Climate Change: Its causes and impacts

Professor Dr Fredolin Tangang

IPCC Working Group I (WG I) Vice-Chair
&
Head,
Research Centre for Tropical Climate Change System (IKLIM),
Universiti Kebangsaan Malaysia (UKM)

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

Public Lecture at Universitas Indonesia, Jakarta, Nov 27, 2012

Climate Change

“Climate Change has been recognized as the most pressing environmental problem that the world will be facing in the 21st century”

Outline

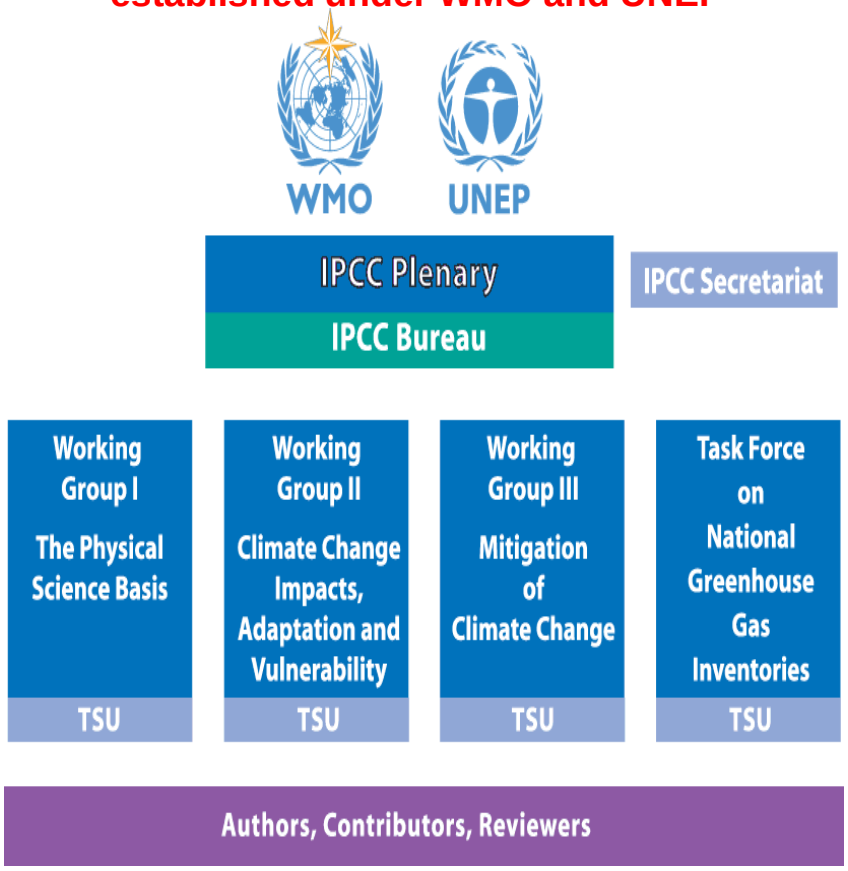
- Introduction
- Introduction to IPCC & how it functions
- Scientific Understanding of Climate Change
- Climate Change Impacts
- COP meetings and its roles
- Summary

What is Climate Change?

…. if you google “climate change” …

Inter-governmental Panel on Climate Change (IPCC)

UNGA 42 proposed the establishment of IPCC and in 1988 IPCC was established under WMO and UNEP



THE IPCC BUREAU

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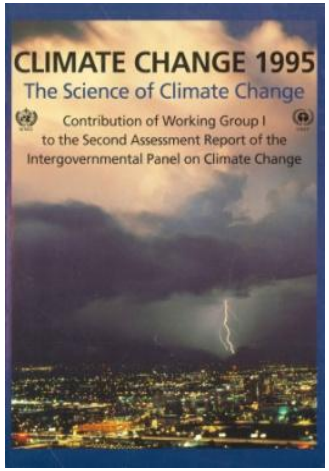
WMO UNEP

Why IPCC?

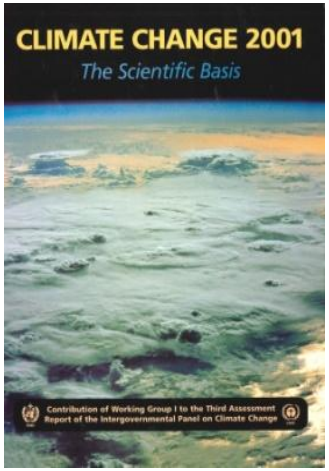
- Prior to the establishment of IPCC, growing number of literatures indicate the Earth's climate system is warming due to increasing GHG concentration in atmosphere
- Independent, objective, fair and transparent assessment of the state of global climate system is required
- The establishment of IPCC was for this purpose
- The IPCC provides such assessment and this becomes the source of information to policy makers and UNFCCC on 1. causes of climate change, 2. potential impacts on built and natural systems and socio-economic, 3. possible response options.
- IPCC Reports are **policy-relevant** NOT **policy-prescriptive**
- Four assessment reports so far & AR5 will be out by 2013.

IPCC Reports

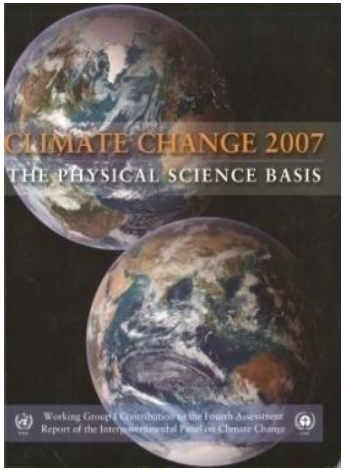
FAR 1990



SAR 1995



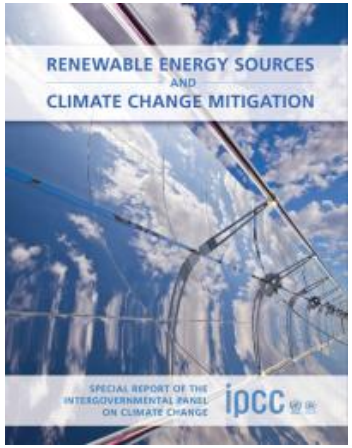
TAR 2001



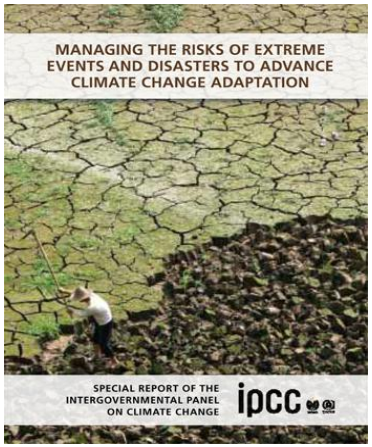
AR4 2007

AR5 2013

IPCC had produced 4 Assessment Reports plus several other special reports including the recently released SREX &



SRREN (2011)



SREX (2012)

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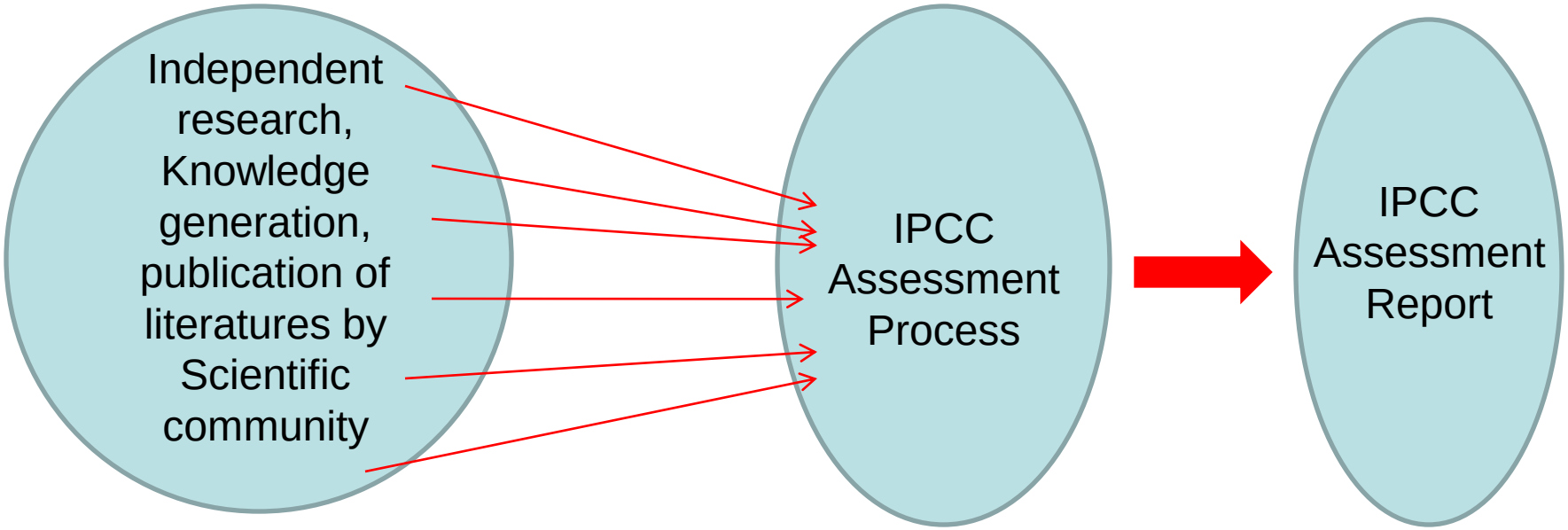
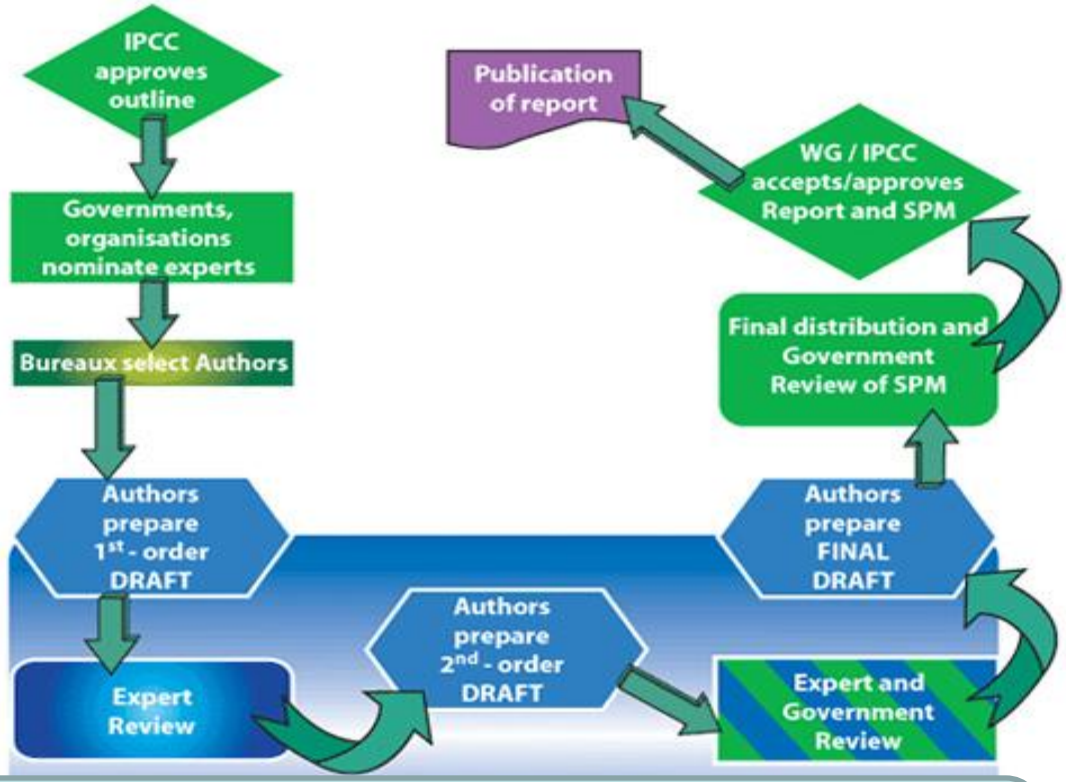
How IPCC produces this its reports?



IPCC doesn't involve at this stage

IPCC Assessment Process



IPCC assessment is based on available peer-reviewed publications

Key « Rules » for IPCC Work

- COMPREHENSIVE – all the latest relevant scientific, technical and socio-economic literature published wordwide is assessed
- BALANCED – differring views are reflected in the reports
- OPEN – selection of authors from all countries and relevant discipline, wide review process by experts and governments
- TRANSPARENT – strict clear procedures

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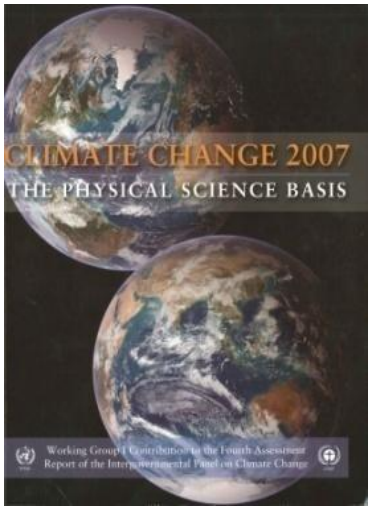
Dr Edvin Aldrian
Director
Center for Climate Change and Air Quality Agency for Meteorology Climatology and Geophysics BMKG, Indonesia

IPCC WGI Lead Author (LA) for AR5 Chapter 14: *Climate Phenomena and their relevance to Future Regional Climate Change*

--- the only scientist from the Southeast Asia region in the LA team

The IPCC Fourth Assessment Report (2007)

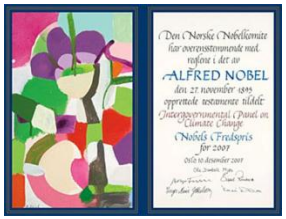


(WG I)

(WG II)

(WG III)

"**Warming of the Earth's Climate System is unequivocal**" (IPCC AR4, 2007)



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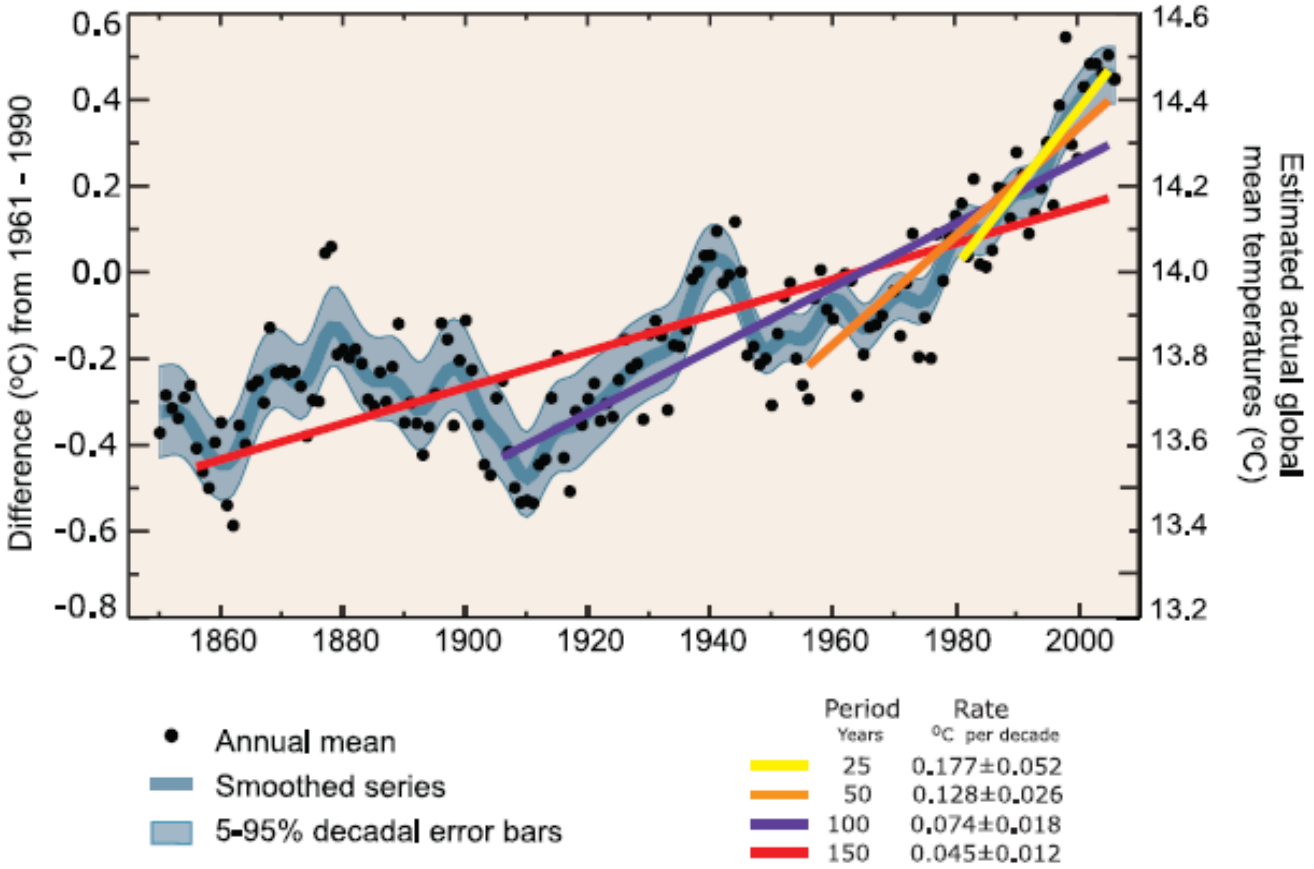
Global Mean Temperature



(IPCC 2007)

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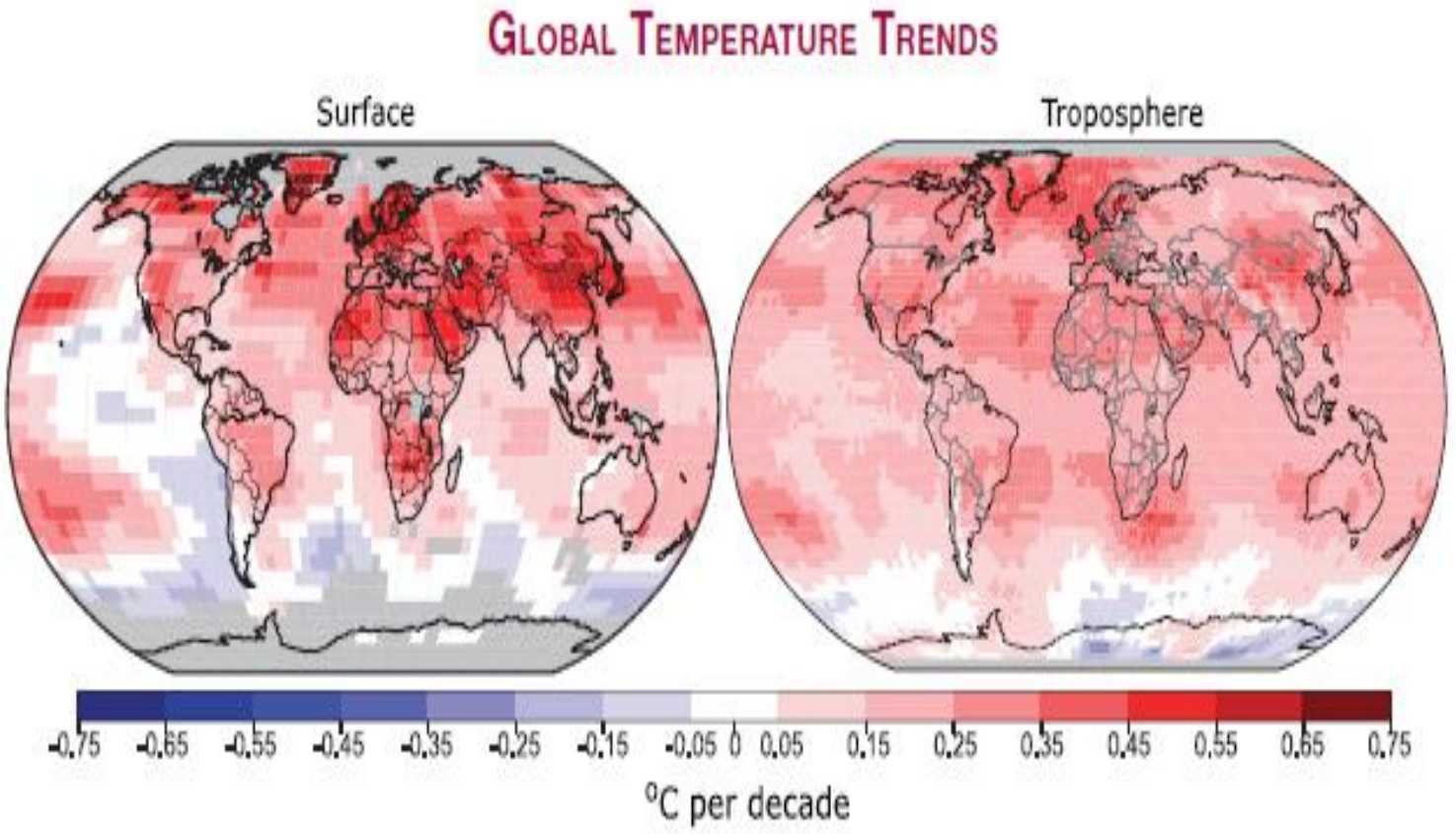
Changes in surface and tropospheric temperatures



(IPCC 2007)

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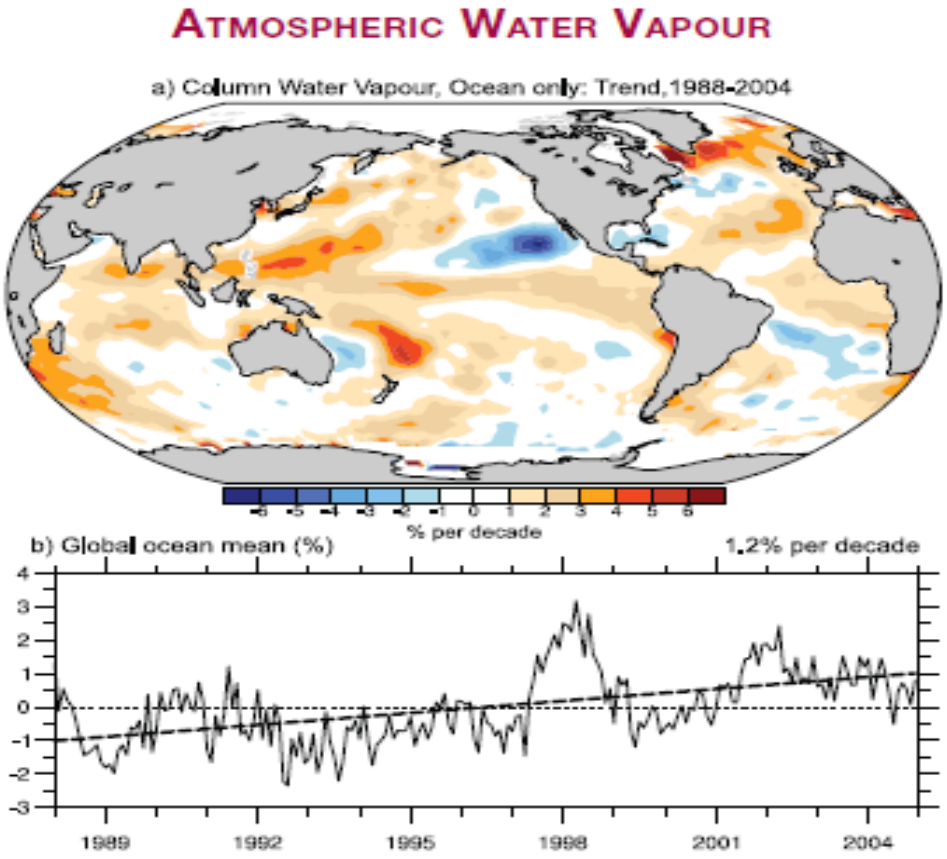
Changes in Atmospheric Water Vapor



