Spatiotemporal vegetation variations and projections driven by atmosphere-ocean oscillations at multiple time scales: a case study in Gansu, China

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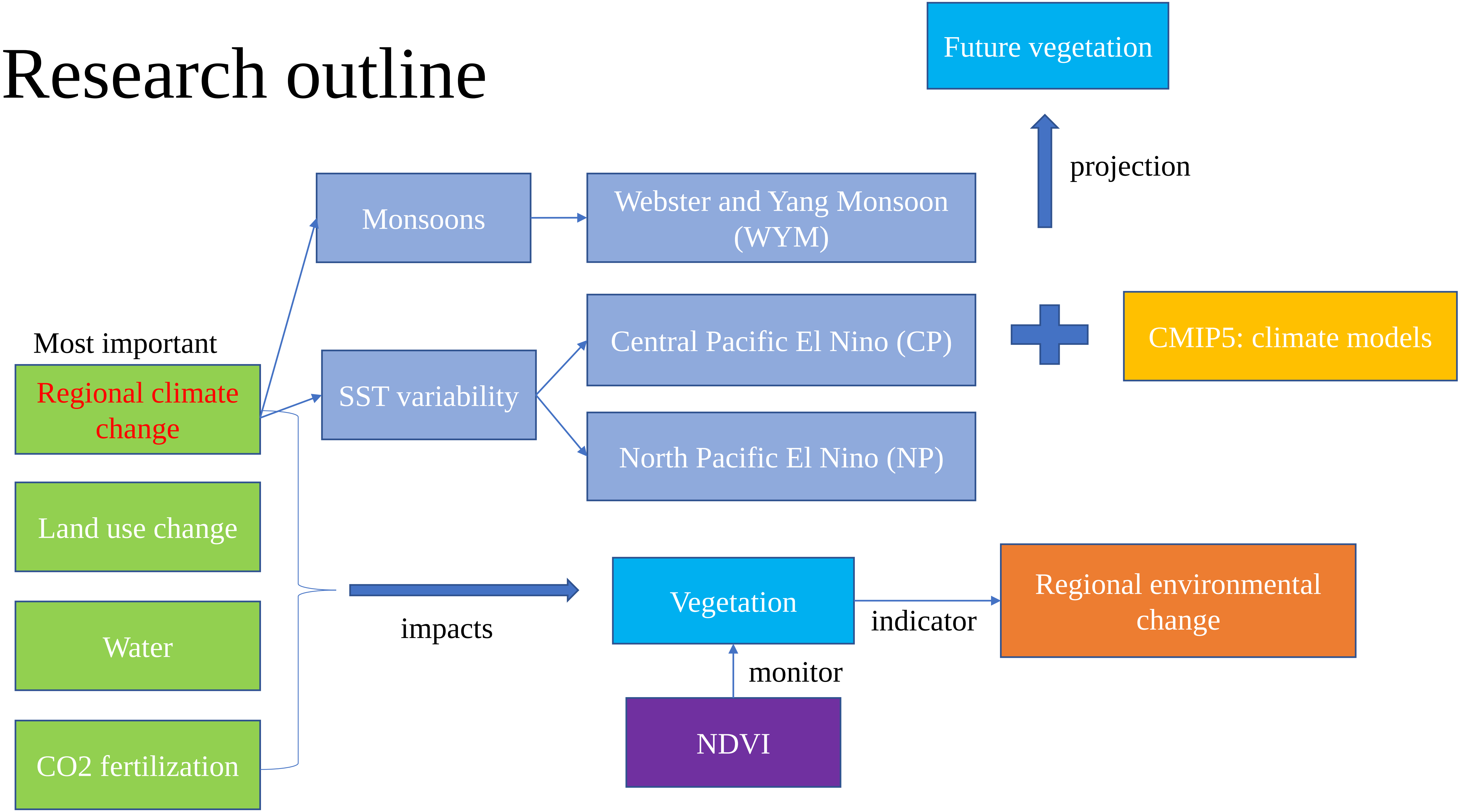
Research outline



