Time Response Characteristics for the Atmosphere-Plant-Interaction, Measured during the Total Solar Eclipses in Southern Germany on August 11, 1999

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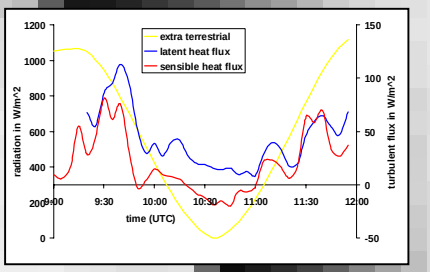
During in the Bavarian Solar Eclipse experiment (BaySoFi) co-ordinated by the Technical University of Munich an integrated micro-meteorological and plant-physiological experiment has been conducted. A maize field near Freising/Weihenstephan (Bavaria, Germany, 48°24'N, 11°43'E, 450 mas) was chosen as the experimental site. The cultivar maize (***Zea mays*** L.) was selected because of the high transpiration rate (even non-irrigated) in mid August. The canopy height was about 2.3-2.5 m. The fetch size was 150 m up-wind of the instrumentation. All turbulence observations were made about 2 m above the top of the canopy.

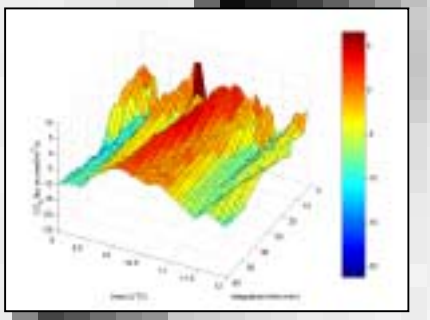
Used equipment during the micrometeorological/plant physiological programme of BaySoFi

Complex	Parameter	instrument
Radiation (canopy level)	Photosynthetic active Photon Flux Density (PPFD) above canopy)	Quantum, LiCor Inc.
Turbulence (canopy level)	Sonic anemometer	CSAT3, Campbell Sci. Inc.
	Krypton hygrometer	KH20, Campbell Sci. Inc.
	CO_2 gas analyser	LI-6262, LiCor Inc.
Transpiration (leaf level)	Transpiration	LI-6400P, LiCor Inc.
Photosynthesis (leaf level)	CO_2-exchange	LI-6400P, LiCor Inc.
	incoming PPFD inside canopy	Quantum, LiCor Inc.

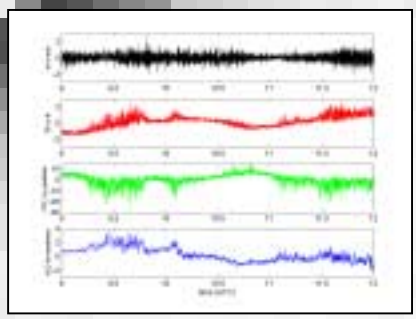
Turbulent fluxes of momentum, sensible and latent heat, and carbon dioxide were measured by the eddy covariance method with an averaging interval of 5 minutes. The friction velocity (not shown in Figure) with a near-zero value at 11:00 UTC indicates a response time shift of nearly 25 minutes. The course of the sensible heat flux (Figure) was very similar to the net radiation with a transition to stable conditions from 10:20 to 11:00 UTC. The latent heat flux decreased from a secondary maximum, due to the short period of high net radiation about 10:05 UTC until 11.00 UTC, with positive values during this time. With the beginning of the turbulence after 11:00, both fluxes increase and follow again the available energy.



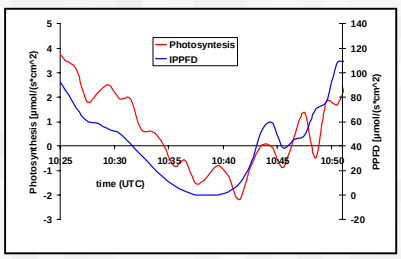
Turbulent fluxes of momentum, sensible and latent heat, carbon dioxide and ozone were measured with the eddy covariance method with an averaging interval of 5 minutes. This short averaging time is acceptable in cases when the high frequency part dominates the turbulent exchange of energy and mass. Due to the strong change in the radiation forcing during the eclipse, the turbulent fluxes of momentum and energy, and of carbon dioxide and ozone, were expected to be in a non-steady state for longer averaging periods. The data quality would therefore not have been acceptable for time scales longer than 5 minutes. The Figure shows as an example the carbon dioxide flux calculated with integration times from 5 to 60 minutes. During the totality the flux is similar for all integration times, while out of this time period the shorter integration times show a strong variability and different flux values compared to the fluxes determined for longer periods.



The time responses to totality for sensible and latent heat flux, carbon dioxide and ozone flux were not as long as the responses for the momentum flux. Nevertheless, the magnitude of these fluxes did not increase as it would have been conform to the increase in net radiation and plant activity after the totality, due to the breakdown of the turbulence regime. The turbulence collapse caused a dampness in the vertical wind velocity (Figure), thus the magnitude of the turbulent fluxes was smaller than it would have been in the case of fully developed turbulence. This effect can be verified for the carbon dioxide flux (compare Figures 'Carbon dioxide flux' and 'Photosynthesis'). All fluxes increased with the beginning of the developed turbulence after 11:00 UTC and again followed the course of available energy and plant activity in the right order of magnitude.



For C4 plants with distinct spatially separated light and dark reaction sites a time delay in the response of carboxylation in the range of one to several minutes should occur, and should be made evident using ***in situ*** short-time step gas exchange observations. Around totality (between 10:28 and 10:51) I_{PPFD} ranged in the linear part of the light response curve (A-I_{PPFD}) for maize. Rapid changes in I_{PPFD} should result in changes of the driven process of carboxylation with a distinct time delay due to the enlarged energy transfer mechanism between the electron transport chain and the Calvin cycle. The Figure clearly shows this time delay between I_{PPFD} and A. This delay results in a visible hysteresis effect of photosynthesis around totality. As an averaged delay time between I_{PPFD} and A Δt=(35±15) sec can be found.



Publications about the BaySoFi-experiment:

Fabian, P., Winterhalter, M., Stohl, A., Foken, Th., Kartschall, T., Berresheim, H., 2000. The BaySoFi campaign - Measurements carried out during the total solar eclipse of August 11, 1999. Meteorol. Z., N. F., **9**: submitted.

Foken, Th., Wichura, B., Klemm, O., Gerchau, J., Winterhalter, M., Weidinger, T., 2000. Micrometeorological conditions during the total solar eclipse of August 11,1999. Meteorol. Z., N. F., **9**: submitted.

Kartschall, Th., Badeck, F., Walosczyk, K., Winterhalter, M., 2000. Temporal dynamics of photosynthetic activity and stomatal conductance in a *Zea mays* L. canopy during the Total Solar Eclipse on August 11, 1999 (Freising, Germany). Meteorol. Z., N. F., **9**: submitted.

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