Appendix A. A compilation of published observational data 1980-2010 on CO_2 and CH_4 fluxes in the circumpolar North.

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
North America								
-1.52	-136.8	Summer (90 days)	1966	70˚29'N 157˚25'W	Meade river, Alaska	CH	Moist tussock	Johnson & Kelley 1970
-0.26	-23.4	Summer (90 days)	1970	71˚18'N 156˚40'W	Barrow, Alaska	CH	Moist/wet sedge	Coyne & Kelley 1975 Tieszen 1975
-0.30	-27	Summer (90 days)	1971	71˚18'N 156˚40'W	Barrow, Alaska	CH	Moist/wet sedge	Coyne & Kelley 1975 Tieszen 1975
-0.28	-25.2	Summer (90 days)	1972	71˚18'N 156˚40'W	Barrow, Alaska	CH	Moist/wet sedge	Coyne & Kelley 1975 Tieszen 1975
3.90	351	Summer (90 days)	1983	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 1993
3.90	351	Summer (90 days)	1984	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 1993
1	90	Summer (90 days)	1985	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 1993
1.34	120.6	Summer (90 days)	1990	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 1993
1.15	103.5	Summer (90 days)	1990	69˚08'N 148˚50'W	Happy Valley, Alaska	CH	Moist tussock	Oechel et al. 1993
0.66	59.4	Summer (90 days)	1990	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Moist sedge	Oechel et al. 1993

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.03	2.7	Summer (90 days)	1990	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Wet sedge	Oechel et al. 1993
0.09	8.1	Summer (90 days)	1990	69˚50'N 148˚45'W	Alaska	CH	Flooded sedge	Oechel et al. 1993
0.22	19.8	Summer (90 days)	1990	69˚50'N 148˚45'W	Alaska	CH	Wet Sedge	Oechel et al. 1993
0.39	35.1	Summer (90 days)	1990	69˚50'N 148˚45'W	Alaska	CH	Moist Sedge	Oechel et al. 1993
0.88	79.2	Summer (90 days)	1991	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Vourtilis et al. 1993
0.67	60.3	Summer (90 days)	1991	69˚08'N 148˚50'W	Happy Valley, Alaska	CH	Moist tussock	Vourtilis et al. 1993
0.32	28.8	Summer (90 days)	1991	69˚25'N 148˚45'W	Sagwon, Alaska	CH	Moist tussock	Vourtilis et al. 1993
0.11	9.9	Summer (90 days)	1991	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Moist tussock	Vourtilis et al. 1993
-0.25	-22.5	Summer (90 days)	1991	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Wet sedge	Vourtilis et al. 1993
-0.39	-35.1	Summer (90 days)	1991	69˚50'N 148˚45'W	Alaska	CH	Flooded sedge	Vourtilis et al. 1993
-0.13	-11.7	Summer (90 days)	1991	69˚50'N 148˚45'W	Alaska	CH	Wet sedge	Vourtilis et al. 1993
0.27	24.3	Summer (90 days)	1991	69˚50'N 148˚45'W	Alaska	CH	Moist sedge	Vourtilis et al. 1993
-0.87	-78.7	Summer (90 days)	1992	71˚19'N 156˚37'W	Barrow, Alaska	EC	Moist/Wet sedge	Oechel et al. 2000a
0.07	6.3	Summer (90 days)	1992	71˚18'N 156˚40'W	Barrow, Alaska	CH	Moist/Wet sedge	Oechel et al. 1995

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.27	24.3	Summer (90 days)	1993	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 2000a
-0.12	-10.8	Summer (90 days)	1993	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Wet sedge	Oechel et al. 1998
0.3	70	Winter (September -May)	1993-1994	69°70°N 148°53'W	North slope, Alaska	CH	Moist tussock	Oechel et al. 1997
0.08	20	Winter (September -May)	1993-1994	69°70°N 148°53'W	North slope, Alaska	CH	Wet sedge	Oechel et al. 1997
-	44	Summer (June-August)	1994	69°70°N 148°53'W	North slope, Alaska	CH	Moist tussock	Oechel et al. 1997
-	4.4	Summer (June-August)	1994	69°70°N 148°53'W	North slope, Alaska	CH	Wet sedge	Oechel et al. 1997
0.3	112	Annual (September 1993-August 1994)	1993-1994	69°70°N 148°53'W	North slope, Alaska	CH	Moist tussock	Oechel et al. 1997
0.08	25	Annual (September 1993-August 1994)	1993-1994	69°70°N 148°53'W	North slope, Alaska	CH	Wet sedge	Oechel et al. 1997
0.114	10.3	Summer	1994	68°38'N 149°36'W	Toolik, Alaska	EC	Lake	Eugster et al. 2003
0.34	30.6	Summer (90 days)	1994	68˚38'N 149˚35'W	Toolik lake, Alaska	CH	Moist tussock	Oechel et al. 2000a

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-0.38	-34.2	Summer (90 days)	1994	69˚08'N 148˚50'W	Happy Valley, Alaska	CH	Moist tussock	Oechel et al. 2000a
-0.51	-45.9	Summer (90 days)	1994	69˚08'N 148˚50'W	Happy Valley, Alaska	EC	Moist tussock	Vourlitis and Oechel, 1999
-0.25	22.5	Summer (90 days)	1994	70˚22'N 148˚45'W	Prudhoe Bay, Alaska	CH	Wet sedge	Oechel et al. 1998
-0.09	-8.1	Summer (90 days)	1994	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	CH	Moist/Wet sedge	Oechel et al. 2000a
-0.14	-12.6	Summer (90 days)	1994	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	EC	Moist/Wet sedge	Vourlitis and Oechel, 1997
-0.58	-52.2	Summer (90 days)	1995	69˚08'N 148˚50'W	Happy Valley, Alaska	EC	Moist tussock	Vourlitis and Oechel, 1999
-0.13	-11.7	Summer (90 days)	1995	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	EC	Moist/Wet sedge	Vourlitis and Oechel, 1997
-0.34	-30.6	Summer (90 days)	1995	69˚56'N 148˚53'W	Alaska	EC	Moist/Wet sedge	Vourlitis and Oechel, 1997
-1.134	-102.1	Summer (June 9 days)	1995	69 °24.06'N 148 °48.34'W	Alaska	EC	Moist acidic tundra	Eugster et al. 2005
-0.9	-81	Summer (June 9 days)	1995	69°26.46'N 148°40.22'W	Alaska	EC	Moist nonacidic tundra	Eugster et al. 2005
0.081	29.5	Annual	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Acidic - Tundra landscapes	Oechel et al. 2000b

Daily CO_2 Flux $gC\ m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** $gC\ m^{-2}$	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.043	15.6	Annual	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Non Acidic - Tundra landscapes	Oechel et al. 2000b
0.128	46.8	Annual	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Shrub - Tundra landscapes	Oechel et al. 2000b
0.002	0.6	Annual	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Wet sedge - Tundra landscapes	Oechel et al. 2000b
-	-4.1	Summer	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Acidic - Tundra landscapes	Oechel et al. 2000b
-	-7.6	Summer	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Non Acidic - Tundra landscapes	Oechel et al. 2000b
-	20.1	Summer	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Shrub - Tundra landscapes	Oechel et al. 2000b
-	-1.7	Summer	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Wet sedge - Tundra landscapes	Oechel et al. 2000b
-	33.6	Winter	1995-1996	69°-70°N 148°53'W	Alaska	EC and CH	Acidic - Tundra landscapes	Oechel et al. 2000b
-	23.2	Winter	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Non Acidic - Tundra landscapes	Oechel et al. 2000b
-	26.7	Winter	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Shrub - Tundra landscapes	Oechel et al. 2000b
-	2.3	Winter	1995-1996	69°70°N 148°53'W	Alaska	EC and CH	Wet sedge - Tundra landscapes	Oechel et al. 2000b
-0.60	-54	Summer (90 days)	1996	69˚08'N 148˚50'W	Happy Valley, Alaska	EC	Moist tussock	Oechel et al. 2000a

