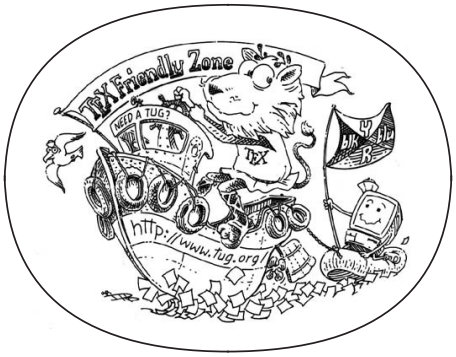
CECIL'S THESIS

CECIL LI



An Homage to The Elements of Typographic Style

March 2014 – version 1.0

Ohana means family.
Family means nobody gets left behind, or forgotten.

— Lilo & Stitch

Dedicated to the loving memory of Rudolf Miede.
1939 – 2005

ABSTRACT

Short summary of the contents...

PUBLICATIONS

Some ideas and figures have appeared previously in the following publications:

Put your publications from the thesis here. The packages `multibib` or `bibtopic` etc. can be used to handle multiple different bibliographies in your document.

We have seen that computer programming is an art,
because it applies accumulated knowledge to the world,
because it requires skill and ingenuity, and especially
because it produces objects of beauty.

— **?** [**?**]

ACKNOWLEDGEMENTS

Put your acknowledgements here.

Many thanks to everybody who already sent me a postcard!

Regarding the typography and other help, many thanks go to Marco Kuhlmann, Philipp Lehman, Lothar Schlesier, Jim Young, Lorenzo Pantieri and Enrico Gregorio[1], Jörg Sommer, Joachim Köstler, Daniel Gottschlag, Denis Aydin, Paride Legovini, Steffen Prochnow, Nicolas Repp, Hinrich Harms, Roland Winkler, and the whole LaTeX-community for support, ideas and some great software.

Regarding LyX: The LyX port was intially done by *Nicholas Mariette* in March 2009 and continued by *Ivo Pletikosić* in 2011. Thank you very much for your work and the contributions to the original style.

1 Members of GuIT (Gruppo Italiano Utilizzatori di TeX e LaTeX)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LISTINGS

ACRONYMS

DRY Don't Repeat Yourself

API Application Programming Interface

UML Unified Modeling Language

Part I

SOME KIND OF MANUAL

You can put some informational part preamble text here. Illo principalmente su nos. Non message *occidental* anglo-romanic da. Debitas effortio simplificate sia se, auxiliar summarios da que, se avantiate publicationes via. Pan in terra summarios, capital interlingua se que. Al via multo esser specimen, campo responder que da. Le usate medical addresses pro, europa origine sanctificate nos se.

1 INTRODUCTION

This template for LaTeX has two goals:

1. Provide students with an easy-to-use template for their Master's or PhD thesis (though it might also be used by other types of authors for reports, books, etc.).

2. Provide a classic, high-quality typographic style that is inspired by **?** 's "*The Elements of Typographic Style*" [**?**].

Cecil's Thesis version 1.0

The bundle is configured to run with a *full* MiKTeX or TeXLive installation right away and, therefore, it uses only freely available fonts.

People interested only in the nice style and not the whole bundle can now use the style stand-alone via the file `classicthesis.sty`. This works now also with "plain" LaTeX.

As of version 3.0, `classicthesis` can also be easily used with LyX[1] thanks to Nicholas Mariette and Ivo Pletikosić. The LyX version of this manual will contain more information on the details.

This should enable anyone with a basic knowledge of LaTeX 2ε or LyX to produce beautiful documents without too much effort. In the end, this is my overall goal: more beautiful documents, especially theses, as I am tired of seeing so many ugly ones.

The whole template and the used style is released under the GNU General Public License.

If you like the style then I would appreciate a postcard:

Andre Miede
Detmolder Strasse 32
31737 Rinteln
Germany

The postcards I received so far are available at:

http://postcards.miede.de

A well-balanced line width improves the legibility of the text. That's what typography is all about, right?

So far, many theses, some books, and several other publications have been typeset successfully with it. If you are interested in some typographic details behind it, enjoy Robert Bringhurst's wonderful book.

IMPORTANT NOTE: Some things of this style might look unusual at first glance, many people feel so in the beginning. However, all things are intentionally designed to be as they are, especially these:

1 http://www.lyx.org

- No bold fonts are used. Italics or spaced small caps do the job quite well.
- The size of the text body is intentionally shaped like it is. It supports both legibility and allows a reasonable amount of information to be on a page. And, no: the lines are not too short.
- The tables intentionally do not use vertical or double rules. See the documentation for the `booktabs` package for a nice discussion of this topic.[2]
- And last but not least, to provide the reader with a way easier access to page numbers in the table of contents, the page numbers are right behind the titles. Yes, they are *not* neatly aligned at the right side and they are *not* connected with dots that help the eye to bridge a distance that is not necessary. If you are still not convinced: is your reader interested in the page number or does she want to sum the numbers up?

Therefore, please do not break the beauty of the style by changing these things unless you really know what you are doing! Please.

1.1 ORGANIZATION

You can use these margins for summaries of the text body...

A very important factor for successful thesis writing is the organization of the material. This template suggests a structure as the following:

- `Chapters/` is where all the "real" content goes in separate files such as `Chapter01.tex` etc.
- `FrontBackMatter/` is where all the stuff goes that surrounds the "real" content, such as the acknowledgments, dedication, etc.
- `gfx/` is where you put all the graphics you use in the thesis. Maybe they should be organized into subfolders depending on the chapter they are used in, if you have a lot of graphics.
- `Bibliography.bib`: the BibTEX database to organize all the references you might want to cite.
- `classicthesis.sty`: the style definition to get this awesome look and feel. Bonus: works with both LATEX and PDFLATEX... and LYX.
- `ClassicThesis.tcp` a TEXnicCenter project file. Great tool and it's free!

2 To be found online at http://www.ctan.org/tex-archive/macros/latex/contrib/booktabs/.

- `ClassicThesis.tex`: the main file of your thesis where all the content gets bundled together.
- `classicthesis-config.tex`: a central place to load all nifty packages that are used. In there, you can also activate backrefs in order to have information in the bibliography about where a source was cited in the text (i. e., the page number).

  Make your changes and adjustments here. This means that you specify here the options you want to load `classicthesis.sty` with. You also adjust the title of your thesis, your name, and all similar information here. Refer to Section 1.3 for more information.

  This had to change as of version 3.0 in order to enable an easy transition from the "basic" style to LyX.

In total, this should get you started in no time.

1.2 STYLE OPTIONS

There are a couple of options for `classicthesis.sty` that allow for a bit of freedom concerning the layout:

. . . or your supervisor might use the margins for some comments of her own while reading.

