Department of Science, Information Technology and Innovation

AussieGRASS Environmental Calculator

Metadata Version 1.6

Remote Sensing Centre

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Queensland Government

Prepared by

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To directly cite the source information in this document, see section 1.8.4 (Suggested Referencing) and 1.9 (References).

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1 Metadata for AussieGRASS Files and General Information

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1.1 Introduction and purpose

This metadata document is an information source to provide AussieGRASS GIS users (internal and external) with 'need to know' details on products and data for data manipulation and analysis. Topics discussed include:

- Description of Raster Files (internal DRR metadata, coordinate system, masking, data units, model/parameter version and file notation)
- Percentile Maps (seasonally dry, median maps)
- Probability of Exceeding Median Maps
- Anomaly Forecast Maps
- Baseline periods
- LEPS (Linear Error in Probability Space) for Growth Forecast Skill Maps (forecast methods)
- Additional Information (frequency of data updates, caveats, conditions of use, disclaimer, suggested referencing).

Information on how to interpret and use specific AussieGRASS products (product and user guide) is provided in a separate document (described below).

1.1.1 General overview of the AussieGRASS system

AussieGRASS (Carter *et al.* 2000) is an Australian spatial representation of the pasture growth and water balance GRASP model (Rickert, *et al*. 2000) that is run with interpolated climate data (Jeffrey *et al*. 2001) and calibrated using satellite data and pasture biomass observations (Hassett *et al.* 2000). AussieGRASS was developed with the view to supporting sustainable management of Australia's rangelands.

AussieGRASS products include simulations of pasture growth, total standing dry matter (TSDM), pasture curing, grassfire risk, available soil water, and ground cover. The simulations are expressed as absolute values (i.e. totals) and ranked relative to historic values (i.e. percentiles). The probabilities of future rainfall, pasture growth and potential flow to stream are assessed using seasonal climate forecasting systems (SOI phases) that have classified historical years into year-types.

The AussieGRASS maps consist of pasture growth, TSDM, potential runoff and rainfall percentiles. These maps are produced each month and placed on the AussieGRASS web sites. Information is produced as postscript files, gif files and ERDAS IMAGINE ® rasters (these can be imported into Arc). The map products are designed to give broad picture information on pasture growth, rainfall, total standing dry matter and a probabilistic risk assessment for future pasture growth.

The operational production system consists of a suite of programs which is run routinely on a monthly and daily basis (daily runs are executed to produce fire products). Typically, at the start of the month the spatial environmental calculator of AussieGRASS is run at continental scale for the past 3 years to present to ensure that the model uses the best available improved (in quality and quantity) rainfall, climate and stock data sets. Subsequently, the best estimate of current conditions (i.e. the state of the pasture system; soil water and available nitrogen) on the day prior to the run of the forecast model is obtained. Three month predictions are also carried out as part of the operational system. Post-processing scripts are run to generate maps, rasters of data, tables and various customised products for clients from estimates of AussieGRASS model outputs

1.1.2 AussieGRASS product availability and guides

Standard products are available on the public accessible site and the AussieGRASS password protected website (via http://www.longpaddock.qld.gov.au/). Non-standard products are made available on the FTP DSITI public server (ftp://climate.mft.derm.qld.gov.au/Climate/agrass/).

Other Guide documents

A companion document "***AussieGRASS Environmental Calculator - User Guide***" provides tutorial information for individuals using the AussieGRASS products. The ***"AussieGRASS Environmental Calculator – Product Guide"*** document semi-technical overview of the major operational products from the AussieGRASS system.

Document location: https://www.longpaddock.qld.gov.au/rainfallandpasturegrowth/index.php

Additional Resources:

- FORAGE reports: https://www.longpaddock.qld.gov.au/forage/
- Seasonal fractional cover: http://www.auscover.org.au/xwiki/bin/view/Product+pages/Landsat+Seasonal+Fractional+Cover
- Seasonal cover deciles: http://www.auscover.org.au/xwiki/bin/view/Product+pages/Seasonal+Cover+Deciles

1.2 Description of Raster Files

The AussieGRASS data are provided to external users in a geographic coordinate system with a cell size of 0.05 degrees. The file format is ERDAS IMAGINE®, image files have an *img* file extension. The files are generated from the internal "Drought Research Raster" (DRR) format files. The Imagine files can be imported into the ArcGrid® package. Compressed files, supplied in a zipped and/or a tar format, are extracted using products such as Winzip®. Metadata within the DRR files transferred during the GDAL (Geospatial Data Abstraction Library, a translator library for raster geospatial data formats) translate the conversion process to the Imagine format that includes model source code version and name of input file.