(IPCC 2007)

WV increases consistent with warming atmosphere

Expected to provide strong positive feedback and enhances the warming

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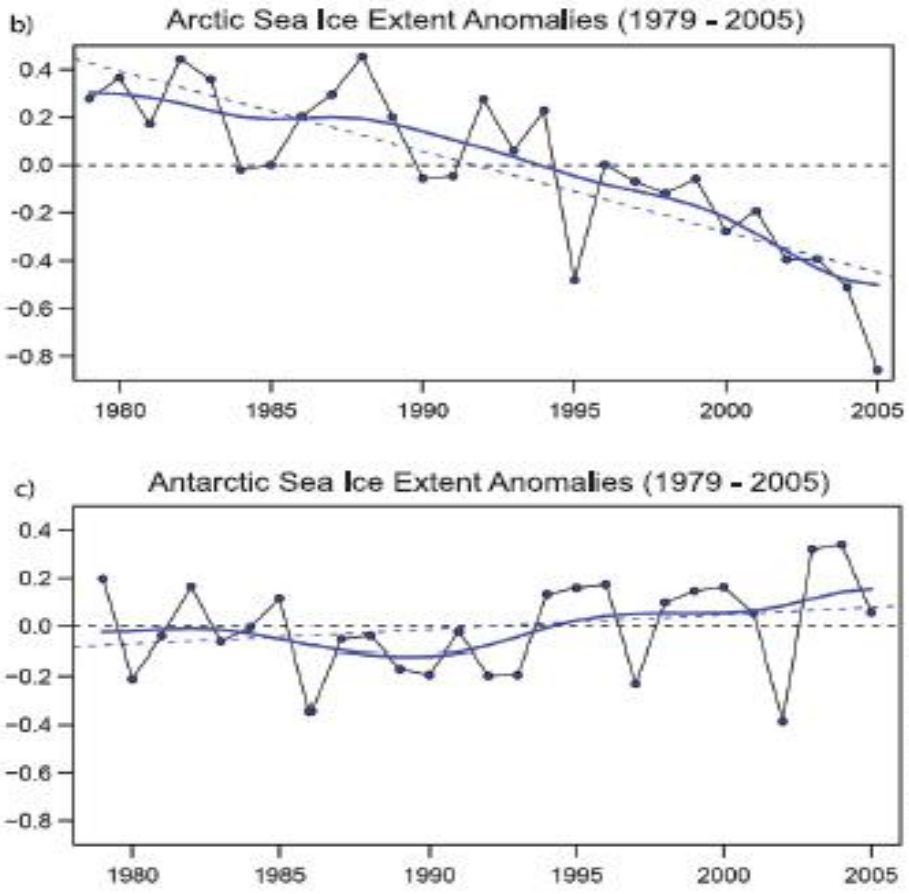
Changes in Sea Ice Extent



(IPCC 2007)

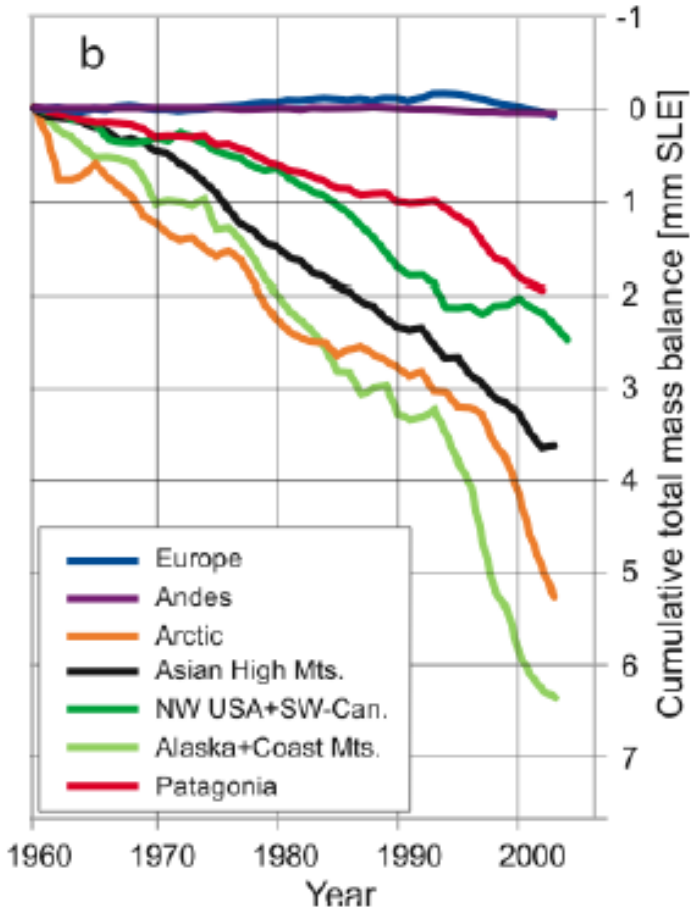
Arctic Sea Ice extent 1980 – 2005 decreases -2.7% per decade

Summer minimum Arctic Sea Ice extent decreases -7.4% per decade

New studies indicate Arctic Sea would be ice-free during summer sooner than expected (IPCC will asses this AR5)

Antarctic sea ice extent: no significant trend

Changes in Glacier Mass Balance

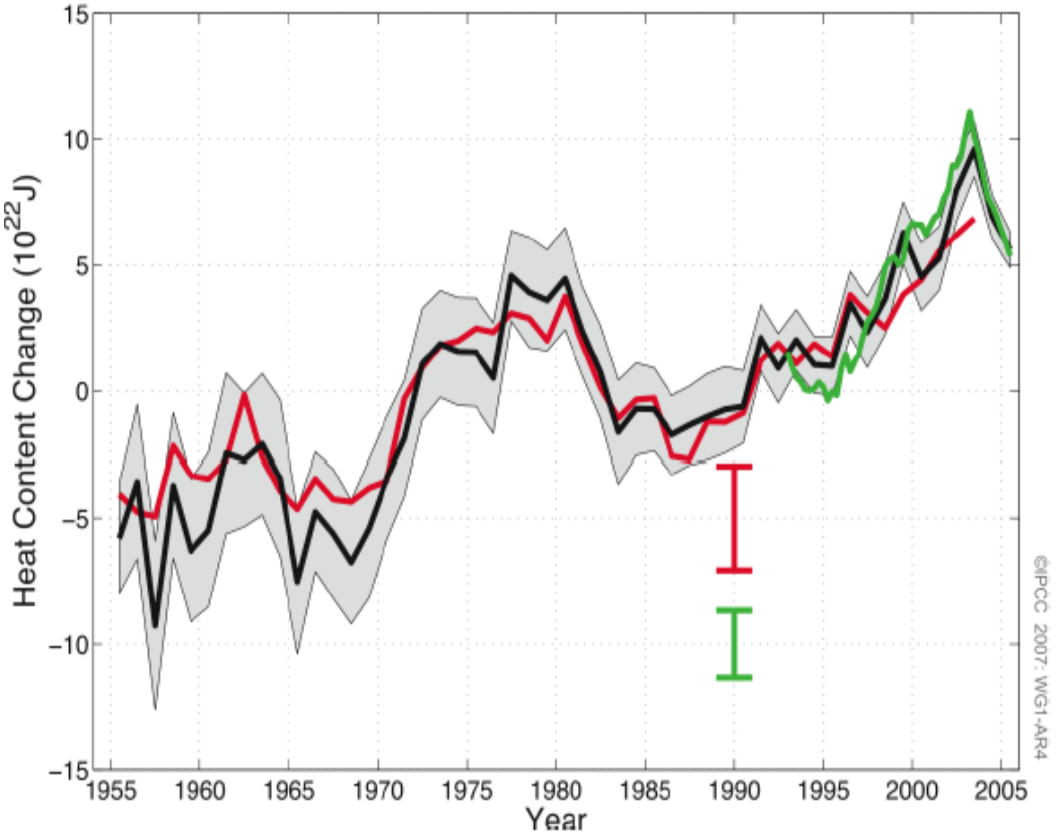


(IPCC 2007)

Cumulative loss of glacier mass over many regions

During the 20th century, glacier and ice caps have experienced widespread mass losses and have contributed to sea level rise

Changes in Ocean Heat Content

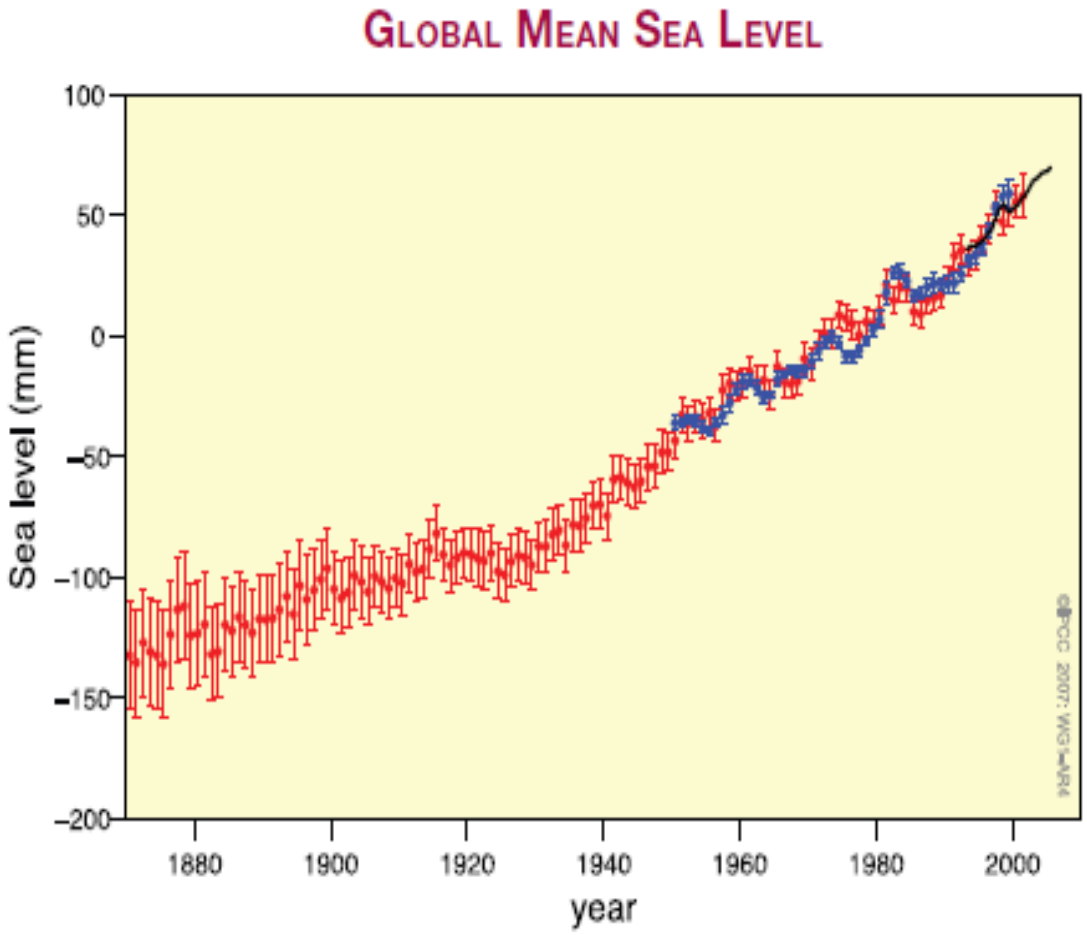


(IPCC 2007)

Ocean temperatures have increased to depths of at least 3000 m

Ocean warming contributes to sea level rise due to thermal expansion

Changes in Global Mean Sea Level



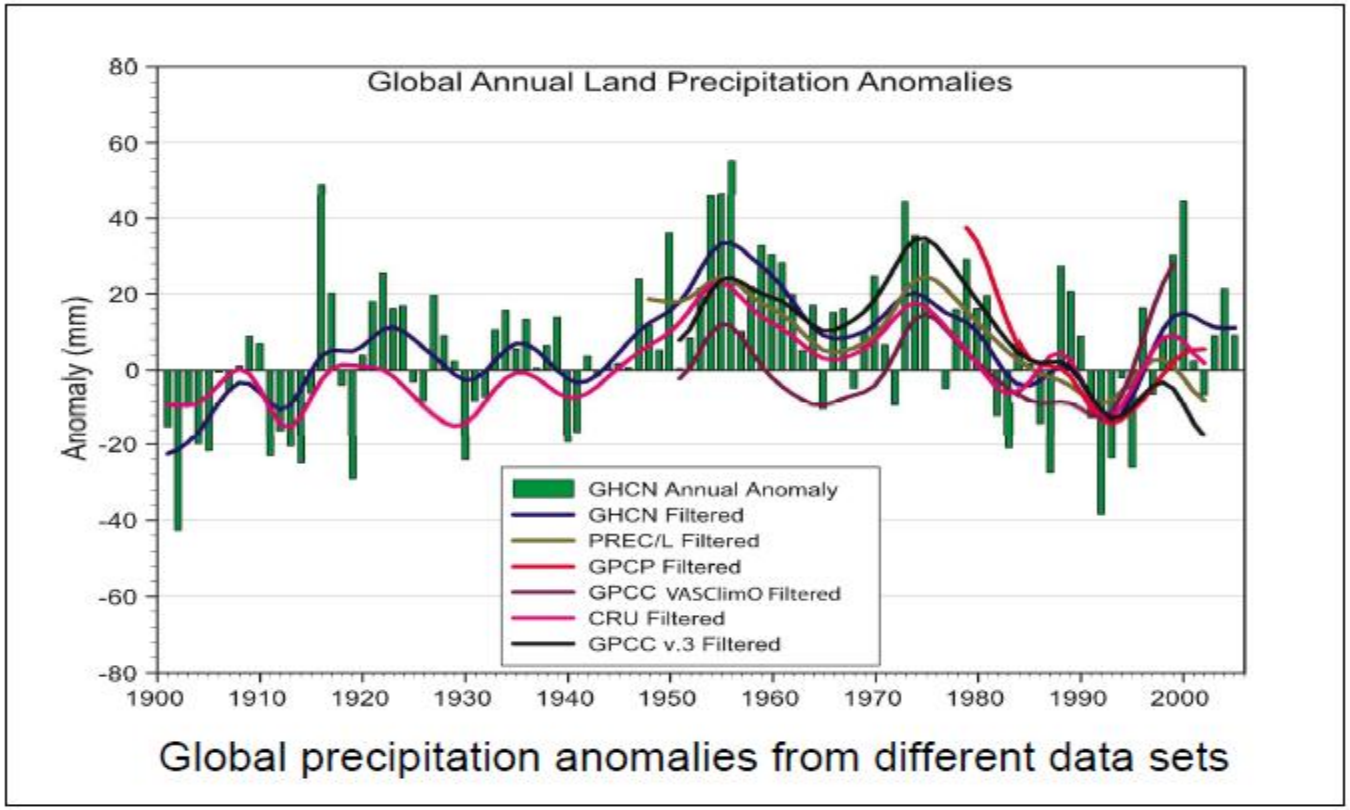
(IPCC 2007)

Sea level has been rising since 1961 at an average rate of 1.8 mm/year

The rate accelerated since 1993 at 3.1 mm/year.

Changes in Precipitation

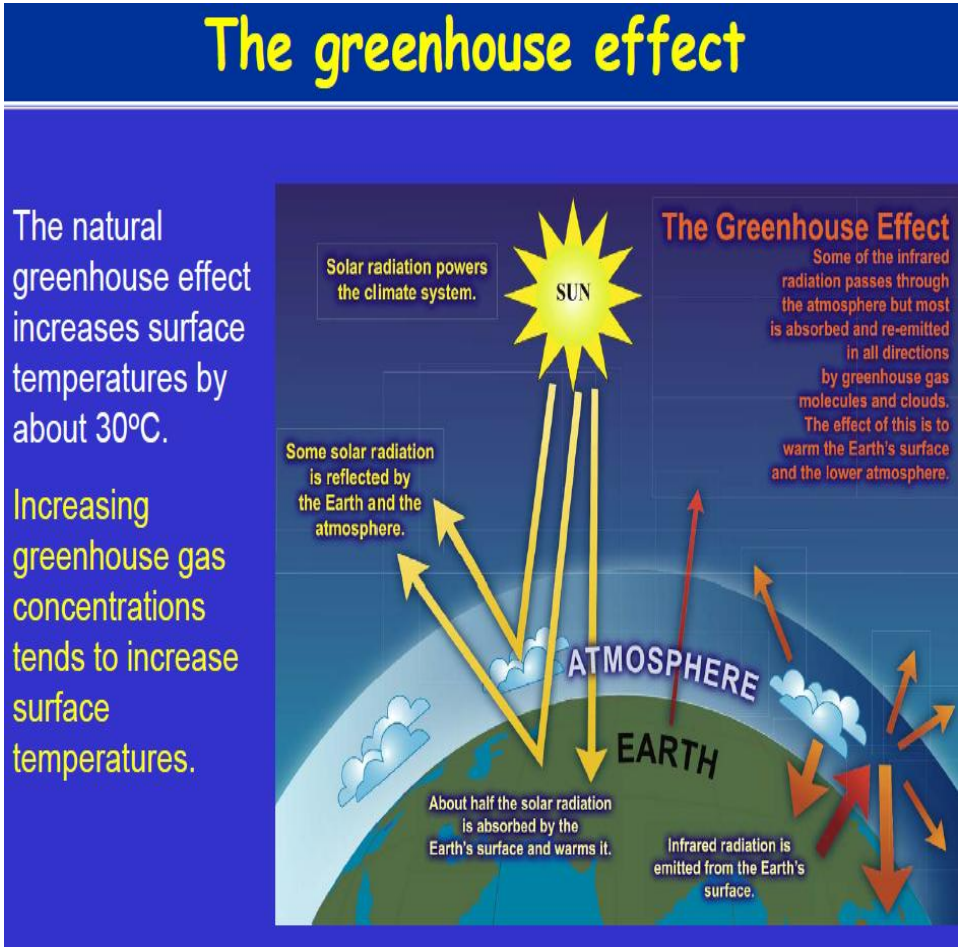
Observed changes in precipitation (2)

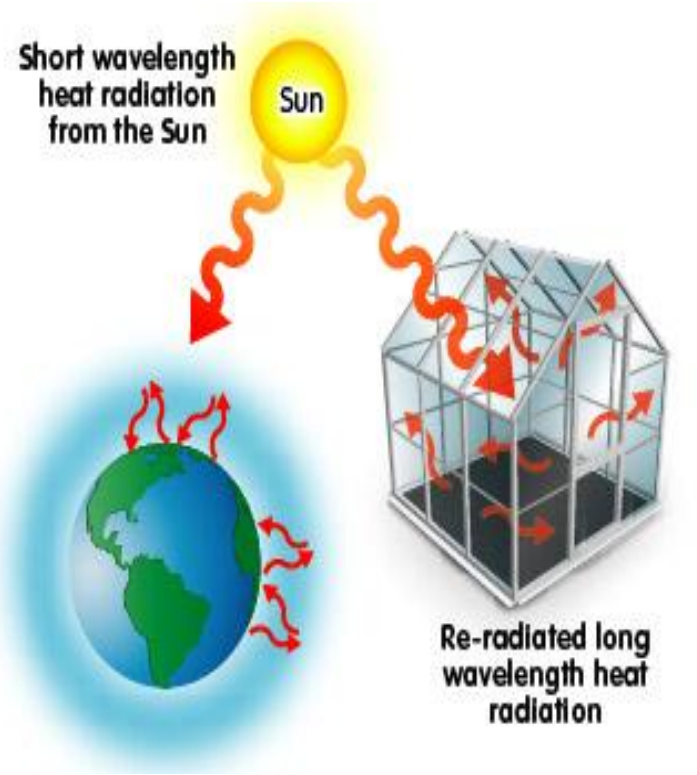


Global precipitation anomalies from different data sets

(IPCC 2007)

What drives Climate Change?





