

# Meeting on RCMES Training

Centre for Climate Change Research (CCCR) Indian Institute of Tropical Meteorology (IITM), Pune, India 24 December 2018

Welcome to

Dr. Kyo Lee Co-investigator, Regional Climate Model Evaluation System (RCMES) team, NASA Jet Propulsion Laboratory (JPL), USA

&

## **IISER** Faculty & Students

Coordinated by

**CORDEX** South Asia Team members

CCCR, IITM



- CCCR-IITM focus on the development of new climate modelling capabilities in India and South Asia to address issues concerning the science of climate change.
- The latest version of the Earth System Model (IITM-ESMv2) developed at CCCR-IITM would be the first climate model from India contributing to the sixth phase of the Coupled Model Intercomparison Project (CMIP6) experiments for the Intergovernmental Panel for Climate Change (IPCC) sixth assessment report (AR6) to be released in 2021
  - Swapna, P., Krishnan, R., Sandeep, N., Prajeesh, A. G., Ayantika, D. C., Manmeet, S., et al. (2018). Long-term climate simulations using the IITM earth system model (IITMESMv2) with focus on the South Asian monsoon. Journal of Advances in Modeling Earth Systems, 10, 1127–1149. https://doi.org/10.1029/2017MS001262
- CCCR-IITM has also generated an ensemble of high resolution (50 km) dynamically downscaled CMIP5 future projections of regional climate over South Asia and Indian monsoon.
- CCCR-IITM leads the WCRP regional activity Coordinated Regional Climate Downscaling Experiment (CORDEX) over South Asia by coordinating the data archiving, management and dissemination activities
  - These CORDEX South Asia multi-model ensemble datasets are found useful for impact assessment studies and for quantifying uncertainties in the regional projections.



## **Coordinated Regional Climate Downscaling Experiment (CORDEX):**

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

# **CORDEX South Asia Co-ordination @ CCCR, IITM, Pune**



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



- Development of multi-model ensemble projections of high resolution (50km) regional climate change scenarios for South Asia
  - Generation of regional climate projections at CCCR-IITM
    - Downscaled 6 CMIP5 AOG CMs using ICTP RegCM4 regional climate model for historical period 1951-2005, and for two future scenarios (RCP4.5 and RCP8.5) for the period 2006-2099

http://cccr.tropmet.res.in/home/cordexsa\_datasets.jsp

- Co-ordination with partner institutions for multi-model ensemble projections SMHI, CSC, IAES, CSIRO, ICTP...
- Development of an Earth System Grid Federation (ESGF) data node at CCCR-IITM for CORDEX South Asia
  - Archival, Management, Dissemination of CORDEX South Asia data
  - Published ~2 TB of IITM-RegCM4 outputs on CCCR-IITM ESGF data node after quality assurance as per CORDEX archival specifications.
- Summary of 17 CORDEX South Asia datasets available on ESGF (~20 TB)
  - IITM-RegCM4: Hist (6); RCP8.5 (6); RCP4.5 (6)
  - SMHI-RCA4 : Hist (10); RCP8.5 (10); RCP4.5 (10); RCP2.6 (5)
  - CSC-REMO2009: Hist (1); RCP8.5 (1); RCP4.5 (1); RCP2.6 (1)
- CCCR-IITM developing a global high resolution (27km) atmospheric version of the IITM Earth System Model



#### ESGF Data Node @ CCCR-IITM

http://cccr.tropmet.res.in/home/esgf\_node.jsp



• CORDEX South Asia Point of Contact (PoC): Dr. R. Krishnan, Executive Director, CCCR, IITM

• CORDEX Science Advisory Team (SAT) member: Dr. J. Sanjay, Scientist, CCCR, IITM



#### http://cccr.tropmet.res.in/home/workshop/oct2012/ presentations/CORDEX-South%20Asia-Ramirez.pdf



Building Model Evaluation And Decision Support Capacity For CORDEX

Paul Ramirez, Jinwon Kim, Duane Waliser, Chris Mattmann, Cameron Goodale, Andrew Hart, Paul Zimdars, Dan Crichton

#### http://cccr.tropmet.res.in/home/workshop/oct2012/ presentations/JKIM\_JPL\_CORDEXSA.pdf

#### Uncertainties in Climate Projections: Evaluating RCM Skills

J. Kim<sup>1</sup>, D.E. Waliser<sup>1,2</sup>, C. Mattmann<sup>2</sup>, C. Goodale<sup>2</sup>, A. Hart<sup>2</sup>, P. Ramirez<sup>2</sup>, D. Crichton<sup>2</sup> in collaboration with :

