Ground based observations of noctilucent cloud brightness and frequency

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Link to video : *https://www.youtube.com/watch?v=avrwhOMHvpA*

What are noctilucent clouds?

Noctilucent clouds

Figure 1: Image taken by Tanel Kindsigo from Tartu, Estonia on 2020-07-08. Sourced from *NLCNET*.

Noctilucent clouds

Figure 2: Image taken by Menno van der Haven from the Netherlands on 2020-06-20. Sourced from *NLCNET*.

Noctilucent clouds

Figure 3: Image taken by Alan C. Tough from Scotland on 2019-07-13. Sourced from *NLCNET*.

Noctilucent clouds

Noctilucent or *night-shining* clouds (NLCs) are a stunning phenomenon in the twilight sky. Formed by ice crystals in the mesosphere, they appear as shimmering, delicate waves in the darkening sky with the sun below the horizon.

Their counterpart, *polar mesospheric* clouds (PMCs) represent the same phenomenon when observed from above by satellites.

First observations of NLCs

NLCs were first observed in 1885, two years after the eruption of Krakatoa.

This seems to mark a very abrupt increase in NLCs. Their frequency dropped gradually into until 1900 and picked up after 1950 (Thomas & Olivero, 2001).

NLC formation

- Moisture
  - Volcanism $+$
  - Tropospheric water vapour (Hadley cells) $+$
  - Methane oxidation $+$
  - Solar flux (photodissociation) $-$
- Temperature
  - Solar flux $-$
  - Ozone $-$
  - CO_2 $+$

Solar flux : Lyman-α

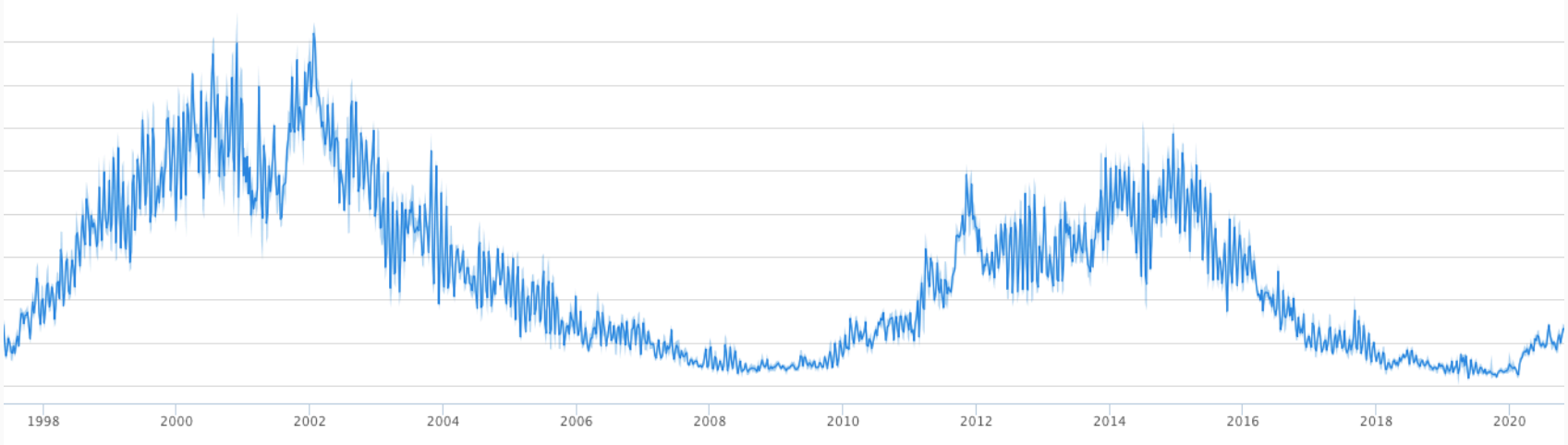


Figure 4: Solar Lyman-α irradiance from LISIRD, LASP.

Solar irradiance peaks every 11 years, with the last maximum at 2014.

There is an anticorrelation between solar Lyman-α and NLC activity, with a time lag of around 1-2 years (Gadsden, 1998).

What is AIM?

Aeronomy of Ice in the Mesosphere satellite mission

The Aeronomy of Ice in the Mesosphere (*AIM*) satellite mission, launched in 2007, is dedicated to studying PMCs.

