Coordinated Regional Climate Downscaling Experiment (CORDEX) for South Asia

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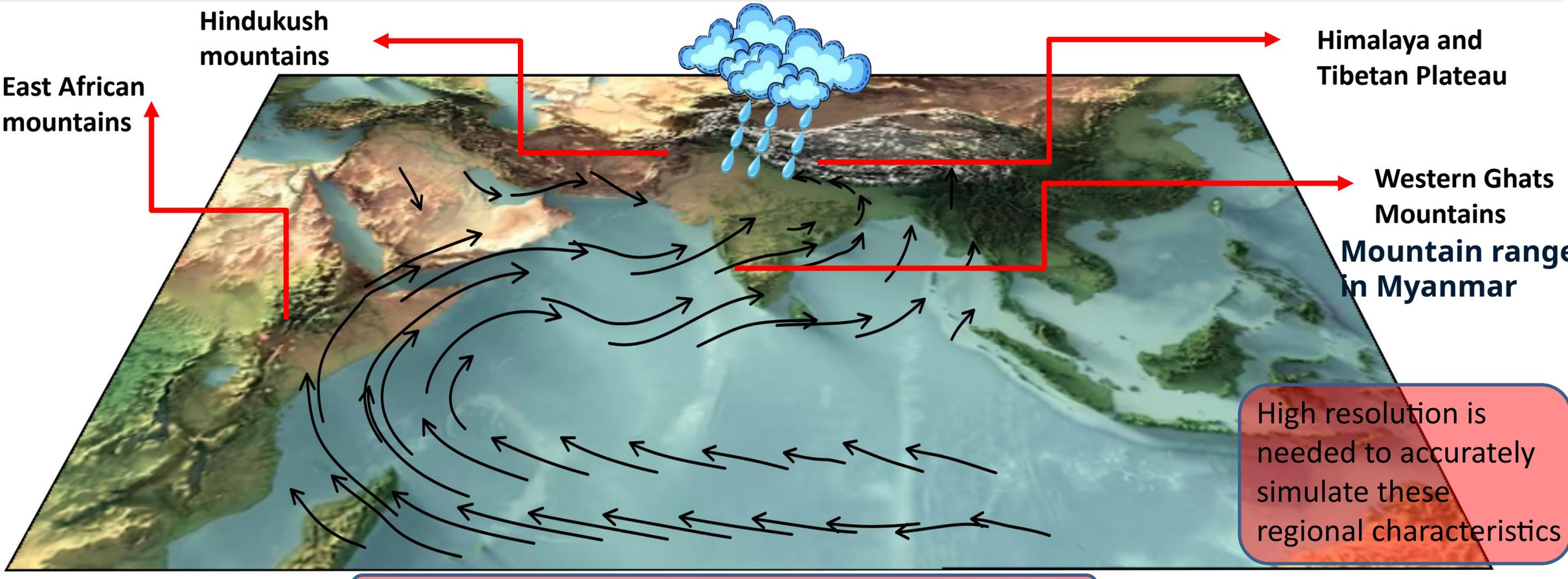
CCR
Center for Climate Change Research

The Complex South Asian Climate



High resolution is needed to accurately simulate these regional characteristics

Climate change adding more complexity towards it

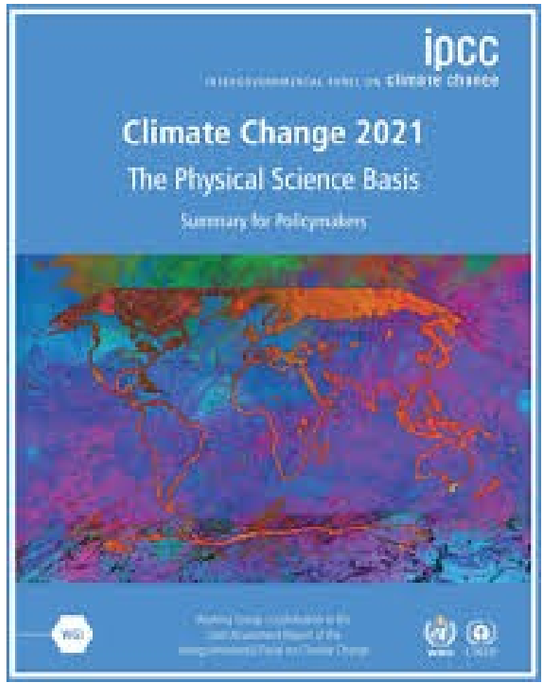
Rising Temperature Extremes:

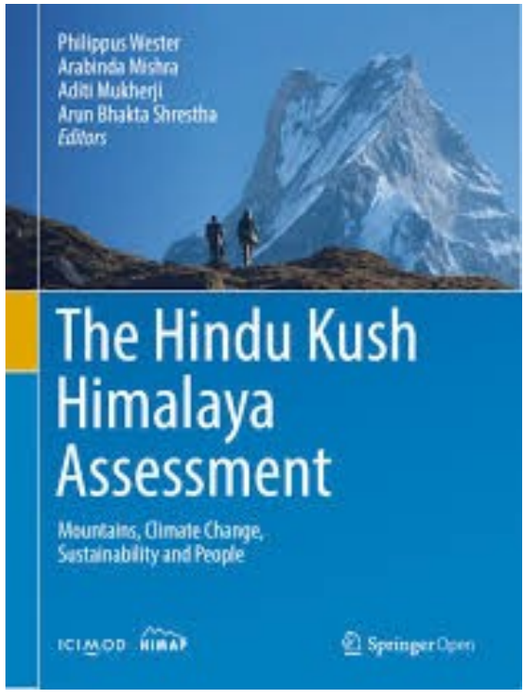
Amplified Monsoon Variability:

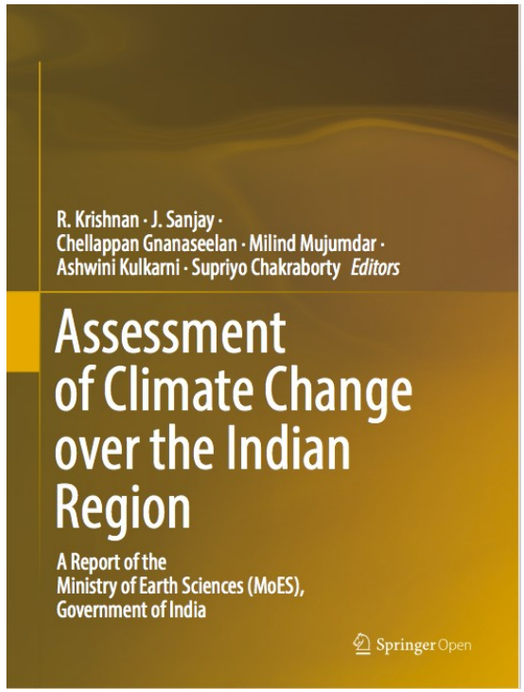
Sea-Level Rise and Coastal Risk:

Increased Frequency of Extreme Weather Events:

Glacier Retreat and Himalayan Vulnerability:







- **Data for these assessments..**
- & when we need to address the science of climate change…
- & to carryout impact assessment studies …
- & to provide various services

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

CORDEX

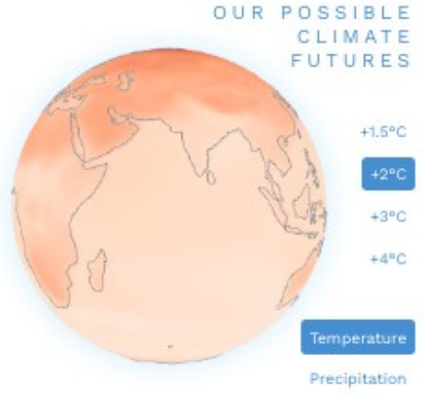
CCCR
Center for Climate Change Research

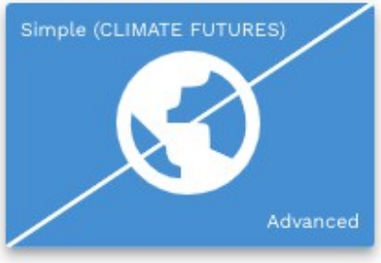
Indian Institute of Tropical Meteorology Pune

IPCC WGI Interactive Atlas

A novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information underpinning the Working Group I contribution to the Sixth Assessment Report, including regional synthesis for Climatic Impact-Drivers (CIDs).

Errata and problem reporting | License, data and citation | Contact





REGIONAL INFORMATION

REGIONAL SYNTHESIS

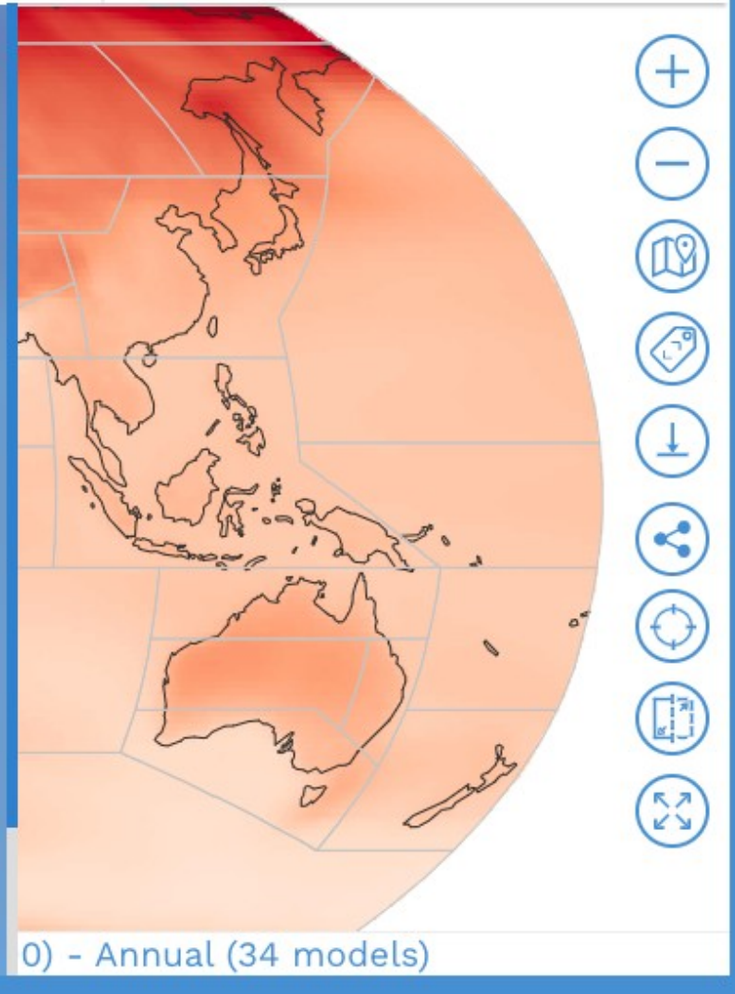
DOCUMENTATION

IPCC WGI Interactive Atlas: Regional information (Advanced)

Home About Guidance License

DATASET VARIABLE QUANTITY & SCENARIO SEASON

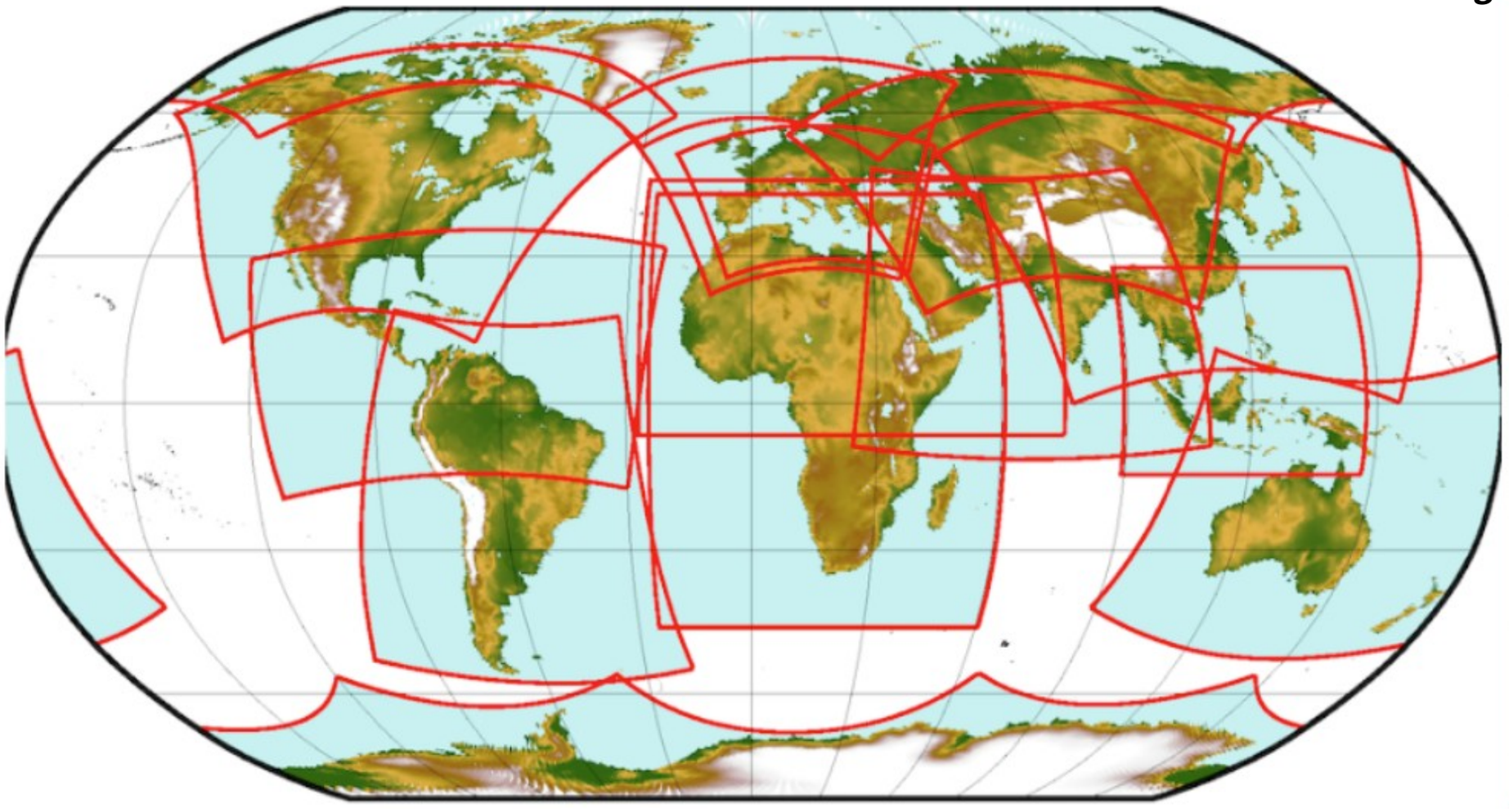
MODEL PROJECTIONS	MODEL HISTORICAL	OBSERVATIONS	PALEOCLIMATE
CMIP6	CMIP6	CRU TS	PMIP4
CMIP5	CMIP5	HadCRUT5	PMIP3
CORDEX Africa	CORDEX Africa	Berkeley Earth	
CORDEX Antarctica	CORDEX Antarctica	GPCC	
CORDEX Arctic	CORDEX Arctic	GPCP	
CORDEX Australasia	CORDEX Australasia	ERA5	
CORDEX Central America	CORDEX Central America	W5E5 (ERA5 adjusted)	
CORDEX East Asia	CORDEX East Asia	Daymet (North America)	
CORDEX Europe	CORDEX Europe	E-OBS (Europe)	
CORDEX Mediterranean	CORDEX Mediterranean	APHRODITE (Asia)	
CORDEX North America	CORDEX North America	AGCD (Australia)	
CORDEX South America	CORDEX South America		
CORDEX South Asia	CORDEX South Asia		



0) - Annual (34 models)

CORDEX Domains

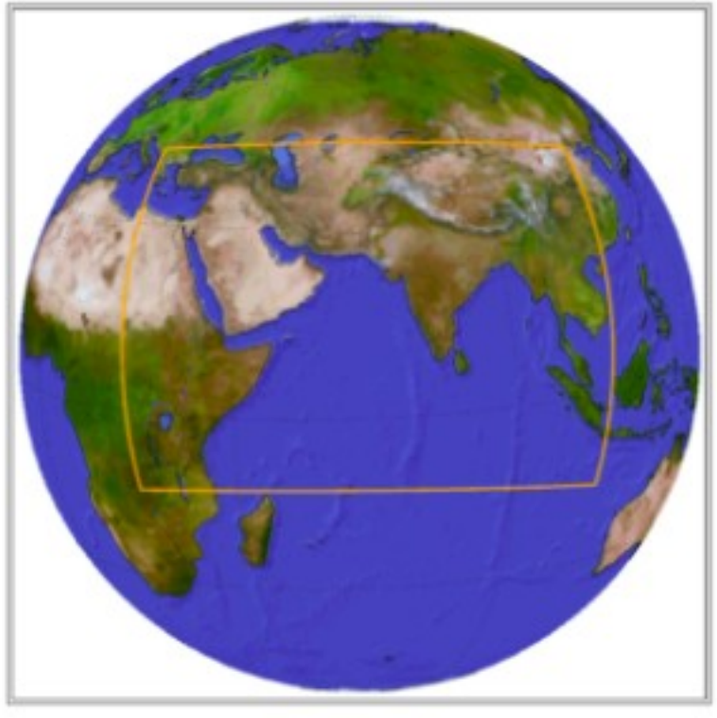
The main CORDEX protocol includes a set of 14 continental-scale domains covering essentially all land areas of the globe.



