Yale 耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

Global lake evaporation: patterns and trends

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Outlines

1. Background & Objective
2. Preliminary results
   - Global lake evaporation distribution
   - Zonal variation trend and zonal temperature sensitivity
   - Evaporation vs. air temperature
   - Selected lakes
   - Global mean

Priestley-Taylor (PT) model

$$\beta = \frac{H}{\lambda E} \qquad EF = \frac{\lambda E}{R_n}$$

$$R_n - G = H + \lambda E$$

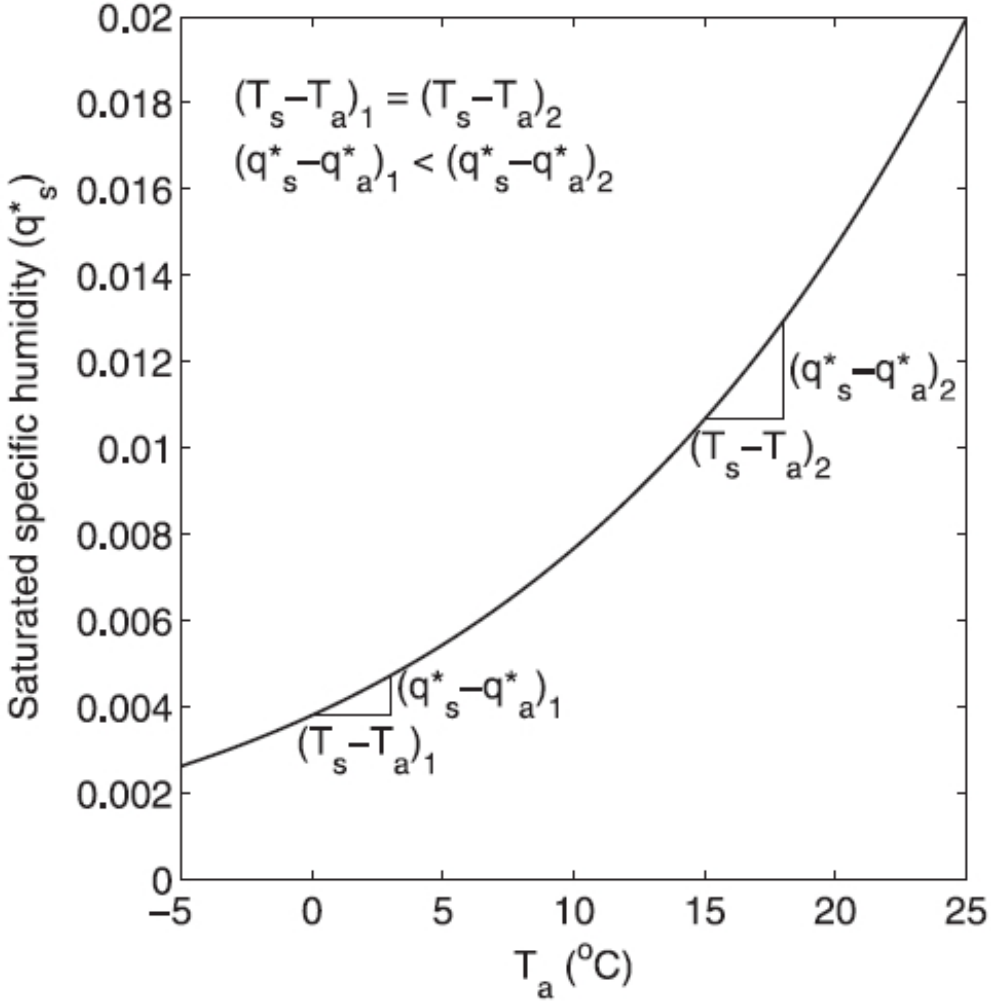
$$H = \rho_a c_p C_H u(T_s - T_a)$$

$$\lambda E = \rho_a \lambda C_E u(q_s - q_a)$$

$$\lambda E = \alpha \frac{\Delta}{\Delta + \gamma}(R_n - G)$$

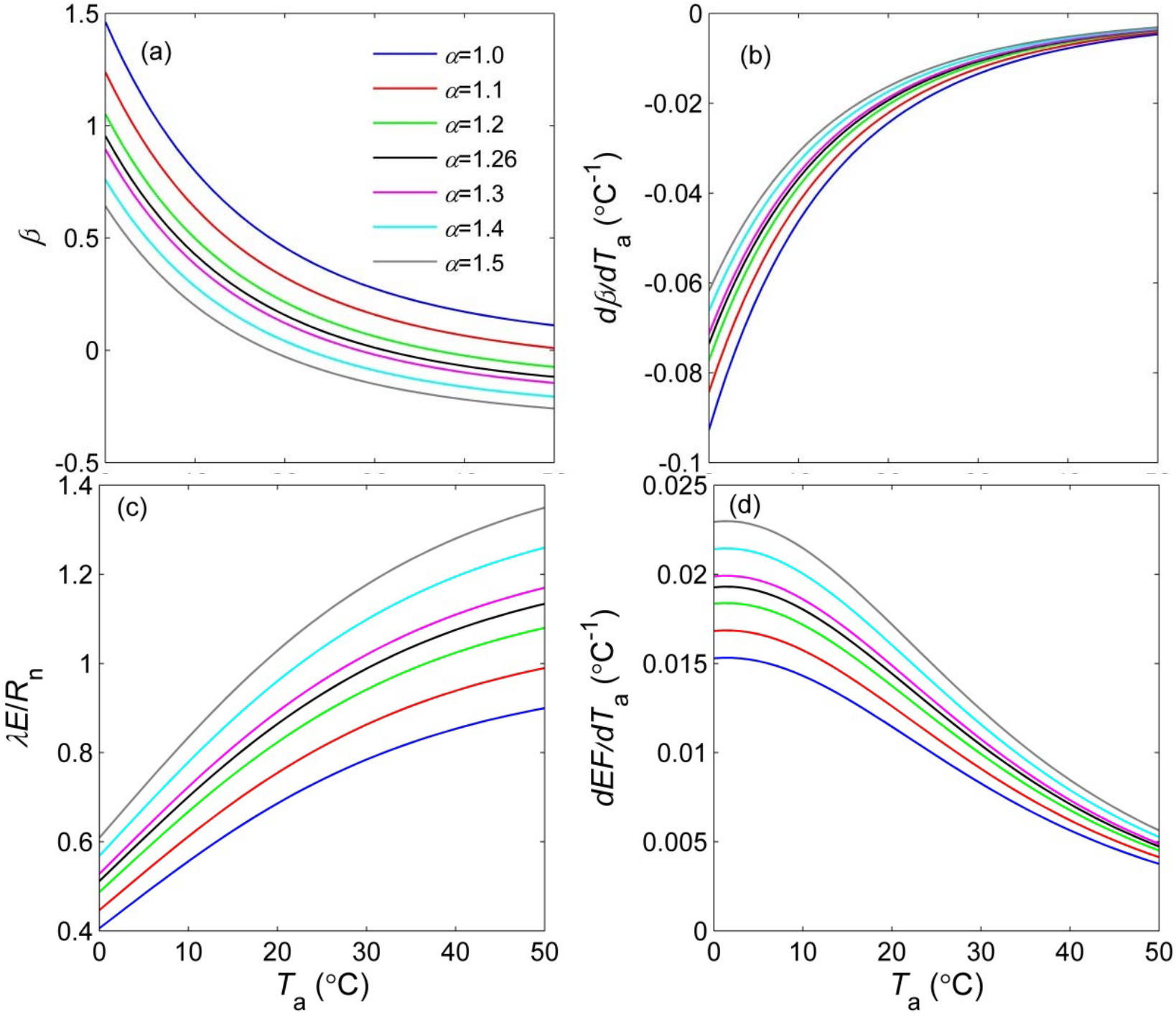
$$\beta = \frac{1}{\alpha}\frac{\gamma}{\Delta} + \frac{1}{\alpha} - 1$$

