固碳土壤学的核心问题：

变异性与不确定性

Variability & Uncertainty:
A Crucial Issue of C Sequestration Science

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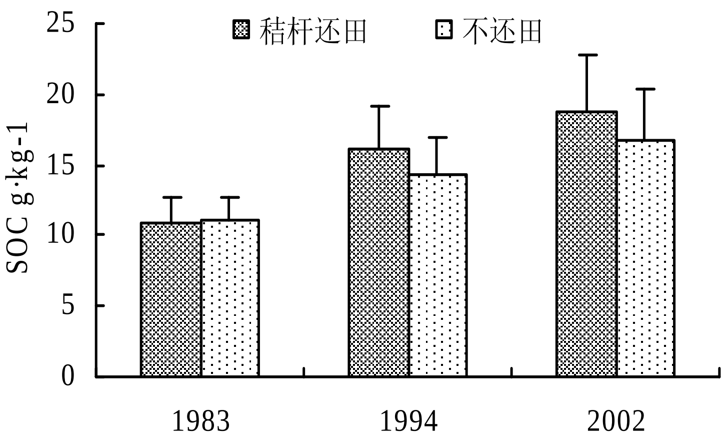
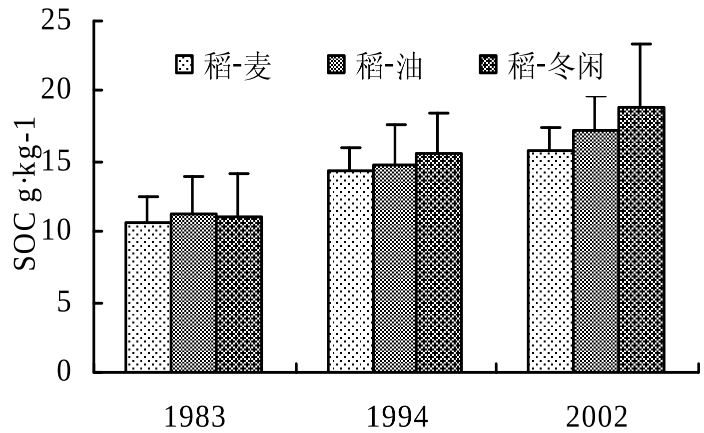
农田有机碳时间尺度的变化因影响因素而异

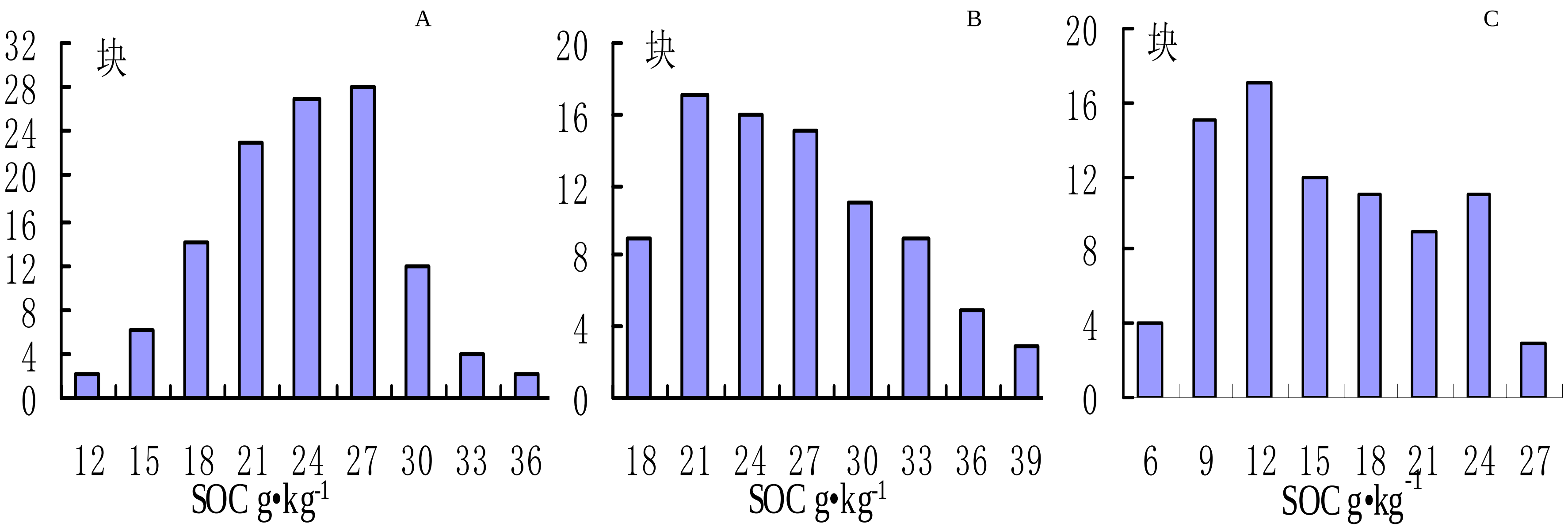




江苏宜兴市农田有机碳监测结果（**1983-2002**）

(Zhang Q et al., 2004)

有机碳的空间变异性(田块尺度)



赣东北不同景观下农田土壤有机碳含量频率图（**A**：港沿村, 河谷盆地;**B**：上祝村,丘陵山地;**C**：板桥村, 红土丘岗）

田块尺度与空间景观尺度有机碳变异性

表土**(0-20cm)**土壤有机碳含量的变异系数**%**

	村内田块间			土壤景观类型
土壤利用	港沿村	上祝村	板桥村	
水田	21.5	23.2	41.1	27.8
旱地	37.2	12.0	63.7	49.7

土壤景观空间差异影响土壤碳固定潜力的估计

赣东北三个不同土壤景观下稻田表土有机碳在不同熟制下的变化

村域	双季稻$g \cdot kg^{-1}$	田块数	单季稻$g \cdot kg^{-1}$	田块数	平均增加的碳固定(g/kg)
港沿村	23.92±4.44	59	21.11±4.84	59	2.82
上祝村	26.61±5.88	41	23.02±5.07	44	3.59
板桥村	15.93±5.39	50	11.08±4.87	32	4.85
总　计	22.02±6.86	150	19.41±6.75	132	3.63

