



放牧利用草原碳水通量多尺度观测与气候适应型管理策略

Multi-scaled observations of carbon-water fluxes in grazing ecosystems and climate-adoption management

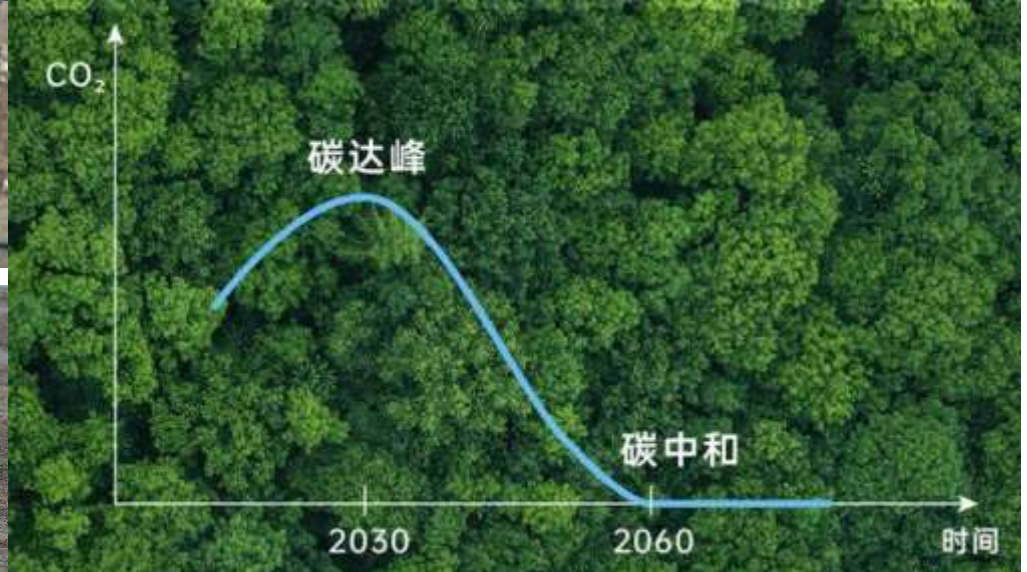
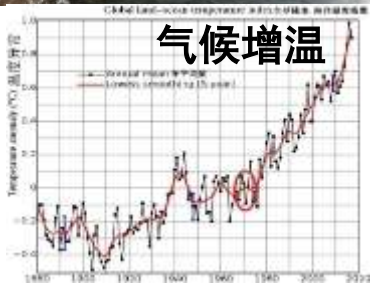
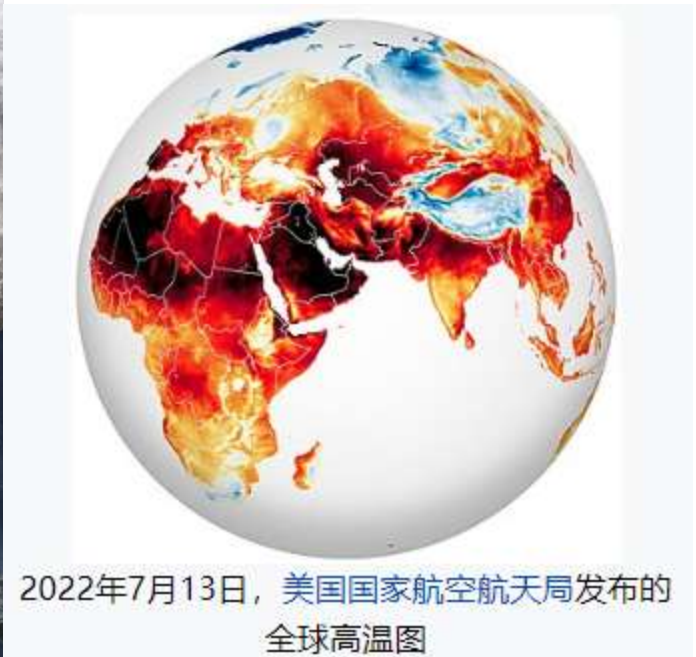
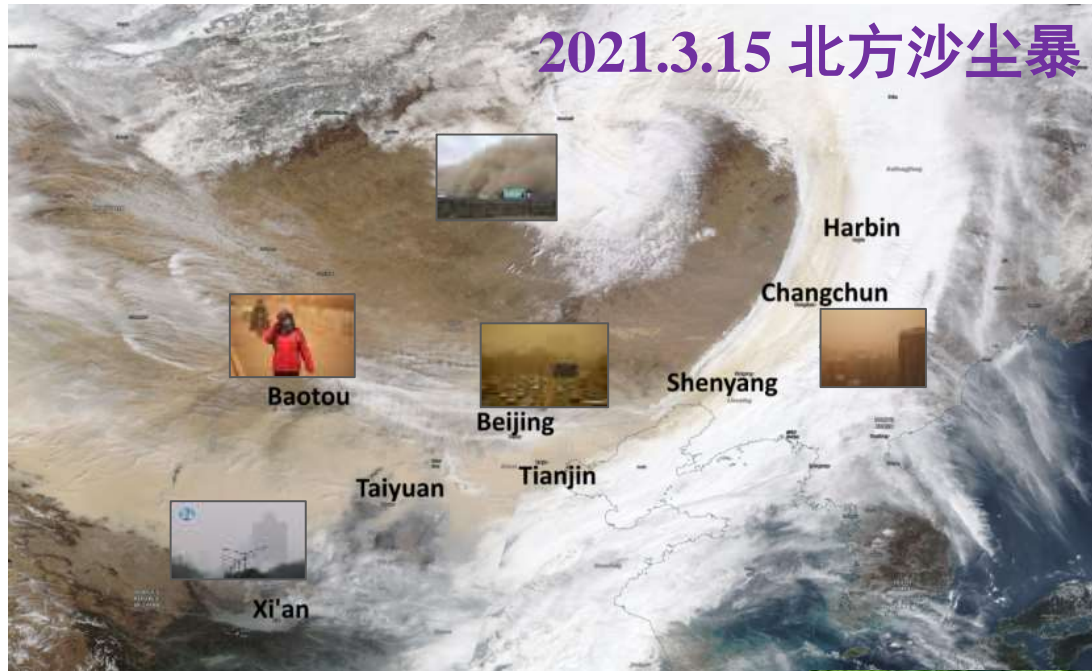
李飞 Fei Li

中国农业科学院草原研究所

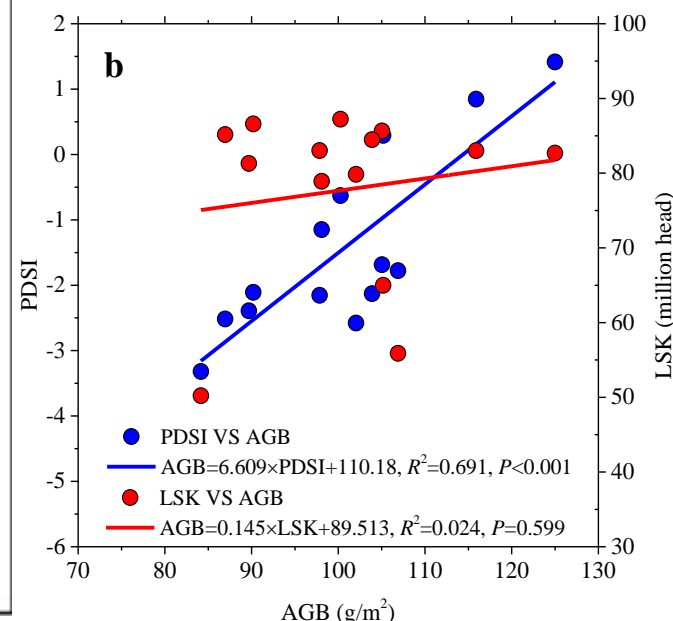
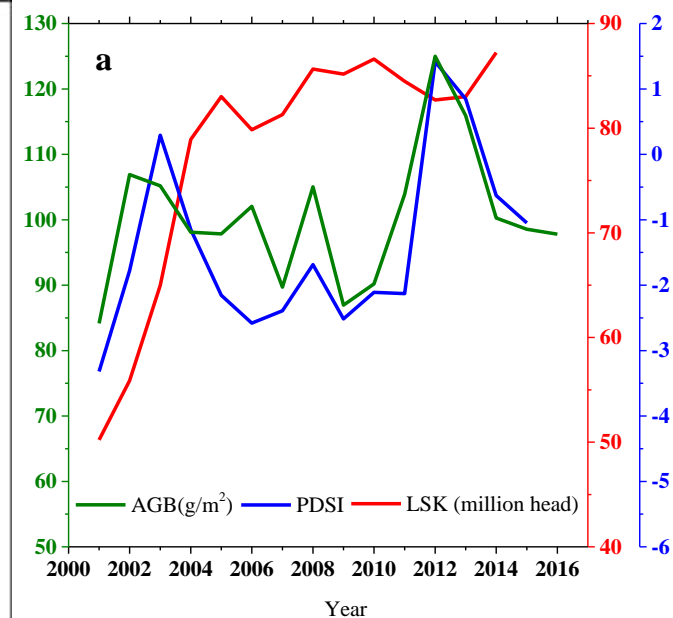
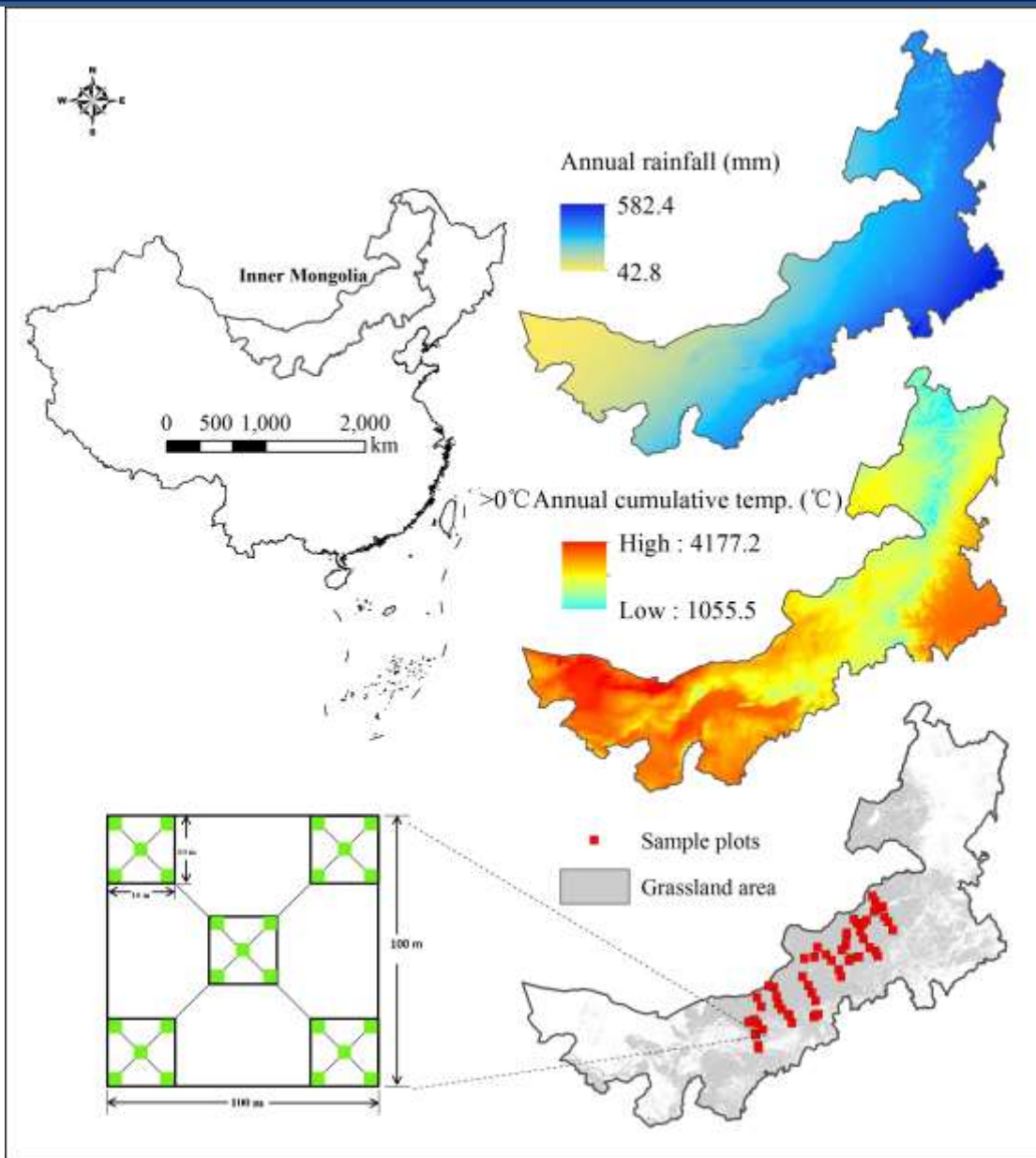
Grassland Research Institute, Chinese Academy of