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.24	21.6	Summer (90 days)	1996	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	EC	Moist/Wet sedge	Oechel et al. 2000a
0.32	31	Summer	1996	68° 38' N, 149° 36' W	Alaska	CH	Tussock tundra	Oberbauer et al. 1998
0.064	5.9	Summer (92 days)	1996	68°38'N 149°38'E	Alaska	Snow profile	Moist acidic tundra	Fahnestock et al. 1998
-	44	Winter (September -May)	1996-1997	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	CH	Moist/Wet sedge	Oechel et al. 2000a
-	40	Annual	1996-1997	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	CH	Moist/Wet sedge	Oechel et al. 2000a
-0.04	-3.6	Summer (90 days)	1997	70˚16'N 148˚53'W	Prudhoe Bay, Alaska	EC	Moist/Wet sedge	Oechel et al. 2000a
0.062	12.3	Winter (240 days)	1996- 1997	69°08'N 70°23'N 148°30'W 149°60'W	Alaska	Snow profile	A wide range of systems	Fahnestock et al. 1999
-0.2	-14.4	Summer (64 days)	1997	58°45'N 94°04'W	Alaska	profile	Subarctic sedge fen	Griffis et al. 2000
-0.41	-27.2	Summer (65 days)	1997	58°45'N 94°04'W	Canada	EC	Treeline forest	Lafleur et al. 2001
-0.3	-20	Summer (65 days)	1997	58°45'N 94°04'W	Canada	profile	Fen tundra	Lafleur et al. 2001
-0.84	-55	Summer (65 days)	1998	58°45'N 94°04'W	Canada	profile	Fen tundra	Lafleur et al. 2001
-2	-130	Summer (65 days)	1998	58°45'N 94°04'W	Canada	EC	Treeline forest	Lafleur et al. 2001
-0.011	-0.9	Annual	1998	71°18'N 156°42'W	Alaska	CH and Model	Tundra (coastal arctic tundra)	Grant et al. 2003

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-0.16	-10.4	Summer (65 days)	1999	58°45'N 94°04'W	Canada	profile	Fen tundra	Lafleur et al. 2001
-1.4	-85.3	Summer (65 days)	1999	58°45'N 94°04'W	Canada	EC	Treeline forest	Lafleur et al. 2001
-0.044	-3.6	Annual	1999	71°18'N 156°42'W	Alaska	CH and Model	Tundra (coastal arctic tundra)	Grant et al. 2003
-1.1	-161.6	Summer (147 days)	1999	71°19'N 156°37'W	Alaska	EC	Tundra (wet sedge tundra)	Harazono et al. 2003
-	-70	Summer	1999	71° 19' N 156° 36' W	Alaska	EC	Wet sedge tundra	Kwon et al. 2006
-	30.9	Summer	1999	71° 19' N 156° 36' W	Alaska	EC	Moist tussock tundra	Kwon et al. 2006
-	60.8	Summer	2000	71° 19' N 156° 36' W	Alaska	EC	Moist tussock tundra	Kwon et al. 2006
-	-46.4	Summer	2000	71° 19' N 156° 36' W	Alaska	EC	Wet sedge tundra	Kwon et al. 2006
-0.7	-104.6	Summer (147 days)	2000	71°19'N 156°37'W	Alaska	EC	Tundra (wet sedge tundra)	Harazono et al. 2003
-	-2	Summer	2001	71° 19' N 156° 36' W	Alaska	EC	Moist tussock tundra	Kwon et al. 2006
-	-51.7	Summer	2001	71° 19' N 156° 36' W	Alaska	EC	Wet sedge tundra	Kwon et al. 2006
-	-60.8	Summer	2002	71° 19' N 156° 36' W	Alaska	EC	Wet sedge tundra	Kwon et al. 2006
-	+2.7	Summer	2002	71° 19' N 156° 36' W	Alaska	EC	Moist tussock tundra	Kwon et al. 2006
-	-48.8	Summer	2003	71° 19' N 156° 36' W	Alaska	EC	Wet sedge tundra	Kwon et al. 2006
-	-1.1	Summer	2003	71° 19' N 156° 36' W	Alaska	EC	Moist tussock tundra	Kwon et al. 2006
-	37.3	Annual	2003	72°52°N 140°168°W	Alaska	EC+modellin g	Mature black spruce	Ueyama et al. 2010

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.86	129.1	Summer (May-September)	2003	64◦41.773'N 148◦19.263'W	Alaska	CH	Permafrost plateau	Wickland et al. 2006
0.45	68	Summer (May-September)	2003	64◦41.773'N 148◦19.263'W	Alaska	CH	Thermokarst wetlands	Wickland et al. 2006
0.53	79.3	Summer (May-September)	2003	64◦41.773'N 148◦19.263'W	Alaska	CH	Thermokarst edges	Wickland et al. 2006
-0.11	-39	Annual	2003-2004	64°52'N 147° 51'W	Alaska	EC+model	Subarctic black spruce	Ueyama et al. 2006
-0.16 to -0.05	-57.2 to -19.1	Annual	2003-2004	64◦ 52N 147◦ 51W	Alaska	EC	Subarctic black spruce	Ueyama et al. 2006
-	-1	Summer	2004	472710° E 7194082° N	Daring lake Canada	CH	Dry heath lichen tundra	Nobrega & Grogan, 2008
-	-37	Summer	2004	472797°E 7194015° N	Daring lake Canada	CH	Mesic dwarf birch	Nobrega & Grogan, 2008
-	-88	Summer	2004	472842° E 7194051° N	Daring lake Canada	CH	Wet sedge meadow	Nobrega & Grogan, 2008
-	-14.8 to -12.06	Summer (14 days)	2004	68° 10–45'N	Alaska	EC and model	Heterogeneous tundra	Shaver et al. 2007
-	-36	Annual	2004	63◦52'42''N, 149◦15'12''W	Alaska	CH	Tussock tundra: minimal thaw	Vogel et al. 2009, Schuur et al. 2009
-0.3	-32	Summer (109 days)	2004	64° 52' N 111° 34' W	Daring Lake, Canada	EC	Mixed tundra	Lafleur and Humphreys 2008
-	26	Annual	2004	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: intermediate thaw	Vogel et al. 2009 Schuur et al. 2009
-	-54	Annual	2004	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: extensive thaw	Vogel et al. 2009 Schuur et al. 2009

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.5 to -2.0	-32 to -82	Summer (109 days)	2004-2010	64° 52' N : 111° 34' W	Daring Lake, Canada	EC	Mixed tundra	Humphreys & Lafleur 2011
0.2 to -2.3	-63 to -111	Summer (109 days)	2006-2010	64° 52' N : 111° 34' W	Daring Lake, Canada	EC	Sedge fen	Humphreys & Lafleur 2011
0.21 to 0.24	49 ± 13	Winter (212 days)	2004-2005	64◦52'N 147◦51'W	Alaska	CH, EC and concentration profile method	Black spruce forest	Kim et al. 2007
-	41.1	Annual	2005	72°–52°N 140°–168°W	alaska	EC+modellin g	Mature black spruce	Ueyama et al. 2010
-0.5	-51	Summer (109 days)	2005	64° 52' N 111° 34' W	Daring lake, Canada	EC	Mixed tundra	Lafleur & Humphreys. 2008
-	-19	Annual	2005	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: minimal thaw	Vogel et al. 2009, Schuur et al. 2009
-	-7	Annual	2005	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: intermediate thaw	Vogel et al. 2009 Schuur et al. 2009
-	-78	Annual	2005	63◦52'42''N, 149◦15'12''W	Alaska	CH	Tussock tundra: extensive thaw	Vogel et al. 2009 Schuur et al. 2009
-0.6	-61	Summer (109 days)	2006	64° 52' N 111° 34' W	Daring lake, Canada	EC	Mixed tundra	Lafleur & Humphreys 2008
-	5	Annual	2006	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: minimal thaw	Vogel et al. 2009, Schuur et al. 2009
-	57	Annual	2006	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: intermediate thaw	Vogel et al. 2009 Schuur et al. 2009
-	40	Annual	2006	63◦52'42''N 149◦15'12''W	Alaska	CH	Tussock tundra: extensive thaw	Vogel et al. 2009 Schuur et al. 2009

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	18.5	Annual	2006	72°–52°N 140°–168°W	Alaska	EC+modelling	Mature black spruce	Ueyama et al. 2010
0.01 to 0.20	0.6 to 12	Summer (June-July)	2006 2007	55°16'N 77°46'W	Canada	CH+EC	Subarctic thaw pond	Laurion et al. 2010
-0.07 to 0.37	-4.2 to 22.2	Summer (June-July)	2006 2007	73°09'N 79°58'W	Canada	CH+EC	Continuous permafrost ponds	Laurion et al. 2010
-1.11	-93.2	Summer (June-august)	2007	71◦ N 156◦ W	Alaska	EC	Young Drained lake basin	Zona et al. 2010
-0.73	-61.3	Summer (June-august)	2007	71◦ N 156◦ W	Alaska	EC	Medium Drained lake basin	Zona et al. 2010
-0.87	-73.1	Summer (June-august)	2007	70◦ N 156◦ W	Alaska	EC	Old Drained lake basin	Zona et al. 2010
North Atlantic Area								
-0.047	-3.9	Summer (83 days)	1995	79°56'N 11°55'E	Svalbard	EC/model	Desert (sub-polar desert)	Lloyd, 2001a; Lloyd, 2001b
0.057	5	Summer (87days)	1996	79°56'N 11°55'E	Svalbard	EC/model	Desert (sub-polar desert)	Lloyd, 2001a; Lloyd, 2001b
-	-96.3	Summer (56 days)	1996	74°28'N 20°34'W	NE Greenland	EC	Fen	Soegaard et al. 1999
-	-64.4	Annual	1996	74°28'N 20°34'W	NE Greenland	EC	Fen	Soegaard et al. 1999
-	-63	Summer	1997	74°28'N 20°34'W	NE Greenland	EC	Fen	Rennermalm et al. 2005
-	-50	Summer	1997	74°28'N 20°34'W	NE Greenland	EC	Fen	Rennermalm et al. 2005
-0.006	-2.3	Annual	1997	74°28'N 20°34'W	NE Greenland	EC / model	Arctic valley (integrated)	Soegaard et al. 2000