> C. Jones and G. Nikulin Sveriges Meteorologiska och Hydrologiskalnstitut

B. Hewitson, C. Jack, C. Lennard, A. Farver University of Cape Town

<sup>1</sup>Joint Institute for Regional Earth System Science and Engineering, UCLA <sup>2</sup>Jet Propulsion Laboratory/California Institute of Technology

CORDEX-South Asia Training Workshop, 17-20 October 2012, Pune, India

#### The 2<sup>nd</sup> WCRP CORDEX Science and Training Workshop

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ICIMOD

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#### http://cccr.tropmet.res.in/home/workshop/cordex2013/web/presentations.jsp 27

#### Investigation of Model Precipitation Biases over the Indian Subcontinent in the CORDEX South Asia Hindcast

August 2013, ICIMOD, Kathmandu, Nepal

J. Kim<sup>1</sup>, D. Waliser<sup>2</sup>, C. Mattmann<sup>2</sup>, P. Ramirez<sup>2</sup>, H. Lee<sup>2</sup>, P. Loikith<sup>2</sup>, M. Bounstani<sup>2</sup>, C. Goodale<sup>2</sup>, A. Hart<sup>2</sup>, J. Sanjay<sup>3</sup>, M.V.S. Rama Rao<sup>3</sup>, R. Krishnan<sup>3</sup>, M. Mujumdar<sup>3</sup>, S. Ingle<sup>3</sup>

> <sup>1</sup>University of California Los Angeles <sup>2</sup>Jet Propulsion Laboratory/NASA

<sup>3</sup>Center for Climate Change Research, Indian Institute of Tropical Meteorology

Demonstration of Regional Climate Model Evaluation System (RCMES) for the CORDEX South Asia Domain

P. Ramirez<sup>1</sup>, D. Waliser<sup>1</sup>, C. Mattmann<sup>1</sup>, J. Kim<sup>2</sup>, H. Lee<sup>1</sup>, P. Loikith<sup>1</sup>, M. Bounstani<sup>1</sup>, C. Goodale<sup>1</sup>, A. Hart<sup>1</sup>, M. Joyce<sup>1</sup>, S. Khudikyan<sup>1</sup>, J. Sanjay<sup>3</sup>, M.V.S. Rama Rao<sup>3</sup>, R. Krishnan<sup>3</sup>, M. Mujumdar<sup>3</sup>, S. Ingle<sup>3</sup>

<sup>1</sup>Jet Propulsion Laboratory/NASA

<sup>2</sup>University of California Los Angeles

<sup>3</sup>Center for Climate Change Research, Indian Institute of Tropical Meteorology



#### CORDEX South Asia data (50km) is available on the CCCR-IITM Climate Data Portal (non-ESGF):



#### Thanks to Grigory Nikulin, Milind Mujumdar, Sandip Ingle

#### 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 Centre for Climate Change Research High resolution climate simulation: **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 Torbus Data hord Salara Jorkes Archus Data hord Salarah Salara Name Darker <thDarker</th> <thDarker</th> <thDarker</th> Ann Boffer Borles Soffer Market Soffer Soffe ----Historical (1950-2005) Experiment Rain Surface Surface Surface Sea-level Surface Surface Surface Downward Name fall Air Air Temp. Air Pressure Specific Zonal Meridonial Shortwave Temp. (psl) Humidity Wind Wind (vas) Radiation (pr) Temp Maximum Minimum (tas) (tasmax) (huss) (uas) (rsds) (tasmin) RCA4(ICHEC) 1 1 1 1 1 1 1 1 1 RegCM4(GFDL) 1 1 1 1 1 1 1 1 RegCM4(LMDZ) 1 1 1 1 1 1 1 1 1 CCLM4(MPI) 1 1 -----1 -1 1 LMDZ4(IPSL) 1 1 1 1 1 1 **REMO2009** 1 1 1 1 1 1 1 (MPI) CCAM(ACCESS) 1 1 1 1 CCAM(CNRM) 1 1 1 1 CCAM(CCSM) 1 1 -----1 CCAM(GFDL) 1 1 \_\_\_\_\_ -1 1

