Statistical Bias correction and Downscaling of Climate Models using DIAS Online Bias Correction & Downscaling Tools

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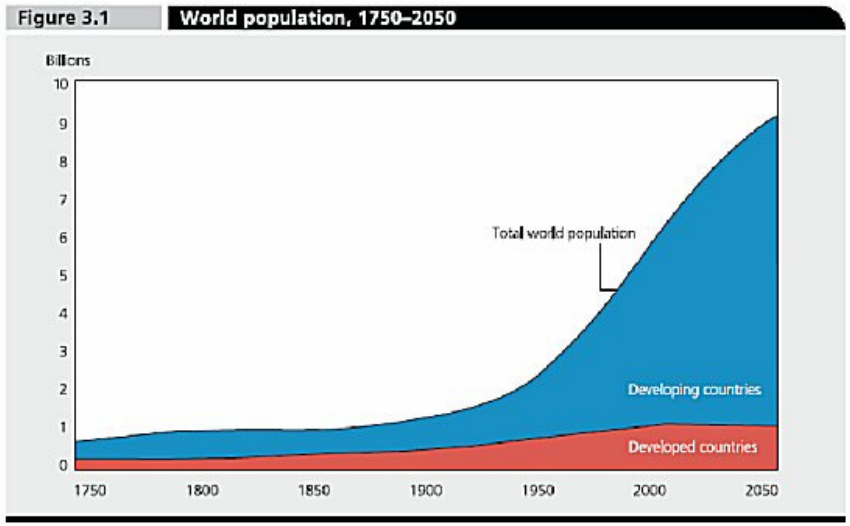
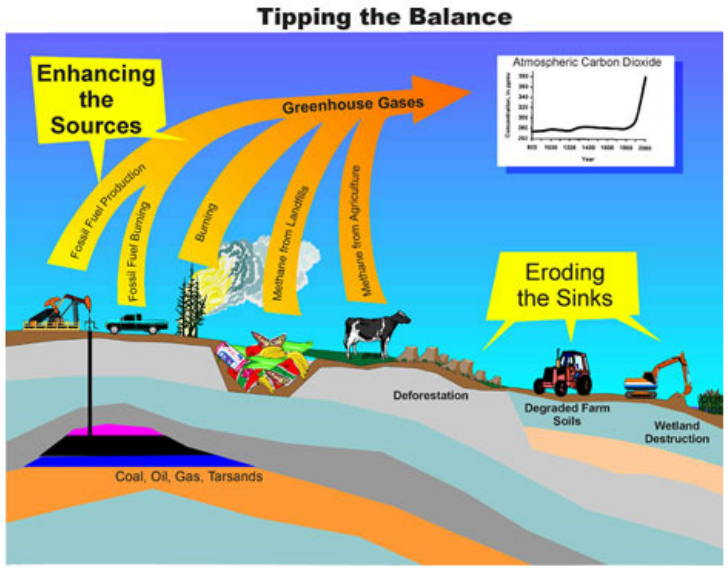
AWCI-Training Program, Pakistan, Sep. 16^{5h} -17th , 2014

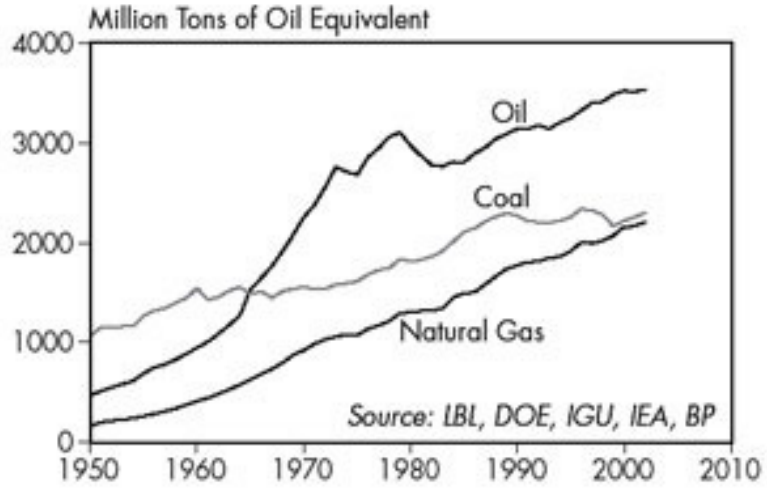
THE UNIVERSITY OF TOKYO

REEL

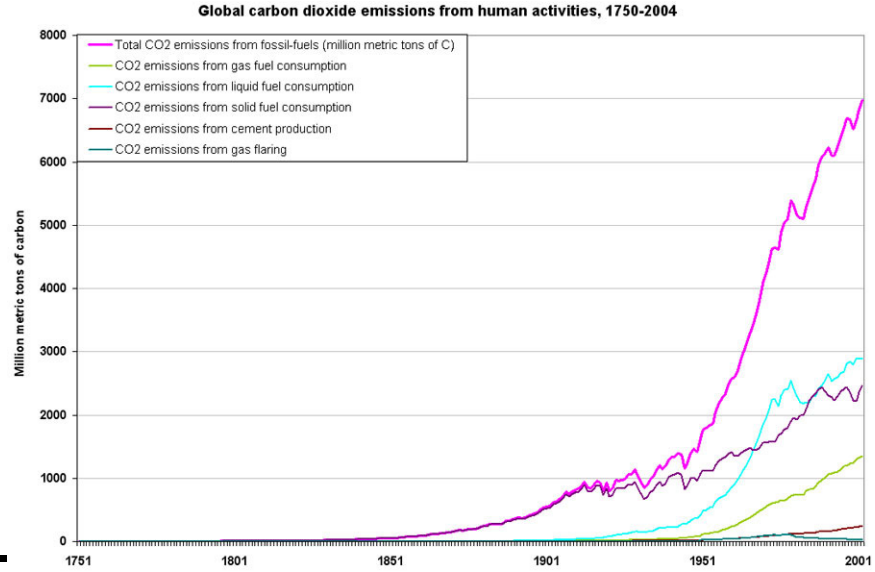
Tipping the Balance & What will happen next?







World Fossil Fuel Consumption by Source, 1950–2002



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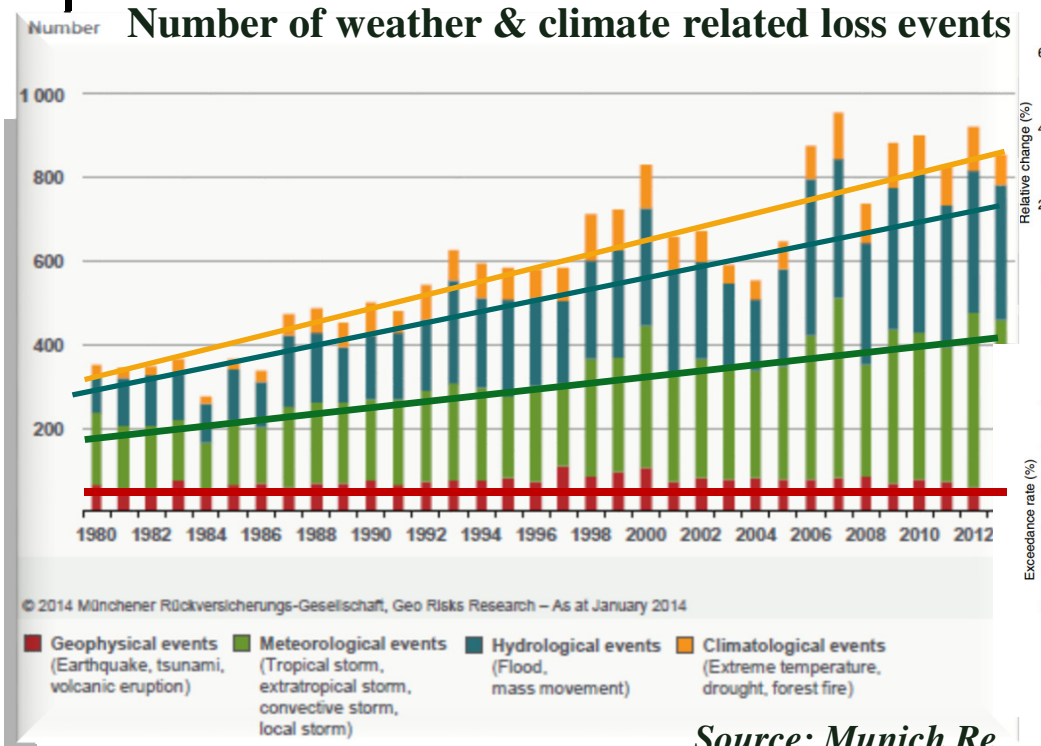
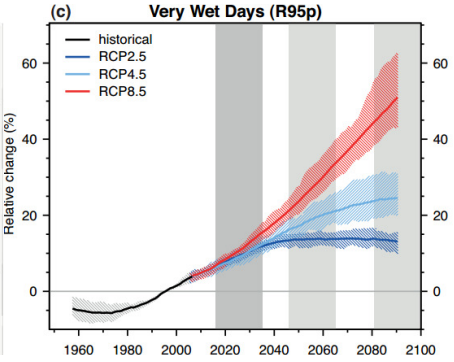
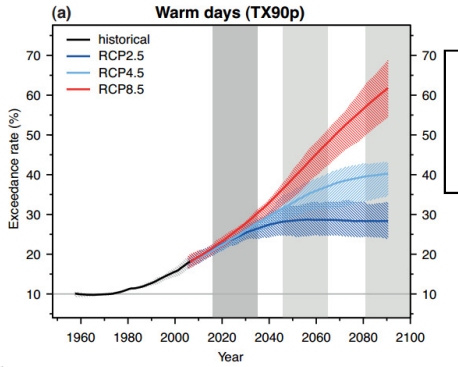
Background



Source: Munich Re



The frequency and intensity of heavy precipitation events will increase (very likely)



heat waves would be intense, frequent and last longer (very likely)

IPCC-AR5

very likely to keep continue the trend !!!

