Image homogenization

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Solarnet (WP8) workshop

Image homogenization : context

- Image standardization (USET pipeline)
  - Algorithms to standardize the geometry and intensity of the solar disk at USET
  - Some of them could be used for the image homogenization
  - General requirements:
    - Valid for the three wavelengths (white-light, H-alpha, Ca II K)
    - Robust for different observation conditions (low atmospheric transparency, bad seeing, image truncated, ..)
  - Status:
    - Limb fitting daily applied in the uset pipeline
    - Limb darkening currently developed
- Image homogenization between different stations
  - Algorithms to homogenize images taken at different station with the main aim to provide continuous, unified and high-quality observing sequence
  - Status: **to be developed**

Solar disk detection

Goals

- Three wavelengths (H-alpha most difficult case due to prominences)
- Robust for different observation conditions

Method

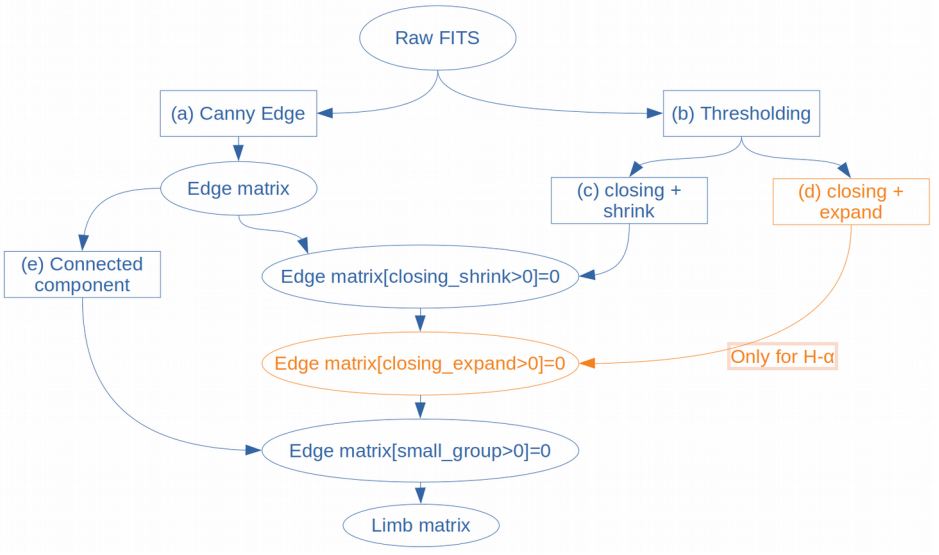
a) Canny edge algorithm
   → all edges detection (limb and solar features)

b) Threshold mask
   → solar disk detection (bright foreground on dark background)

c) Shrinking of the threshold mask
   → mask to remove all the edges inside the solar disk

d) (H-alpha only) expanded mask
   → mask to remove all the edges outside the solar disk

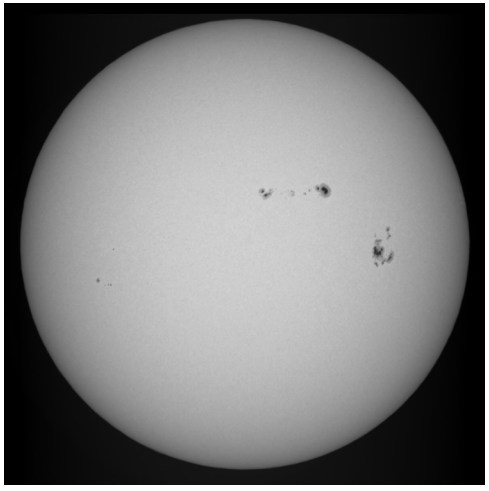
e) Connected component
   → remove remaining edges detected that are not part of the limb

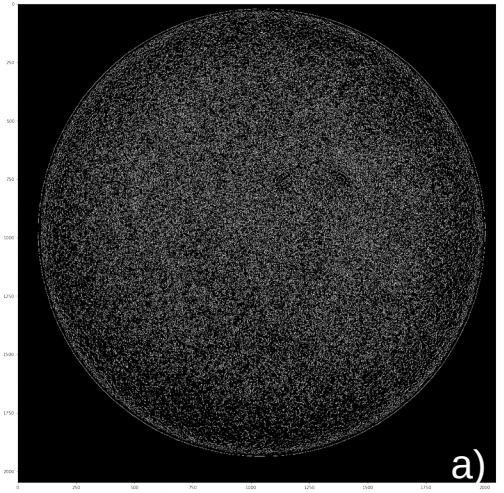


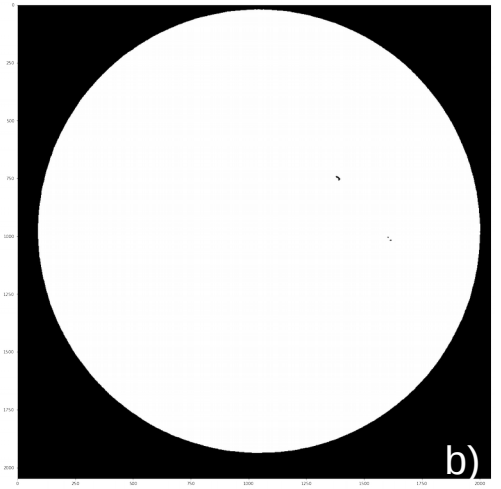
Current status

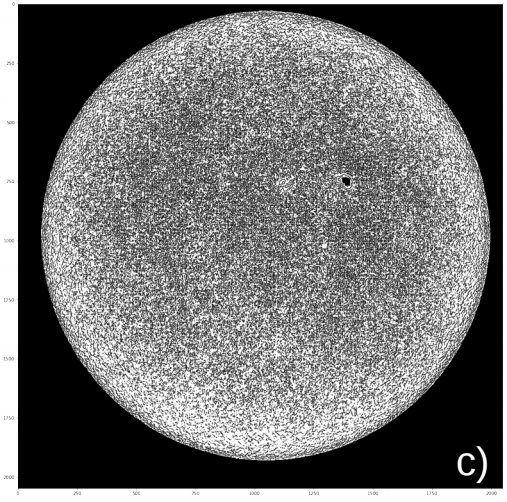
Operational for USET

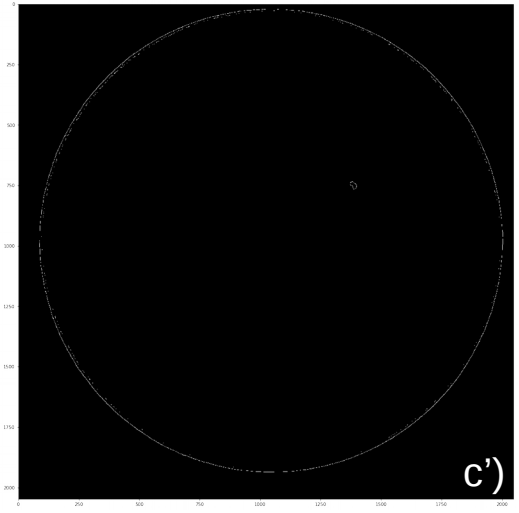
Solar disk detection: illustration for white-light

