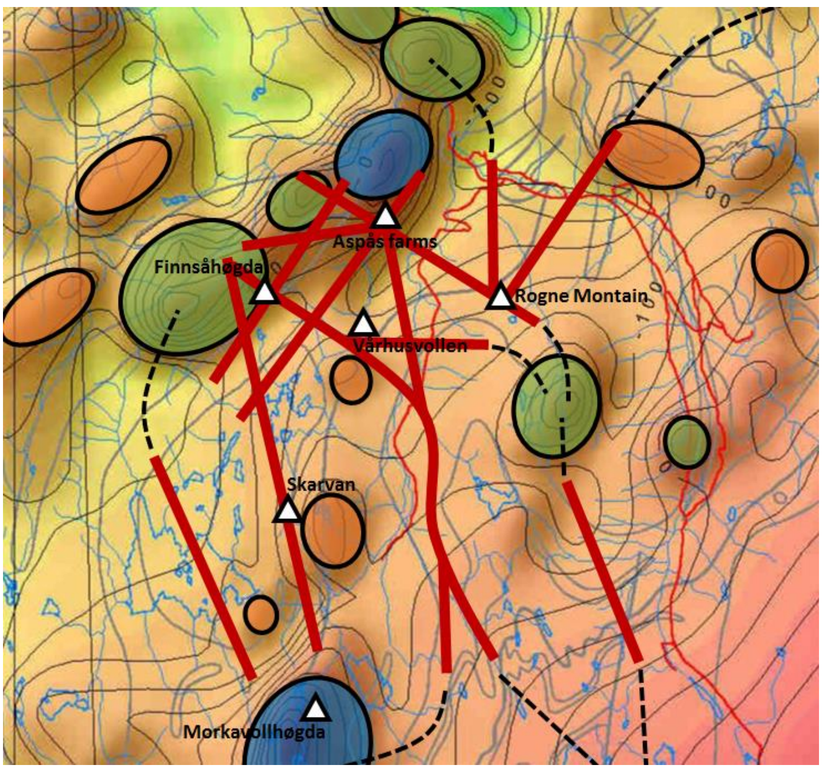
Hessdalen Database Analysis



By Torbjørn Aamodt

This Analysis

Background information behind this analysis are taken from Hessdalen.org

Theories and study sources are listed in Appendix A

Index:

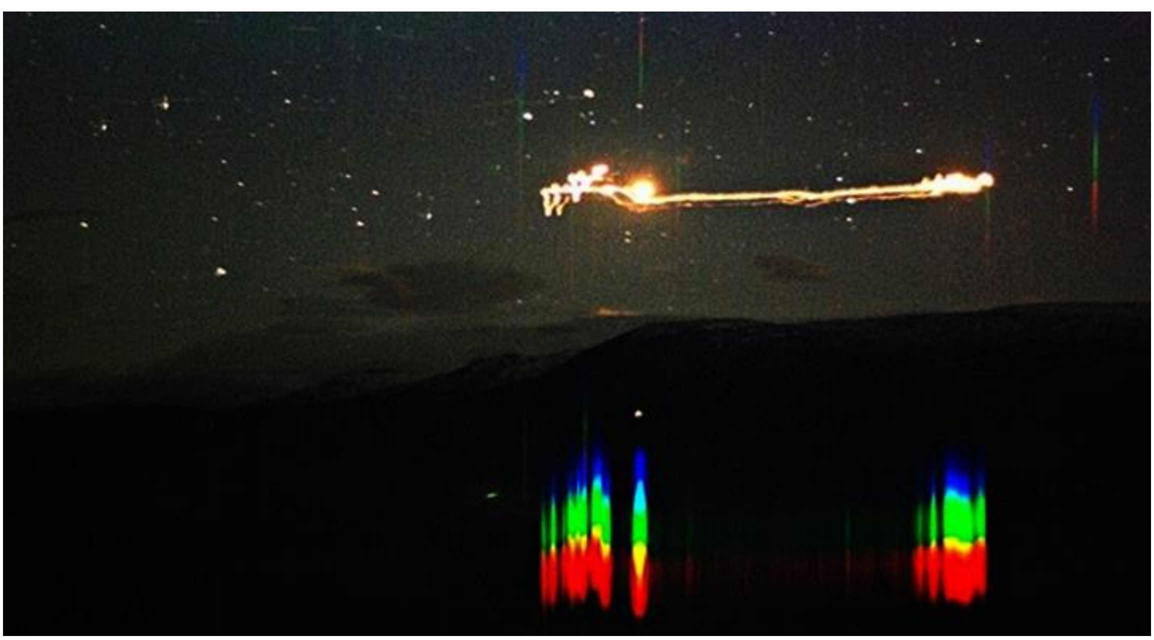
This is Hessdalen lights

Hessdalen is a small valley in the central part of Norway. At the end of 1981 through 1984, residents of the Valley became concerned and alarmed about strange, unexplained lights that appeared at many locations throughout the Valley. Hundreds of lights were observed. At the peak of activity there were about 20 reports a week.

Lights are still being observed in the Hessdalen Valley, but their frequency has decreased. An automatic measurement station was put up in Hessdalen in August 1998. In 2017, lights are still being reported.

<u>So what are the lights?</u>

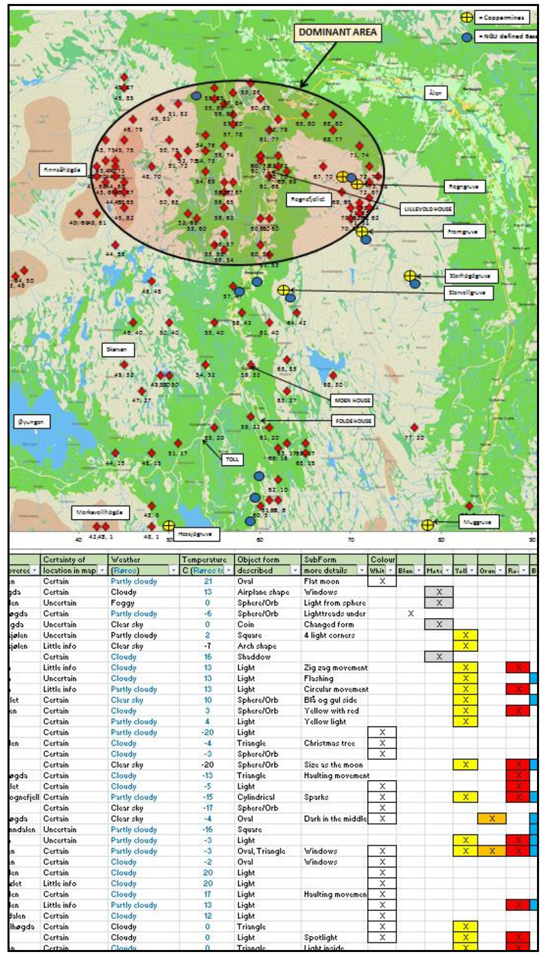
Many thinks the lights are PLASMA. The fourth state of matter. The three common states are: Solids, Liquids and gas. When continuous very high pressure and temperature is added to gas, the positive atoms and the electrons will separate from being bounded to each other and exist as free particles in a gaseous cloud. Being free electrons, the plasma will easily lead electric charges, and light up. Lightnings is a good example of Plasma state.



Hessdalen database

Database goal

The primary goal of the database is to capture the whole picture that all observations create, and not to go into detail in each single observation. With this approach, the data strengthen itself by giving clearer patterns.



Data Source

All the data used in the database has its origin from the **www.Hessdalen.org** webpage where many observations through the years have been reported. All observations that have specified location in some degree have been used.

Database assumptions

The information located in each observation report can be very good, but also minimal, when it comes to location of the observed light/object. Also local naming, time, shape, colors, path and distance can give uncertainties to defining the observation in the database. The database use Certainty and Uncertainty on observations with coordinates. Certain location can still have some uncertainty to it, but are placed in the correct area. An exsample could be a light observed above Rognefjell. Here you can place the observation within some km^2, giving some Uncertainty, but Certainty of the area.

Hessdalen database

Observation nr	UTM 32 N		Coordinate	Coordinate	Time		Location	Certainty of	Weather	Temperature	Object form	SubForm	Colour								Observer	Physical / Emotional	Comments, Summary of event
Obs.Route	North	East	X	Y	Date		first discovered	location in map	(Røros)	C (Røros te	described	more details	Whit	Blanl	Meta	Yell	Oran	Re	Blu	Gree	Name	affected	For more details, visit: www.Hessdalen.org
1	6959091	612577	62	16	29.08.1976	21:30	Grøtådalen	Certain	Partly cloudy	21	Oval	Flat moon	X								Krogstad		The object that was big flew from Grøtådalen t
2	6967314	606614	42	68	23.08.1983	14.00	Finnsåhøgda	Certain	Cloudy	13	Airplane shape	Windows			X						Havik	Phys/Emot affected	Airplane in metal color came out of an invisible
3	6970231	610272	55	85	13.01.1996	22:40	Aspåskjølen	Uncertain	Foggy	0	Sphere/Orb	Light from sphere			X						4 young people		A smaller light came out of the other
4	6965703	610696	56	57	20.01.1996	06:30	Heggsethøgda	Certain	Partly cloudy	-6	Sphere/Orb	Lighttreads under		X							Tamlag, Gjørsvoll		Observed from a car. Light treads under light.
5	6957636	612434	62	6	04.04.1996	12:36	Grønåshøgda	Uncertain	Clear sky	0	Coin	Changed form			X						Two persons		Hang, turned 90 degrees, then high speed tow
6	6968914	611793	61	77	12.04.1996	23:35	Hessdalskjølen	Uncertain	Partly cloudy	2	Square	4 light corners				X					Person in a car	Felt anxiety	Location uncertain. Sharp yellow light. Square
7					15.04.1996	23:45	Hessdalskjølen	Little info	Clear sky	-7	Arch shape					X				X	Rønning		4 bows/arcs went towards a center
8	6966237	609677	52	61	31.07.1996	15:00	Røstan	Certain	Cloudy	16	Shaddow				X						Sagen, Ås		A gray shadow that sail between the trees
9					07.08.1996	03:00	Rugldalen	Little info	Cloudy	13	Light	Zig zag movement				X		X		X	Grønås		Moving zigzag up the valley
10	6957640	618423	83	5	24.08.1996	06:00	Rugldalen	Uncertain	Cloudy	13	Light	Flashing				X			X		Grønås		Double size as a star, disappeared after 3-4 se
11					16.09.1996	22:30	Hessdalen	Little info	Partly cloudy	13	Light	Circular movement				X		X		X	Røkke		Flashing lights in circle around another object,
12	6966009	614846	70	60	18.09.1996	22:00	Rognefjellet	Certain	Clear sky	10	Sphere/Orb	Blå og gul side				X			X		Lillevold		Sphere flashed blue on one side, yellow on the
13	6967294	609985	54	69	30.09.1996	22:50	Finnsådalen	Certain	Cloudy	3	Sphere/Orb	Yellow with red				X		X			Barwin		Yellow sphere with red ls inside. 2-3 min
14	6969784	610742	57	84	08.10.1996	22.57	Aspås	Certain	Partly cloudy	4	Light	Yellow light				X					Karlsson		30 seconds
15	6969913	611573	60	83	10.11.1996	19:30	Hamren	Certain	Partly cloudy	-20	Light		X								Lillevold		Bright light against Hamren
16	6962966	610698	55	40	15.11.1996	21:45	Finnsåvollen	Certain	Cloudy	-4	Triangle	Christmas tree	X								Young couple		Collection of strong light in a "christmas tree",
17	6968536	611038	52	73	17.11.1996	17:30	Aspås	Certain	Cloudy	-3	Sphere/Orb		X								Lillevold		Downside of Finnsåhøgda, floated into Aspås
18	6967525	612017	61	68	26.11.1996	21:20	Lillevold	Certain	Clear sky	-20	Sphere/Orb	Size as the moon				X		X	X	X	Lillevold		Yellow-red light above a blue-green ball that w
19	6965890	611907	60	60	03.01.1997	07:30	Heggsethøgda	Certain	Cloudy	-13	Triangle	Haulting movement						X			Lillevold		Triangular shape with tip up. Strong Red-Oran

Database coloums

The coloums in the database are created based on the content of the reports, but also for further use in other workflows or analysis. UTM 32 N coordinates are given. Weather and temeprature are rearly given in the reports. This information is therefor retrived from the weather station at Røros close by where it is possible to search weather/temperature by date, going back several years.

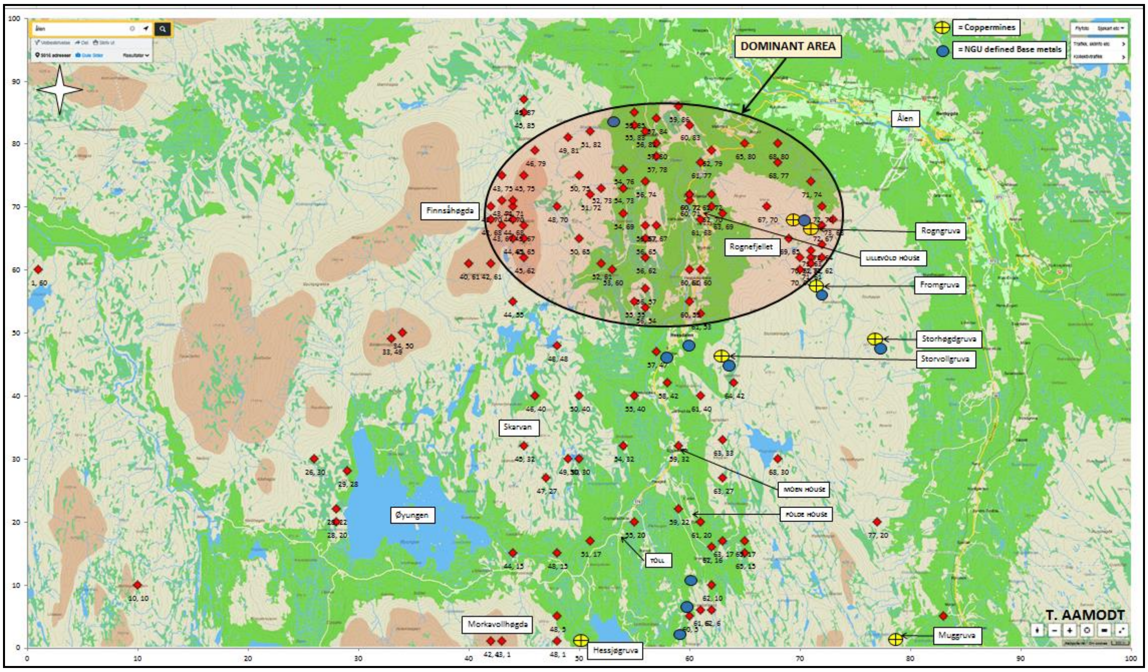
Object form and shape are sometimes given in creative wording, and therefor this creative words are given a more suiteable shape definition.

Database list:

- Observation number
- Observation route
- UTM coordinate
- Excel map coordinate
- Time
- Location of observation
- Certainty
- Weather
- Temperature
- Object form/shape
- Subform
- Colours
- Observer(s)
- Physical/Mentally affected
- Comments

Observer coloumn is included to link the observation. In some reports, the observer has been affected by the object, mentally or physically. Mostly mentally – emotional. One case with a watch stopping is included. Also a case where the person became paralyzed is included (the Portal-case).

Hessdalen database

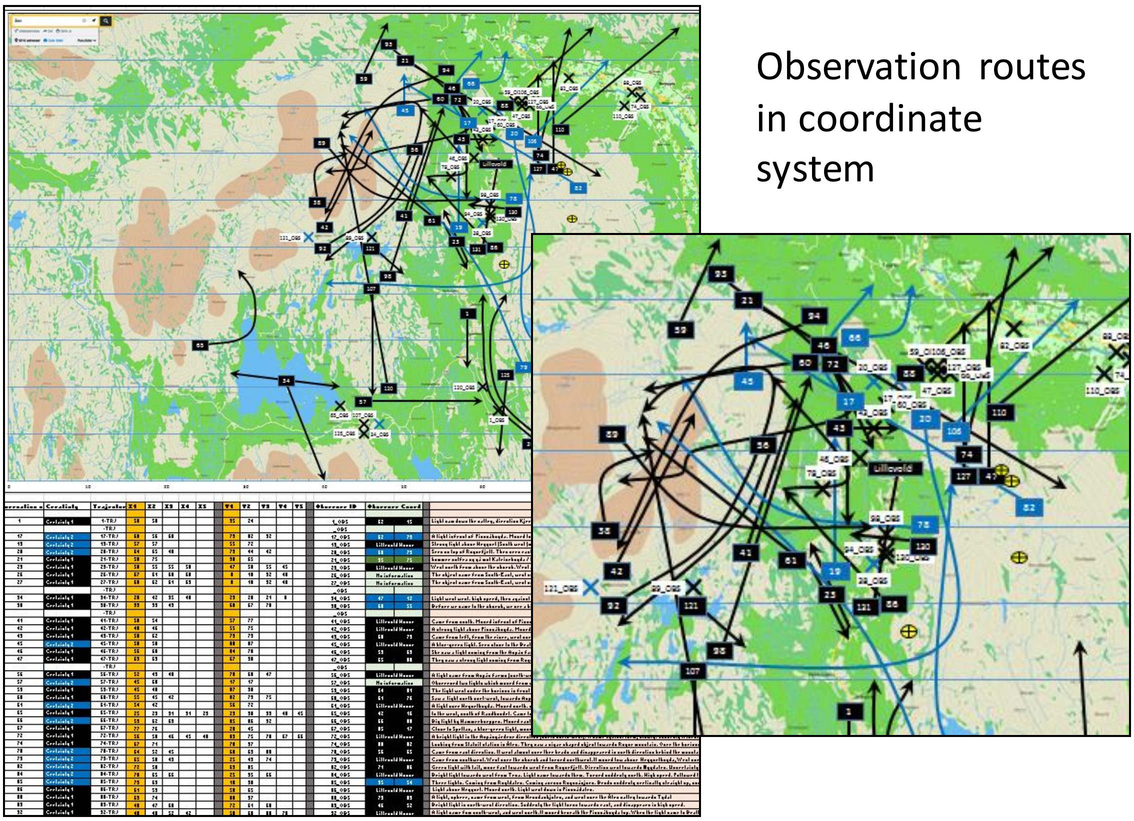


Database Excel map

At the start of making this database, I used a map overlooking Hessdalen, and placed this in a 100 X by 100 Y coordinate system. Simple. Today, a software where you can plot universal coordinates would be better. But it was sufficient for my task (UTM coordinates are included in the database).

Going through all reported observations, I found 130 observations that could give a fearly exact location on the map. Other observations are disgarded. Using the 130 observation points raging from 1996 to 2015 (Year 2007, 2008 and 2009 are missing), I created a map pinpointing each observation. Also year 1976 and 1983 are included. This gives a good picture of where the observations are likely to occur. But this is also the part of the Hessdalen where most people are, and also this «dominant area» are close to Ålen. So having most observation here can be influenced by this fact.

Hessdalen database



Observation routes in coordinate system

Database Observed routes (Database version 2)

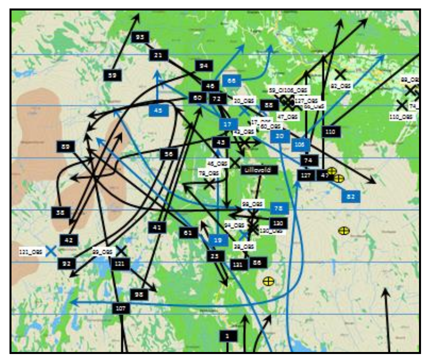
Route database has now been included. In the same coordinate system type as All observations, 100 X by 100 Y coordinate system. Each arrow has its own cordinates, and observer position has its own coordinate. Colors are given to give certainty to routes and observer location (see page 6 for definition). Black is quite certain, while blue color could deviate in X or Y direction, but has quite certain origin and end. Green color is very uncertain. The arrow describes the path of the observation, described in the report from the observer. Not all observations have the details to make this, only the most certain observations are put here. Ex. Observations that has a direction to it, but not the origin are not included. Difficult to set an arrow without the origin (where the observer first saw the observation).

Hessdalen database

Observation certainty

<u>Certain observation, black color:</u>

Observations that state clear location like «…over the top of Finnsåhøgda» or «…went over the church» are certain observation where I can place the observation quite correctly within few meters, and give a route of the light that can be plotted. 99 of the 130 observations are certain and can give an exact point. Of the 99, only 47 can give a certain path of the observation.



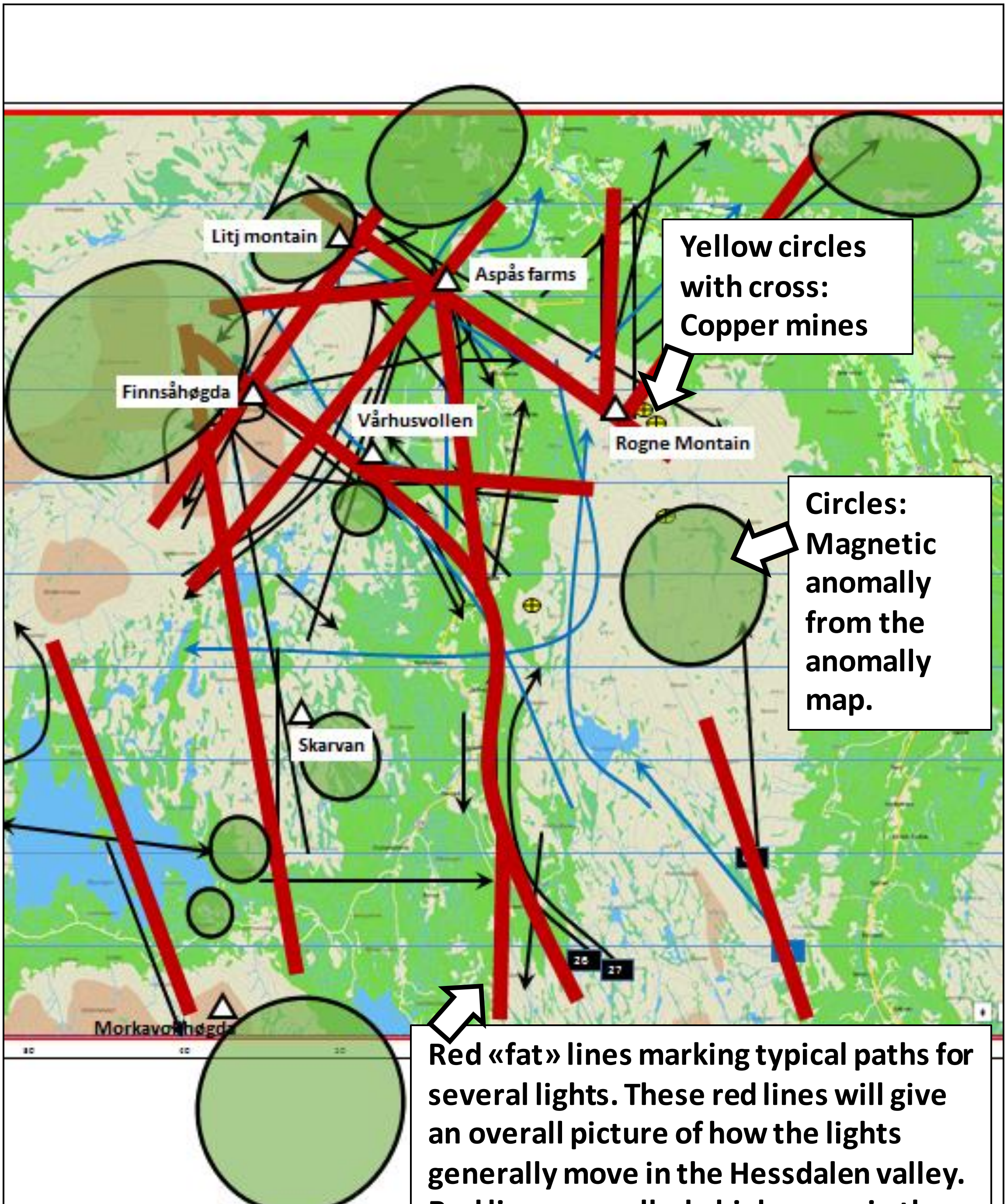
<u>Observation, blue color:</u>

These are observations that either has a clear point of origin or end. Either we do not know from where they came, but clear point where it ended, or we have a clear point from from where they came but not ended. It could be like «…Two lights in north, they came together when going over Finnsåhøgda».

