TRAINING ON
Regional climate change projections:

Climate change analysis using CORDEX regional climate models over South Asia
12–14 and 19–21 October 2020 | Platform: Microsoft Teams

Day 3 – Wednesday, 14 OCTOBER 2020 [09:00 NPT]

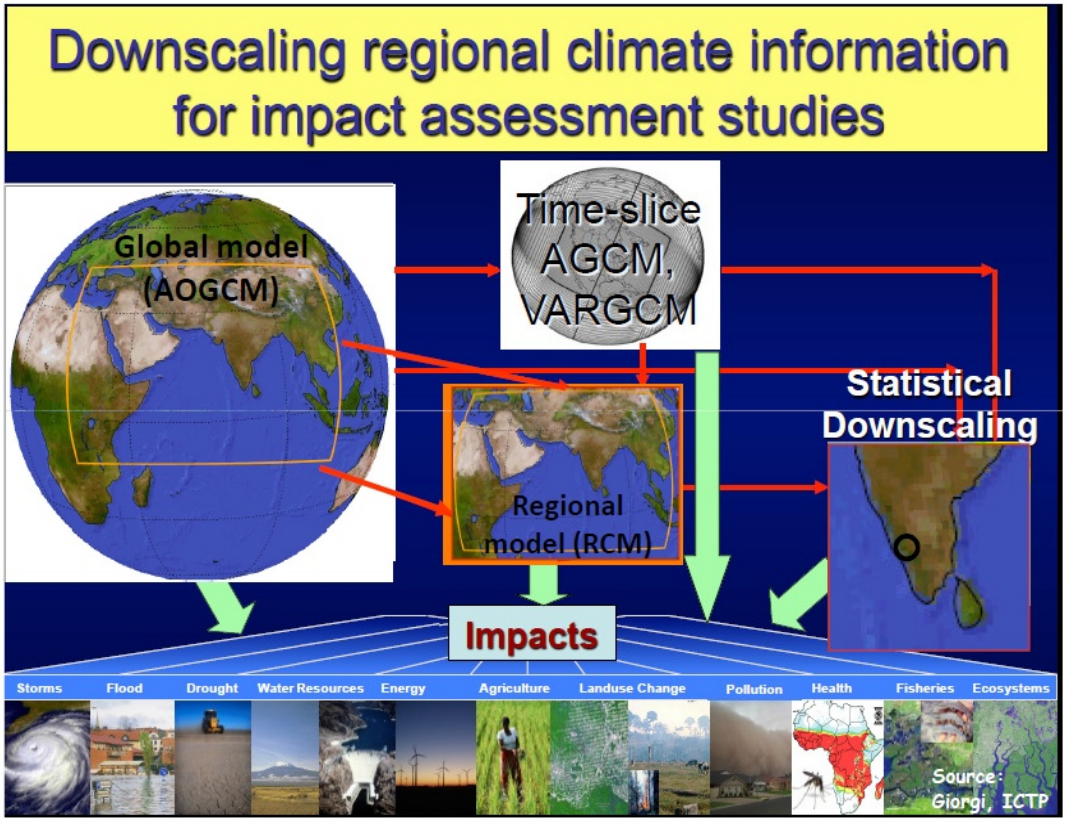
Introduction to CORDEX datasets and data download

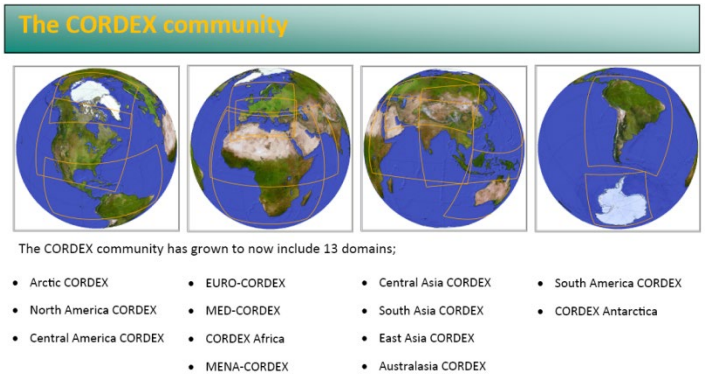
J. Sanjay, R. Mahesh, Sandip Ingle, R. Krishnan

Centre for Climate Change Research (CCCR)
Indian Institute of Tropical Meteorology (IITM)
Ministry of Earth Sciences (MoES)
Government of India

Regional Climate Information for Application Studies CORDEX South Asia

The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships. https://cordex.org/





CCCR is leading CORDEX (Coordinated Regional Climate Downscaling Experiment) over South Asia Region

High Resolution (50 km) Dynamical Downscaling of CMIP5 Climate Projections based on RCP Scenarios during 1950-2100 using multiple RCMs

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

Coordinated Regional Climate Downscaling Experiment (CORDEX):

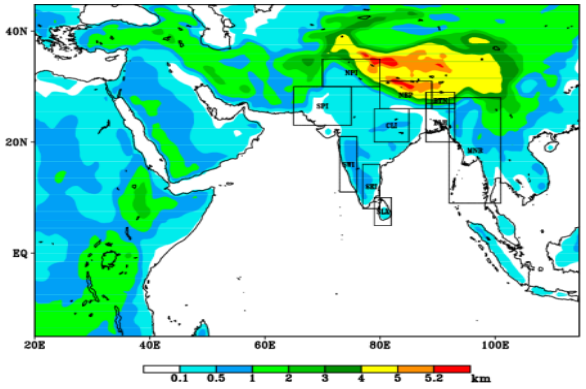
The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships

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 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.

ESGF Data Node @ CCCR-IITM
http://cccr.tropmet.res.in/home/esgf_node.jsp

- **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**

https://cordex.org/experiment-guidelines/cordex-core/cordex-core-simulations/

CORDEX CORE Simulations

CORDEX Coordinated Output for Regional Evaluations (CORE)

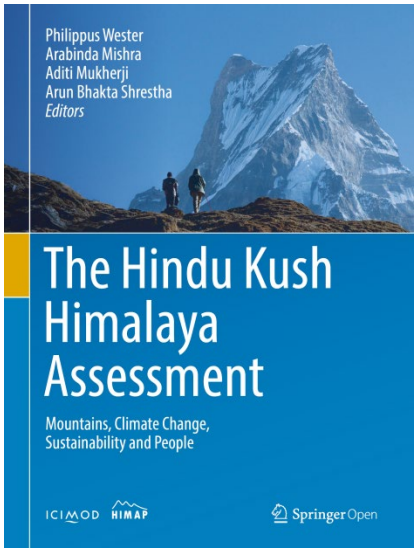
High resolution regional climate information for the world

Background

With the growing demand for high-resolution information about regional climate change and its impact all over the world, the WCRP CORDEX developed the CORDEX-COmmon Regional Experiment (CORE) Framework. CORDEX-CORE aims at contributing to the next IPCC report with a homogeneous dataset of high-resolution regional climate information and providing this information for all major inhabited areas of the world.

The main ideas of the CORDEX CORE framework are:

- to provide an ensemble of high-resolution (at least 25 km) regional climate change information.
- to provide a basis for assessments of future extreme events for all major inhabited regions of the world.
- to use the ensemble for further analysis such as climate change impacts on the different global warming levels, e.g. +1.5 °C or +2.0 °C.
- to be incrementally extended with further contributions by additional models/experiments
- CORDEX CORE (~25km) is extending (not replacing) the CORDEX (~50km) regional climate information and provides a basis for further downscaling activities



Unravelling Climate Change in the Hindu Kush Himalaya: Rapid Warming in the Mountains and Increasing Extremes

Krishnan R., A. B. Shrestha, G. Ren, R. Rajbhandari, S. Saeed, J. Sanjay, Md. A. Syed, R. Vellore, Y. Xu, Q. You, Y. Ren (2019)

In: Wester P., Mishra A., Mukherji A., Shrestha A. (eds) The Hindu Kush Himalaya Assessment. Springer, Cham, 2019, pp. 57-97, DOI: https://doi.org/10.1007/978-3-319-92288-1_3.

