MONT-MÉGANTIC INTERNATIONAL DARK-SKY RESERVE

2017 ANNUAL REPORT

Contents

Summary

10 years! It was in September of 2007, during a symposium held at the Mont-Megantic's ASTROLab, that the region surrounding the Mont Megantic national park and astronomical observatory was recognized as the first IDA's International Dark Sky Reserve. Ten years later, the Mont-Megantic Dark Sky Reserve is alive and well. The great efforts made more than ten years ago to obtain this certification and the continuous ones that have been done since are visible in the great quality of the night sky and in the flow of people coming to experience a truly dark night. Also officially certified by the Royal Astronomy Association of Canada, the Mont-Mégantic International Dark Sky Reserve (MMIDSR) covers a territory of 5,300 km^2, including two RCMs (Regional County Municipalities) as well as the City of Sherbrooke. It unites 35 municipalities and over 200,000 citizens under dark skies.

It would be an understatement to say that 2017 was a busy year for the MMIDSR. With the tenth anniversary, a lot of efforts were put on the outreach and increasing the sense of belonging for the residents of the Reserve. A lot of work has also been done to acquire better sky brightness measurements and increase light pollution monitoring.

Many activities were held in different towns in the territory of the Reserve so that residents could experience the wonders of the night sky. Our astronomy evenings at the ASTROLab still start with an introduction about light pollution and the creation of the Dark Sky Reserve, which means that everyone visiting us in the evening is informed about the effects of artificial light at night and the benefits of a dark night.

On the regulatory side, we chose to refocus our efforts on the inside of the Reserve. After last year's publication by the Bureau de normalisation du Québec (BNQ) of a provincial level Standard to control light pollution, we are now working on updating the regulations already in place on the MMIDSR territory to better assist municipal inspectors and respond to changes in lighting technologies.

More and more town and villages also install or replace lighting fixtures with pc-amber LED ones that have become the new standard. New projects are also being started to convert bad luminaires around Mount Megantic that were either not converted in 2006 or were recently installed.

Outreach

- More than 23,000 people participated in the ASTROLab's astronomy outreach program at Mont Mégantic. During every astronomical evenings, our presentation starts with a short talk about light pollution and how we preserve the nighttime environment in the region.
- Many outreach activities with our telescopes were held in different municipalities during the summer for the 10th anniversary of the IDSR. The goal was to go where people lived and show them the benefits of living under dark skies.
- A big event took place in Lac-Mégantic for the 10th anniversary were hundreds of people came. Each kid that was born in 2007, the year of the Mont-Megantic IDSR creation, was named a « guardian of the stars » and received a gift package. People could come and see the Moon and Saturn through our telescopes, watch our movie « Cosmic Rhythms », and get popcorn and hot cocoa. The event was a big success and families came from many of the municipalities of the IDSR.

- Our followers on Facebook continue to grow with more than 16,000 for the ASTROLab's Facebook page, an increase of approximately 25% for a single year.
- Updates were made on the Reserve's website (ricemm.org) to give access to more documentation and recommended lighting fixtures.
- The 10th anniversary was a good opportunity to talk about the Mont-Megantic IDSR in the media. Astronomical events like the solar eclipse generated a lot of interviews and traffic on our websites.
- A conference was given to amateur astronomers from the city of Drummondville.
- A new intergenerational space for families featuring Mount Megantic Observatory and the Solar System was inaugurated in Lac-Megantic's Sport Center.
- Parks Canada asked us for a formation about light pollution and good lighting practices. The formation given by Remi Boucher in Québec was based on our eco-lighting program for municipalities and was adapted to the reality of national parks and historical sites.
- A double-page about the Dark Sky Reserve, the negative impacts of light pollution and good lighting practices was at the center of the park's visitor guide.