Agricultural Sciences

Context and Issues



Modelling AGB dynamics in IMAR and driving forces

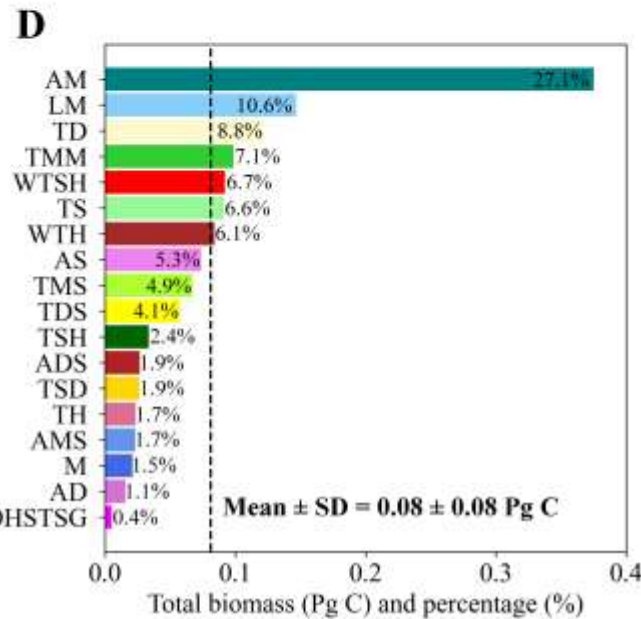
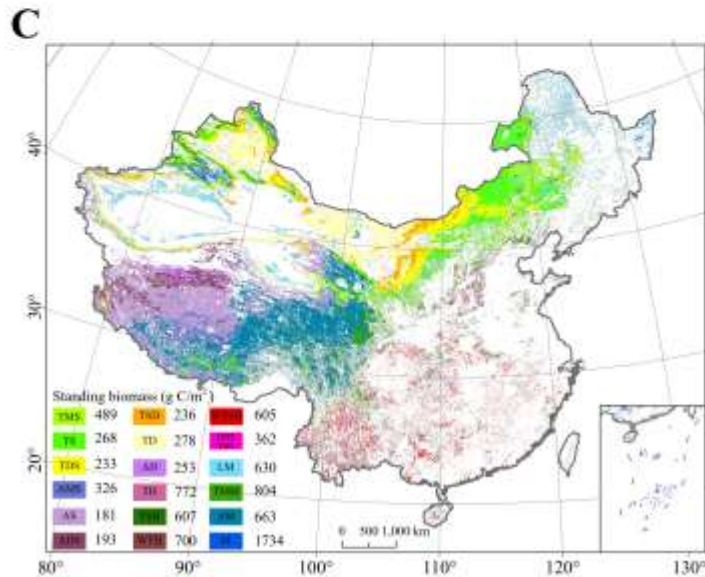
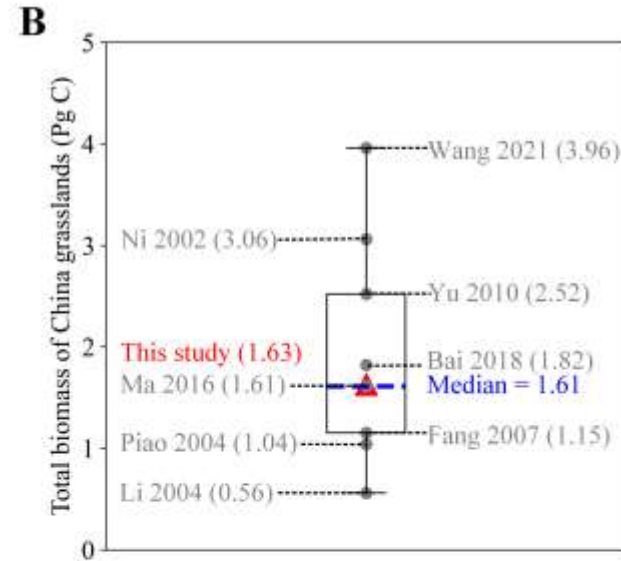
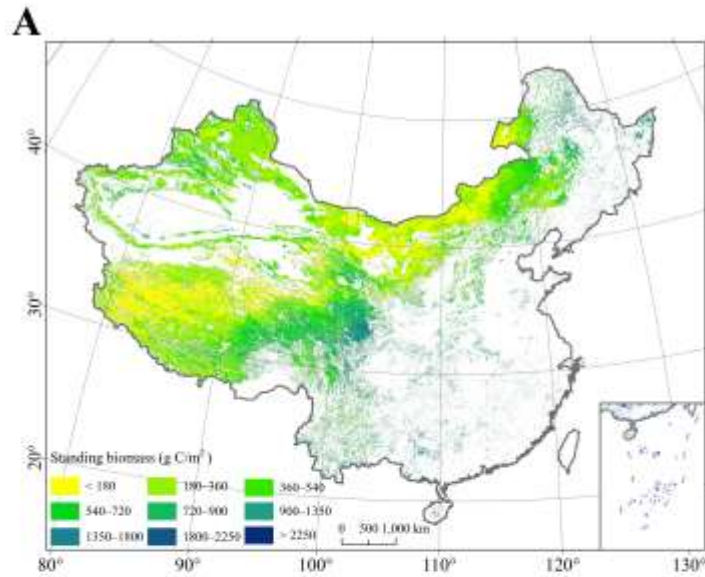


Response to climate aridity (PDSI and precipitation)

Category	PDSI	Year	Precipitation (mm)	AGB (g/m ²) Mean±STD	Total AGB (Tg)
Slightly wet	1.00 - 2.00	2012	409.35	124.97±76.33	107.99
Incipient wet spell	0.50 - 1.00	2013	359.51	115.87±81.25	100.13
Near normal	0.50 - -0.50	2003	332.96	105.17±68.47	90.88
Incipient drought	-0.50 - -1.00	2014	311.74	100.28±75.02	86.65
Mild drought	-1.00 - -2.00	2002/2004/2008	291.89	103.32±74.24	89.29
Moderate drought	-2.00 - -3.00	2005-2007/2009-2011	231.68	95.11±72.09	82.19
Severe drought	-3.00 - -4.00	2001	241.00	84.16±70.97	72.72

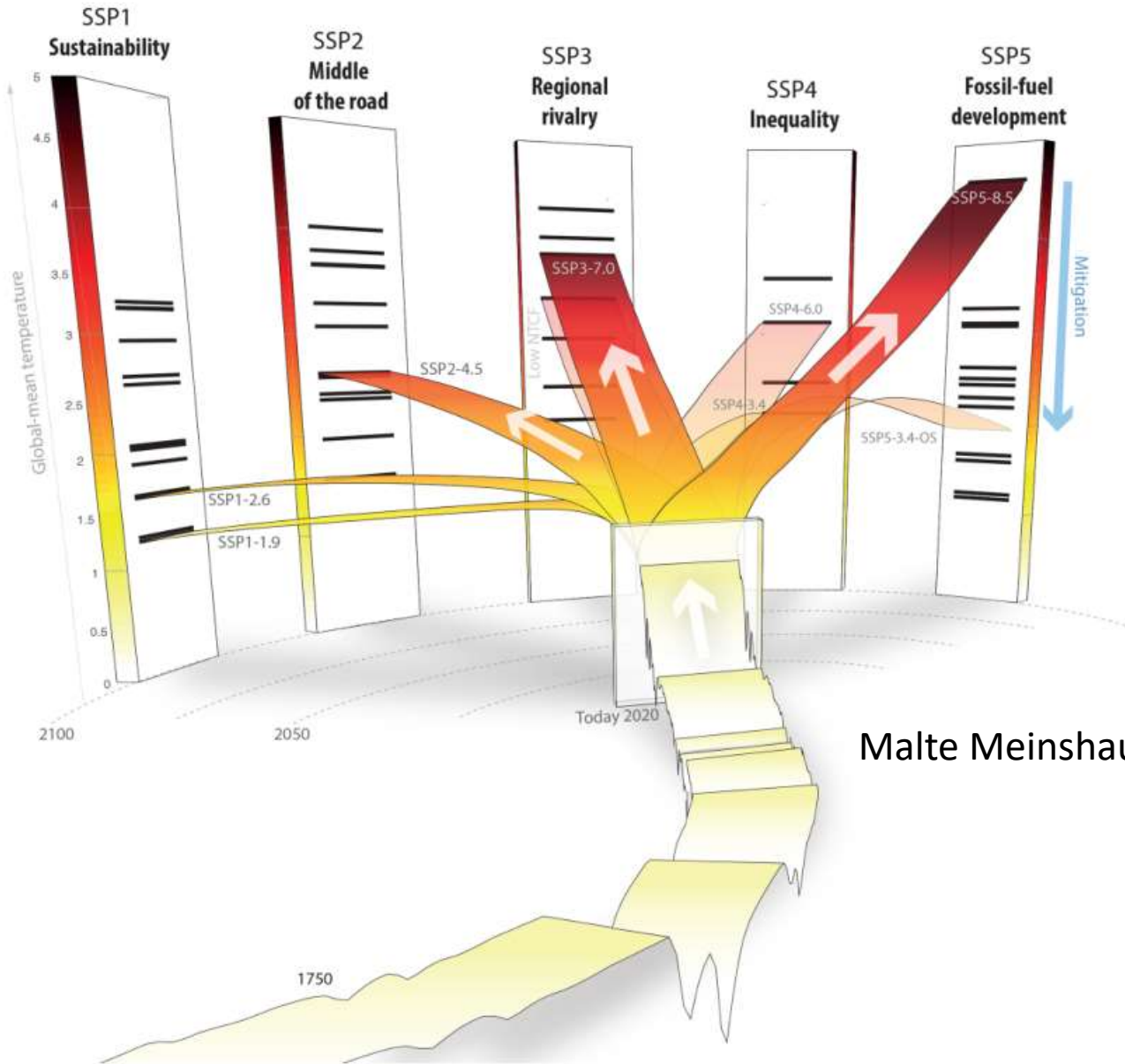
For a normal climate (e.g., an annual precipitation ~332.96 mm in 2003), we predicted ~90.88 Tg of AGB for the grassland biome. With climatic anomalies (either wet or dry), grassland AGB in IMAR would be substantially altered. For example, ~107.99 Tg of AGB was estimated for the slightly wet year of 2012 (precipitation = 409.35 mm), which is ~19% (or 17.11 Tg) more than a normal climate year. For a severe drought year like 2001 when the entire Mongolia Plateau had been experiencing ongoing drought since 1999, the annual precipitation decreased to 241 mm. This led to an 18.16 Tg (20%) loss in AGB at ~72.72 Tg.

