Project Number 282910

ÉCLAIRE

Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems

Seventh Framework Programme

Theme: Environment

D8.3: Concentration and deposition maps and D17.2 Database of ammonia concentration and nitrogen deposition data for the regional and landscape domain

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Organisation name of lead contractor for this deliverable :
STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND (ECN)

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Dissemination Level		
PU	Public	☐
PP	Restricted to other programme participants (including the Commission Services)	☒
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Executive Summary

- The objective of Deliverable 8.3 is to produce maps of high spatial resolution pollutant concentration (NH_3, NO_x and O_3) and nitrogen deposition in order to analyse local scale interactions between the pollutant sources and sinks that cannot be resolved by larger-scale models (e.g. the EMEP chemical transport model).
- The achievement of this objective, not only results in the completion of Deliverable 8.3 but also completes Deliverable 17.2 (Database of ammonia concentration and nitrogen deposition data for the regional and landscape domain) since the latter deliverable is basically the transfer of data from WP8 to WP17.
- The objective at the regional scale was achieved by applying the EMEP4UK chemical transport model at spatial resolutions of 5×5 km^2 and 1×1 km^2 for sub-domains of the EMEP grid and by applying local-scale atmospheric dispersion models (for NH_3 concentrations and N deposition only) to landscapes in Scotland and the Netherlands at a resolution of 25×25 m^2 and 50×50 m^2, respectively.
- Hourly pollutant (NH_3, NO_x and O_3) concentrations and dry and wet deposition rates (reduced and oxidised nitrogen) were simulated by EMEP4UK for the target year 2008 for the three domains (UK and NL at 5×5 km^2 and Scotland and NL at 1×1 km^2).
- At the local scale, for the Scottish landscape (Burnsmuir), the local area dispersion and deposition (LADD) model was used to simulate annual NH_3 concentrations and dry deposition rates for the target year 2008. The modelled dry deposition estimates were combined with data on wet deposition of reduced N and the dry and wet deposition of oxidised N calculated using the UK FRAME model for 2008 at a 1×1 km^2 resolution, to produce an estimate of total nitrogen deposition.
- For the Dutch landscape, the integrated modelling system INITIATOR-OPS was used to simulate annual NH_3 concentrations and dry deposition rates. Total N was calculated by adding NO_x deposition and the background NH_3 deposition from sources outside the NFW, including the contribution from non-agricultural sources.

2. Objectives:

The objective of this deliverable is to produce maps of high spatial resolution pollutant concentration (NH_3, NO_x, O_3) and nitrogen deposition to analyse local scale interactions between pollutant sources and sinks that cannot be resolved by larger-scale models (e.g. the EMEP chemical transport model). These objectives were achieved by applying the EMEP4UK chemical transport model (Vieno et. al., 2010) at spatial resolutions of 5 × 5 km^2 and 1 × 1 km^2 for nested sub-domains of the EMEP grid and by applying local-scale atmospheric dispersion models (for NH_3 concentrations and N deposition only) to the study landscapes in Scotland and the Netherlands at a resolution of 25 × 25 m^2 and 50 × 50 m^2, respectively.

3. Activities:

3.1. Specification of modelling domains

Domains were chosen to cover two contrasting European case-study areas; Scotland and the Netherlands. A nested domain was designed that consists of one European domain (50 × 50 km^2 horizontal resolution) a second domain (5 × 5 km^2 horizontal resolution) including both countries and two sub-domains (1 × 1 km^2 horizontal resolution) that covered each country separately (Figure 1). Within each sub-domain a study landscape was chosen for the local-scale dispersion modelling (50 × 50 m^2 or 25 × 25 m^2, depending on data availability). The landscape domains are referred to as the Burnsmuir landscape in Scotland and the Noordelijke Friese Wouden (NFW) in the Netherlands.