Regulation

- We are currently in the process of updating the regulations in our 2 main regional county municipalities (RCM, county-like political entities). The work that started with the Granit RCM will also be applied to the Haut-Saint-François RCM. Those regulations are 2 of the 3 currently in force on the territory. Sherbrooke already updated its regulation a few years ago to address the changes in the lighting technologies and market. As a reminder, this update aims to:
    - Better control the color of light by using the color temperature and the percentage of blue-light content instead of using the types of technologies. This will prevent that the regulation become obsolete and difficult to apply to changing technologies.
    - Simplify the tables used by having one summary table where an individual can easily read what parameters to look for and apply them to a specific lighting application.
    - Using the 4 aspects of lighting (Timing, Orientation, Color and Intensity) to continue our efforts to make good lighting practices easy to understand.
    - Provide a better control and guideline for architectural lighting.
    - Adding a town to the reserve which is part of the Granit regional county municipality but not yet in the MMIDSR. This would bring the total protected area from 5300 to 5500 km^2.
- After putting on hold their city-wide LED conversion projects last year, Montreal and Québec, the two largest cities in the Province of Quebec, have decided to install 3000K LED fixtures instead of the 4000K planned or already installed. The decision came after a lot of noise was generated by protests and after the negative impacts of white LEDs on light pollution and health where brought to light. Even if pc-amber would have been a better choice, especially in the residential areas, the decision to go with 3000K instead of 4000K still represent a great victory for the cause. (http://www.cbc.ca/news/canada/montreal/montreal-led-streetlights-1.3940889)
- Continuation of the Granit Night Sky Preservation Committee with officials from the Haut-Saint-François County that joined the committee to extend it's actions. The next meeting will be hold later in October.

Conversion

Since our symposium in 2012 about finding solutions to the growing concerns that white LED exterior lighting poses, pc-amber LED fixtures have become the de-facto type of luminaires that are installed in the Mont-Megantic IDSR. High Pressure Sodium luminaires are also still being installed since they also represent a good option to mitigate light pollution and are sometimes necessary when higher intensities are needed.

- Sherbrooke, by far the largest city in the Reserve, is where we find the most pc-amber LED fixtures installed. We don't have precise numbers from Hydro-Sherbrooke yet, but we know that the first order of 700 were completely installed last year and that more were bought and installed for different projects. This brings the total to somewhere around a thousand units for this city alone. Like it was the case with cutoff HPS fixtures when the IDSR was created, the installation process in Sherbrooke is progressive and the fixtures are either replacement of old HPS cobrahead or new installations in developing areas of the city.
- Lac-Mégantic is the second place with the most pc-amber LED fixtures in the Reserve. Installed mostly following the reconstruction of the downtown area that was destroyed by the 2013 train wreck, there is now a total number of 118 pc-amber luminaires used for street lighting in this city. This doesn't count private/commercial lighting used for parking and building perimeters which would add a few dozens of units to this number. A recent census show that pc-amber now represent 13% of Lac-Megantic's street luminaires and that there is less than 1% of old non-cutoff cobrahead still in place. The future efforts should now be directed toward commercial or industrial lights that do not meet the requirements of the regulation in place, mostly because of grandfather clause to non-converted luminaires.
- Following the example of villages closer to the core of the IDSR like Notre-Dame-des-Bois, Val-Racine and Chartierville, more municipalities also continue to replace old luminaires with new full cutoff pc-amber LED. Together, these smaller installations represent a total of 125 streets luminaires. The electricians working in the region are also more familiar with these new lights, helping in the preservation of the night sky everywhere in the Reserve.
- A larger conversion project for the city of East-Angus is also currently in talk. Depending on the decision from the city counsel to proceed or not, this could represent the replacement of more than 500 luminaires. This particular project would also be a perfect case to study and measure before-and-after light levels in this area and could be done with the cooperation of Martin Aubé from the College de Sherbrooke.
- A pilot project to convert a small number of privately owned luminaires around the mountain is currently underway. We are working with Nature Cantons-de-l'Est, an environmental organization, for this project. The goal is to identify luminaires that do not meet the

