# Diurnal Variations of Surface Fluxes and Boundary Layer over Tibetan Plateau (Session 3: In-site Flux Observation studies)

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# Diurnal Variations of Surface Fluxes and Boundary Layer over Tibetan Plateau

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## Abstract

During the GAME-Tibet IOP, surface eddy fluxes were directly measured at four stations as well as radiation fluxes. These flux data were summarized and compared in the diurnal and seasonal basis. Another important issue is the interaction between the surface fluxes and the atmospheric boundary layer. It is clearly observed in sensible heat flux and mixed layer development, and mixed layer during the daytime leads to large amplitude of diurnal variation in surface wind speed.

## 1. Introduction

During the GAME-Tibet IOP, in-situ surface measurements were carried out in many sites and already reported preliminary in the previous papers. Among the surface meteorological stations, surface eddy flux were directly observed at 4 sites. Other meteorological site data can be lead to surface fluxes using profile or bulk aerodynamic formula with some assumptions.

In the present study, diurnal and seasonal variations are summarized for the eddy flux sites and the interaction between surface fluxes and boundary layer are discussed.

## 2. Surface flux measurements

Four eddy flux sites were selected among the surface meteorological stations. In these sites, net radiation and soil heat flux data are directly available and heat fluxes of sensible heat and latent heat were obtained with turbulence measurements. These sites are listed as follows.

1) Amdo PBL site(32 ° 15'N, 91 ° 38'E, 4700m; short grass)
2) North PAM site(31 ° 55'N, 91 ° 42'E,4765m; wet short grass)
3) Naqu BJ site(31 ° 22'N, 91 ° 54'E, 4496m; short grass)
4) South PAM site(31 ° 01' N, 91 ° 39'E, 4820m; short grass)

Surface measurement system are almost similar in these 4 sites and details are given in Table 1. Surface soil heat flux is the most difficult one to determine as normal heat flux plate only measures at some depth.

Table 1 Flux measurement system at 4 eddy flux sites

| Site Name | QN | QG | QH | QE |
|---|---|---|---|---|
| Amdo PBL | 4-comp. Meas. | Flux plate | SAT | SAT+IR |
| North PAM | 4-comp. Meas. | Flux plate | SAT | Bandpass |
| Naqu_BJ | 4-comp. Meas. | Fluxplate+storage | SAT+Wire | SAT+Krypton |
| South_PAM | Net meas(Q7) | Flux plate | SAT | (none) |

### 3. Diurnal/seasonal variations of surface processes and atmospheric boundary layer

According to the previous studies, the monsoon onset was clearly observed in the middle of June on the plateau. Surface fluxes also changed from sensible heat release to latent heat release. Fig.1 shows sensible heat flux variation during the IOP. (Unfortunately some data are missing June for Naqu and SPAM sites.) Sensible heat flux change due to monsoon onset is more clearly observed in Amdo site than NPAM site, as the latter is situated in rather wet area. Combining with the latent heat flux data, total flux of sensible heat and latent heat are almost constant throughout the IOP.