$$EF = \frac{1}{1+\beta}$$

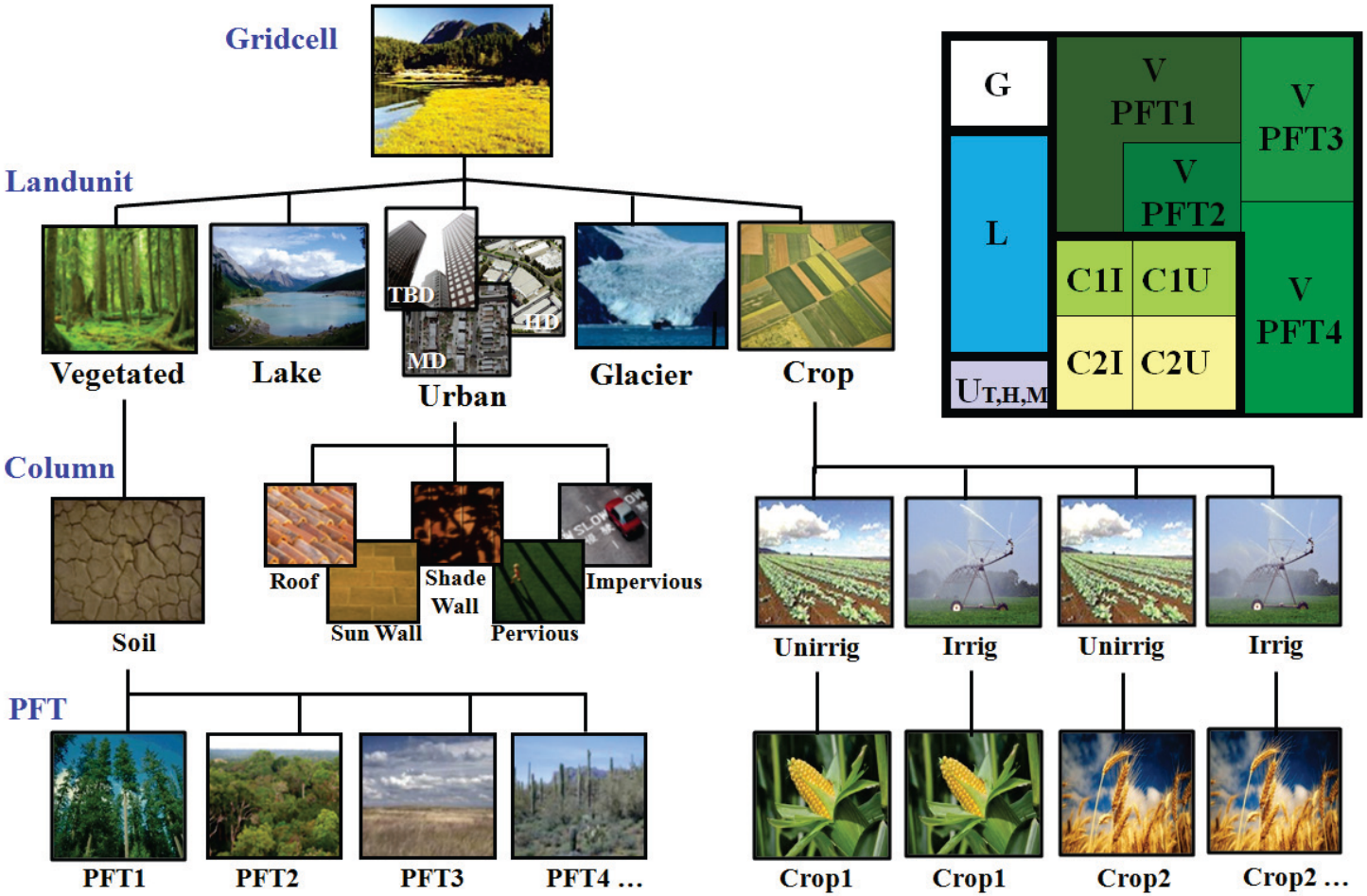


(Priestley and Taylor, 1972; Brutsaert, 1982; Garratt, 1992)

(Monteith, 1981)


(a)
(b)
(c)
(d)
α=1.0
α=1.1
α=1.2
α=1.26
α=1.3
α=1.4
α=1.5
β
dβ/dT_a (°C^-1)
λE/R_n
dEF/dT_a (°C^-1)
T_a (°C)
T_a (°C)

