Title: Growth characteristics of natural and planted Dahurian larch in northeast China

Dear Referee #2:

Thank you very much for your help to our manuscript! According to your suggestions, we revised our manuscript. All the modifications were listed as follows.

Comment: the climate change, although relevant, is not the only research field where the DataBase would be useful! Authors should improve this topic;

Response: Thank you for your suggestions, the importance of the Dataset was also emphasized on forest management and carbon sequestration in **Introduction**.

Comment: Authors should add some sentences commenting previous data collections;

Response: The previous data collections were commented in Lines 56-60.

Comment: The statistical section should be revised (see minor comments, too);

Response: P-value was added in Line 154 and 162.

Comment: Data stored in a pdf are not so easily accessible in order to perform some check.

Response: Data stored in an Excel form at https://doi.org/10.1594/PANGAEA.880984.

Comment: In the following lines, authors will find minor comments with the line number reference: 19 declare the meaning of DBH and use only the acronym in the rest of the manuscript;

Response: The meaning of DBH (i.e. diameter at breast height) was given in Line 20 and the acronym was used in the rest of the manuscript.

Comment: 22 (MAP)) double parenthesis;

Response: Line 22: climate (mean annual temperature (MAT) and mean annual precipitation (MAP)), in the sentence the double parenthesis is right.

Comment: 31 use Dahurian larch in the text, not the scientific name;

Response: The scientific name "*Larix gmelinii*" was substituted by "Dahurian larch" in the whole text.

Comment: 39 unclear please rephrase;

Response: "greenhouse effective" **was revised to** "greenhouse effect" in Line 40.

Comment: 41 add citation;

Response: The reference (Fang et al., 2001) was added in Line 43.

Comment: 44 see the previous comment;

Response: The reference (Yang, 2009) was added in Line 47.

Comment: 47 see the previous comment;

Response: The reference (Huang, 2011) was added in Line 51.

Comment: 53 unclear please rephrase;

Response: "For larch forests in northeast China, synthesis studies mainly focused on biomass and net primary production with increasing samples in recent decade" **was revised to** "Synthesis studies mainly focused on larch biomass and net primary production with increasing samples in recent decade in northeast China" in Lines 56-58.

Comment: 72 unclear please rephrase;

Response: "in Dahurian larch forests including natural and planted forests in order to develop a growth data set" **was revised to** "in natural and planted Dahurian larch forests in order to construct a growth data set" in Lines 75-77.

Comment: 79 check transparency, coordinate labels and scale bar in Figure 1;

Response: Line 84: The transparency, labels and scale bar were checked in Figure 1.

Comment: 84 add citation;

Response: Line 87: The distribution range of natural Dahurian larch was shown in Fig.1, which was from the dataset.

Comment: 88 data source or citation?

Response: Mean annual temperature and mean annual precipitation were from data sources in Lines 92-93.

Comment: 114 unclear: are these methods carried out by the authors or extracted from consulted sources?

Response: These methods were summarized from the dataset references in Line 119.

Comment: 130 check parenthesis;

Response: The parenthesis was checked in Line 135, and it was right.

Comment: 149 p-value is missing, moreover, it's not a correlation but a linear model;

Response: Lines 153-154: $P<0.001$ was added, and "establish the linear H-DBH correlation" **was revised to** "establish the H-DBH correlation with power function".

Comment: 155 p-value is missing;

Response: P<0.001 was added in Line 162.

Comment: 165 it’s not a correlation;

Response: "H was estimated with the H-DBH correlation" **was revised to** "H was estimated with the H-DBH model" in Line 181.

Best regards

Sincerely yours,

Bingrui Jia and Guangsheng Zhou

Growth characteristics of natural and planted Dahurian larch in northeast China

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Abstract. Dahurian larch (*Larix gmelinii* Rupr.) is the dominant species in both natural and planted forests in northeast China, which situated in the southernmost part of the global boreal forest biome and undergoing the greatest climatically induced changes. Published studies (1965–2015) on tree aboveground growth of Dahurian larch~~*Larix gmelinii*~~ forests in northeast China were collected in this study, critically reviewed, and a comprehensive growth data set was developed from 123 sites, which distributed between 40.85° N and 53.47° N in latitude, between 118.20° E and 133.70° E in longitude, between 130 m and 1260 m in altitude. The data set was composed of 776 entries, including growth data (mean tree height, mean diameter at breast height (DBH), mean tree volume and/or stand volume) and the associated information, i.e., geographical location (latitude, longitude, altitude, aspect and slope), climate (mean annual temperature (MAT) and mean annual precipitation (MAP)), stand description (origin, stand age, stand density and canopy density), and sample regime

(observing year, plot area and number). It would provide quantitative references for plantation management practices and boreal forest growth prediction under future climate change. The data set is freely available for noncommercial scientific applications, and the DOI for the data is https://doi.org/10.1594/PANGAEA.880984.

