EVALUATION OF BACKWARD LAGRANGIAN STOCHASTIC DISPERSION MODELLING FOR NH₃: INCLUDING A DRY DEPOSITION ALGORITHM

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Backward Lagrangian Stochastic Dispersion Modelling

- Backward Lagrangian stochastic (bLS) dispersion model by Flesch et al. (2004)
- Simple surface layer model for distances < 1000 m
- Vertical wind profile and wind statistics based on Monin-Obukhov Similarity Theory (MOST)
- interval lengths between 10 and 120 min
- calculation of the ratio between the average concentration $C$ at sensor $M$ and the emission rate $Q$ from a surface area source
- calculation of an ensemble of (back-) trajectories released at sensor (typically >50'000 trajectories)
Why including a dry deposition algorithm?

- Ammonia (NH$_3$) absorbs well on surfaces (especially wet surfaces)
- bLS model does not include dry deposition

source: Flesch et al. (2004)
Release Experiment on November 17th 2016

- 3 releases (each approx. 1.5h) with 5% NH\textsubscript{3} in 95% CH\textsubscript{4}
  - 09h15 to 10h45
  - 11h45 to 13h10
  - 13h50 to 15h15
- Parallel measurements of both, NH\textsubscript{3} and CH\textsubscript{4}
- CH\textsubscript{4} used as an inert tracer
- Line-integrated measurement of NH\textsubscript{3} using miniDOAS (MD) instruments (Sintermann et al 2016)
- Line-integrated measurement of CH\textsubscript{4} using GasFinder (GF) instruments (Boreal Laser Inc, Edmonton, Alberta, Canada)
- Path lengths: 40 m (1-way)
Release Experiment – Artificial Source and Method

- Artificial source with 36 orifices

- Source diameter $\approx 20$ m ($\sim 3$ m between individual orifices)

- Constant mass flow rate at 20 to 25 nL/min

- Release in/on grass canopy
Recovery Rates of CH4 and NH3

- Recovery rates = measured C / modelled C
- CH4 recovery rates are close to 100%
- NH3 recovery rates are systematically lower
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- CH4 recovery rates are close to 100%
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- NH3 shows similar trend as CH4 towards the end of the day, but differs at the beginning
- Small differences amongst different measurement locations
Measured Factors that Influence Deposition
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- Surface temperature increases -> Deposition decreases
Measured Factors that Influence Deposition

- Surface temperature increases -> Deposition decreases
- Leaf wetness decreases -> Deposition decreases
Dry Deposition Post-Processing - Principles

- modelling deposition at each touchdown by a deposition velocity \( (v_{dep}) \):
  \[ F_{dep} = -C_{traj} \times v_{dep} \]
- Assumptions:
  - inside source: \( F_{dep} = 0 \)
  - outside source:
    - equilibrium between surface & ambient air
    - Compensation point enhancement can be neglected
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- approximate $v_{dep}$ by a resistances approach:
  - $v_{dep} = \frac{1}{R_b + R_c}$
  - $R_b$: pseudo-laminar boundary layer resistance
  - $R_c$: (overall) canopy resistance

Source: Nemitz et al. (2001)
Deposition Post-Processing – Model Input

- Post-processing with a (even more) simplified approach assuming that $R_c$ is dominated by the cuticular Resistance ($R_w$)
- Flechard et al. (2010), grassland site in Switzerland: $R_w = R_{w,\text{min}} \cdot \exp(a \cdot (RH - 100)) \cdot \exp(0.15 \cdot T)$, with $R_{w,\text{min}} = 10$ s/m
Modelled Dry Deposition Effect

- Significant reduction in NH$_3$ due to modelled deposition
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- Significant reduction in $\text{NH}_3$ due to modelled deposition
- Similar trend in both, the modelled deposition effect and the measured ratio between $\text{NH}_3$ and $\text{CH}_4$
- Trend near – far – far.low is less pronounced/not existent in $\text{NH}_3/\text{CH}_4$ ratio
Conclusion & Outlook

- Recovery rates around 100% for CH$_4$ measurements
- Systematically lower NH$_3$ recovery rates between 60% and 100%
- Deposition post-processing compares good with lower NH$_3$ recovery rates
- Further results from 6 experiments with a gas mixture of 5% NH$_3$ in 95% CH$_4$ during March/April 2017 will be evaluated
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Thank you for your attention!
References


