LATENT AND SENSIBLE HEAT FLUXES OVER A SHALLOW LAKE

Gennady N. Panin, Alexander E. Nasonov

Institute of Water Problems, RAN, Moscow

Horst Lohse

GKSS Research Centre, Geesthacht

Thomas Foken

University of Bayreuth

Content

G. N. Panin, A. E. Nasonov
Institute of Water Problems, Moscow
H. Lohse
GKSS Research Centre; Geesthacht

Th. Foken
University of Bayreuth
Dept. of Micrometeorology

1. The Classical Bulk Approach for Air-Sea Interaction

$$Q_H = c_p \cdot \rho \cdot u(z) \cdot C_H \cdot [T(z) - T_0]$$

$$Q_E = \lambda \cdot \rho \cdot u(z) \cdot C_E \cdot [q(z) - q_s(T_0)]$$

Two solution:

- Parameterization of the bulk coefficients

- Integration of the exchange coefficients

G. N. Panin, A. E. Nasonov
nstitute of Water Problems, Moscow
H. Lohse
GKSS Research Centre; Geesthacht

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University of Bayreuth
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1.1 Parameterization of the Bulk Coefficients

Bulk coefficients are functions of:

- **height**
- **roughness**
- **thickness of molecular layer**
- **Prandtl or Schmidt number**

$$C_H = f_H\left(z/h_S;\ z/L;\ h_S/\delta_\nu;\ \mathrm{Pr}\right)$$

$$C_E = f_E\left(z/h_S;\ z/L;\ h_S/\delta_\nu;\ Sc\right)$$

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1.1 Parameterization of the Bulk Coefficients

$$C_{H,E} \approx 10^{-3} \left(\frac{z_0 u_*}{\nu} \right)^{0.11} \cdot \begin{cases} (1 - z/L) & z/L < 0 \\ 1/(1 + 3.5 \cdot z/L) & z/L > 0 \end{cases}$$

Panin, G. N., 1985. Heat and mass exchange between water and the atmosphere in nature (in Russian). Nauka, Moscow, 206 pp.

1.2 Three Layer Model

$$Q_H = \Gamma \cdot \left[T(z) - T_0 \right]$$

$$\Gamma = \left(\int_0^z \frac{dz}{K_H + \nu_{Tt} + \nu_T} \right)^{-1}$$

$$\Gamma = \frac{\kappa \cdot u_*}{\left(\kappa \cdot \Pr - 1/6 \right) \cdot \delta_T^+ + 5 + \ln \frac{u_* \cdot z}{30\nu}}$$

Foken, Th., 1984. The parametrisation of the energy exchange across the air-sea interface. Dynamics of Atmosphere and Oceans 8: 297-305

2. Transformation to Shallow Lakes

$$Q_H^{\,SL} = Q_H + Q_H \cdot k_T^{\,SL} \cdot \frac{\sigma_h}{H} \approx Q_H (1 + 2\sigma_h / H)$$

$$Q_E^{\,SL} = Q_E + Q_E \cdot k_E^{\,SL} \cdot \frac{\sigma_h}{H} \approx Q_E (1 + 2\sigma_h / H)$$

$$k_T^{\,SL} \approx k_E^{\,SL} \approx 2.0$$

Panin, G.N., Nasonov, A.E., Souchintsev, M.G., 1996. Measurements and estimation of energy and mass exchange over a shallow sea. In: M. Donelan (Editor), The air-sea interface. Miami, pp. 489-494.

