UNIVERSITY OF CAMBRIDGE

ENGIE

A Temporally Consistent Image-based Sun Tracking Algorithm for Solar Energy Forecasting Applications

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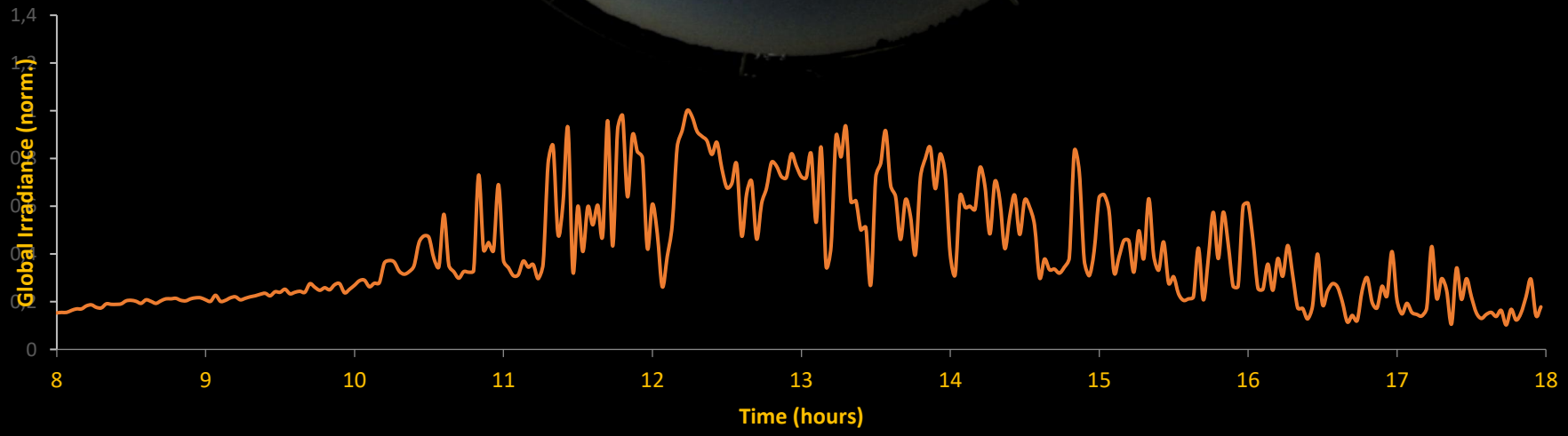
EPSRC

NEURAL INFORMATION PROCESSING SYSTEMS

SIRTA

SITE INSTRUMENTAL DE RECHERCHE PAR TÉLÉDÉTECTION ATMOSPHÉRIQUE


Global Irradiance (norm.)
1,4
0
8
9
10
11
12
13
14
15
16
17
18
Time (hours)

Short-term forecasting using sky images

- Temporal resolution: **1-2 min**
- Predictions up to **next 20 min**

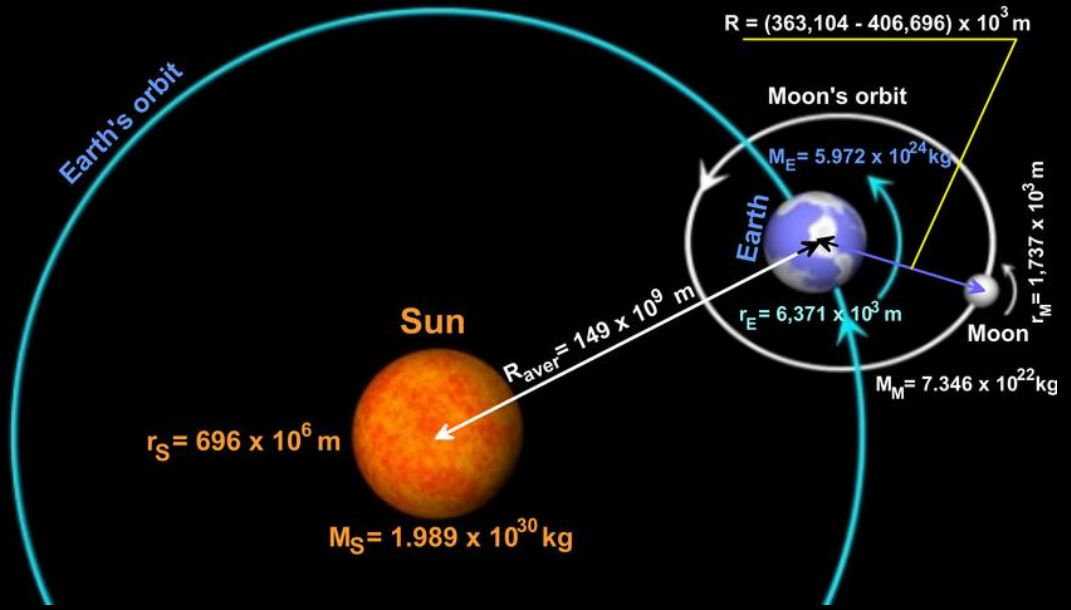
What is the position of the Sun in the image?

Short-term forecasting using sky images

- Temporal resolution: **1-2 min**
- Predictions up to **next 20 min**

Existing methods

1. Find the angular position of the Sun in the sky (θ, φ)*

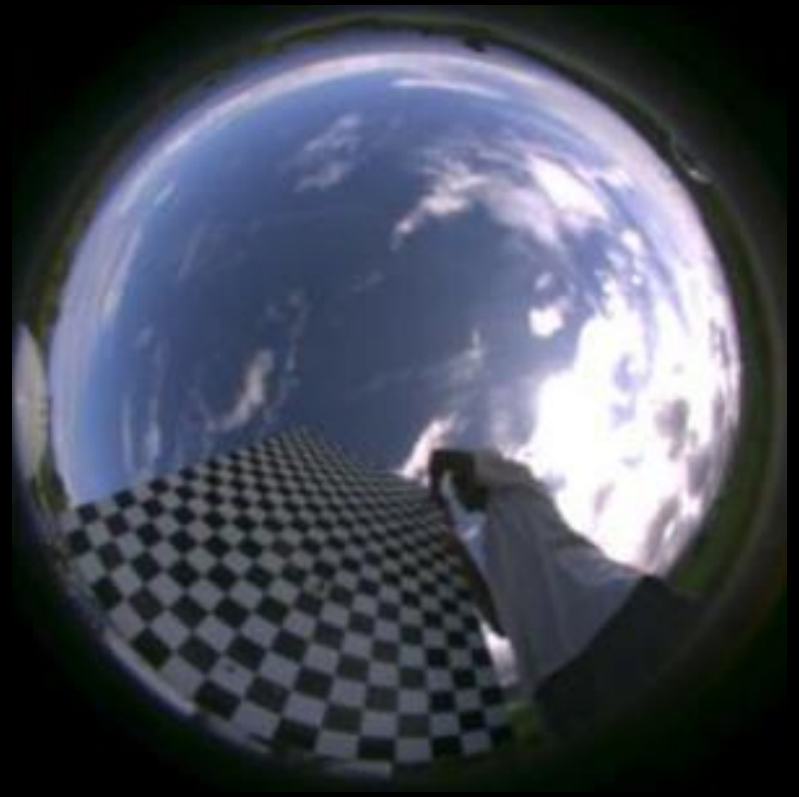


Source: Dangerous atmospheric events: a new physical-mathematical approach, Sergey A. Arsen'yev et al. 2019

*Ibrahim Reda and Afshin Andreas. Solar position algorithm for solar radiation applications. Solar Energy, 2004.
Philippe Blanc, Lucien Wald. The SG2 algorithm for a fast and accurate computation of the position of the Sun for multi-decadal time period. Solar Energy, 2012.

Existing methods

1. Find the angular position of the Sun in the sky (θ, φ)
2. Calibrate the camera*



*Davide Scaramuzza, et al. A Toolbox for Easily Calibrating Omnidirectional Cameras. Iros, 2006.

