

ACETONE AND ACETALDEHYDE EXCHANGE ABOVE A MANAGED TEMPERATE MOUNTAIN GRASSLAND

Lukas Hörtnagl¹, Ines Bamberger², Martin Graus^{2*}, Taina M. Ruuskanen^{2**}, Ralf Schnitzhofer², Armin Hansel², and Georg Wohlfahrt¹
¹ Institute of Ecology, University of Innsbruck, Austria | ² Institute of Ion Physics and Applied Physics, University of Innsbruck, Austria
 * current address: Chemical Sciences Division, NOAA Earth System Research, Laboratory, Boulder, CO, USA
 ** current address: Division of Atmospheric Sciences, University of Helsinki, Finland

BACKGROUND

Volatile organic compounds (VOCs) have received increasing attention in the past two decades due to their role in atmospheric chemistry¹. Plants emit a wide spectrum of biogenic VOCs to the atmosphere, and although anthropogenic sources can dominate in urban areas, terrestrial vegetation is the main source on a global scale². In the past, most studies focused on hydrocarbon compounds such as isoprenoids, but recently there is a growing interest in a small group of biogenic oxygenated VOCs³ (BOVOCs) which have been measured in surprising abundance throughout the remote troposphere⁴.

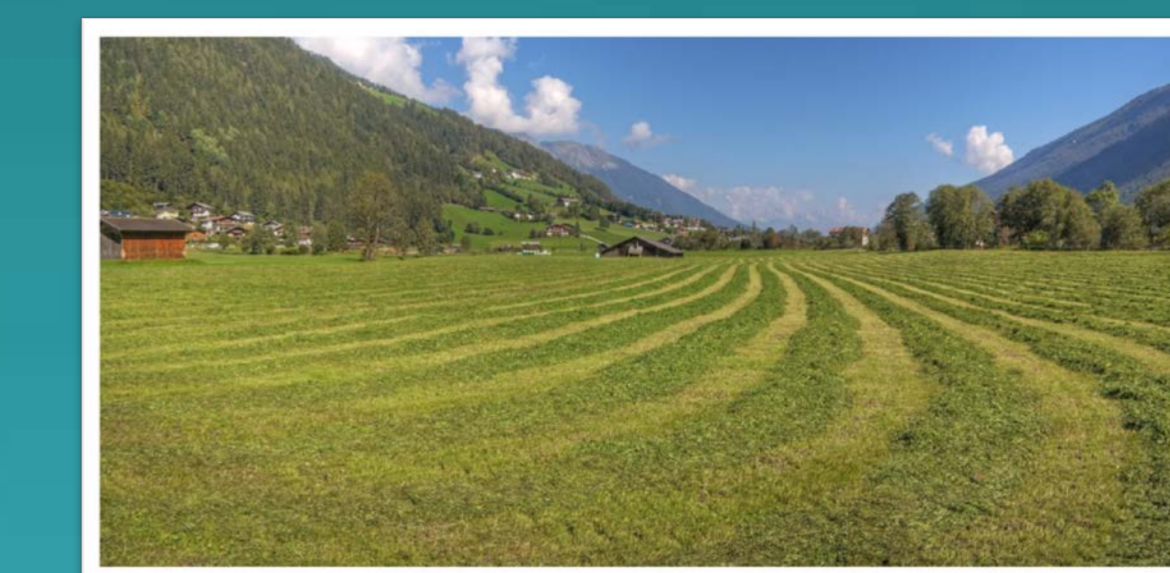
BOVOCs include three compounds: methanol, acetaldehyde and acetone. Their combined biogenic source strength amounts to around 268 Tg C y⁻¹, which is about half the source strength of isoprene. Previous studies have shown that land ecosystems can act both as sources and sinks for all three species^{5,6,8}.

ACETALDEHYDE

Acetaldehyde has a lifetime of less than one day and plays an important role as a precursor of ozone, peroxyacetyl nitrate⁷ and hydrogen radicals⁴ and is considered a hazardous air pollutant. The global source is dominated by atmospheric production (< 60 %⁸), but plants represent a non-negligible source (~ 10 %⁸). During periods of high soil water content when the roots are oxygen limited acetaldehyde is produced through oxidation of ethanol which is transported from the roots to the leaves⁹. Production of acetaldehyde has also been reported during light-dark transitions by a pyruvic acid overflow mechanism¹⁰. Dry deposition to land has been reported before¹¹, but is considered a minor sink on a global scale.

