THIRD CONFERENCE OF WORLD ASSOCIATION FOR SOIL AND WATER CONSERVATION

# Soil $CO_2$ emissions under different slope gradients and positions in semiarid Loess Plateau of China

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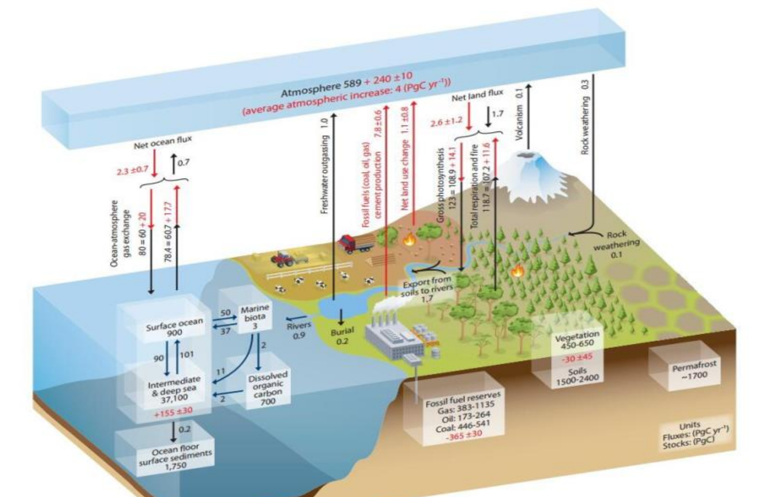
# Background



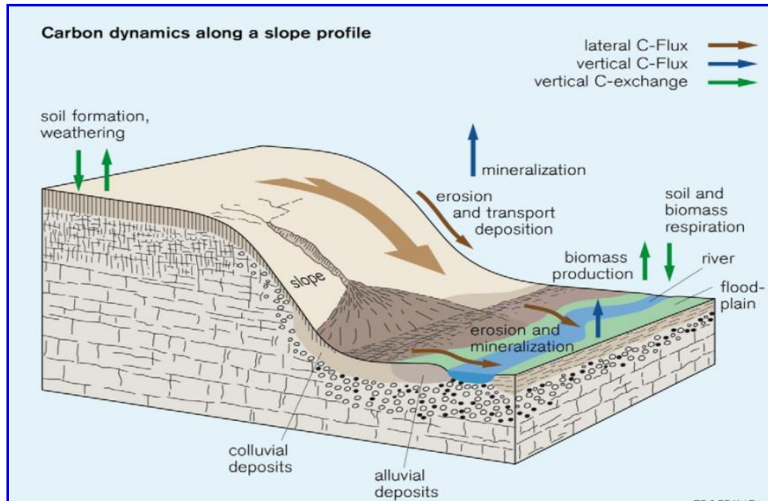

(IPCC，2013)

More than 60% of the global land areas are slopes of gradients > 8$^{o}$.

Variations in slope steepness potentially affect soil water and heat distribution, change soil properties and vegetation growth, which all possibly influence soil $CO_2$ emissions.

Soil $CO_2$ emissions, as a linkage, can have significant effects both on the atmospheric $CO_2$ concentration and soil organic carbon stock.

Substantial research dedicated to soil $CO_2$ emissions, but mostly on flat field. Nearly no investigation on $CO_2$ emissions on sloping land.




(Kirkels et al., Geomorphology, 2014, 226, 94–105)

# Background

The knowledge of the effect of slope land on soil $CO_2$ emissions is essential for a better understanding of the global atmospheric $CO_2$ budget and climate change.

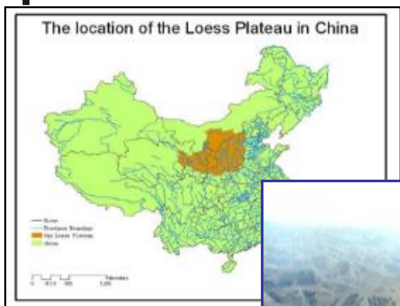
While generally regulated by soil moisture, SOC and fine root biomass, $CO_2$ emissions in sloping land are particularly affected by their spatial distribution on different slope gradients and positions.

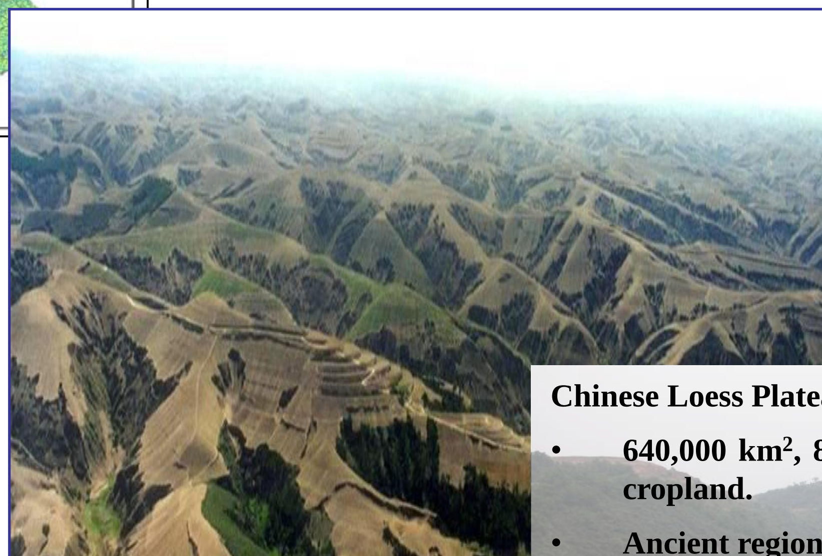
Soil moisture significantly lower than on plains, mostly because of the increase of runoff loss and a corresponding reduction in infiltration;