For the first time the projected changes in near-surface air temperature and precipitation based on high resolution (0.5°) dynamically downscaling of CMIP5 GCMs using CORDEX RCMs were used

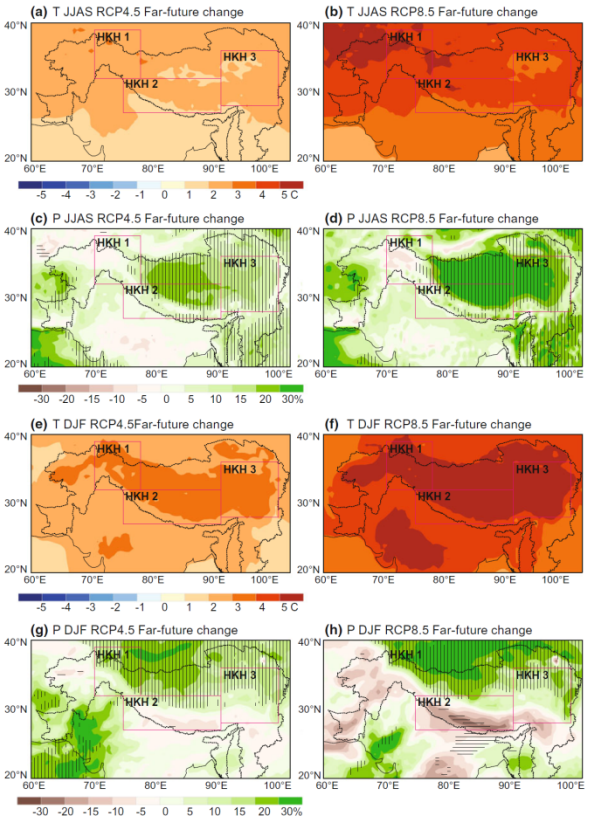
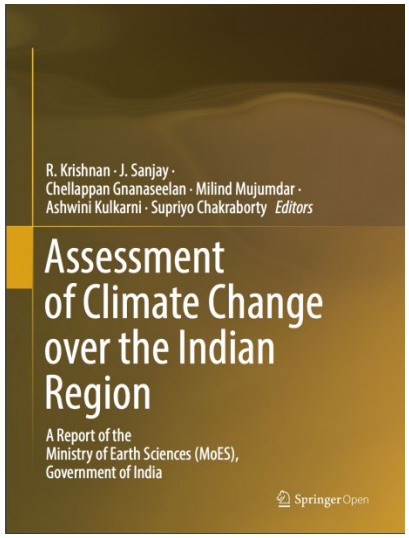


Fig. 3.13 Seasonal ensemble mean climate change in the Hindu Kush Himalaya (HKH) in the far future ([2066–2095]–[1976–2005]) for (top panels) surface air temperature (°C) and (bottom panels) total precipitation (%), with scenarios (first and third column) RCP4.5 and (second and fourth column) RCP8.5, during (**a–d**) summer monsoon (JJAS) and (**e–h**) winter (DJF) seasons. Ensemble mean of downscaling CMIP5 GCM with CORDEX South Asia RCM (listed in Annex 4 and Table 3.5). Striping in bottom panels indicates where at least 10 of the 13 realizations concur on an increase (vertical) or decrease (horizontal) in RCPs. The HKH boundary is shown by a dashed line. The boxes represent three HKH sub-regions used for detailed analysis (see text) (*Source* Sanjay et al. 2017b)

Sanjay, J., Krishnan, R., Shrestha, A. B., Rajbhandari, R., & Ren, G. Y. (2017b). Downscaled climate change projections for the Hindu Kush Himalayan region using CORDEX South Asia regional climate models. *Advances in Climate Change Research, 8*(3), 185–198. https://doi.org/10.1016/j.accre.2017.08.003.

Key Findings

- In the future, even if global warming is kept to 1.5 °C, warming in the Hindu Kush Himalaya (HKH) region will likely be at least 0.3 °C higher, and in the northwest Himalaya and Karakoram at least 0.7 °C higher.
- For the past five to six decades, the HKH have shown a rising trend of extreme warm events; a falling trend of extreme cold events; and a rising trend in extreme values and frequencies of temperature-based indices (both minimum and maximum).
- The HKH is experiencing increasing variability in western disturbances and a higher probability of snowfall in the Karakoram and western Himalaya, changes that will likely contribute to increases in glacier mass in those areas.
- Consensus among models for the HKH region is weak—a result of the region's complex topography and the coarse resolution of global climate models.



New book on Assessment of Climate Change over the Indian Region

A Report of the
Ministry of Earth Sciences (MoES), Govt. of India

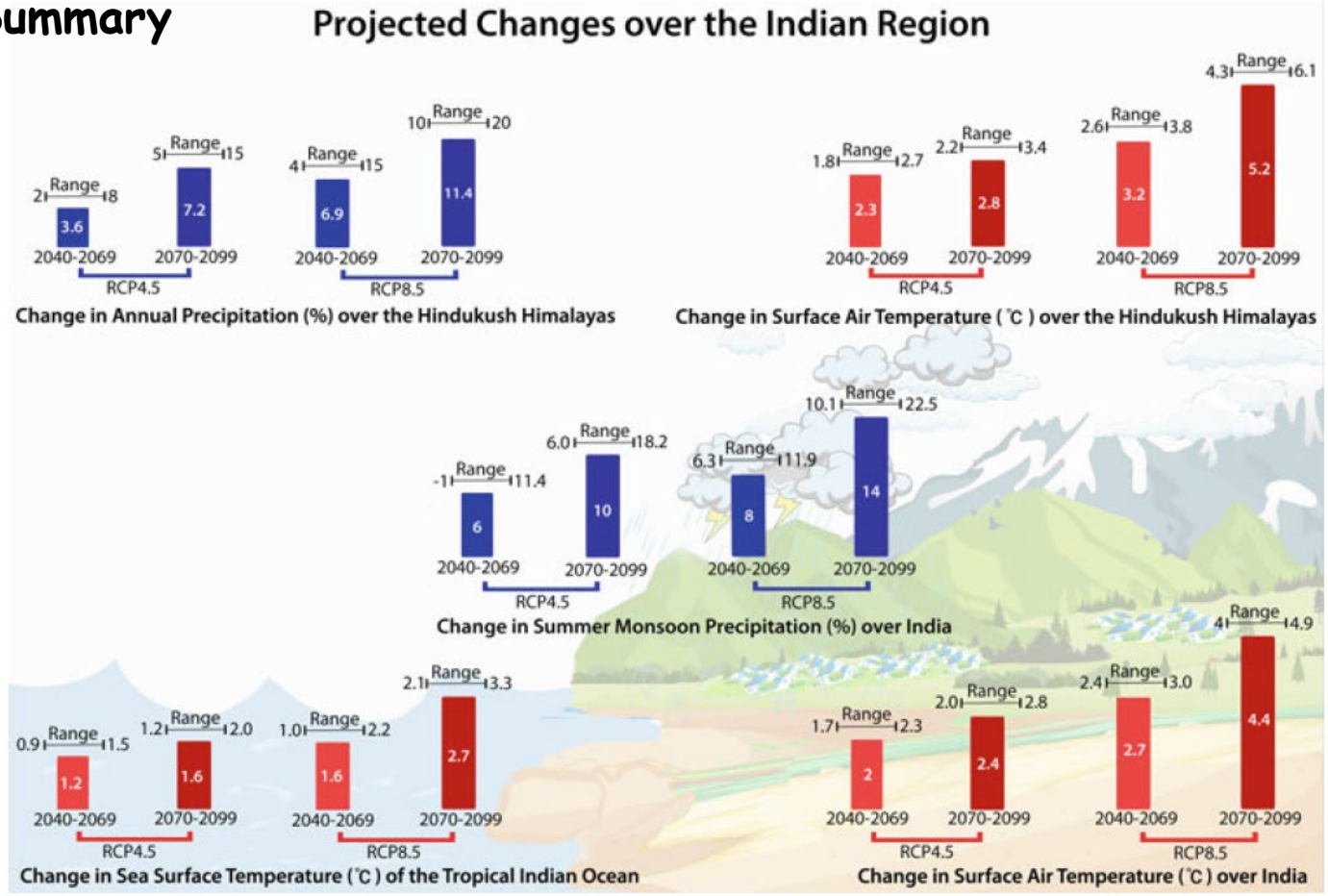
R. Krishnan, J. Sanjay, Chellappan Gnanaseelan, Milind Mujumdar,
Ashwini Kulkarni, Supriyo Chakraborty (*Editors*)

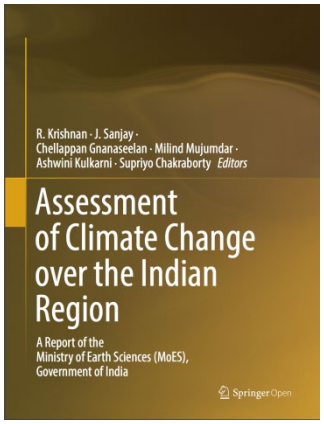
Source: Springer Nature 2020, https://doi.org/10.1007/978-981-15-4327-2

- A new open access book on Assessment of Climate Change over the Indian Region has been published.
- The book discusses the influence of human-induced global climate change over the Indian subcontinent and the regional monsoon, the adjoining Indian Ocean and the Himalayas.
- The assessments presented in this book are based on peer-reviewed scientific publications, published IPCC reports, analyses of long-term observed climate records, paleoclimate reconstructions, reanalysis datasets and climate model projections from the WCRP through their CMIP and the CORDEX South Asia scientific projects.

Also available at: http://cccr.tropmet.res.in/home/docs/cccr/2020_Book_AssessmentOfClimateChangeOverT.pdf

Executive Summary





- The mean temperature rise over India by the end of the 21st century is projected to be in the range of 2.4–4.4 °C across GHG scenarios relative to the average temperature over 1976–2005.
- Since IPCC-AR5, the RCP 8.5 has been thought to be very unlikely, while the intermediate RCP 4.5 scenario seems to provide more realistic guidance at least in the coming 2-3 decades.

