Webinar on

Climate Impacts and Vulnerability Assessments

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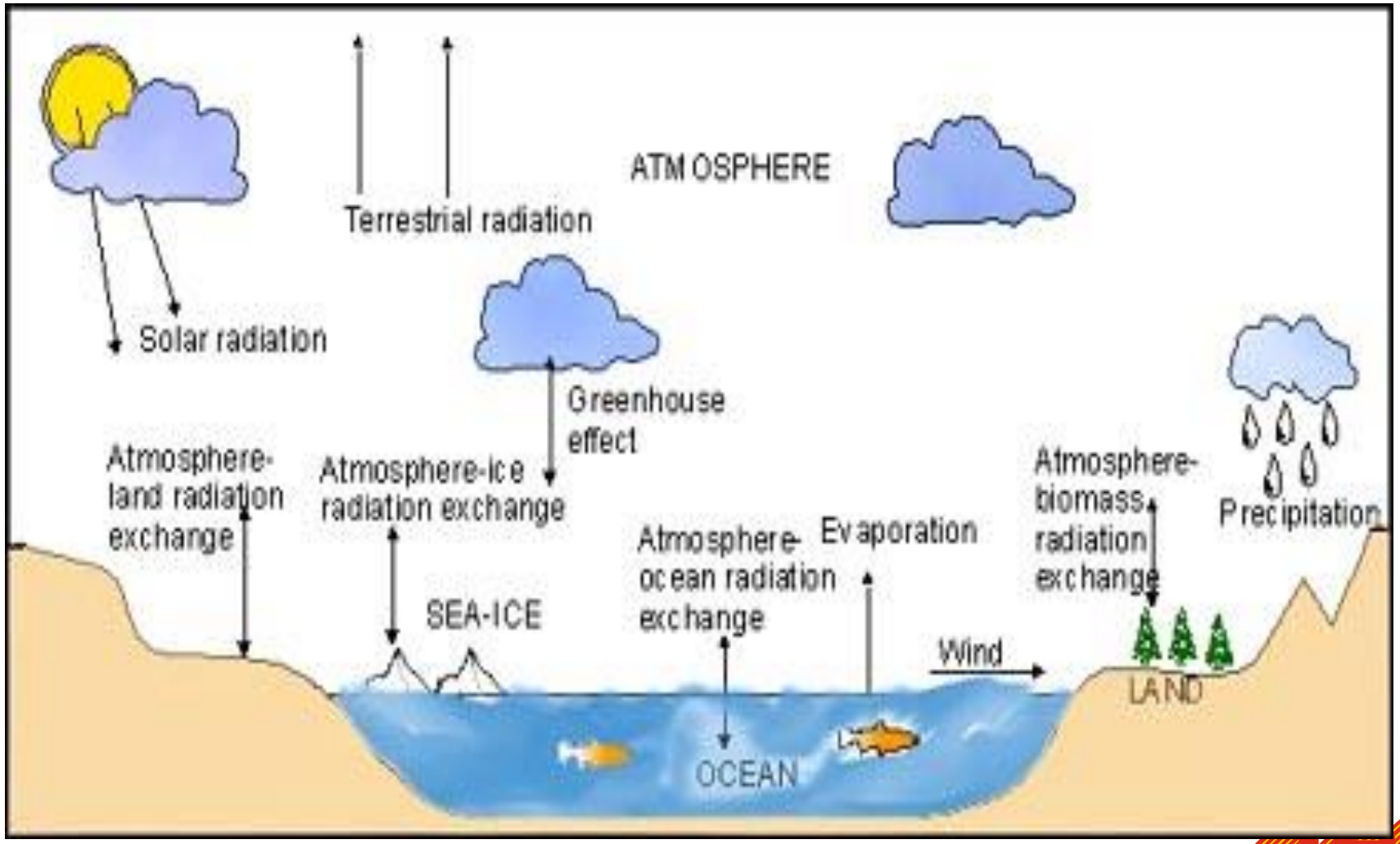
DST&E, Government of Puducherry, 28th Jan 2021

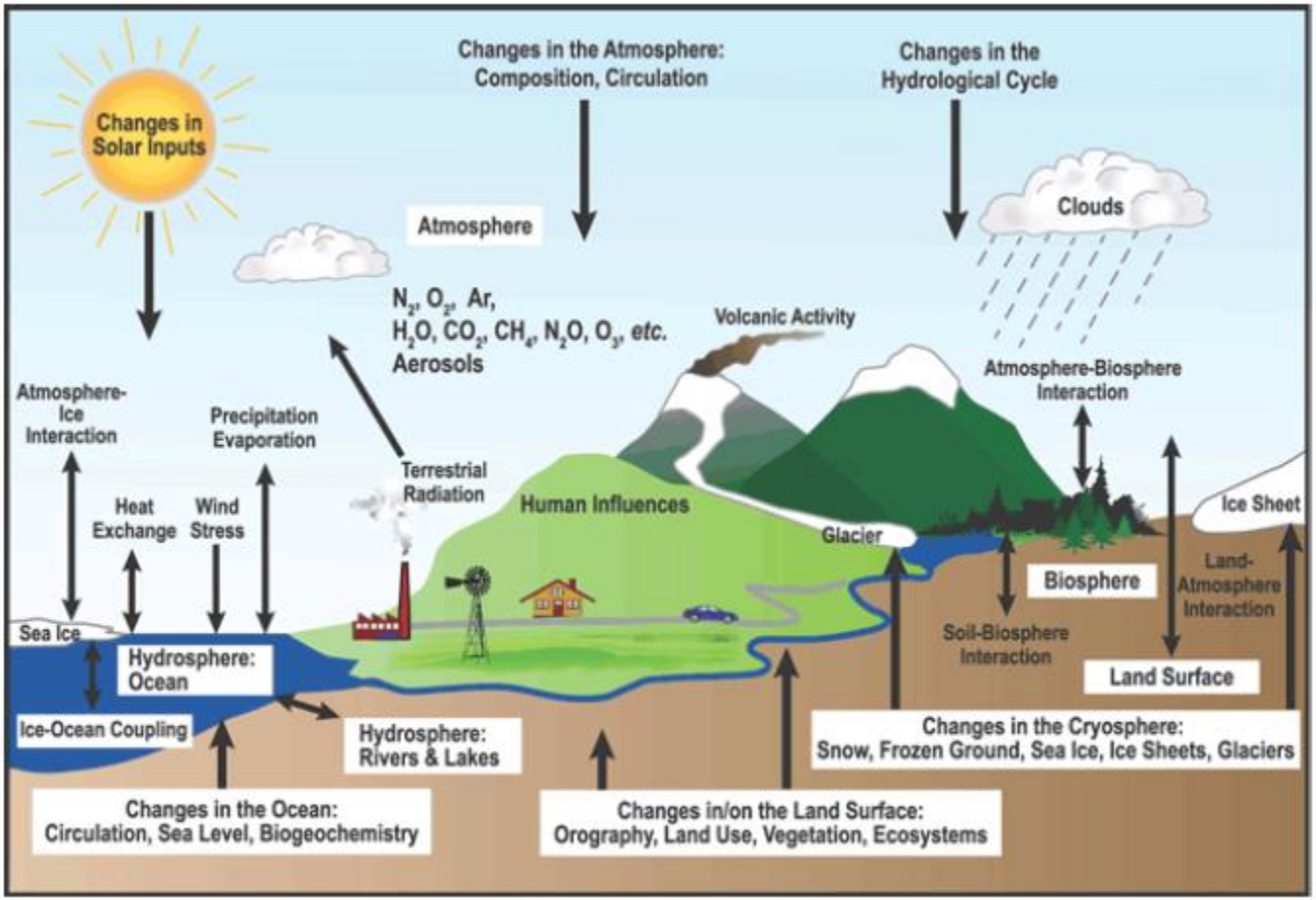
What is Climate

- Climate is average weather of a given region or area over a given period of time – it is what we expect and weather is what we get.
- Result of a delicate balance between the sun, atmosphere, oceans, water systems, plants, all living organisms, and topography.
- Important factors taken into account - rain, sunshine, humidity, wind and temperature. distance from the sun and the composition of the atmosphere.

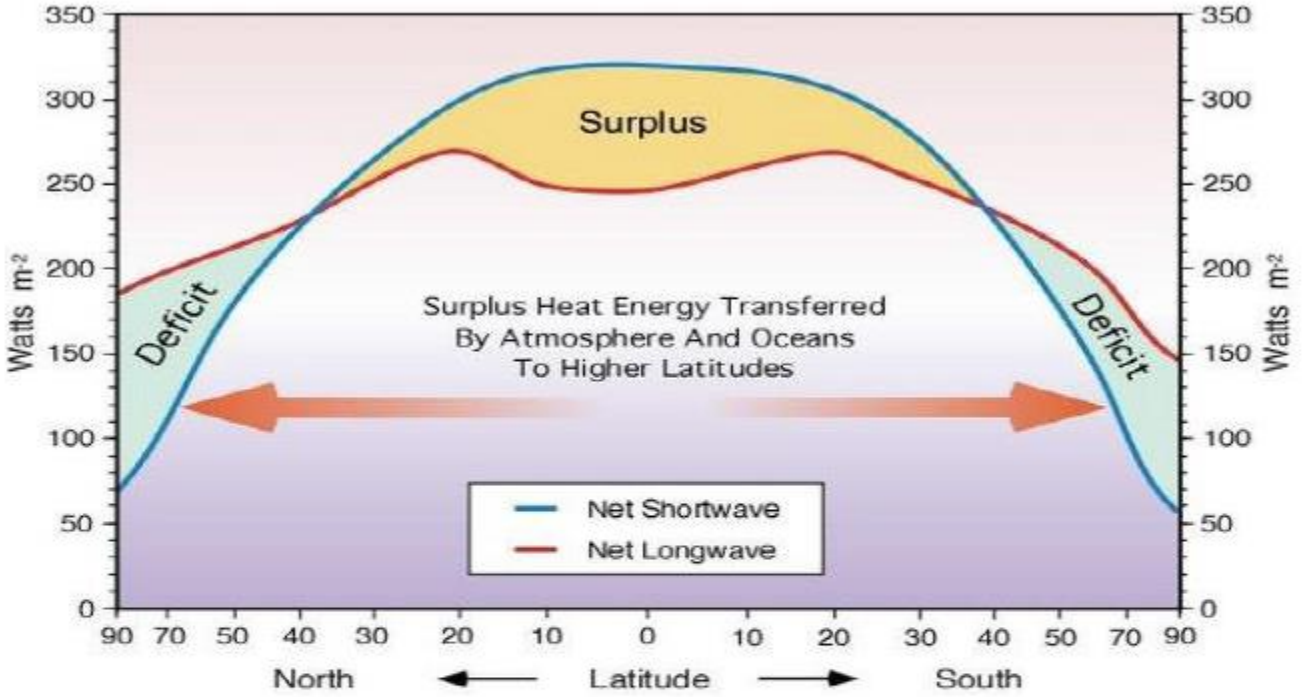
The Climate System



Interactions



The non-linear interaction among the components leads to climate variability at a range of spatial and temporal scales

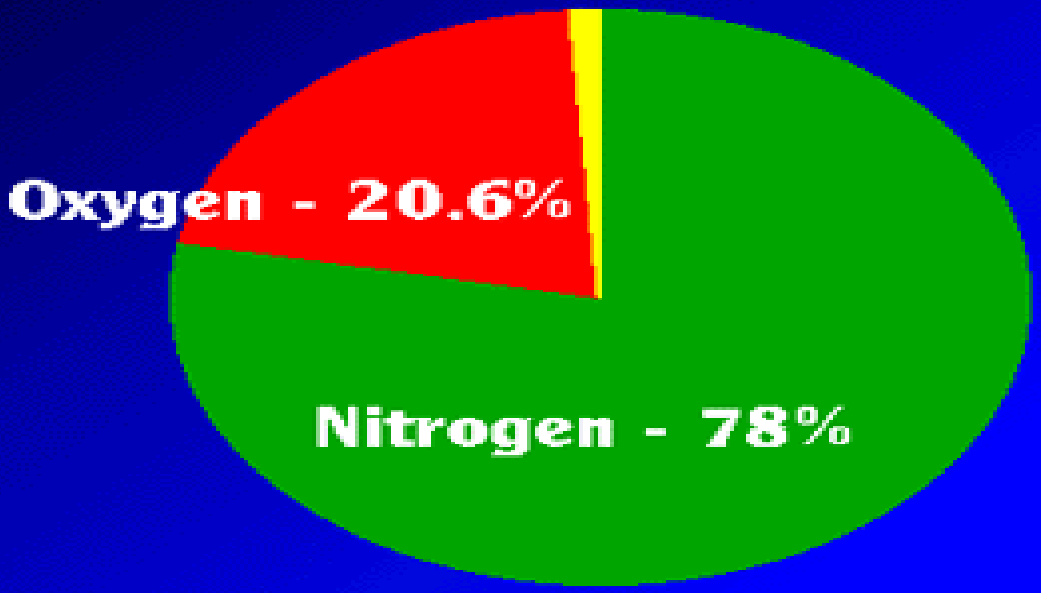


Radiation is not evenly distributed over the surface of the earth. The high-latitudes have an energy deficit and the low latitudes has excess. But the low latitudes don't indefinitely get hotter and the high-latitudes don't get colder. Why?

The atmosphere and ocean transfer energy from low to high latitudes

Composition of the Earth's Atmosphere

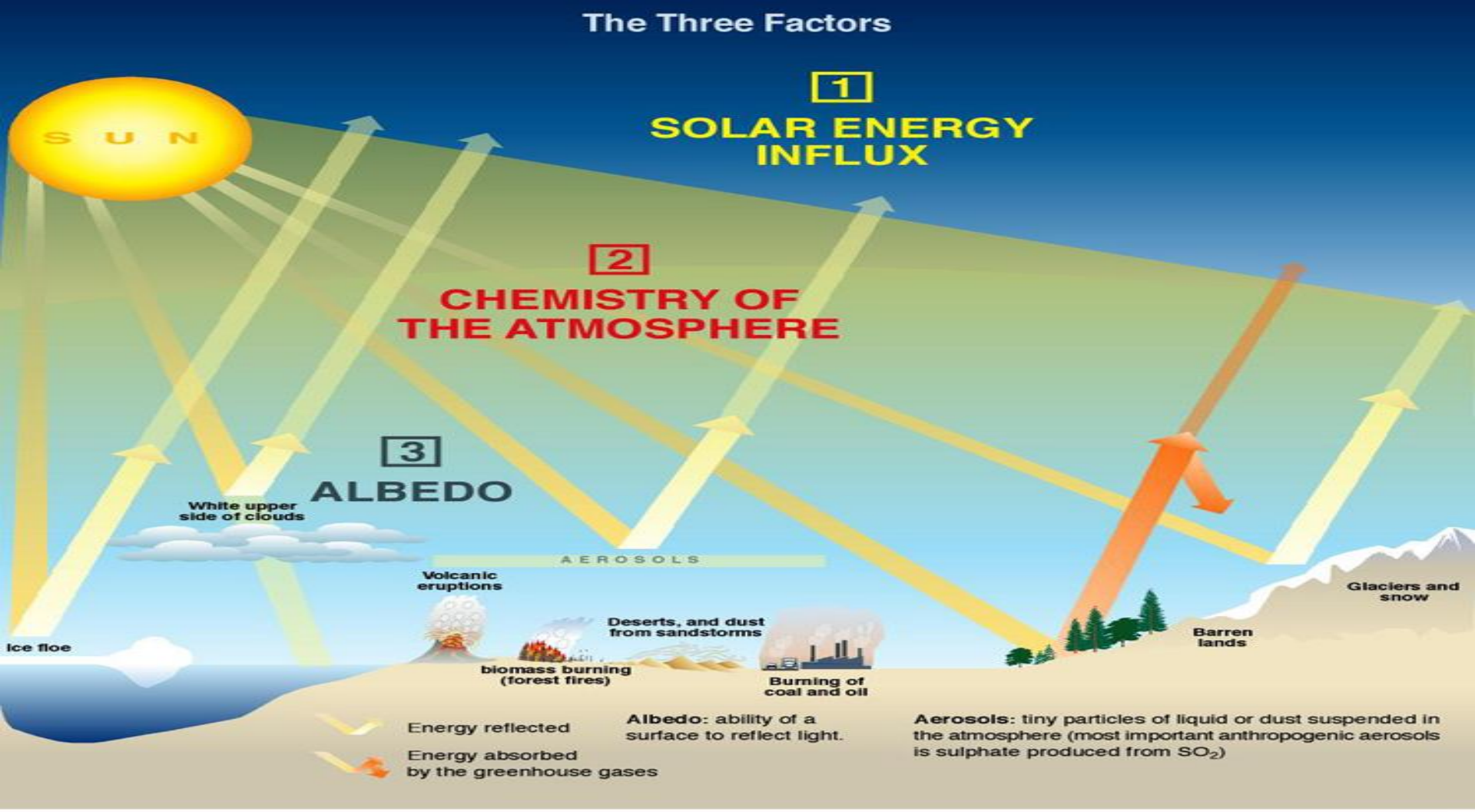
(Gases - Percent by Volume)



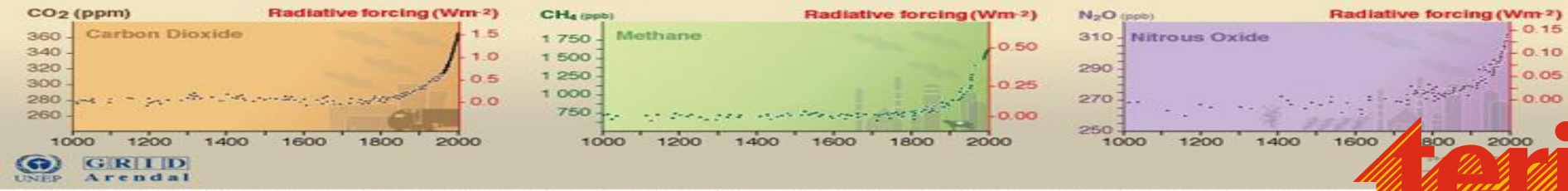
Argon (0.934%)
Water Vapor (0.4%)
* Carbon Dioxide (0.035%)
Neon (0.00182%)
Hellum (0.000524%)
* Methane (0.00015%)
Krypton (0.000114%)
Hydrogen (0.00005%)
* N_2O (0.00003%)
* Ozone (0.000005%)
* CFCs (0.0000001%)

* Known Greenhouse Gas

CG Figure 7



Indicators of the human influence on the atmosphere during the industrial era : changing chemistry



UNEP GRID Arendal

Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protec
Washington, Climate change 1995, *The science of climate change*, contribution of working group 1 to the second assessment report of the intergovernment
change, UNEP and WMO, Cambridge university press, 1996 ; *Radiative forcing of climate change*, the 1994 report of the scientific assessment working gro
for policymakers, WMO, UNEP ; L.D. Danny Harvey, *Climate and global environmental change*, Prentice Hall, pearson Education, Harlow, United Kingdom,