- Region 1: South America
- Region 2: Central America
- Region 3: North America
- Region 4: Africa
- Region 5: Europe (EURO)
- Region 6: South Asia
- Region 7: East Asia
- Region 8: Central Asia
- Region 9: Australasia
- Region 10: Antarctica
- Region 11: Arctic
- Region 12: Mediterranean (MED)
- Region 13: Middle East North Africa (MENA)
- Region 14: South-East Asia (SEA)

Region 6: South Asia

Regional Climate Information for Application Studies
CORDEX South Asia



Ref: Description of the CORDEX domains
(23/10/2015 version)

A) For rotated polar RCMs (in rotated coordinates):

RotPole (236.66; 79.95)
TLC (327.88; 35.20)
Nx=193
Ny=130

B) For non-rotated polar RCMs (in actual coordinates):

TLC (19.88; 43.5)
CNB (68.41; 45.07)
TRC (115.55; 41.0)
CWB (23.48; 15.51)
CPD (67.18; 16.93)
CEB (110.47; 13.09)
BLC (26.19; -12.97)
CSB (66.29; -11.66)
BRC (106.43; -15.23)

CORDEX actively involved in production of regional climate information and involve in dialogue with **regional impact communities, stakeholders and authorities**.

CORDEX goals include interaction with users of regional climate information, through which **CORDEX will be able to cater for climate service** perspective.

The main four CORDEX goals include

i) understanding relevant regional/local climate phenomena,

ii) improving regional climate downscaling models and techniques,

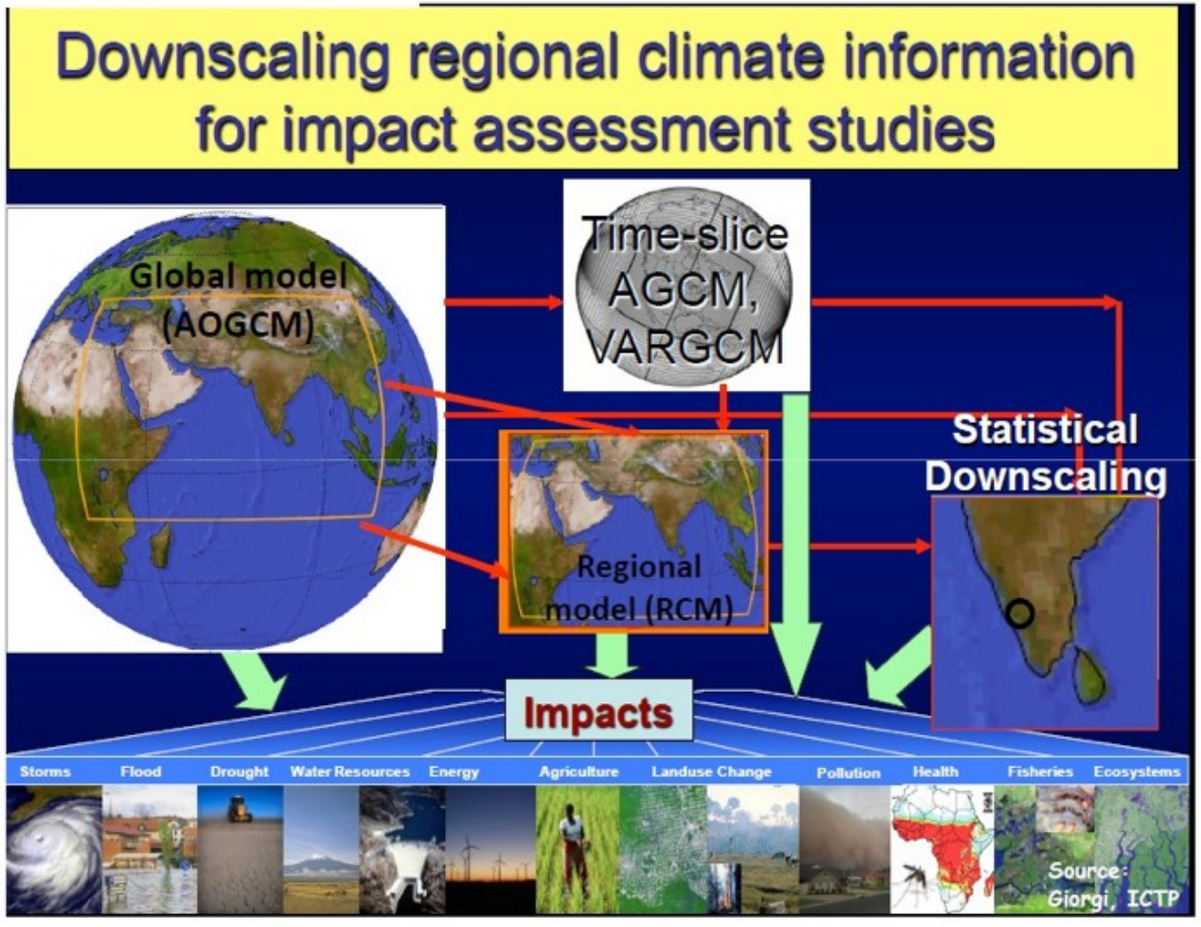
iii) producing coordinated sets of regional high-resolution downscaled projections worldwide and

iv) fostering communication and knowledge exchange with users of regional climate information.

Regional Climate Information for Application Studies
CORDEX South Asia

WCRP CORDEX

The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships.



IITM is coordinating the CORDEX South Asia activities.

50/22 km resolution simulations based on CMIP5-RCP scenario &, 27 km simulations based on CMIP6-SSP scenarios, and 15 km RegCM-based simulations.

Simulation cover historical and future periods, following the established CMIP and CORDEX protocols.

More information for CORDEX South Asia data access from CCCR-IITM Climate Data Portal and ESGF data node are provided at:
http://cccr.tropmet.res.in/home/cordexsa_datasets.jsp

WAS-25^

Colour legend: planned running completed published

	Institution(s)	IITM	Uni-Hamburg
	RCM	IITM-AGCM	WRF
driving_model	ensemble	&RegCM	
ERA5		evaluation	evaluation
IITM-ESM	r1i1p1f1	hist ssp245 ssp585	
MPI-ESM1-2-HAM	r1i1p1f1		hist ssp370
MPI-ESM1-2-LR	r1i1p1f1		hist ssp126 ssp245 ssp370 ssp585
TBD	TBD	hist ssp245 ssp585	
TBD2	TBD	hist ssp245 ssp585	

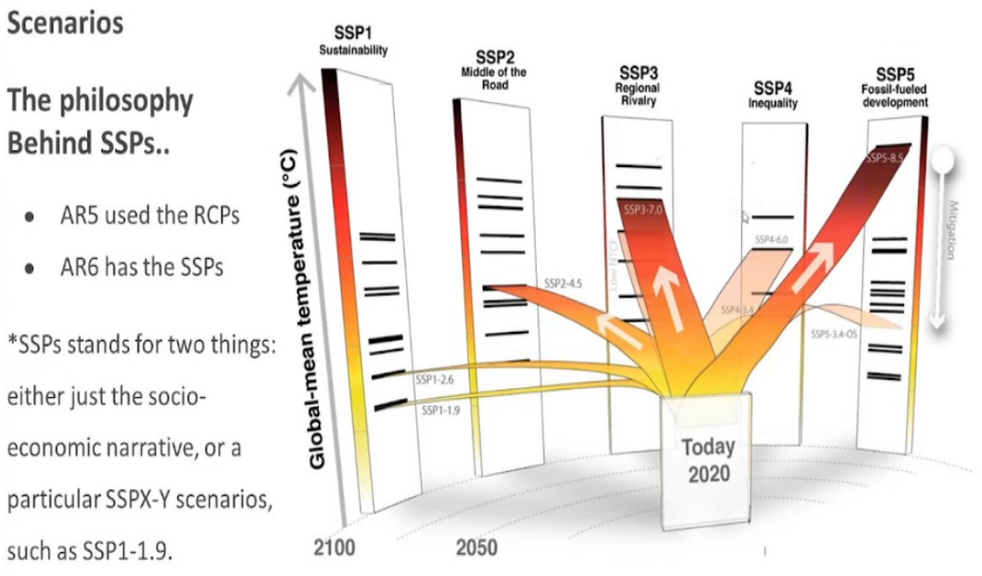
Similar to CMIP: simulations designed to address science of climate change

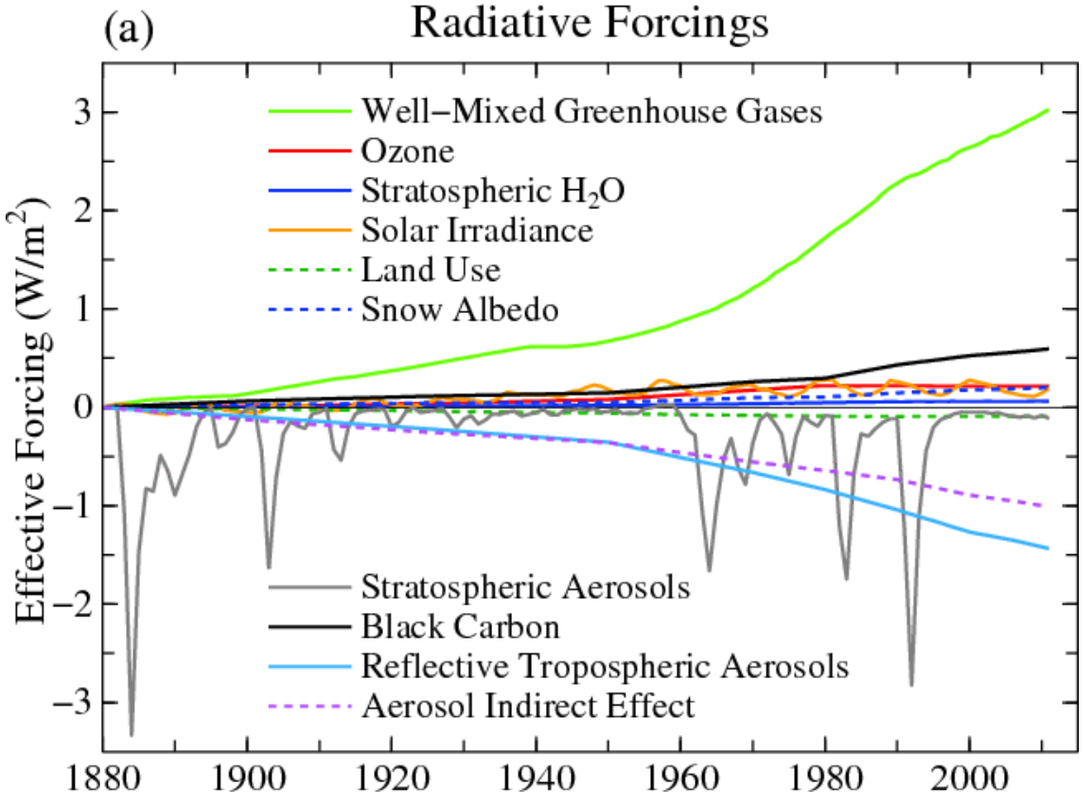
Role of CMIP programe of WCRP
CORDEX also follows this

Historical (1860-2014):

Includes natural and anthropogenic (GHG, aerosols, land cover etc) climate forcing during the historical period (1860 – 2014)

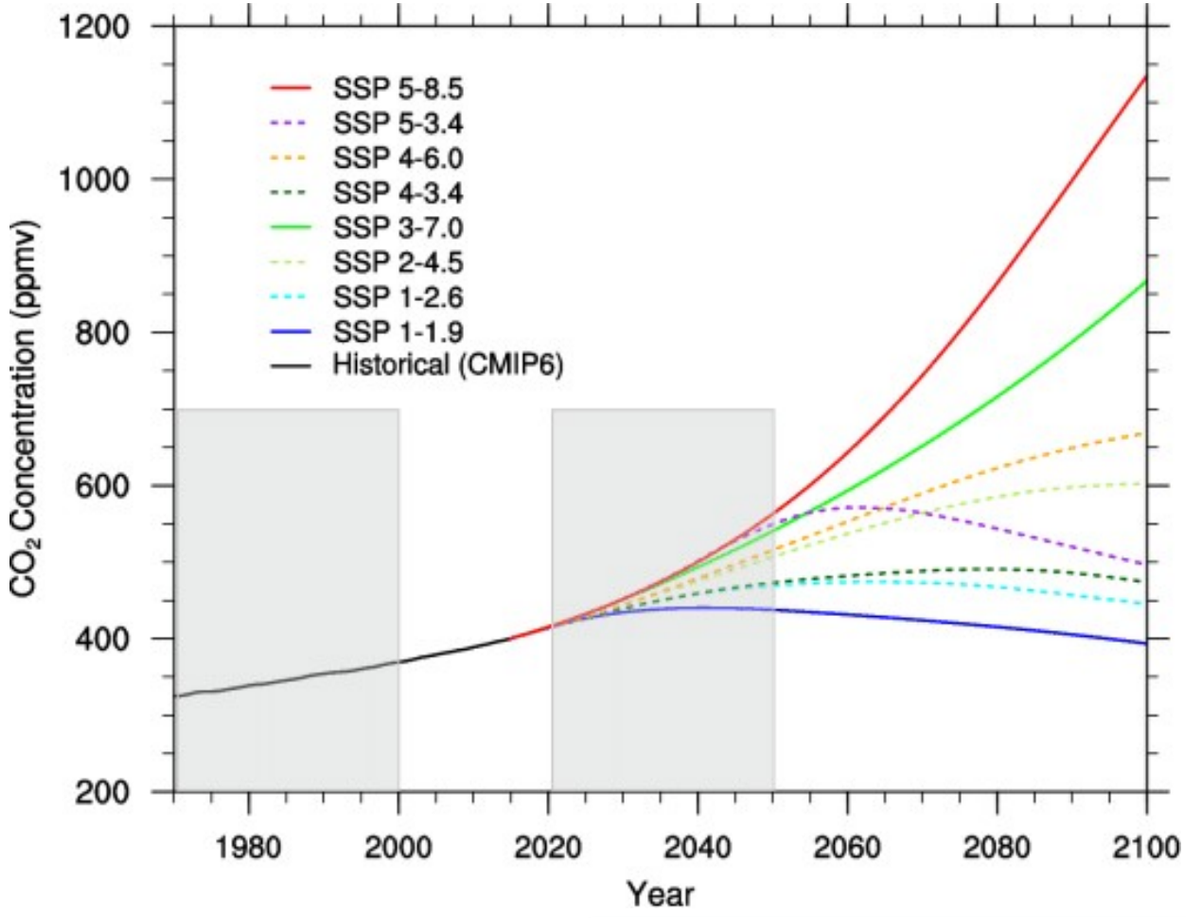
Future simulations also follows the CMIP protocols



