

Rainfall and PET

University of Oklahoma/HyDROS Module 2.3

Module 2.3 / Rainfall and PET

Outline – Day 2

EF5 OVERVIEW DEM DERIVATIVES RAINFALL AND PET

- Satellite meteorology
- TMPA data
- PET data
- Visualize rainfall and PET grids
- Prepare EF5 to use example rainfall and PET grids

AUTOMATIC CALIBRATION

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+ OVERVIEW	You are here: Pro	ect » TRMM » Gridded	» <u>3B42: 3-Hour 0.25</u>	x 0.25 degree merged TRMN	and other satellite estimates

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We need observations of the rain that is falling so our model can produce runoff in response to the rain

• We call this rainfall "forcing"

Rainfall is typically measured using rain gauges (point measurements), but we are using <u>distributed</u> hydrological models so we need <u>distributed</u> rainfall information

Satellites to the rescue! Satellites can see clouds, cloud top temperatures and in some cases cloud structures





Two ways for satellites to observe rainfall information

Passive

Instrument is only <u>receiving</u> information; think of this as being in a well lit room

Infrared measurements from GEO satellites or microwave measurements from LEO satellites (TRMM Microwave Imager)

Active

Instrument <u>transmits</u> information and then <u>receives</u> information in return; think of this as using a flash light in a dark room so you can see

Examples include precipitation radar on TRMM, GPM





Passive measurements can occur over many wavelengths; this reveals different information in each spectrum

Infrared spectrum is used to derive cloud top temperatures Then other relationships relate cloud top temperatures to rain rates







Satellite Meteorology



Passive measurements can occur over many wavelengths revealing different information in each spectrum

Multi-channel microwave measurements to see through cloud layers

More complicated relationships between brightness temperatures and rain rates

TRMM calibrates microwave measurements to precipitation radar measurements



Typhoon Nesat Threatens the Philippines", available at pmm.nasa.gov/missionupdates/trmm-news/typhoon-nesat-threatens-philippines, April 2015





Measurements made on geosynchronous satellites

Pros:

- Rapid updates (~1-15 minutes)
- Good resolution (~1-4 km²)
- Good coverage (nearly global)

Cons:

- Cannot see through clouds
- Precipitation may not be reaching the ground!





Measurements made on low Earth orbit satellites

Pros:

- Multiple wavelength measurements can often measure through clouds to the ground
- Better resolution (<1 km²)

Cons:

- Long revisit time (~hours to days)
- Incomplete global coverage
- Narrow swaths



'About TRMM", available at trmm.gsfc.nasa.gov/overview_dir/ background.html, April 2015







Let's combine LEO and GEO measurements!

Tropical Rainfall Measurement Mission – Multi-Satellite Precipitation Analysis (TMPA)

Uses many passive microwave satellites with probabilitymatching to the core TRMM satellite

Gaps in LEO satellite coverage filled with data from GEO satellites







TRMM Multisatellite Precipitation Analysis

TRMM stands for Tropical Rainfall Measurement Mission Available every 3-hours, on a 0.25° x 0.25° grid from 50°N to 50°S

Also known as "TRMM RT" or "TRMM real-time"







Alternatives to "real time" data

If you are doing historical work and want better precipitation estimates, there is a gauge-corrected TMPA product available 3-hourly estimates summed to monthly, rain gauge data accumulated on 1° x 1° grid for a month (TMPA bias-adjusted and 3-hourly products are rescaled) Also known as "TRMM V6" or "TRMM V7"







So how do you get TMPA data?

NASA's servers

Real time feed:

ftp://trmmopen.gsfc.nasa.gov/pub/merged/mergelRMicro/

Older data:

ftp://disc2.nascom.nasa.gov/ftp/data/s4pa/TRMM_RT/TRMM_3B42RT.007/

Gauge corrected product:

ftp://disc2.nascom.nasa.gov/ftp/data/s4pa/TRMM_L3/TRMM_3B42/







"Forcing" isn't just precipitation – the model also needs to know how much water is lost to the atmosphere due to evaporation and transpiration

Important for droughts and water resources management

- Not so important for rainfall-driven flooding events
- We prefer to use monthly averages because this greatly reduces data requirements for running hydrological models
- This means one set of 12 files (one for each month) fulfills the PET requirement for running the model anywhere in the world



Potential Evapotranspiration



We use global monthly mean PET

- They cover the world, from -180 to +180 degrees longitude, and from -90 to +90 degrees latitude
- The daily PET is calculated on a spatial basis using the Penman-Monteith equation
- Then this data is standardized in accordance with the Food and Agriculture Organization's published research
- The actual data is produced by the U.S. Geological Survey and the U.S. Agency for International Development

http://earlywarning.usgs.gov/fews/downloads/





Open QGIS and go to "Layer" \rightarrow "Add Layer" \rightarrow and "Add Raster Layer..."