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-0.015	-5.4	Annual	1997	74°28’N 20°34’W	NE Greenland	EC / model	Fen	Nordstroem et al. 2001
-0.88	-18.8	Summer (June – august)	1997	74°28’N 20°34’W	NE Greenland	EC	Arctic valley (integrated)	Soegaard et al. 2000
-3	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Arctic valley (integrated)	Christensen et al. 2000
-0.09	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Cassiope heath	Christensen et al. 2000
-2,6	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Continuous fen	Christensen et al. 2000
-0.75	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Salix snowbed	Christensen et al. 2000
-4.8	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Grassland	Christensen et al. 2000
-4.5	-	Summer (June-August)	1997	74°28’N 20°34’W	NE Greenland	CH	Hummocky fen	Christensen et al. 2000
-1.88	-48.7	Summer (90 days)	1997	74°28’N 20°34’W	NE Greenland	EC	Fen	Soegaard et al. 2000
-0.53	-7.1	Summer (90 days)	1997	74°28’N 20°34’W	NE Greenland	EC	Heath	Soegaard et al. 2000
-	-1.4	Summer	1997	74°28’N 20°34’W	NE Greenland	EC	Heath	Groendahl et al. 2007
-	-18.9	Summer (80 days)	2000	74°28’N 20°34’W	NE Greenland	EC	Heath	Groendahl et al. 2007
-	-8.3	Summer (80 days)	2001	74°28’N 20°34’W	NE Greenland	EC	Heath	Groendahl et al. 2007

Daily CO_2 Flux $gC\ m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** $gC\ m^{-2}$	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-9.9	Summer (80 days)	2002	74°28'N 20°34'W	NE Greenland	EC	Heath	Groendahl et al. 2007
-	-23.3	Summer (80 days)		74°28'N 20°34'W	NE Greenland	EC	Heath	Groendahl et al. 2007
-1.09	-98.1	Summer (June – august)	2004	74°28'N 20°34'W	NE Greenland	CH	Arctic valley (integrated)	Groendahl et al. Submitted
-0.54	-198.1	Annual estimate	2005	65◦19_N, 14◦56_W,	Eastern Iceland	EC	Larch plantation	Bjarnadottir et al. 2007
-1.89	-170	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Continuous fen	Tagesson et al. 2010
-1.65	-148.5	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Hummocky fen	Tagesson et al. 2010
-0.94	-84.6	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Grassland	Tagesson et al. 2010
-0.24	-21.6	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Salix snowbed	Tagesson et al. 2010
-0.14	-12.6	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Cassiope heath	Tagesson et al. 2010
-0.25	-22.5	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Dryas heath	Tagesson et al. 2010
-0.20	-18	Summer (June-August)	2007	74°28' N 20°34' W	NE Greenland	CH	Vaccinium heath	Tagesson et al. 2010

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
Northern Europe								
-0.26	-98	Annual	1993	62°47'N 30°56'E	Finland	CH	Low sedge pine fen	Alm et al. 1997
0.16 to 0.30	30 to 53	Winter (November -May)	1994-1995	65°51'N, 30°53'E	Finland	CH + snowpack diffusion method	Ombortrophic bog	Alm et al.1999
0.14 to 0.35	30 to 76	Winter (November -May)	1994-1995	65°51'N 30°53'E	Finland	CH + snowpack diffusion method	Minerotrophic fen	Alm et al.1999
-1.53 to 0.449	-229.5 to 67.3	Summer (June – September)	1995	69°08'N 27°17'E	Finland	EC and CH	Fen (flark fen)	Heikkinen et al. 2002b
-2.04	-122.4	Summer (60 days)	1996	69°28'N 27°14'E	Finland	EC	Forrest (Birch ecosystem)	Aurela et al. 2001
-1.09 [1]	-101.4	Summer (93 days)	1998	69°49'N 27°10'E	Finland	CH	Mire (Palsa mire)	Nykanen et al. 2003
0.155	28.8	Winter (186 days)	1998 – 1999	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2002
-0.052	-19	Annual	1998- 1999	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2002
-0.05	-18	Annual	1998-1999	69°08'N 27°17'E	Finland	EC	Mesotrophic subarctic fen	Aurela et al. 2002
-0.92	-85.6	Summer (93 days)	1999	69°49'N 27°10'E	Finland	CH	Mire (Palsa mire)	Nykanen et al. 2003
-0.074 to -0.036	-27 to -13.2	Annual	2001-2003	68°21'N 19°02'E	Sweden	EC	Mire (subarctic mire)	Friborg in prep.

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-4	Annual	1997	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
-	-2	Annual	1998	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
-	-8	Annual	1999	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
-	-6	Annual	2000	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
-	-37	Annual	2001	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
-	-53	Annual	2002	69°08'N 27°17'E	Finland	EC	Fen (subarctic flark fen)	Aurela et al. 2004
0.831	86.4	Summer (June-September)	-	68°21' N 19°00' E	Sweden	CH	Sub-Arctic mire ombrotrophic	Ström & Christensen. 2007
-1.968 to -1.43	-204.7 to -148.9	Summer (June-September)	-	68°21' N 19°00' E	Sweden	CH	Sub-Arctic mire minerotrophic	Ström & Christensen. 2007
-0.01	-3	Annual	2002-2007	68°20′N 19°03′E	Sweden	CH	Mixed mire	Backstrand et al. 2009
0.08	30	Annual	2002-2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, palsa site	Backstrand et al. 2009
-0.10	-35	Annual	2002-2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, Shagnum site	Backstrand et al. 2009
-0.10	-35	Annual	2002-2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, Eriophorum site	Backstrand et al. 2009
-	-108.7	Summer (July-August)	2004	68°18'N 18°51'E	Sweden	EC	Arctic tundra (integrated)	Fox et al. 2008

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-140.7	Summer (July-August 2004)	2004	68°18'N 18°51'E	Sweden	CH	Arctic tundra (integrated)	Fox et al. 2008
-0.12	-43	Annual	2005	61◦50_N 24◦12_E	Finland	EC	Boreal oligotrophic fen	Rinne et al. 2007
-0.24	-89	Annual	2006-2007	68°20′N, 19°03′E	Sweden	EC	Mixed mire	Jackowicz-Korczyński et al. 2010
-0.98 to -0.62	-147 to -93	Summer (May-September)	2007	68°20' N, 18°58' E,	Sweden	CH	Subarctic bog	Lund et al. 2009
Eurasia								
-	51	Winter (October-February)	1989-1990	69° N 162°E	Russia	CH	Moist shrub and grass	Zimov et al. 1993
-0.24	-28.1	Summer (117 days)	1993-1998	65 -74°N 63°E-172°W	Russia	CH / model	Tundra landscape	Zamolodchikov et al. 2001
-0.286	-6	Summer (21 days)	1995	67°57'N 64°40'E	Russia	CH	Tundra -tall Shrub	Zamolodchikov et al. 2000
	7	Winter (February)	1995	57° N 82° E	Russia		Ombrotrophic bog	Panikov & Dedysh 2000
0.30	14	Summer (47 days)	1996	67°20'N 64°44'E	Russia	CH	Tundra – Dwarf Shrub (60% of total area)	Zamolodchikov et al. 2000
-0.915	-43	Summer (47 days)	1996	67°20'N 64°44'E	Russia	CH	Tundra – Sedge bog	Zamolodchikov et al. 2000
-0.64	-30	Summer (47 days)	1996	67°20'N 64°44'E	Russia	CH	Tundra - shrub	Zamolodchikov et al. 2000

