Hydrogen bonds at work

It is common knowledge that large bodies of water have a “moderating” effect on the local weather, reducing the extremes of temperature that occur in other areas. Water temperatures change much more slowly than do those of soil, rock, and vegetation, and this effect tends to affect nearby land masses. This is largely due to the high heat capacity of water in relation to that of land surfaces—and thus ultimately to the effects of hydrogen bonding. The lower efficiency of water as an absorber and radiator of infrared energy also plays a role.

Adiabatic heating and cooling of the atmosphere

The specific heat capacity of water is about four times greater than that of soil. This has a direct consequence to anyone who lives near the ocean and is familiar with the daily variations in the direction of the winds between the land and the water. Even large lakes can exert a moderating influence on the local weather due to water's relative insensitivity to temperature change.

During the daytime the land and sea receive approximately equal amounts of heat from the Sun, but the much smaller heat capacity of the land causes its temperature to rise more rapidly. This causes the air above the land to heat, reducing its density and causing it to rise. Cooler oceanic air is drawn in to fill the void, thus giving rise to the daytime sea breeze.

In the evening, both land and ocean lose heat by radiation to the sky, but the temperature of the water drops less than that of the land, continuing to supply heat to the oceanic air and causing it to rise, thus reversing the direction of air flow and producing the evening land breeze.
Why it gets colder as you go higher: the adiabatic lapse rate

The air receives its heat by absorbing far-infrared radiation from the earth, which of course receives its heat from the sun. The amount of heat radiated to the air immediately above the surface varies with what’s on it (forest, fields, water, buildings) and of course on the time and season. When a parcel of air above a particular location happens to be warmed more than the air immediately surrounding it, this air expands and becomes less dense. It therefore rises up through the surrounding air and undergoes further expansion as it encounters lower pressures at greater altitudes.

Whenever a gas expands against an opposing pressure, it does work on the surroundings. According to the First Law \( \Delta U = q + w \), if this work is not accompanied by a compensating flow of heat into the system, its internal energy will fall, and so, therefore, will its temperature. It turns out that heat flow and mixing are rather slow processes in the atmosphere in comparison to the convective motion we are describing, so the First Law can be written as \( \Delta U = w \) (recall that \( w \) is negative when a gas expands.) Thus as air rises above the surface of the earth it undergoes adiabatic expansion and cools. The actual rate of temperature decrease with altitude depends on the composition of the air (the main variable being its moisture content) and on its heat capacity. For dry air, this results in an adiabatic lapse rate of 9.8°C per km of altitude.

Santa Anas and chinooks: those warm, wild winds

Just the opposite happens when winds develop in high-altitude areas and head downhill. As the air descends, it undergoes compression from the pressure of the air above it. The surroundings are now doing work on the system, and because the process occurs too rapidly for the increased internal energy to be removed as heat, the compression is approximately adiabatic. The resulting winds are warm (and therefore dry) and are often very irritating to mucous membranes. These are known generically as Fohn winds (which is the name given to those that originate in the Alps). In North America they are often called chinooks (or, in winter, "snow melters") when they originate along the Rocky Mountains.
Among the most notorious are the Santa Ana winds of Southern California which pick up extra heat (and dust) as they pass over the Mohave Desert before plunging down into the Los Angeles basin. Their dryness and high velocities feed many of the disastrous wildfires that afflict the region.
Contributors

Stephen Lower, Professor Emeritus (Simon Fraser U.) Chem1 Virtual Textbook