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Potential advantages of using a dynamically downscaled higher resolution regional scale model PRECIS over India

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Background: Downscaling is a method for obtaining high resolution climate information from relatively coarse-resolution global climate models (GCMs). RCM takes account of much smaller scale terrain effects than GCMs due to better resolving of coastlines, which is particularly important for simulating orographic precipitation. It is important to assess the performance of RCMs over its driving GCM to explore the efficacy of dynamical downscaling. Such dynamically downscaled information is imperative in assessing regional climate risks which assists in much better planning for climate impacts at that scale. We present the potential improvements of PRECIS over its parent model HADGEM2-ES in simulating regional precipitation.

Data & Method:

- The PRECIS model is run over the Indian domain at a spatial resolution of 0.22º using the large-scale information from the parent GCM HADGEM2-ES (1.875º x 1.25º). The historical simulation of precipitation (1971-2000) is validated using IMD observation gridded dataset available at 0.25º resolution. (*Pai et al. 2013*).
- The performance of the two models are compared over homogeneous regions (India) by analyzing the patterns of JJAS mean precipitation, inter-annual variability, extreme precipitation, and active and break spells of ISMR.
- Summary statistics of errors for the historical simulation are presented for the parameters mean, max and min temperature validated using IMD temperature observation gridded dataset available at 1º resolution. (*Srivastava et al. 2009*)
- Core Monsoon region: 18^0N – 28^0N, 73^0E – 82^0E (*Rajeevan et.al., 2010*)
- Definition of Active/break spells over CMR: *(Abhilash et. al. 2014)*

