**IC4.3: Microclimates Exercise: The Microclimate of the Keweenaw Peninsula**

**Megan Babich, NWS Marquette**

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**Overview:** Lake Effect/Lake Enhanced Snow (LES) is common across the Great Lakes region during the winter season, and is common place across the Keweenaw Peninsula of Michigan. Snow rates greater than two inches an hour, and visibilities dropping to near zero are not a surprise to seasoned residents of Northern Houghton and Keweenaw counties. In fact, storm total snowfall can sometimes exceed a foot within a 24 hour period! The main ingredients to LES are moisture, instability, and lift. As such, the Keweenaw provides a fantastic lake effect environment, because it is a peninsula with at least 70 miles of Lake Superior on three sides and it is made up of mountainous terrain. These factors combine to make a considerably challenging area to forecast for, and an important area to forecast for, mainly because there is an airport (Houghton County Memorial Airport) for which the Marquette NWS produces TAFS for. See figure 1 for a topographic map of the Keweenaw Peninsula.

**Synoptic-scale ingredients:**

Any type of synoptic pattern which brings cold arctic air over the relatively warm waters of Lake Superior brings favorable conditions for LES to develop across Keweenaw County. The trick of the forecast is whether or not the winds will be favorably oriented along the longest fetch of the Lake, and whether or not the terrain will play a part in enhancement of the snowfall. Sometimes this can be a passing low pressure system; where in the wake of the low strong northwest to westerly winds and lingering moisture are present. Other times it could be a strong high pressure system to the north or to the west bringing northerly or easterly flow to the Peninsula. Additional factors, such as the orientation of the winds to the terrain (upslope versus downslope or along terrain) play a part. Typically, the lake-air temperature difference needs to be at or above 13 degrees in order for there to be enough instability for the LES to begin (solely by itself). Many impressive incidents have occurred with the additional support (lift) of a low pressure system, which we call lake-enhanced. In these situations, where winds are oriented approximately perpendicular to the spine of the Keweenaw, lake-air temperature differences are large enough, and there is additional synoptic-scale support, is where we can see some of the highest snowfall amounts, particularly in the higher terrain. In addition, the low pressure systems leave lingering moisture in the low-mid levels that can aid in precipitation production. During times of easterly flow, KCMX (Houghton airport) can see an excessive amount of snow, as the cold air flows over Lake Superior, picks up more moisture from Torch Lake (approximately east of Houghton), and heads upslope to the airport. See figure 2 for a close up topographic image of the Houghton airport (KCMX).

**Diagnosis and Prognosis:**

Once again, the main way to diagnose lake effect snow across the Keweenaw is through the assessment of the necessary ingredients of lake effect situations. *Typically*, water – air temperature differences need to be at least 13 C for sufficient instability to develop convection across the lake. In addition, winds need to be oriented in a favorable direction across Lake Superior (longer fetch is better). Experienced forecasters use the model-forecasted winds to get ideas of where the bands will develop. For example, we frequently discuss in area forecast discussions how snowfall amounts will be highest in "areas favored by a northwest wind," which includes the Keweenaw Peninsula. Forecasters also will also use the topographic map to get an idea of where upslope flow will play a part in larger snowfall totals. Models do a good job capturing the synoptic wind flow, however the precipitation amounts due to lake effect can be largely underdone (if they show up at all-especially with larger-scale model forecasts). Therefore, forecasters rely on their experience and the principles behind LES development, in addition to smaller local models that may hint at the more dominant bands, to put together a reasonable forecast.