- General:
  - `drafting`: prints the date and time at the bottom of each page, so you always know which version you are dealing with. Might come in handy not to give your Prof. that old draft.
- Parts and Chapters:
  - `parts`: if you use Part divisions for your document, you should choose this option. (Cannot be used together with `nochapters`.)
  - `nochapters`: allows to use the look-and-feel with classes that do not use chapters, e. g., for articles. Automatically turns off a couple of other options: `eulerchapternumbers`, `linedheaders`, `listsseparated`, and `parts`.
  - `linedheaders`: changes the look of the chapter headings a bit by adding a horizontal line above the chapter title. The chapter number will also be moved to the top of the page, above the chapter title.
- Typography:
  - `eulerchapternumbers`: use figures from Hermann Zapf's Euler math font for the chapter numbers. By default, old style figures from the Palatino font are used.
  - `beramono`: loads Bera Mono as typewriter font. (Default setting is using the standard CM typewriter font.)

  - `eulermath`: loads the awesome Euler fonts for math. (Palatino is used as default font.)
  - `pdfspacing`: makes use of pdftex' letter spacing capabilities via the `microtype` package.[3] This fixes some serious issues regarding math formulæ etc. (e. g., "ß") in headers.
  - `minionprospacing`: uses the internal `textssc` command of the `MinionPro` package for letter spacing. This automatically enables the `minionpro` option and overrides the `pdfspacing` option.

- Table of Contents:
  - `tocaligned`: aligns the whole table of contents on the left side. Some people like that, some don't.
  - `dottedtoc`: sets pagenumbers flushed right in the table of contents.
  - `manychapters`: if you need more than nine chapters for your document, you might not be happy with the spacing between the chapter number and the chapter title in the Table of Contents. This option allows for additional space in this context. However, it does not look as "perfect" if you use `\parts` for structuring your document.

- Floats:
  - `listings`: loads the `listings` package (if not already done) and configures the List of Listings accordingly.
  - `floatperchapter`: activates numbering per chapter for all floats such as figures, tables, and listings (if used).
  - `subfig(ure)`: is passed to the `tocloft` package to enable compatibility with the `subfig(ure)` package. Use this option if you want use classicthesis with the `subfig` package.

The best way to figure these options out is to try the different possibilities and see, what you and your supervisor like best.

In order to make things easier in general, `classicthesis-config.tex` contains some useful commands that might help you.

1.3 CUSTOMIZATION

This section will give you some hints about how to adapt `classicthesis` to your needs.

The file `classicthesis.sty` contains the core functionality of the style and in most cases will be left intact, whereas the file `classicthesis-config.tex` is used for some common user customizations.

3 Use `microtype`'s `DVIoutput` option to generate DVI with pdftex.

The first customization you are about to make is to alter the document title, author name, and other thesis details. In order to do this, replace the data in the following lines of `classicthesis-config.tex`:

Modifications in `classic-thesis-config.tex`

```
1 \newcommand{\myTitle}{A Classic Thesis Style\xspace}
  \newcommand{\mySubtitle}{An Homage to ...\xspace}
  \newcommand{\myDegree}{Doktor-Ingenieur (Dr.-Ing.)\xspace}
```

Further customization can be made in `classicthesis-config.tex` by choosing the options to `classicthesis.sty` (see Section 1.2) in a line that looks like this:

```
\PassOptionsToPackage{eulerchapternumbers,listings,drafting,
    pdfspacing, subfig,beramono,eulermath,parts}{classicthesis}
```

If you want to use backreferences from your citations to the pages they were cited on, change the following line from:

```
\setboolean{enable-backrefs}{false}
```

to

```
\setboolean{enable-backrefs}{true}
```

Many other customizations in `classicthesis-config.tex` are possible, but you should be careful making changes there, since some changes could cause errors.

Modifications in `classicthesis.sty`

Finally, changes can be made in the file `classicthesis.sty`, although this is mostly not designed for user customization. The main change that might be made here is the text-block size, for example, to get longer lines of text.

1.4 ISSUES

This section will list some information about problems using `classicthesis` in general or using it with other packages.

Beta versions of `classicthesis` can be found at the following Google code repository:

http://code.google.com/p/classicthesis/

There, you can also post serious bugs and problems you encounter.

Compatibility with the `glossaries` Package

If you want to use the `glossaries` package, take care of loading it with the following options:

```
\usepackage[style=long,nolist]{glossaries}
```

Thanks to Sven Staehs for this information.

Compatibility with the (Spanish) `babel` Package

Spanish languages need an extra option in order to work with this template:

```
\usepackage[spanish,es-lcroman]{babel}
```

Thanks to an unknown person for this information (via Google Code issue reporting).

Compatibility with the `pdfsync` Package

Using the `pdfsync` package leads to linebreaking problems with the `graffito` command. Thanks to Henrik Schumacher for this information.

1.5 FUTURE WORK

So far, this is a quite stable version that served a couple of people well during their thesis time. However, some things are still not as they should be. Proper documentation in the standard format is still missing. In the long run, the style should probably be published separately, with the template bundle being only an application of the style. Alas, there is no time for that at the moment... it could be a nice task for a small group of LaTeXnicians.

Please do not send me email with questions concerning LaTeX or the template, as I do not have time for an answer. But if you have comments, suggestions, or improvements for the style or the template in general, do not hesitate to write them on that postcard of yours.

1.6 LICENSE

Part II

THE SHOWCASE

You can put some informational part preamble text here. Illo principalmente su nos. Non message *occidental* anglo-romanic da. Debitas effortio simplificate sia se, auxiliar summarios da que, se avantiate publicationes via. Pan in terra summarios, capital interlingua se que. Al via multo esser specimen, campo responder que da. Le usate medical addresses pro, europa origine sanctificate nos se.

2

WATER BALANCE

In the study of hydrology, the water influx and efflux of a system can be described using **Water Balance Model**. The system can be one of various domains and scales, such as a drainage basin across a large surface area[5], or as small as the soil water balance in the root zone of a single plant[1]. For a soil-based water system, the influx of water includes precipitation and irrigation whilst the efflux of water includes surface runoff, subsurface runoff, deep drainage, evaporation and transpiration. The latter two of water efflux are often combined and called evapotranspiration in hydrology.

A general equation of the water balance is given as

$$P = Q + E + \Delta S \tag{1}$$

Where P is the Precipitation, Q is runoff, E is Evapotranspiration and ΔS is the change in storage(in soil or bedrock).

The water balance model is essentially based on the law of conservation of mass: any change in the water content of a fixed soil volume during a specified period of time must be equal to the difference between the amount of water added to the soil and the amount of water extracted from it. As illustrated in Figure 1, in a hydrological cycle, the water content of the soil volume will increase from precipitation, and decrease from evapotranspiration or deep drainage.
A variety of water balance models that derived from Equation 1 exists, it can have different levels of complexity depending on the objectives of the study and data availability.

