Modeling the plankton component

- Bio-optical components already built into *GrassLight* for given levels of Chl *a*
- Metabolic component required to calculate
  - Gas exchange
  - Nutrient removal & regeneration
  - Algae growth, grazing and sinking
  - Subsequent impact on water transparency

Modeling the plankton component

- The 2-D (depth,time) model:
  - Easily integrated into *GrassLight* bio-optical structure
  - Calculates biologically mediated changes in
    - O2, DIC & therefore pH
    - Dissolved nutrients
  - Ultimately driven by light availability
    - Includes a self-shading component from algal biomass
  - Responsive to nutrient concentrations
    - But does not require explicit definition of Michaelis-Menten coefficients
- It does NOT presently consider
  - Mixotrophic & motile algae (e.g. Dinoflagellates) that exhibit complex behaviors & trophic relations
  - Benthic & pelagic grazing
  - Advection

Modeling the photosynthesis

- $P^B_g(z)$ is controlled by light availability:

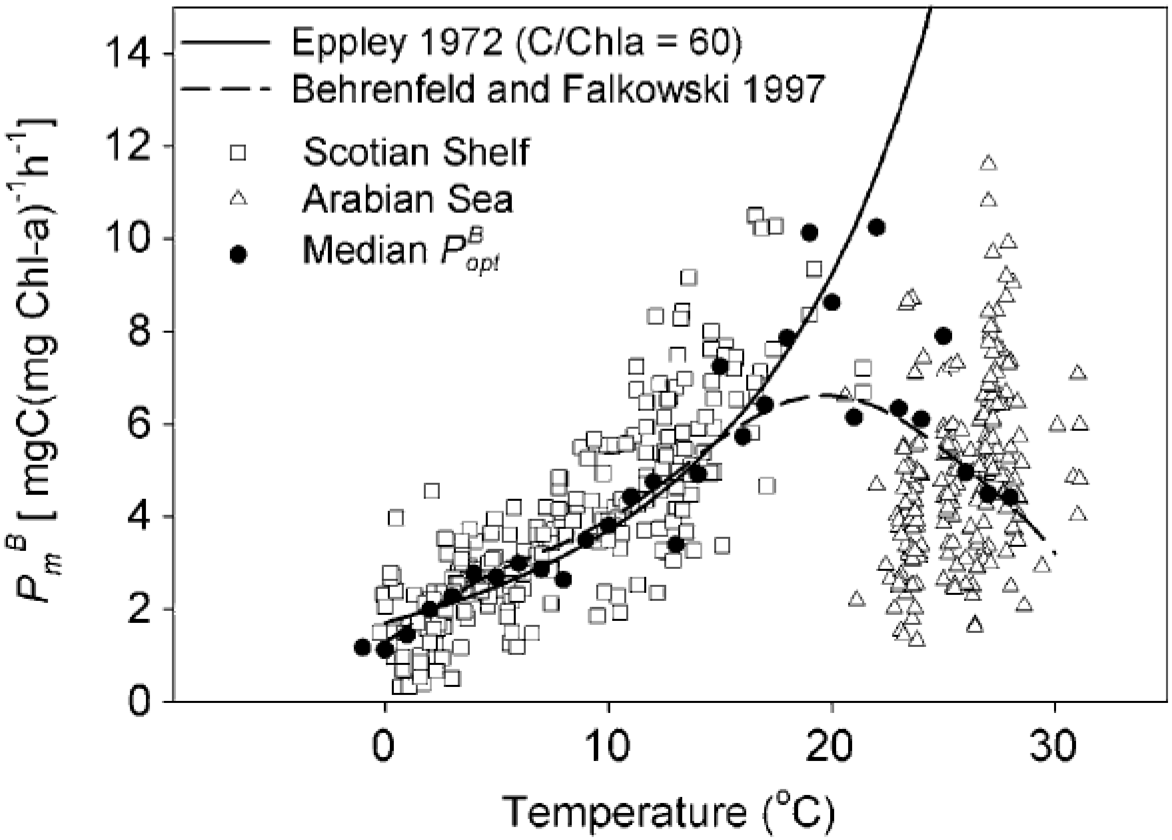
$$P_g^B = P_E^B \left(1 - \mathrm{e}^{\frac{\phi_{\mathrm{P}} \cdot A_\phi^*(\lambda) \cdot [\mathrm{Chl}\, a] \cdot E(\lambda, t, \mathrm{z})}{P_E^B}} \right)$$

- ϕ_P – quantum yield of photosynthesis (=1/8)
- $A^*_\phi(\lambda)$ – spectral phytoplankton absorptance
- [Chl *a*] – biomass, to scale absorptance
- $E(\lambda, t, z)$ – wavelength, time and depth-dependent irradiance

Modeling temperature effects

$$\log P_E^B \text{ or } \log R^B = T\left(\frac{\log Q_{10}}{10}\right) + C$$

- P^B_E and R are temperature dependent
- Q_{10} = 3 to 20° C
- P^B_E decreases linearly with T to 38° C



Bouman, H., T. Platt, S. Sathyendranath, and V. Stuart. 2005. Dependence of light-saturated photosynthesis on temperature and community structure. Deep Sea Research Part I: Oceanographic Research Papers **52: 1284-1299.**

Modeling carbon balance and nutrient requirements

- Net productivity is defined by the balance between photosynthesis and respiration

$$P_{net}^{V} = B\left[P_{g}^{B} - R^{B} \right]$$

- Redfield Ratios define the amounts of dissolved inorganic nitrogen (N) and phosphorus (P) required to convert net photosynthesis into new biomass:

