ClimChAlp
Interreg III B Alpine Space
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Evaluation of Regional Climate Models for the Alpine Space and Implications for Hydrological Impact Analysis

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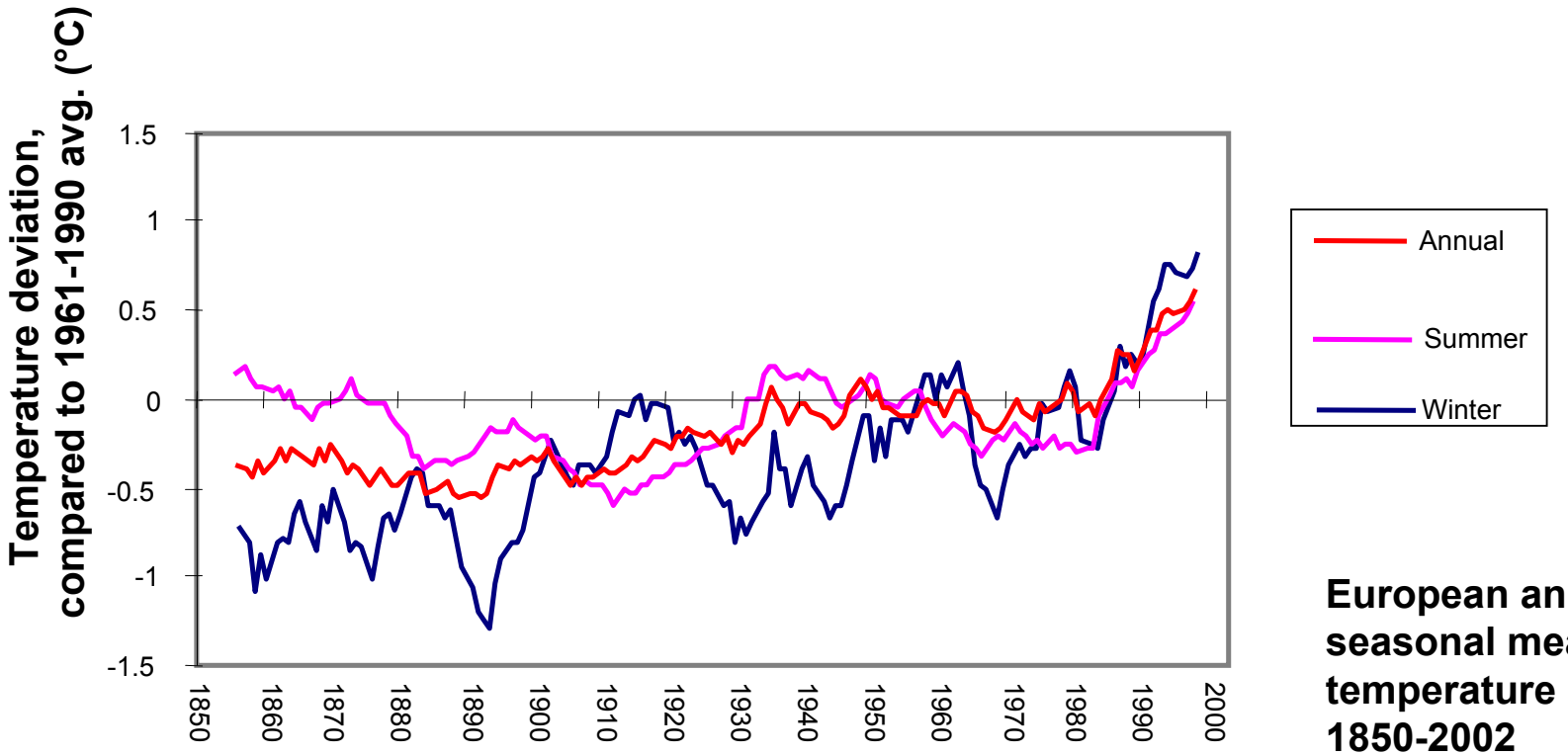
Motivation Alpine Space



European annual and seasonal mean temperature deviations, 1850-2002

- Global Temperature: + 0.7 ±0.2 °C in past 100 years
- Europe: +0.95 °C; **Alps +1.6°C**
- Summer +0.7°C ; Winter +1.1°C

Regional Climate change >> global trend ⇒ climate sensitive regions

Motivation Alpine Space

Observed trend Alpine regions past 120 years

- Increase of mean annual temperature up to 2.0°C
- Seasonal redistribution of precipitation: increase in late winter & spring (up to 20 - 30%) and decrease in summer (> 20%)
- Increasing number and intensities of meteorological extreme events (heavy precipitation, heat waves, storms)

Specific hydrological problems in Alpine regions

- Extremely fast precipitation-runoff response times, extremely short warning times
- Precipitation intensities are expected to increase under climate change
- Due to orography: small atmospheric circulation changes can induce large regional/local hydrometeorological changes

Motivation Alpine Space

Severe flooding 1999, 2002, 2005

Severe droughts 2003, 2007

Motivation Evaluation Study

Stakeholders demand delineation of adaptation strategies

- Flood protection measures (adaptation of infrastructure)
- Future hydropower potential (low flows)
- Water availability for agriculture, forestry, …
- Winter tourism

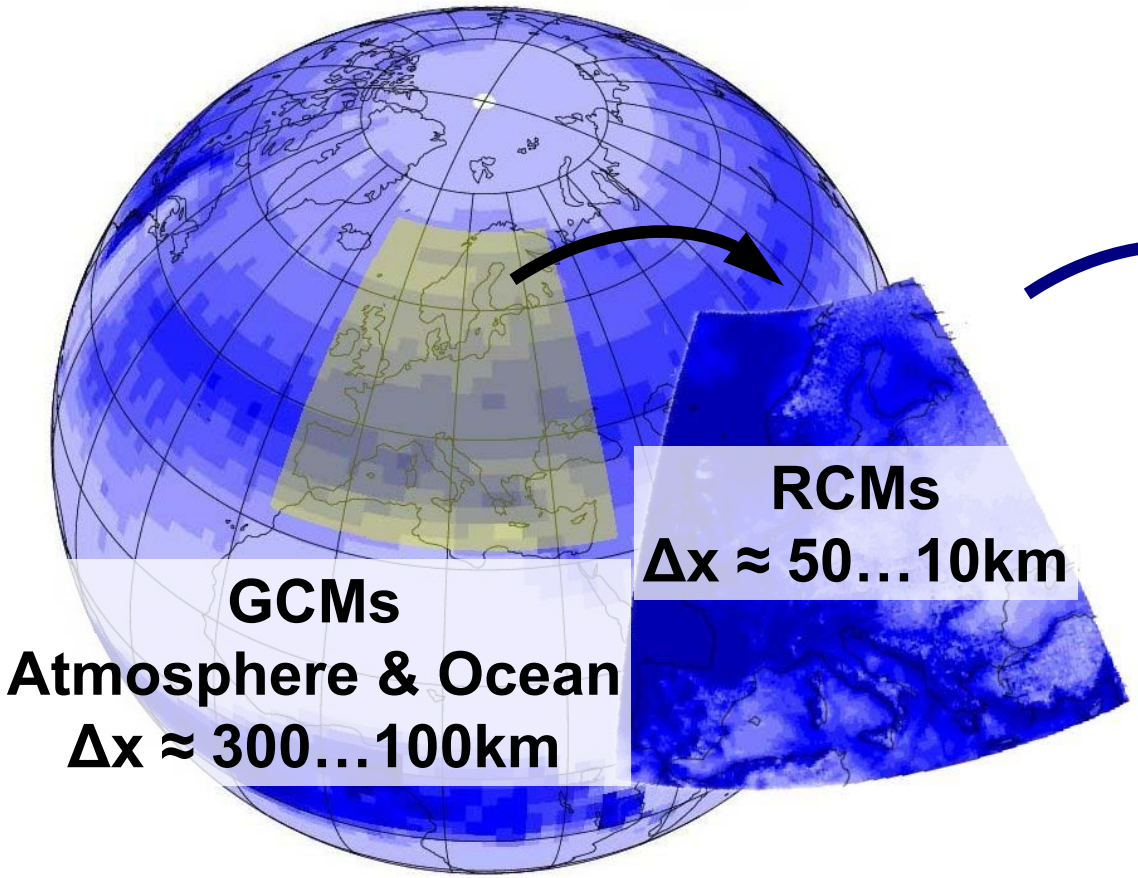
Requirements in hydrological climate change impact investigations

