SUMMARY AND CONCLUSIONS

Monitoring the variation of the emission of CO_2 from the soil surface and the evaluation of the biophysics, environmental factors and rainfall variability are the fundamental to understanding the evolution of carbon emission from a wheat and peanut fields. The conclusions of this research are following:

(1) The high-temporal resolution of soil CO_2 concentration at 0.04 and 0.08 m depths and continuously soil surface CO_2 efflux provide a more complete understanding of the rapid CO_2 transport in soil during and after rainfall when the surface layers were wetted by small amounts of rainfall. The data point to the fact that only water content in the top soil layers impact soil CO_2 efflux, which is itself triggered by microbial activity in the shallow layers of agricultural soils. The dynamic pattern of soil CO_2 efflux in response to rainfall in both field showed an immediate decreased about 13-66% when compared with the efflux before the rain and then increased exponentially within 2-3 days after rainfall. Subsequently, soil CO_2 efflux appeared to be declined to pre-rainfall levels 5-6 days after rainfall events, corresponding with declined in soil water content. This reduction in soil CO_2 efflux was associated with the lack of a continuous air-filled pore space pathway to the atmosphere and reduction of the soil air-filled pore space, resulting in reduced gaseous diffusivities. These results indicated that rainfall acts as a barrier to inhibiting soil CO_2 efflux during rainfall, and then eventually increases the escape rate to a greater value than before the rainfall value. Additionally, negative relationship between the reductions in soil CO_2 efflux and soil water content before rain in peanut

field suggested that soil water content was the most important factor responsible for the soil CO_2 efflux during the rainfall events. However, the soil CO_2 efflux values for both peanut and wheat plants and for at all growth stages approach pre-rainfall values approximately five to six days following light and heavy rainfall events and very likely is a reflection of the soil evaporation rate. This further suggests that the impact of rainfall events on soil CO_2 efflux from agricultural soils is large if short-lasting.

Additionally, immediately after rainfall, the soil CO_2 efflux was highest during the flowering stage of the peanut plant with soil CO_2 efflux approximately 1.5 times higher than the soil CO_2 efflux measured on days preceding the rainfall. This surge in efflux is thought to be attributed to increase in root activity. During the flowering stage, the plant needs to have assimilates from the photosynthesis to increase leaf area expansion, and to increase root density for absorption water and nutrient to maximize crop growth and soon after, to pod growth. So the partitioning of assimilates from the leaves to the roots and pods promotes an increase of activity, stimulating soil CO_2 efflux.

There was no significant difference in the soil CO_2 efflux rate between the day before and two days following the rain on DOY 163 and DOY 210, indicated that soil CO_2 effluxes during early- and late- growing stages are less sensitive to change in rainfall amount and this, despite a relatively low soil water content. This was due to the increased need of energy spent during flowering stage, thus promoting increased respiration. Pod filling period, to some degree, also contributes to increased in respiration, if to a lesser extent than at the flowering stage. When taken together, the present results on CO_2 efflux examined as a function of peanut growth stage along with the behavior of CO_2 pulses following rewetting of dry soils suggest that the growth stage of plant was found to be more important than the amount of rainfall and initial soil moisture in generating post-rain soil CO_2 efflux.

(2) Soil CO_2 efflux, measured by continuously gradient method and soil automated chamber were respond differently to the variation in soil temperature and soil water content in a wheat and peanut fields. The variation in soil CO_2 efflux in the untrenched (root and heterotrophic respiration) and trenched (heterotrophic respiration) plots in a wheat field showed a similar pattern of seasonal change in soil temperature (0.69 to 4.17 μmol $m^{-2}s^{-1}$ and 0.45 to 2.95 μmol $m^{-2}s^{-1}$), respectively. Heterotrophic respiration in the trenched plot ranged from 36% to 86% of total soil CO_2 efflux. In the untrenched plot, total soil CO_2 efflux was limited by soil water content while soil temperature was a minor influencing whereas in the trenched plot, heterotrophic respiration was correlated with both soil temperature and soil water content but soil temperature seemed to have the larger effect. This result suggested that the factors controlling the seasonal change of soil CO_2 efflux differ between heterotrophic respiration and total soil CO_2 efflux. Total soil CO_2 efflux and heterotrophic respiration were driven by different mechanisms and respond differently to environmental factors. The variation in soil CO_2 efflux in peanut field showed a similar pattern of seasonal change in volumetric soil water content at 0.02-0.05 m (1.25 to 7.78 μmol$m^{-2}s^{-1}$). Volumetric soil water content exerted the determinant control in the seasonal variation of the soil CO_2 efflux when soil temperature appeared neither extremely high nor extremely low. However, the higher frequency of rainfall events in this study period leads to large efflux after 1-3 days after rainfall. This suggested that the short-term effect of rainfall events were reflected in temporal

variation in soil CO_2 efflux and may play an important role in the variation in soil CO_2 efflux.

Based on these studies, using high-temporal frequency data is indicated to quantify soil CO_2 loss in agricultural soils. Such data provides invaluable clues regarding large CO_2-rich pulses arising as a result of soil rewetting and its accompanying increased microbial activity; this information is of particular relevance for ecosystems characterized by frequent drying-wetting cycles and highlight the need for rethinking the current weekly-bi-weekly soil CO_2 efflux sampling protocols.