Existing methods

1. Find the angular position of the Sun in the sky (θ, φ)
2. Calibrate the camera
3. Translate the angular position of the Sun into pixel coordinates

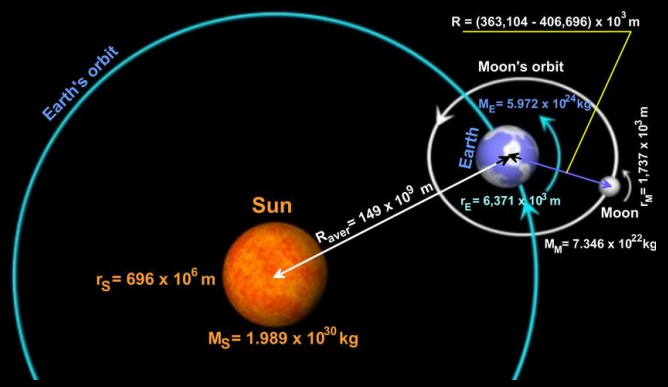
$$(\theta, \varphi) \Rightarrow (x, y)$$

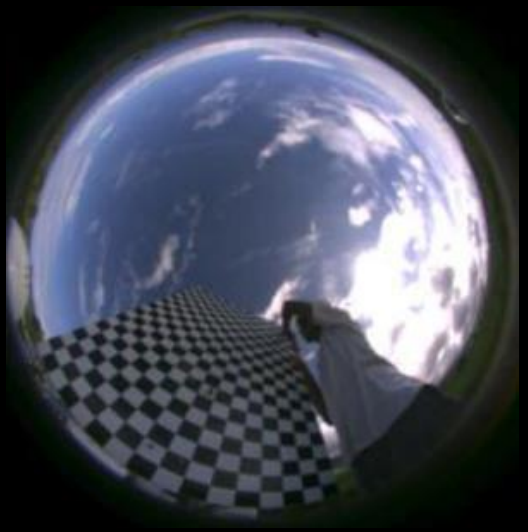
Existing methods

1. Find the angular position of the Sun in the sky (θ, φ)
2. Calibrate the camera
3. Translate the angular position of the Sun into pixel coordinates

Requires external parameters and access to the camera!
=> Limits research on open access datasets and industrial applications

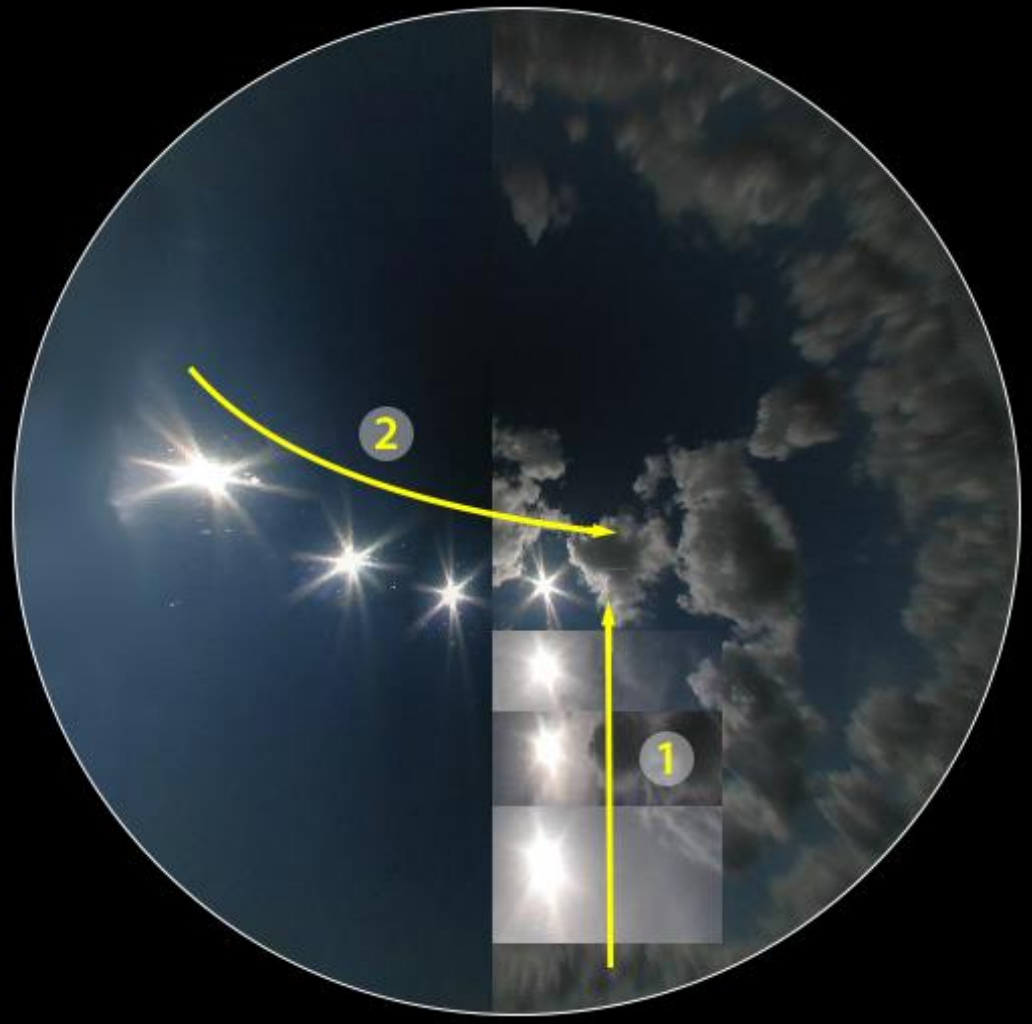
Suggested method: estimate the position of the Sun based solely on the sky images





Suggested method: estimate the position of the Sun based solely on the sky images