  Active Spell: Area averaged rainfall > 40% of long term mean

  Break Spell: Area averaged rainfall < 40% of long term mean

  Normal Spell: Area averaged rainfall between -40% to 40%

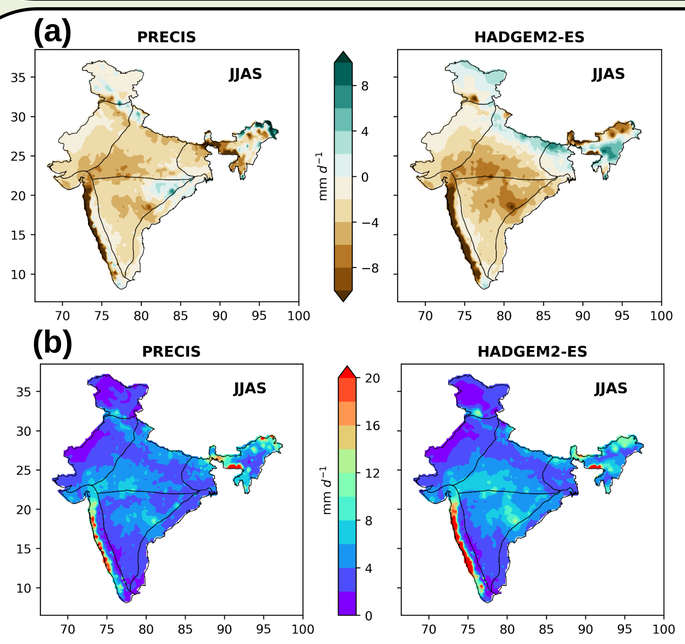

Figure 1. JJAS precipitation (a) mean bias and (b) RMSE

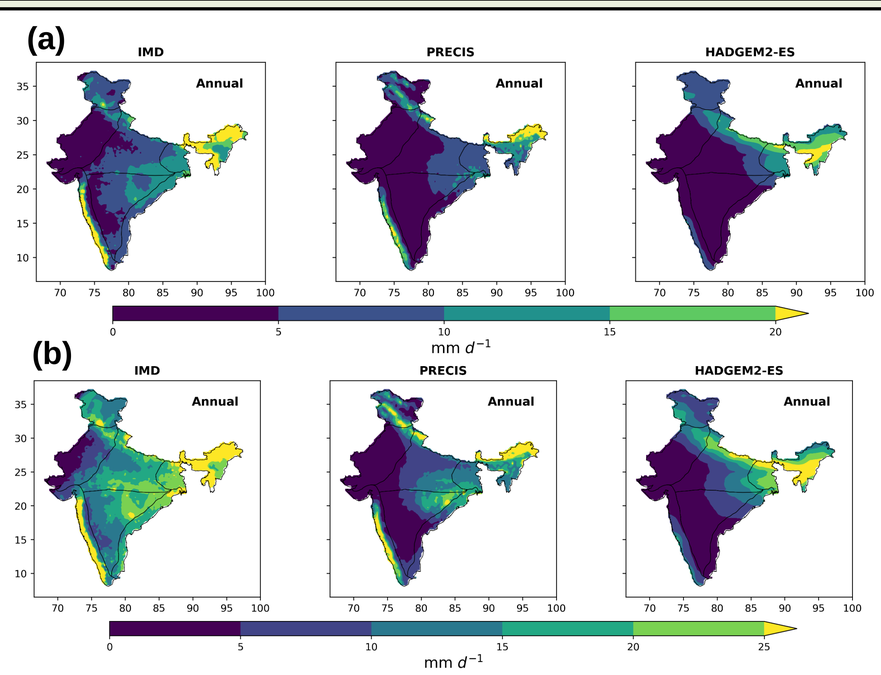

Figure 2. (a) 90th, and (b) 95th percentile of daily mean precipitation.

