**A near real-time model of Forest Flammability**

**firerisk.conservation.org**

**Technical Document**

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**Table of Contents**

1.0 Overview 2

2.0 System requirements 3

2.1 Amazon Web Services CLI (AWS-CLI) (optional) 4

2.2 GrADs Grid Analysis and Display System 4

2.2.1 Bin Guan's GrADS Script Library http://bguan.bol.ucla.edu/bGASL.html 4

2.3 GDAL Geospatial Data Abstraction Library 4

2.4 HDFlook 8.0 4

2.5 Other Dependencies 4

3 Model Description 4

3.1 Model parameters 5

3.1.1 Geographic extents 5

3.1.2 Projection Information 6

AMZEX 6

IDN 6

3.2 Model inputs 6

3.2.1 IMERG Late-run 6

3.2.2 MODIS 7

3.2.3 Elevation Mask 8

3.2.4 ImageMagick CLUTs and Masks for PNGs 8

3.2.5 CRU climatology data 8

3.3 Model outputs 8

3.3.1 Rainfall 8

a. Daily rainfall sum 8

b. 9-hour rainfall duration 8

c. 15-hour rainfall duration 8

d. 24-hour rainfall duration 8

3.3.2 Days Since Last Rainfall (DSLR) drought index 9

3.3.3 Temperature 9

3.3.4 Relative Humidity 9

a. Air Temperature 9

b. Dew Point Temperature 10

3.3.5 Keetch-Byram Drought Index (KBDI) 11

4.0 Running the model near real-time 11

4.1 Crontab 11

4.2 Initiating Rainfall models 11

4.3 Initiating Firerisk models 12

5.0 Running the model in manual mode 12

5.1 Rerunning Rainfall models 12

5.2 Rerunning firerisk models 13

5.3 Other scripts to run 13

6.0 References 14

7.0 Appendix 14

7.1 Appendix A 14

7.2 Appendix B 15

7.3 Appendix C 16

7.4 Appendix D 17

7.5 Appendix E 18

# 1.0 Overview

The model is based on the fact that dead litter is ignitable at moisture contents of 15 percent or less. Flammability increases as moisture content decreases below this threshold. Litter moisture contents vary over time depending on moisture uptake from precipitation and moisture loss from evaporation to the surrounding air. The average moisture content for a given piece of litter varies more slowly for large pieces than for small pieces. This variation in exchange rate is described by a lag-time and average litter moisture is calculated for different size classes. These relationships are quantitatively described by the US Forest Service based on years of field experiments.

This model uses the US Forest Service equations for estimating litter moisture content using daily satellite inputs. The satellite observations used in this model are rainfall duration, land surface temperature (LST) and near-surface relative humidity (RH). Rainfall duration are calculated from the Integrated Multi-sattelitE Retrievals for GPM (IMERG) half-hourly rainfall rates at 0.1 degree spatial resolution.The near real-time (3IMERG) rainfall data set is used in the fire model. LST and RH are derived from the daily, 5-km MODIS atmospheric product MOD07L2 Atmospheric Profiles. LST is obtained form MOD07 surface temperature (SFT) while RH data are derived from estimates of air temperature (Tair) and dew point temperature (Tdpt) at the bottom of the atmospheric profile. The MODIS temperature and moisture profiles are produced at 20 vertical atmospheric profiles. The profiles divide the vertical height of the atmosphere by upper and lower limits of air pressure.  The pressure levels are related to altitude in meters therefore surface elevation is associated with atmospheric height and must be considered when applying the profiles to a region of interest. The Amazon model run for lowland tropical forest, therefore only profile 20 is used. Any elevation above 330 m is masked out of the region using elevation data from the Shuttle Radar Topography Mission (SRTM) (USGS, 2004).

The model can also generate 2 other drought indices, days since last rainfall(DSLR) and the Keetch-Byram Drought Index (KBDI) (Keetch and Byram, 1968). Days since last rainfall is a simple drought index that counts the number of days since the last 24 hour rainfall greater then 5mm. This fire-risk index is commonly used in tropical environments. Twenty days or more since a rainfall event is considered drought-like conditions. KBDI is a water balance drought index based on soil moisture. The index is an estimate how much rainfall is required to saturate the top 203 mm (8”) of soil at any time. Moisture is lost from the soil only by evaporation based on maximum daily temperatures and the soil is saturated by rainfall events. The first 5 mm of rainfall is assumed to be absorbed by the vegetation canopy. KBDI values range from 0-203 mm where 0 is a saturated soil and no risk of drought and 203 mm indicate extremely dry conditions. KBDI assumes the landscape if flat and there is uniform drying. The KBDI product is calculated based on equations from Keetch and Byram (1968) and Crane (1982).

# 2.0 System requirements

**Operating System**: 64-bit Ubuntu Server

**Processors**: TBD <= 4 physical <= 8 virtual

**RAM**: TBD <= 4GB

P**rivileges**: Sudoer or root for installation, read/write/execute access to model workspace.

\*\*\*The following installations should be installed to their default directory using apt-get. Those not available through the apt-get command should be installed as specified in their installation instructions. Those that satisfy neither of the above conditions should be installed to /$HOME/BIN/ as the PATH environment variable

## 2.1 **Amazon Web Services** CLI (AWS-CLI) (optional)

Amazon Web Services (AWS), a collection of remote computing services, also called web services, make up a cloud-computing platform offered by [Amazon.com](http://amazon.com). These services operate from 11 geographical regions across the world. The most central and well-known of these services arguably include Amazon Elastic Compute Cloud and Amazon S3. The command line interface tools must be installed and credentials with access to s3 commands must also be obtained. Contact your AWS administrator for assistance.

AWS CLI Tools are only necessary if output is to be pushed to an AWS s3 bucket. If output is being pulled, then you may disregard this prerequisite and use the “enterdatabase=0” option.

