Introduction

Anthropogenic land use/land cover change (LUCC) has significant impact on climate change. Located in the typical East Asian monsoon region, the land-atmosphere interaction in the Yangtze River Delta is even more complicated due to intensive human activities. To better understand these effects on microclimate change, we study analyzed micro-meteorological elements, energy distribution, and land surface factors observed at four ground sites over different surface types around Nanjing from Mar. to Aug., 2013. Then, we quantified the contribution of the surface factors, including surface albedo, roughness length, and evaporation respectively, to surface temperature changes (ΔTs).

Methodology

From surface energy balance, the surface temperature change can be decomposed into three direct factors, (1) radiation balance, (2) aerodynamic resistance and (3) evaporation, and one indirect factor of air temperature on large scale.

\[ \Delta T_s = \frac{2}{\rho c_p} \frac{\Delta f}{(1 + f)} + \frac{1}{r} R_s' - \frac{1}{R_d} - \frac{1}{R_a} - \Delta T' \]

Where \( \Delta T_s \) is the surface temperature difference between other managed sites and grass site, \( \Delta f = 1/4 \alpha \varepsilon \rho c_p \) is the local climate sensitivity, \( f \) is the energy redistribution factor, \( R_s \) is net shortwave radiation, \( R_d \) is the parent net radiation, \( c_p \) is the surface emissivity, \( \varepsilon \) is the Stefan-Boltzmann constant, \( \Delta T_r \) is air temperature difference, \( \beta = H/LE \) is Bowen ratio.

Data and Method

Observation sites and data

(a)DX-urban site, around by average 19.7m height of buildings;
(b)XL-suburb site, with 7cm high grass in the 50m×50m area which is surrounded by man-made forest;
(c)LS-grass site, covered by average 60cm high grass;
(d)LS-crop site, planted rice from Jun. to Nov. and winter wheat from Nov. to Jun. of next year.

The measurements contain sensible and latent heat flux measured by the eddy covariance system (EC3000, Campbell), micro-meteorological elements of air temperature (HMP45C-L, Vaisala), precipitation (TE525MM-L, Texas Electronics), and surface radiation fluxes including short-wave (CM21, Kipp & Zonen) and long-wave (CG4, Kipp & Zonen) fluxes at half-hour intervals.

Characteristics Analysis

1. Differences in micro-meteorological elements

The year 2013 is a typical hot and dry year in this region. In daily variation (Fig.2), large differences in T and RH between the four sites mainly appear at April and August, when precipitation is relatively small.

Table 1 shows except XL site in JJA as a result of woodland, the seasonal maximum and minimum values of these micro-meteorological elements occur at LS-crop site and DX-urban site which are most affected by human activities.

Fig.3 Human impacts is shown more obviously in Ts than Tm. The ranges of diurnal variation of Ts are both small at DX-urban site and LS-crop site, and nighttime Ts is higher than that in other sites by nearly 2°C due to the urban heat island effects. Due to the higher RH, the maximum value of diurnal Ts at LS-crop site is lower than other sites.

2. Differences in surface net radiation and energy

Fig.4 Daily variation of (a) downward shortwave radiation (DSR), (b) upward shortwave radiation (USR), (c) downward longwave radiation (DLR), and (d) upward longwave radiation (ULR).

3. Differences in land surface factors

In summer, the grassland abode at XL-suburb site gradually becomes larger than that at LS-grass, and since the forest-like effects becomes distinct, LE/Rn increases rapidly. Thereby, although Ts is higher at XL-suburb there is no large difference in Ts between the two sites.

Mechanism Analysis

Evaporation Cooling
Tm
Tb
RH
Air Flow
Absorbed Energy
Turbulence Exchange
Bowen Ratio
Roughness
Urban
Surface Factors
Crop

Conclusions

Our study presents the first-hand observational evidences for the land-atmosphere interaction in Yangtze River Delta. It shows that the crop cooling and urban heat island were both obvious. Different land use types alter the energy exchanges between land and atmosphere through modifying the surface factors, like Albedo, roughness and Bowen ratio, and finally change the micro-meteorological elements.

For the study of LUCC effects on microclimate change, more attention should be paid to nonradiative forces and the feedbacks from the background circulation. After quantification, we find Evaporation cooling is the dominant contribution to surface temperature change induced by human in the region.