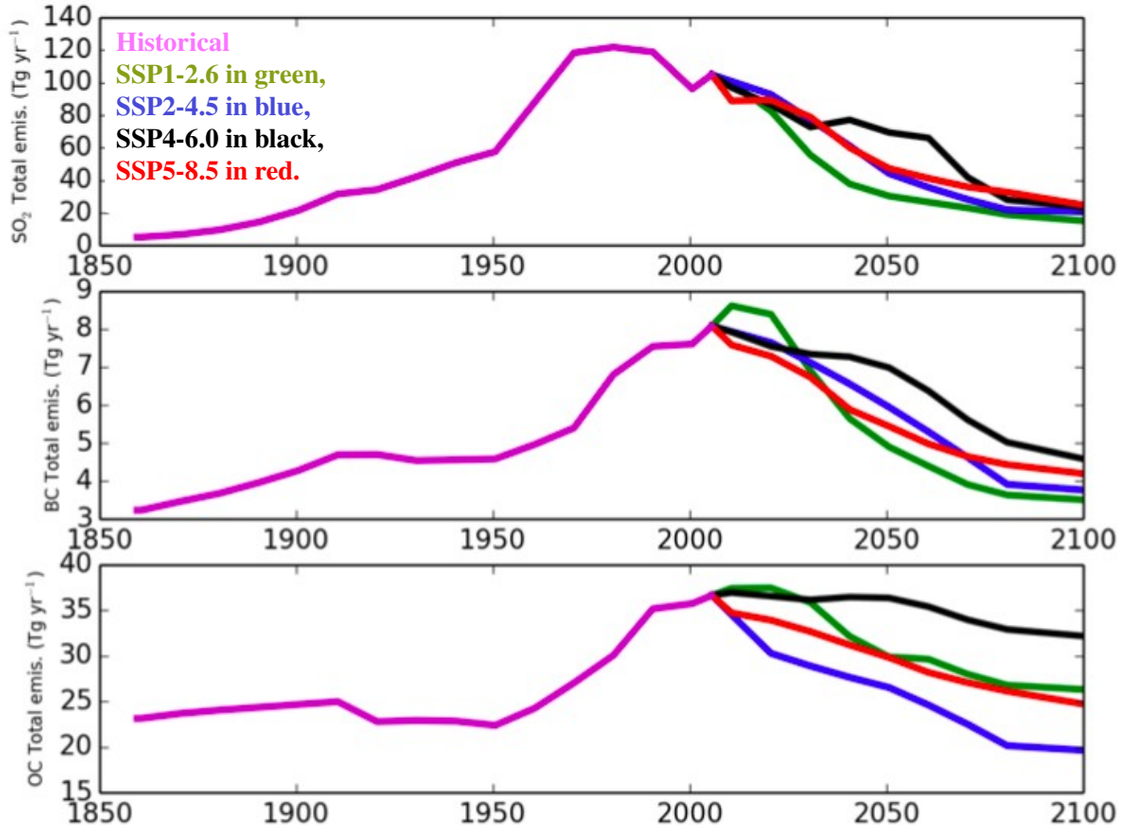


Make Future Changes due to respective CO_2 and Aerosol concentration

Expected CO_2 concentrations under various future scenarios



Expected Aerosol concentrations under various future scenarios



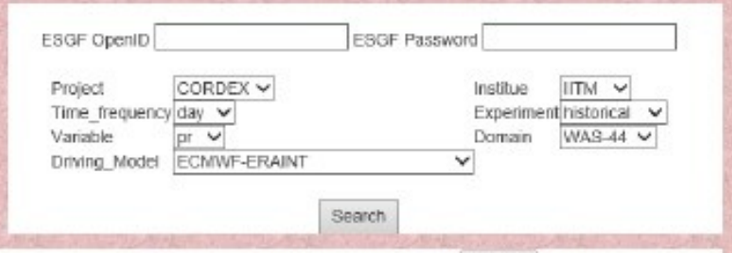
In the future, CO_2 is expected to increase irrespective of the scenario, whereas aerosol levels are expected to decrease

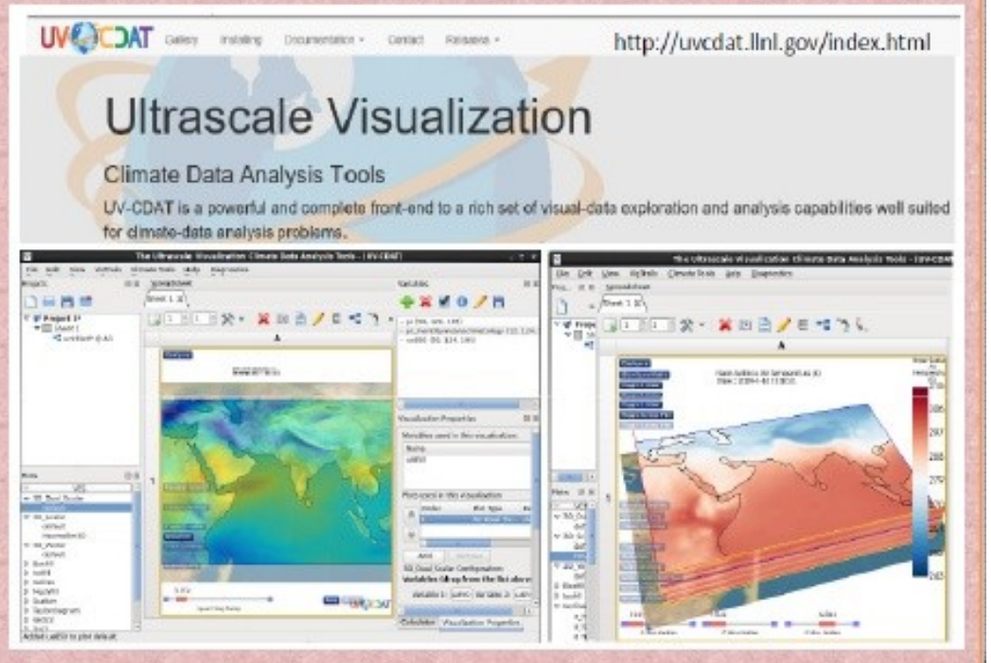
CORDEX South Asia Data Access and Analysis Tools

ESGF Data Extraction Tool

http://cccr-dx.tropmet.res.in:8000/projection/

Web Interface based on python developed by CCCR-IITM for users to explore and remotely access subsets of CORDEX South Asia datasets published on ESGF





WCRP CORDEX
Coordinated Regional Climate Downscaling Experiment

The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships.

Search

How to access the data

An initial focus of the CORDEX initiative was to establish a cen
supplemented by regional data portals. However, it soon beca
geographically distributed archiving system such as the Earth
(ESGF) would offer much greater flexibility for the provision of
simulations produced by many modelling groups across the gl
Coupled Model Intercomparison Project Phase 5 (CMIP5).

ESGF is an up-to date scientific infrastructure for distributing climate data and will now become WCRP's main tool for providing global and regional climate simulations together with observations and reanalyses over the next decade. At the first CORDEX Science Advisory Team (SAT) meeting in May 2014 the CORDEX data archiving progress was discussed in detail and the SAT strongly recommended the use of ESGF as the main tool for providing CORDEX data to users. However, a number of CORDEX simulations for different CORDEX domains were completed before CORDEX-ESGF archiving infrastructure was in

Centre for Climate Change Research
Indian Institute of Tropical Meteorology, Pune, India

Ministry of Earth Sciences

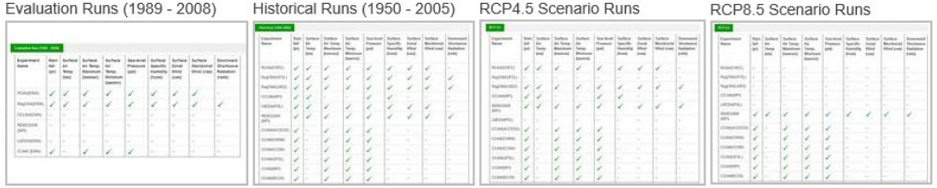
CORDEX South Asia data is available on the CCCR-IITM Climate Data Portal (non-ESGF):

About Climate Data Portal http://cccr.tropmet.res.in/home/old_portals.jsp

The CCCR Climate Data Portal is designed to facilitate the dissemination of climate information using a publicly accessible FTP and web-based interface. click here

CORDEX-South Asia Multi Model Output http://cccr.tropmet.res.in/home/ftp_data.jsp

Evaluation Runs (1989 - 2008) | Historical Runs (1950 - 2005) | RCP4.5 Scenario Runs | RCP8.5 Scenario Runs



Historical (1950-2005)

Experiment Name	Rain fall (pr)	Surface Air Temp (tas)	Surface Air Temp. Maximum (tasmax)	Surface Air Temp. Minimum (tasmin)	Sea-level Pressure (psl)	Surface Specific Humidity (huss)	Surface Zonal Wind (uas)	Surface Meridonial Wind (vas)	Downward Shortwave Radiation (rsds)
RCA4(ICHEC)	✓	✓	✓	✓	✓	✓	✓	✓	--
RegCM4(GFDL)	✓	✓	✓	✓	✓	✓	✓	✓	✓
RegCM4(LMDZ)	✓	✓	✓	✓	✓	✓	✓	✓	✓
CCLM4(MPI)	✓	✓	--	--	✓	✓	--	--	--
LMDZ4(IPSL)	✓	✓	✓	✓	✓	✓	✓	✓	--
REMO2009 (MPI)	✓	✓	✓	✓	✓	✓	✓	✓	✓
CCAM(ACCESS)	✓	--	✓	✓	✓	--	--	--	--
CCAM(CNRM)	✓	--	✓	✓	✓	--	--	--	--
CCAM(CCSM)	✓	--	✓	✓	✓	--	--	--	--
CCAM(GFDL)	✓	--	✓	✓	✓	--	--	--	--
CCAM(MPI)	✓	--	✓	✓	✓	--	--	--	--
CCAM(BCCR)	✓	--	✓	✓	✓	--	--	--	--

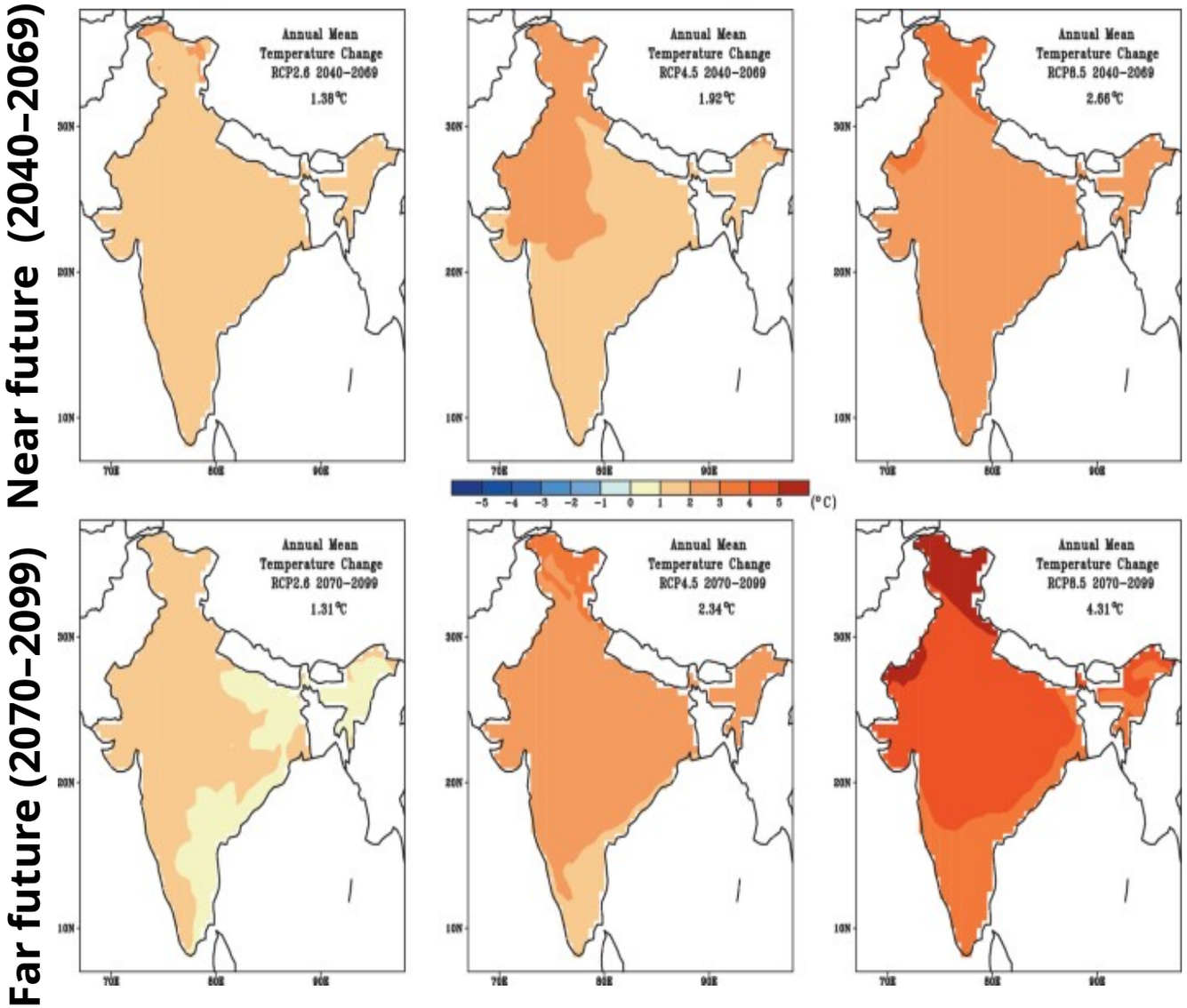
Table: List of CORDEX South Asia Regional Climate Model (RCM) Experiments