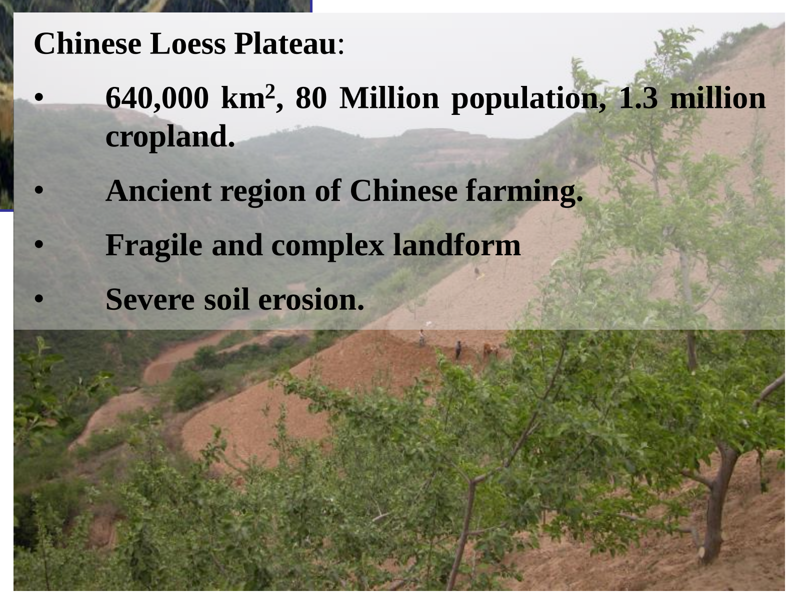
Soil moisture can also be spatially different along the slope.

SOC, as the main substrate for microbial organism, can also differ spatially along slopes due to selective or non-selective erosion effects.

# Background





**Chinese Loess Plateau**:

- **640,000 km$^2$, 80 Million population, 1.3 million cropland.**
- **Ancient region of Chinese farming.**
- **Fragile and complex landform**
- **Severe soil erosion.**

# Objectives

**In this study:**

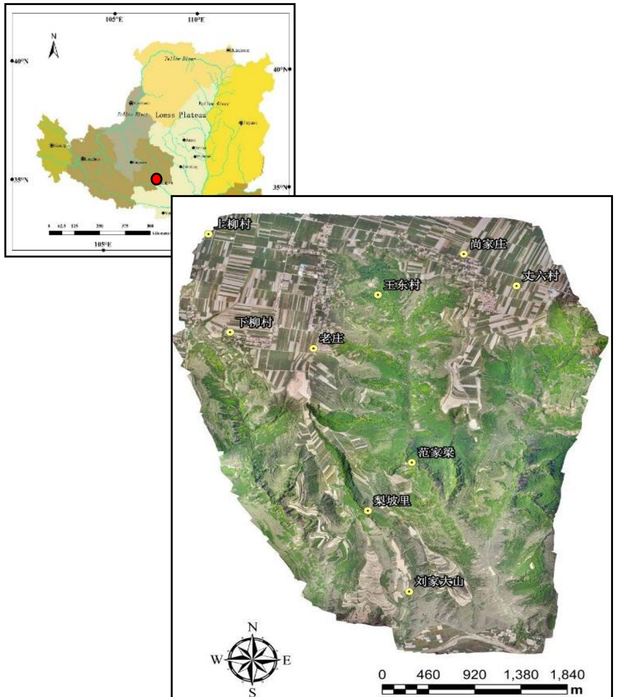
**the magnitude of $CO_2$ emissions at different slope gradients were related to erosion induced variations of water, crop growth and SOC across slope gradients and positions.**

