

VECTRI v1.4.6

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The malaria model presented is a grid-point distributed dynamical model and is referred to as the VECToR borne disease community model of ICTP, TRieste. (VECTRI).

Getting started:

Key requirements to get/run the code

gfortran
netcdf libraries
git

Useful optional code to postprocess and examine files

cdo
R
ncview
ncdump

Installing requisite software

Ubuntu:

```
$ sudo apt-get install libnetcdf-dev  
$ sudo apt-get install libnetcdf-f77-dev  
$ sudo apt-get install netcdf-bin  
$ sudo apt-get install gfortran  
$ sudo apt-get install git  
$ sudo apt-get install cdo  
$ sudo apt-get install ncview
```

MAC: On a MAC, one can use MACPORTS to update software.

After you have installed macports, you can then do:

e.g. `$ sudo port install gfortran`
and so on...

If you want to use VECTRI in the future, please sign up online and download instructions will be sent to you:

<http://users.ictp.it/~tompkins/vectri/download>

You will get an automated email reply telling you how to download a copy from the gitlab repository. ICTP keeps a register of users who may be occasionally (once or twice per year) contacted with VECTRI news unless you specify **not** to be included.

However, you can simply clone the code directly using the following command. This will retrieve the code and put it in a **subdirectory** of your present location called “vectri”. Make sure you run the following command from a suitable location (e.g. `$ cd $HOME` first to put the code under your home directory).

```
$ git clone https://gitlab.com/tompkins/vectri.git
```

VECTRI code location

Since v1.2.4, the runtime directories are kept separate from all the source and datafiles to keep things cleaner. The model needs to know where these files are. To do this set up an environmental variable VECTRI with the location of the model.

ksh or bash: \$ export VECTRI=directory

csh: \$ setenv VECTRI directory

If you have just run the clone command you can set up the variable with the following command:

```
$ export VECTRI='pwd'/vectri
```

Note the forward sloping single quotes. These execute the pwd command and place the results in the quoted location.

TIP: If you want to run VECTRI regularly, you can place this definition command in your .cshrc .kshrc or .bashrc (according to your shell choice) to set this variable automatically on login, however, you will need to make sure you set the whole absolute path! e.g. if you have placed the directory under your HOME:

```
$ export VECTRI=$HOME/vectri.
```

You should not use the 'pwd' as that depends on the directory location from where the command is run.

You can check the variable is set correctly by:

```
$ ls $VECTRI
```

which should give a listing of the code directories:

```
data doc graphics README.txt scripts source
```

running location

where do you want to run? Just make a run directory and go there! e.g.

```
$ mkdir -p $HOME/run
```

```
$ cd $HOME/run
```

TIP: In bash hit “tab” to complete path and filenames

TIP: Remember you can use the short-cuts ~ or \$HOME to refer to your home directory.

Running the model

The model can be run using two different methods.

Method 1 - fixed form input

```
$ $VECTRI/scripts/vectri_driver mode options  
following by a list of numbers that define the options
```

Method 2 - free form input

```
$ $VECTRI/scripts/vectri_driver --option1 value  
--option2 value
```

Method 1 is shorter (less typing) but you need to put the options in the correct order. Method 2 is more flexible but you need to know which combination of options to specify. The driver code looks at the first argument, and if it is an integer between 1 to 5, the fixed form method 1 is assumed. Otherwise free-form options are assumed. **You can not mix the two options.**

The first number, *mode* after the `vectri_driver` command, tells the program which mode to run `vectri` in. At the moment there are three main modes, with two special modes:

mode=

- 1 constant value temperature and rainfall
- 2 station data in a netcdf file (defunct - now use mode 3)
- 3 netcdf file input - can import gridded satellite rainfall and ERA temperatures
- 4 Special mode to read ASCII station data (fixed format for West Africa)
- 5 Special mode to read ASCII station data (fixed format for example file)

mode=1: constant input

The model is run using the commands

```
$ $VECTRI/scripts/vectri_driver 1 temperature  
rainfall population
```

where **temperature** is given in degree C

rainfall in mm day^{-1}

population is the density as people km^{-2}

mode=3: gridded or single location runs, netcdf input format

The model is run using the commands

```
$ $VECTRI/scripts/vectri_driver 3 lat1 nlat dlat  
lon1 nlat dlat date1 date2 preprocess rainfile  
tempfile experiment downscale initfile population run
```

This mode can be used to either run for a region or for a point with netcdf input, or it can also be used to import precipitation observations from CMORPH, FEWS or TRMM (if the datasets are available locally). **Instructions for this mode to follow soon.**

mode=5: single location, ASCII Tmax/Tmin format

```
$ $VECTRI/scripts/vectri_driver 5 stationfile  
population nday
```

stationfile: the name of the ASCII input file (can include directory structure)

population: the density as people km^{-2}

nday: length of integration in days, set to 0 for the whole file.

