

Dry deposition of reactive nitrogen to European ecosystems: a comparison of inferential models across the NitroEurope network – Supplementary Material

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A1 Introduction

This supplement provides additional details concerning the implementation of four dry deposition (inferential) routines as part of the model inter-comparison at the ecosystem scale presented in the aforementioned article, with respect to ecosystem characteristics, micrometeorology and canopy wetness simulation.

A2 Canopy characteristics

For the modelling of trace gas and particle deposition at national or regional scales, the inferential routines of the four models (i.e. CBED, CDRY, EMEP-03, IDEM) normally use either land use class (LUC)-specific, monthly default values, or phenological functions, for the key canopy characteristics (canopy height h_c , roughness length z_0 and leaf area index LAI), since such data are not available at the ecosystem scale for every node of the grid domain nor for every day of the year. These default values or functions for each LUC logically differ between the four models since they were developed for different countries or climatic zones.

In this paper, however, the models are applied locally to a number of ecosystem study sites, rather than to a whole geographical domain. Measurements of h_c and of LAI were made as part of CarboEurope IP at most sites of the NitroEurope (NEU) inferential network (Table 1 of main paper). These measurements were carried out typically a few times during the growing season but the data capture was very uneven between sites. While the temporal (seasonal) variations were extremely well documented with very frequent (weekly) measurements at a few sites of the network, too few data were available at the majority of the

1 other sites to reliably interpolate over time, as required for input to deposition models. This is
2 largely due to the fact that in many cases only the maximum LAI was recorded during the
3 growing season, while the conditions at the start and end of the growing season can only be
4 guessed. With several cuts per year in grasslands, or more than one crop per year in arable
5 systems, the frequent measurements needed were not available for all sites. There was also the
6 added problem that the NEU project (2006-2010) was shifted in time relative to CarboEurope
7 IP (2004-2008), so that much of the LAI and h_c data collected as part of CarboEurope were
8 not contemporaneous with the NEU trace gas and aerosol datasets (initiated in 2007). Another
9 difficulty resides in the method or type of LAI measurement (single-sided, double-sided,
10 projected, total) not being recorded, so that the available data may not be compatible with the
11 input required for modelling.

12 Based on these considerations, model base runs in this study use model default values of LAI,
13 combined with time-interpolated values of h_c derived from the available measured data
14 ('ModLAI / MeasHc', see Table A2). The choice of model default LAI is primarily motivated
15 by the potentially large error in measured LAI data, which may be considered just as
16 uncertain as model default values. By contrast, h_c is a more easily measured and defined
17 canopy characteristic, which can arguably be considered constant for forests over the time
18 frame of CarboEurope and NEU. More importantly, the measurement heights for the sonic
19 anemometers and for the DELTA gas and aerosol sampling apparatus were in practice set
20 according to the true h_c . Thus the measured pollutant concentrations reflected vertical
21 gradients and turbulent mixing conditions consistent with the real h_c , but not necessarily with
22 a model default value.

23 Nevertheless, if the objective is to fully inter-compare models, rather than obtain the 'truest'
24 model deposition estimates, one could argue that h_c and LAI descriptions in default lookup
25 tables can be regarded as intrinsic model parameters, and should therefore both be used as
26 inputs ('ModLAI / ModHc'). Conversely, using both sets of measured LAI and h_c as common
27 inputs to the four models ('MeasLAI / MeasHc') could be defended as providing a better set-
28 up for inter-comparing the models treatment of surface resistances, in which the confounding
29 effects of surface roughness and area are removed. These alternative choices for the model
30 inputs values of LAI and h_c are presented to assess the sensitivity of annual dry deposition
31 fluxes (Figure A3). For the reconstruction of seasonal time series of daily h_c and LAI, the data
32 were interpolated between consecutive measurements if their time resolution was sufficient;

1 alternatively, generic annual curves were computed on the basis of the standard EMEP-03
 2 phenological functions (Simpson et al., 2003), then scaled using the measured minimum and
 3 maximum values at each site.

4

5 **A3 Micrometeorological data**

6 Fundamental variables needed to compute the atmospheric resistances R_a and R_b include u_* ,
 7 sensible heat flux H , and z_0 . At 51 of the 55 sites of the NEU inferential network, long-term
 8 eddy covariance (EC) measurements of CO_2 and H_2O exchange were carried out within the
 9 framework of CarboEurope IP (Aubinet et al., 2000), and thus actual in-situ measurements of
 10 u_* and H were available on a half-hourly basis and obtained courtesy of the CarboEurope-IP
 11 database. For the 4 remaining non-CarboEurope IP sites (DE-Hoe, FI-Lom, NL-Spe, UA-Pet),
 12 eddy covariance flux measurements were initiated as part of NitroEurope IP. In the base
 13 model runs presented hereafter, all available measured (EC) u_* and H data were used by
 14 default for the calculation of atmospheric resistances.