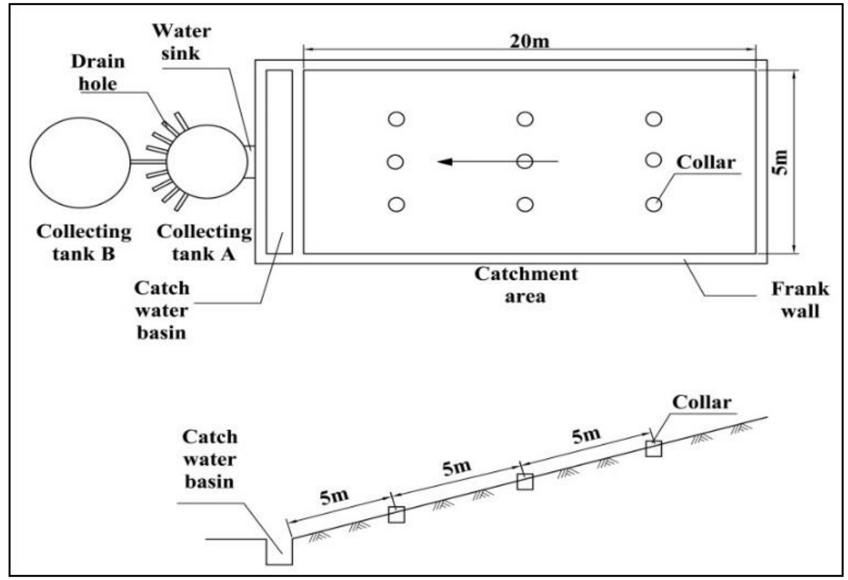
**With the aim to investigate:**

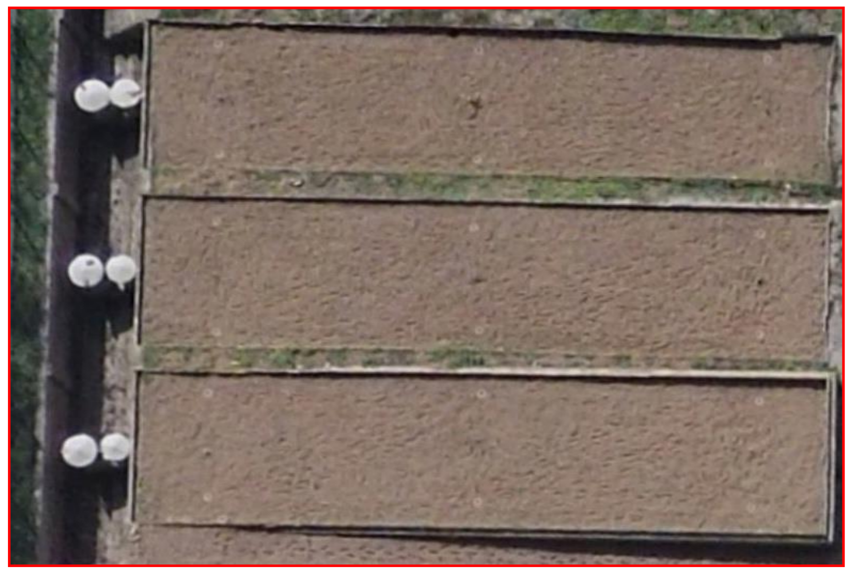
**1) to compare the differences of $CO_2$ emissions across slope gradients and positions;**

**2) to evaluate the potential effects of slope differentiated water, crop growth and SOC on $CO_2$ emissions at an eroded slope.**

