Analysis of Ca II K Images Aiming to Determine Long-term Trends in Solar Irradiance Variability

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Motivation

We aim to determine the presence and strength of long term trends in solar irradiance using numerical models and long data records on solar surface magnetism. Our data comprises of historical Ca II K images of the sun from different solar observatories. Here we test two different feature identification methods that are used to derive the area coverage of solar magnetic features on the full disc solar images. These are first applied to a set of recent images from the PSPT (Rome) instrument. Then the performance of these methods is tested on the historical images from Mt. Wilson ,Kodaikanal and Arcetri archives.

Concept

Solar irradiance variations on time scales longer than a day are due to the evolution of solar surface magnetic field (1). To reconstruct solar irradiance variations into the past, models use proxies of solar magnetic activity. The longest available series is the sunspot number, which goes back to 1610. It reasonably describes the evolution of active regions with time, but is not necessarily a good proxy of the evolution of the weaker surface magnetic field (ephemeral magnetic regions, ERs), which are responsible for the secular change in solar irradiance.

We propose to use historical Ca II images to investigate long-term changes in the ER coverage (3).

Data

Full disk images of the Sun taken in the Ca II K line (393.3 nm) at the Mount Wilson (MW), Arcetri (Ar) & Kodaikanal (Ko) observatory since early 20th century.

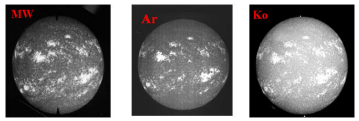
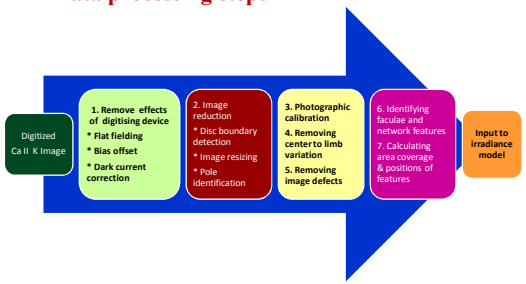


Fig. 1 Ca II K images from 3 observatories taken in June 1958 (3)

	Mount Wilson	Kodaikanal	Arcetri
No. of images	34166	19522	4052

Historical images suffer from in-homogeneities like geometrical distortion, random spots, lines, variable stray light levels and absence of calibration information. This flow diagram shows the sequential steps of processing that has to be followed to extract information accurately from historical data (3)

Data processing steps

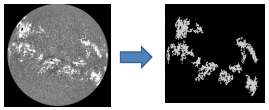


Methods to identify solar features from Ca II K images

Method 1: Uses a single intensity threshold and pixel grouping

Calculates optimum background intensity for each image (2).

Uses this as an intensity threshold to create mask of bright features. (3).



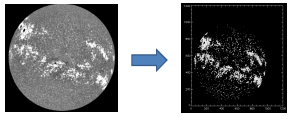
From mask, contiguous pixels are grouped as features. Desired features are selected by setting a feature size threshold.

Number of features detected depend on both intensity and feature size threshold.

Method 2: Uses multiple intensity thresholds

It is based on Multiple Level Thresholding.

A number of intensity thresholds are applied in decreasing order (4).



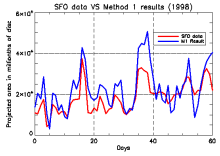
At each threshold level, smaller and fainter structures are detected.

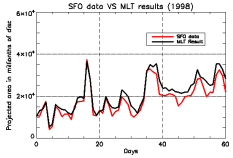
Number of features detected depend on the lowest intensity threshold chosen.

Results

1. Feature identification on modern Ca II K images

The two feature recognition algorithms are tested to identify facular regions on a set of Ca II K images taken by the PSPT instrument (Rome) in the year 1998. The results are compared with facular area data from the San Fernando Observatory (5) for the corresponding days.

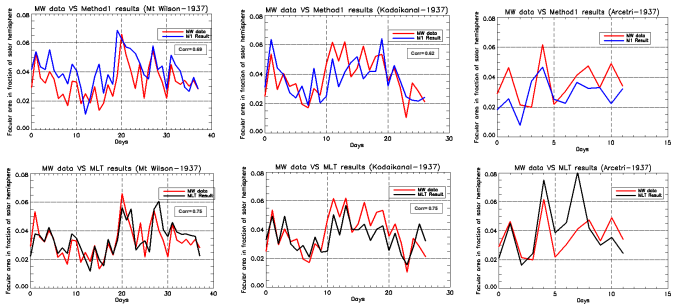




	SFO-M1	SFO-MLT	M1-MLT
Correlation	0.81	0.96	0.78

2. Feature identification on historical Ca II K images (year: 1937)

Mount Wilson | Kodaikanal | Arcetri



The two feature recognition algorithms are tested on Ca II K images of the year 1937 taken from the Mount Wilson Kodaikanal and Arcetri archives. The results are compared with the values from Mount Wilson facular area dataset (6). The preliminary results obtained are encouraging, since they were derived from images affected by large scale brightness patterns and other image defects. We are currently working to both verify and improve the results obtained.

Acknowledgement

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References

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