Dynamics of Soil State Variables and Related Processes Across a Land Use Gradient in Spatial and Temporal Transition:

Space-Time Fields of CO_2 Flux at the Land Surface

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The Problem:

Process behavior of soil state variables of soil water, carbon and nitrogen in space and time, characterized through:

spatial covariance
temporal covariance
representativity
spatial association
temporal stability

For a given sample size, spacing and domain, how do relevant soil state variables vary in space and time and to which other variables are they related?

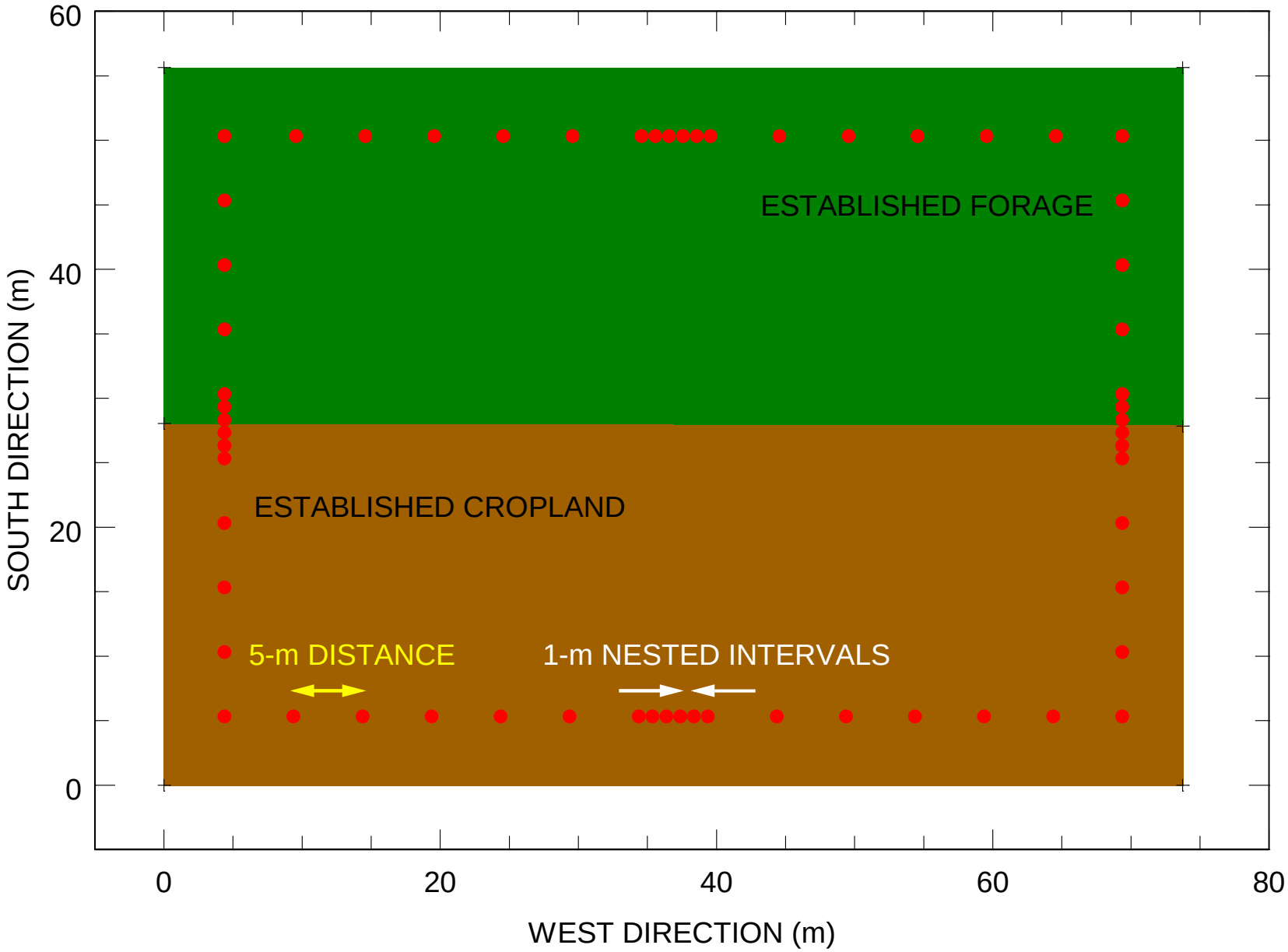
The Objectives:

- To characterize spatial and temporal processes of soil water, organic carbon, nitrogen and underlying processes (e.g., textural composition) and their spatio-temporal associations

- To understand spatio-temporal process behavior in two land use systems

- To characterize processes before, during and after land use change.

The Approach:



Measurements:

Nested transect approach:

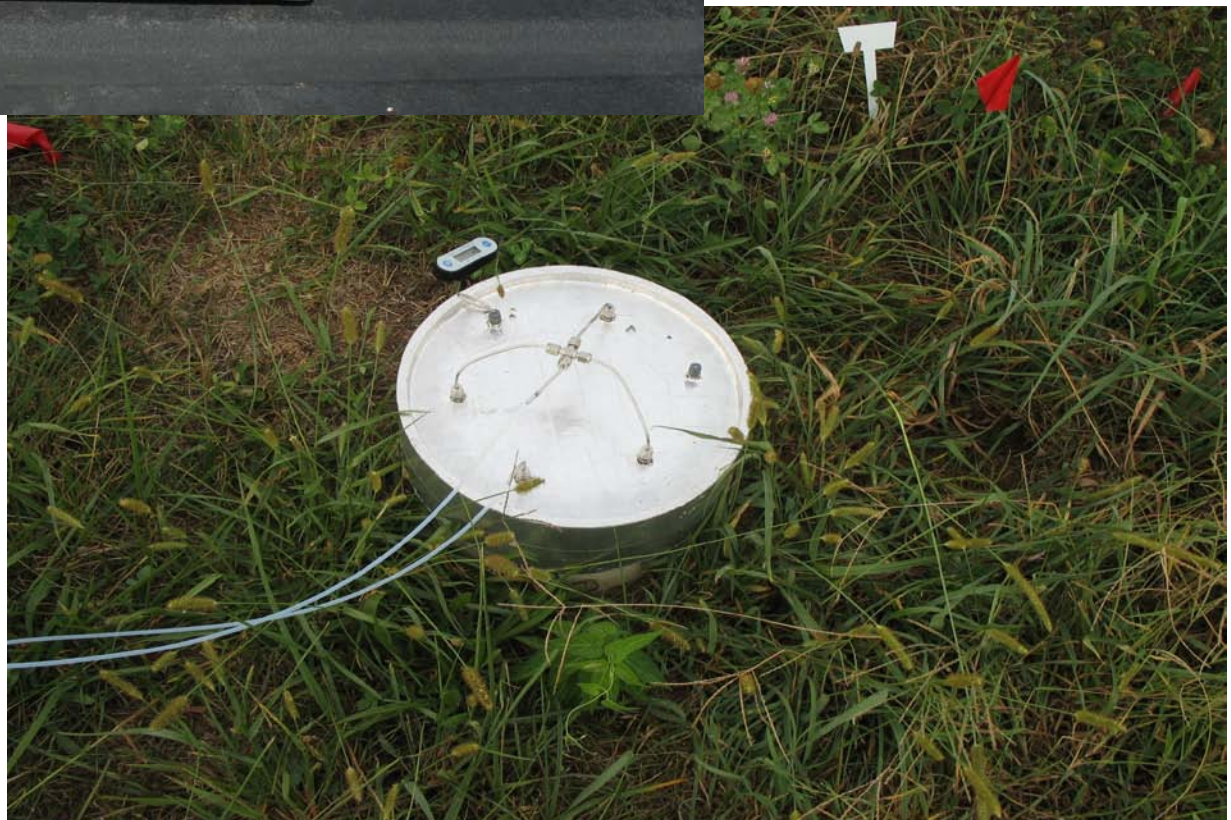
- Soil textural composition
- Surface gas fluxes: CO_2, N_2O, NH_4
- Soil temperature
- Soil water content (10-cm-depth increments)
- Field hydraulic conductivity K(h), h = -10, -5, -1 cm
- Aggregate stability
- Gas diffusivity – air-filled porosity relationship
- Soil hydraulic properties

