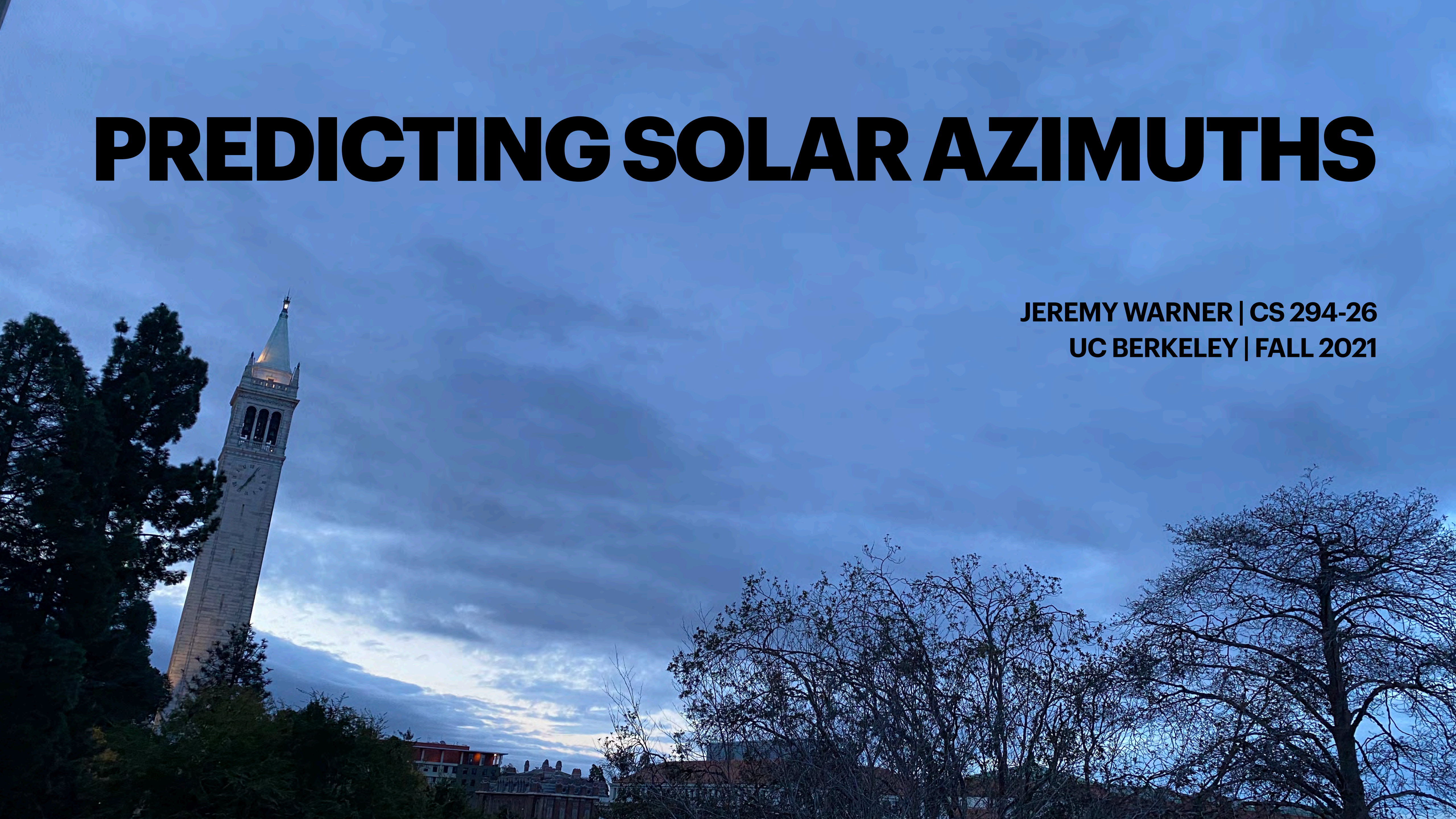


# PREDICTING SOLAR AZIMUTHS

JEREMY WARNER | CS 294-26  
UC BERKELEY | FALL 2021







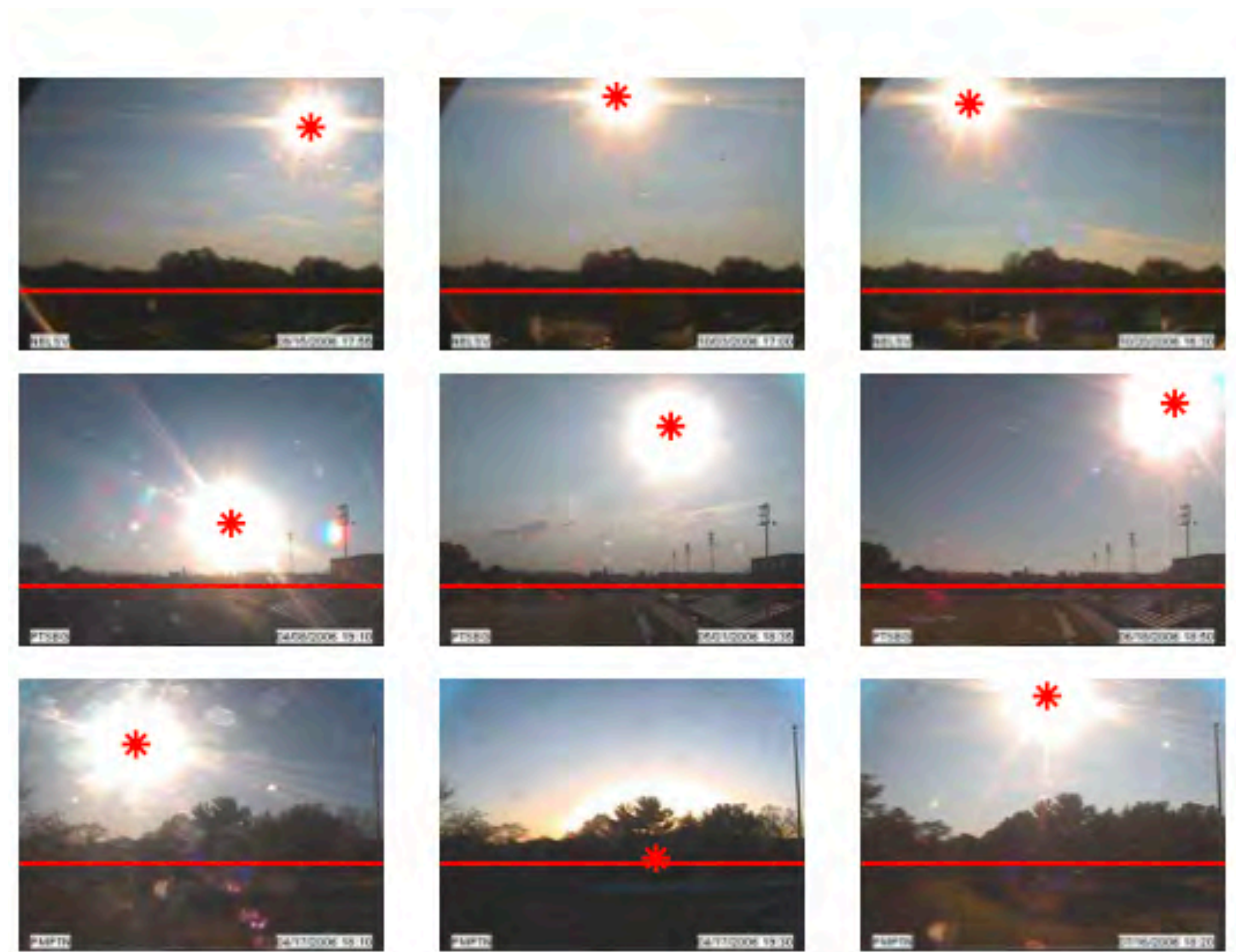


**GOAL: INFER CAPTURE TIME**

**PRIOR WORK**

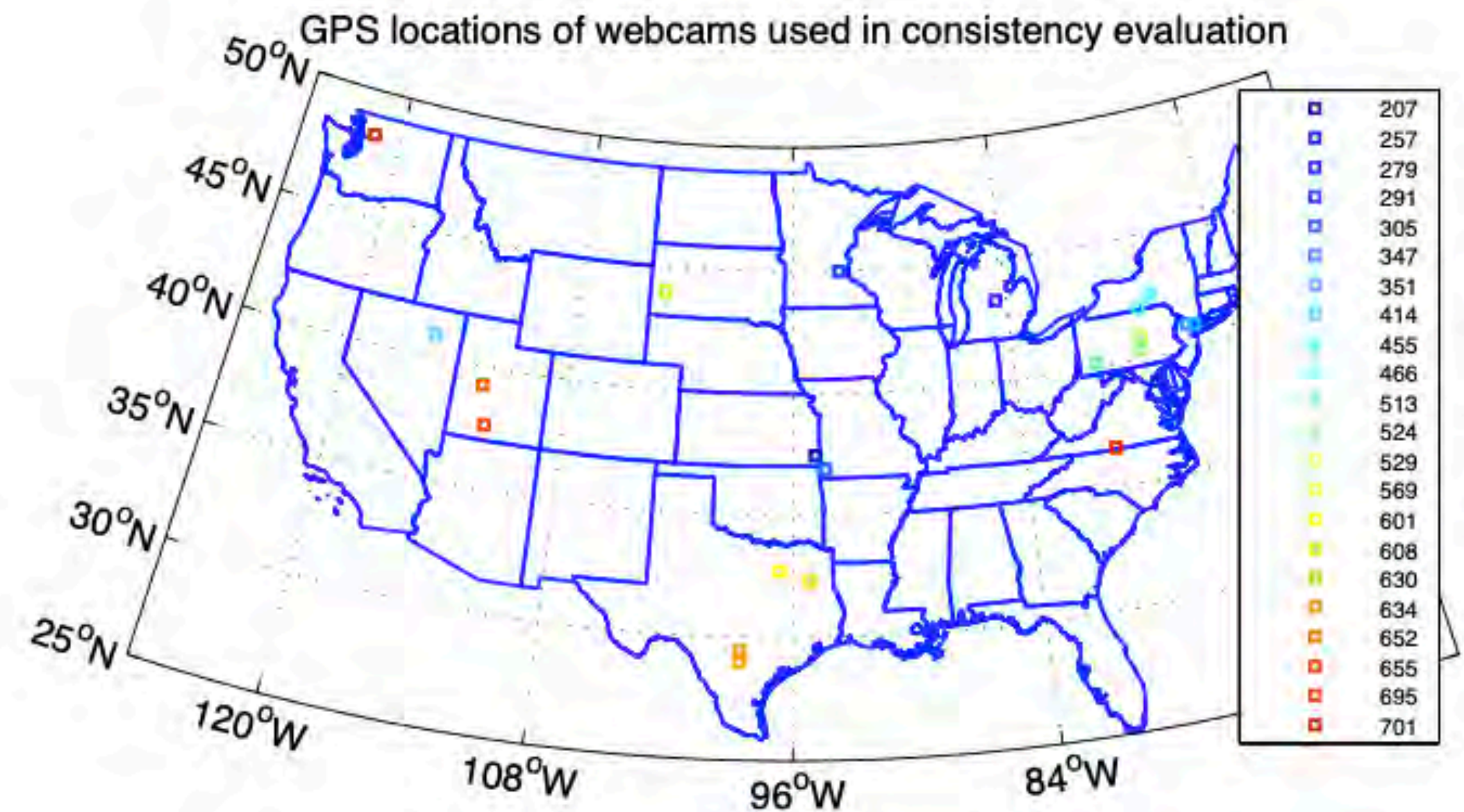
# WHAT DO THE SUN AND THE SKY TELL US ABOUT THE CAMERA?

