Potential impacts of climate change on vegetation dynamics and ecosystem function in a mountain watershed on the Qinghai-Tibet Plateau

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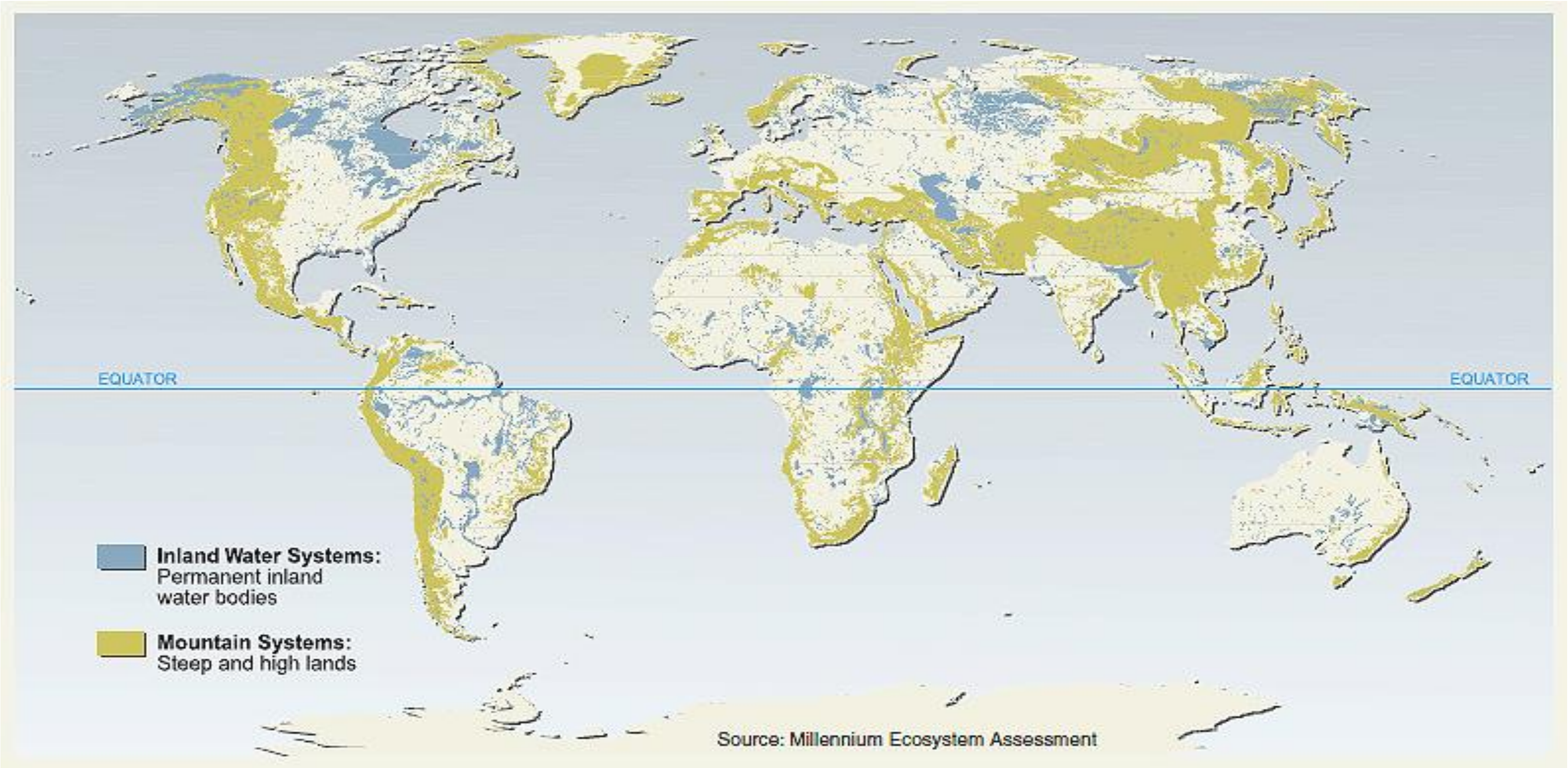
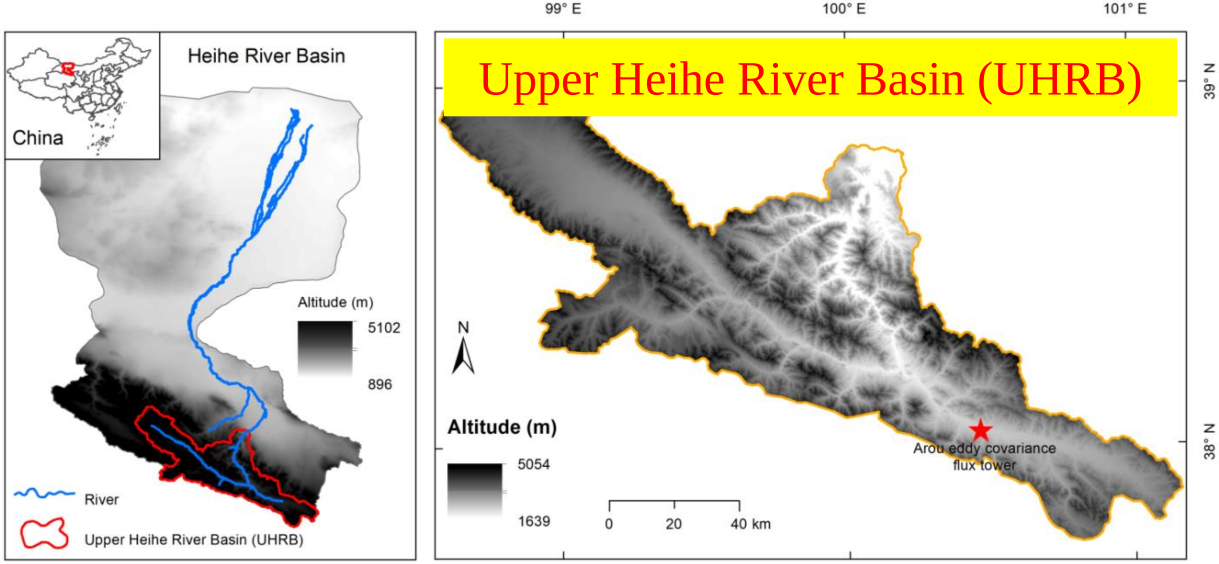
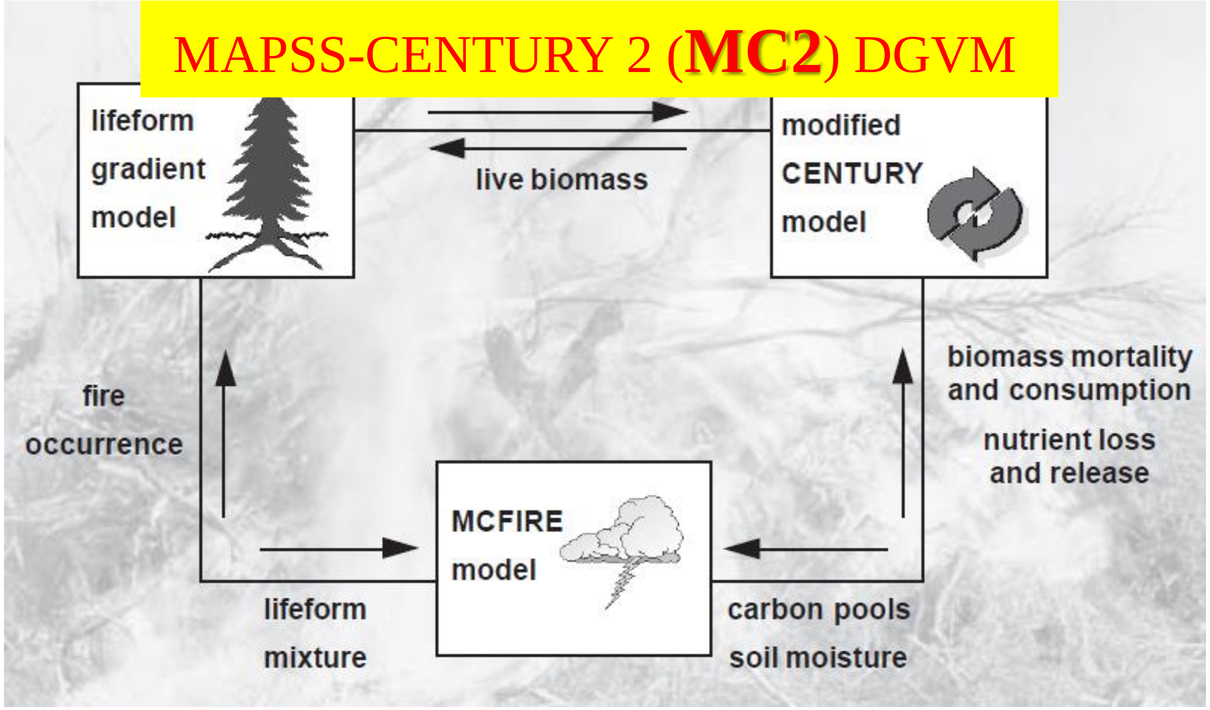


