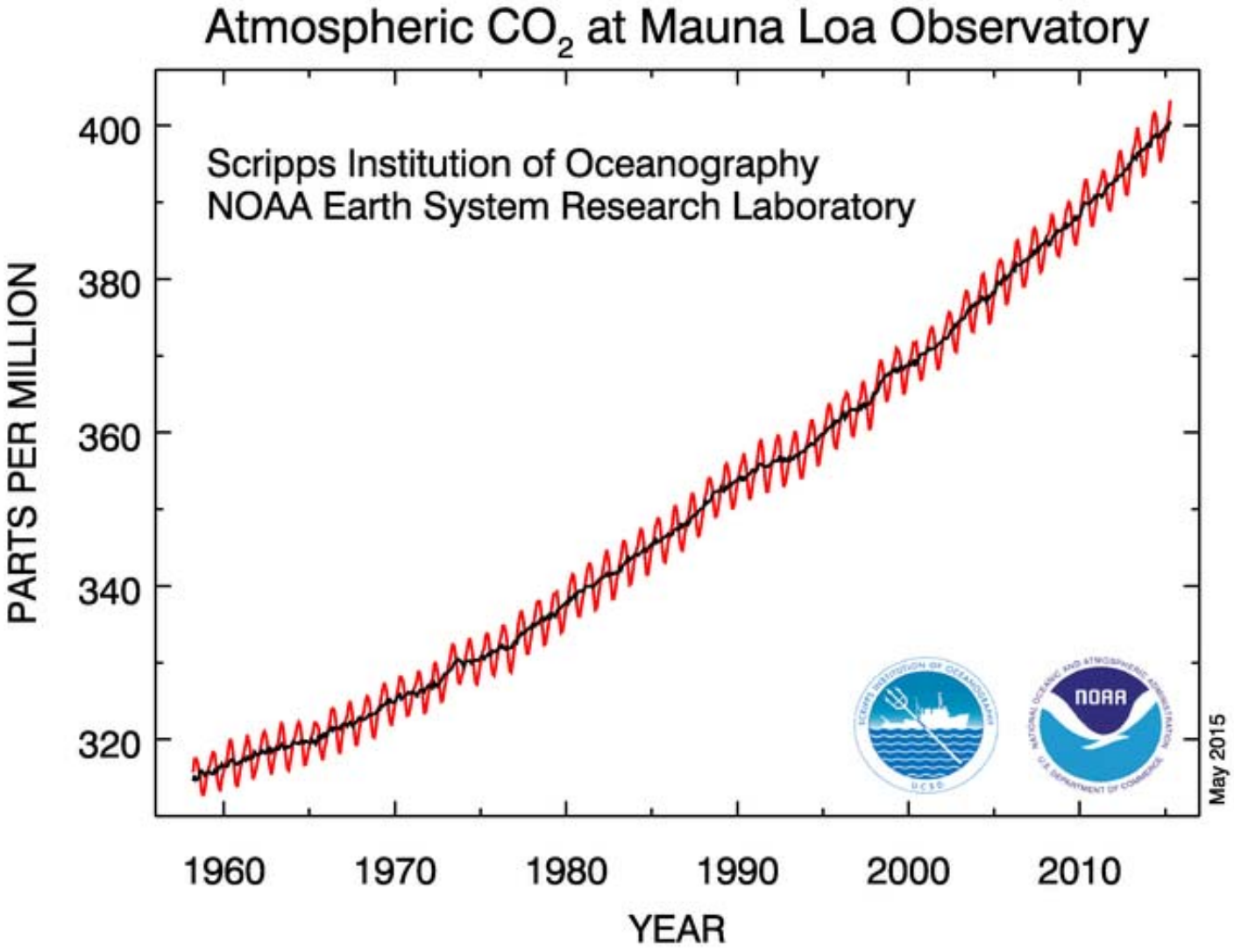
Global average sea level has risen by 1.8mm/year since 1961 and by 3.1mm/year since 1993



Anthropogenic activities are increasing concentration of greenhouse gases (GHGs)

- Main sources of GHG emissions:
  - Burning of fossil fuels (coal, oil, natural gas, shale)
  - Industrial activities
  - Burning and exploiting forests
  - Food production (methane), cattle
  - Waste landfills (methane)

Concentration of CO_2 in the atmosphere has increased from 295 parts per million (ppm) in 1870 to 403 ppm in April 2015


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
NOAA
May 2015

IPCC

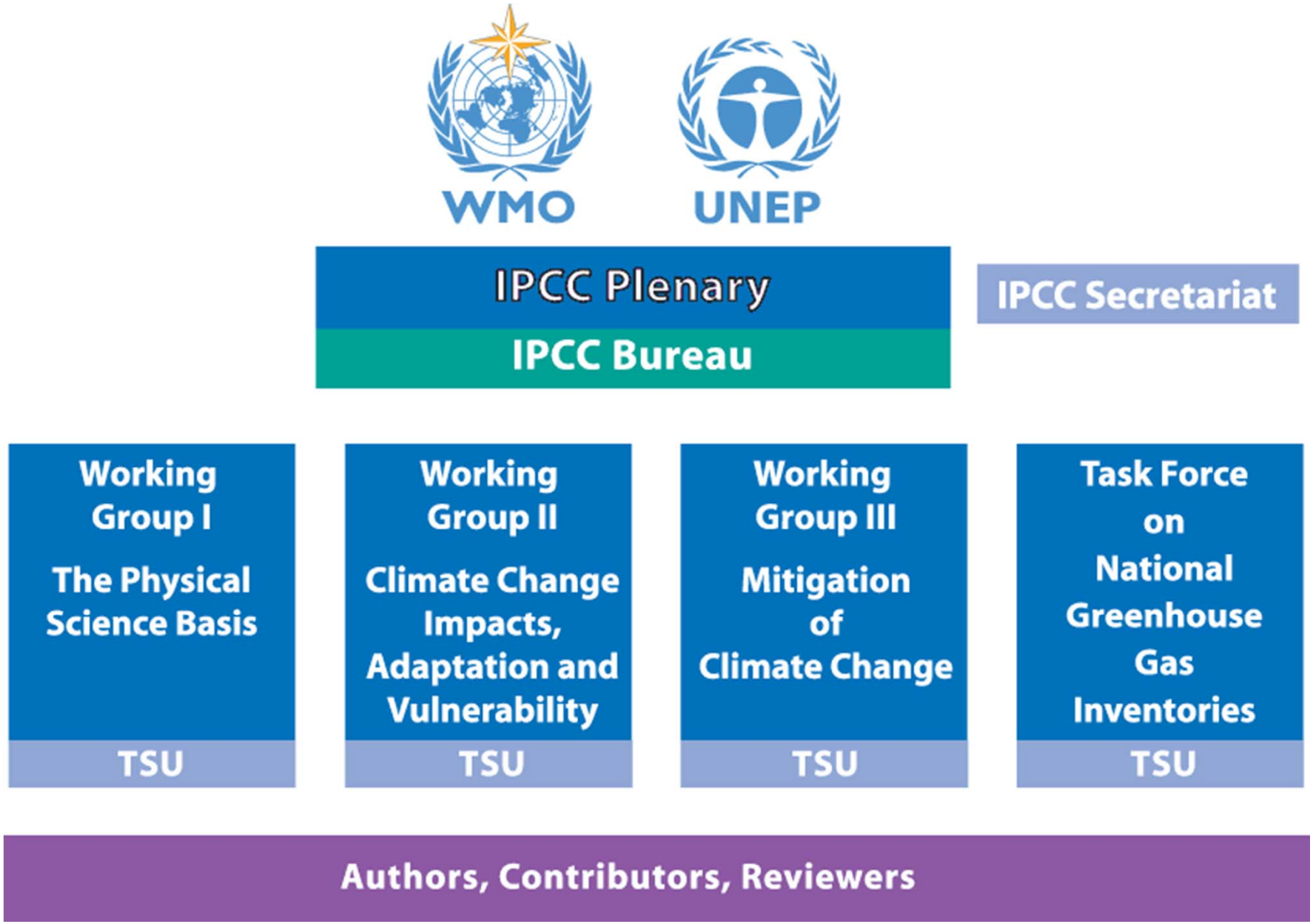
- Formed by United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO) in 1988.
- Conduct ‘assessments’ of state of knowledge of CC, vulnerabilities and consequences of CC, options to avoid, prepare for, and respond to changes.
- All countries that signed UNEP or WMO convention are members of IPCC.