Research region

- inner land of northwest China
- The terrain is inclined from south-west to north-east, with an elevation ranging from 598 to 5602 m
- The climate in Gansu is complicated, involving cold desert climate (Bwk), cold semiarid climate (Bsk), temperate continental climate (Dwb) and cool continental climate (Bwc), based on Köppen Geiger climate classification system
- Owing to the arid climate, limited water resources and unsustainable exploitation, the desertification becomes more and more serious in the Gansu, which have greatly impeded the sustainable development of agriculture and economy in this region

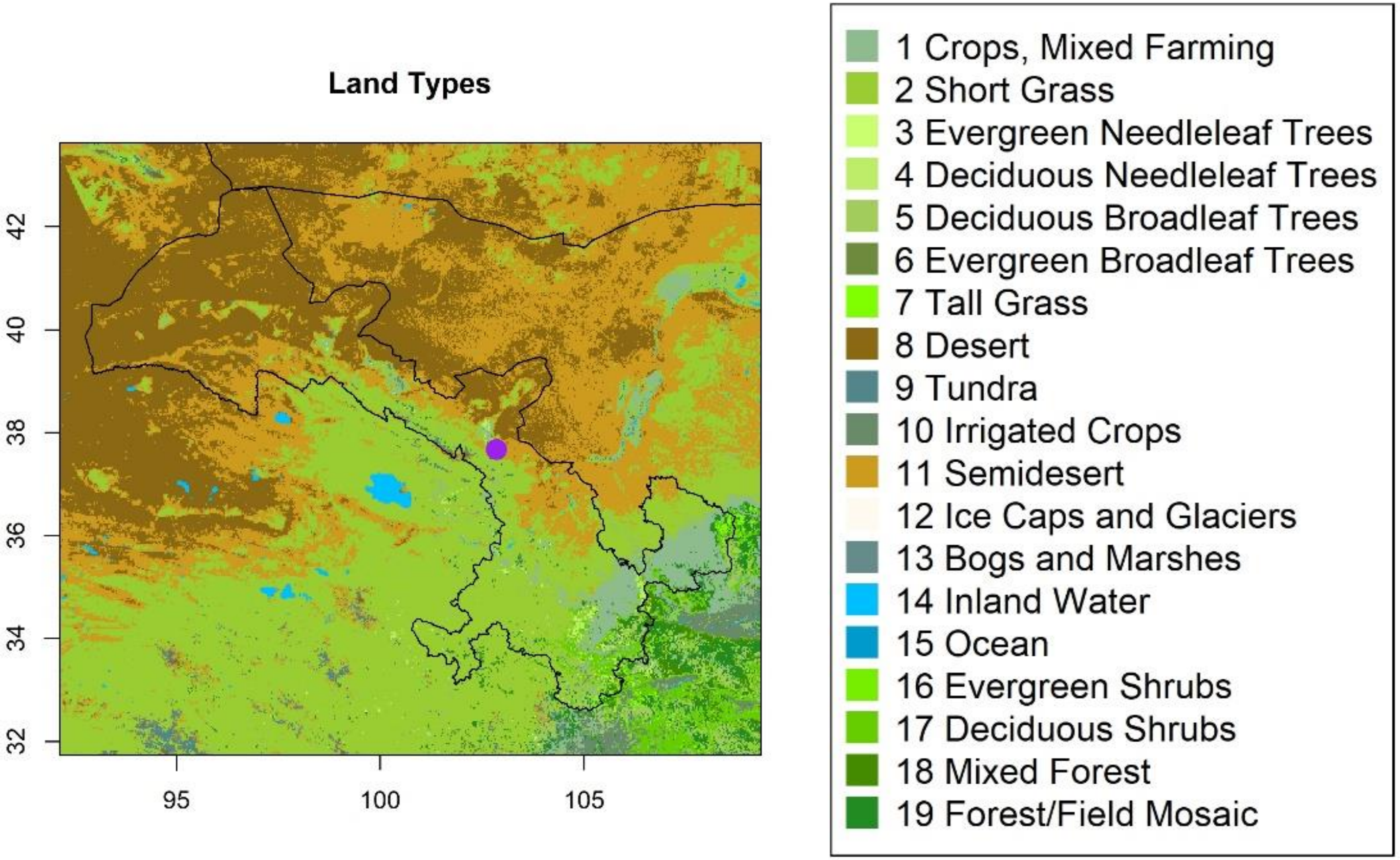
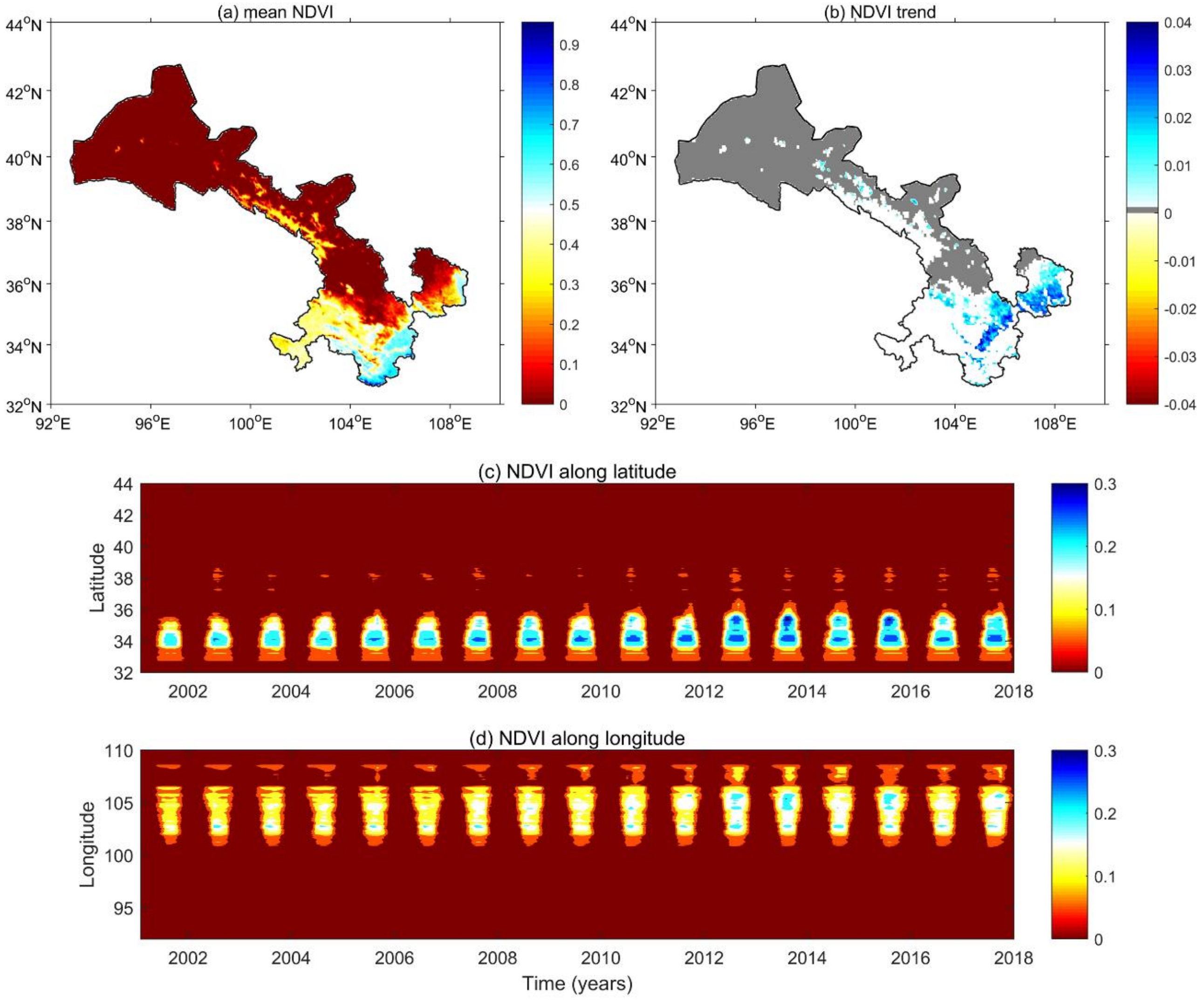


Figure 1. Land types with meteorological stations of Gansu, China.

