

Climate Change and Associated Uncertainty

**CAPACITY BUILDING WORKSHOP ON SYSTEMS THINKING AND ADAPTIVE GOVERNANCE:
THE CONTEXT OF URBAN FLOODING AND WATER STRESS IN BANGALORE**

24-25 April 2014, TERI-Bangalore, Karnataka

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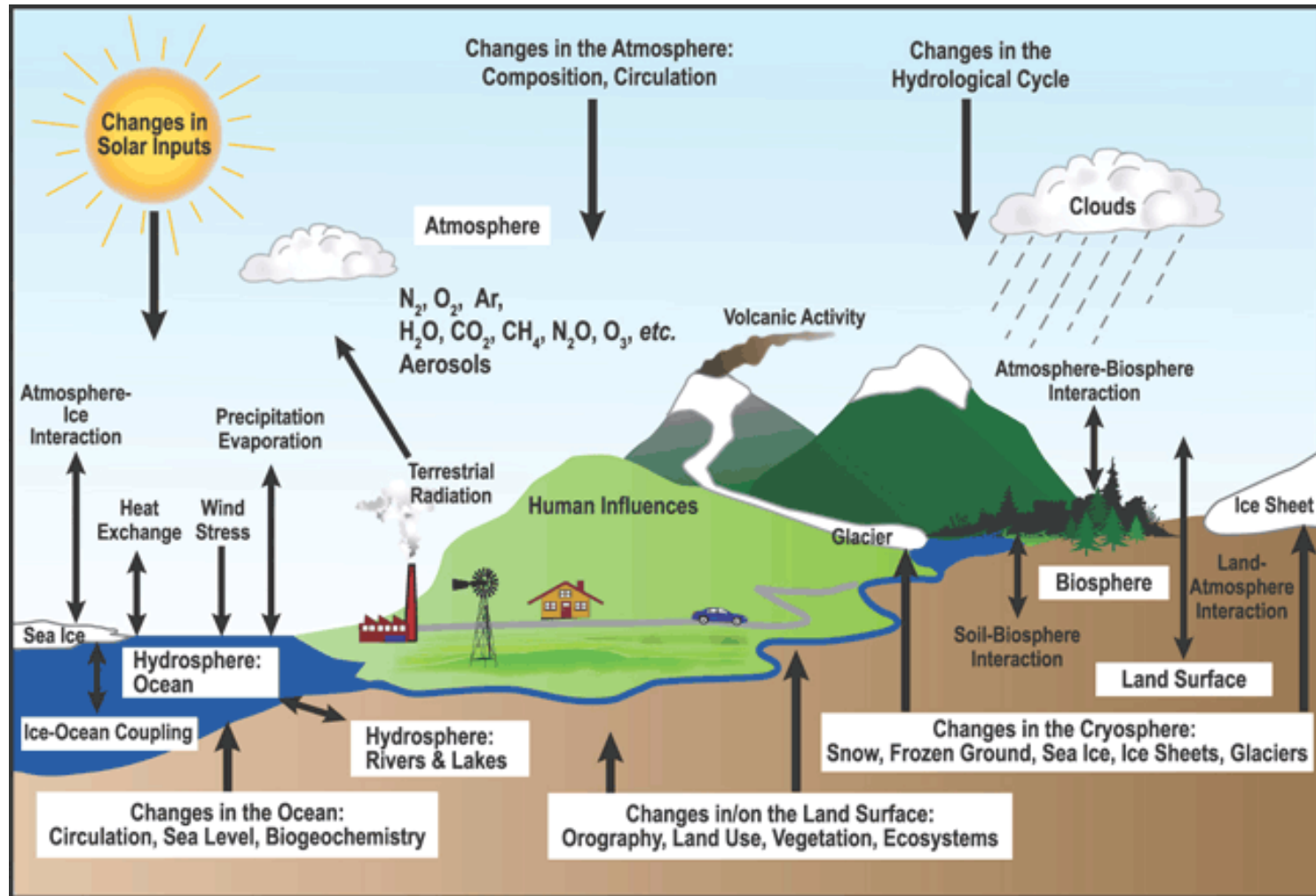
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Interactions



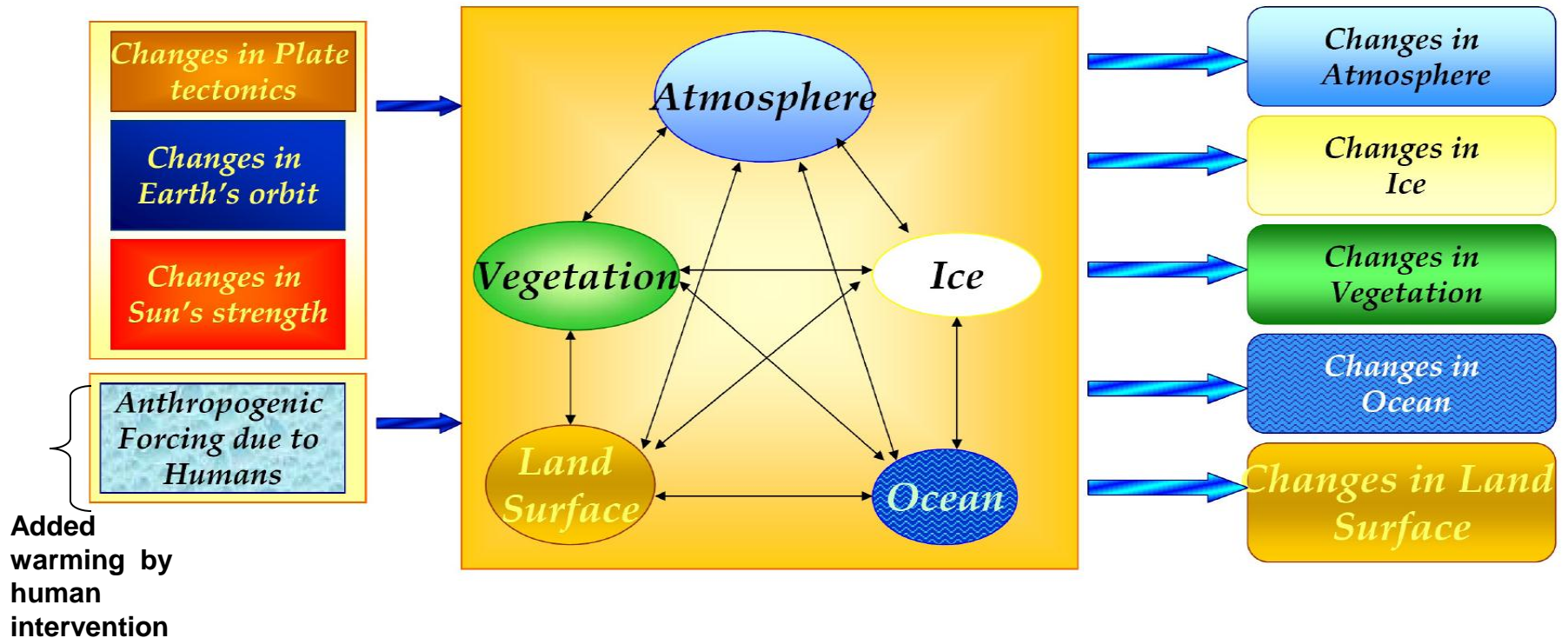
The non-linear interaction among the components leads to climate variability at a range of spatial and temporal scales

Review of Basics: Climate System

Causes (external or anthropogenic forcing)