1 Introduction

Boreal forests, the second largest biome in the world, cover about one-third of the Earth's forest area (Achard et al., 2006; Keenan et al., 2015). Dahurian larch ~~(*Larix gmelinii* Rupr.)~~ is a dominant tree species in Chinese boreal forest, which is distributed primarily in northeast China. Dahurian larch~~*Larix gmelinii*~~ forest is also the predominant timber source in China, occupying 55% of Chinese boreal forest area and accounting for 75% of Chinese boreal forest volume (Xu, 1998; Zhou et al., 2002). Dahurian larch~~*Larix gmelinii*~~ forest is situated in the southernmost part of the global boreal forest biome (Shugart et al., 1992) and undergoing the greatest climatically induced changes. Thus understanding the growth characteristics of Dahurian larch~~*Larix gmelinii*~~ forest in China are of critical need for management and prediction under future climate change.

With increased greenhouse effect~~effective~~ and climate warming in recent years, forest carbon sink has being paid~~is payed~~ more and more attention by the world (Bastin et al., 2017). Forestation is the main measure to offset the greenhouse gas emission and increase carbon sink (Fang et al., 2001). China has the largest area of forest plantations in the world, approximately 79 million ha or one-fourth of world total (FAO, 2015; Payn et al., 2015). The forest cover showed an increasing trend through reforestation in northeast China (Achard et al., 2006). Dahurian larch~~*Larix gmelinii*~~ is an important fast-growing and cold-tolerant tree species used in forestation in northeast China (Yang, 2009). Dahurian larch~~*Larix gmelinii*~~ is usually planted after fire or logging. The growth rates of Dahurian larch~~*Larix gmelinii*~~

plantations are important indexes in the assessment of forest recovery processes and carbon sequestration potentials, which could supply strategies for post-fire or post-harvest management (Huang, 2011). The data set can provide basis for evaluating and predicting the carbon sequestration and its potential of the forestation activities.

Relating the easily measured variables (e.g. DBH, tree height~~tree height, diameter~~) to other structural and functional characteristics, is the most common and reliable method for estimating forest biomass, net primary production and biogeochemical budgets (Luo, 1996; Fang et al., 2001). ~~For larch forests in northeast China, synthesis~~ Synthesis studies mainly focused on larch biomass and net primary production with ~~a small quantity of~~ increasing samples in recent decade in northeast China, for example, N=28 (Luo, 1996), N=17 (Wang et al., 2001a), N=18 (Wang et al., 2001b; Zhou et al., 2002), N=36 (Wang et al., 2005), N=83 (Wang et al., 2008), N=50 (Zeng, 2015), N=150 (Zeng et al., 2017). However, large numbers of growth measurements (e.g. age, DBH, tree height~~, DBH~~, volume) have scarcely been studied systematically at the large scale. Therefore, a comprehensive growth data set (N=776) of Dahurian larch in northeast China was developed in this paper.

2 Data and methods

2.1 Research origin descriptors

(1) Identity: Growth data set of natural and planted Dahurian larch in northeast China, version 1.0

(2) Originators:

Bingrui Jia, State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China;

Guangsheng Zhou, Chinese Academy of Meteorological Sciences, Beijing 100081, China.

(3) Period of Study: From January 1965 to December 2015.

~~**(4) Objectives:**~~ We conducted a complete literature ~~and book~~ review of published studies on age, DBH, tree height, ~~DBH,~~ and/or volume in natural and planted Dahurian larch~~*Larix gmelinii*~~ forests ~~including natural and planted forests~~ in order to construct~~develop~~ a growth data set. The data set can be used to analyze growth characteristics of Dahurian larch~~*Larix gmelinii*~~ forests and assess their potential productivity in future climate warming.

2.2 Site description

(1) Site type: Data were derived from 123 study sites in northeastern China. This region includes Heilongjiang, Liaoning, Jilin provinces and the eastern part of Inner Mongolia Autonomous Region (Fig. 1).