Fig. 1 Best estimate and range in climate model projections of future changes in 1. Surface air temperature over India (°C; bottom right panel), 2. Sea surface temperature of the tropical Indian Ocean (°C; bottom left panel), 3. Surface air temperature over the Hindu Kush Himalayas (°C; top right panel), 4. Summer monsoon precipitation over India (% change; centre panel), 5. Annual precipitation over the Hindu Kush Himalayas (% change; top left panel). All the changes are computed relative to their climatological average over the 30-year period 1976–2005. Projected changes are reported for the middle and end of the 21st century under the RCP4.5 and RCP8.5 scenarios (defined in Box 1). Details regarding the models and computations are discussed in the respective chapters

Source: Executive Summary, MoES Report 2020

CORDEX South Asia future projections of annual average surface air temperature changes over India

Source: MoES Report 2020, Fig. 2.7, 2.8

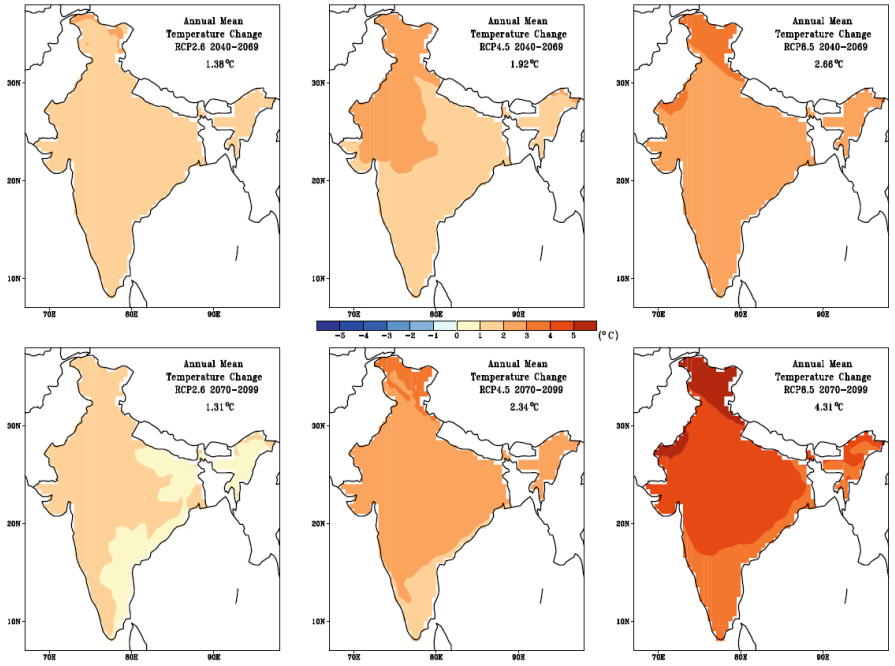


Fig. 2.7 CORDEX South Asia multi-RCM ensemble mean projections of annual average surface air temperature changes (in °C) over India for the mid-term (2040–2069) and long-term (2070–2099) climate relative to 1976–2005 under RCP2.6, RCP4.5 and RCP8.5 emission scenarios. The estimates of all India averaged ensemble mean projected changes are shown in each panel

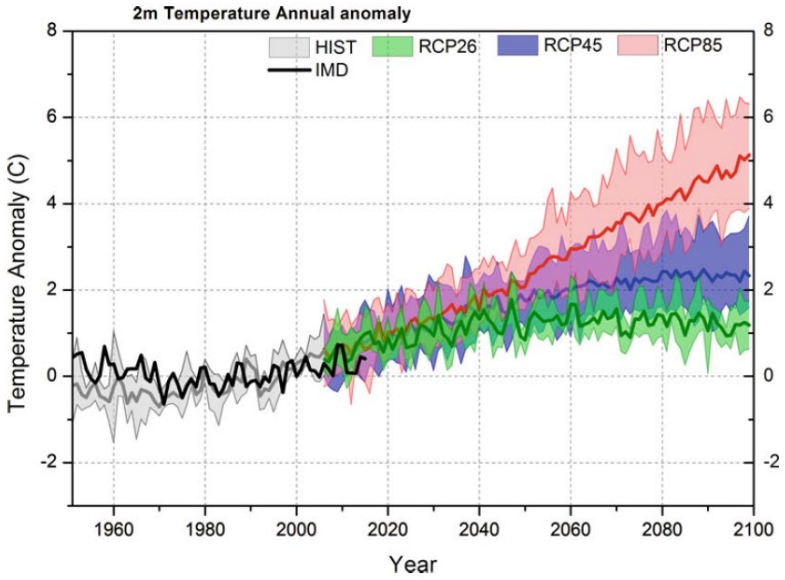
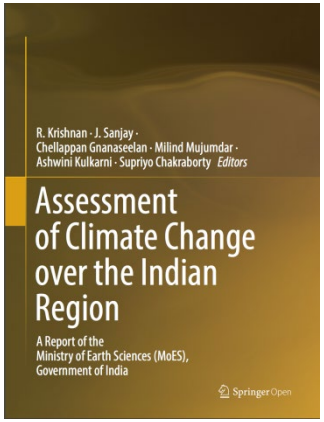
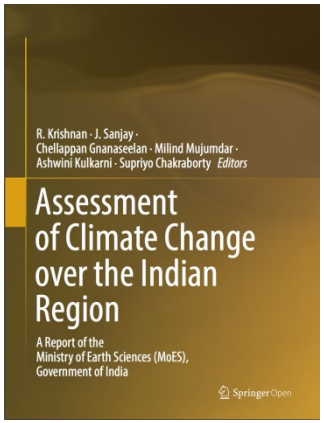


Fig. 2.8 Time series of Indian annual mean surface air temperature (°C) anomalies (relative to 1976–2005) from CORDEX South Asia concentration-driven experiments. The multi-RCM ensemble mean (solid lines) and the minimum to maximum range of the individual RCMs (shading) based on the historical simulations during 1951–2005 (grey), and the downscaled future projections during 2006–2099 are shown for RCP2.6 (green), RCP4.5 (blue) and RCP8.5 (red) scenarios. The black line shows the observed anomalies during 1951–2015 based on IMD gridded station data



Future projections of mean precipitation over India

Source: Chapter 3, MoES Report 2020



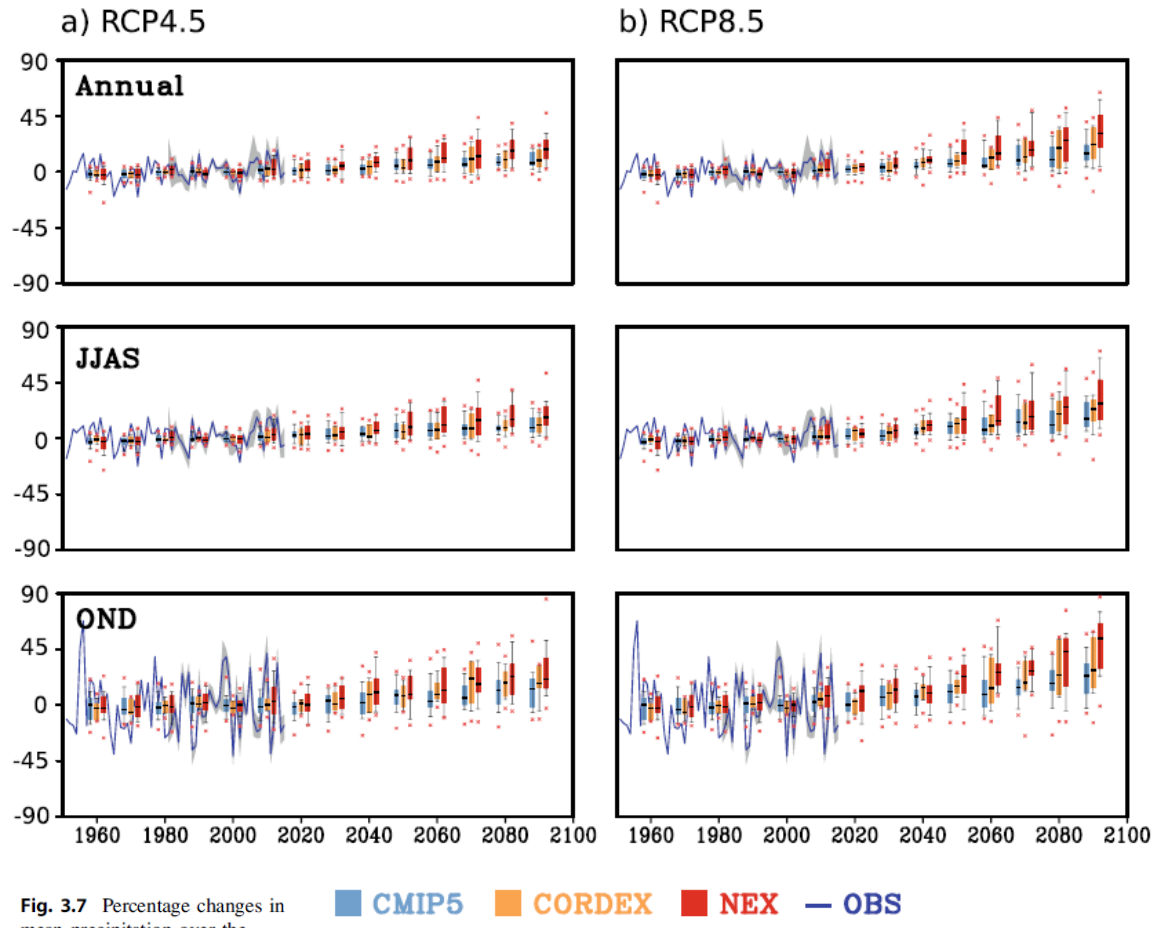
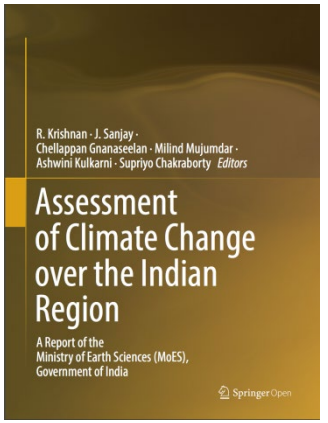