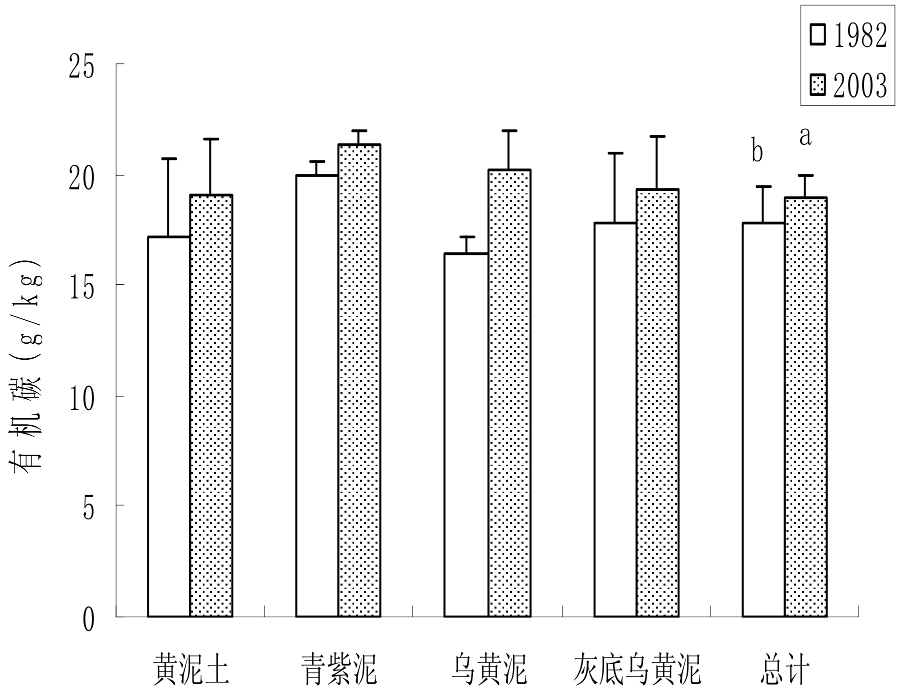
张琪等,2004

时间尺度的变化与利用类型变化的比较

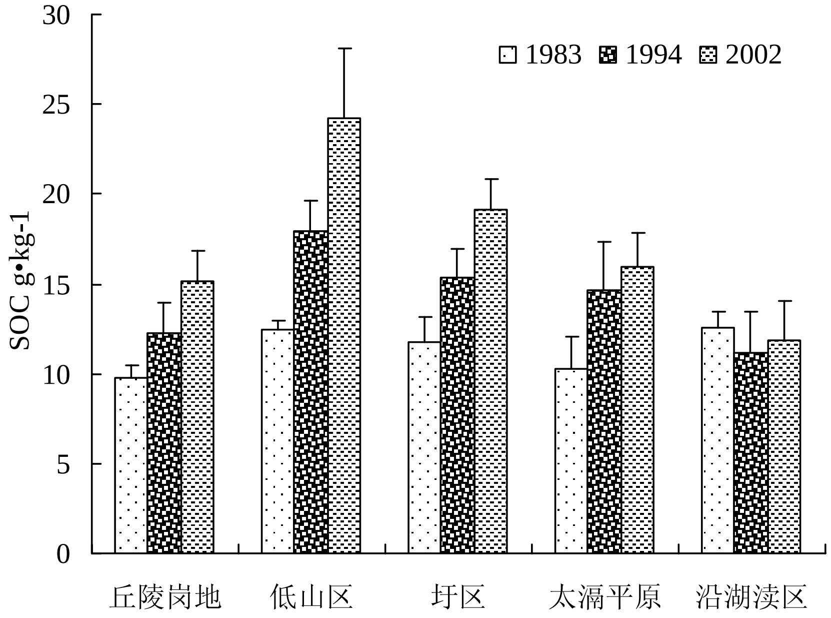
苏州吴江市六种不同土地利用类型土壤有机碳含量（2003年）比较

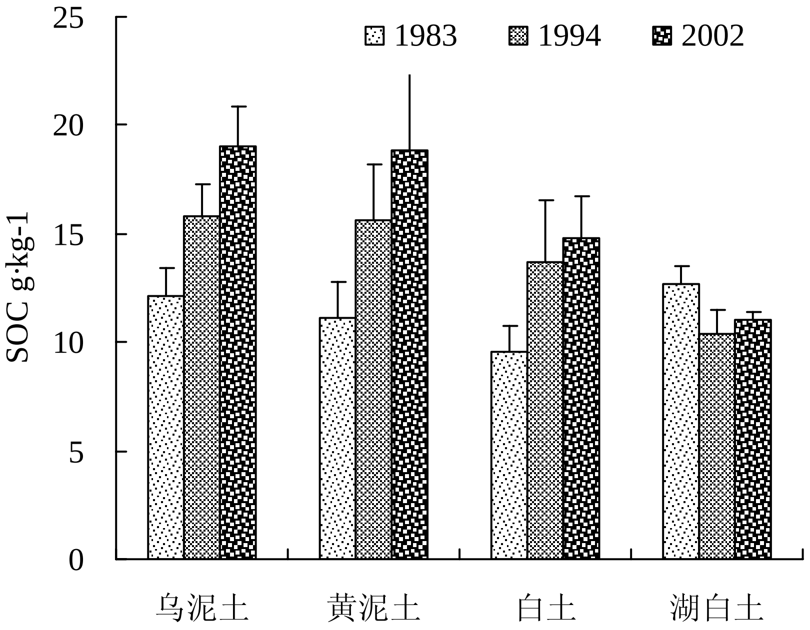
土地利用类型	面积(kha)	田块样本数	范围(g/kg)	有机碳(g/kg)
稻田	18,293	110	8.58—24.71	16.95±3.13 a
林地	5,340	33	3.64—22.50	14.37±4.00 b
果园	0.7	10	4.76—18.67	13.15±4.44 b
桑园	4,106	26	6.24—24.76	15.53±4.37 b
菜地	1,947	15	8.12—19.66	14.68±3.20 b
旱地	0.7	84	3.64—24.76	14.91±4.04 b
总计	31,087	278	3.64—24.76	16.05±4.00

