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Contents

From the editors' desk

The route ahead

You are now reading the second issue of the UV4Plants Bulletin. Which we hope you will find entertaining and useful reading. In this issue, we have both offered and invited contributions, plus the regular *letter from the president* as content. One article by Paul Barnes remembers Ron Ryel who paused away last year. Matt Robson interviewed Steve Flint who has been involved on the study of plant responses to UV-B since well before the ozone hole was first described. An article from Brian Jordan and collaborators describes ongoing research on the flavonoid metabolism and its regulation in the primitive plant marchantia. Sari Siipola and myself, review books, which although not related to UV radiation are in my opinion 'must reads' for anybody who makes decisions in the broadest sense and are interested to know what makes for a successful career. I give my viewpoint in an article explaining why measuring UV-B radiation is difficult, and I continue describing and exemplifying the use of the suite of R packages that I am developing to easy photobiological calculations. In this issue, I describe calculations related to photoperiod and sun position. The regular *letter from president* highlights some recent advances in the study of the possible involvement of UV radiation in plant-insect interactions. Marcel Jansen's letter highlights a new proposed role for UV radiation in plant-animal interactions.

Because of recent events at my university I have been spending time thinking about how management decisions and evaluation criteria affect the kind of research we can 'safely' do, or we can expect to be awarded funding for pursuing, as Marcel hints at in his letter. A recent blog post by Charles Krebs titled *The Volkswagen Syndrome and Ecological Science* (Krebs 2015) discusses this problem from the perspective of Ecology, using a viewpoint I can easily relate to. Charles Krebs highlights in his blog post the tension that exists between doing research in simplified and consequently artificial contexts and doing research in the complexity of real natural systems. This tension reflects into how research and researchers are evaluated and funding made available. Time is at the core: how fast are results and publications expected, for how long a period grants are awarded, and is there an expectation of short-term impact of those publications.

My own view is that there is a place for model systems and model organisms in research, but the danger is in forgetting that those models are a step in a long route towards understanding the complexity of natural and agricultural systems. Even though at the molecular level there may be strong similarities between 'components' among plant species, differences in the regulation, both by internal and external cues and signals, makes each plant species, accession or even cultivar different from the point of view of its ecology. Selling studies on model systems and model organisms as what will save mankind from starvation, or some other future disaster, is damaging because the most difficult, slow, and costly part of research *that leads to actual applications in plant production* is that done to study the complexity of realistically complex systems. The study of model systems is a prerequisite for many real-world studies, but the most effective path to real progress in solving societal problems is collaboration and cross-fertilization of ideas across different research approaches and philosophies. I hope the Bulletin as part of the UV4Plants Association will help all of us to reach out and work together with those working outside the boundaries of the level of organization at which each of us is most comfortable.

The *niche* that the Bulletin will occupy in the publishing arena depends both on our editorial aims and on the manuscript submissions we receive. Even if we do not want the scope to overlap with that of well established scientific journals, there is still room for very different types of articles. The contents of the present issue have a different focus to those of the first issue, simply because the manuscripts submitted were different. The future direction of the Bulletin is very much in the hands of our members and others willing to submit articles. Several of the pieces in this issue are good examples of articles that could be useful in building our UV4Plants community: two researcher profiles and the presentation of an ongoing project by a research group willing to develop new collaborations. As I mentioned in the first issue, we wish to encourage our members and outside contributors to be imaginative and broad-minded with the manuscripts they submit to the UV4Plants Bulletin. In addition the submission of illustrations to be used on the cover are very welcome, either accompanying manuscripts or on their own.

Any type of constructive feedback and suggestions are (please contact directly any of editors). We aim at publishing the next issue, 2016:2, in the Autumn. The deadline for manuscript submissions for next issue is approximately the end of August. Some later submissions will make it into this issue but others may need to wait for the following issue.

Pedro J. Aphalo (editor)
Helsinki, May 2016.

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Letter from the President
Here Comes the Sun!

Marcel Jansen, ORCID: 0000-0003-2014-5859
School of Biological, Earth and Environmental Sciences, UCC, Cork, Ireland

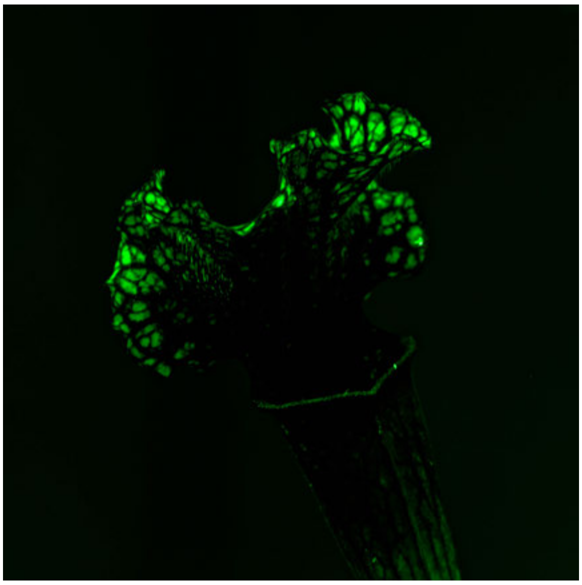

Figure 2.1: Green fluorescence under UVA excitation in *Sarracenia* sp. Photograph: Pedro J. Aphalo.

Those of us who are of a certain age will be familiar with the lyrics of "Here Comes the Sun", written by George Harrison. The song was released as part of the 1969 Beatles album Abbey Road. For those of us based at higher latitudes, the spirit of "Here Comes the Sun" also captures the annual joy of getting some decent sunlight following the dark, gloomy winter days. However, as scientists we have to be a little more critical about the rest of the lyrics, which go like "Here comes the sun, and I say, It's all right". Focusing on plants, and leaving aside aspects such as excess photosynthetic radiation, far-red and infra-red wavelengths, and UV-A, the question whether UV-B is "all right" is a rather vexing one.

Plenty of papers have discussed in detail the question whether UV-B is a stressor and/or a specific regulator. What is surprising about many of these discussion papers is their rather limited focus, i.e. these studies relate to work on *Arabidopsis thaliana*, as well as a small number of other ecologically and/or commercially relevant species, typically only considering vegetative growth. In reality, it is likely that the role of UV-B and UV-A wavelengths in natural ecosystems is highly complex.

Let's look at a real life scenario. Substantial numbers of carnivorous plants display strong emissions of blue fluorescence following excitation with UV-wavelengths (366 nm). Fluorescence is particularly strong at the capture spots (for example the rim of the beaker-structure of *Nepenthes* sp.) and has been associated with enhanced capture of, amongst others, various arthropod species (Kurup et al. 2013). Plant structures emitting UV-induced fluorescence are, of course, only half the story, as the spectral sensitivity of vision by the prey also needs to be considered. This example highlights the rather exquisite role that UV-wavelengths (and therefore sunlight) can potentially play in real life ecosystems. Quite rightly, readers might argue that prey capture by carnivorous plants might not top the agenda at many funding bodies. This is correct, but (1) this is a fun subject, and (2) once we start considering the role of UV-radiation in attracting insect pollinators (Llorens et al. 2015), we are touching on a very important process for ecology, horticulture, and for feeding the world. I am not sure whether I have convinced you, but I have just ordered a collection of carnivorous plants to play around with this summer…!

When you read this editorial the first major UV4Plants conference plus training school, will be about to start. I hope you will enjoy the meeting, and all of us in the UV4Plants management team would like to hear your feedback on the meeting, and on future activities to be organised by the association.

Happy Reading!

Marcel
(Marcel A. K. Jansen
President UV4Plants)

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News

Links of UV4Plants to other organizations

The Global Plant Council's web editor is now subscribed to our blog and web site updates and will republish, as she did with the announcement of our conference, any news of general interest to plant scientists in the site at http://globalplantcouncil.org/. The Global Plant Council is an umbrella organization for scientific societies on research related to plants.

The European Society of Photobiology (http://photobiology.eu/) awarded grants allowing three young researchers to participate in our conference and training school. The Society for Experimental Biology (http://www.sebiology.org/) awarded a grant to one participant. We thank ESP and SEB for supporting our meeting.

Distinctions

Professor Lars Olof Björn was named honorary citizen of Guangzhou. In the photograph he is accompanied by his wife Dr. Gunvor Björn and his hosts in China. After retiring from the professorship he held at Lund University, he became professor at the School of Life Science of South China Normal University, in Guangzhou, China.

We very warmly congratulate Lars Olof for this honor and for his 80th birthday!

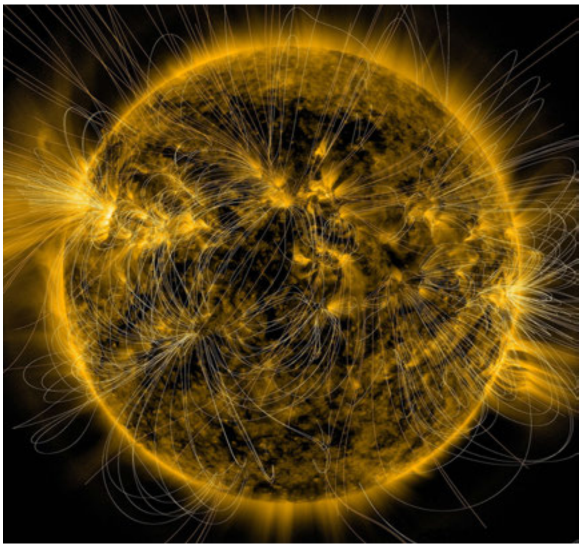

Figure 3.1: Found on the internet. This illustration lays a depiction of the sun's magnetic fields over an image captured by NASA's Solar Dynamics Observatory at 17.1 nm on March 12, 2016. NASA has posted images of the Sun registered in very short UV wavelengths of 17 to 20 nm. We reproduce here one example from NASA's account in Flickr. Credits: NASA/SDO/AIA/LMSAL. Licenced under CC BY 2.0. Source: https://flic.kr/p/ESwamb

Submit your institutional or other news bits to the editor to have them appear in this section of the Bulletin. They will be published at the discretion of the editors, and submitters should remember the publishing schedule of two issues per year, in Spring and Autumn.

Research Profiles

Contributions of Ron Ryel to plant UV research

Paul W. Barnes, ORCID: 0000-0002-5715-3679
Department of Biological Sciences and Environment Program, Loyola University New Orleans, New Orleans, Louisiana 70118, USA

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Figure 4.1: Ron Ryel taking epidermal transmittance measurements with an UV-A PAM instrument in 2007.

It is with great sadness that I report the passing of Ronald J. Ryel who died on 20 October 2015 from complications arising from pancreatic cancer. Ron was a close friend and valued colleague who made a number of significant contributions to ecology, natural resource management and our understanding of the ecophysiological effects of UV radiation on plants. He was born in West Branch, Michigan in 1955 and spent much of his youth outdoors in central Michigan along side his father who was a wildlife biologist. Ron was a skilled modeler and quantitative ecologist who had broad and diverse interests. He earned a B.S. in Environmental Science from Michigan State University, a M.S. in Wildlife Ecology from Utah State University and a Ph.D. in Plant Physiological Ecology from the University of Würzburg. Ron spent 20 years as an Environmental Consultant in Logan, Utah and was a guest scientist at several universities in Germany. During this time he worked closely with Wolfram Beyschlag (Bielefeld University), Martyn Caldwell (USU) and their students on several field projects utilizing canopy models to study canopy architecture and plant-plant interactions (e.g. Beyschlag and Ryel 1999; Ryel et al. 1993; Werner et al. 2001). He joined the USU faculty in 2002 where he mentored a number of students and postdocs on various basic and applied research projects ranging from soil moisture, carbon and nitrogen relations in Great Basin plant communities, the causes and ecological consequences of aspen (*Populus tremuloides*) decline in western North American forests, and the effects of UV radiation on plants (e.g. Flint and Caldwell 2003; LaMalfa and Ryle 2008; Ryel et al. 2003, 2010, 2008). While on the faculty at USU Ron was awarded a Fulbright Scholarship with the Instituto Superior de Agronomia in Lisbon, Portugal where he studied soil water dynamics and shrub encroachment in Portugal's cork oak (*Quercus suber*) woodlands as part of a broader effort to preserve these iconic forests.