Vegetation variations

Figure 2. The mean NDVI (a) and NDVI trend (b) between 2001 and 2017. The NDVI along latitude(a) and longitude (d). For the trend map, only significant trends with 95% significance level are presented.

- The spatial distribution of the mean annual NDVI in Gansu exhibited high value in southeast but low value in northwest during the period of 2001 to 2017, suggesting high spatial variability in its distribution pattern.
- NDVI was found to be increased at a rate around 0.03 per year in southeast Gansu, but no significant changes in other regions
- Seasonal clusters of NDVI were found along both latitude and longitude.



Climate drivers

- The seasonal WYM and decadal NP had significant positive contributions to the vegetation coverage over the whole Gansu, especially the southeast region.
- Despite not statistically significant, the interannual CP negatively contributed to the vegetation variation over the most part of the Gansu, especially the northwest region, but positively to the southeast region.
- The vegetation coverage is mainly concentrated in the southeast Gansu, which is positively affected by three climate factors.

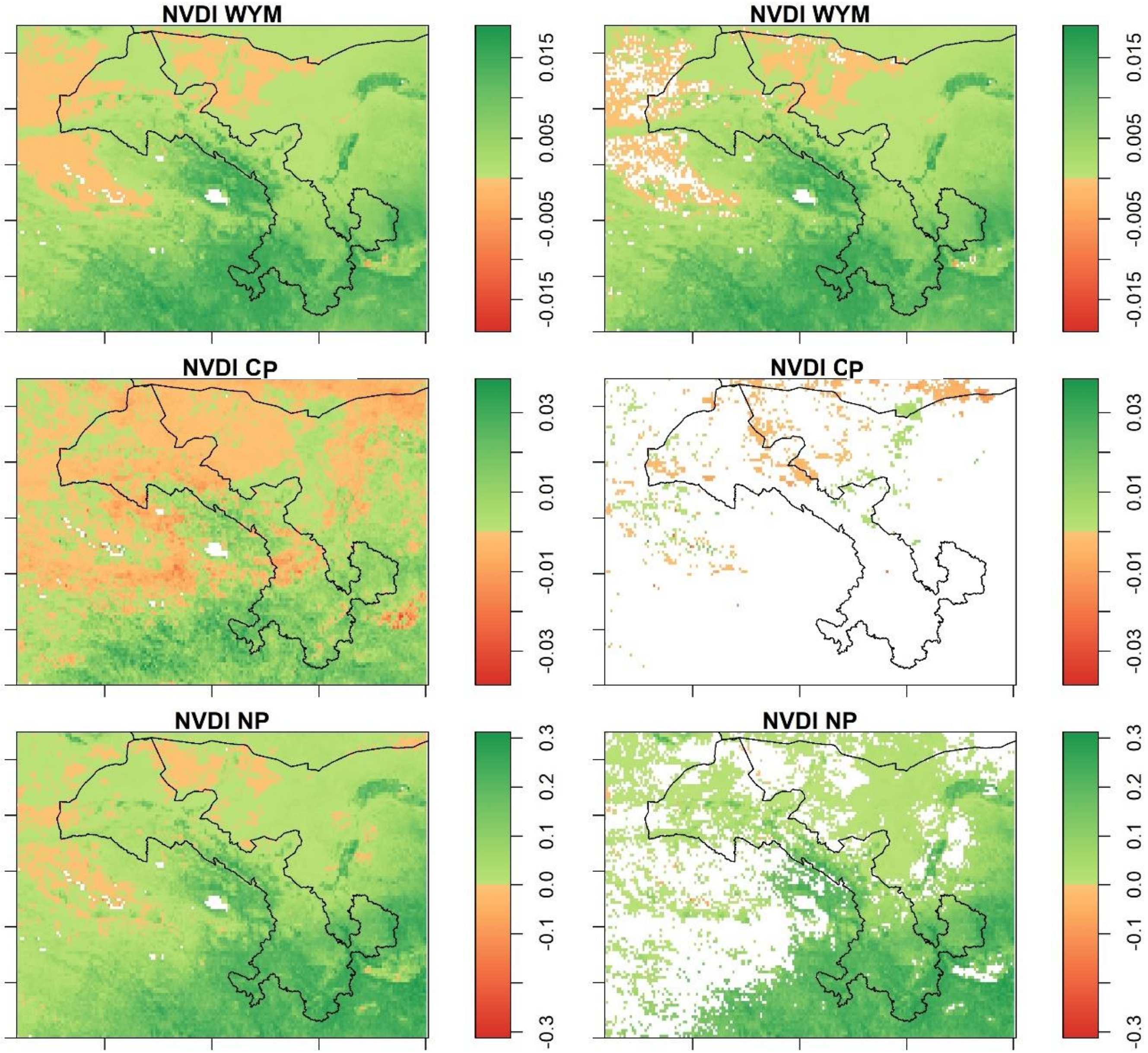


Figure 3. The NDVI regressed by WYM, CP and NP. The left are regressed coefficient, while the right are only for significant coefficients.

Model assessment

- In this study, we used 5 climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) with climate variables outputs available for two scenarios (RCP4.5 and RCP8.5), as summarized in Table 1.
