Improving nowcast capability through automatic processing of combined ground-based measurements

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Motivation

In addition to daily or hourly space weather forecast, the nowcast at the ground/ionospheric level is needed for **last-minutes high accuracy warning**. Such nowcast requires automated evaluation of the current condition, which will be improved by combining different types of data.

To combine **auroral image** and **magnetometer data**, we propose:
(1) "**Local all-sky index**" that characterizes auroral strength as a number or a set of numbers (depends on the camera and location).
(2) "**GIC proxy**" by two methods: (a) dB/dt method (gradient of peak-to-peak variation), and (b) sd(B) method (standard deviation).

When we surveyed the strongest auroras during 2017, the peak of sd(B) is few minutes before the peak of dB/dt, which matches with the peak of all-sky index. This is not surprizing because fluctuations often arrives before the large change in the magnetic field. If this is true, it opens up a possibility of few-minutes forecast.

Work in progress: all-sky index and GIC proxy

Non-specialist must easily understand (Keogram is still difficult to digest and do not cover 360°) ⇒ must be line plot (time-series)

GIC proxy: compare (a) peak-to-peak dB/dt & (b) sd(B).

Local All-Sky indices from jpg images: ⇒ simple expert system is ok

(a) for each pixel: change RGB to HSL ⇒ L is virtual photometers

(b) different **"nowcast" indices** for different purposes, e.g., local GIC, GIC in south, and satellite protection.

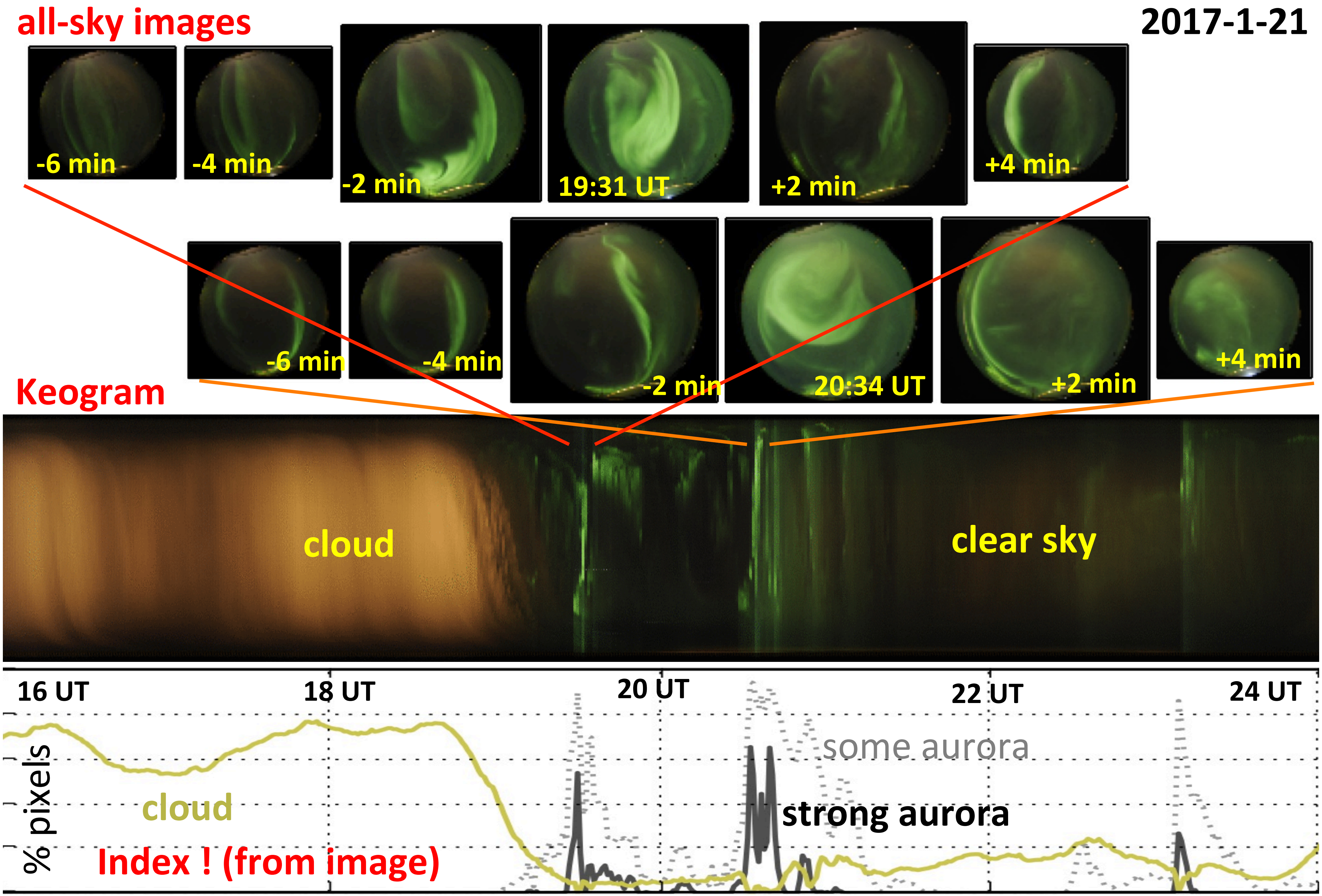
(b1) for discrete aurora: $\sum_{strong}$ exp(intensity) or $\sum_{strong}$ intensity ($\sum_{strong}$ integrates only strongest pixels)