15 For cases when valid turbulence data from EC were not available due to instrument failure,
 16 strong nocturnal atmospheric stability, small wind speeds or insufficient fetch (Aubinet et al.,
 17 2000), u_* and H needed to be gap-filled from standard meteorological data (wind speed, net
 18 radiation, temperature) measured at each site. This was done in a similar fashion to
 19 meteorological sub-modules of regional chemical transport models (CTMs), which derive
 20 their u_* from numerical weather prediction (NWP) model output data, such that (Thom,
 21 1975):

$$22 \quad u_* = \frac{\kappa U(z_{ref} - d)}{\left[\ln\left(\frac{z_{ref} - d}{z_0}\right) - \psi_M\left(\frac{z_{ref} - d}{L}\right) + \psi_M\left(\frac{z_0}{L}\right) \right]} \quad (\text{A1})$$

23 where z_0 is roughness length and d is displacement height, both being dependent on h_c , U is
 24 wind speed, κ is von Karman's constant ($= 0.41$), ψ_M is the integrated atmospheric stability
 25 correction function for momentum, and L is the Obukhov stability length:

$$26 \quad L = -\frac{\rho_a \theta C_p u_*^3}{\kappa g H} \quad (\text{A2})$$

1 with ρ_a the density of dry air (g m^{-3}), θ the potential air temperature (K), C_p the specific heat
2 capacity of air ($= 1.005 \text{ J g}^{-1} \text{ K}^{-1}$) and g the gravitational acceleration ($= 9.81 \text{ m s}^{-2}$) (Thom,
3 1975). However, this also requires the knowledge of L , which is itself a function of both u_*
4 and H (Eq. A2). In the absence of valid micrometeorological measurements, a first and
5 necessary step adopted here as in other models (e.g. Bassin et al., 2004) consists in a rough
6 estimation of H assuming the closure of the surface energy balance and a partitioning of the
7 available energy such that:

$$8 \quad H = R_n - \lambda E - G \quad (\text{A3})$$

9 Here G is the ground heat flux, and the latent heat flux λE was estimated using the Penman-
10 Monteith (P-M) equation, which may only be done in a first approximation assuming neutral
11 stratification, since H and L are both unknown. As R_a and R_s are also needed, as rather poorly
12 quantified drivers of evaporation, in the P-M equation, both estimates of λE and H are
13 necessarily quite uncertain, all the more as the surface energy closure assumption is often not
14 confirmed in the field (e.g. Wohlfahrt et al., 2009). From the H estimate thus obtained, both u_*
15 and L are then calculated iteratively using Eqs. (A1) and (A2). The overall effect of the gap-
16 filling procedure for H on annual N_r fluxes appears to be small, however, as the error in H
17 does not propagate very strongly into u_* (Bassin et al., 2004), and also because
18 micrometeorological data gaps are by nature strongly correlated with periods of reduced wind
19 speeds and suppressed turbulence, during which potential rates of tracer exchange are very
20 small.

21

22 **A4 Surface potentials**

23 For the calculation of stomatal and non-stomatal resistances, and of the NH_3 compensation
24 point (Eqs. 3 to 10 in main Paper), values of the surface scalars temperature and relative
25 humidity are required. From the viewpoint of a numerical weather prediction (NWP) model,
26 ‘surface’ actually means anything between the measurement height (z_{ref}) of a standard
27 meteorological station within the surface layer, typically 2-3 m above ground or up to 10
28 meters above tree tops in the case of a forest, up to 50-100 m. From a micrometeorological,
29 field-scale point of view, ‘surface’ corresponds to the notional height $z_s = d+z_0$, ‘below’ the
30 viscous sublayer, with z_0 the roughness length for heat and trace gases (Monteith and
31 Unsworth, 1990). There can be substantial differences between scalars at z_s and z_{ref} ,

1 depending on the intensity of turbulent mixing, canopy roughness, solar radiation and
 2 atmospheric thermal stratification, especially over short vegetation. The temperature
 3 difference between z_s and z_{ref} has a particularly strong impact on the calculation of the
 4 stomatal compensation point (χ_s), which increases exponentially with temperature and doubles
 5 approximately with every additional 4 – 5 K (Flechard and Fowler, 2008; Personne et al.,
 6 2009), while for stomatal resistance the *vpd* stress factor f_e is best evaluated using relative
 7 humidity at z_s .

8 By default in this paper, model base runs used ambient temperature and relative humidity data
 9 as measured by meteorological stations at z_{ref} , a few m above vegetation, which is the closest
 10 approximation to the outputs of NWP models that are normally used as inputs to CTMs. The
 11 sensitivity of modelled fluxes to input T and RH was however tested in alternative model runs
 12 by using the potentials at z_s rather than z_{ref} as input to the deposition routines (see ‘Surface
 13 potentials’ model runs in Table A2 and Fig. A3). The z_s potentials were first computed from
 14 measured micrometeorological fluxes of both sensible (H) and latent heat (λE), following
 15 (e.g. Monteith and Unsworth, 1990):

$$16 \quad T(z_0') = T(z_{ref} - d) + \frac{H}{\rho C_p} (R_a(z_{ref} - d) + R_{b,heat}) \quad (A4)$$

17 and

$$18 \quad e(z_0') = e(z_{ref} - d) + \frac{pE}{\rho \varepsilon} (R_a(z_{ref} - d) + R_{b,H_2O}) \quad (A5)$$

19 where e is water vapour pressure, p is atmospheric pressure, E is the water vapour flux and ε
 20 is the ratio of the molecular weight of water to the mean molecular weight of dry air (= $18/29$), and the surface relative humidity is given by

$$22 \quad RH(z_0') = \frac{e(z_0')}{e_{sat}(T(z_0'))} \quad (A6)$$

23 where $e_{sat}(T)$ is the saturation water vapour pressure at T .

