Localizing Auroras with ISS Imagery

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Problem:

Use ISS image sequences to determine camera orientation and extract aurora coverage on Earth

1st Attempt:
Brute Force Algorithm

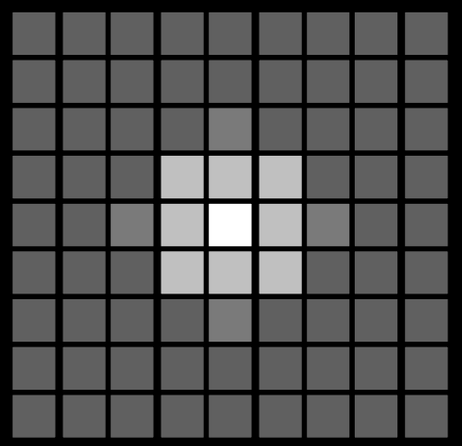
Brute force algorithm

Known bright star coordinates (RA, DEC)

Choose 3 parameters: RA, DEC, rotation angle (neglect plate constant distortion)

Spherical projection to (x, y) pixel coordinates

Star centroiding & hot pixel filtering algorithm



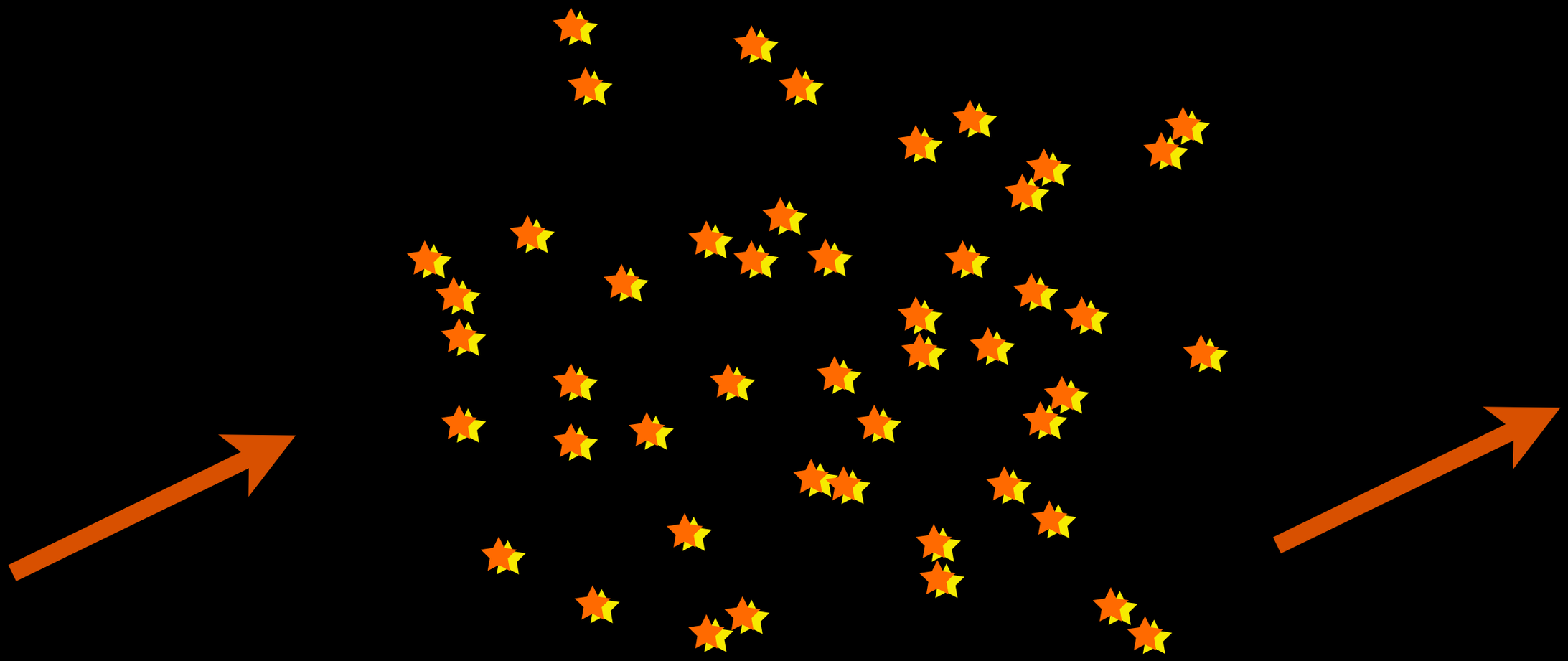
SNR Condition:
Mean (3x3 pixel box) > SNR x Median (9x9 pixel box)

(x, y) pixel coordinates of stellar centroids

Sum distances to nearest neighbour

3D least squares optimization

Resolution of least squares 3D search grid must be much smaller than the inter-stellar spacing



