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The Implication of Heat and Water Balance Changes in a Lake Basin on the Tibetan Plateau

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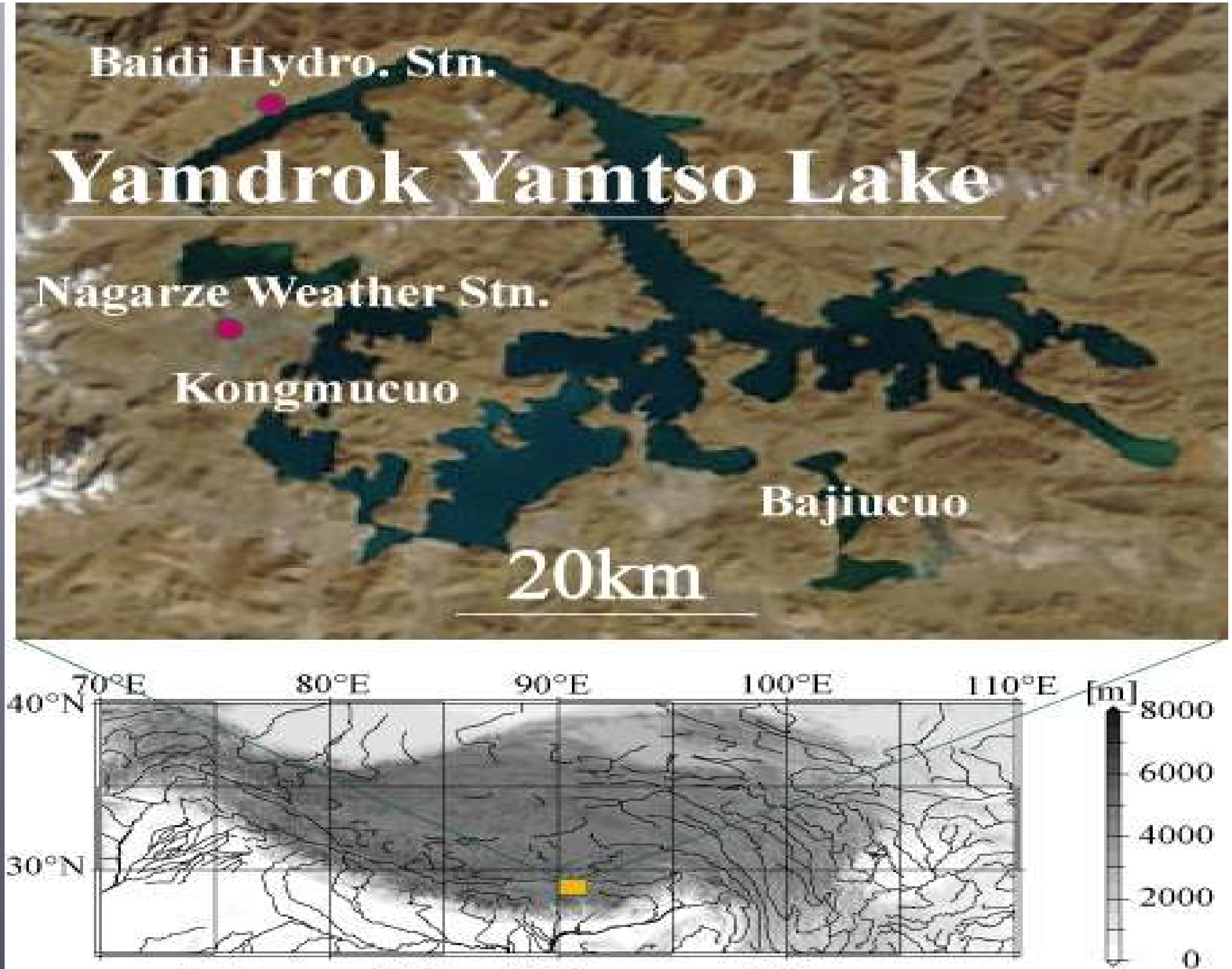
Location



Map of the Tibetan Plateau

The distance from hydrological station to meteorological station is about 18km (Xu etal,2009)

Study purpose:

Lakes play a key role in continental hydrological cycles. The Tibetan Plateau contains numerous lakes covering a total area of 44,993.3km^2, including more than 1091 with individual areas greater than 1.0km^2.