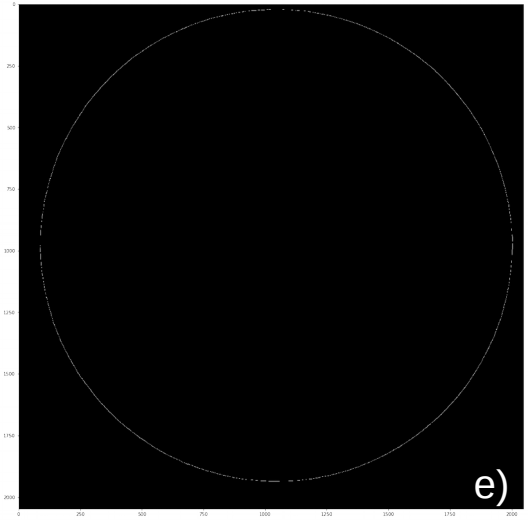




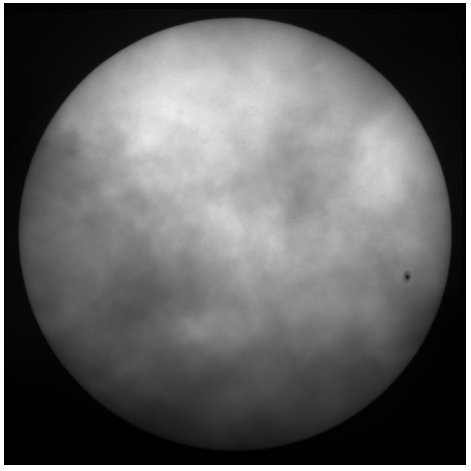


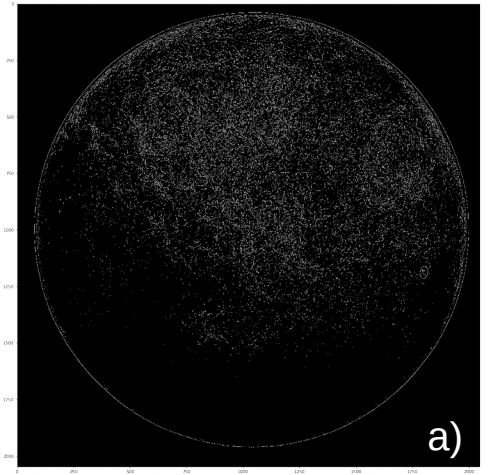


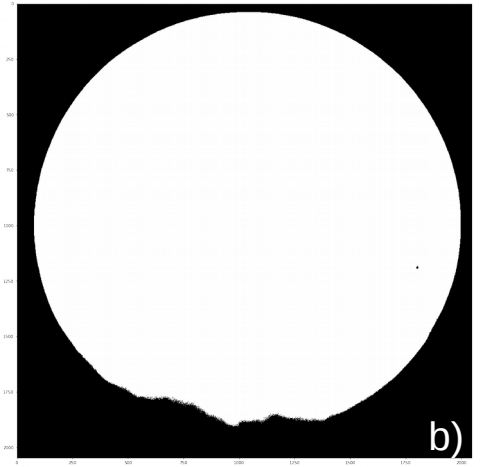


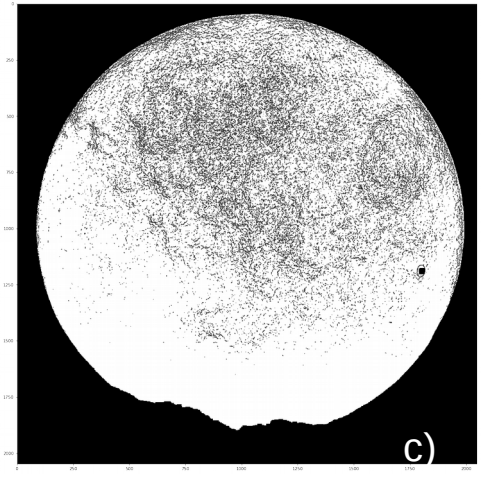


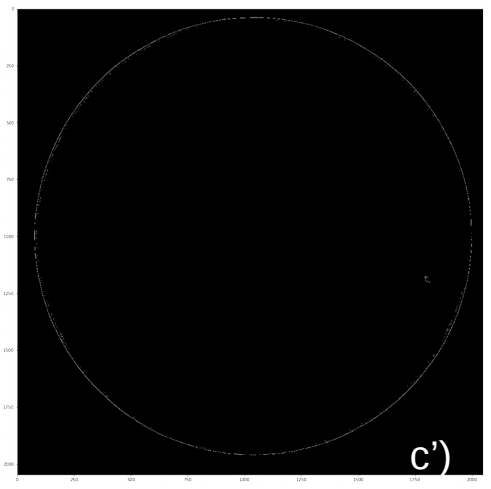
Solar disk detection: illustration for white-light and **clouds**

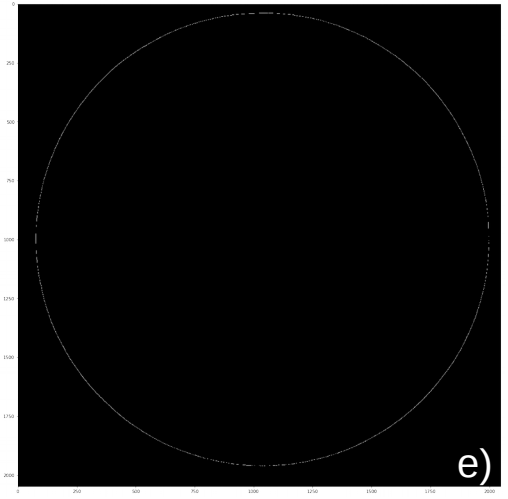




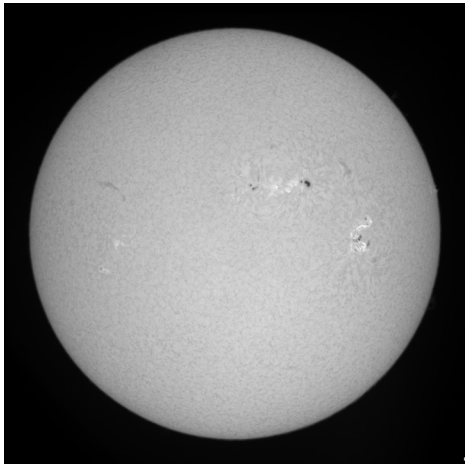


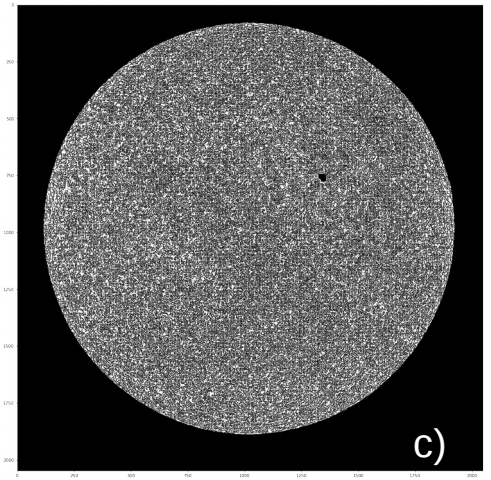


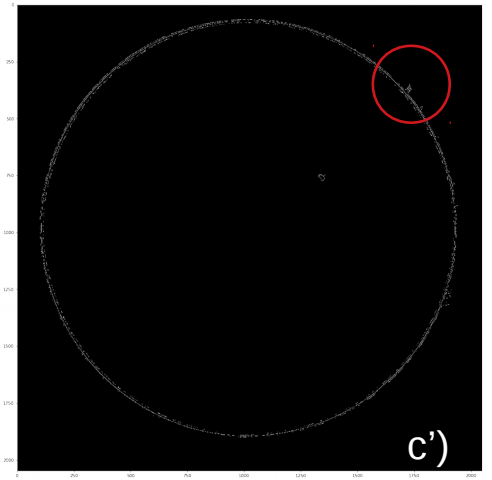


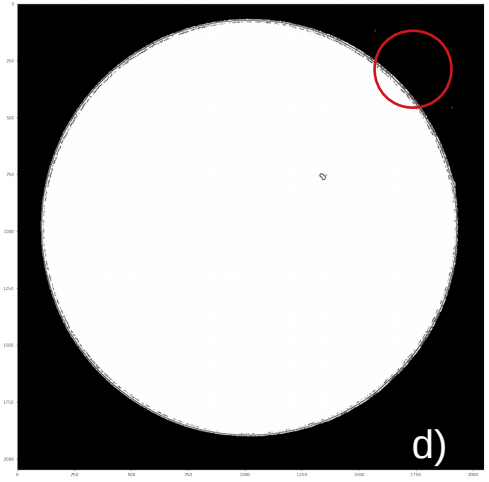


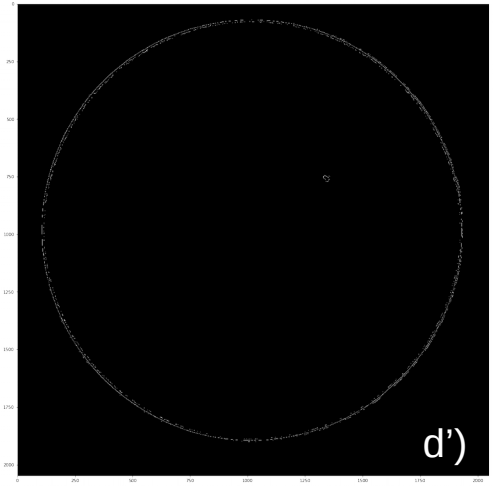
Solar disk detection: illustration for H-alpha