IPCC: ‘scientific’ basis for climate change

“Scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change."

Though IPCC organized within political institutional framework, basically scientific body of leading scientists from around the world. To keep to its mandate and maintain objectivity IPCC does not make policy recommendations (it is ‘policy relevant’ not ‘policy prescriptive’).

IPCC Assessments (five so far) most comprehensive evaluations of climate change on which climate policy is based.


WMO
UNEP
IPCC Plenary
IPCC Bureau
IPCC Secretariat
Working Group I
The Physical Science Basis
TSU
Working Group II
Climate Change Impacts, Adaptation and Vulnerability
TSU
Working Group III
Mitigation of Climate Change
TSU
Task Force on National Greenhouse Gas Inventories
TSU
Authors, Contributors, Reviewers

IPCC Structure

Working Group 1

The Physical Science Basis

(What is happening vis-à-vis CC?)

Working Group 2

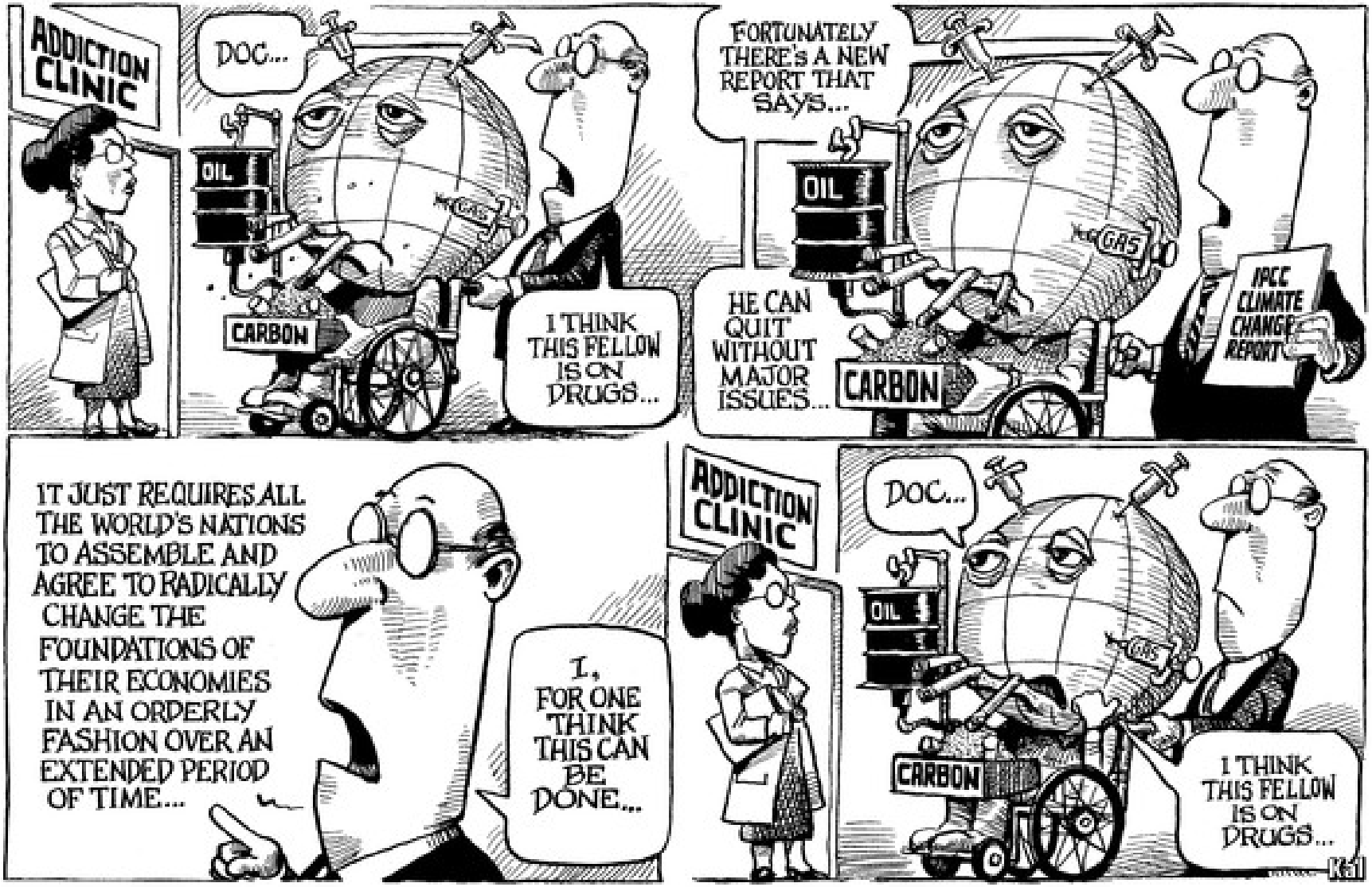
Impacts and Adaptation

(How CC will impact regions, how do we cope?)

Working Group 3: Mitigation

(What should/can we do about it?)

IPCC (WG 3) Pipe Dreams



UNFCCC

Objective: “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”

Non binding convention but lays down the architecture of global negotiations (which is now under threat)

UNFCCC Principles

- Industrialised countries have historical responsibility for climate change and are more developed
- Thus, they are to take the lead in emissions reductions
- Principle of common but differentiated responsibilities (CBDR)
- Commitment to transfer financial resources and technology to developing countries