- Leverage web-cam sequences  
(22 cameras, 250k images)



# MODELING THE CAMERA

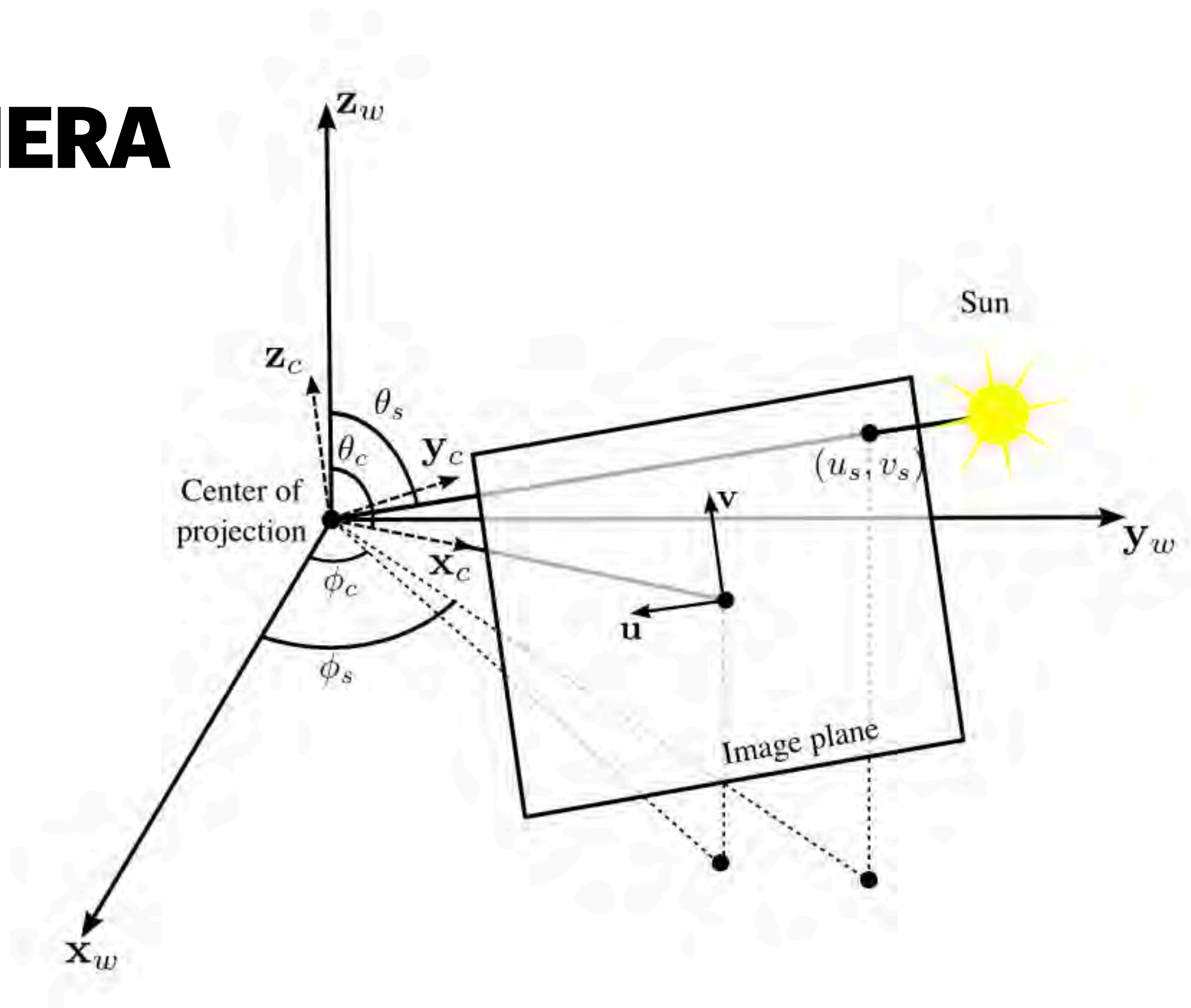
- Low resolution image sequences
- Geographically distributed in US





# MODELING THE CAMERA

- Calculate camera geometry
- Estimate GPS position (~100km)




---

# **RISE OF THE CELL PHONE CAMERA**





- **GPS and capture time automatically recorded**
- **Covers much larger geographic distribution**
- **Many more available reference images**

- 
- **GPS and capture time automatically recorded**
  - **Covers much larger geographic distribution**
  - **Many more available reference images**

**flickr**



## Prior Work

- Given time/sequence,  
estimate GPS position, camera

Jean-François Lalonde, Srinivasa G. Narasimhan, and Alexei A. Efros (2011)