Yamdrok Yumtso Lake is one of the three largest lakes of the Tibetan Plateau. Situated 120km south of Lhasa at 4441m above sea level, the lake has a catchment area of approximately 6110km^2 and surface area of 638km^2.

However, the plateau is extremely sensitive to global warming. The mechanism of the water cycle change is still unknown.

In this study, we estimated the heat and water balance and analyzed the seasonal and longterm change in the Yamdrok Yumtso Lake basin.

Yamdrok Yumtso Lake

Observed water temperature data: 1978-1995 (May-Sept.)

Daidi hydrological station

Large Pan: area=20m², depth= 2m, This type of pan is known as a "20m² basin", The evaporation from the pan is nearly the same as the real evaporation of a lake.

Data period: 1984-1995 (May-September)

Small Pan:

Diameter = 20cm

Data period:

1961-2005

Calculation Method for lake evaporation:

$R{\downarrow} = \varepsilon\,\sigma T_S{}^4 + H + \iota E + G,$ (1)

$H = c_p\,\rho\,C_H U\,(T_S - T_A),$ (2)

$\iota E = \iota\,\rho\,\beta\,C_H U\,(q_S - q_A),$ (3)

$G = c_w \rho_w\, z\, dT/dt.$ (4)

Here, $R{\downarrow} = (1 - ref)\,S{\downarrow} + \varepsilon L{\downarrow}$.

For water surface, $\varepsilon = 0.98$, $\beta = 1$, and $ref = 0.06$

It is said that the depth of lake is about (z=)2-8 meters,

Lake can be considered as a finite water surface. The averaged width of the lake is about (X=) 4km, the original form of (3) is

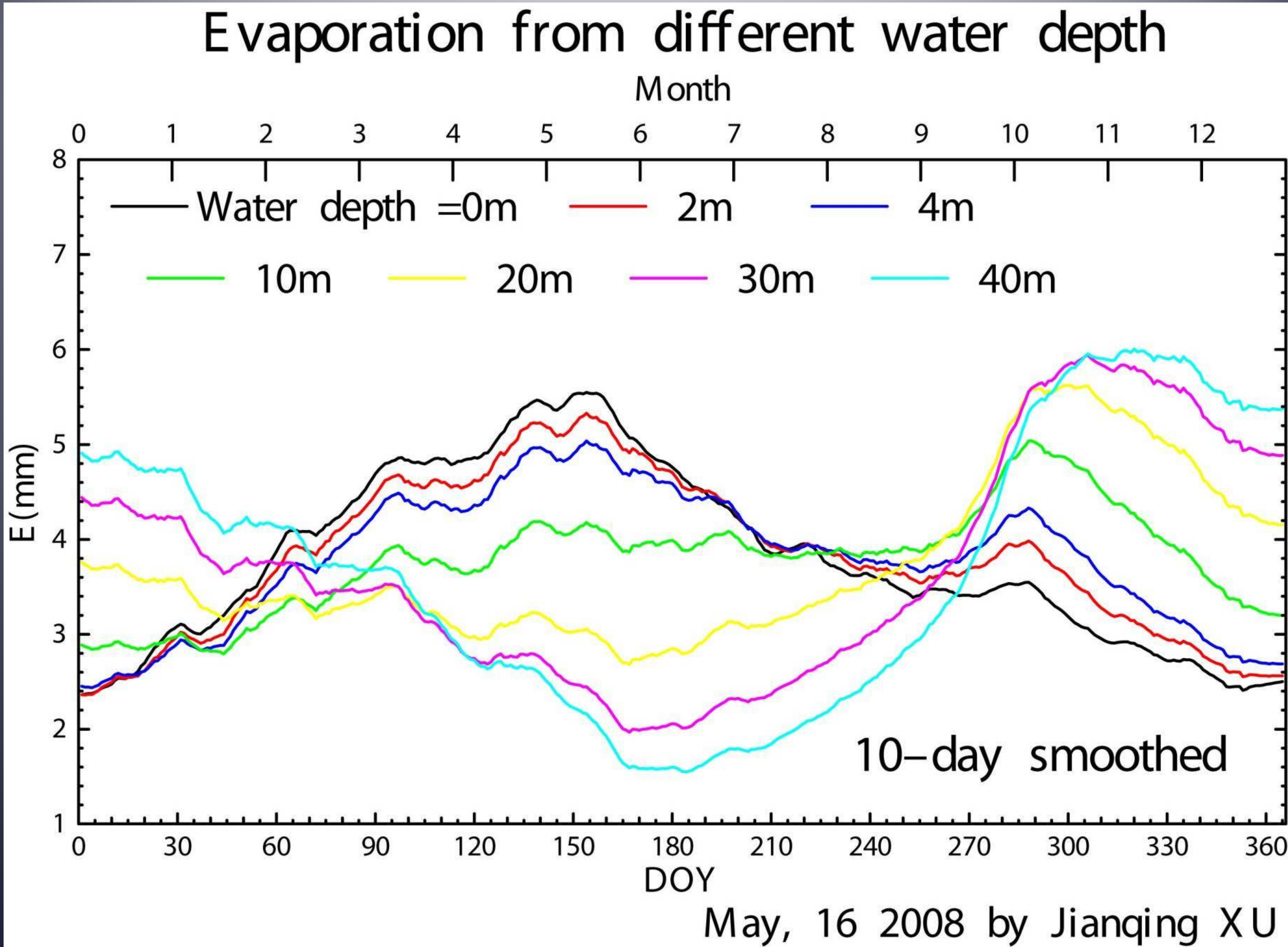
$E = J/2\,\rho\,U\,(q_S - q_A)\,Sc^{-2/3},$

