Automatic flare recognition and filament eruption detection at Kanzelhöhe Observatory

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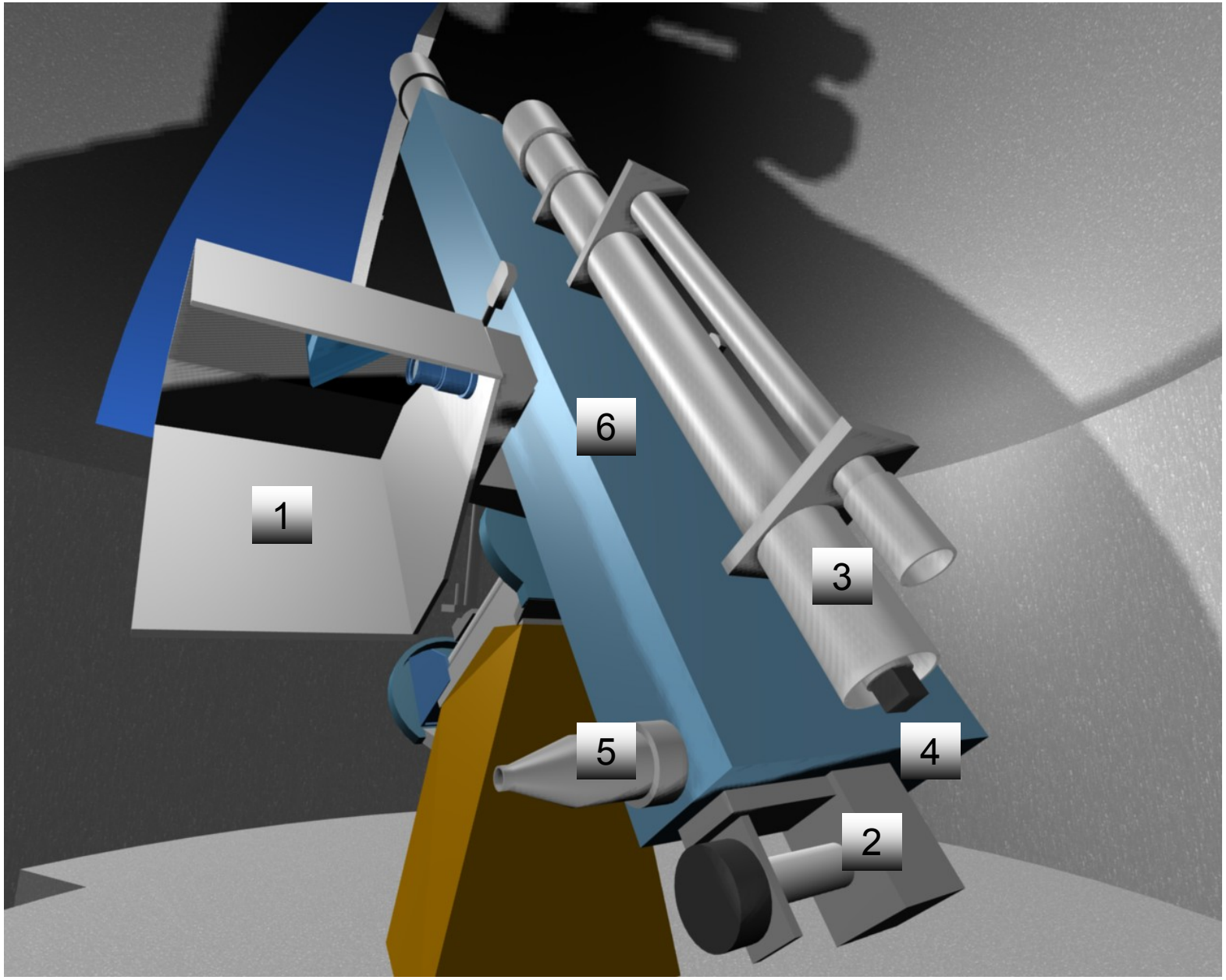
Gerlitzen (1910m)
Observatory (1524m)
Kanzelhöhe
Tschlein
Treffen am Ossiacher See
Seespitz
Ossiacher See (500m)
Oswaldiberg
94
Villach
83
A10
A2
Bundesstr.
Triester Str.
Bachstr.
Seebacher Allee
Image © 2012 TerraMetrics
Image © 2012 GeoEye
© 2012 Google
©2010 Google
Bildaufnahmedatum: 10/10/2006
2006
46°37'58,49" N 13°51'09,46" O Höhe 570 m
Sichthöhe 3,73 km

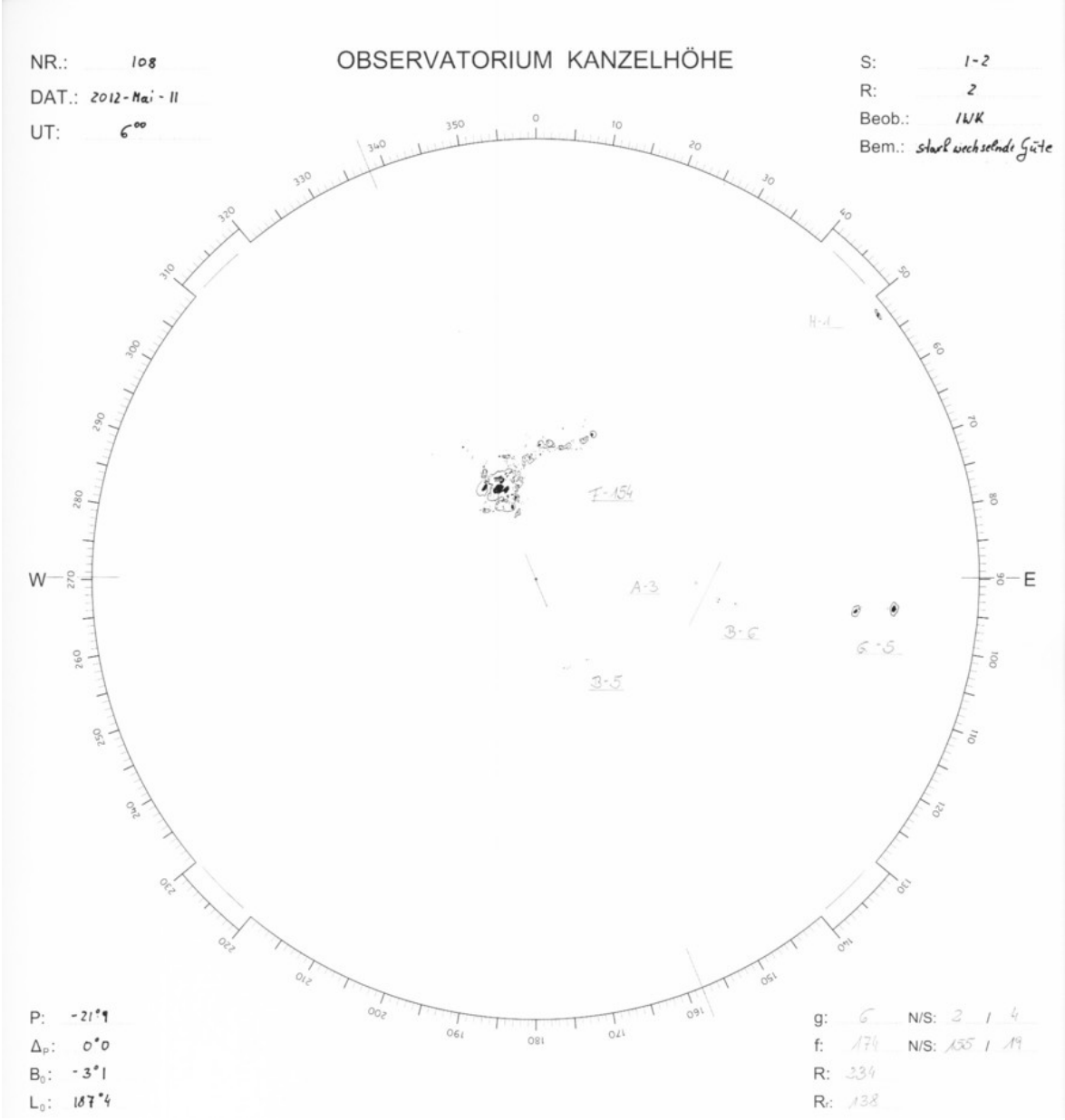
The Patrol Instrument at KSO

1. Drawing Device
2. Hα Telescope
3. Whitelight Telescope
4. CaIIK Telescope
5. Hα Eyepiece
6. Guiding Telescope



Sunspot Drawing

A drawing is produced every day (since 1944)
From the drawing the Sunspot Number is derived and sent to the SIDC, for calculation of the International Sunspot Number (ISN)