2.1 SIMPLE BUCKET MODEL

Simple bucket model is a widely-used water balance model in a simple conceptual scenario. It considers the controlled volume system as a bucket which is filled up from rainfall and emptied by evapotranspiration. If the bucket is full, extra water added is considered deep drainage. The only data that are necessary for this model are precipitation, evaporation, transpiration and the water storage capacity of the volume.

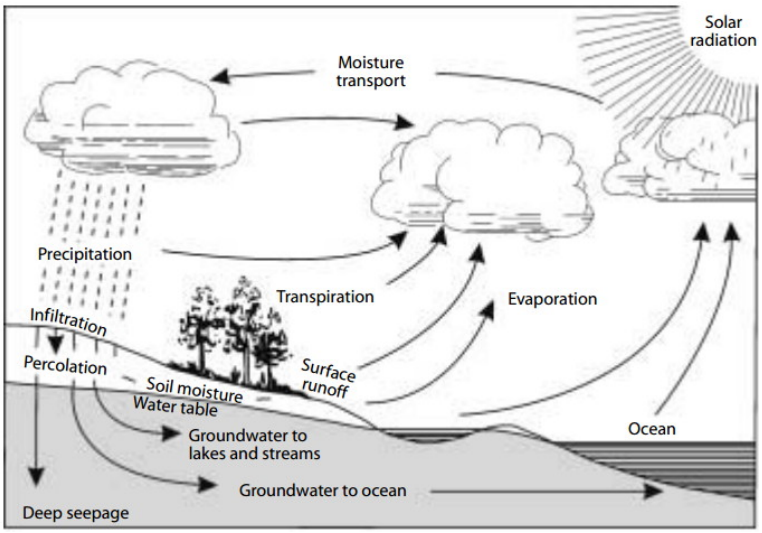


Figure 1: The hydrological cycle[1]. Reprinted from "Water balance modelling: concepts and applications", by Zhang et al., 2007, *ACIAR MONOGRAPH SERIES, 84*, p.33. Copyright 2002 by Zhang et al..

2.2 ROOT ZONE WATER BALANCE

The water balance model can also be applied in relatively small scaled field studies based on a specific root zone soil water balance equation [6], given as:

$$(\theta_t - \theta_{t-1})H = P + I - D - ET - R \tag{2}$$

Where
θ_t and θ_{t-1} are the initial and final depth-averaged soil water content of the root zone in one time step.
H is the root zone depth.
P is the precipitation.
I is the Irrigation.
D is the drainage out of the root zone, the positive value of D means downward percolation out of the root zone, whereas the negative value of it indicates upward capillary rise into the root zone.
ET is the actual evapotranspiration.
R is the surface runoff.

Figure 2 shows the relation of a root zone modelled by the root zone water balance Equation 2 as a plot-sized profile in a catchment. The catchment can be considered as a collection of such root zone profiles, of which the total recharge in the catchment is estimated by adding the recharge from each profile.

This generalisation from root zone model is not applicable to catchments that contain complex lateral redistribution of water, thus it is

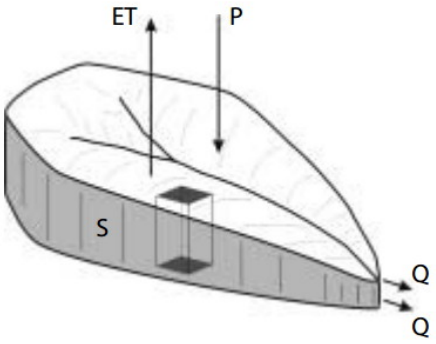


Figure 2: Schematic diagram of a catchment[1]. The box indicates the control volume of a root zone. S is water balance, ET is evapotranspiration, P is precipitation, Q is water runoff or flow. Reprinted from "Water balance modelling: concepts and applications", by Zhang et al., 2007, *ACIAR MONOGRAPH SERIES, 84*, p.36. Copyright 2002 by Zhang et al..

difficult to estimate the recharge at a catchment scale. In most cases, it is inappropriate to assume that the catchment-scale recharge is equal to the sum of plot-scale water balance recharges, without in-depth research of the hydrogeological condition of the catchment, such as the recharge pathways and spatial heterogeneity of soil properties[1].

2.3 COMPLEX MODELS

There are complex models that investigate not only the soil moisture dynamics but also the overall hydrological cycle over a large region of interest, they are designed to simulate interactions of different components within the system and to provide more thorough experimental results of many aspects[7]. For some purposes, simple bucket water balance models are appropriate, but other uses require greater functionality and/or more extensive analysis on a large geographic scale. For example, when analyzing the ecosystem of a large area of interest, there are various feedback between processes and different sub-systems that need to be taken into account, including the hydrological cycle, nutrient balance of soil and vegetation, heat balance, atmospheric change and more.

2.3.1 *Study of Amazon Basin: a system in equilibrium*

For instance, the Water Balance Model can be applied to the entire Amazon Basin in Brazil, South America [3], which explains the status of water flow in the Amazon forest ecosystem in a quantitative manner, as shown in Figure 3.

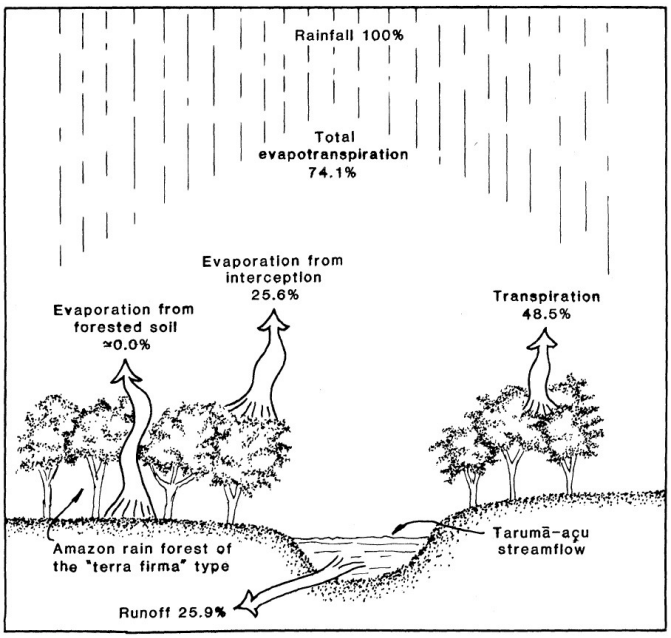


Figure 3: Water balance from a study of a model basin near Manaus, Brazil[2]. Reprinted from "Amazon basin: a system in equilibrium", by Salati and Vose, 1984, *Science,4658*, p.130. Copyright 1984 by Salati and Vose.

This model applies to the horseshoe-shaped Amazon Basin as a whole system, it uses knowledge of different domains in Meteorology. However, due to the lack of proper infrastructure in Brazil when the study was conducted. Accurate measurements on precipitation, evapotranspiration and other hydrological attributes over a large area were not available for analysis at a high precision level.