(IPCC 2007)

Greenhouse Effect was discovered in early 1900

Svante Arrhenius

(1859-1927, Nobel Prize for Chemistry 1903)

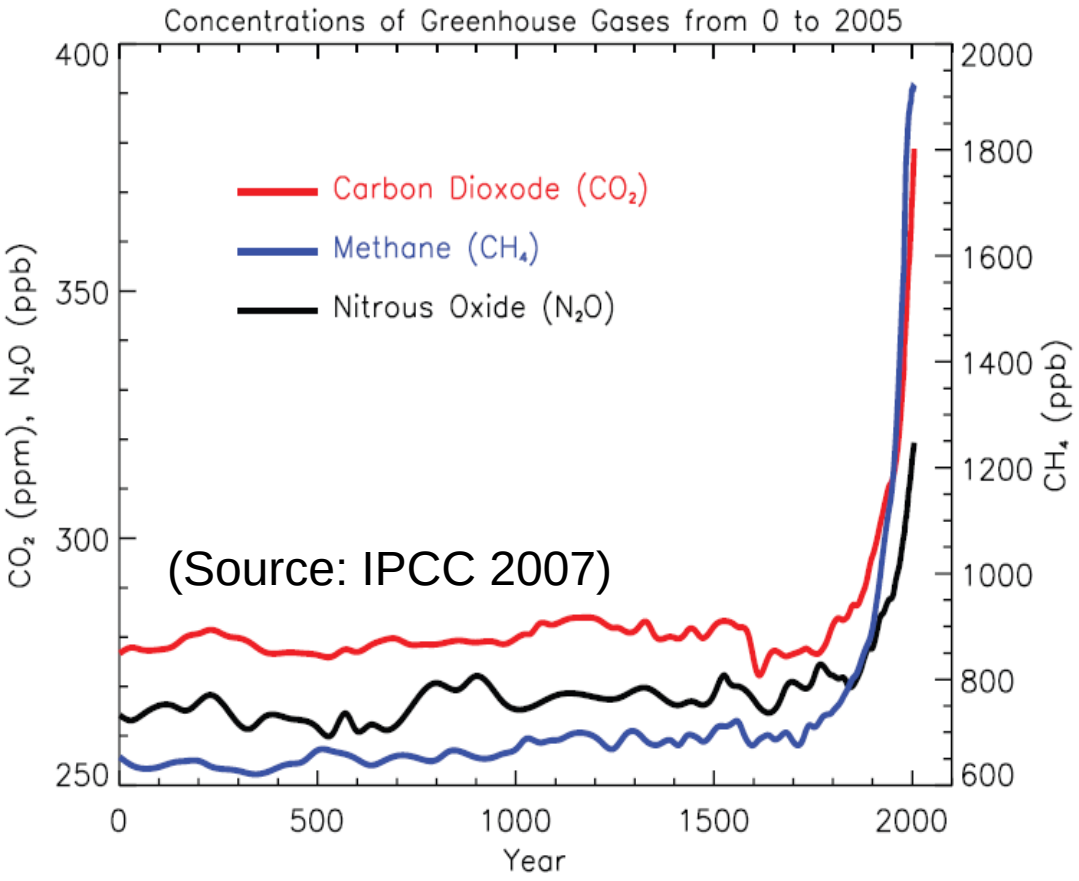
- Published a paper in early 1900 highlighting the greenhouse effect

- The first person to predict that emission of CO_2 from burning of fossil fuels would cause global warming

- Predicted doubling of CO_2 would result 5-6^oC increase in mean temperature (IPCC projection was 2-4.5^oC)

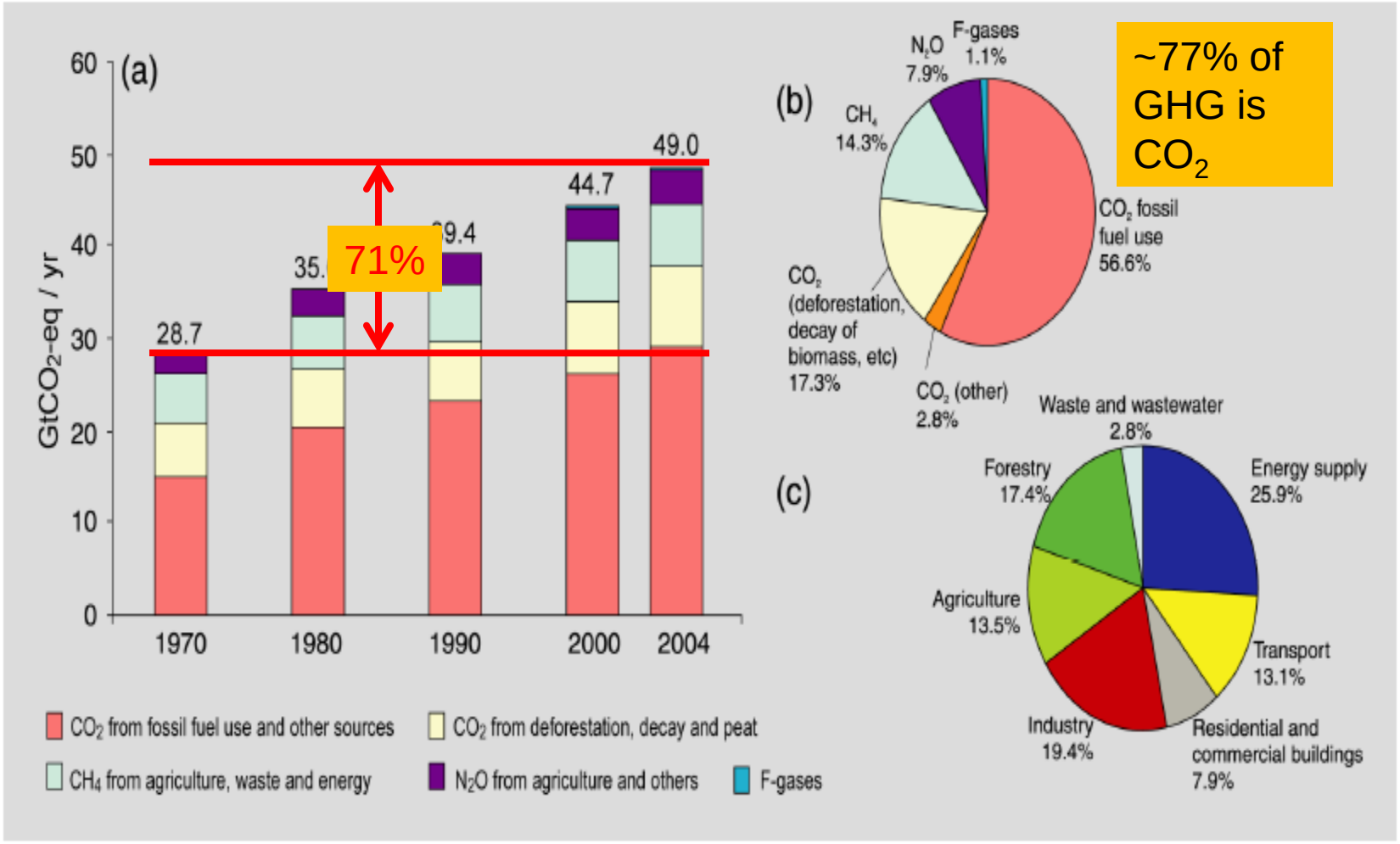
- Predicted it would take 3000 years to double the CO_2 concentration (IPCC estimated this would be achieved within this century).

GHG Emission in 20th century

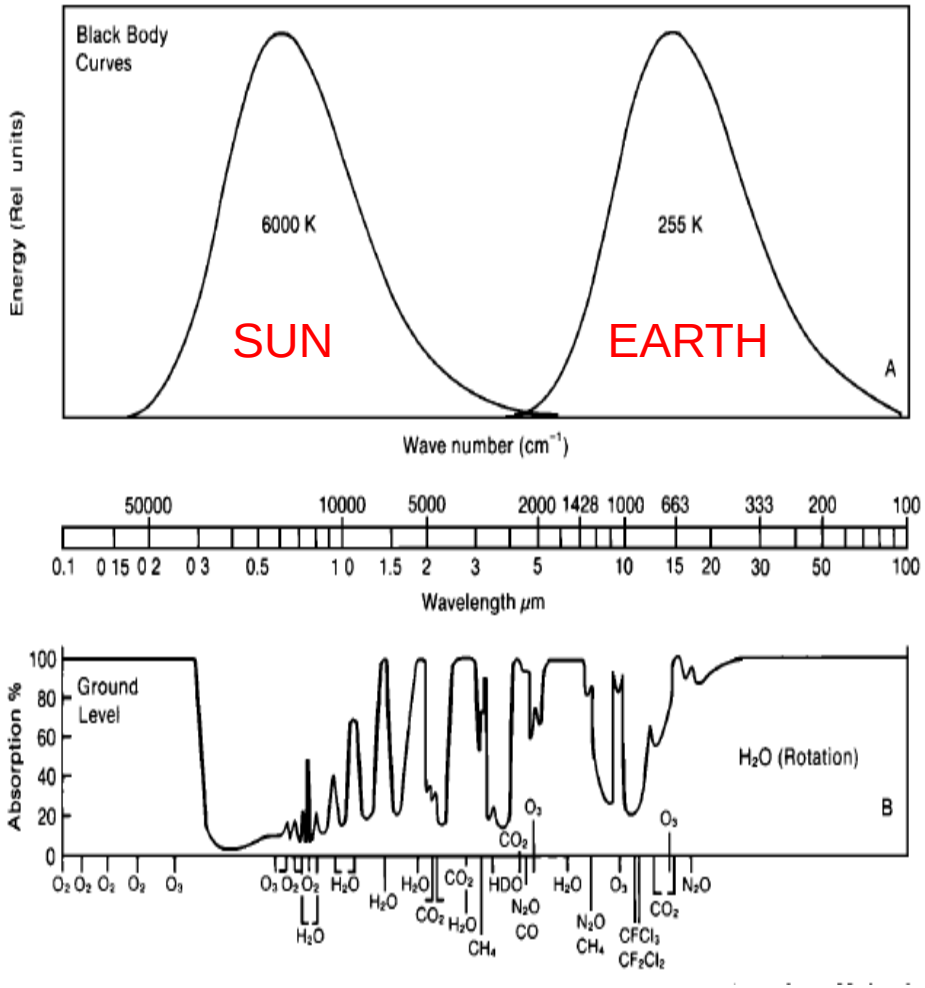


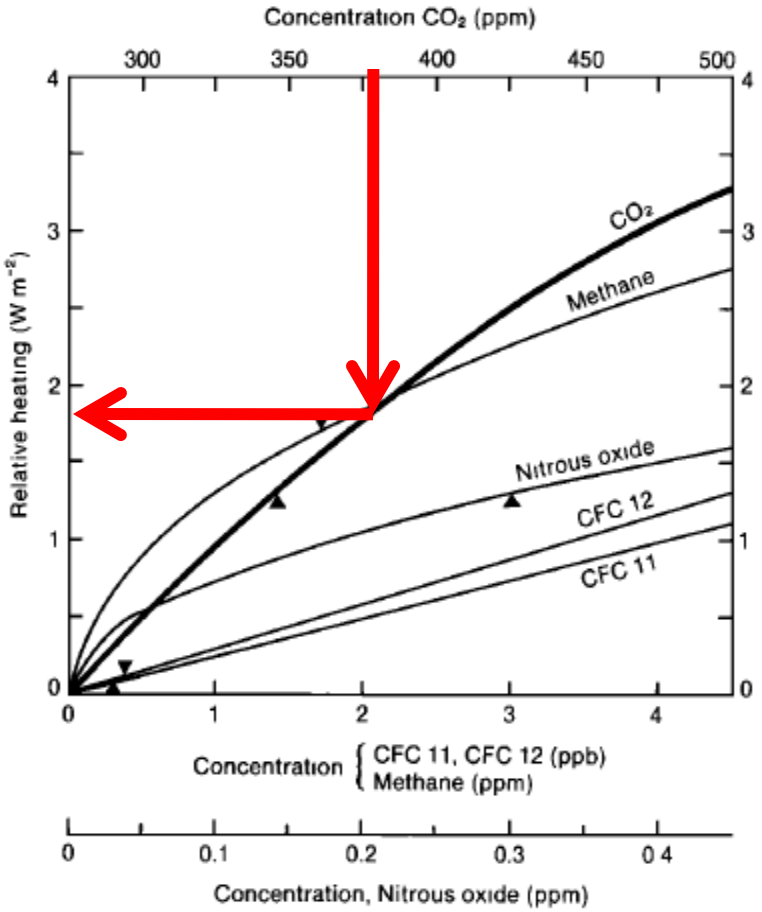
Dramatic increase of GHG concentration the atmosphere since the beginning of European Industrial Era

Global anthropogenic GHG emissions



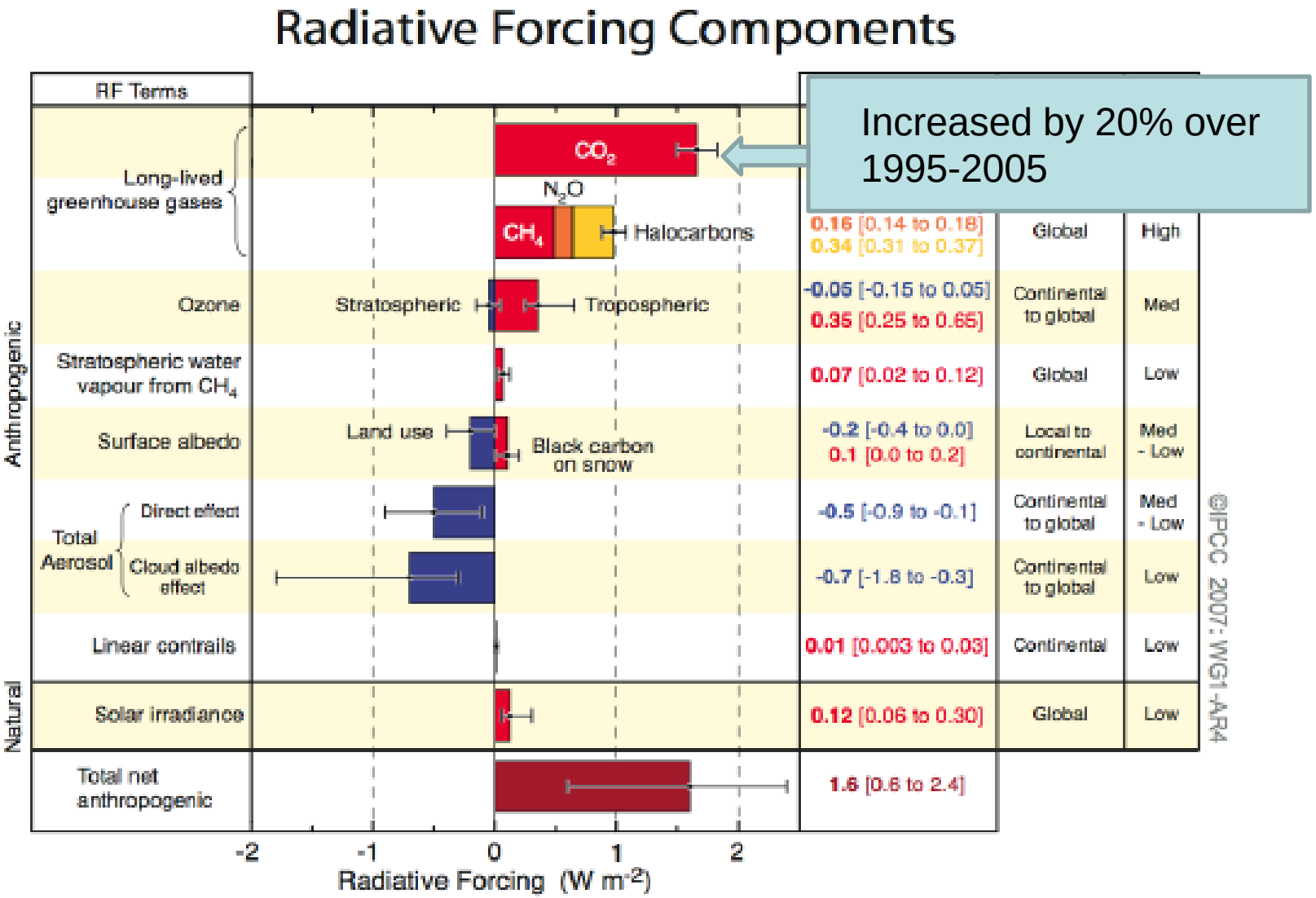
(Source: IPCC 2007)



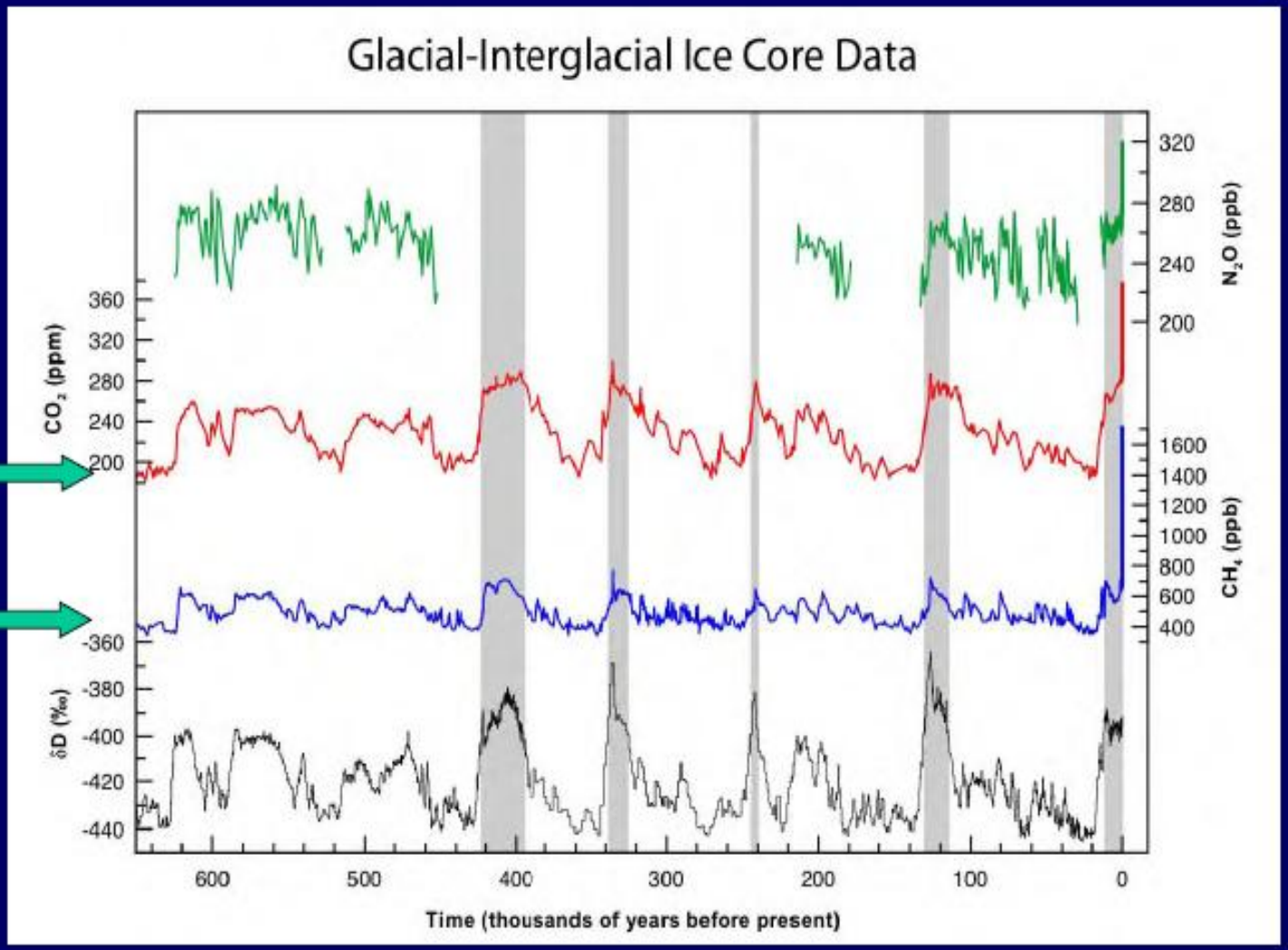


(Mitchell, 1989)

Change in Energy Balance in the Climate System (Used to compare different drivers of climate change)



(Source: IPCC 2007)

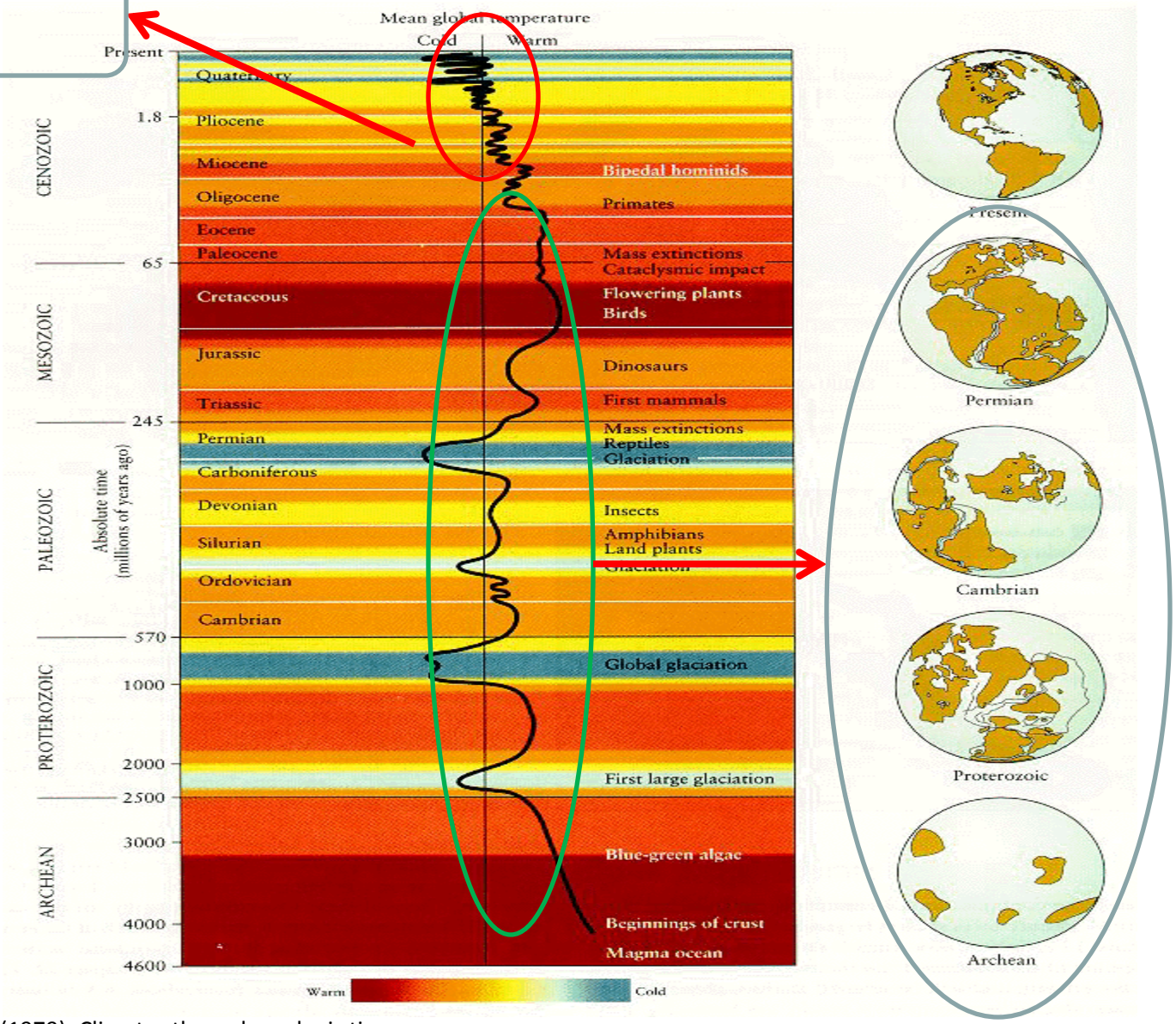


The atmospheric concentration of CO_2 and CH_4 in 2005 exceeds by far the natural range of the last 650,000 years

(Source: IPCC 2007)