Ron's contributions to our understanding of plant and ecosystem responses to UV radiation were similarly broad and diverse. His initial involvement in UV research came in 1986, when he joined a research team at USU led by Martyn Caldwell that included Wolfram Beyschlag, Stephan Flint and myself on a project examining the effects of enhanced UV-B radiation on plant competition. Ron modified an existing single-species canopy radiation and photosynthesis model to accommodate multiple species and through these efforts showed that subtle UV-induced

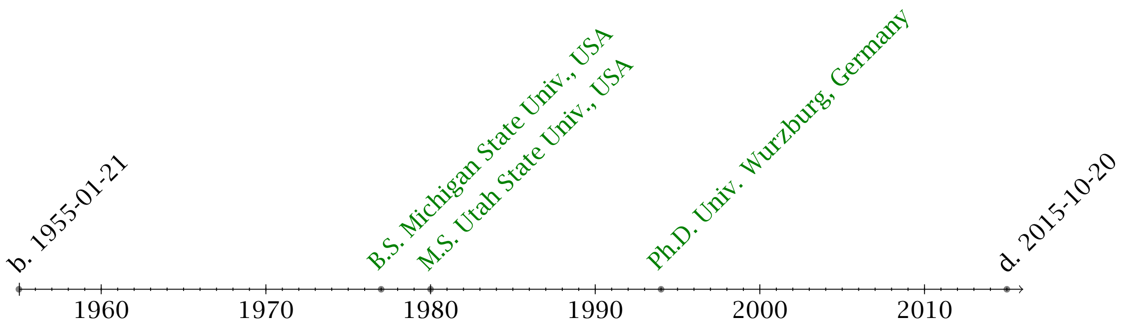

Figure 4.2: Time line for Ron Ryel's education.

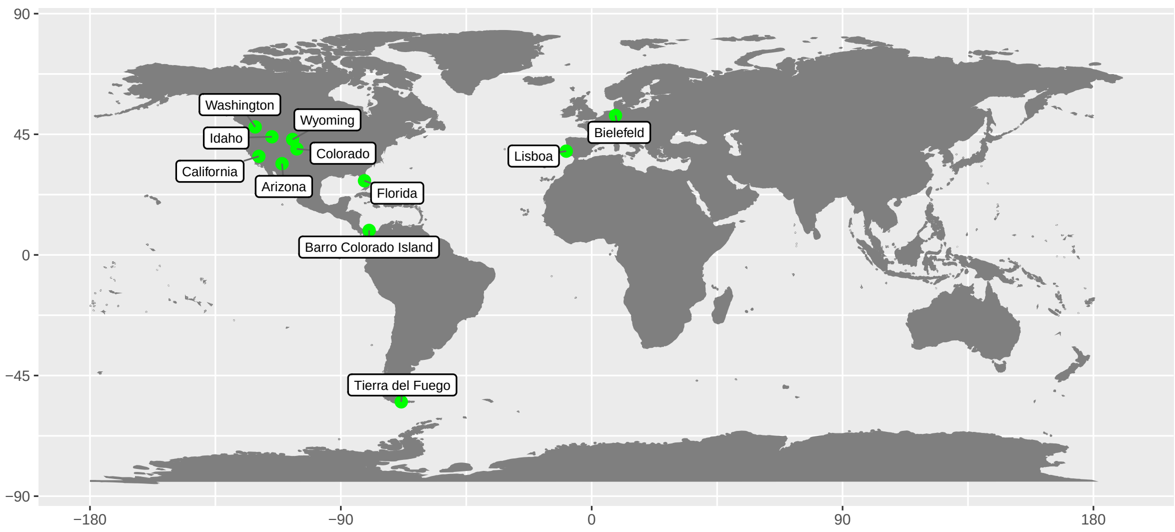

Figure 4.3: Sites where Ron Ryel has done research.

photomorphogenic alterations in shoot morphology could have significant consequences for light interception and canopy photosynthesis of plants when growing in mixed-species stands (P. Barnes et al. 1990; P. W. Barnes et al. 2005; Beyschlag et al. 1990; Ryel et al. 1990). Later, Ron collaborated with Martyn Caldwell, Peter Searles, Carlos Ballaré and myself to explore the utility of chlorophyll fluorescence as a non-invasive probe of epidermal UV-transmittance. Initial studies were conducted using the less-than field portable XE-PAM fluorometer on plants in Argentina (P. W. Barnes et al. 2000). This interest led to studies using the smaller, more portable UVA-PAM fluorometer to examine UV-protection in native and exotic plants along an elevation gradient in Hawaii. It was during these measurements that Ron observed that the UV-shielding in the study plants seemed to differ from morning to midday. This discovery led to the documentation that several plants in the Hawaiian alpine were indeed capable of diurnal changes in epidermal UV transmittance (P. W. Barnes et al. 2008). Subsequent studies have now demonstrated that these rapid adjustments in UV-sunscreen protection are widespread among plants and are not restricted to those growing in high UV environments (Barnes, Flint, et al. 2016; Barnes, Tobler, et al. 2016).

Ron was enthusiastic and passionate about his research but he was also an avid birder, a competitive runner and table tennis player, a skier, hiker, biker and river rafter. He had a special gift for interacting with people from all walks of life and continually sought to relate his research to broader questions of natural resource management, ecological theory and global and regional environmental problems. We remember Ron not only for his numerous scientific accomplishments but also his love of the outdoors, his adventuresome spirit and his courage and optimism as he battled his disease. The *Ronald J. Ryel Natural Resource Conservancy Scholarship* was established in 2014 at Utah State University to provide educational support for students who intend to become natural resource professionals in an agency or non-governmental organization (https://qcnr.usu.edu/scholarships/ron_ryel).

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Edited by: P. J. Aphalo and T. M. Robson.

Research Profiles
Interview with Steve Flint

T. Matthew Robson, ORCID: 0000-0002-8631-796X
ViPS, Department of Biosciences, University of Helsinki, Helsinki, Finland

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Introduction

I interviewed Steve Flint about his career as a researcher. Steve has participated in many of those studies in plant UV research that have laid the foundations for the development of the field. He has been a contributor to the UNEP panel assessing the environmental effects of ozone depletion and its interactions with climate change, and worked with Martyn Caldwell on action spectra since the 1970's: to the present day he participates in field experiments all over the world, recently with Ron Ryel and Paul Barnes investigating diurnal patterns in UV-absorbing compounds.

I know Steve from our time together working with Martyn Caldwell at Utah State University, where Steve generously allowed me to invade his lab while writing up my dissertation! Steve is amongst the shrewdest and most passionate scientists whom I have meet, with a staggering depth of knowledge of UV research and an eye for detail allows him to set up impressive and innovative experiments.

Questions and answers

Q How did you get started in research?

A I didn't have opportunities for undergraduate research, probably both because this was less common in the early '70s and I was at a smaller school that was less research oriented. One different thing that I did was take a couple of summer classes at a bigger institution (University of Washington in Seattle) between Junior and Senior years. (In the US, university tuition is particularly expensive if you are not a resident of that state. But summer is different—usually the out-of-state tuition is not charged. So as a Californian I attended the University of Washington that summer at resident rates.) That summer, plant ecology captured my interest more than freshwater invertebrates. We had a supplemental reading list, and the physiological ecology articles intrigued me. Instrumentation was much simpler – for example people measuring transpiration could publish comparative work where they never calculated absolute values, just the relative instrument responses.

Q And what about UV research? When did that first come on the scene?

A After finishing my MS (seed germination and weed ecology) I found temporary work for about 14 months in a poisonous plants lab. Then Martyn Caldwell had a postdoc that moved away, and I was in the right place at the right time to start working for him as a technician in '79. My initial work was treating germinating pollen with UV. Never expected the work in Utah to last for over 27 years—when Martyn retired, I continued doing the same work with Ron Ryel. I've been gone from Utah for almost 10 years now and still have things to write up!

Q Why did people think to start studying UV radiation? What were the expectations of its effect then?

A When Martyn began his field work on UV effects in the '60s, people knew that UV was more intense in the Alpine since mountain climbers experienced problems with sunburn. However, little work had been done with plants in the field. Laboratory work done in those days was not very helpful as the lamps that were used produced shortwave UV not found in sunlight. Ozone depletion was not an impetus for research till the

Figure 5.1: Steve Flint on Mauna Kea in 2005 during the measurement campaign when diurnal changes in epidermal UV transmittance first came to light—see Barnes et al. (2008). Photo kindly provided by Paul W. Barnes.

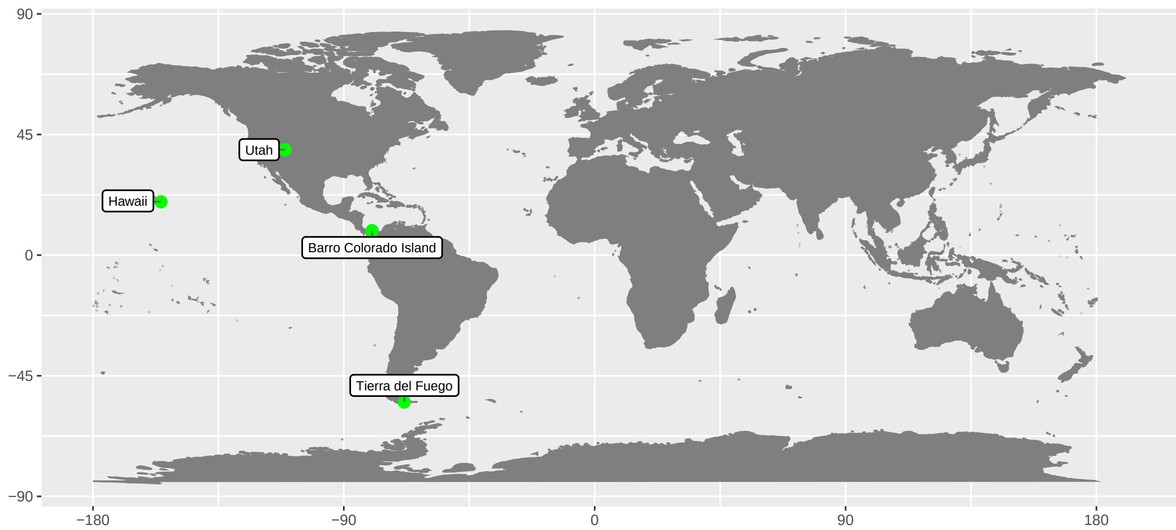

Figure 5.2: Sites where Steve D. Flint has done research.

'70s, and the ozone hole was not discovered till the '80s.

Q When the ozone hole was discovered did you (& others) already have an idea about how much / little effect this change in UV irradiance might have on plants?

A We already had suspicions that the effects would be fairly subtle. It is ironic to look back on this now and realize the major ozone hole effects are not UV related but are caused by changes in Southern Hemisphere wind patterns! (See Robinson and Erickson 2015)

Q You've worked in lots of exotic places! Where did you most enjoy doing field research?

A Tierra del Fuego. Waking up and seeing the wind howling from the west whipping up waves in the Beagle Channel almost every morning, and realizing Darwin's awkward square-rigged ship had to sail into it, made our problems keeping the filters intact seem fairly trivial.

Q What was it like doing field research with Martyn Caldwell?

A In the early days before I got to Logan the Desert Biome (International Biological Program) was funding a lot of people and USU had research in the cold desert—a remote site in Curlew Valley, north of the Great Salt Lake. Martyn had people doing field gas exchange, measuring root growth with root boxes, etc. and probably was in the field a lot those first few years ('68–'72). He even found time to go to the Arctic in summer of '70 and take some UV measurements. When I got to Logan (Utah) in '74 the ozone depletion issue had surfaced and I don't think he spent much time in the field after that. He typically had research going on two separate topics—UV was one and ecophysiology of cold desert plants was the other. This kept him in the office more than in the field.

Q Who was it most fun to do field work with?

A I should probably incriminate some people here…Actually, on the field projects away from Logan, I was most often involved in getting the projects set up. So I was following Martyn's lead and not getting in the field much myself!

