The science behind the creation of the Lake Champlain Recreational Forecast:

The National Weather Service in Burlington produces the Lake Champlain recreational forecast from April through December, twice per day at approximately 4 am and 4 pm, with updates made when weather conditions become unrepresentative. Forecasts are valid for either 36 or 48 hours dependent on issuance time, and predict winds, significant wave heights, sensible weather, and associated restrictions to visibility if applicable over the open lake waters. Text, graphical and "point and click" forecasts are available to the user. In addition to these official forecasts, the NWS in Burlington produces a Lake Champlain model forecast which is run 4 times daily. These "model produced" forecasts are created automatically, with no human involvement and predict winds and wave heights only. They have been shown to predict these elements reasonably well under most conditions, and provide an extra source of information to those wanting access to more data. However, having no human involvement should throw caution to the wind and during most situations boaters should refer to the official NWS forecast for the most accurate and representative information. Below are more specific frequently asked questions (FAQs) regarding the Lake Champlain Recreational Forecast process.

FAQs:

1. **What real-time marine weather information is available on the lake?**

We monitor three real-time observational meteorological platforms on the lake maintained by the University of Vermont through the Vermont Monitoring Cooperative. These include Colchester Reef, Diamond Island and Burton Island. Each site provides wind, air temperature, dewpoint temperature, water temperature and relative humidity. There are no wave measurements available. Real-time data is available off our website at: http://www.weather.gov/btv/html/lake/php.