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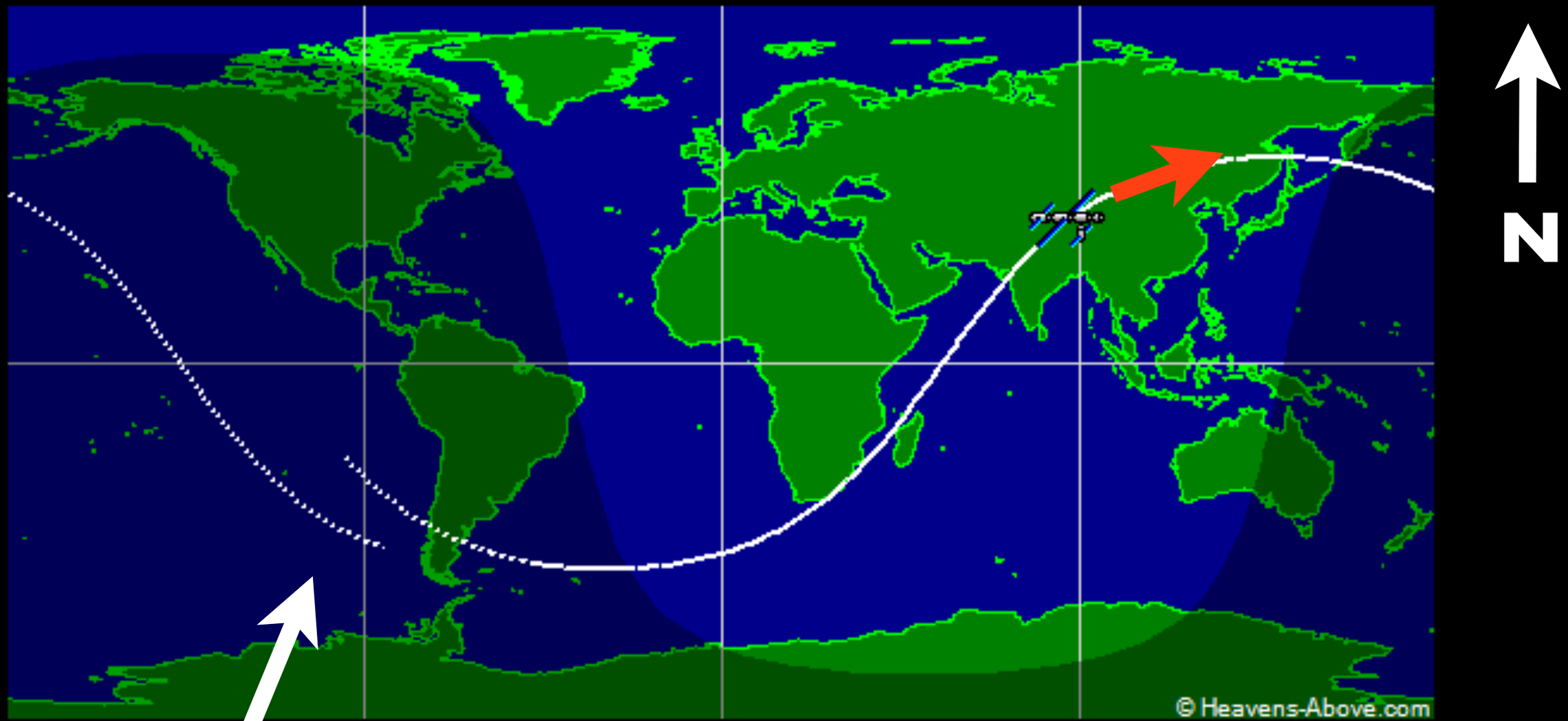
> 10^12 image centres must be searched for least squares optimization on 50 stars in 60 degree FOV

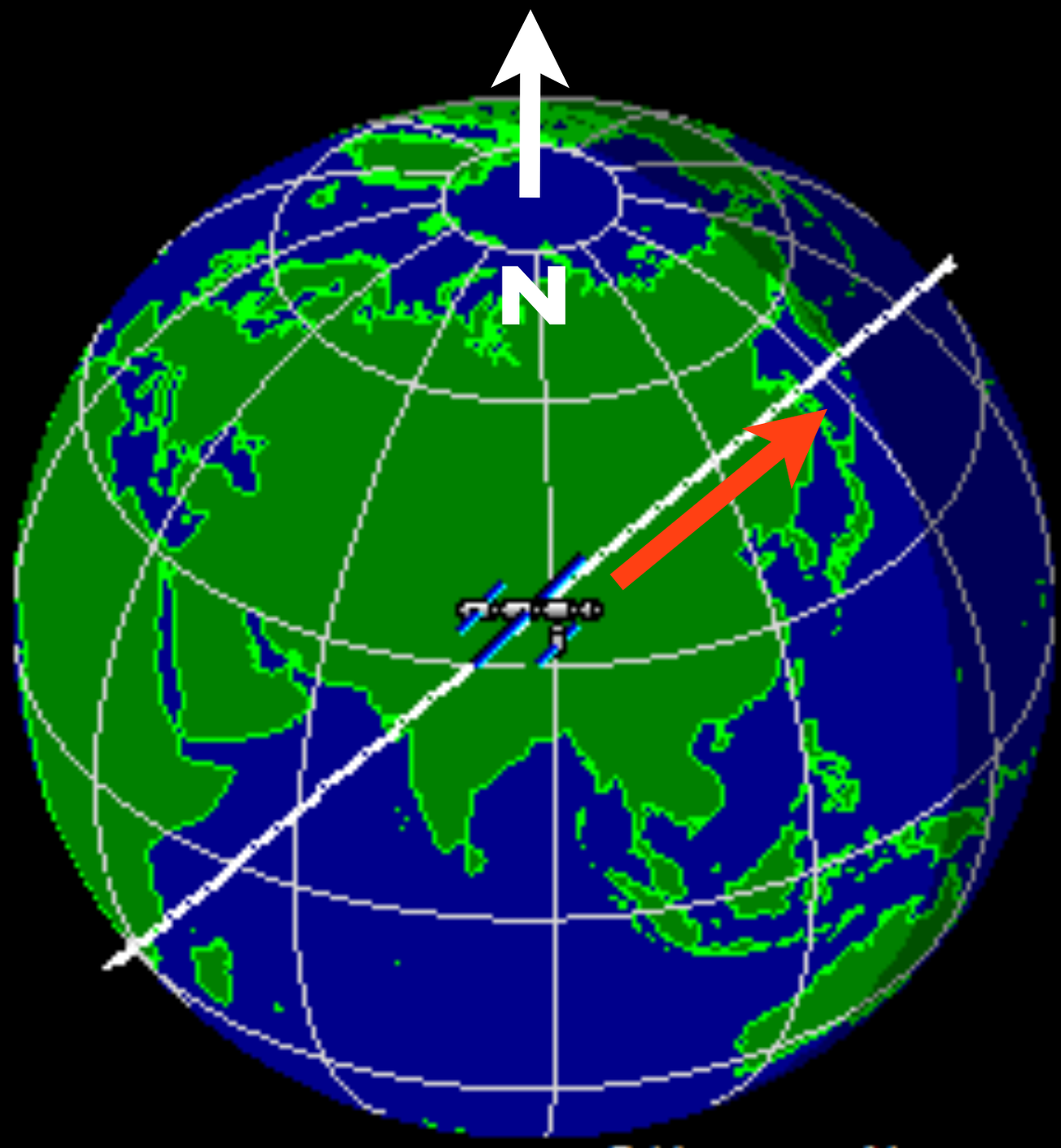
2nd Attempt: Incorporation of time domain information