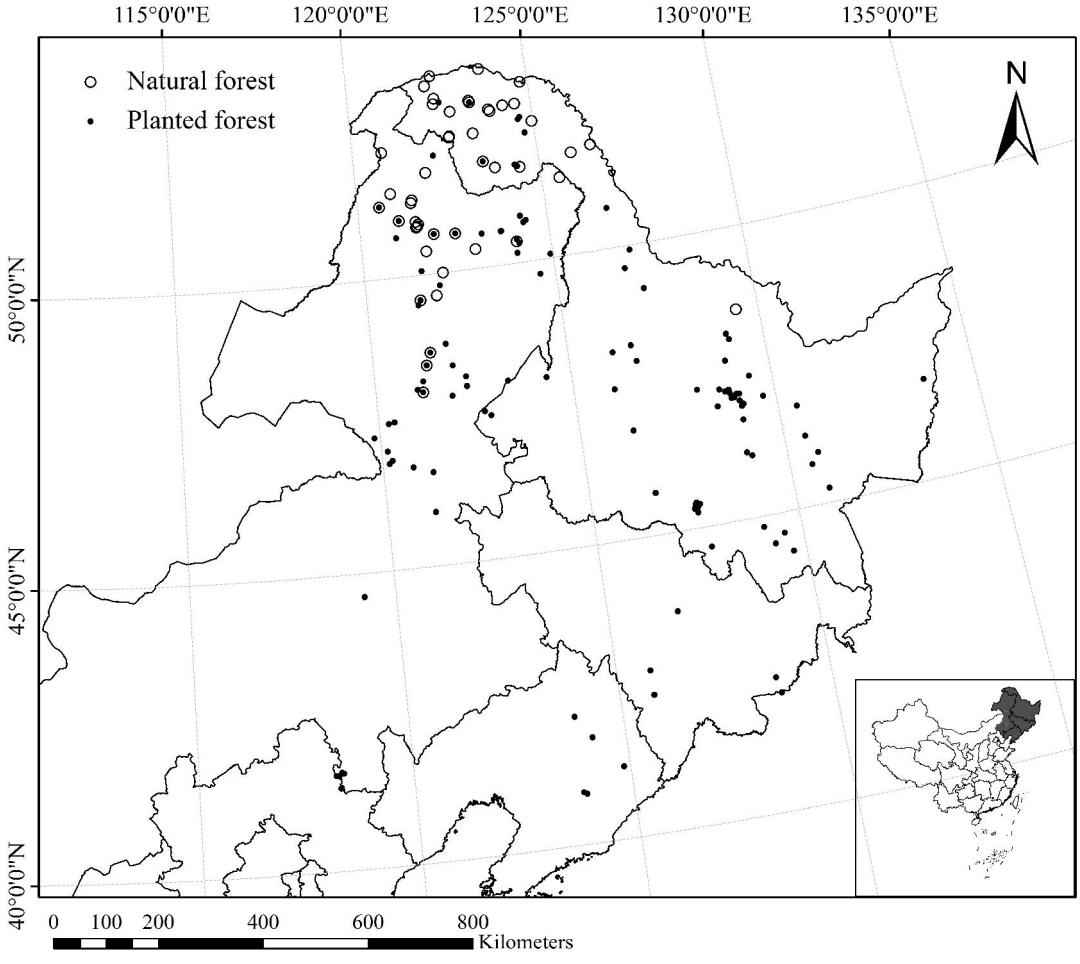

Figure 1. Study sites of Dahurian larch~~*Larix gmelinii*~~ across northeastern China, including Heilongjiang, Liaoning, Jilin provinces and the eastern part of Inner Mongolia Autonomous Region. Open circles represent natural forests and dots represent planted forests.

(2) Habitat: Dahurian larch~~*Larix gmelinii*~~ forest is naturally distributed in Great Xing'an Mountains of northeastern China. Dahurian larch~~*Larix gmelinii*~~ was usually planted in barren hills, post-fire or post-harvest area in northeast China.

(3) Climate: The climate in northeast China is controlled by the high latitude East Asia monsoon, changing from cool temperate to temperate zones from north to south, and from semi-arid to humid zones from west to east. Mean annual temperature (MAT) for these sites ranged from -6.1 to 7.0 °C, and mean annual precipitation (MAP) from 355 to 926 mm.

