Climate downscaling and scale interaction

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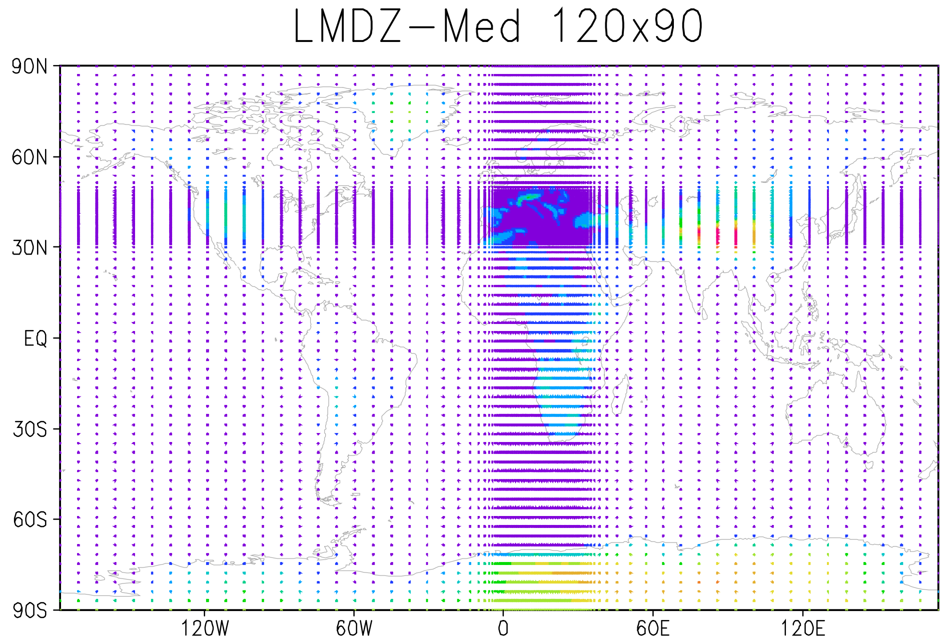
- Downscaling of climate change scenarios in China
- Climatic effects of land-use changes (urbanization): Global versus regional
- A promising methodology for scale interaction: two-way nesting

Two French zoomed climate models



LMDZ-Mediterranean (IPSL, Paris)

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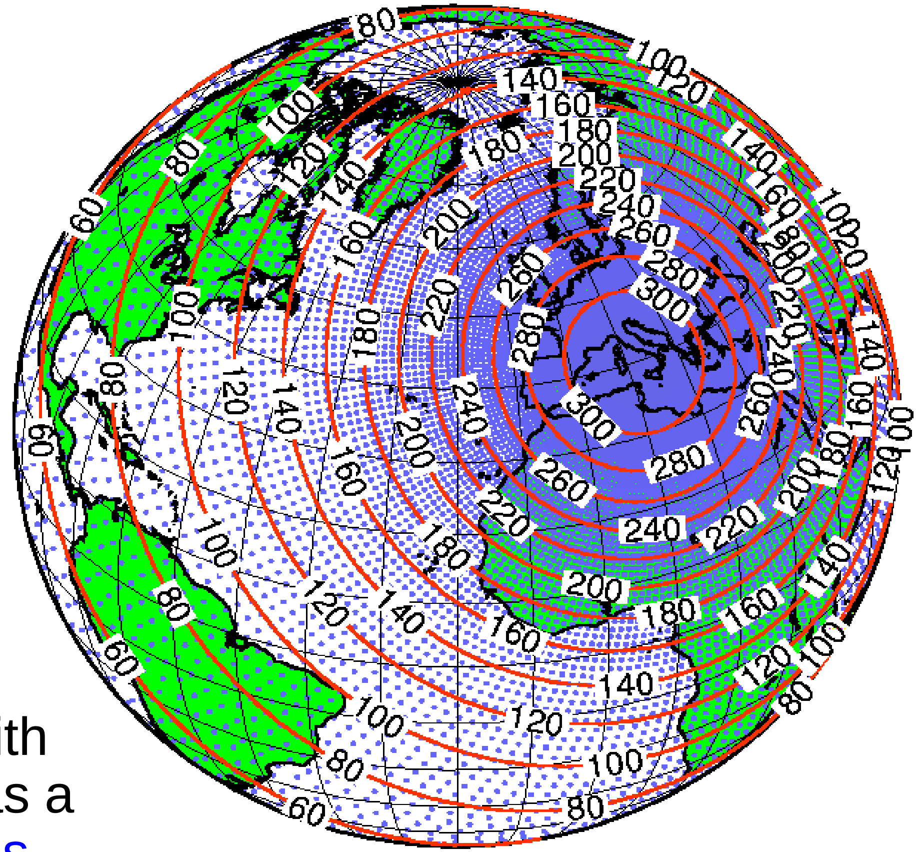


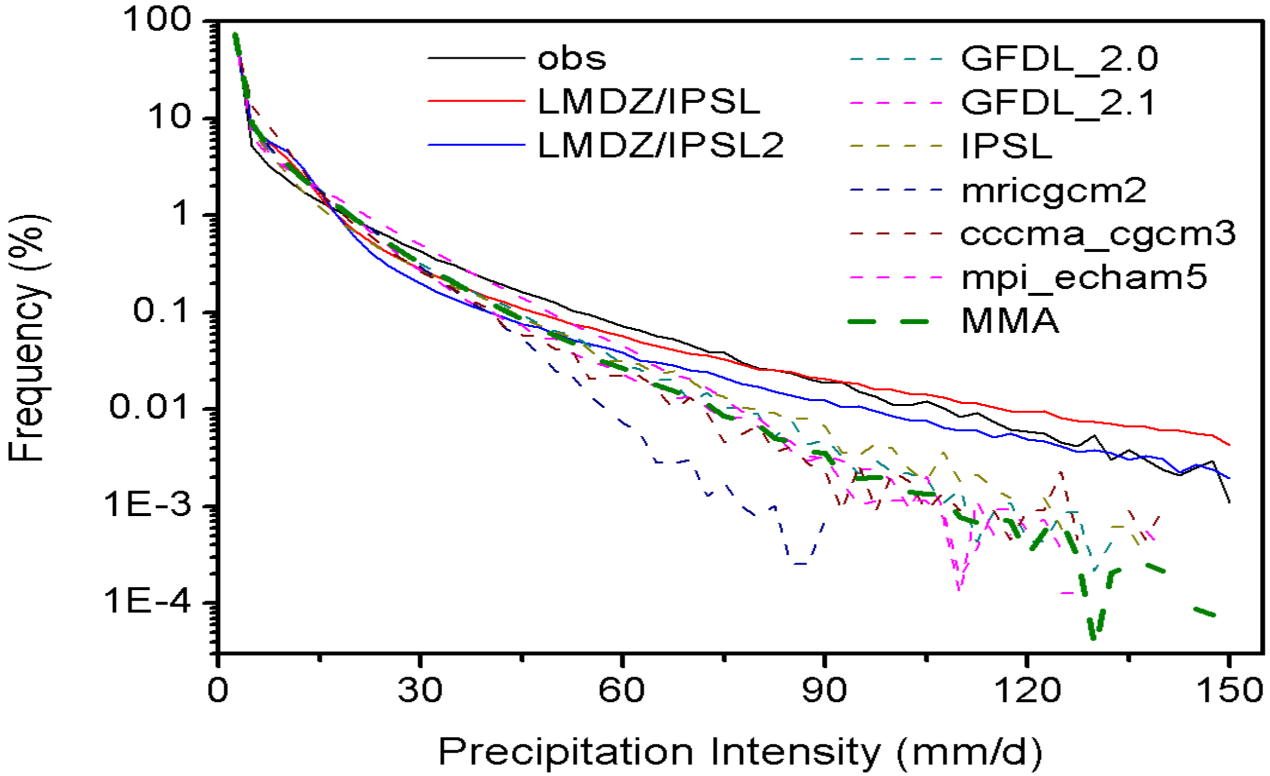
Arpege-Mediterranean
(Météo-France, Toulouse)

LMDZ is a global atmospheric GCM with variable grid and zoom. It can be run as a regional model, with nudging conditions outside the zoom. The model is free to have its own behaviors inside the zoom.

$$\frac{\partial X}{\partial t} = M(X) + \frac{X^a - X}{\boldsymbol{\tau}}$$

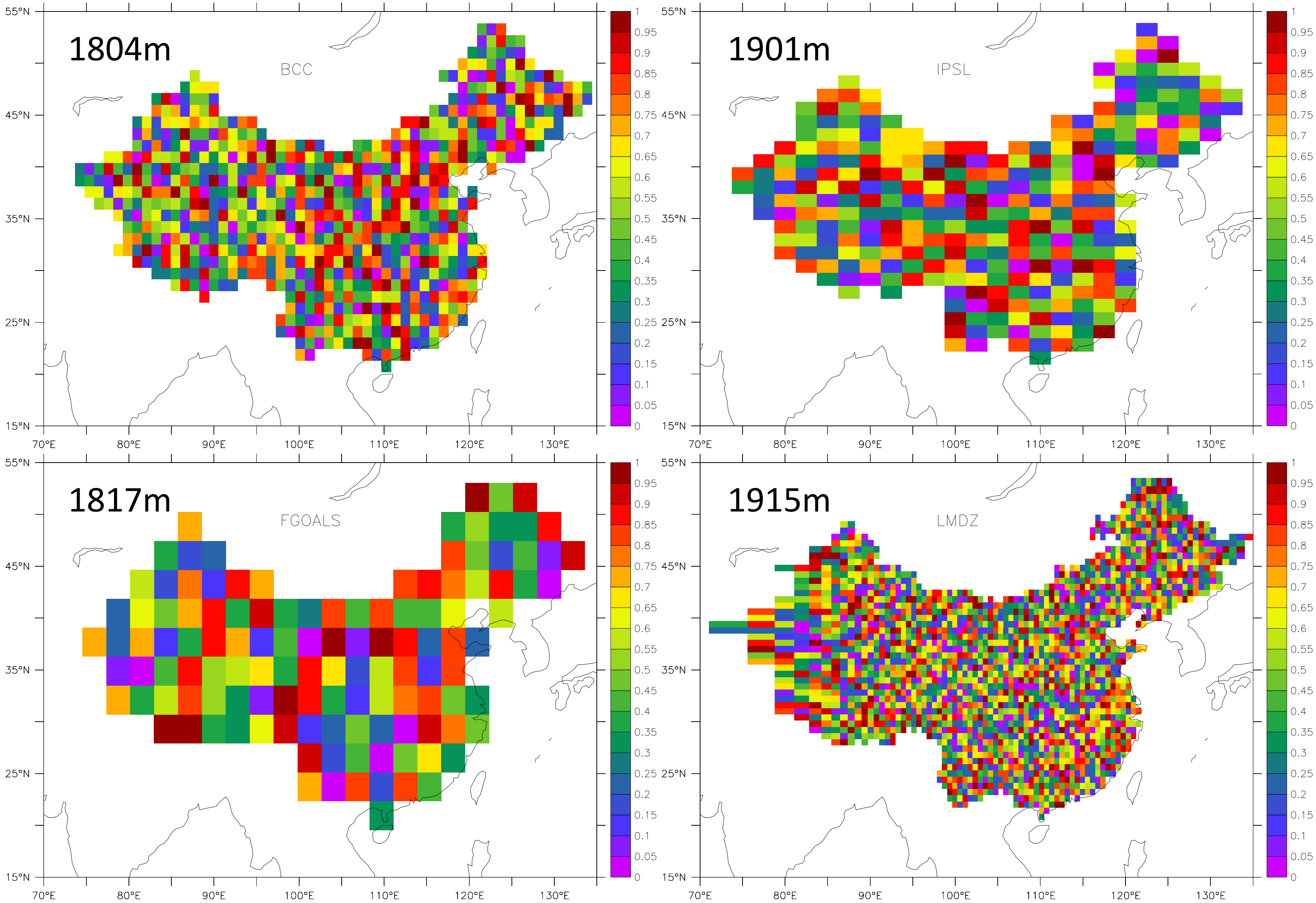
Added values of LMDZ-regional: extremes

Spectral distribution of rainfall in southeast China, comparison between the observation, LMDZ/CTRL, LMDZ/CTRL2, and a few other coarse-resolution global models. Added values of high-resolution models can be clearly identified.



