5 Ecological Risks

Yuanyuan Yin, Qiuhong Tang, Xingcai Liu and Huijuan Cui

5.1 Background

Climate change has strong influence on terrestrial ecosystems, and the influence is almost certain to grow in the near future (IPCC 2014). Continuing climate change and climate extremes may cause significant impacts on the terrestrial ecosystems, such as decrease in regional carbon stocks and reduction in vegetation leaf cover (Donohue et al. 2013). China has a variety of ecosystems ranging from alpine tundra to evergreen tropics and from desert to forest. The impact of climate change on terrestrial ecosystems in China has received considerable attention.

Many impact assessments focused on one or a few aspects such as vegetation structure and distribution (Tao and Zhang 2010; Wang 2014), or carbon cycle [e.g., carbon flux and stock, net primary productivity (NPP)] (Tao and Zhang 2010; Piao et al. 2009; Ni 2011). However, it is difficult to identify the main factors influencing ecosystem shifts and to know the degree of climate change tolerated prior to the shift of complex ecological systems. In order to quantify the comprehensive risks of ecosystem alterations under climate change, Heyder et al. (2011) proposed an aggregated metric, Γ, of joint changes in macroscopic ecosystem features. This metric is based on a specific subset of macroscopic variables (e.g., carbon fluxes, carbon stocks, and water fluxes) that characterize the ecosystem state. Essentially, this metric Γ uses aggregated changes in the biogeochemical ecosystem state as a proxy for the risk of ecosystem shifts. Ecosystem shift in this study refers to the state that the ecosystem has been pushed beyond the point of recovering (Scheffer and Carpenter 2003). Based on the specific subsets of variables, this metric could also be used to identify the main factors influencing ecosystem shifts. To identify the high-risk areas and the main contributing factors of the predicted ecosystem shifts in China, a multi-model analysis of ecosystem shift risk using the metric Γ was presented over the naturally vegetated land of China in this chapter (Yin et al. 2016).

5.2 Method

In this chapter, the ecosystem change metric Γ was calculated following Heyder et al. (2011) (Eq. 5.1). The metric calculates the difference between an ecosystem state under climate change and the current state. Ecosystem states are characterized as vectors in a multi-dimensional state space by the variables (Table 5.1) simulated by four global gridded vegetation models (GGVMs) in ISI-MIP (Table 5.2), with each dimension representing a specific fluxes change, stock, or process variable. The simulation outputs of the GGVMs were provided from 1971 to 2099. Three GGVMs (JeDi, JULES, and LPJmL) presented simulation results under four representative concentration pathways (RCPs) namely, RCP2.6, RCP4.5, RCP6.0, and RCP8.5 of five general circulation models (GCMs) from the Fifth Coupled Model Inter-comparison Project (CMIP5) while VISIT model offered simulation results exclusively for RCP2.6 and RCP8.5 of three GCMs. The model outputs of LPJmL and VISIT were provided on a 0.5° × 0.5° grid, and the model outputs of JeDi and JULES were provided on a 1.25° × 1.85° grid. We assigned the value of a 0.5° × 0.5° grid or 1.25° × 1.85° grid, to which the central point of a 1 km grid belong, to the 1 km grid (Taylor et al. 2012). All the GGVMs took into account of the CO_2 fertilization effects. As the land surface was assumed to be covered by natural vegetation only during these model simulations, the ecosystem shifts suggested by the GGVMs were only driven through climate change rather than land-use change. Therefore, we focused on the risk of only natural vegetation by excluding sandy desert, swamp, and cultivated areas.

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IHDP/Future Earth-Integrated Risk Governance Project Series, DOI 10.1007/978-981-10-4199-0_5

Table 5.1 Variable subsets used for analysis

Subset	Variables
Carbon fluxes	NPP; fire carbon
Carbon stocks	Carbon contained in vegetation and soil
Water fluxes	Transpiration; evaporation; runoff
All	Carbon fluxes; carbon stocks; water fluxes; soil water content (SWC)

Table 5.2 Overview of the GCMs and GGVMs

	Name	Institute
GCMs	HadGEM2-ES	Met Office Hadley Centre
	IPSL-CM5A-LR	Institute Pierre-Simon Laplace
	MIROC-ESM-CHEM	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
	GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory
	NorESM1-M	Norwegian Climate Centre
GGVMs	JeDi	Max-Planck-Institut für Biogeochemie (Germany)
	JULES	Centre for Ecology and Hydrology (UK); Met Office Hadley Centre (UK); University of Exeter (UK)
	LPJmL	PIK (Germany)
	VISIT	National Institute for Environmental Studies (Japan)

$$\Gamma = \left\{\Delta V + cS(c, \sigma_c) + gS\left(g, \sigma_g\right) + bS(b, \sigma_b)\right\}/4 \quad (5.1)$$

where ΔV is change in vegetation structure; c is relative, local change of ecosystem; g is absolute, global change of ecosystem; b is changes in the relative magnitude of key biogeochemical exchange fluxes; and $S(x, \sigma_x)$ is change in inter-annual variability (a normalized sigmoid function of the ratio to standard deviation in the reference period, and computed for c, g and b). The range of value for the above dimensions is 0–1. Since the vegetation composition data are unavailable, ΔV is not included in the calculation. The remaining three components (c, b, and g) were scaled up accordingly in Eq. (5.1) and the factor in the denominator becomes 3 instead of 4.

The period of 1981–2010 was used as the reference period to estimate the current state of ecosystem. The reference period was also used in calculation of c, g, and $S(x, \sigma_x)$. The g was calculated based on data in China. The relative change of NPP and the ecosystem change metric Γ were computed between future periods (2011–2040, 2041–2070, and 2071–2099, respectively) and the reference period. The metric Γ was first calculated for each of the variable subset 'carbon fluxes', 'carbon stocks', or 'water fluxes' individually and then was calculated for the variable subset 'all' (Table 1). There were five GCMs and four GGVMs, making a maximum number of 20 model pairs under each RCP. However, this study used 18 model pairs for RCP2.6 and RCP8.5, and 15 model pairs for RCP4.5 and RCP6.0 due to unavailability of some model simulations in ISI-MIP. The Multimodel-ensemble Medians (MMs) of relative change of NPP or Γ were calculated for the periods of 2011–2040, 2041–2070, and 2071–2099, respectively. The MMs of Γ were divided into ten levels (Table 5.3). The standard deviation (SD) of the relative change or Γ from all the available GCM-GGVM pairs was used to quantify the model uncertainty.

5.3 Results

5.3.1 Relative Change of NPP and Risk Ecological Risk Under Climate Change

The relative change of NPP is less than zero in certain regions of transition zone between cropping area and nomadic area and northwest China. The largest increase of NPP is in Tibetan Plateau and in most regions of northwest China. The relative change is predicted to be greater under higher emission scenario.

Depending on the variable subset considered, the spatial patterns of the metric vary greatly. It suggests that the contributing factors to the ecosystem shifts are dissimilar for different regions. For a specified variable subset considered, the spatial pattern of the metric under different RCPs is similar. However, the metric is generally small under the

Table 5.3 Ecological risk levels

Risk level	1	2	3	4	5	6	7	8	9	10
MM of Γ	≤ 0.1	0.1–0.15	0.15–0.2	0.2–0.25	0.25–0.3	0.3–0.35	0.35–0.4	0.4–0.45	0.45–0.5	>0.5

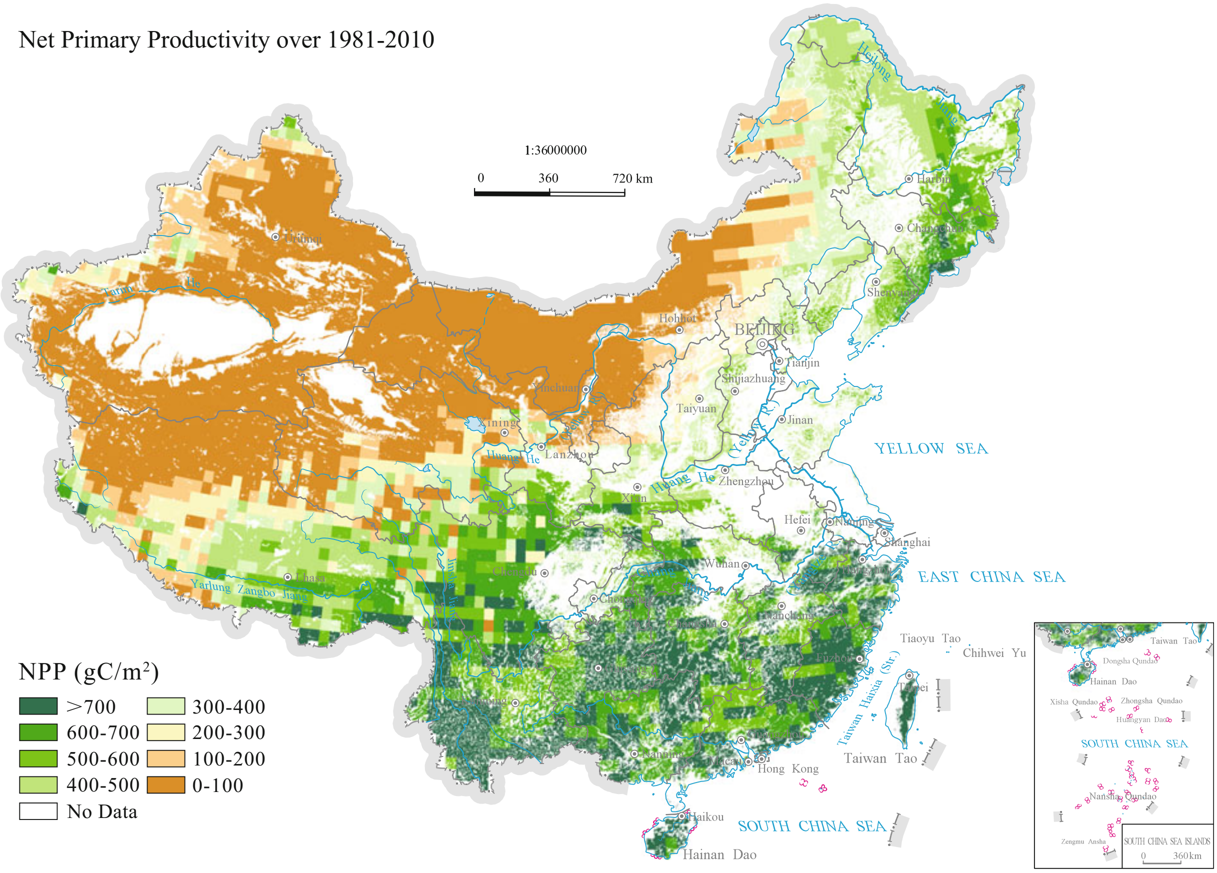
lowest emission scenario and becomes greater under higher emission scenario. The metric Γ for carbon fluxes under RCP8.5 is considerable in the Tibetan Plateau and temperate humid/subhumid regions. The metric Γ for carbon stocks under RCP8.5 is greater than 0.3 in the Tibetan Plateau and the eastern China regions. Based on simulations of the GGVMs, the metric Γ for water fluxes is small in most parts of China under all emission scenarios. The only exception is the Tibetan Plateau region, where the median of the metric Γ for water fluxes is greater than 0.25, indicating a considerable influence of water fluxes change on ecosystem shift, under RCP8.5 scenario.

For all variable subsets, the ecosystem change metric Γ is small in most parts of China excluding for an area in the Tibetan Plateau region under the lowest emission scenario RCP2.6. Under RCP8.5 scenario, the Tibetan Plateau region, part of the temperate humid/subhumid, and cold temperate humid regions would have severe risks of ecosystem shifts. The high value of Γ over the Tibetan Plateau region results from the combined changes of carbon fluxes, carbon stocks, and water fluxes. The temperate humid/subhumid and cold temperate humid regions would have moderate risks of ecosystem shifts. The risk of ecosystem shifts is generally low in the northwest arid region and tropical and subtropical humid regions.

5.3.2 Model Spread and Uncertainty

The standard deviation of relative changes in NPP and Γ (for carbon fluxes, carbon stocks, water fluxes, and all variables) calculated from all available GCM-GGVM pairs over 2071–2099 for RCP8.5 are illustrated in five maps. The model spread of the relative change of NPP is high in the west China, and low in the east China. The model spread of the Γ for carbon fluxes is high in transition zone between cropping area and nomadic area and certain regions in the Tibetan Plateau. The model spread of the Γ for carbon stocks is large than 0.2 in most regions of east China as well as in the Tibetan Plateau region, while it is smaller than 0.2 only in some regions in northwest China. The model spread of the integrated metric Γ is less than 0.1 under all RCPs in the northwest arid region and southern part of the tropical and subtropical humid region, where the risk of ecosystem shift is generally low. The model spread is generally high in those areas, where the estimated risk of ecosystem shift is high. The largest model spread is related to the Tibetan Plateau region and northeast China. The standard deviation of the Γ estimates is about 0.25 under RCP8.5 scenario.

5.4 Maps


Net Primary Productivity over 1981-2010
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0 360 720 km
NPP (gC/m²)
>700
600-700
500-600
400-500
300-400
200-300
100-200
0-100
No Data
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Hohhot
Yinchuan
Xining
Lanzhou
Zhengzhou
Hefei
Nanjing
Shanghai
Wuhan
Hong Kong
Haikou
Hainan Dao
Taiwan Tao
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YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Yarlung Zangbo Jiang
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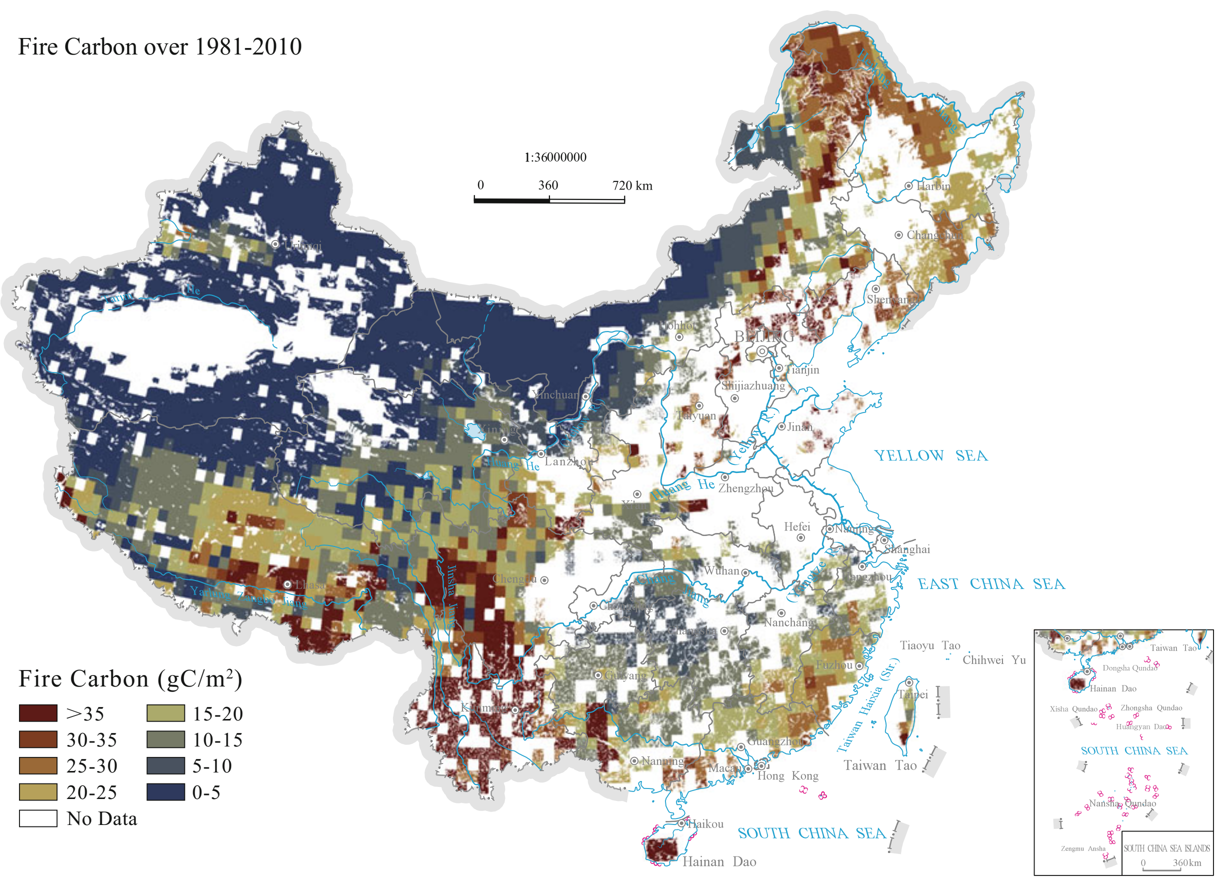
Huangyan Dao
Nansha Qundao
SOUTH CHINA SEA ISLANDS
360km


Fire Carbon over 1981-2010
1:36000000
0 360 720 km
Fire Carbon (gC/m²)
>35
30-35
25-30
20-25
15-20
10-15
5-10
0-5
No Data
BEIJING
Tianjin
Shijiazhuang
Jinan
Yinchuan
Lanzhou
Zhengzhou
Hefei
Nanjing
Shanghai
Wuhan
Nanchang
Fuzhou
Taipei
Nanning
Macao
Hong Kong
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Hainan Dao
Taiwan Tao
Tiaoyu Tao
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SOUTH CHINA SEA
Huang He
Dongsha Qundao
Xisha Qundao
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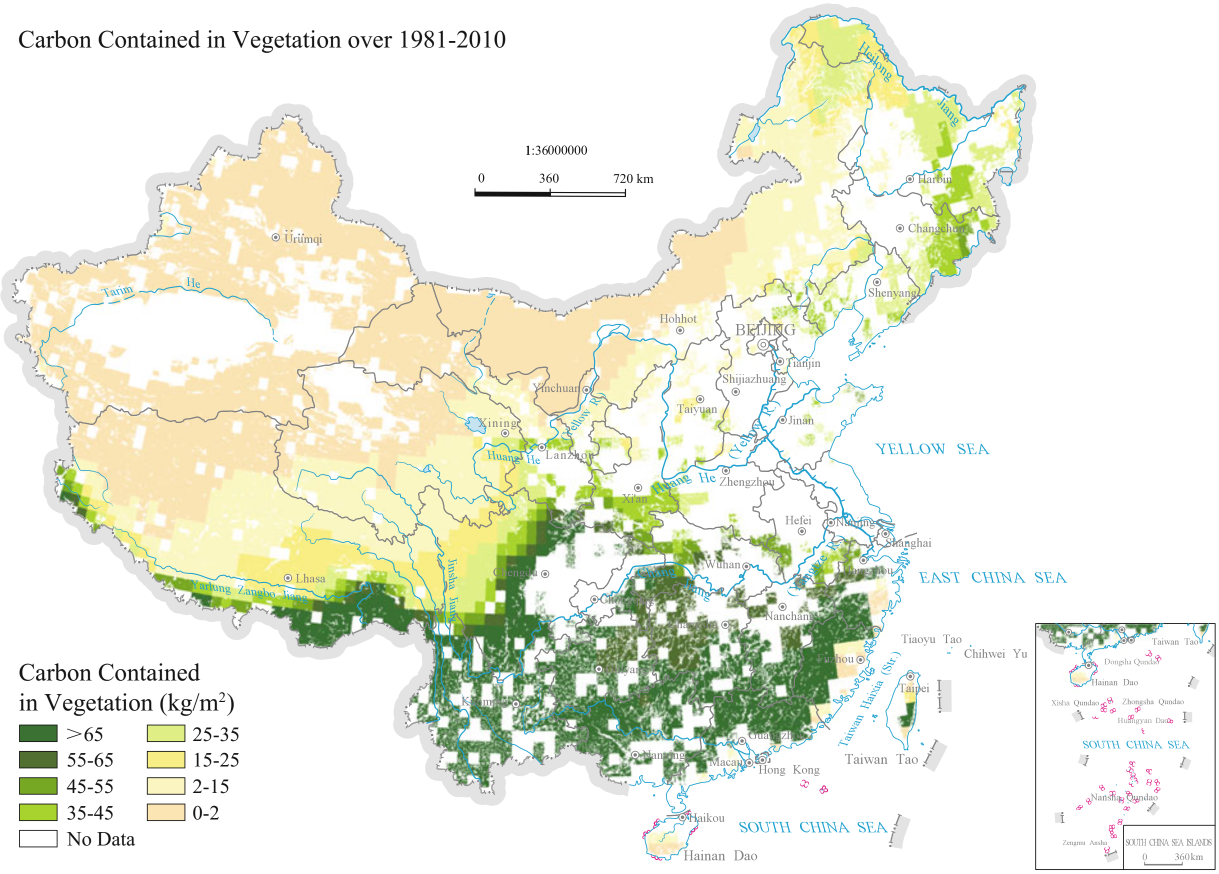
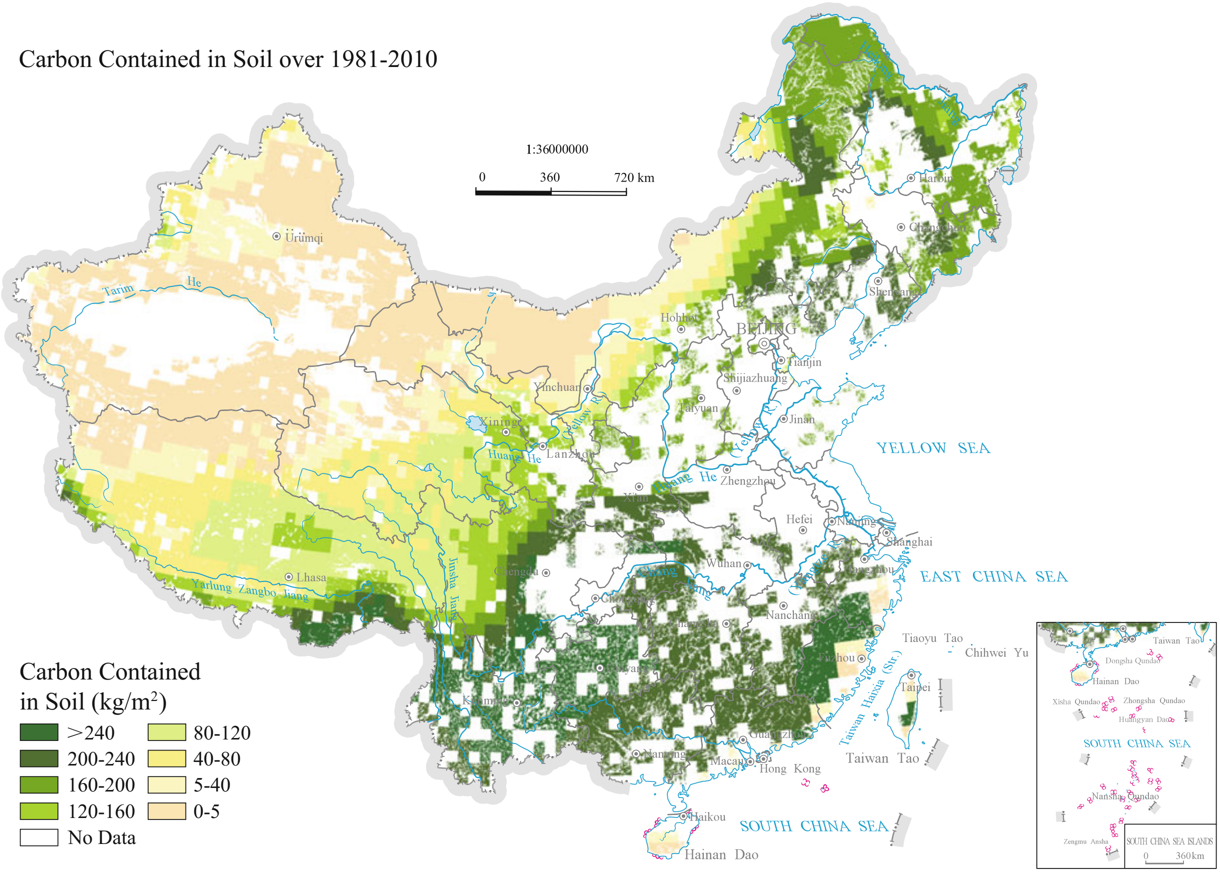
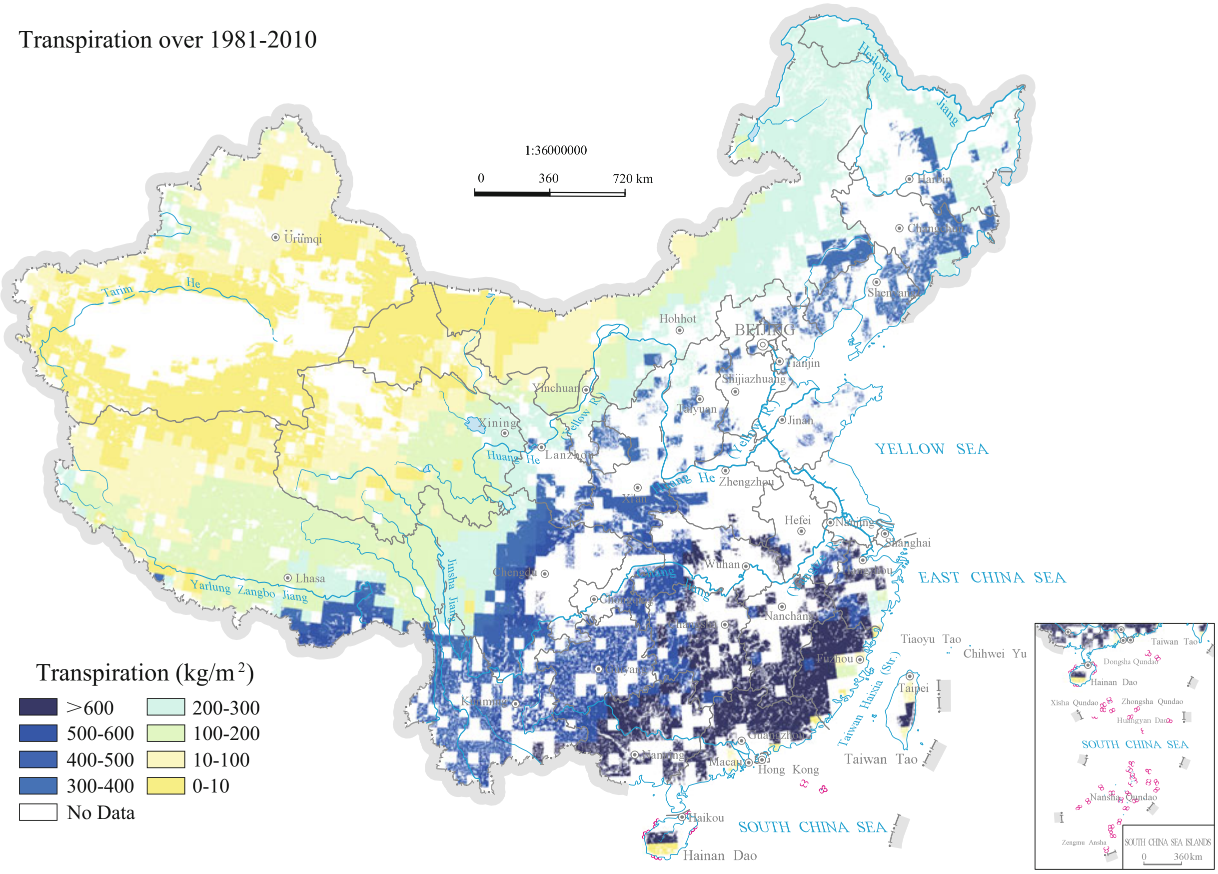
Huangyan Dao
Nansha Qundao
SOUTH CHINA SEA ISLANDS
360km

Carbon Contained in Vegetation over 1981-2010



Carbon Contained in Soil over 1981-2010




Transpiration over 1981-2010
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0 360 720 km
Transpiration (kg/m²)
>600
500-600
400-500
300-400
200-300
100-200
10-100
0-10
No Data
Ürümqi
Tarim He
Hohhot
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
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Lanzhou
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Shanghai
Wuhan
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Jinsha Jiang
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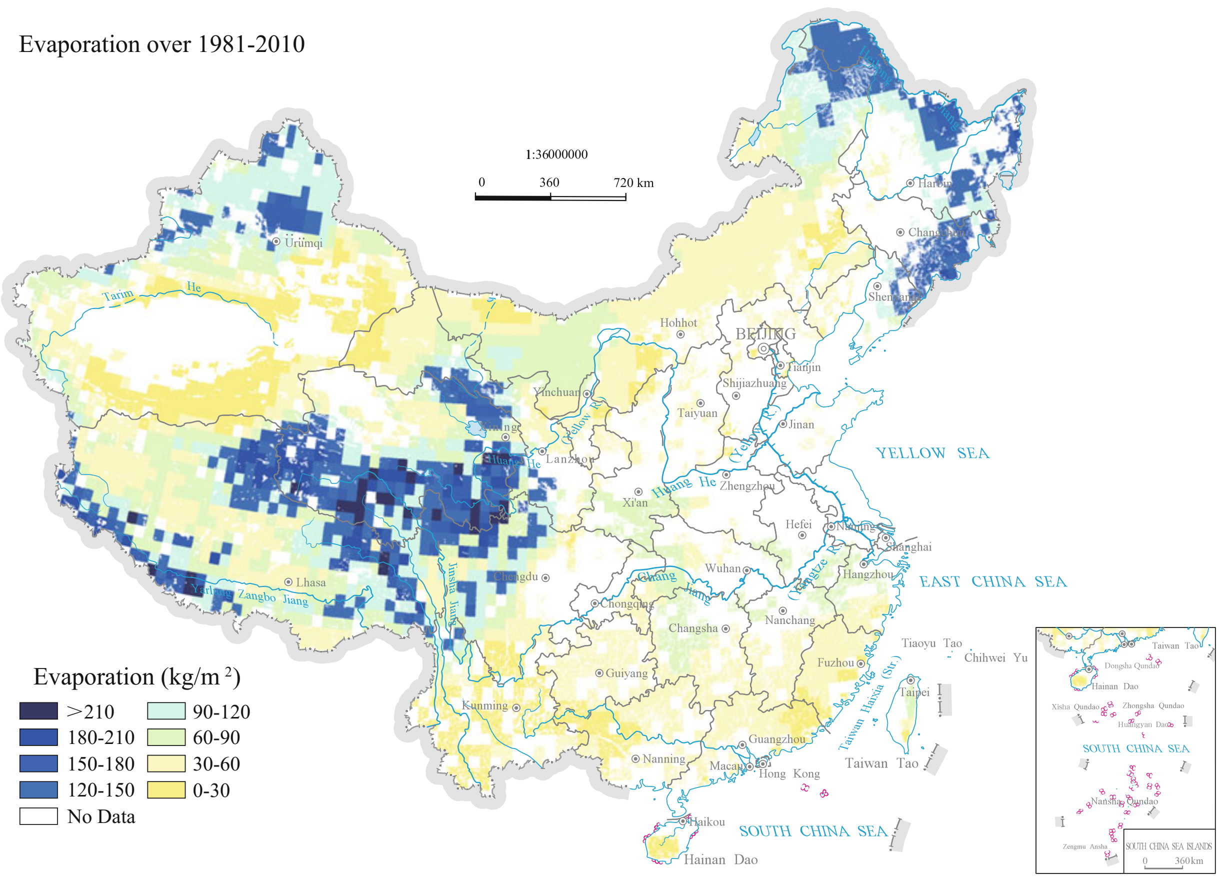
Tiaoyu Tao
Chihwei Yu