## 2.2 **GrADs** Grid Analysis and Display System

The Grid Analysis and Display System (GrADS) is an interactive desktop tool that is used for easy access, manipulation, and visualization of earth science data. The format of the data may be either binary, GRIB, NetCDF, or HDF-SDS (Scientific Data Sets). GrADS has been implemented worldwide on a variety of commonly used operating systems and is freely distributed over the Internet. GrADS uses a 4-Dimensional data environment: longitude, latitude, vertical level, and time.

<http://grads.iges.org/grads/>

### 2.2.1 Bin Guan's GrADS Script Library <http://bguan.bol.ucla.edu/bGASL.html>

Only one script (save.gs) from this library is used. It has two dependencies, (parsestr.gsf and qdims.gsf) found in the same library. You can either download these 3 scripts and place them at /$HOME/lib/gscript/<save.gs|parsestr.gsf|qdims.gsf> or download the entire library and unzip it to /$HOME/lib/

## 2.3 **GDAL** Geospatial Data Abstraction Library

The GDAL (Geospatial Data Abstraction Library) is a library for reading and writing raster and vector geospatial data formats, and is released under the permissive X/MIT style free software license by the Open Source Geospatial Foundation. As a library, it presents a single abstract data model to the calling application for all supported formats. It may also be built with a variety of useful command-line utilities for data translation and processing.

## 2.4 **HDFlook** **8.0**

Software package to mosaic, subset, reproject and convert format of MODIS Hierarchical Data Format (HDF) data. The MAPS directory is not a necessary component for model use.

Installation files located in the model repository’s /lib folder

More Information at (<http://www-loa.univ-lille1.fr/informatique/index.php?lang=us&p=about&app=HDFLook>)

## 2.5 Other Dependencies

bash - (Bourne Again Shell) - All shell scripts are written in bash and call to the built-in commands extensively. (These scripts may work with another Bourne-type shell or z-shell, but absolutely will not work with a C-type shell)

**gcc** - (GNU Compiler Collection) for C code - To compile ANSI-C Fire Risk Algorithm Scripts

**jre** - (Java Runtime Environment) - .jar bundle generates text file of the names of all MODIS files needed for one day of coverage over the extent of the window.

**ncftp** - ftp client with useful command-line options. Used in z-shell scripts to download MODIS data.

# 3 Model Description

## 3.1 **Model parameters**

### 3.1.1 Geographic extents

The Amazon Extended window includes a subset of low lying tropical forests in Bolivia, Peru, Brazil, and Columbia. The model only includes forests at elevations less then 330 meters. This is necessary because with the satellite derived data, there are often large areas of no data due to clouds. We use a spatial interpolation technique to fill in no data holes. The drier, colder air at higher elevations would provide false data when used to fill holes at lower elevations.

The geographic window is 28° south to 13° latitude and 84° west to 52° west longitude.

#### 

### 3.1.2 Projection Information

### AMZEX

ROWS: 911

COLS: 622

Upper Left (-1556728.200, 1440526.400) ( 82° 21’ 4.34"W, 13° 1’ 31.62"N)

Lower Left (-1556728.200,-3120850.600) ( 83° 51’ 22.46"W, 28° 12’ 7.95"S)

Upper Right ( 1557625.800, 1440526.400) ( 53° 38’ 25.87"W, 13° 1’ 31.62"N)

Lower Right ( 1557625.800,-3120850.600) ( 52° 8’ 4.63"W, 28° 12’ 7.95"S)

PIXEL\_SIZE:——————————————————————————————————————5007m

MAP\_UNITS:——————————————————————————————————————meters

PROJECTION\_NAME:———————————————————————————————Sinusoidal

Center Longitude:——————————————————————————————————68.0 W

SPHEROID\_NAME:——————————————————————————————————WGS 84

DATUM\_NAME:————————————————————————————————————WGS 84

### IDN

ROWS: 406

COLS: 1031

Upper Left (10518661.468, 815300.694) ( 95° 16’ 23.74"E, 7° 22’ 22.52"N)

Lower Left (10518661.468,-1217541.306) ( 96° 15’ 2.60"E, 11° 0’ 35.00"S)

Upper Right (15680878.468, 815300.694) (142° 1’ 49.01"E, 7° 22’ 22.52"N)

Lower Right (15680878.468,-1217541.306) (143° 29’ 14.81"E, 11° 0’ 35.00"S)

PIXEL\_SIZE:——————————————————————————————————————5007m

MAP\_UNITS:——————————————————————————————————————meters

PROJECTION\_NAME:———————————————————————————————Sinusoidal

Center Longitude:————————————————————————————————————0.0

SPHEROID\_NAME:——————————————————————————————————WGS 84

DATUM\_NAME:————————————————————————————————————WGS 84

# 3.2 Model inputs

## 3.2.1 **IMERG Late-run**

Half-hourly IMERG 3B-HHR-L precipitation from ftp://jsimpson.pps.eosdis.nasa.gov/data/imerg/late/*YYYYMM*/3B-HHR-L.MS.MRG.3IMERG.*YYYYMMDD*-SHHmmss-E$(currHMS\_1).$(printf "%.4d" $min).V03E.RT-H5

Where YYYY=4 digit year, MM=2 digit month, DD = 2 digit day, HH = 2 digit hour, mm = 2 digit minute, ss = 2 digit second, and mmmm = 4 digit minute of day.

Version 5 from 2005 to 2009-02-17-00

Version 6 from 2009-02-17-03 to present. The new version has a combined precipitation field which means the data is calibrated to monthly climatology of TRMM 3b42 to reduce bias in the 3B42RT product.

Version 7 is expected in late 2009. This will include a complete reprocessing of the 3B42RT product from January 1998.

3B42RT

Dataset resolution is 0.25 decimal degrees.

The 3-hourly binary files are ~7 MB uncompressed and ~350 KB compressed.

Integer values for source are:

0 = no observation

1 = AMSU

2 = TMI

3 = AMSR

4 = SSMI

5 = SSMIS

6 = MHS

30 = AMSU&MHS avg.