G. N. Panin, A. E. Nasonov
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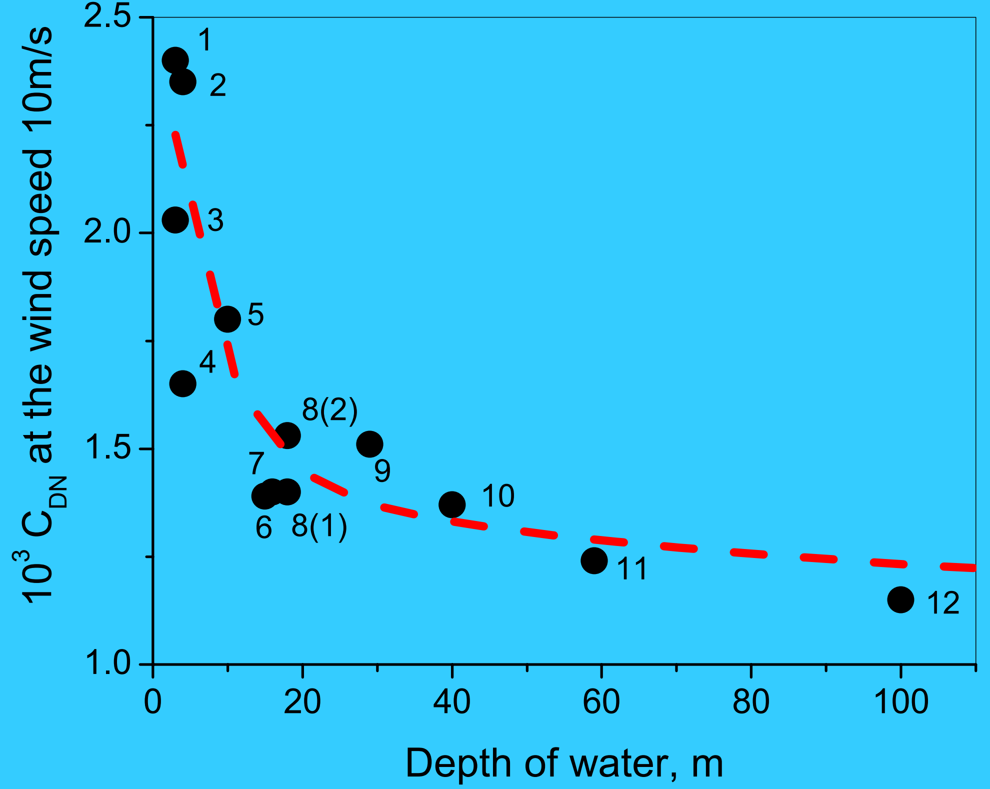
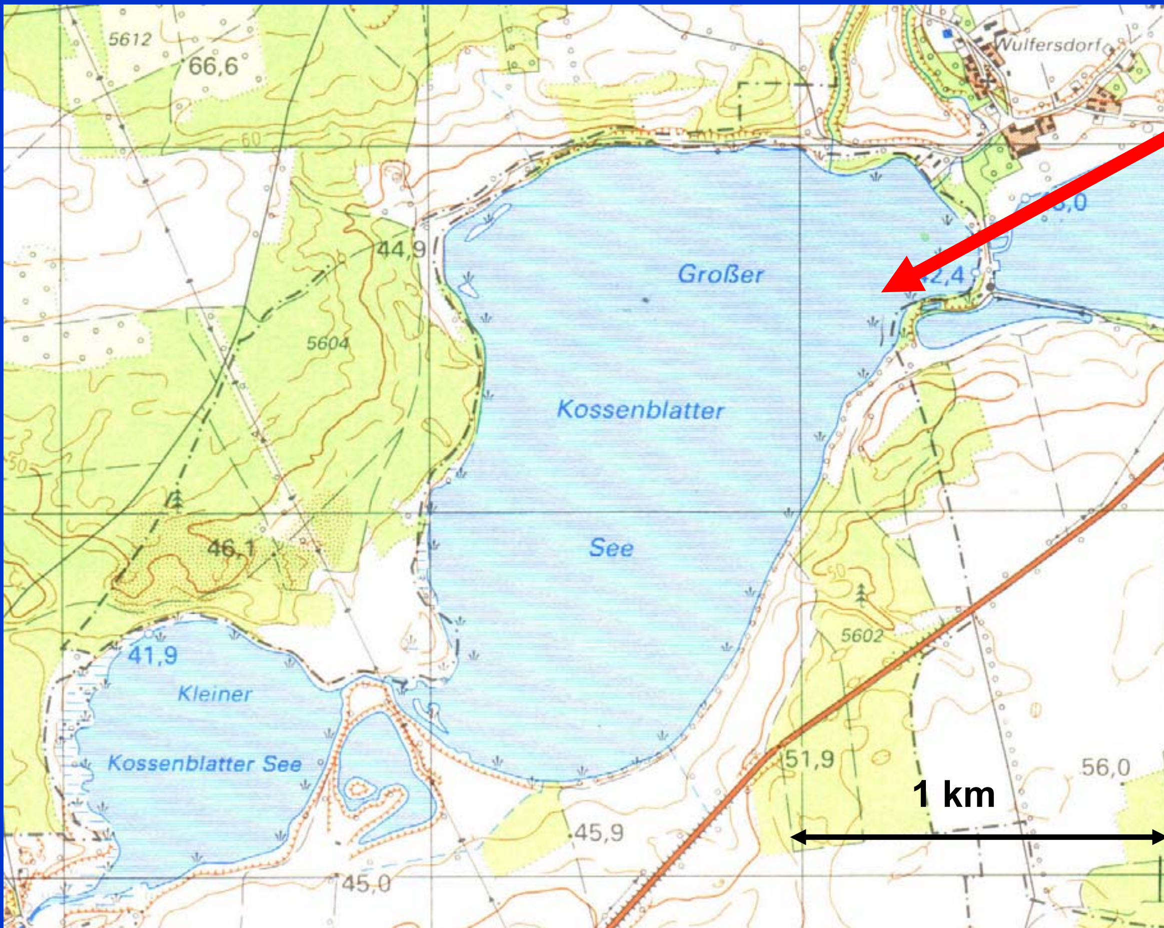
2. Transformation to Shallow Lakes