Configuration of the CLM subgrid hierarchy



(Oleson et al., 2013)

Global Lake and Wetland Databse
Global Lake Database version 2 used in CLM4.5-LISSS

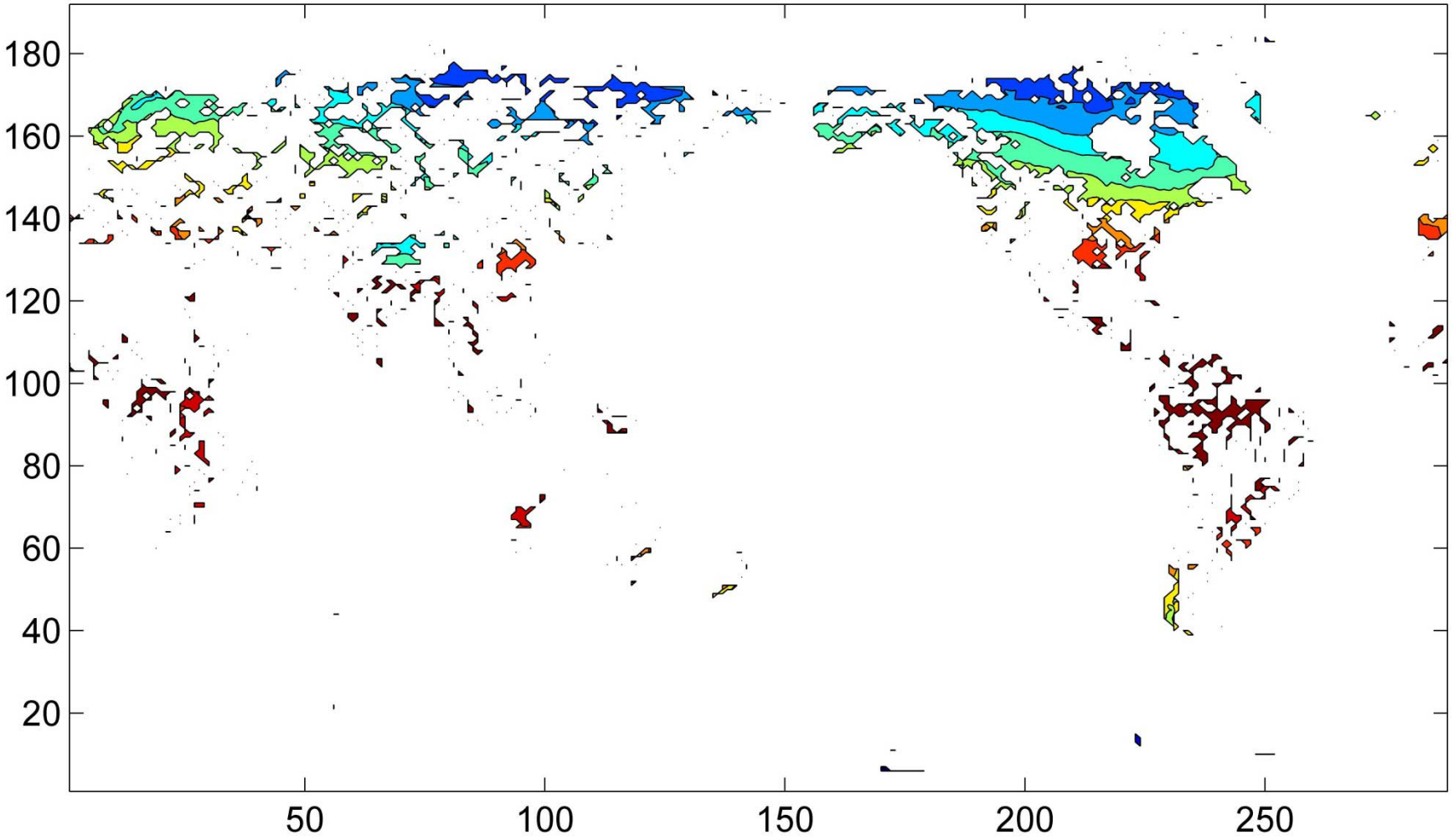
Lake type	Number	With depth	Fraction %	<5 m	<5 m fraction %	<10 m	<10 m fraction %
Freshwater	13155	8378	63.69	2247	26.82	6180	**73.76**
Saline	221	144	65.16	100	69.44	118	**81.94**
All	13376	8522	63.71	2347	27.54	6298	**73.90**

Global lake coverage: 2.3 million km^2.

20-year (1991-2010) simulation was conducted using CLM4.5-LISSS by Zachary Subin on monthly scale.

(Lehner and Doll, 2004;
Kourzeneva et al., 2009, 2010, 2012)

