

1 **Supplemental Materials**
2

3 A list of all references (in alphabetical order) taken into account in the literature review
4 of ozone air-surface exchange displayed in Table 2. This list of references does not claim
5 to be complete.
6

7

8 **Table 2 :** Literature review showing the frequency of usage of each method available to
9 calculate an ozone flux (EC = eddy correlation; PG = profile gradient; CH = chamber),
10 the platforms used for each method, and the various landscape categories above which
11 fluxes are being calculated. Also, the ranges of measured ozone gas exchange under each
12 category are being reported.

13

14 (*) The list of all references taken into account in the statistics of this table is given in the
15 Appendix.

Method/ Percent*	Platform	Percent* method	Landscape type by category	Percent* of studies	Gas exchange range (cm s^{-1})
EC 65.3	Tower	50.8	agriculture	22.0	0.0 → 2.0
			forest	37.3	-1.5 → 1.8
			natural grass	20.3	0.0 → 0.5
			bare soil	3.4	0.05 → 0.25
			sand	1.7	0.04 → 0.15
			snow	11.9	-0.05 → 0.5
			ocean	3.4	0.005 → 0.04
			urban	0	-
Aircraft	Aircraft	12.1	agriculture	46.7	0.01 → 1.2
			forest	20.0	0.8 → 1.0
			natural grass	20.0	0.12 → 0.23
			bare soil	6.7	0.3 → 0.9
			sand	0.0	-
			snow	0.0	-
			ocean	6.7	0.05
			urban	0	-
Balloon	Balloon	2.4	agriculture	0	-
			forest	0	-
			natural grass	33.3	0.3 → 0.72
			bare soil	0	-
			sand	0	-
			snow	33.3	0.006 → 0.3
			ocean	0	-
			urban	33.3	0.085
PG 25.8	Tower	22.6	agriculture	30.8	0.3 → 0.6
			forest	30.8	0.04 → 1.1
			natural grass	19.2	-0.4 → 2.3
			bare soil	0	-
			sand	0	-
			snow	7.7	-3.3 → 1.7
			ocean	7.7	0.08 → 1.15
			urban	3.8	0.13
Ground	Ground	1.6	agriculture	0	-
			forest	0	-
			natural grass	0	-
			bare soil	0	-
			sand	0	-
			snow	0	-
			ocean	0	-
			urban	100	0.0 → 0.45
Balloon	Balloon	1.6	agriculture	0	-
			forest	66.7	Not available
			natural grass	0	-
			bare soil	33.3	Not available
			sand	0	-
			snow	0	-
			ocean	0	-
			urban	0	-
CH 8.9	-	8.9	agriculture	0	-
			forest	18.2	0.0 → 0.5
			natural grass	9.1	0.3 → 5.0
			bare soil	18.2	0.5 → 5.0
			sand	9.1	1.6 → 2.5
			snow	18.2	0.004 → 0.125
			ocean	27.3	0.015 → 0.1
			urban	0	-