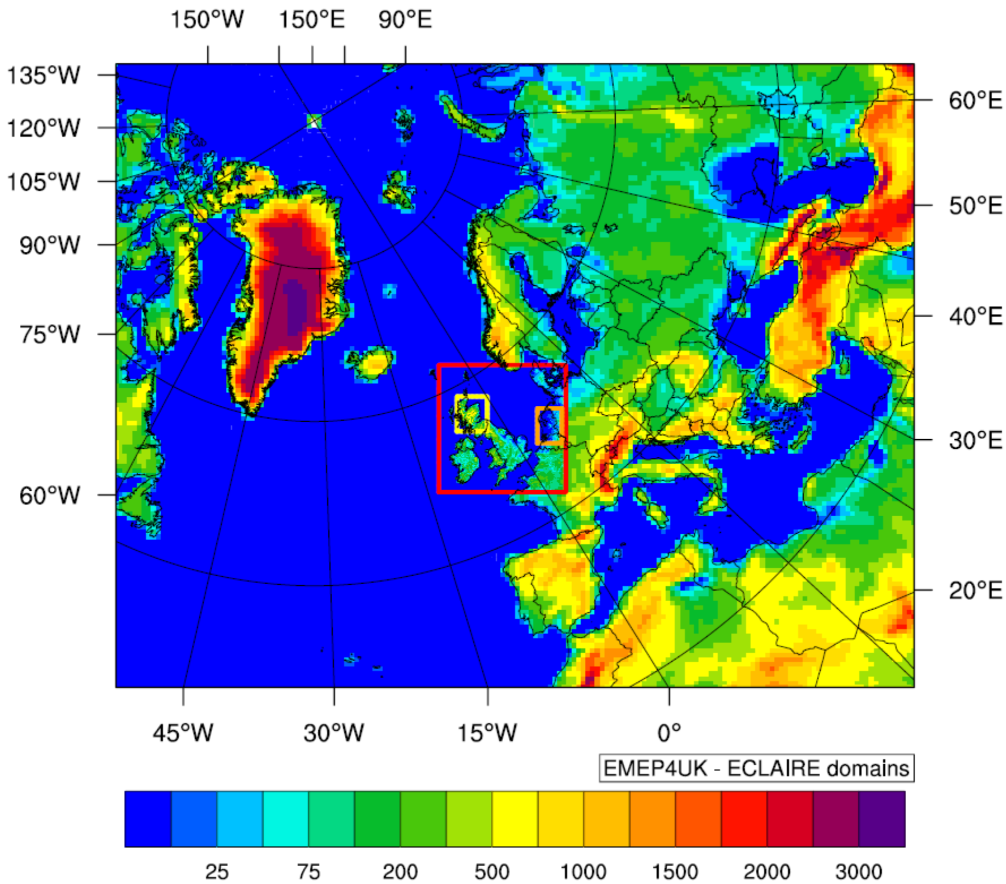

Figure 1: Elevation map showing the extent of the domain used to generate the meteorological fields (map extent), the 5 × 5 km^2 domain covering the UK and the Netherlands (red box) and the 1 × 1 km^2 domains covering the Netherlands (orange box) and Scotland (yellow box) for the EMEP4UK simulations.

3.2. Model set-up and application

EMEP4UK simulations

Various sources of pollutant emission data were used for the simulations, as described in Table 1. The default EMEP MSc-W model rv4.3 land cover data were used for the simulations and the weather research and forecast model (WRF) version 3.1 l was used to generate the meteorological fields. The WRF model included data assimilation (Newtonian nudging) of the numerical weather prediction (NWP) model meteorological reanalysis from the US National Center for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) Global Forecast System (GFS) at 1 resolution, every 6 hours. The large European domain at 50 × 50 km^2 provides the chemical boundary conditions for the study areas. The EMEP MSC-W land cover has been updated to cover the whole area included in this study with a common datasets at 1 × 1 km^2 resolution. Some of the emissions for the Netherlands have been provided at 1 × 1 km^2 and it is anticipated that the simulations will be re-run with higher resolution input data (e.g. emissions, land cover etc.), as they become available throughout the project.

Table 1: Summary of the emission data and their geographical coverage

	Model resolution	
Geographical area	**1 × 1 km^2**	**5 × 5 km^2**
The Netherlands	Extrapolated from the 50x 50 km^2 EMEP emissions.	Extrapolated from the 50 × 50 km^2 EMEP emissions.
United Kingdom	1 × 1 km^2 NAEI emissions	1 × 1 km^2 NAEI emissions
EU (excluding NL and UK)	50 × 50 km^2 EMEP emissions	50 × 50 km^2 EMEP emissions

Hourly pollutant (NH_3, NO_x and O_3) concentrations and dry and wet deposition rates (reduced and oxidised nitrogen) were simulated for the target year 2008 for the three domains (UK plus NL at 5 × 5 km^2 and Scotland and NL at 1 × 1 km^2). Mean annual concentration and total annual deposition maps were then produced from the hourly model output data.

