



Supplement of

Mapping three decades of urban growth in China: a 30 m annual building height dataset (1990–2019)

Yizhi Zhang et al.

Correspondence to: Quanhua Dong (dqh@pku.edu.cn)

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Supplementary Materials:

Figure S1. Accuracy assessment (RMSE, MAE, R^2 and OLS result) for each year from 1990 to 2019

Figure S2. Violin plot of different building height for each year from 1990 to 2019

Figure S3. Distribution of building height in our dataset each year from 1990 to 2019

Figure S4. A brief method demonstration of 1km VV backscatter reconstruction

Table S1. Detailed sample counts for each year after data augmentation.

Table S2. Number of validated samples and accuracy using Lianjia data

Table S3. RMSEs, MAEs and R^2 s for each year

Table S4. Accuracy Assessment ((RMSE, MAE and R^2) for each training sample city each year from 1990 to 2019 (excerpt in 2019)

Table S5. Annual statistics for mean height, impervious surface area, and building volume

Table S6. VV regression model accuracy in different cities across China in 2019



Figure S1. Accuracy assessment (RMSE, MAE, R^2 and OLS result) for each year from 1990 to 2019. Some of the regression lines are shorter because the small proportion of samples with taller height in the original distribution were not selected during the random train-test-split process.

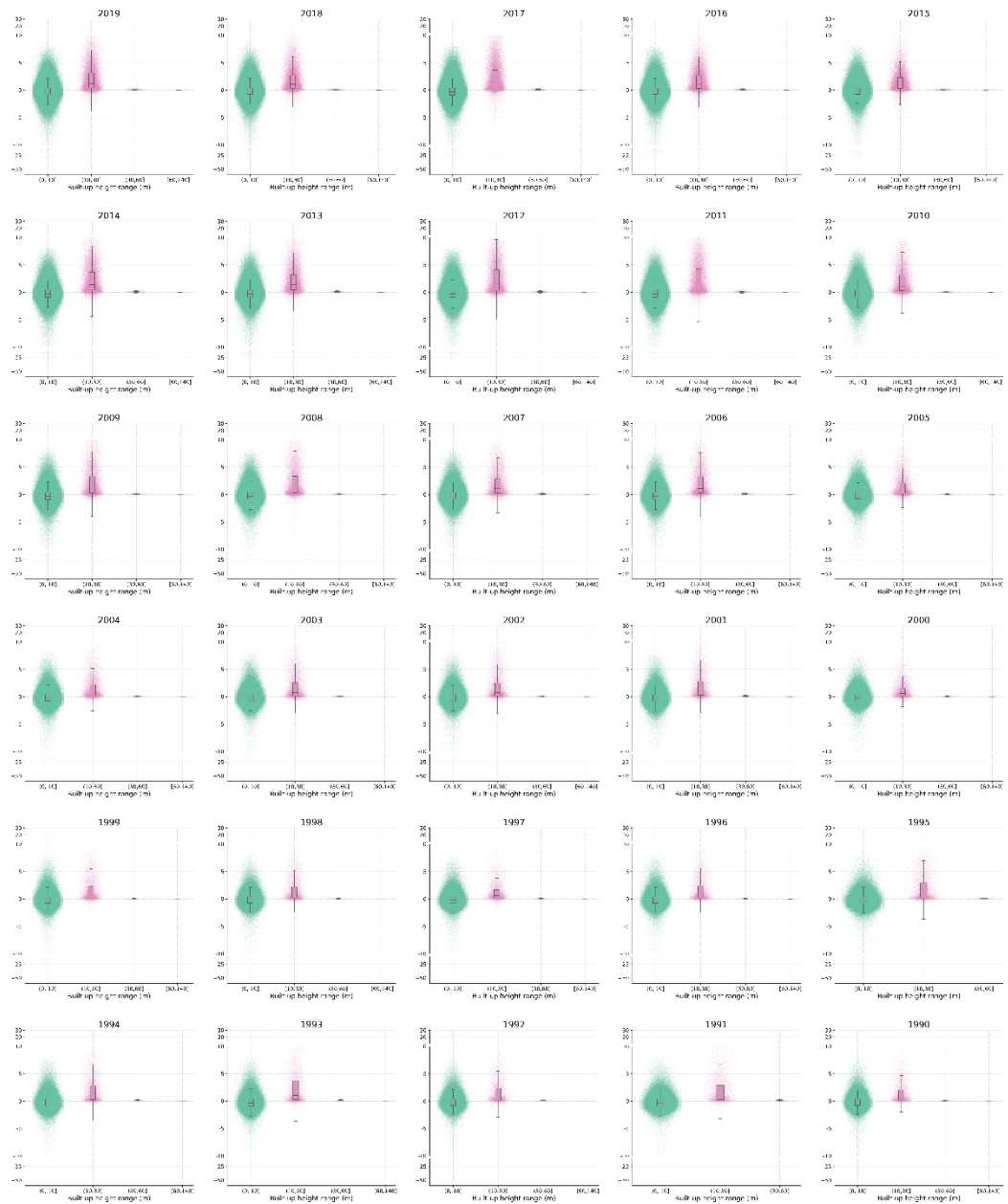


Figure S2. Violin plot of different building height for each year from 1990 to 2019

