Climate scenarios for impact assessment and adaptation planning

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Acknowledgement

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- HICAP Project
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CICERO
Center for International Climate and Environmental Research - Oslo

UNEP GRID ARENDAL
Environmental Knowledge for Change

International Centre for Integrated Mountain Development (ICIMOD)

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Programmes

- Adaptation to change
- Transboundary Landscape
- River Basins
- Cryosphere and Atmosphere
- Mount Information System

- Intergovernmental International organization working in the Hindu Kush-Himalayan Region
- Established in 1983

Contents

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- Introduction
- Downscaling techniques
- Results of GCM downscaling
- Conclusions

INTRODUCTION

Himalayan Climate Change Adaptation Programme

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1. **Climate change scenarios**
2. Water availability and demand scenarios
3. Ecosystem services
4. Food security
5. Vulnerability and adaptation
6. Women in adaptation
7. Communications and outreach

CLIMATE CHANGE SCENARIOS

Climate change scenarios

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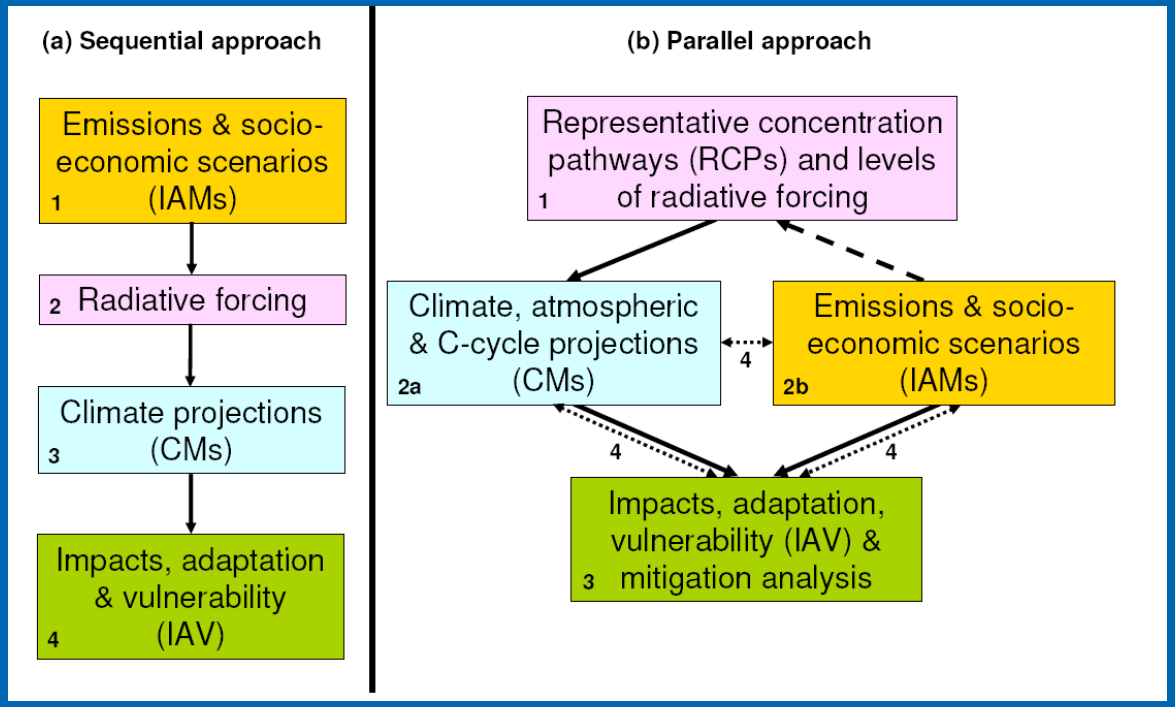
Different approach to climate change projections
5th assessment report (AR5) IPCC



AR4 **AR5**

Climate change scenarios

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Use two representative concentration pathways (RCP)

- RCP8.5 (8.5 W/m2 in 2100) → extreme
- RCP4.5 (4.5 W/m2 in 2100) → less extreme

Forcing regional and global circulation models until 2050

- RCM Bjerknes Center for Climate Research
- 4 GCMs spanning entire range of possible futures:
  - Dry & cold
  - Dry & warm
  - Wet & cold
  - Wet & warm

Total 2 RCPs x 5 models = 10 sets of climate projections

DOWNSCALING APPROACHES

Downscaling GCMs

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Goal: Connect global scale predictions to regional climate

- Dynamic downscaling: Nesting regional climate model (RCM) into existing GCM
    - RCM boundary conditions are obtained from GCM
- Statistical downscaling
    - Linking local variables to variables in GCM using statistical regressions or empirical relations

