Mathematics-in-Industry NZ 2016

MI 20
NZ 16

4 - 8 July

Held at Victoria University, Wellington

Organised by the Mathematics in Industry NZ, Victoria University and KiwiNet

Co-Directors:	Professor Emeritus Graeme Wake FRSNZ, Massey University
	Professor Mark McGuinness
Deputy Directors:	Dr Luke Fullard, Massey University
	A/Prof Winston Sweatman, Massey University
Administrators:	Seumas McCroskery, KiwiNet Innovation Network
	Moana Pointon, Victoria University
Plenary Speaker:	Professor Andrew Fowler, Professor of Applied Mathematics, University of Limerick and University of Oxford
Guest Speakers:	Hon Steven Joyce, Minister of Business, Innovation and Employment
	Prof Mike Wilson Victoria University's Pro-Vice Chancellor of Science
	Dr Mary Quin, CEO Callaghan Innovation
	Ambassador Toshihisa Takata, Japanese Ambassador to New Zealand

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Welcome

The MINZ (Mathematics-in-Industry for NZ) group is delighted to welcome you to the second Mathematics-in-Industry for NZ - Study Group being held at Victoria University. This is a national event established to add value to our community and our industry as well as provide academic opportunities for many of us. We warmly acknowledge support from all our sponsors, but specially KiwiNet: a consortium established to foster industry links with experts such as those in the mathematics community. KiwiNet continues to provide the administrative structure to make this event happen.

This year we were fortunate to obtain support via an arrangement administered through the Royal Society of NZ (RSNZ) in conjunction with the Japanese Society for the Promotion of Science (JSPS). This has enabled strong Japanese participation in this event, and we especially welcome our colleagues from there. This award also enables a reciprocal involvement of six NZ mathematians at the similar event in Fukuoka /Tokyo in late July/early August. There is also a math challenge from companies from both countries at reciprocal workshops, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and Transpower from NZ. We thank the RSNZ and JSPS for their welcome support and opportunity to incorporate an international flavour to our study week. We have six exciting challenges put forward to the mathematical group from six dynamic and important companies**: Fonterra, Transpower, Compac, NZ Steel, Zespri,** and **JAMSTEC,** it is a pleasing mix of those that have taken part in similar events and those new to the study group concept. Thank you all.

We are very pleased to welcome many participants from around New Zealand and the world. One such guest is Professor Andrew Fowler, University of Limerick and Oxford University, we are delighted to have him here and look forward to his plenary talk, and contributions both formal and informal throughout the week ahead. The Study Group concept for Mathematics-in-Industry began in Oxford in the 1960s, (our co-director was there!!). It has now spread around the world with tremendous speed.

It is a great honor to also welcome both Hon. Steven Joyce, Science and Innovation, Tertiary Education, Skills and Employment Minister and Professor Mike Wilson, Pro Vice-Chancellor (Science), who have graciously accepted our invitation to open MINZ 2016. We also look forward to the invited talk by Dr Mary Quinn CEO of Callaghan Innovation, an agency of the NZ government there to power up innovation in business by utilizing the best R&D smarts on offer.

Co-Directors:

Professor Emeritus Graeme Wake, Massey University @ Auckland

Professor Mark McGuinness, Victoria University of Wellington

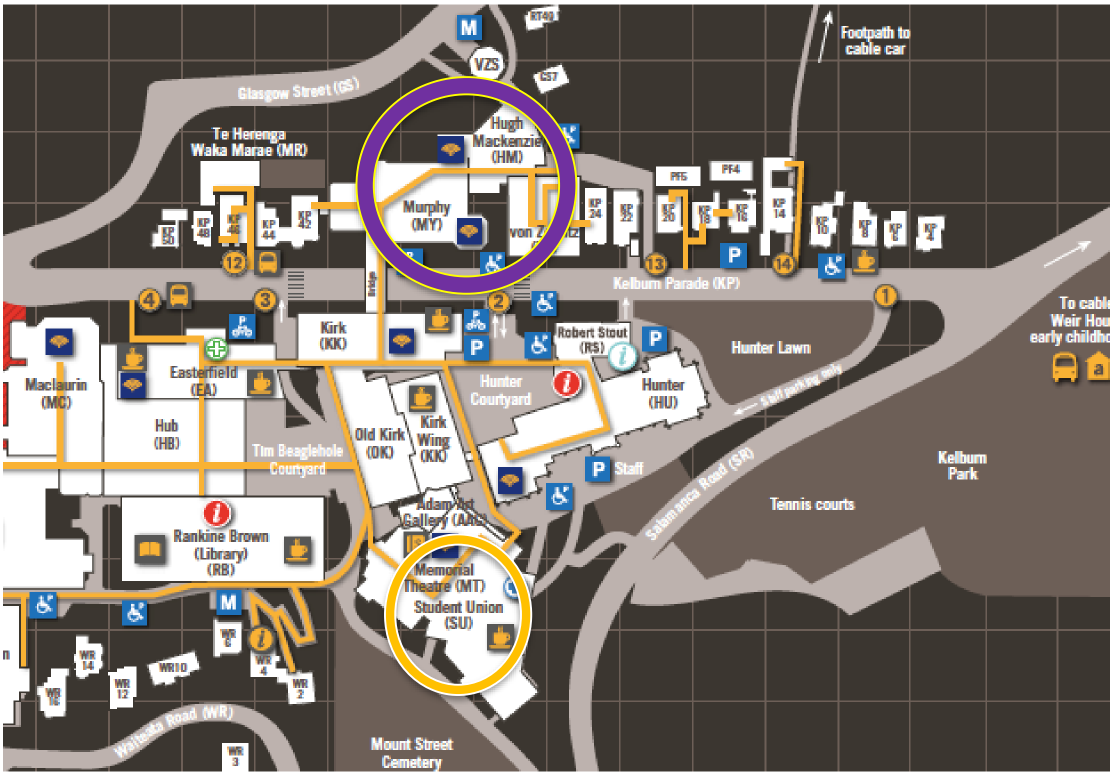
June 2016

Maps

The majority of the time we will be in the Hugh Mackenzie /Murphy Buildings (circled in Purple) at Victoria University, 4 – 8 July, 2016. There will be MINZ signage.