# Material & Methods – Exp. Design



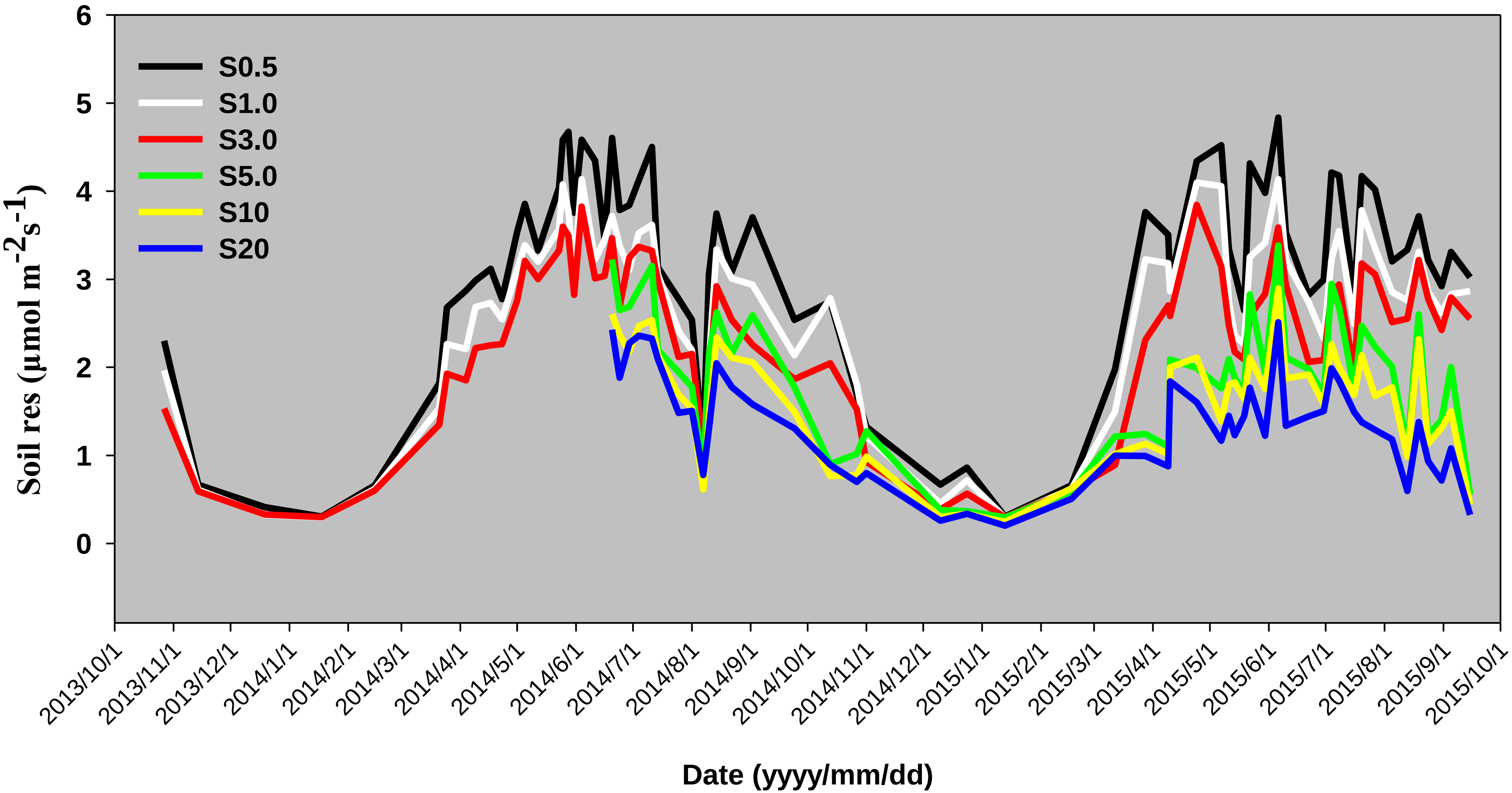



**Six slope gradients：**

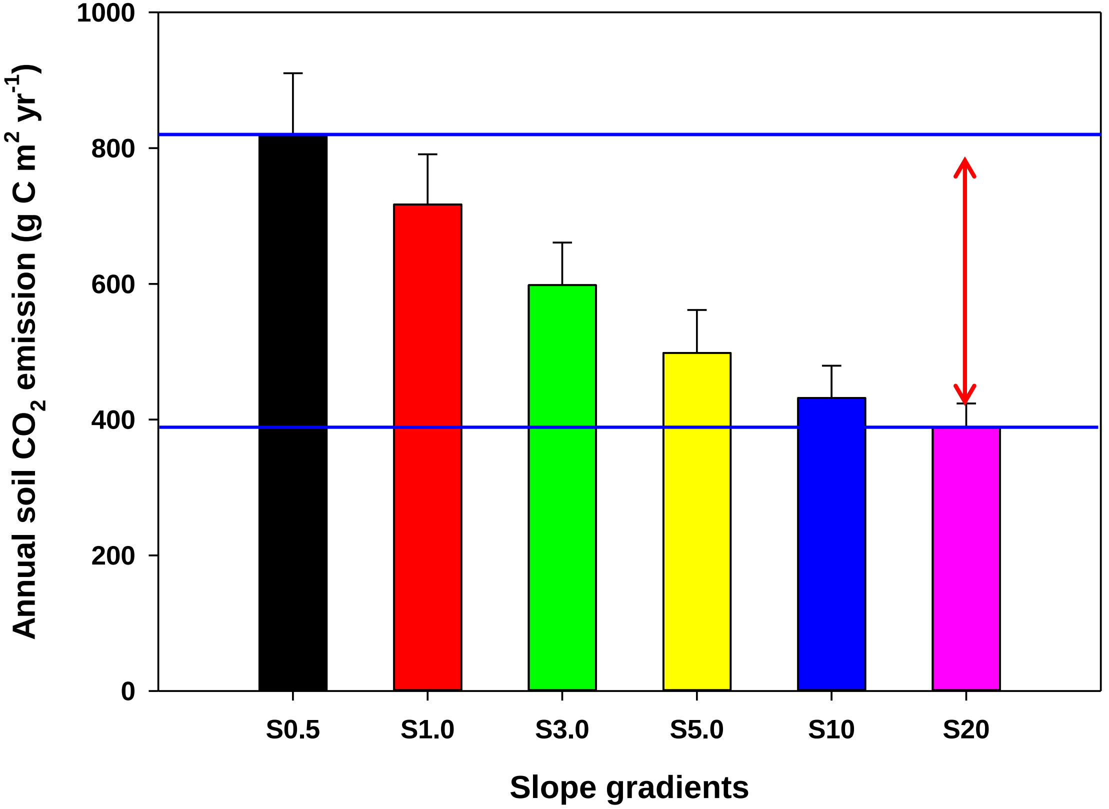
- 0.5° ($S_{0.5}$)
- 1° ($S_1$)
- 3° ($S_3$)
- 5° ($S_5$)
- 10° ($S_{10}$)
- 20° ($S_{20}$)