- The Nash–Sutcliffe model efficiency (NSE) is used for model assessment.

$$NSE = 1 - \frac{\sum_{i=1}^{N}\left(X_m^i - X_o^i\right)^2}{\sum_{i=1}^{N}\left(X_o^i - \overline{X_o}\right)^2}$$

the closer the NSE value to 1, the more reliable the estimation is.

Table 1. CMIP5 climate models, institution and spatial resolution.

Model	Institution	Spatial resolution (LonxLat)
ACCESS1	Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia	1.875°x1.25°
GFDL	Geophysical Fluid Dynamics Laboratory (GFDL), New Jersey	2°x2.5°
bcc	Beijing Climate Center (bcc), China Meteorological Administration, China	~2.8°x2.8°
CNRM	Centre National de Recherches M´et´eorologiques/Centre Europ´een de Recherche et For-mation Avanc´ees en Calcul Scientifique, France	~1.4°x1.4°
IPSL	Institut Pierre-Simon Laplace (IPSL), France	3.75°x1.875°
MPI	Max Planck Institute (MPI) for Meteorology, Germany	1.875°x1.875°

Model assessment

City	Lon	Lat
Dunhuang	94.71	40.13
Gaotai	99.84	39.14
Jiayuguan	98.28	39.78
Jiuquan	98.5	39.71
Lanzhou	103.73	36.03
Tianshui	105.69	34.6
Wuwei	102.61	37.94
Yumen	97.58	39.81
Zhangye	100.46	38.93
Xian	108.95	34.27

- ◆Under both RCP45 and RCP85, models have best performances in Dunhuang and Gaotai, and least in Jiayuguan and Xian.
- ◆Generally, IPSL performs the best for all cities under both RCP45 and RCP85.
- ◆ Models have different performance for different cities.