吴江市表土有机碳1982年与2003年比较



农田土壤有机碳含量的土壤和地理变异

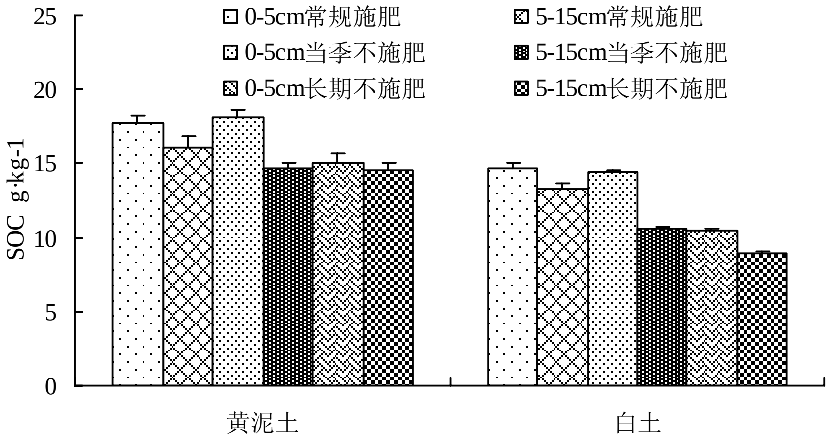




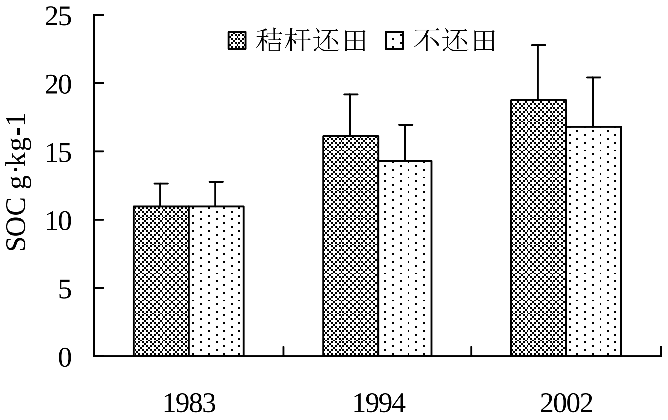
江苏宜兴市不同时期农田土壤有机碳监测结果对比

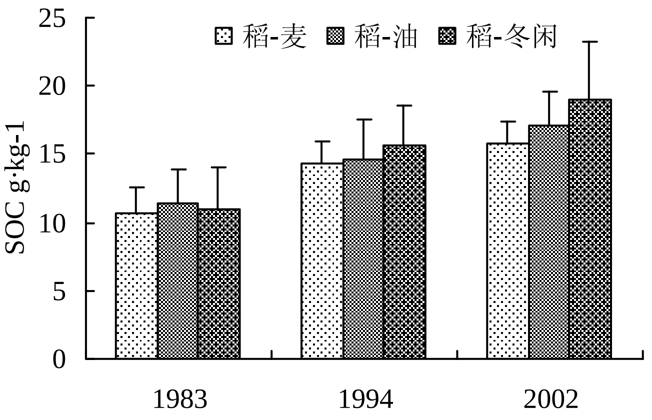
管理措施的影响可能比空间因素弱

宜兴市定点监测农田不同管理因素下表土有机碳的变化

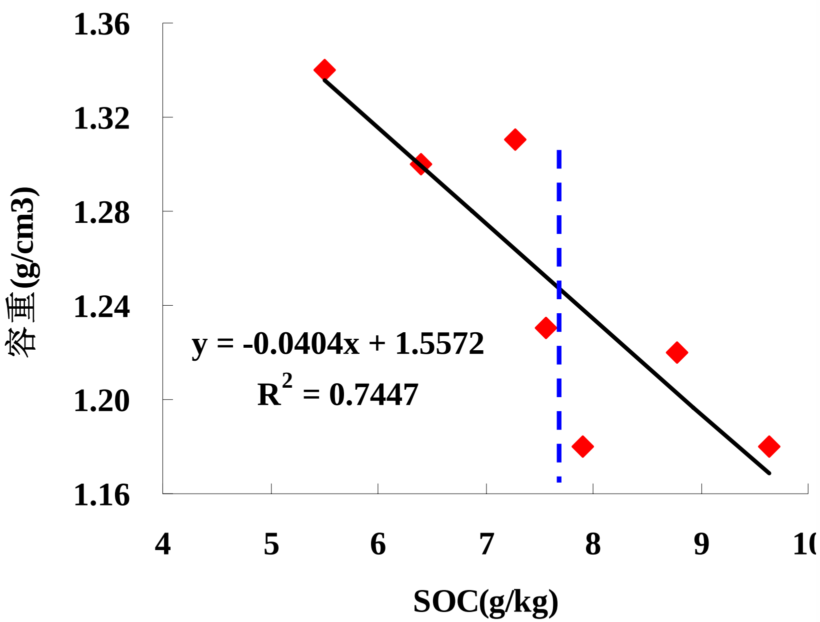


张琪等,2004

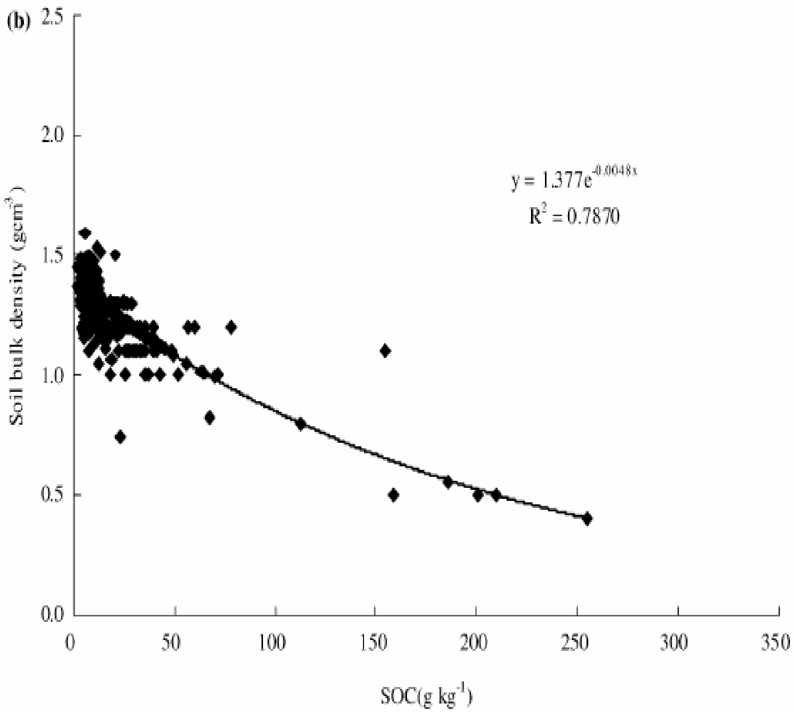