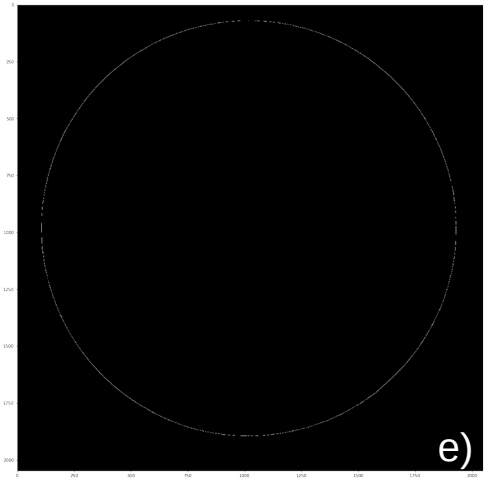




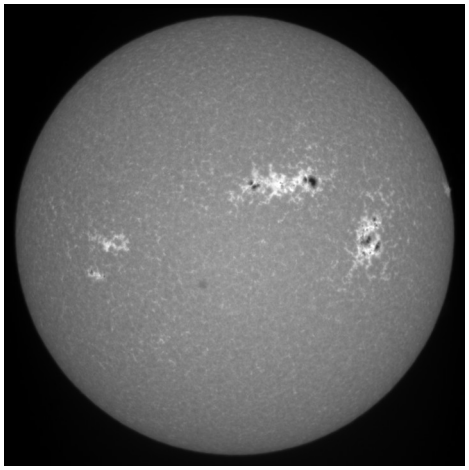


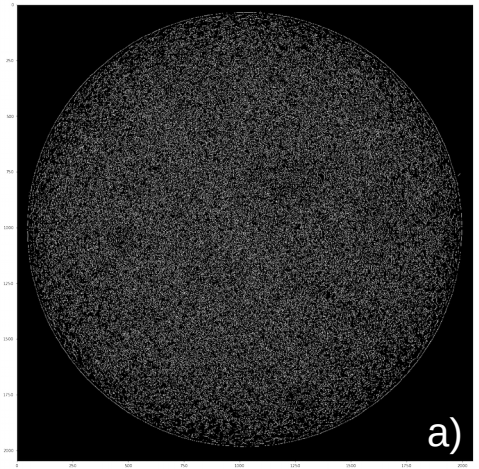


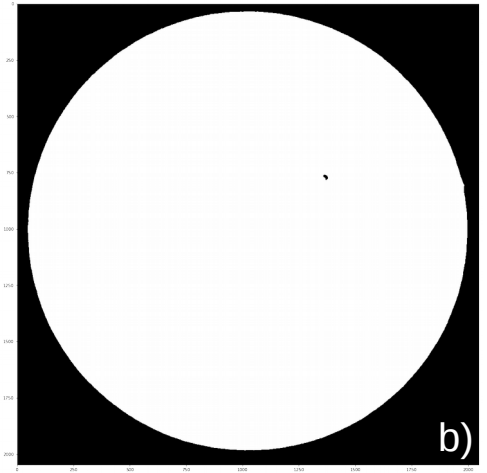


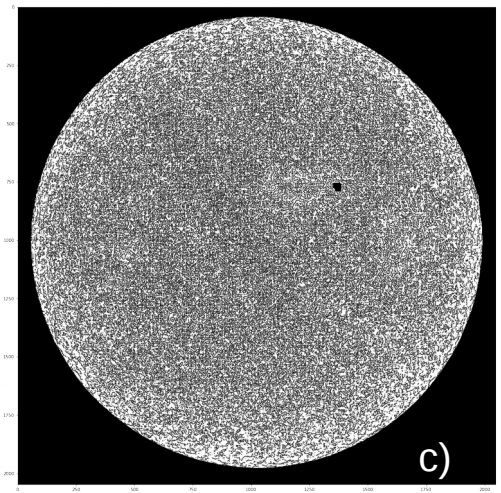


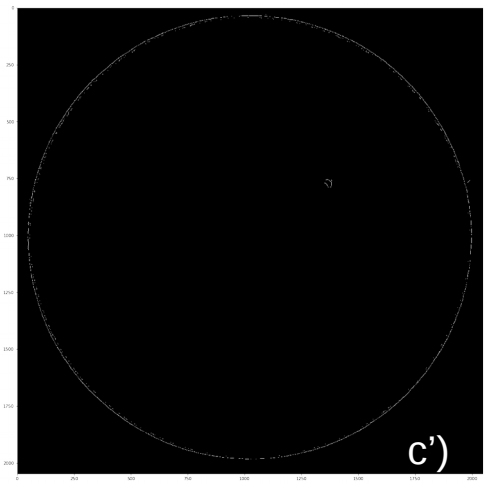
Solar disk detection: illustration for Ca II K

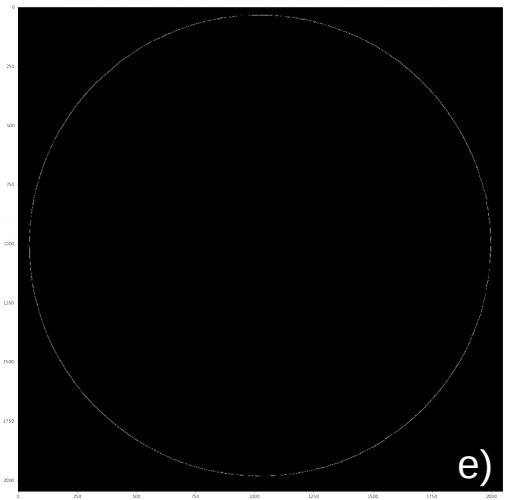












Limb darkening

Goals

- Three wavelengths
- Robust for different observation conditions

Method

a) Cartesian to polar transformation

→ rectangular grid where the columns contain samples at fixed radius and row at fixed angles

b) Polynomial fit intensity versus the radius

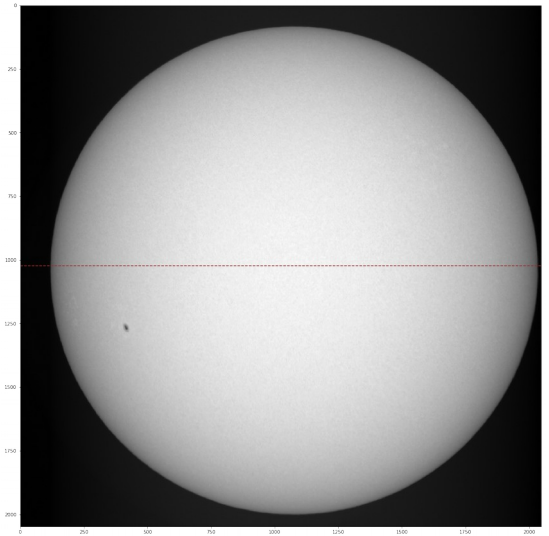
→ mask of the radial background

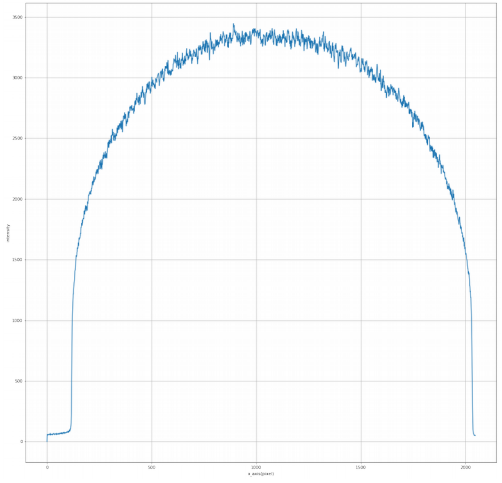
c) Divide the original image by the mask of the radial background

