RAINFALL AND PET

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

MANUAL CALIBRATION

AUTOMATIC CALIBRATION

INTERPRETING AND USING MODEL OUTPUT
Need observations of the rain that is falling so our model can produce runoff in response to the rain (forcing)

Rainfall is typically measured using rain gauges (point measurements), but we are using distributed hydrological models so we need distributed 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 receiving 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 transmits information and then receives 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
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

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 km$^2$)

Cons:
- Long revisit time (~hours to days)
- Incomplete global coverage
- Narrow swaths
Let's combine LEO and GEO measurements!

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

Uses many passive microwave satellites with probability-matching to the core TRMM satellite

Gaps in LEO satellite coverage filled with data from GEO satellites
Tropical Rainfall Measurement Mission – Multi-Satellite Precipitation Analysis Data

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”
TMPA Data – Better?

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/mergeIRMicro/

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

- Gauge corrected product:
  
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
We use global monthly mean PET

- This has the advantage of reducing the entire forcing dataset to just 12 files
- 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” → “Add Layer” → 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
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.
Here’s a singleband pseudocolor of PET, varying from 0.000957 mm/h in bright green to 0.290087 mm/h in bright red.

I used the “Identify Features” tool and then right-clicked near Rundu.

Select “Table” from the dropdown menu at the bottom of the “Identify Results” panel and you get a value of about 0.236 mm/h.

This is the grid from the month of January.
I plotted the precip on the same red-green scale as the PET

I removed the color from the smallest levels of precipitation (that is, when it’s near zero)

And then I changed the PET color table to go from light red to dark red, and got this:
Visualizing Precipitation and PET

Now if I use the “Identify Features” tool I get rainfall of up to 19 – 21 mm/hr just a few pixels north of Rundu!

Note that you can’t always trust the default maximum and minimum values listed for a raster layer in the left pane of the QGIS window (it only shows the maximum TRMM value as ~0.6, not the true value of ~21)
Let’s get our precipitation and PET data ready for use in the Okavango River example.
In `\EF5_training\data\PET`, you have a file called `bibimo.zip`

- Right-click, and click “Extract All…”
- Extract to `\EF5_training\examples\okavango\pet`
Unzip Precipitation and PET

You should see this pop up after the unzip process is complete:
In \EF5\_training\data\TRMM, you have a file called trmm2007.zip

- Right-click, and click “Extract All…”
- Extract to \EF5\_training\examples\okavango\precip
- This process can take a while
Unzip Precipitation and PET

You should see this pop up after the unzip process is complete:
Prepare the PETForcing Block

Open control.txt in EF5_training\examples\okavango

Let’s check the PETForcing block first

- TYPE is BIF
- UNIT is mm/d (millimeter per day)
- FREQ is m (monthly)
- LOC is pet\n- NAME is PET025.MM.bif (“MM” is read as the numbers corresponding to months, so PET025.01.bif, PET025.02.bif, etc.)

So we need to change LOC and FREQ but everything else looks ready to go

- Change LOC to pet\bibimo\n- Change FREQ to mm/h
Prepare the PrecipForcing Block

Now check the PrecipForcing block

- **TYPE** is BIF
- **UNIT** is mm/d (millimeter per day)
- **FREQ** is d (daily)
- **LOC** is precip
- **NAME** is TR_YYYYMMDD.bif
  (We read “YYYY”, “MM”, and “DD” as years, months, and days, so TR_20070101.bif, TR_20070102.bif, etc..)
Prepare the PrecipForcing Block

Let’s fix the PrecipForcing block

- **TYPE** should be TRMMRT
- **UNIT** should be mm/h
- **FREQ** should be 3h, since we have a new TRMM file every 3 hours
- **LOC** is precip\ - this is fine!
- **NAME** should be 3B42RT.YYYYMMDDHH.7R2.bin.gz (This gets parsed by EF5 to 3B42RT.2007010103.7R2.bin.gz, 3B42RT.2007010106.bin.gz, etc..)
Let’s update the Gauge block

From Module 1.4, we learned Rundu’s location in decimal degrees as well as the approximate area of the example basin in km²

• The title of the Gauge block should be Rundu
• LON should be 19.767
• LAT should be -17.901
• OBS should be obs\rundu.csv, since we moved our observations there in Module 1.4
• BASINAREA should be 79,632.00 (in km²)
• OUTPUTTS should remain TRUE
Prepare the Basin Block

We’re moving on to the Okavango River at Rundu station, so let’s update our Basin block

- Change the name of the Basin block from Wangchu to Okavango
- GAUGE should be Rundu

Now the updated control.txt file appears at right →

We’ll tackle parameter sets and the rest of the control file in Module 2.2
Additional PrecipForcing Options

In **TYPE**, 6 values are possible:

- **ASC**
  This is the ESRI ASCII grid format, with header as shown →
- **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**.
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

In NAME, the precipitation files must have names that include a valid date

Available 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
In the PETForcing block, three **TYPE** values are available:

- **ASC**
  This is the ESRI ASCII grid format, with header as shown →

- **BIF**
  A binary version of the ESRI ASCII grid format

- **TIF**
  Float32 GeoTiff grid

**UNIT**, **FREQ**, and **NAME** operate identically to the PrecipForcing block
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**
Coming Up….

The next module is

Manual Calibration

You can find it in your \EF5_training\presentations directory

Module 2.1 References


EF5 Training Doc 4 – EF5 Control File, (March 2015).