Geometry of Star Trails

ISS Orbit



Precession due to rotation of Earth during ~90 min ISS period



Direction of ISS velocity given by d/dt(nadir)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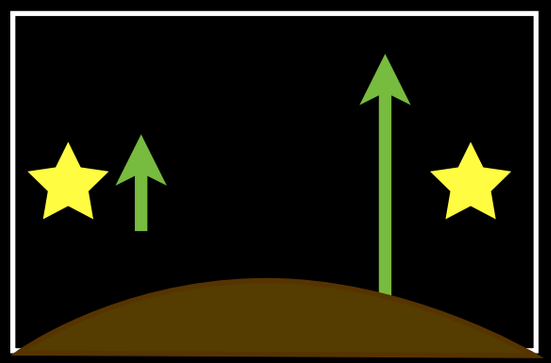
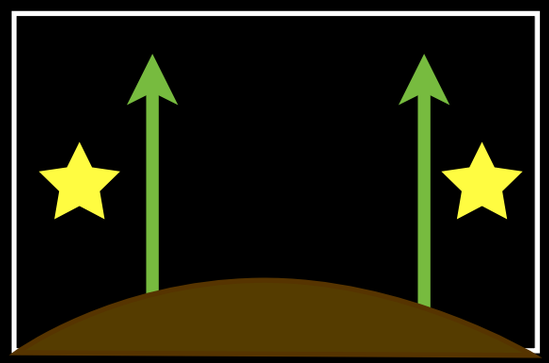
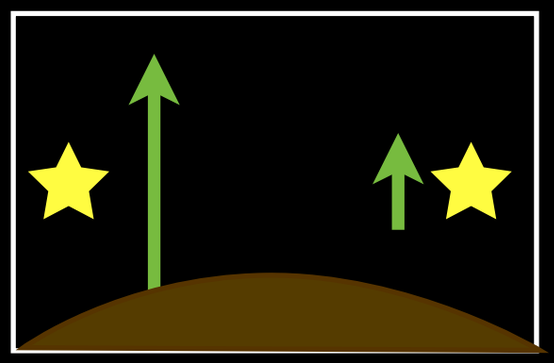
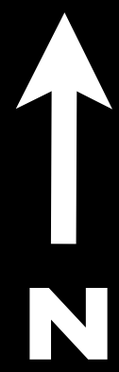
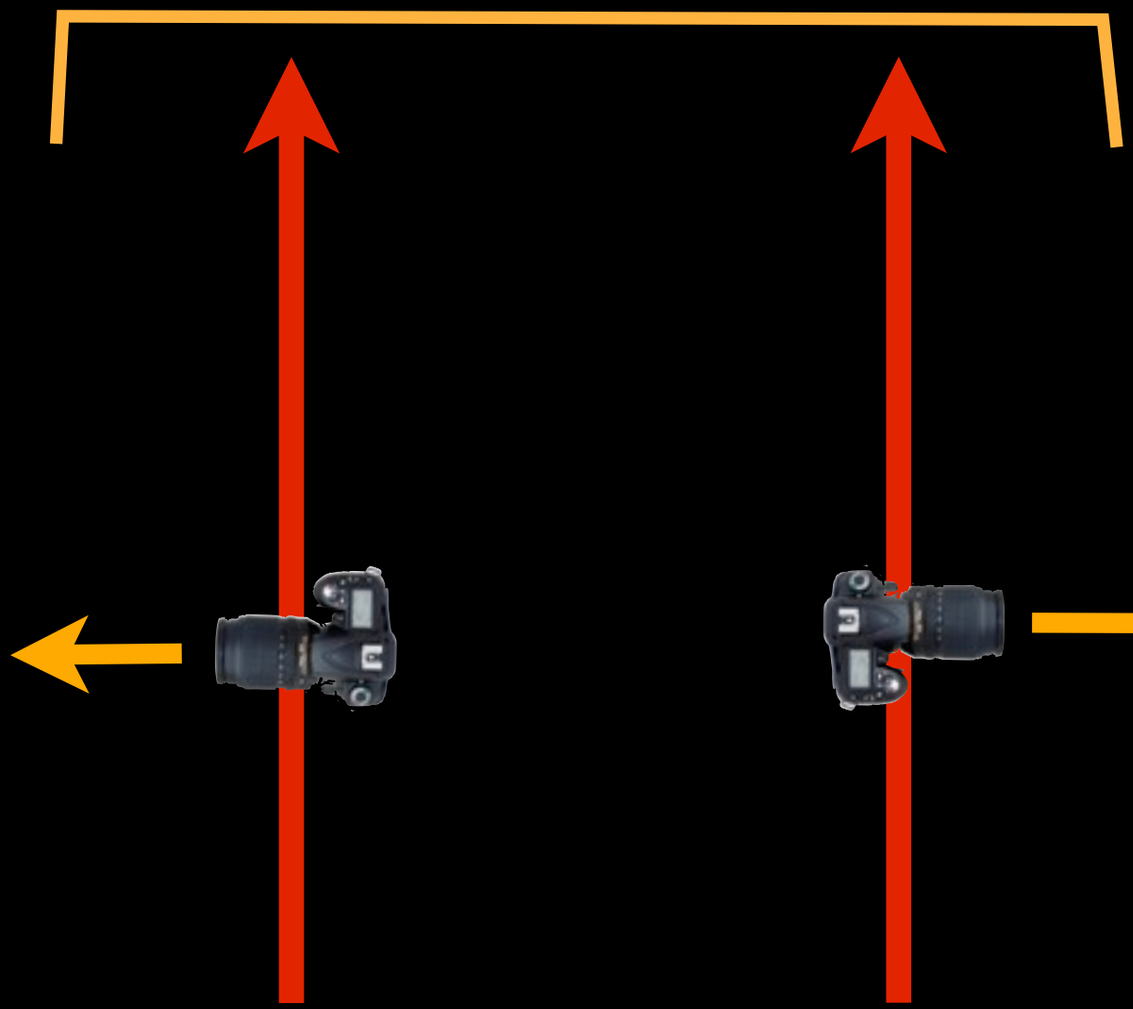


