The global dataset of soil hydraulic and thermal parameters for earth system modeling

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1. Introduction

In order to simulate soil water content using the Richards equation, land surface models (LSMs) for hydrometeorological and climate studies employ three empirical functions, one for the soil water retention curve, one for the soil hydraulic conductivity and one for soil thermal properties. Since the hydraulic parameters associated with these functions are difficult to measure directly, empirical relationships are used to relate these parameters to readily available soil properties, referred to as pedotransfer functions (PTFs).

We developed a global dataset of soil hydraulic parameters using different PTFs. We selected PTFs to derive the parameters in the Clapp and Hornberger Functions (FCH) and in thermal dynamic equation. The inputs into the PTFs include gravel, soil particle-size distribution, bulk density and soil organic matter, which are provided with our newly-developed global soil characteristic dataset (Shangguan et al., 2014). The resolution is 30 arc-seconds (about 1 km at the equator).The vertical variation of soil property was captured by eight layers to the depth of 2.3 m (i.e. 0-0.045, 0.045-0.091, 0.091-0.166, 0.166-0.289, 0.289-0.493, 0.493-0.829, 0.829- 1.383 and 1.383- 2.296 m) for convenience of use in the Common Land Model and the Community Land Model (CLM).

2. Data description

2.1 NetCDF format

Here we take the saturated water content of FCH (file “theta_s_l1.nc”) as an example to show the data. The dataset takes the NetCDF Climate and Forecast Metadata Convention (CF-1.0). The extent is 180°W -180°E and 90°N -90°S. The following is the metadata:

```
dimensions:
        lon = 43200 ;
        lat = 21600 ;
        depth = 1 ;
variables:
        float lon(lon) ;
```

```
                lon:long_name = "longitude" ;
                lon:units = "degrees_east" ;
        float lat(lat) ;
                lat:long_name = "latitude" ;
                lat:units = "degrees_north" ;
        float depth(depth) ;
                depth:long_name = "depth to the bottom of a soil layer" ;
                depth:units = "centimeter" ;
        short theta_s(lon, lat) ;
                theta_s:missing_value = -9999 ;
                theta_s:units = "" ;
                theta_s:scale_factor = 0.001 ;
                theta_s:long_name = "Saturated water content of FCH" ;

; // global attributes:
                :Conventions = "CF-1.0" ;
```

2.2 Coordinate system of the dataset

The coordinate system is WGS_1984, and the parameters are:

Semimajor Axis: 6378137.000000000000000000

Semiminor Axis: 6356752.314245179300000000

Inverse Flattening: 298.257223563000030000

3. Data usage

The data in NetCDF file format can be used by multiply software. Here we give three example softwares, i.e. Panoply, NCL and R.

3.1 Panoply

This software is recommended to a fast visual look at the data. It can be downloaded here (www.giss.nasa.gov/tools/panoply).

3.2 NCAR Command Language (NCL)

Here is an example of NCL script to use the data:

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

begin

THSdata = addfile("theta_s_l1.nc","r")
lat = THSdata->lat
lon = THSdata->lon
THS= THSdata-> theta_s
;printVarSummary(THS)
```

```
THS@_FillValue = -999

wks = gsn_open_wks("pdf","THS")
gsn_define_colormap(wks,"rainbow+white+gray")

res      = True
res@gsnAddCyclic = False

res@mpLimitMode = "LatLon"
res@mpMaxLatF = 90
res@mpMinLatF = -90
res@mpMaxLonF = 180
res@mpMinLonF = -180

res@cnFillOn=True
res@cnLinesOn=False

res@lbLabelAutoStride=True
res@lbBoxLinesOn=False

res@gsnSpreadColors=True
res@gsnSpreadColorStart=50
res@gsnSpreadColorEnd=-3

res@cnFillMode = "RasterFill"
res@cnLevelSelectionMode="ManualLevels"
res@cnMinLevelValF=0.0
res@cnMaxLevelValF=90.0
res@cnLevelSpacingF = 5.0

plot = gsn_csm_contour_map(wks,THS(0,:,:),res)

end
```

Note that workspace reallocation would exceed maximum size 32556688, the easiest way to increase the size is to put a line like the following into your ~/.hluresfile:

*wsMaximumSize : 500000000

1.3 R language

The NetCDF files can be used by loading "RNetCDF" package or “ncdf4” package.

4. Citation

Details about the dataset are in the peer-reviewed paper.

Full acknowledgement and referencing of all sources must be included in any documentation using any of the material contained in the dataset, as follows:

Dai, Y., W. Shangguan, Q. Duan, B. Liu, S. Fu, G. Niu, 2013: Development of a China Dataset of Soil Hydraulic Parameters Using Pedotransfer Functions for Land Surface Modeling. Journal of Hydrometeorology, 14: 869-887

Dai et al., 2014: Implementation of a New Global Soil Dataset in the Common Land Model (in preparation).

5. Reference

Shangguan, W., Y. Dai, Q. Duan, B. Liu and H. Yuan (2014), A Global Soil Dataset for Earth System Modeling, Journal of Advances in Modeling Earth Systems, 6: 249-263.

6. Contact

If you have any questions when using PTFC data set, please email: shanggv@bnu.edu.cn (Dr. Wei Shangguan).

7. Updates

2016.6.6: The dataset was updated to fix the faults in land type setting for the Qinghai-Tibet Plateau, Greenland and parts of Canada.