# Results – soil $CO_2$ emission rates from six slopes

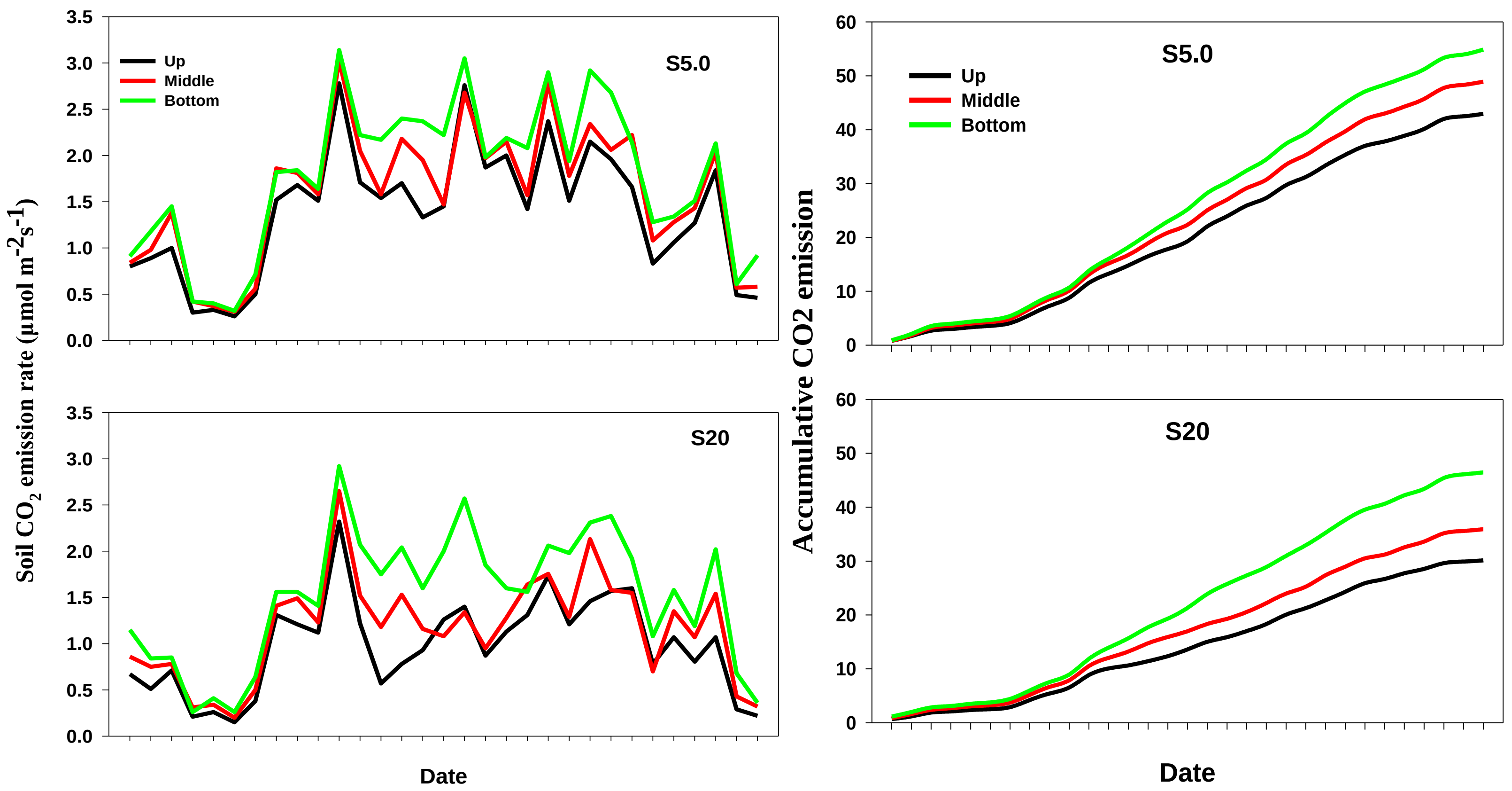



- **Temporal variations over seasons**
- **Soil $CO_2$ emission rates decreased with slope gradients**

# Results – soil annual $CO_2$ emissions from six slopes

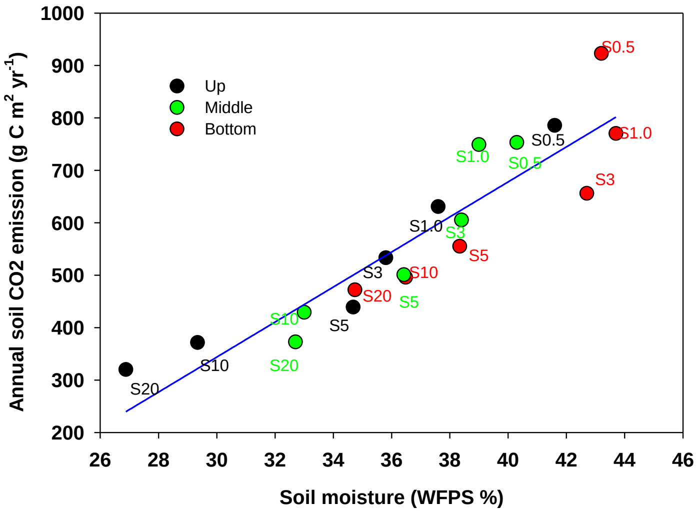


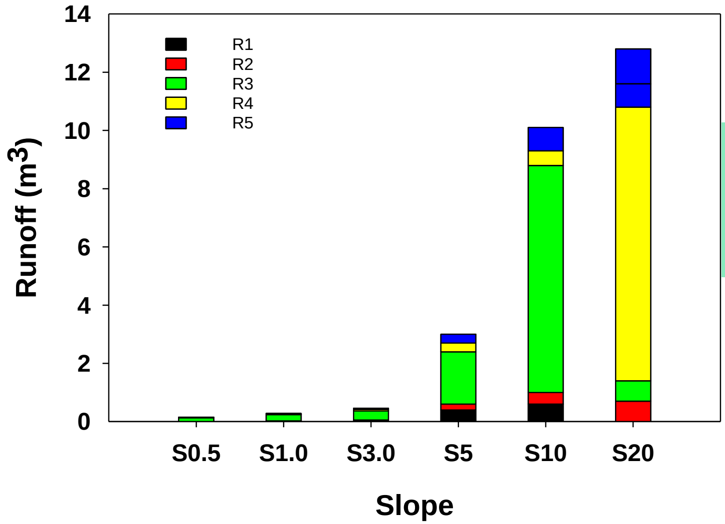
# Results – soil $CO_2$ emissions on three slope positions