2012-05-11

H-Alpha Telescope

Focal length: 2000 mm
Diameter: 100 mm

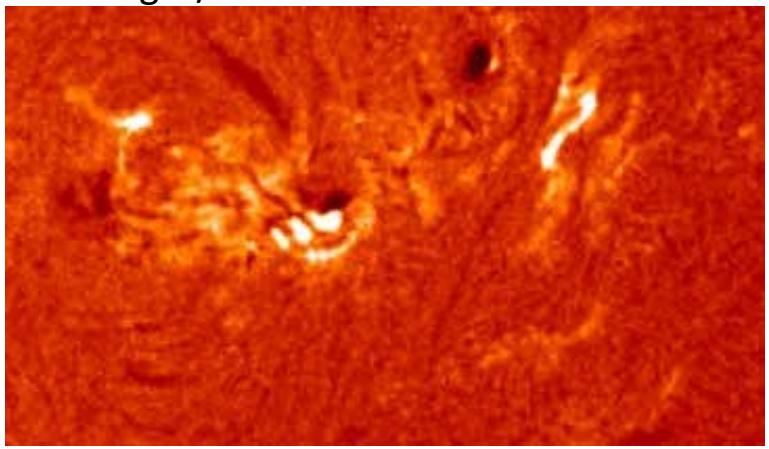
Zeiss-Lyot Filter:
FWHM 0.7 Å

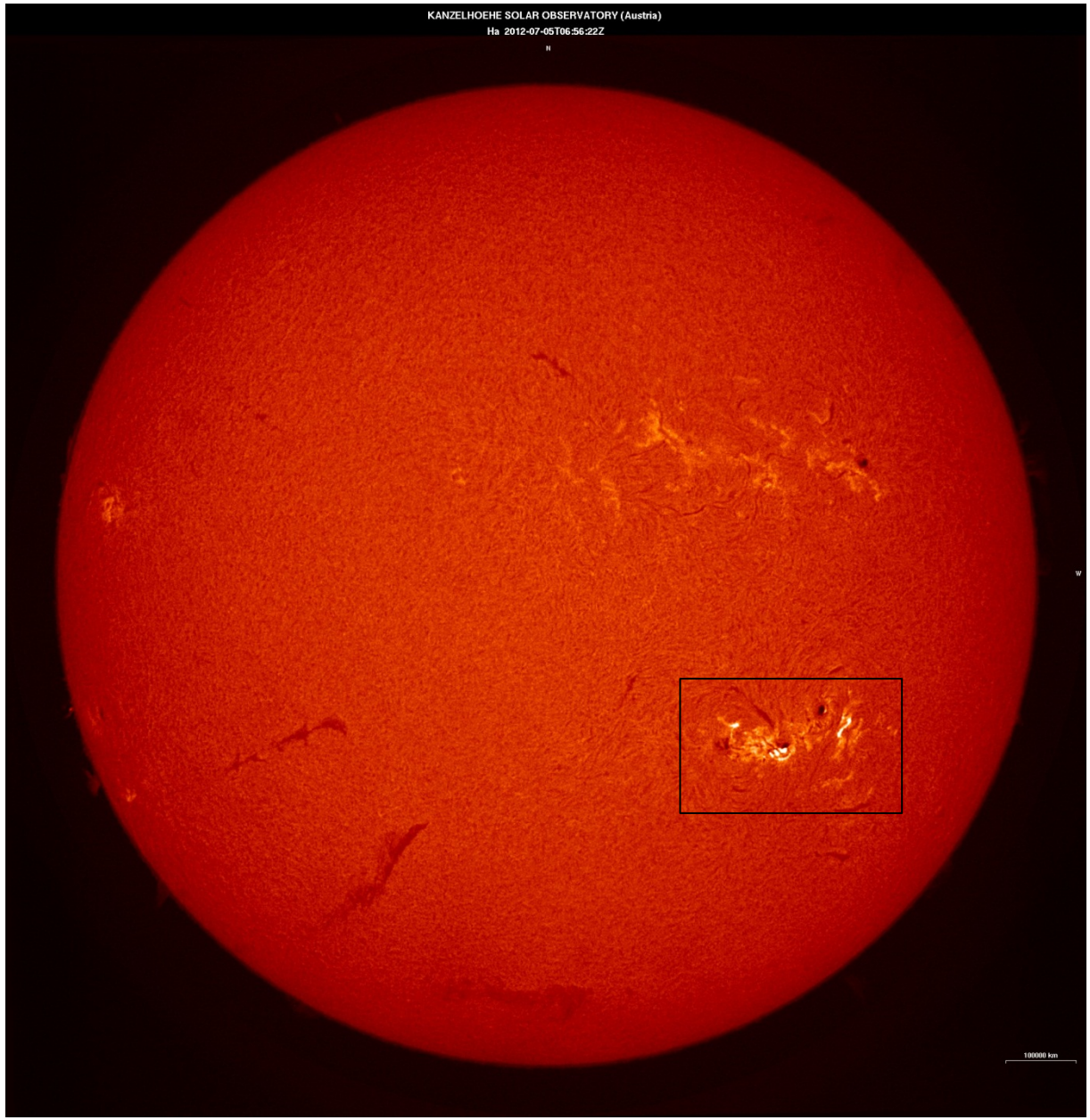
4 MegaPixel 12 bit (patrol)