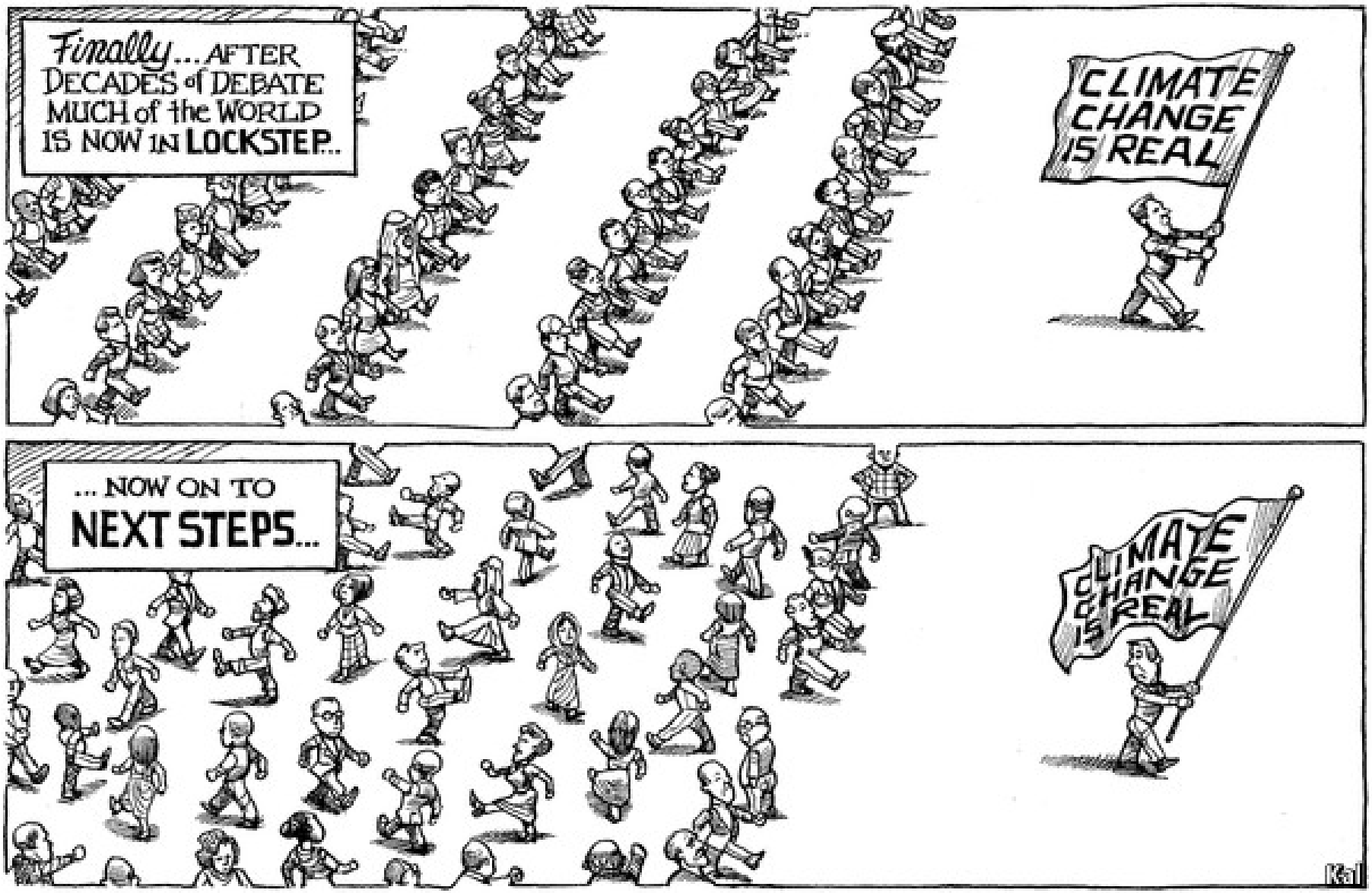
Conference of Parties under UNFCCC

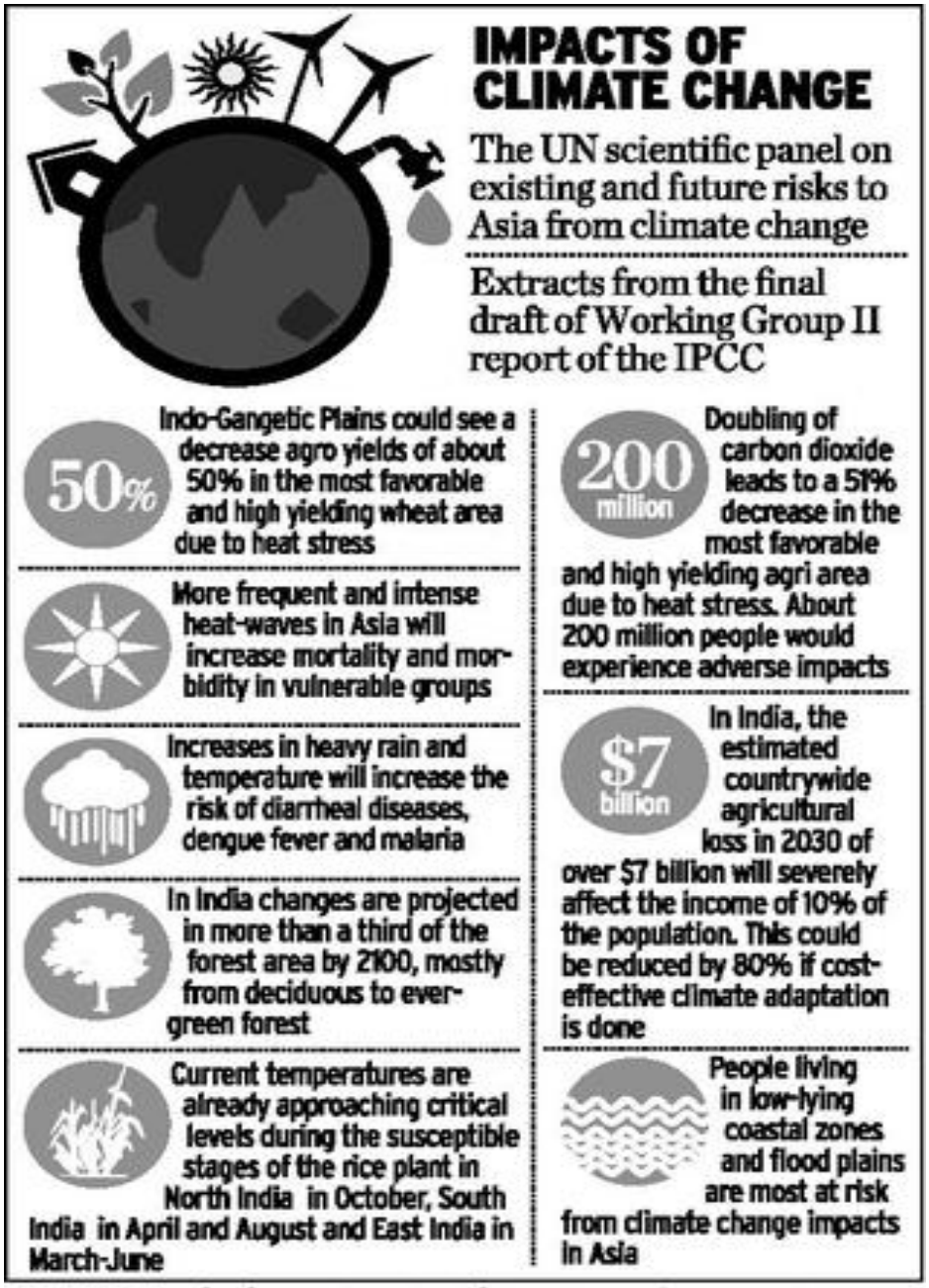
- Annual meeting – COP1 in 1995
- COP3 at Kyoto (1997) “Kyoto Protocol”
- COP8 at New Delhi (2002)
- COP15 at Copenhagen (2009)
- COP21 at Paris (2015)
- and so on…

Political Issues

- The US, a a major emitter, did not ratify the Kyoto Protocol (but is a Party to UNFCCC)
- Pressure to engage developing countries which do not have targets but have rapidly increasing emissions (e.g., China, India)
- Undo UNFCCC separation between Annex 1 i.e., past and rich contributors and non-Annex 1 (all the rest)

Global (In)action?





IPCC Working Group 2

Warns of risks world will face if GHG emissions not curtailed and countries don't adapt quickly enough

For agriculture-dependent countries such as India, the report warns of ominous changes in crop yields. "With or without adaptation, climate change will reduce median yields by 0-0.2% per decade for the rest of the century compared to baseline without climate change."