2.3 Data sources

Published studies (1965-2015) were collected from available online full-text databases, including China Knowledge Resource Integrated Database (http://www.cnki.net/), China Science and Technology Journal Database (http://www.cqvip.com/), Wanfang Data Knowledge Service Platform (http://www.wanfangdata.com/), ScienceDirect (http://www.sciencedirect.com/), ISI Web of Science (http://isiknowledge.com/) and Springer Link (http://link.springer.com/). The different combination of the terms "Dahurian larch (or *Larix gmelinii*)" with "height", "diameter at breast height (or DBH)", "tree volume" ~~and~~ or "stand volume" were searched in full text. Meanwhile, we also looked up the related books (e.g. Ma, 1992; Wang, 1992; Zhou, 1994; Yang, 2009). We attempted to compile a complete growth data set of natural and planted Dahurian larch in northeastern part of China (between 40.85° N and 53.47° N; between 118.20°E and 133.70° E).

2.4 Data collection criteria

A critical review of the literatures collected from the above-mentioned sources was conducted to obtain reliable growth data using the following criteria:

(1) Scope: The objective of this study was to provide the data for understanding growth characteristics of Dahurian larch~~*Larix gmelinii*~~ natural forests (pure Dahurian larch~~*Larix gmelinii*~~ or its proportion more than 50%) and monoculture plantations. Forest stands

included in the data set were restricted to those not recently disturbed by logging, fire, or insect pests. Additionally, the following small numbers of special types were excluded: (i) Dahurian larch~~*Larix gmelinii*~~ afforestation in wetland (Li et al., 1985; Song & Li, 1990; Huang, 2011; Cui et al., 2013), pastureland (Duan, 2005), or abandoned mine land (Yang et al., 2013); (ii) hybrid test between Dahurian larch~~*Larix gmelinii*~~ and other larch (Deng et al., 2010; Zhang et al., 2005); (iii) low-yield stands in hard environment~~, e.g. igneous rock forest~~ (Wang et al., 1979~~), old man forest (~~; Wang et al., 1991).

(2) Study design and sampling: DBH and tree height ~~and DBH~~ were averaged from the measurement values of all trees in plots or with random/systematic sampling method. Tree regeneration layer, generally below 5 cm in DBH or 1.3 m in height, was neglected in sampled plots. Stem volume of individual tree was computed from felled-wood samples or local tree volume equations. Stand volume was usually calculated by multiplying mean individual volume with stand density. Besides the growth data (i.e. DBH, height ~~DBH~~ and/or volume), the necessary information should be provided in the original sources, e.g., stand age, stand orign, study site, etc.

(3) Quality control: The data quality has been carefully reviewed by the authors. Data has undergone substantial checking, for example, cross-check for the relevant information from different sources, preliminary correlation analysis among growth variables.

Consequently, 776 records that met the above criteria were selected to develop a comprehensive growth data set of Dahurian larch in China. The data set includes growth characteristics of Dahurian larch (i.e. mean tree height (m), mean DBH (cm), mean tree volume (10^{-3} m^3) and/or stand volume (m^3/ha)). In addition, associate information was included, if available in original sources or ascertainable from other relevant literatures, i.e., geographical location (province location and locality name of study site, latitude (°), longitude (°), altitude (m), aspect and slope (°)), stand description (origin, stand age (years),

stand density (trees/ha) and canopy density), climate (mean annual temperature (MAT, °C) and mean annual precipitation (MAP, mm)), and sample regime (observing year, plot size and number).

2.5 Data structural descriptors

Table 1 Variable information in the data set.