*Climate System
(internal interactions)*

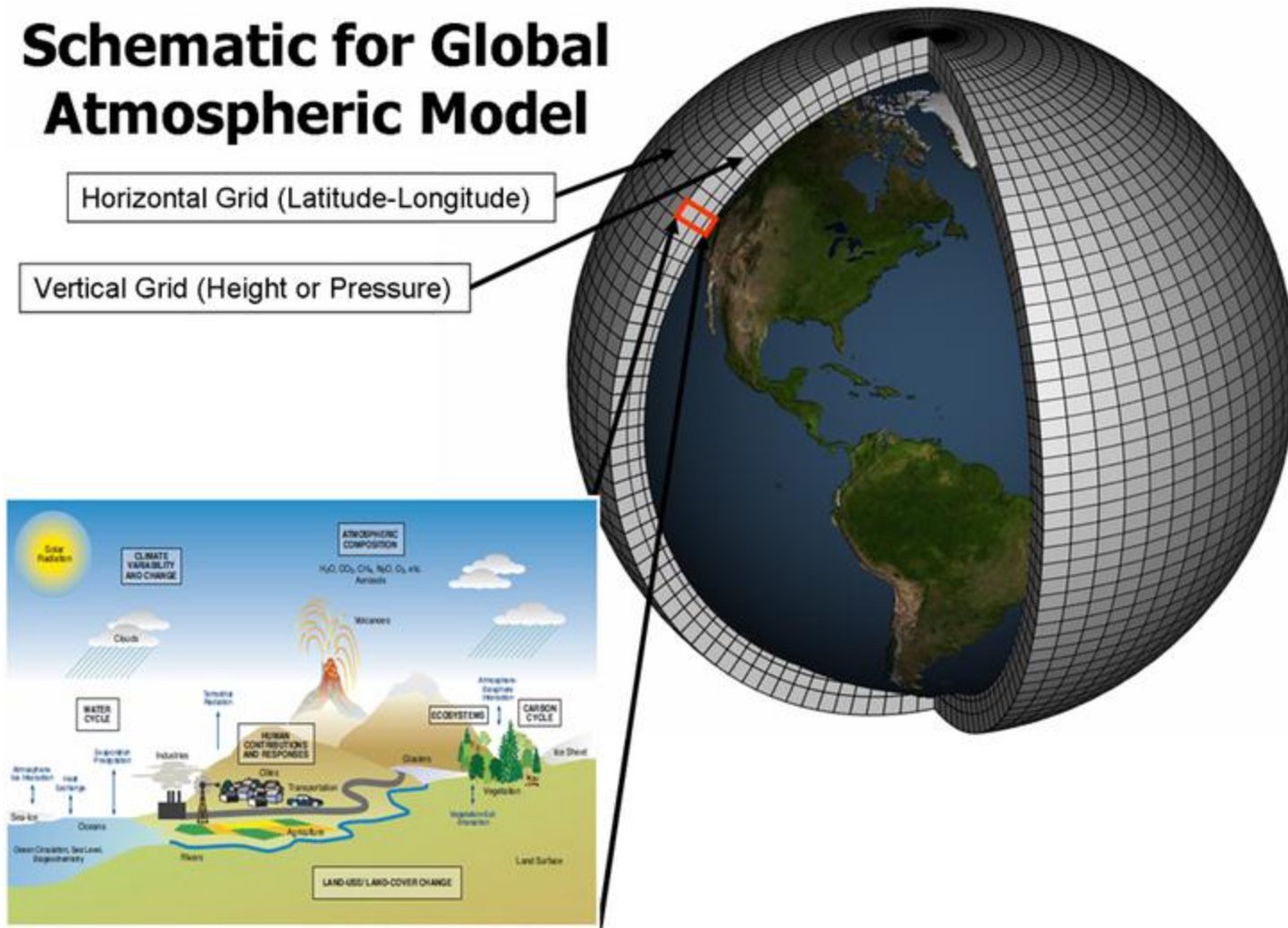
*Climate variations
(internal responses)*



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

Numerical Solution: Time steps and Grid boxes

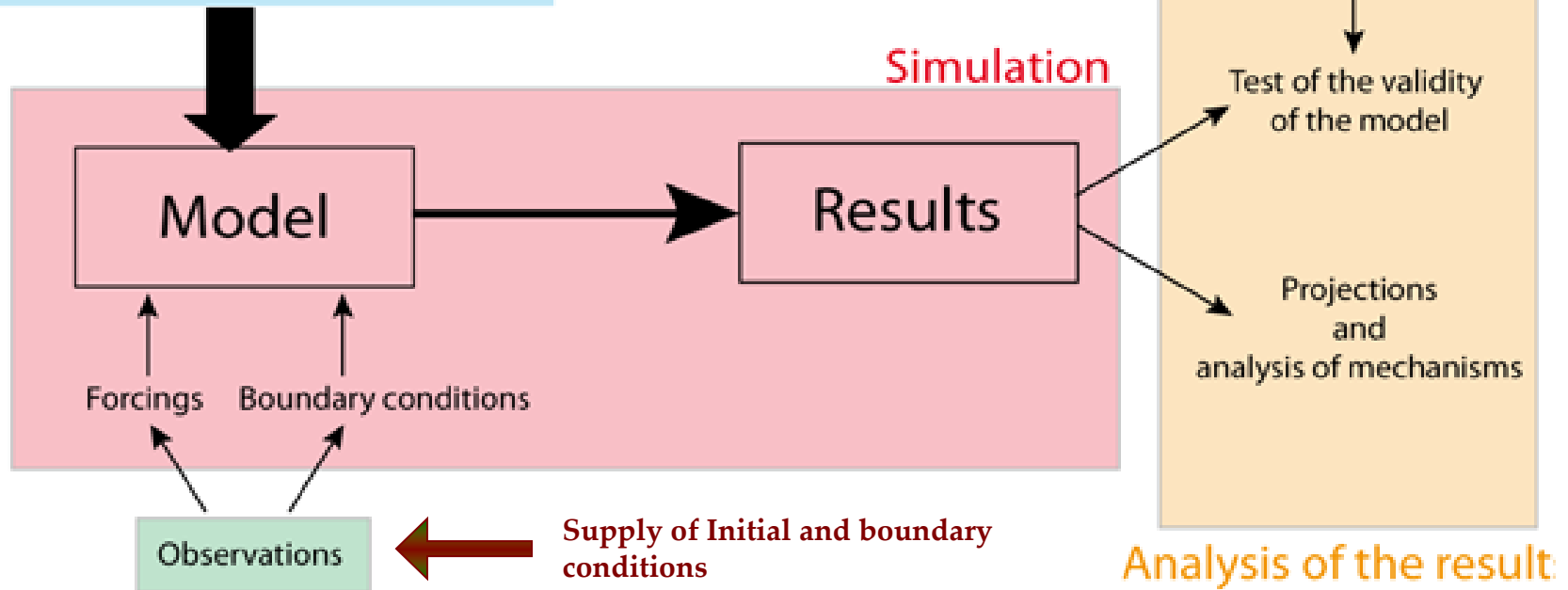
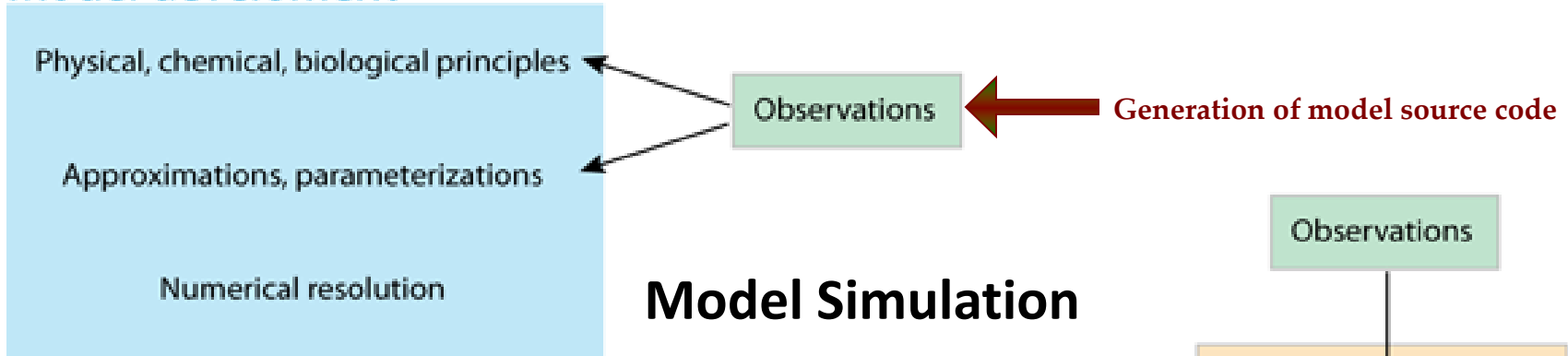
Schematic for Global Atmospheric Model



All the physical processes occurring in the climate system are resolved at individual grid and the coupling occurs at these grids.