31 = conical avg.

50 = IR

1,2,3,4,5,6 + 100 = sparse-sample HQ

All fields have 1440 columns by 480 rows (0-360ºE, 60ºN-S).

The upper left grid cell center is (0.125ºE, 59.875ºN).

The temporal resolution is every 3 hours at Coordinated Universal Time (UTC) hours (00 UTC, 03 UTC, ..., 21 UTC).

Even though the Grid coverage is 60°N-S, the maximum extent of data is 50°N-S.

The precipitation field has a bias correction to the 3B42 climatologies.

The uncalibrated precipitation field is the multi-satellite precipitation before the version 6 calibration.

Read more details about TRMM 3B42RT in Huffman and Bolvin (2009).

Input 3-hourly, global, TRMM 3B42RT data are located at:

/FIRERISK/DATA/GLOBAL/3B42RT/YYYY/3-hourly/

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### 3.2.2 MODIS

MOD07\_L2 Atmospheric profile product from

ftp://ladsweb.nascom.nasa.gov/allData/5/MOD07\_L2/YYY/JJJ/

File names are as follows: MOD07\_L2.AYYYYJJJ.HHHH.VVV.yyyyddddhhmmss.hdf

Where YYYY=4 digit year, JJJ is the 3 digit Julian day, HHHH is the 4 digit UTC time of overpass in hours, VVV is the 3 digit version, and yyyydddhhmmss is the processing time and date.

MODIS Level-2 data are in HDF format.

We use 3 Scientific Data Sets (SDSs) from the MOD07\_L2 product.

- Surface\_Temperature (Temperature 150 to 350 K)

- Retrieved\_Temperature\_Profile (Temperature 150 to 350 K)

- Retrieved\_Moisture\_Profile (Dew Point Temperature 150 to 350 K)

We can also use an optional quality control SDSs

-Quality\_Assurance (bit field Interpretation of Byte 0)

0) Retrieved Temperature Profile QA

0 = Not Useful

1 = Useful

1) Retrieved Temperature Profile Confidence

0 = Lowest Confidence

1 = Intermediate Confidence

2 = High Confidence

3 = Highest Confidence

4) Retrieved Moisture Profile QA

0 = Not Useful

1 = Useful

5) Retrieved Moisture Profile Confidence

0 = Lowest Confidence

1 = Intermediate Confidence

2 = High Confidence

3 = Highest Confidence

Dataset resolution is 5km.

Maximum File Size: 28 MB

More information about MOD07\_L2 is at:

[http://modis-atmos.gsfc.nasa.gov/MOD07\_L2/index.html](http://modis-atmos.gsfc.nasa.gov/mod07_l2/index.html)

Input MODIS HDFs are located at:

/FIRERISK/DATA/AMZ/MOD07L2/YYYY/

#### 

### 3.2.3 Elevation Mask

Mask of geographic extent where 1 is land < 330 m elevation and 0 is water and land with > 330 m elevation. The mask file is generated from 90m SRTM data and regridded to 5km resolution.

The binary mask file is located at:

/FIRERISK/DATA/AMZ/MASK/demmask\_330m\_win1\_filt\_noshore.bin

### 3.2.4 ImageMagick CLUTs and Masks for PNGs

-Color Look Up Tables (CLUTs) are used by ImageMagick to scale output PNG files.

The CLUTs are located at:

/FIRERISK/SCRIPTS/CLUT/

-Images used by ImageMagick to draw country borders, and mask out water, non-forest and elevation > 330m.

The images are located at:

/FIRERISK/DATA/AMZ/MASK/

### 3.2.5 CRU climatology data

Average annual precipitation is calculated from CRU CL 2.0 20th century climatology data (New et al., 2002).

CRU data located at:

/FIRERISK/DATA/AMZ/CRU/

## 3.3 Model outputs

### 3.3.1 Rainfall

The TRMM 3B42RT 3-hourly, global, binaries are converted from units of rate (0.01 mm/hour) to 1) duration (hours) for 3 time periods (24-hour, 9-hour, and 15 hour) and 2) 24-hour sum (mm) based on local time which is -5 GMT. The durations and sum are subsetted to the geographic window and projected to Sinusoidal projection with datum WGS 84, center of longitude 60 W and cell size 5000m using GCTP libraries.

Code is named dursum\_3B42RT6\_AMZ.c with Make.dursum\_3B42RT6\_AMZ

Located in /FIRERISK/SOURCE/

#### a. Daily rainfall sum

Sum of daily precipitation for Amazon window. Daily rainfall sums are for local 24 hour days (06 GTM to 06 GMT the following day). Output is a signed 16-byte file with units (mm).

Daily precipitation sums are located at:

/FIRERISK/DATA/AMZ/3B42RT/YYYY/daysum/

The 10-hour moisture class requires calculation of moisture uptake in two time periods.

#### b. 9-hour rainfall duration

9-hour rainfall duration is required for calculated the 10-hour moisture class. The rainfall duration is calculated from 3am to noon in the current day.

Output is a unsigned 8-byte file with units (hours).

9-hour precipitation duration data are located at:

/FIRERISK/DATA/AMZ/3B42RT/YYYY/09\_hrdur/

#### c. 15-hour rainfall duration

15-hour rainfall duration is required for calculated the 10-hour moisture class. The rainfall duration is calculated from noon the previous day to 3am.

Output is a unsigned 8-byte file with units (hours).

15-hour precipitation duration data are located at:

/FIRERISK/DATA/AMZ/3B42RT/YYYY/15\_hrdur/

#### d. 24-hour rainfall duration

24-hour rainfall duration is required for calculation of the 100-hour and 1000- hour moisture classes. Output is a unsigned 8-byte file with units (hours).

24-hour precipitation duration data are located at:

/FIRERISK/DATA/AMZ/3B42RT/YYYY/24\_hrdur/

### 3.3.2 Days Since Last Rainfall (DSLR) drought index

DSLR is a simple drought index that counts the number of days since the daily rainfall sum > 5mm. The threshold is adjustable as an input argument required by the executable. Output is a unsigned 8-byte file with units (hours).