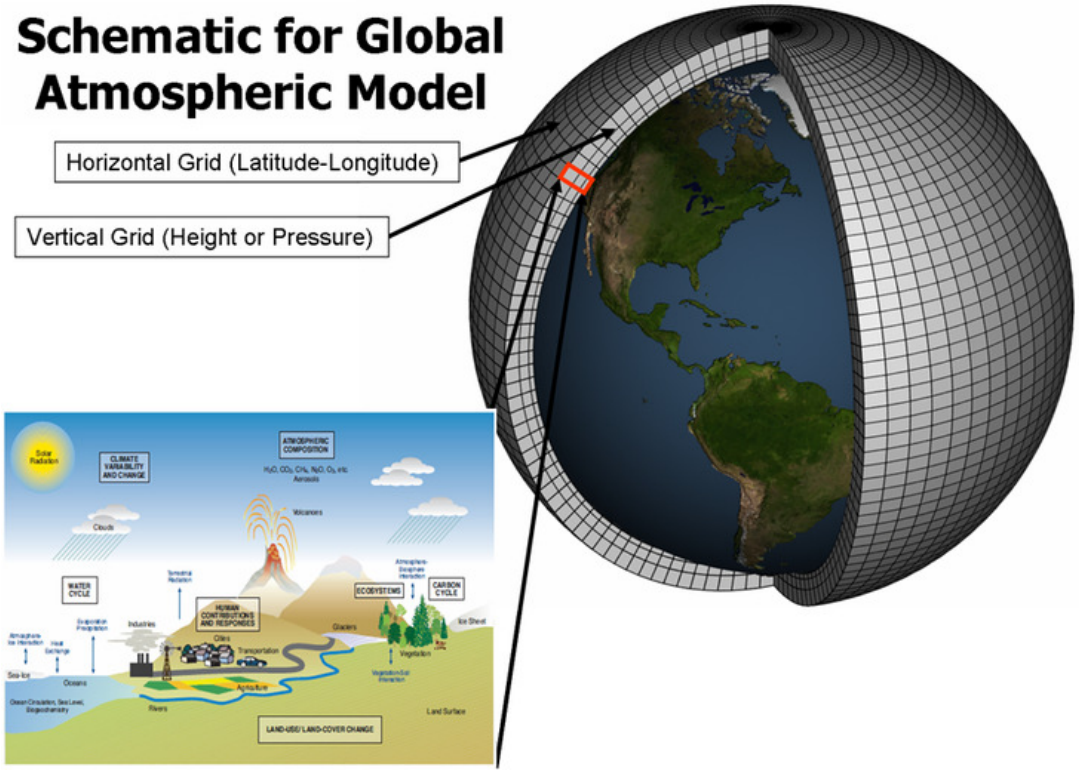
- **Improving understanding and downscaling/prediction capabilities of meteorological, hydrological, and climatological events, will improve our resilience and adaptation mearsures, reduce risks and damages, and bring several social and economic benefits.**

GCMs – Fundamental tool for weather & climate

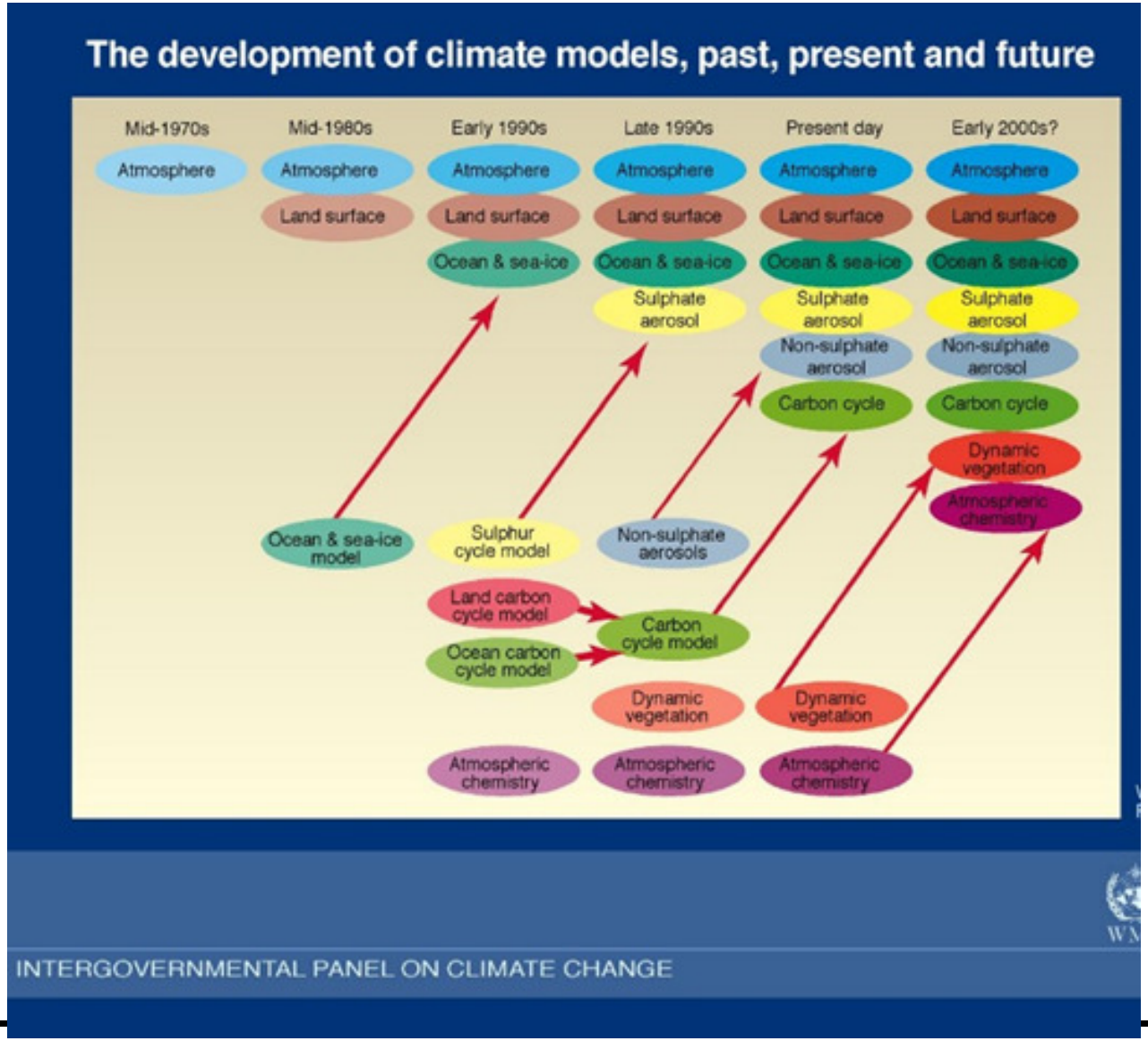
A General Circulation Model (GCM) is a mathematical model of the general circulation of the planet's atmosphere (and oceans) based on mathematic equations that represent physical processes.