Navigate to \EF5_training\data\PET and add test_pet.asc



Now from \EF5_training\data\TRMM add test_trmm.asc









- <u></u>	Layer Properties - test_pet Style
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You can right-click on either layer, select "Properties" and then in the "Style" tab, select "Singleband pseudocolor"

Play around with the color options until you feel comfortable that you can tell what's happening in both the precipitation and PET grid

- Think of looking at the PET as a sort of "sanity check"
- This is a grid from January, summer in the Southern Hemisphere, so the sun angle is higher there and PET should be higher, too
- Sure enough, that's what I see
- You can use the "Identify Features" tool to click around and prove it to yourself, if you want \rightarrow







You can also play with the colors in the precipitation file

- I right-clicked and selected "Properties"
- Then I used a yellow-green "YIGn" color map, and rightclicked on the color for values of 0.000000
- You can turn "Opacity" to "0%" so that the areas where precipitation is zero disappear from the map

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And here's the final result:



Looks like what we would expect precipitation systems to look like, so that's a good thing!



Example 2



Let's get our precipitation and PET data ready for use in the Bogota River example



Module 2.3 / Rainfall and PET





In \EF5_training\data\PET, you have a file called bibimo.zip

- Right-click, and click "Extract All..."
- Extract to \EF5_training\examples\example2\pet

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C:\Users\raceclark\Desktop\EF5_training\examples\example2\precip	
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You should see this pop up after the unzip process is complete:

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In \EF5_training\data\TRMM, you have a file called trmm2002.zip

- Right-click, and click "Extract All..."
- Extract to \EF5_training\examples\example2\precip
- This process can take a while

🖻 🌗 Extract Compressed (Zipped) Folders	→ 7% complete → □ ×
Select a Destination and Extract Files Files will be extracted to this <u>f</u> older:	Copying 2,920 items from trmm2002.zip to precip 7% complete II × Speed: 10.2 MB/s
C:\Users\raceclark\Desktop\EF5_training\examples\example2\precip C:\Users\raceclark\Desktop\EF5_training\examples\example2\basic	
C:\Users\raceclark\Desktop\EF5_training\examples\example2\obs C:\Users\raceclark\Desktop\EF5_training\examples\example2\output C:\Users\raceclark\Desktop\EF5_training\examples\example2\pet	Name: 3B42RT.2002012821.7R2.bin.gz Time remaining: About 2 minutes and 30 seconds Items remaining: 2,698 (771 MB)
C:\Users\raceclark\Desktop\EF5_training\examples\example2\precip C:\Users\raceclark\Desktop\EF5_training\examples\example2\qgis	Fewer details



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	3B42RT.2002010300.7R2.bin.gz	5/13/2015 5:12 PM	GZ File	329 KB	
	3B42RT.2002010303.7R2.bin.gz	5/13/2015 5:12 PM	GZ File	284 KB	



Module 2.3 / Rainfall and PET

The PrecipForcing Block

Open control.txt in EF5_training \examples\example2

In the PrecipForcing block, we see

- The name of the block is TRMM
- TYPE is TRMMRT (This depends on what type of precipitation you're using, so if you use the gaugecorrected TRMM data instead, you would put TRMMV7 here. For a full list of options, see the EF5 Readme included in the training materials)
- UNIT is mm/h (millimeter per hour; these are the units of the precipitation data)
- FREQ is 3h (every three hours; this is how frequently new precipitation files are available)

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[PETForcing FEWSNET] TYPE=BIF			
UNIT=mm/h			
FREQ=m			
LOC=pet\bibimo\			
NAME=PET025.MM.bif			¥
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The PrecipForcing Block



- LOC is precip\ (this is where the precipitation files are located relative to the control.txt file)
- NAME is 3B42RT.YYYYMMDDHH. 7R2.bin.gz (The naming scheme of the precipitation files <u>must</u> include date and time information, so that EF5 knows *when* in the simulation the precipitation occurs. YYYY translates to a four-digit year, MM to a two-digit month, MM to a two-digit day, and HH to a two-digit hour. So the final file names are 3B42RT.2002010103.bin.gz, 3B42RT.2002010106.bin.gz, etc., and sure enough, these match what we see in the screenshot below)