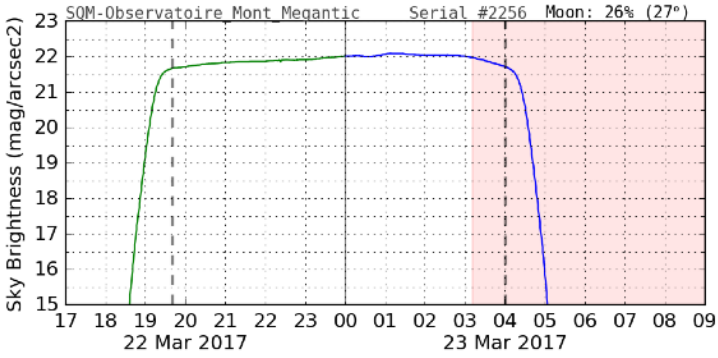
regulations in place and have a negative impact on the visual environment. The closest and most apparent lights from the summit of Mount Megantic will be our first targets. This will allow us and Nature Cantons-de-l'Est to develop new tools and protocols to interact with residents of the area and give us more experience to continue on a larger scale in the coming years. High resolution panoramas were taken earlier this year to help identify potential targets. These pictures (see on p. 12) will also be useful to show before-and-after results.

Monitoring and measurements

Increasing our efforts in measuring and monitoring light pollution has been one of our main goal for this year. We now have larger and stronger data than ever before on the dark sky situation in the Mont-Megantic ISDR. Those different metrics and tools put in place will make it possible for us to follow the evolution of light pollution on the territory.

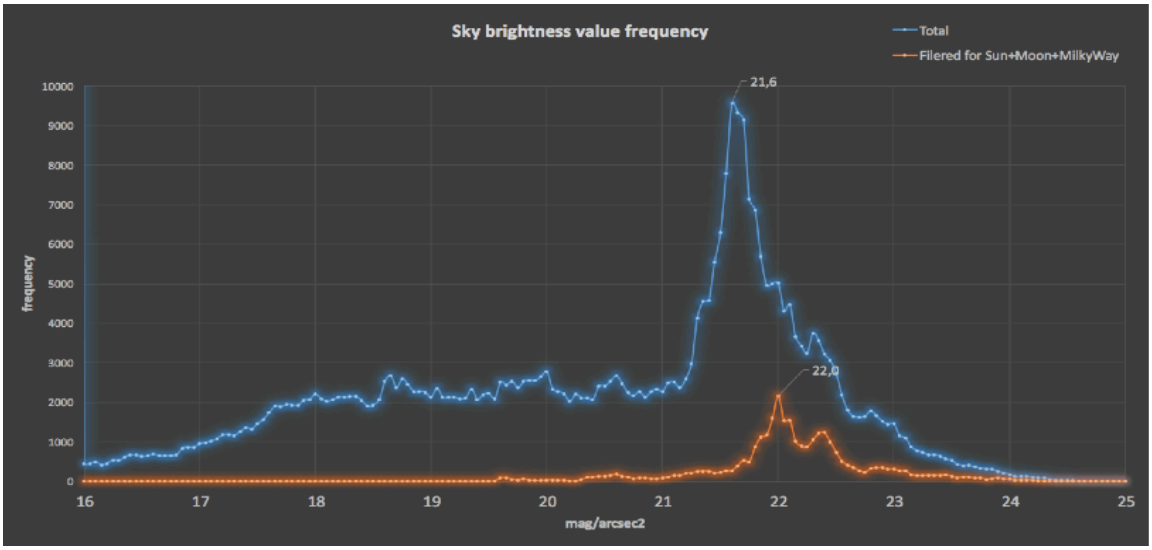
Sky Quality Meter:

- A SQM-LE was installed at the summit of Mount Megantic, near the Mont-Megantic Popular Observatory, in June of 2016. Compared to manual measurements with a normal SQM that was used in the past, the continuous data taken with the SQM-LE greatly improved our knowledge of the zenith sky brightness at the core of the Reserve. It is now obvious that using a manual SQM can give results that do not reflect the true conditions that are present at a given site. Even when it is well pointed by the user and that multiple measurements are averaged, a lot of factors affect the reading of a SQM and makes the measurements and comparison between sites very difficult. While there is obvious shortcomings to this kind of instruments, in particular the fact that it only measures a small part of the sky around the zenith, the resolution in time and under changing sky conditions gives very valuable data and insights on how the sky brightness change under multiples conditions of cloudiness and Moon phases. With more than a complete year of data, the darkest conditions are known and contribution of natural phenomenon can also be measured. The presence of an all sky webcam next to the SQM-LE also gives us informations about the weather



conditions associated with the readings.

