EMS7/ECAM8 Abstracts,
Vol. 4, EMS2007-A-00043, 2007
7th EMS Annual Meeting / 8th ECAM

1 Influence of wind direction and a slanting beam angle on surface layer scintillometer estimates of sensible heat flux

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Abstract:

Understanding the partitioning of net irradiance into its component energy balance

flux including sensible heat and latent energy flux measurements can provide valuable information about the local weather patterns. Such information is useful for water resource management, agriculture and environmental studies. This work was carried out with the main aim of comparing sensible heat flux estimated by the surface layer scintillometer (SLS) method with that obtained by the eddy covariance (EC) method for wind direction approximately or nearly perpendicular to the SLS beam path, with measurements obtained when the wind direction is approximately parallel to the beam path. Also investigated was the comparison of sensible heat flux measured by the SLS at slanting beam angles with that obtained by the EC method, as well as determination of the SLS footprint and comparison with the EC footprint. Measurements of sensible heat flux (F_h) by the EC and SLS methods over a mixed grassland experimental site were compared for (i) periods when the SLS beam was set up in a slanting position with the transmitter set at a height of 1.68 m above the ground level while the receiver was at 0.68 m; and (ii) for wind directions approximately perpendicular to the SLS beam path and wind directions either random or approximately parallel to the beam path.

Results show generally good agreement in the measurements of F_h by the EC at a height of 2 m and SLS measurement methods with the SLS set up in an inclined position with the 30-min data resulting in more improved agreements. These findings confirm that the SLS set up does not impair its performance in measuring sensible heat flux. This also shows that the SLS method would work well in non-ideal (heterogeneous) conditions which the inclined optical beam path mimics. In most cases, real field measurements take place in such conditions and hence the importance of testing the SLS for such. For those days for wind directions were nearly approximately perpendicular to the beam, the F_h agreement by the EC and SLS methods improved compared to random wind directions or directions approximately parallel to the SLS beam path. Wind speed also seems to influence theF_h estimates by the two methods since the agreement in the F_h values obtained by the two methods is greater when wind speed is higher compared to times of the day when the wind speed is reduced. The atmospheric stability influences the peak position of footprint with the peak footprint position being further from the measurement point when the atmospheric stability condition is closer to stable as denoted by the Obukhov length of -5 and closer to the measurement point for convectively unstable atmospheric conditions as shown by the Obukhov length of -30. Also shown is that a larger fetch is required when the atmosphere is convectively unstable as indicated by the contours plotted on top of the footprint plots. The footprint for the two methods (EC and SLS) differ more when the wind direction is random compared to when the wind direction is mainly perpendicular to the beam and this may be part of the reason why the sensible heat flux comparisons between the two methods improved for wind directions mainly per-

pendicular to the SLS beam path than for directions more random or parallel to the beam.

In general, there seems to be very good agreement in the sensible heat flux values obtained by the two methods and since SLS offers areal-averaged sensible heat flux measurements compared to the EC method which is basically a point measurement method, the correspondence between the sensible heat flux obtained by the two methods is considered very good.

Key terms: Sensible heat flux. Surface layer scintillometer, eddy covariance, wind direction, beam angle.