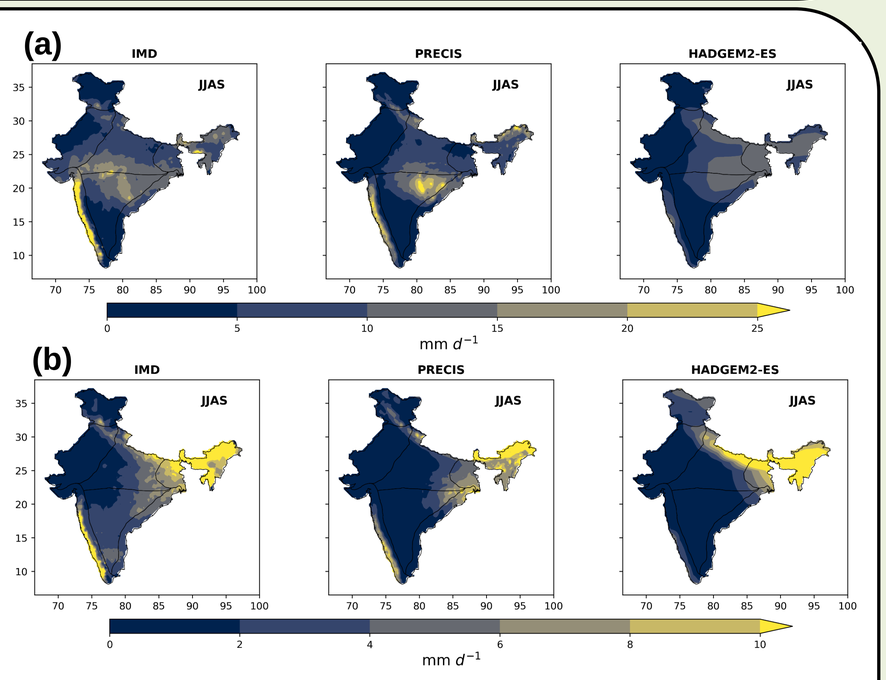

Figure 3. (a) Active composite, and (b) Break composite

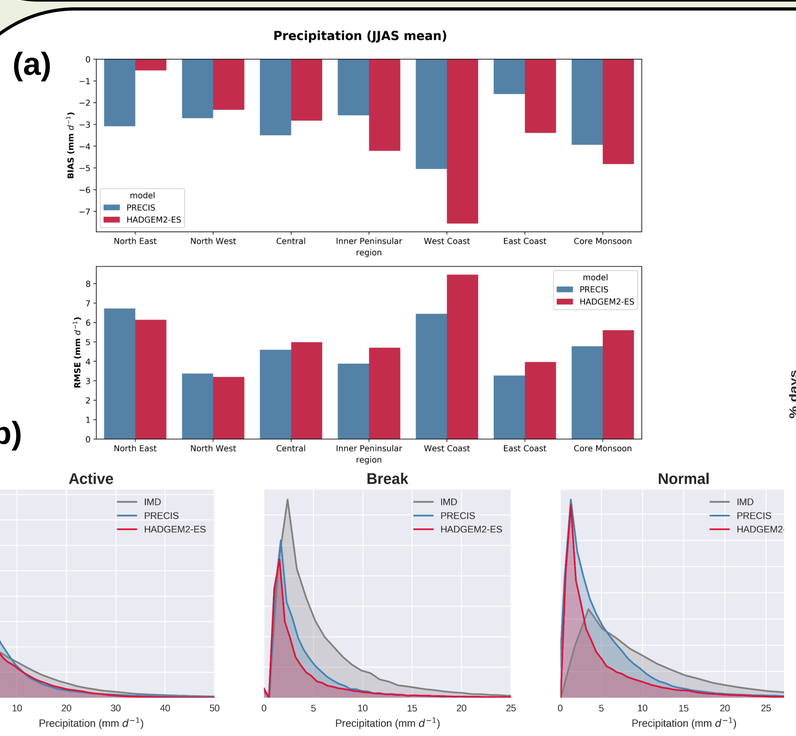

Figure 4. (a) Region wise area averaged BIAS and RMSE, and (b) PDF for Active, Break and Normal composites for the Core Monsoon Region.

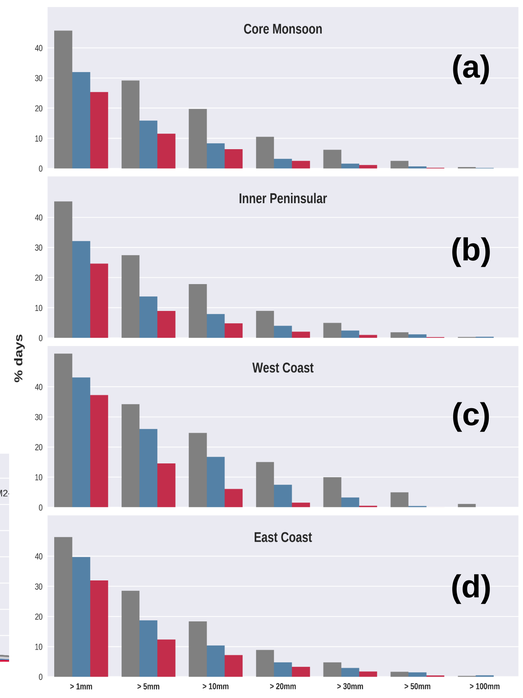

Figure 5. % of days with pr > 1, 5, 10, 20, 30, 50 and 100mm for (a) Core Monsoon Region, (b) Inner Peninsular, (c) West Coast and (d) East Coast

Metric	Model	C	NW	NE	WC	EC	CMR	IND
90p	HADGEM2-ES	0.39	0.63	0.2	0.59	0.9	0.35	0.55
	PRECIS	0.52	0.66	0.2	0.82	0.8	0.69	0.71
95p	HADGEM2-ES	0.35	0.6	0.2	0.56	0.9	0.39	0.55
	PRECIS	0.28	0.57	0.2	0.78	0.8	0.58	0.62
99p	HADGEM2-ES	0.09	0.49	0.2	0.56	0.9	0.36	0.51
	PRECIS	-0.02	0.28	0.2	0.71	0.8	0.36	0.45
A_abs	HADGEM2-ES	-0.24	0.34	-0.1	0.6	0.9	0.25	0.44
	PRECIS	0.45	0.44	0.2	0.82	0.9	0.62	0.71
B_abs	HADGEM2-ES	0.79	0.89	0.4	0.73	0.9	0.48	0.74
	PRECIS	0.77	0.61	0.3	0.88	0.9	0.85	0.77
cdd_1_5	HADGEM2-ES	0.37	0.76	0.3	0.73	0.1	0.51	0.39
	PRECIS	0.57	0.83	-0.1	0.59	0.8	0.48	0.72
cwd_1_5	HADGEM2-ES	0.29	0.61	0.3	0.47	0.7	0.36	0.38
	PRECIS	0.6	0.8	0.6	0.63	0.6	0.67	0.69
timmean	HADGEM2-ES	0.34	0.67	0.3	0.62	0.9	0.3	0.54
	PRECIS	0.62	0.62	0.3	0.83	0.9	0.7	0.72
timstd	HADGEM2-ES	-0.03	0.48	-0	0.46	0.6	0.17	0.29
	PRECIS	0.17	0.49	0.3	0.68	0.6	0.38	0.45

Table 1.

Region wise field correlation* (JJAS precipitation) for the two models.