- Looking at all the data generated since June 2016, we can see that under every types of sky conditions, the most frequent reading we have for the zenith is 21.6 mag/arcsec^2, followed very closely by 21.65 and 21.70. For this frequency analysis, SQM values were binned in .05 mag/arcsec^2. Since this represent data taken under different weather conditions, cloud altitudes, Moon phases, Moon and Sun altitudes, Milky Way positions and airglow conditions, the 21.60 to 21.70 values represent what happens the most frequently at zenith for this site. Looking closely at the data, we can see that these values are mainly due to the presence of the Milky Way at or near zenith for many hours between the month of June to December. The usually better weather between mid-June to mid-October also add weights by increasing the numbers of measurements taken under clear skies when the Milky Way is overhead.
- By adding ephemeris data for the Sun, Moon and Milky Way to the SQM readings, it is possible to filter the data to obtain the values under darker conditions, when these main sources of natural light are not present. By filtering for data when the Sun is >18° below the horizon, the Moon is >5° below the horizon and the galactic latitude is >45° (to avoid measurements near the galactic plane), the most frequent reading now becomes 22,00 mag/arcsec^2. While this does not remove measurements taken when clouds are present, the fact that cloudy conditions gives very variable SQM readings basically spread those readings over multiple values and so they occur less often than readings taken when the sky is clear and its brightness more stable. These values indicate that there is virtually no light pollution at zenith over Mount Megantic.



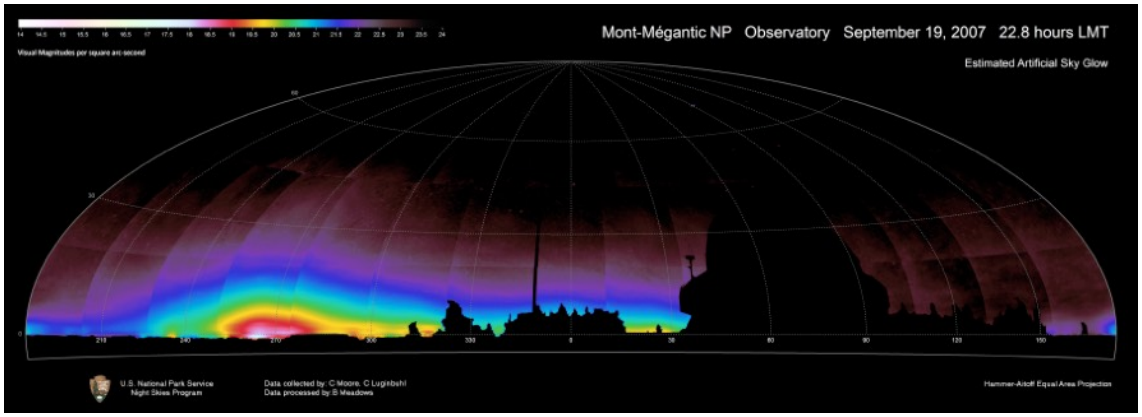
- With 22,0 mag/arcsec^2 of zenithal sky brightness, we are basically measuring changes in natural sky conditions with the SQM. Future analysis of the data could be used to remove measurements taken during cloudy conditions and more precisely compare to natural values. The variations on a short timescale could offer a way to identify and remove some of the cloudy values. We are currently working on a project to automatically compare each value measured by the SQM to a natural sky brightness model and generate a delta value.
- We also acquired two SQM with data-logging capabilities. These will be use for either mobile measurements with a vehicle or for measuring sky brightness in other area to the Reserve. For example, measurements taken before and after the replacements of luminaires in a city could be done to show the changes in light pollution levels. By taking measurements inside and near the city, we could measure how the situation improved.