$$\frac{\partial \mathrm{N}}{\partial t} = \frac{16}{106} P_{net}^{V}$$

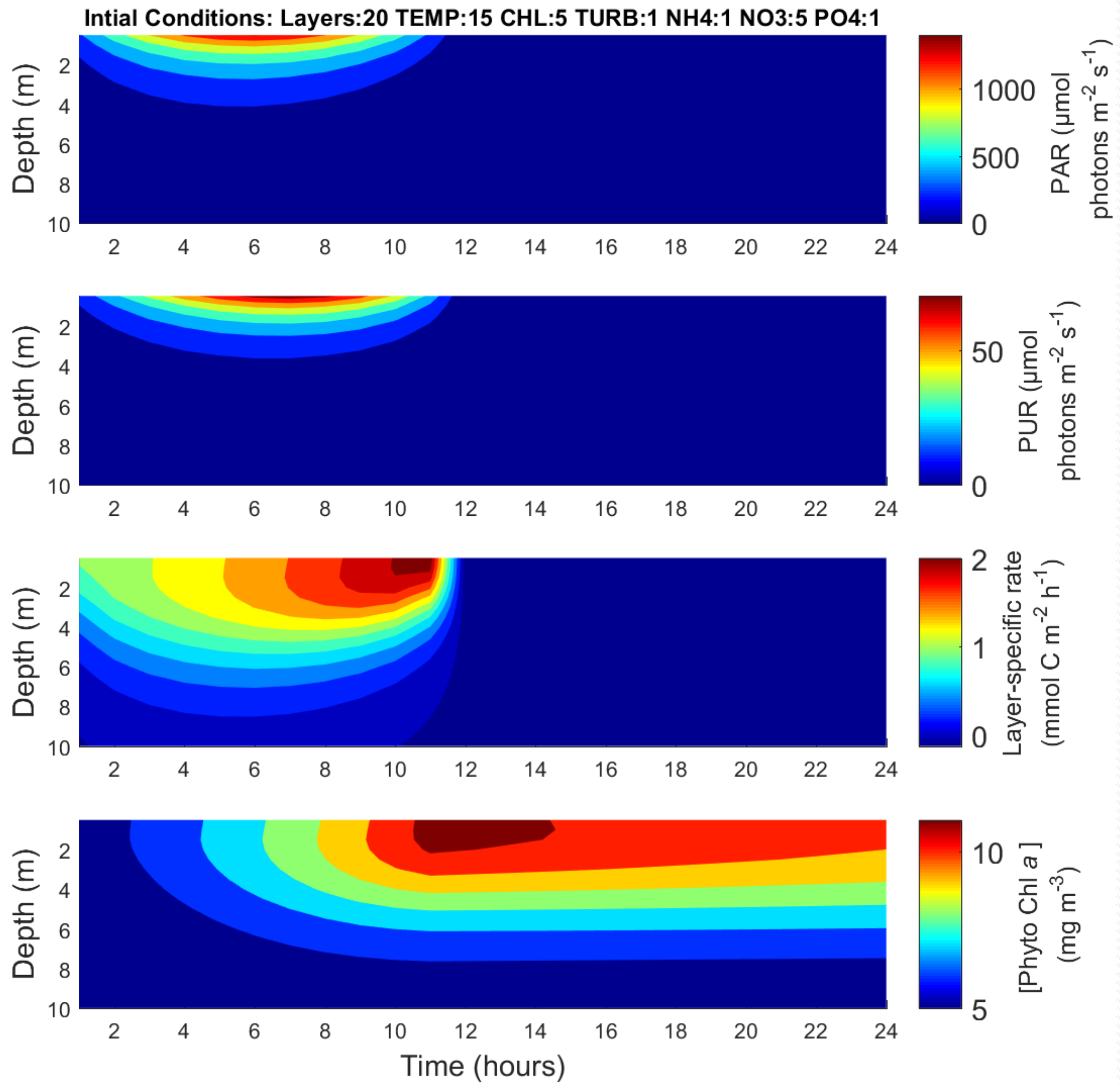
$$\frac{\partial \mathrm{P}}{\partial t} = \frac{1}{106} P_{net}^{V}$$

Modeling nutrient limitation

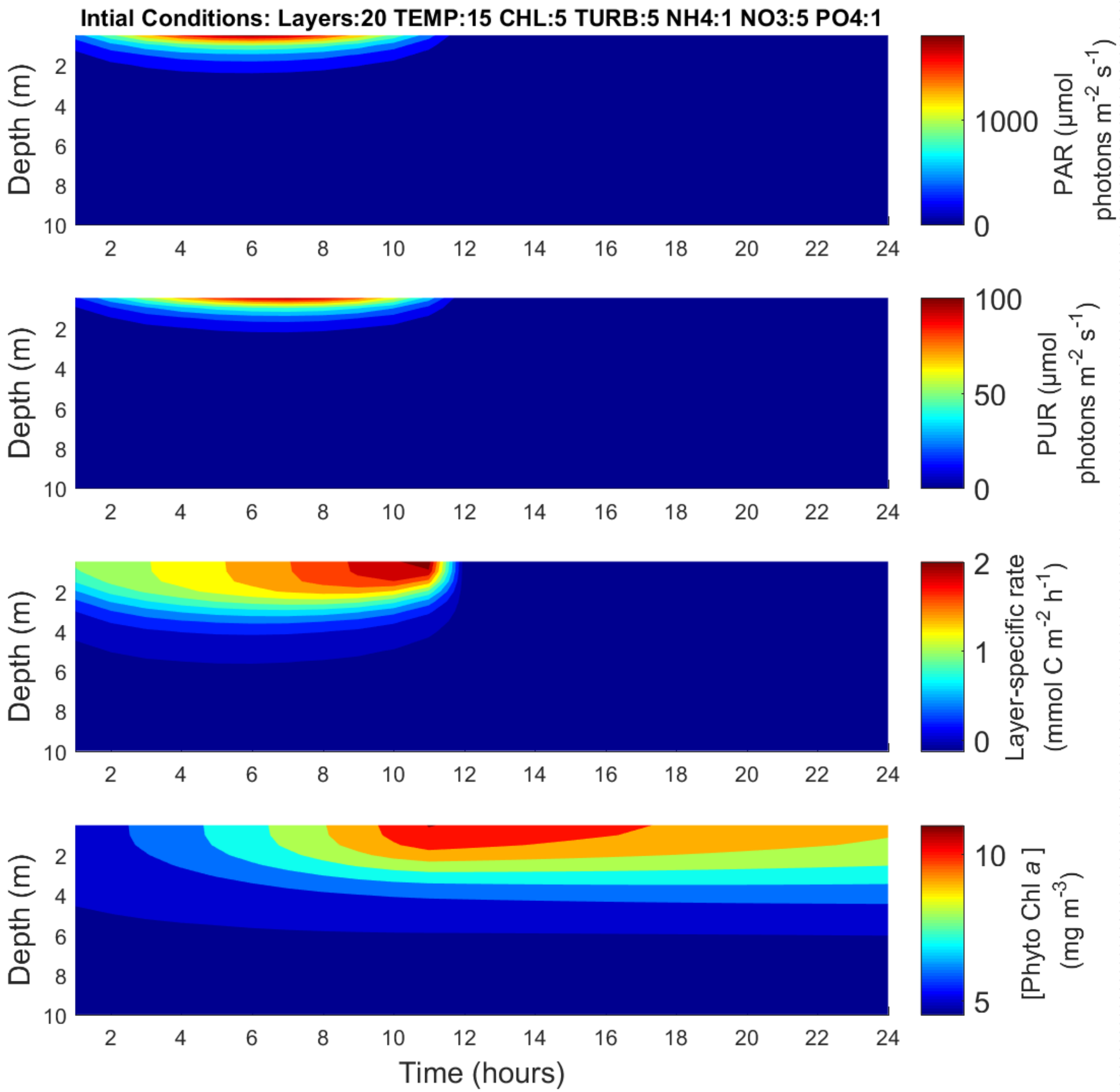
- if $\frac{\partial N}{[N]} \leq 1$ and $\frac{\partial P}{[P]} \leq 1$, phytoplankton growth is defined by P^V_{net} and the concentrations of dissolved inorganic N and P are reduced accordingly
- NH_4^+ taken up before NO_3^-
- If $\frac{\partial N}{[N]} > 1$ or $\frac{\partial P}{[P]} > 1$, phytoplankton growth is limited by the nutrient in shortest supply, all of which is taken up:

$$\frac{\partial Phyto}{\partial t} = P^V_{net} \cdot lesser\ of\ \frac{[N]}{\partial N}, \frac{[P]}{\partial P}$$