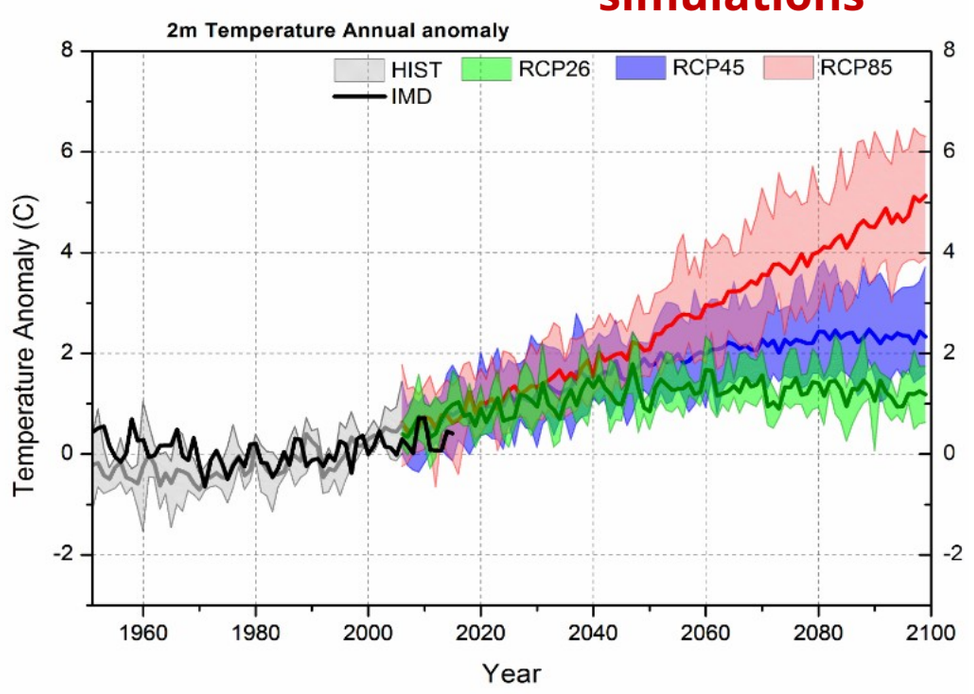
Experiment Name	RCM Description	Driving GCM	Contributing Institute
CCLM4(MPI)	COnsortium for Small-scale MOdelling (COSMO) model in CLimate Mode version 4.8 (CCLM; Dobler and Ahrens, 2008)	Max Planck Institute for Meteorology, Germany, Earth System Model (MPI-ESM-LR; Giorgetta et al 2013)	Institute for Atmospheric and Environmental Sciences (IAES), Goethe University, Frankfurt am Main (GUF), Germany
RCA4(ICHEC)	Rossby Centre regional atmospheric model version 4 (RCA4; Samuelsson et al., 2011)	Irish Centre for High-End Computing (ICHEC), European Consortium ESM (EC-EARTH; Hazeleger et al. 2012)	Rosssy Centre, Swedish Meteorological and Hydrological Institute (SMHI), Sweden
CCAM(ACCESS)	Commonwealth Scientific and Industrial Research Organisation (CSIRO), Conformal-Cubic Atmospheric Model (CCAM; McGregor and Dix, 2001)	ACCESS1.0	CSIRO Marine and Atmospheric Research, Melbourne, Australia
CCAM(CNRM)		CNRM-CM5	
CCAM(CCSM)		CCSM4	
CCAM(GFDL)		GFDL-CM3	
CCAM(MPI)		MPI-ESM-LR	
CCAM(BCCR)		NorESM-M	
LMDZ4(IPSL)	Institut Pierre-Simon Laplace (IPSL) Laboratoire de Me´te´orologie Dynamique Zoomed version 4 (LMDZ4) atmospheric general circulation model (Sabin et al., 2013)	IPSL Coupled Model version 5 (IPSL-CM5-LR; Dufresne et al. 2013)	Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India
RegCM4(LMDZ)	The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al., 2012)	IPSL LMDZ4	CCCR, IITM
RegCM4(GFDL)	ICTP RegCM4	Geophysical Fluid Dynamics Laboratory, USA, Earth System Model (GFDL-ESM2M-LR; Dunne et al. 2012)	CCCR, IITM
REMO2009(MPI)	MPI Regional model 2009 (REMO2009; Weblink: http://cccr.tropmet.res.in/cordex/docs/REMO-CORDEX-DATA-WAS-IITM_4.pdf	MPI-ESM-LR (Giorgetta et al 2013)	Climate Service Center, Hamburg, Germany

http://cccr.tropmet.res.in/home/docs/cordex/Table_CORDEX_Expts_all.doc

Projections of annual average surface air temperature changes

Inference from CORDEX simulations



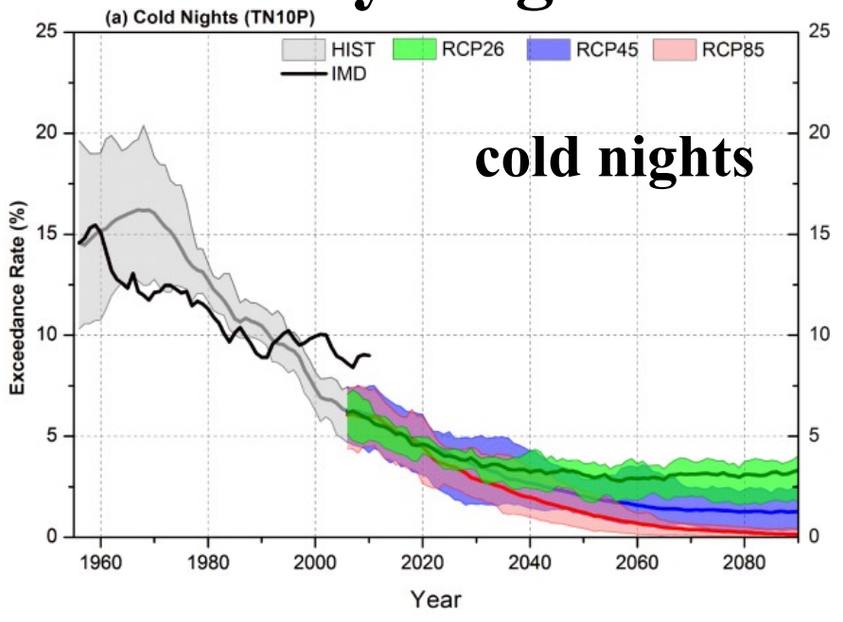


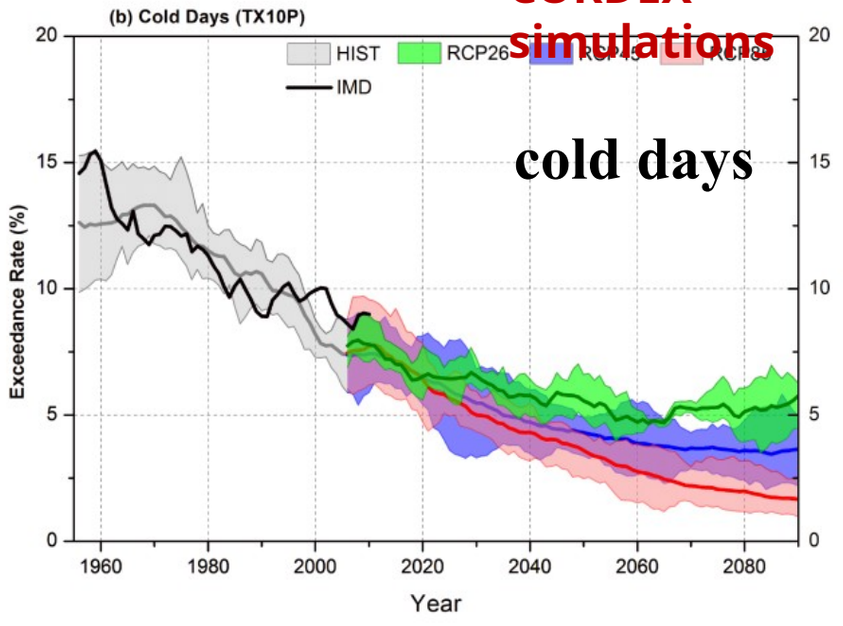
Near future (2040–2069) and far future (2070–2099) climate relative to 1976–2005 under RCP2.6, RCP4.5 and RCP8.5 emission scenarios. The estimates of all India averaged ensemble mean projected changes are shown in each panel

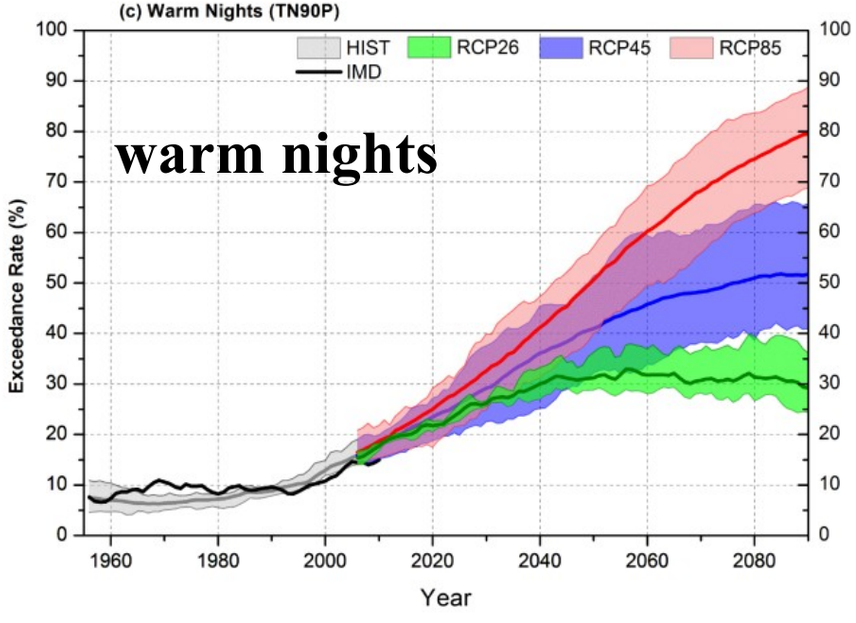
Projected cold & warm days/nights

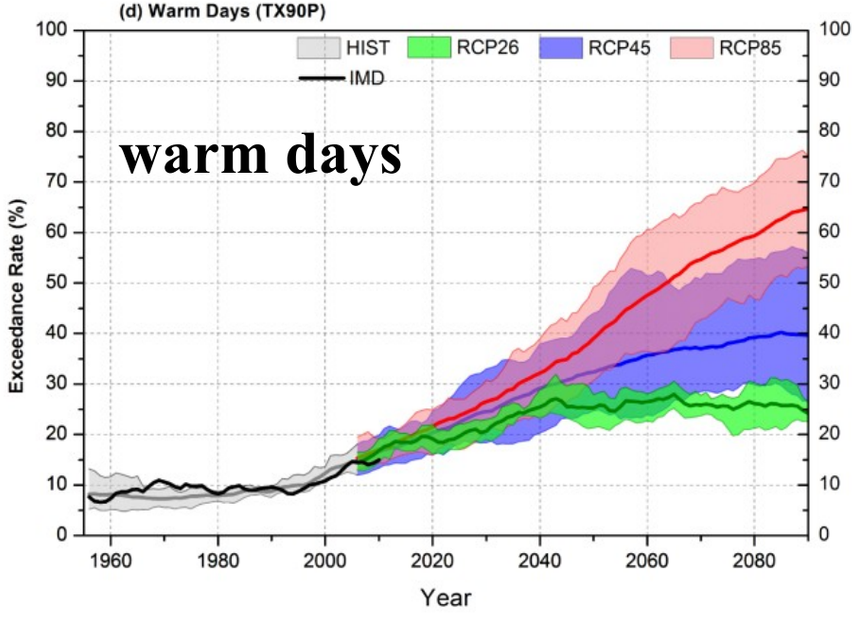
Inference from CORDEX simulations

India averages of temperature indices over land as simulated by the CORDEX South Asia multi-RCM ensemble



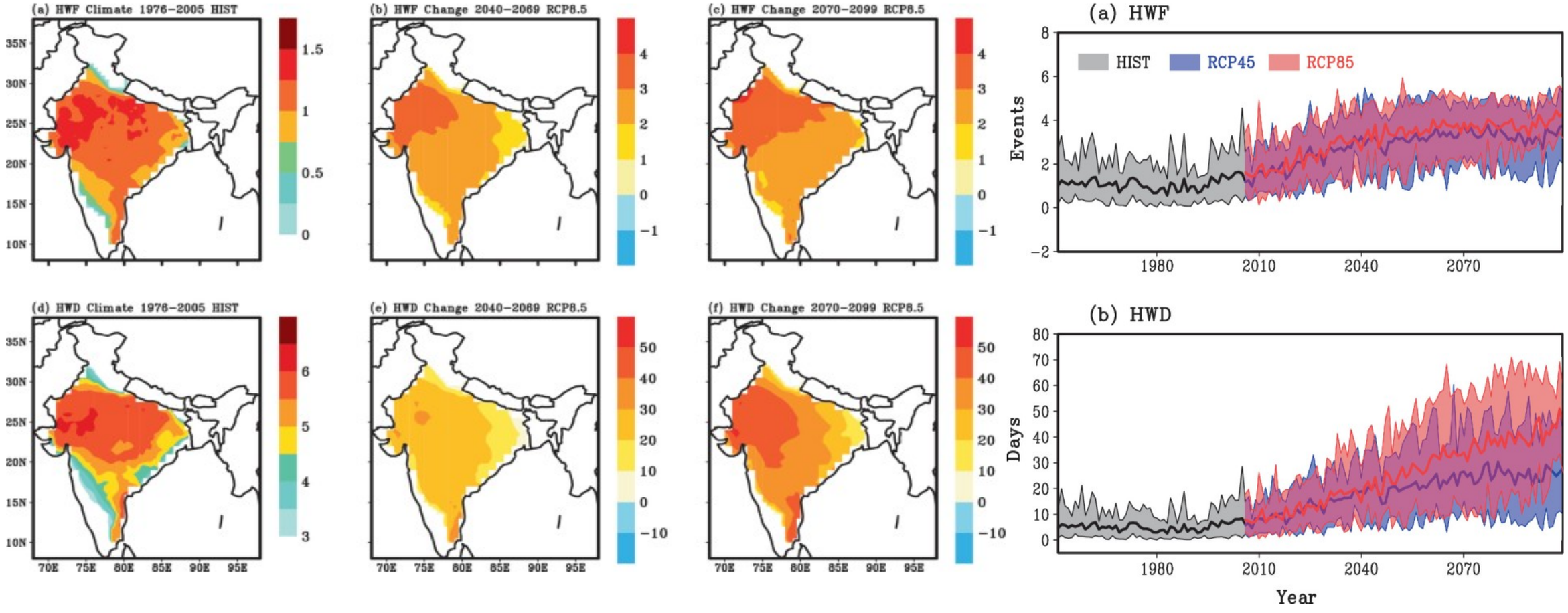






Heatwave frequency (HWF; events per season) and heatwave duration (HWD; days per season)

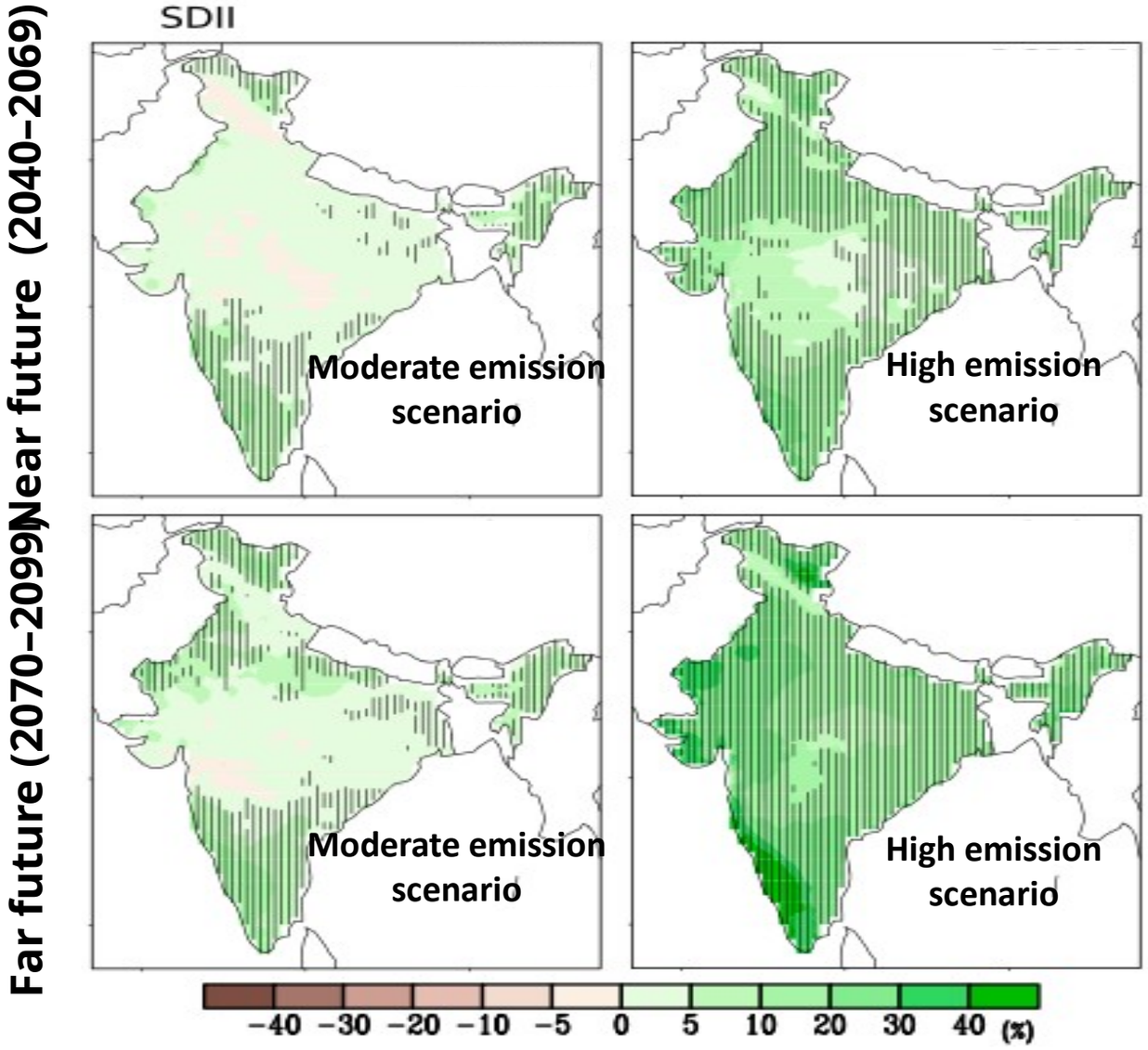
Inference from CORDEX simulations



CORDEX South Asia multi-RCM projections of the summer (April–June) based on the historical simulations during 1951–2005