Change &Variation of Climate Over Time

Earth's orbital changes



Source: Frakes (1979), Climates through geologic time

The Earth's Climate System

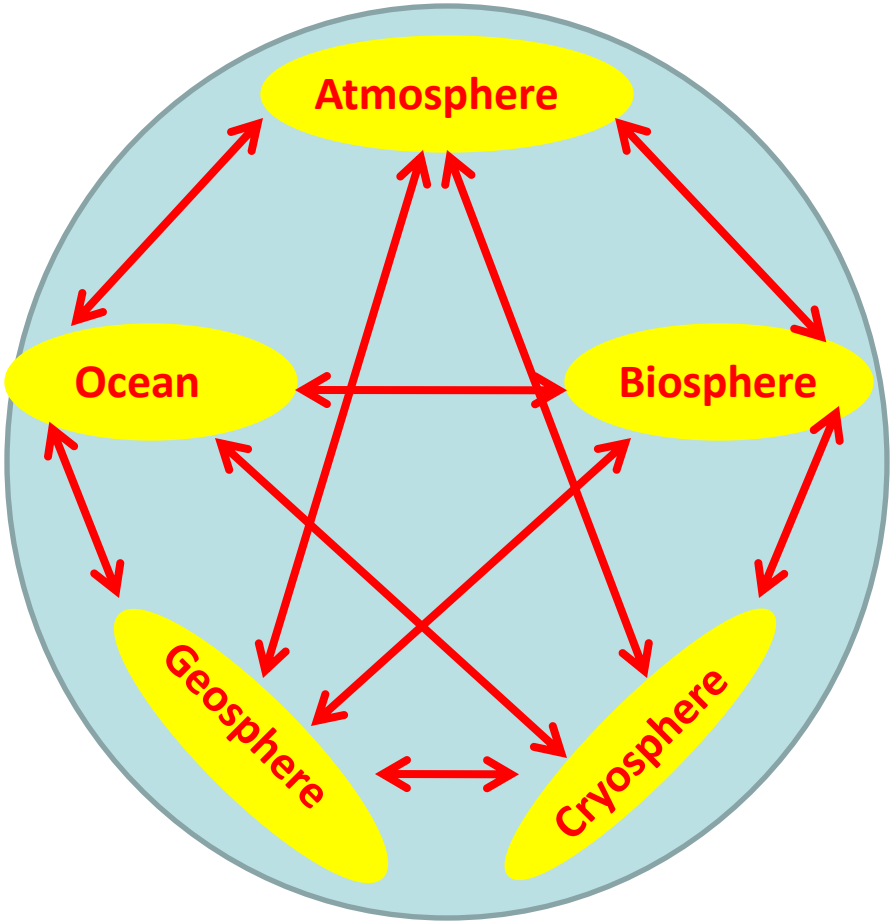
Natural Forcing

Sun's strength changes

earth's orbital changes

Volcanic eruptions

Internal multi-ways Interactions



Climate Variability

Changes in Atmosphere

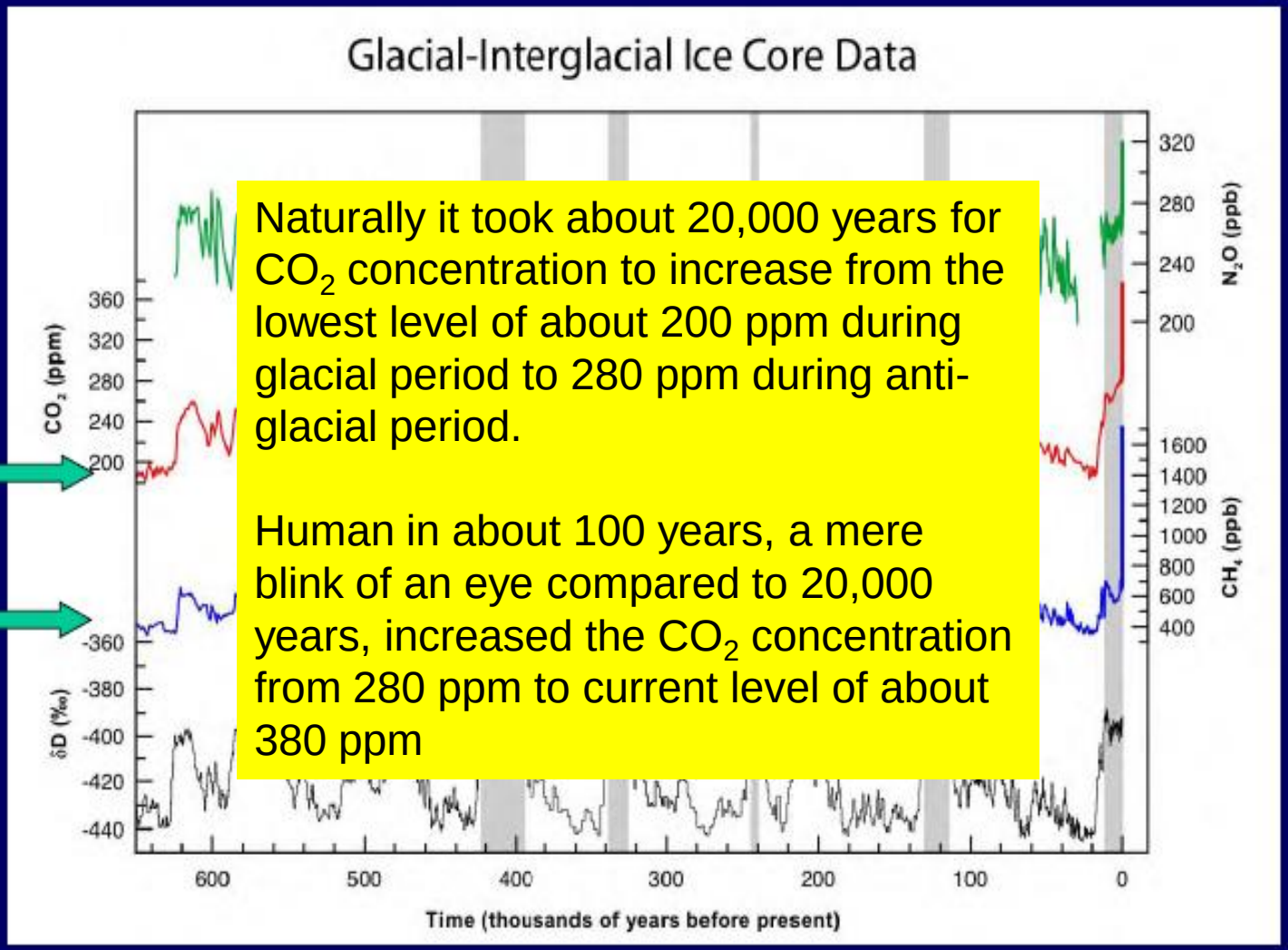
Changes in Ocean

Changes in Biosphere

Changes in Cryosphere

Changes in land surface

"Immense Complexity"



CO_2

CH_4

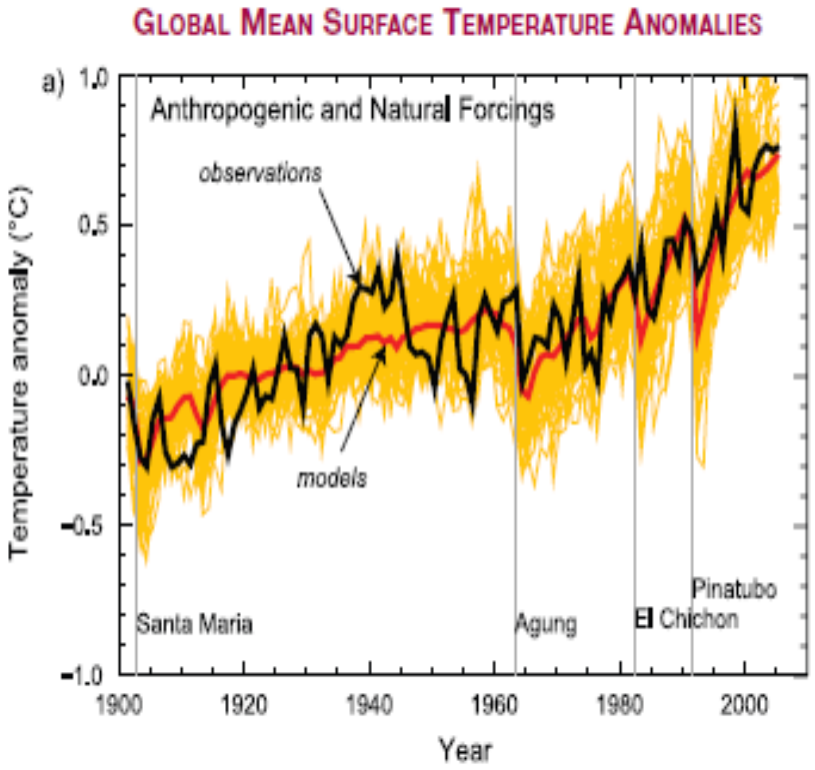
Naturally it took about 20,000 years for CO_2 concentration to increase from the lowest level of about 200 ppm during glacial period to 280 ppm during anti-glacial period.

Human in about 100 years, a mere blink of an eye compared to 20,000 years, increased the CO_2 concentration from 280 ppm to current level of about 380 ppm

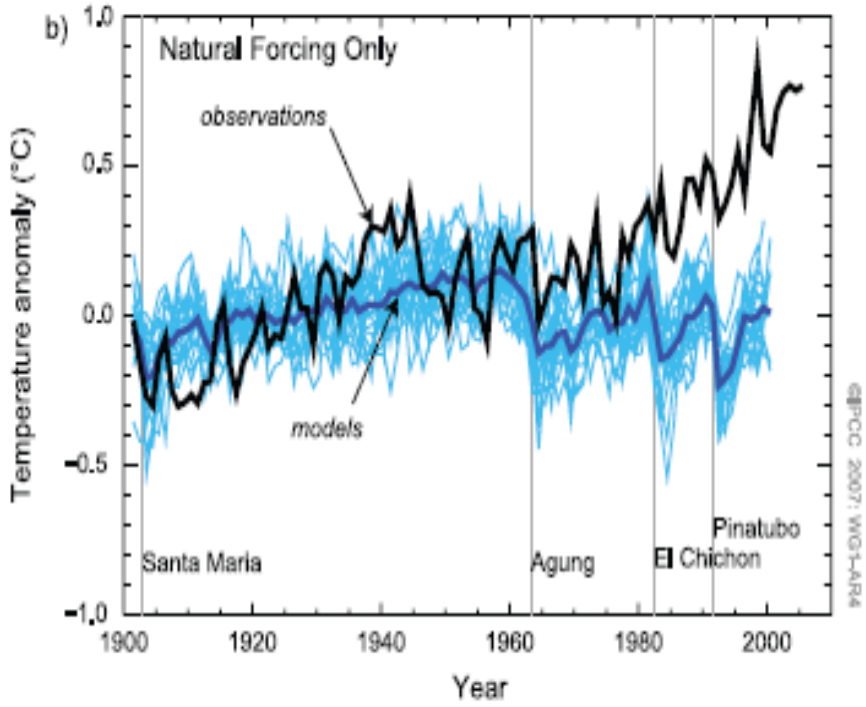
The atmospheric concentration of CO_2 and CH_4 in 2005 exceeds by far the natural range of the last 650,000 years

(Source: IPCC 2007)

Attribution to GHG Anthropogenic Forcing



(Natural + Anthropogenic)



(Natural)

(IPCC 2007)

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The Altered Earth's Climate System

Internal multi-ways Interactions

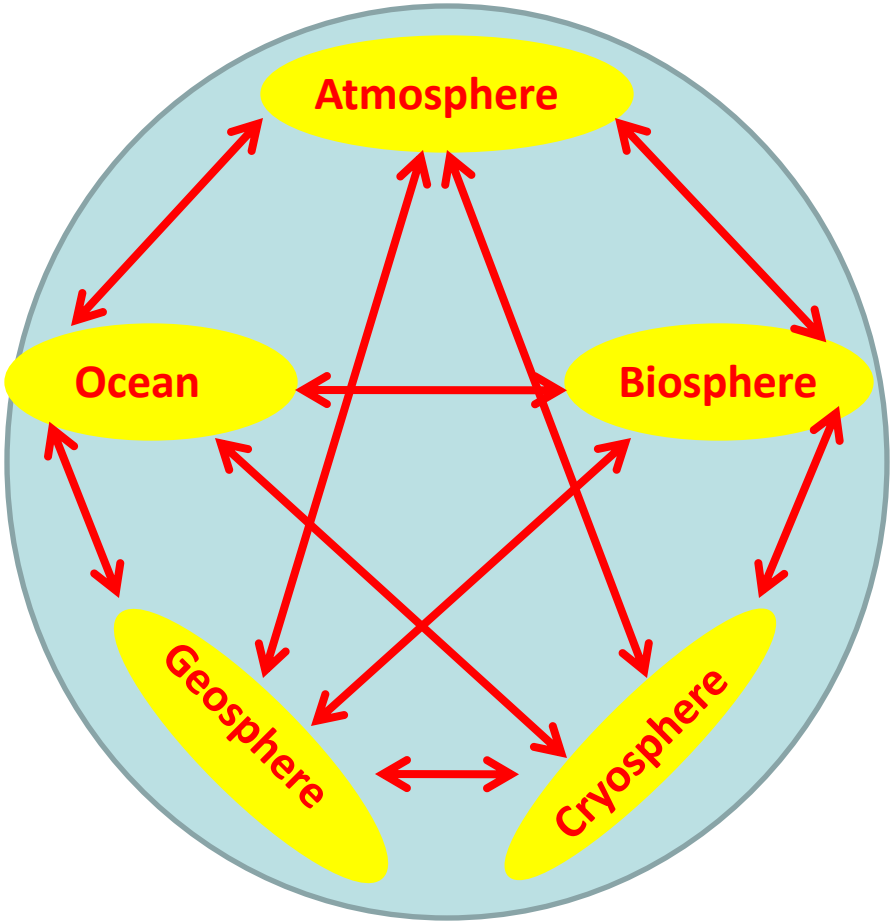
Climate Change & Climate Variability

Natural Forcing

- Sun's strength changes
- earth's orbital changes
- Volcanic eruptions

Anthropogenic Forcing

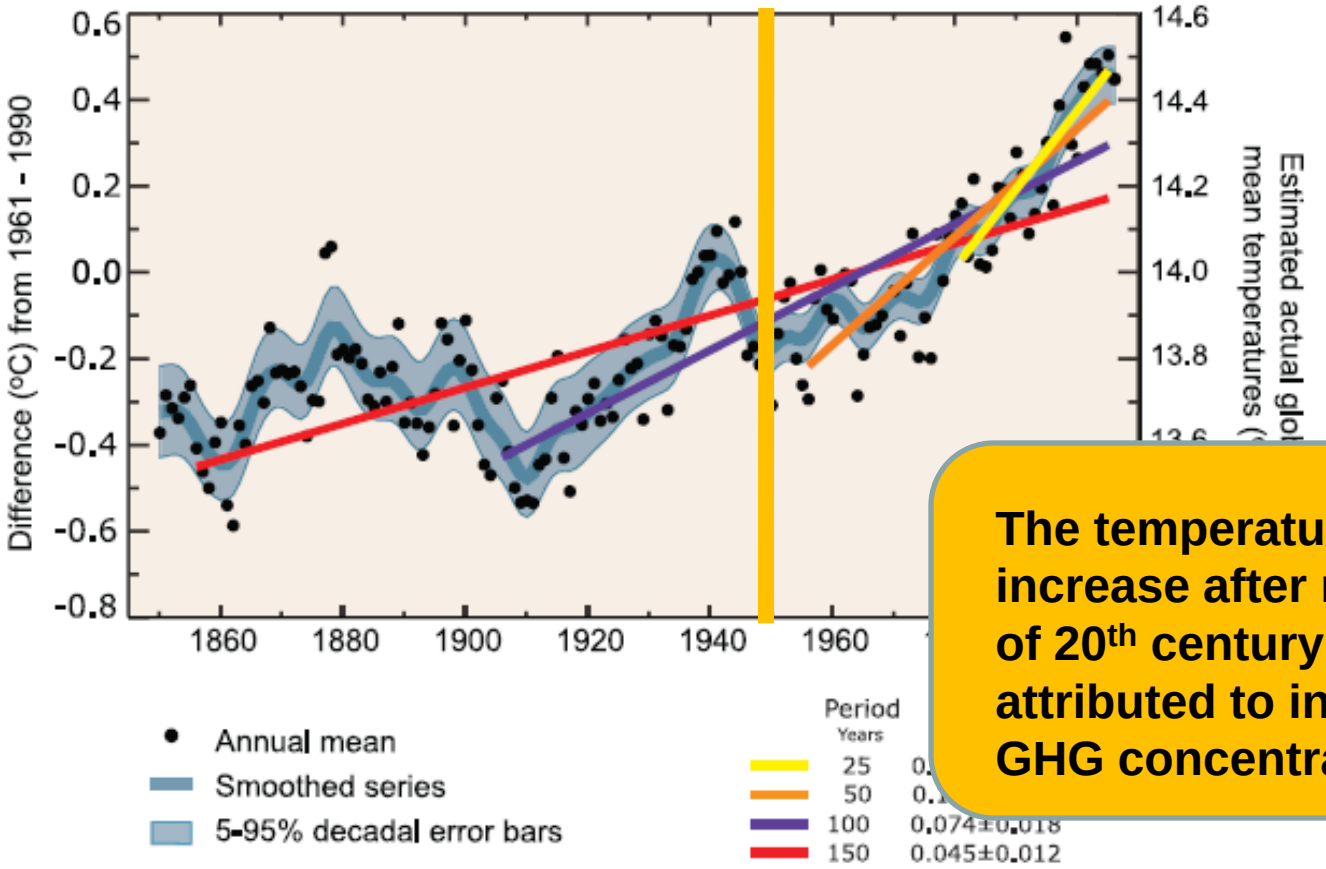
- GHG



- Changes in Atmosphere
- Changes in Ocean
- Changes in Biosphere
- Changes in Cryosphere
- Changes in land surface

"Immense Complexity"

Attribution to GHG



The temperature increase after middle of 20th century was attributed to increased GHG concentration

(IPCC 2007)

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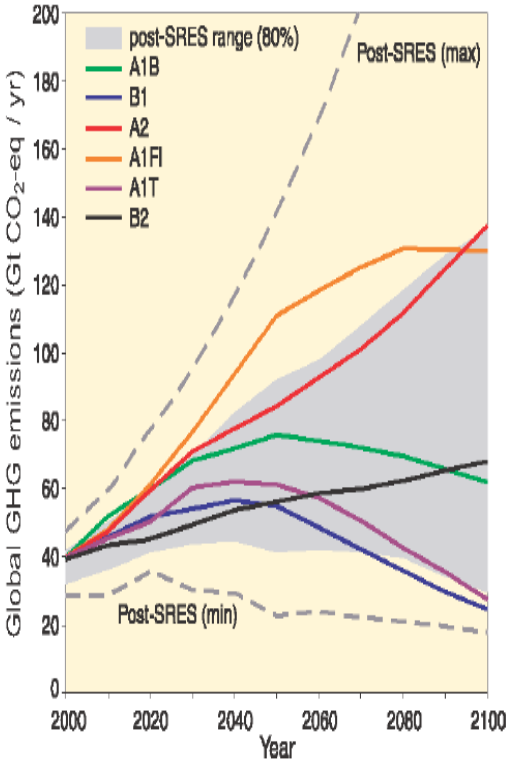
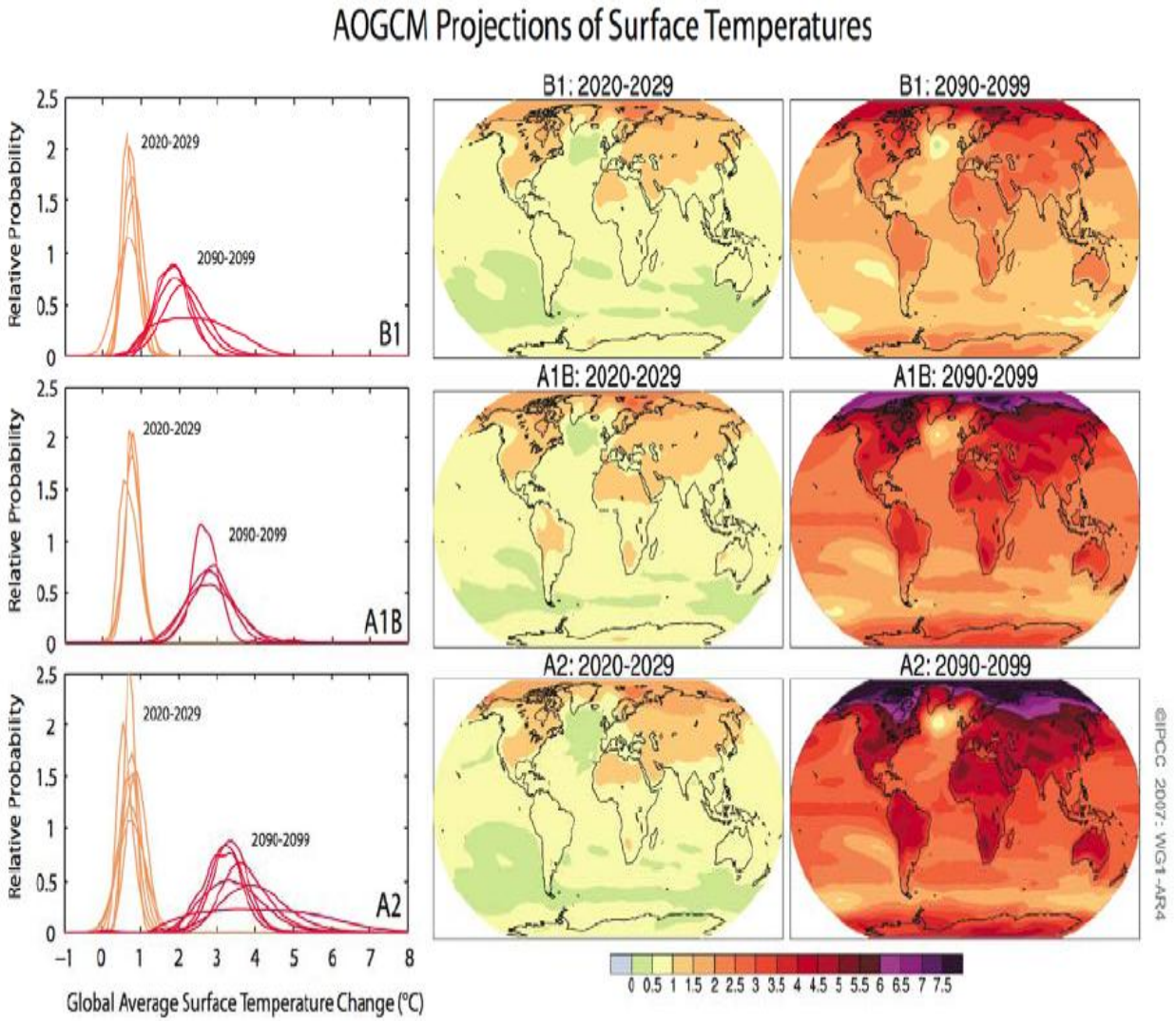
Projection of Global Mean Temperature