Chen et al. 2011, Clim Dyn

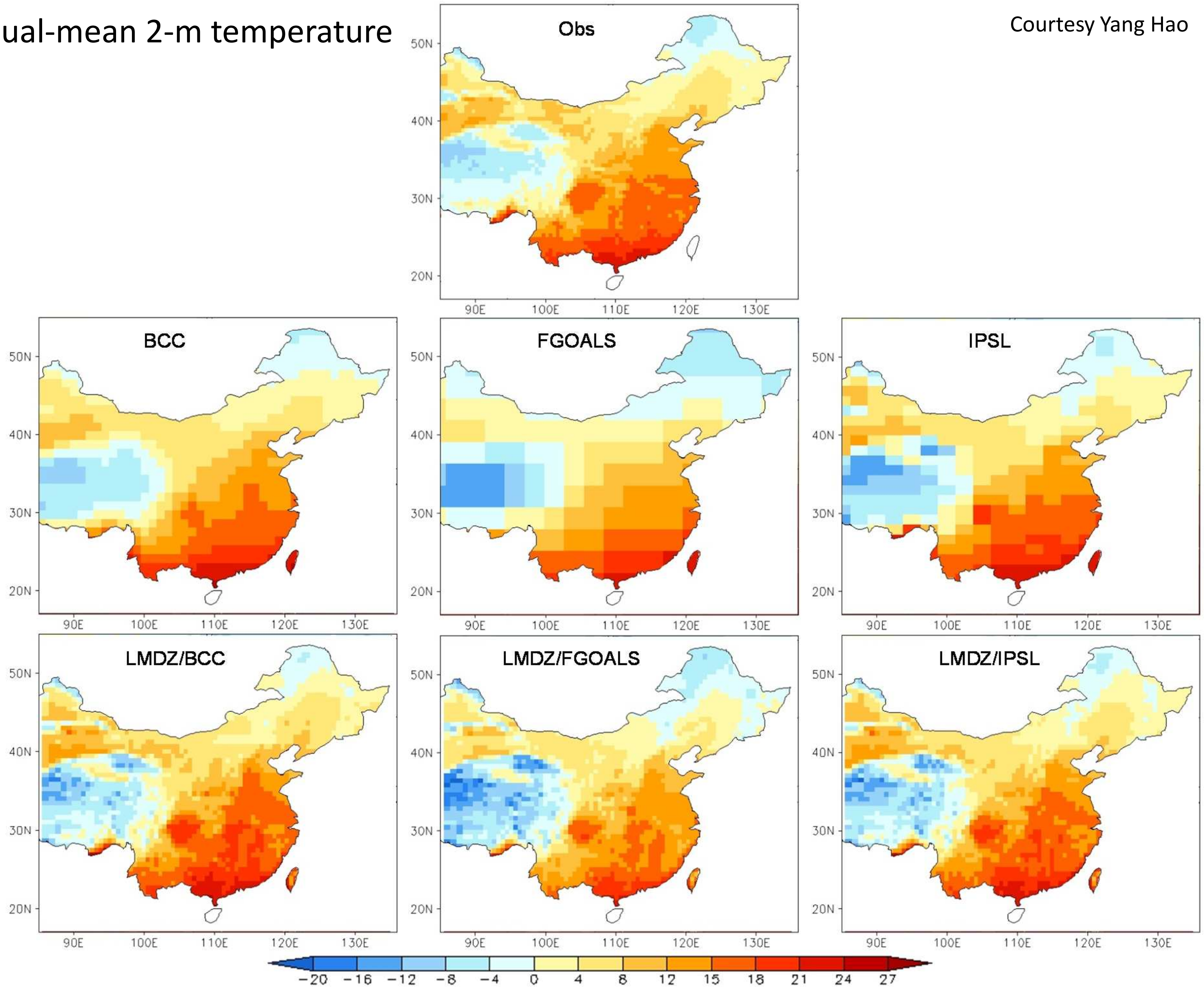
Schematic of models grid in China



IPCC/CMIP5 runs: **historical** (1951-2005); **rcp4.5** (2006-2100); **rcp8.5** (2006-2100)

