Gamma-ray remote sensing of salt source materials in the Murray-Darling Basin

Phil Bierwirth
Defence Imagery and Geospatial Organisation (DIGO)
Airborne gamma-ray spectroscopy (GRS)

• hyperspectral in gamma-ray part of EM spectrum
• emissions from radioactive elements
• element concentrations at 50 m image resolution
• “penetrates” to 30-45cm of upper soil/rock layer
• unique data source
  – gives an uninterrupted picture of soils

Landsat TM bands 3,4,5 = RGB

Airborne Potassium

5 km
Previous work on GRS

- Original AGSO project investigated use of GRS in soil and land mapping /degradation studies

- demonstrated relationship with soil properties

- needs to be interpreted with geology and landform

- inconclusive findings in relation to salinity due to localised and limited study areas

- GRS not a recognised tool (like AEM) for directly managing salinity
Revisiting the salinity – GRS relationship

Revisit because:
• new related work by other researchers
• more significant coverage of GRS
• availability of GRS data through GADDS system (Geoscience Aust)
• new supporting data through MDBC data collection program
  - airborne EM data surveys, deep borehole sampling
CSIRO mapping identified aeolian dust deposits (McKenzie and Gallant, 2005)
- characterized by low radiometric K and low slope
- English et al 2002 suggested aeolian (wind-blown) materials are sources of salt
- drill holes show salt is localized in CSIRO-modelled aeolian areas
Evidence for aeolian (wind-blown) salt sources

- salts have been introduced to the landscape rather than being derived from bedrock sources.
- salt accompanying dust is “blown in” (aeolian) during arid phases
- associated deflation of salt-lakes in the Murray basin.

Previous work has shown that:
- extensive deposits of aeolian materials in SE Australia
- aeolian deposits are significant sources of salt
- present day aeolian dust contains up to 50% salt
- aeolian materials across MDB have similar signatures
Billabong Ck - gamma element relationships with borehole salt

- upland boreholes indicate relationships between salt and gamma-ray signatures
- errors in comparison of airborne “footprint” measurements and borehole averages
- some overlap with geology, K with Sandstones, Th with metasediments

Airborne K

Airborne Th

Airborne U – not used due to noisy and poorly calibrated data.

AEM study area

![Graphs showing airborne K and Th](image)
GRS upland salt source model – Billabong Ck

- Alluvial areas masked in the GRS model since no expected relationship with salt in transported sediments

AEM study area

Euclidean Distance Model

$E_D = \sqrt{(K_i - K_t)^2 + (Th_i - Th_t)^2}$

Red = aeolian salt source, white = AEM 25m

Relationship between borehole salt (EC1:5) and Euclidean distance to target (K, Th)
Comparison of AEM with GRS salt source model at Billabong Ck

GRS salt source model

AEM – surface ~ 25m depth

AEM – PCA

Upland - BC 5

Alluvials – BC 16
GRS model versus salt – upland boreholes from combined AEM areas

- upland boreholes selected using MRVBF (CSIRO) topographic index
- insitu versus upslope averages of model values
- upslope materials likely to influence borehole salt levels
- relationship supports gamma-ray salt-source model

Figure: Soil EC 1:5 insitu upland boreholes versus airborne GRS Euclidean distance to aeolian target signature.
GRS **salt-source** model for the MDB

- Regional pattern fits with dust derived from deflation events of the ancient hypersaline (Pleistocene Lake Bungunnia and its’ remnants)
Other evidence – correlations with AEM data (Billabung Ck, NSW)

- area contributing to Murrumbidgee salt loads
- low K, low slope probably residual aeolian (mapped as alluvium)
- aeolian signature transgresses lithology
- GRS model defines salt-sources
- comparison with AEM?
Other evidence – correlations with AEM data (Billabung Ck, NSW)

- (c) shows close match between (a) and (b) gamma-radiometrics model versus near-surface AEM layers
- deeper AEM shows salt dispersal (not shown)
- gamma model splits AEM into sources and accumulations rather than salt “stores”
- aeolian materials relate to low slope residual landscapes
Conclusions

- lines of evidence suggests GRS salt source model may be valid
- a regional tool for identifying upland salt source materials, i.e. regions for focussed management
- GRS data available and inexpensive

Further work:

• calibration of airborne data sets involving ground measurements
• analysis of available ground truth data, e.g. stream salinity, drilling, soils data
• modelling potential geology-related false inclusions
• data fusion - incorporating GRS with AEM data for analysis of salt sources, stores and pathways in the landscape for more effective salinity management

Figure: Salt scald mapping (white), Central West, NSW over salt-source model