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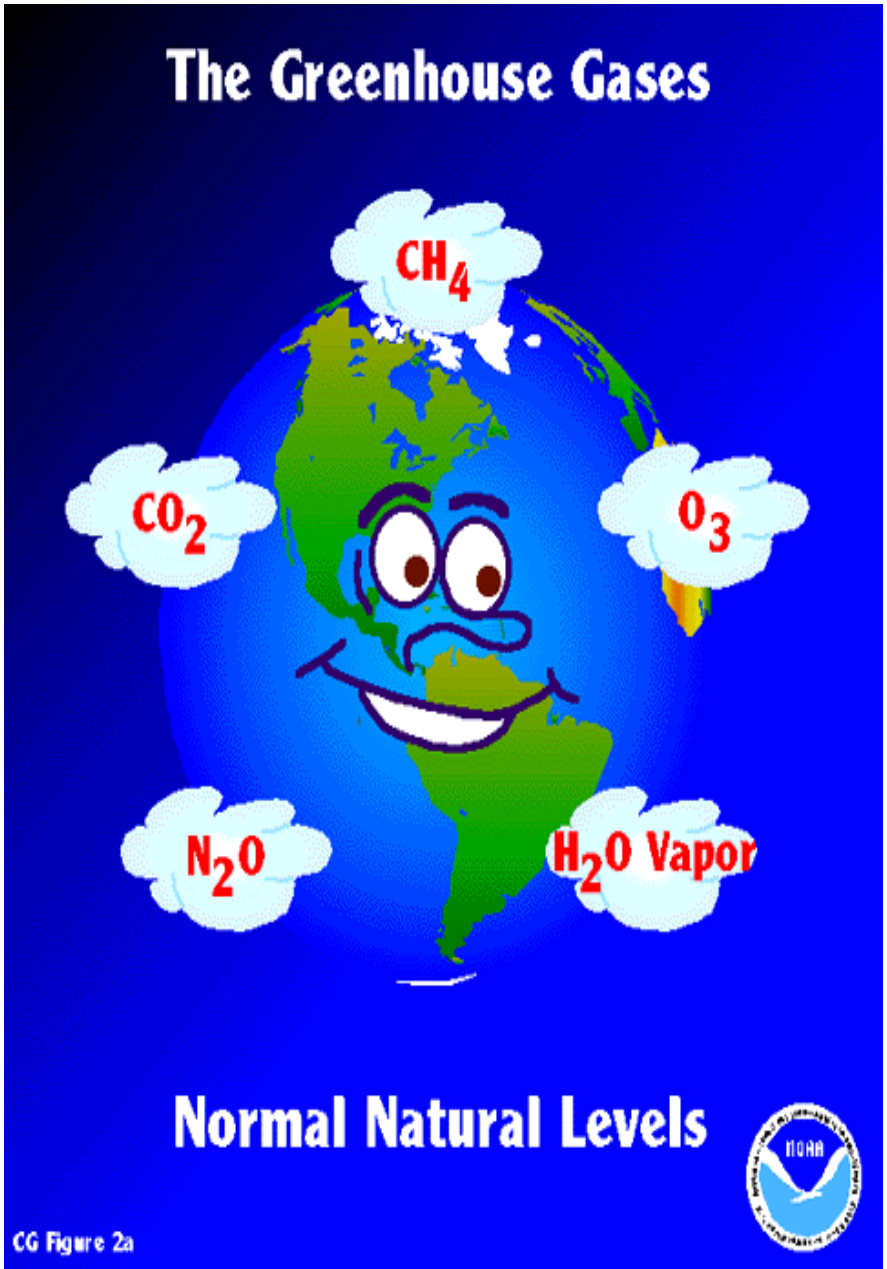
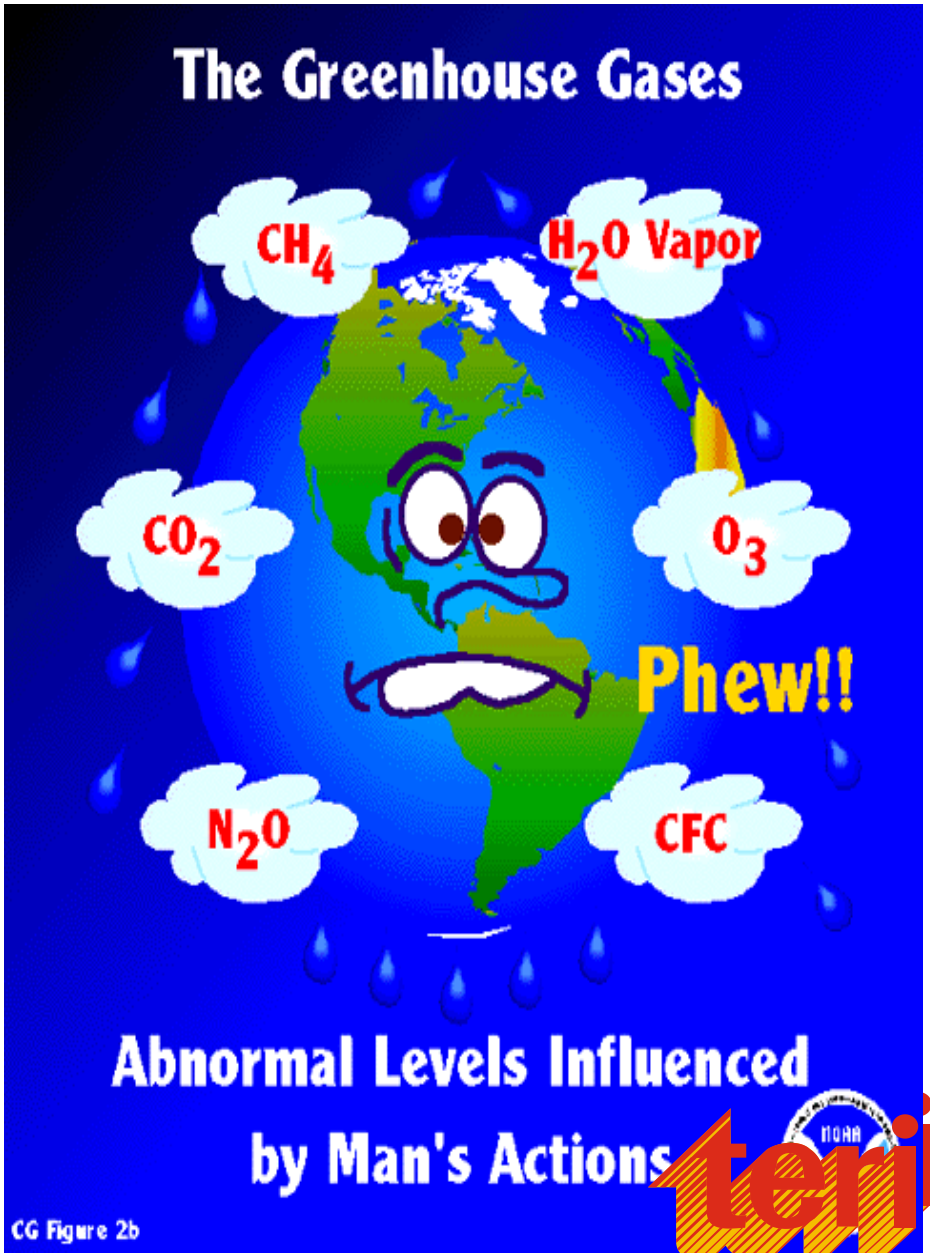
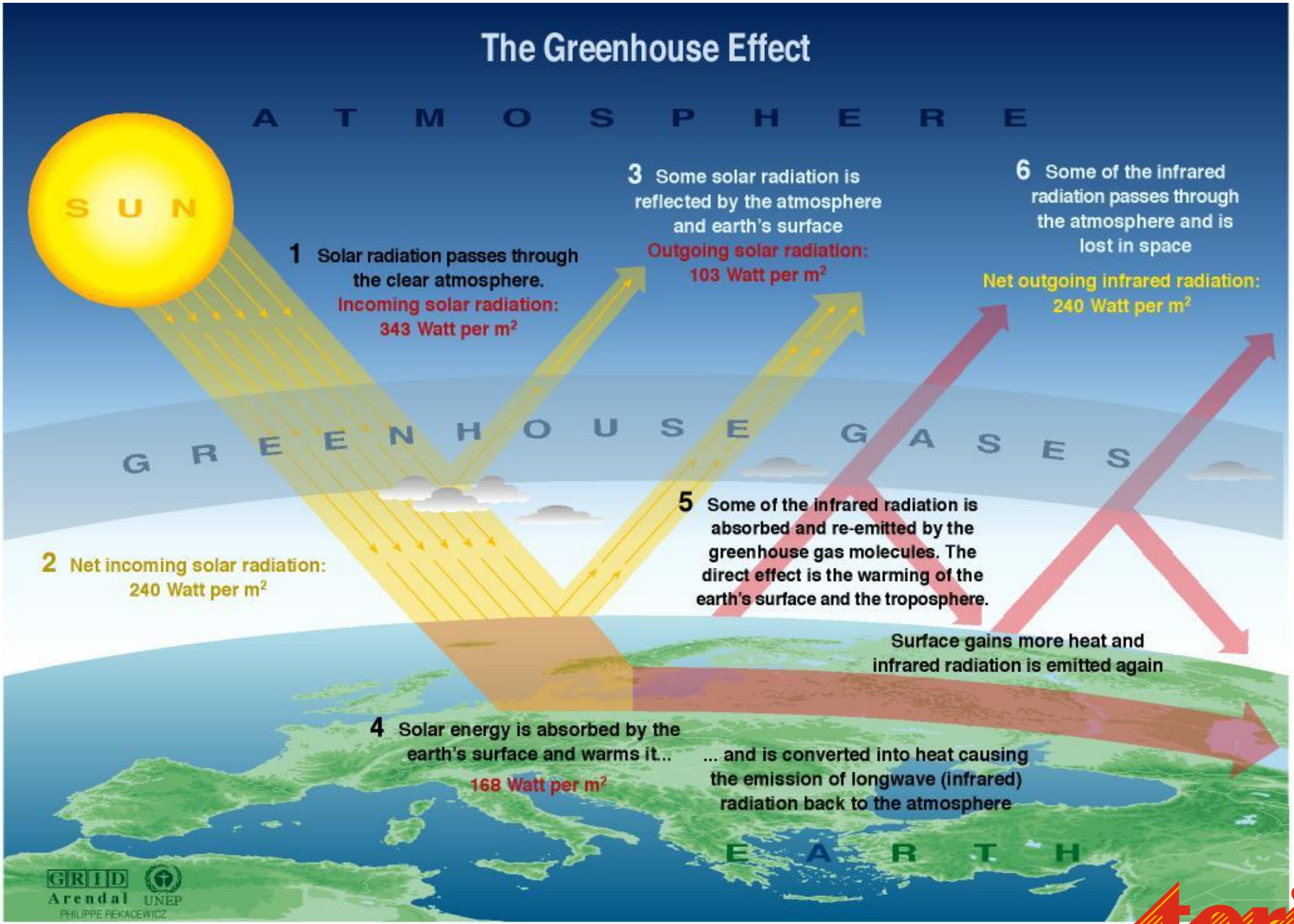
Greenhouse Effect







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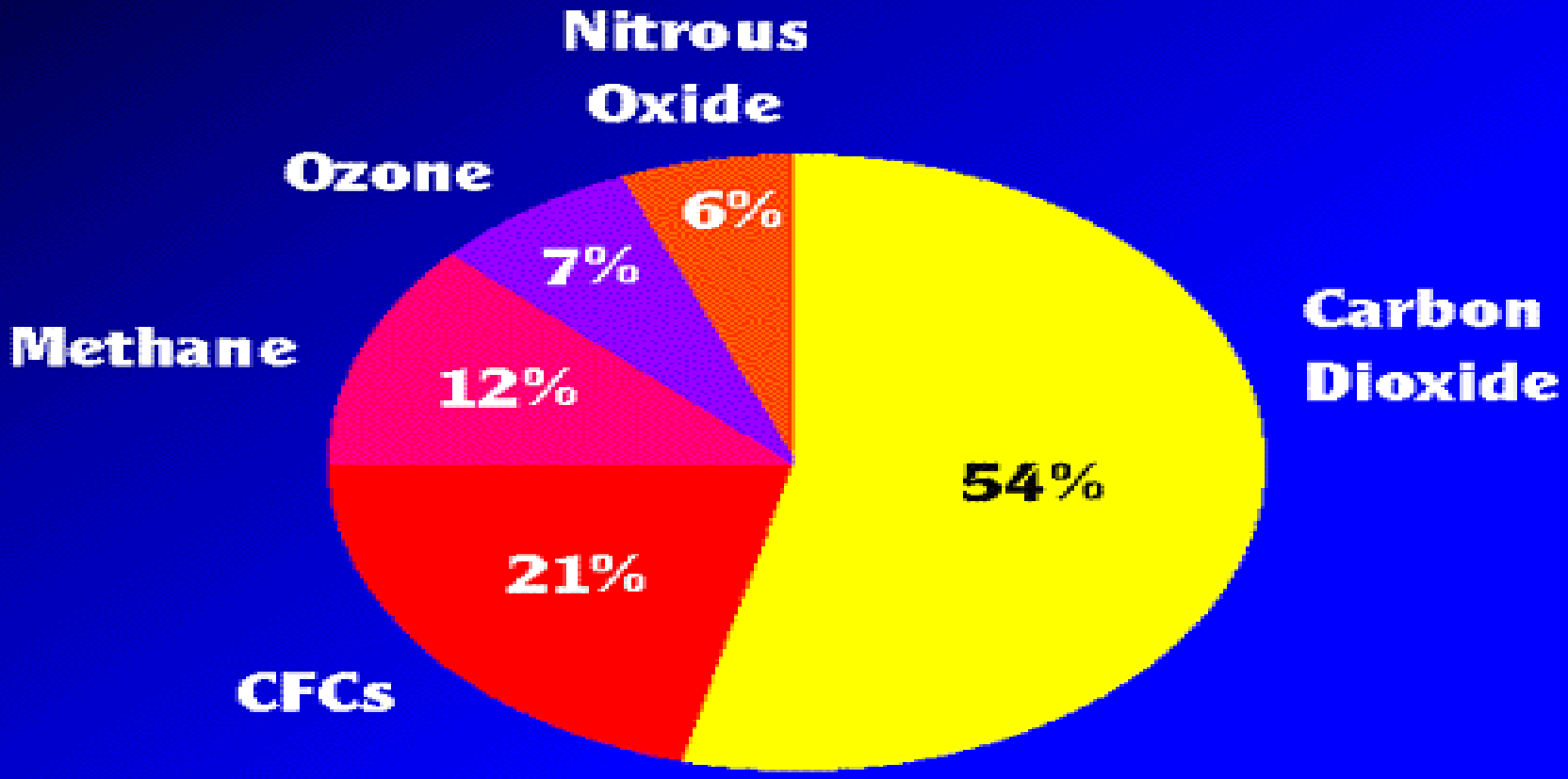
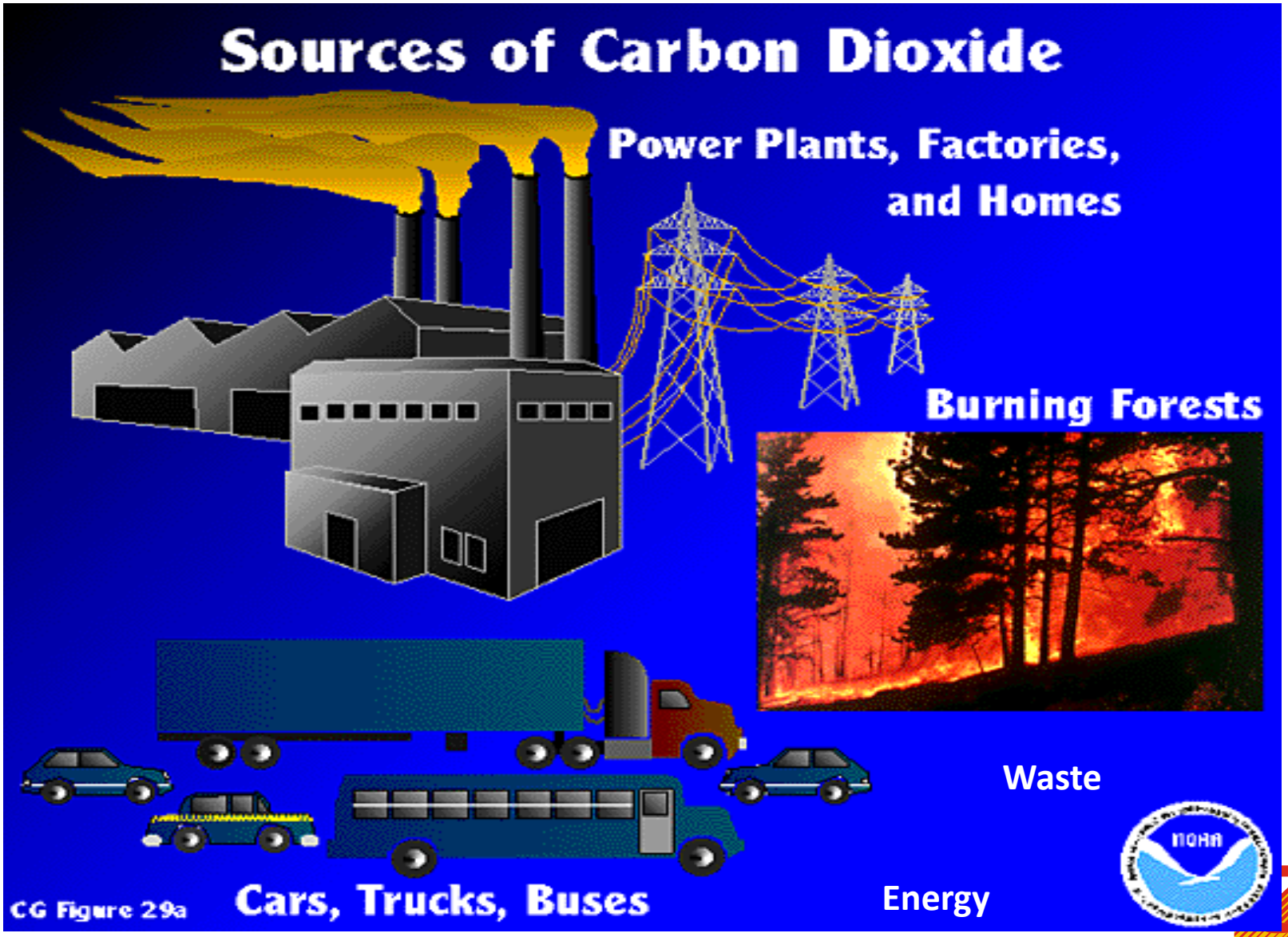
UNEP and WMO, Cambridge university press, 1996.