Column code	Definition	Unit	Number	Range
ID	Unique identification number of each record	N/A	776	1—776
Province	Province location of study site	N/A	7764	N/A
Study site	Locality name of study site	N/A	123	N/A
Latitude	Latitude of study site	°	776	40.85—53.47
Longitude	Longitude of study site	°	776	118.20—133.70
Altitude	Altitude of study site	m	776	130—1260
Aspect	Slope direction of study site, including flat slope (FL), sunny slope (SU: South), half-sunny slope (HSU: West, Southwest, Southeast), shady slope (SH: North) and half-shady slope (HSH: East, Northwest, Northeast)	N/A	300	N/A
Slope	Slope degree of study site	°	357	0—60
Origin	Stand origin was classified into natural and planted forests	N/A	776	N/A
MAT	Mean annual temperature, from original study or other related ference	°C	776	-6.1—7.0
MAP	Mean annual precipitation, from original study or other related reference	mm	776	355—926
Age	Stand age, which is generally defined as age since germination in natural forest and since planting in planted forest. Stand age is usually obtained from historical records or tree rings.	years	776	1—280
Height	Mean tree height	m	670	0.24—29.40
DBH	Mean diameter at breast height, base diameter was only given in some young forests and marked with [B]	cm	661697	0.70—34.89
V_{tree}	Mean tree volume, the estimated tree volume data from the two-variable larch equation were marked with [E]	10^{-3} m^3 /tree	696	0.04—935.736
V_{stand}	Stand volume, the estimated stand volume data from the estimated tree volume and stand density were marked with [E]	m^3/ha	590	0.07—975.32
Density	Stand density/Canopy density, planting density was only given in some studies and marked with [P]	trees/ha %	656 150	213—13275 0.2—1.0
Area	Plot area	m^2	397	50—10000
Plot	Plot numbers, i.e. replications	N/A	573	1—25
Year	Investigation year	N/A	533	1954—2014
Reference	Data sources, the sources used to supplement climate information lacking in the original publications were added asterisks.	N/A	226	1965—2015

3 Data estimates and evaluation

3.1 Geographical location

Google Earth (Version: 7.1.8.3036) was used to estimate latitude, longitude, and/or altitude when the geographic coordinates was unavailable in original sources.

3.2 Tree and stand volume

The missing tree and stand volumes were estimated with the available information (mean DBH, mean tree height and stand density). Stem volume of individual tree was calculated with the larch equation in northeast China (V_{tree}= 0.000050168241 $DBH^{1.7582894}$ $H^{1.1496653}$), the best method recommended by the ministry standard of China: Tree volume tables (LY 208-77) (Agriculture and Forestry Ministry of China~~Forestry Administration of China~~, 1978; Liu, 2017). Meanwhile, available 590 pairs of mean tree height and mean DBH in the data set were used to establish the ~~linear~~ H-DBH correlation with power function (R^2=0.~~8377~~8919, P<0.001, see Fig. 2). To calculate tree volume from only one known variable of DBH, tree height was firstly calculated with the power~~linear~~ H-DBH equation in Fig. 2. The estimated stand volume was determined by multiplying the estimated tree volume with stand density.