ACETONE

Acetone stays considerably longer in the atmosphere than acetaldehyde with a lifetime of 53 days and is a major source of PAN and hydrogen oxide radicals. Land ecosystems can act both as major sources and sinks, whereby pathways from which acetone emissions can arise are currently poorly understood³. Acetone is produced as a byproduct from the cell walls from cyanogenic plants and was reported to be light dependent¹³.



METHODS

Acetaldehyde and acetone fluxes were measured above a managed, temperate mountain grassland in Stubai Valley (Tyrol, Austria) during two growing seasons (2008 and 2009). Half-hourly flux values were calculated by means of the disjunct eddy covariance method using 3-dimensional wind-data of a sonic anemometer and mixing ratios of both species measured with a proton-transfer-reaction-mass-spectrometer (PTR-MS).

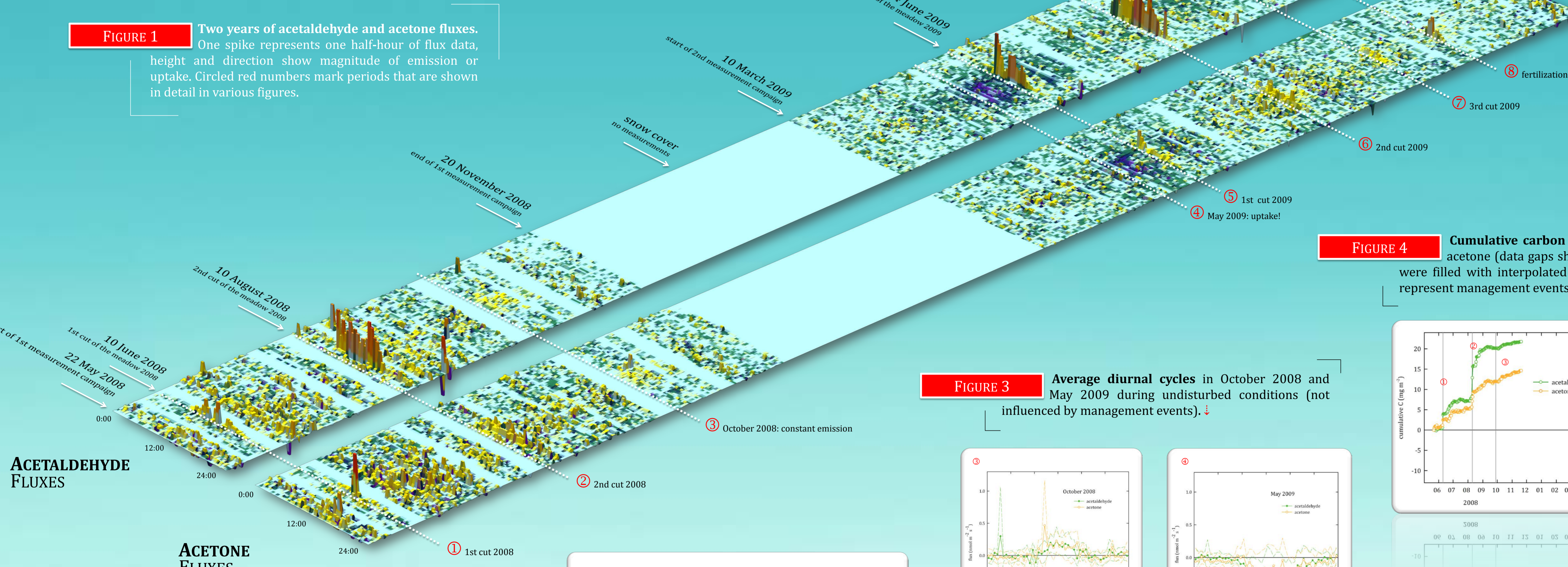
RESULTS & DISCUSSION

Largest perturbations of the exchange of acetaldehyde and acetone were caused by the **cutting** of the meadow, causing half-hourly peak emissions of 12.1 nmol m⁻² s⁻¹ for acetaldehyde and 10.1 nmol m⁻² s⁻¹ for acetone (Fig. 1,2,5).