One very different experiment occurred early in the Hawaii work with Ron Ryel. Ron had purchased a UV-A PAM for non-destructive epidermal transmittance measurements. Since this instrument was new on the market, we thought we would get a quick survey paper out before other people had a chance to do something similar. We knew that on the big island of Hawaii that mullein (*Verbascum thapsis*) grew from sea level to 13 000 feet (ca. 4 000 m). There should be a detectable gradient of epidermal transmittance as UV increased with elevation. We started with measurements at mid elevation, then went down to the coast and were shocked to see lower epidermal transmittance! We went back to the first site (we had marked the measured leaves) and the transmittances had changed. This diurnal change became the focus of several papers, and the original UV gradient epidermal measurements (from 2003 and 2004) are still not published!

Q When I was working on the Chile/Argentina border in Tierra del Fuego we had some run-ins with the border police, the *carabineros* from Chile and the *guarda parques* from Argentina. Did you ever get into scrapes with officialdom related to your field experiments?

A No run-ins come to mind, but this reminds me of an interesting story: In Panama (only a short time after Noriega was removed from office) there was occasional unrest in Panama City. People would warn us that there was chaos ahead, with burning tires etc., and suggest we take a taxi rather than the usual bus that ran through the area where the demonstrations were happening.

Q How did you and Martyn Caldwell get the idea to make an action spectrum? Tell us about the equipment you used?

A Martyn began this work during his doctoral research at Duke. Because the effectiveness of UV increased so dramatically at shorter wavelengths, it was clear that a function was needed to represent this so that "weighted UV-B" could be reported. Part of his work was experimental: irradiating leaves to quantifying epidermal tissue damage at different wavelengths. (A "home-made" monochromator was available at Duke; in the 90's it was no longer being used at Duke and we were able to move it to Logan for our action spectra work.) The second part was a literature review of existing action spectra. Together this became the "generalized plant response" in the early '70s, yet none of the spectra involved whole-plant responses of plants grown in light! This was why we continued to pursue the action spectra work.

Q What is the most difficult aspect of designing and making a good UV experiment, in your opinion?

A Selecting a proper control. Much more difficult than it would appear. In the early days people would occasionally try to compare plants under lamps with those in the open. That clearly wasn't appropriate, but this problem still surfaces once in a while. Then there was the problem of people hanging lamps at different heights. Many researchers trained in physiology do not realize how subtle differences in visible light (e.g., different shading by lamps hanging at different heights) can influence plant growth and confound an experiment. We did one experiment in Hawaii to address "global dimming", where we used an open plastic mesh (like would be used to keep birds off crops) as a source of 12% shade. For various reasons the results were mostly minimal, which is probably why few people have seen this work.

Q What is the most (and least) UV resistant plant species that you have ever worked on? (In my opinion *Nothofagus antarctica* is pretty resistant to most stresses!).

A Wheat seemed pretty tough—WoBey (ed. Wolfram Beyschlag) couldn't impair photosynthesis even with remarkably high UV.

Mustard family would be my guess as most sensitive. We didn't do much with them—one of the problems is some of the crop mustards are so sensitive to insects. Even if the seed are pesticide treated there are still insect problems. I did briefly grow a *Brassica* in a mechanistic field experiment (UV treatment vs. a control where solar UV-B was removed) and saw a reduction in shoot mass. Your question got me interested, so I looked to see if others found similar results—turns out only a few people have treated *Brassica* in the field. Surprising.

Q What is the most recurring problem that you find when reviewing papers related to UV?

A Experimental realism, closely followed by not having a good control and pseudoreplicating. As we learn more about plant responses and see how the acclimation responses even fluctuate on a diurnal basis, it is clear that realism in experiments is all that much more important. [We had a figure in Climatic Change (Caldwell and Flint 1994, Fig. 4) showing how most greenhouse and growth chamber conditions did not compare well with real field conditions (Fig. 5.3). Surprisingly some growth chamber trials were more realistic than the greenhouse!]

Control issues have ranged from filters that block different amounts of PAR in filtered sunlight experiments to hanging lamps at different heights to achieve different doses.

Pseudoreplication—using the plant rather than the plot—can give unrealistically "good" statistical results by increasing the degrees of freedom. Sometimes the plant (or pot) can be reasonably used as a replicate if there is rotation. But one always wonders if there are some under-replicated studies published with "good" results and a corresponding number of similarly under-replicated studies with no results that are never published?

Q Finally, is there a nagging unanswered question in UV research that you would have loved to get to the bottom of?

A Many people are headed in the right direction looking at the various indirect effects.

One thing that has bothered me is we are still using about the same system in field supplementation as in the '70s—fluorescent lamps. Someone should try using these huge UV lamps used in the printing process to cure ink. (I'm talking of big scary electronics here—thousands of watts.) They could be hung high; there would be no shading, and one could have a gradient of the dose. It might take some work filtering to get the right spectrum but would be a novel and potentially more realistic approach.

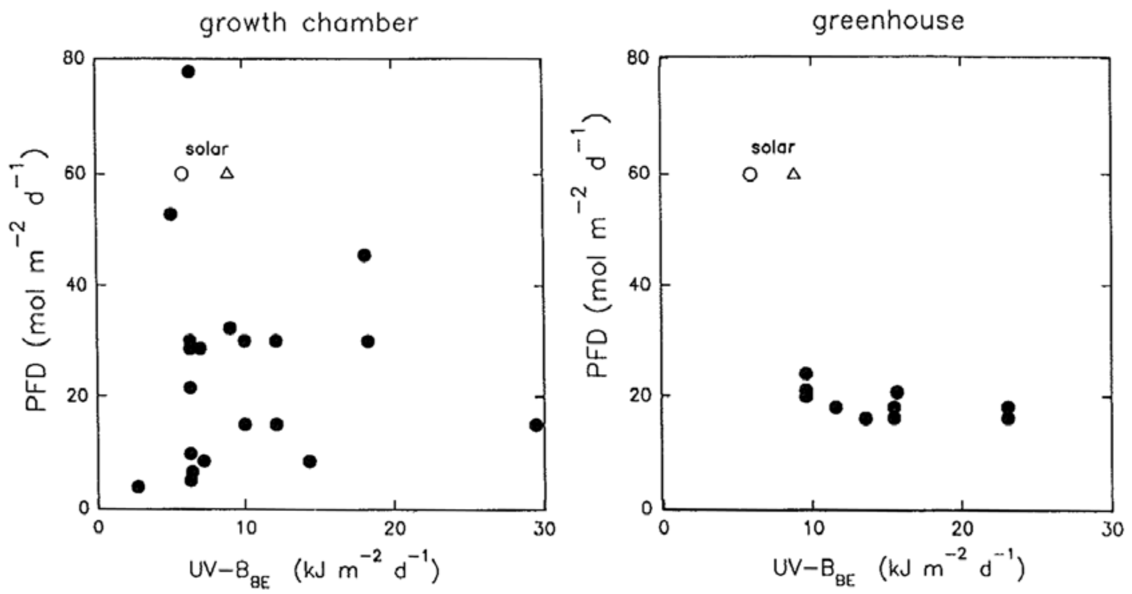

Fig. 4. Average daily integrated biologically effective UV-B using the generalized plant action spectrum weighting function (Caldwell, 1971) normalized to 300 nm (UV–B$_{BE}$) and total photon flux in the 400–700 nm waveband (PFD) employed in growth chamber and greenhouse experiments (•). For comparison, measured solar UV–B$_{BE}$ and PFD on a clear day (3 August 1993) at 1450 m elev. and 41° N latitude (○) and the corresponding value computed (using the measured values as a basis) for a 20% reduction of the ozone column (△). The same papers as surveyed for Figure 3 were used in this depiction.

Figure 5.3: Reproduced from *Climatic Change* (Caldwell and Flint 1994, , Fig. 4) with permission from the publisher, ©1994 Springer.

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Edited by: P. J. Aphalo and T. Kotilainen.

Invitation If you know of someone whose life in UV-research you think would make an interesting feature for the uv4plants bulletin, let us know. Suggest an interviewee or do the interview yourself and submit it for publication!

Ongoing research

Regulation of UV-Induced Flavonoid Production in *Marchantia polymorpha*: a role in the evolution of plants for land colonisation?

Brian Jordan[1], ORCID: 0000-0003-0280-681X
Nick Albert[2], ORCID: 0000-0002-8579-529X
William Clayton[2], ORCID: 0000-0002-3042-4694
Simon Deroles[1,2], ORCID: 0000-0001-8154-1922
Kathy Schwinn[2], ORCID: 0000-0002-6337-3627
Kevin Davies[2], ORCID: 0000-0001-5652-5015
[1]Lincoln University, Christchurch, New Zealand
[2]The New Zealand Institute for Plant & Food Research Limited, Palmerston North, New Zealand

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Plants are thought to have colonized the land around 500 million years ago. One of the major challenges the first pioneers faced was protection against UV radiation. UV has severe detrimental effects on plant cells and was at particularly high levels during the period of land colonisation because the ozone layer was not fully developed. Seed plants use a mix of secondary metabolites as UV 'sunscreens', and of these the flavonoid group of phenylpropanoids is of particular importance. UV-B is perceived in seed plants by the UVR8 photoreceptor, whose activation stimulates a cascade of transcription factors that up-regulate flavonoid gene transcription. Of particular importance are the initial target protein, the bZIP HY5, and the direct activators of the flavonoid genes, which together form the MYB-bHLH-WDR (MBW) transcriptional complex. There are no convincing reports of the identification of flavonoids from algae and it is generally accepted that the phenylpropanoid pathway arose in land plants. However, it is an open question whether inducible flavonoid production for UV-B tolerance is a universal system in plants that may have evolved during land colonization, as data is lacking from organisms outside the angiosperms. Indeed, an alternative proposal is that the flavonoid pathway arose for control of auxin action, as flavonols are modulators of auxin activity.

As the closest living relatives of the first land plants, bryophytes can help to inform us about systems that have an early evolutionary origin. With funding from The Marsden Fund of New Zealand, we are defining the UV tolerance mechanisms of the liverwort *Marchantia polymorpha* (marchantia) and comparing them with those of angiosperms, with a focus on the flavonoids. Marchantia is an outstanding model system: it is a small rapidly growing plant, it is easily transformable, the main life stage is haploid, it can be rapidly clonally propagated via gemmae and it has a small, recently sequenced, genome. Marchantia produces flavones, which are a key UV-induced flavonoid of many angiosperms and a red pigment thought to be related to anthocyanins (Riccionidin A). In other liverworts that have been studied, Riccionidin A appears to be bound to the cell wall, as opposed to the usual vacuolar location of anthocyanins in angiosperms. Liverworts also produce a great variety of other small metabolites, including many that are thought to be derived from the phenylpropanoid pathway. Of particular note are the bibenzyls, which are produced in abundance and have great structural variety in liverworts, including marchantia. Bibenzyls show anti-fungal activities and are also induced by general stresses such as ABA treatment or UV-C exposure.

Figure 6.1: *Marchantia polymorpha* plant with an archegonia (female sexual organ) and a close up image of the clonal reproductive organ, the gemmae cup, stained to visualise flavonoids

Nothing is known on the biosynthesis of flavonoids in marchantia. We have used RNAseq analysis of UV-treated plants and Blast interrogation of transcriptome and genome resources to identify biosynthetic and regulatory gene candidates for the marchantia flavonoid pathway. While the early steps of the shikimate and phenylpropanoid pathway can be identified with confidence from sequence similarity to angiosperm genes, the later steps of flavonoid biosynthesis will require functional studies for gene assignment. With regard to finding candidate regulatory genes, these are even more challenging to identify based on phylogenetic analysis alone. Thus, we are characterizing our candidate biosynthetic and regulatory genes using transgenic over-expression, CRISPR mutagenesis and functional analysis in genetically defined angiosperm mutants. Results to date include the identification of a UV-induced transcription factor that when over-expressed in marchantia confers constitutive production of large amounts of flavonoids. Strikingly, the over-expression transgenics are deep red in colour, from production of large amounts of Riccionidin A. When we generate CRISPR lines for this gene, the transgenics lose the ability to form red pigmentation.