Process of Model Simulation

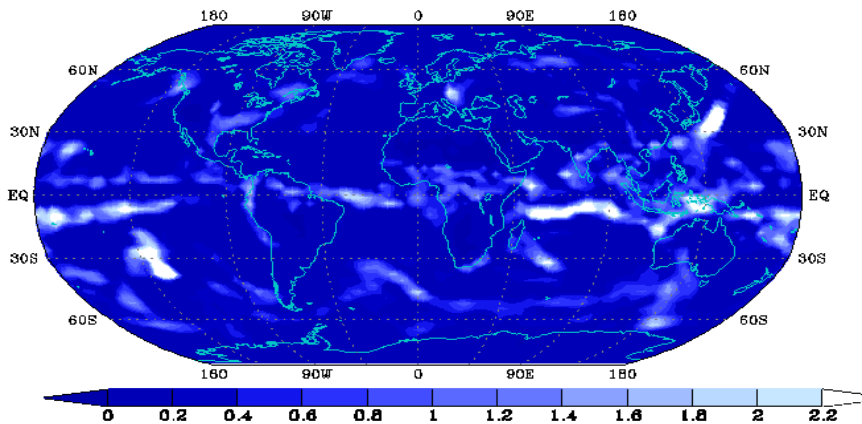
Model development



Simulations using a Global Coupled Model:

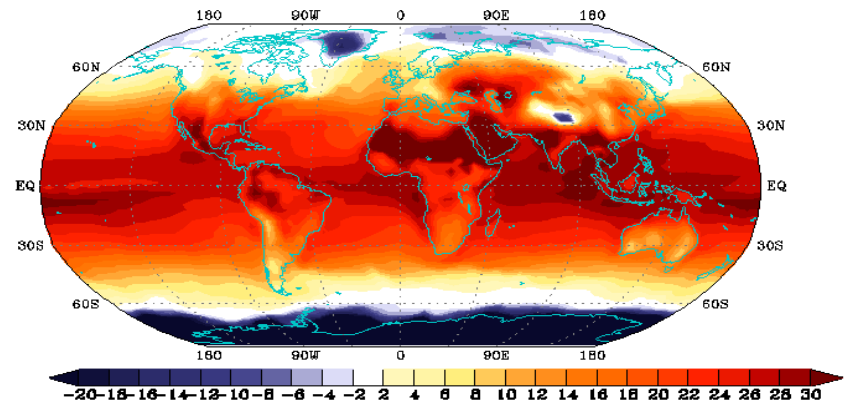
Test run results from Community Climate System Model Version 3
Rainfall (in mm/day) variation from June–September

Time: 04JUN1902



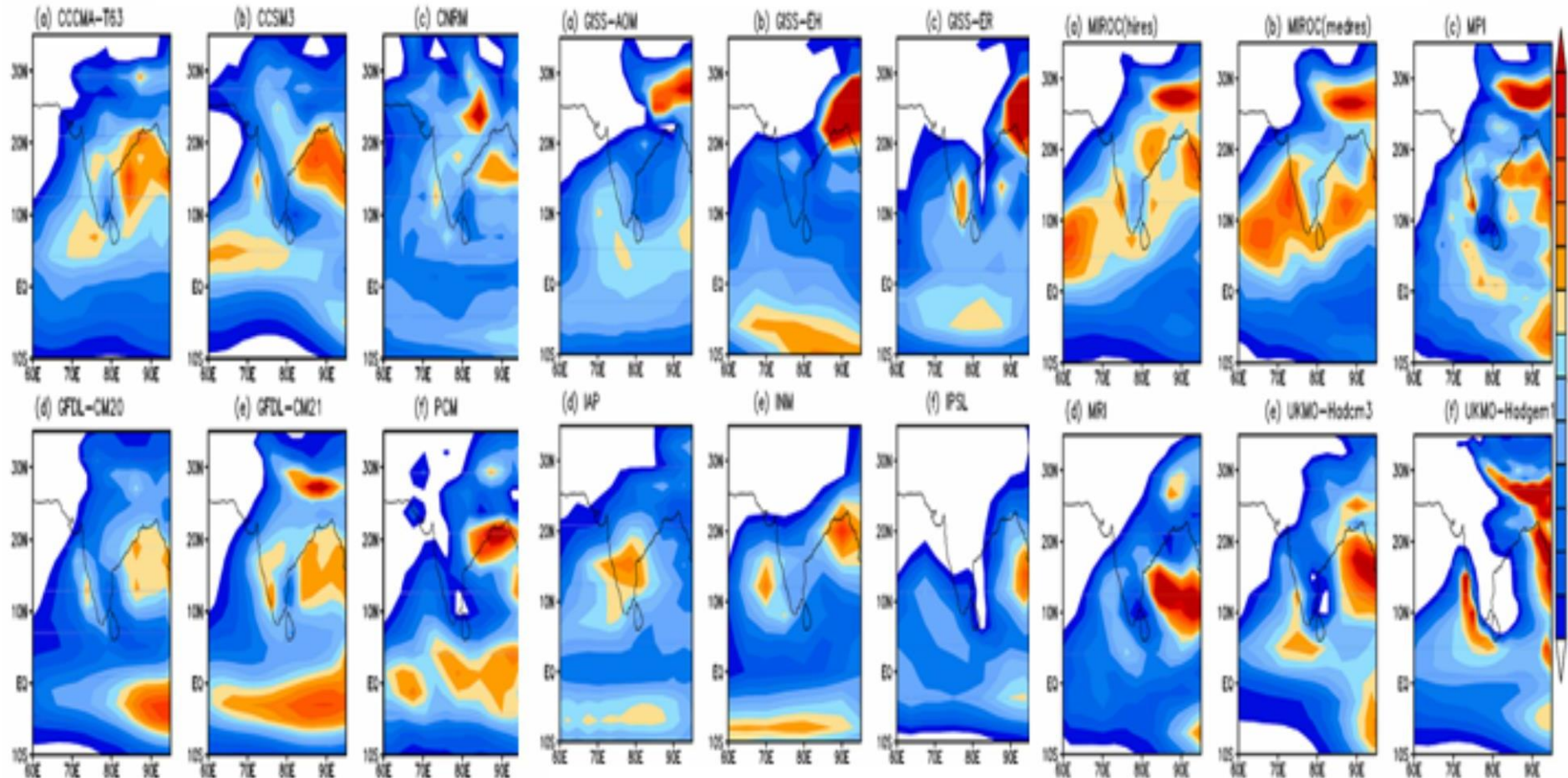
Test run results from Community Climate System Model Version 3
Temperature (in °C) variation from June–December

Time: 04JUN1902



The simulations of a model should be comparable to the observations, this step is called as Validation of the model outputs

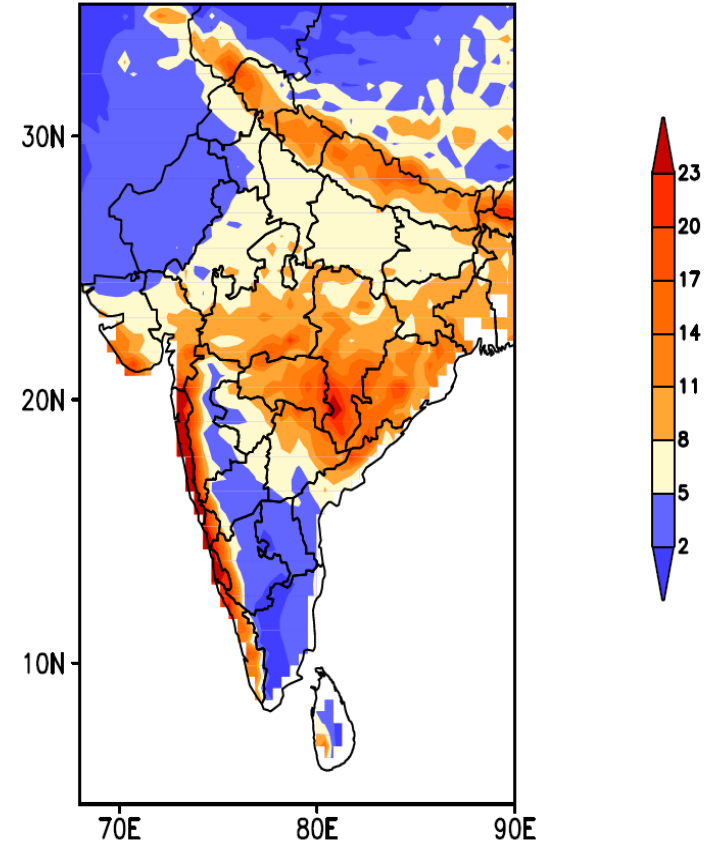
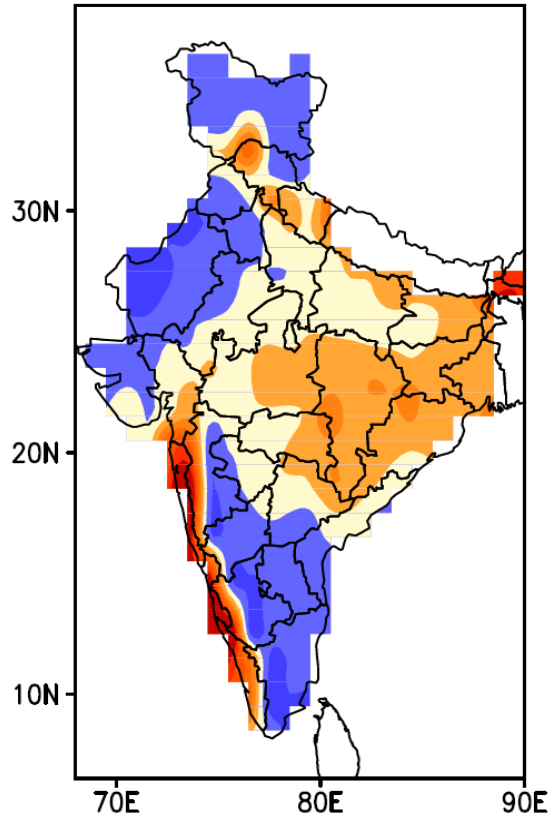
Need for Regional Climate Modeling Tool



