Supplementary materials for: Measuring dry deposition of ammonia using flux-gradient and eddy covariance methods with two novel open-path instruments.

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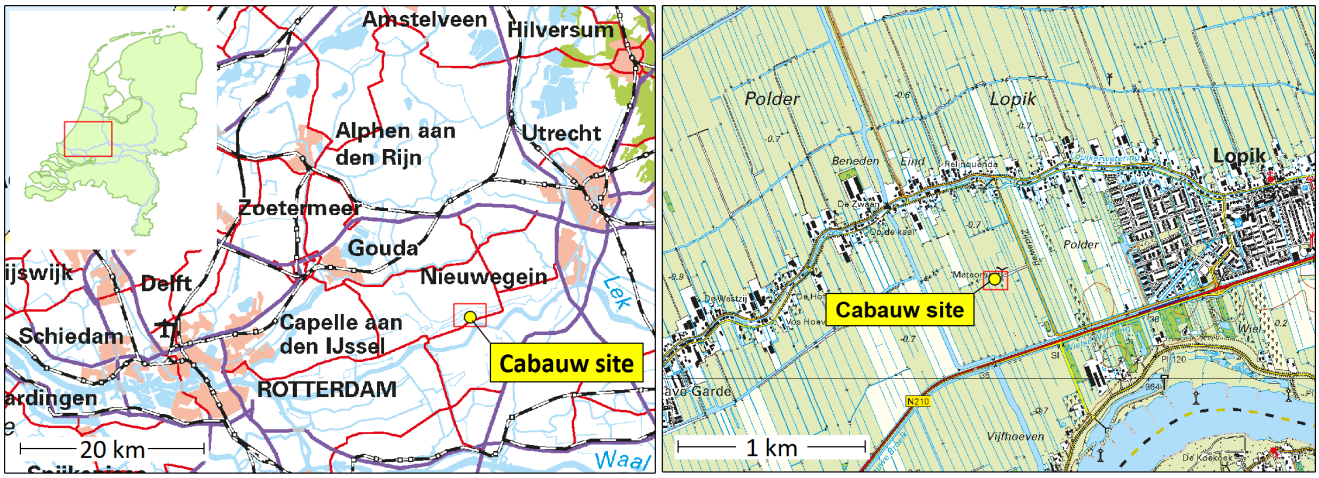

Figure S1. The location of Cabauw in the Netherlands. Maps from www.pdok.nl/ (downloaded 07-02-2021).