Statistical downscaling techniques

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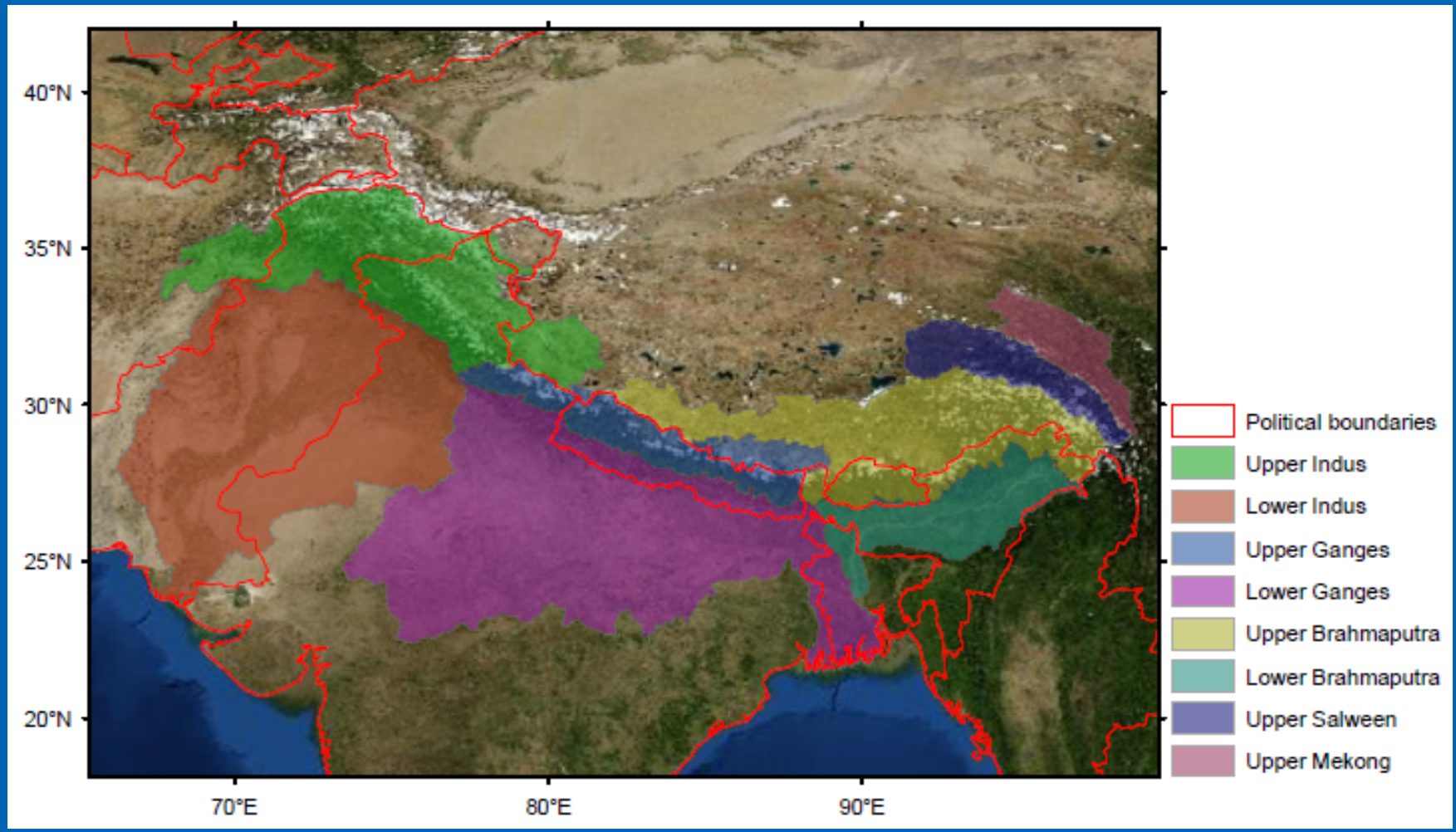
- Delta change approach
  - Changes in climate projected by GCM superimposed on high resolution reference climate data
  - Simple: Assume linear change
- More sophisticated:
  - Advanced delta method (e.g. *van Pelt, HESS, 2012*)
  - Quantile mapping (e.g. *Themeßl, Climatic Change, 2011*)

APPROACH


40°N
35°N
30°N
25°N
20°N
70°E
80°E
90°E
Political boundaries
Upper Indus
Lower Indus
Upper Ganges
Lower Ganges
Upper Brahmaputra
Lower Brahmaputra
Upper Salween
Upper Mekong

Selection of GCMs

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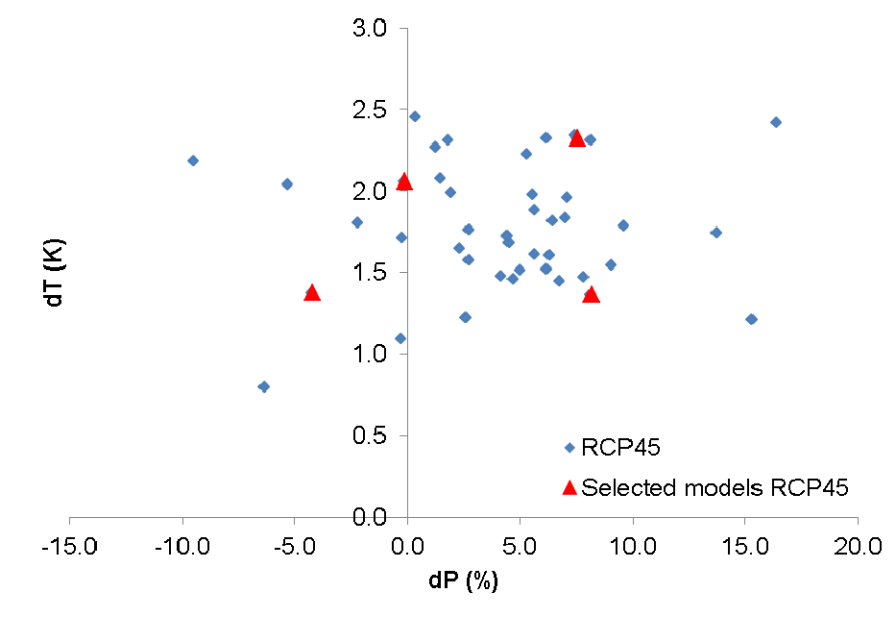
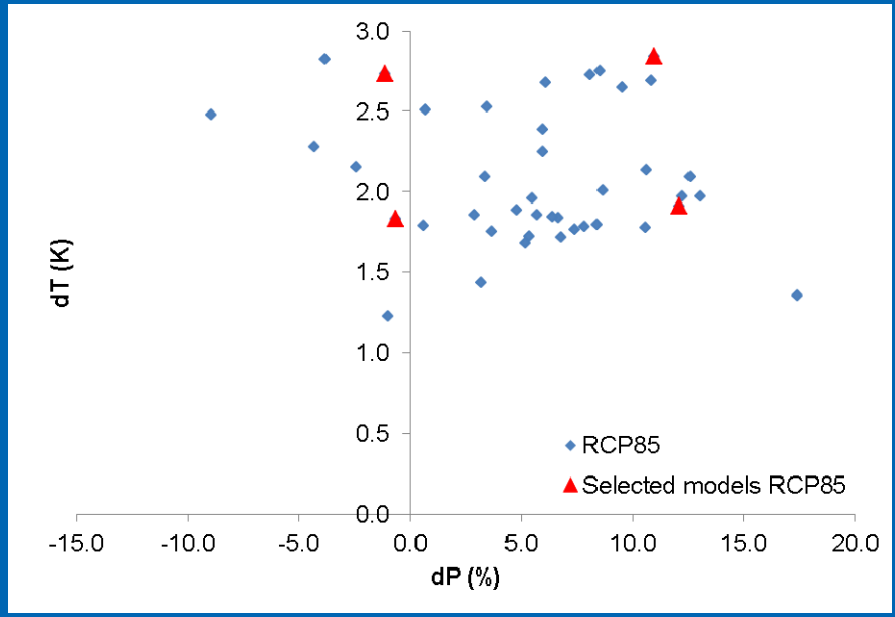
- 43 model runs analysed for RCP 4.5
- 41 model runs analysed for RCP 8.5
- For each model run average annual difference in precipitation (%) and temperature (K) determined for total study area (2021-2050 relative to 1961-1990)

