Mathematics-in-Industry Study Groups in Australia, New Zealand (and Japan)

Winston L. Sweatman

Massey University

The annual Mathematics in Industry Study Groups (MISG) in Australia began in 1984. My first experience was in 2004 when this meeting moved to New Zealand for three years. I have been fortunate to attend nearly every year subsequently. Since 2015, study groups have been regularly held in both countries (MISG in Australia and MINZ in New Zealand). I will describe some projects and the 2016 exchange between New Zealand and Japanese MISGs.

What is an MISG?

(in Australia/New Zealand)

- Mathematics-in-Industry Study Group
- One week's duration
- Projects brought by industry (typically 4 to 7)
- Industry representatives stay the whole week
- Small teams of workers on each project
- Groups led by moderators, responsible for coordination and reporting (midway and at end)
- Discussion and idea generation
- INSTRUCTIVE and LOTS OF FUN

The mathematical modelling of cheese ripening

Winston L. Sweatman[1] Steven Psaltis[2]
Steven Dargaville[3] Alistair Fitt[4] Tony Gibb[5]
Brodie Lawson[6] Kaye Marion[7]

(Received 29 July 2014; revised 29 July 2014)

Abstract

A mathematical model is developed for the ripening of cheese. Such models may assist predicting final cheese quality using measured initial composition. The main constituent chemical reactions are described with ordinary differential equations. Numerical solutions to the model equations are found using Matlab. Unknown parameter values have been fitted using experimental data available in the literature. The results from the numerical fitting are in good agreement with the data. Statistical analysis is performed on near infrared data provided to the MISG. However, due to the inhomogeneity and limited nature of the data, not many conclusions can be drawn from the analysis. A simple

Final Papers are published in the ANZIAM Journal (E)

Some Recent Australian/New Zealand Study Groups (That I participated in)

- New Zealand: Massey University (Auckland): 2004, 2005, 2006;
- Australia: University of Wollongong: 2007, 2008, 2009; RMIT: University 2010, 2011, 2012; QUT (Queensland University of Technology): 2013, 2014, 2015; University of South Australia: 2016, 2018;
- New Zealand (MINZ): Massey University: 2015; Victoria University of Wellington: 2016; AUT (Auckland University of Technology): 2018; University of Auckland: 2019;

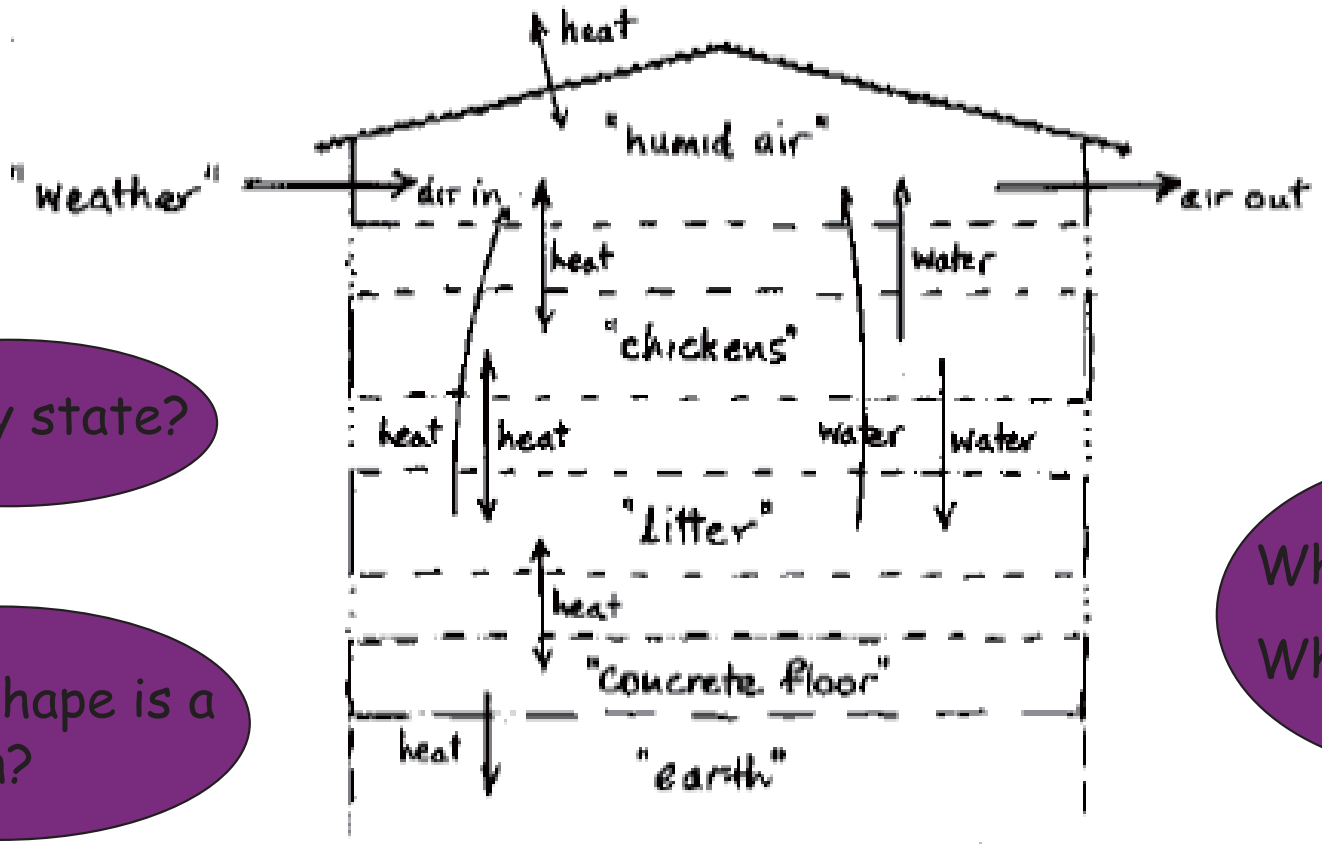
MISG at Massey University, Auckland, Industry Partners:

- 2004: New Zealand Steel, Transpower, Compac Sorting Equipment, Environment Canterbury, Solid Energy NZ, **NRM/Tegel**,

- 2005: New Zealand Steel, Transpower, Compac Sorting Equipment, Environment Canterbury, Fisher & Paykel, **Backyard Technology**, Lincoln Ventures Ltd/Plant Protection Chemistry NZ,

- 2006: New Zealand Steel, Transpower, Fisher & Paykel, Ensis Ltd, **Plant Protection Chemistry NZ**, Crop & Food Research Ltd, Centre for Water in the Minerals Industry

MISG 2004 Chicken shed – a mass and energy balance problem



Steady state?

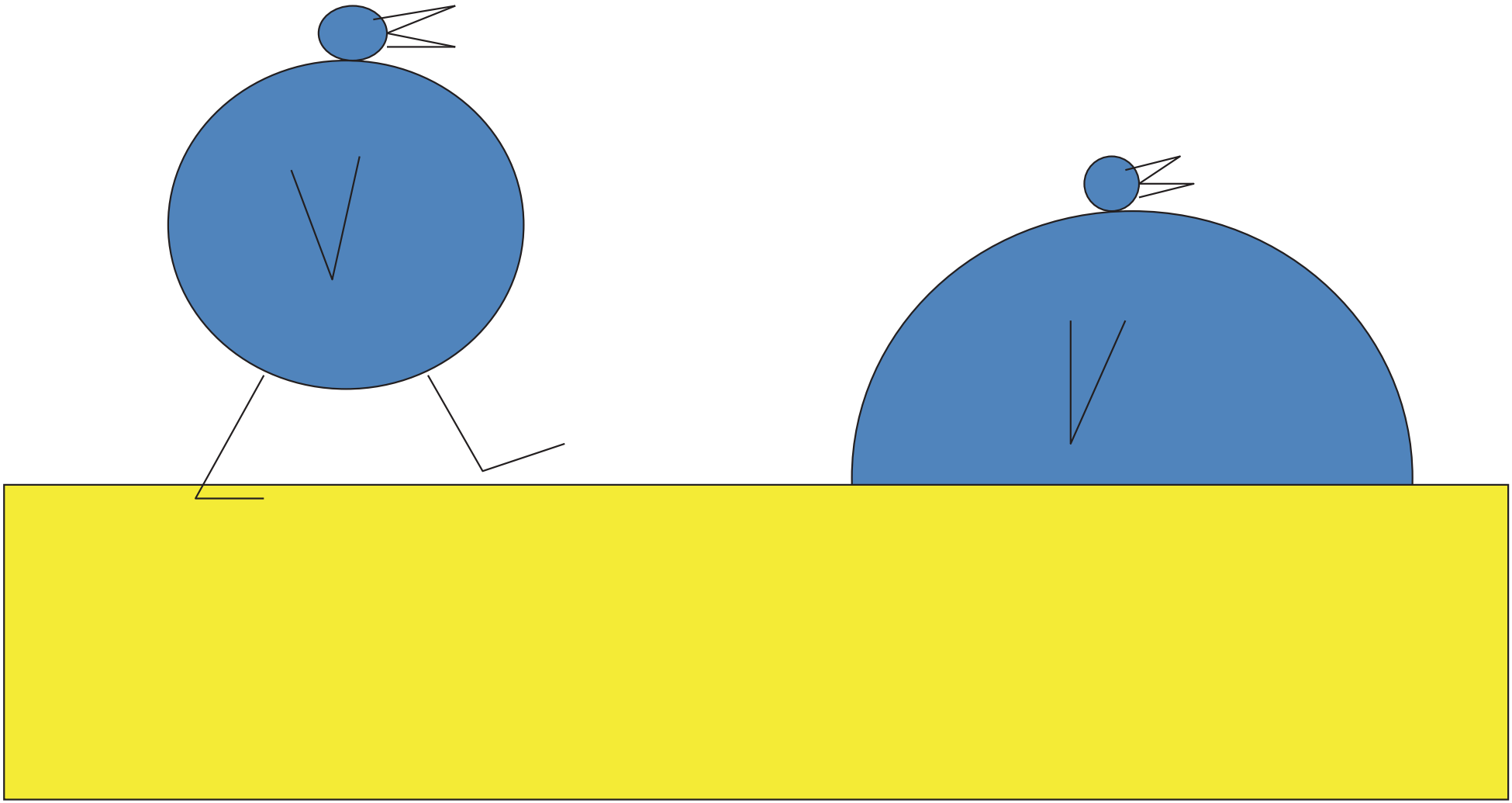
What shape is a chicken?