The measurements were taken from 1981 to 1983 in a controlled field in Barro-Branco watershed[8]. Precipitation data was obtained by use of a simple rain gauge installed at the reserve's meteorological station whereas the discharge was determined by use of a 0.8-m-wide rectangular weir and a water level recorder. Thus, the inferences of the influx and efflux of water in the area are based on assumptions made from wind conditions and a single point-based data as the averaged value over large areas which includes non-forest areas and are also influenced by other factors.

2.4 WATER BALANCE MODEL FOR THIS THESIS

There is a trade-off in choosing between complex models and simpler models such as the simple bucket model for conducting the analysis in this thesis. With greater functionality comes greater complexity. One of the issues with using a more complex water balance model

is that there are more parameters required to complete the model. Which means that more data and man-hours are involved to understand and interpret the equation into a machine-readable form. If there isn't sufficient data of various parameters, then selecting a complex model is inappropriate for the objectives. The key to successful modelling is to match model complexity with data availability and the analysis objectives.

2.4.1 *Data availability*

The objective of analysis in this thesis primarily concentrates on Australia as opposed to any other regions. Thus, one of the main data source being used is the Australian Water Availability Project (AWAP), which provides historic temporal-spatial meteorology data for the entire Australia. As described in the AWAP Final Report [9], the AWAP is a partnership between CSIRO Marine and Atmospheric Research (CMAR), the Bureau of Meteorology (BoM) and the Bureau of Rural Science (BRS), aiming to monitor the status and trend of the water balance of the Australian territories, using model-data fusion methods to combine measurements and model predictions. The AWAP data is discussed in more detail in Chapter 3 DATA INTEGRATION.

The AWAP provides essential meteorology data for water balance calculations, such as the precipitation, evapotranspiration, surface runoff and deep drainage etc.

A farm location in Richmond, Tasmania, Australia, of geographic coordinate latitude: -42.61 and longitude: 147.39, is chosen for demonstration purpose. The location is marked on Google Maps[10] as shown in Figure 4.

For this given location, the following time-series data of meteorology attributes: precipitation, evapotranspiration of soil and vegetation, open water evapotranspiration, surface runoff and deep drainage are acquired from AWAP, plotted in Figure 5, Figure 6, Figure 7 and Figure 9 respectively.

Figure 5 shows the rainfall data of this location, plotted from Year 2007 to 2014. It has shown a consistent amount of precipitation for each of the years. The maximum rainfall per day is 0.0152 m/day which occurred during the week of 04-Jul-2011. Furthermore, year 2011-2012 has a slightly higher overall precipitation amount than the other years. In general, the chosen location has a dry start, then wet in Summer and Autumn throughout the year[11].

Figure 6 shows the evapotranspiration data of this location. The blue

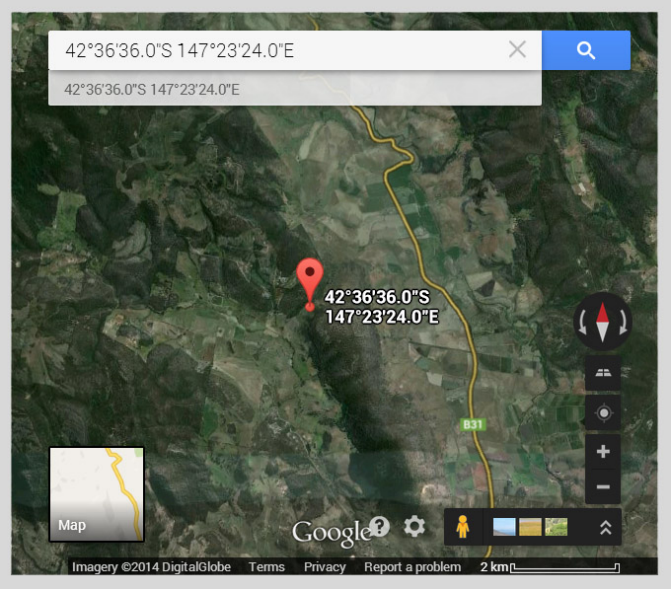


Figure 4: Satellite View of location latitude: -42.61 and longitude: 147.39, in Tasmania, Australia. Acquired from Google Maps.

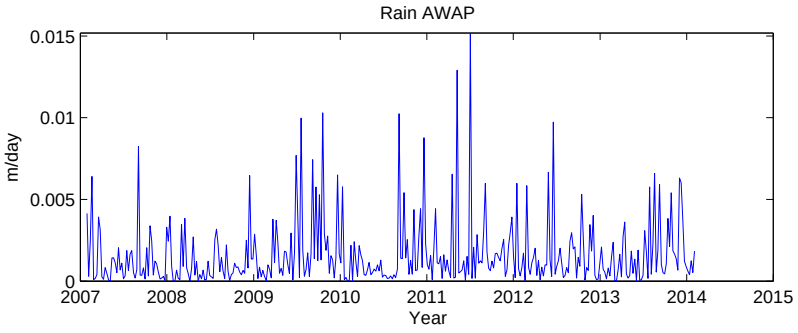


Figure 5: Time series of AWAP data: Rainfall, for location lat: -42.61, lon:147.39

line indicates the combined evapotranspiration of soil and vegetation, which has a clear and consistent chronological pattern throughout the years. The evapotranspiration reaches its lowest point during Winter season and climbs up to the highest point in the Summer season, which then declines during Autumn thus forming a repetition pattern.
On the other hand, open water evapotranspiration is indicated by the green line, which remains as zero for this location, due to the lack of open water in the surrounding terrestrial environment.

Figure 7 shows the surface runoff data of this location. Throughout the timespan, most of the weeks' surface runoff are zero while there are a few spikes in the figure. According to the AWAP datasheet[9]:

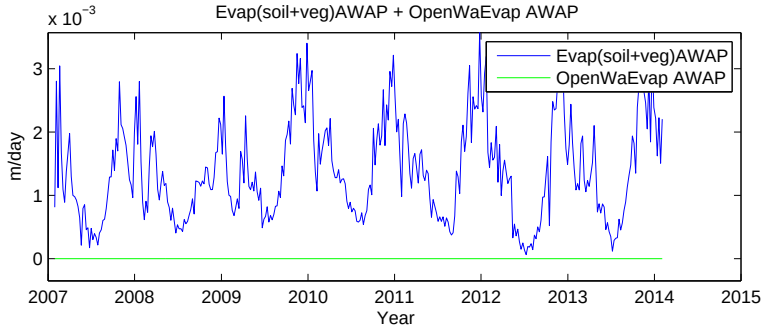


Figure 6: Time series of AWAP data: Evapotranspiration of soil and vegetation, and Open water evapotranspiration, for location lat: -42.61, lon:147.39