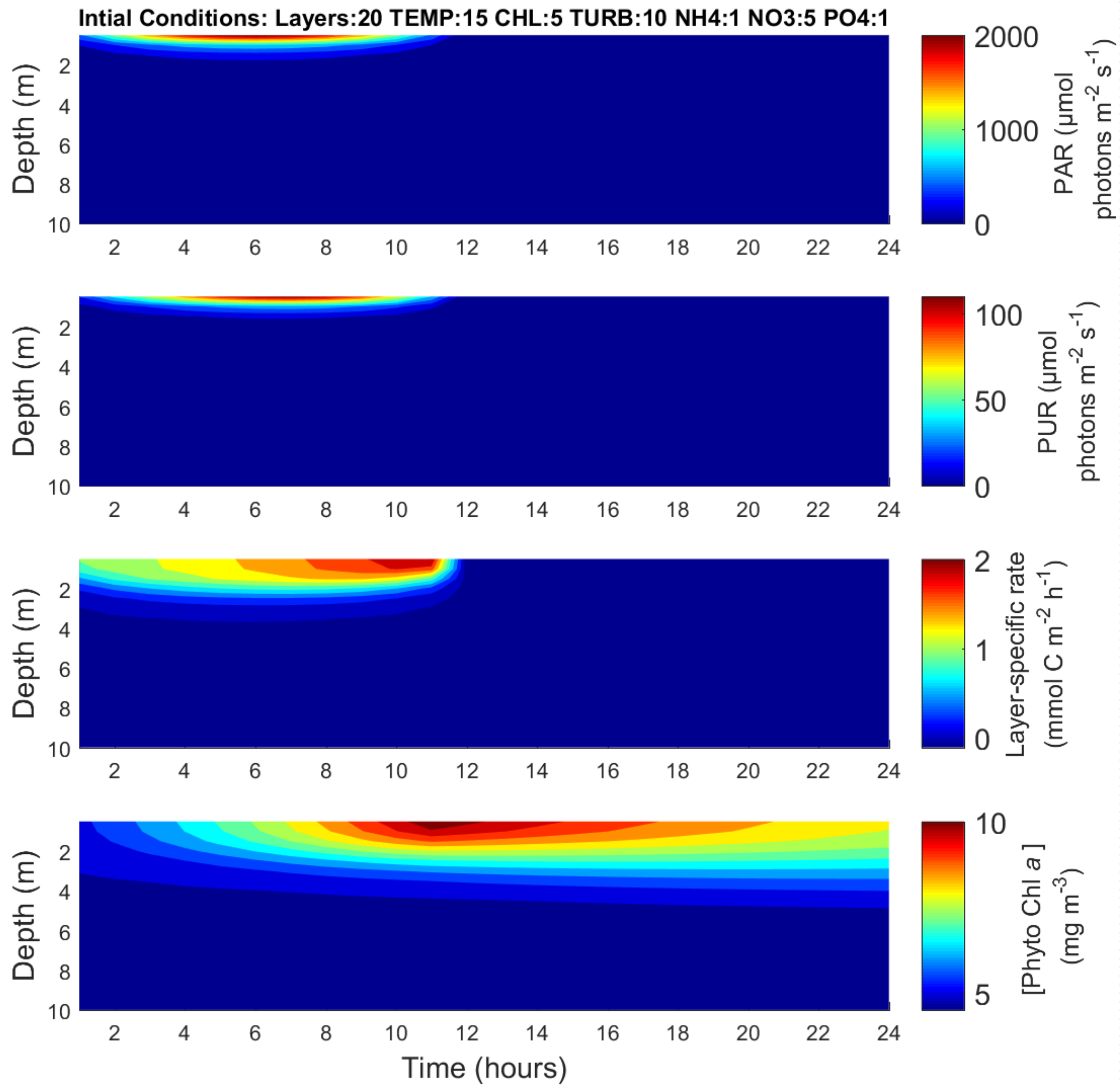
Effect of water transparency on phytoplankton productivity



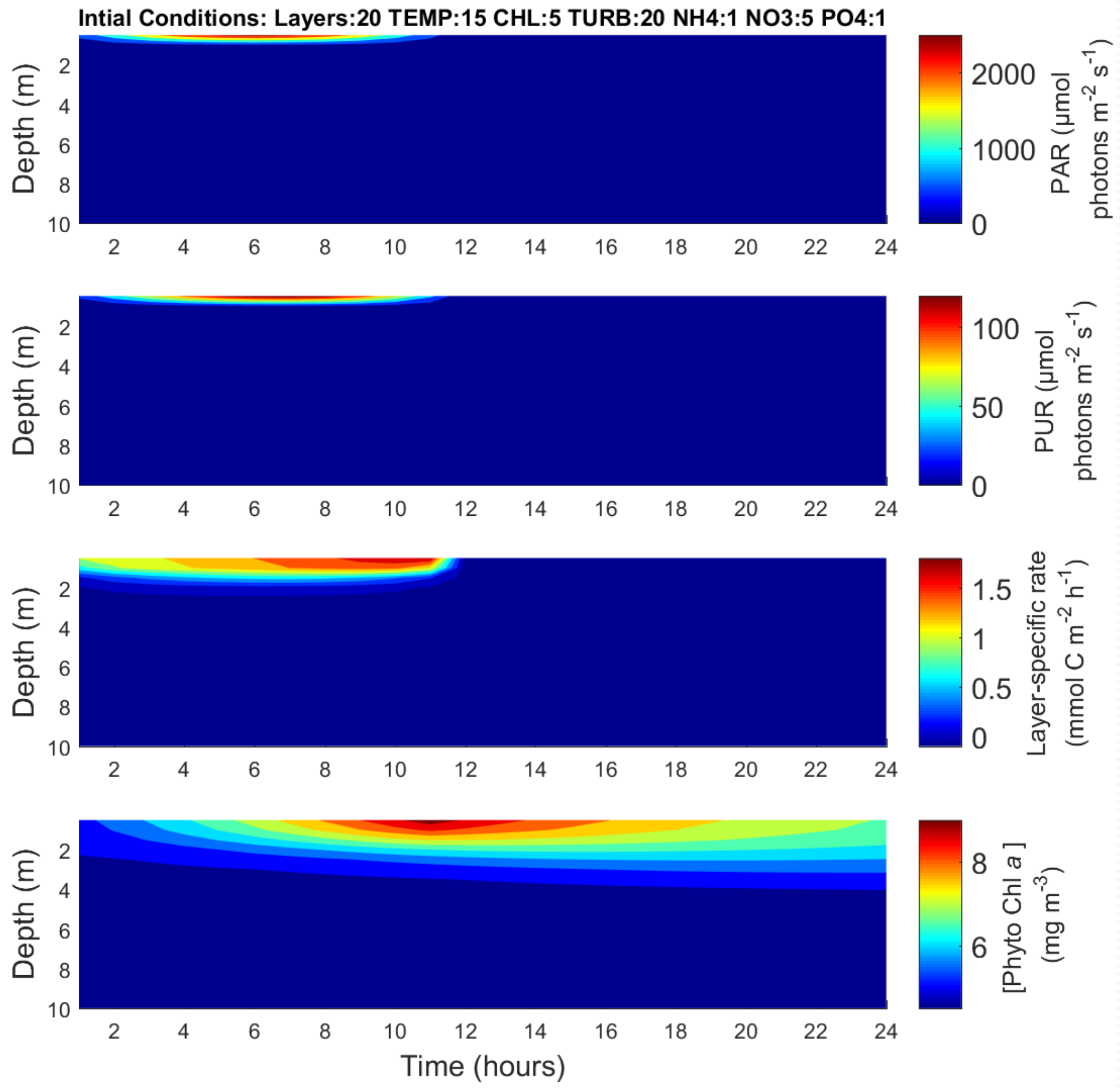
Effect of water transparency on phytoplankton productivity