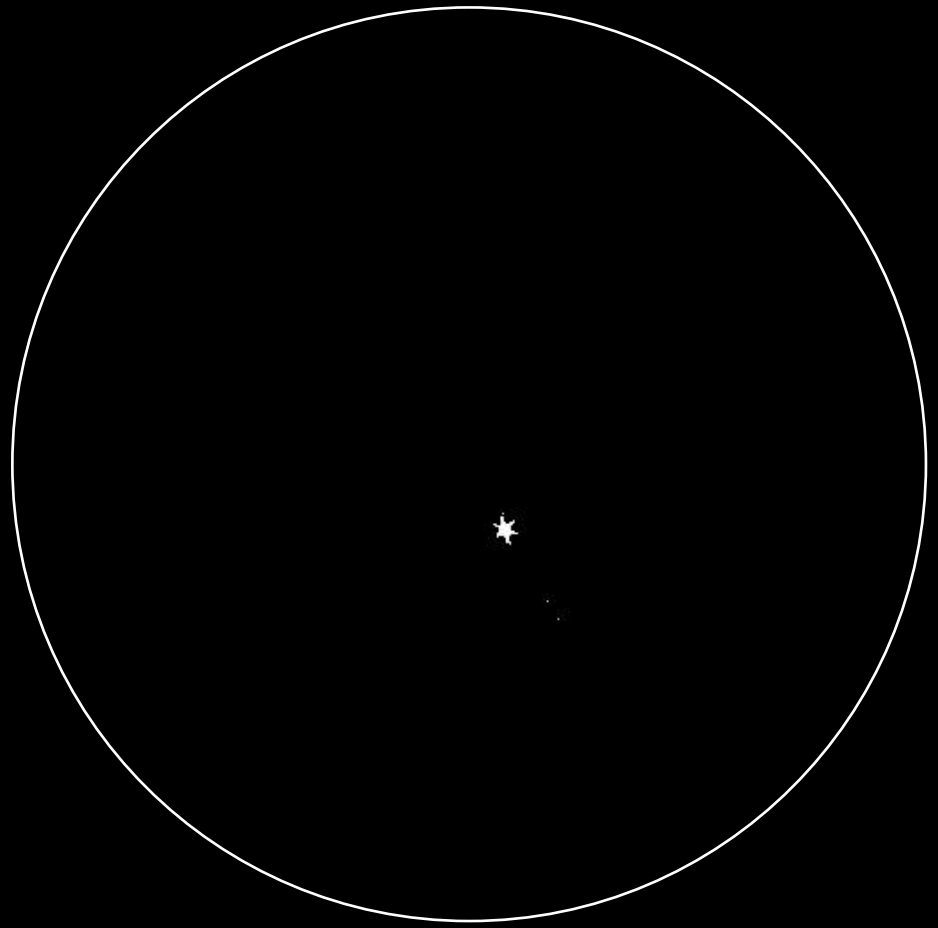
Smooth Sun Trajectory

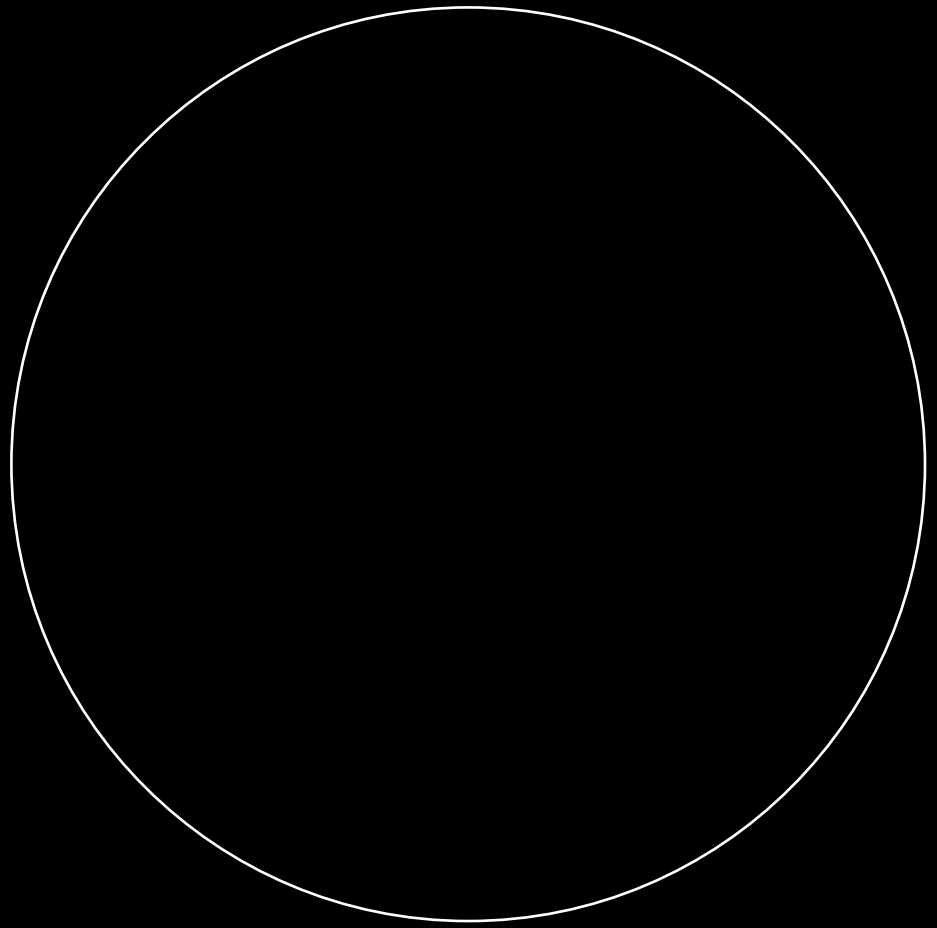


1. Position of the Sun for four consecutive months at 12:00
2. Position of the Sun for four consecutive hours over a day

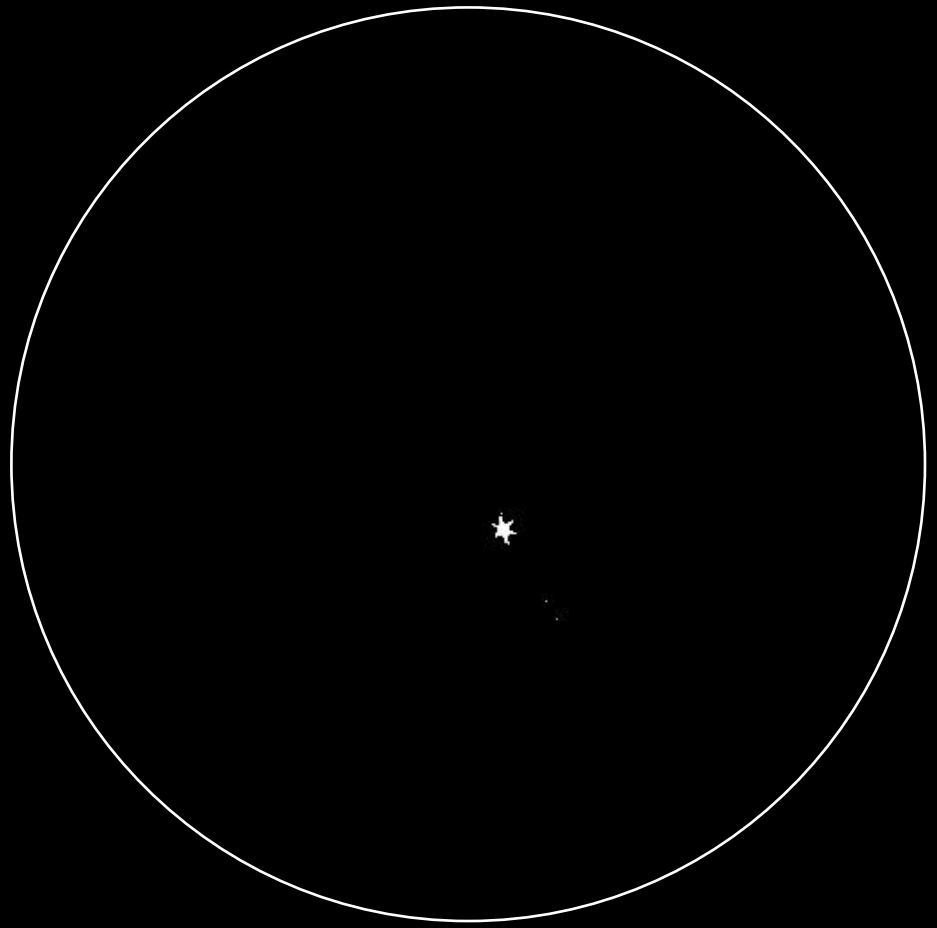
Binary segmentation – Visible / hidden Sun

