Issues of Heat Flux Estimation in Geothermal Areas and a Practical Checklist for Observing Temperature Distribution

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Remote observations of the temperature distribution of the ground surface in geothermal areas have been carried out widely. The formula (henceforth, SY formula) which Sekioka and Yuhara (1974) showed has been applied to many of these observation results to estimate heat fluxes.

SY formula is one of the methods to estimate heat flux from heat balance at the ground surface. It presumes that heat flux in geothermal area is the sum of the following terms.

(1) Radiation anomaly from the ground surface.

(2) Anomaly of atmospheric radiation computed by the empirical formula from the ground surface temperature and cloud amount.

(3) Anomaly of sensible heat flux presumed by product of an averaged parameter of transfer velocity and estimated vertical gradient of temperature near the ground surface above.

(4) Latent heat flux presumed by (3) divided by Bowen ratio.

According to Sekioka (1983), heat flux is mainly depending on (3) and (4) in typical geothermal areas. After basic meteorological consideration on surface layer, we have found that each term of (2), (3) and (4) contains the below-mentioned issue, respectively.

- Issue on (2): According to Churei et al. (1986), radiations of any two adjacent areas are almost the same. This term should be removed.
- Issue on (3): Sensible heat flux is dependent on wind velocity. In case of small wind velocity, natural convention, which is approximately proportional to vertical gradient of temperature near the ground surface to the power of 4/3, plays a leading role of it. In the other cases, it probably is proportional to both average wind velocity and the vertical gradient of temperature near the ground surface above.
- Issue on (4): Latent heat flux can be approximated to zero, except when ground surface is moist, namely except when there is precipitation or soon after that. This term can be removed.

What we point out above support Sekioka's (1986) indication that the method should be completely reviewed.

Based on these points and some observation data in 2002 by Japan Meteorological Agency, we propose the checklist as below for periodical observation of the temperature distribution of the ground surface in geothermal area. This checklist is made from a viewpoint of using observation data for evaluation of heat activities in geothermal areas.

(1) Weather, cloud amount, atmospheric temperature, vapor pressure and average wind velocity should be recorded as weather condition during each observation.

(2) Following weather conditions should be avoided because they possibly give an unrepresentative heat flux.

- Daytime and immediately after sunset
- Raining and soon after an end of rain
- Unusually high or low temperature and very strong wind

These conditions may influence radiation, latent heat flux and sensible heat flux, respectively.

(3) Evaluating changes of distribution pattern of temperature anomalies or temperatures at fixed points are effective.

(4) Reference points in geothermal areas must have similar surface radiation characteristic (e.g. vegetation and inclination) to the objects of observation.

(5) Experiment for studying the influence of a weather condition is desirable.

(6) At most geothermal areas with recognized gas emissions, fumaroles have much more heat flux than ground surface has. Fumarole activities in these areas also should be observed.

We would like to collect data set obtained by observation according to the above checklist, in the very near future. Then, we will propose a practical formula that gives estimated heat flux of geothermal area in consideration of weather conditions.