A new version of the global high-resolution dataset of soil hydraulic and thermal parameters for land surface modeling

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1. Introduction

A newly developed global dataset of soil hydraulic and thermal parameters using multiple Pedotransfer Functions (PTFs) or soil thermal conductivity schemes (STCs) that are widely cited or recently developed is provided for Land Surface Modeling.

The published variables have been listed on the website page. These variables are all provided at the spatial resolution of 30" ranging from 90°N to 90°S, 180°W to 180°E, with four sets of vertical profiles available [i.e., as vertical resolutions of SoilGrids (0 - 0.05 m, 0.05 - 0.15 m, 0.15 - 0.30 m, 0.30 - 0.60 m, 0.60 - 1.00 m, and 1.00 - 2.00 m), Noah-LSM (0 - 0.1 m, 0.1 - 0.4 m, 0.4 - 1.0 m, and 1.0 - 2.0 m), JULES (0 - 0.1 m, 0.1 - 0.35 m, 0.35 - 1.0 m, and 1.0 - 3.0 m) and CoLM/CLM (0 - 0.0451 m, 0.0451 - 0.0906 m, 0.0906 - 0.1655 m, 0.1655 - 0.2891 m, 0.2891 - 0.4929 m, 0.4929 - 0.8289 m, 0.8289 - 1.3828 m, 1.3828 - 3.8019 m)]. The dataset is currently stored in the binary format.

The basic soil information is given as the volumetric fractions of all the available soil constituents we collected, namely gravels, soil organic matters (SOM), sand, silt and clay, letting in each soil layer the equation "vf_gravals+vf_om+vf_sand+vf_clay+vf_silt+theta_s=1" holds. "theta_s" represents the soil porosity. The soil water retention parameters, based on the Campbell [1974] and van Genuchten [1980] (hereafter VG) models, are obtained from a fitting method to find the optimal water retention parameters from ensemble PTFs. The soil hydraulic conductivity is estimated as the median values of ensemble PTFs. The heat capacity of soil solids is calculated as the volumetric weighted average of the heat capacity of mineral soils, SOM and gravels. And the soil thermal conductivity is estimated following the models of Johansen [1975] and Balland and Arp [2005], with all the effects of soil constituents such as SOM and gravels considered.

2. Data description and usage

The dataset is currently stored in the binary format. Each file only contains the information of one soil layer. The vertical profile of each variable (from top to bottom) applying to a specific model is packed. The spatial coverage of each binary file is

global, with 43200 columns (longitude) and 21600 rows (latitude), and the variable is defined at the center of each grid cell. The values of each variable are stored by rows, from 180°W to 180°E and from 90°N to 90°S, and the missing value (over ocean or land surface water body) is $-1.0*10^{36}$. The data is written in 8 bytes (double float).

The dataset can be easily used by many programming languages. Here, we give demos using two popular languages (Fortran and NCL) to show how to read the data.

2.1 Fortran

Assuming that you want to use the variable "theta_s" (the soil porosity) calculated for the CoLM (8 layers), you can use the following codes to read the data:

```
   character(len=256) c
   integer iunit
   integer length
   integer nrow
   integer MODEL_SOIL_LAYER
   integer, parameter :: r8 = selected_real_kind(12)
   integer, parameter :: nlat = 21600    ! 180*(60*2)
   integer, parameter :: nlon = 43200    ! 360*(60*2)
   real(r8) tmp(nlon)
   real(r8) theta_s(nlon,nlat)

   iunit = 100

   DO MODEL_SOIL_LAYER = 1, 8
        write(c,'(i1)') MODEL_SOIL_LAYER
        inquire(iolength=length) tmp
        open(iunit,file='theta_s_l'//trim(c),access='direct',recl=length,form='unformatt
ed',status='old')
        do nrow = 1, 21600
             read(iunit,rec=nrow) theta_s(:,nrow)
        enddo
        close(iunit)
!-------------------------------------------------------------------------------------------------------
!       Do the calculations at each soil layer with the variable "theta_s" by the users
!-------------------------------------------------------------------------------------------------------
   ENDDO
```

2.2 NCAR Command Language (NCL)

Based on the example above, you can also read the data via NCL as the following script:

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_csm.ncl"

begin
do j = 1, 8
   path = “theta_s_l”+sprinti(“%0.1i”,j)
   theta_s = new((/21600,43200/),double)
   do i=0, 21600-1
        theta_s(i,:) = fbindirread(path, i, 43200, “double”)
   end do
   ;-----------------------------------------------------------------------------------------------------
   ; Do the calculations at each soil layer with the variable “theta_s” by the users
   ;-----------------------------------------------------------------------------------------------------
   delete (theta_s)
end do

end
```

Note that the workspace allocation may exceed the maximum size 32556688 in NCL, and the easiest way to increase the size is to put a line into your “~/.hluresfile” as follows:

*wsMaximumSize : 500000000

In addition, it will cost relatively longer time to read the data via NCL because NCL is not good at doing loops. If you want to process the data or plot figures using NCL more efficiently, you may consider to call a Fortran subroutine or function from your NCL script to read the data. Fortran can process loops much faster. You can access the way to call Fortran subroutines from NCL via the link: http://www.ncl.ucar.edu/Document/Manuals/Ref_Manual/NclExtend.shtml

3. Citation

Details about the dataset can be found via the following two articles. Full acknowledgement and referencing of the two articles must be included in any documentation using any of the material contained in this dataset as follows:

Dai, Y., N. Wei, H. Yuan, S. Zhang, W. Shangguan, S. Liu, X. Lu and Y. Xin (2019a), Evaluation of soil thermal conductivity schemes for use in land surface modelling, J. Adv. Model. Earth System, accepted.

Dai, Y., Q. Xin, N. Wei, Y. Zhang, W. Shangguan, H. Yuan, S. Zhang, S. Liu, and X. Lu (2019b), A global high-resolution dataset of soil hydraulic and thermal properties for land surface modeling, J. Adv. Model. Earth System, accepted.

4. Contact

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