- Solar Occultation For Ice Experiment (*SOFIE*)
- Cloud Imaging and Particle Size (*CIPS*) experiment
- Cosmic Dust Experiment (*CDE*)

Aeronomy of Ice in the Mesosphere satellite mission

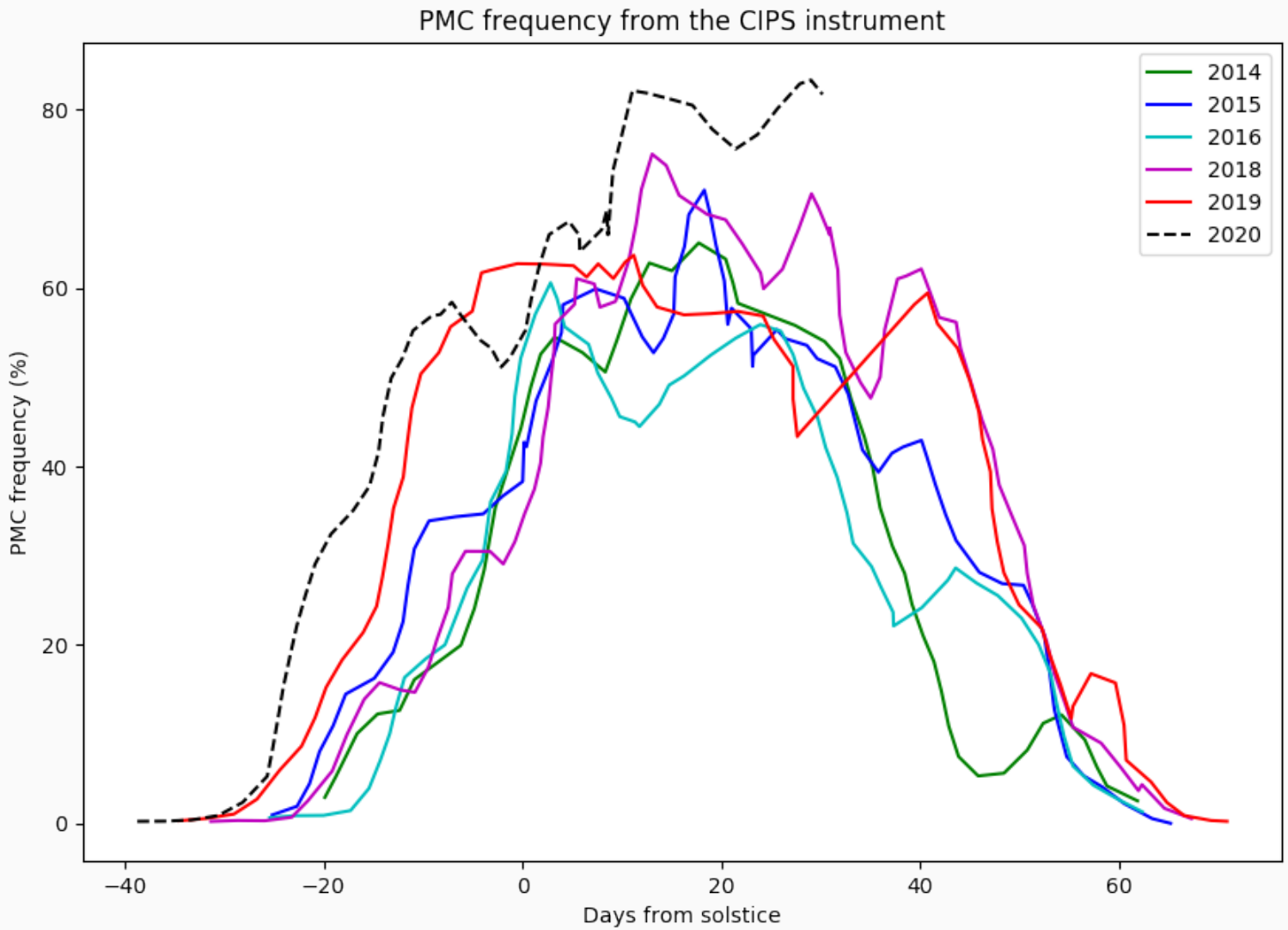


Figure 5: PMC frequency from CIPS at 80°N.

What is NLCNET?

Noctilucent Cloud Observing Network

The Noctilucent Cloud Observing Network (*NLCNET*) is an internet forum where observers report sightings of NLCs, along with pictures.