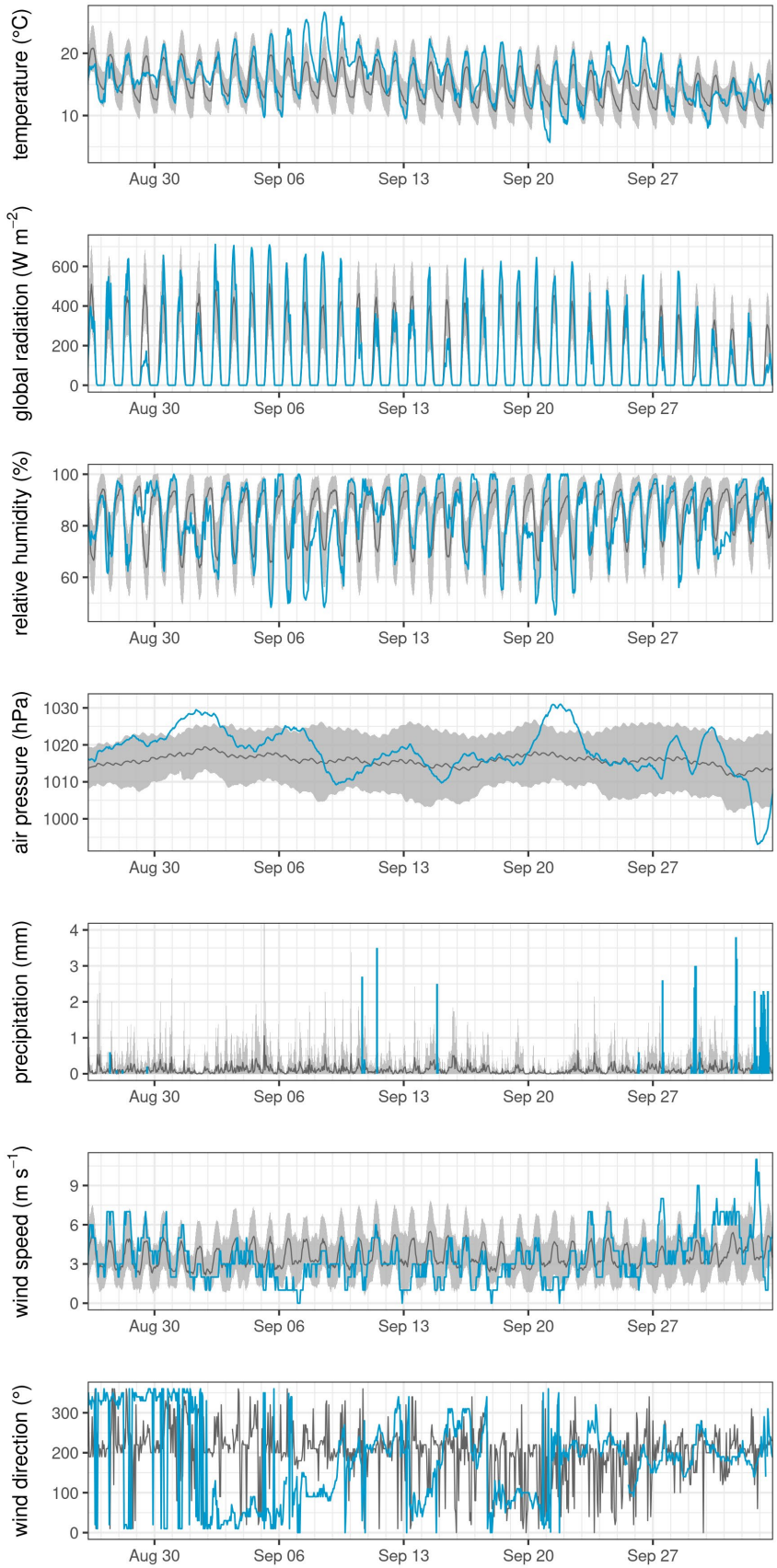

Figure S2. The weather conditions during the measurement campaign (blue lines) as observed by the KNMI automated weather station (hourly averages). The grey lines represent the average weather conditions of the past 30 years (1991-2020), and the grey area the corresponding standard deviation. For the wind direction, the mode (most frequently occurring wind direction) of the past 30 years is plotted.

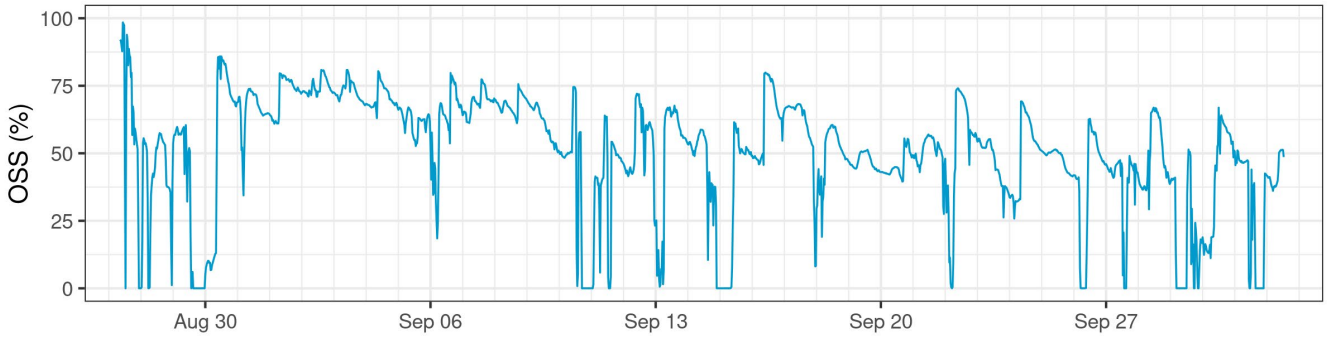

Figure S3. Optical signal strength (OSS) of the HT instrument during the measurement campaign.

