基于FFP通量源区模型的涡度相关的 CO_2通量信号的拆分

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2020.8.28

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1. 前言

- 从微气象学的角度而言，在地势平坦冠层均质的通量观测点所获得的通量观测数据是最值得信赖的。然而，为了考虑观测点的区域代表性，绝大部分EC观测点的下垫面类型都是不均一的。对于这种复杂的下垫面，准确、客观地分析与解释观测数据的空间代表性是进行通量观测的目标之一。
- 通量源区（footprint）分析可以将涡度相关所观测的通量源区进行空间定量化，从而来评价观测数据的空间代表性。

1. 前言

- footprint是指通量观测点上风向上的空间代表区域，能够反映空间代表区域对应的下垫面源区内每一点对观测点的通量贡献的权重大小。
- 在非均一的下垫面下，footprint的大小和形状会因下垫面类型的不同发生改变。将footprint的模型计算和土地分类地图相结合，可定量评价不同下垫面类型所观测的通量权重占比，由此推算出所研究区域内CO_2、CH_4等通量信号的来源。

2.文献汇报

Biogeosciences, 16, 255–274, 2019
https://doi.org/10.5194/bg-16-255-2019

Biogeosciences Open Access EGU

Interpreting eddy covariance data from heterogeneous Siberian tundra: land-cover-specific methane fluxes and spatial representativeness

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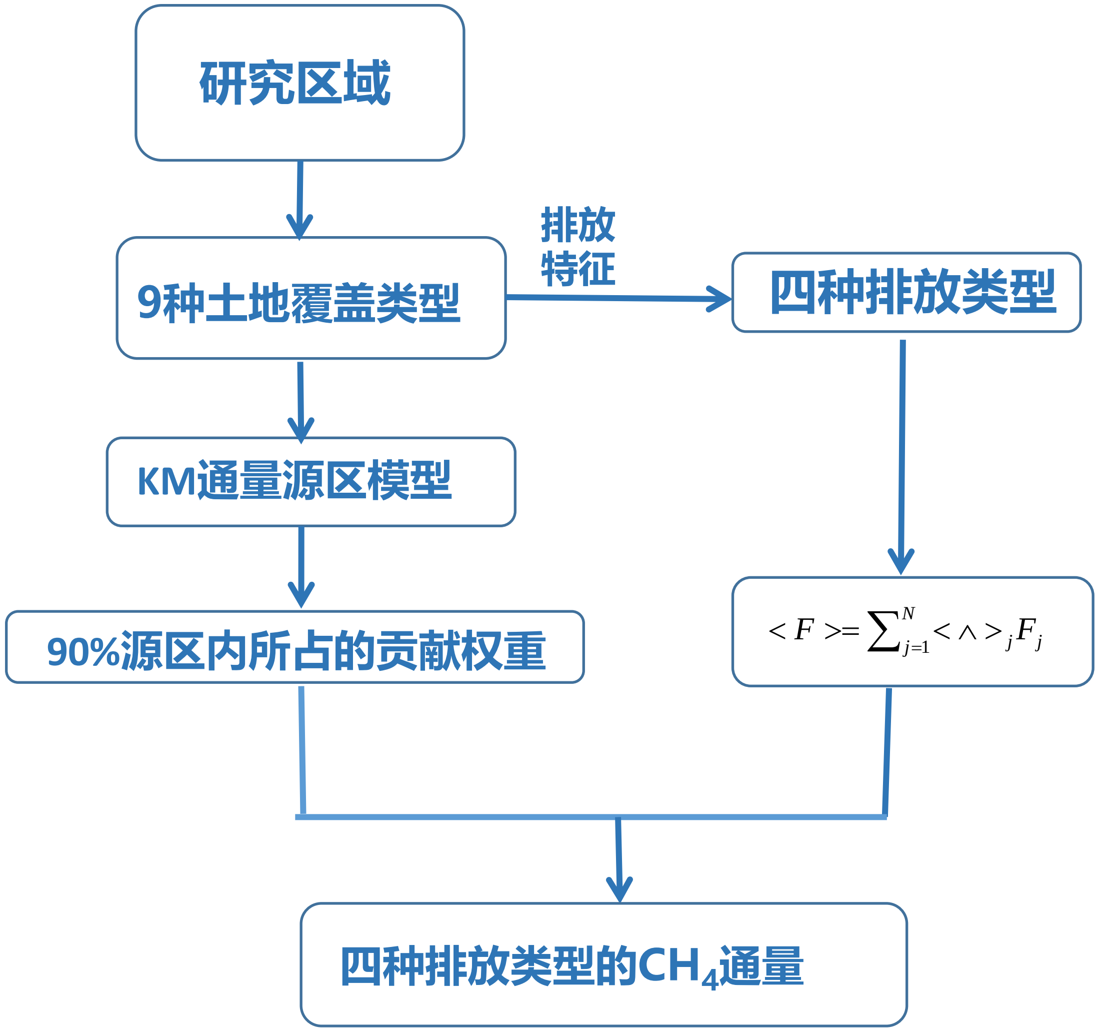
实验地点：俄罗斯东北部Tiksi　　实验时间：2014.7.5-8.29