RCP 4.5



RCP 8.5



Selection of GCMs

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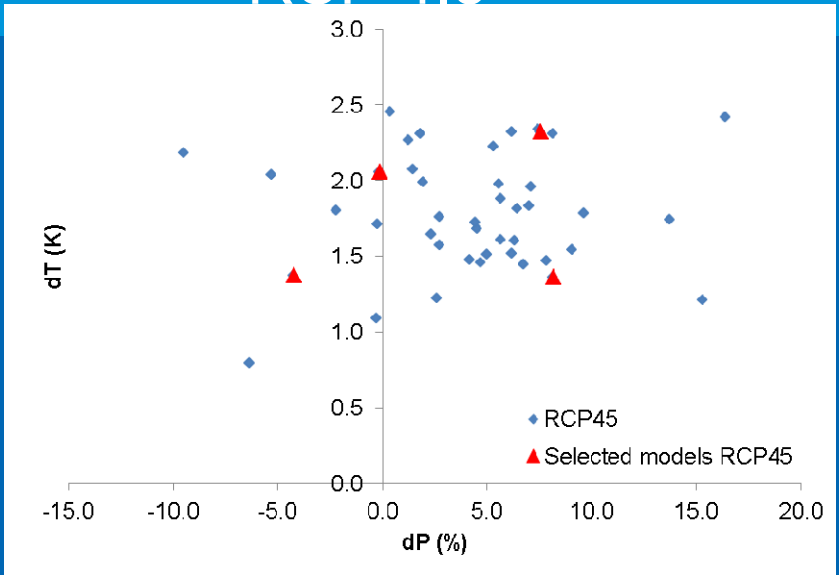
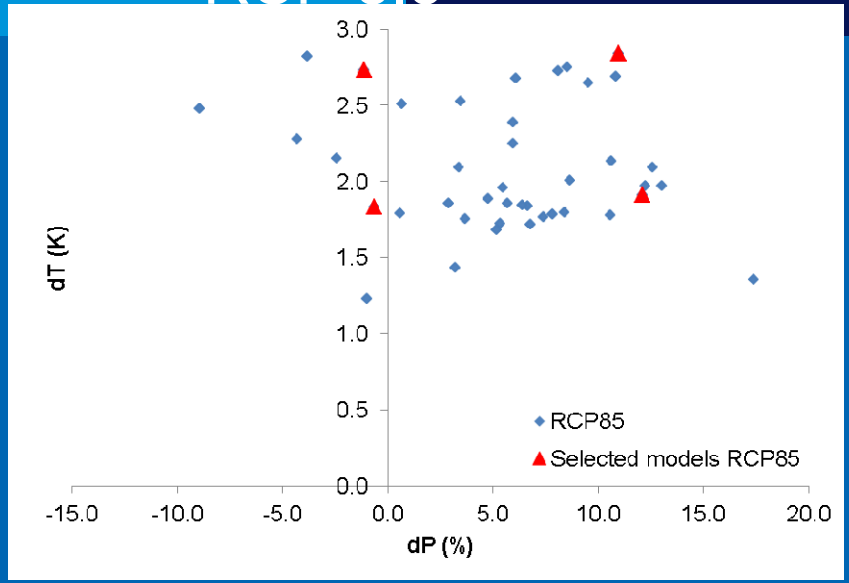
RCP 4.5



RCP 8.5



- Ensemble of models is selected for 4 combinations:
  - Dry, cold
  - Dry, warm
  - Wet, cold
  - Wet, warm
- Selection based on the 10th and 90th percentile values to:
  - include all 4 corners of the projected changes in temperature and precipitation
  - avoid including outliers, which can be unreliable

Climate change scenarios

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Selected models for HICAP with average delta values for entire domain:

Description	RCP	dP (%)	dT (K)	Selected Model
DRY, COLD	RCP45	-1.8	1.4	GISS-E2-R-r4i1p1_rcp45
DRY, WARM	RCP45	-1.8	2.3	IPSL-CM5A-LR-r4i1p1_rcp45
WET, COLD	RCP45	8.9	1.4	CCSM4-r5i1p1_rcp45
WET, WARM	RCP45	8.9	2.3	CanESM2-r4i1p1_rcp45
DRY, COLD	RCP85	-1.1	1.7	GFDL-ESM2G-r1i1p1_rcp85
DRY, WARM	RCP85	-1.1	2.7	IPSL-CM5A-LR-r4i1p1_rcp85
WET, COLD	RCP85	12.1	1.7	CSIRO-Mk3-6-0-r3i1p1_rcp85
WET, WARM	RCP85	12.1	2.7	CanESM2-r4i1p1_rcp85

Delta change approach

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- Final products are monthly delta change grids for the future relative to a reference period
  - Reference period 1961-2000
  - Future period 2021-2050
- Delta change grids reflect the change in temperature (K) and precipitation (%) over 60 years
- Seasonal changes are included by calculating monthly delta values

RESULTS

Basin-averaged ΔT RCP4.5 – 4 GCM mean

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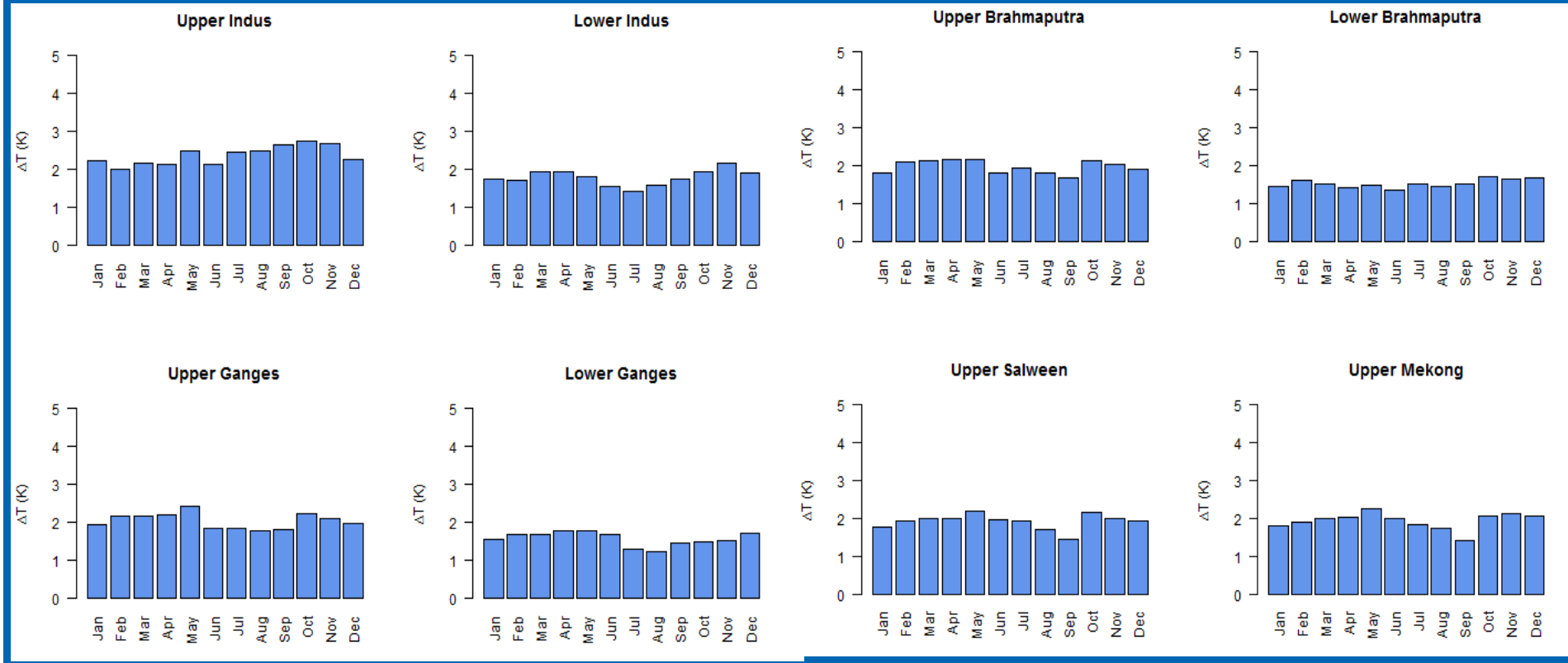

Basin-averaged ΔT RCP8.5 – 4 GCM mean

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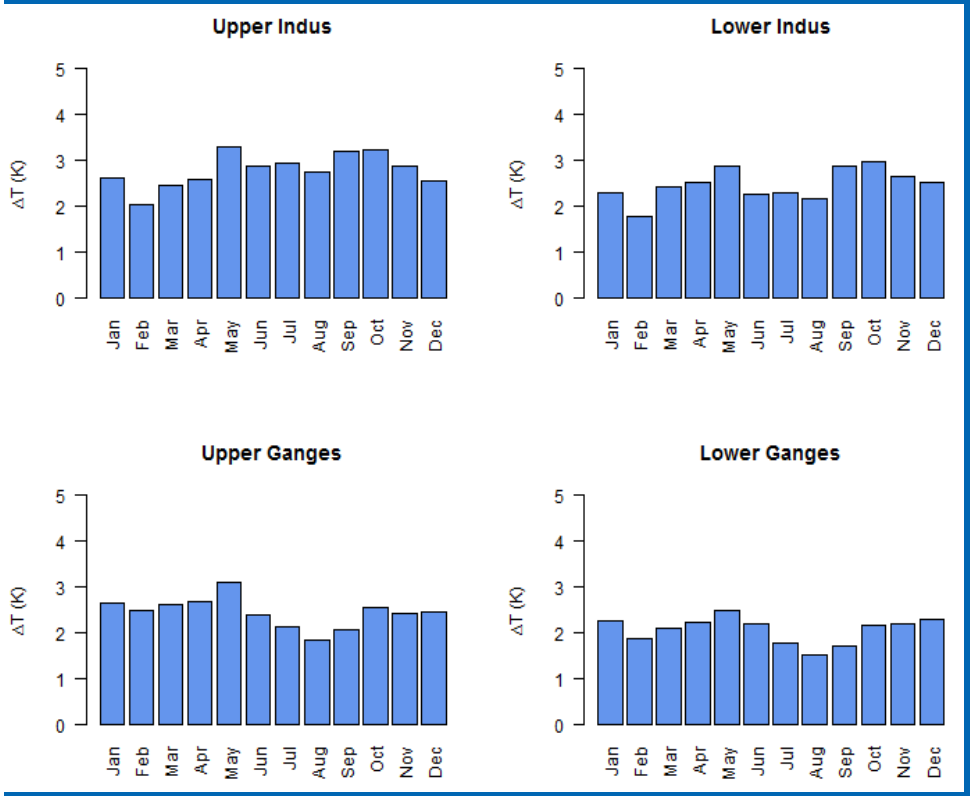