1 MegaPixel 10 bit (guiding)

1 Eyepiece

10 images/minute



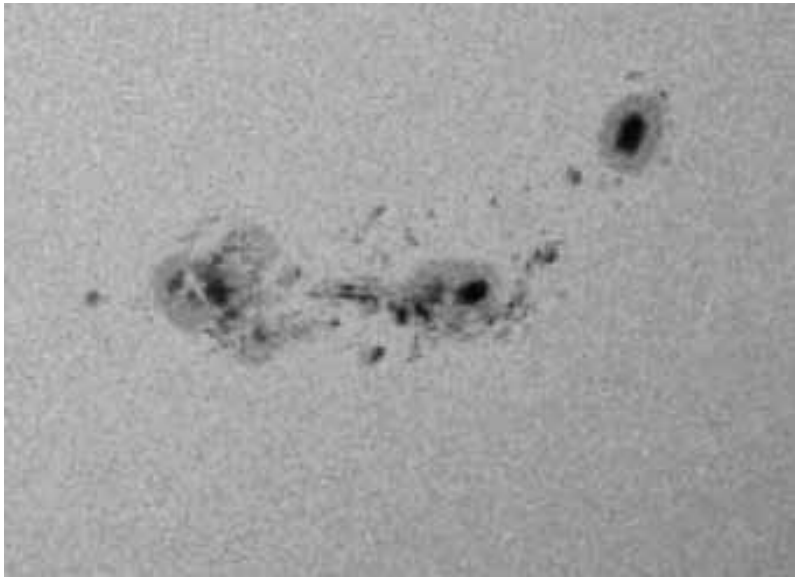


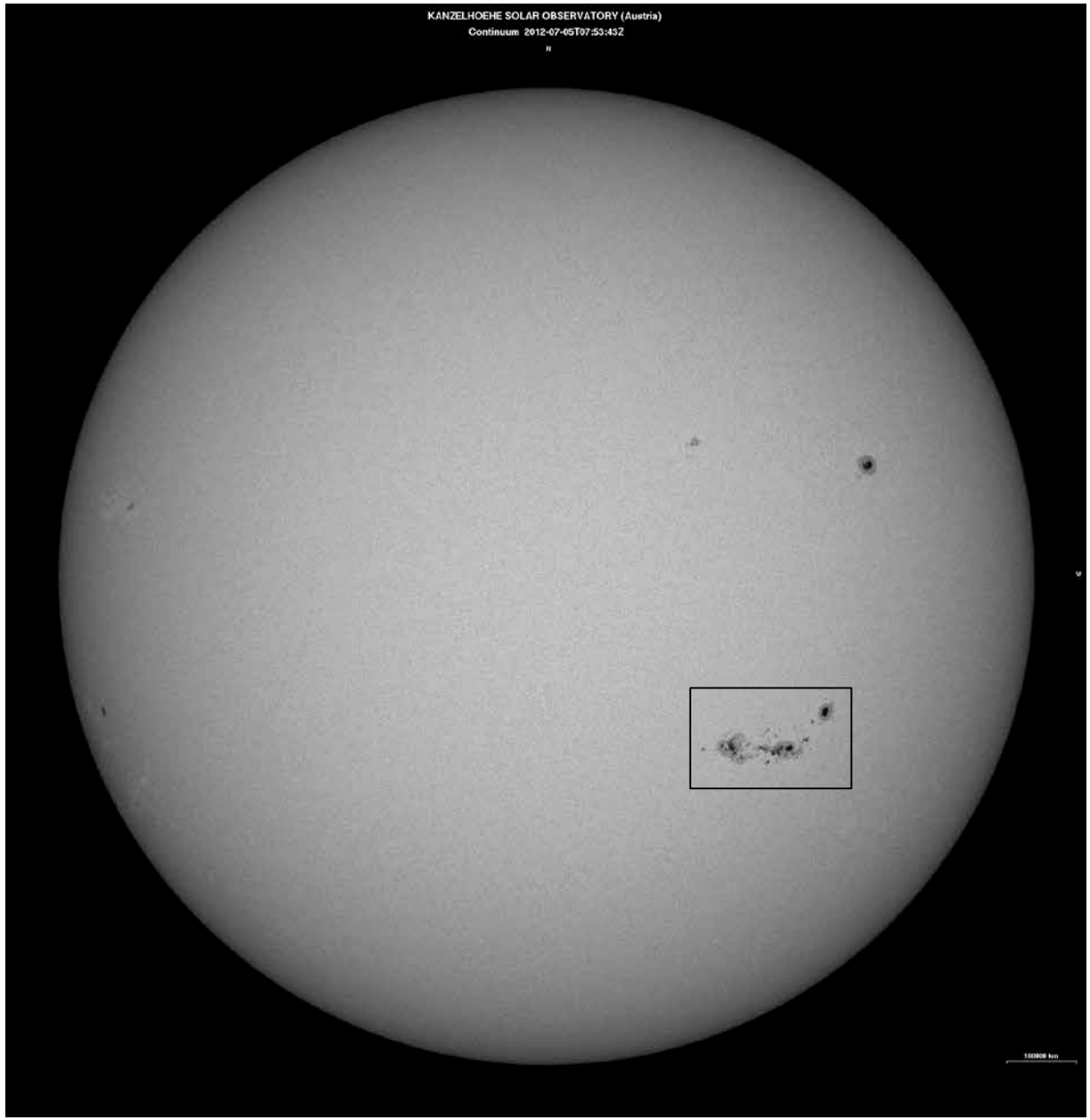
Whitelight Telescope

Focal length: 1950 mm
Diameter: 130 mm

Interference Filter:
CWL 546 nm
FWHM 100 Å

4 MegaPixel 10 bit (patrol)
1 image/minute



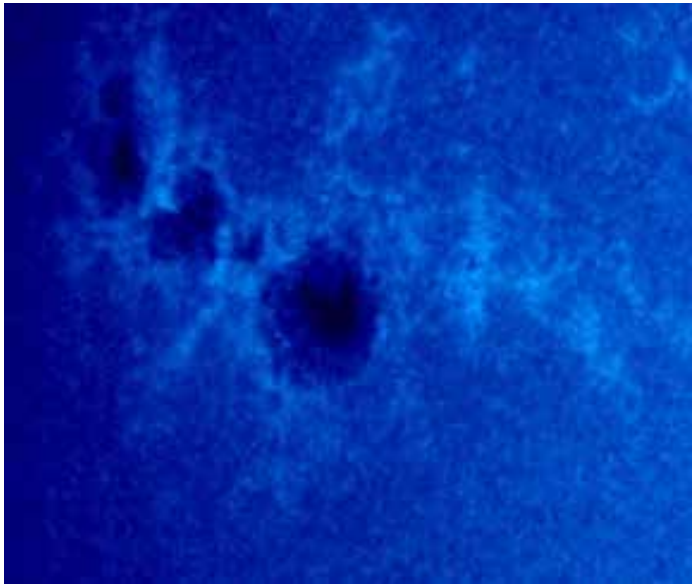


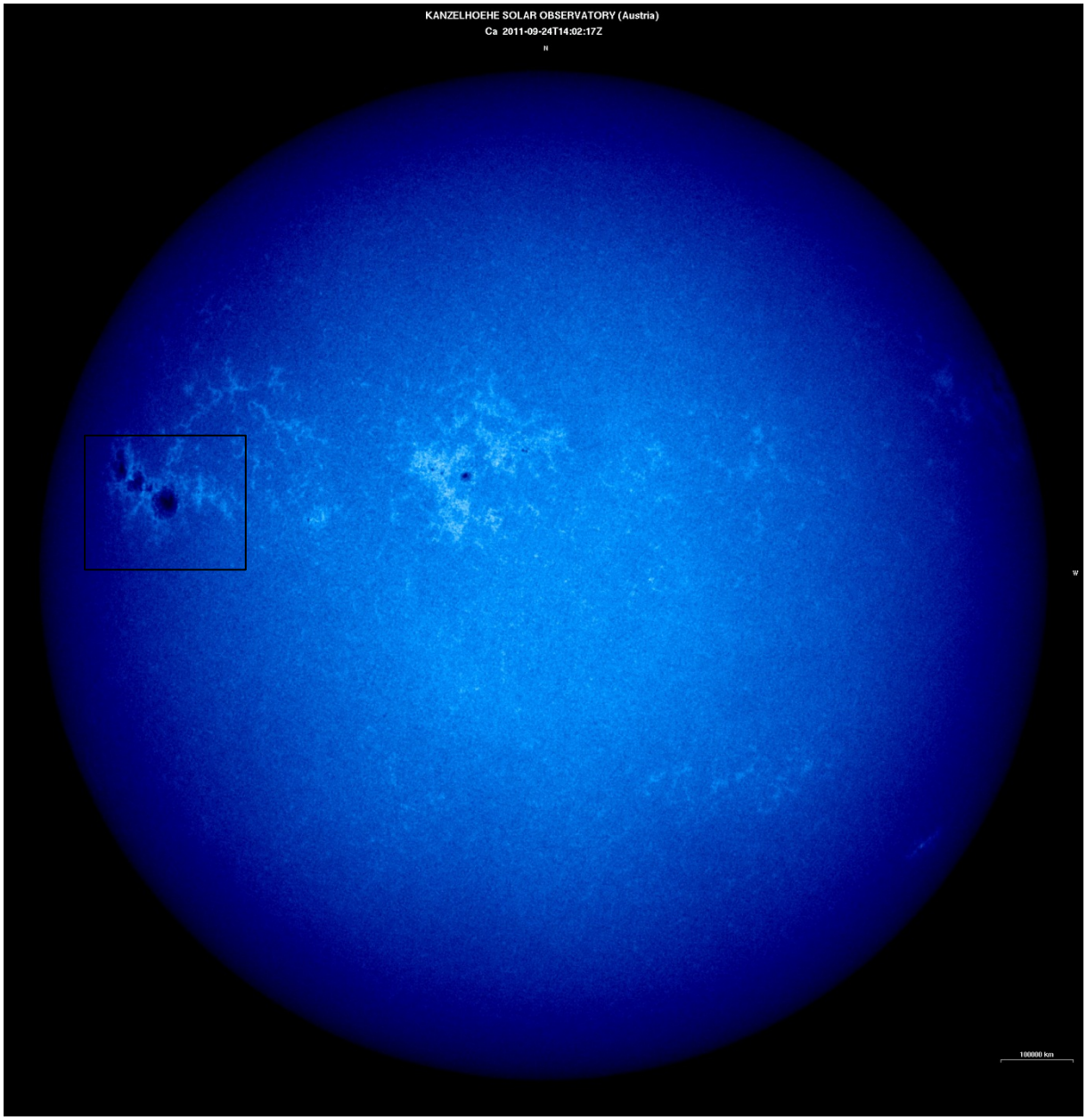
CaIIK Telescope

Focal length: 1650 mm
Diameter: 110 mm

Filter Lunt
CWL 393 nm
FWHM 2 Å

4 MegaPixel 12 bit (patrol)
10 images/minute





Space Weather Precursor Services Operations (SN-IV 2)
Ground-based H-alpha Solar Monitoring Service

(in the framework of ESA SSA - SWE SN IV-2 activity)

Tasks

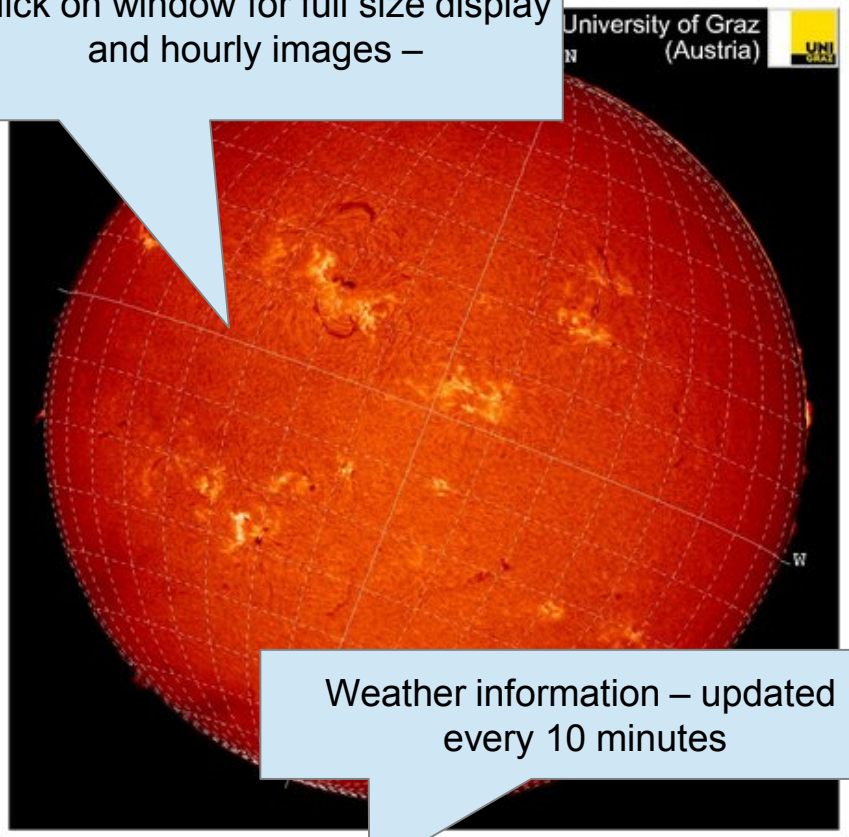
1. Near real-time H-alpha images and movies
2. Automatic Flare detection
3. Automatic Filament eruption detection
4. Alerting of Events

Near real-time H-alpha images and movies

Ground-based H-Alpha Solar Monitoring Service

Kanzelhöhe Observatory

Click on window for full size display and hourly images –



Click on image for full size

Type	Begin	Max	Position	Size
Flare	1034	1039	N14E21	SF
Flare	0908	0908	N11E55	SF
Flare	0624	0625	N10E60	SF
Flare	0521	0522	S25E32	SF

Info Button for table entries

Flare and filament eruption information
Updates every minute, ongoing events are in red color

H-Alpha Movie popup-Window

» H-alpha Movie...

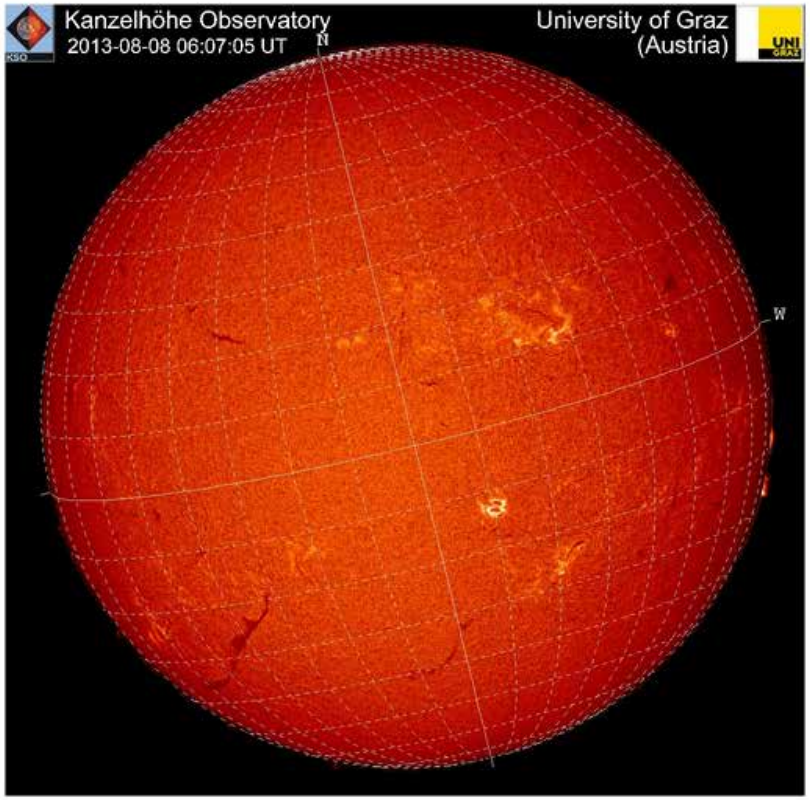
Weather information – updated every 10 minutes

page refresh each 60 seconds

http:\\cesar.kso.ac.at\main\esa_live.php

Near real-time H-alpha images and movies

Ground-based H-Alpha Solar Monitoring Service
Kanzelhöhe Observatory



Type	Begin	Max	Position	Size
Flare	0603	ongoing...	S13W09	SF/31
Flare	0550	0555	S13W09	SF/37
Flare	0541	0542	S13W08	SF/60
Flare	0533	0534	S13W10	SF/54

Marking of ongoing events in red colour.

Ongoing events are events that have not yet reached the peak, when the peak is reached, the peak time is displayed.

» H-alpha Movie...