Most of AR4 coupled models even with high spatial resolution of 110km x 110km were unable to represent the mean monsoon pattern similar to observations.

Regional Modelling Product

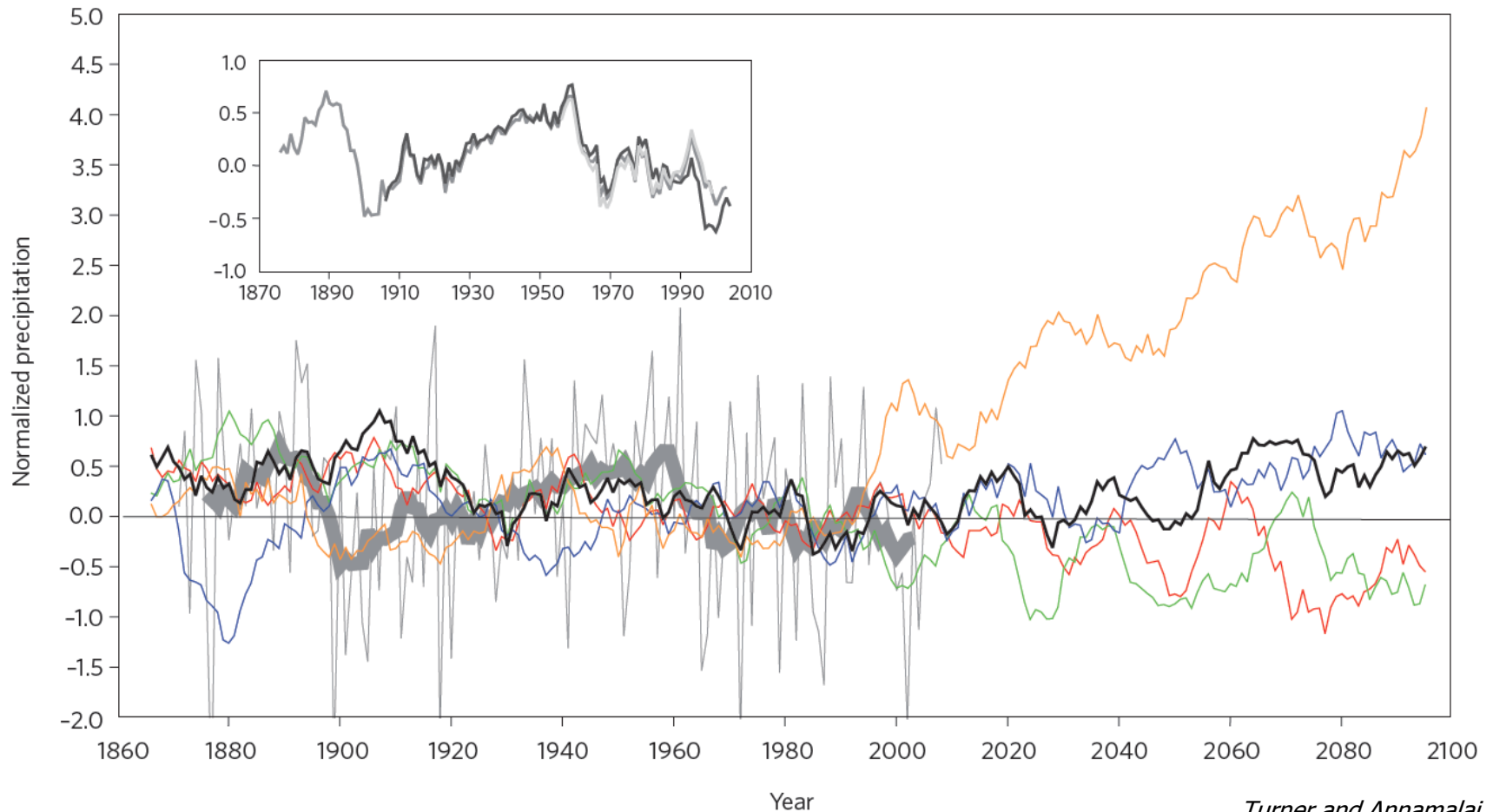
IMD JJA rainfall mean of 50 years (1961–2007) PRECIS JJA rainfall mean of 30 years (1960–1990)



Source: TERI (2011)

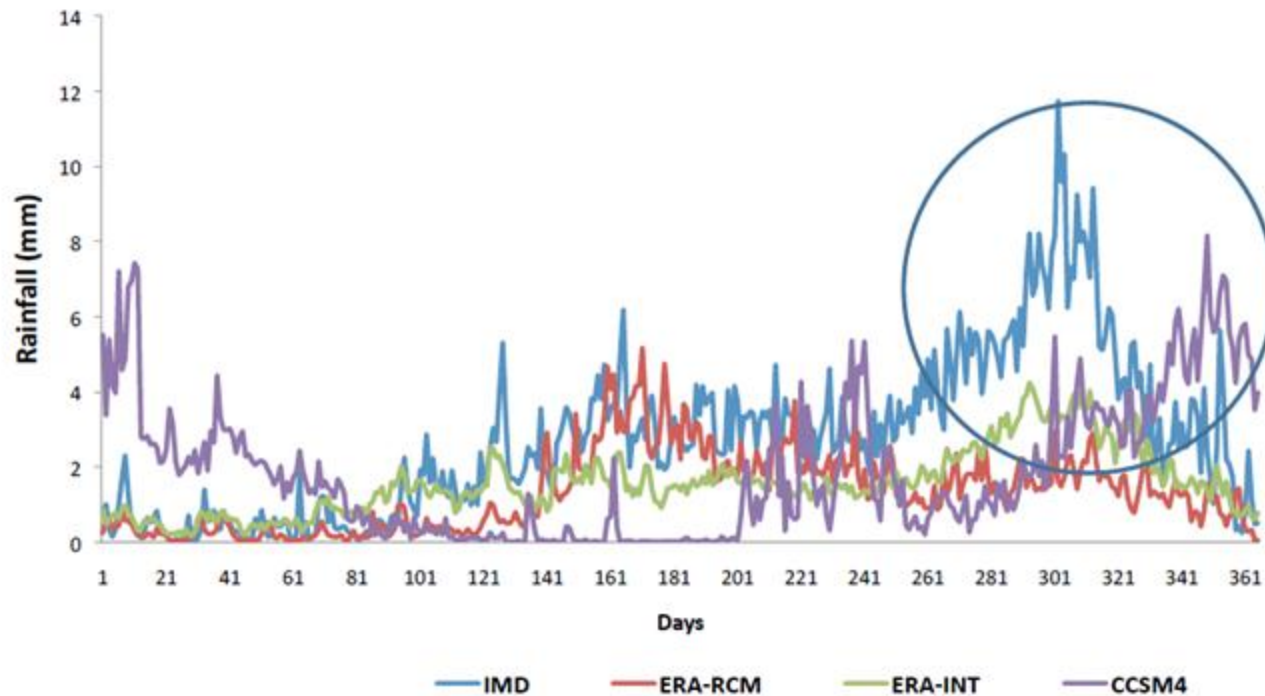
RCM is able to capture the major features but overestimates the rainfall in few regions.