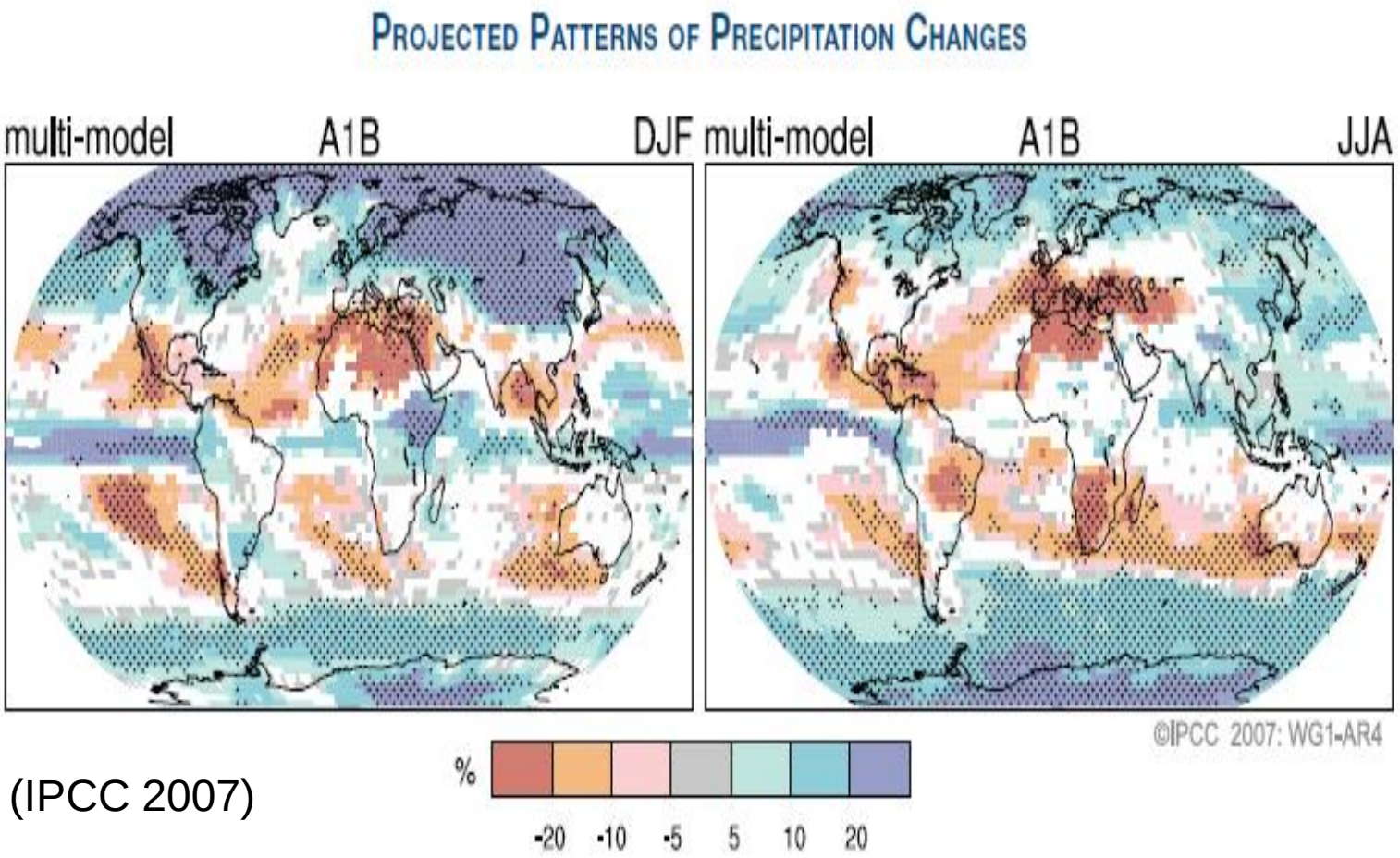
Emission scenarios





(IPCC 2007)

Projected Pattern of Precipitation Changes by 2100



(IPCC 2007)

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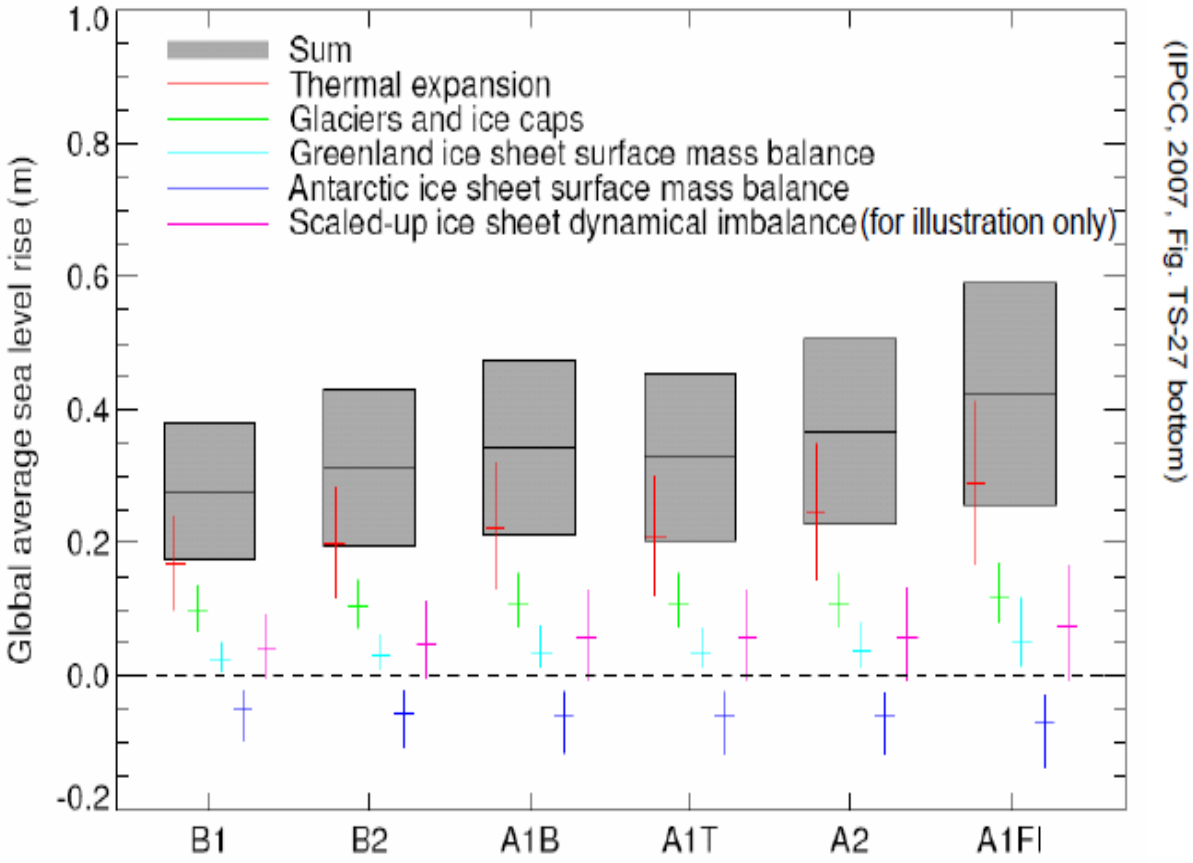
Sea Level Rise Projection (2090-2099) Relative to (1980-1999)

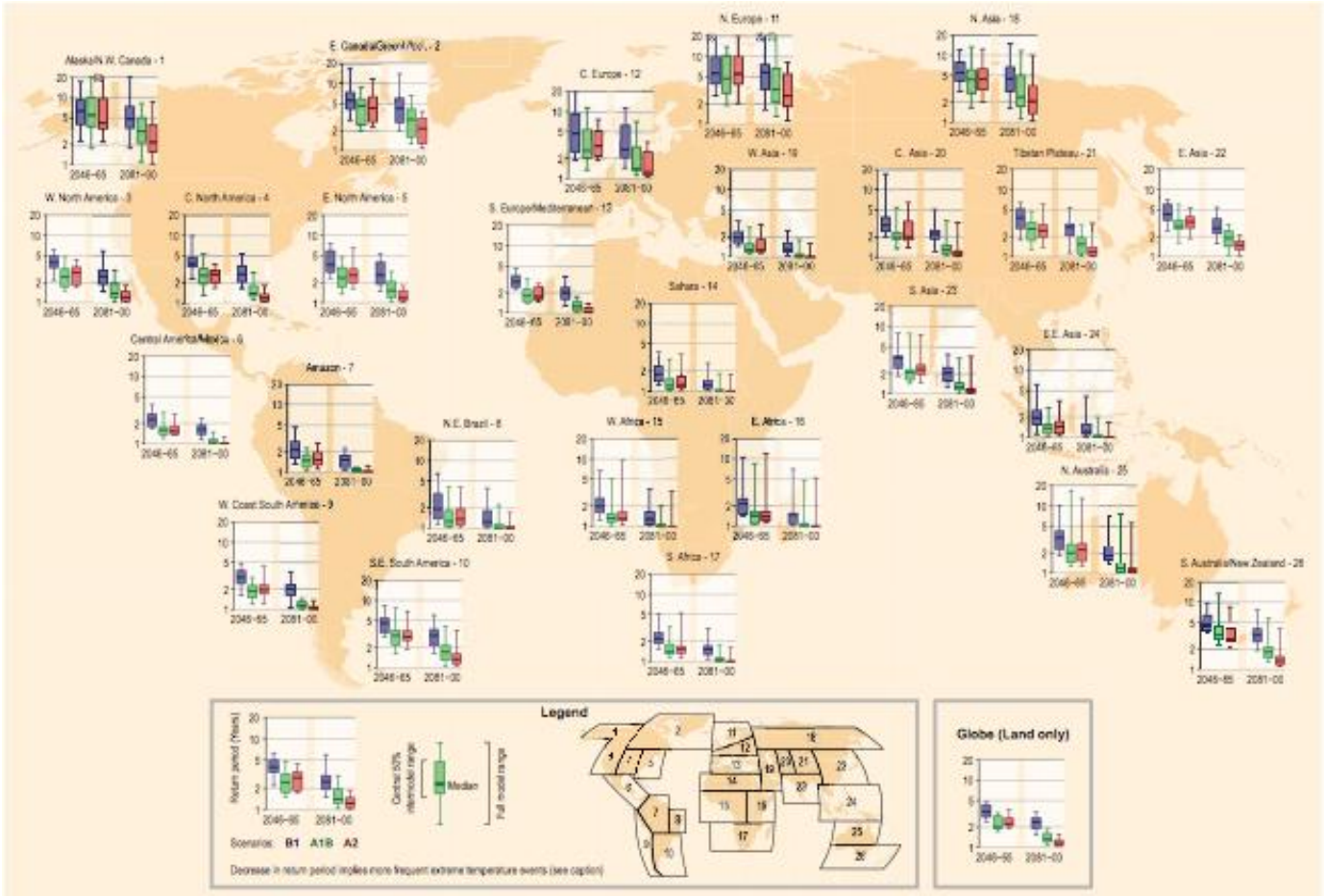


(IPCC 2007)

Several new studies indicated IPCC AR4 Models underestimated SLR.

The new estimate could be higher > 1 m (will be assessed in AR5)

Climate Extremes and Impacts (Based on SREX 2012)



Projected return periods for maximum daily temperature that was exceeded on average once during a 20-period in 1981-2000

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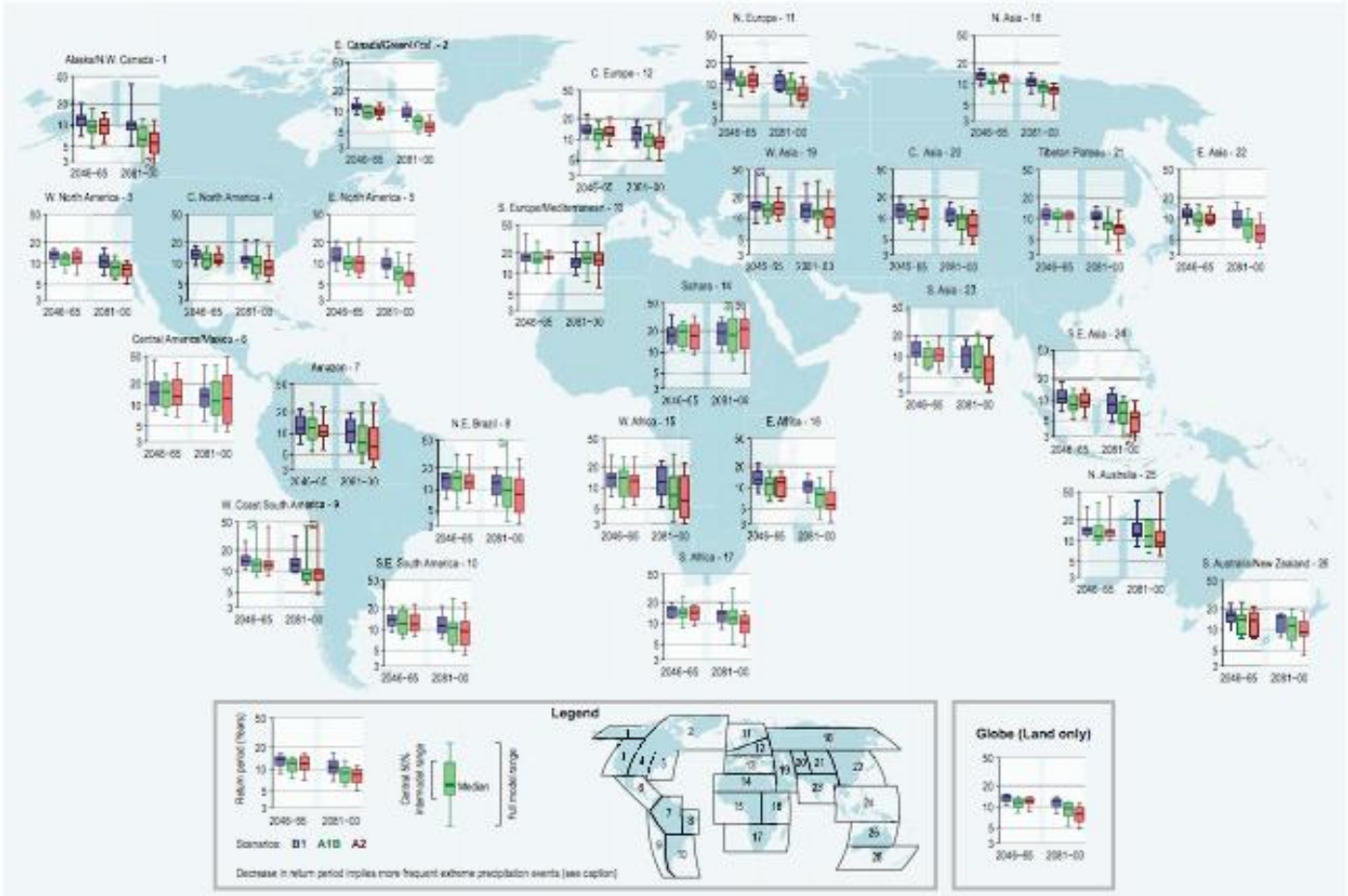
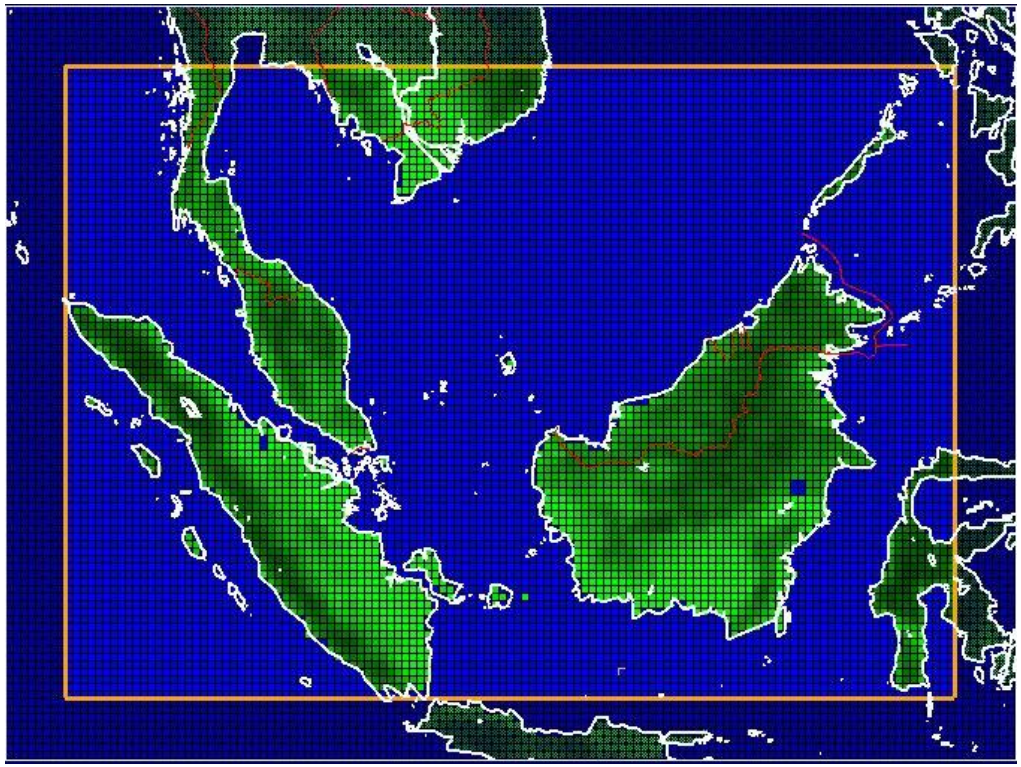
Climate Extremes and Impacts (Based on SREX 2012)



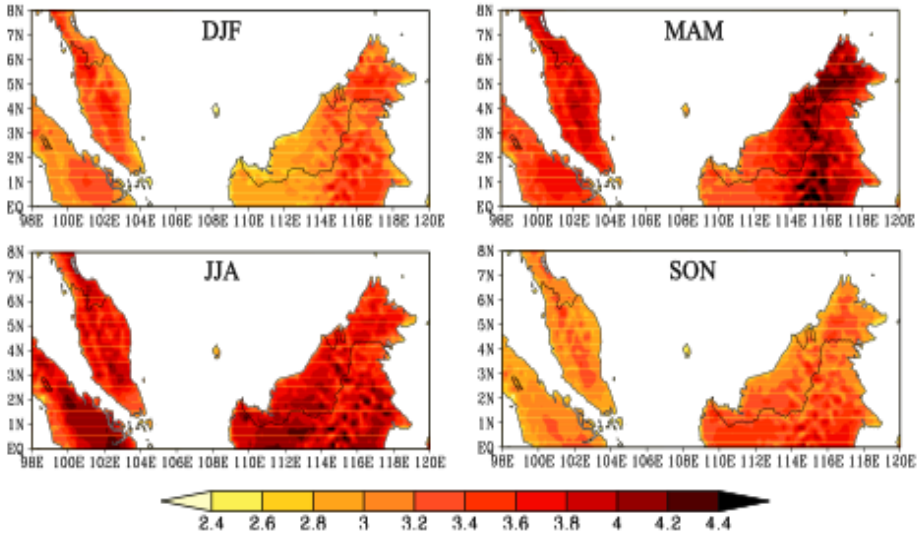
Projected return periods for a daily precipitation event that was exceeded on average once during a 20-period in 1981-2000

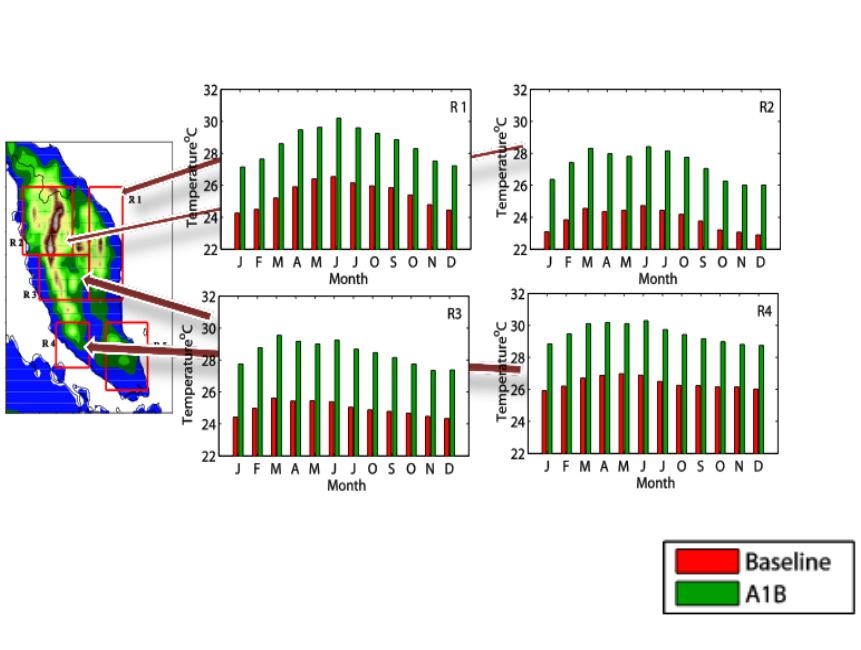
Dynamical Downscaling of Hadley Centre GCMs