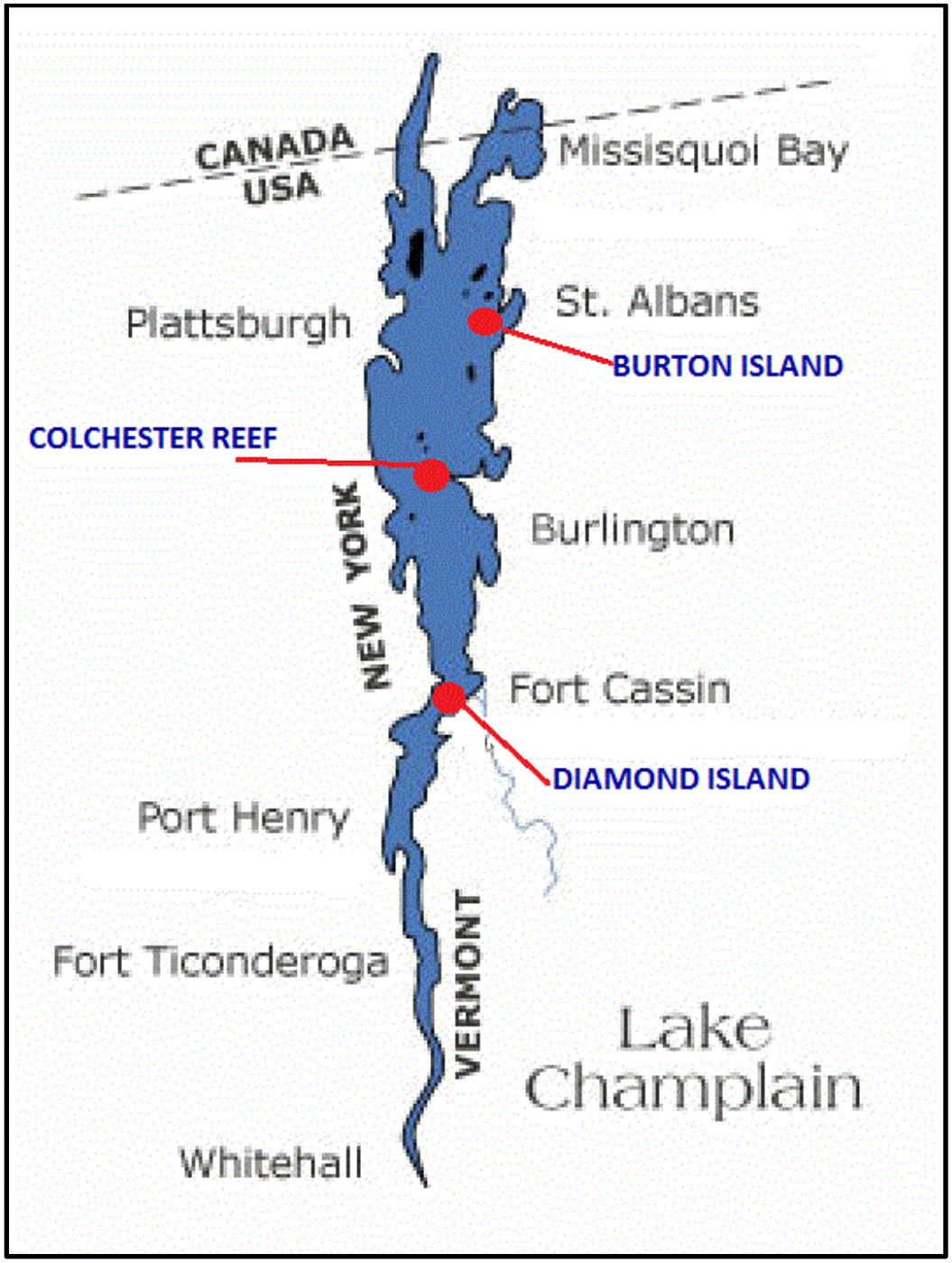

Figure 1: Location of marine observational platforms on Lake Champlain (red circles).

2. **With no wave measurements on the lake, how do you forecast wave heights?**

There are several methods available, including empirically derived data from historical wind/wave observations on the lake and deep water wave/fetch nomograms. However, the most preferred method is through a locally run wind/wave model from the Great Lakes Environmental Research Laboratory (GLERL). The model is run at a 2.5 km resolution, and is based on statistics developed from observed winds and wind fetch, and resulting wave heights. While the GLERL wave model is not nearly as robust as other wave models, such as WaveWatch3 used globally and regionally by the NWS and other meteorological agencies over larger ocean basins, it is adequate under most circumstances for relatively short fetches such as exist over the Great Lakes and Lake Champlain. As typical in other marine forecast products, the wave height values are expressed as significant wave height. For more information about the GLERL wind wave model, please visit the COMET/METED training site at: htpps://www.meted.ucar.edu/index.php.

3. **What is significant wave height?**

Significant wave height is generally defined as the mean or average wave height of the highest third of the waves (see figure below). This concept may be a tad confusing so please refer to the diagram below. Another important point is that a small percentage of waves may actually exceed the significant wave height such that the maximum potential wave may approach twice this height. For example, if a steady state wind is blowing at 22 knots, we may forecast waves in the 1 to 3 foot range. However, many waves will be a foot or less and a few may reach 4 to 5 feet. This variability may be even more pronounced under rapidly changing conditions, especially over more expansive areas of open water such as the ocean.