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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)		ACCESS1.0		
CCAM(CNRM)	and Industrial Research	CNRM-CM5		
CCAM(CCSM)	Organisation (CSIRO),	CCSM4	CSIRO Marine and Atmospheric Research.	
CCAM(GFDL)	Conformal-Cubic Atmospheric Model	GFDL-CM3	Melbourne, Australia	
CCAM(MPI)	(CCAM; McGregor and	MPI-ESM-LR		
CCAM(BCCR)	Dix, 2001)	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

#### http://wcrp.ipsl.jussieu.fr/cordex2013/posters/poster\_presentations\_all.pdf



Two different cumulus schemes in the NCAR ARW RCM (E4 & E5) also brings out the large sensitivity of the physics to the simulated annu

However the ensemble mean (EM) of these 6 RCMs show relatively lesser dry bias over Indian region (Fig. 3h) than the CMIP5 ensemble mean (Fig. 21). INTERNATIONAL JOURNAL OF CLIMATOLOGY Int. J. Climatol. 35: 4557–4573 (2015)

#### Uncertainties in estimating spatial and interannual variations in precipitation climatology in the India–Tibet region from multiple gridded precipitation datasets

J. Kim,<sup>a</sup>\* J. Sanjay,<sup>b</sup> C. Mattmann,<sup>c</sup> M. Boustani,<sup>c</sup> M. V. S. Ramarao,<sup>b</sup> R. Krishnan<sup>b</sup> and D. Waliser<sup>a,c</sup>

<sup>a</sup> Atmospheric and Oceanic Science, University of California, Los Angeles, CA, USA <sup>b</sup> Climate and Global Modelling Division, Indian Institute of Tropical Meteorology, Pune, Maharashtra, India <sup>c</sup> Instrument and Science Data Systems Section, Jel Propulsion Laboratory, Pasadena, CA, USA

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(Asia)

GPCC

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more suited to end-users appears to be

more useful for understanding local monthly precipitation climate in regions that have complex topography such as Nepal, Bangladesh, Bhutan & Myanmar. Acknowledgements. we generally acknowledge the modeling

(BLH) Bhutan (BTN

(MNR)

APHROI

IMD (Inc

#### Signal-to-noise ratio 1979-2007



Enal: sonjay@tropmet.res.in

aimed towards bringing out additional

value of regional climate information

required for impact assessments and

value gained via dynamical downscaling.

decision support activities and the





## http://cccr.tropmet.res.in/home/esgf\_node.jsp

Latest Updates .(HMA)" during 8-12 Oct		ober 2018 at CCCR-IITN	M, Pune *** *** "C	limate Change over India" - An l	nterim Report ***	*** Aer	osols 'shrinking' India's monsoon. ***		
A	About CCCR	Research -	Publications	Data & Tools <del>-</del>	News & Events -	Reports -	People	¥.	
	ESCE Question		CCCR-II	TM ESGF Data Node	Dat	a Publisl	hing 8	& Maintenance:	Sandip Ingle
ESGF Overview CORDEX-South Asia Data			The Ea archive	arth System Grid Fe of climate data we	ederation (ESGF) mair orld-wide. The ESGF	tains a global Data Node at	system of CCCR-IIT	federated data centers that M is focused on supporting	allow access to the largest CCCR-IITM climate model
6 <del>.</del>	CORDEX-South As	ia Data on ESGF	dataset	ts (CORDEX-South	Asia and CMIP6). This	Data node is p	presently p	peered with SMHI-NSC ESGF	Index Node
87			The CC	CCR-IITM site does	not provide the OpenIE	), Please go to	the SMHI	NSC ESGF Index Node to re	equest an OpenID.
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	Earth System Grid								

NEX-GDDP India

The quality checked CORDEX-South Asia Data are published on the CCCR-IITM Earth System Grid Federation (ESGF) Data Node

The ESGF maintains a global system of federated data centers that allow access to the largest archive of climate data world-wide