Dependence of the drag coefficient on the depth of the water (different experiments and authors), Panin et al. (2004) in preparation

3. The Experimental Design



Tower position

Großer Kossenblatter See
52° 08’ 17” N
14° 06’ 37” E
43 m a.s.l.

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Th. Foken
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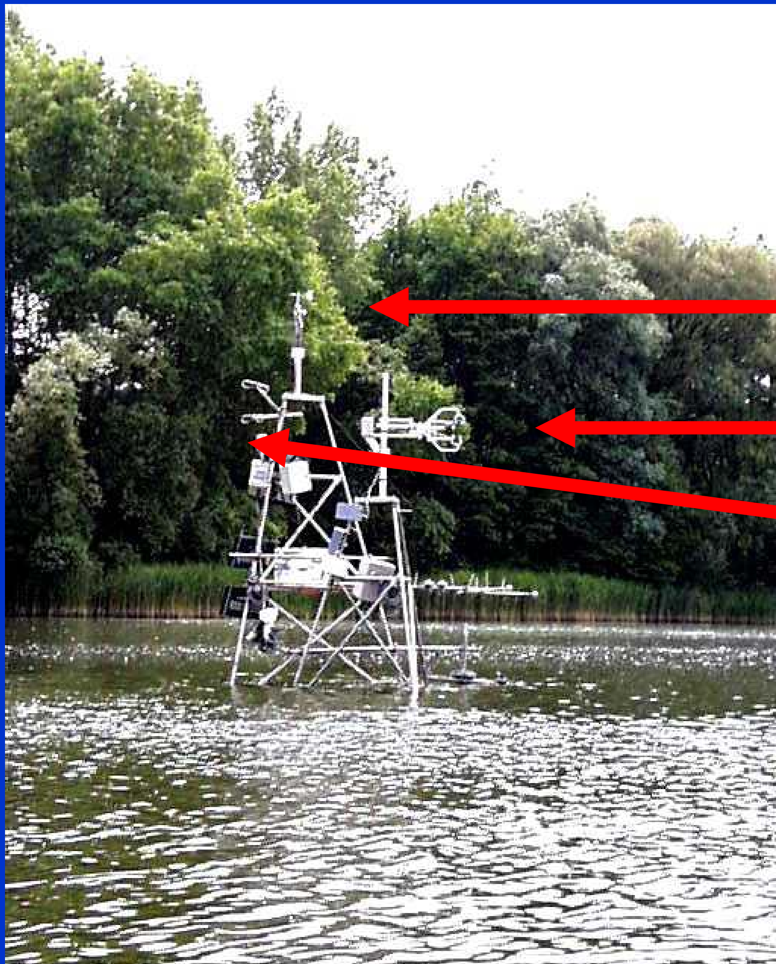