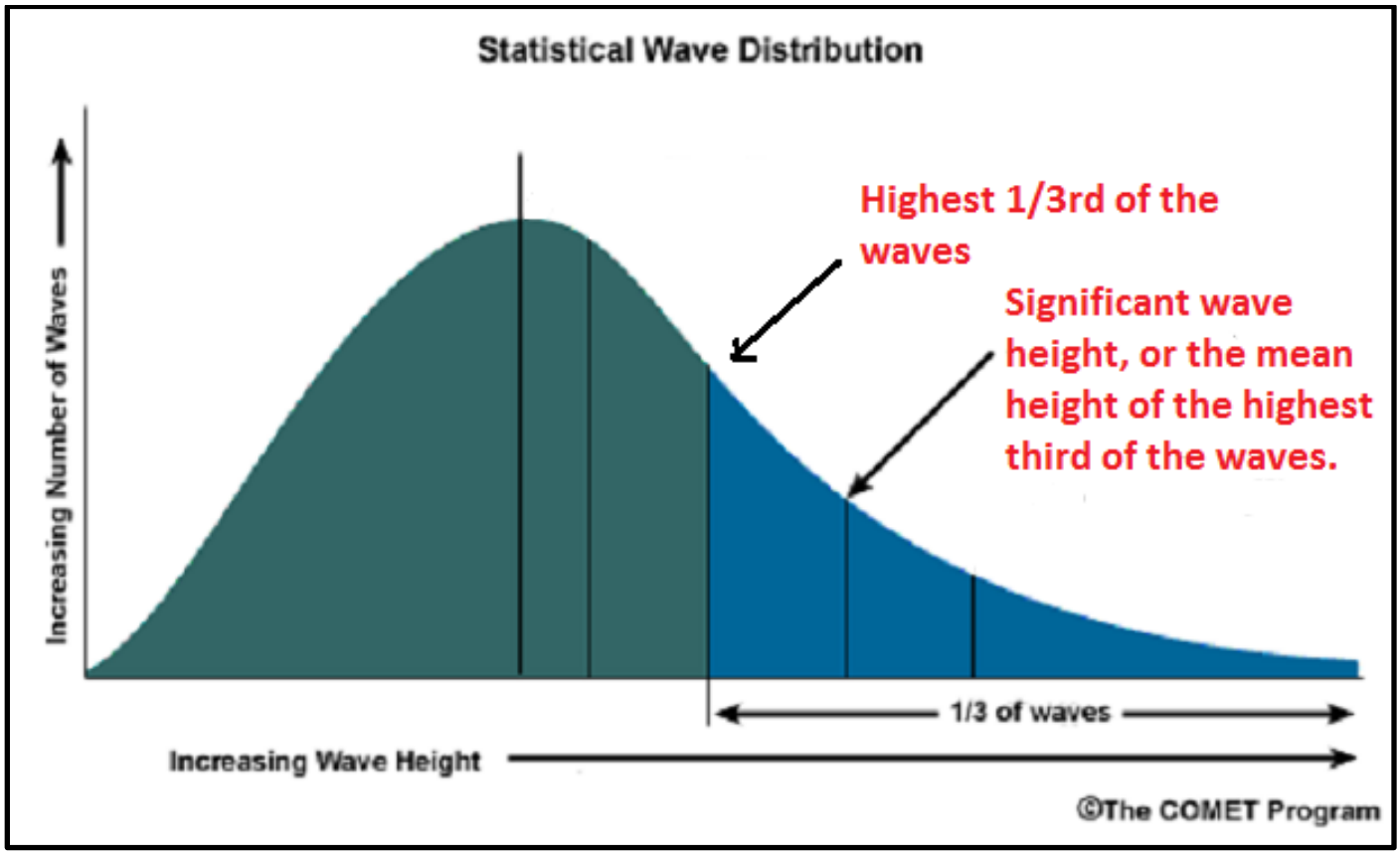

Figure 2: Diagram highlighting the concept of significant wave height.

4. Is the wave model accurate?

For the most part it is, especially under light to moderate wind conditions. However, when wind speeds trend above 25 knots, there is a known high-bias in wave heights over the larger open waters of the broad lake. In these instances, we attempt to dampen this effect by relying on empirical wind/wave relationships historically recorded on the lake. The model may also underperform in smaller bays and near shore waters, where fine-scale current and/or frictional effects are more difficult to resolve.

5. What are the pros and cons of the Lake Champlain model?

Pros:

The Lake Champlain wind/wave model is run 4 times daily at 00Z, 06Z, 12Z and 18Z and at two resolutions (1km and 4 km). The model is able to pick up fine-scale details of wind and wave behavior on the open lake in most circumstances, and often its forecasts will be quite similar to the official Lake Champlain forecast.

Cons:

Accuracy may suffer slightly in near shore waters and in smaller bays where land/water frictional effects and/or blocked winds are not resolved well. In these cases, local knowledge will likely prove valuable. A high-bias of open water wave heights is also more common when winds trend stronger than 25 to 30 knots. Significant wave heights will rarely exceed 6 feet on the open waters, even under strong wind conditions. However the model occasionally produces waves in excess of 7 feet which in general is unrepresentative during such episodes.