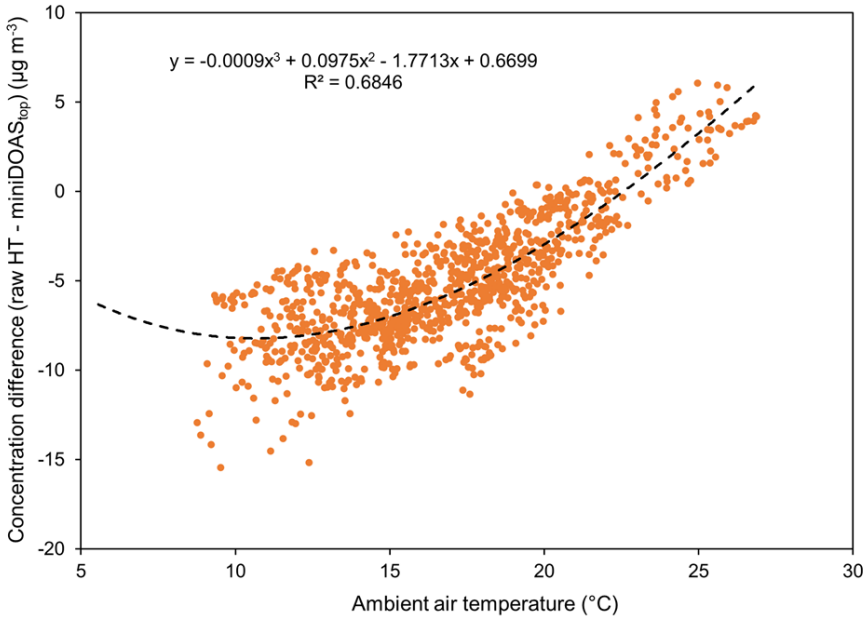

Figure S4. HT concentrations offset (after comparing with miniDOAS$_{top}$) correlation with ambient air temperature.

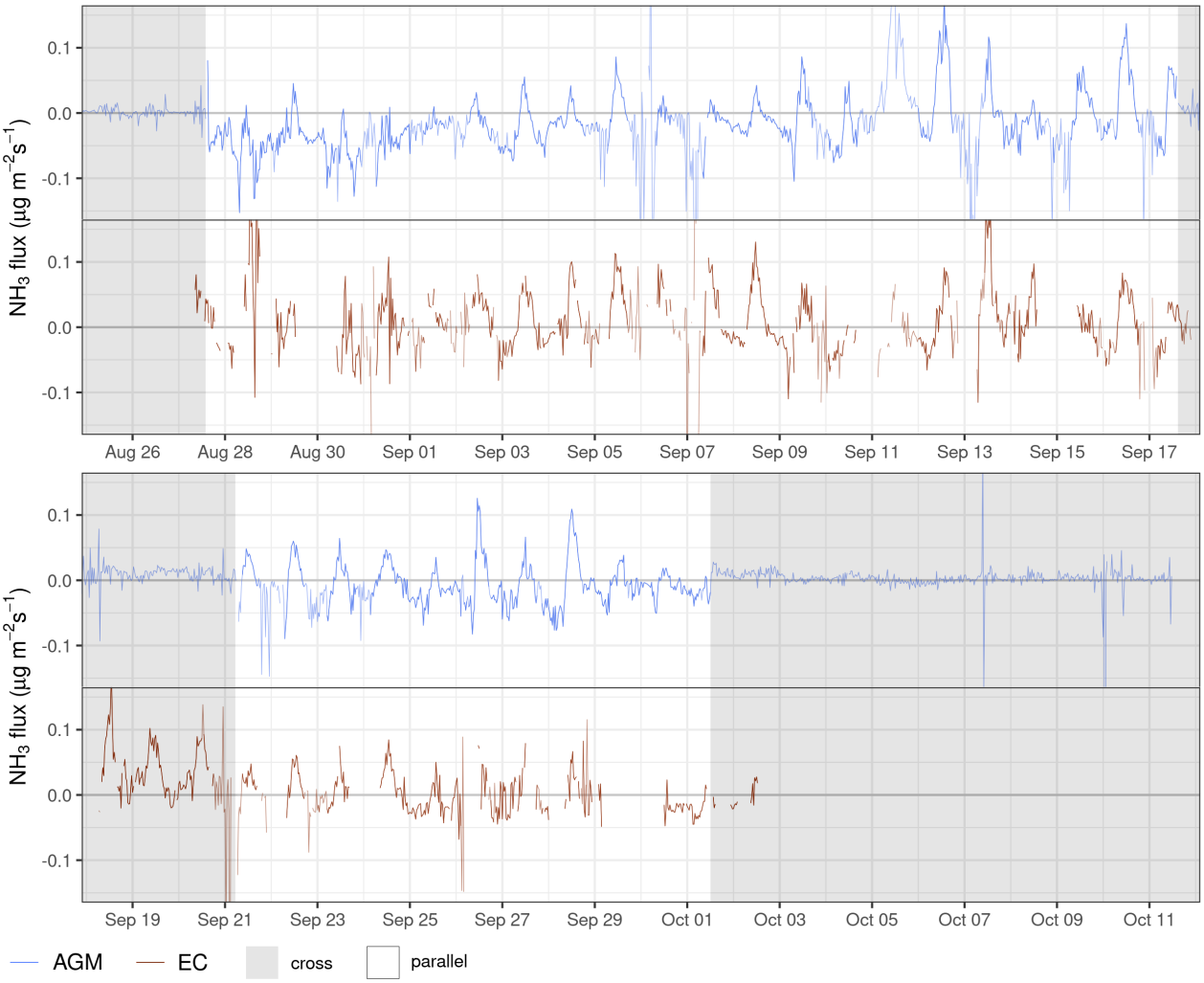

Figure S5. Full time series of the AGM (a) and EC (b) NH_3 fluxes. The grey areas depict measurement periods used for inter-instrumental calibration of the miniDOAS$_{bottom}$ and miniDOAS$_{top}$ (i.e. cross-periods). The transparent lines either indicate measurement during low-mixing conditions ($u_* < 0.1$ m s^{-1}) or outliers.