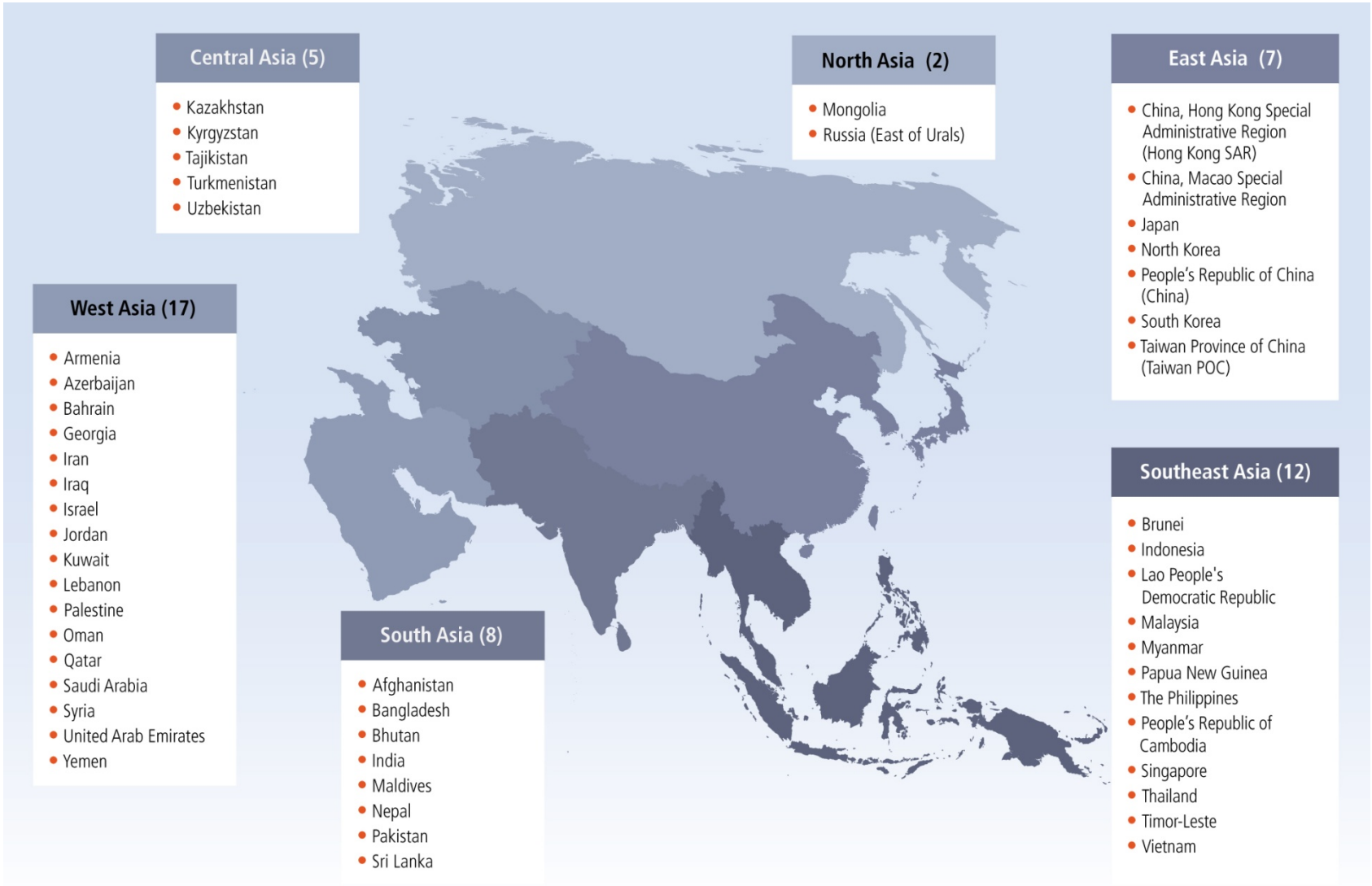
Climate Change and Developing Countries

- Though all countries affected by climate change, they are affected in different ways and to a different extent

- Developing countries will be particularly badly hit, for three reasons:
  - geography (non-temperate latitudes)
  - greater dependence on agriculture
  - fewer resources i.e., greater vulnerability

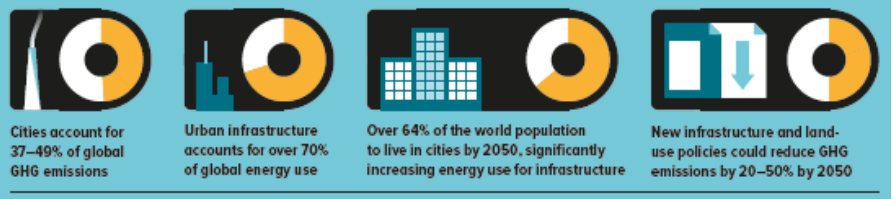
Climate Change and Asia

- **Effects of rising temperatures on Asia**
  - declining crop yields; reduced fresh water supplies; rising sea-levels; increased floods, droughts and extreme weather events; biodiversity loss; higher risk of diseases
- **India-specific assessments**
  - **NATCOM (2004):** General country-wide vulnerability assessment; post-2070 scenarios
  - **INCCA (2010) Indian Network for Climate Change Assessment**
  - Finer-grained 4x4 assessment
  - 2030 time-horizon
  - 4 regions: Western Ghats, Himalayan Region, Coastal India, North-East
  - 4 sectors: Agriculture, Water, Forests, Human Health


Central Asia (5)
Kazakhstan
Kyrgyzstan
Tajikistan
Turkmenistan
Uzbekistan
North Asia (2)
Mongolia
Russia (East of Urals)
East Asia (7)
China, Hong Kong Special Administrative Region (Hong Kong SAR)
China, Macao Special Administrative Region
Japan
North Korea
People's Republic of China (China)
South Korea
Taiwan Province of China (Taiwan POC)
West Asia (17)
Armenia
Azerbaijan
Bahrain
Georgia
Iran
Iraq
Israel
Jordan
Kuwait
Lebanon
Palestine
Oman
Qatar
Saudi Arabia
Syria
United Arab Emirates
Yemen
South Asia (8)
Afghanistan
Bangladesh
Bhutan
India
Maldives
Nepal
Pakistan
Sri Lanka
Southeast Asia (12)
Brunei
Indonesia
Lao People's Democratic Republic
Malaysia
Myanmar
Papua New Guinea
The Philippines
People's Republic of Cambodia
Singapore
Thailand
Timor-Leste
Vietnam

Cities on the front line of a changing climate

Urban centres account for more than half of the world's population, most of its economic activity and the majority of energy-related emissions. The role of cities in reducing emissions and protecting their inhabitants is therefore central to effective climate policies.



Cities account for 37–49% of global GHG emissions

Urban infrastructure accounts for over 70% of global energy use

Over 64% of the world population to live in cities by 2050, significantly increasing energy use for infrastructure

New infrastructure and land-use policies could reduce GHG emissions by 20–50% by 2050

IMPACTS

Climate change is expected to affect numerous aspects of urban life.

Sea-Level Rise

Two-thirds of cities with populations above 5 million are located in the Low Elevation Coastal Zone. Rising sea levels and storm surge flooding could have widespread effects on populations, property, and ecosystems, presenting threats to commerce, business and livelihoods.

Food Insecurity

All aspects of food security are potentially affected by climate change, including access to food, food utilisation and price stability. Climate change is likely to cause food production in some regions (including the ocean due to warming and acidification) to decline.

Extreme Weather Events

Changes in extreme rainfall could cause the amount of sewage released to the environment from combined sewage overflow spills and flooding to increase by 40% in some cities. Inland flooding is often made worse by uncontrolled city development.

Increased Temperatures

The mean temperature rise in some cities could be over 4°C by 2100, with peak seasonal temperatures even higher. More hot days will exacerbate urban heat island effects, resulting in more heat-related health problems and, possibly, air pollution.

Freshwater Availability

Risks to freshwater resources, such as drought, can cause shortages of drinking water, electricity outages, water-related diseases (through use of contaminated water), higher food prices and increased food insecurity from reduced agricultural supplies.