Code is named days\_since\_last\_rain\_AMZ.c

Located in /FIRERISK/SOURCE/

Executable arguments:

days\_since\_last\_rain\_AMZ <previous Day's DSLR file> <current day rainfall summation> <output DSLR> <threshold mm>

Days since last rainfall files are located at:

/FIRERISK/DATA/AMZ/3B42RT/YYYY/dslr/

### 3.3.3 Temperature

The MOD07 Profile product includes a “Surface Temperature” product which is the air temperature at the earth’s skin.

The batch script below is used by HDFLook to select all the MODIS tiles covering the geographic window for the specified date (JJJ=3 digit Julian data and YYYY=4 digit year). The script tells HDFLook to select the Scientific Data Set (SDS), “Surface\_Temperature”, and mosaic the tiles before reprojecting the image to the Amazon geographic extent and projection.

verbose

clear\_data

set\_input\_directory /FIRERISK/DATA/AMZ/MOD07L2/YYYY/

set\_output\_directory /FIRERISK/DATA/AMZ/MODOUT/SFT/ YYYY /

set\_projection\_to\_geometry ProjectionTo="Sinusoidal" WidthTo=555 HeightTo=444 PixelSizeXTo=5000 PixelSizeYTo=5000 LatitudeMinTo=-20.0 LatitudeMaxTo=0.0 LongitudeMinTo=-75.0 LongitudeMaxTo=-50.0

set\_input\_hdf\_file /FIRERISK/DATA/AMZ/MOD07L2/ YYYY /MOD07\_L2.A YYYYJJJ\*

select\_SDS SDSName= "Surface\_Temperature"

set\_misc\_options OnlyDay=Yes

create\_MODIS\_SDS\_MOSAIC FileName="SFT\_MOD07\_ YYYYJJJ\_Day\_AMZ.bin" ClearFile=Yes scaling="y=a(x-b)" Index=1

Output surface temperature file is 32-byte float with units degrees Kelvin and named SFT\_MOD07\_YYYYJJJ\_Day\_AMZ.bin.

Output Temperature data is located at:

/FIRERISK/DATA/AMZ/MODOUT/SFT/YYYY/

Surface Temperature is then spatially interpolated to fill in no data from swath gaps and clouds using a distance weighted interpolation of 4 closest pixels in 32 cardinal directions.

Code to interpolate surface temperature is interpolate\_MOD07\_SFT.c. Compile with Make. interpolate\_MOD07\_SFT.

Located in /FIRERISK/SOURCE/

Interpolated Surface Temperature is signed 16-byte integer with units Kelvin \*10 named SFT\_MOD07\_2009001\_Day\_AMZ\_int1.bin.

Output Interpolated Temperature data is located at:

/FIRERISK/DATA/AMZ/MODOUT/SFT/YYYY/

### 3.3.4 Relative Humidity

Relative Humidity is not a MODIS product but is derived from air temperature and dew point temperature. The MOD07 Atmospheric Profile product has both variables.

#### a. Air Temperature

The batch script below is used by HDFLook to select all the MODIS tiles covering the geographic window for the specified date (JJJ=3 digit Julian data and YYYY=4 digit year). The script tells HDFLook to select the Scientific Data Set (SDS), “Retreived\_Temperature\_Profile” at level 20 (0-330m elevation), and mosaic the tiles before reprojecting the image to the Amazon geographic extent and projection.

verbose

clear\_data

set\_input\_directory /FIRERISK/DATA/AMZ/MOD07L2/YYYY/

set\_output\_directory /FIRERISK/DATA/AMZ/MODOUT/TP\_PROFILE/ YYYY /

set\_projection\_to\_geometry ProjectionTo="Sinusoidal" WidthTo=555 HeightTo=444 PixelSizeXTo=5000 PixelSizeYTo=5000 LatitudeMinTo=-20.0 LatitudeMaxTo=0.0 LongitudeMinTo=-75.0 LongitudeMaxTo=-50.0

set\_input\_hdf\_file /FIRERISK/DATA/AMZ/MOD07L2/ YYYY /MOD07\_L2.A YYYYJJJ\*

select\_SDS SDSName= "Retrieved\_Temperature\_Profile" Index=20

set\_misc\_options OnlyDay=Yes

create\_MODIS\_SDS\_MOSAIC FileName="AT\_MOD07\_ YYYYJJJ\_Day\_AMZ.bin" ClearFile=Yes scaling="y=a(x-b)" Index=20

Output air temperature is a 32-byte float with units degrees Kelvin and filename AT\_MOD07\_YYYYJJJ\_Day\_AMZ.bin.

Output Temperature data is located at:

/FIRERISK/DATA/AMZ/MODOUT/TP\_PROFILE/YYYY/

#### b. Dew Point Temperature

The batch script below is used by HDFLook to select all the MODIS tiles covering the geographic window for the specified date (JJJ=3 digit Julian data and YYYY=4 digit year). The script tells HDFLook to select the Scientific Data Set (SDS), “Retreived\_Moisture\_Profile” at level 20 (0-330m elevation), and mosaic the tiles before reprojecting the image to the Amazon geographic extent and projection.

verbose

clear\_data

set\_input\_directory /FIRERISK/DATA/AMZ/MOD07L2/YYYY/

set\_output\_directory /FIRERISK/DATA/AMZ/MODOUT/TP\_PROFILE/ YYYY /

set\_projection\_to\_geometry ProjectionTo="Sinusoidal" WidthTo=555 HeightTo=444 PixelSizeXTo=5000 PixelSizeYTo=5000 LatitudeMinTo=-20.0 LatitudeMaxTo=0.0 LongitudeMinTo=-75.0 LongitudeMaxTo=-50.0

set\_input\_hdf\_file /FIRERISK/DATA/AMZ/MOD07L2/ YYYY /MOD07\_L2.A YYYYJJJ\*

select\_SDS SDSName= "Retrieved\_Moisture\_Profile" Index=20

set\_misc\_options OnlyDay=Yes

create\_MODIS\_SDS\_MOSAIC FileName="DPT\_MOD07\_ YYYYJJJ\_Day\_AMZ.bin" ClearFile=Yes scaling="y=a(x-b)" Index=20

Output dew point temperature is 32-byte float with units degrees Kelvin and named DPT\_MOD07\_YYYYJJJ\_Day\_AMZ.bin.

