Aurora Field Guide

for Citizen Science

Acknowledgments

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1. 1 Welcome!

Welcome to all citizen scientists and scientists who observe and study the aurora!

We hope this document can be helpful during your valuable work and communication with each other.

We have also written a handbook with much more detailed information, which you can find **HERE**.

Photo Credit:
Eero Karvinen

1. 2 Explanation of the Guide

The aurora can appear in many shapes, colors and types of movement. Within these forms are auroral phenomena that have names (both scientific and common terms). Some of these optical features are not aurora, but can be visible with the aurora.

Here are some terms that can be used when a scientist is communicating about what they are studying or when a citizen scientist is communicating about what they see in their photos.

This is **NOT** intended as a formal aurora classification list, but as terms helpful for communication.

Marjan Spijkers

1. 3 What is the Aurora?

The aurora is the emission of light caused by collisions between energetic charged particles with atoms and molecules in the upper atmosphere, primarily in polar regions.

Read More

1.4 Aurora Colours & Altitudes

- The auroral emissions come from oxygen atoms and nitrogen molecules in our atmosphere
- Red and green light is from oxygen atoms
- Blue/purple light is from nitrogen molecules
- Red is at the highest altitude, followed by green and then blue/purple aurora
- Two different colours of aurora in the same place may appear as a different colour to your eye
- Aurora seen far in the distance may seem purely red, since it is so far away that you only see the colour of the top of the curtain

Photo Credit:
Les Ladbrook

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1.5 When to go out?

This is an elusive question with no easy answer, but checking the following can help you decide:

- Moon phase
- Aurora forecasts
- Kp index
- Solar wind Bz
- Ground magnetometer data
- Real-time online updates

Read More

Steele Hill/NASA

1.5 When to go out?

A substorm offers prime conditions for aurora viewing, with different types of auroras visible in each of its three phases.

Here's a brief overview with estimated durations:

1) **Growth (1 hour)**: e.g. quiet, active and SAR arcs, diffuse/veil, IPA, undulations, RAGDA

2) **Expansion (30 min)**: e.g. westward traveling surge, beads, curls, bands, spirals

3) **Recovery (1-3 hours)**: e.g. pulsating aurora/patches, STEVE

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Steele Hill/NASA

1.6 Taking Photos for Science

To use your photos, scientists need:

- Accurate time + date (universal time)
- GPS location
- What camera and lens were used for the photos
- What settings were used (ISO, aperture, exposure)
- RAW format is best
- Indicate what kind of feature you see and where it is in the photo

Tip: Take a photo of your camera time with your mobile. Then you can figure out the correct time later and your phone will give you a GPS location (if enabled in settings).
Also taking a camera photo of the www.time.is site and saving that with the photos from each observation session is helpful.

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Photo Credit:
Katie Herlingshaw

1.7 Camera Tips - Settings & General

- General settings depends on your camera, but a good start point for most cameras is ISO 3200, lowest aperture value (lens wide open), and exposure time 5-10 seconds - Adjust the values and see what happens
- Turn on 2 second timer to minimize shaking
- Tape over the timer light
- Wipe your lens regularly if you have condensation or frost
- If your camera is ISO invariant, use base ISO and adjust exposure time to avoid overexposure and capture more details

Read More

1.8 Camera Tips - How to Focus

- Go into manual mode and enable manual focus (MF)
- Move the focus wheel to the infinity symbol
- Find a distant bright point of light (e.g. streetlight or star)
- Zoom in as far as possible
- Move the focus wheel back and forward until the point light is smallest
- Check regularly if your camera is still in focus by zooming in on stars in your photos

1.9 Field Checklist – What to Take

- Camera
- Tripod
- Extra batteries
- Extra SD cards
- Headlamp
- Remote shutter
- Wildlife protection/defense
- Microfiber cloth
- Cell phone + booster
- Take a friend or tell someone where you will be.
- Share your location on your cell phone with someone.
- Full tank of fuel
- Reflective clothing
- Food and water
- WINTER – Heat packs, thin gloves, mittens, warm hat, neck warmer, boots and thick socks, sleeping bag

Read More

2. The Colours of the Aurora

2.1 Green Aurora

Photo Credit:
Matti Helin

Green aurora occurs between 90-160 km above the Earth and is caused by glowing atomic oxygen.

2.2 Red Aurora

Red aurora occurs above 160 km and is caused by glowing oxygen atoms.