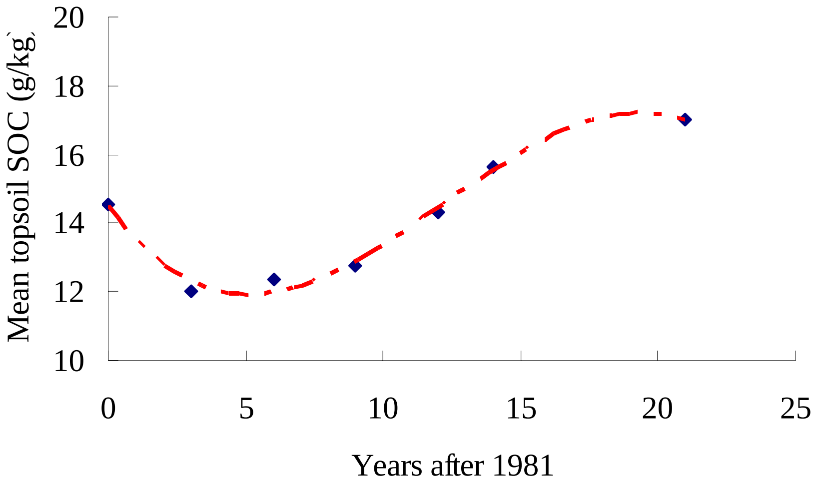
容重与有机碳关系的不确定性



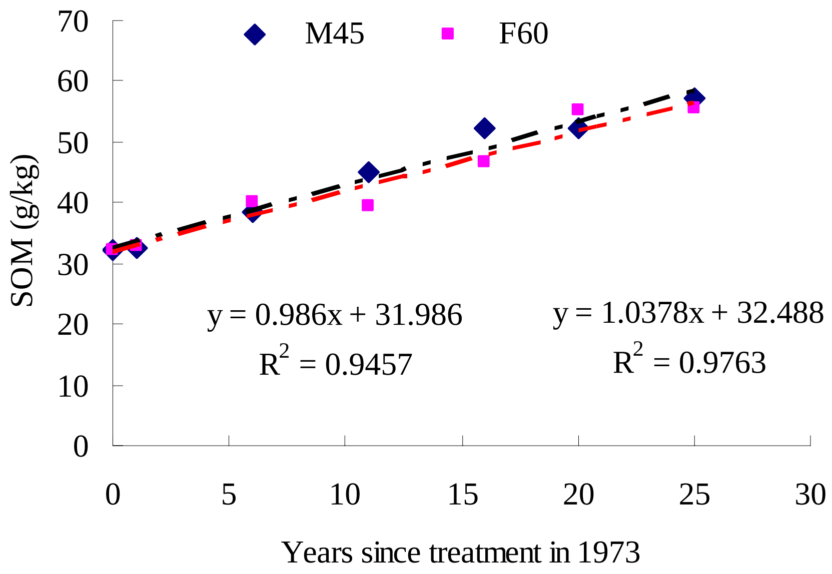
某土壤有机碳含量与容重的关系



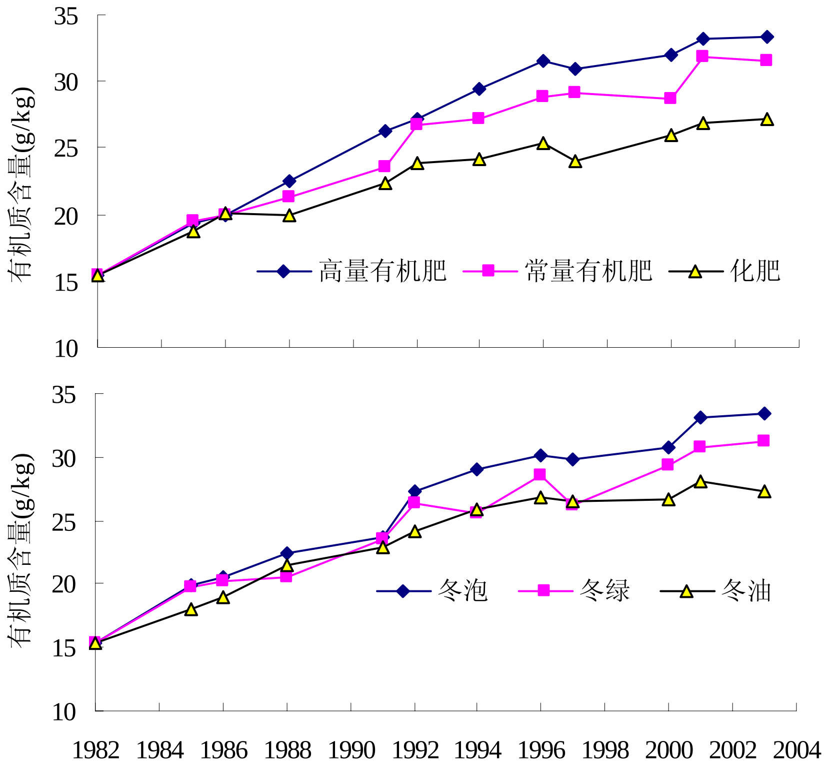
中国耕作土壤容重与有机碳含量的关系（Song et al., 2005



宜兴耕地土壤有机碳监测平均值曲线



路桥长期试验有机质变化



20年内农田有机质的稳定趋势

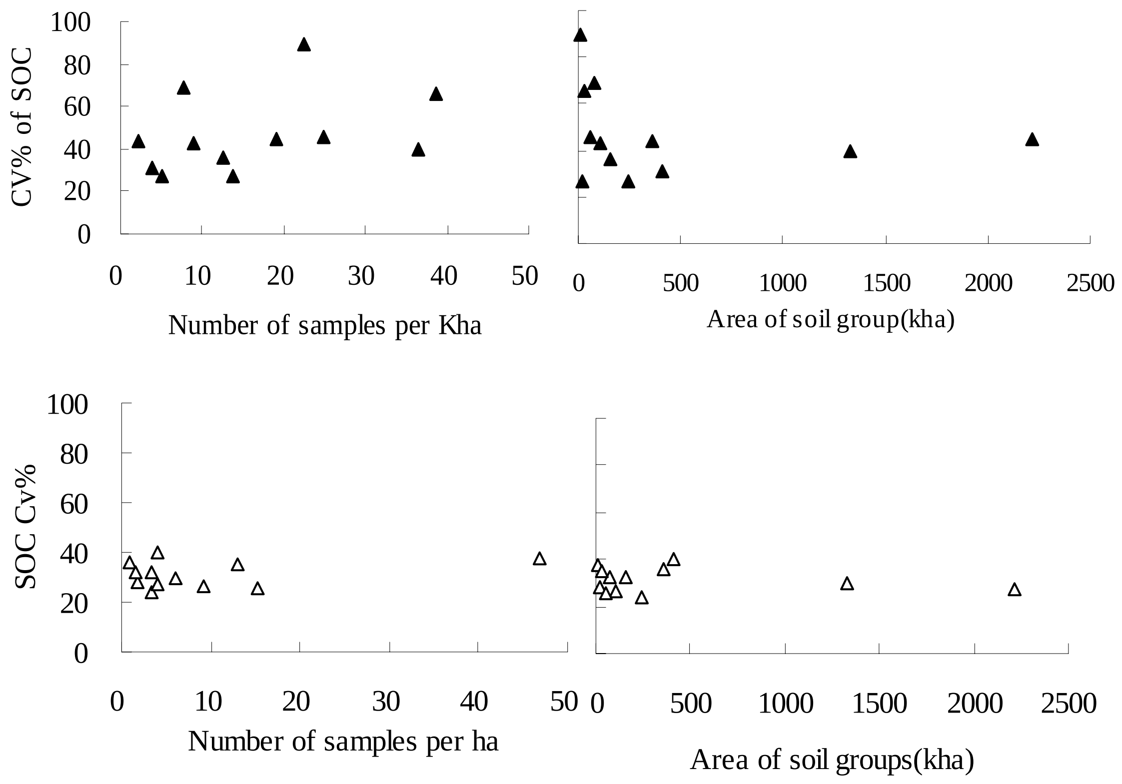
红壤性水稻土不同处理下有机质变化（湖南，刘克樱等，2004）

Variation coefficient of topsoil SOC with sample categories from Jiangsu