Statistical Analysis:

- Spatial and temporal covariance
- Temporal stability
- State-space analysis, autoregressive and physically-based time series filter

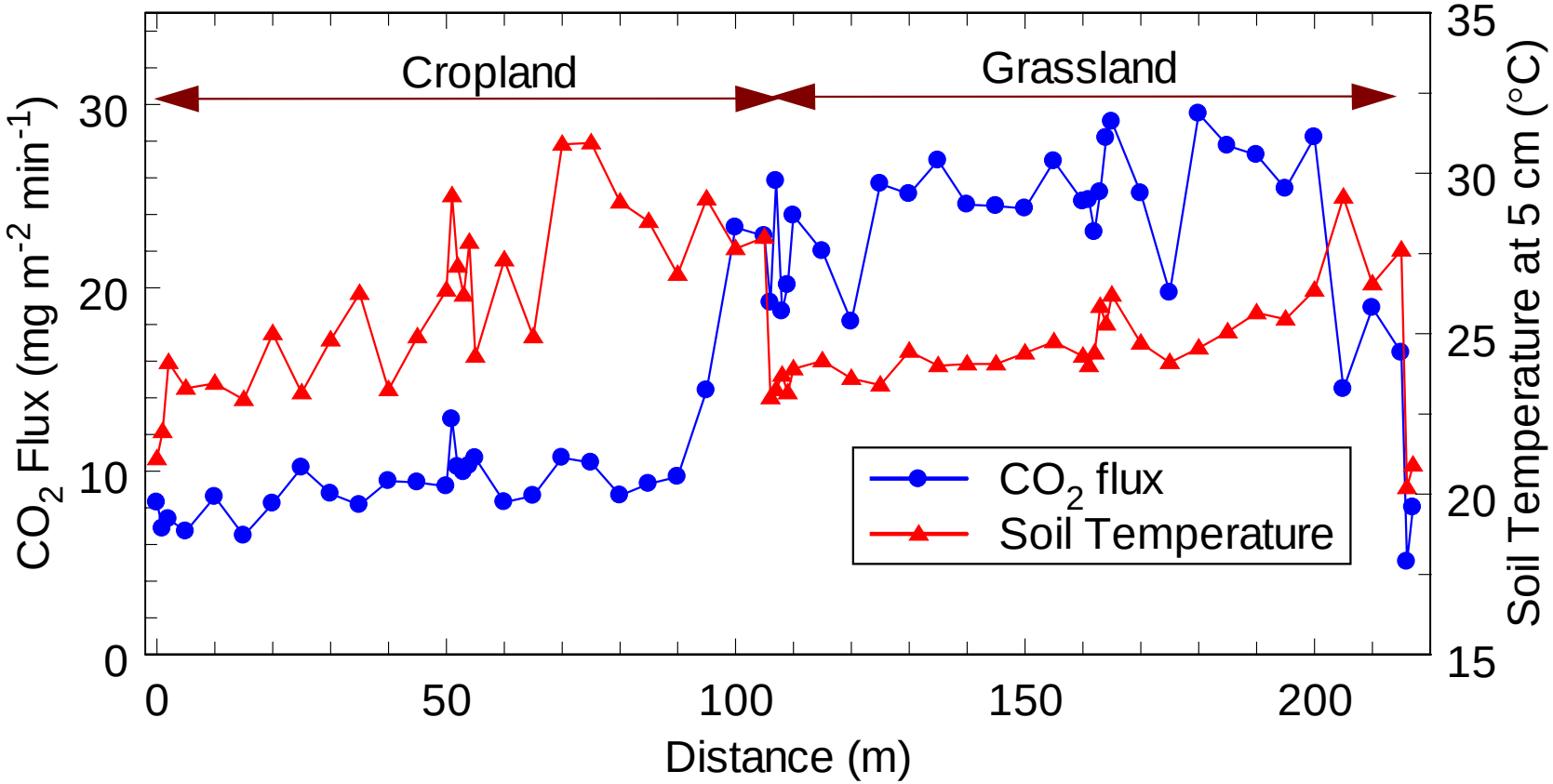
Focus:

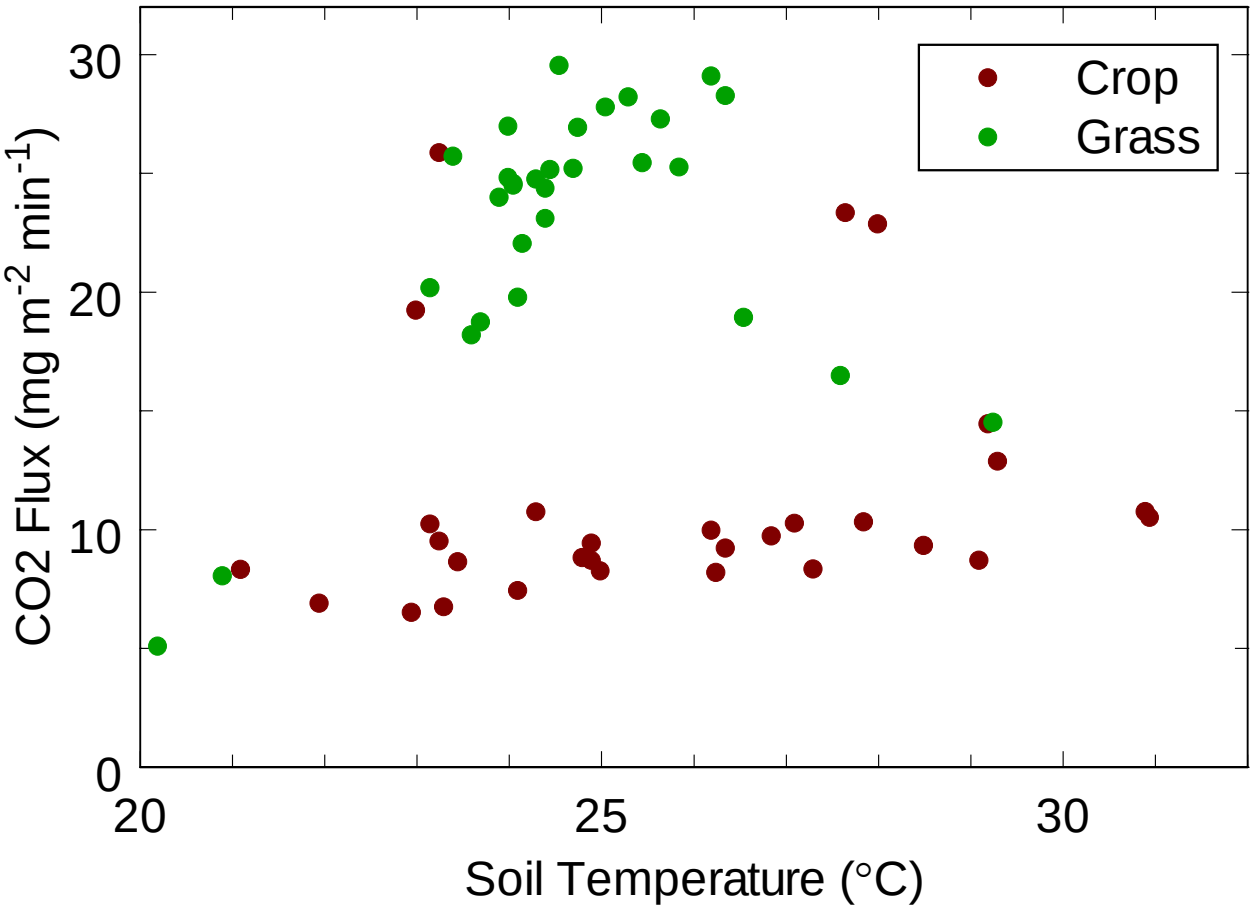
- Space- time patterns and analysis of surface CO_2 flux

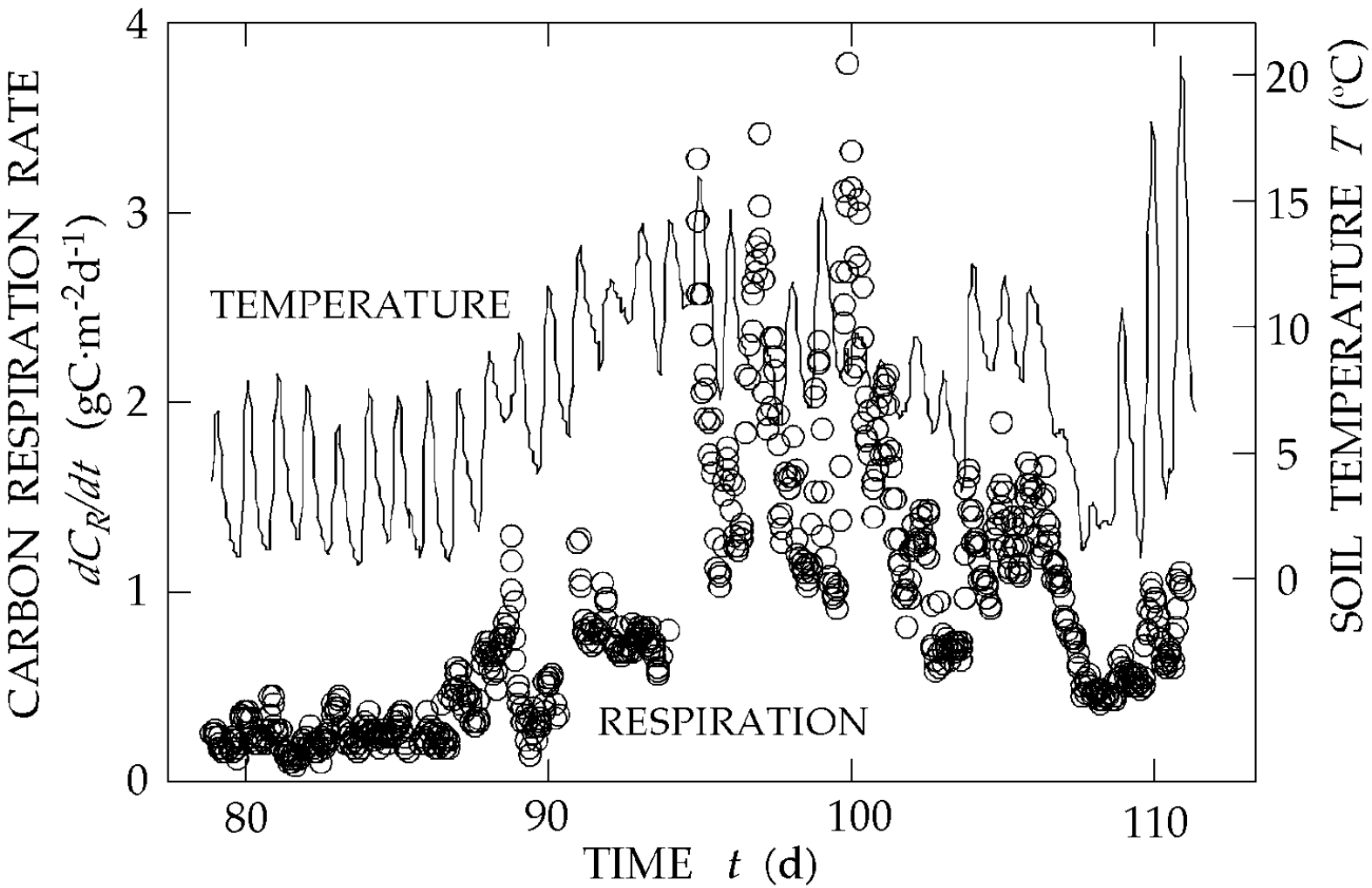


Photoaccoustic Gas Monitor

Results:


Cropland
Grassland
CO_2 Flux (mg m^{-2} min^{-1})
Soil Temperature at 5 cm (°C)
Distance (m)
CO_2 flux
Soil Temperature
0
10
20
30
15
20
25
30
35
0
50
100
150
200

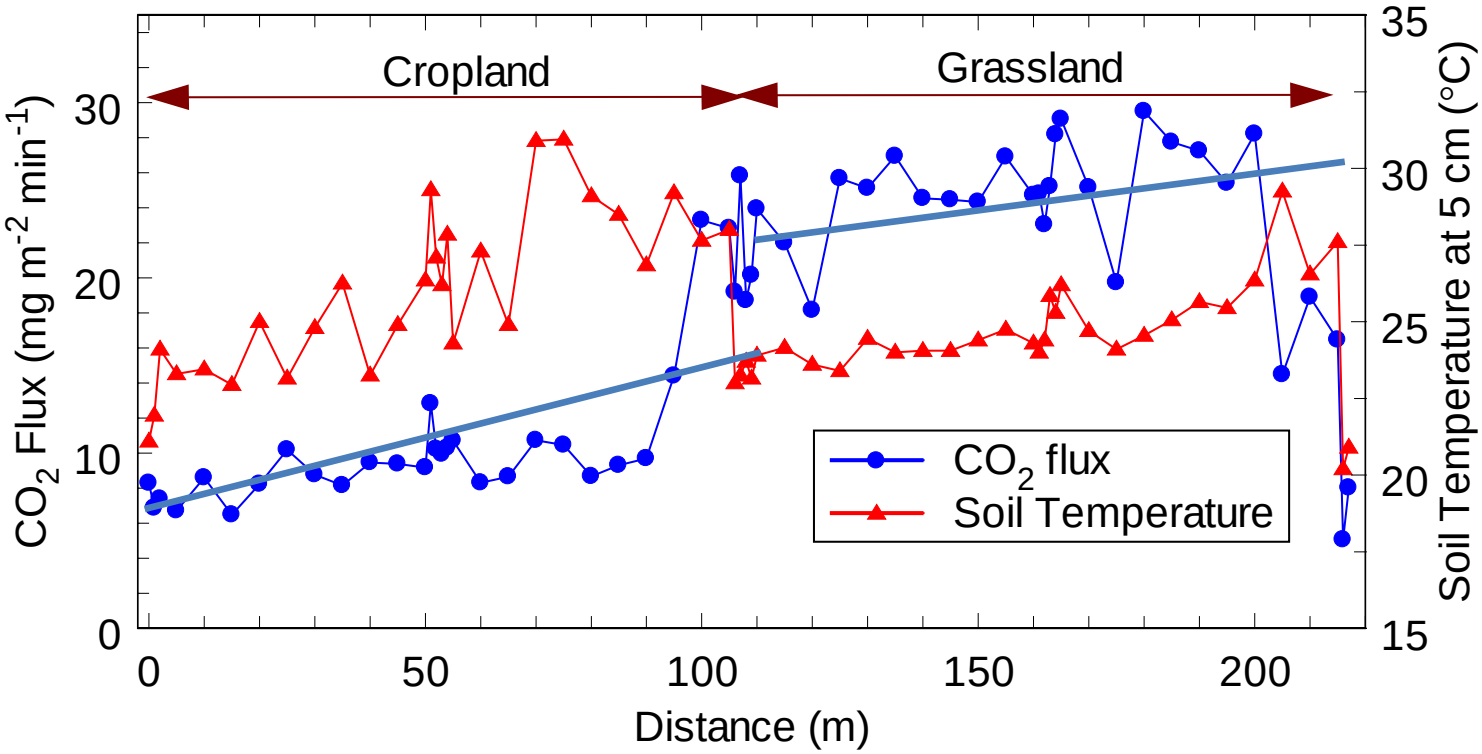

Crop
Grass
CO2 Flux (mg m-2 min-1)
Soil Temperature (°C)