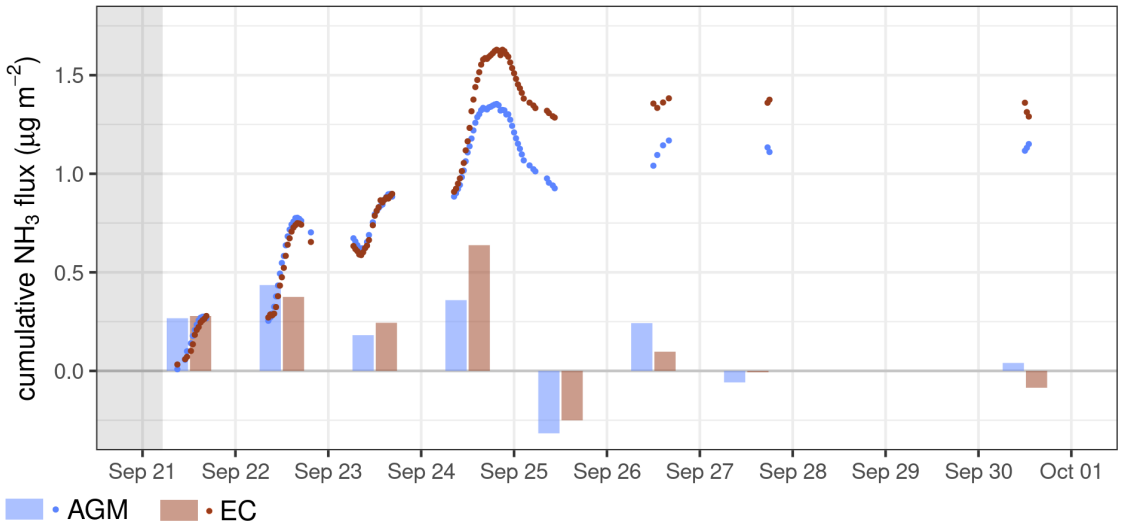

Figure S6. Cumulative EC and AGM NH_3 flux for the period after cross-period 2. Here, filtered NH_3 fluxes from only the green and light green wind directions where both systems have a valid flux observations were used. The bars represent the daily totals per system.

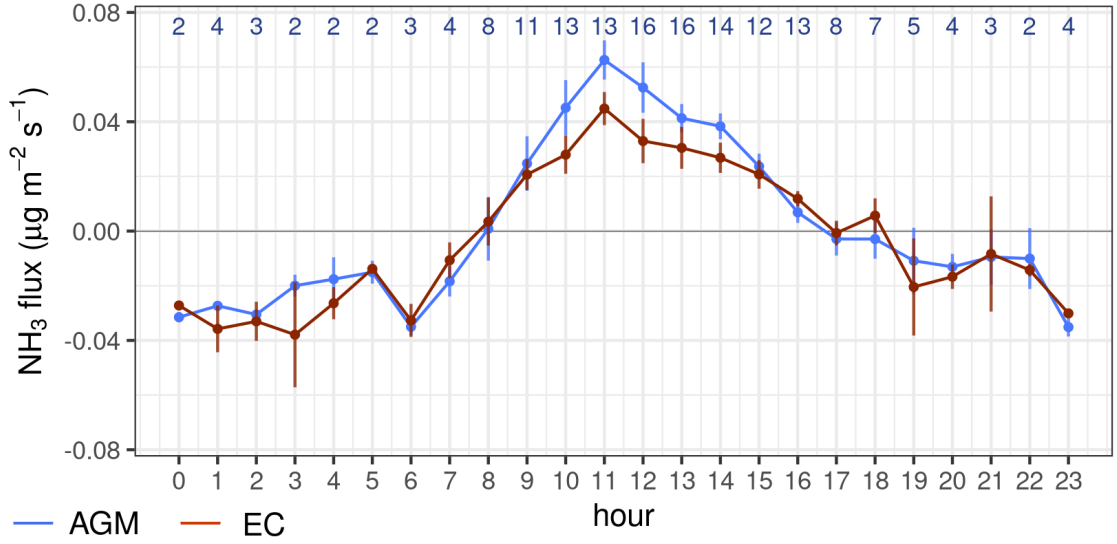

Figure S7. Mean diurnal cycle of the AGM and EC NH_3 flux. Only measurements after September 15 are included, when manure application was not allowed anymore. The error bars indicate the standard error of the hourly mean $(\sigma/\sqrt{n})$. The number of hours averaged (n) are listed in blue text at the top. Here, filtered NH_3 fluxes from only the green and light green wind directions where both systems have a valid flux observation were used.