- Mountains: ecological indicators of climate change effects
- **¼** of the land area, providing services to **>1/2** of the population
- Previous efforts generally focused on short-term historical trends
- A significant **challenge to regional applications of DGVMs**





Objectives

- calibrate/evaluate MC2 to the UHRB using the best available data
- Simulate the climatic change effects on the potential vegetation type and two key ecosystem services: carbon sequestration and the water budget.

Input data

90 m soil data + 90 m DEM

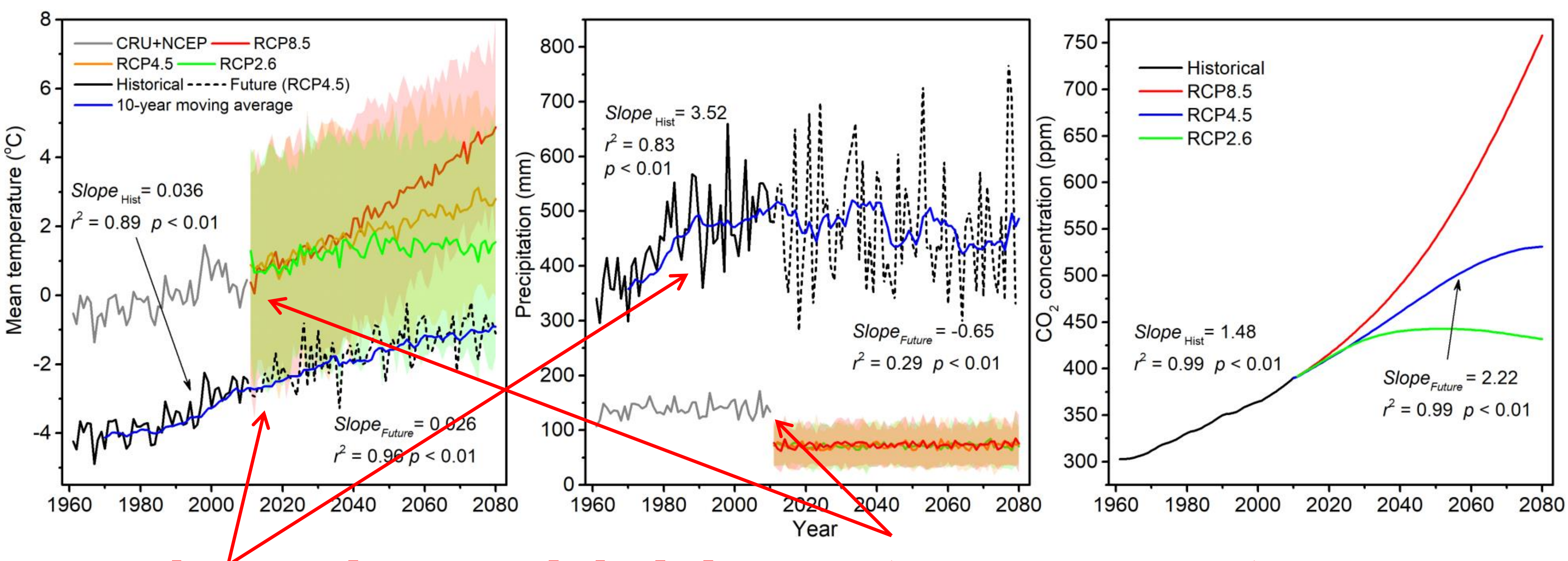
CO_2 concentration

Historical climate (1961-2012)

Climate reanalysis data, 1km
15 meteorological stations + 25 hydrological stations + RIEMS 2.0

Climate projection (2005-2080)

RIEMS 2.0 + RCP4.5, 3-km
downscaled to 1 km using the delta method



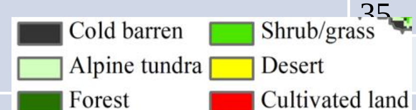
This study

Global dataset (CRU + GCMs)