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-62.2	Summer (June-September)	1998	56◦27_N 32◦55_E	Russia	EC	Tundra - bog	Arneth et al. 2002
-	21.5	Summer (April-October)	1999	56◦27_N 32◦55_E	Russia	EC	Tundra - bog	Arneth et al. 2002
-	-51.1	Summer (June-September)	1998	60◦45_N 89◦23_E	Russia	EC	Tundra - bog	Arneth et al. 2002
-	-45.5	Summer (April-November)	1999	60◦45_N 89◦23_E	Russia	EC	Tundra - bog	Arneth et al. 2002
-	-62.6	Summer (April-November)	2000	60◦45_N 89◦23_E	Russia	EC	Tundra - bog	Arneth et al. 2002
-0.94	-72.4	Summer (77 days)	1999	67°23'N 63°22'E	Russia	CH	Tundra – wetlands	Heikkinen et al. 2002a
1.8	138.6	Summer (77 days)	1999	67°23'N 63°22'E	Russia	CH	Tundra –shrub	Heikkinen et al. 2002a
-0.5	-89	Summer	1999	56°51'N 82°58'E	Russia	EC	Wetland	Friborg et al. 2003
-0.12	-10.2	Summer (85 days)	2000	65°36'N 171°04'E	Russia	EC	Tundra	Zamolodchikov et al. 2003
-0.43	-160	Annual estimate	2001	62°15'18.4''N , 129°37'07.9'' E).	Russia	EC	Larch forest	Dolman et al. 2004
-1.21	-108.9	Summer (90 days)	2001	67°23'N 63°22'E	Russia	CH	Tundra (wet)	Heikkinen 2003, Heikkinen et al. 2004
0.75	67.5	Summer (90 days)	2001	67°23'N 63°22'E	Russia	CH	Tundra (dry)	Heikkinen 2003, Heikkinen et al. 2004

Daily CO_2 Flux $gC\ m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** $gC\ m^{-2}$	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-0.104	-38	Annual	2002-2003	68°37’N 161°21’E	Russia	EC	Tussock tundra	Corradi et al. 2005
-	-53	Summer (July-Octo ber)	2002	69°36’47’’N 16°120’29’’E	Russia	EC + CH	Arctic wet tundra	Merbold et al. 2009
-	15	Summer (July-Octo ber)	2003	69°36’47’’N 16°120’29’’E	Russia	EC + CH	Arctic wet tundra	Merbold et al. 2009
-	4	Summer (July-Octo ber)	2004	69°36’47’’N 16°120’29’’E	Russia	EC + CH	Arctic wet tundra	Merbold et al. 2009
-0.19	−119	Summer (May-Octo ber)	2003-2004	72°22’ N 126°30’ E	Russia	EC	Wet arctic tundra	Kutzbach et al. 2007
-1.53	-92	Annual	2003-2006	70°49’ 36.28’’ N, 147°29’ 56.23’’ E	Russia	EC+CH	Mixed moist tundra	van Huissteden et al. 2008, van der Molen et al. 2007
-0.85 to -0.83	-78 to -68	Summer (91 days)	2004	64°16’N 100°12’E	Russia	EC	Larch forest	Nakai et al. 2008
-	8	Summer (July-Octo ber)	2005	69°36’47’’N 16°120’29’’E	Russia	EC + CH	Drained arctic wet tundra	Merbold et al. 2009
-0.33 to -0.10	-1.22 to -35	Annual	-	65◦46’_N 89◦25’_E	Russia	Biomass and soil carbon analysis (biometric method).	Larch forest	Vedrova et al. 2006
-3.44	-344	Summer (100 days)	2006	62°05’N 129°45’E	Russia	EC	Larch forest	Lopez et al. 2008

Daily CO_2 Flux gC $m^{-2}d^{-1}$	**Seasonal CO_2 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-1.38	-138	Summer (May-August) 100 days	2006	62°05'N 129°45'E	Russia	EC	Grassland thermokarst depression (alas ecosystem)	Lopez et al. 2008

*The growing season (summer) was assumed to last 90 days when non-specified by the authors
**EC stands for Eddy covariance method and CH means Chamber method.

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
North America								
0.022	-	Summer (August)	-	68°38'N 149°39'W	Alaska	CH	Meadow & tussock tundras	King et al. 1989
0.004	0.36	Summer (August)	1984	70'N	Alaska	CH	moist tundra	Sebacher et al. 1986
0.089	8.01	Summer (August)	1984	70'N	Alaska	CH	waterlogged tundra	Sebacher et al. 1986
0.03	2.7	Summer (August)	1984	70'N	Alaska	CH	Wet tussock meadows	Sebacher et al. 1986
0.217	21.7	Summer (August)	1984	70'N	Alaska	CH	Alpine fen in the Alaskan range	Sebacher et al. 1986
0.017	6.2	Annual	1987	65'N	Alaska, Fairbanks	CH	Tussock tundra composite	Whalen & Reeburg 1988 Whalen & Reeburg. 1992
0.003	0.27	Summer (August)	1987	69'N	Alaska, N.Slope	CH	Tussocks	Morissey and Livingsson, 1992
0.048	4.32	Summer (August)	1987	69'N	Alaska, N.Slope	CH	Meadow tundra	Morissey and Livingsson, 1992
0.002	0.18	Summer (August)	1987	69'N	Alaska, N.Slope	CH	Intertussocks	Morissey and Livingsson, 1992
0.075 to 0.191	6.75 to 17.19	Summer (August)	1987	69'N	Alaska, N.Slope	CH	Wet tundra	Morissey and Livingsson, 1992
0.002 to 0.019	0.4 to 3.2	Annual	1987 -1990	65'N	Alaska, Fairbanks	CH	Intertussock	Whalen & Reeburg 1988 Whalen & Reeburg. 1992
0.002 to 0.340	0.6 to 45.6	Annual	1987 -1990	65'N	Alaska, Fairbanks	CH	Carex sedge	Whalen & Reeburg 1988 Whalen & Reeburg. 1992

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.022 to 0.073	6 to 10.2	Annual	1987 -1990	65'N	Alaska, Fairbanks	CH	Tussocks	Whalen & Reeburg 1988 Whalen & Reeburg. 1992
0.90	37.8	Summer (42 days)	1988	6045N	Alaska	CH	wet meadow tundra	Bartlett et al. 1992
0.01	0.42	Summer (42 days)	1988	6045N	Alaska	CH	dry upland tundra	Bartlett et al. 1992
0.008	0.72	Summer (July-august)	1988	61°05.41'N 162°00.92'W	Alaska	EC	Dry tundra	Fan et al. 1992
0.022	1.98	Summer (July-august)	1988	61°05.41'N 162°00.92'W	Alaska	EC	Dry tundra	Fan et al. 1992
0.019	1.71	Summer (July-august)	1988	61°05.41'N 162°00.92'W	Alaska	EC	Integrated area	Fan et al. 1992
0.038	3.42	Summer (July-august)	1988	61°N	Alaska	EC	Tundra: Yukon-Kuskokw im Delta	Ritter et al. 1992
0.008	0.72	Summer (July-august)	1988	61°N	Alaska	EC	Tundra: Alaskan North Slope (ANS) region	Ritter et al. 1992
0.073	5.3 to 6.1	Summer (June-Aug)	1991 -1992	68°38'N 149°38'W	Toolik Lake Alaska	CH	Wet sedge	Christensen 1993.
0.019	1.4 to 2.7	Summer (June-Aug)	1991 -1992	68°38'N 149°38'W	Toolik Lake Alaska	CH	Mesic tussock tundra	Christensen 1993.
0.08	-	Summer (July)	1991	68° 38' N 149° 34' W	Alaska	CH	Tundra	Schimel, 1995.

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.02	-	Summer (July)	1992	68° 38' N 149° 34' W	Alaska	CH	Tundra	Schimel, 1995.
0.07	-	Summer (July-August)	1993	68° 38' N 149° 34' W	Alaska	CH	Tundra	Schimel, 1995.
-	-0.03	Annual estimate (May-September)	1994	68°38' N, 149°34'W	Alaska	CH	Barrens	Reeburgh et al. 1998
-	0.06	Annual estimate (May-September)	1994	68°38' N 149°34'W	Alaska	CH	Shrublands	Reeburgh et al. 1998
-	0.12	Annual estimate (May-September)	1994	68°38' N 149°34'W	Alaska	CH	Nonacidic tundra	Reeburgh et al. 1998
-	0.41	Annual estimate (May-September)	1994	68°38' N 149°34'W	Alaska	CH	Acidic tundra	Reeburgh et al. 1998
-	3.65	Annual estimate (May-September)	1994	68°38' N 149°34'W	Alaska	CH	wet tundra	Reeburgh et al. 1998
0.13 to 0.45	3.2 to 5.1	Annual	1995 -1996	68°38’N 149°39’W	Alaska	Pulse-labeling experiment & CH	Wet sedge tundra	King & Reeburg 2002