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	TYPE=TRMMRT	
	UNIT=mm/h	
	FREQ=3h	
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	NAME=3642K1.11111mm00HH.7K2.01H.g2	
	[PETForcing FEWSNET]	
	TYPE=BIF	
	UNIT=mm/h	
	FREQ=m	
	LOC=pet\bibimo\	
	NAME=PEI025.MM.bif	4
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Module 2.3 / Rainfall and PET

The PETForcing Block

In the PETForcing block, we see

- The name of the block is
 FEWSNET
- TYPE is BIF (this is a binary version of an ESRI ASCII grid)
- UNIT is mm/h (millimeter per hour; these are the units of the PET data)
- FREQ is m (every month; this is how frequently new PET files are available)
- LOC is pet\bibimo\ (this is where the PET files are located relative to the control.txt file)

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NAME=3B42RT.YYYYMMDDHH.7R2.bin.gz		
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UNIT=mm/h		
FREQ=m		
LOC=pet\bibimo\		
NAME=PEI025.MM.D1+		~
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The PETForcing Block



NAME is PET025.MM.bif (As with precipitation, the naming scheme of the PET files must include date and time information, so that EF5 knows when in the simulation the precipitation occurs. MM translates to a two-digit month, so the final file names are PET025.01.bif, PET025.02.bif, etc., and sure enough, these match what we see in the screenshot below)

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LOC=	=pet'	\bibimo	<u>۱</u>							
NAME	E=PE	T025.MW	l.bif							4
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In the Gauge block, we see

- The name of the block is PuentePortilo
- LON should be -74.6 (this is the longitude of the gauging station in degrees, where degrees west are negative; remember we used this longitude in QGIS in Module 2.2)
- LAT should be 4.45 (this is the latitude of the gauging station in degrees, where degrees south are negative; remember we used this latitude in QGIS in Module 2.3)

control.txt - Notepad	-	x
<u>F</u> ile <u>E</u> dit F <u>o</u> rmat <u>V</u> iew <u>H</u> elp		
[Gauge PuentePortillo] LON=-74.6 LAT=4.45 OBS=obs\puente_portillo.csv BASINAREA=6000.00 OUTPUTTS=TRUE		^
[Basin Bogota] GAUGE=PuentePortillo		~



RUDER CONTROL CONTROL

- OBS should be obs \puente_portillo.csv (this is the file path to the observations relative to control.txt; from there, you enter the obs folder and then see puente portillo.csv)
- BASINAREA should be 6000.00 (this tells EF5 the approximate value to search for in the FAC grid when finding the gauge outlet, in km²)
- OUTPUTTS should be TRUE (you can run EF5 for multiple gauges simultaneously by adding additional Gauge blocks to the control file; this option tells EF5 which sets of results to actually output to file)

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[Basin GAUGE=F	Bogota] PuentePo	prtill	Lo					



Hydrox and Parray of the Parra

In the Basin block, we see

- The name of the block is Bogota
- GAUGE should be PuentePortillo (this is the name of the gauge block to be included in this Basin block)

Control.txt - Notepad	-	х
<u>F</u> ile <u>E</u> dit F <u>o</u> rmat <u>V</u> iew <u>H</u> elp		
<pre>[Gauge PuentePortillo] LON=-74.6 LAT=4.45 OBS=obs\puente_portillo.csv BASINAREA=6000.00 OUTPUTTS=TRUE</pre>		^
[Basin Bogota] GAUGE=PuentePortillo		Ŷ





Basin blocks are not physical basins; they are just a collection of gauges that you want EF5 to model together

Multiple Basin blocks are possible; each gauge must be included in a Basin block

EF5 then has a Task block (which we'll get to in Module 2.4), and in that Task block, you can tell EF5 which Basin block to model

One final comment on the Gauge and Basin blocks: you do <u>not</u> need to use the actual names of the gauges or basins over which you are modeling

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[Ga LON LAT OBS BAS OUT	uge =-64 =-10 =obs INAR PUTT	Ex3] \ex3.cs EA=4900 S=TRUE	5V 9.00				
[Ga LON LAT OBS BAS OUT	uge =64 =32 =obs INAR PUTT	Ex4] \ex4.cs EA=4500 S=FALSE	5V 00.00				
[Ba GAU GAU	sin GE=E: GE=E:	Bas1] x3 x2					
[Ba GAU GAU	sin GE=E: GE=E:	Bas2] x1 x4					~