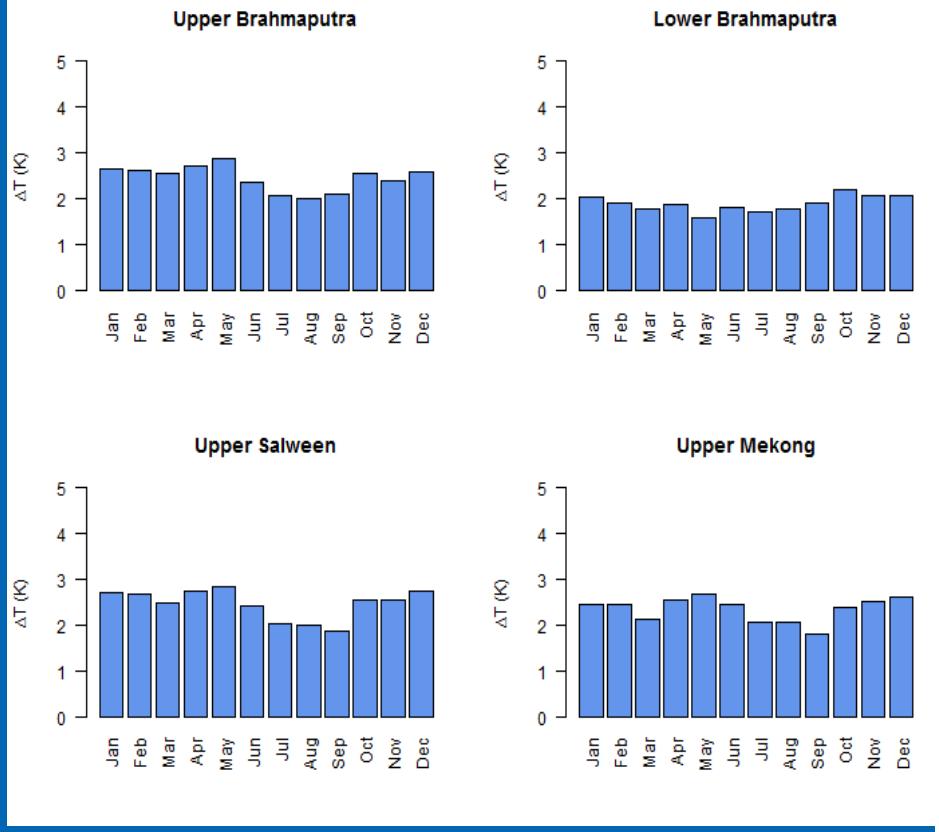

Large variation between GCMs

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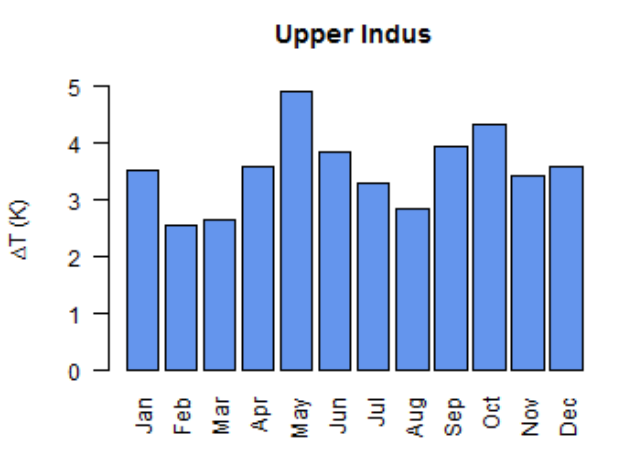
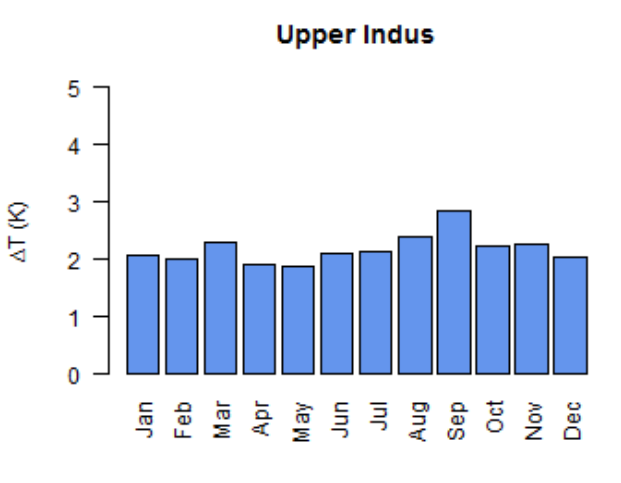
2 GCMs RCP8.5





