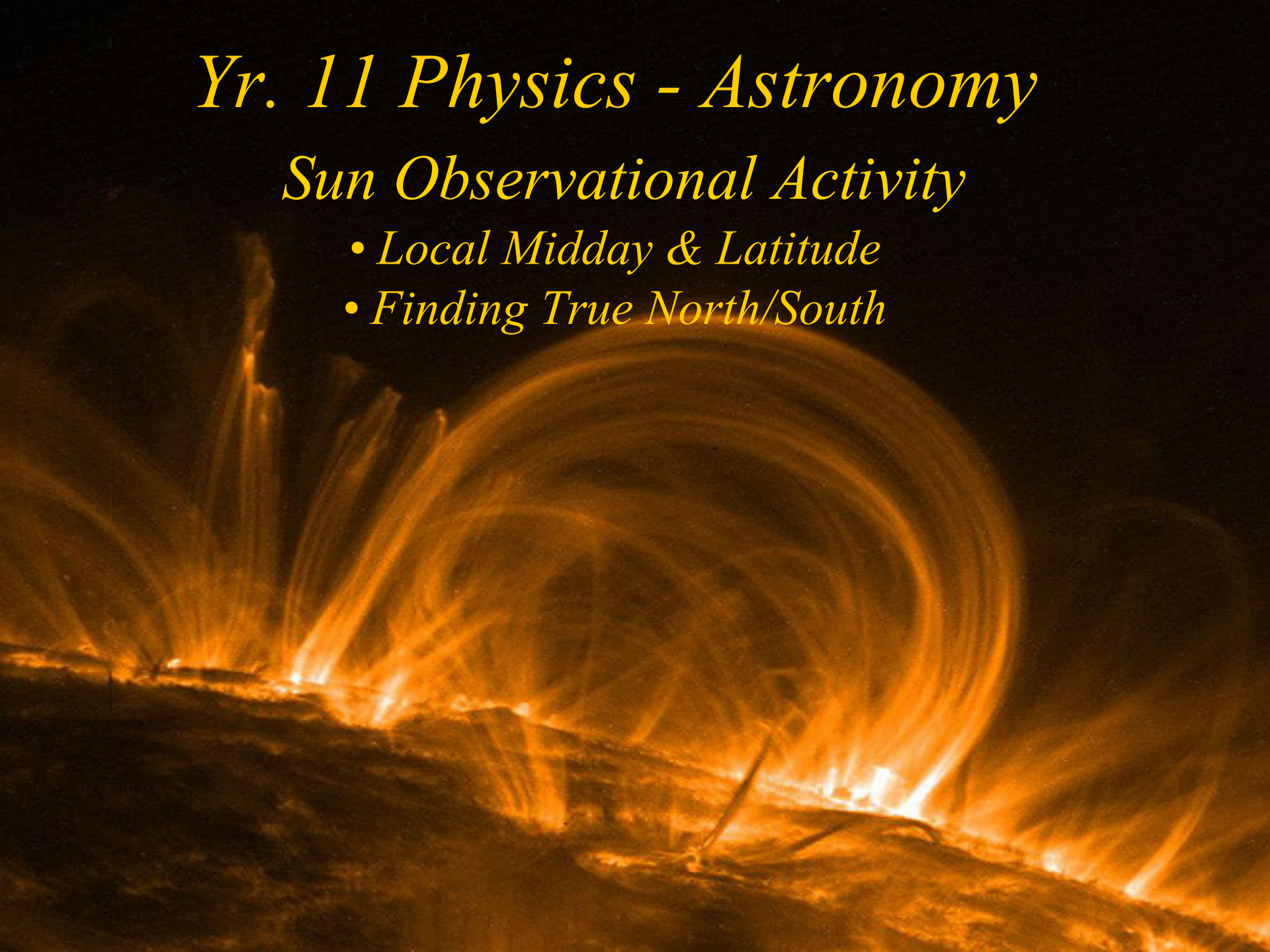
Yr. 11 Physics - Astronomy

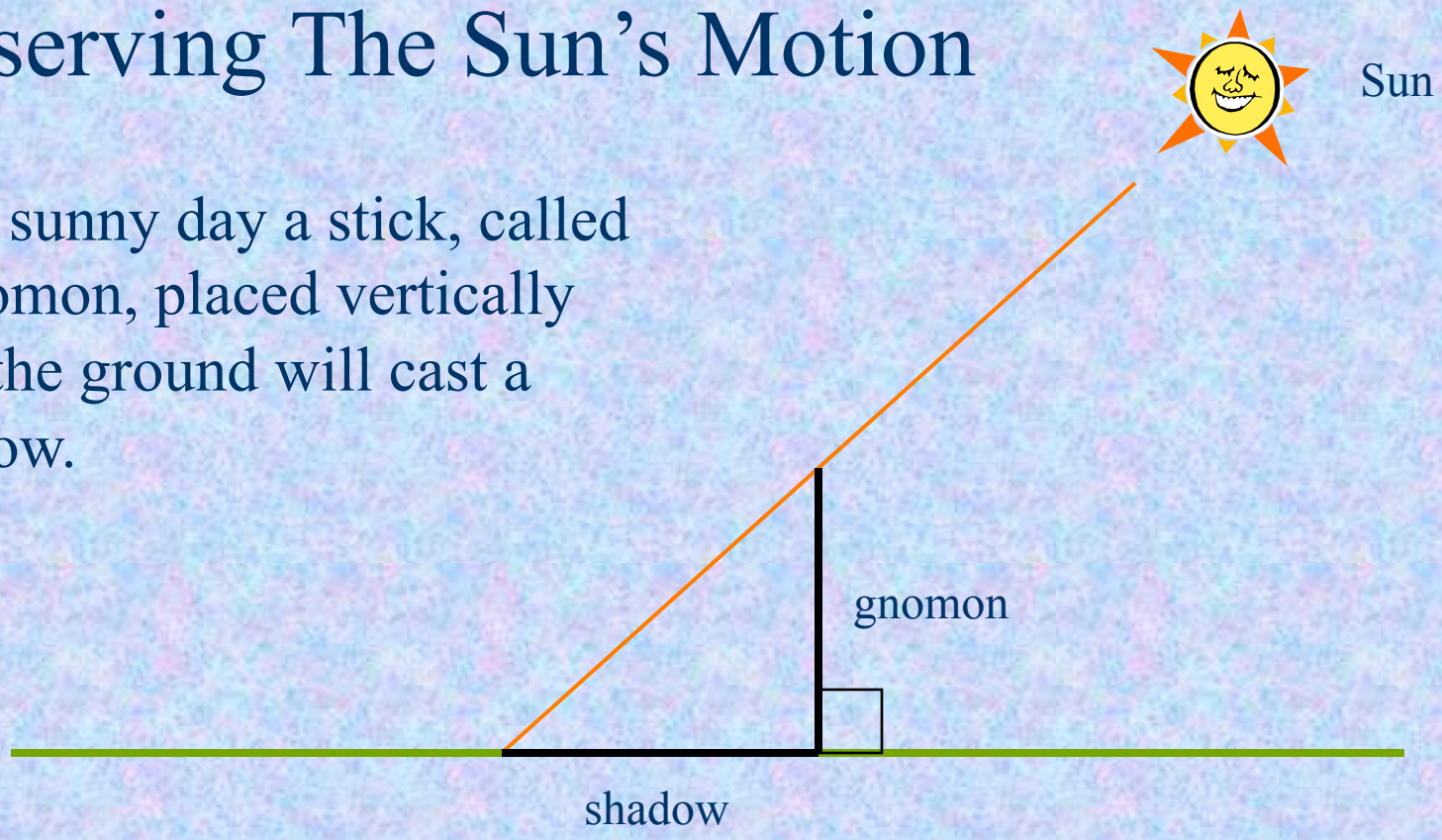
Sun Observational Activity

- *Local Midday & Latitude*
- *Finding True North/South*



Observing The Sun's Motion