During most of the two-year investigation period no clear diurnal cycles could be observed, both species exhibiting close-to-zero or noisy fluxes. However, both species exhibited a clear diurnal cycle during certain time periods: Distinct emissions of acetaldehyde and acetone were observed in **October 2008** (Fig. 3), with emission rates of up to 3.7 nmol nmol m⁻² s⁻¹ for acetaldehyde and up to 3.2 nmol nmol m⁻² s⁻¹ for acetone. Uptake of both acetaldehyde and acetone could be observed in late **May 2009** (Fig. 3), with rates up to 1.8 and 2.1 nmol nmol m⁻² s⁻¹, respectively.

The reason for this clear emission/uptake has yet to be explained, a statistical analysis using ancillary data like soil water content yielded no satisfying results. However, in **May 2009** the concentrations of both acetaldehyde and acetone showed highly-significant, negative correlations with their respective fluxes and **compensation points** of 0.3 and 1.2 ppb, respectively.

FIGURE 1 Two years of acetaldehyde and acetone fluxes. One spike represents one half-hour of flux data, height and direction show magnitude of emission or uptake. Circled red numbers mark periods that are shown in detail in various figures.



ACETALDEHYDE FLUXES
ACETONE FLUXES

FIGURE 4 Cumulative carbon fluxes of acetaldehyde and acetone (data gaps shorter or equal to two hours were filled with interpolated values). Grey vertical lines represent management events.