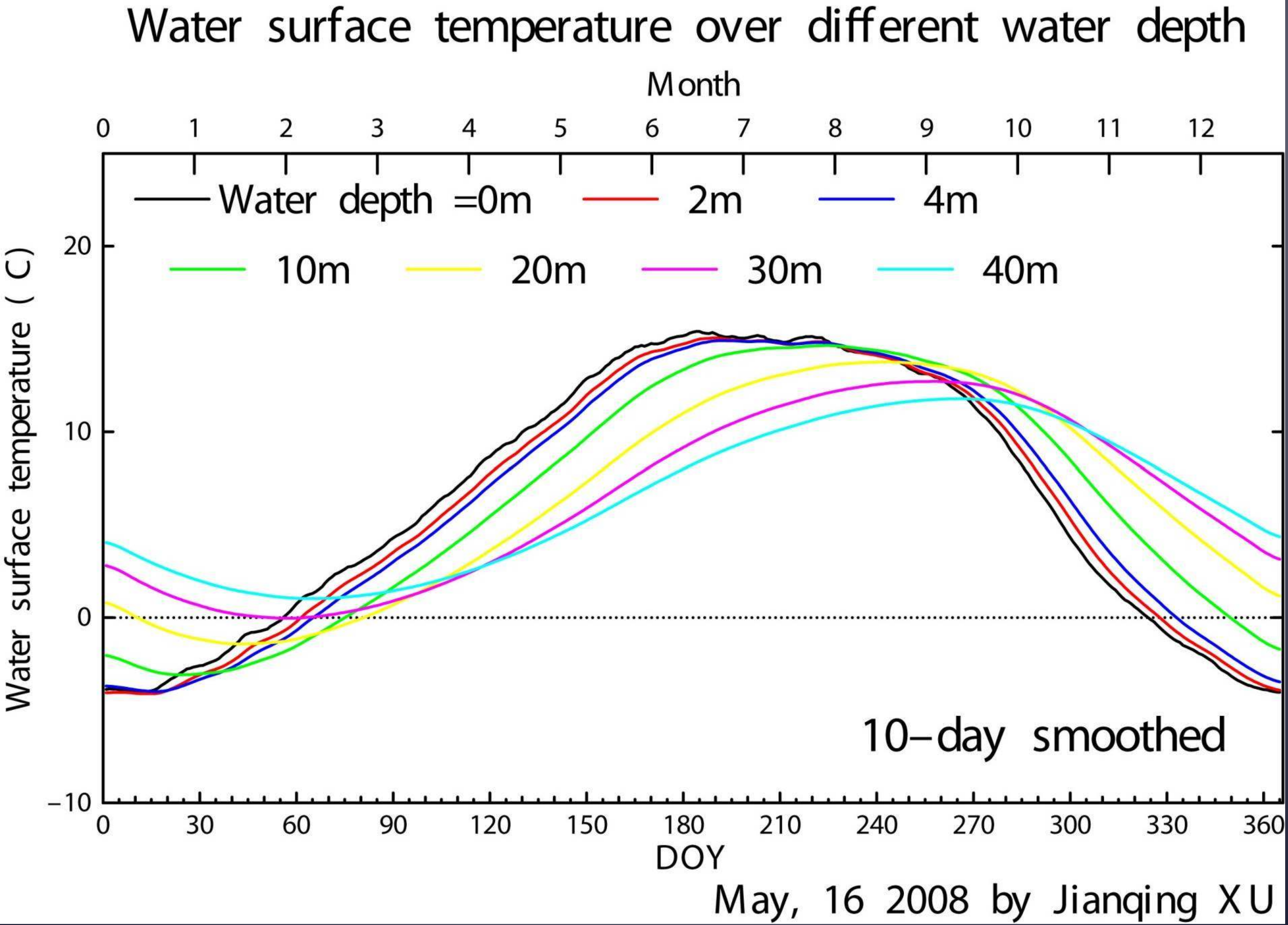
Where, Schmidt number $Sc = \nu / Datm$,