cup anemometer

CSAT3 + KH20

psychrometer

operated by
GKSS Research Centre

water depth approx. 2.5 m

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Institute of Water Problems, Moscow
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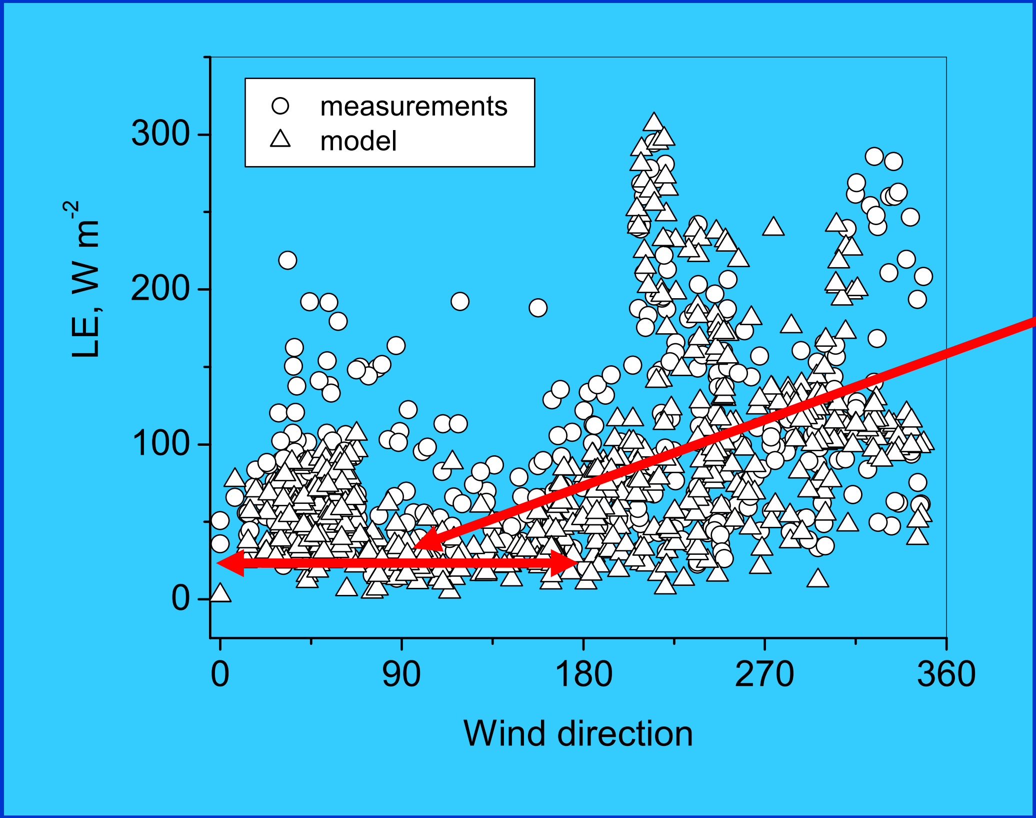
GKSS Research Centre; Geesthacht

Th. Foken
University of Bayreuth
Dept. of Micrometeorology

4. Validation of the Model



Large differences because of limited fetch and footprint conditions

Latent heat flux during the LITFASS-98 experiment and its dependence on the wind direction, modeled data according to model (parameterization + shallow lake)

G. N. Panin, A. E. Nasonov
Institute of Water Problems, Moscow
H. Lohse
GKSS Research Centre; Geesthacht

Th. Foken
University of Bayreuth
Dept. of Micrometeorology

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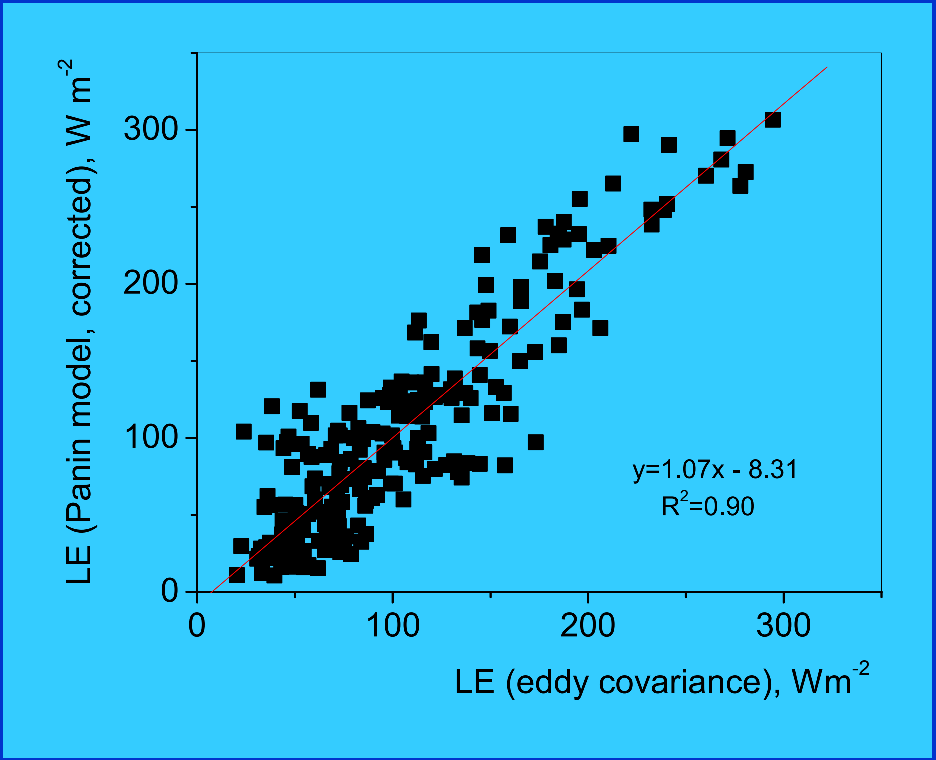