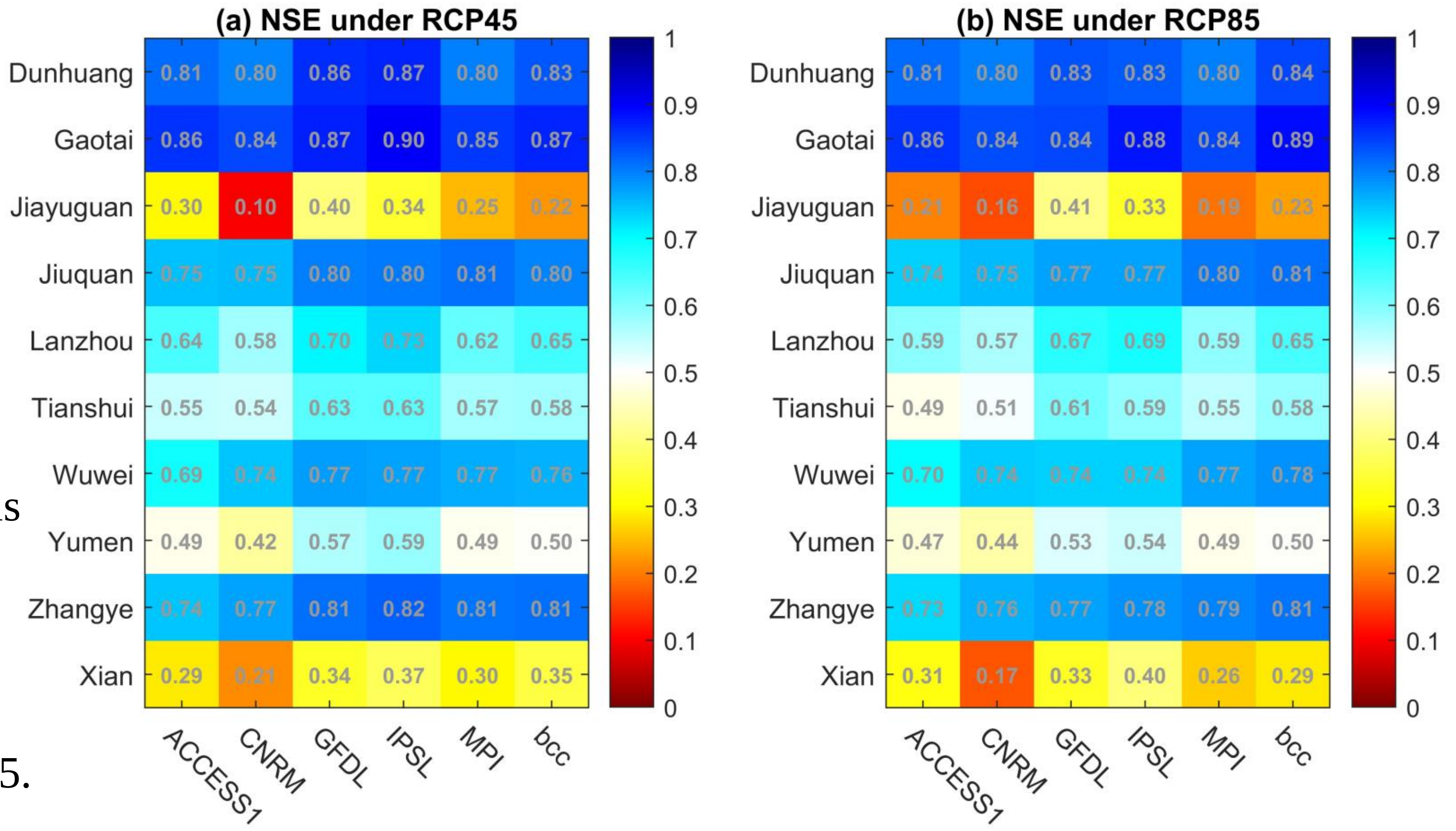


Figure 5. The NSE between different modelled and satellite-based NDVI in different cities under RCP4.5 and RCP8.5.

Vegetation projections

- Since most plants flourish in the summer and die in the winter, there is little change in vegetation throughout the year.
- In the vegetation growing season (i.e., summer July), two modelled NDVI showed a significant decline after 2020 for both RCP4.5 and RCP8.5 in Gansu.
- In winter (January), the NDVI is increasing under the RCP4.5, but decreases under the RCP8.5, suggesting the more greenhouse gas may harm the vegetation growth in Gansu.

