## The Simple Thermal Circulation Cell – the Land and Sea Breeze

One way to make high or low pressure cells is by a process called **differential heating**. The various materials that make up the earth's surface heat up and cool off at different rates. The best example is the difference between land and water. Land heats up and cools off rapidly, so we are used to a day-night temperature difference of about 20 degrees F. However, the ground itself can easily have temperature range of twice that. In contrast, water heats up and cools of extremely slowly. For example, the temperature of the surface of a lake may not change at all from day to night. Its temperature will change with the seasons but not on the day night cycle. (Water has a higher **specific heat** than soil meaning that it must absorb much more energy for an equal rise in temperature. This contributes to water's higher **thermal inertia**.) Thus, on the day-night cycle, there is a time when the land is warmer than the water, and a time when the water is warmer than the land. The atmosphere responds to these differences in temperature.

Air that has contact with the earth's surface will gain or lose energy depending on the temperature differences. Obviously, warm air in contact with a cooler surface will lose energy or cool. Cooler air in contact with warmer ground (or water) will gain energy or warm. Such energy exchange sets into motion a whole series of events causing the air to move or circulate. The air in contact with a warmer surface will expand, become less dense, develop buoyancy and start to rise. (This is also called **a thermal**.) As the air moves away from the surface source of energy, its temperature decreases. As the air moves upward, more air converges in to the area replacing the air that rose. Consequently a

low pressure cell is created over the surface with the comparatively warmer temperature.

Meanwhile, the air in contact with a surface that is cooler than it is, will lose energy and cool off. It becomes more dense, heavier and sinks. As the air descends, it diverges outward as more air descends above it. This process creates a high pressure cell over the surface with the comparatively cooler temperature. In the afternoon to early evening, the land has the higher temperature and resulting low pressure while the cooler water has high pressure. The wind flows from water to land. This is called a **sea breeze** or **on shore** wind. From about midnight to mid-morning, the water has the warmer temperature and resulting low pressure while the cooler land has high pressure. The wind now reverses flowing from land to water. This is called a **land breeze** or **off shore** wind. These processes make shorelines windy places.

Several thousand feet above the ground, a counter flow develops that connects the two pressure cells. The direction of this wind is opposite that of the surface winds. This flow aloft completes the loop. Since the air can move continuously through this system, it is called a circulation cell or a **simple circulation cell** with one high pressure area and one low pressure area.

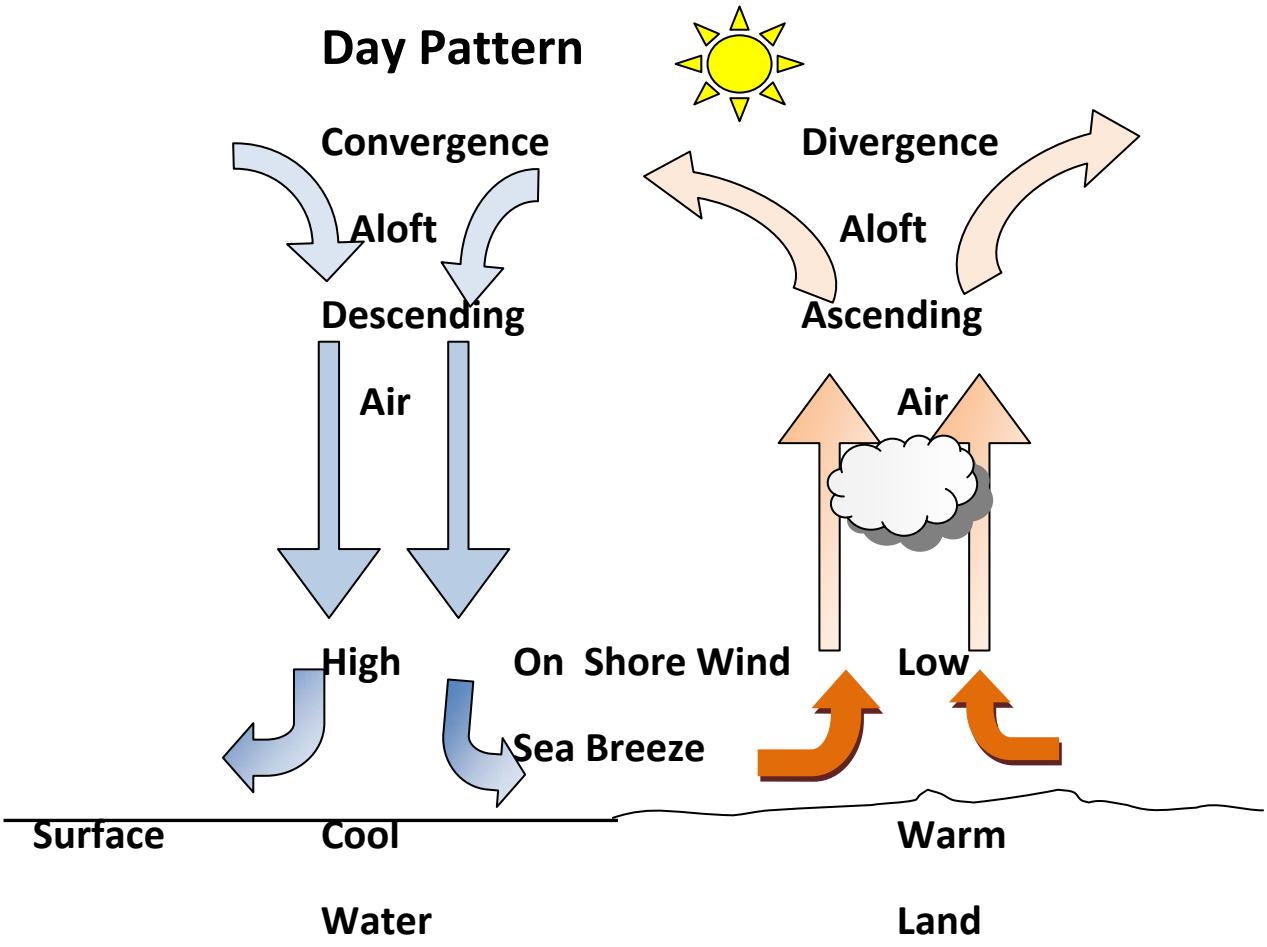
Note how convenient the daily reversal of winds is to people like fishermen who live and work along coastlines. In former times before gas or steam engines, the power to move a boat came from the wind. A dawn, when the night pattern is best developed, the fisherman sails out to sea with the off shore wind. During the day, the winds reverse,