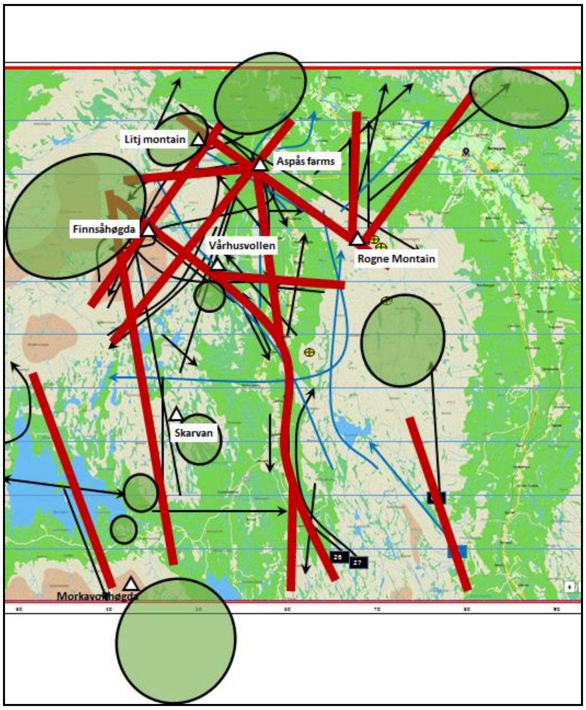
<u>Uncertain observation, green color:</u>

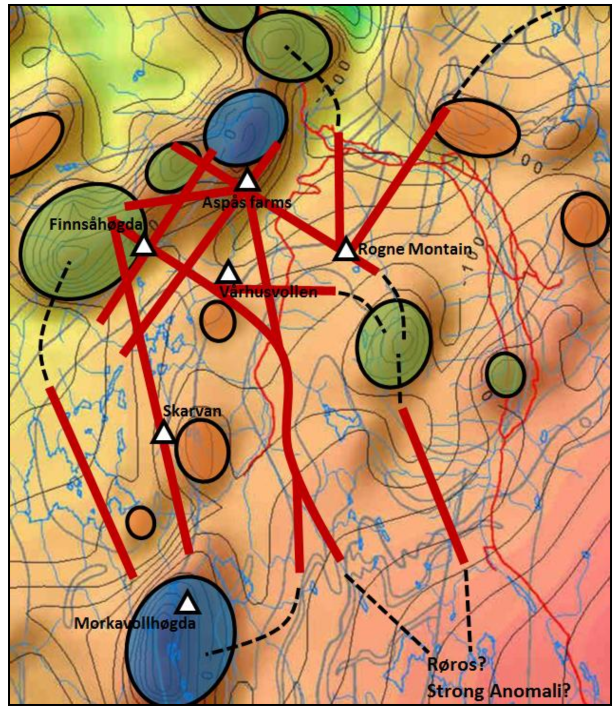
This is very unceratain. «The light was see in the direction of…». In these cases you have a direction, but not where, distance or height in that direction. These observations are not included on the map.

Hessdalen database



Hessdalen database





«Highways» and magnetic anomalies

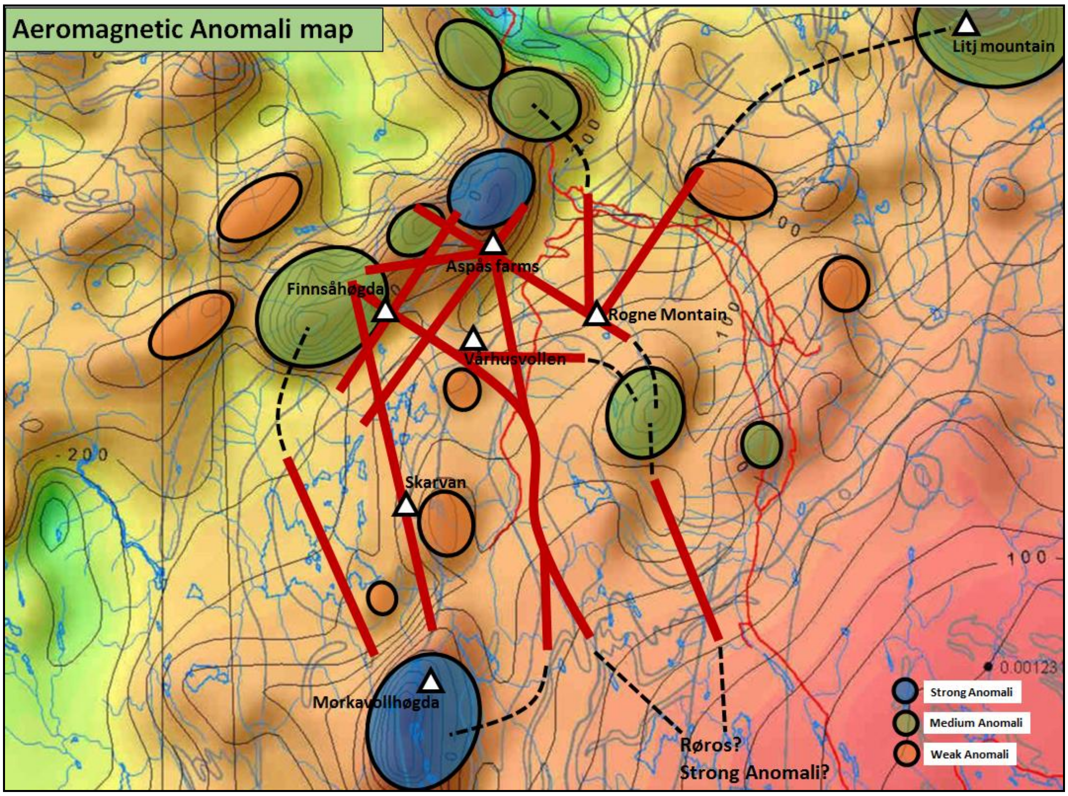
Database – Main routes

This picture is the most powerful of them all and give a good picture of the main paths – highways – of the lights and objects. These «highways» are then used further in the analysis. The black dotted lines on the end of the red lines (on the right picture) are speculations of origin or end.
Whether these are typical routes of the lights and objects that are seen in Hessdalen can be discussed, but this is only a visual conclusion created from all path observations, an overall picture.

Keeping the Hessdalen «highways» (red lines) will make it easier to use this information combined with other data.

Again here I use simple approaches, by overlapping data on different data maps. Ex. Aeromagnetic anomalies from NGU.

Hessdalen database



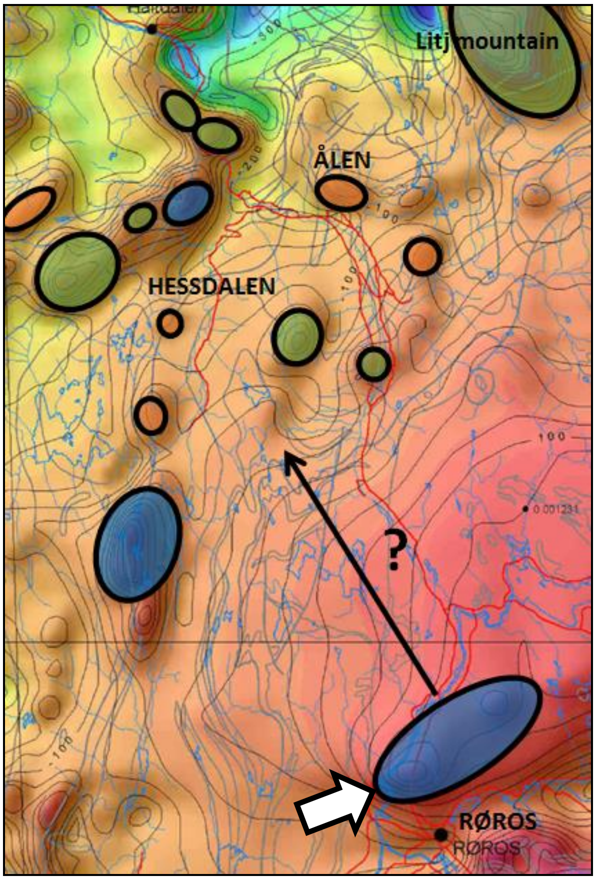
Database – Areomagnetic Anomaly map

Here is where the surprise comes. In the magnetic anomaly map (downloaded from NGU.no) the light/object «highways» are matching impressively with the magnetic anomalies, indicating that the observations are travelling from one anomali to another.

This also explains why most observations are in the north of Hessdalen, because the anomalies are mainly in this area.

Earlier in the study it was unclear why some lights were travelling across Ålen to the other side of the valley, outside Hessdalen. But there is a big and strong magnetic anomaly at Litj mountain which could explain that connection.

Hessdalen database



What is Magnetic Anomaly:

Magnetic anomaly is a static and local differance in the Earth's magnetic field resulting from variations in the chemistry or magnetism of the rocks.

Areomagnetic Anomaly:

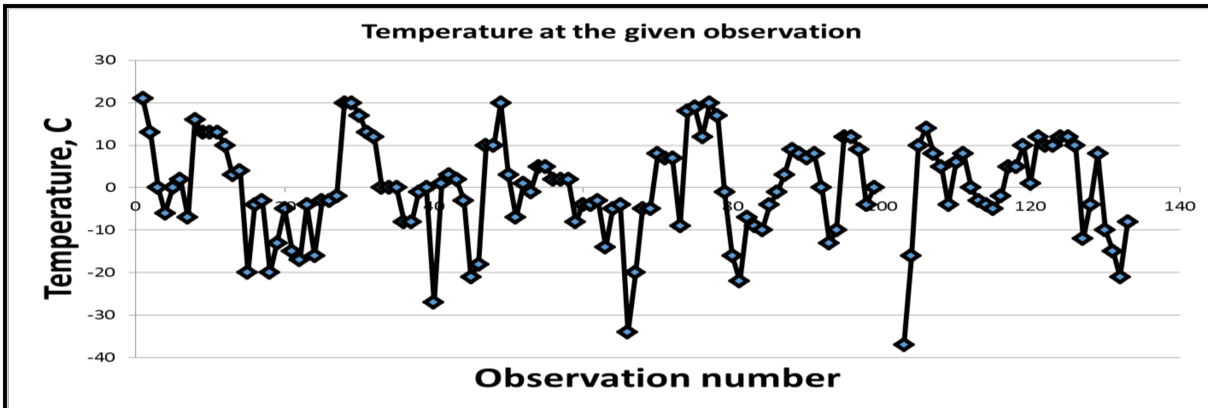
Aeromagnetic surveys are widely used to aid in the production of geological maps and are also commonly used during mineral exploration.

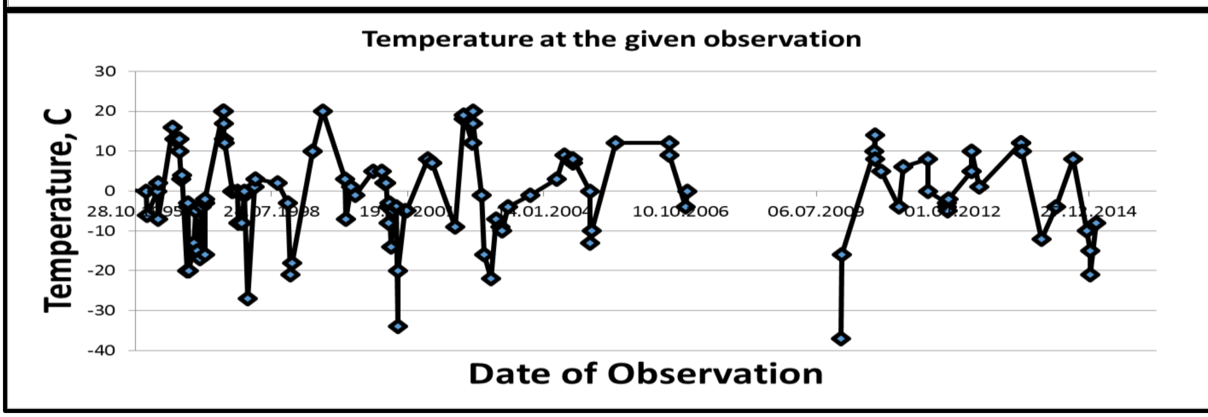
Database – Aeromagnetic Anomaly map cont.

Looking further south than Hessdalen we find a strong anomaly north of Røros. Some obervations are explained to come from south of Hessdalen and also going south. A connection to the big anomaly north of Røros cold explain that connection.

Magnetic anomally maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no/side/aeromagnetiske-anomalikart

Analysis - Temperature



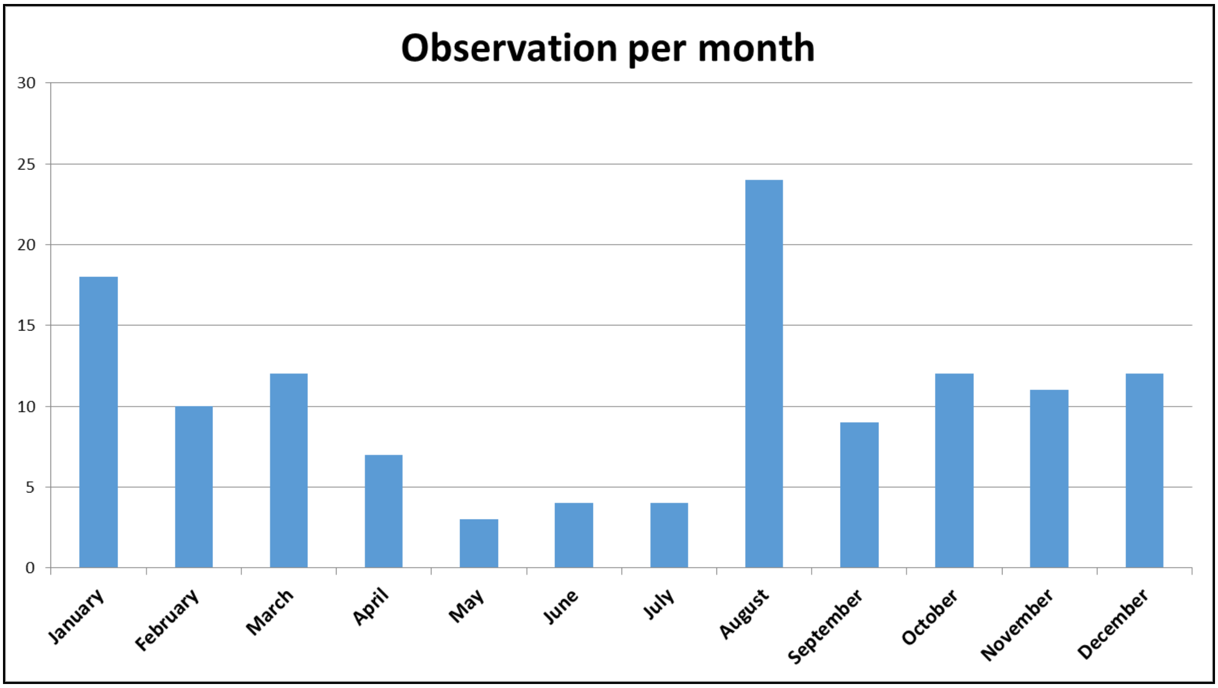


Database – Temperature vs Observation

Analyse to find if there is a tyipcal temperature or temperature range which has to be in place to fullfill a criteria for the light phenomena to occur – the conclusion is: Temperature do not have a triggering effect as a general to seeing Hessdalen lights. Observations are seen on the whole temeprature scale. The average temperature from all 130 observations is 0.06 degC. Temperatures are however mainly from the Røros weather station, which is the nearest weather station.

Later in the report, the temeprature will be linked to shapes to see if there is any trend. Temperatures in the Database which are blue are all from the station in Røros (nearest). This means that the temeprature could be different in Hessdalen, but assume it is close to the Røros temperatures.

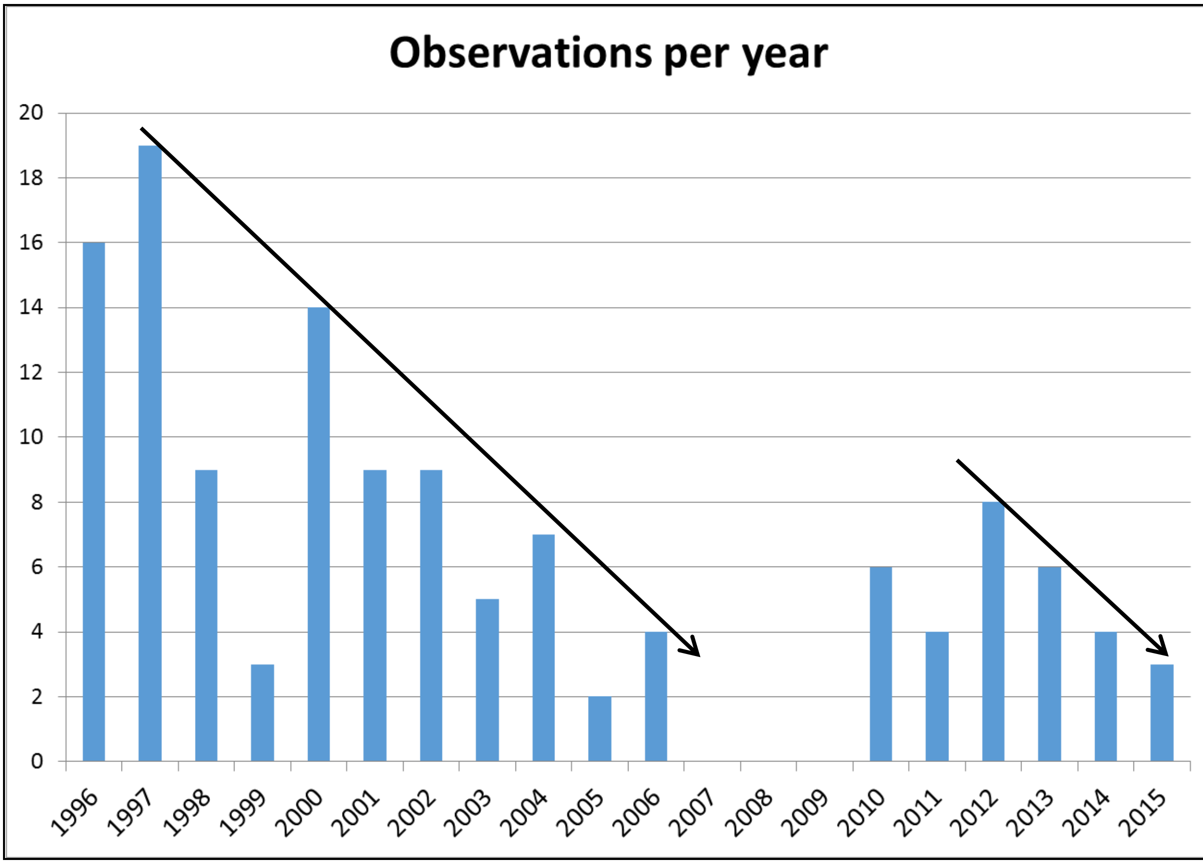
Analysis - Occurance



Database – Observations per month

These are all the observations in the database sorted per month. It looks like spring and summer has a downside, but then in August there is general boost in observations. Then autumn and winter tend to have the same possibilities for observations. During the last 20 years, October to March have summed up just above 10 observations per month, except January which have a boost in observations.

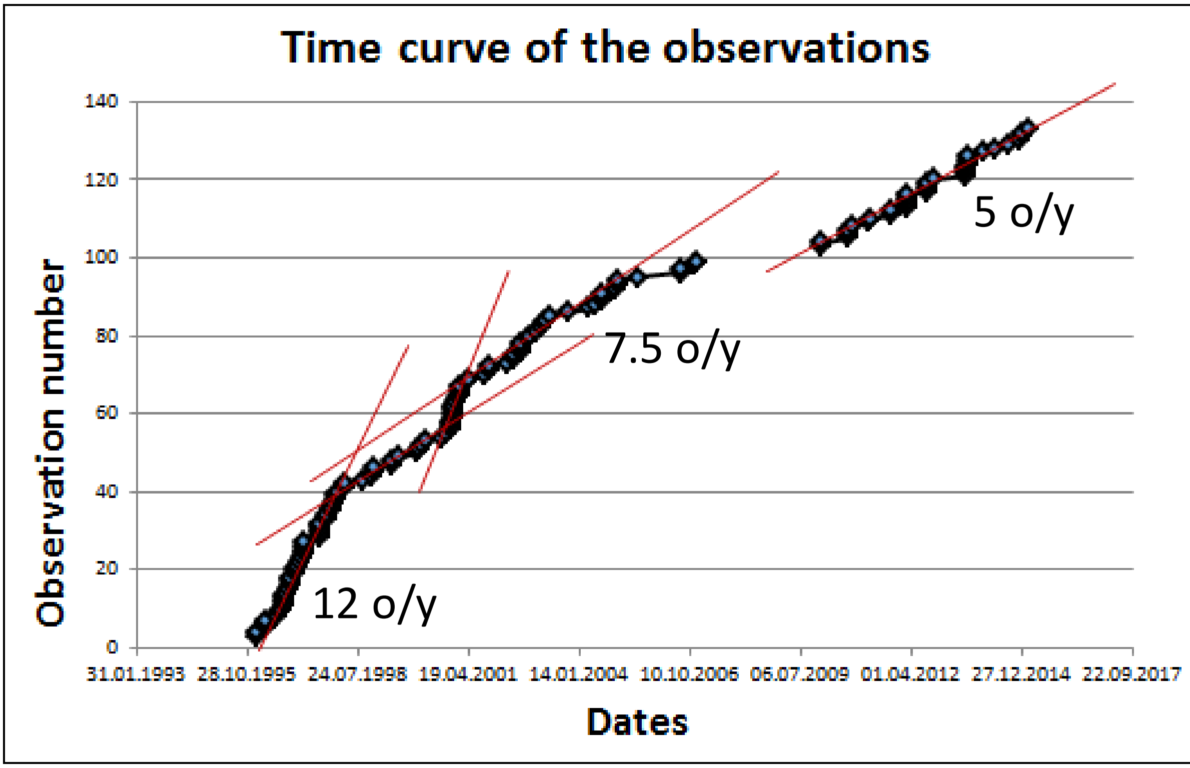
Analysis - Occurance



Database – Observations per year

Number of reported observations per year is decreasing. Wether this reflects a decrease in Hessdalen «lights» in general is speculation, but there is a clear trend. So far in 2015 there has been 4 reported observations (one not included in Database because of insufficient info).