Fig. 3.7 Percentage changes in mean precipitation over the Indian land across CMIP5, CORDEX-SA, and NEX-GDDP simulations from the **a)** RCP4.5 **b)** RCP8.5 scenario for annual, JJAS and OND seasons. Changes in 10-year means, with respect to the reference period (1976–2005), are shown as box-whiskers

- With anticipated reductions in aerosol emissions, future changes in the monsoon precipitation are expected to be prominently constrained by the effects of GHG warming.
- With the resultant increase in temperature and atmospheric moisture, climate models project a considerable rise in the mean, extremes and interannual variability of monsoon precipitation by the end of the century

Future projections of climate over the Hindukush Himalayas (HKH)



- The HKH underwent rapid warming at a rate of about 0.2°C per decade during the last 6–7 decades (*High confidence*).
- Higher elevations of the Tibetan Plateau (> 4 km) experienced even stronger warming in a phenomenon alluded to as Elevation Dependent Warming (*High confidence*).
- With continued global warming, the temperature in the HKH is projected to rise substantially during the 21st century.

Source: MoES Report 2020, Fig. 11.3

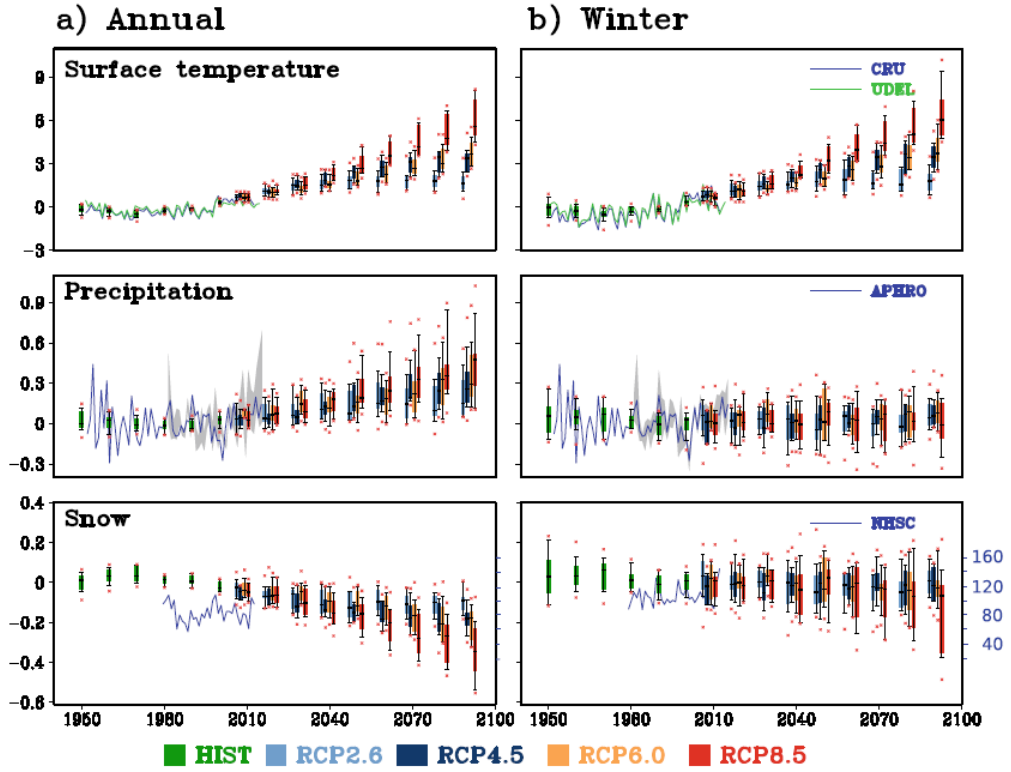


Fig. 11.5 Box whiskers of variations in surface air temperature (°C), precipitation (mm/day) and snow (mm/day) over the HKH from the CMIP5 projections for the different future scenarios (Annual mean (**a**) and Winter season (**b**)). Variations in ten-year means, with respect to the reference period (1976–2005), are presented as box whiskers plots. Observed temperature (CRU) and precipitation (APHRODITE) are shown during 1951–2015. Precipitation from GPCP and CMAP are also shown during 1981–2015. Grey shade is the ensemble spread during 1981–2015. The snow cover observation is based on the NSIDC dataset from 1979 to 2012 (NHSC: Northern Hemisphere State of Cryosphere, right y-axis). Note that variations in observed snow cover extent are expressed in x 10000 km^2. The CMIP5 projected variations in snowfall are expressed in mm/day (left y-axis)

- The HKH experienced a significant decline in snowfall and glacial area in the last 4–5 decades (*Medium confidence*).
- With continuing warming, climate models project a continuing decline in snowfall over the HKH during the 21st century, but with wide inter-model spread.
- In contrast, parts of the Karakoram Himalayas have experienced increase in wintertime frozen precipitation in the recent decades, in association with enhanced amplitude variations of Western Disturbances.

https://cordex.org/data-access/cordex-data-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

CORDEX data on ESGF

To find a table showing the CORDEX data available on the ESGF click here.

You can also have a look at GCM-RCM overview for an overview of what simulatiosn are available and how.

Domain	Model	Driving Model
WAS-44	HadRM3P	ECMWF-ERAINT
WAS-44	RCA4	CCCma-CanESM2
WAS-44	RCA4	CNRM-CERFACS-CNRM-CM5
WAS-44	RCA4	CSIRO-QCCCE-CSIRO-Mk3-6-0
WAS-44	RCA4	ECMWF-ERAINT
WAS-44	RCA4	ICHEC-EC-EARTH
WAS-44	RCA4	IPSL-IPSL-CM5A-MR
WAS-44	RCA4	MIROC-MIROC5
WAS-44	RCA4	MOHC-HadGEM2-ES
WAS-44	RCA4	MPI-M-MPI-ESM-LR
WAS-44	RCA4	NCC-NorESM1-M
WAS-44	RCA4	NOAA-GFDL-GFDL-ESM2M
WAS-44	REMO2009	MPI-M-MPI-ESM-LR
WAS-44	RegCM4-4	CCCma-CanESM2
WAS-44	RegCM4-4	CNRM-CERFACS-CNRM-CM5
WAS-44	RegCM4-4	CSIRO-QCCCE-CSIRO-Mk3-6-0
WAS-44	RegCM4-4	ECMWF-ERAINT
WAS-44	RegCM4-4	IPSL-IPSL-CM5A-LR
WAS-44	RegCM4-4	MPI-M-MPI-ESM-MR
WAS-44	RegCM4-4	NOAA-GFDL-GFDL-ESM2M

CORDEX DATA ACCESS

Data access
- How to access the data
- ESGF
- Impact Portals
- Regional Data Portals
- Individual institutes
- CORDEX RCM List
- CORDEX data on ESGF
- Bias-adjusted RCM data

Training sessions will be accessing these CORDEX South Asia domain (WAS-44) data available on ESGF CORDEX archive

Hosted by DKRZ DEUTSCHES KLIMARECHENZENTRUM is-enes

Powered by ESGF and CoG

Welcome, **Guest**. | Login | Create Account

Example of CORDEX South Asia Domain (WAS-44) data search

https://esgf-data.dkrz.de/search/cordex-dkrz/

You are at the ESGF-DATA.DKRZ.DE node

Home | **Technical Support**

Project +
Product +
Domain −
- [x] WAS-44 (17)

Institute +
Driving Model +
Experiment −
- [x] historical (17)

Experiment Family +
Ensemble +
RCM Model −
- [ ] RCA4 (10)
- [ ] REMO2009 (1)
- [ ] RegCM4-4 (6)

Downscaling Realisation +
Time Frequency −
- [x] day (17)

Variable −
- [x] tas (17)

Enter Text: | Search | Reset | Display 10 results per page | [More Search Options]

[ ] Show All Replicas [ ] Show All Versions [ ] Search Local Node Only (Including All Replicas)

Search Constraints: WAS-44 | historical | day | tas

Total Number of Results: 17
-1- 2 Next >>
Please login to add search results to your Data Cart
Expert Users: you may display the search URL and return results as XML or return results as JSON

