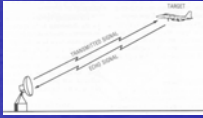


AR²C

University of Adelaide
Radar Research Centre

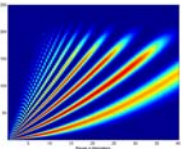
Director : Prof Douglas Gray (EEE)
Deputy Director : Prof Iain Reid (Physics)



The Centre

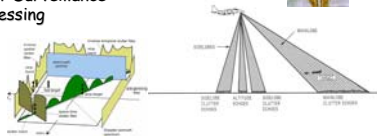
Established in October 2009

Located in University of Adelaide
School of EEE and discipline of Physics



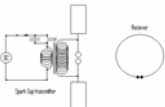
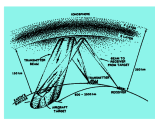


Vision : Establish a national centre that is internationally recognised for its work in

- Remote Sensing and Environmental Monitoring using Radar
- Radar Systems for Surveillance
- Radar Signal Processing
- Radar Education



Researchers Involved

Name	Affiliation	Role
Prof Lang White	EEE	Academic Researcher
A/Prof Christopher Coleman	EEE	Academic Researcher
Prof Bob Vincent	Physics	Academic Researcher
Dr Andrew MacKinnon	Physics	Academic Researcher
Mr Richard Mayo	ATRAD Pty Ltd	Principal Engineer
Prof Chris Baker	ANU	Adjunct Professor
Prof Don Simnett	EEE	Adjunct Professor
Prof Bevan Bates	DSTO	Adjunct Professor
Prof Yuri Abramovich	DSTO	Adjunct Professor
Dr Peter May	BoM	Adjunct Researcher
Mr. Marian Viola	EEE	Research Fellow
Mr. Richard Drake	EEE	Research Fellow
Dr Tariq Salim	EEE	Research Fellow
Mr. Mathew Trinkle	EEE	Research Fellow
Dr Brian Ng	EEE	Academic Researcher
A/Prof Christophe Fumeaux	EEE	Academic Researcher
Dr Chris McCarroll	Raytheon	Project Member
Prof Bill Moran	University of Melbourne	Project Member

International Links

University of Pisa, Italy,
University of Bath, UK,
University of Siegen, Germany,
University of Massachusetts, USA,
Raytheon USA

North Western Research Associates in the USA
QINETIQ in the UK,
Laboratoire Météorologie Dynamique, Ecole Polytechnique (France),
Kyoto University and the National Polar Research Institute (Japan),
National Center for Atmospheric Research, University of Colorado,
University of Illinois (USA),
Aerospace Corporation (USA),
Institute for Atmospheric Physics,
Institute of Geology and Geophysics,
Chinese Centre for Applied and Space Physics.

Australian Links - Joint projects and adjunct positions

University of Melbourne, Prof Bill Moran, A/Prof Geoff Walker
Australian National University Prof Chris Baker
Defence Systems Integration Centre - DSIC
Defence Science and Technology Organisation - DSTO
Bureau of Meteorology - BoM
Australian Antarctic Division
Raytheon Australia
Apogee
ATRAD
British Aerospace - BAe

Remote sensing and environmental monitoring

Synthetic Aperture Radar




- Soil moisture
- Vegetation classification
- River Red Gums

Weather Monitoring

- Radar Networks, digital polarimetric radars and phased array
- Passive radar

Solar-terrestrial and atmospheric physics

- VHF Wind Profiling Radars
- VHF Meteor Radars
- RASS: Radio Acoustic Sounding System
- Lidar facility

Soil Moisture (Melbourne and Flinders University and DSTO)

NASA SMAP mission in 2013 (sun synchronous orbit 670 km)
 Surface soil moisture, surface freeze/thaw state
 L-band radar (3Km res) and L-band radiometer (40Km res)
 shared parabolic mesh reflector



Airborne Simulator

Radiometer (PLMR) - accurate soil moisture measurements
 low spatial resolution (1 Km)
 L-band scatterometer (SAR) (PLIS)- less accurate
 scattering coefficients (10m) - polarimetric



Built by ProSensing USA (delivery Dec 2009)

Workup trials and calibration around Adelaide

Experimental program - 2010 commence

Collection over Murrumbidgee irrigation area

existing soil moisture measuring network

Data collection of vegetation along Murray river

Interferometric phase change measurements



River Red Gums

Prolonged drought and consequent reduced river flows and flooding having a serious consequence on the health of old/mature vegetation along the River Murray

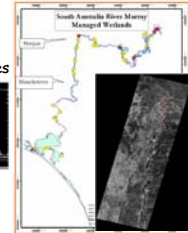
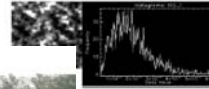
Use of satellite SAR to measure the effect of reducing soil moisture and increasing salinity on the ecosystem of Red Gum Trees along River Murray
 Terra SAR X (HH/VV) and ALOS L band data