The control file contains details of inputs used for the AussieGRASS model run such as pasture and soil parameter sets, climate datasets, stock sets, fire datasets, initial state conditions, ocean mask file used, static datasets (such as tree basal area, vegetation species and soil type rasters, etc.), and model options used. All routine model run outputs are archived along with source code and parameter files. Manual FTP download is in binary mode. All AussieGRASS outputs are of type "real" unless specified otherwise.

1.2.1 Internal DRR Metadata

This metadata contains a set of standard identifying text lines in the header in order to identify each model run. They include the creation date of the raster by the GRASP model on output, the working directory name on the DSITI High Performance Computer, the spatial GRASP model version used for the run and name of control file. Table 1 below displays the bottom, left, top, and right coordinates for the 0.05^0 grid (5×5 km), 0.1^0 grid (10×10 km) and 0.25^0 grid (25×25 km) AussieGRASS input rasters are occasionally supplied to users. These are supplied as a 0.01 degree grid 4301 * 3401 with the same map extent for larger grids.

Table 1. Raster extents (i.e. Left, Right, Bottom and Top coordinates), for 0.050, 0.10 and 0.250 grid rasters. ACT is not supplied separately.

	Bottom	Top	Left	Right	5 km		10km		25 km	
					nRows	nCols	nRows	nCols	nRows	nCols
Aus	-44	-10	112	154	681	841	341	421	137	169
Qld	-29.15	-10.55	137.95	153.60	373	314	187	158	76	63
NSW	-37.50	-28.10	140.95	153.65	189	255	95	128	39	52
NT	-27	-10.10	128.95	138.05	339	183	170	93	69	37
SA	-38.50	-26	128.95	141.05	251	243	126	123	51	49
VIC	-39.50	-33.50	140.90	150	121	183	61	92	25	37
Tas	-44	-39	143.50	148.50	101	101	51	51	21	21
WA	-36	-13	112	133.05	461	422	231	212	93	85

(NB These coordinates are for the centre of a pixel – WARNING many systems reference the top right hand corner of the pixel).

AussieGRASS model outputs are generated at cell size of 0.05 degrees, however, rainfall and rainfall percentile data were produced at a 0.1 degree resolution. From June 2015, newly created rainfall and rainfall percentile outputs will be at 0.05 degrees (5x5km), backdated to 2014. For some time following June 2015, there will be a mix of resolutions for rainfall and rainfall percentile data until a complete rerun can be uploaded.

The AussieGRASS data are not defined to a datum as it is of minor relevance to 0.05 degree grid cells. If users wish to reference to a coordinate system, we suggest the spheroid and datum to be set to Spheroid GRS1980, Datum GDA94, respectively. Occasionally users may be supplied with source GIS data used to build stock and tree cover rasters, these are at a resolution of 0.01 degree and for Australia have the same corner coordinates with 3401 rows and 4201 columns.

1.2.2 Coordinate System

The coordinate system that is used for AussieGRASS outputs is geographic (i.e. uses a latitude longitude grid). Users should be aware that this system does not preserve pixel area and pixels in the north of Australia represent a larger area than those in southern Australia. Calculations that add mass or volume across significant extents of the continent (rather than deal with mass/unit area) should be adjusted by the user.

1.2.3 Masking

Masking values have been applied to pixels for various purposes to denote: ocean, lakes, areas that are seasonally dry and firescars. A full list of variables with mask type and value are given in Table 2 below.

Ocean pixels are set to ‘0’ and users should apply their own coastline mask. It is worthwhile noting that ocean pixels and land pixel values can be the same value (e.g. when pasture growth is 0). Coastline masks may not align completely with pixels as only those pixels with greater than 50% land area are retained for modelling purposes. Similarly, pixels observed on the perimeter of national parks with a greater than 50% land area are assigned as un-grazed areas.