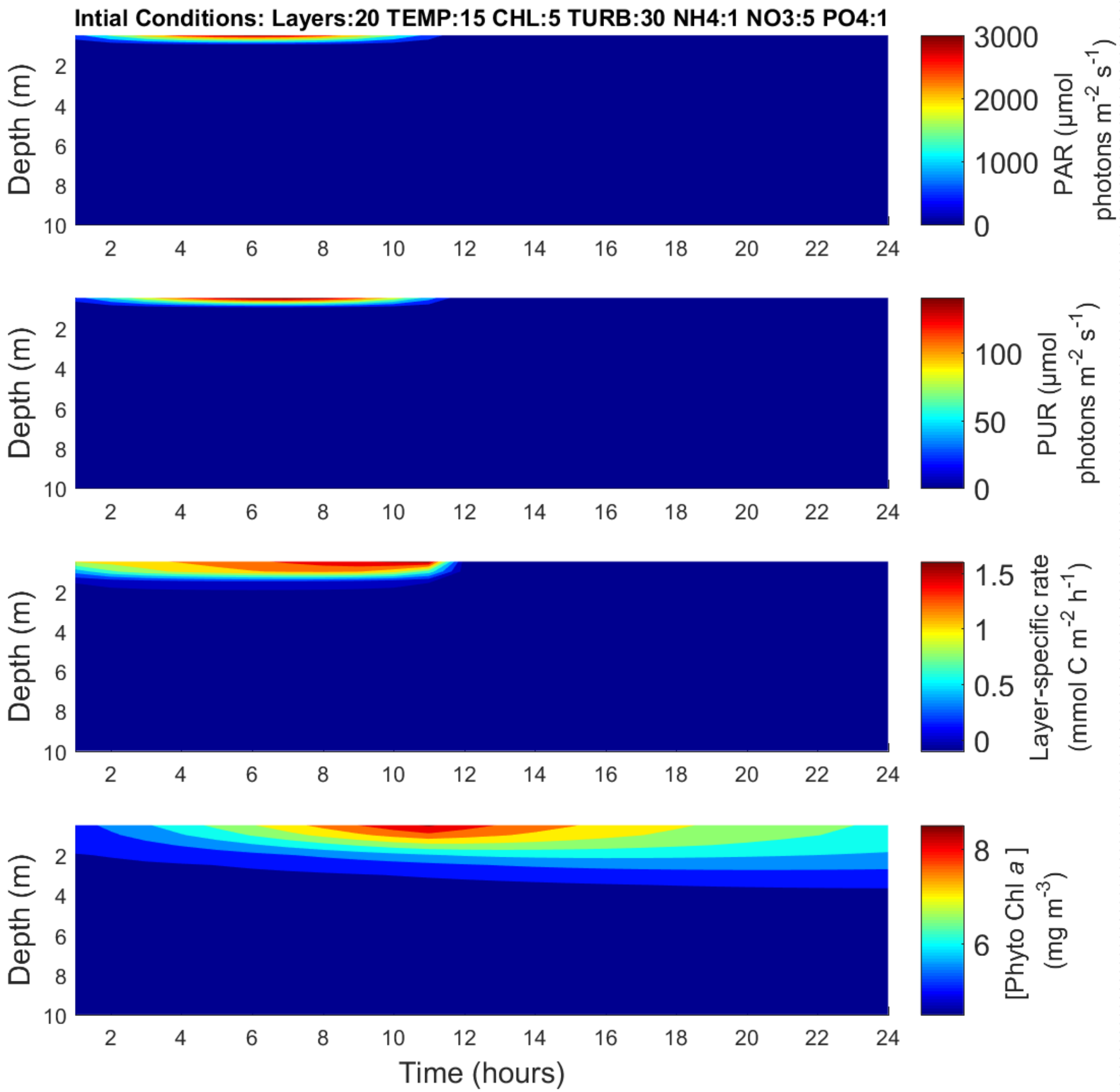
Effect of water transparency on phytoplankton productivity



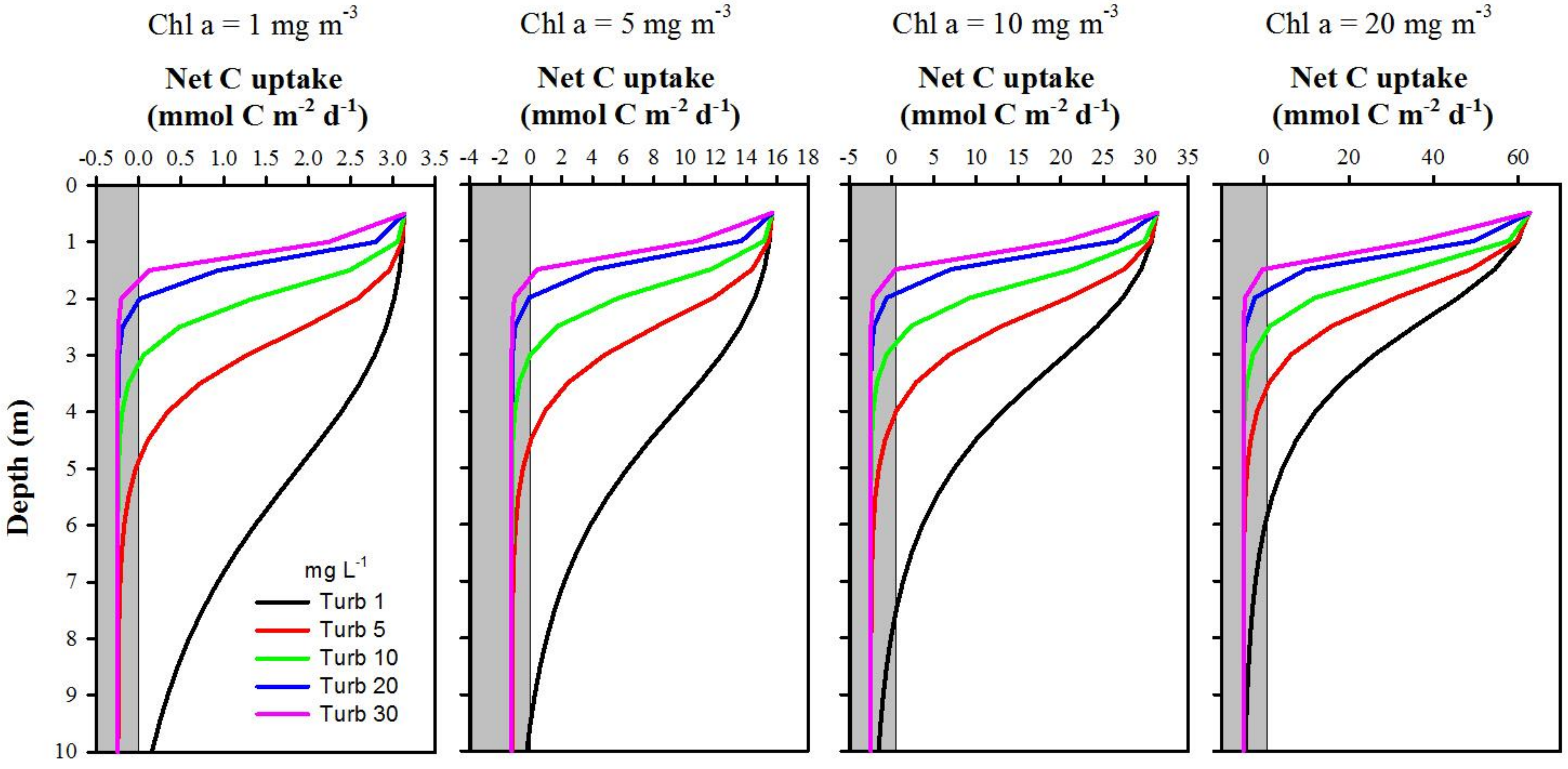
Effect of water transparency on phytoplankton productivity



