Aircraft Turbulence Measurements to Estimate Surface Heat Fluxes
from the Mixed Layer Variance Methods over Semi-arid Grassland in Mongolia

Ayumi Kotani and Michiaki Sugita (Univ. of Tsukuba)

Surface flux at regional scale can be obtained spatial observation by aircraft.

Variance method to estimate surface flux has virtue in need of only scalar measurements and directly available surface flux, in contrast to eddy correlation method.

Objective

To investigate the mixed layer variance method with airborne data

Aircraft Observation

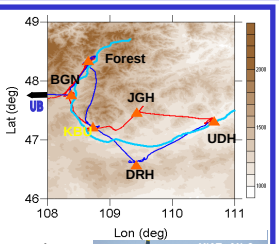
Kherlen river basin 2003-IOP (Jun-Oct, 11Flights)

Flight height: 100,200,500 and 1000m at each ground station

Flight speed: 100 - 150 km/hr

Path length: longer than 10km (5min)

10Hz sampling of air temperature, humidity and surface radiation temperature
(in this study, air temperature data processed to remove linear trend is used)

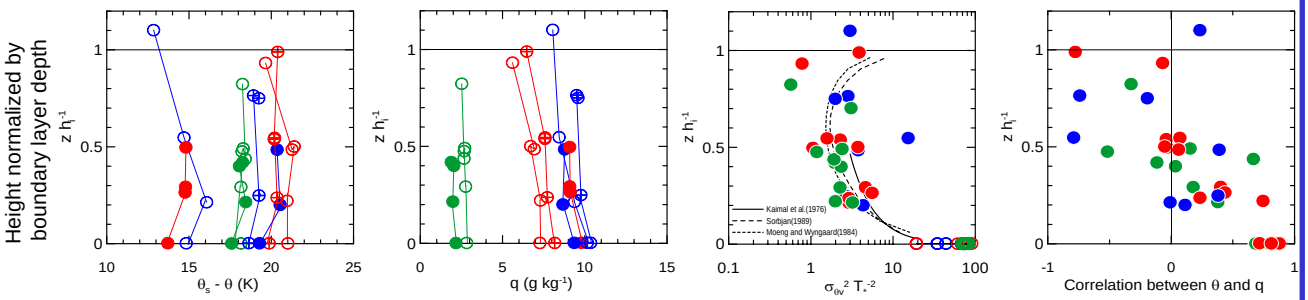


Ground Observation

As referenced surface flux
Flux station (KBU)
Eddy covariance method
[Directly measurements]
AWS station
(BGN, JGH, DRH, UDH)
Bulk similarity method
[temperature, humidity, radiation, wind speed, ground heat flux]

Vertical Profile of scalar statistics

July August October 12:00 - 16:00 (local noon～14:00)



- Vertical developments of boundary layer (700-1200m estimated by method of Liu et al.1997)
- Entrainment effect especially at the upper level (data scatter and negative correlation btw temperature and humidity

Flux Estimation by Variance Methods

Flux-variance relationship

1) Free convection model (only surface flux) for lower half of ABL [eg. Kaimal etal.,1976]

$$\frac{\sigma_\theta^2}{T_*^2} = a(z/h)^{-2/3},\ T_* = \left[\overline{\theta}\left(\overline{w'\theta'_0}\right)^2 (gh_i)^{-1}\right]^{1/3}$$

2) Top-down Bottom-up diffusion model (surface flux and inversion flux) [eg. Moeng and Wyngaard, 1984]

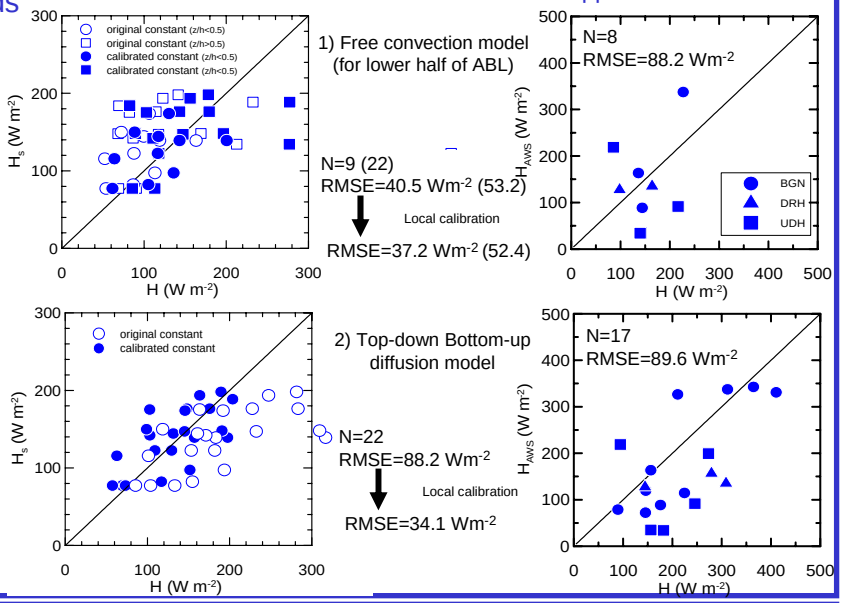
$$\sigma_\theta^2 = \underbrace{\left(\frac{\overline{w\theta_h}}{v_h}\right)^2 f_t(z/h)}_{\text{Top-down}} + \underbrace{2\left(\frac{\overline{w\theta_h}}{v_h}\frac{\overline{w\theta_0}}{v_0}\right) f_{tb}(z/h)}_{\text{Correlation term}} + \underbrace{\left(\frac{\overline{w\theta_0}}{v_0}\right)^2 f_b(z/h)}_{\text{Bottom-up}}$$

Calibration of the constants to fit the current data set

+ Variance of temperature→surface fluxes (not at the obs. height)

-- Requirement of some parameters (boundary layer height etc.)

Application to AWS site



Summary

The vertical profile of scalar statistics indicates the developments of mixed layer with effect of entrainment flux at the top of boundary layer.

Temperature variance has produced the sensible heat fluxes with an rms error of the order of 40 and 90 Wm^{-2} compared with eddy correlation method and bulk similarity method, respectively.