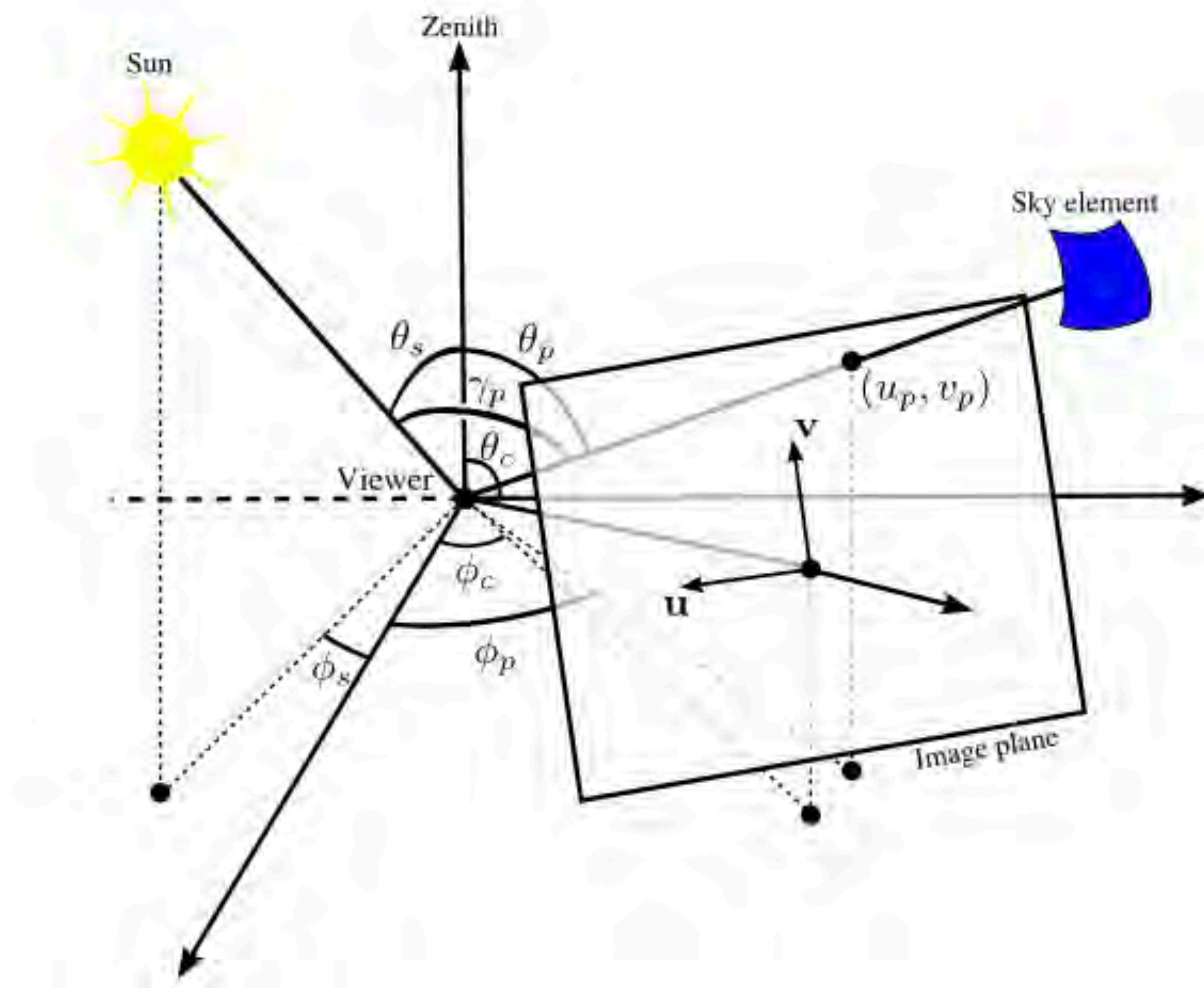
## This Work

- Given GPS/image,  
estimate time

# **INFERRING CAPTURE TIME**

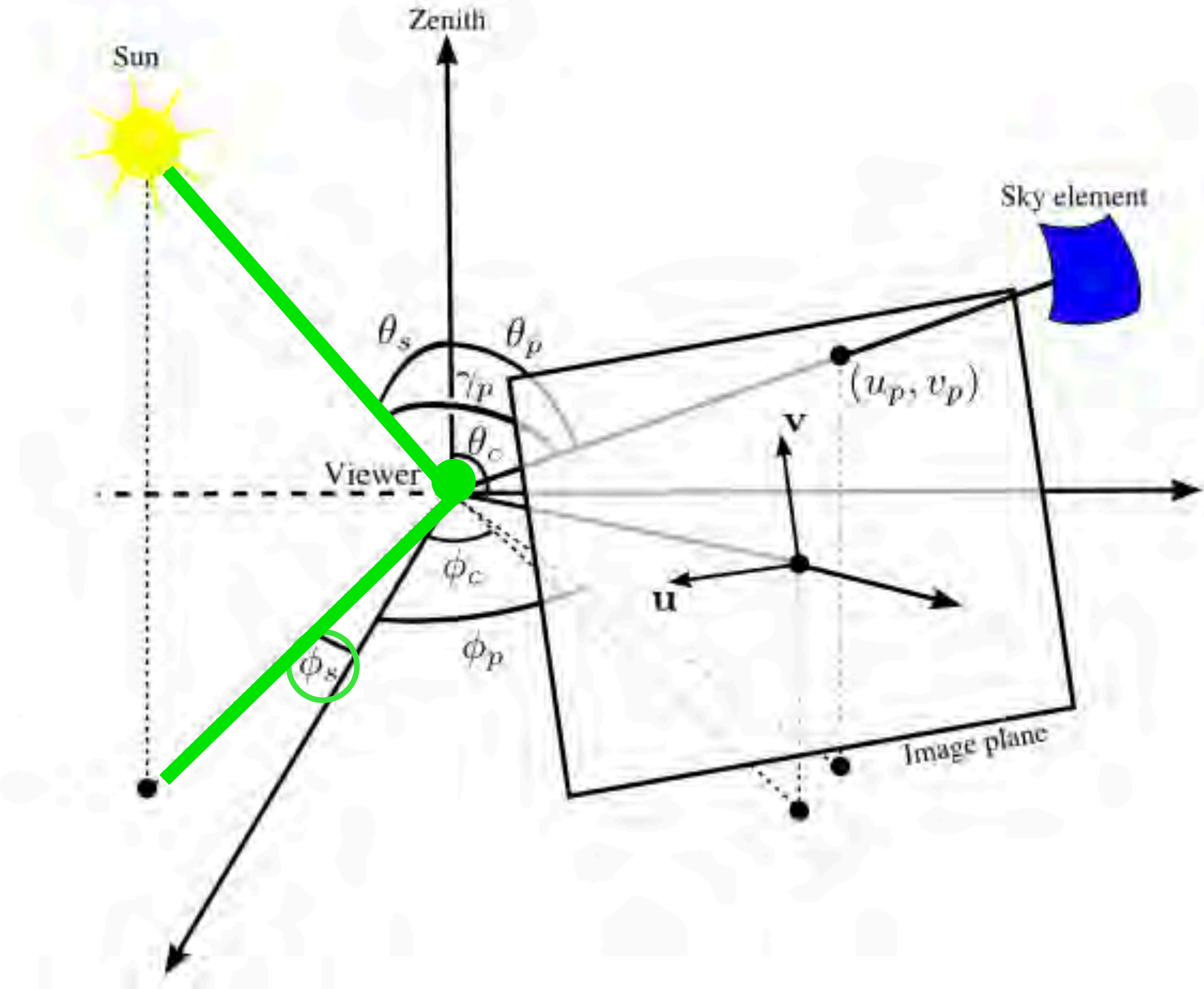


# INFERRING CAPTURE TIME





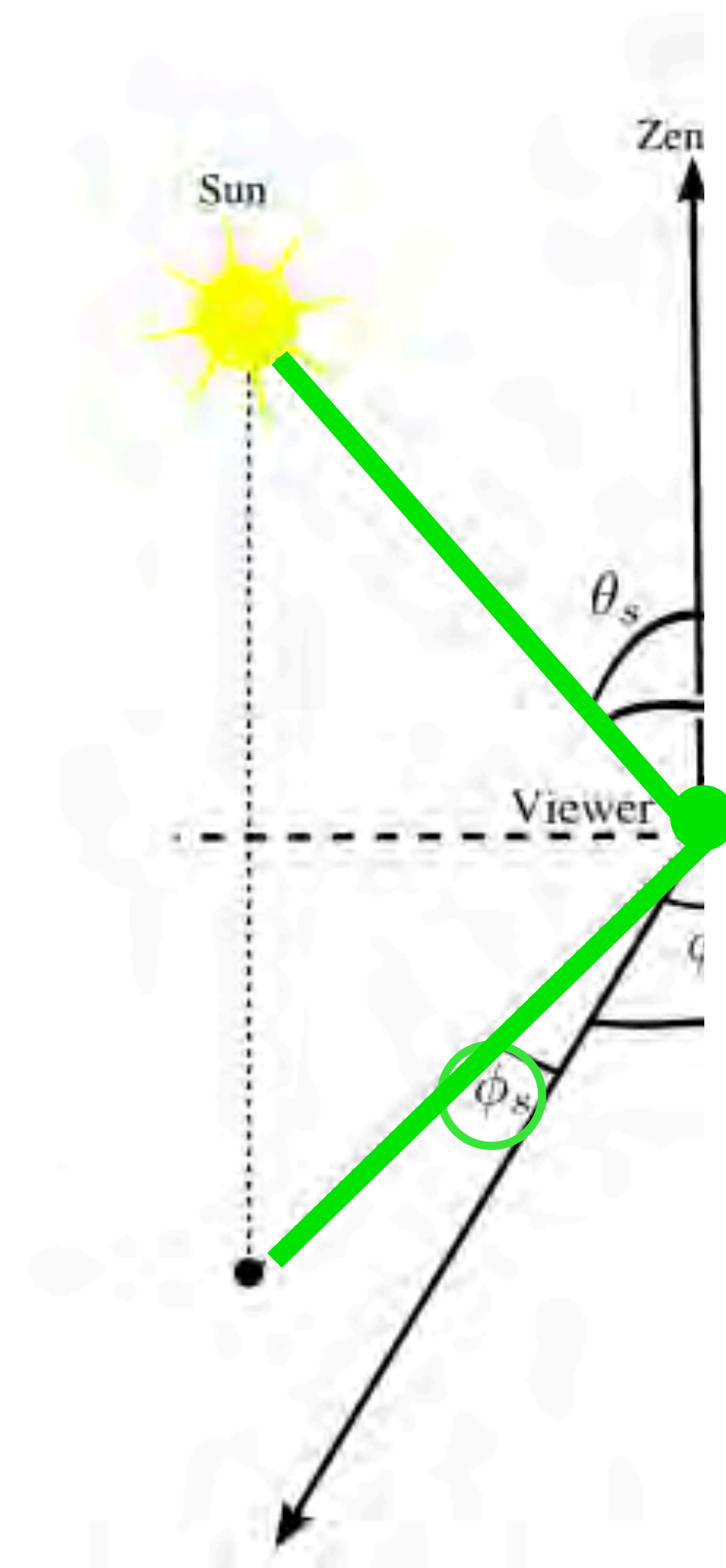
# SOLAR AZIMUTH AS A TIME PROXY



# AZIMUTH-TIME RELATION

$$\cos \phi_s = \frac{\sin \delta \cos \Phi - \cos h \cos \delta \sin \Phi}{\sin \theta_s}$$

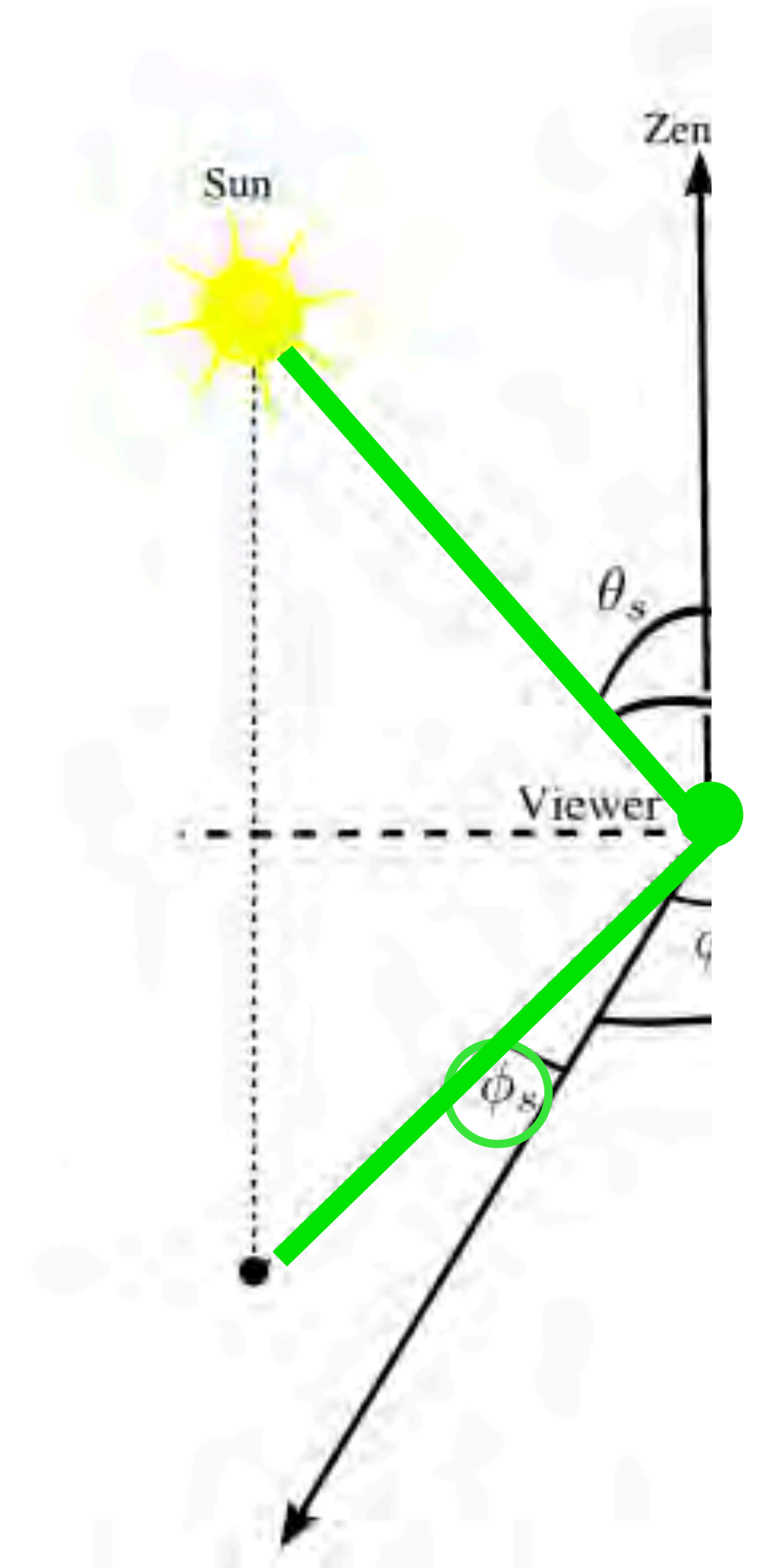
- $\phi_s$  is the solar azimuth angle
- $\theta_s$  is the solar zenith angle
- $h$  is the hour angle, in the local solar time
- $\delta$  is the current sun declination
- $\Phi$  is the local latitude