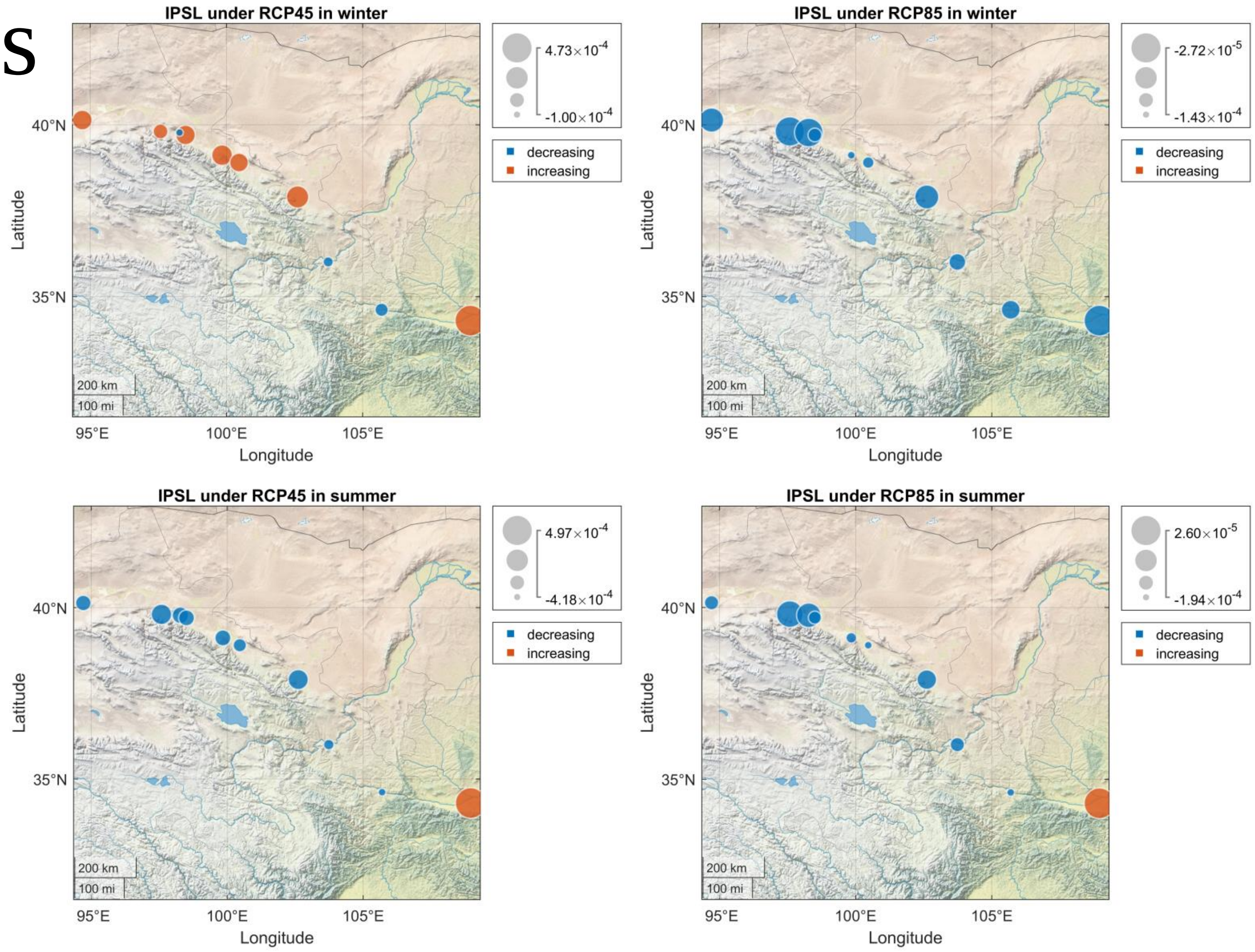


Figure 5. The bubble map of projected NDVI variations during 2020 and 2099 using RCP4.5 and RCP8.5 by IPSL model in different cities.