Evaporation over 1981-2010
1:36000000
0 360 720 km
Evaporation (kg/m²)
>210
180-210
150-180
120-150
90-120
60-90
30-60
0-30
No Data
Ürümqi
Tarim He
Hohhot
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Yinchuan
Lanzhou
Huang He
Zhengzhou
Xi'an
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Nanjing
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Chengdu
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Guiyang
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Haikou
Hainan Dao
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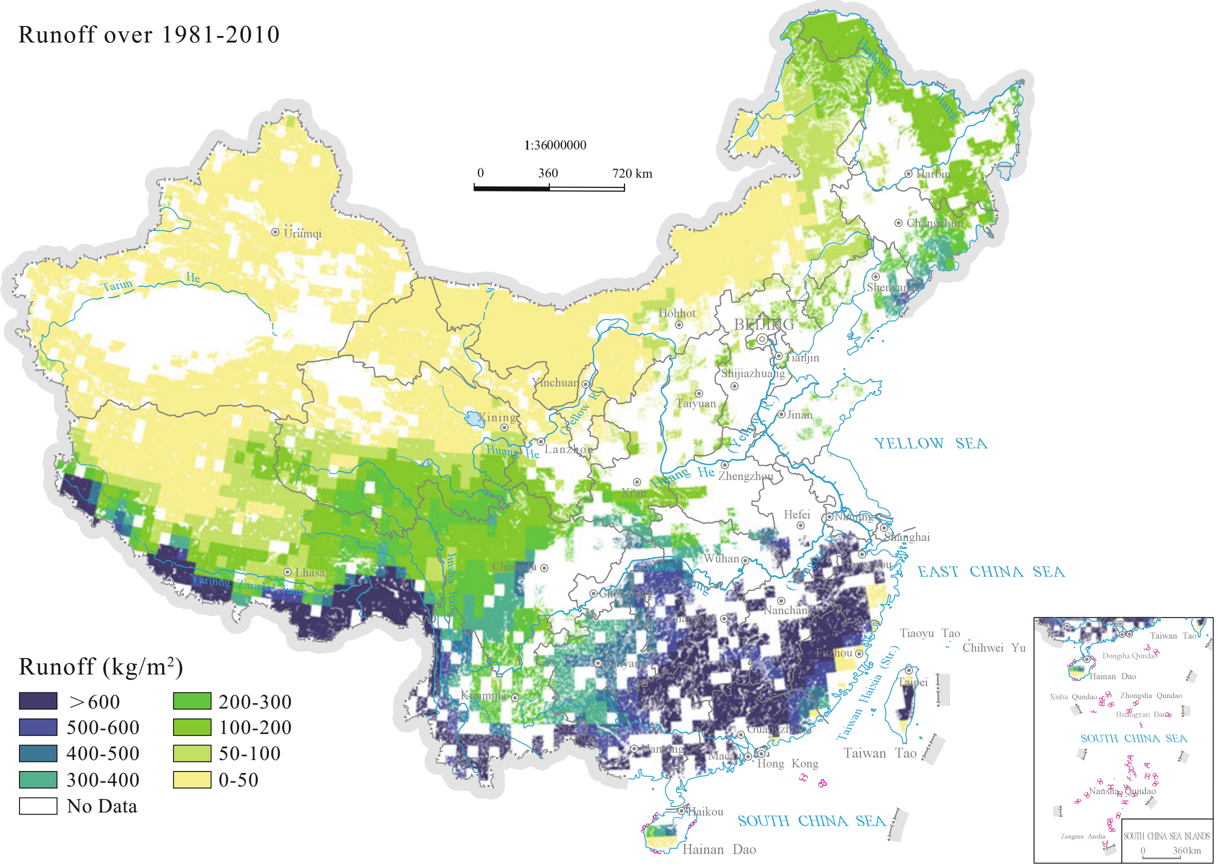
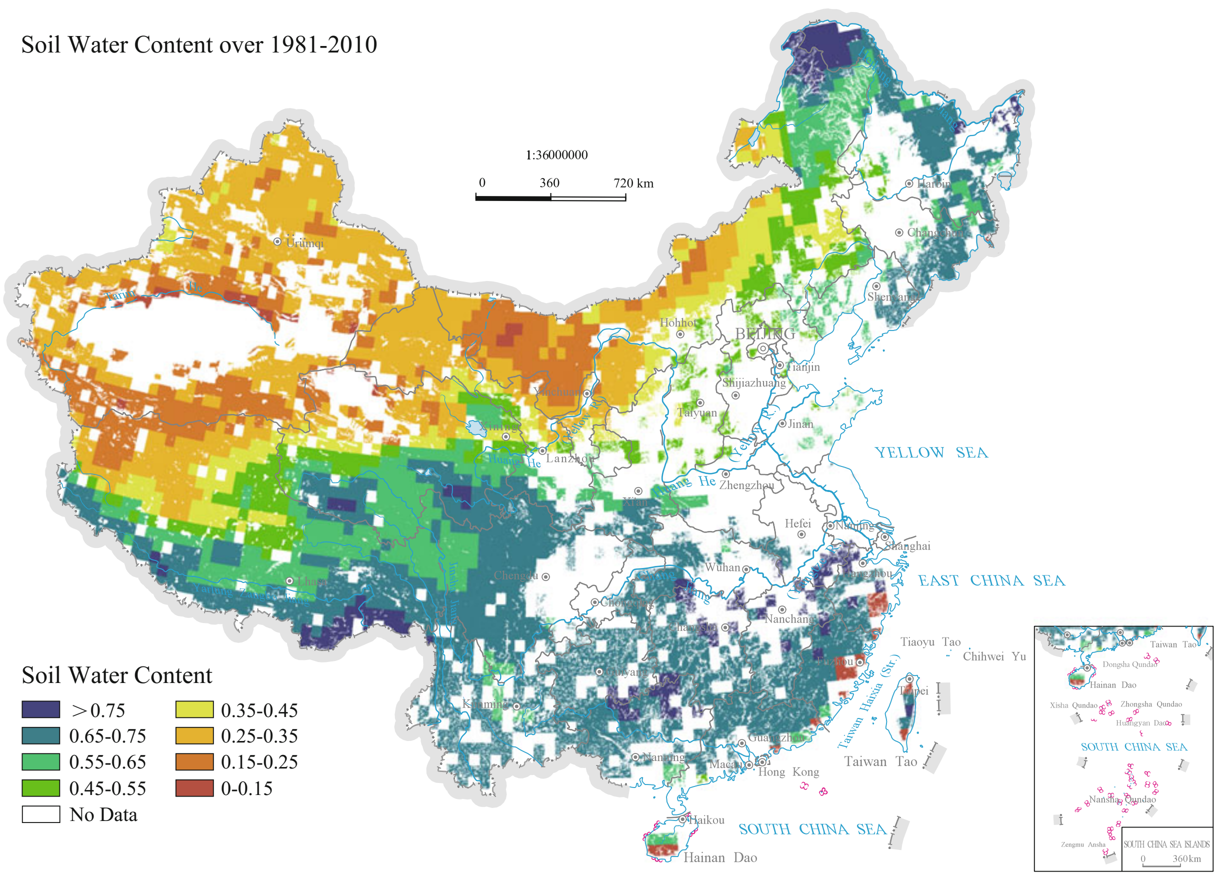
EAST CHINA SEA
SOUTH CHINA SEA
Tiaoyu Tao
Chihwei Yu