Model calibration

MC2 Actual vegetation

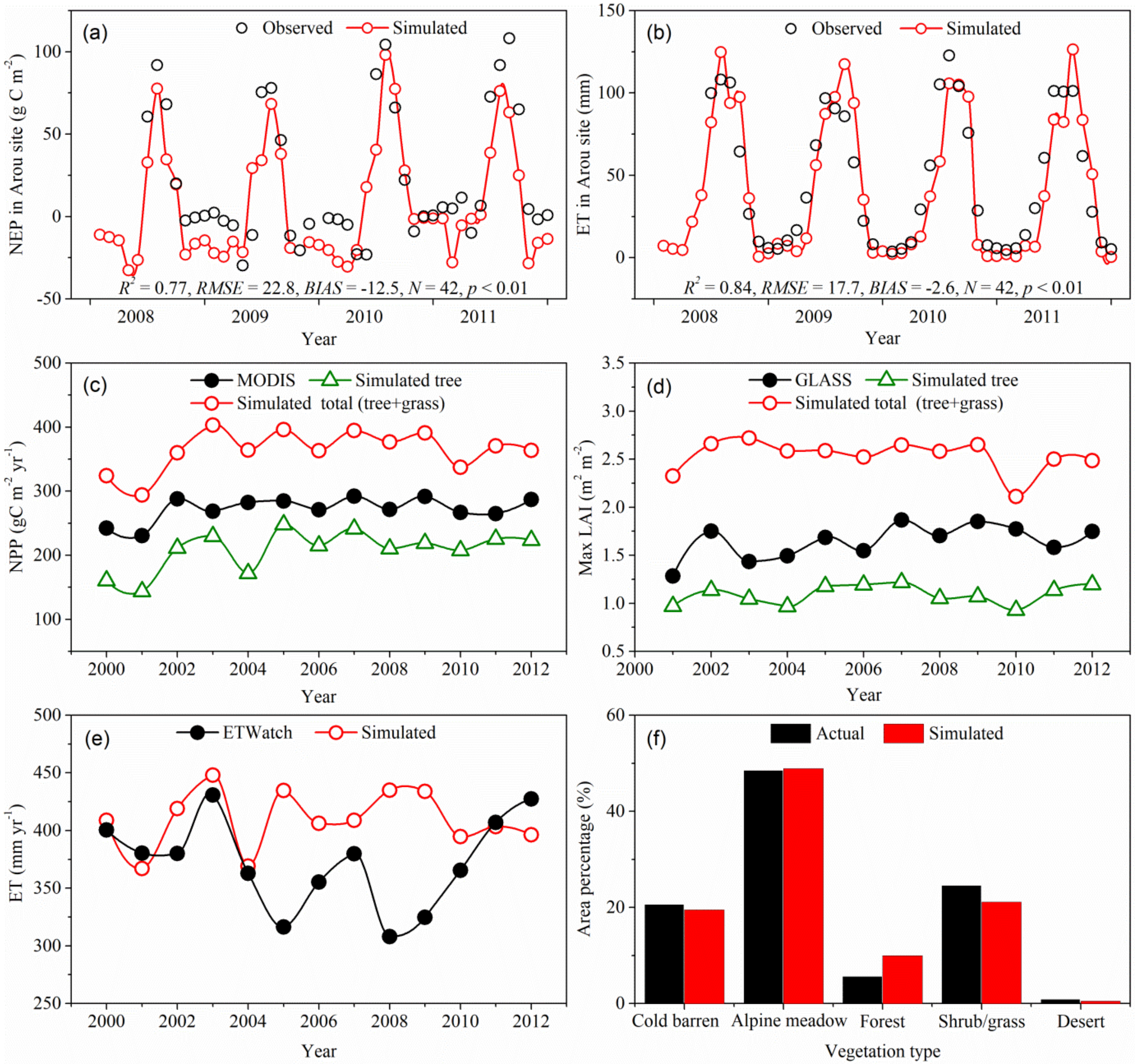
Parameter	Description	Default	Calibrated
bz_thres (˚C)	Upper limit of low monthly temperature for the boreal climate zone	-15	-17
t_low (˚C)	Upper limit of low monthly temperature for needleleaf tree type	-15	-25
t_mid (˚C)	Lower limit of low monthly temperature for broadleaf tree type	1.5	-13.5
p_low (mm)	Upper limit of warm season precipitation for evergreen tree type	70	56
p_hi (mm)	Lower limit of warm season precipitation for deciduous tree type	90	105
pprdwc (a, b, c) (dimensionless)	Productivity coefficient that represents how much water is available to the trees	(0.5, 1, 0.9)	(0.3, 1, 0.6)
ppdf(1) _EN (˚C)	Optimum (ppdf(1)) and maximum (ppdf(2)) temperatures for production for parameterization of a Poisson density function curve to simulate temperature effect on growth for evergreen needleleaf (EN) tree type, deciduous broadleaf (DB) tree type, and C3 grass.	15	20
ppdf(1) _DB (˚C)		22	23
ppdf(1) _C3 grass (˚C)		18	12
ppdf(2) _EN (˚C)		30	30
ppdf(2) _DB (˚C)		35	41
ppdf(2) _C3 grass (˚C)		[illegible]	22
max_NPP_EN/DB (g C m⁻²)	Potential aboveground monthly production for EN and DB	250	250
max_NPP_C3 grass (g C m⁻²)	Potential aboveground monthly production for C3 grass	150	120
max_LAI (m² m⁻²)	Maximum leaf area index for EN and DB	8	4
forest_thres (g C m⁻²)	Lower limit of total tree carbon for forest	3000	2500
woodl_thres (g C m⁻²)	Upper limit of tree carbon for shrubs	1150	800
desert_treec_max (g C m⁻²)	Upper limit of tree carbon for deserts	27	300
desert_grassc_max (g C m⁻²)	Upper limit of grass carbon for deserts	385	150
grassfrac_thres	Lower limit of grass fraction for grassland	0.6	0.5