- 17
18 Aldaz, 1969: Flux measurements of atmospheric ozone over land and water. *J. Geophys. Res.*, 74, 6934-
19 6946.
20 Broder et al., 1981: Ozone fluxes in the nocturnal planetary boundary layer over hilly terrain. *Atmos.*
21 *Environ.*, 15(7), 1195-1199.
22 Chang et al., 2004: Ozone deposition to the sea surface: chemical enhancement and wind speed
23 dependence. *Atmos. Environ.*, 38(7), 1053-1059.
24 Cieslik, 1998: Energy and ozone fluxes in the atmospheric surface layer observed in southern Germany
25 highlands. *Atmos. Environ.*, 32(7), 1273-1281.
26 Coe et al., 1995: Canopy scale measurements of stomatal and cuticular O₃ uptake by Sitka Spruce. *Atmos.*
27 *Environ.*, 29(12), 1413-1423.
28 Colbeck and Harrison, 1985: Dry deposition of ozone: some measurements of deposition velocity and of
29 vertical profiles to 100 meters. *Atmos. Environ.*, 19, 1807-1818.
30 Couach et al., 2003: An investigation of ozone and planetary boundary layer dynamics over the complex
31 topography of Grenoble combined measurements and modeling. *Atmos. Chem. Phys.*, 3, 549-562.
32 Cros et al., 1992: Vertical profiles of O₃ between 0 and 400m in and above the African Equatorial forest. *J.*
33 *Geophys. Res.*, 97(D12), 12877-12887.
34 Dabberdt et al., 1993: Atmosphere-surface exchange measurements. *Science*, 260, 1472-1481.
35 Delany et al., 1986: Direct measurement of NO_x and O₃ fluxes over grassland. *J. Atmos. Chem.*, 4, 429-
36 444.
37 Desjardins et al., 1995: Flux estimates of latent and sensible heat, carbon dioxide and ozone using aircraft-
38 tower combination. *Atmos. Environ.*, 29, 3147-3158.
39 Droppo, 1985: Concurrent measurements of ozone dry deposition using eddy correlation and profile flux
40 methods. *J. Geophys. Res.*, 90, 2111-2118.
41 Duyzer et al., 1983: Measurements of dry deposition velocities of NO, NO₂ and O₃, and the influence of
42 chemical reactions. *Atmos. Environ.*, 17(10), 2117-2120.
43 Duyzer and Weststrate, 1995: The use of the gradient method to monitor trace gas fluxes over forest: flux-
44 profile functions for ozone and heat. *Studies Environ. Sci.*, 64, 21-30.
45 Duyzer et al., 1995: Exchange of ozone and nitrogen oxides between the atmosphere and coniferous forest.
46 *Water, Air, & Soil Pollut.*, 85(4), 2065-2070.
47 Enders et al., 1989: Profiles of ozone and surface layer parameters over a mature spruce stand. In
48 Mechanisms and Effects of Pollutant-Transfer into Forests. By Georgii, Eds. Kluver Academic
49 Publishers, 21-35.
50 Enders, 1992: Deposition of ozone to a mature spruce forest: measurements and comparison to models.
51 *Environ. Pollut.*, 75, 61-67.
52 Fabian and Junge, 1970: Global rate of ozone destruction at the Earth's surface. *Archive Met. Geophys.*
53 *Bioklim. Ser. A*, 19, 161-172.
54 Fan et al., 1990: Atmosphere-biosphere exchange of CO₂ and O₃ in the central Amazon forest. *Geophys.*
55 *Res. Lett.*, 95(D10), 16851-16864.
56 Finkelstein et al., 2000: Ozone and sulfur dioxide dry deposition to forests: observations and model
57 evaluation. *J. Geophys. Res.*, 105(D12), 15365-15377.
58 Finkelstein, 2001: Deposition velocities of SO₂ and O₃ over agricultural and forest ecosystems. *Water, Air,*
59 *Soil Pollut.*, 1, 49-57.
60 Fitzjarrald and Lenschow, 1983: Mean concentration and flux profiles for chemically reactive species in the
61 atmospheric surface layer. *Atmos. Environ.*, 17, 2505-2512.
62 Fontan et al., 1992: Vertical ozone profiles in a pine forest. *Atmos. Environ.*, 29, 863-869.
63 Galbally, 1968: Some measurements of ozone variation and destruction in the atmospheric surface layer.
64 *Ibid.*, 218, 456-457.
65 Galbally, 1971a: Surface ozone observations at Aspendale Victoria 1964-1970, *Atmos. Environ.*, 5, 15-25.
66 Galbally, 1971b: Ozone profiles and ozone fluxes in the atmospheric surface layer. *Q. J. R. Meteorol. Soc.*,
67 97(411), 18-29.
68 Galbally and Allison, 1972: Ozone fluxes over snow surfaces. *J. Geophys. Res.*, 77(21), 3946-3948.
69 Galbally and Roy, 1980a: Destruction of ozone at the Earth's surface. *Q. J. R. Meteorol. Soc.*, 106, 599-620.
70 Galbally and Roy, 1980b: Ozone and nitrogen oxides in the Southern hemisphere. *Proc. International Ozone*
71 *Symposium*, Boulder, CO, pp. 431-438.
72 Galbally et al., 1986: Surface ozone at rural sites in the Latrobe valley and Cape Grim, Australia. *Atmos.*
73 *Environ.*, 20, 2403-2422.
74 Gallagher and Coe, 2001: Ozone deposition to coastal waters. *Q. J. R. Meteorol. Soc.*, 127(572), 539-558.
75 Garratt, 1980: Surface influence upon vertical profiles in the atmospheric near-surface layer. *Q. J. R.*
76 *Meteorol. Soc.*, 106, 803-819.
77 Garland and Derwent, 1979: Destruction at the ground and the diurnal cycle of concentration of ozone and
78 other gases. *Q. J. R. Meteorol. Soc.*, 105, 169-183.