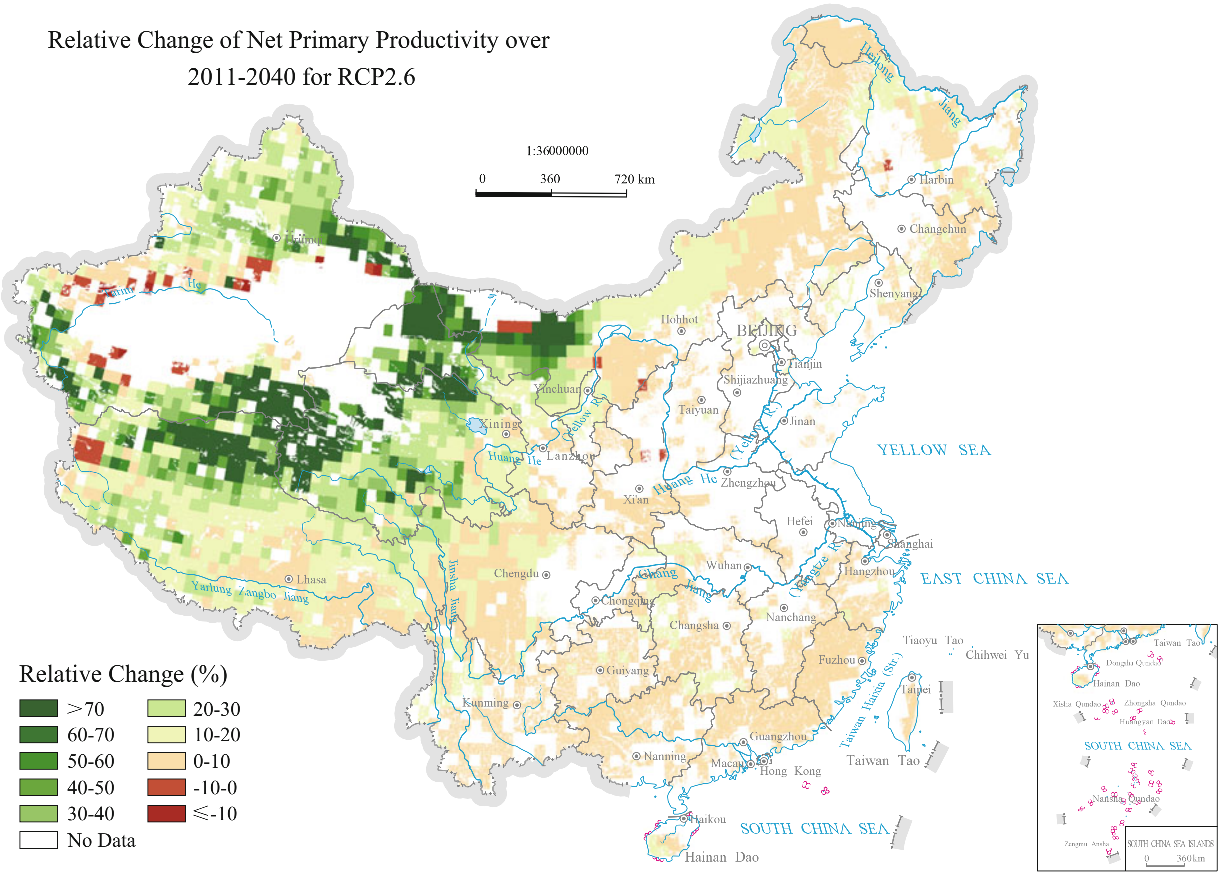
Runoff over 1981-2010



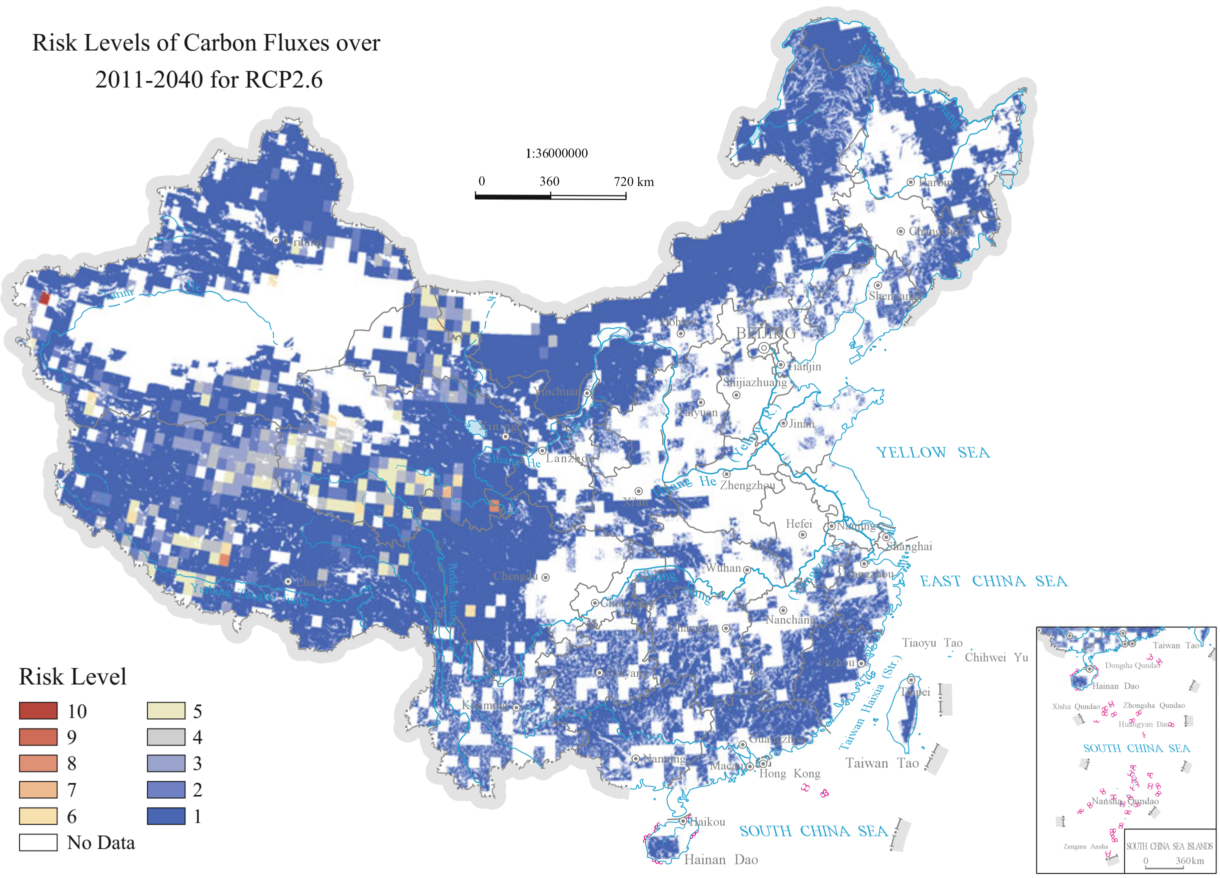
Soil Water Content over 1981-2010

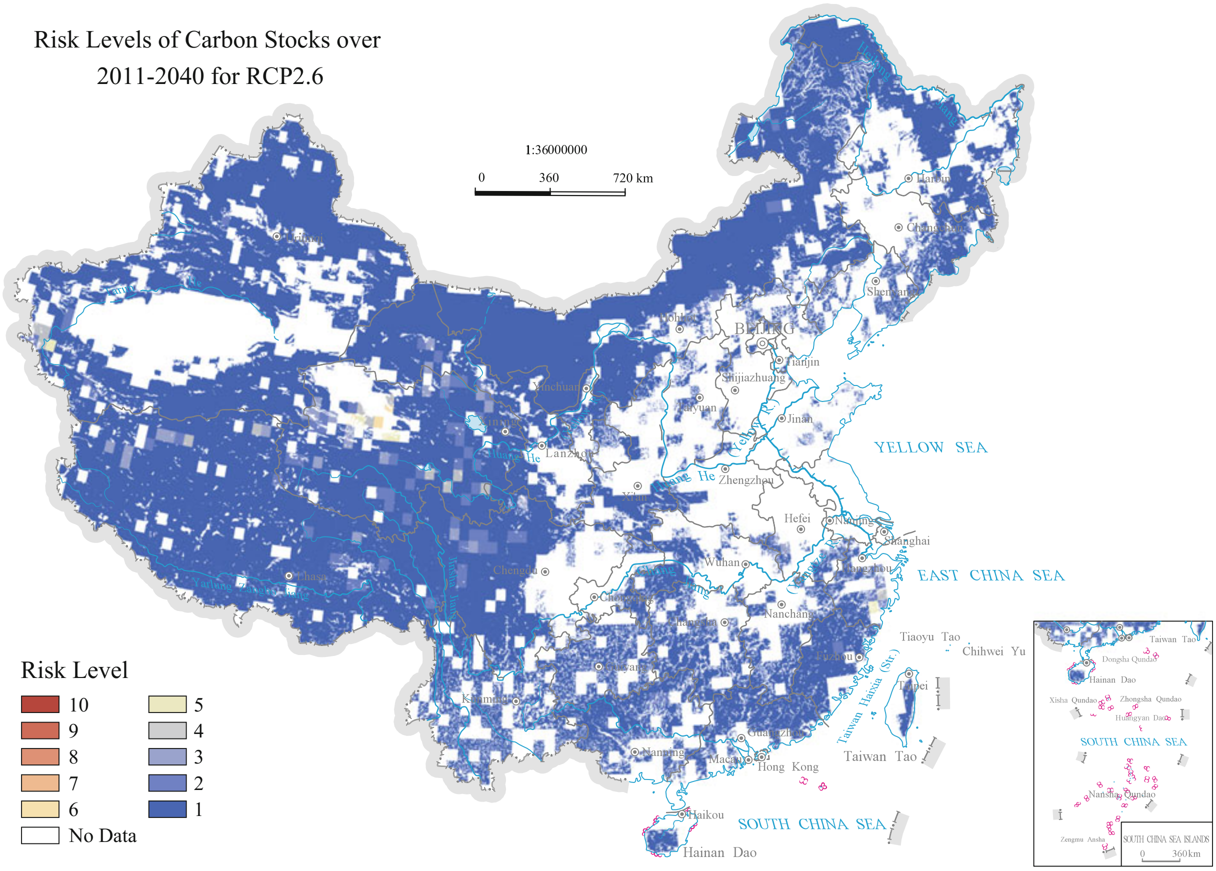


Relative Change of Net Primary Productivity over
2011-2040 for RCP2.6



Risk Levels of Carbon Fluxes over
2011-2040 for RCP2.6




Risk Levels of Carbon Stocks over
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0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
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Tianjin
Shijiazhuang
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Zhengzhou
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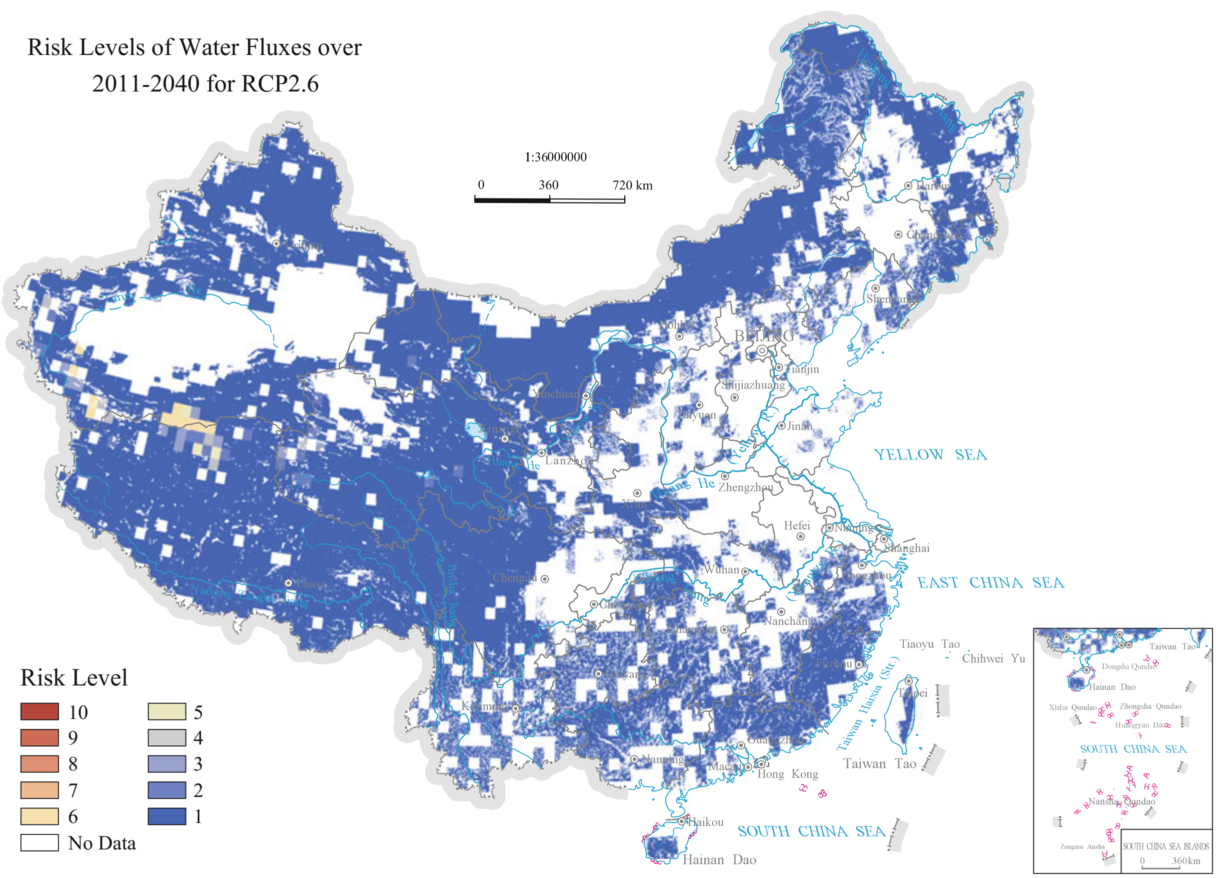
Risk Levels of Water Fluxes over
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0 360 720 km
Risk Level
10
9
8
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6
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3
2
1
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Shijiazhuang
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Nanjing
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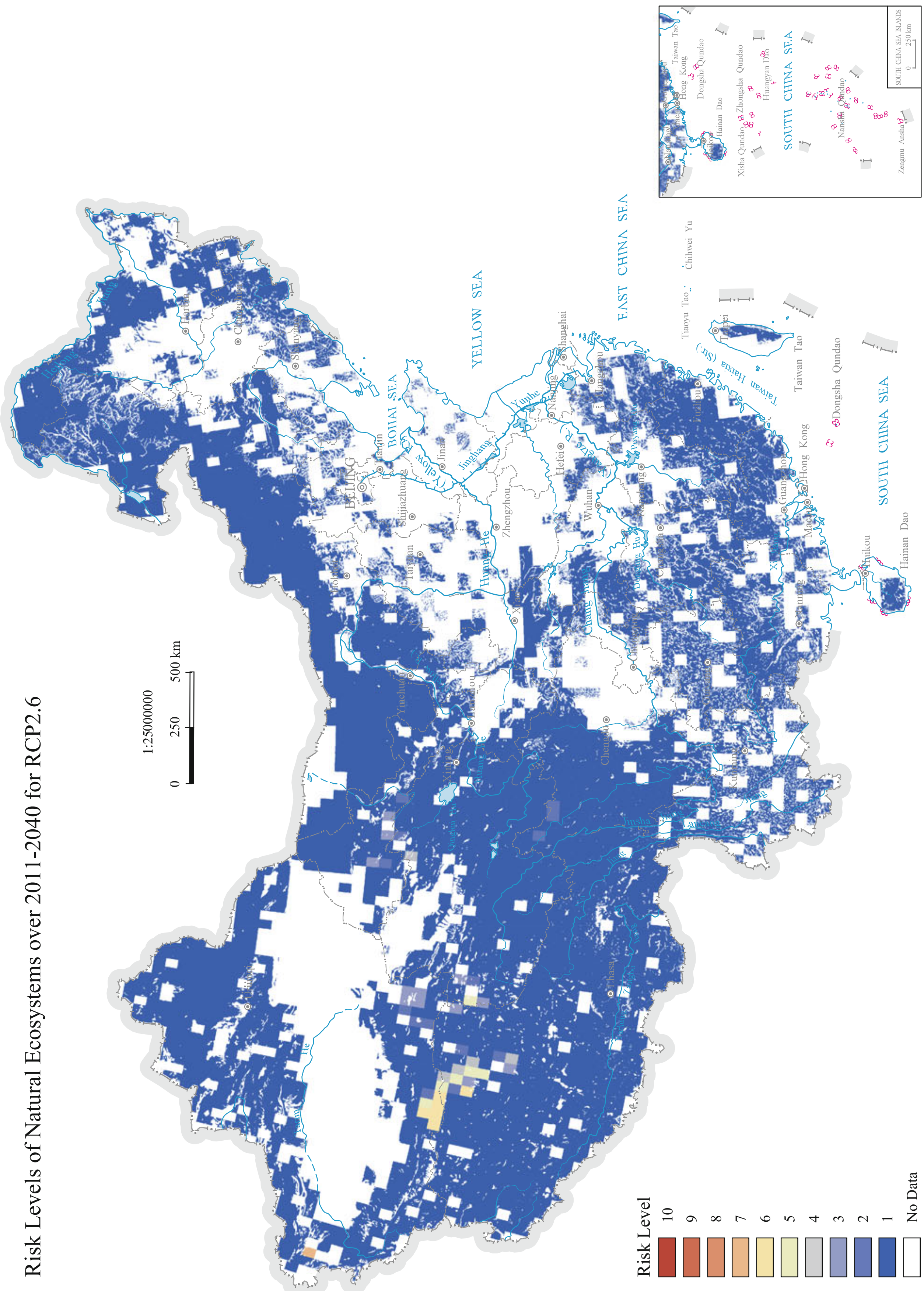
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Risk Level
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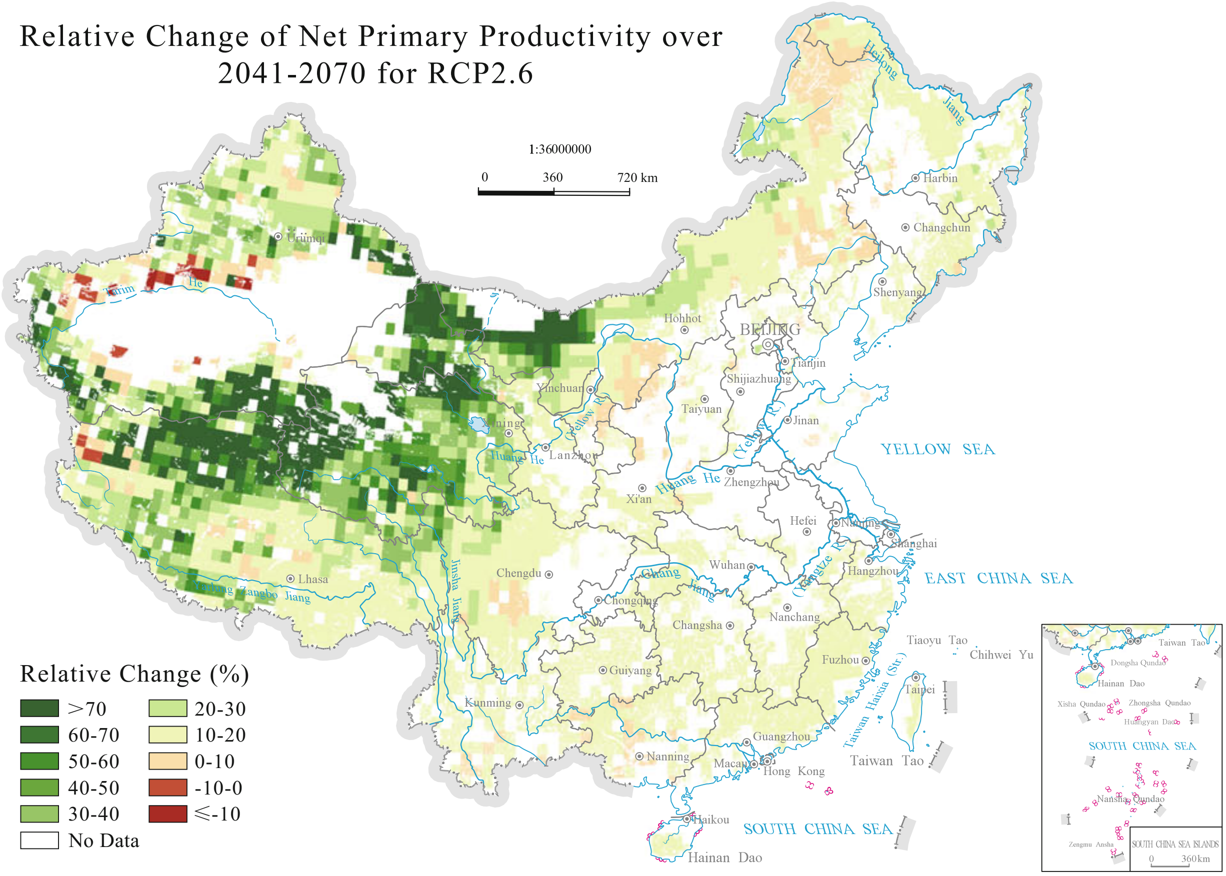
Relative Change of Net Primary Productivity over
2041-2070 for RCP2.6
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
⩽-10
No Data
BEIJING
Harbin
Changchun
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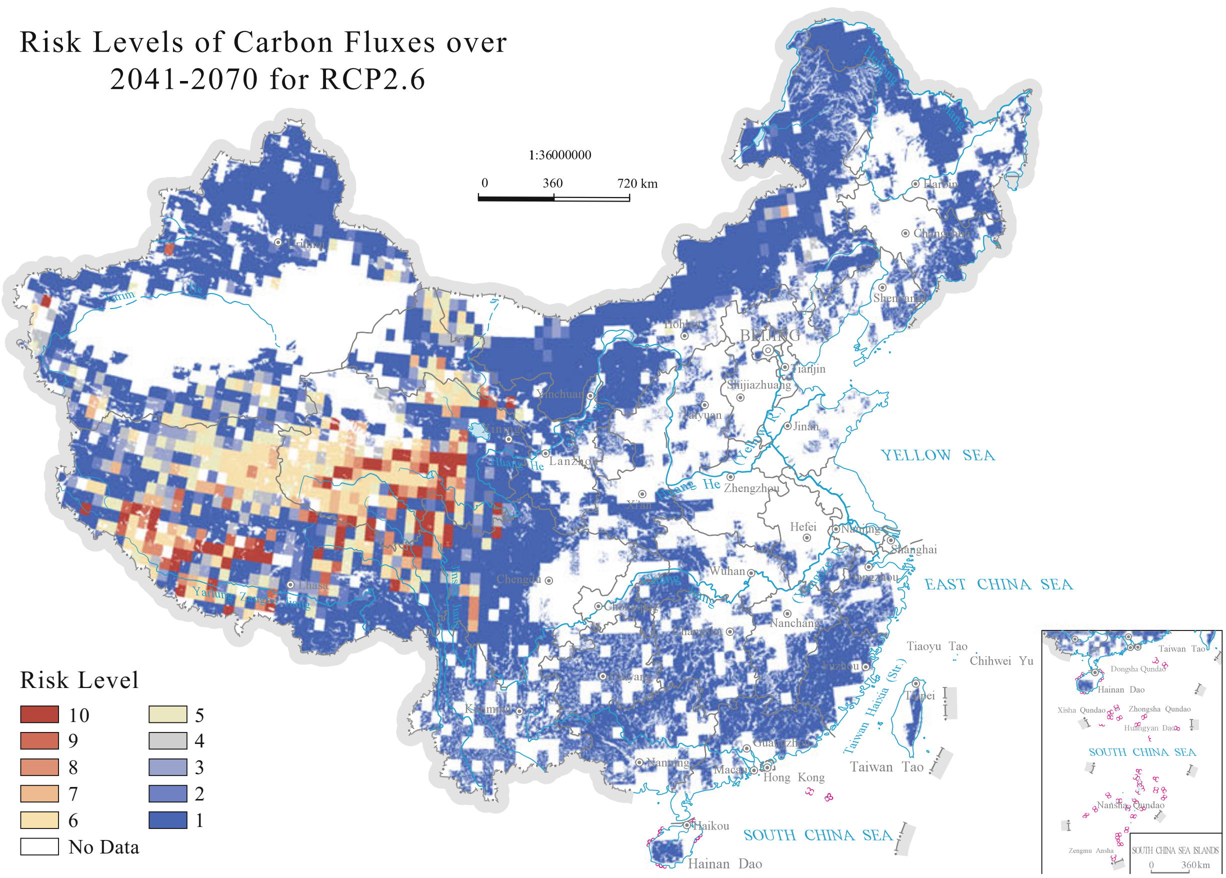
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Risk Level
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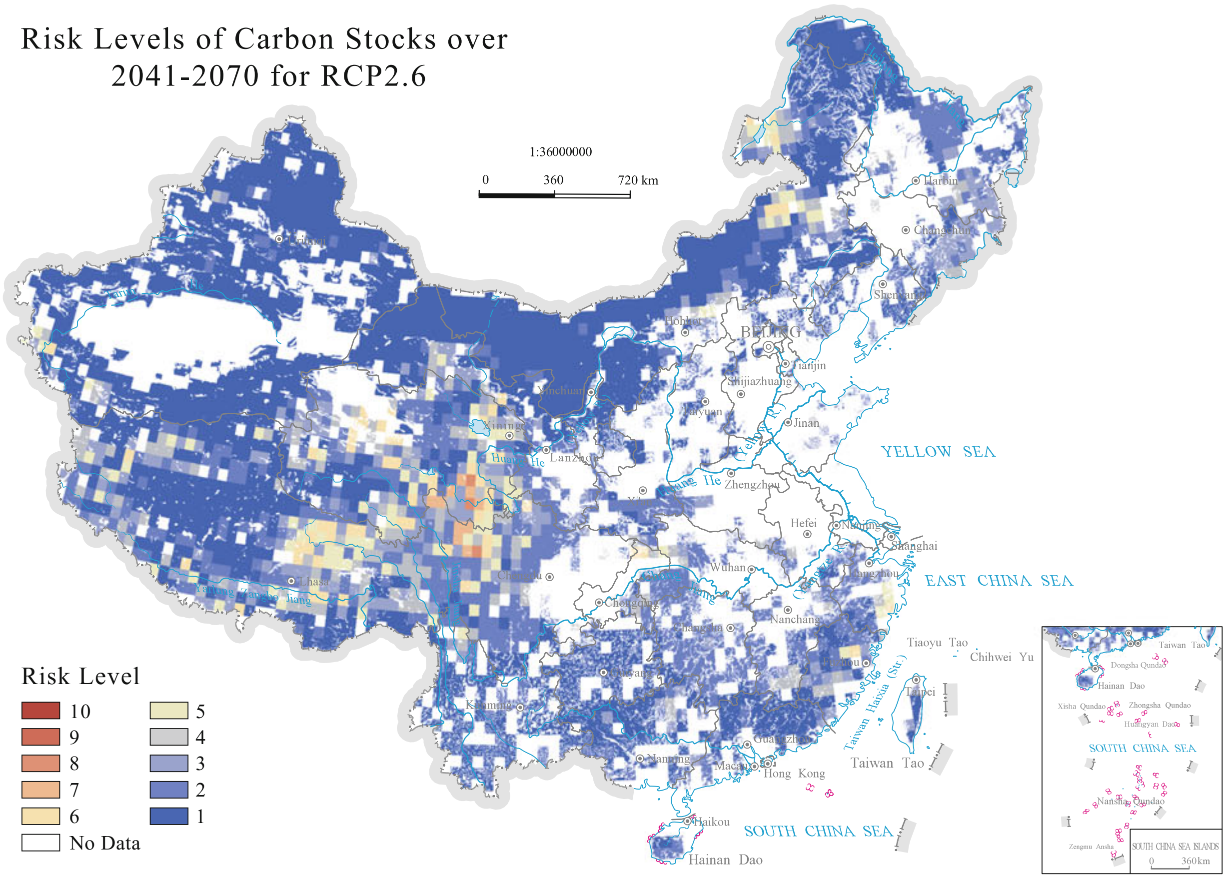
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Taiwan Tao
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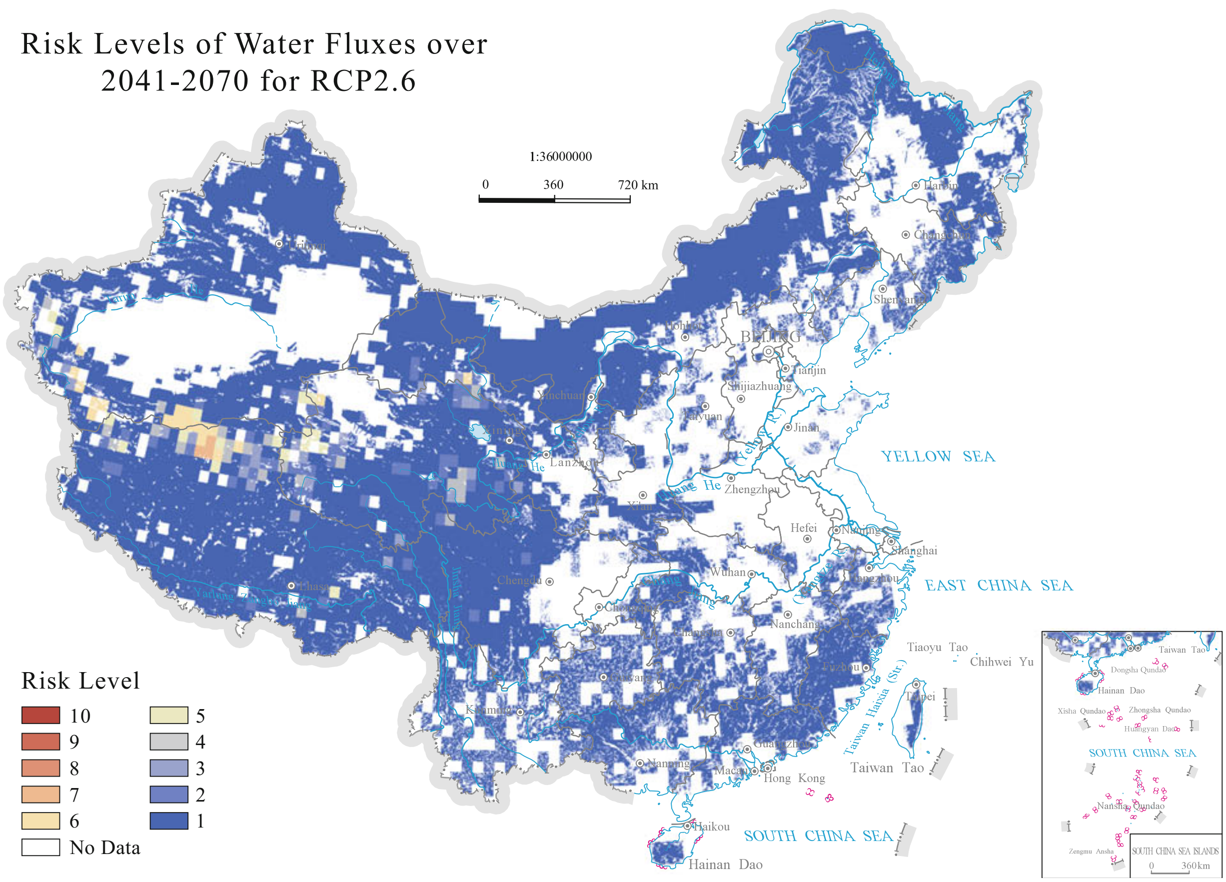
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Taiwan Tao
Risk Level
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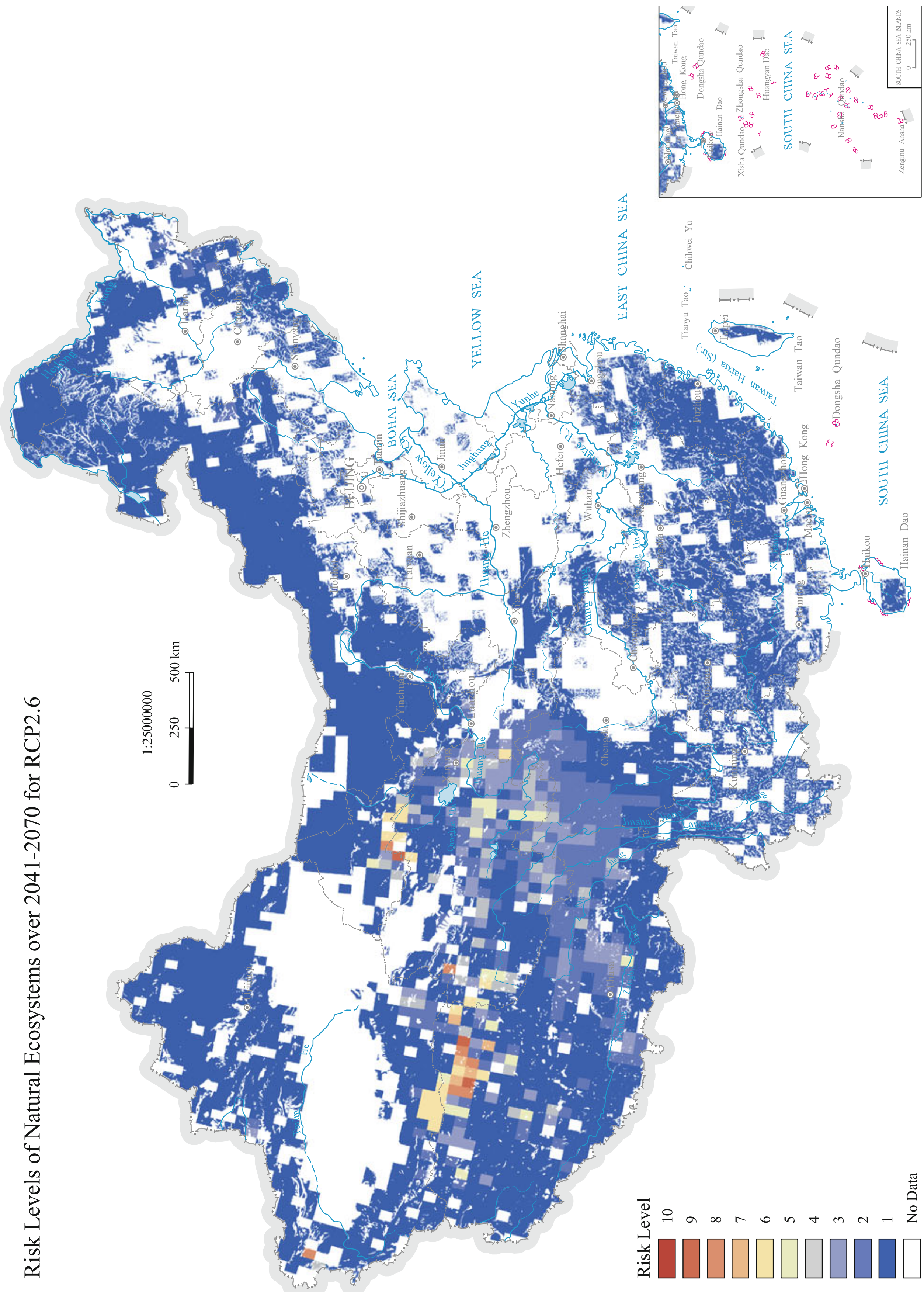
Risk Levels of Natural Ecosystems over 2041-2070 for RCP2.6
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Hefei
Nanjing
Shanghai
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Hong Kong
Macao
BOHAI SEA
YELLOW SEA
EAST CHINA SEA
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Dongsha Qundao
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Haikou
Xisha Qundao
Zhongsha Qundao
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS
0 250 km
Risk Level
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1
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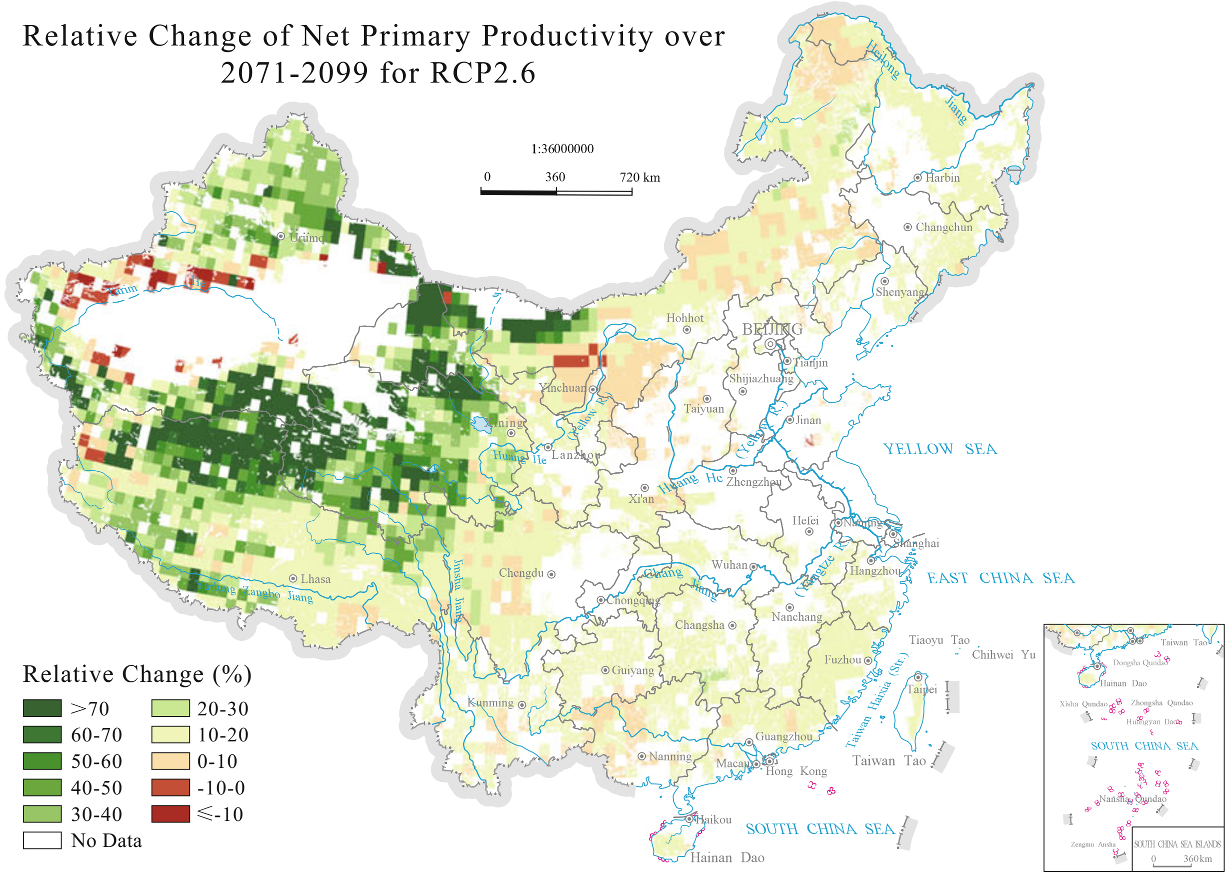
Relative Change of Net Primary Productivity over
2071-2099 for RCP2.6
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
⩽-10
No Data
YELLOW SEA
EAST CHINA SEA
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BEIJING
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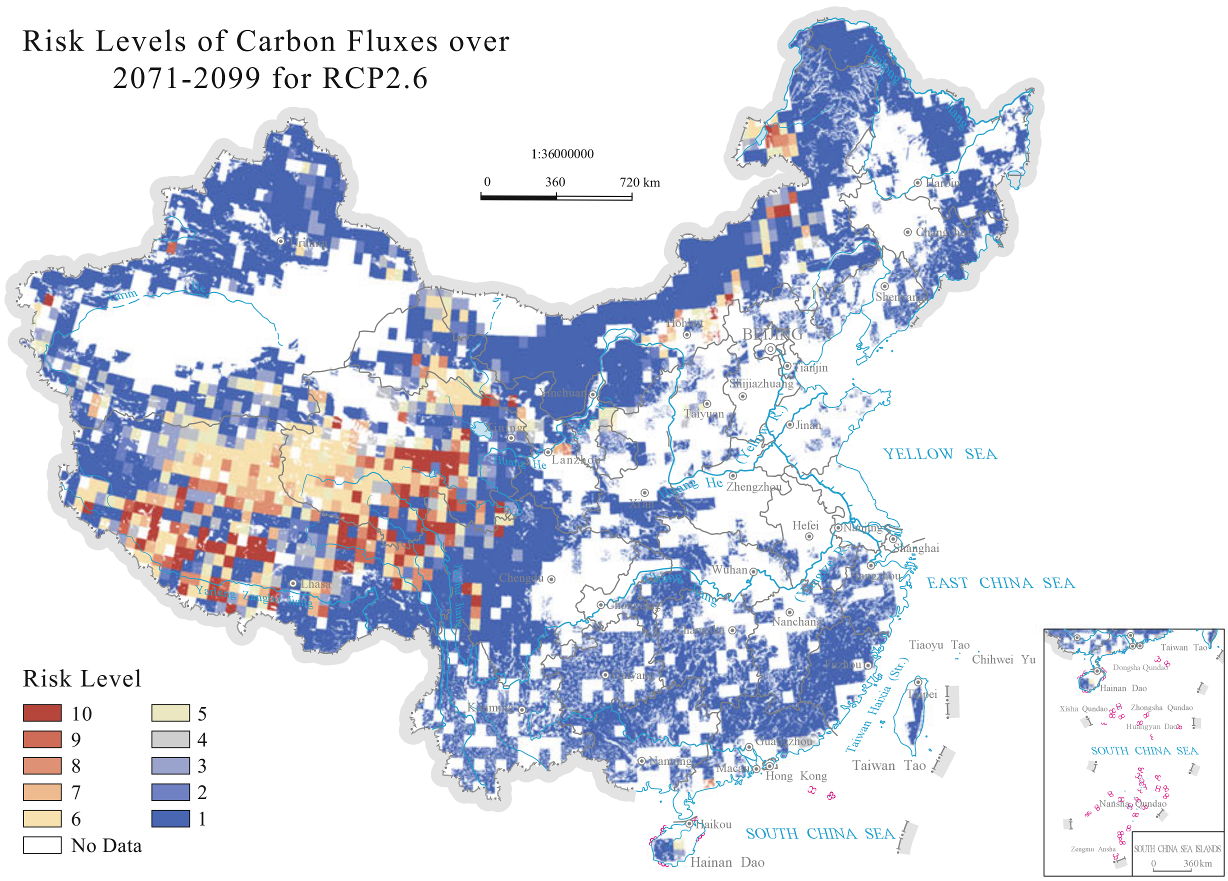
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2071-2099 for RCP2.6
1:36000000
0 360 720 km
Risk Level
10
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8
7
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3
2
1
No Data
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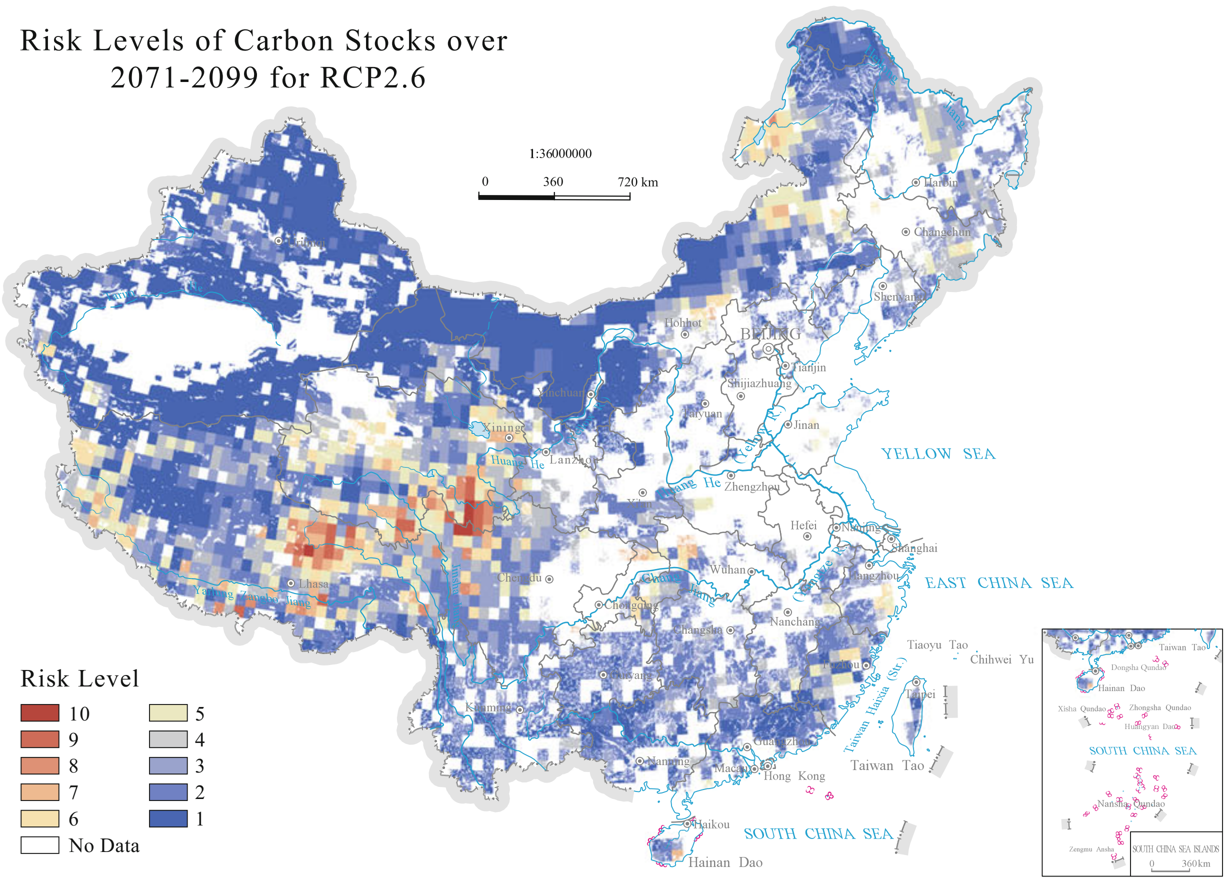
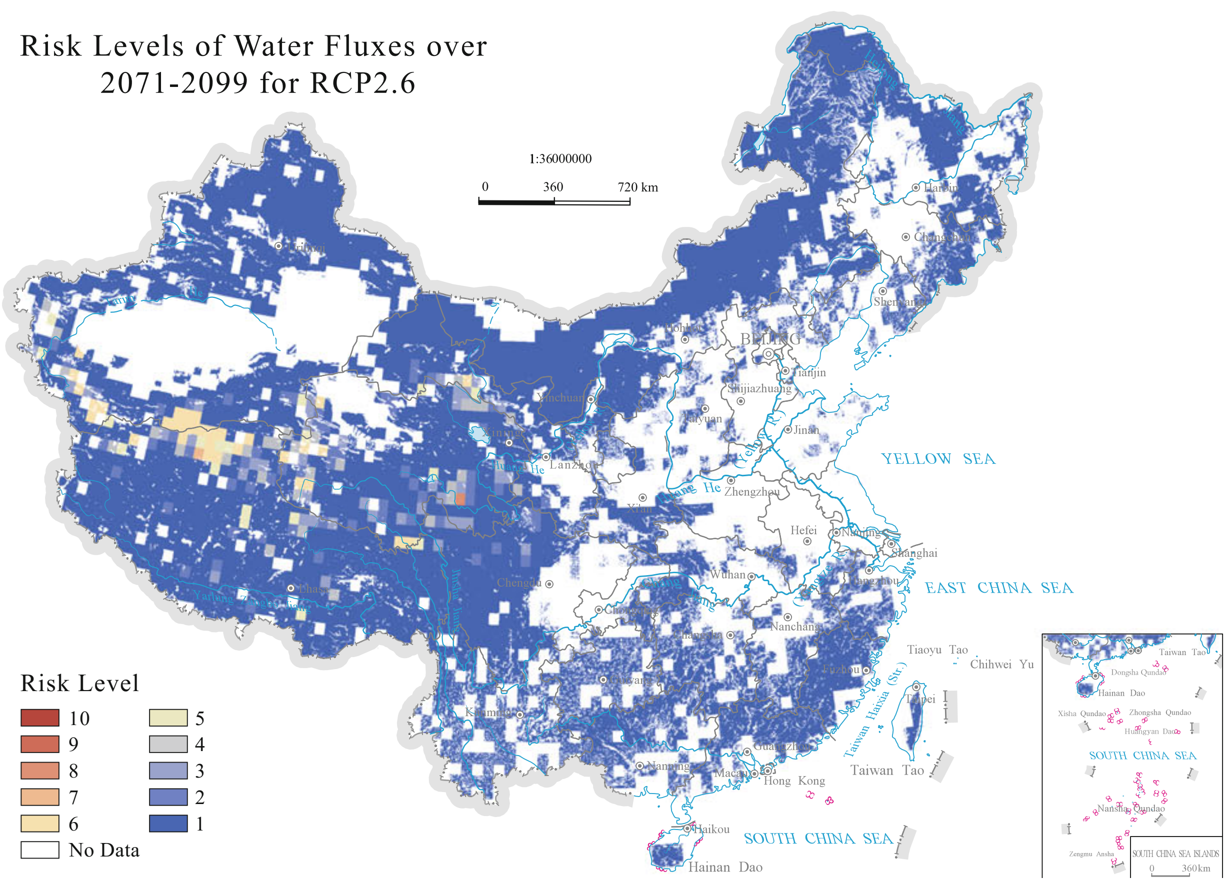
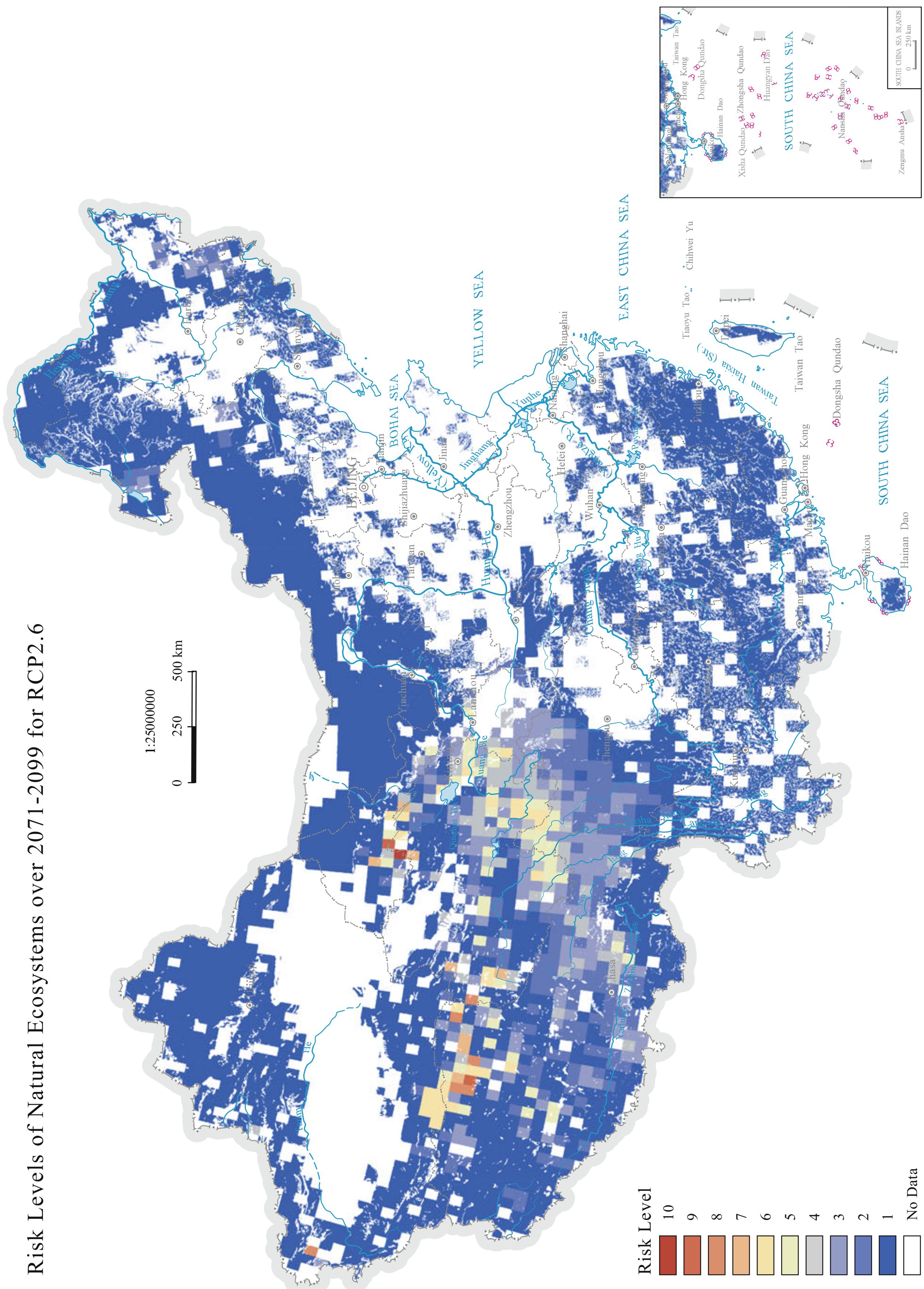
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Zhengzhou
Hefei
Nanjing
Shanghai
Wuhan
Nanchang
Lanzhou
Macau
Hong Kong
Haikou
Hainan Dao
Taiwan Tao
Tiaoyu Tao
Chihwei Yu
SOUTH CHINA SEA ISLANDS

Risk Levels of Carbon Stocks over 2071-2099 for RCP2.6

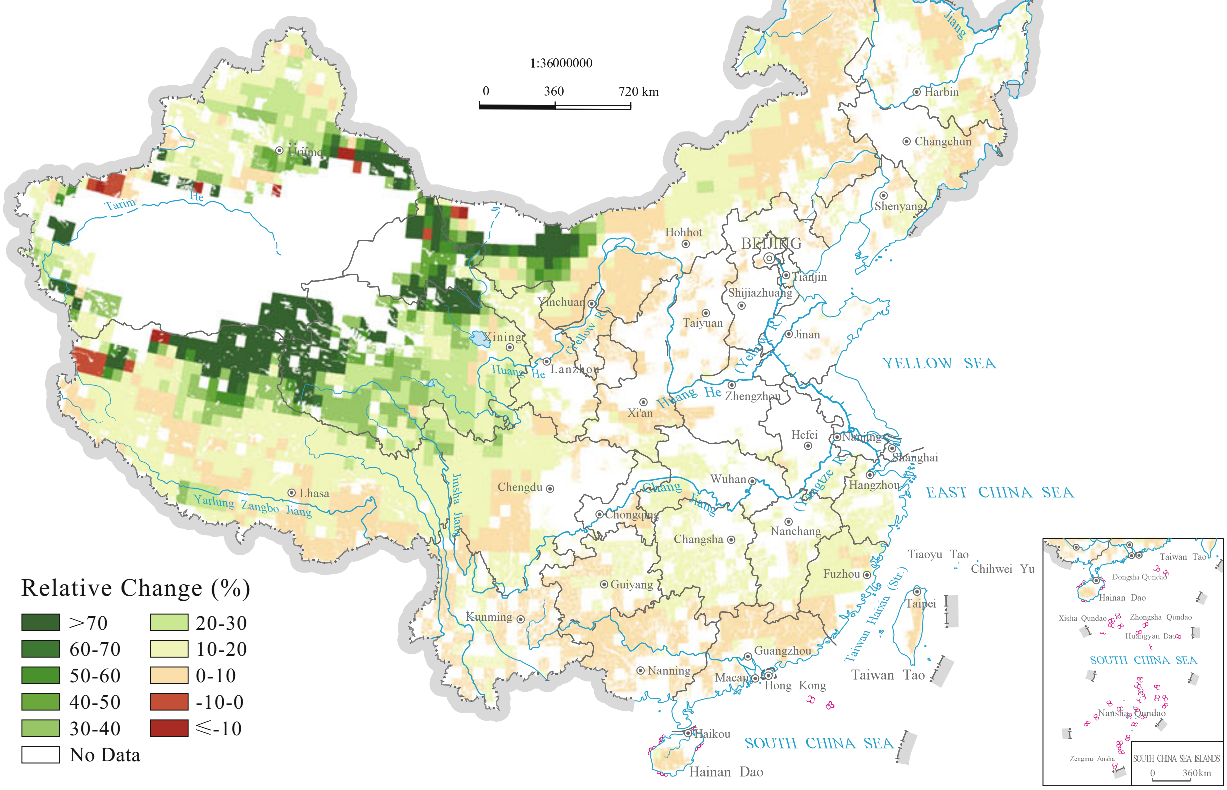


Risk Levels of Water Fluxes over 2071-2099 for RCP2.6

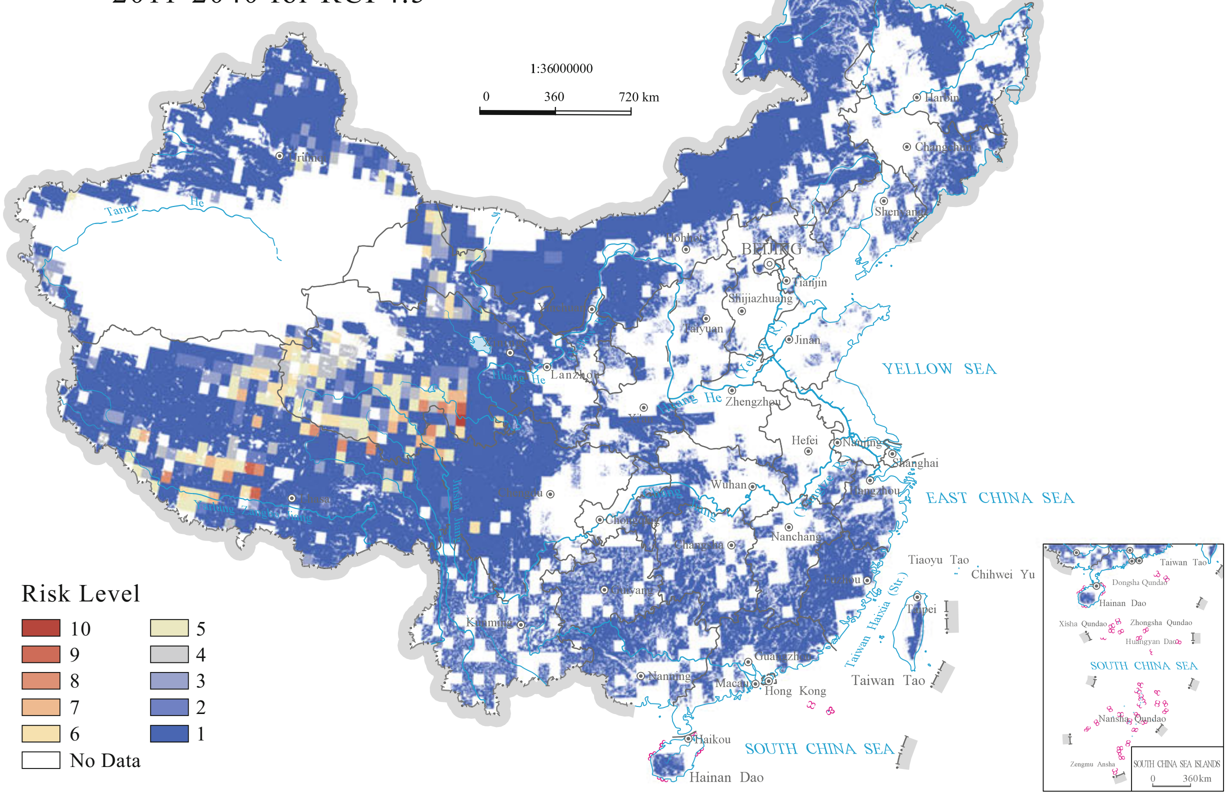


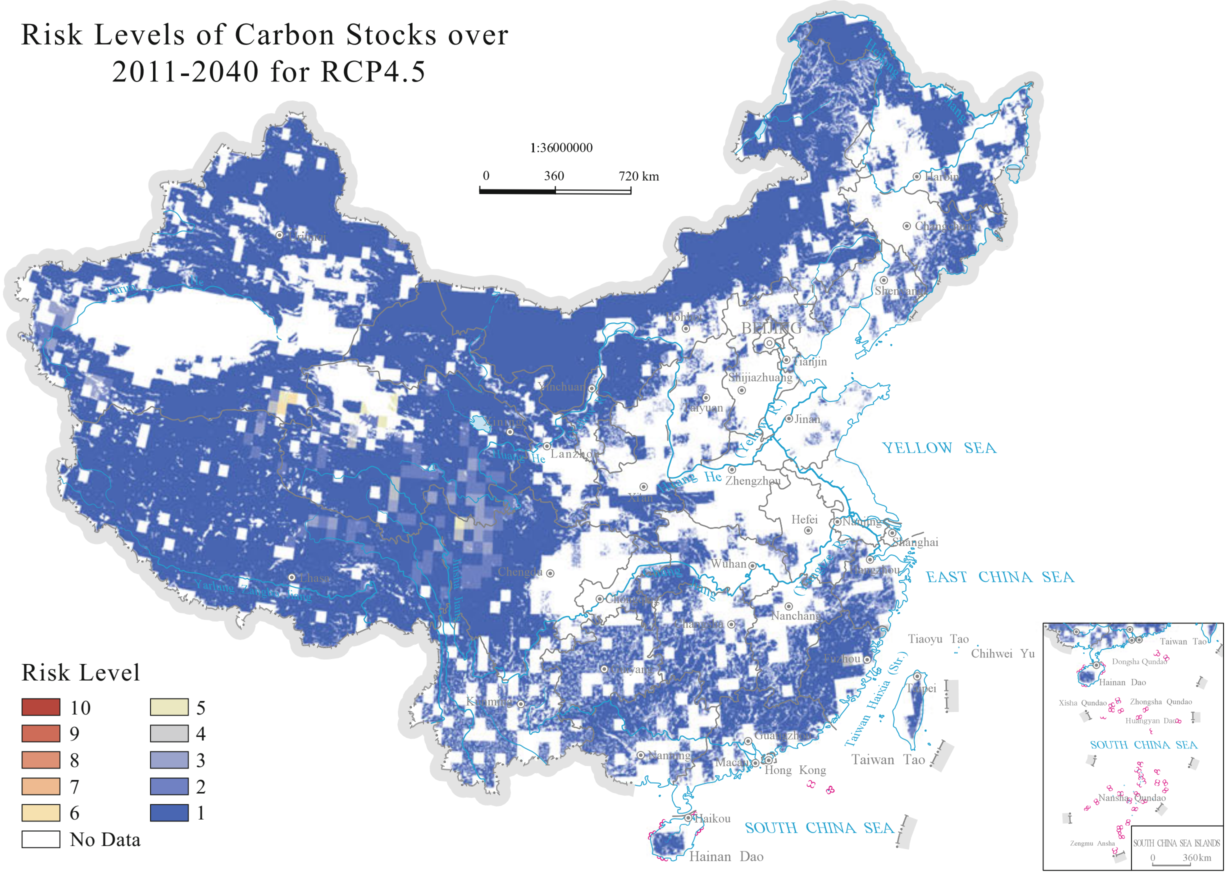

Risk Levels of Natural Ecosystems over 2071-2099 for RCP2.6
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BEIJING
YELLOW SEA
BOHAI SEA
EAST CHINA SEA
SOUTH CHINA SEA
Taiwan Haixia (Str.)
Taiwan Tao
Dongsha Qundao
Hong Kong
Hainan Dao
Chihwei Yu
Tiaoyu Tao
Shanghai
Nanjing
Hefei
Wuhan
Zhengzhou
Shijiazhuang
Jinan
Lanzhou
Chengdu
Lhasa
Haikou
Xisha Qundao
Zhongsha Qundao
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS

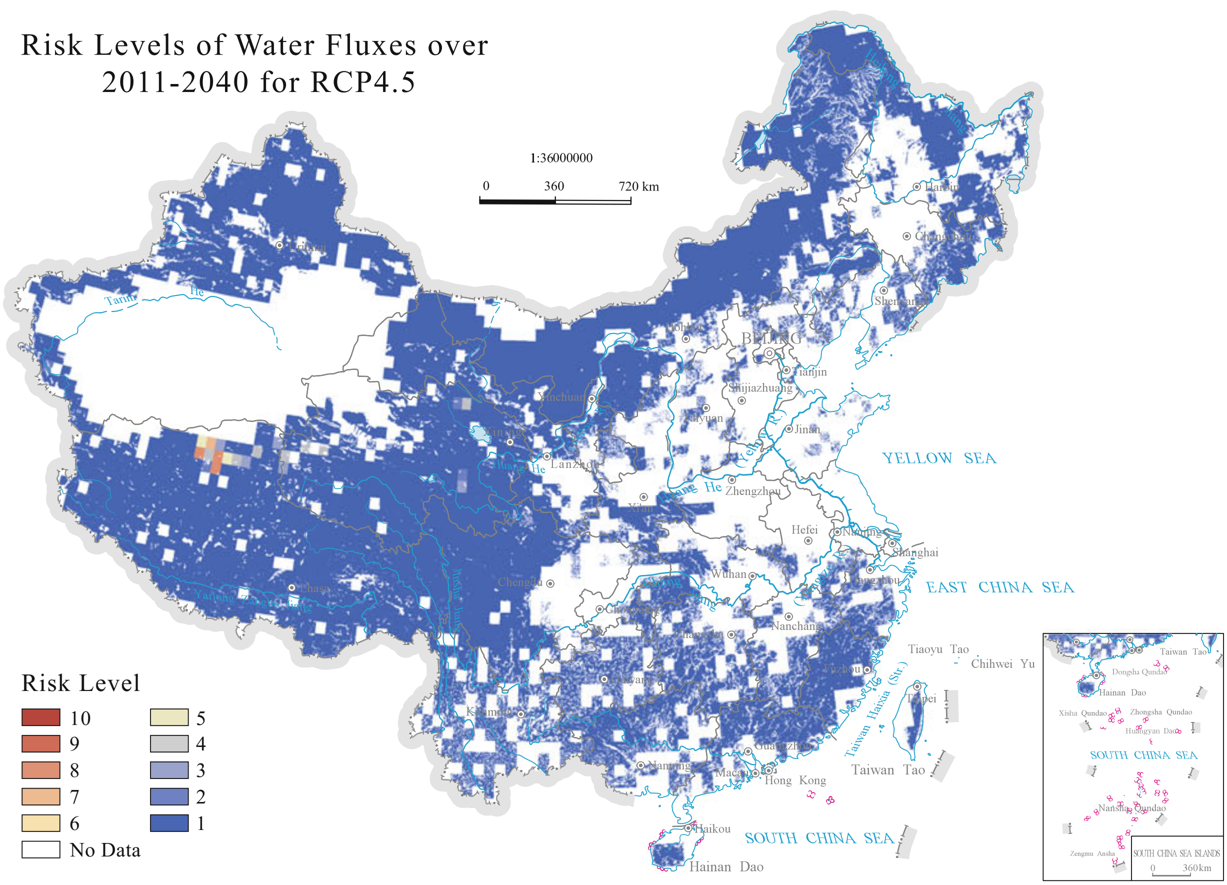
Relative Change of Net Primary Productivity over 2011-2040 for RCP4.5



Risk Levels of Carbon Fluxes over 2011-2040 for RCP4.5




Risk Levels of Carbon Stocks over
2011-2040 for RCP4.5
1:36000000
0 360 720 km
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Hainan Dao
Taiwan Tao
Hong Kong
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data


Risk Levels of Water Fluxes over
2011-2040 for RCP4.5
1:36000000
0 360 720 km
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Hainan Dao
Taiwan Tao
Hong Kong
Risk Level
10
9
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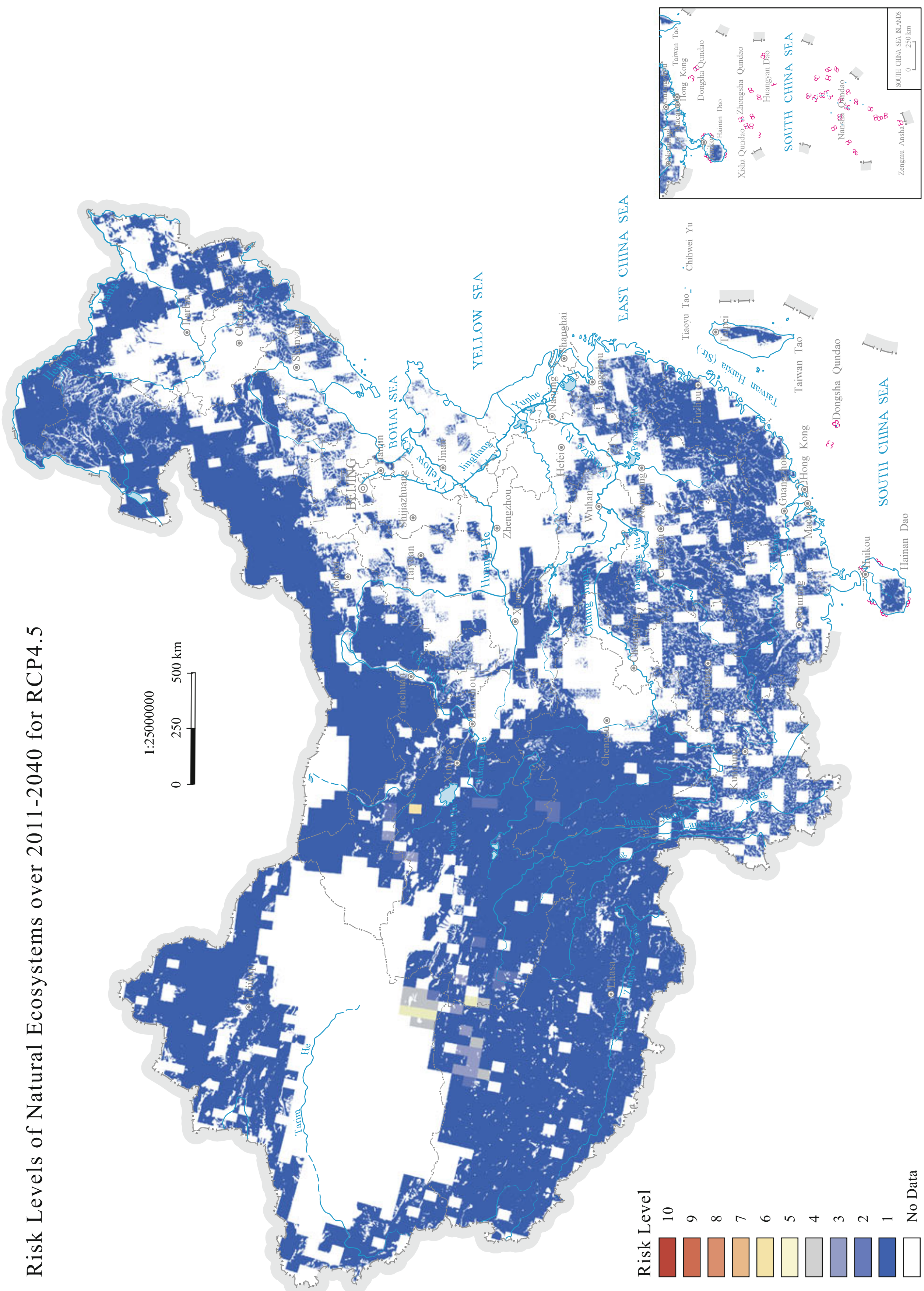
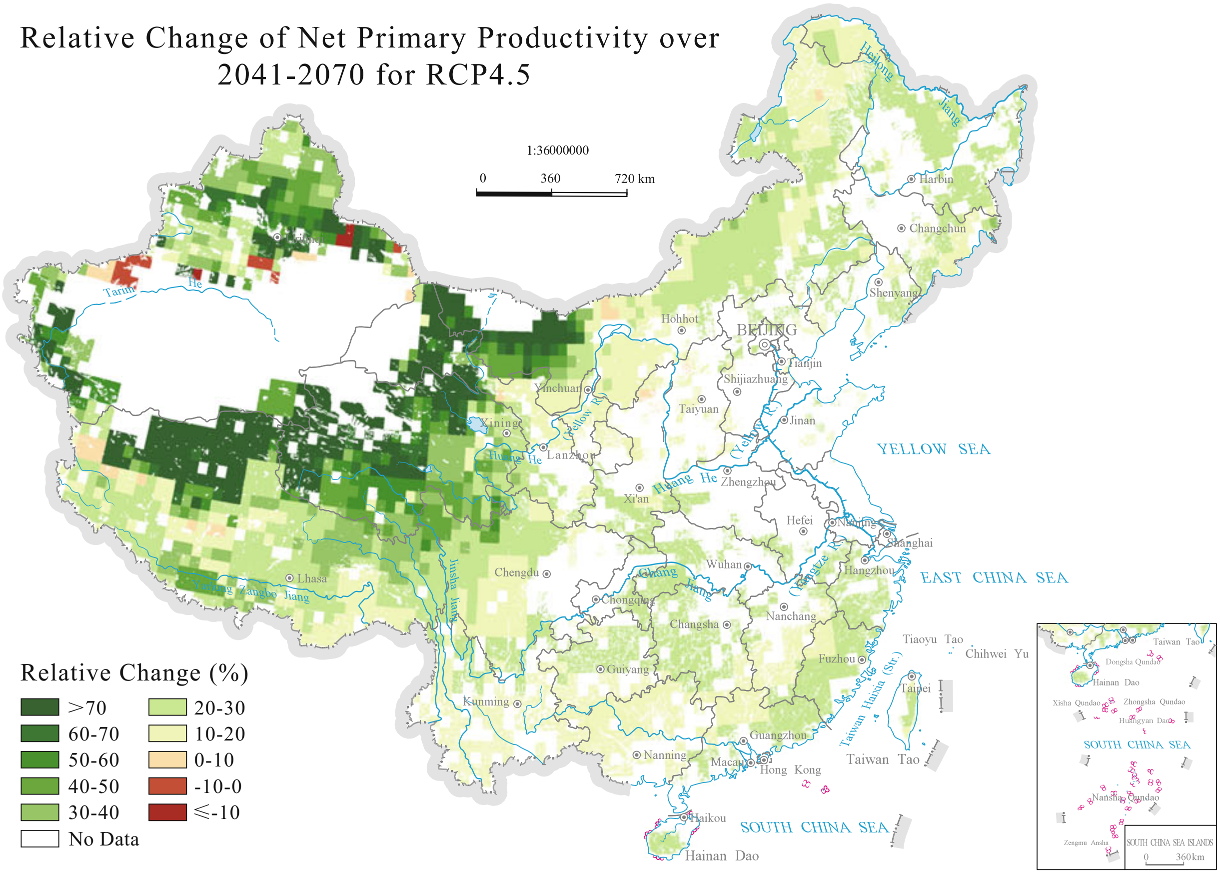

Risk Levels of Natural Ecosystems over 2011-2040 for RCP4.5
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
YELLOW SEA
BOHAI SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Shanghai
Wuhan
Zhengzhou
Hefei
Lhasa
Hainan Dao
Taiwan Dao
Dongsha Qundao
Hong Kong
Taiwan Haixia (Str.)
Chihwei Yu
Tiaoyu Tao
Yellow
Haikou
Nanjing
Jinan
Shijiazhuang
Guangzhou
Changjiang


Relative Change of Net Primary Productivity over
2041-2070 for RCP4.5
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
≤-10
No Data
BEIJING
Harbin
Changchun
Shenyang
Hohhot
Tianjin
Shijiazhuang
Yinchuan
Taiyuan
Jinan
Xining
Lanzhou
Zhengzhou
Xi'an
Hefei
Nanjing
Shanghai
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Hangzhou
Chengdu
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Fuzhou
Guiyang
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Guangzhou
Nanning
Macao
Hong Kong
Haikou
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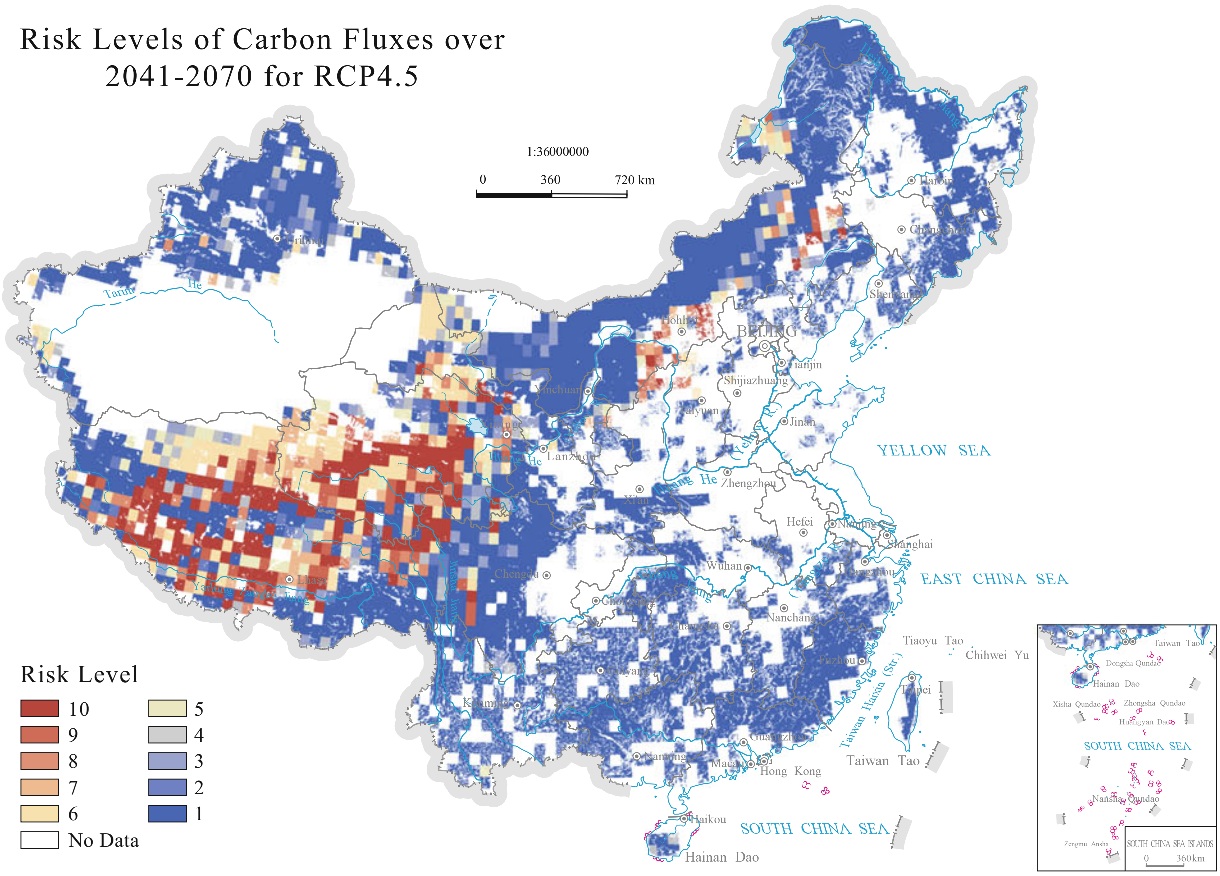
Chihwei Yu
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
SOUTH CHINA SEA ISLANDS


Risk Levels of Carbon Fluxes over
2041-2070 for RCP4.5
1:36000000
0 360 720 km
Risk Level
10
9
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7
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3
2
1
No Data
BEIJING
Tianjin
Shijiazhuang
Jinan
Lanzhou
Zhengzhou
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Nanjing
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Chihwei Yu
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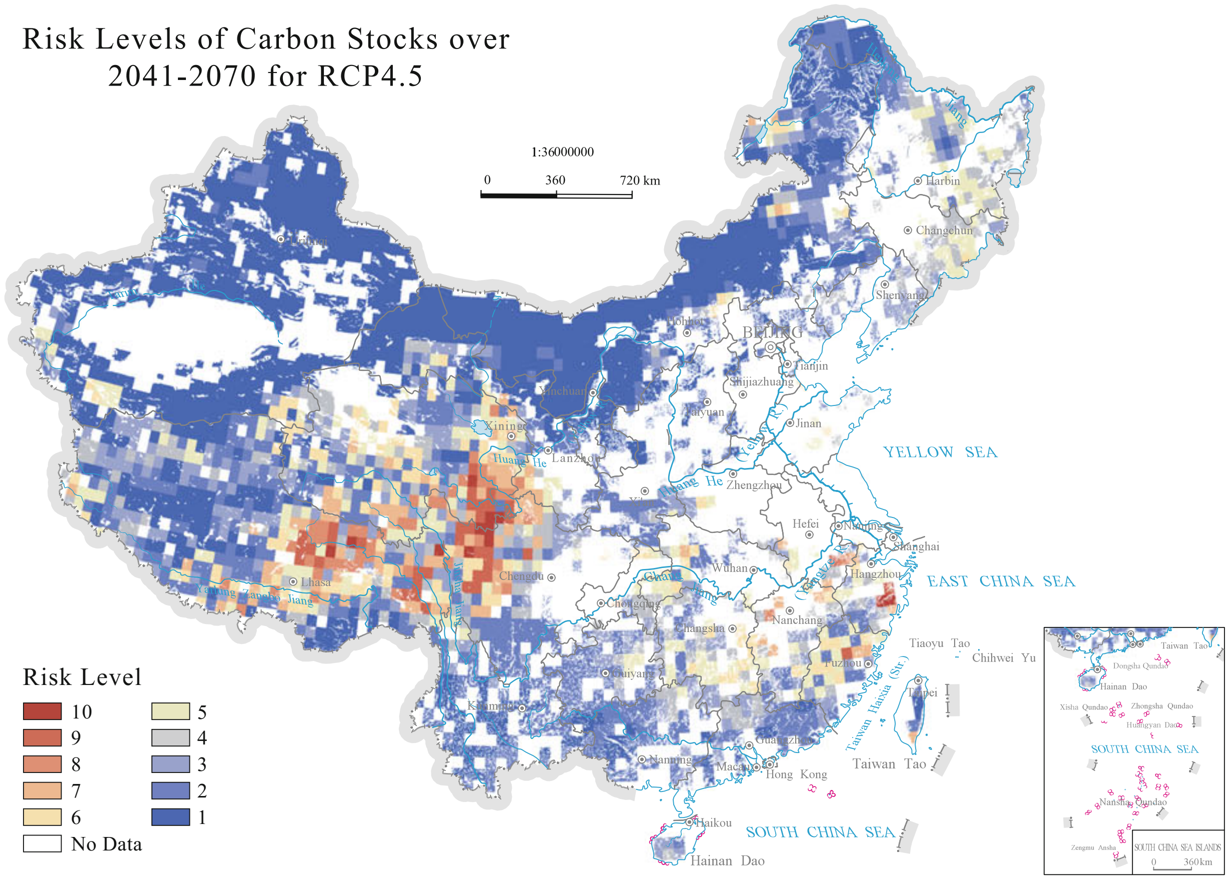
SOUTH CHINA SEA
SOUTH CHINA SEA ISLANDS


Risk Levels of Carbon Stocks over
2041-2070 for RCP4.5
1:36000000
0 360 720 km
Risk Level
10
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7
6
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4
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2
1
No Data
Harbin
Changchun
Shenyang
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Yinchuan
Xining
Lanzhou
Huang He
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Hefei
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Guiyang
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Nanning
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Macao
Hong Kong
Haikou
Hainan Dao
Taipei
Taiwan Tao
Tiaoyu Tao
Chihwei Yu
Taiwan Haixia (Str.)
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
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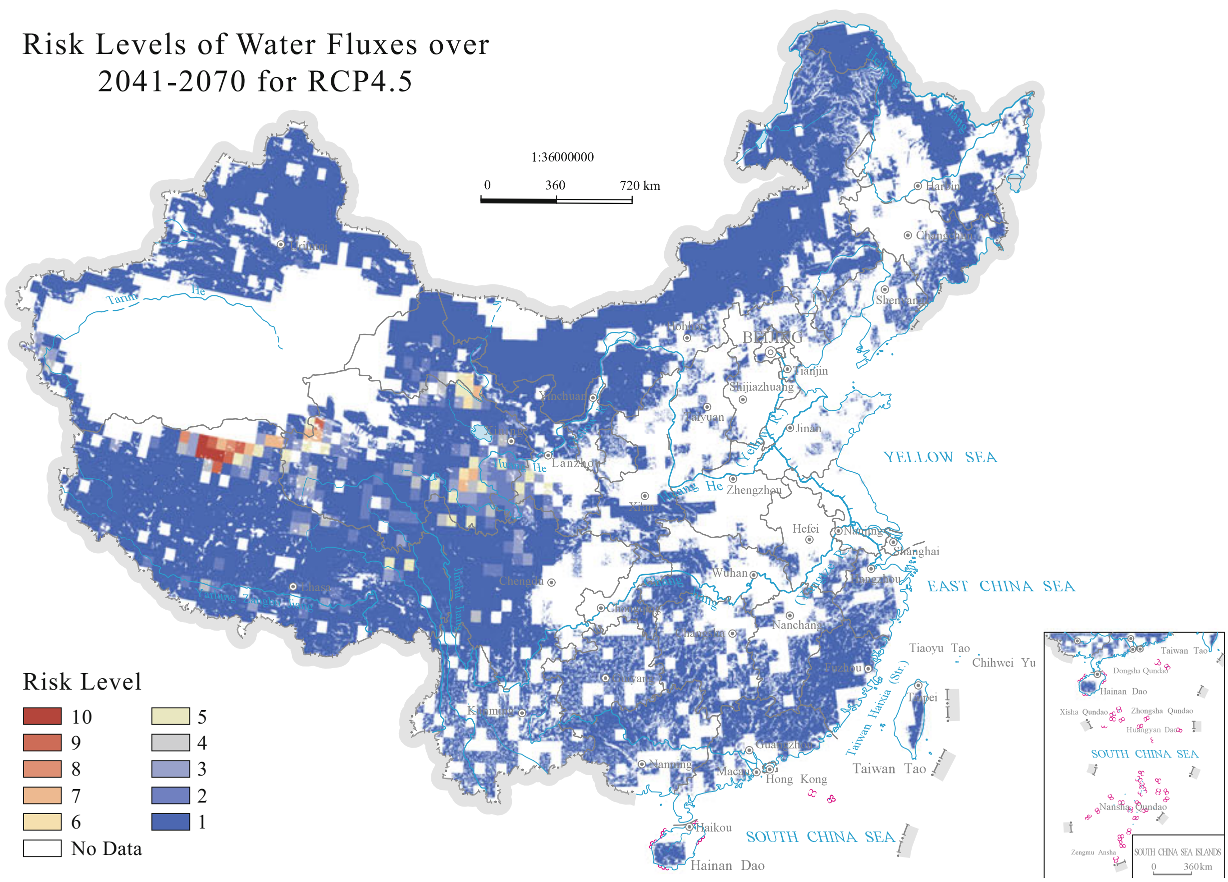
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS
0 360km


Risk Levels of Water Fluxes over
2041-2070 for RCP4.5
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0 360 720 km
Risk Level
10
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8
7
6
5
4
3
2
1
No Data
Tarim He
Harbin
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
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Lanzhou
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Hefei
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Haikou
Hainan Dao
Taiwan Tao
Tiaoyu Tao
Chihwei Yu
Taiwan Haixia (Str.)
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Dongsha Qundao
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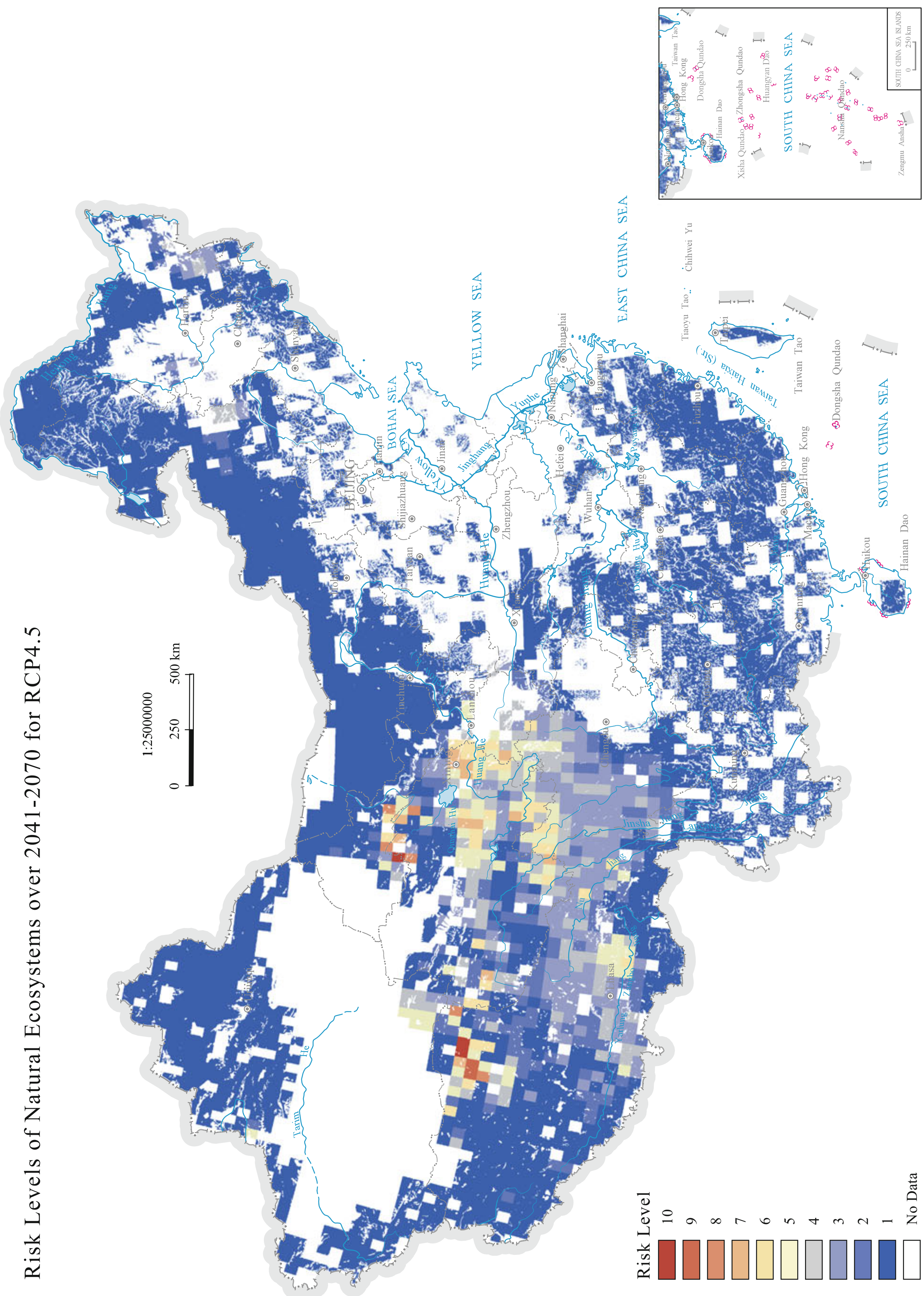
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS
0 360km


Risk Levels of Natural Ecosystems over 2041-2070 for RCP4.5
1:25000000
0 250 500 km
Risk Level
10
9
8
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6
5
4
3
2
1
No Data
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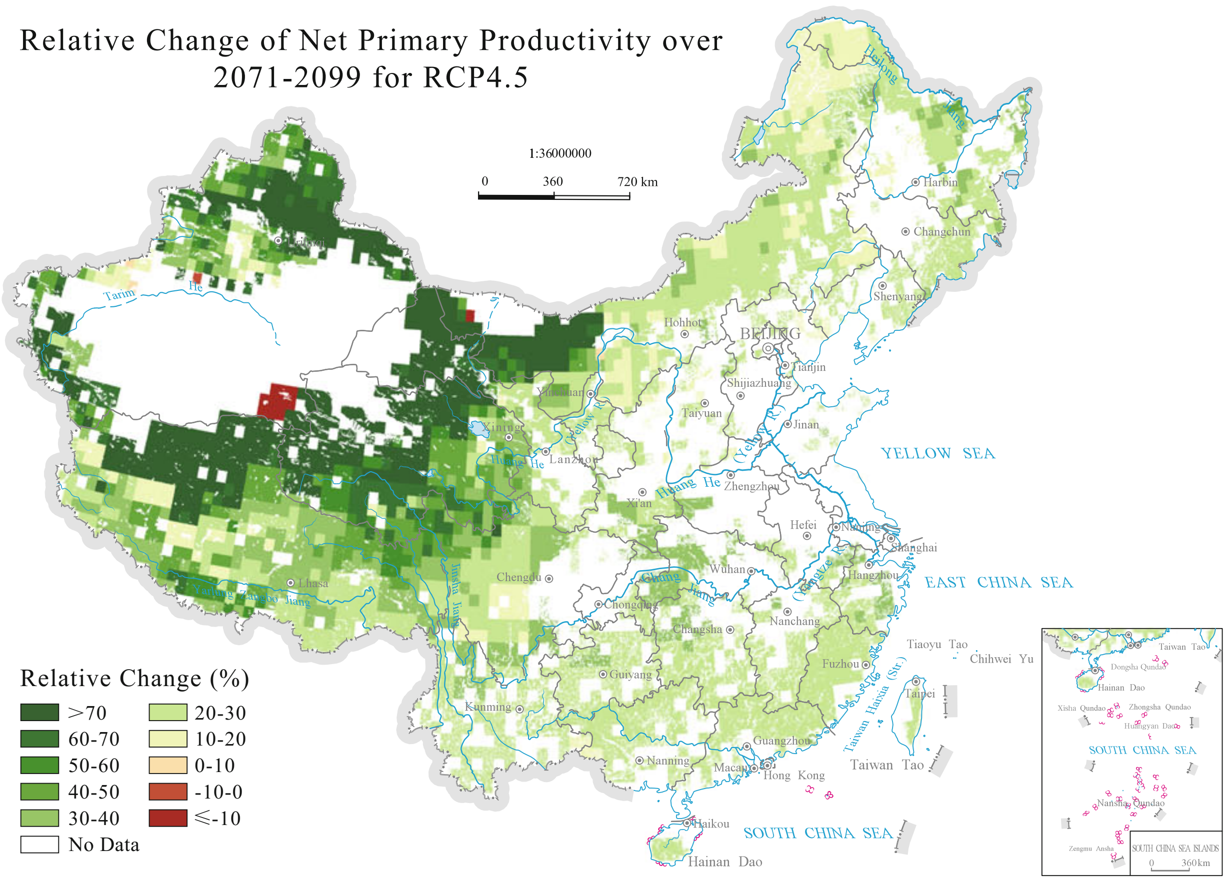
SOUTH CHINA SEA
BOHAI SEA
Taiwan Haixia (Str.)
Hainan Dao
SOUTH CHINA SEA ISLANDS


Relative Change of Net Primary Productivity over
2071-2099 for RCP4.5
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
⩽-10
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Harbin
Changchun
Shenyang
Hohhot
Tianjin
Shijiazhuang
Taiyuan
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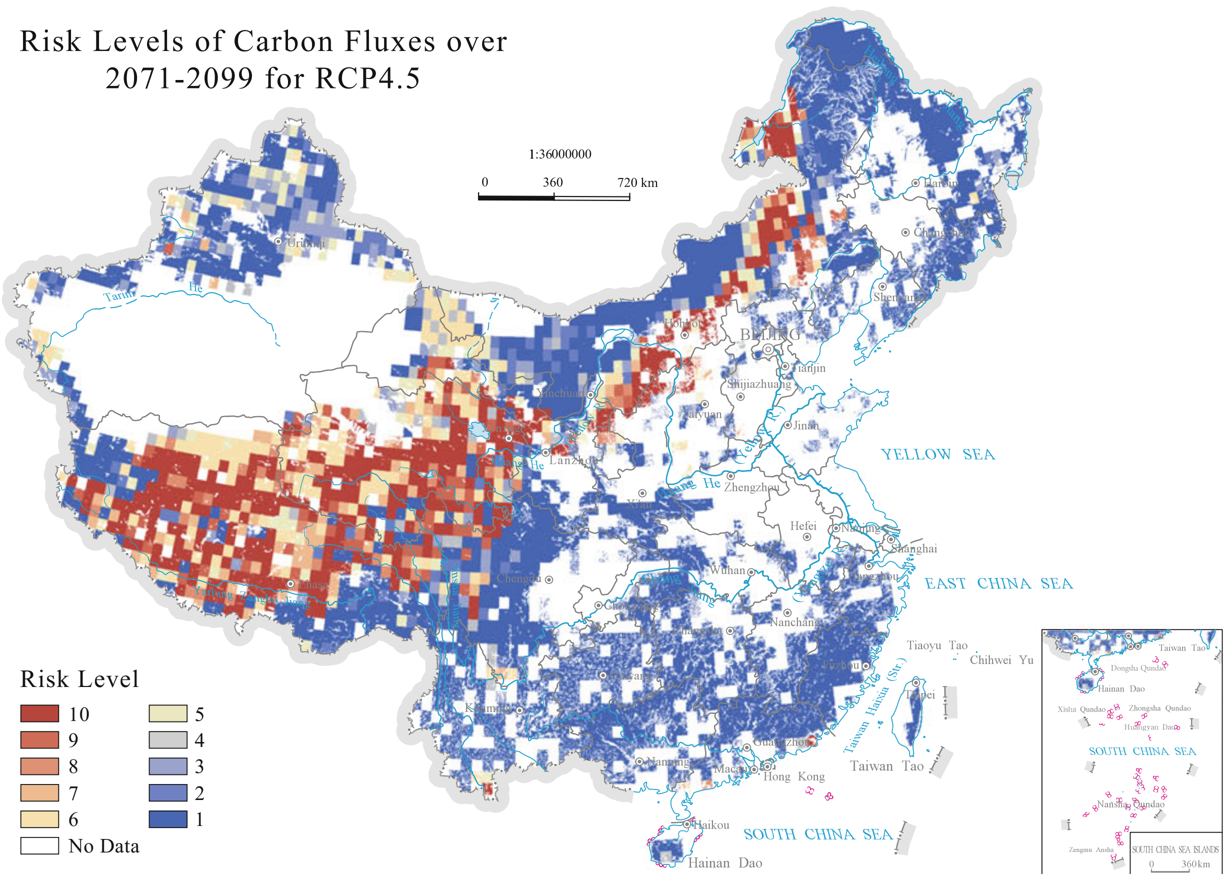
SOUTH CHINA SEA ISLANDS