Relative changes in the Daily Intensity Index (SDII) for Near Future and Far Future with respect to 1976–2005 reference period

Inference from CORDEX simulations

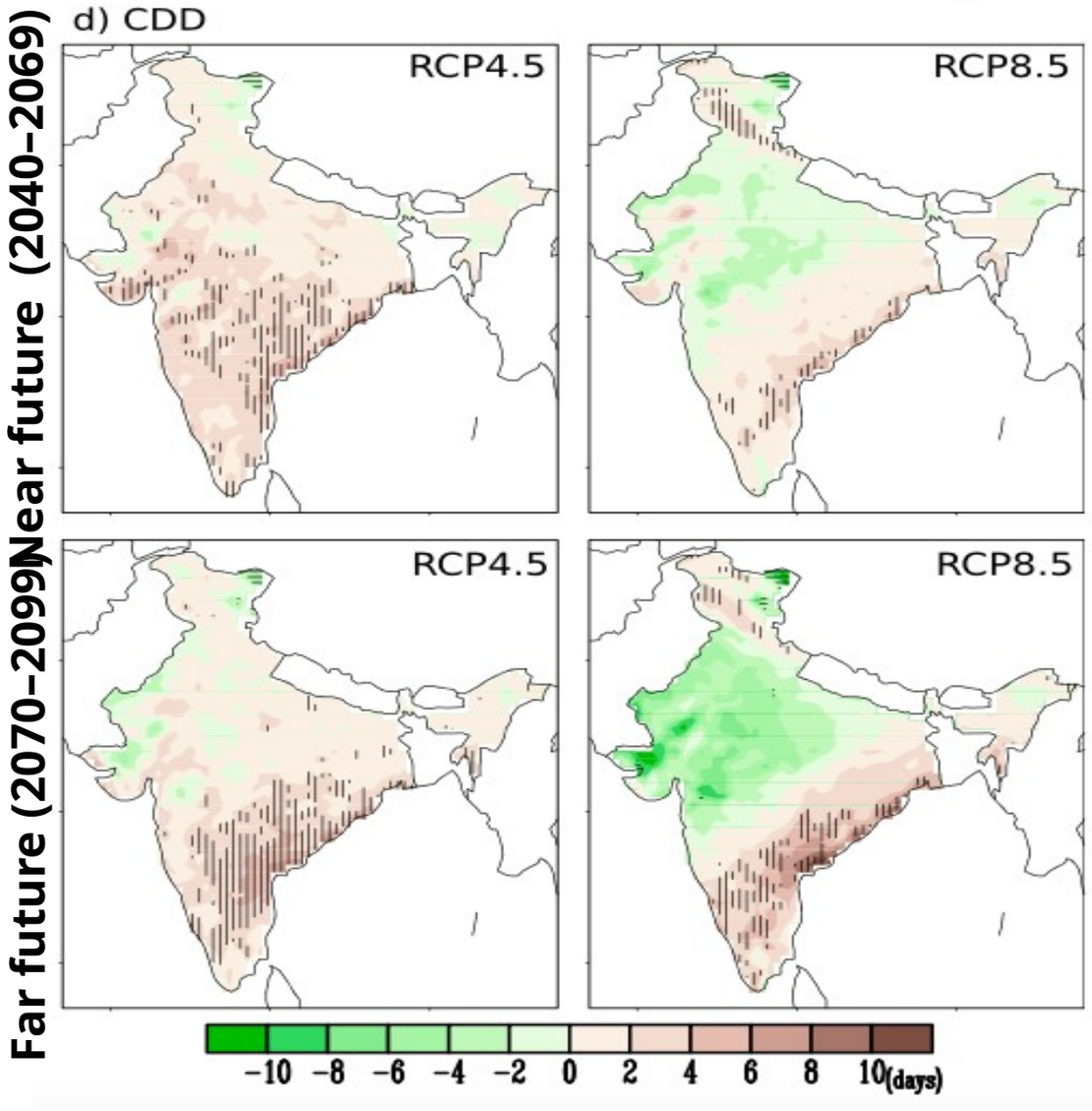


The value obtained by dividing the total rainfall in a season by the number of rainy days in a season. If the SDII is increasing, it can be assumed that it has rained more in a few days. It has to be assumed that conditions such as floods may increase Models estimate that rainfall intercity (SDII) may increase by 21% by the end of the 21st century

Sum of precipitation in wet days, and dividing that by the number of wet days

Relative changes in the Consecutive dry days (CDD) for Near Future and Far Future with respect to 1976–2005 reference period

Inference from CORDEX simulations

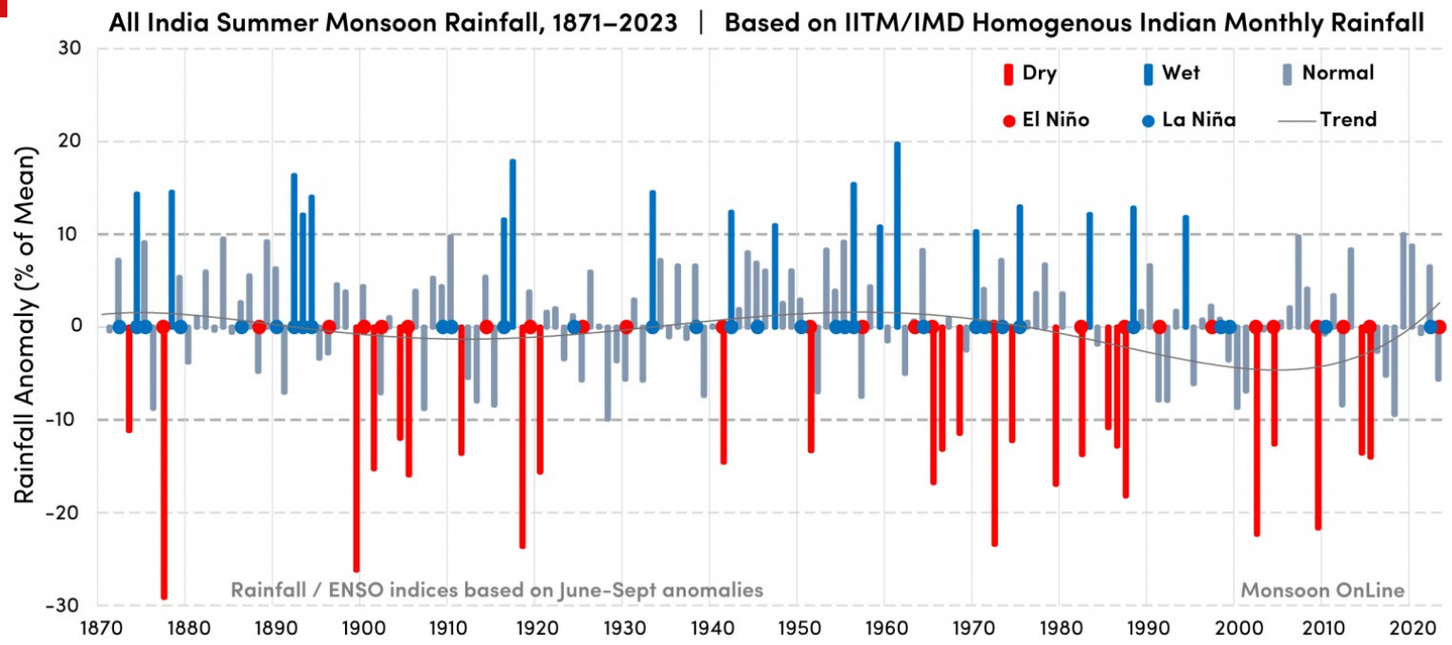


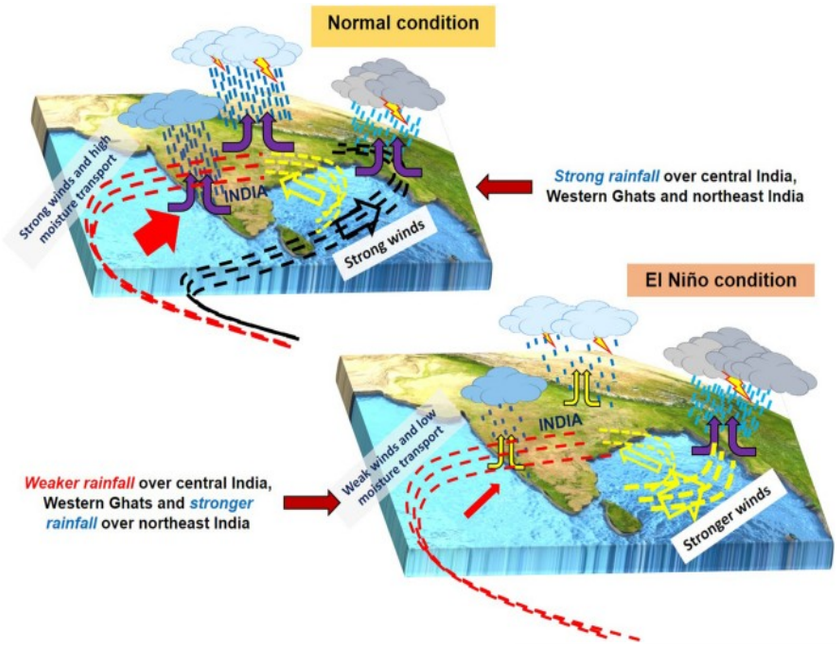
Consecutive dry days are used to describe the duration of precipitation extremes according to the daily precipitation.

CDD means the maximum number of consecutive days with precipitation less than a certain threshold

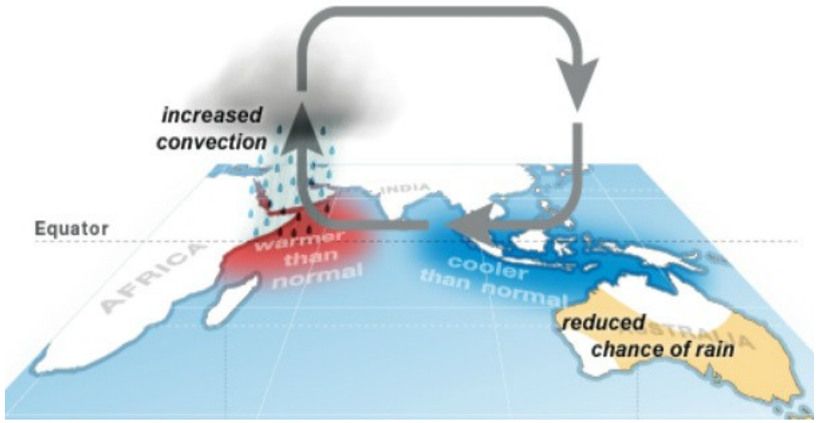
Regional downscaling & our alternative approach

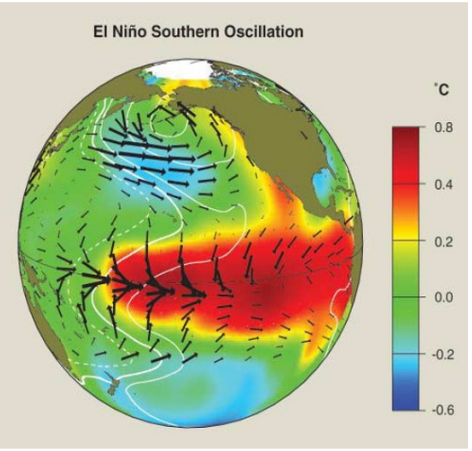
Monsoonal climate modulated by large-scale oceanic processes





The year to year variations in the seasonal (June – September) summer monsoon rains over India are influenced internal dynamics and external drivers



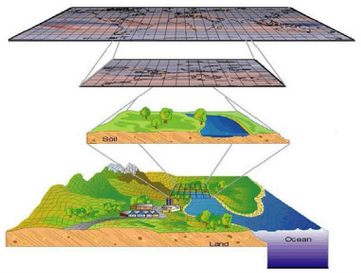


This implies the need for global models to better understand the monsoon

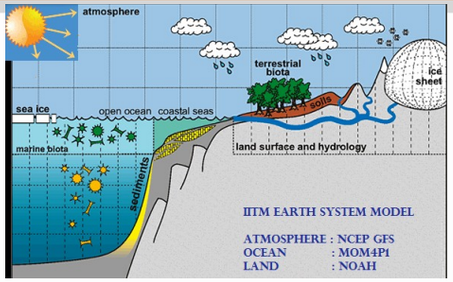
A different approach

Regional downscaling & our alternative approach

Regional Downscaling

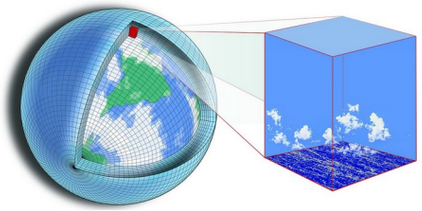


IITM-ESM with T62



High-resolution global Atmospheric model

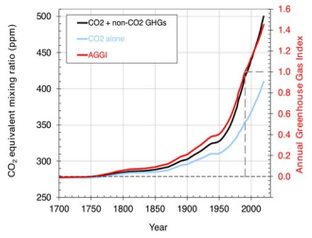
T574 ~ 27km



Global model

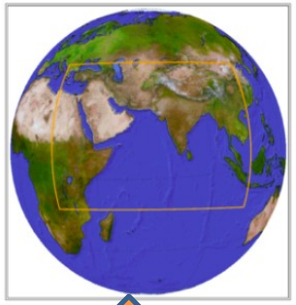
High-resolution global Atmospheric model

Global forcing's:
CO2/Aerosols/LULC



Global climate information
(in a 27km horizontal resolution)

Region 6: South Asia



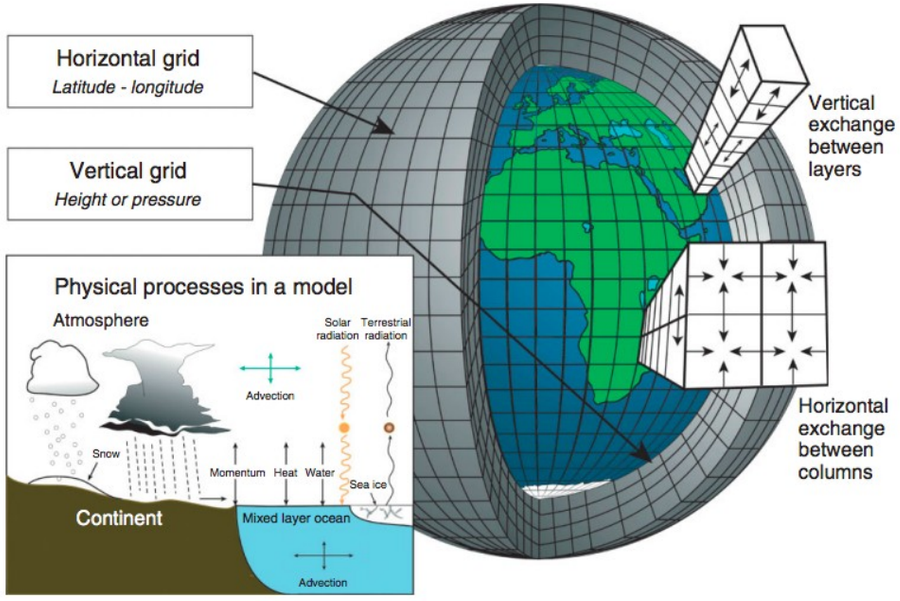
Which will be used for regional studies

WCRP CORDEX

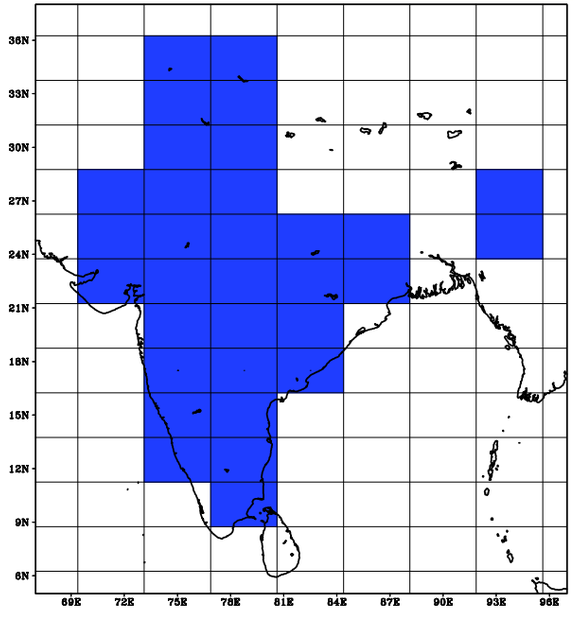
Coordinated Regional Climate Downscaling Experiment