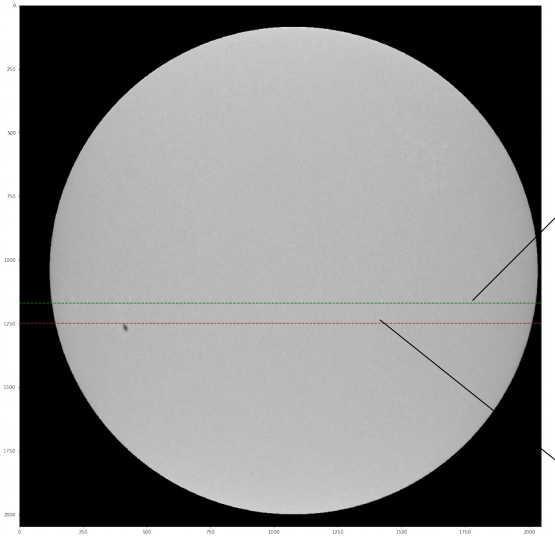
Current status

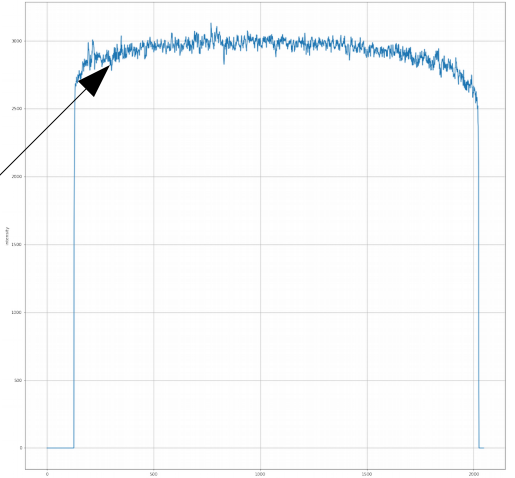
- The general idea works well for the three wavelengths with good atmospheric transparency
- Test on more statistics (quiet/active sun, different observation conditions)
- Working on cases with non radial variations (i.e. clouds) → could be useful for image homogenization

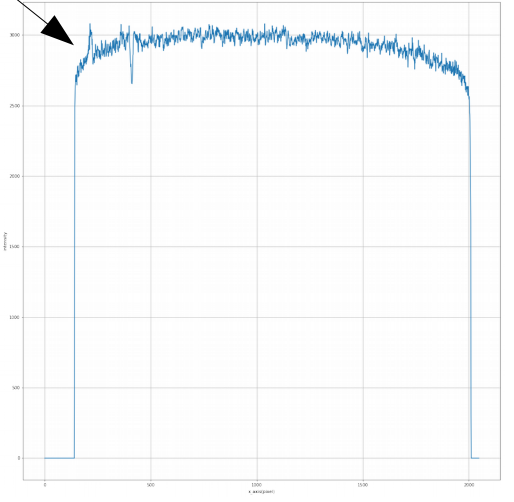
Limb darkening: Illustration for white-light





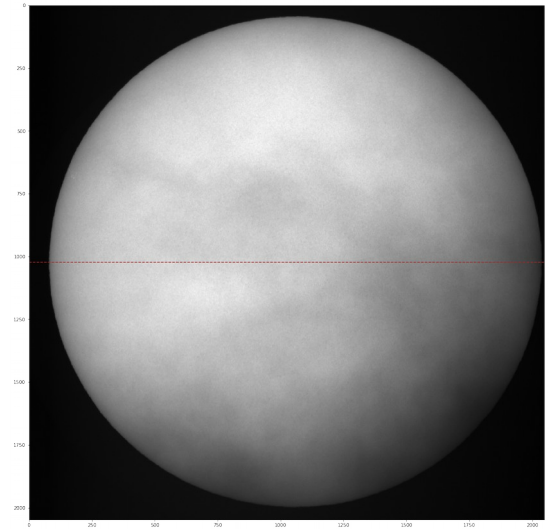


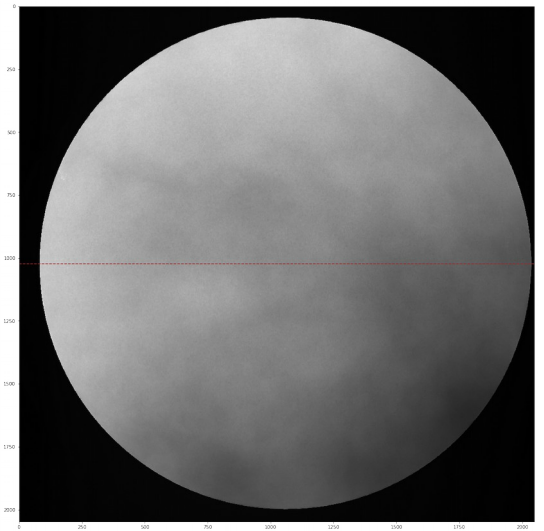


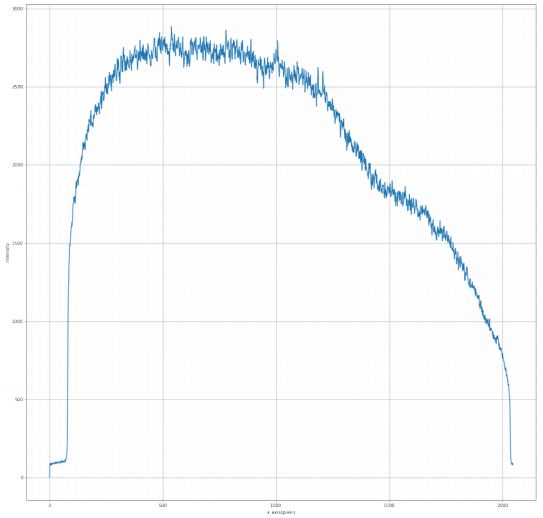


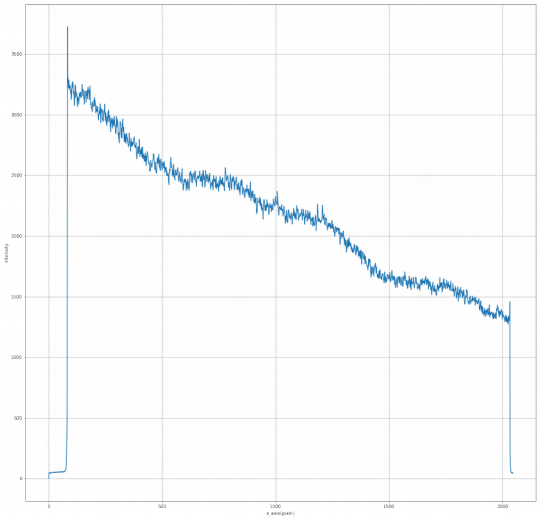
- Contribution to limb darkening highly suppressed
- Try more iterations to remove the remaining radial variation