Analysis - Occurance

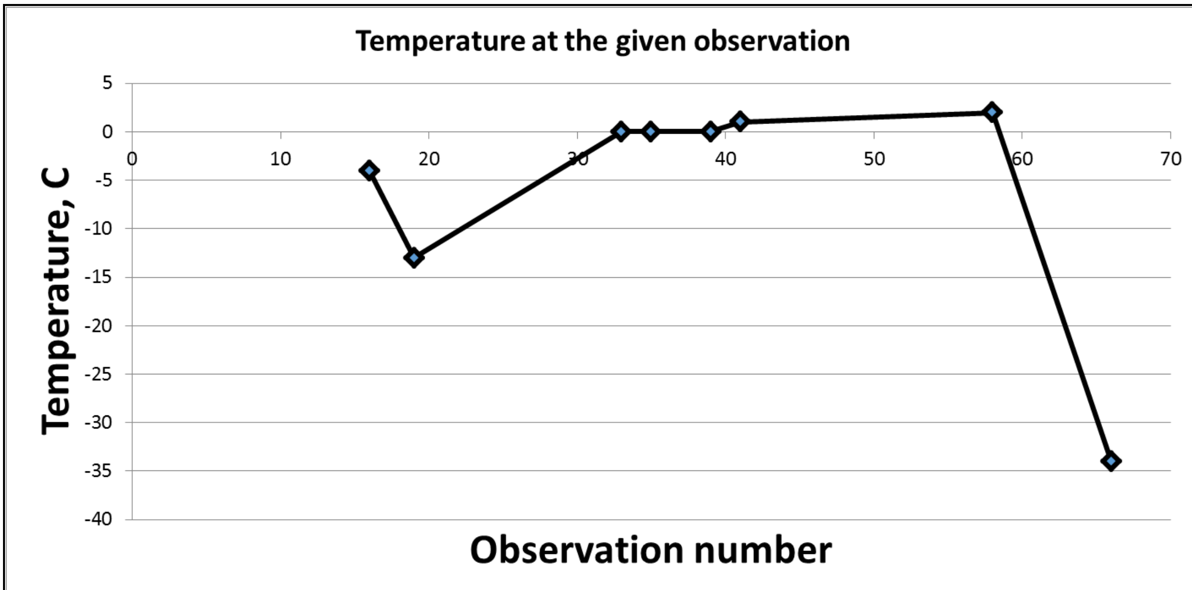


Database – Observation time curve

Figure above show cumulative observations from 1995 to 2015, giving a slope and average observations per time unit.

Setting a slope curve to the graph, one can see quite stable reported observations per year. From 1996 to 2000 there were average 12 reported observations per year. From 2001 to 2004 there were reported in average 7.5 observations per year. Then from 2010 to 2015 there were reported in average 5 observations per year. Decreasing trend.

Analysis - Shape



Certainty of	Weather	Temperature	Object form	SubForm	Colour							
location in map	(Røros)	C (Røros te	described	more details	Whit	Blan	Met	Yell	Oran	Re	Blu	Gree
Certain	Cloudy	-4	Triangle	Christmas tree	X							
Certain	Cloudy	-13	Triangle	Haulting movement						X		
Certain	Cloudy	0	Triangle		X			X				
Certain	Cloudy	0	Triangle	Light inside				X		X		
Certain	Cloudy	0	Triangle	Haulting movement					X			
Certain	Cloudy	1	Triangle		X				X			
Uncertain	Cloudy	2	Triangle					X	X	X	X	X
Certain	Cloudy	-34	Triangle					X		X		

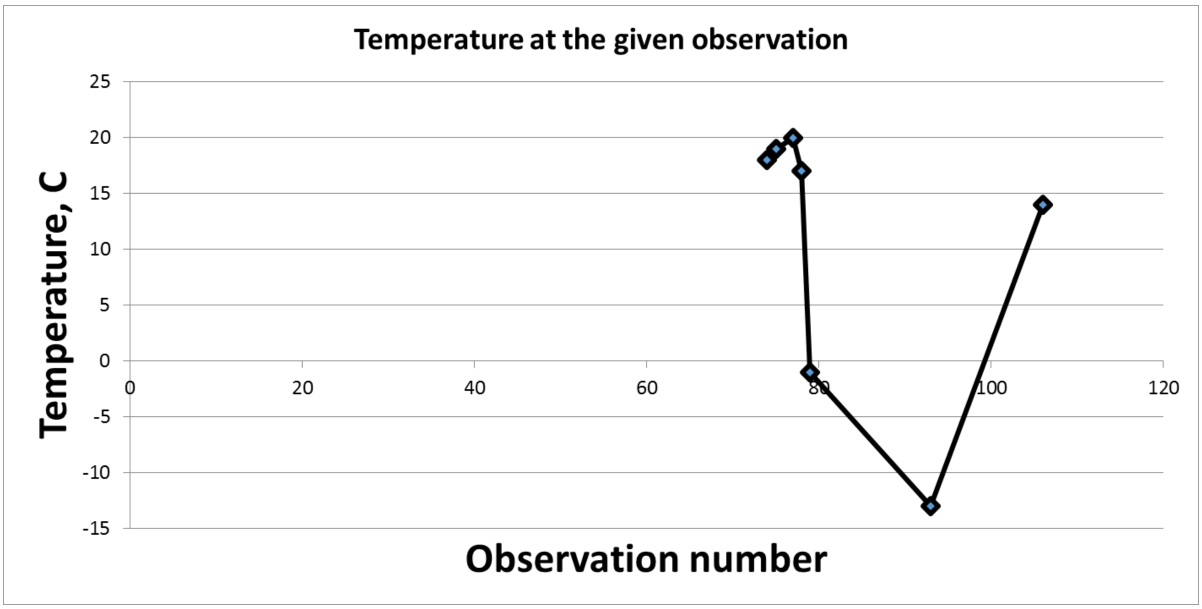
Database – Triangular observations

X	X	X	X	X

Colors in the Observations database show the different colors of the light(s) that was observed during the observation of the light(s).

Filtering out all observations that were defined triangular. These observations have reported certain colors. Also looking at the temperature at these given observations.
Triangular Obs. seem to occur in cooler temperatur. From 0 and colder. Most Triangular shaped observations has been in the warmer colors. Basically in the orange color area with neighbouring red and yellow.
On the weather side, most observations occur during cloudy or partly cloudy days. Triangle observations occur only in cloudy weather.

Analysis - Shape



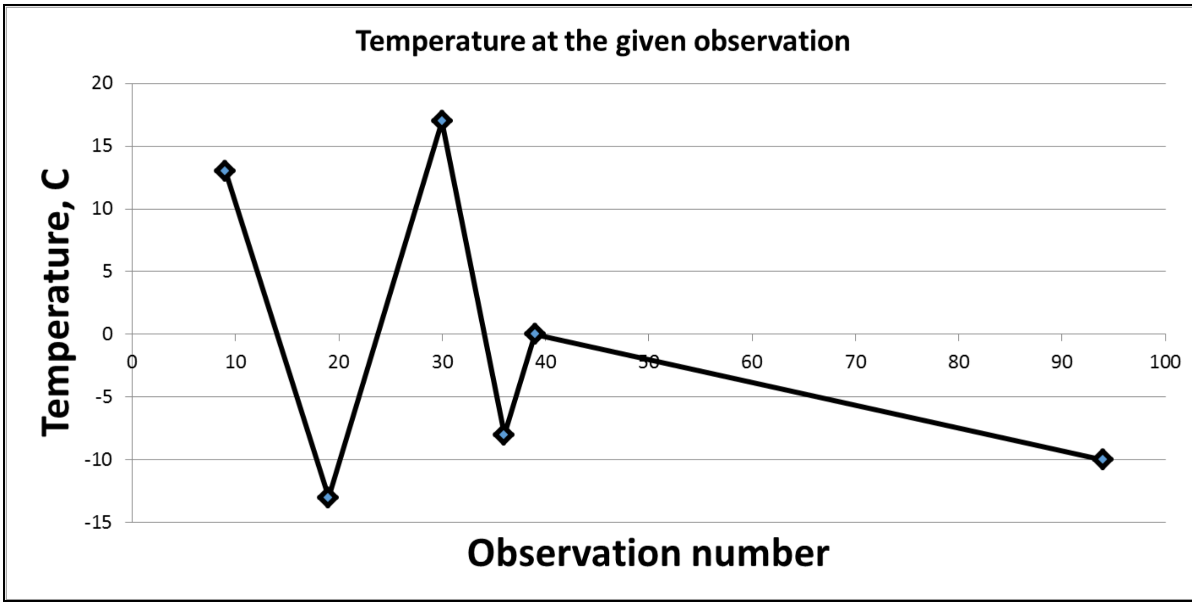
Location	Certainty of	Weather	Temperature	Object form	SubForm	Colo
Rognefjellet	Certain	No weather data	18	Cigar	Dark in the middle	X
Finnsåhøgda	Certain	No weather data	19	Cigar	Narrow in the middle	
Grønåshøgda	Certain	No weather data	20	Cigar	Size as grown tree	
Vårhuskjølen	Certain	No weather data	17	Cigar	Dark in the middle	X
Eavollen	Certain	Cloudy	-1	Cigar	Dark in the back	
Aspåsgårdene	Certain	No weather data	-13	Cigar	Airplane shape	X
Rognefjellet	Certain	Cloudy	14	Cigar	Dark in the middle	X

Database – Cigar observations

Filtering out all observations that were defined cigar shaped.

There are reported 7 cigar shaped objects. Three of them have been described identical: Cigar shape, white, but dark in the middle. Two of them in 2002, and one in 2010. All three in 14-18 degC range. July to September. Cloudy. Two of them over Rognefjellet (Rogne mountain).

Analysis - Shape



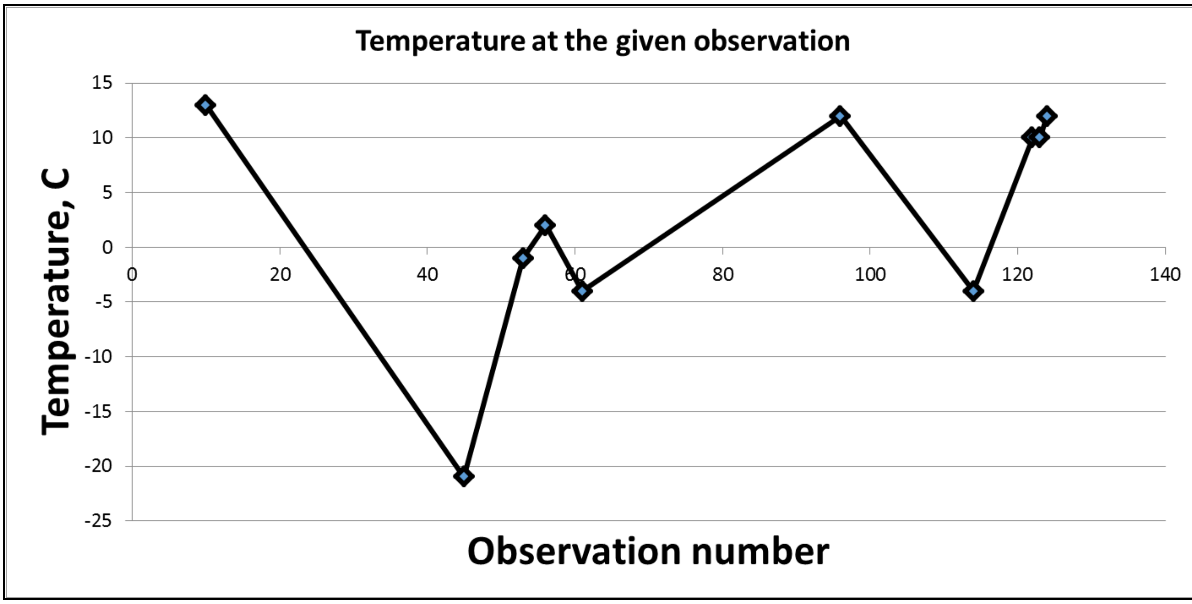
Certainty of location in map	Weather (Røros)	Temperature C (Røros te	Object form described	SubForm more details	Colour Whit	Blanl	Metc	Yell	Oran	Re	Blu	Gree
Little info	Cloudy	13	Light	Zig zag movement				X		X		X
Certain	Cloudy	-13	Triangle	Haulting movement						X		
Certain	Cloudy	17	Light	Haulting moveme	X							
Certain	Cloudy	-8	Light	Haulting moveme	X					X		
Certain	Cloudy	0	Triangle	Haulting movement					X			
Certain	Cloudy	-10	Light	Haulting moveme	X							

Database – Objects with Haulting movement

Filtering out all observations that were defined with haulting movement.

Some objects move in a jerky way, they move – hault – move – hault – etc. This particular movement was mostly seen on objects observed in the 90's (96-98). Except one in 2005. Mostly yellow to red color.

Analysis - Shape



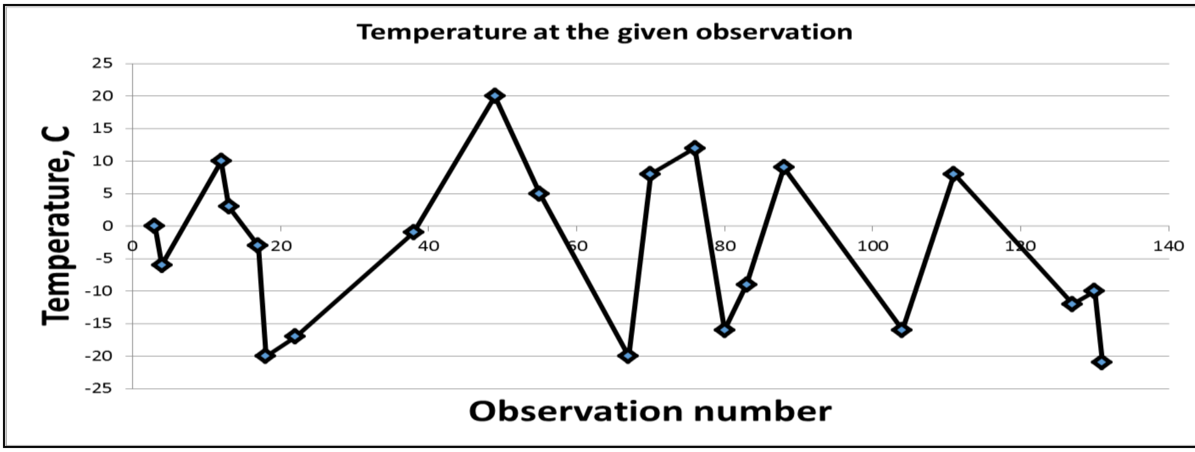
Location first discovered	Certainty of location in map	Weather (Røros)	Temperature C (Røros te	Object form described	SubForm more details	Colour Whit	Blanl	Met	Yell	Oran	Re	Blu	Gree
Rugldalen	Uncertain	Cloudy	13	Light	Flashing				X			X	
Brattbekken	Certain	Cloudy	-21	Light	Flashing							X	X
Finnsåhøgda	Certain	Cloudy	-1	Light	Flashing	X							
Finnsåhøgda	Certain	Cloudy	2	Light	Flashing						X		X
Heggsethøgda	Certain	Cloudy	-4	Light	Flashing	X							
Finnsåhøgda	Certain	Partly cloudy	12	Light	Flashing	X					X		
Skarvan	Uncertain	Cloudy	-4	Light	Flashing	X							
Holtålstjønna	Certain	Cloudy	10	Light	Flashing	X						X	
Øyungen	Certain	Cloudy	10	Light	Flashing	X							
Øyungen	Certain	Cloudy	12	Light	Flashing	X							

Database – Light observations: Flashing

Filtering out all observations that were defined flashing lights.

The most common observation is the «Light», sometimes it is observed in a distance, so it is hard to tell color of light or shape. It becomes «Light». Other times the object is very bright so it is hard to see the shape. Mostly it is a white color. In the Database, all (except one) of the the light that was described as flashing, were observed on the west side of Hessdalen.

Analysis - Shape



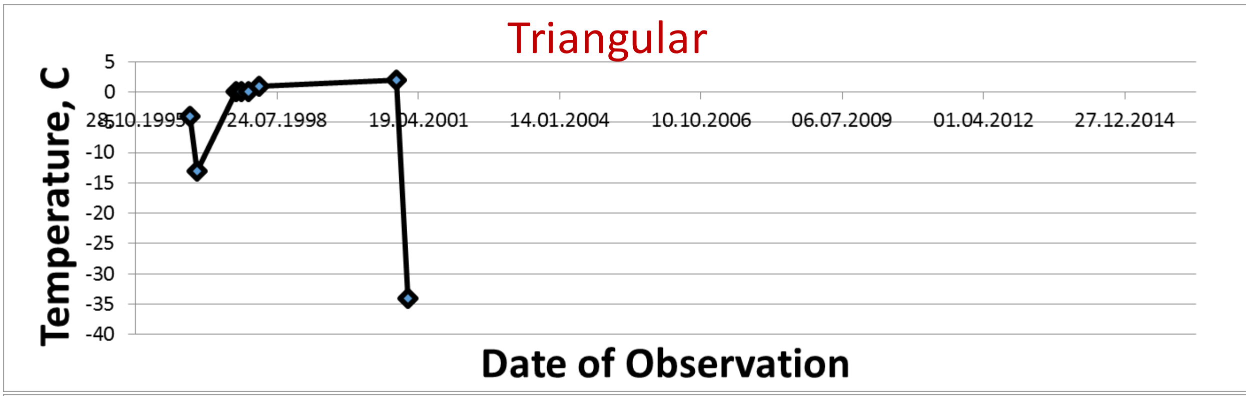
Weather (Røros)	Temperature C (Røros te	Object form described	SubForm more details	Colour Whit	Blan	Met	Yell	Oran	Re	Blu	Gree
Foggy	0	Sphere/Orb	Light from sphere			X					
Partly cloudy	-6	Sphere/Orb	Lighttreads under		X						
Clear sky	10	Sphere/Orb	Blå og gul side				X			X	
Cloudy	3	Sphere/Orb	Yellow with red				X		X		
Cloudy	-3	Sphere/Orb		X							
Clear sky	-20	Sphere/Orb	Size as the moon				X		X	X	X
Clear sky	-17	Sphere/Orb		X							
Cloudy	-1	Sphere/Orb	Moved arc shaped							X	
Cloudy	20	Sphere/Orb	Stood still		X						
Partly cloudy	5	Sphere/Orb	Moved arc shaped							X	X
Cloudy	-20	Sphere/Orb	Tail, fast							X	X
Clear sky	8	Sphere/Orb	Shrank, unshrank				X				
No weather data	12	Sphere/Orb	Rotating	X			X		X		
No weather data	-16	Sphere/Orb	Went vertical up					X			
No weather data	-9	Sphere/Orb	Rotating						X		
No weather data	9	Sphere/Orb					X				
Clear sky	-16	Sphere/Orb	Christmas tree	X		X	X	X	X	X	X
Cloudy	8	Sphere/Orb					X				
Cloudy	-12	Sphere/Orb	Tail				X		X		X
Partly cloudy	-10	Sphere/Orb	Rotating								X
Partly cloudy	-21	Sphere/Orb							X		

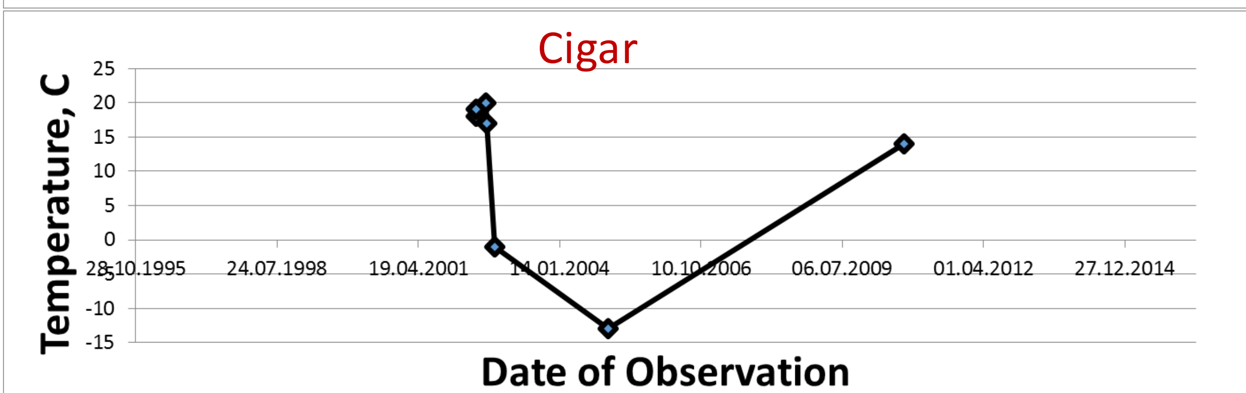
Database – Sphere/Orb observations

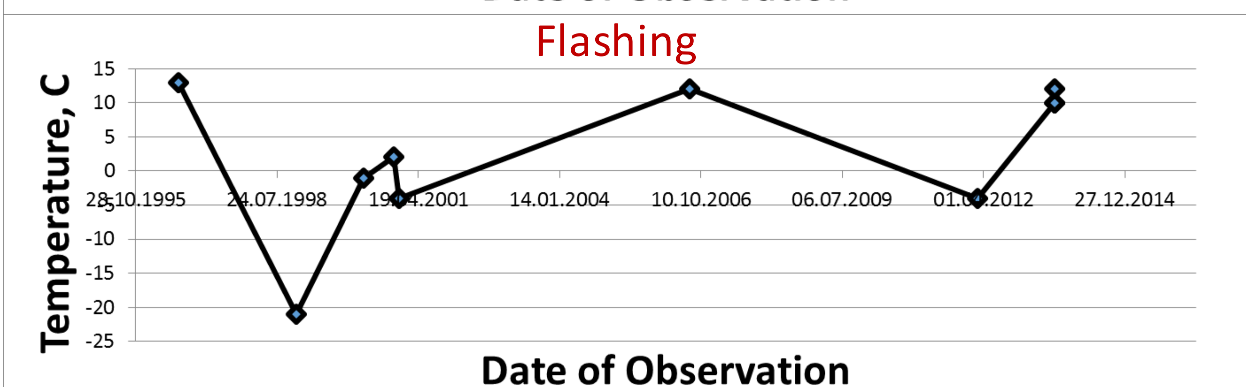
Filtering out all observations that were defined as Orbs/Sphere.