What comes in?

What goes out?

Slide by Robert McKibbin

Standing and seated chickens



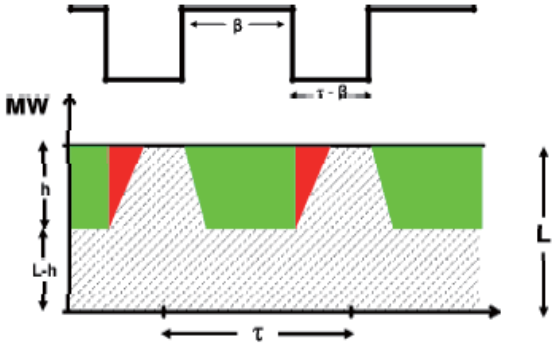
MISG at University of Wollongong, Industry Partners

- 2007: Bluescope Steel Research, Integral Energy × 2, **Transpower**, DSTO, Trading Technology Australia

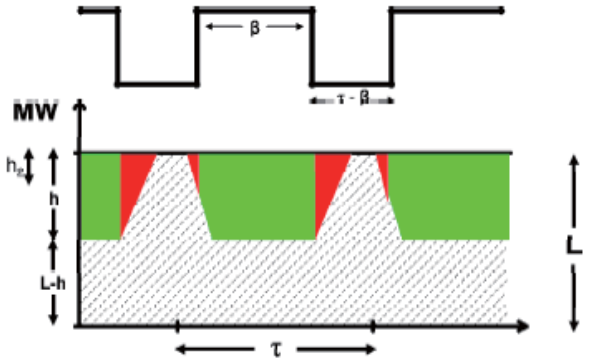
- 2008: **New Zealand Steel**, Integral Energy × 2, Transpower, Geoscience Australia, Australian Bureau of Statistics, Provisor and Food Sciences Australia

- 2009: **Bluescope Steel Research** × 2, Integral Energy, Geoscience Australia, ICT Research

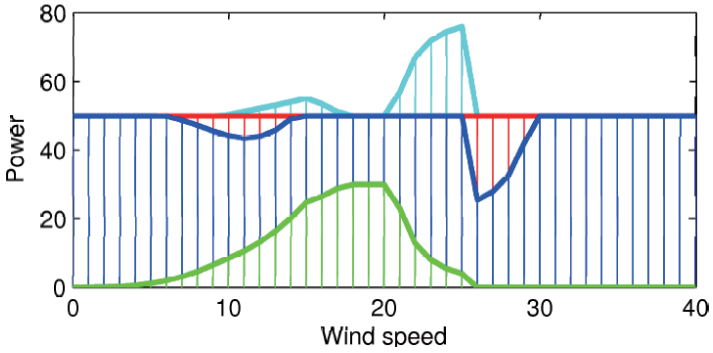
MISG 2007 Operating and planning an electricity transmission grid to maximize the contribution of wind (Transpower)



(a) Reactive model.