# AZIMUTH-TIME RELATION

$$\cos \phi_s = \frac{\sin \delta \cos \Phi - \cos h \cos \delta \sin \Phi}{\sin \theta_s}$$

- $h$  is the **hour angle**, in the local **solar time**

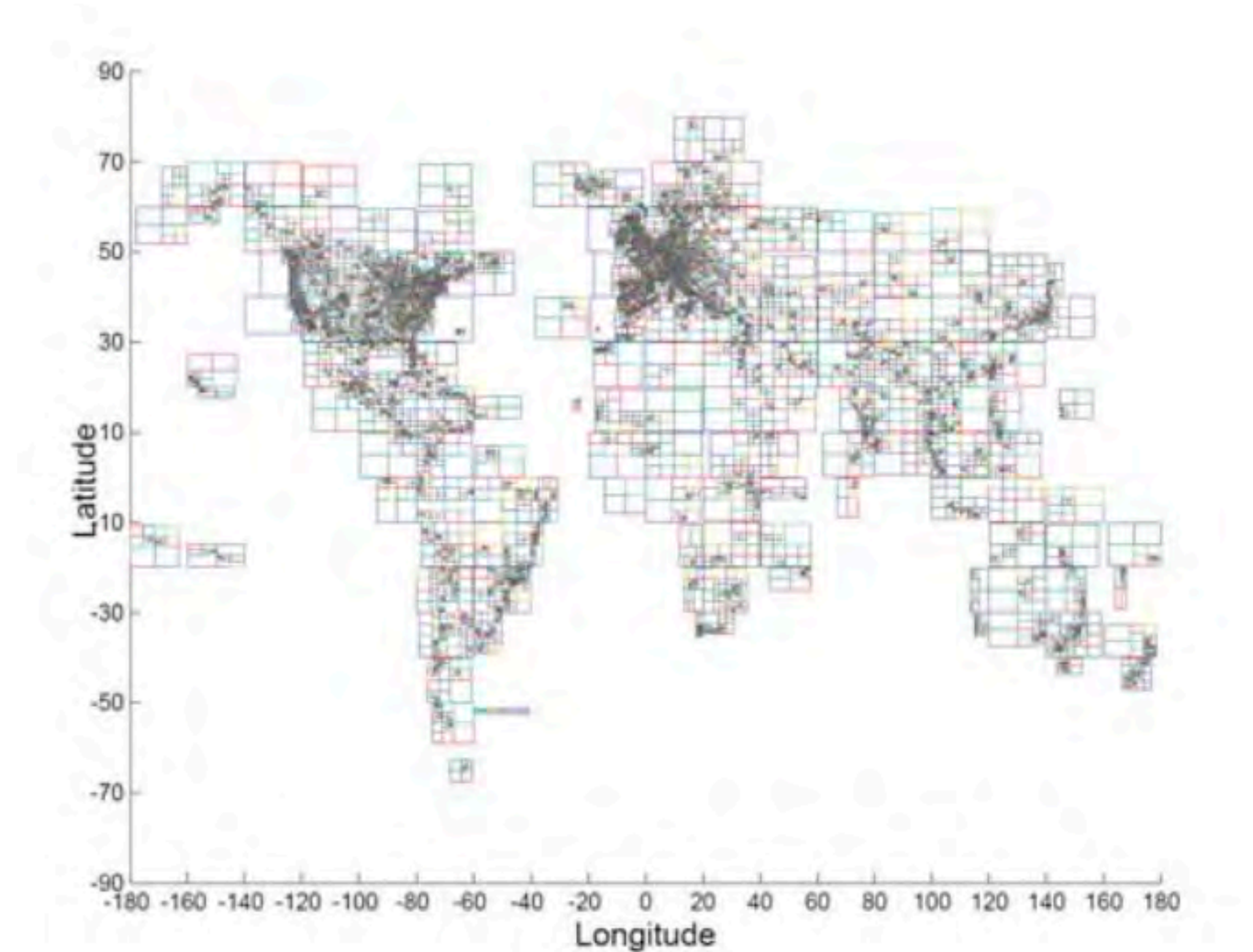


**TRAINING**

# MASSIVE FLICKR DATASET

WORLD-WIDE SCALE GEOTAGGED IMAGE DATASET FOR  
AUTOMATIC IMAGE ANNOTATION AND REVERSE GEOTAGGING

- 14 M geotagged, timestamped images
- Spatially distributed across the globe

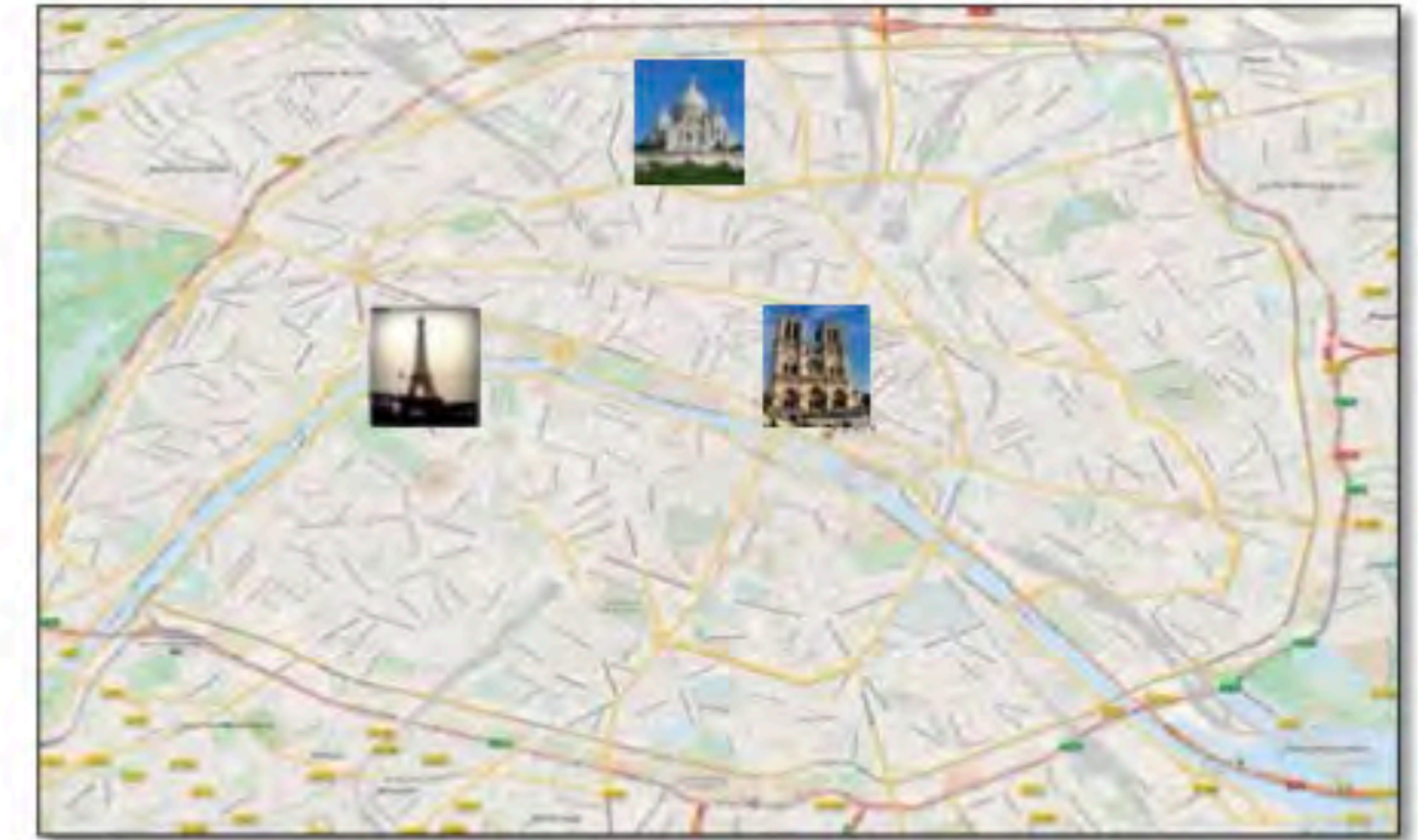


# MASSIVE FLICKR DATASET

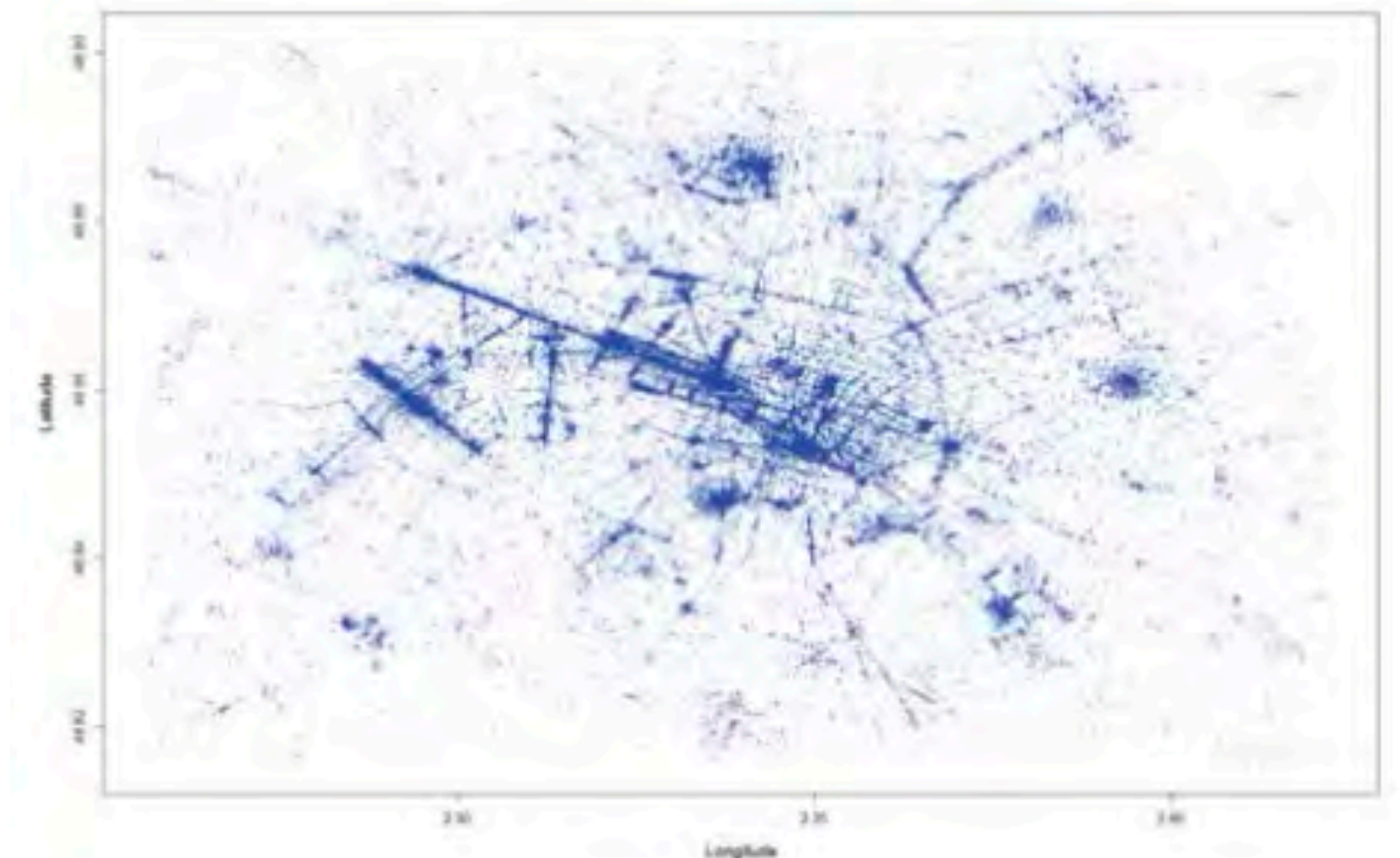
WORLD-WIDE SCALE GEOTAGGED IMAGE DATASET FOR  
AUTOMATIC IMAGE ANNOTATION AND REVERSE GEOTAGGING