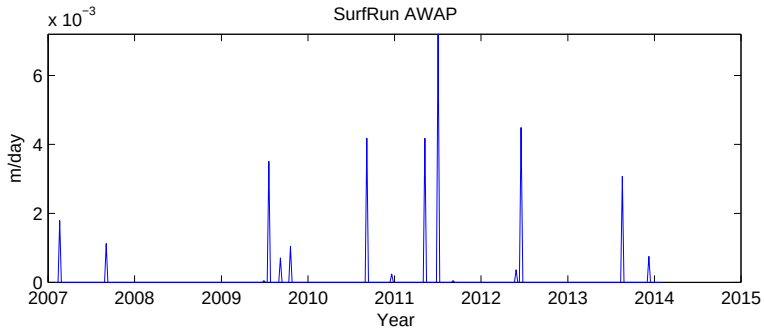


Figure 7: Time series of AWAP data: Surface Runoff, for location lat: -42.61, lon:147.39

> *Surface runoff (FWRun) is given by a step function: all precipitation runs off when the upper-layer soil is saturated, and there is no runoff otherwise.*

As shown in Figure 8, by comparing the rainfall data, as indicated by the blue line, and the surface runoff data, as indicated by the red line, we can confirm that the above statement is correct, because the spikes of surface runoff only occur where there are continuously heavier rainfalls. That is, surface water runoff occur only when the soil moisture is in saturation status due to heavy and continuous precipitation.

Figure 9 shows the deep drainage data of this location. By observing the curve itself, there is not any linear or chronological pattern apparent in the data. Nevertheless, according to the AWAP datasheet:

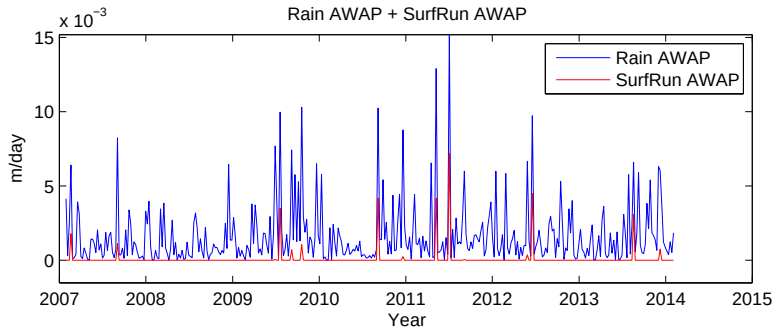


Figure 8: Time series of AWAP data: Rainfall and Surface Runoff, for location lat: -42.61, lon:147.39

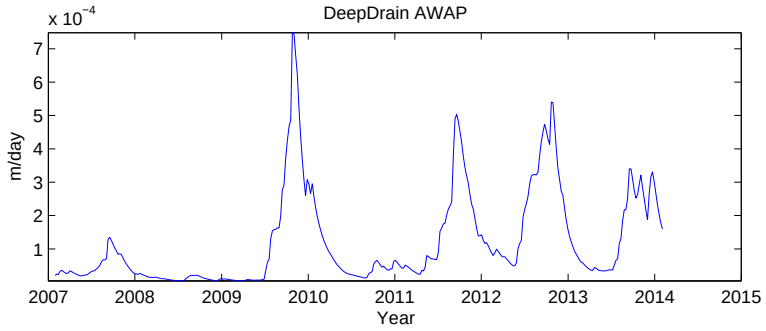


Figure 9: Time series of AWAP data: Deep Drainage, for location lat: -42.61, lon:147.39

Leaching (F_{WLch}) or drainage downward out of soil layer i is given by

$$F_{WLch\ i} = K_{Si} w_i^{\gamma} \tag{3}$$

Where γ is an exponent specifying the response of drainage to relative soil water w_i, and K_{Si} [m/day] is the saturated hydraulic conductivity of soil layer i.

Figure 10 plots the soil moisture of low level and normalized deep drainage on the same figure. The data are normalized against the minimum and maximum so that both data scale from 0 to 1. There is an apparent direct correlation between the two meteorological attributes of the point of interest, which confirms the relationship defined in Equation 3. This means that deep drainage occur if the lower level of soil moisture is saturated.

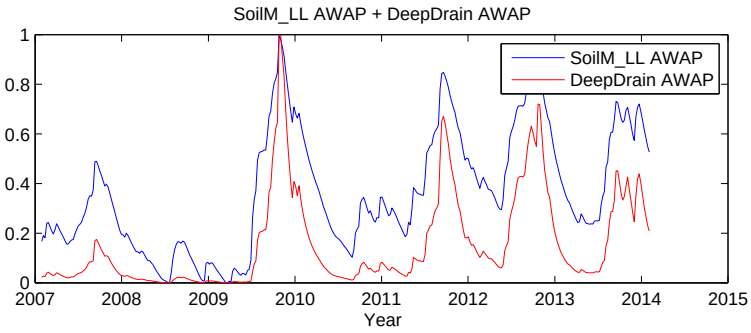


Figure 10: Time series of normalized AWAP data: Deep Drainage and Soil Moisture of low level, for location lat: -42.61, lon:147.39

2.4.2 *Implementing water balance model*

In this thesis, a water balance model is implemented from the equation

$$\Delta\langle S\rangle = \langle P\rangle - \langle ET\rangle - \langle Q\rangle - \langle R\rangle \tag{4}$$

Where
$\Delta\langle S\rangle$ is the change in spatially averaged catchment water storage, which ideally is zero when there is perfect balanced influx and efflux of the system.
$\langle P\rangle$ is the spatially averaged precipitation, acquired from AWAP rainfall data, represented by the variable *{rain AWAP}* in the integrated data source.
$\langle ET\rangle$ is the spatially averaged catchment evapotranspiration, acquired by adding two variables from AWAP, evapotranspiration of soil and vegetation & open water evapotranspiration, represented in the integrated data source as *{Evap(soil+veg)AWAP + OpenWaEvap AWAP}*.
$\langle Q\rangle$ is the spatially averaged catchment surface runoff, acquired from AWAP surface runoff data, represented by the variable *{SurfRun AWAP}*.
$\langle R\rangle$ is the spatially averaged catchment recharge, acquired from AWAP deep drainage data, represented by the variable *{DeepDrain AWAP}*, while sub-surface flow is considered zero.

Figure 11 plots the calculated water balance index for the given location from year 2007 to 2014, using Equation 4. For this point of interest, the water balance index fluctuates around the zero line, which means during the time when there is rainfall, the water balance is at higher level, and vice versa.