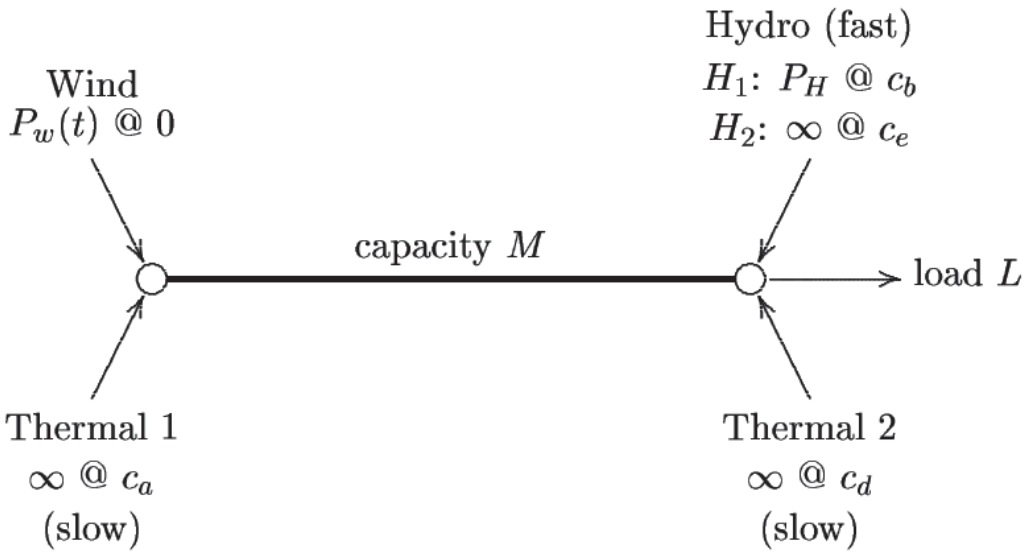
(b) Anticipating model.



Problem:

wind variability

- Power supply maintenance
- Finite power line transmission capacity



For constant wind power it is cheapest to fill the transmission line to capacity (M).

http://www.maths-in-industry.org/miis/133/

MISG 2012: How far can a simplified network rights auction be extended?

OB_{AB} = Obligation FTR from A to B

OP_{AB} = Option FTR from A to B

PA = Price at A

$$f_{AB} + X^{AB}_{AC} f_{AC} + X^{AB}_{BC} f_{BC} \leq Q_{AB}$$

Num Nodes	Num f, g Vars	Num Constraints	Vars × Constraints
2	3	2	6
3	9	24	216
4	18	216	3,888
5	30	1,920	57,600
6	45	18,000	810,000
7	63	181,440	11,430,720
8	84	1,975,680	165,957,120
9	108	23,224,320	2,508,226,560
10	135	293,932,800	39,680,928,000
11	165	3,991,680,000	658,627,200,000
12	198	57,959,193,600	11,475,920,332,800

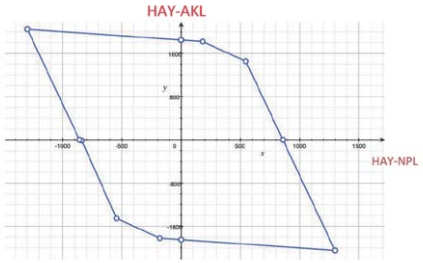


Figure 7: The polygon of constraints for Haywards-Auckland and Haywards-Napier transfers.

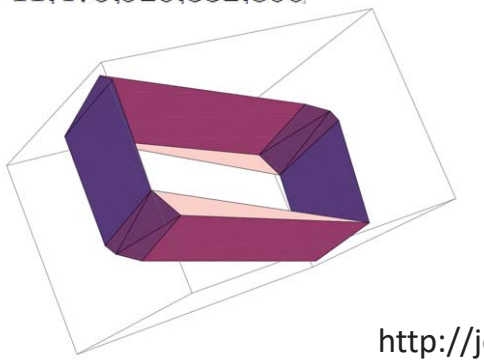
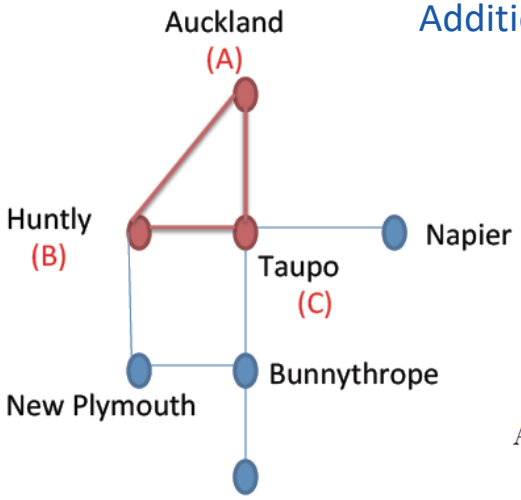
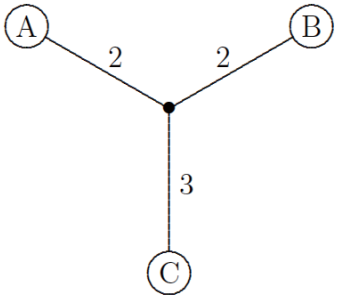


Figure 8: The polyhedron of constraints for Haywards-Auckland, Haywards-New Plymouth, and Huntly-Auckland transfers.



Additional constraints may arise



A network which cannot be simplified.