Binary segmentation – Visible / hidden Sun

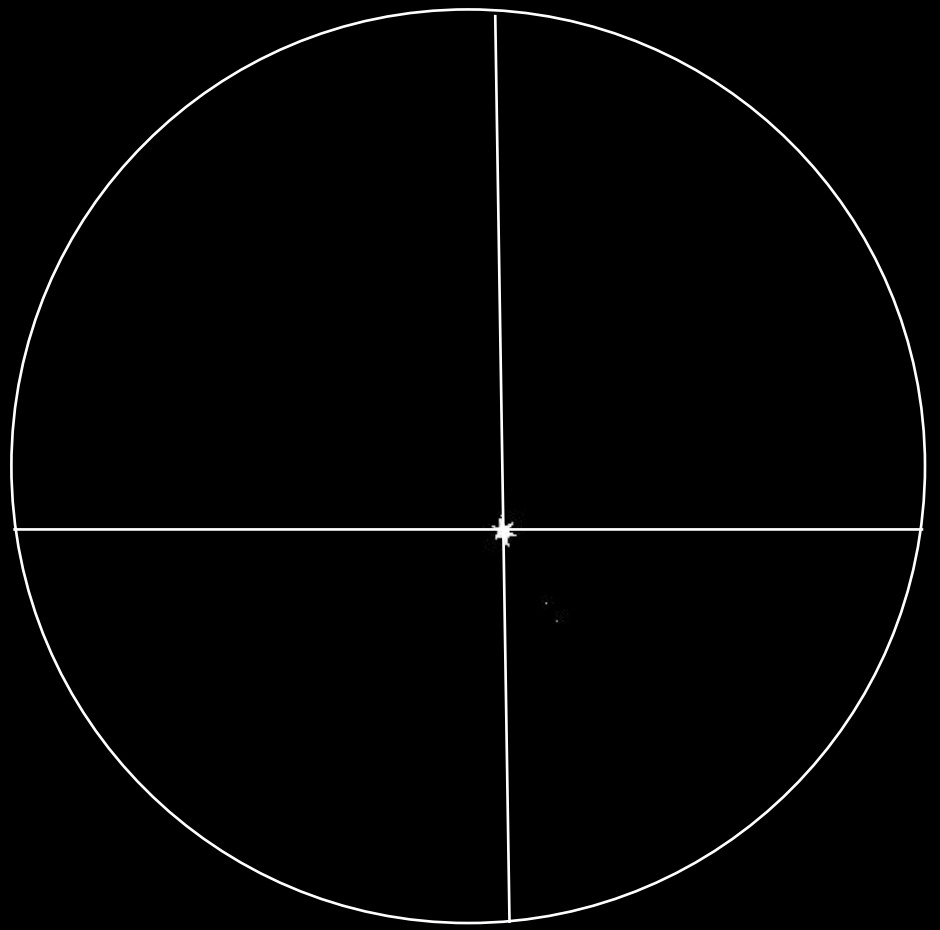




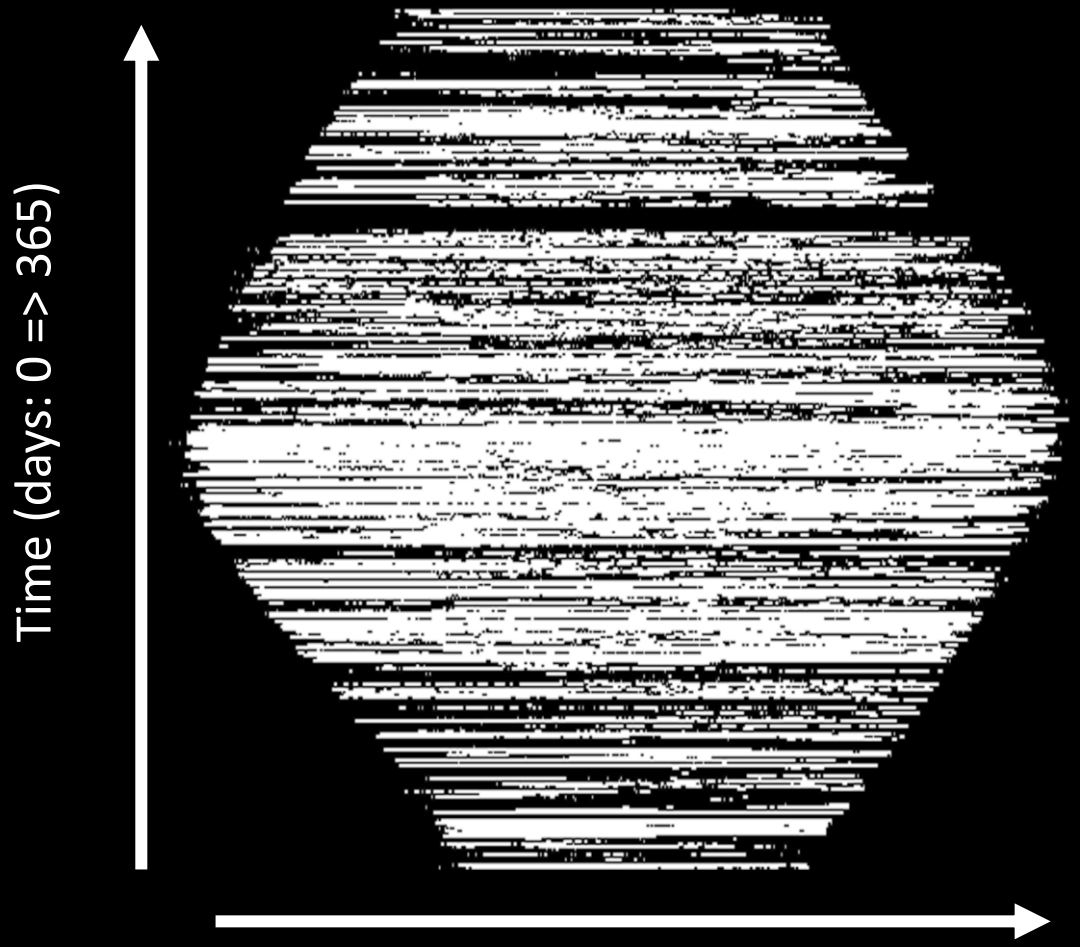
Sun Localisation



Sun Localisation

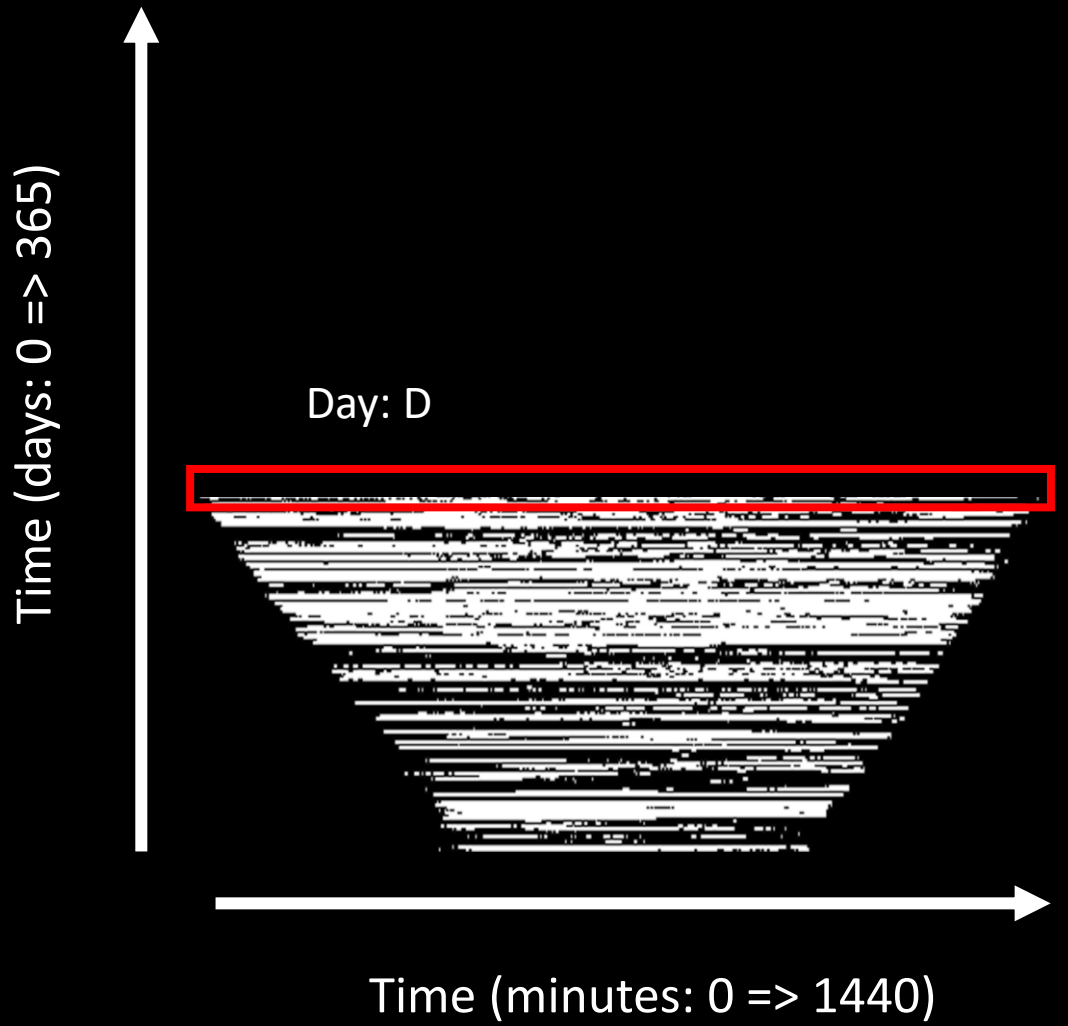


Distribution of visible Sun position over a year



White pixel: Visible Sun position
Black pixel: Not visible Sun position