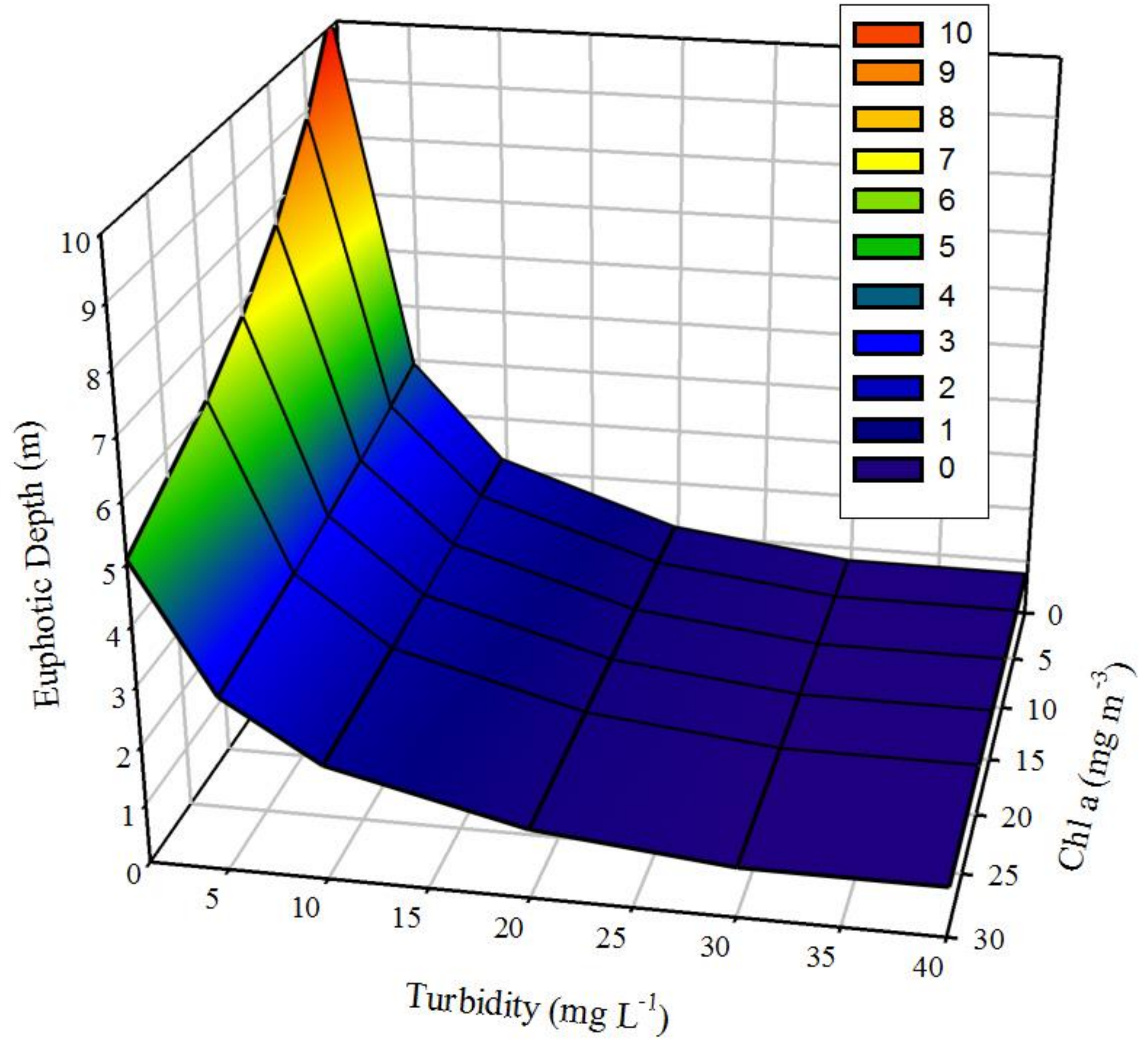
Effect of water transparency on phytoplankton productivity



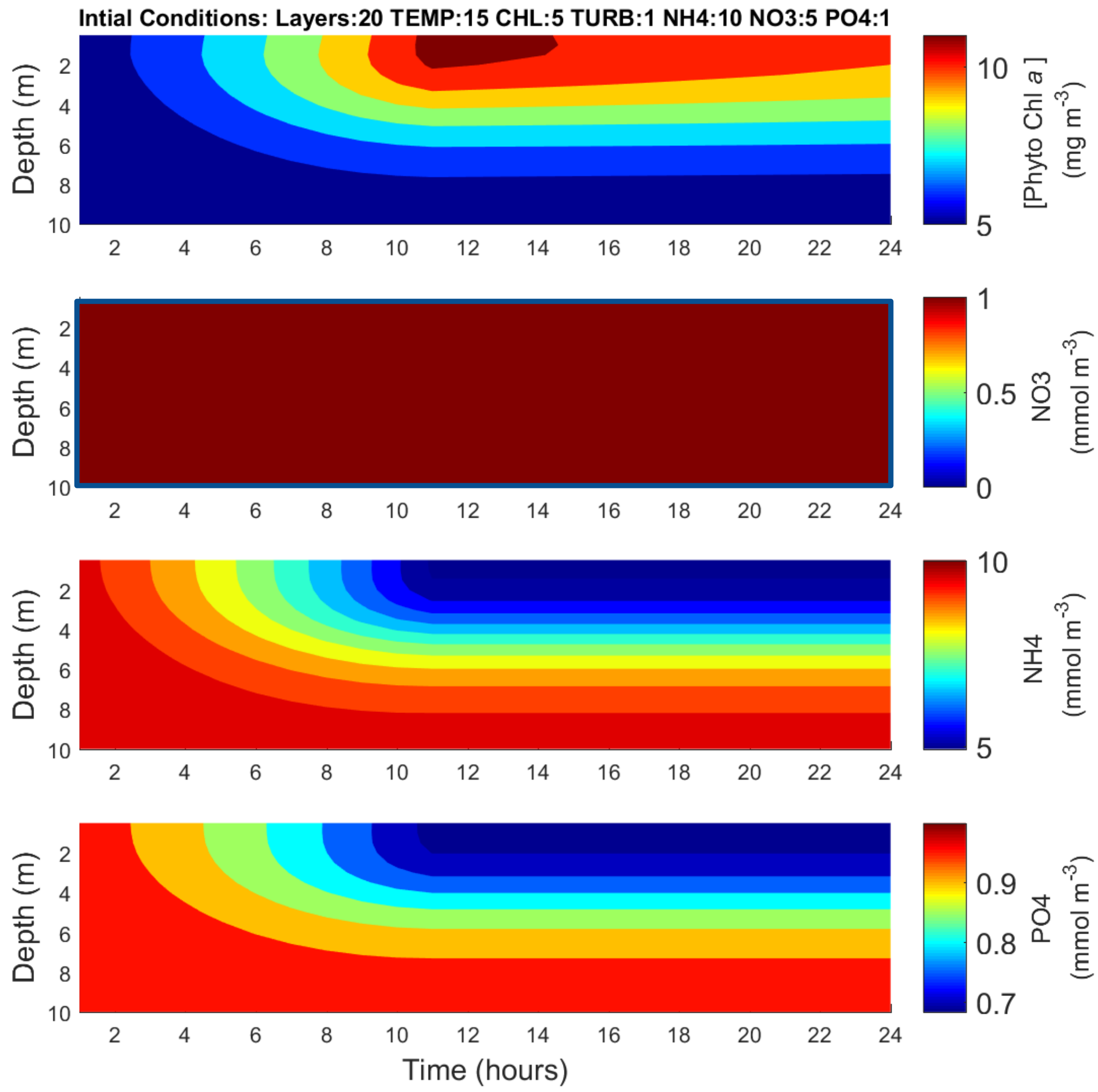
Effect of water transparency on phytoplankton productivity