1. **cordex.output.WAS-44.MPI-CSC.MPI-M-MPI-ESM-LR.historical.r1i1p1.REMO2009.v1.day.tas**
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   Version: 20140918
   Total Number of Files (for all variables): 9
   Full Dataset Services: [Show Metadata] [List Files] [THREDDS Catalog] [WGET Script] [Globus Download]
2. **cordex.output.WAS-44.IITM.CSIRO-QCCCE-CSIRO-Mk3-6-0.historical.r1i1p1.RegCM4-4.v5.day.tas**
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   Version: 20170113
   Total Number of Files (for all variables): 11
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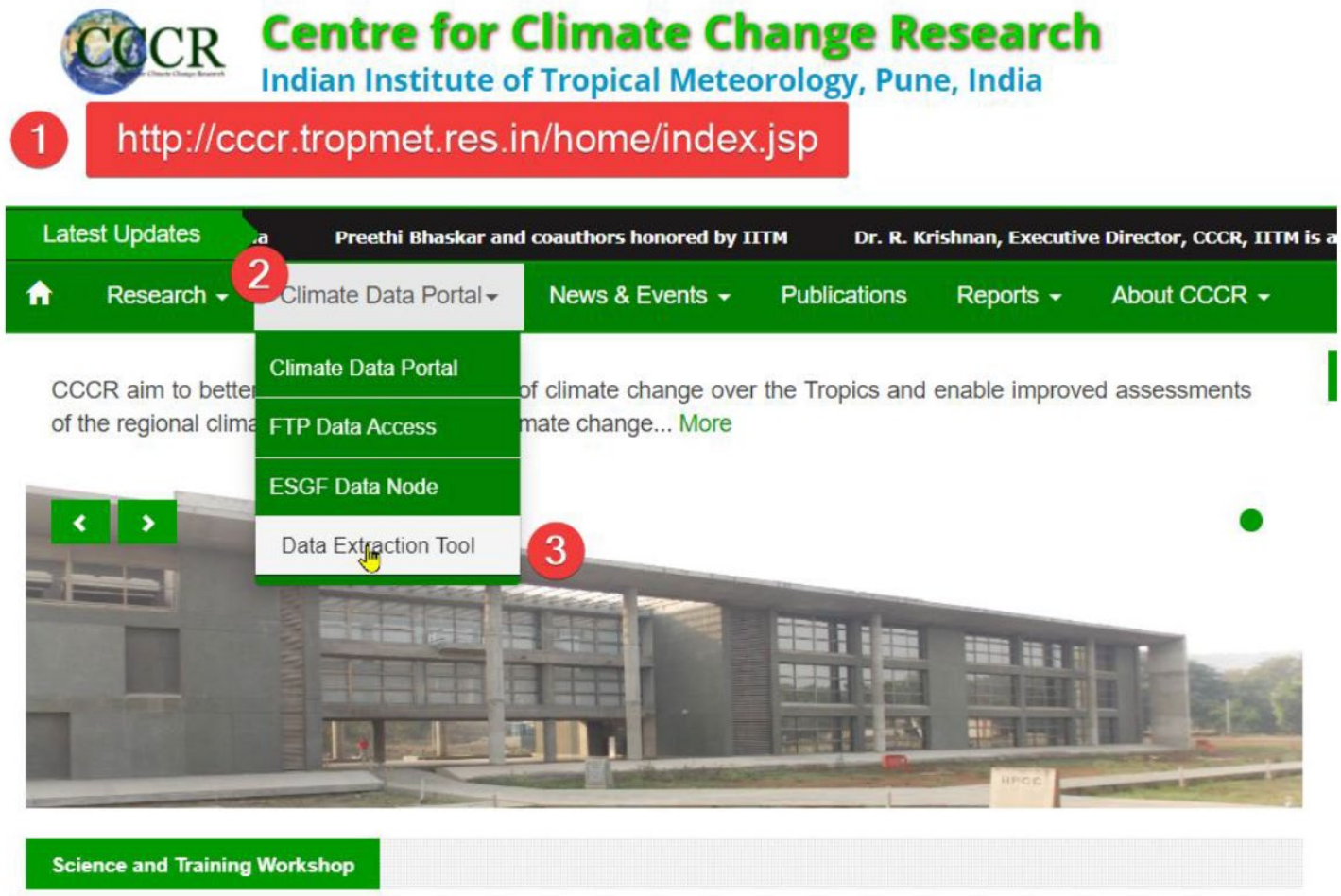
   Data Node: esg-cccr.tropmet.res.in
   Version: 20170321
   Total Number of Files (for all variables): 11

IITM-RegCM4 RCM outputs published on ESGF by Sandip Ingle

CCCR-IITM ESGF Data Extraction Tool will be used to subset and select the CORDEX data over your region, and download the extracted data on your computer

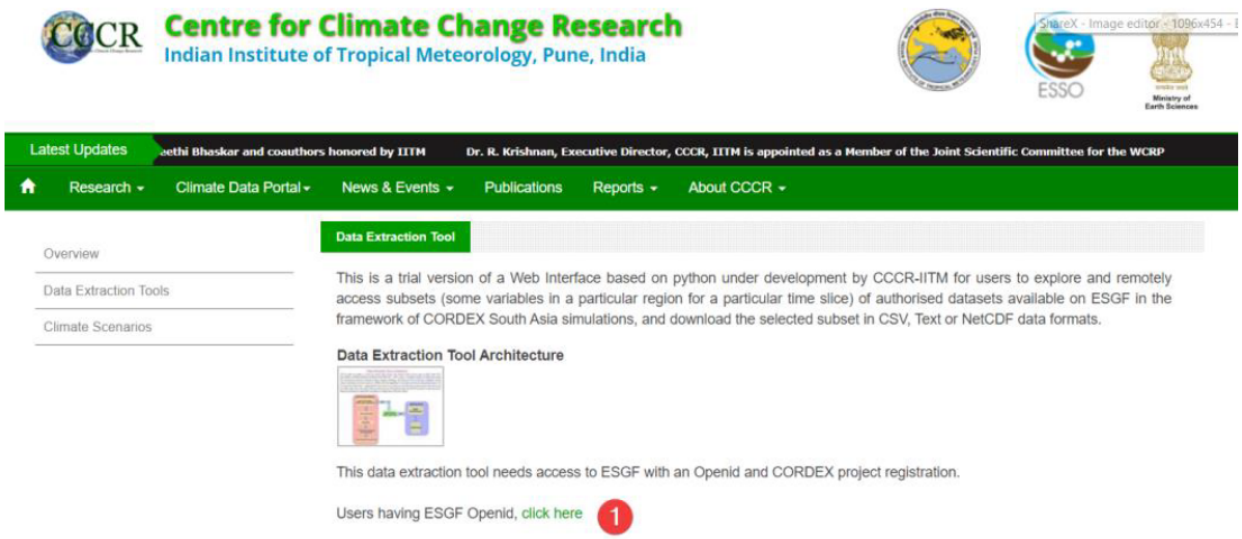
1: Go to the website of IITM Pune (http://cccr.tropmet.res.in/home/index.jsp)



2: Click on ‘Climate Data Portal’

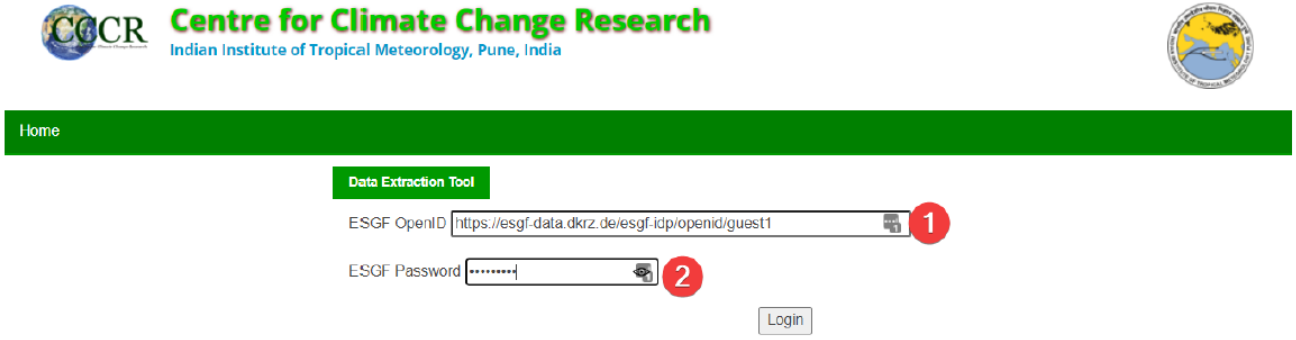
3: Click on Data extraction Tool

1: Now, go to IITM Pune website [http://cccr.tropmet.res.in/home/data_cccrdx.jsp] and click 'Users having ESGF OpenID, 'click here' link



Web interface based on Python developed by R. Mahesh

You will be taken to a new page where you can keep the ESGF OpenID link that you received during the registration:



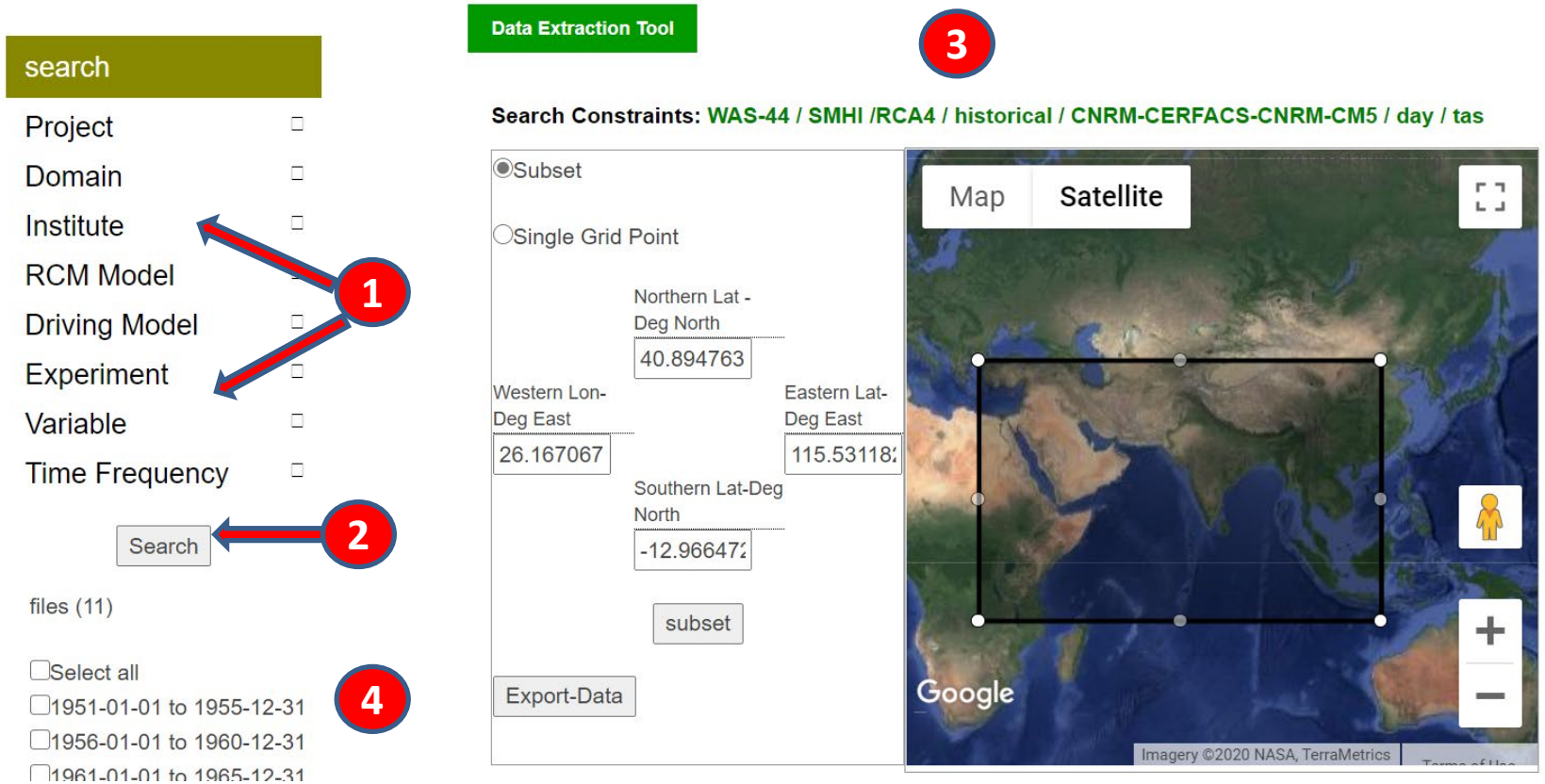
1: Keep your ESGF OpenID here
2: Enter your password here

You will be taken to a page from where you can download CORDEX datasets:

Example for selecting a dataset from ESGF CORDEX South Asia data archive

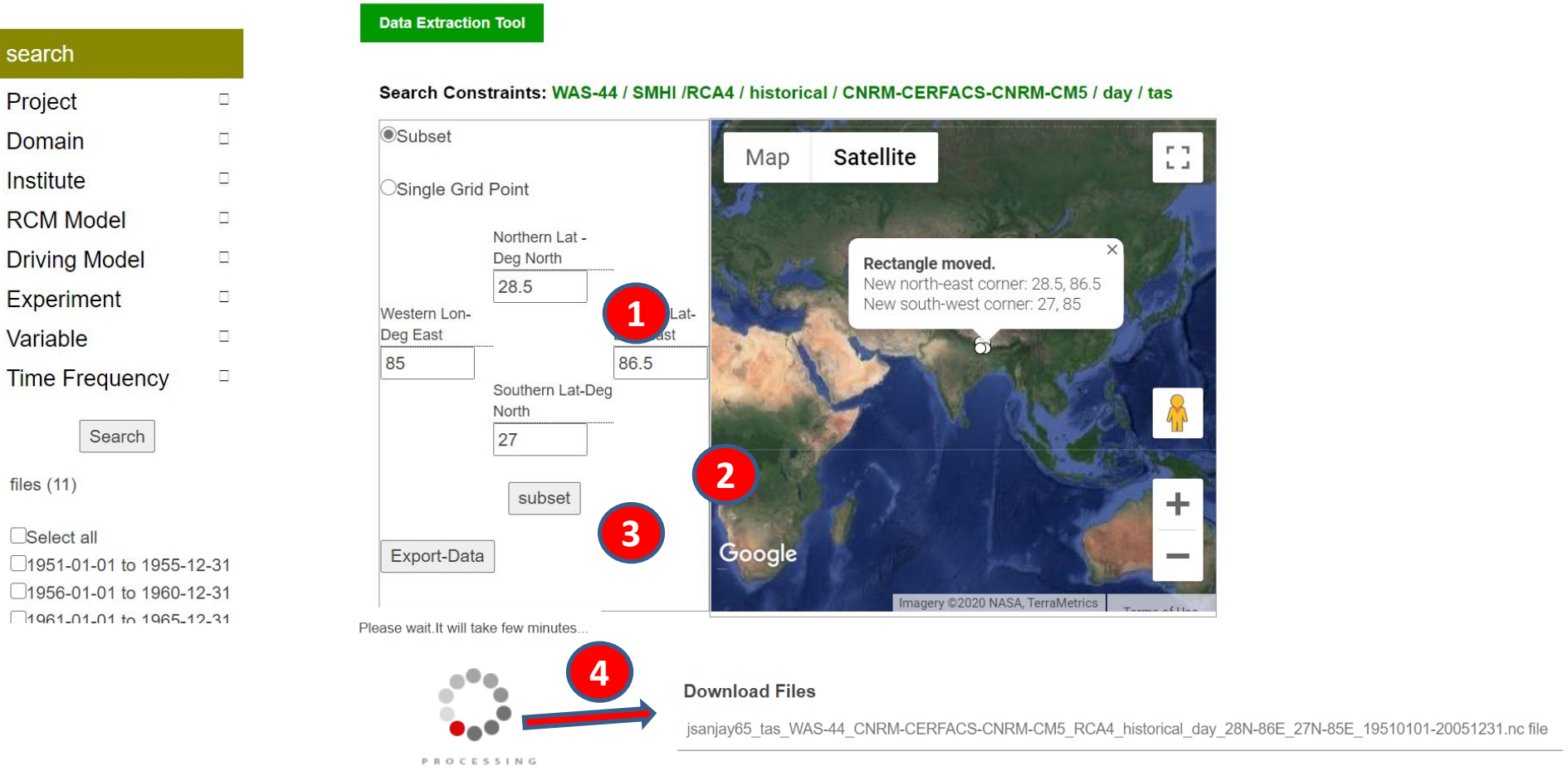
1. **Select** Domain: **WAS-44**
   Institute: **SMHI**
   RCM Model: **RCA4**
   Driving Model: **CNRM-CERFACS-CNRM-CM5**
   Experiment: **historical**
   Variable: **tas**
   Time Frequency: **day**

2. Click "Search" **3. Confirm selected Search Constraints** **4. Select Time Periods**



Example for subsetting the selected dataset over Kathmandu region and downloading from ESGF CORDEX South Asia data archive