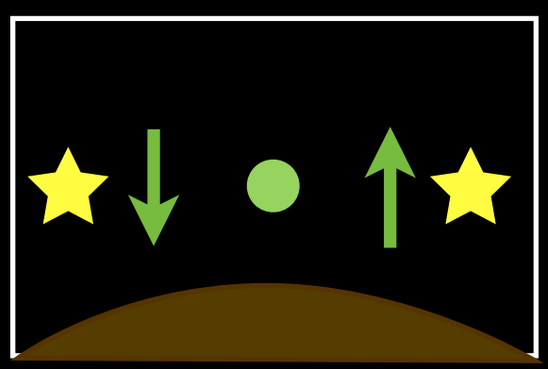


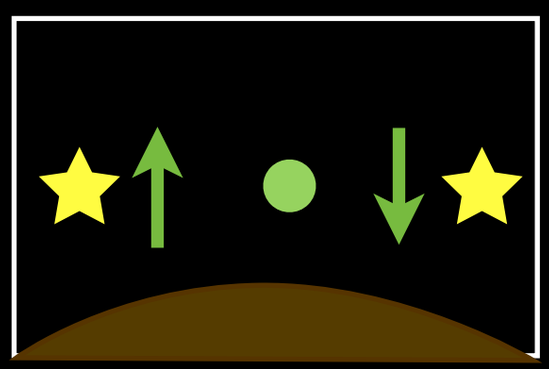


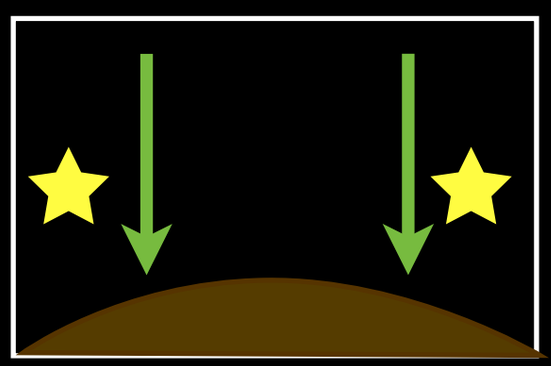

N

Points to ISS revolution axis