- 79 Garland and Penkett, 1976: Absorption of peroxy acetyl nitrate and ozone by natural surfaces. *Atmos.*
80 *Environ.*, 10, 1127-1131.
- 81 Georgiadis et al., 1995: Inferring ozone deposition on agricultural surfaces: an application to herbaceous
82 and tree canopies. *Water Air Soil Pollut.*, 84, 117-128.
- 83 Gerosa et al., 2005: Ozone uptake by an evergreen Mediterranean forest in Italy. Part I: micrometeorological
84 flux measurements and flux partitioning. *Atmos. Environ.*, 39, 3255-3266.
- 85 Geyer and Stutz, Vertical profiles of NO₃, N₂O₅, O₃ and NO_x in the nocturnal boundary layer: model
86 studies on the altitude dependence of composition and chemistry. *J. Geophys. Res.*, 109(D12307).
- 87 Godowitch, 1990: Vertical ozone fluxes and related deposition parameters over agriculture and forested
88 landscapes. *Bound-Layer Meteorol.*, 50, 375-404.
- 89 Gong et al., 1997: Mechanisms for surface ozone depletion and recovery during polar sunrise. *Atmos.*
90 *Environ.*, 31, 969-981.
- 91 Granat and Richter, 1995: Dry deposition to pine of sulfur dioxide and ozone at low concentration. *Atmos.*
92 *Environ.*, 29(4), 1677-1683.
- 93 Greenhut, 1983: Resistance of a pine forest to ozone uptake. *Bound-Layer Meteorol.*, 27, 387-391.
- 94 Greenhut et al., 1984: Transport of ozone by turbulence and clouds in an urban boundary layer. *J. Geophys.*
95 *Res.*, 89, 4757-4766.
- 96 Guo et al., 1995: A simple scheme for partitioning aircraft-measured ozone fluxes into surface-uptake and
97 chemical transformation. *Atmos. Environ.*, 29(21), 3199-3207.
- 98 Güsten and Heinrich, 1996: On-line measurements of ozone surface fluxes: part I methodology and
99 instrumentation. *Atmos. Environ.*, 30(6), 897-909.
- 100 Güsten et al., 1996: On-line measurements of ozone surface fluxes: part II surface level O₃ fluxes onto the
101 Sahara Desert. *Atmos. Environ.*, 30, 911-918.
- 102 Güsten et al., 1998: Nocturnal depletion of ozone in the Upper Rhine Valley. *Atmos. Environ.*, 32(7), 1195-
103 1202.
- 104 Gut et al., 2002: Exchange fluxes of NO₂ and O₃ at soil and leaf surfaces in an Amazonian rainforest.
105 *Geophys. Res. Lett.*, 107(D20), 8060.
- 106 Hargreaves et al., 1992: The exchange of NO, NO₂ and O₃ between pasture and atmosphere. *Environ.*
107 *Pollut.*, 75, 53-59.
- 108 Hasel et al., 2005: Airborne measurements of turbulent trace gas fluxes and analysis of eddy structure in the
109 convective boundary layer over complex terrain. *Atmos. Res.*, 74(1-4), 381-402.