Sun position interpolation from past observations



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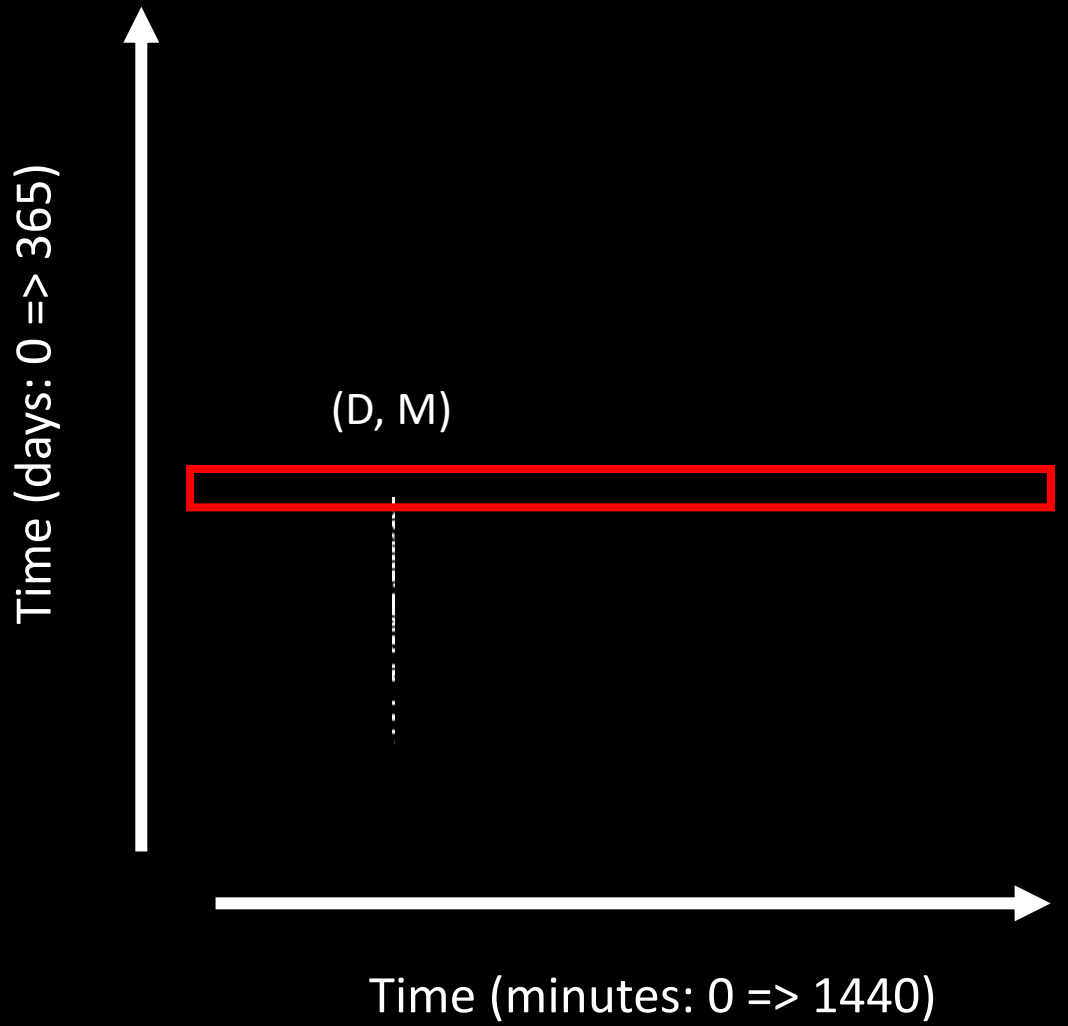
Sun position interpolation from past observations



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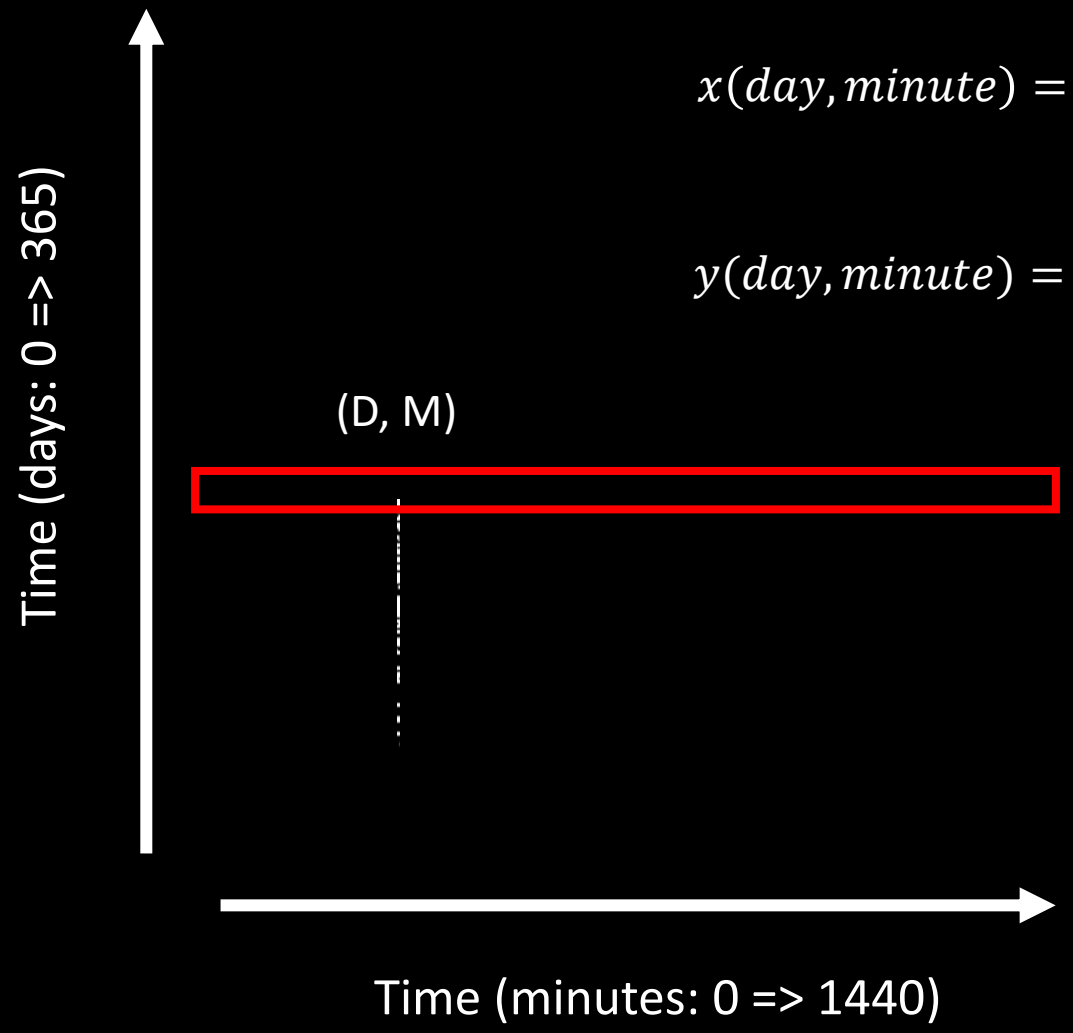
Sun position interpolation from past observations

