Expert Workshop under the UNECE Convention on Long-range Transboundary Air Pollution

Atmospheric Ammonia:
Detecting emission changes and environmental impacts

4-6 December 2006, Edinburgh, Scotland

Workgroup 1: Critical Levels for NH_3

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History and Background

- Previous estimates of NH_3 Critical Levels
  - Workshops Bad Harzburg 1988, Egham 1992, Gothenburg 1992, Bern 2000,…
    CLEs based on Van der Eerden et al. 1991:
    hour: 3300 / day: 270 / month: 23 / year 8 µg m^{-3}
- New discussion/insights since 1991/1994 CLEs:
  - CLEs and CLOs may not be converted into each other (though this should be possible via including deposition velocity) because of several reasons
    - target (species vs. ecosystems)
    - duration (short-term vs. long-term)
    - CLOs: no differentiation between different reactive N species
    - …
  - At present annual CLE, N deposition from NH_3 alone would exceed CLO for N deposition by far
  - Data base for CLEs nearly exclusively from the Netherlands

History and Background

- Base line across most of Europe does not represent pristine background situations: see ecosystem N loss (data from Van Breemen 2002, and Perakis & Hedin 2002)

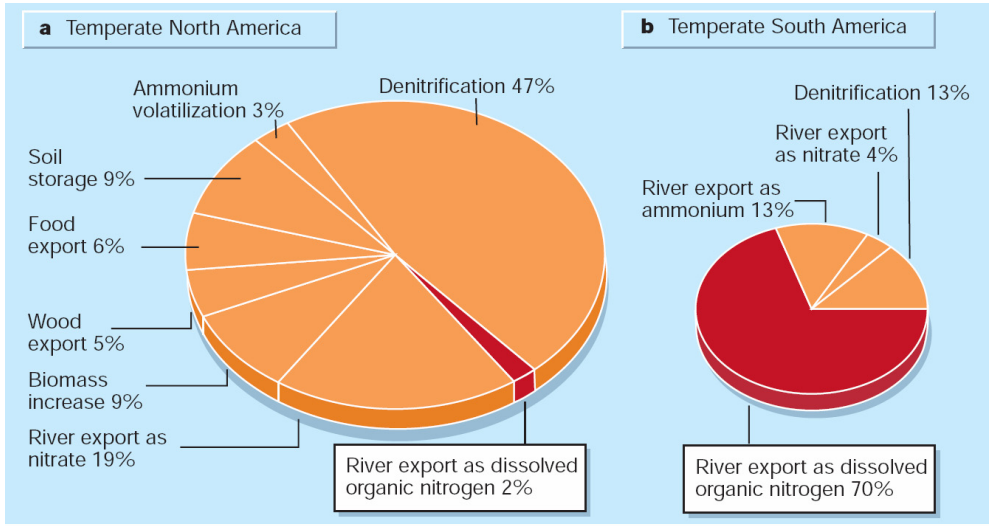


Figure 1 **Forms of nitrogen storage in, or export from, two ecosystems in North and South America.** a, **Data for a largely forested region in the northeastern United States[3]. Here, nitrogen is found to be exported primarily in inorganic form.** b, **The pristine forest area in Argentina and Chile studied by Perakis and Hedin[1]. Most notably, most of the nitrogen exported in streams and rivers here is in organic, rather than inorganic, form. The two regions have about the same annual precipitation of 1,100 mm. But the total 'sinks' in** a **are almost ten times those in** b **(about 36.4 kg ha^{-1} yr^{-1} compared with 0.4 kg ha^{-1} yr^{-1}). The difference is due to a much greater input of nitrogen through human agency in the United States. As well as nitrogen export in water, and denitrification, sinks in the forested northeastern United States include export in agricultural and forestry products (food and wood); volatilization of ammonia from manure and fertilizers; storage in growing forests (biomass increase); and accumulation in soils, mainly in forests and in suburban land. The budget in** b **was estimated from the new data[1], with the assumptions that the nitrogen in soils and biomass is in steady state, and that the ratio of denitrification to nitrate export is the same in both regions.**

History and Background

- New insights since 1991/1994 CLEs (cont'd):
  - Both species and ecosystems may show acclimation
  - Responses of higher plant species are now being detected at much lower concentrations than the current 1 year CLE
  - Epiphytic lichens and bryophytes are affected at [NH_3] much lower than the current CLE
  - …
- CLE for ammonia needs revision !