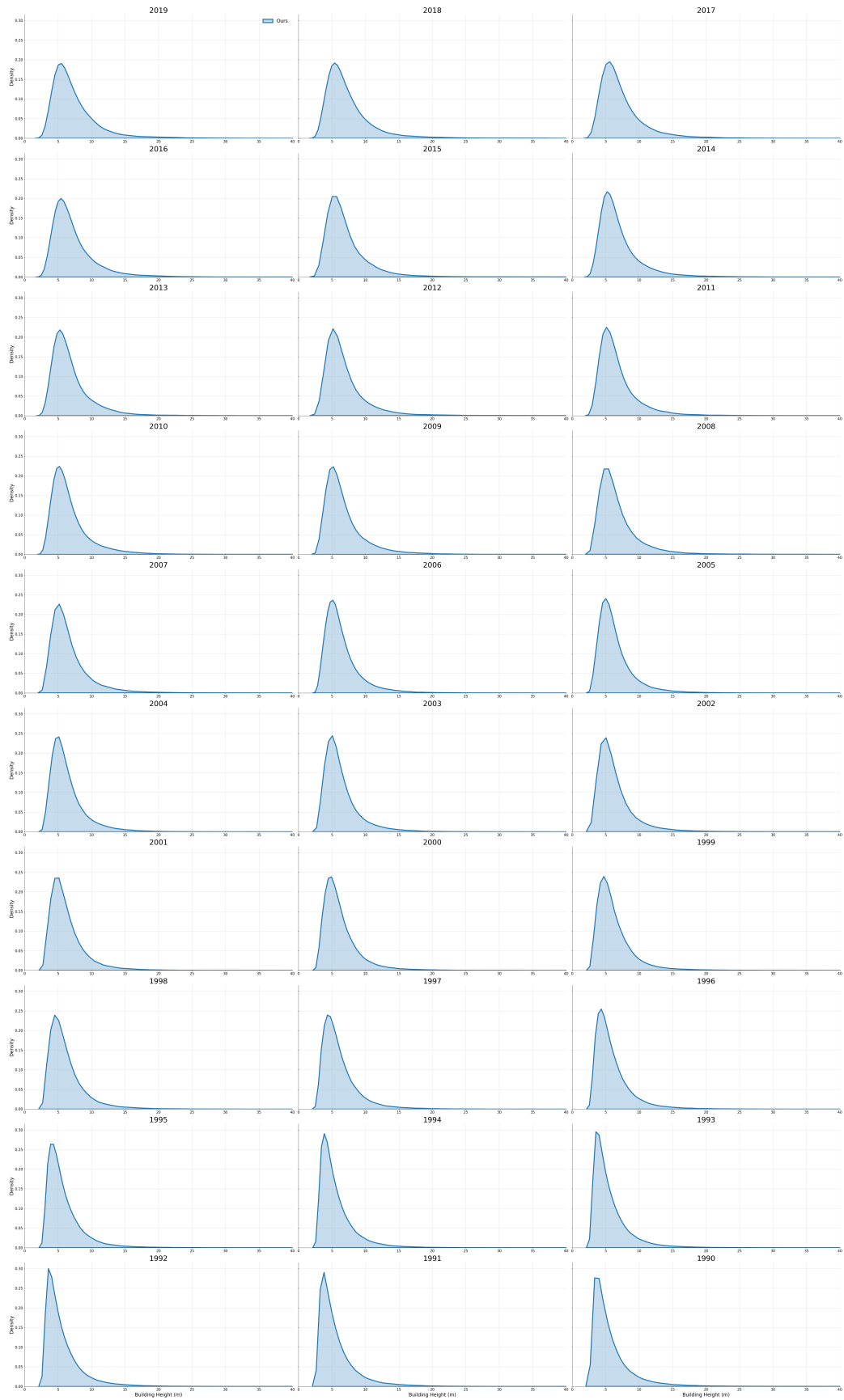


Figure S3. Distribution of building height in our dataset each year from 1990 to 2019

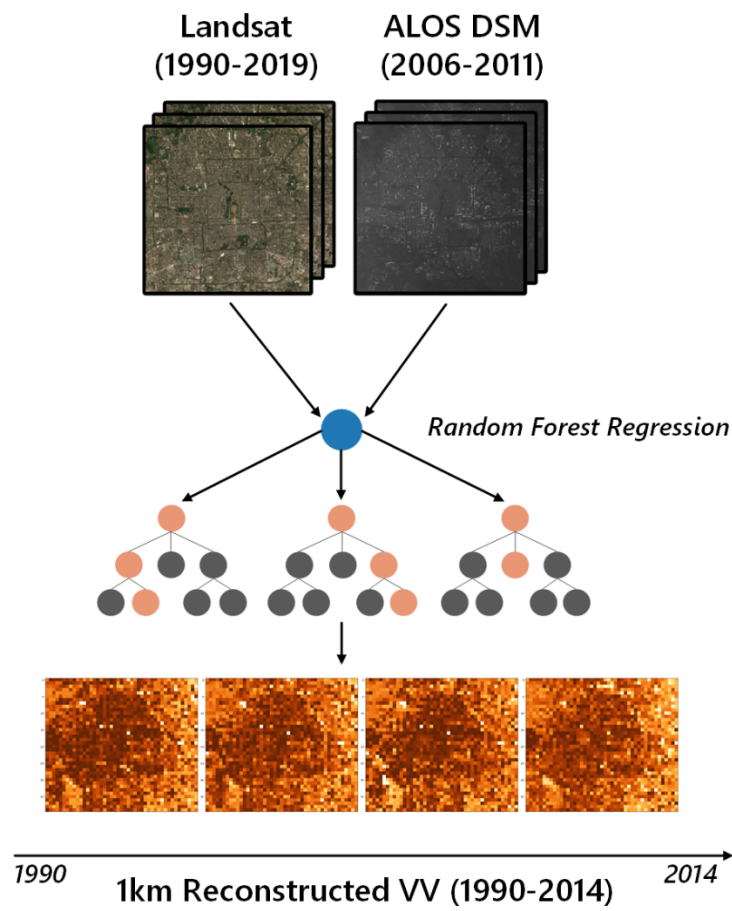


Figure S4. A brief method demonstration of 1km VV backscatter reconstruction

Table S1. Detailed sample counts for each year after data augmentation.

Year	Total	Height			
		<10m	10-30m	30-60m	>60m
1990	2925078	2250063	225005	225005	225005
1991	3041462	2339588	233958	233958	233958
1992	3132599	2409692	240969	240969	240969
1993	3264198	2510922	251092	251092	251092
1994	3438375	2644905	264490	264490	264490
1995	3611900	2778386	277838	277838	277838
1996	3762725	2894405	289440	289440	289440
1997	3897648	2998191	299819	299819	299819
1998	4020193	3092458	309245	309245	309245
1999	4143187	3187069	318706	318706	318706
2000	4338766	3337513	333751	333751	333751
2001	4626719	3559016	355901	355901	355901
2002	4961464	3816511	381651	381651	381651
2003	5282849	4063730	406373	406373	406373
2004	5707837	4390645	439064	439064	439064
2005	6159368	4737977	473797	473797	473797
2006	6613910	5087624	508762	508762	508762
2007	7060925	5431481	543148	543148	543148
2008	7472704	5748235	574823	574823	574823
2009	7950644	6115880	611588	611588	611588
2010	8357469	6428823	642882	642882	642882
2011	8898677	6845138	684513	684513	684513
2012	9258691	7122070	712207	712207	712207
2013	9718533	7475796	747579	747579	747579
2014	10196881	7843756	784375	784375	784375
2015	10695350	8227193	822719	822719	822719
2016	11094447	8534190	853419	853419	853419
2017	11488907	8837621	883762	883762	883762
2018	11977999	9213847	921384	921384	921384
2019	12401142	9539343	953933	953933	953933