Additional PrecipForcing Options



In TYPE 6 values are possible:

• ASC

This is the ESRI ASCII grid format, with header as shown \rightarrow

- TIF
 - Float32 GeoTiff grid
- TRMMRT
 TRMM real-time binary format grid
- TRMMV7 TRMM 3B42V7 HDF5 grid
- MRMS

Multi-Radar Multi-Sensor binary grid (generally only used in the USA)

In UNIT, you can use y for year, m for month, d for day, h for hour, u for minute, and s for second, along with m for meters, cm for centimeters, and mm for millimeters

Numbers are also allowed before the time, like mm/3hr

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<pre>[PrecipForcing TRMM] TYPE=TRMMRT UNIT=mm/h FREQ=3h LOC=precip\ NAME=3B42RT.YYYYMMDDHH.7R2.bin.gz</pre>	^
[PETForcing FEWSNET] TYPE=BIF UNIT=mm/h FREQ=m LOC=pet\bibimo\ NAME=PET025.MM.bif	¥
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Additional PrecipForcing Options



In FREQ, you can use y for year, m for month, d for day, h for hour, u for minute, and s for second

Numbers are also allowed here, like 3h

In NAME, the available date and time codes are

YYYY for year (like 2014, 2015, etc..), MM for month, DD for day, HH for hour, UU for minute, and SS for second (each running like this: 01, 02, 03 etc..) Do not use YYYY, MM, DD, HH, UU, and SS in the filename outside of marking the appropriate date and time

control.txt - Notepad -	×
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[PrecipForcing TRMM] TYPE=TRMMRT	^
FREQ=3h	
NAME=3B42RT.YYYYMMDDHH.7R2.bin.gz	
[PETForcing FEWSNET] TYPE=BIF	
UNIT=mm/h	
FREQ=m	
LOC=pet\bibimo\	
NAME=PET025.MM.bif	~
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Module 2.3 / Rainfall and PET

Additional PETForcing Options

In the PETForcing block, three TYPE values are available:

• ASC

This is the ESRI ASCII grid format, with header as shown \rightarrow

• BIF

A binary version of the ESRI ASCII grid format

• TIF

Float32 GeoTiff grid

UNIT, FREQ, and NAME operate identically to the PrecipForcing block

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[PrecipForcing TRMM] TYPE=TRMMRT	^
UNIT=mm/h FREQ=3h	
LOC=precip\	
NAME-3042KT.TTTTMM00hin.7K2.011.gz	
[PETForcing FEWSNET]	
UNIT=mm/h	
FREQ=m	
LOC=pet\bibimo\ NAME=PET025.MM.bif	Ļ
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Additional Gauge Options



In the Gauge block, there are some other options available:

• CELLX and CELLY

These are the x- and y-coordinates of the gauge in the topographical files instead of LAT and LON

BASINAREA

This is actually optional, but recommended, as EF5 will search the topographical files for a nearby FAC cell corresponding to the area you enter

• OUTPUTTS

Tells EF5 to output the time series for this gauge

• WANTDA

Tells EF5 to do data assimilation for the gauge

• WANTCO

Tells EF5 to include the time series in a combined output file

For OUTPUTTS, WANTDA, and WANTCO, values of YES, NO, TRUE, and FALSE are allowed. WANTCO defaults to NO and the others default to YES



EF5 will tell you if the control file has a problem

If a file is missing, or a file path is incorrect, or a part of the task block doesn't match the rest of the control file, etc., you will get an error that should identify where the problem is

Then open up your control file and try to fix it!

Control file errors are there to help you, so always remember: <u>don't panic</u>







The next module is

Automatic Calibration

You can find it in your \EF5_training\presentations directory

Module 2.3 References

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 Huffman, G. J., R. F. Adler, D. T. Bolvin, et al, (2007). The TRMM Multi-satellite Precipitation Analysis: Quasi-Global, Multi-Year, Combined-Sensor Precipitation Estimates at Fine Scale. *J. Hydrometeor.*, 8: 1, 38-55.
 Shuttleworth, J. 1992. Evaporation. In *Handbook of Hydrology*, ed. D. Maidment, 4.1-4.53, New York: McGraw-Hill.