- High resolution spatial and temporal distribution of future temperature & precipitation

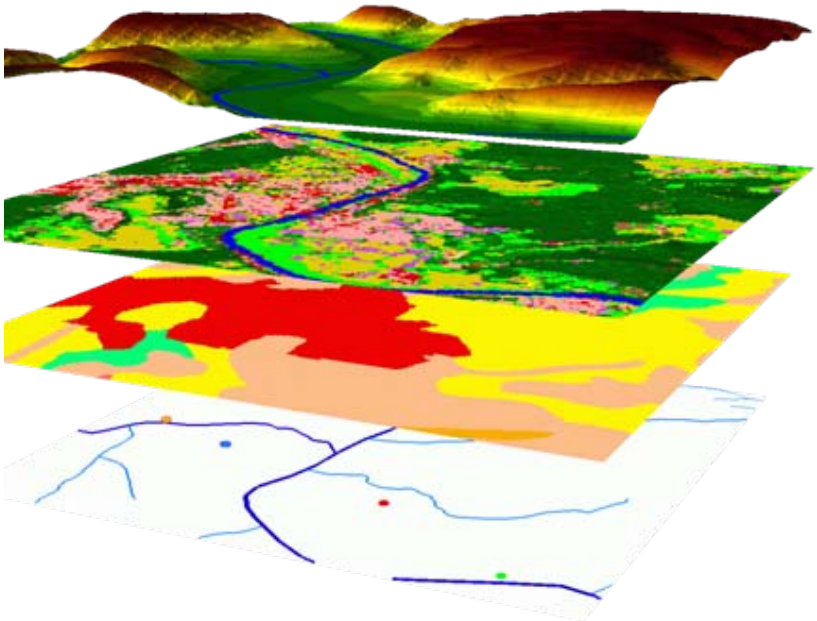
How well are current regional climate predictions suited for that purpose?

Hydrological Impact Analysis

Scale gaps

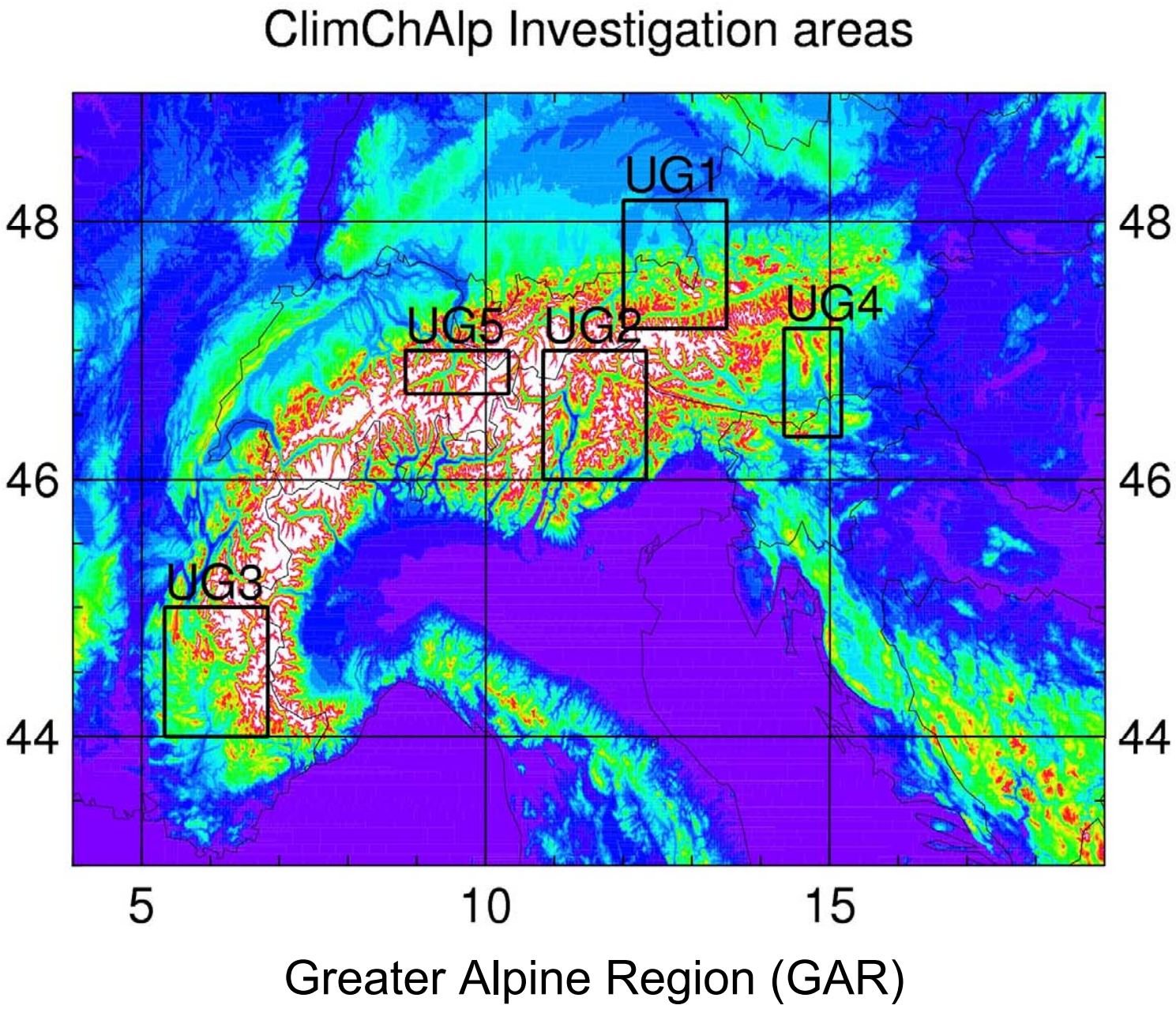


Catchment Hydrology:
Δx ≈ 1km…100m



Dynamic downscaling by RCMs

Investigation Areas



Available High Resolution Data (Δx < 20km)

SRES	GCM	RCM	SDM	Ensembles
SRES B1	ECHAM5	CLM		2?
	ECHAM5	REMO		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES B2	Had3	RegCM		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A1B	ECHAM5	CLM		2?
	ECHAM5	REMO		1
SRES A1FI	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A1	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A2	Had3	HIRHAM		1
	Had3	ReGCM		1
	EGHAM5	REMO		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1

