

# Lower Atmosphere Research

The lower atmosphere research group is active in the following two broad areas:

## 1. Radar Entomology and Insect Migration (Alistair Drake)

- The development of Insect Monitoring Radar (IMR) technology and of procedures for interpreting IMR observation data. Recent research has focused on extracting as much information as possible from the echo signals in order to discriminate between different target types (locusts, moths, bugs, etc.), and on developing summaries and representations of the IMR data that can be produced routinely and that are readily assimilated by users in pest-management (especially locust-control) organizations. Effort is now being redirected to modifications of the radar design aimed at extending its applicability and increasing the confidence with which targets can be identified, and to laboratory measurements of target radar characters to facilitate interpretation of the radar data. In addition to work with the School's own IMRs, assistance is being given to two Chinese research groups currently establishing IMR capabilities.
- Improving understanding of locust migration in inland eastern Australia, and increasing the confidence with which locust migrations can be detected and forecast. This work draws on archival IMR datasets extending over several seasons, as well as continuing observations, and is being conducted in collaboration with entomologists and forecasters at the Australian Plague Locust Commission. The datasets are also being explored for more general insights into insect migratory activity and its relation to weather, climate, and geography.

## 2. Monitoring the atmospheric boundary layer (Barbara Burns, David Low, John Taylor)

- The development of ground-based systems for acoustic and electromagnetic remote sensing of the atmospheric boundary layer and the utilization of these systems for understanding the mean and turbulent structure of the atmospheric boundary layer. A major focus is on the interaction between the boundary layer and mesoscale meteorological phenomena such as fronts, local wind systems and gravity waves. These problems are being approached in observational and modelling studies.
- Investigation of the initiation and subsequent organization of convection, and the propagation of convective lines, via a "complex systems" approach.
- The algorithmic extraction of useful parameters (temperature, moisture, turbulence, etc) from atmospheric echoes: the process of modelling what contributes to electromagnetic and acoustic echoes from the atmosphere, and separating the individual contributions from each other.
- Instrumental comparisons: how different sensors see the same parcel of air in different ways. In particular, how turbulence is seen by different instruments.
- Investigation of algorithms for extracting water depth from hyperspectral imagery of coastal waters.

Application of error analysis and sensitivity studies to determine error bars in algorithm extractions.

## Members

### Academic Staff:

**Dr David Low** (d.low@adfa.edu.au) BSc, PhD *Adelaide*, MAIP, MAMOS, MAGU

**Dr John Taylor** (j.taylor@adfa.edu.au) BSc, PhD *ANU*, MAIP, MAGU

### Visiting Fellow:

**Dr Alistair Drake** (a.drake@adfa.edu.au) BA (Hons), DPhil, *Oxford*, GradCertHEd, *UNSW*, MAIP

### Research Associate:

**Dr Barbara Burns** (part time) (barbara.burns@adfa.edu.au) BSc *Wisconsin*, PhD *Cornell (USA)*

### Visiting Research Associate:

**Haikou Wang** BSc, MSc *Nanjing Agricultural University*, PhD *UNSW*. Currently with the Australian Plague Locust Commission, Canberra.

### Research Student:

**Kenn Batt** - Research Topic - The observation and modelling of the summer-time easterly over the ACT.

### Recent Graduate Student:

**Haikou Wang** - Research Topic - Evaluation of insect monitoring radar technology for monitoring locust migrations in inland Eastern Australia, PhD Thesis, 2008.

### Recent Honours Student:

**Jamie Moogan** - Research Topic - An investigation into fog clearance forecasting, 2008.

### Research Collaborators:

**T. Deveson** (Australian Plague Locust Commission, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra)

**Dr R. Hughes** (Maritime Operations Division, DSTO)

**Prof. M. Reeder** (Centre for Dynamical Meteorology and Oceanography, Monash University)

**Dr D. Reynolds** (University of Greenwich, Chatham, UK and Rothamsted Research, Harpenden, UK)

**Assoc. Prof. H. Sidhu** (PEMS, UNSW@ADFA)

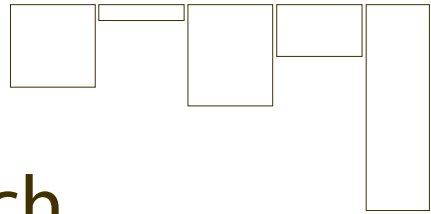
**Dr M. Steinbauer** (LaTrobe University, Melbourne)