In addition to ocean and seasonally dry masks (see section 3.31), fresh and salt lakes may be masked as spatial reference points in percentile and anomaly maps. These masks are shown in the presentation maps (i.e. gif, postscript files); they are also present in the spatial data (i.e. imagine files).

Firescars in TSDM percentiles are masked in the Gif files only where fires have occurred over the last three months. As firescars are only available for part of the ‘1957 to current’ period, any percentile TSDM calculation is biased ‘low’ for firescar areas.

Percentile rainfall does not use the standard ocean mask and the land areas are generally buffered to 10-15 pixels (~50-75km). This is inherent in the SILO rainfall grids to allow users to access islands and fragments of the coastline that would otherwise be missed.

Table 2. AussieGRASS variables with mask type and value.

Variable	Type	Periods (months)	Ocean Mask	Lakes Mask	Seasonal Dry Mask	Smooth (factor value)
TSDM	Totals	1	0	0		
Growth	Totals	1	0	0		
TSDM	Percentile	1	0	254		
Growth	Percentile	1, 2, 3, 4, 6	0	254	255	
growth	Percentile	12, 18	0	254		median=2
growth	Percentile	3, 6	0	254	255	median=2
Growth	Percentile	24, 36, 60	0	254		
Streamflow	Percentile	1, 3, 6	0	254	255	
Streamflow	Percentile	12, 18, 24 36	0	254		
Totalcover	Percentile	1, 3, 6, 12, 24, 36	0	254		
Growthndx	Percentile	1, 3, 6, 12, 24, 36	0	254		
Availsw	Percentile	1, 2, 3, 6, 12, 24, 36	0			
Curing	Percentile	1	0	254		
Totalcover	Anomaly	1	0	254		
Curing	Anomaly	1	0	254		
Grassfire	Firerisk	1	0			average=2
Curing	Firerisk	1	0	254		
Growth	Probability	3	0	254	255	
Streamflow	Probability	3	0	254	255	
Totalcover	Probability	3	0	254	255	
Variable	Type	Periods (months)	Ocean Mask	Lakes Mask	Seasonal Dry Mask	Smooth (factor value)

Variable	Type	Periods (months)	Ocean Mask	Lakes Mask	Seasonal Dry Mask	Smooth (factor value)
Groundcover	Fuel	Daily	0	0		
Greengrass	Fuel	Daily	0	0		
Deadgrass	Fuel	Daily	0	0		
Grasslitter	Fuel	Daily	0	0		
Treelitter	Fuel	Daily	0	0		
Groundcover	pcntcover change	1	0	2		
totcoverchange	pcntcover change	1	0			
Rain	Totals	1	0	0		
rain	Percentile	1, 3, 4, 6, 12, 18, 24, 36, 48, 60	0	0		
rain	Probability	3	0			
Totalcover	Percentile	1, 3	0			
Totalcover	Percentile	12	0			
Streamflow	Percentile	1, 3, 12	0			
Availsw	Percentile	1, 3, 12	0			
Max	Percentile	1, 3, 12	0			
Min	Percentile	1, 3, 12	0			
Rain	Percentile	1, 3, 12	0			

1.2.4 Data Units

These vary for various products but for mass-based variables the units are kg DM ha^{-1}. Soil moisture is in mm of rainfall equivalents. Indices are scaled either 0-1 or 0-100.

1.2.5 Model/Parameter version

This metadata applies to model version src3, with parameterisation data 200812. Alternative and later versions will be documented here.

1.2.6 File Notation

Typical monthly AussieGRASS file notations are as follows: *yyyymmp.variable.type.region.format* and *yyyymmddp.variable.type.region.format* for monthly and daily data, respectively. Table 3 defines the notation used. For historical reasons the rainfall maps names do not include a variable type "rain".