Forest

A structured approach: NPP/LAI→biogeography rules

Model evaluation

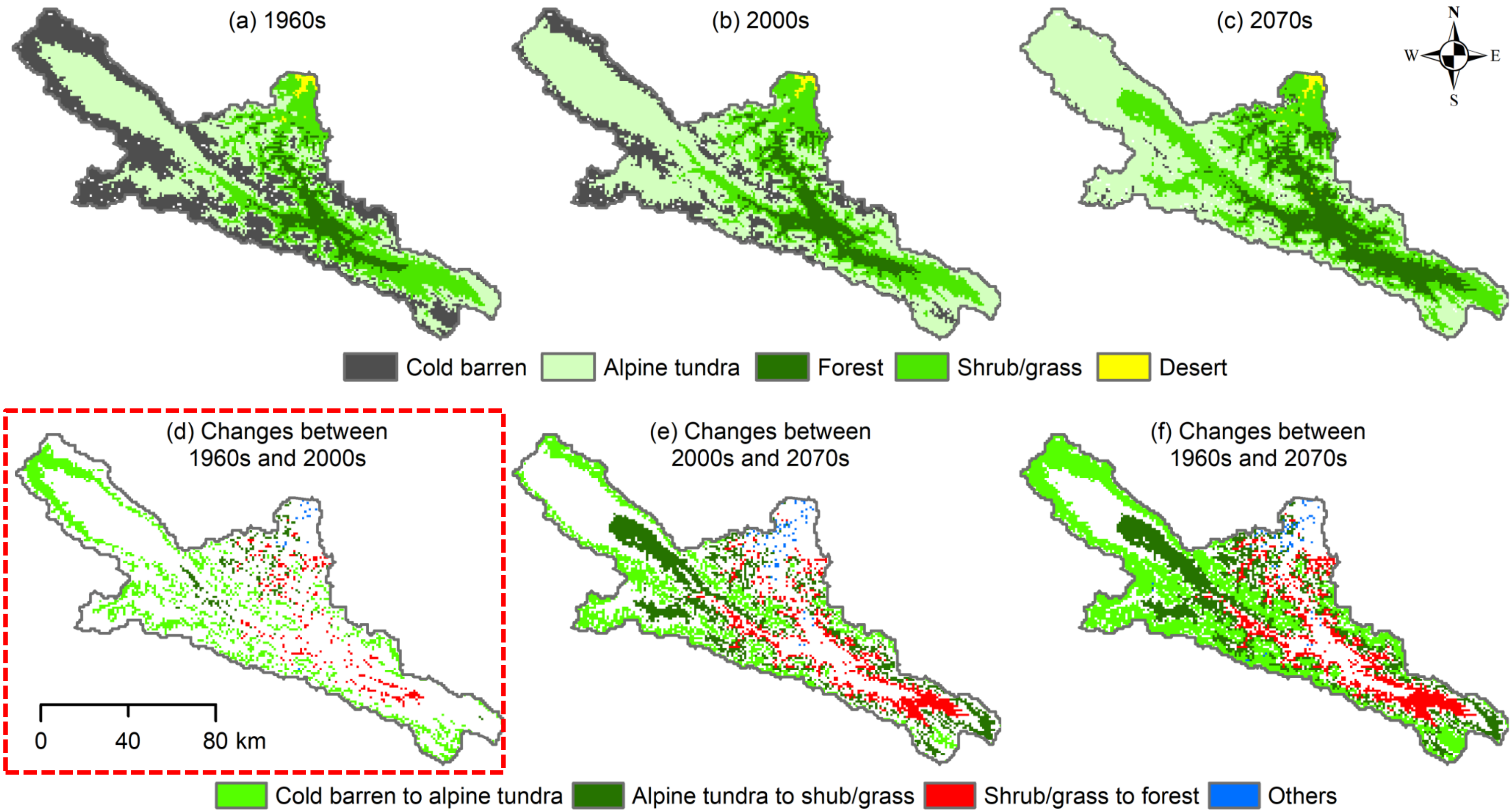


Arou EC flux data

MODIS NPP
GLASS LAI

ETWatch
Vegetation map

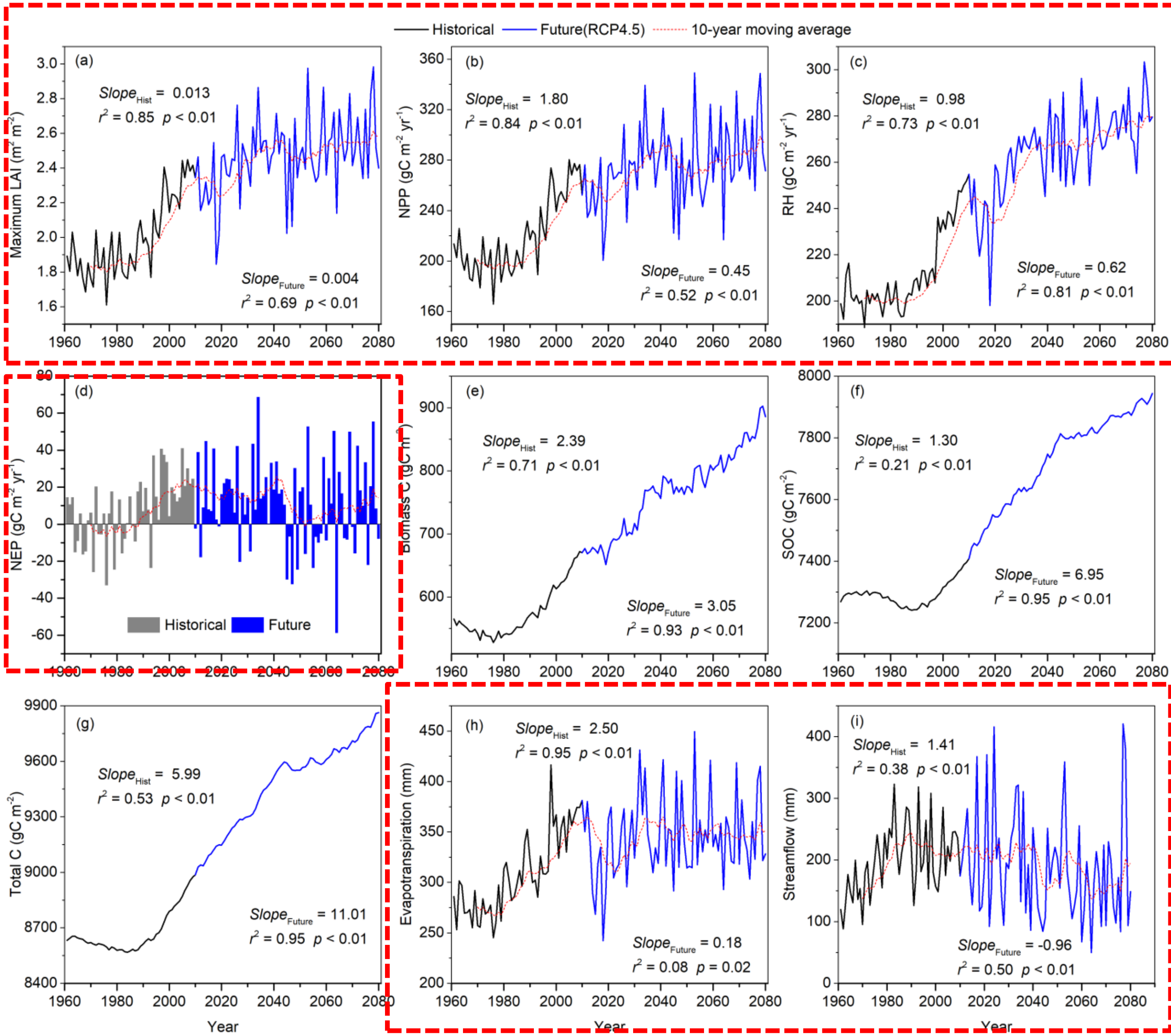
Model Results: Changes in potential vegetation distribution