Ongoing T574 simulation

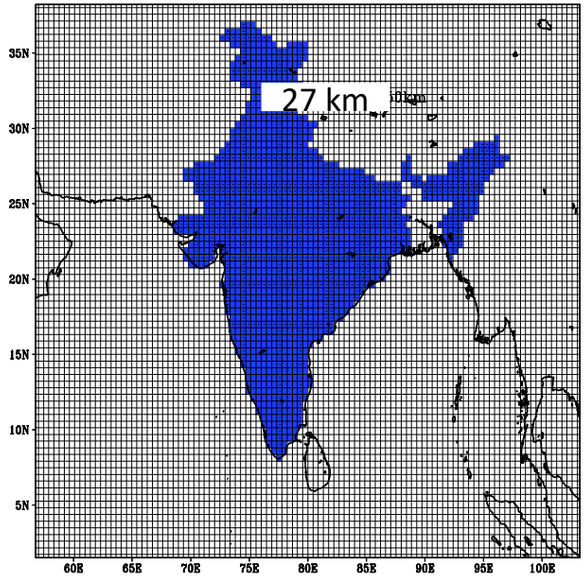
High resolution IITM-ESM AGCM (T574, ~27 Km)



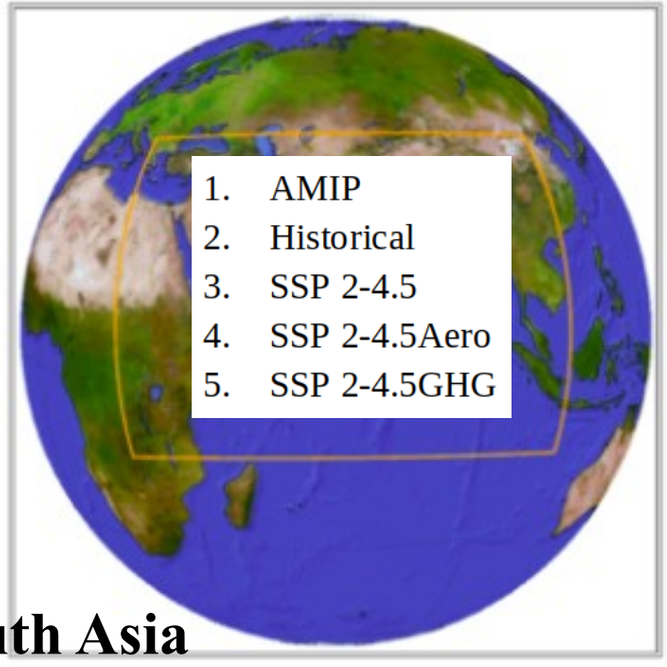
- **Dynamical downscaling of IITM-ESM v2 CMIP6 historical simulation (1951-2015) using the high-resolution (27 km grid) atmospheric component of IITM-ESM v2 is nearing completion.**
- **This is an important activity which CCCR initiated to produce high-resolution climate simulations towards various assessments for the country, along with addressing some scientific issues**



The normal Global model horizontal grid

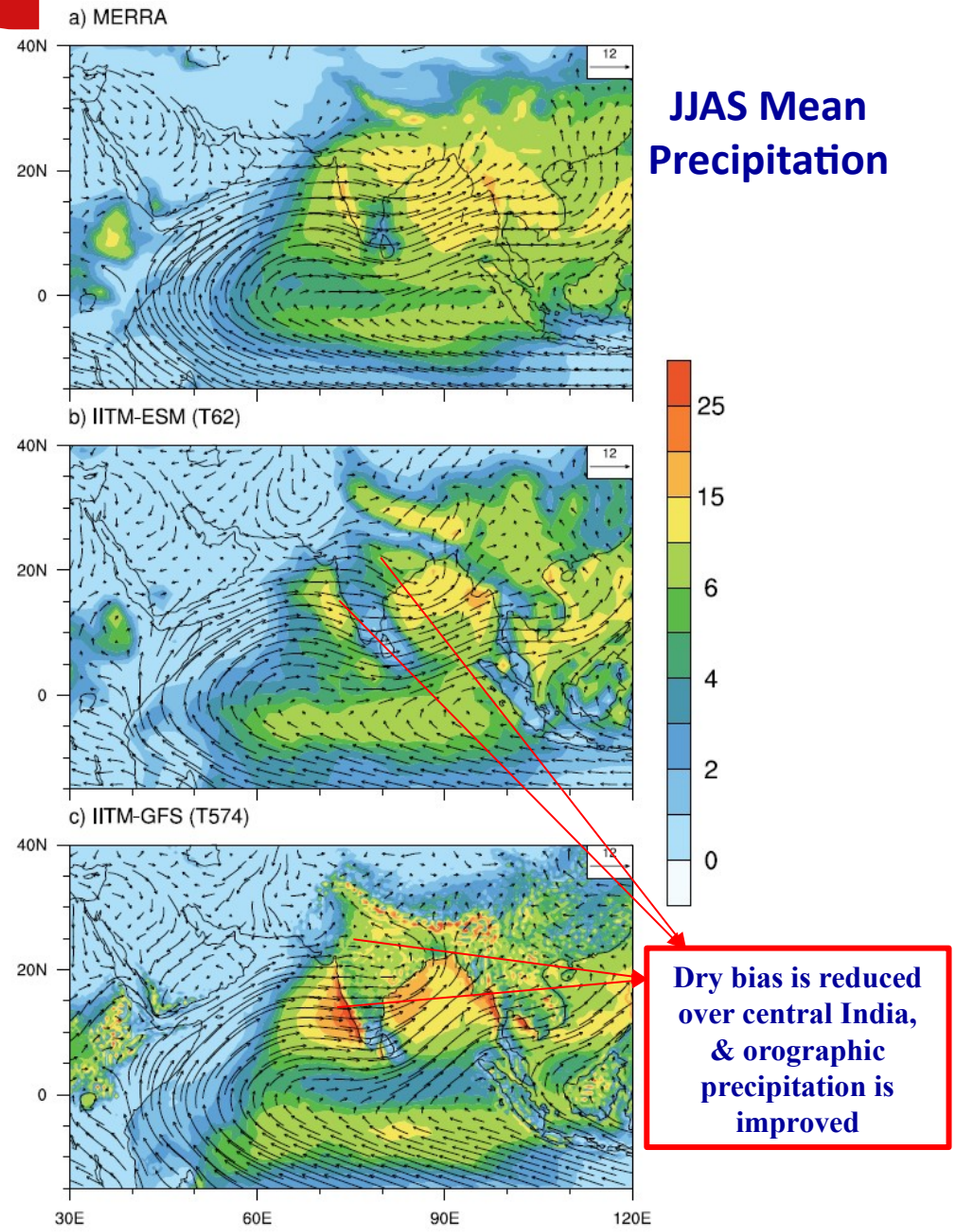


The high resolution global model/ regional model horizontal grid



South Asia

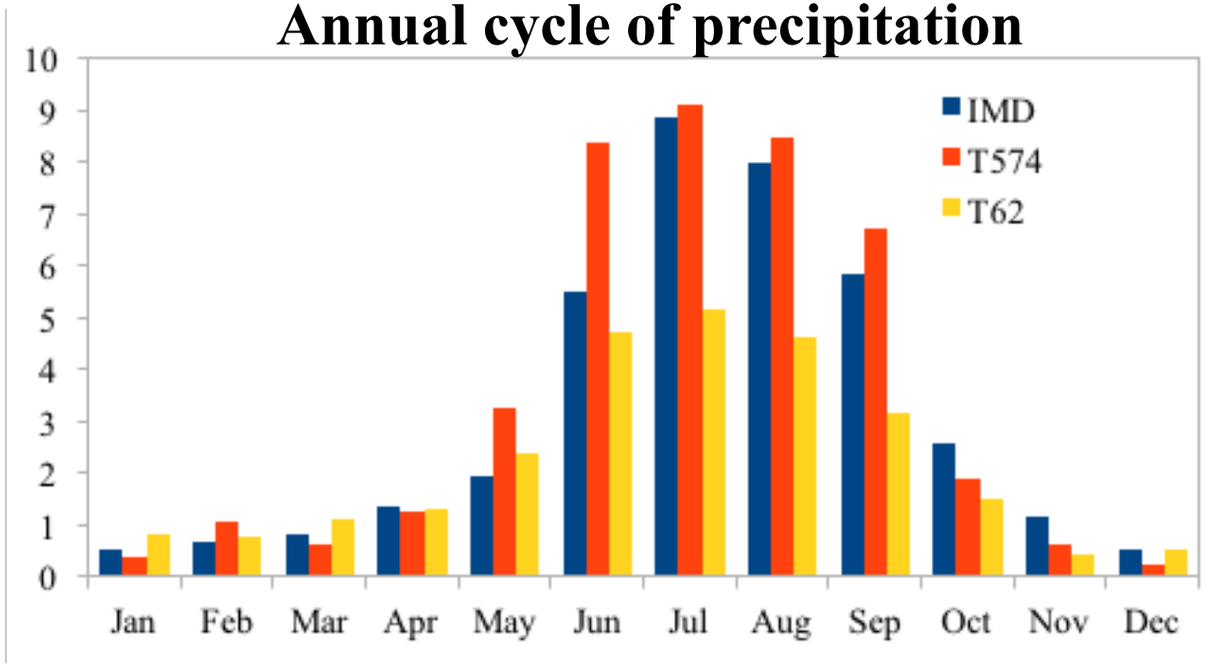
T574, ~27 Km simulation for regional studies



Clear improvement is visible in the simulated precipitation pattern in the high-resolution model

Narrow orographic precipitation over the western Ghats and precipitation over the monsoon trough is significantly improved in the 27km version

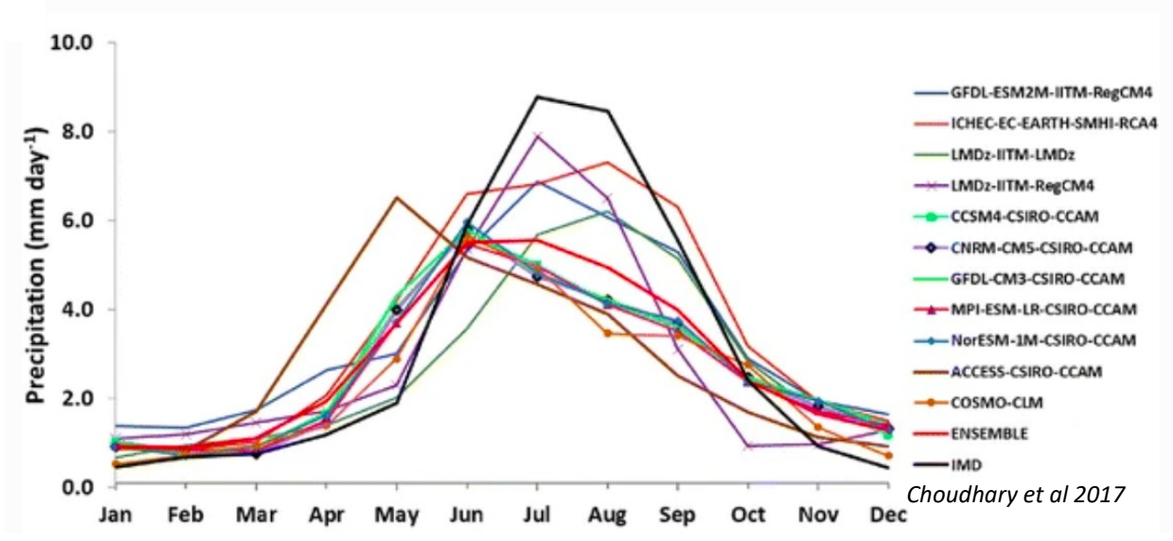
Annual cycle of precipitation



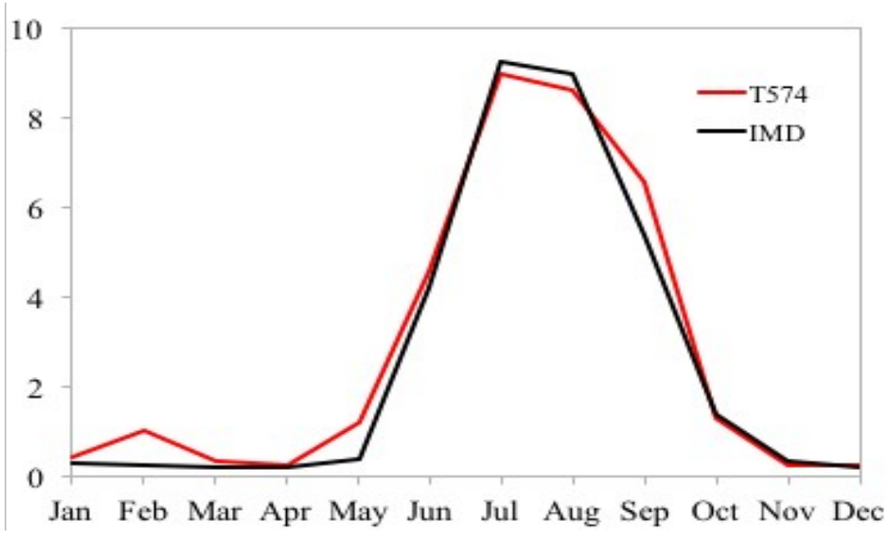
Is this simulation good ?

