IIASA'S Terrestrial Full Carbon Account for Russia: Revised Uncertainty Estimates and its Role in a Bottom-up/Top-down Accounting Exercise

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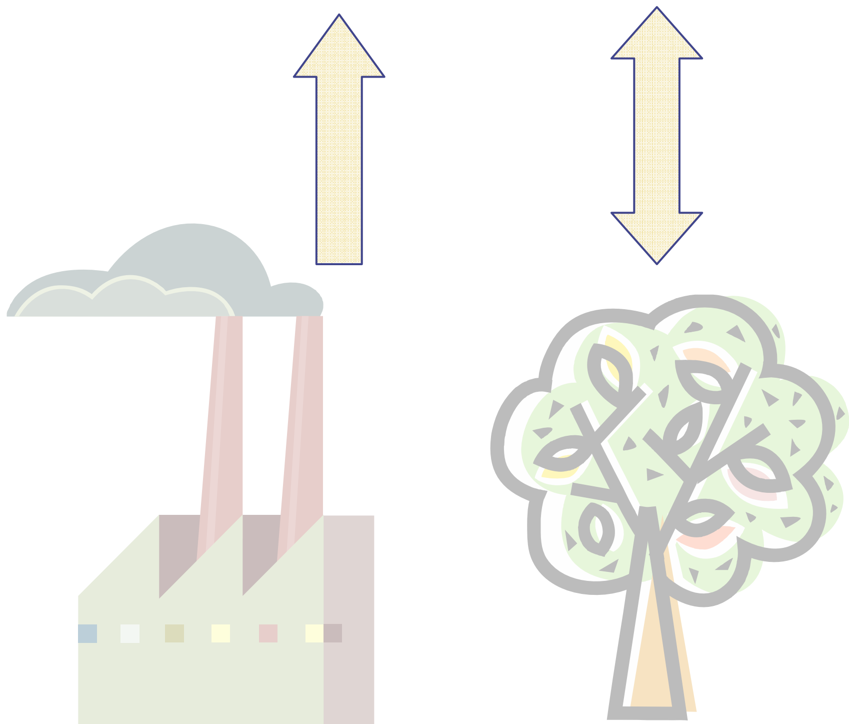
Overview

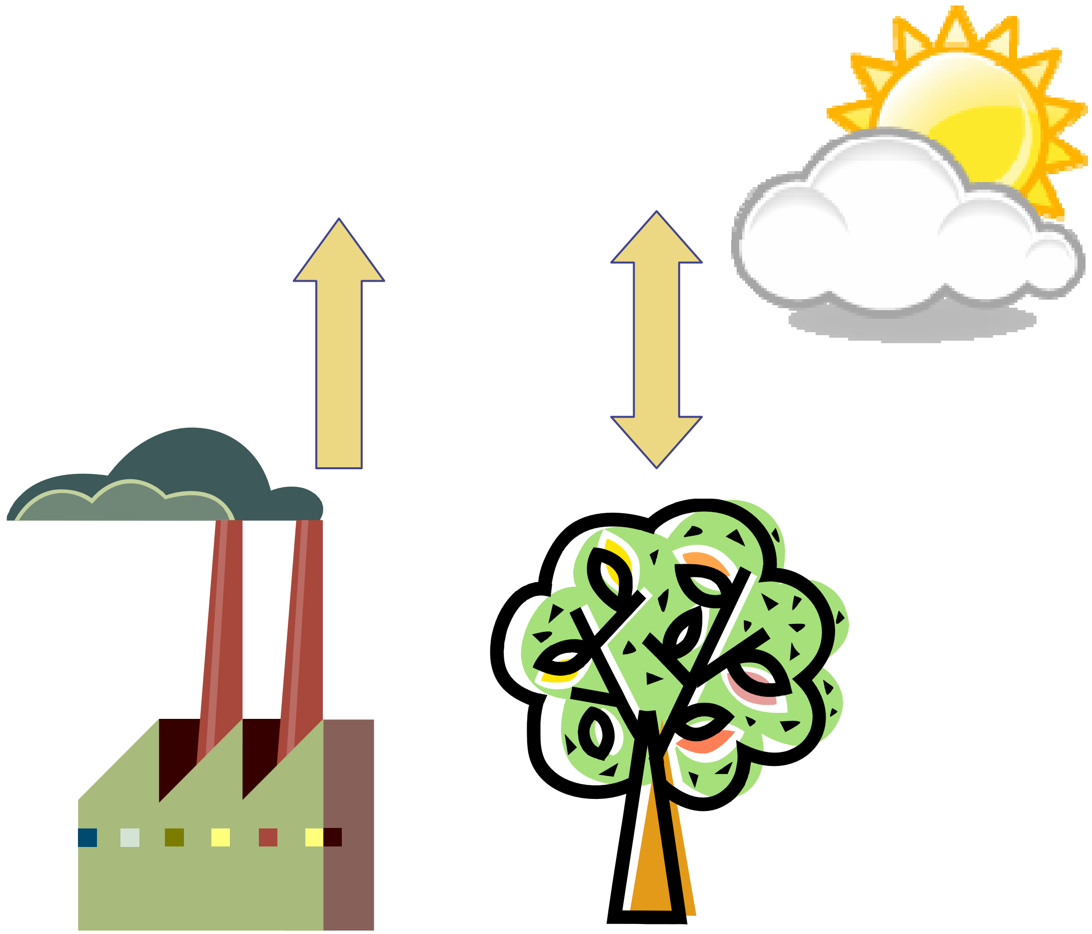
- Introduction
- Objectives
- Methodology
- Results and discussion
- Conclusions