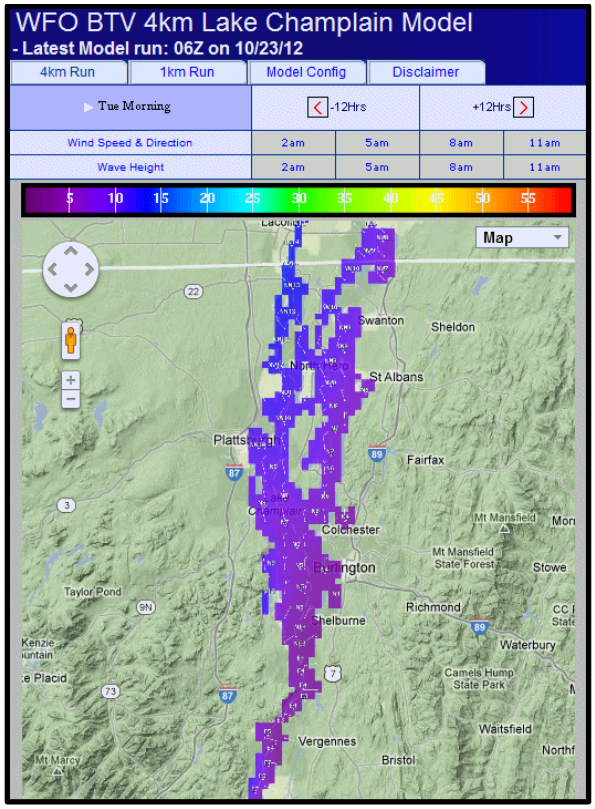

Figure 3: Lake Champlain Model (4 km) graphical display at: http://www.erh.noaa.gov/btv/html/4kmlakewrf/.

6. Why do I see differences in the lake level at various locations?

This is a common question we get here at the NWS in Burlington. In simple terms it all has to do with wind and the movement of water. In large lakes that are long and narrow such as Lake Champlain, winds drive a phenomenon known as a seiche (pronounced say-sh). During such events, winds pile water at one end of the lake, thus raising its level. From the conservation of mass equations, it follows that the level at the opposite end of the lake must fall. When the winds relax, this seiche effect disappears and water levels return to a near uniform level across the lake. On Lake Champlain, the total amplitude of the seiche during a strong wind episode may be as much as 1 to 1.5 feet.