Basin-averaged ΔP RCP4.5 – 4 GCM mean

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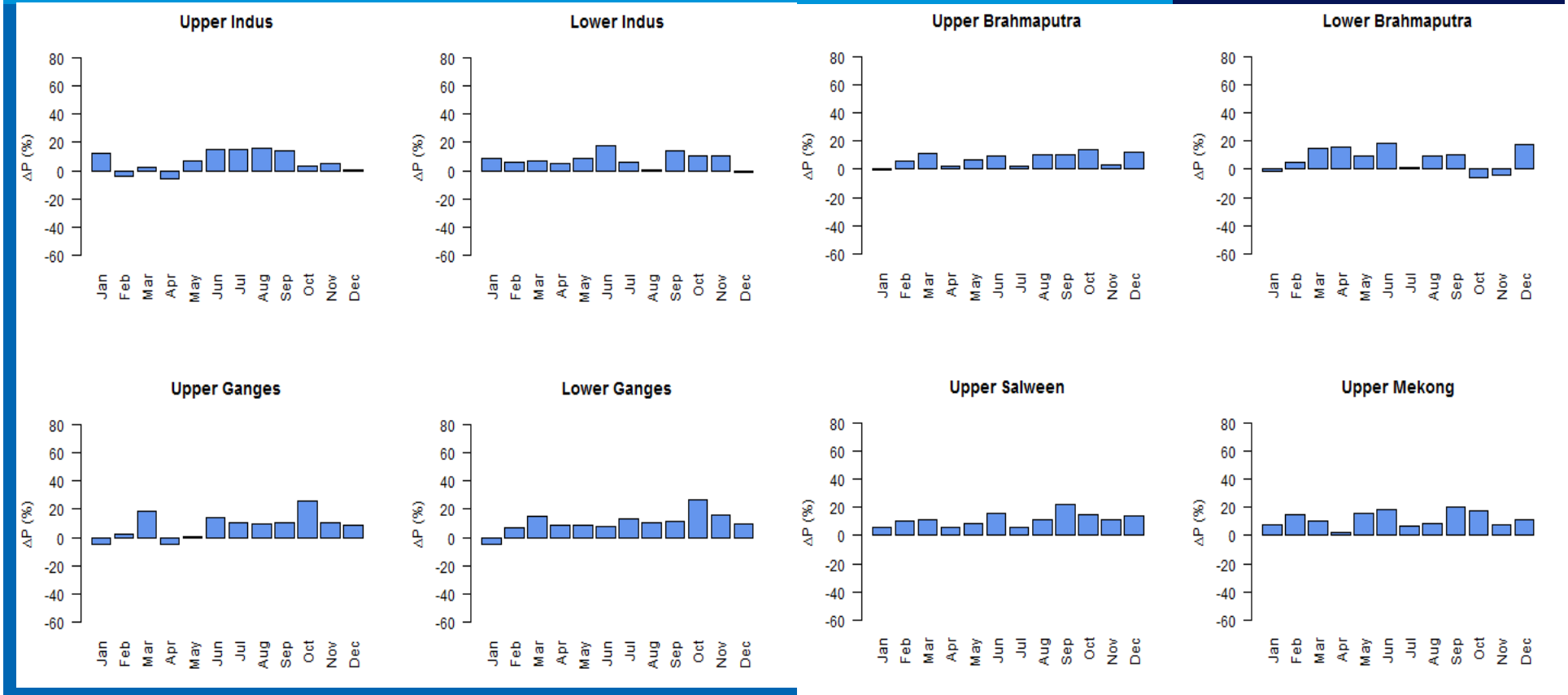

Basin-averaged ΔP RCP8.5 – 4 GCM mean

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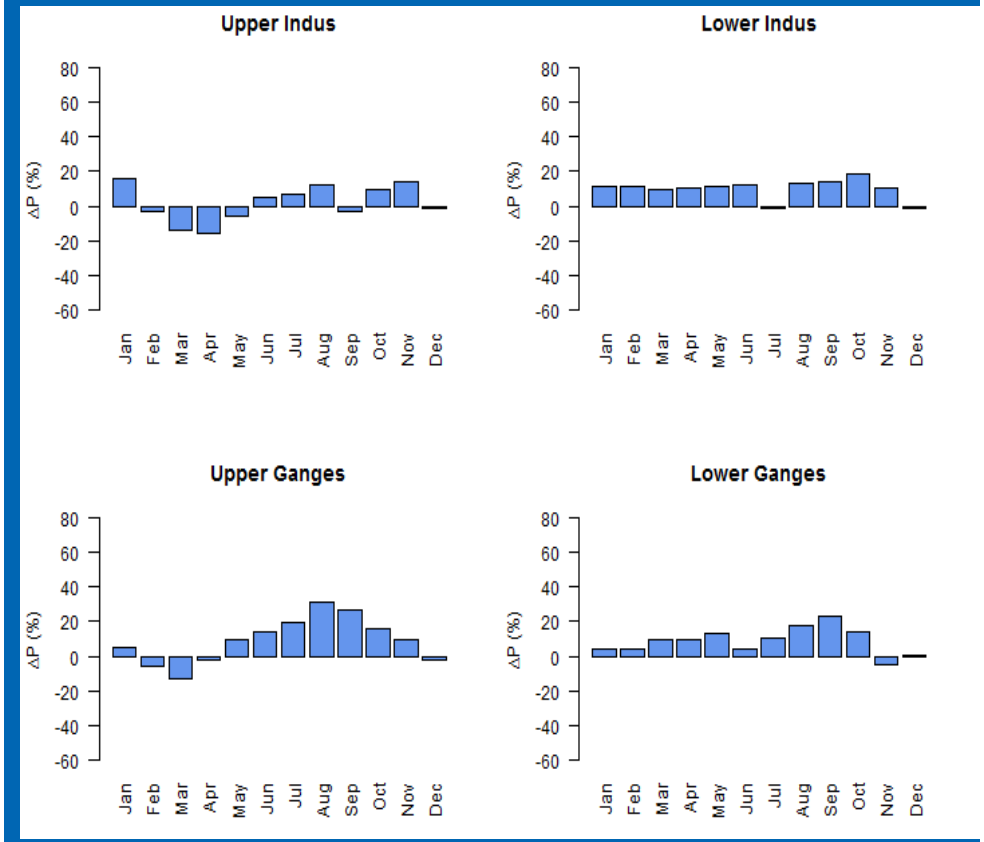

