Evaporation trend in ▶ Results in increased vertical gradients ▶ Across region, heads in deep aquifers decreasing ▶ Results in increased vertical gradients compared to historical values

Across region, heads in deep aquifers decreasing ▶ Irrigation locally increases recharge of shallow aquifer ▶ Results in further enhancement of vertical gradients

Vertical Flux?

- Steep gradients present potential for vertical flow of saline water
- Initial flux estimates made based on physical (head) measurements
  ▶ Complex transient problem: pumping, irrigation, river leakage
  ▶ Further complicated by unknown extent of aquitard windows
- Can use hydrochemistry to improve head-based flux estimates
- Must choose representative parameters to model system

Evaporation trend in $^{18}$H/$^{18}$O data
- Consistent with 25%-50% humidity
- Groundwater trend suggests mixing of depleted and enriched waters
- In general, $^{18}$O in Shepparton > Calivil > Renmark
- Temporally, small changes in $^{18}$H/$^{18}$O values at a given location
- Spatially, $^{18}$O increases in all aquifers with groundwater flow, from east (above right) to west (above left) before a step-decrease beyond the irrigation areas.

Cluster Analysis

- Samples: data are more homogeneous in Renmark, Calivil than Shepparton
  ▶ Two general clusters corresponding to eastern and western GMA
  ▶ Smaller clusters and poorer spatial correlation in Shepparton
- Analytes: samples from each aquifer show similar data structure
  ▶ Two general clusters corresponding to meteoric/vertical recharge (A) and water-rock interaction (B)

Conclusions

- Geochemical data support vertical mixing of waters between aquifers
  ▶ Increasing $^{18}$H/$^{18}$O and Cl in all aquifers in direction of GW flow
  ▶ Groundwater chemistry influenced by vertical recharge of evaporated water
- Mixing less apparent in non-irrigated areas
  ▶ More depleted $^{18}$H/$^{18}$O down gradient of irrigation areas
  ▶ Lower TDS concentrations in groundwater samples
  ▶ Smaller vertical gradients
  ▶ Water-rock interaction appears to significantly influence groundwater composition
- Differences in chemical composition can be used to quantify flux between aquifers
  ▶ Vertical differences between aquifers, horizontal differences within aquifers
  ▶ $^{18}$H/$^{18}$O and Cl good indicators of mixing
  ▶ Si, K and other silicate mineral components also potentially useful

Future Research

- Calculate fluxes using geochemical data and compare to physical estimates
  ▶ Focus on 2D transects through irrigation areas
- Further characterization of regolith and mixing end members
  ▶ Regolith, precipitation sampling
- Measure seasonal variation in surface water
- Radiotopes ($^{14}$C) to constrain mixing time frames
  ▶ $^{3}$H if mixing occurred in recent history

References