$$x(day, minute) = \sum_{i=0}^{4} \beta i \; day^i = f_x(day)$$

$$y(day, minute) = \sum_{i=0}^{4} \lambda i \; day^i = f_y(day)$$



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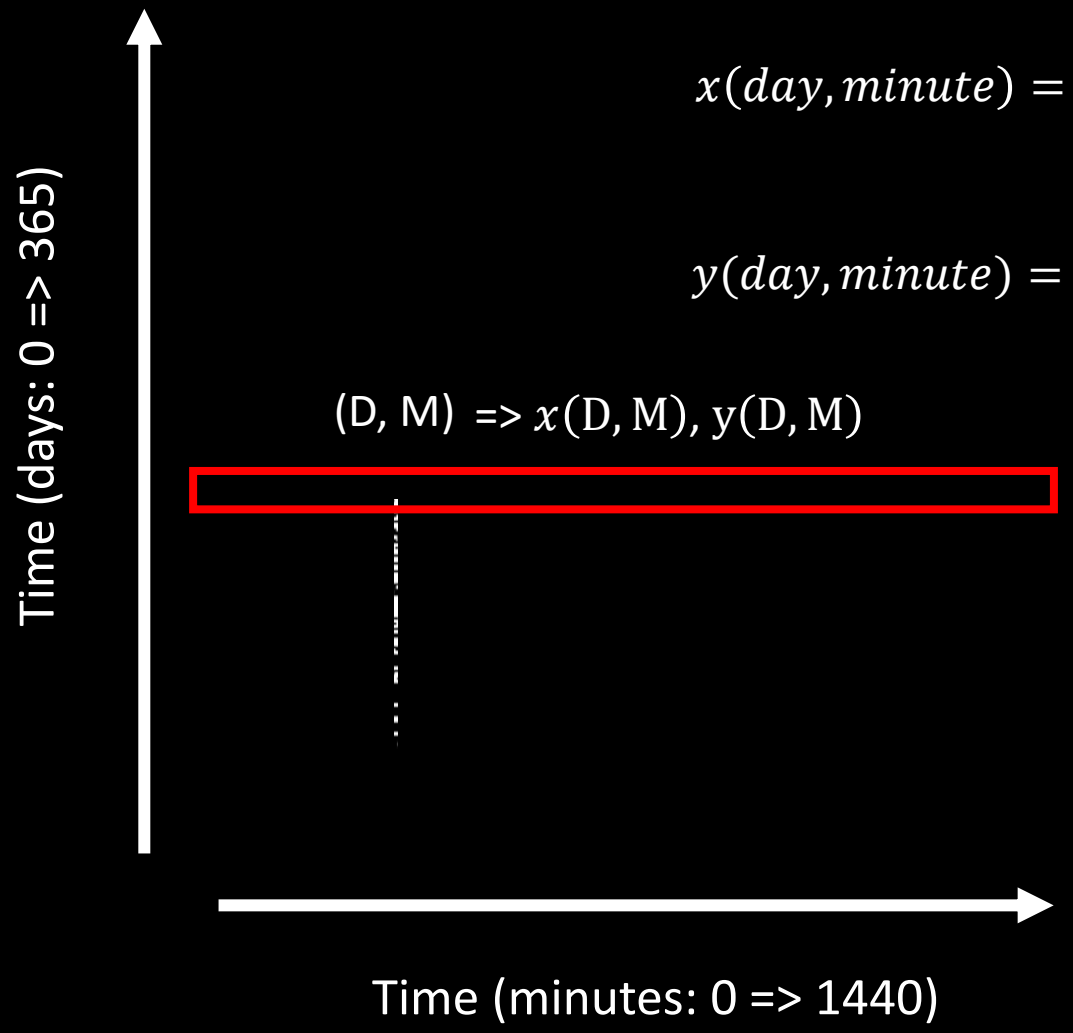

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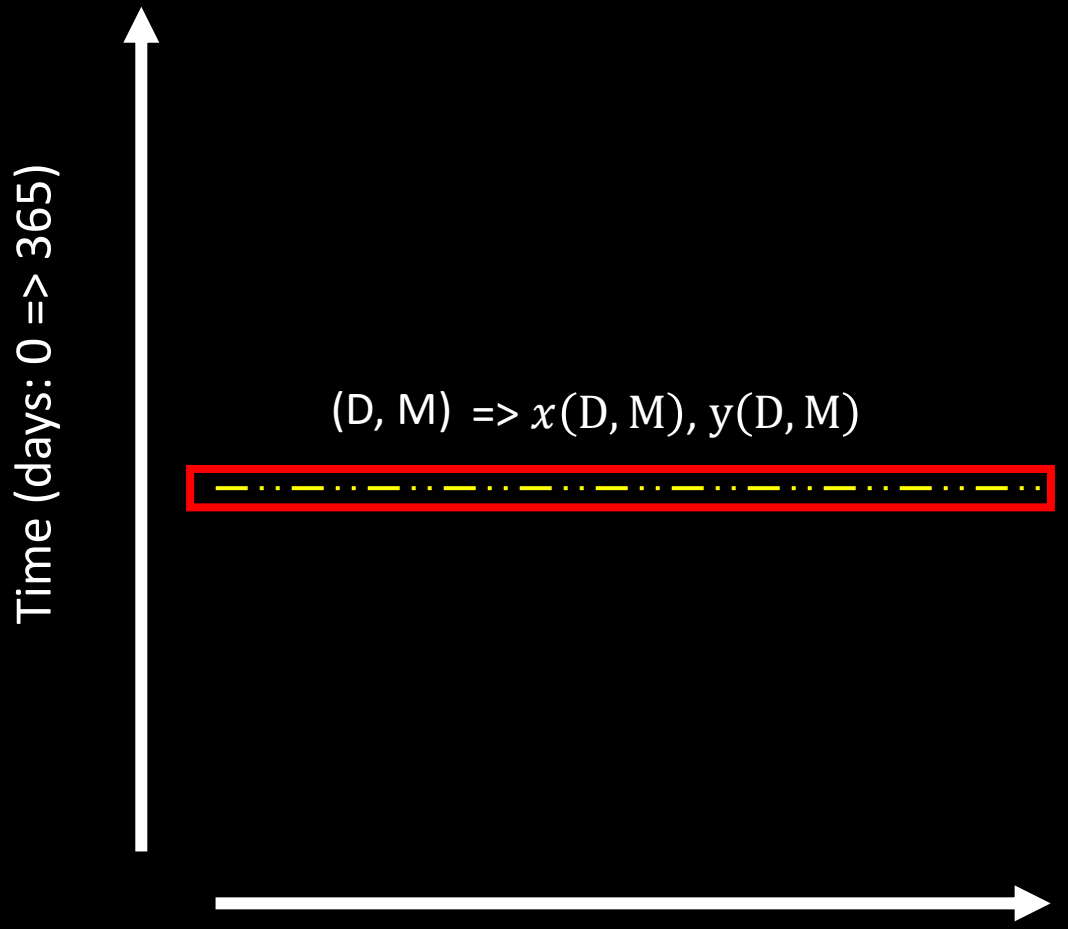