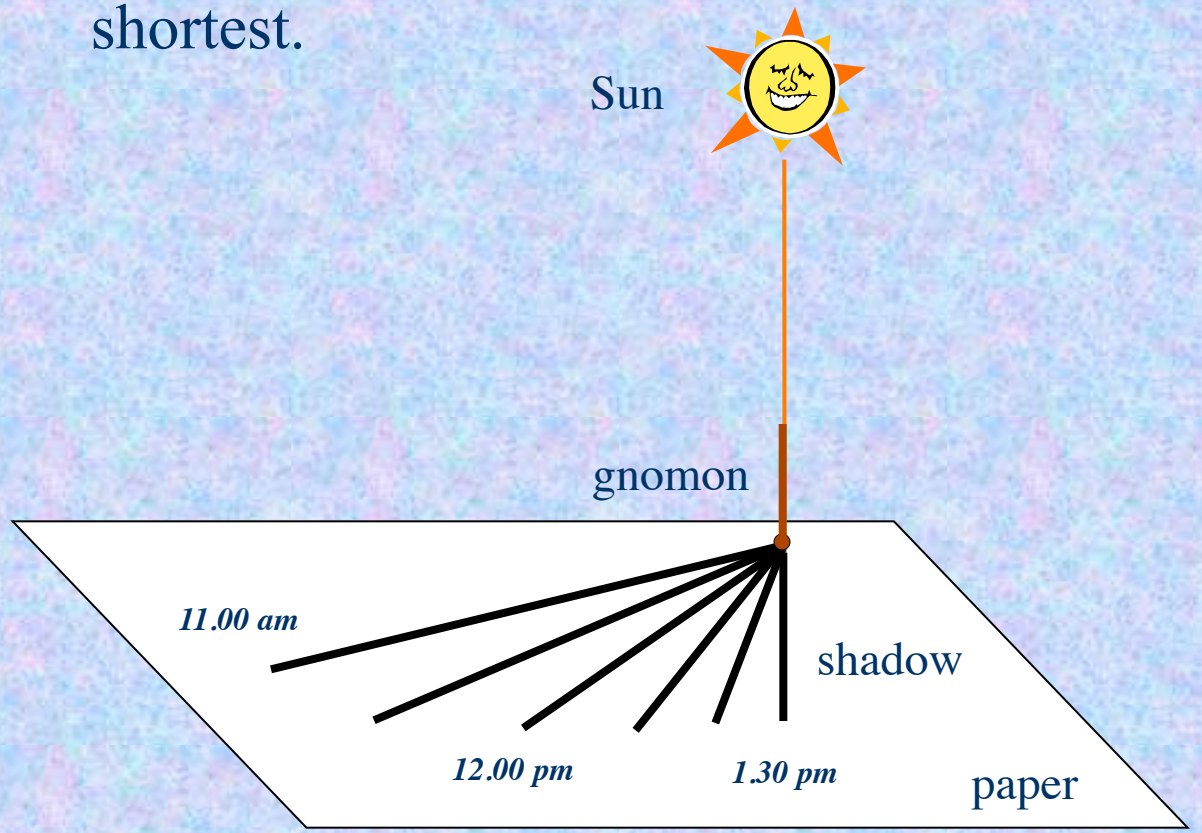
On a sunny day a stick, called a gnomon, placed vertically into the ground will cast a shadow.



The movement of the gnomon's shadow can be used to:

- track the Sun's passage across the sky
- determine local midday
- find True North and South
- determine the latitude of your location

From sunrise in the morning the length of the shadow cast by the gnomon gets shorter until at midday the shadow is at its shortest.

