Data Article

# Dataset of the net primary production on the Qinghai-Tibetan Plateau using a soil water content improved Biome-BGC model

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## ARTICLE INFO

## ABSTRACT

The Biome-BGC (biome biogeochemical cycles) model is widely used for modeling the net primary productivity (NPP) of ecosystems. However, this model ignores soil water changes during the freeze-thaw process in permafrost regions, which may lead to considerable errors in the NPP estimations. In this context we propose a numerical simulation method for improving soil water content during the freeze-thaw process based on the field observation data of soil water and temperature. This approach does not require new parameters and has no impact on other modules. The improvement of soil water content during the freeze-thaw process was then incorporated in the Biome-BGC model for NPP in an alpine meadow in the central Qinghai-Tibetan Plateau (QTP). Interpretation of this data can be found in a research article entitled "An approach for improving soil water content for modeling net primary production on the Qinghai-Tibetan Plateau using Biome-BGC model" (Li et al., 2019).

Specifications Table

| Subject | Ecological Modelling |
|---|---|
| Specific subject area | Net Primary Productivity, Permafrost Region |
| Type of data | Table |
| How data were acquired | Model results Analysis data |
| Data format | Raw and Analysed |
| Parameters for data collection | The Tanggula station is located in the middle of Qinghai-Tibetan Plateau, and its climate condition is close to the multi-year average level of Qinghai-Tibetan Plateau. The main vegetation is alpine meadow, which is the constructive species of Qinghai Tibet Plateau. It provides a good opportunity to study the applicability of Biome-BGC model in the Qinghai- Tibetan Plateau. |
| Description of data collection | In this dataset, there are four files, 1) the average sunshine shortwave radiant flux density and sunshine hours were calculated by the MTCLIM4.0 model on the Tanggula site, which located in the central Qinghai-Tibetan Plateau; 2) the outputs from the original model; 3) the outputs from the improved model, and 4) the analysis and validation data. |
| Data source location | Cryosphere Research Station on the Qinghai-Tibetan Plateau, State Key Laboratory of Cryospheric Science, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences Qinghai-Tibetan Plateau, China 91°54′E, 32°51′N |
| Data accessibility | Repository name: Mendeley Data DOI: 10.17632/jky2frt4pk.4 Direct URL to data: https://data.mendeley.com/datasets/jky2frt4pk/4 |
| Related research article | Chuanhua Li, Hao Sun, Xiaodong Wu, Haiyan Han. Approach for improving soil water content for modeling net primary production on Qinghai-Tibetan Plateau using Biome-BGC model [1]. DOI:https://doi.org/10.1016/j.catena.2019.104253 |

**Data Value**

- The Qinghai-Tibetan Plateau is the largest permafrost region in the high altitude area in the world. The data include information about net primary productivity in the permafrost region of Qinghai-Tibetan Plateau from 2012 to 2014.
- The data contain all the driving data and outputs of the Biome-BGC model, which are helpful to analyze the structure and pattern of soil moisture in permafrost area.
- These data may be helpful for comparative analysis in other permafrost areas.
- These data can improve our understanding of vegetation growth in permafrost region under the background of climate warming.

## 1. Data

The "MTCLIM-XL_0.4 Tanggula.xlsx" includes the average solar shortwave radiation flux density (SRFD) and daylength (Daylen) calculated from MTCLIM 4.0 model in 2012−2014, which are used to drive the Biome-BGC model. The "Documentation" sheet introduces the model, "Improved. annout" and "Original. annout" are the outputs of each year from the improved model and the original model, and "Improved. dayout" and "Original. dayout" are the results of each day output from the improved model and the original model. "miss5093.ini" sheet is the number of sites, "miss5093.restart" sheet is the parameter obtained after the initial simulation, "miss5093.met" sheet is the daily input meteorological data, "co2" sheet is the concentration of carbon dioxide, "epc" sheet is the physiological and ecological parameters of vegetation. The "analysis data. xlsx" includes soil water data, water stress coefficient data and net primary productivity data.

## 2. Experimental design, materials, and methods

The Biome-BGC was created by the Numerical Terradynamic Simulation Group (NTSG), University of Montana. It is a biogeochemical model that simulates the storage and flux of water, carbon, and nitrogen between the ecosystem and the atmosphere, and within the components of the terrestrial ecosystem. This model also can simulate photosynthesis, respiration, allocation of organic matter, litter

and decomposition of plant tissues, and circulation and migration of nutrients in different ecosystems [2].

The Biome-BGC is driven by three types of parameters: site parameters (Table 1), daily meteorological data, and plant physiology and ecological parameters. Soil texture, latitude, longitude, and altitude, were obtained from field measurements. The atmospheric carbon dioxide concentration data were based on relevant literatures [3,4].

