View this page within its module.

Observations

Hydrolapse Profiles

Saturation at the surface does not always lead to fog formation. In some situations, both the dewpoint and the temperature decrease, but visibilities remain excellent. Mixing is often blamed for the lack of fog development, but examining the vertical distribution of specific humidity (hydrolapse) provides a more meaningful explanation. If specific humidity decreases in the vertical, fog does not tend to form except in very still air. Instead, dew or rime usually deposits on the ground, which acts to dry the lower atmosphere and delay or prevent fog development. The decreasing vertical humidity profile can explain many of the situations with surface saturation and no fog.

Commonly applied forecast techniques ignore vertical humidity changes because the shelter-height dewpoint is the only widely available measure of moisture in the lower atmosphere. Even though RAOBs measure dewpoint values, their resolution in the lower boundary layer is usually insufficient to be useful. ACARS instruments with dewpoint sensors may provide better information, but their current availability is limited.

How do we make use of our knowledge of the hydrolapse without recent or timely observations of specific humidity aloft for a particular airport? In practice it is really not that difficult to infer the humidity structure aloft by observing the behavior of the shelter-height dewpoint temperature during the warmest part of the day when the air is the most deeply mixed.

Crossover Temperature
Inferring the hydrolapse has been accomplished with reasonable success by aviation forecasters from the United Parcel Service (UPS) by using a value called the Crossover Temperature. The crossover temperature is used to imply the humidity state of the entire potential fog layer. In practice, the crossover temperature is defined as the lowest dewpoint temperature observed during the warmest part of the day. Conceptually, this represents the dewpoint temperature of the air at about 200 ft AGL, since this is when the layer is the most mixed and uniform. A more thorough presentation of the UPS fog forecast method is found in the Resources section of the DLAC1 Website.

Several assumptions are made when using the crossover temperature:

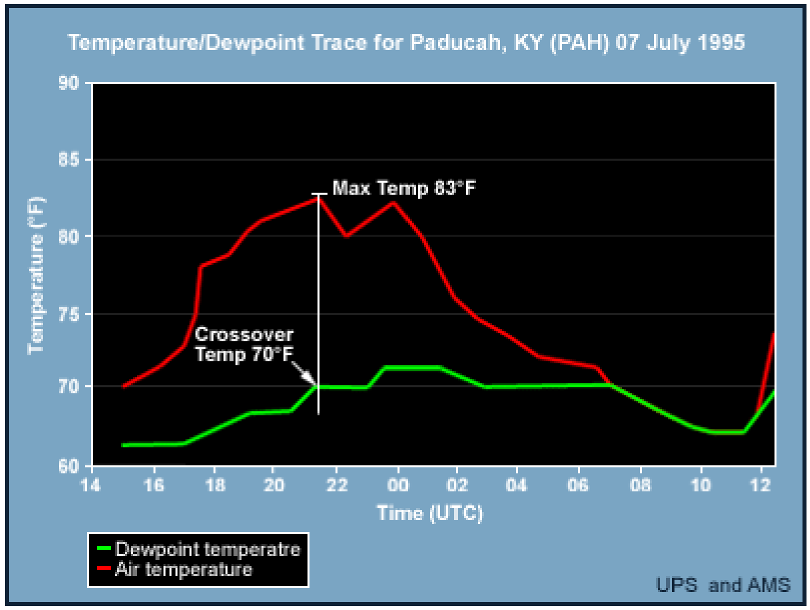
- No warm or cold advection is occurring
- No precipitation or moisture advection is expected
- No dry air advection is expected

The behavior of the dewpoint temperature should be monitored during the day. If the dewpoint drops as the temperature rises, we can infer drier air aloft, which can inhibit or prevent fog development. If the dewpoint remains constant or rises, we can infer constant or increasing humidity aloft, which can promote fog development or initiate it earlier. Of course, these inferences are only valid if there is no horizontal moisture or dry air advection occurring.

To illustrate the method using the crossover temperature, examine the time series of temperatures and dewpoints shown here. In this case, the dewpoint rose during the day, suggesting that moisture was increasing with height. This situation can pose an increased fog risk if other factors are also favorable. The crossover temperature would be 70°F, which was the lowest dewpoint temperature during maximum heating.

These tendencies are related to the fact that, under normal circumstances, specific humidity decreases with height, and the daytime mixing will simultaneously bring drier air downward and cause an upward flux of water vapor from the surface. Both these processes dry the lower atmosphere. Plots such as shown in the temperature/dewpoint graphic above will provide you with a crossover temperature to use with your expected nighttime minimum temperature to asses fog development potential. The general rules to apply this information are:

- Fog may initially form when the shelter-height temperature actually reaches the crossover temperature
- When the shelter-height temperature falls to a few degrees (3°F) below the crossover temperature, forecast ceilings and visibilities to decrease rapidly, with visibilities often falling to one mile or less



In the example to the right, the observations from Paducah, KY show that fog initially formed when the air temperature dropped to the crossover temperature of 70°F at about 0700 UTC and then became dense as the temperature dropped to 1 or 2 degrees below the crossover temperature. For another, more typical example, see the UPS paper in the Resources section.

Surface Observations for Paducah, KY for 07-08 July 95

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SA 1850 M25 BKN 35 BKN 10 200/78/68/2608/013
SA 1950 25 SCT M35 BKN 10 197/81/69/2508/012
SA 2050 25 SCT M35 BKN 10 190/82/70/2307/010
SA 2150 25 SCT M35 BKN 10 190/80/70/2007/010
SA 2250 23 SCT 100 SCT 10 183/82/71/2307/008
SA 2350 23 SCT 10 183/80/71/2009/008
SA 0050 20 SCT 250 -SCT 10 183/78/71/1906/008
SA 0150 250 -SCT 10 184/75/71/2106/008
SA 0250 60 SCT 10 187/74/70/2105/009
SA 0350 60 SCT 10 187/73/70/2106/009
SA 0450 60 SCT 10 191/72/70/2206/010
SA 0550 55 SCT 7 195/72/70/2304/012
SA 0650 CLR 5F 195/70/70/2404/012
RS 0750 CLR 2F 195/69/69/2303/011
SP 0807 W1 X 1/2F 0000/012
SA 0850 W1 X 1/8F 195/68/68/0000/012
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NOAA/NWS

Of course, strict use of this technique has several limitations as noted below and should always be used with all other available data sources. However, incorporating the information on the hydrolapse is one more piece toward solving the fog vs. no fog puzzle.

Limitations

- Advective events introduce added variables such as moisture advection that may cause the method to fail, so the method is most straightforward and reliable for radiation fog events
- In order to accurately assign a crossover temperature, you should check other neighboring dewpoint observations and trends
- Automated sites are prone to dewpoint errors (for example, when mirrors are dirty)
- Does not account for moisture or dry advection
    - When present, use upstream dewpoint observations and soundings for better representation of the humidity profile of the incoming air mass
    - Precipitation presents additional problems in assessing crossover temperature values
- Does not take into account ground temperatures, which can cause misleading results
    - Ground temperature less than crossover temperature increases fog risk
    - Ground temperature greater than crossover temperature decreases fog risk