Daily CH_4 Flux $gC\ m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** $gC\ m^{-2}$	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.06	4.13	Annual estimate (June-August)	1995	68° 38' N 149° 34' W	Alaska	CH	Tundra	Verville et al. 1998, King et al. 1998
-	-0.05	Annual estimate (May-September)	1995	68°38' N 149°34'W	Alaska	CH	Barrens	Reeburgh et al. 1998
-	0.28	Annual estimate (May-September)	1995	68°38' N 149°34'W	Alaska	CH	Shrublands	Reeburgh et al. 1998
-	0.14	Annual estimate (May-September)	1995	68°38' N, 149°34'W	Alaska	CH	Nonacidic tundra	Reeburgh et al. 1998
-	1.09	Annual estimate (May-September)	1995	68°38' N 149°34'W	Alaska	CH	Acidic tundra	Reeburgh et al. 1998
-	4.5	Annual estimate (May-September)	1995	68°38' N 149°34'W	Alaska	CH	wet tundra	Reeburgh et al. 1998
0.002 to 0.01	0.15 to 0.9	Summer (July-August)	1995	68° 38' N 149° 36' W	Alaska	CH	Tussock tundra	Oberbauer et al. 1998
0.05	3.23	Annual estimate (June-August)	1996	68° 38' N 149° 34' W	Alaska	CH	Tundra	Verville et al. 1998, King et al. 1998

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-0.05	Annual estimate (May-September)	1996	68°38' N 149°34'W	Alaska	CH	Barrens	Reeburgh et al. 1998
-	0.31	Annual estimate (May-September)	1996	68°38' N 149°34'W	Alaska	CH	Shrublands	Reeburgh et al. 1998
-	0.05	Annual estimate (May-September)	1996	68°38' N 149°34'W	Alaska	CH	Nonacidic tundra	Reeburgh et al. 1998
-	0.34	Annual estimate (May-September)	1996	68°38' N 149°34'W	Alaska	CH	Acidic tundra	Reeburgh et al. 1998
-	3.51	Annual estimate (May-September)	1996	68°38' N 149°34'W	Alaska	CH	wet tundra	Reeburgh et al. 1998
0.001 to 0.005	0.01 to 0.04	Summer (July-August)	1996	68° 38' N 149° 36' W	Alaska	CH	Tussock tundra	Oberbauer et al. 1998
0.063	23	Annual	1998	71°18’N 156°42’W	Alaska	CH and Model	Tundra (coastal arctic tundra)	Grant el al. 2003
0 to 0.004	0 to 0.36	Summer (July-October)	1998 -1999	55◦51’N, 107◦41’W	Canada	CH	Peatlands (permafrost)	Turetsky et al. 2002
0.055	20.1	Annual	1999	71°18’N 156°42’W	Alaska	CH and Model	Tundra (coastal arctic tundra)	Grant el al. 2003
0.016 to 0.051	1.92 to 6.16	Summer (120 days)	1999 -2000	71° N 156° W	Alaska	CH	Wet Sedge	Harazono et al. 2003

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.007	0.315	Summer (May-September)	2003	64°41.773'N 148°19.263'W	Alaska	CH	permafrost plateau	Wickland et al. 2006
0.086	31.28	Annual estimate (May-September)	2003	64°41.773'N 148°19.263'W	Alaska	CH	thermokarst wetlands	Wickland et al. 2006
0.007	2.41	Annual estimate (May-September)	2003	64°41.773'N 148°19.263'W	Alaska	CH	thermokarst edges	Wickland et al. 2006
0.0005	0.11 ± 0.07	Winter (212 days)	2004 -2005	64◦52_N 147◦51_W	Alaska	CH, EC and concentration profile method	Black spruce forest	Kim et al. 2007
0 to 0.005	0 to 0.45	Summer (June-July)	2006 2007	55°16'N 77°46'W	Canada	CH+EC	Subarctic thaw pond	Laurion et al. 2010
0 to 0.068	0 to 6.12	Summer (June-July)	2006 2007	73°09'N 79°58'W	Canada	CH+EC	Continuous permafrost ponds	Laurion et al. 2010
0.003	0.24	Summer (July-August)	2007	71°17′N 156°37′W	Alaska	CH	Dry tundra	von Fisher et al. 2010
0.015	0.65	Summer (July-August)	2007	71°17′N 156°37′W	Alaska	CH	moist tundra	von Fisher et al. 2010
0.037	1.68	Summer (July-August)	2007	71°17′N 156°37′W	Alaska	CH	wet tundra	von Fisher et al. 2010
0.063	2.81	Summer (July-August)	2007	71°17′N 156°37′W	Alaska	CH	flooded tundra	von Fisher et al. 2010

Daily CH_4 Flux gC $m^{-2}d^{-1}$	Seasonal CH_4 Flux* gC m^{-2}	Season	Year	Geographical position	Location	Method**	Ecosystem	Reference
North Atlantic Area								
0.0324	2.79	Summer (86 days)	1997	74°28'N 20°34'W	NE Greenland	EC	Fen	Friborg et al. 2000
0.0341	3.07	Summer (June-August)	1997	74°28'N 20°34'W	NE Greenland	CH	Integrated Arctic valley(wet)	Christensen et al. 2000
-	3.38	Summer (June-October)	2007	74.30°N 21.00° W	NE Greenland	CH	Arctic fen	Mastepanov et al. 2008
Northern Europe								
-0.002 to 0.002	-0.31 to 0.31	Summer (April-October)	1970	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.004 to 0.012	0.7 to 2.25	Summer (April-October)	1970	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Semi-dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.02 to 0.18	3.6 to 32.9	Summer (April-October)	1970	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.024 to 0.043	4.32 to 7.78	Summer (April-October)	1970	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet intermediate ombro-minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.077 to 0.432	13.82 to 77.77	Summer (April-October)	1970	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999

Daily CH_4 Flux $gC\ m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** $gC\ m^{-2}$	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.02	3.6	Summer (April-October)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.001	0.182	Summer (April-October)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.012	2.25	Summer (April-October)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Semi-dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.044	7.78	Summer (April-October)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet intermediate ombro-minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.27	49.02	Summer (April-October)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.0087	0.1	Annual estimate (June-September)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: ombrotrophic	Svensson 1976. Svensson & Rosswall 1984
0.0436	1.08	Annual estimate (June-September)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire:intermediate	Svensson 1976. Svensson & Rosswall 1984
0.2707	22.93	Annual estimate (June-September)	1974	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: minerotrophic	Svensson 1976. Svensson & Rosswall 1984
0.082	30	Annual	1993	62°47'N 30°56'E	Finland	CH	Low sedge pine fen	Alm et al. 1997

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-0.0002	-0.033	Summer (April-October)	1994	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.011	2.1	Summer (April-October)	1994	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Semi-dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.004	0.78	Summer (April-October)	1994	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.034	6.14	Summer (April-October)	1994	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet intermediate ombro-minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.18	32.69	Summer (April-October)	1994	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.0042	2.04	Winter (November-May)	1994 -1995	65°51'N 30°53'E	Finland	CH + snowpack diffusion method	Ombortrophic bog	Alm et al.1999
0.0246	6	Winter (November-May)	1994 -1995	62°47'N 30°56'E	Finland	CH + snowpack diffusion method	Minerotrophic fen	Alm et al.1999
0.024	4.32	Summer (April-October)	1995	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet intermediate ombro-minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
-0.0005	-0.091	Summer (April-October)	1995	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.004	0.70	Summer (April-October)	1995	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Semi-dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.04	6.7	Summer (April-October)	1995	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.15	27.47	Summer (April-October)	1995	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.0019 to 0.0168	0.17 to 1.51	Summer (May)	1996	68°21'N 19°02'E	Sweden	EC and CH	Mire (subarctic mire)	Friborg et al. 1997
0.0112	4.13	Annual estimate (May to October)	1998 -1999	69°8'N 27°16'E	Finland	EC	Mire (aapa mire)	Hargreaves et al. 2001
0.091	8.19	Summer (90 days)	1998	69°49'N 27°10'E	Finland	CH	Mire (Palsa mire)	Nykanen et al. 2003
0.03	11	Annual	1998 -1999	69°08'N 27°17'E	Finland	EC	Mesotrophic subarctic fen	Aurela et al. 2002
0.133	11.97	Summer (90 days)	1999	69°49'N 27°10'E	Finland	CH	Mire (Palsa mire)	Nykanen et al. 2003
-0.002 to 0.002	-0.31 to 0.31	Summer (April-October)	2000	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.004 to 0.012	0.7 to 2.25	Summer (April-October)	2000	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Semi-dry ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.02 to 0.18	3.6 to 32.9	Summer (April-October)	2000	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet ombrotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999