Uncertainties in Observation and Models



Lack of observations: poor model result

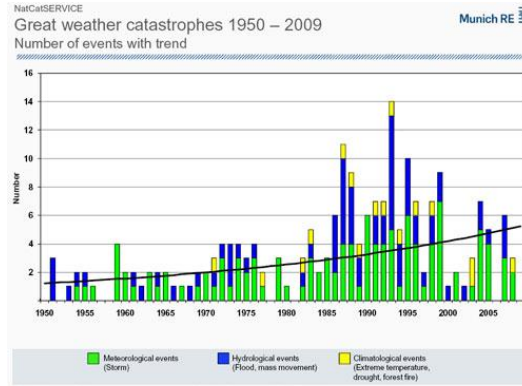
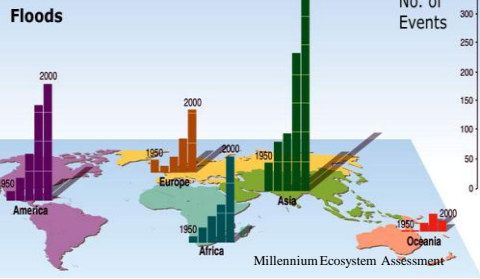
Observed rainfall climatology compared with IPRC_RegCM over peninsular India



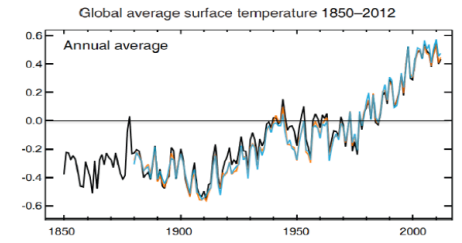
Reanalysis – temporal variability of atmospheric states and internal variability preserved – yet, results are not encouraging

Monsoon region – lack of 3-D moisture observations – severe constraint

Evidences



Annual Global Combined Land and Sea Temperature

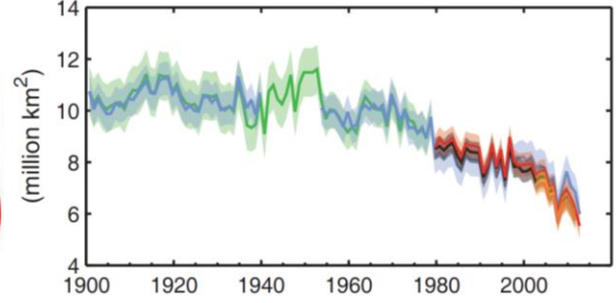
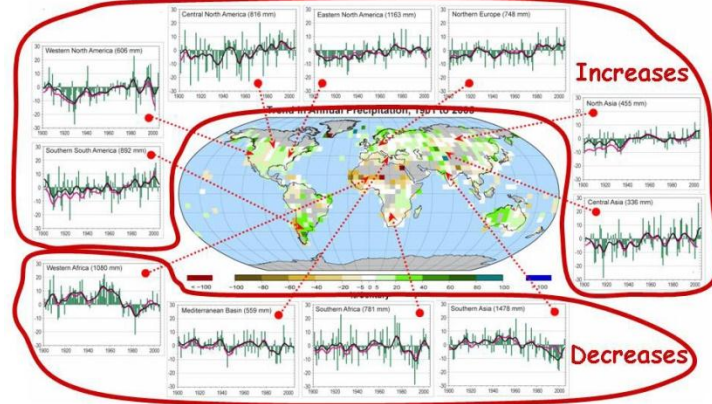
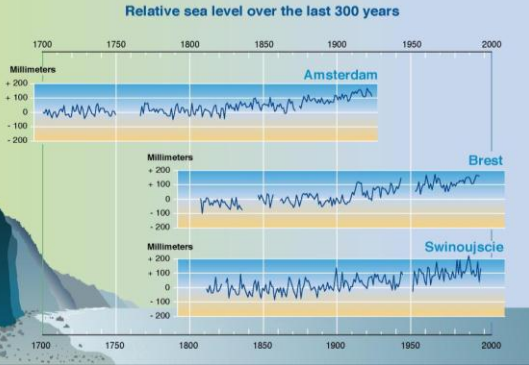


HadCRUT4 (black), MLOST (orange) and GISS (blue) are shown.

The globally averaged combined land and ocean surface temperature data, show a warming of 0.85 [0.65 to 1.06] °C, over the period 1880–2012. The total increase between the average of the 1850–1900 period and the 2003–2012 period is 0.78 [0.72 to 0.85].

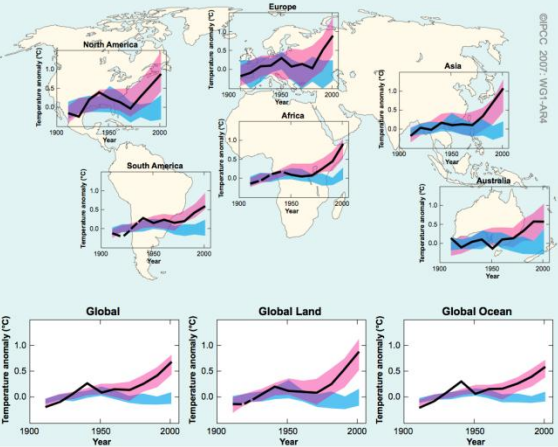
IPCC AR5 Working Group I
Climate Change 2013: The Physical Science Basis

ipcc
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

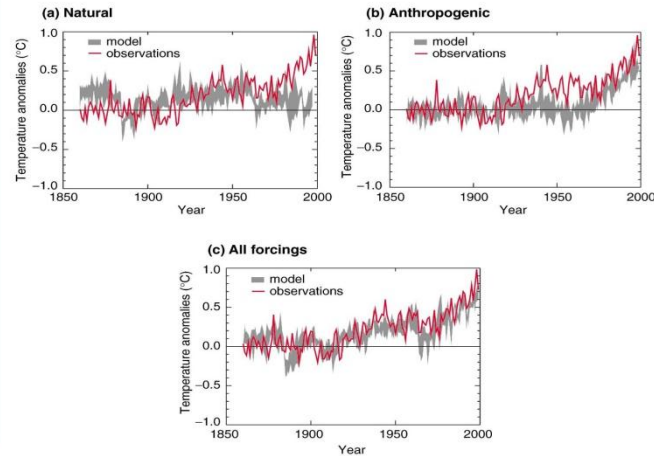


Human Attribution

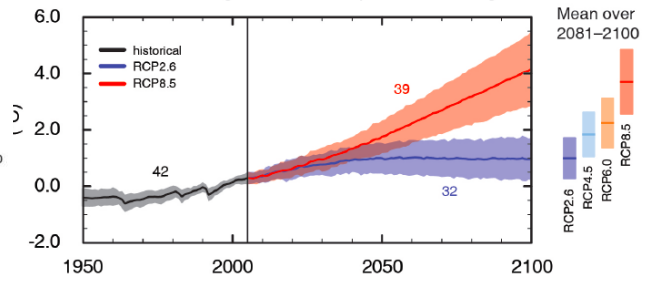
Global and Continental Temperature Change



Simulated annual global mean surface temperatures



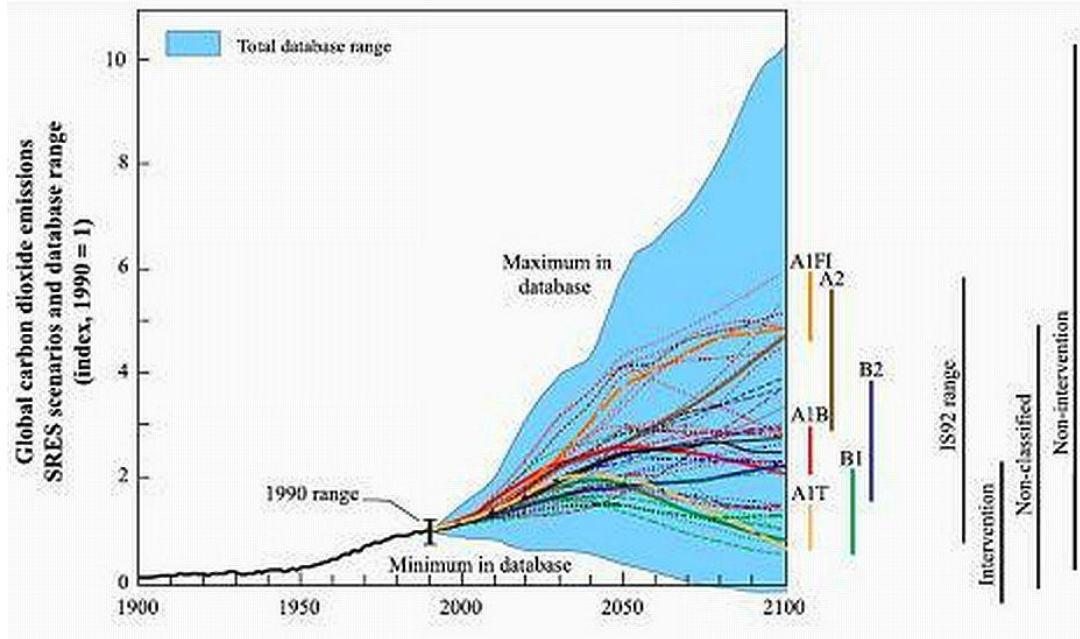
Global average surface temperature change



