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

• 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

- 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 AOGCMs 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

• 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
Uncertainties in Climate Projections: Evaluating RCM Skills

J. Kim1, D.E. Waliser1,2, C. Mattmann2, C. Goodale3, A. Hart3, P. Ramírez2, D. Crichton2

in collaboration with:

C. Jones and G. Nikulin
Sveriges Meteorologiska och Hydrologiska Institut

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

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

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

Building Model Evaluation And Decision Support Capacity For CORDEX

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

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

P. Ramírez1, D. Waliser1, C. Mattmann1, J. Kim2, H. Lee3, P. Loikith1, M. Bounstani1, C. Goodale1, A. Hart1, M. Joyce1, S. Khudikyan1, J. Sanjay1, M.V.S. Rama Rao1, R. Krishnan1, M. Mujumdar3, S. Ingle3

1Jet Propulsion Laboratory/NASA
2University of California Los Angeles
3Center for Climate Change Research, Indian Institute of Tropical Meteorology

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


1University of California Los Angeles
2Jet Propulsion Laboratory/NASA
3Center 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):

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

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

<table>
<thead>
<tr>
<th>Experiment Name</th>
<th>RCM Description</th>
<th>Driving GCM</th>
<th>Contributing Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCLM4(MPI)</td>
<td>Csortium for Small-scale Modelling (COSMO) model in CLIMATE Mode version 4.8 (CCLM: Dobler and Ahrens, 2008)</td>
<td>Max Planck Institute for Meteorology, Germany, Earth System Model (MPI-ESM-LR; Giorgetta et al 2013)</td>
<td>Institute for Atmospheric and Environmental Sciences (IAES), Goethe University, Frankfurt am Main (GFU), Germany</td>
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<td>RCA4(ICHIE)</td>
<td>Rosby Centre regional atmospheric model version 4 (RCA4; Samuelsson et al., 2011)</td>
<td>Irish Centre for High-End Computing (ICHEC), European Consortium ESM (EC-EARTH; Hazeleger et al. 2012)</td>
<td>Rosssy Centre, Swedish Meteorological and Hydrological Institute (SMHI), Sweden</td>
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<tr>
<td>CCAM(ACCESS)</td>
<td>Commonwealth Scientific and Industrial Research Organisation (CSIRO)</td>
<td>ACCESS1.0</td>
<td>CSIRO Marine and Atmospheric Research, Melbourne, Australia</td>
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<tr>
<td>CCAM(CNRM)</td>
<td>Conformal-Cubic Atmospheric Model (CCAM; McGregor and Dix, 2001)</td>
<td>CNRM-CM5</td>
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<td>CCAM(CCSM)</td>
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<td>CCAM(BCCR)</td>
<td>Conformal-Cubic Atmospheric Model (CCAM; McGregor and Dix, 2001)</td>
<td>NotEM-M</td>
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<tr>
<td>LMDZ4(IPSL)</td>
<td>Institut Pierre-Simon Laplace (IPSL) Laboratoire de Méteorologie Dynamique Model version 4 (LMDZ4)</td>
<td>IPSL Coupled Model version 5 (IPSL-CM5-LR; Duflon et al. 2013)</td>
<td>Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India</td>
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<tr>
<td>RegCM4(LMDZ)</td>
<td>The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al., 2012)</td>
<td>IPSL LMDZ4</td>
<td>CCR, IITM</td>
</tr>
<tr>
<td>RegCM4(GFDL)</td>
<td>ICTP RegCM4</td>
<td>Geophysical Fluid Dynamics Laboratory, USA, Earth System Model (GFDL-ESM2-LR; Dume et al. 2012)</td>
<td>CCR, IITM</td>
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</tbody>
</table>

http://cccr.tropmet.res.in/home/docs/cordex/Table_CORDEX_Expts_all.doc
**Signal-to-noise ratio 1979-2007**

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

**INTRODUCTION**

The fidelity of regional climate models (RCMs) is reproducing the observed regional climate is important for providing reliable information on regional climate change. The CORDEX (Coordinated Regional Climate Downscaling Experiment) initiative by WCRP provides a framework to understand model uncertainties through use of multiple RCMs which are driven by boundary conditions from state-of-the-art coupled atmosphere ocean general circulation models (AOGCMs).

**OBJECTIVE**

To evaluate the performances of the RCMs participating in the CORDEX South Asia evaluation in historical experiments in comparison with those of the AOGCMs participating in the fifth phase of the Coupled Models Intercomparison Project (CMIP5) to facilitate multi-model intercomparison over South Asia.

**DATA AND METHODS**

- The performance of the CORDEX AOGCMs and RCMs are assessed for a common 15-year simulation period (1990-2004) using the Regional Climate Model Evaluation System (RCMES) tool from NASA, JPL, USA, by upsampling the model simulations with the monthly mean rain gauge-based global land precipitation dataset available at 0.5° spatial resolution from the Climatic Research Unit (CRU) at the University of East Anglia. For intercomparison, the monthly mean values of each model data are bilinearly interpolated onto the same grid.