Rank	Urban Agglomeration	Population (million)
1	Tokyo	37.19
2	Delhi	36.06
3	Shanghai	30.75
4	Mumbai	27.80
5	Beijing	27.71
6	Dhaka	27.37
7	Karachi	24.84
8	Cairo	24.50
9	Lagos	24.24
10	Mexico City	23.86
11	São Paulo	23.44
12	Kinshasa	20.00
13	Osaka	19.98
14	New York-Newark	19.89
15	Kolkata	19.09
16	Guangzhou, Guangdong	17.57
17	Chongqing	17.38
18	Buenos Aires	16.96
19	Manila	16.76
20	Istanbul	16.69
21	Bangalore	14.76
22	Tianjin	14.66
23	Rio de Janeiro	14.17
24	Chennai	13.92
25	Jakarta	13.81
26	Los Angeles	13.26
27	Lahore	13.03
28	Hyderabad	12.77
29	Shenzhen	12.67
30	Lima	12.22

Modelling Impact of Climate Change

- Many studies have linked weather and climate to outcomes such as yields, land values, and farm profits.
- Agronomic studies focus on yields -- emphasise dynamic physiological process of plant growth and seed formation (complex and dynamic in nature -- don't easily fit in a regression framework).
- These phenological studies take production systems and nutrient applications as exogenous: do not account for behavioural response by farmers butare the predominant tool for evaluating effects of climate change on crop yields.
- Economic studies use hedonic models to link land values to land characteristics, including climate, using reduced-form linear regression models (e.g., Mendelsohn et al. (1994), Schlenker et al. (2006), Ashenfelter and Storchmann (2006)). Also known as Ricardian approach

Northern Thailand

Rice production in **17 provinces** over **24 years (1989-2012)**

Monthly temperature and precipitation for the growing season (May to October).

Mean: Increase in temperature reduces mean rice production, with an elasticity of around 1 percent, where as more rainfall is beneficial for the crop, with the coefficient being 0.01. (a one percent increase in rainfall increases mean rice yield by 0.01 percent).

Variance: higher the average temperature, higher the variability; higher the rainfall, higher the variability.

China

26 provinces over 23 years **(1985 – 2007)**
Rice, wheat, corn, sorghum, millet, tubers and beans.

Variance: Higher standard deviation of precipitation leads to higher variability. The result is opposite for standard deviation of sunshine., i.e. it has a risk decreasing effect.

Bangladesh

Three major rice crops: Aus, Aman and Boro in Bangladesh for the period 1972–2009.

Climate change increases variability of all three crops.

Higher max temp increases yield variability and higher min temp reduces it, higher rainfall increases yield variability.

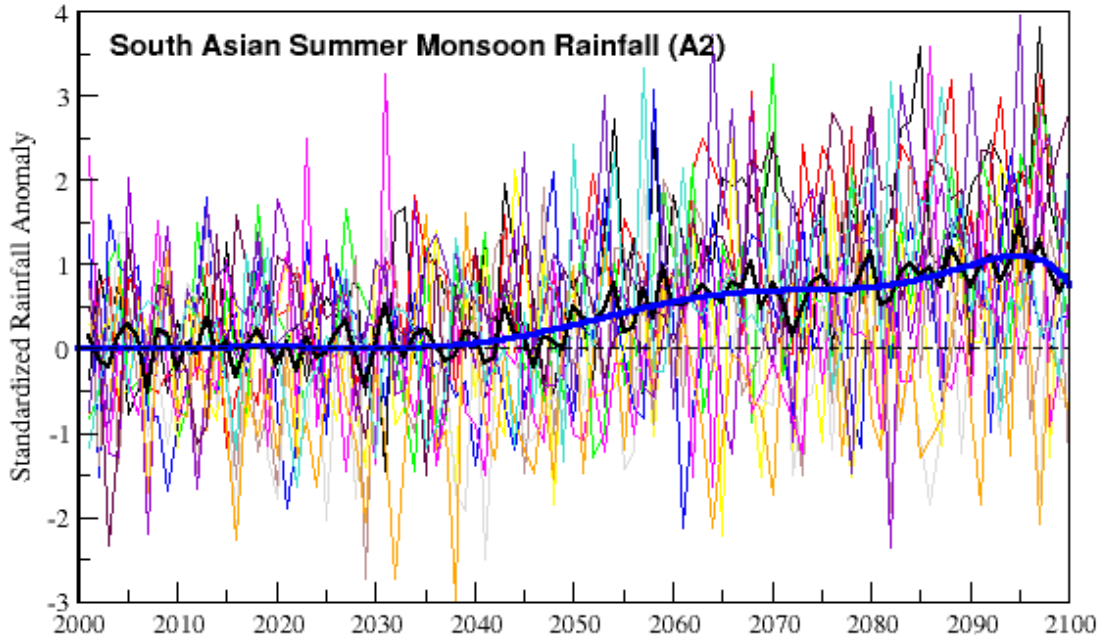
Expected Climate Change in India by 2030

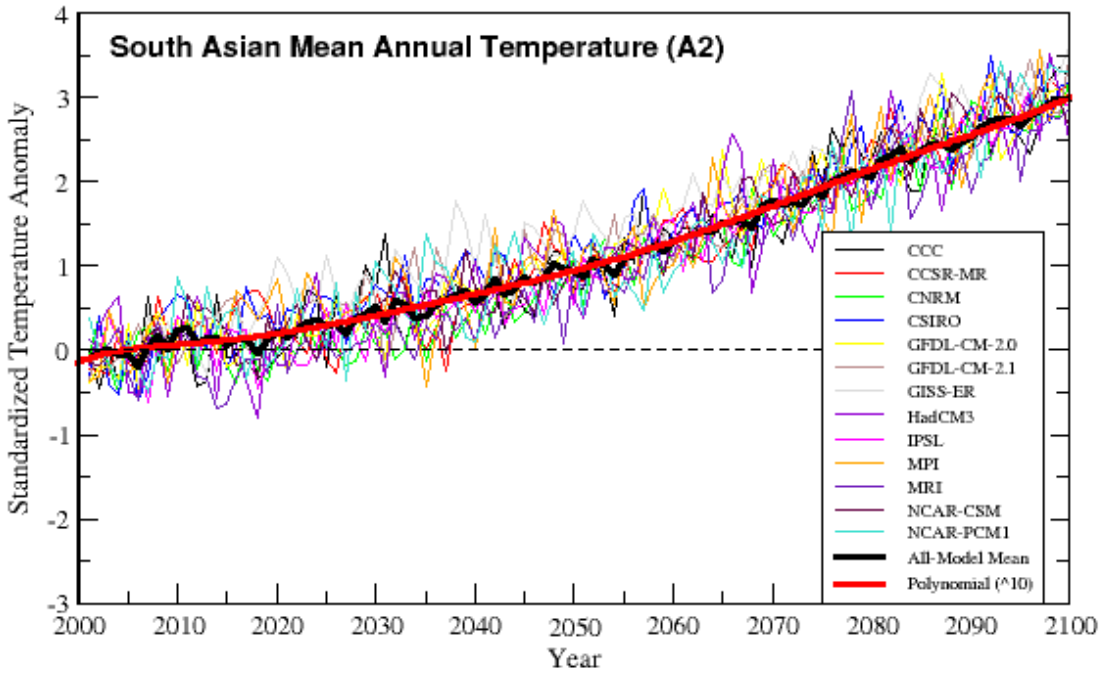
- Regional climate models project by the 2030s, annual mean temperatures and summer monsoon rainfall both expected to increase 'on average'
  - increase in avg. surface temperature by 2-4 degrees C
  - changes in the **distribution** of rainfall (inter-temporal and spatial) during both monsoon and non-monsoon months:
    - decrease in number of rainy days by > than 15 days
    - increase in intensity of rainfall by 1-4 mm/day
  - increase in frequency and intensity of cyclonic storms
- Thus, medium-run projections for climate seem to indicate it will be warmer and wetter, **but with significant regional variation**

Future scenarios for summer monsoon rainfall
and
annual temperature over South Asia under A2 Scenario (High Emissions)

based on IPCC AR4 simulations of AOGCMs

(anomalies relative to current period)