24

25 **A5 Canopy wetness**

26 Surface wetness controls non-stomatal resistances for soluble trace gases in all four models,
 27 particle rebound (EMEP-03, CDRY), and even stomatal ‘blocking’ (CDRY). Depending on

1 the process, chemical species and model considered, the wetness effect is either quantified by
2 a continuous function of RH (e.g. Eq. 4-7 in main paper), or qualified by a binary (or boolean)
3 indicator (wet =1 or true, dry =0 or false), with different surface resistances for the dry and
4 wet cases. In the IDEM model, both a wetness indicator and the RH function (Eq. (7) in main
5 paper) are used in turns for R_{ext} in the case of NH_3 . Canopy wetness was actually monitored at
6 a few sites of the NEU network (e.g. BE-Bra, CH-Oe1, NL-Spe, FR-Gri, UK-Amo) using
7 surrogate sensors (e.g. Model 237 Leaf Wetness Sensor, Campbell Scientific, Logan, UT), but
8 at most sites no measurements were available. For models in which a wetness boolean was
9 required, this needed to be estimated from ancillary environmental data.

10 Although modelled R_w , R_c and deposition flux are highly sensitive to wetness, canopy wetness
11 is difficult to predict reliably. This is compounded by the fact that, although a leaf surface
12 may appear dry to the eye or to surrogate wetness sensors, thin water films on microscopic
13 scales, as demonstrated by leaf wetness/conductivity clips (Burkhardt and Eiden, 1994), still
14 provide sinks for atmospheric gases, and thus a leaf surface might seldom be fully 'dry'.
15 Various RH thresholds have been used as proxies to determine canopy wetness; van Jaarsveld
16 (2004) determines a dry-wet switch point of 87% from surface wetness observations over
17 mixed forest, while for grassland Wichink Kruit et al. (2008, 2010) suggest a smaller
18 threshold at 71%. Both studies used ambient (z_{ref}) RH data, but it could be that the same
19 analyses using $RH(d+z_0')$ (see Section A4) might have yielded thresholds which were more
20 similar to each other, given the larger vertical RH gradients over grassland than over forest.
21 Some dry deposition models such as CDRY predict surface wetness semi-mechanistically and
22 distinguish dew from rain, based on precipitation data and on night-time cloud cover and u_*
23 for dew formation. Other models either treat wetness as an input variable provided e.g. by
24 NWP models, or use rule-of-thumb decisions based on ambient RH and precipitation. The
25 CBED model does not actually require any wetness indicator to quantify the non-stomatal
26 resistance for N_r gases.

27 Since the treatment of surface wetness prediction by the inferential models is rather crude and
28 model-dependent, and since surface wetness can be regarded as an input variable to the
29 models (rather than an output), it was preferred here to use a common wetness
30 parameterisation to feed all four models. This suppresses the inter-model variability that
31 would be caused by differing wetness schemes, and allows the model intercomparison to focus
32 on discrepancies in surface resistances and fluxes. The approach used to simulate common

1 wetness data was based on the mechanistic, big leaf, surface wetness energy balance (SWEB)
2 and canopy water budget model by Magarey et al. (2006). The SWEB model was originally
3 designed for grapes but model canopy characteristics (LAI, h_c) can be adjusted to deal with
4 other crops and vegetation types. Inputs to the model are T and RH at the canopy height,
5 precipitation, wind speed U measured at $z_{ref}-d$ above the canopy and R_n . The model is
6 dynamic, allowing surface water to accumulate up to the maximum storage capacity and to
7 evaporate depending on meteorological conditions. The model therefore requires continuous
8 input data, which were routinely available from meteorological stations at each site of the
9 network. For cases when key meteorological variables were missing to run SWEB, but
10 ambient RH was still available, canopy wetness was decided on the basis of a wet-dry
11 threshold of 81%, which corresponds to the deliquescence point of ammonium sulphate
12 (Flechard et al., 1999), although in reality deposited material on leaf surfaces is a mixture of
13 various salts and organic aerosols. For the CDRY model, which requires a distinction of dew-
14 from rain-wetted surfaces, the output of SWEB was split following CDRY decision rules.