- Retains good resolution detail at a local level

Mousselly-Sergieh et. al, *MMSys '14*, March 19-21 2014, Singapore, Singapore

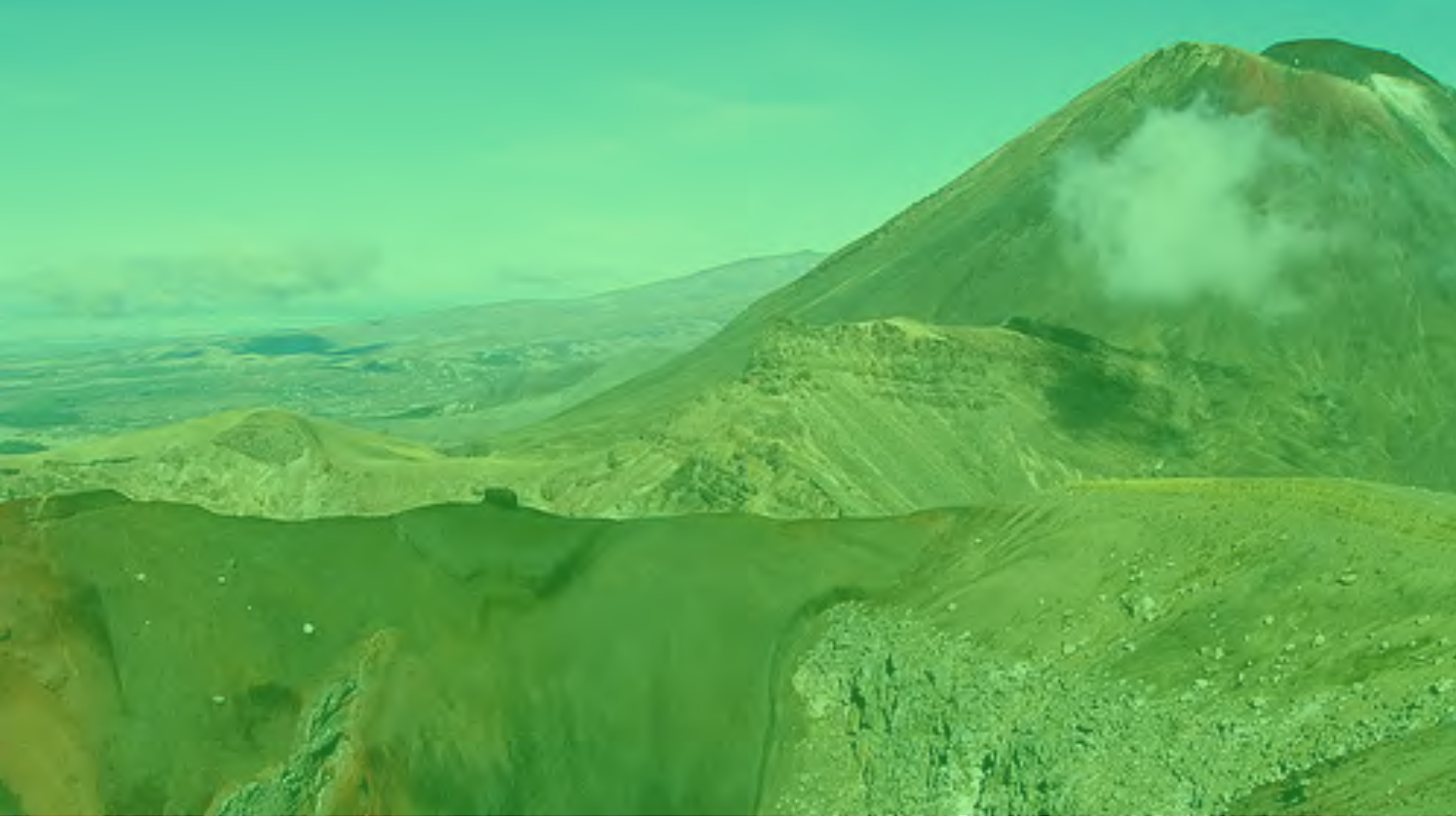


a) Paris city map with famous landmarks



b) Approximation of Paris city map using the geotags of images taken in Paris

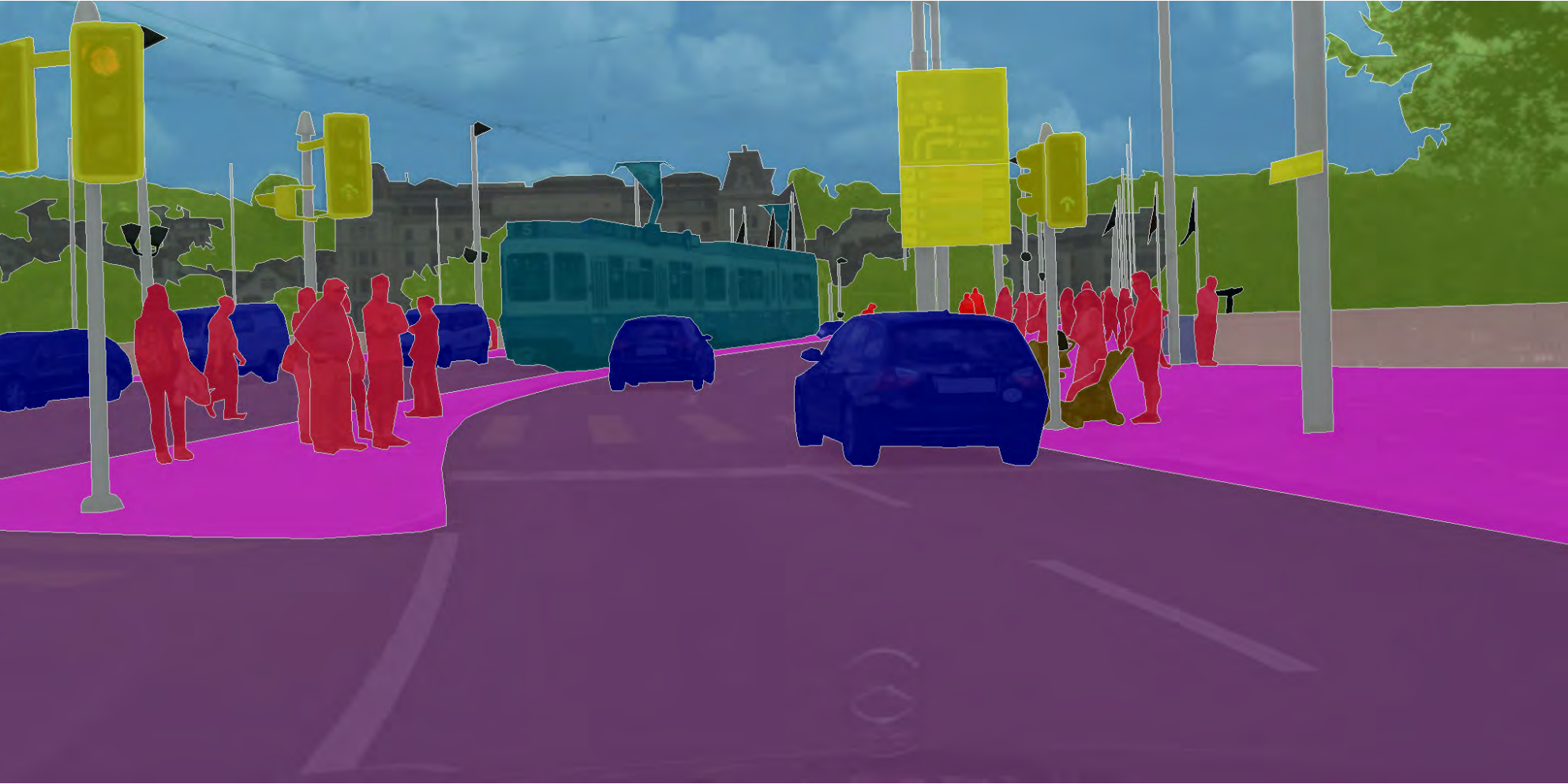






