

Flux Measurement Fundamentals

July 27 to 31, 2015 *A technical short course with focus in the use of micrometeorological methods to obtain and analyze fluxes of momentum, heat and gases by eddy-covariance and related techniques.*

Instructors: HaPe Schmid, Frederik De Roo, Katja Heidbach, Janina Hommeltenberg, Matthias Mauder, Rainer Steinbrecher, Matthias Zeeman, Karlsruhe Institute of Technology (KIT), IMK-IFU, Garmisch-Partenkirchen

- We expect the course participants to be familiar with **basic statistics** and **time-series analysis** (including spectra and Fourier transforms). To brush up on these topics, we recommend to read Chapters 2 and 8 in Stull (1988).
- Sunday evening from 07:00 PM on: icebreaker at "Sausalitos"

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| Monday, 09:00 AM | <i>Seminar Room:</i> Welcome and orientation Introduction to turbulent exchange measurements (overview of various techniques, pros and cons, applicability for different flux "species"); site selection, instrument height, measurement logistics, etc. Open-path eddy covariance system. Eddy covariance. Instruments and equipment to be used: CSAT-3, LICOR 7500, CR3000 logger. CR3000 CSI-Basic program. 3 m aluminum tower and tower safety. | <i>Schmid</i> <u>reading:</u> Baldocchi 2003; Pattey et al. 2006; Aubinet et al., 2012; |
| Monday, 01:00 PM | <i>Seminar Room:</i> Implementation of instruments; Wiring of instruments in class-room; connect to logger; data logger programming, test program and monitor instrument readings. Set up field tower. | <i>Schmid, Steinbrecher, Zeeman</i> |
| Tuesday, 08:30 AM | <i>Field site:</i> Group: Visit TERENO EC training site; download data and check system; preview data | <i>Schmid, Steinbrecher</i> |
| Tuesday, 09:30 AM | <i>Seminar Room:</i> Boundary layer and turbulence theory Atmospheric stability, Monin-Obukhov Similarity Theory, Turbulent Kinetic Energy, Reynolds decomposition, Turbulence Spectra, Energy Cascade | <i>Schmid</i> |
| Tuesday, 01:00 PM | <i>Seminar Room:</i> Calculations of turbulence statistics : mean and fluctuations; variance, turbulence intensity; TKE; covariance; autocorrelation function; lagged covariance function; spectra and spectral ranges; co-spectra; momentum, heat and gas fluxes; stability; WPL "correction" (mixed lecture and exercises). | <i>De Roo, Schmid</i> <u>reading:</u> Finnigan et al. 2003; Leuning 2007; |

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| Wednesday, 08:30 AM | <i>Field site:</i> Group: download data and check system; preview data | <i>Schmid, Steinbrecher</i> |
| Wednesday, 09:00 AM | <i>Seminar Room:</i> QA/QC Uncertainty and systematic errors (coordinate rotation; spectral cut off at low/high frequency; fetch/footprint; low-turbulence / u^* ; uncertainty estimation for individual fluxes and annual accumulation) | <i>Heidbach, Hommeltenberg, Zeeman</i> <u>reading:</u> Aubinet et al. 2012; Mauder et al. 2013; |
| Wednesday, 01:00 PM | <i>Seminar Room:</i> Missing data and flux partitioning: Issues and techniques Analyze data (energy balance, CO ₂) | <i>Zeeman</i> <u>reading:</u> Moffat et al. 2007; Lasslop et al. 2010; Vickers et al. 2009; |
| Thursday, 08:30 AM | <i>Field site:</i> Group: download data and check system; preview data | <i>Schmid, Steinbrecher</i> |
| Thursday, 09:00 AM | <i>Seminar Room:</i> Post-processing automation for long-term measurements: Introduction in the software TK3 and presentation of other freely available software packages such as EddyPro. Calculation of fluxes incl. corrections and quality tests using TK3/EddyPro | <i>Mauder, Hommeltenberg</i> <u>reading:</u> Mauder and Foken, 2011; Burba 2013; |
| Thursday, 02:00 PM | <i>Seminar Room:</i> Preparation for Student Panel Discussion | <i>Group</i> |
| Thursday, 05:00 pm | Panel Discussion chaired by students Obligatory for students applying for CPs | <i>Schmid, Mauder, Steinbrecher</i> |
| Thursday, 06:30 pm | Joint course dinner at the "Hausberg Lodge" | |
| Friday, 09:00 AM | <i>Seminar Room:</i> Alternative flux measurement techniques DEC-, REA-, Flux-Gradient-, Enclosure techniques <i>Field site:</i> Group: download data, bring down tower Analyze data (energy balance, CO ₂) Compute and interpret daily variations, monthly ensemble daily courses, seasonal variations (using existing data from TERENO, energy, H ₂ O and CO ₂), wrap-up | <i>Steinbrecher</i> <u>reading:</u> <i>Steinbrecher et al. 2002;</i> <i>Pattey et al. 2006;</i> <i>Schmid, Mauder, Steinbrecher,</i> |
| Friday, 01:00 PM | <i>Seminar Room:</i> Panel Discussion chaired by students Obligatory for students applying for CPs | <i>Schmid, Mauder, Steinbrecher,</i> |
| Friday, 03:00 PM | Departure | |

References:

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- Lasslop, G. et al. 2010. Separation of net ecosystem exchange into assimilation and respiration using a light response curve approach: critical issues and global evaluation. *Global Change Biology* 16, 187-208.
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- Mauder, M., Foken, T., 2011. Documentation and instruction manual of the eddy covariance software package TK3. Universität Bayreuth, Abt. Mikrometeorologie, Arbeitsergebnisse, 60 pp. (Print: ISSN 1614-8916; Internet: ISSN 1614-8926).
- Mauder et al. 2013. A strategy for quality and uncertainty assessment of long-term eddy-covariance measurements. *Agricultural and Forest Meteorology* 169, 122-135.
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- Pattey et al. 2006. Towards standards for measuring greenhouse gas flux agricultural fields using instrumented towers. *Canadian Journal of Soil Science* 86, 373-400.
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