Long-term measurements of NH_3 and SO_2 fluxes at three contrasting grasslands by time averaged gradients (TAG)

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INTRODUCTION & METHOD

The ***TAG*** (Time Averaged Gradient) is a low-cost system to measure long-term (weekly to monthly) deposition fluxes of trace gases between the surface and the atmosphere using the flux-gradient method by *conditional sampling*. Over daily periods, atmospheric conditions can range from high stability, where the vertical gradients of ambient concentration are enhanced due to very small diffusivity, to highly unstable conditions, in which concentration gradients are small due to the intense turbulent activity of the surface layer. The large vertical gradients generated by high stability would bias the estimate of the actual flux: to avoid this, the TAG system samples *conditionally*, within a carefully defined range of stability (see *Famulari et al., 2007*). In Fig.1 is shown a diagram of the TAG system applied to measure long-term dry net exchange fluxes of NH3 and SO2 to three contrasting temperate grasslands in the UK described below (see Fig.2).

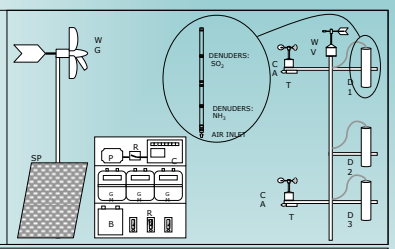


Fig.1. Diagram of TAG:: **CA**: cup anemometer **T**: temperature sensor **WV**: wind vane **GM**: gas flow meters **WG**: wind power generator **SP**: solar panels **B**: battery **P**: air pump **CL**: Campbell 21X data logger **D1,2,3**: denuder trains **RM**: rotameters **R**: relay.

THE SITES

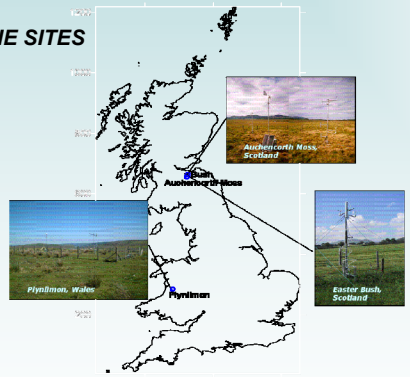


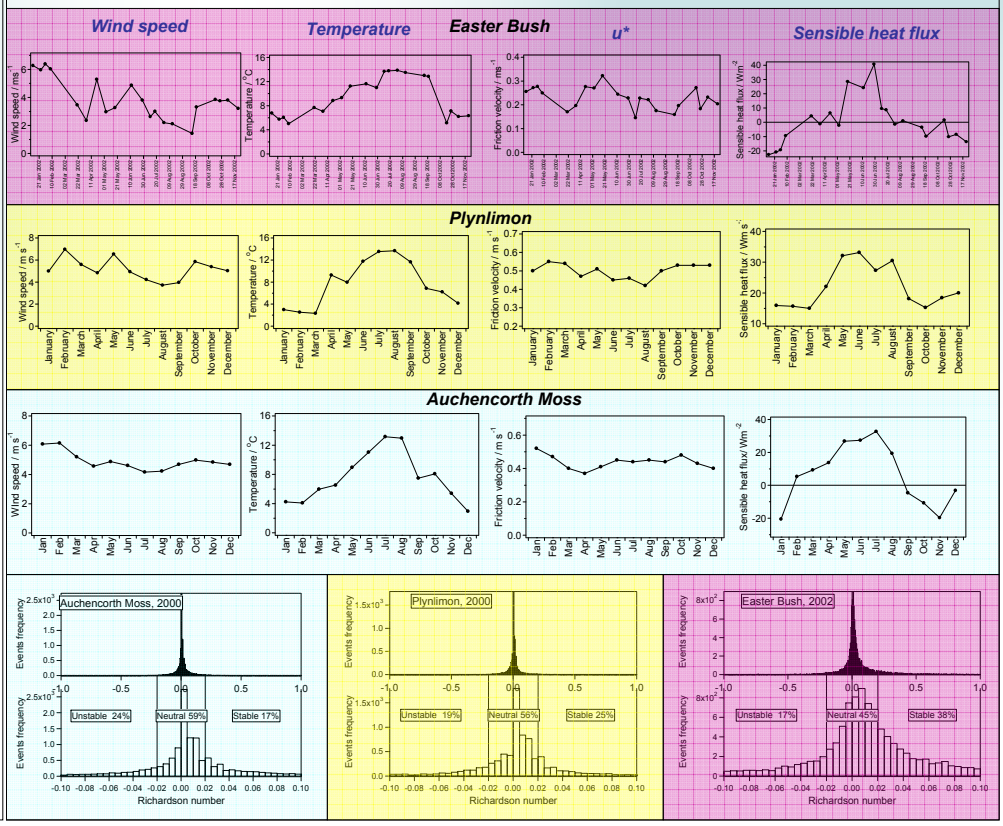
Fig.2 *Map of the UK, showing the locations of the 3 sites.*

Auchencorth Moss: blanket bog over a surface of 1000 ha, located in Midlothian (NT221562, lat. 55º47'30'', long. 3º14'20'', alt. 270m ASL). The moorland vegetation comprises a succession of hummocks and hollows (vertical range 60 cm) including grasses, sedges, rushes, Sphagnum, and other bryophyte species. The site is used for sheep grazing at a very low density of about 0.1 to 1 sheep/ha. Low intensity agricultural activities in the vicinity. Flux monitoring of NH_3 and SO_2 during 1999-2003.