Daily CH_4 Flux gC $m^{-2}d^{-1}$	Seasonal CH_4 Flux* gC m^{-2}	Season	Year	Geographical position	Location	Method**	Ecosystem	Reference
0.024 to 0.043	4.32 to 7.78	Summer (April-October)	2000	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet intermediate ombro-minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.077 to 0.432	13.82 to 77.77	Summer (April-October)	2000	68° 22'N 19° 03'E	Sweden	CH	Subarctic mire: Wet minerotrophic	Christensen et al.,2003; Oquist and Svensson, 2002; Svensson, 1980; Svensson et al., 1999
0.0139	5.07	Annual Campaigns	2001 -2002	68°21’N 19°02’E	Sweden	EC	Mire (subarctic mire)	Friborg et al. in prep.
0.016	6	Annual	2002 -2007	68°20′N, 19°03′E	Sweden	CH	Mixed mire	Backstrand et al. 2009
0.002	1	Annual	2002 -2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, palsa site	Backstrand et al. 2009
0.016	6	Annual	2002 -2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, Shagnum site	Backstrand et al. 2009
0.088	32	Annual	2002 -2007	68°20′N 19°03′E	Sweden	CH	Mixed mire, Eriophorum site	Backstrand et al. 2009
0.0848	7.63	Summer	2004 -2006	68°N 19° E	Sweden	CH	Wetland	Petrescu et al. 2008
0.026	9.4	Annual	2005	61◦50_N 24◦12_E	Finland	EC	Boreal oligotrophic fen	Rinne et al. 2007
0.0036 to 0.6514	0.32 to 58.63	Summer (June-September)	-	68°21’ N 19°00’ E	Sweden	CH	Sub-Arctic mire	Ström & Christensen. 2007
0.055 to 0.112	20	Annual	2006 -2007	68°20′N 19°03′E	Sweden	EC	Mixed mire	Jackowicz-Korczyński et al. 2010
0.0038 to 0.0081	0.57 to 1.21	Summer (May-September)	2007	68°20’ N 18°58’ E,	Sweden	CH	Subarctic bog	Lund et al. 2009
Eurasia								

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.012 to 0.0574	1.08 to 5.17	Summer	1993	71.5°N 130.0°E	Russia	CH	Waterlogged tundra	Nakano et al. 2000
0.0002 to 0.0011	0.02 to 0.1	Summer	1993	71.5°N 130.0°E	Russia	CH	Drier peat mound	Nakano et al. 2000
0.0017	0.15	Summer	1994	67-77 °N	Russia	CH	Mesic	Christensen et al. 1999
0.035	3.15	Summer	1994	67-77 °N	Russia	CH	Wet	Christensen et al. 1999
0.1241	11.17	Summer (July-August)	1995	68°5'N 161°4'E	Russia	CH	Horsetail grassland	Tsuyuzaki et al. 2001
0.055	4.95	Summer (July-August)	1995	68°5'N 161°4'E	Russia	CH	*Carex* grassland	Tsuyuzaki et al. 2001
-0.0014	-0.13	Summer (July-August)	1995	68°5'N 161°4'E	Russia	CH	*Eriophorum* grassland	Tsuyuzaki et al. 2001
0.06	0.17	Summer (August)	1995	68°08'N, 71°42'E	Russia	CH	Tundra	Heyer et al. 2002
0.0882 to 0.391	7.938 to 35.19	Summer	1995	68.5°N 161.4°E	Russia	CH	Waterlogged tundra	Nakano et al. 2000
-0.003 to 0.0011	-0.27 to 0.1	Summer	1995	68.5°N 161.4°E	Russia	CH	Grassland	Nakano et al. 2000
0.026	0.15	Summer (June)	1996	68°08'N, 71°42'E	Russia	CH	Tundra	Heyer et al. 2002
-0.04	-4.8	Summer (May-September)	1999	N 72°22 E 126°28	Russia	CH	Polygon depression tundra	Wagner et al. 2003, 2004
0.03	3.6	Summer (May-September)	1999	N 72°22 E 126°28	Russia	CH	Polygon rim tundra	Wagner et al. 2003, 2004

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.021	1.89	Summer (August)	1999	72.37N 126.47E	Russia	CH	Wet polygonal tundra	Kutzbach et al. 2004
0.0032	0.29	Summer (August)	1999	72.37N 126.47E	Russia	CH	Polygon rim tundra	Kutzbach et al. 2004
0.0835	7.52	Summer (90 days)	2001	67°23'N 63°22'E	Russia	CH	Tundra(wet)	Heikkinen 2003. Heikkinen et al. 2004
0.0004	0.01	Summer (90 days)	2001	67°23'N 63°22'E	Russia	CH	Tundra (dry)	Heikkinen 2003. Heikkinen et al. 2004
-	20	Summer (July-October)	2002	69°36'47''N, 161°20'29''E	Russia	CH	arctic wet tundra	Merbold et al. 2009
0.0328	12	Annual estimate (summer 60 days)	2002 -2003	68°37'N 161°21'E	Russia	EC	Tussock tundra	Corradi et al. 2005
-	20	Summer (July-October)	2003	69°36'47''N, 161°20'29''E	Russia	CH	arctic wet tundra	Merbold et al. 2009
0.47	28	Annual	2003 -2006	70°49' 36.28'' N, 147°29' 56.23''E	Russia	EC+CH	Mixed moist tundra	van Huissteden et al. 2008, van der Molen et al. 2007
0.0226	2.37	Annual (June-October)	2003 -2004	72°22'N, 126°30'E	Russia	EC	Wet polygonal Tundra	Wille et al. 2008
0	-0.04	Summer (August-November)	2003	67°29.90'N 86°25.26'E	Russia	CH	Bog plateaux	Flessa et al. 2008
-0.0002	-0.08	Summer (August-November)	2003	67°29.90'N 86°25.26'E	Russia	CH	Well-drained mineral soils	Flessa et al. 2008

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0	-0.03	Summer (August-November)	2003	67°29.90'N 86°25.26'E	Russia	CH	Mineral soils with gleyic properties	Flessa et al. 2008
-	6.23	Summer (August-November)	2003	67°29.90'N 86°25.26'E	Russia	CH	Thermokarst ponds and lakes	Flessa et al. 2008
-	24	Summer (July-October)	2004	69°36'47''N, 161°20'29''E	Russia	CH	arctic wet tundra	Merbold et al. 2009
0.0233 to 0.0377	2.1 to 3.39	Summer	2004 -2006	70°N, 147° E	Russia	CH+model	Wetland	Petrescu et al. 2008
-	-0.004	Summer (May-September)	2004	62°19'N, 129°30'E	Russia	CH	Dry grassland (Continuous ecosystem)	Takakai et al. 2008
-	6.36	Summer (May-September)	2004	62°19'N, 129°30'E	Russia	CH	Wet grassland (Continuous ecosystem)	Takakai et al. 2008
-	-0.013	Summer (May-September)	2004	62°19'N, 129°30'E	Russia	CH	Forest (Continuous ecosystem)	Takakai et al. 2008
-	0.6	Summer (July-October)	2004	69°36'47''N, 161°20'29''E	Russia	CH	Drained arctic wet tundra	Merbold et al. 2009
-	-0.005	Summer (May-September)	2005	62°19'N, 129°30'E	Russia	CH	Dry grassland (Continuous ecosystem)	Takakai et al. 2008
-	39.2	Summer (May-September)	2005	62°19'N, 129°30'E	Russia	CH	Wet grassland (Continuous ecosystem)	Takakai et al. 2008

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
-	-0.008	Summer (May-September)	2005	62°19'N, 129°30'E	Russia	CH	Forest (Continuous ecosystem)	Takakai et al. 2008
-0.006	-0.5	Summer (July-august)	2005	62°15'18''N, 129°37'08''E	Russia	CH	Moist forest	van Huissteden et al. 2008
0.024	2.16	Summer (July-august)	2005	62°15'18''N, 129°37'08''E	Russia	CH	Mesotrophic fen	van Huissteden et al., 2008
0	-0.03	Annual	2006 -2007	67°29.90'N 86°25.26'E	Russia	CH	Bog plateaux	Flessa et al. 2008
-0.0002	-0.09	Annual	2006 -2007	67°29.90'N 86°25.26'E	Russia	CH	Well-drained mineral soils	Flessa et al. 2008
0	-0.02	Annual	2006 -2007	67°29.90'N 86°25.26'E	Russia	CH	Mineral soils with gleyic properties	Flessa et al. 2008
-	15.04	Annual	2006 -2007	67°29.90'N 86°25.26'E	Russia	CH	Thermokarst ponds and lakes	Flessa et al. 2008
-0.0067	-0.01	Summer (July-august)	2006	62°15'18''N, 129°37'08''E	Russia	CH	Dry forest	van Huissteden et al. 2008
-0.01	-0.86	Summer (July-august)	2006	62°15'18''N, 129°37'08''E	Russia	CH	Moist forest	van Huissteden et al. 2008
0.0141	1.45	Summer (103 days)	2006	72°22′N, 126°30′E	Russia	EC+CH	Wet polygonal tundra	Sachs et al. 2008
0.0707	6.36	Summer (August)	2006	72°22′N, 126°30′E	Russia	CH+EC	Polygonal tundra: very wet soils	Sachs et al. 2010