Comparison of the latent heat fluxes calculations according to the parameterization model by Panin with the shallow water correction and eddy covariance data for the 'Großer Kossenblatter See' during LITFASS-98

G. N. Panin, A. E. Nasonov
Institute of Water Problems, Moscow
H. Lohse
GKSS Research Centre; Geesthacht

Th. Foken
University of Bayreuth
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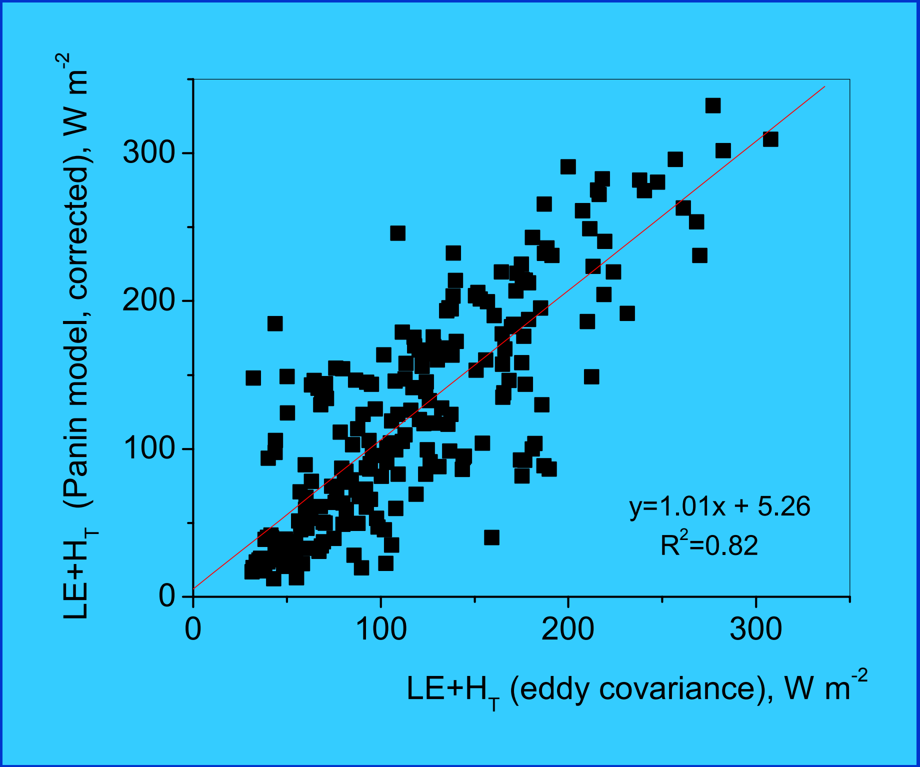

Comparison of the sum of the sensible and latent heat fluxes calculations according to the parameterization model by Panin with the shallow water correction and eddy covariance data for the 'Großer Kossenblatter See' during LITFASS-98