Contributions to Global Warming by the Major Greenhouse Gases



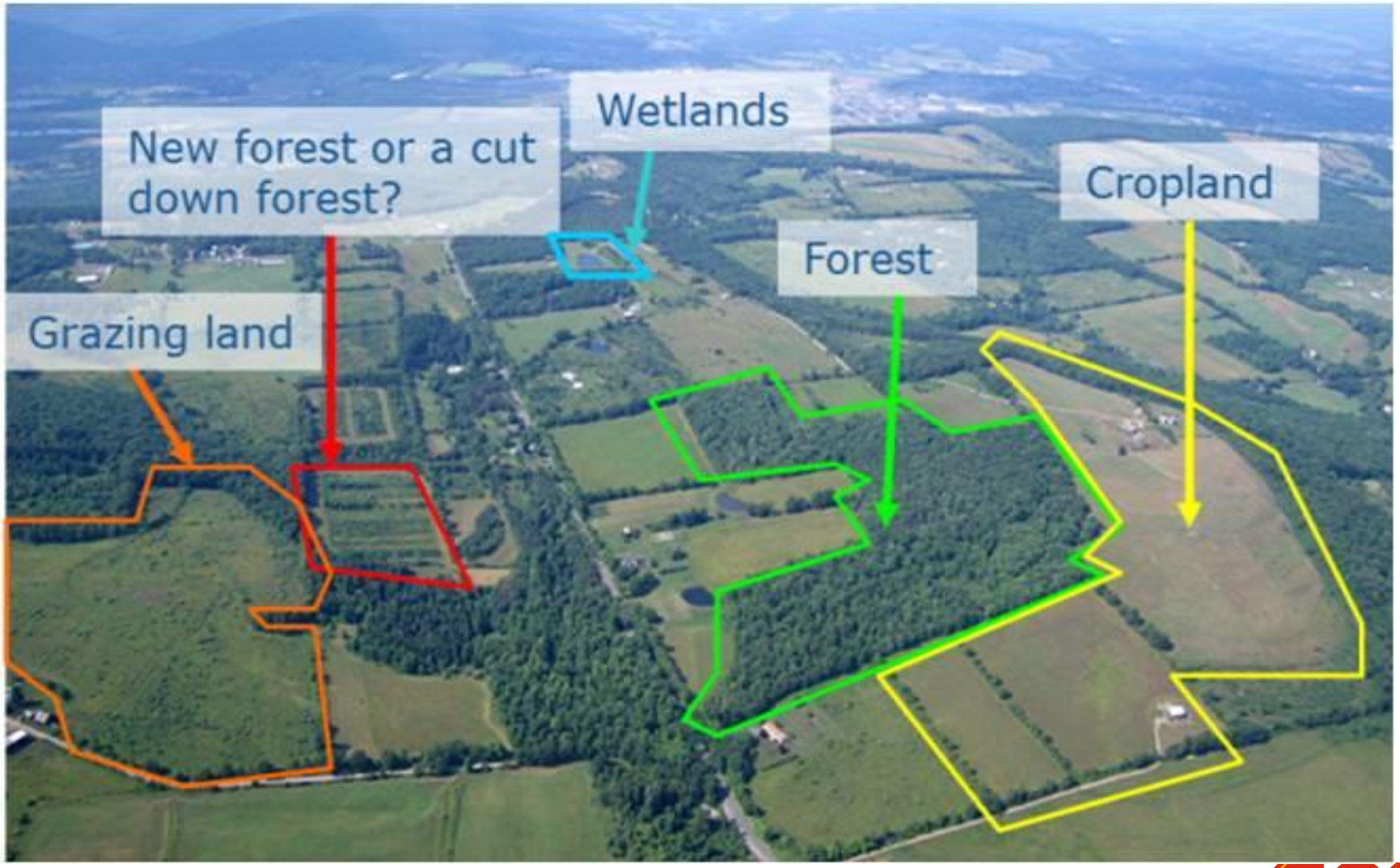
Source - *The Greenhouse Trap*, Francesca Lyman, World Resources Institute, 1990

Sources of GHGs



Mount Pinatoba

LULUCF



Source: EC

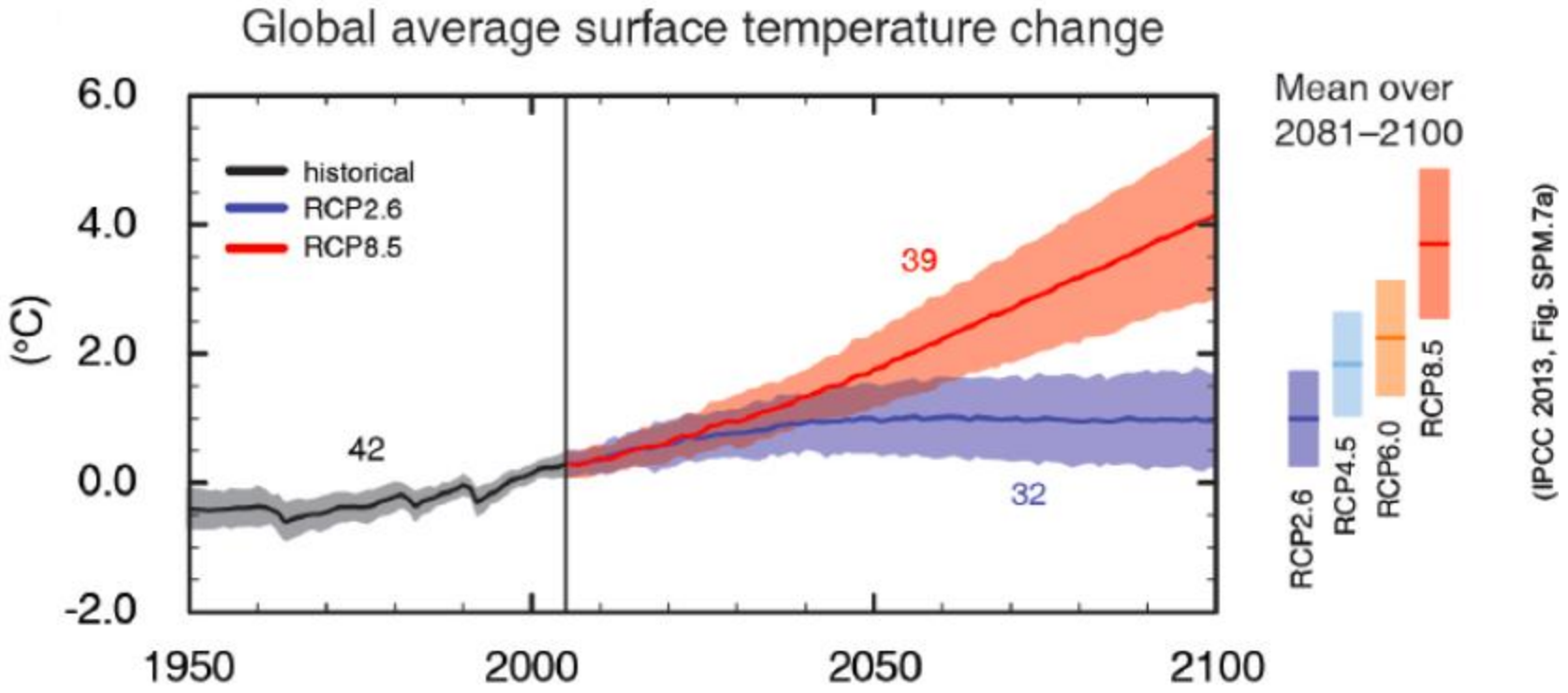
IPCC Report Findings: 20th century

- Increase in global mean temperature by over 0.7^{0}C
- Decrease in snow cover and ice extent
  - 10 % reduction in snow cover since late 1960s
  - 10 -15 % reduction in spring/ summer ice content since 1950s
- 0.1– 0.2 m rise in global sea level
- 1990s the warmest decade of the millennium

IPCC Report: 21st century projections

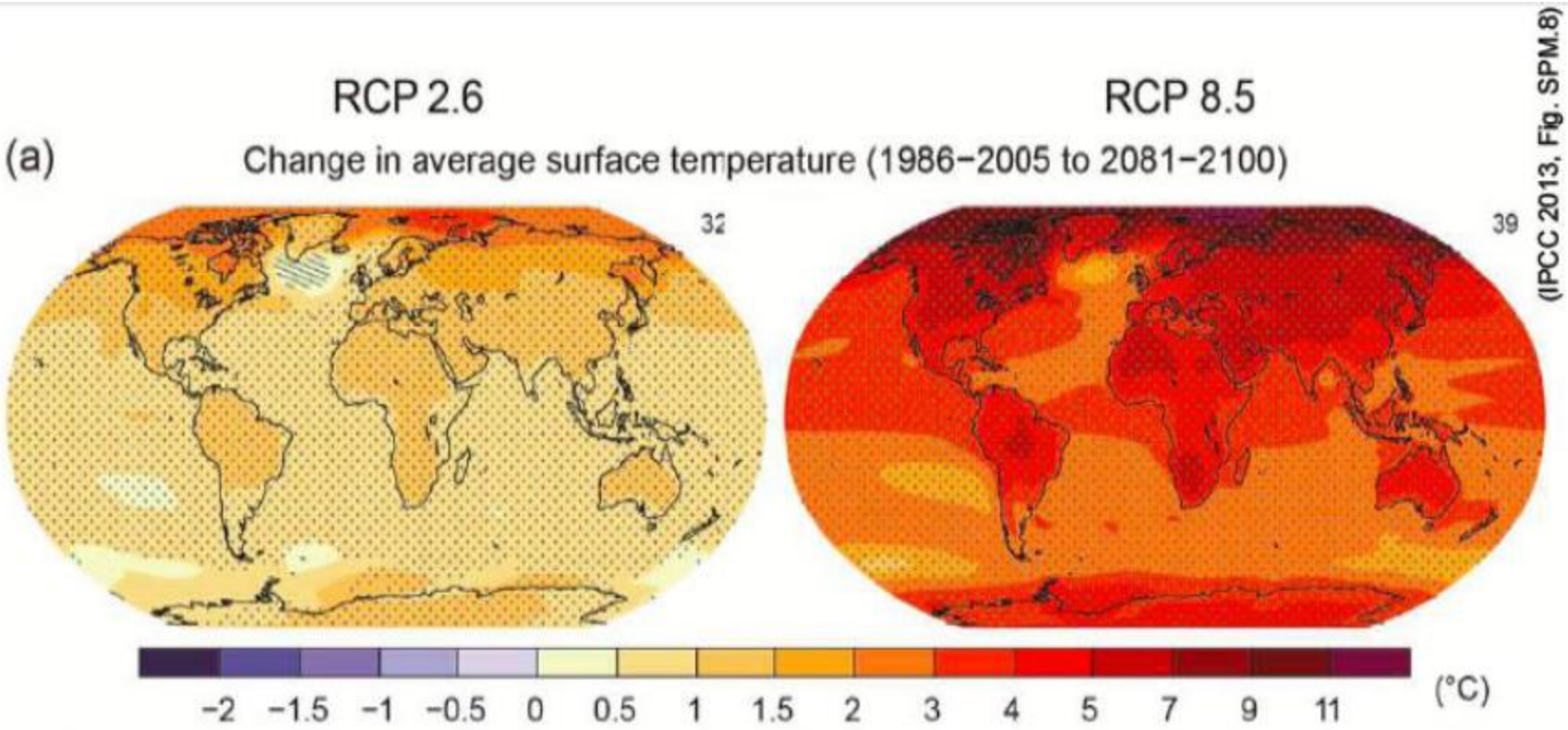
Global mean temperatures and sea level projected to rise under all IPCC scenarios

- Mean surface temperature to increase by 1.1 to 6.4 ^{0} C
- Mean sea level to rise by 0.09 to 0.88 m as compared to 0.18 to 0.59 m in the AR4
- Decrease in Northern Hemisphere snow cover and sea-ice extent
- Increase in summer flows of river systems followed by reductions as glacier disappears



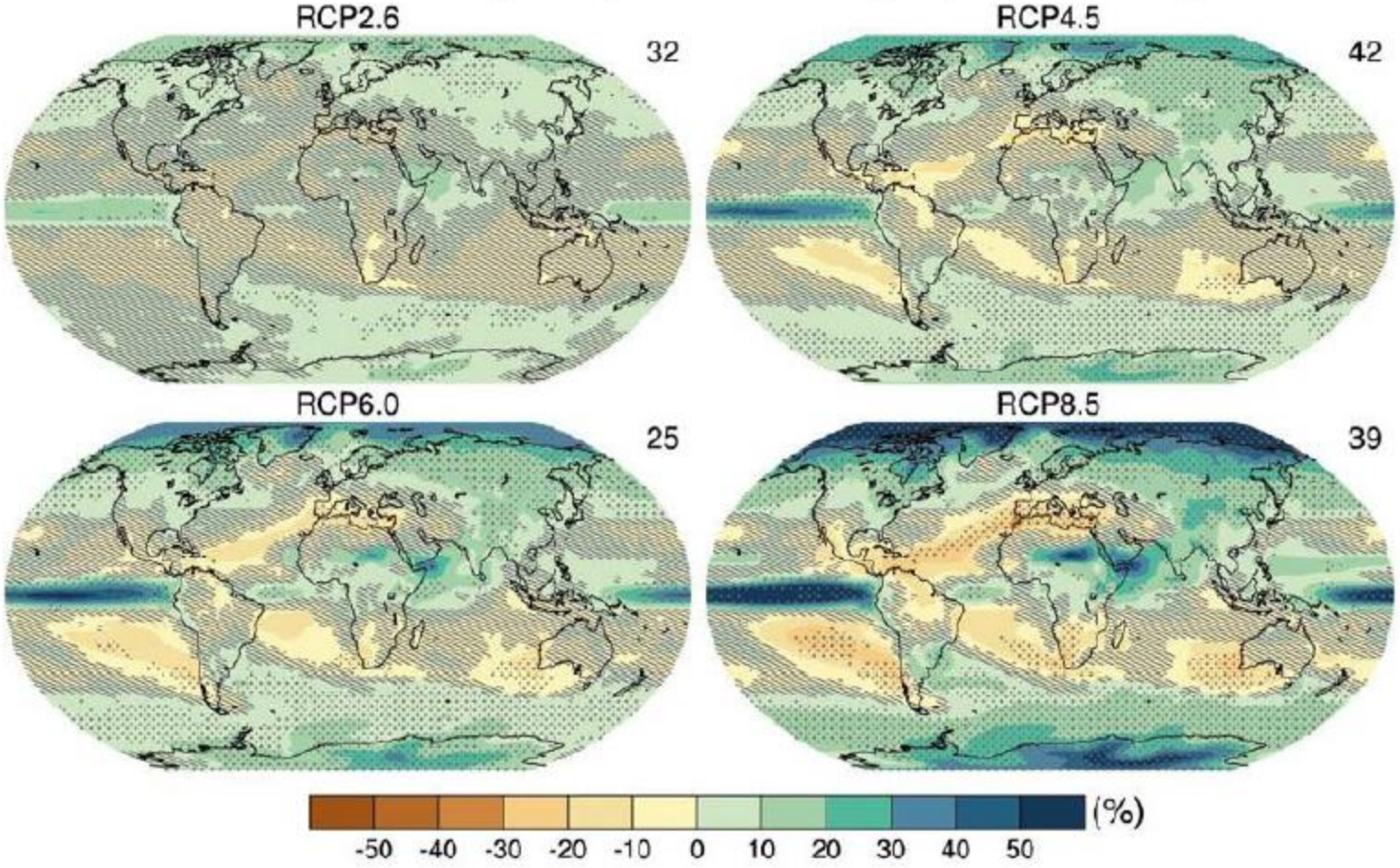
Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 for all scenarios

Changes in precipitation patterns, evapotranspiration rates, humidity levels and increase in the frequency and intensity of extreme events



Increase of global mean surface temperatures for 2081–2100 relative to 1986–2005 is projected to likely be in the ranges derived from the concentration driven CMIP5 model simulations, that is, 0.3°C to 1.7°C (RCP2.6), 1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5).

Annual mean precipitation change (2081-2100)



IPCC AR5

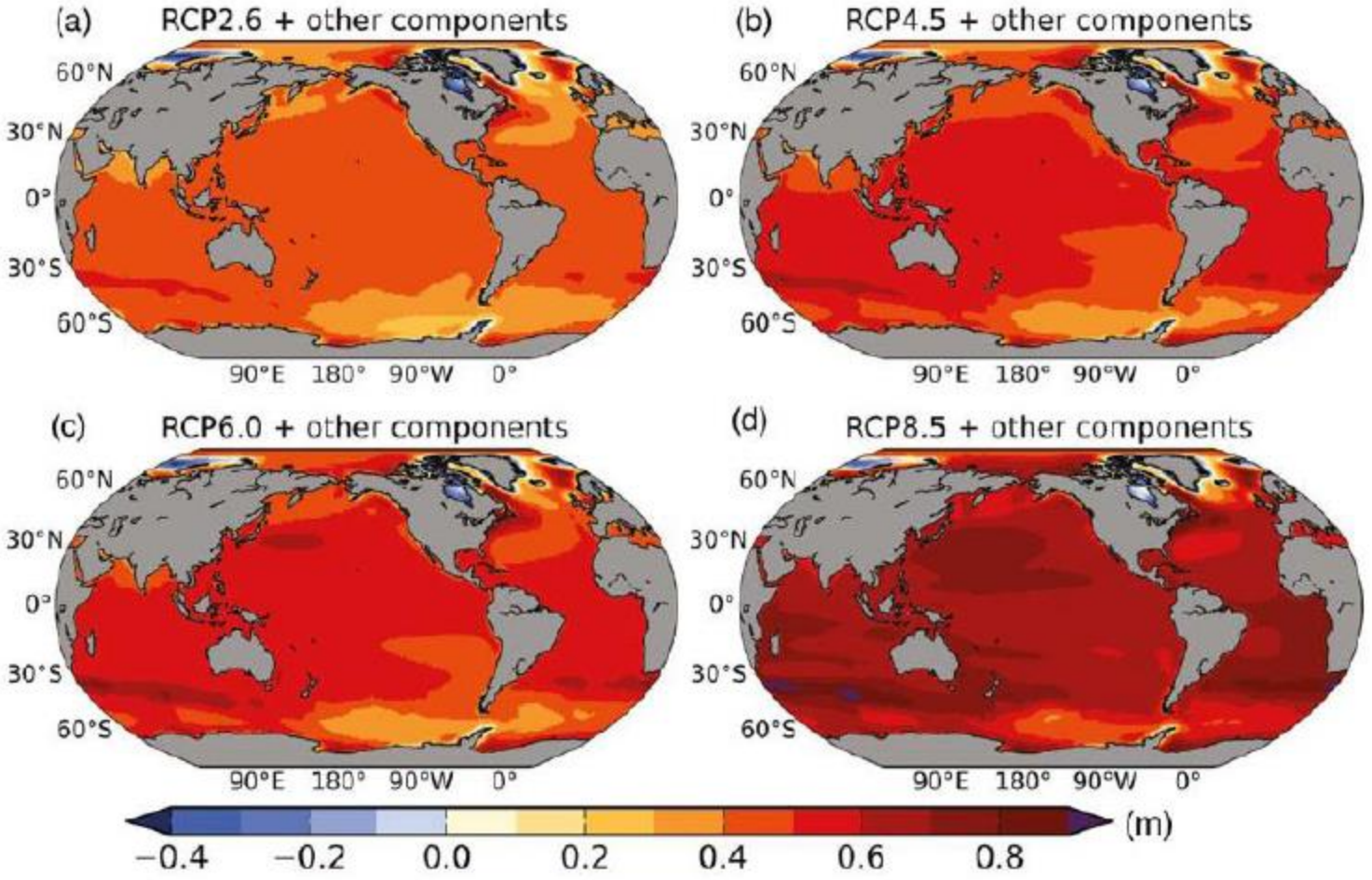
More heavy precipitation and more droughts….

Sea Level Variations

Observed rate of global sea level rise and estimated contributions from different sources		
	Rate of sea level rise (mm/year)	
Source of sea level rise	1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5	3.1 ± 0.7
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0
Note: Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.		