Photo Credit:
Colin Legg

2.3 Blue (Purple, Pink) Aurora

Blue aurora is caused by glowing nitrogen molecules above 90 km. It is blue in the spectrum, but can appear purple or pink.

2.3 Blue (Purple, Pink) Aurora

The pink fringe that occurs below an altitude of 100 km during intense aurora is also spectrum blue and caused by glowing nitrogen.

2.4 Sunlit Top

The sunlit top occurs just after sunset or before sunrise. Nitrogen molecules have been transported higher up in altitude and emit a blue color.

2.4 Sunlit Top

Photo Credit:
Emma Bruus

2.5 Black Aurora

Black aurora is an absence of aurora within diffuse emission.

2.5 Black Aurora

2.6 Great Red Aurora

A great red aurora occurs during an intense magnetic storm. The sky lights up a diffuse blood red, casting a red glow on the land, often lasting for less than a half hour.

Photo Credit:
Colin Legg

2.7 Dayside Aurora

Dayside aurora is viewed in the polar regions in places where it can be dark during the daytime hours. It is usually more red than green since the particles that cause it have less energy than those causing nighttime aurora.

Photo Credit:
Mikko Syrjäsuo

3. Discrete Aurora

3.1 Quiet Arc

Photo Credit:
Minna Glad

A quiet arc is a single straight ribbon with a sharp lower edge.

3.1 Quiet Arc

Photo Credit: Minna Glad

Photo Credit: Eero Karvinen

3.2 Active Arc

An active arc is a restless long ribbon with a sharp lower edge. When you are directly under the aurora oval, you may see several ribbons running parallel.

Photo Credit: Vincent Ledvina

3.2 Active Arc

Photo Credit:
Eero Karvinen

Active arcs often have some kind of structuring inside of the arc.

3.3 Rays, “Pillars”

A ray or a pillar is a bright vertical streak that displays the magnetic field line.

Photo Credit:
Les Ladbrook

3.3 Rays, “Pillars”

A ray or pillar appears bright to the naked eye and can last a while - 10 minutes or so. Sometimes more than one appear at a time.

Photo Credit:
Matti Helin

Photo Credit:
Eero Karvinen

A rayed arc is a tall auroral structure with a long series of rays that stretch up the magnetic field line across the arc.

3.4 Rayed Arc, “Curtain”

Photo Credit:
Matti Helin

Photo Credit:
Colin Legg

Photo Credit:
Eero Karvinen

3.5 Bands

Bands are the twisting random forms with a bright lower edge which usually occur after the arc has broken up.

Photo Credit:
Donna Lach

3.5 Bands

Photo Credit:
Eero Karvinen

3.6 Beads

Beads are evenly spaced bright features in the auroral arc that occur just prior to substorm onset.

© Maxime Grandin

3.6 Beads

Photo Credit: Matti Helin

3.7 Curls

Curls can develop from beads, when the arc is twisted counterclockwise (clockwise) in the northern (southern) hemisphere.
You must be below the arc to see these structures.

© Minna Glad

3.8 Folds

Folds are loops that develop from a straight arc. These are bigger than curls.

© Maxime Grandin

3.9 Spiral, “Cinnamon Roll”

A spiral is a vortex shape that can develop from folds. Viewed up in the northern (southern) hemisphere spirals wind (counter) clockwise. This is the opposite direction to curls. Spirals often occur in periodic chains.

Photo Credit: Vincent Ledvina

3.9 Spiral

A “chain of spirals” or Vortex Street is when more that one appear along an auroral band in a series.

3.10 Corona

A corona is the appearance of a crown above you during intense aurora, converging at the zenith (directly overhead).

Marjan Spijkers

3.10 Corona

3.11 Westward Traveling Surge

A westward traveling surge occurs at substorm onset, and is seen as a bulge in the arc on the poleward side, like a whip.

© Maxime Grandin

3.11 Westward Traveling Surge

Photo Credit:
Dave Knudsen

3.12 Enhanced Aurora

Enhanced aurora is a particularly thick and well-defined lower edge of the aurora band that sometimes occurs during substorm onset.

© Minna Glad

3.12 Enhanced Aurora

4. Diffuse Aurora

Photo Credit:
Donna Lach

4.1 Diffuse, “Veil”

Diffuse aurora is featureless aurora without any clear structures. Also known as ‘Veil’ aurora.