Table S2. Number of validated samples and accuracy using Lianjia data

Year	Total Validated Samples	Accurate Samples	Accuracy(%)
1990	268267	178351	66.48
1991	291148	193505	66.46
1992	331777	218945	65.99
1993	374071	244216	65.29
1994	411879	269261	65.37
1995	463103	307051	66.3
1996	515976	342303	66.34
1997	564208	373214	66.15
1998	622275	421245	67.69
1999	672652	462295	68.73
2000	758118	528517	69.71
2001	832633	569839	68.44
2002	905789	616905	68.11
2003	982672	683523	69.56
2004	1053250	759842	72.14
2005	1120137	838019	74.81
2006	1178456	904747	76.77
2007	1224090	965382	78.87
2008	1275174	1033647	81.06
2009	1316426	1097526	83.37
2010	1358834	1160563	85.41
2011	1387420	1206570	86.97
2012	1415484	1262628	89.2
2013	1433020	1306494	91.17
2014	1449677	1347021	92.92
2015	1462710	1385135	94.7
2016	1472736	1423383	96.65
2017	1476362	1452553	98.39
2018	1477628	1470337	99.51
2019	1477758	1477758	100

Table S3. RMSEs, MAEs and R²s for each year

Year	RMSE	MAE	R²
1990	3.39	2.38	0.82
1991	3.72	2.62	0.78
1992	3.41	2.44	0.82
1993	3.84	2.70	0.76
1994	3.66	2.59	0.79
1995	3.60	2.55	0.79
1996	3.46	2.43	0.81
1997	3.27	2.29	0.83
1998	3.43	2.39	0.81
1999	3.48	2.45	0.81
2000	3.20	2.27	0.83
2001	3.62	2.58	0.79
2002	3.57	2.52	0.80
2003	3.60	2.52	0.79
2004	3.48	2.45	0.81
2005	3.48	2.44	0.81
2006	3.84	2.70	0.77
2007	3.78	2.65	0.78
2008	3.89	2.72	0.78
2009	4.01	2.78	0.77
2010	3.90	2.72	0.78
2011	4.28	2.95	0.75
2012	4.25	2.95	0.76
2013	3.99	2.77	0.79
2014	4.11	2.83	0.78
2015	3.58	2.49	0.84
2016	3.73	2.59	0.82
2017	4.14	2.86	0.78
2018	3.75	2.61	0.82
2019	3.90	2.70	0.80

Table S4. Accuracy Assessment ((RMSE, MAE and R²) for each training sample city each year from 1990 to 2019 (excerpt in 2019)

Year	2019		
	RMSE	MAE	R ²
aomen	4.93	2.60	0.72
baoding	3.52	2.48	0.55
beijing	3.83	2.71	0.75
changchun	3.53	2.54	0.61
changsha	5.52	3.57	0.54
changzhou	4.31	2.86	0.58
chengdu	5.14	3.50	0.62
chongqing	6.16	4.09	0.57
dalian	4.35	2.89	0.52
dongguan	4.49	2.67	0.42
eerduosi	4.15	2.64	0.30
foshan	12.31	7.73	-1.96
fuzhou	4.75	3.14	0.45
guangzhou	12.51	7.67	-1.68
guiyang	6.21	3.60	0.47
haikou	3.23	1.82	0.68
hangzhou	5.57	3.42	0.48
harbin	4.54	3.23	0.66
hefei	5.38	3.58	0.50
huhehaote	3.54	2.62	0.57
huizhou	4.96	2.78	0.65
jiaxing	4.43	2.96	0.34
jinan	4.48	3.18	0.58
jinhua	3.82	2.59	0.55
kunming	4.82	3.14	0.69
lanzhou	3.48	2.50	0.66
lasa	2.03	1.43	0.09
luoyang	4.42	3.13	0.64
nanchang	4.32	2.94	0.49
nanjing	4.26	2.89	0.48
nanning	4.85	2.61	0.63
nantong	3.95	2.71	0.52
ningbo	4.75	3.01	0.47
qingdao	4.13	2.84	0.54
sanya	2.88	1.67	0.61
shanghai	3.98	2.74	0.62
shantou	2.98	2.03	0.62
shaoxing	4.13	2.68	0.47
shenzhen	5.59	3.06	0.66