Bottom-up and Top-down estimates of CO_2 fluxes

- Bottom-up: AtmConc = Sum of measur./estim. fluxes
- Top-down: Net flux = f(measured AtmConc)

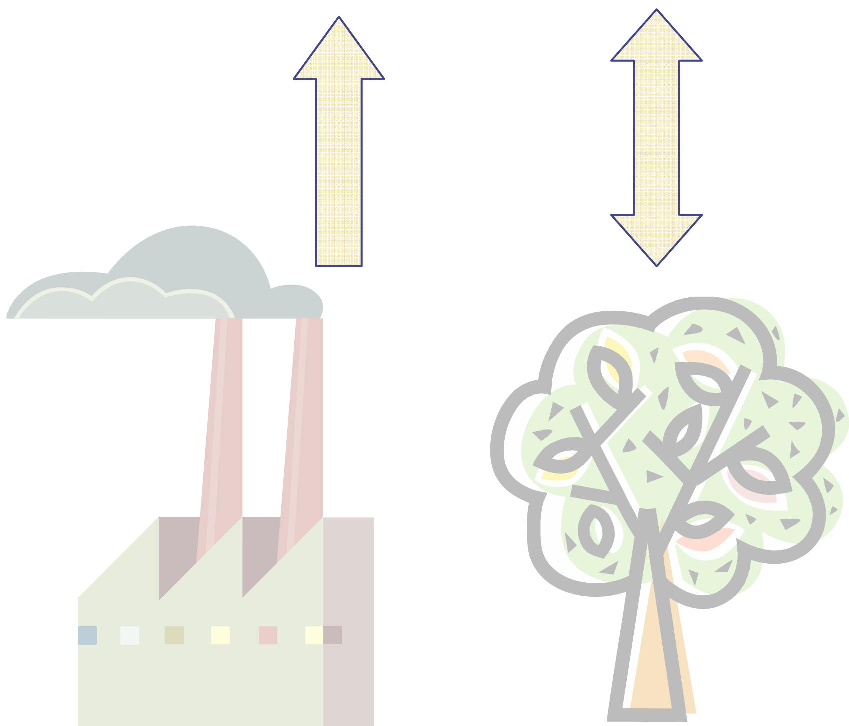


How can we check whether our bottom-up estimates of CO_2 fluxes are correct?