# SEARCH FOR SKY

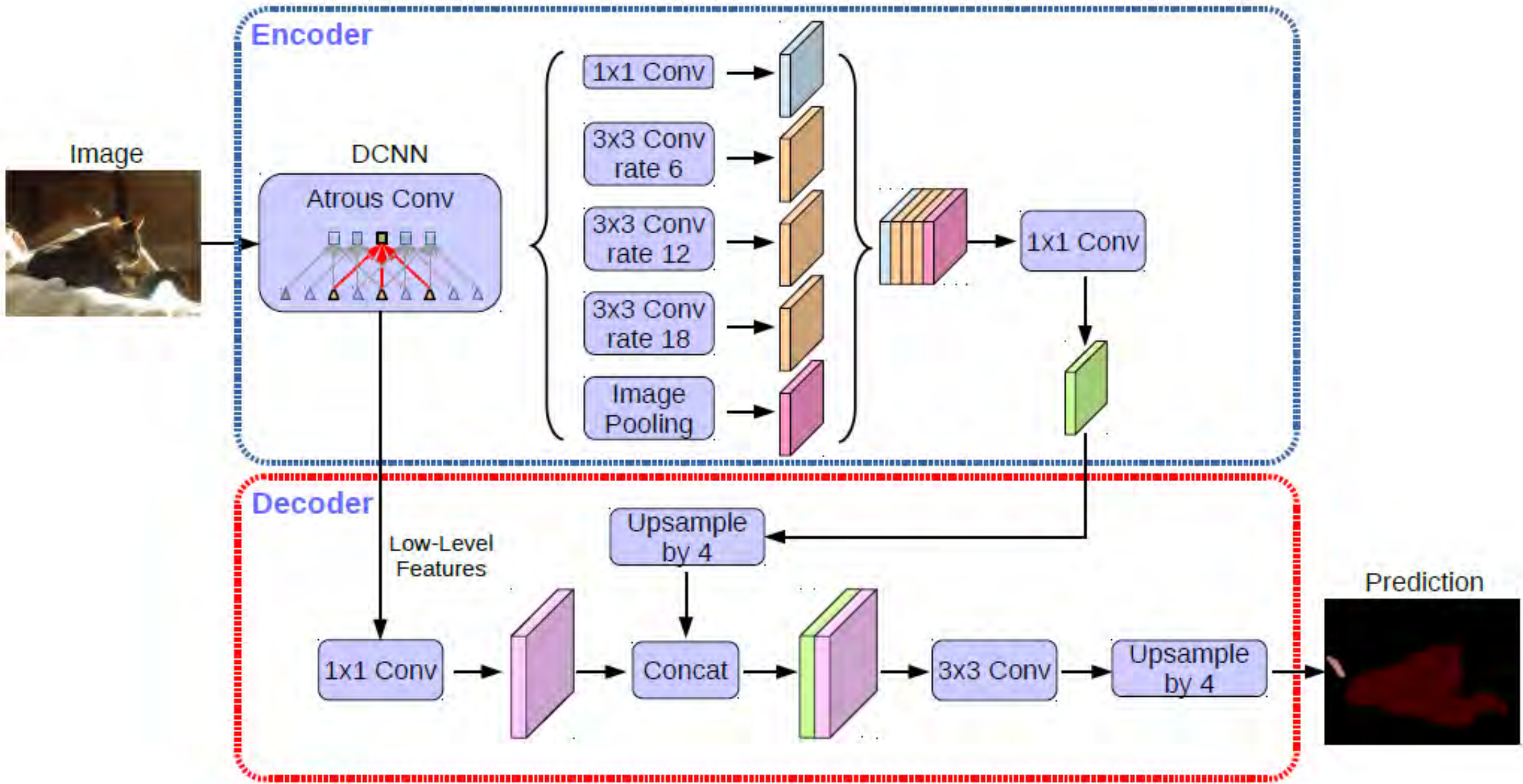
## ENCODER-DECODER WITH ATRIOUS SEPARABLE CONVOLUTION FOR SEMANTIC IMAGE SEGMENTATION



### DEEPLAB V3 - CITYSCAPES

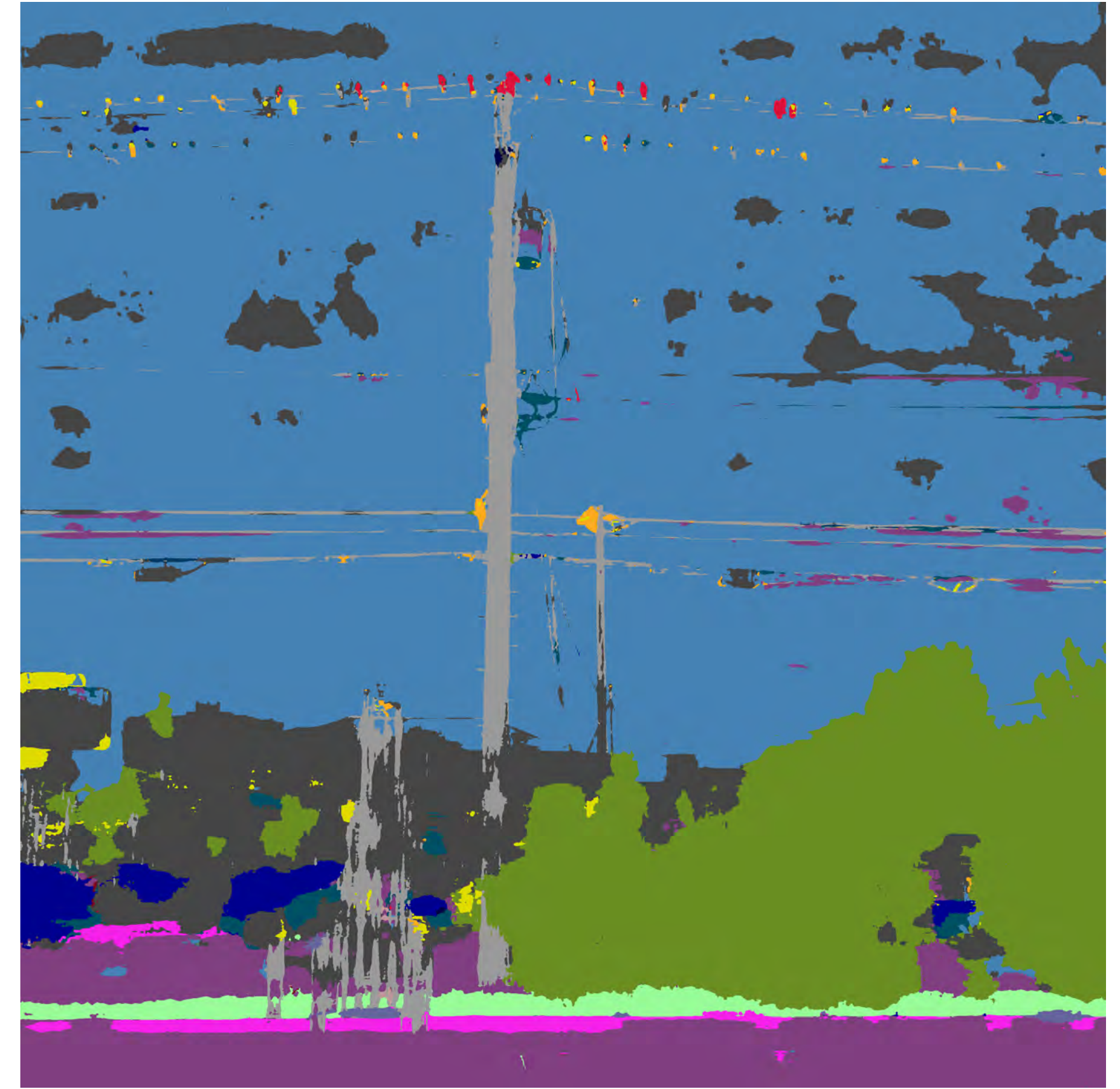
[1] [Rethinking Atrous Convolution for Semantic Image Segmentation](#)

[2] [Encoder-Decoder with Atrous Separable Convolution for Semantic Image Segmentation](#)