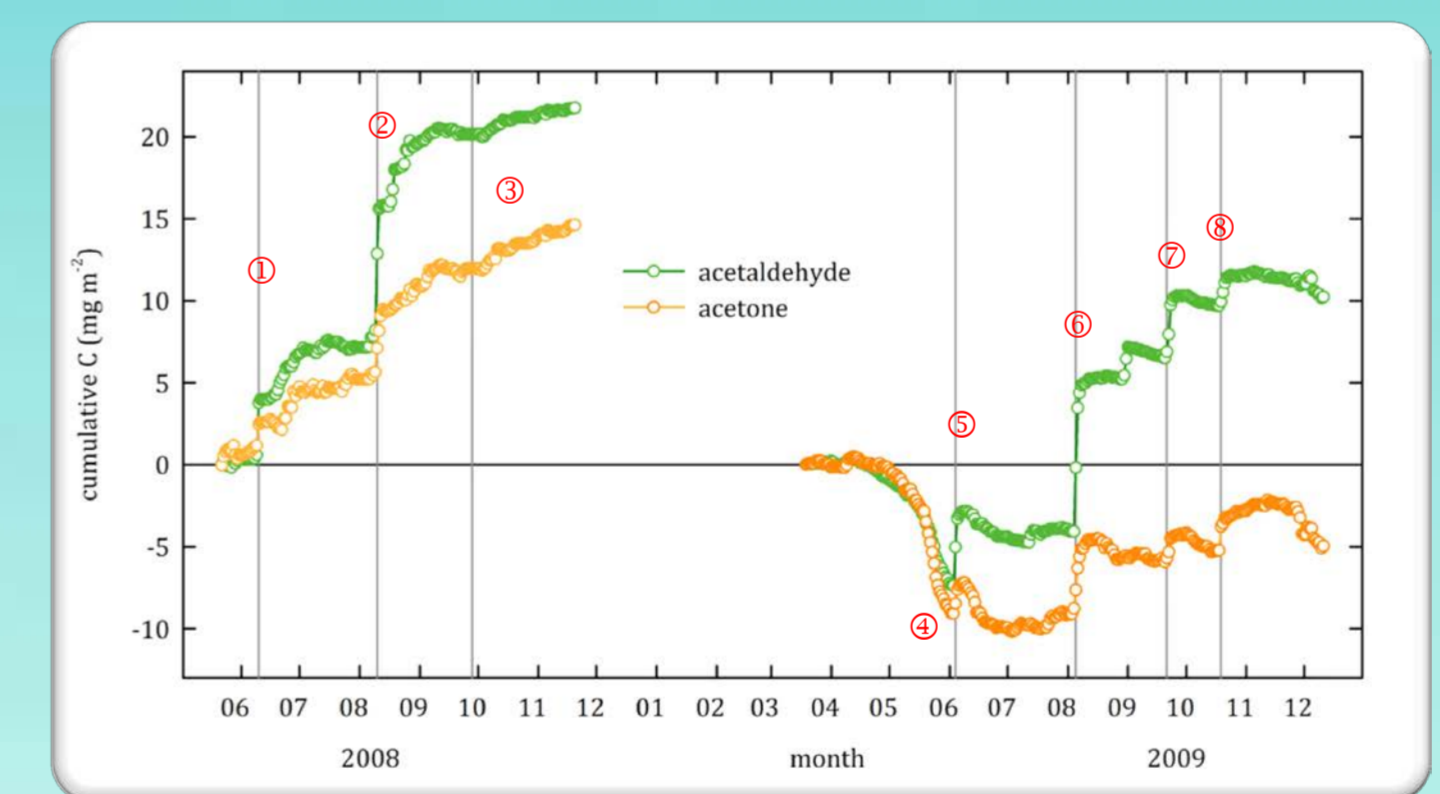


FIGURE 3 Average diurnal cycles in October 2008 and May 2009 during undisturbed conditions (not influenced by management events).