Global lake distribution



Surface flux solution in CLM4.5-LISSS

$$\beta\vec{S}_g - \vec{L}_g - H_g - \lambda E_g - G = 0$$

$$H_g = -\rho_{atm} C_p \frac{\left(\theta_{atm} - T_g\right)}{r_{ah}}$$

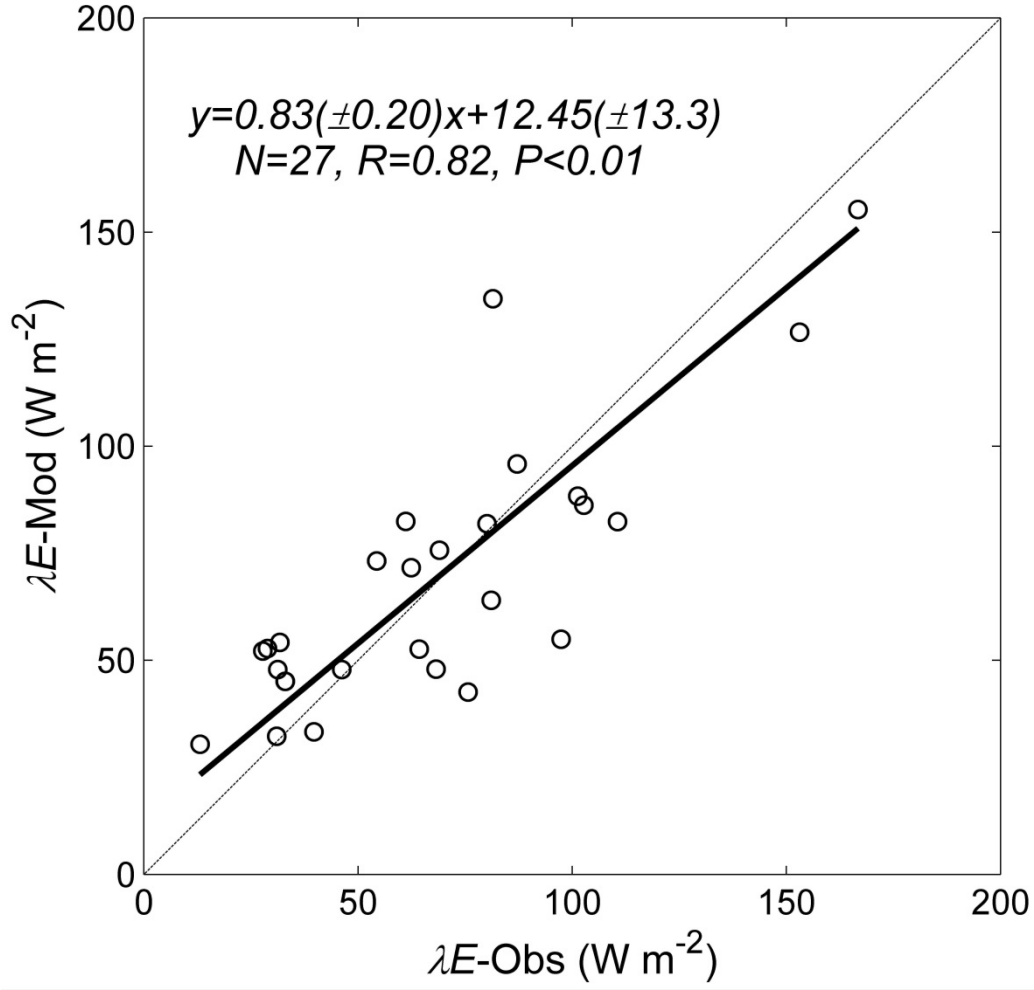
$$E_g = -\frac{\rho_{atm}\left(q_{atm} - q_{sat}^{T_g}\right)}{r_{aw}}$$

(Oleson et al., 2013)

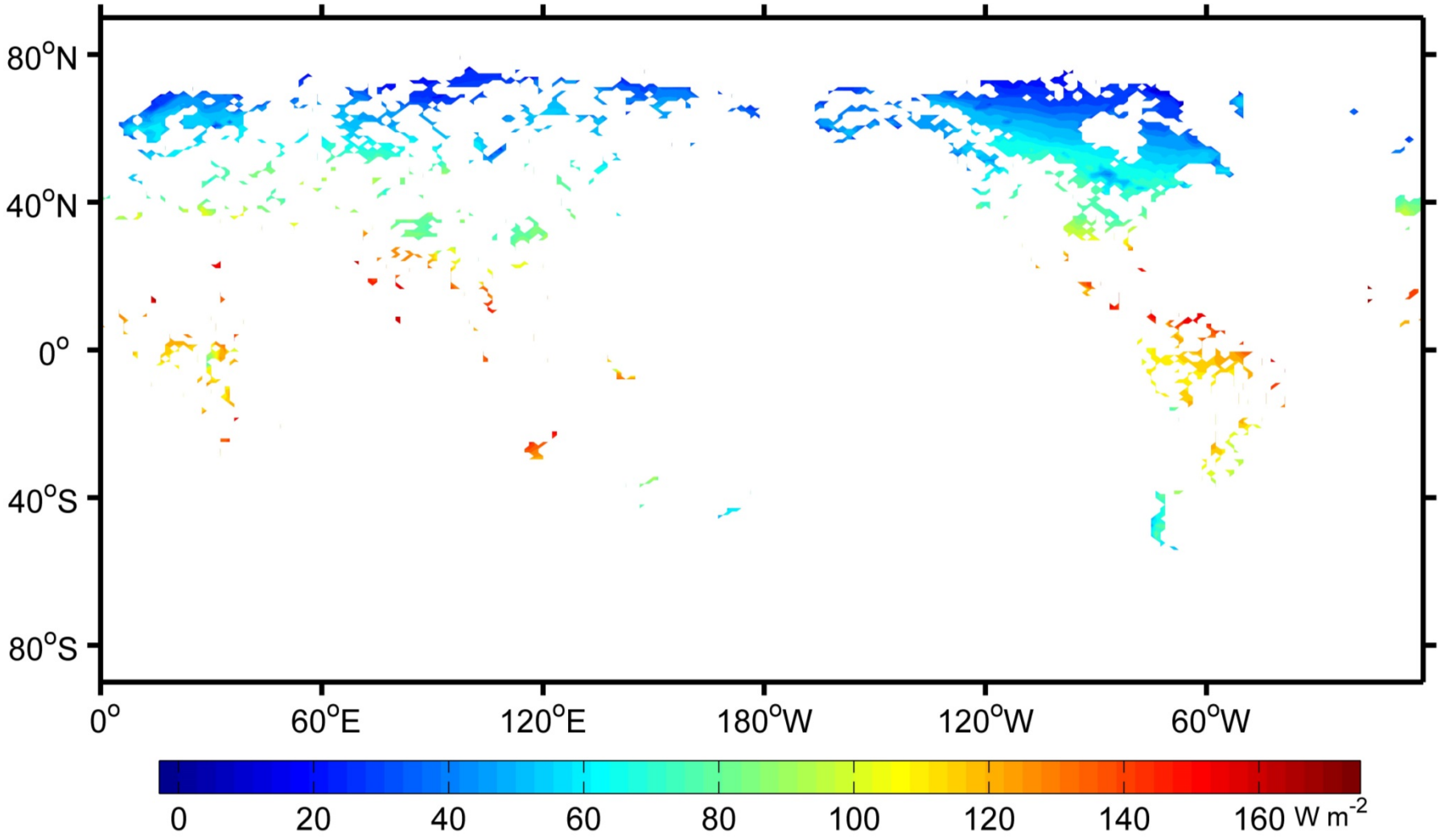
Objective

- To investigate the temporal and spatial variations of global lake evaporation;
- To identify the main controls of variations in lake evaporation.