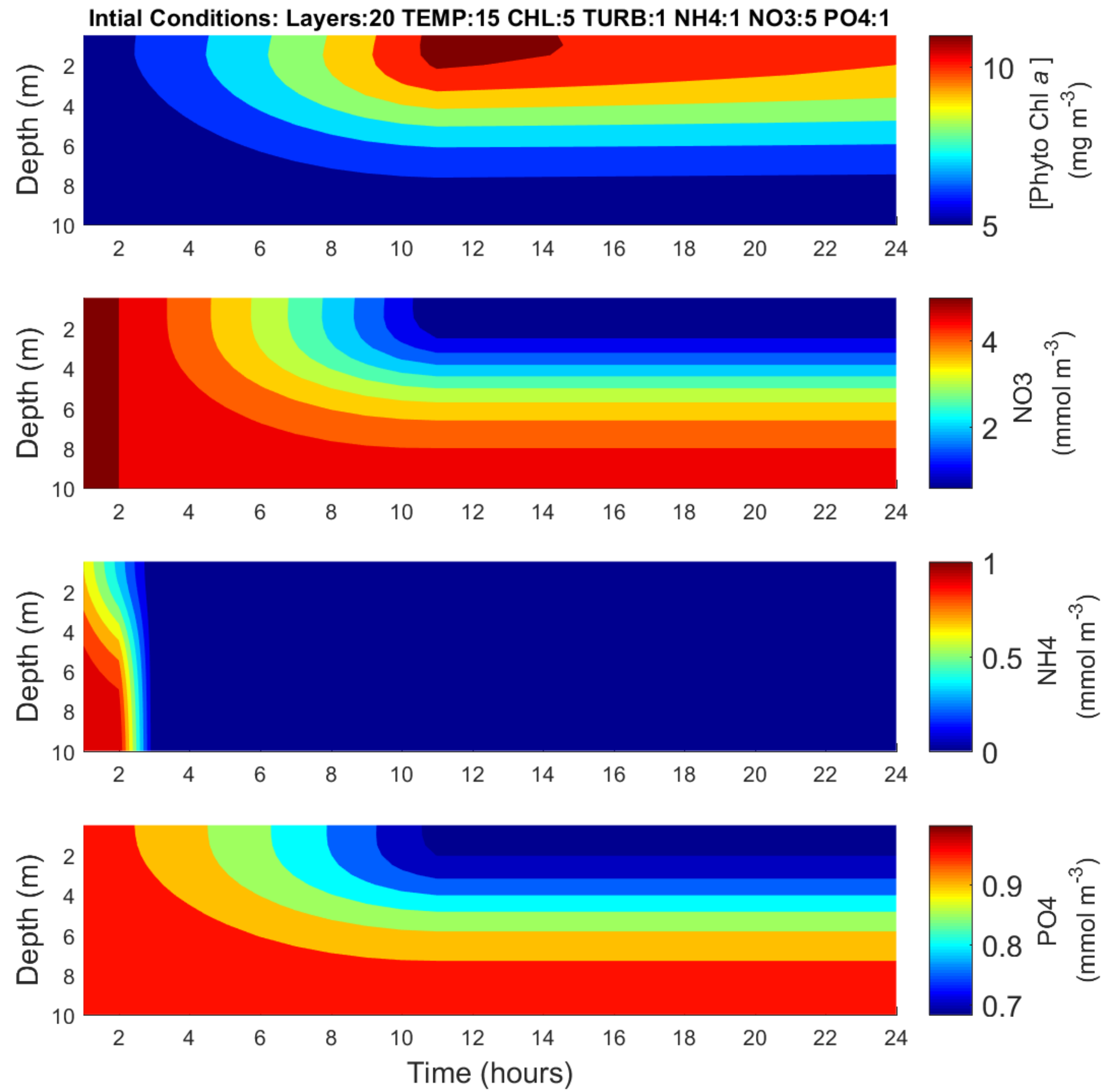
Turbidity has a greater effect on the euphotic depth than Chl *a*