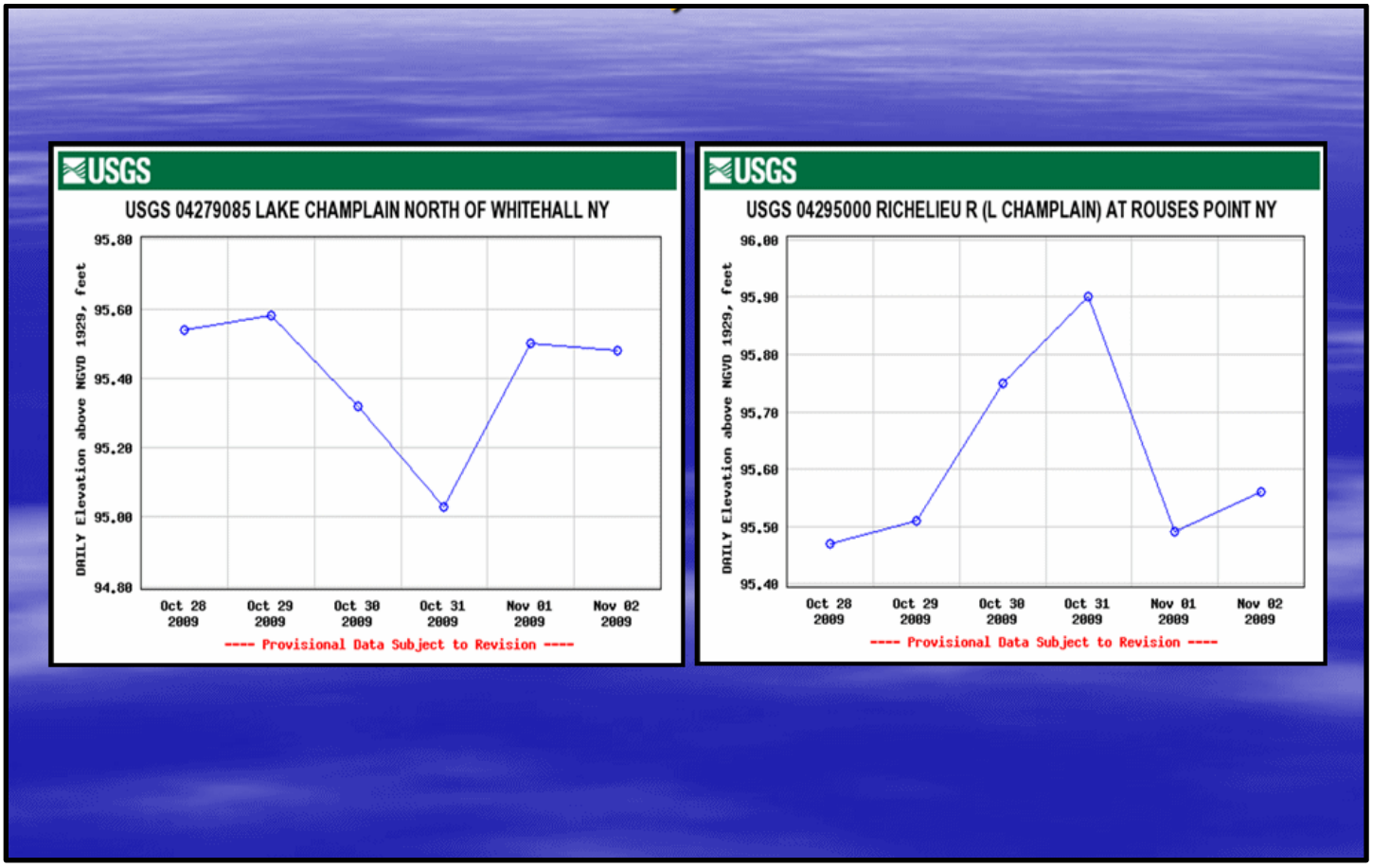

Figure 4: USGS Lake Champlain water gage plots at Whitehall, NY (left) and Rouses Point, NY (right) during a strong south wind event on 10/31/2009. Note the drop in water level at Whitehall, and the corresponding rise at Rouses Point. This seiche event had an amplitude of approximately 1 foot.

7. **Your forecasts are generally good, but for certain locations on the lake they seem less accurate. Why?**

This was addressed somewhat in discussing significant wave height above. The primary areas in which forecasts tend to drift from reality is in the near shore waters and in the smaller bays. Why? The main reason is due to small-scale currents and land/water frictional effects that typically occur in these locations where the wind may be blocked or channeled. These small-scale effects are often not resolved well by the wind/wave model due to its resolution (2.5 km). Examples include Saint Albans Bay, Keeler Bay and Whallon Bay. In these cases, applying local knowledge to the existing forecast may aid the mariner substantially. In other small bays the model may perform quite well. For example, it depicts higher wave heights and choppy waters quite with a fair degree of accuracy in Shelburne Bay under northwesterly wind conditions when the fetch tends to increase.