0
10
20
30
20
25
30

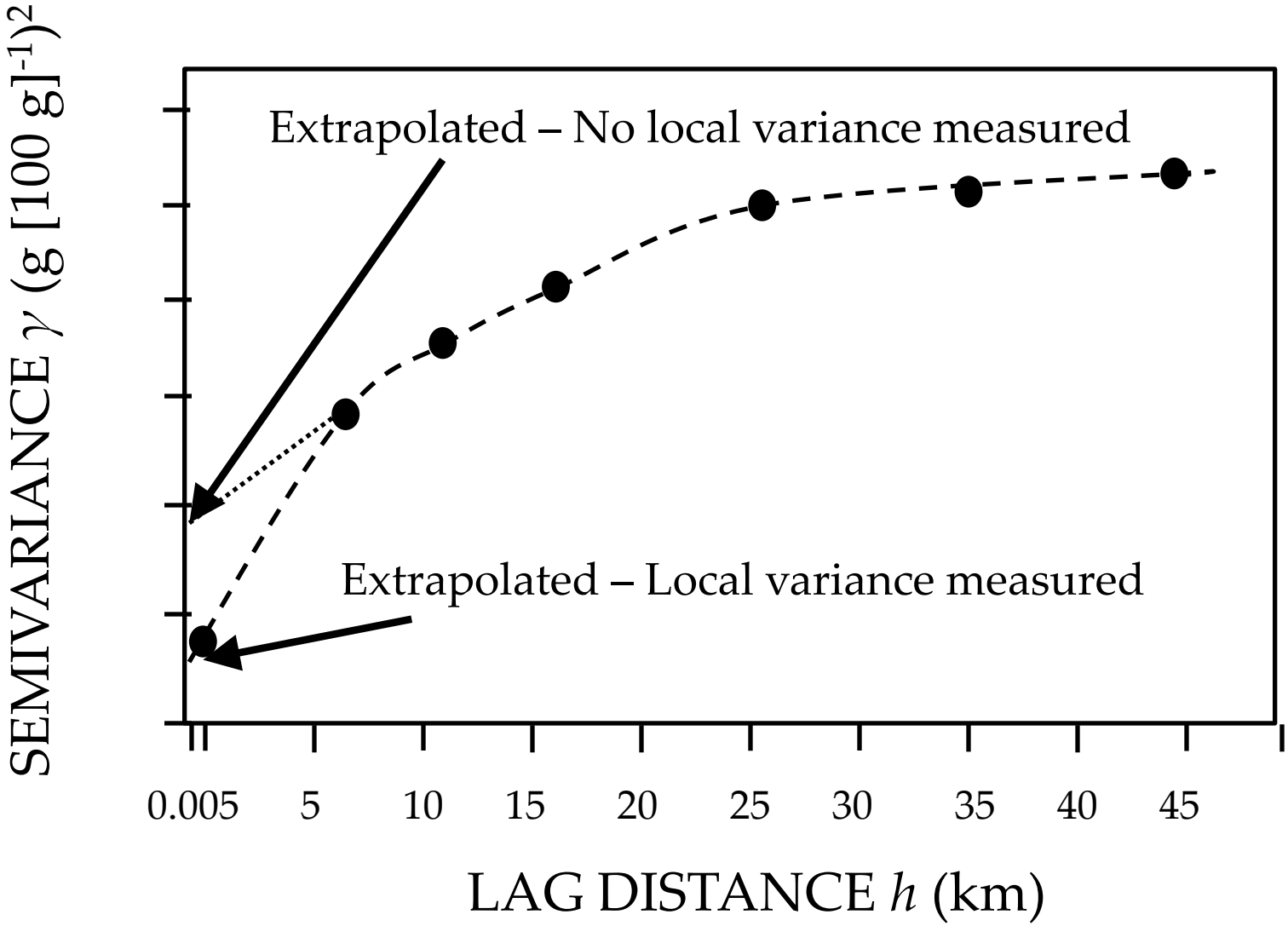


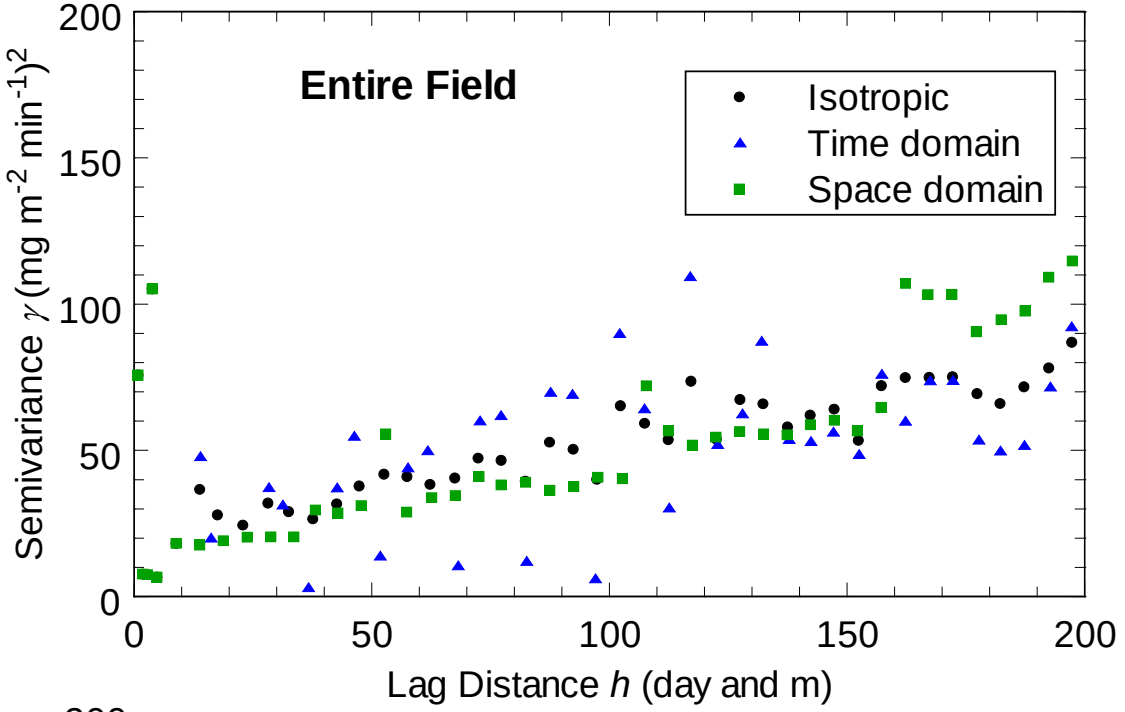
Nielsen and Wendroth, 2003

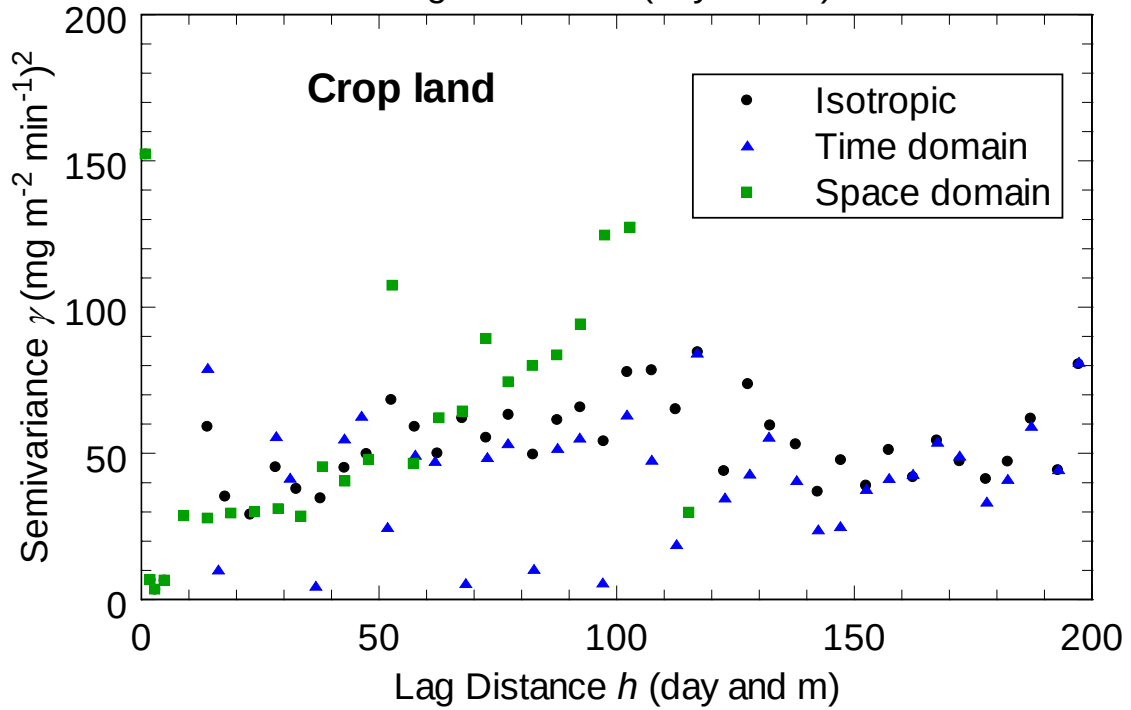
How to adjust Gas flux measured during a day for the effect of ambient soil temperature?