Note Wednesday morning (6th July) we are in the Student Union Building (Circled in Orange)

There is very little parking, it is our recommendation to take the bus to and from the University.



Challenges

Challenge 1: Transpower

Inter-regional variability of irradiance and implications for future PV generation on the power system

Challenge 2: Compac

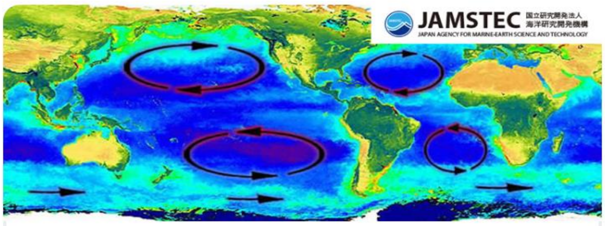
Designing a mathematical model for accurately estimating weight of a moving object from noisy & heavily biased signals involving both known & unknown sources of data contamination.

Challenge 3: Zespri

Predicting fruit quality in the supply chain from harvest to market

Challenge 4: Fonterra

Can we predict - how long we can store milk powders especially in elevated temperatures and humidities?



Challenge 5: JAMSTEC

Attempt on getting smoother probabilistic distribution of ensemble climate prediction output produced by global climate models

Challenge 6: NZ Steel

Improve the Finishing Mill Roll Gap Setup Model for our 4 stand 4 Hi Finishing Mill in NZSteel Hot Strip Mill

MINZ- Study Group Agenda

Monday 4th July

Hugh Mackenzie Building Rm HMLT205

8:00 - 9:15am	Greeting/Registration	
9:30 am – 10:30am	**Welcome** MINZ Co-directors Graeme Wake & Mark McGuiness Bram Smith, GM KiwiNet	
	Opening Address **Hon. Steven Joyce, Minister of Business, Innovation and Employment.** **Prof Mike Wilson Victoria University's Pro-Vice Chancellor of Science**	
10:30 – 10:35 am	What's coming up next – Graeme Wake	
10:35 – 10:55 am	**Morning Tea Rm MY354**	
	Industry presentations	
11:00 – 11:30 am	Transpower	
11:30 – 12:00 pm	Compac	
12:00 – 12:30 pm	Zespri	
12:30 – 1:15 pm	**Lunch Rm MY354**	
1:15 – 1:45 pm	Fonterra	
1:45 – 2:15 pm	Jamstec	
2:15 – 2:45 pm	NZ Steel	
2:45 – 3:15 pm	**Afternoon Tea**/ Group sorting	
3:15 – 5.00 pm	Initial project Meetings (Led by moderators and Industry Reps)	
Rm MY103	Breakout Room 1	Transpower
Rm MY105	Breakout Room 2	Compac
Rm MY107	Breakout Room 3	Zespri
Rm MY531	Breakout Room 4	Fonterra Ltd
Rm MY631	Breakout Room 5	JAMSTEC
Rm MY632	Breakout Room 6	NZ Steel
5.10 - 7:00 pm	Informal Reception Rm MY354	

Tuesday 5th July

Hugh Mackenzie Building

Project working sessions as determined by the moderators and posted on noticeboards etc

8.30 – 5.00 pm

Rm MY103	Breakout Room 1	Transpower
Rm MY105	Breakout Room 2	Compac
Rm MY107	Breakout Room 3	Zespri
Rm MY531	Breakout Room 4	Fonterra Ltd
Rm MY631	Breakout Room 5	JAMSTEC
Rm MY632	Breakout Room 6	NZ Steel

5:15pm – 7pm Student get-together @ MY632 (Pizza and drinks provided)

Informal talk by Prof. Graeme Wake

Wednesday 6th July

Student Union Building SUMT228

9:00 – 9:05 am	Feedback on Challenge 1
9.05 – 9:10 am	Feedback on Challenge 2
9.10 – 9:15 am	Feedback on Challenge 3
9.15– 9.20 am	Feedback on Challenge 4
9.20 – 9.25 am	Feedback on Challenge 5
9.25 – 9.30 am	Feedback on Challenge 6

9:30 – 9.50 am Invited Speaker – Dr Mary Quin CEO Callaghan Innovation

9.50 – 10.30 Plenary Speaker – Professor Andrew Fowler, and Limerick Universities

10:30 – 10.50 Morning Tea

Back to Hugh Mackenzie Building

Rm MY103	Breakout Room 1	Transpower
Rm MY105	Breakout Room 2	Compac
Rm MY107	Breakout Room 3	Zespri
Rm MY531	Breakout Room 4	Fonterra Ltd
Rm MY631	Breakout Room 5	JAMSTEC
Rm MY632	Breakout Room 6	NZ Steel

12.30 – 1.00 pm	Lunch	Rm MY354
2.30 – 2.50 pm	Afternoon tea	Rm MY354

6:00 – 9.00 pm Informal Dinner – Wellesley Boutique Hotel
2-8 Maginnity Street Wellington

In honour of our Visiting mathematicians from Japan, we are privileged to have the Japanese Ambassador to New Zealand, Toshihisa Takata address us at the beginning of dinner (6:30pm).