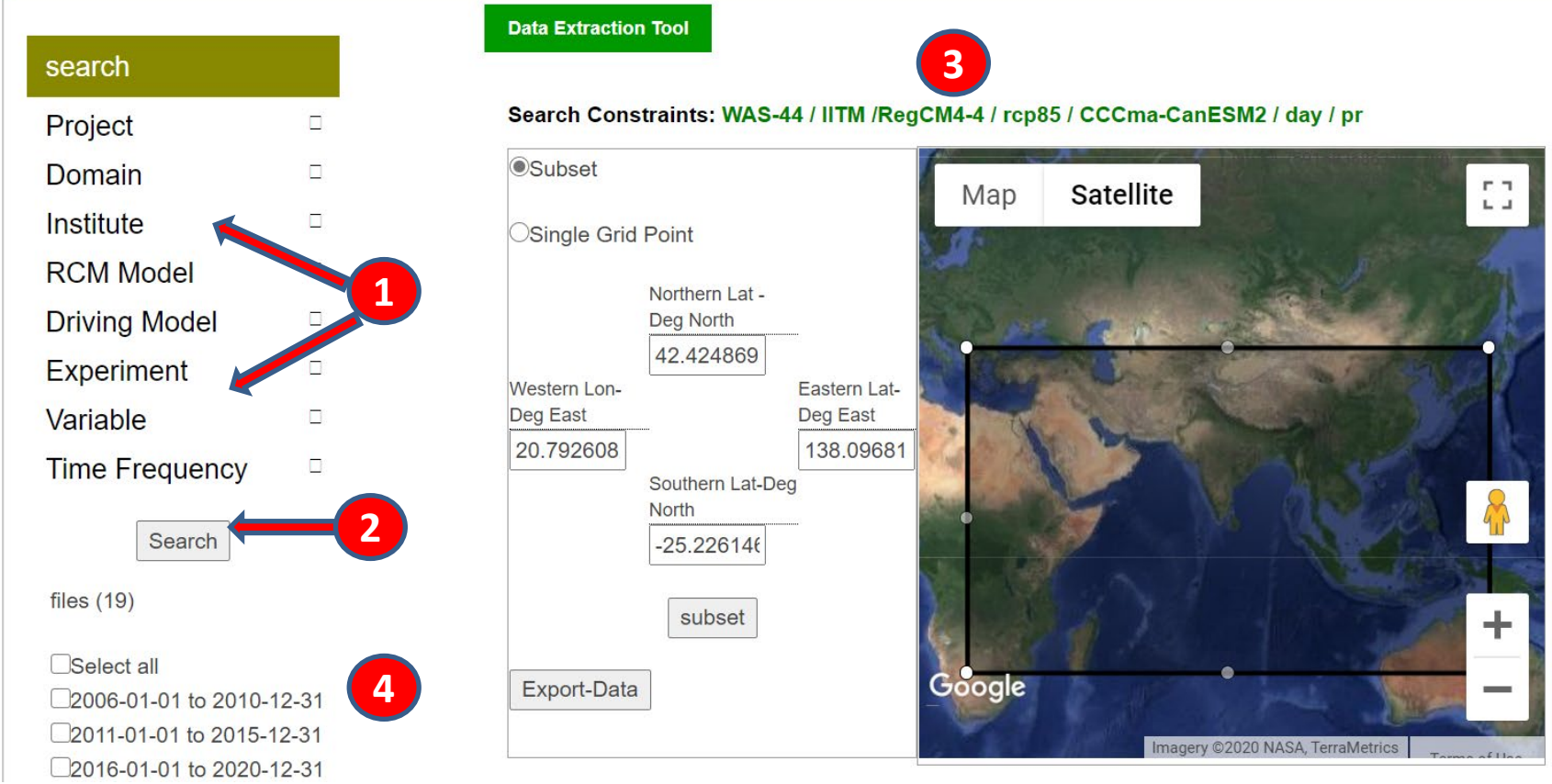
1. Input Longitude & Latitude coordinates: 85.0°E-86.5°E; 27.0°N-28.5°N
2. Click "subset" & confirm the selected region on map
3. Click "Export Data"
4. Please wait for the data file to be processed & right click on the file name to download



Example for selecting a dataset from ESGF CORDEX South Asia data archive

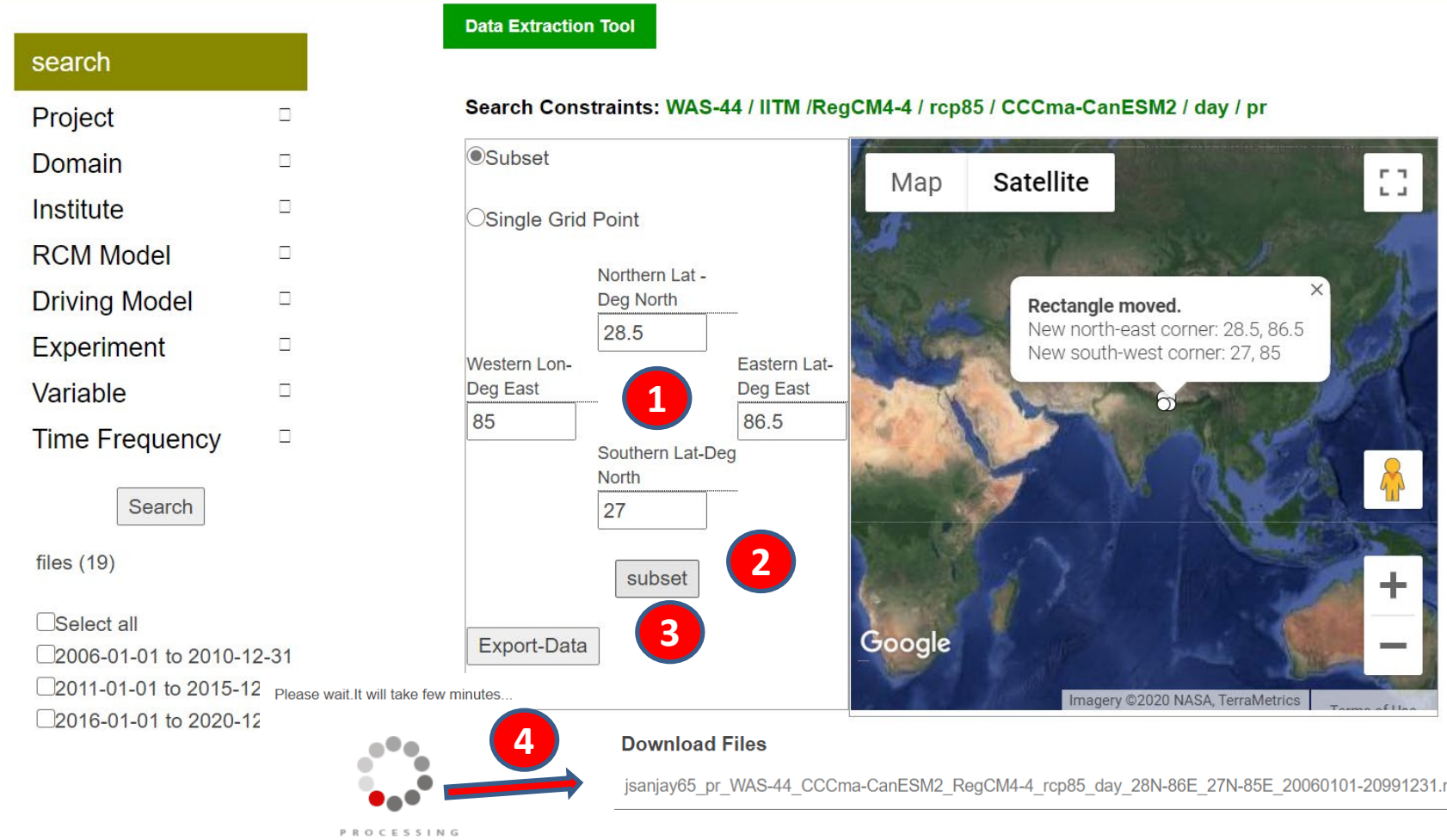
1. **Select** Domain: **WAS-44**
   Institute: **IITM**
   RCM Model: **RegCM4-4**
   Driving Model: **CCCma-CanESM2**
   Experiment: **rcp85**
   Variable: **pr**
   Time Frequency: **day**

2. Click "Search" **3. Confirm selected Search Constraints** **4. Select Time Periods**



Example for subsetting the selected dataset over Kathmandu region and downloading from ESGF CORDEX South Asia data archive

1. Input Longitude & Latitude coordinates: 85.0°E-86.5°E; 27.0°N-28.5°N
2. Click "subset" & confirm the selected region on map
3. Click "Export Data"
4. Please wait for the data file to be processed & right click on the file name to download



```
[sanjay@localhost ICIMOD-CORDEX-Training2020]$ cdo sinfov CORDEX/NewDelhi/SMHI/pr/jsanjay65_pr_WAS-44_CNRM-CERFACS-
CNRM-CM5_RCA4_historical_day_29N-78E_28N-76E_19510101-20051231.nc
   File format : NetCDF4
    -1 : Institut Source   Steptype Levels Num    Points Num Dtype : Parameter name
     1 : unknown  unknown  instant       1   1         9   1  F32  : pr
   Grid coordinates :
     1 : curvilinear             : points=9 (3x3)
                          lon : 76.56147 to 77.57009 degrees_east
                          lat : 27.92141 to 28.85313 degrees_north
   Vertical coordinates :
     1 : surface                 : levels=1
   Time coordinate :  20089 steps
     RefTime =  1949-12-01 00:00:00  Units = days  Calendar = standard  Bounds = true
  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss
  1951-01-01 12:00:00  1951-01-02 12:00:00  1951-01-03 12:00:00  1951-01-04 12:00:00
  1951-01-05 12:00:00  1951-01-06 12:00:00  1951-01-07 12:00:00  1951-01-08 12:00:00
  1951-01-09 12:00:00  1951-01-10 12:00:00  1951-01-11 12:00:00  1951-01-12 12:00:00
  1951-01-13 12:00:00  1951-01-14 12:00:00  1951-01-15 12:00:00  1951-01-16 12:00:00
```