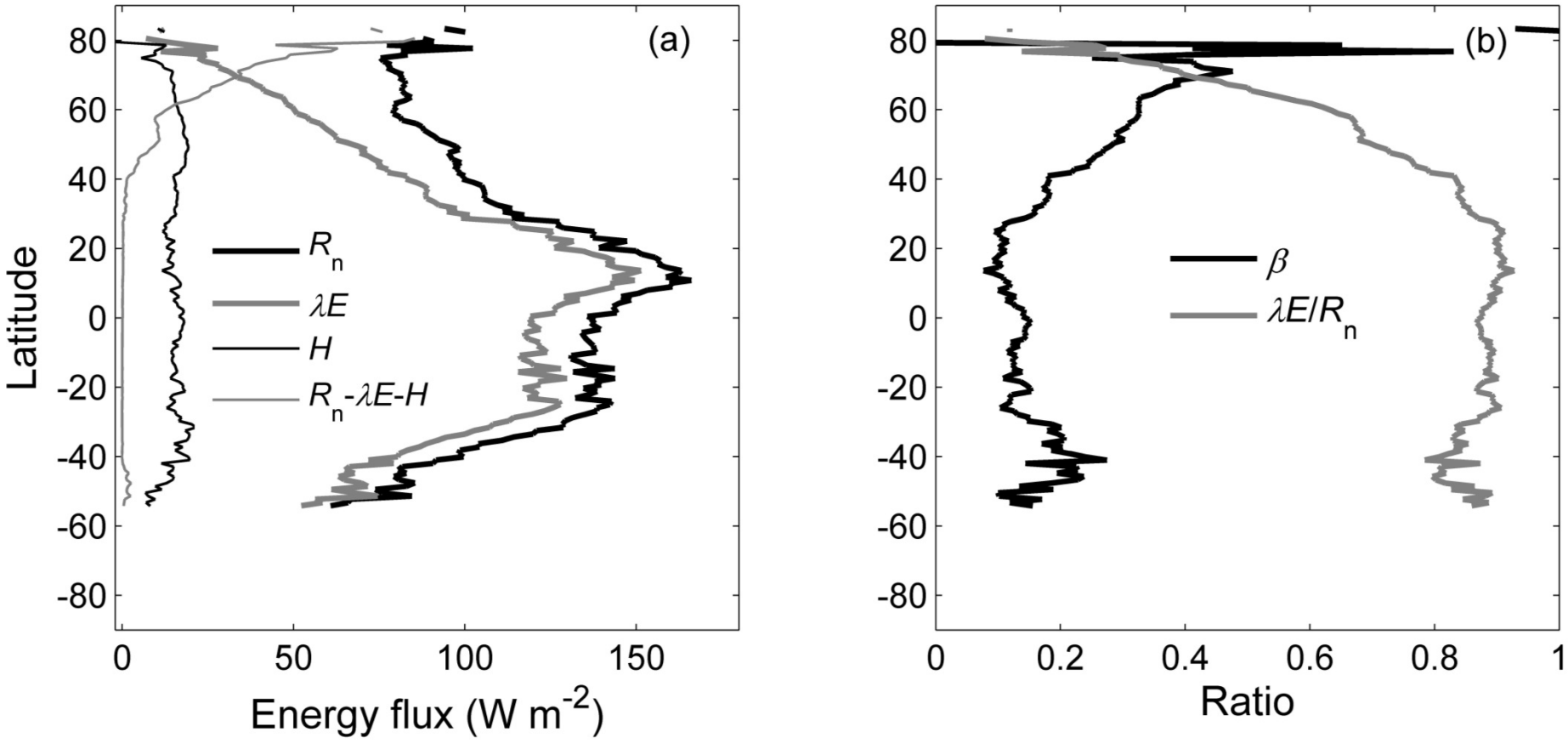
Validation of evaporation simulation by CLM4.5-LISSS