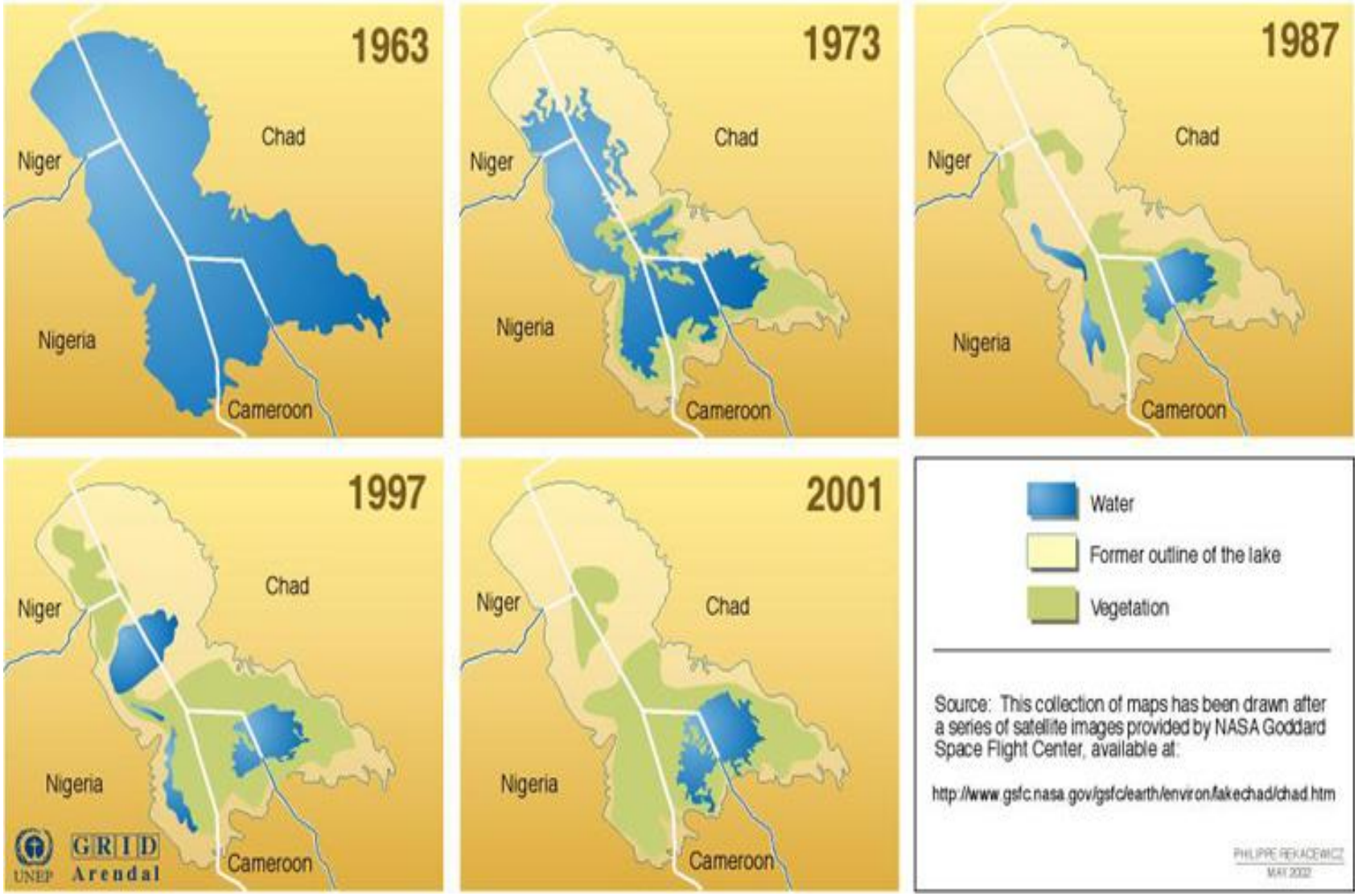
Source: Bindoff *et al.*, 2007

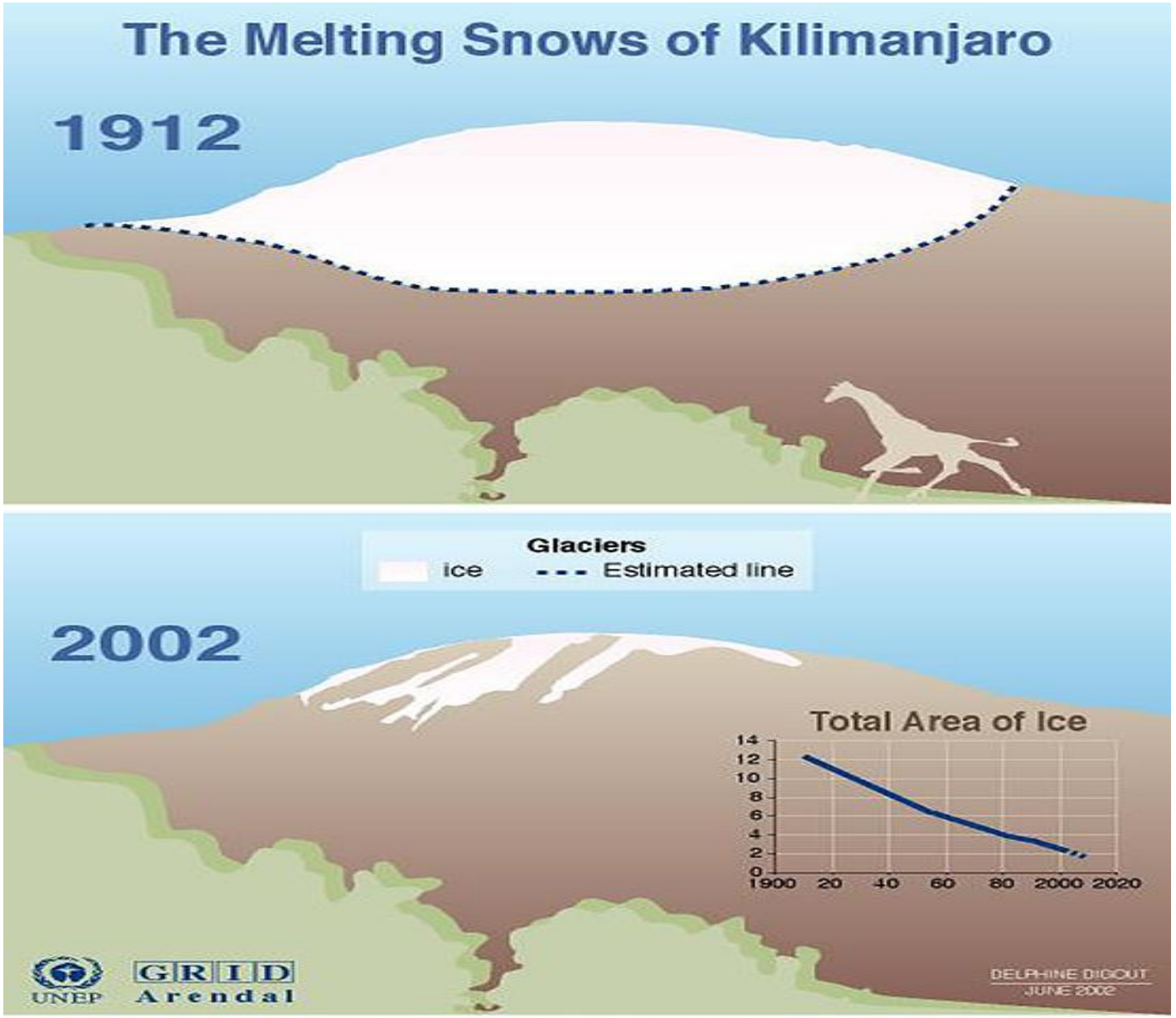
Sea Level



IPCC AR5

The Disappearance of Lake Chad in Africa





Sources: Meeting of the American Association for the Advancement of Science (AAAS), February 2001 ; Earthobservatory.nasa.gov.

Impact on water availability: retreat of glaciers

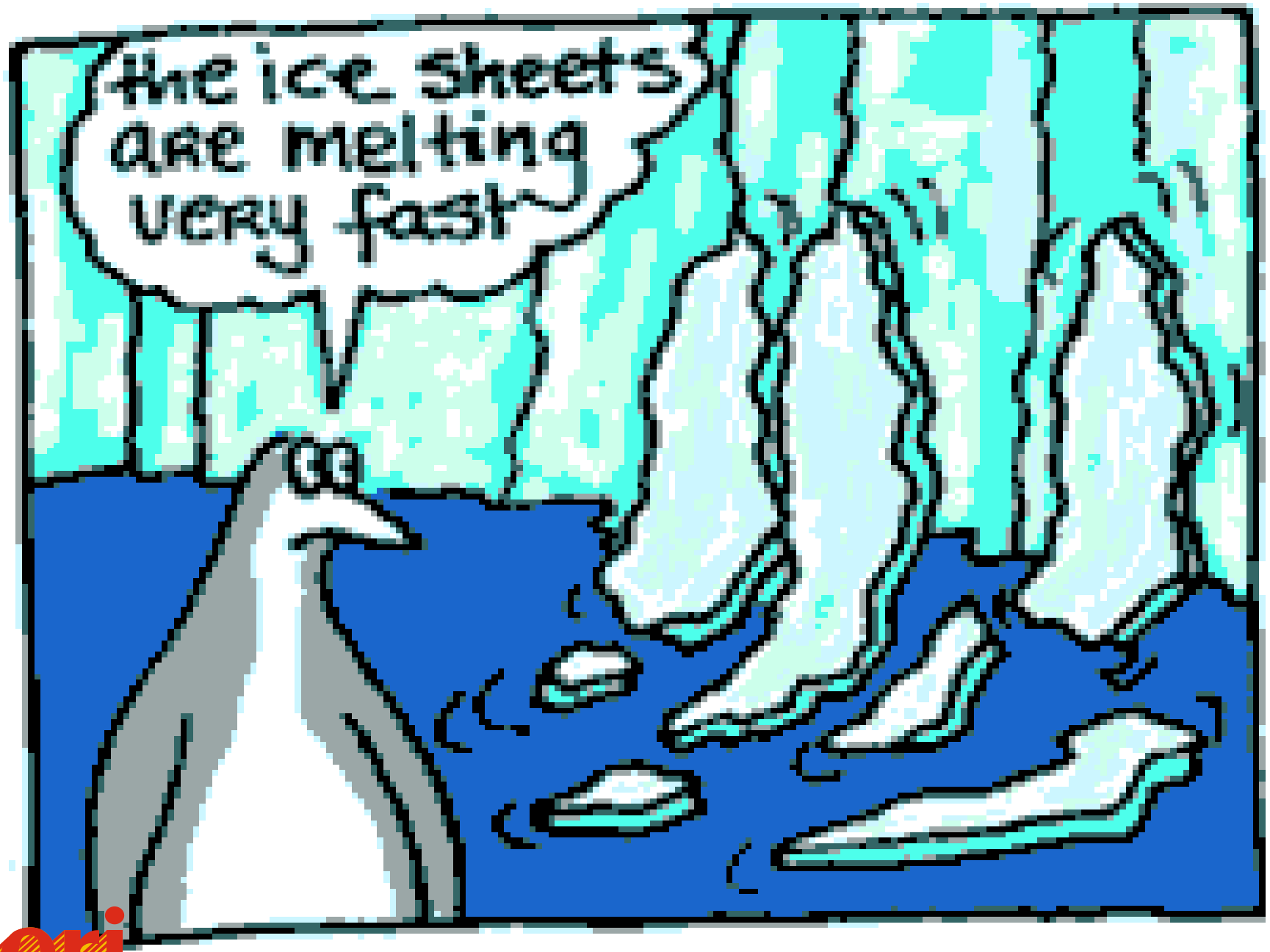
Source: NASA

Increase in forest fires

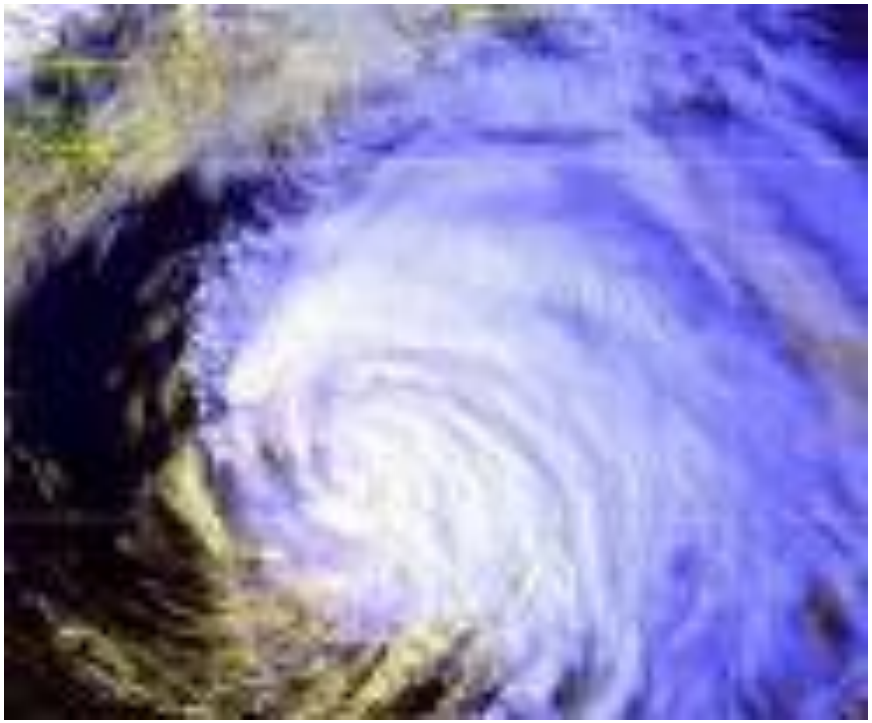
Coral bleaching

Desertification

Floods, landslides


The ice sheets are melting very fast

Droughts – 2/3rd land area under arid and semi-arid conditions
Frequency of hot days and multiple-day heat wave has increased in past century; increase in deaths due to heat stress in recent years (IPCC AR4)

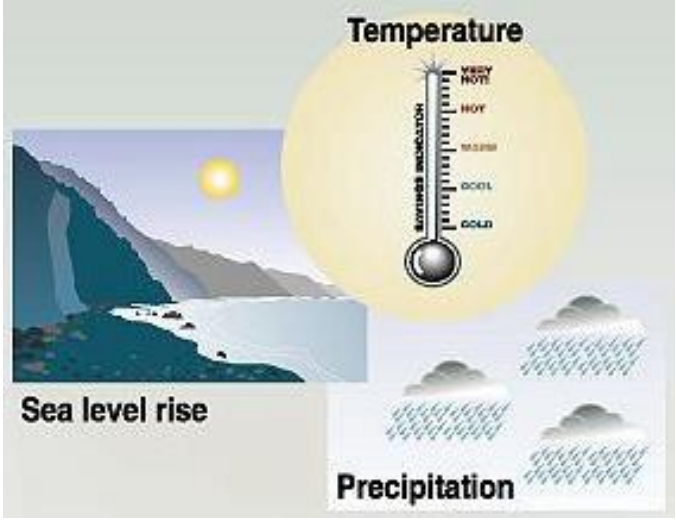


Cyclones – 1999 Super Cyclone in Orissa resulted in significant
loss of life, damaged 1828532 houses, 1810091 hectares of agriculture land and significant infrastructure damage affecting one third population of the state.

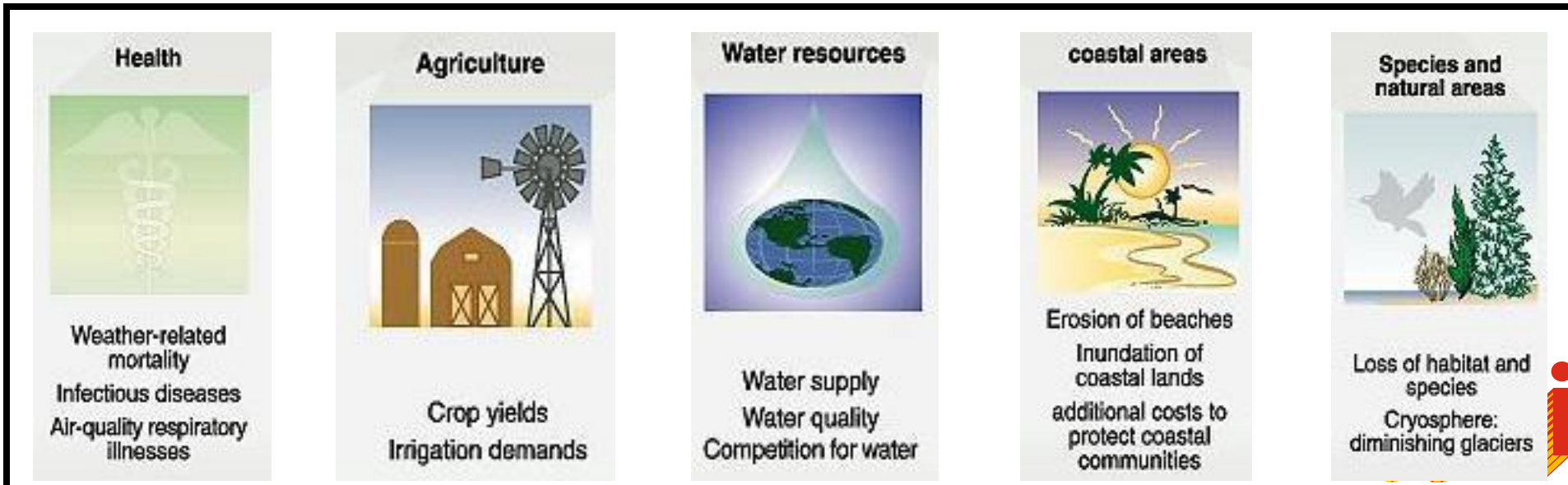
Floods – Nearly 40 Mha of land liable to floods
Diarrhoeal diseases and outbreaks of other infectious diseases (IPCC AR4)

Cyclones originating from Bay of Bengal and Arabian Sea noted to decrease since 1970 but intensity has increased. Damage caused by intense cyclones has risen significantly in India (IPCC AR4)

Source: GRID Arendal

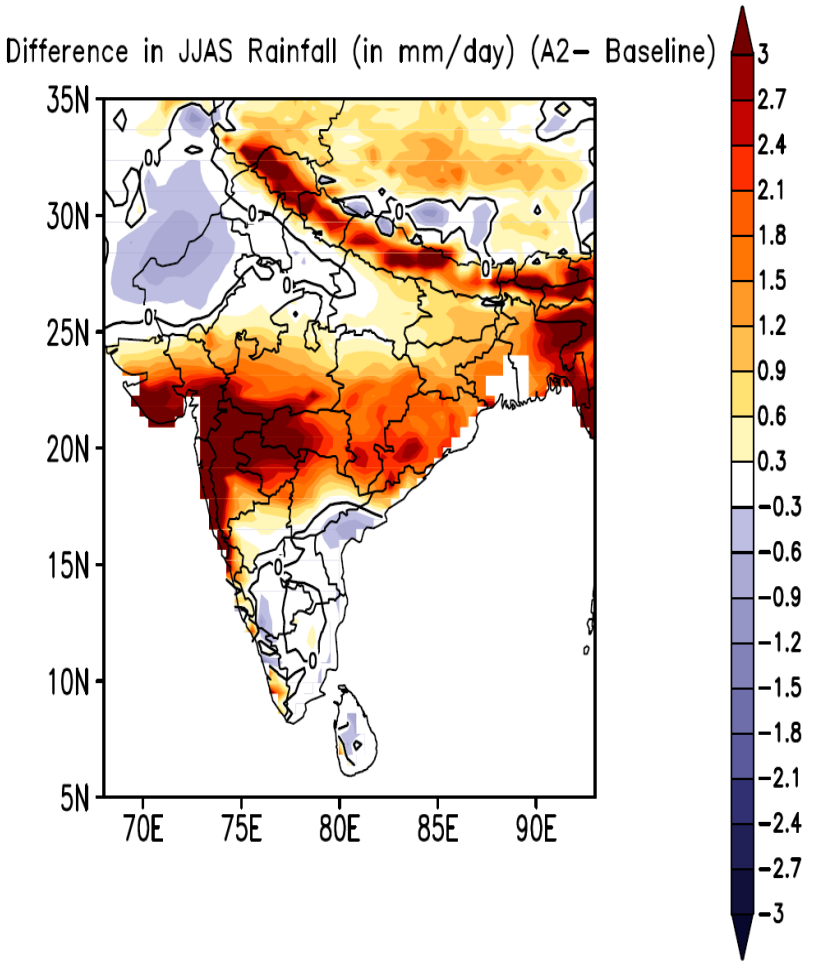


Impacts

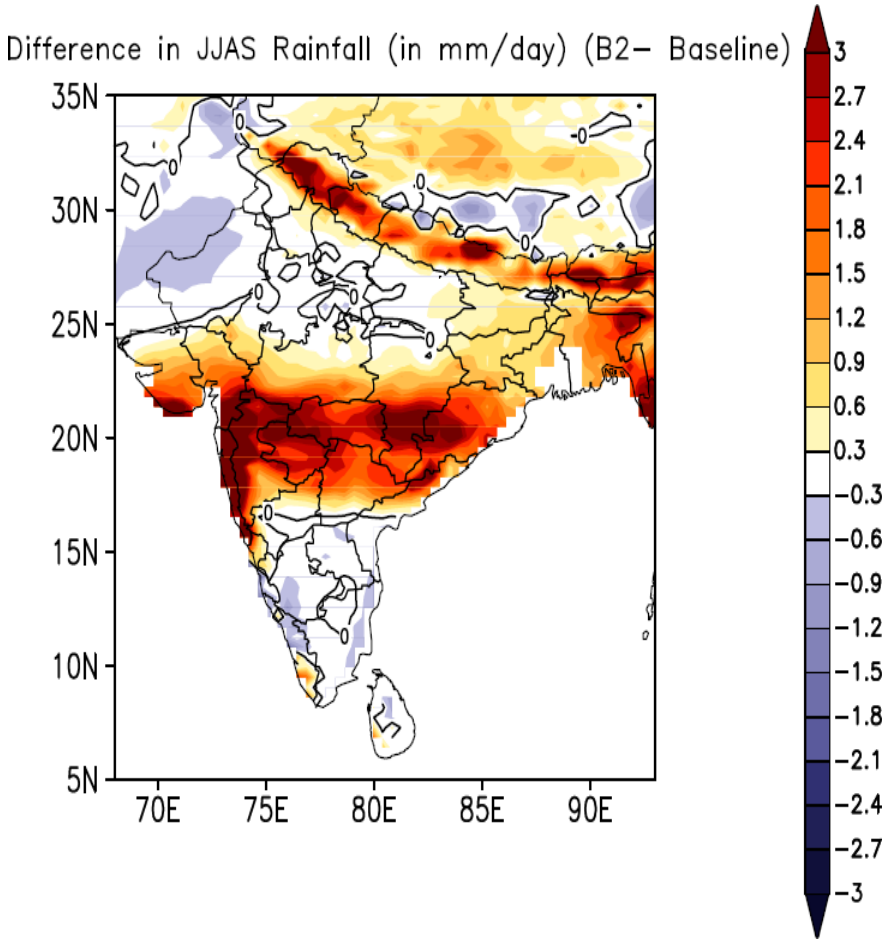


Climate Modelling- Rainfall Projections using PRECIS (2071–2099)