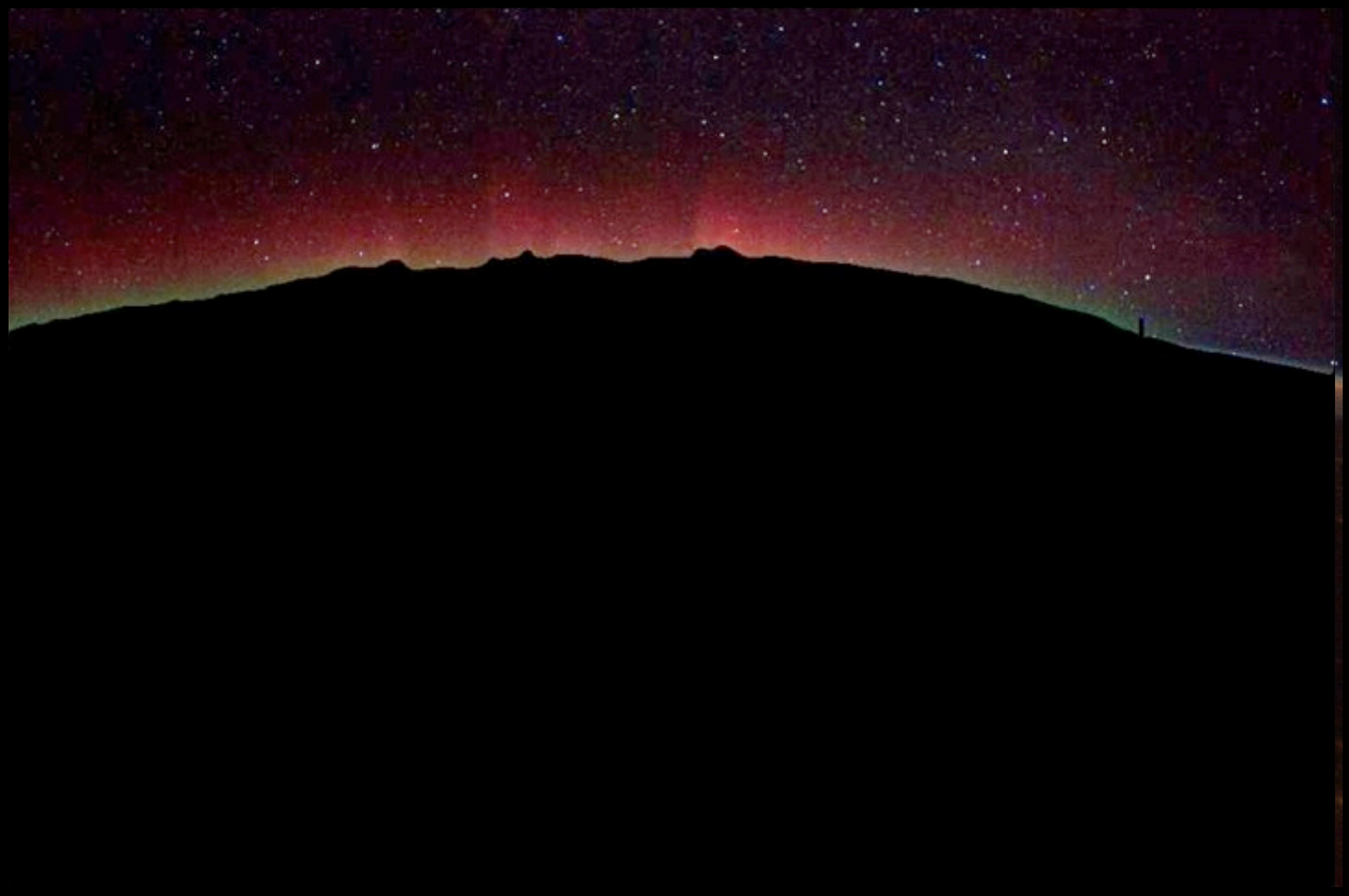


Star Trail Computational Method

Orientation via Star Trails

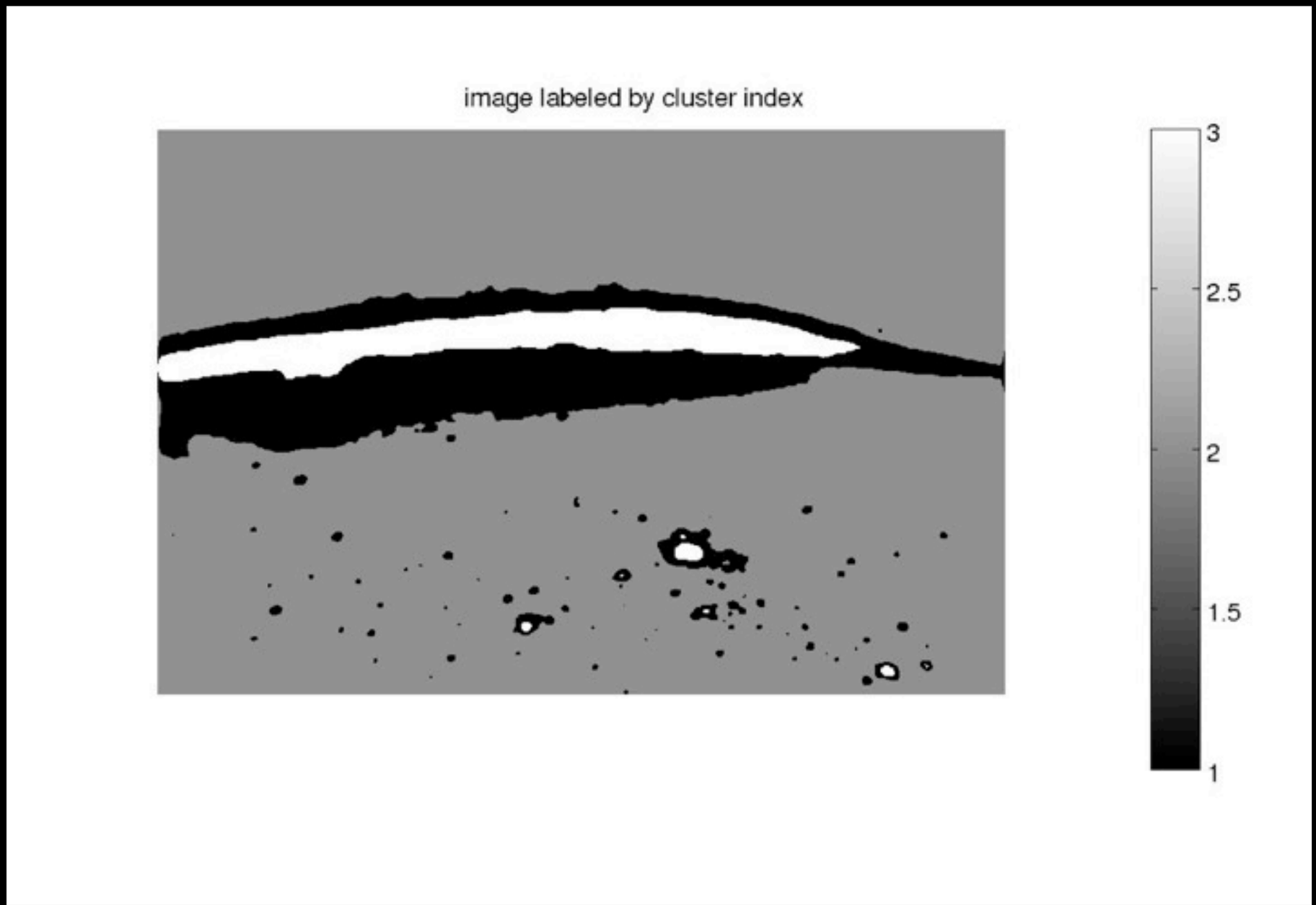
Remove Earth from image via K-means image segmentation