Plynlimon located in the Cambrian Mountains at SN 806853 (lat. 52º27'26'', long. 3º47'46'', alt. 500m). The site is quite exposed, windy and rainy. The land cover is a mixture of dwarf-shrub heath, blanket bog and unimproved acid grassland: it is used for sheep grazing almost all year round. Surrounding the area monitored by the TAG system there are farming activities at a distance of 1 to 1.5 miles. Flux monitoring of NH_3 and SO_2 during 2000-2003.

Easter Bush intensively managed grassland located south of Edinburgh (NT245641, lat. 55º52', long. 3º2', alt. 190 m ASL). The field is used for silage production, cattle and sheep grazing covered by more than 90% with Lolium Perenne, with a minor presence of *Phleum Pratense, Ranunculus repens, Poa Annua, Trifolium Repens*. Around the field site is a mixture of woodland, roads, rough grazing land and farms. Flux monitoring of NH_3 during 2001-2003.

CHARACTERISATION OF THE DIFFERENT SITES: METEOROLOGY AND STABILITY

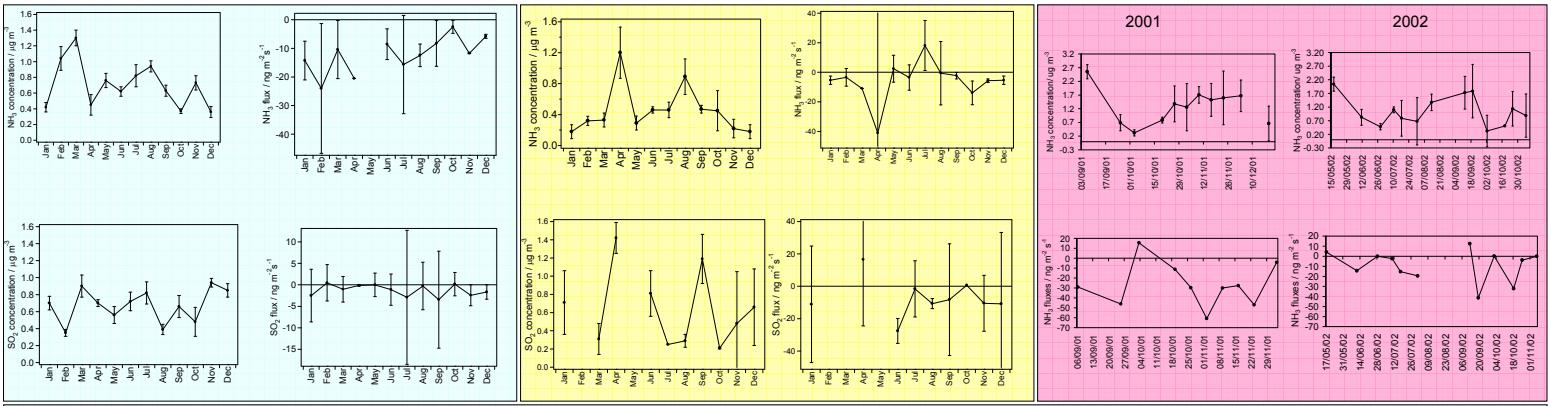


CHEMICAL CLIMATE FOR NH_3 AND SO_2 AT THE THREE SITES AND EXCHANGE FLUXES

AUCHENCORTH MOSS

PLYNLIMON

EASTER BUSH



CONCLUSIONS

Several years of net deposition fluxes of NH_3 and SO_2 have been measured at three contrasting grasslands in the UK using Time Averaged Gradient technique (TAG): the low-cost system provides long term estimates of S and N dry deposition for comparison between different environments. The data show the meteorological differences between the sites, and through the seasonal cycles. This information, coupled with the measurement of the chemical climate and the land cover description, provide a very useful tool in the description of long-term trends, for validation of models and development of their parameterisation, although the data do not permit accurate description of short term fluxes.

The description of the sites shows their suitability for the application of the TAG system: in general, for similar fetches, windier sites are better suited for atmospheric neutrality, and allow better data coverage: all sites in this work showed sufficient data coverage to describe reliably the deposition fluxes, but the scenario might change radically in more continental (more stable) conditions.

For ammonia the dry deposition fluxes were on average -7.6, -5.98, and -12.2 ng m^{-2} s^{-1} for Auchencorth Moss, Plynlimon and Easter Bush respectively, indicating differences in NH_3 concentrations and exchange processes, reflecting the interaction of temperature, rain and different grassland managing regimes. The measurements of SO_2 fluxes have suffered from the low background concentrations at the sites (close to detection limit): the overall results show deposition is dominating, but values are very often in the noise-around-zero region, with average values at -7.04 ng m^{-2} s^{-1} and -3.4 ng m^{-2} s^{-1} at Plynlimon and Auchencorth Moss, respectively.

AKNOLEDGEMENTS

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REFERENCES

D. Famulari, D. Fowler, R.L. Storeton-West, E. Nemitz, K. Hargreaves, G. Rutherford, Y.S. Tang, M.A. Sutton, K.J. Weston. "Development of a low-cost system for measuring SO2 and NH3 deposition fluxes on the field scale by micrometeorology" Submitted to Environmental Pollution, 2007.

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