90p, 95p, 99p	$(90,95,99)^{th}$ percentile (JJAS)
A_abs	Active composite
B_abs	Break composite
cdd_1_5	pr<1mm (ndays ≥ 5)
cwd_1_5	pr>1mm (ndays ≥ 5)
timmean	Climatological mean (JJAS)
timstd	Inter-annual variability (JJAS)

	Season	DJF							MAM							JJAS							ON						
	Region	C	CMR	EC	IP	NE	NW	WC	C	CMR	EC	IP	NE	NW	WC	C	CMR	EC	IP	NE	NW	WC	C	CMR	EC	IP	NE	NW	WC
VAR	Model																												
pr	HADGEM2-ES	1	0.6	1.2	0.5	1.1	0.8	0.4	0.9	0.5	1.4	0.7	3.1	1	1	5	5.6	4	4.7	6.1	3.2	8.5	1	1.2	4.3	2.1	2.2	0.9	2.8
	PRECIS	0.6	0.4	1	0.5	1.2	0.4	0.5	0.5	0.4	1.5	0.7	4.4	0.5	0.8	4.6	4.8	3.3	3.9	6.7	3.4	6.4	1.3	1.3	4.3	2.2	3	0.7	2.5
tasmax	HADGEM2-ES	6.8	4.2	2.7	1.5	11	7.5	2.1	5.8	3.7	5.3	4.5	8.9	5.6	5.1	3	2.2	2.3	2.3	5.7	2.7	2	5.8	3.3	2.5	2.4	10	5.4	2
	PRECIS	2.1	1.4	1.4	1.3	5.3	2.5	1.6	3.2	1.7	3.4	1.8	7.1	3	2	2.8	2.2	2.8	2.1	5	3.9	2.3	2.9	2.4	2.7	3.1	5.5	2.4	2.4
tas	HADGEM2-ES	5.1	3.5	2.1	1.8	8.7	5.7	2	4	2.2	1.3	1.4	6.9	3.6	1.5	2.3	1.7	1.7	1.7	4.4	2.2	1.3	5.2	2.9	2.1	2.1	9.4	4.6	1.9
	PRECIS	3.1	2.7	2.1	2	5.7	3.9	2.1	2.4	1.7	1.2	1.4	5.4	2.4	1.9	2	1.5	1.6	1.3	4.2	2.6	1.9	2.3	1.6	1.5	1.5	5.5	2.5	1.4
tasmin	HADGEM2-ES	3.6	3.5	2.2	3	5.9	4.4	2.7	3.7	3.4	2	3.3	4.8	3.5	2.2	1.7	1.2	1.4	1.1	3.5	1.8	1.3	4.7	3.5	2.6	3	7.9	4.1	2.3
	PRECIS	4.4	3.8	3.5	3.3	6	5.3	3.1	3.3	3.4	2.3	3	4.3	3.8	3.4	1.6	1.2	1.1	1.1	3.6	2	1.6	3.7	2.6	2.9	2.2	6	3.8	2.3

Table 2. Region wise seasonal RMSE* for the two models for the parameters pr (mm d^{-1}), tasmax, tas, and tasmin (ºC).

* **Green** represents where PRECIS performs better. **C**: Central, **CMR**: Core Monsoon Region, **EC**: East Coast, **IP**: Inner Peninsular, **NE**: North East, **NW**: North West, **WC**: West Coast, **IND**: India.

Concluding Remarks:

- Although both the models show a significant dry bias in monsoonal mean precipitation over all the regions, PRECIS shows a smaller RMSE error in almost all regions except NE and NW and a better spatial pattern of inter-annual variability across all regions.
- Extreme precipitation (90th and 95th percentile) over WC and CMR is much better represented in PRECIS.
- PRECIS performs much better in simulating the wet days in the CMR, IP, WC and EC regions, and has a lower presence of the drizzle effect which is inherent in the CMIP5 GCMs.
- The active spells of the ISMR are much better represented in PRECIS in terms of the intensity (PDFs), and spatial correlations of the composite. The break spells are too dry in both the models, however PRECIS has a better spatial pattern over the CMR.
- Lower errors (RMSE) are noted across almost all seasons and regions for mean and max temperature, however the errors are significantly worse for min temperature.

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Future Outlook :

- The results shown here are preliminary.
- An inter-comparison of other regional models over the Indian region is currently underway.
- Future works will focus on statistical assessment of precipitation and temperature extremes.

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