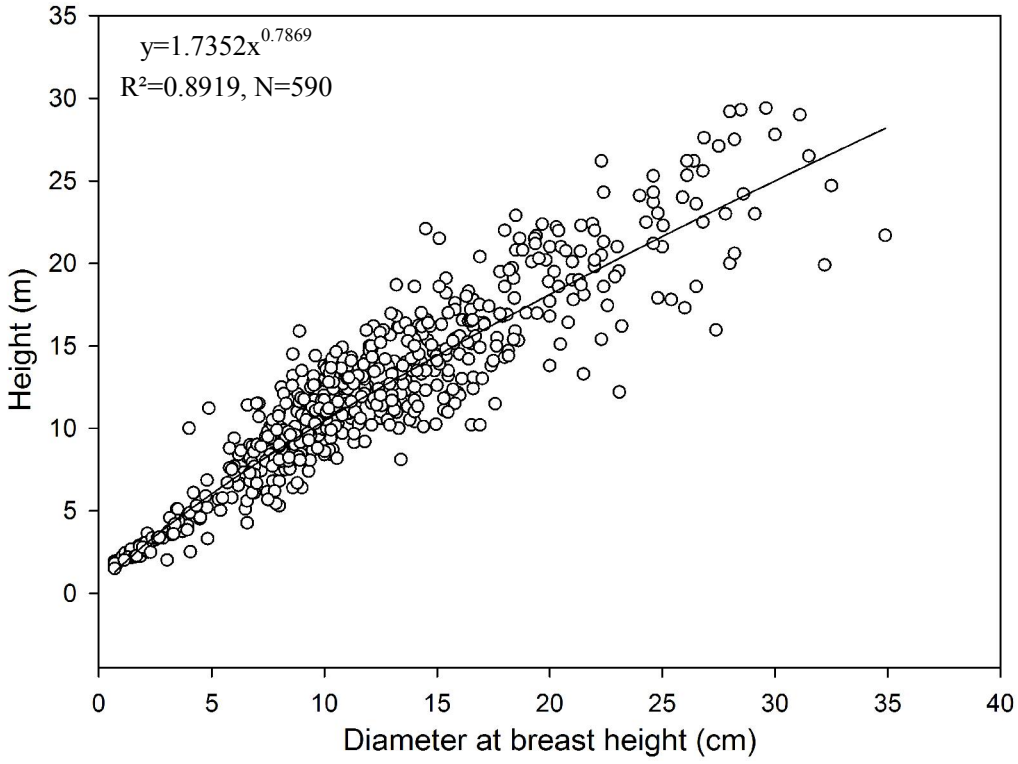

Figure 2. Relationship between mean tree height and diameter at breast height in the data set.

The accuracy of tree volume was assessed by comparing the extracted data from references with the calculated data from the above-mentioned two-variable tree volume equation (Fig. 3). The coefficient of determination (R^2) was 0.9724 (P<0.001) and the slope was 1.~~0737~~0733. Therefore, we were confident in applying the larch volume equation to interpolate tree and stand volume data in this study.

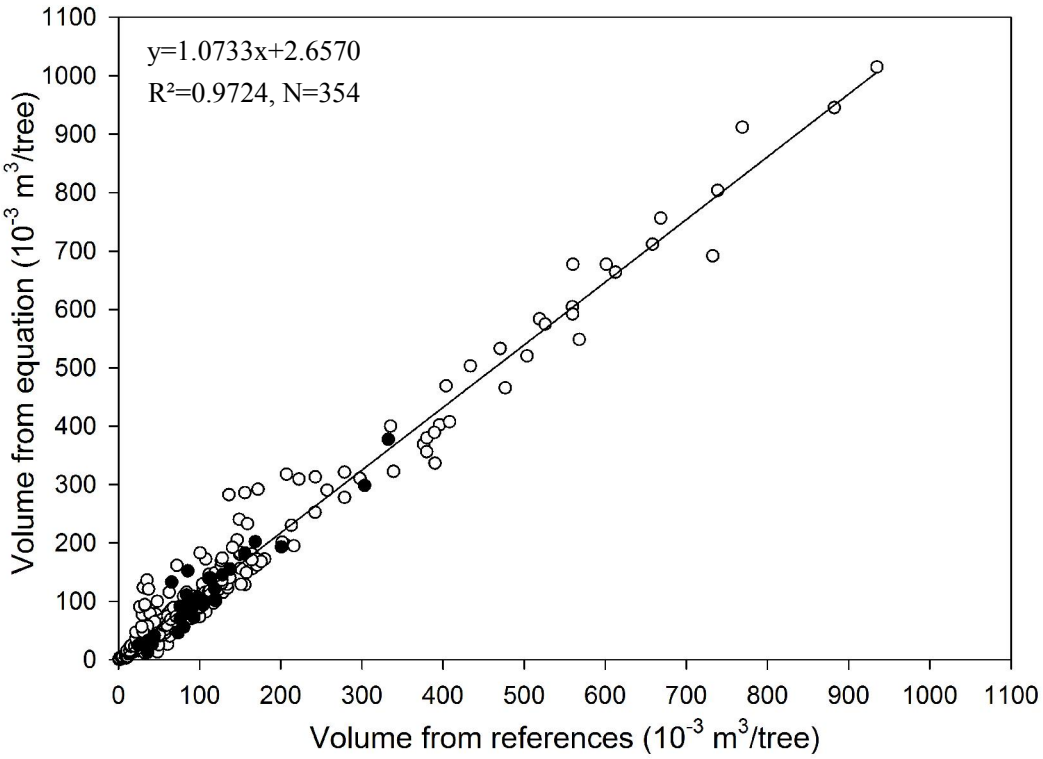

Figure 3. Comparison of available tree volume from references with simulated values from the two-variable tree volume equation (V_{tree}=0.000050168241 $DBH^{1.7582894}$ $H^{1.1496653}$). Open circles (N=317): tree height (H) and diameter at breast height (DBH) were available in the references, solid circles (N=37): DBH was only available in the references and H was estimated with the H-DBH ~~correlation~~ model from Fig. 2.

Acknowledgements. We would like to acknowledge ~~the~~ many scientists and researchers whose field measurements made this work possible. This research was supported by the

National Key Research and Development Program of China (2017YFC0503906) and China Special Fund for Meteorological Research in the Public Interest (GYHY201406034).

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