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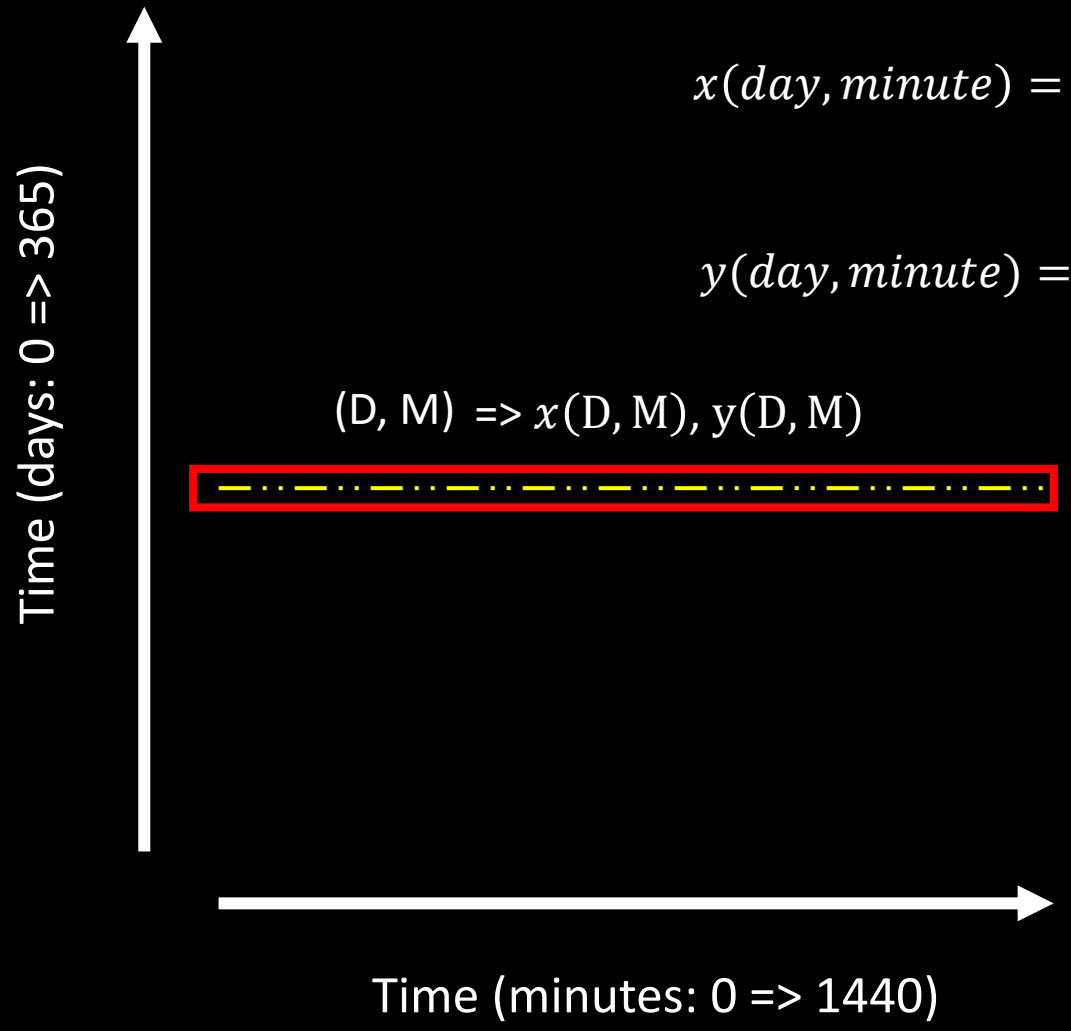
Daily Sun trajectory from minute-by-minute estimates

$$x(day, minute) = \sum_{i=0}^{4} \beta i \; minute^{i} = g_x(minute)$$

$$y(day, minute) = \sum_{i=0}^{4} \lambda i \; minute^{i} = g_y(minute)$$



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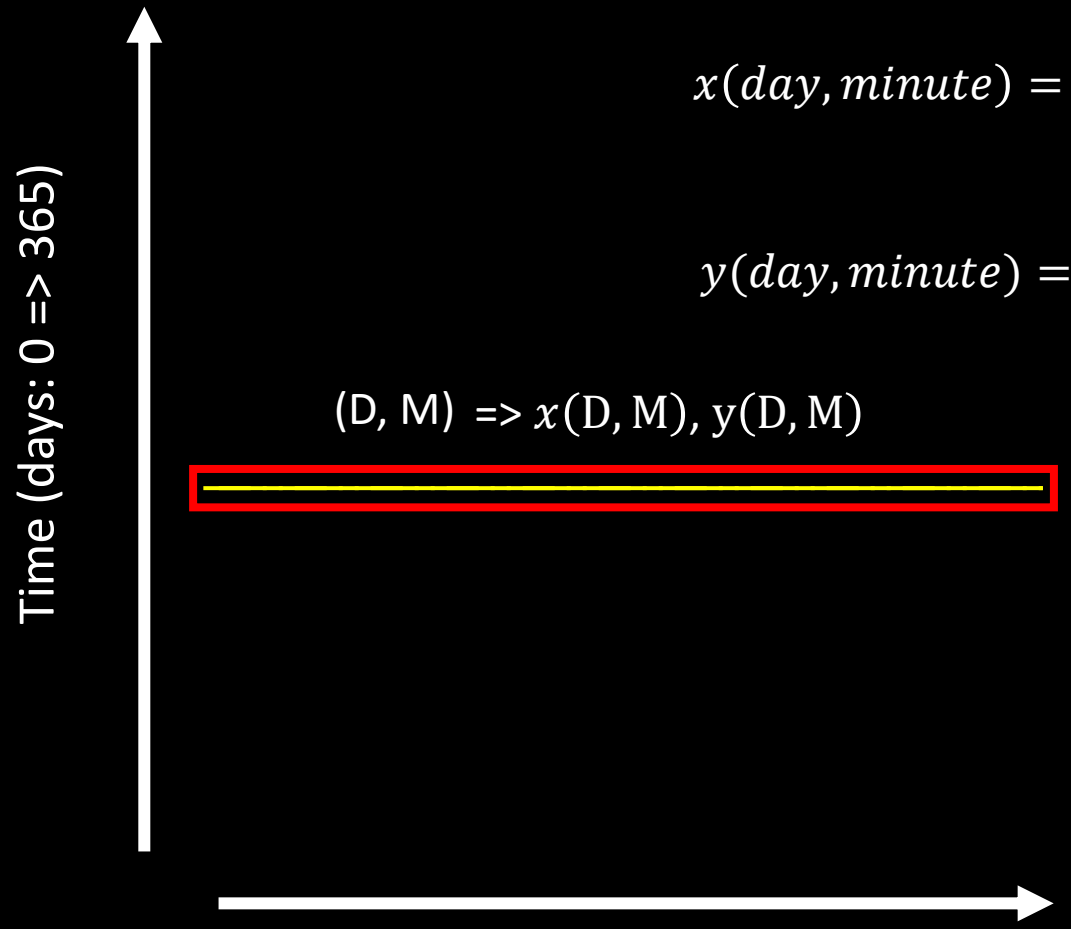
(D, M) => $x(\mathrm{D}, \mathrm{M})$, $\mathrm{y}(\mathrm{D}, \mathrm{M})$