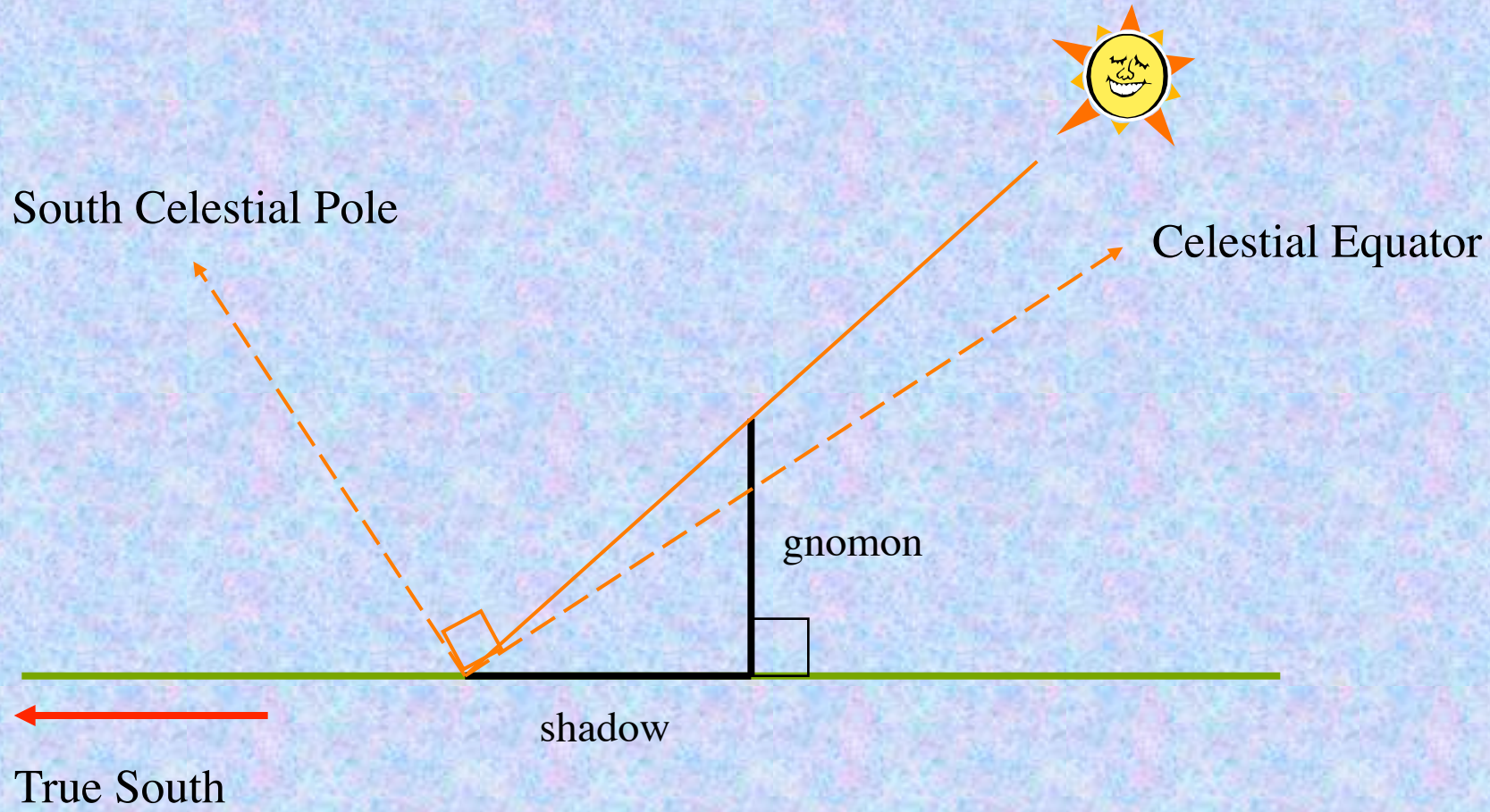


Due to the tilt in the Earth's axis the length of the midday shadow changes throughout the year.

It is shortest, in the Southern Hemisphere, on December 21st - the Summer Solstice.