Total biomass of China grasslands in 2020 from satellite



In preparation,
Huaqiang Li, Fei Li*

Future climate from the SSP scenarios

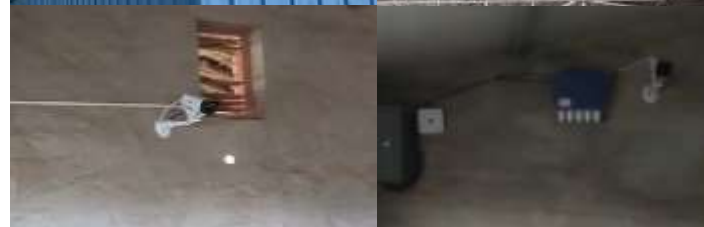


Malte Meinshausen et al., 2020

Climate-adoption livestock-farming management in grazing ecosystems



小计量4214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
小计量42	409	20.6	0.18	22.3	45	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



Context and Issues

研究背景

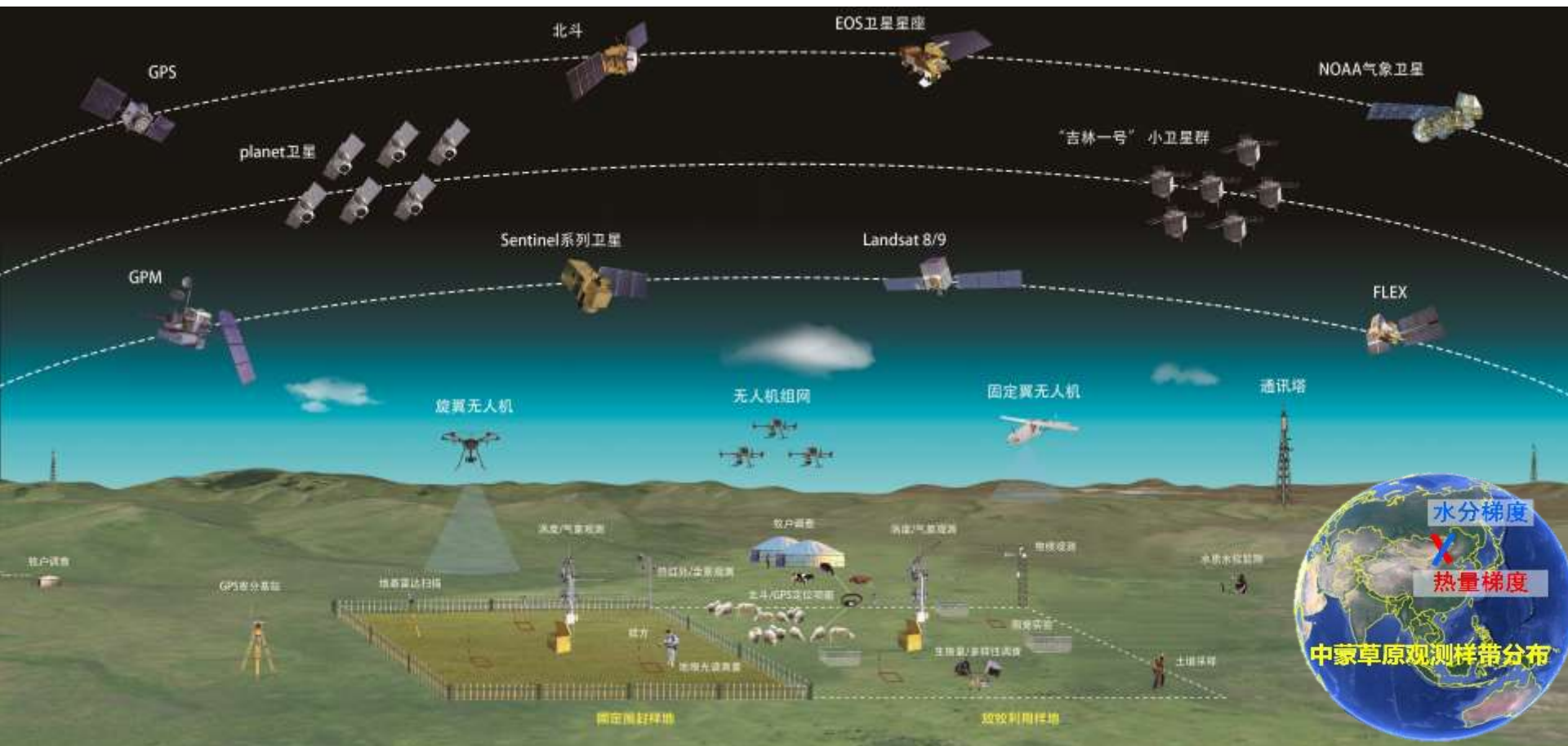
- 1、草地资源管理的角度---实现以草定畜；
- 2、生态系统安全的角度—生态系统服务价值的稳定性—碳收支

关键问题

- 1、如何量化草地的放牧利用强度；
- 2、如何精准反演关键草地生态产量（地上生物量（地面观测+线性混合模型）、ANPP-CASA（气候+NDVI+地面测量 ϵ_{\max}^* ）、GPP-MODIS-LUE（3个家庭牧场通量监测+6个碳收支测量系统））；
- 3、如何定量分析草地碳收支相应放牧利用强度的变化（气候与放牧利用的混合效应）。

Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

- “星（卫星）-空（无人机）-地（涡度通量观测、水碳同位素测量）” **多尺度观测**；
- 草地植被退化表征以及气候变化趋势**评价指标体系**，气候梯度样带草原水热碳**交换**。



李飞, 李冰, 闫慧, 李华强, 吕鹏飞, 白海花. 草地遥感研究进展与展望. 中国草地学报, 2022, 44(12): 87-99.

温性荒漠草原牧户单元



温性典型草原牧户单元



温性草甸草原牧户单元

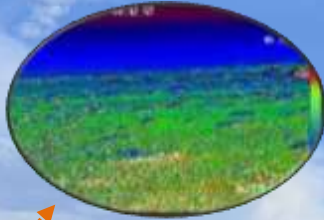


Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

全景观测



红外观测



涡动相关通量观测



日光诱导叶绿素荧光观测系统

土壤呼吸数据分析与传输

物候观测

土壤呼吸测量

Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

● 涡度相关通量观测及其指标



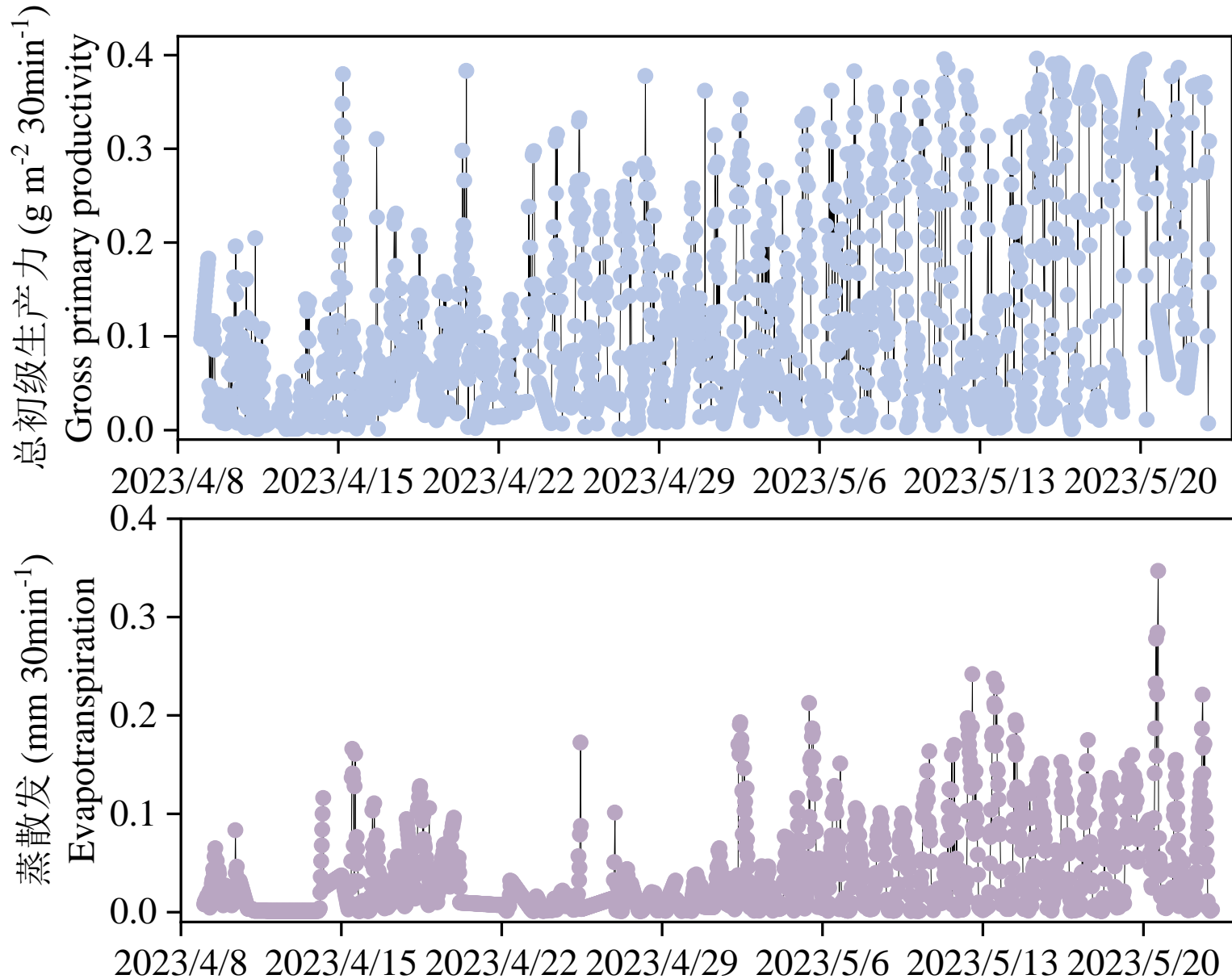
西

东

测定指标 Test parameter

土壤热通量(Wm^{-2})	CO_2 通量($\mu mol.m^{-2}.s^{-1}$)	空气温度(K)	土壤温度($T_s^{\circ}C$)
显热通量(Wm^{-2})	H_2O 通量($mmol.m^{-2}.s^{-1}$)	气压(Pa)	土壤电导率($dS m^{-1}$)
潜热通量 (Wm^{-2})	CH_4 通量($\mu mol.m^{-2}.s^{-1}$)	湿度(RH%)	水汽压(Kpa)
三维风速(m/s)	光合有效辐射($mmol m^{-2}$)	降雨量(mm)	

Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

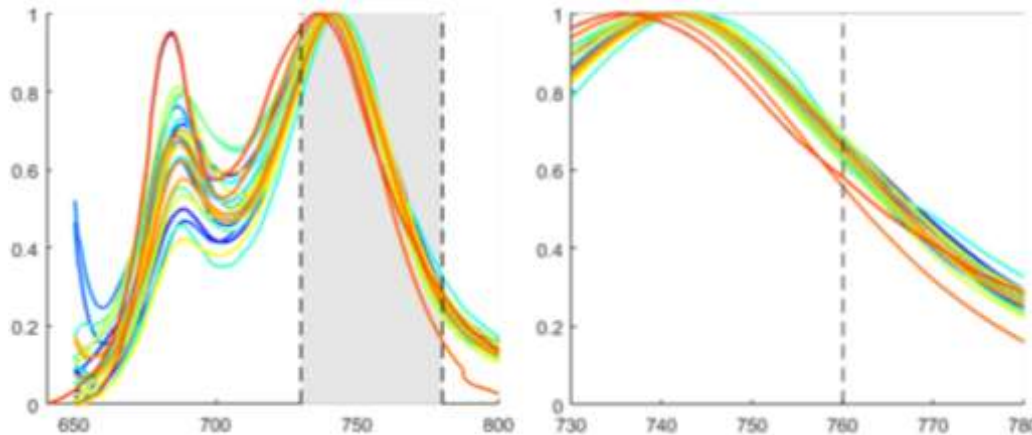


Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

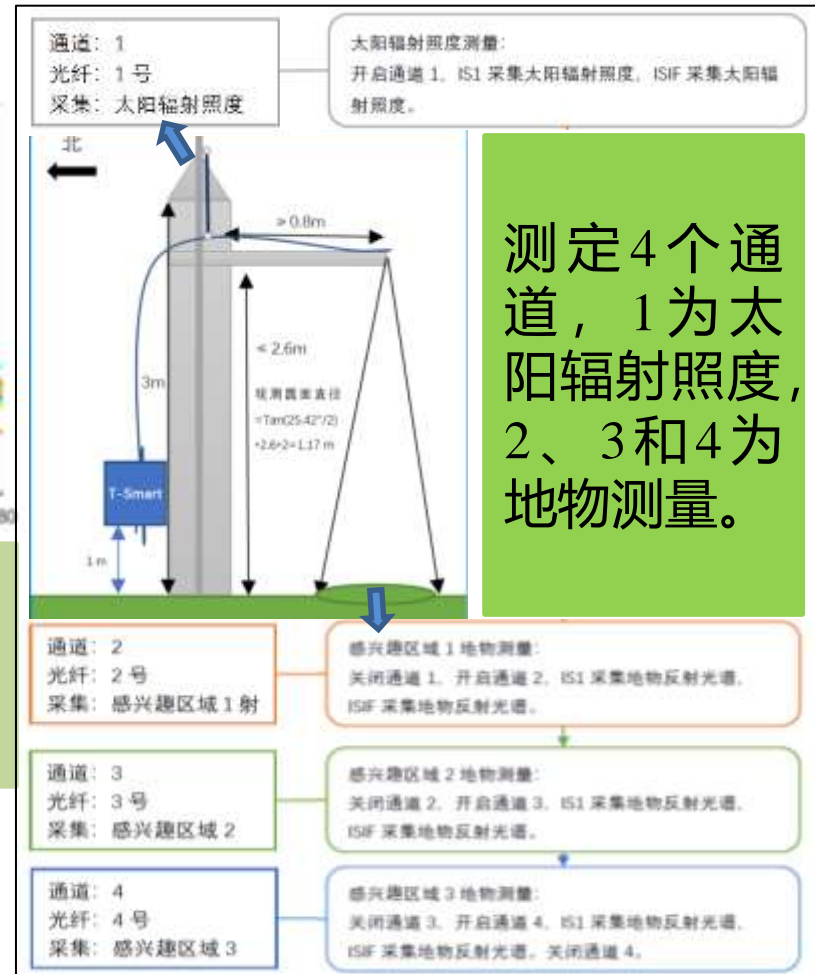
● 日光诱导叶绿素荧光观测系统

日光诱导叶绿素荧光 (Sun-Induced Chlorophyll Fluorescence, SIF) :

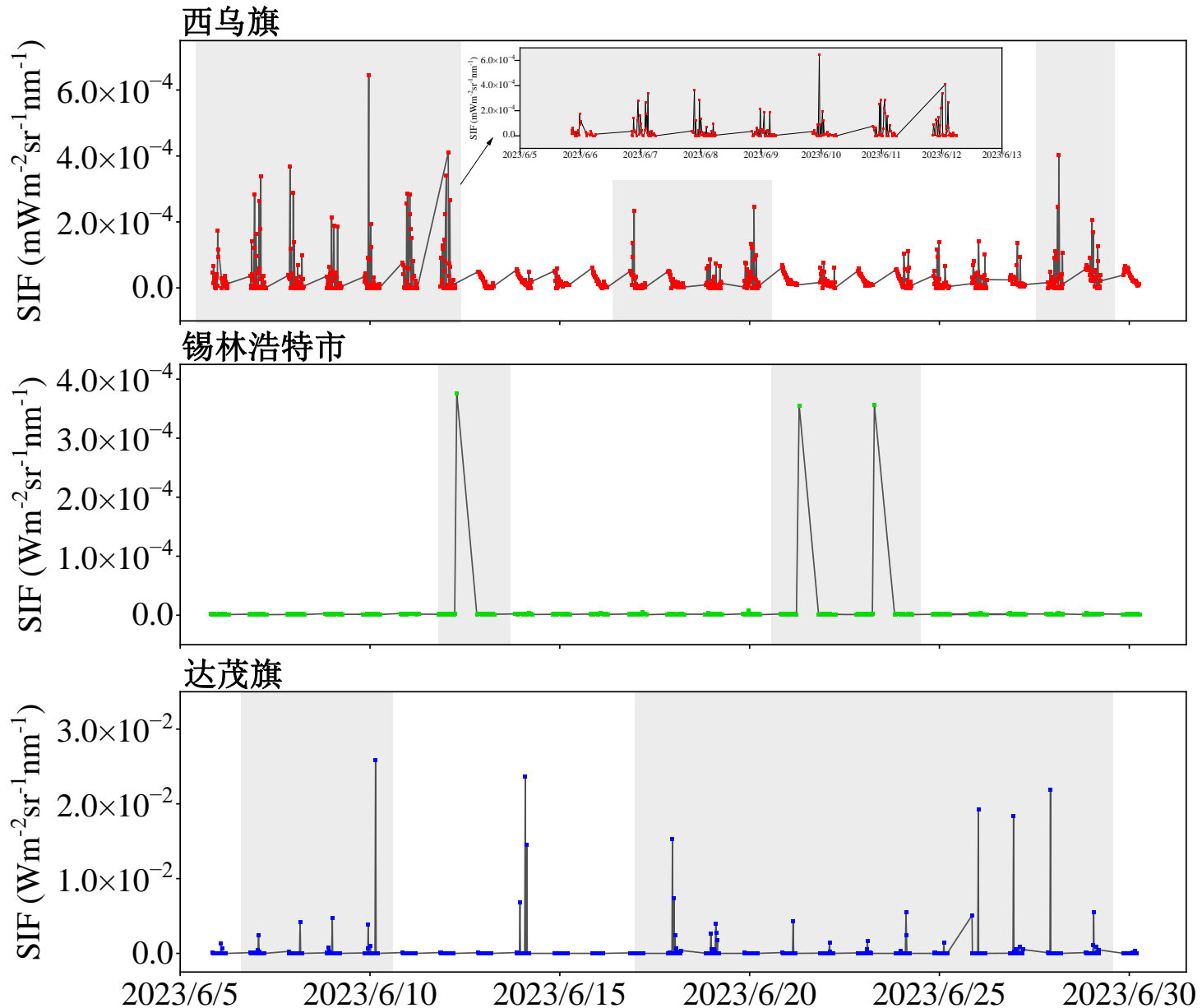
是植被吸收辐射后发射出的微弱信号。



SIF信号从红光波段延伸到近红外波段 (650 nm – 800 nm) , 整体辐射强度在 0 - 3 mW/m²/sr/nm。



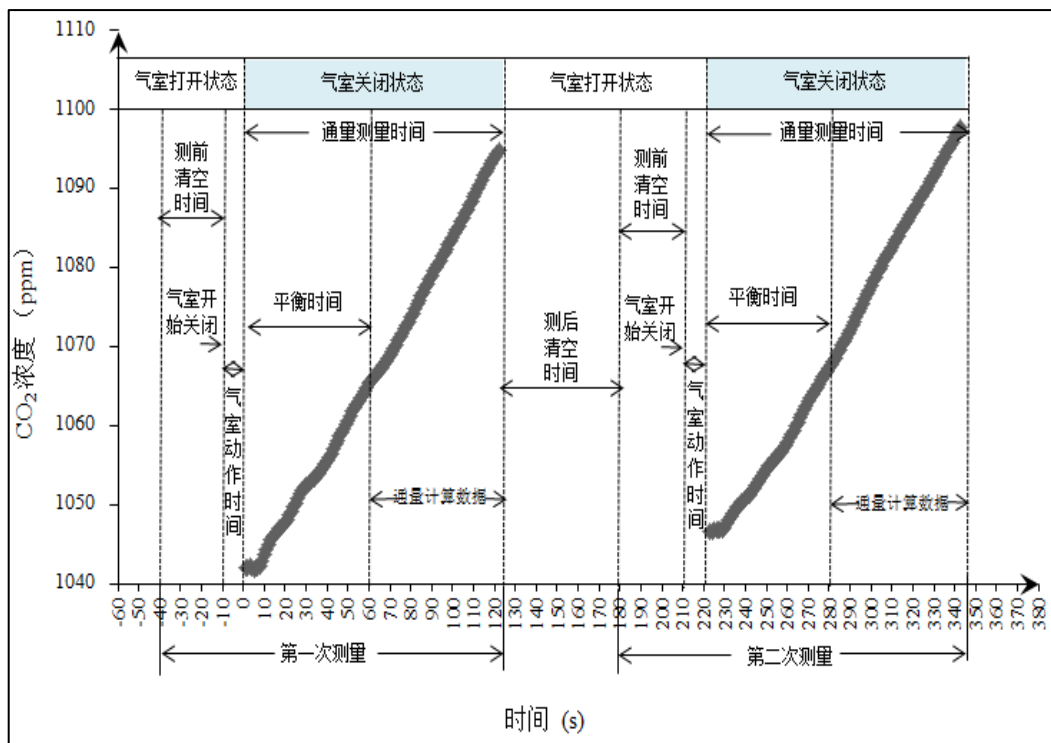
Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

● SF-9000全自动多通道长期土壤通量测量系统

SF-9000全自动系统在测量过程，对气体浓度随时间的变化进行线性回归，最终得到被测量气体的排放速率，计算土壤碳通量。



序号	名称	含义
1	CO ₂ _Flux_ umol/(m ² *s)	CO ₂ 通量值
2	H ₂ O_Avg_ ppm	H ₂ O 浓度值 平均值
3	AirP_Avg_ kPa	大气压强值 平均值
4	ChamberT_Avg_C	气室温度值 平均值
5	R ² _CO ₂	CO ₂ 浓度对应的回归拟合系数
7	SoilT_C	土壤温度
8	SoilVWC_ %	土壤湿度

