WRF-VRPM modeling system
Preprocessor for VPRM
Users Manual

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Table of Contents

Software requirements

- GNU Linux/Unix OS
  - tested on x86_64 Suse Linux
- GNU Bash
  - tested with version 2.05b.0(1)
- HDF5 tools
  - tested with version 1.6.4
  - obtained from: http://www.hdfgroup.org/HDF5/
- H4toH5 conversion tool
  - tested with version 1.2
  - obtained from: http://www.hdfgroup.org/h4toh5/
- MODIS Land Data Operational Product Evaluation (LDOPE) tool
  - tested with version: 1.0
  - obtained from: http://gcmd.nasa.gov/records/LDOPE.html
- MODIS Reprojection Tool (MRT)
  - tested with version: 3.3
  - optained from https://lpdaac.usgs.gov/lpdaac/tools/modis_reprojection_tool
- NETCDF library and tools
  - tested with version: 3.6.0-p1
  - optained from: http://www.unidata.ucar.edu/software/netcdf/
- R
  - tested with version: 2.5.1
  - optained from: http://cran.r-project.org/
- Rmap package for R
  - tested with version: 1.1.0
  - obtained from: http://www.maths.lancs.ac.uk/Software/Rmap/
- HDF package for R (hdf5)
  - tested with version 1.6.2
  - obtained from: http://cran.r-project.org/
- NETCDF package for R (RNetCDF)
  - tested with version 1.2-1
  - obtained from: http://cran.r-project.org/

Installation

1. Extract the archive.
2. Patch LDOPE tool.
   Some modifications to **math_sds.c** and **cp_proj_param.c** were made by Christoph Gerbig. Patch files are included in the distribution of this preprocessor. The patches are in the root directory of the preprocessor called: **cp_proj_param.patch** and **math_sds.patch**.
   Apply the patches and then recompile LDOPE tools. Patched and precompiled LDOPE binaries can also be downloaded from: http://www.bgc-jena.mpg.de/~rkretsch/vprmpreproc/
3. Configure the preprocessor, see next section.
4. Prepare SYNMAP.
   Vegetation information is obtained from SYNMAP by Jung et al. which is given for the whole globe at 1km horizontal resolution. You can download smaller areas (Europe, North America) from : http://www.bgc-jena.mpg.de/~rkretsch/vprmpreproc/
   Execute **<PATH_TO_PREPROCESSOR>/get_synmap.sh** to create a SYNMAP file based on the settings in config.r which can be read by the preprocessing script.
5. **The bash script uses <PATH_TO_PREPROCESSOR>/RSources/gridEurope.r** to create the SYNMAP file covering your domain. The R script contains detailed explanation on how to use it. Basically you set up three values:
   I) A binary file containing the SYNMAP of the whole globe. Can be downloaded from: http://www.bgc-jena.mpg.de/~rkretsch/vprmpreproc/
   II) Latitude and longitude borders of your domain. Make sure it covers the whole area of your domain. III) The name of the map.
6. Compile C sources.
   Some parts of the preprocessor a written in C. Compile them by running compile.sh from the shell. This script is located in the root directory of the preprocessor.

Configuration

Set up the preprocessor by editing the configuration file **config.r**. This script is located in the root directory of the preprocessor. A detailed description of every option is given in the script. The configuration script will be sourced by the main script to load your configuration.

Downloading MODIS Reflectance Data

MODIS MOD09A1 data need to be available in the "modisrep" folder specified in config.r. Different tiles for the desired year can be downloaded from the web site earthexplorer.usgs.gov. Note that some time periods are missing, those can be identified on the web page landweb.nascom.nasa.gov/prod_www/.
Download can also be done automatically when setting flag "ftdata <- TRUE" in the main script VPRMpreproc.r.

Execution

Change into preprocessor directory and run **preprocess.sh**. After starting you can log off, since the script is executed as background process. The whole preprocessing may take several days depending on your hardware and the domain size. Standard output of the script is written to a log file called **run.log**. This file is saved in the root directory of the preprocessor.
Another way of running the script is using a queuing system like the Load Sharing Facility (LSF) for execution on a cluster. To do so can use the **submit_preproc.sh** bash script in the preprocessor root directory. You may have to alter the script to fit the configuration of your queuing system and cluster.

The final output files of the preprocessing are written in to a directory you specified in **config.r**.
When the preprocessing has finished the output directory contains 7 NETCDF files: indices, maximum, minimum values each for LSWI and EVI, together with the vegetation fraction map.
Each of these files follows the NetCDF Climate and Forecast (CF) Metadata Conventions version 1.4.

In case you want to rerun the preprocessor, you may want to clean old intermediate or output files respectively. To do so you can use the scripts **clean.sh** and **clean_all.sh**. The first script leaves all the loess filtered tiles, whereas clean_all.sh deletes these, too.

There is the possibility to run loess filtering in parallel on a cluster system. To do so you may have to modify the **submit_loess.sh** script to match the configuration of your cluster and queuing system. This script is called by **VPRMpreproc.r**. Both scripts are stored in the root directory of the preprocessor. Additionally you have to switch on the “do_parallel” variable in **config.r**.

Evaluation of preprocessing results

You may want to use the script **check_output.r** to check results of the preprocessing tool. The script defines some basic checks for the results and can be found in the preprocessor root directory. An easy way to use it is to run **check_output.sh** from the command line.

Contact & references

The tool was written by:
Christoph Gerbig <cgerbig@bgc-jena.mpg.de>
Roberto Kretschmer <rkretsch@bgc-jena.mpg.de>

VPRM:
Mahadevan, P., S. Wofsy, D. M. Matross, X. Xiao, A. Dunn, J. C. Lin, C. Gerbig, J. W. Munger, V. Y. Chow, and E. Gottlieb, A Satellite-Based Biosphere Parameterization for Net Ecosystem CO2 Exchange: Vegetation Photosynthesis and Respiration Model (VPRM), Global Biogeochem. Cycles, 22, GB2005, doi:10.1029/2006GB002735, 2008.

WRF-VPRM:
Ahmadov R; Gerbig C; Kretschmer R; Koerner S; Neininger B; Dolman AJ; Sarrat C (2007): Mesoscale covariance of transport and CO2 fluxes: evidence from observations and simulations using the WRF-VPRM coupled atmosphere-biosphere model. Journal of Geophysical Research - Atmospheres 112, D22107

Ahmadov, R., Gerbig, C., Kretschmer, R., Körner, S., Rödenbeck, C., Bousquet, P., and Ramonet, M.: Can we use hourly CO2 concentration data in inversions? Comparing high resolution WRF-VPRM simulations with coastal tower measurements of CO2, Biogeosciences Discuss., 5, 4745-4776, 2008.

SYNMAP:
Martin Jung, Kathrin Henkel, Martin Herold, and Galina Churkina. Exploiting synergies of global land cover products for carbon cycle modeling. Remote Sensing of Environment, 101(4):534-553, April 2006.

Additional remarks

Please see also comments made in the code to see which parts of the code need improvement or optimization or to get more details about the implementation. As starting point you may want to look into **VPRMpreproc.r** which is the main script. It is located in the root directory of the preprocessor.

In contrast to the 11 vegetation classes as described in the VPRM paper by Mahadevan et al. we currently support only 8 classes. The mapping of classes from SYNMAP to VPRM is described in the code (**VPRMpreproc.r**) and also in the metadata of the NETCDF output files of the preprocessor. In future versions we might also add additional vegetation classes if needed.