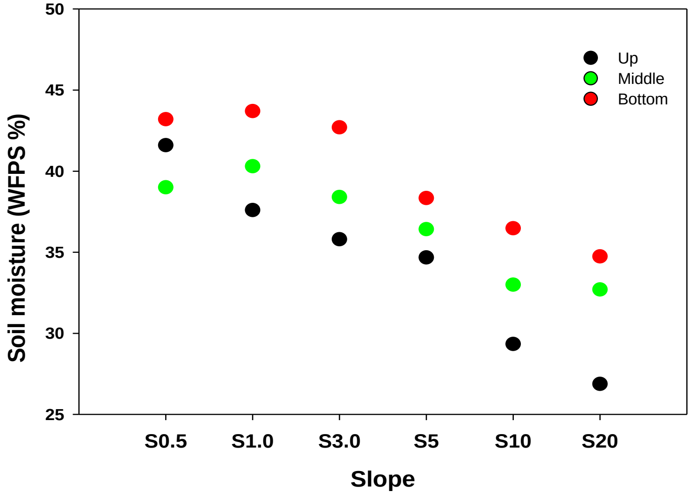

**Upper < Middle < Bottom**

# Results – soil $CO_2$ emissions and soil moisture



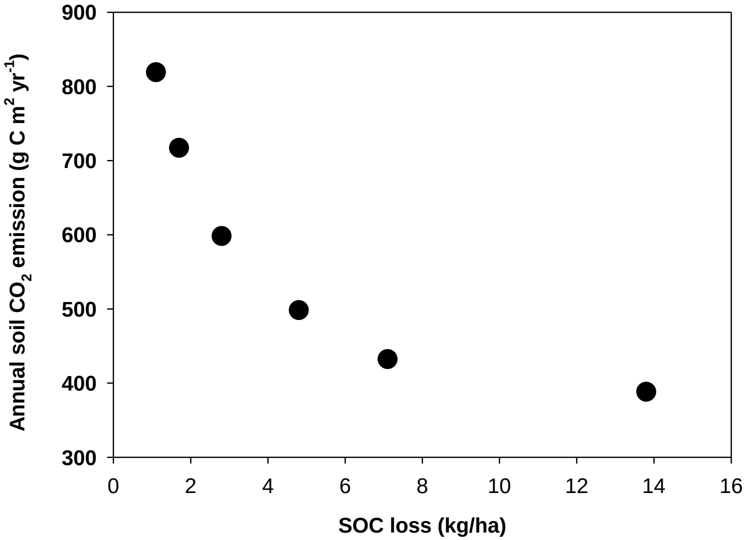

More runoff, thus less water on steeper slopes

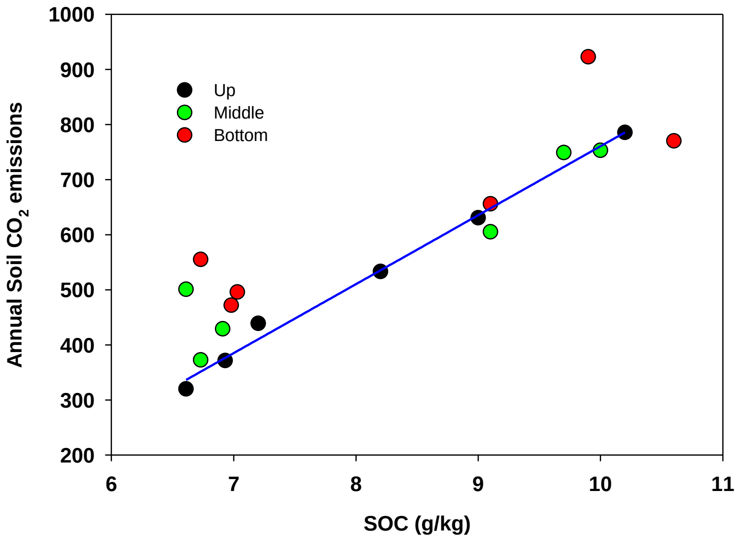



Water tends to accumulate at lower positions

- **Soil annual $CO_2$ emissions linearly increased with soil moisture**
- **Soil water differentiated among six slopes, and also spatially redistributed across three slope positions**