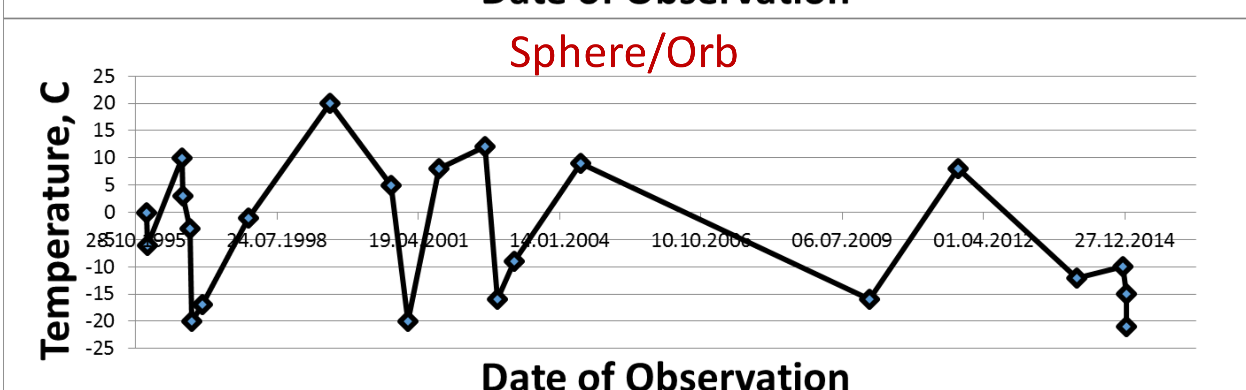
Sphere/Orb observations has no trend or pattern. They are seen in many different conditions and colors, but normally they are multi-colored.

Shape vs date









Hessdalen Rock

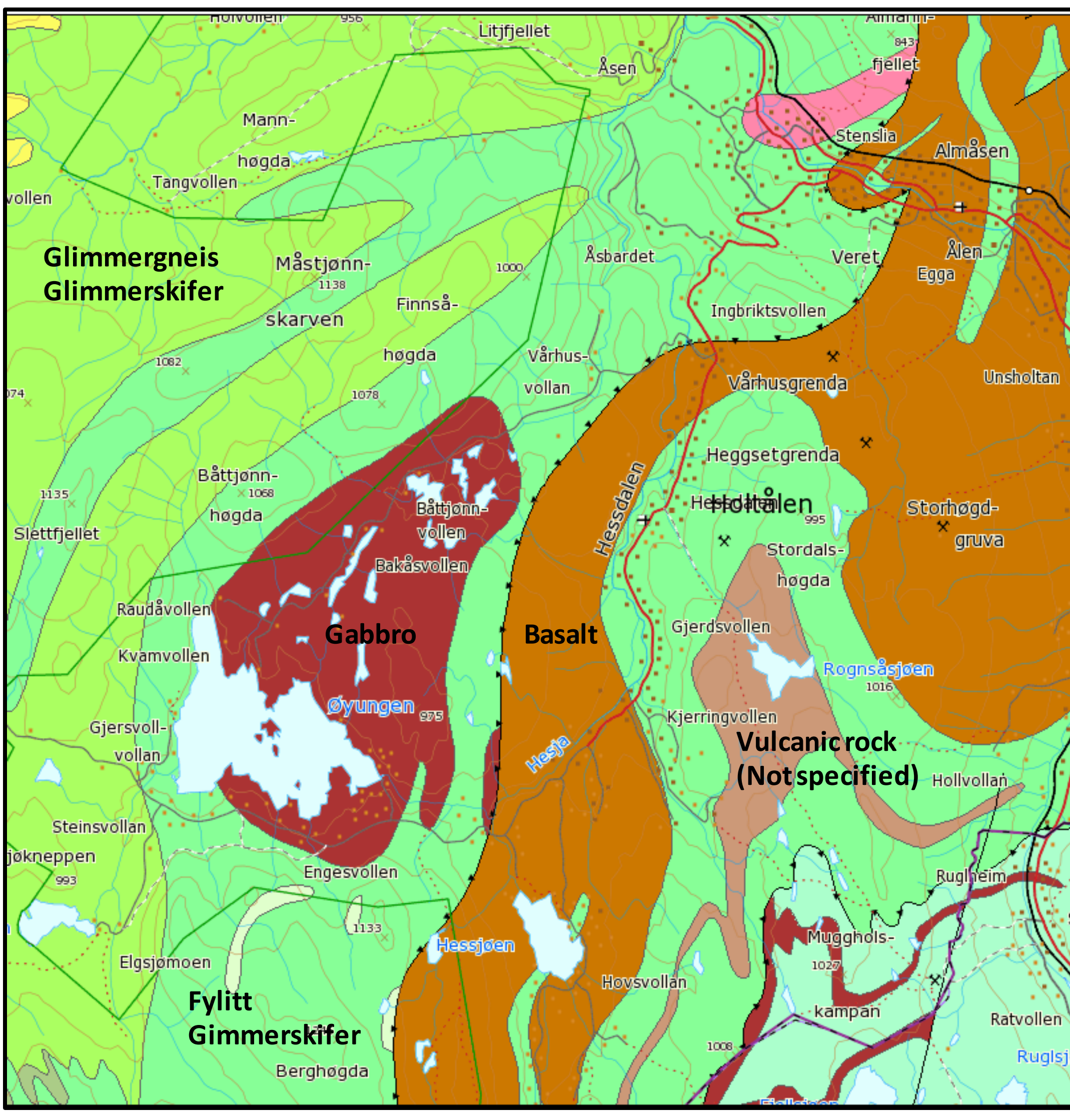
Basalt:

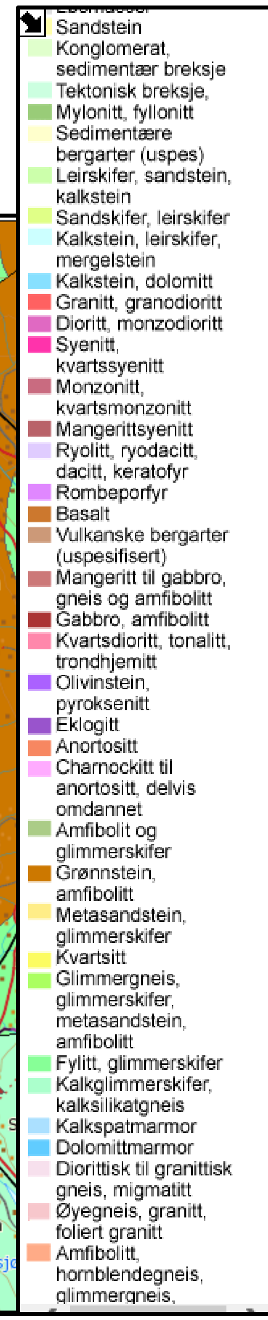
- Felspat (Plagioklas): Kalium K^{+}, Natrium Na^{+} og Kalsium Ca^{+}
- Pyroksen (Augitt): Magnesium Mg^{2+}, Jern Fe^{3+}, Kalsium K^{+}, Natrium Na^{+}, Litium Li^{+}

Gabbro:

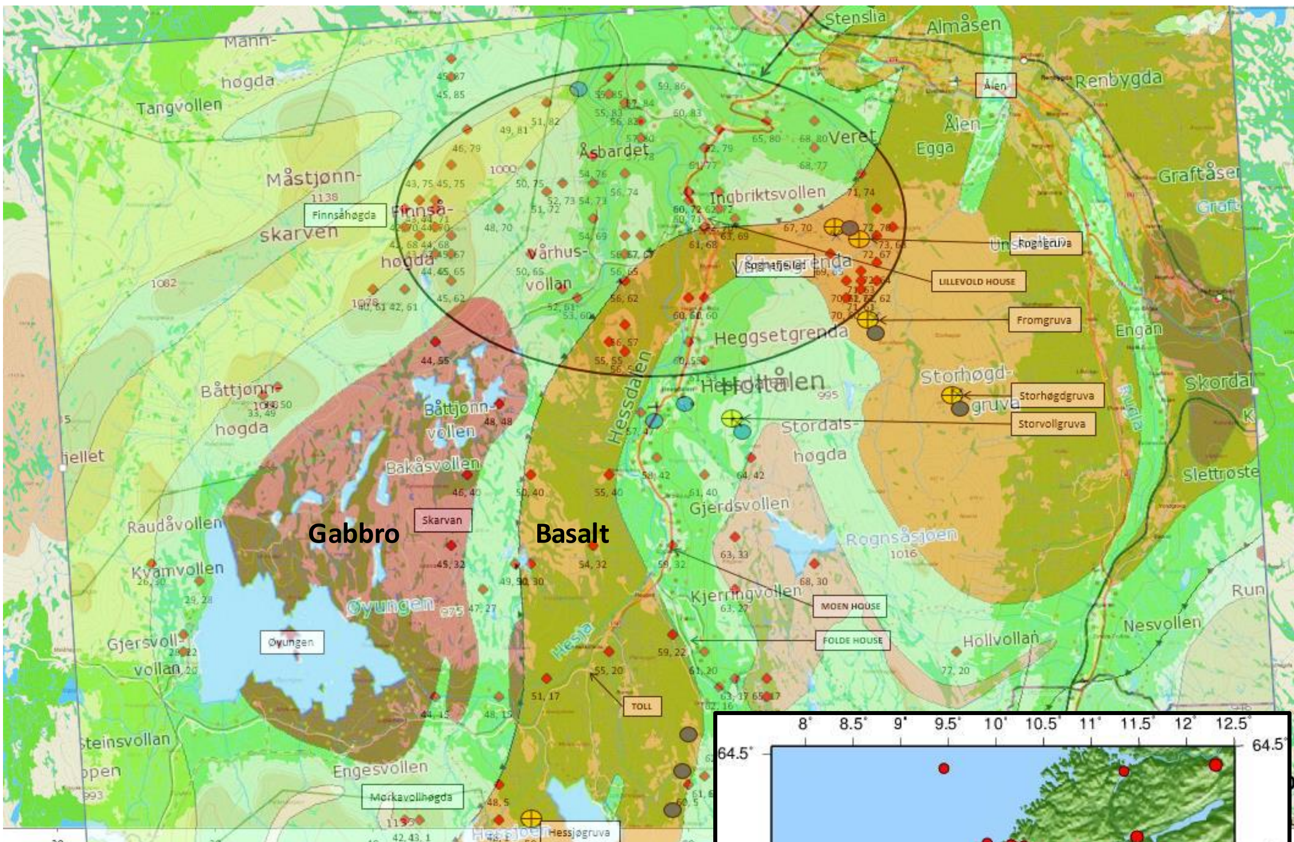
- Felspat (Plagioklas): Kalium K^{+}, Natrium Na^{+} og Kalsium Ca^{+}
- Pyroksen (Augitt): Magnesium Mg^{2+}, Jern Fe^{3+}, Kalsium K^{+}, Natrium Na^{+}, Litium Li^{+}
- Amfibol (Hornblende): Ca^{2+}, Fe^{3+}, Mg^{2+}, Al, Si
- Olivin: Mg^{2+}, Fe^{3+}, Si^{2-}, O^{2-}

Glimmer: Kalium K^{+}, Natrium Na^{+} og Kalsium Ca^{+}

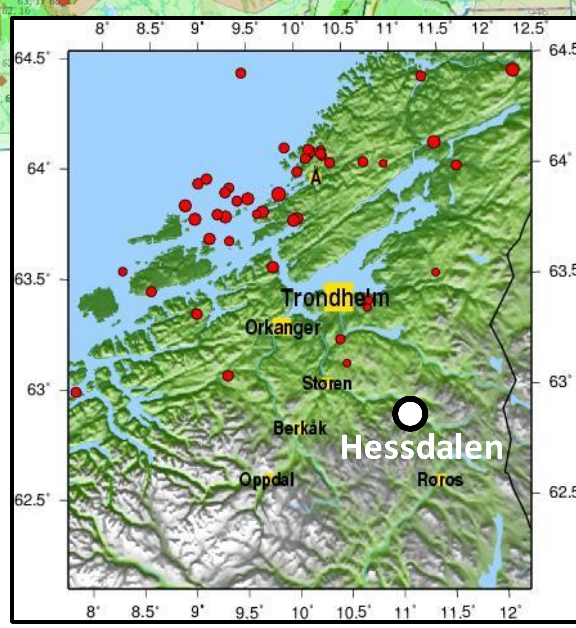




Observations vs. rock



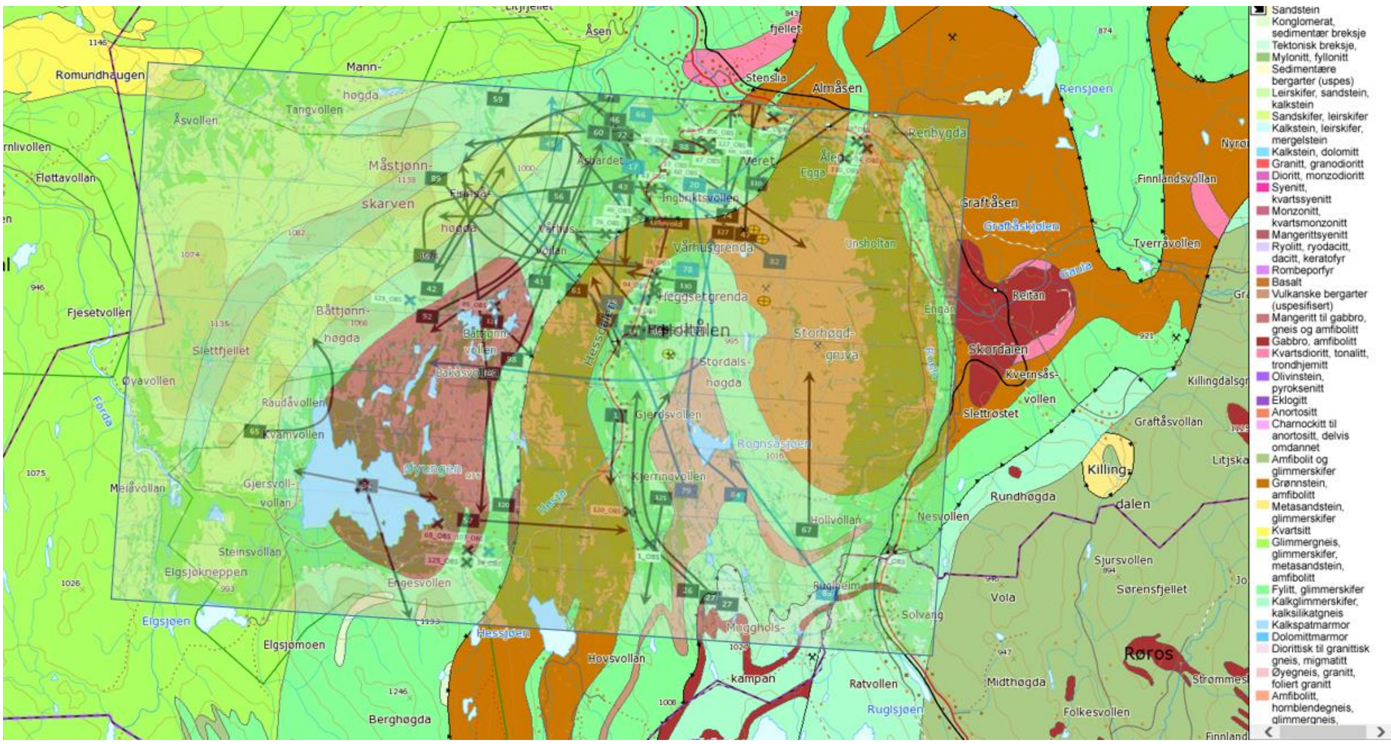
Picture: Rock types above observations.



Picture: Seismic activity from 1995 to 2015 in Sør Trøndelag county (Source: www.jordskjelv.no)

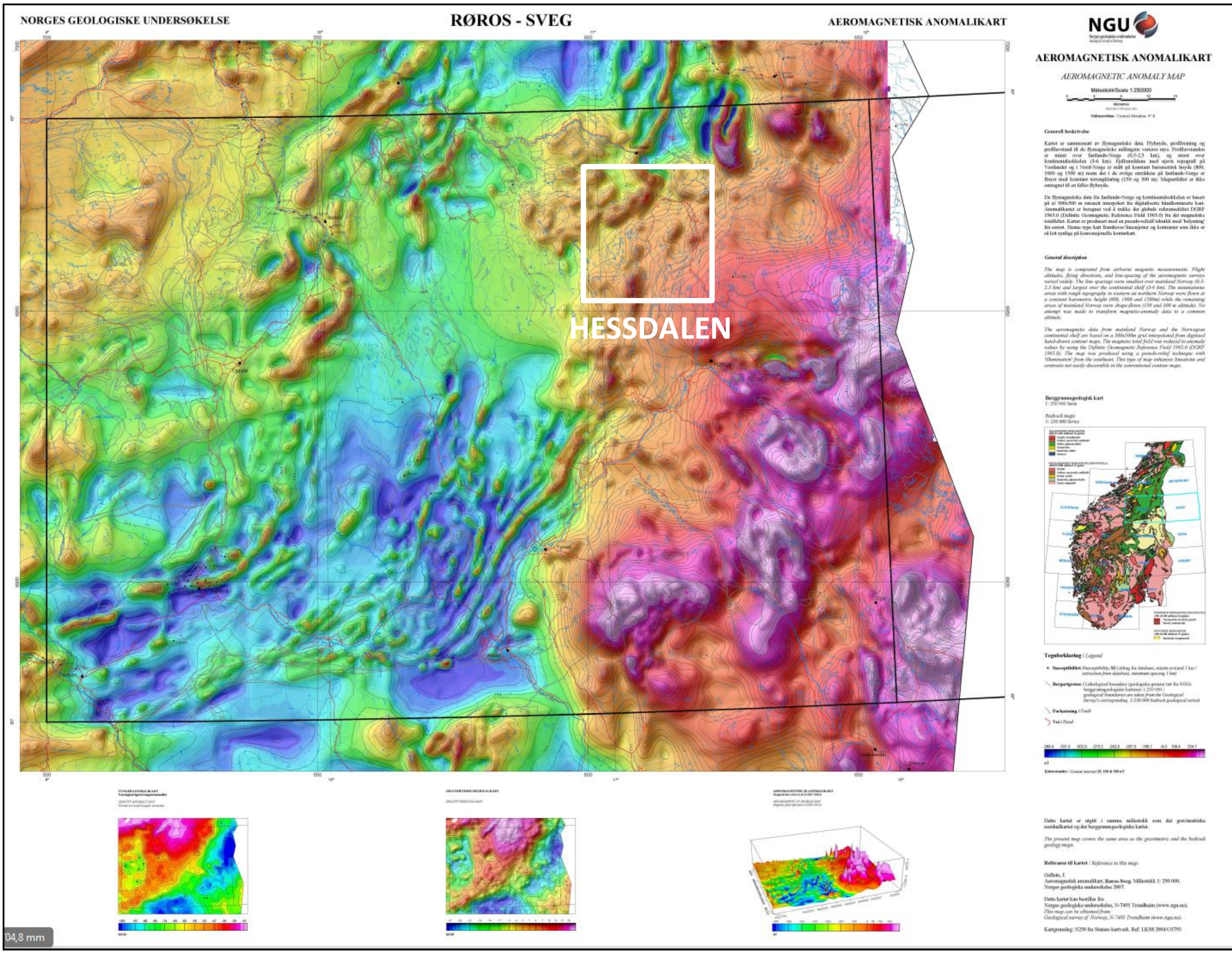
In the National Geographic article, Freund describe light being generated by crystals from Gabbro and Basalt being crushed just before an earthquake. In Hessdalen there are not many earthquakes documented from 1995 to 2015. Picture show most seismic activity on the coast.
But the Basalt – Gabbro theory cannot be disregarded, since this is dominating a lot of the valley rock.

Observations vs. rock



Picture: Rock types above observations with path.

Hessdalen database

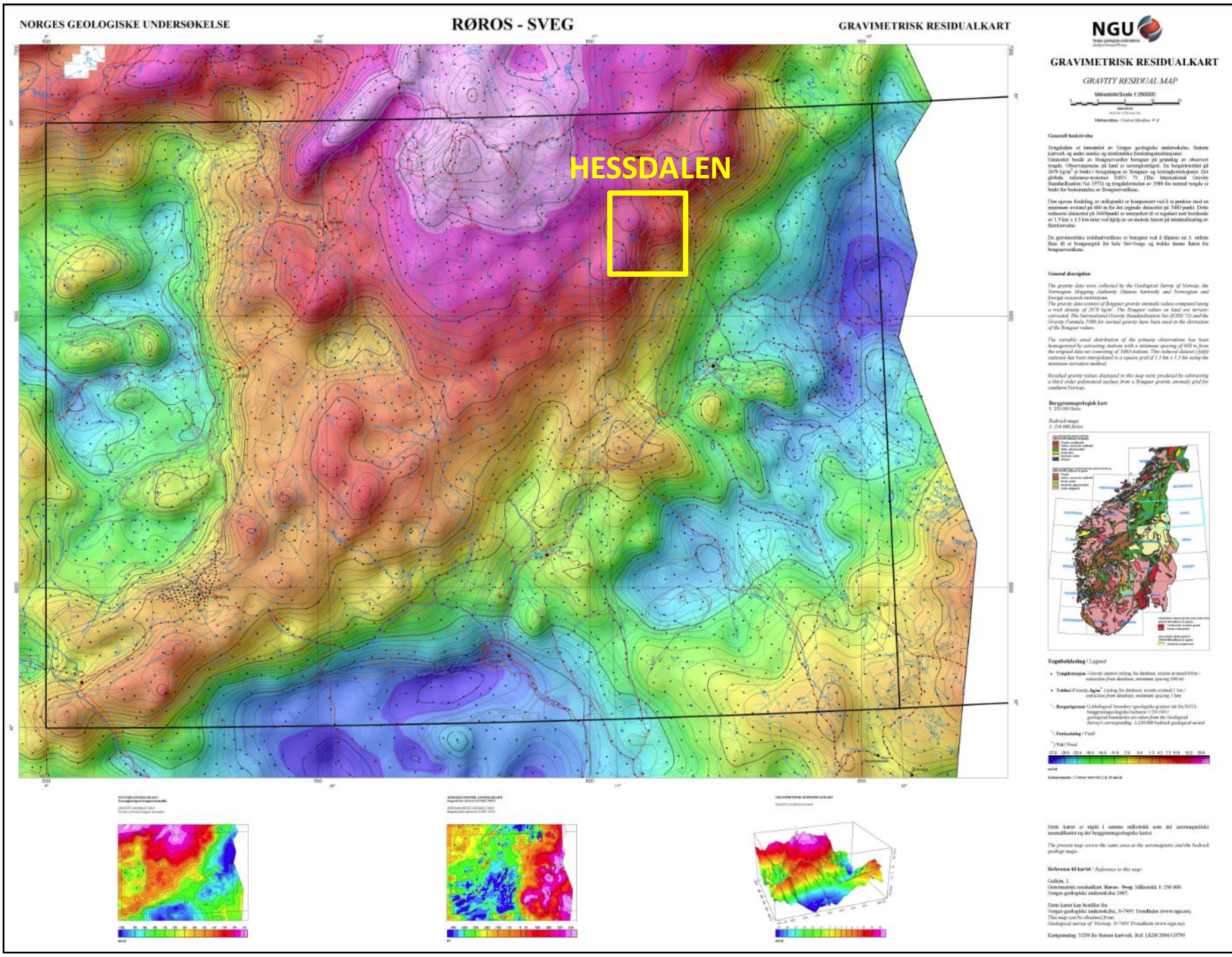


Database – Aeromagnetic Anomaly map

The original map used

Magnetic anomally maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no/side/aeromagnetiske-anomalikart