Table 3. AussieGRASS outputs naming convention

Notation	Option	Output rule	Description
yyyy	*e.g.* 2008		year
mm	01 to 12		month
dd	01 to 31		day
p	d	inst	daily
	m	acc, inst	duration or period: 1 month
	q	acc	3 months
	h	acc	6 months
	y	acc	12 months
	24	acc	24 months
	36	acc	36 months
region			aus qld nsw vic tas nt sa wa
format	gif		gif files
	ps		postscript files
	img		imagine files
	pcnt		percentile

Notation	Option	Output rule	Description
type	tot		total
	prob		seasonal probability
	skill		seasonal probability skill score (LEPS)
	median		median
	anom		anomaly
	avg		average
	pcnt		percentile
variable	curing	inst	pasture curing index (0-1)
	grassfire	low, moderate, high	pasture grass fire risk (20, 30 or 40)
	growth	acc	pasture growth (kg/ha)
	pfts	acc	potential flow to stream (mm)
	tsdm	inst	total standing dry (matter pasture biomass kg/ha)
	greenpool	inst	green leaf + green stem (kg/ha)
	deadbiomass	inst	dead leaf + dead stem(kg/ha)
	litter	inst	mass of grass detached material (kg/ha)
	treelitterleaf	inst	mass of tree litter (leaf and sticks < 25mm)
	totalcover	avg	total ground cover prop. used in runoff (0-1)
	availsw	avg	water available to grass from 0-1 metre (mm)
	sw1	avg	soil water available to grass from 0-10 cm (mm)
	gindx	avg	growth index - index of potential growth (0-1)

† Linear Error in probability Space (LEPS) is a measure of forecast skill

acc – is accumulated over a period (e.g. for monthly pasture growth)

inst – instantaneous (on the day snapshot)

avg – is the average value over a period.

1.3 Percentile Maps

1.3.1 Percentiles, deciles and quartiles

The percentile of a number indicates where the number lies in a set of numbers. For example, if last year's rainfall was ranked at the 30th percentile of the long-term annual rainfall record, then the rainfall in 30% of the years in the record are less than (or equal to) last year's rainfall and the rainfall in the remaining 70% of years in the record are greater than last year’s rainfall.

Percentiles that are multiples of 25 are called quartiles. The 25th percentile is the first quartile, the 50th percentile is the second quartile, and the 75th percentile is the third quartile. Similarly, percentiles that are multiples of ten are called deciles.

For rainfall or pasture growth, the percentile value needs to be interpreted by comparing it with the real value. This is because in some areas the annual rainfall or pasture growth is very low; a high value of annual rainfall or pasture growth in percentile for the same period can be misleading because of an actual low annual rainfall or pasture growth amount.

1.3.2 Seasonally Dry Issue

In the dry season over much of Australia the most common rainfall, runoff and pasture growth amount is zero. In some cases 80% of months in a 100 year sequence may have zero rainfall. On receiving another rainfall amount of zero the question often is: is this value ‘percentile zero’, ‘percentile 80’, or somewhere in between? For this case the maps produced by AussieGRASS the value is set at the mid-point of the string of zeros (i.e. the 40^{th} percentile).

Because of the frequency distribution of rainfall amounts, in some instances, small amounts of rainfall of just a few mm can generate a rainfall percentile of greater than 90. This rainfall is largely meaningless in terms of biology and hydrology, but gives the appearance of being ‘significant’.

To overcome this problem we often mask presentation maps as “seasonally dry”. However, **this carries its own risk of hiding the very rare say 1:50 - 1:100 year rainfall events that are actually meaningful.** In longer term percentile analyses this issue is no longer a problem as there is rainfall in most accumulation periods greater than three months. Masking is applied with different thresholds for various variables as shown in the table below.

Table 4. Threshold values for "seasonally dry" masks with respect to relevant percentile products. Maps are masked as white ("seasonally dry") when values are below the tabulated values.

Duration (months)	Pasture growth (kg/ha)	Streamflow (mm)	Rainfall (mm)
1	10	0.5	5
2	15	not produced	15
3	25	1.5	30
4	30	2.0	20
5	40	2.5	25
6	50	3.0	30

1.3.3 Median Maps

The median is by definition the 50th percentile. By sorting the data in the data set from the lowest to the highest value, the median is the middle value in the distribution. If there is an even number of members in the set, the median is computed as the mean of the two middle values.