SF-9000 控制单元

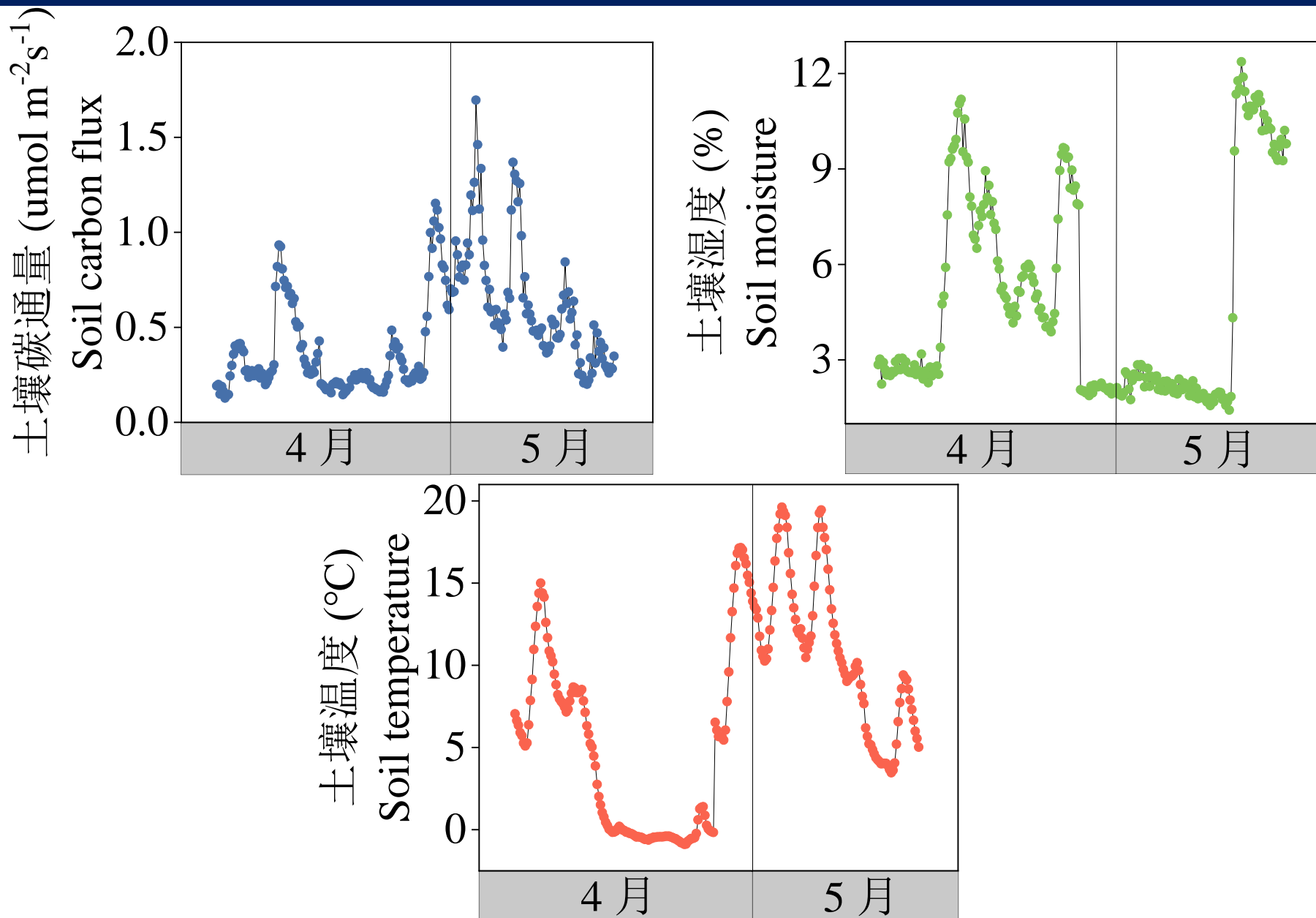


测量过程

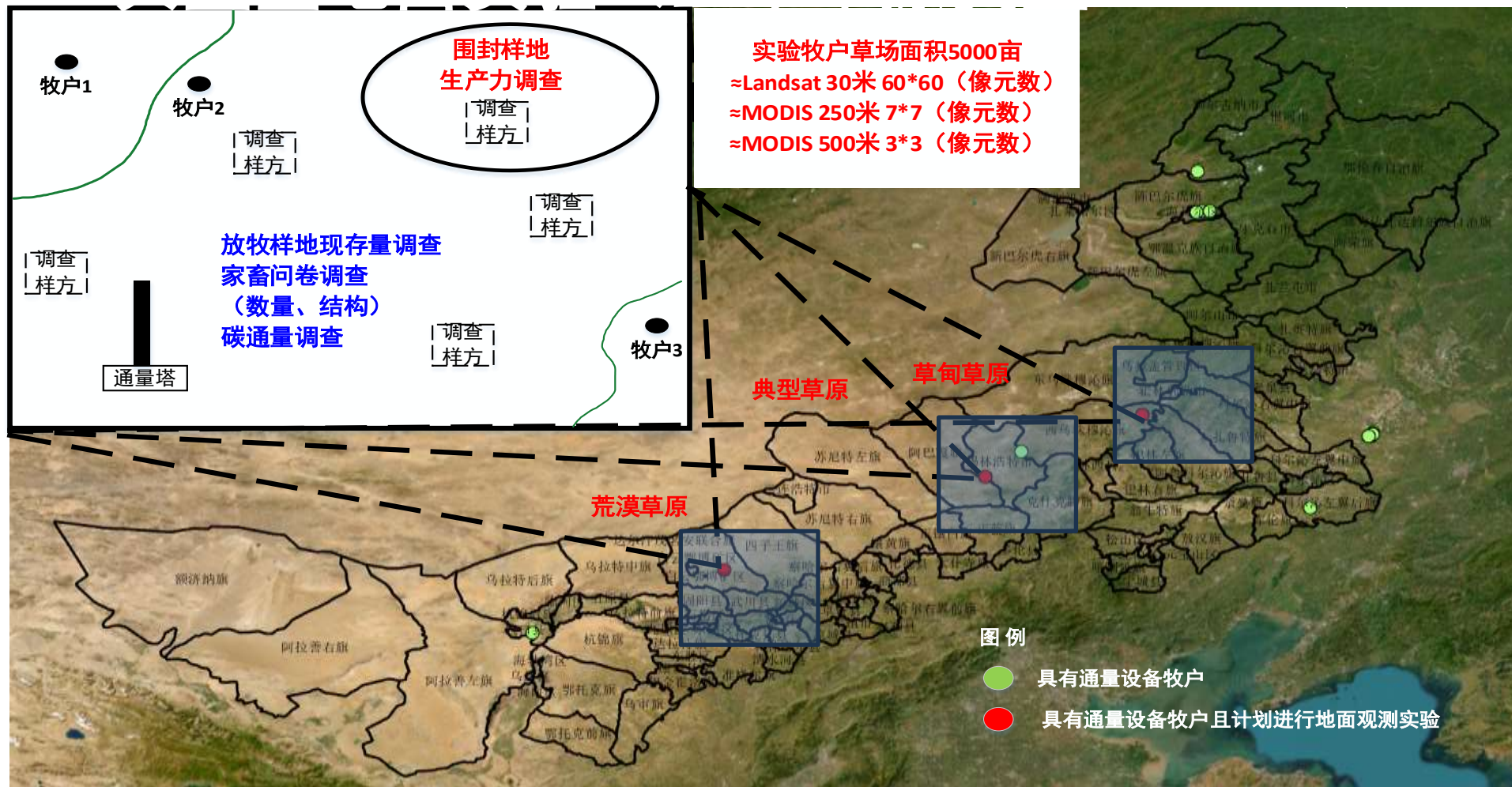


数据输出

Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



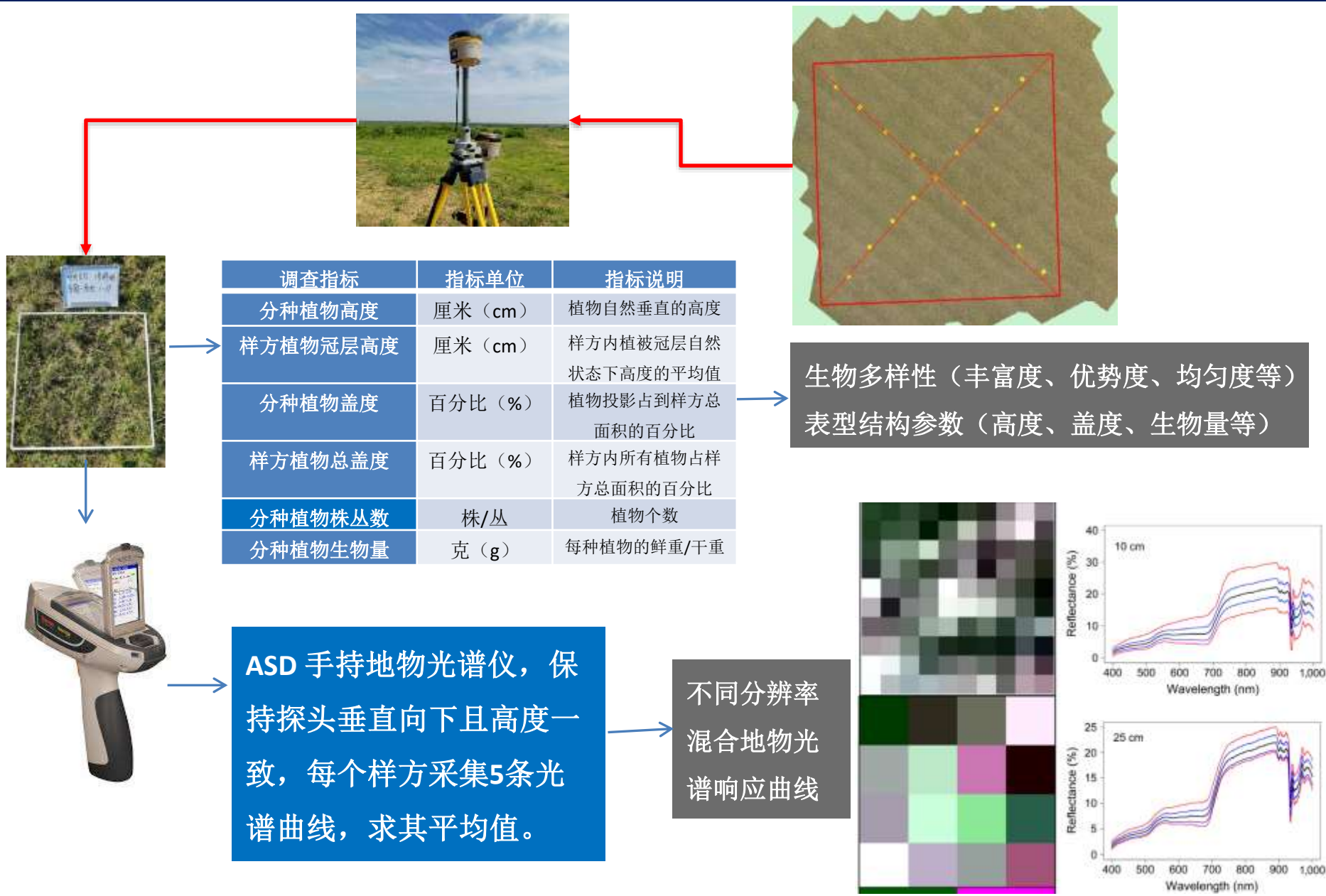
Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



机载多光谱成像仪



机载激光雷达



机载高光谱成像仪

飞行前拍摄辐射定标毯，后期利用Pix4D软件进行辐射定标。利用控制点坐标，将无人机飞行获取的多/高光谱数据影像进行地理配准。

光谱多样性，包括反射率、光谱角、光谱吸收深度、植被指数、光谱变异系数。

利用飞行作业中惯导数据，雷达数据和地面RTK控制数据进行解算工作。

冠层高度及其变异、冠层盖度

任务荷载	数据产品要求
多光谱	(1) 谱段间配准精度优于0.2像元； (2) 航带间配准精度优于1个像元； (3) 几何定位精度优于0.1m。
高光谱	(1) 谱段间配准精度优于0.2像元； (2) 航带间配准精度优于2个像元； (3) 几何定位精度优于0.1m。
激光雷达	(1) 航带间配准精度优于0.05m； (2) 几何定位精度优于0.1m。
产品精度要求	数据产品的精度要达到测绘产品1:500 - 1:1000比例尺要求。

序号	资料名称	数据格式
1	地基激光雷达点云原始数据	*.rxp
2	地基激光雷达点云拼接后数据	*.las
3	点云数据分类成果	*.las
4	数字表面模型	Tiff或Geotiff
5	数字高程模型	Tiff或Geotiff
6	归一化数字高程模型	Tiff或Geotiff
7	高光谱原始数据	*.cub
8	高光谱几何及辐射定标产品 (*.bil)	*.bil
9	多光谱原始数据	*.tif
10	多光谱几何及辐射校正产品 (*.tif)	*.tif