White pixel: Visible Sun position
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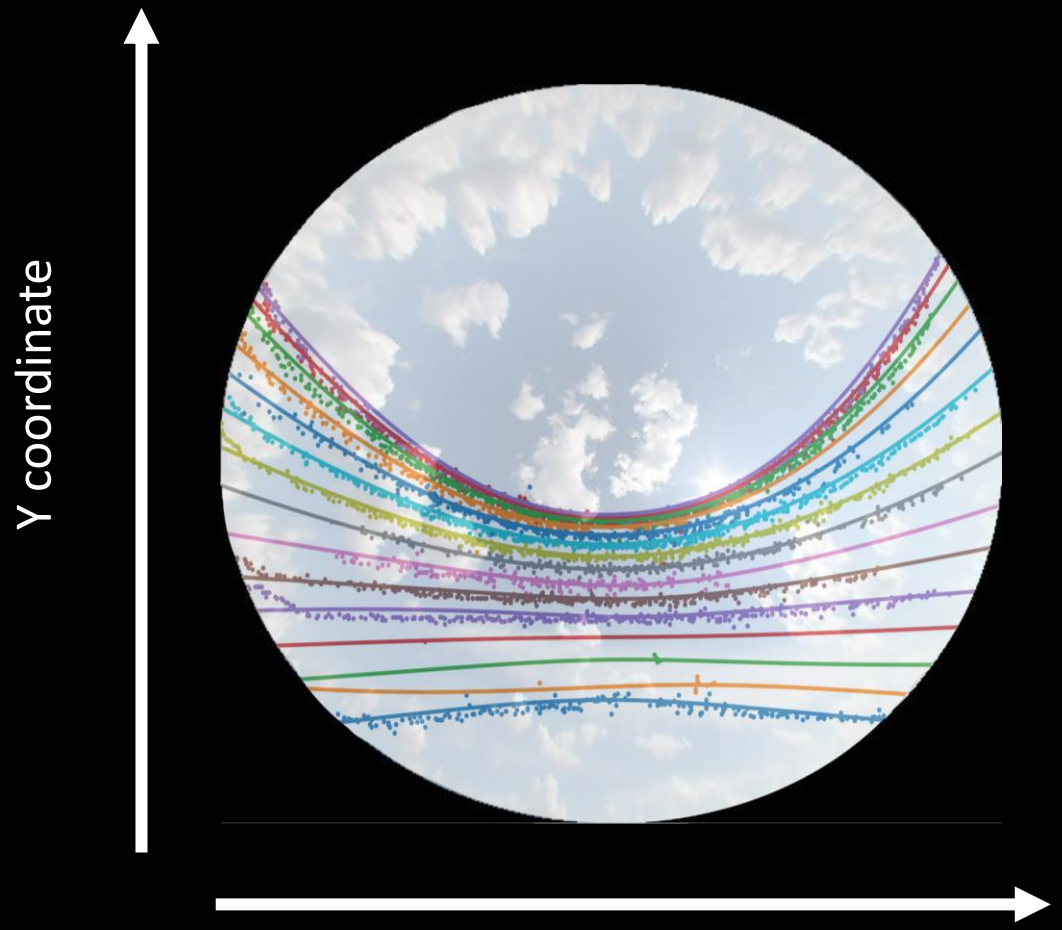
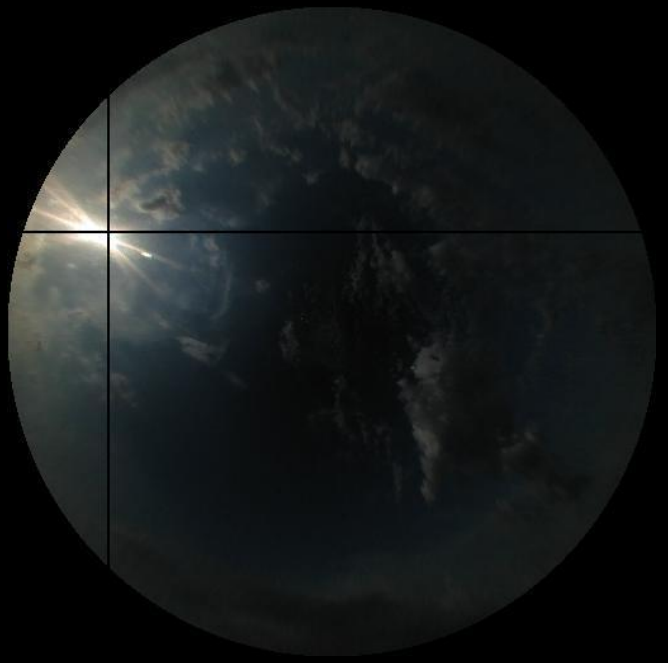
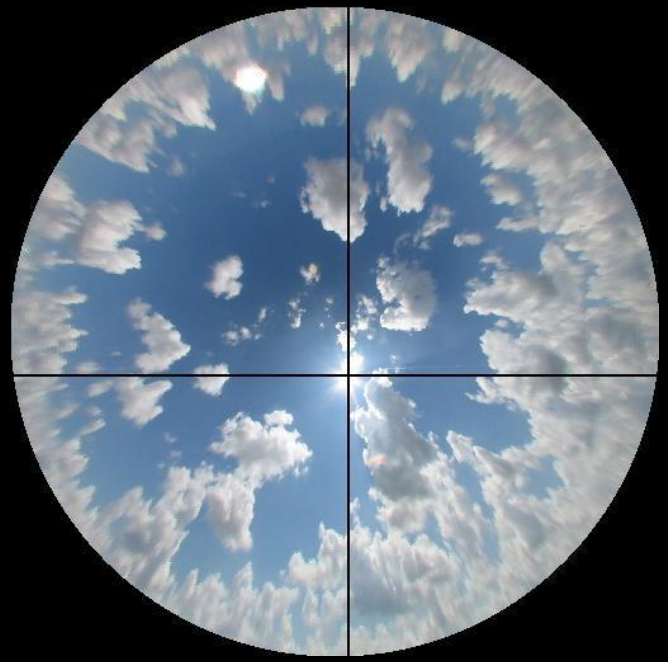
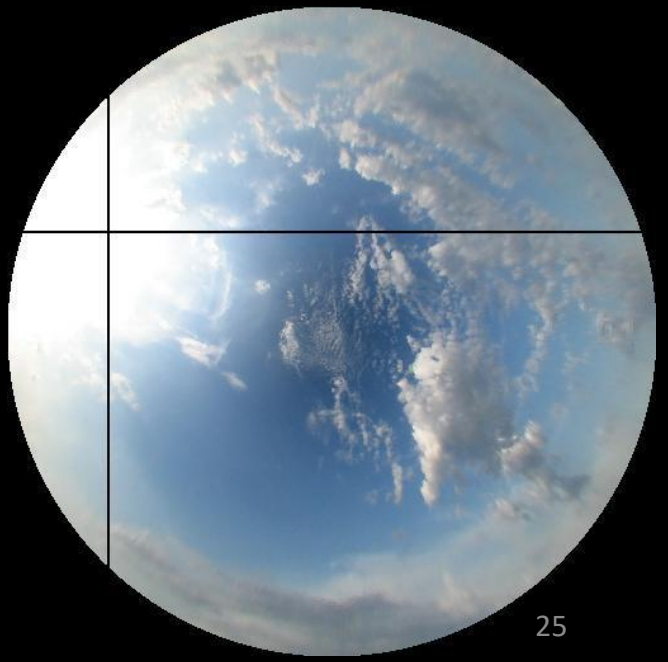
Smooth trajectory of the Sun over days



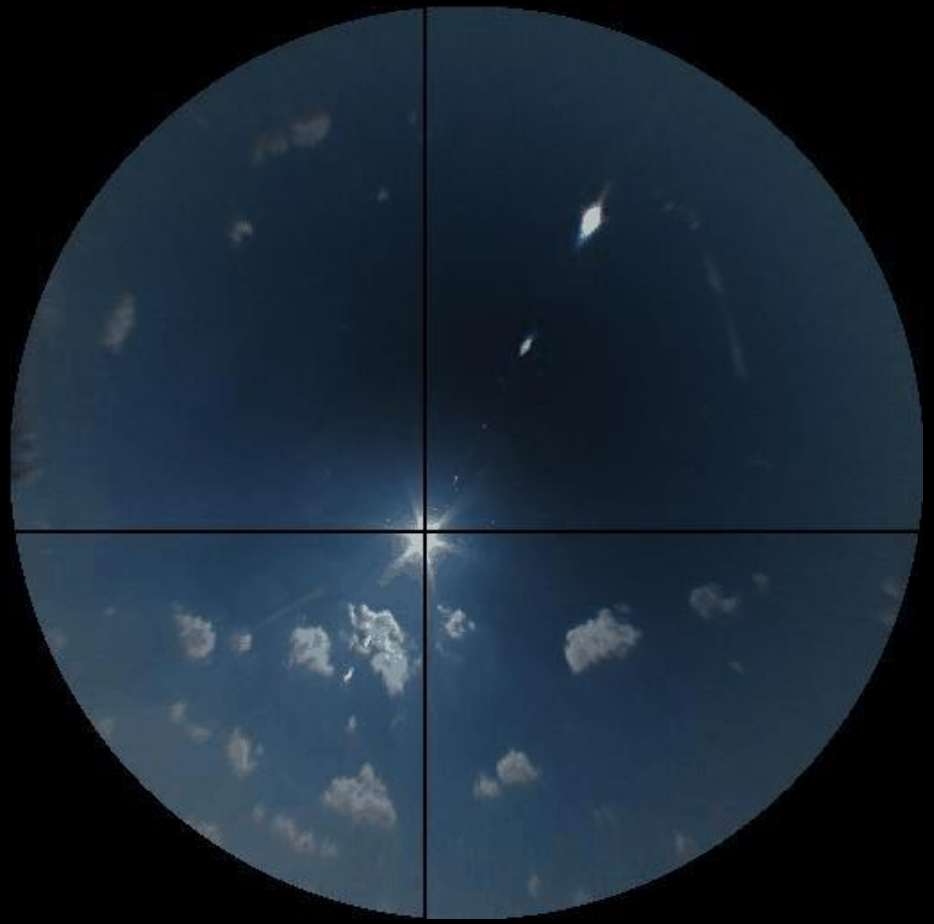
Dots: visible Sun

Solid lines: trajectory of the Sun predicted by the algorithm



Predicts a smooth trajectory of the Sun



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