15 The SWEB scheme (Magarey et al., 2006) was run systematically, regardless of the
16 inferential model used, but the wetness output was slightly model-dependent, due to the
17 differences in model LAI defaults. SWEB outputs are evaluated and compared in Fig. A2
18 with measured data at five sites of the network, which were equipped with surrogate leaf
19 wetness sensors (BE-Bra, CH-Oe1, FR-Gri, NL-Spe and UK-Amo). The data show the
20 frequency (or probability) of wetness occurrence as a function of the time of day; there are
21 strong seasonal variations that are driven by meteorological conditions, but for clarity the data
22 are here averaged over the whole year. All sites describe a strong diurnal cycle, with the
23 largest wetness frequency occurring toward late night/early morning, and the driest period
24 occurring in mid to late afternoon, consistent with night-time dewfall and daytime
25 evaporation of foliar wetness. The occurrence of rainfall may be considered to be randomly
26 distributed through the day, having thus no effect on the shape of the diurnal cycle, though
27 this is probably not be true for all sites.

28 Diurnal patterns and overall average wetness frequency are broadly consistent between
29 observations and modelled values. The “wettest” canopy was found at the cut grassland site
30 CH-Oe1 in both measurements and model simulations, with a night-time frequency of 90%
31 and a daytime minimum of 40%. By contrast the other sites showed a night-time wetness
32 probability of 50-80% and daytime minima of typically 20-30%. This was consistent with the

1 average annual rainfall being largest at CH-Oe1 (1200 mm). CH-Oe1 and FR-Gri had
2 frequent dewfall due to frequent night-time inversions in semi-continental climates, while BE-
3 Bra, NL-Spe and UK-AMo are windier sites in more oceanic conditions.

4 Differences between the various SWEB model runs at each site shown in Fig. A2 can
5 essentially be ascribed to the canopy-scale, leaf surface wetness storage capacity, and
6 consequently the different average leaf wetness durations, which are driven by different LAI
7 defaults from each model. For example at the arable site of FR-Gri, the model run using
8 EMEP-03 LAI defaults provided much smaller wetness frequencies than the other models,
9 which was consistent with a much smaller mean annual LAI in EMEP-03 (0.42) than in
10 CBED (1.35), CDRY (1.22) and IDEM (1.72). SWEB was also run for comparison using
11 estimates of LAI provided at each site. At BE-Bra, CH-Oe1 and FR-Gri this did not
12 significantly improve nor lessen SWEB performance, as compared with observations, but at
13 NL-Spe and UK-AMo there was a noticeable improvement for night-time conditions, where
14 observations apparently indicated much less frequent wetness occurrences than the canopy
15 water budget approach.

16 It should be noted that “observed” wetness measurements can have significant uncertainties,
17 and for example the small wetness values seen at night-time at the blanket bog site UK-AMo
18 seem somewhat surprising (one would expect almost 100% humidity near the surface at night
19 at such sites, which ought to cause wetness), but the representativity of, and the potential
20 errors in, wetness measurements made using generally only one surrogate sensor cannot be
21 assessed here and have been treated elsewhere (e.g. Wichink Kruit et al., 2008). The lack of
22 spatial or vertical resolution in such data and the different behaviours of wetness sensors and
23 leaves or needles with respect to water evaporation, condensation and to particle deposition,
24 which favours condensation at smaller *RH* (Burkhardt and Eiden, 1994), might explain some
25 of the discrepancies observed between measurements and models. On the other hand, any
26 surface wetness and energy balance approach will suffer shortcomings and may perform
27 better for certain types of vegetation than others. It is perhaps not surprising that the SWEB
28 model by Magarey et al. (2006), having been developed for agricultural vegetation, seemed to
29 give best results over grass at CH-Oe1 and cropland at FR-Gri, but in forests (BE-Bra, NL-
30 Spe in Fig. A2) big leaf limitations may be significant. More validation data are required, but
31 based on the few sites where a comparison was performed (Fig. A2), the SWEB approach
32 may be considered robust and valid for the purposes of inferential modelling.