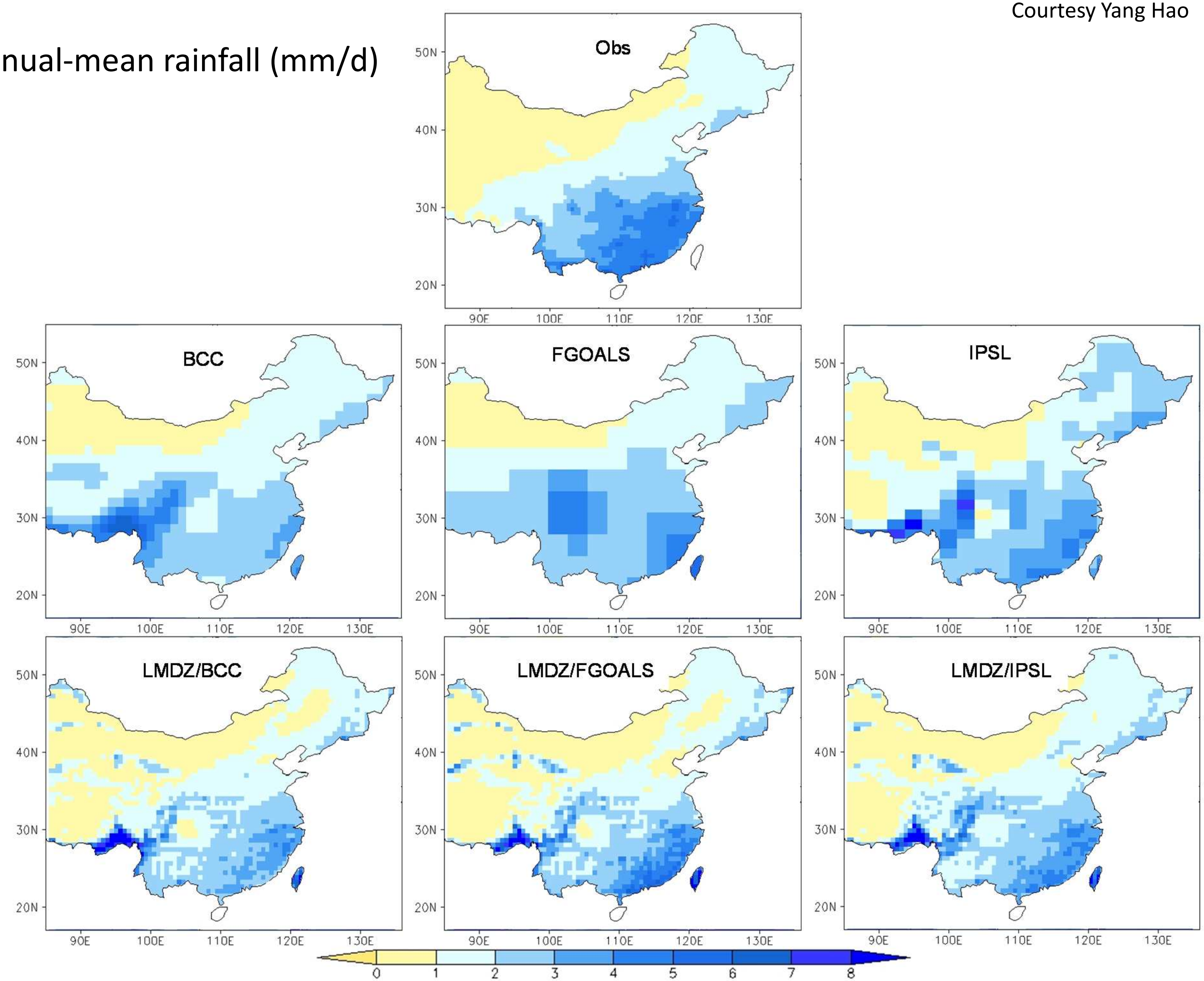
Annual-mean 2-m temperature

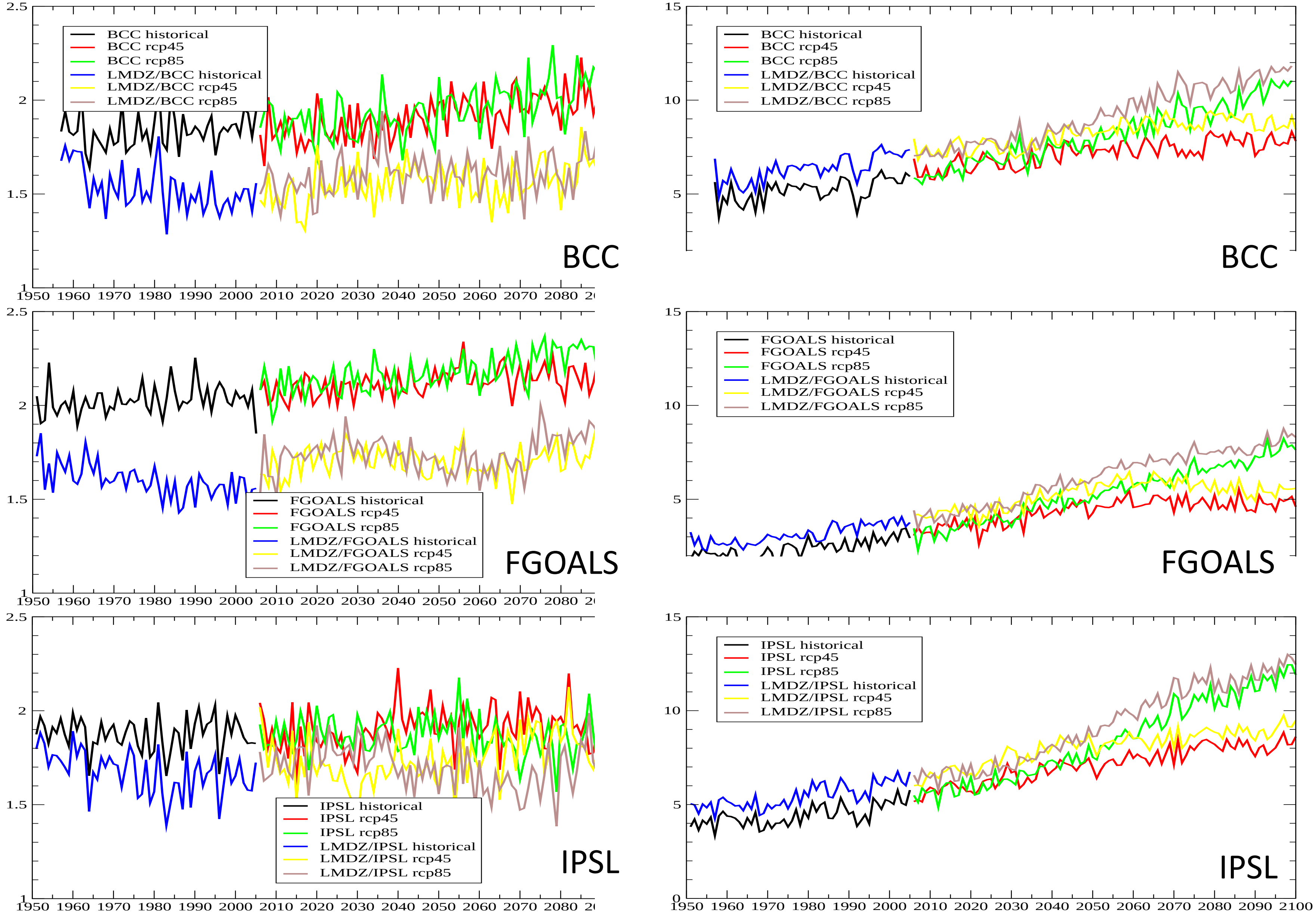
Courtesy Yang Hao



Courtesy Yang Hao

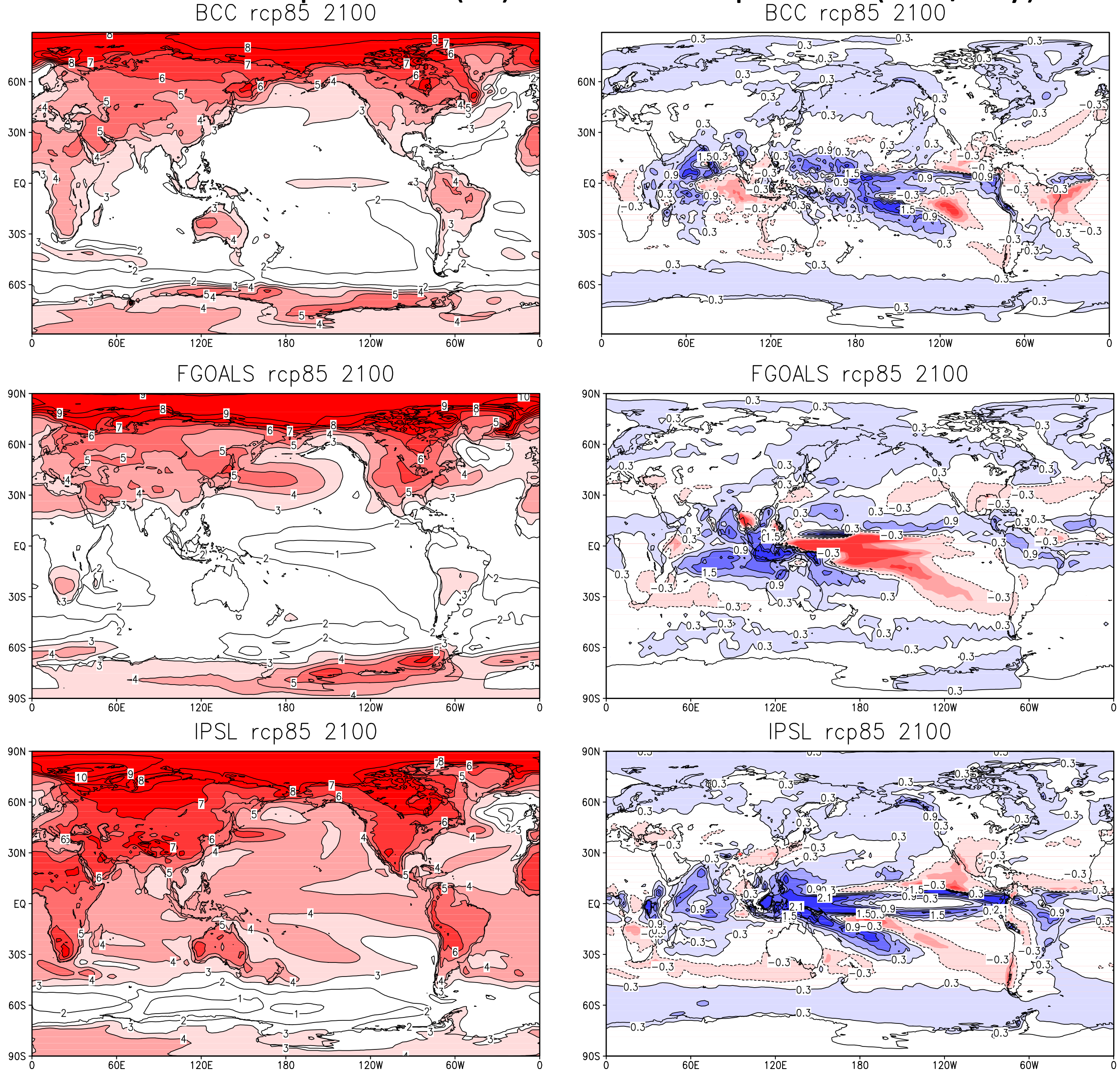
Annual-mean rainfall (mm/d)





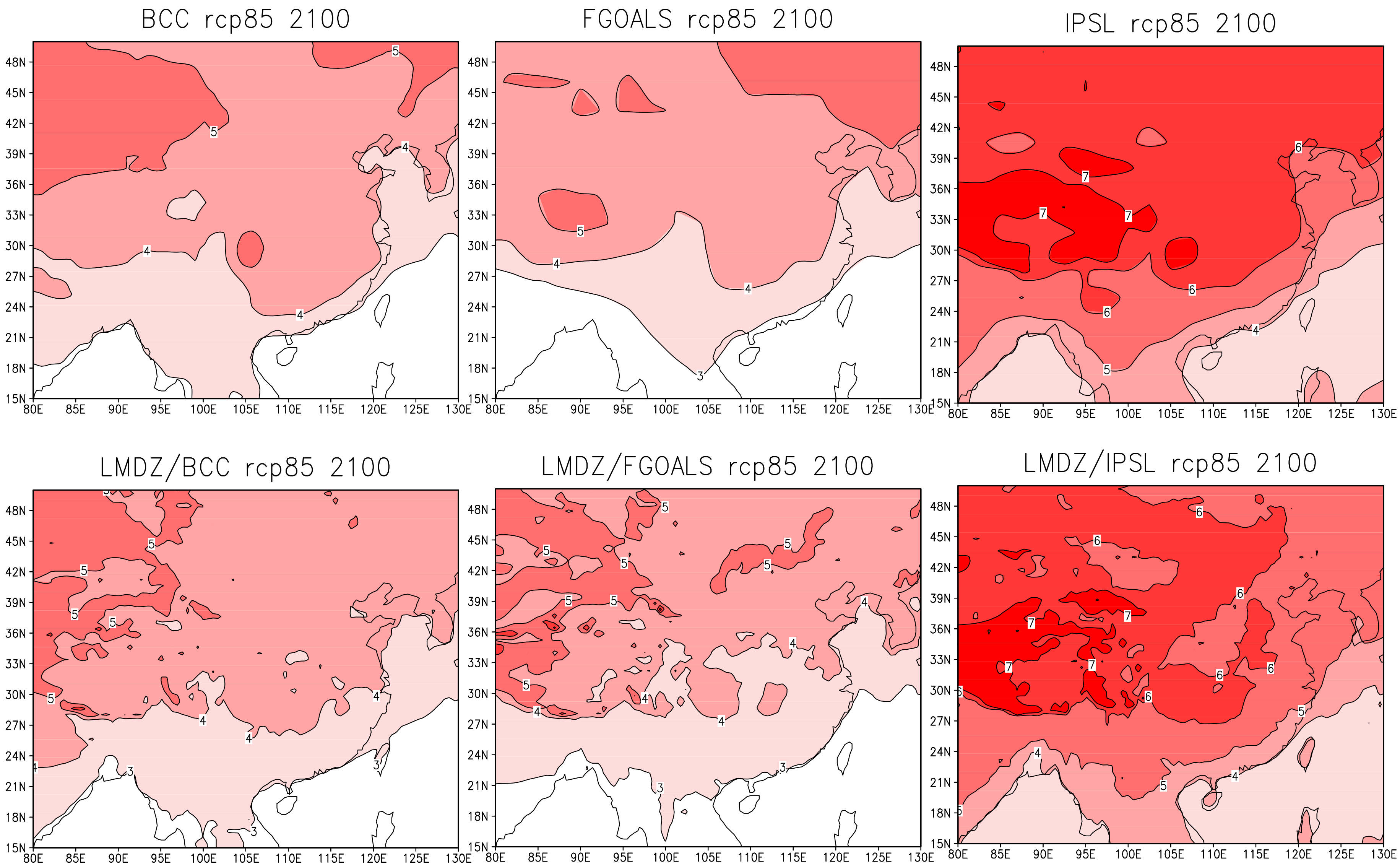
China-mean **rainfall** (mm/day, left) and surface air **temperature** (°C, right)
in global models and in LMDZ: historical, rcp4.5 and rcp8.5

Surface air temperature (°C) | Precipitation (mm/day)