Hessdalen database



Database – Gravimetric residual map

Not used

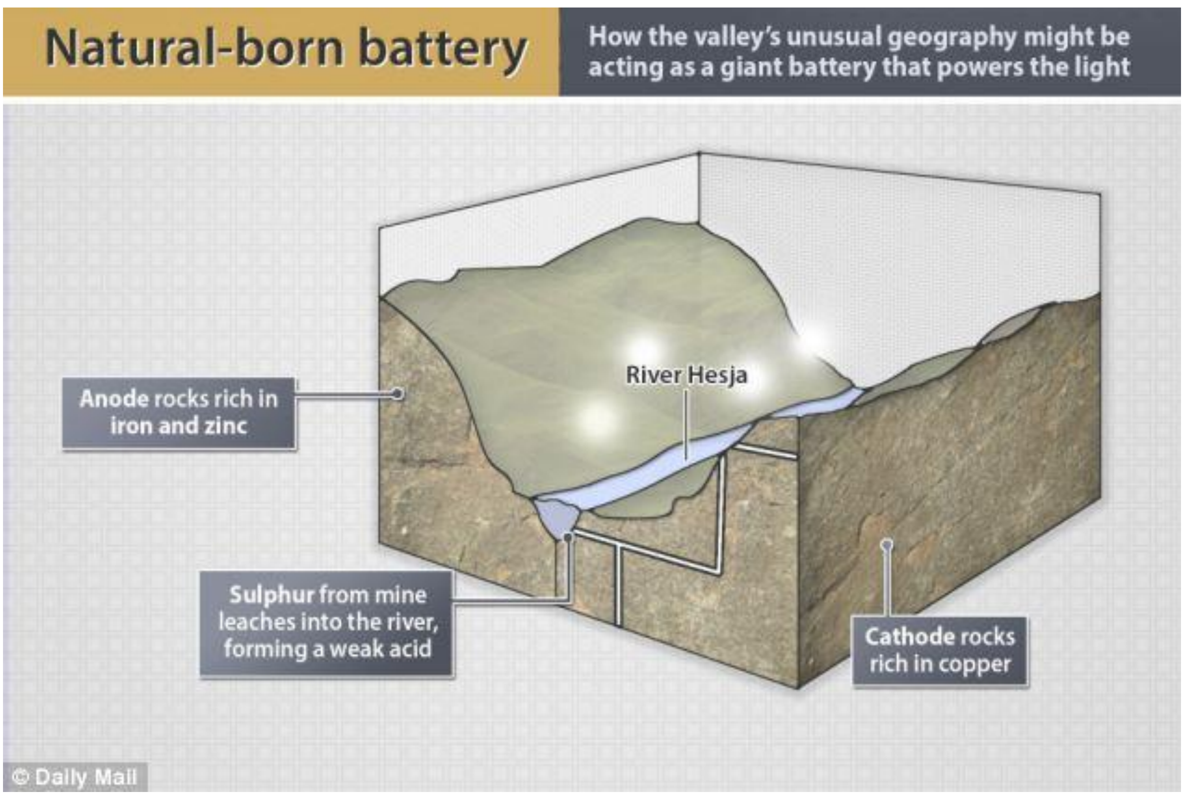
Gravimetric maps can be found at Norges Geologiske Undersøkelse: http://www.ngu.no

Light theories

- **The Battery theory**
- **The EQL theory** (EarthQuake Light)
- **Lightning Balls** formed of silicon, iron and calcium and in addition an element called scandium.
- Massive electric charge and that **Static electricity** on the mountains were whipped up by strong winds.
- **Radioactivity and the decay of radon** in the atmosphere. Lights are made from 'dusty plasma' containing ionized dust particles.
  Search for the presence of radon in the valley to test their idea that bubbles of the gas could erupt from the ground, pick up dust and enter the air as a glowing orb.

Battery theory

Theories about Sulphur gas being created and energized up in humid air by reaction between iron and zinc on one side of the valley and copper on the other side, with the river in the middle as an electrolyte ("The battery theory" by Jader Monari of the Institute of Radio Astronomy in Medicina, Italy



Dr Monari believes that bubbles of ionised gas are created when sulphurous fumes from the River Hesja react with the humid air of the valley. The geology also forms electromagnetic field lines in the valley, which could explain why the orbs of light move around

The Earthquake Light theory

EQL Theory - mainly seen before earthquakes

When nature stresses certain rocks, electric charges are activated, as if you switched on a battery in the Earth's crust," he says. The types of rocks that are particularly given to the phenomenon are basalts and gabbros, which have tiny defects in their crystals. When a seismic wave hits, electrical charges in the rocks may be released. In some areas, basalts and gabbros are present in vertical structures called dikes, which formed as magma cooled along vertical faults and may reach as deep as 60 miles (97 kilometers) underground. These dikes may funnel electrical charges along, the scientists wrote.

Picture: Earthquake lights are captured in this photo taken at Tagish Lake, in the Yukon Territory, in 1972

Friedemann Freund, an adjunct professor of physics at San Jose State University and a senior researcher at NASA's Ames Research Center says "sometimes earthquake lights can take many different shapes, forms, and colors".

See link to National Geographics:

http://news.nationalgeographic.com/news/2014/01/140106-earthquake-lights-earthquake-prediction-geology-science/

EQL theory paper

Article by Freund, Thériault, Friedemann and Derr (***text copied***)

"Prevalence of Earthquake Lights Associated with Rift Environments"

Generation of the Lights:

Our preferred model for the generation and propagation of earth currents and ensuing EQL formation is based on work by Freund *et al.* (1994, 2006, 2007, 2009), Freund (2002, 2007, 2010), and Freund and Pilorz (2012) that describes experiments stressing igneous rocks (quartz-bearing and quartz-free), limestone, marble, and others. These experiments demonstrate that electronic charge carriers are activated in the high-grade metamorphic and igneous rocks (in particular mafic and ultramafic rocks) when subjected to deviatoric stresses, turning them into semiconductors. The charge carriers derive from pre-existing defects in the matrix of the minerals, electrically inactive in their dormant state as peroxy bonds or links (i.e., $O_3Si/OO\backslash SiO_3$), and are introduced into the matrix of minerals during cooling at high temperatures when two oxygen anions convert from their normal valence state 2− to the valence state 1−, that is, O^{2-} to O^{-}. When subjected to stress, mineral grains slide along grain boundaries or dislocations sweep through, causing peroxy links to break. The O^{-} states thus formed represent defect electrons in the oxygen anion sublattice, which turn into highly mobile electronic charge carriers, referred to as positive holes or *pholes*. These previously unrecognized charge carriers have the remarkable ability to flow out of the stressed rock volume and to move away from where they have been generated.

Invariably, several types of pholes are generated during stressing of rocks, characterized by different lifetimes ranging from less than a second to longer than days. As the long-lived pholes diffuse outward, they can reach the Earth's surface. There, they form surface/subsurface charge layers, which cause locally high electric fields, often strong enough to ionize the air and even trigger corona discharges. The corona discharges are associated with the emission of visible light close to the ground and with the formation of ozone.

There is yet another aspect of the same basic process of stress activation of pholes: the highest charge carrier densities can be achieved if stresses increase so rapidly that even short-lived pholes do not have the time to recombine. This implies that, if tectonic stresses deep in the Earth's crust increase very rapidly in any given rock volume, the number densities of pholes can reach a critical value beyond which the electronic wave functions of both the pholes and the coactivated electrons begin to overlap. This is expected to create a plasma-like state, that is, a volume of rock with a very high mobile-charge density and high conductivity. It has been suggested (St-Laurent et al., 2006) that, inside the Earth's crust, this plasma state will become unstable and will rapidly expand outward. When such an intense charge state reaches the Earth's surface and crosses the ground–air interface, it is expected to cause a dielectric breakdown of the air and, hence, an outburst of light. This process is suspected to be responsible for flashes of light coming out of the ground and expanding to considerable heights at the time when seismic waves from a large earthquake pass by. Those waves, especially S waves, subject the rocks to very rapid shear forces, causing mineral grains to move relative to each other, possibly even generating dislocation movements within the grains. This activates peroxy defects and creates the capability to momentarily generate high concentrations of pholes (Heraud and Lira, 2011). Igneous rocks, in particular mafic igneous rocks, have much higher concentrations of pre-existing peroxy defects than sedimentary rocks. Hence, the processes that seem to be responsible for the generation of EQL can be expected to occur preferentially in those rocks, providing a possible explanation for the often reported close association of EQL with mafic dikes and intrusions (e.g., Saguenay, Ebingen, and Pisco Peru earthquakes).

The positive hole theory can account not only for EQL but also for other pre-earthquake phenomena, such as:

- Air ionization at the ground-to-air interface.
- Changes in the electrical conductivity of the soil.
- Geo-electric and geomagnetic anomalies in the Earth's crust.
- Ionospheric perturbations.
- Ultralow and extremely low frequency (ULF/ELF) and radio frequency (RF) emissions.
- Anomalous infrared emissions from around a future epicentral area.
- Anomalous fog/haze/cloud formation and unusual animal behavior (Derr *et al.*, 2011).

Data Synthesis

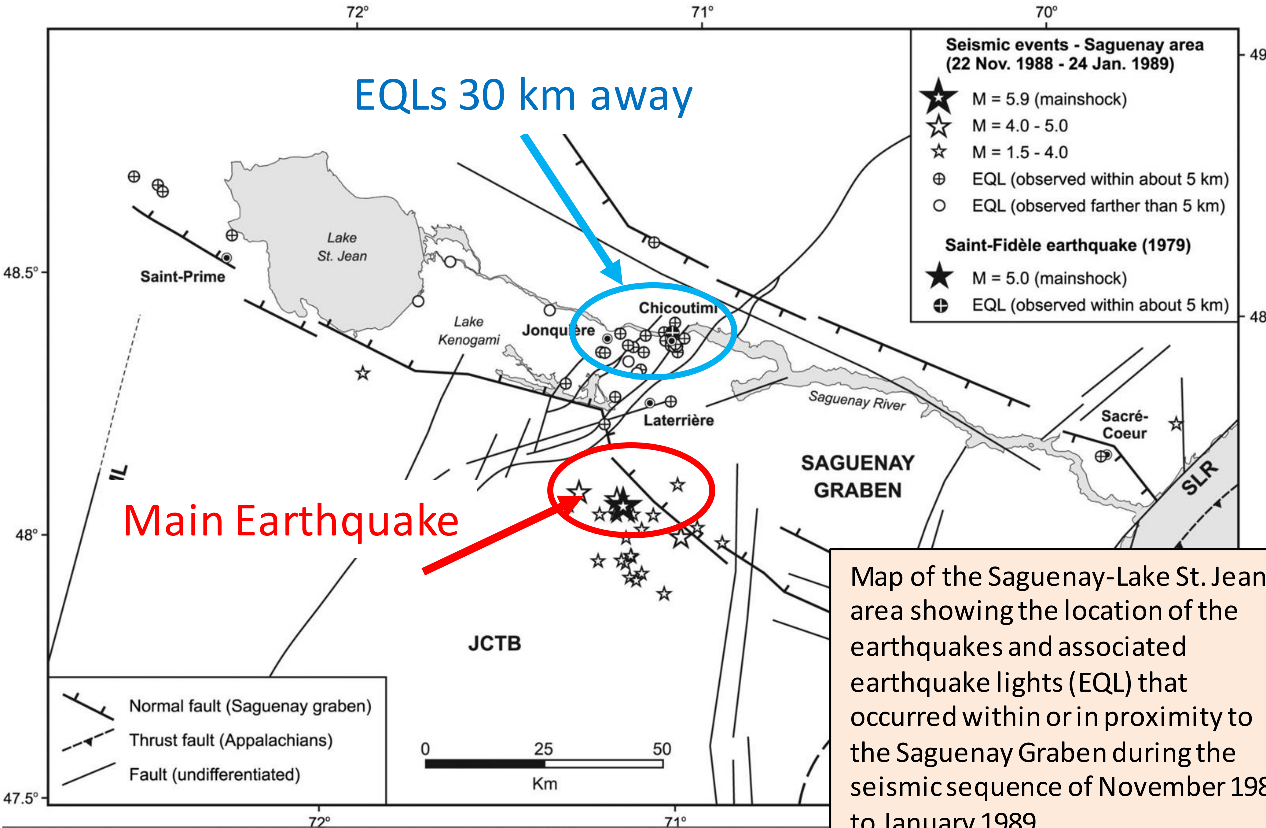
Magnitude of Earthquakes Associated with Luminosities

EQL are generated in association with earthquakes over a wide range of magnitude from 3.6 to 9.5. It can hence be concluded that EQL may occur regardless of the earthquake magnitude, although the majority of the listed cases (i.e., 80%) were observed for events with magnitudes greater than 5.0. As already noted by Hedervari and Noszticzius (1985), our compilation also indicates that the maximum distance at which EQL are observed tends to increase with the magnitude of the event. For example, EQL have been reported for distances up to 600 km from the epicenter in the case of the New Madrid earthquake, which had a magnitude of about 8.

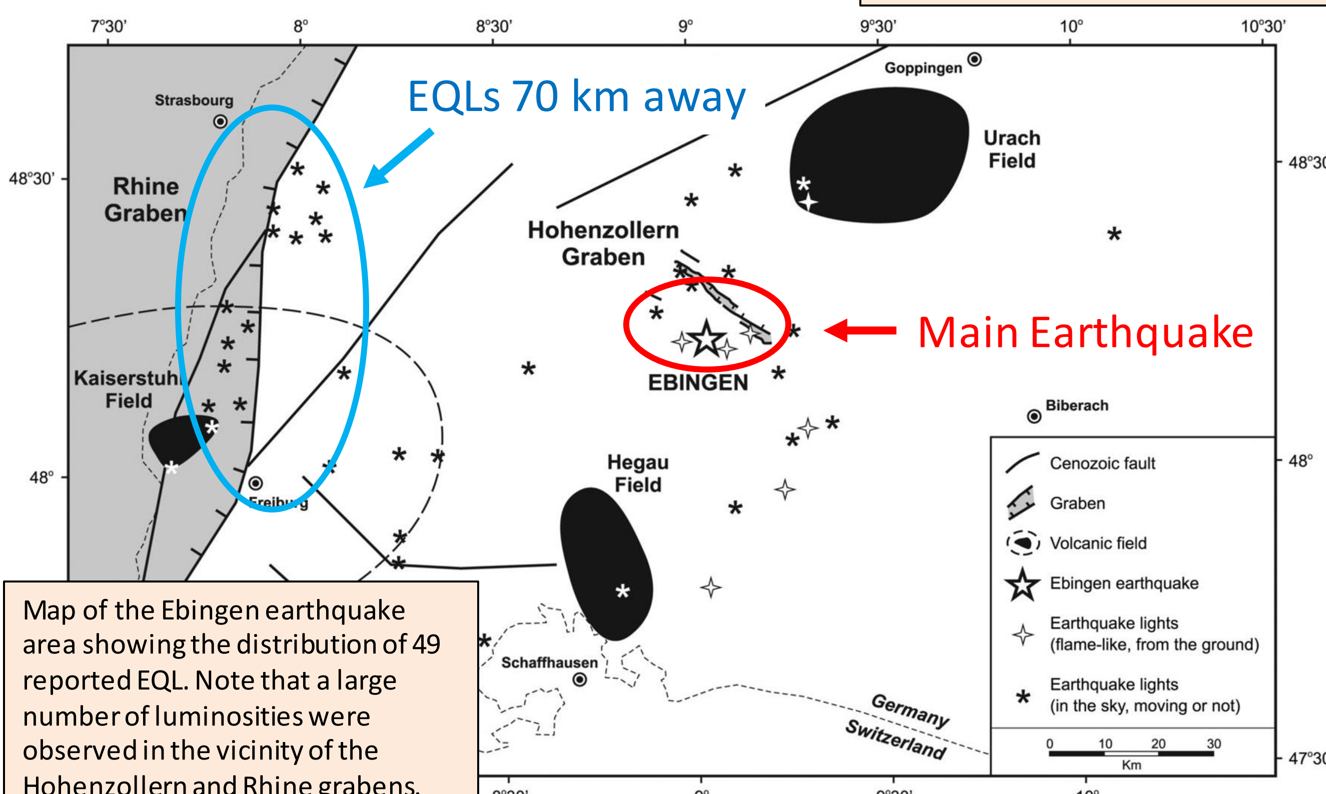
Distance between EQL and Earthquake Epicenter

At rare occasions, EQL have been seen as far as 600 km from any given epicenter, as our compiled list of earthquakes shows (e.g., New Madrid earthquake). More typically, EQL have been observed at distances not more than about 300 km from an epicenter. Pre-earthquake luminosities were generally seen closer to the epicenter relative to coseismic luminosities, a few at 200 km but the majority of them occurring at 150 km or less.

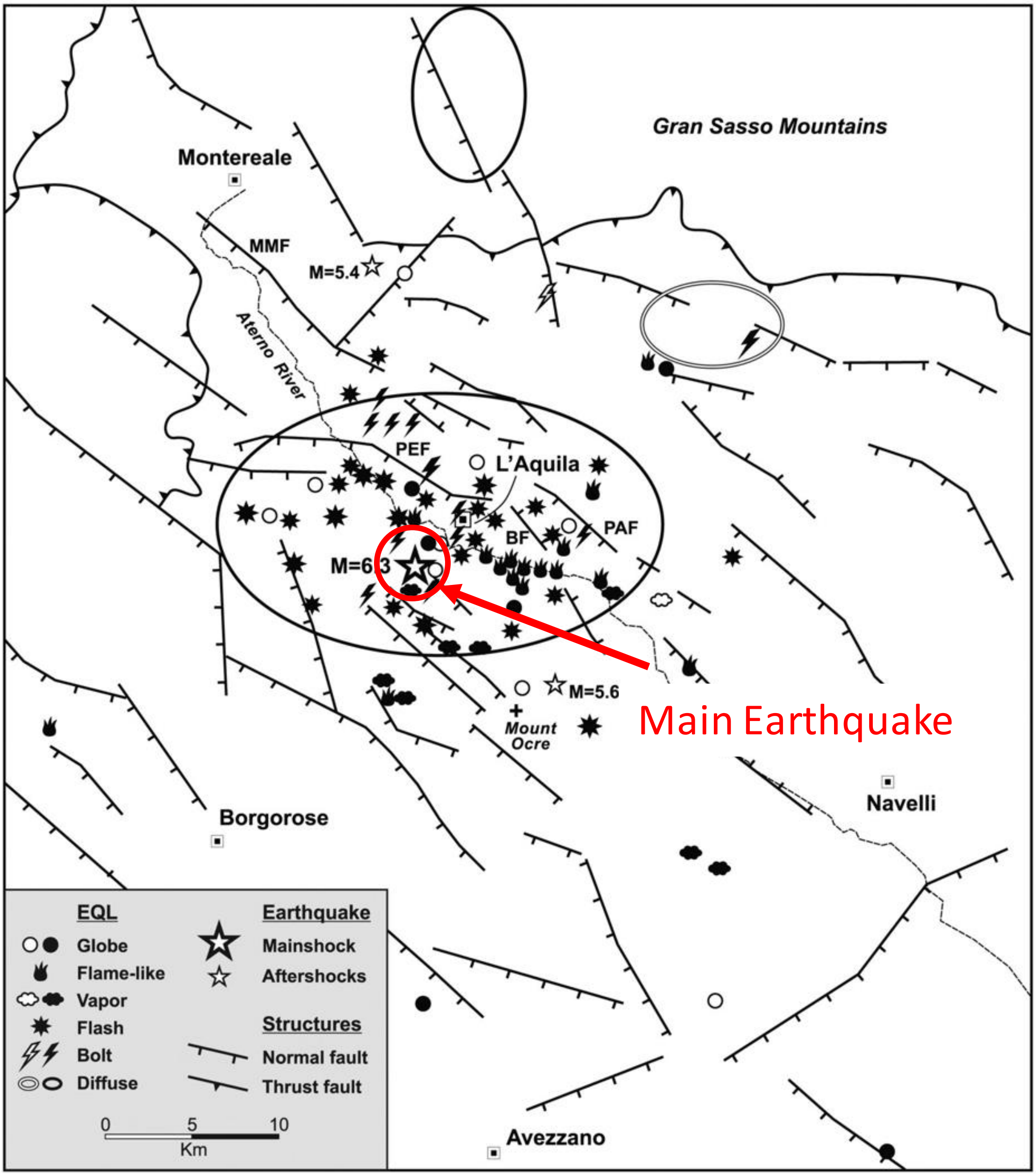
It is important to note that when EQL were seen far away from the epicenter, as some reports for the New Madrid earthquake suggest, they seem to be always time correlated with the passing of the seismic waves. The most definite evidence comes from Lima, Peru, in which the passage of the seismic wavetrain associated with the 2007 M_w 8.0 Pisco earthquake (coming from a distance of 150 km) was recorded by a seismometer on the PUCP university campus, while the EQL were recorded simultaneously by automated surveillance cameras (Heraud and Lira, 2011). In this case, it was clear that the outbursts of light did not occur during the passage of the compressional (*P*) waves but during the passage of the shear (*S*) waves. This implies a direct coupling between the crustal rocks and the very rapid, high-amplitude change in shear stress caused by the *S* wavetrains (Gharibi *et al.*, 2003).



Map of the Saguenay-Lake St. Jean area showing the location of the earthquakes and associated earthquake lights (EQL) that occurred within or in proximity to the Saguenay Graben during the seismic sequence of November 1988 to January 1989.