A great advantage of marchantia is the ease of transformation combined with its haploid genome, as CRISPR events are obtained in the initial transgenic generation. We are now generating CRISPR knockouts for other genes of interest that may relate to the flavonoid/UV-B system. UVR8 and HY5 have been reported as conserved across plants and this is the case in marchantia, which has single copy candidate genes for each. To test the function of both of these we are currently generating CRISPR mutant lines, and would be interested to collaborate on the functional analysis of these with other researchers. Moreover, studies on evolution are most powerful when data is available from a wide range of organisms, and we would be pleased to hear from other groups that are studying flavonoids and UV-B responses in species beyond seed plants.

Edited by: P. J. Aphalo, T. M. Robson and M. Jansen.

The Team We are studying the mechanism of UV-B tolerance in some of our most basic plant species, the liverworts, so it can be compared to the well characterised flavonoid-based systems of angiosperms. The project is based in the Plant Pigments Team of Plant & Food Research. The team of about a dozen staff is led by Kathy Schwinn and located in Palmerston North in the North Island of New Zealand. The group carries out a wide range of both applied and fundamental research on plant pigments. The liverwort project is led by Kevin Davies and Simon Deroles in collaboration with Brian Jordan. Brian was previously the leader of the Plant Pigments team, having joined the team from the Institute of Horticulture Research, UK in 1994. Brian's research expertise has focused on light and plant development and since 1990 he has been recognized as an authority on plant cellular responses to UV-B. Brian is now based at Lincoln University, but has stayed a close friend and colleague of the Palmerston North team. In 2011 the opportunity was taken to develop a research collaboration on UV-B regulation of the flavonoid pathway in the model liverwort species *Marchantia*.

In 2013 a prestigious New Zealand Marsden Grant was awarded and funded the appointment of post-doctoral and PhD fellows. Enter Will and Nick! Will Clayton joined the team after completing his Master's in biotechnology at Massey University, Palmerston North. He started as a PhD student on the project in 2014, studying changes in flavonoid production, plant physiology and gene expression following UV-B exposure of marchantia. Currently based at Lincoln University but working closely with the team in Palmerston North, Will is developing many new skills and enjoying the challenge of working towards unravelling this novel UV-B story. Nick Albert originally completed his PhD with Kathy and the team, and after a few years working elsewhere returned for the Marsden post-doctoral appointment. He has developed molecular tools for marchantia, including CRISPR-based mutagenesis and is identifying the genes that regulate flavonoid production in liverworts. We are now two thirds through the project with many exciting results and concepts emerging. We very much hope that the UV4Plants community finds our research interesting and we look forward to future collaborations. Best Wishes from New Zealand.

Figure 6.2: On the left, the Palmerston North team, from left to right Kevin Davies, Simon Deroles, Kathy Schwinn and Nick Albert, and on the right Brian and Will.

Methods

Measuring solar UV-B: why is it so difficult?

Pedro J. Aphalo, ORCID: 0000-0003-3385-972X
ViPS, Department of Biosciences, University of Helsinki, Helsinki, Finland
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The problem

I expect readers to be aware of the fact that measuring UV-B radiation is difficult. However, a short demonstration of some of the causes behind the difficulties will be of interest. I will discuss how the properties of the emission spectrum of a radiation source, the shape of the biological spectral weighting functions, and the spectral response of radiation detectors interact. I will demonstrate that spectra that when plotted on a linear scale can look completely noisy-free can suffer from very serious stray-light problems. Furthermore, I will demonstrate that this "unnoticeable" amount of stray is large enough to cause huge errors in estimates of effective UV exposures, and to a lesser extent in unweighted UV irradiances and exposures.

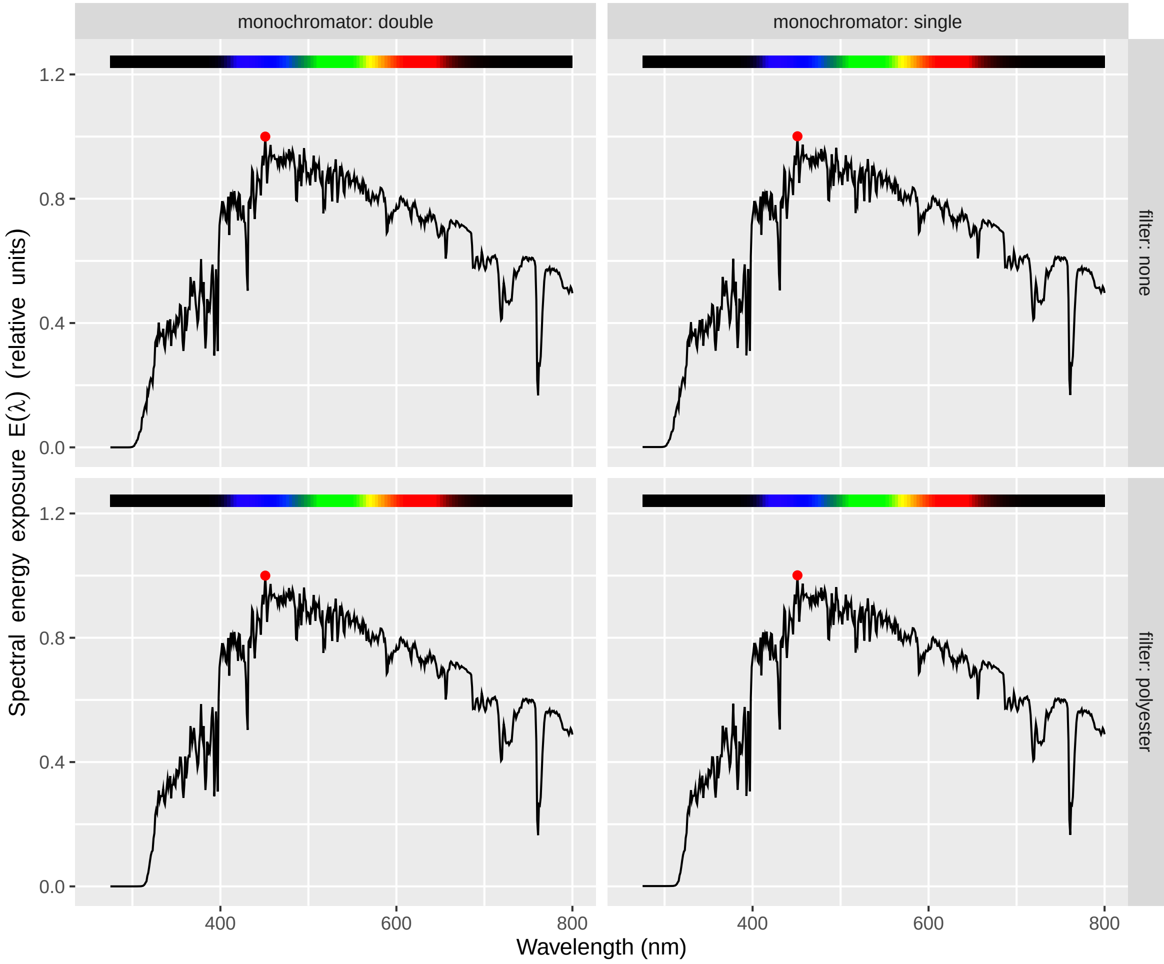
The difficulties of consistently measuring solar UV-B radiation at ground level has kept geophysicists and meteorologists occupied for many decades. In spite of this there is no easy or automated solution to the problem. Careful application of strict protocols both at the time of instrument calibration and at the time of measurement are needed to achieve acceptably good estimates (Seckmeyer et al. 2001, 2005, 2010).

The main problem is that UV-B irradiance is only a small fraction of the global solar irradiance at ground level. In winter at medium and high latitudes the UVB:PAR ratio is at its minimum, and very close to zero, and when the sun is at its highest elevation at Midsummer in Helsinki, the UVB:PAR photon ratio is at its maximum, but still only $\approx 0.002 : 1$. Being this the maximum, and global radiation approximately twice as much as PAR, we will normally want to resolve changes in the UVB:PAR irradiance ratio as small as 0.0001. In other words, we want to resolve a change in the flux of UV-B photons that is nearly 10 000 times smaller than the flux of photons in the band from 400 to 700 nm, and do this reliably and without recalibration of the instruments even when the shape of the spectrum changes with solar elevation.

Broad-band sensors are easier to use and cheaper than spectrometers. However, as their spectral response curve is broad and with a shape that depends on both the characteristics of the detector and of the additional filters used, they need always to be separately calibrated for each type of light source to be measured (see Aphalo et al. 2012). If only one light source is to be measured, for example sunlight, it is possible to use broadband sensors with a good protocol that takes into account sources of bias like sensor temperature and solar elevation. When measuring the UV-B output from different sources it becomes cumbersome and error-prone to have to switch among calibrations and regularly repeat all the calibrations. In the case of measurements of mixed radiation from sources of different types, broadband sensors should be avoided in most cases. In the current article, I will only discuss spectral measurements.

The main cause of difficulties is stray light within spectrometers. Stray light is light that has gone *astray from its expected optical path* and may, for example, reach a pixel in an array detector it is not expected to imping on, such as one corresponding to a different wavelength. Stray light originates in reflections and scattering at mirror and grating surfaces and to some extent can be attenuated by blackening the interior of the spectrometer case and adding baffles. However, the most effective solution is to separate the light beam into different wavelengths twice by means of two monochromators po-

Figure 7.1: Simulated effect of spectrometer stray light. In this figure the effect of a small amount of stray light is simulated based on the characteristics of two types of spectroradiometers. The two spectra for each light source are visually indistinguishable although the simulated amounts of stray light differ. Stray light was simulated by adding a baseline of 1:1 000 of the spectral irradiance at the peak of the spectrum (marked with red dot) for the single monochromator, and a baseline of 1:1 000 000 of the spectral irradiance at the peak for the double monochromator instrument.



sitioned 'in series' in the optical path.

There is only one type of instrument in common use that has a good-enough stray light performance for reliably and consistently quantifying UVB irradiance in sunlight: a highly-specified double-monochromator scanning-spectroradiometer with a cooled detector. These instruments vary from big to very big in size, and are usually difficult to transport and expensive. On the other hand the stray light level can be as good as 1:1 000 000. In single monochromator scanning spectrometers stray light is about 1/1000 as good or about 1:1 000. With a suitable grating, array spectrometers can provide good spectral resolution. Spectrometers with array detectors, cannot be built with two monochromators operating in tandem and consequently can achieve "physical" stray light specifications of from 1:500 to 1:1 000 in the UV-region.

If we plot the measured solar spectrum using a linear scale, stray light of 1:1000 is almost impossible to notice by sight, even in direct comparison with a figure showing data with no stray light (Figure 7.1). Consequently, at first sight, one would conclude that such an small amount of stray light is harmless. However, if we calculate biologically effective irradiance and look in detail at the UV-B region of the spectrum, we can see that the error introduced by the stray light is really of large magnitude (Figure 7.2). Especially under a polyester filter, it would appear that there is a significant amount of UV-B radiation present, when in reality it is absent. This example is a simplified simulation, but based on actual data measured by Lasse Ylianttila on our Maya2000 Pro spectrometer.

A partial solution: estimate stray light from UV-C region

Can we estimate stray light to correct the readings? Yes, we can estimate it if the stray light affects adjacent regions of the array similarly (stray light is truly scattered). As very few photons emitted by the sun at wavelengths shorter than 293 nm reach ground level, we can assume solar spectral irradiance in this region to be zero. From this it follows that non-zero readings at these short wavelengths are a measurement of stray light—after subtracting the pixel readings in full darkness measured very close in time. The dark measurement should be paired to the actual measurement and obtained at most within a minute or so of each other. This approach seems to sometimes work well enough with spectrometers based on Sony's ILX511B linear silicon CCD array when measuring artificial UV sources in the absence of strong visible light. This is an approximation because the stray light is unlikely to be 100% scattered. In practice there is another constraint to consider: that array detectors usually have different regions coated with different filters, which affect the sensitivity of their pixels to stray light. Consequently, which of these pixels can be used to assess stray light will depend on the instrument. As with any correction, it needs to be validated and applied in exactly the same way during measurements and instrument calibration.