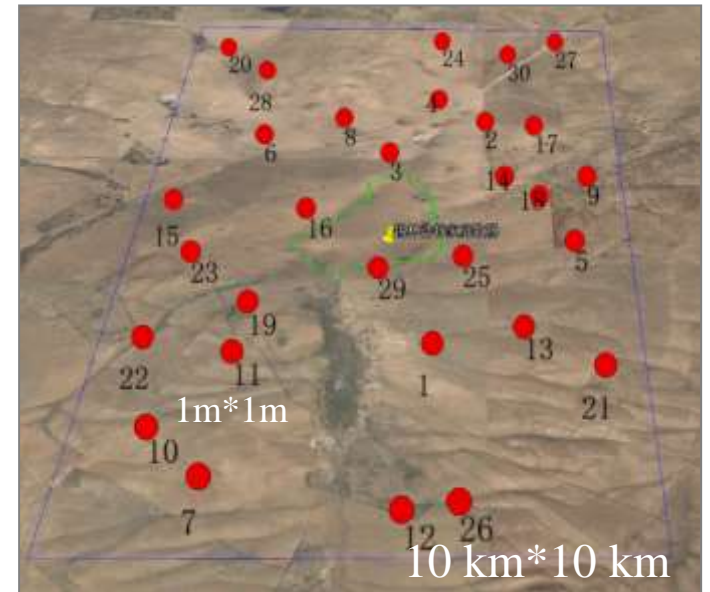
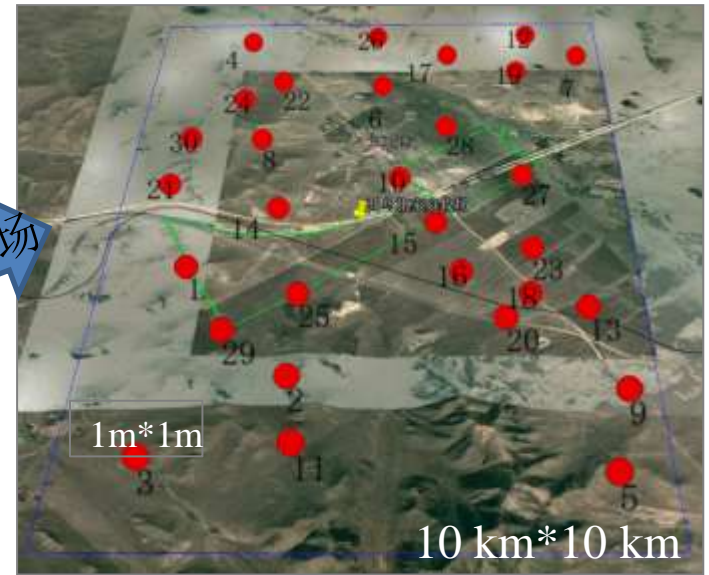
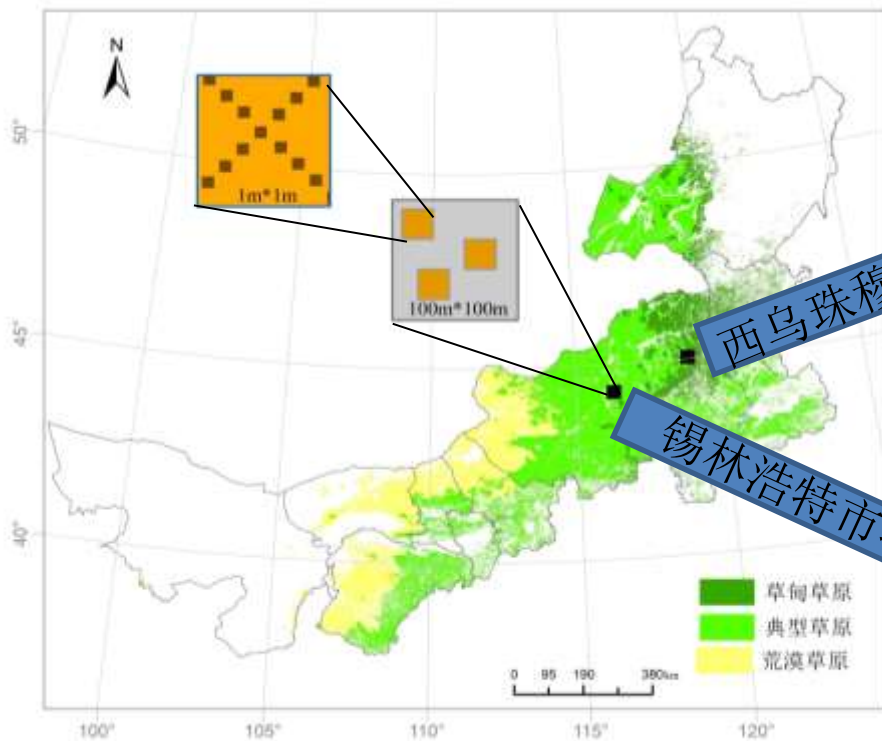
Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



样地布设

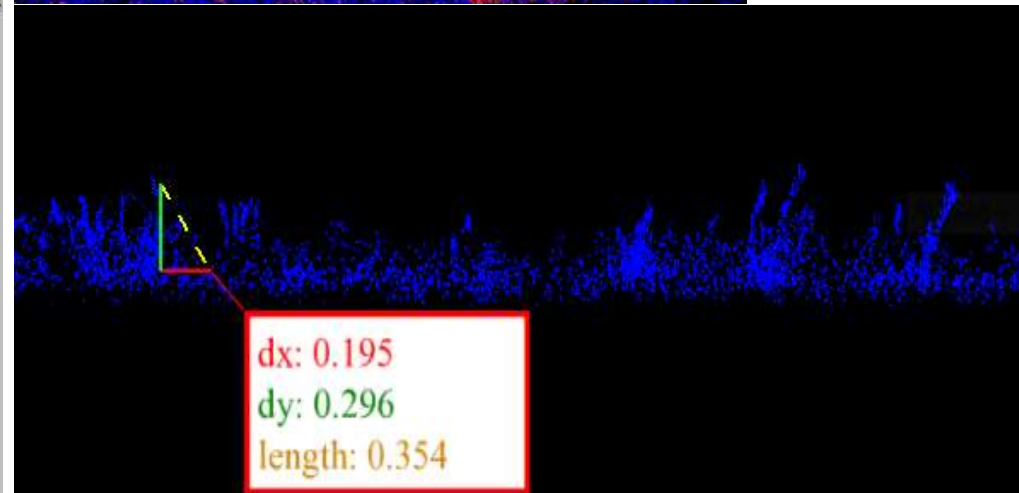
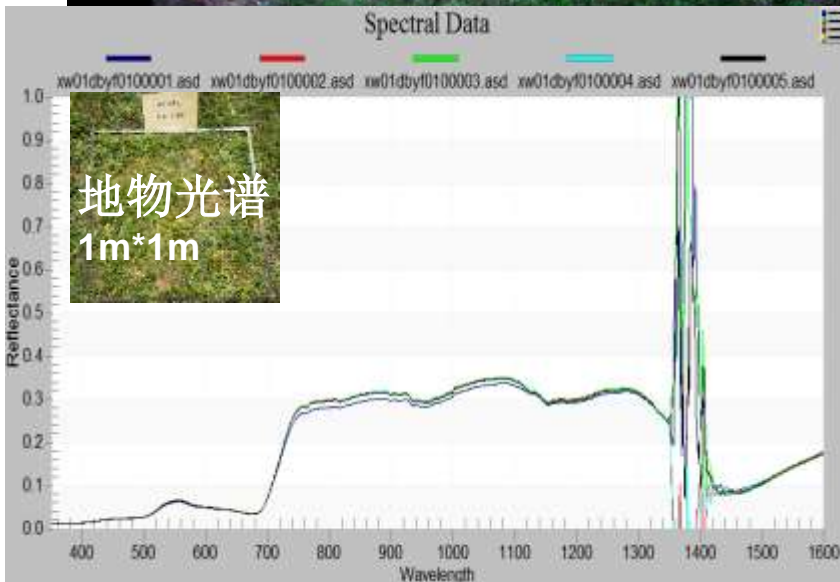
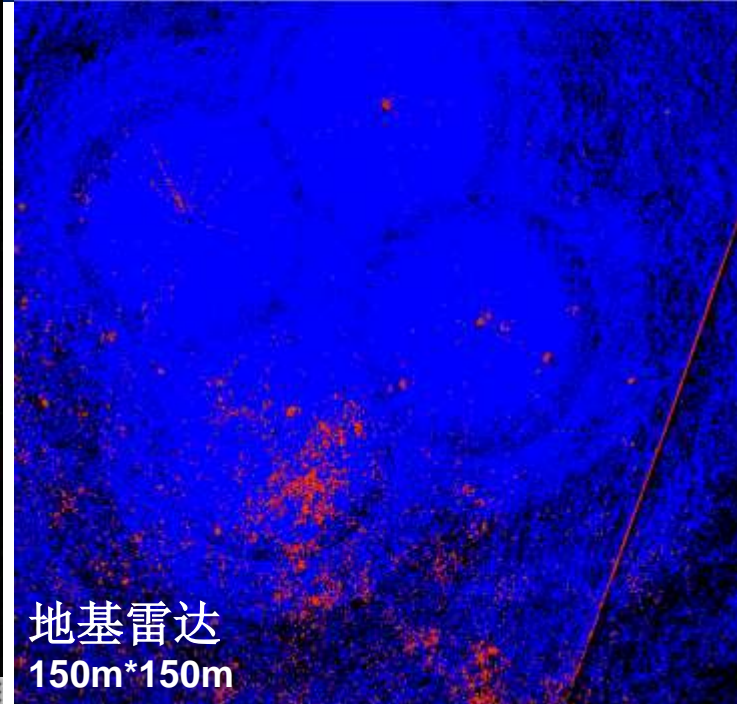
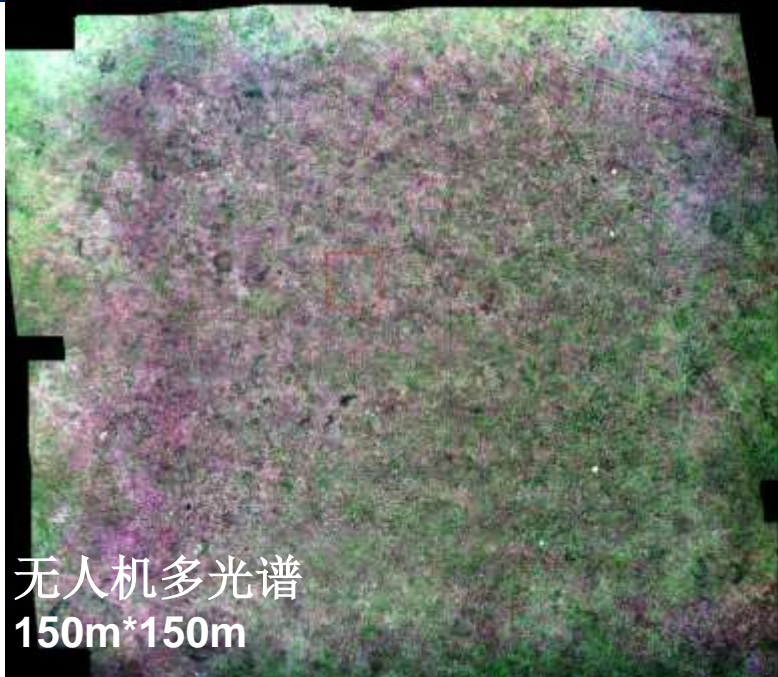
数据获取

Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient

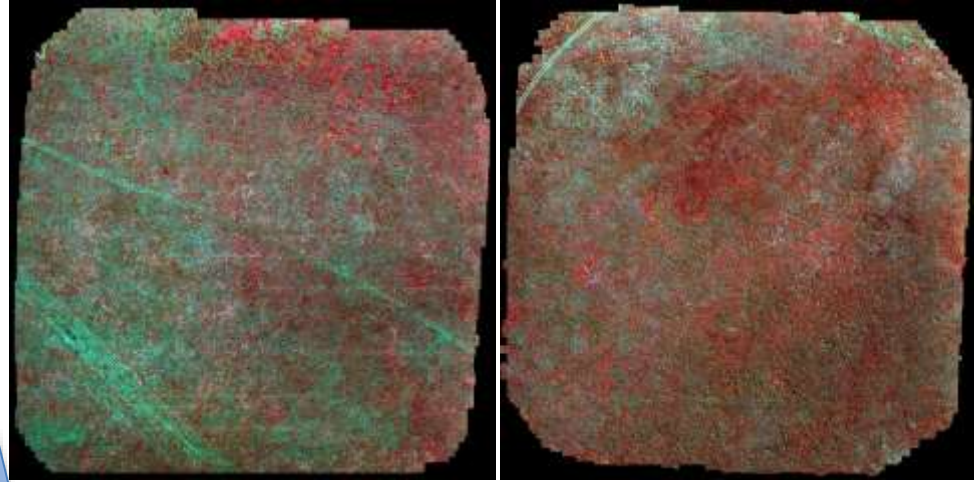
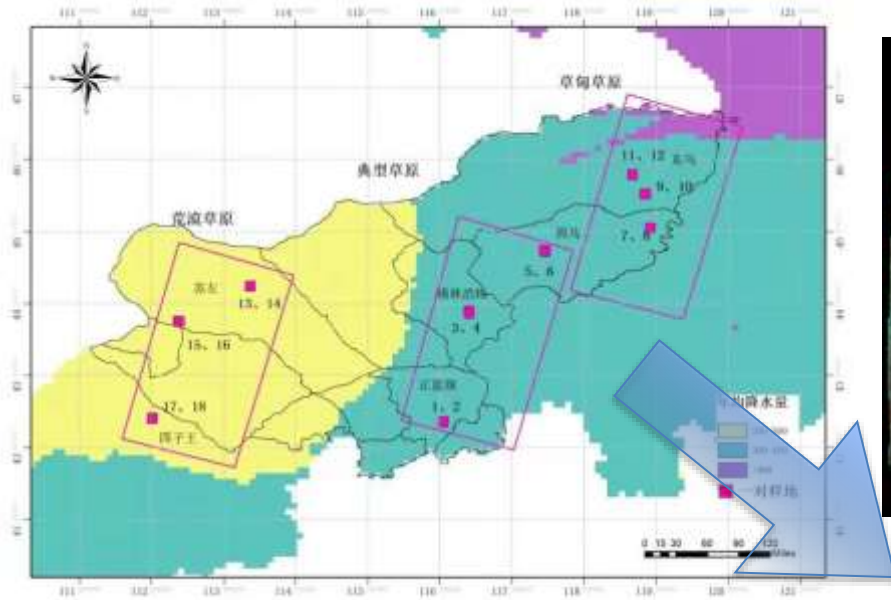


覆盖范围	数据来源	数据内容
10 km * 10 km	WorldView-3	光谱多样性
100 m * 100 m	无人机多光谱	
	1 m * 1 m	地基雷达
1 m * 1 m		地物光谱仪
		地面调查(牧场内外)

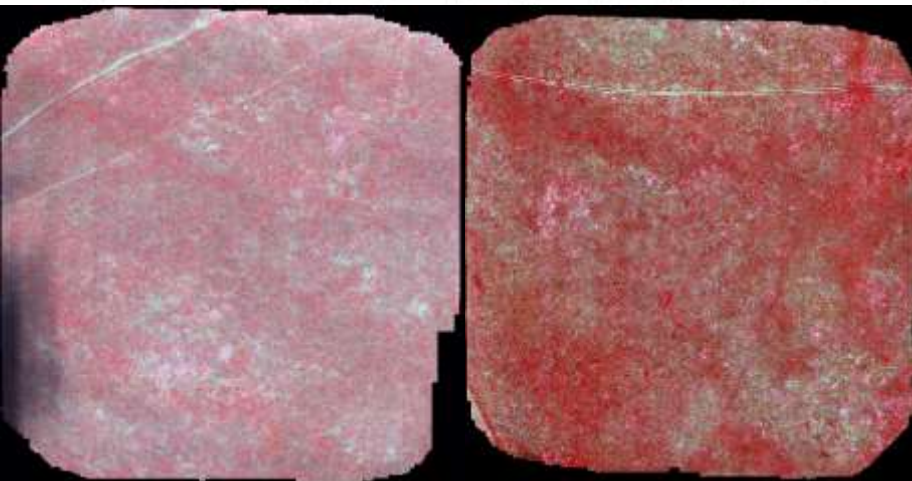
Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



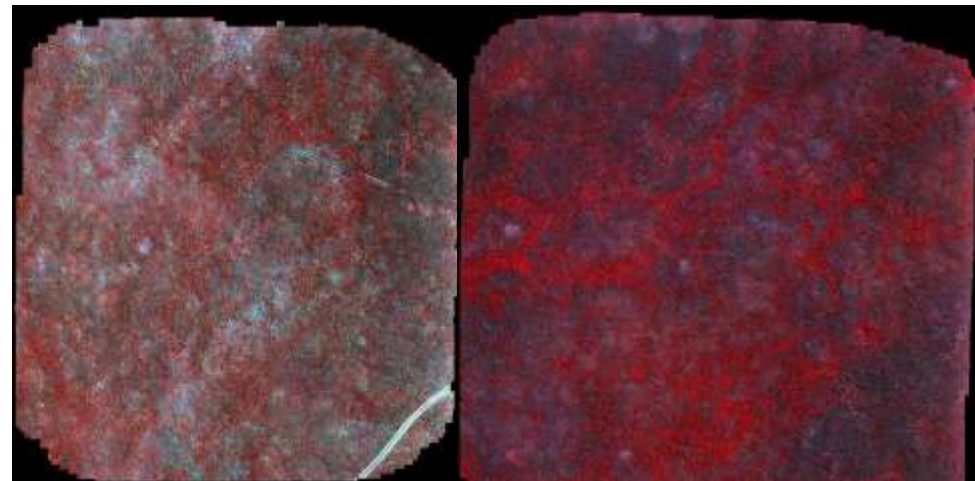
Network of carbon-water fluxes monitoring in grazing ecosystems along the precipitation gradient



7、8号样地

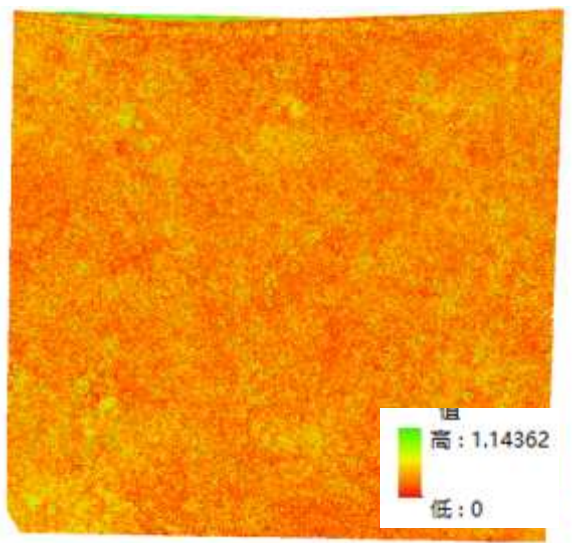
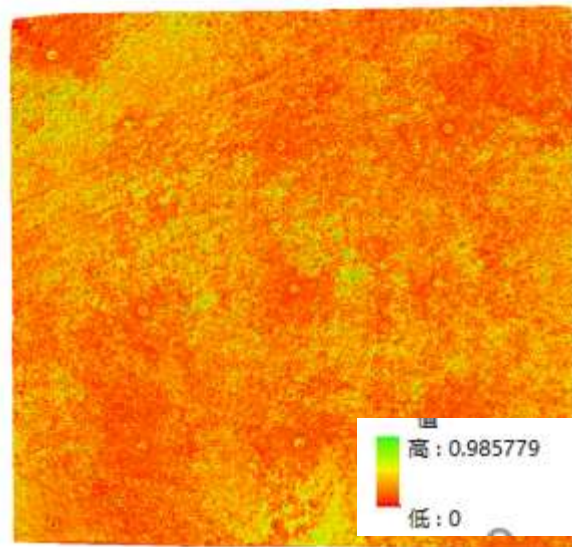


9、10号样地

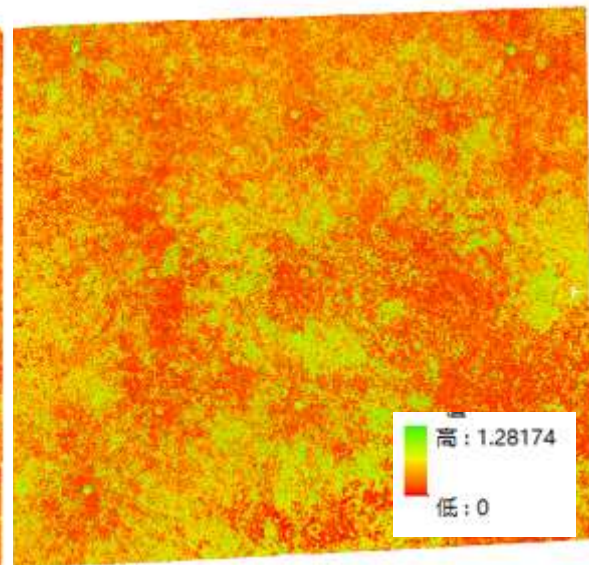
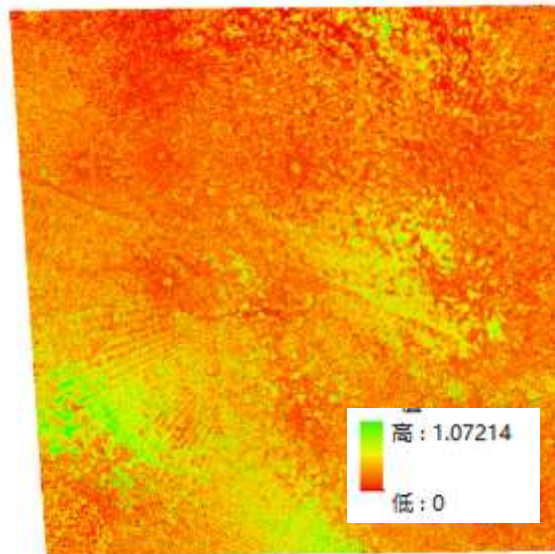


11、12号样地

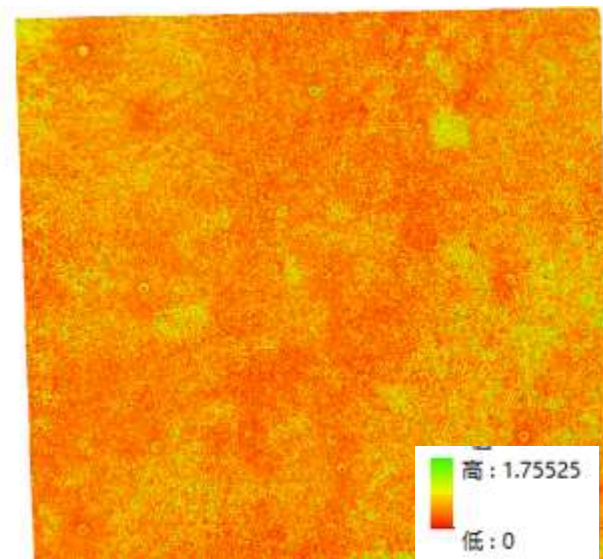
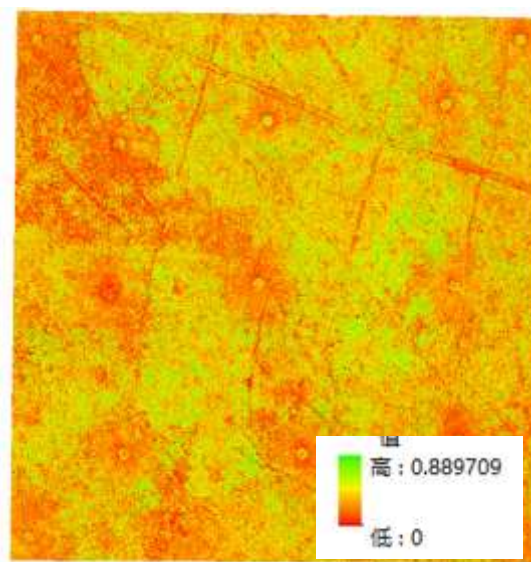
植被冠层高度 CHM(m)