Thursday 7th July

Hugh Mackenzie Building

Project working sessions as determined by the moderators and posted on noticeboards etc

8.30 – 5.00 pm

Rm MY103	Breakout Room 1	Transpower
Rm MY105	Breakout Room 2	Compac
Rm MY107	Breakout Room 3	Zespri
Rm MY531	Breakout Room 4	Fonterra Ltd
Rm MY631	Breakout Room 5	JAMSTEC
Rm MY632	Breakout Room 6	NZ Steel

10:30 – 10.50	Morning Tea	Rm MY354
12.30 – 1.00 pm	Lunch	Rm MY354
2.30 – 2.50 pm	Afternoon tea	Rm MY354

Friday 8th July

Hugh Mackenzie Building Rm HMLT205

Project moderators reports on progress and recommendations followed by comments from Industrial representatives

9:00 – 9:05 am	Short address by Co-directors Prof. Emeritus Graeme Wake & Prof. Mark McGuiness
9:05 – 9:10 am	Short address by Dr Seumas McCroskery, KiwiNet Innovation Manager
Challenge Summaries	
9:10 – 9:30 am	Transpower (Moderator/Group + Industry rep)
9:30 – 9:50 am	Compac (Moderator/Group + Industry rep)
9:50 – 10:10 am	Zespri (Moderator/Group + Industry rep)
10:10 – 10:50 am	Morning Tea
10:50 – 11:10 am	Fonterra Ltd (Moderator/Group + Industry rep)
11:10 – 11:30 am	JAMSTEC (Moderator/Group + Industry rep)
11:30 – 11:50 pm	NZ Steel (Moderator/Group + Industry rep)
11:50 – 12:00 pm	Closing remarks by the Co-director Prof. Mark McGuiness
12:00 – 1:00 pm	Lunch
1:30	Finish

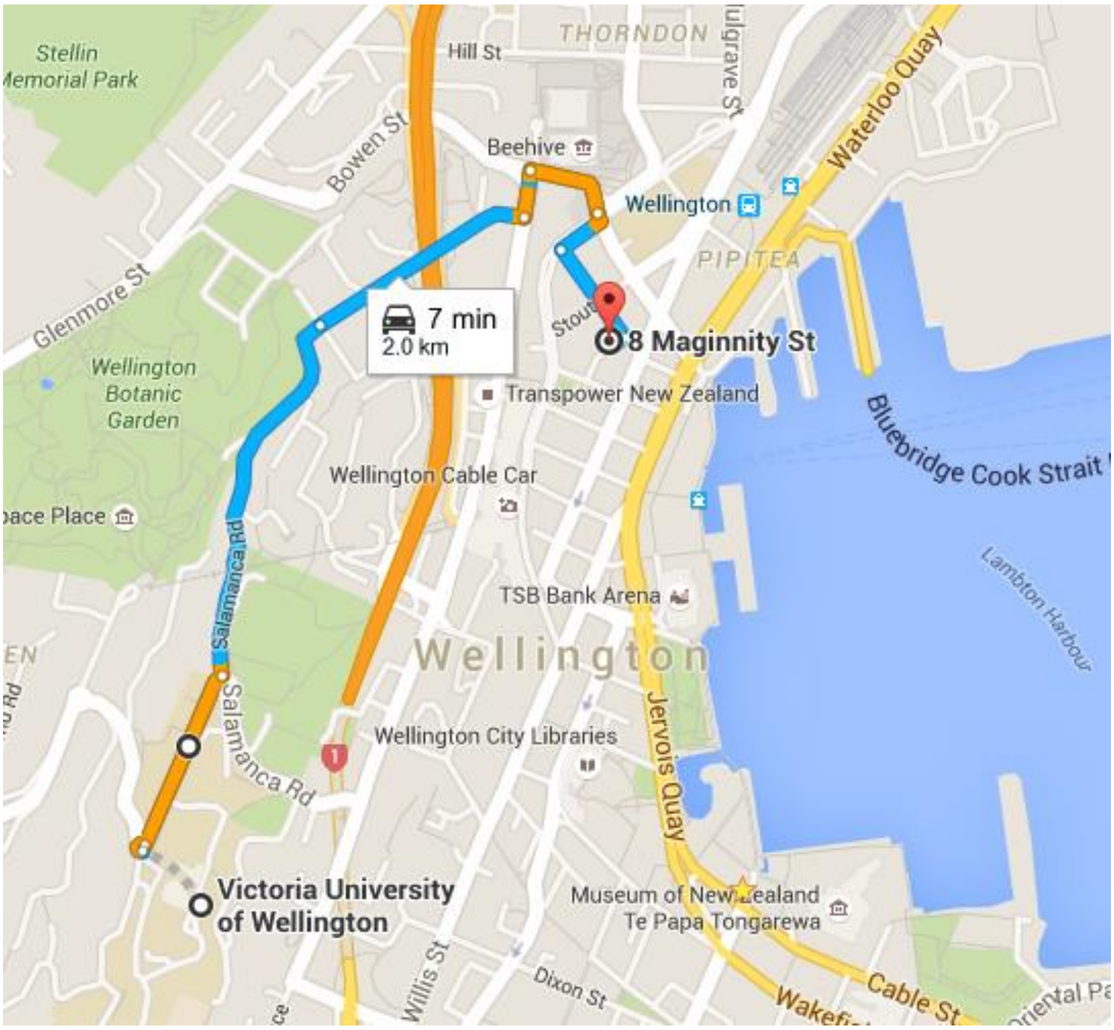
Note we are expecting Yr 12 and 13 Science/Math/Tech students to come listen to the closing summaries.

Other Information

Informal Dinner

The informal MINZ dinner is being held at Wellesley Boutique Hotel, which is located 2-8 Maginnity Street, Wellington.

There will be a shuttle bus available from the Victoria University, which will depart 5.30pm sharp. It will leave from the bus stop on Kelburn Pde (Look for MINZ signage).



On campus Internet Access

Look to the white board in break out rooms for internet access.

Challenge Outlines

Challenge 1 – Transpower

Moderators: Barry McDonald, Massey University
Jamas Enright, Stats Department

Student Moderator: Sheng Gong, Massey University

Industry Representative: Tim Crownshaw
Conrad Edwards

Title: Inter-regional variability of solar irradiance and implications for future solar PV generation on the New Zealand power system

Background

The group will investigate the likelihood and corresponding magnitude of changes to net transmission flows between region interfaces that could arise from potential PV generation, taking into account all possible combinations of weather states by region. The key analysis steps are outlined below:

1. Determine all possible two-group allocations of all 16 council regions in NZ, across region interface boundaries. Reduce these allocations to interfaces where transmission assets exist.