Landscape simulations

For the Scottish landscape (Burnsmuir), the Local Area Dispersion and Deposition (LADD) model was used to simulate annual NH_3 concentrations and dry deposition rates, as described by Vogt et al. (2013). Ammonia emission data were calculated by applying a combination of UK average emission factors (as used in the national inventory) and specific emission factors to account for agricultural practice/mitigation measures applied, as required, to detailed agricultural activity data obtained through farm visits and surveys. Land cover/use data were obtained through aerial photographs of the landscape supplemented by information from farm visits, and wind statistics were calculated from data collected for 30-min-intervals during 2008 at a continuous measurement site near the centre of the study area. LADD was applied for the target year 2008 at 25 × 25 m^2 resolution over an area of 7 × 7 km^2, with the model domain extended by 500 m on all sides to limit possible edge effects. Annual average NH_3 concentrations at 1.5 m height above ground level and total dry deposition rates were simulated. The model output was calibrated to eliminate systematic model bias using mean annual NH_3 concentration measurements made at 31 locations within the landscape. The calibrated modelled dry deposition estimates were then combined with the less spatially variable wet deposition of reduced N and the dry and wet deposition of oxidised N as calculated using the UK FRAME model run for 2008 at a 1 × 1 km^2 resolution (Dore et al., 2012).

For the Dutch landscape (NFW), the integrated modelling system INITIATOR-OPS was used to simulate annual NH_3 emissions, NH_3 concentrations and dry deposition rates, as described by Kros et al. (2011). Mean annual NH_3 emissions at a spatial resolution of 50 × 50 m^2 were calculated with the INITIATOR model from landscape activity data for the year 2007. These emission data were then used as input to the OPS atmospheric dispersion model in order to simulate annual NH_3 concentrations and dry deposition rates at a spatial resolution of 50 × 50 m^2 for 2007. Total N was calculated by adding total NO_x deposition and the background NH_3 deposition from sources outside the NFW, including the contribution from non-agricultural sources and the wet deposition inside the NFW. These deposition fluxes from other sources of N were delivered by the Netherlands Environmental Assessment Agency at a resolution of 5 × 5 km^2, based on national OPS model calculations and using emission data for the year 2006 (Kros et al., 2011).

4. Results:

EMEP4UK simulations

Figure 2 shows some example maps from the EMEP4UK simulations with the different domains superimposed.