The ASCII input file is assumed to have a column format of form:
yyyy mm dd T_{min} T_{max} rainfall. VECTRI assumes that the mean temperature is simply the average of the maximum and minimum values.

There is an example file for mode 5 in the data directory. You can view it using

```
$ less $VECTRI/data/highland_location_africa.txt
```

VECTRI automatically looks for the file in the data directory. If your data file is stored elsewhere you need to remember to include the **path** in the filename (e.g.

```
/scratch/myname/mydatadir/myinputdata.txt )
```

Note, long word options are with a **double** hyphen!

-m mode OR --mode mode

domain opts: --lat1 x --nlat x --dlat x --lon1 x --nlon x --dlon x

date opts: --date1 yyyyymmdd --date2 yyyyymmdd

process opts: --preproc 1/0 --dscale 0/1 - switches to
preprocess/interpolate input files and downscale temperature

climate opts: --temp ncdf_filename or "era"

climate opts: --prec ncdf_filename or "obsfew", "obstrmm",
"obscmorph"

population opts: --pop density or "afripop" "grump"

misc opts: --init none or restart_file --station station_filename

vectri.nc

The main output file is called **vectri.nc** which is found in the subdirectory *output* after each successful run. The file is in standard netcdf format and you can use two commands to examine its content `$ ncvview` and `$ ncdump`.

Using ncdump

ncdump outputs the entire contents of a file, perhaps a little more than you bargained for, so use the useful option `-h` to examine the file *header*:

```
$ ncdump -h ./output/vectri.nc
```

The command lets us know the dimensions of the output, gives a list of the model output variables, as well as their *metadata*. Lastly, but certainly not least, the dump provides a list of all the model run **global attributes**. Here you find stored all of the run parameters. Many of these can be set by the user, so it is very useful to have a record **inside the file**!

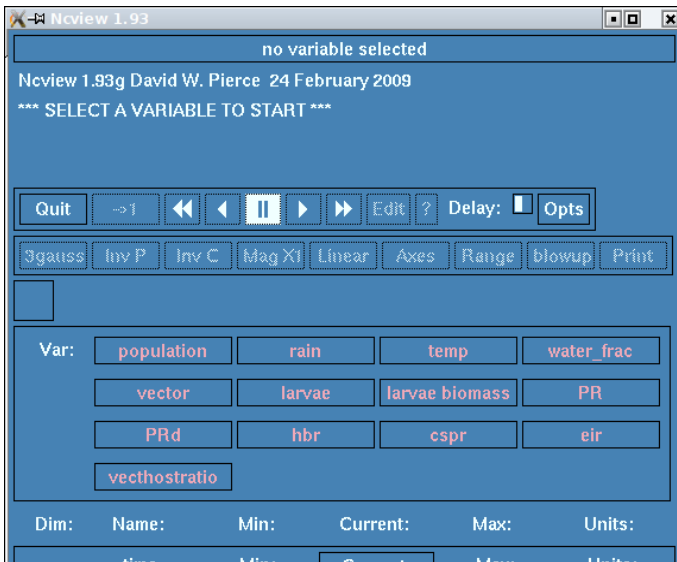
We could dump a individual variable using the `$ ncdump -v variable` command, but it is also possible to graphically interrogate the file using `ncview`.

Using ncview

Using the command

```
$ ncview ./output/vectri.nc
```

launches the graphical viewer. There is a panel containing a list of variables. Clicking on one of these variables launches a display window (Fig. 1). If you conducted a gridded regional integration then you will get a map of the output, otherwise you will get a line graph for a station integration



The input variables of population, temperature and rainfall are stored in the file.

Table: The Vectri output

name	definition	units
population	population density	m^{-2}
rain	rainfall	mm day^{-1}
temp	temperature	deg C
water_frac	fraction of grid box covered by pond breeding sites	
vector	mosquito density	m^{-2}
larvae	larvae density	m^{-2}
larvae_biomass	larvae biomass	mg m^{-2}
PRd	proportion of population with detectable malaria (day 10+)	
hbr	human bite rate	$\text{number person}^{-1} \text{ day}^{-1}$
cspr	Circum sporozoite protein ratio (fraction eir/hbr)	fraction
eir	entomological inoculation rate (number of infectious bites)	$\text{number person}^{-1} \text{ day}^{-1}$
cases	number of new cases ¹	fraction
immunity	proportion of immune population	fraction

¹Note: Unless the model is calibrated you must normalize cases before comparison to data

It is possible to set options in VECTRI. This is done in the file **vectri.options** which you should save in the sub-directory **input**.

vectri.options

You may open the file vectri.options using the text editor of your choice (e.g. gedit, vi, vim, emacs, xemacs):

```
$ gedit ./output/vectri.options.
```

The file is empty by default, but you can enter a list of parameter values to control vectri, which must be separated by a comma.