Daily CH_4 Flux gC $m^{-2}d^{-1}$	**Seasonal CH_4 Flux*** gC m^{-2}	**Season**	**Year**	**Geographical position**	**Location**	**Method****	**Ecosystem**	**Reference**
0.0058	0.52	Summer (August)	2006	72°22′N, 126°30′E	Russia	CH+EC	Polygonal tundra: drier or moderately moist soils	Sachs et al. 2010
0.06	5.4	Summer (July-August)	2007	70°49’44.9’’ N 147°29’39.4’’E	Russia	EC+CH	Mixed moist Tundra	Parmentier et al. 2011
0.05	1.125	Summer (July-August)	2008	70°49’44.9’’ N 147°29’39.4’’E	Russia	EC+CH	Mixed moist Tundra	Parmentier et al. 2011
0.03	0.675	Summer (July-August)	2009	70°49’44.9’’ N 147°29’39.4’’E	Russia	EC+CH	Mixed moist Tundra	Parmentier et al. 2011

*The growing season was assumed to last 90 days when non specified by the authors
**EC stands for Eddy covariance method and CH Means Chamber method.

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Appendix B. Description of Regional Process-Based Model Applications in this Study

1. LPJ-Guess WHyMe

LPJ-GUESS (Lund-Potsdam-Jena General Ecosystem Simulator - Smith et al. 2001) is a process-based model of biogeochemistry and vegetation dynamics. It is designed for both regional and global applications. Biophysical and physiological processes are represented mechanistically, based on the same formulations as the Lund-Potsdam-Jena dynamic global vegetation model (LPJ-DGVM; Sitch et al. 2003; Gerten et al. 2004), but plant resource competition is more detailed that LPJ-DGVM, being based on the interactions of plant individuals (each belonging to one of a set of prescribed plant functional types (PFTs)) at the neighbourhood scale. LPJ-GUESS has been evaluated in numerous studies (see Hickler et al. 2012 and references therein).

LPJ-GUESS has now been developed to model upland and peatland ecosystems at high latitudes by incorporating recent developments to LPJ-DGVM by Wania et al. (LPJ WHyMe v1.3.1 - Wania et al. 2009a, 2009b, 2010) that include soil freezing processes, peatland hydrology, peatland PFTs, and methane dynamics. This updated version of the LPJ-GUESS model has been used in this study and is referred to throughout as LPJ-Guess WHyMe. We have adopted the approach of Wania et al. (2009a, 2009b) by introducing a numerical solution of the heat diffusion equation to LPJ-GUESS. The model's soil column consists of four compartments: a snow layer of variable thickness, a litter layer of fixed thickness (5 cm), a soil column of depth 2 m (with sublayers of thickness 0.1 m), and finally a "padding" column of depth 48 m (with thicker sublayers) which is present to aid in the accurate simulation of temperatures in the overlying compartments. Soil temperatures in each sublayer are updated daily, in response to changing surface air temperature forcing and precipitation input, and taking into account both the insulating effects of snow and phase changes in the soil water.

For peatland fractions of each gridcell, we use the hydrology scheme of Wania et al. (2009a) and Granberg et al. (1999), in which the water table depth is updated daily in response to precipitation, snowmelt, evapotranspiration and surface runoff. Furthermore, the 2 m peatland soil column is subdivided into an upper 0.3 m acrotelm (within which the water table is allowed to fluctuate) above a 1.7 m permanently saturated catotelm layer. The water table is also allowed to extend above the soil surface to a maximum depth of 0.1 m.

Thirteen PFTs are simulated by LPJ-Guess WHyMe in this study. These include five trees, namely shade tolerant and intolerant boreal needleaved, evergreen trees; a needleaved, summergreen tree; and both a boreal and temperate broadleaved summergreen tree. The remaining eight PFTs consist of four shrub (up to 2 m in height) and four open ground PFTs, as introduced to LPJ-GUESS by Wolf et al. (2008). The model allows the establishment of six plant functional types (PFT) on peatlands. Flood-tolerant graminoids (such as *Carex* spp.) and *Sphagnum* types dominate, and follow the treatment of Wania et al. (2009b) and Yurova et al. (2007), with minor modifications. We also include two low (<0.5 m) evergreen and summergreen shrub PFTs from Wolf et al. (2008), e.g. *Vaccinium* spp. Finally, PFTs of both the prostrate dwarf shrub tundra and cushion forbs, lichens mosses tundra types from Wolf et al. (2008) can exist on peatlands in the high Arctic. These PFTs differ in their tolerance of high water table positions in the acrotelm. For example, graminoids dominate at high water table levels, and shrubs only survive when the water table is low.

Modelled net ecosystem exchange (NEE) used in this study is the difference between net carbon dioxide taken up by the modelled PFTs (i.e. NPP) and soil carbon decomposition (heterotrophic respiration). For upland soils, soil carbon decomposition is treated as in the standard LPJ-GUESS model set-up (Smith et al. 2001): decomposition rates for the carbon pools increase exponentially with soil temperature at 25 cm depth in a modified Arrhenius relationship (Lloyd and Taylor, 2004), and are reduced linearly with soil moisture content from field capacity to wilting point using the empirical relationship of Foley (1995). For peatland soils, however, we again follow Wania et al. (2009b), such that decomposition rates for the carbon pools increase exponentially with soil temperature at 25 cm depth, but are reduced uniformly by 60 % to account for reduced decomposition rates under inundated conditions typical of these ecosystems. Neither peatland fires nor DOC export are treated in LPJ-Guess WHyMe. The treatment of methane emission from peatlands follows Wania *et al*. (2010). Methane production, transport (via diffusion, plant-mediated and ebullition pathways) and oxidation are modelled on a daily timestep, and respond to changing soil temperatures and water table depths. Soil carbon emitted as methane does not contribute to NEE.

The model was run twice for the transient climate simulation; once for the standard upland hydrology, and once with the peatland hydrology. Gridcell-averaged carbon (CO_2 and CH_4) fluxes were then calculated by taking into account the peatland fraction of each gridcell. Using a similar procedure to TEM6 below, we derived carbon pools and vegetation in equilibrium with the conditions in the year 1901 by using a 500-year spin-up procedure for each 0.5º cell in the Arctic tundra region shown in Figure 1. Forcing for this spin-up period was taken from the CRU TS 3.0 dataset (Mitchell and Jones, 2005), and consisted of (detrended) monthly temperature, precipitation and cloudiness for the period 1901-30, repeated throughout the 500 year period. CO_2 concentration data for the spin-up period were held constant at the year 1901 level (296 ppm, approx.). Thereafter transient CRU forcing for the period 1901-2006 was applied to force the model, along with observed CO_2 concentrations. A similar procedure was adopted for the constant climate simulations, though in that case the spin-up forcing was continued beyond the 500 initialisation period until 2006.

2. Orchidee

The version of Orchidee used in this study is based on that Krinner et al. (2005) and includes a detailed one-dimensional permafrost soil carbon model POPCARN [Khvorostyanov et al., 2008a, 2008b] into the global land surface/carbon cycle model Orchidee. Orchidee calculates the fluxes of carbon, water, and energy for terrestrial ecosystems. POPCARN is a soil carbon model, which calculates vertically-resolved input of soil organic matter (SOM) from litter, first-order decomposition processes at each model level, moisture-dependent diffusion of oxygen and methane in soils and anoxic decomposition processes. SOM is separated into three pools with different residence times, each a function of soil temperature and texture (active = 0.85 yr, slow = 31 yr, and passive = 1400 yr at 5_C). The model represents the effect of SOM on soil temperatures, using the prognostic soil carbon stocks in Orchidee to define the soil thermal conductivity and heat capacity. This creates the opportunity for a feedback in soil carbon accumulation, in which additions of soil carbon modify the soil thermal regime and thus the residence time of soil carbon, which leads to a new steady-state soil carbon stock. The model also includes a simplified vertical mixing scheme to account for the effects of cryoturbation on the redistribution of SOM. Cryoturbation is a physical mixing process driven by ice growth and soil density changes that accompany freeze-thaw cycles. This mixing allows the soil carbon, which is generated near the soil surface, to move downwards into colder regions of the soil. The implementation of the model in this study was similar to region simulations described in Koven et al. (2009, 2011).