ν is kinematic viscosity coefficient of air, Datm the coefficient of molecular diffusion of vapor.

J is a function of turbulent Reynolds number Re, and $Re = X\,U/\nu$

When Z=0, evaporation is potential evaporation Ep, and wetness index WI=Ep/Pr, where Pr is precipitation.


Evaporation from different water depth
Month
0 1 2 3 4 5 6 7 8 9 10 11 12
Water depth =0m
2m
4m
10m
20m
30m
40m
E(mm)
8 7 6 5 4 3 2 1
10-day smoothed
0 30 60 90 120 150 180 210 240 270 300 330 360
DOY
May, 16 2008 by Jianqing XU


Water surface temperature over different water depth
Month
0
1
2
3
4
5
6
7
8
9
10
11
12
Water depth =0m
2m
4m
10m
20m
30m
40m
20
10
0
−10
Water surface temperature (C)
10−day smoothed
0
30
60
90
120
150
180
210
240
270
300
330
360
DOY
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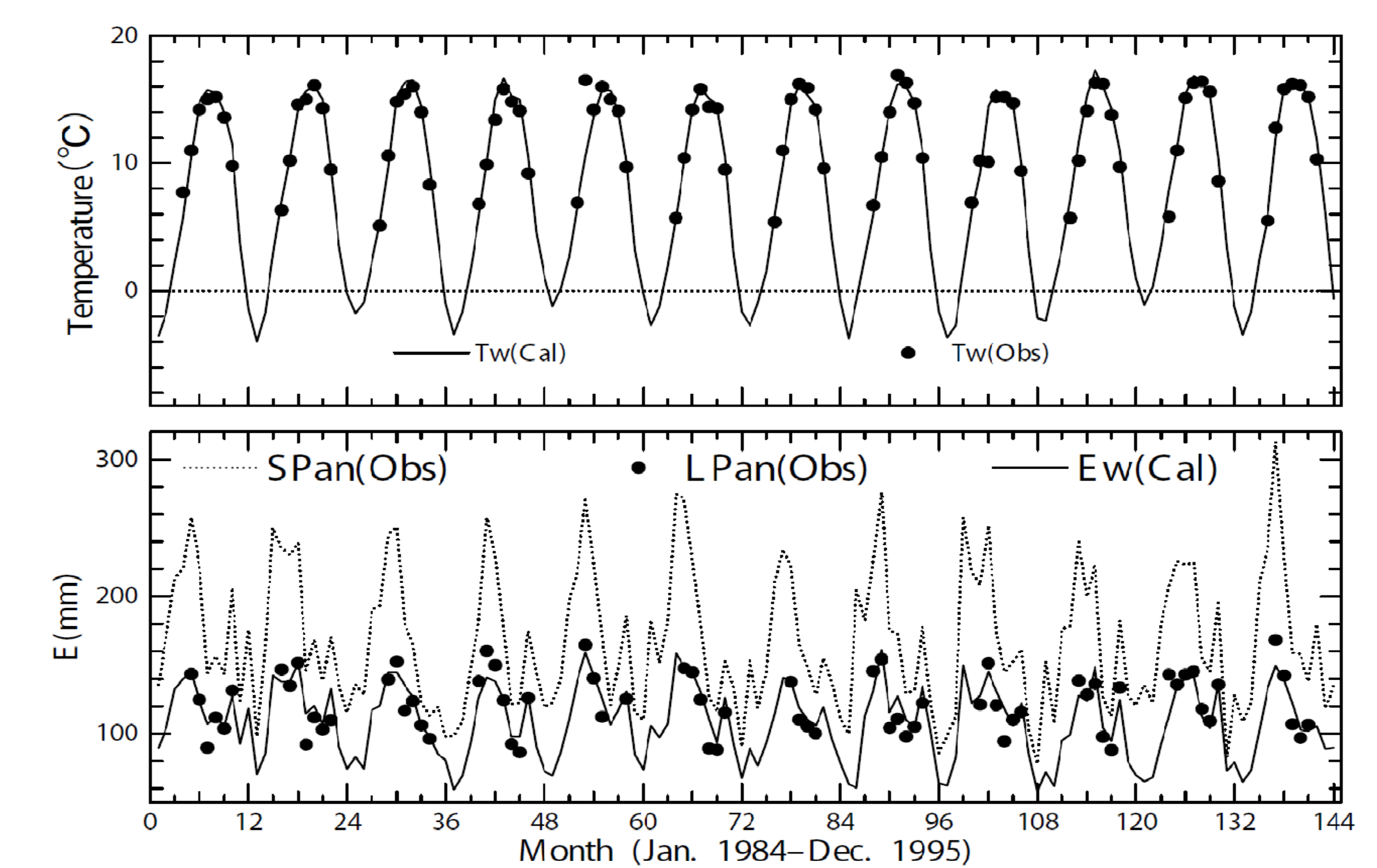
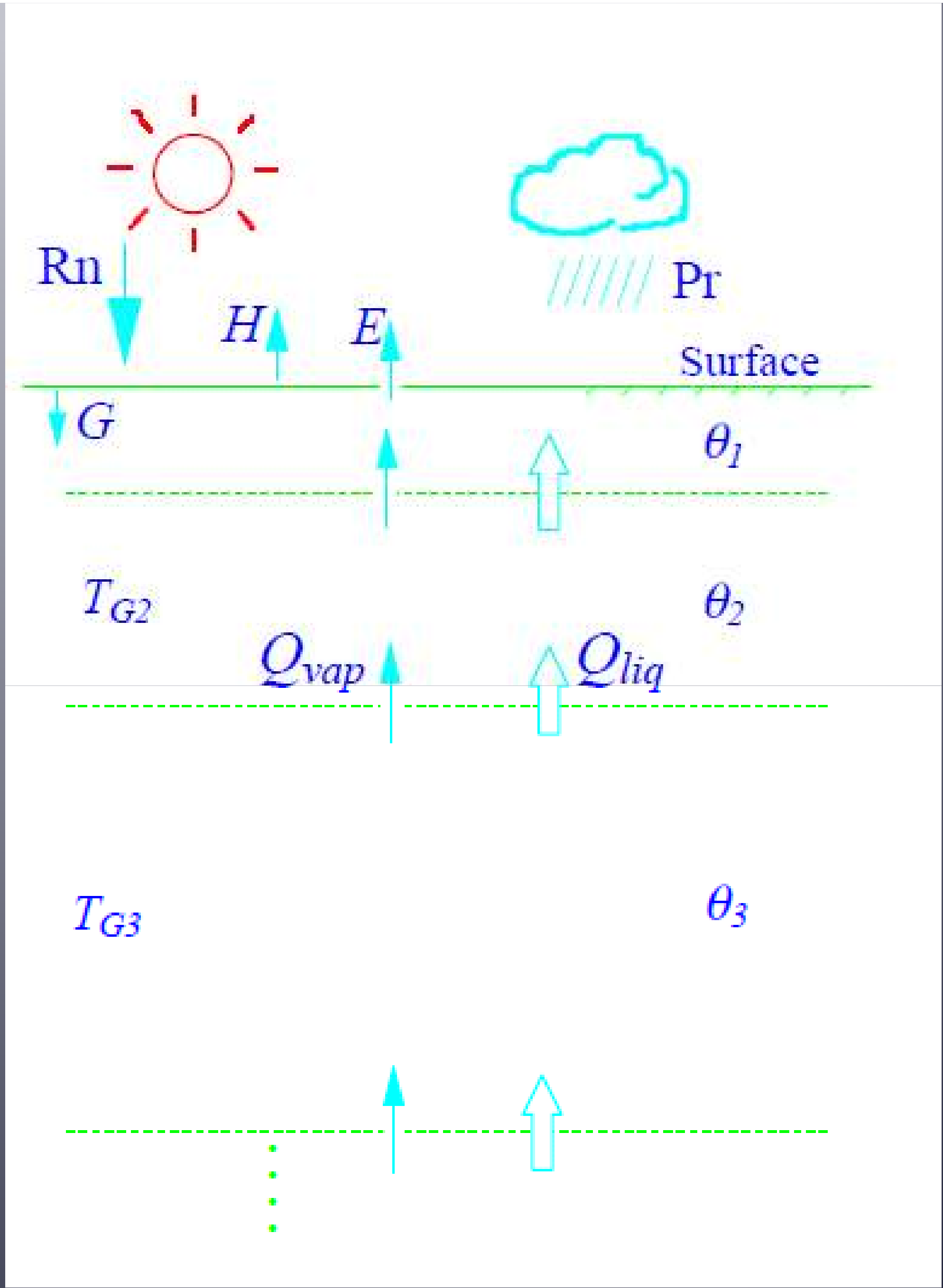
Seasonal changes of the observed water temperature (top) and pan evaporation (bottom). The solid lines and black circles show the calculated results and the observations, respectively. The dotted line shows the observed small pan data.(Xu etal,2009)