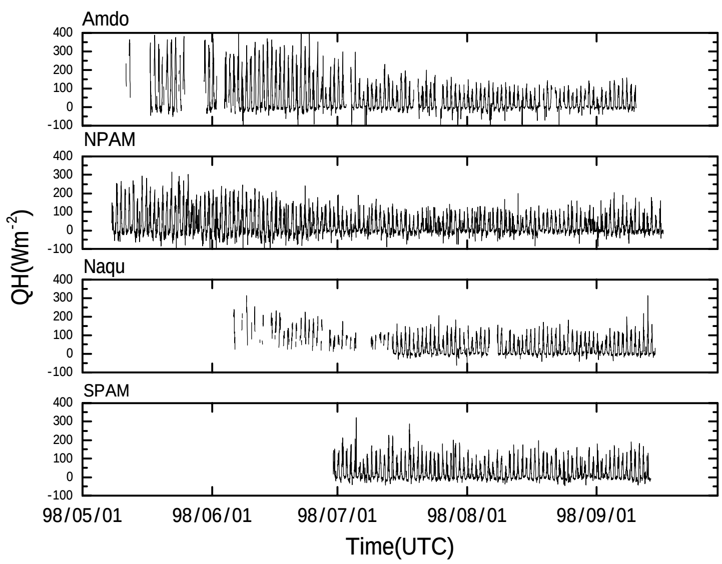


Fig.1 Sensible heat flux time series in 4 eddy flux site

The structure of the atmospheric boundary layer are obtained from the GPS sonde at Amdo PBL site(Endo et al.,1999). The routine upper air soundings were made 3 times a day(00,06,12UTC) and additional soundings(3 hourly;8 times a day) were made for the enhanced period(6-21 June).  In order to find the differences between pre-monsoon and monsoon period, diurnal variations of surface fluxes(QN: Net radiation, QH: Sensible heat flux, QE: Latent heat flux) are plotted in Fig.2.

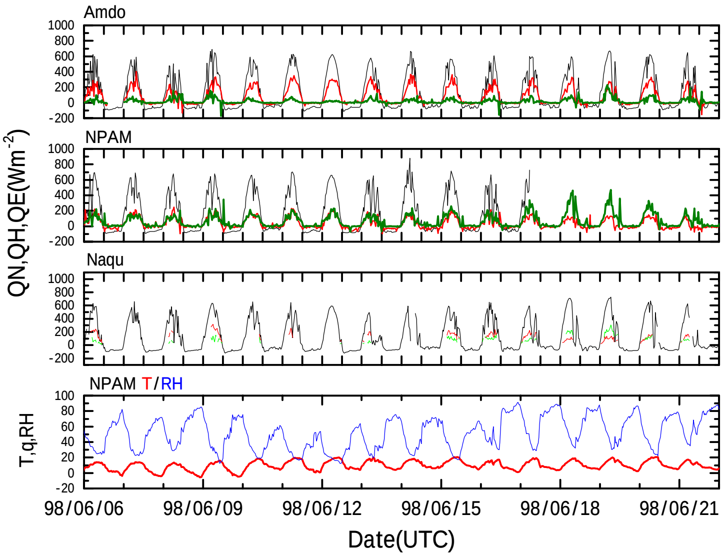


Fig.2  Diurnal variations of surface heat fluxes(upper 3 figs) and air temperature /humidity(lowest) during the sonde enhanced period(upper 3 figures)

According to the upper air sounding data, the monsoon onset was observed in 13 June (Endo et al.,1999), which is based on specific humidity increase in the boundary layer. However, surface precipitation started on 17 June and surface soil moisture increased on the day. Accordingly, dominant surface heat flux changed from sensible heat to latent heat in 17 June at NPAM site as shown in the figure. Amdo site and Naqu site data also shows large latent heat flux after 17th.

During the pre-monsoon period, sensible heat supply was dominant and well defined mixed boundary layer were observed as high as 2000m from the surface. Throughout the mixed layer, potential temperature and specific humidity are almost constant with height. This mixed layer is considered to be the result of active sensible heat supply from the surface. Due to large convective mixing, upper air large momentum is easily transported to surface layer and daytime surface wind speed(westerly) increases very sharply as shown in Fig.3. The upper air sounding data also shows the large wind speed down to the surface. While, during the monsoon period after mid June, well defined dry mixed layer is less observed as the sensible heat supply decreases. As a result, wind speed increase during the daytime is less dominant as shown in the figure.

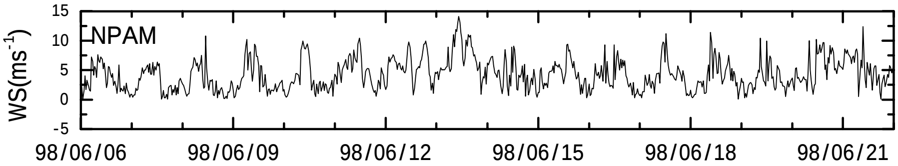


Fig.3 Diurnal variations of surface wind speed in June

## 4. Concluding remarks

In order to understand surface heat and water balance in the whole plateau area, remote sensing technique can be applied with surface validation data. In the present study, 4 eddy flux site data were summarized. These data are useful not only for surface validation but also for understanding of surface transport mechanism. Heat and water vapor transport to the atmosphere control the atmospheric boundary layer evolution. The boundary layer structure evolution feed back to surface layer structure and again reflected to the surface fluxes.

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