All sky measurements:

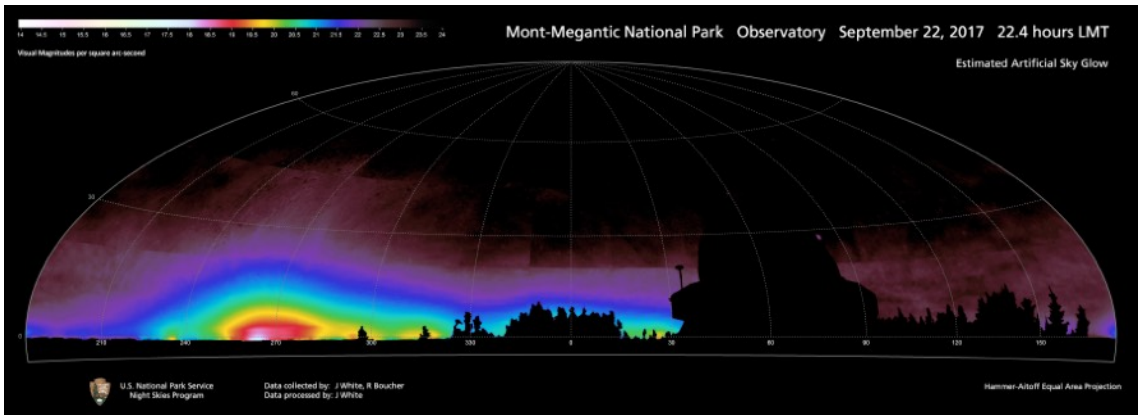
- The SQM data shows that zenith measurements might not be the best way to monitor light pollution at the core of the Mont-Megantic IDSR since there is virtually no light pollution visible in this portion of the sky. While it is interesting to continue the gathering of data with the SQM for monitoring, all sky measurements gives us a better knowledge of the light pollution seen from the summit and allow us to better see changes over time.
- In September of 2007, after the conversion of thousands of lights in the region, members of the NPS Night Skies Program took measurements with their calibrated CCD camera. Their data and the following analysis showed that the skies above Mont-Megantic are very good, with most of the light pollution contained below 20 degrees above the horizon, and mostly present on the western (toward Sherbrooke) and northern horizons. http://www.sierranights.com/nightsky/reports/PCMM070920.html
- 10 years later, in September of 2017, Jeremy White, from the Colorado State University and the NPS, came to take new all sky measurements using the same methods. On our last night, we were treated with very good conditions and no clouds. The analysis of this new data showed that the light pollution situation has basically stayed the same above Mount Megantic. For us, this is a great victory and it shows

that our efforts made continuously after the creation of the IDSR worked to keep the skies dark. Knowing that the population continued to grow by about 10% in the Mont-Megantic IDSR territory and that new lights are being installed, the fact that we don't see an increase in light pollution is very good news.

2007



2017



- Comparing 2007 and 2017, the Sky Quality Index (SQI), a metric developed by the NPS to describe light pollution levels across the sky, were exactly the same. No light pollution was measured at zenith, neither in 2007 or 2017, which is consistent with our reading from the SQM.
- Darker measurements were also obtained later on that night from a site on the park's road, approximately 7 km East-South-East from the summit. The greater distance from Sherbrooke and the shadowing effect of the landscape probably helps to obtain

a darker sky there. With the absence of lights visible on the horizon, it was truly remarkable how dark it felt. This shows that although most of our measurement are done from Mount Megantic because of the presence of the Observatory, darker areas can be found elsewhere in the Mont-Megantic IDSR.