2.1文献研究内容


研究区域
9种土地覆盖类型
排放特征
四种排放类型
KM通量源区模型
90%源区内所占的贡献权重
$< F >= \sum_{j=1}^{N} < \wedge >_j F_j$
四种排放类型的CH_4通量

2.2文献研究方法

2.2.1 土地覆盖类型分类

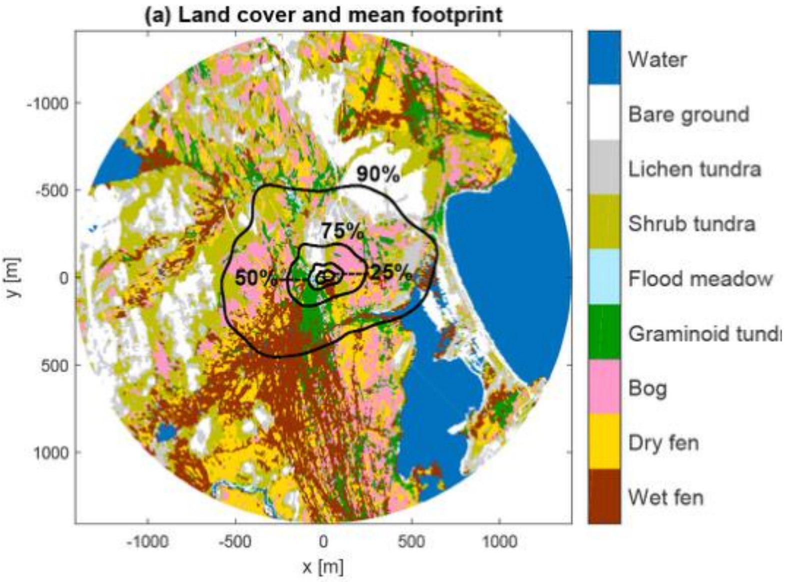


图1

LCC group description	LCCs included
Strong source	Wet fen, TWI > 4 Graminoid tundra, TWI > 4
Moderate source	Wet fen, TWI ≤ 4 Dry fen Water, above sea level
Sink	Bare ground Lichen tundra
Neutral	Other

表1

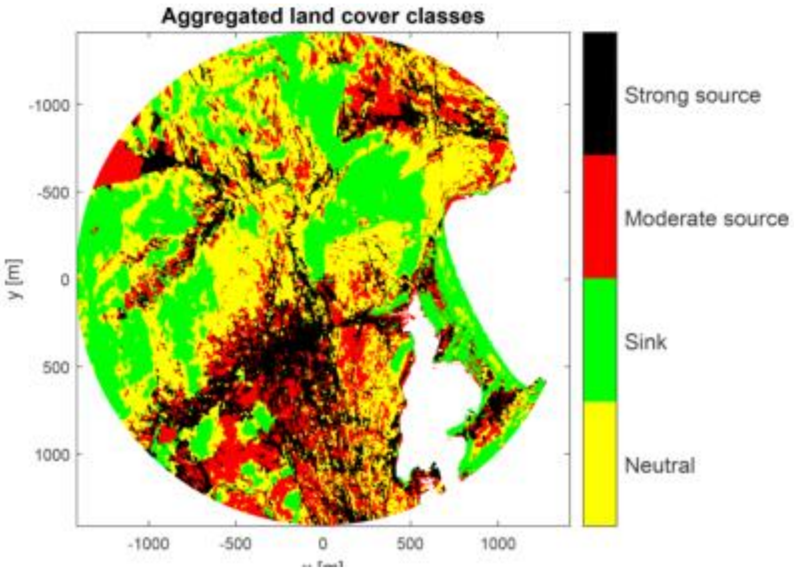


图2

2.2.2 footprint权重和CH_4通量的计算

- 基于KM通量源区模型计算不同土地覆盖类型通量贡献权重

Parameter	*Description*	*Units*	*Admissible range*
Time	measurement time	days after 1.1.1900	>1
x_{sensor}	x coordinate of receptor (E-W coordinate)	m	-5000 to 5000
y_{sensor}	y coordinate of receptor (S-N coordinate)	m	-5000 to 5000
u_*	friction velocity	ms^{-1}	0.01 to 5
L	Obukhov length	m	-99999 to 99999
σ_v	standard deviation of cross wind speed	ms^{-1}	0 to 20
wdir	wind direction	degrees	0 to 360
z_m	measurement height (z-d)	m	0 to 1000
U	horizontal wind speed	ms^{-1}	0 to 30

Output	*Description*	*units/dimension*
z0	Zero displacement height	m
phitot	Integral of footprint function over considered domain	%
Field_x	Footprint contribution of field x	%
Umaj	U, Constant in power-law profile of the wind velocity	$L^{1-m}T^{-1}$
Kmaj	K, Constant in power-law profile of the eddy diffusivity	$L^{2-n}T^{-1}$
m	Exponent of the wind velocity power law	-
n	Exponent of the eddy diffusivity power law	-
A,B,C,D,E	A-E parameters defining footprint function, (see above)	-
KM_p01a	Intersection point of 1%- ellipse nearest to sensor	m
KM_p01b	Intersection point of 1%- ellipse farthest from sensor	m
KM_p01c	Half width of 1%-ellipse	m