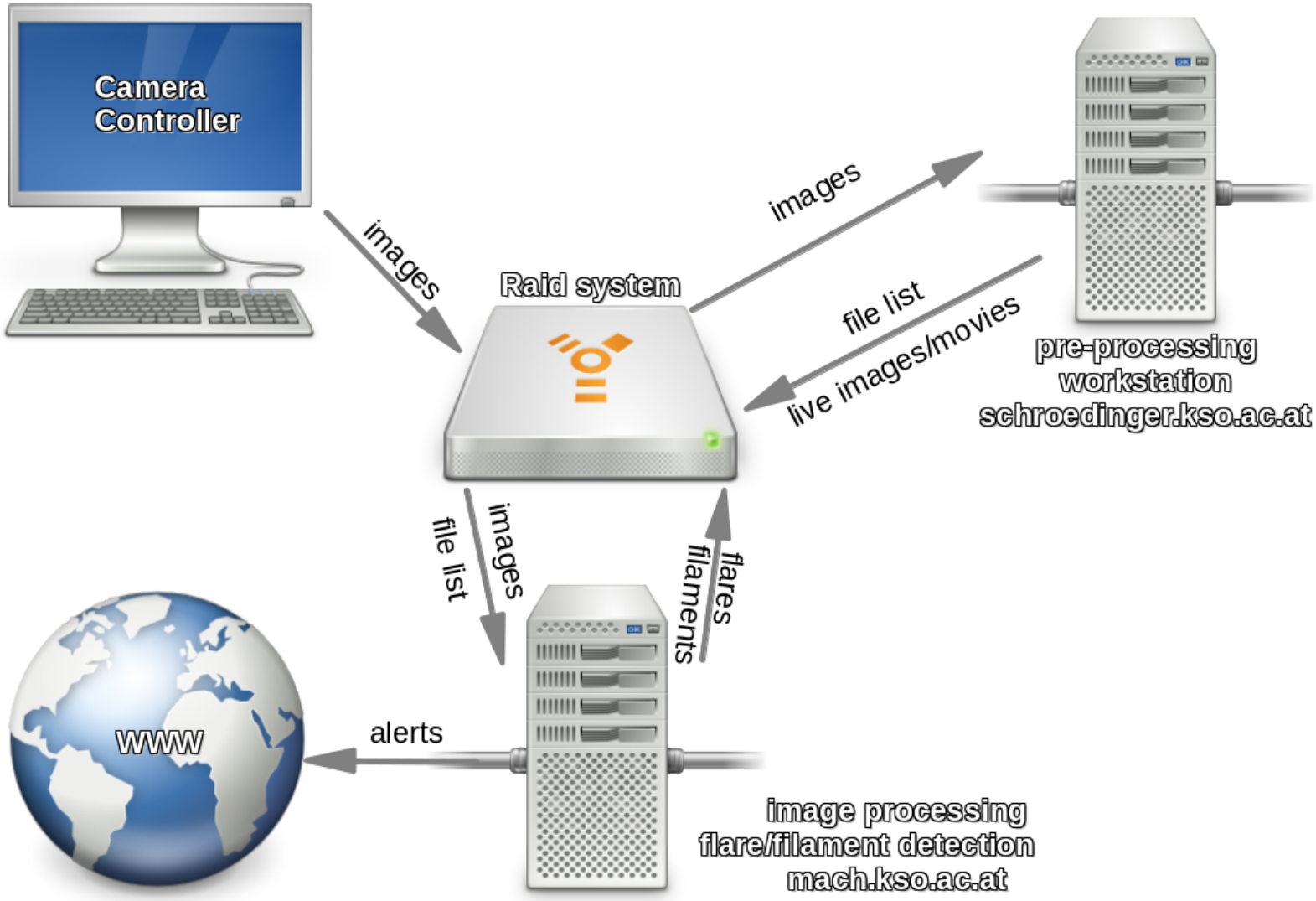
Click on images for full size

page refresh each 60 seconds

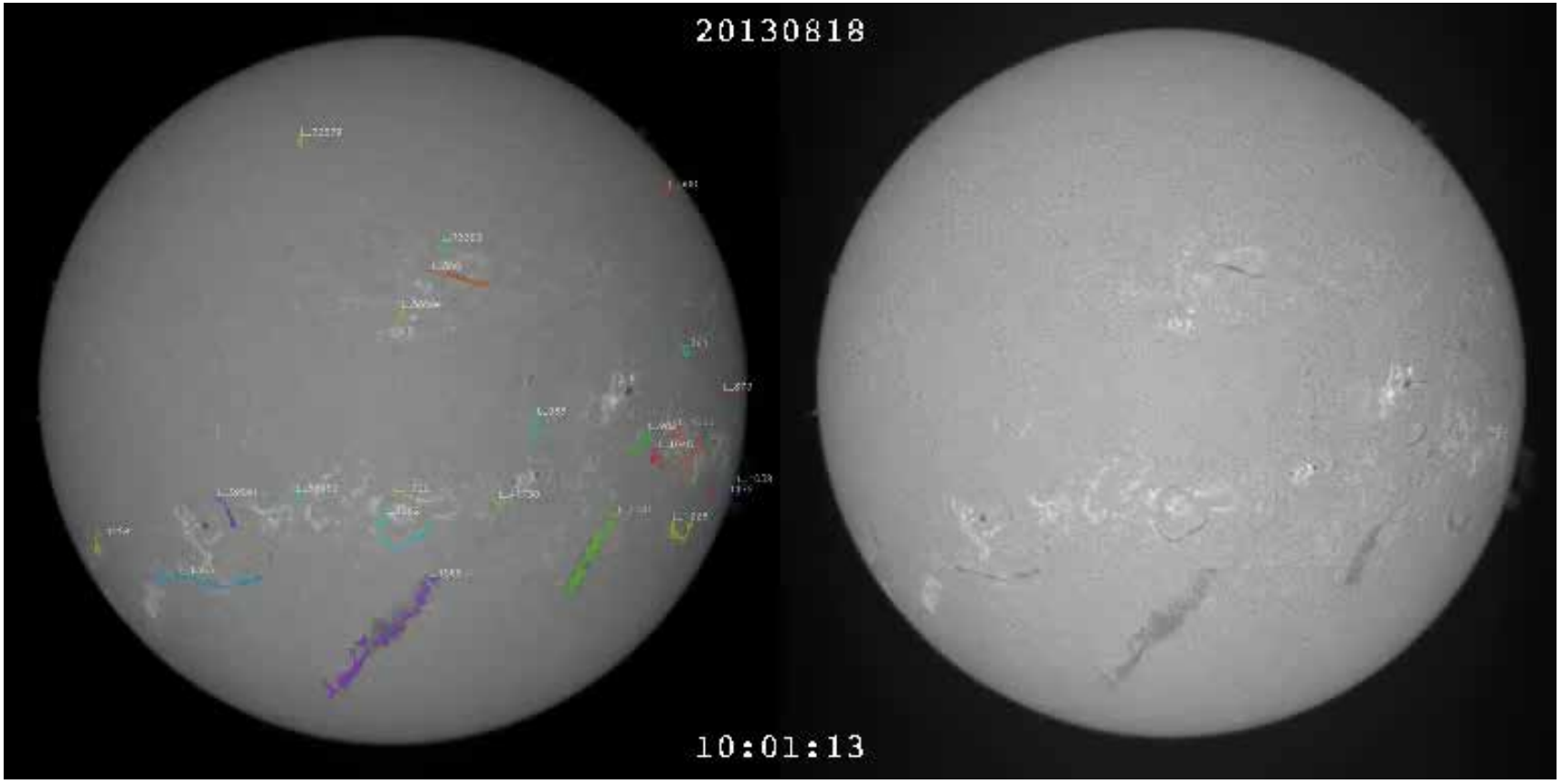
Last update: 20130808 06:06UT

Processing steps for feature recognition and alerting

1. Check image size and quality.
2. Postprocessing of the image.
3. Store processed image as FITS file.
4. Convert processed image to JPEG file.
5. Send JPEG image to the web server.
6. Create/update a log file with H-alpha image observation time and publishing time.
7. Create/update javascript movie and GIF movie.
8. Write input information for the image recognition algorithm to file list.
9. Analyse the incoming images with the image recognition algorithm and save the relevant information on the detected features to flare and filament log files. Save results to summary output log file.
10. Analyse the flare and filament log files to identify flares and filament eruptions.
11. If either a flare and/or a filament is detected, save/update the calculated parameters to a file which contains for each time step (among other supporting information): heliographic position, size, brightness (in case of flares); heliographic position and length (in case of erupting filaments).
12. If a flare identified exceeds the given threshold and/or if filament erupts, issue/update an alert message on the SWE H-alpha subportal. Send email alert message to predefined users.
13. For each flare and filament alert that is provided create/update a log file which includes all the characteristic parameters determined (position, size, importance classification, brightness classification, start and peak time).


Camera Controller
images
Raid system
images
file list
live images/movies
pre-processing workstation
schroedinger.kso.ac.at
file list
images
flares
filaments
www
alerts
image processing
flare/filament detection
mach.kso.ac.at

Feature recognition



Sample result on filament recognition on KSO H-alpha image sequence: Right: raw image. Left: the detected filaments are outlined in color. Each filament has an ID assigned, which is annotated in the image. Too small detections (L < 150 arcsec) and regions >60° from Suns center are not yet excluded.

Feature recognition

1) Preprocessing: Different intensity distributions caused by varying seeing conditions are addressed. A structural bandpass filter, which suppresses additive noise in the images on small scales but also filters large-scale intensity variations caused by clouds and the center-to-limb variation is applied.

2) Feature selection: a) What are the characteristic attributes of filaments and of flares, i.e. what discriminates them from quiet solar regions ("background")?
b) How can we efficiently model these attributes?

3) Multi-label segmentation: Assign a class/label to each pixel. Make the result smooth.

4) Postprocessing: Every object is identified with an ID. In the time sequence of the H-alpha images, the ID of each flare and filament identified has to remain the same. Characteristic properties of the filaments and flares are derived to categorize them.