FTR on empty FTR grid	Max FTR MW
AB	994.3
AC	1352.3
BC	945.2

FTR on FTR grid with a pre-existing FTR		
Pre-existing FTR		Max FTR MW
AC	100	961.9
BC	100	1278.7
AB	100	988.1

Delta	Ratio
32.4	0.324
73.6	0.736
-42.9	-0.429

Auck is A
Taupo is C
Huntly is B

	Max FTR MW
AB	994.3
AC	1352.3
BC	945.2

Pre-existing FTR		Max FTR MW
BC	100	1061.9
AB	100	1325.9
AC	100	888.1

Delta	Ratio
-67.6	-0.676
26.4	0.264
57.1	0.571

	Max FTR MW
AB	994.3
AC	1352.3
BC	945.2

Pre-existing FTR		Max FTR MW
CA	100	1026.6
CB	100	1426.0
BA	100	902.3

Delta	Ratio
-32.4	-0.324
-73.7	-0.737
42.9	0.429

	Max FTR MW
AB	994.3
AC	1352.3

Pre-existing FTR		Max FTR MW
CB	100	927.0
BA	100	1378.7

Delta	Ratio
67.3	0.673
-26.4	-0.264

http://journal.austms.org.au/ojs/index.php/ANZIAMJ/article/view/6221

MISG at RMIT University, Industry Partners

- 2010: **DSTO**, Brain Research Institute, Australian Antarctic Division, Western Australian Geothermal Centre of Excellence

- 2011: DSTO, **New Zealand Steel**, Transpower, Fonterra, EPA Victoria

- 2009: **Transpower**, Fonterra, Geoscience Australia, AGL

MISG 2010 Influence diagrams to support decision making.

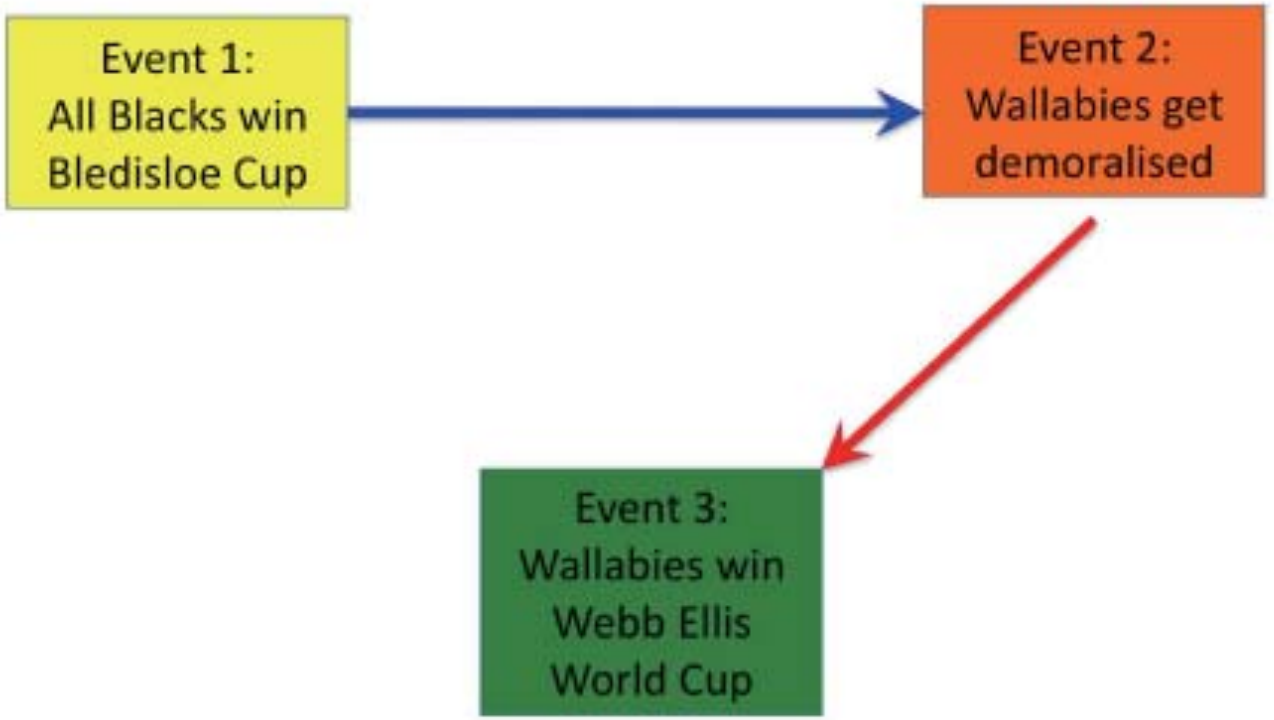
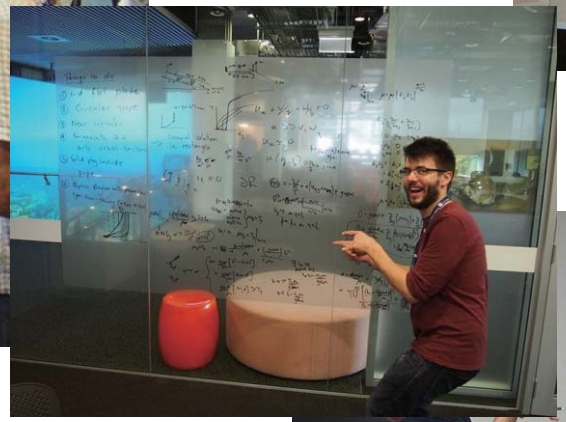