http://cccr.tropmet.res.in/home/cordexsa\_datasets.jsp

CORDEX South Asia RCM	RCM Description	Contributing CORDEX Modeling Center	Driving CMIP5 AOGCM (see details at https://verc.enes.org/data/enes- model-data/cmip5/resolution)	Contributing CMIP5 Modeling Center
IITM- RegCM4 (6 ensemble members)	The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al., 2012)	Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India	CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis (CCCma), Canada
			NOAA-GFDL-GFDL- ESM2M	National Oceanic and Atmospheric Administration (NOAA), Geophysical Fluid Dynamics Laboratory (GFDL), USA
			CNRM-CM5	Centre National de Recherches Me'te'orologiques (CNRM), France
			MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M), Germany
			IPSL-CM5A-LR	Institut Pierre-Simon Laplace (IPSL), France
			CSIRO-Mk3.6	Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia
	Rossby Centre regional atmospheric model version 4 (RCA4; Samuelsson et al., 2011)	Rosssy Centre, Swedish Meteorological and Hydrological Institute (SMHI), Sweden	ICHEC-EC-EARTH	Irish Centre for High-End Computing (ICHEC), European Consortium (EC)
SMHI-RCA4			MIROC-MIROC5	Model for Interdisciplinary Research On Climate (MIROC), Japan Agency for Marine-Earth Sci. & Tech., Japan
(6 ensemble members)			NOAA-GFDL-GFDL- ESM2M	NOAA, GFDL, USA
			CNRM-CM5	CNRM, France
			MPI-ESM-LR	MPI-M, Germany
			IPSL-CM5A-MR	IPSL, France
MPI-CSC- REMO2009 (1 ensemble member)	MPI Regional model 2009 (REMO2009; Teichmann et al., 2013)	Climate Service Center (CSC), Germany	MPI-ESM-LR	MPI-M, Germany



This is a trial version of a Web Interface based on python under development by CCCR-IITM for users to explore and remotely access subsets (some variables in a particular region for a particular time slice) of authorised datasets available on ESGF in the framework of CORDEX South Asia simulations, and download the selected subset in CSV, Text or NetCDF data formats.

#### **Data Extraction Tool Architecture**



This data extraction tool needs access to ESGF with an Openid and CORDEX project registration.

Users having ESGF Openid, click here

New users can create ESGF account following instructions given in SMHI Index Node

CORDEX data on a grid with rotated poles be rotated back?) [please click here]

CORDEX also requires a Group Registration (see the detailed instructions on SMHI Website) to access CORDEX data.

ESGF-CoG FAQ on guestions concerning data, e.g. data format, data processing, CMIP and CORDEX data (e.g., How can

#### Tutorial

Data Extraction Tools

Climate Scenarios







Slide 4







This is a trial version of a Web Interface based on python under development by CCCR-IITM for users to explore and remotely access subsets (some variables in a particular region for a particular time slice) of authorised datasets available on ESGF in the framework of CORDEX South Asia simulations, and download the selected subset in CSV, Text or NetCDF data formats.

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# Downscaled climate change projections for the Hindu Kush Himalayan region using CORDEX South Asia regional climate models

Jayanarayanan SANJAY<sup>a,\*</sup>, Raghavan KRISHNAN<sup>a</sup>, Arun Bhakta SHRESTHA<sup>b</sup>, Rupak RAJBHANDARI<sup>c</sup>, REN Guo-Yu<sup>d</sup>

<sup>a</sup> Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune 411008, India

<sup>b</sup> International Centre for Integrated Mountain Development, Kathmandu 3226, Nepal

<sup>c</sup> Department of Meteorology, Tri-Chandra Campus, Tribhuvan University, Kathmandu 3226, Nepal

<sup>d</sup> Laboratory for Climate Studies, National Climate Center, China Meteorological Administration, Beijing 100081, China



Available online at www.sciencedirect.com





Advances in Climate Change Research 8 (2017) 185-198

Fig. 1. IITM-RegCM4 RCM elevation (km) over the region covering HKH, with parts of the hilly sub-regions within HKH defined by grid cells in each box above 2500 m a.s.l. (non-greyscale): northwest Himalaya and Karakoram (HKH1); central Himalaya (HKH2); southeast Himalaya and Tibetan Plateau (HKH3). The HKH boundary is shown with dashed line.

 The new information available from CORDEX South Asia are found useful for contributing to the Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP; http://www.icimod.org/himap)