3. Terrestrial Carbon Flux (TCF) model

The TCF model is based on a simple 3-pool soil decomposition model with cascading decomposition rates scaled from a prescribed optimum rate for different biome types and reduced for unfavorable surface (<10 cm depth) soil moisture and soil temperature conditions. NEE is computed on a daily basis as a residual difference between vegetation GPP and ecosystem respiration (R_{eco}), defined as the summation of autotrophic and heterotrophic components. The TCF algorithm doesn't account for other carbon emission sources, including fire disturbance, so NEE is assumed approximately equivalent to NEP. The soil organic carbon (SOC) stock within the surface soil layer is estimated as the sum of three coupled SOC pools ($\hat{C}$) of declining litter quality and associated decomposition rates. Vegetation NPP is derived from GPP assuming a biome-specific constant autotrophic respiration fraction, while heterotrophic respiration (R_h) is computed from $\hat{C}$ and a soil decomposition rate determined from soil moisture (M_s) and soil temperature (T_s) conditions; *SM* and T_s are dimensionless scalars ranging from 0 (fully constrained) to 1 (no constraint) and derived from ancillary soil moisture and soil temperature inputs, and biome-specific response curves. A major assumption of the TCF model is dynamic (steady-state) equilibrium between NPP and surface SOC; soil decomposition and R_h processes are defined solely within the surface soil layer using ancillary soil moisture and temperature inputs, while R_h contributions from deeper soil layers are not represented. A detailed description of the TCF model framework is provided elsewhere (Kimball et al., 2009). For this investigation the TCF model runs were driven by ancillary GPP inputs from the MODIS (MOD17) GPP product (Zhao and Running, 2010) and daily surface soil moisture and soil temperature inputs from the MERRA global reanalysis (Rienecker et al., 2008). The MERRA reanalysis provides reasonably accurate depictions of surface soil moisture and temperature conditions, including boreal forest and tundra areas, relative to similar observations from satellite remote sensing, model reanalysis and in situ measurement networks (Yi et al., 2011); however, the MERRA global database has relatively coarse (0.5º) spatial resolution and does not resolve sub-grid scale processes. For this investigation, the 1-km resolution MODIS 8-day cumulative GPP product series was linearly interpolated to a daily time step. The daily GPP and MERRA soil moisture and temperature fields were then re-projected to a 25 x 25 km modeling grid using a bi-linear interpolation scheme. The model simulations were conducted over the entire MODIS period of record (2000-2009).

4. Terrestrial Ecosystem Model version 6 (TEM6)

TEM6 was modified from Felzer et al. (2004), which simulated ozone pollution effects, to also include the influence of permafrost dynamics (Zhuang et al., 2003; Euskirchen et al., 2006), atmospheric nitrogen deposition, biological nitrogen fixation, DOC leaching, wildfire (Balshi et al., 2007), agricultural conversion and abandonment, and timber harvest on terrestrial C dynamics. C pools and associated fluxes are simulated at a monthly time-step for individual ‘cohorts’ of unique vegetation types and disturbance history organized within spatially explicit 0.5^{o} latitude x 0.5^{o} longitude grid cells. We used the methane dynamics module of Zhuang et al. (2004, 2007) to estimate biogenic emissions of methane from Arctic tundra. To initialize the C, N and water pools for the beginning of the analysis period (1997 – 2006), in each model run we simulated dynamics since the year 1000 for each cohort among the half-degree grid cells covering the Arctic tundra region. The TEM simulations in this study were driven by temporally- and spatially-explicit data sets on atmospheric carbon dioxide concentration ([CO_2]), tropospheric ozone (O_3), N deposition, climate variability and change, and fire, forest harvest, and agricultural establishment and abandonment. Global annual atmospheric [CO_2] data are from the Mauna Loa station (Keeling and Whorf, 2005). [CO_2] data for the time period of years 1000 to 1900 are held constant at the year 1901 level (296.3 ppm). Monthly air temperature (^oC), precipitation (mm), and incident short-wave solar radiation (Wm^{-2}) data derived from observations for the period 1901–2002, gridded at 0.5^o resolution, were obtained from the Climate Research Unit (CRU; University of East Anglia, UK; Mitchell and Jones, 2005). The CRU climate variables were extended to 2006 with NCEP/NCAR Reanalysis 1 data sets (NOAA-ESRL Physical Sciences Division, Boulder CO) using a regression procedure based on data anomalies from a ten-year (1993 – 2002) mean for each variable (see Drobot et al., 2006). These data sets were hind-casted to year 1000 by a repeating 30-year cycle of the 1901 – 1930 monthly data to initialize the carbon pools with climate variability (except for the simulation without climate variability, where 1901 – 1930 monthly means were used to drive the model for each year). The ozone (O_3) pollution data set used in this study, represented by the AOT40 index (a measure of the accumulated hourly ozone levels above a threshold of 40 ppbv), is based on Felzer et al. (2005) and covers the time period from 1860 to 2006. Before 1860, the ozone level in each 0.5^o grid cell was assumed to equal the AOT40 of 1860 (which is equal to zero). The atmospheric N deposition data were based on van Drecht et al. (2003), extended from 2000 to 2006 by adding the difference in annual N deposition rate from 1999 to 2000 to succeeding years, for each 0.5^{o} grid cell (e.g. 2001 N deposition rate = 2000 + (2000-1999), etc.). For years 1000 to 1859, annual N deposition was assumed to equal the per grid cell rates in 1860. More information on TEM6 can be found in McGuire et al. (2010) and Hayes et al. (2011).

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Appendix C. Estimation of Central Estimate and Uncertainty Ranges of CO_2-C and CH_4-C exchange from Arctic Tundra to Atmosphere for Observations, Process-Models, and Inversion Models.

1. CO_2-C Exchange

For the observations, the central estimate for CO_2-C exchange was developed as an area-weighted mean of mean estimates for North America, North Atlantic, Northern Europe, and Eurasia sub-regions. The mean per area estimate for North America and Northern Europe are based on the annual estimates for 1990-2009, 2000-2009, and 1990-2009 reported in Table 3. The mean per area estimate for the North Atlantic sub-region was developed by adding a winter flux of 33 g C m^{-2} yr^{-1} (the mean winter flux among North America, Northern Europe, and Eurasia) to the North Atlantic sub-region mean summer estimates for each time period. The mean per area estimate for Eurasia for 1990-1999 was developed by adding summer 1990-1999 and the Eurasia winter. The mean per area estimate for Eurasia 2000-2009 and 1999-2009 was developed by adding the summer estimate to a winter flux of 33 g C m^{-2} yr^{-1} (the mean winter flux among North America, Northern Europe, and Eurasia) since the winter estimate for Eurasia was based on studies for the 1990-1999 period. The lower and higher per area estimates of the uncertainty range were developed in a similar way as the mean, but were based on the lower and upper values of the confidence intervals reported in Table 3. The areas used to develop a central estimate were 4,265,569, 108,065, 166,436, and 4,627,247 km^2 for the North America, North Atlantic, Northern Europe, and Eurasia sub-regions, respectively.

The central estimate for the regional and global process-based models was developed by taking the mean NEE of regional and global estimates in the lower half of Tables 5 and 6, for the time periods 1990-1999 and 2000-2006, respectively. The uncertainty range was developed as the maximum and minimum NEE estimates of the regional and global estimates in the lower half of Tables 5 and 6, for the time periods 1990-1999 and 2000-2006, respectively. The central estimate for the inversion models was developed by taking the mean of 1990-1999 and 2000-2006 estimates in the left half of Table 8. The uncertainty range was developed as the maximum and minimum estimates of the 1990-1999 and 2000-2006 estimates in the left half of Table 8.

2. CH_4-C Exchange

For the observations, the central estimate for CH_4-C exchange was developed as an area-weighted mean of mean estimates for the area of wetlands in the tundra regions of North America, North Atlantic, Northern Europe, and Eurasia sub-regions. The mean per area estimate for North America and Northern Europe are based on the annual estimates for 1990-1999 and 2000-2009 reported in Table 3. The mean per area estimate for the North Atlantic is assumed to be intermediate between the North America and Northern Europe estimates. The mean per area estimate for Eurasia uses the annual estimate for the 2000-2009 period in Table 3 for all three time periods. The lower and higher per area estimates of the uncertainty range were developed in a similar way as the mean, but were based on the lower and upper values of the confidence intervals reported in Table 3. The wetland areas used to develop a central estimate were 772,076, 7,540, 18,139, and 812,969

km^2 for the North America, North Atlantic, Northern Europe, and Eurasia sub-regions, respectively.

The central estimate for the regional process-based models was developed by taking the mean BIOCH4 of the regional estimates in the lower half of Tables 5 and 6, for the time periods 1990-1999 and 2000-2006, respectively. The uncertainty range was developed as the maximum and minimum BIOCH4 estimates of the regional estimates in the lower half of Tables 5 and 6, for the time periods 1990-1999 and 2000-2006, respectively.