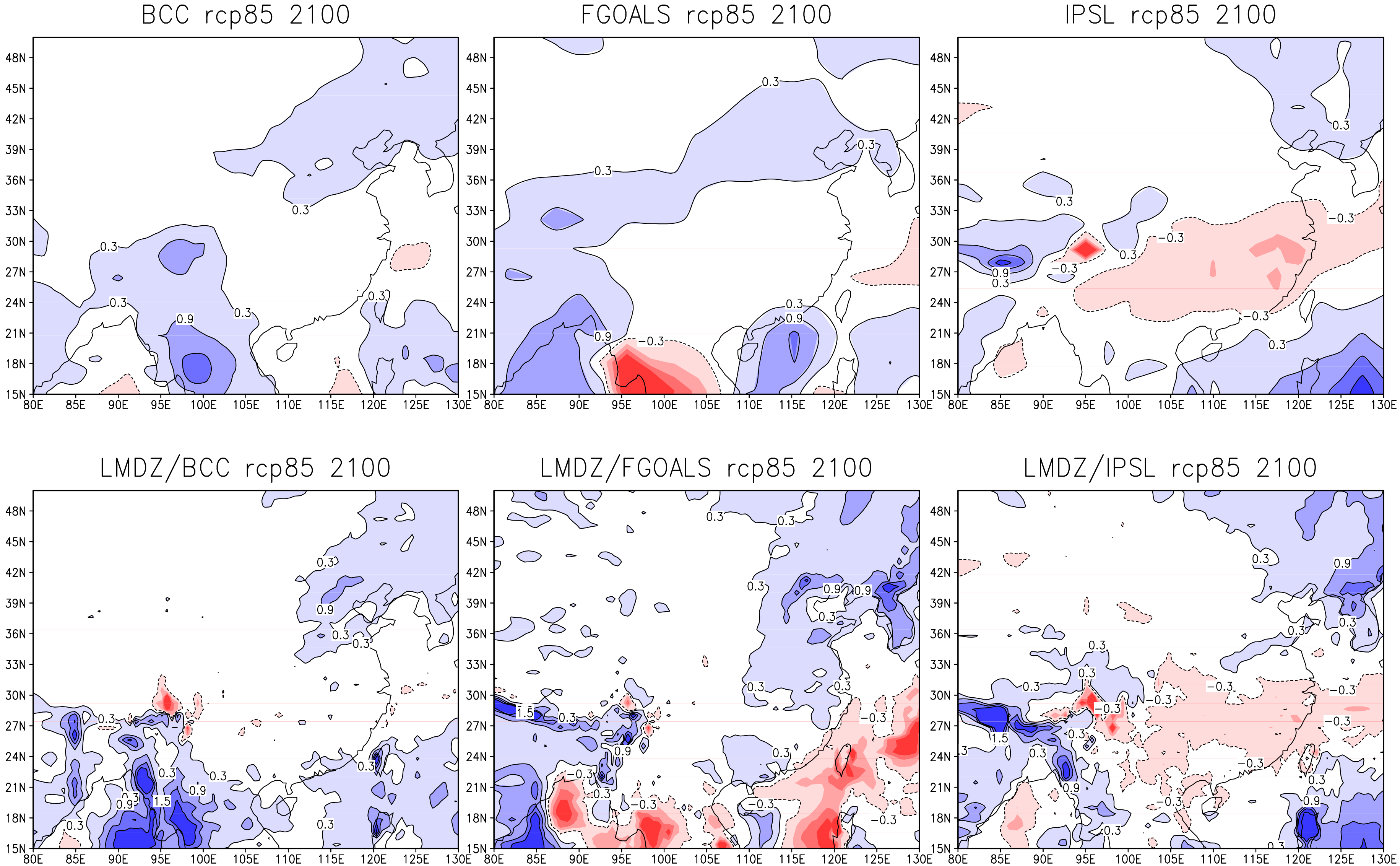


Global models, RCP8.5
(2071/2100 – 1971/2000)

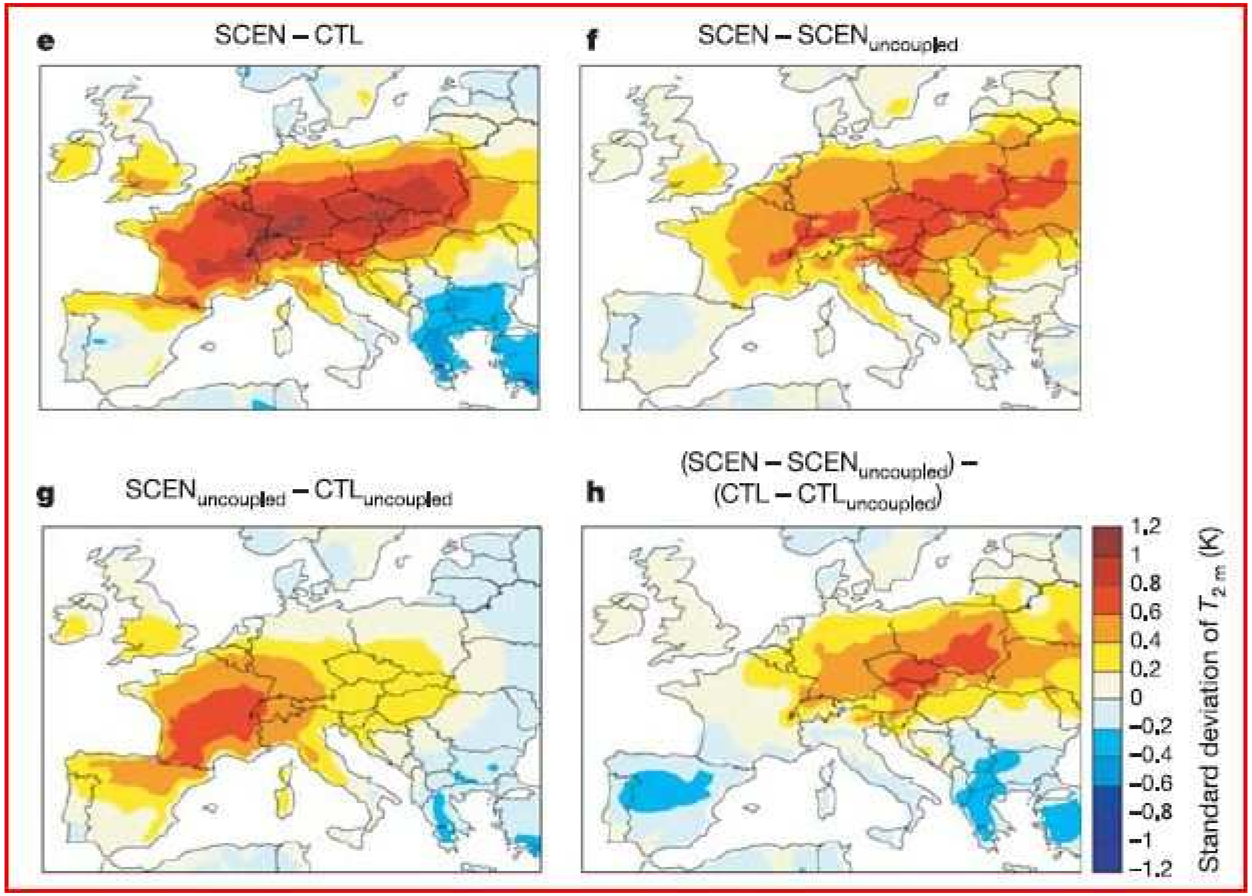
Changes (2071/2100 – 1971/2000, RCP8.5) in surface air temperature (°C) in global models (upper panels) and regional models (lower panels)



Changes (2071/2100 – 1971/2000, RCP8.5) in rainfall rate(mm/day) in global models (upper panels) and regional models (lower panels)

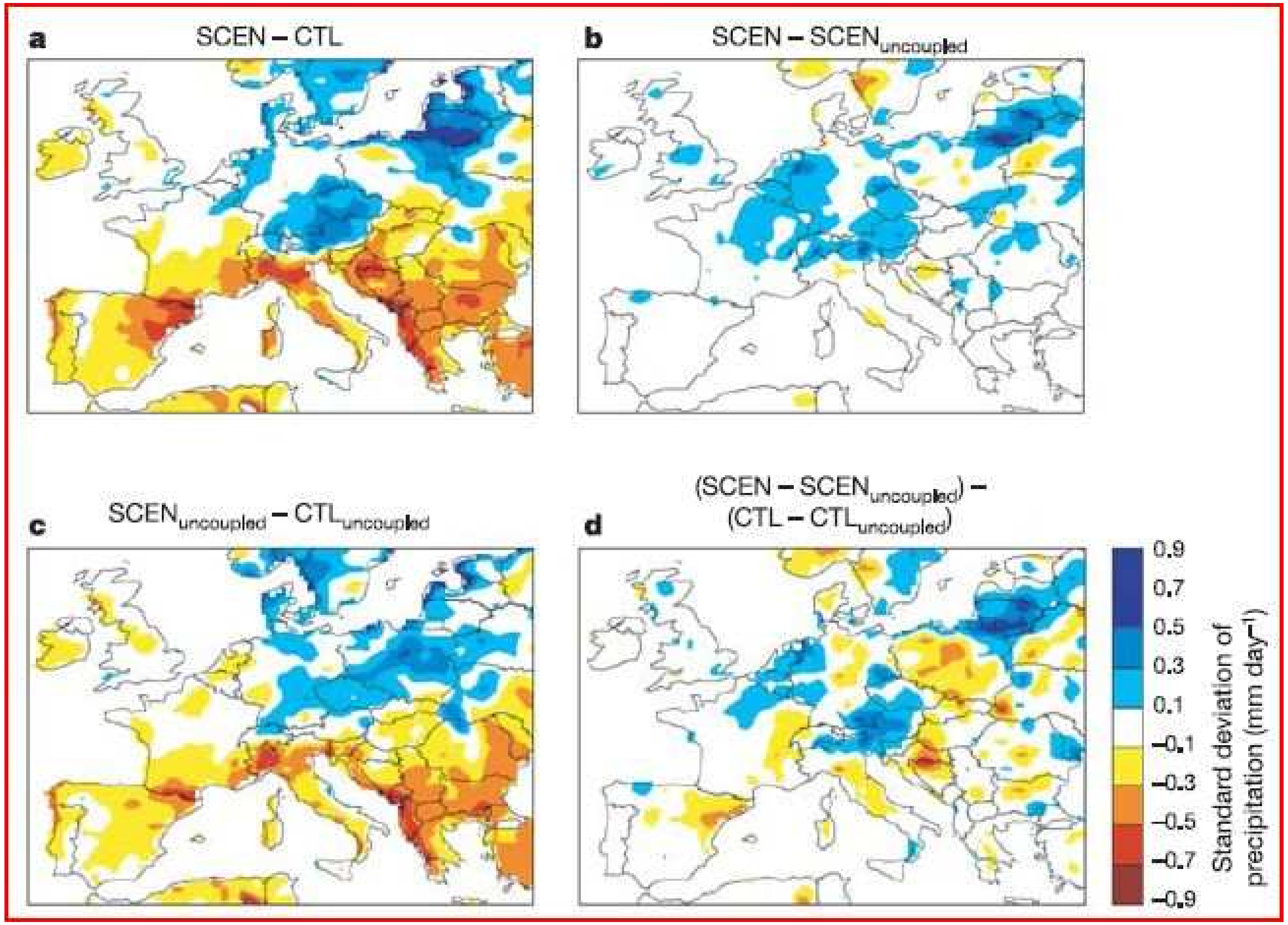


Effects of land–atmosphere coupling on greenhouse-gas induced changes in interannual variability of summer two-metre temperature.



Seneviratne et al. 2006, Nature

Effects of land–atmosphere coupling on greenhouse-gas-induced changes in interannual variability of summer precipitation.