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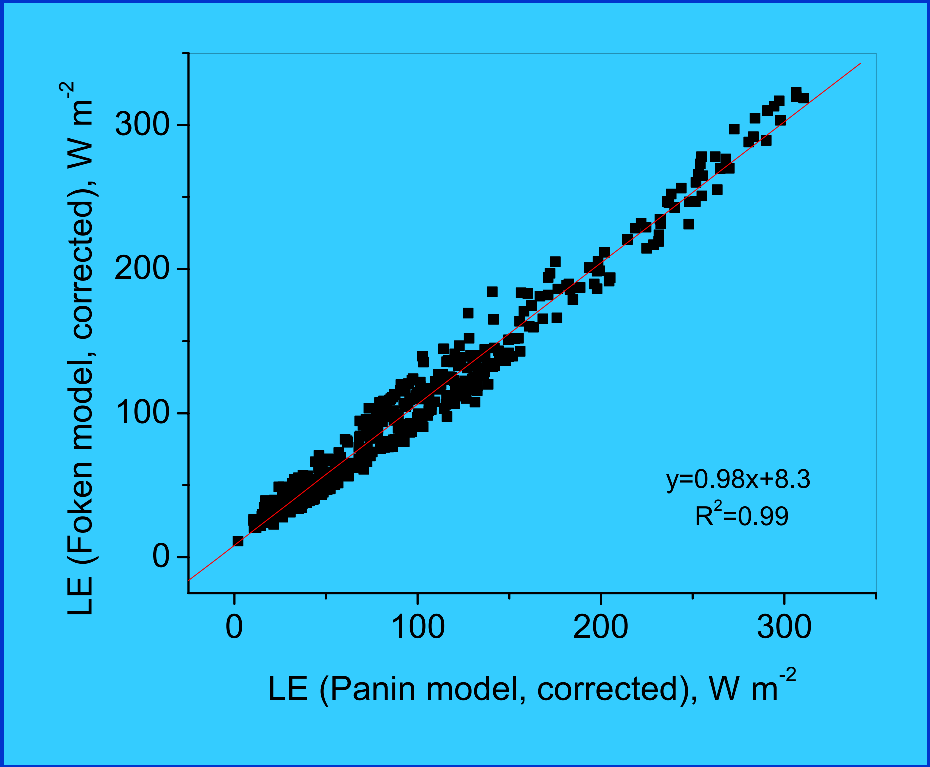

Comparison of the latent heat fluxes calculations according to the parameterization model by Panin and the three-layer model by Foken, both with the shallow water correction, for the 'Großer Kossenblatter See' during LITFASS-98

G. N. Panin, A. E. Nasonov
nstitute of Water Problems, Moscow
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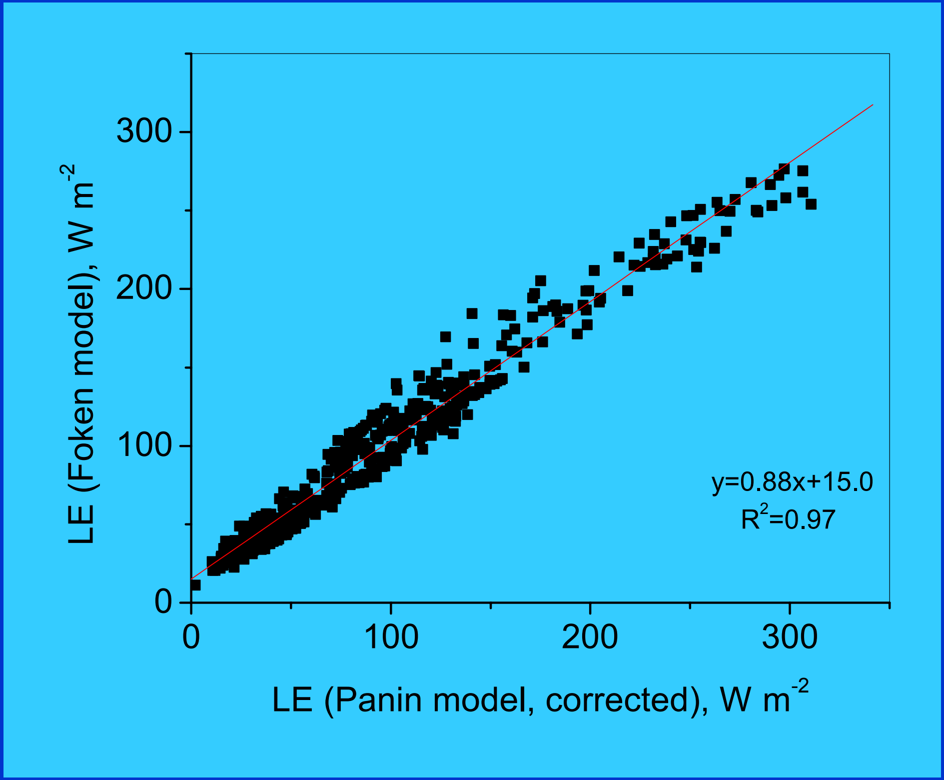

Comparison of the latent heat fluxes calculations according to the parameterization model by Panin with the shallow water correction and the three-layer model by Foken for the ‘Großer Kossenblatter See’ during LITFASS-98

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5. Conclusions

- Both the bulk parameterization and the three-layer models produce comparable turbulent fluxes.
- The shallow water correction increases the fluxes by approx. 10-15 %.
- Model results and direct measurements with the eddy covariance method are in a good agreement if footprint and fetch conditions are fulfilled.
- For limited footprint and fetch conditions, the model can be used as a gap filling technologies for direct measurements.

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