CLM - Germany (2001-2100)
hourly data, Δx≈18km

HIRHAM - DMI, Denmark(2070-2099)
daily data in the Internet (PRUDENCE)
Δx≈13km

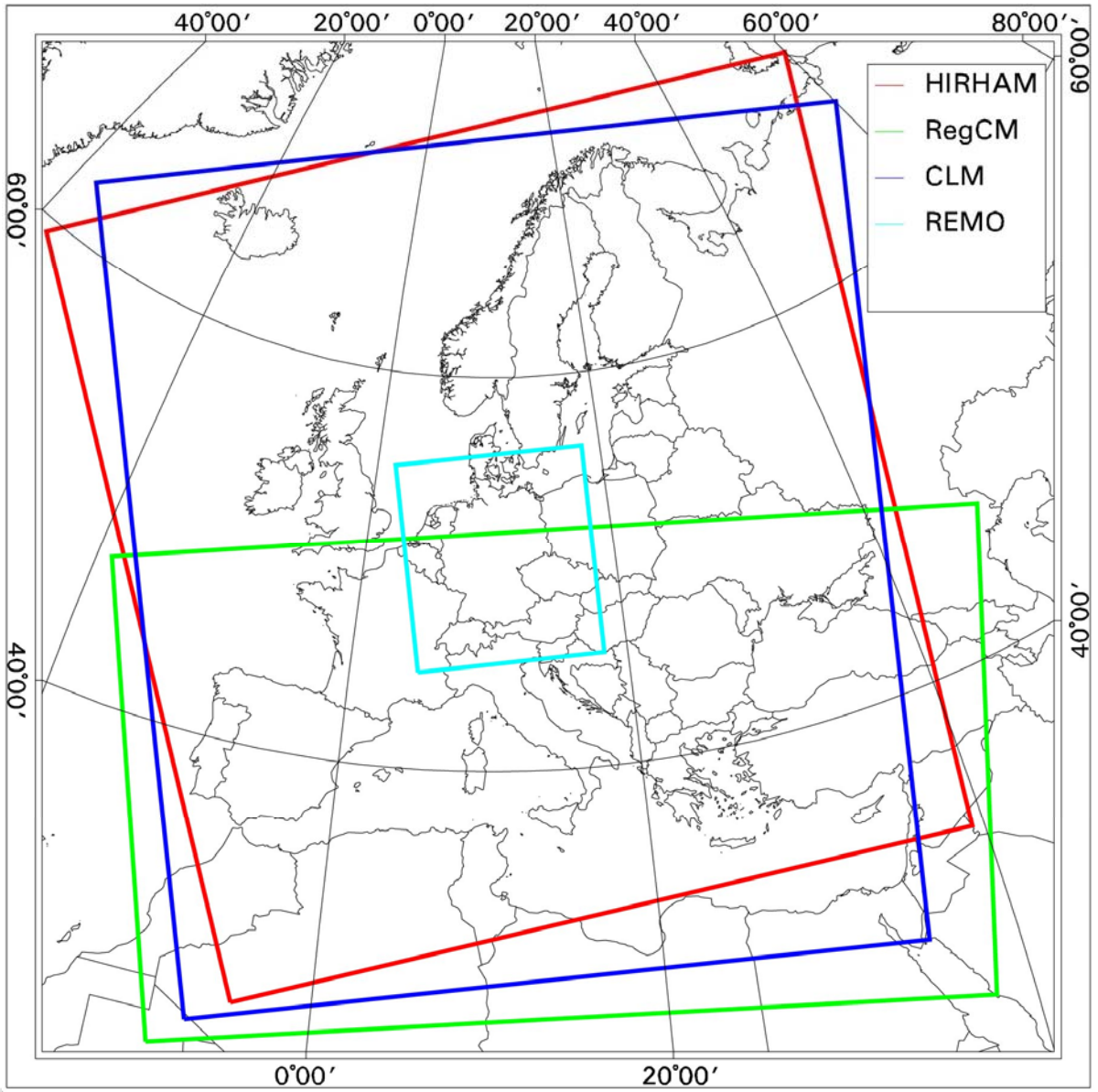
RegCM - ICTP, Italy (2070-2099)
daily data, Δx≈20km

REMO - MPI, Germany (2001-2100)
hourly data, Δx≈10km

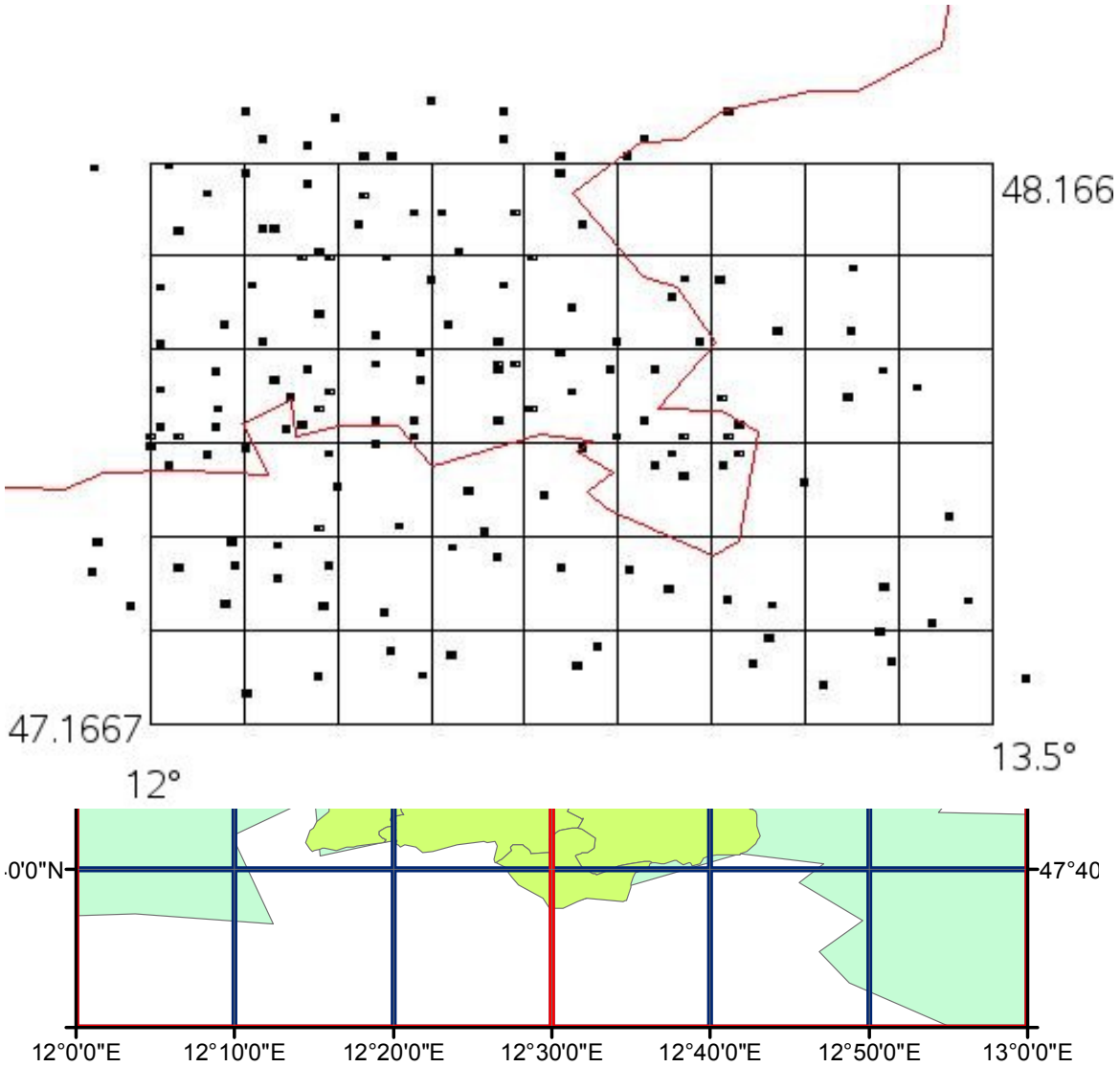
TYN – Tyndall Centre,UK, statistical downscaling

Different GCMs & different scenarios !