Risk Levels of Carbon Fluxes over
2071-2099 for RCP4.5
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0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Tianjin
Shijiazhuang
Taiyuan
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Yinchuan
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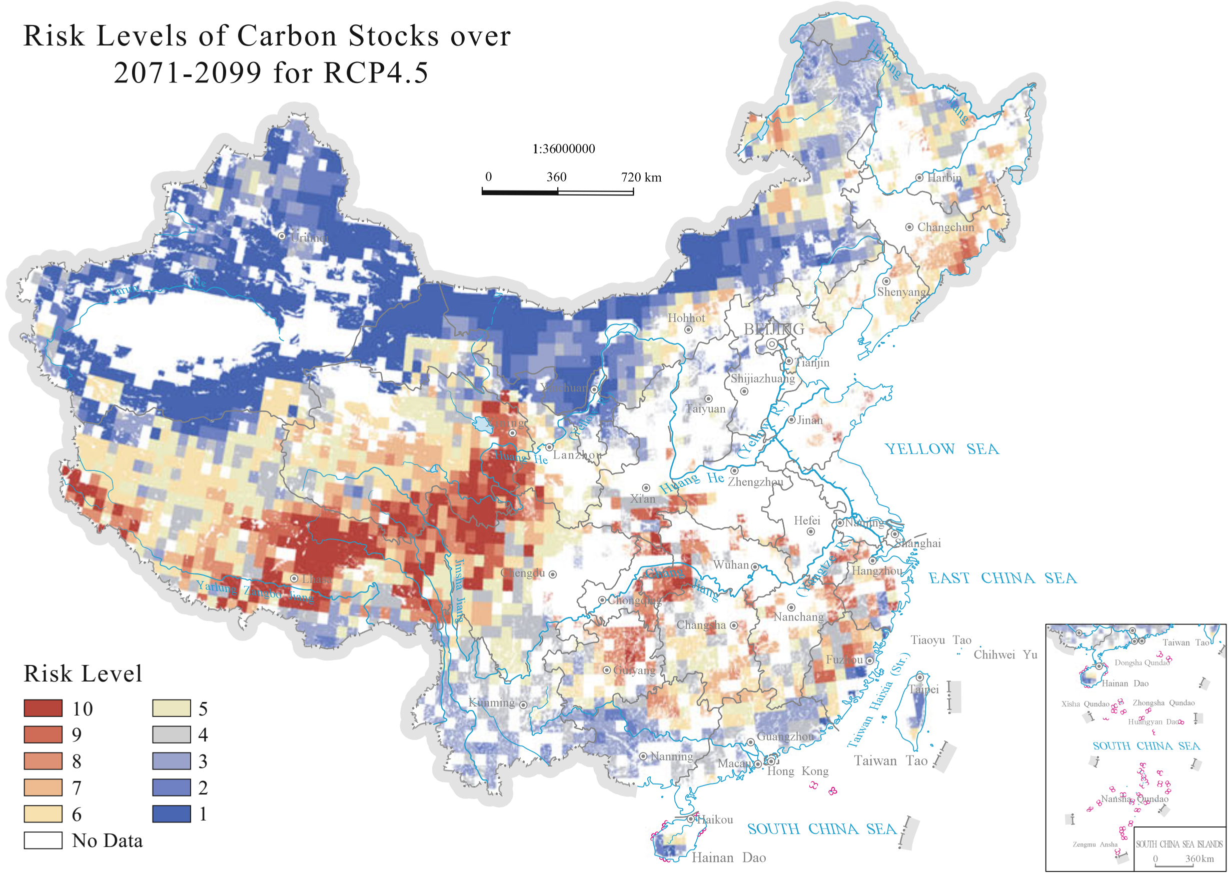
SOUTH CHINA SEA ISLANDS


Risk Levels of Carbon Stocks over
2071-2099 for RCP4.5
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0 360 720 km
Risk Level
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No Data
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4
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Harbin
Changchun
Shenyang
Hohhot
BEIJING
Tianjin
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Haikou
Hainan Dao
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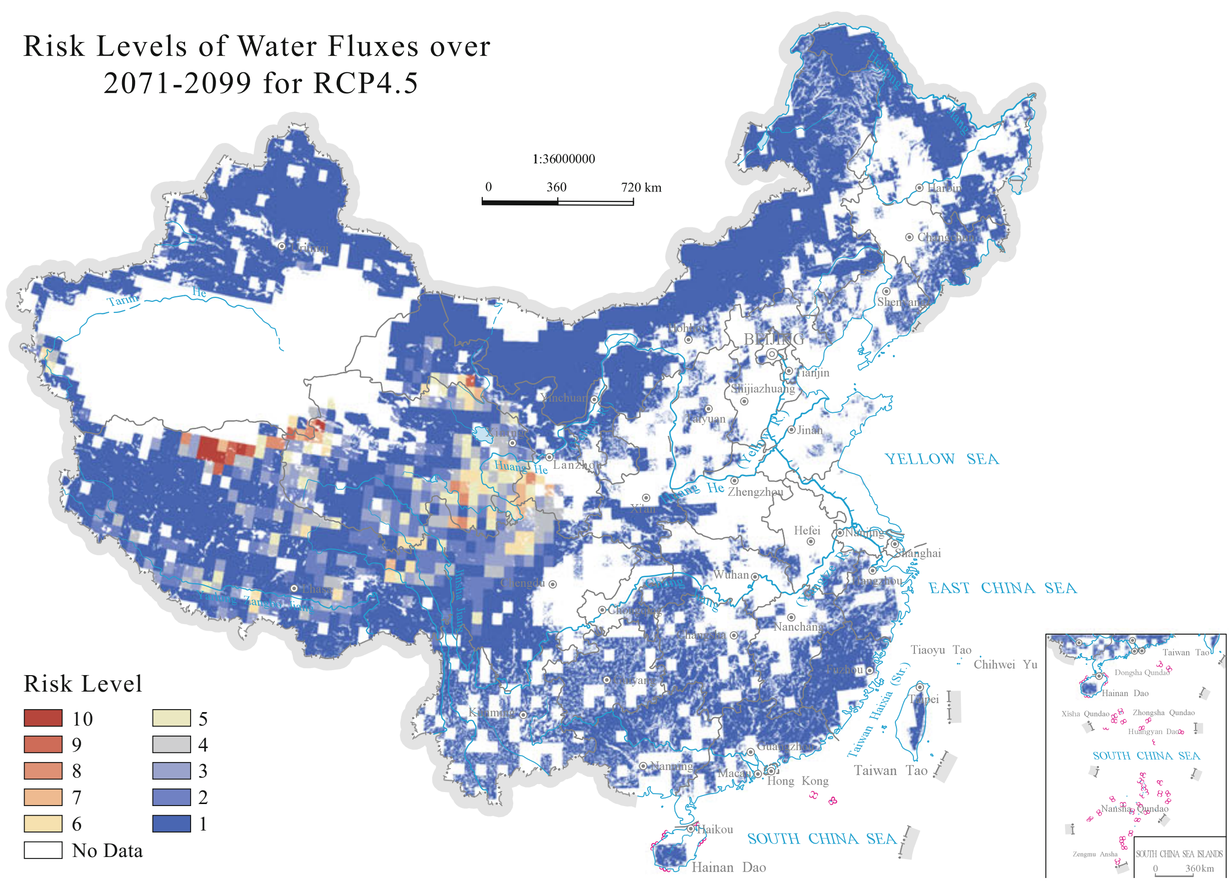
Chihwei Yu
Taiwan Haixia (Str.)
Huang He


Risk Levels of Water Fluxes over
2071-2099 for RCP4.5
1:36000000
0 360 720 km
Risk Level
10
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8
7
6
No Data
5
4
3
2
1
BEIJING
Tianjin
Shijiazhuang
Jinan
Lanzhou
Zhengzhou
Hefei
Nanjing
Shanghai
Wuhan
Nanchang
Macao
Hong Kong
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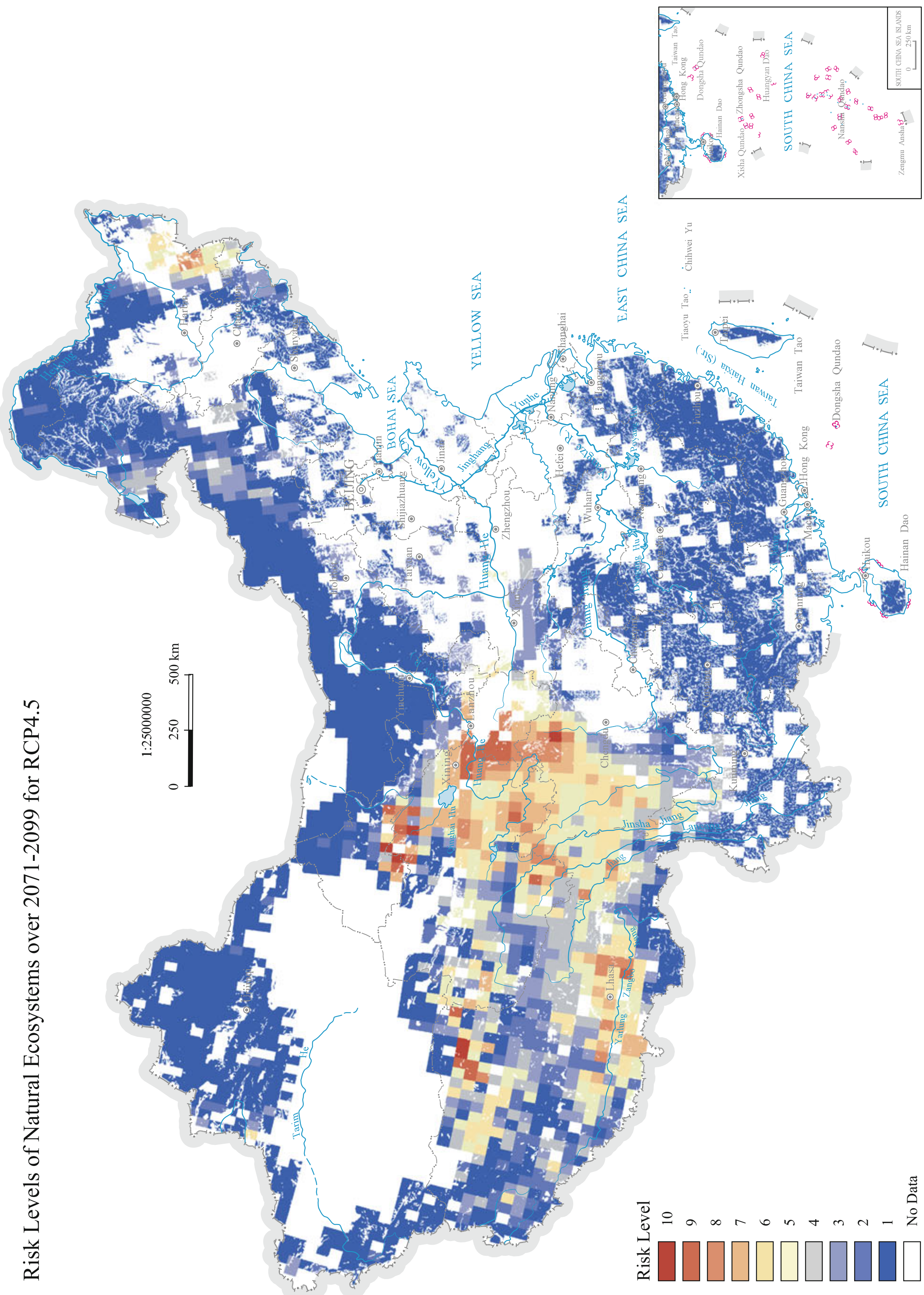
Tiaoyu Tao
Chihwei Yu
Huang He


Risk Levels of Natural Ecosystems over 2071-2099 for RCP4.5
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0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BOHAI SEA
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Lhasa
Hefei
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Hong Kong
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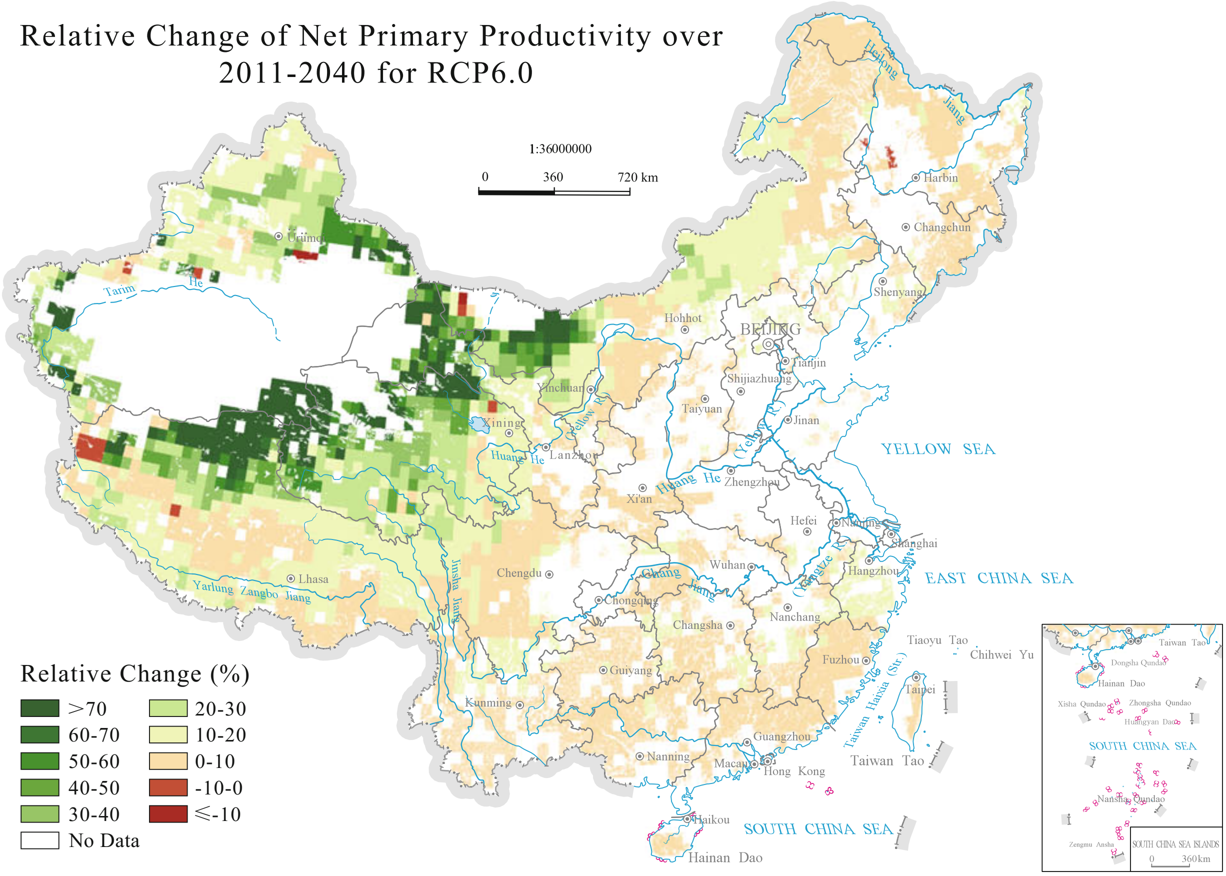
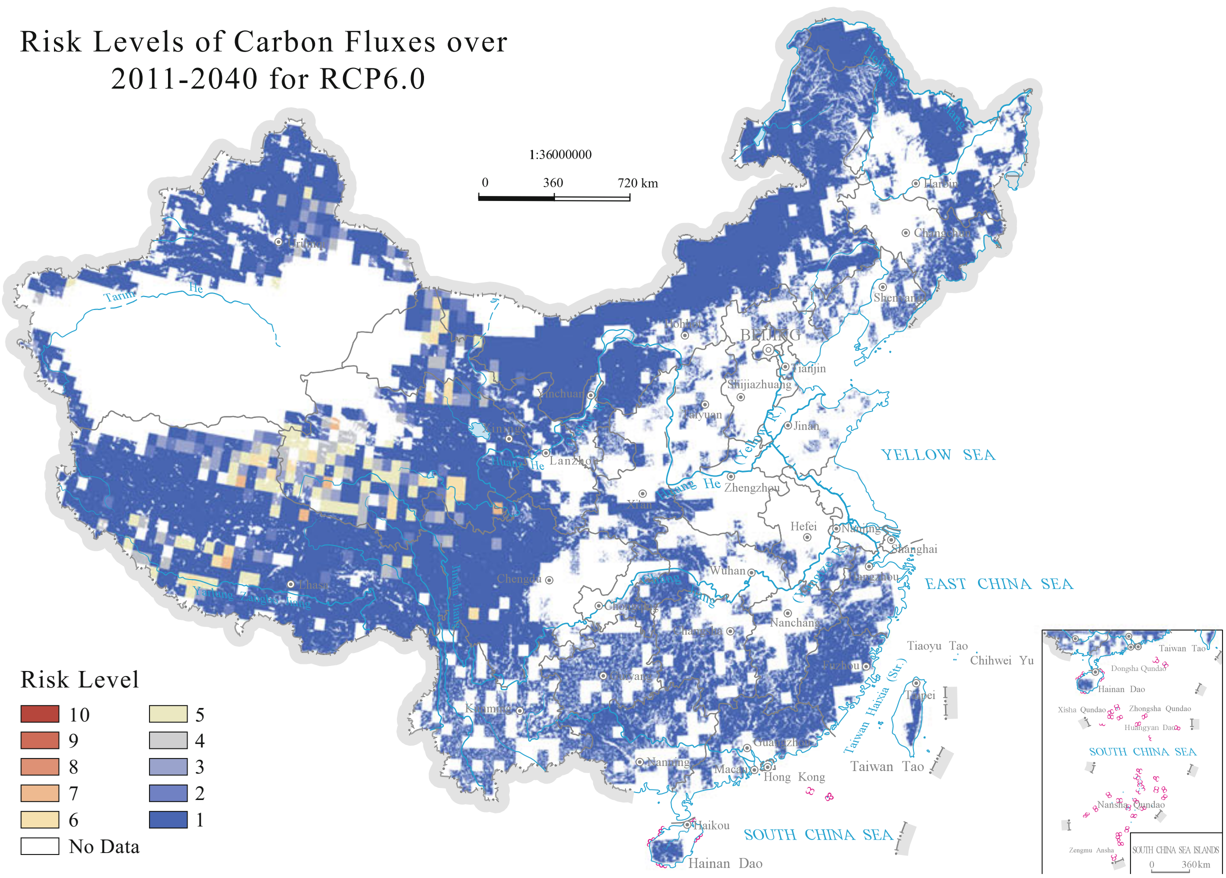
Jinsha Jiang
Tarim He
Huang He


Relative Change of Net Primary Productivity over
2011-2040 for RCP6.0
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
≤-10
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING


Risk Levels of Carbon Fluxes over
2011-2040 for RCP6.0
1:36000000
0 360 720 km
Risk Level
10
9
8
7
6
5
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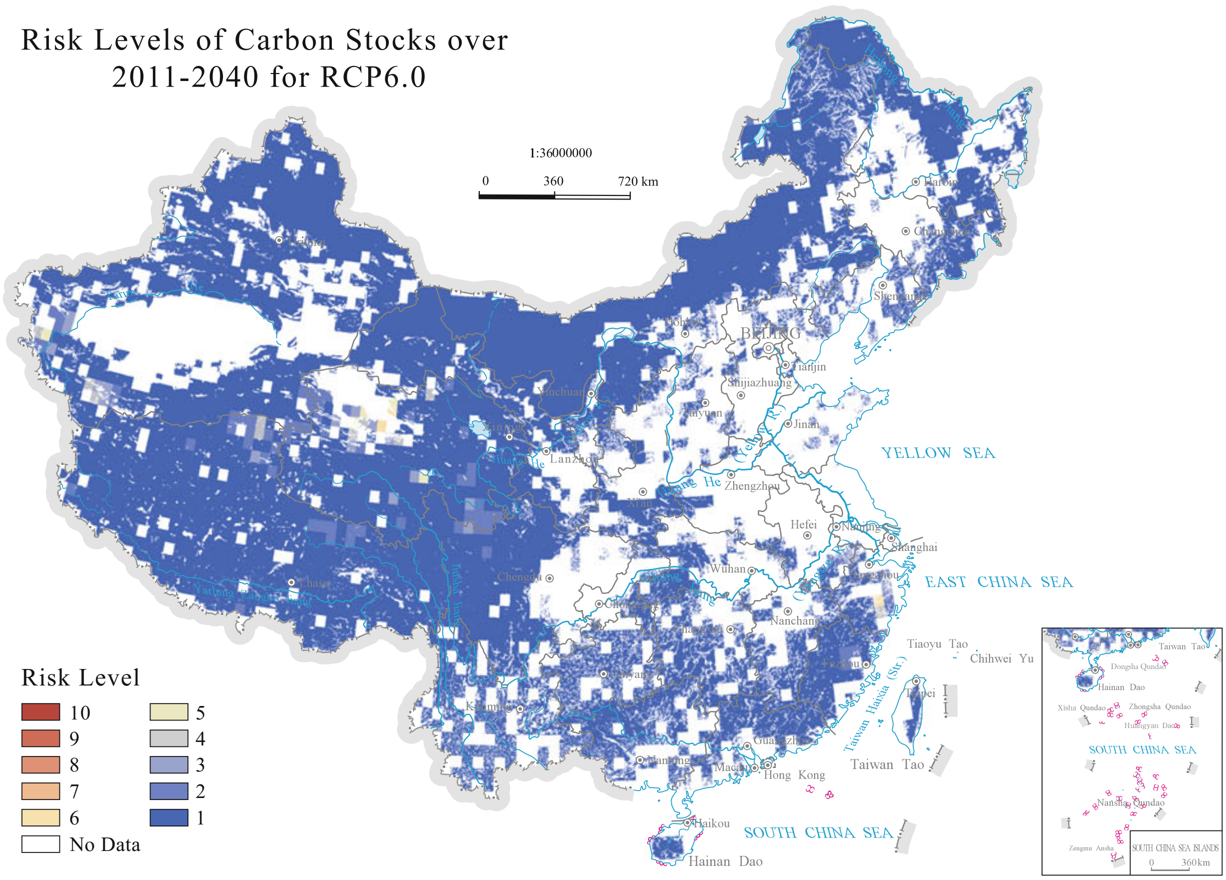
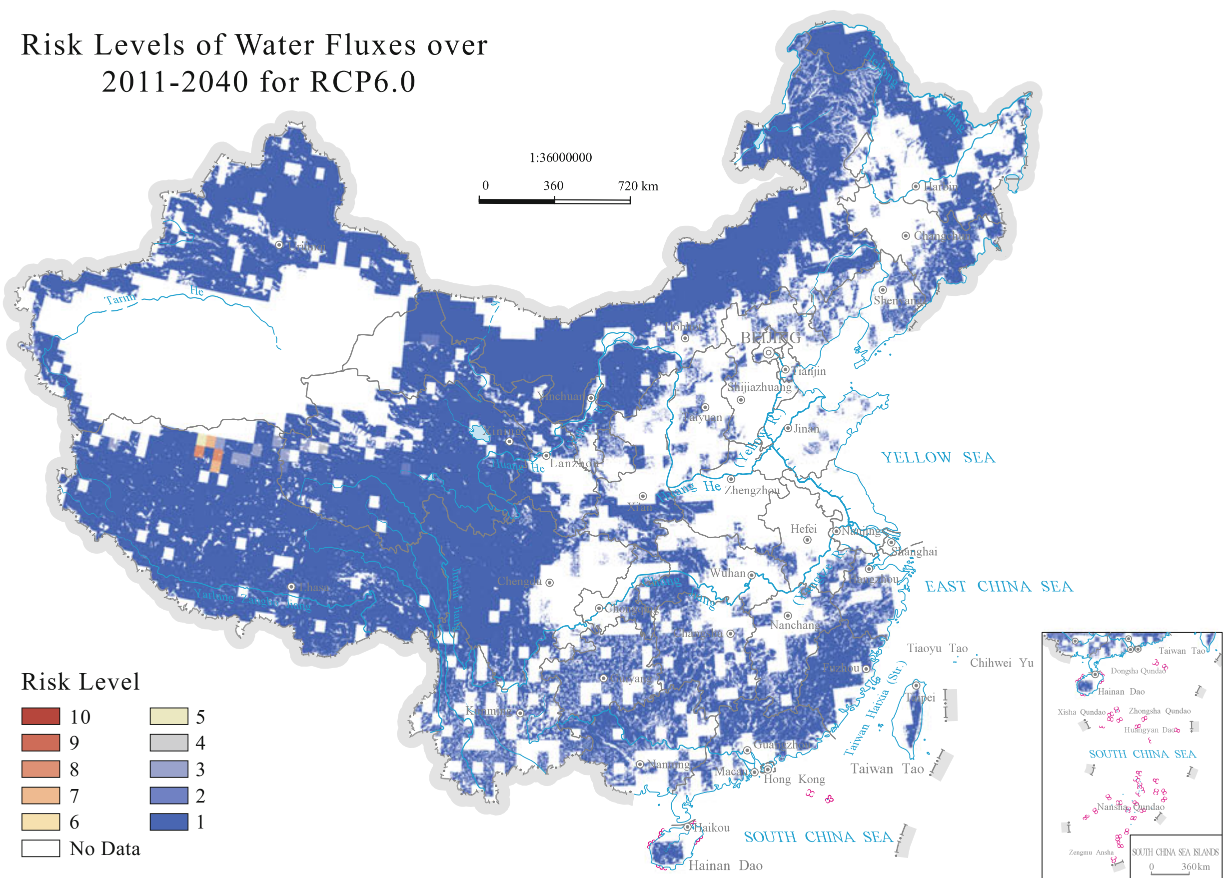
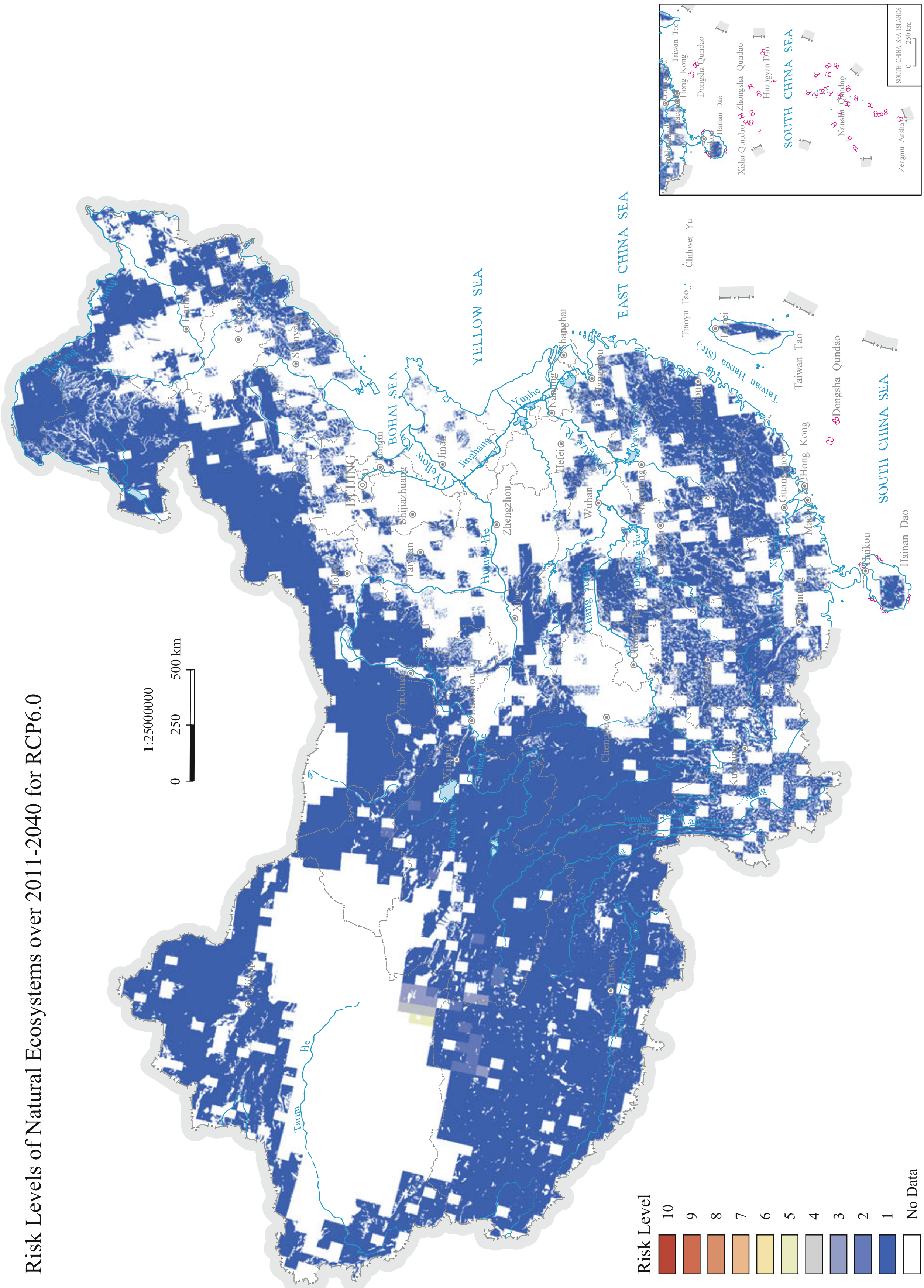
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING

Risk Levels of Carbon Stocks over 2011-2040 for RCP6.0



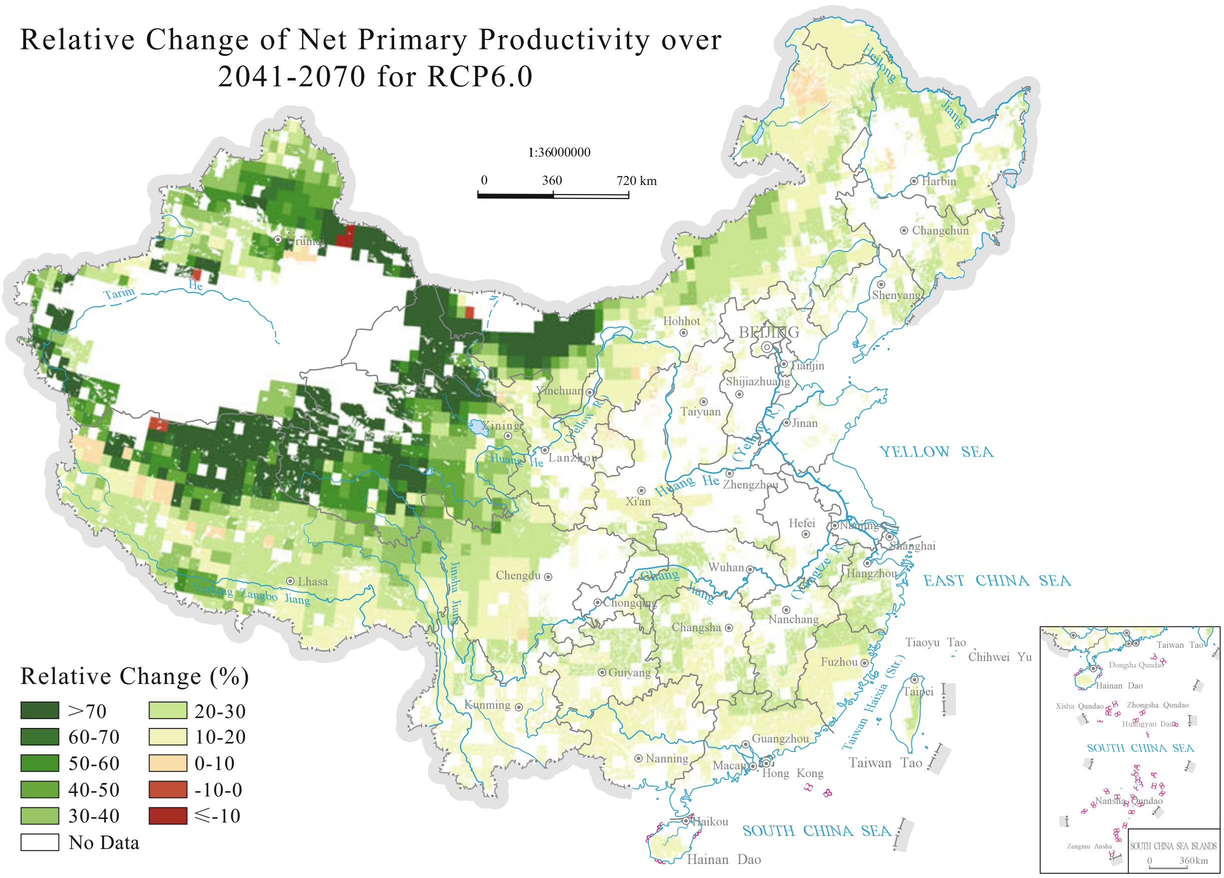
Risk Levels of Water Fluxes over 2011-2040 for RCP6.0



