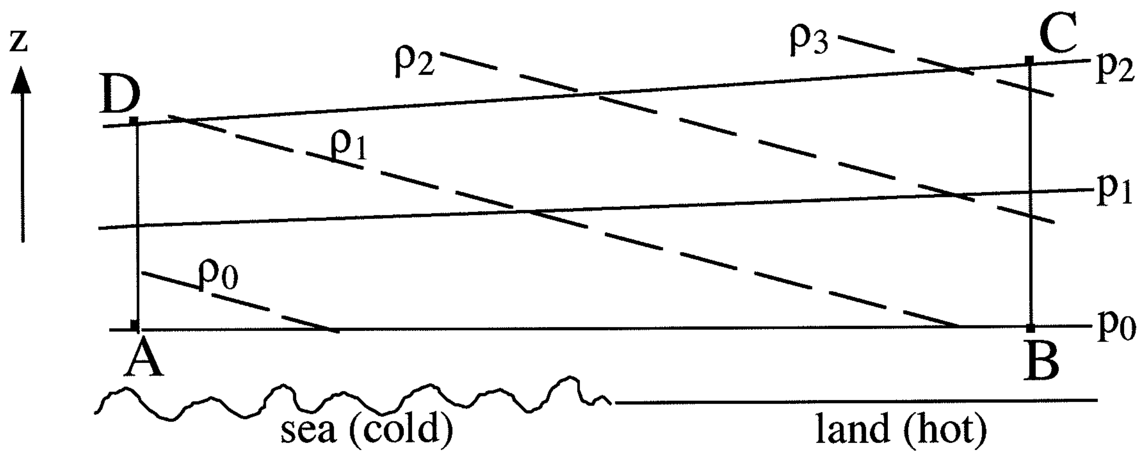
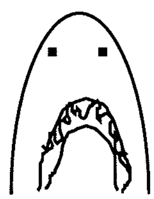
METR 3123, Atmospheric Dynamics II
LECTURE 27

<u>Circulation Thm applied to sea-breeze (continued)</u>



jaws-->



- Earth's rotation can influence the motion but lets not worry about it for now (ignore it for a first stab at the problem).

Then
$$\frac{DC}{Dt} = -\oint \frac{dp}{\rho} = -\left[\underbrace{\int \frac{dp}{\rho}}_{\text{A to B} \,\to\, 0} + \underbrace{\int \frac{dp}{\rho}}_{\text{B to C}} + \underbrace{\int \frac{dp}{\rho}}_{\text{C to D} \,\to\, 0} + \underbrace{\int \frac{dp}{\rho}}_{\text{D to A}} \right]$$

(since dp=0 everywhere along any isobaric sfc)

Bring in ideal gas law,

$$p = \rho R T$$

$$\therefore \quad \rho = \frac{p}{RT}$$

$$\therefore \quad \frac{DC}{Dt} = -\int_{\text{B to C}} RT\,\frac{dp}{p} - \int_{\text{D to A}} RT\,\frac{dp}{p}$$

$$= -R\int_{\text{B to C}} T\,d\ln p - R\int_{\text{D to A}} T\,d\ln p$$

$$= -R\underbrace{\int_{\ln p_0}^{\ln p_2} T\,d\ln p}_{\text{over land}} - R\underbrace{\int_{\ln p_2}^{\ln p_0} T\,d\ln p}_{\text{over sea}}$$

$$= R\underbrace{\int_{\ln p_2}^{\ln p_0} T\,d\ln p}_{\text{over land}} - R\underbrace{\int_{\ln p_2}^{\ln p_0} T\,d\ln p}_{\text{over sea}}$$

scratch paper to simplify the integrals ______________________

$$\text{ave} = \frac{\text{integral}}{\text{interval}} \qquad \therefore \qquad \bar{T} = \frac{1}{\ln p_0 - \ln p_2}\int_{\ln p_2}^{\ln p_0} T\,d\ln p$$

$$\therefore \quad \int_{\ln p_2}^{\ln p_0} T\,d\ln p = \left(\ln p_0 - \ln p_2\right)\bar{T}$$

$$= \ln\left(\frac{p_0}{p_2}\right)\bar{T}$$

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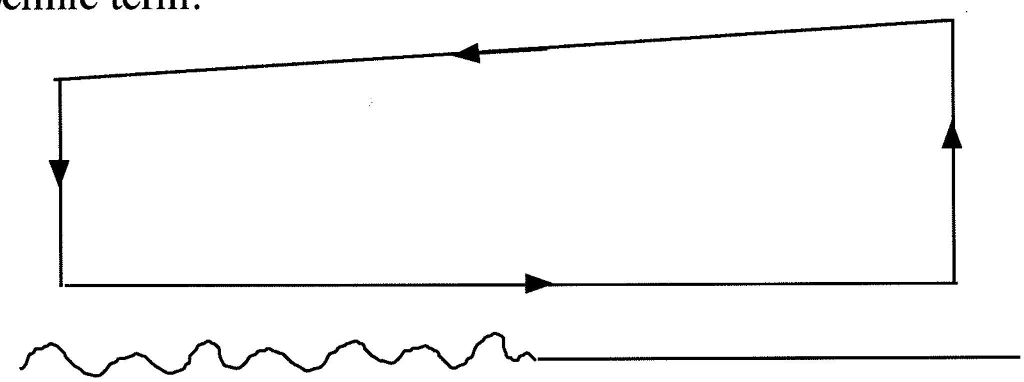
$$\therefore \quad \frac{DC}{Dt} = R \ln\left(\frac{p_0}{p_2}\right) \bar{T}_{\substack{\text{over}\\\text{land}}} - R \ln\left(\frac{p_0}{p_2}\right) \bar{T}_{\substack{\text{over}\\\text{sea}}}$$

$$\therefore \quad \frac{DC}{Dt} = \underbrace{R \ln\left(\frac{p_0}{p_2}\right)}_{+} \underbrace{\left(\bar{T}_{\substack{\text{over}\\\text{land}}} - \bar{T}_{\substack{\text{over}\\\text{sea}}}\right)}_{+} > 0$$

$p_0 > p_2 \;\therefore\; p_0/p_2 > 1$, $\therefore \ln\left(\frac{p_0}{p_2}\right) > 0$. And $\bar{T}_{\substack{\text{over}\\\text{land}}} > \bar{T}_{\substack{\text{over}\\\text{sea}}}$

$\therefore$ positive (counter-clockwise) circulation is generated by baroclinic term.



arrows denote sense of wind induced by baroclinic term (in same direction that we evaluate C --> counterclockwise)

If we had included the earth's rotation we'd find that the flow gradually develops an along-shore component (flow is deflected out of page at low levels and into page at upper levels). By mid-afternoon flow ends up being nearly parallel to the shore.

- Briefly consider case of katabatic flow on a slope. Draw/label appropriate diagram and get a very similar formula at the end.

Now let's watch some videos!