shijiazhuang	4.49	3.19	0.66
suzhou	4.19	2.59	0.49
taiyuan	3.80	2.67	0.60
tangshan	3.17	2.15	0.61
tianjin	3.73	2.58	0.60
wenzhou	4.04	2.75	0.49
wuhan	4.94	3.27	0.45
wuhu	3.66	2.58	0.37
wuxi	4.23	2.82	0.53
xiamen	5.24	2.98	0.38
xian	5.51	3.68	0.61
xianggang	7.60	3.39	0.71
xining	3.50	2.48	0.65
xuzhou	3.53	2.53	0.52
yangzhou	2.93	2.15	0.34
yantai	1.84	1.31	0.22
yinchuan	3.82	2.66	0.39
zhengzhou	4.57	3.18	0.61
zhongshan	2.91	1.87	0.61

The full table including indices from 1990 to 2019 is very long and could be acquired at https://github.com/ivywpson/BH_mapping in 'Accuracy assessment by city.xlsx'

Table S5. Annual statistics for mean height, impervious surface area, and building volume

Year	Mean Height (m)	Impervious surface Area (km²)	Building Volume (km³)
1990	6.72	54407.02	365.98
1991	6.65	57099.29	380.15
1992	6.68	59527.28	398.00
1993	6.70	62291.48	417.64
1994	6.69	65519.19	438.58
1995	6.76	68571.14	464.04
1996	6.80	71550.47	487.02
1997	6.77	74352.78	503.57
1998	6.68	77311.80	516.42
1999	6.65	80759.16	537.18
2000	6.49	85330.14	554.45
2001	6.45	89054.61	574.37
2002	6.31	93230.15	588.60
2003	6.18	96620.34	597.80
2004	6.13	100066.00	613.94
2005	6.09	103822.41	632.63
2006	6.06	107632.07	653.00
2007	6.02	111870.29	674.24
2008	6.00	116188.50	697.36
2009	5.97	120594.27	720.01
2010	5.97	125293.50	748.88
2011	5.95	131203.16	781.46
2012	5.88	137743.03	810.73
2013	5.79	145245.75	841.11
2014	5.62	152231.04	855.53
2015	5.36	160565.12	861.76
2016	5.23	168078.19	879.78
2017	5.16	169687.17	876.89
2018	5.14	170588.85	878.10
2019	5.17	170595.06	882.43

Table S6. VV regression model accuracy in different cities across China in 2019

Geographical Region	Representative City	Number of Pixels	RMSE (dB)	MAE (dB)	rRMSE	R²
Northern China	Beijing	645	1.74	1.17	34.6%	0.90
Plain	Shijiazhuang	398	1.91	1.29	27.4%	0.89
Northeast Plain	Harbin	451	1.92	1.35	28.9%	0.89
	Changchun	422	1.77	1.21	22.0%	0.87
Northwest Arid Zone	Lanzhou	160	1.57	1.26	34.6%	0.90
	Yinchuan	120	1.98	1.37	31.0%	0.85
Yangtze River Delta	Shanghai	548	1.98	1.29	28.6%	0.90
	Suzhou	463	1.97	1.26	34.1%	0.90
Yangtze River Basin	Wuhan	380	2.16	1.31	35.0%	0.89
	Changsha	320	2.34	1.41	38.1%	0.89
Sichuan Basin	Chengdu	493	1.97	1.29	38.1%	0.89
	Chongqing	179	1.74	1.17	30.7%	0.93
Southwest	Kunming	130	1.68	1.18	40.1%	0.90
Highland	Guiyang	250	1.81	1.31	31.3%	0.89
Southeast	Fuzhou	172	2.37	1.61	49.3%	0.82
Coastal	Xiamen	262	1.76	1.19	29.5%	0.92
Pearl River Delta	Guangzhou	267	2.45	1.35	56.1%	0.84
	Shenzhen	259	2.05	1.34	43.6%	0.86
National Pooled	All 59 cities	13997	1.97	1.34	36.7%	0.89