Feature recognition – Output Log Files

Flare log file

Date	Time	Sun_x	Sun_y	Radius	Id	Flare_x	Flare_y	Area	Mean_I	rms	Min_I	Max_I	Max_x	Max_y
20130526	071809	1046.61	1040.98	933.07	3	930.89	735.40	53	2.2507	0.1134	2.0214	2.5127	931.00	736.00
20130526	071809	1046.61	1040.98	933.07	4	1246.71	958.29	48	1.8623	0.0680	1.7507	2.0114	1248.00	956.00
20130526	071945	1046.61	1040.98	932.98	3	931.59	734.37	51	2.2550	0.1385	1.9282	2.5993	931.00	735.00
20130526	071945	1046.61	1040.98	932.98	4	1248.00	959.29	41	1.8796	0.0966	1.6860	2.1466	1250.00	958.00
20130526	072040	1046.61	1040.98	932.51	3	932.21	735.17	29	2.2318	0.1058	1.9452	2.3990	932.00	736.00
20130526	072059	1046.61	1040.98	932.82	3	933.40	734.55	58	2.2384	0.1332	1.9272	2.6114	934.00	734.00
20130526	072059	1046.61	1040.98	932.82	4	1248.76	959.26	50	1.8666	0.0776	1.6910	1.9924	1247.00	960.00
20130526	072111	1046.61	1040.98	932.53	3	933.65	735.78	54	2.2175	0.0986	2.0740	2.4530	933.00	737.00
20130526	072124	1046.61	1040.98	932.53	3	934.23	733.70	70	2.2612	0.1339	2.0473	2.6575	934.00	734.00

Filament log file

Date	Time	Sun_x	Sun_y	Radius	Id	Fil_x	Fil_y	Length
20130526	063701	1046.61	1040.98	932.58	37	850.43	411.27	22
20130526	063701	1046.61	1040.98	932.58	60	931.38	531.87	31
20130526	063701	1046.61	1040.98	932.58	67	613.03	450.21	435
20130526	063701	1046.61	1040.98	932.58	82	980.89	588.05	78
20130526	063701	1046.61	1040.98	932.58	122	1480.43	672.58	91
20130526	063701	1046.61	1040.98	932.58	123	213.92	682.42	55
20130526	063701	1046.61	1040.98	932.58	145	785.22	713.16	133
20130526	063701	1046.61	1040.98	932.58	168	892.14	782.97	102
20130526	063701	1046.61	1040.98	932.58	182	675.34	826.42	102
20130526	063701	1046.61	1040.98	932.58	209	1116.57	901.65	163

Flare Alerts – Data processing

1. Conversion of the image recognition flare log file
2. Flare event extraction from converted flare log file
3. Update information on SWE portal
4. Flare alerting
5. Alert updating

Flare areas:
Are converted to microhemispheres.
Correction for foreshortening and filter effects
(see movie below!)

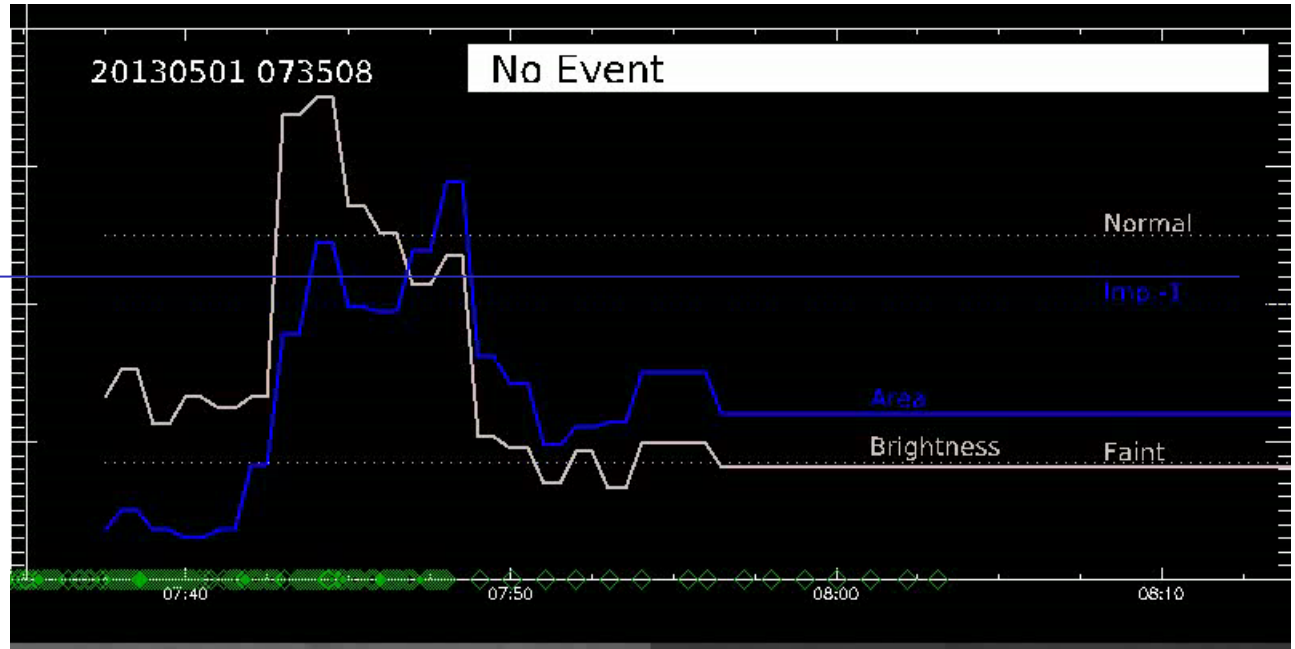
H-alpha flare importance	Flare area (in solar micro-hemispheres)
S[ubflares]	< 100
1	100 – 250
2	250 – 600
3	600 – 1200
4	> 1200

Brightness values:
after the file conversion, the brightness values for the different brilliance levels had to be compared with visually detected flares (2012-06 to 2012-08 and 2013-03 to 2013-06)

H-alpha flare brilliance	Brightness difference (maximum – mean)
No Flare [-]	< 0.85
F[aint]	0.85 – 2.5
N[ormal]	2.5 – 4
B[rilliant]	> 4.0

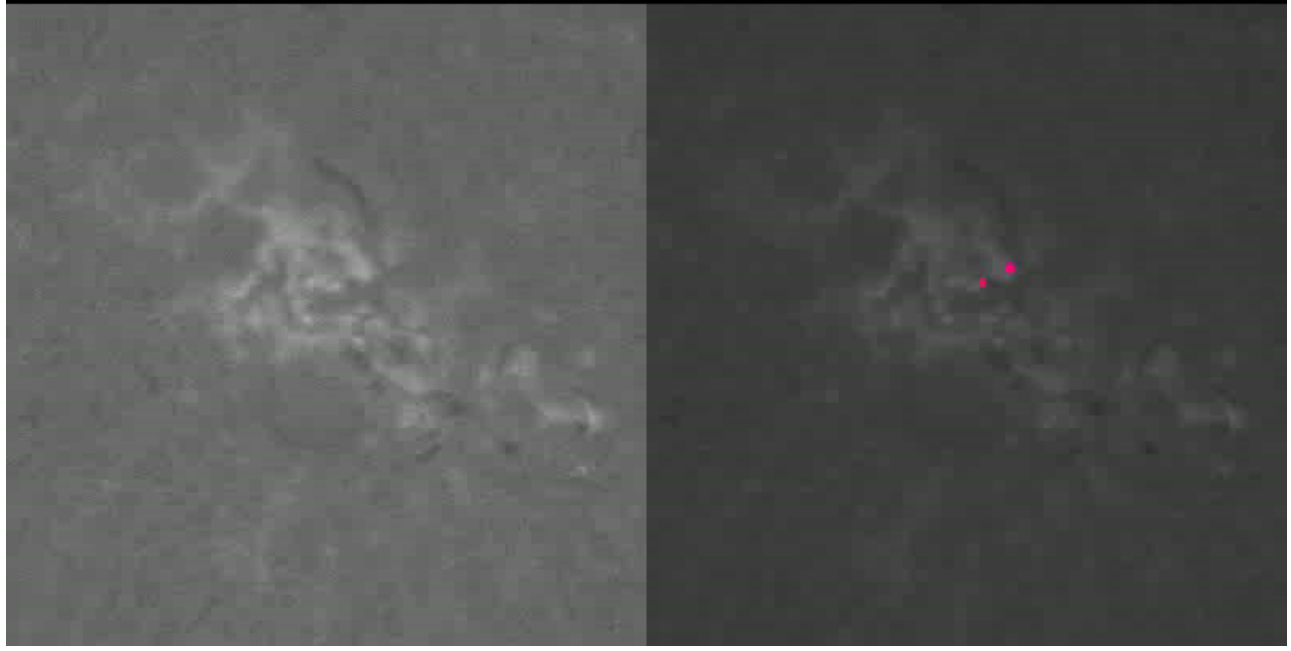
Area and brightness evolution of a 1N flare