The primary earth system components in GCM include the atmosphere, oceans, land surface – including vegetation, and the cryosphere (ice and snow)

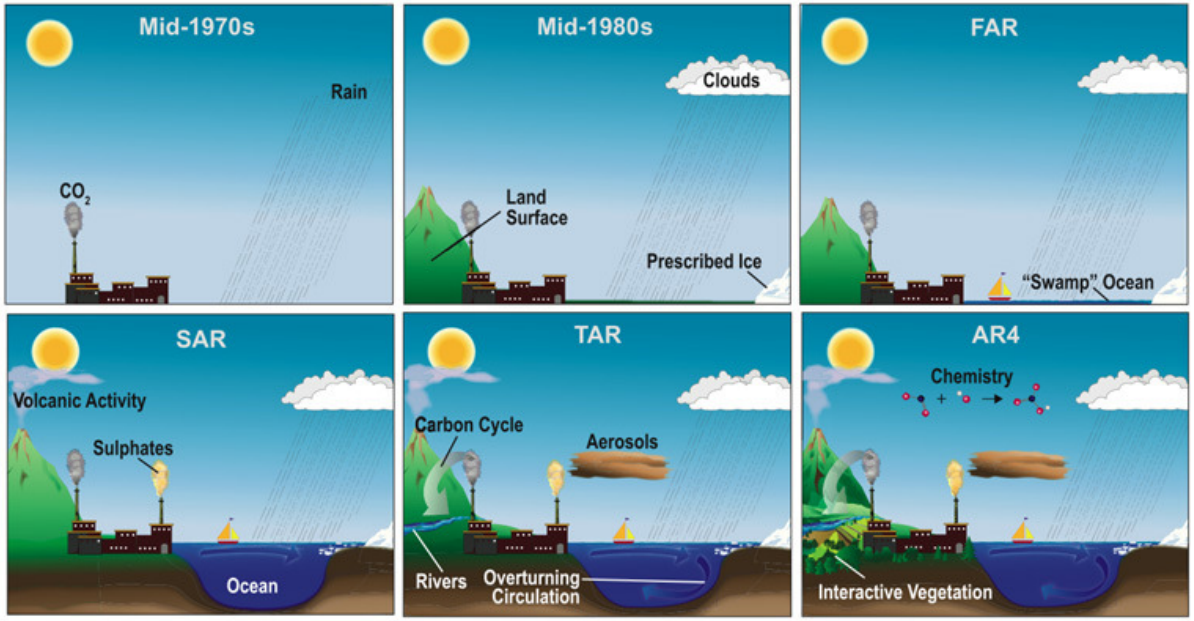
→ more complicated but major hope for reliable results

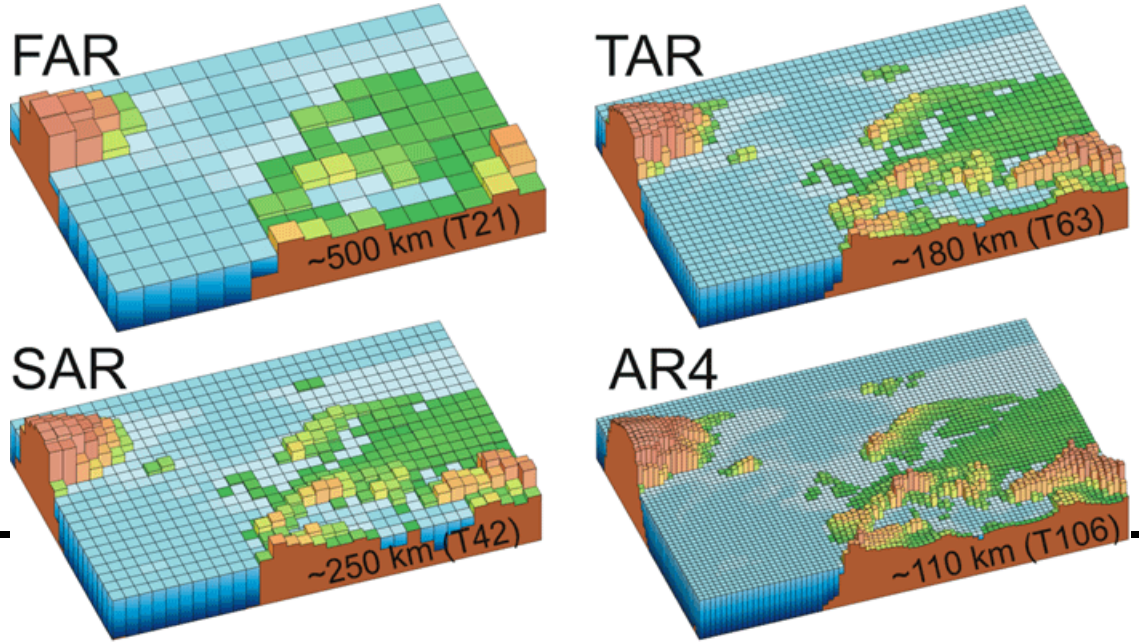


Evolution of GCMs



Evolution of GCMs





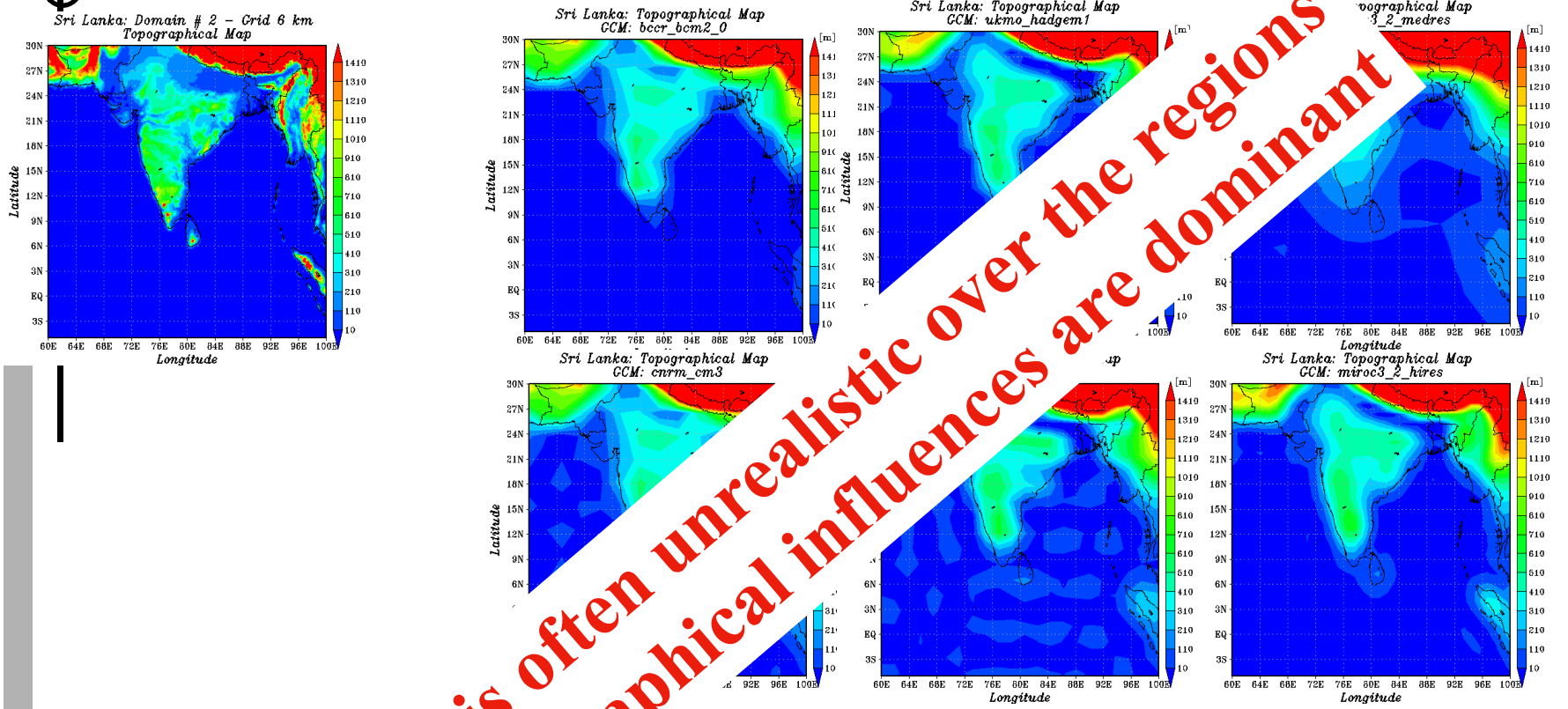
AR4 WG 1 Cha

Bias in CGCM

Biases in GCM output have been attributed to various climate model deficiencies such as

1. **Coarse representation of terrain**
2. **Cloud and convective precipitation parameterization**
3. **surface albedo and vegetation feedback**
4. **representation of land-atmosphere interactions**
5. **--**
6. **---**
7. **---**
8. **---**
9. **---**
10. **--**
11. **so on.**

Topography in GCMs-CMIP3



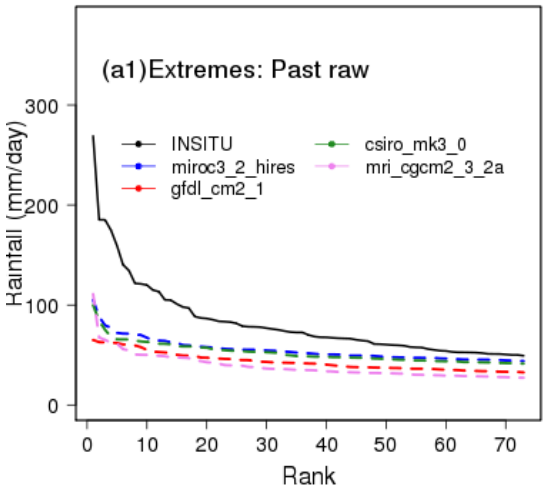
Precipitation is often unrealistic over the regions where the topographical influences are dominant

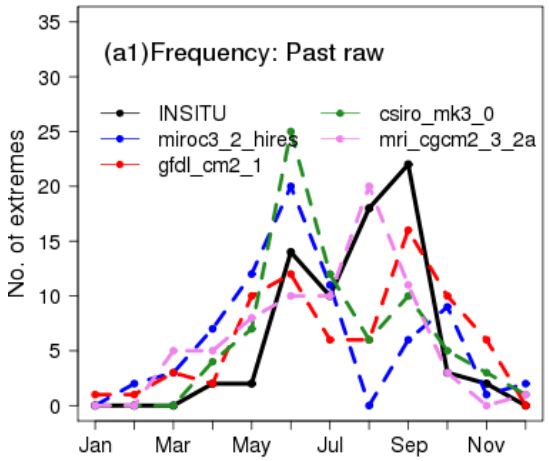
Restricti pography, land use, and land-sea distribution.