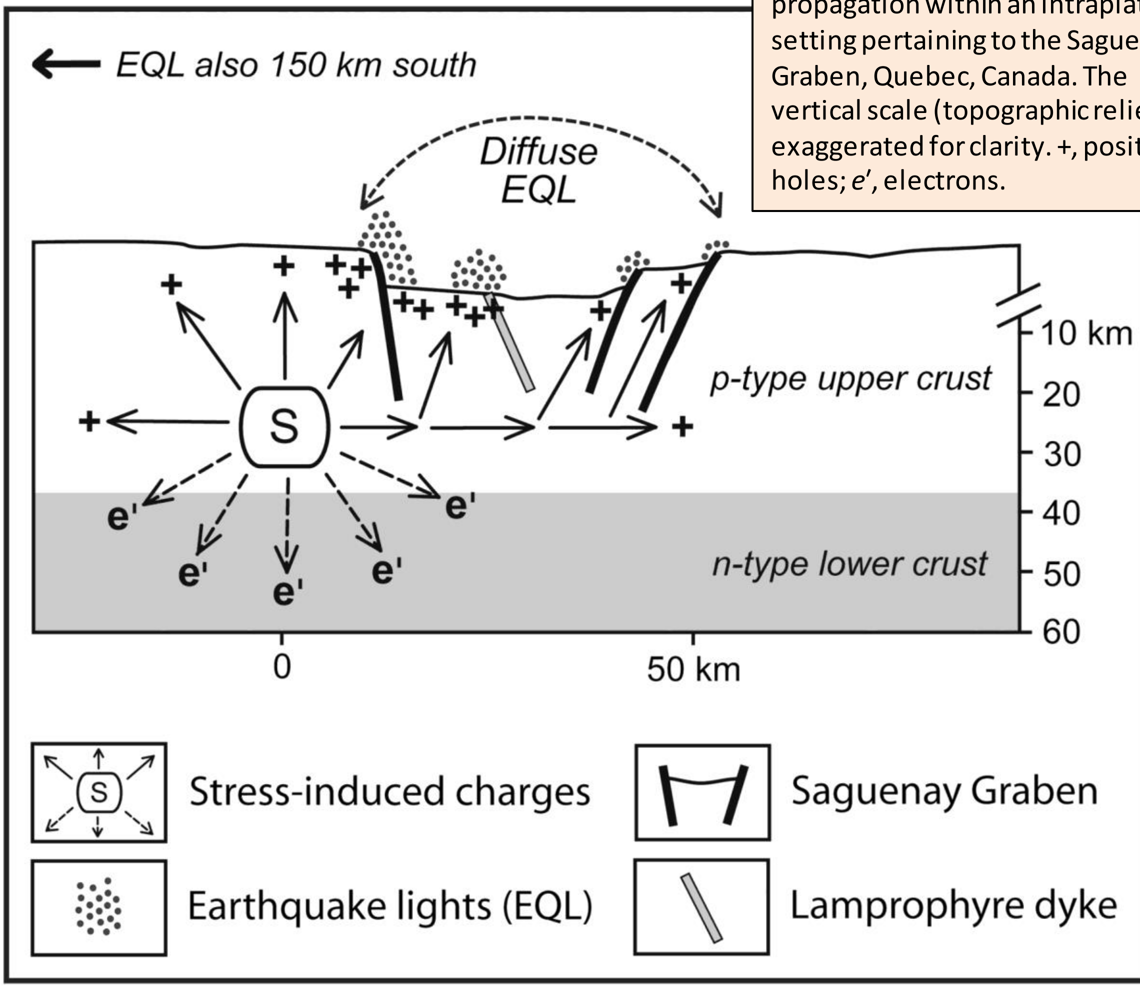


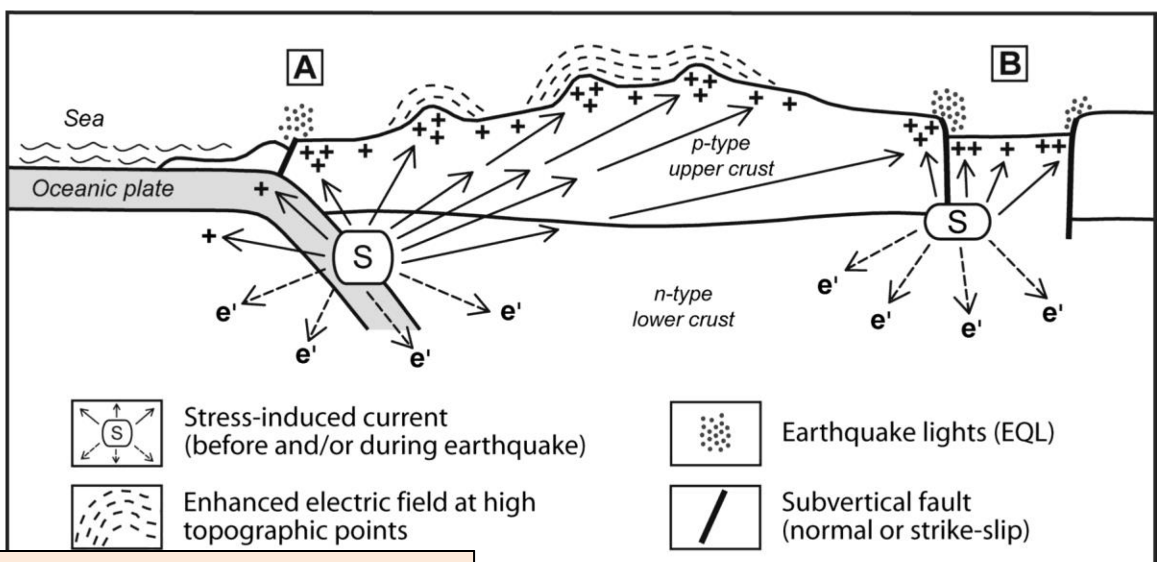
Map of the Ebingen earthquake area showing the distribution of 49 reported EQL. Note that a large number of luminosities were observed in the vicinity of the Hohenzollern and Rhine grabens. EQL were seen within a radius of 110 km from the Ebingen earthquake.



Map of the western part of the Abruzzo region of Italy, in the vicinity of L'Aquila, showing the location of various types of earthquake lights (EQL) observed prior to and during the L'Aquila earthquake of April 2009.

Simplified model of phole propagation within an intraplate rift setting pertaining to the Saguenay Graben, Quebec, Canada. The vertical scale (topographic relief) is exaggerated for clarity. +, positive holes; *e'*, electrons.





Simplified model of phole propagation within an interplate, orogenic tectonic setting in a subduction zone environment (i.e., Andean-type)..

Hessdalen lights vs EQL

Theory and data

The very essential part of generating lights from rock, is ex. the need for mafic rock. Common mafic rock is basalt and gabbro. Hessdalen has both. When subjected to stress, mineral grains in Gabbro and Basalt slide along grain boundaries, causing peroxy links to break, which (in short) turn into highly mobile electronic charge carriers, referred to as positive holes or *pholes*. If these pholes are overlapping, increasing in density, they can generate the plasma state. If plasma surface, it can generate dielectric breakdown of the air and generate spherical lights.

We have two situations to get stress in these rocks. Fault stresses and induced stress from earthquakes.

In public webpage www.jordskjelv.no you can veiw all earthquakes happened in Norway and around, from 1998 until today. Since EQL (EarthQuake Lights) are more common in areas with stronger magnitude earthquakes (normally magnitude 5 or more), the assumption that Hessdalen lights could be EQL, is not strong. The theroy is however interesting and is worth checking out.

Earthquakes in Norway have a more common magnitude between 2 and 3, and not above 5 which have been found to dominate the appearance of EQL (80% of EQL appear with earthquakes above 5 in magnitude). EQL's are said to appear before, during and after an Earthquake. Database from www.jordskjelv.no was checked with the Hessdalen lights dates and matches can be seen in Table EQL.1 and Figure EQL.1.

Another common ocurrance is that EQL normally happen within 150 km of the Earthquake, but have been assumed happening 600 km away, but then after a high magnitude earthquake (M=8). High magnitude earthquakes are not the case for Hessdalen, and since most earthquake epicenters in Norway are between 300 km and 400 km away from Hessdalen, the EQL theory for Hessdalen is found to be - not a good match ! See Figure EQL.2

Earthquakes in North Europe

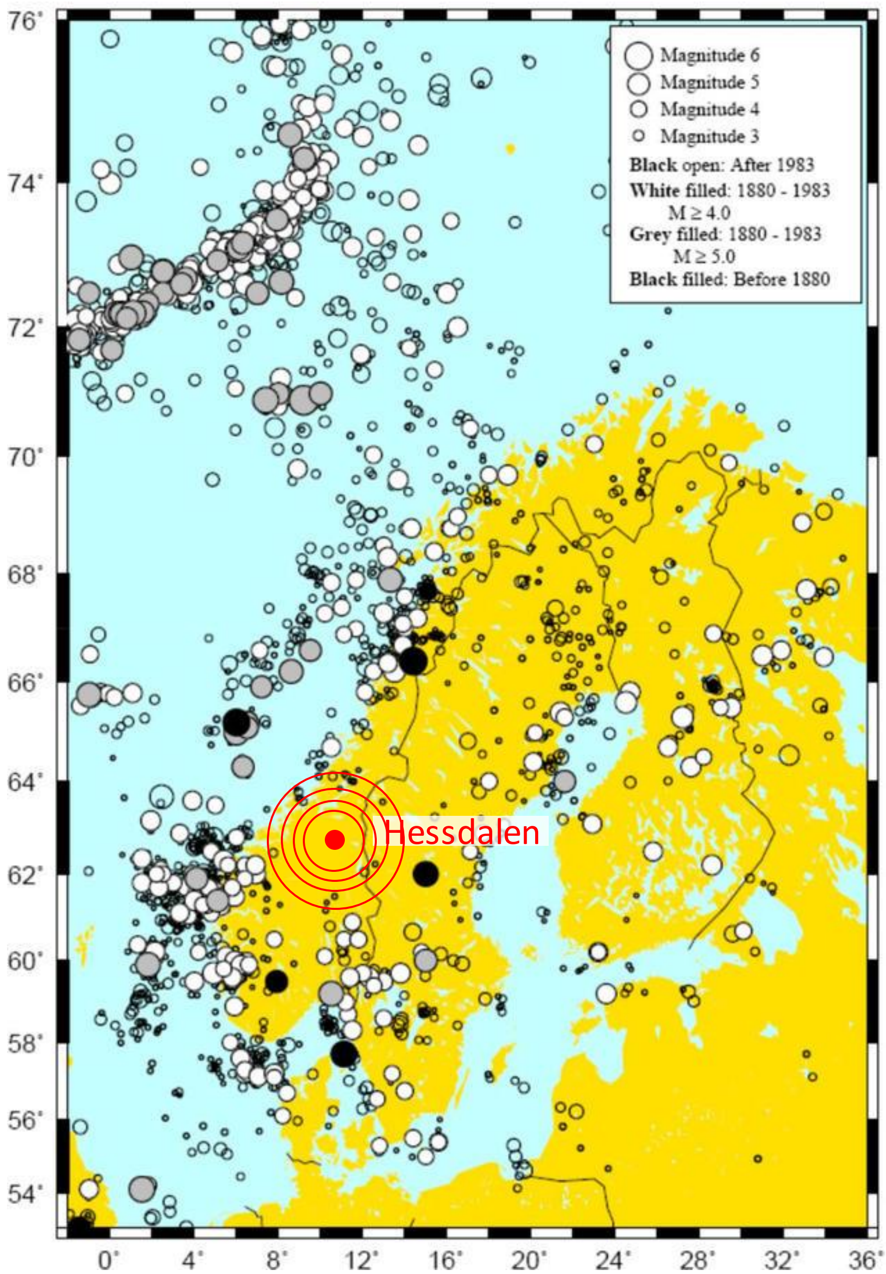


Figure EQL.1

Earthquakes in the same period (± 1 day) as Hessdalen observation

Number	Observation	Origin Time	Lati	Long	Depth	Magnitude	Area
1	05.09.2014	06.09.2014 18:56	60.13	6.562	0	2.91	SOUTHERN NORWAY
2	05.05.2014	05.05.2014 15:34	62.288	6.101	18	2.46	SOUTHERN NORWAY
3	18.01.2014	18.01.2014 15:25	60.045	6.546	0	1.99	SOUTHERN NORWAY
23	17.08.2013	16.08.2013 18:01	70.179	18.427	16	2.01	NORTHERN NORWAY
23	17.08.2013	16.08.2013 18:01	70.179	18.427	16	2.01	NORTHERN NORWAY
23	16.08.2013	16.08.2013 18:01	70.179	18.427	16	2.01	NORTHERN NORWAY
NS	17.08.2012	16.08.2012 13:22	74.48	10.292	0	2.89	NORWEGIAN SEA
4	13.09.2010	13.09.2010 18:02	65.423	12.676	0	2.02	NORTHERN NORWAY
NS	12.01.2010	11.01.2010 15:45	64.699	7.404	9	2.41	NORWEGIAN SEA
X	05.01.2010	06.01.2010 06:34	66.525	13.878	0	2.37	NORTHERN NORWAY
NN	05.12.2006	04.12.2006 07:31	68.446	11.361	0	2.16	NORWEGIAN SEA
5	23.07.2006	24.07.2006 22:55	61.809	4.141	0	2.29	SOUTHERN NORWAY
6	22.07.2006	21.07.2006 04:27	60.055	10.556	0	1.96	SOUTHERN NORWAY
7	21.12.2004	22.12.2004 14:42	60.681	10.929	6	2.21	SOUTHERN NORWAY
NS	15.12.2004	16.12.2004 06:57	73.34	16.442	16	1.85	NORWEGIAN SEA
NN	14.08.2004	15.08.2004 22:39	68.769	18.014	0	1.06	NORTHERN NORWAY
8	13.08.2004	12.08.2004 18:36	69.046	17.667	0	1.82	NORTHERN NORWAY
9	31.07.2004	31.07.2004 19:26	62.921	6.673	14	2.30	SOUTHERN NORWAY
NS	12.06.2004	12.06.2004 02:32	72.906	4.818	0	2.01	NORWEGIAN SEA
10	13.03.2003	13.03.2003 09:21	63.862	9.404	0	2.23	SOUTHERN NORWAY
X	26.02.2003	26.02.2003 13:27	60.177	4.936	0	2.17	SOUTHERN NORWAY
X	28.01.2003	29.01.2003 23:05	68.48	14.097	30	2.31	NORTHERN NORWAY
11	12.10.2002	13.10.2002 00:26	61.932	3.03	18	2.38	NORWEGIAN SEA
12	14.08.2002	14.08.2002 15:53	59.33	9.812	0	2.09	SOUTHERN NORWAY
NS	10.08.2002	11.08.2002 11:37	71.299	16.181	0	2.29	NORWEGIAN SEA
13	05.06.2002	05.06.2002 15:16	58.432	6.072	0	1.67	SOUTHERN NORWAY
NS	17.10.2001	21.10.2001 19:08	65.967	-0.072	0	2.62	NORWEGIAN SEA
14	16.10.2001	16.10.2001 13:23	59.963	10.704	0	1.84	SOUTHERN NORWAY
15	15.09.2001	16.09.2001 21:39	63.989	10.019	37	2.17	SOUTHERN NORWAY
NS	13.04.2001	12.04.2001 15:50	62.028	4.619	12	2.01	NORWEGIAN SEA
X	05.02.2001	05.02.2001 15:26	59.591	4.88	0	2.30	SOUTHERN NORWAY
16	27.01.2001	28.01.2001 18:44	66.087	14.484	1	1.90	NORTHERN NORWAY
X	02.01.2001	02.01.2001 15:54	61.083	4.328	9	2.10	SOUTHERN NORWAY
17	07.12.2000	08.12.2000 01:48	60.185	5.277	11	3.80	SOUTHERN NORWAY
18	02.12.2000	02.12.2000 16:09	59.258	9.817	6	1.50	SOUTHERN NORWAY
19	29.11.2000	29.11.2000 03:22	59.925	7.304	13	2.70	SOUTHERN NORWAY
20	14.11.2000	14.11.2000 12:32	59.453	10.596	12	1.90	SOUTHERN NORWAY
21	10.11.2000	10.11.2000 09:43	68.918	17.263	0	2.05	NORTHERN NORWAY
NS	11.08.2000	12.08.2000 06:34	72.607	16.551	0	2.37	NORWEGIAN SEA
NS	21.12.1998	21.12.1998 01:16	63.315	5.692	0	2.66	NORWEGIAN SEA
NS	10.12.1998	11.12.1998 23:05	74.793	10.999	31	2.00	NORWEGIAN SEA
22	23.11.1998	23.11.1998 21:24	61.948	4.073	0	1.56	SOUTHERN NORWAY

Table EQL.1

NS = Norwegian Sea (not in map), NN = Northern Norway (not in map), X = Not found, Number = In map

Earthquakes in the same period (± 1 day) as Hessdalen observation

There are many earthquakes at the same time as the Hessdalen observations, but it is hard to conclude if there is any connection between them. The eartquake magnitude and distance does not match the EQL observations elsewhere.

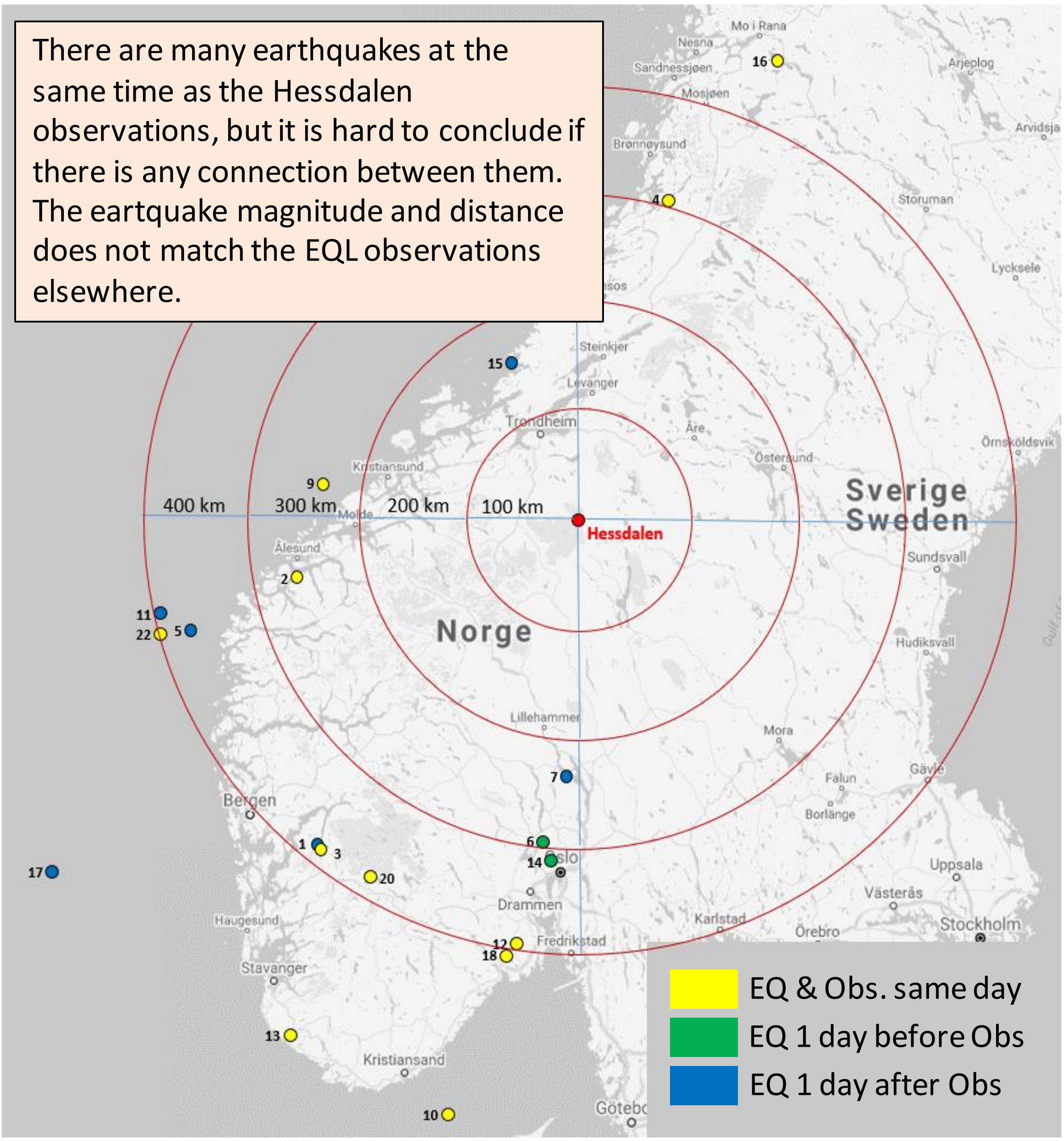


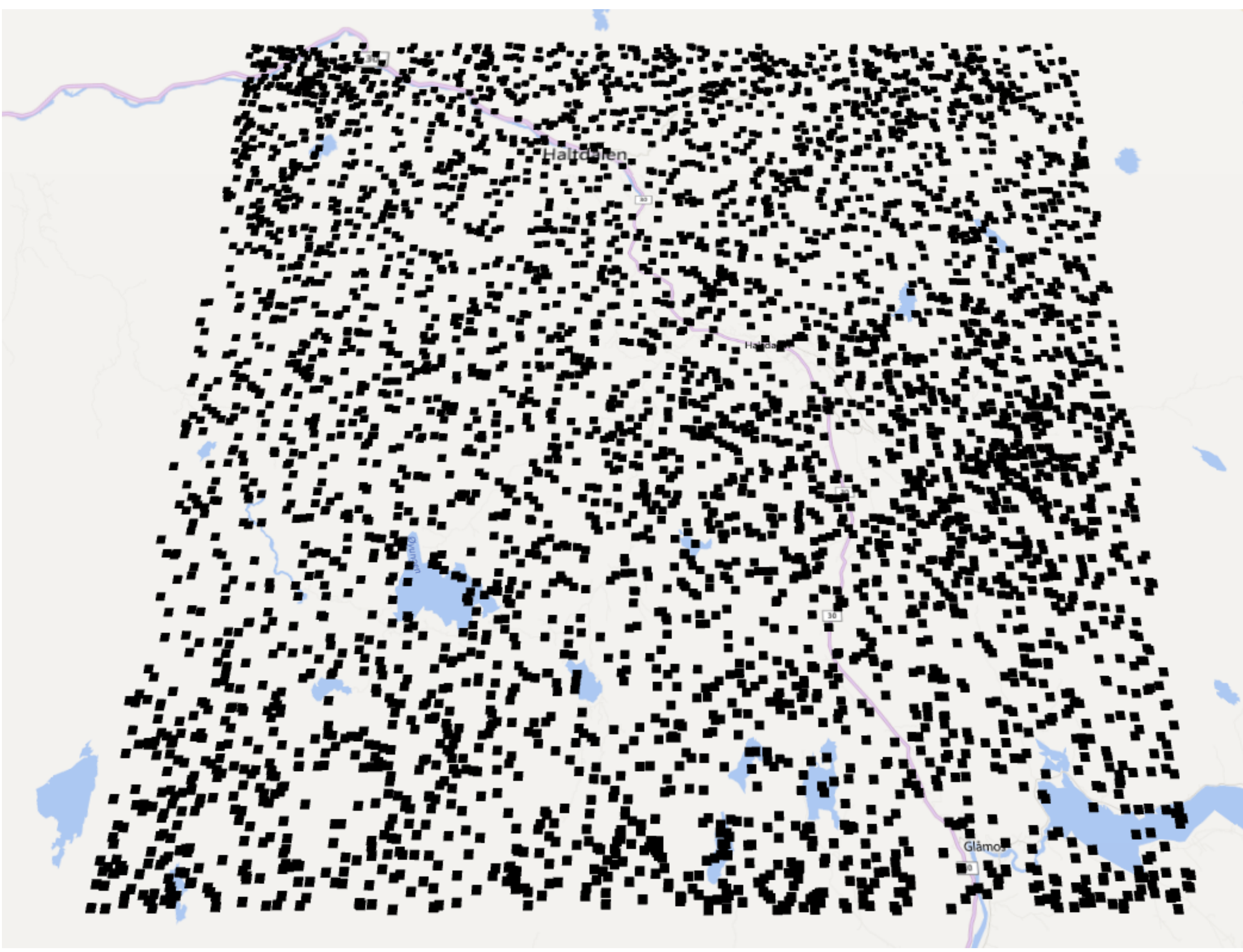
Figure EQL.2

EQ = EarthQuake
Obs = Observation

Lightning database

Lightnings from 2001 to 2014 over Hessdalen. Data from Sintef.

