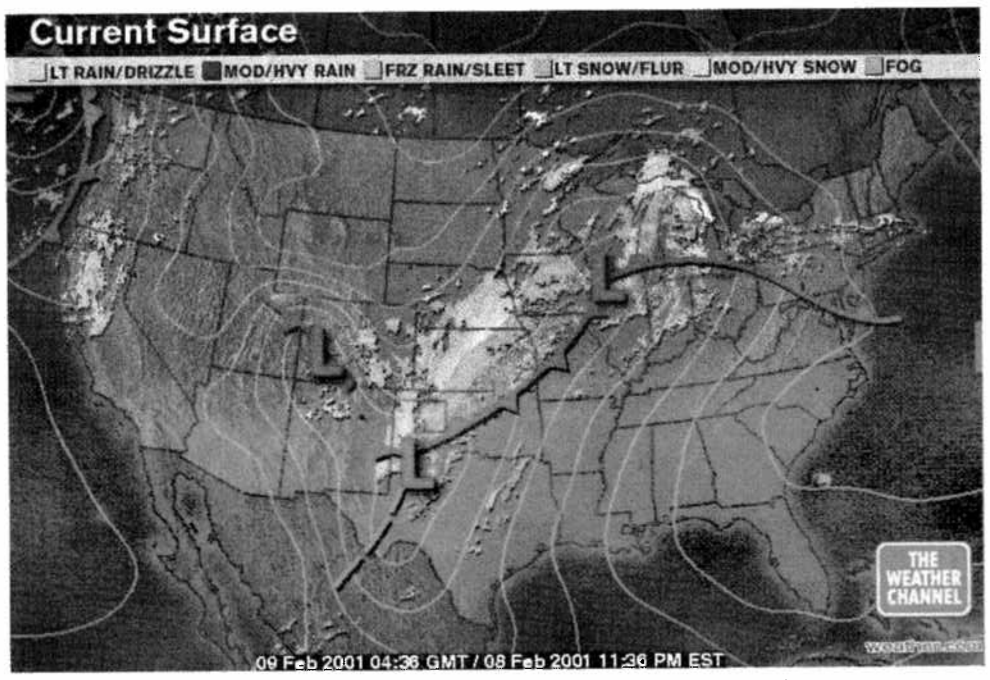
ENVIRONMENTALLY SPEAKING Peter Schwartzman

What's With the Weather? — A primer

Snow, sleet, and freezing rain are all forms of precipitation that fall on and around us during the cold months of the year. And while most of us have a love-hate relationship with these moist deliveries from the sky, we all recognize that they are part of our lives whether we like them or not.

On closer inspection, we realize that these, and other, weather phenomena provide numerous opportunities to engage with our surroundings and learn from the Earth's majestic wonder. We have practical reasons for knowing more about the weather. When flying, driving, biking, hiking, golfing, or just walking in the presence of dangerous or changing weather, a basic knowledge of meteorological phenomena greatly improves one's chances of living through a severe event unscathed. Data over past five decades in the U.S. indicates that deaths due to lightning, tornadoes, and hurricanes are down significantly, though our nation's population has continued to increase during the entire period. It appears the growth in our collective wisdom regarding weather has been a true lifesaver. Having the ability to anticipate precipitation events can also be a saver in other areas. For instance, it allows folks to conserve water use by reducing their need to water plants, gardens, or lawns when natural sources are "just around the corner." Thoughtful interaction with meteorological elements is also a means to a better connection with one's surroundings. Many scholars argue that an important reason why environmental services (such as clean water, clean air, and native ecosystems) are not properly treated by our society has to do with our lack of knowledge and connection with the places that we live. Although the weather is only one of many aspects of one's place, it may be an entry way for some to make a connection with the place one inhabits and lives.

Now that we have reason to be informed, let's take a look at a few of the most important (albeit basic) principles that are essential to understanding weather phenomena. First, *warm air rises*. Warm air rises because it is lighter (i.e., more spread out, so less dense) than cold air. So when cold air masses and warm air masses collide, the warm air will be the one to climb in elevation (almost like going up a mountain, in fact). Second, *moist air rises*. It turns out, contrary to intuition and our culture expressions surrounding humidity, moist (humid) air is lighter than dry (arid) air. This is a bit more complicated but it boils down the fact that water vapor molecules (H_2O) are a bit lighter than the most dominant atmospheric gases, namely, nitrogen (N_2) and oxygen (O_2). So, when an air mass gets more moisture, water molecules displace other gases, which makes the moistened air mass lighter. When a wet air mass comes in contact with a dry one, the moist air will naturally rise to higher elevations. Third, *a warm atmosphere can hold more water vapor than a cold one.* Because of this basic principle, one tends to find moister air as one gets closer to the equator (or the Gulf of Mexico). Fourth, *when an air mass contains all the water vapor that it can hold (based on its*



temperature), condensation begins. As trite as this sounds, this feature of air masses makes them excellent repositories for clouds. Fifth, *condensation (of water droplets) results in the release of energy.* Condensation is the inverse reaction of evaporation. Everyone knows that evaporation (or "boiling" off) of liquid water requires energy from the system. When evaporated gaseous water molecules condense (i.e., form liquid droplets) much of the energy that was used to evaporate them (in the first place) is returned to the system (i.e., the surrounding air). Since condensation is an exothermic reaction (i.e., releases energy to its surroundings) it is the source of much of the energy in the upper atmosphere and is the key way in which storms obtain necessary energy. Sixth, *rising air is a major source of instability in the atmosphere.* Since rising air often moves into regions that are colder, it often results in condensation and, consequently, energy is released into the atmosphere. This excess energy is expended to create winds of increasing strength, to cause winds to spin (referred to as vorticity), to stimulate lightning, and to drive updrafts (which lead to more condensation).