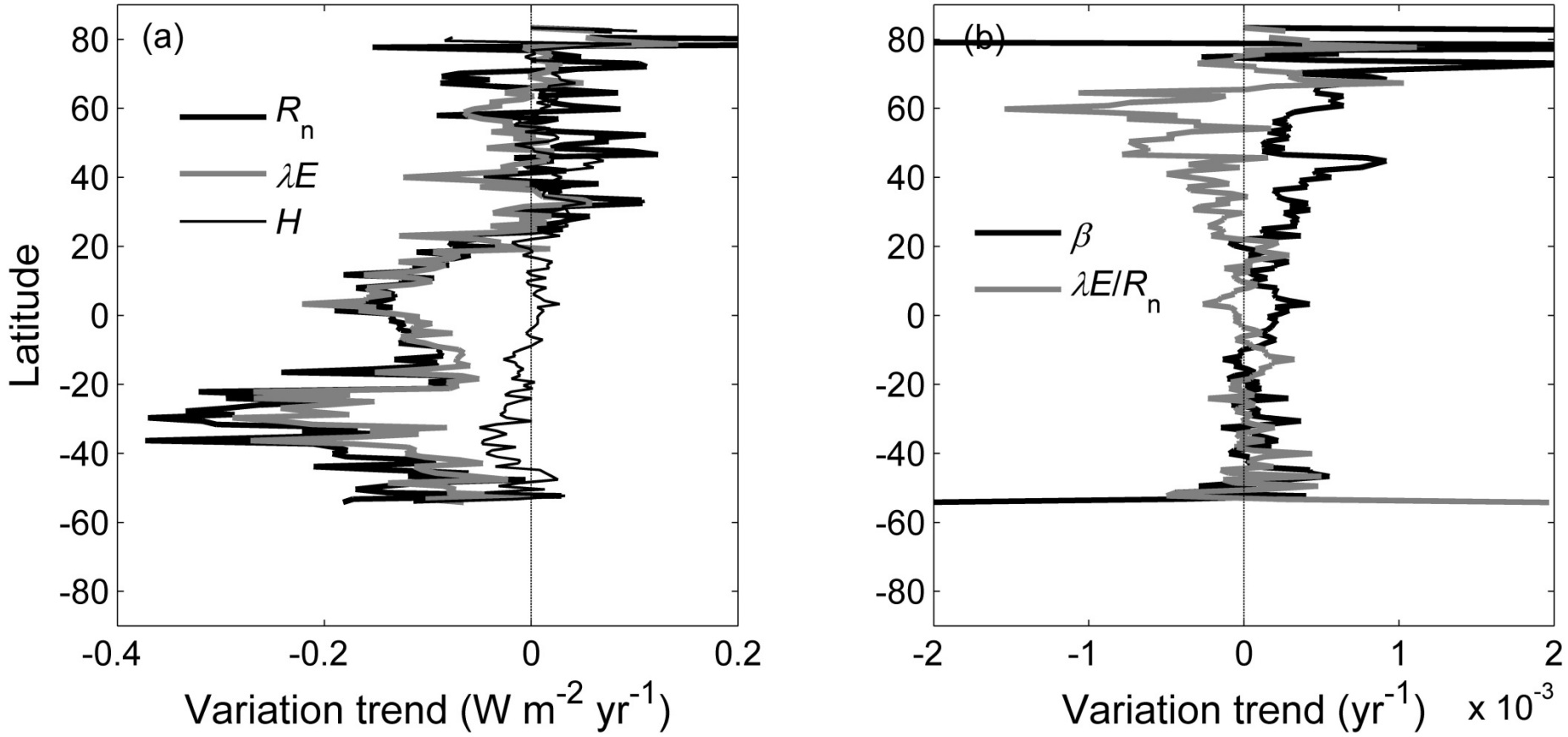
1991-2010 annual mean evaporation



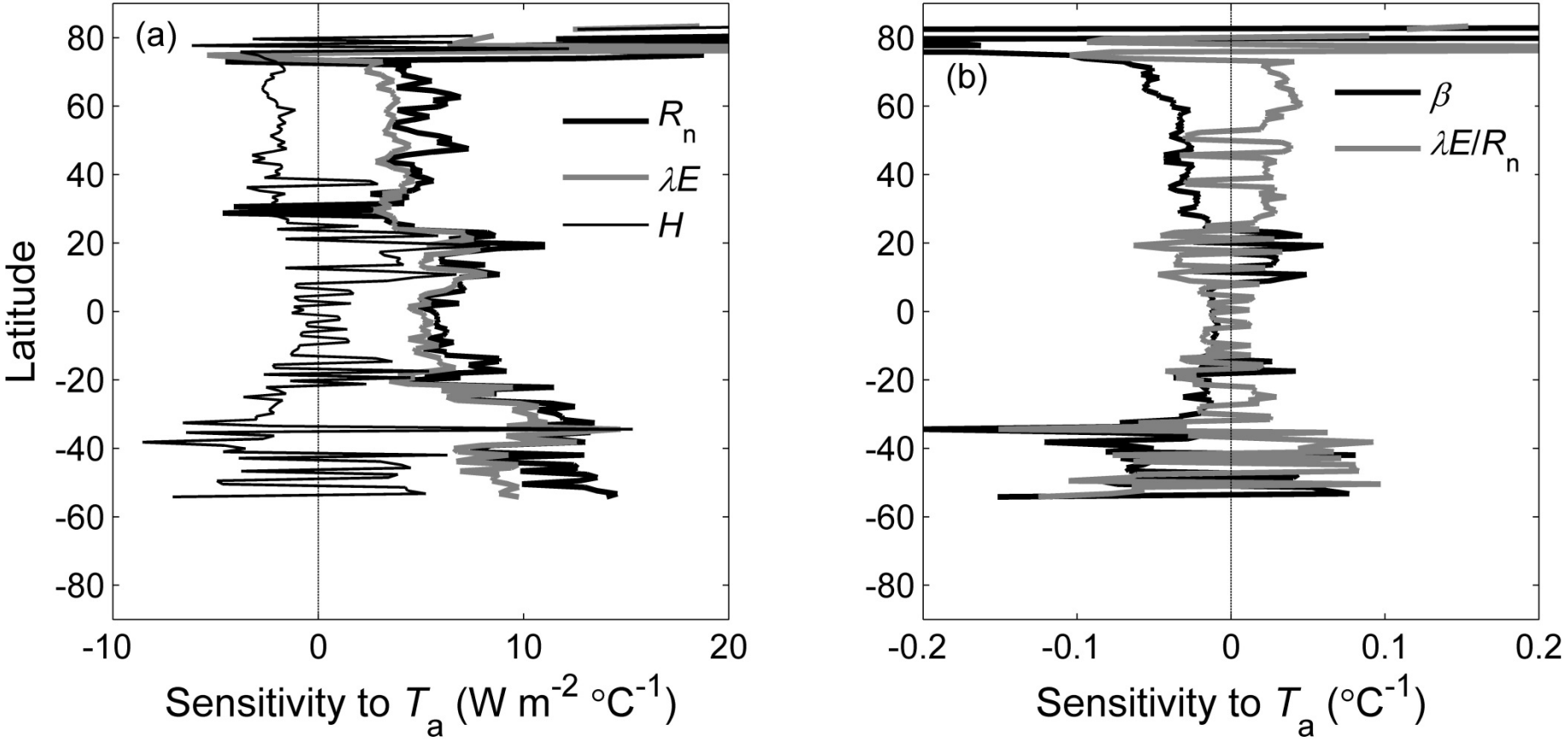
Zonal average of energy fluxes and Bowen ratio/evaporation fraction