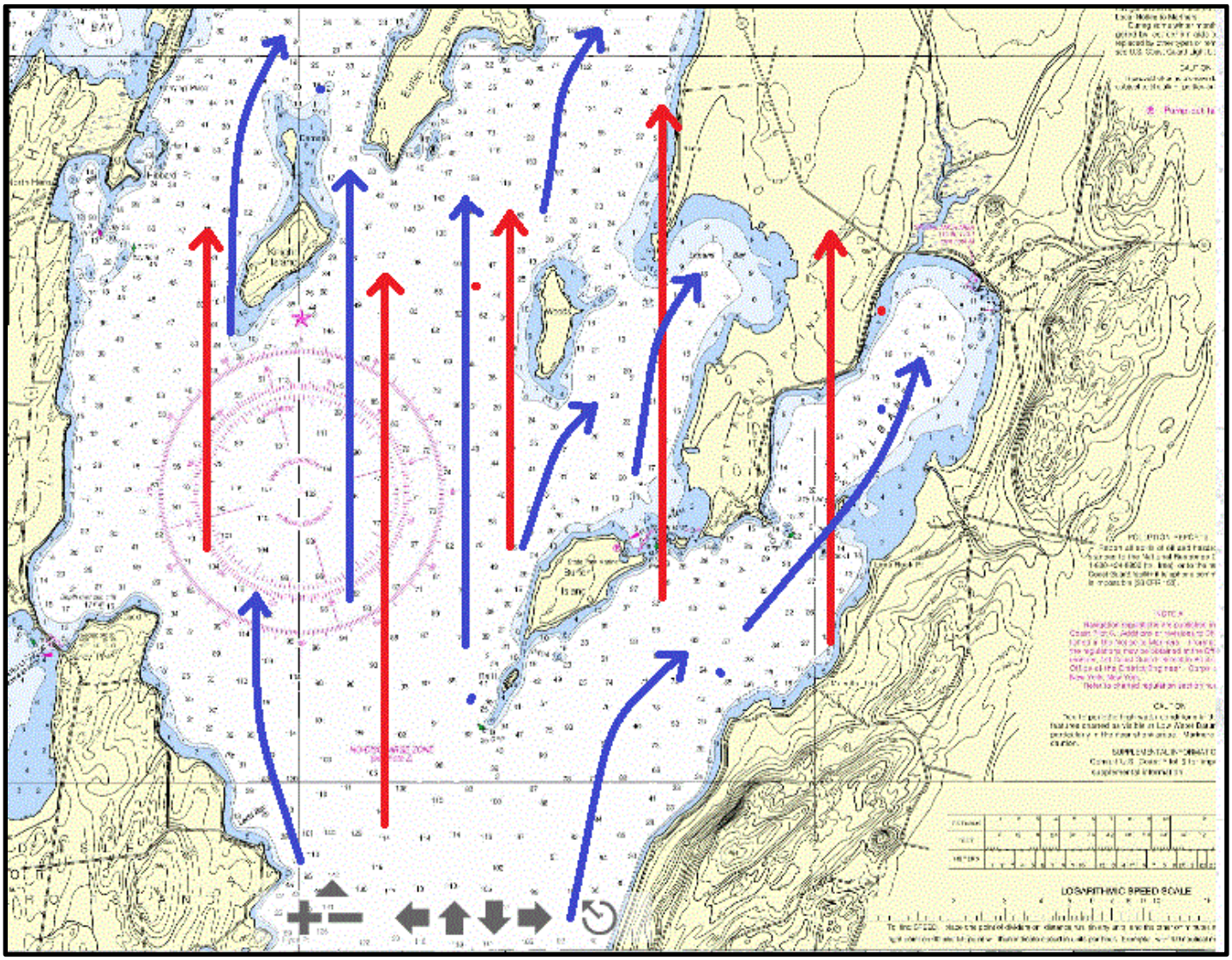

Figure 5: Model winds (red) compared to true/observed winds (blue) under a southerly wind regime on the northern broad lake. Note the directionality of the true winds as they channel through smaller islands and bays.

8. Why do I see differences in the text, graphical, and point and click lake forecasts?

This is also a question we encounter from time to time, and the answer is fairly straightforward. The worded forecast is produced by a computerized text formatter that samples the entire lake to produce "average" conditions of winds, waves, weather etc. Thus conditions at Rouses Point, Malletts Bay, Willsboro Bay as well as the broad lake waters are all taken into account. On the other hand the point and click forecast is a customized 2.5 sq km gridded forecast available for all open water areas on the lake. Thus the user will inevitably get more precise information for his or her area when using this option, though the forecast may differ slightly from the standardized worded forecast. For example, via the point and click option a user can get a customized 2.5 sq km forecast for Converse Bay. Finally, the graphical forecast displays standard wind, wave, weather and visibility forecasts in 3 hour increments, with no worded text available. Nonetheless this option may also provide the user with more precise information for their specific area of choice, especially for those who prefer a visual option.