The plant physiology and ecological parameters include both labeled and unlabeled parameters (Table 2). The labeled parameters are Boolean and do not require sensitivity analysis. The unlabeled parameters were analyzed for sensitivity. In this study, the sensitivity parameters of the Biome-BGC

**Table 1**
Site parameters for Biome-BGC model.

| name | value | type | Description |
|---|---|---|---|
| **SIM_CONTROL** | | | |
| EPC_COLUMN | c3grass | String | Ecophysiological constants column in the 'epc' worksheet that describes the vegetation |
| SIM_YEARS | 11 | Integer | Number of years to simulate |
| FIRST_SIM_YEAR | 2005 | Integer | First year of simulation |
| PROGRESS | TRUE | Boolean | Display progress information? |
| SIM_TYPE | 2 | Integer | Simulation Type: 1 = Spinup, 0 = Normal, 2 = Spin and Go |
| **CLIM_CHANGE** | | | |
| TMAX_OFFSET | 0 | Float | Additional offset for maximum temperature |
| TMIN_OFFSET | 0 | Float | Additional offset for minimum temperature |
| PRCP_MULT | 1 | Float | Multiplier for precipitation (dim) |
| VPD_MULT | 1 | Float | Multiplier for VPD (dim) |
| **CO2_CONTROL** | | | |
| CO$_2$_FLAG | 1 | Boolean | 0 = Use a fixed $CO_2$ concentration, 1 = Use $CO_2$ values in the CO$_2$_WORKSHEET |
| **SITE** | | | |
| SOIL_DEPTH | 0.6 | Float | Soil Depth (meters) |
| SOIL_SAND | 67 | Float | Soil Sand (%) |
| SOIL_SILT | 30 | Float | Soil Silt (%) |
| SOIL_CLAY | 3 | Float | Soil Clay (%) |
| ELEV | 5100 | Integer | Elevation (meters) |
| LAT | 32.9 | Float | Latitude (decimal degrees) |
| LON | 91.9 | Float | Longitude (decimal degrees) |
| **SITE_N** | | | |
| RAMP_NDEP_FLAG | 0 | Boolean | Do nitrogen deposition ramping? |
| REF_NDEP_YEAR | 2000 | Integer | Reference year for nitrogen deposition |
| IND_NDEP | 0.0001 | Float | Industrial nitrogen deposition |
| NDEP | 0.0001 | Float | Pre-industrial nitrogen deposition |
| NFIX | 0.0006 | Float | Nitrogen fixation |
| **SITE_W** | | | |
| INIT_SNOWW | 10 | Float | Initial snow wate |
| INIT_SOILW | 0.5 | Float | Initial soil water as a fraction of saturation |
| **SITE_C** | | | |
| FY_MAX_LEAFC | 0.001 | Float | First year maximum leaf carbon |
| FY_MAX_STEMC | 0 | Float | First year maximum stem carbon |
| **OUTPUT** | | | |
| DO_DAILY | TRUE | Boolean | Do daily outputs? |
| DO_ANNUAL | TRUE | Boolean | Do annual summary outputs? |
| NUM_VARS | 9 | Integer | Number of output variables beginning on the next row |
| 1 | GPP | String | Gross Primary Productivity |
| 2 | NPP | String | Net Primary Productivity |
| 3 | MR | String | Net Ecosystem Exchange |
| 4 | ET | String | Evapotranspiration |
| 5 | OF | String | Soil water outflow |
| 6 | PRCP | String | Precipitation |
| 7 | LAI | String | Leaf Area Index |
| 8 | TSOIL | String | Soil temperature |
| 9 | SOILW | String | Soil water |