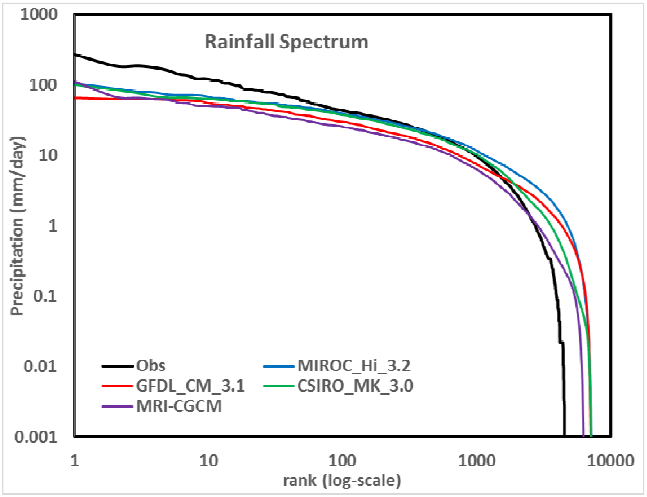
Downscaling approaches

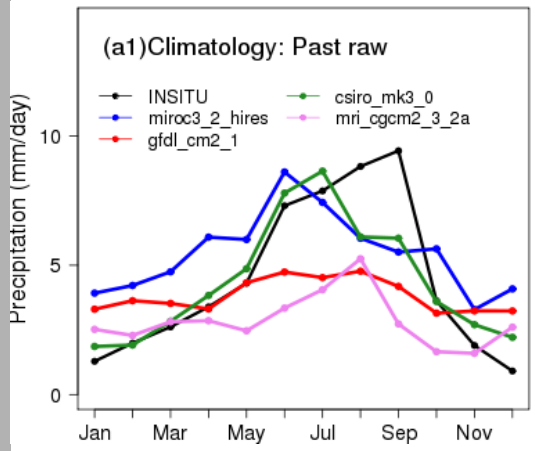
- SD → Derivation of transfer function
  - Low-cost, Site dependent
  - GCM biases greatly influence the downscaled information.
- DD → RCMs & higher resolution datasets to simulate finer-scale processes consistent with larger scale evolution from GCMs.

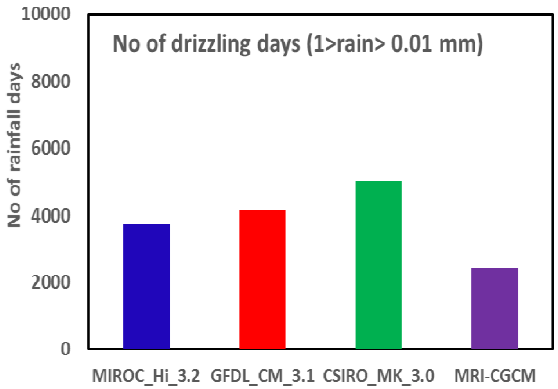
CGCMs rainfall characteristics – Tone River Basin









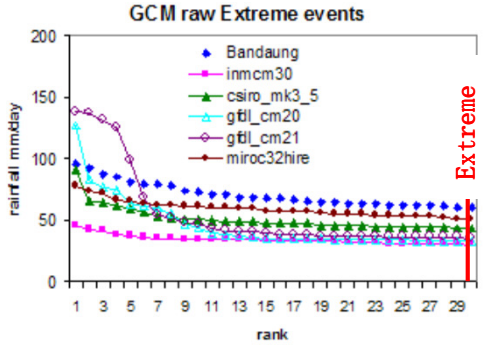
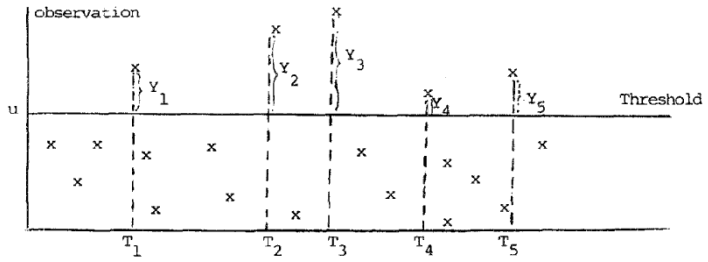
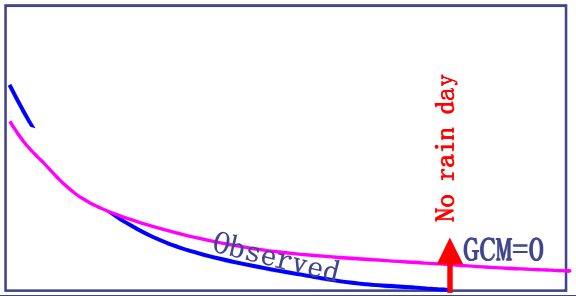
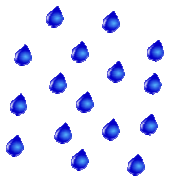
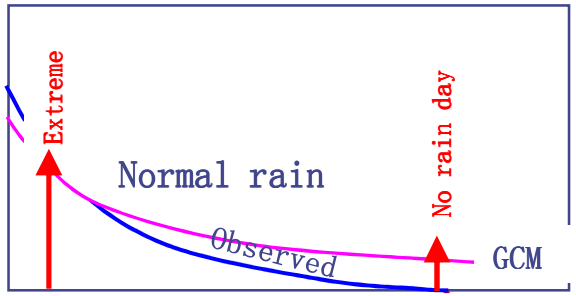
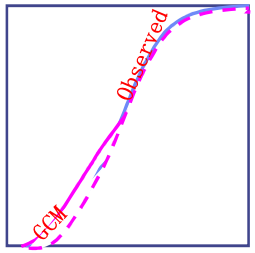


- **Rainfall Biases in the selected CGCMs**
  - **Extreme**
  - **Climatology**
  - **Number of rainfall days**
- **Impact models cannot be forced with the native form of CGCM**

Bias in CGCM

Some of these deficiencies, as persistent model characteristics, would be expected to result in biases in the GCM output that are similar during different historical periods and into the future.

Review: Station Based Statistical Bias correction

Rain Type	Threshold	Correction
Extreme 	- > 99% of daily precipitation during analysis period *- same frequencies of extreme as insitu station as in GCM* 	*Generalized Pareto Distribution* -Non every year statistics -Extreme (long or short tailed) fitting *-Peak over threshold method*  **Fig. 2.** Illustration of threshold model.
No rain day 		Ranking order statistics - *frequency of no rain day in GCM is same as obs.* - less than no rain day threshold change zero rainfall.
Normal 		Gamma Distribution - *monthly CDF of GCM mapping to monthly CDF of station* - inverse of Gamma CDF in each month is corrected rain  ***Tanda et al. 2013, JSCE/AJHE***