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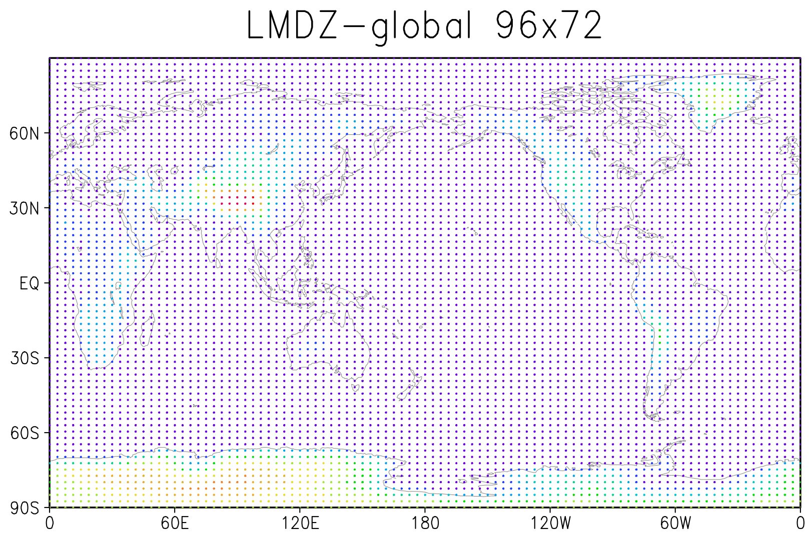
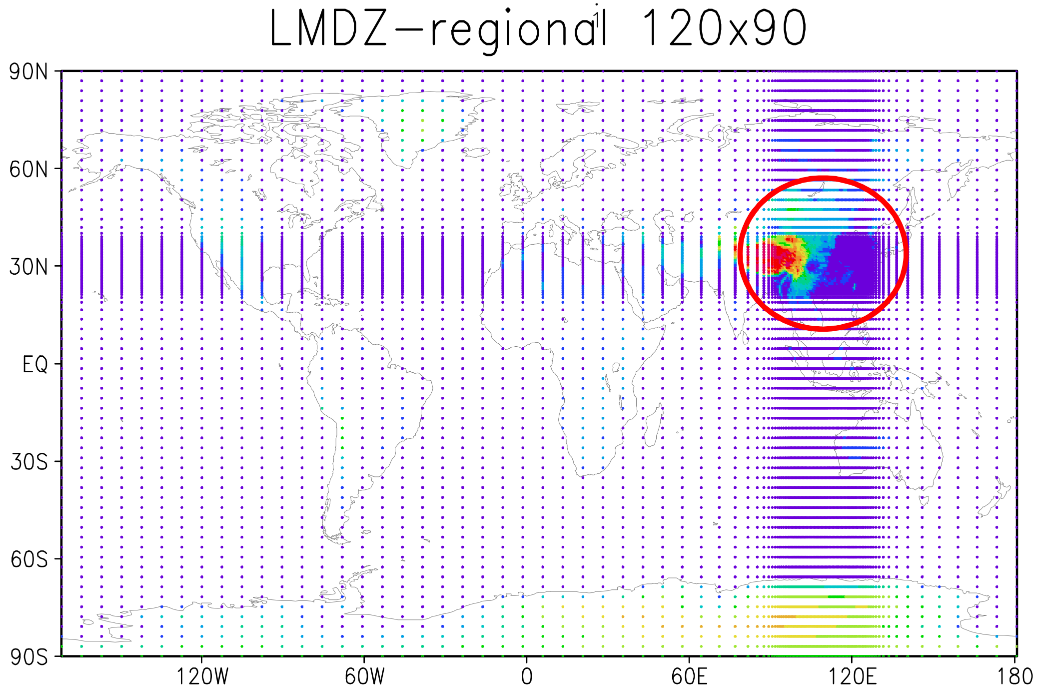
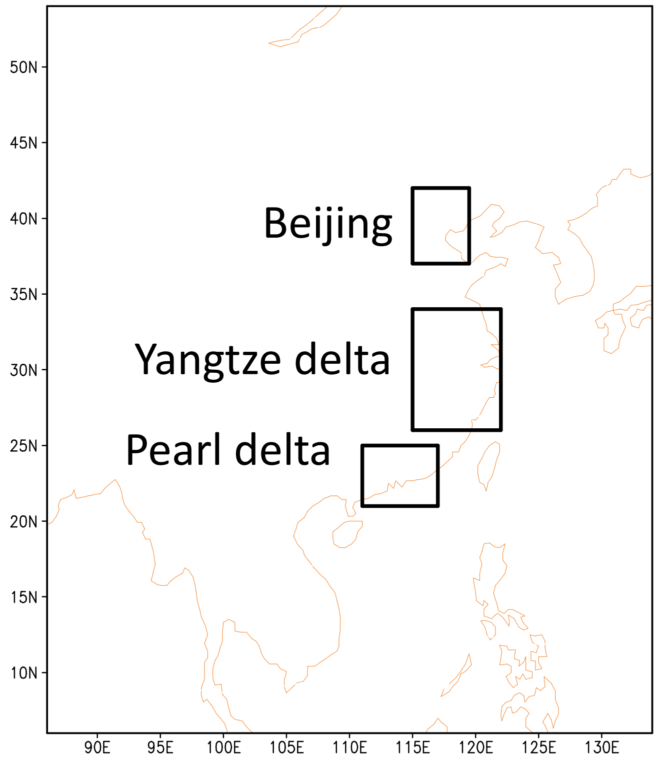


LMDZ-global: about 200 km

LMDZ-regional: about 60 km

Arable land converted to bare soil to mimic urbanisation. Two versions of LMDZ, global and regional, are used.





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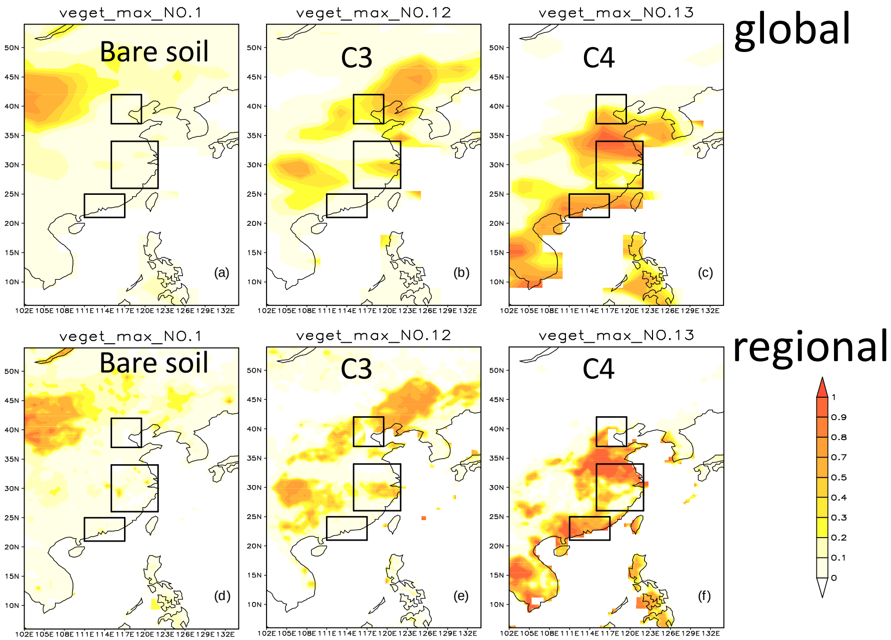
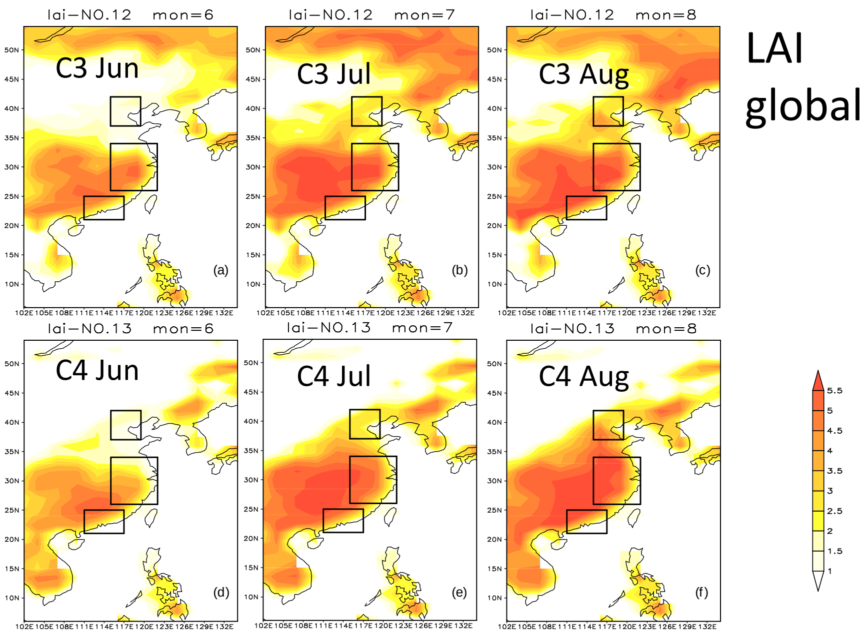
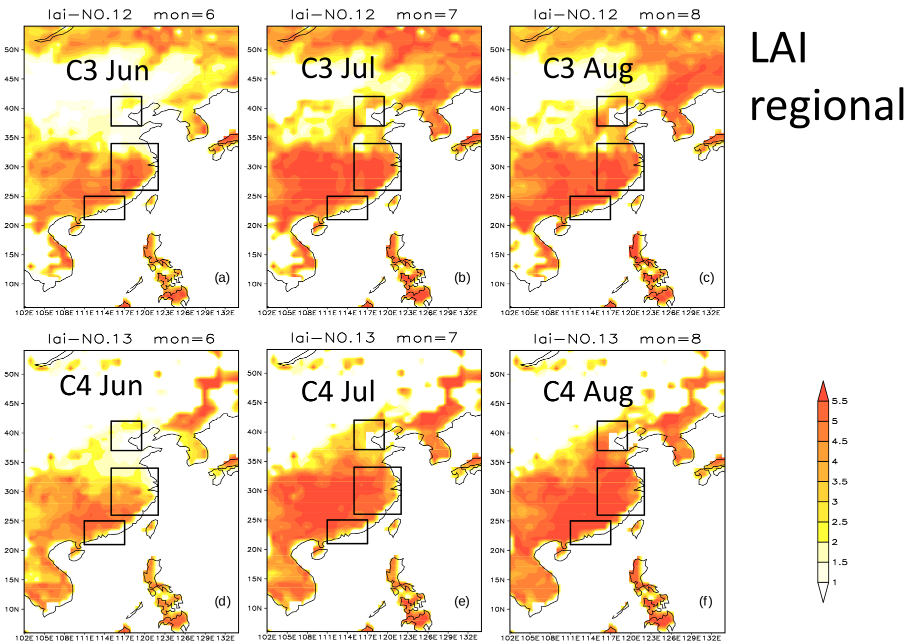