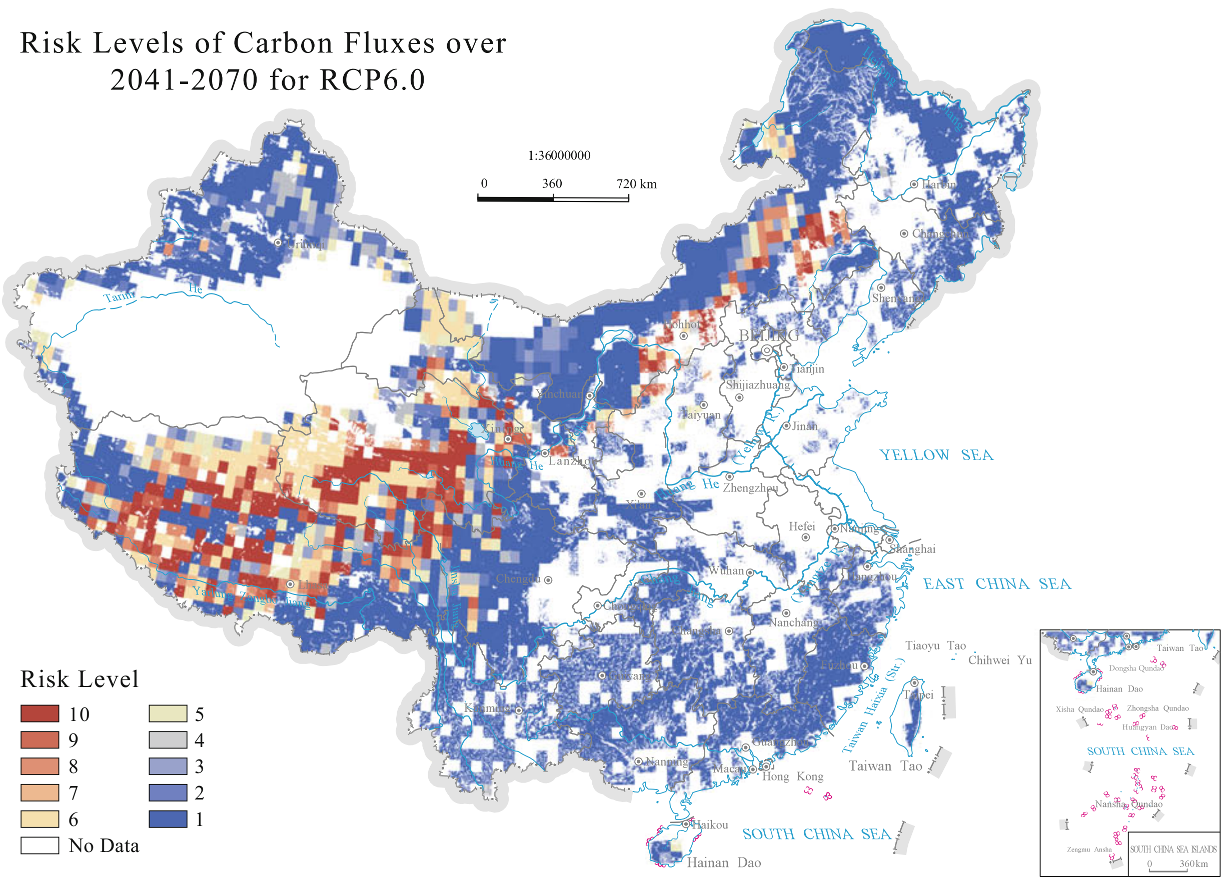


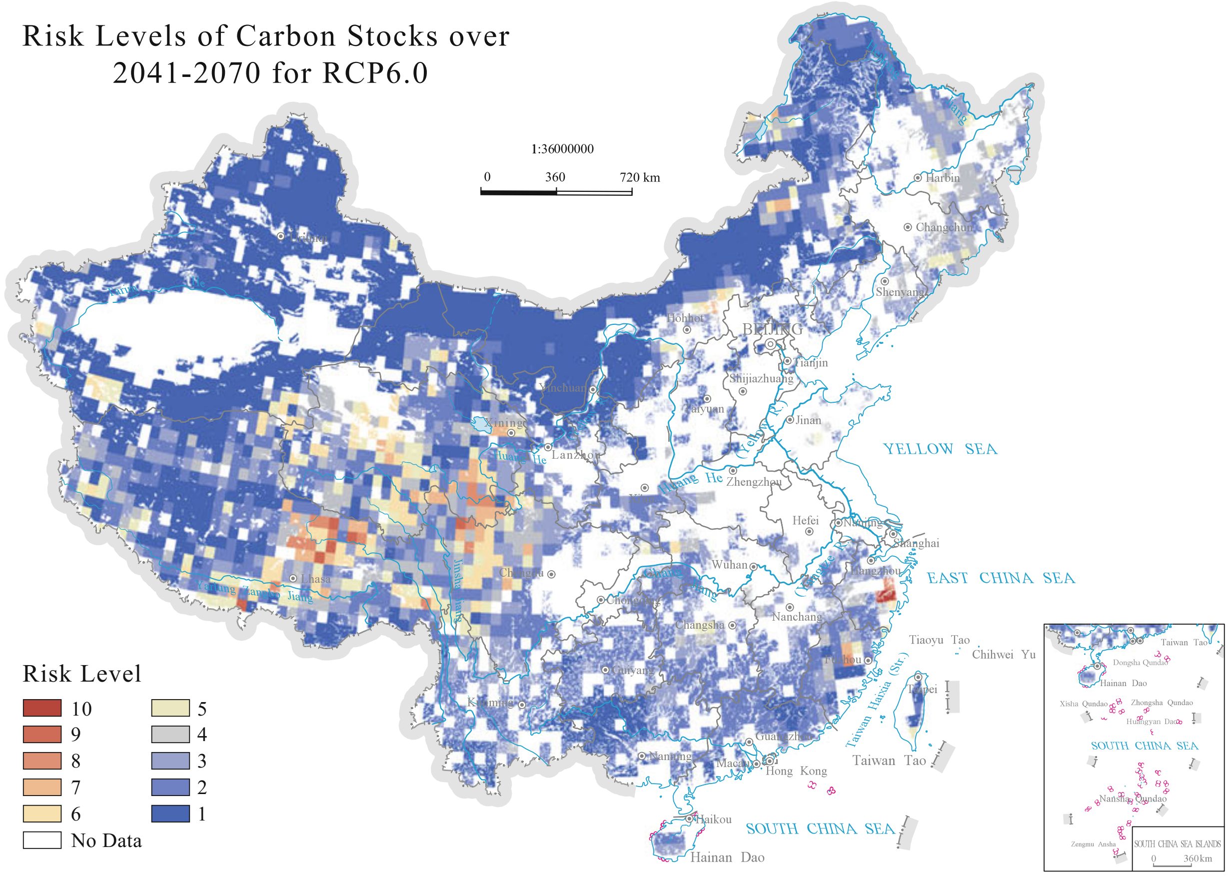
Risk Levels of Natural Ecosystems over 2011-2040 for RCP6.0

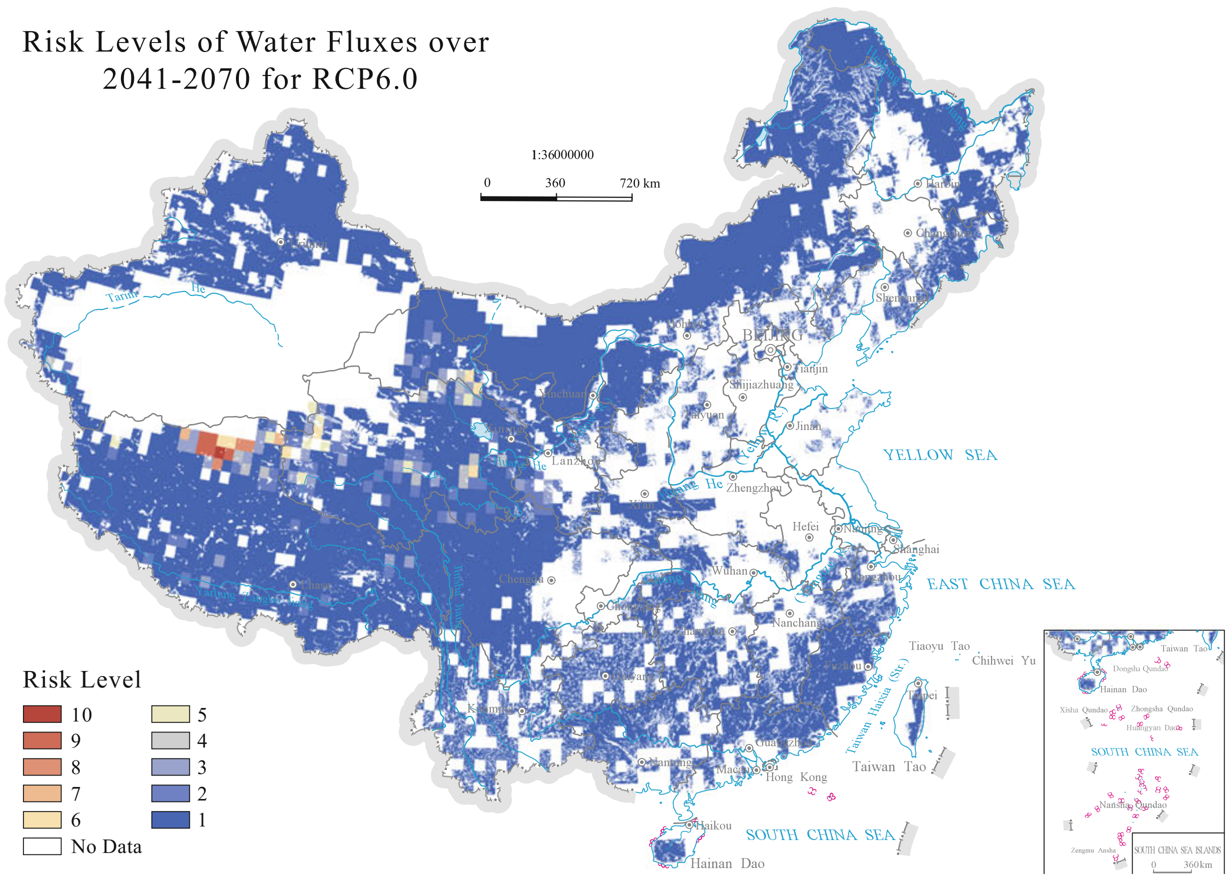
Relative Change of Net Primary Productivity over 2041-2070 for RCP6.0



Risk Levels of Carbon Fluxes over 2041-2070 for RCP6.0




Risk Levels of Carbon Stocks over
2041-2070 for RCP6.0
1:36000000
0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
Harbin
Changchun
Shenyang
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Yinchuan
Lanzhou
Xining
Zhengzhou
Hefei
Nanjing
Shanghai
Hangzhou
Wuhan
Nanchang
Changsha
Chengdu
Lhasa
Kunming
Nanning
Guangzhou
Macau
Hong Kong
Haikou
Hainan Dao
Taipei
Taiwan Tao
Tiaoyu Tao
Chihwei Yu
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Taiwan Haixia (Str.)
SOUTH CHINA SEA ISLANDS


Risk Levels of Water Fluxes over
2041-2070 for RCP6.0
1:36000000
0 360 720 km
Risk Level
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9
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7
6
5
4
3
2
1
No Data
BEIJING
Tianjin
Shijiazhuang
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Hefei
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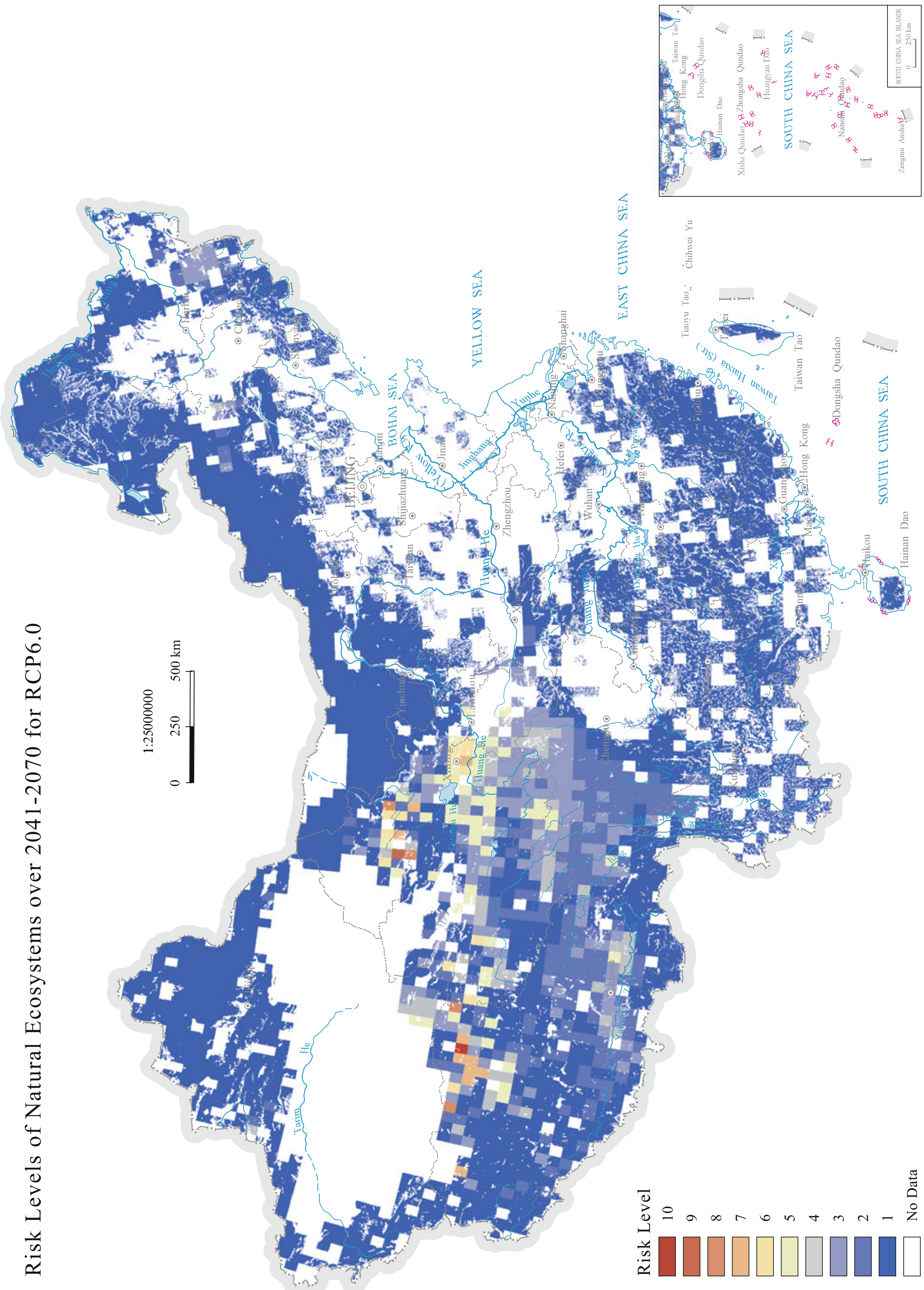
SOUTH CHINA SEA
Taiwan Haixia (Str.)
SOUTH CHINA SEA ISLANDS


Risk Levels of Natural Ecosystems over 2041-2070 for RCP6.0
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BOHAI SEA
BEIJING
Shijiazhuang
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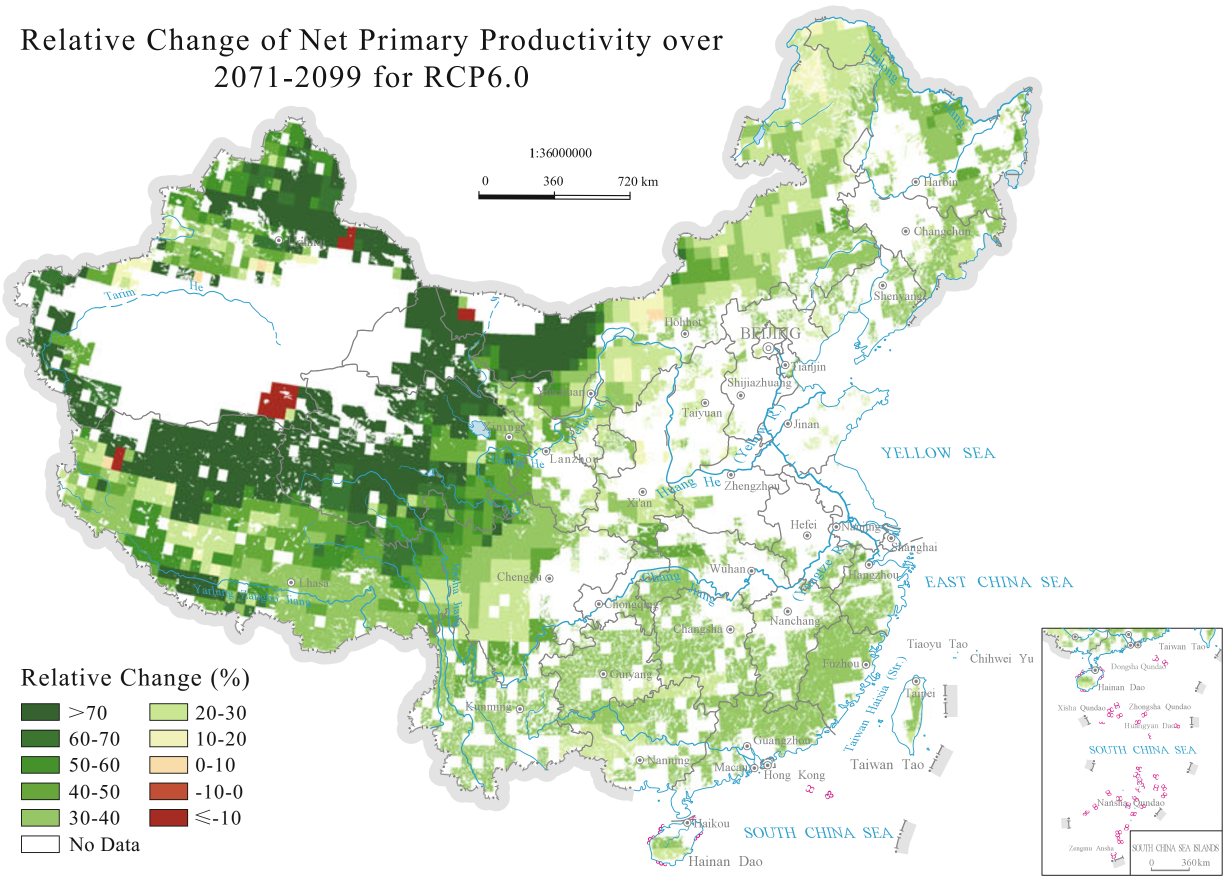
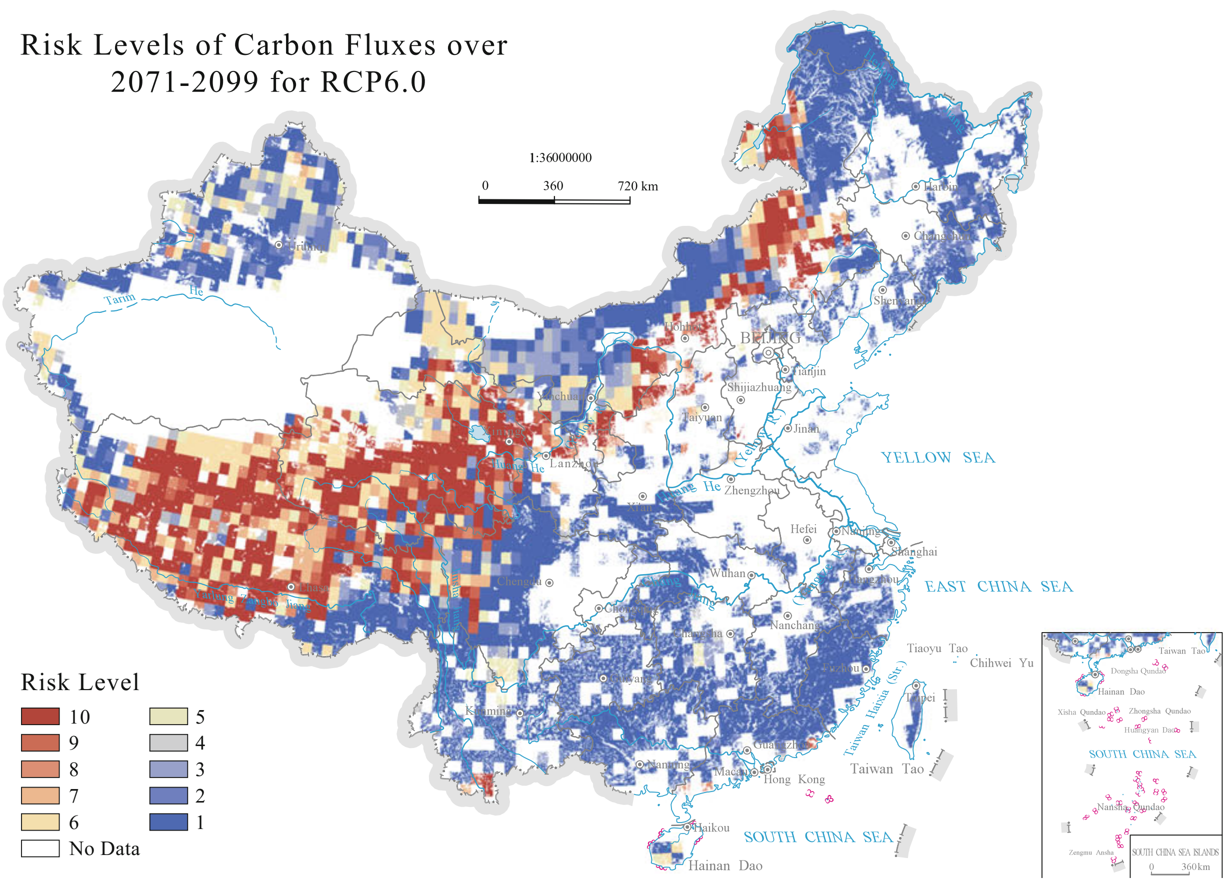
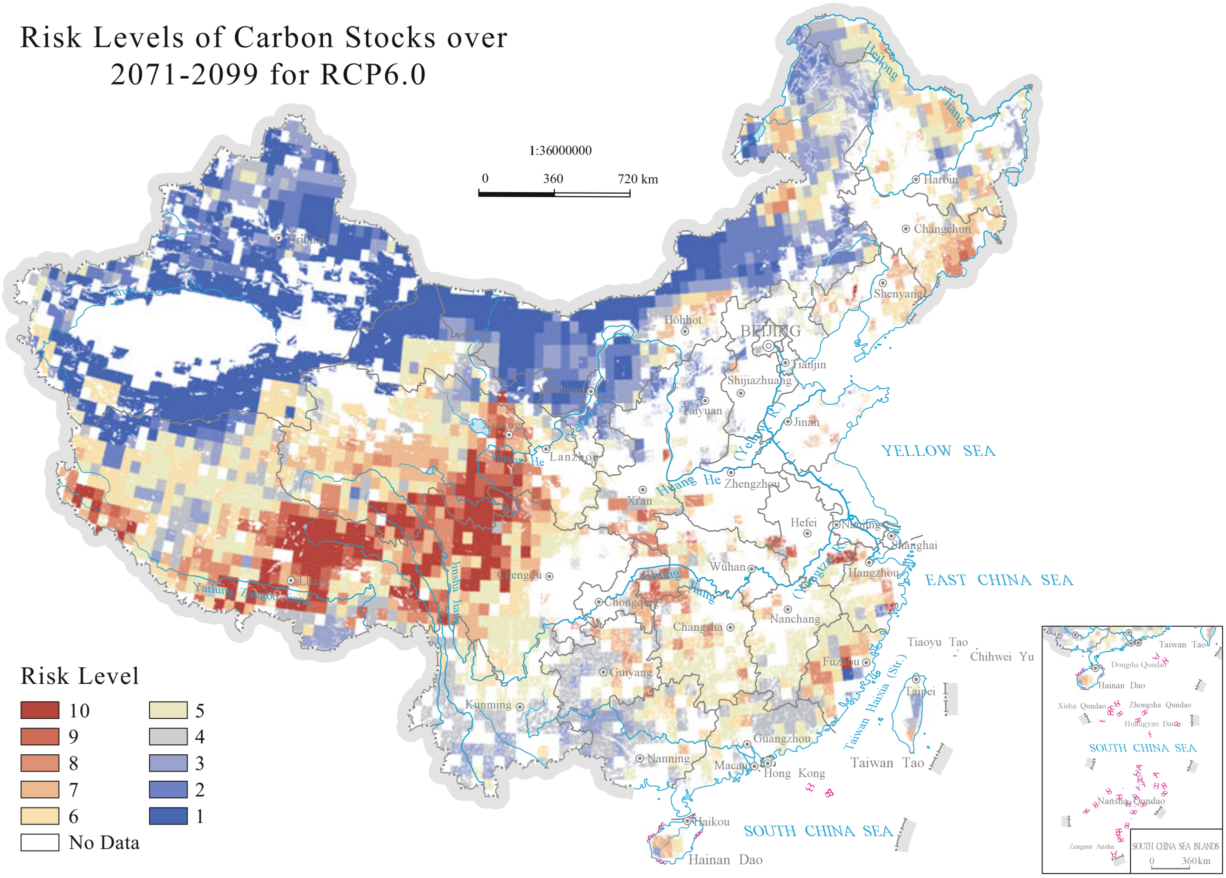
Huangyan Dao
Nansha Qundao
Zengmu Ansha
Tarim
He


Relative Change of Net Primary Productivity over
2071-2099 for RCP6.0
1:36000000
0 360 720 km
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
≤-10
No Data


Risk Levels of Carbon Fluxes over
2071-2099 for RCP6.0
1:36000000
0 360 720 km
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data


Risk Levels of Carbon Stocks over
2071-2099 for RCP6.0
1:36000000
0 360 720 km
Risk Level
10
9
8
7
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4
3
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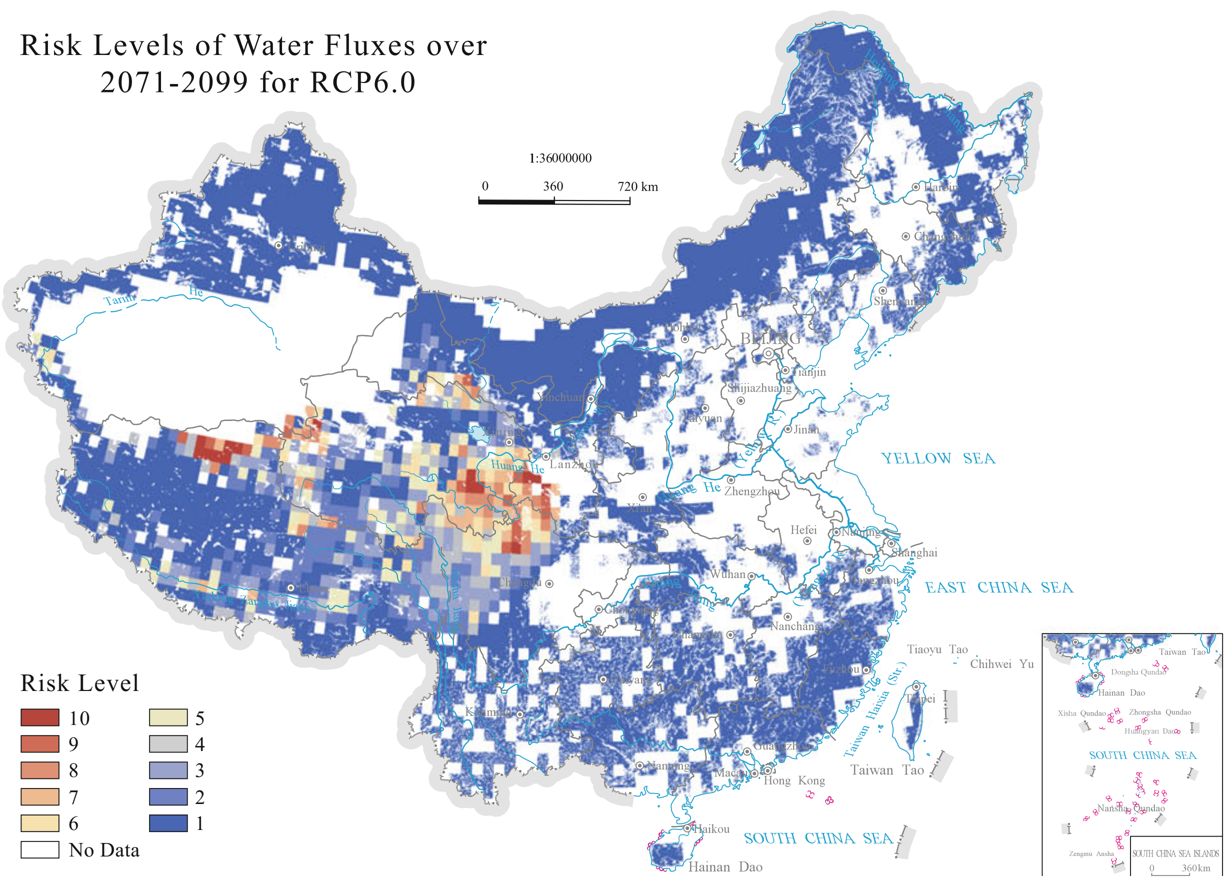
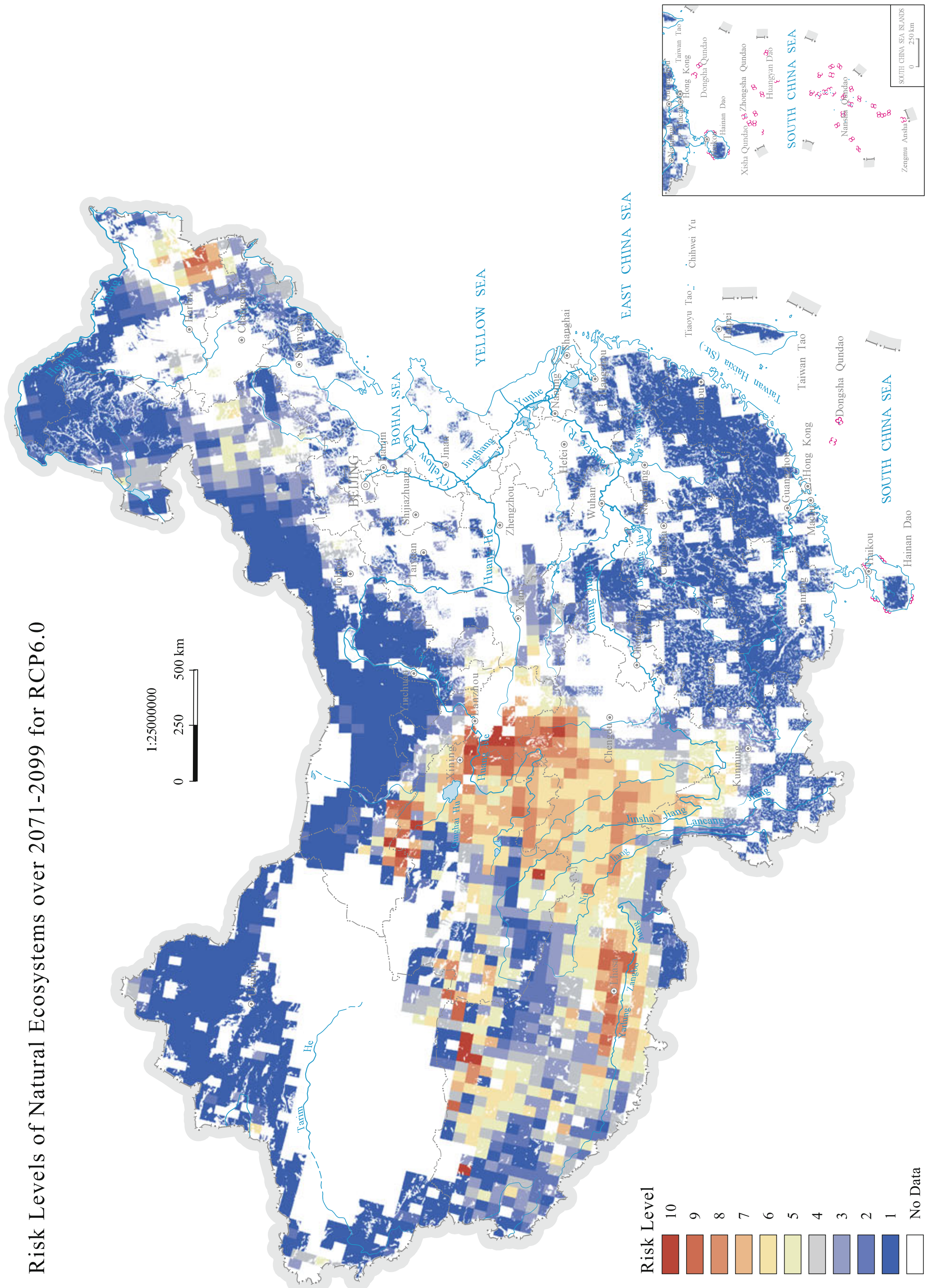
1
No Data
BEIJING
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Hainan Dao
Taiwan Tao


Risk Levels of Water Fluxes over
2071-2099 for RCP6.0
1:36000000
0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BEIJING
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Hainan Dao
Taiwan Tao


Risk Levels of Natural Ecosystems over 2071-2099 for RCP6.0
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BOHAI SEA
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Shanghai
Zhengzhou
Wuhan
Hefei
Chengdu
Kunming
Xining
Lanzhou
Haikou
Hainan Dao
Hong Kong
Taiwan Tao
Dongsha Qundao
Chihwei Yu
Tiaoyu Tao
Taiwan Haixia
Shijiazhuang
Huang He
Chang Jiang
Jinsha Jiang
Lancang
Tarim
Xisha Qundao
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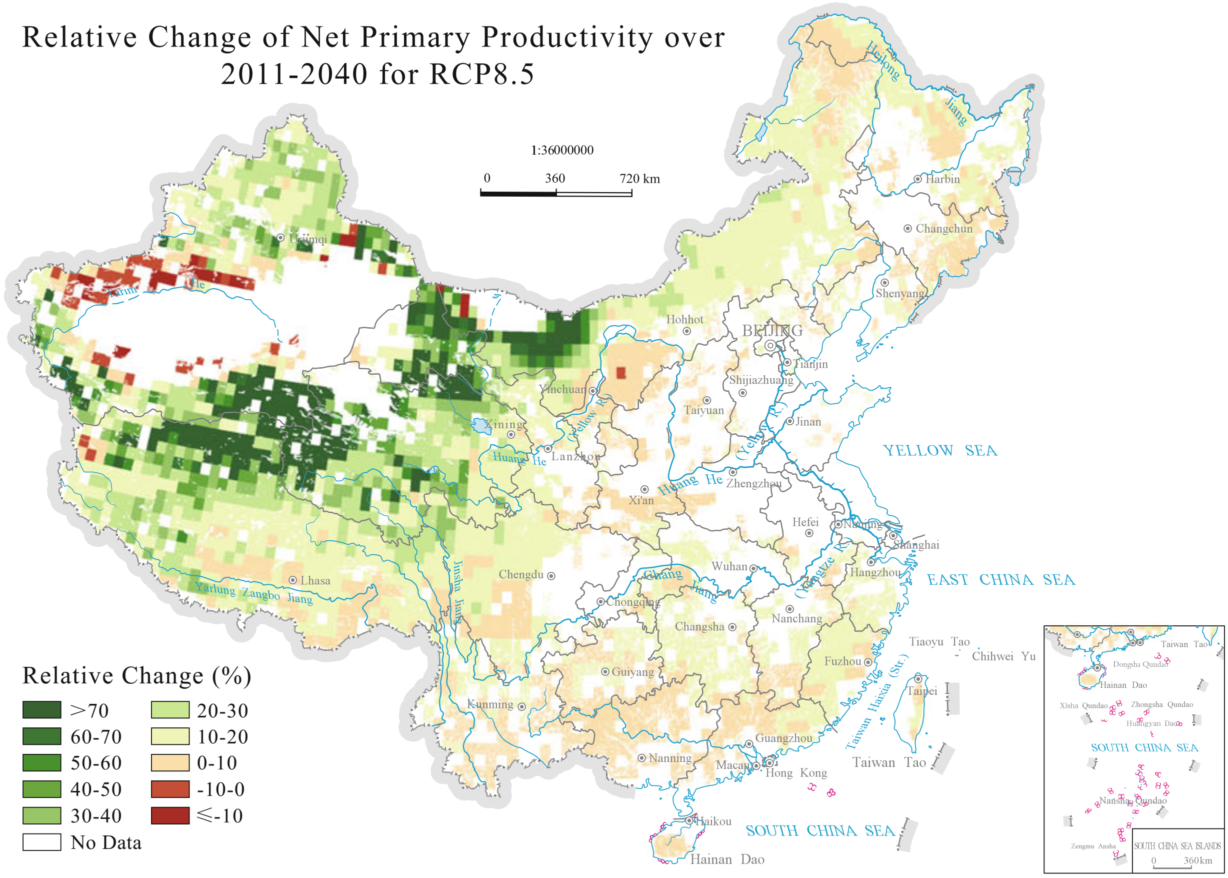
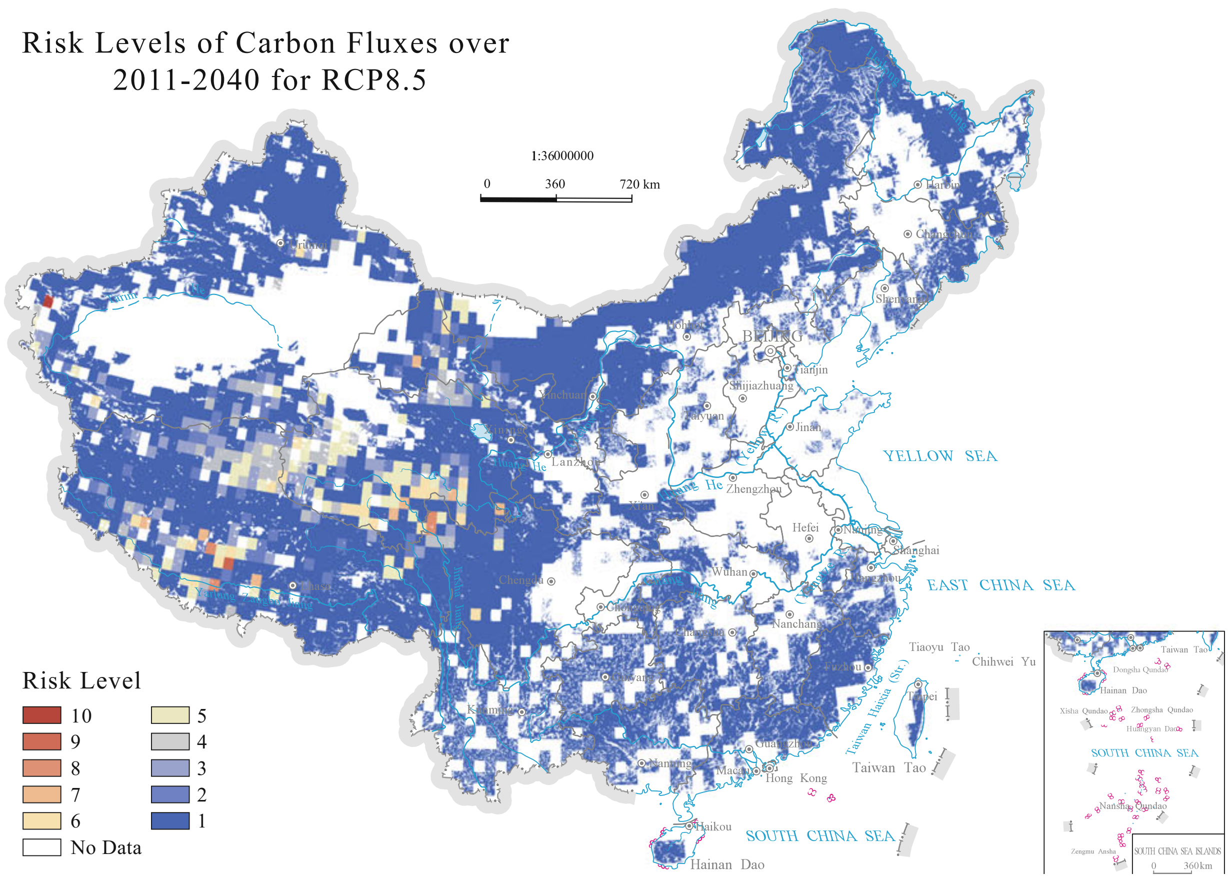
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS

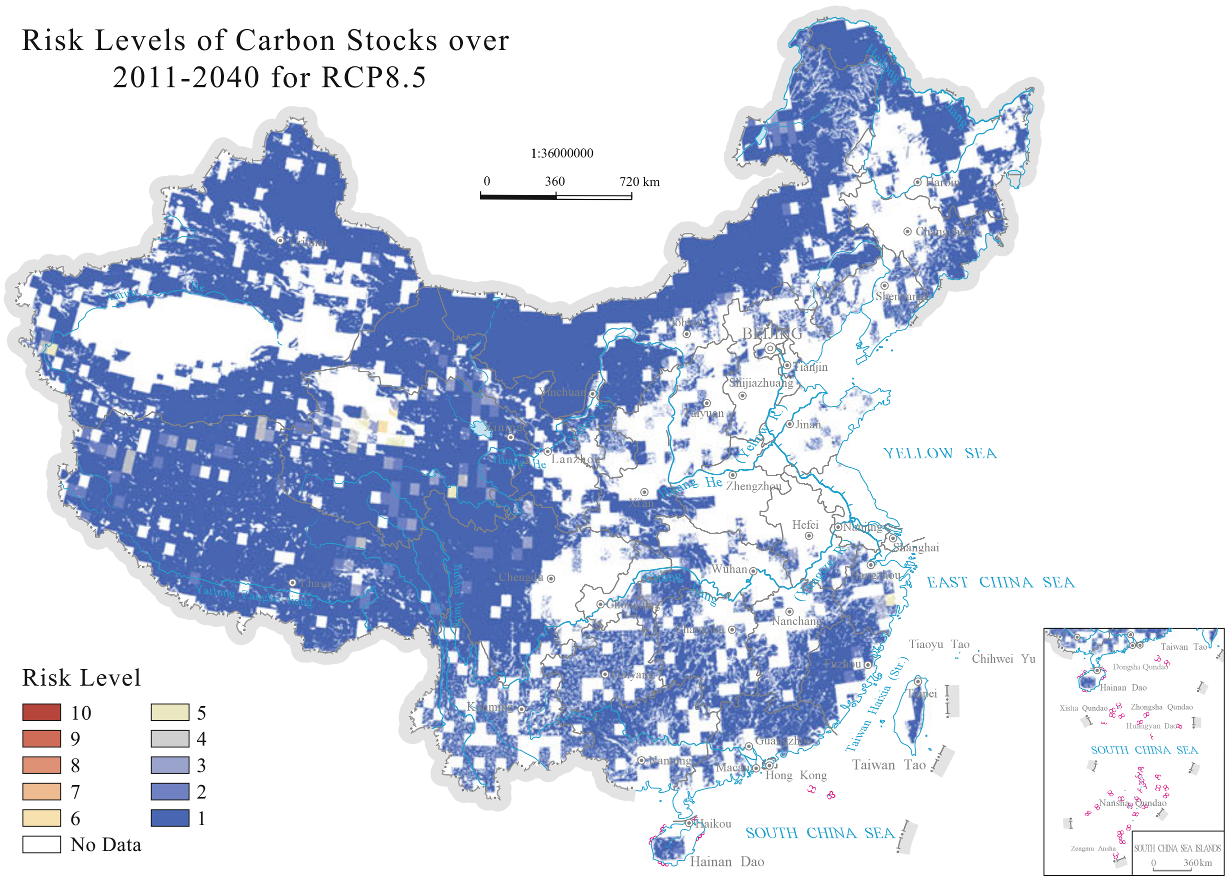
Relative Change of Net Primary Productivity over 2011-2040 for RCP8.5



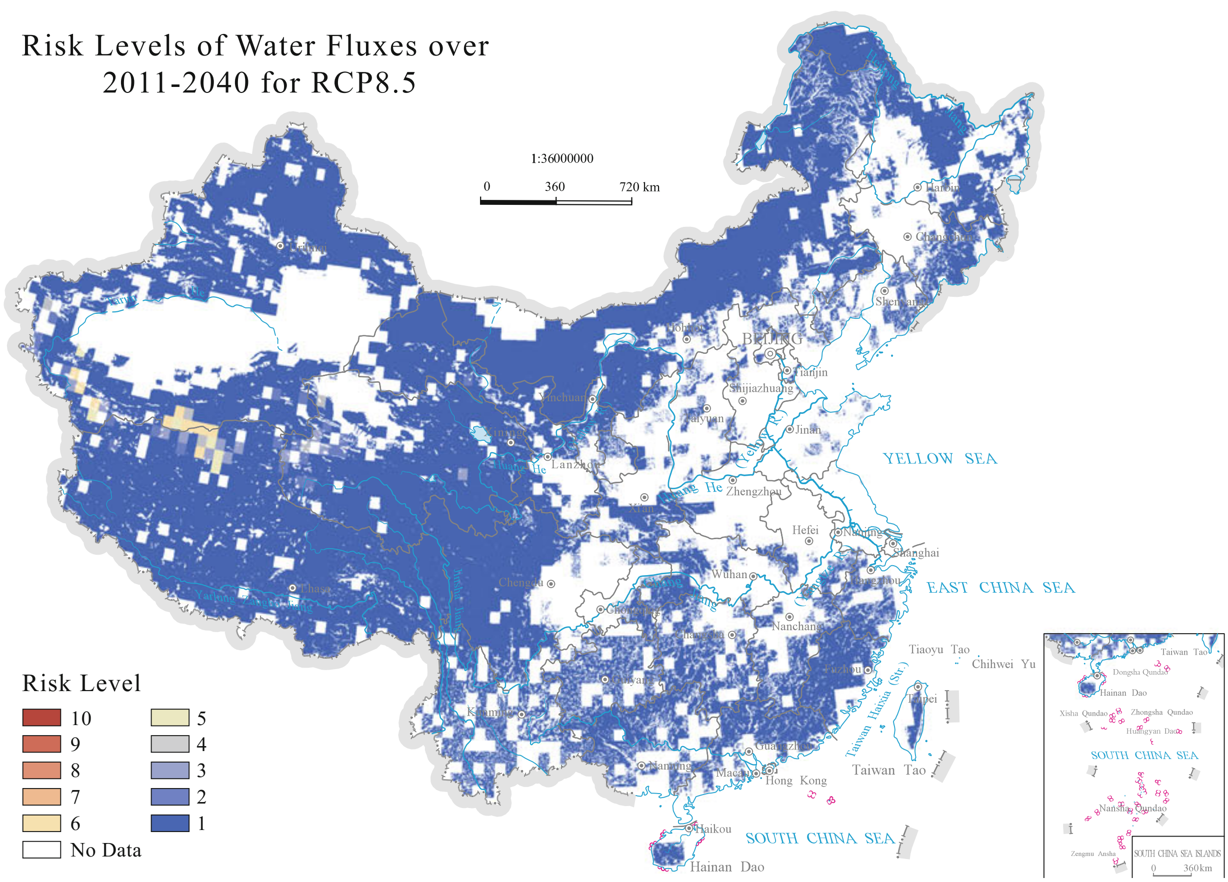
Risk Levels of Carbon Fluxes over 2011-2040 for RCP8.5

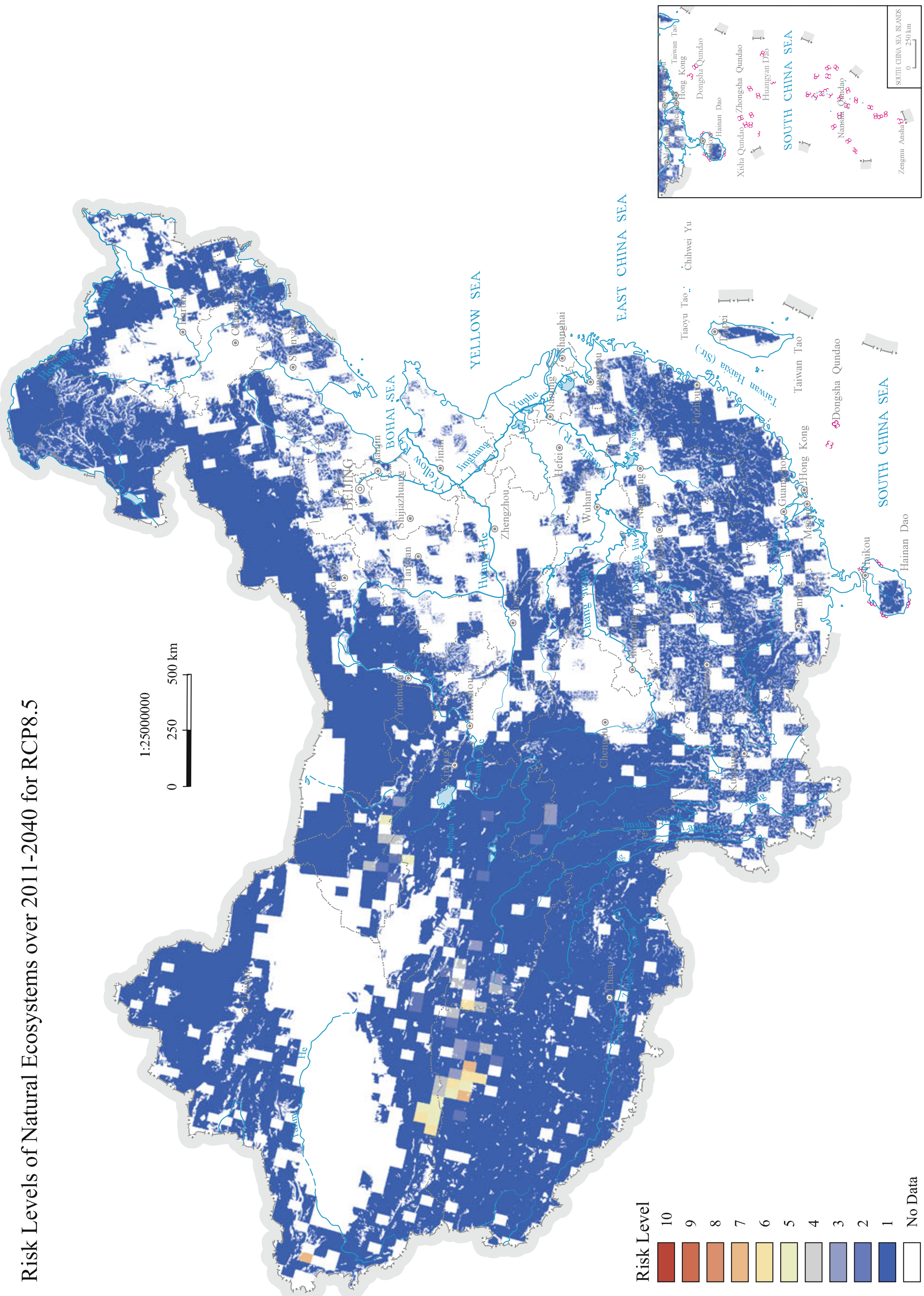


Risk Levels of Carbon Stocks over 2011-2040 for RCP8.5



Risk Levels of Water Fluxes over 2011-2040 for RCP8.5




Risk Levels of Natural Ecosystems over 2011-2040 for RCP8.5
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BEIJING
YELLOW SEA
BOHAI SEA
EAST CHINA SEA
SOUTH CHINA SEA
Shanghai
Hefei
Wuhan
Zhengzhou
Shijiazhuang
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Taiyuan
Lhasa
Hainan Dao
Taiwan Tao
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Hong Kong
Taiwan Haixia (Str.)
Chihwei Yu
Tiaoyu Tao
Xisha Qundao
Zhongsha Qundao
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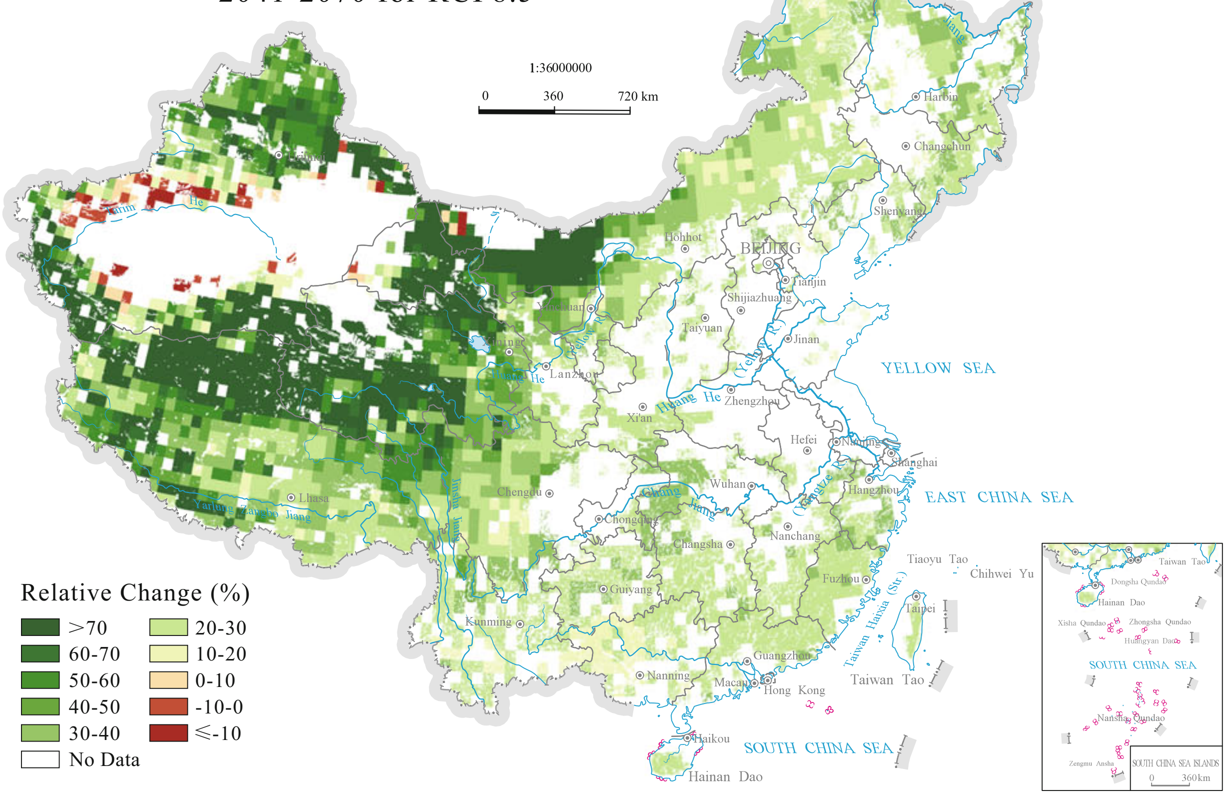
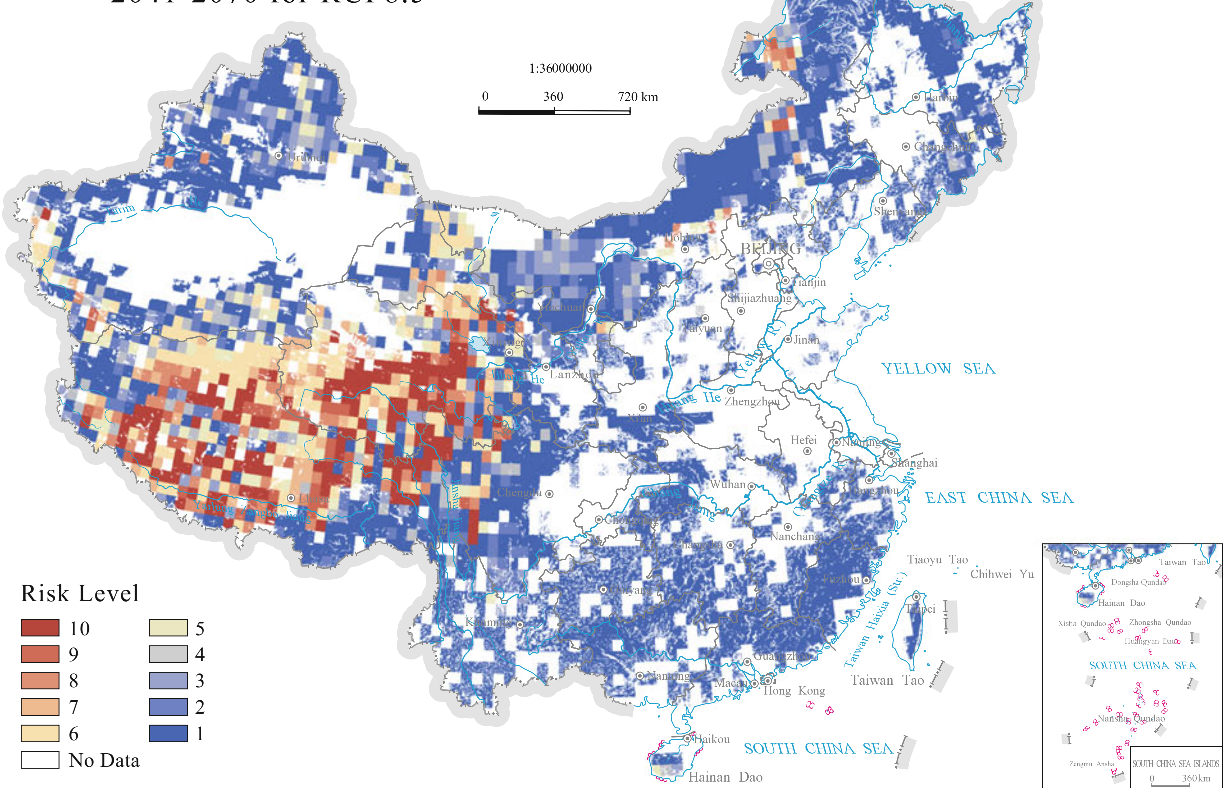
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS

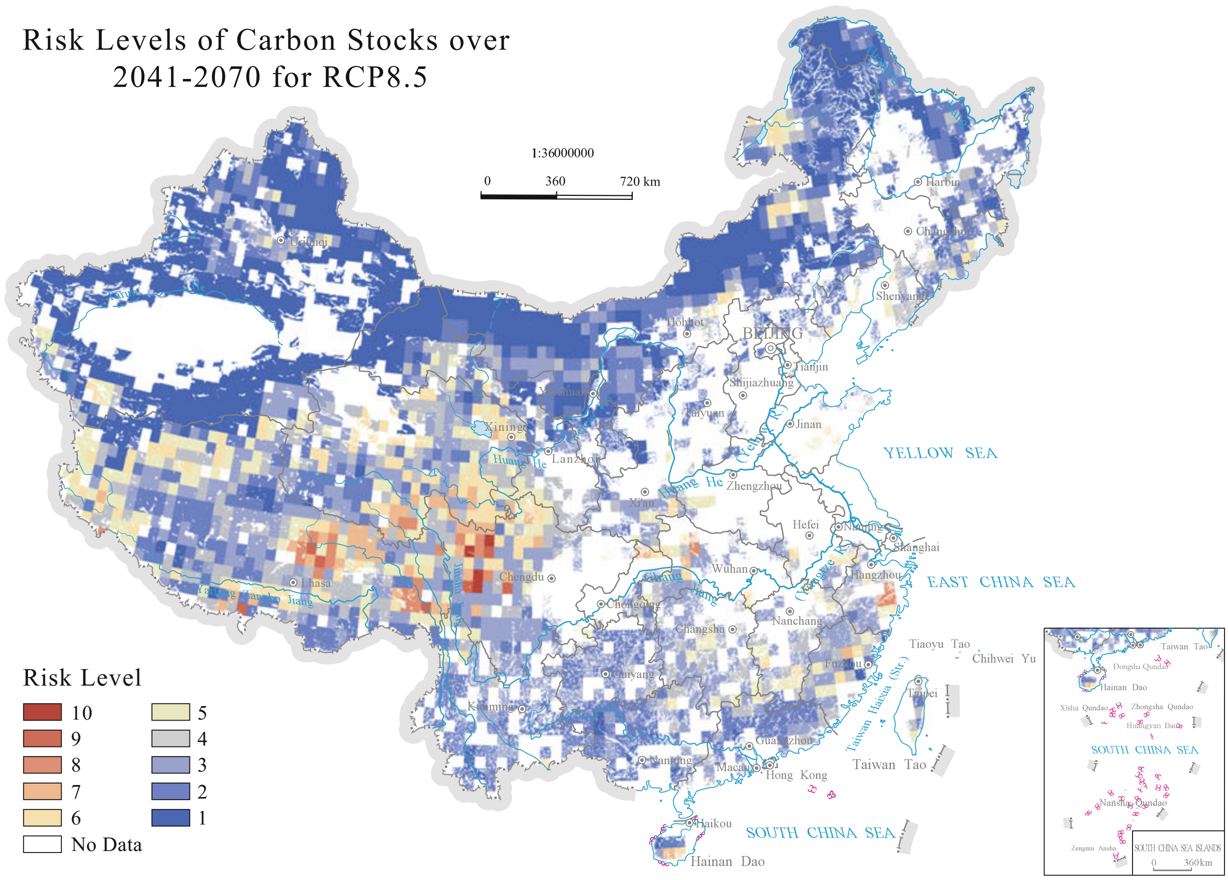
Relative Change of Net Primary Productivity over 2041-2070 for RCP8.5



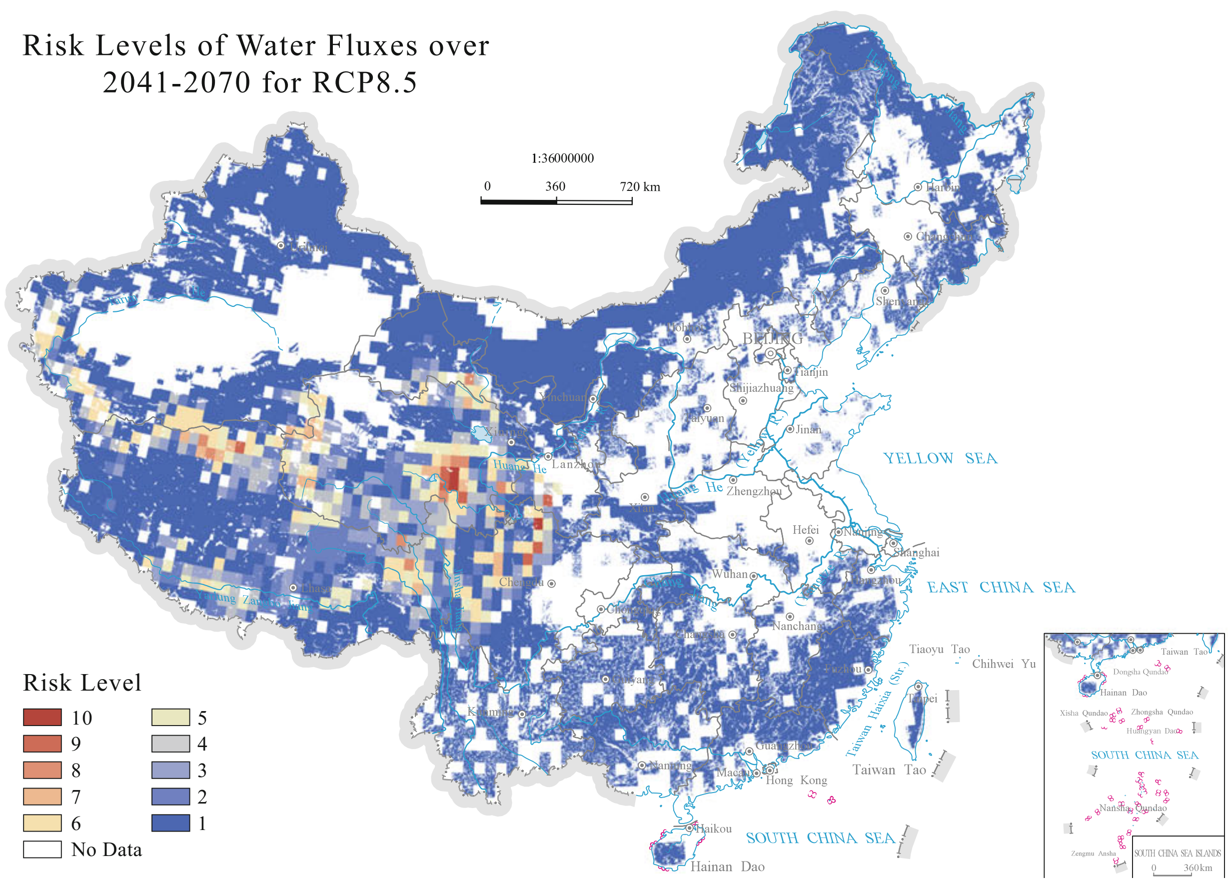
Risk Levels of Carbon Fluxes over 2041-2070 for RCP8.5

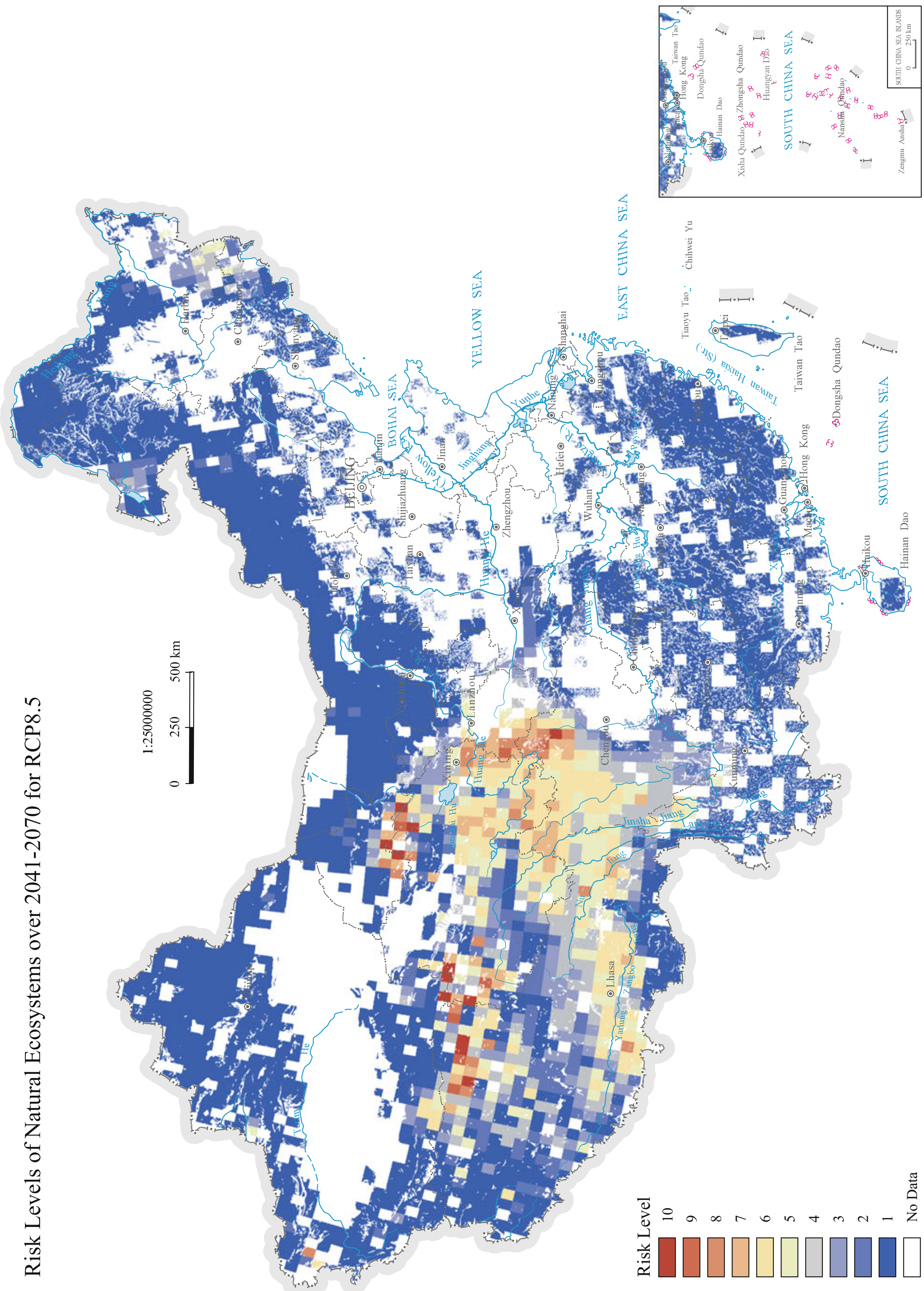


Risk Levels of Carbon Stocks over 2041-2070 for RCP8.5



Risk Levels of Water Fluxes over 2041-2070 for RCP8.5




Risk Levels of Natural Ecosystems over 2041-2070 for RCP8.5
1:25000000
0 250 500 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BEIJING
YELLOW SEA
BOHAI SEA
EAST CHINA SEA
SOUTH CHINA SEA
Lhasa
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Hong Kong
Macao
Haikou
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Taipei
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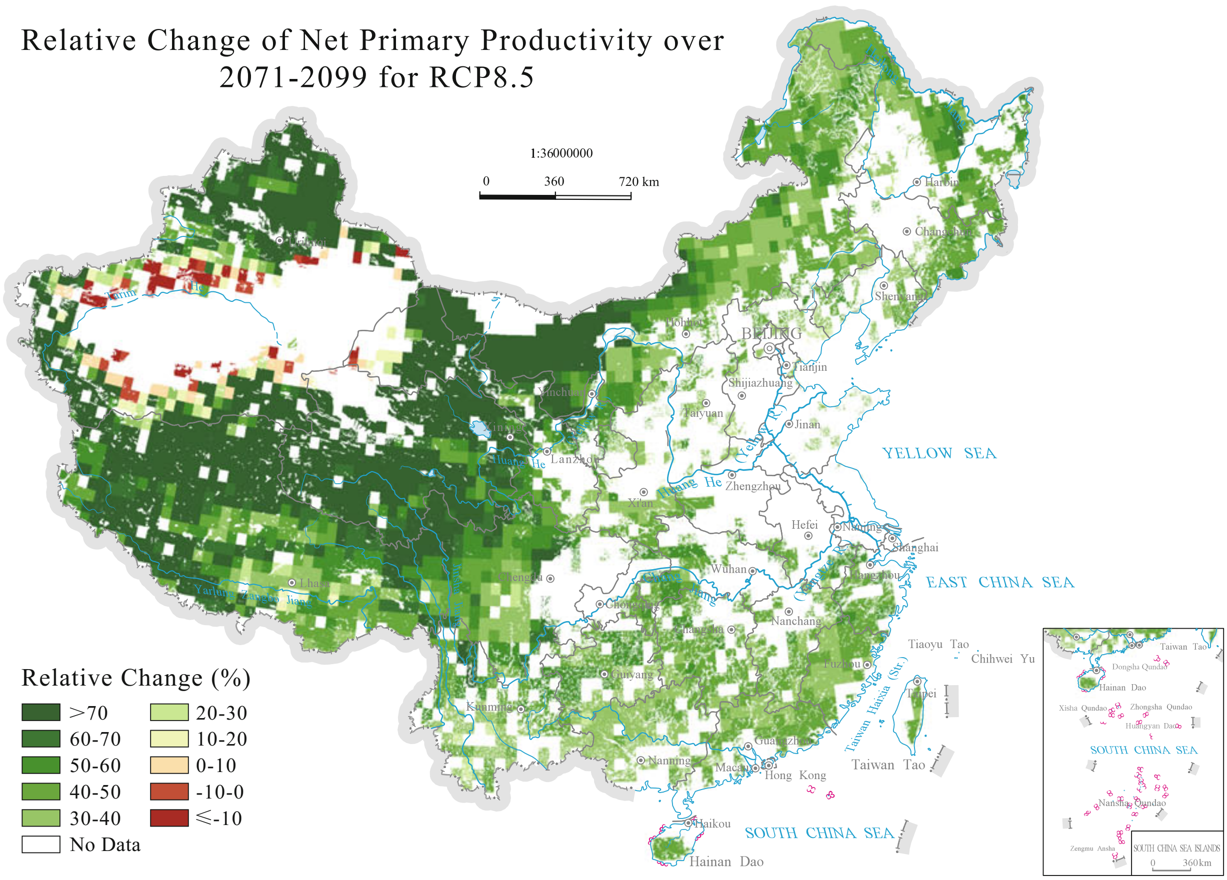
Chiwei Yu
Diaoyu Tao
Jinsha Jiang
Yarlung Zangbo
Huang He