CORDEX South Asia RCM	outh RCM Description Modeling Center		Driving CMIP5 GCM (https://verc.enes.org/da ta/enes-model- data/cmip5/resolution)	Contributing CMIP5 Modeling Center
		Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India	CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis (CCCma), Canada
	The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al. 2012)		NOAA-GFDL-GFDL-ESM2M	National Oceanic and Atmospheric Administration , Geophysical Fluid Dynamics Laboratory (GFDL), USA
IITM-RegCM4			CNRM-CM5	Centre National de Recherches Me´te´orologiques (CNRM), France
(six ensemble members)			MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M), Germany
			IPSL-CM5A-LR	Institut Pierre-Simon Laplace (IPSL), France
			CSIRO-Mk3.6	Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia
	Rossby Centre		ICHEC-EC-EARTH	Irish Centre for High-End Computing (ICHEC), European Consortium (EC)
SMHI-RCA4 (six ensemble	regional atmospheric model version 4	Rosssy Centre, Swedish Meteorological and	MIROC-MIROC5	Model for Interdisciplinary Research On Climate (MIROC), Japan Agency for Marine-Earth Sci. & Tech., Japan
members)	(RCA4;	(SMHI) Sweden	NOAA-GFDL-GFDL-ESM2M	NOAA, GFDL, USA
	Samuelsson et al.	(Simili), Sweden	CNRM-CM5	CNRM, France
	2011)		MPI-ESM-LR	MPI-M, Germany
			IPSL-CM5A-MR	IPSL, France
MPI-CSC- REMO2009 (one member)	MPI Regional model 2009 (REMO; Teichmann et al. 2013)	Climate Service Center (CSC), Germany	MPI-ESM-LR	MPI-M, Germany

## Spatial Distribution of the Seasonal Mean Climatology 1976-2005



Fig. 2. Spatial distribution of the seasonal mean climatology during 1976–2005 based on APHRODITE gridded observations for (top panels) surface air temperature (°C) and (bottom panels) total precipitation (mm d<sup>-1</sup>) during (a–b) summer monsoon and (c–d) winter seasons. The HKH boundary is shown with dashed line. The boxes represent the three HKH sub-regions used for detailed analysis (see text).



Multi-model Statistics of the Seasonal Mean Climatology for 1976-2005 in the 3 hilly sub-regions within HKH

### CMIP5 AOGCMs CORDEX RCMs APHRODITE



Fig. 4. Boxplots showing the (red colours) CORDEX RCMs and (blue colours) CMIP5 AOGCMs multi-model statistics for seasonal mean (left panels) surface air temperature (°C) and (right panels) total precipitation (mm  $d^{-1}$ ) during (left sub-panels) summer monsoon and (right sub-panels) winter seasons in the three hilly sub-regions within HKH. The box represents the interquartile range (IQR) and the horizontal black line in each box is the multi-model median value. The whiskers represent the furthest model value within 1.5 times the IQR. The symbols show the outliers. The observed values based on APHRODITE are shown as a thick black line in the middle of each sub-panel.

# Unravelling Climate Change in the Hindu Kush Himalaya

- For the first time the Hindu Kush Himalayan (HKH) Monitoring and Assessment Programme (HIMAP) coordinated by ICIMOD (http://www.icimod.org/himap) used projected changes in near-surface air temperature and precipitation based on the WCRP regional activity CORDEX coordinated over South Asia by CCCR-IITM
- In the long term (2066-2095), regional warming is projected to be 2.2-3.3 °C for RCP4.5 and 4.2-6.5 °C for RCP8.5
- Increased warming during the winters is also projected
- Monsoon precipitation is projected to increase by 4-25% in the long term
- Winter precipitation is projected to increase by 7-15% in the Karakoram, but to decline slightly in the Central Himalaya
- Krishnan, R., A. B. Shrestha, G. Ren, R. Rajbhandari, S. Saeed, J. Sanjay, Md. A. Syed, R. Vellore, Y. Xu, Q. You and Y. Ren (forthcoming) "Unravelling Climate Change in the Hindu Kush Himalaya: Rapid Warming in the Mountains and Increasing Extremes", Chapter 3 in P. Wester, A. Mishra, A. Mukherji, A. B. Shrestha (eds) The Hindu Kush Himalaya Assessment – Mountains, Climate Change, Sustainability and People. SpringerNature, Dordrecht.P.

(The final drafts of the chapters of the HKH Assessment are available at: hi-map.org/public\_forum])



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© Springer Science+Business Media Singapore 2017 M.N. Rajeevan and S. Nayak (eds.), Observed Climate Variability and Change Over the Indian Region, Springer Geology, DOI 10.1007/978-981-10-2531-0\_16

Future regional climate change scenarios are created for the period 1950–2100 by downscaling the simulations of four coupled climate models.

- 1. The projections indicate significant temperature increases (more than 1.5 °C) over the central and northern parts of India in the mid-term (2031–2060) period. The annual warming range over South Asia land areas is 1.8–3.0 °C by 2060.
- 2. However, the summer monsoon season precipitation change over India is uncertain not just in magnitude but also in sign.