Limb darkening: Illustration for white light and **clouds**



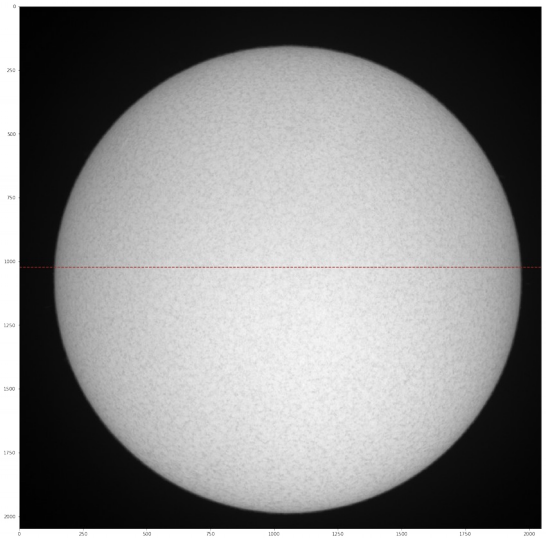


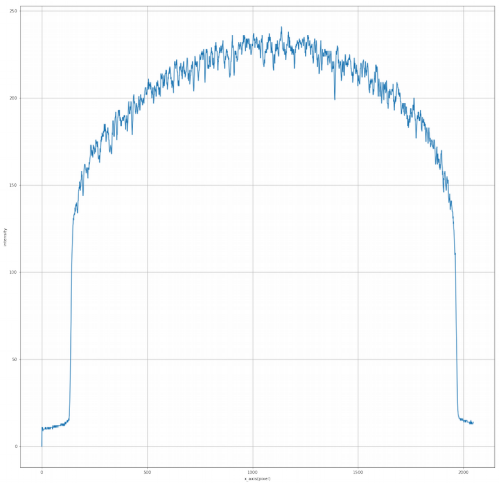


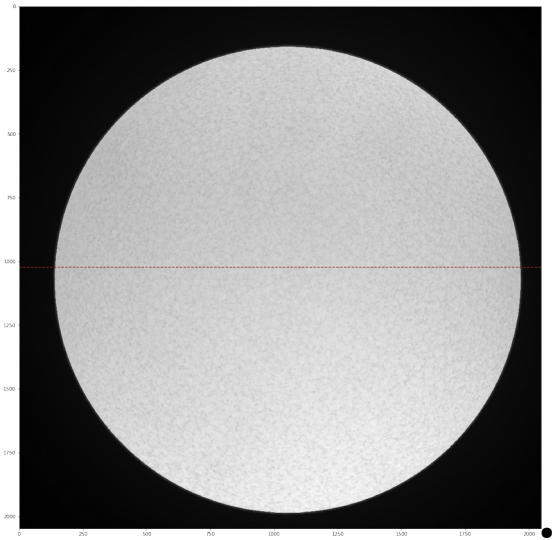


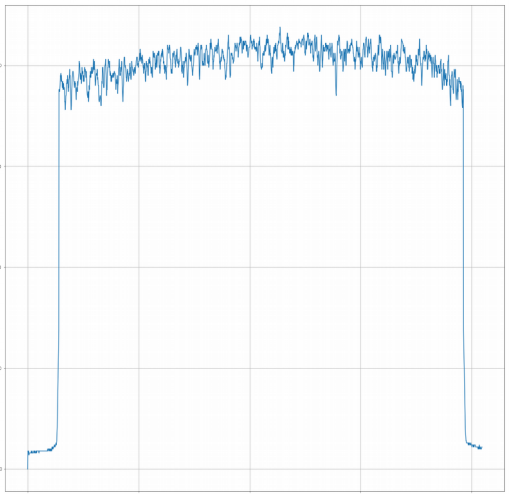
- What remains after the limb darkening removal is essentially the intensity variation due to the clouds
- Currently working on method to decrease this contribution (bilinear fit of the intensity variation, high-pass filter, ..)

Limb darkening: Illustration for H-alpha



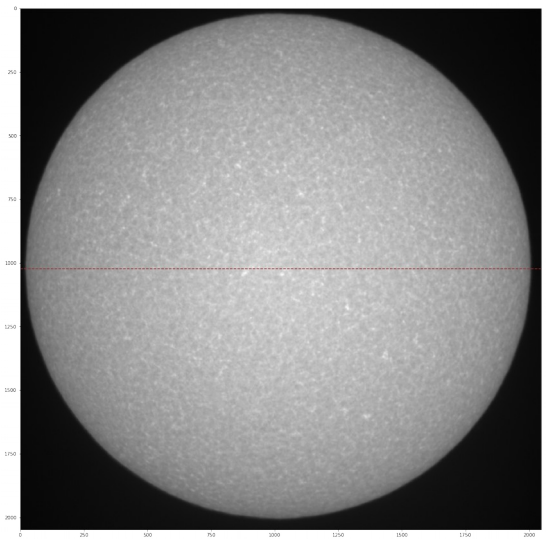


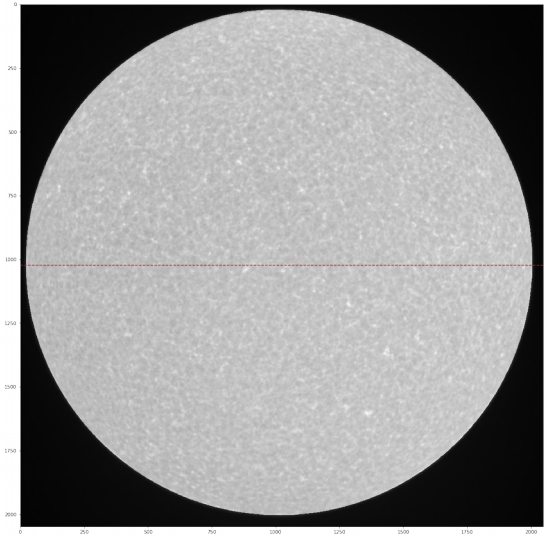


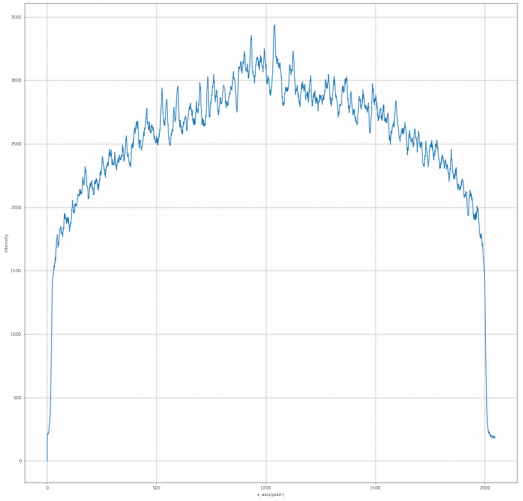


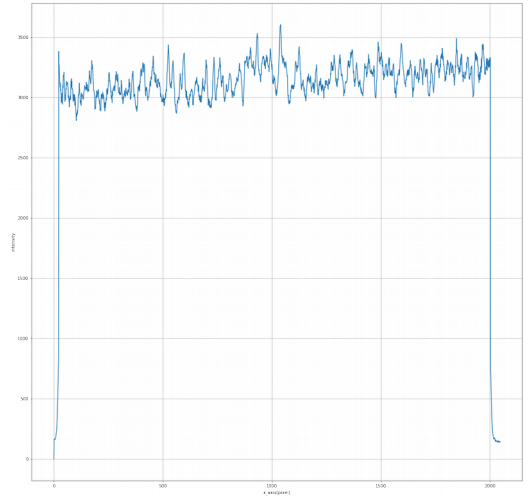
- Contribution to limb darkening highly suppressed
- Try more iterations to remove the remaining radial variation
- Presence of non radial contribution

Limb darkening: Illustration for Ca II k









- Contribution to limb darkening highly suppressed

Image homogenization: general ideas

Each station has specific set-up:

- Optical : f/D, optical aberration
- Filters : Bandpass and bandwith
- Imaging : CCD size, noise
- Atmospheric : Transparency, seeing

Algorithms to homogenize images taken at different station with the main aim to provide continuous, unified and high-quality observing sequence

Evolved products:

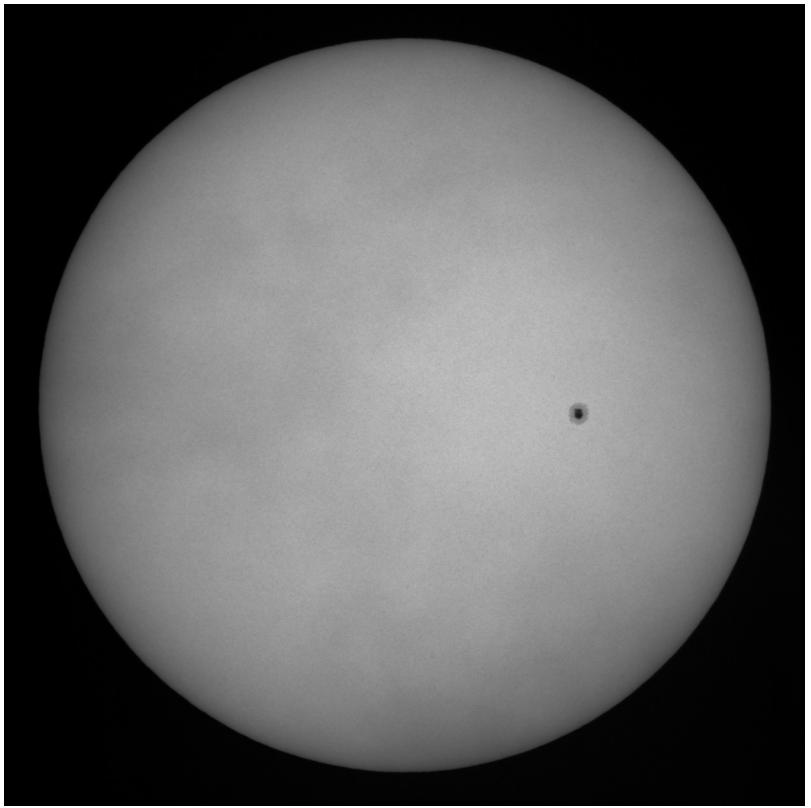
- Flare/event detection
- Solar feature detection (filament, etc..) and their statistical properties
- high cadence movies
- synoptic maps

Image homogenization: general ideas

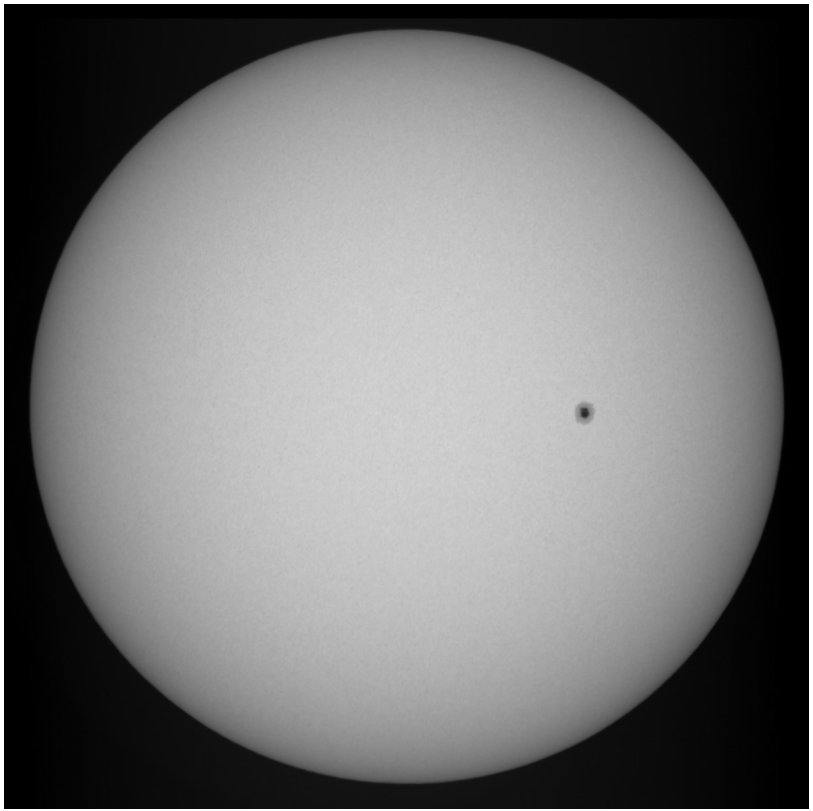
- First step: systematic exploration of images from different stations (ex USET & KSO)
  - identification of the main sources of inhomogeneity
- Joint campaing involving different stations, and concentrating on one varying parameter at a time
  - Isolate the inhomogeneity
  - Model it and develop a dedicated correction

Image comparison: White-light

KSO 20190415 08:34:24



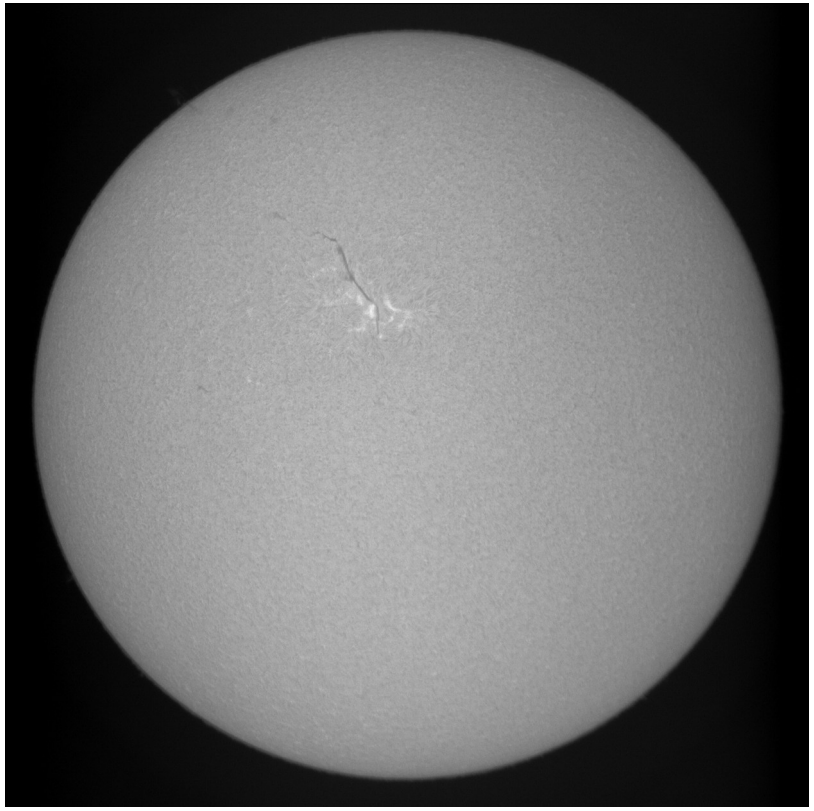
USET 20190415 08:15:00



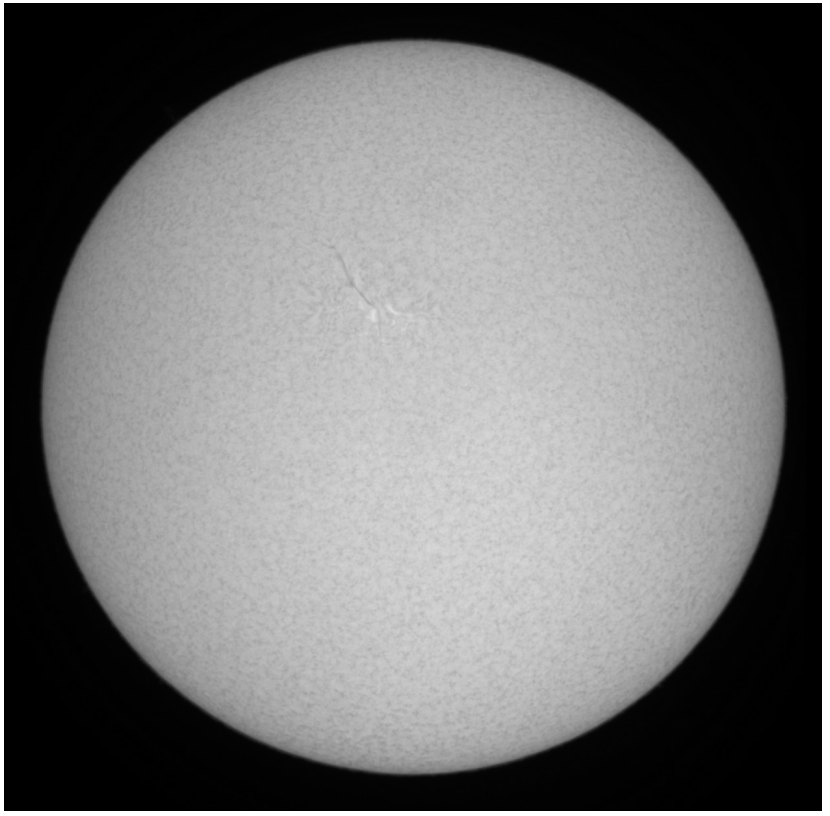
- Disk size different → geometrical transformation
- Check the co-alignment
- Observing condition different (presence of clouds) → atmosphere transparency correction