1.3.4 Date convention

Percentiles dates refer to the end of the accumulation period not the beginning. For example, the filename for the October 1974 to March 1975 six month period percentile would be 197503h.variable.pcnt.aus.drr.

1.4 Probability of Exceeding Median Maps

Operationally, our three month prediction with AussieGRASS is done using the SOI Phase System (Stone and Auliciems, 1992) but in principle any method can be used which can split the past weather record into a number of classes (*year-types*). The best estimate of the future is made by selecting those past years which have the same year-type as the current period. This set of past years is known as the set of *analogues* of the current period and from it we obtain a distribution of likely weather for the coming three months, based on the fact that the current year has the same year-type.

We can use these analogues to obtain a distribution of likely pasture growth by running the AussieGRASS pasture growth model forward from current conditions, using each of the analogue years as an estimate of coming weather. From this distribution of estimated future pasture growth, we can count the proportion which exceed the long-term median growth for the time of year, and thus obtain a probability of exceeding median growth in the coming three months. This is the probabilistic categorical forecast, for the current period.

The process outlined above can, of course, also be applied to any other point in history. This is known as 'hindcasting', and gives a pairing of an observation and a prediction.

1.5 Anomaly Forecast Maps

Total cover and curing index anomaly forecast maps are generated on a monthly basis as part of the AussieGRASS operational runs. The forecast anomaly is computed from the difference between the last day of a three month run (based on historical model runs using all years from 1957), and the last day of a three month ahead forecast run (based on a subset of years as defined by the SOI phase system).

1.6 Baseline periods

Outputs of AussieGRASS that are used in operational products use a baseline for all percentile and anomaly analysis that is a 'current value' relative to all values back to 1957 to the most recent previous period. This period is used, as prior to 1957 there is only a very low density of climate stations that record temperature and other climate variables (in addition to rainfall).
In the case of forecasts to 'probability of exceeding the median', the base period for the calculation of the median, is 1957 to the most recent period.

Analogue years for the forecast are selected from the period 1900 to the previous year.

Prior to 1890 there were only ~2000 rainfall stations in Australia, which we consider is too sparse for analysis. The decade of 1880-1890 is used in AussieGRASS for the purpose of a model 'spin-up' to achieve reasonable starting conditions for pasture biomass and soil moisture conditions, but this period not used in any analyses.

The period 1890-1900 (while is used in some analyses), is not considered to have high enough quality to be included in analogue years for use in forecasts.

1.7 LEPS (Linear Error in Probability Space) for Growth Forecast Skill Maps

LEPS is used to measure the skill of a forecast. In particular we are interested in a probabilistic categorical forecast. The "categorical" part refers two categories (*i.e*. above and below median), while the "probabilistic" part refers to forecasting a probability of an outcome in each category (*e.g.* 30% chance of below median; 70% chance of above median). In order to assess the skill, using LEPS, we combine a set of such forecasts with the actual outcomes (*i.e*. which category actually occurred, paired with each forecast).

If we repeat the hindcasting process for every month in the historical record (115 years, by 12 months), we will have a set of observed predicted pairs (or 12 sets, if we keep each month of the year separate), from which we can calculate a LEPS score. In order to do this, the forecasting process must be run for each month in history; this involves running every other year as an analogue of the weather from that time, so the total number of runs is 115*12*114 = 157320. To do this with AussieGRASS in its usual form would be unfeasible, due to the computation time, so a subset of the pixels was run, comprising every 5th pixel in *x* and *y* directions, (*i.e*. 1/25th of the total number of pixels). This still took over a month of continuous computation. The full resolution version would take 25 times as long, (which would take over two years to complete).

The set of outputs from these runs is a 3 month growth estimate for every year/month, using every other year as analogue for the weather. Note that, so far, we still have not imposed any particular forecast system on it (*i.e*. we have not yet made our probabilistic forecast of growth). This is done by using the year-types defined by SOI Phase, and grouping the growth estimates in classes, based on year-type, and thus calculating a probability of exceeding median growth, given the year-type. Pairing this with the observation (of simulated growth using real weather), and repeating for all years, we have 115 observed/predicted pairs, for a given time of year, and from this we calculate a LEPS score. This is done on a per-pixel basis, so we end up with maps of LEPS skill, per pixel, per time of year. We can do this calculation for all years together, or for only those years of a given year-type, to examine the different level of skill in different year-types.