The growth stage of the plant modifies significantly the response of soil CO_2 efflux on soil water content. Soil CO_2 efflux during flowering stage, as seen in both peanut and wheat studies, is most susceptible to the impact of rain on soil CO_2 efflux. This likely result from an increase in root activity during the flowering period. In the present study, rainfall events totaling 10 mm or more significantly influence soil CO_2 efflux and, was shown to be strongly dependent on the growth stage of the plant. Soil CO_2 efflux in both wheat and peanut fields decreases sharply during rainfall. This is likely caused by the decrease of diffusion of CO_2 from the topsoil and the effect of which is likely to be brief. The present study suggests that high-resolution soil CO_2 efflux measurements should be made to capture a large pulses in CO_2 emissions to adequately model carbon-water cycling from agricultural soils to the atmosphere.

(3) Eddy covariance CO_2 efflux measurements made over a winter wheat and summer peanut fields during January to September 2007 are described. The mean diurnal patterns of NEE were quite similar in both fields during the growing season. The dial amplitude of NEE varied substantially within the growing season, with the

largest dial changes occurring in mid-March in a wheat field and in mid-July in a peanut field, about the same time as the occurrence of seasonally maximum LAI. The maximum NEE occurred before noon, while ecosystem respiration (nighttime NEE) occurred around 18:00-19:00 pm. The weekly averaged in NEE ranged from -36.90 to 7.95 μ mol $m^{-2}s^{-1}$ in a wheat field and from -34.28 to 12.69 μ mol $m^{-2}s^{-1}$ in a peanut field. These different resulting from those plants has both different root systems and productivity. Fluxes of CO_2 throughout the day (daytime NEE) in both fields were dependent on net radiation and the stage of canopy development in both fields.

In the wheat experiment, gross primary production (GPP) increased when soil temperature was less than 23 °C and soil water content was less than 0.15 m^3m^{-3}. Soil temperature and soil water content was accounted for 32% and 40% of the variation in daily GPP. Change in LAI and aboveground biomass was accounted for 94% and 82% of the variation in daily GPP respectively. Additionally, ecosystem respiration (Re) showed strong dependent on canopy air temperature which accounted for 50% of variation in Re. In the peanut experiment, the seasonal distribution of weekly GPP and Re follows that of the green leaf area. About 68% and 70% of the variation in GPP and Re were explained by change in LAI. Soil water content was an important environmental factor regulated the variation of both GPP and Re. The weak relationship between Re and temperature during summer season because temperature are always hot and do not limit respiration. The range of seasonal distribution of weekly Re was two-third lower than that of the weekly GPP. This result indicated that seasonal distribution of weekly Re was mainly controlled by the crop canopy than by soil temperature and soil water content.

(4) Sharp increase of Re due to increasing soil water content after rainfall event was observed in a wheat field. It is indicated that increase in soil water content after rainfall caused an increase in the respiratory release of CO_2. Respiration rate might have increased more than photosynthesis because increases in water availability can enhance cell expansion, construction of root and leaf tissue, leading to an increase in plant growth and maintenance respiration. In terms of amount of rainfall response, there was a weak significant relationship between GPP and Re and amount of rainfall per week. This suggested that the amount of rainfall may not be an important factor to controls the seasonal distribution of net carbon exchange.

Based on these studies, the patterns of variation in NEE during the growing season in wheat and peanut fields mainly deepened on the following variables: light, plant growth, temperature, and soil moisture. Higher absolute NEE values for winter wheat than for summer peanut were observed, due to the longer season length for carbon assimilation. The difference in NEE between both fields was due to variation of climate and crop species. GPP was correlated with some meteorological factors (temperature, soil moisture), and they showed a positive linear correlation with aboveground biomass, LAI and Re. Under water limitation in summer season, nighttime NEE (Re) showed a strong non-linear relationship with soil moisture but no relationship with soil temperature, demonstrating that respiratory processes in the ecosystem were limited by soil moisture.

In summary, through intensive field sampling and data analyses, this dissertation research has significantly contributed to a new information regarding the effects of rainfall variability on soil CO_2 efflux and net carbon exchange. Soil CO_2

efflux has provided information regarding decomposition and microbial activity. The net carbon exchange has provided information regarding important environmental regulators of plant carbon gain or loss in wheat and peanut, which will influence predictions of community dynamics under future climate change. Carbon exchange data in this study will provide the basis for developing and validating crop models and satellite data monitoring of crop phenology and gross/net primary production on a large-scale basis. Such models simulate to varying degrees of empiricism, processes, such as whole-plant photosynthesis and autotrophic/heterotrophic respiration, which in turn estimate gross primary production and ecosystem respiration. Therefore, information on carbon exchange and soil CO_2 efflux for major agricultural crops is essential to test and to anticipate possible impacts of climate change scenarios and give the modelers a better basic to improve and validate their model.

The available experimental data in the research was subject to many constraints particularly the limitation of number of instrumentations. It is recommended that the followings categories should be carry out to over come these constraints:

1. The next generation of soil CO_2 efflux models will need to consider the basal effects of deep soil temperature and soil water content.

2. The number of factors should be sufficient for account more significantly on the physiological mechanisms that describe how soil microbes response to increase in soil water content such as pH, microbial biomass, organic matter, etc.

3. Manipulate experiment will need to developing ways to a better understand of the role of amount of water and substrate supply for both autotrophic and heterotrophic respiration sources.

4. Multi-year experiments on CO_2 exchange over agricultural ecosystem will need if we are going to include agriculture land in the national debate on curbing carbon emission.