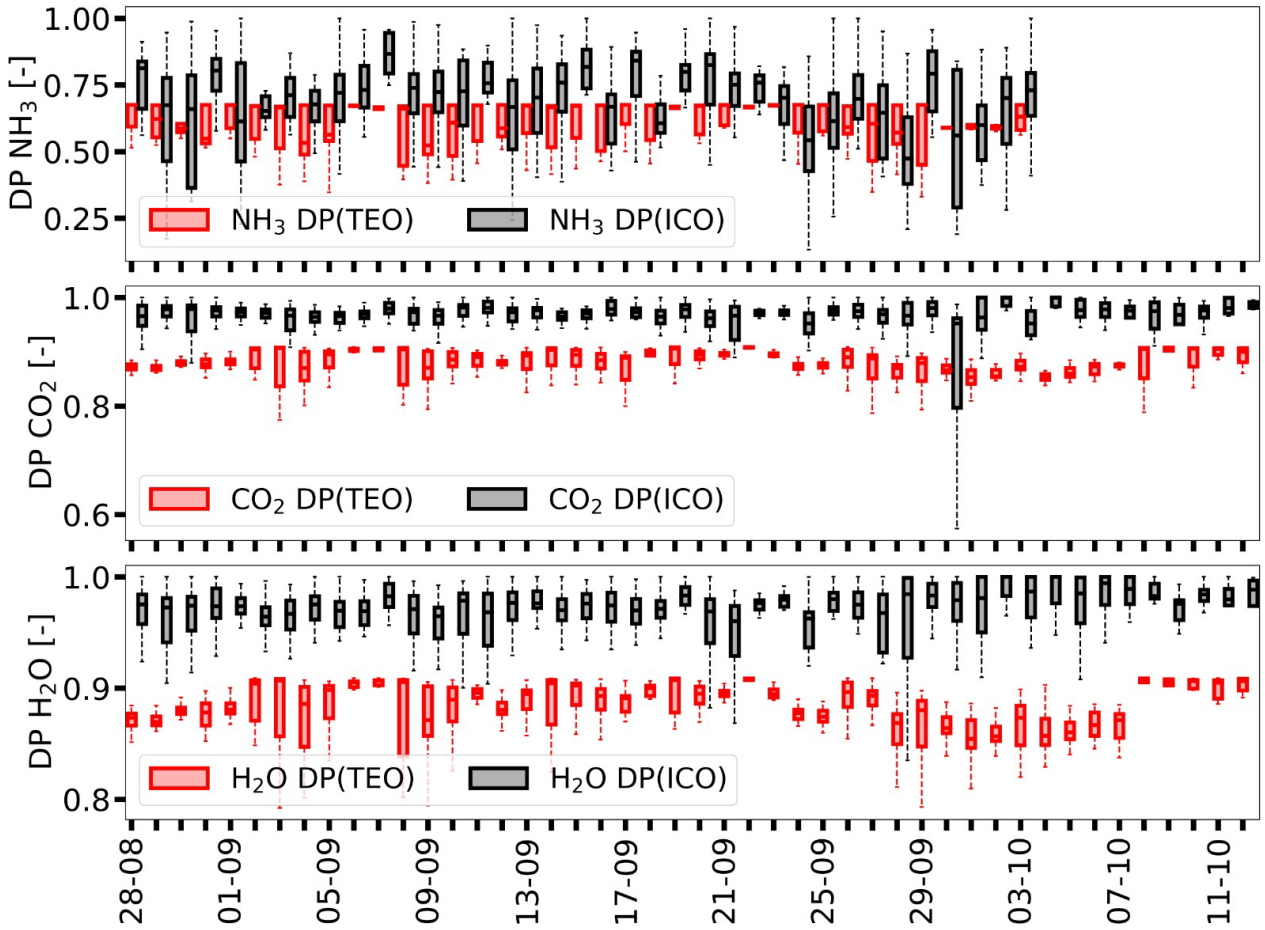

Figure S8. Box--and-whisker plots (box frame = 25 % to 75 % interquartile range (IQR), bold line = median, whisker = 1.5*IQR) of EddyPro theoretical method (TEO) and ICO experimental method calculated damping factors (DP) for NH_3, CO_2 and H_2O flux, respectively.