Output Dew Point Temperature data is located at:

/FIRERISK/DATA/AMZ/MODOUT/TP\_PROFILE/YYYY/

Both air temperature and dew point temperature are spatially interpolated to fill in no data from swath gaps and clouds using a distance weighted interpolation of 4 closest pixels in 32 cardinal directions.

Code to interpolate air temperature and dew point temperature is interpolate\_MOD07\_TP.c. Compile with Make. interpolate\_MOD07\_TP.

Located in /FIRERISK/SOURCE/

Interpolated Air Temperature is signed 16-byte integer with units Kelvin \*10 named AT\_MOD07\_2009001\_Day\_AMZ\_int1.bin.

Interpolated Dew Point Temperature is signed 16-byte integer with units Kelvin \*10 named DPT\_MOD07\_2009001\_Day\_AMZ\_int1.bin.

Output Interpolated Air Temperature and Interpolated Dew Point Temperature data are located at:

/FIRERISK/DATA/AMZ/MODOUT/TP\_PROFILE/YYYY/

Relative Humidity is calculated by the following equation:

VP = 0.611 \* exp(17.27 \* (Tair – 273) / (Tair – 36))

SVP = 0.611 \* exp(17.27 \* (Tdpt – 273) / (Tdpt – 36))

RH = SVP / VP

Where VP is vapor pressure in kPa, SVP is saturated vapor Pressure in kPa, Tair is air temperature in degrees Kelvin, Tdpt is dew point temperature in Degrees Kelvin and RH is relative humidity in percent (Monteith and Unsworth, 1990).

Code to calculate relative humidity with interpolated dew point and air temperature inputs is rhumid\_at\_dpt.c. Compile with Make.rhumid\_at\_dpt.

Located in /FIRERISK/SOURCE/

Calculated Relative Humidity in signed 16-byte integer with units percent \*10 named RH\_MOD07\_YYYYJJJ\_Day\_AMZ.bin

Output Relative Humidity data is located at:

/FIRERISK/DATA/AMZ/MODOUT/RH/YYYY/

### 3.3.5 Keetch-Byram Drought Index (KBDI)

Code to calculate KBDI is Keetch\_Byram\_SI.c. Compile with Make. Keetch\_Byram\_SI.

Located in /FIRERISK/SOURCE/

Calculated KBDI in signed 16-byte integer with units mm named KB\_YYYYJJJ\_day\_AMZ.bin

Output KBDI data is located at:

/FIRERISK/DATA/AMZ/KBDI/YYYY/

# 4.0 Running the model near real-time

## 4.1 Crontab

The model initiates with two crontab commands.

At the command prompt enter the following to see the 2 events.

X-FireRisk:~ # crontab –l

0 21 \* \* \* /FIRERISK/SCRIPTS/TRMM3B42RT\_cron\_GMTminus5.sh

0 22 \* \* \* /FIRERISK/SCRIPTS/firerisk\_init.sh

The first line initiates the TRM download and processing script at 21:00 hours.

The second line initiates the firerisk model at 22:00 hours.

To edit the crontab use command:

X-FireRisk:~ # crontab –e

This opens the crontab in VI editor.

**To exit vi and save changes:** ZZ or :wq

**To exit vi without saving changes:** :q!

## 4.2 Initiating Rainfall models

**TRMM3B42RT\_cron\_GMTminus5.sh**

1. Downloads TRMM data from ftp://trmmopen.gsfc.nasa.gov/pub/merged/mergeIRMicro/
2. Unzips files
3. Subsets to Amazon region with /**FIRERISK/SCRIPTS/dursum\_3B42RT\_AMZ\_daily.sh**
4. Converts binaries to 8 bit for image conversion to PNGs for website images with /FIRERISK/BIN/convert\_sint2uchar
5. Then converts to PNG using imagemagick convert
6. calculate days since last rainfall drought index

/FIRERISK/SCRIPTS/days\_since\_last\_rain\_daily.sh

## 4.3 Initiating Firerisk models

**firerisk\_init.sh**

1. **MOD7Downloader.jar** - searches the MOD03 geolocation file on ladsweb.nascom.nasa.gov for time codes associated with our Amazon window. Once the time codes are found, it gerenates a list of MOD07 files for that day with the appropriate time codes to be downloaded. The list of files names is written to "/FIRERISK/DATA/AMZ/MOD07L2/YYYY/MOD07\_L2.AYYYYJJJ.txt"
2. **get\_MOD07.sh** reads filenames from textfile “/FIRERISK/DATA/AMZ/MOD07L2/YYYY/MOD07\_L2.AYYYYJJJ.txt" and pulls files from ftp site ladsweb.nascom.nasa.gov saving them to /FIRERISK/DATA/AMZ/MOD07L2/YYYY/
3. **AMZ\_MOD07\_FIRERISK.sh** generates batch files for HDFLook to execute to mosaic and subset the MOD07 HDF files. Then spatially interpolates temperature and dew point files.

Calculated Relatives Humidity.

Generates litter moisture for 10, 100, and 10000 hour times classes.