A partial solution: measure and subtract the stray light

Can we measure stray light to correct the readings? Yes, but only if variation of irradiance in time is negligible. If comparable paired measurements can be made we can measure the stray light by blocking the UV radiation with a filter for one of these measurements. In this case we can correct for stray light using stray light measured at the wavelengths of interest. This approach seems to be needed, at least for some instruments based on detectors such as Hamamatsu's back-thinned 2D FFT-CCD 'array' used in Ocean Optics high end spectrometers like the Maya2000 Pro. The reason why this instrument behaves different is that stray light is not fully scattered—different pixels in the detector will receive stray photons from different spectral regions of the radiation being measured. In our own Maya2000 Pro mostly from the near infra-red (NIR) region.

This type of stray light measurement is just a rough quantification because the filter used to measure stray may also absorb some of the photons being reflected and scattered inside the instrument to produce the stray light itself. Consequently the filter used should be chosen taking this into account, for example high NIR transmittance may be needed. How effective this correction will be in practice cannot be easily simulated and will also be instrument specific. As with the correction described in the previous section, this correction is not good enough for measuring effective UV-B radiation in sunlight, but may work well enough when measuring lamps.

More complex approaches

More complex approaches use one of the two methods described above to estimate stray light but in addition correct for the slit function of the instrument. This improves the wavelength resolution by correcting for the light that 'bleeds' to adjacent pixels. Furthermore, measuring low signal and high signal areas of the spectrum with different integration times and merging the resulting spectra significantly increases the dynamic range of the instrument. In many cases, this allows a signal to noise ratio as good as 1:10 000 to be attained in sunlight. Such complex sets of corrections need to be carefully validated against a reference instrument such as a well calibrated double-monochromator scanning spectroradiometer under a range of daylight conditions and other sources to be

Figure 7.2: Simulated effect of spectrometer stray light. In this second figure we plot the same data but limiting the range of wavelengths and instead of plotting the raw spectral irradiance we plot the spectral irradiance weighted with Green's formulation of M. M. Caldwell's Generalized Plant Damage Spectrum (GEN_G). The effect of the minute amount of stray light on the estimated UV-B irradiance is large in the case of single monochromator instruments resulting in an overestimation by more than 50% of the effective irradiance for unfiltered lamps (the best case) and in an overestimation by 85 *times* for the polyester-filtered lamps! Now the effect of instrument stray light is clearly visible as the red area!

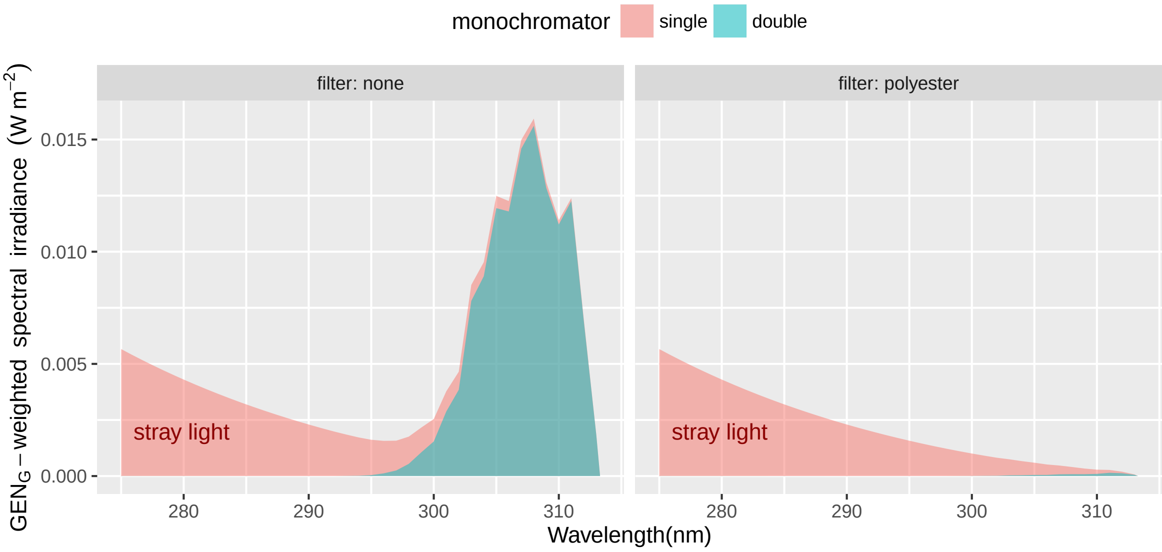


Figure 7.3: Simulated effect of spectrometer stray light. In this third set of figures, we plot the new data simulating measurements with a single monochromator spectrometer *corrected for stray-light, slit-function, and obtained using 'bracketing' of integration time*, as in Figure 7.2 the range of wavelengths is limited and instead of plotting the raw spectral irradiance, the spectral irradiance weighted with Green's formulation of M. M. Caldwell's Generalized Plant Damage Spectrum (GEN_G) is plotteed. Now the improvement achieved by the simulated use of the special measurement and data processing protocols is visible as a reduction of the red area compared to that in Figure 7.2.

measured.

Different algorithms and approaches for applying corrections and characterising array spectrometers have been published in the optics, meteorology and geophysics literature (Ansko et al. 2008; Coleman et al. 2008; Kreuter and Blumthaler 2009; Seckmeyer et al. 2010; Ylianttila et al. 2005; Zong et al. 2006). Even with all such corrections, array spectrometers are not comparable to double-monochromator scanning spectroradiometers in their performance and usually considered unsuitable for long-term monitoring, but may be good enough for short-term or spot measurements when errors as large as $\pm 15\%$ are tolerable (Figure 7.3).

A hardware-based solution: VIS-blind detectors

Can we make the instrument blind to stray light? Yes. There is a new type of array detector under development. These arrays are made of silicon carbide (SiC) instead of silicon and are intrinsically blind to visible radiation. Sensitivity at 320 nm is 20 *orders of magnitude* higher than at 500 nm. At the moment there is only one commercial instrument available (Fig. 7.4). Spectral resolution is about 3 nm and quantum efficiency lower than that of more traditional arrays. Of course, this instrument can be used to measure only UV radiation.

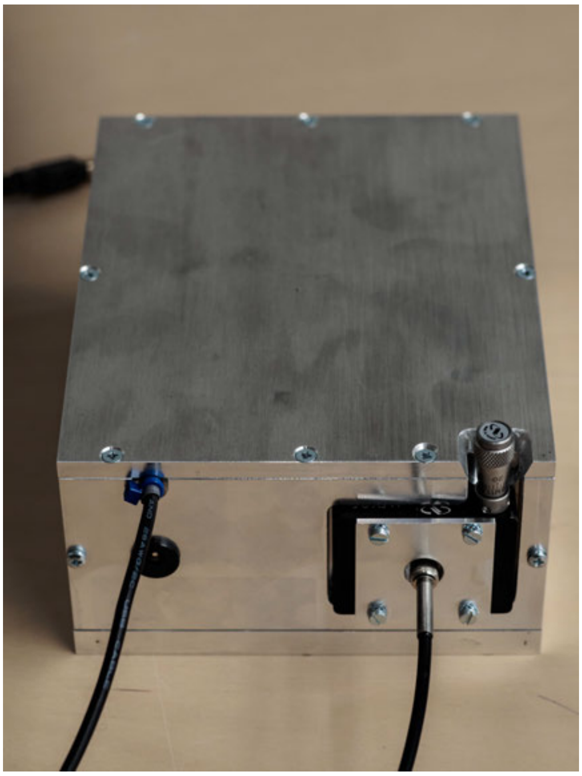


Figure 7.4: Photograph of a sglux LIN128 spectrometer. The array detector used in this instrument is blind to visible radiation and consequently immune to visible and infra-red stray light. In addition it is equipped with a convex grating that focuses the radiation directly onto the detector. Not having additional mirrors in the optical path also contributes to improved stray-light characteristics.

A model-based solution: radiative transfer models

For the estimation of daily, and in some cases hourly, spectral UV exposure radiative transfer models (RTMs) are accurate especially for clear sky conditions (e.g. García et al. 2016). The effect of clouds can be estimated in different ways, but a reliable and easy to implement method is to use measured global radiation to estimate the cloud depth (Lindfors et al. 2009, 2007). Instantaneous estimates are also possible but these require global radiation to be measured on site. The model 'libRadtran' is widely used for this purpose, and in its latest version can simulate the whole solar spectrum at ground level (Emde et al. 2015). The spectral irradiance under large sized filters can be approximated by convolving the spectral transmittance of filters by the simulated solar spectrum. The accuracy of the estimated spectral irradiance under a filter will be subject to errors at low solar elevations because of stray light, and because the total transmittance of filters at narrow angles of incidence may decrease due to increased reflection.

The model 'libRadtran' is currently popular and actively maintained, and has its main focus in atmospheric radiation transfer and spectral simulation. There another model that can be also used for spectral simulations: Tropospheric Ultraviolet and Visible (TUV) radiation model (Madronich 1992). This model is actively maintained, however much of it is related to the modeling of atmospheric chemistry. There is an on-line version, or Quick-TUV (http://cprm.acom.ucar.edu/Models/TUV/Interactive_TUV/) which can be used to simulate the UV region of the solar spectrum, and simpler to use than the full-blow version or 'libRadtran'. The much older and simpler model developed by Green and Björn, is considered to been superseded by the more complex models described above.

Conclusions

Array spectrometers have advantages compared to scanning spectrometers. Most importantly the whole spectrum is measured simultaneously and almost instantaneously while with scanning spectrometers the acquisition of a single spectrum can take even minutes and each data point is acquired at a different instant in time. Array spectrometers are also smaller, use less power, and are less sensitive to vibration than scanning spectrometers, making them suitable for field measurements at remote locations.

Although it is possible to use array spectrometers for measuring solar UV radiation, even after applying corrections, UV-B estimates are only of good quality under a limited range of conditions (Egli et al. 2016; Seckmeyer et al. 2010). In the case of UV-B lamps and UV-B LEDs if their output is measured in the absence of other comparatively stronger sources of visible radiation, good estimates are obtainable as long as a good protocol is used.

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■ Methods

The r4photobiology suite: sun angles and day length

Pedro J. Aphalo, ORCID: 0000-0003-3385-972X
ViPS, Department of Biosciences, University of Helsinki, Helsinki, Finland
DOI: 10.19232/uv4pb.2016.1.15

Introduction

This article is the second in a series of articles describing the different packages in the R4Photobiology suite. The first article in the series gave an overall description of the suite and the overall design (Aphalo 2015). Starting from the present article, each article in this series will describe features related to individual classes of problems encountered in photobiological research.

There are several different reasons why you may need in your own research to do the calculations described in this article. Local time very rarely agrees with solar time, as solar time varies continuously with E/W longitude while time-zones are discrete and usually 1 h-wide. There is in addition the use of daylight saving time-shifts which in some cases are of more than 1 h. In extreme cases local-time noon may occur as much as 2 h earlier or 3 h later than solar noon (Figure 8.1). When doing UV-B supplementation experiments outdoors, for realism we need to center the period of artificial UV-irradiation on solar noon. Even if we do not use UV supplementation, it is very useful in the case of plants growing in sunlight to report sampling times according to solar time, as gene-expression and physiological activity vary throughout the photoperiod as well as the more obvious circadian leaf movements.

Day and night lengths themselves depend mainly on latitude and date but being able to include the exact location and the actual angular elevation of nearby obstacles like mountains and buildings allows day and night lengths at a specific location to be estimated with greater precision. For some experiments this is important.

When studying photoperiodic responses of plants outdoors vs. in controlled environments it is good to keep in mind that irradiance increases gradually from dawn until sunrise and decreases gradually from sunset until dusk. The critical irradiances perceived as the boundaries of the photoperiod differ between plant species and only rarely correspond to the astronomical sunrise and sunset times usually used to define the daylight period (Takimoto and Ikeda 1961).

When hemispherical canopy images are available, being able to calculate the path of the sun across the sky allows the prediction of when sunflecks will occur on a given day and how long they will last. This type of information has been used to assess the light conditions under which different forest understorey plant species thrive.