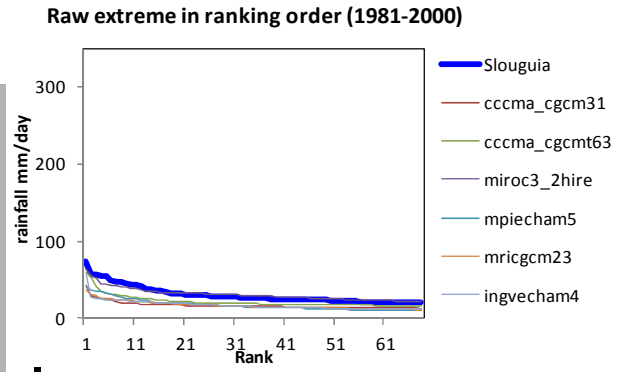
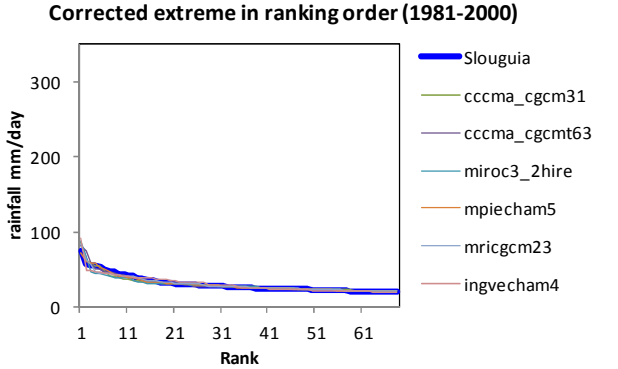
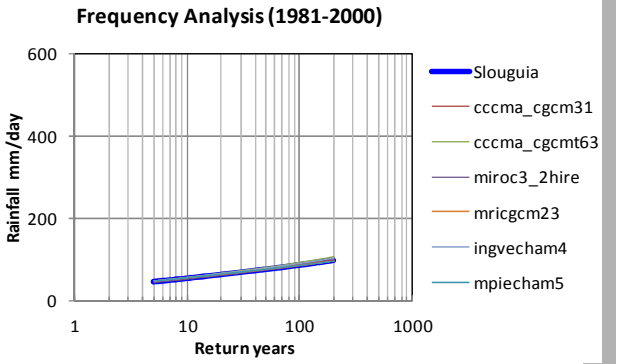
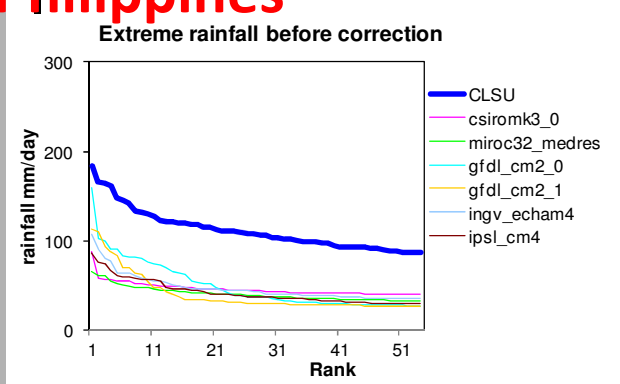
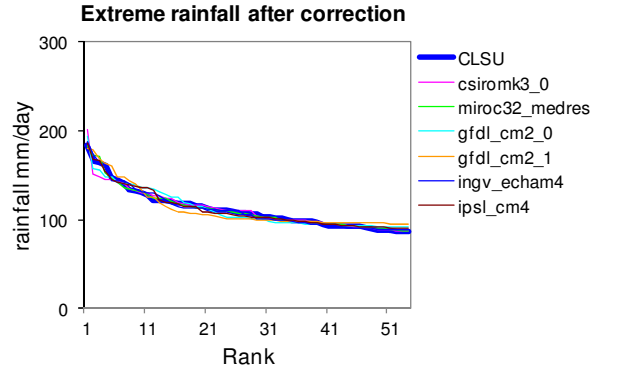
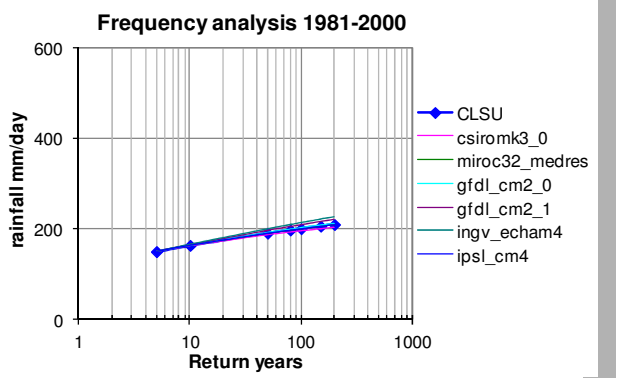
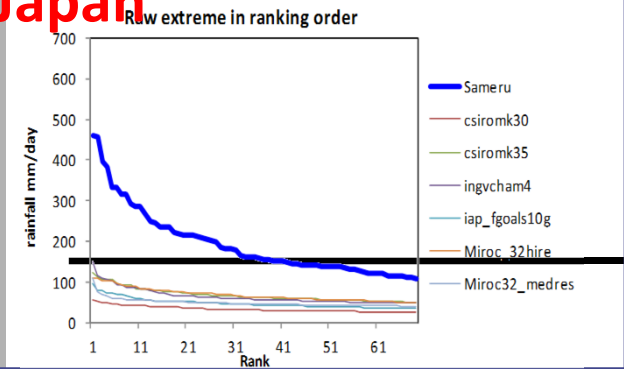
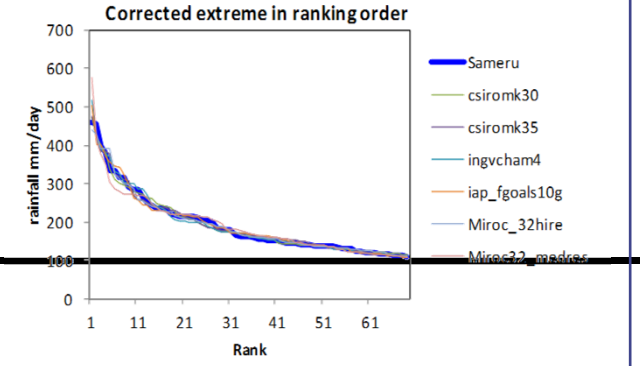
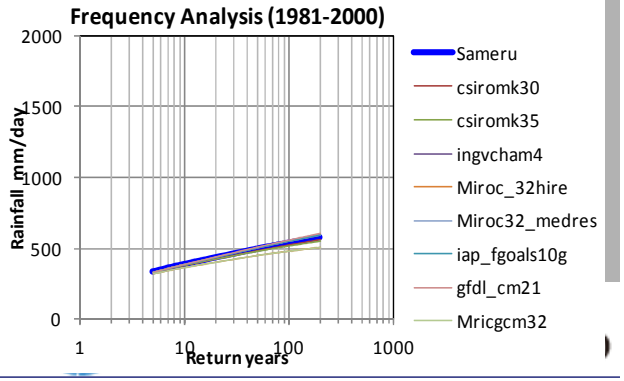
Bias correction: Major Assumptions