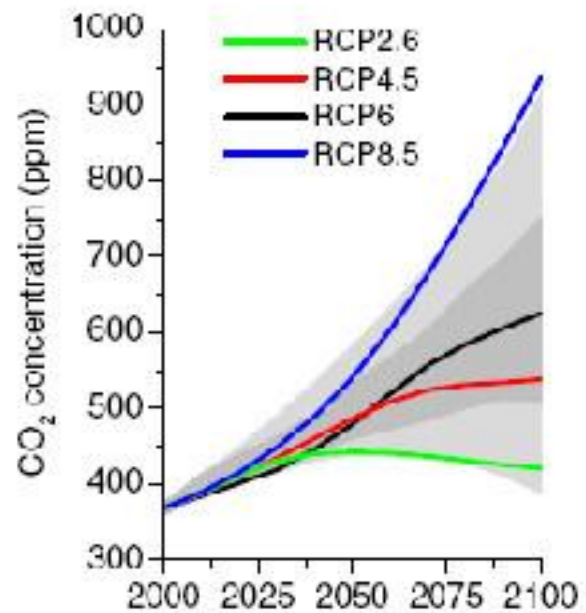
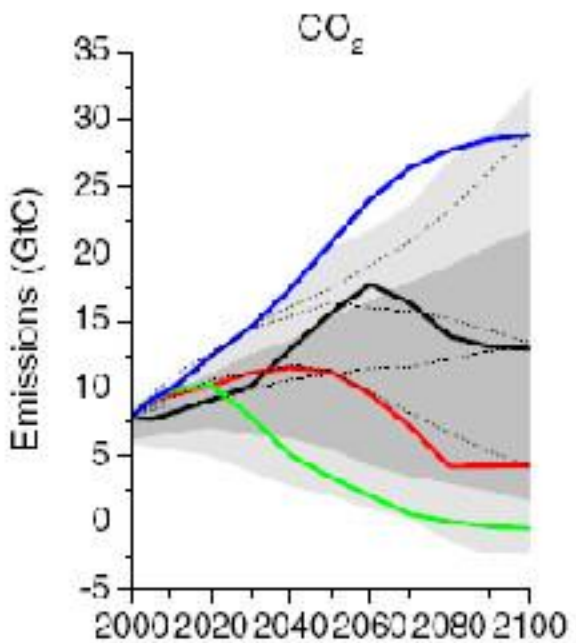
Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 for all scenarios

IPCC Scenarios Approach

- Were developed because previous IPCC assessments did not make a clear distinction between uncertainty among climate model forecasts and uncertainty in the emissions trajectory itself.
- “...are alternative images of how the future might unfold...”
- Differ in their assumptions regarding “demographic development, socio-economic development, technological change, radiative forcing changes due to mitigation actions ”
- Are given memorable names like
 - SRES: A1 (A1b,A1fi, A1T),B1, A2, and B2 (last decade)
 - RCP: 8.6, 6.0, 4.5, 2.5 (latest 2013 onwards)



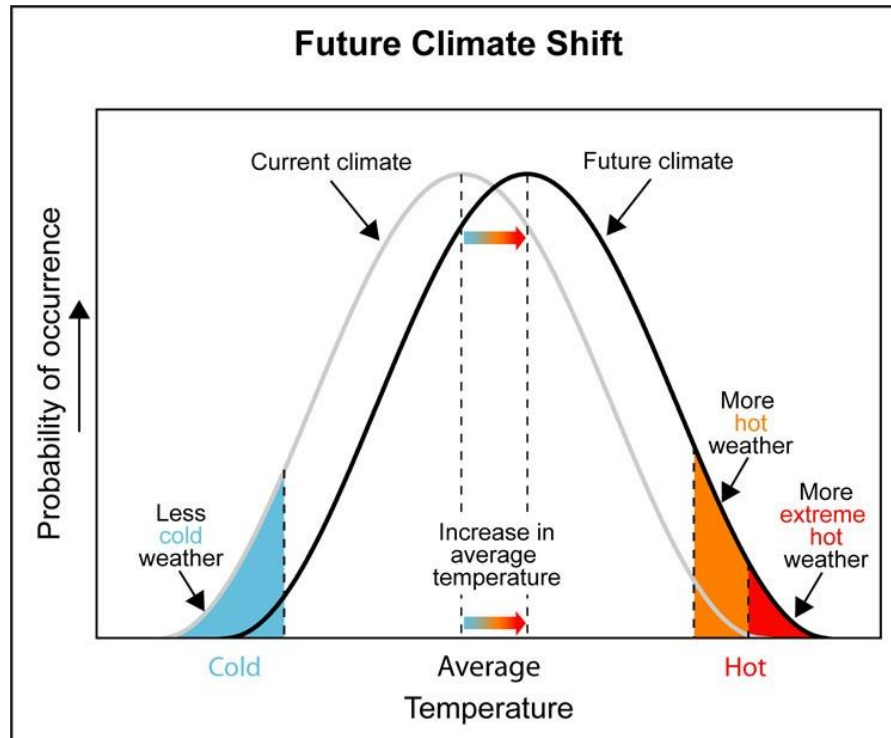
- A1Fi and A2 are having high range emissions at 2100
- B2 and A1B Median range emissions; and
- B1 and A1T Low range emissions



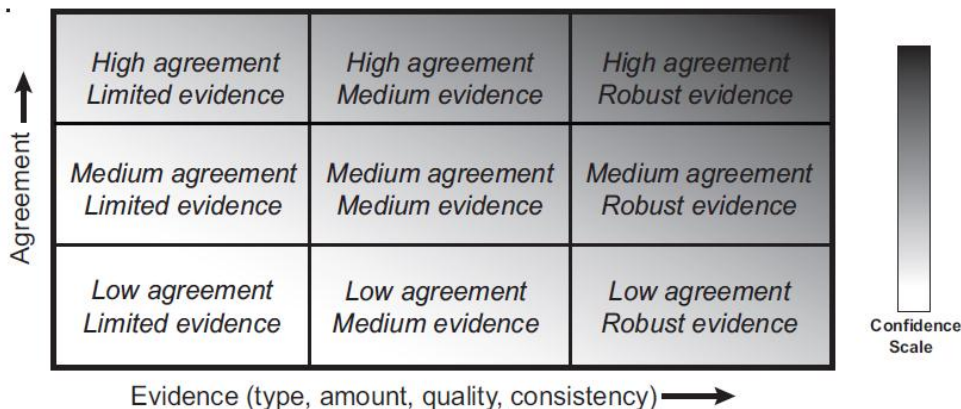
- RCP8.5 rapidly increasing CO₂ concentrations.
- RCP6 and RCP4.5 show a stabilizing CO₂ concentration.
- RCP2.6 modest decline to around 400 ppm CO₂ by the end of the century

Points on Emissions Scenarios

- Scenarios are not forecasts.
- Considered useful planning tools.
- There are no probabilities associated with the occurrence of these scenarios.
- The emissions scenarios provide standard parameters for climate modellers to make inter-comparison of their projections easier.