Basic questions to WG 1

- Defining approaches for NH_3 critical levels
  - CLEs by broad habitat or by plant species/species group?
  - If by habitat: are there indicators of loss of ecosystem integrity?
  - Safety factor to be included?
  - CLE = NOEL or smaller than NOEL?
  - Can empirical and modelling approaches be combined?
- Interpretation of effects
  - What responses to be considered for CLE?
  - Are these "direct" effects?
  - Importance of background [NH_3] for CLE definition

Basic questions to WG 1

- Evaluation of new data
  - Is there new evidence that leads to changing the existing values of critical levels for short term exposure (i.e. 1 hour, 1 day, 1 month, 1 year)?
  - What would be the critical levels for long-term exposure to atmospheric ammonia over a period of 20-30 years, comparable with the protection period for empirical critical loads? (i.e. the mean NH_3 concentration that is sustainable in the long term)
  - Is there sufficient data/understanding to specify regional differences in CLE values for NH_3?
  - …

Basic questions for WG 1

- Key outputs
  - Tabulate the NH_3 critical level values for different receptors (e.g. habitats and/or species) and for different time periods (e.g. daily, monthly, annual, long term (20-30 yrs)
  - List the main indicators of effects and source of evidence (e.g. laboratory, field transects, regional studies etc) and give an indication of uncertainty

Answers formulated by WG 1

- First, after having one afternoon of intenisive discussion, we reformulated the questions a little (keeping in mind the expectations)
- The very basic question:
  Do we want CLEs (given the existing CLOs that appear more diverse, more protective etc. than the current CLEs)

  → **YES!**

- because:
  - CLEs and CLOs serve for different purposes
  - CLEs are important for nature preservation at more local scale,
  - are used in air quality regulations
  - [NH_3] can be measured more easily than N deposition
  - ….

Answers formulated by WG 1

- Basic question #2: what to assess (which is the response for CLEs to be based on)

Shifts in species composition

- Some outcomes from the group discussion:
  - shift in species composition is regarded as an adverse effect
  - covers the aspect of impacts on biodiversity
  - covers the long-term aspect of CLE since shifts in species composition take time
  - other assessments may be useful (such as %N in tissue or soluble NH_4^+) but still require 'translation' into adverse effects
  - …

Answers formulated by WG 1

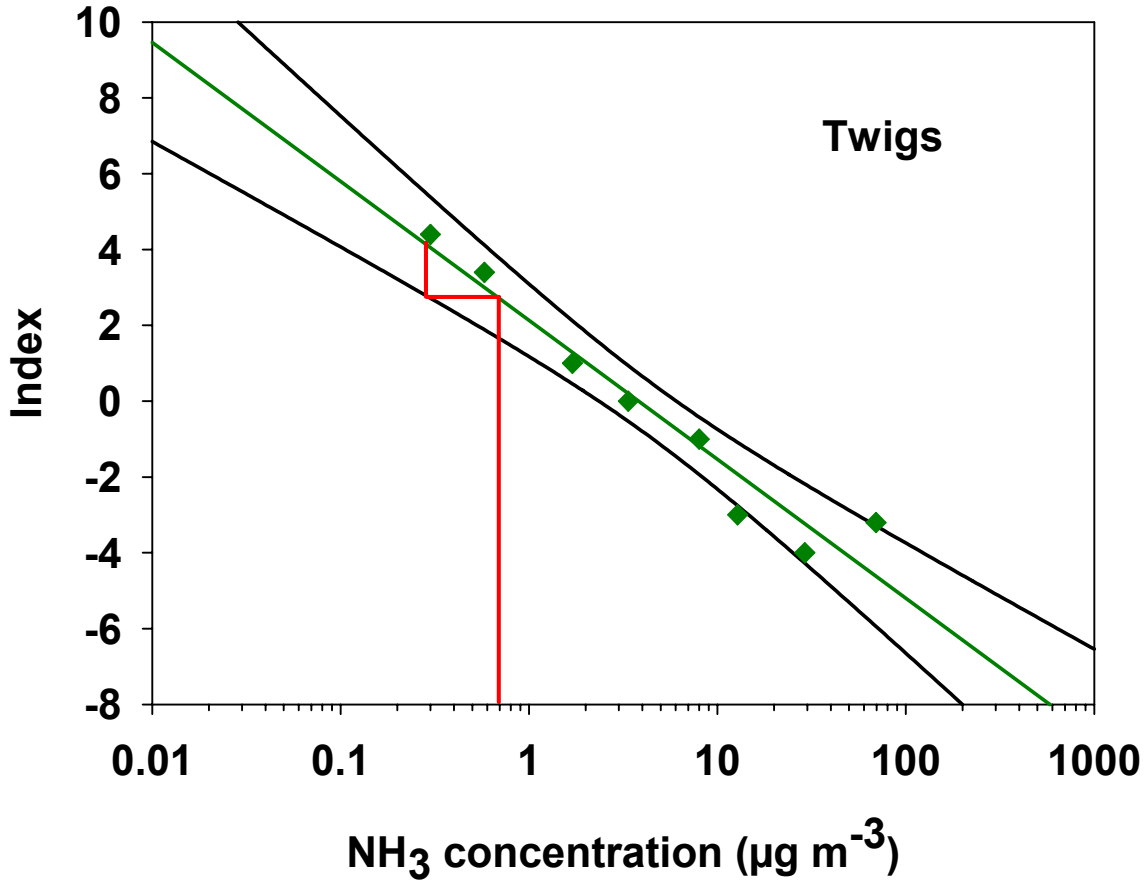
- Basic question #3: how to assess (empirical? model? which kind of statistics? safety factor?)