How can we check whether our bottom-up estimates of CO_2 fluxes are correct?

- Compare bottom-up and top-down estimates



Objectives

- Revise uncertainty estimates in FCA for Russia
- Compose bottom-up CO_2 budget for BCZ
- Compare the bottom-up estimate with top-down
- Estimate additional value of the study for top-down studies

Methodology: General

- CO_2 fluxes for 1988-1992 in FCA 2000 (Nilsson et al. 2000)
- HR and NPP determine net atmospheric flux and uncertainty
- Fluxes by BCZ – uncertainties <100%; good for comparison with top-down
- 90% Confidence Interval

Methodology: Forest NPP

New estimate 36% higher than FCA 2000

New estimate (Shvidenko et al., 2006; Shvidenko 2007)

- Forest inventory,
- forest growth models,
- live biomass models and
- ecological parameters of production process
- Partially eliminated biases and decreased random error

FCA 2000:

- Bioproductivity database (average NPP for 196x…)
- Selected with actual age
- Adjusted for disturbances
- Fine root NPP is not well estimated

Methodology: Forest NPP

Distribution among BCZ:

$$\left\{\sum_{i=1}^{8}\frac{\left(NPP_{old}^{i}-NPP_{new}^{i}\right)^{2}}{S_{i}^{2}}*\left(1-0.61\right)^{2}+\sum_{i=1}^{7}\left({}^{*}NPP_{Sib2}^{i}-{}^{*}NPP_{new}^{i}\right)^{2}*r_{i}^{2}*\left(1-0.18\right)^{2}\right\}\rightarrow \min$$

Methodology: Agriculture NPP

- Additional knowledge on relative uncertainties from Austrian Carbon Database (Jonas and Nilsson, 2002)
- A bias found in FCA 2000 NPP estimates
- Harvest losses (10-50%) were not taken into account
- Downscaling: oblast + LC + BCZ