(b2) for diffuse aurora: $\sum_{all}$ [1 or 0] (depending on (a))

(c) criterion is different between different camera and location

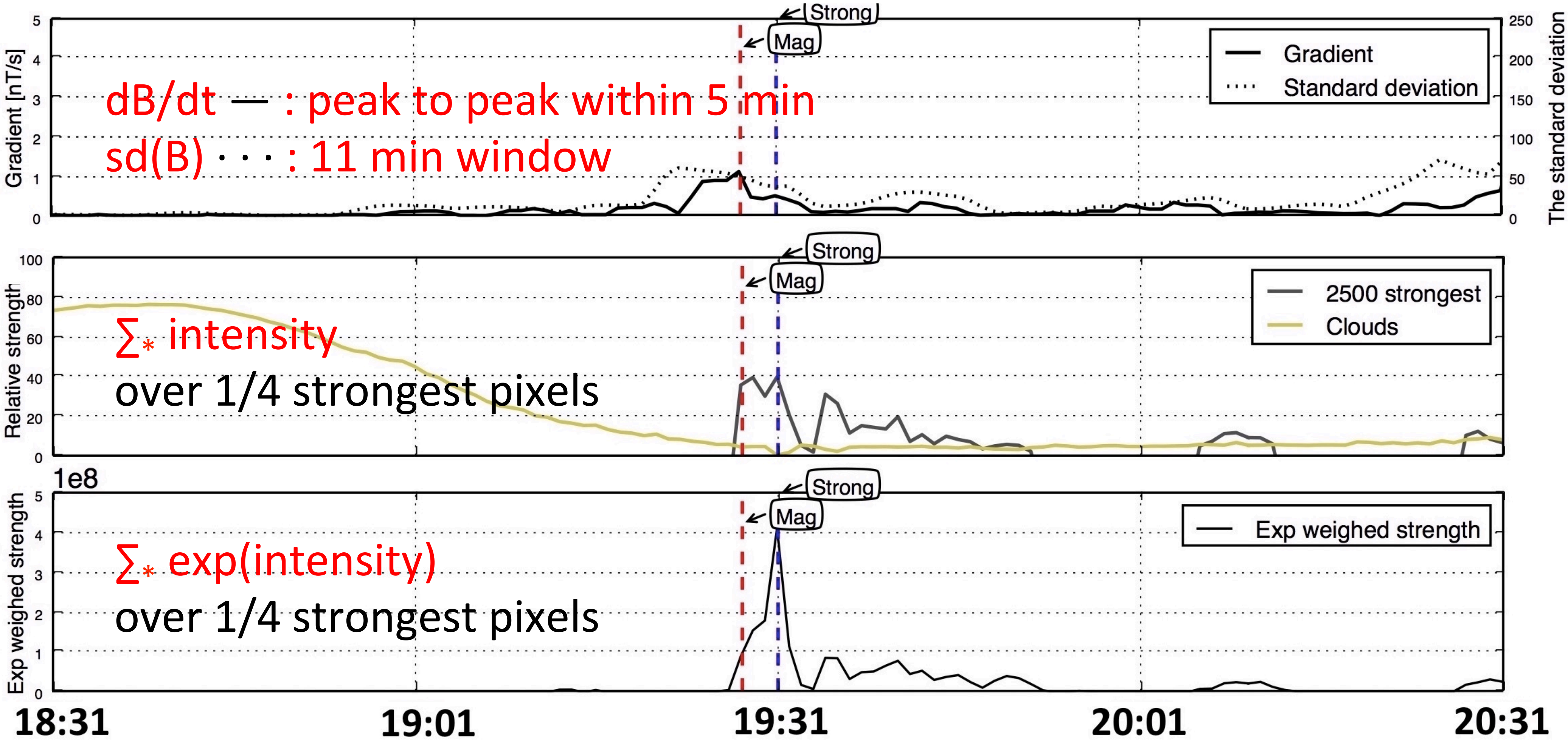
Note when combining: adding many line plots is no longer digestive.