Extreme - scenario



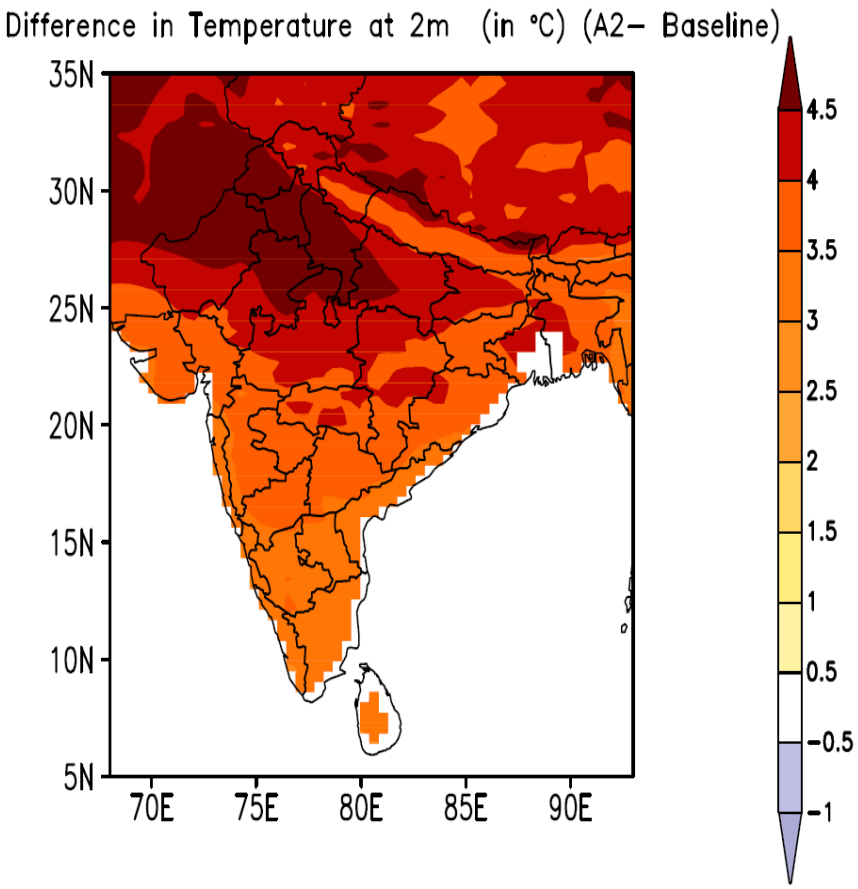
Moderate-scenario



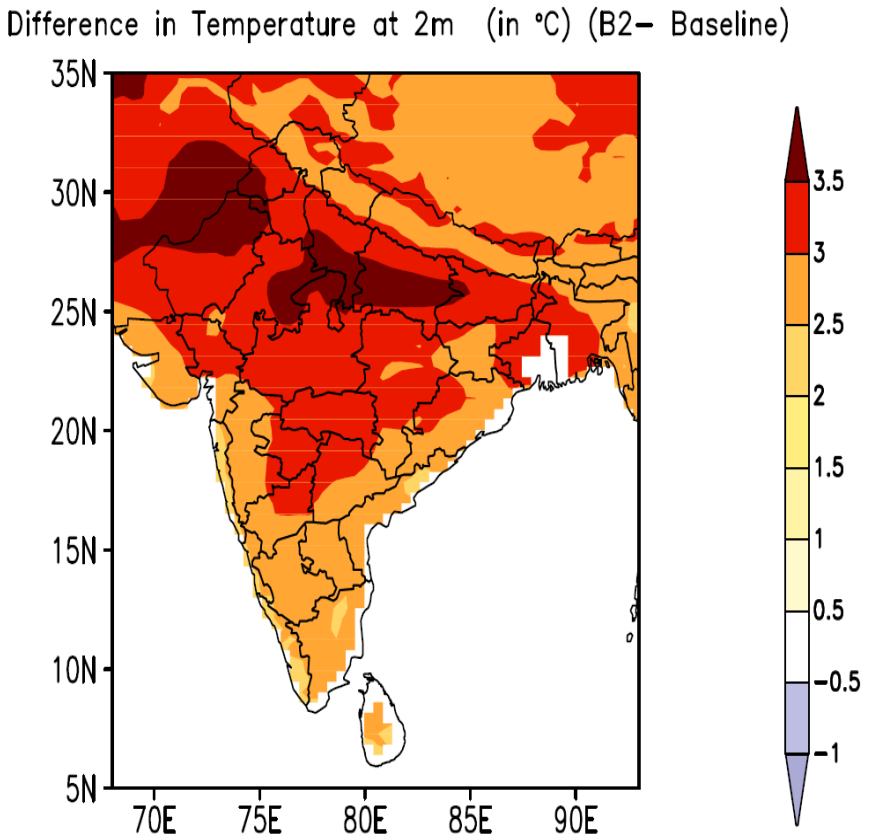
Temperature change using PRECIS

(2071–2099)

Extreme-scenario

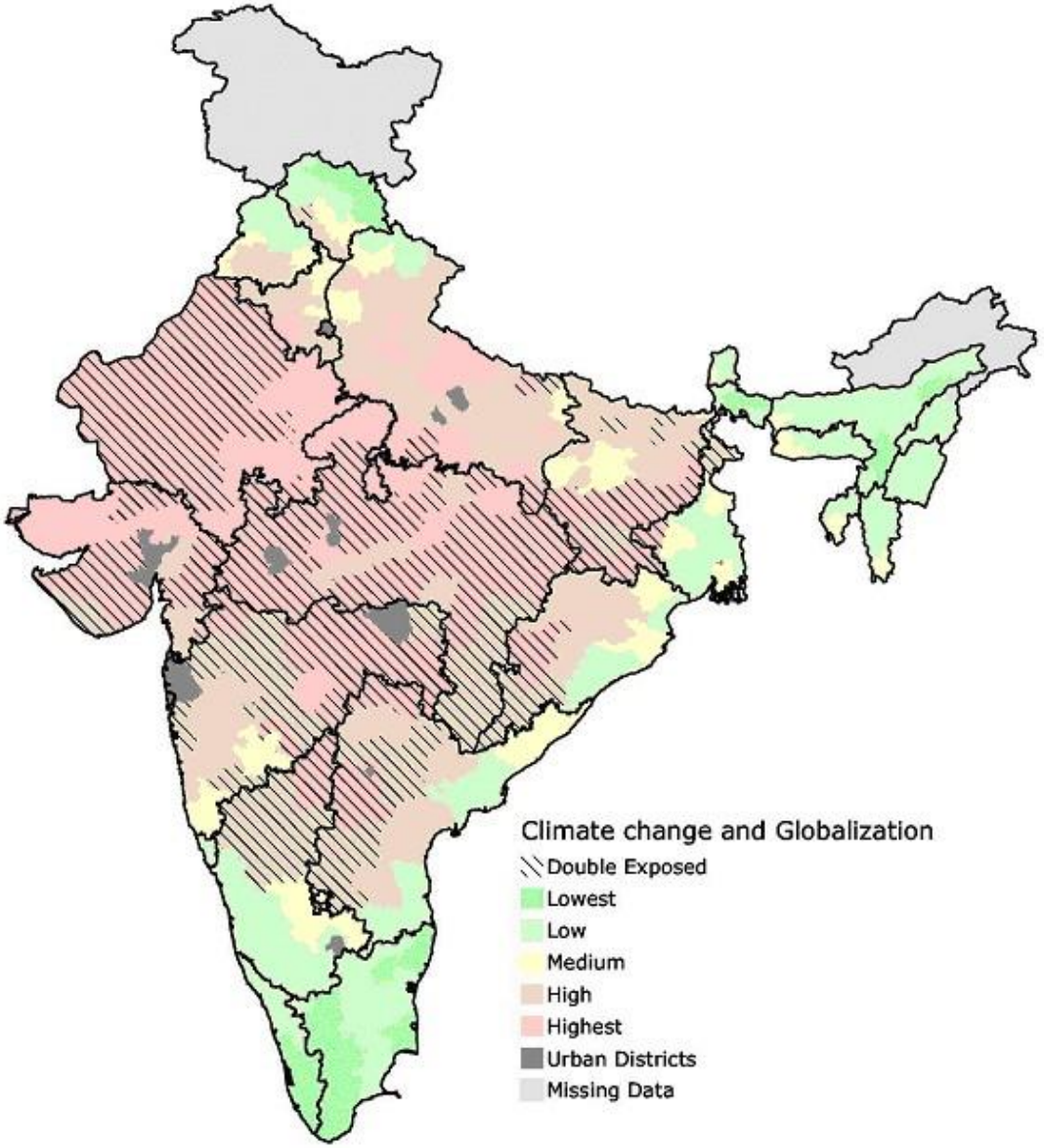


Moderate-scenario



Impacts, vulnerability and adaptation

- All sectors
  - Agriculture – crop growth models
  - Water – storm surge, hydrological models
  - Forests/ biodiversity – biome model/ RS and GIS
  - Coastal regions – RS and GIS and
  - Health – statistical analysis
- National and regional assessments
- Climate Risk Screening of Infrastructure projects
- Investment and financial needs

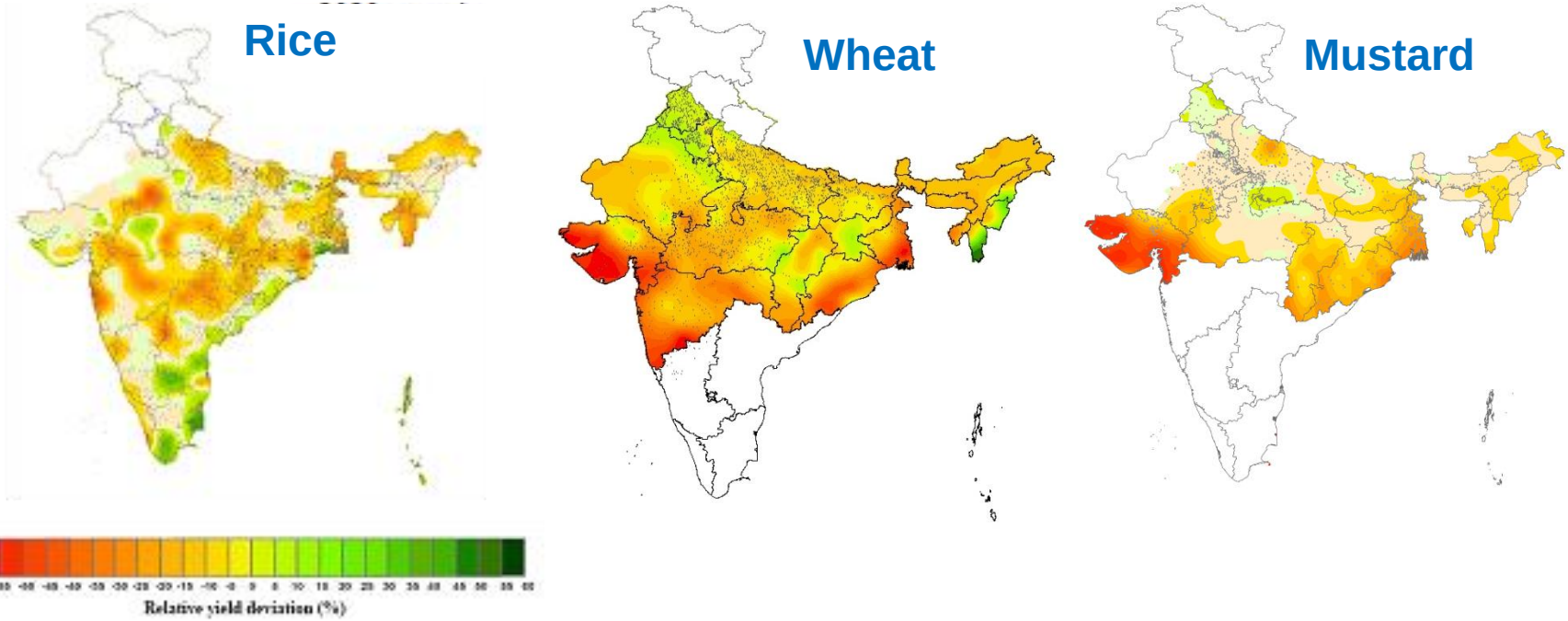


Impact on Agriculture and food security

- Direct Impacts
  - Due to changes in temperatures, CO_2 fertilization effect
- Indirect Impacts
  - Water Scarcity, Extremes, Pests and Diseases

- **Yields and Production to be affected**
- Substantial **decreases in cereal production** especially in case of the tropics

Impacts of climate change in 2020 scenario on various crops



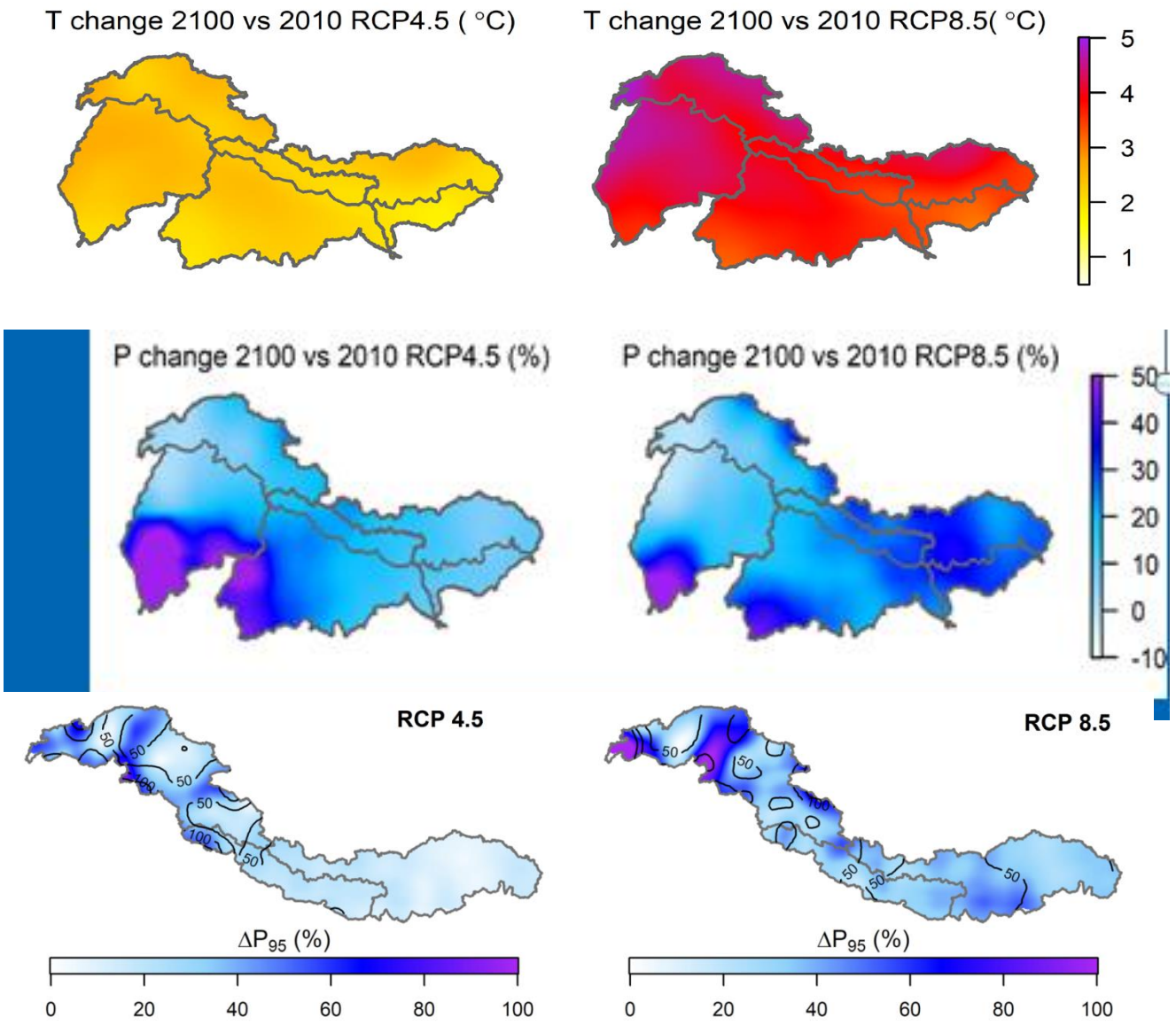
- **Irrigated rice, wheat and mustard productions may be reduced by 6%, 4% and 4%, respectively.**
- **Adaptation strategies can compensate the reductions.**

Source: H Pathak, 2013

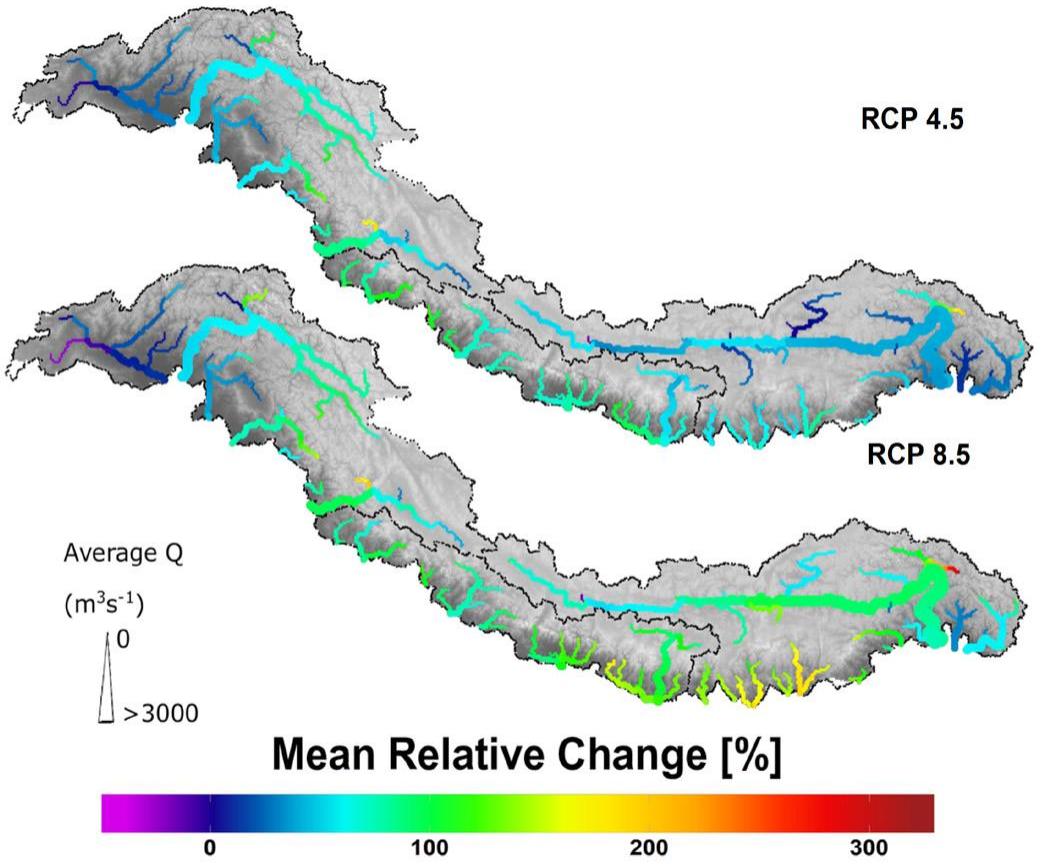
Impact on hydrology and water resources

- **Water availability and its quality to be affected**
- **Intense rain occurring over fewer days**,
  - Implies increased frequency of floods during the monsoon, will also result in loss of the rain water as direct runoff resulting in reduced groundwater recharging potential.