So, as we see from the totality of these six central principles of weather, stormy conditions can often be obtained by getting air to rise. But what processes promote air to rise? Well, here is where meteorologists really get excited. It turns out that there are several mechanisms (or processes) that give air the impetus and support to rise. And the presence (or absence) of these mechanisms at any given time can be very helpful in projecting how a storm will develop, whether it will intensify, how dangerous it will become, and when, inevitably, it will diminish/weaken.

The first process occurs when the surface air becomes heated. This usually occurs during the day as the surface absorbs sunlight, thereby warming, and consequently, through conduction heats the nearby air. This warmed air near the surface heats up and eventually rises—through a process known as convection. Convection is a very important source of rising air and the outbreak of storms in the summer months when the sunlight is most available.

The second mechanism that gets air to rise relates to the presence of orographic elements (such as mountains or more gradual inclines such as the one found near lake/ocean and land boundaries). When an air mass confronts a mountain, say on the westward side of the Rocky Mountains, it must rise. This is an important source of atmospheric instability and is an important reason why windward sides of mountains get much more rain and snow than leeward sides do. (On leeward sides, air sinks to fill in valleys and, in doing so, brings stability to the atmosphere.)

The third force compelling air to rise is a low pressure system. Everywhere they are found, low pressure systems direct air inwards and upwards. These surface features benefit as well from fast moving winds in the upper atmosphere which drive air molecules out from above a low pressure system, thus maintaining low pressures at the surface. (Pressure is just a measure of the cumulative weight of a column of atmosphere above any given location; somewhat shockingly, at the surface, on average, this weight amounts to nearly 15 pounds per square inch). Low pressure regions are locations where storms are most likely, and so tracking the movement of them is probably the best guide to future storm development in one's locale. Though not too typical of lows in the mid-latitudes where *The Zephyr* resides, hurricanes are renown tropical low pressure systems which cause havoc. Recently two hurricanes have resulted in a tremendous loss of money (some $25 billion by Hurricane Andrew in 1992) and loss of lives (some 10,000 by Hurricane Mitch in 1998) in our hemisphere. Lows in our backyard are not as large as hurricanes but they can still cause significant damage, as we've seen a few do locally in recent years, via tornadoes and flash floods. Conversely, high pressure locations are generally clear and free of precipitation. The included figure indicates where lows (L's) and highs (H's) were on a recent day. Daily weather maps like the one shown are updated at least once an hour at The Weather Channel's website: <http: //www.weather.com>.

The fourth and fifth mechanisms contributing to storms both relate to fronts—hypothetical three dimensional surfaces that serve as boundaries between air masses of different characteristics, such as temperature and moisture levels. Moving fronts represents regions where different types of air masses are forced to mix. Based on principle one above, when warm air comes in contact with cold air, the warm air rises. Based on principle two, when moist air comes in contact with dry air, the moist air rises as well. So the mixing of air masses that have different physical properties always results in rising air of some kind. Along cold fronts (shown as curved lines with triangular markers in the diagram), which serve as locations where cold air is moving into regions of warm air, warm air gets push up very quickly, particularly because cold fronts are very steep (vertically). The warm air that rises often has a fair bit of moisture in it (usually coming from the Gulf of Mexico in the Midwest) and so when it rises rapidly, it releases a great deal of energy during condensation (or cloud building). The weather map provided shows a decent low pressure system that moved through the Midwest in the winter of 2001. Wind speeds and directions at the surface can be estimated by the closeness of the isobars (lines of constant pressure; shown as faint wavy lines found throughout the map; the close the lines the faster the wind speeds) and location of the low (at the surface, winds flow counterclockwise around the low and slightly inward). The map also indicates regions of precipitation—in many forms, snow, sleet, freezing rain and rain—with shading; at The Weather Channels website, these shaded areas are color coded for clarity. While Chicago only received an inch or so of snow from this storm system, it certainly provided us with a fairly typical winter weather event for this part of the country.

Now while weather maps are a handy tool to determine wind speeds, wind directions, and the movement and development of storms, there is still much that can be gained by going outside and looking to the sky for direct information. By keeping track of changes in temperature, wind direction, and cloud cover, all variables that can be measured fairly easily from the steps of one's porch, future weather developments can often be projected with a fair bit of confidence. How so? How about a few examples that will suggest how this might be done, at least in the Midwest (other locations will have their own particular nuances to consider).

Scenario 1: You look outside and notice the winds are easterly (meaning they are coming from the east) and cloudiness has been increasing over past several hours. There is a strong reason to believe that a warm front is approaching from the southwest. This means that you can expect it to get more cloudy and warmer over the next several hours. Precipitation (i.e., rain or snow) is possible, but likely not to be heavy at least not for a while.

Scenario 2: You go outside and notice that the winds have been shifting from southeasterly to southwesterly and it has been getting warmer (and the temperatures are higher than average for this time of year). It is likely that you are southeast of a surface low pressure system and a cold front is to your west. Thus, you can expect stormy conditions in the near future and much colder than normal conditions to prevail after the storm passes. (The dramatic change in temperature is more likely in the winter.)

As you can see, with just a little information about the weather, one can make useful projections, at least in the near term. With these principles in mind and regular meteorological observations of one's surroundings, we can almost guarantee a safer and more conscientious society.

Peter Schwartzman, a resident of Galesburg, is chair of the Environmental Studies Program at Knox College. He is a research climatologist with peer-reviewed publications in the area of climate change and human population growth and he is currently writing two books focused on bringing environmental understanding to a wider audience.