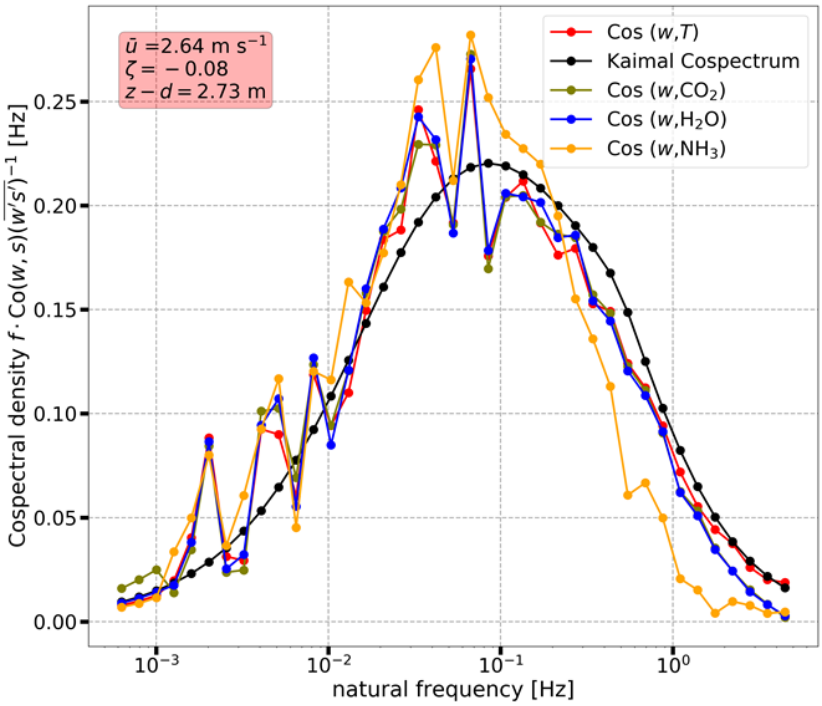

Figure S9. Normalized cospectra of temperature (red), NH_3 (orange), CO_2 (olive), and H_2O (blue) differentiated by their respective colours. Shown cospectra were averaged from 19 September 08:00 to 19 September 12:30. In the red box, average wind speed ($\overline{u}$) and stability (ζ) are shown. Values were used to derive the Kaimal Cospectrum (black).

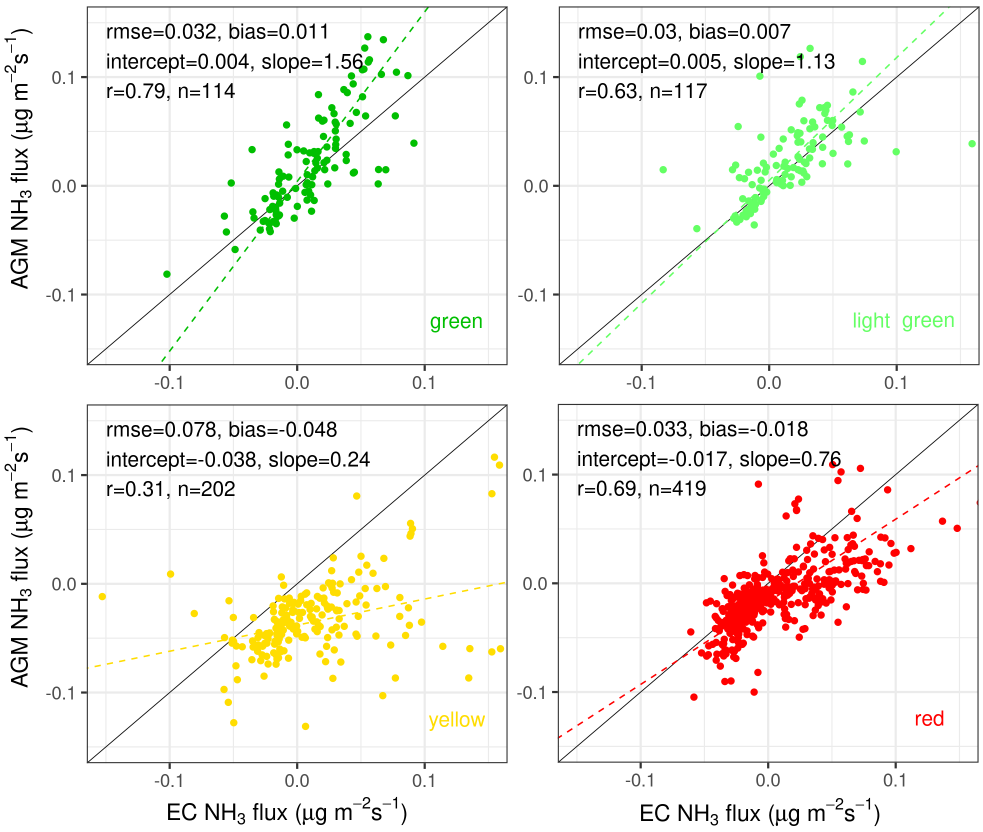

Figure S10. Comparison of the AGM NH_3 fluxes from the miniDOAS instruments and the EC NH_3 fluxes from the HT per categorised wind direction with ICO spectral correction method.