Rising temperatures and wetter futures in South Asian glacier and snow-fed river basins



Changes in Return Periods of floods



The average river flow is projected to increase : roughly 30%–40% in the upper Ganga, and 25%–50% in the upper Brahmaputra towards the end of the century.

Depending on the scenario, the intensities of 'once in 50 years' flood events are expected to increase by 40%–110% on average in the upstream areas and 115%–150% in the downstream areas of the river basins towards the end of the century.

Adverse effects likely on various social and economic sectors

- *Changes in 50-year return period discharge (flood event which has a 1 in 50 chance of occurring in any given year)*

Sectoral Impacts: Coastal Areas

Agriculture

- loss of agricultural land
- sea water intrusion and coastal erosion would degrade coastal soil fertility and reduce yields

Water resources

- contamination of fresh water by salt water causing deterioration of quality and decline in availability of fresh water resources

Fisheries

- loss of marine habitats
- primary activity of economic importance in coastal areas to be affected

Settlement

- more than half the world's population lives within 60 km of the sea
- average growth rate of coastal population is higher than that of global population
- dislocation and resettlement of people - difficult, expensive, cause hardship

Infrastructure

- important infrastructure located along coast (port/ tourism) to be affected
- threatened by inundation, increased flooding, coastal erosion, land loss, extreme events

Tourism

- loss of beaches due to erosion, inundation
- degradation of ecosystems (mangroves/ coral reefs)
- damage to tourist infrastructure

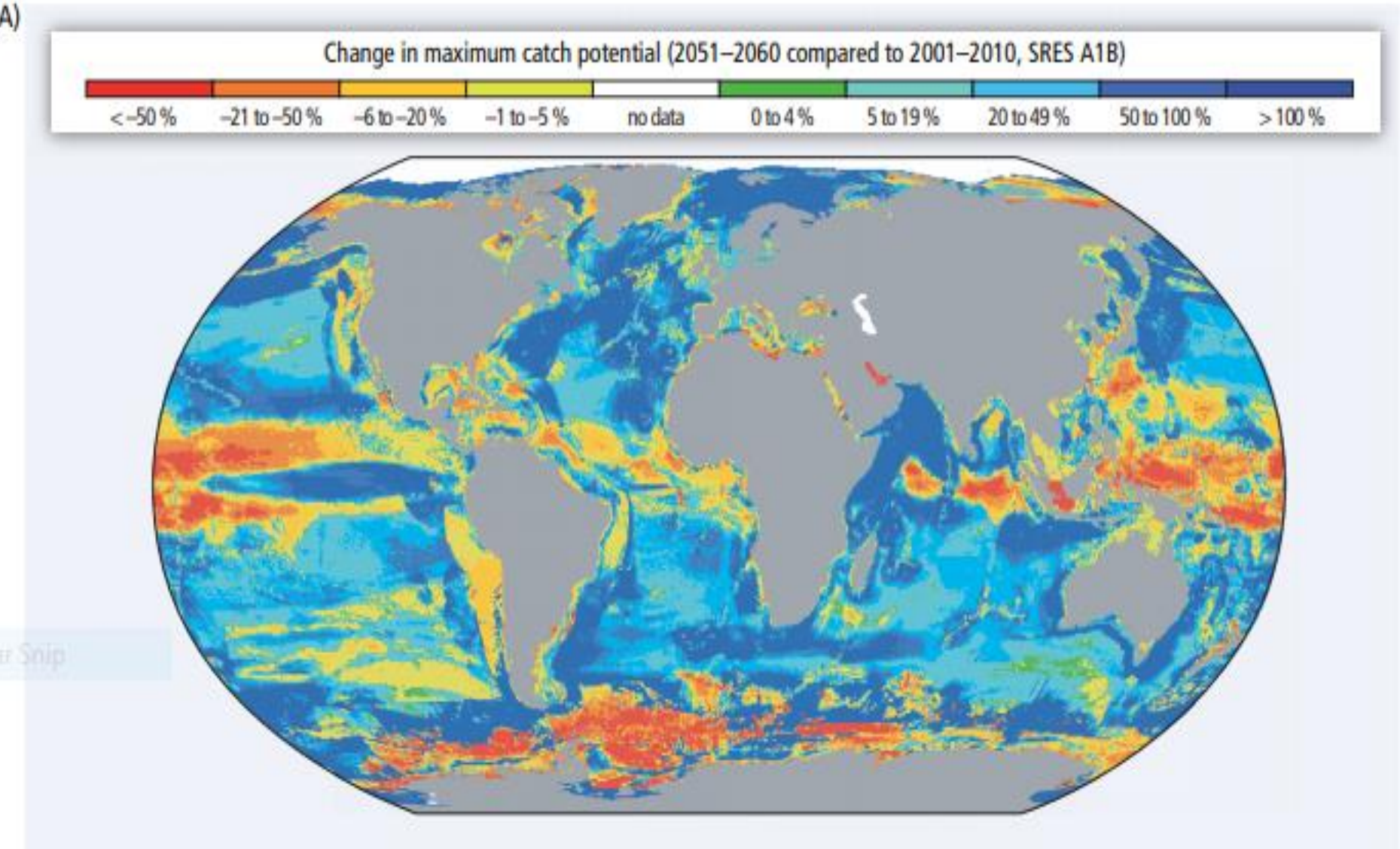
Human health

- fresh water salinization and contamination
- changes in distribution of disease vectors
- loss of life, population displacement

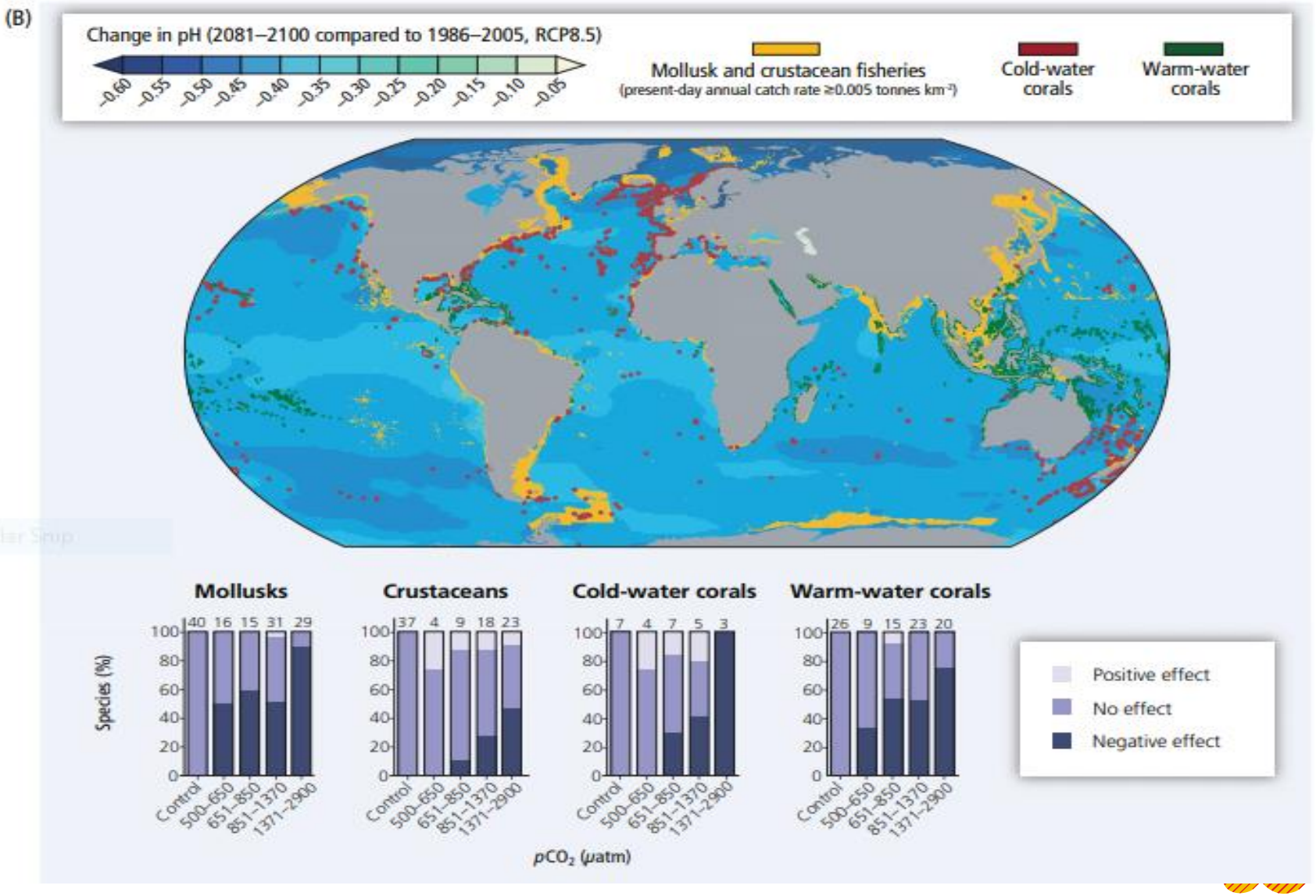
Impact on Coastal and low lying areas

- **Projected sea level rise would affect millions of people living in the low lying area**s of South, Southeast and East Asia such as in Vietnam, Bangladesh, India and China
- Even under the most conservative scenario, sea level **will be about 40 cm higher than today by the end of 21st century and projected to increase the annual number of people flooded in coastal population from 13 million to 94 million**
- **Expected that almost 60% of the increase will be in South Asia** (along coasts from Pakistan, through India, Sri Lanka and Bangladesh to Burma)

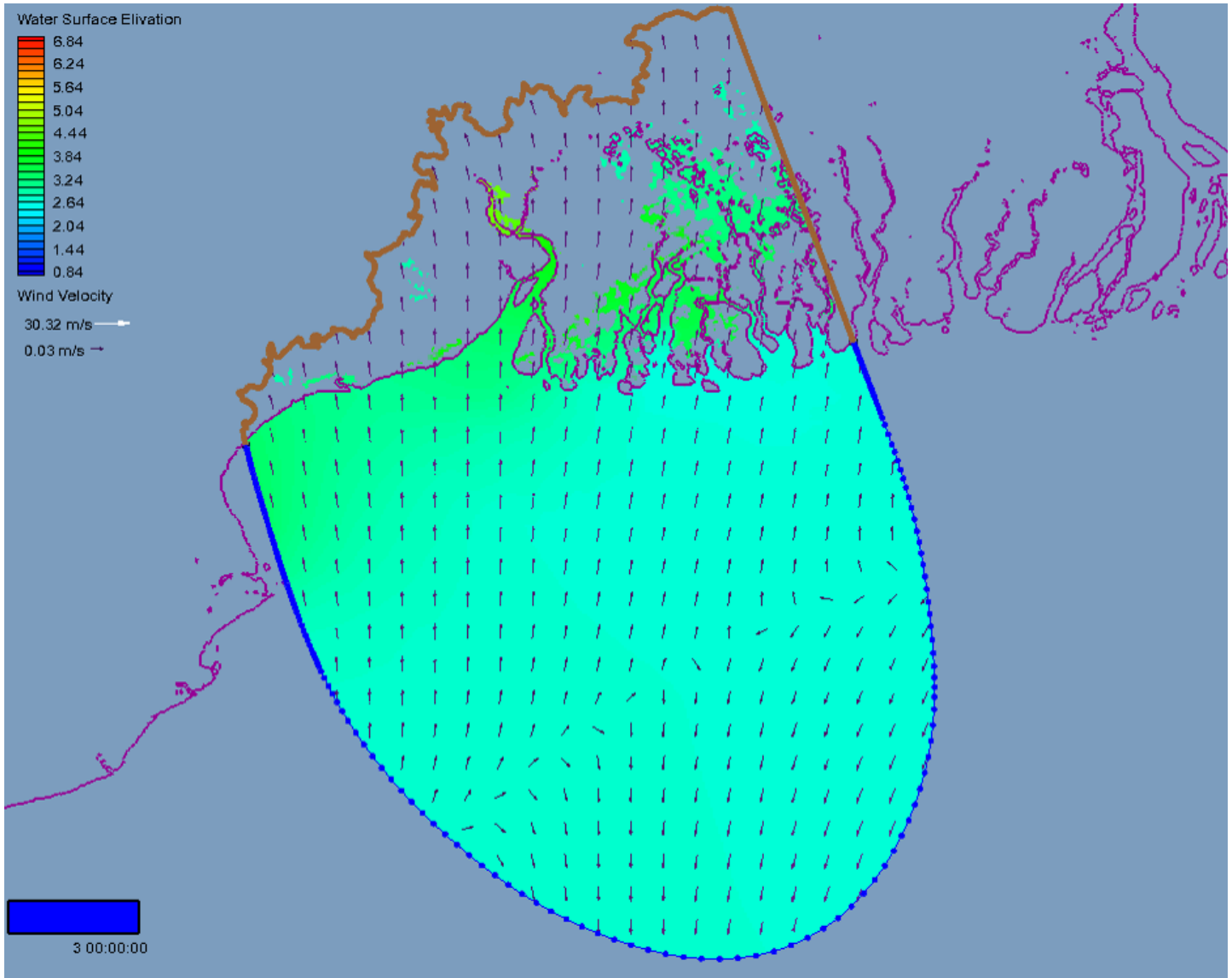
Catch potential changes



Ocean acidification

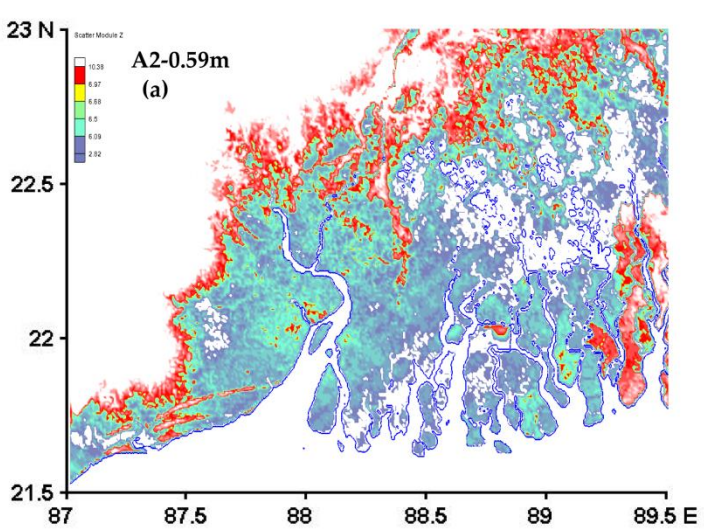


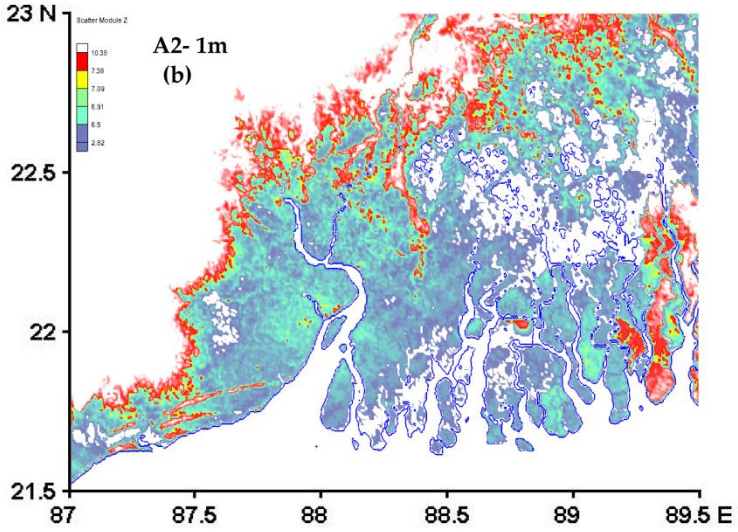
STORM SURGE SIMULATION: WETTING AND DRYING MECHANISM

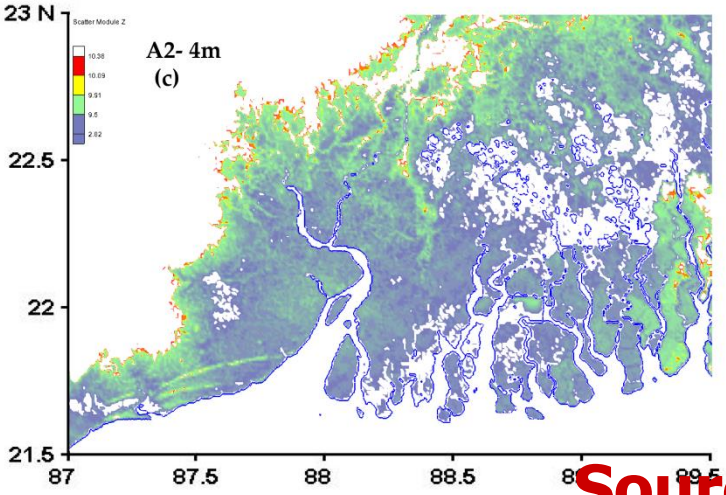


TERI (2012)