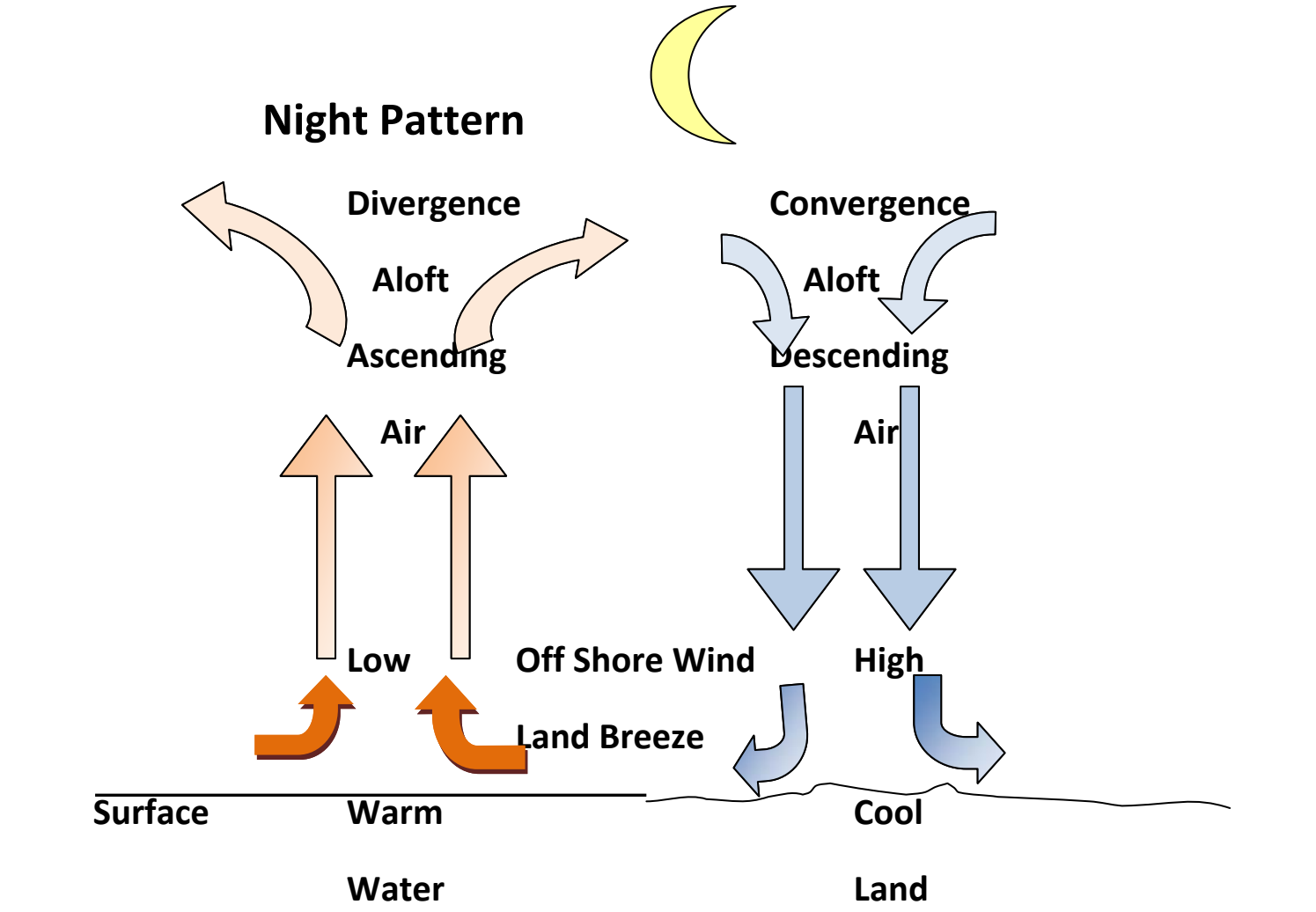
and the day pattern is best established near sunset when the fisherman sails back to the coast with the on shore wind.