FIGURE 1: A simple influence diagram connecting three events. Links are coloured blue for positive influence and red for negative.

http://journal.austms.org.au/ojs/index.php/ANZIAMJ/article/view/3572

MISG at Queensland University of Technology

- 2013: **Fonterra**, Plant Protection Chemistry NZ, Australian Bureau of Statistics, The Kirby Institute, Department of Transport and Main Roads, Australian Institute of Marine Science



Slide: Troy Farrell

www.mathsinindustry.com

MISG 2013 Can we predict how cheese matures?

- Investigated data provided by Fonterra
- Developed and implemented ODE model of bacteria, protein and lactose in cheese
- Fitted experimental data from literature
- Also developed equations for fat and pH

http://journal.austms.org.au/ojs/index.php/ANZIAMJ/article/view/8918

MISG 2016 ran from 1-5 February 2016. The problems included:

- Inference in a knowledgebase (DST Group)
- Sequencing ore extraction to control blend quality (Schneider Electric)
- Modelling water pollutant density associated with surface water runoff (SA Water)
- Optimisation of household PV and storage (Ergon Energy).

University of South Australia, Adelaide

MISG 2016: Determining a mining sequence to meet blending targets where there is uncertainty in the geological model *Schneider Electric*

Industry representative: Adam Ghandar

Moderators: Winston Sweatman, Kevin White

Team members: Amie Albrecht, Erika Belchamber,

Elizabeth Bradford, Ajini Galapitage, Martin Peron, Peter Pudney, Judith Shand, Markus Stumptner, Graeme Wake, Brian Webby, David Whittle, Youngho Woo, Peng Zhou

doi:10.21914/anziamj.v58i0.12475

MISG 2018: Optimising Carcase Cuts in the Red Meat Industry

Australian Lamb Company

Industry representatives: Michelle Henry, Sean Miller, Wayne Pitchford, Chris Smith

Moderators: Winston Sweatman, Kevin White

Team members: Amie Albrecht, Tony Gibb, Youngjin Kim, Martin Peron, Pubudu Thilan, Li Sun, Xuan Vu, Youngho Woo, Wenzheng Ying

Activities

- Generate optimisation model
- Wrangle realistic data into the model
- Consider production line constraints
- Have a BBQ

Twinned Study Groups:
New Zealand and Japan, 2016

Exchange visits funded by RSNZ and JSPS

(The Royal Society of New Zealand and Japanese Society for the Promotion of Science)

through **Joint Workshop Programme**

awarded to Graeme Wake and Yasuhide Fukumoto

Six Japanese participants in New Zealand

Six New Zealand participants in Japan

MINZ 2016, Wellington, Winter

Challenges

https://minz.org.nz/2016/

Challenge 1: Transpower

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

Challenge 2: Compac

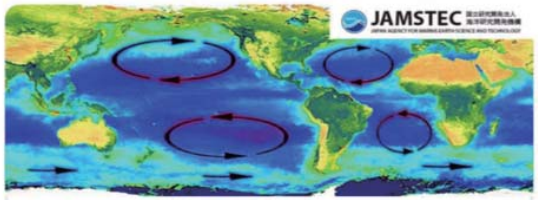
Designing a mathematical model for accurately estimating weight of a moving object from noisy & heavily biased signals involving both known & unknown sources of data contamination.

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?