- Systematic biases in different models are evaluated with regard to simulation of the annual mean climate, as well as the seasonal cycle over different sub-regions of South Asia.

**EXPECTED OUTCOME**

- Such evaluation methodologies of the CORDEX AOGCMs and CORDEX RCMs are aimed towards bringing our additional value of regional climate information required for impact assessments and decision support activities and the value gained via dynamical downscaling.

**RESULTS AND DISCUSSION**

The AOGCMs & RCMs skill in simulating the amplitude & phase of the FAM with respect to the CRU data is summarized for all seasons using performance diagrams:

- Mean squared error normalized by CRU anomaly

- Correlation coefficients (CC)

- The individual RCM bias vary from dry to wet over certain areas, the best over the eastern regions (Fig. 4c).

- The spatial distribution of the bias is similar for the three AOGCMs (Fig. 4d) 6 Hz (Fig. 4e) with the CRU bias ranging from -1.0 to 1.0 Hz

**CONCLUSIONS**

The following are the major outcomes of the present study:

- Most AOGCMs & RCMs show significant biases in estimating the main features of the annual precipitation climatology over the South Asia.

- However, dynamical downscaling of AOGCM output by using RCMs to the scale needed to end uses appear to be more useful for understanding local monthly precipitation climate in regions such as the Northern regions such as Nepal, Bangladesh, Bhutan & Myanmar.
Data Publishing & Maintenance: Sandip Ingle

The Earth System Grid Federation (ESGF) maintains a global system of federated data centers that allow access to the largest archive of climate data world-wide. The ESGF Data Node at CCCR-IITM is focused on supporting CCCR-IITM climate model datasets (CORDEX-South Asia and CMIP6). This Data node is presently peered with SMHI-NSC ESGF Index Node.

The CCCR-IITM site does not provide the OpenID. Please go to the SMHI-NSC ESGF Index Node to request an OpenID.

ESGF-CoG FAQ on questions concerning data, e.g. data format, data processing, CMIP and CORDEX data (e.g., How can CORDEX data on a grid with rotated poles be rotated back?) [please click here]
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
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 also requires a [Group Registration](#) (see the detailed instructions on [SMHI Website](#)) to access CORDEX data.

ESGF-CoG FAQ on questions concerning data, e.g. data format, data processing, CMIP and CORDEX data (e.g., How can CORDEX data on a grid with rotated poles be rotated back?) [please [click here](#)]
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.
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)
<table>
<thead>
<tr>
<th>CORDEX South Asia RCM</th>
<th>RCM Description</th>
<th>Contributing CORDEX Modeling Center</th>
<th>Driving CMIP5 GCM (<a href="https://verc.enes.org/data/enes-model-data/cmip5/resolution">https://verc.enes.org/data/enes-model-data/cmip5/resolution</a>)</th>
<th>Contributing CMIP5 Modeling Center</th>
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<tr>
<td>IITM-RegCM4</td>
<td>The Abdus Salam International Centre for Theoretical Physics (ICTP) Regional Climatic Model version 4 (RegCM4; Giorgi et al. 2012)</td>
<td>Centre for Climate Change Research (CCCR), Indian Institute of Tropical Meteorology (IITM), India</td>
<td>CCCma-CaNESM2</td>
<td>Canadian Centre for Climate Modelling and Analysis (CCCma), Canada</td>
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<td>ICHEC-EC-EARTH</td>
<td>Irish Centre for High-End Computing (ICHEC), European Consortium (EC)</td>
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<td>Model for Interdisciplinary Research On Climate (MIROC), Japan Agency for Marine-Earth Sci. &amp; Tech., Japan</td>
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<td>IPSL, France</td>
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<td>MPI-CSC-REMO2009</td>
<td>MPI Regional model 2009 (REMO; Teichmann et al. 2013)</td>
<td>Climate Service Center (CSC), Germany</td>
<td>MPI-ESM-LR</td>
<td>MPI-M, Germany</td>
</tr>
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</table>
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⁻¹) 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.


(The final drafts of the chapters of the HKH Assessment are available at: hi-map.org/public_forum)
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.
Future Climate Change Projections over the Indian Region

Lead Author: J. Sanjay

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 $1.35 \pm 0.23$°C under RCP2.6, $2.41 \pm 0.40$°C under RCP4.5 and $4.19 \pm 0.46$°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
Climate Scenarios for South Asia and Indian Monsoon

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.
CORDEX South Asia Related Publications

http://cccr.tropmet.res.in/home/cordexsa_pub.jsp


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

http://cccr.tropmet.res.in

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