1

2 **A6 References**

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- 16

1 Table A1. Selected references for the measurement sites

| Site Code | Site Name | Authors | Year | Journal | Vol. | Pages | |
|-----------|------------------|---|------|--|-------|-----------|--|
| BE-Bra | Brasschaat | Neiryneck et al. | 2005 | Atmos. Environ. | 39 | 5013-5024 | |
| BE-Vie | Vielsalm | Heinesch et al. | 2007 | Boundary Layer Meteorol. | 122 | 457-478 | |
| CH-Lae | Laegeren | Ruehr et al. | 2010 | Biogeochemistry | 98 | 153-170 | |
| CZ-BK1 | Bily Kriz | Sedlak et al. | 2010 | Agric. Forest Meteorol. | 150 | 736-744 | |
| DE-Hai | Hainich | Knohl et al. | 2003 | Agric. Forest Meteorol. | 118 | 151-167 | |
| DE-Hoe | Höglwald | Kreutzer et al. | 2009 | Plant Biol. | 11 | 643-649 | |
| DE-Tha | Tharandt | Grünwald and Bernhofer | 2007 | Tellus | 59B | 387-396 | |
| DE-Wet | Wetzstein | Anthoni et al. | 2004 | Glob. Change Biol. | 10 | 2005-2019 | |
| DK-Sor | Soroe | Pilegaard et al. | 2003 | Boreal Environ. Res. | 8 | 315-333 | |
| ES-ES1 | El Saler | Sanz et al. | 2002 | Environm. Pollution | 118 | 259-272 | |
| ES-LMa | Las Majadas | Casals et al. | 2009 | Soil Biol. Biochem. | 41 | 1915-1922 | |
| FI-Hyy | Hyytiälä | Vesala et al. | 2005 | Glob. Biogeochem. Cycles | 19 | n° GB2001 | |
| FI-Sod | Sodankylä | Thum et al. | 2008 | Biogeosciences | 5 | 1625-1639 | |
| FR-Fon | Fontainbleau | Davi et al. | 2006 | Agric. Forest Meteorol. | 139 | 269-287 | |
| FR-Hes | Hesse | Granier et al. | 2008 | Ann. For. Sci. | 64 | n° 704 | |
| FR-LBr | Le Bray | Rivalland et al. | 2005 | Ann. Geophysicae | 23 | 291-304 | |
| FR-Pue | Puechabon | Allard et al. | 2008 | Glob. Change Biol. | 14 | 714-725 | |
| IT-Col | Collelongo | Scartazza et al. | 2004 | Oecologia | 140 | 340-351 | |
| IT-Ren | Renon | Marcolla et al. | 2005 | Agric. Forest Meteorol. | 130 | 193-206 | |
| IT-Ro2 | Roccarespampani | Tedeschi et al. | 2006 | Glob. Change Biol. | 12 | 110-121 | |
| IT-SRo | San Rossore | Chiesi et al. | 2005 | Agric. Forest Meteorol. | 135 | 22-34 | |
| NL-Loo | Loobos | Dolman et al. | 2002 | Agric. Forest Meteorol. | 111 | 157-170 | |
| NL-Spe | Speulderbos | Erisman et al. | 1999 | Water, Air, and Soil Pollution | 109 | 237-262 | |
| PT-Esp | Espirra | Pereira et al. | 2007 | Biogeosciences | 4 | 791-802 | |
| PT-Mi1 | Mitra II (Evora) | Pereira et al. | 2007 | Biogeosciences | 4 | 791-802 | |
| RU-Fyo | Fyodorovskoye | Ramonet et al. | 2002 | Tellus | 54B | 713-734 | |
| SE-Nor | Norunda | Grelle et al. | 1999 | Agric. Forest Meteorol. | 98-99 | 563-578 | |
| SE-Sk2 | Skyttorp | Lindroth et al. | 2008 | Tellus | 60B | 129-142 | |
| UK-Gri | Griffin | Clement et al. | 2003 | Scottish Forestry | 57 | 5-10 | |
| DE-Meh | Mehrstedt | Don et al. | 2009 | Glob. Change Biol. | 15 | 1990-2002 | |
| ES-VDA | Vall d'Alinyà | Sebastià | 2007 | J. App. Ecology | 44 | 158-167 | |
| FI-Lom | Lompolojännkä | Aurela et al. | 2009 | Boreal Environ. Res. | 14 | 699-710 | |
| HU-Bug | Bugac | Nagy et al. | 2007 | Agric. Ecosys. Environ. | 121 | 21-29 | |
| IT-Amp | Amplero | Gavrichkova et al. | 2010 | Agric. Ecosys. Environ. | 136 | 87-96 | |
| IT-MBo | Monte Bondone | Vescovo and Gianelle | 2006 | Agric. Ecosys. Environ. | 115 | 141-149 | |
| NL-Hor | Horstermeer | Hendriks et al. | 2007 | Biogeosciences | 4 | 411-424 | |
| PL-wet | POLWET | | | | | | |
| UK-AMo | Auchencorth Moss | Flechard et al. | 1998 | Quart. J. Roy. Meteorol. Soc. | 124 | 733-757 | |
| CH-Oe1 | Oensingen | Flechard et al. | 2005 | Glob. Change Biol. | 11 | 2114-2127 | |
| DE-Gri | Grillenbug | Tittebrand et al. | 2009 | Theor. Appl. Climatol. | 98 | 171-186 | |
| DK-Lva | Rimi | Gryning et al. | 2009 | Boreal Environ. Res. | 14 | 204-212 | |
| FR-Lq2 | Laqueuille | Allard et al. | 2007 | Agric. Ecosys. Environ. | 121 | 47-58 | |
| IE-Ca2 | Carlow | Abdalla et al. | 2009 | Geoderma | 151 | 327-337 | |
| IE-Dri | Dripsey | Byrne et al. | 2005 | Agric. Forest Meteorol. | 135 | 82-92 | |
| NL-Ca1 | Cabauw | Jacobs et al. | 2007 | Biogeosciences | 4 | 803-816 | |
| UK-EBu | Easter Bush | Milford et al. | 2001 | Water Air Soil Pollution Focus | 1 | 167-176 | |
| BE-Lon | Lonze | Moureaux et al. | 2006 | Agric. Forest Meteorol. | 139 | 25-39 | |
| DE-Geb | Gebesee | Anthoni et al. | 2004 | Agric. Forest Meteorol. | 121 | 55-67 | |
| DE-Kli | Klingenberg | Tittebrand et al. | 2009 | Theor. Appl. Climatol. | 98 | 171-186 | |
| DK-Ris | Risbyholm | Houborg and Soegaard | 2004 | Remote Sensing Environ. | 93 | 150-167 | |
| FR-Gri | Grignon | Lamaud et al. | 2009 | Agric. Forest Meteorol. | 149 | 1385-1396 | |
| IT-BCi | Borgo Cioffi | Vitale et al. | 2009 | Acta Physiol. Plant. | 31 | 331-341 | |
| IT-Cas | Castellaro | Rossini et al. | 2010 | Agric. Forest Meteorol. | 150 | 1283-1296 | |
| UA-Pet | Petrodolinskoye | Medinets et al. | 2009 | Ecology of the cities and recreation zones, ISBN 978-966-8885-28-0 (in russian) | | 103-107 | |
| UK-ESa | East Saltoun | http://www.geos.ed.ac.uk/abs/research/micromet/Current/esaltoun/ | | | | | |