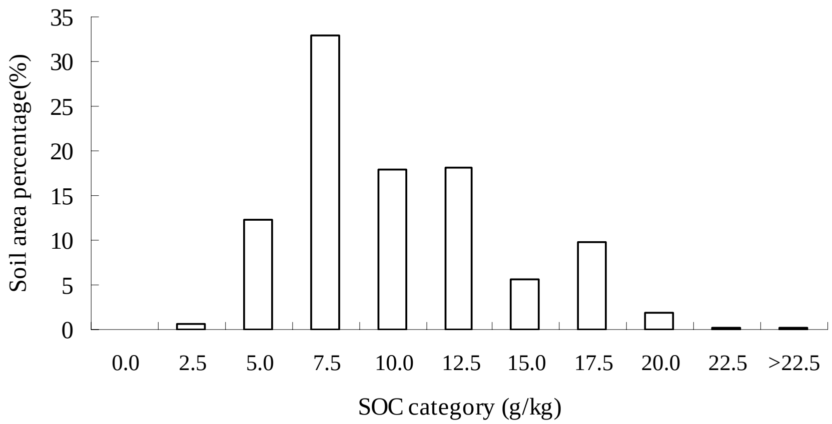
Category	By random sampling in 1982		By grid sampling in 2004	
	Inter-	**Intra-**	**Inter-**	**Intra-**
Soil Group	**67.2**	**26.8-89.2**	**20.7**	**25.9-40.4**
Agro-Eco Region	**28.7**	**27.7-37.9**	**24.8**	**24.8-35.3**
Municipality	**30.2**	**20.3-50.5**	**20.5**	**22.7-35.1**

