# Summary

For the request of the Hungarian Meteorological Service we developed a system for supporting the work of the observers, and improved it continously. We wish to specify their estimations with the help of a computer vision system on certain fields: the examination of the cloud cover state of the sky, verification of cloud types, determination of wind direction and finally estimation of start and finish time of rainfall. We had to optimize our algorithms according to different constraints. Those are for example taking photoes relatively rarely or using the already set up cameras that are looking at the horizont or vertically towards the sky. Despite of that our estimations are not perfect, we can help the work of the observers with the results.

We can set apart clouds from the sky during the process of cloud cover state estimation, when the sky is grey. It works well independently the color of the clouds. Furthermore it can detect correctly even if the cover state is 8 oktas, or the sky is clear. As a result we get true data for the state of cloud cover as well. Worthy of note that observers work within 1 okta margin of error, so they are allowed to diverge one okta from the correct value. So during testing we also accepted this variance as correct. We tested the program on different types of clouds, with fully covered and clear sky under different circumstances. It turned out that our algorithm can filter different noises well. But we have to take into consideration that on the picture there could be different types of clouds at the same time. In that case the program can specify only the type of lower clouds, or Cumulus, if the image contains these types, regardless of Stratus clouds on the picture.

The result is 87.06% tested on 491 images, that contains single and series pictures as well. We got this data, so that we took 0.5 weight on the images, where just one of the results were correct. We also executed tests on single and series images witouth weighting (when one of the results is bad, we consider it incorrect). We also tested during rainy weather, and the result was 85.71%.

During the estimation of wind direction we observed the movement of the clouds. We tested on more than 1000 images provided by the Hungarian Meteorological Service, that includes Cumulus and Stratus types, and images with raindrops as well. With our algorithm we got better results on images with various colors, than we did with mostly homogen pictures. In the first case the biggest difference was half quarter compared to the correct value, while we could not make obvious estimations on homogen images. We were able to improve our results by increasing the number of images examined together, and taking into consideration the result of cloud cover state estimation. We coud also use the result of rain detection. When it is raining, the detection of wind direction is simply not possible.

We tried to determine the most accurate number of raindrops during the process of rain detection. The more precisely we know the location of raindrops the more correctly we can estimate the change in weather. In the collection of photoes we got from the Hungarian Meteorological Service there are four series of images with actual raining on them, so we could test our algorithm. The cameras took photoes from dawn until twilight in every querter of an hour. We got various results. Unfortunately it was inevitable that sometimes the algorithm also detected cloud parts as raindrops, because their structure is exactly the same. We got the best results on the images from the camera placed on Kékestető. The background lacks details, and there is a great contrast between colors of environment and the sky, so the algorithm could detect most of the raindrops well. Thanks to the good result of this detection we could estimate the starting and finishing times of raining within 15 minutes margin of error. On the images from the cameras placed in Siófok and Kabhegy the system detected the ending times of raining late - presumably because of the small number of raindrops. We also tested with vertical images. The system could detect raindrops well, but the time data were not fully correct because of the rare taking of photoes. Altough we have to say that starting time of raining is more important for observers than ending time.

The modules of our program are equally useful even when separated, but by using them together, we can make a nearly full report of the current weather of a location. The Hungarian Meteorological Service thinks that our program is very important and could be very useful for them, and if we can provide the required accuracy, they would be glad to use our application.