A test site: http://www2.irf.se/Observatory/?link[Magnetometers]=Data
and http://www2.irf.se/maggraphs/aurora_detect.php



all-sky images
2017-1-21
-6 min
-4 min
-2 min
19:31 UT
+2 min
+4 min
-6 min
-4 min
-2 min
20:34 UT
+2 min
+4 min
Keogram
cloud
clear sky
16 UT
18 UT
20 UT
22 UT
24 UT
% pixels
some aurora
cloud
strong aurora
Index ! (from image)

Real-time display of GIC proxy & all-sky indices



Peak defined by dB/dt (GIC proxy)

Peak defined by strong aurora

2017-1-21

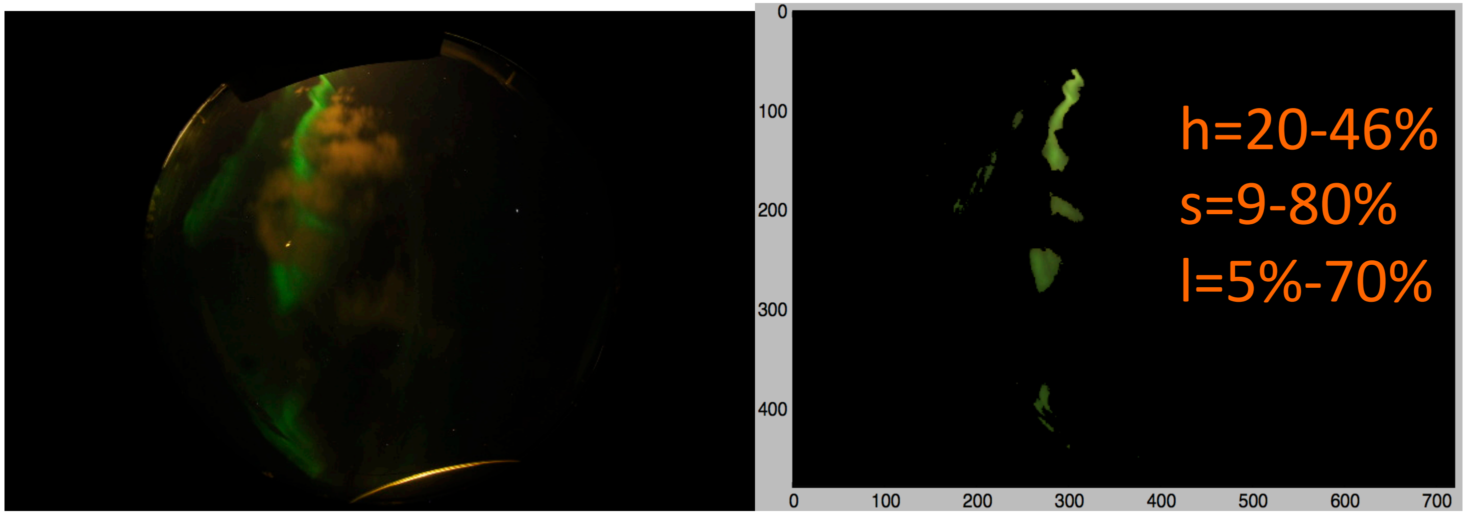
At moment we use criterions of (1) aurora: h=18-46%, s=8-15%, l=10-80%

