Effects of deforestation on land surface air temperature in Eastern China

1. Introduction
Deforestation affect land surface air temperature through biogeochemical and biophysical processes (Bonan, 2008). Climate models of large-scale deforestation suggest that land clearing cools the local surface air in boreal and temperate zones and heats it in tropical zones (e.g., Betts 2000, Bala et al., 2007). These effects have been confirmed by field observations in North America (Lee et al., 2011). In Lee et al. (2011), the deforestation effect, expressed as the temperature difference \( \Delta T \) between open land and an adjacent forest (\( \Delta T = T_{\text{open}} - T_{\text{forest}} \)), decreases from high latitude to low latitude. However, it is not known if a similar latitudinal pattern also exists in other continents.

2. Objectives
In this study, we investigated the effects of deforestation on local surface air temperature in Eastern China. We used 5 forest eddy-covariance sites, including Changbaishan temperate mixed forest (CBS), Qianyanzhou subtropical coniferous plantation (QYZ), Ailaoshan subtropical evergreen broad-leaved forest (ALS), Dinghushan subtropical evergreen broad-leaved forest (DHS), and Xishuangbanna tropical rainforest (XSBN). The main objectives were (1) to determine changes in \( \Delta T \) between open land and an adjacent forest, (2) to quantify seasonal variations in \( \Delta T \), and (3) to characterize changes in the diurnal temperature range (DTR) in Eastern China.

3. Methods
3.1 Sites
CBS, QYZ, ALS, DHS, and XSBN are typical forest ecosystems along a temperate to tropical climate gradient, in the North-South Transect of Eastern China (NSTEC). The information about the five sites is given in Figure 1 and Table 1.

3.2 Field measurement and data processing
Comparison was made of the surface air temperature measured on the forest eddy-covariance tower and that in an adjacent surface weather station. As in Lee et al. (2011), we used the surface weather stations as proxies for small cleared land.

In this study, the data was obtained from 2003 to 2006 at CBS, QYZ, DHS, and XSBN. At ALS, the data was obtained in 2010. We analyzed daily maximum (\( T_{\text{max}} \)), daily minimum (\( T_{\text{min}} \)), and daily mean air temperature (\( T_{\text{mean}} \)). The mean temperature difference (\( \Delta T \)) was calculated as air temperature at the surface weather station minus that recorded at the forest site. DTR was the difference between \( T_{\text{max}} \) and \( T_{\text{min}} \). Correction for altitude difference between the paired sites was made according to the lapse rate of 6.5\(^\circ\)C km\(^{-1}\).

4. Results
4.1 Latitudinal and seasonal variations in \( \Delta T \)
A latitudinal gradient is found along the NSTEC (Fig. 2). At the CBS site pair, surface air temperature was lower in the open land than in the forest. The pattern was reversed at the three site pairs in low latitudes (ALS, DHS, and XSBN). At the QYZ site pair, the difference was close to zero. The seasonality was not obvious except at the CBS site pair, where deforestation caused cooling in the winter but not in the summer (Fig. 3).

4.2 Changes in diurnal temperature pattern
The daily maximum air temperature was higher in the open land than in the forest at all the site pairs throughout the year (Fig. 4). The daily minimum air temperature did not exhibit a consistent pattern: open land \( T_{\text{min}} \) was lower than that at the forest site at CBS, was almost the same as that at the forest at QYZ and ALS, and was higher than that at the forest at DHS and XSBN.

4.3 Effect of precipitation on \( \Delta T \)
Annual mean \( \Delta T \) increased with increase in precipitation (Fig. 6). The results indicate that higher precipitation made the heating effect of deforestation more significant. Since it decreases with increasing latitude, precipitation appears to be an important driver of the observed latitudinal pattern. Precipitation was also a cause of interannual variability in \( \Delta T \).

5. Conclusions
• Along the NSTEC in Eastern China, deforestation caused cooling at the temperate CBS site pair and warming at the subtropical and tropical site pairs.
• Deforestation increased the DTR, especially in the temperate area.
• Precipitation was an important driver of the latitudinal and interannual variations in the deforestation effect.

References