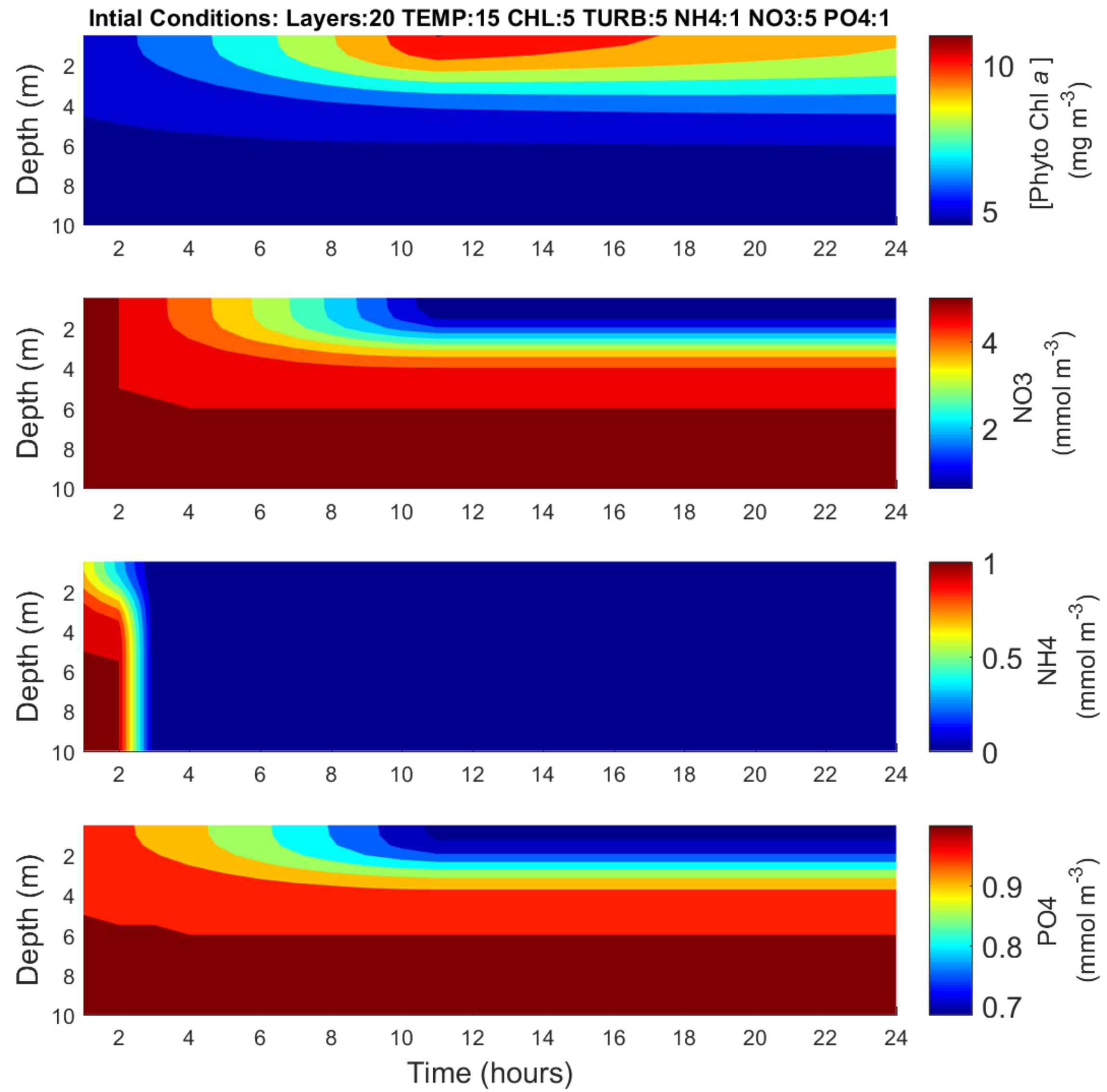
Effect of water transparency on nutrient use



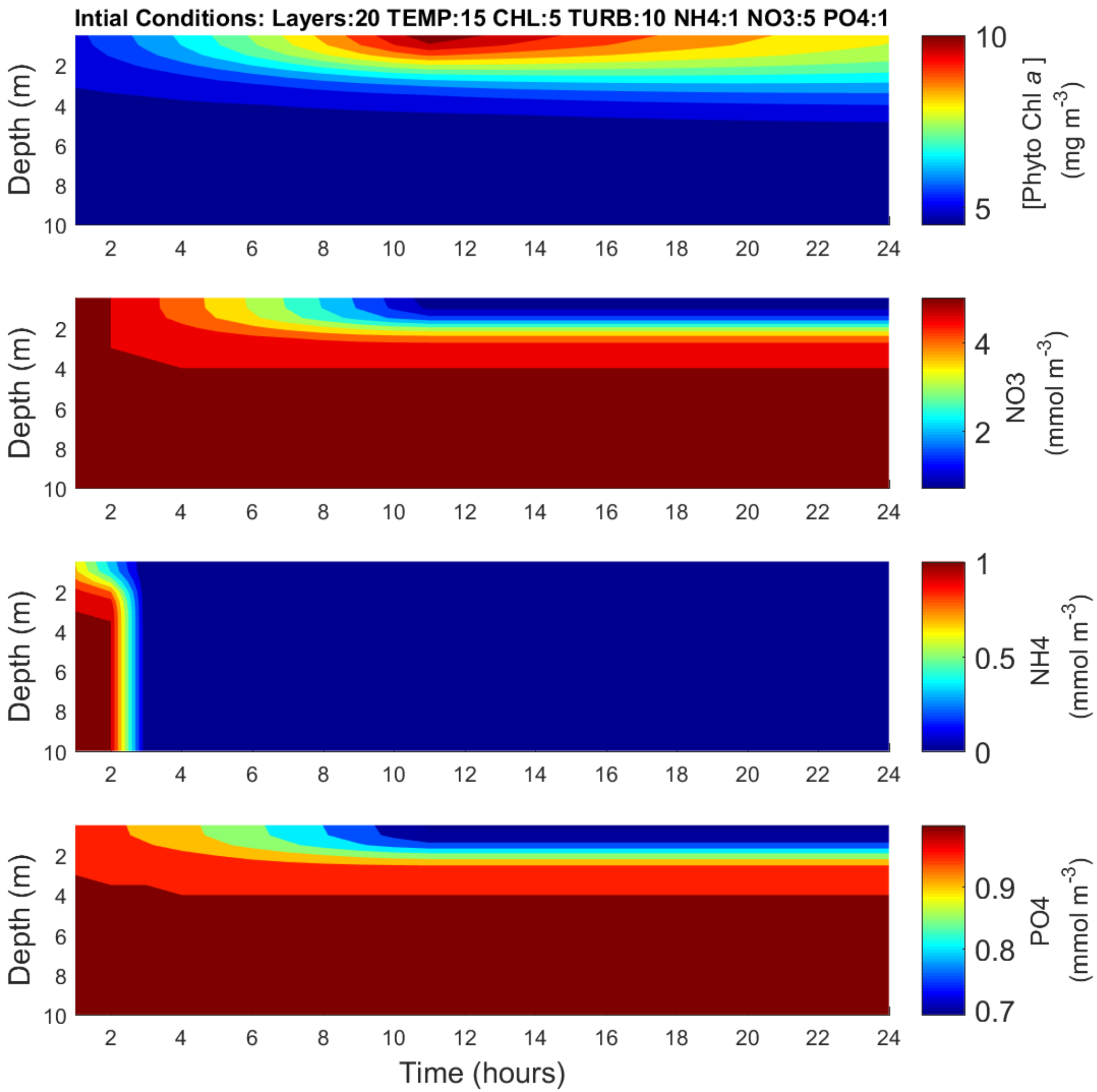
Effect of water transparency on nutrient use