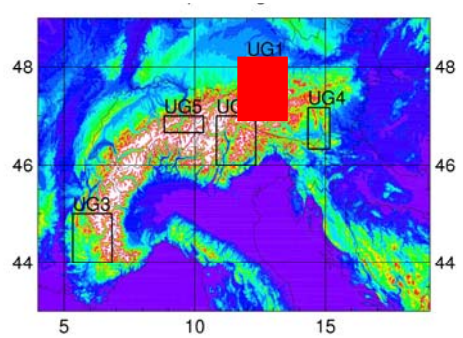
Extent of High Resolution Data



River Alz – Area, Southern Bavaria: UG1



UG1



Rain stations

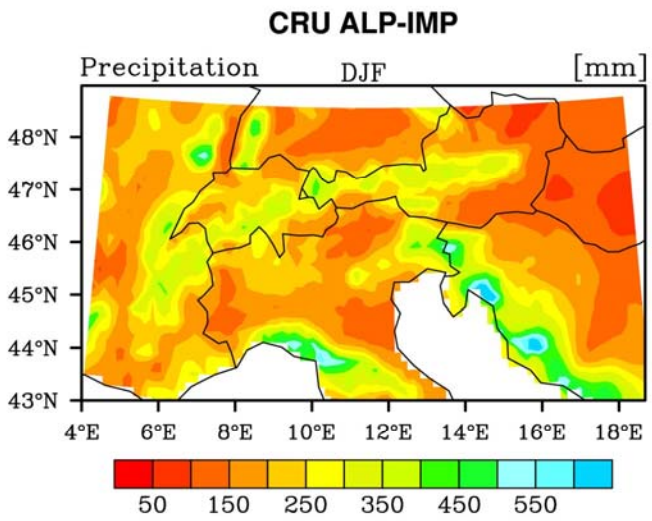
Red - 0.5° x 0.5° grid

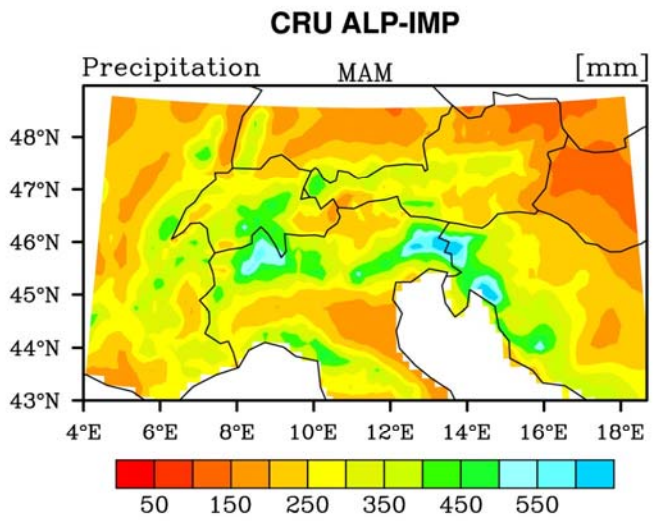
Blue – 10' x 10' grid

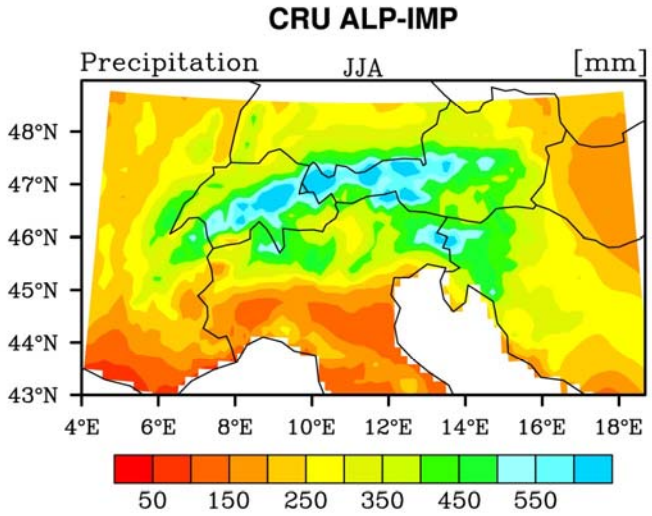
In any investigation at least 2Δx!

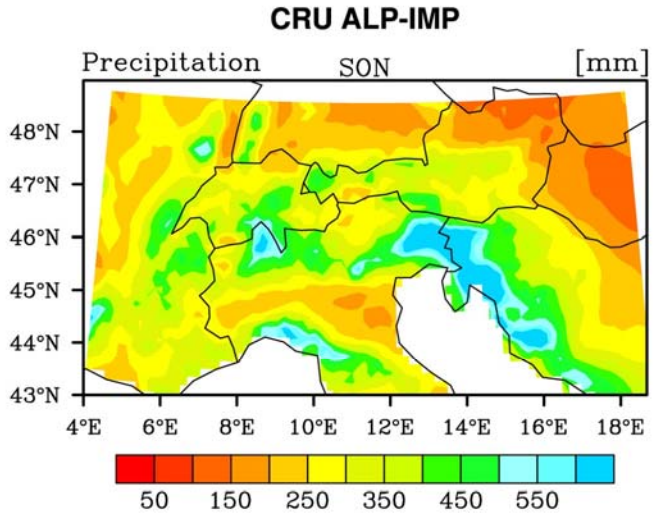
Observational Data

- CRU ALP-IMP 10’ gridded monthly
- CRU TS1.2 10’ gridded monthly
- CRU 0.5° gridded monthly
- Delaware University 0.5° gridded monthly