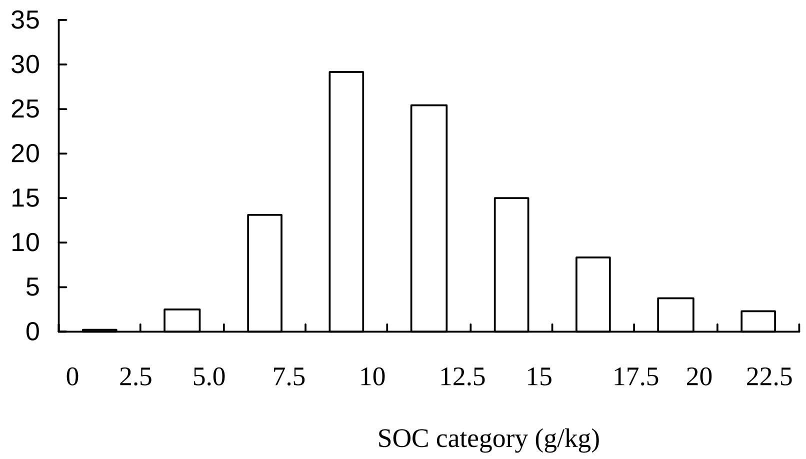
Estimation of topsoil SOC Stock(TgC) of Jiangsu soils by different statistical approaches

Sampling year	Single samples	Soil Groups	Soil regions	Municipal soils	Total mean
1982	149.8±68.0	156.5±65.4	145.1±49.9	144.5±49.2	149.0±58.1
2004	171.6±59.8	177.4±51.3	171.4±49.2	172.5±45.3	173.2±51.4



Variation coefficient of SOC level of soil groups with sampling density and soil area in 1982(Upper) and 2004(Bottom)





Frequency distribution of topsoil OC of single samples (Upper, 1979-1982; Bottom, 2004)

Variation of topsoil SOC(g/kg) with soil regions

Geographical region	1982		2004	
	Sample number	Mean	Sample number	Mean
Tai Lake plain	129540	14.04±3.89aA	3090	15.3±3.8aB
Inner lowlands	72060	11.72±3.65bA	3275	13.2±3.3bB
Yangtze river plain	111280	8.47±3.13dA	2923	10.2±3.4dB
Ningzhen hills	72430	10.09±3.83cA	3413	11.3±3.2cB
Costal plain	89820	7.31±1.68deA	3675	8.40±2.6fA
Northwestern	187560	6.73±3.02eA	7809	9.24±2.96eB
Total/mean	662690	9.44±3.18A	24185	10.83±3.82B

Different low case and capital letters indicated difference between soil regions and sampling periods at $p<0.05$ respectively.

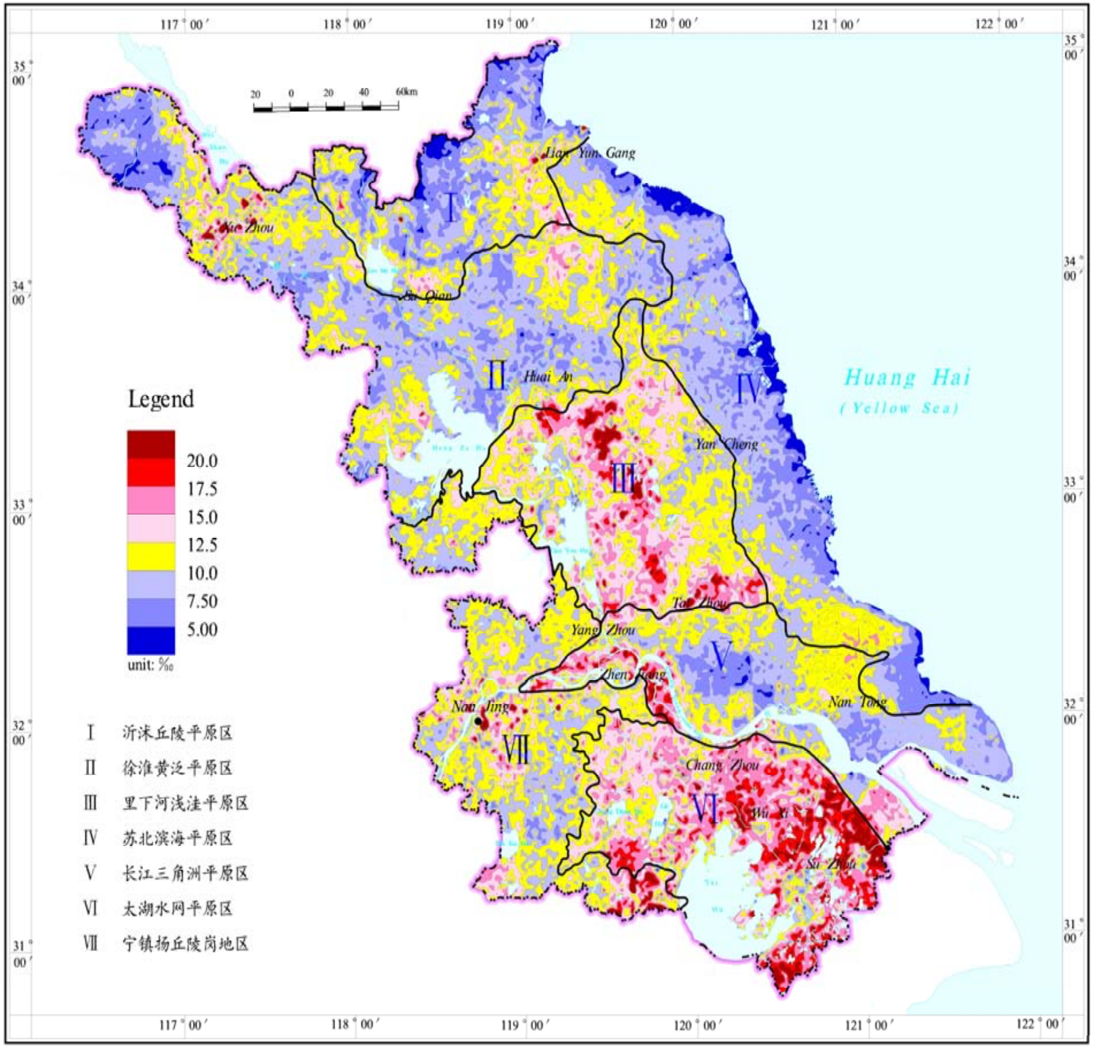
SOC contents(g/kg) of municipalities of Jiangsu in 1982 and in 2004