Quality of observational dataset limits the quality of bias corrections

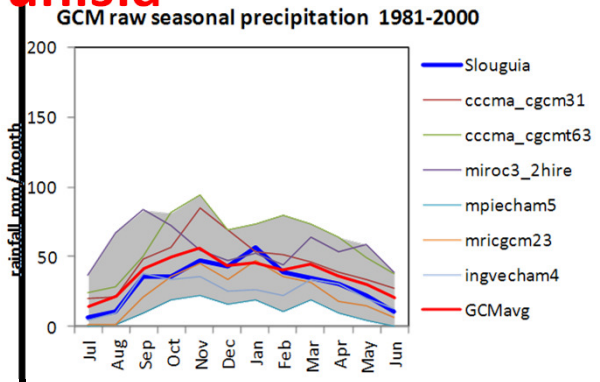
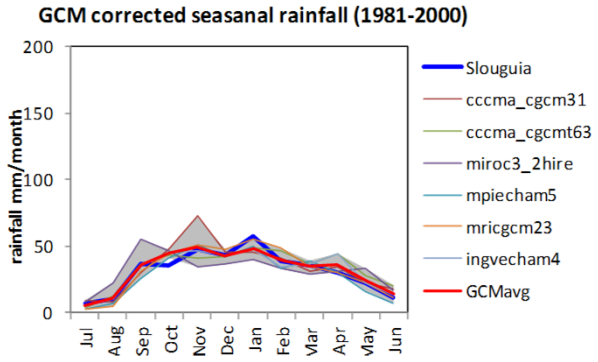
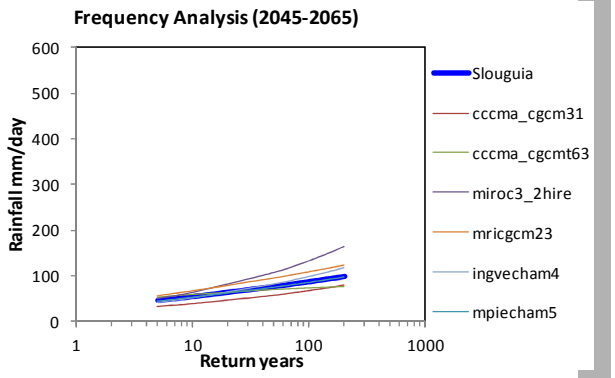
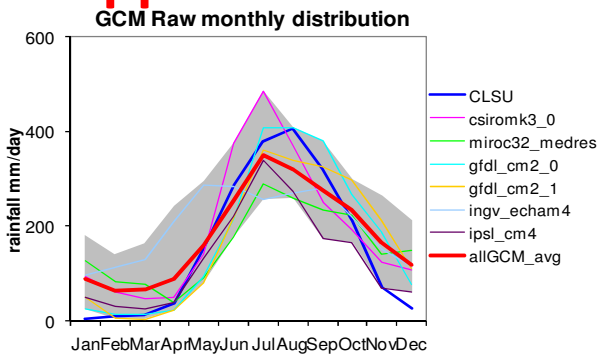
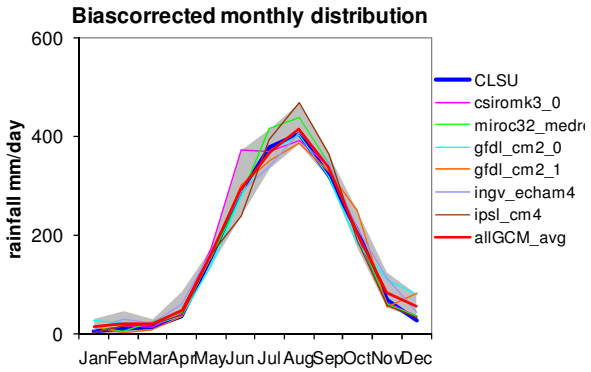
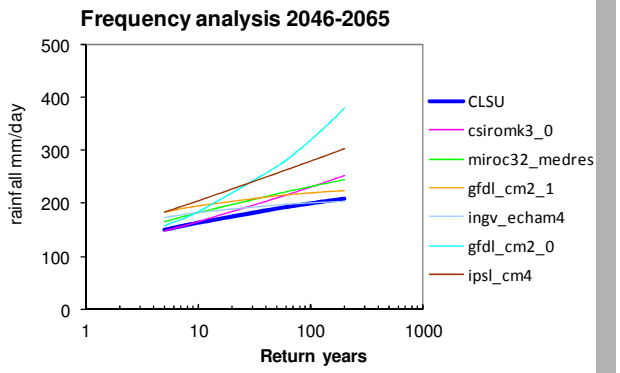
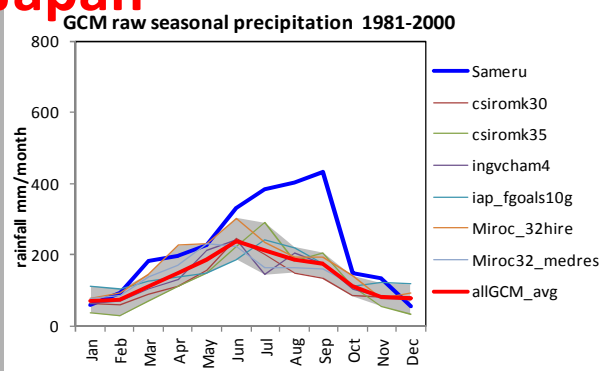
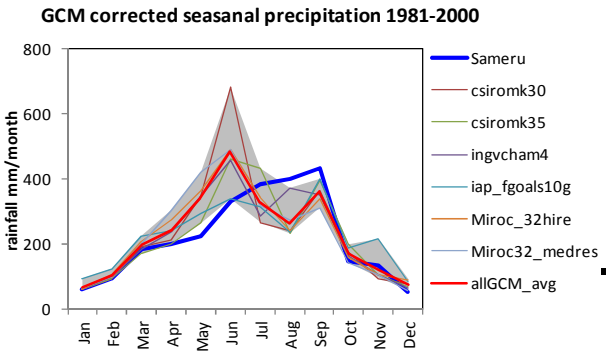
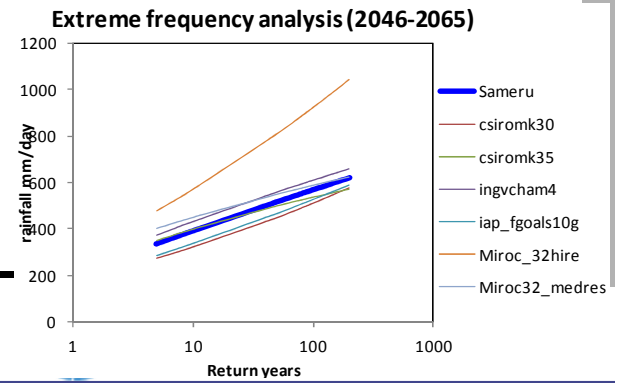
The bias behavior of the model does not change with time, i.e., the transfer function is time independent and thus applicable for future

Limitation: Temporal error major circulation systems can not be corrected, i.e., onset of monsoon

Validation Point Scale (Extremes)

Before Bias-Correction	After Bias-correction	Extreme Frequency Analysis
Tunisia		
		
Philippines		
		
Japan		
		

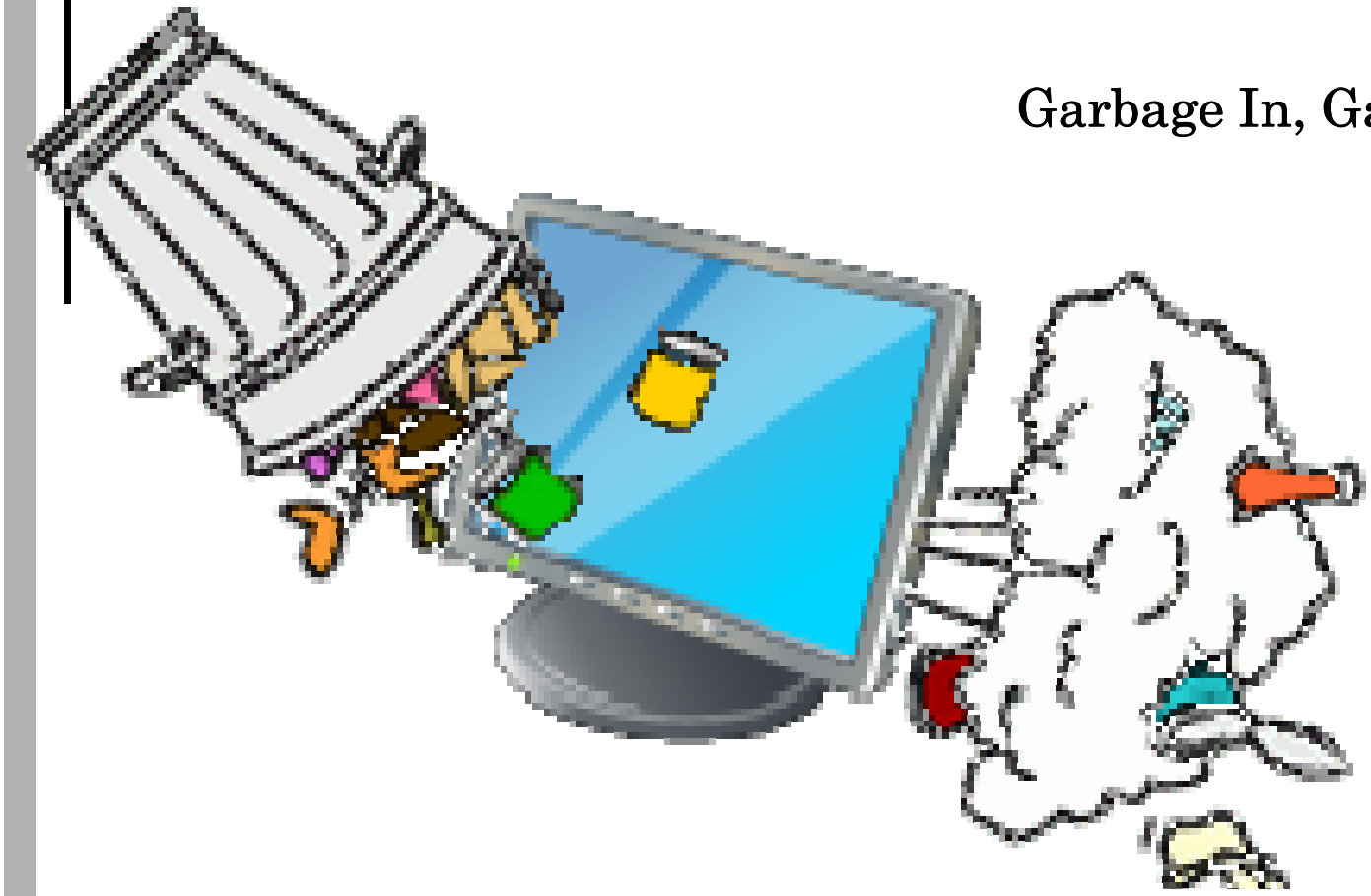
Validation Point Scale (Seasonal)

	Before Bias-Correction	After Bias-correction	Future Extreme Frequency Analysis
Tunisia			
Philippines			
Japan			

Input Data: Accuracy and Completeness

A famous slogan in computing simulation:

Garbage In, Garbage Out



— *Upload data to get better output* —

Data Availability in AWCI Data Archive

#	Country	CCAA Study Basin Name	Identical with AWCI DP basin?	# of Stations.	Obs.	Period (longest period)	Remarks
1	Bangladesh	Meghna	yes	8	Precipitation	1980 - 2000	
2	Bhutan	Punatsangchhu	yes	14	Precipitation	1985 - 2010	
3	Cambodia	Sangker	yes	5	Precipitation	1981 - 2008	
4	India	Upper Bhima	no	36 17 10	Precipitation Discharge Temperature	1970 - 2006 1973 - 2007 1985 - 2002	
5	Indonesia	Citarum	no	116	Precipitation	1980 - 2009	
6	Japan	Tone	yes	4	Precipitation	1901 - 2000	
7	Korea	Upper Chungju-dam	yes				
8	Lao PDR	Sebangfai	yes				
9	Malaysia	Langat	yes	19	Precipitation	1980 - 2000	
10	Mongolia	Tuul	no	8	Precipitation	1980 - 2000	
11	Myanmar	Shwegyin	yes	3	Precipitation	1980 - 2000	
12	Nepal	Narayani	no	51	Precipitation	1957 - 2010	
13	Pakistan	Hunza	no	2	Precipitation	1999 - 2008	
14	Philippines	Pampanga	yes	3 6	Precipitation AWS	1961 - 2000 1961 - 2011	
15	Sri Lanka	Kalu Ganga	yes	8	Precipitation	1980 - 2010	
16	Thailand	Mae Wang	yes	6	Precipitation	1921 - 2011	
17	Uzbekistan	Chirchik-Okhangaran	yes	11	*Precipitation*	1979 - 2005	
18	Vietnam	Huong	yes	9	Precipitation	1976 - 2009	