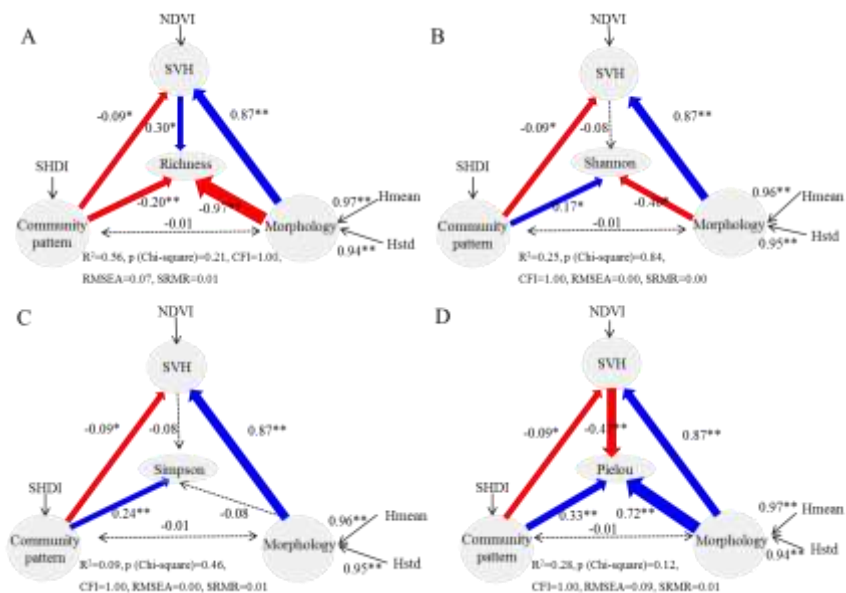
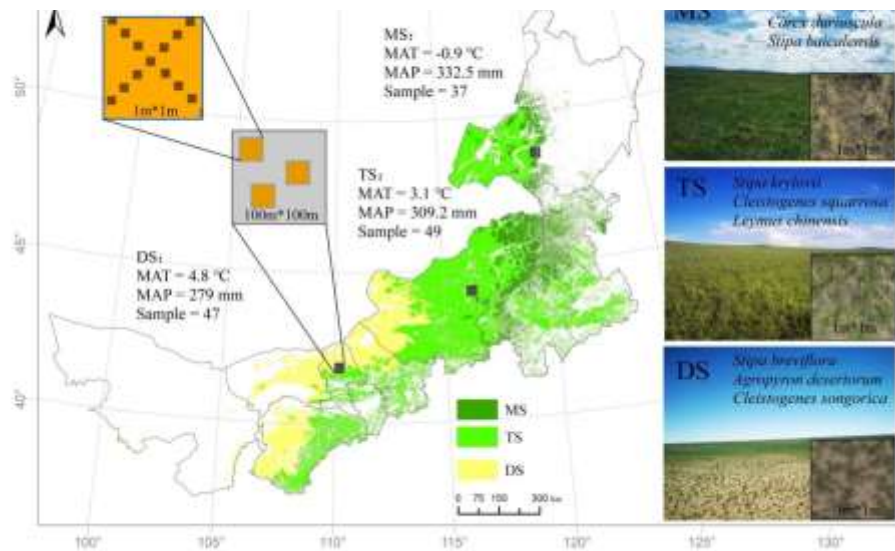
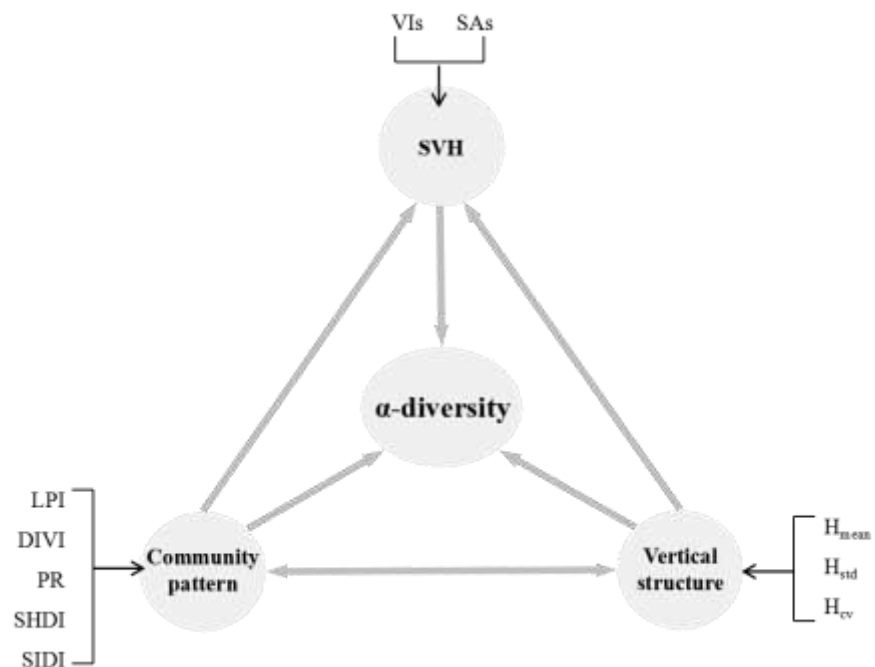
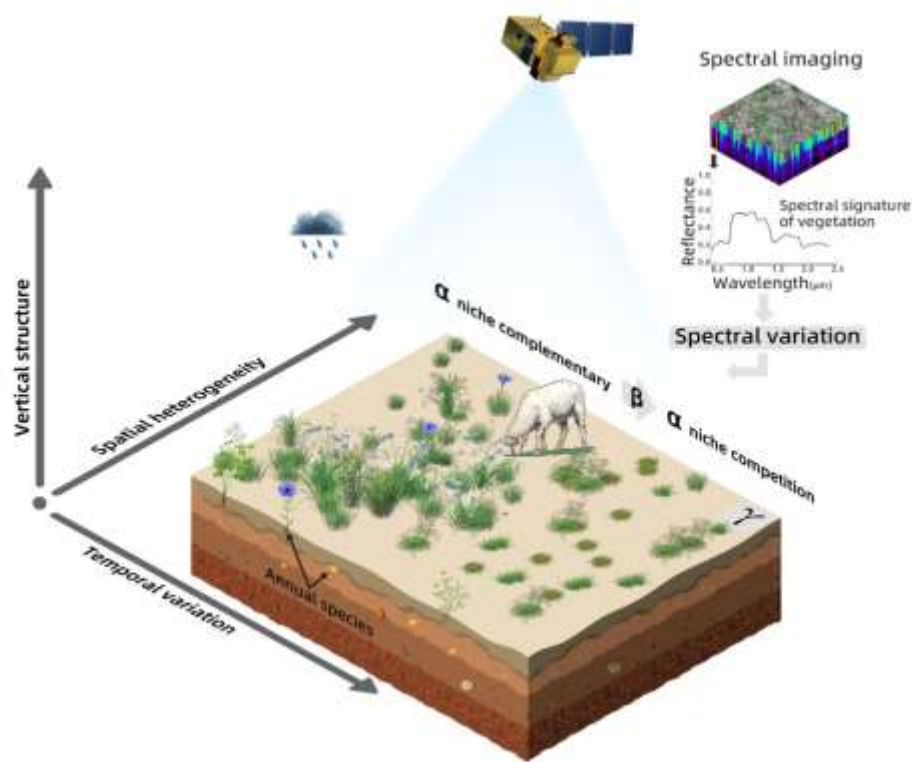
9、10号样地



7、8号样地

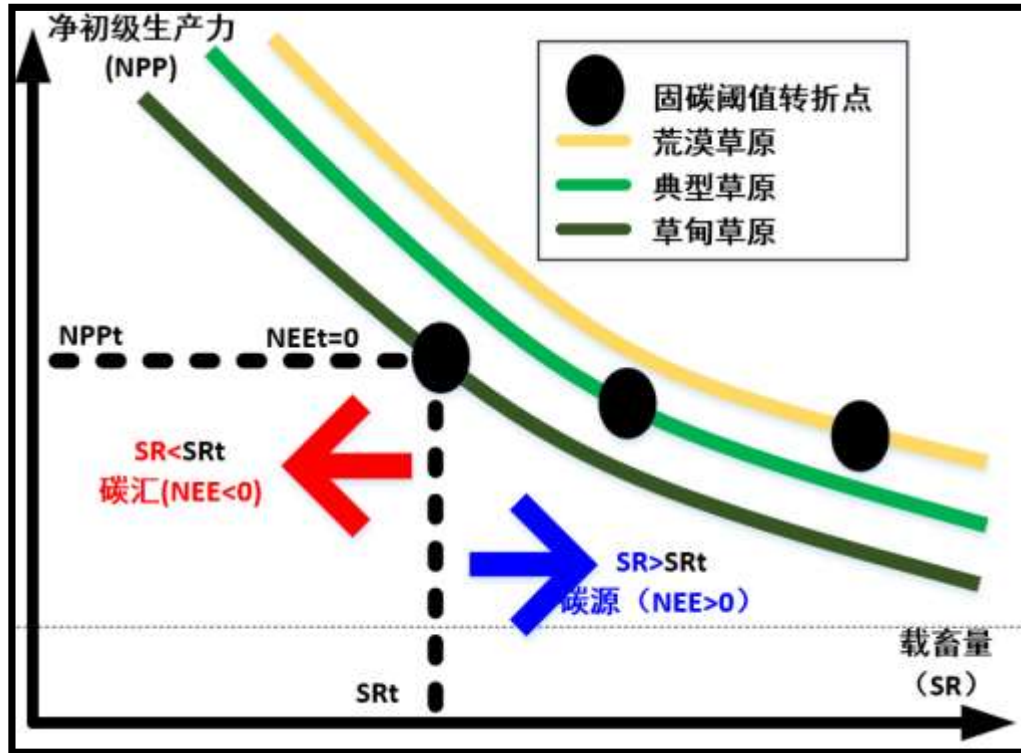


11、12号样地



Yan, H., **Li, F.***, & Liu, G. (2023). Diminishing influence of negative relationship between species richness and evenness on the modeling of grassland α -diversity metrics. *Frontiers in Ecology and Evolution*, 11, 154.

Climate-adoption livestock-farming management in grazing ecosystems



$$NEE = GPP - ER$$

$$NPP = GPP - ER_p$$

$$ER = ER_p + ER_m$$

$$NPP = NEE + ER_m \quad (NPP-NEE \text{ 关系公式})$$

其中，GPP是总初级生产力；NPP是净初级生产力；ER是生态系统呼吸；ER_p是植物自身进行呼吸代谢所消耗的能量；ER_m是微生物自身进行呼吸代谢所消耗的能量；NEE是净生态系统交换。

NEE转换—AGB (8月份静态存量量) / NPP/GPP--
-碳收支

SR----GUI(放牧扰动强度)

Thanks for your attention!

Looking for communication and collaboration!