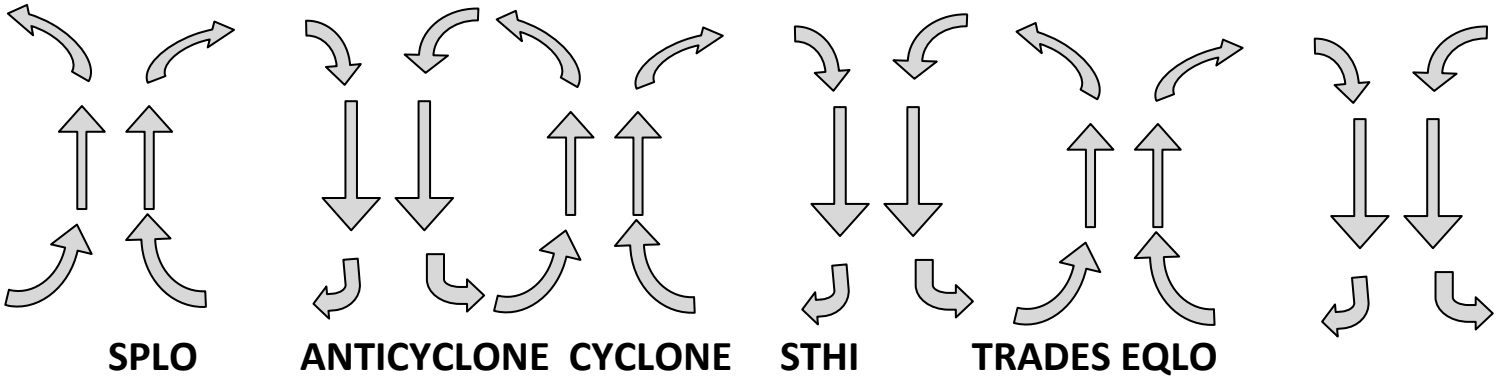
While the land and sea breeze is the best example of a simple thermal circulation cell, there are many others. All that is needed are substantial areas of materials with different thermal characteristics. The mountain valley wind is very similar. The air moves up the mountain during the day as the slopes heat up and down the mountain at night as the slopes cool off. There are circulation cells that develop between areas with extensive irrigated agriculture next to a surrounding dry desert. Another example is driven by the thermal contrast between ice and bare soil or forest.

Finally the simple thermal circulation cell can be created by seasonal temperature changes so there is an **annual cycle** instead of a day-night cycle. The best example is the **Asian Monsoon**. Asia is the world's largest land mass and much of it is located a fairly northern latitudes. Parts of **Siberia** have the greatest temperature change from summer to winter in the world. Such changes can easily result in a 100° F. temperature range. This extreme range if temperatures is called **continentality.** With this much land changing temperatures so much, the atmosphere must respond. With the extreme cold of winter, a massive high pressure cell develops over Siberia. So during the winter, the cold air diverges out of East Asia heading for the Pacific and Indian Oceans. This is cold and dry air and there is little precipitation. During the summer a strong low pressure cell develops further south over India and southern China as the continent warms. So during the

summer, hot and humid air converges into South Asia from the Pacific and Indian Oceans bringing the welcome monsoon rains. The word monsoon in Arabic means “season”. Not only is there wet season and a dry season; but also, across India, the winds shift a complete 180°.




Night Pattern
Divergence
Aloft
Ascending
Air
Convergence
Aloft
Descending
Air
Low
Off Shore Wind
High
Land Breeze
Surface
Warm
Water
Cool
Land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