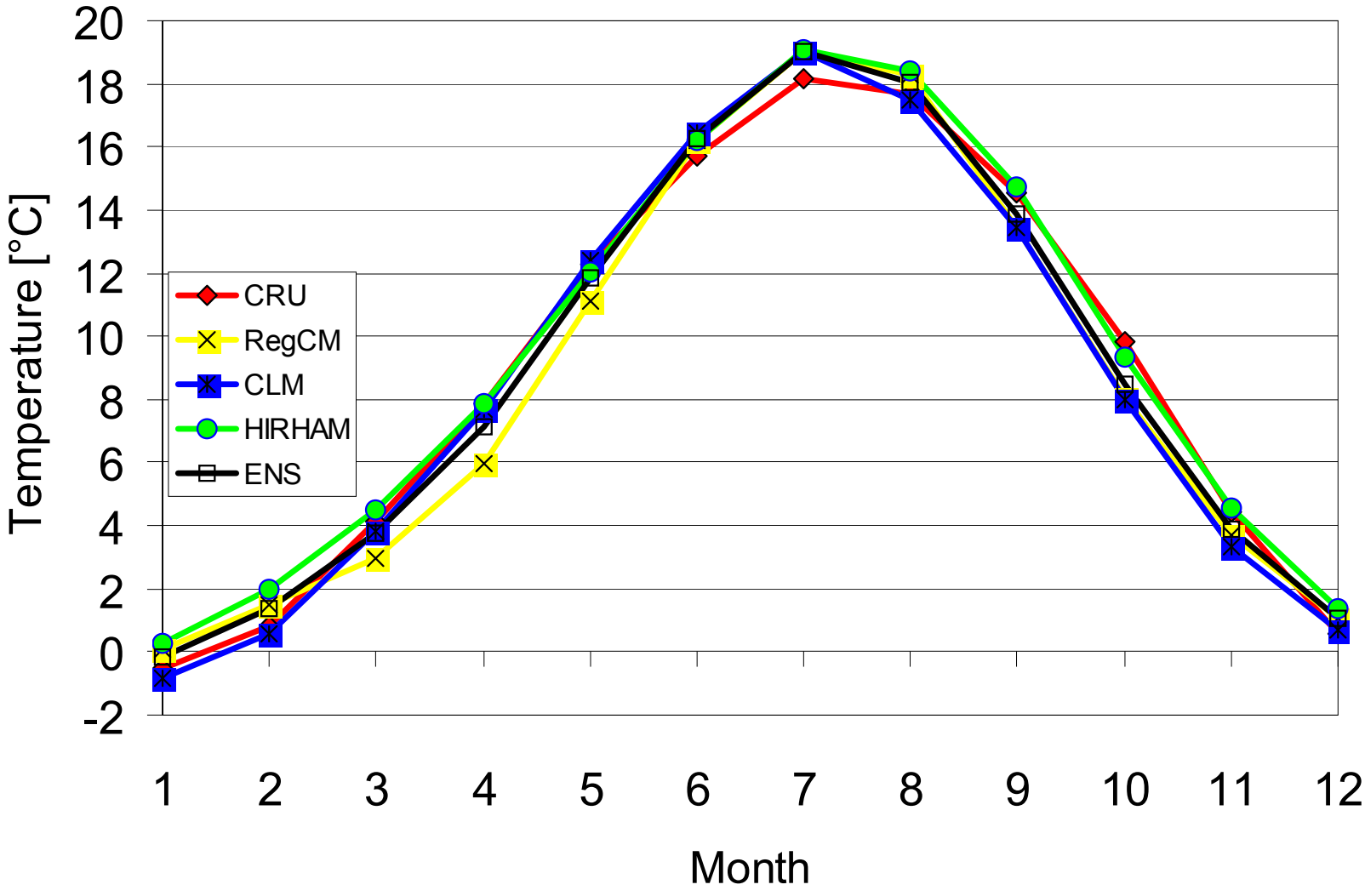




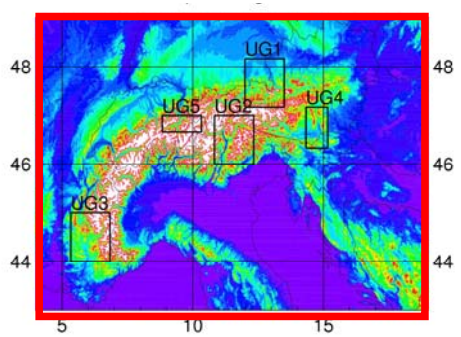




Performance Present Climate: GAR



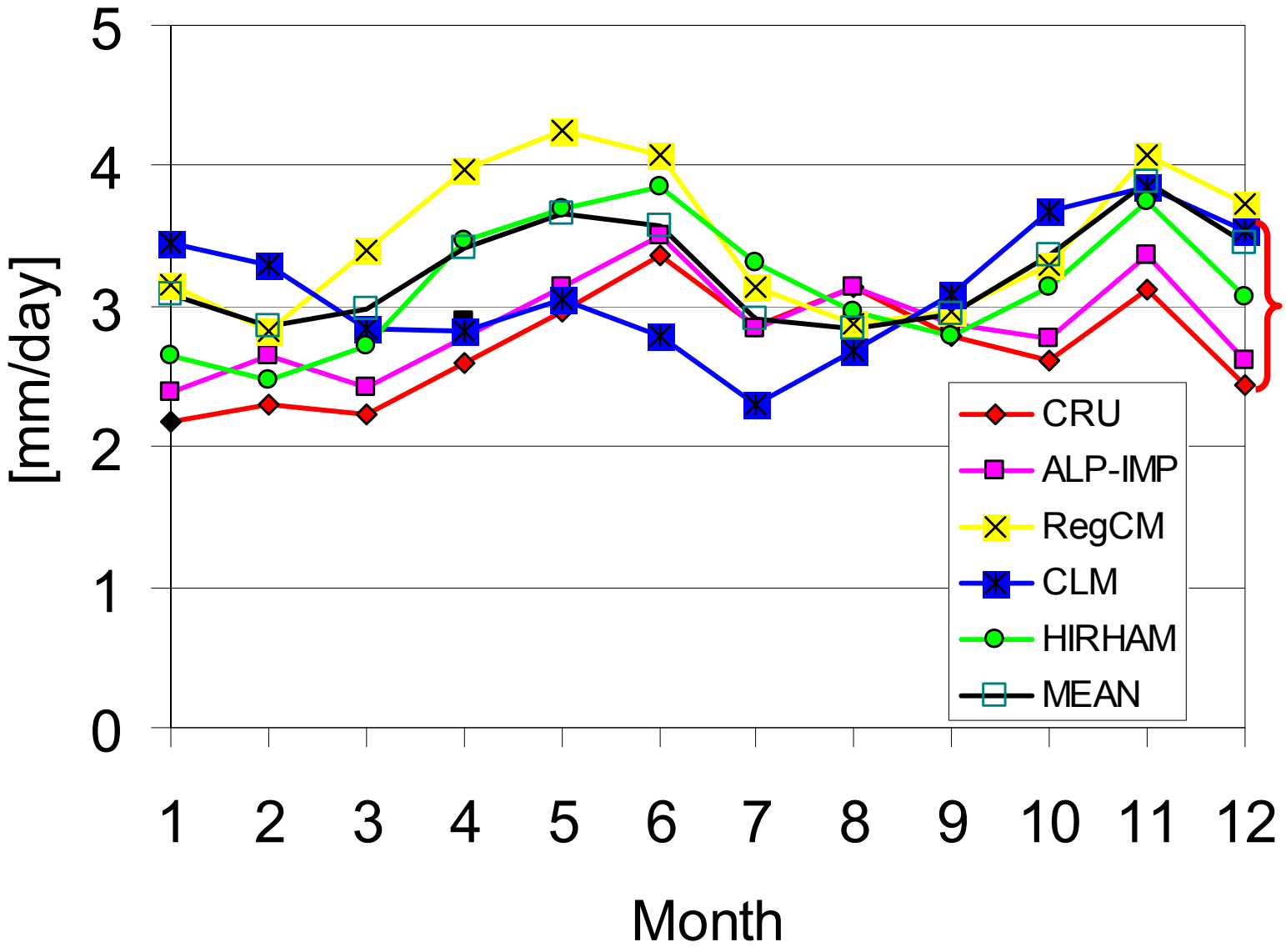
GAR



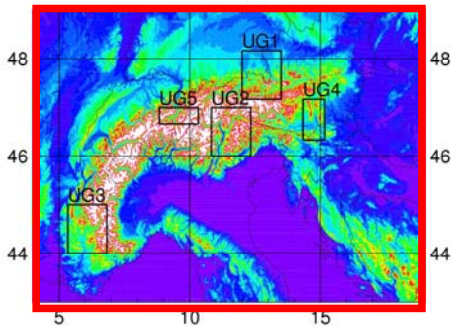
Mean monthly temperature bias +/- 1°C

1961-90

Performance Present Climate: GAR



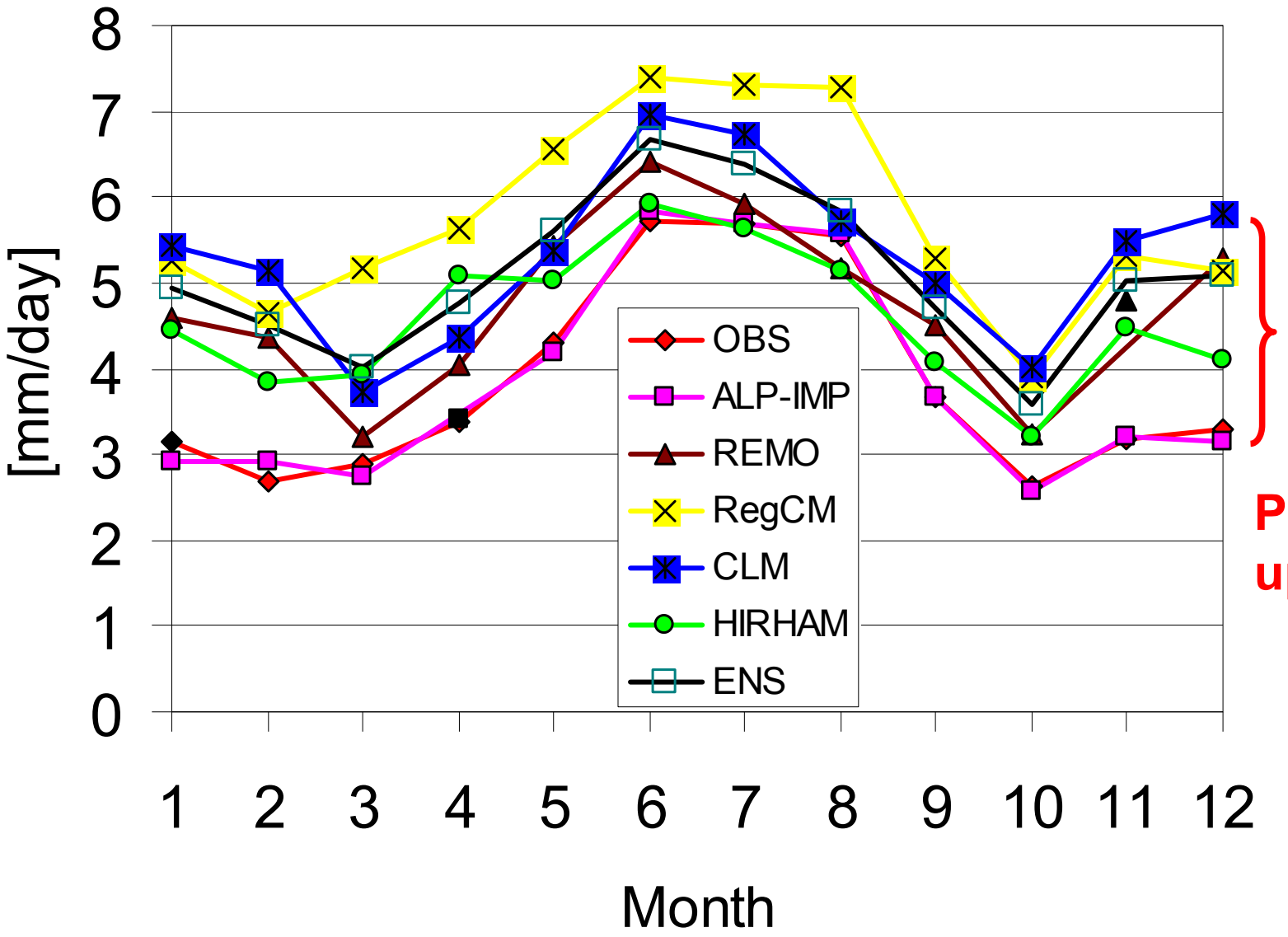
GAR



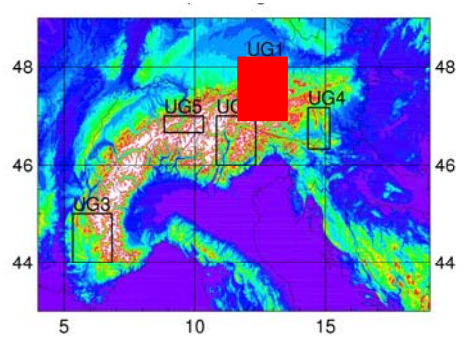
Precipitation bias up to 1.5 mm/day

1961-90

Performance Present Climate: UG1



UG1

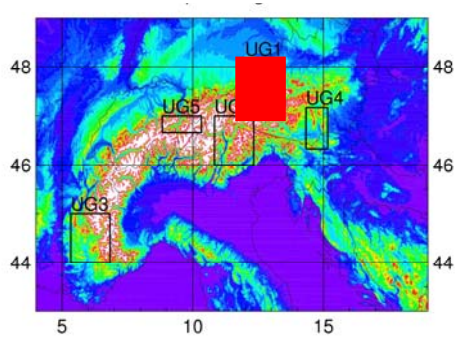


Precipitation bias up to +2.5 mm/day!

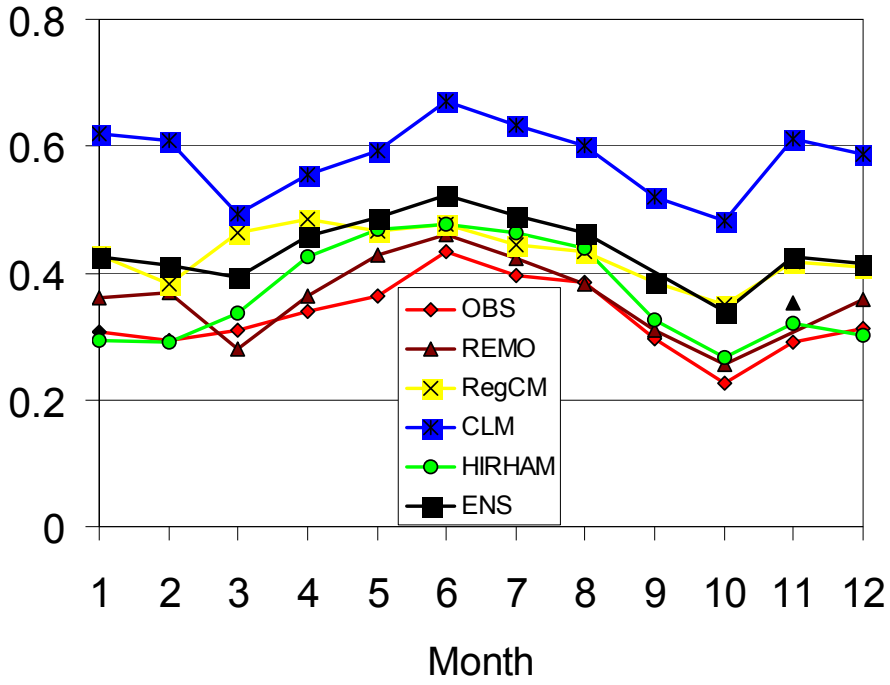
1961-90

Performance Present Climate: UG1

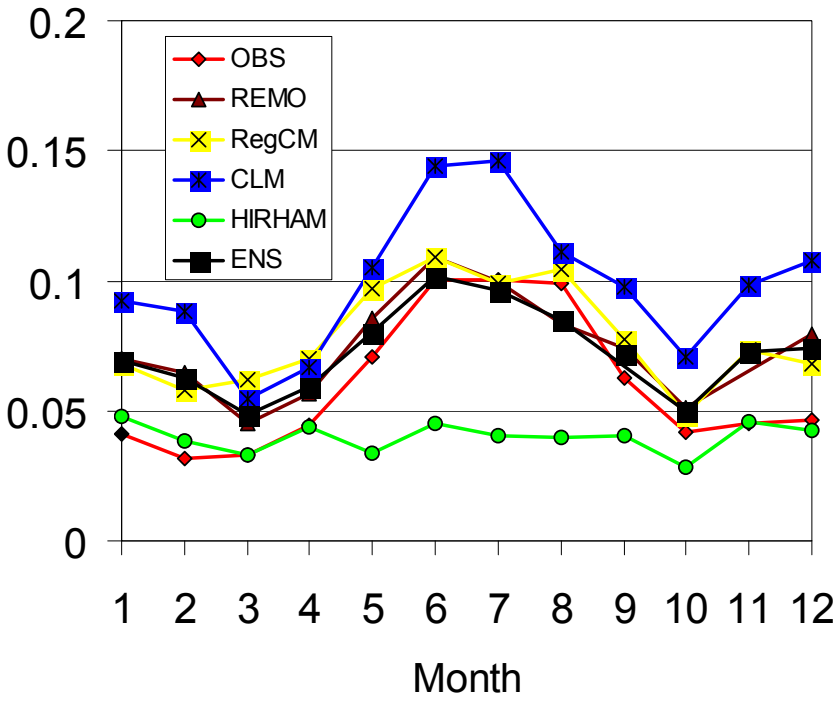
FRE: frequency (fraction) of days with **UG1**



FRE 1: P > 1mm



FRE 15: P > 15mm



Performance Present Climate: Precipitation

Bias of RCM in domain mean (diagnostics in % of observed values)

Model	DJF							
	GAR	UG1			UG2	UG3	UG4	UG5
	Mean	Mean	FRE-1	FRE-15	Mean	Mean	Mean	Mean
CLM	34	80	99	142	58	58	15	35
HIRHAM	7	36	-3	8	38	3	8	31
RegCM	27	65	34	63	36	48	-1	108
REMO	-	56	19	80	-	-	-	-
ENS	23	60	37	74	44	36	7	58
OBS	-	-	-	-	-	-	-	-
ALP-IMP	2.55				1.75	2.9	1.7	2.9
	JJA							
CLM	-18	15	37	34	-6	-8	-38	-9
HIRHAM	7	-2	14	-59	17	28	-9	1
RegCM	6	30	12	4	42	10	-14	35
REMO	-	3	4	-3	-	-	-	-
ENS	-2	12	22	-6	17	10	-20	9
OBS	-	5.7	0.4	0.1	-	-	-	-
ALP-IMP	3.16				4	2.3	4.6	4.6