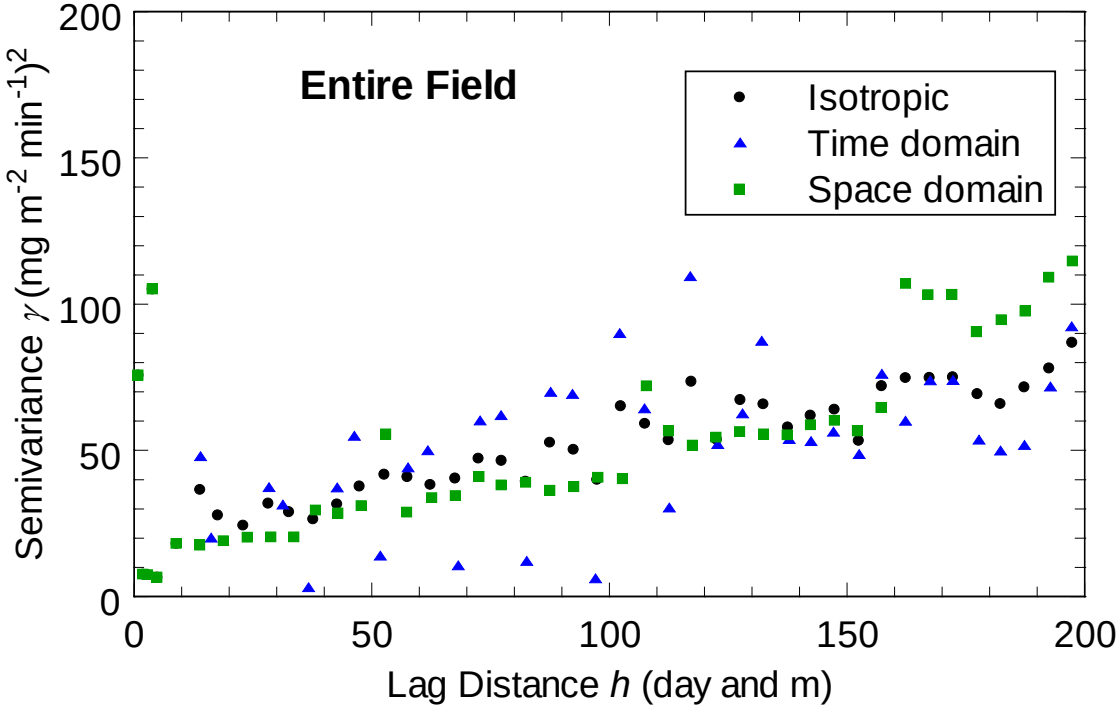
Time-regression approach:

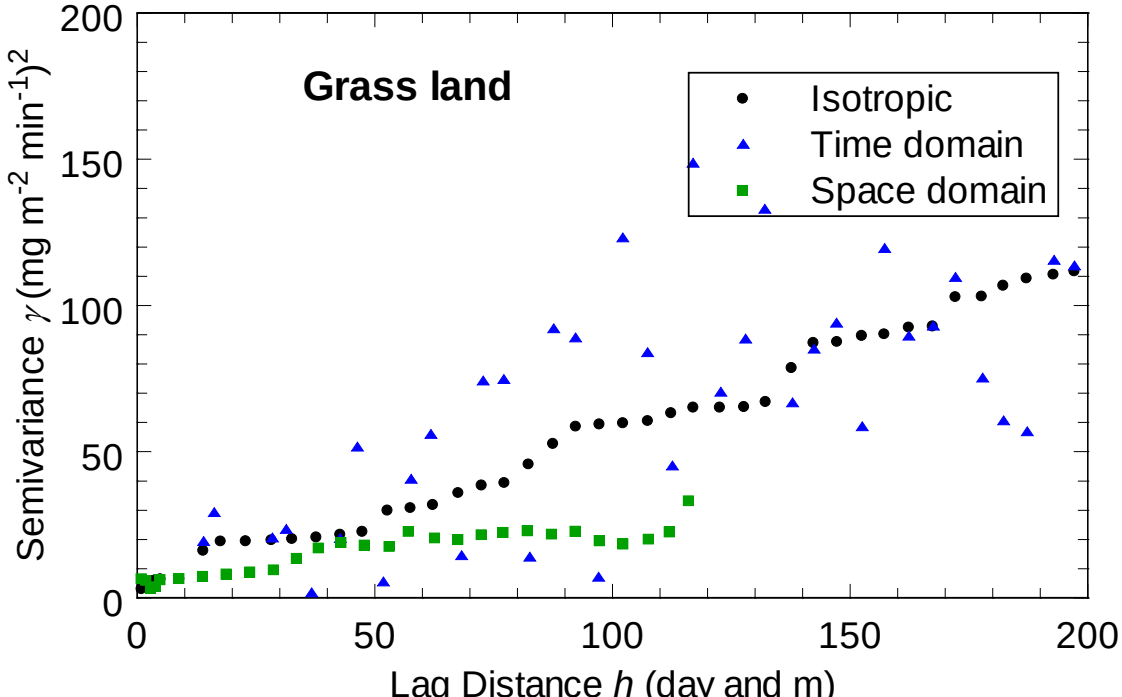



Extrapolated – No local variance measured
Extrapolated – Local variance measured
SEMIVARIANCE γ (g [100 g]-1)2
0.005
5
10
15
20
25
30
35
40
45
LAG DISTANCE h (km)