Lightning data can be bought from Sintef (website in Norwegian):
http://www.sintef.no/sintef-energi/produkter-og-tjenester



Lightning Energy

First, lets look at the energy that one lightning can bring down to the ground. A Cloud-to-Ground (CG) lightning.

According to Williams,E R, “The Electrification of Thunderstorms”, a typical lightning has a voltage of several hundred million volts. Lightning carries 10 ^ 20 electrons in a fraction of a second as the process develops a peak current of 10 kA. Current and voltage multiplied gives us Effect. If peak flow is 10 kiloamps and voltage 500 million volts, then we get that a lightning strike has an effect of 5000 MW:

P = I * V = 10 kA * 500 000 kV = 5 000 000 kW = 5000 MW

It sounds powerful, but if we take into account the timing of it all, we can see quickly that this does not corresponds to much energy. If we assume that it lasts 30 microseconds, ie 30 millions of a second (30/1 000 000 s), it gives us the following amount of energy:

E = P * time = 5000 MW * 30/1 000 000 s = 0.15 MJ = 150 000 J

150,000 joules is equal to 41.7 Wh.

Conclusion: **a 10 kA lightning can power a 40W light bulb for one hour**.

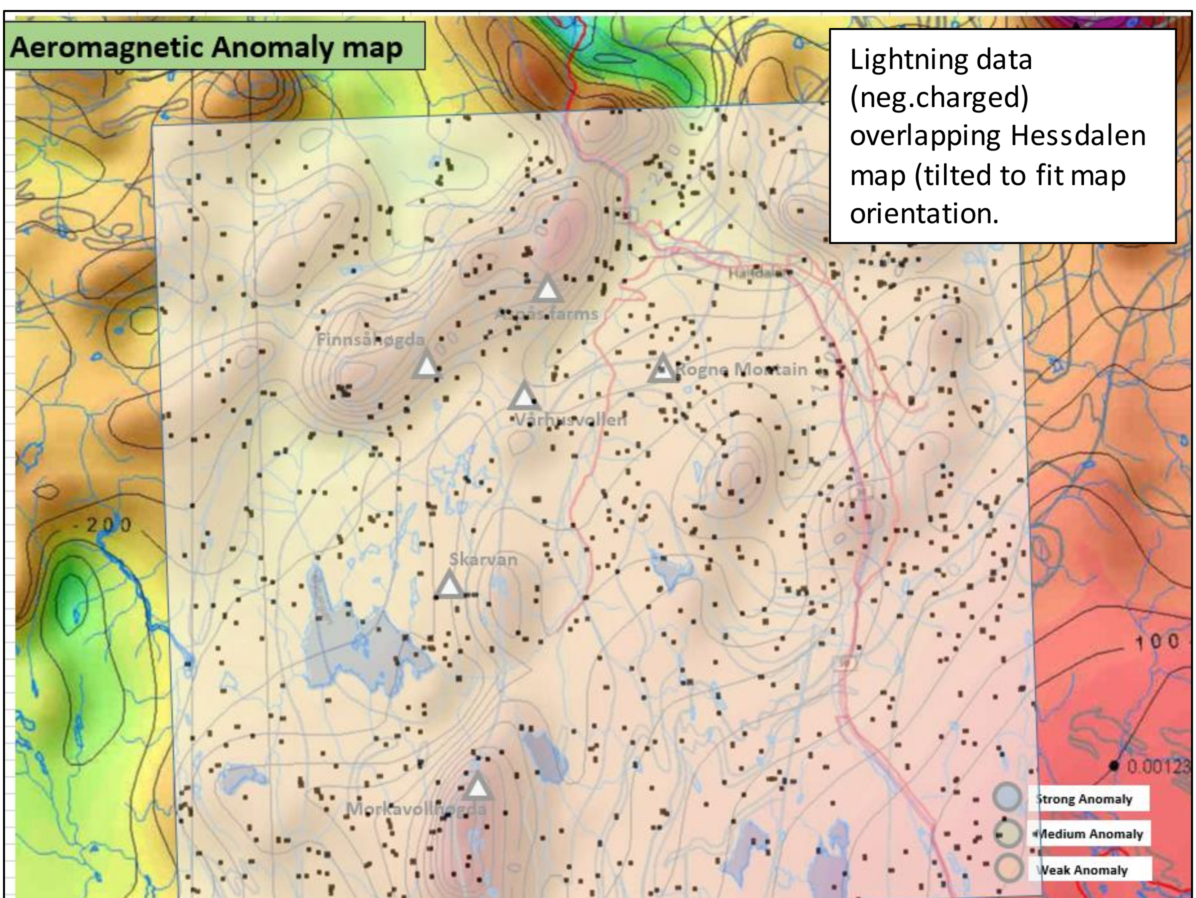
This being a normal negative charged lightning (-kA), a positive charged lightning (+kA) are normally 6-10 times stronger.
(https://en.wikipedia.org/wiki/Lightning)

Following pages will present if there is a pattern to the lightning's that hit Hessdalen.

Lightning database

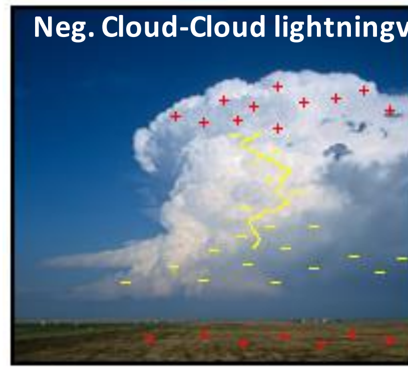
Question is: «Where does the energy of the Hessdalen lights come from?».

There is the «Car-battery-theory» that is the resent theory, I introduce here Lightning as one theory. Now, a «Lightning + Car-Battery» theory could be feasible. How the lightning then would trigger the lights or maybe be «stored» in the ground («battery») for later occurance is another question, which I cannot answer. But a lightning database from 2001 to 2014 for Hessdalen has been aquired from Sintef and a database has been created to be used together with the observation database, which in combination can give interesting findings. Findings that are including and excluding for lightning to have a meaning in Hessdalen will be presented.

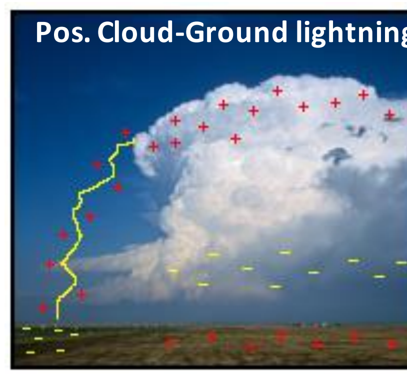


Positive and Negative Lightning

As more and more positive charge builds in the upper part of the storm and on the ground beneath the storm, more and more negative charge builds in the lower part of the cloud. When you have sufficient electrical potential , a lighting strike occurs and electrons flow. These are examples of negative lightning because electrons flow towards the positive charge.



There is another type of lightning that is far more powerful, one in which positive charge flows instead of electrons.
However, instead of discharging with the negative charge at the base of the cloud, it travels outside the cloud and strikes the ground where there's a pool of negative charge. They tend to be about 5 times more powerful and hotter than a negative strike, last about 10 times longer, strike several miles away from the storm and produce huge amounts of ELF and VLF radio waves. So instead of power up a lightbulb (40W) for 1 hour, it could power up something with 2000W for 1 hour. And that's energy !! Positive lightnings are also said to be main cause of sprites and elves (light phenomena above clouds).



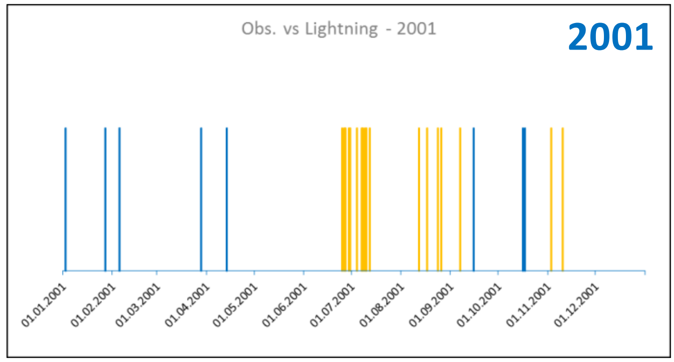
Reference:
http://www.weatherimagery.com/blog/positive-negative-lightning/

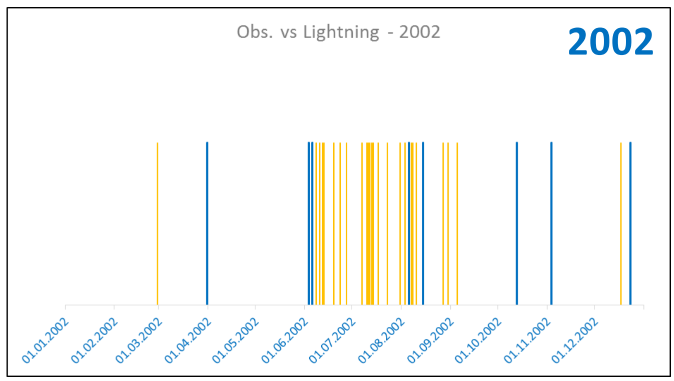
Lightning database

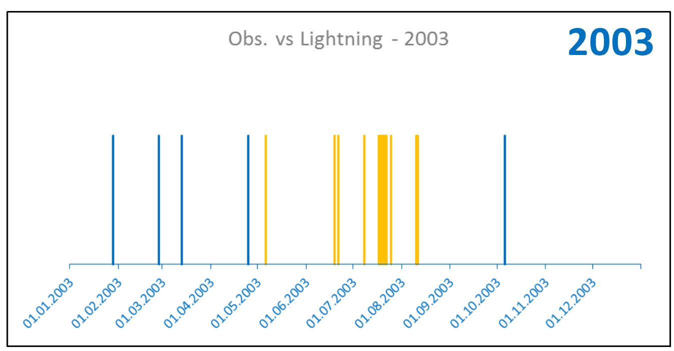
Tables show observations as blue color and days with lightning in the Hessdalen Area as orange color.

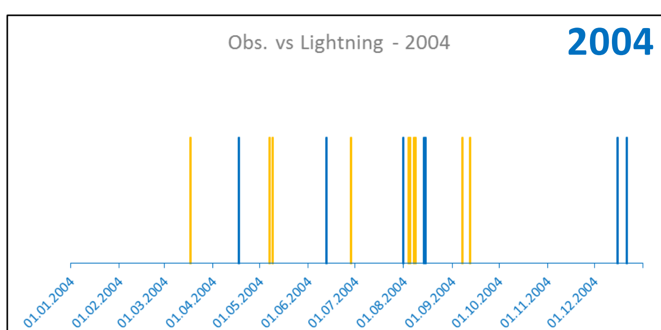
Looking at the lightning data from year 2001 to 2014, there is no clear pattern or connection between lightnings in Hessdalen and the observations.

Most lightnings happen in the rain season, July-Agust.





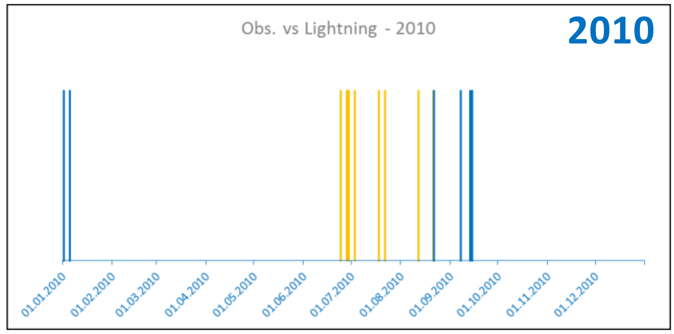


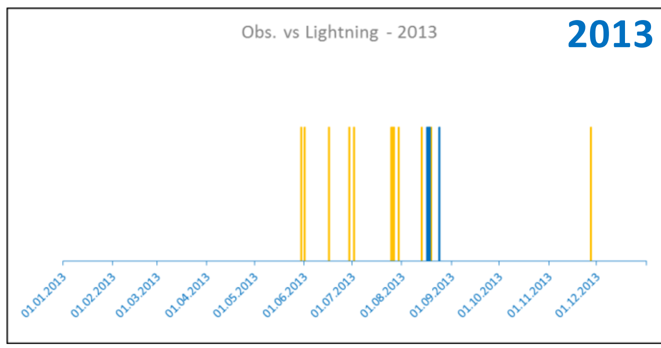


Lightnings

Observations

Lightning database





In some years there are no observations in the July-august when the lightnings are occuring the most, but straight after in the following months.

However, there are also observations in the winter months when lightnings have not been ocuring for a while.

It can not be stated that lightnings has any effect on the occurance of Hessdalen observations.

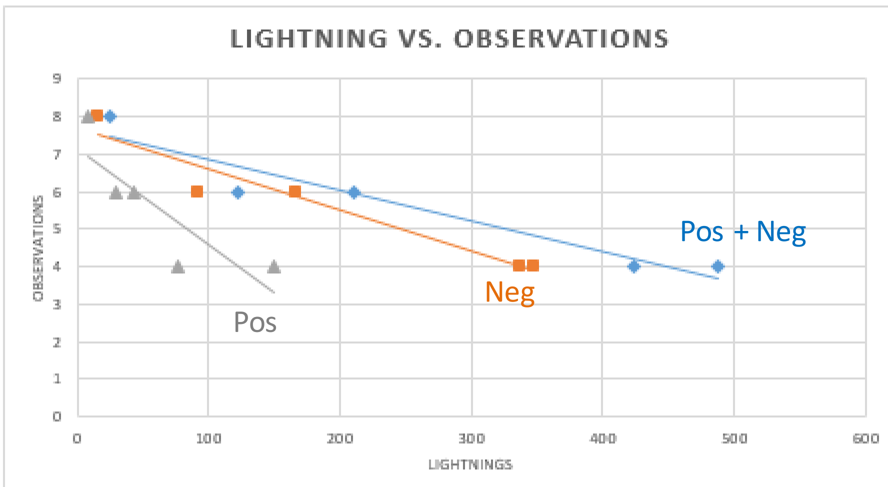
Lightnings

Observations

Lightning vs. Observation

Cloud-to-Ground		
Year	Lightnings	Observations
2010	210	6
2011	424	4
2012	25	8
2013	122	6
2014	487	4

Lightnings neg	Lightnings pos
166	44
347	77
16	9
92	30
337	150

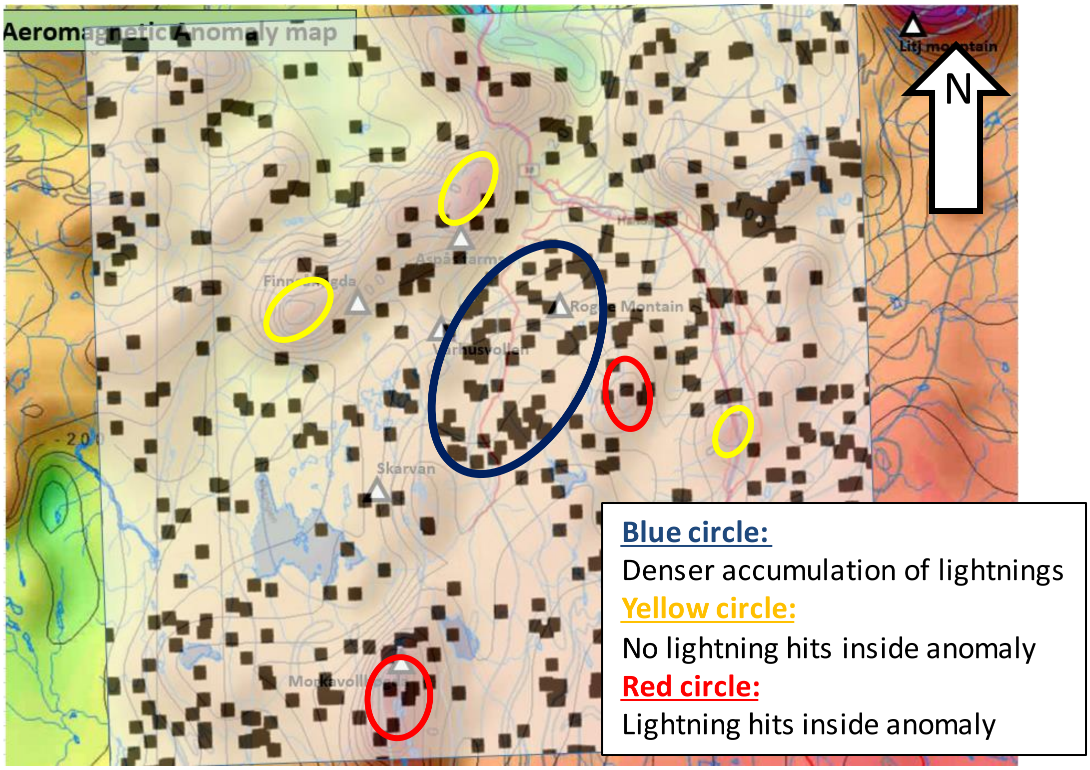


Lightning database from 2010 to 2014 have marked Cloud-Cloud lightnings that can be taken out. This leaves the Cloud-to-Ground lightnings that are the most interesting lightnings for Hessdalen data analysis. If we take the number of CS-lightnings vs. Observations from the database in the same year, we get above trend. The less lightnings, the more observations. Specially, the less pos lightnings, the more observations.

This is opposite of what I was expecting. This is just an observation of the data. Difficult to prove , but I present it here anyway. Hessdalen lights are observed by people that normally tend to stay indoors when rain and lightning occur. Thats why we almost never have observations in bad weather.

Lightning database

Lightnings all Cloud-to-Ground from 2011 to 2014 over Hessdalen.
Lightning data from Sintef.

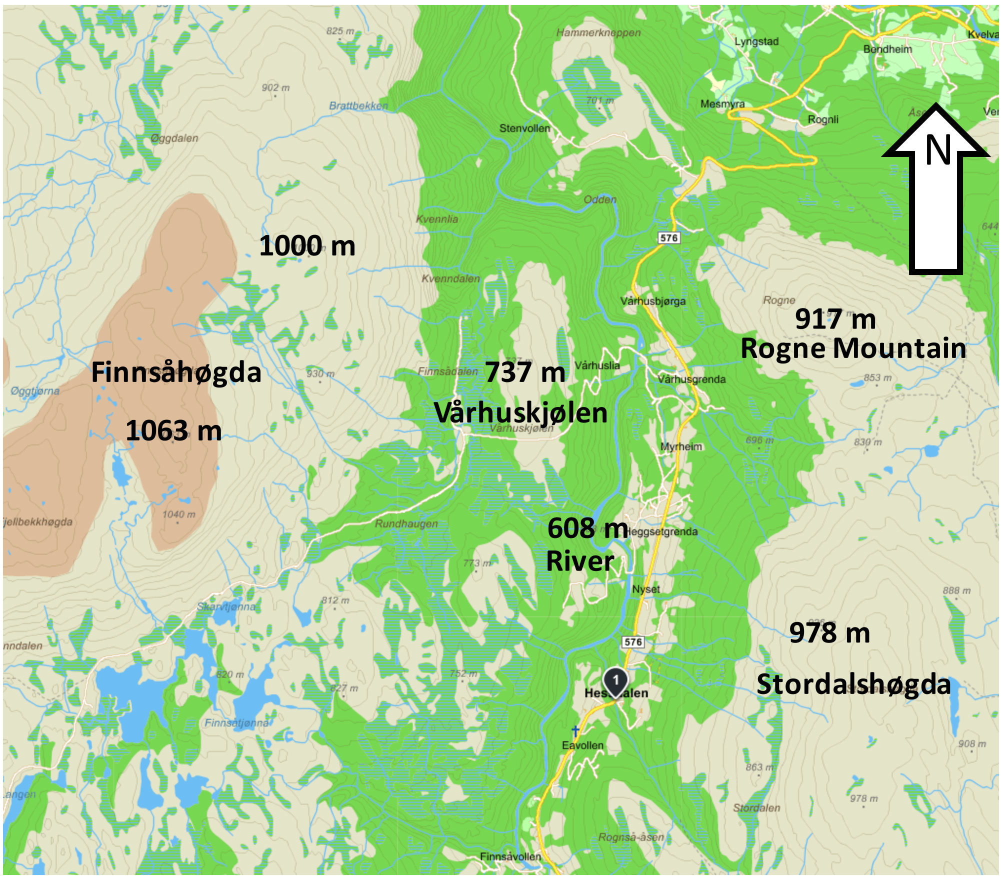


All lightnings from Cloud-to-Ground (CG) from 2011 to 2014 i displayed here. In 2011 Sintef replaced lightning tracker system to new and better ones. The new system could differ from Cloud-to-Ground and Cloud-to-Cloud lightnings. This is why I use only lightnings from 2011 to 2014 here.

<u>Result of plotting all Cloud-to-Ground lightnings:</u>
Anomalies on the west side of Hessdalen do not have lightning hits inside the anomaly area (yellow color). There is a denser lightning hit area inside the valley, and to the east side. Considering wind direction, during 5 years there is still significant increased lightning hits in the blue circle (Rogne Mountain).

Lightning database

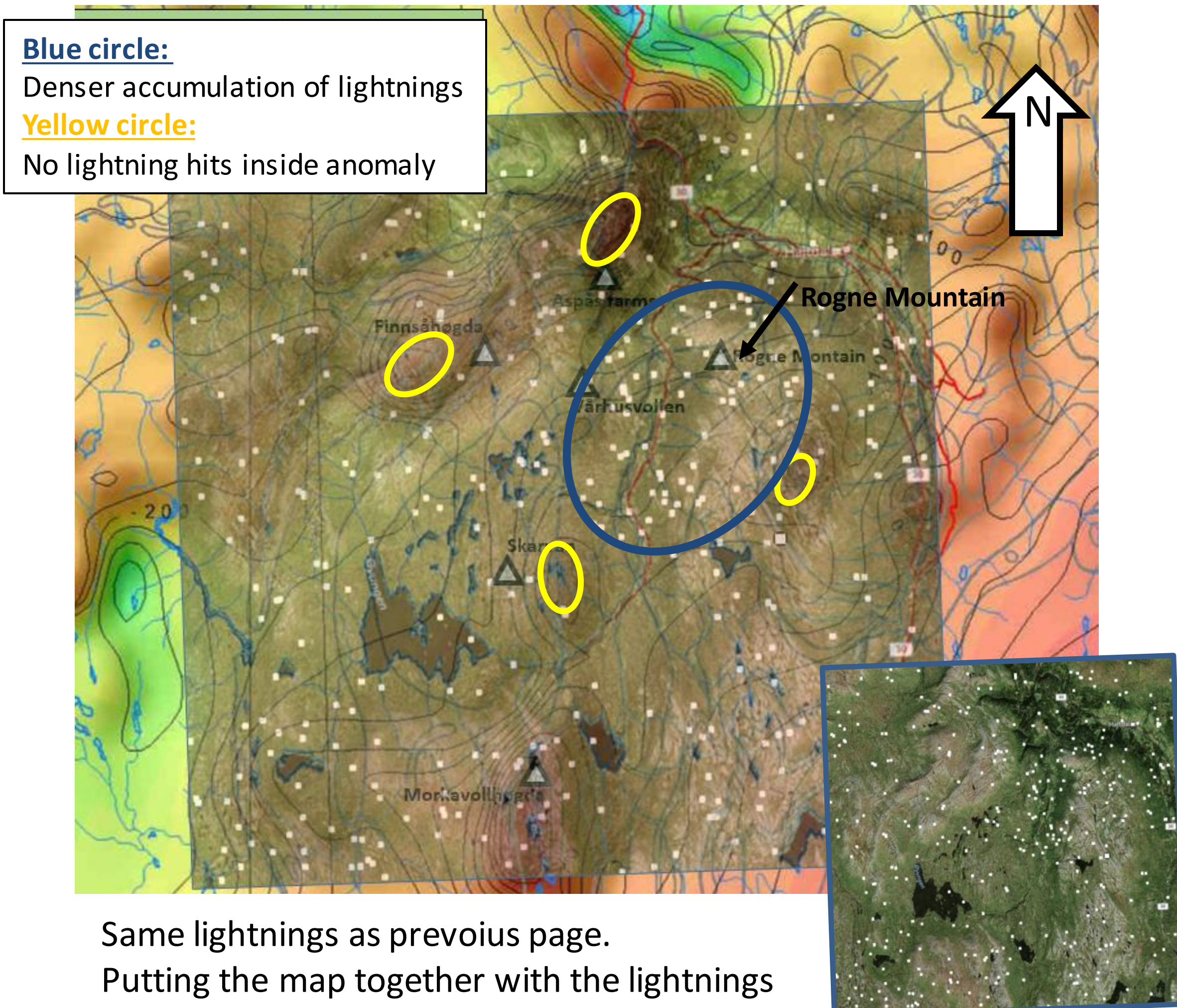
Hessdalen height map



Even if a lot of the lightning hit the tip of Rogne Mountain where highest point is 917 meter, this is by far the highest point in the area, both Finnsåhøgda on the west side and Stordalshøgda south of Rogne Mountain is higher.