Bias Correction & Downscaling Scheme

GCM gridded data

Spatial Disaggregation

Insitu rainfall

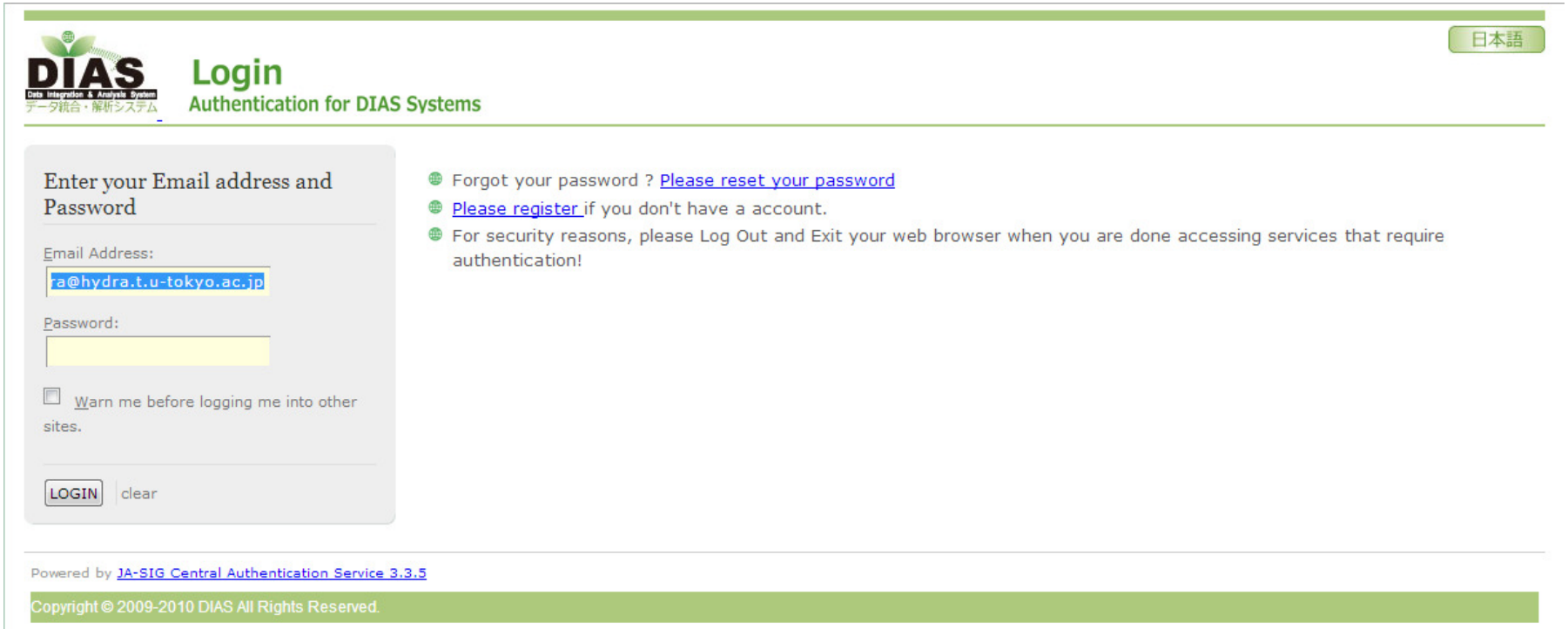
Bias corrected
GCM Precipitation
At stations

IDW interpolation

Bias corrected and
downscaled GCM
precipitation

Engineer--one who makes the life comfortable

Log-In to the DIAS



Log-In to the DIAS

dias.tkl.iis.u-tokyo.ac.jp/model-eval/stable/index.html

Quantitative Evaluation of AOGCM *** Release 1.2 : New functions added (17/June/2013)

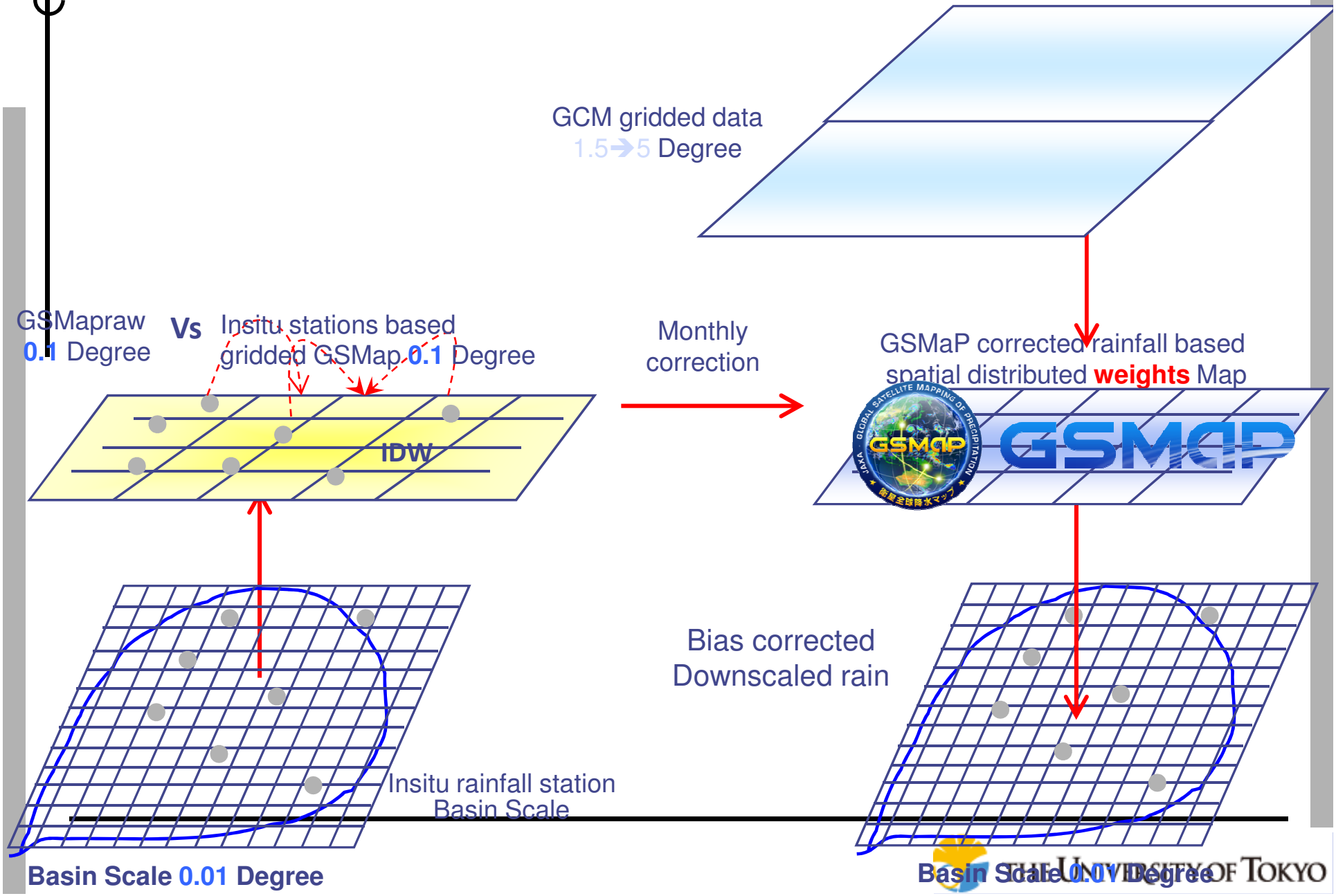
1. Intercomparison : Re-analysis/Observation Data vs. CMIP3 Model Output
   - 1-D Plot (time-series)
   - 2-D Plot
   - Vector Diagram
   - Cross-sectional View
     - Longitude/Latitude-Time , Longitude/Latitude-Height
   - Vertical Profile
     - 1-D Plot , Vector Diagram
2. Comparison of Global Warming Projection between:
   - Climate Models
   - Emission Scenarios
   - Periods of Analysis Time (Multimodel Ensemble Prediction)
     - Daily Data , Monthly Data
3. Tools for CMIP3
   - Bias Correction (AWCI training program participants only)
     - APHRODITE , In-situ Data
   - Data Download
     - Daily Data , Monthly Data
   - Model Evaluation
     - Monthly Data (Restricted Access)

