Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02290, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02290
EGU General Assembly 2008

The inverse nature of an Australian bay

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Hervey Bay, a large coastal embayment situated off the central eastern coast of Australia, is a shallow tidal area (average depth = 15m), close to the continental shelf. It shows features of an inverse estuary, due to the high evaporation rate (approx. 2 m/year), low precipitation (less than 1 m/year) and on average almost no freshwater input from three rivers that drain into the bay.

We applied a multi-purpose three-dimensional ocean general circulation model to compute the temperature, density and salinity distribution within the bay. The numerical studies are performed with the COupled Hydrodynamical Ecological model for REgioNal Shelf seas (COHERENS). A model validation and calibration was carried out after recent field campaigns.

Observations and model results show that the bay is in parts vertically well mixed throughout the year and that the horizontal distribution of properties is strongly influenced by the bathymetry. As in other inverse estuaries, the annual mean salinity increases towards the shore to form a nearly persistent salinity gradient. This gradient can exceed 2 PSU over a distance of 80 km, caused by high evaporation rates, solar heat flux and asymmetries in the bottom topography. Density induced currents (up to 3 cm/s) also lead to a stabilisation of the inverse circulation. The region therefore acts as an effective source of salt production. The annual mean outflow of salt into the open ocean is computed as 12.500 kg/s. This numerical estimate is distinctly higher than estimates by simple box models (8.300 kg/s). As a result of an ongoing drying trend at the East Coast of Australia, the export shows a rising trend with an increase of 220 tons/year.

Observations and validated model results further demonstrate that air temperature, solar heat flux and wind direction are the main driving forces for the strength of the salinity gradient across the bay.