**Example Image**

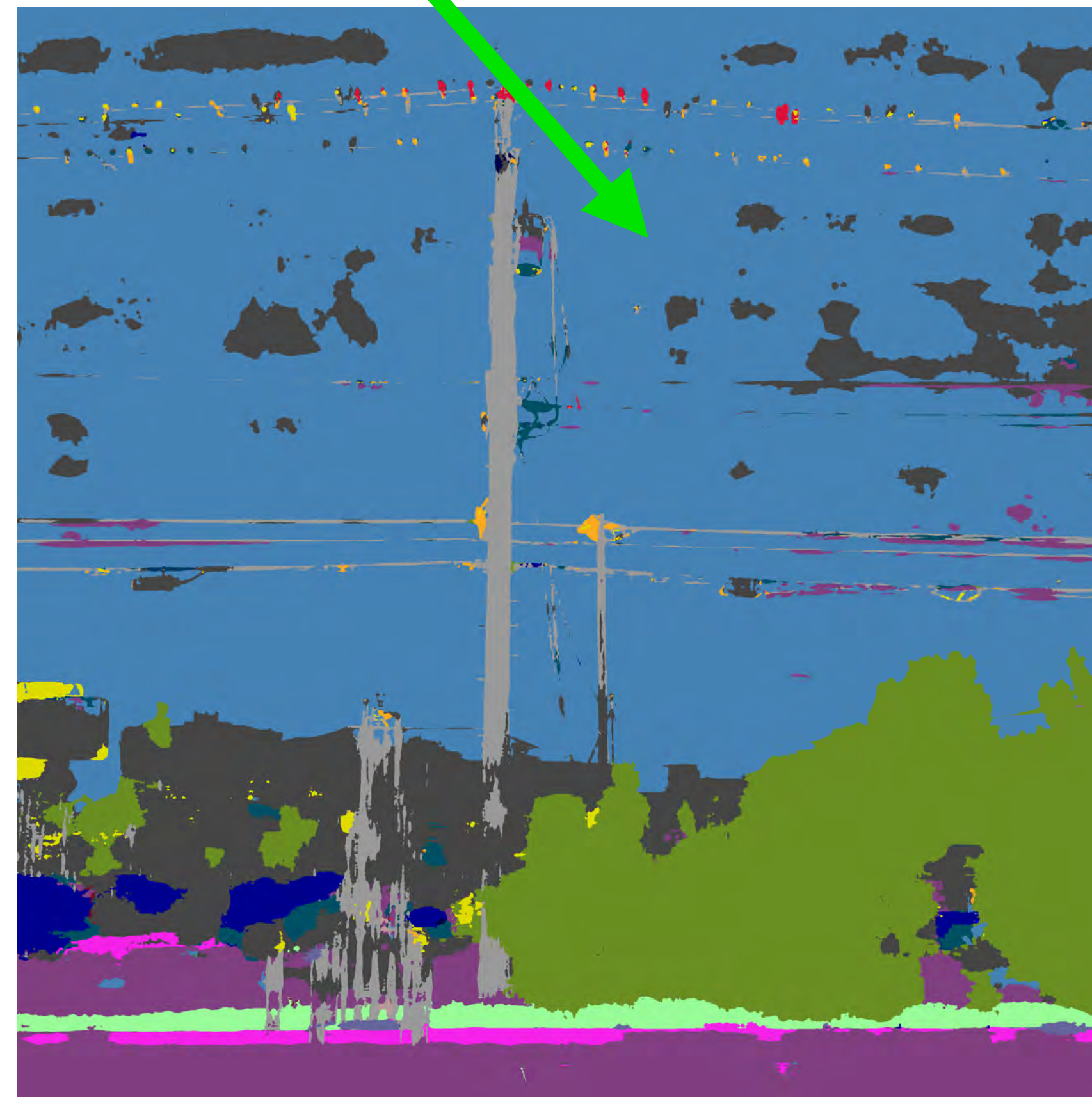


**Semantic Mask**



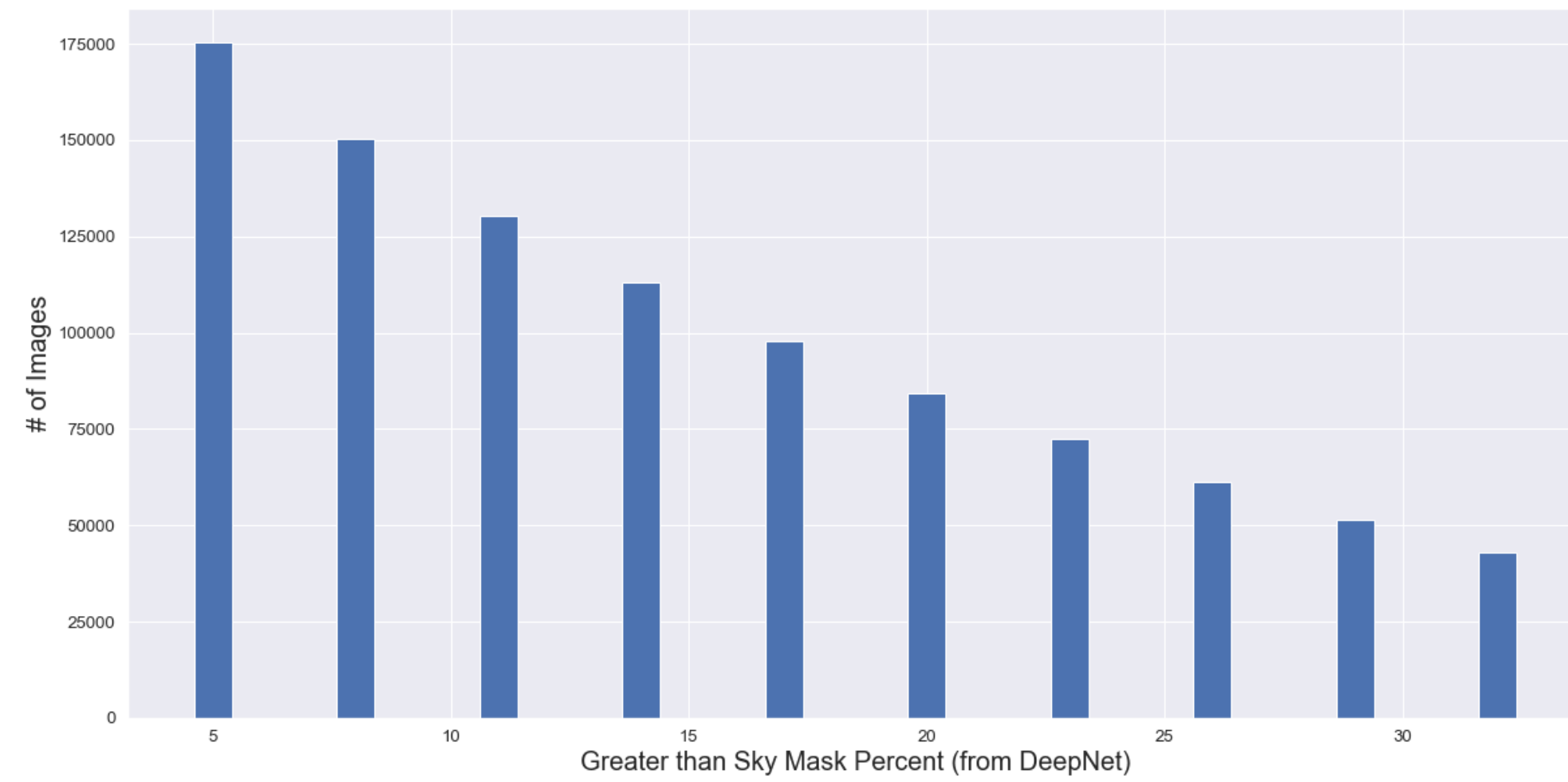
**Example Image**

**19 classes, blue=sky**

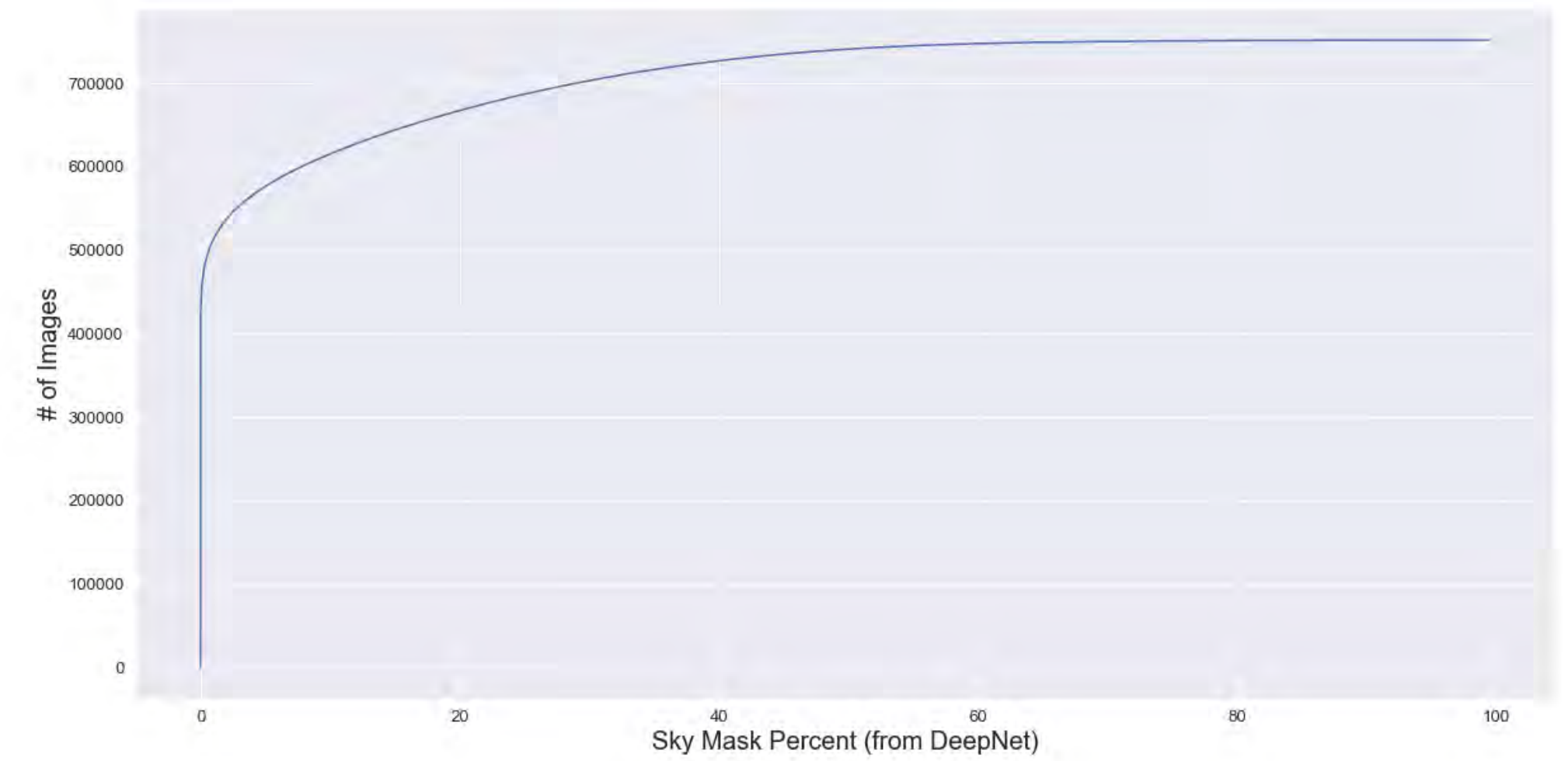


**Semantic Mask**

## Sky percent / images



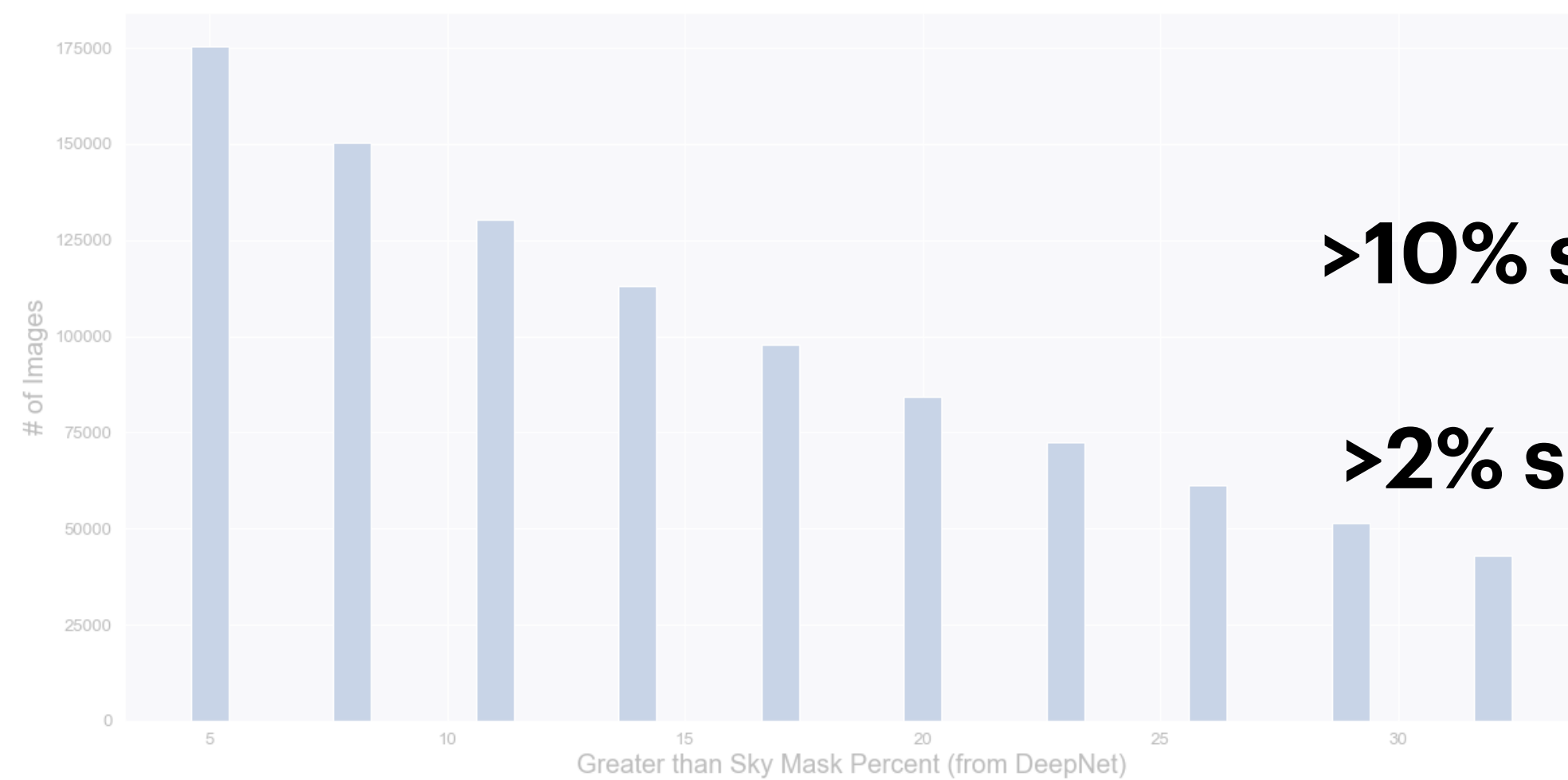
## Image (focused range)



## Sky percent / images

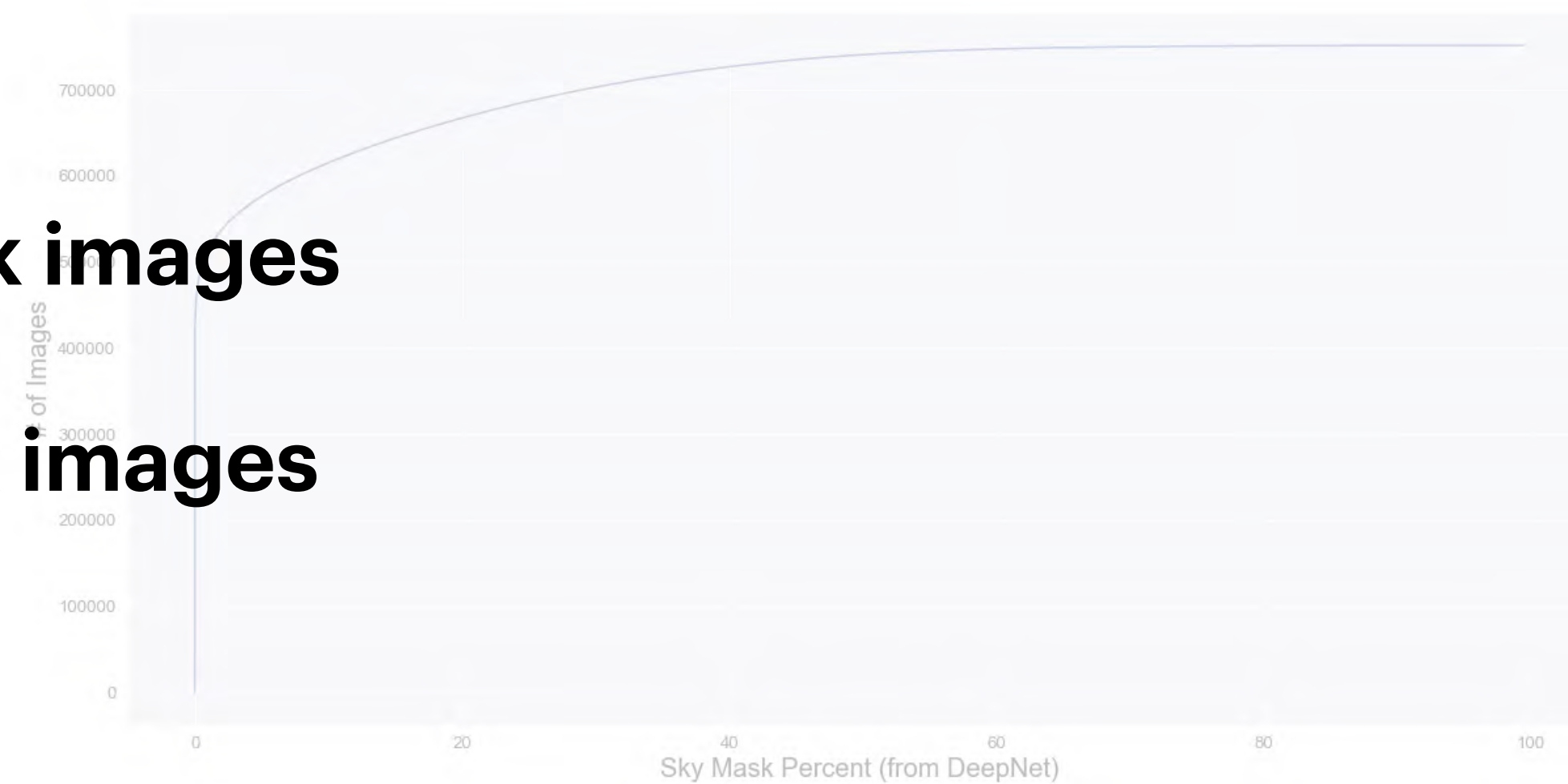