Empirical approach

- This is because:
  - we found enough new sound empirical data to build on
  - we still lack a mechanistic understanding translated into a modelling approach that could serve to derive CLEs (though the physiological understanding is quite advanced)
  - …

Answers formulated by WG 1

- How to derive CLEs from the empirical data?



Lichen acidophyte-nitrophyte index downwind of poultry farm, S.E. Scotland

Answers formulated by WG 1

- After scanning through all the information that was on the table, we came up with some new long-term CLEs (a moment, please)

- However, we did **not** manage to:
  - derive new CLEs for short-term (monthly, daily, hourly)
  - cover any desired type of habitat/ecosystem / region / …

  (simply because lack of information)

Answers formulated by WG 1

- The new CLEs (1)
- Target:
  epiphytic lichen communities and bryophytes;
  ecosystems with significant abundance of ground dwelling lichens and/or bryophytes
- Likely system response:
  shifts in species composition,
  potential for species extinctions,
  effects on ecosystem matter cycling

- Long-term CLE:

  1 µg m^{-3} NH_3

- Definition of long-term: we believe that this CLE would be protective over a period of several years.
  However, there is no warranty that it would protective for periods longer than 20-30 years.

Answers formulated by WG 1

- The new CLEs (1)
- Evidence for this new CLE of 1 µg m^{-3} NH_3:
  - Lichen community studies from case study in UK
  - Lichen community studies from all over UK
  - Whim bog experiment
  - Lichen community study from Switzerland
  - Lichen community study from Portugal
  - Lichen community study from Italy
  - …

Answers formulated by WG 1

- The new CLEs (2)
- Target:
  heathland, ground flora in forests
- Likely system response:
  shifts in species composition,
  potential for species extinctions

- Long-term CLE:

  3 µg m^{-3} NH_3 as best guess

  with an uncertainty range of 2.0 – 4.0 µg m^{-3} NH_3

- Definition of long-term: as given above
- We want to have this CLE also for any other vegetation type not dominated by lichens/bryophytes

Answers formulated by WG 1

- The new CLEs (2)
- Evidence for this new best guess for an CLE of 3 µg m^{-3} NH_3:
  - Findings from Whim bog experiment (bog and heather systems)
  - Ground flora of forests studied in UK
  - … (there is less data available than on epiphytic lichen communities and on bryophytes)