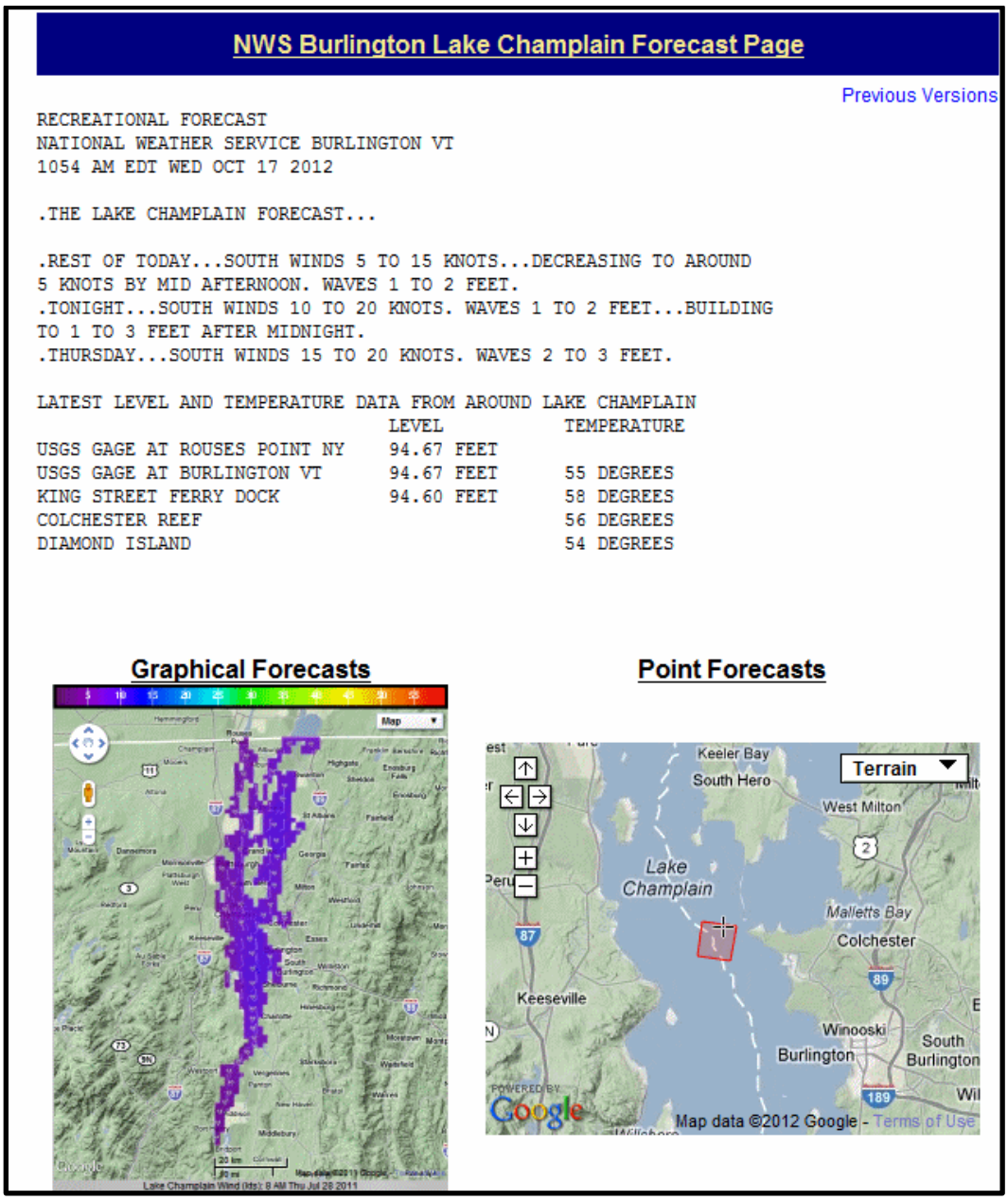

Figure 6: The Lake Champlain Recreational Forecast is displayed in three formats.

9. Why do winds typically blow stronger over the lake during fall?

This all has to do with turbulent or mechanical mixing of the atmosphere. Typically in the fall the waters of the lake are warmer than the surrounding air. Sure, the water temperature is cooler than in the summer, so "warmer" is a relative term. Nonetheless, when the water is warmer than the air, the lower 500 to 1,500 feet of the atmosphere over the lake becomes unstable such that higher momentum air aloft becomes mixed down to the surface. It is through this process that stronger winds are observed on the lake. The exact opposite occurs during the early spring when air temperatures begin to rise, but the lake waters remain cold. In this scenario, the colder lake waters actually produce a stable layer of air in the lower levels, thus inhibiting the turbulent mixing process and resulting in lighter winds.