The histogram of the water balance index data is plotted with 50 bars,

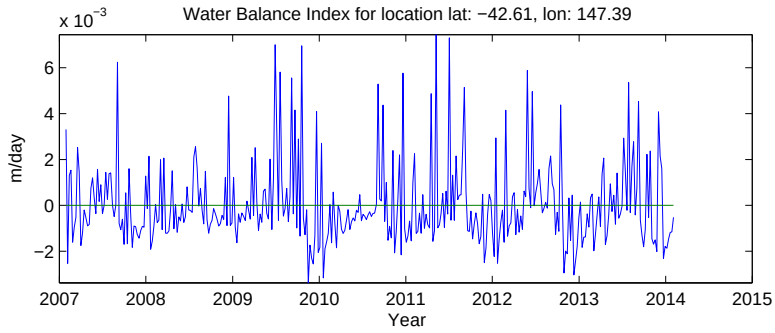


Figure 11: Time series of calculated water balance index from AWAP data, for location lat: -42.61 lon:147.39

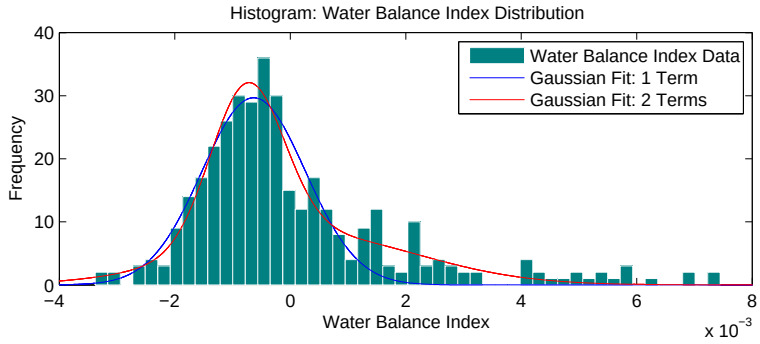


Figure 12: Histogram of calculated water balance index with fitted Gaussian Distribution

as shown in Figure 12. Two Gaussian distributions are generated to fit the data, both one term and two terms fittings, the parameters are given below.

Explain the physical meaning of having normally distributed water balance indices.

$$f(x) = a_1 * e^{-((x-b_1)/c_1)^2)} \tag{5}$$

$$g(x) = a_2 * e^{-((x-b_2)/c_2)^2)} + a_3 * e^{-((x-b_2)/c_2)^2)} \tag{6}$$

Where the coefficients (with 95% confidence bounds) are:
$a_1 = 29.68\ (26.58, 32.78)$
$b_1 = -0.0006337\ (-0.0007418, -0.0005256)$
$c_1 = 0.001269\ (0.001116, 0.001422)$
$a_2 = 25.25\ (20.61, 29.89)$
$b_2 = -0.0007439\ (-0.0008451, -0.0006426)$
$c_2 = 0.0008972\ (0.000711, 0.001083)$
$a_3 = 7.916\ (4.042, 11.79)$
$b_3 = 0.0003042\ (-0.00053, 0.001138)$
$c_3 = 0.002693\ (0.001877, 0.00351)$

From the Gaussian distribution fittings in Figure 12, the data generally is normally distributed while slightly skewed to the right.

3 DATA INTEGRATION

3.1 THE DATASETS

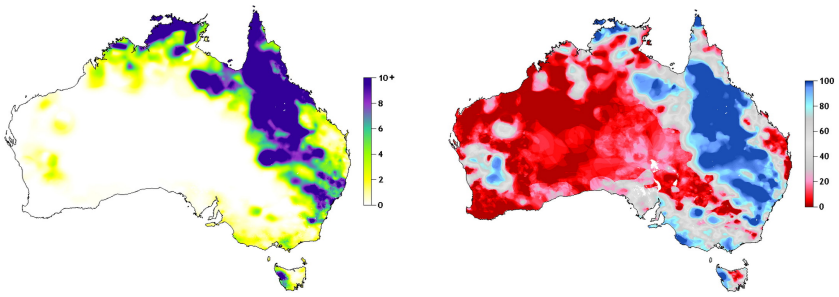
3.1.1 *Australian Water Availability Project*

As mentioned in Section 2.4.1 Data availability, the Australian Water Availability Project (AWAP) is a joint effort contributed by CSIRO Marine and Atmospheric Research (CMAR), the Bureau of Meteorology (BoM) and the Bureau of Rural Science (BRS)[9].

The AWAP aims to contribute to the overall understanding and monitoring of the Australian landscape systems, particularly the changes and feedback in climate, so that proper and robust management can be applied on a system-scale. It monitors the state and trend of the terrestrial water balance of the Australian continent.

The approach it takes is based on model-data fusion, which is combining information from both the models and the data to maximise knowledge about the system. It contains historic and up-to-date data of soil moisture and all water influx and efflux contributing to changes in soil moisture (rainfall, transpiration, soil evaporation, surface runoff and deep drainage etc.), across Australia at a spatial resolution of 5 km.

The AWAP data is available for access through a web interface, it provides three forms: (1) weekly near-real-time reporting, (2) historical monthly time series (1900 to present), and (3) monthly climatologies.



(a) Precipitaion[mm/d] (b) Percent Rank Precipitaion[%]

Figure 13: Example of AWAP weekly near-real-time data. Date: 2014/02/17 to 2014/02/23. Acquired from CSIRO[4].

Figure 13 shows an example of AWAP weekly data acquired from the web interface hosted by CSIRO. The example displays the precipitaion data in both physical values(Figure 13a) and percentage rank(Figure 13b) of the week from 2014/02/17 to 2014/02/23 on the Australian territories.

3.1.2 *CosmOz: Australian National Cosmic Ray Soil Moisture Monitoring Facility*

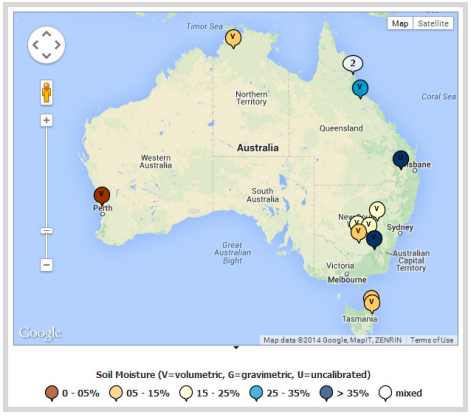
The Australian National Cosmic Ray Soil Moisture Monitoring Facility(CosmOz) is a near-real-time soil moisture measurement network provided by CSIRO, Monash University, Charles Darwin University and the University of New South Wales[12]. it aims to test the utility of cosmic ray sensor system for water management, water information and hydrological process research applications, as well as to test the feasibility and utility of a national near-real time soil moisture measurement network. CosmOz also supports the evaluation of remote sensing products and hydrological models by expanding the set of soil moisture data available over Australia.

CosmOz currently has deployed 13 sensor systems at 12 locations across Australia, shown in Figure 14a. Each CosmOz sensor system includes: 1* Hydroinnova CRS-1000 cosmic ray soil moisture sensor, 1* Hydrological Services tipping-bucket rain gauge, 3* Campbell TDR soil moisture probes and Quaesta data logger with integrated Iridium SBS satellite data communications.