2. Specify PV capacity allocation between regions stochastically based on census data, with equal W/person and current regional W/person values setting feasible PV uptake limits.

3. Develop a methodology for simulating the spatial aggregation of point-source PV sites to determine representative regional curves.

4. Analyse normalised PV generation data for each of the region groupings, taking into account uncertainty in regional PV capacity allocations, to determine the probability and magnitude of transmission MW changes.

5. 'Map' the 16 region analysis to geographic divisions more relevant to Transpower, ie. the 14 GOS zones.

6. Evaluate the greatest risk (given by the product of probability and impact) inter-region variability induced imbalances for further discussion and analysis.

7. Carry out additional analysis using these results, e.g. test correlation against various other time series data (wind & hydro resource, prices, HVDC transfers) to draw some high-level conclusions about potential impacts.

The problem scope will be refined based on preliminary results and any opportunities identified over the week.

Data required

- Irradiance derived PV generation data (normalised W generated/W installed per 10 minute period at 16 regional sites over 16 years), including site co-ordinates
- Census data for population by region and population density
- Transpower network asset map and GOS zone boundaries
- Other: historical wind generation, hydro inflows, wholesale market prices, HVDC transfers etc.

All data is publically available or has already been procured by Transpower.

Benefits

The study will produce a statistically robust quantification of potential inter-region net transmission changes induced by possible future PV generation, under expected irradiance variability. This will identify high risk net demand imbalances and correlate these with the relevant market data.

This information, or a similar, will be required in future Transpower work. Future studies will directly reference the results of the study, particularly in regard to:

- Evaluating thermal constraints on the 110 kV network
- A methodology for simulating the spatial aggregation of PV sites over regions based on available point-source data
- Transmission MW changes and associated probability functions for power flow studies
- Likely region level PV generation magnitudes

The final report will provide a methodology for dealing with inter-regional irradiance variability which can be reused in later investigations with up to date data. The report will also cover study assumptions, results and high-level conclusions. Any mathematical models or algorithms developed will be supplied for further analyses carried out by Transpower.

No specific power system implications will be inferred as this is likely excessively technical for the MINZ format. However, areas for further study may be identified.

Challenge 2 – Compac

Moderators:	Prof. Mark McGuiness, Victoria University Stefanie Gutschmidt, University of Canterbury
Student Moderator:	Will Munn, Victoria University
Industry Representatives:	Andrew McIntyre Yaniv Gul

Title Estimating the Weight of a Moving Article Across Multiple Weigh Points

Background

The problem stated here aimed at designing a mathematical model for accurately estimating weight of a moving object from noisy and heavily biased signals involving both known and unknown sources of data contamination.

Problem

To design a mathematical model for accurately estimating an article's weight when it is supported by multiple points that are weighed at different times, on a rapidly moving conveyor system.

The main challenge arising from the proposed weighing system design is related to the fact that as different (contact) points where an article is supported, on the conveyor, pass over a load cell, the load cell is required to flex in order to get a reading of the weight. It is this flexing of the load cell, which will potentially redistribute some weight to other supporting points during the weighing process.
Also, as linear speed across the weighing platform is increased, the time available for 'transition onto load cell' vibrations to dissipate is reduced.
In order to double the time period for weighing on the load cell, we have a system where we can weigh two consecutive weigh points at the same time on separate load cells. The data from this system and a single-load cell system will be provided for comparison.

Desired Outcomes

- Propose a model for estimating article weight from the provided datasets, which is robust to the article position and weight distribution on the weigh points.

- Determine the theoretical weighing accuracy expected at a range of speeds, including the maximum linear speed for which we can achieve sufficient weighing accuracy (will be specified).
- Compare the accuracy of the two-load cell system with the single-load cell system.

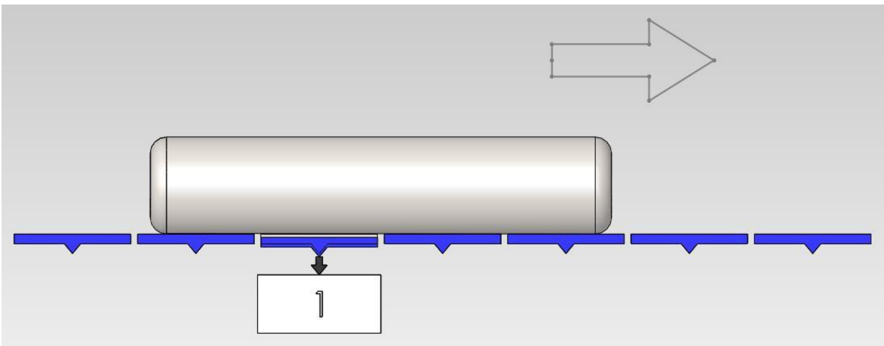
Data

- Two sets of load cell data available as the weigh points pass over the load cell(s) carrying articles under different parameters:
  1. A single load cell that weighs each weigh point one after another.
  2. Two load cells creating alternating weigh points to allow longer weighing time.
- Static weights obtained from the above two system settings.
- Deflection of load cells under certain loads.
- Physical length of the different weigh sections (load cell plates).
- Weight of the weigh points themselves

System Diagram

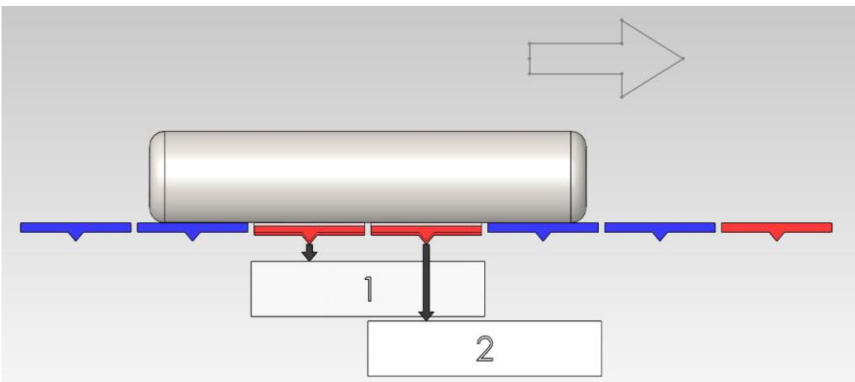
Single Load Cell

Below shows an article which has four supporting points with one supporting point getting weighed on a single the load cell.