# Results – soil $CO_2$ emissions and SOC redistribution



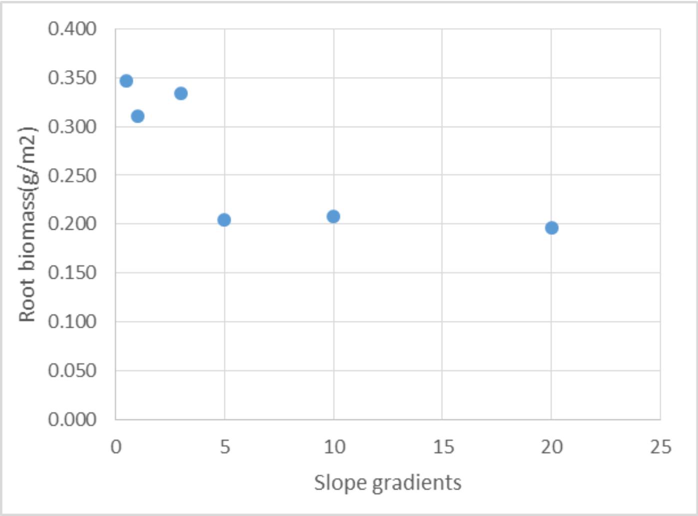



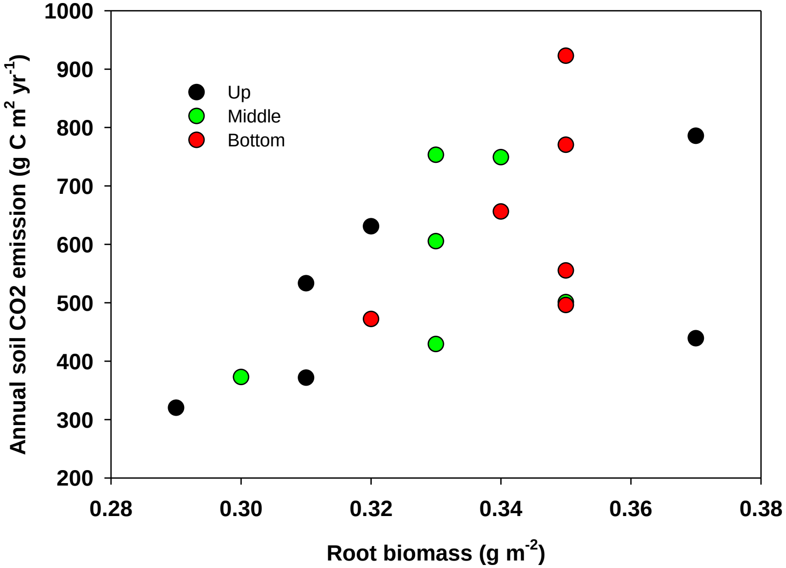

- **Soil annual $CO_2$ emissions exponentially decreased with SOC loss**

- **SOC loss differentiated among six slopes, and also spatially redistributed across three slope positions**