T574, ~27 Km simulation; mean features

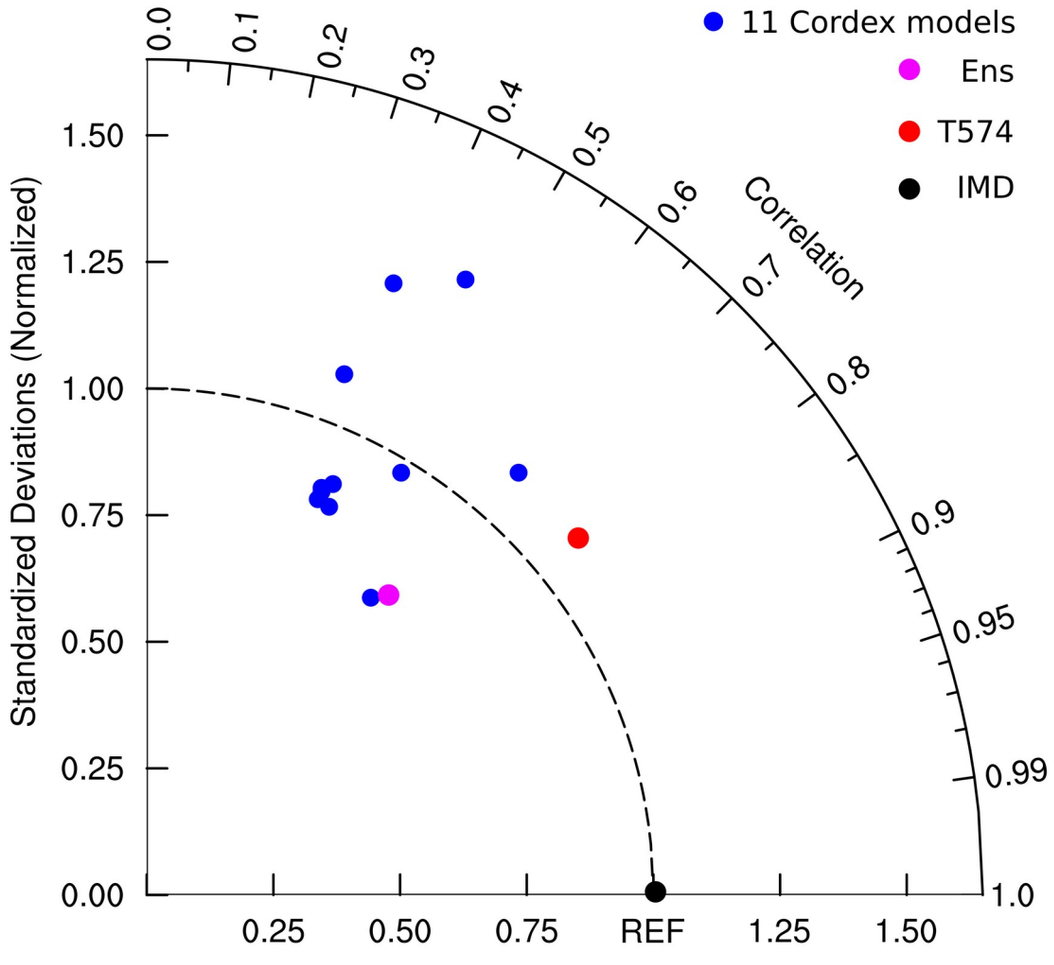
Annual cycle of precipitation; comparison with CORDEX models



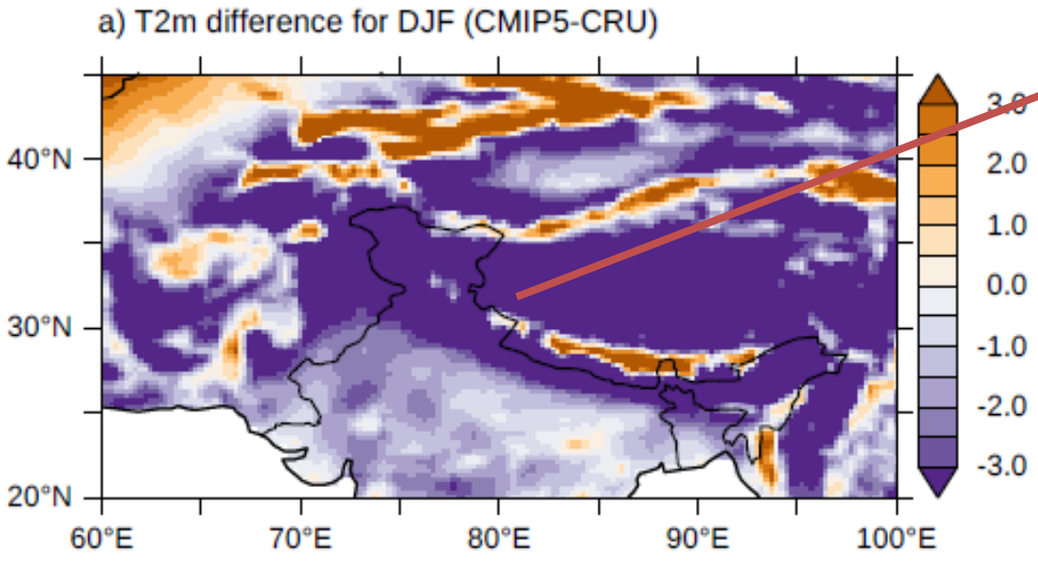
Choudhary et al 2017

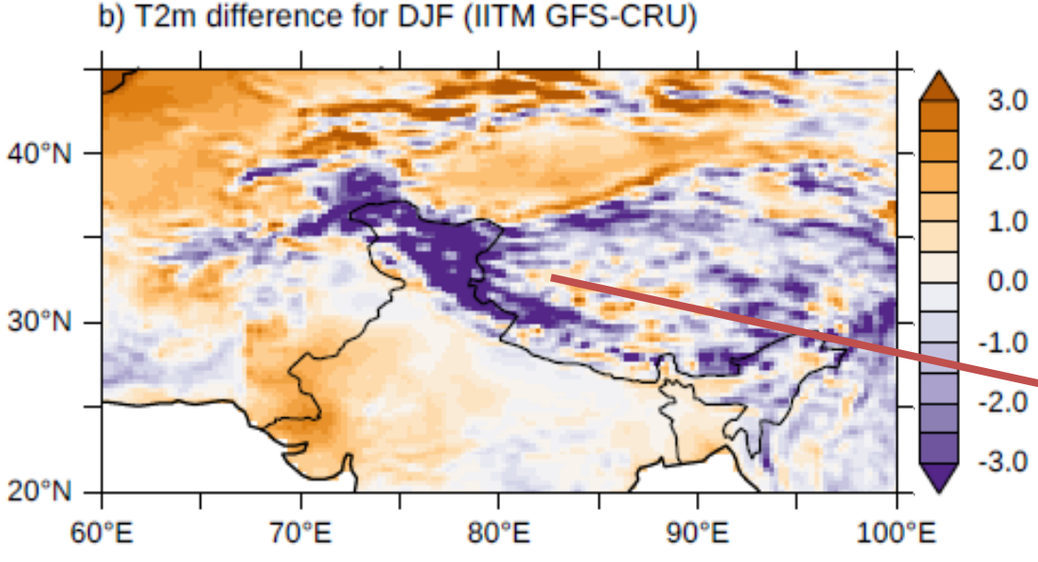


Taylor diagram; JJAS precipitation



Bias in simulated wintertime surface temperature…..

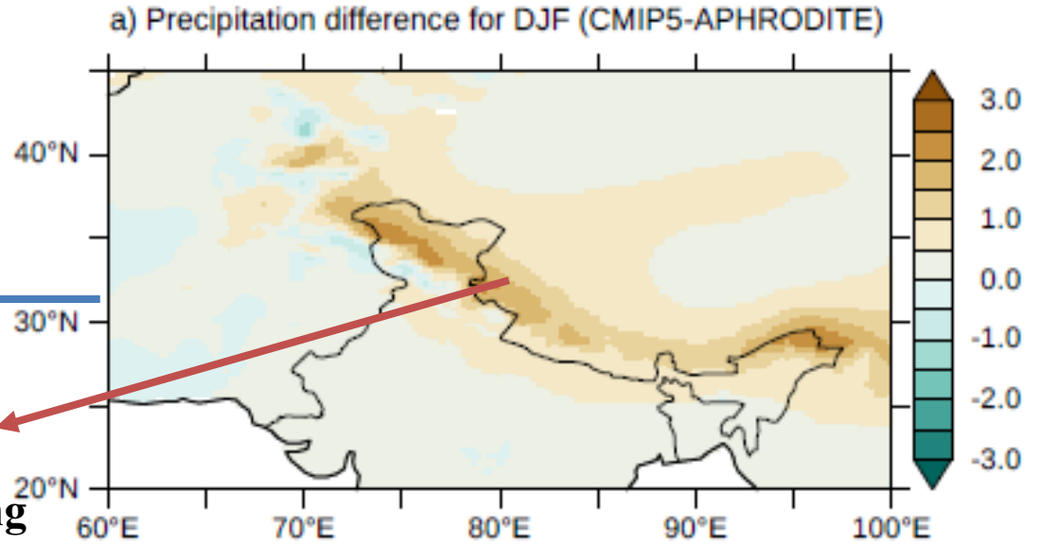


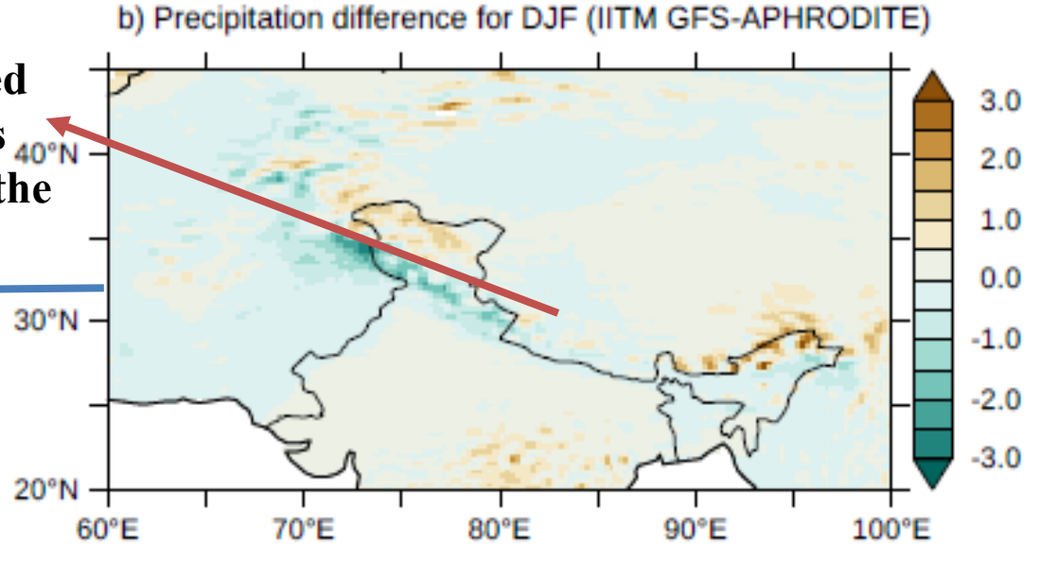


CMIP models shows large cold bias over Himalaya during wintertime

Cold bias is reduced considerably in the IITM-GFS

Bias in simulated wintertime precipitation….



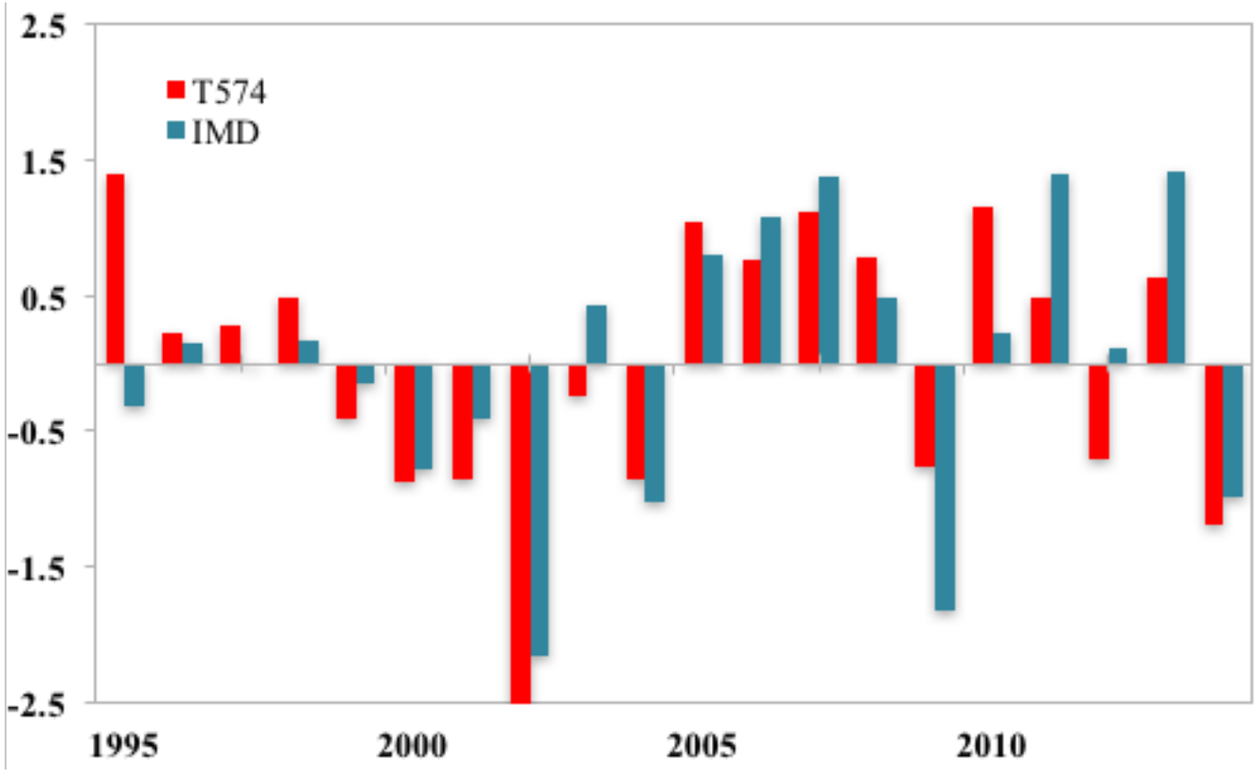


CMIP models shows large wet bias over Himalaya during winter months

Bias in simulated precipitation is relatively less in the IITM-GFS

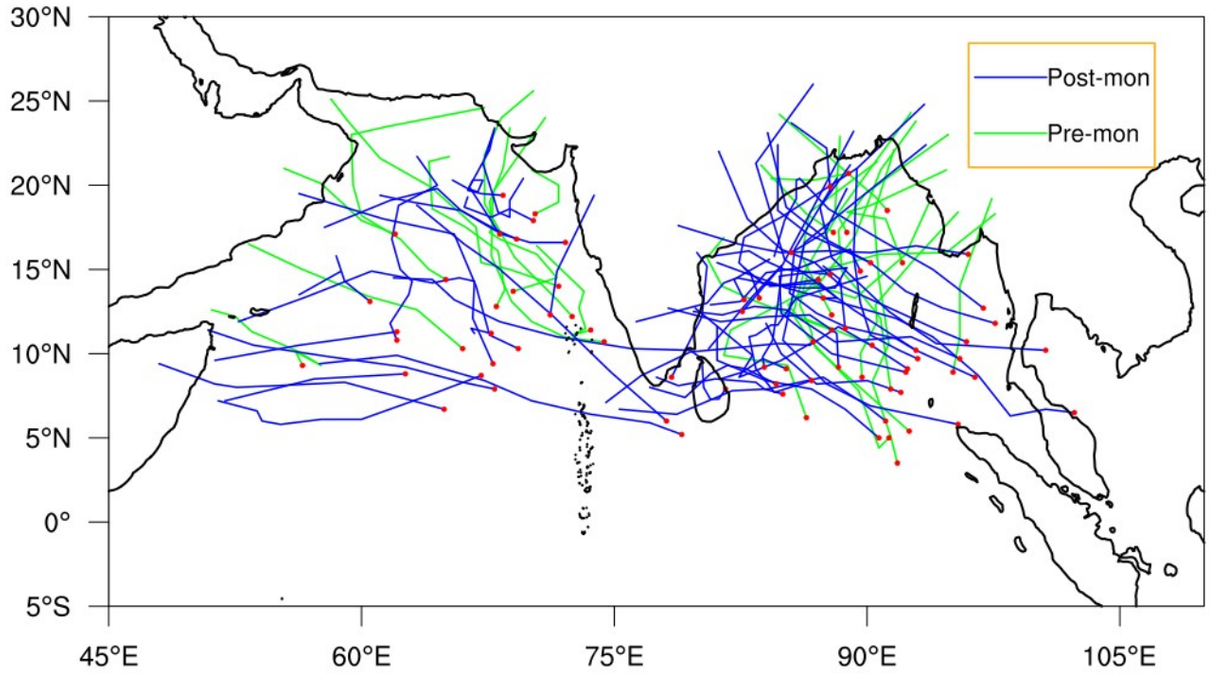
T574, ~27 Km simulation variabilities and features

Inter-annual variability of Indian summer monsoon



- Model is able to capture the annual fluctuations of Indian summer monsoon reasonably well