Dual Load Cell

Below shows an article which has four supporting points with the two red supporting points getting weighed on separate load cells. Both the red supporting points will start and stop weighing at the same time. The red and blue colours indicate the pairs of points which get individually weighed at the same time.



Challenge 3 – Zespri

Moderators:	Robert Davies, Statistics Research Associates Nokuthaba Sibanda, Victoria University
Student Moderator:	Lindsay Morris, Victoria University
Industry Representatives:	John White, Matt Adkins Frank Bollen

Title: Predicting fruit quality in the supply chain from harvest to market.

Problem specification

- Two varieties
- Orchards harvested over a range of maturities and different orchard have different quality and storage potential
- Fruit shipped over a 6 month period
- Orchards have to be shipped to arrive in the market in good condition – getting the shipping order optimized is the secret to a successful season
- Knowing what lines to prioritise for shipping is only generally known. There are often lines that do not perform according to expectations and being able to predict which lines are unlikely to meet their potential (or more correctly, perhaps, accurately predict their potential) has potentially major benefits to the industry.
- Features of this data are partial information, noisy data due to the fact information is based on small sample sizes

Possible outputs

- New analytics and tools for analyzing complex fruit quality data
- Improved designs for the sampling and monitoring systems
- Optimisation of the quality prioitising process

Data available

- Harvest quality parameters for all orchards in New Zealand
- Monitoring data during storage
- Quality information at various points along the supply chain

Challenge 4 – Fonterra Ltd

Moderators: Luke Fullard, Massey University
Steve Taylor, University of Auckland

Student Moderator: Mr Ruanui Nicholson, University of Auckland

Industry Representatives: Scott Rusby
Scott Walbran
Jamie Heather
Dr Kate O'Byrne

Dairy for life

Title: Can we predict - how long we can store milk powders especially in elevated temperatures and humidities?

Background

Fonterra Co-operative Group is the world's larger exporter of dairy products, owned by around 10,500 New Zealand dairy farmers and a leading multinational dairy company. The Fonterra Group's global supply chain stretches from Fonterra's shareholders' farms in New Zealand through to customers and consumers in more than 100 countries. Collecting around 15 billion litres of New Zealand milk each year along with around 6.5 billion litres sourced globally, Fonterra manufactures and markets over 2 million tonnes of product annually. This makes the Fonterra Group the world's leader in large scale milk procurement, processing and management, with some of the world's best known dairy brands.

Fonterra continue to focus on our quality and food safety infrastructure, ensuring that we identify and remain ahead of emerging food safety risks. One such risk is product deteriorating whilst in storage. In the case of milk powder the risks are minimised by nature of the drying process and appropriate packaging and handling of the finished goods, but there will always be some deterioration in storage and require a method for assessing what the commercial shelf-life really is

Problem for MINZ:

Milk powder is a very complex material whose sensory properties change with time and it is the possible development of taints corrupting the powder – either through chem/micro reactions within powder or coming through the packaging membrane from the storage environment. The kinetics of these reactions are not well known and as a result generic storage rules have developed such as store below

25C for now longer than x months have been developed and used, but increasingly there is desire to better define these rules and establish shelf-lives for product stored in less than ideal conditions

Factors that might influence the shelf life might include

- Chemical (and microbiological) composition of the powder.
- Levels and types of fortification (eg calcium, iron, zinc, vitamins)
- Powder physical properties
- Packing material properties
- Packing configuration (arrangement of bags on pellet, pellets in shipping containers/warehouses etc)
- Environmental conditions during storage/transit, including temperature, humidity
- Seasonal effects
- Cattle feed, including supplements

While there is some data from historic storage trials this data is often of limited use as often at only NZ ambient conditions and often using powder stored at laboratory scale (not 25kg or larger bags). Processing technologies have also developed significantly and both the gross and micronutrient nature of milk powders has changed so cannot be applied to commercially stored product, but may be possible to develop a crude “overall powder quality”

Some customer complaint data is also available, but this too is of limited value as often there is insufficient knowledge of how the powder was stored or transported to assess

From the workshop we would like a model to be produced, taking into account a number of the above factors, that will provide us with an estimate of the true shelf-life. This may include assessing if an overall powder quality parameter can create as a surrogate for each individual quality measurement and if a realistic worst case kinetic model for this can be constructed. Alternatively, taking a more statistical approach, to look at the type of experimental design that best suited for a shelf-life trial that can take into account many of the aspects and while this is very likely to be along the lines of a fractional factorial split-plot type design with repeated time measurements are there alternative experimental designs that more appropriate

Challenge 5 – Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Moderators: Dimetre Triadis, La Trobe University
Prof. Robert McKibbin, Massey University

Student Moderator: Anton Gulley, University of Auckland

Industry Representative: Hirofumi Sakuma

Project 1 Title: Attempt on getting smoother probabilistic distribution of ensemble climate prediction output produced by global climate models

Background

Reflecting grave concern on the global environmental degradation relating probably to anthropogenic warming, the application of short-term climate information or seasonal prediction to various societal activities is now gathering momentum. After a decade of the world-leading short-term climate variability prediction studies, especially on the important tropical variability such as ENSO and IOD which exerts a tremendous societal impact on Asia-Oceania regions (Fig. 2), JAMSTEC had launched application studies using the outcome of a state-of-the-art climate model SINTEX-F (Fig. 1). This activity is in accord with the third world climate conference (WCC-3) high-level declaration on the establishment of a global framework for climate services and, so far, we have been promoting agricultural applications through collaborating with domestic as well as such international institutions as IRRI

Fig.1: A schematic view of SINTEX-F model and an example of its ensemble prediction on IOD.