Each record includes the date and time of the sighting, the location of the sighting, and the approximate brightness of the NLC.

Data from 2014 onwards include negative reports.

Noctilucent Cloud Observing Network

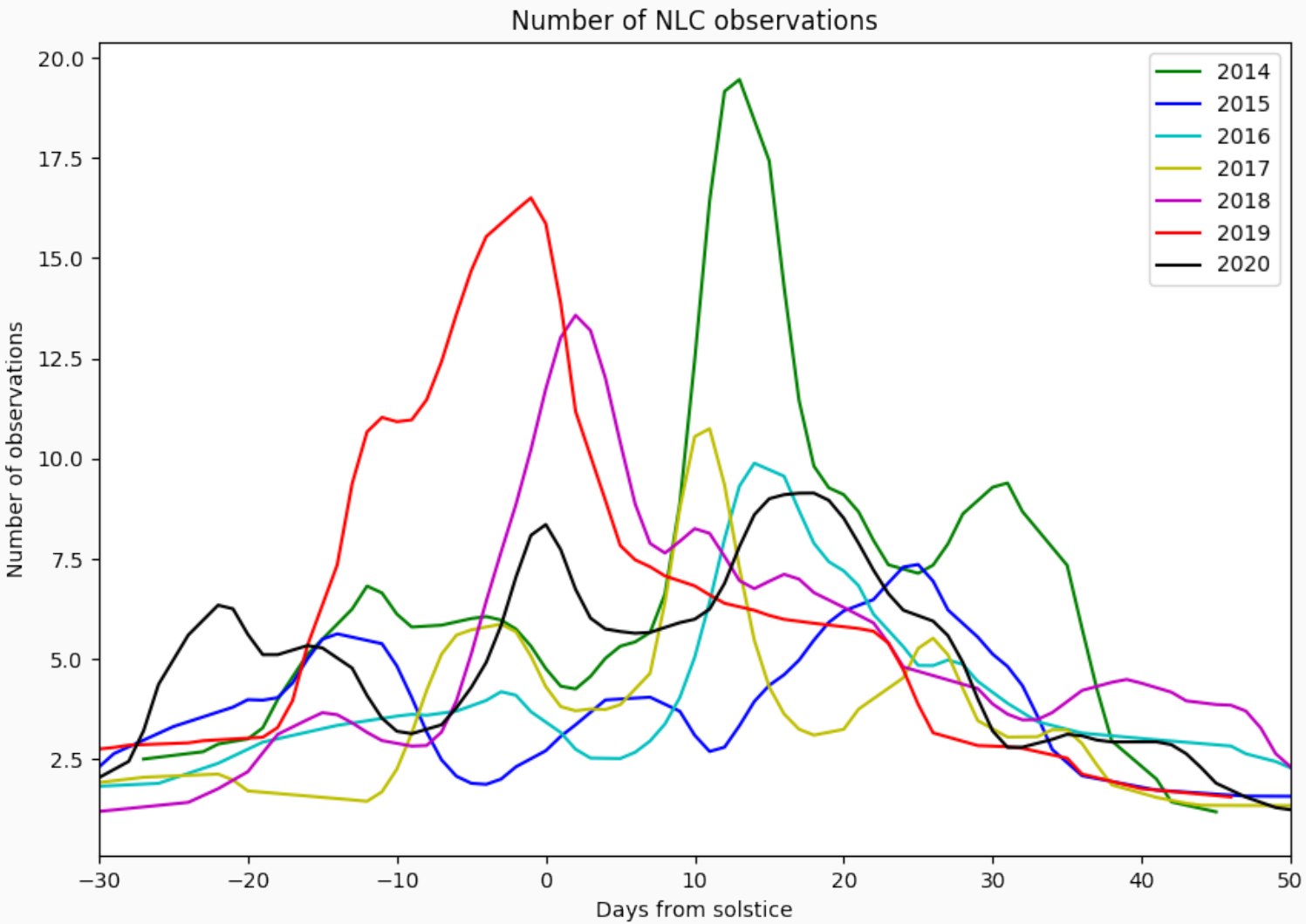


Figure 6: Number of observations per day, from *NLCNET*.