Image comparison: H-alpha

KSO 20190219 10:24:39



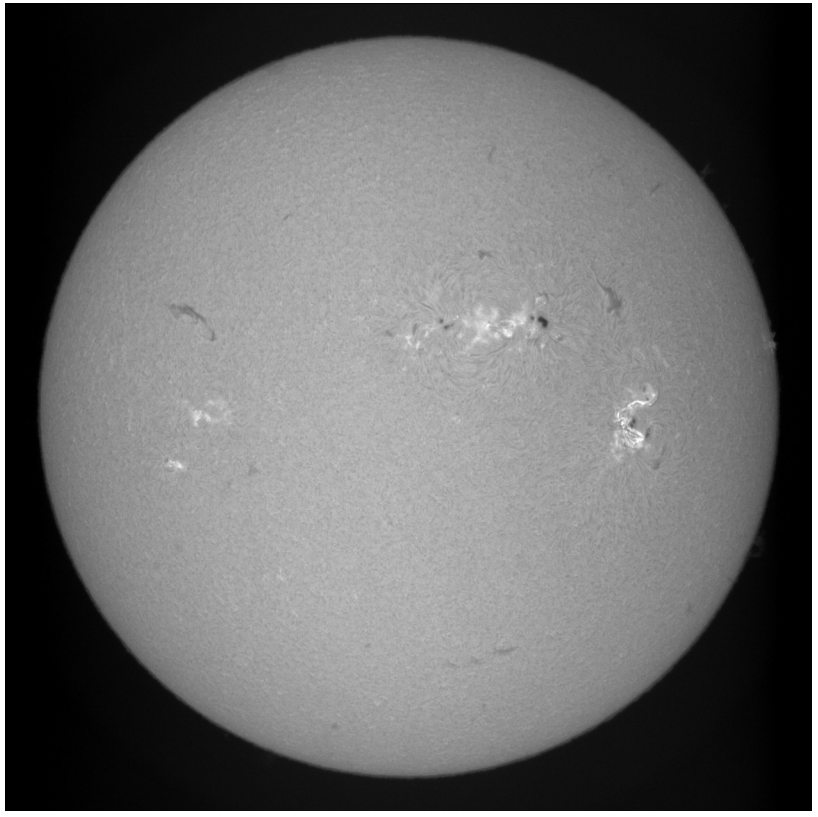
USET 20190219 10:24:40



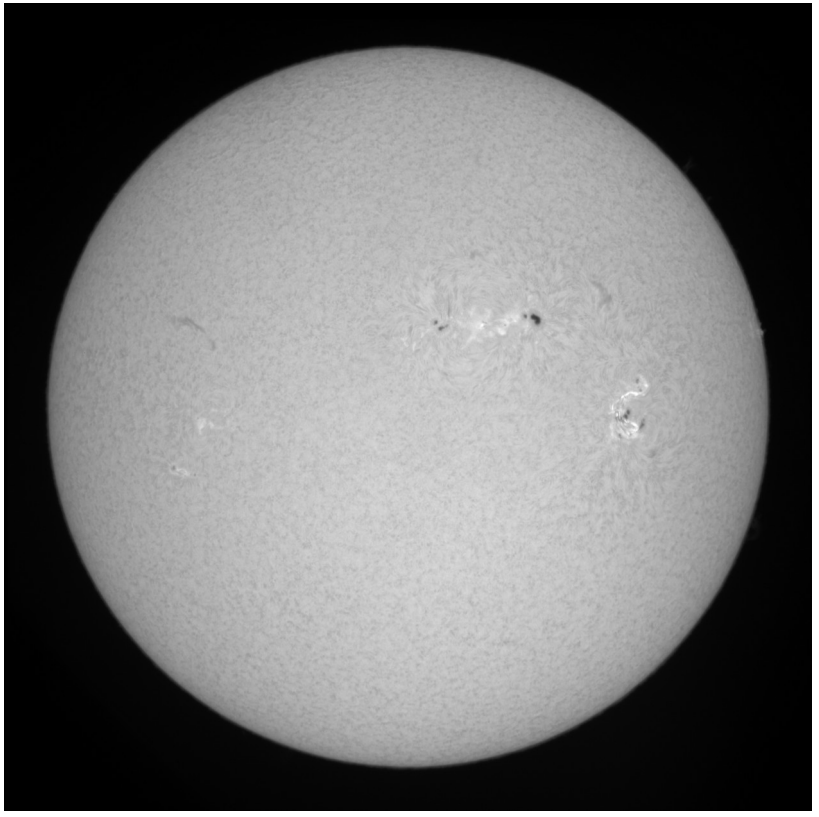
- Disk size different → geometrical transformation
- Filament more contrasted on KSO image and surface structure different → different band-pass/bandwidth ?