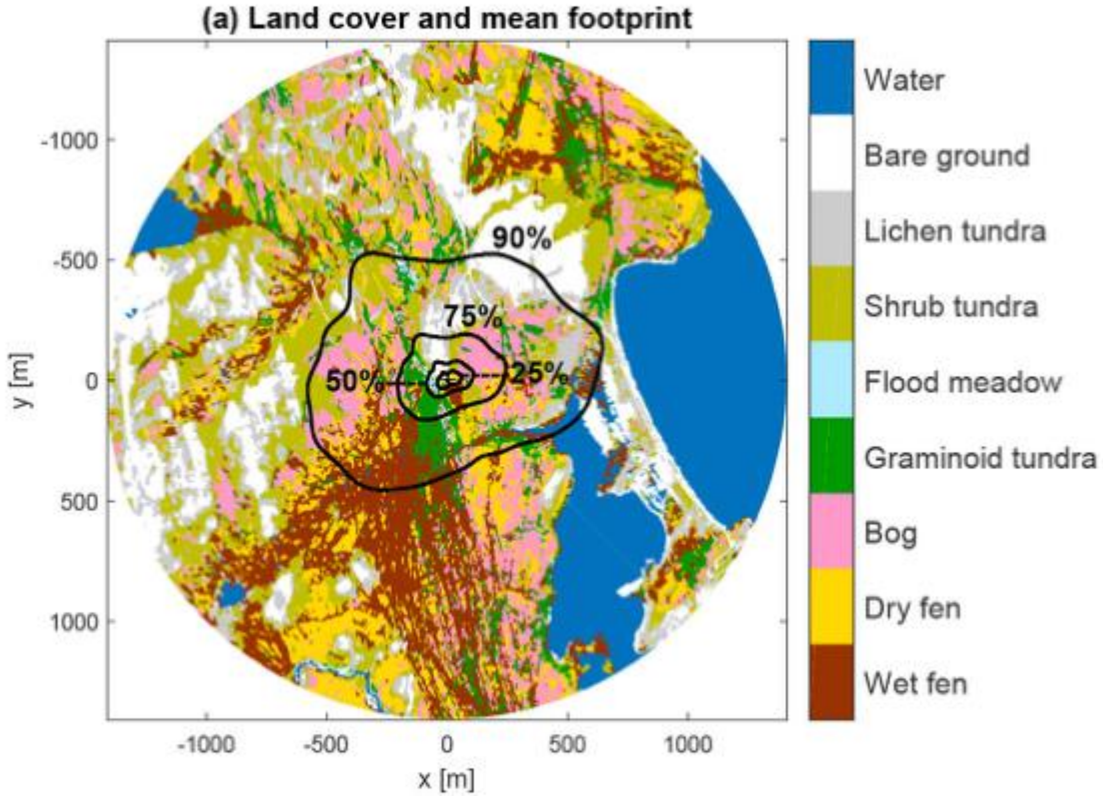
- 四个排放类型的CH_4通量计算

$$\langle F \rangle = \sum_{j=1}^{N} \langle \Lambda \rangle_j F_j ,$$

EC观测的总通量值

Field_X

2.3文献结果分析



Land cover class	Weighted	Area	Area, 90 %	Region
Wet fen	9.0	17.7	15.1	16.4
Dry fen	17.0	12.8	10.3	11.6
Bog	17.8	12.8	23.0	9.1
Graminoid tundra	11.7	6.6	11.6	3.4
Flood meadow	3.3	0.7	1.4	0.4
Shrub tundra	12.8	21.1	18.2	27.4
Lichen tundra	15.1	12.4	10.9	11.1
Bare ground	13.0	13.6	8.0	15.3
Water	0.2	2.3	1.4	5.3
Total	100.0	100.0	100.0	100.0

表2

LCC group description	CH_4 flux	95 % confidence interval
	($\mu g\ CH_4\ m^{-2}\ s^{-1}$)	
Strong source	0.949	[0.871, 1.028]
Moderate source	0.264	[0.180, 0.348]
Sink	−0.131	[−0.172, −0.089]
Neutral	−0.007	[−0.035, 0.021]

表3

LCC group	Study area[a] ($6.3\ km^2$)		Region[a] ($35.8\ km^2$)	
	Coverage[b] (%)	Flux[c]	Coverage (%)	Flux
Strong source	17.7	0.168 (91.8 %)	15.1	0.144 (89.8 %)
Moderate source	19.5	0.052 (28.3 %)	20.3	0.054 (33.5 %)
Sink	26.0	−0.034 (−18.6 %)	26.4	−0.035 (−21.6 %)
Neutral	36.8	−0.003 (−1.4 %)	38.1	−0.003 (−1.7 %)
Upscaled flux[d]	0.183 [0.156, 0.209]		0.160 [0.134, 0.186]	