Quantifying NLC brightness and frequency

Quantifying NLC brightness and frequency

Brightness

$$\beta = \frac{1}{n + n^-} \sum_i b_i.$$

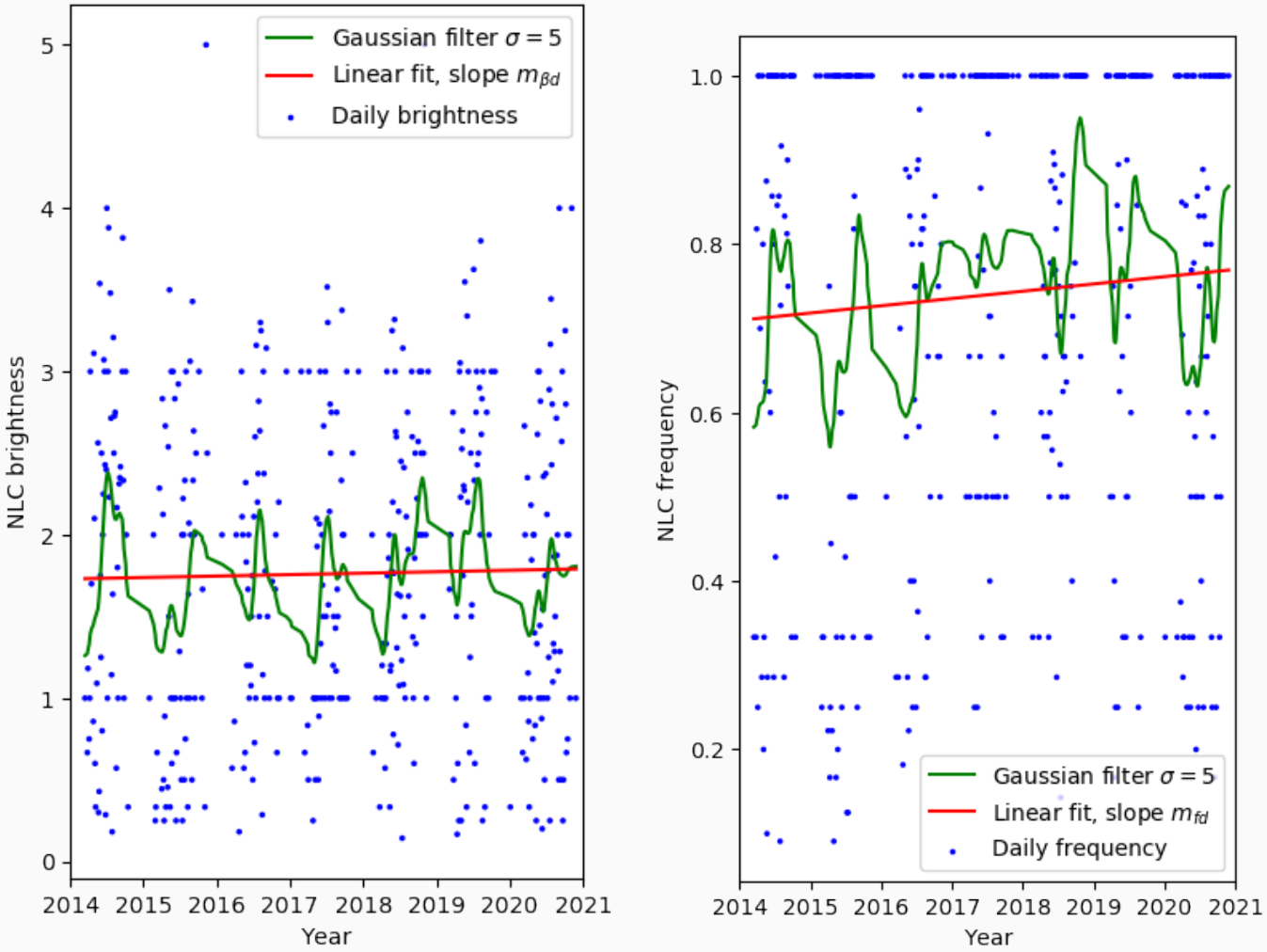
Frequency

$$f = \frac{n}{n + n^-}.$$

$$\begin{aligned} n &= \text{Number of positive reports.} \\ n^- &= \text{Number of negative reports.} \end{aligned}$$

Calculated over the span of a *single day* or a *single month*.