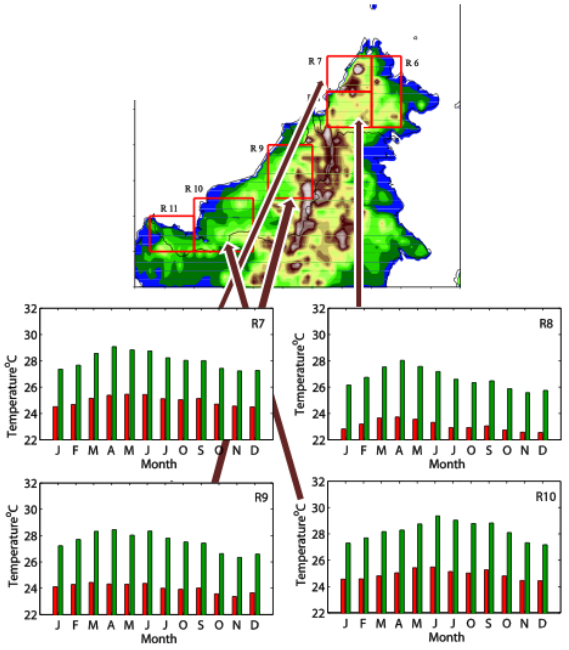


PRECIS RCM 25 km x 25 km

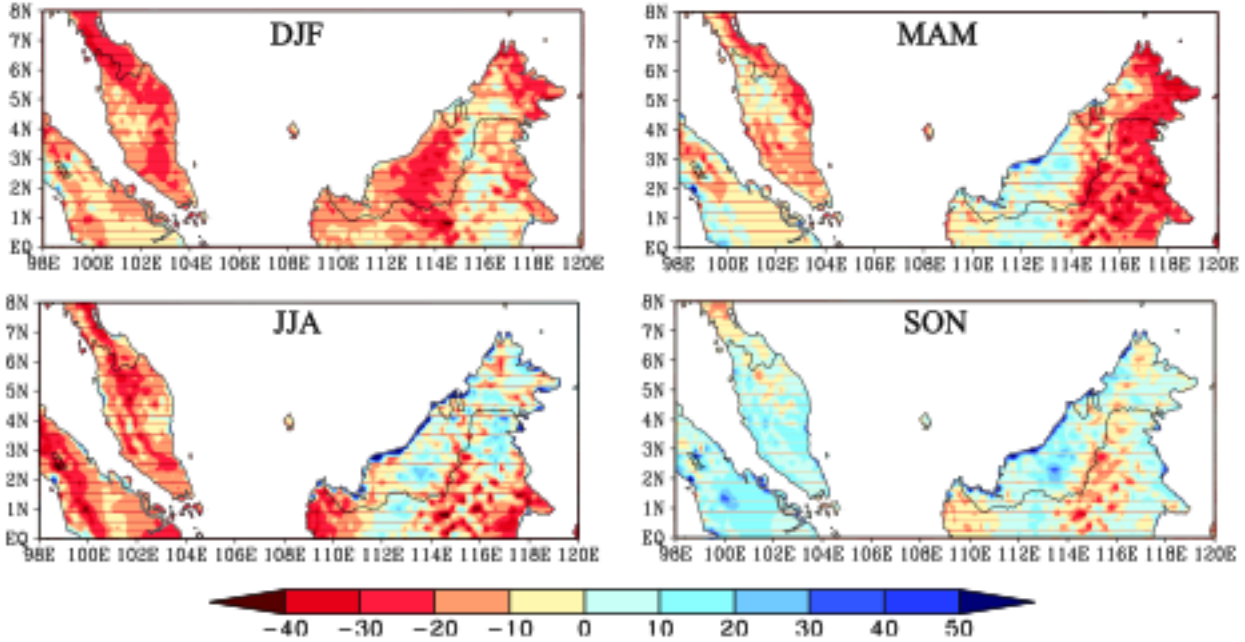
Projected Tmean Changes for 2070-2100

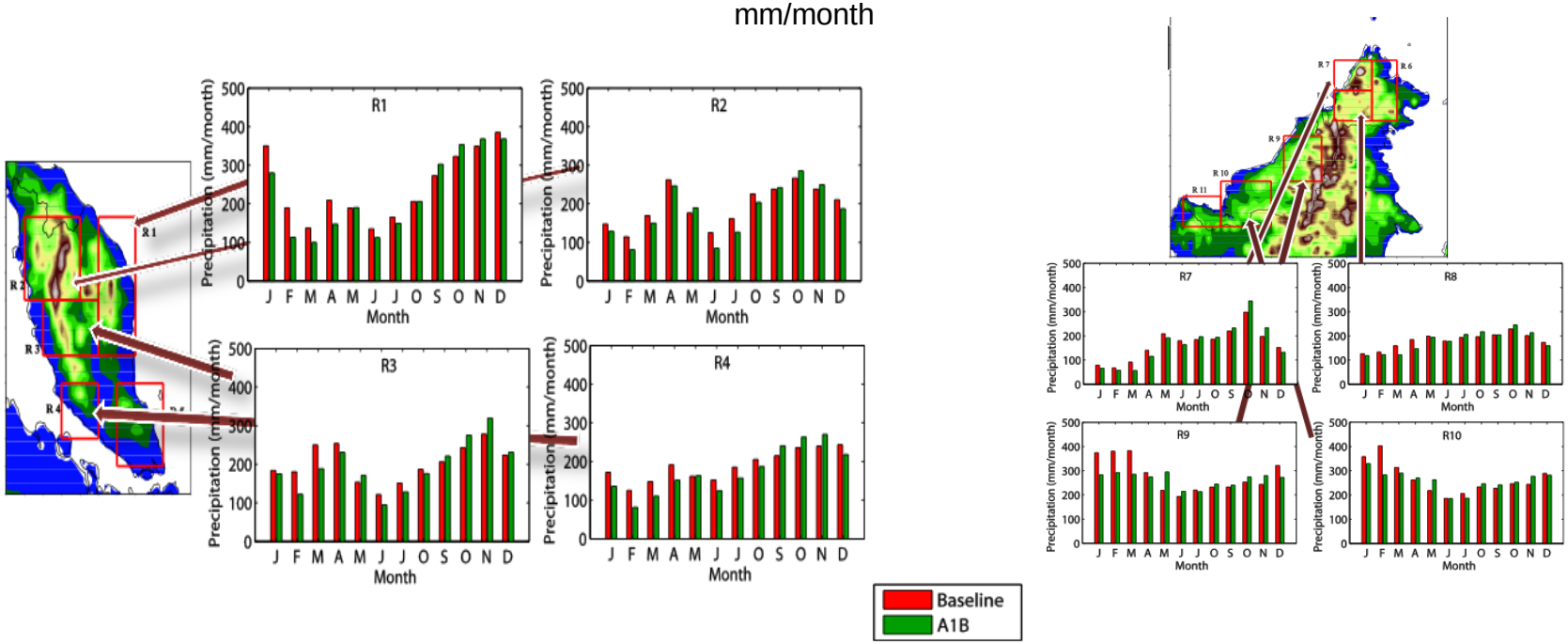




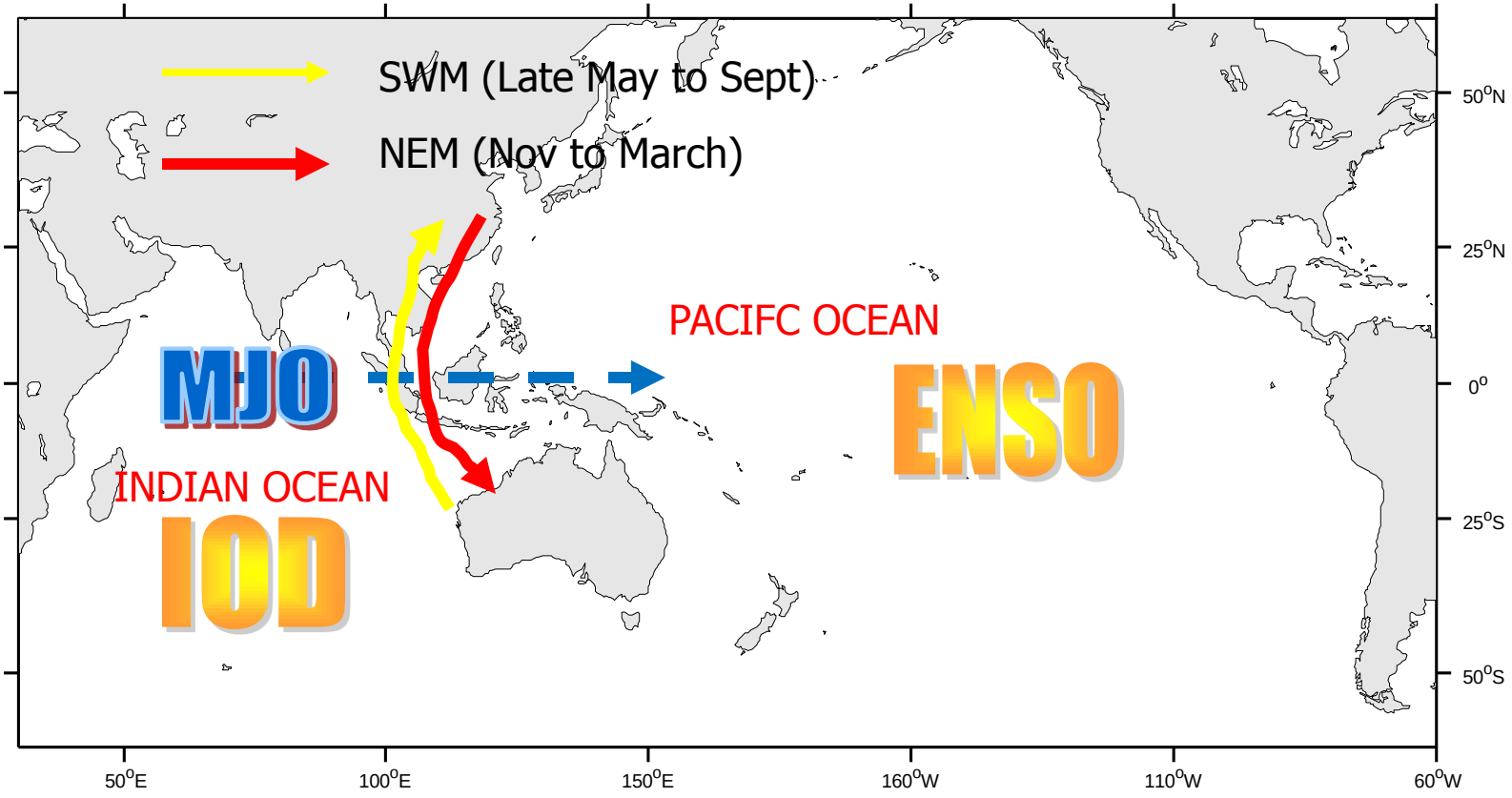


Projected Mean Precip changes for 2070-2100



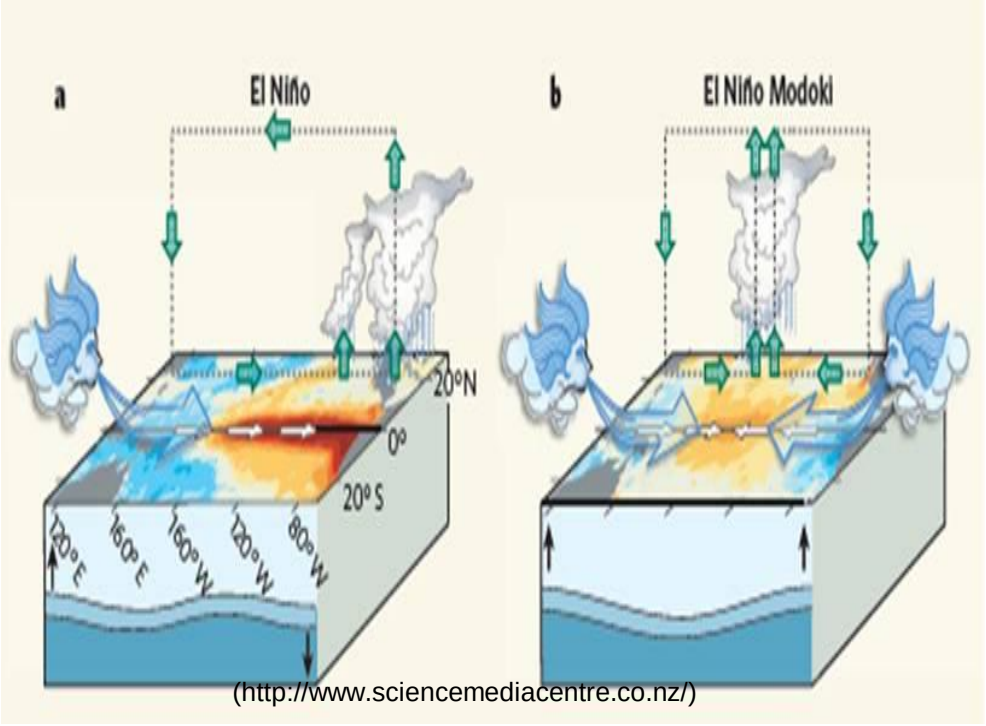


Monsoon & Dominant Modes of Climate Variability



Indian Ocean Dipole (IOD), El Nino-Southern Oscillation (ENSO) ---- Interannual oscillation (2-7 years)

Madden-Julian Oscillation (MJO) – intra-seasonal oscillation (20-60 days)



(http://www.sciencemediacentre.co.nz/)

El Nino Modoki becomes prevalence after 1980s due to changes on ocean sub-surface temperature distribution along the equatorial Pacific (Ashok et al. 2007; Kug et al. 2009)

Climate model projections for 21st century shows the coupled atmosphere-ocean in the tropical Pacific prefers the El Nino Modoki (Ashok et al. 2007)

How much we understand ENSO impacts on Southeast Asia region?

Impacts of conventional El Nino vs. El Nino Modoki on Malaysian/ Indonesian climate?

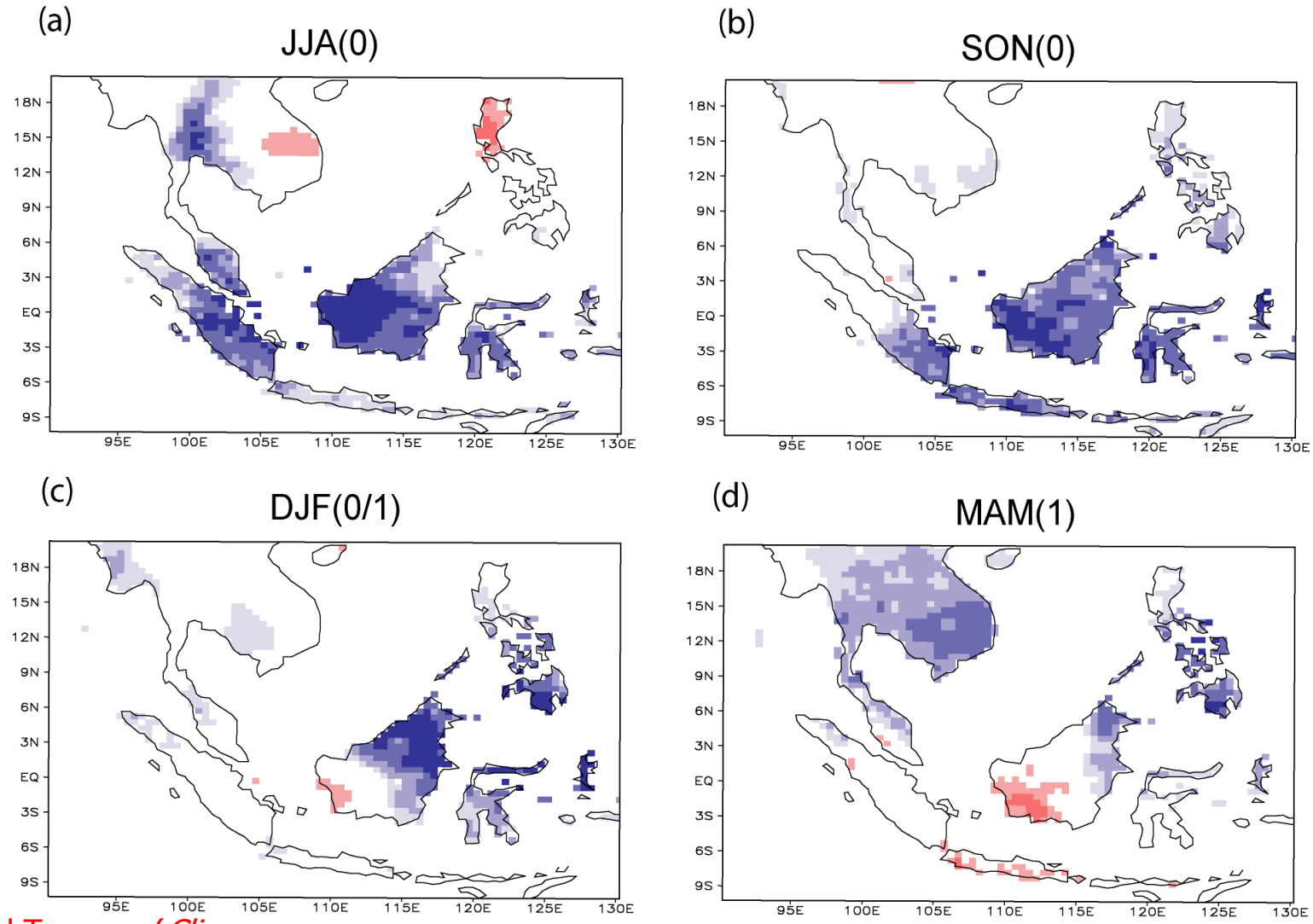
Global warming & ENSO. More El Nino Modoki? What would be the impacts on Malaysian / Indonesian Climate

---- Limited literatures

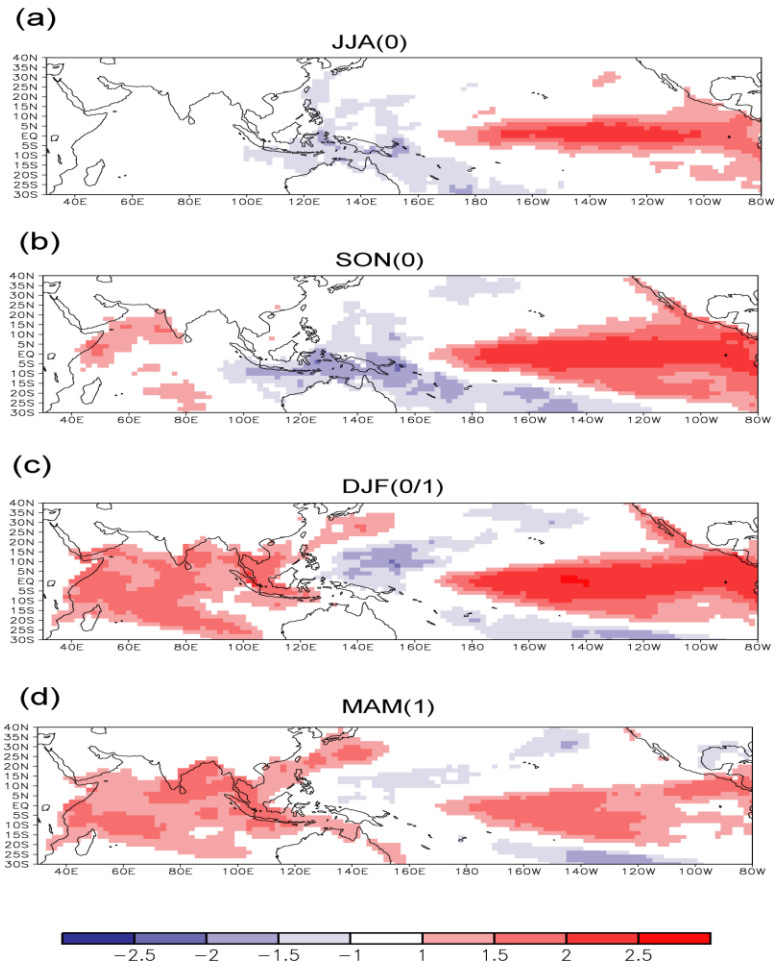
Dominant mode of Seasonal evolution of ENSO related signal in anomalous precipitation (~ 20% total variance)

Initial phase

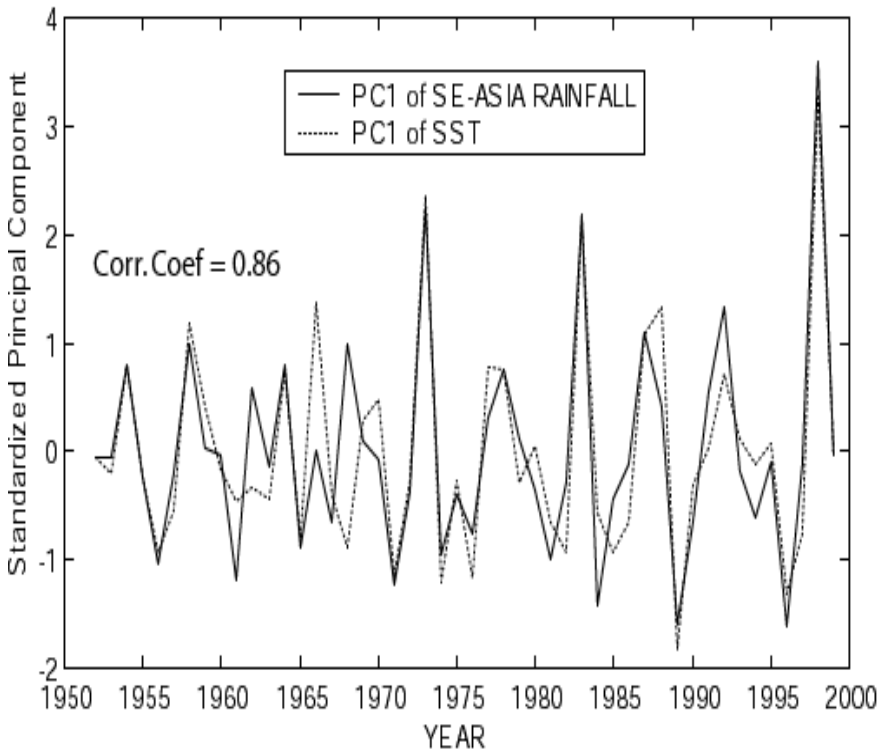
Peak phase



Juneng and Tangang (*Clim Dyn* 2005)



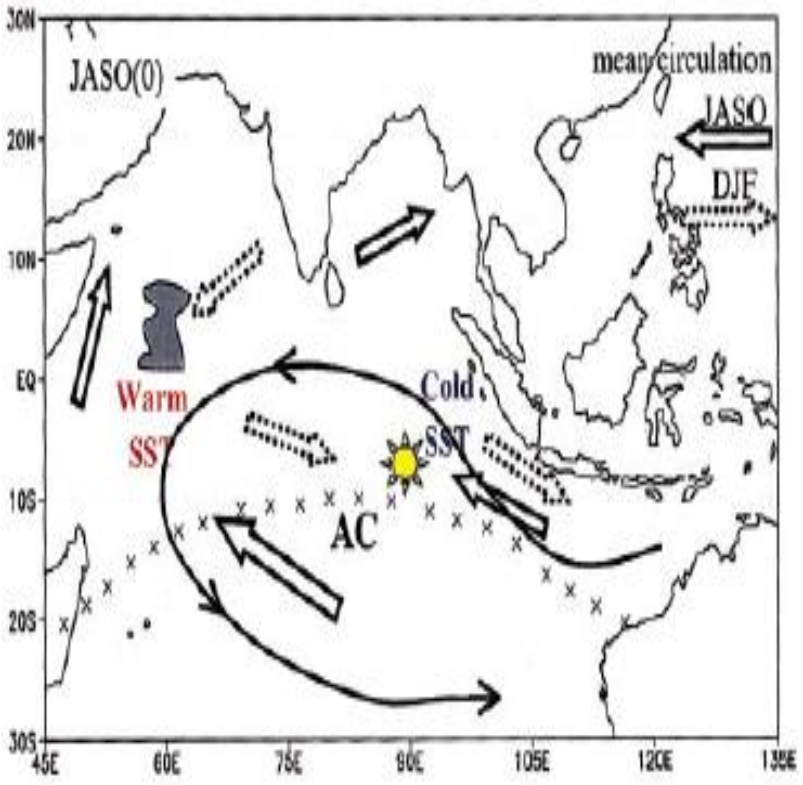
Typical evolution anomalous SST associated with an El Nino (La Nina)



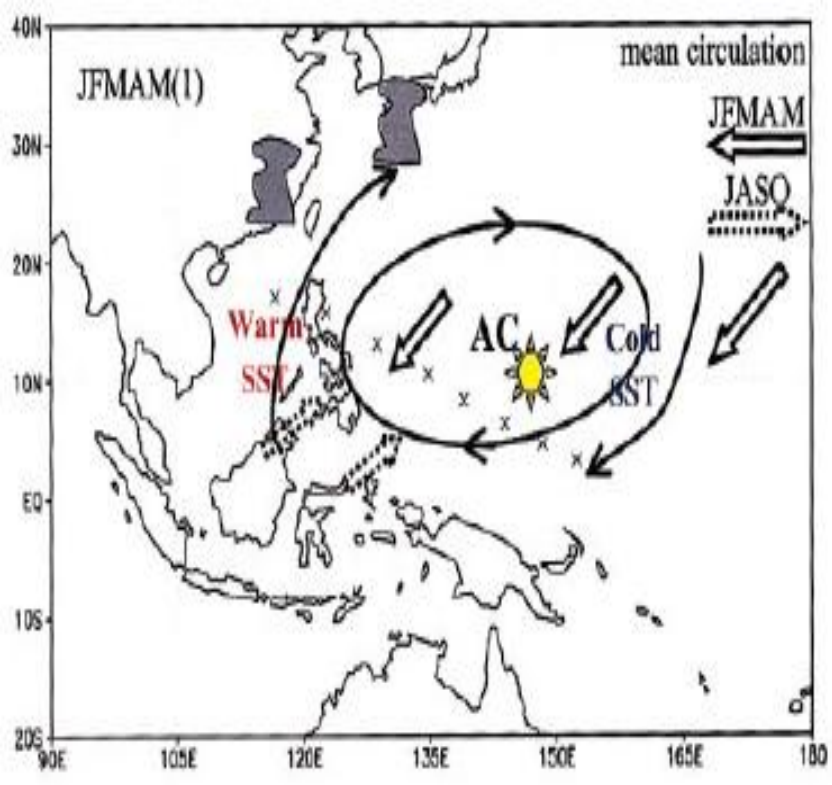
Juneng and Tangang (*Clim Dyn* . 2005)

Evolution of ENSO Signal over SEA is modulated Ocean-Atmosphere Interaction

SIO Region



NWP Region

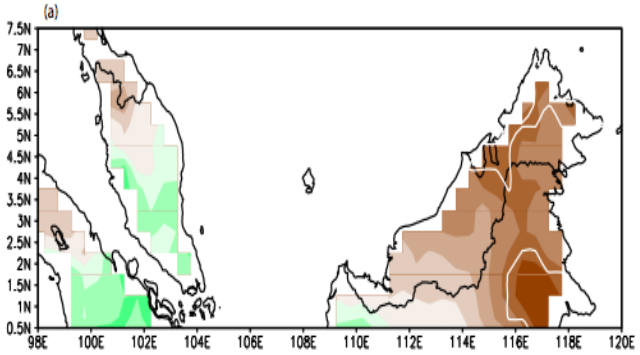


How these regional atmosphere-ocean interactions evolve under a warmer environment?