Guidelines to communicate Uncertainty



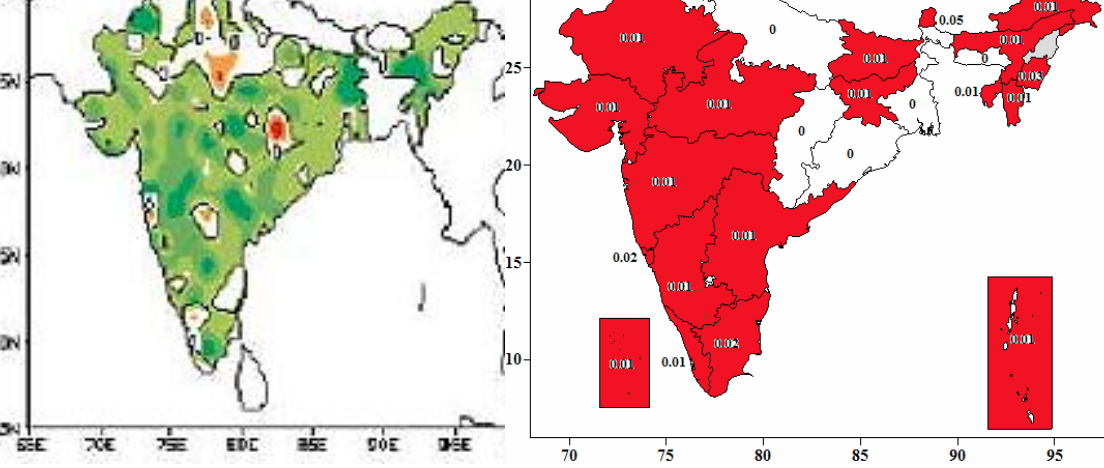
Summary statements for evidence and agreement and their relationship to confidence.

Figure 1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

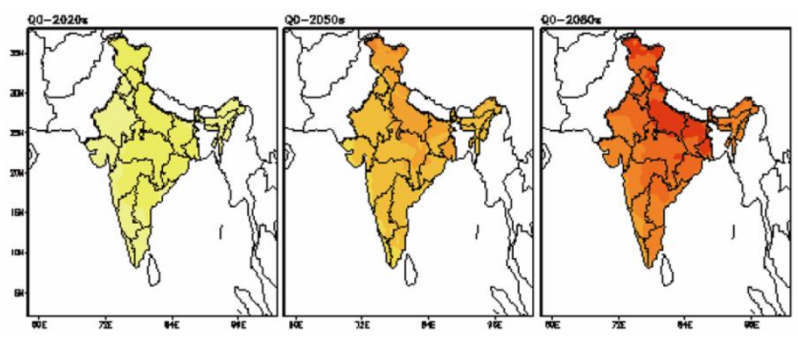
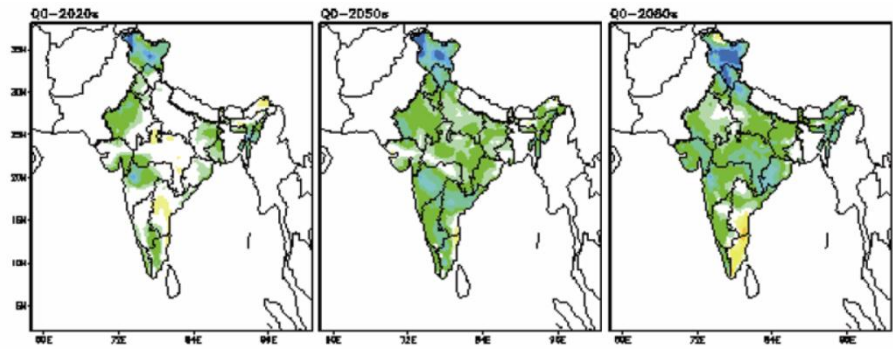
Likelihood provides calibrated language for describing quantified uncertainty

Table 1. Likelihood Scale	
Term*	Likelihood of the Outcome
<i>Virtually certain</i>	99-100% probability
<i>Very likely</i>	90-100% probability
<i>Likely</i>	66-100% probability
<i>About as likely as not</i>	33 to 66% probability
<i>Unlikely</i>	0-33% probability
<i>Very unlikely</i>	0-10% probability
<i>Exceptionally unlikely</i>	0-1% probability

* Additional terms that were used in limited circumstances in the AR4 (*extremely likely* – 95-100% probability, *more likely than not* – >50-100% probability, and *extremely unlikely* – 0-5% probability) may also be used in the AR5 when appropriate.



The MoEF's INCCA report (2010) and IMD's State level trend report (2013) indicates significant increasing trends for the extreme precipitation and temperatures the Karnataka region for the period last 50 to 100 years.



The mean annual rainfall, intensity of extreme rainfall and temperature for the Karnataka region is projected to increase in 2030s, 2050s and 2080s.

Extreme rainfall one of the important factors of flooding

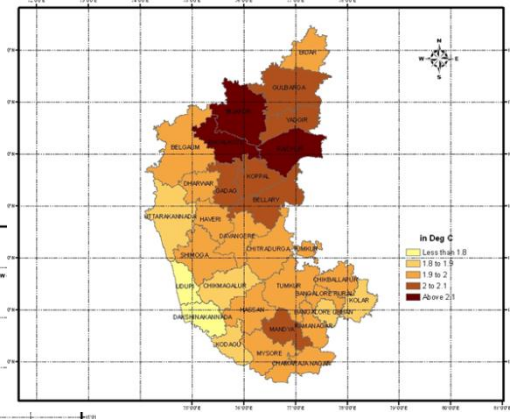
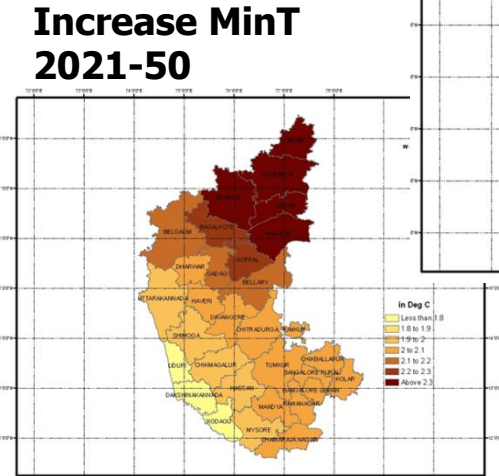
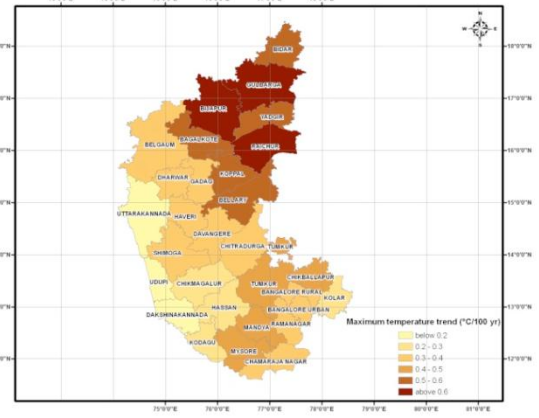
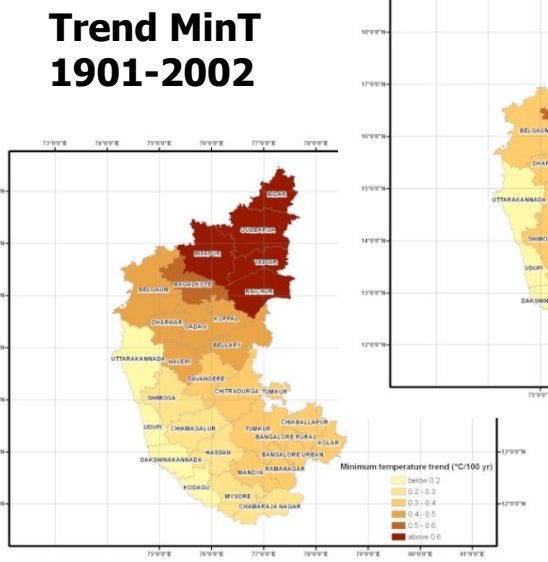
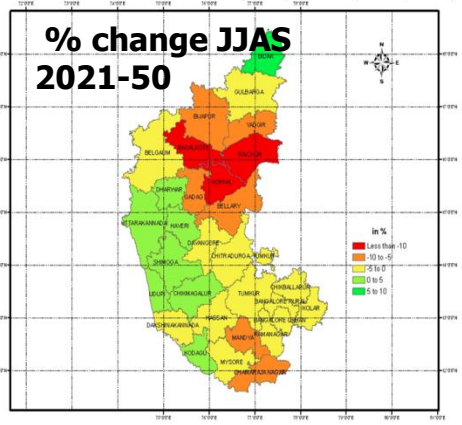
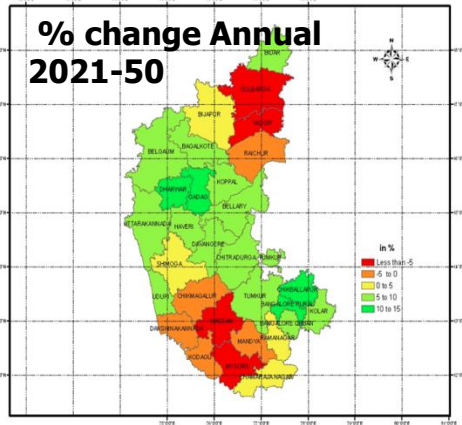
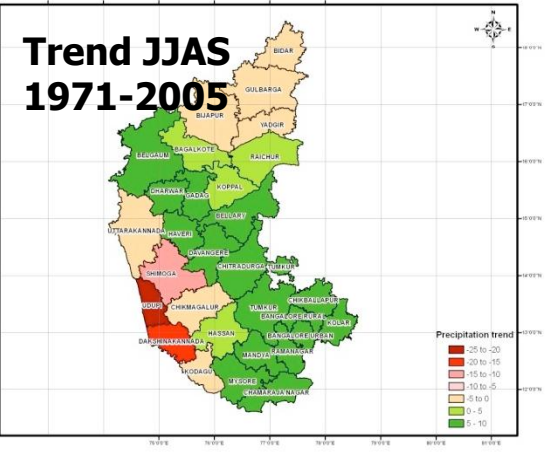
Surface water flooding occurs where heavy rainfall can't absorb into the ground or drain away.