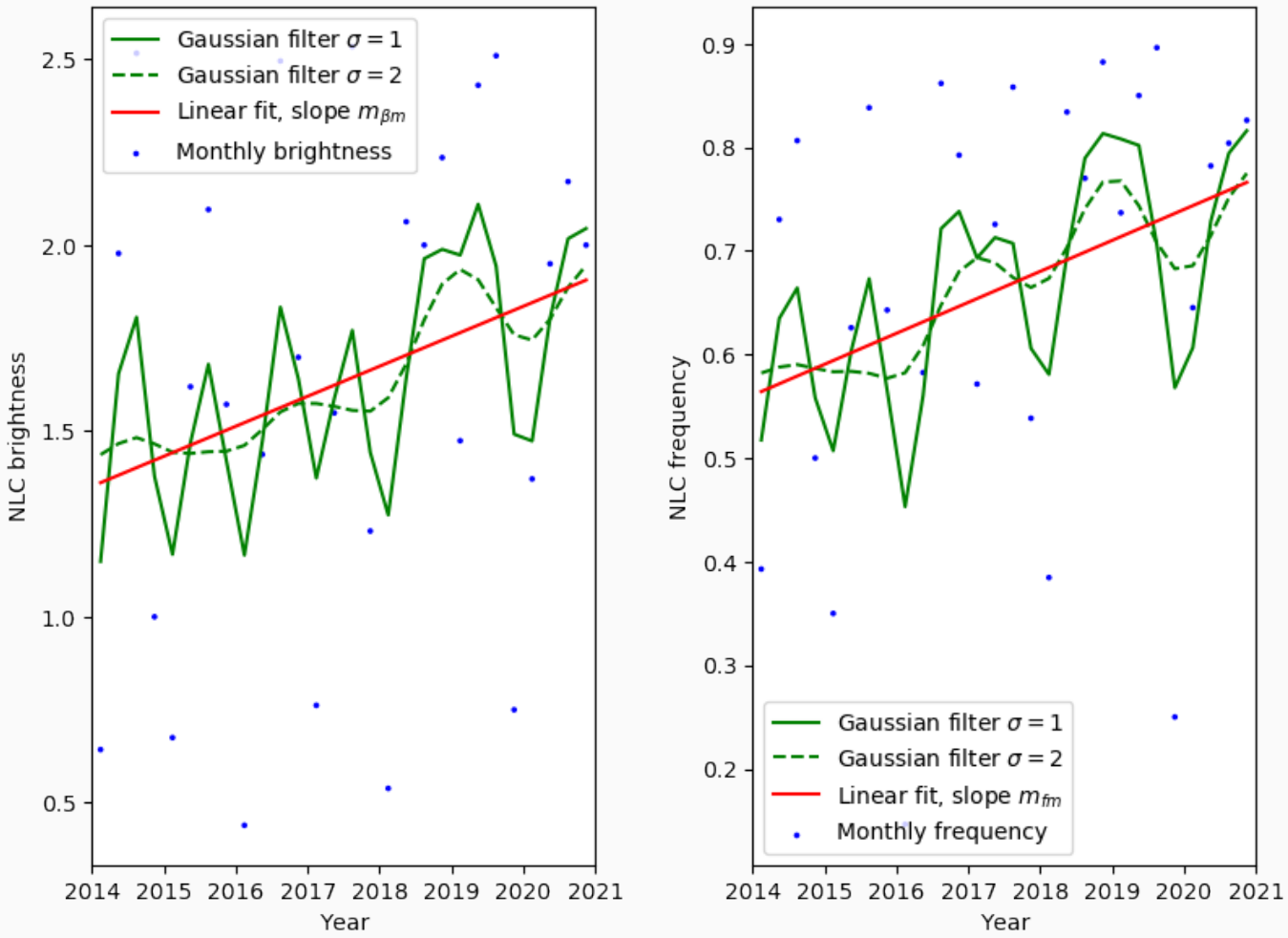
Daily trends



(a) β_d (b) f_d

Figure 7: Daily trends in brightness and frequency.

Monthly trends



(a) β_m (b) f_m

Figure 8: Monthly trends in brightness and frequency.

Conclusions

Conclusions

NLC frequency and brightness has increased in the 50°N to 60°N latitude range since 2014.

NLCNET data is consistent with data from AIM and past studies.

The influence of the solar cycle is hinted at, but further analysis requires NLCNET data over longer time periods.

The role of climate change (CO_2 and methane) is unclear, and remains a promising avenue of research.