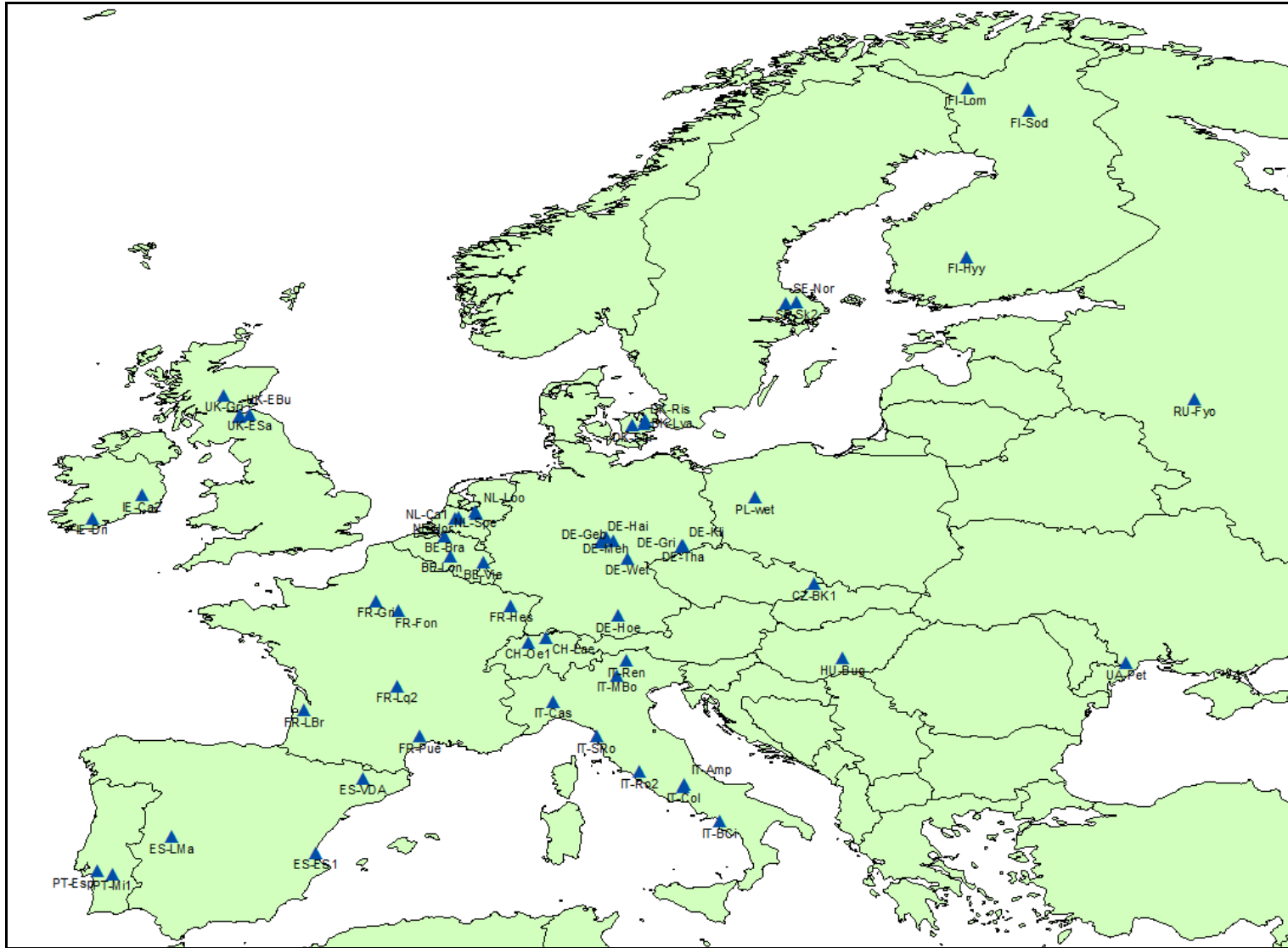
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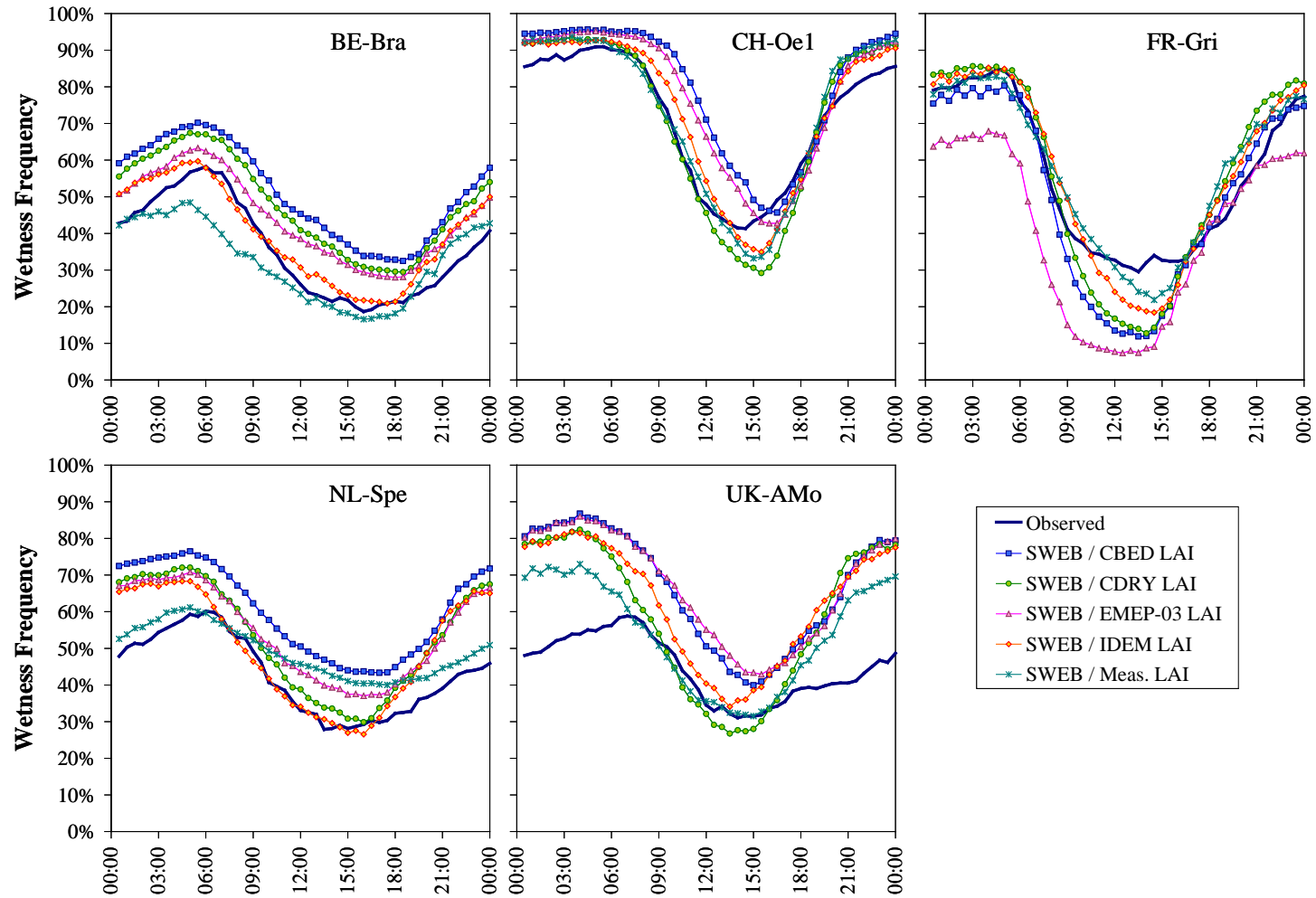
1 Table A2. Summary of input data used in model base runs and tested for sensitivity in
 2 alternative runs.

