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Conférencier/Lecturer:	Thomas Spengler (Bergen University, Norway)
Sujet/Subject:	The Dynamics of Heat Lows
Présentation/Presentation:	Anglais / English
Lieu/Room:	Salle des vents (Dorval)

iweb: http://web-mrb.cmc.ec.gc.ca/mrb/rpn/SEM/
web: http://collaboration.cmc.ec.gc.ca/science/rpn/SEM/index.php

Abstract

Heat Lows are a significant climatological feature of the rather dry subtropical latitudes where most of the solar heat input is converted into sensible heat fluxes. The formation of heat lows relies on differential heating at the lower boundary establishing a thermally direct circulation. In this study we use an idealized three-dimensional hydrostatic model where the differential heating is related to the heating contrast between an island undergoing a diurnal cycle of heating surrounded by sea, which is kept at constant sea surface temperature.

Of particular interest here is the diurnal and day-to-day evolution of the upper and lower-level circulations related to heat lows, and the degree of balance that exists in these. The heat low is surmounted by an anticyclone, the development of which is closely tied to the outflow branch of the sea breeze. The anticyclone has a much smaller diurnal variation than the heat low and, unlike the heat low, is largely in balance, except in the region affected by the upward-propagating gravity wave induced by the inland-penetrating sea breeze. There is a strong analogy to certain aspects of tropical cyclones, which have a warm core, a shallow unbalanced boundary layer, and which are surmounted also by an anticyclone. Principles governing the absolute angular momentum budget are the same as those relating to the tropical cyclones and to the zonal-mean flow over Antarctica. Implications of these principles for obtaining a realistic steady state in long-term integrations of axisymmetric models are discussed.

In all cases, the flow shows a significant diurnal variation in which the sea-breeze circulation is the prominent feature during the daytime and the nocturnal low-level jet is the prominent feature at night. If the land area is large enough so that the sea breezes do not cover it entirely during the diurnal cycle, strong convergence associated with the low-level jet leads to the formation of intense, but shallow, cold fronts along the inland boundaries of sea-breeze air. These fronts decay rapidly after sunrise when surface heating leads to renewed vertical mixing, which destroys the low-level stable layer.

The presence of a uniform easterly flow leads to the formation of a west-coast trough, similar to the situation commonly observed over Western Australia. The

trough broadens during the day due to the heating of the land, while at night it sharpens and again frontogenesis occurs at low levels near the leading edge of the sea breezes to form shallow cold fronts. In these calculations there is an east-west asymmetry in the sea-breeze circulations: the cool air behind the west-coast sea breeze is shallower than that behind the east-coast sea breeze, but the vertical circulation associated with the west-coast sea breeze is deeper. The east-coast sea-breeze front penetrates further inland, but is more diffuse and is recognizable more by its signature in the relative vorticity than by that in the horizontal temperature gradient.

The presence of a horizontal shear-flow leads to the deformation of the heat trough, a process that appears to play an important role in the formation of cold fronts over central Australia. Again the calculations show the formation of shallow fronts over the land during the night, which frontolyse rapidly after sunrise. Despite the idealized nature of the calculations, the associated patterns of low-level vorticity, divergence and horizontal temperature gradient that develop overnight show remarkable similarity to those observed, e.g., over central Australia. Indeed, the calculations help to interpret the observations of nocturnal frontogenesis over this region and help to understand certain aspects of wild fire weather situations.