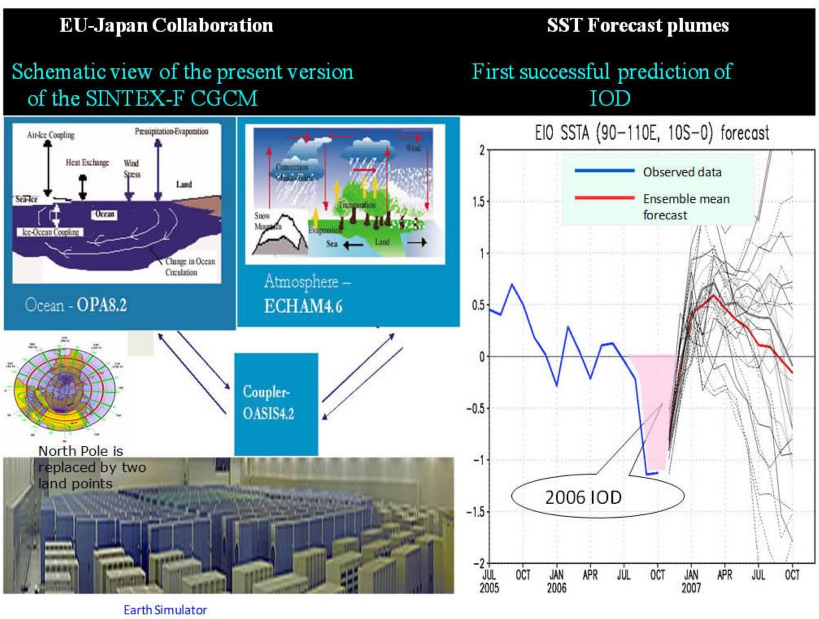


Fig. 2: Huge societal impact caused by 2006 IOD

Challenge overview

State-of-the-art (short-term) climate predictions issued by the world-leading operational centers and JAMSTEC APL are the outcomes of sophisticated climate models (coupled atmosphere and ocean models) that run on super-computers equipped with huge data storage. Needless to say, for global climate studies and predictions, a global model is an inevitable research tool, however, from the view point of application studies, we can safely say that, in almost all cases, a set of time series data on (or around) a specified grid point, as is illustrated in the right panel of Fig. 1, are all we need for the studies. Totally independent of this aspect of application studies, as a part of cutting-edge research efforts in improving the quality of prediction by enhancing computing capability, considerable increase of ensemble members of climate models aiming at having better probabilistic distributions of climate variables is now in the planning stage.

Taking these two different aspects of the ongoing activities in climate study community into consideration, it seems to deserve considering a possibility that simulated ensemble outputs illustrated in Fig. 1 may be further refined (to have smoother probability density distribution) in a certain approximate sense by utilizing advanced knowledge on, say, filtering of statistical modeling, of which performance will be evaluated later by direct simulations with a larger number of ensemble. The aim of studying such a possibility is clear. Obtaining smoother probabilistic distributions of climate variables even in an approximate sense without running costly super-computers is quite desirable from the view point of application studies as well as the dissemination of climate prediction output to general public.

Springboard for discussion and goal

As a speculative draft of such an attempt, I am going to provide a statistical model as a testbed of our discussion. The details of the model will be given later at the workshop. At present, here we describe a basic idea of the statistical model. We start from a simple fact that no further information is available other than ensemble time series data provided from a given climate model. To extract meaningful structural information from a given finite-length time series data without adding artificial information, we can employ the Maximum Entropy Method (MEM) by Burg. It can be shown that a give finite-length time series data can be approximated by a generalized trigonometric series whose frequencies are determined through MEM and the approximation is done in a least-square sense. That is to say, a given finite-length time series data is transformed into the sum of a generalized trigonometric series with suitable length (a deterministic part which contains the information on important climate mode in terms of frequencies) and a Gaussian noise term that may be interpreted as a simplified model of intrinsic chaotic behaviour of climate. Thus, for each ensemble member of the output of a given climate model, we can specify a "statistical sub-model" having a deterministic as well as a non-deterministic noise term which can be run as many times as we want. Simple addition or a collection of these sub-models leads to a targeted statistical model that would produce a smoother probabilistic distribution. As the number of ensemble provided by a climate model increases, the difference between the original output of climate model and that of the transformed statistical model would converge, so that the above model could be a candidate of the targeted model. Of course, there would be other better ways to have such statistical models and the real challenge or goal is, if possible, to identify a measure to evaluate the performance of candidate models.

Project 2 Title: Plant population issues in ecology

Background

In natural vegetation, a plant population is composed of individuals hav- ing various sizes (e.g. plant weight, plant height, and stem diameter) and competing with other individuals for resources such as light, nutrients, water and so on. To investigate how competition and coexistence processes emerge from such a complex system is one of the most interesting subjects in plant ecology. Furthermore, to investigate size-structure dynamics and species co- existence conditions in plant communities is important for applied biological sciences such as agriculture and forestry.
Many models so far proposed for the study of growth dynamics in plant populations divide into two categories, spatial and non-spatial models. Most of these models consider interactions between individuals based on the growth of each individual in a population. Spatial models take into account spatial distributions of individuals, whilst

non-spatial models do not, assuming that the spatial distribution of individuals is homogeneous.