The main focus of the 'r4photobiology' suite of R packages is the processing of spectral irradiance data required for quantification of radiation in photobiological research. There is in addition support for calculations related to tri-chromic vision and the position of the sun, and derived quantities such as day and night length. In the current article I describe functions from package 'photobiology' of my authorship, and of other R packages that can be used to calculate the position of the sun and day and night lengths on a certain date and at a given geographical location.

Definitions

The **solar elevation angle** is the angle measured from the horizon to the centre of the solar disk. When the sun is at the zenith its value is $\alpha = 90°$. The **solar zenith angle** is the complement of the elevation angle. The zenith angle is measured downwards from the zenith, and abbreviated as θ and related

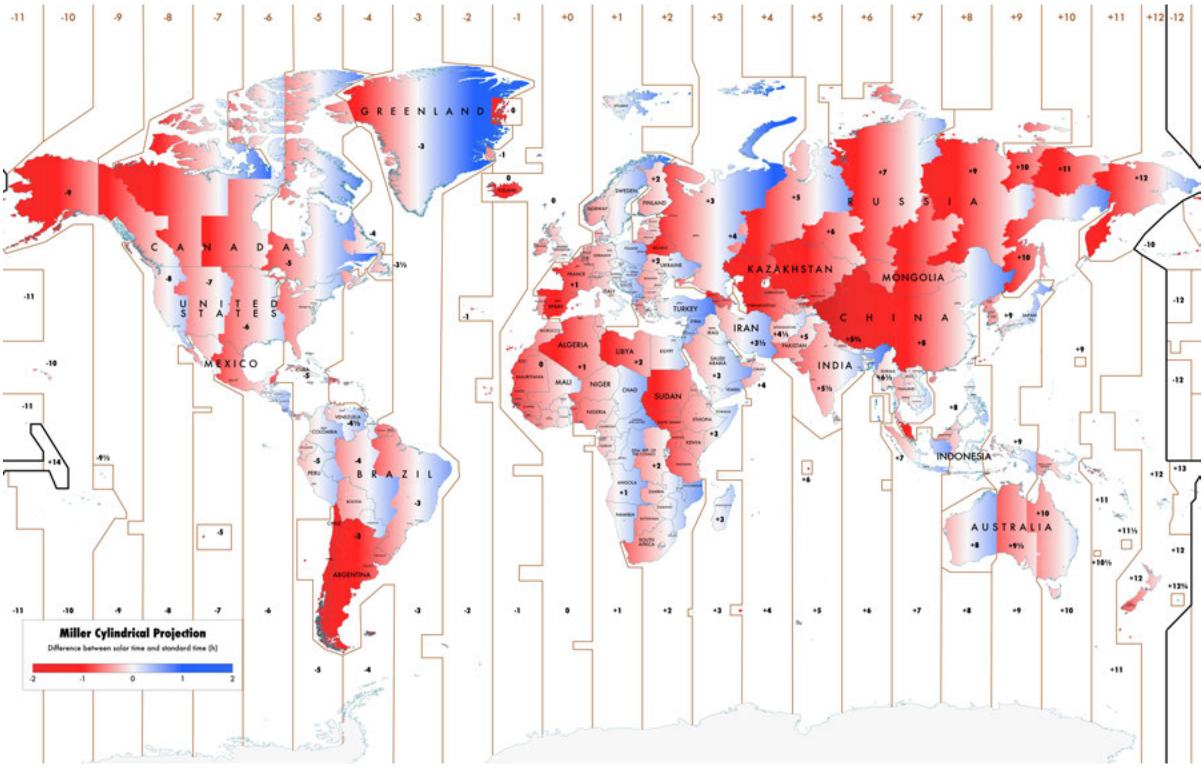


Figure 8.1: Map showing how much the standard local times differed from solar time across the world in 2015. This shift does not take into account the additional, usually -1 h-long shift due to daylight saving time that many countries implement during summer. The map is in the public domain (Maggiolo 2015) and also available through Wikimedia Commons.

to α such that $\alpha + \theta = 90^{\circ}$.

Sunset and sunrise are sometimes defined as the times at which the center of the solar disk is at the horizon—solar elevation angle is zero. Other definitions use other, slightly different, positions to describe these events, i.e. when the center of the solar disk is 0.5° below the horizon. Given that the diameter of the solar disk as seen from Earth is very slightly over 0.5°, this second definition is in practice given by the time when the upper rim of the solar disk is slightly below the horizon, in simpler words when the whole solar disk is occluded.

Twilight are the periods immediately before sunrise and immediately after sunset when, although the solar disk is occluded, sunlight scattered in the atmosphere still makes an important contribution to ambient light (Figure 8.2). In the morning the period of twilight starts at *dawn* and ends at *sunrise*. In the evening twilight starts at *sunset* and ends at *dusk*. There are different operational definitions for dusk and dawn, and although they are defined in terms of (negative) solar elevation angles (α), the definitions had their origin in practical problems. In order of negative elevations of increasing magnitude: a) **civil twilight** ($\alpha = -6^{\circ}$) enough light to see objects outdoors without need of artificial illumination, b) **nautical twilight** ($\alpha = -12^{\circ}$) enough light to make it possible to navigate using the horizon as a guide, and c) **astronomical twilight** ($\alpha = -18^{\circ}$), between dawn and dusk based on this definition (and in the absence of light pollution from artificial light sources) almost all astronomical observations are possible. In the summer, at latitudes $> 48.5^{\circ}$, there are periods when twilight lasts for the whole night.

In practice except at places where topography is completely flat and surrounding objects absent the effective horizon will be above the theoretical horizon, in other words the solar disk will appear later in the morning and/or occlude earlier in the evening than

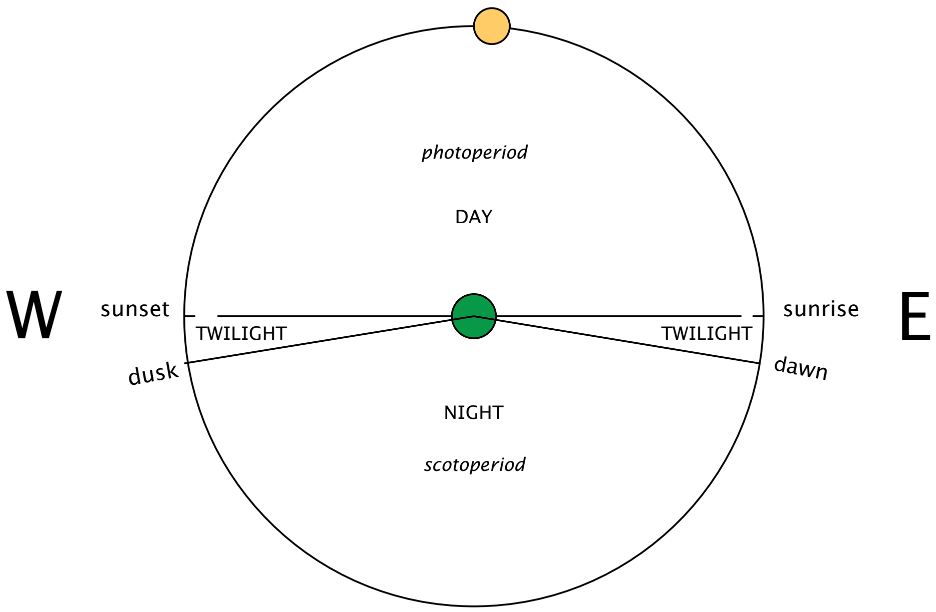


Figure 8.2: Diagram showing the apparent path of the Sun as seen by an observer at a fixed position on the Earth surface. The green disk represents the earth and the yellow disk the sun, E indicates the observer's East and W, West, the horizontal dashed line represents the observer's horizon. The angles between the horizon and the lines delimiting dawn and dusk will depend on the definition of twilight used, and are exaggerated to increase the clarity of the diagram.

when $\alpha = -0.5°$. Although non-standard, in field experiments, calculating the day length based of effective times of solar occlusion at the actual location of the experiment can be very useful.

All the times and angles described in this section can be calculated using functions defined in R package 'photobiology', although the current implementation accepts only a restricted range of dates from 1950 to 2050. To operate with geographic coordinates (geocodes) and times, other R packages will be used as an aid. The balance of this article describes how to do these calculations in practice.

Geographical coordinates

We can obtain geographical coordinates from GPS devices, maps—printed and digital—and by searching for locality names or addresses. For address searches, Google maps is a convenient tool. Package 'ggmap' (Kahle and Wickham 2013) defines functions not only for downloading and plotting maps and satellite images, but also for searching geographical coordinates based on addresses or locality names (Example 8.1).

Times and dates

Package 'lubridate' (Grolemund and Wickham 2011) makes it easy to work with dates and times in R (Examples 8.2 and 8.3). When working with *both dates and times* one should be extremely careful with the handling of time zones and daylight saving times (summer time). The default in R is in most cases to default to the time zone settings of the computer on which R is running. Time zone is passed through parameter `tz`. One should also distinguish between expressing a given time instant in a different time zone, and in calculating a new time instant so that the local time is the same in the new time zone as in the original time zone.

Box 8.1: Example code for obtaining geocodes for a location.

```
library(ggmap)
```

```
library(ggmap)
geocode("Helsinki, Finland")

##     lon   lat
## 1 24.94 60.17

geocode("Helsinki, Finland", output = "latlona")

##     lon   lat           address
## 1 24.94 60.17 helsinki, finland

geocode("Helsinki, Finland", output = "more")

##     lon   lat     type     loctype           address north south  east  west locality
## 1 24.94 60.17 locality approximate helsinki, finland  60.3 60.03 25.25 24.83 Helsinki
##   administrative_area_level_3 administrative_area_level_2 administrative_area_level_1
## 1                    Helsinki                    Helsinki                     Uusimaa
##   country
## 1 Finland
```

```
geocode("Viikinkaari 1, Helsinki, Finland", output = "latlona")

##     lon   lat                              address
## 1 25.02 60.23 viikinkaari 1, 00790 helsinki, finland

geocode("Viikinkaari 1, Helsinki, Finland", output = "more")

##     lon   lat           type loctype                                address north
## 1 25.02 60.23 street_address rooftop viikinkaari 1, 00790 helsinki, finland 60.23
##   south  east  west street_number       route locality administrative_area_level_3
## 1 60.22 25.02 25.02             1 Viikinkaari Helsinki                    Helsinki
##   country postal_code
## 1 Finland       00790
```

Day length

Plant photoperiodic responses depend on the length of the photoperiod. Natural photoperiod depends on latitude and day of the year. In addition, in may be of interest to obtain the times at solar noon, sunrise and sunset expressed in the locally used time coordinates or in universal time coordinates. All these values can be calculated with functions in R package 'photobiology' (Example 8.4). Plotting of the length of the day for the whole year at a certain location is also simple if one takes advantage of the recycling rules of the R language to create a vector of dates (Example 8.5). There are different standard definitions in use for twilight corresponding to different positions of the sun below the horizon that can sometimes be useful. More useful to those studying plants is the calculation of the sunset or sunrise times for solar elevations above the horizon corresponding to obstacles such as mountain ridges, nearby tall vegetation or buildings (Example 8.6).