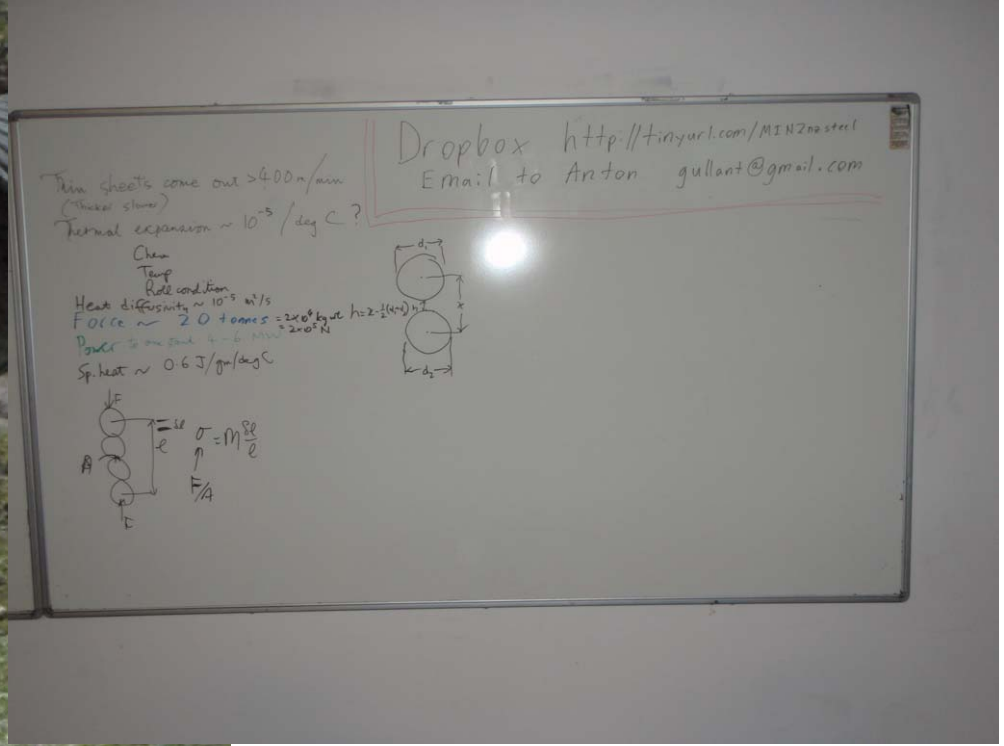
Challenge 5: JAMSTEC

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

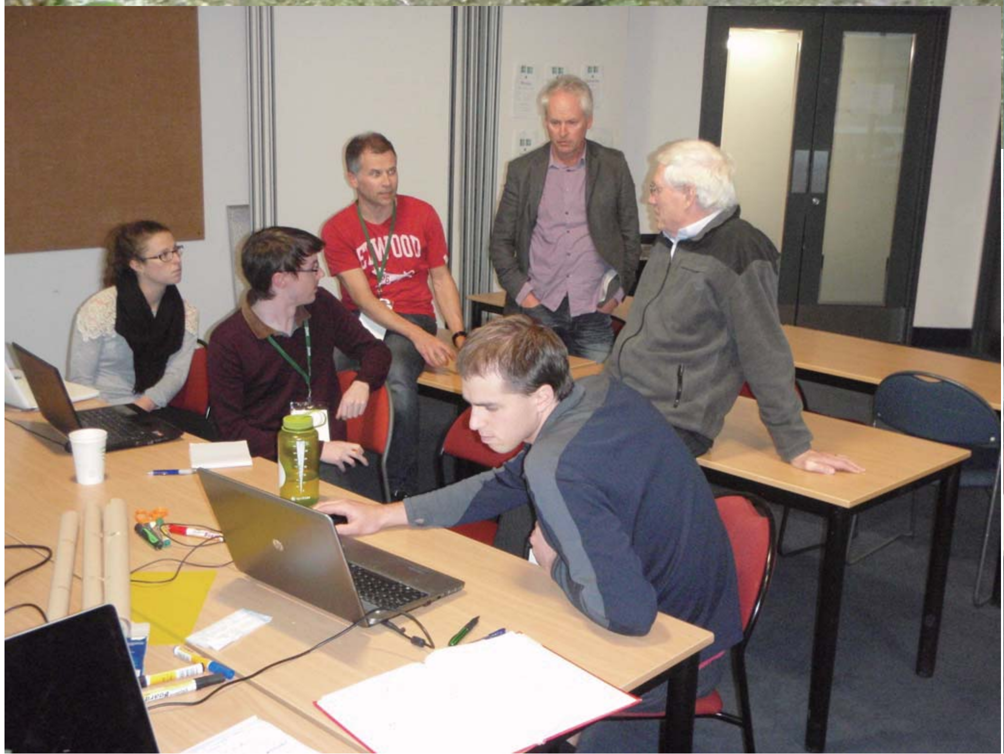
Challenge 6: NZ Steel

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

Sunrise from Mount Holdsworth, Tararua Mountains (Winter)