1.7.1 Caveats

Testing on the ability to forecast what the model would simulate is carried out; the “observation” of growth is simulated growth, not actual on-the-ground growth.

The significance of a LEPS score depends on how many observed/predicted pairs went into it the calculation. The precision of the estimate is lower for a single year-type by itself, as the number is reduced (with SOI Phase, each year-type typically has around 20 years, out of 115 in total).

It is not possible to investigate the ‘lagged skill’ in forecasting growth in same way it is done with rainfall, as rainfall is a measurement, whereas pasture growth needs to be simulated.

1.7.2 Forecast Methods

AussieGRASS has also been upgraded to use general circulation model consensus forecasts of El Niño state (Barnston *et al.* 2003). These forecasts have a longer lead time and are likely to be more resistant to climate change than the current SOI phase system (Stone and Auliciems, 1992) which has operational problems of large changes in forecasts for small changes in SOI around “phase boundaries”. This new system is operational internally, however, it is not available externally to clients, due to the lack of ability to test the skill of systems that have a short operational history. Other forecast systems such as SPOTA-1 have been run in non-operational tests and could be used on a regular basis in the future.

1.8 Additional Information

1.8.1 Frequency of Data Updates

Daily updates can occur for total rainfall and rainfall percentile maps within 12 months of the current date, as the Bureau of Meteorology update their data with postal returns. Monthly rainfall and rainfall percentile maps more than 12 months old are updated each 12-36 months on an ad hoc basis.

Forecast products issued on a monthly basis are usually generated between day 2 and 5 of the month and are not updated once produced. After June 2013, all model outputs and forecasts are rerun at ~day 10 of the month, to take advantage of the large amount of rainfall data that is supplied to the BoM via postal means.

Percentile maps of pasture growth, total standing dry matter, potential flow to stream, fuel load and curing indices are not updated on the web server on a routine basis. These maps may be updated on an ad hoc basis (3-5 years) to reflect significant improvements in historical climate data, model parameterisation and model functionality.

Fuel load products (GIS data via FTP service) are calculated daily, and files for the last 30 days are updated.

The defined currency of the model input/output data may not apply to ad hoc data requests due to the use of more current and model versions.

1.8.2 Conditions of Use

The AussieGRASS datasets and mapping products are for single use only from requesting groups and are to be used within a specified project only.

1.8.3 Disclaimer

1.8.4 Suggested Referencing

The statement below (or something similar) would be sufficient to describe the AussieGRASS model system with associated processes.

The AussieGRASS environmental Calculator (Carter *et al.* 2000), is a continental scale spatial implementation of the GRASP daily time-step pasture production and water balance model (Rickert *et al.* 2000) using daily climate data from SILO (Jeffrey *et al.* 2001).

AussieGRASS (Carter *et al.* 2000) is an Australian spatial representation of the pasture growth and water balance GRASP model (Rickert, *et al*. 2000) that is run with interpolated climate data (Jeffrey *et al*. 2001) and calibrated using satellite data and pasture biomass observations (Hassett *et al.* 2000).

1.8.5 Trade Mark

The Australian Grassland and Rangeland Assessment by Spatial Simulation (**AussieGRASS**) holds a certificate of registration of trade mark. The certificate reads as follows:

> I, Ruth Naomi Mackay, Register of Trade Marks, hereby certify -
> that the trade mark represented on this certificate has been registered as a **Trade Mark, No. 971285** in the Register of Trade Marks for the period of ten years commencing 22 September 2003 and that Department of Natural Resources, Mines and Energy of Climate Impacts and Natural Resource Systems 80 Meiers Road INDOOROOPILLY QLD 4068 Australia has been entered in the Register of Trade Marks as the owner of the trade mark.

The trade mark is registered for the following goods and/or services:

Modelled climate and pasture research to support sustainable management of Australia's grazing lands through provision of scientific information via internet-based services being services in class 42.

On 11/02/2013, the trade mark (No. 971285) registration was renewed to 22/09/2023 in the name: Department of Science, Information Technology and the Arts (DSITIA).

1.9 References.

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