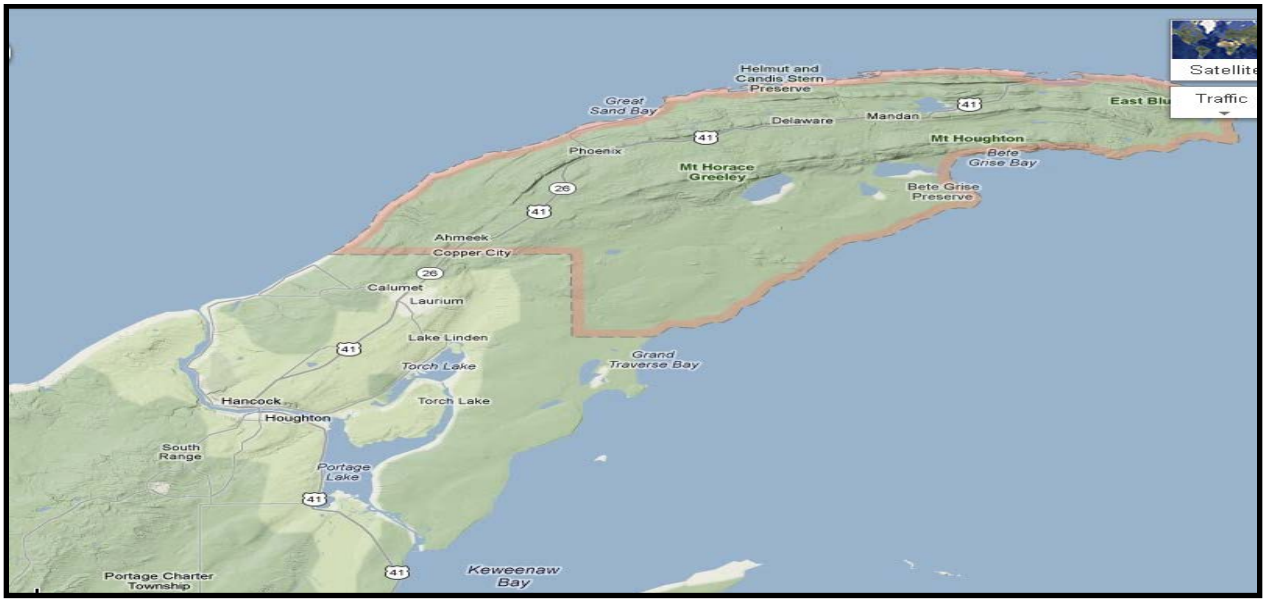


***Figure 1.*** *Map showing the Keweenaw Peninsula in Upper Michigan. Note the center of the Keweenaw has higher terrain (the 'spine' of the Keweenaw). Map from Google Maps, 2012.*