表4

$$\langle F \rangle = \sum_{j=1}^{N} \langle \Lambda \rangle_j F_j ,$$

F_j → CH_4 flux

3.基于FFP通量源区模型的涡度相关的CO_2通量信号的拆分

3.1 研究目的

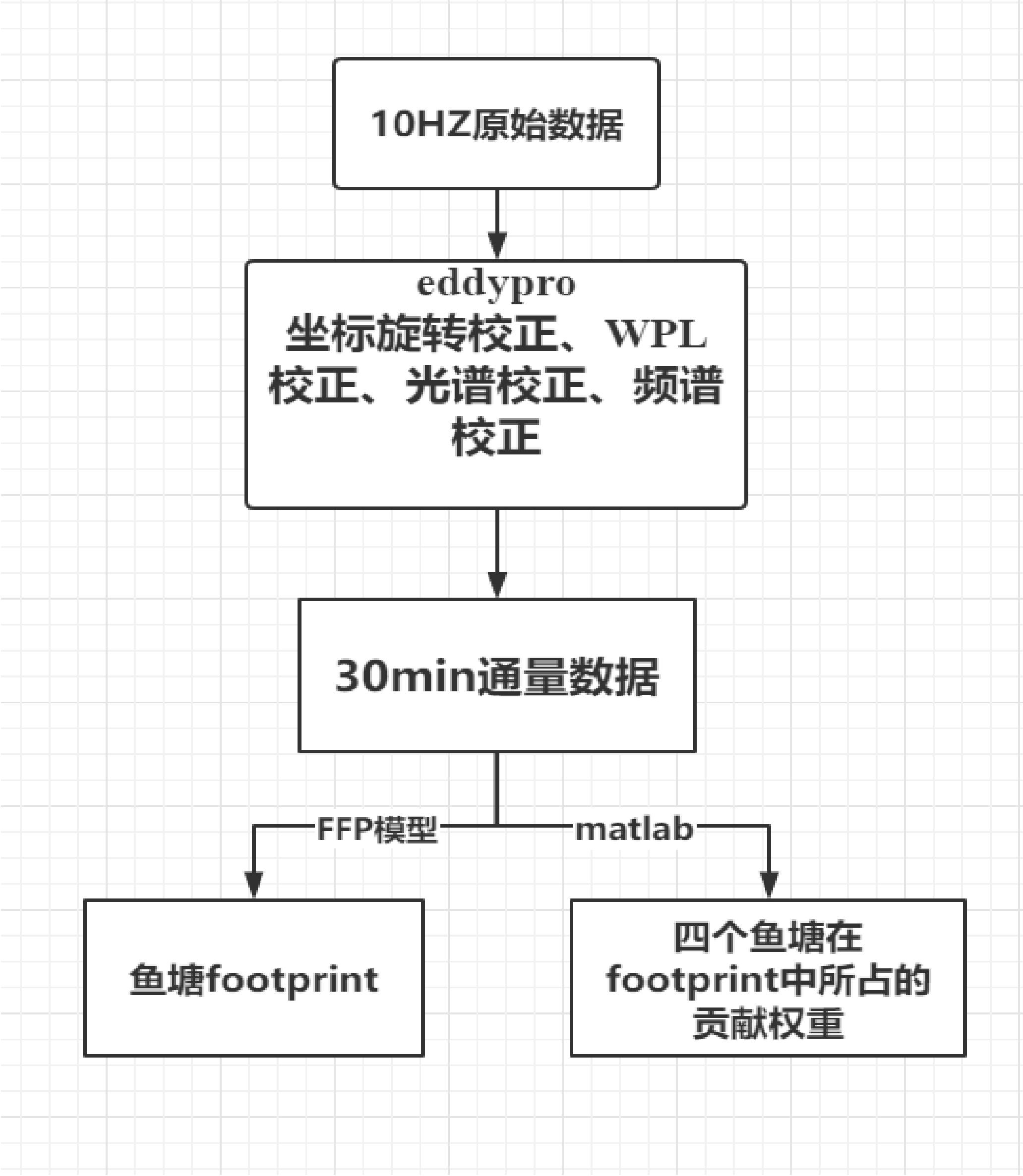
3.1.1 当前研究目的

通过FFP通量源区模型来计算四个鱼塘在80%通量源区内的通量贡献权重，以此评价四个鱼塘在涡度相关系统中所观测到的通量信号之间的贡献差异。

3.1.2 最终研究目的

基于FFP通量源区模型对官渡鱼塘以及周边不同下垫面的EC观测到的CO_2通量信号进行拆分，计算出不同鱼塘及下垫面的CO_2通量贡献权重，从而分析CO_2通量信号的来源。

3.2 研究方法



10HZ原始数据
eddypro
坐标旋转校正、WPL校正、光谱校正、频谱校正
30min通量数据
FFP模型
matlab
鱼塘footprint
四个鱼塘在footprint中所占的贡献权重

3.2.1 footprint函数的获取

$$\phi_K = \overline{f^y}(x)\frac{1}{\sigma_y\sqrt{2\pi}}exp\left(\frac{-y^2}{2\sigma_y^2}\right)$$

FFP Input

All inputs as scalars

zm	= Measurement height above displacement height (i.e. z-d) [m]
z0	= Roughness length [m] - enter [NaN] if not known
umean	= Mean wind speed at zm [ms-1] - enter [NaN] if not known
h	= Boundary layer height [m]
ol	= Obukhov length [m]
sigmav	= Standard deviation of lateral velocity fluctuations [ms^{-1}]
ustar	= Friction velocity [ms^{-1}]