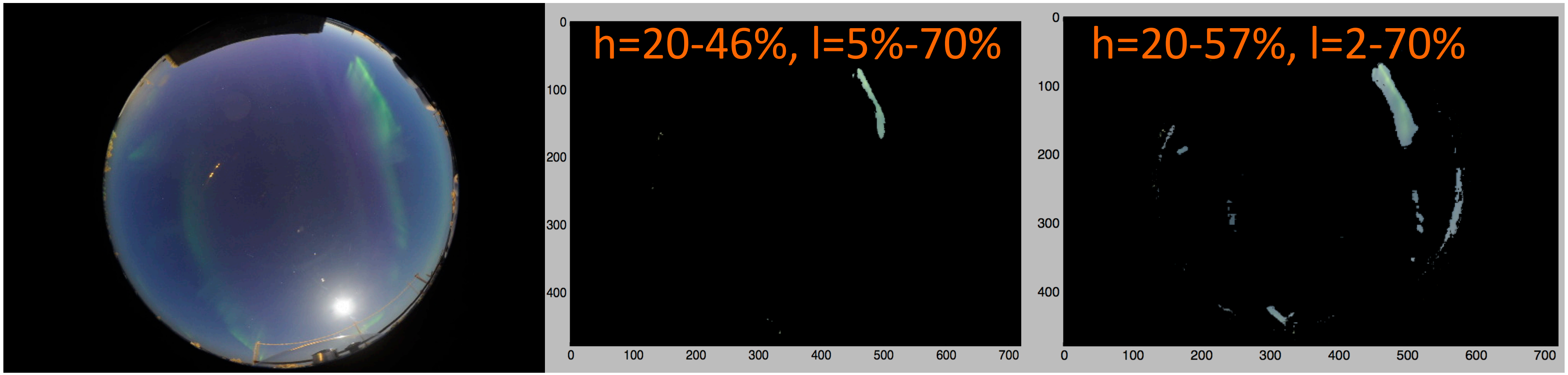
(2) **strong: h=20-46%, s=8-20%, l=20-80%**

(3) cloud: h=0-16%, s=10-80%, l=15-80%

cf. moon: l>80%, sky: h=60-80%

But this might not yet optimum.