Orientation via Star Trails



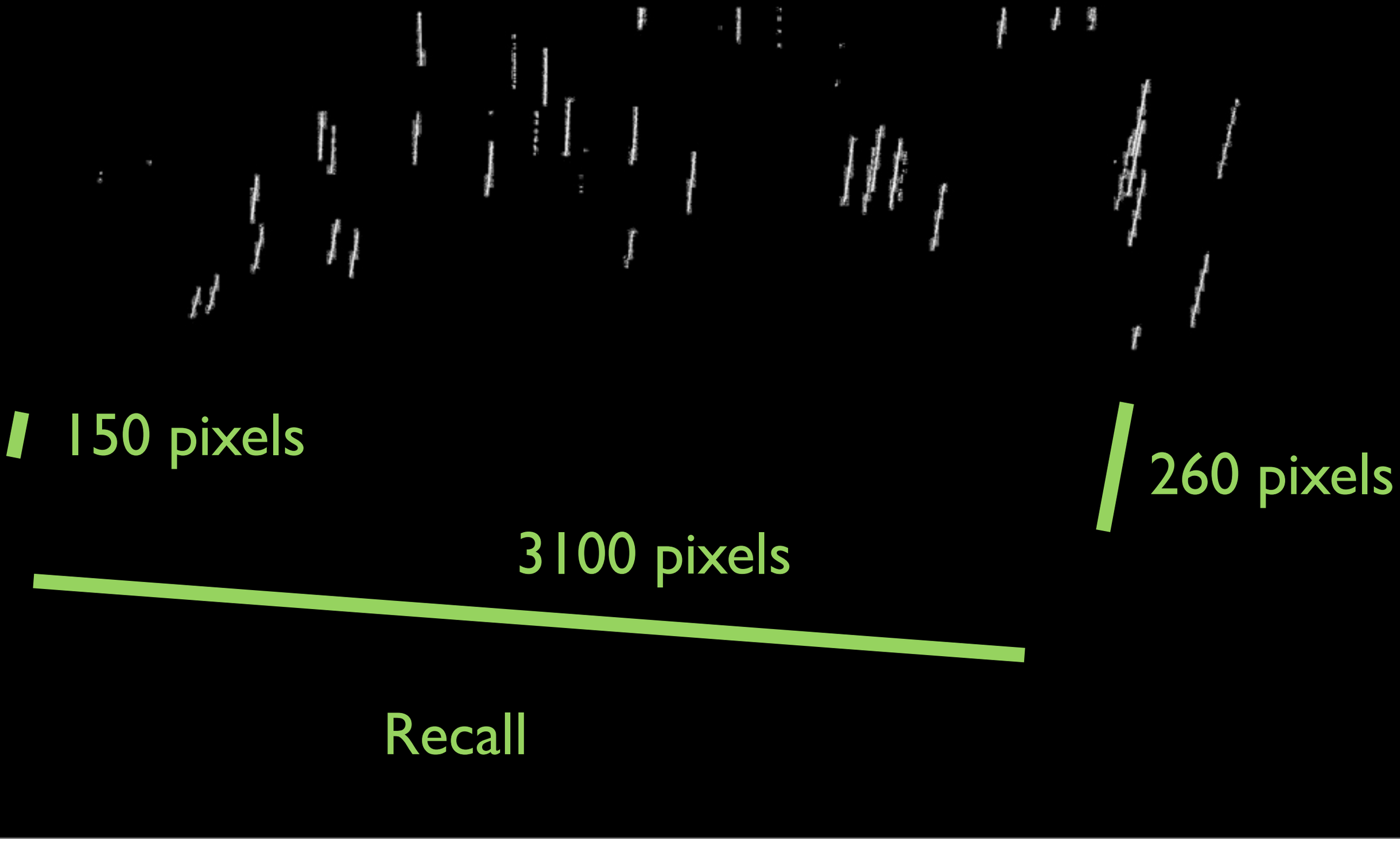
Remove Earth from image via K-means image segmentation