Methodology: HR

HR = (1-RC) x SR

Measured / estimated

Measured

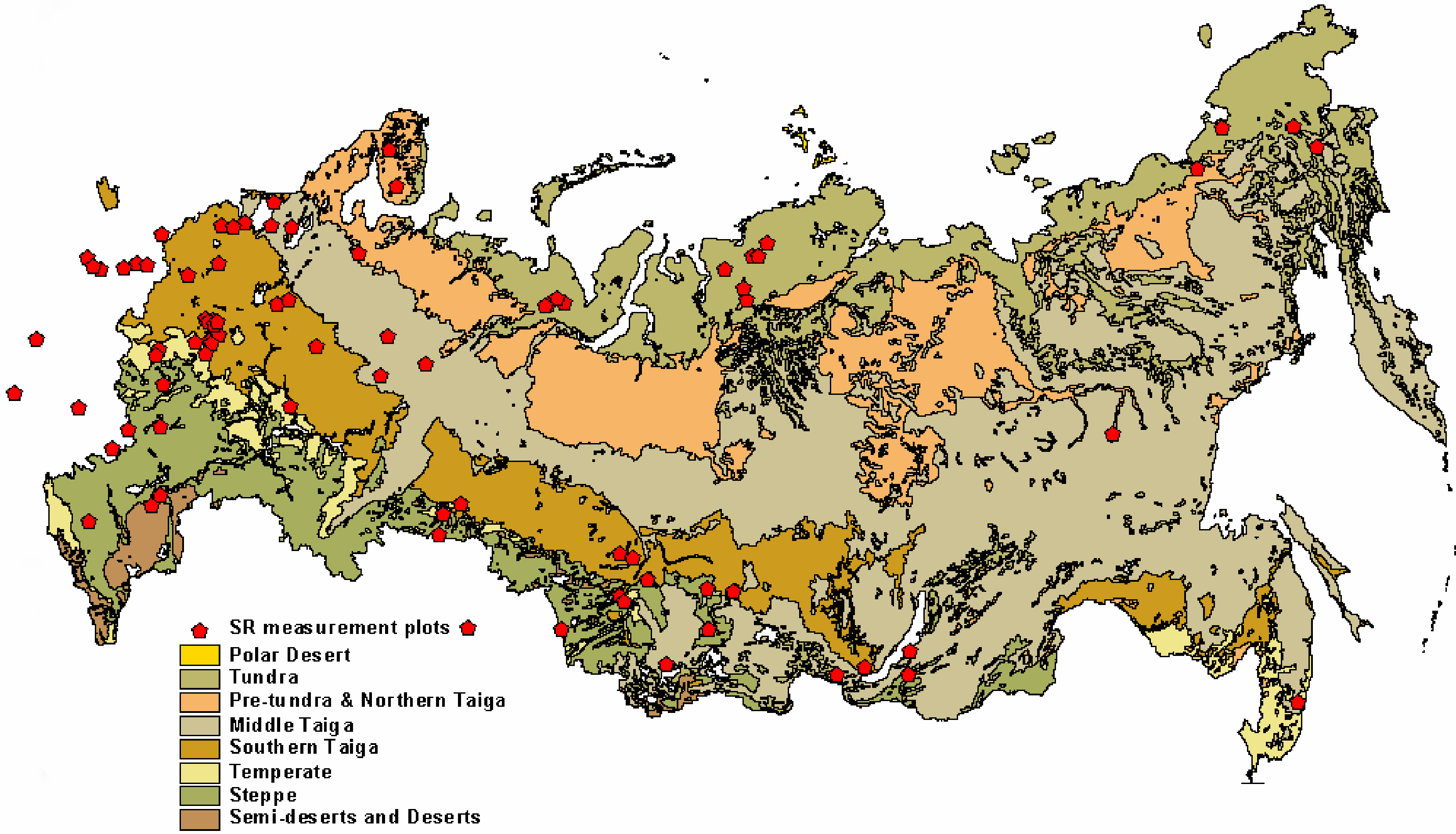
Stolbovoi (FCA 2000) and Kurganova, 2002

RC=21%

RC=52%

Methodology: HR

Soil respiration measurement plots



Methodology: HR

Soil Division	Bcz / Soil division area, 10^6 ha / number of measurements								
	Polar desert	Tundra	Pre-tundra & Northern Taiga	Middle taiga	Southern taiga	Temperate	Steppe	Semi-deserts and deserts	Total
Alcaline clay-differentiated	0.00 0	0.00 0	0.10 0	0.01 0	0.28 0	1.50 0	5.35 0	2.34 1	**9.59** **1**
Al-Fe-Humic	0.00 0	56.59 9	62.57 7	233.68 5	8.80 0	0.27 2	3.03 0	0.51 0	**365.45** **23**
Alluvial	0.00 0	4.62 0	3.77 3	7.92 0	0.65 1	0.51 0	1.67 0	0.16 0	**19.31** **4**
Cryozems	0.23 0	11.57 5	0.00 0	0.00 0	0.00 0	0.00 0	0.00 0	0.00 0	**11.80** **5**
Gleyzems	0.00 0	118.35 3	73.96 0	46.63 1	3.33 0	0.10 0	0.00 0	0.23 0	**242.59** **4**
Humic-accumulative	0.00 0	0.24 0	0.64 0	6.37 9	10.54 7	19.54 17	122.45 29	5.97 5	**165.76** **67**
Metamorphic	0.00 0	6.52 4	17.71 0	165.42 0	14.69 2	12.80 5	3.99 0	2.94 0	**224.06** **11**
Peat	0.00 0	7.69 1	24.62 0	33.74 1	24.82 53	0.24 1	0.00 7	0.00 0	**91.11** **64**
….	…	…	….	….	….	….	….	….	**…**
Sod-organic-accumulative	0.00 0	6.73 0	23.20 0	63.89 0	13.66 0	1.04 0	0.37 0	0.07 0	**108.96** **0**
Texture-differentiated	0.00 0	0.80 4	22.59 0	82.92 19	132.22 101	22.28 41	6.73 4	0.05 3	**267.59** **172**
Total without 'non soil'	**0.23** **0**	**233.46** **26**	**229.80** **10**	**666.69** **35**	**210.81** **164**	**59.63** **66**	**145.65** **40**	**12.60** **9**	**1558.87** **350**

Methodology: HR

Bias=f(mes.meth.)