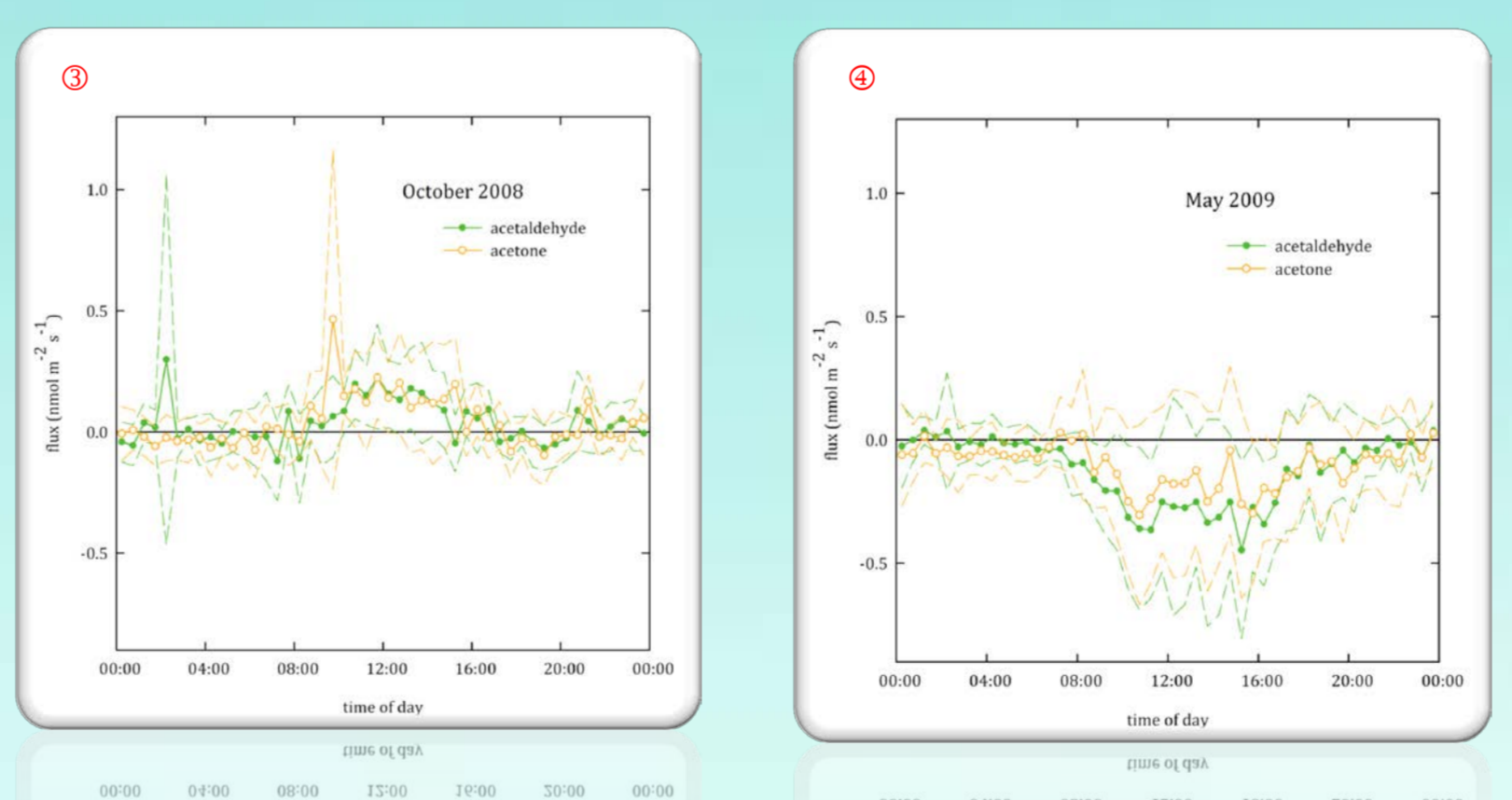


FIGURE 2 Daily average acetaldehyde and acetone flux measurements during the vegetation periods 2008 and 2009 at the study site Neustift. Grey vertical lines represent management events.