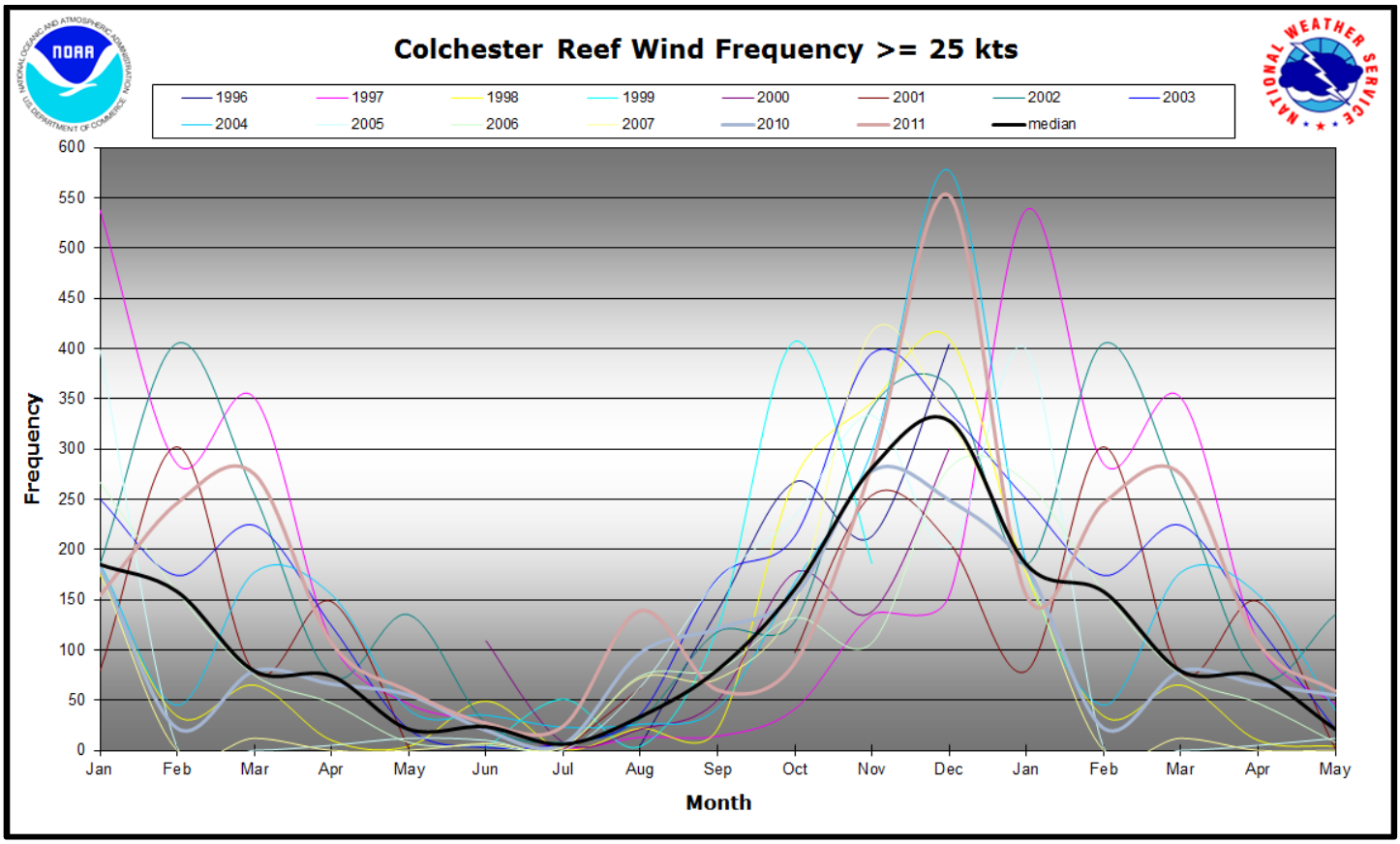

Figure 7: Plot of Colchester Reef Wind Frequency ≥ 25 knots from 1996 to 2011. Median line is shaded as a bold black line. Note the significantly higher number of events in the autumn into the winter months when water temperatures are relatively warmer than the air. Conversely, note the relative paucity of events during the late winter into the spring when relatively cooler lake waters and/or ice effects inhibit atmospheric mixing.

10. What are your criteria for lake wind advisories?

Lake Wind Advisories are issued when sustained winds are forecast to equal or exceed 25 knots for several hours during the first period (12 hours) of the forecast. Wind speeds are often expressed in ranges given inherent variability and uncertainty. Thus a forecast of wind speeds from 20 to 30 knots, or 15 to 25 knots would both constitute lake wind advisory criteria. It is analogous to small craft advisories that the NWS issues for the Great Lakes and near shore ocean waters.