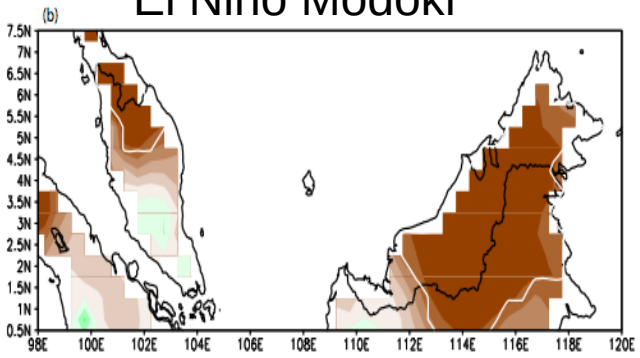
(Wang et al. 2003)

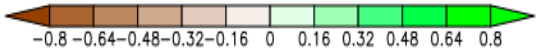
Composites of Anomalous DJF Precipitation

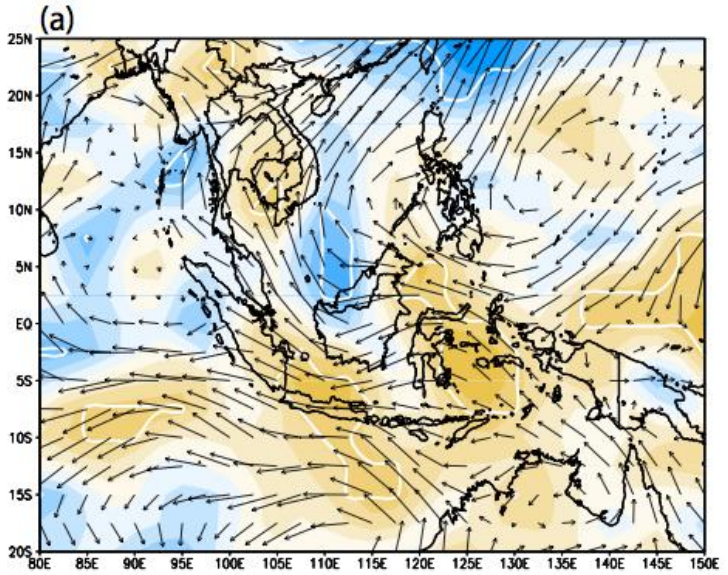
Conventional El Nino

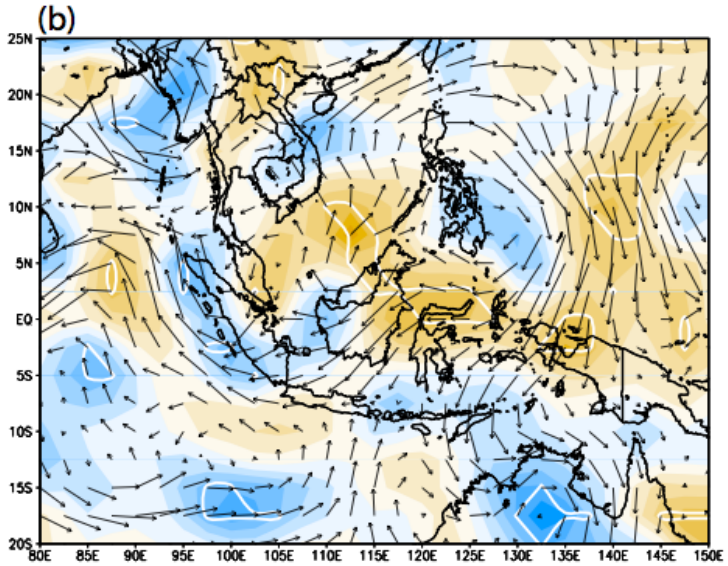


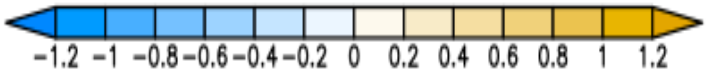
El Nino Modoki

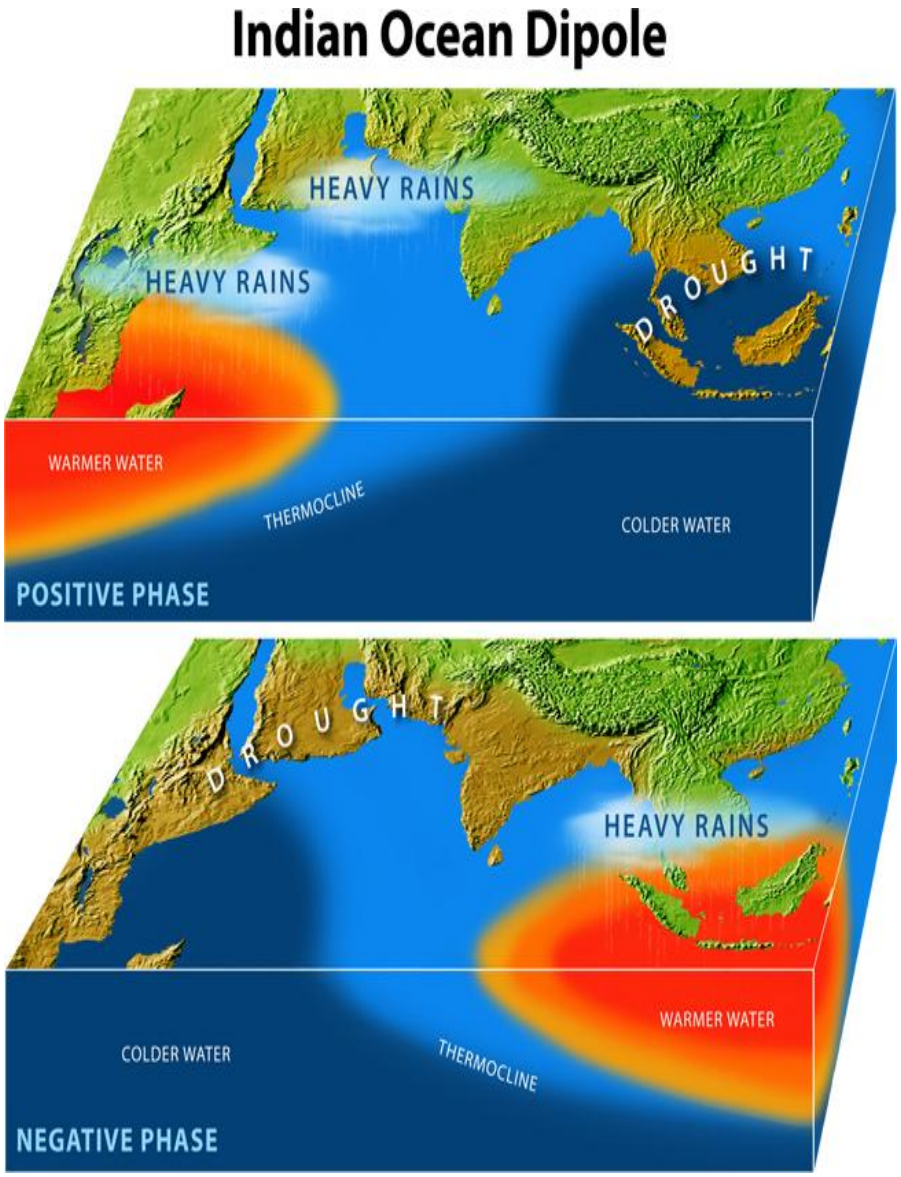










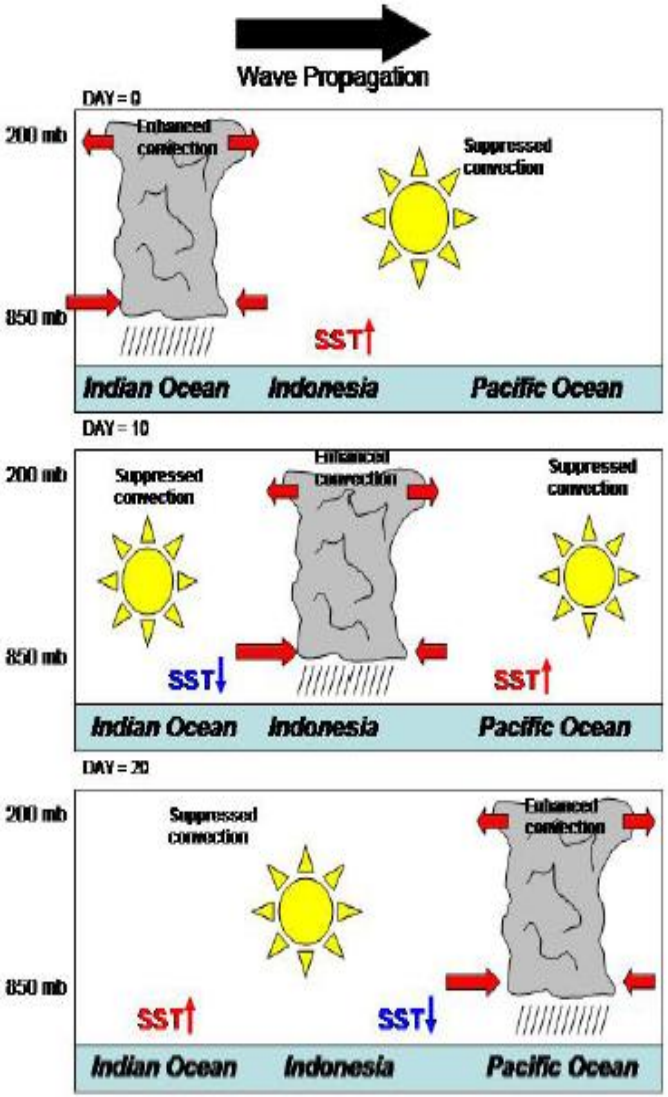


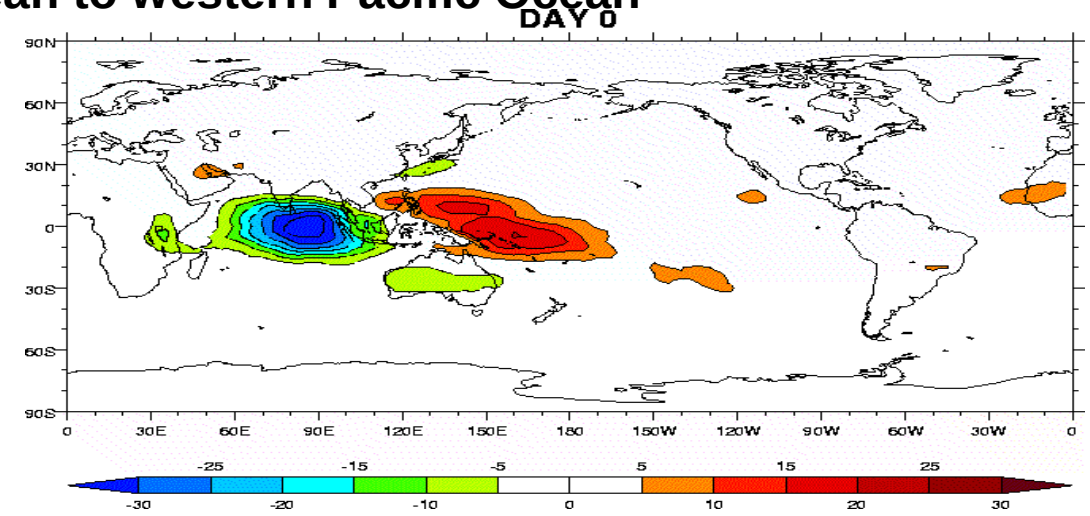
(http://mit.whoi.edu/)

Relationship between IOD & Malaysian / Indonesian climate?

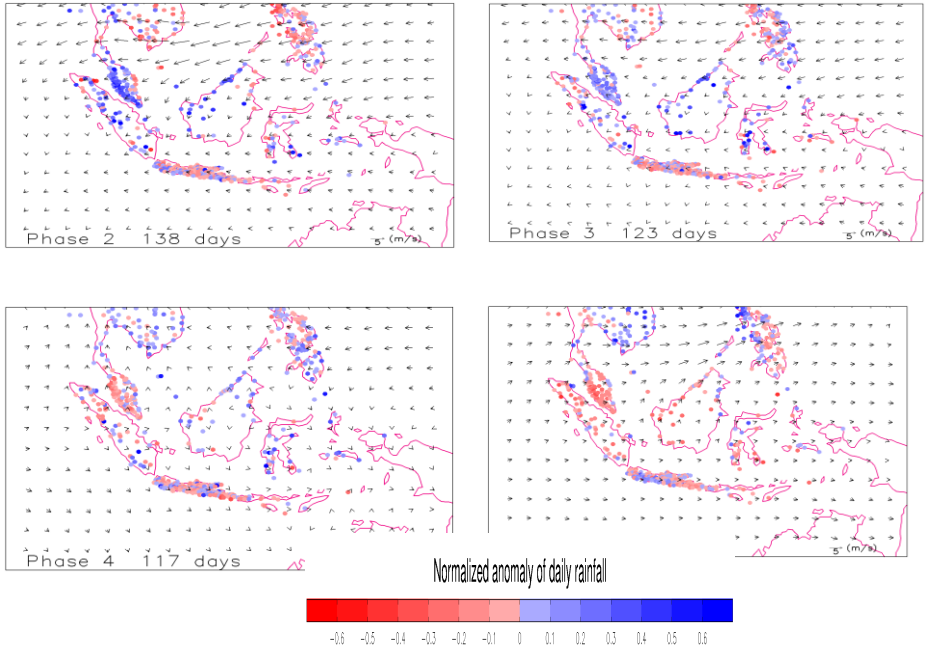
IOD & Global Warming? Impact on Malaysian / Indonesian climate ?

Schematic Representation of MJO eastward propagation from Indian Ocean to western Pacific Ocean





Composite of Daily (JJA)



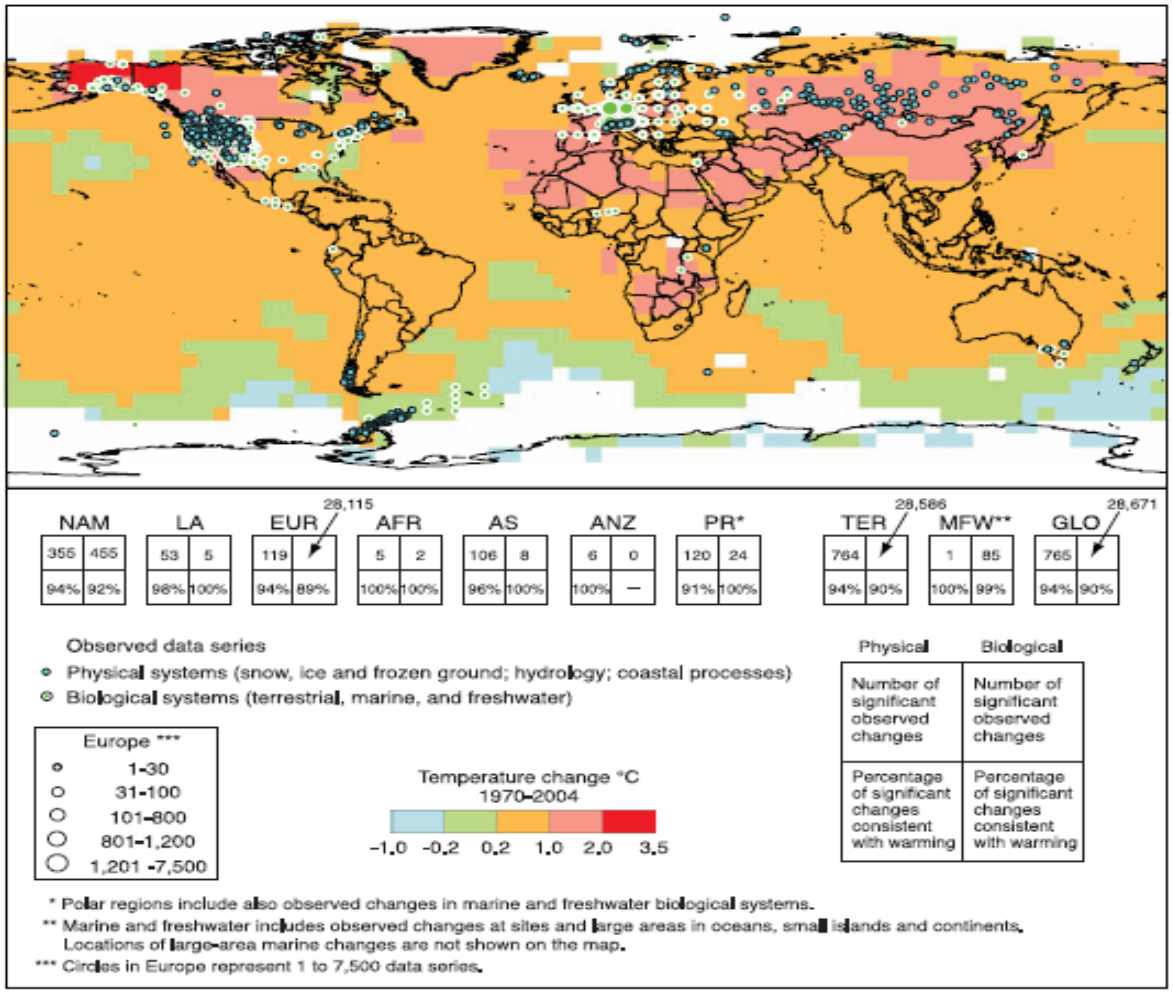
Ecosystems & their Services






Sensitive to temperature and water related stresses and others such as ocean acidification

Climate Change Impacts on Physical and Biological Systems



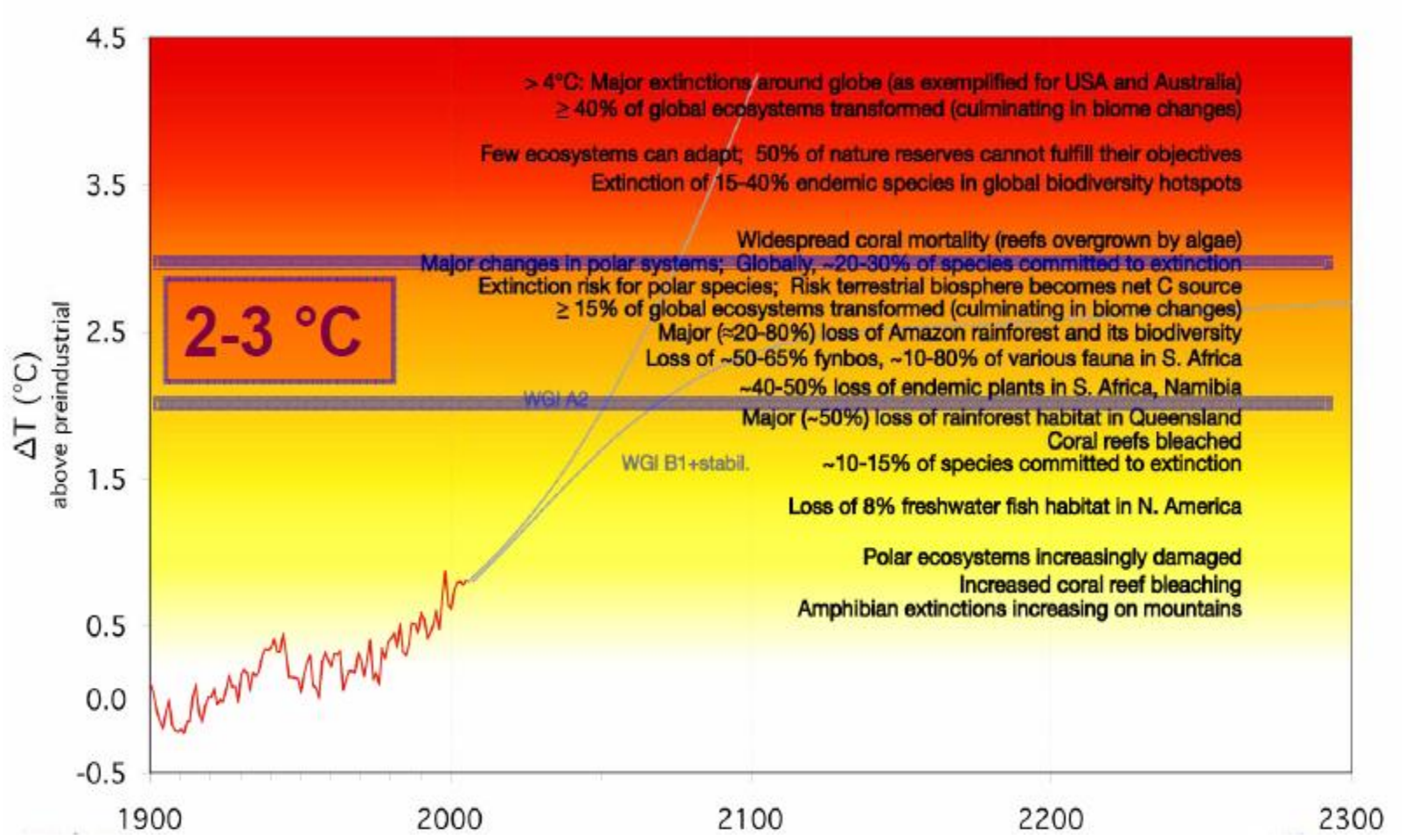
(IPCC WGII, 2007)