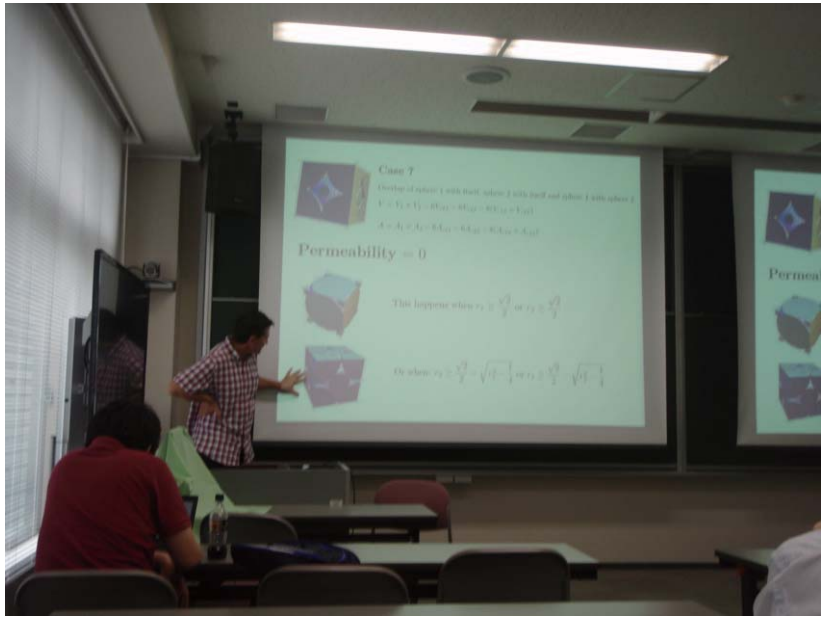


Dropbox http://tinyurl.com/MINZnzsteel
Email to Anton gullant@gmail.com
Thin sheets come out >400m/min
(Thicker slower)
Thermal expansion ~ 10^-5 /deg C ?
Chem
Temp
Roll condition
Heat diffusivity ~ 10^-5 m^2/s
Force ~ 20 tonnes = 2×10^4 kg wt = 2×10^5 N
Sp. heat ~ 0.6 J/gm/deg C



EXIT

SGW 2016, Fukuoka and Tokyo, Summer



SGW 2016, Fukuoka and Tokyo: New Zealand Group

1 Industry Representative, 4 Academic Staff Members, 1 Student

Steve Taylor, University of Auckland

Winston Sweatman, Massey University, Auckland

Barry McDonald, Massey University, Auckland

Luke Fullard, Massey University, Palmerston North

Alex Van-Brunt, University of Kyoto

Tim Crownshaw, Transpower

The Japanese team structure was similar

Study Group Workshop2016

July 27, 2016			July 28, 2016	July 29, 2016	August 01, 2016	August 02, 2016	
Kyushu University, Ito Campus					The University of Tokyo, Komaba Campus		
IMI Auditorium, West Zone 1			10:00-17:00	10:00-17:00	10:00-17:00	10:00-14:00	14:30-17:30
9:50-10:00	Opening Organizing Committee, Kyushu University						
10:00-10:40	**Tim Crownshaw** Inter-regional variability of solar irradiance and implications for future solar PV generation on the New Zealand power system Transpower NZ Ltd. Moderators : O. Saeki & K. Hirose	⇒	Lecture Room S (W1-C-504) Discussion		Room 002 Discussion		Debriefing session at Lecture hall
10:40-10:45	BREAK						
10:45-11:25	**Takeshi Tsuji** Description of heterogeneous rock pore structures using mathematical methods I^{2}CNER, Kyushu University Moderators : T. Shirai & T. Shibuta	⇒	Seminar Room (W1-D-725) Discussion		Room 056 Discussion		
11:25-11:40	DISCUSSION & BREAK						
11:40-12:20	**Hirofumi Sakuma** Brief introduction to application studies on climate prediction at JAMSTEC and a couple of current mathematical problems relating to them Japan Agency for Marine-Earth Science and Technology Moderator : R. Nishii	⇒	Seminar Room (W1-D-625) Discussion		Room 123 Discussion		
12:20-13:50	DISCUSSION & LUNCH						
13:50-14:30	**Shin'ichi Higai** Mathematical Modeling of Human Body for Electronic Biosensing Murata Manufacturing Co., Ltd. Moderators : M. Koiso & Y. Mizoguchi	⇒	Lecture Room M (W1-C-515) Discussion		Room 122 Discussion		
14:30-14:35	BREAK						
14:35-15:15	**Junichi Nakagawa** Solving optimization problems by ground-state search of Ising models NIPPON STEEL & SUMITOMO METAL CORPORATION Moderators : D. Tagami & M. Uesaka	⇒	Seminar Room (W1-C-615) Discussion		Room 126 Discussion		
15:15-15:30	DISCUSSION & BREAK						
15:30-16:10	**Masaya Katoh** Detecting the abnormal state of equipment through analyzing multimodal sensor values ABeam Consulting Ltd. Moderators : Y. Ninomiya & O. Maruyama	⇒	Seminar Room (W1-C-715) Discussion		Room 270 Discussion		
16:10-16:45	DISCUSSION				18:00-20:00		
18:00-20:00	*Banquet* *(Tenjin)* *Japanese Restaurant "Tenjin Fuyo"*				*Banquet* *(The Universtiy of Tokyo)* *Komaba Faculty House "S" seminar room*		

Promoting MINZ – see T-shirt

Sunrise from Mount Fuji, Japan (Summer)

Acknowledgement

Thank you to the many MISG participants: Directors, Industry Representatives, Moderators, Group Members.

It has been instructive and enjoyable!