Orientation via Star Trails

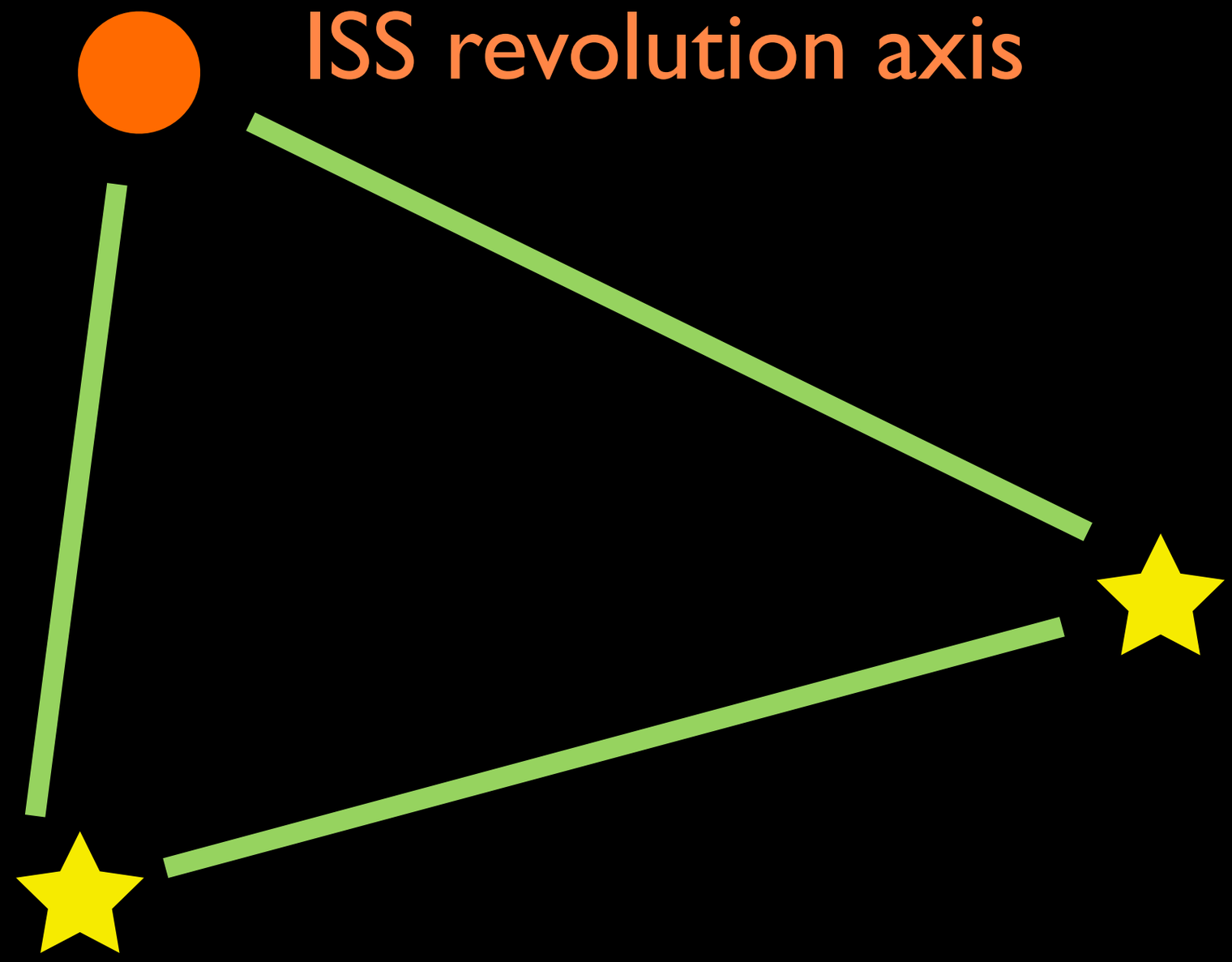


Remove Earth from image via K-means image segmentation

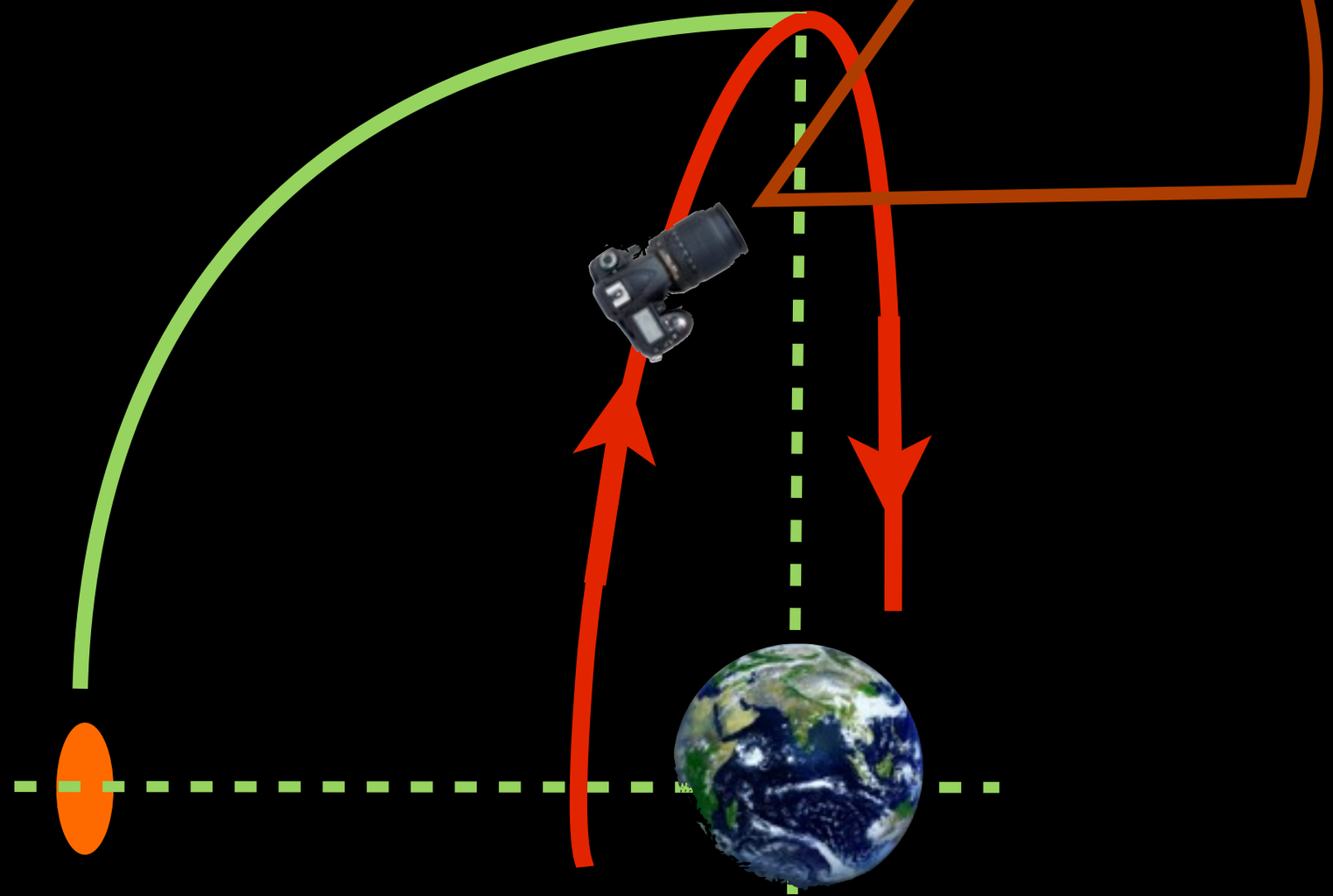
Star Trails



Star Trails

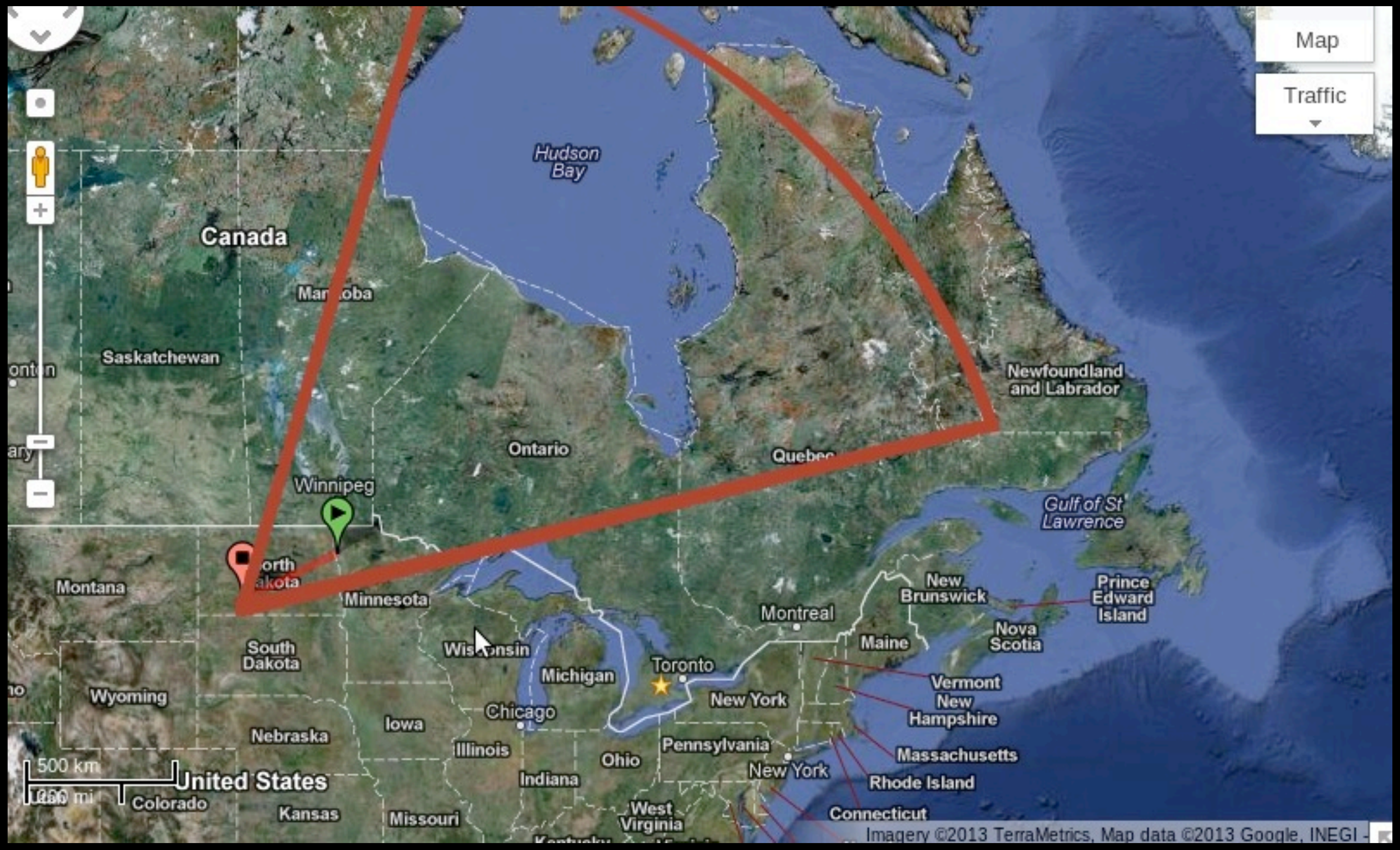


Star Trails



ISS revolution axis

Field of View Wedge



Aurora Extraction

Isolate aurora via K-means image segmentation

Field of View Wedge

Method Summary

Direction of ISS velocity given by d/dt(nadir)

Rotation of camera given by lengths of star trails

Pitch of camera given by altitude and direct image measurement

Efficient camera orientation method; can extrapolate the location of the aurora