Selection of homogeneous regions of interest (ROI)

Identification of red gum trees' stand in SAR (X- and L-bands)

SAR data to be correlated with ground truth data to identify different tree species within the ROI on the different images

identify differences in health of particular species



Vegetation classification

PhD project : Tishampati Dhar (Apogee)

Classify and measure change in various crop types using satellite SAR and other data

Multifrequency/polarimetric techniques

Track changes over the growing season

Cereals crops

Sites at Roseworthy Agricultural Campus of UoA

Wheat, barley, peas, canola and beans

TerraSAR-X HH/HV data (3m range, 6m azimuth) 3 passes 11 days apart over drying season

Backscatter histogram analysis, alpha entropy for volume versus dipole versus moist soil scattering

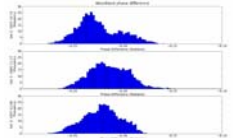
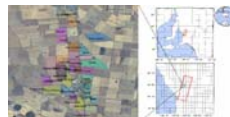
Dryland Vegetation - Australian bush

Canopy, understory and bare earth

Gaussian mixture models to separate contributions

TerraSAR-X HH/HV phase differences

River Murray sites



Weather Monitoring

A network of distributed radars to measure weather phenomena and to monitor bushfire activity

Three year ARC linkage grant

Use of existing DSTO network for preliminary measurements

Various upgrades

Set up network of radars around Adelaide

Build three fully polarimetric digital X band radars (low cost)

Three stage fusion/integration approach using

loosely synchronised range-Doppler

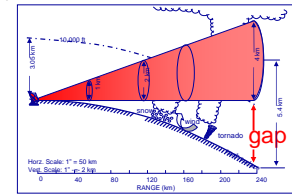
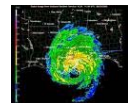
processed results

synchronised range profiles

synchronised raw data

Incorporation of Raytheon phased array module

Collaboration with CASA in USA



Lidar Facility at Buckland Park

- Within the School of Chemistry and Physics the Atmospheric Physics Group in collaboration with Optics and Photonics Group are setting up a new Lidar facility
- Measure atmospheric temperature, wind and dynamic processes with high spatial and

temporal resolution from 15 to 100 km altitude



Lidar Facility at Buckland Park

- First stage:
 Lidar building finished and power laser under development
 Implement all parts for Lidar in building
 From 2010 on Rayleigh temperatures from 30 to 60 km altitude
- Second stage from 2011 on:
 Power laser for resonance measurements
 Extend altitude range for Rayleigh measurements 15 to 80 km
 Combined Rayleigh and Resonance measurements
 Continuous observation from 15 to 100 km on a regular basis
- Scientific aims:
 Study seasonal temperature structure at 36°S
 Study dynamical processes such as tidal, planetary and gravity waves
 Validate these local observations with Satellite and Model results
 Intercomparison of South-North hemisphere and along 36° longitude

Surveillance

Wideband Digital Phased Array Receivers
Radar, EW and GPS
Monopulse with distributed adaption

Digital Radar
L-band rooftop radar for aircraft tracking

Radar Classification
Low resolution navigation radars
High resolution (ISAR) radars

Synthetic Aperture Radar
Change Detection
Multi-channel jammer cancellation

Bistatic
3-D SAR using multiple repeat passes

Passive Radar
Using GPS signals as illuminating sources

INGARA Bistatic SAR (Alvin Goh DSTO)

Radar and GPS Signal Processing

Direction Finding
Fast high resolution DF for EW

MIMO Radar
Noise waveforms
Element and beam space approaches
Co-arrays

SAR Change Detection
Algorithmic - Likelihood ratios for change detection

Distributed Adaption
Adaptive monopulse for multiple interference cancellation across communicating FPGAs

GPS Interference Mitigation
CTD demonstrator being developed

Synthetic Aperture Radar

Repeat pass interferometric SAR
Change Detection
Bayesian algorithm

Change Detection Comparison.

Log likelihood:
 $P_{fa} = 0.05$
 $P_d = 0.71 (0.70)$
 Threshold = -0.45 (-1.45)

RCS Ratio Change:
 $P_{fa} = 0.05$
 $P_d = 0.42 (0.28)$
 Threshold = 0.33 (0.31)

Sample Coherence:
 $P_{fa} = 0.05$
 $P_d = 0.23 (0.21)$
 Threshold = 0.18 (0.19)

Radar Education

Maintain and expand current cohort of 17 PhD students - some examples

- Rowan Fry : Wideband Radar
- Peter Ly : DOA Estimation
- Alvin Goh : Bistatic SAR
- Luke Balzan : MIMO Radar
- Khairul Mahmood : SAR Image Formation
- David Kettler : SAR and Radon Transforms
- Shivaan Sathasilvam : Radar for Animal Tracking
- Akhilesh Verma : UWB Polymer Antennas

Develop a Masters Degree focussing on Radar
Collaboration with Uni of Pisa

Specialised short courses for industry on radar