## Current Research

### Radar entomology and insect migration

#### Alistair Drake, Haikou Wang

The Insect Monitoring Radar at Bourke operated throughout 2008, with observations being accessed daily during the locust season by scientists at the Australian Plague Locust Commission and used by them to develop forecasts of the locust situation and to plan survey patrols. The observations were also incorporated into the long-term dataset of seasonal insect movements for this site, and some improvements were made to the data-processing and analysis software. In late December 2008 the Bourke unit



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was damaged by a windstorm. Most of its components were subsequently brought back to Canberra for repair (or replacement) and testing, and it is expected that the unit will be running again before the end of the year. At the same time, procurement and construction proceeded for an upgrade to incorporate current microcomputer technology and digital rather than analogue signal processing. As well as allowing existing units to be maintained in operation for several more years, the new design will make construction of additional units, if the need arises, relatively straightforward.

Alistair Drake has been drafting a monograph, co-authored with D.R. Reynolds (University of Greenwich, Chatham, UK), on radar entomology. He spent time with Dr Reynolds in Britain in both 2008 and 2009. While there he participated in a workshop on "drift" (of animals migrating in atmospheric and oceanic flows) at Rothamsted Research, Harpenden, UK.

## Atmospheric boundary layer research

**John Taylor, David Low, Barbara Burns**

**During 2008/2009 we ran two field experiments:**

- Through May, June, July and August 2008 meteorological data was collected continuously from a High Frequency (HF) sodar, radio acoustic sounding system (RASS), ultrasonic anemometer and Automatic Weather Station (AWS) at the School of PEMS field site. In addition, during the morning, a digital camera automatically recorded images for visibility monitoring. This data set was used for **Jamie Moogan's** Honours project on fog clearance modeling and for a model verification study of the meteorological component of the CSIRO atmospheric model TAPM (The Air Pollution Model).
- Starting in December 2008 and running through to the end of April 2009 we collected meteorological data from a sodar and an AWS located at the Molonglo Radio Telescope (University of Sydney), near Hoskinstown, NSW. Over the same period, data was also collected from a HF sodar and AWS at the School's field site. This experiment was a major component of **Kenn Batt's** PhD. Project on summertime easterly wind changes in the ACT region.

A sequence of images showing the clearance of a thick fog on the morning of 29th May 2009. Images times: 8:18, 8:24, 8:30, and 8:36 am EST. The images were captured by the visibility monitoring system at the PEMS field site and used in Jamie Moogan's Honour's project.



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## Research Achievements/Recent Research

**Alistair Drake** and his insect monitoring radar equipment (IMRs), located at Bourke and Thargomindah, were featured in an article reported by ABC News on 16 October 2008 (see <http://www.abc.net.au/news/stories/2008/10/16/2392414.htm>). Another article mentioning Alistair's research appeared in the *Herald Sun* on 22 October 2008.

## Student Research

### Evaluation of insect monitoring radar technology for monitoring locust migrations in inland Eastern Australia

**Haikou Wang, PhD Thesis, 2008**

#### **Abstract:**

To evaluate the utility of insect monitoring radar (IMR) technology for long-term monitoring of insect migration, a mini-network of two IMR units in Bourke, NSW, and Thargomindah, Qld, and a base-station server in Canberra, ACT, was set up in eastern Australia. The IMR operated automatically every night under the control of a personal computer that also conducted data acquisition and processing. Digitisation of radar signals, their analysis (delimitation of echoes from background noise and adjoining echoes, followed by extraction of estimates for each target's speed, displacement direction, body alignment, radar cross-section, and wingbeat frequency and modulation pattern), and generation of observation summaries were implemented as a fully automated procedure. Wingbeat frequency was found to be retrievable from the IMR's rotary-beam signals, and this allowed each individual target to be characterised by its wingbeat as well as its size and shape. By drawing on ancillary information from the Australian Plague Locust Commission's database of field survey and light trap records, the echo characters indicative of Australian plague locust, *Chortoicetes terminifera* (Walker), were identified. Using these, about 140 nights with detectable plague locust migrations were identified for the Bourke IMR site during 1998-2001 and 31 nights for Thargomindah during 1999-2000. Analysis of these nights confirmed that *C. terminifera* migrates in association with disturbed weather, especially tropical troughs, in eastern Australia. Trajectory simulation based on IMR-derived displacement directions and flight speeds allowed the identification of population movements likely to reach favourable habitats and thus to develop rapidly and possibly cause a plague. The outbreak during 1999-2001 most likely originated from the southeastern agricultural belt after migrations and multiplications over several generations. The IMR observations demonstrated that *C. terminifera* migrates over long distances with the wind at night and indicated that it may have an orientation behaviour that prevents it from being taken too far into the arid inland, a trait that could be highly adaptive in this environment. The two IMRs were operational for more than 85% of scheduled time during the study period and provided a wealth of information of potential value for locust management and migration research.