With an uncertain future and probabilistic scenarios on climate change, the expected flooding concern becomes most important.

District 1901-2008	Pre-monsoon (Jan -May)			Southwest monsoon (Jun- Sep)			Northeast monsoon (Oct- Dec)			Annual	
	Trend	mm	(%)	Trend	mm	(%)	Trend	mm	(%)	Trend	mm

South interior Karnataka

Bangalore Rural	↑	141	18	↓	427	54	↓	222	28	↓	790
Bangalore Urban	↑	168	19	↑	466	53	↑	241	28	↑	875



Bangalore weather swinging to extremes

Rohith BR, TNN | Dec 28, 2013, 05:28AM IST

Heavy rain floods streets in Bangalore

GENERAL ARTICLES CURRENT SCIENCE, VOL. 100, NO. 11, 10 JUNE 2011

41 AM IST

Urban floods in Bangalore and Chennai: risk management challenges and lessons for sustainable urban ecology

Anil K. Gupta* and Sreeja S. Nair

THE BELL TOLLS

Encroached storm water drain leads to flooding in Kadugodi apartment premises

Google map places Kadugodi's Sai Garden apartment complex right next to the path of the natural drain. If the residents are not able to find a quick and sustainable solution, the floods could prove detrimental.

Nikita Malusare, 14 Sep 2013, Citizen Matters

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GARVIBAVI PALYA NEAR HOSUR ROAD

HOSUR ROAD FLOODED IN BANGALORE



HOUSE IN JP NAGAR BANGALORE

TRAFFIC JAM DUE TO HEAVY RAINS



Flood inside Sai Gardens premises, in Kadugodi near Whitefield.



SUBWAY BETWEEN MAJESTIC

RISING WATER LEVEL AND VEHICLES

AND RAILWAY STATION

Tropical Street Trees and Climate Uncertainty in Southeast Asia

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Additional index words: climate change, water stress, drought physiology, drought deciduous, wet evergreen, monsoonal dry evergreen, urban forestry

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http://wgbs.ces.iisc.ernet.in/energy/water/paper/urbanfloods_bangalore/floods_city.htm

CITIES > BANGALORE

BANGALORE, February 7, 2012

Updated: February 7, 2012 14:16 IST

Rise in Bangalore's temperature attributed to high carbon emissions

Tuesday, April 15, 2014 03:09 PM

1,077 areas in city are flood-prone

By Prabhu Mallikarjunan | ENS - BANGALORE | Published: 28th June 2013 09:21 AM
Last Updated: 28th June 2013 09:21 AM



The Bruhat Bengaluru Mahanagara Palike has identified 1,077 areas in Bangalore as "flood-prone" and 85 per cent of them have been categorised as "critical". | EPS/File

NBN Live

Bangalore losing its charming weather

Priyanjana Dutta,

CNN-IBN

Jun 03, 2010 at 04:40pm

IST

CITIES > BANGALORE

BANGALORE, June 5, 2013

Updated: June 5, 2013 10:27 IST

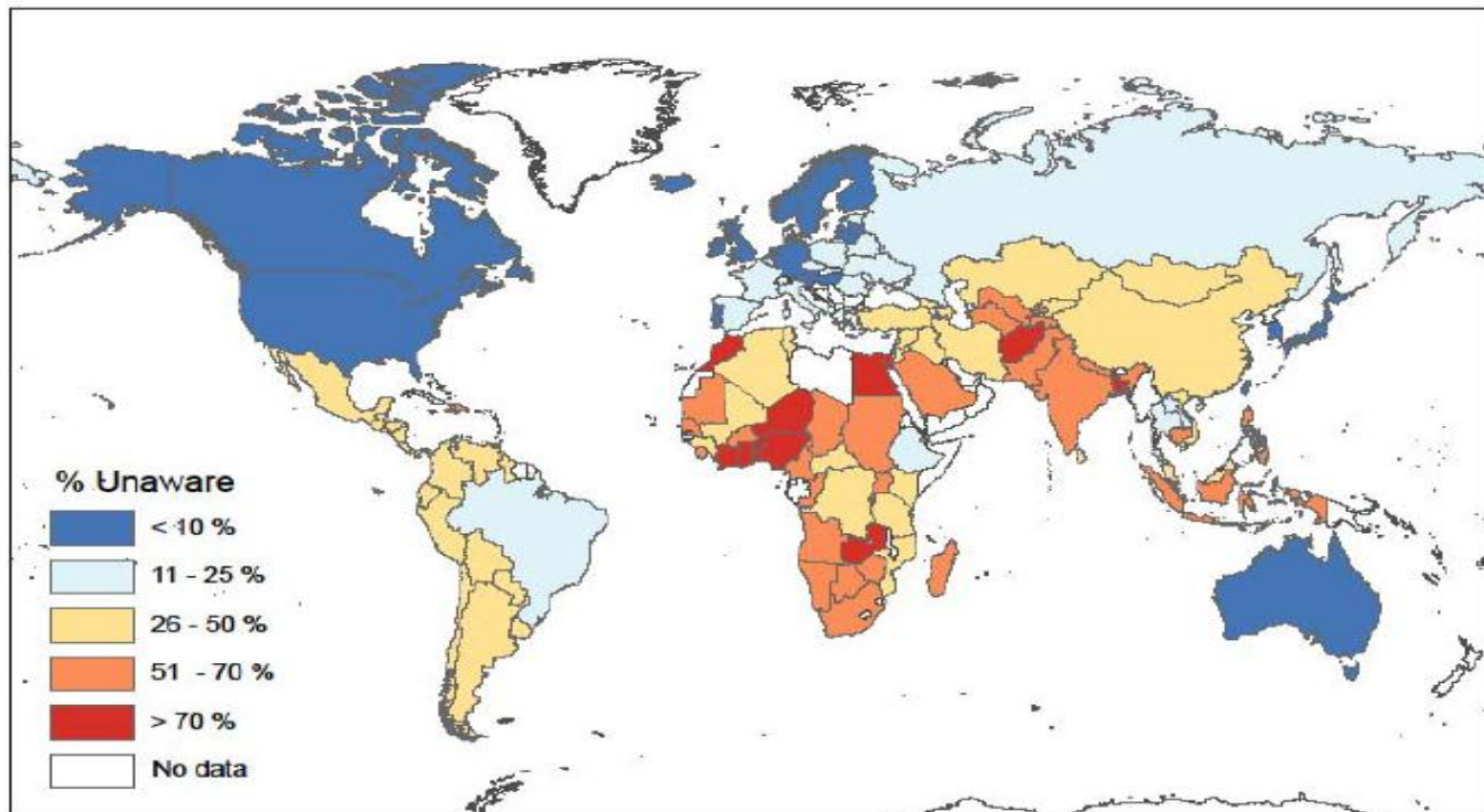
Yes, our chilled out city is changing for the worse, Bangaloreans say

“Unaware” of Climate Change

“How much do you know about global warming or climate change?”

(I've never heard of it; don't know; refused)

n = 269,913 in 132 countries (2007-2009)



J. Marlon, University of Oregon

Climate Change Vulnerability Index 2011