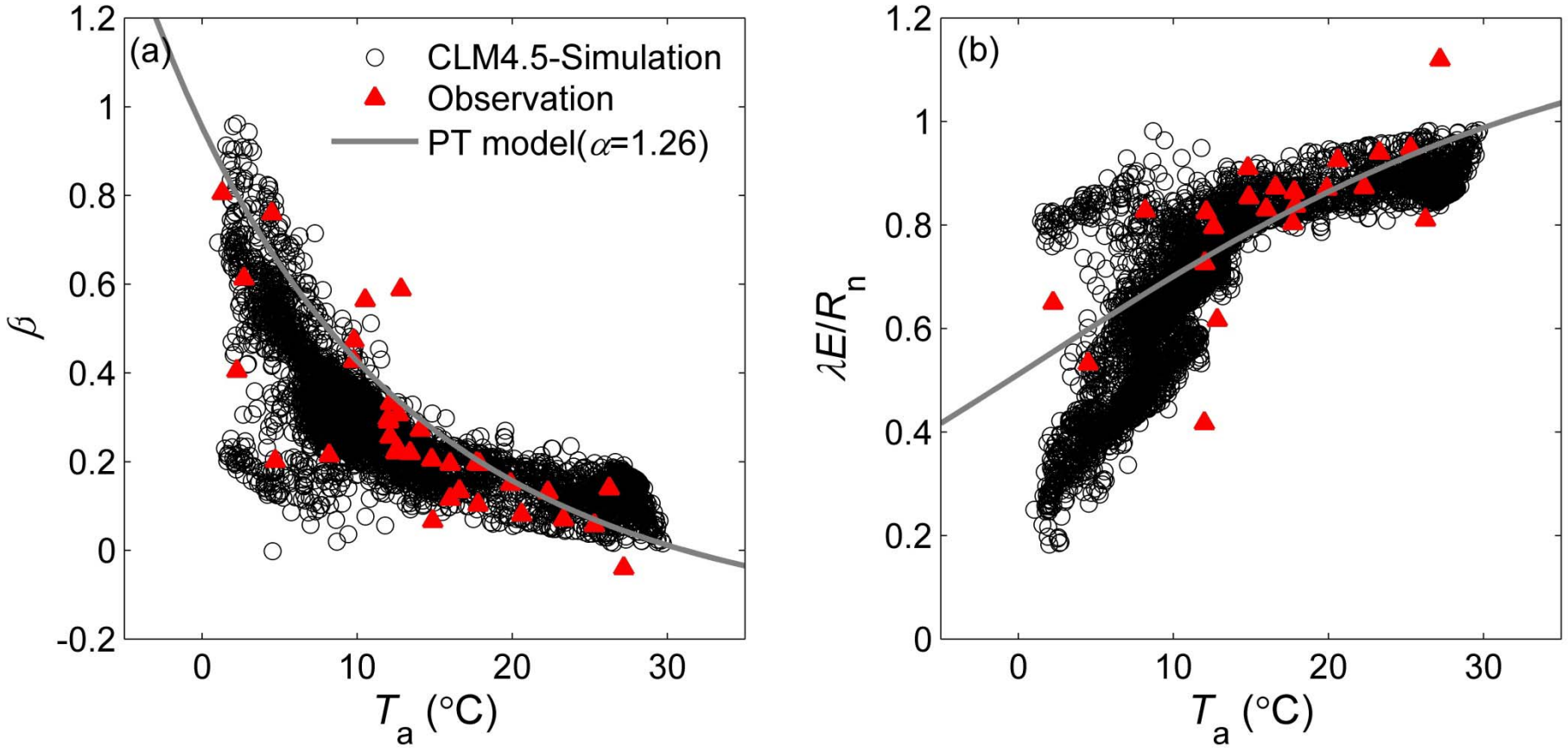
Variation trends of energy fluxes and Bowen ratio/evaporation fraction from 1991 to 2010



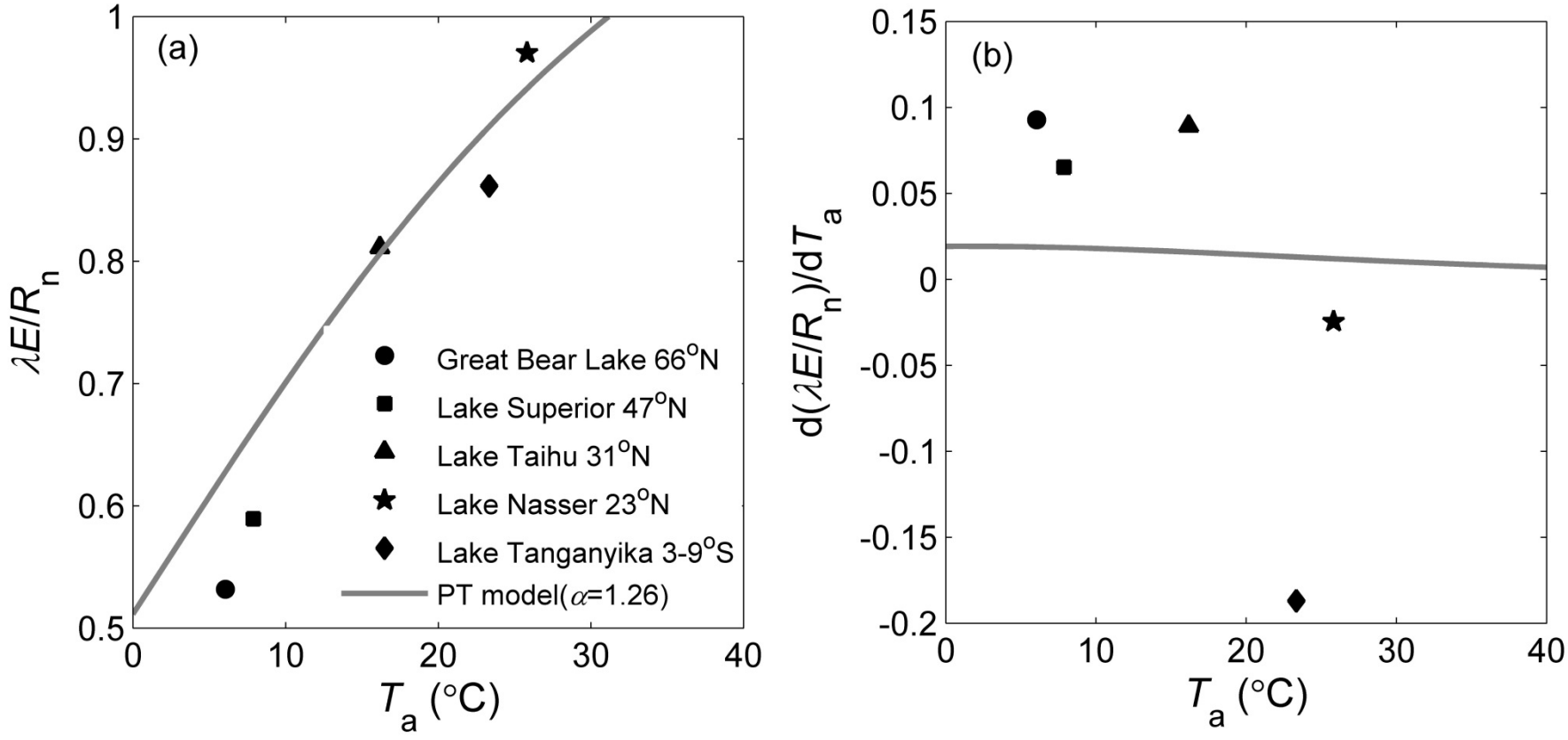
Zonal temperature sensitivity of energy fluxes and Bowen ratio /evaporation fraction