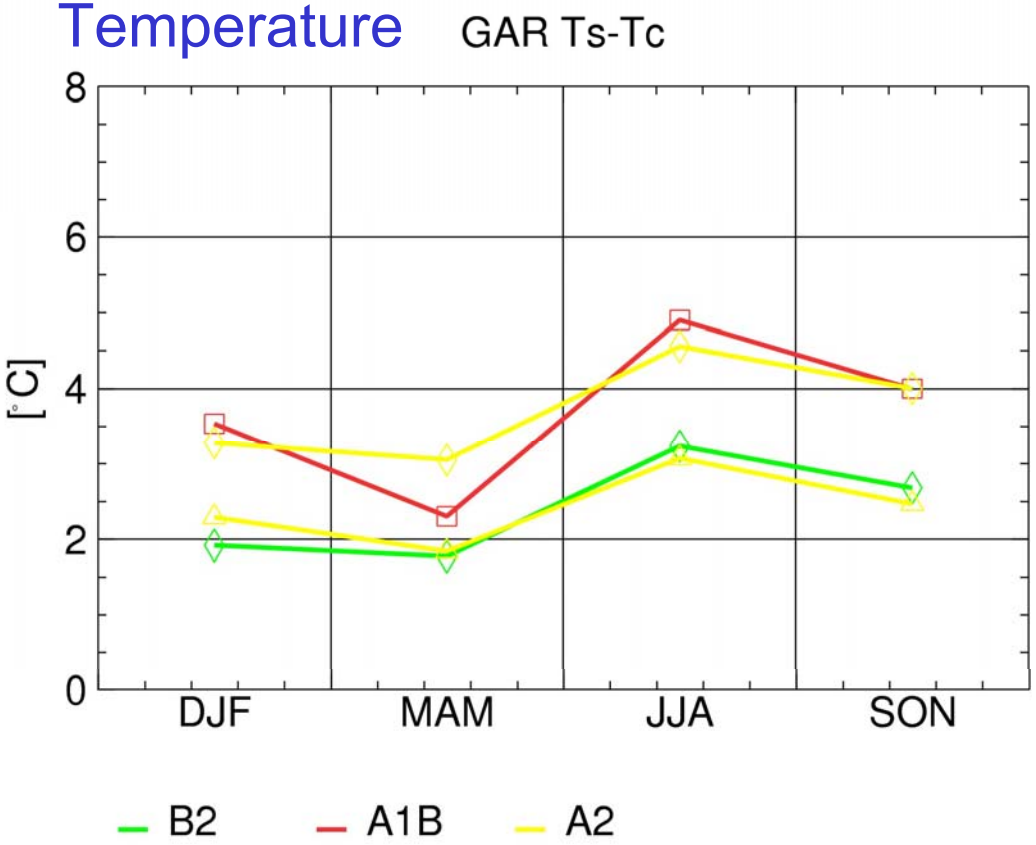
No single model can be identified as best:

performance depends on selected variable and area

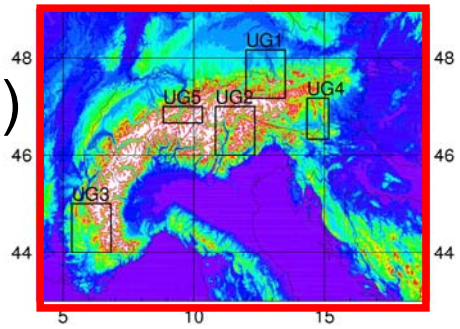
[model resolutions < 20 km]

Future Climate: GAR

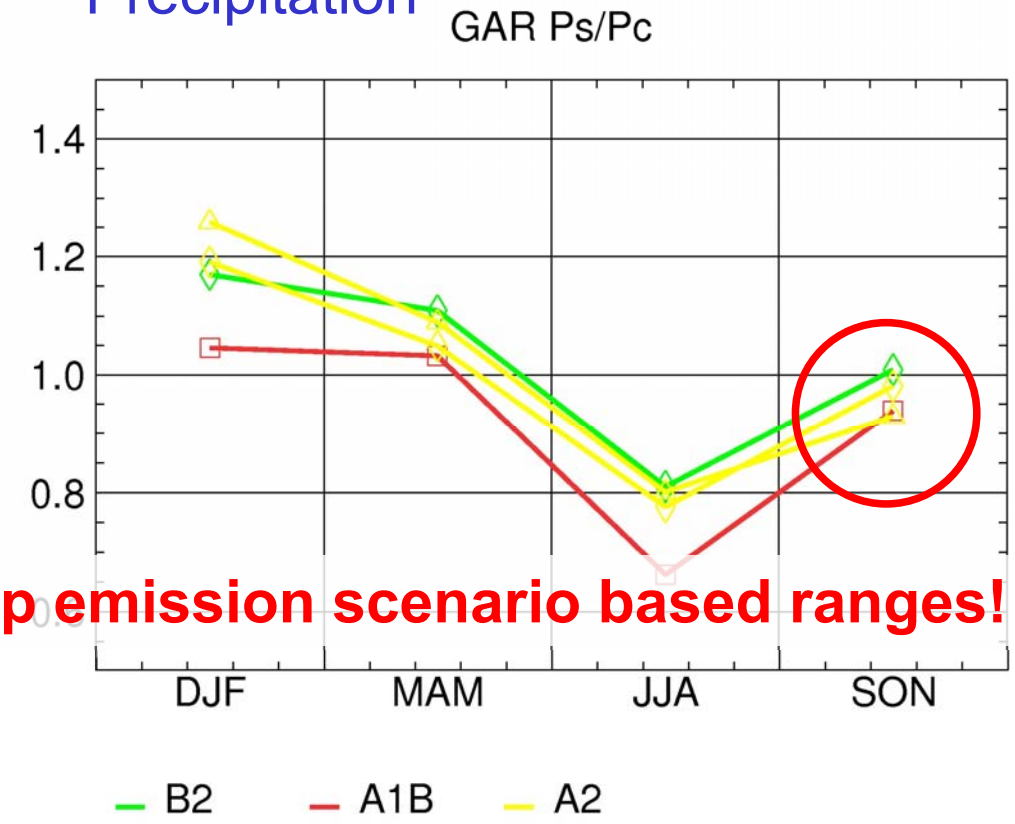
Temperature



Δ: HIRHAM (HadCM3)
□: CLM (ECHAM5)
◊: RegCM (HadCM3)



Precipitation

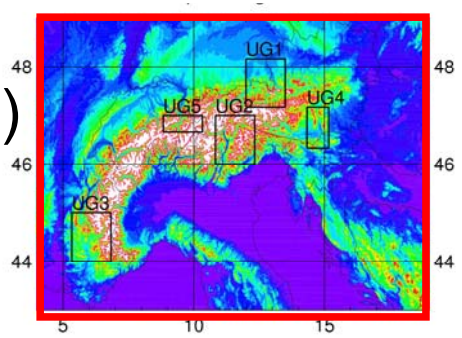


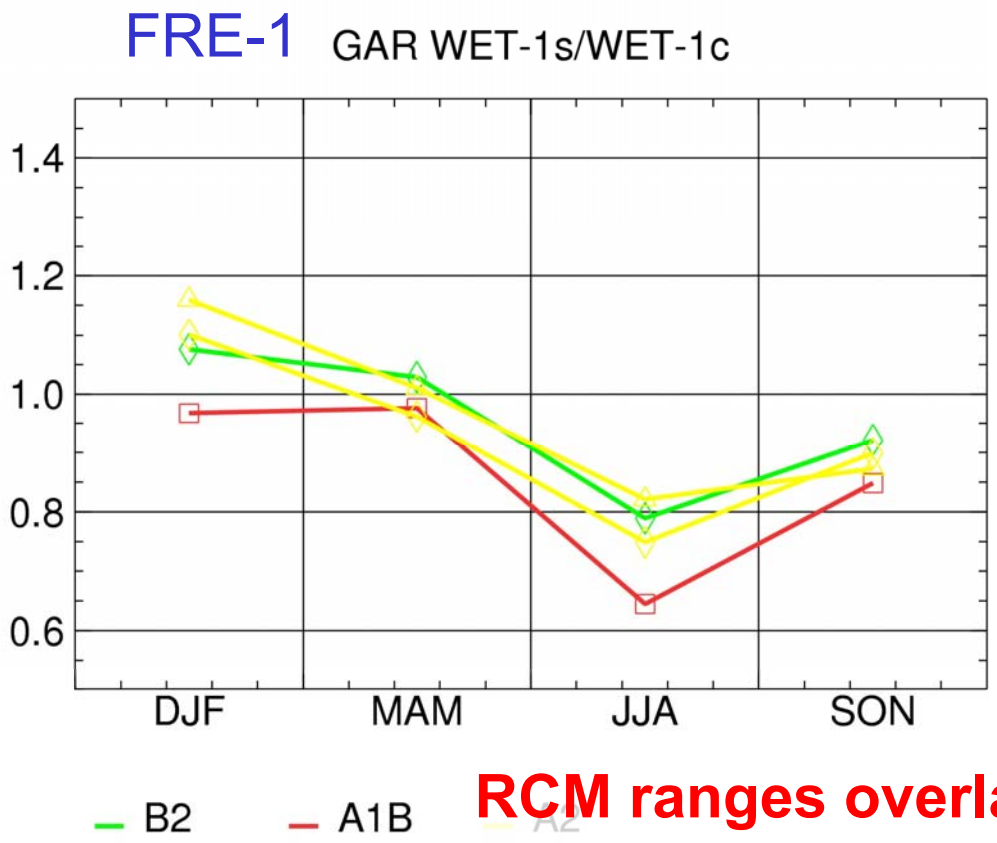
RCM ranges overlap emission scenario based ranges!