Municipality	1982		2004	
	Sample number	Content	Sample number	Content
Xuzhou	7445	6.32±3.19aA	2850	9.46±2.77abB
Huaiyin	9080	7.08±3.07aA	4432	10.22±2.50cB
Lianyungang	3003	7.08±2.55aA	1047	9.03±2.97abB
Yancheng	10070	8.12±2.67bcA	3746	8.95±2.45aB
Nantong	8709	7.71±1.57abA	2169	9.72±2.42bB
Yangzhou	8222	10.85±4.35cA	2976	12.50±3.23eB
Suzhou	6585	15.95±3.25fA	1685	15.47±4.40fA
Wuxi	3343	13.46±3.19eA	1018	15.39±3.79fB
Changzhou	3026	10.56±3.02dA	1043	13.09±3.03eB
Zhenjiang	2608	10.67±3.71dA	942	12.18±2.77eB
Nanjing	4079	10.96±3.89dA	1650	11.42±2.78dA
Total/Mean	66170	9.45±2.49A	24167	10.95±3.84B

Variation of SOC(g/kg) with soil groups in 1982 and in 2004

Soil group	1982		2004	
	N	Mean	N	Mean
Altudic Ferralsol	100	9.11±2.44bA	37	13.7±3.87a B
Arpudic Luvisols	810	10.8±4.72 abA	329	11.7±4.25abB
Lessive Luvisols	2020	4.66±1.68 eA	533	7.80±2.51eB
Halpustic Luvisols	920	6.22±2.67c A	951	10.9±2.89bB
Cabudic Cambisols	1120	17.0±11.2 aA	376	10.6±3.69bB
Udorthic Entisols	1390	11.1±5.10 aA	853	8.60±2.23dA
Purpudic Cambisols	210	6.50±5.80 cA	435	9.50±3.61cB
Carbudic Vertisols	3390	8.11±2.20b A	811	10.7±2.54bB
Motudic Cambisols	48690	6.76±2.67d A	7970	9.50±2.83cB
Aquhydroagric Anthrosols	42230	12.2±5.05ab A	9145	13.3±3.67aB
Aquorthic Halosols	1540	7.27±2.26cd A	1682	7.80±3.15deA
Hapstagnic Gleysols	570	31.8±22.0a A	111	14.3±4.61aB
Total/mean	102990	9.97±4.15 A	24167	10.9±3.8B

Spatial Scale and Variability of SOC: Example of Jiangsu



Spatial distribution of Topsoil SOC of Jiangsu Province (Liao, et al., 2006)

C Counting

土壤有机碳密
度：

$$D_{oc} = \text{SOC} \times \gamma \times H \times (1 - \delta_{2\,\text{mm}}/100) \times 10^{-1}$$

土壤有机碳储量：

$$P_{oc}(tC) = \sum_{i=1}^{n} S_i \times \sum_{j=1}^{n} \text{SOC}_j \times \gamma_j \times H_j \times 10^{-1}$$