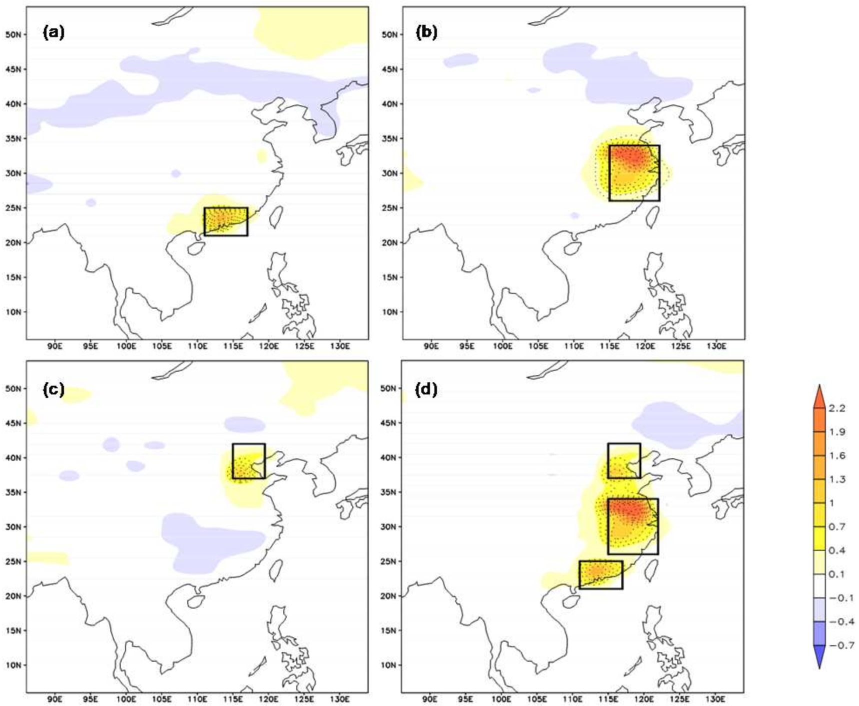
Arable land converted to bare soil to mimic urbanisation. Global: 200km; Regional: 60km

	Pearl		Yangtze		Beijing	
	global	regional	global	regional	global	regional
Bare soil（%）	2.4	2.3	3.4	4.2	5.0	4.6
C3-agriculture（%）	2.3	3.3	10.6	12.3	23.1	26.1
C4-agriculture（%）	43.7	56.0	33.7	45.8	15.3	23.1
Land area(10^5 km2)	1.62	2.48	5.49	5.77	2.44	1.89
C3+C4 agri. area (10^5 km2)	1.41	2.32	4.24	4.33	1.32	1.37
Mean LAI	3.31	3.71	4.13	4.24	2.61	2.69

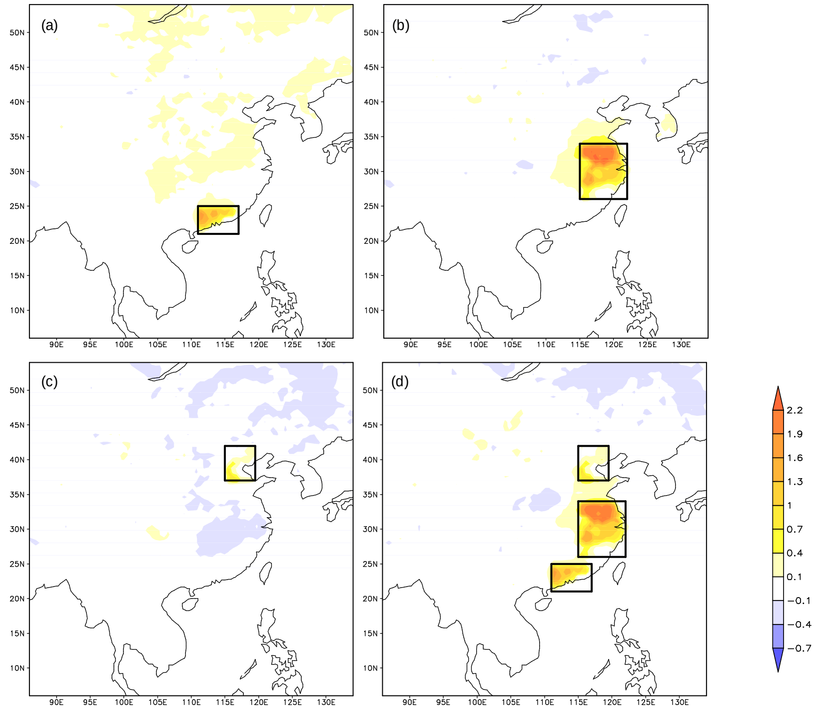


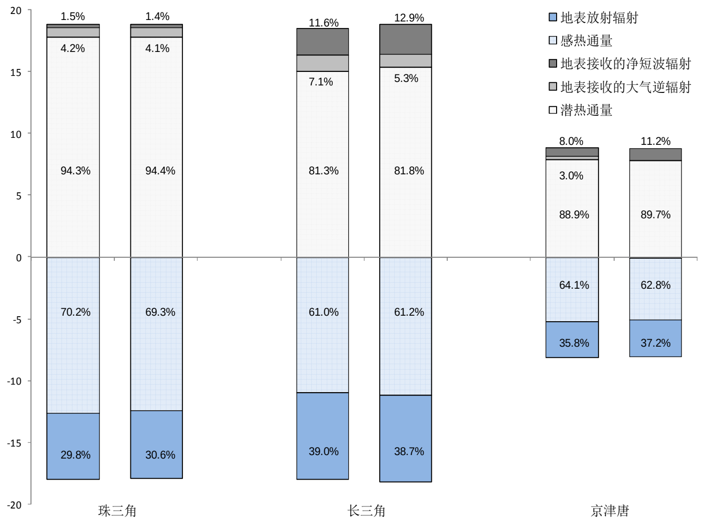


Global: changes in T2m

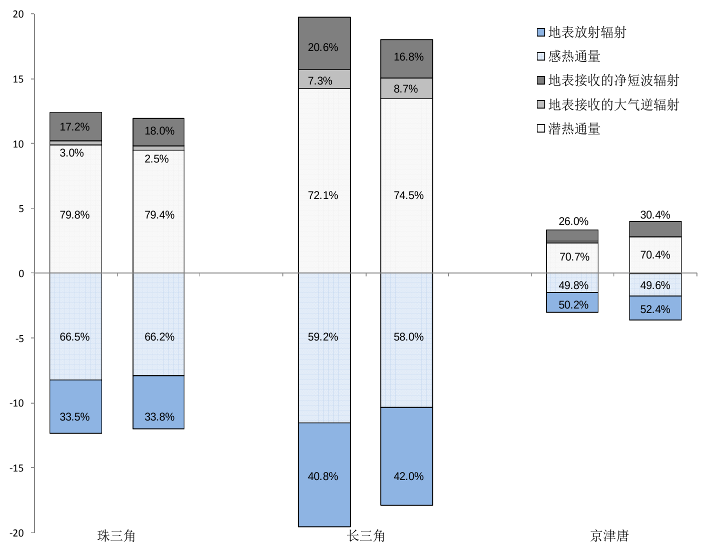


Regional: changes in T2m





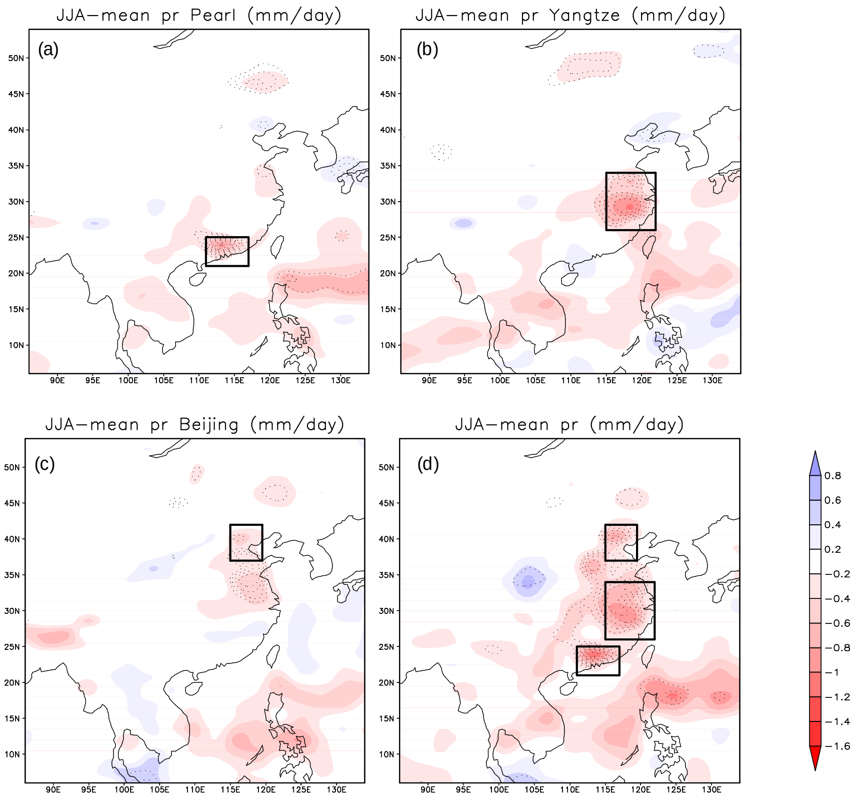
Global: changes in surface energy balance



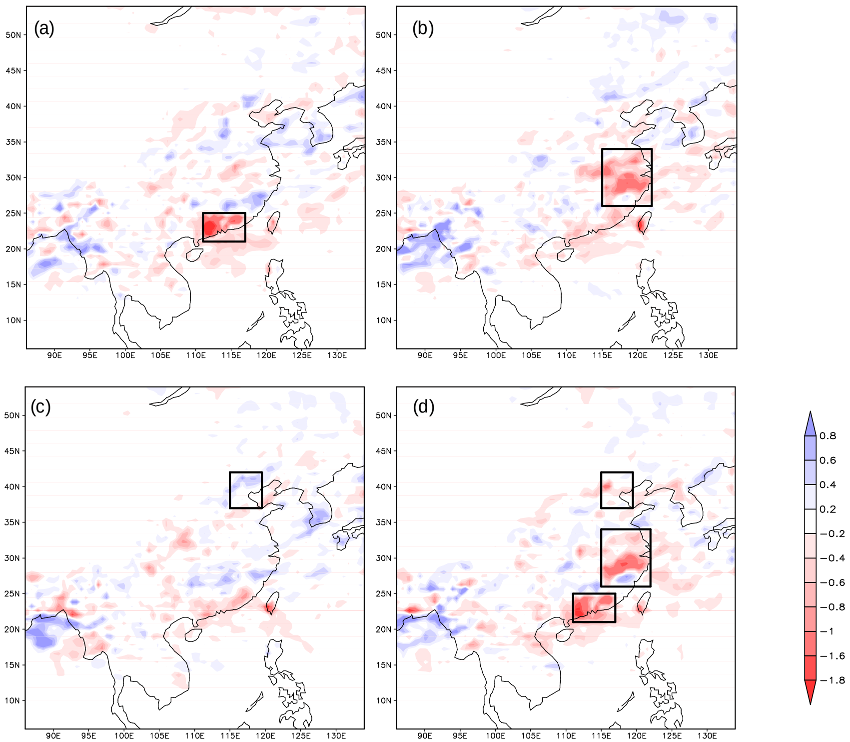
Regional: changes in surface energy balance