Extracted Data Format: NetCDF

More details in CORDEX Archive specification document on webpage:
https://cordex.org/experiment-guidelines/experiment-protocol-rcms/

Data Summary using Climate Data Operators (CDO)

```
[sanjay@localhost ICIMOD-CORDEX-Training2020]$ cdo sinfov ./CORDEX/NewDelhi/SMHI/pr/jsanjay65_pr_WAS-44
_CNRM-CERFACS-CNRM-CM5_RCA4_rcp45_day_29N-78E_28N-76E_20060101-21001231.nc
   File format : NetCDF4
    -1 : Institut Source   Steptype Levels Num    Points Num Dtype : Parameter name
     1 : unknown  unknown  instant       1   1         9   1  F32  : pr
   Grid coordinates :
     1 : curvilinear             : points=9 (3x3)
                          lon : 76.56147 to 77.57009 degrees_east
                          lat : 27.92141 to 28.85313 degrees_north
   Vertical coordinates :
     1 : surface                 : levels=1
   Time coordinate :  34698 steps
     RefTime =  1949-12-01 00:00:00  Units = days  Calendar = standard  Bounds = true
  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss
  2006-01-01 12:00:00  2006-01-02 12:00:00  2006-01-03 12:00:00  2006-01-04 12:00:00
  2006-01-05 12:00:00  2006-01-06 12:00:00  2006-01-07 12:00:00  2006-01-08 12:00:00
  2006-01-09 12:00:00  2006-01-10 12:00:00  2006-01-11 12:00:00  2006-01-12 12:00:00
```

CORDEX

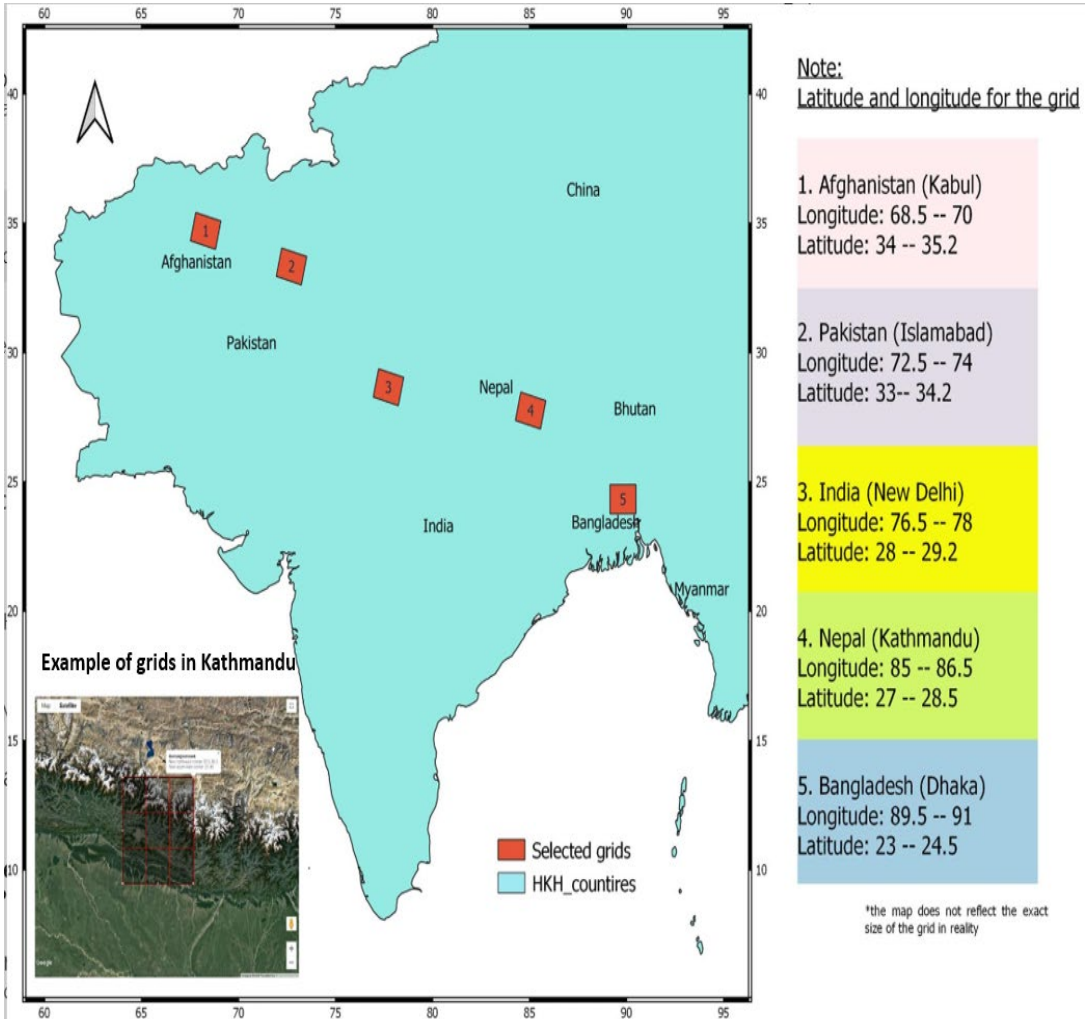
- **NewDelhi**
  - **SMHI**
    - **pr** **[CNRM-CM5]**
      - **HIST**
      - **RCP4.5**
      - **RCP8.5**

```
[sanjay@localhost ICIMOD-CORDEX-Training2020]$ cdo sinfov ./CORDEX/NewDelhi/SMHI/pr/jsanjay65_pr_WAS-44
_CNRM-CERFACS-CNRM-CM5_RCA4_rcp85_day_29N-78E_28N-76E_20060101-21001231.nc
   File format : NetCDF4
    -1 : Institut Source   Steptype Levels Num    Points Num Dtype : Parameter name
     1 : unknown  unknown  instant       1   1         9   1  F32  : pr
   Grid coordinates :
     1 : curvilinear             : points=9 (3x3)
                          lon : 76.56147 to 77.57009 degrees_east
                          lat : 27.92141 to 28.85313 degrees_north
   Vertical coordinates :
     1 : surface                 : levels=1
   Time coordinate :  34698 steps
     RefTime =  1949-12-01 00:00:00  Units = days  Calendar = standard  Bounds = true
  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss  YYYY-MM-DD hh:mm:ss
  2006-01-01 12:00:00  2006-01-02 12:00:00  2006-01-03 12:00:00  2006-01-04 12:00:00
  2006-01-05 12:00:00  2006-01-06 12:00:00  2006-01-07 12:00:00  2006-01-08 12:00:00
  2006-01-09 12:00:00  2006-01-10 12:00:00  2006-01-11 12:00:00  2006-01-12 12:00:00
```

Extract data from other capital cities

Location of the 3x3 grids for the analysis for capital cites given here

Please use these lat lon to extract data from your capital cities



Exercise: Using the ESGF Data Extraction Tool select each of the 16 CORDEX South Asia RCM simulations, subset over your region, and download:

CORDEX South Asia RCM	RCM description	Contributing CORDEX modelling center	Driving CMIP5 AOGCM (see details at https://verc.enes.org/data/enes-model-data/cmip5/resolution)	Contributing CMIP5 modelling center
IITM-RegCM4 (6 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 RecherchesMe´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
SMHI-RCA4 (10 members)	Rossby Centre Regional Atmospheric Model Version 4 (RCA4; Samuelsson et al. 2011)	Rossby Centre, Swedish Meteorological and Hydrological Institute (SMHI), Sweden	ICHEC-EC-EARTH	Irish Centre for High-End Computing (ICHEC), European Consortium (EC)
			MIROC-MIROC5	Model for Interdisciplinary Research On Climate (MIROC), Japan Agency for Marine-Earth Sci. & Tech., Japan
			NCC-NorESM1	Norwegian Climate Centre (NCC), Norway
			MOHC-HadGEM2-ES	Met Office Hadley Centre for Climate Change (MOHC), United Kingdom
			CCCma-CanESM2	CCCma, Canada
			NOAA-GFDL-GFDL-ESM2M	NOAA, GFDL, USA
			CNRM-CM5	CNRM, France
			MPI-ESM-LR	MPI-M, Germany
			IPSL-CM5A-MR	IPSL, France
			CSIRO-Mk3.6	CSIRO, Australia

Daily Variables:

- **tas** (surface air temperature)
- **pr** (precipitation rate)

RCM Ensemble Members:

- **IITM-RegCM4 (6)**
- **SMHI-RCA4 (10)**

Experiments & Time Periods:

- **Historical (1951 to 2005)**
- **RCP4.5 Scenario (2006 to 2099)**
- **RCP8.5 Scenario (2006 to 2099)**

Thanks for your attention

sanjay@tropmet.res.in

Thank You

- ICIMOD-ARRCC-CORDEX Training Organisers
- Director IITM