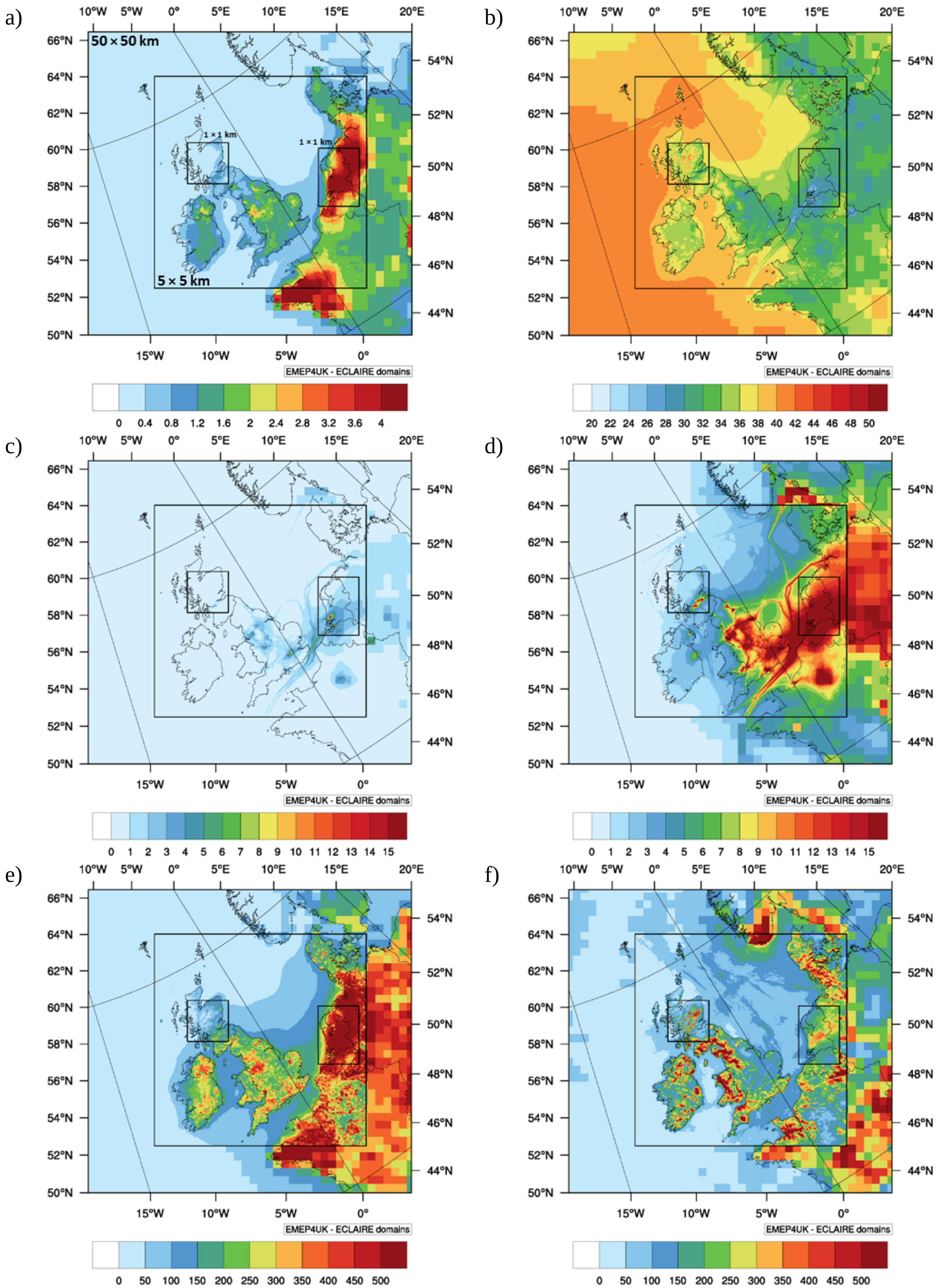

Figure 2: EMEP4UK simulation output of mean annual concentrations of a) NH_3 (µg m^{-3}), b) O_3 (ppb), c) NO (µg m^{-3}), d) NO_2 (µg m^{-3}), and annual e) dry and f) wet deposition of reduced nitrogen (mg N m^{-2} yr^{-1}). The black boxes show the extents of the nested domains.

Landscape simulations

Figures 3 and 4 show calibrated annual mean NH_3 concentration and total nitrogen deposition, respectively, for the Scottish landscape.

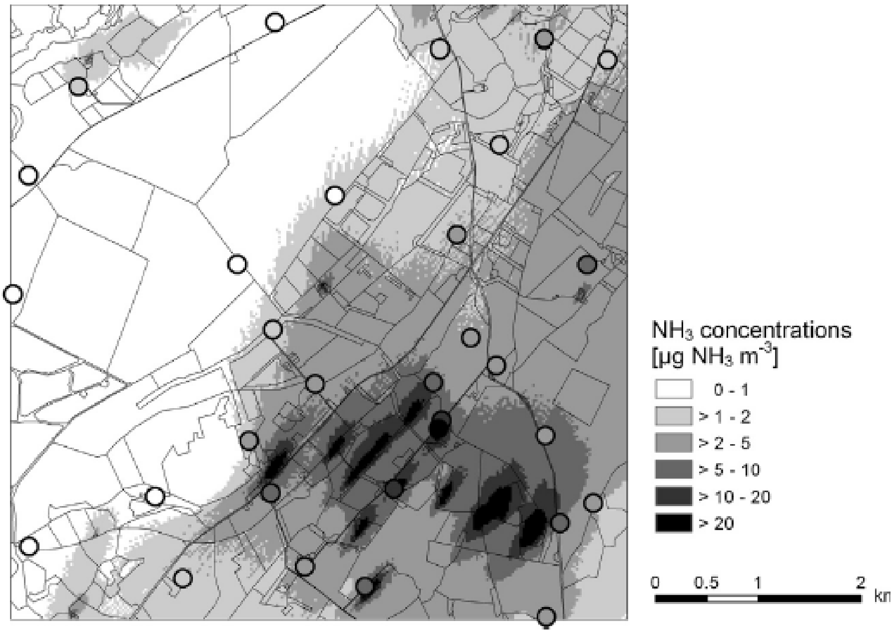

Figure 3: Calibrated modelled (background colours) and measured (circles) NH_3 concentrations within the landscape (taken from Vogt et al., 2013).