Uses imagemagick to creates PNG's from binaries. Enters model outputs (both binary and PNG) into database

1. **Keetch-Byram.sh** initiates the executable Keetch\_Byram\_SI. This code uses today's temperature, precipitation, and yesterday's KBDI index to calculate today's KBDI index. Added 6-26-2009

# 5.0 Running the model in manual mode

## 5.1 Rerunning Rainfall models

HOW to RUN:

1. Open **/FIRERISK/SCRIPTS/TRMM3B42RT\_day\_GMTminus5.sh**

set input parameters. Previous year and month refer to the day and month of the previous day. See the following example.

prevyear=2008

prevmonth="07"

prevday="06"

prevjday=188

curryear=2008

currmonth="07"

currday="07"

The last few lines give the option to enter into the database. This is commented out since the rainfall binaries and pngs have already been entered into the data base.

If the data was never downloaded or generated then uncomment the last line #saveimagedb.pl -p "/FIRERISK/DATA/AMZ/3B42RT/${prevyear}/dslr/ppt\_3b42rt\_${prevyear}$(printf "%.3d" $prevjday)\_dslr\_AMZ.bin" -t 0 -f 1 -r 0 -j "${prevyear}$(printf "%.3d" $prevjday)"

1. Rerun days since last rain fall from that day forward **/FIRERISK/SCRIPTS/days\_since\_last\_rain.sh**

change line 5: year=2008

change line 6: "prevyear=$year" if first day is January 1st

change jdays in loop to start with problem day and run to present days

for (( day = 255; day <=262; day++ ))

Make sure if previous year is a leap year to change body so that prevday is set to 366

1. Re run the ketch byram index with **Keetch-Byram\_SI\_manual.sh\***

Calculates KBDI Uses imagemagick to creates PNG's from binaries.

Enters model outputs (both binary and PNG) into database

\*If updating to current day, you must change /FIRESRISK/SCIRPTS/KBDI\_last.txt to the most recent date for the near-real time process.

## 5.2 Rerunning firerisk models

**firerisk\_init\_manual.sh**

1. Calls to julianconvert.ksh to convert Julian date and year to YYYY-MM-DD format

Then runs java -jar /FIRERISK/BIN/MOD7Downloader.jar to generate text file of available file names

1. Using previous text file in /FIRERISK/SCRIPTS/get\_MOD07.sh to download the MOD07 data
2. /FIRERISK/SCRIPTS/AMZ\_MOD07\_FIRERISK\_manual.sh generates batch files for HDFLook to execute to mosaic and subset the MOD07 HDF files. Then spatially interpolates temperature and dew point files.

Calculated Relatives Humidity.

Generates litter moisture for 10, 100, and 10000 hour times classes.

Uses imagemagick to creates PNG's from binaries. Enters model outputs (both binary and PNG) into database

#### Shell Options #####

#enterdatabase flag

#0=no records only BIN to image data base to avoid duplicating PNG entry

#1=yes to record PNG and BIN outputs to image database /usr/local/bin/saveimagedb.pl

enterdatabase=0

year=2008

beginjday=264

endjday=265

#prevyear is the year of the previous julian day which is the same year unless beginjday is 1.

prevyear=2008

prevjday=263

**AMZ\_littermoisture\_day.sh**

Manual script to run only litter moisture outputs

edit options

#### Shell Options #####

year=2006

beginjday=1

endjday=365

prevyear=2005

prevday=365

## 5.3 Other scripts to run

Post-processed TRMM data

sum\_3B42PP\_GLOBAL\_day.sh- global daily rainfall sums (GMT)

sum\_3B42PP\_GLOBAL\_month.sh-global monthly rainfall sums (GMT)

sum\_3B42PP\_GLOBAL\_month\_leap.sh- global monthly rainfall sums for a leap year (GMT)

# 6.0 References

Crane, W.J.B. 1982. Computing grassland and forest fire behavhoir, relative humidity and drought index by pocket calculator. *Australian Forestry.* 42(2):89-97.

Keetch, J.J. and Byram, G.M. 1968. A drought index for forest fire control. US Department of Agriculture Forest Service Research Paper SE-38. Asheville, North Carolina, USA.

Huffman, G. J. and D. T. Bolvin. 2009. Real-time TRMM multi-satellite previpitation analysis data set documentation. Laboratory for Atmospheres, NASA Goddard Space Flight Center and Science Systems and Applications, Inc. ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B4XRT\_doc.pdf [accessed online July 14 2009].

Monteith, J. L. and M. H. Unsworth. 1990. Principles of Environmental Physics. Second edition

Edward Arnold Publishers, New York, New York, USA.

New, M., Lister, D., Hulme, M., Makin, I., 2002. A high-resolution data set of surface climate over global land areas. Climate Research 21, 1-25.

Steininger, M.K., K. Tabor, J. Small, C. Pinto, J. Soliz, E. Echeverria, 2009. A satellite model of forest flammability. (submitted).

USGS. 2004. Shuttle Radar Topography Mission, 3 arc second scene SRTM\_u03\_n008e004, 608 Unfilled Unfinished 2.0, Global Land Cover Facility, University of Maryland, College Park, 609 Maryland, February 2000.

# 7.0 Appendix

## 7.1 Appendix A

Crontab function

**How to edit the crontab in vi editor**

crontab -l (lists current cron jobs)

crontab -e (enters cron : must be edited with vi)

<cron>i (instert)

<cron> ctrl+v (pastes text)

<cron>mm hh \* \* \* /dirpath/script.sh

"esc"

"ZZ"

10=minute, 13=hour \* \* \*= run daily

## 7.2 Appendix B

Date Function for UNIX

Usage: date [OPTION]... [+FORMAT]

or: date [-u|--utc|--universal] [MMDDhhmm[[CC]YY][.ss]]

Display the current time in the given FORMAT, or set the system date.

-d, --date=STRING display time described by STRING, not `now'

-f, --file=DATEFILE like --date once for each line of DATEFILE

-r, --reference=FILE display the last modification time of FILE

-R, --rfc-2822 output date and time in RFC 2822 format

--rfc-3339=TIMESPEC output date and time in RFC 3339 format.

TIMESPEC=`date', `seconds', or `ns' for

date and time to the indicated precision.