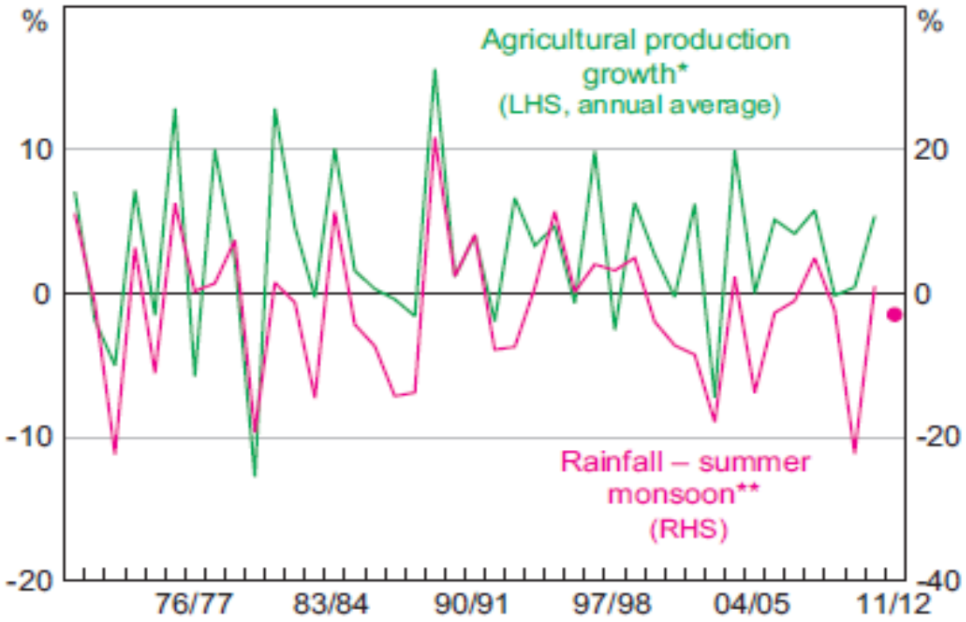


Impact of Climate Change for India (INCCA 2010)

- **Agriculture**
  - Up to 50% reduction in maize yields
  - 4-35% reduction in rice yields (with some exceptions)
  - Rise in coconut yields (with some exceptions); reduced apple production
  - Negative impacts on livestock in all regions
- **Fresh water supply**
  - High variability predicted in water yields (from 50% increase to 40-50% fall)
  - 10-30% increased risk of floods; increased risks of droughts
- **Forests and natural ecosystems**
  - Shifting forest borders; species mix; negative impact on livelihoods and biodiversity
- **Human health**
  - Higher morbidity and mortality from heat stress and vector/water-borne diseases
  - Expanded transmission window for malaria

Importance of Rainfall (Summer Monsoon)

- The summer monsoon is also the most economically important weather pattern.
- Agricultural production in India is strongly correlated with the summer monsoon rainfall (Figure).
- Out of the total net sown area of 141 million hectares (Mha) in India, rain fed area is 85 Mha spread over 177 districts.



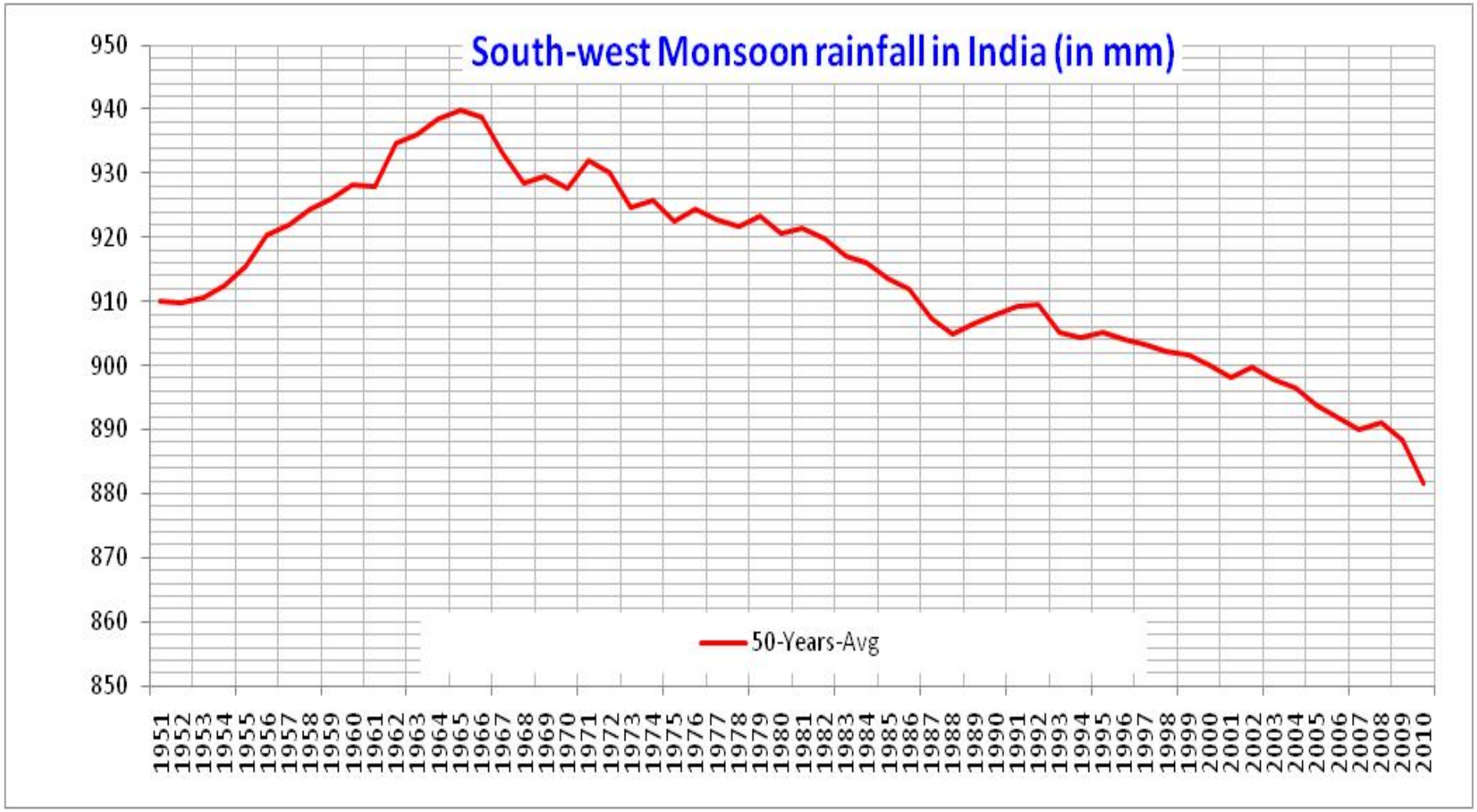
** Percentage deviation from long-run average

Variability in Southwest Monsoon Rainfall

- Mean rainfall 848 mm and standard deviation 83 mm for the period 1871-2009.
- 23 deficient rainfall years and 20 excess rainfall years, slight negative trend of -0.4 mm per year, huge variability:
  - 1871-1920 deficient rainfall years > excess rainfall years
  - 1921-1960 deficient rainfall years < excess rainfall years
  - 1961-2009 deficient rainfall years > excess rainfall years
- **1951-2007: extreme rainfall events and their intensity are increasing**
  - alarming rise in intensity 1980 onwards (Uttarakhand floods – “Himalayan tsunami”, Kashmir)