High resolution panorama:

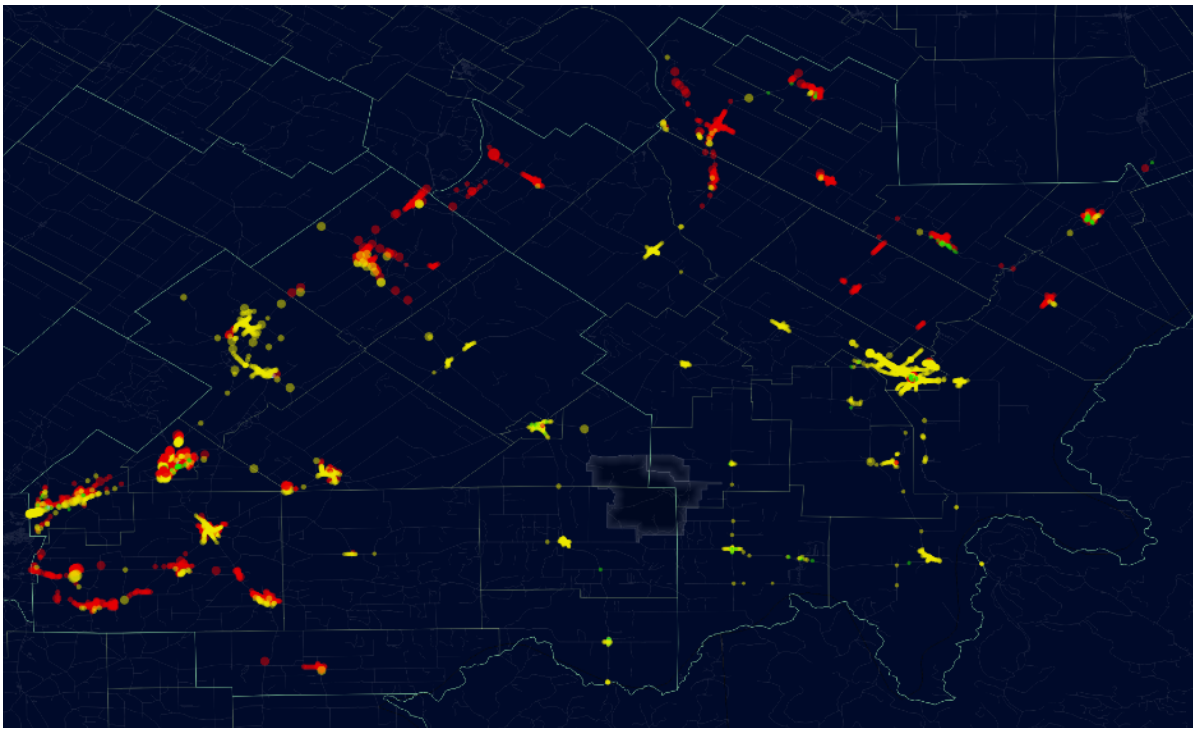
- As stated in the Conversion section, we took high resolution panoramas with a telephoto lens from the summit of Mount Megantic to identify problematic luminaires in the vicinity. Covering the horizon on 360° and aimed well below the horizon when necessary, the long exposure used allow us to identify the origin of most light sources. Being relatively simple to do, we will be able to repeat them over time to spot any changes, good or bad.

Large scale luminaire survey and conversion database:

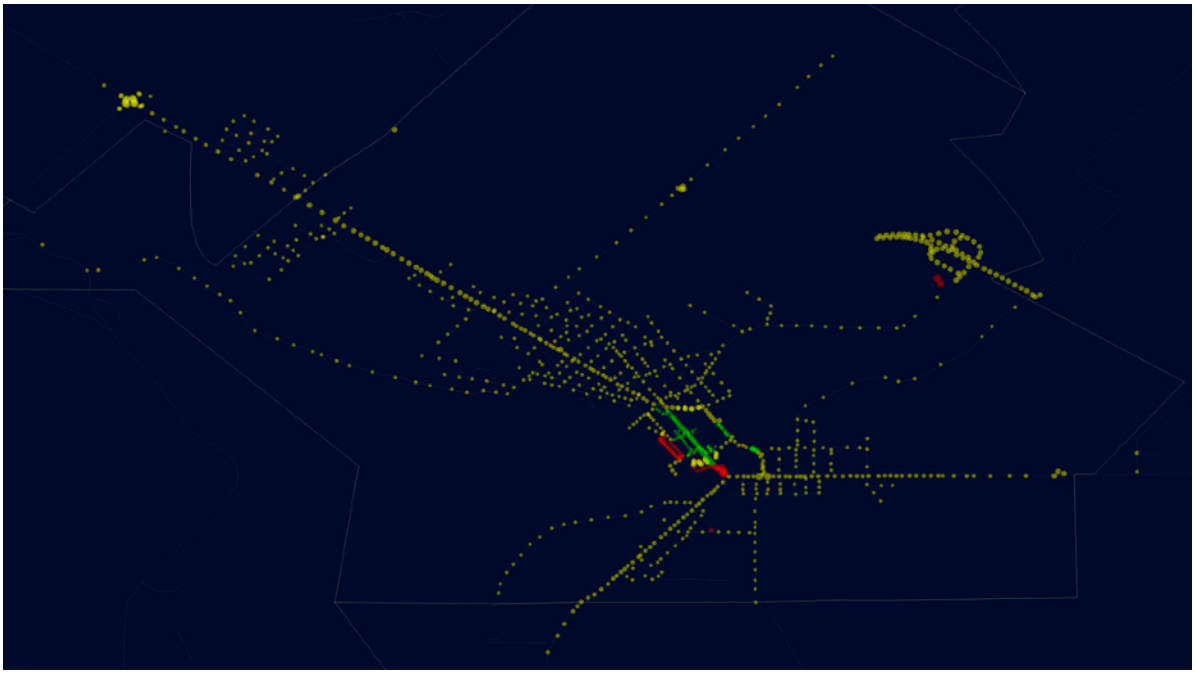
- This summer, Sarah Knefati, a graduate student in Environmental engineering at École des Technologies Supérieures, worked on a project for the Mont-Megantic IDSR. The project was divided in many parts:
  - Search and analysis of historical information about sky brightness over Mount Megantic. We did find partial information about the sky brightness that dated back to the 70's, before the Mont-Megantic Observatory was built, but a lack of a precise methodology, unknown spectral characteristics of the photometer

used and not so precise measurements didn't allow us to do a direct comparison to today's measurements. Ideally, we would have liked to identify a trend, but adding the fact that no light pollution is currently measured at the zenith, it is probable that no real trend could have been seen with zenithal measurements.

- A comparison with every other IDA's Reserves was also done to identify what methods were and are currently done in other Reserves for the monitoring of light pollution and the conversion of luminaires. Since there is no universal way of doing this, it is interesting to see what others are doing and how we can apply some of it to the Mont-Megantic IDSR.
- The creation of a geolocalized database of the 2006-2007 luminaires conversion files. While we knew the numbers of luminaires converted during the big project done in the years before the creation of the Reserve, the individual files with addresses, types of luminaires, wattage and other informations were still archived only on paper. Sarah transformed all those files into a geolocalized digital database that could be helpful for light pollution modeling or to verify if a particular luminaire was present or not when the regulation were put in place. This database will also be useful for future conversion projects.
- Knowing that the Granit RCM was already working on a private lighting database, we decided to do a geolocalized public street lighting survey for both Granit and Haut-Saint-François RCMs. Covering more than 4900 km^2, this database include more than 4400 luminaires, each labeled with their respective location, model, wattage, source type, height, etc. For us, this gives us extremely valuable information about the state of the Reserve, precise data for modeling or visualization, and better planning of future actions. Our goal is to share this database with the Granit and Haut-Saint-François RCMs and the municipalities to update it over time.



Every street luminaires in zone 1 and zone 2 of the Mont-Megantic IDSR.
Types of luminaires are color coded : Yellow = cutoff, Red = non-cutoff .
Size of dot represent the wattage of each luminaire.



Zoom on Lac-Megantic. The new pc-amber LED luminaires are shown in green.

Management

Sébastien Giguère, the ASTROLab scientific coordinator, and Rémi Boucher, the Mont-Megantic IDSR scientific coordinator, are leading the main activities of the Dark Sky Reserve.

Camille-Antoine Ouimet is supervising the efforts in the monitoring of light pollution and the projects linked to conservation.

Operation of the Reserve is carried out by the ASTROLab corporation, with great support from the Mont-Megantic National Park (SEPAQ).

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