1/5 changed in 1961-2010

2/5 was projected to change by the 2070s

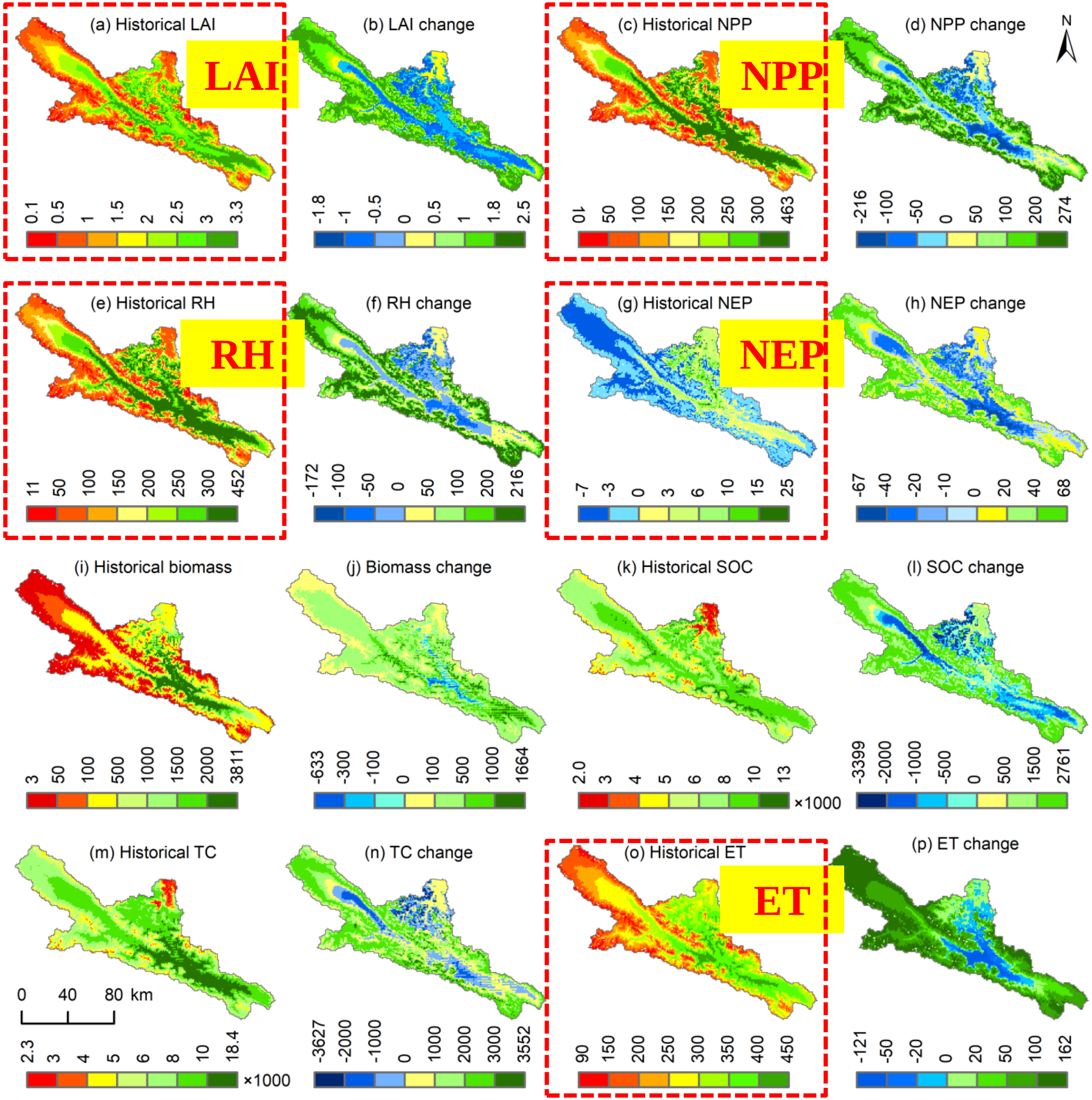
Model Results: Changes in carbon and water budgets