FFP output

FFP	= Structure array with footprint climatology data for measurement at [0 0 zm] m
FFP.x_2d	= x-grid of footprint climatology [m]
FFP.y_2d	= y-grid of footprint climatology [m]
FFP.fclim_2d	= Normalised footprint function values of footprint climatology [m^{-2}]
FFP.r	= Percentage of footprint as in input, if provided
FFP.fr	= Footprint value at r, if r is provided [m^{-2}]
FFP.xr	= x-array for contour line of r, if r is provided [m]
FFP.yr	= y-array for contour line of r, if r is provided [m]
	For array of percentage values, structure entries can be accessed as FFP(1).r, FFP(1).xr
FFP.n	= Number of footprints calculated and included in footprint climatology
flag_err	= 1 in case of error, 2 if not all contour plots (r%) within specified domain, 0 otherwise
	If the source area is calculated for 20%, 40%, 60% and 80%, and the 80% contour is extending further than the domain (but the other r's are within the domain), flag_err = 2 and all results are provided apart from those for the contour at 80%.

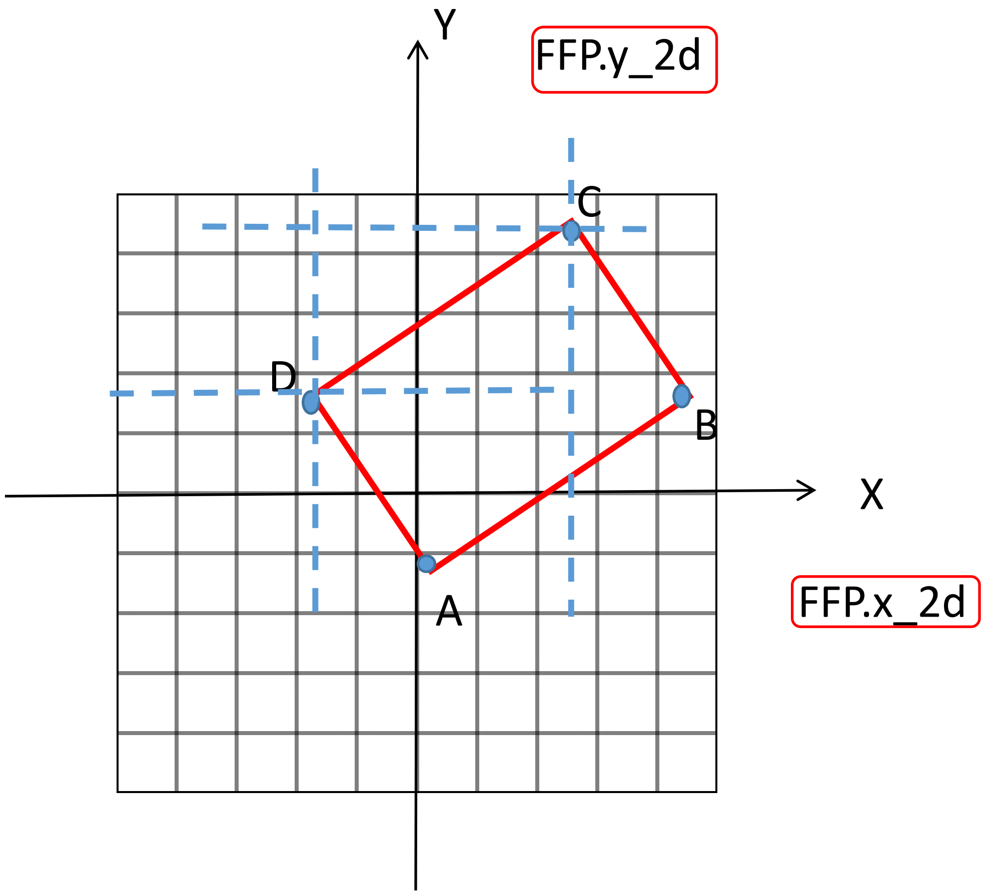
3.2.2 footprint 贡献权重的计算

$$\phi_{\Omega i} = \sum_{j=1}^{M} \phi_j . A_{cell}$$

Φ_j为footprint函数—FFP. fclim_2d

A_{cell}为所计算区域内网格点的面积— $S=_\triangle|y|^2$ m^2

M为网格点个数—斜率判断



4.初步工作

4.1 2018年footprint 和鱼塘通量贡献权重

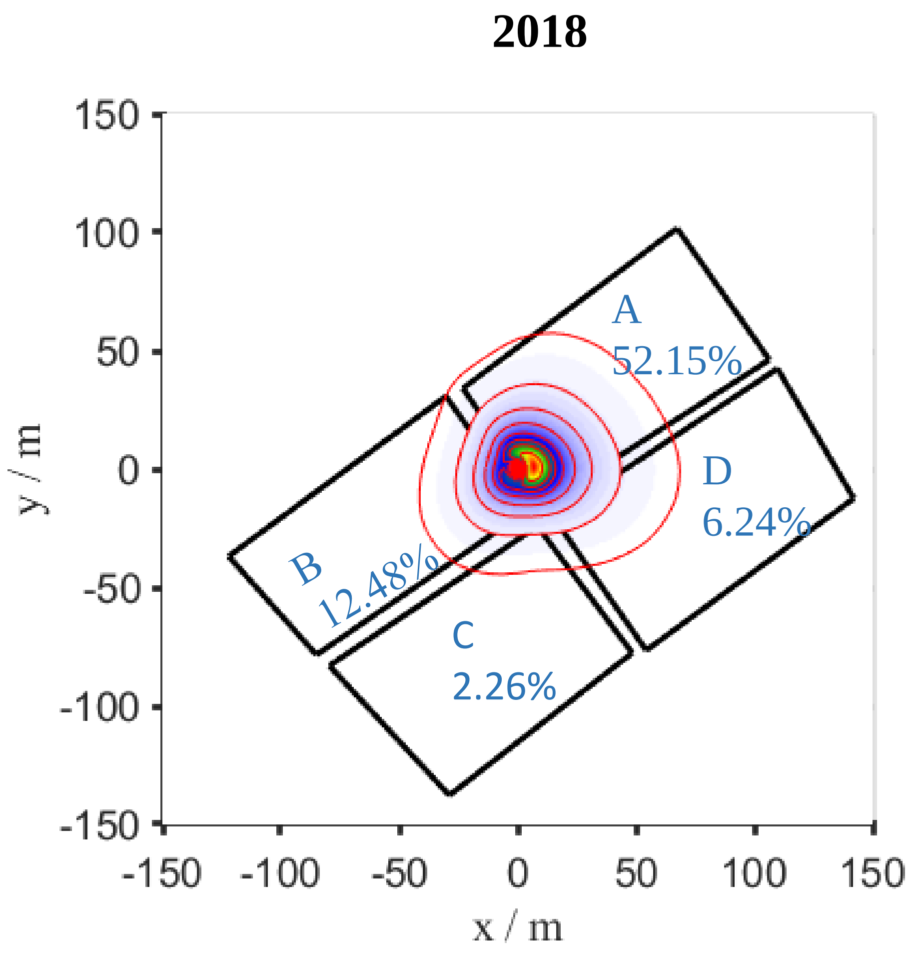


图3

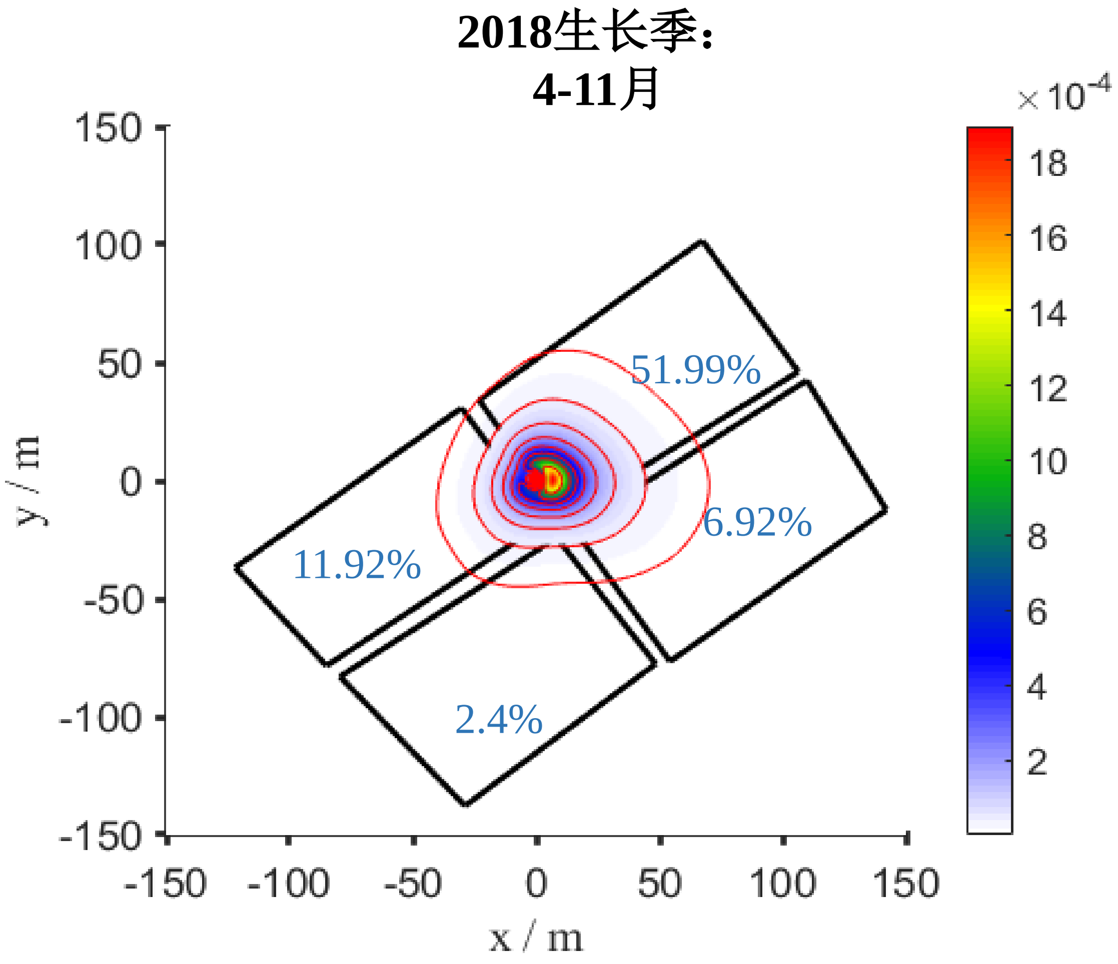
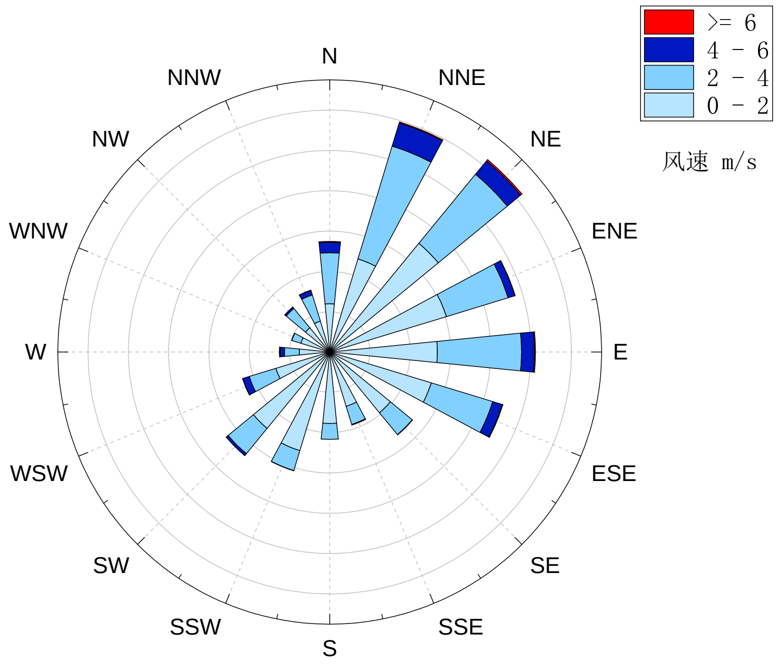