Observed Climate Variability and Change over the Indian Region

2 Springer





## Future Climate Change Projections over the Indian Region

Lead Author: J. Sanjay

Co-authors: R. Krishnan, M.V.S. Ramarao, R. Mahesh, Bhupendra Singh, Jayashri Patel, Sandip Ingle, Preethi Bhaskar, J.V. Revadekar, T.P. Sabin, M. Mujumdar

#### http://cccr.tropmet.res.in/home/reports.jsp

• The all India mean surface air temperature change for the near-term period 2016–2045 relative to 1976–2005 is projected to be in the range of 1.08°C to 1.44°C, and is larger than the natural internal variability. This assessment is based on a reliability ensemble average (REA) estimate incorporating each RCM performance and convergence, and is associated with less than 16% uncertainty range (Table 2.1, Box 2.4).

• The all India mean surface air temperature is projected to increase in the far future (2066–2095) by 1.35 ± 0.23 °C under RCP2.6, 2.41 ± 0.40 °C under RCP4.5 and 4.19 ± 0.46 °C under RCP8.5 scenario respectively. These changes are relative to the period 1976–2005. The semi-arid north-west and north India will likely warm more rapidly than the all India mean (Table 2.1, Fig. 2.1).

# Indian annual mean anomalies (relative to 1976–2005) from CORDEX South Asia concentration-driven experiments











## http://cccr.tropmet.res.in/home/data\_projection.jsp

Home

## Climate Scenarios for South Asia and Indian Monsoon Web Design & Maintenance: R. Mahesh

The CCCR at IITM focus on the development of new climate modelling capabilities in India and South Asia to address issues concerning the science of climate change.

CCCR-IITM has generated an ensemble of high resolution dynamically downscaled future projections of regional climate over South Asia and Indian monsoon, which will be useful for impact assessment studies and for quantifying uncertainties in the regional projections. A brief overview of this core climate change modeling activity of CCCR-IITM was presented in an Interim Report on Climate Change over India.

The results of further detailed analysis of these regional climate projections are presented here as maps and time series, with selected data available for download.









Latest Updates			*** Dr. R. Krishnan, Execu	tive Director, CCCR, 1	ITM is appointed as a Member of the Joint Scientific Committee for the WCRP ***	*** A science and		
A	About CCCR	Research +	Publications	Data & Tools -	News & Events +	Reports -	People -	
CORDEX South Asia Related Publications <u>http://cccr.tropmet.res.in/home/cordexsa_pub.jsp</u>								
AN Sanjay, J. Krishnan, D. Shreetha, A.R. Daibhandari, D. Den, C. V. (2017). Downesolid climate shance projections for the Hindu								

Sanjay, J., Krishnan, R., Shrestha, A.B., Rajbhandari, R., Ren, G.-Y (2017) Downscaled climate change projections for the Hindu Kush Himalayan region using CORDEX South Asia regional climate models. Advances in Climate Change Research, 8, 185-198, DOI: 10.1016/j.accre.2017.08.003.

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http://cccr.tropmet.res.in/home/workshop/oct2018/index.jsp October 08 - 12, 2018, IITM, Pune, India

- The CCCR-IITM co-organised jointly with the ESSO-MoES, Divecha Center for Climate Change (DCCC), Indian Institute of Science, Bengaluru and the Monsoon Asia Integrated Research for Sustainability Future Earth (MAIRS-FE) at DCCC, a 5 day 'Science and Training Workshop on Climate Change over the High Mountains of Asia (HMA) and Annual Climate Change workshop of CCCR-IITM' during 8-12 Oct 2018, at IITM, Pune
- The overarching goals of this workshop was envisaged towards integrating the regional climate downscaling activities, facilitating cross-fertilization of scientific expertise and engaging the community of Asian scientists for further capacity building pertaining to the HMA. These goals would benefit the development of appropriate inputs for further exploitation of the science-based climate information, with higher-level of confidence using model-based projections and knowledge of regional / local experts, by the Vulnerability, Impact and Adaptation (VIA) community
- There were 48 Participants (8 International & 40 National) and 28 Scientific Experts which included 5 International and 23 National Faculties (including experts from IITM). The international Participants were from Nepal, Srilanka, Cambodia, Laos, Thailand and Spain. The international Experts/Faculty was from Nepal, Japan, South Africa, UK and USA.

# Thanks for your attention

sanjay@tropmet.res.in



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Centre for Climate Change Research (CCCR) Indian Institute of Tropical Meteorology (IITM), Pune Earth System Science Organization (ESSO) Ministry of Earth Sciences (MoES), Government of India