Multi-layer soil model (Kondo & Xu, JAM,1997) for the Land Surface.



Monthly variations of the heat and water balance of the basin. Heat fluxes over

(a) the lake's surface

(b) land surface.

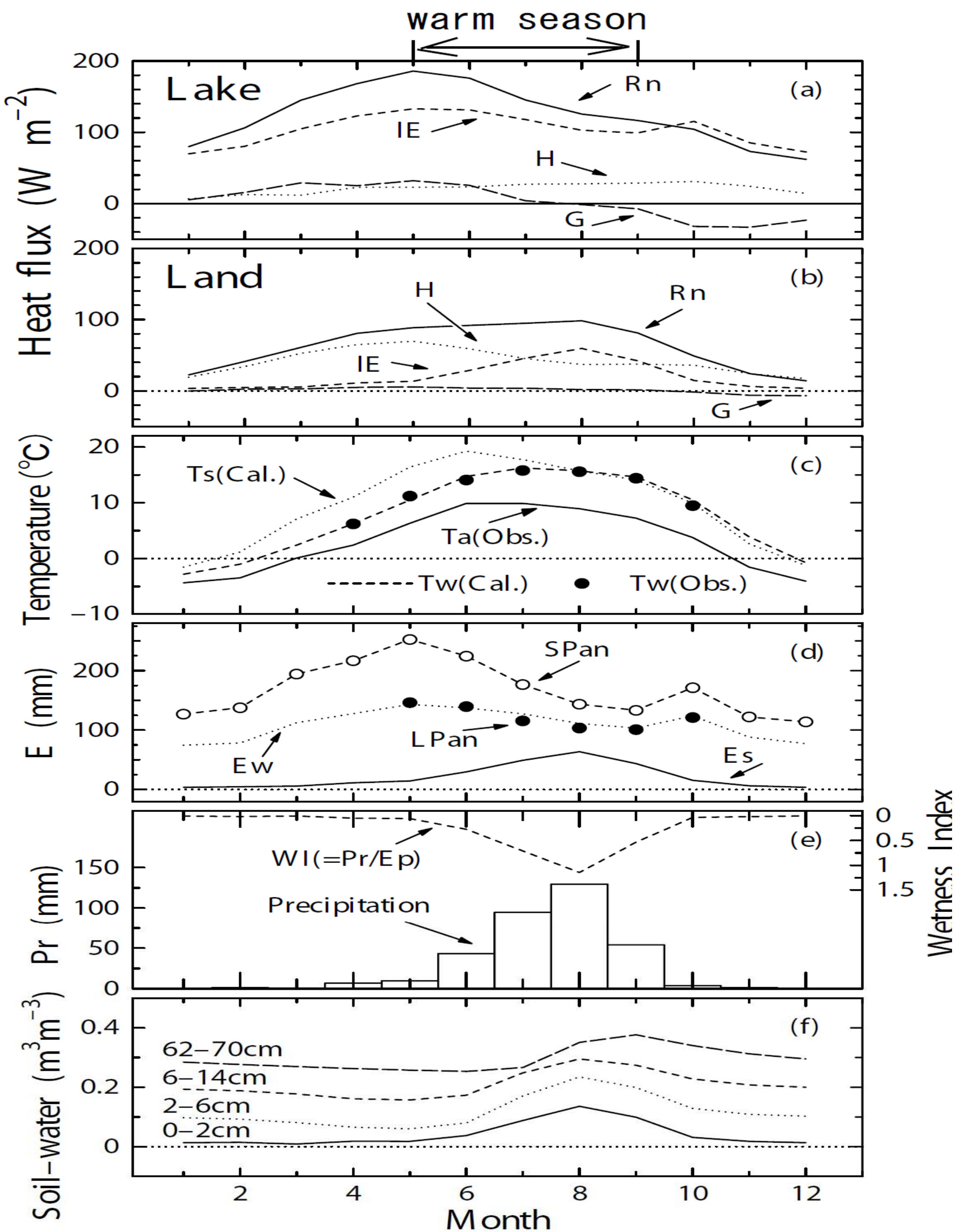
(c) Land surface temperature T_S, water temperature *Tw*, and observed air temperature.

(d) Observed SPan evaporation, LPan evaporation, and calculated evaporation from the lake *Ew* and land surface *Es*.

(e) Precipitation *Pr* and wetness index *WI*.