图4

2018风向玫瑰图



主风向为22.5°-112.5°

图5

2018主风向

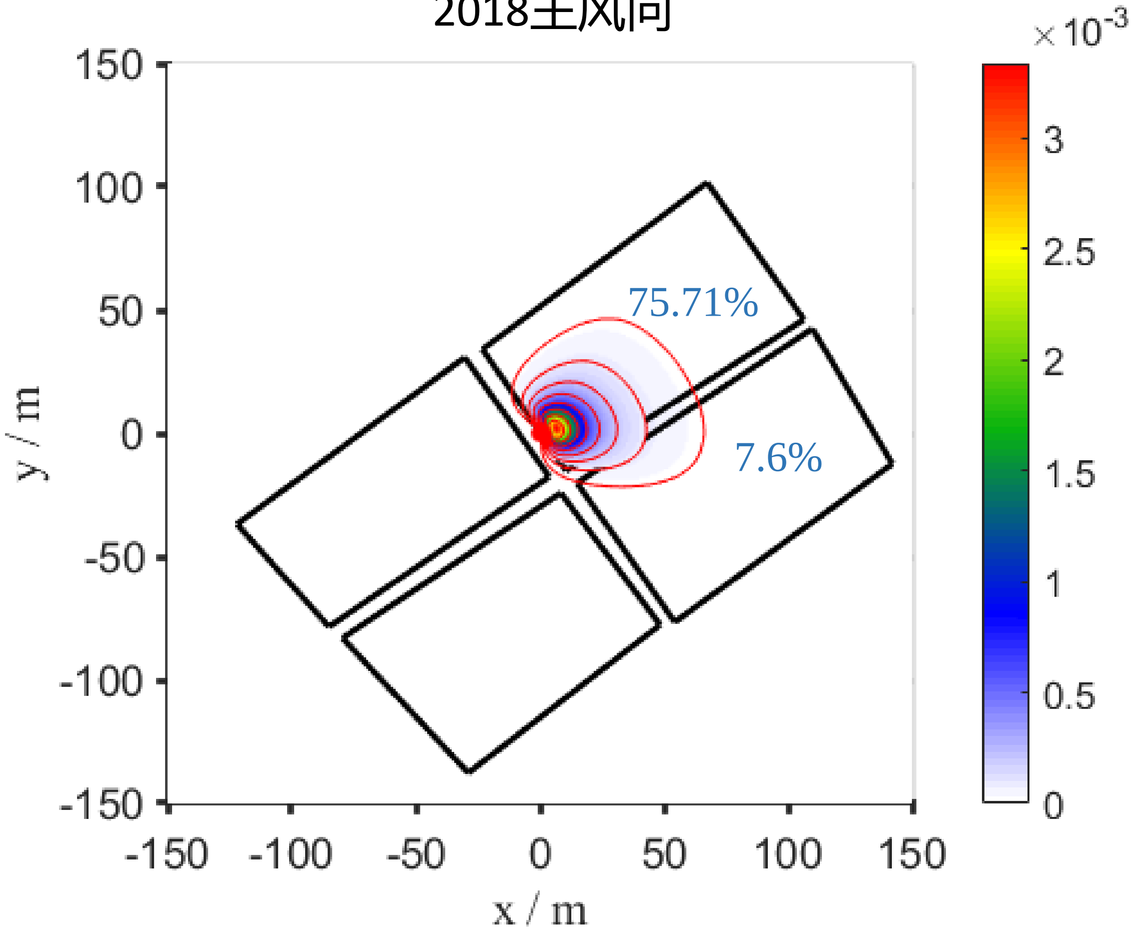
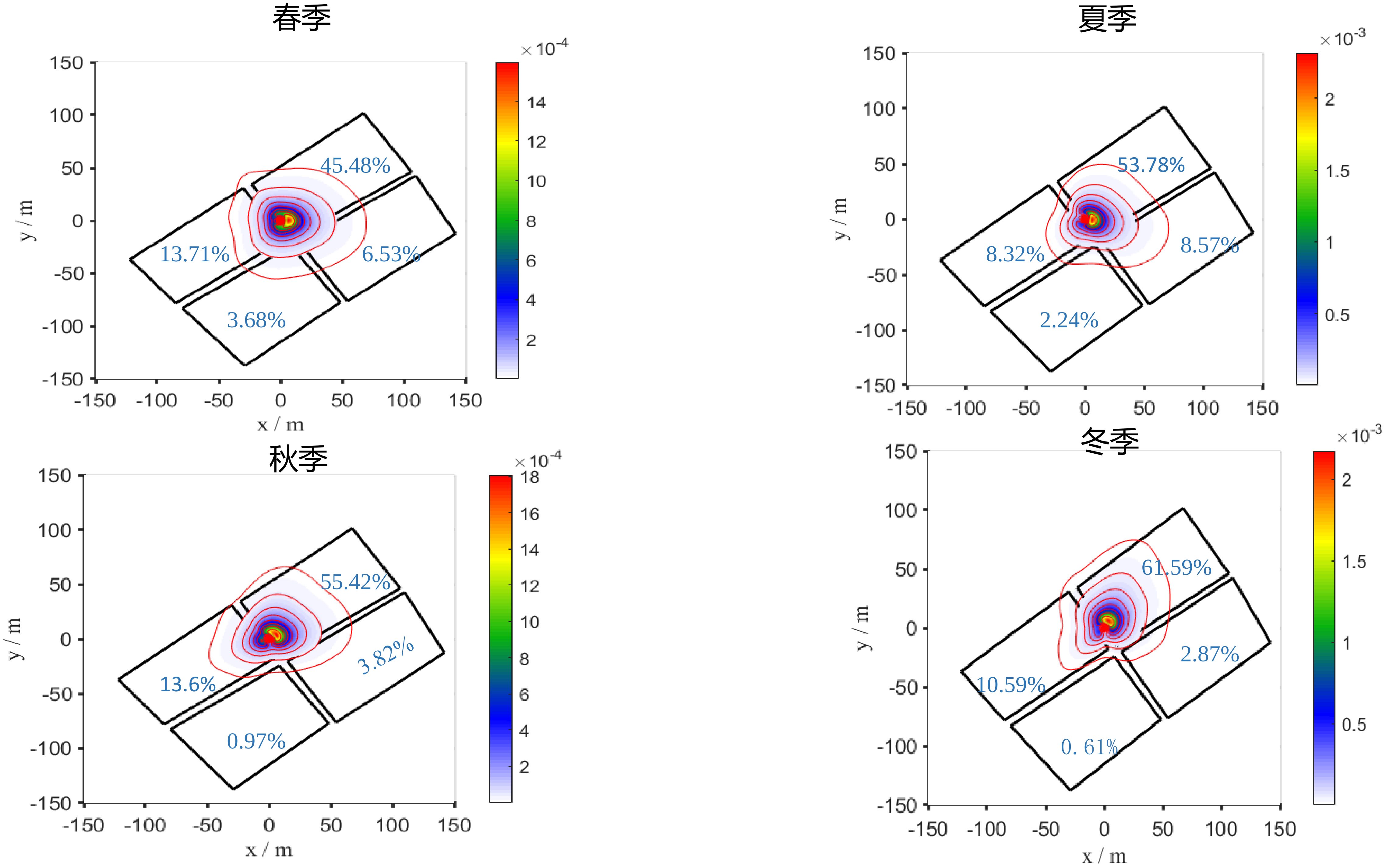


图6



春季
夏季
秋季
冬季
45.48%
13.71%
6.53%
3.68%
53.78%
8.32%
8.57%
2.24%
55.42%
13.6%
3.82%
0.97%
61.59%
10.59%
2.87%
0. 61%
x / m
y / m

四个鱼塘通量贡献总权重

	总权重
2018	73.13%
生长季	73.23%
春季	69.40%
夏季	70.17%
秋季	73.81%
冬季	75.36%
主风向	83.31%

表5

1. 可以看到在四个鱼塘的权重并没有达到100%。意味着在鱼塘外的下垫面也对EC观测的通量有所贡献。

2. 现在的80%footprint是包含鱼塘边的田埂，但目前并没有对其贡献权重进行计算。

5.下一步工作

1.计算出各鱼塘的CO_2通量值。

$$\langle F \rangle = \sum_{j=1}^{N} \langle \Lambda \rangle_j F_j ,$$

2.对鱼塘附近进行土地分类。

3.对除鱼塘外其余土地覆盖类型进行CO_2通量信号拆分。

感谢观看