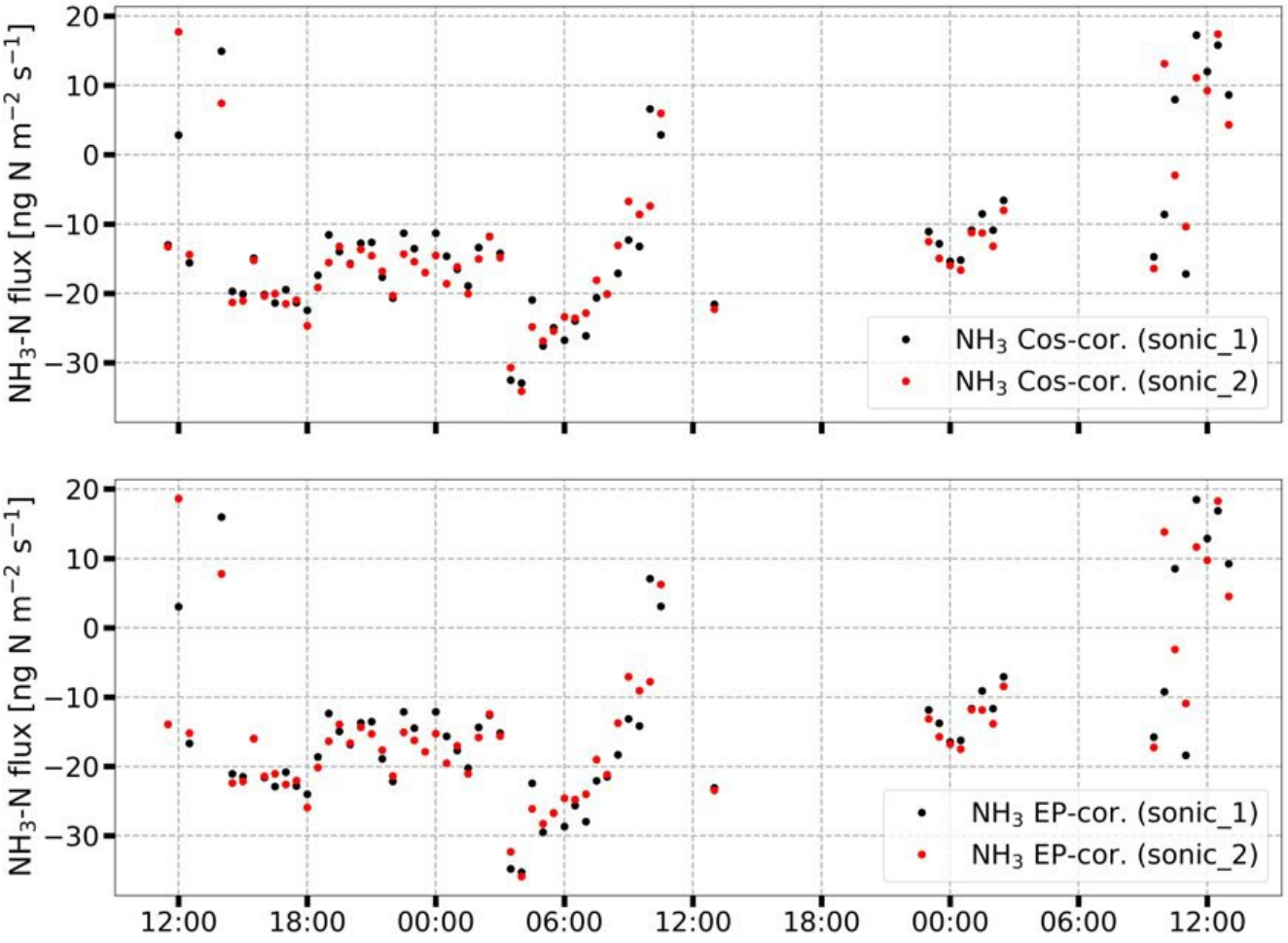

Figure S11. The NH_3 flux computed with the EC method using vertical wind component measurements from either sonic #1 (black) or sonic #2 (red). Damping correction either by ICO method (upper panel) or TEO (lower panel) during the overlapping period: Sep 30 – Oct. 1.

Table S1. EddyPro basic settings for sonic#1, sonic #2, HT8700E and LI-7500DS.

