Drought Monitoring and Evaluating for Qinghai-Tibet Plateau Grassland

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Introduction

The grassland is the main part of the Qinghai-Tibet Plateau which consists of 30% of grassland in China. The method of grassland drought monitoring and evaluating was studied on base of Penman-Monteith equation (Allen et al. 1998) and AVIM-GRASS model (Qian et al. 2012) using daily meteorological data in Qinghai-Tibet Plateau from 1961 to 2007. Temperature, precipitation, sunshine hours, evapotranspiration, water surplus and deficit of a year and four seasons, in the growing season from April to September were systemically calculated and analysed. The grassland drought index was developed according to climate suitability of grassland vegetation, water surplus and deficit, net primary productivity (NPP). The grassland drought index and indicators of drought monitoring and evaluating were validated using data in 2006 and 2007, applied in 2012 for Qinghai-Tibet Plateau grassland. Results showed the index and indicators reflected the water surplus and deficit, drought conditions and its influence on grassland productivity.

Methods

The water surplus and deficit amount during "*j*" stage for "*i*" year in certain grassland type $GWD_{i,j}$:

$$GWD_{i,j} = P_{i,j} - ET_{i,j} \quad (1)$$

In equation (1), the positive value of $GWD_{i,j}$ shows water surplus, the negative value shows water deficit, zero shows that the precipitation is fitted to demand of grassland evapotranspiration. $P_{i,j}$ and $ET_{i,j}$ are respectively precipitation and evapotranspiration during "*j*" stage for "*i*"year for same grassland type. The evapotranspiration was calculated by Penman-Monteith equation using daily maximum temperature, minimum temperature, average temperature, average wind speed, sunshine hours, real vapour pressure.

The grassland drought index during "*j*" stage for "*i*" year in certain grassland type $GDI_{i,j}$

$$GDI_{i,j} = \frac{GWD_{i,j} - \overline{GWD_{i,j}}}{\overline{GWD_{i,j}}} * 100\% \quad (2)$$

In equation (2), $GDI_{i,j}$ is an anomaly percentage of water surplus and deficit, reflects the drought degree relative to normal year. $GWD_{i,j}$ is shown in equation (1). $\overline{GWD_{ij}}$ is the average of water surplus and deficit during "*j*" stage for "*i*" year from 1961 to 2007 for same grassland type.

Table 1. Indicators of monitoring and evaluating drought for Qinghai-Tibet Plateau grassland

Drought type	Water surplus grassland($\overline{GWD_{i,j}} > 0$)	water deficit grassland($\overline{GWD_{i,j}} < 0$)
No	$GWD_{i,j} \geq \overline{GWD_{i,j}}$	$GWD_{i,j} \geq \overline{GWD_{i,j}}$
	$GDI_{i,j} \geq 0$	$GDI_{i,j} \leq 0$
	$ANPP_{i,j} \geq 0$	$ANPP_{i,j} \geq 0$
light	$GWD_{i,j} < \overline{GWD_{i,j}}$	$GWD_{i,j} < \overline{GWD_{i,j}}$
	$-25\% \leq GDI_{i,j} < 0$	$0 < GDI_{i,j} \leq 25\%$
	$-10\% \leq ANPP_{i,j} < 0$	$-10\% \leq ANPP_{i,j} < 0$
Middle	$GWD_{i,j} < \overline{GWD_{i,j}}$	$GWD_{i,j} < \overline{GWD_{i,j}}$
	$-50\% \leq GDI_{i,j} < -25\%$	$25\% < GDI_{i,j} \leq 50\%$
	$-25\% \leq ANPP_{i,j} < -10\%$	$-25\% \leq ANPP_{i,j} < -10\%$
Severe	$GWD_{i,j} < \overline{GWD_{i,j}}$	$GWD_{i,j} < \overline{GWD_{i,j}}$
	$-80\% \leq GDI_{i,j} < -50\%$	$50\% < GDI_{i,j} \leq 80\%$
	$-50\% \leq ANPP_{i,j} < -25\%$	$-50\% \leq ANPP_{i,j} < -25\%$
Extreme	$GWD_{i,j} < \overline{GWD_{i,j}}$	$GWD_{i,j} < \overline{GWD_{i,j}}$
	$GDI_{i,j} < -80\%$	$80\% < GDI_{i,j}$
	$ANPP_{i,j} < -50\%$	$ANPP_{i,j} < -50\%$

