In February 2013, we have observed the comet ISON on three dates in R and I filters, using 2-m HCT telescope of IIA, Hanle, India:

2013-02-19
2013-02-21
2013-02-22

On these dates, the weather was very bad with heavy clouds and the Moon, and though we took many exposures, on most of the frames the comet is not seen. For example, on 19th February, the background was ~11,000 counts, while the comet was only ~200 counts above the b/g with seeing >7 arcsec. On 21st February, the b/g was ~2,800 and the comet of ~400 above the b/g, with seeing ~7 arcsec. Though we have taken 14 exposures, only on one frame (wb210021.fits) the comet is very clearly seen. On 22nd Feb, out of total 31 exposures in R, only 6 are good. We have reduced only those images where the comet can be clearly seen. But for the sake of completeness, we present here all frames where the comet can be seen, even if barely – these can be useful for the astrometry of the comet.

This dataset contains the following subdirectories with following data in the directories:

Imaging/February19/:

Raw/:

Comet images	**filter**	**exposure (sec)**
wb190042.fits	I	30.000
wb190043.fits	I	30.000
wb190044.fits	I	200.000
wb190045.fits	I	300.000

Biases:

wb190001.fits	"1 Free"	0.000
wb190017.fits	"1 Free"	0.000
wb190058.fits	"1 Free"	0.000
wb190059.fits	"1 Free"	0.000
wb190076.fits	"1 Free"	0.000
wb190078.fits	"1 Free"	0.000
wb190103.fits	"1 Free"	0.000
wb190154.fits	"1 Free"	0.000

Sky flats:

wb190014.fits	I	10.000
wb190015.fits	I	20.000
wb190016.fits	I	35.000

Calibration/:

19f_zero.fits	Master Bias
19f_flati.fits	Master Flat in I
ScienceCombine.fits	Illumination Correction Frame

Processed/:

`cc' - means cosmic ray cleaned, `f' - flat-fielded and `b' – de-biased, 'ic' -- illumination-corrected

fbwb190042.fits	ccfbwb190042.fits	icccfbwb190042.fits
fbwb190043.fits	ccfbwb190043.fits	icccfbwb190043.fits
fbwb190044.fits	ccfbwb190044.fits	icccfbwb190044.fits
fbwb190045.fits	ccfbwb190045.fits	icccfbwb190045.fits

Documentation/:

Feb19preprocessing.cl	-	Preprocessing IRAF code
cosmic_rays.cl	-	IRAF code for cosmic rays removal

Imaging/February21/:

Raw/:

Comet images	filter	exposure (sec)
wb210021.fits	R	60.000
wb210022.fits	R	150.000
wb210023.fits	R	60.000
wb210024.fits	R	100.000
wb210025.fits	R	100.000
wb210026.fits	R	100.000
wb210027.fits	I	100.000
wb210028.fits	I	200.000
wb210029.fits	R	200.000
wb210030.fits	R	200.000
wb210031.fits	R	200.000
wb210032.fits	R	200.000
wb210033.fits	R	125.000
wb210034.fits	R	125.000
Biases:		
wb210001.fits	"1 Free"	0.000
wb210017.fits	"1 Free"	0.000
Sky flats:		
wb210011.fits	R	3.200
wb210012.fits	R	5.200

wb210013.fits	R	9.000
wb210014.fits	I	10.000
wb210015.fits	I	15.000
wb210016.fits	I	32.000

Calibration/:

21f_zero.fits	Master Bias
21f_flati.fits	Master Flat in I
21f_flarR.fits	Master Flat in R
ScienceCombineR4.fits	Illumination Correction Frame

Processed/:

`cc' - means cosmic ray cleaned, `f' - flat-fielded and `b' - de-biased, 'ic' -- illumination-corrected

fbwb210021.fits	ccfbwb210021.fits	icRccfbwb210021.fits
fbwb210022.fits	ccfbwb210022.fits	icRccfbwb210022.fits
fbwb210023.fits	ccfbwb210023.fits	icRccfbwb210023.fits
fbwb210024.fits	ccfbwb210024.fits	icRccfbwb210024.fits
fbwb210025.fits	ccfbwb210025.fits	icRccfbwb210025.fits
fbwb210026.fits	ccfbwb210026.fits	icRccfbwb210026.fits
fbwb210027.fits	ccfbwb210027.fits	-
fbwb210029.fits	ccfbwb210029.fits	icRccfbwb210029.fits
fbwb210030.fits	ccfbwb210030.fits	icRccfbwb210030.fits

Document/:

preprocessing.cl	-	Preprocessing IRAF code

Imaging/February22/:

Raw/:

Comet images	**filter**	**exposure (sec)**
wb220034.fits	R	100.000
wb220046.fits	R	150.000
wb220047.fits	R	150.000
wb220048.fits	R	150.000
wb220049.fits	R	150.000
wb220050.fits	R	150.000

Biases:

wb220001.fits	"1 Free"	0.000
wb220017.fits	"1 Free"	0.000

Sky flats:

wb220011.fits	R	3.500
wb220012.fits	R	5.500
wb220013.fits	R	8.500

Calibration/:

22f_zero.fits	Master Bias
22f_flatr.fits	Master Flat in R

Processed/:

`cc' - means cosmic ray cleaned, `f' - flat-fielded and `b' – de-biased, 'r' – means aligned – registered on the comet.

fbwb220034.fits	ccfbwb220034.fits	rccfbwb220034.fits
fbwb220046.fits	ccfbwb220046.fits	rccfbwb220046.fits
fbwb220047.fits	ccfbwb220047.fits	rccfbwb220047.fits
fbwb220048.fits	ccfbwb220048.fits	rccfbwb220048.fits
fbwb220049.fits	ccfbwb220049.fits	rccfbwb220049.fits
fbwb220050.fits	ccfbwb220050.fits	rccfbwb220050.fits

Document/:

preprocessing.cl	-	Preprocessing IRAF code

HFOSC CCD characteristics and Reduction procedure:

CCD:

Photometric data was obtained on February 19, 21 and 22, 2013, using the Himalayan Faint Spectrograph and Camera (HFOSC) mounted on the 2.0-m HCT of the Indian Astrophysical Observatory (IAO) of the Indian Institute of Astrophysics (IIA), located at 4500 m above sea level, Hanle, Leh, Ladakh.
HFOSC is equipped with a Thompson CCD of 2048x2048 pixels with a pixel scale of 0.296”/pix and a field of view of ~10x10 arcmin. The readout noise, gain and readout time of the CCD are 4.87 e, 1.22 e/ADU, and 90 sec, respectively.

Reduction Procedure.

Basic reduction was performed by using IRAF-based script that employs IRAF procedure *ccdproc*, and includes trimming the frames to [500:1500,500:1500], *zerocombine* for bias subtraction, and *flatcombine* for flat-fielding. The code creates Master bias frame called **Zero.fits**, and Master flat frames for each filter: **FlatI.fits** and **FlatR.fits.** Since on these dates, there was a frost on the windows due to very low temperatures (-22C), we have tried to remove the background by median combining science frames to create an `illumination correction' frame **ScienceCombine.fits,** and dividing every science frame by it. The code

preprocessing.cl used on each date is attached. Cosmic rays were removed using IRAF-based script that employs IRAF task *crmedian*. The code ***cosmic_rays.cl*** is attached.
Due to the bad weather, many calibration frames were unusable for the preprocessing. Since this CCD is very stable over the course of few days, we have combined the good calibration frames from each of these dates, and used them for preprocessing:

On February 19th, we have supplemented the flat frames with good quality flats from 21st February:
wb210014.fits
wb210015.fits
wb210016.fits

On February 21st, we have used additional biases from 19th February:
wb190001.fits
wb190017.fits
wb190057.fits
wb190058.fits
wb190059.fits
wb190078.fits

On February 22nd, all bias frames but one was corrupted, we have used additional biases from 19th and 21st February:
wb190001.fits
wb190017.fits
wb190057.fits
wb190058.fits
wb190059.fits
wb190078.fits
wb190130.fits
wb210001.fits
Similarly, we have added the flats frames from 21st February:
wb210011.fits
wb210012.fits
wb210013.fits

Alignment.

All images are aligned on the brightest part of the comet (optocentre) using IRAF procedure *imalign*. After debiasing and flat-fielding, we register the images on the brightest part of the comet as if it were a star. Since the images were taken very close in time, the focal length of the telescope did not change and a translation only is required. We find the brightest pixel, or the location of the peak brightness of the coma, using the IRAF task *imexamine* with the command that prints 11x11 grid of pixel values and integer coordinates. These integer coordinates and user-calculated shifts are supplied to the task as the initial estimate for each

image of the shift in each axis relative to the reference image. The sense of the shifts is such that: Xshift=Xref-Xin and Yshift=Yref-Yin. The task *imalign* will cause the image to be shifted such that the object is positioned at the same pixel location as in the reference. The IRAF task *imalign* measures the *x* and *y* shifts between a list of input images and a reference image, registers the input images to the reference image using the computed shifts, and trims the input images to a common overlap region (if required). The basic operation of the task is to find centres for the list of registration objects or features in the coordinate frame of each image and then to subtract the corresponding centres found in the reference image. In the final centering, all the sources are recentred in each image using the initial estimate of the relative shift for each image. The centroiding algorithm used here is *centroid*, *which* computes the intensity weighted mean and mean error of the centering box *x* and *y* marginal distributions using points in the marginal arrays above (below) the minimum (maximum) data pixel plus (minus) a threshold value. The centroid is calculated with respect to the level specified by background. The images are shifted using the *imshift* of the task *imalign* with `linear' interpolation function, where output image grey levels are determined by interpolating in the input image at the positions of the shifted output pixels. Note that *imshift* task does not calculate the shifts; this is done by the centroiding algorithm of the task *imalign*, which is not limited by the initial integer inputs and can calculate sub-pixels shifts.