Output on SWE portal



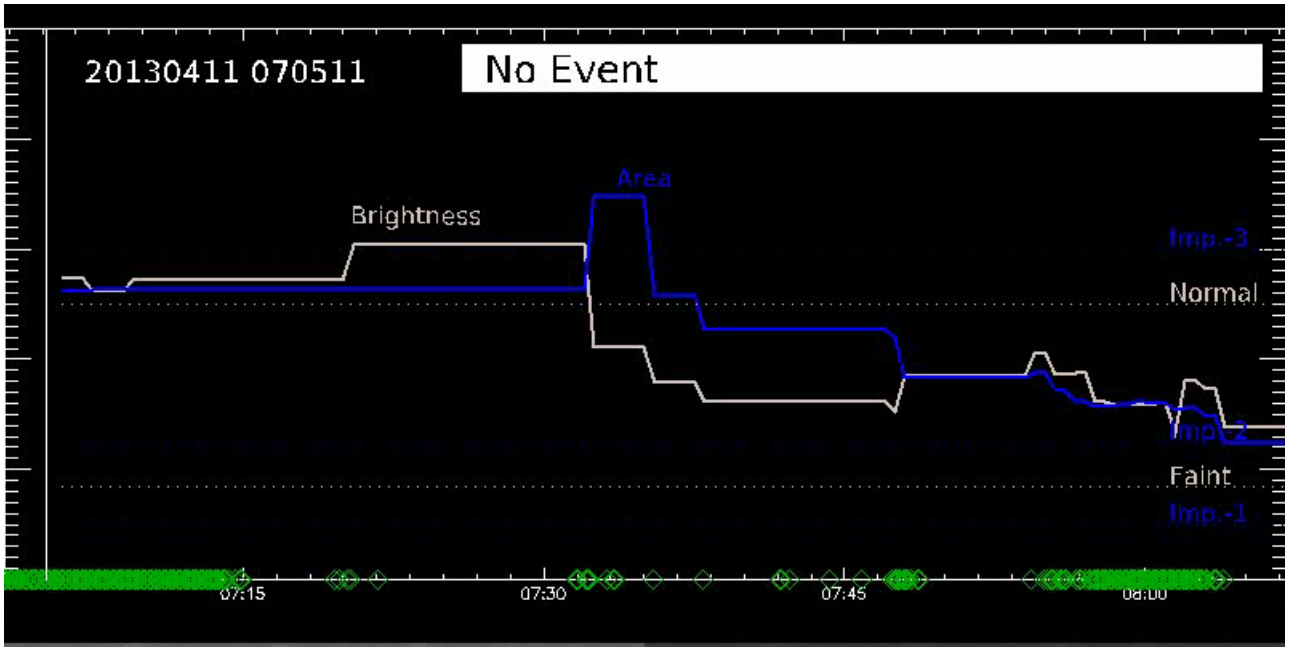
Original data

Output of segmentation algorithm overlaid on original data



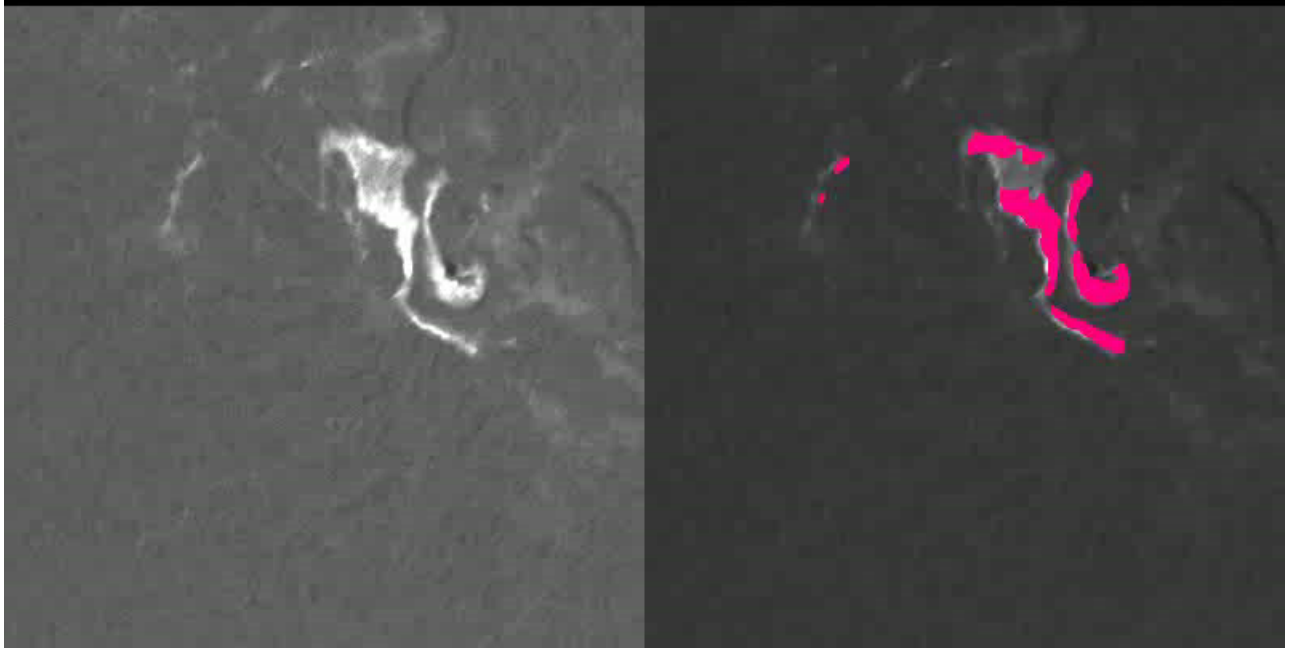
Area and brightness evolution of a 3N flare

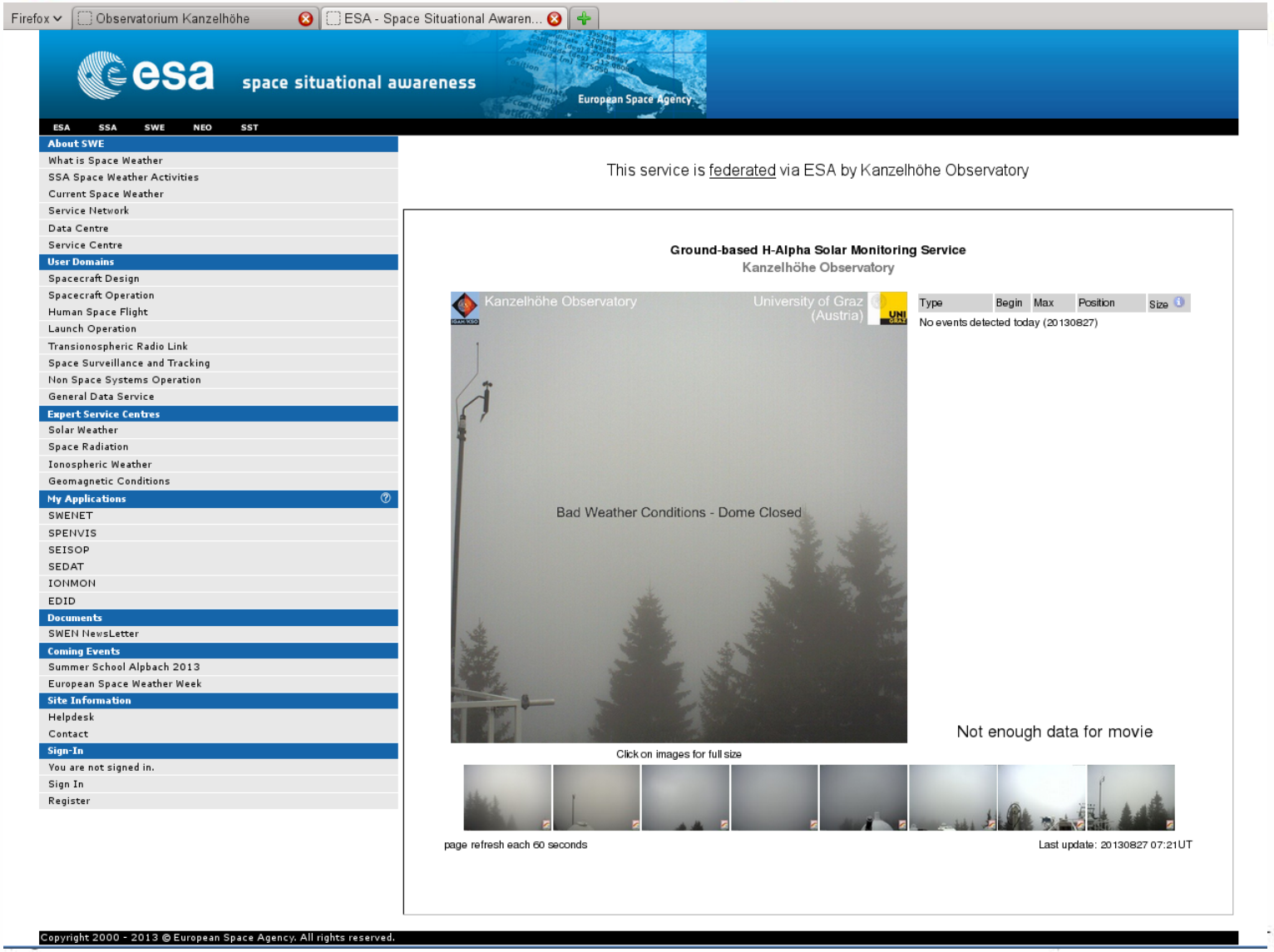
Output on SWE portal



Original data

Output of segmentation algorithm overlaid on original data




Firefox
Observatorium Kanzelhöhe
ESA - Space Situational Awaren...
esa
space situational awareness
European Space Agency
ESA SSA SWE NEO SST
About SWE
What is Space Weather
SSA Space Weather Activities
Current Space Weather
Service Network
Data Centre
Service Centre
User Domains
Spacecraft Design
Spacecraft Operation
Human Space Flight
Launch Operation
Transionospheric Radio Link
Space Surveillance and Tracking
Non Space Systems Operation
General Data Service
Expert Service Centres
Solar Weather
Space Radiation
Ionospheric Weather
Geomagnetic Conditions
My Applications
SWENET
SPENVIS
SEISOP
SEDAT
IONMON
EDID
Documents
SWEN NewsLetter
Coming Events
Summer School Alpbach 2013
European Space Weather Week
Site Information
Helpdesk
Contact
Sign-In
You are not signed in.
Sign In
Register
This service is federated via ESA by Kanzelhöhe Observatory
Ground-based H-Alpha Solar Monitoring Service
Kanzelhöhe Observatory
Kanzelhöhe Observatory
University of Graz (Austria)
Bad Weather Conditions - Dome Closed
Type Begin Max Position Size
No events detected today (20130827)
Not enough data for movie
Click on images for full size
page refresh each 60 seconds
Last update: 20130827 07:21UT
Copyright 2000 - 2013 © European Space Agency. All rights reserved.

Flare Alerts

Flare alerts are issued when one of the following criteria is fulfilled:

1.The flare detected is of importance class 1 or higher or a subflare with an area exceeding a threshold of 50 micro-hemispheres, or

2.the flare importance class reaches a higher class level (e.g., a flare of importance 1 evolves further to a flare of importance 2).