Lightning database

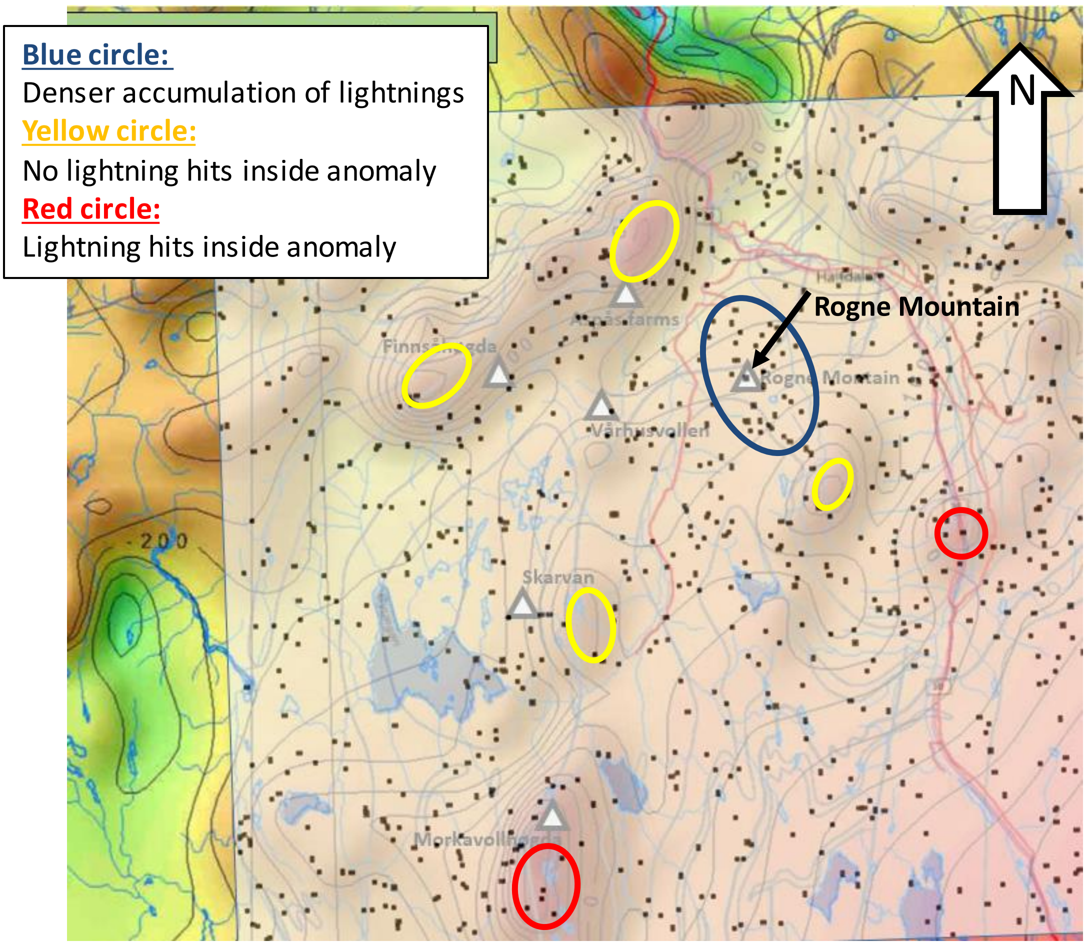
Lightnings all Cloud-to-Ground from 2011 to 2014 over Hessdalen.
Lightning data from Sintef.



Same lightnings as prevoius page.
Putting the map together with the lightnings and the anomalies, we clearly see that most Cloud-to-Ground lightnings hit the eastern part of Hesssdalen rather than the west (inside blue circle).
If this could be explained by the theory that the eastern part of Hessdalen has a different charge than the western part is not for me to say, but there is clearly a difference on the map.

Lightning database

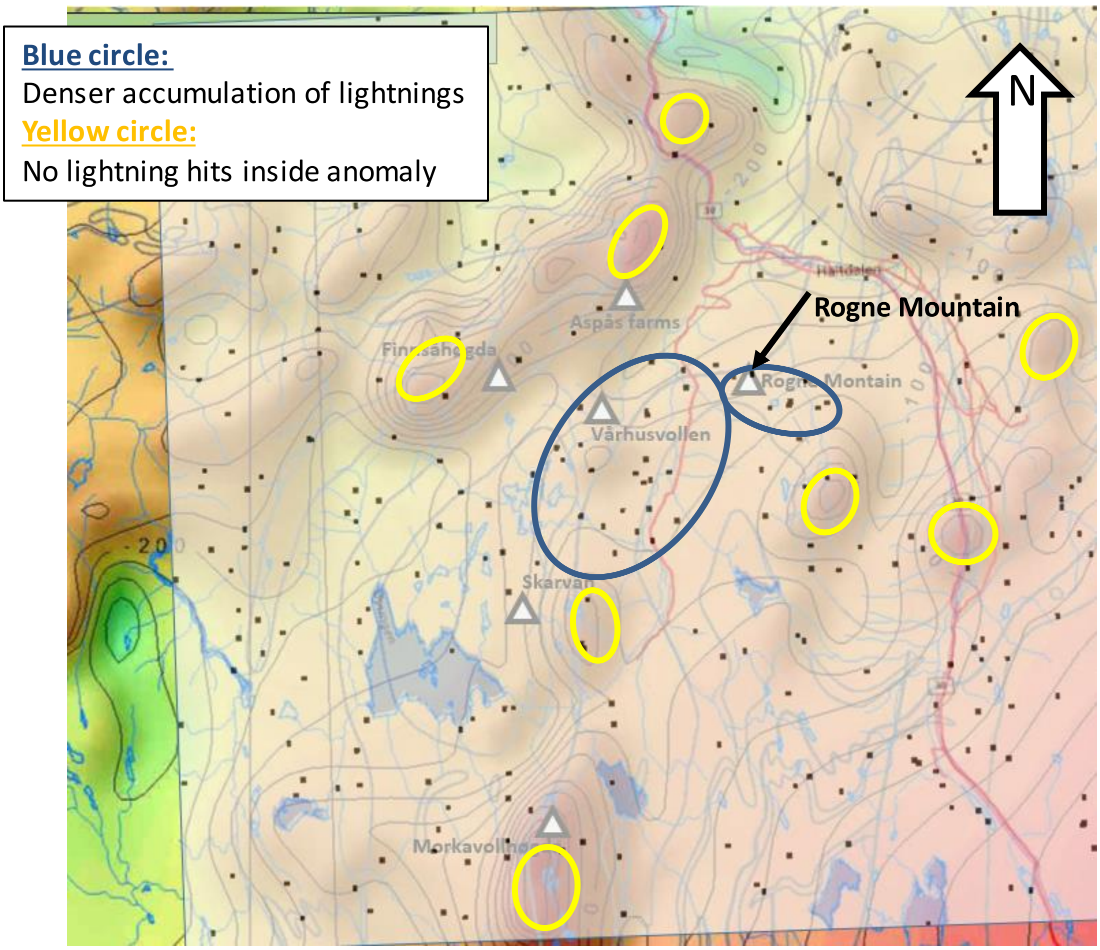
Lightnings with –kA (negative) from 2005 to 2014 over Hessdalen.
Lightning data from Sintef.



Negative charged lightnings are the most common lightning. Here lightnings the last 10 years. In Hessdalen they hit quite random. No lightning hit inside an anomaly around Hessdalen, except the two with red color (outside Hessdalen). How the lightnings hit inside and outside the anomalies could be coincidence. Rogne mountain seem to have a cluster of hits (blue circle).

Lightning database

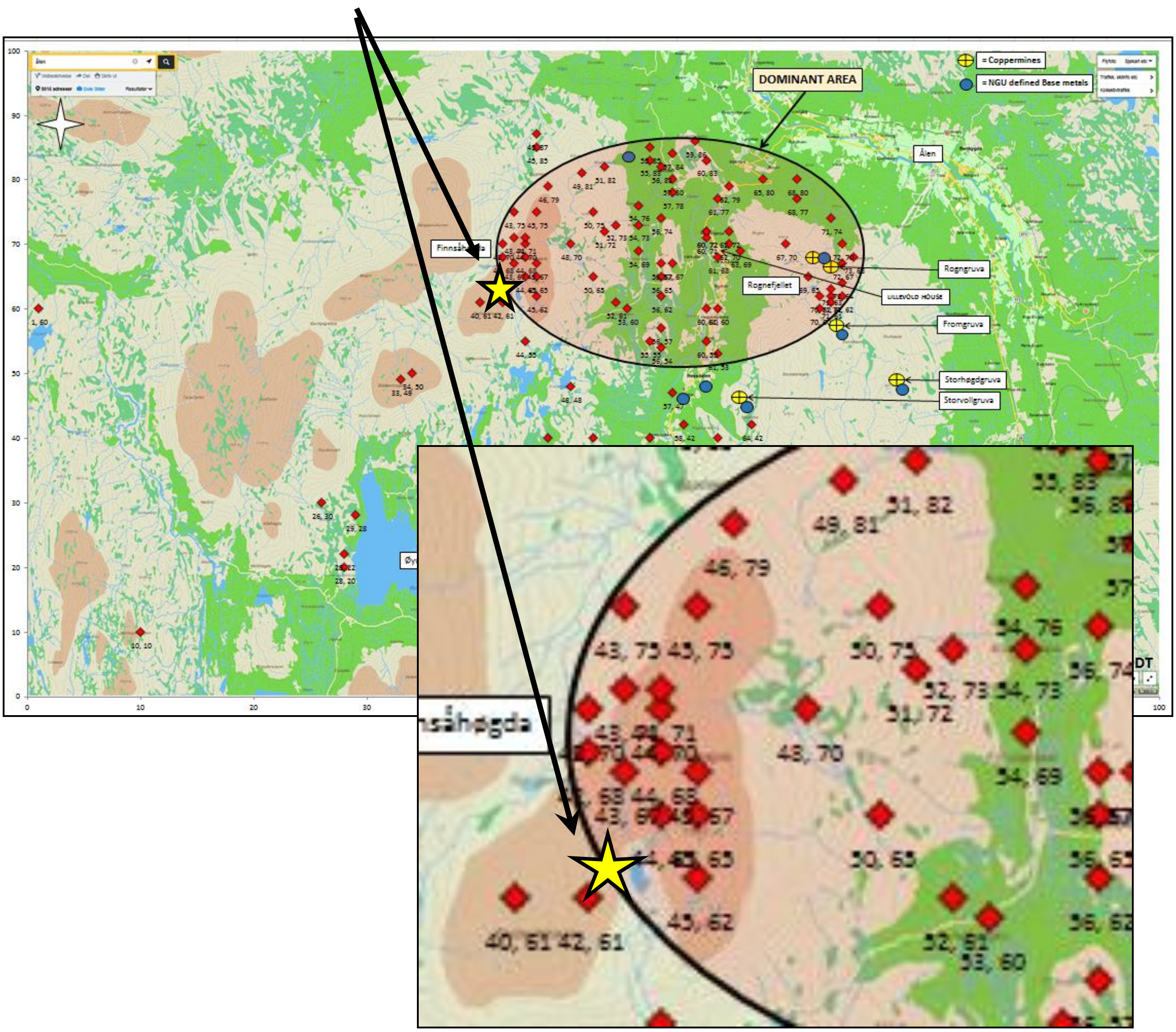
Lightnings with +kA (positive) from 2005 to 2014 over Hessdalen.
Lightning data from Sintef.



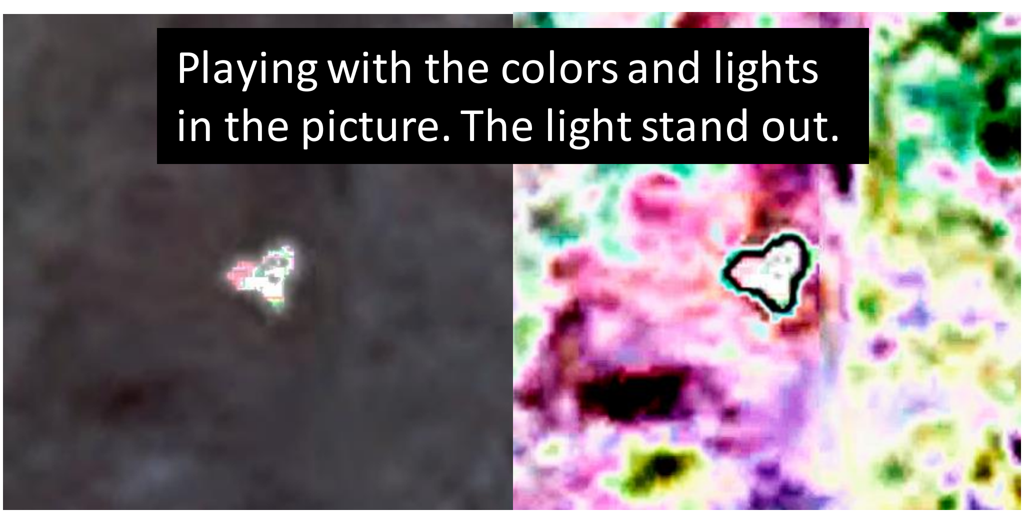
Positive charged lightnings are not happening as frequent as the negative charged lightnings. Here no lightnings have hit inside the magnetic anomalies. The positive lightnings are hitting more frequent inside the Hessdalen valley than on the mountain on each side of the Hessdalen valley (blue circle). Also the northern tip of Rogne mountain has more hits.

Hessdalen Light in Google Map?

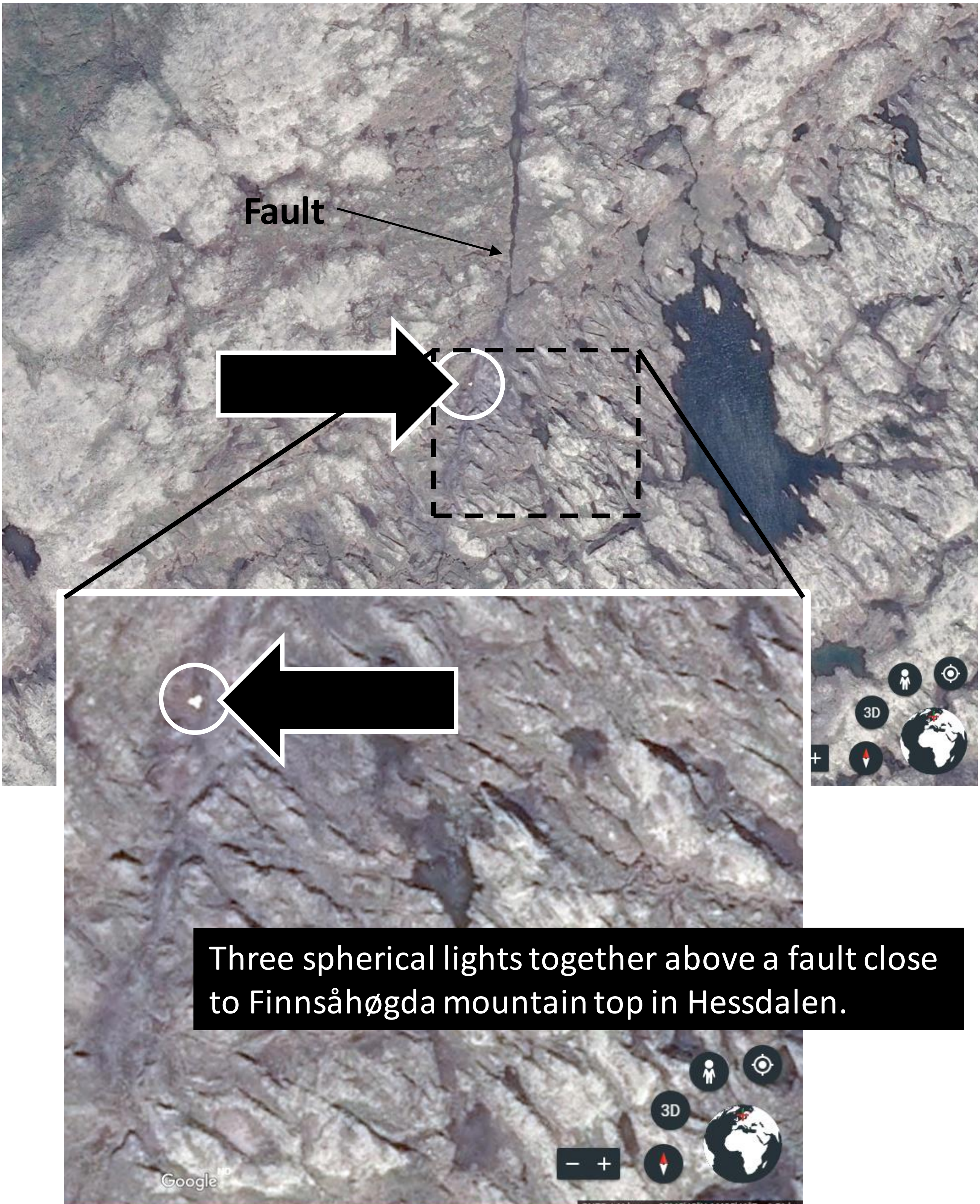
Bright triple round lights found here on Google map



Hessdalen light?

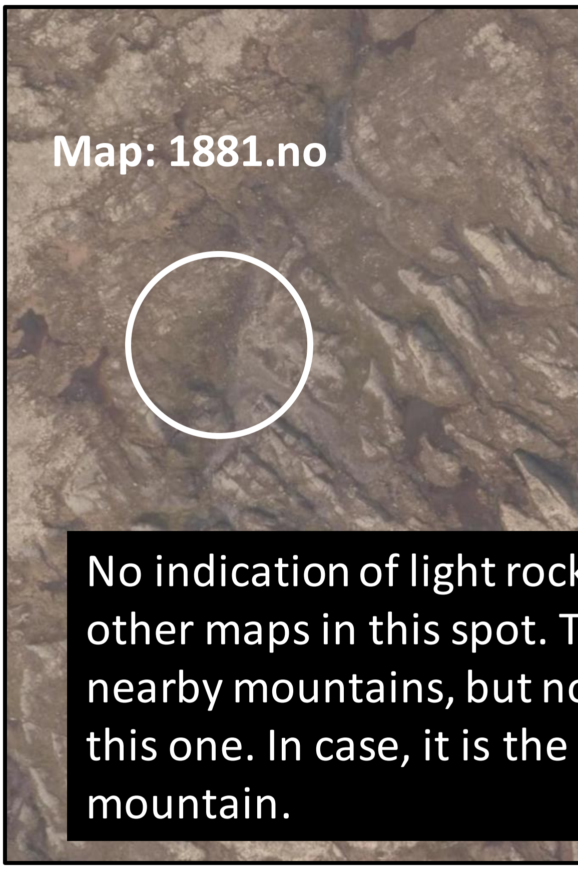


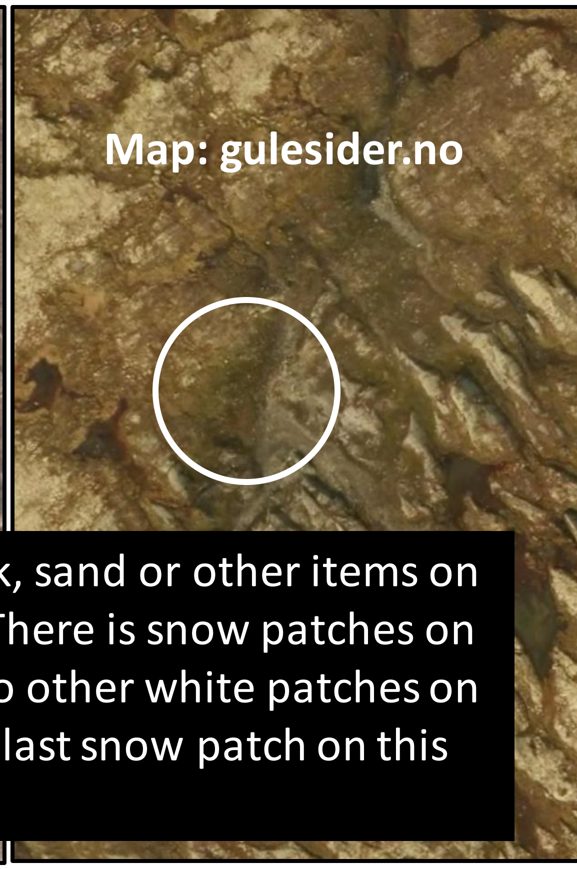
LINK: https://earth.google.com/web/@62.81195936,11.09472672,1022.62207999a,489.94821342d,35y,-0h,0t,0r



Three spherical lights together above a fault close to Finnsåhøgda mountain top in Hessdalen.

Compared to other maps





No indication of light rock, sand or other items on other maps in this spot. There is snow patches on nearby mountains, but no other white patches on this one. In case, it is the last snow patch on this mountain.

Appendix A

Norwegian geology and observations:

http://www.ngu.no
http://www.hessdalen.org

Battery theory:

http://www.dailymail.co.uk/

EQL theory:

http://srl.geoscienceworld.org/content/85/1/159

Lightnings:

https://en.wikipedia.org/wiki/Lightning

http://www.weatherimagery.com/blog/positive-negative-lightning/

http://www.sintef.no/sintef-energi/produkter-og-tjenester

Eartqake:

http://www.jordskjelv.no
http://news.nationalgeographic.com/news/2014/01/140106-earthquake-lights-earthquake-prediction-geology-science/