Soil Division	Bcz / bias (%)								
	Polar desert	Tundra	Pre-tundra & Northern Taiga	Middle taiga	Southern taiga	Temperate	Steppe	Semi-deserts and deserts	Total
Alcaline clay-differentiated								10	**10**
Al-Fe-Humic		-3	8	6		-20			**5**
Alluvial			-30		10				**-22**
Cryozems		-10							**-10**
Gleyzems		-1	10	10					**3**
Halomorphic									
Humic-accumulative				-1	-1	-1	-5	-7	**-4**
Lithozems									
Low-humic accumulative-calcareous									
Metamorphic		-20	-20	-20	10	-20			**-20**
Peat		-30		0	-4	-3			**-4**
Shallow weakly developed									
Sod-organic-accumulative				10					**10**
Texture-differentiated		10	-3	-2	-11	-9	-5	-6	**-8**
Volcanic									
Total		**-4**	**4**	**-1**	**-8**	**-9**	**-5**	**-3**	**-3**

Methodology: HR

$$U90p = \frac{STD * t_{0.9}(N-1)}{\sqrt{N}}$$

$$R\_U90p = \frac{U90p}{M} * 100\%$$

Soil Division	Bcz / Relative precision (%)								
	Polar desert	Tundra	Pre-tundra & Northern Taiga	Middle taiga	Southern taiga	Temperate	Steppe	Semi-deserts and deserts	Total
Alcaline clay-differentiated								90	**90**
Al-Fe-Humic		33	24	36		90			**26**
Alluvial			63		90				**51**
Cryozems		54							**54**
Gleyzems		87	90	90					**52**
Halomorphic									
Humic-accumulative				51	53	16	18	54	**15**
Lithozems									
Low-humic accumulative-calcareous									
Metamorphic		67	75	90	90	38			**72**
Peat		90		90	23	43			**47**
Shallow weakly developed									
Sod-organic-accumulative				90					**90**
Texture-differentiated		90	41	19	8	22	70	59	**7**
Volcanic									
Total		**45**	**35**	**44**	**8**	**16**	**17**	**49**	**20**

Methodology: HR

HR uncertainty for BCZ

$$U90_{HR_k} = \sqrt{\sum_{i=1}^{L}\left[\left(\sum_{j=1}^{J} U90^2_{SR_{ijk}} * S^2_{ijk}\right) * \left(1 - \frac{RC_{ik}}{100}\right)^2 + \left(\sum_{j=1}^{J} SR_{ijk} * S_{ijk}\right)^2 * \left(\frac{U90_{RC_{ik}}}{100}\right)^2\right]} * \frac{1}{\sum_{i,j=1}^{L,J} S_{ijk}}$$

k – *BCZ number*
L - number of vegetation types within bioclimatic zone (*L*=4)
J - number of soil divisions (*J*=15)

Methodology: HR

Correlation between BCZ:

$$Corr_{AB} = \frac{\sum_{i=1}^{4} U90^2_{AR_i} SR_i}{U90_{HR_A} U90_{HR_B}}$$

Bioclimatic zone	Polar desert	Tundra	Forest tundra & Northern taiga	Middle taiga	South taiga	Temperate forest	Steppe	Semi-desert
Polar desert	**1,00**	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Tundra	0,00	**1,00**	0,11	0,12	0,00	0,00	0,00	0,00
Forest tundra & Northern taiga	0,00	0,11	**1,00**	0,32	0,00	0,00	0,00	0,00
Middle taiga	0,00	0,12	0,32	**1,00**	0,00	0,00	0,00	0,00
South taiga	0,00	0,00	0,00	0,00	**1,00**	0,06	0,08	0,01
Temperate forest	0,00	0,00	0,00	0,00	0,06	**1,00**	0,12	0,03
Steppe	0,00	0,00	0,00	0,00	0,08	0,12	**1,00**	0,16
Semi-desert	0,00	0,00	0,00	0,00	0,01	0,03	0,16	**1,00**