Large variations between GCMs

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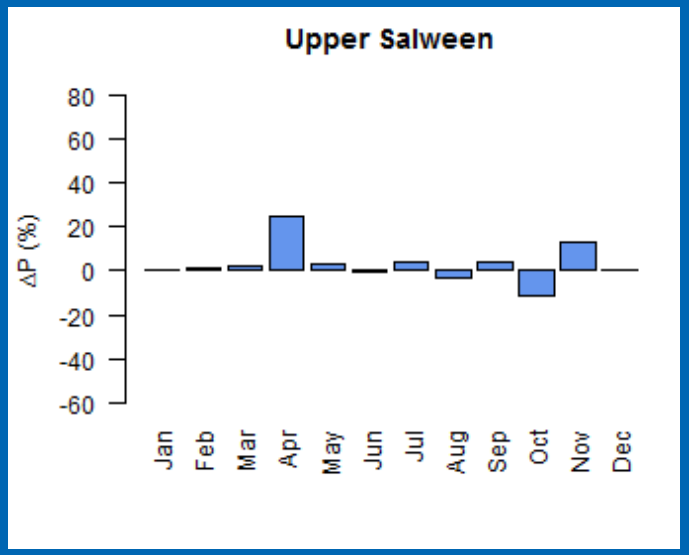
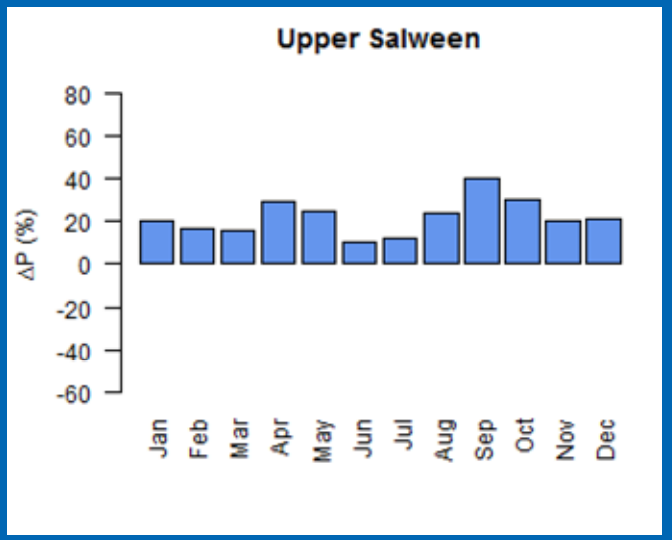
2 GCMs RCP8.5





Strong variation within basins

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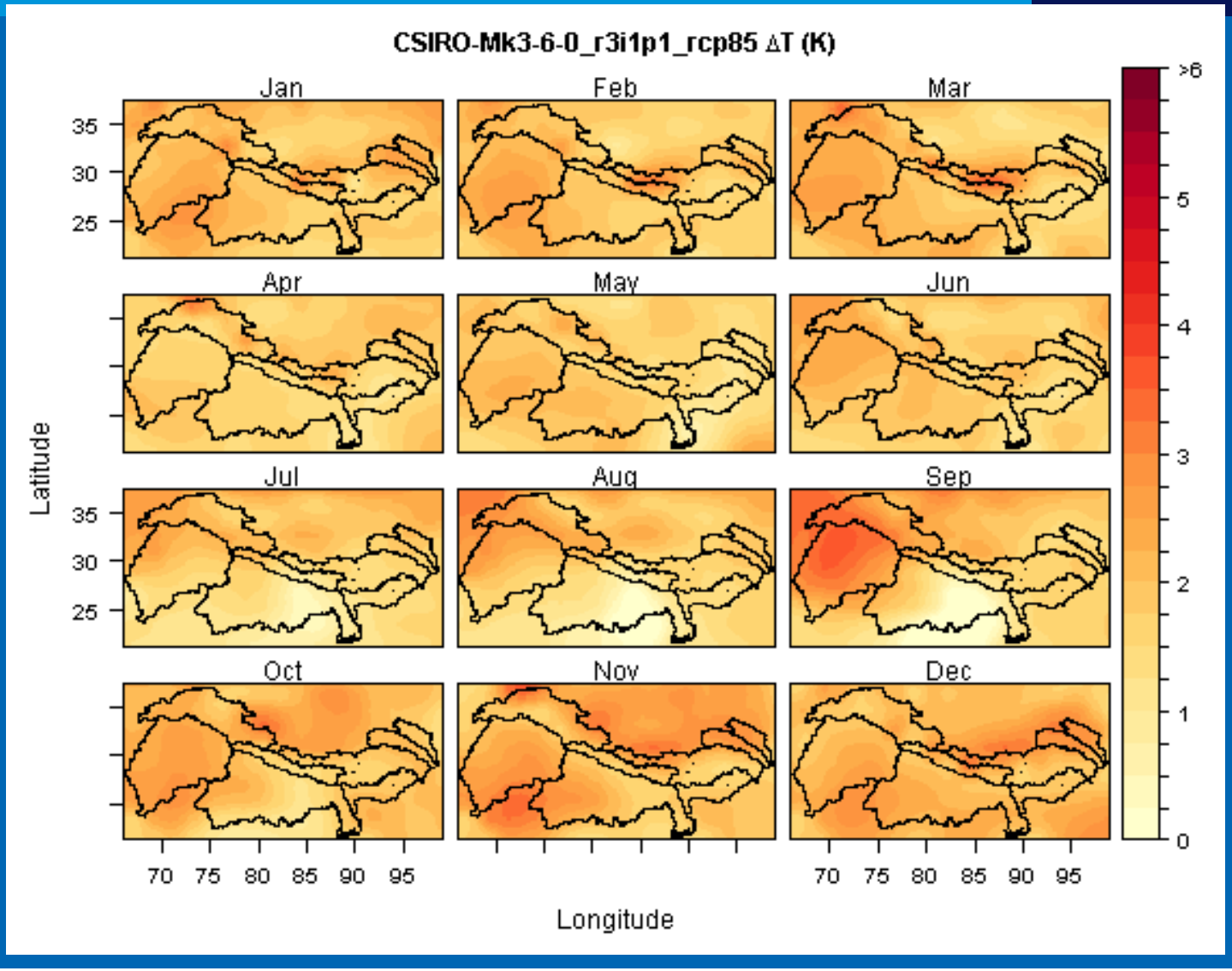