© Maxime Grandin

4.1 Diffuse, “Veil”

Photo Credit:
Matti Helin

© Maxime Grandin

4.2 Omega Band

Omega bands are forms at the edge of the diffuse aurora that look like the Greek letter Omega (Ω), with the open end poleward. They are most often seen during the morning sector (after midnight).

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4.2 Omega Band

Photo Credit: Donna Lach

4.3 Pulsating Aurora/Patches

Pulsating aurora is irregular shapes of diffuse aurora that turn dim and bright. It occurs after substorm onset, during the recovery phase. A long exposure can reveal much more colour.

4.3 Pulsating Aurora/Patches

4.4 Giant Undulations

Giant undulations are seen as a wavy edge on the equatorward side of the diffuse aurora, usually before midnight. They are large structures.

4.4 Giant Undulations

Dunes are finger-like stripes in the diffuse aurora. If you watch dunes over time, the diffuse aurora seems to flow like water over them.

4.5 Dunes

Photo Credit:
Colin Legg

Photo Credit:
Matti Helin

4.6 Isolated Proton Aurora (IPA)

IPA blobs or arcs appear on the equatorward side of the main aurora and are usually green.

Photo Credit:
Eero Karvinen

Photo Credit:
Eero Karvinen

4.7 Continuum

A continuum looks almost white to the eye, but is actually made up of all the different colours that combine together to create the off-white appearance.

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Marjan Spijkers

4.7 Continuum

Photo Credit:
Les Ladbrook

Photo Credit:
Sophie Cordon

4.8 Fragments

Fragments are similar to streaks, and are most often seen on the poleward side of the oval. Their orientation is perpendicular to the magnetic field direction.

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4.8 Fragments

Photo Credit:
Sophie Cordon

5. Sub-Auroral Optical Emissions

5.1 STEVE (Strong Thermal Emission Velocity Enhancement)

STEVE is a purple ribbon that can remain in the sky for a long time.

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5.1 STEVE

Photo Credit:
Donna Lach

5.2 Picket Fence, “Pickets”

The Picket Fence is the series of vertical bright green stripes adjacent to or below STEVE that are lined up with the magnetic field.

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5.3 Streaks

Photo Credit:
John Andersen

Streaks are the horizontal green patches below the STEVE's pickets, and are perpendicular to the magnetic field direction.

5.3 Streaks

Photo Credit:
Donna Lach

5.4 SAR (Stable Auroral Red) Arc
A SAR arc is red and equator ward of the main aurora. It is usually faint and not visible to the naked eye. During intense aurora storms it can be much brighter.
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5.4 SAR Arc

Photo Credit:
Matti Helin

Photo Credit:
Les Ladbrook

5.5 RAGDA (Red Arc with Green Diffuse Aurora)

RAGDA (red arc with green diffuse aurora) is a 2-colour combination of diffuse aurora with a long lifetime.
Read more about RAGDA.

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Photo Credit:
Donna Lach

5.5 RAGDA
Red Arc
Green Diffuse Aurora
© Minna Glad

5.6 SAMPS (Sub Auroral Morning Proton Spots)

SAMPS appear during the morning sector on the equatorward side of the aurora, usually a long distance from the main aurora. They are diffuse green and stable emissions with an extended lifetime.

Photo Credit:
Eero Karvinen

6. The Reality of Observations

- What you see on your camera will look different to what you see with your eyes! Your eyes are not as sensitive at seeing the colours in darkness as the camera and the white balance setting on the camera can change the apparent colour in the image.
- What you observe will vary depending on your geomagnetic latitude (polar, auroral, sub-auroral, and low latitude). For example, at low latitudes you seldom see the green as it is below your horizon. However you will see the sub-auroral features more often.
- We hope our guide will help you figure out what aurora you saw, but often in reality the aurora can be complicated with a mixture of types.

6.1 Mixtures of Different Types of Aurora

Photo Credit:
Matti Helin

In reality you will often have a mixture of different features in one picture.

6.1 Mixtures of Different Types of Aurora

Photo Credit:
Les Ladbrook

Sometimes the colours of the aurora mix, so that “new” colours are generated

6.2 Global Emissions: Airglow

Airglow is not aurora. It is a very faint colored light in the sky, often appearing as stripes. It occurs at all latitudes. Read more about airglow.

7. Aurora Reporting Websites

For scientists to use your images in research, you need to report them on an online aurora database.

You can use Skywarden or Aurorasaurus

Thank you for contributing to scientific discovery!

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Happy Aurora Hunting!
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