Image comparison: H-alpha

KSO 20170906 08:22:55



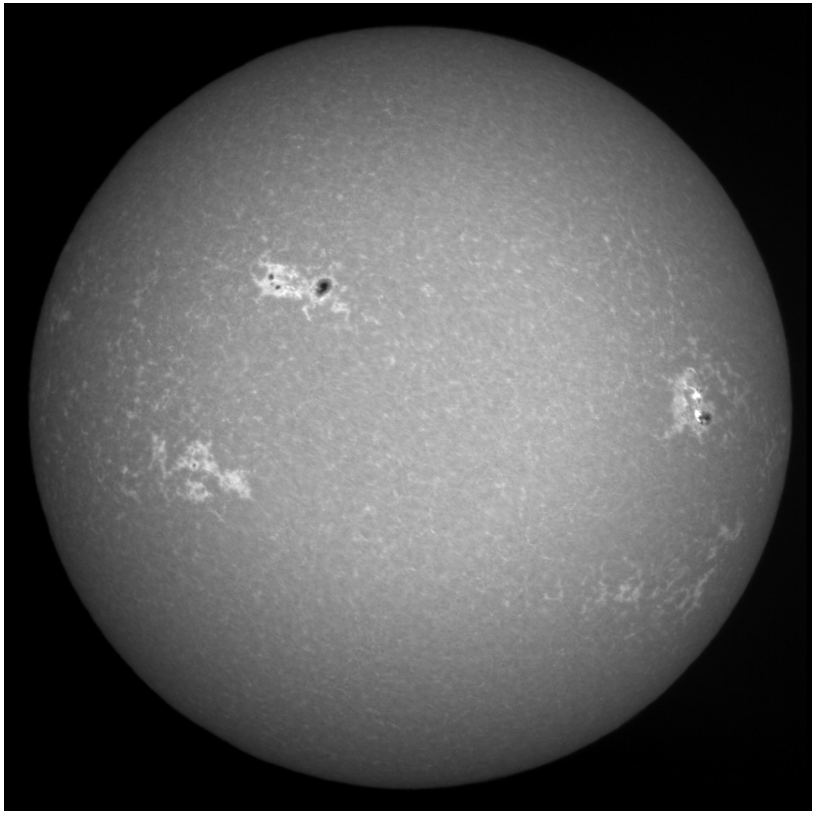
USET 20170906 08:12:17



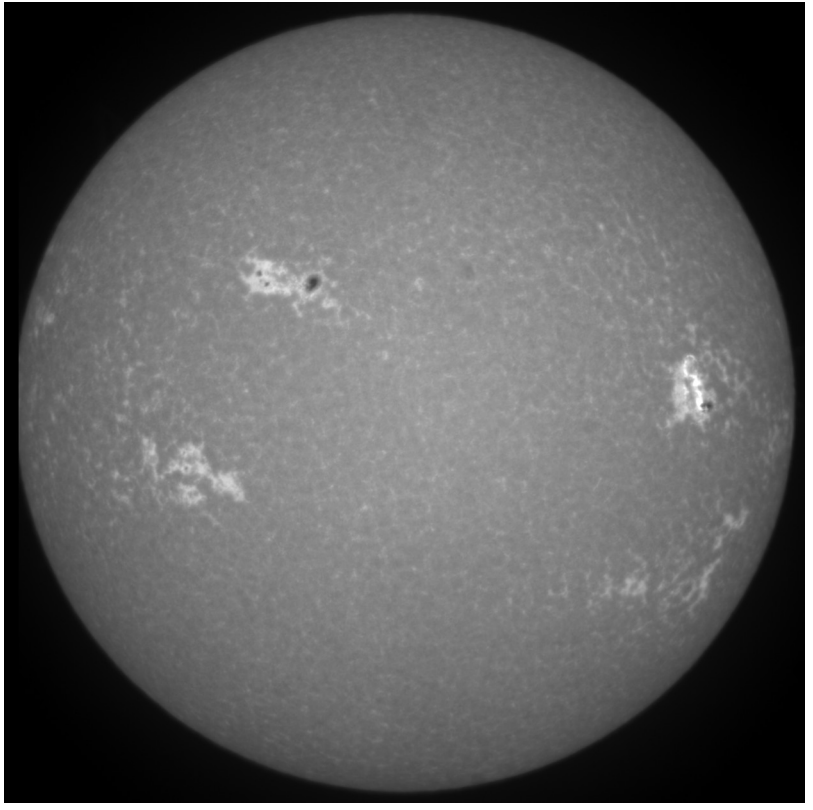
- Disk size different → geometrical transformation
- Filament more contrasted on KSO image and surface structure different → different band-pass/bandwidth ?

Image comparison: Ca II K

KSO 20160128 11:57:40

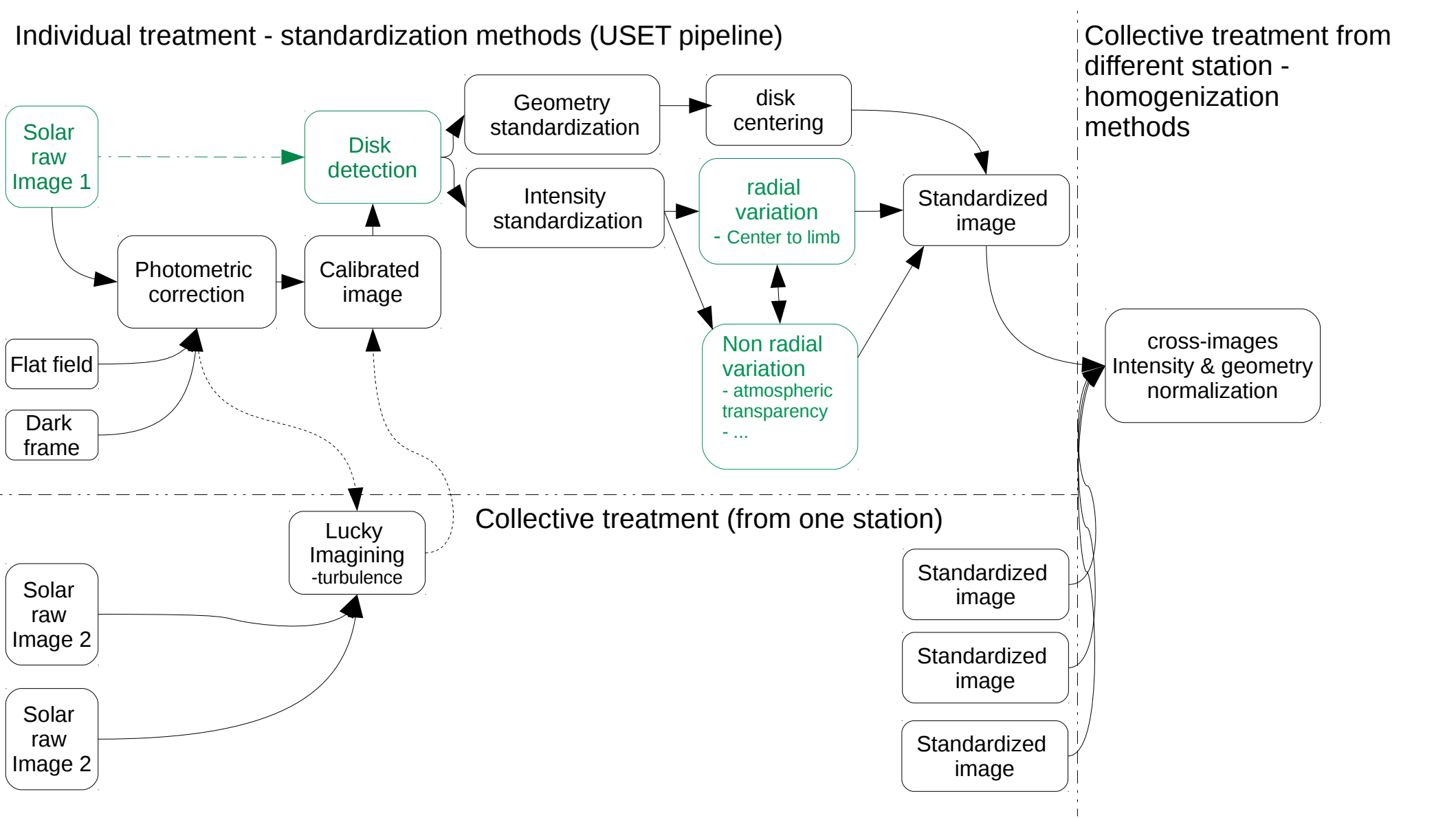


USET 20170128 12:00:17



- Disk size different→ geometrical transformation
- Observing condition different → atmosphere transparency correction

Back-up slides


Individual treatment - standardization methods (USET pipeline)
Collective treatment from different station - homogenization methods
Solar raw Image 1
Disk detection
Geometry standardization
disk centering
Intensity standardization
radial variation
- Center to limb
Standardized image
Photometric correction
Calibrated image
Flat field
Dark frame
Non radial variation
- atmospheric transparency
- ...
cross-images Intensity & geometry normalization
Collective treatment (from one station)
Lucky Imagining
-turbulence
Solar raw Image 2
Solar raw Image 2
Standardized image
Standardized image
Standardized image

Determination of the solar disk center

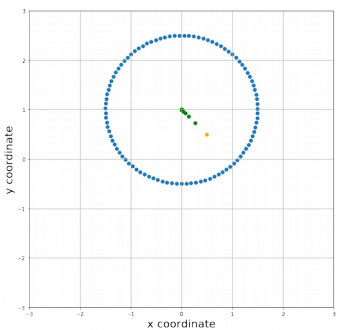
Goals

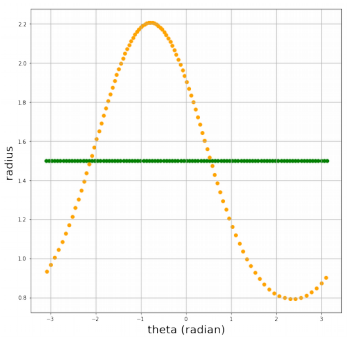
- Three wavelengths
- Robust for different observation conditions

Method

a) First guess of the center position

b) Centroid search





Current status

- Operational for USET