- 110 Hicks and McMillen, 1984: A simulation of eddy accumulation method for measuring pollutant fluxes. *J.*
111 *Climate Appl. Meteorol.*, 23, 637-643.
- 112 Hicks et al., 1989: A micrometeorological investigation of surface exchange of O₃, SO₂, and NO₂: a case
113 study. *Bound-Layer Meteorol.*, 47, 321-336.
- 114 Hole et al., 2004: Ozone deposition to a temperate coniferous forest in Norway: gradient method
115 measurements and comparison with the EMEP deposition module. *Atmos. Environ.*, 38(15), 2217-2223.
- 116 Hopper et al., 1998: Ozone and meteorology during the 1994 Polar Sunrise Experiment. *J. Geophys. Res.*,
117 103, 1481-1492.
- 118 Jacob et al., 1992: Deposition of ozone to tundra. *JGR*, 97(D15), 16473-16479.
- 119 Kelly and McTaggart Cowan, 1968: Vertical gradient of net oxidant near the ground surface at Barrow, AK.
120 *J. Geophys. Res.*, 73, 3328-3330.
- 121 Kerstiens and Lendzian, 1989: Interactions between ozone and plant cuticles. *New Phytol.*, 112, 13-19.
- 122 Kirkman et al., 2002: Surface exchange of NO, NO₂ and O₃ at a pasture in Rondonia, Brazil. *Geophys.*
123 *Res. Lett.* 107(D20), 8083.
- 124 Klemm and Mangold, 2001: Ozone deposition at a forest site in NE Bavaria. *Water, Air, and Soil Pollu.*, 1,
125 223-232.
- 126 Kramm et al., 1991: A modified profile method for determining vertical fluxes of NO, NO₂, O₃ and HNO₃ in
127 the atmospheric surface layer. *J. Atmos. Chem.*, 13, 265-288.
- 128 Labatut, 1997: Ozone and heat fluxes over a Mediterranean pseudosteppe. *Atmos. Environ.*, 31, 177-184.
- 129 Lenschow et al., 1980: Airborne measurements of vertical flux of ozone in the boundary layer. *Bound-Layer*
130 *Meteorol.*, 19, 249-265.
- 131 Lenschow et al., 1981: Estimating the ozone budget in the boundary layer by use of aircraft measurements
132 of ozone eddy flux and mean concentration. *J. Geophys. Res.*, 86, 7291-7297.
- 133 Lenschow et al., 1982: Measurements of ozone vertical flux to ocean and forest. *J. Geophys. Res.*, 87,
134 8833-8837.
- 135 Leuning et al., 1979: Ozone fluxes to tobacco and soil under field conditions. *Atmos. Environ.*, 13, 1155-
136 1163.
- 137 Leuning et al., 1979: Ozone uptake by corn: a general approach. *Agric. Meteorol.*, 20, 115-135.
- 138 Liss and Slater, 1974: Flux of gases across the air-sea interface. *Nature*, 247, 181-184.
- 139 Lopez et al., 1993: Analysis of atmospheric ozone measurements over a pine forest. *Atmos. Environ.*, 27A,
140 555-563.