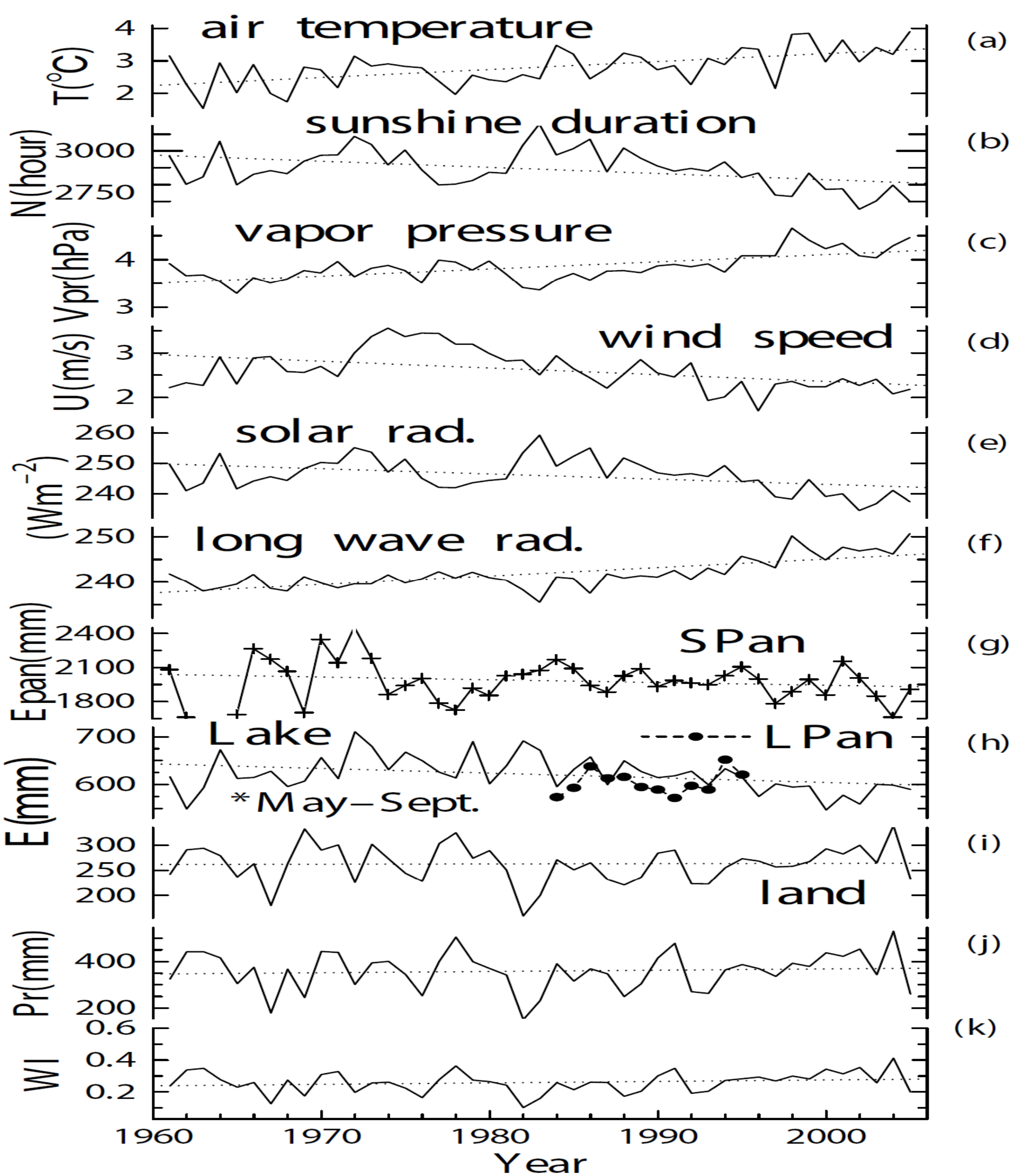
(f) Volumetric soil water content for four layers.

(Xu etal, 2009)



Interannual variations for the basin 1961-005. Dotted lines represent the trends obtained by linear regression.

(a) Air temperature,
(b) sunshine duration,
(c) vapor pressure,
(d) wind speed,
(e) solar radiation flux,
(f) longwave radiation flux,
(g) small pan evaporation,
(h) evaporation from the lake and large pan,
(i) evaporation from the land surface,
(j) precipitation,
(k) *WI*.
(Xu etal,2009)



Summary and concluding remarks

We analyzed variation in the water cycle in Yamdrok Yumtso Lake basin under the temperature increase of 1.13C during the 45 years from 1961-2005. Both vapor pressure and relative humidity increased by approximately 17%, resulting in a 13.7% increase in longwave radiation flux and a smaller daily range of surface air temperature. A 5.7% decrease in sunshine duration caused solar radiation flux to decrease by 3%. The lake covers 10% of the total basin area. Evaporation from the lake was larger than that from land, with lake evaporation making up 26% of the basin total. Evaporation from the lake decreased 7% (May-September) over the study period, and observed small pan evaporation also decreased. This trend was not found in the evaporation from land and from precipitation. With water vapor in the air increasing and evaporation from the ground surface (lake and land) decreasing, the water vapor may have come from areas outside the basin and possibly even beyond the plateau. Future research will analyze long-term change in large-scale weather conditions around the plateau. (Xu etal, 2009)

Thank you!
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