Relative Change of Net Primary Productivity over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
≤-10
No Data
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Zhengzhou
Lanzhou
Hefei
Nanjing
Shanghai
Wuhan
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Hainan Dao
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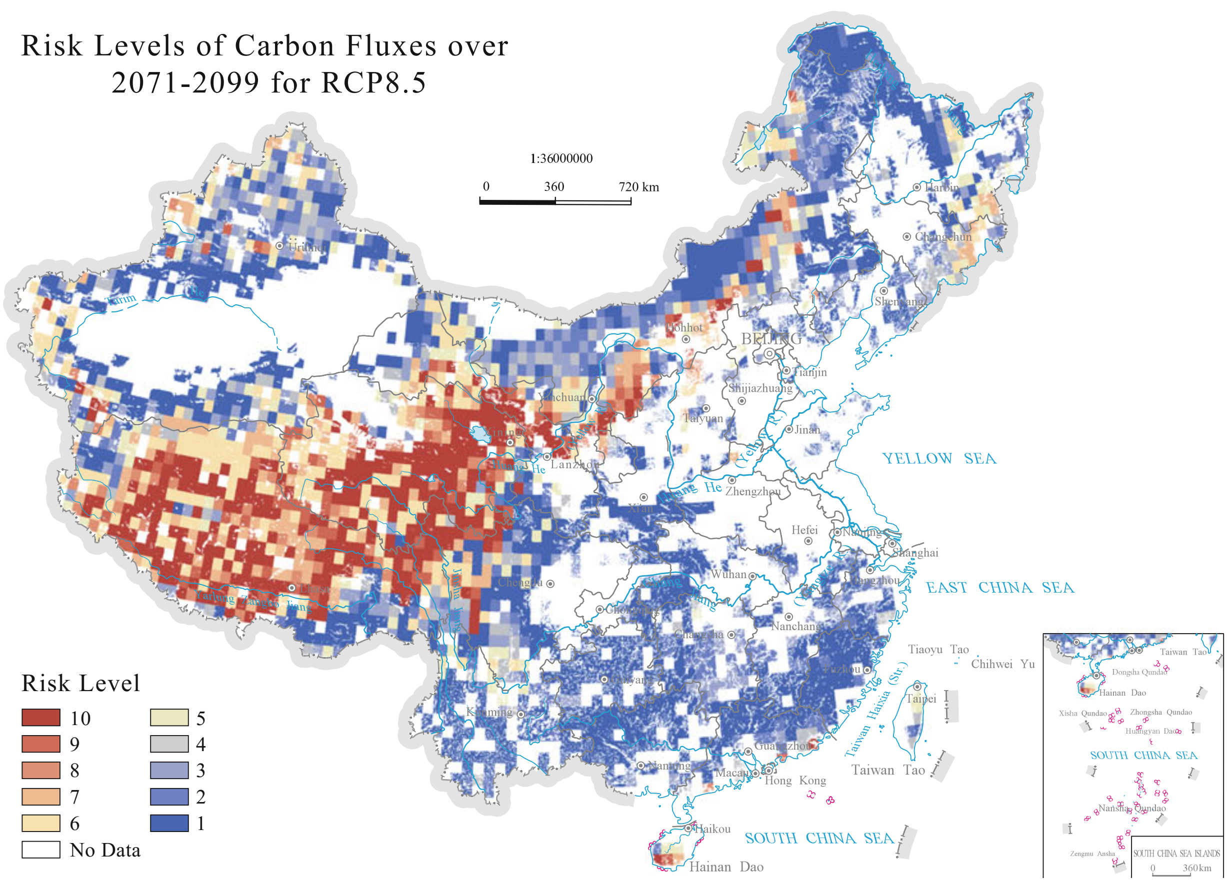
Taiwan Tao
Tiaoyu Tao
Chihwei Yu
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Taiwan Haixia (Str.)
Huang He
Dongsha Qundao
Xisha Qundao
Zhongsha Qundao
Huangyan Dao
Nansha Qundao
SOUTH CHINA SEA ISLANDS
0 360km


Risk Levels of Carbon Fluxes over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
BEIJING
Tianjin
Shijiazhuang
Taiyuan
Jinan
Zhengzhou
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Nanjing
Shanghai
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Taipei
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YELLOW SEA
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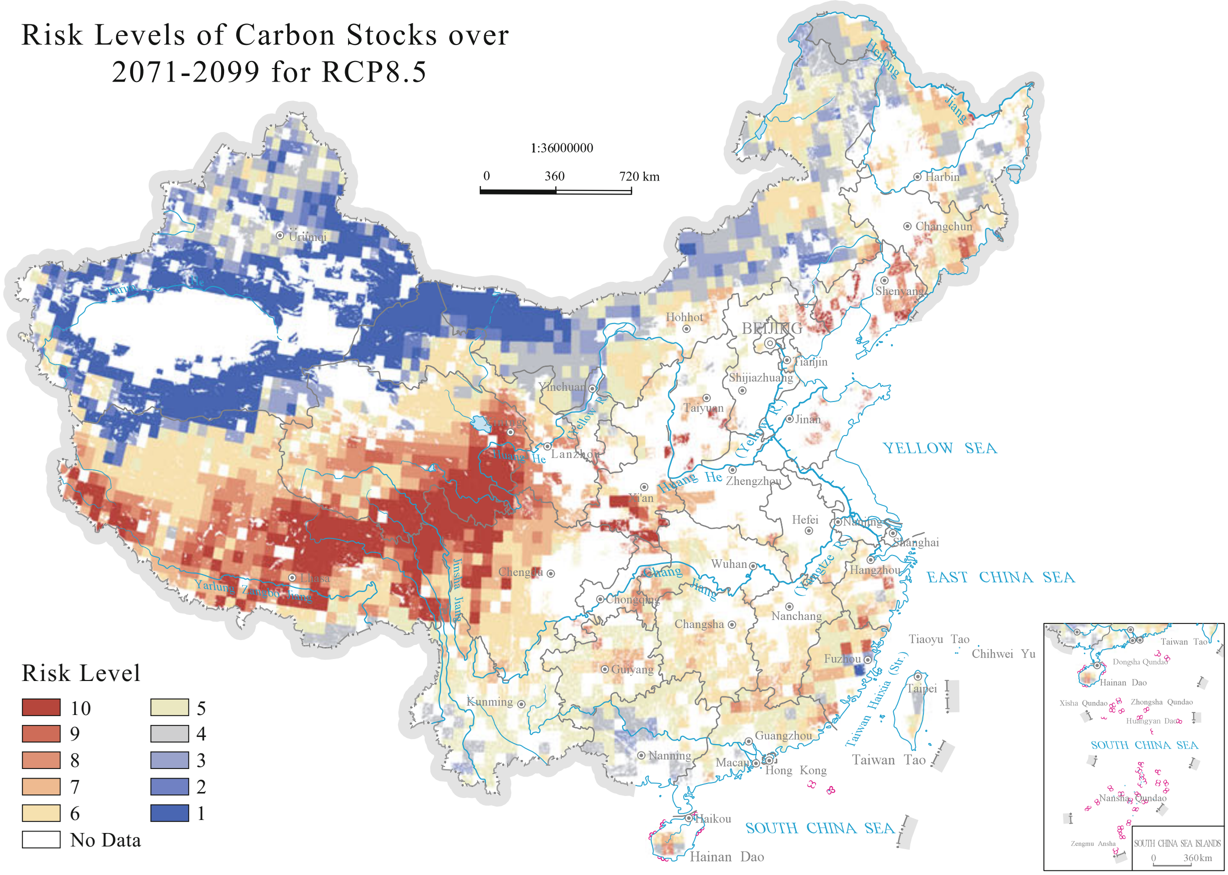
Huangyan Dao
Nansha Qundao
SOUTH CHINA SEA ISLANDS
0 360km


Risk Levels of Carbon Stocks over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Risk Level
10
9
8
7
6
5
4
3
2
1
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
Hainan Dao
Taiwan Tao
BEIJING
Harbin
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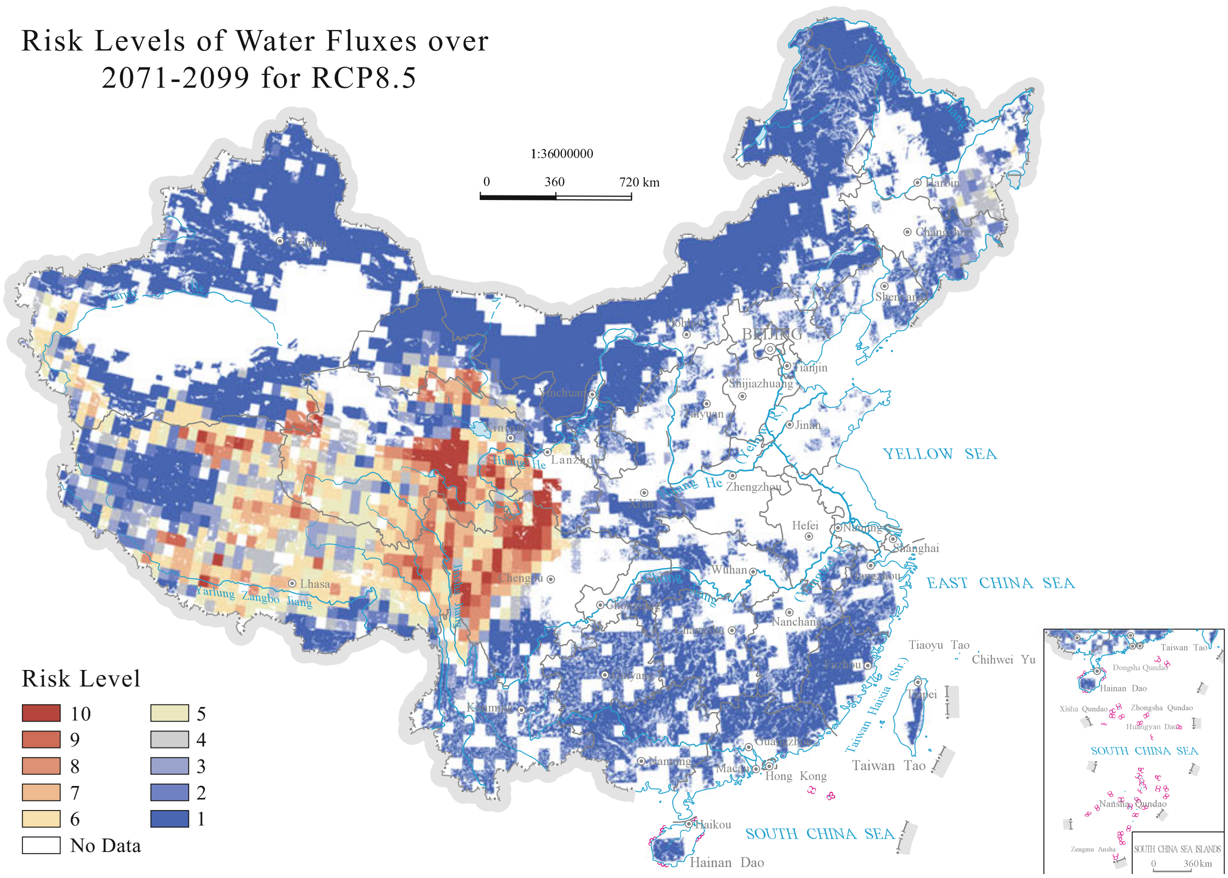
Risk Levels of Water Fluxes over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Risk Level
10
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8
7
6
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4
3
2
1
No Data
YELLOW SEA
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BEIJING
Shijiazhuang
Lanzhou
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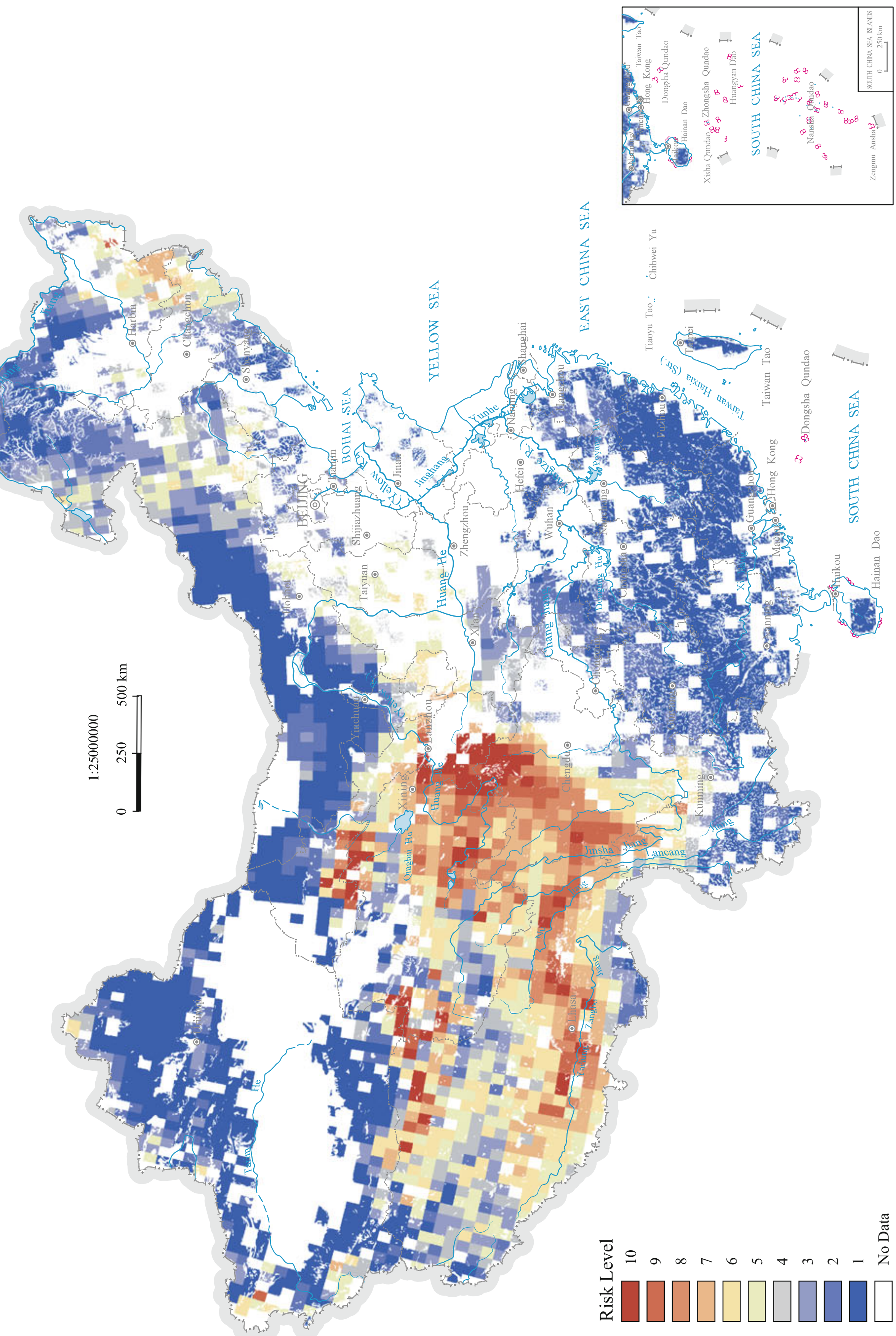
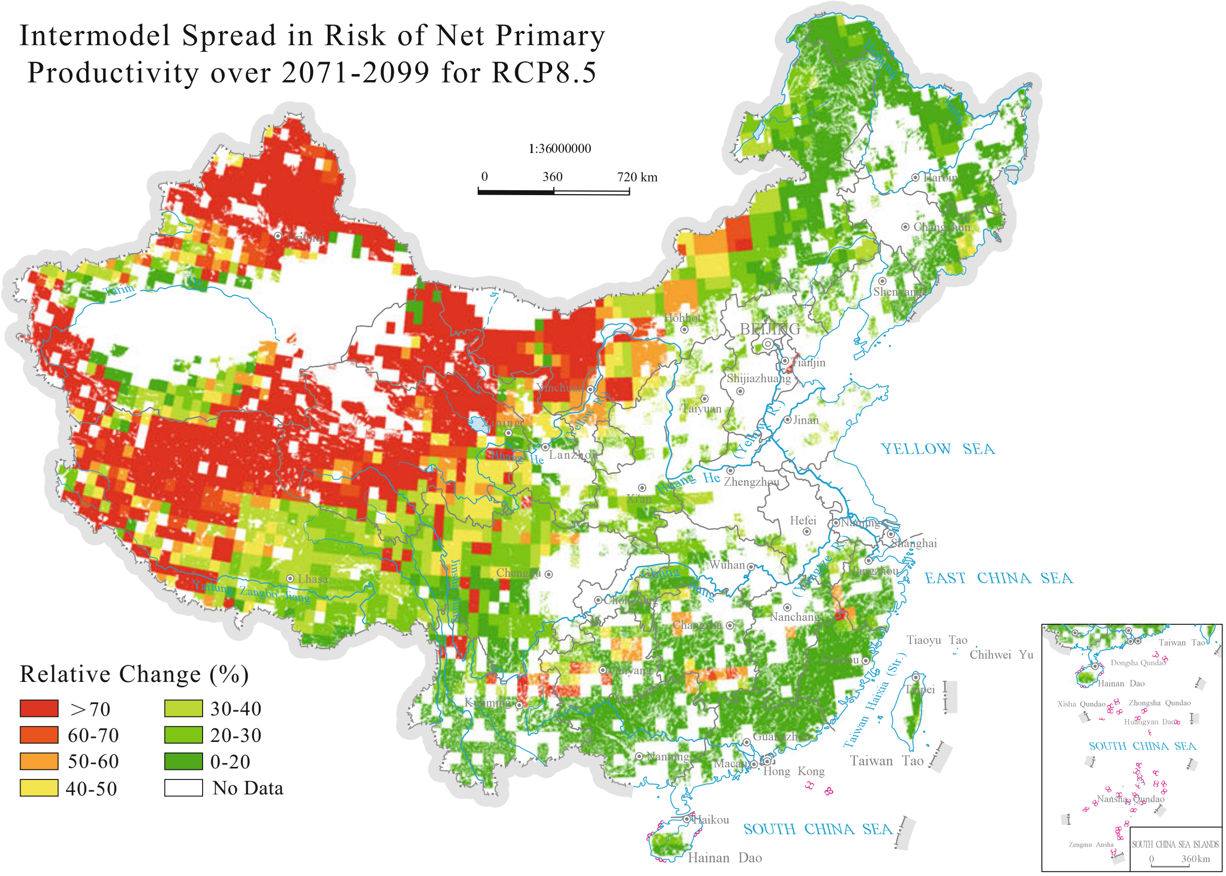
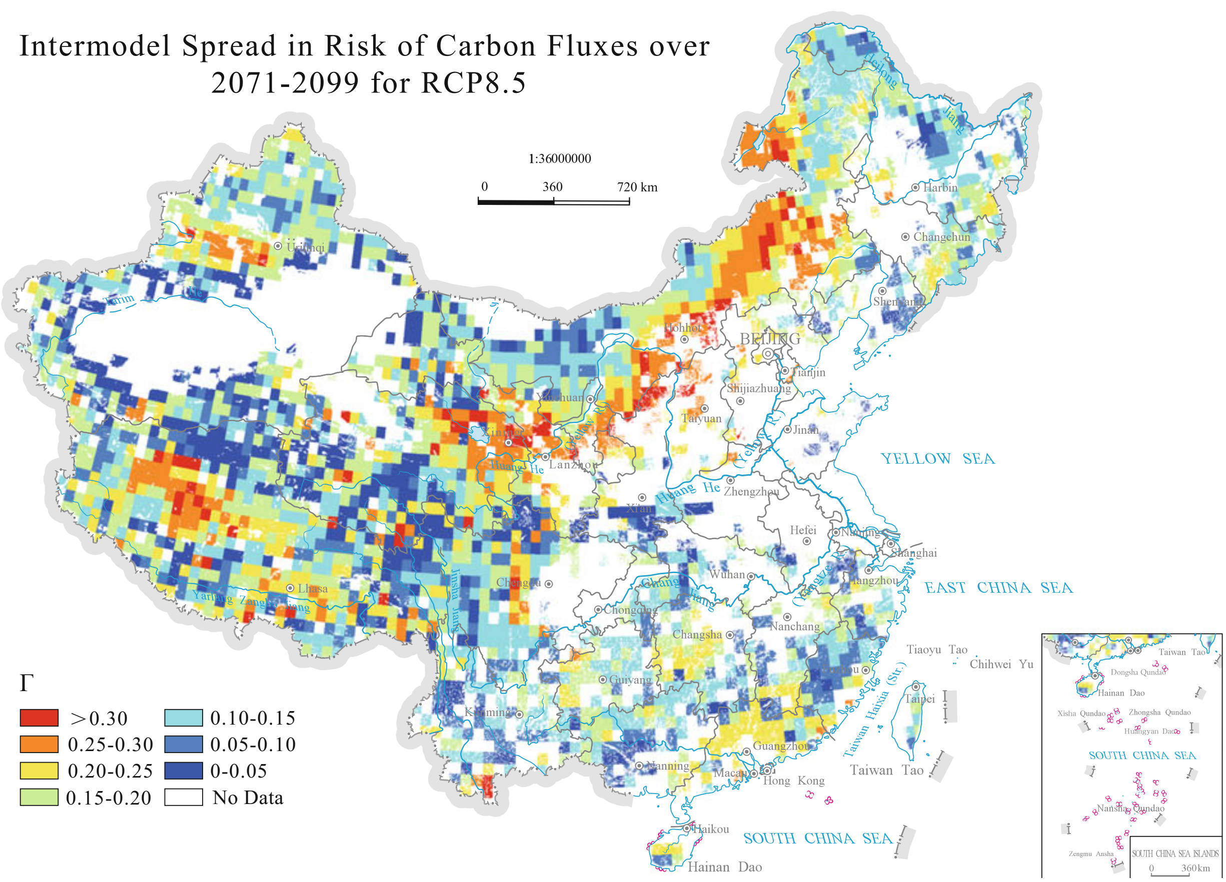
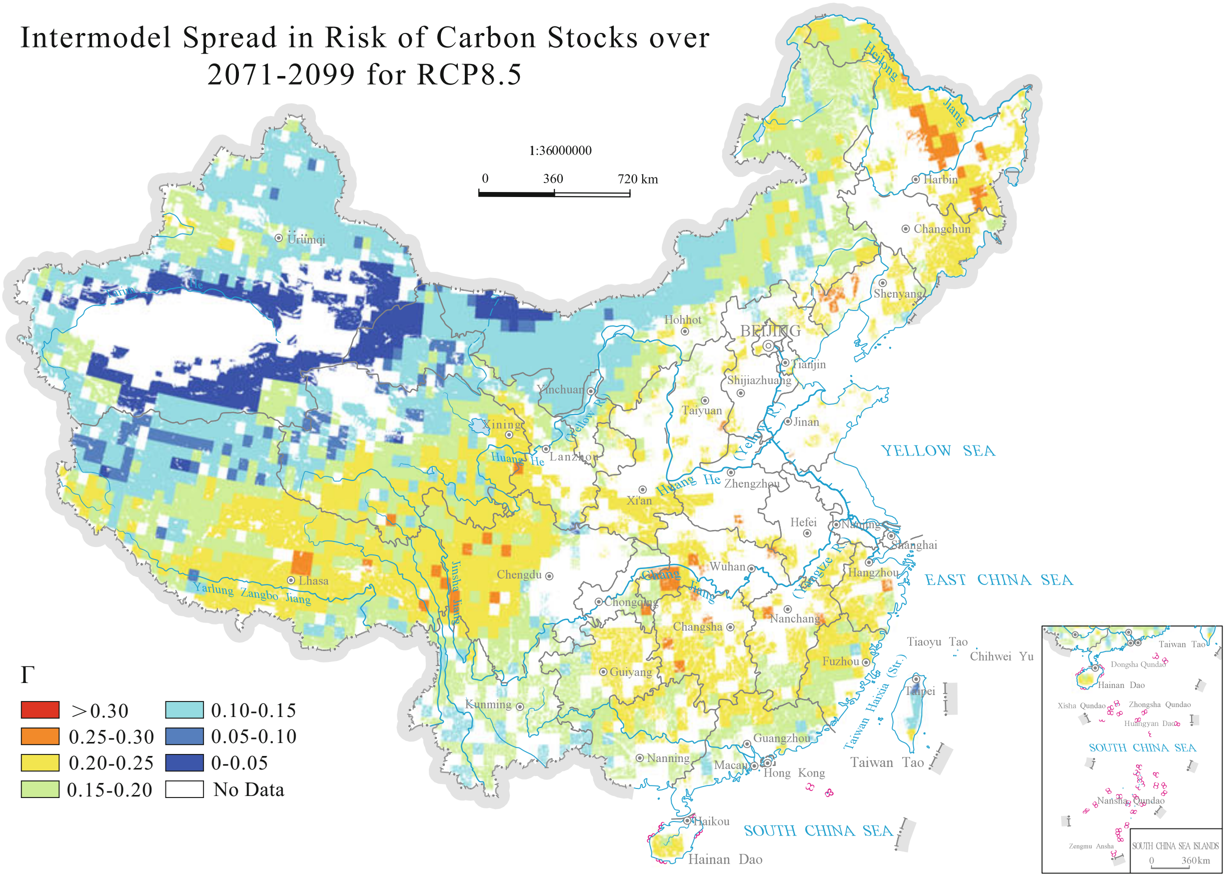
Chihwei Yu

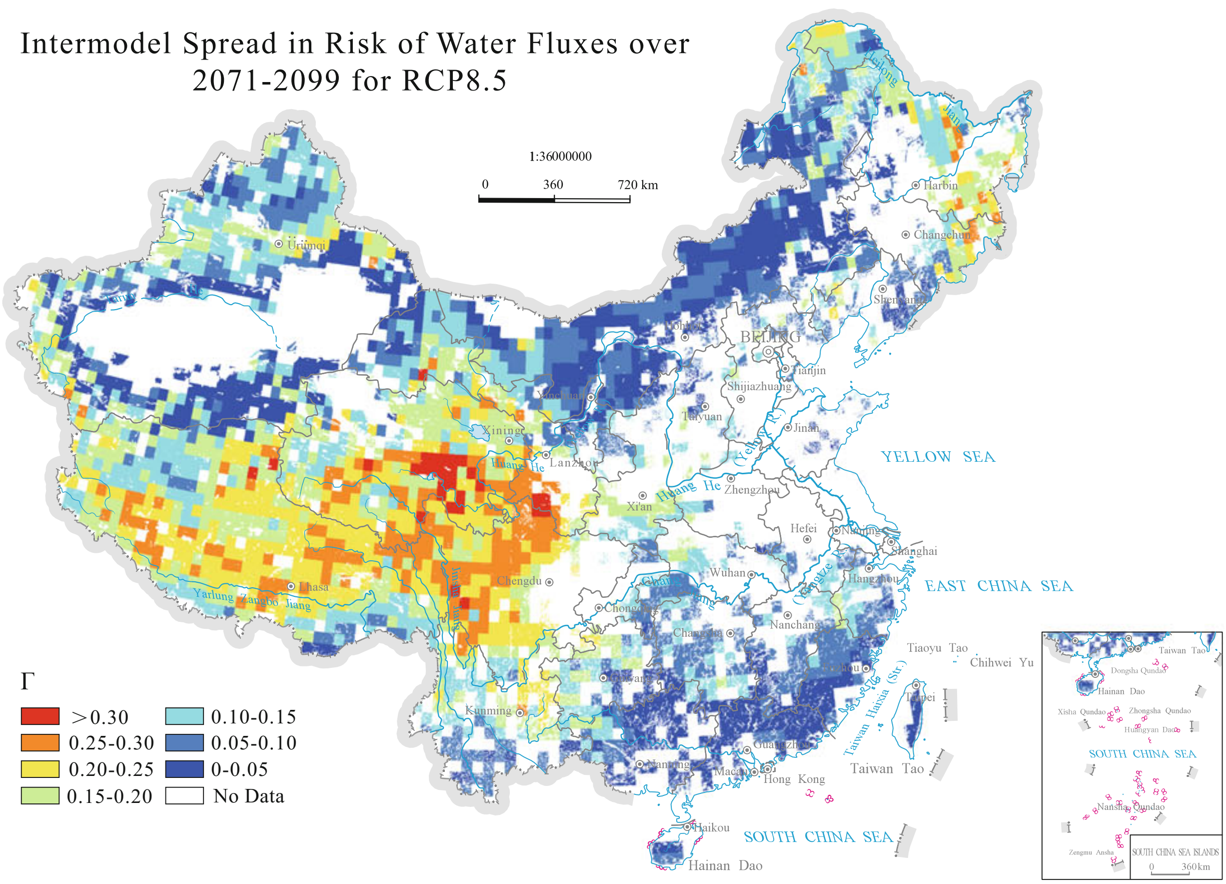
Risk Levels of Natural Ecosystems over 2071-2099 for RCP8.5




Intermodel Spread in Risk of Net Primary Productivity over 2071-2099 for RCP8.5
1:36000000
0 360 720 km
Relative Change (%)
>70
60-70
50-60
40-50
30-40
20-30
0-20
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Hainan Dao
Taiwan Tao


Intermodel Spread in Risk of Carbon Fluxes over 2071-2099 for RCP8.5
1:36000000
0 360 720 km
Γ
>0.30
0.25-0.30
0.20-0.25
0.15-0.20
0.10-0.15
0.05-0.10
0-0.05
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING
Hainan Dao
Taiwan Tao


Intermodel Spread in Risk of Carbon Stocks over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Γ
>0.30
0.25-0.30
0.20-0.25
0.15-0.20
0.10-0.15
0.05-0.10
0-0.05
No Data
YELLOW SEA
EAST CHINA SEA
SOUTH CHINA SEA
BEIJING


Intermodel Spread in Risk of Water Fluxes over
2071-2099 for RCP8.5
1:36000000
0 360 720 km
Γ
>0.30
0.25-0.30
0.20-0.25
0.15-0.20
0.10-0.15
0.05-0.10
0-0.05
No Data
YELLOW SEA
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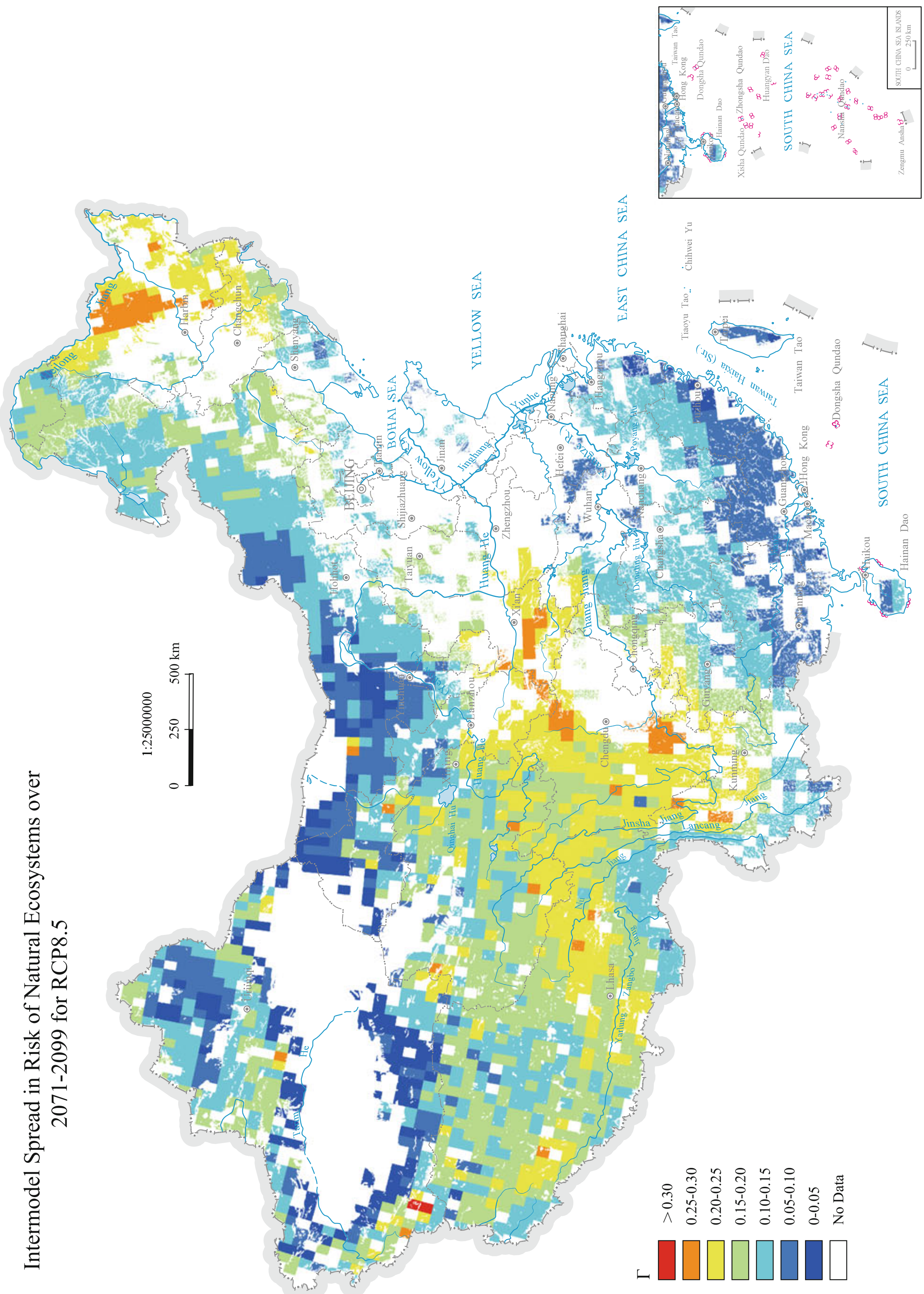
BEIJING


Intermodel Spread in Risk of Natural Ecosystems over
2071-2099 for RCP8.5
1:25000000
0 250 500 km
Γ
>0.30
0.25-0.30
0.20-0.25
0.15-0.20
0.10-0.15
0.05-0.10
0-0.05
No Data
BEIJING
YELLOW SEA
BOHAI SEA
EAST CHINA SEA
SOUTH CHINA SEA
Taiwan Haixia (Str.)
Harbin
Changchun
Shenyang
Tianjin
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Taiwan Tao
Dongsha Qundao
Tiaoyu Tao
Chihwei Yu
Xisha Qundao
Zhongsha Qundao
Huangyan Dao
Nansha Qundao
Zengmu Ansha
SOUTH CHINA SEA ISLANDS
250 km
Huang He
Chang Jiang
Jinsha Jiang
Lancang Jiang
Yarlung Zangbo Jiang
Qinghai Hu
Dongting Hu
Poyang Hu
Yunhe

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