| Model runs | LAI | h_c | Temperature | Relative humidity | Stability corrections |
|--|---------------|---------------|-------------|-------------------|-----------------------|
| Base Runs | | | | | |
| <i>ModLAI / MeasHc</i> | Model default | Measured | Ambient | Ambient | Yes |
| Alternative Runs | | | | | |
| <i>ModLAI / ModHc</i> | Model default | Model default | Ambient | Ambient | Yes |
| <i>MeasLAI / MeasHc</i> | Measured | Measured | Ambient | Ambient | Yes |
| <i>Surface Potentials</i> | Model default | Measured | z_0' | z_0' | Yes |
| <i>No stability correction (CBED)</i> | Model default | Measured | Ambient | Ambient | No |

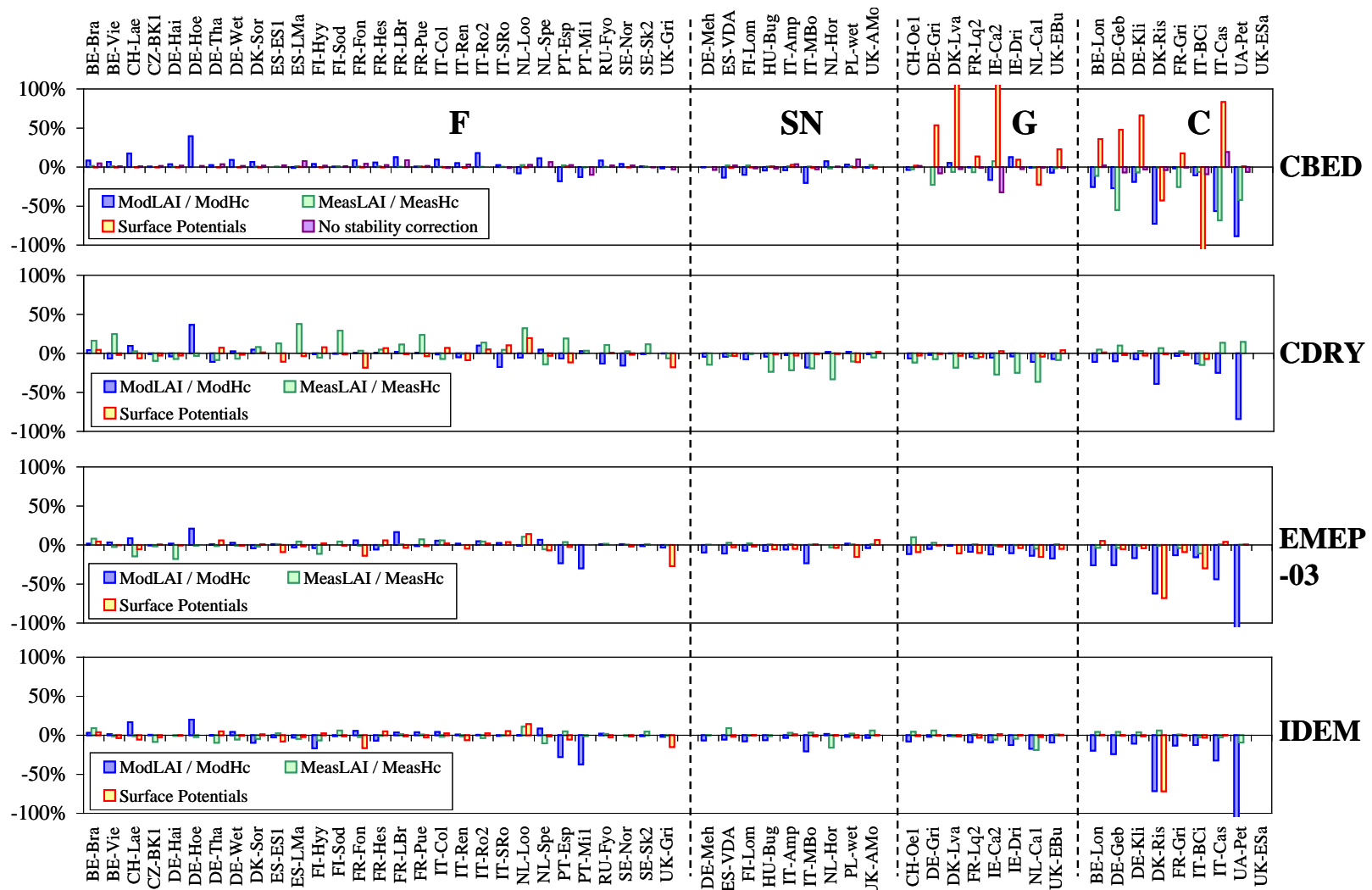


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Figure A1. Geographical locations of NITROEUROPE inferential network sampling sites.



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 2 Figure A2. Comparison of observed and modelled annual diurnal cycles of canopy wetness frequency at five sites of the inferential network.
 3 Modelled values were obtained by running the surface wetness energy balance model (SWEB, Magarey *et al.*, 2006), using as input either the
 4 model default LAI values for each of CBED, CDRY, EMEP-03 and IDEM, or using the measured LAI.
 5



1
2 Figure A3. Sensitivity of modelled annual N_r dry deposition fluxes to the choice of input data for LAI, h_c (measured vs model default), to the
3 use of temperature and relative humidity at the surface ($d+z_0'$) rather than ambient, and to the non-implementation of stability corrections
4 (CBED only). The percentage differences are expressed relative to the model base runs as detailed in Table A2, with a negative number
5 indicating larger dry deposition (or smaller emission), and a positive number indicating smaller dry deposition (larger emission).