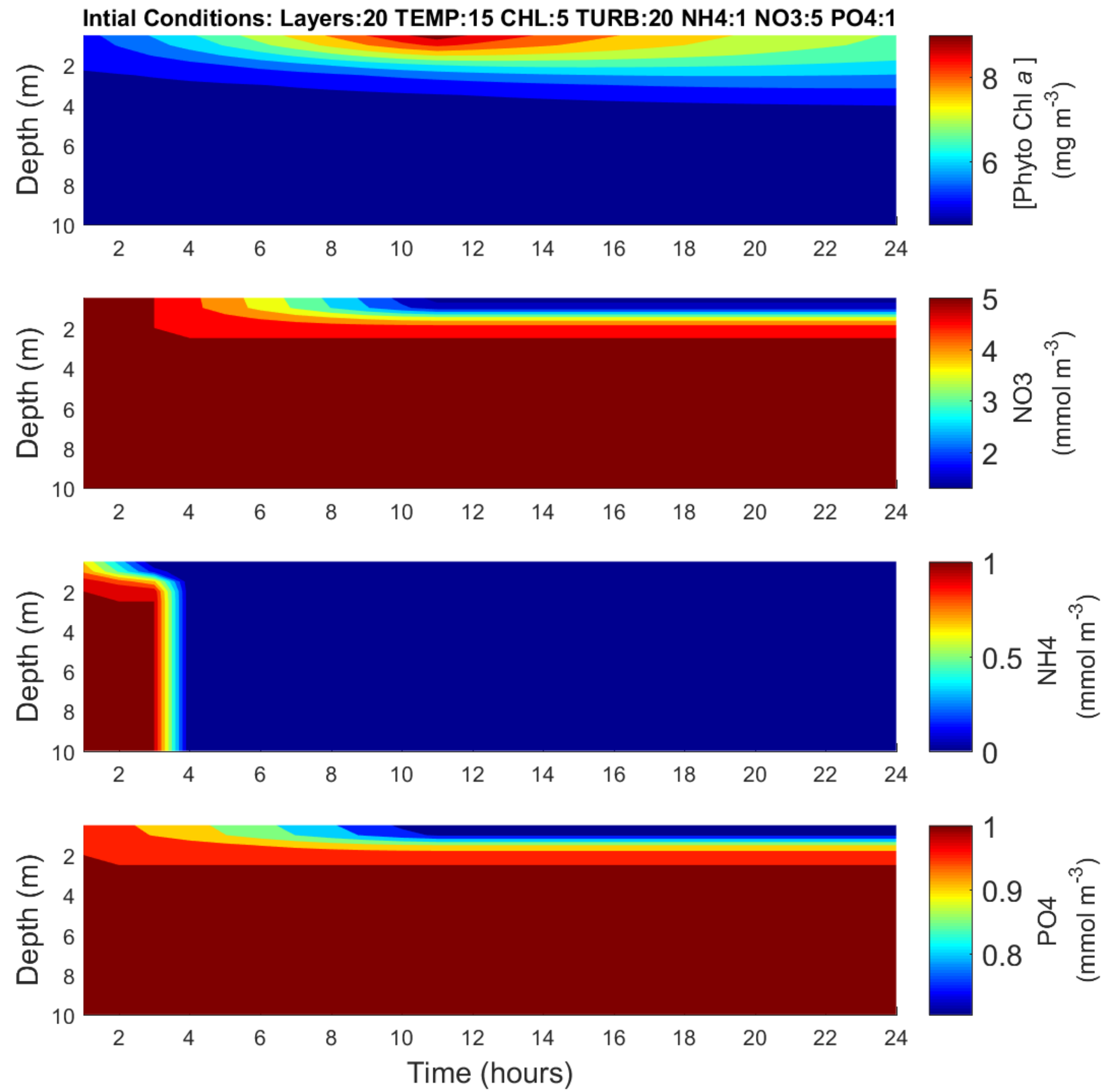
Effect of water transparency on nutrient use



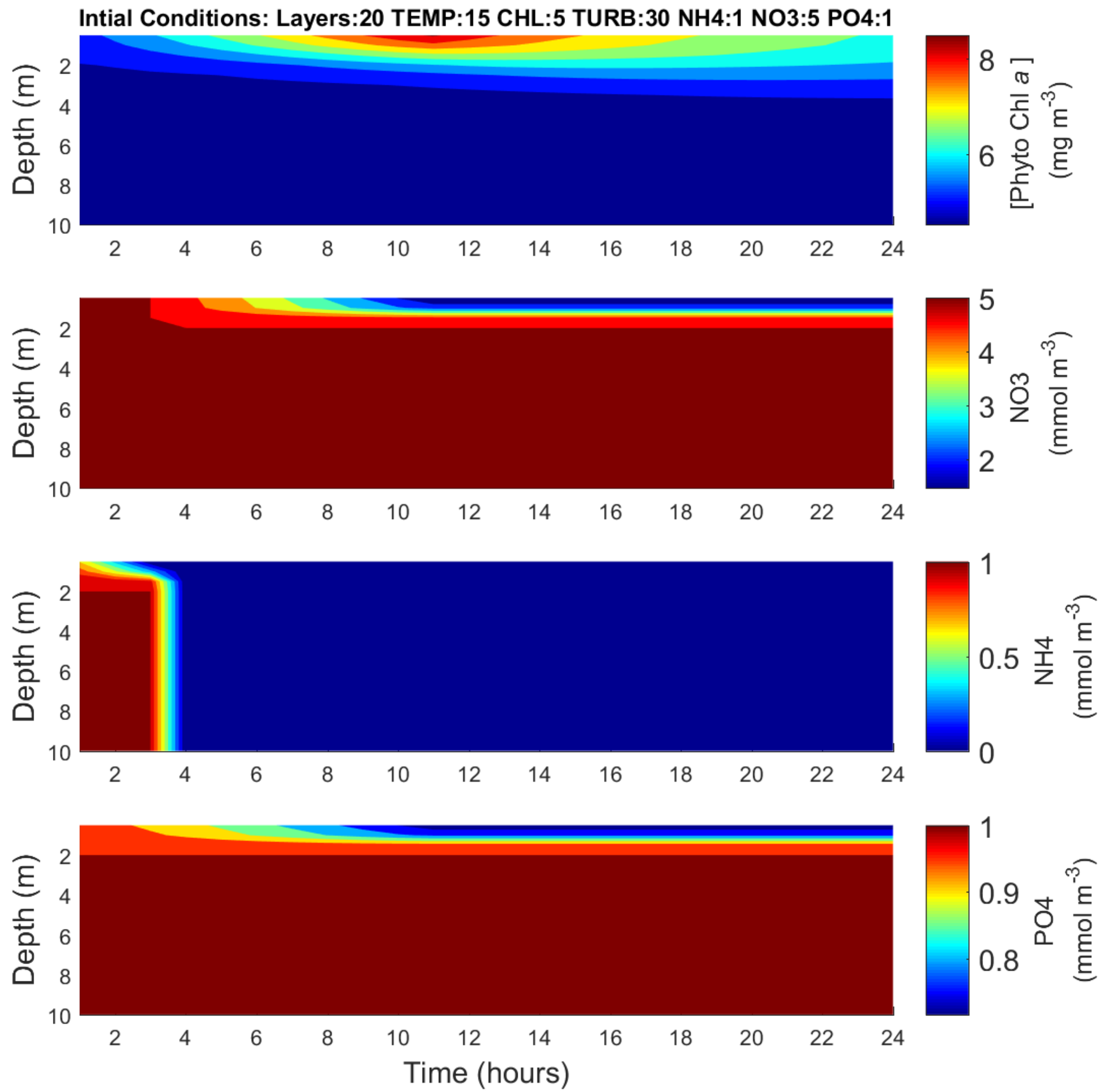
Effect of water transparency on nutrient use



Effect of water transparency on nutrient use



Effect of water transparency on nutrient use



Conclusions

- *GrassLight* accurately predicts
  - SAV distribution & density in polyhaline & mesohaline regions
  - Predicts some resilience to increasing temperature
  - Suggests potential for SAV expansion in response to improved water quality
- Phytoplankton module indicates
  - Tribs light limited from suspended particulates more than phytoplankton
    - Sediment and organic detritus
  - Light limitation prevents nutrient drawdown
  - Probably net heterotrophic
  - Vulnerabe to hypoxia