Methodology: HR

- Final HR:

$$HR = 1/3 * (HR_{CS} + HR_{Stolbovoi} + HR_{Kurganova})$$

- Uncertainty:

$$U90a = \frac{STD * t_{0.9}(N-1)}{\sqrt{N}}$$

$$U90 = \sqrt{U90a^2 + U90p^2}$$

Methodology and Results: Value of "good" bottom-up

Help of P.Rayner, LSCE

Top-down estimate with new constraint:

12 stations (1988)

Constraint: ±0.48 GtC/year

Post. Uncert.: ±0.47 GtC/year

(1 sigma)

Top-down estimate with new constraint:

77 stations (2003)

Constraint: ±0.48 GtC/year

Post. Uncert.: ±0.45 GtC/year

Top-down estimate without new constraint:

12 stations (1988)

Constraint: ±8 GtC/year

Post. Uncert.: ±2.36 GtC/year

(1 sigma)

Top-down estimate without new constraint:

77 stations (2003)

Constraint: ±8 GtC/year

Post. Uncert.: ±1.39 GtC/year

Methodology and Results: Comparison with Top-down estimates

Upscale current study results to Eurasia and Extratropical Northern Hemisphere:

Area-specific Net CO_2 flux for Russia X considered Vegetated Area

Pg C/year

Atmospheric inversion – 1980-1989 (House et. al, 2003)		FCA 2000 – 1988-1992 Scaled-up (Nilsson et al., 2003a)		Current study – 1988-1992 Scaled-up	
Eurasia	Extratropical Northern Hemisphere	Eurasia	Extratropical Northern Hemisphere	Eurasia	Extratropical Northern Hemisphere
-0.94	-1.45	-0.77	-1.22	-2.1	-3.3
[-2.3 .. 0.72]	[-2.3 .. -0.6]	[-1.16 .. -0.39]	[-1.83 .. -0.61]	[-4.2 .. 0.0]	[-6.6 .. 0.0]

Results: Major CO_2 Fluxes

Tg C/year

BCZ	NPP	HR	Disturbunces	Consumption	Total
Polar Desert	0.05	0.10	0.00	0.00	0.05
Tundra	350.71	235.63	9.62	9.80	-95.66
Pre-Tundra & Northern Taiga	532.88	252.29	49.17	16.05	-215.37
Middle Taiga	2 100.62	1 062.91	75.31	69.58	-892.82
Southern Taiga	736.74	611.06	62.20	190.88	127.41
Temperate Forest	232.59	187.57	23.06	89.70	67.74
Steppe	592.48	522.89	18.88	157.18	106.46
Semi-Desert & Desert	115.80	47.51	1.49	11.76	-55.04
Total	4 661.86	2 919.97	239.80	545.00	-957.09

Results: Major CO_2 Fluxes (Uncertainties)

Tg C/year

BCZ	NPP*	HR*	Disturbunces	Consumption	Total
Polar Desert	0 .. 0.1	0 .. 0.25	0.00	0.00	0.16
Tundra	142.51	139.53	3.76	3.55	199.57
Pre-Tundra & Northern Taiga	118.92	149.20	17.97	7.23	192.45
Middle Taiga	498.84	577.31	15.43	20.15	763.80
Southern Taiga	190.70	135.81	9.89	38.86	239.14
Temperate Forest	60.53	37.66	4.12	43.66	85.82
Steppe	194.58	113.60	2.46	30.30	227.69
Semi-Desert & Desert	52.20	28.50	0.29	3.52	59.59
Total	647.80	686.97	49.21	100.73	956.06