-s, --set=STRING set time described by STRING

-u, --utc, --universal print or set Coordinated Universal Time

--help display this help and exit

--version output version information and exit

FORMAT controls the output. The only valid option for the second form

specifies Coordinated Universal Time. Interpreted sequences are:

%% a literal %

%a locale's abbreviated weekday name (e.g., Sun)

%A locale's full weekday name (e.g., Sunday)

%b locale's abbreviated month name (e.g., Jan)

%B locale's full month name (e.g., January)

%c locale's date and time (e.g., Thu Mar 3 23:05:25 2005)

%C century; like %Y, except omit last two digits (e.g., 21)

%d day of month (e.g, 01)

%D date; same as %m/%d/%y

%e day of month, space padded; same as %\_d

%F full date; same as %Y-%m-%d

%g the last two digits of the year corresponding to the %V week number

%G the year corresponding to the %V week number

%h same as %b

%H hour (00..23)

%I hour (01..12)

%j day of year (001..366)

%k hour ( 0..23)

%l hour ( 1..12)

%m month (01..12)

%M minute (00..59)

%n a newline

%N nanoseconds (000000000..999999999)

%p locale's equivalent of either AM or PM; blank if not known

%P like %p, but lower case

%r locale's 12-hour clock time (e.g., 11:11:04 PM)

%R 24-hour hour and minute; same as %H:%M

%s seconds since 1970-01-01 00:00:00 UTC

%S second (00..60)

%t a tab

%T time; same as %H:%M:%S

%u day of week (1..7); 1 is Monday

%U week number of year with Sunday as first day of week (00..53)

%V week number of year with Monday as first day of week (01..53)

%w day of week (0..6); 0 is Sunday

%W week number of year with Monday as first day of week (00..53)

%x locale's date representation (e.g., 12/31/99)

%X locale's time representation (e.g., 23:13:48)

%y last two digits of year (00..99)

%Y year

%z +hhmm numeric timezone (e.g., -0400)

%:z +hh:mm numeric timezone (e.g., -04:00)

%::z +hh:mm:ss numeric time zone (e.g., -04:00:00)

%:::z numeric time zone with : to necessary precision (e.g., -04, +05:30)

%Z alphabetic time zone abbreviation (e.g., EDT)

By default, date pads numeric fields with zeroes.

The following optional flags may follow `%':

- (hyphen) do not pad the field

\_ (underscore) pad with spaces

0 (zero) pad with zeros

^ use upper case if possible

# use opposite case if possible

After any flags comes an optional field width, as a decimal number;

then an optional modifier, which is either

E to use the locale's alternate representations if available, or

O to use the locale's alternate numeric symbols if available.

## 7.3 Appendix C

Image Magick

Creating gradients for png images

SUM PPT

convert xc:azure xc:cyan xc:DeepSkyBlue xc:blue xc:purple \

+append -filter Cubic -resize 255x30\! \

-draw 'fill DarkSlateGray rectangle 0,0 1,30' \

gradient\_sumppt.png

GRADIENT ALL

convert xc:red xc:yellow xc:limeGreen xc:cyan xc:blue \

+append -filter Cubic -resize 255x30\! \

-draw 'fill white rectangle 0,0 1,30' \

gradient\_all.png

GRADIENT LST

convert xc:blue xc:cyan xc:limeGreen xc:yellow xc:red \

+append -filter Cubic -resize 255x30\! \

gradient\_lst.png

GRADIENT DSLR

convert xc:purple xc:cyan xc:yellow xc:red \

+append -filter Cubic -resize 255x30\! \

gradient\_dslr.png

## 7.4 Appendix D

MOD07 bit flags

0 Retrieved Temperature Profile QA 0 = Not Useful

1 = Useful

1-2 Retrieved Temperature Profile Confidence QA 0 = Lowest Confidence

1 = Intermediate Confidence

2 = High Confidence

3 = Highest Confidence

3 (spare) n/a

4 Retrieved Moisture Profile QA 0 = Not Useful

1 = Useful

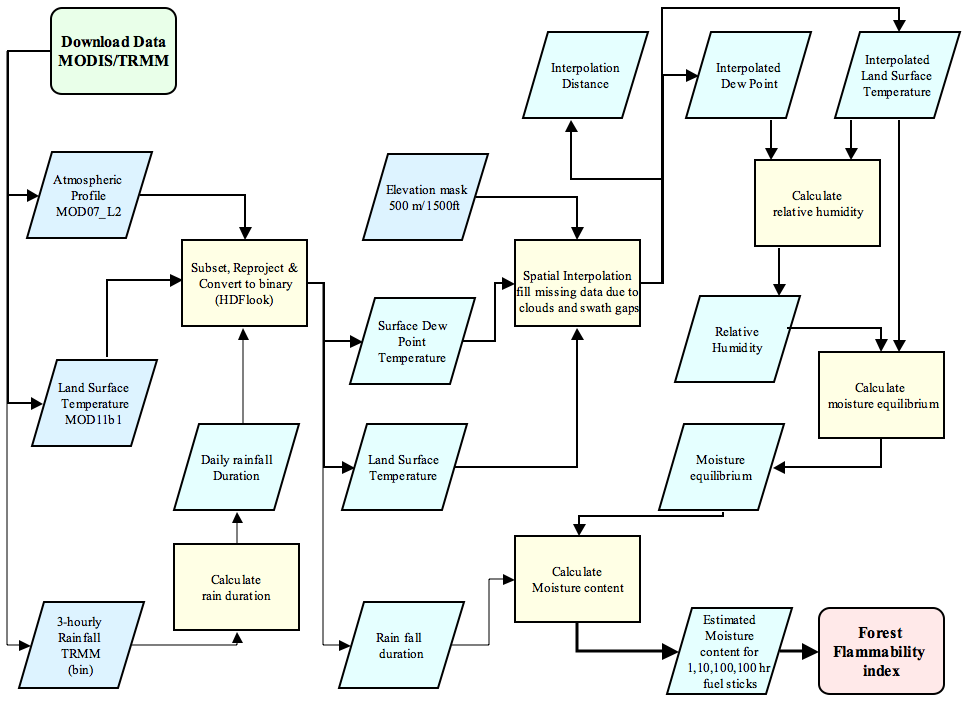
5-6 Retrieved Moisture Profile Confidence QA 0 = Lowest Confidence