Position of the sun

In addition to finding the times for a given position of the sun in the sky, we may be interested in calculating the position of the sun at a certain time, for example, the exact time

Box 8.2: Example code for obtaining and entering dates and times.

```
library(lubridate)

##
## Attaching package: 'lubridate'
## The following object is masked from 'package:base':
##
##     date
```

Current time can be obtained with function `now()`.

```
now()

## [1] "2016-06-19 17:55:28 UTC"

now(tz = "UTC")

## [1] "2016-06-19 17:55:28 UTC"

now(tz = "EET")

## [1] "2016-06-19 20:55:28 EEST"
```

Current date can be obtained with function `today()`.

```
today()

## [1] "2016-06-19"

today(tz = "UTC")

## [1] "2016-06-19"
```

It is also easy to convert strings into times or dates.

```
ymd_hms("2016-04-15 12:00:00", tz = "EET")

## [1] "2016-04-15 12:00:00 EEST"

ymd_hms("2016/04/15 12.00.00", tz = "EET")

## [1] "2016-04-15 12:00:00 EEST"

ymd_hms("20160415 120000", tz = "EET")

## [1] "2016-04-15 12:00:00 EEST"
```

Box 8.3: Example code for manipulating dates and times.

```
my.time <- mdy_hm("04/15/16 12:00", tz = "EET")
my.time

## [1] "2016-04-15 12:00:00 EEST"
```

When calculating the position of the sun, we may need to increment, decrement, or extract and replace components.

```
hour(my.time)

## [1] 12

day(my.time)

## [1] 15

days(my.time)

## [1] "1460710800d 0H 0M 0S"

wday(my.time)

## [1] 6

wday(my.time, label = TRUE)

## [1] Fri
## Levels: Sun < Mon < Tues < Wed < Thurs < Fri < Sat
```

```
my.time + minutes(10)

## [1] "2016-04-15 12:10:00 EEST"

my.time - hours(2)

## [1] "2016-04-15 10:00:00 EEST"

my.time + hours(0:5)

## [1] "2016-04-15 12:00:00 EEST" "2016-04-15 13:00:00 EEST" "2016-04-15 14:00:00 EEST"
## [4] "2016-04-15 15:00:00 EEST" "2016-04-15 16:00:00 EEST" "2016-04-15 17:00:00 EEST"
```

Box 8.4: Example code for calculation of day length, night length, and position of the sun at a given location.

```
library(photobiology)
```

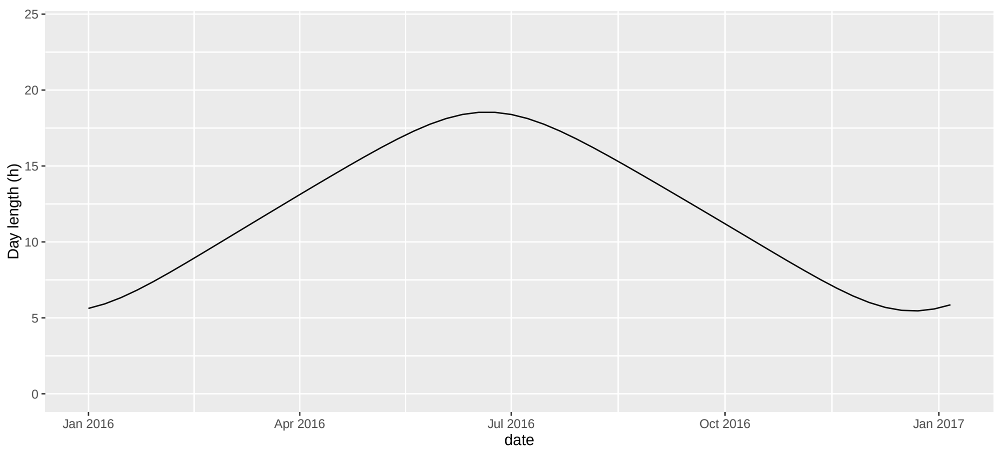
```
my.geocode <- geocode("Helsinki, Finland")
day_length(today(), tz = "EET", geocode = my.geocode)

## [1] 14.65

night_length(today(), tz = "EET", geocode = my.geocode)

## [1] 9.347

sunrise_time(today(),  tz = "EET", geocode = my.geocode)

## [1] "2016-04-18 06:00:43 EEST"

sunset_time(today(),  tz = "EET", geocode = my.geocode)

## [1] "2016-04-18 20:39:55 EEST"
```

Box 8.5: Example code for plotting of day length.

```
library(dplyr)
```

```
dl.df <- data_frame(date = lubridate::ymd("2016-01-01", tz = "EET") + weeks(0:53))
dl.df <- transform(dl.df,
                   day.length = day_length(date, geocode = geocode("Helsinki, Finland")))
```

```
ggplot(dl.df, aes(date, day.length)) +
   geom_line() + ylim(0,24) +
   labs(y = "Day length (h)")
```



Box 8.6: Example code for calculation of the time of occurrence of solar events.

Objects of class `"source_spct"` can contain geocode and time data as metadata. When they contain it, it is possible to directly calculate the position of the sun at the time and place of measurement.

```
my.location <- geocode("Helsinki, Finland")
my.date <- lubridate::ymd("2016-04-16", tz = "EET")
noon_time(my.date, my.location, tz = "EET")

## [1] "2016-04-16 13:20:20 EEST"

sunrise_time(my.date, my.location, tz = "EET")

## [1] "2016-04-16 06:06:31 EEST"

sunset_time(my.date, my.location, tz = "EET")

## [1] "2016-04-16 20:35:00 EEST"
```

For sunset and sunrise, by default the times returned are those when solar elevation is zero degrees. However, different standard twilight angles can be given by name to change this default.

```
sunset_time(my.date, my.location, twilight = "none", tz = "EET")

## [1] "2016-04-16 20:35:00 EEST"

sunset_time(my.date, my.location, twilight = "civil", tz = "EET")

## [1] "2016-04-16 21:29:32 EEST"

sunset_time(my.date, my.location, twilight = "nautical", tz = "EET")

## [1] "2016-04-16 22:33:30 EEST"

sunset_time(my.date, my.location, twilight = "astronomical", tz = "EET")

## [1] "2016-04-17 00:11:10 EEST"
```

Arbitrary angles expressed in degrees are also accepted as argument for `twilight`, for example to determine sun occlusion by an obstacle such as a nearby mountain or building that is 10° above the theoretical horizon we would use the following code.

```
sunset_time(my.date, my.location, twilight = 10, tz = "EET")

## [1] "2016-04-16 19:12:11 EEST"
```

and location when irradiance was measured. Additional values of interest can be the distance from the Sun to the Earth and the apparent diameter of the solar disc. All these values can be easily calculated (Example 8.7). Objects of the spectral classes defined in package 'photobiology' as described earlier (Aphalo 2015) can contain time and location metadata allowing these calculations (Example 8.8).

Resources

A web site dedicated to the `r4photobiology` suite of R packages, located at http://www.r4photobiology.info/ provides installation instructions. Each of the packages contains one or more vignettes like User Guides and/or catalogues of the included data examples, and the individual methods, functions, operators and data objects have been documented with help pages accessible through R's built-in documentation system. A handbook on *Photobiological calculations with R* is being written by myself, Andreas Albert, Titta Kotilainen and T. Matthew Robson. A draft version will be made available on-line in late 2016, and the final version published by the end of 2016.

Acknowledgements

The development of the suite has benefited from earlier work by many different people. From the point of view of R code development and coding, the packages and books written by Hadley Wickham and collaborators have been of enormous importance. It is also necessary to acknowledge the contributors to the development of R itself, and the openness of the whole R community for sharing information and tips and their willingness to help through on-line forums. From the perspective of photobiological calculations themselves, many members of the UV4Growth COST Action have contributed 'problems' with their questions, and/or data and use examples that have been very useful for the design and testing of the suite. Some people need to be mentioned specially for their contributions related to algorithms used for calculations and discussions about reliability and reproducibility: Andy McLeod, Lars Olof Björn, Lasse Ylianttila, T. Matthew Robson and Anders Lindfors where the main contributors on these aspect. Titta Kotilainen and T. Matthew Robson have been my *guinea pigs* always willing to give quick feedback on my sometimes not so wise design decisions and showing me new uses of my own code. Other members of the Action, specially the students attending the training schools, have contributed very useful feedback, sometimes in writing and other times with their questions and facial expressions during training events. Several companies and researchers have allowed the inclusion of their data in the suite. They are acknowledged in the documentation. There is one additional person to thank: Nigel Paul. A chat with him at one of the first UV4Growth meetings where we exchanged ideas about the need of making this type of calculations easier, and to improve the reliability and reproducibility of UV research with plants, was what led to my decision of spending a considerable proportion of my work (and free) time during the last three years on the development of the suite.

References

Aphalo, P. J. (2015). "The r4photobiology suite: spectral irradiance". In: *UV4Plants Bulletin* 2015.1, pp. 19–27.

Grolemund, G. and H. Wickham (2011). "Dates and Times Made Easy with lubridate". In: *Journal of Statistical Software* 40.3, pp. 1–25.

Kahle, D. and H. Wickham (2013). "ggmap: Spatial Visualization with ggplot2". In: *The R Journal* 5.1, pp. 144–161.

Maggiolo, S. (2015). *The time it takes to change the time*. URL: http://blog.poormansmath.net/the-time-it-takes-to-change-the-time/ (visited on 05/12/2016).

Takimoto, A. and K. Ikeda (1961). "Effect of Twilight on Photoperiodic Induction in Some Short Day Plants". In: *Plant and Cell Physiology* 2.3, pp. 213–229.

Edited by: T. Kotilainen and T. M. Robson.

Box 8.7: Example code for calculation of the position of the sun.

We can calculate the current position of the sun,

```
sun_angles(geocode = geocode("Helsinki, Finland"))

## $time
## [1] "2016-04-18 17:05:48 UTC"
##
## $longitude
## [1] 24.94
##
## $latitude
## [1] 60.17
##
## $azimuth
## [1] 285.5
##
## $elevation
## [1] 3.998
##
## $diameter
## [1] 0.5309
##
## $distance
## [1] 1.004
```

or at a given time and date, in this case the time when the first UV4Plants Congress is scheduled to start.

```
sun_angles(time = ymd_hms("2016-05-30 14:00:00", tz = "EET"),
           geocode = geocode("Helsinki, Finland"))

## $time
## [1] "2016-05-30 14:00:00 EEST"
##
## $longitude
## [1] 24.94
##
## $latitude
## [1] 60.17
##
## $azimuth
## [1] 195.6
##
## $elevation
## [1] 50.98
##
## $diameter
## [1] 0.5259
##
## $distance
## [1] 1.014
```

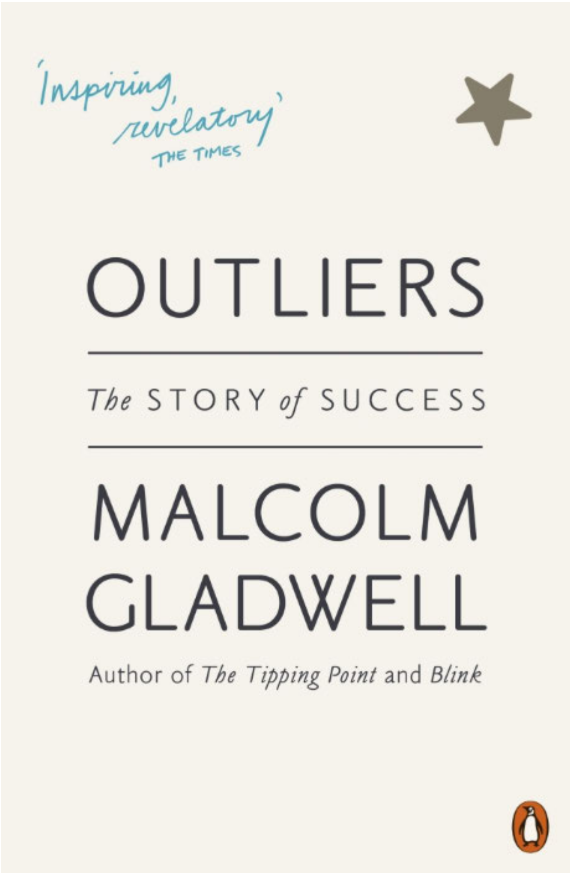

Box 8.8: Example code for calculation of the position of the sun at the time of measurement.

Objects of class "source_spct" can contain geocode and time data as metadata. If they contain metada, it is possible to calculate the position of the sun at the time and place of measurement.

```
sun_angles(time = getWhenMeasured(sun.spct),
           geocode = getWhereMeasured(sun.spct))

## $time
## [1] "2010-06-22 09:51:00 UTC"
##
## $longitude
## [1] 24.96
##
## $latitude
## [1] 60.21
##
## $azimuth
## [1] 168.1
##
## $elevation
## [1] 52.83
##
## $diameter
## [1] 0.5246
##
## $distance
## [1] 1.016
```

Book Review
Outliers: The Story of Success (by Malcolm Gladwell)

Sari Siipola, ORCID: 0000-0003-1411-3121
ViPS, Department of Biosciences, University of Helsinki, Helsinki, Finland
DOI: 10.19232/uv4pb.2016.1.91



We all know people who are described to be "extraordinary" or "genius". They are the top experts who seem to achieve everything imaginable in their field. What is the story behind their success? Are these individuals exceptionally skilful or just extremely lucky? In the book, "Outliers -- The story of success", Malcolm Gladwell ponders the factors behind the possibility for people to achieve the best possible outcome and become the exceptional professionals we read about in the newspapers.

