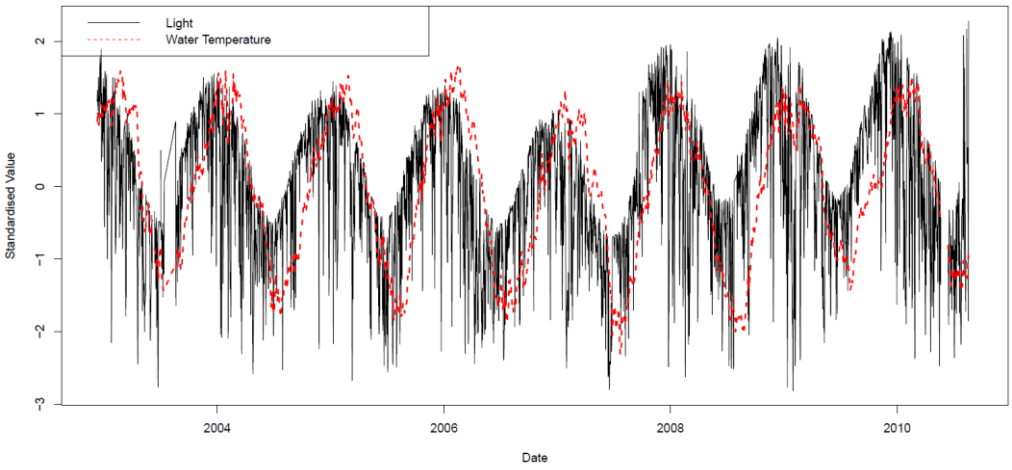
Supplementary Material

I. Correlation and time lag of water temperature at 6m and light irradiance

Figure below shows the correlation between water temperature at 6m and light irradiance at the surface from January 2003 to June 2010 illustrating the clear time lag between the two factors as temperature consistently lags .



II. Multistate Markov model

Assume a finite number of state, $\mathcal{S} = \{1, \ldots, \mathrm{R}\}$ the transition between the states is governed by a continuous time stochastic process $x(t)$ which has value in $\mathcal{S}$. Let $\mathrm{H}_{\mathrm{t}_1}^{-}$ denote the history of the stochastic process up to time t_1, the probability of transitioning from state *r* to state *s* is $\mathrm{p}_{\mathrm{rs}}(\mathrm{t}_1, \mathrm{t}_2)=\mathrm{p}(x(\mathrm{t}_2)=\mathrm{s}|x(\mathrm{t}_1)=\mathrm{r}, \mathrm{H}_{\mathrm{t}}^{-})$. The transitional probability, $\mathrm{p}_{\mathrm{rs}}(\mathrm{t}_1, \mathrm{t}_2)$, is governed by the *transition intensity*, q_{rs} which is the instantaneous hazardous rate of moving from state *r* to state *s* is

$$\mathrm{q}_{\mathrm{rs}}(\delta\mathrm{t}, \mathrm{H}_{\mathrm{t}_1}^{-}) = \lim_{\delta\mathrm{t}\to 0} \frac{\mathrm{p}(x(\mathrm{t}_1 + \delta\mathrm{t}) = \mathrm{s}|x(\mathrm{t}_1) = \mathrm{r}, \mathrm{H}_{\mathrm{t}}^{-})}{\delta\mathrm{t}}$$

The effect of covariates are then included in the model through the intensity matrix, i.e

$$\mathrm{q}_{\mathrm{rs}}(\delta\mathrm{t}, \mathrm{H}_{\mathrm{t}_1}^{-}) = \mathrm{q}_{\mathrm{rs}}^{0}(t, H_t^{-})\exp(\beta_{rs}^{T}\mathbf{z})$$

where $\mathrm{q}_{\mathrm{rs}}^{0}(t, H_t^{-})$ is the baseline intensity at time *t*, $\mathbf{z}$ is the covariate vector and β_{rs} is the effect of covariates for transition from state *r* to *s*.

Different assumptions can be made about the dependency between transition rate and time, Meira-Machado et al. (2008) has detailed description of different assumptions and associated models.