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Effects of deforestation on land surface air temperature in Eastern China

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1.Introduction

Deforestation affect land surface air temperature through biogeochemical and biophysical processes (Bonan, 2008). Climate models of larges-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 ΔT between open land and an adjacent forest (ΔT = T at open land – T at 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 broadleaved forest (ALS), Dinghushan subtropical evergreen broad-leaved forest (DHS), and Xishuangbanna tropical rainforest (XSBN). The main objectives were (1) to determine changes in ΔT with latitude, (2) to quantify seasonal variations in ΔT, 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

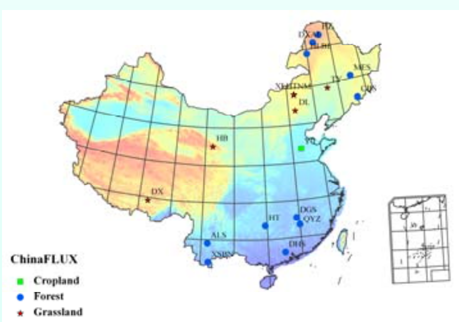

Figure1: ChinaFlux map showing the five sites used in this study

Table 1: Site information

	CBS		QYZ		DHS		ALS		XSBN	
	Flux tower	Surface station	Flux tower	Surface station	Flux tower	Surface station	Flux tower	Surface station	Flux tower	Surface station
Location	42°24'N 128°05'E	42°23'N 128°06'E	26°44'N 115°03'E	26°28'N 115°04'E	23°10'N 112°34'E	23°10'N 112°33'E	24°32'N 101°01'E	24°32'N 101°01'E	21°55'N 101°16'E	21°55'N 101°15'E
Altitude(m)	738	738	102	76	240	105	2476	2461	750	580
MAT(℃)	3.6		17.9		21.0		11.3		21.5	
P(mm)	695		1485		1956		1840		1493	

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_{max}), daily minimum (T_{min}), and daily mean air temperature (T). The mean temperature difference (ΔT) was calculated as air temperature at the surface weather station minus that recorded at the forest site. DTR was the difference between T_{max} and T_{min}. Correction for altitude difference between the paired sites was made according to the lapse rate of 6.5℃ km^{-1}.

4. Results

4.1 Latitudinal and seasonal variations in ΔT

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).

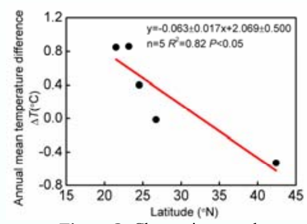

Figure 2: Change in annual mean temperature difference with latitude

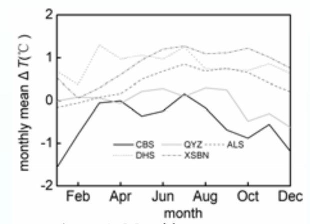

Figure 3: Monthly mean temperature difference at the five site pairs

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_{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.

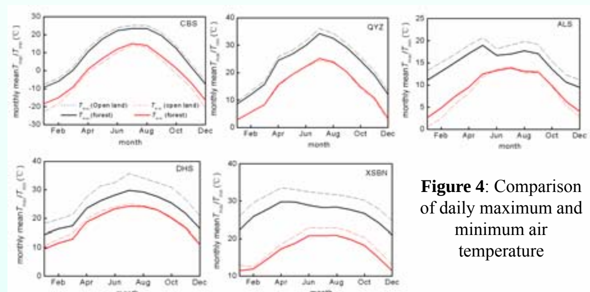

Figure 4: Comparison of daily maximum and minimum air temperature

DTR was larger in the open land than in the forest at all the five site pairs (Fig. 5), suggesting that deforestation should increase DTR. The largest difference was observed at CBS and DHS and the smallest difference at forest site at QYZ and XSBN.

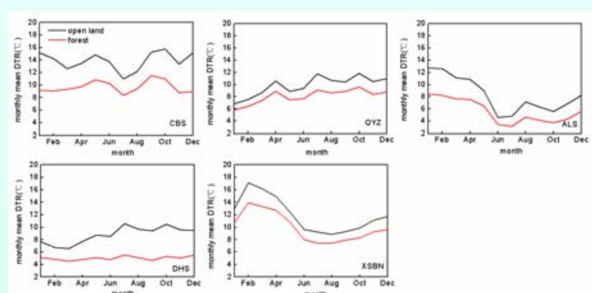

Figure 5: Seasonal variations of diurnal temperature range

4.3 Effect of precipitation on ΔT

Annual mean ΔT 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 ΔT.

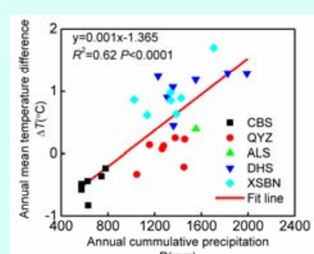

Figure 6: Relationship between annual mean temperature difference and annual precipitation

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

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