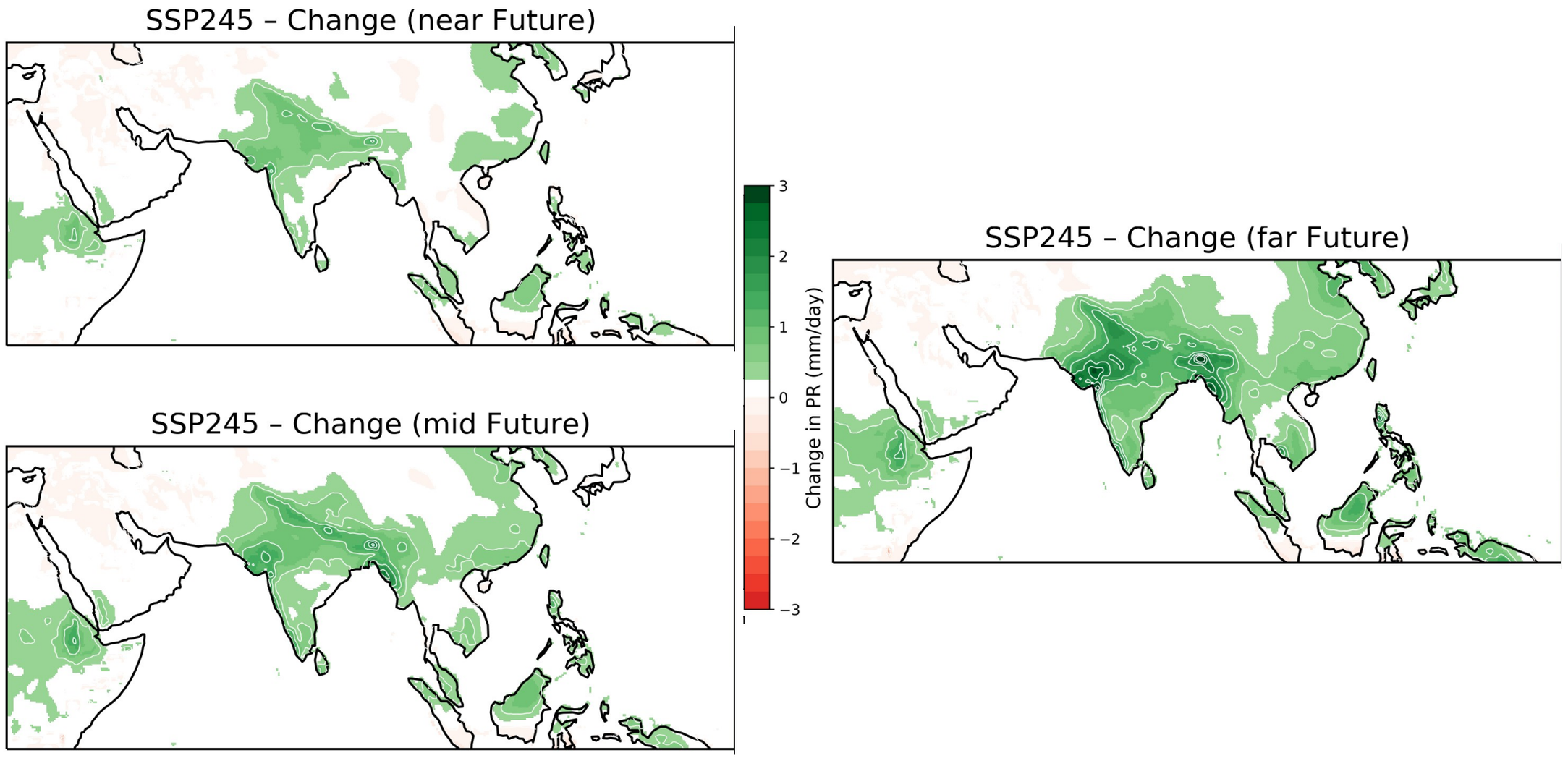
North Indian ocean Tropical cyclones



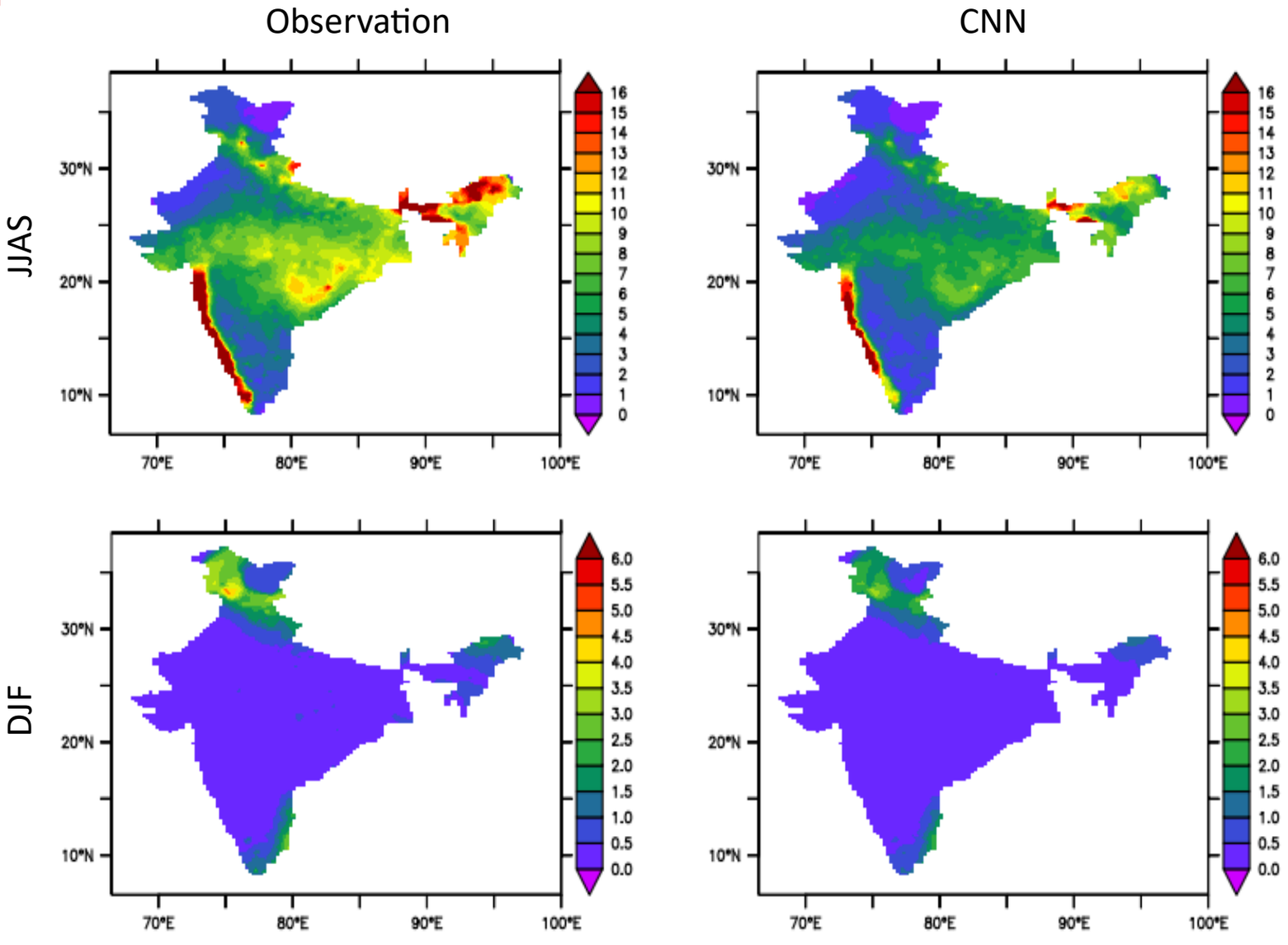
- 27 km model is able to capture the NIO - TC's

This simulation seems to be OK if we are making an assessment over a larger domain covering India and the adjoining regions

Change in seasonal (JJAS) mean rainfall with respect to present day



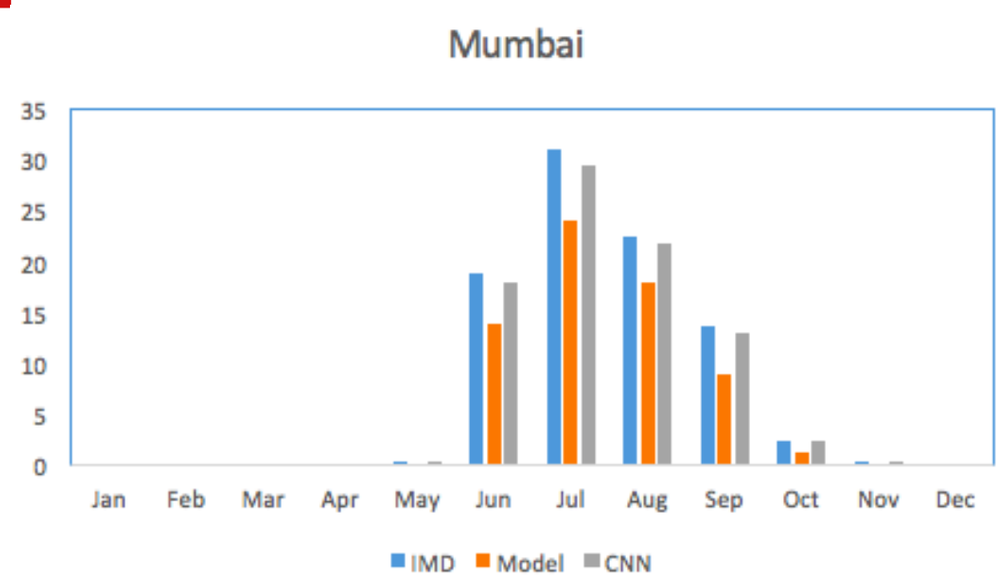
CNN-based bias-corrected Mean Summer and winter precipitation

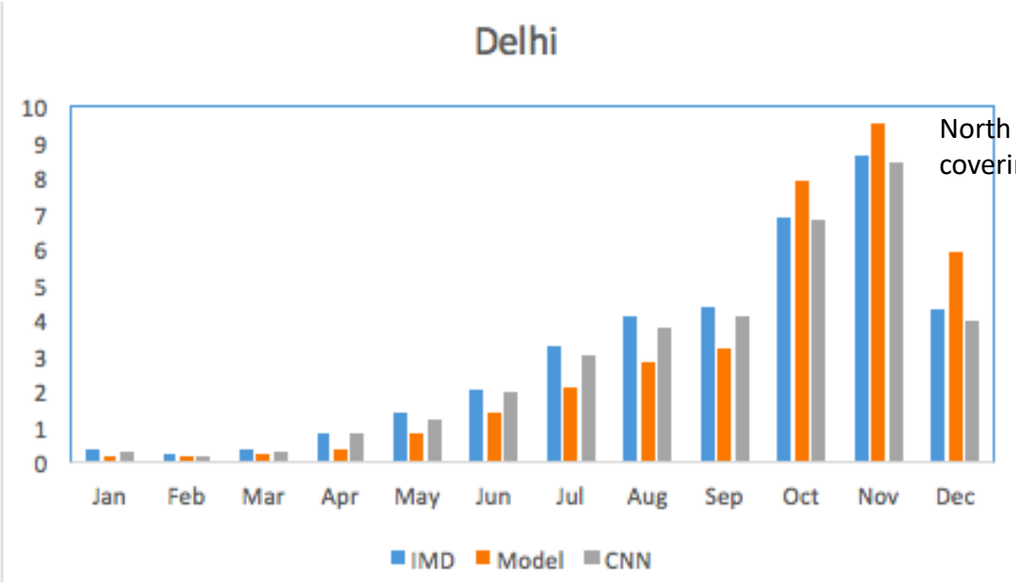


The mean summer monsoon pattern shows improvement, but it remains underestimated, particularly over central India. In contrast, the wintertime precipitation bias is better represented after bias correction.

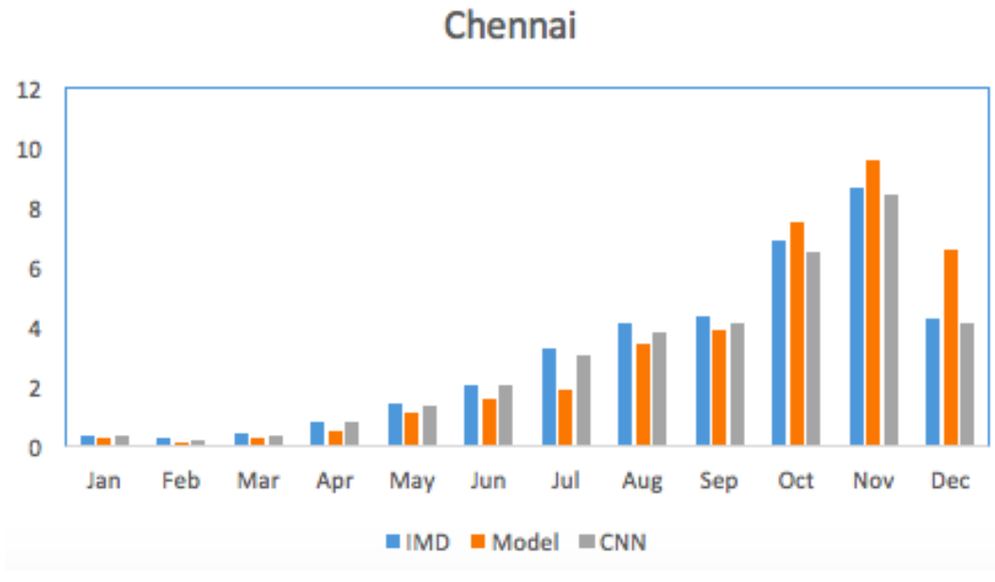
Preliminary results from CNN

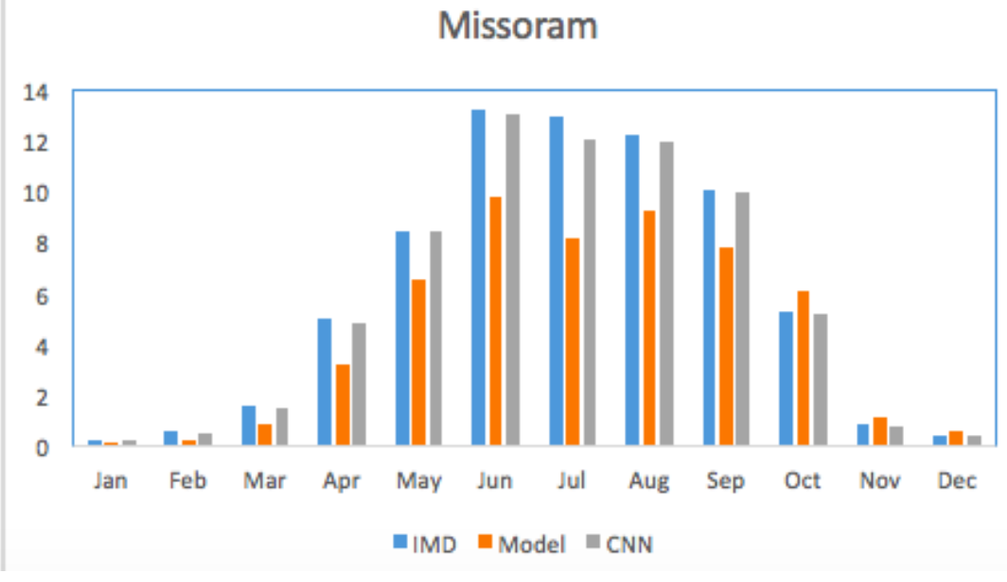
CNN-based bias-corrected local performance





North of Delhi covering Himalaya





Annual cycle of precipitation

Summary

- **CORDEX provides an important opportunity to carry out regional climate assessments, which in turn allows for the critical evaluation of climate models and ultimately enhances the quality of simulations with improved regional detail.**
- **The newly generated datasets, we will make it available to users through the CORDEX platform or through our IITM's internal server.**
- **If SAHF can frame a uniform analysis approaches, enabling the development of a consensus-based climate assessment that would mark a significant step forward in advancing regional climate understanding over this complex domain.**

Thank you