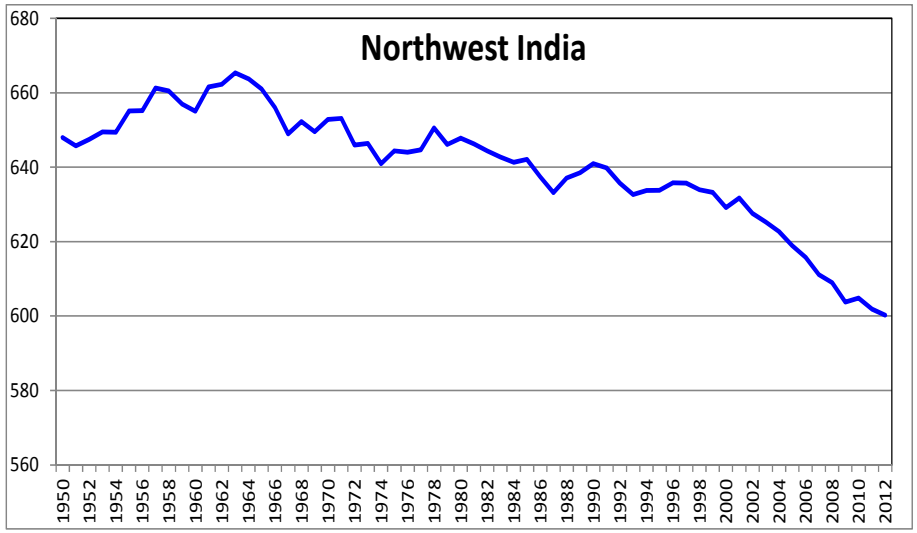
South-west Monsoon Rainfall - National

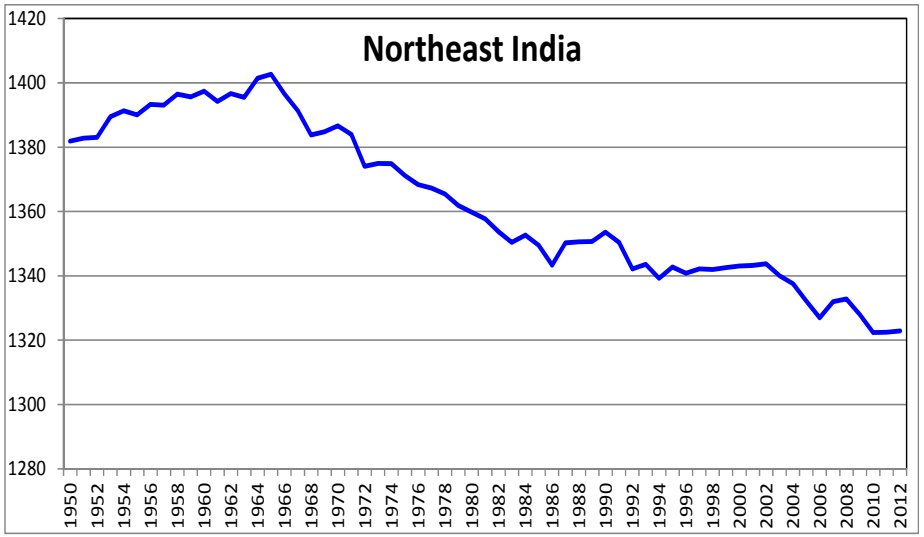
50 year moving average (mm) – Long Period Average (LPA)

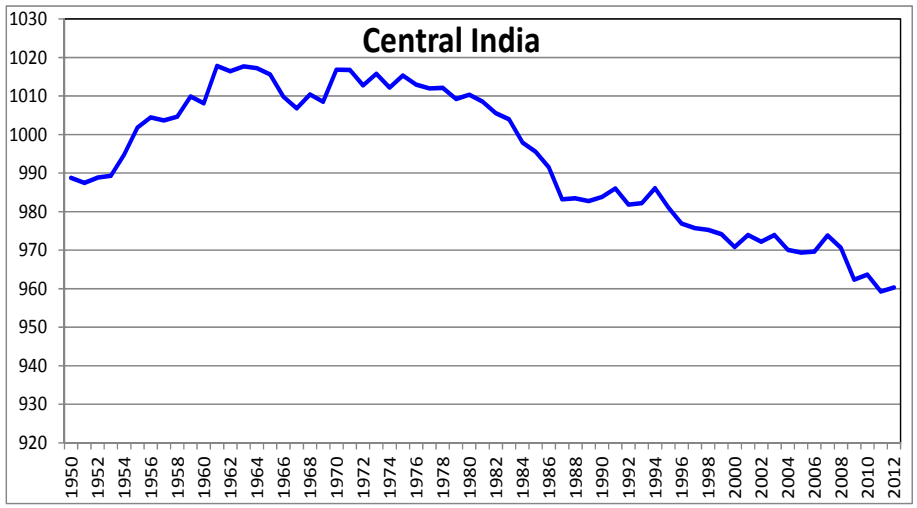


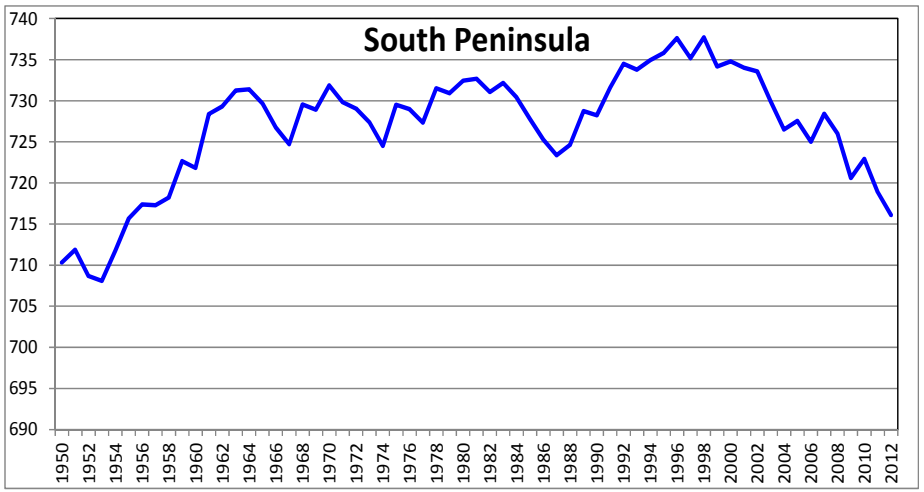
IMD-Long Period Average (LPA) is calculated every 10 years as the 50 years average i.e. IMD LPA for 2011-2019 is 89 cm and it is the average annual rainfall for the country as a whole for the period 1951-2000.

Southwest Monsoon Rainfall – by Region









Implications

- Declining trends in three of four regions, all agriculturally sensitive
- Sharpest decline in Central region, which is most rain-dependent and grows some key crops – pulses, oilseeds, millets
- July-August rainfall, most important for Kharif production, shows sharp downtrend
- Out of 36 meterological sub-divisions 17 show a downtrend in Sothwest monsoon rainfall

Agriculture in India

- Rice--most important food crop in India accounting for 23.3% of gross cropped area and about 43% of total food-grain production, as well as 46% of cereal production.

- Rice (including paddy) ranked highest by value among all agricultural products in India with a total output of about $38.4 billion in 2010

- Millets on the other hand are traditional ‘coarse cereals’ whose importance is more in terms of their role as a staple crop consumed by the poor.

Rice and Millets in India

- Three rice seasons —autumn (pre-*kharif*), winter (*kharif*) and summer (*rabi*)
- Winter or *kharif* rice (sown during Jun-Jul and harvested in Nov-Dec) is the main growing season -- 84% of the country's rice crop
- *Bajra* (pearl millet) most widely grown millet followed by *Jowar* (sorghum)
- Because of their tolerance to difficult growing conditions such as drought, low soil fertility and high temperature, millets can be grown in areas where other cereal crops, such as rice or wheat would not survive

District level climate data

- Publicly available Climate Research Unit (CRU) TS2.1 dataset (Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK).
- Consists of interpolated (on 0.5 degree latitude-longitude grid) global monthly data on variables such as rainfall and temperature from 1901 to 2002. The CRU data was transformed to the district level by simple linear averaging from the gridded data of the CRU dataset by India Meteorological Department (IMD).
- Two variables used from this database – monthly rainfall (mm) and monthly average temperature (min, max, average)

India

- Positive effect of rainfall on yield
- Impact of average temperature on the yield of rice is negative- as temperatures increase, the yield of rice declines but at a decreasing rate
- Results point to strong dependence of yields on climactic factors and agricultural inputs -- consistent with other studies for India

COP 21 (Paris, Dec 2015)

- At Lima (COP20) no breakthrough
- INDC (Intended Nationally Determined Contributions)
- Volunary
- Non binding

IPCC WG1 Storyline

•Each of the past 3 decades has been warmer than all preceding decades since 1850, with the period 2000-2010 being the warmest (p. SPM-3, line 3-4), although the rate of warming over the past 15 years (of 0.05C over the period 1998-2012) “is smaller than the trend since 1951” (which was at 0.12C per decade).