3.1.3 *Landsat program*

The Landsat program is a joint effort of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA). The lantsat satellites have continuously acquired and delivered images of the Earth's land surface since 1972[**?**]. The Landsat satellites have provided a valuable archive of space-based land remotely sensed data, contributed greatly in the studies of agriculture, geology, forestry, education, region planning, mapping and global change research.

Landsat 8 is the eighth and the latest Landsat satellite, launched on 11 February 2013. Table 1 details the eight Landsat satellites in terms of launch/decommission time, operation status and the sensors on-board respectively. In the "Sensors" column, Landsat 1,2,3 carries Multispectral Scanner (MSS) and Return Beam Vidicon Camera (RBV), Landsat 4,5 carries MSS and Thematic Mapper (TM), Landsat 6 carries Enhanced Thematic Mapper (ETM), Landsat 7 carries Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 carries Op-



(a) Location of the 12 CosmOz monitoring sites. Acquired from University of Arizona[13]

(b) CosmOz system installed at Tullochgorum in Tasmania. Reprinted from "CosmOz Wiki Page", by Thew et al., 2013. Copyright 2013 by Thew et al..

Figure 14: The Australian National Cosmic Ray Soil Moisture Monitoring Facility(CosmOz) and one of its probes deployed in Tullochgorum site.

erational Land Imager (OLI) and Thermal Infrared Sensor (TIRS).

Satellite	Launch	Decommissioned	Sensors
Landsat 1	23 July 1973	6 January 1978	MSS/RBV
Landsat 2	22 January 1975	27 July 1983	MSS/RBV
Landsat 3	5 March 1978	7 Septermber 1983	MSS/RBV
Landsat 4	16 July 1982	15 July 2001	MSS/TM
Landsat 5	1 March 1984	2013	MSS/TM
Landsat 6	5 October 1993	Did not achieve orbit	ETM
Landsat 7	15 April 1999	Operational	ETM+
Landsat 8	11 February 2013	Operational	OLI/TIRS

Table 1: Details of Landsat missions. Adapted from "Landsat: A Global Land-Imaging Mission", by USGS, 2013. Copyright 2013 by USGS.

It is noteworthy that both Landsat 6 and Landsat 7 suffered from operational failures. Landsat 6 did not achieve its target orbit during launching procedure, thus it was officially declared as a failure by the National Oceanic and Atmospheric Administration (NOAA)[**?**]. Landsat 7 experienced a failure in its Scan Line Corrector (SLC) mechanism, which resulted in wedge-shaped scan-to-scan gaps. As shown

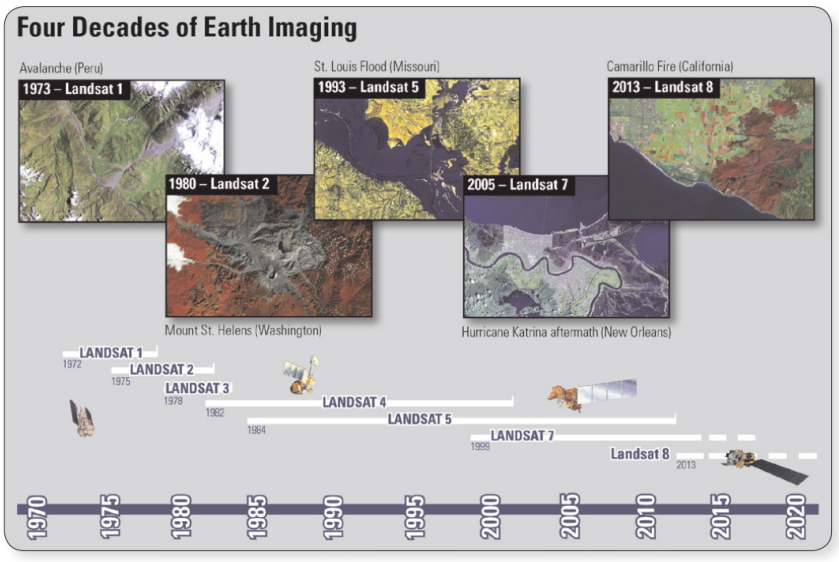
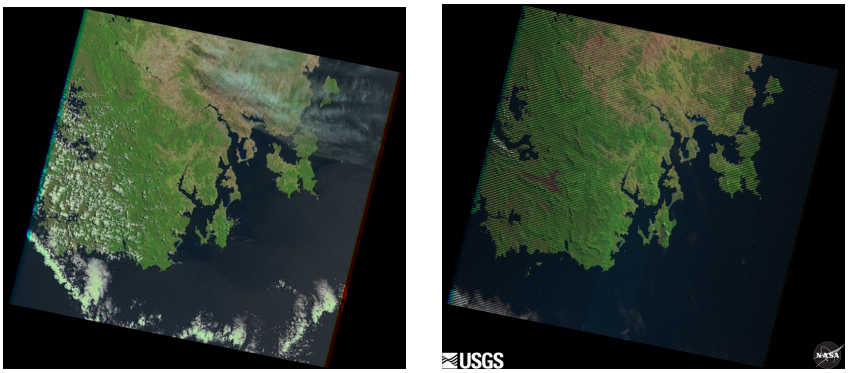


Figure 15: Overview of the Landsat program. Reprinted from "Landsat: A Global Land-Imaging Mission", by USGS, 2013. Copyright 2013 by USGS.

in Figure 16b comparing to Figure 16a, there are blank gaps on the image where data is not available.



(a) Landsat 7 Natural Color Image with SLC-ON. Captured on 9 January 2003.

(b) Landsat 7 Natural Color Image with SLC-OFF (with gaps). Captured on 25 March 2007.

Figure 16: Landsat 7 ETM+ images of the Tasmania south-eastern area captured before and after the SLC failure. Acquired from USGS.

3.1.4 *Moderate-resolution Imaging Spectroradiometer*

3.1.5 *National Elevation Data Framework*

3.1.6 *SILO*

Part III

APPENDIX

A

APPENDIX TEST

Aliquam lectus. Vivamus leo. Quisque ornare tellus ullamcorper nulla. Mauris porttitor pharetra tortor. Sed fringilla justo sed mauris. Mauris tellus. Sed non leo. Nullam elementum, magna in cursus sodales, augue est scelerisque sapien, venenatis congue nulla arcu et pede. Ut suscipit enim vel sapien. Donec congue. Maecenas urna mi, suscipit in, placerat ut, vestibulum ut, massa. Fusce ultrices nulla et nisl.

Etiam ac leo a risus tristique nonummy. Donec dignissim tincidunt nulla. Vestibulum rhoncus molestie odio. Sed lobortis, justo et pretium lobortis, mauris turpis condimentum augue, nec ultricies nibh arcu pretium enim. Nunc purus neque, placerat id, imperdiet sed, pellentesque nec, nisl. Vestibulum imperdiet neque non sem accumsan laoreet. In hac habitasse platea dictumst. Etiam condimentum facilisis libero. Suspendisse in elit quis nisl aliquam dapibus. Pellentesque auctor sapien. Sed egestas sapien nec lectus. Pellentesque vel dui vel neque bibendum viverra. Aliquam porttitor nisl nec pede. Proin mattis libero vel turpis. Donec rutrum mauris et libero. Proin euismod porta felis. Nam lobortis, metus quis elementum commodo, nunc lectus elementum mauris, eget vulputate ligula tellus eu neque. Vivamus eu dolor.