- 141 Lorenzini and Nali, 1995: Analysis of vertical ozone and nitrogen oxides profiles in a *Prunus cerasifera*
142 canopy. International J. Biometeorol., 39(1), 1-4.
- 143 MacPherson et al., 1995: Aircraft-measured ozone deposition in the San Joaquin Valley. Atmos. Environ.,
144 29(21), 3133-3145.
- 145 Mahrt et al., 1995: Ozone fluxes over a patchy cultivated surface. J. Geophys. Res., 100(D11), 23125-
146 23131.
- 147 Massman, 1993: Partitioning ozone fluxes to spare grass and soil and the inferred resistances to dry
148 deposition. Atmos. Environ., 27A, 167-174.
- 149 Massman et al., 1994: An evaluation of the RADM surface module for ozone uptake at 3 sites in the San
150 Joaquin Valley of California. J. Geophys. Res., ???
- 151 Massman et al., 1995: Surface conductances for ozone uptake derived from aircraft eddy correlation data.
152 Atmos. Environ., 29, 3181-3188.
- 153 Matsuda et al., 2005: Ozone dry deposition above a tropical forest in the dry season in northern Thailand.
154 Atmos. Environ., 39, 2571-2577.
- 155 Matt and Womak, 1989: Atmospheric surface exchange of ozone to a spruce forest: measured and inferred.
156 In Ozone in the Atmosphere, By Bojkov and Fabian, Eds. Deepak Publishing, 490-493.
- 157 Mikkelsen et al., 2000: Ozone uptake by an evergreen forest canopy: temporal variation and possible
158 mechanisms. Environ. Pollut., 109, 423-429.
- 159 Munger et al., 1996: Atmospheric deposition of reactive nitrogen oxides and ozone in a temperate deciduous
160 forest and a sub-artic spruce woodland. Part 1: Measurements and mechanisms. J. Geophys. Res.,
161 101, 12639-12657.
- 162 Musselman and Massman, 1999: Ozone flux to vegetation and its relationship to plant response and
163 ambient air quality standards. Atmos. Environ., 33(1), 65-73.
- 164 Neu et al., 1994: On the relationship between ozone storage in the residual layer and the daily variation in
165 the near surface ozone concentration -A case study. Bound-Layer Meteorol., 69, 221-247.
- 166 Neuman and Den Hartog, 1985: Eddy correlation measurements of atmospheric fluxes of ozone, sulphur
167 and particulates during the Champaign intercomparison study. J. Geophys. Res., 90, 2097-2111.
- 168 Padro et al., 1992: Modeled and observed dry deposition velocity of O₃ above a deciduous forest in winter.
169 Atmos. Environ., 26A, 775-784.
- 170 Padro, 1993: Seasonal contrasts in modeled and observed dry deposition velocities of O₃, SO₂ and NO₂
171 over three surfaces. Atmos. Environ., 27A, 807-814.
- 172 Padro et al., 1994: Dry deposition velocity of ozone over a vineyard obtained from models and observations:
173 the 1991 California Ozone Deposition Experiment. Water Air Soil Pollut., 74, 1-16.
- 174 Padro, 1996: Summary of ozone dry deposition velocity measurements and model estimates over vineyard,
175 cotton, grass and deciduous forest in summer. Atmos. Environ., 30(13), 2363-2369.
- 176 Pederson, 1991: Documentation for SJVAQS vineyard tower measurements. The San Joaquin Valley Air
177 Pollution Study Agency, contract 91-2.
- 178 Pederson et al., 1995: California Ozone Deposition Experiment: methods, results and opportunities. Atmos.
179 Environ., 29(21), 3115-3132.
- 180 Pilegaard et al., 1995: Seasonal and diurnal variation in the deposition velocity of ozone over a spruce forest
181 in Denmark. Water Air Soil Pollut., 85(4), 2223-2228.
- 182 Pilegaard et al., 1995: Deposition of nitrogen oxides and ozone to Danish forest sites. Studies Environ. Sci.,
183 64, 31-40.
- 184 Pio et al., 2000: Seasonal variability of ozone dry deposition under southern European climate conditions, in
185 Portugal. Atmos. Environ., 34, 195-205.
- 186 Pleijel et al., 1995: Surface wetness enhances ozone deposition to a pasture canopy. Atmos. Environ.,
187 29(22), 3391-3393.
- 188 Ray et al., 1986: Fast chemiluminescence method for measurement of ambient ozone. Anal. Chem., 58,
189 598-600.
- 190 Regener, 1957: The vertical flux of atmospheric ozone. J. Geophys. Res., 62, 221-228.
- 191 Regener and Aldaz, 1969: Turbulent transport near the ground as determined from measurements of the
192 ozone flux and the ozone gradient. J. Geophys. Res., 74, 6935-6942.
- 193 Regener, 1974: Destruction of atmospheric ozone at the ocean surface. Archive Met. Geoph. Bioklim. Ser.
194 A, 21, 131-135.
- 195 Rich et al., 1970: Ozone uptake by bean leaves. Science, 169, 79-80.
- 196 Rondon et al., 1993: Dry deposition of NO₂ and O₃ to coniferous forests. J. Geophys. Res., 98, 5159-5172.
- 197 Ro-Poulsen et al., 1998: Ozone deposition in relation to canopy physiology in a mixed conifer forest in
198 Denmark. Chemosphere, 36(4-5), 669-674.
- 199 Rummel et al., 2007: Seasonal variation of ozone deposition to tropical rain forest in southwest Amazonia.
200 Atmos. Chem. Phys.Disc., 7, 7399-7450.
- 201 Sehmel, 1980: Particle and gas dry deposition: a review. Atmos. Environ., 14, 983-1011.