Von alert@kso.ac.at
Betreff **Kanzelhoehe Observatory flare alert**
An observer@kso.ac.at

```
Kanzelhoehe Observatory solar flare alert
2013-08-12T10:31Z, Flare of importance SF at S21E20
.
```

1st Alert message

Alert update

Von alert@kso.ac.at
Betreff **Kanzelhoehe Observatory flare alert**
An observer@kso.ac.at

```
Kanzelhoehe Observatory solar flare alert
2013-08-12T10:41Z, Flare of importance 1N at S21E18
.
```

Filament Eruption Alerts - Data processing

1. Conversion of the image recognition filament log file
2. Filament eruption extraction from the converted filament log file
3. Update information on SWE H-alpha subportal
4. Filament eruption alerting

Date	Time	Length	Position	Id
20130722	061233	59	W35 N60	4
20130722	061239	65	W35 N60	4
20130722	061244	66	W35 N60	4
20130722	061257	60	W35 N60	4
20130722	061303	55	W35 N59	4
20130722	061309	58	W35 N59	4
20130722	061321	67	W35 N59	4
20130722	061328	58	W35 N60	4
20130722	061333	65	W35 N60	4
20130722	061340	63	W35 N60	4
20130722	061346	66	W35 N60	4
20130722	061358	65	W35 N60	4
20130722	061404	62	W35 N60	4
20130722	061411	61	W35 N59	4
20130722	061422	58	W35 N60	4
20130722	061429	66	W35 N60	4
20130722	061435	68	W35 N59	4
20130722	061441	62	W35 N59	4
20130722	061453	57	W35 N59	4

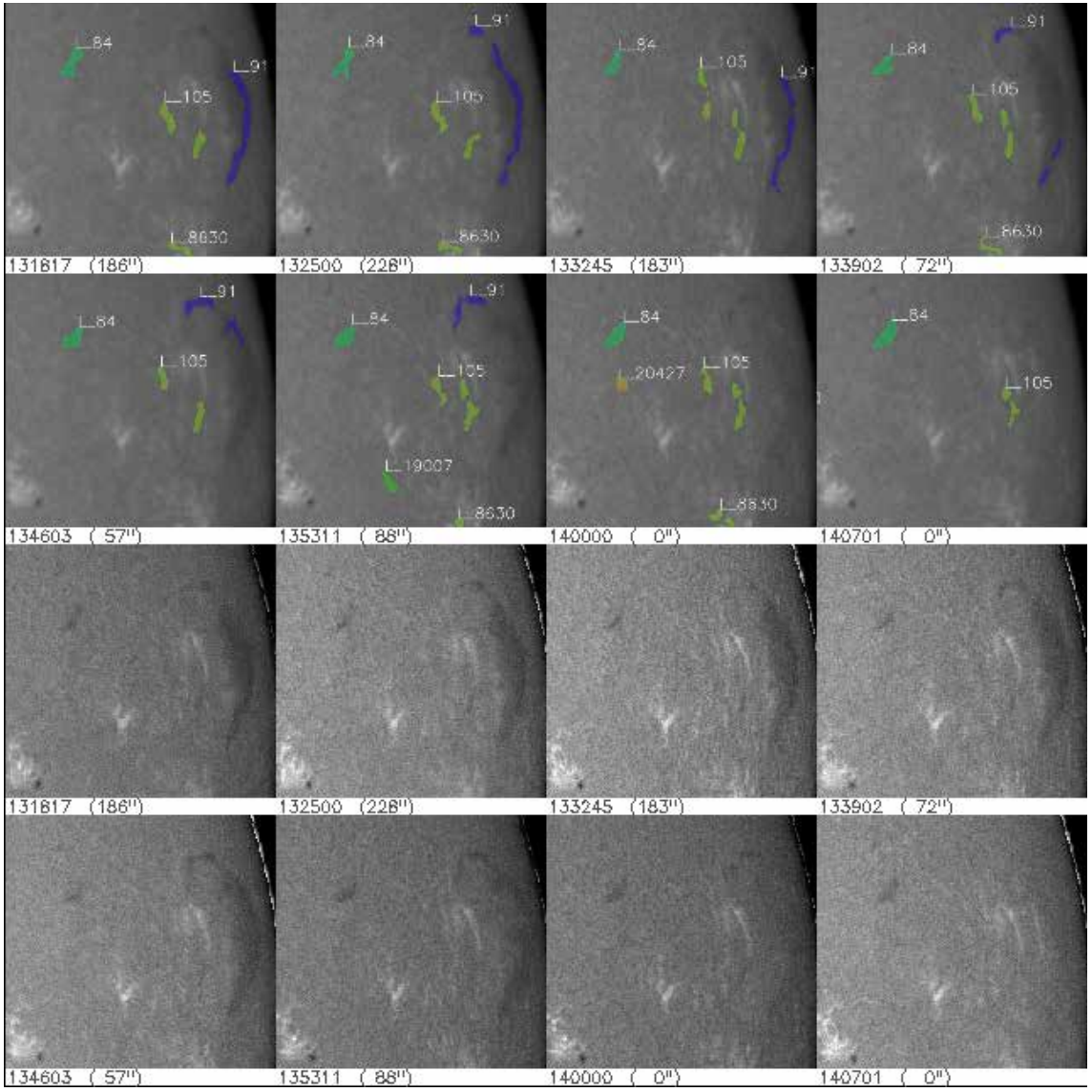
- All pixel coordinates have to be converted into heliographic coordinates. For this purpose, the solar disc coordinates and the radius information is needed.
- The filament length has to be converted into arcseconds. No correction for foreshortening is applied in the length calculation.
- Very short filaments (<30 arcsec) and filaments outside 60° from disc centre are removed from the list. Very short filaments are not of interest at all as only filaments >150 arcsec are taken into account for alerting.
- Filaments are sorted according to their IDs.

Filament eruption

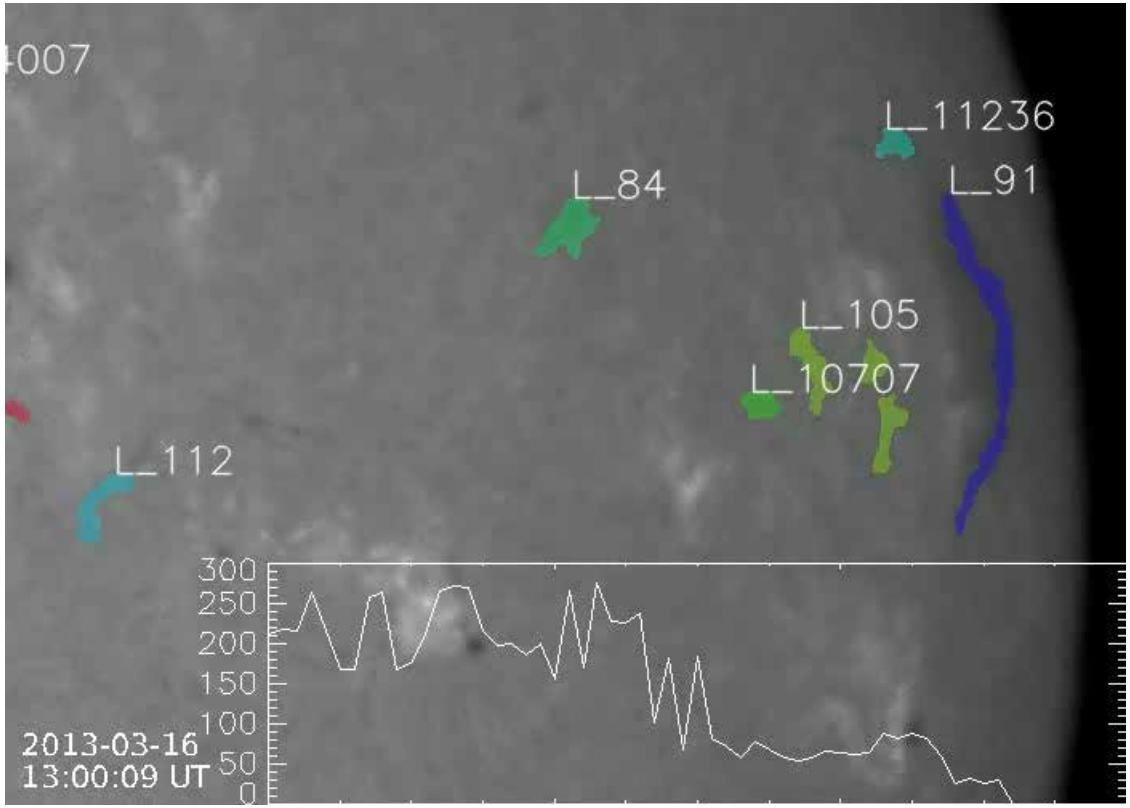
The filament with the label L_91 disappears from the sequence.

This event was detected on 2013 March 16.

During the validation phase there was no event!



Filament eruption



Filament Alerts- Portal Integration

Type	Begin	Max	Position	Size
Flare	1449	1454	19W53	F
Fil. Eruption	1354		N25W57	190
Flare	1353	1355	05W31	F
Flare	1351	1353	18W54	N
Flare	1340	1341	18W53	F
Flare	0704	0830	18W50	F

On the SWE-Portal information about start time, mean position and average length before eruption are displayed.

Filament Alerts

Alerts are issued when the following criteria are fulfilled:

1.The filament length before the eruption is on average >150 arcsec.

2.The filament position before the eruption is within 60° from solar disc centre.

Von alert@kso.ac.at

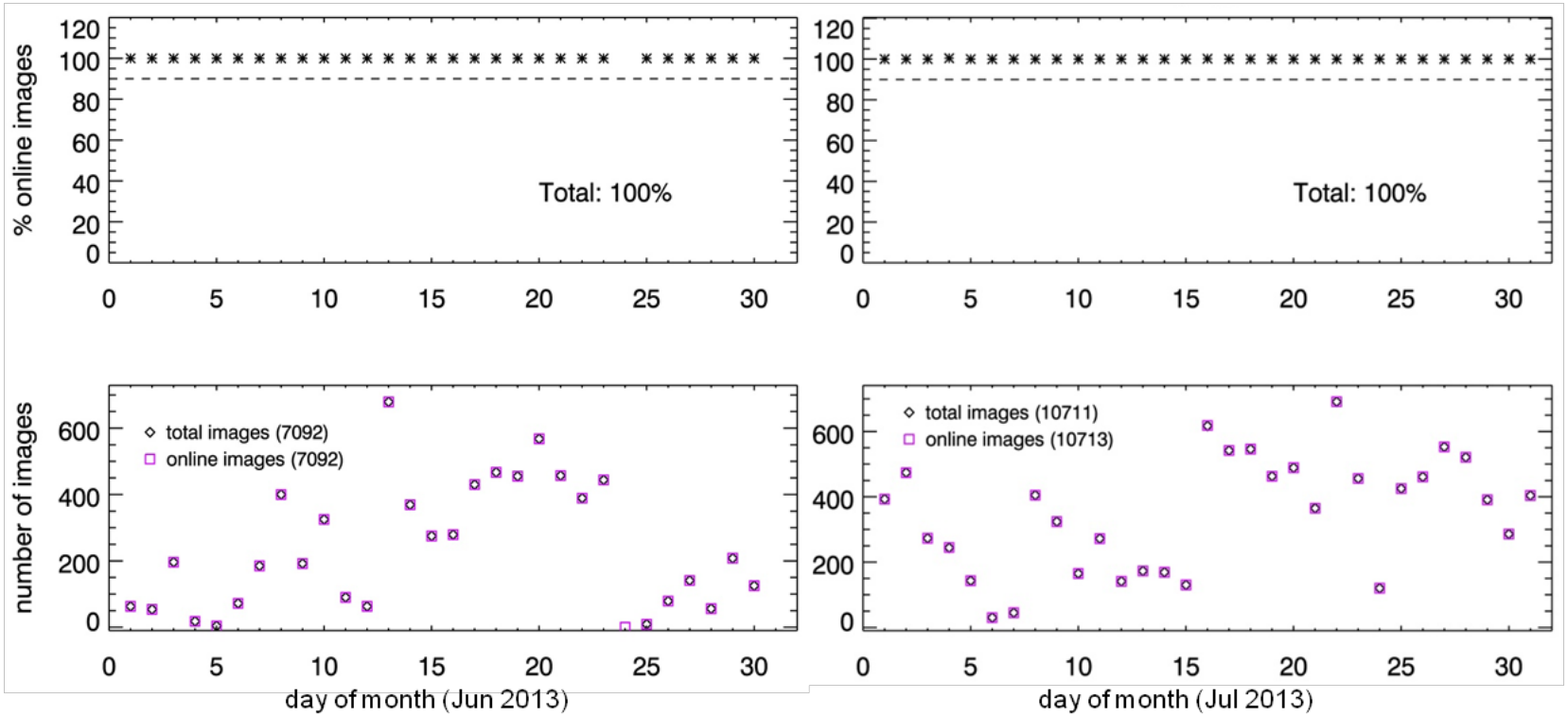
Betreff **Kanzelhoehe Observatory filament eruption alert**