You may put each parameter on a new line for clarity if you wish:

```
parameter1=value,  
parameter2=value,
```

The parameters you may specify are given in the follow tables, which associate parameters according to themes:

Table: run control parameters

parameter	definition
nyearspinup	length of spinup period discarded from output

Table: scheme choice parameters

parameter	definition
nlarv_scheme	larvae water temperature scheme (1,2,3) 1=ermert:2011a,2=jepsen47,3=bayoh lindsey 2003
nsurvival_scheme	mosquito survival temperature scheme (1,2,3) 1=MartinsI,2=MartinsII,3=Bayoh

Table: larvae parameters (version 1.2.6)

parameter	definition
neggm	eggs laid per female vector
nlayingmax	maximum number of vectors allow to lay (-ve no limit)
rlarv_tmax	maximum temperature for larvae survival
rlarv_eggttime	time for egg hatching
rlarv_pupaetime	time for pupae stage
rlarv_flushmin	minimal daily survival L1 larvae after intense rainfall
rlarv_flushtau	exponential decay of flushing with rainrate
rmasllarv_stage4	mass of L4 larvae
biocapacity	larvae biomass carry capacity of pools
rlarvsurv	base survival rate due to predation

Table: larvae parameter (version 1.3.5 onwards)

parameter	definition
neggm	eggs laid per female vector
nlayingmax	maximum number of vectors allow to lay (-ve no limit)
rlarv_tmin	minimum temperature for larvae survival
rlarv_tmax	maximum temperature for larvae survival
rlarv_eggttime	time for egg hatching
rlarv_pupaetime	time for pupae stage
rlarv_flushmin	minimal daily survival L1 larvae after intense rainfall
rlarv_flushtau	exponential decay of flushing with rainrate
rmasllarv_stage4	mass of L4 larvae
biocapacity	larvae biomass carry capacity of pools
rlarvsurv	base survival rate due to predation and non-climatic factors

Table: hydrology (version 1.2.6, a new beta scheme is available in 1.3.0)

parameter	paper	definition
ipud_vers		puddle parametrization version (126/130)
rwaterfrac_perm	w_0	permanent breeding site fraction
rwaterfrac_max	w_{max}	maximum coverage by breeding sites
rwaterfrac_rate	K_w	pond geometry factor
rwaterfrac_evap126	$E + I$	infiltration and evaporation rate loss of ponds
rwater_tempoffset	T_{wat}	temperature offset of pond to air

Table: interventions (not yet operative)

parameter	definition
rnobednetuse	proportional of host NOT using bednet
rbednettreat (INOPERATIVE)	proportion of bednets insecticide treated

Table: biting parameters

parameter	definition
rzoophilic_tau	e-folding population density for zoophilicity rate
rzoophilic_min	minimum anthropophilic bite rate at low population densities

Table: immunity and transmission parameters

parameter	definition
rhostclear	clearance rate for non-immune adults
rpthost2vect_I	probability of infected host transmission to vector
rpthost2vect_R	probability of host with immunity transmission to vector (blocking)
rptvect2host	probability of infected transmission from infected vector to host
rimmune_gain_eira	Annual EIR required for 95% of population to gain immunity.
rbitehighrisk	ratio of risk of biting between infectious groups and susceptibles (crude behaviour)
rimmune_loss_tau	e-folding timescale for immunity loss

Table: gonotrophic and sporogenic

parameter	definition
rtgono	threshold temperature for egg development in vector
dgono	degree days for egg development in vector
rtsporo	threshold temperature for parasite development
dsporo	degree days for for parasite development

Table: population

parameter	definition
rpop_growth	population growth rate
rpop_death_rate	fraction of population renewed each year (births=deaths)
rpodensity_min	minimum population density considered
rmigration	simple migration fraction imported cases

Table: toy climate

parameter	definition
rtemperature_offset	temperature offset
rtemperature_trend	temperature trend
rainfall_factor	ratio to scale rainfall by

Background
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Running the model
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Output

Setting options in VECTRI