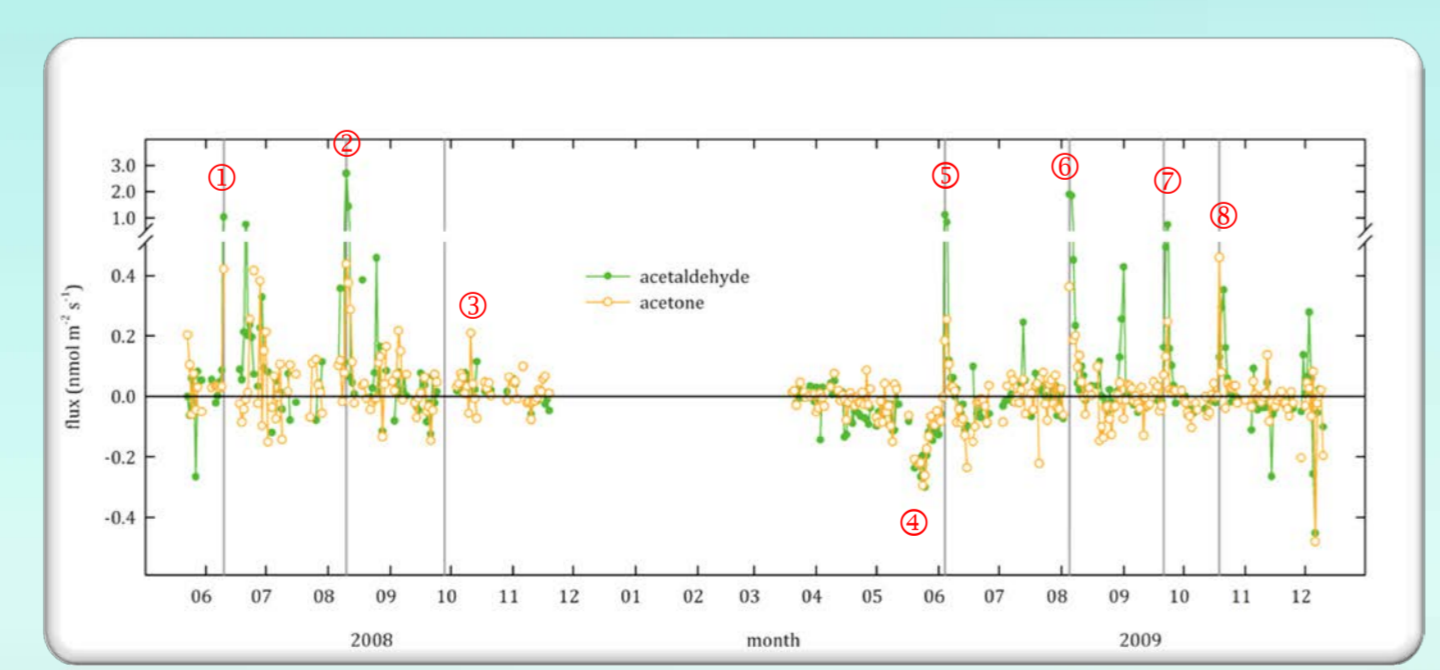
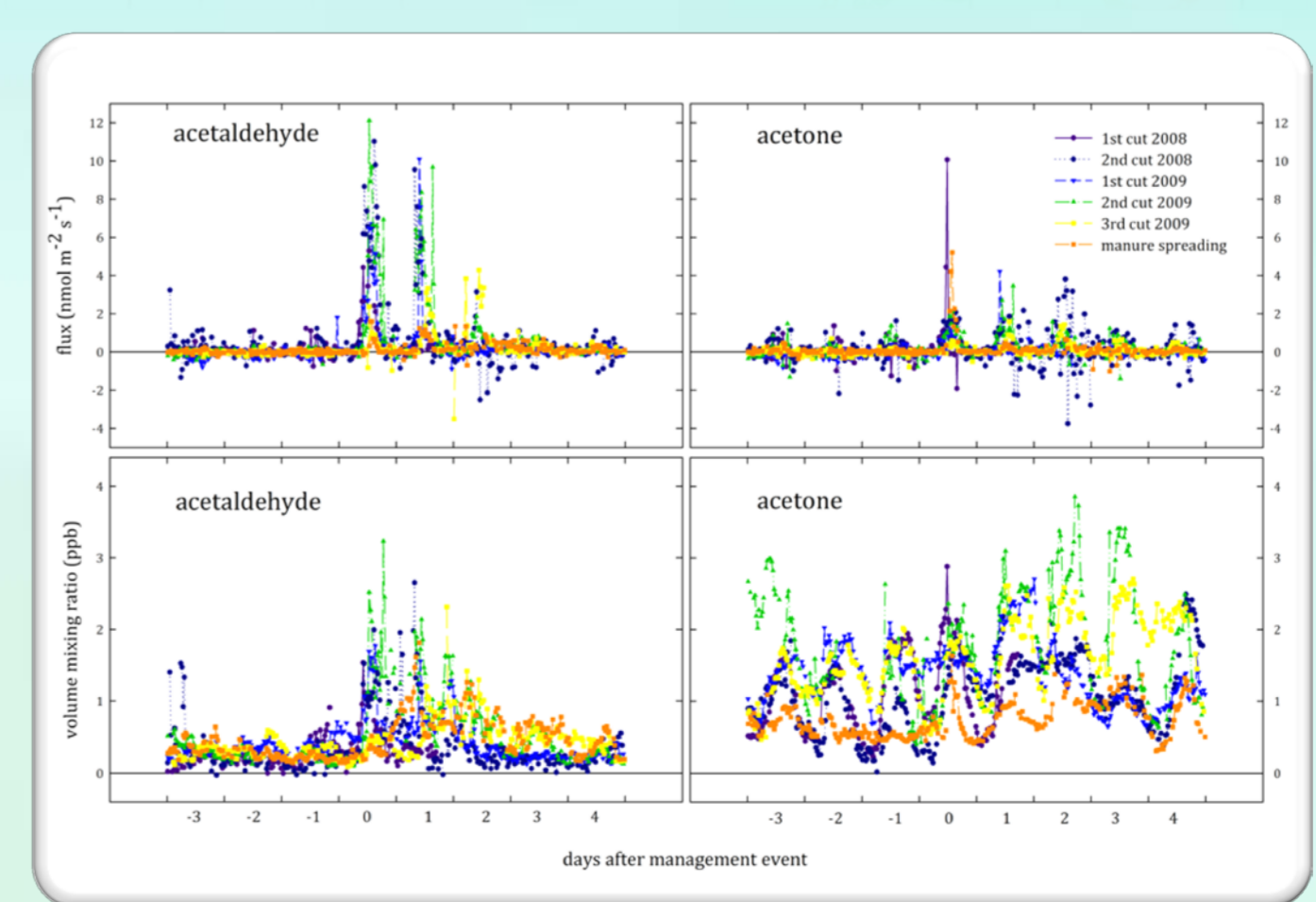


FIGURE 5 The effect of cutting and fertilization on acetaldehyde and acetone exchange. Symbols represent one half-hour of data.



General Assembly
 Vienna | Austria | 03 - 08 April 2011

Visit us:
BIOMET Innsbruck
 www.biomet.co.at