A.1 APPENDIX SECTION TEST

Nulla in ipsum. Praesent eros nulla, congue vitae, euismod ut, commodo a, wisi. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Aenean nonummy magna non leo. Sed felis erat, ullamcorper in, dictum non, ultricies ut, lectus. Proin vel arcu a odio lobortis euismod. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Proin ut est. Aliquam odio. Pellentesque massa turpis, cursus eu, euismod nec, tempor congue, nulla. Duis viverra gravida mauris. Cras tincidunt. Curabitur eros ligula, varius ut, pulvinar in, cursus faucibus, augue.

More dummy text

Nulla mattis luctus nulla. Duis commodo velit at leo. Aliquam vulputate magna et leo. Nam vestibulum ullamcorper leo. Vestibulum condimentum rutrum mauris. Donec id mauris. Morbi molestie justo et pede. Vivamus eget turpis sed nisl cursus tempor. Curabitur mollis sapien condimentum nunc. In wisi nisl, malesuada at, dignissim sit amet, lobortis in, odio. Aenean consequat arcu a ante. Pellentesque porta elit sit amet orci. Etiam at turpis nec elit ultricies imperdiet. Nulla facilisi. In hac habitasse platea dictumst. Suspendisse

LABITUR BONORUM PRI NO	QUE VISTA	HUMAN
fastidii ea ius	germano	demonstratea
suscipit instructior	titulo	personas
quaestio philosophia	facto	demonstrated

Table 2: Autem usu id.

Listing 1: A floating example

```
for i:=maxint to 0 do
begin
{ do nothing }
end;
```

viverra aliquam risus. Nullam pede justo, molestie nonummy, scelerisque eu, facilisis vel, arcu.

A.2 ANOTHER APPENDIX SECTION TEST

Curabitur tellus magna, porttitor a, commodo a, commodo in, tortor. Donec interdum. Praesent scelerisque. Maecenas posuere sodales odio. Vivamus metus lacus, varius quis, imperdiet quis, rhoncus a, turpis. Etiam ligula arcu, elementum a, venenatis quis, sollicitudin sed, metus. Donec nunc pede, tincidunt in, venenatis vitae, faucibus vel, nibh. Pellentesque wisi. Nullam malesuada. Morbi ut tellus ut pede tincidunt porta. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam congue neque id dolor.

Donec et nisl at wisi luctus bibendum. Nam interdum tellus ac libero. Sed sem justo, laoreet vitae, fringilla at, adipiscing ut, nibh. Maecenas non sem quis tortor eleifend fermentum. Etiam id tortor ac mauris porta vulputate. Integer porta neque vitae massa. Maecenas tempus libero a libero posuere dictum. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Aenean quis mauris sed elit commodo placerat. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Vivamus rhoncus tincidunt libero. Etiam elementum pretium justo. Vivamus est. Morbi a tellus eget pede tristique commodo. Nulla nisl. Vestibulum sed nisl eu sapien cursus rutrum.

BIBLIOGRAPHY

[1] Lu Zhang, GR Walker, and WR Dawes. Water balance modelling: concepts and applications. *ACIAR MONOGRAPH SERIES*, (84):31–47, 2002. URL http://www.researchgate.net/publication/228947764_Water_balance_modelling_concepts_and_applications/file/d912f51258ba62592b.pdf.

[2] P.R Leopoldo, Franken.W, and E Salati. *Acta amazonica*. 1982. URL http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Acta+Amazonica#3.

[3] E Salati and PB Vose. Amazon basin: a system in equilibrium. *Science*, 225(4658):129–138, 1984. URL http://www.biology.ufl.edu/COURSES/pcb5356/2010Spring/Kitajima/SalatiVose84.pdf.

[4] CSIRO. AWAP 2007-present weekly series, 2014. URL http://www.csiro.au/awap/cgi/awap2.pl.

[5] JM Kirby and A Van Dijk. balance accounts across the Murray-Darling Basin, 1990-2006. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields. Technical report, 2008. URL http://www.csiro.co.uk/files/files/pnq6.pdf.

[6] Ying Ma, Shaoyuan Feng, and Xianfang Song. A root zone model for estimating soil water balance and crop yield responses to deficit irrigation in the North China Plain. *Agricultural Water Management*, 127:13–24, September 2013. ISSN 03783774. doi: 10.1016/j.agwat.2013.05.011. URL http://linkinghub.elsevier.com/retrieve/pii/S0378377413001303.

[7] G.R. Walker and L. Zhang. *Plot-scale models and their application to recharge studies*. CSIRO Publishing., Melbourne, 2001.

[8] PR Leopoldo, WK Franken, and NA Villa Nova. Real evapotranspiration and transpiration through a tropical rain forest in central Amazonia as estimated by the water balance method. *Forest Ecology and . . .*, 73, 1995. URL http://www.sciencedirect.com/science/article/pii/037811279403487H.

[9] M R Raupach, P R Briggs, V Haverd, E A King, M Paget, and C M Trudinger. *Australian Water Availability Project (AWAP): CSIRO Marine and Atmospheric Research Component : Final Report for Phase 3*. Number 013. 2009. ISBN 9781921605314.

[10] Google Maps. Tasmania, Australia. Latitude: -42.61 , Longitude: 147.39, 2014. URL https://www.google.com.au/maps/place/42%C2%B036'36.0%22S+147%C2%B023'24.0%22E/@-42.6200899,147.3998392,10892m/data=!3m1!1e3!4m2!3m1!1s0x0:0x0.

[11] Australian Bureau of Meteorology. Tasmania in 2013: a hot start, then wet and windy. Technical report, Australian Bureau of Meteorology, 2014.

[12] Peter Thew, David McJannet, Ryan Meintjes, Andrew Terhorst, and Aaron Hawdon. CosmOz Wiki page, 2014. URL https://wiki.csiro.au/display/cosmoz/Home.

[13] University of Arizona. Location of CosmOz Probes, 2014. URL http://cosmos.hwr.arizona.edu/Probes/australia.php.

COLOPHON

This document was typeset using the typographical look-and-feel `classicthesis` developed by André Miede. The style was inspired by Robert Bringhurst's seminal book on typography "*The Elements of Typographic Style*". `classicthesis` is available for both LaTeX and LyX:

http://code.google.com/p/classicthesis/

Happy users of `classicthesis` usually send a real postcard to the author, a collection of postcards received so far is featured here:

http://postcards.miede.de/

DECLARATION

Put your declaration here.

Canberra, March 2014

Cecil Li, March 23, 2014