**More runoff, thus more SOC loss on steeper slopes**

# Results – soil $CO_2$ emissions and root biomass



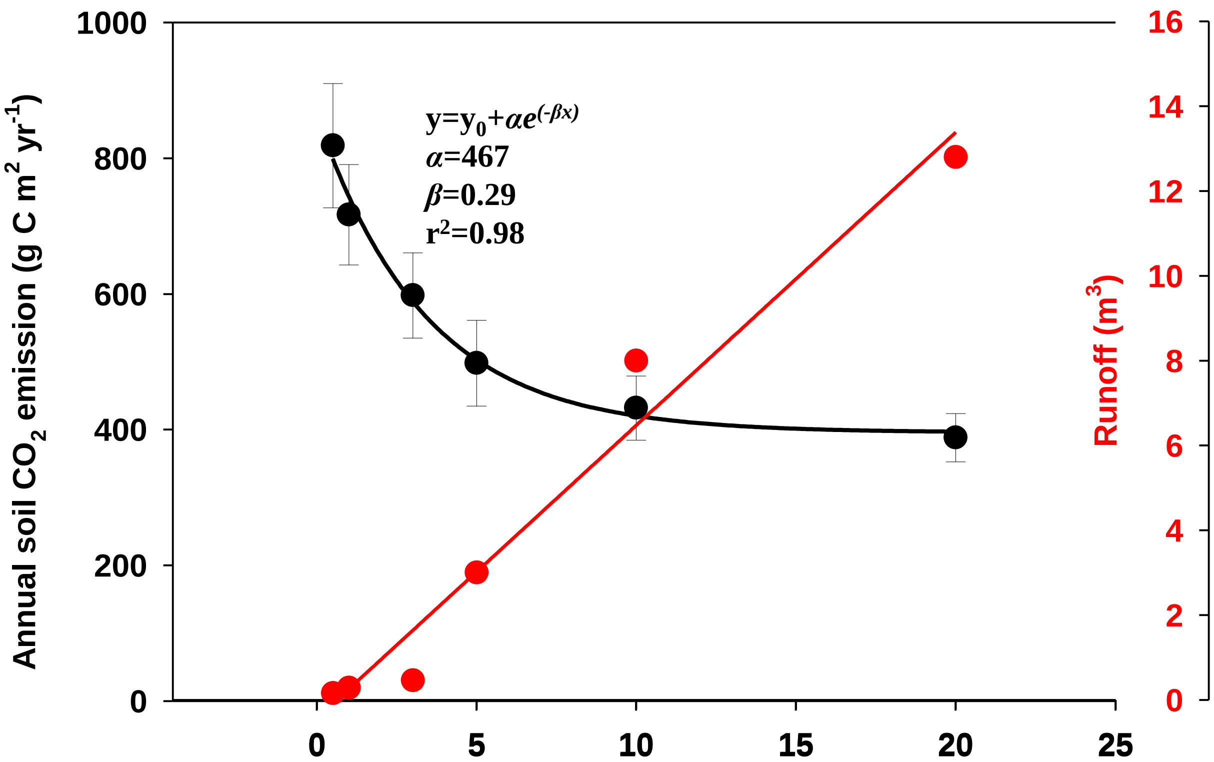




**Greater root biomass at lower positions, potentially contributing higher $CO_2$ emissions**

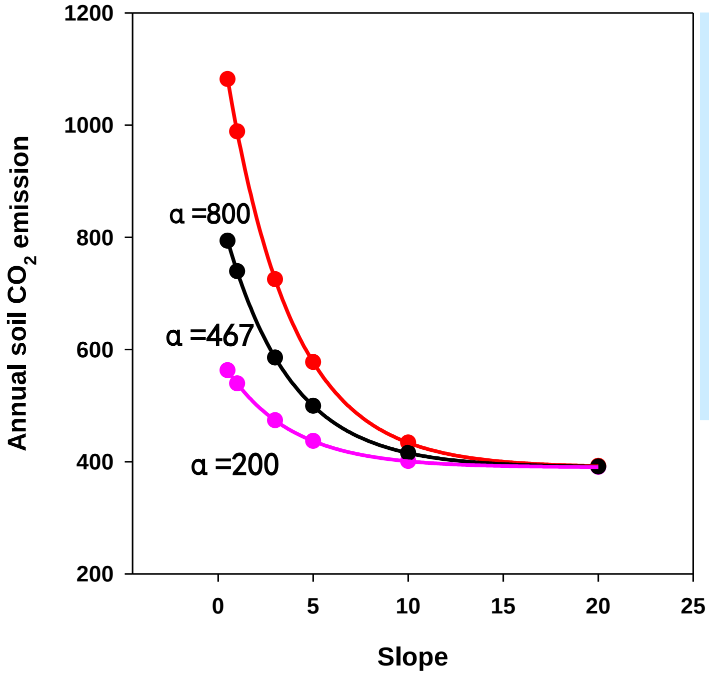
# Implications – Slope index?

On the sloping land, differences in soil $CO_2$ emissions related to soil water, SOC and root biomass, which resulted from runoff, SOC loss by sediments, and crop growth.

1) Clearly, $y_0$ means the minimum soil $CO_2$ emissions. That is to say, even at extremely steep slope, any soils would still have a minimum soil CO2 emission.
2) Technically, by changing α and β, clearly see what they really mean.



# Implications – Slope index?

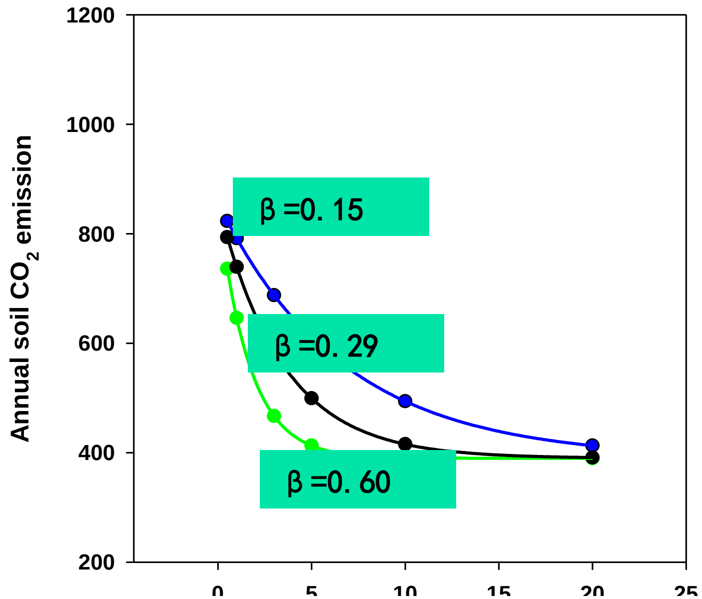



3) When **α** changes from 200 to 800, CO2 emissions shift up and down, without changing the shape. That may suggest, for the same erosion events, inherent soil properties may decide the maximum potential of soil CO2 emissions at different slope gradients.

4) When **β** changes from 0.15 to 0.60, the maximum and minimum of CO2 emissions does not change, but the decreasing rate of CO2 emissions are much greater. This may imply, for the same soil, erosion amounts or soil loss may decide the sensitivity of soil CO2 emissions at every unit increase of slope gradient.

Does this mean, we somehow find a **slope coefficient**? For each soil, is it possible to have a certain slope coefficient, such as β, to estimate its potential CO2 emissions?

While limited by many other factors, such as soil water, temperature and vegetation, our results still cast a new light into CO2 emissions on sloping land. They are definitely not the same as on flat land. They certainly have something to do with the slope gradients!



# *Thank you for  the attention!*

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## *Acknowledgements*

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