## Image (focused range)

**Of 1M image subset:**



**>10% sky → 110k images**

**>2% sky → 173k images**



# RESULTS

---

# ***TRAINING...***

**BASELINE: RESNET50. MODEL YET TO PRODUCE DECENT RESULTS...**

**FUTURE**



Summer ↻ Winter

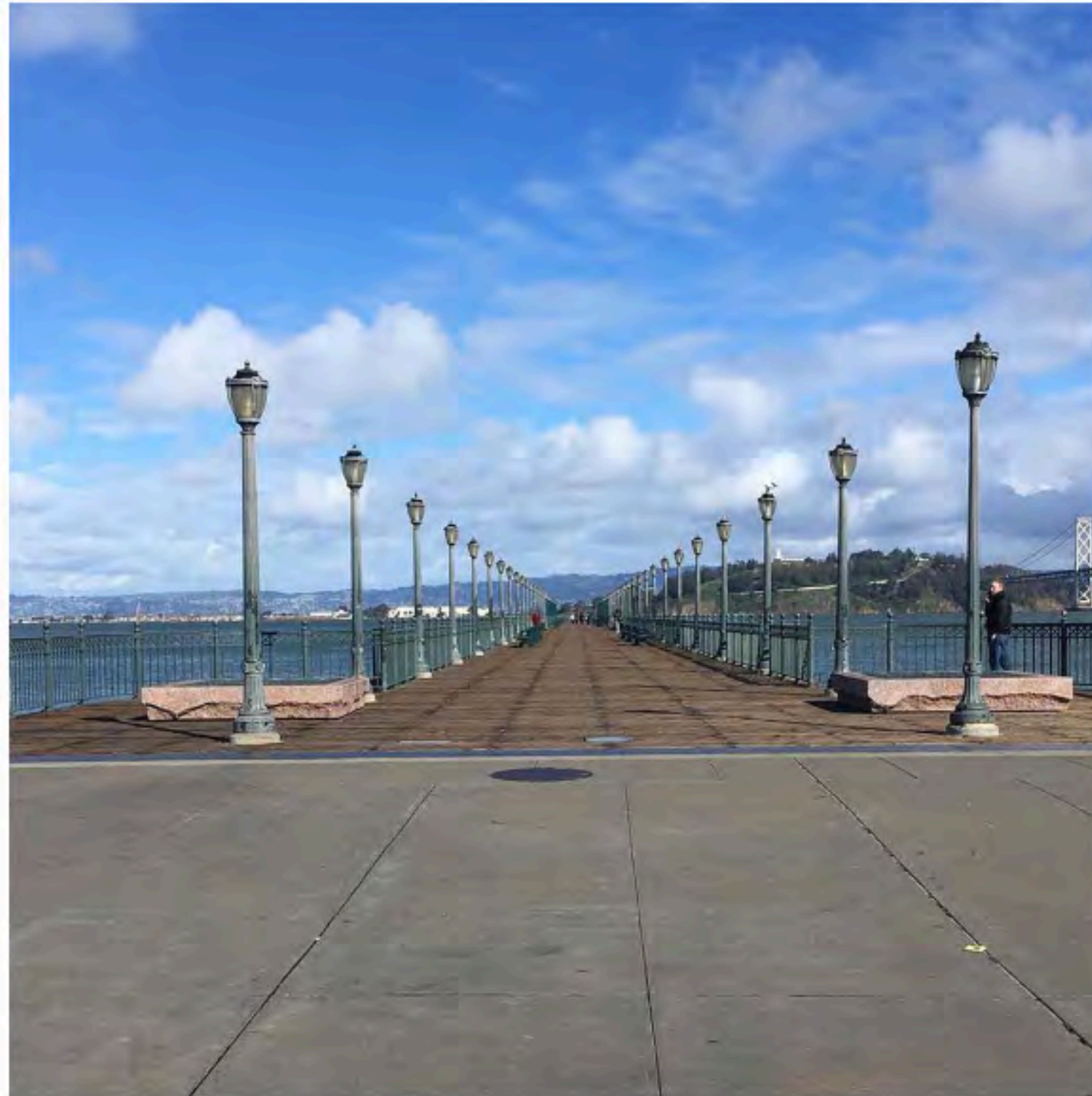


summer → winter



winter → summer

**Inferring Date**



**Driving Temporal Transformation**

# PREDICTING SOLAR AZIMUTHS

JEREMY WARNER | CS 294-26  
UC BERKELEY | FALL 2021

