The Miami Model of climatic net primary production of biomass

Jürgen Grieser, René Gommes and Michele Bernardi
The Agromet Group, SDRN
FAO of the UN, Viale delle Terme di Caracalla, 00100 Rome, Italy

August 28, 2006

The Miami Model of climatic net primary production of biomass $NPP$ was introduced by Lieth during a conference in Miami in 1972. It is a simple conceptual model that links $npp$ to longterm annual mean temperature $T$ in °C and precipitation sum $P$ in mm. $NPP$ is assumed to increase with both increasing temperature and increasing precipitation. $NPP$ is limited by either temperature or precipitation. Therefore the Miami model estimates $NPP$ as a function of the limiting of both factors. In both cases, however, a saturation value of 3000 $gDM/m^2/year$ ($DM$ stands for dry matter) cannot be exceeded. One should keep in mind that the monotonic character of the modeled dependence from temperature and precipitation does not allow for a negative effect of too much rain or too high temperatures. The model equations are

$$NPP = \min(NPP_T, NPP_P)$$ (1)

with

$$NPP_T = 3000 \left(1 + \exp(1.315 - 0.119 \cdot T)\right)^{-1}$$

$$NPP_P = 3000 \left(1 - \exp(-0.00664 \cdot P)\right).$$ (2)

The climatic sensitivity of $NPP$ can be defined as the derivative of $NPP$ with respect to changes in the climatic variables, $\lambda_P = \partial NPP/\partial P$ in $g(DM)/m^2/year/(mm/year) = gDM/m^2/mm$ and $\lambda_T = \partial NPP/\partial T$ in $gDM/m^2/year/°C$ respectively. Direct differentiation leads to

$$\lambda_T = \begin{cases} 
\frac{3000 \cdot 0.199 \exp(1.315 - 0.119 \cdot T)}{(1 + \exp(1.315 - 0.119 \cdot T))^2}, & \text{if } NPP_T < NPP_P \\
0, & \text{else}
\end{cases}$$ (3)

and

$$\lambda_P = \begin{cases} 
3000 \cdot 0.00664 \exp(-0.00664 \cdot P), & \text{if } NPP_P < NPP_T \\
0, & \text{else}
\end{cases}.$$ (4)
Reference