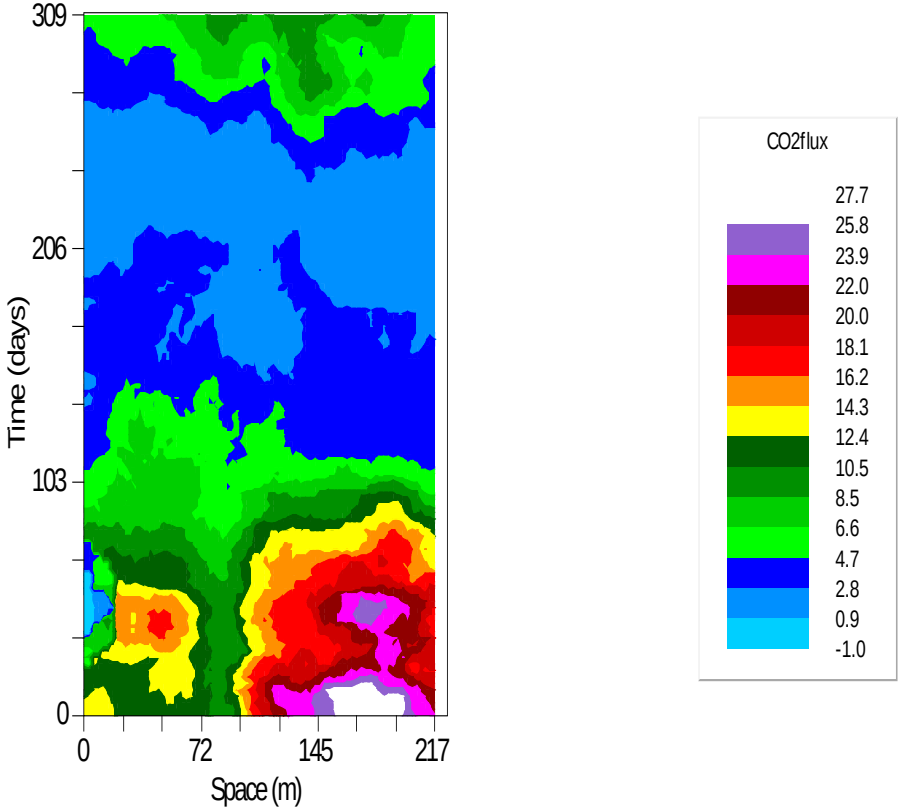

Entire Field
Isotropic
Time domain
Space domain
Semivariance γ (mg m-2 min-1)2
Lag Distance h (day and m)
0
50
100
150
200


Crop land
Isotropic
Time domain
Space domain
Semivariance γ (mg m-2 min-1)2
Lag Distance h (day and m)
0
50
100
150
200

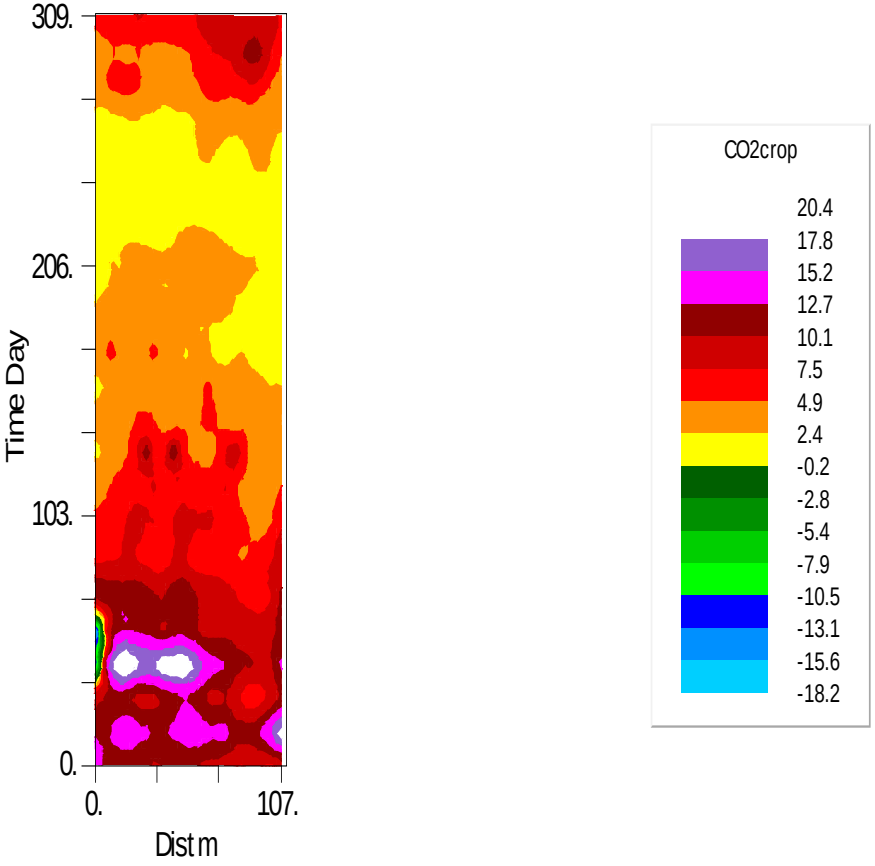

Entire Field
Isotropic
Time domain
Space domain
Semivariance γ (mg m-2 min-1)2
Lag Distance h (day and m)
0
50
100
150
200


Grass land
Isotropic
Time domain
Space domain
Semivariance γ (mg m-2 min-1)2
Lag Distance h (day and m)
0
50
100
150
200

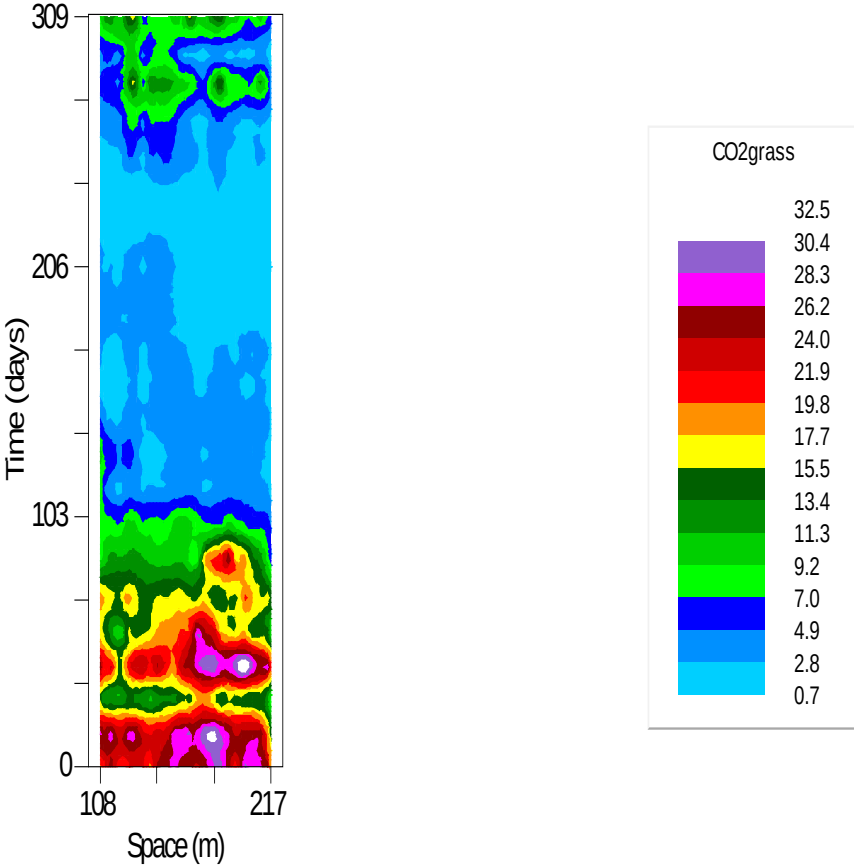
Entire Field



Cropland



Grassland



Temporal stability of spatial behavior:

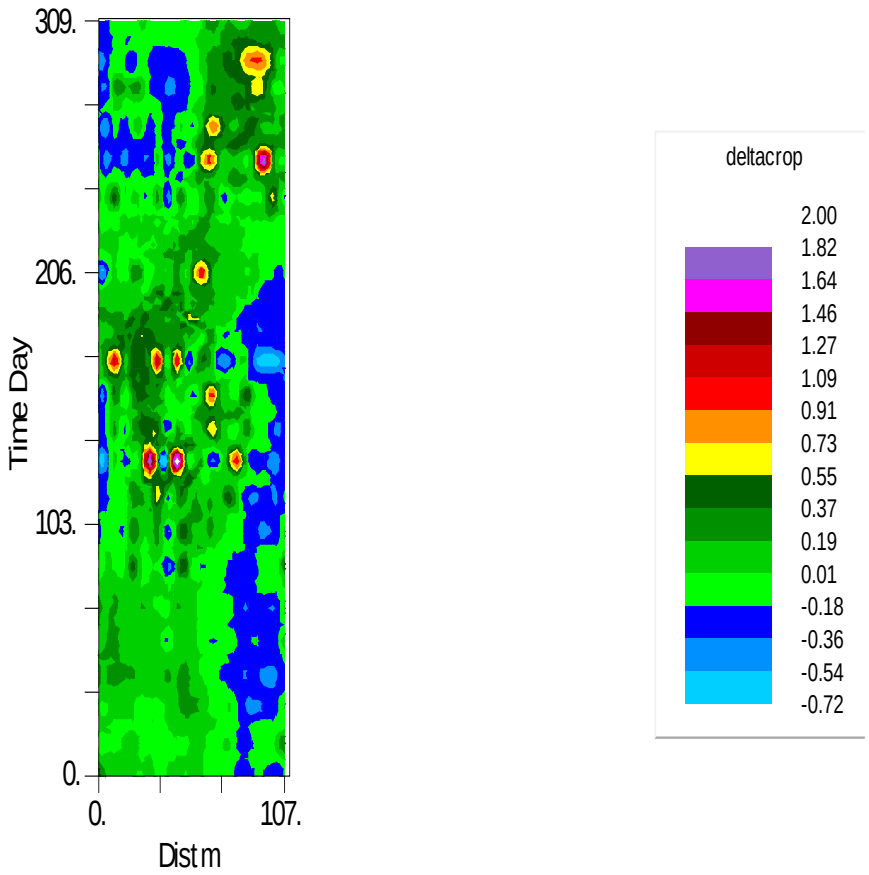
Vachaud et al. (1985):

$$\Delta_{i,j} = F_{i,j} - \overline{F}_j$$

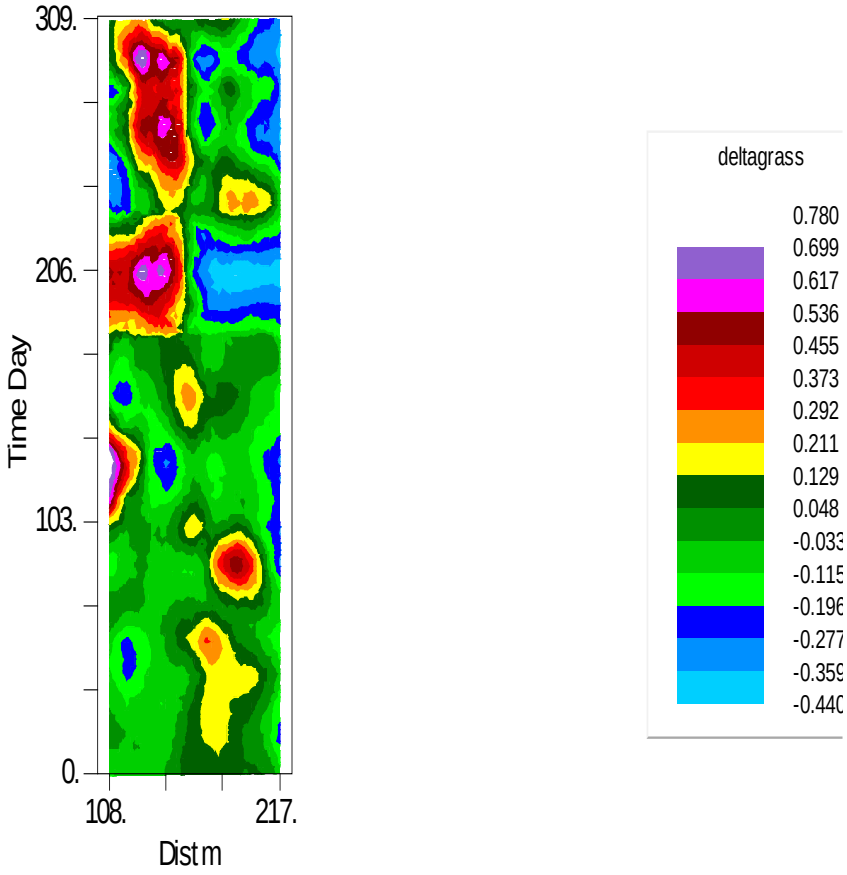
$$\overline{F}_j = \frac{1}{N}\sum_{i=1}^{N} F_{i,j}$$

$$\delta_{i,j} = \frac{\Delta_{i,j}}{\overline{F}_j}$$

Cropland



Grassland



Conclusion:

- New: Space-time field of CO_2-flux
- New: Approach to adjustment of measurements
- CO_2-flux varies twice as much in the temporal domain than in the spatial domain
- Obvious temporal stability in CO_2-fluxes
- On a relative basis, more pronounced patterns of CO_2-fluxes in grass land.

Future:

- What are the drivers of the variance
- Validate different adjustment methods

Acknowledgement:

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