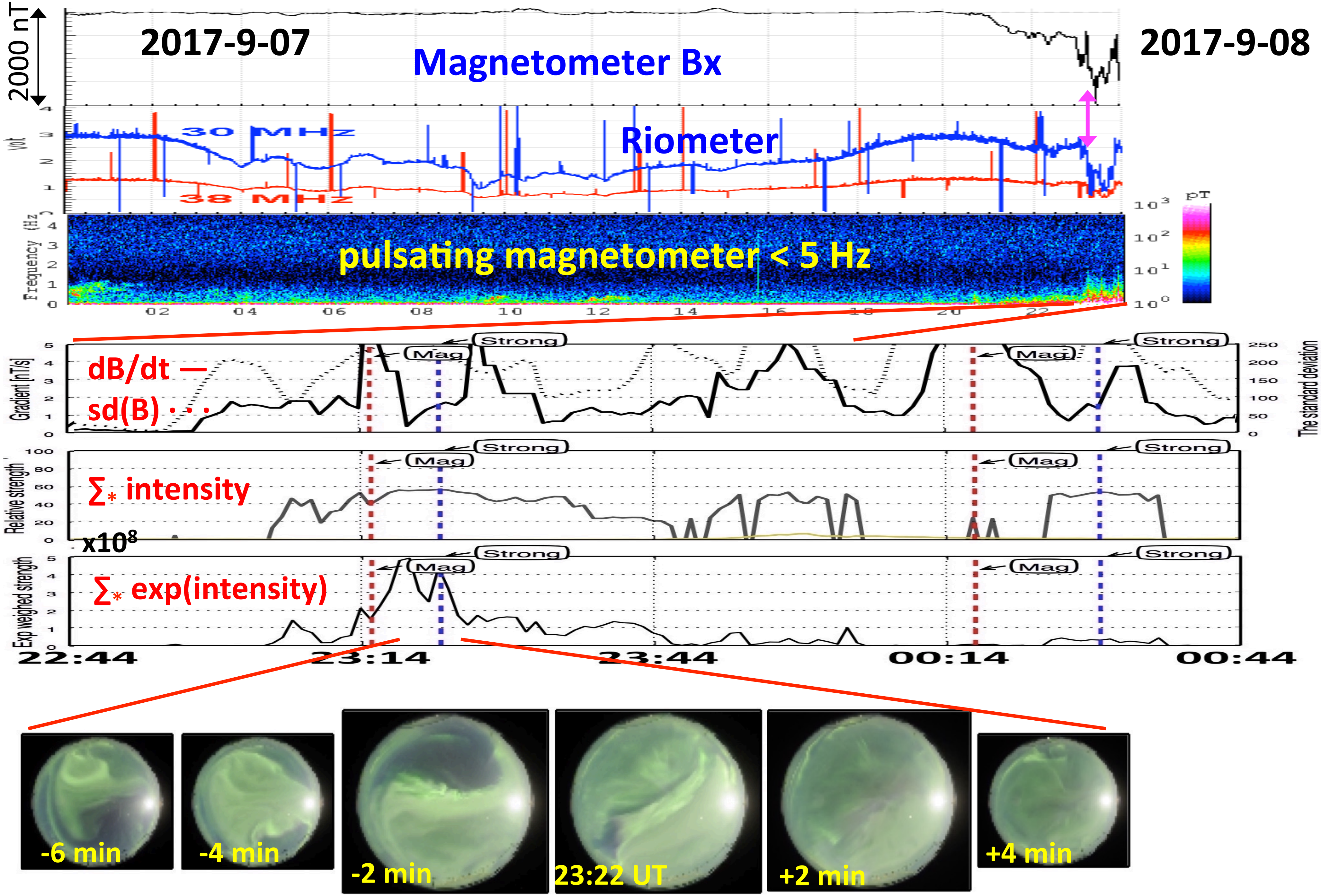
Current status, and Problems to solve

GIC proxy: Both dB/dt and sd(B) are **useful**
AI-1: Find out relation between dB/dt and actual induction current
AI-2: Use pulsation magnetometer data to improve GIC proxy
AI-3: Can sd(B) be used as precursor for large dB/dt or large GIC?
AI-4: Find out best window time for prediction

All-sky indices: **Useful** (even with cloud!) and consistent with GIC proxy!
AI-5: Define optimum HLS criteria of "aurora pixels" for different cameras
AI-6: Define optimum HLS criteria of "cloud" without city light reflection
AI-7: Define optimum integration scheme of auroral strength to obtain "indices" for different aurora (discrete, diffuse, surge, pulsation, omega band)
AI-8: Find out relation between these indices and GIC proxy and GIC
AI-9: Use riometer and ionosonde data to improve these indices

cf. 6-10 September 2017 space weather event

2017-9-07 = first day of camera operation



2000 nT
2017-9-07
Magnetometer Bx
2017-9-08
Riometer
30 MHz
38 MHz
Volt
Frequency (Hz)
pulsating magnetometer < 5 Hz
pT
02
04
06
08
10
12
14
16
18
20
22
dB/dt —
sd(B) · · ·
Gradient [nT/s]
The standard deviation
Mag
Strong
$\sum_*$ intensity
Relative strength
x10^8
$\sum_*$ exp(intensity)
Exp weighed strength
22:44
23:14
23:44
00:14
00:44
-6 min
-4 min
-2 min
23:22 UT
+2 min
+4 min