Changes in precip (mm/d)

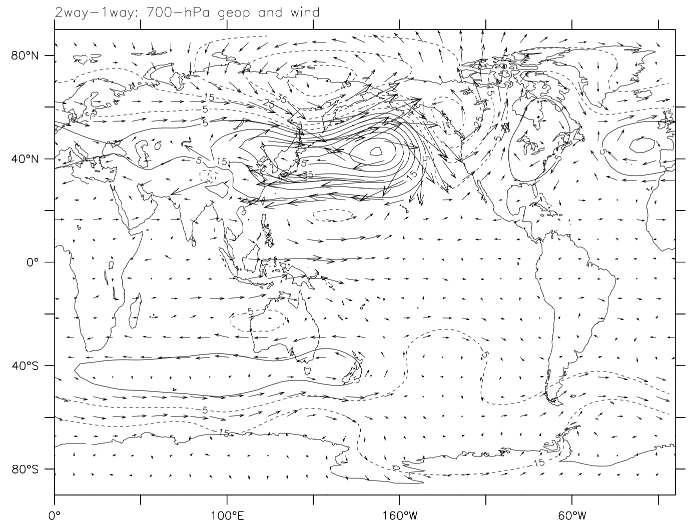
Global



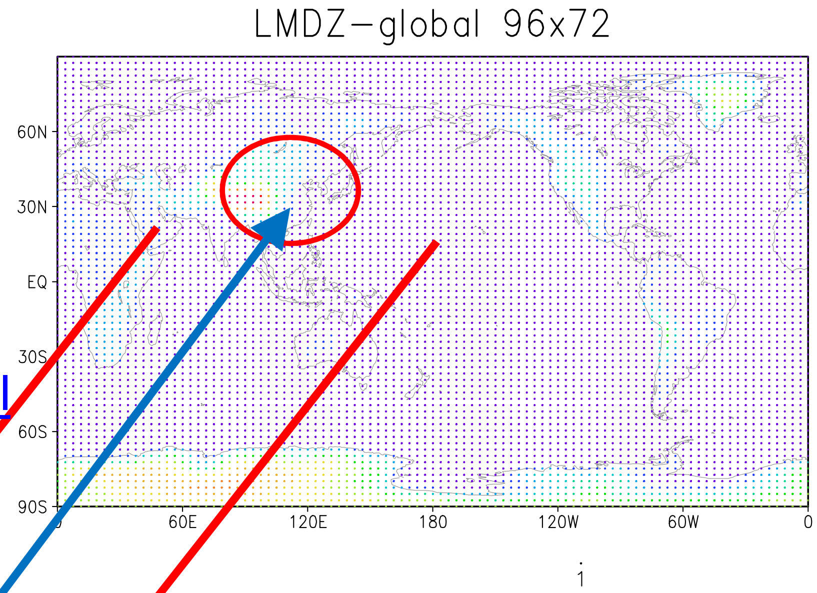
Regional

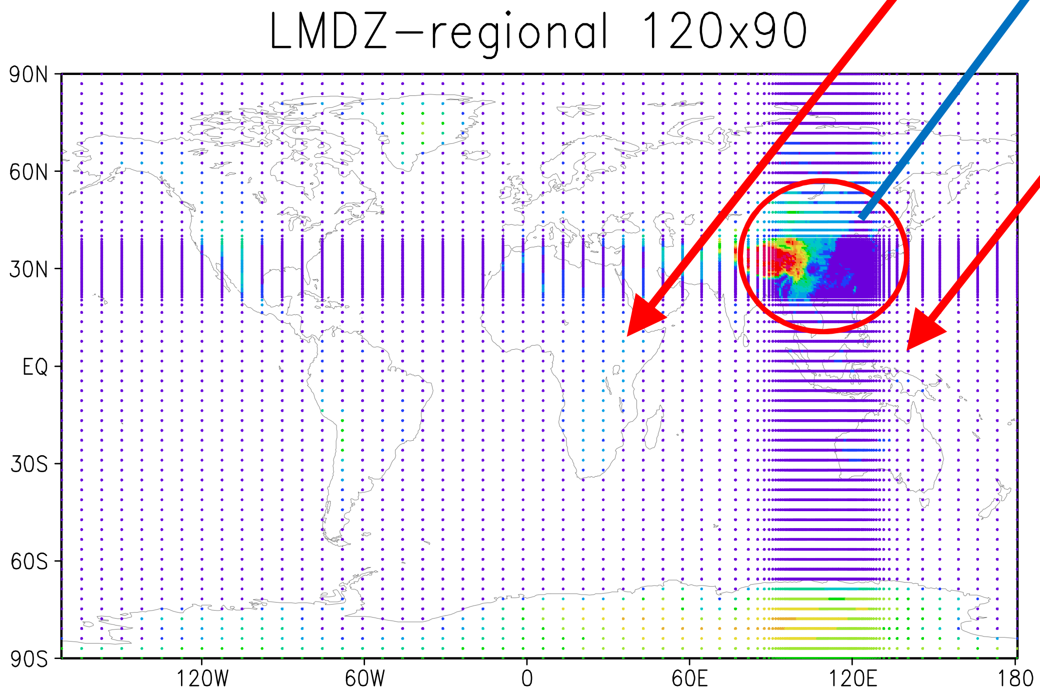


2way – 1way in LMDZ-global: 700-hPa height and wind



[Two-way nesting between LMDZ-regional and LMDZ-global]





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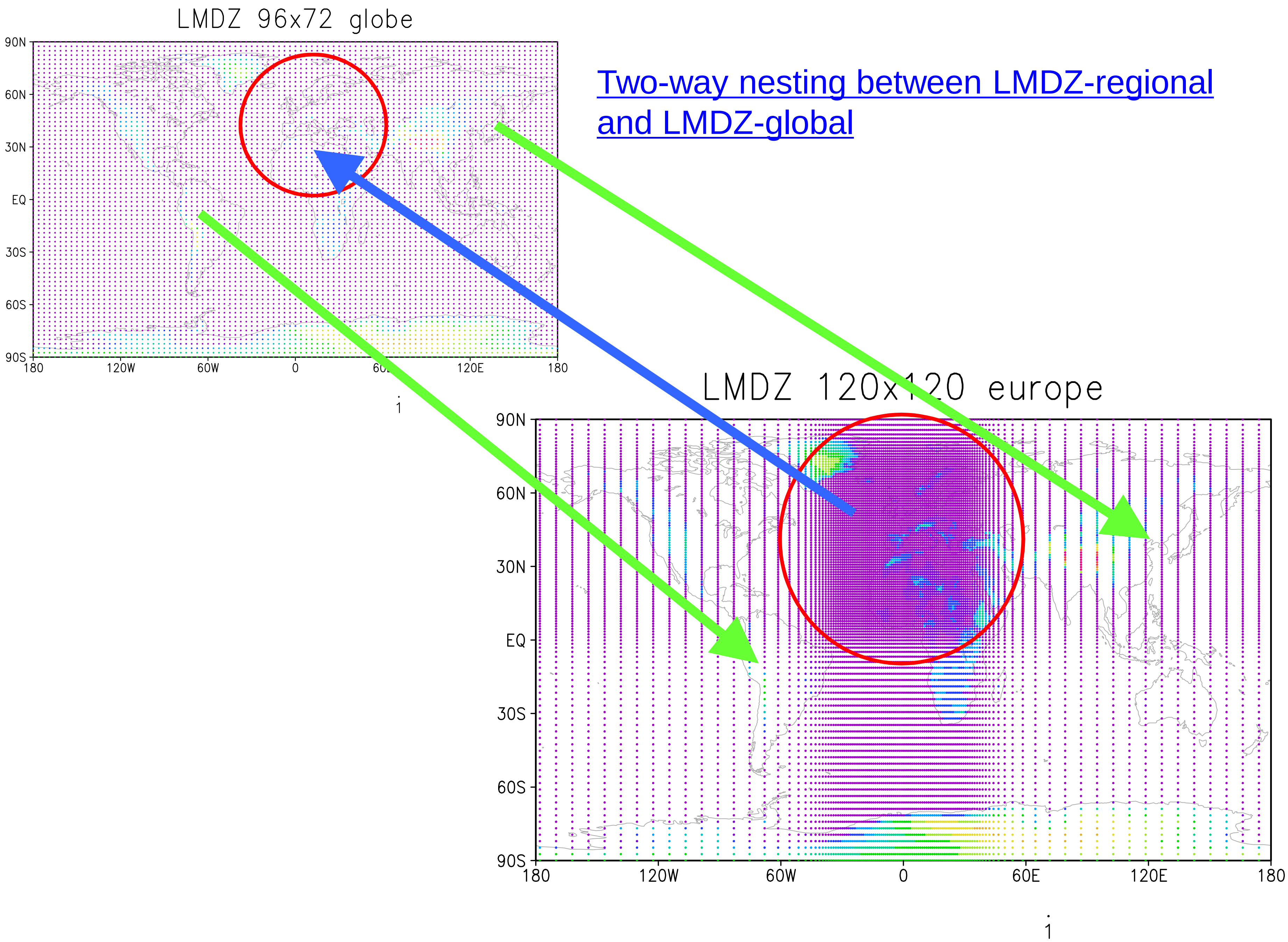
Chen et al. 2011, Climate dynamics