**Table 2**
Plant physiology and ecological parameters.

| Keyword | c3grass | Type | Description |
|---|---|---|---|
| WOODY_FLAG | 0 | (flag) | 1 = WOODY 0 = NON-WOODY |
| EVERGRN_FLAG | 0 | (flag) | 1 = EVERGREEN 0 = DECIDUOUS |
| C3_FLAG | 1 | (flag) | 1 = C3 PSN 0 = C4 PSN |
| MODEL_PHEN_FLAG | 0 | (flag) | 1 = MODEL PHENOLOGY 0 = USER-SPECIFIED PHENOLOGY |
| ONDAY | 120 | *(yday) | yearday to start new growth |
| OFFDAY | 290 | *(yday) | yearday to end litterfall |
| TRNS_GR_PROP | 1 | *(prop.) | transfer growth period as fraction of growing |
| LIT_FALL_PROP | 1 | *(prop.) | litterfall as fraction of growing season |
| LFR_TURNOVER | 1 | (1/yr) | annual leaf and fine root turnover fraction |
| LWOOD_TURNOVER | 0 | (1/yr) | annual live wood turnover fraction |
| MORT_FRAC | 0.1 | (1/yr) | annual whole-plant mortality fraction |
| FIRE_MORT_FRAC | 0.001 | (1/yr) | annual fire mortality fraction |
| ALLOC_FR_LEAF | 0.881 | (ratio) | new fine root C: new leaf C |
| ALLOC_STEM_LEAF | 0 | (ratio) | new stem C: new leaf C |
| ALLOC_LWOOD_TOTWOOD | 0 | (ratio) | new live wood C: new total wood C |
| ALLOC_CROOT_STEM | 1.0263 | (ratio) | new croot C: new stem C |
| GR_PROP | 0.5 | (prop.) | current growth proportion |
| LEAF_CN | 33.7356 | (kgC/kgN) | C:N of leaves |
| LLITTER_CN | 49.7 | (kgC/kgN) | C:N of leaf litter, after retranslocation |
| FR_CN | 49.7 | (kgC/kgN) | C:N of fine roots |
| LWOOD_CN | 0 | (kgC/kgN) | C:N of live wood |
| DWOOD_CN | 0 | (kgC/kgN) | C:N of dead wood |
| LIT_LAB_PROP | 0.39 | (DIM) | leaf litter labile proportion |
| LIT_CEL_PROP | 0.44 | (DIM) | leaf litter cellulose proportion |
| LIT_LIG_PROP | 0.17 | (DIM) | leaf litter lignin proportion |
| FR_LAB_PROP | 0.3 | (DIM) | fine root labile proportion |
| FR_CEL_PROP | 0.45 | (DIM) | fine root cellulose proportion |
| FR_LIG_PROP | 0.25 | (DIM) | fine root lignin proportion |
| DWOOD_CEL_PROP | 0.76 | (DIM) | dead wood cellulose proportion |
| DWOOD_LIG_PROP | 0.24 | (DIM) | dead wood lignin proportion |
| CANOPYW_INT_COEF | 0.021 | (1/LAI/d) | canopy water interception coefficient |
| CANOPY_LT_EXT_COEF | 0.48 | (DIM) | canopy light extinction coefficient |
| LEAF_AREA_RAT | 2 | (DIM) | all-sided to projected leaf area ratio |
| AVG_SLA | 12.35 | (m2/kgC) | canopy average specific leaf area |
| SHADE_SUN_SLA_RAT | 2 | (DIM) | ratio of shaded SLA:sunlit SLA |
| FLNR | 0.21 | (DIM) | fraction of leaf N in Rubisco |
| GS_MAX | 0.006 | (m/s) | maximum stomatal conductance |
| GC_MAX | 0.00001 | (m/s) | cuticular conductance (projected area basis) |
| GB | 0.04 | (m/s) | boundary layer conductance (projected area basis |
| PSI_MIN | −0.6 | (MPa) | leaf water potential: start of conductance reduction |
| PSI_MAX | −2.3 | (MPa) | leaf water potential: complete conductance reduction |
| VPD_MIN | 930 | (Pa) | vapor pressure deficit: start of conductance reduction |
| VPD_MAX | 4100 | (Pa) | vapor pressure deficit: complete conductance reduction |

model were analyzed based on the coefficient of variation, and the parameters with coefficients of variation greater than 0.1 were field measurements. The SLA (specific leaf area) was calculated by scanning the field samples. Specifically, the leaf samples were collected at each sampling site, and then the samples were scanned by a scanner to obtain the digital images. The area of each leaf was measured, and then the sample was dried to measure the dry weight. The ratio of average leaf area to dry weight was the specific leaf area. The contents of carbon and nitrogen in the sample were analyzed using an automatic chemical analyzer (SmartChem 2000, Alliance, France).

The description of soil water cycle in the original model involves several processes, such as canopy interception and evaporation, soil water potential energy and content, stomatal conductance and evapotranspiration, surface evaporation, flooding, and infiltration. The calculation of soil water content in the original model can be summarized as follows:

$$W_{\text{vwc}} = f_{\text{vwc}}(P, k_{\text{int}}, L_A, E_{\text{int}}, t, VPD, \psi, \theta, PPFD \ldots) \times 1000 \times d_{\text{soil}} \tag{1}$$

where $f_{vwc}(P, k_{int}, L_A, E_{int}, t, VPD, \psi, \theta, PPFD\ldots)$ is the soil volumetric water content, $P$ is the precipitation, $k_{int}$ is the canopy interception coefficient, $L_A$ is the leaf area index, $E_{int}$ is the canopy interception evaporation coefficient, $t$ is the temperature, $VPD$ is the water pressure, $\psi$ is the soil water potential energy, $\theta$ is the field water holding capacity, $PPFD$ is the stomatal conductance, and $d_{soil}$ is the soil depth. The improved formula is as follows:

$$W_{vwc} = f_{vwc}(P, k_{int}, L_A, E_{int}, t, VPD, \psi, \theta, PPFD\ldots) \times 1000 \times d_{soil} + f_{FTW}(T_{soil}) \qquad (2)$$

where $f_{FTW}(T_{soil})$ is the freeze-thaw water content and $T_{soil}$ is the soil temperature.

## Acknowledgments

## Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104740.

## References

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