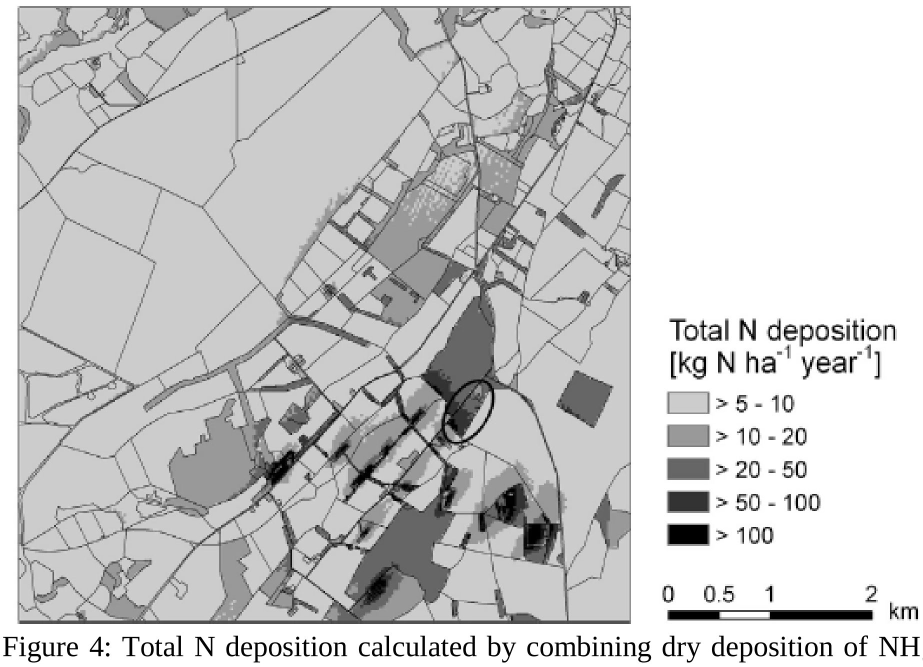

Figure 4: Total N deposition calculated by combining dry deposition of NH_3 simulated by LADD (calibrated) with the remaining components of N deposition from FRAME. The circled area shows a patch of woodland analysed in more detail in Vogt et al., (2013).

Figure 5 shows the modelled annual total N deposition for the Dutch landscape.

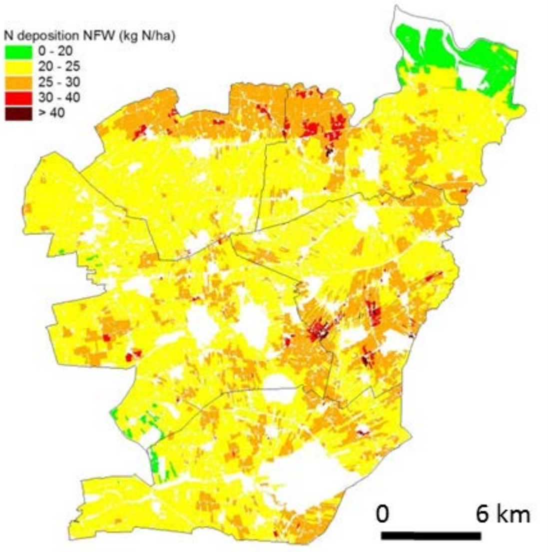

Figure 5: Total N deposition in the NFW landscape in 2007 simulated with the INITIATOR-OPS modelling system.

Data Management

EMEP4UK model output (annual concentration and deposition maps) will be submitted to the ÉCLAIRE JRC database (AFOLU). Landscape concentration and deposition data will also be submitted to the AFOLU database, unless restricted by confidentiality conditions.

5. Milestones achieved:

- MS36: Concentration/Deposition maps (e.g. NH_3 on 50 × 50 km^2, 5 × 5 km^2, 1 × 1 km^2, up to 50 × 50 m^2 resolution) available for further use in ÉCLAIRE (e.g. WP17)
- MS74: Database of atmospheric concentrations and deposition (from WP8) for the present period (e.g. 2010) at the regional and landscape scales complete

6. Deviations and reasons:

The high spatial resolution landscape simulations were originally planned to be carried out using the updated NitroScape model. However, delays in the development of NitroScape (WP8) have required the use of contingency plans to produce the necessary concentration and deposition maps using other modelling approaches. Following discussions during a teleconference held in July 2013 and at the 3rd General Assembly in October 2013, it was decided that the best approach would be to take advantage of previous high resolution modelling carried out for the two landscapes. It was generally felt that it was important to use the best possible approach to simulate the concentrations and deposition rates for each landscape (i.e. the LADD model for the Scottish landscape and the INITIATOR-OPS model for the Dutch landscape), even though different modelling tools were applied to the two landscapes. It is anticipated that the simulations carried out for this deliverable will be re-run when higher resolution input data become available, and for the landscape scale modelling when the NitroScape model is fully developed and tested.

7. Publications:

The simulations for the Scottish and Dutch landscape have previously been published in Vogt et al. (2013) and Kros et al. (2011), respectively.

8. Meetings:

The work plan for completing this deliverable has been developed through teleconferences involving participants of WP8 and WP17 in June 2012 and July 2013 and during the sessions held at the annual project meetings.

9. List of Documents/Annexes:

None

10. References

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Kros, J., K.F.A Frumeau, A. Hensen and W. de Vries, 2011. Integrated analysis of the effects of agricultural management on environmental quality at landscape scale. Environmental Pollution 159: 3170–3181.

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