Model

Let us consider an even-aged plant population which grows in a homogeneous environment, i.e. the plants have the same size distribution per unit area at any place in the stand we consider. Let f (t, x) be a distribution density of individuals of plant size x (e.g. plant weight, height and stem diameter) per unit area at time t. It is assumed that the basic equation governing the dynamics of f (t, x) is given by:

$$\frac{\partial f(t,x)}{\partial t} = \frac{1}{2}\frac{\partial^2}{\partial x^2}[D(t,x)f(t,x)] - \frac{\partial}{\partial x}[G(t,x)f(t,x)] - M(t,x)f(t,x) \quad (1)$$

where G(t, x) and D(t, x) are the mean and variance of growth rate in plant size, x, respectively, and M (t, x) is the mortality rate. The diffusion term may be important for a long-term simulation in which the statistical variability of growth rate may largely affect the size distribution (Hara, 1984). Here, we consider an even-aged plant population without the recruitment, i.e. zero birth rate, then impose the boundary condition.

$$f(t,A) = f(t,B) = 0 \quad (2)$$

$$0 \le A \le x \le B < \infty, 0 \le t < \infty$$

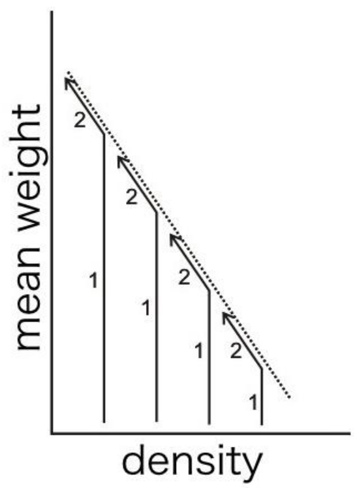
Additionally, $J = G(t,x)f(t,x) - (1/2)\partial[D(t,x)f(t,x)]/\partial x = 0$, at $x = A, B$.

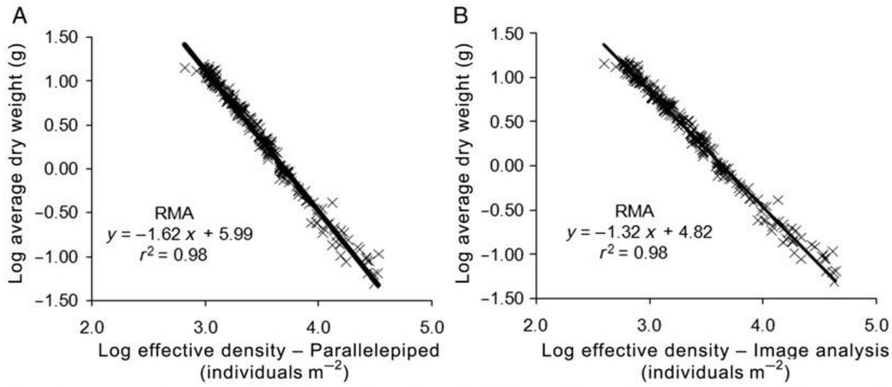
Self-thinning rule

Yoda et al. (1963) proposed the so-called '-3/2 power law of self-thinning', which states that the relationship between mean plant weight, $\bar{x}$, and density, ρ, is given as

$$\log \bar{x}(t) = \log K + c \log \rho(t) \quad (3)$$

where K and c are constants and c ~ −3/2 irrespective of species and conditions (see also Westoby, 1984; White, 1981).





Dry weight of individual mussels vs culture density, and linear fits performed by RMA, where N is the effective density calculated from the projected area of the parallelepiped (A), and where N is the effective density calculated from the image analysis (B). In both cases, only RMA is shown because the SFF estimates identical parameters and the likelihood value is less than that obtained using RMA. ANCOVA following Zar (1984) was performed to compare the exponents observed in the present study with theoretical values for FST and SST (−4/3 and −3/2, respectively).

http://mollus.oxfordjournals.org

Problem

From eq.(1), the density ρ(t) and the mean weight x¯(t) are given as follows:

$$\rho(t) = \int_A^B f(t,x)dx \qquad (4)$$

$$\bar{x}(t) = \int_A^B x f(t,x)dx \qquad (5)$$

Let us assume the empirical *D* and *G* function forms, while several types of function forms are proposed and *G* function can be formulated theoretically based on canopy photosynthetic processes.
For *D* function,

$$D(t,x) = \sigma^2 \qquad (6)$$

$$D(t,x) = \sigma^2 x^2 \qquad (7)$$

For *G* function,

$$G(t,x) = x(a_0 - a_1 x^m) \qquad (8)$$

$$G(t,x) = x\{a_0 - a_1 x^m - a_2 \int_x^B z^n f(t,z)dz\} \qquad (9)$$

And for M function, as it should M (t, x) → 0 as x → ∞, we can assume the function form as follows:

$$M(t,x) = \exp(a + bx) \qquad (b < 0) \qquad (10)$$

Then, are there some restrictions among functions, *D, G, M* and *f*?, when a plant population develops obeying the self-thinning rule (eq.(3)).

Assuming the empirical functions of D, G and M as eqs (6)-(10), what we want to know is the relationships among coefficients, σ2, a_0, a_1, a_2, a and b and the distribution density *f* (t, x) for each combination of function forms.

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Challenge 6 – NZ Steel

Moderators:	Ass.Prof. Winston Sweatman, Massey University Adj. Prof. Graham Weir, Massey University
Student Moderator	Mr Ruanui Nicholson, University of Auckland
Industry Representatives:	Isaac Loh Rory Kimber, Kevin Niederberger, Robert Bebelman

Title: Improve the Finishing Mill Roll Gap Setup Model for our 4 stand 4Hi Finishing Mill in NZSteel Hot Strip Mill

Background

NZS Hot Strip Mill Plant (HSM) has the requirements to improve our Finishing Mill Roll Gap Setup to achieve on-gauge for the Head End of bar. The performance of our Gauge hasn't been good in our head-end.
Currently:-

- NZS HSM has a Finishing Mill Roll Gap Model (from Toshiba) that predicts the gap required for each stand to achieve the head-end strip thickness.
- This Finishing Mill Roll Gap Model will then send a command to setup the gaps in the rolls for each stand in our HSM
- This Finishing Mill Roll Gap Model works well in Short Term Learning (Bar to Bar on same chemistry and product dimensions) but not Long Term Learning.

Challenge

Can a Model be designed to produce an accurate predicted finishing mill roll gap to achieve output thickness of hot strip to be within the specification required by customer. With this model, reduce the non-prime products due to thickness out of specification.