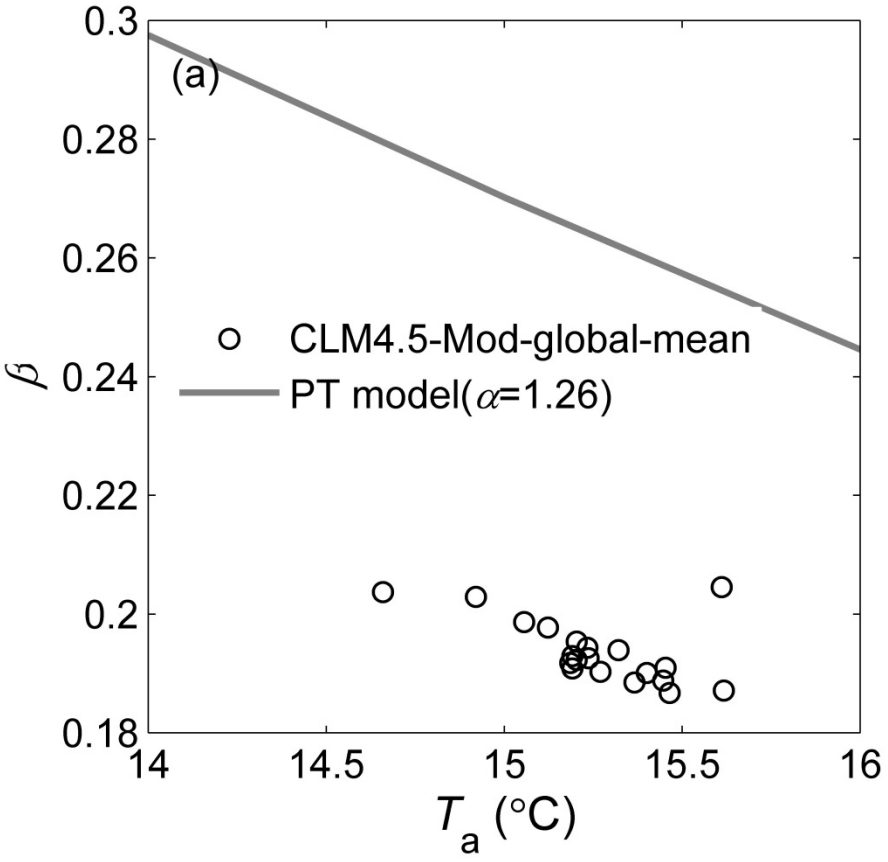
Bowen ratio/evaporation fraction varying with air temperature

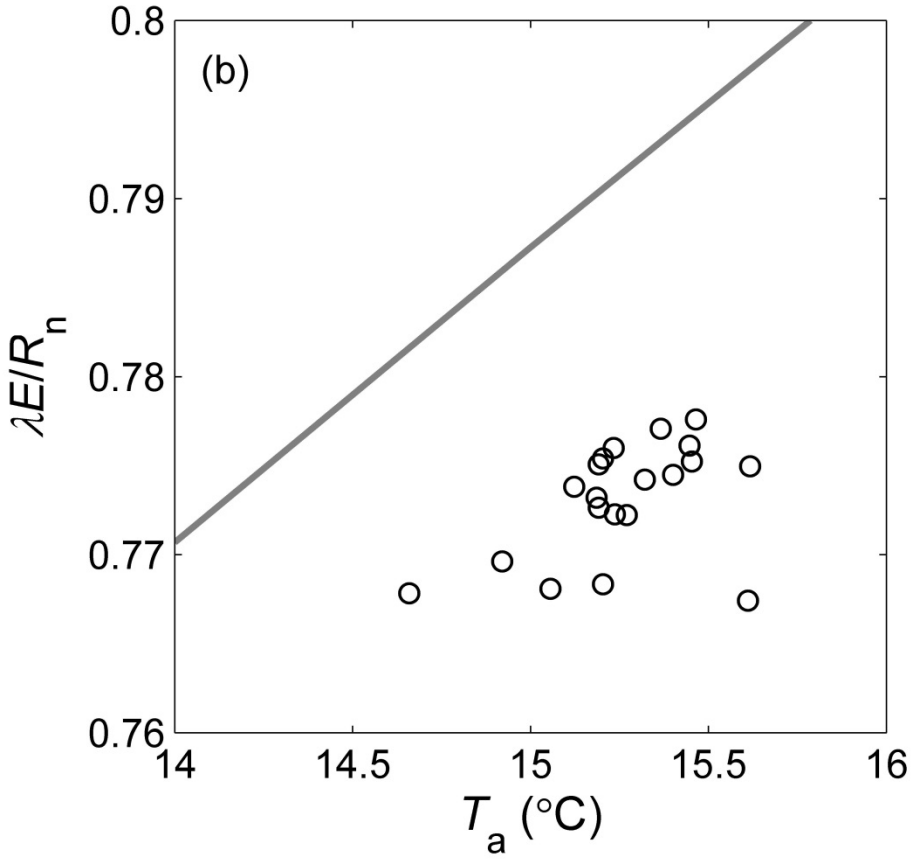


Selected lakes



Global mean


(a)
CLM4.5-Mod-global-mean
PT model(α=1.26)
β
0.3
0.28
0.26
0.24
0.22
0.2
0.18
14
14.5
15
15.5
16
T_a (°C)


(b)
λE/R_n
0.8
0.79
0.78
0.77
0.76
14
14.5
15
15.5
16
T_a (°C)