## PhD Opportunities and Scholarships

If you are interested in a PhD or Masters by Research with the Lower Atmosphere Research group:

#### **Contact:**

**Dr Alistair Drake** (a.drake@adfa.edu.au)

Radar entomology, and its application to insect migration.

**Dr David Low** (d.low@adfa.edu.au)

**Dr John Taylor** (j.taylor@adfa.edu.au)

Atmospheric boundary layer research.

## Major Facilities

- Insect Monitoring Radars installed at Bourke (NSW) and Thargomindah (Qld), and a mobile IMR.
- Atmospheric boundary layer research: medium and high frequency sodars, radio acoustic sounding system, boundary layer electromagnetic wind profiler, ultrasonic anemometer, meteorological mast, located at the School's field site in Campbell, ACT.
- Laboratory space in PEMS Sth (Vibration Lab G08, Remote Sensing Lab G07) with instrumentation for RF and acoustic instrument development (including RF spectrum and scalar analyser, frequency synthesizer and peak power meter).

## Publications

### 2008 publications

#### **Conference - Proceedings unrefereed**

Carmody, D., Dekker, A. & **Taylor, J.**, 2008, Deriving bathymetry from multispectral and hyperspectral imagery, *Proceedings 14<sup>th</sup> Australian Remote Sensing and Photogrammetry Conference*, Darwin, NT, Australia.

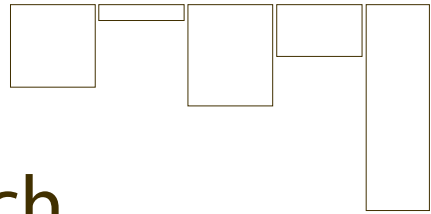
#### **Conference - Abstract**

**Wang, H. & Drake, V.A.**, 2008, Estimation of insect migration trajectories with flight parameters measured by insect monitoring radar, *Abstracts CD and Author's List, XXIII International Congress of Entomology*, Durban, South Africa.

**Wang, H., Drake, V.A. & Deveson, E.D.**, 2008, The 1999-2001 Australian plague locust outbreak in eastern Australia from the perspective of insect monitoring radar, *Abstracts CD and Author's List, XXIII International Congress of Entomology*, Durban, South Africa.

#### **Theses**

**Wang, Haikou**, 2008, Evaluation of insect monitoring radar technology for monitoring locust migrations in inland Eastern Australia, School of Physical, Environmental & Mathematical Sciences, Australian Defence Force Academy, UNSW, PhD Thesis, Available at: <http://handle.unsw.edu.au/1959.4/38923>.



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## Grants

### UNSW Grant

**J.R. Taylor**, H.S. Sidhu & R.J. Hughes, Investigation of uncertainties in bathymetric retrievals using a semi-analytic method, Defence-Related Research Funding Scheme, 2008: \$18,627.

## Visitors

The School was awarded one UNSW@ADFA Summer Scholarship for summer 08/09. This was held by **Annette Hirsch** (from the ANU) who worked with John Taylor through December 2008 and January 2009 on modelling of winter time meteorological conditions in the ACT region. Annette's project is the basis for on-going work in this area.

## Conference Participation

Alistair Drake participated in a workshop on "drift" at Rothamsted Research, UK in 2009 and will attend an APEC-sponsored workshop on migratory insect pests in Suwon, S. Korea, in October.