Requirements

Setup Roadmap to understand the current model and opportunity.
New Roll Gap Model based on all known process variable for achieving accurate on-gauge in Short Term Learning and Long Term Learning.

New Roll Gap Model must be robust with capability:

- For Process Engineers to fine-tune in future.
- Capable of handling multiple input chemistries, dimensions and running conditions of the plant.
- Ability to be integrated into our current PLC language.

Improvement of non-prime products due to thickness out of specification by 20%

Attendees

As at 13 June 2016

First name	Last name	Posiiton	Organisation
Nurudeen Adedayo	Adegoke	Ph.D Student	Massey University New Zealand
Matt	Adkins	Innovation Leader - Fruit Physiology	Zespri
Nirmal D	Aggarwal	Chair & Professor of Mathematics	Embry-riddle Aeronutical University
Maryam	Alavi	Post-doctoral Research Fellow	University of Auckland
Seyedvahid	Amirinezhad	PhD student	Victoria University of Wellington
Boris	Baeumer	Associate Professor	University of Otago
Gari	Bickers	Market Technologies Specialist	Transpower
Frank	Bollen	Technical Project Manager	Zespri
Pieta	Brown	Chief Analytics Officer	Lab360
Nadeem	Caco	Masters student	Massey University
Vincent James	Carroll	Postgraduate student	Victoria University of Wellington
Pierluigi	Cesana	Lecturer	La Trobe University
Valerie	Chopovda	Student	Massey University
Hyuck	Chung	Lecturer	Auckland University of Technology
Richard	Clarke	Senior Lecturer	University of Auckland, Dept Engineering Science
Daniel	Clarke	PhD Student	University of Canterbury
Terry	Collins-Hawkins	Student	University of Otago
Rob	Crawford	Business Assurance and Compliance Lead	Fonterra
Tim	Crownshaw	Market Operations Analyst	Transpower
Rose	Davies	Lecturer	School of Aviation, Massey University
Robert	Davies	Statistician	Statistics Research Associates

Glauce	De Souza	Technical Team Lead Powders	Fonterra
Kevin	Duckworth	Business Manager	Transpower
Rotem	Edwy	Student	Auckland University of Technology
Jamas	Enright	Statistical Analyst	Statistics New Zealand
Yasuhide	Fukumoto	Professor	Kyushu University
Luke	Fullard	Postdoctoral Fellow in mathematics	Massey University
Tony	Gibb	Director	Adelaide Advanced Engineering
Matthias	Glomsda	Postgraduate Student	Massey University, Albany
Sheng	Gong	PhD student	Massey University
Jonathan	Goodman	PhD Student	University of Canterbury
Emma Elizabeth	Greenbank	Phd student	Victoria University of Wellington
Saima	Gul	Student	Massey University Palmerston North
Anton	Gulley	PhD Student	University of Auckland
Stefanie	Gutschmidt	Senior Lecturer, Dynamics	University of Canterbury
Lisa	Hall	Research Statistician	Fonterra
James	Hannam	PhD student	University of Auckland
Mahrita	Harahap	Student	University of Technology Sydney
John	Harper	Emeritus Professor	Victoria University of Wellington
Noh	Heesang	Doctoral Program	KAIST
Gordon	Hiscott	Student	University of Otago
Ashley	Hoskin	Professional Engineer	Fonterra
Soomin	Jeon	Student	KAIST
Jamie	Jordan	Investigations Engineer	Transpower
Hohyun	Jung	Ph.D. Candidate	KAIST
Wanmo	Kang	Professor	KAIST
Deepak	Karunakaran	PhD student	Victoria University of Wellington
Bernd	Krauskopf	Professor	University of Auckland
Celia	Kueh	Postdoctoral Fellow	Massey University

June-yub	Lee	Professor	Ewha University
Chang-Ock	Lee	Professor	KAIST
Jong Mun	Lee	Student	KAIST
Minghao	Li	Lecturer	Univeristy of Canterbury
Gerrard	Liddell	Retired	University of Otago
Xudong	Liu	Student	Auckland University of Technology
Isaac	Loh	Technical Superintendent Rolling Mills	NZ Steel
Daniel	Lond	Postdoc	University of Canterbury
John H	Maindonald	Retired visiting fellow, Math Sci, Inst.	The Australian National University
Seumas	McCroskery	Innovation Manager	KiwiNet
Barry	McDonald	Senior Lecturer	Massey University (Albany)
Mark	McGuinness	Professor of Applied Mathematics	Victoria University of Wellington
Andrew	McIntyre	Mechanical Design Engineer	Compac
Robert	McKibbin	Professor of Applied Mathematics	Massey University, Auckland
Dimitrios	Mitsotakis	Senior Lecturer	Victoria University of Wellington
Lindsay	Morris	Student	Victoria University of Wellington
William	Munn	Student	Victoria University of Wellington
Alireza	Nejati	Research Fellow	University of Auckland
Ha	Nguyen	Student	Victoria University of Wellington
Ru	Nicholson	Ph.D. student	University of Auckland
Jeff	Nijsse	Lecturer (Physics)	Auckland University of Technology
Yoshiyuki	Ninomiya	Associate Professor	Kyushu University
Sione	Paea	Lecturer	The University of the South Pacific
Michael	Plank	Associate Professor	University of Canterbury
Krishna Sami	Raghuwaiya	Assistant Lecturer	University of the South Pacific

		in Mathematics	
Jai	Raj	Student Learning Specialist	University of the South Pacific
Osamu	Saeki	Professor	Kyushu University
Hirofumi	Sakuma	Principal Scientist	JAMSTEC.
Nokuthaba	Sibanda	Lecturer	Victoria University of Wellington
Vinai K.	Singh	Professor	Raj Kumar Goel Institute of Technology
Rowan	Sprague	PhD student	Bio-Protection Research Centre at Lincoln University
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Steve	Taylor	Senior Lecturer	University of Auckland
Atsushi	Tero	Associate Professor	Kyushu University
Jean	Thompson	Applied statistician	JAD Associates
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			Technology
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