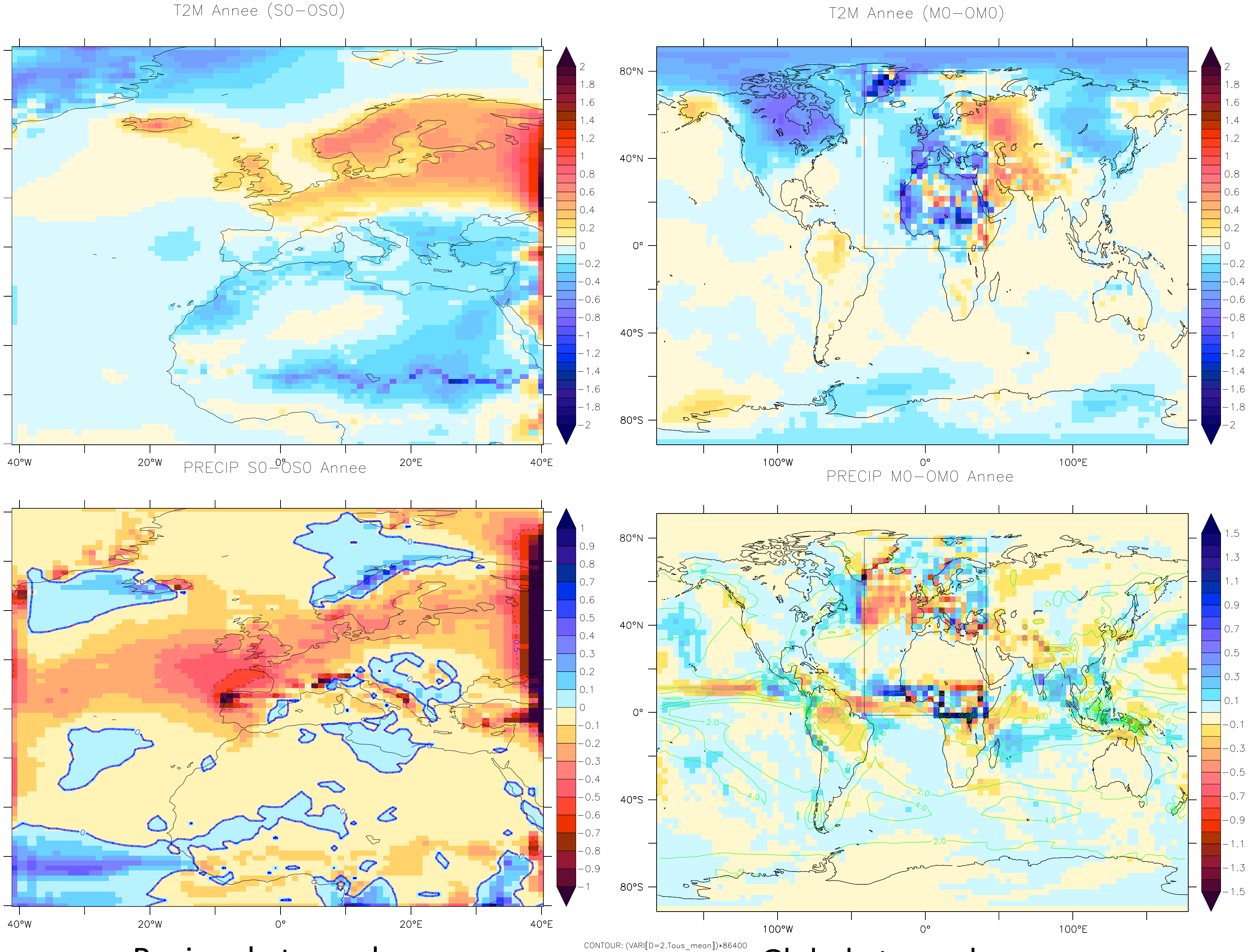
Two-way nesting between LMDZ-regional and LMDZ-global



Atmospheric t2m and precipitation (2way-1way), annual mean

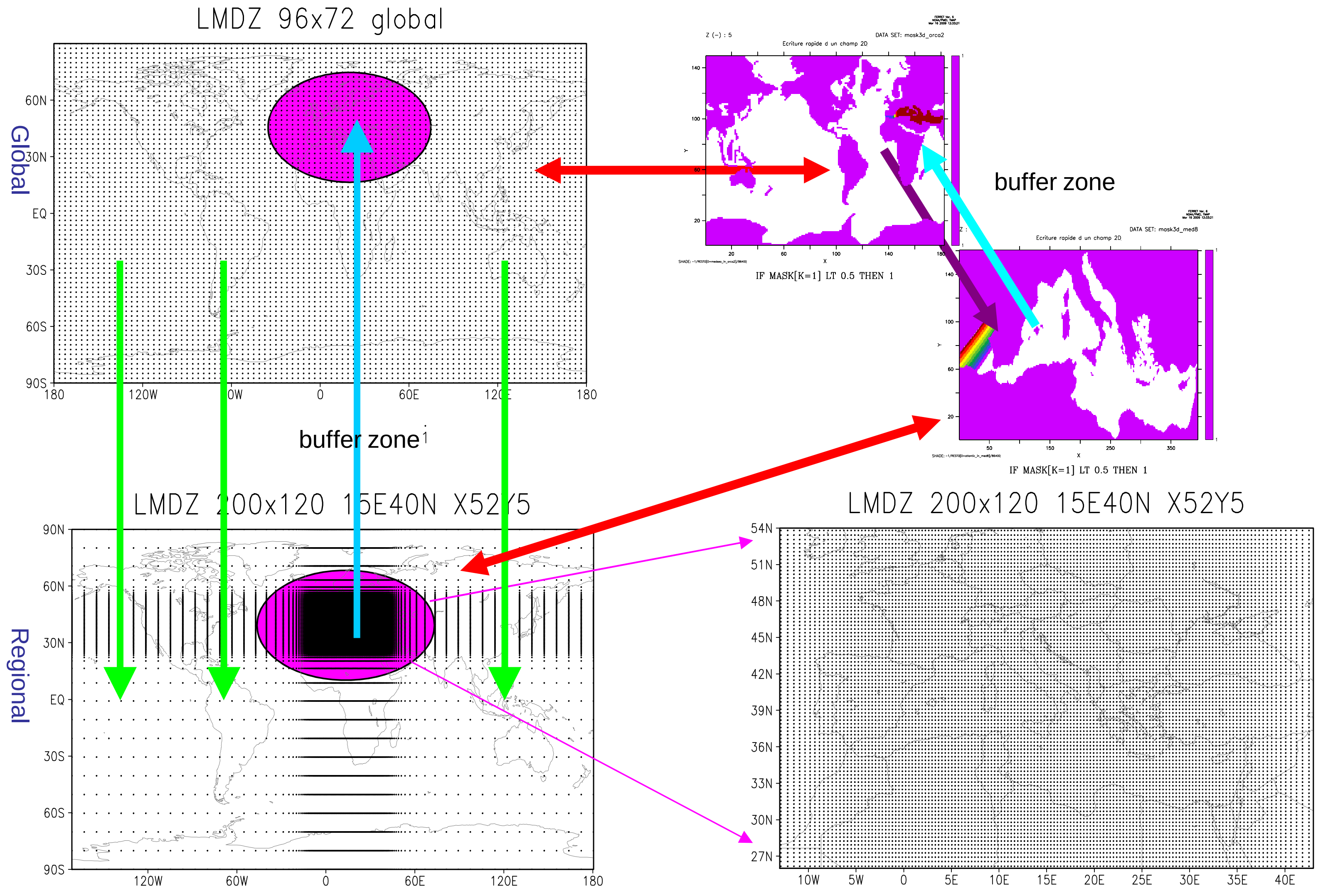
tas

pr



Regional atmosphere

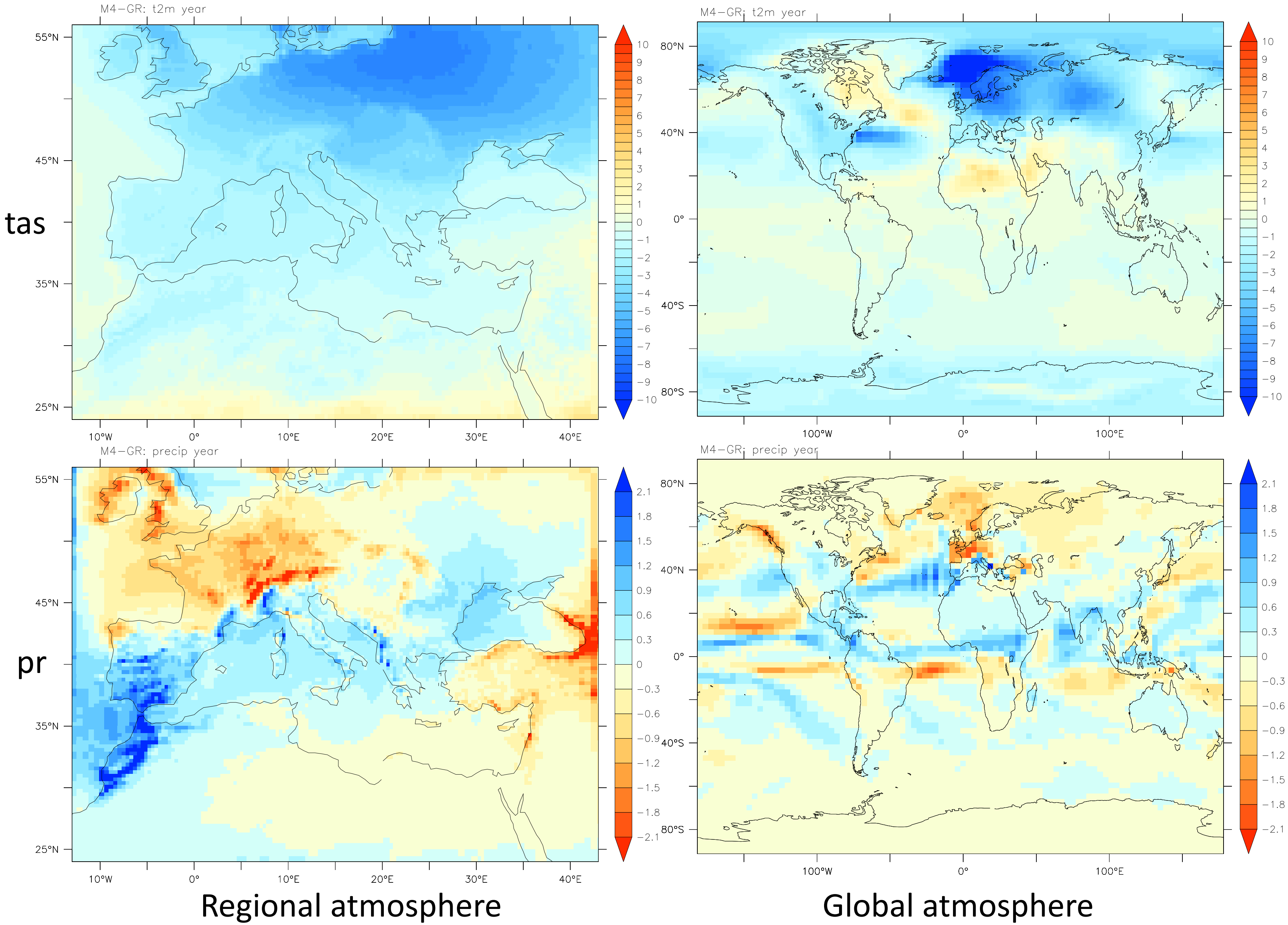
Global atmosphere



- **Global O-A coupled model: LMDZ-global / ORCA2**
- **Regional O-A coupled model: LMDZ-regional / MED8**
- **Two atmospheric models are coupled through buffer zones**
- **Two oceanic models are also coupled through buffer zones**

Schematic of the quadruple coupling: M4

Atmospheric t2m and precipitation (M4-GR), annual mean over 1971/2000



Conclusions

- LMDZ, a global climate model with possible configurations of **zoom** and **nudging**, is a useful tool for climate downscaling and scale interaction.
- We have performed a multi-model **ensemble of climate change projections** and downscaling, available for further analysis and diagnostics. Focus will be on **extreme events**. Multi-disciplinary climate change **impact** studies will be promoted.
- We observe a few limitations in using limited-area climate model for studies on climate effects of land-use changes
- With the **two-way nesting** system (two models or four models), we assessed the contributions to the global climate if the climate of a region is taken into account with higher resolution. We also assessed the potential biases in regional climate if feedbacks from global climate are neglected.