$$ANPP_{i,j} = \frac{NPP_{i,j} - \overline{NPP_{i,j}}}{\overline{NPP_{i,j}}} * 100\% \quad (3)$$

In equation (3), $ANPP_{i,j}$ is an anomaly percentage of grassland NPP during "*j*" stage for "*i*" year in certain grassland, reflecting the productivity of grassland vegetation relative to normal year in same period. $NPP_{i,j}$ is grassland NPP during "*j*" stage for "*i*" year. $\overline{NPP_{ij}}$ is the average of grassland NPP during "*j*" stage for "*i*" year from 1961 to 2007 for same grassland type.

Results

The indicators of grassland drought monitoring and evaluating was designed and decided (Table 1) according to climate suitability of grassland vegetation, water surplus and deficit, NPP from 1961 to 2007 for Qinghai-Tibet Plateau. If $\overline{GWD_{ij}}$ is the positive value for the water

surplus grassland, the relationship between $GDI_{i,j}$ and $ANPP_{i,j}$ is positive. If $\overline{GWD_{ij}}$ is the negative value for the water deficit grassland, the relationship between $GDI_{i,j}$ and $ANPP_{i,j}$ is negative (Table 1).

Discussion

The grassland drought index was validated using data in 2006 and 2007, applied in 2012 for Qinghai-Tibet Plateau grassland (Figure 1). The distribution of grassland drought and proportions in drought grades were agreed to actual conditions. The indicators of monitoring and evaluating drought reflected the water surplus and deficit, drought conditions and its influence on grassland productivity. The accuracy of grassland drought monitoring and evaluating was above 90%. The method and indicators also can be applied to monitor and evaluate nationwide grassland drought in China.

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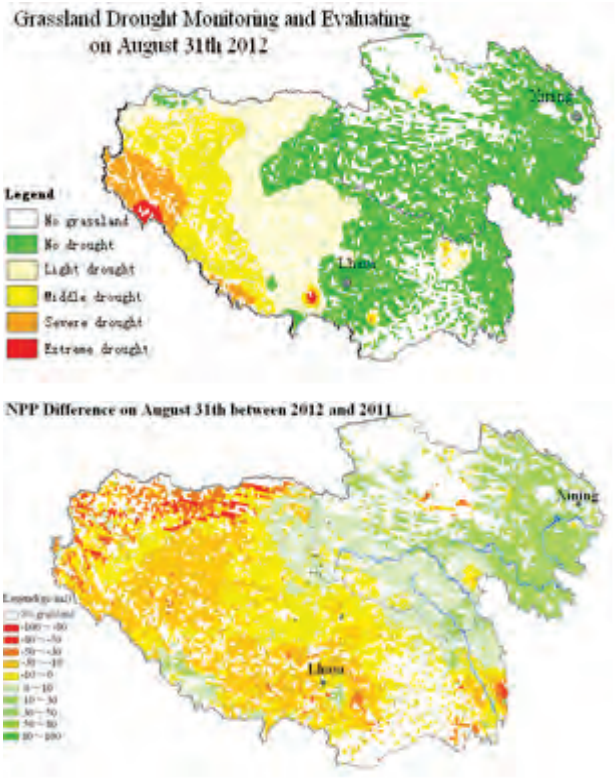

Figure 1. Distribution of drought monitoring and evaluating on August 31th 2012 (Top), NPP difference compared with 2011 (Bottom) in Qinghai-Tibet Plateau grassland