29,000 observational data series, ~ 90% show changes consistent with warming

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

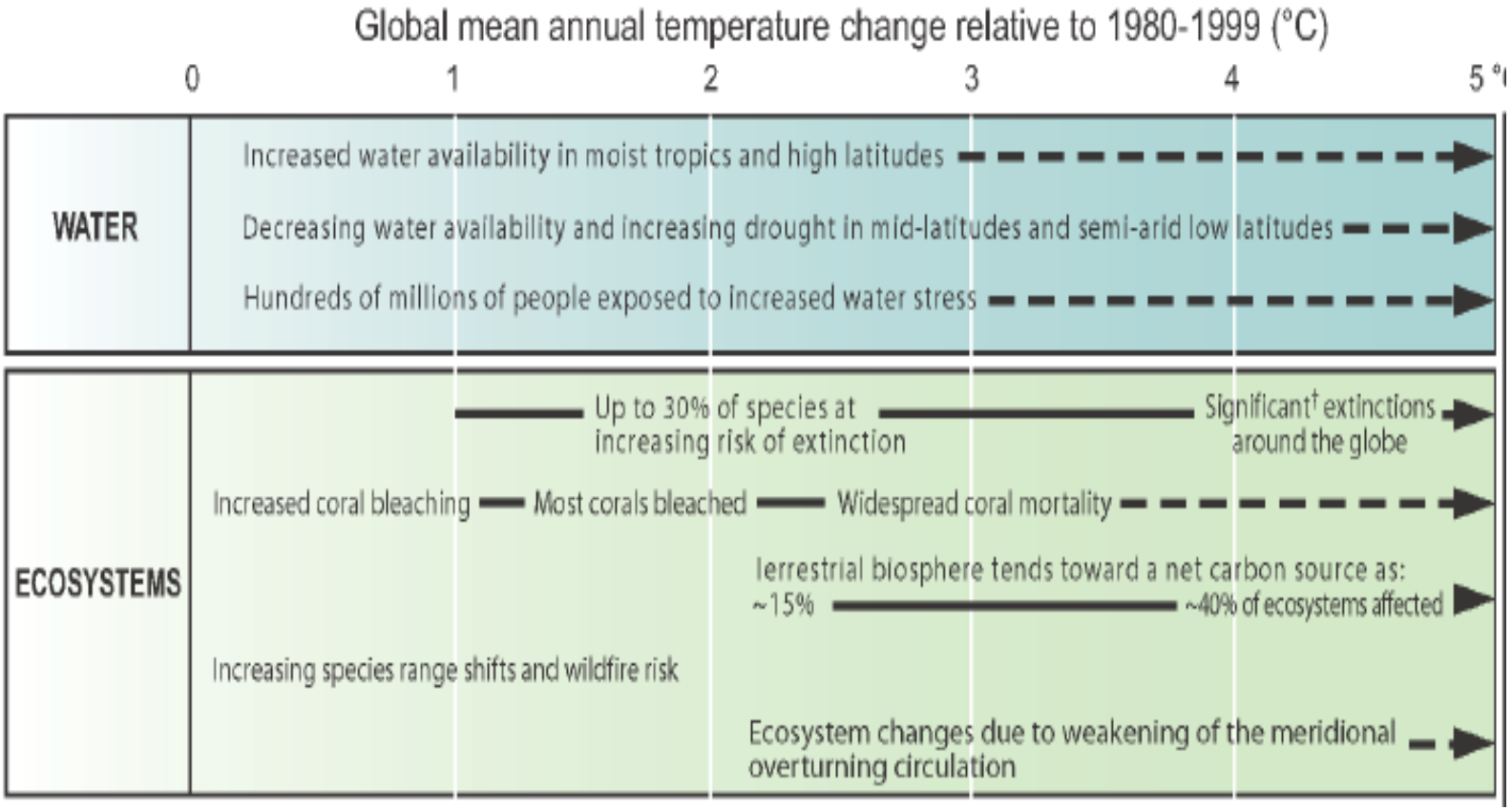
Projected Climate Change Impacts on Ecosystems



ipcc
INTERGOVERNMENTAL PANEL ON climate change

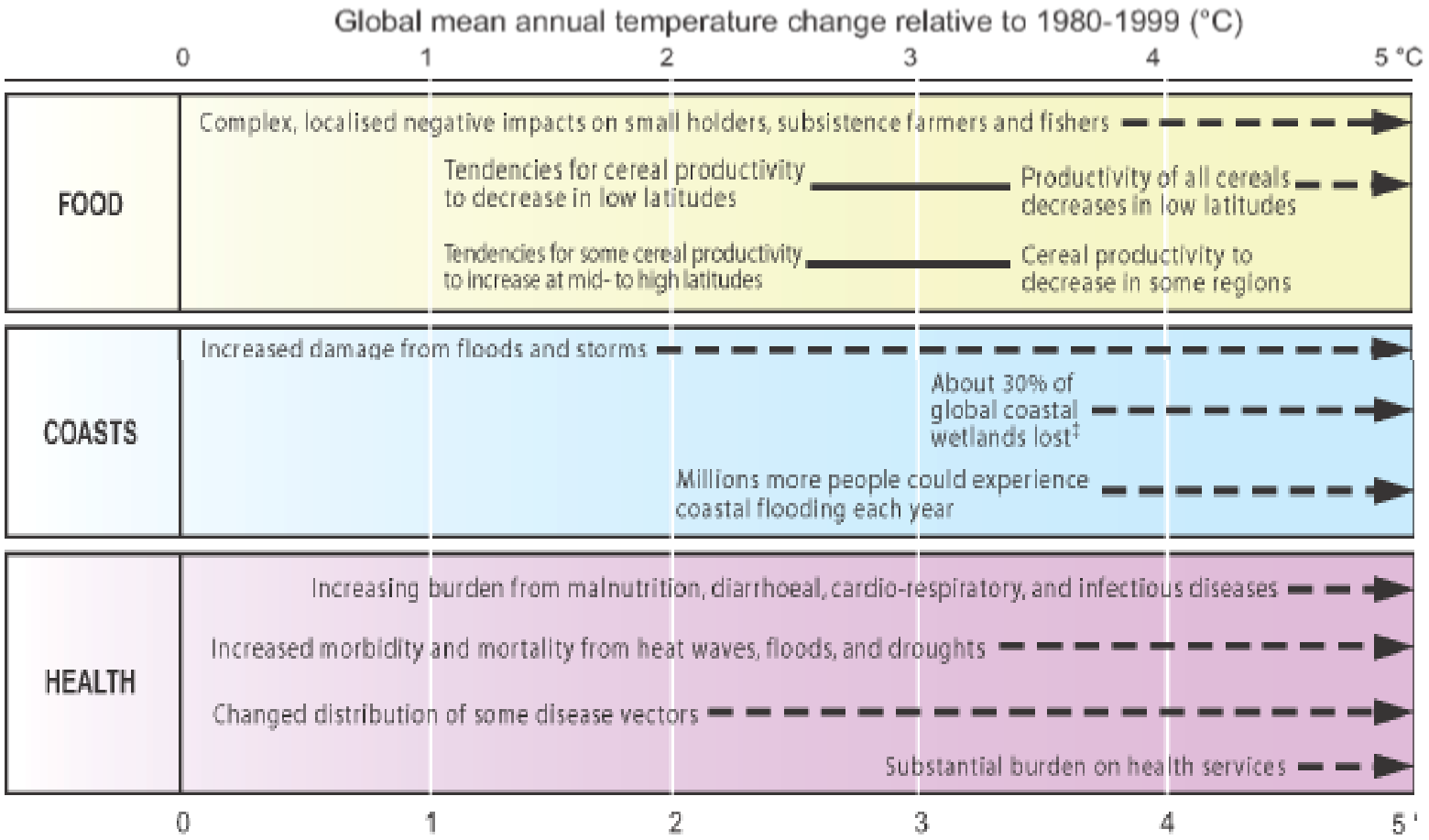
WMO UNEP

Projected Climate Change Impacts on Various Sectors



(IPCC WGII, 2007)

Climate Change Impacts on Various Sectors



(IPCC WGII, 2007)

Global warming, Climate Change & Impacts

Global Warming

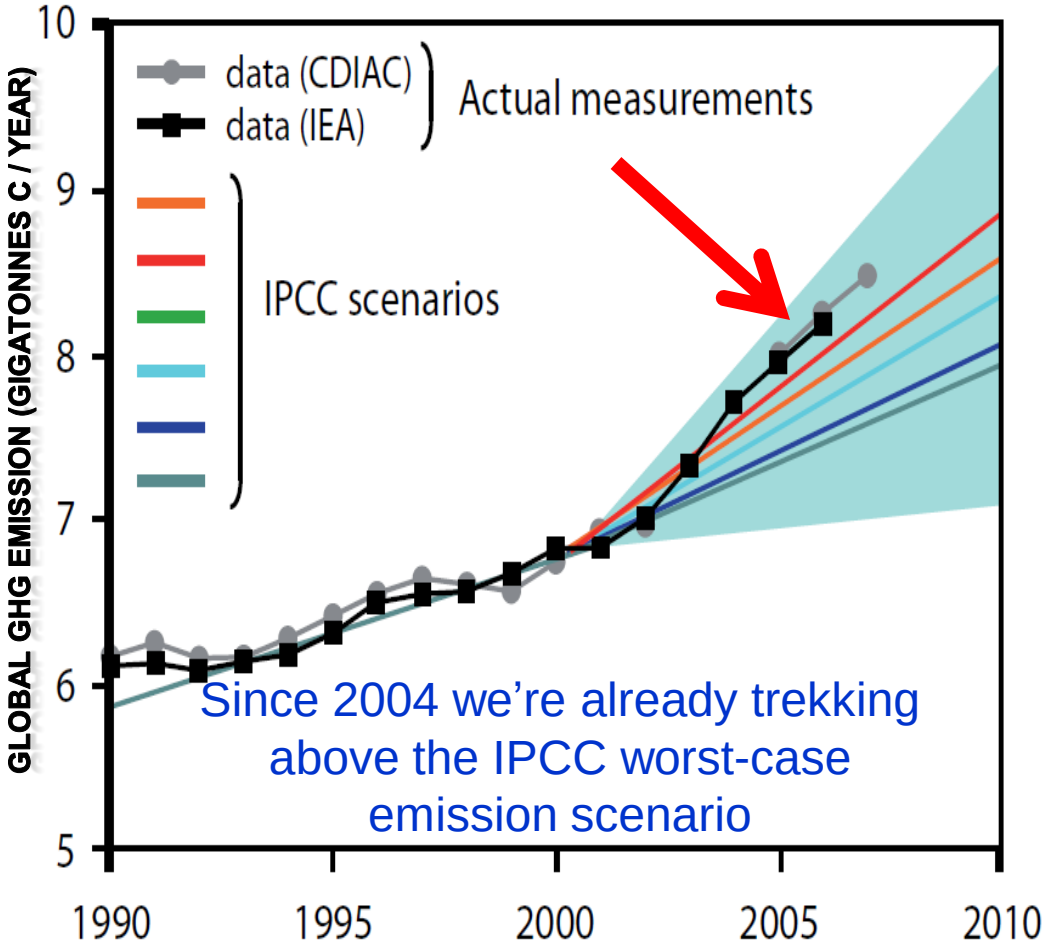
> 80% of excess heat is absorbed by the oceans

Climate Change

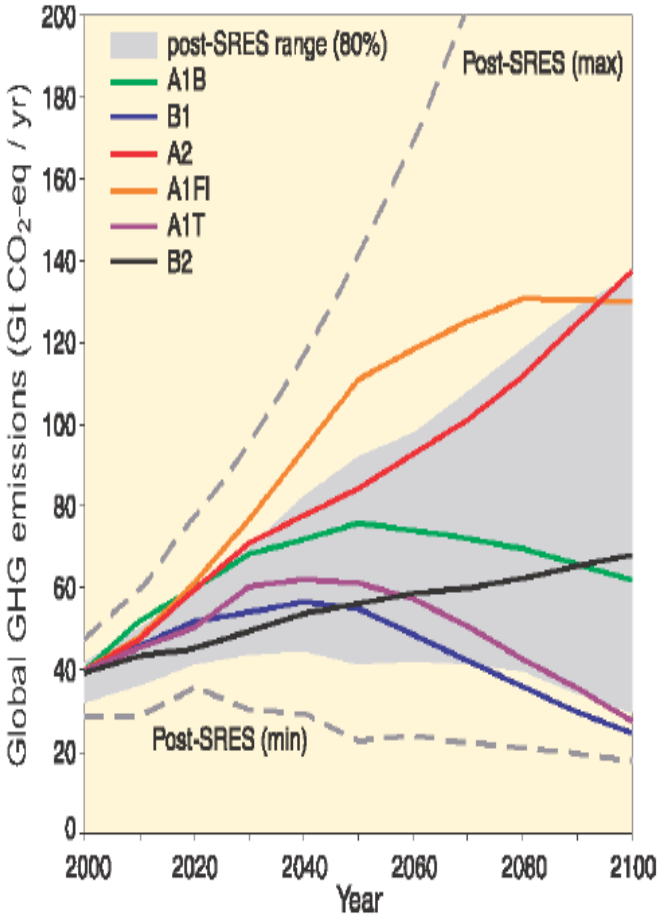
- Changes in global and regional climate patterns
- Changes in extreme climate events (floods, droughts, storms, typhoons /hurricanes)
- Changes in ocean heat and circulation
- Sea Level Rise & Coastal erosion

Impacting human systems & environment

Current Global GHG Emission



(UNEP 2009)



(IPCC 2007)

Interesting statistics:1800 vs 2000

Observed

	1800	2000	Δf
Population (billion)	1	6	x6
GDP (trillion 1990 $)	0.3	30	x100
Primary energy (EJ)	13	420	x30
CO_2 emissions (GtC)	0.3	6.4	x20
Mobility (km/person/day)	0.04	40	x1,000

World Energy Council, 2004

$\Delta T \sim 0.75^{o}C$

1800, 2000 vs 2050

Scenario characteristics

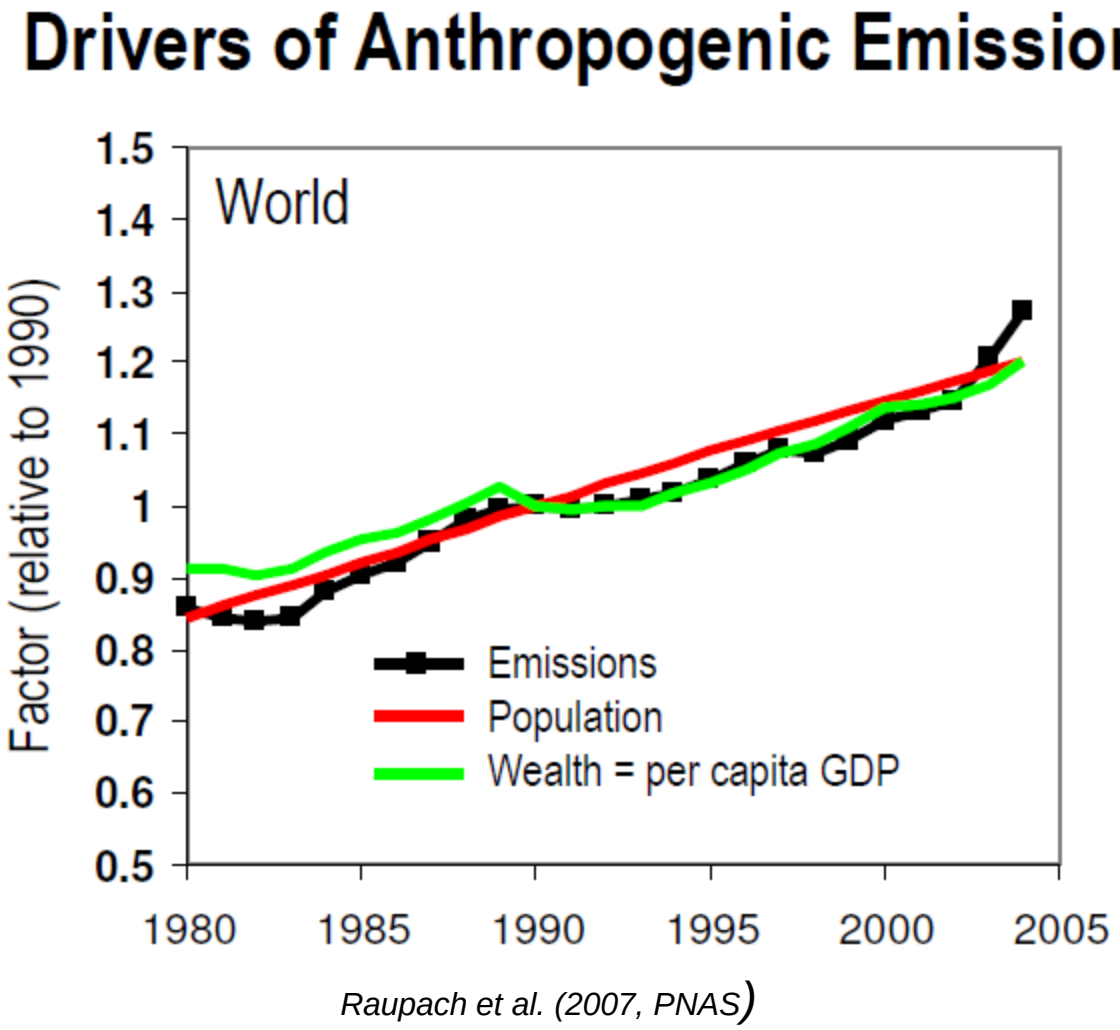
(34 scenarios, IPCC/WEC)

	1800	2000	Δf	2050	Δf
Population (billion)	1	6	x6	10	x1.6
GDP (trillion 1990 $)	0.3	30	x100	85-110	<x3-x4
Primary energy (EJ)	13	420	x30	600-1,040	x1.5-x2.5
CO_2 emissions (GtC)	0.3	6.4	x20	5-15	<x1-x3
Mobility (km/person/day)	0.04	40	x1,000	120-160	x3-x4

World Energy Council, 2004

Projected ΔT ~ 1-3°C

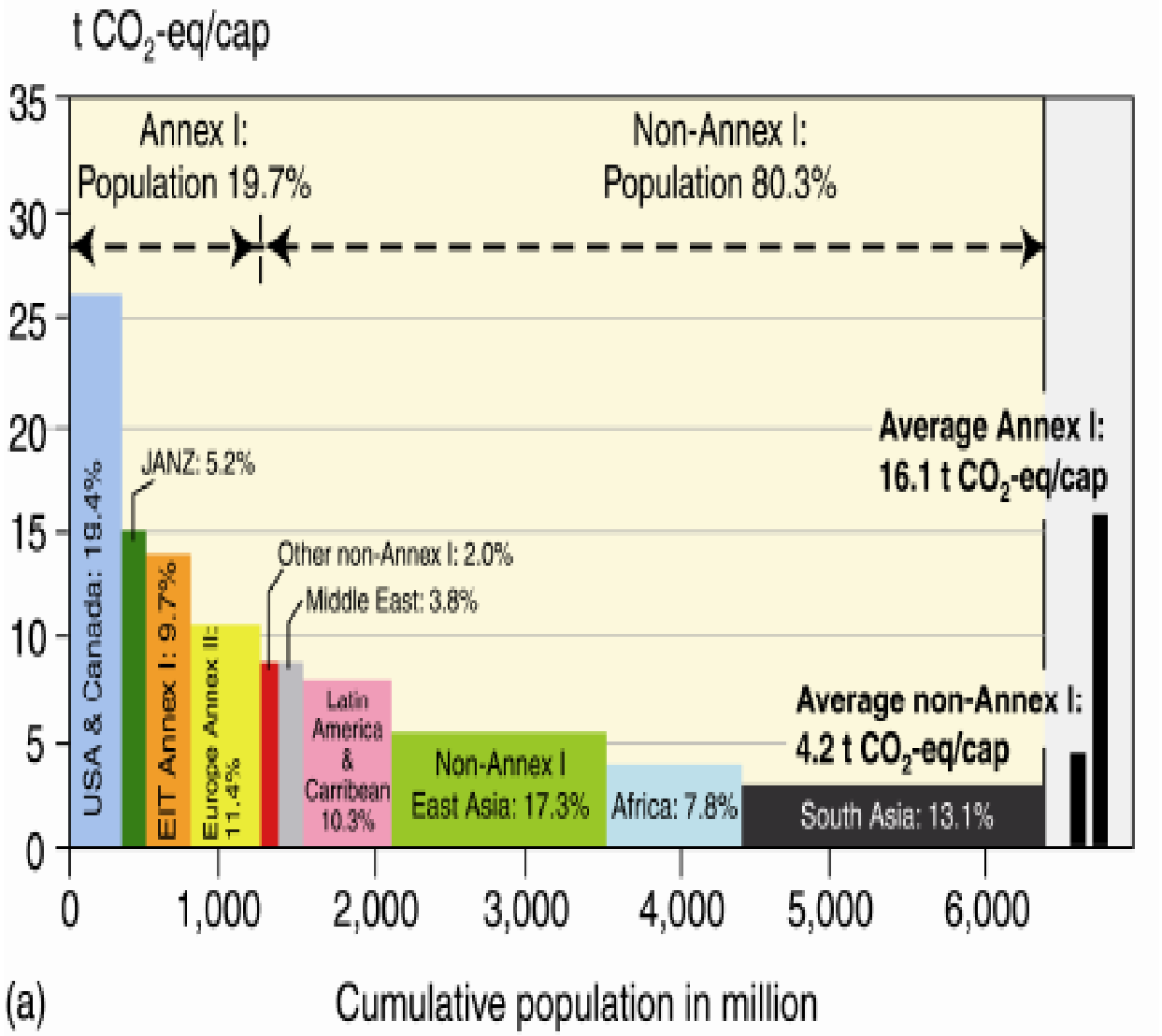
Population, Wealth & Emissions



Raupach et al. (2007, PNAS)

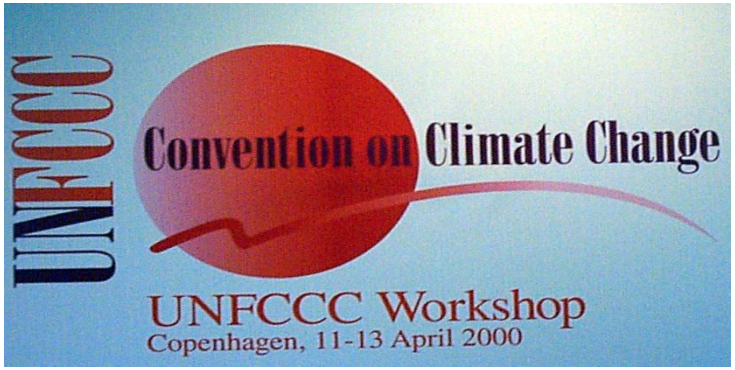
The future of the climate system (and our survival) depends on our ability to decouple future emissions from the other two factors: population and economic growth

Regional distribution of per Capita GHG Emissions



Annex I countries with ~20 % world population, produced 57% of world's GDP and 46% of emissions

(Source: IPCC 2007)



Agreement to cut emissions by all countries in the world depends on the successful and effectiveness of the COP meetings.

Summary

- Climate change is real and it is the result of unsustainable practices
- Climate Change is projected to intensify in decades to come. With current GHG concentration of 460 ppm and increasing at 2.5 ppm per year, an increase of 4^{o}C in global mean temperature by end of 21st century is almost certain
- Humanity can be greatly impacted by climate change in decades to come
- The world needs to move to low carbon economy and drastically decouple GHG emissions from energy and wealth growth
- Failure / slow progress at COP meetings reflect the ineffectiveness of the world political / economic system to deal with the problem
- Educating the citizens about climate change and the choices he or she can make is important

Thank You

Universiti Kebangsaan Malaysia
The National University of Malaysia