Basin Boundary Information

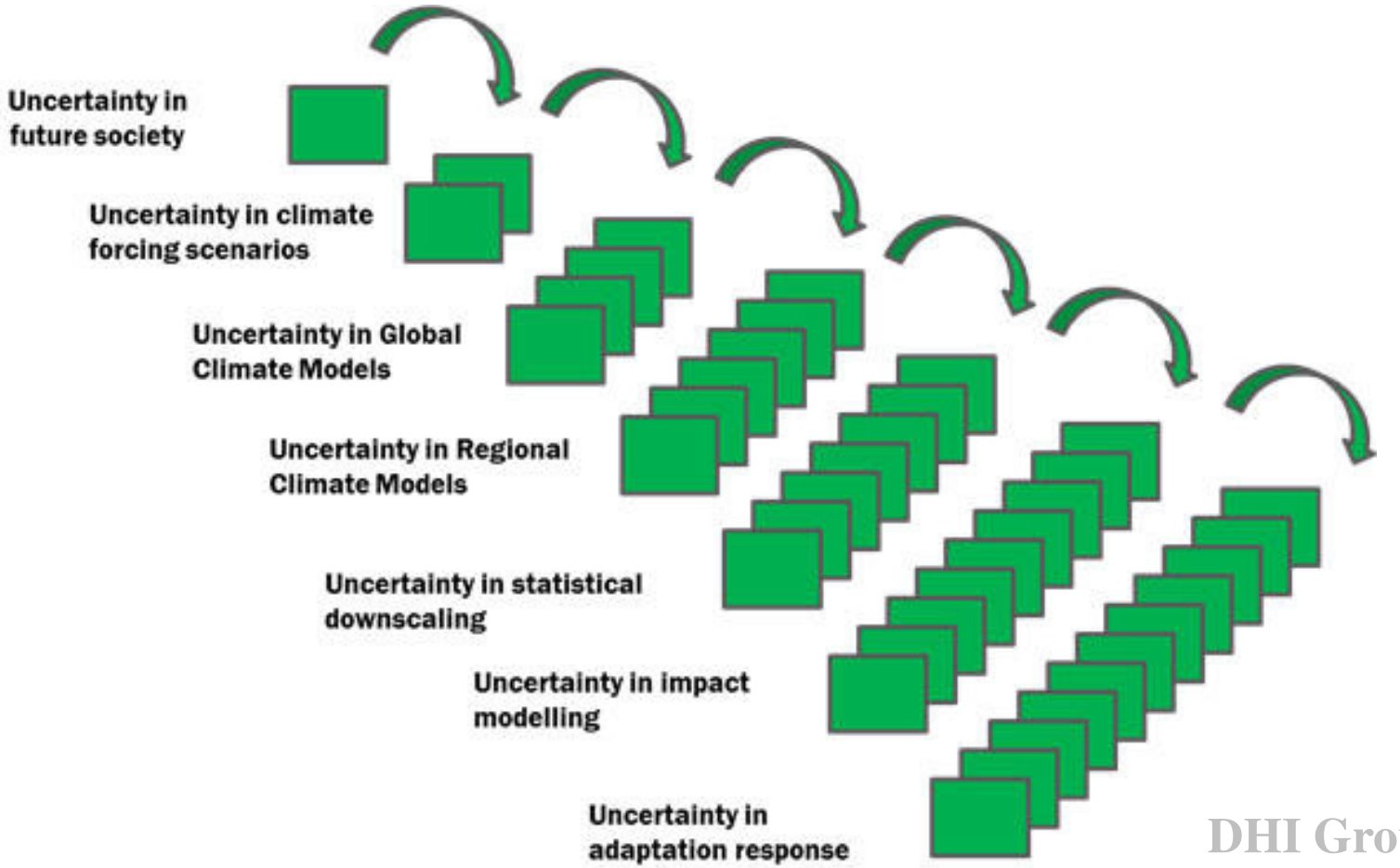
Country	Basin lon-lat (approx)
Bangladesh-**A**	23-26N, 90-95E
Bhutan-**S**	26-30N, 89-91E
Cambodia-**P**	12-14N, 102-104E
India	N/A
Indonesia-**P**	6-8S, 107-108E
Japan-**S**	36-38N, 138-140E
Malaysia-**A**	2-4N, 101-104E
Mongolia-**S**	46-50N, 102-109E
Myanmar-**A**	17-19N, 96-98E
Nepal-**S**	27-30N, 82-86E
Pakistan-**A**	35-38N, 74-76E
Philippines-**P**	15-17N, 120-122E
Sri Lanka-**A**	6-8N, 79-81E
Thailand-**P**	16-21.5N, 96-101E
Uzbekistan	40-43N, 69-72E
Vietnam-**P**	15-17N, 107-108E

-Thank You-

GSMAP--Monthly Downscaling Scheme



Uncertainty Cascade



The uncertainty cascade in climate change impact assessment and adaptation analysis

Bias correction: Major Assumptions

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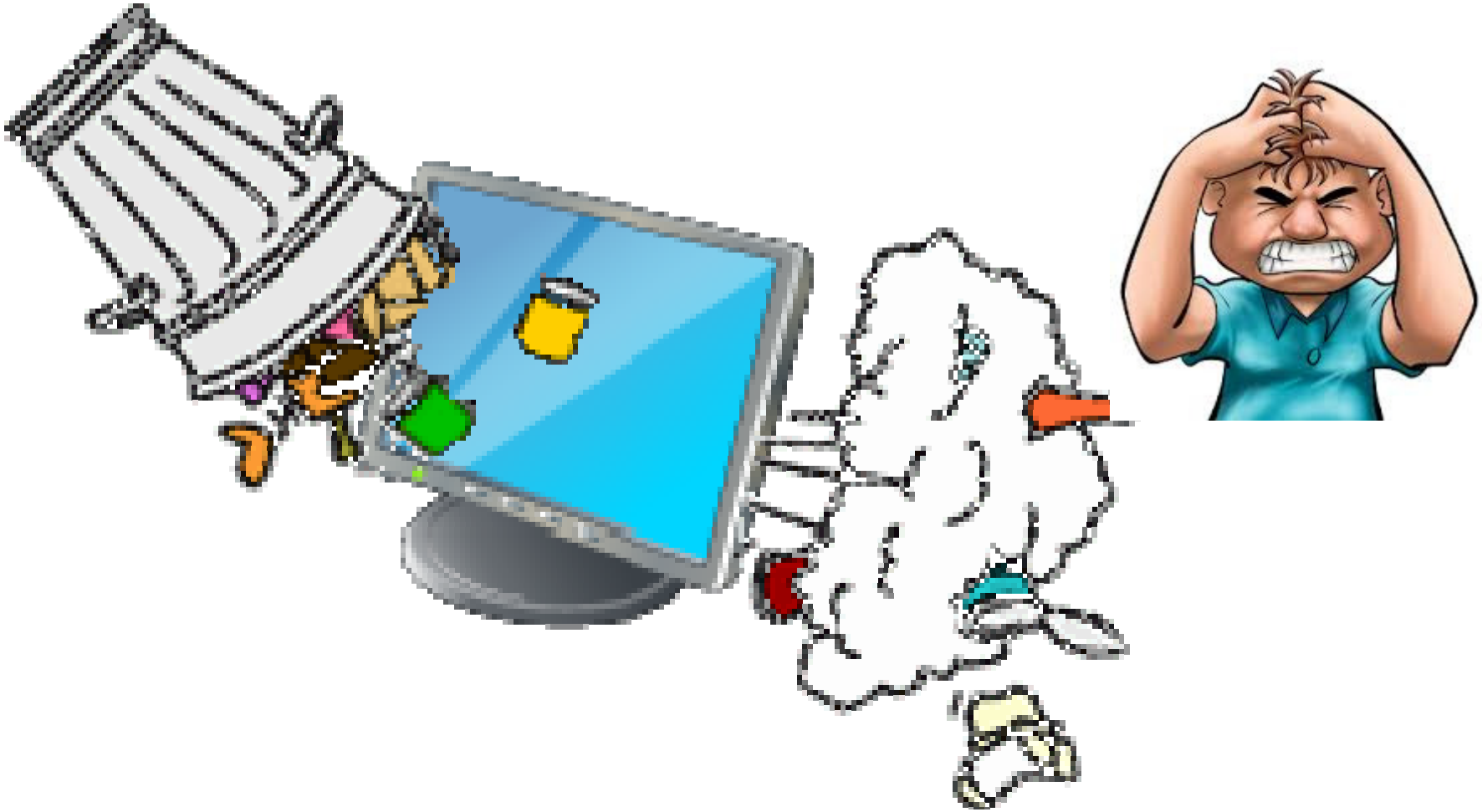
The bias behavior of the model does not change with time, i.e., the transfer function is time independent and thus applicable for future

Limitation: Temporal error major circulation systems can not be corrected, i.e., onset of monsoon

Input Data: Accuracy and Completeness



Please upload data to get better output