Typical samples collected in 2nd Soil Survey

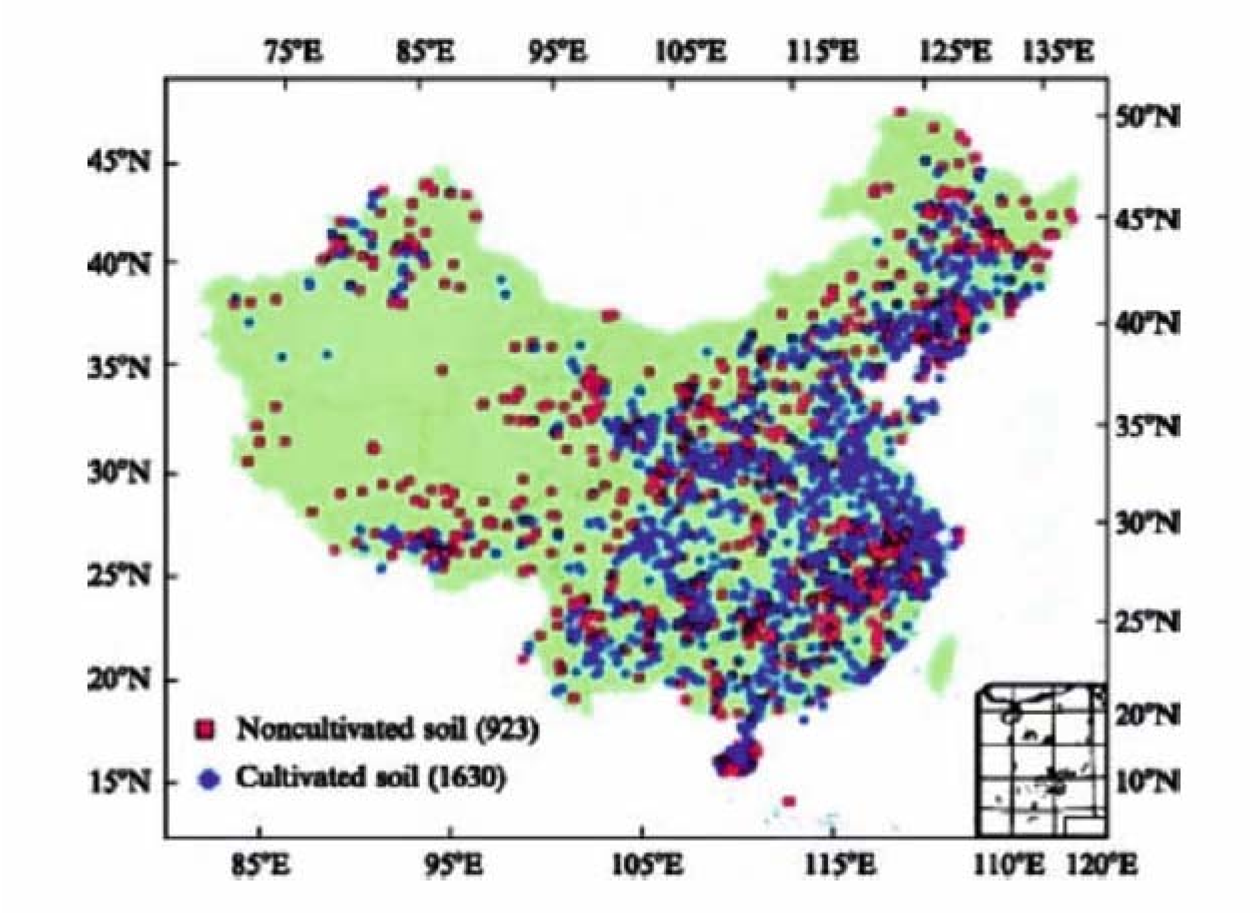
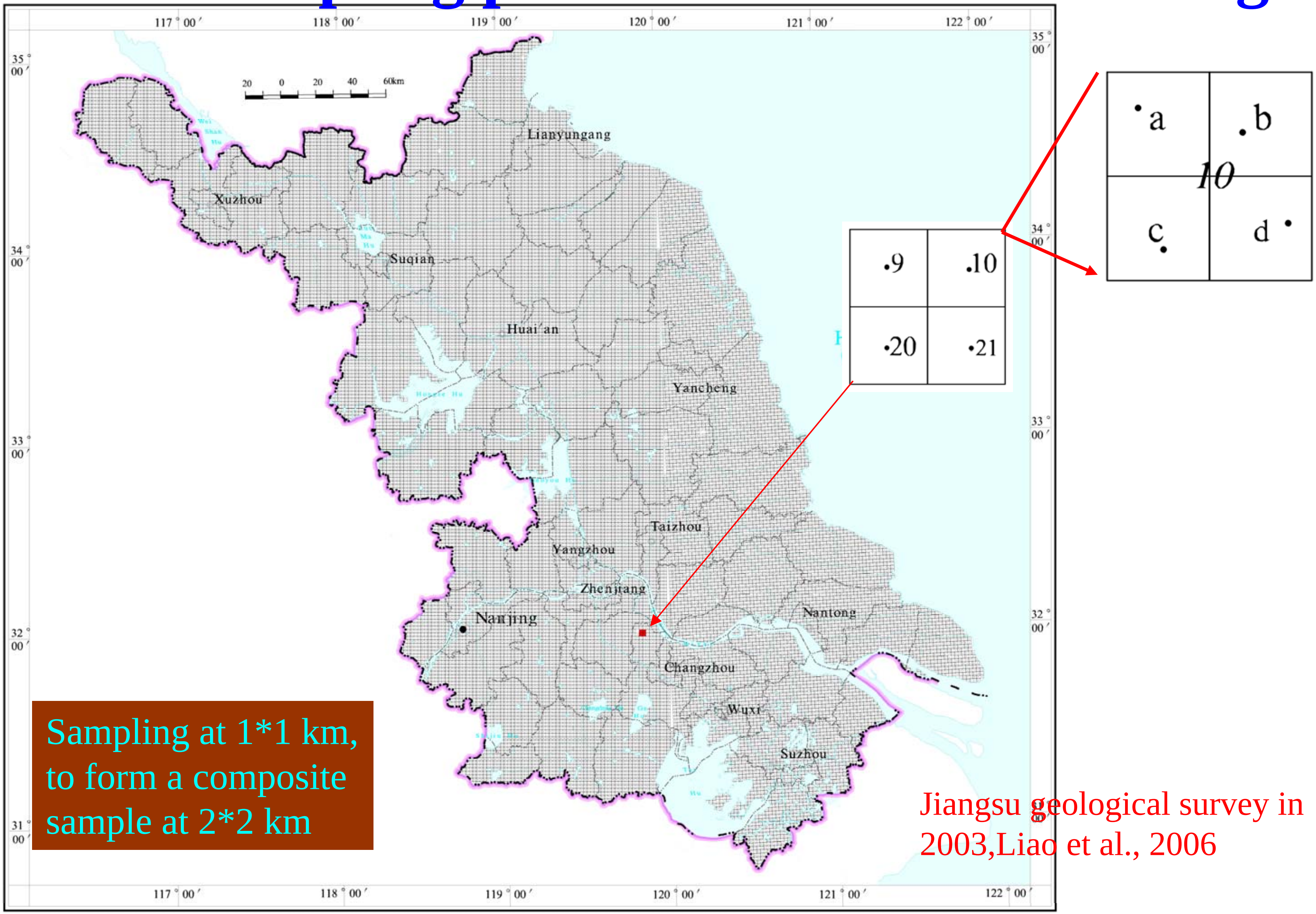


Figure 1. Sampling locations of the typical profiles of the 2456 Soil Series during the 2nd State Soil Survey of China 1979–1982 (Cited from Wu et al., 2003).

Grid sampling procedure for C measuring



Sampling at 1*1 km, to form a composite sample at 2*2 km

Jiangsu geological survey in 2003,Liao et al., 2006

Background

- IPCC AR4 of Global Climate Change Mitigation
- Demand of GHG emission reduction in post-Kyoto Protocol period
- C management and C trading into action

Demand of GHG emission reduction in post-Kyoto Protocol period

- Accounting
- Measurable
- and Verifiable
- Management
- and Trading

Soil C Sequestration

- Variation in Forms, Pools,
- Variation in temporal and spatial scales
- Process,mechanisms,mediations
- Protection, Transformation, Stabilization
- Coupling of soil quality, ecosystem functioning?

Status of China's Soil C Cycle Study

- Data accumulation
- C Stock estimate-Not yet commonly accepted
- C Dynamics—case studies, data statistics
- SCS Potential- dedicate works insufficient
- SCS Mechanism study: few but aggregate level

C Sequestration in Cropland Soils: Processes, Controls and Impacts

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