1 = Intermediate Confidence

2 = High Confidence

3 = Highest Confidence

7 (spare) n/a

****

## 7.5 Appendix E

**x-firerisk**

**IT Support Plan**

Author: Keith Green

Conservation International

**Version 1.0**

**October 29, 2008**

**Important Information**

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Conservation International

Revisions

Conservation International Support Plan

**1.0 Overview**

This support plan is a complete documentation and reference package for the specified system, operated by Conservation International. It includes all pertinent documentation, diagrams and details for running, maintaining and troubleshooting the system, as well as references to additional documentation available.

The purpose of this Support Plan is to document this system for Conservation International’s IT Division. Information contained within this document is beneficial to ensure knowledge of system parameters and configuration when working properly. This document will also be essential during troubleshooting of problems that may arise in the future. There is a specific section that outlines problem resolution and escalation.

**2.0 System Purpose**

This system supports the entire Fire Risk system

**3.0 Scope**

The scope of this Support Plan is to document the system in its entirety. Some additional documentation will exist within respective eRooms and Subversion Version Control. It is intended to be the first document for reference for this system, and will contain links to additional locations for further information.

In addition, see Red Hat Network for additional detailed information on servers managed via this service.

**4.0 Documentation Confidentiality**

The technical portion of the system documentation is considered confidential information for CI network staff. Please do not share these technical details with other individuals, as they could perform an infiltration of the system and disrupt services.

**5.0 System Architecture**

* 1. Server Name: x-firerisk
  2. Serial Number/Service Tag
  3. Rack
  4. Operating System: Suse Linux
  5. Processors/Cores
  6. RAM
  7. Logical Volumes (Hard Drives)
  8. Purchase Date
  9. Support Renewal Data

1. **Network Architecture**
   1. Internal IP Address: 192.168.1.28
   2. External IP Address: 65.205.36.64
   3. Primary DNS:
   4. Secondary DNS:
   5. Mask
   6. Gateway
   7. Fully Qualified Domain Name
   8. Network Ports Open
   9. SAN Connectivity
   10. SSL Requirements
2. Server Configuration
   1. **Installed Applications with version numbers**
      1. **PHP**
      2. **MySQL**
   2. **Installed Packages**
      1. Library GCTPC-c.2.0-installed at /FIRERISK/lib/gctpc/ Downloadable at ([http://gcmd.nasa.gov/records/USGS-GCTP.html](http://gcmd.nasa.gov/records/usgs-gctp.html))
      2. ImageMagick-6.3.7-installed at /usr/local/share/ Downloadable at (http://www.imagemagick.org/script/index.php)
      3. HDFLOOK-5.0 –installed at /bin/HDFLOOK\_linux. Downloadable at (http://www-loa.univ-lille1.fr/Hdflook/hdflook\_gb.html)
   3. **Automatic Operating System Updates**
   4. **Supporting Application Configuration**
   5. **System Ports Open**
   6. **Users and Passwords**
      1. **root, USM719049J**
3. Regular Maintenance/Scripts
   1. When a MODIS download fails, initiate the download and run that day's fire risk with:

/FIRERISK/SCRIPTS/firerisk\_init\_manual.sh.

* 1. When a TRMM download fails, initiate the TRMM download and processing with /FIRERISK/SCRIPTS/TRMM3B42RT\_day\_GMTminus5.sh

NEXT STEP is to rerun the days since last rain fall from that day forward

/FIRERISK/SCRIPTS/days\_since\_last\_rain.sh

THEN RERUN firerisk for same days:

/FIRERISK/SCRIPTS/AMZ\_littermoisture\_day.sh

* 1. If OS is reinstalled: Replicate old server and remake Cron scripts:

0 13 \* \* \* /FIRERISK/SCRIPTS/TRMM3B42RT\_cron\_GMTminus5.sh

0 22 \* \* \* /FIRERISK/SCRIPTS/firerisk\_init.sh

1. Important Addresses/Information
   1. Fire Risk System <http://firerisk.conservation.org>
   2. Development Fire Risk System: <http://firerisk.conservation.org:7777>
2. **Hosted Custom Applications**
   1. **Fire Risk System**
      1. Deployment Procedures
         1. New website – copy code from subversion
         2. New scripts – modified directly on server, managed by Karyn
      2. Business Owner: Fire Risk/Cluster 2, CABS
      3. IT Sponsor: Information Systems
      4. Target Audience: general public
      5. Critical Use Times: Intermittent web access 24/7/365
      6. Approximate Outage Threshold: 2 – 3 days
      7. Confirmation Application is Up: can access <http://firerisk.conservation.org> and can view yesterdays fire risk image
      8. Requirements and Other Documentation
         1. Most code and scripts are in Subversion at xvm-svn1/science/FireRisk
         2. Data and other documentation resides on the server
3. System Support
   1. Monitoring
      1. Hard Drive Space
      2. CPU utilization
      3. Network configuration/performance
      4. Application Monitoring (website is up and accessible)
   2. Backup
      1. Continual Backup Needs
         * since data is created daily as binary files stored on the filesystem, nightly backups are needed
      2. Periodic Backup Needs
         * initial baseline
         * before any major configuration change
         * before new application deployments
   3. Problem Resolution & Escalation
      1. Tier 1: reboot server
      2. Tier 2: contact Information Systems team
4. Licensing & Maintenance Contract Details
5. Contact Information
   1. Information Systems:
      * Howard Kistler: [hkistler@conservation.org](mailto:hkistler@conservation.org), x2517
   2. Fire Risk:
      * Karyn Tabor: [ktabor@conservation.org](mailto:ktabor@conservation.org), x2560