1. Metadata file	Canopy height	0.10 m					
1.1. Station	Displacement height	0.07 m					
	Roughness length	0.02 m					
1.2. Instruments		Anemometers Sonic#1	Gas Analyser info and their related distances to sonic #1		Anemometers Sonic#2	Gas Analyser info and their related distances to sonic #2	
	Manufacturer	Gill	LI-COR	Other Generic Open Path	Gill	LI-COR	Other Generic Open Path
	Model	Windmaster Pro	LI-7500DS	HT8700E	Windmaster	LI-7500DS	HT8700E
	Embedded software version	2329-105-01	8.8.36		2329-701-01	8.8.36	
	Instrument ID	Y071900			W211801		
	Height	2.80 m			2.80 m		
	Wind data format	U,V & W			U,V & W		
	North alignment	Spar			Spar		
	North off-set	40.0 °			320.0 °		
	Northward separation	Reference	-14.14 cm	-135.20 cm	Reference	95.46 cm	34.64 cm
	Eastward separation	Reference	14.14 cm	77.50 cm	Reference	-95.46 cm	-20.00 cm
	Vertical separation	Reference	3.00 cm	0.00 cm	Reference	0.00 cm	0.00 cm
	Longitudinal path length			50.00 cm			50.00 cm
	Transversal path length			10.00 cm			10.00 cm
	Time response			0.10 s			0.10 s

1.3(a). Raw File Description for sonic#1	1 ~ 4	5 ~ 6	7 ~ 8	9	10
Variable	u,v,w; sonic temperature	CO_2, H_2O	Ambient temperature and pressure	OSS	NH_3
Instrument	Sonic 1: Windmaster Pro	Irga 1: LI-7500DS	Irga 1: LI-7500DS	Irga 2: Generic Open Path	Irga 2: Generic Open Path
Measurement type		Molar/Mass density		Other	Molar/Mass density
Input unit	m/s; K	mmol/m^3	K; Pa	Dimensionless	µg/m^3
Nominal time log	0 s	0 s			
Minimum time log	0 s	-3.0 s	-3.0 s	-5.0 s	-5.0 s
Maximum time log	0 s	3.0 s	3.0 s	5.0 s	5.0 s

1.3(b). Raw File Description for sonic#2	1 ~ 4	5 ~ 6	7 ~ 8	9	10
Variable	u,v,w; sonic temperature	CO_2, H_2O	Ambient temperature and pressure	OSS	NH_3
Instrument	Sonic 2: Windmaster	Irga 1: LI-7500DS	Irga 1: LI-7500DS	Irga 2: Generic Open Path	Irga 2: Generic Open Path
Measurement type		Molar/Mass density		Other	Molar/Mass density
Input unit	m/s; K	$mmol/m^3$	K; Pa	Dimensionless	$\mu g/m^3$
Nominal time log	0 s	0 s			
Minimum time log	0 s	-5.0 s	-5.0 s	-3.0 s	-3.0 s
Maximum time log	0 s	5.0 s	5.0 s	3.0 s	3.0 s

2. Basic settings		
	Missing samples allowance:	40%
	Flux averaging interval:	30 min
	Cross wind correction of sonic temperature applied by the anemometer firmware:	Yes

3. Advanced settings		**Raw data processing for sonic #1**	**Raw data processing for sonic #2**
3.1 Processing options	Fix 'w boost' bug:	Yes	No
	Angle-of-attack correction for wind components:	Yes	Other settings are same as sonic #1
	Rotation method:	Double rotation	
	Detrend method:	Linear detrending	
	Time lag detection method:	Covariance maximization with default	
	Random uncertainty estimation:	Finkelstein and Sims(2001)	
		Cross-correlation first crossing 1/e	
		10.0 s	
	Flagging policy:	Mauder and Foken (2004)(0-1-2 system)	
3.2 Spectral Correction Options	Low frequency range:	Analytic correction of high-pass filtering effects (Moncrieff et al. 2004)	
	High frequency range:	Correction of low-pass filtering effects: Moncrieff et al. (1997) - Fully analytic	

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Table S2: Number of AGM and EC NH_3 flux observations that were left after quality control steps.

	Filter criteria	AGM miniDOAS			EC HT		
		[nobs]	**[hours]**	**[%]**	**[nobs]**	**[hours]**	**[%]**
Total campaign duration		2283	1142	100%	1737	869	100 %
Gaps or intercalibration*		1491	746	65 %	1370	685	79 %
Filter 1	QF = 2	n/a	n/a	n/a	1229	615	71 %
Filter 2	u_*>0.1	1201	601	53 %	1035	517	60 %
Filter 3	2σ outlier filter	1193	597	52 %	1031	516	59 %
Filter 4	exclude 11-09-2022	1146	573	50 %	1002	501	58 %
Filter 5	both systems have flux	848	426	37 %	848	424	49 %
Wind sector	green	113	57	5 %	113	57	7 %
	lightgreen	115	58	5 %	115	58	7 %
	yellow	199	100	9 %	199	100	11 %
	red	421	211	18 %	421	211	24 %

*****For the EC, data gaps were either weather-related and/or due to low optical signal strength (OSS). For the AGM, there were less observations due to the intercalibration of the miniDOAS instruments.*