LAI, NPP, RH Increase since the mid-1980s remain at reduced rates in the future

C neutral to C sinks

ET: Increase
Streamflow: Decrease



Large spatial variability

Mid-elevations

larger NPP, RH, ET

weak carbon sinks

<u>decrease in future</u>

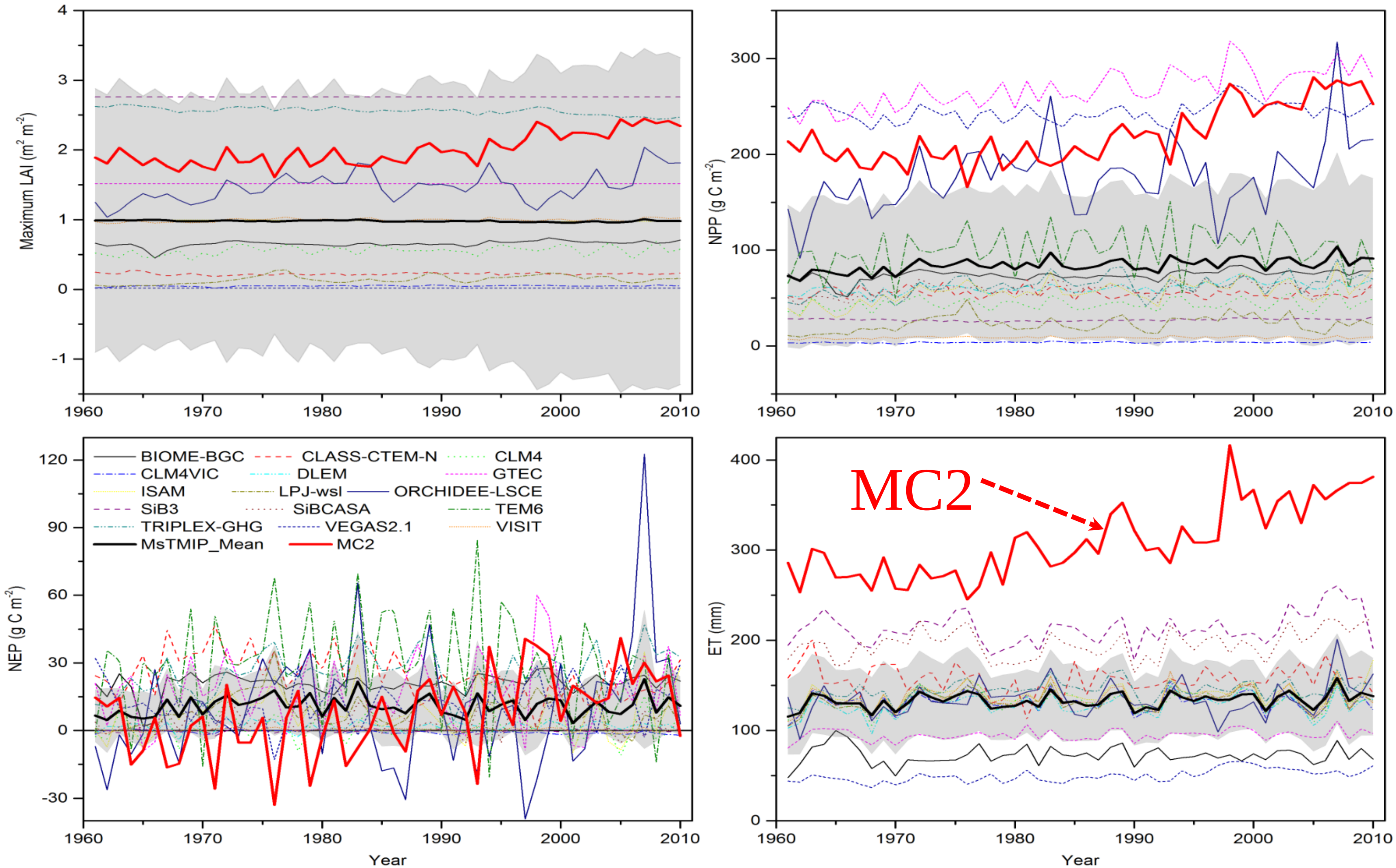
High-elevations

lower NPP, RH, ET

weak carbon source

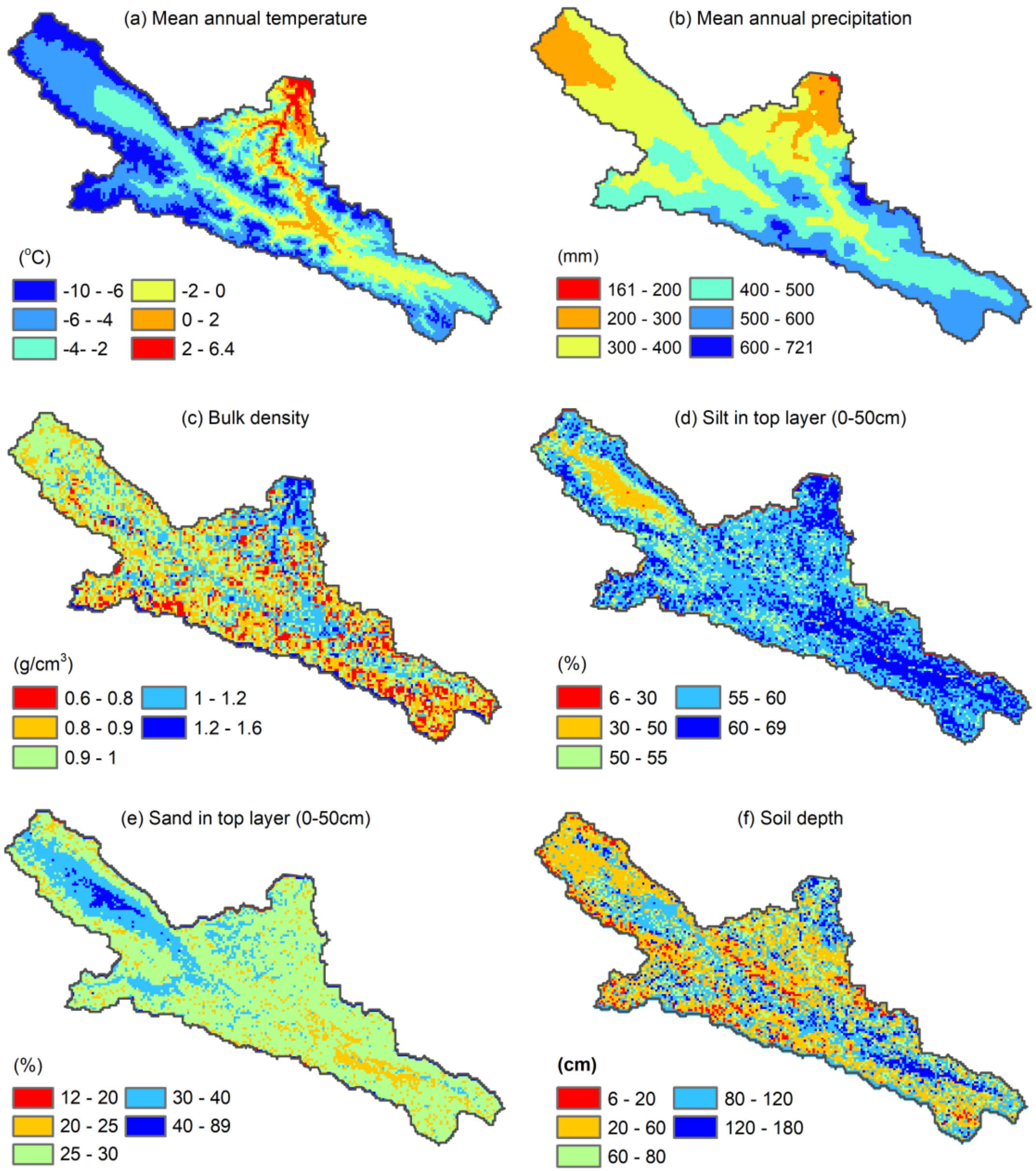
<u>increase in future</u>

A comparison of MC2 and global model outputs

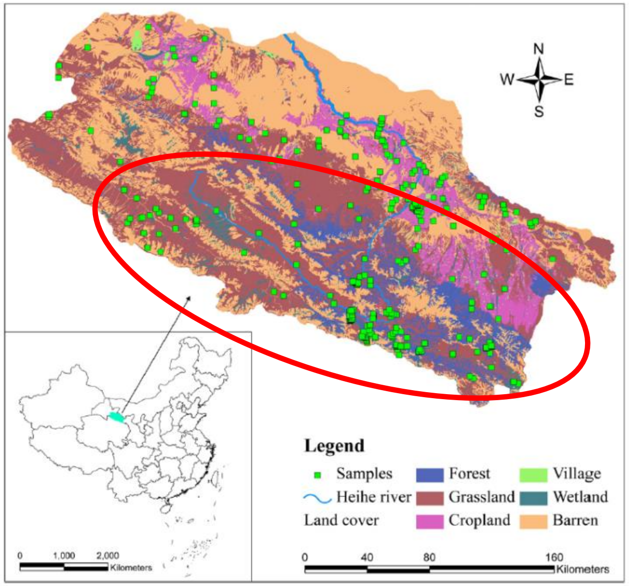


15 global terrestrial biosphere models published by the MsTMIP

Uncertainties: data and model structure



- The 1-km spatial resolution may not adequately capture the heterogeneity of microclimates
- A single regional climate model + one climate change scenario
- Imitated soil profiles in the UHRB



Summary

- Climate change may have driven substantial shifts in vegetation distribution in the UHRB, and characterizes future shifts under the RCP4.5 scenario;
- The UHRB is simulated to have experienced increases in LAI, NPP, RH, and ET in the past, and those trends are projected to continue into the future, albeit at lower rates;
- MC2 simulates large spatial variability of the vegetation dynamics in response to climate change;
- More studies should continue to improve the input data and model structure to more robustly quantify the potential ecosystem dynamics in mountainous area.

(Zhou et al. 2019, under review)

谢谢！ 敬请批准指正！

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