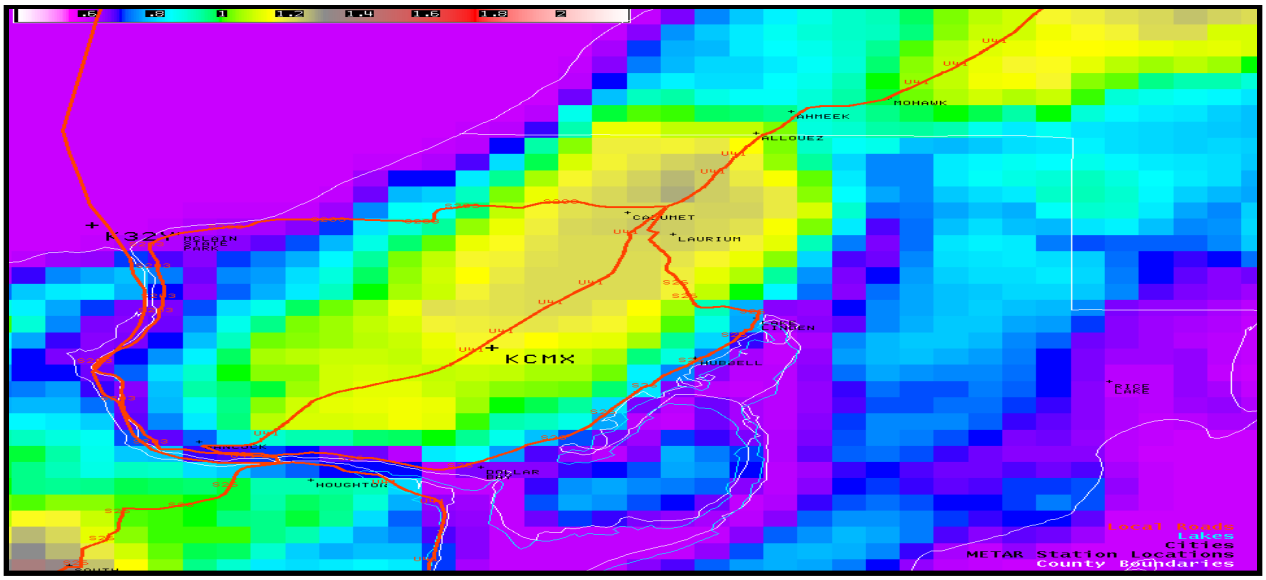


***Figure 2.*** *Here is a topographic map of the Houghton Area, showing the highest terrain in yellow/brown colors and the lower terrain in the blue. All but southwesterly winds are favorable for Lake Effect on the Keweenaw Peninsula.*

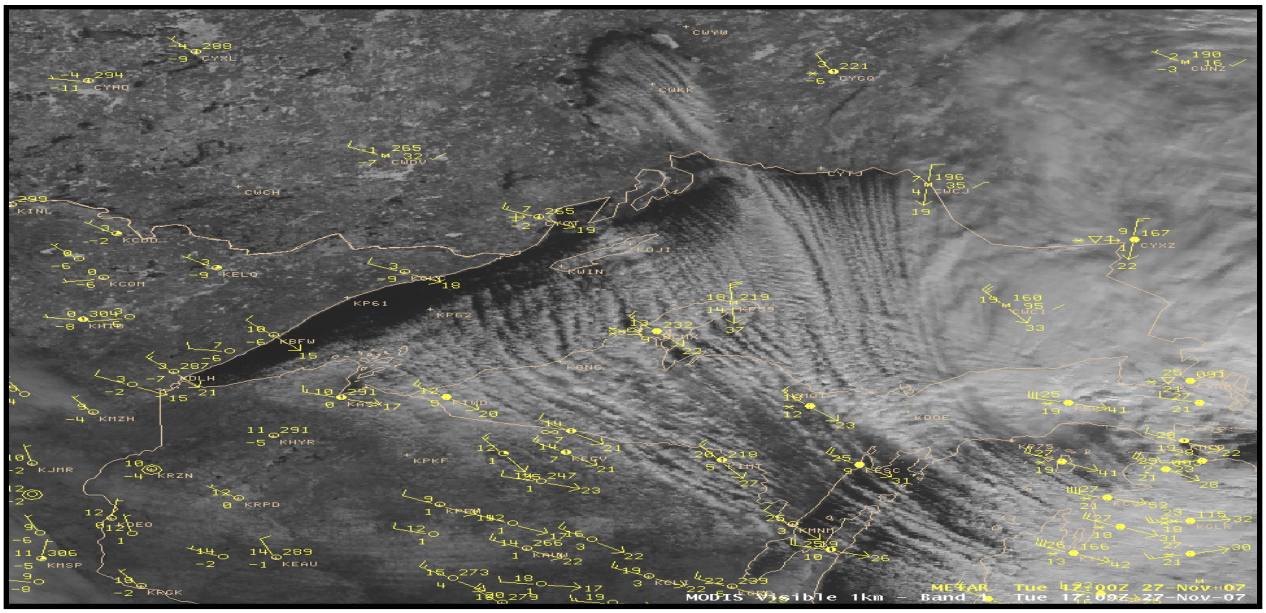


**Figure3.** A visible satellite image of a LES event over the Keweenaw (and many other areas) across Upper Michigan. From the observations, winds are north to northwest (roughly parallel with the bands).