Recommendations

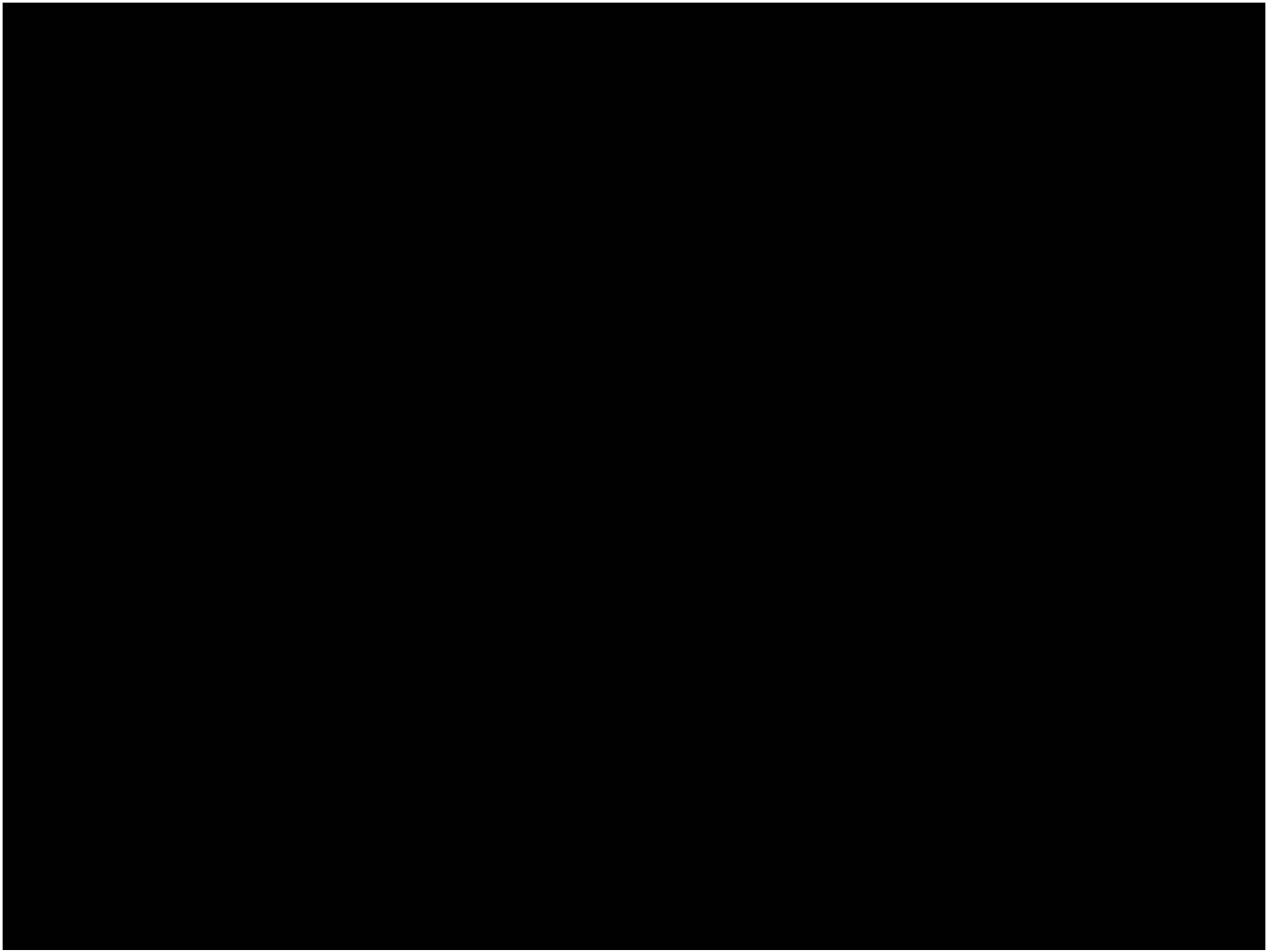
What we should do:

- Dig for other relevant data from other regions that is already existing
- Calibration – linking intrinsic measurements with shifts in species composition
- Standardise methodologies on
  - lichen mapping
  - vegetation mapping
  - nitrogen indication methodology (nitrophilic/nitrophobic)
- Find mechanistic explanation (physiology based, including compensation point) to create models as predictive tools for systems where empirical evidence is lacking
- Define priority habitats for future work (low N status ecosystems, southern European (mediterranean) systems, continental Eastern Europe ecosystems (because lack of data/knowledge)

Recommendations

What we need:

- Scientific basis for necessity of monthly CLE (→ peak concentrations after changing policy and timing of manure application)
- Understanding of seasonal effects
- Understanding of intermittant vs. constant exposure at same average [NH_3]
- Assessment and understanding of accelerated growth cycles
- Assessment and understanding of accelerated system N cycling
- Long-term measurements of ambient NH_3
- Experimental data (Whim bog study as a "prototype")



A German example – Eberswalde-Finow

(Photographs: A. Fangmeier, from surroundings of a pig "factory" at Eberswalde-Finow with 170,000 pigs. Farm was closed in 1989, pictures were taken September 1991.
Last picture: Schorfheide-Chorin (biosphere reservate, 50 km distance from Eberswalde)