- 202 Sigler et al., 2002: Ozone dynamics and deposition processes at a deforested site in the Amazon basin.
203 *Ambio.*, 31(1), 21-27.
- 204 Stocker et al., 1993: Fluxes of nitrogen oxides and ozone measured by eddy correlation over a short grass
205 prairie. *J. Geophys. Res.*, 98(D7), 12619-12630.
- 206 Stocker et al., 1995: O₃ and NO₂ fluxes over snow measured by eddy correlation. *Atmos. Environ.*, 29(11),
207 1299-1305.
- 208 Sun and Massman, 1999: Ozone transport during the California Ozone Deposition Experiment. *J. Geophys.*
209 *Res.*, 104(D10), 11939-11948.
- 210 Tiefenau and Fabian, 1972: The specific ozone destruction at the ocean surface and its dependence on
211 horizontal wind velocity from profile measurements. *Archive Met. Geoph. Bioklim. Ser. A*, 21, 399-412.
- 212 Tiwari and Sreedharan, 1973: Ozone concentration studies and ozone flux measurements near the ground
213 at Poona. *Pure and Appl. Geophys.*, 106(1), 1124-1138.
- 214 Turner et al., 1973: Removal of ozone by soil. *J. Environ. Quality*, 2, 259-264.
- 215 Turner, 1974: Removal of ozone from the atmosphere by soil and vegetation. *Nature*, 250, 486-489.
- 216 Van Dop et al., 1977: Some measurements of the vertical distribution of ozone in the boundary layer. *Atmos.*
217 *Environ.*, 11(1), 65-71.
- 218 Walton et al., 1997: Ozone and NO₂ exchange to fruit orchards. *Atmos. Environ.*, 31(17), 2767-2776.
- 219 Wang et al., 2006: Vertical profiles of O₃ and NO_x chemistry in the polluted nocturnal boundary layer in
220 Phoenix, AZ: I. Field observations by long-path DOAS. *Atmos. Chem. Phys.*, 6, 2671-2693.
- 221 Wesely et al., 1978: Daytime variations of ozone eddy fluxes to maize. *Bound-Layer Meteorol.*, 15, 361-373.
- 222 Wesely et al., 1981: Field measurement for small ozone fluxes to snow, wet bare soil, and lake water.
223 *Bound-Layer Meteorol.*, 20(4), 459-471.
- 224 Wesely et al., 1982: An eddy correlation measurement of NO₂ flux to vegetation and comparison to O₃ flux.
225 *Atmos. Environ.*, 16, 815-820.
- 226 Wesely, 1983: Turbulent transport of ozone to surfaces common in the Eastern half of the US. In *Trace*
227 *atmospheric constituents, properties, transformation and fates*, by S. E. Schwartz. Ed. Wiley and Sons,
228 346-370.
- 229 Wesely et al., 1983: Fluxes of gases and particles above a deciduous forest in wintertime. *Bound-Layer*
230 *Meteorol.*, 27(3), 237-255.
- 231 Zeller and Hehn, 1994: Wintertime anomalies in ozone deposition above a subalpine spruce-fir forest. *Proc.*
232 *4th USDA Forest Service, Research and Applications of Chemical Sciences in Forestry*, USDA, 131-
233 138.
- 234 Zeller and Hehn, 1995: Ozone deposition in a snow-covered subalpine spruce-fir forest environment.
235 *Proceedings Boulder Symposium, IAHS*, 228.
- 236 Zeller and Hehn, 1996: Measurements of upward turbulent ozone fluxes above a subalpine spruce-fir forest.
237 *Geophys. Res. Lett.*, 23(8), 841-844.
- 238 Zeller, 2000: Wintertime ozone fluxes and profiles above a subalpine spruce-fir forest. *J. Appl. Meteorol.*,
239 39(1), 92-101.
- 240 Zeller and Nikolov, 2000: Quantifying simultaneous fluxes of ozone, carbon dioxide, and water vapor above
241 a subalpine forest ecosystem. *Environ. Pollut.*, 107, 1-20.
- 242 Zeller, 2002: Summer and autumn ozone fluxes to a forest in the Czech Republic Brdy Mountains. *Environ.*
243 *Pollut.*, 119, 269-278.
- 244 Zhang et al., 2002: On ozone dry deposition -with emphasis on non-stomatal uptake and wet canopies.
245 *Atmos. Environ.*, 36, 4787-4799.
- 246 Ziomas et al., 1983: On the strength of the ozone sink at the ground. *Meteorol. and Atmos. Phys.*, 33(3),
247 229-236.