An observer@kso.ac.at

```
Kanzelhoehe Observatory filament eruption alert
2013-08-19T06:06Z, Filament eruption at S08W34
.
```

Validation – Data Availability

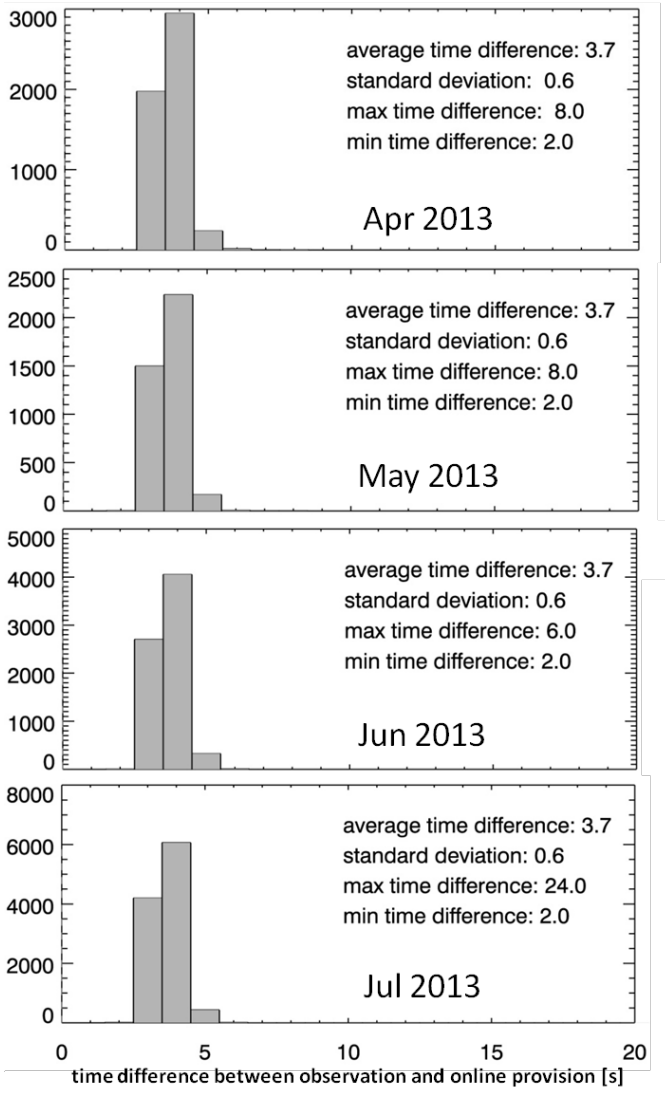
June 2013 July 2013



H-alpha services are available for >90% of KSO observing time.

Starting with February 2013 almost 100%!

A.Validation – Data Latency



April 2013:
- total number of images: 5179

May 2013:
- total number of images: 3913

June 2013:
- total number of images: 7092

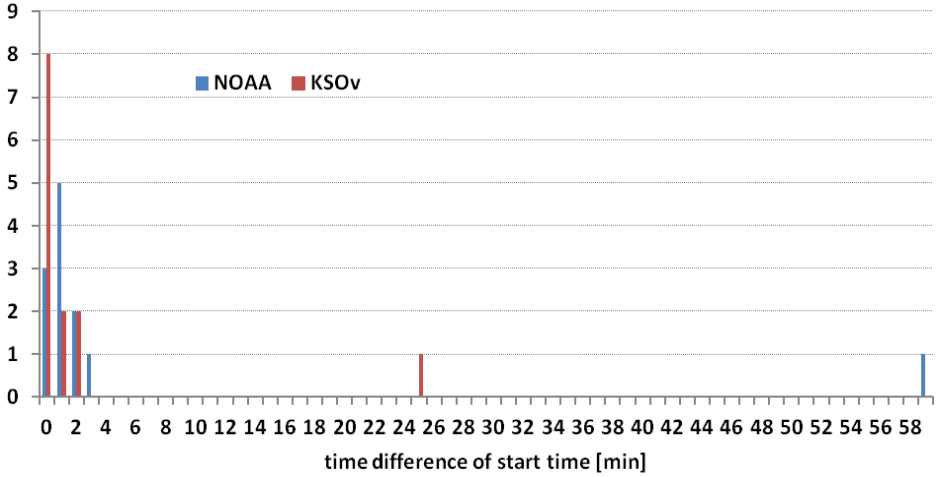
July 2013:
- total number of images: 10702

For the overall data set, the mean time difference between image observation and online provision is 4.2 ± 1.3 seconds.

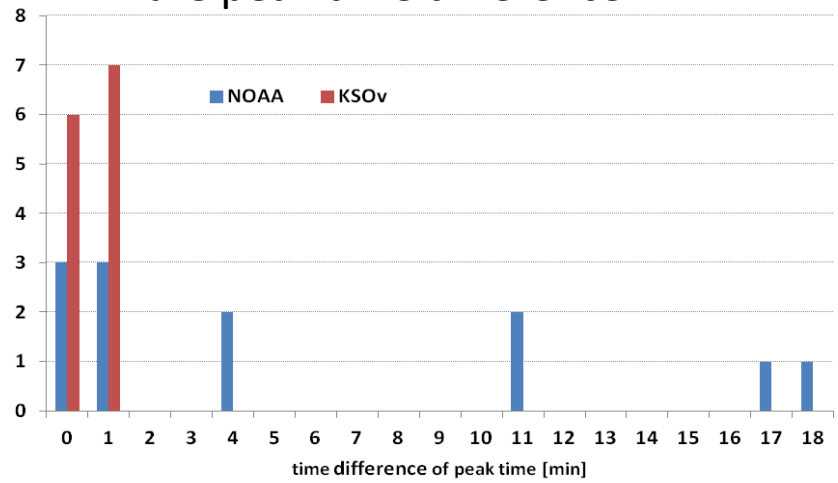
Validation

	Start time			Peak time			Position			Type			Area
	SURYA	NOAA	KSOv	SURYA	NOAA	KSOv	SURYA	NOAA	KSOv	SURYA	NOAA	KSOv	SURYA
27/06	09:38	B09:38	09:38	09:41	U09:42	09:41	S16E23	S16E25	S16E23	SF	SF	SF	60
30/06	09:11	09:14	-	09:33	09:16	-	S15W20	S16W19	-	SF	SF	-	74
04/07	09:21	-	-	09:22	-		S11E45	-	-	SF	-	-	50
05/07	04:26	B05:25	05:01	05:16	U05:34	05:16	S08E30	S06E38	S08E30	SF	SF	SF	87
	06:57	06:58	06:57	06:59	07:03	06:59D	S09E30	S09E33	S09E29	SF	SF	SF	60
09/07	07:38	-	07:38E	07:40	-	07:40U	S08W23	-	S13W18	1F	-	1F	156
	08:32[7]	-	-	08:36	-	-	S08W24	-	-	SF	-	-	115
	13:27	13:26	13:27	13:31	13:31	13:32	S10W21	S12W21	S10W21	SN	1N	SN	82
10/07	06:20	06:21	06:20U	06:32	06:43	06:31D	S14W13	S15W13	S14W13	1F	1N	1N	177
	07:07	-	-	07:08	-	-	S13W15	-	-	SF	-	-	72
16/07	10:11	10:12	10:10	10:20	10:16	10:20	S12E03	S12E04	S12E03	SF	SF	SF	96
21/07	06:41	06:43	06:41	06:44	06:44	06:45	N22W07	N23W07	N22W08	SF	SF	SF	61
	08:25	08:25	08:25	08:30	08:41	08:31	S07E30	S06E31	S07E31	1F	1F	1F	151
	12:16	12:17	12:17	12:19	12:18	12:18	N22W09	N22W09	N22W09	SN	SF	SN	51
	14:13	-	14:11	14:13	-	14:14	N23W11	-	N24W11	SF	-	SF	65
25/07	06:05	06:05	06:05E	06:08	06:07	06:08	S06W20	S08W22	S06W20	SN	SF	SN	59
28/07	12:07	12:05	12:05	12:23	12:23	12:22	S11W59	S13W60	S11W59	SF	SF	SF	70

Flare start time difference



Flare peak time difference



The **median of the start time difference** when compared to **NOAA is 1 min**, to **KSOv is 0 min**. For 92% of the flares detected, the derived flare start times lie within 5 min with respect to the NOAA and KSOv reports.

The **median of the peak time difference** when compared to **NOAA is 2.5 min** to **KSOv is 1 min**. For 100% (67%) of the events the flare peak time differences are <5 min with respect to the reports by KSOv (NOAA).