Strong variation within basins

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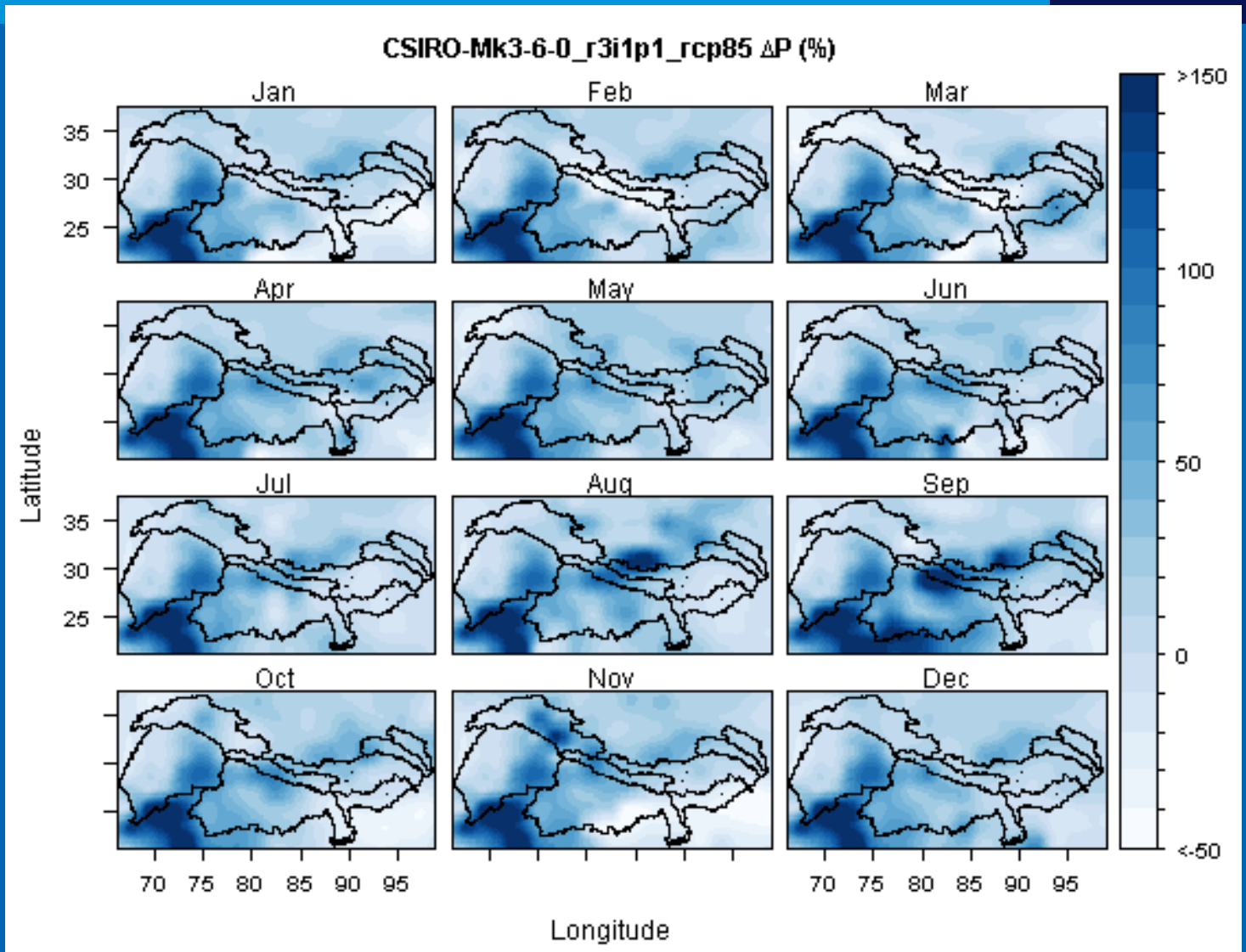

Conclusions

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- Simple delta change method efficient way to assess climate change for HICAP domain
- Consistent increase in temperature projected for entire domain, stronger for RCP8.5 than RCP4.5
- Precipitation projections have large uncertainty
  - Large variations between GCMs
  - Large seasonal variations in projected changes
  - Large spatial variations in projected changes
  - Uncertainty RCP8.5 larger than RCP4.5