According to the book, there are numerous events and circumstances in our life, which we never come to think of, that determine, at least in part, the direction of our lives. The usual assumption is that successful people either just work harder than others or possess some extraordinary talent. Either of these arguments is completely wrong; one has of course to work hard and have some amount of flair to be able to stand out with an exceptional performance in any field of art, science or commerce. However, this is not necessarily the whole story behind success.

Getting to the top in ice hockey is a perfect example of a career that is a result of hard practice. Ice hockey in Canada is highly competitive and requires countless hours of training. A psychologist called Roger Barnsley was the first to find a variable that is closely linked to success in ice hockey in Canada. From every age class, starting from age nine, the most promising players are selected to play in the all-stars-teams. Being in this group allows these young players to get better coaching and teammates as well as double amount of playing hours. The system guarantees that the most talented youngsters from every age group have similar possibilities to make it to the top. Or do they? When Roger Barnsley looked at the data for any elite group in Canada, he noticed that 40 percent of the players were born between January and March and, furthermore, another 30 percent between April and June. This is surprising but easily explained. The selection for the advanced players is made yearly in January. The timing of selection gives a huge advantage to those who are older in January, because at young age, a relatively small difference in age can be crucial for physical development. In the next year's round, these children in the advanced team have already been trained harder, which makes it so much easier for them to do well in the following selections and develop their skills effectively.

Not only the time of the year, but also the year itself might make a difference in the opportunities available specializing in certain subjects. It seems that there is indeed a perfect time to be born to become a top level programmer or to amass a huge fortune. The main reason for this are the different periods of human or country history and how they match different phases in peoples' lives. Studying in a school where it was possible to freely practice programming at a time when most students did not have any possibilities of using computers, gave Bill Gates a good starting point to success in this area. And if you happened to be in the right age and right place when Wall Street emerged and the railroads were built in the United States, you had a fairly good change to use the opportunity and to become one of the richest people in the world's history.

Still, even the luckiest individuals need practice. Malcolm Gladwell uses a term "ten-thousand-hour rule". This particular number of hours of practice needed to really master any skill was first mentioned in a psychological test by K. Anders Ericsson. The test showed clearly that the amount of time a pianist uses for practicing correlates with his/her career success. There were no "naturals" who would develop fast without training. In the book, the histories of Bill Gates, Mozart and the Beatles are described, in order to show that all of them actually spent a long time practicing before becoming exceptionally skilled professionals.

It seems that the secrets behind success have been revealed. But the author goes further, considering how IQ tests have been designed and what type of intelligence they are able to reveal. Furthermore, he questions the benefit of an exceptionally high IQ and suggests that our background has a stronger impact to our behaviour than we tend to expect. Although partly simplified and even provocative, the examples of the book are relatively well justified. The text is entertaining and easy to read. I found myself questioning quite a few claims of the book but I do not think this is necessary a negative thing. This book is an inspiring discussion about the complexity of the impact of backgrounds in human life and the importance of the people we surround ourselves with.

References

Gladwell, M. (2009). *Outliers : the story of success*. London New York: Penguin Books. ISBN: 0141036257.

Edited by: T. Kotilainen and P. J. Aphalo.

Malcom Gladwell is a Canadian writer and reporter born in England. He has belonged to the staff of the *The New Yorker* since 1996. He is well known as author of books and articles that challenge common views on management, decision making and social dynamics (Gladwell 2001, 2006).

References

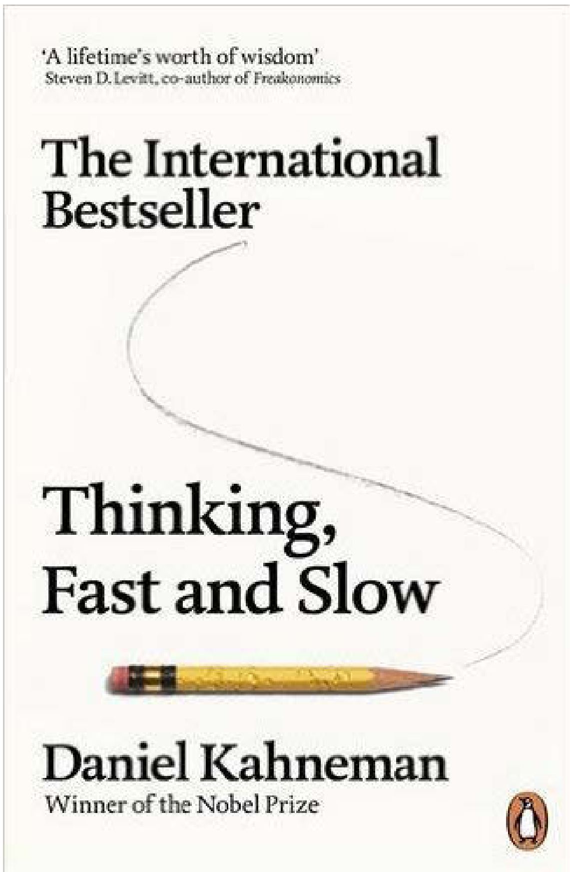
Gladwell, M. (2001). *The tipping point : how little things can make a big difference*. London: Abacus. ISBN: 0349113467.

– (2006). *Blink : the power of thinking without thinking*. London: Penguin. ISBN: 0141014598.

Book Review

Thinking, Fast and Slow (by Daniel Kahneman)

Pedro J. Aphalo, ORCID: 0000-0003-3385-972X
ViPS, Department of Biosciences, University of Helsinki, Helsinki, Finland
DOI: 10.19232/uv4pb.2016.1.92



I have found *Thinking, Fast and Slow* extremely interesting. Understanding how and why we make choices is important for everybody. If you are a scientist or aspire to be one in the future, understanding why we accept more readily some experimental results than others, why we are more comfortable with some hypotheses than others, is of fundamental importance, both to guard against bias, and to be able to present our new ideas in a way that will make them more acceptable.

If you are a teacher or aspire to be one in the future, understanding how we can make ideas easier to remember, or how to trigger rational versus intuitive functioning of the brain of those who listen to us, or those who read what we write, will be very useful.

If you are a student, you will will learn when to be on guard, to avoid intuition leading you into wrong answers. You will learn how to write in a way that triggers positive "feelings" in a reader, and why apparently unimportant things like the choice of font may affect how what you write is assessed and graded (without the person doing the grading even noticing…)

Many of these effects are usually subtle, and not too large under "normal" circumstances, but understanding how humans (and other organisms) make decisions is very important when we need to make rational decisions and aim at being objective. The book also discusses to some extent why two contrasting systems for thinking may have evolved.

There is a review of the book from a statistician's viewpoint at Patrick Burn's web site, and videos of a lecture by Daniel Kahneman on the subject of the book available in YouTube.

References

Kahneman, D. (2012). *Thinking, fast and slow.* London: Penguin Books. ISBN: 0141033576.

Edited by: T. Kotilainen and S. Siipola.

Daniel Kahneman is an Israeli-American psychologist, Eugene Higgins Professor of

Psychology, Emeritus, and Professor of Psychology and Public Affairs, Emeritus, Woodrow Wilson School, Princeton University. He was awarded the Nobel Prize in Economic Sciences in 2002. His biography at the Nobel Prize Official website sheds light on how a research career leading to a Nobel Prize can be based on a lifetime of exploration of a range of subjects rather than a focused pursuit of known target. This brings us back to Gladwell's *Outliers: The Story of Success* reviewed in this issue by Sari Siipola (Page 41).

UV4Plants

The International Association for Plant UV Research

Key aims of the UV4Plants international association are to

- promote and foster research-excellence and good practice in plant UV research through the organisation of innovative events in research, public engagement and education
- provide channels for members to inform the plant UV research community about relevant activities or events of common interest
- enhance the usefulness of plant UV research by facilitating the transfer of knowledge from academia to stakeholders and the general public
- initiate and foster stakeholder contacts as part of an agenda of product development
- liaise with scientific funding bodies to influence their research agenda
- develop with its members the benefits of membership and the relevance of the Association

The Rules of the UV4Plants association, information on membership, management committee and up-to-date news are available at `http//www.uv4plants.org`.

A new association with a history The origin of UV4Plants was the very successful COST Action FA0906 'UV4Growth' which was active from 2009 to 2014. It brought together photobiologists, molecular biologists, ecologists, meteorologists and stakeholders from agriculture and industry. Many new collaborations were started and new ideas developed.

Three large conferences, and several workshops and training events were organized. Four special journal issues were produced: *Physiologia Plantarum* **145**, 4, *Emirates Journal of Food and Agriculture* **24**, 6, *Plant Physiology and Biochemistry* **93**, and *Plant, Cell & Environment* **38**, 5.

Most participants, the members of the managing committee and the external evaluator all agreed in that a way of continuing and furthering the achievements of 'UV4Growth' was needed.

Invitation to Join UV4Plants UV4Plants welcomes a whole spectrum of members from both academia and industry, applied and basic research. Membership fees for 2016 are EUR 25.00 for students and retired staff, EUR 50.00 for academic members, and EUR 250.00 for industry members. See `http://www.uv4plants.org/news/invitation-to-join-our-association/` or contact `mailto:secretary@uv4plants.org` for details.

UV4Plants

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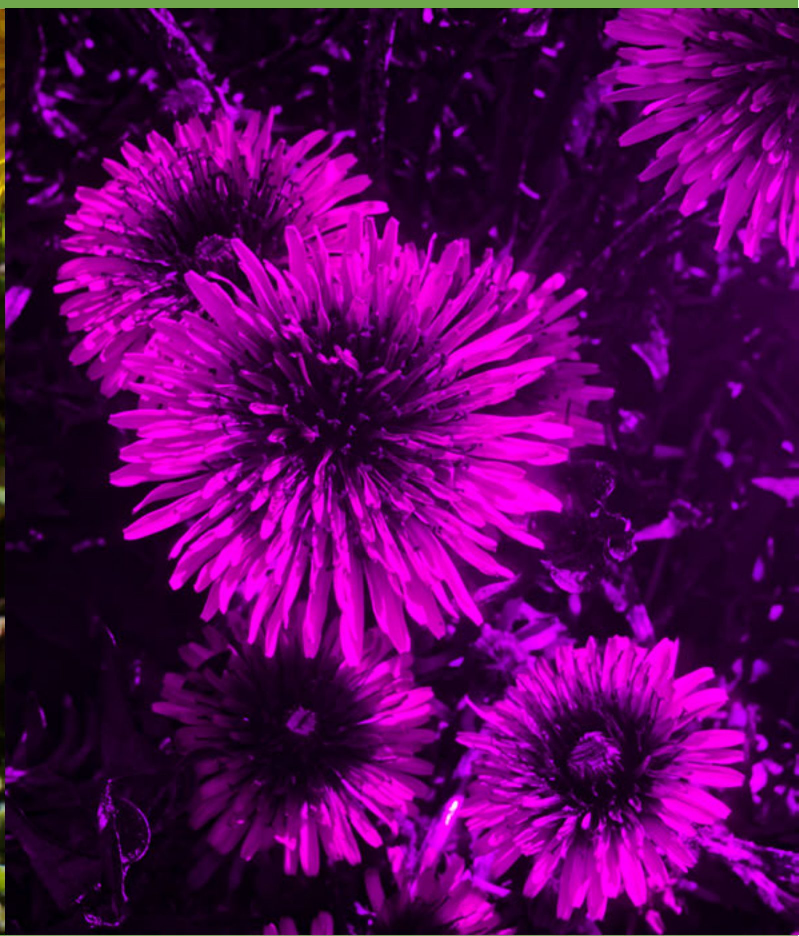

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