PLAUSIBLE SLR INCREASE + STORM SURGE SCENARIO over WB

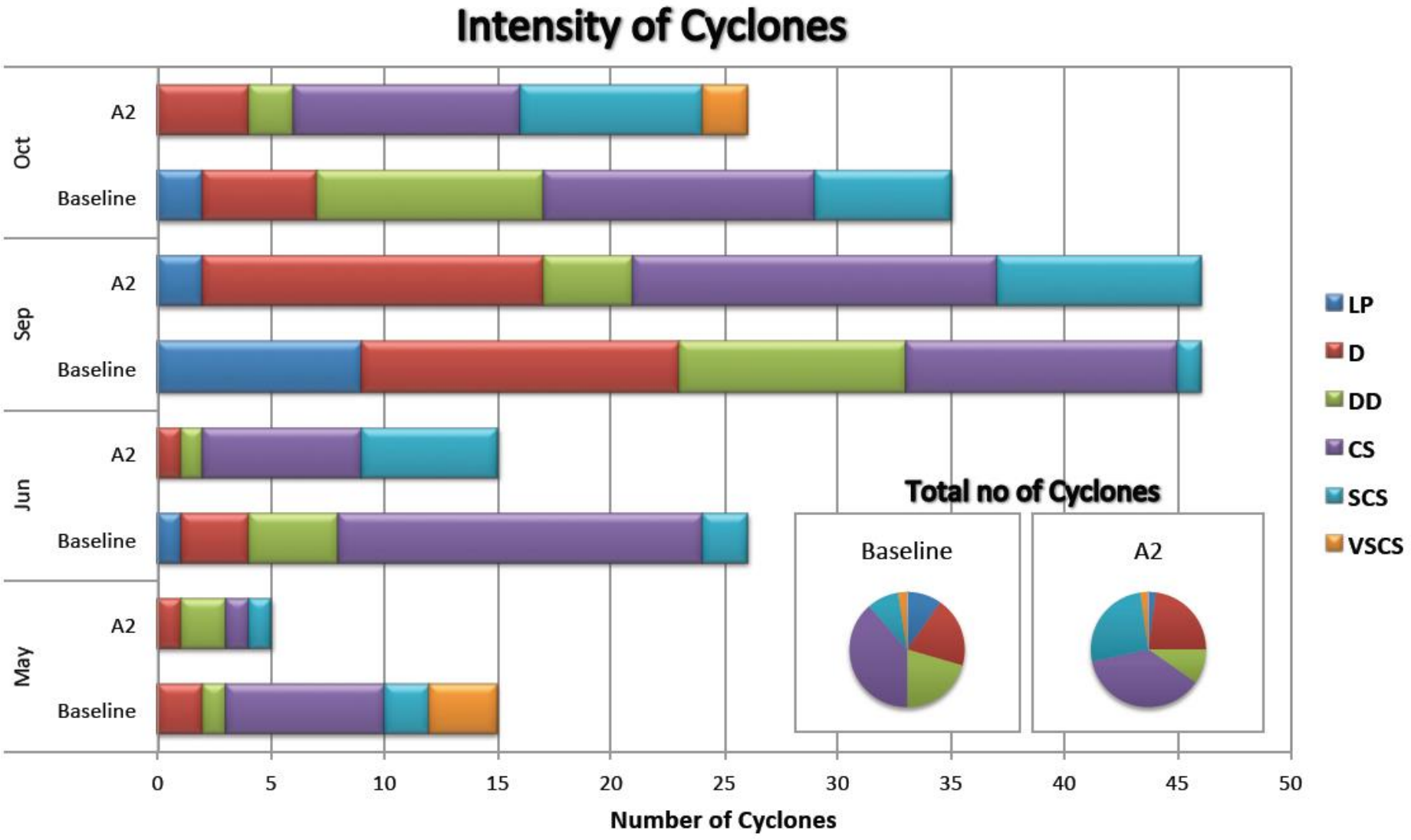






Source: TERI Report, 2012

Cyclone Occurences Eg., BoB and AS



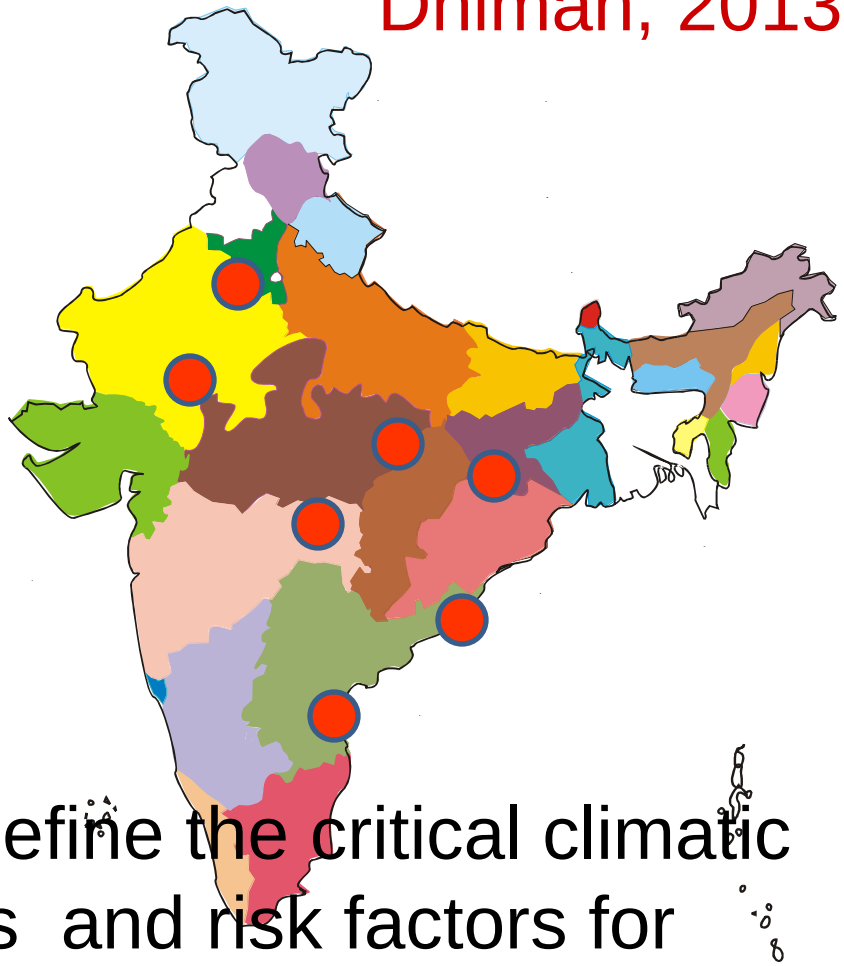
Source: TERI Report, 2012

Mortality due to Heat wave

Heat waves occur in the month of March to June. Maximum deaths (1658) occurred in the year 1998. Andhra Pradesh, Orissa, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh suffer the most.

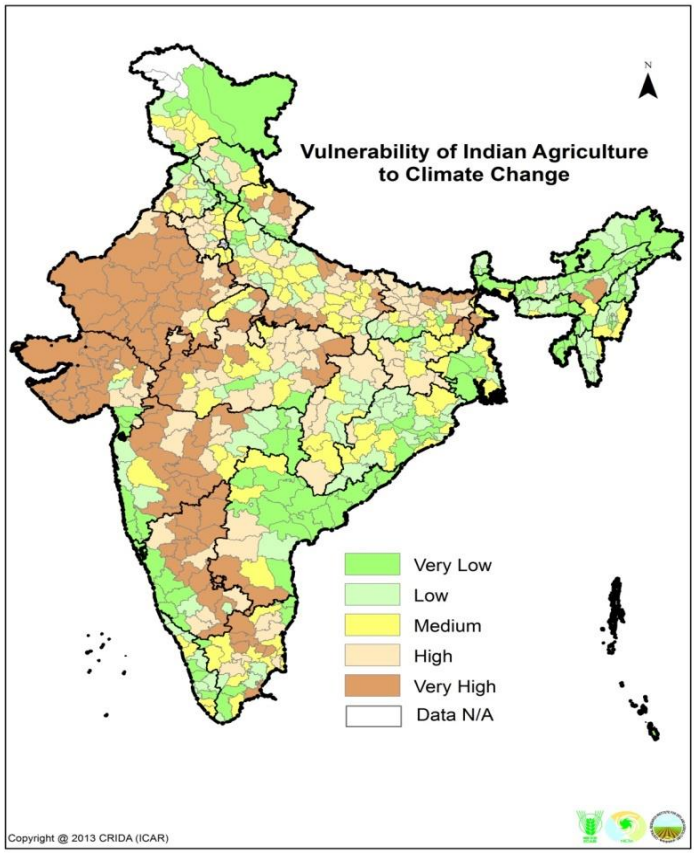
(Akhtar R 2007. Global Environ. Research 11(1): 51-57)

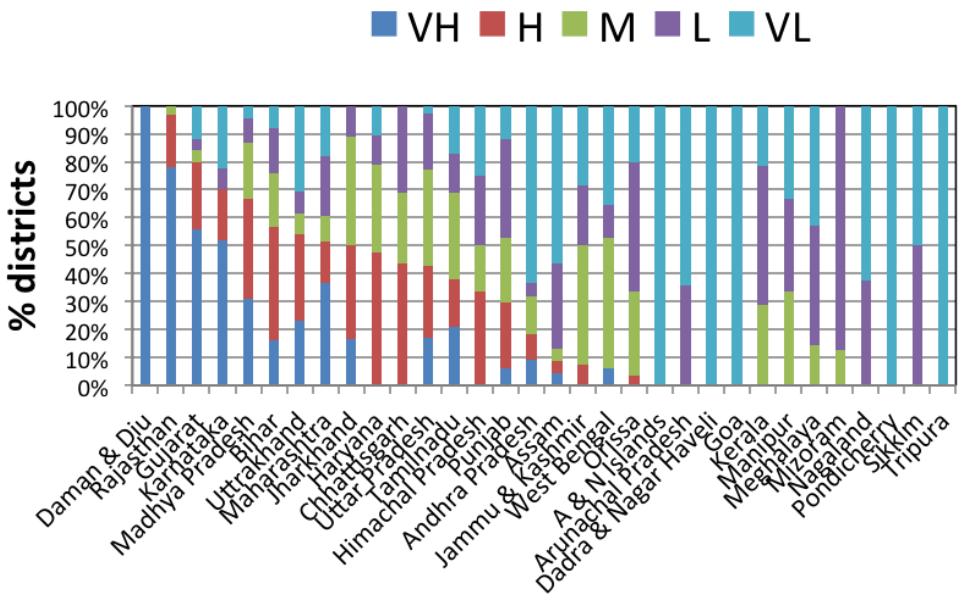
Dhiman, 2013



Heat stress sector should define the critical climatic conditions, nutritional status and risk factors for mortality so that health advisory may be possible.

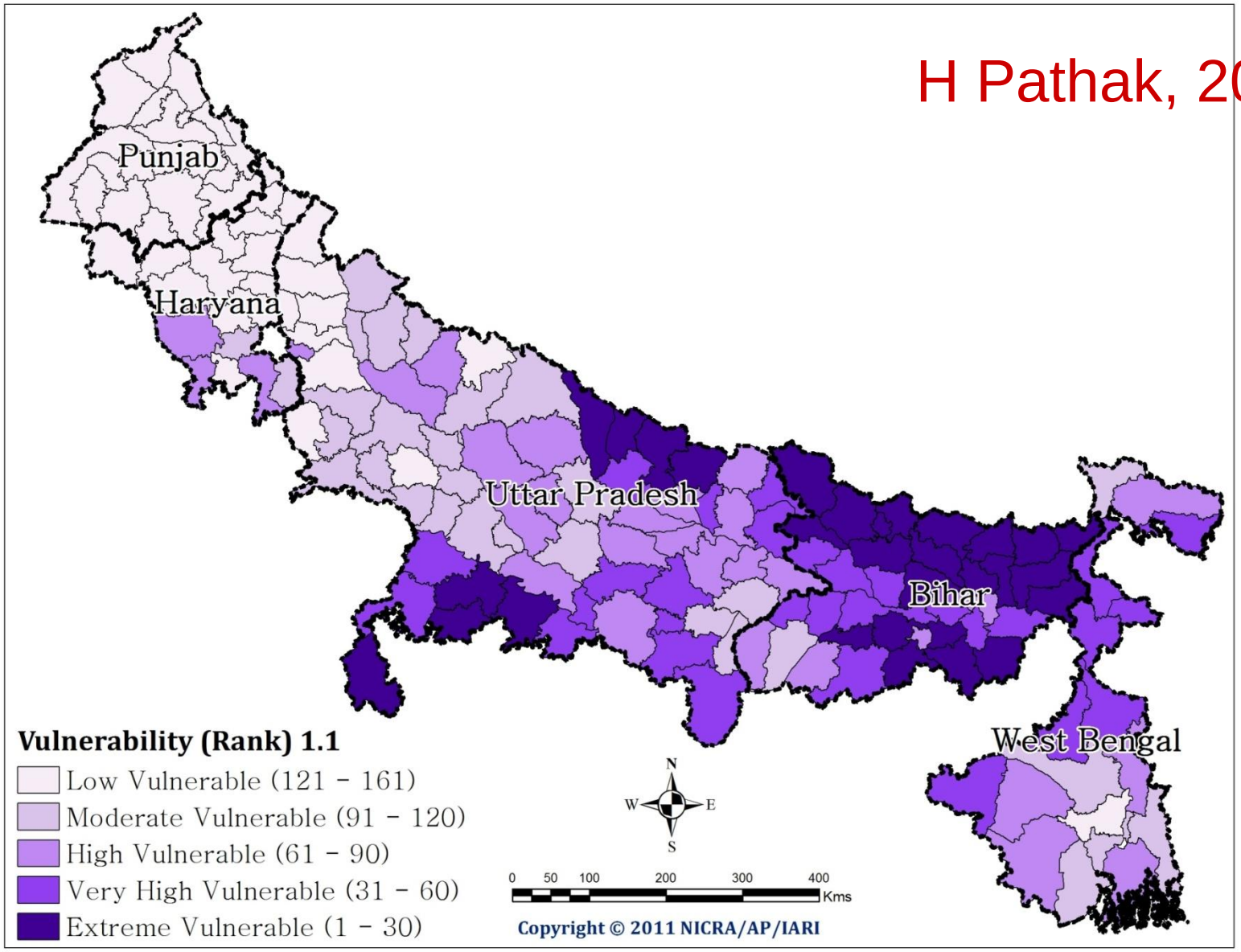
Vulnerability of Indian Agriculture to Climate Change: A District Level Assessment in 2050



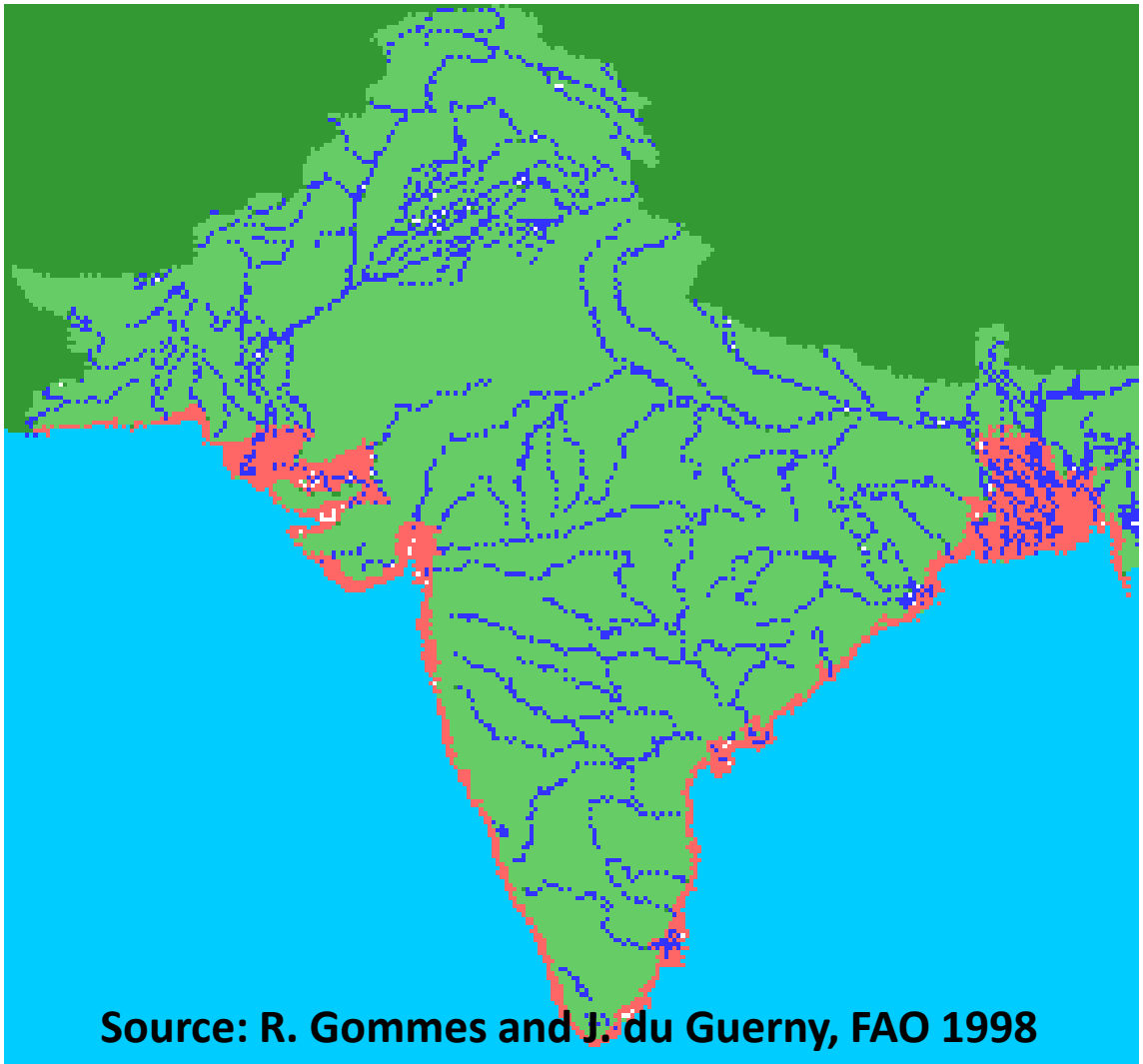


NICRA (2013)

Current Vulnerability of Agriculture in the IGP



Densely populated coastal lowlands of India, Bangladesh, and Pakistan under threat due to sea level rise



Source: R. Gommes and J. du Guerny, FAO 1998

Health

- Changes in weather and climate exert a major influence on human health
  - direct effects …….of extreme events such as heat waves, floods and storms
  - indirect influences …..on the distribution and transmission intensity of infectious diseases
- IPCC projects with high probability increase in human morbidity and mortality, associated with changes in temperature and precipitation patterns as well as with expected rise in the frequency and intensity of extreme events
- Tropics uniquely placed with high temperatures and its exposure to extremes….