•CO2 atmospheric concentrations increased more than 20% since 1958 and by about 40% since 1750 due to human activity, from 278ppm in 1750 to 390.5ppm in 2011.

•Global mean surface temperatures are projected to increase, likely from 1-4.5C depending on the projection methodology used.

IPCC WG1 Storyline (continued)

Continued emissions of GHGs would cause further warming, with global mean surface temperature changes relative to preindustrial levels likely to be more than 1.5C to more than 2C but unlikely to exceed 4C by 2081-2100. The upper ocean (sea level to few hundred meters deep) would likely see warming of more than 0.5C-2.5C.

NOTE: Working Group I SPM notes climate models were able to reproduce the warming of the second half of the 20th century but "do not generally reproduce the observed reduction in surface warming trend over the last 10-15 years" and that there is "medium confidence that this difference between models and observations is to a substantial degree caused by unpredictable climate variability, with possible contributions from inadequacies in the solar, volcanic, and aerosol forcings used by the models and, in some models, from too strong a response to increased greenhouse-gas forcing".

Message from IPCC WG1 that will play a key role in UNFCCC: Carbon budget and '50 by 50'

- Limiting climate change requires substantial and sustained reductions of CO2 emissions
- Cumulative CO2 emissions need to be limited to about 1000 PgC (petagrams of carbon, 1 PgC = 1 GtC) since the beginning of industrial era if warming is to be less than 2C relative to pre-industrial
- Half of the budget (460-630 PgC) already emitted by 2011 leaving only around half as the budget for 2012-2100
- Only under scenario RCP2.6 is temperature change > **2^0C** unlikely.
- This scenario requires limiting emissions to 140-410 PgC during 2012-2100, or around 270 PgC

Achieving scenario RCP2.6 means average emission reduction of 50% (range 14 - 96%) by 2050 relative to 1990 levels. Actual range of carbon budget for this scenario is 140-410 PgC (513.4 - 1503.5 GTCO2eq).

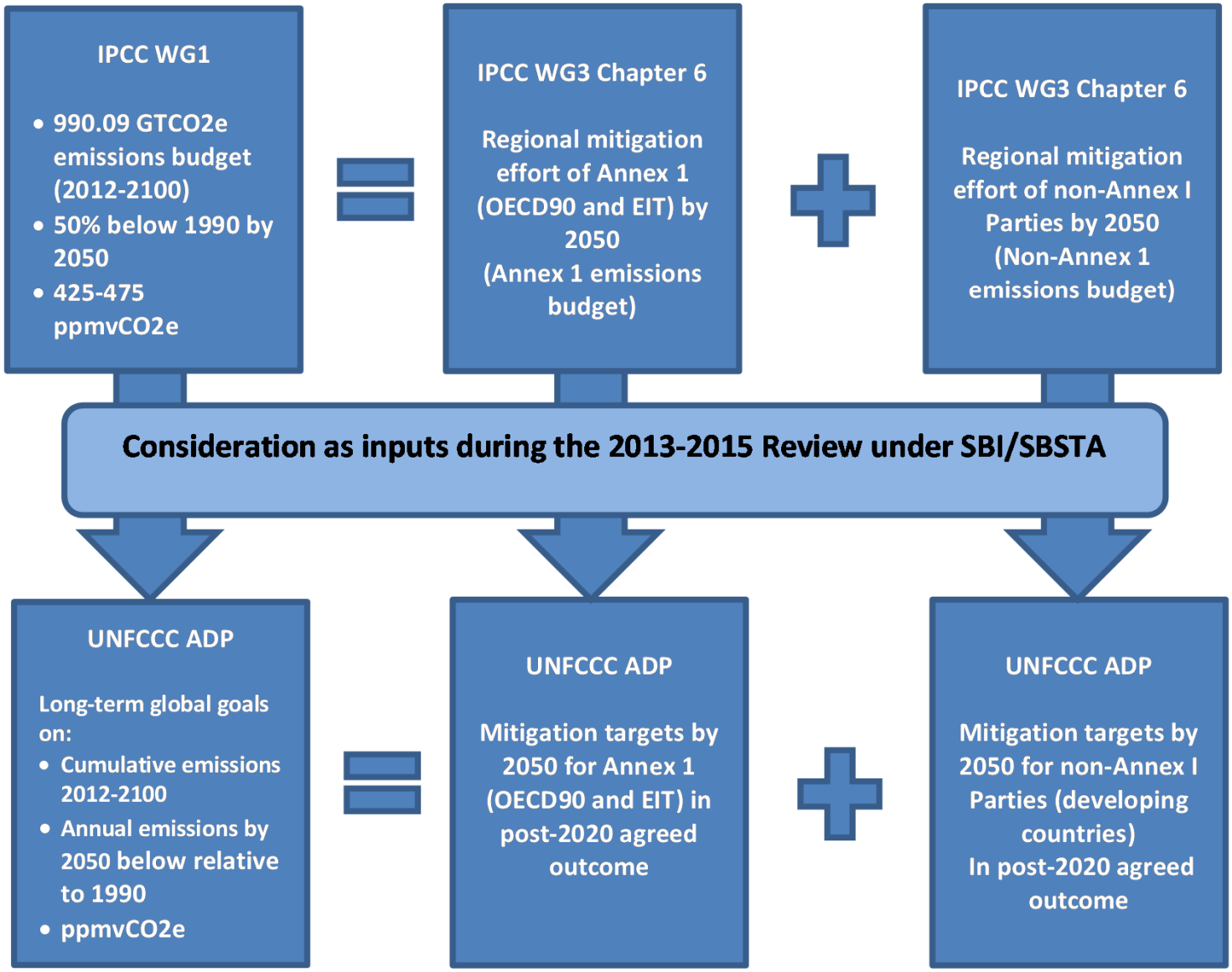
In the context of the onging negotiations it is therefore likely developed countries will use the IPCC Working Group I report and SPM (Summary for Policymakers) as the “scientific” basis, through inclusion as one of the inputs for establishing a long-term global emissions reduction goal of 50% by 2050.

IPCC WG1 + IPCC WG3 Ch6 = Mitigation Targets and Allocation Scheme

• IPCC AR5 Working Group I report suggests that keeping below 2C above pre-industrial levels would require achieving scenario RCP2.6:
→ limiting cumulative global emissions to between 140-410 PgC, or equivalent to 513.4 GTCO2eq -1503.47 GTCO2eq with a mean of 270 PgC (990.09 GTCO2eq)
→ limiting atmospheric GHG concentrations to between 425-475 ppmvCO2eq (mean of 450ppmv)
→ reducing global annual GHG emissions to 50% below 1990 levels by 2050 (i.e. no more than 15.62 GTCO2eq)

Chapter 6 of the IPCC AR5 Working Group III report will then suggest what the regional emission allowances and the regional distribution of the global mitigation effort should be that would be consistent with scenario RCP2.6 – i.e. the extent to which Annex I and non-Annex I Parties, categorized according to geographical regions, could emit GHGs (and conversely the extent to which they would have to reduce emissions)

Transforming IPCC AR5 Results into Negotiated UNFCCC Commitments



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