Thermally-forced Circulations

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Thermally-driven Winds: Some Basic Concepts

• A class of mesoscale circulations driven by horizontal gradients in surface heating or cooling.
  – Land-water contrasts.
  – Elevated terrain.
  – Urban-rural contrasts.
  – Contrasts in ground wetness.
  – Snow cover contrasts.
  – Variations in cloud shadowing.
  – Contrasts in ground brightness and vegetation.
Landscape Contrasts over Northern Utah

water
playa
snow
evergreen forest
shrubs and grass
Basic Concepts (Cont’d)

- Thermally-driven winds dominate when the large-scale flow is weak.
- These flows usually evolve in the same way from one day to the next (i.e., they are highly repeatable).
  - Fairly easy to predict the onset and cessation of thermally-forced flows, and their impact on the sensible weather.
Direct Thermal Circulation

Courtesy of Michael Pidwirny
Two Basic Types of Thermally-forced Air Flows

i. Breezes generated by surface heating contrasts (e.g., sea/lake breeze).

ii. Diurnal mountain winds.
i. Breezes generated by surface heating contrasts

- Sea/lake breeze
  - Result from horizontal temperature (density) contrast between sea and adjacent land.
  - Temperature contrast caused by unequal heating and cooling rates of land and water.
Sea- and land breezes

Courtesy of Michael Pidwirny

Courtesy of Michael Pidwirny
Sea Breeze: A Real Example
i. Breezes generated by surface heating contrasts

• “Sea breeze” circulations also develop completely over land.
• All that is required is a horizontal contrast in heating or cooling.
  – Snow covered area adjacent to “bare” ground.
  – Irrigated land adjacent to non-irrigated land.
  – Brightly colored sand dunes surrounded by darker desert soils.
Brightness and wetness contrasts between salt flat and surrounding desert leads to a horizontal contrast in heating.
Result: “Sea breeze” completely over land. Flow off salt lake during day; flow onto lake at night.

ii. Diurnal Mountain Winds

- A diurnal wind pattern that routinely develops along mountain slopes.
- Produced by horizontal temperature differences that develop everyday in complex terrain.
Slope Winds

Upslope breeze

Downslope breeze
Evolution of Upslope Flow

Morning

Afternoon

The COMET Program
Evolution of Downslope Flow

Evening

Late night

The COMET Program
Up- and Down-valley Winds

Daytime

Nighttime

The COMET Program
What Causes Along-valley Winds?

Valley contains a smaller volume of air than nearby plain (or plateau). Air within the valley warms faster than that over the plain. Thus, low pressure develops in the valley, and high pressure over the plain. The resulting pressure gradient drives the winds into the valley.
The Slope-Valley Wind System

- Upslope just after sunrise
- Upslope and up-valley midday
- Downslope just after sunset
- Downslope and down-valley midnight

The COMET Program
Using JViz and the FDDA Image Viewer to Diagnose Thermally-driven flows

14-15 July 1998 case over DPG

This demonstration will cover:

- Recognizing the wind and potential temperature patterns associated with:
  - i. Sea/lake breezes, including “sea breezes” completely over land.
  - ii. Diurnal mountain flows.
Further Reading