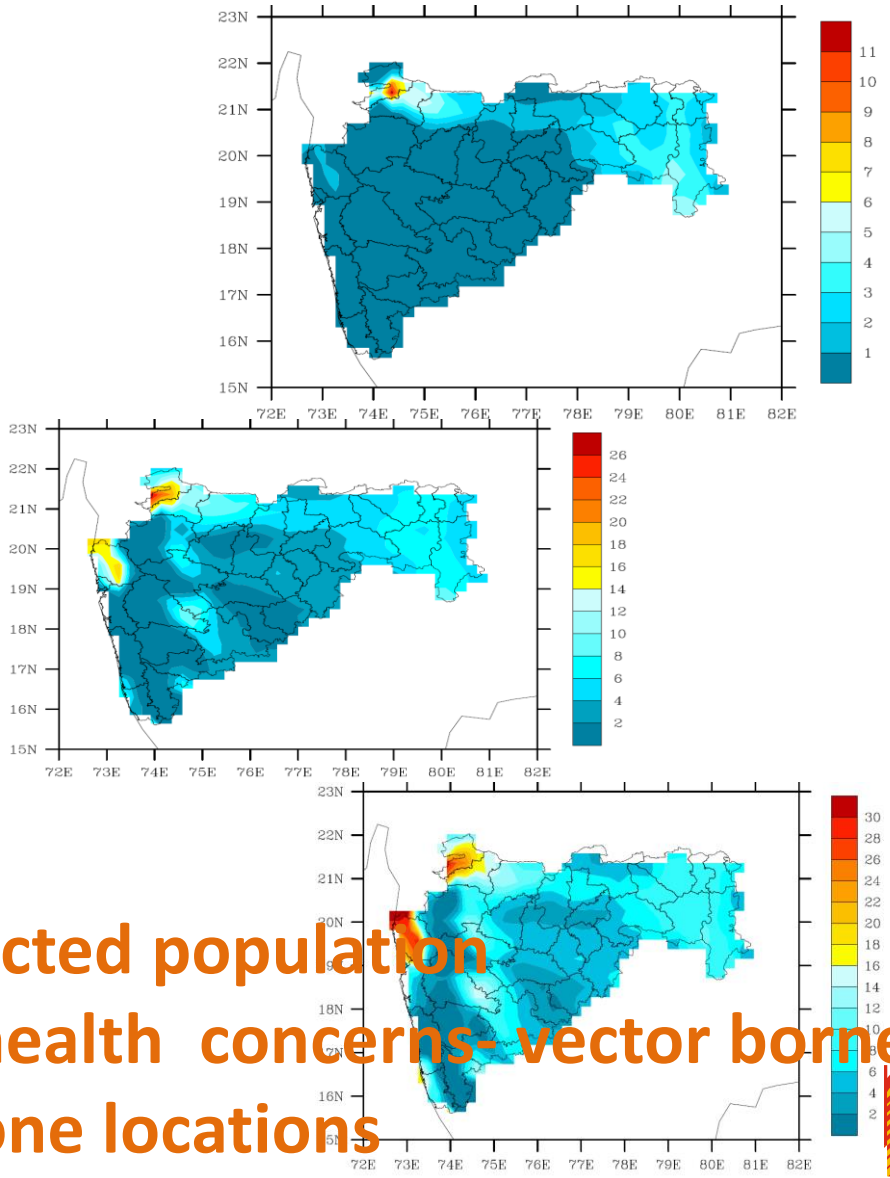
For instance, in case of malaria

Malaria transmission (via *P. falciparum*) in period between May to October for 3 time periods: Baseline (1971-2000); 2030s (2021-2040) and 2050s (2041-2060):

Average relative humidity varies between 55-80%

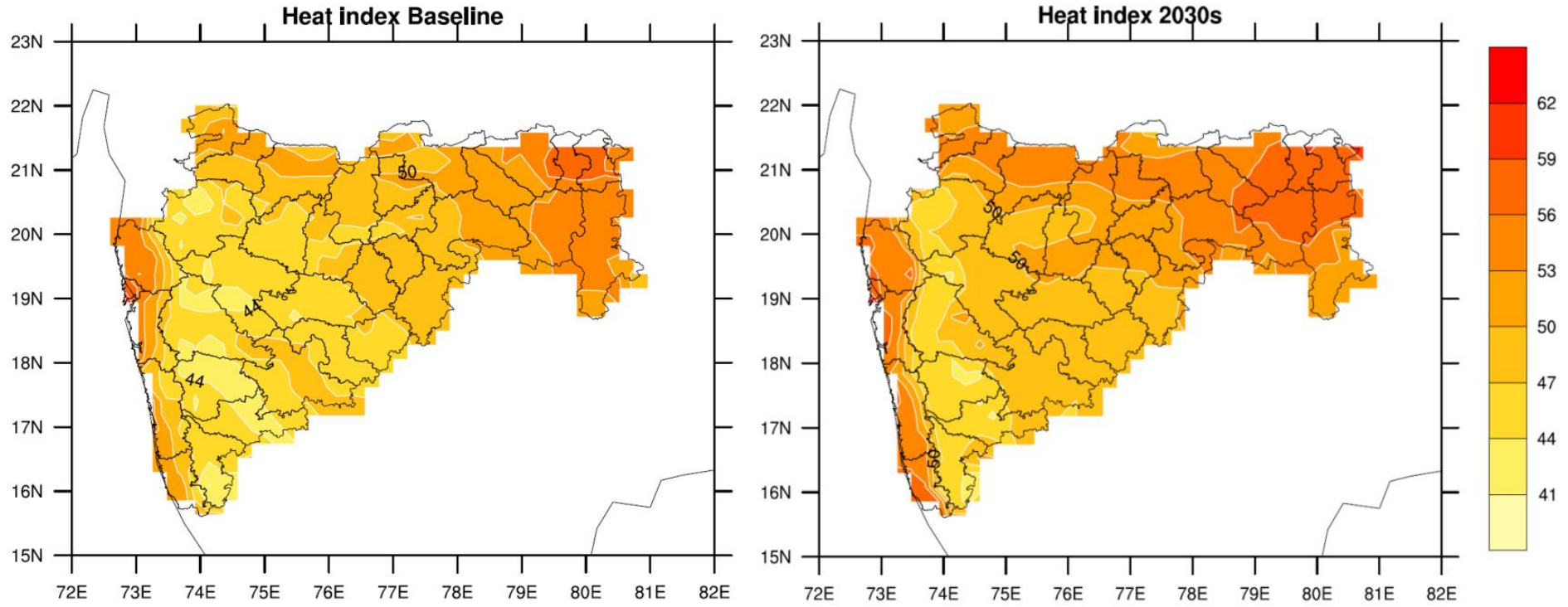
Three temperature (mean) classes with the following ranges:

- **Transmission Window Class I: 20-25 °C**
- **Transmission Window Class II: 25-30 °C**
- **Transmission Window Class III: 30-35 °C**



Identify priority areas and affected population for Interventions and related health concerns- vector borne diseases, heat stress, flood prone locations

Heat Index: an index that combines air temperature and relative humidity in an attempt to determine the human perceived equivalent temperature- how hot it feels, termed as the felt air temperature



Heat and Discomfort Index

	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
42°	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80	82
41°	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76	79
40°	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
39°	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70	72
38°	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67	69
37°	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66
36°	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62	63
35°	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59	61
34°	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58
33°	34	36	37	39	40	41	43	44	46	47	48	50	51	53	54	55
32°	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52	53
31°	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
30°	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
28°	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27°	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
26°	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38	39
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
24°	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34	35
23°	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22°	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30	31

http://www.eurometeo.com/

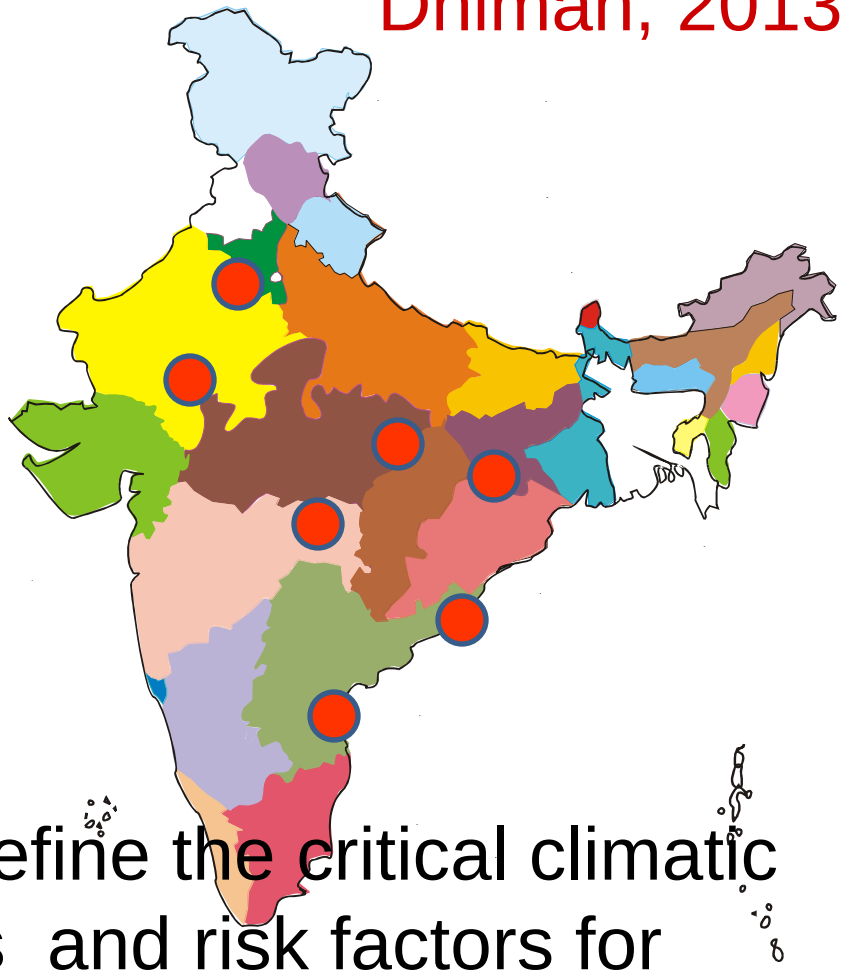
Up to 29 C°	*No discomfort*
From 30 to 34 C°	*Slight discomfort sensation*
From 35 to 39 C°	*Strong discomfort. Caution: limit the heaviest physical activities*
From 40 to 45 C°	*Strong indisposition sensation. Danger: avoid efforts*
From 46 to 53 C°	*Serious danger: stop all physical activities*
Over 54 C°	*Death danger: imminent heatstroke*

Mortality due to Heat wave

Heat waves occur in the month of March to June. Maximum deaths (1658) occurred in the year 1998. Andhra Pradesh, Orissa, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh suffer the most.

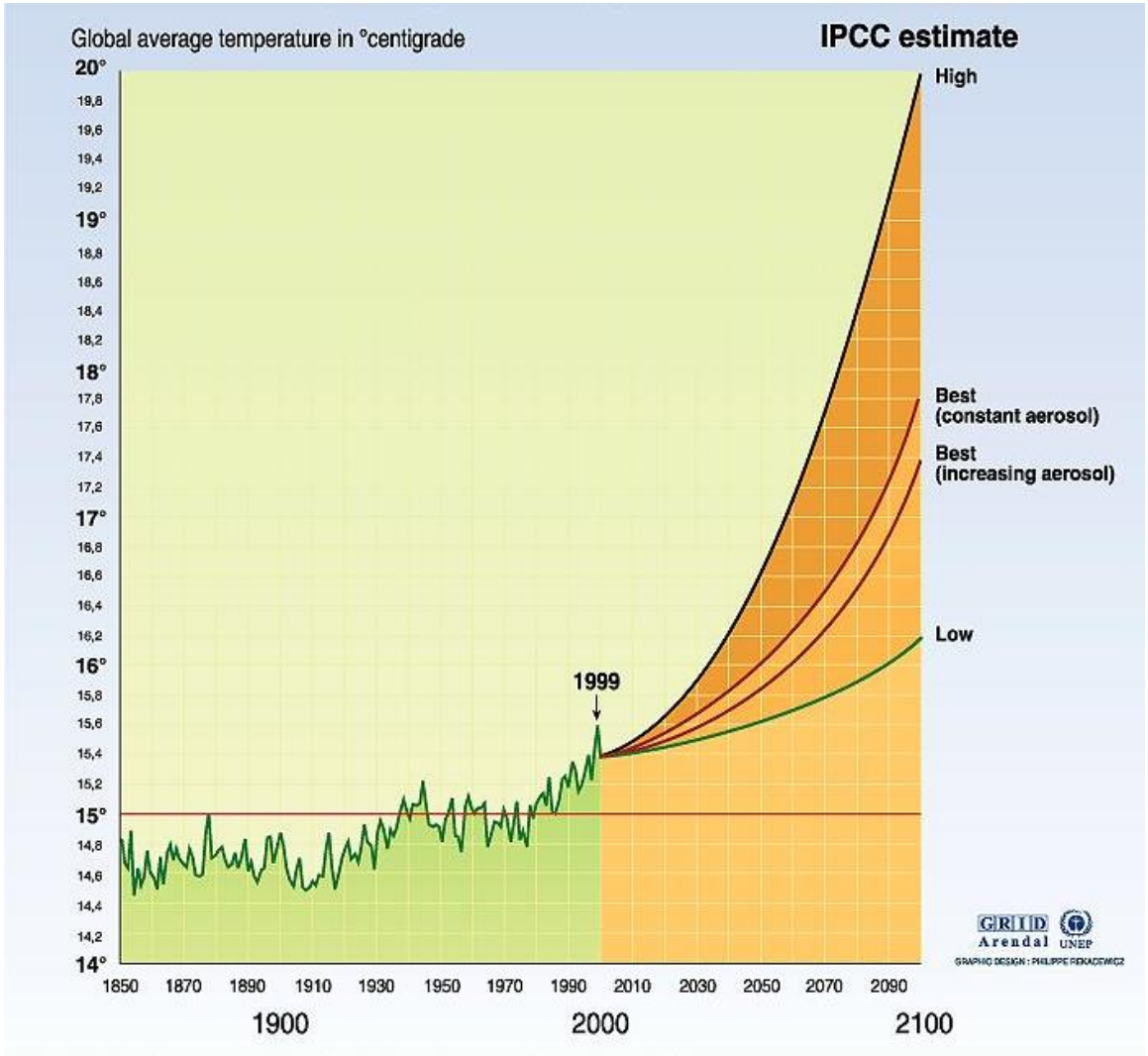
(Akhtar R 2007. Global Environ. Research 11(1): 51-57)

Dhiman, 2013



Heat stress sector should define the critical climatic conditions, nutritional status and risk factors for mortality so that health advisory may be possible.

Climate change introduces huge unknowns

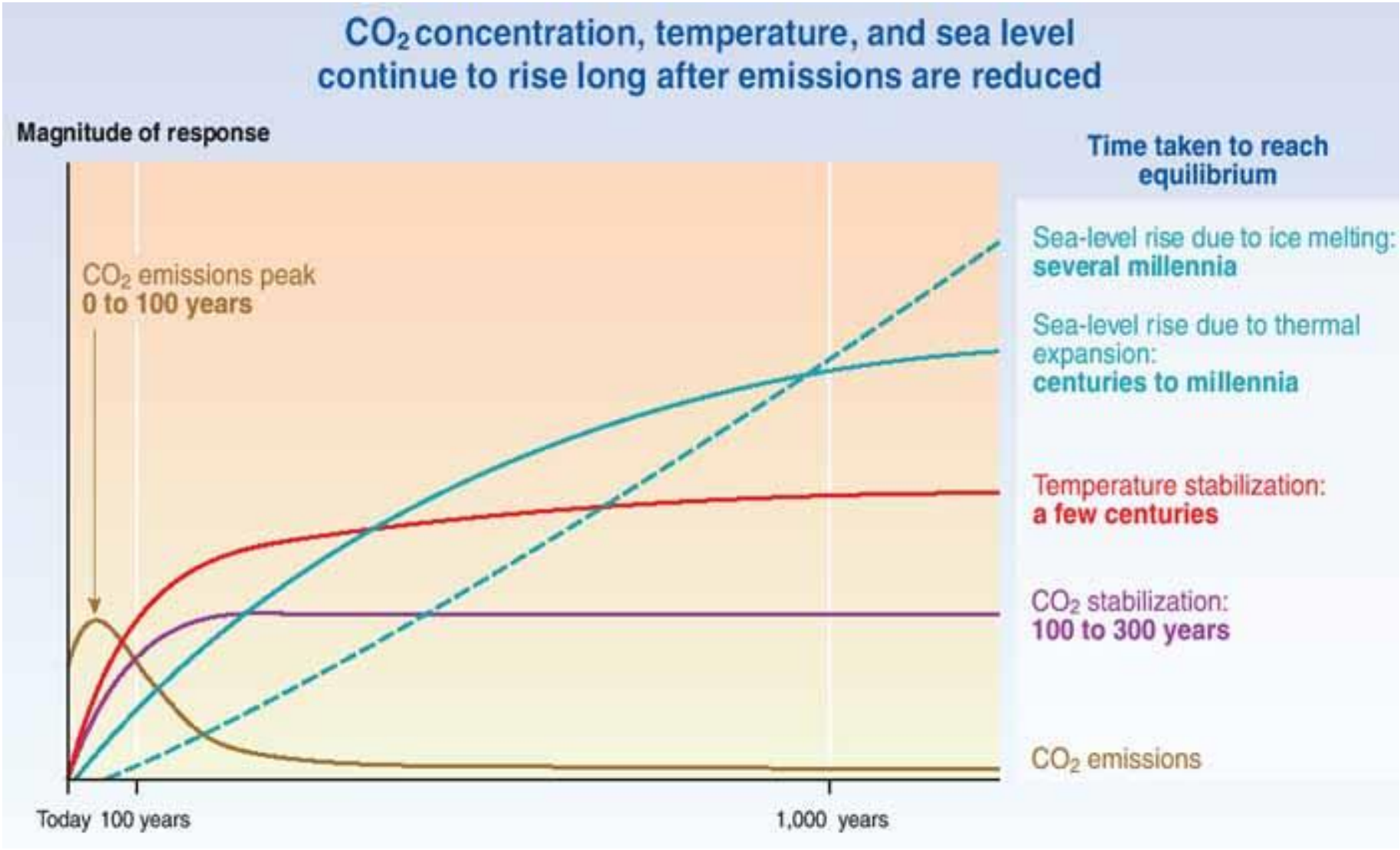


Source : Temperatures 1856 - 1999: Climatic Research Unit, University at East Anglia, Norwich UK. Projections: IPCC report 95.

Human-induced climate change has the potential to trigger large-scale changes in Earth systems that could have severe consequences at regional or global scales. The **probabilities of triggering such events though limited** should not be ignored, **given the severity of their consequences.**

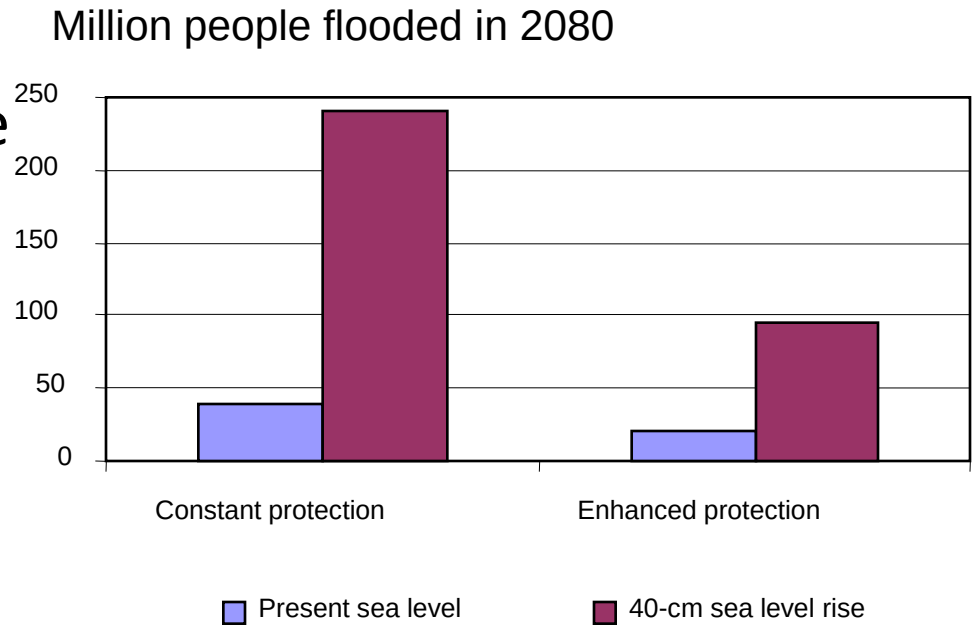
Source: IPCC, Climate Change 2001: Synthesis Report

Time scales


CO_2 concentration, temperature, and sea level continue to rise long after emissions are reduced
Magnitude of response
CO_2 emissions peak 0 to 100 years
Today
100 years
1,000 years
Time taken to reach equilibrium
Sea-level rise due to ice melting: several millennia
Sea-level rise due to thermal expansion: centuries to millennia
Temperature stabilization: a few centuries
CO_2 stabilization: 100 to 300 years
CO_2 emissions

Adaptation to climate change

- Potential to reduce adverse impacts of climate change
- Necessary strategy at all scales
- Planned adaptation can supplement autonomous adaptation



- Can often produce immediate ancillary benefits
- Draw on experience with adaptation to climate variability and extremes

Thank you

http://www.teriin.org
http://www.teriin.org/coping

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