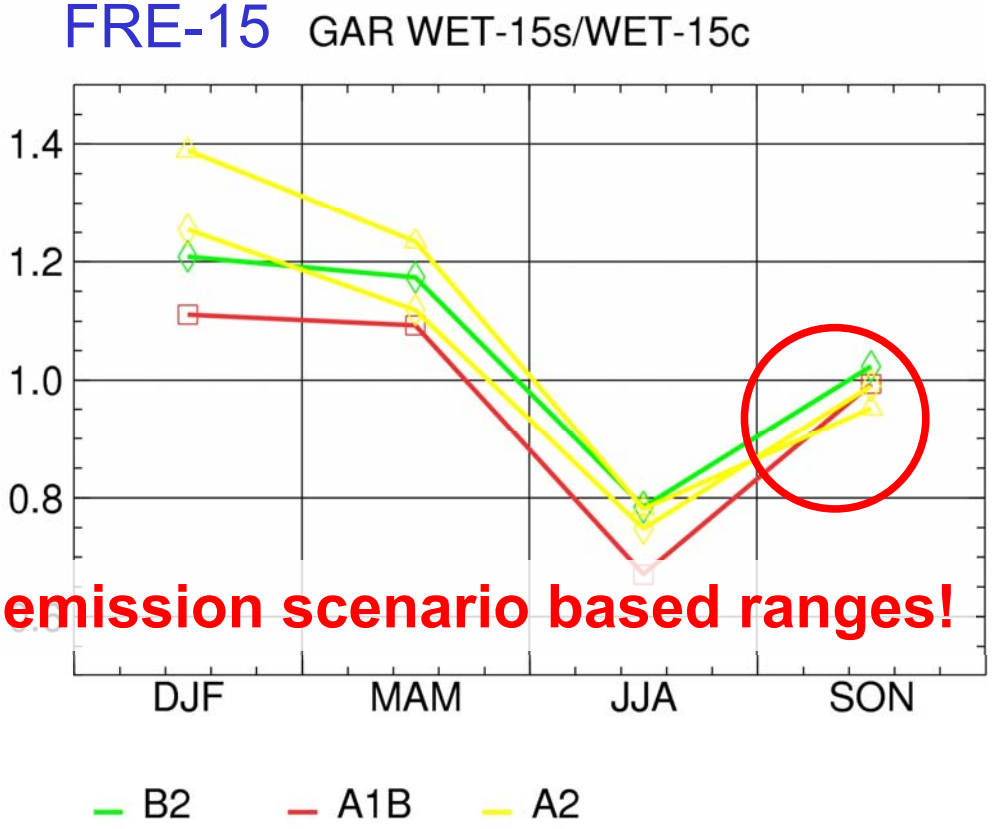
c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Future Climate: GAR

Δ: HIRHAM (HadCM3)
□: CLM (ECHAM5)
◊: RegCM (HadCM3)



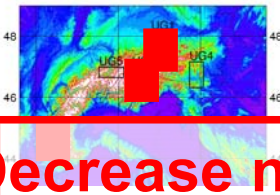




RCM ranges overlap emission scenario based ranges!

c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Future Climate: UG1, UG2, UG3

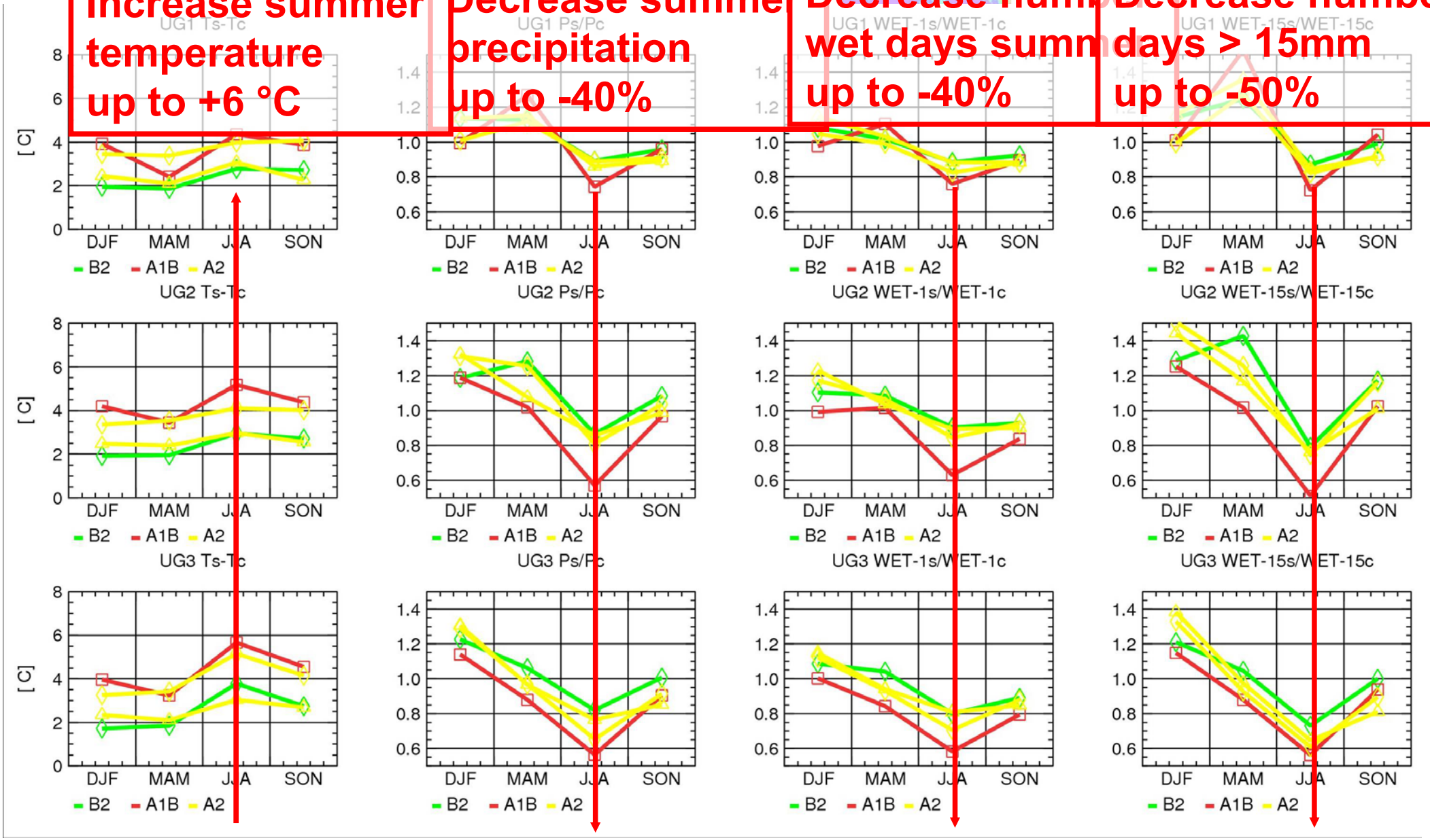


Increase summer temperature up to +6 °C

Decrease summer precipitation up to -40%

Decrease number wet days summer up to -40%

Decrease number days > 15mm up to -50%



Conclusions & Implications for Impact Analysis

- **No single model can be identified as best**:
  performance depends on selected variable and area
  $\Rightarrow$ Hydrological impact studies by ensemble data set

- **Significant biases in precipitation detected!**
  $\Rightarrow$ Biases in precipitation actually require correction techniques

- **RCM ranges overlap emission scenario based ranges!**

- There is further a clear need for high resolution RCM data

- More detailed climatology needed (daily station-statistics)


Thank you for your attention