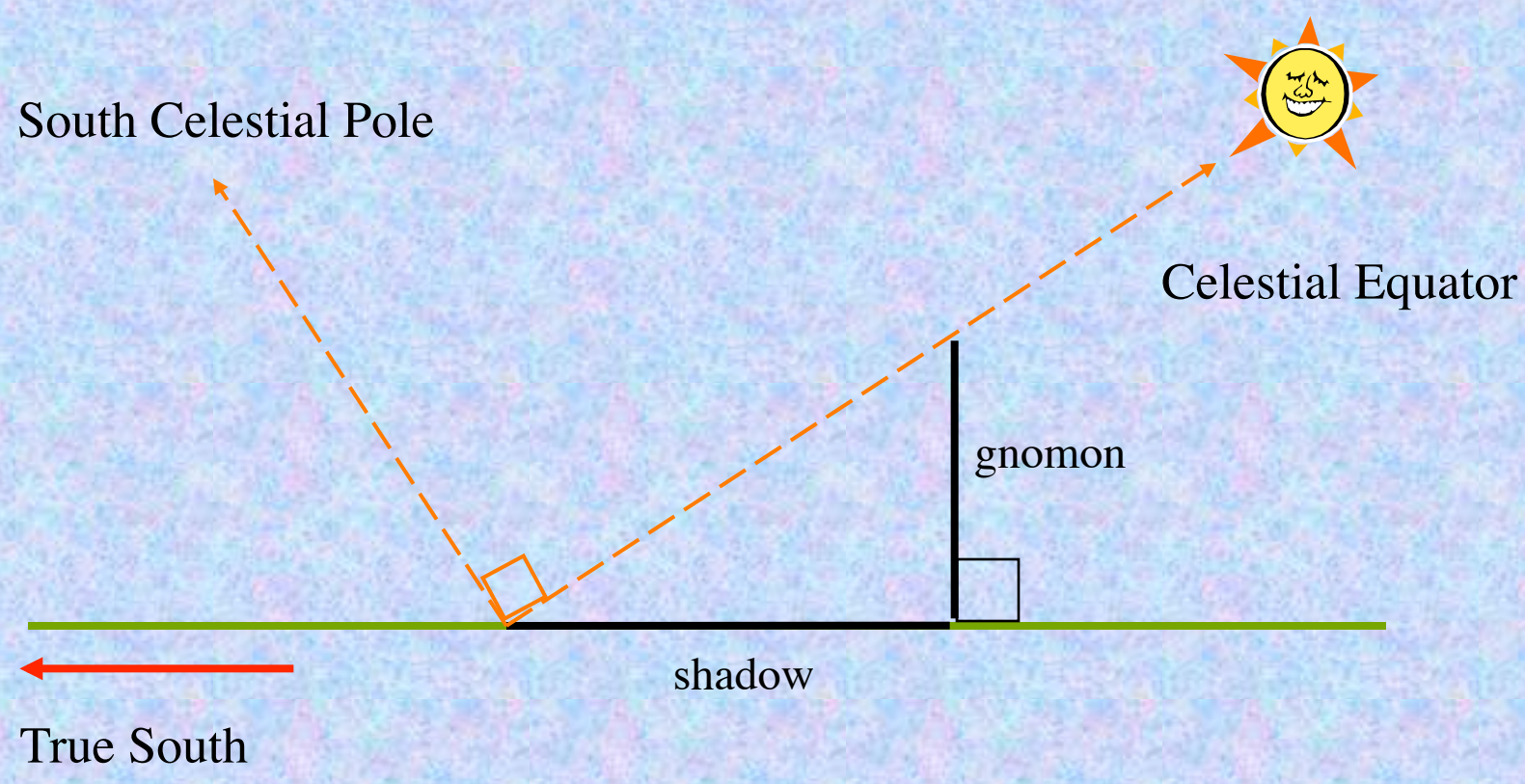
Conversely, the gnomon's midday shadow will be longest on June 21st - the Winter Solstice.

Summer Solstice - Midday December 21st



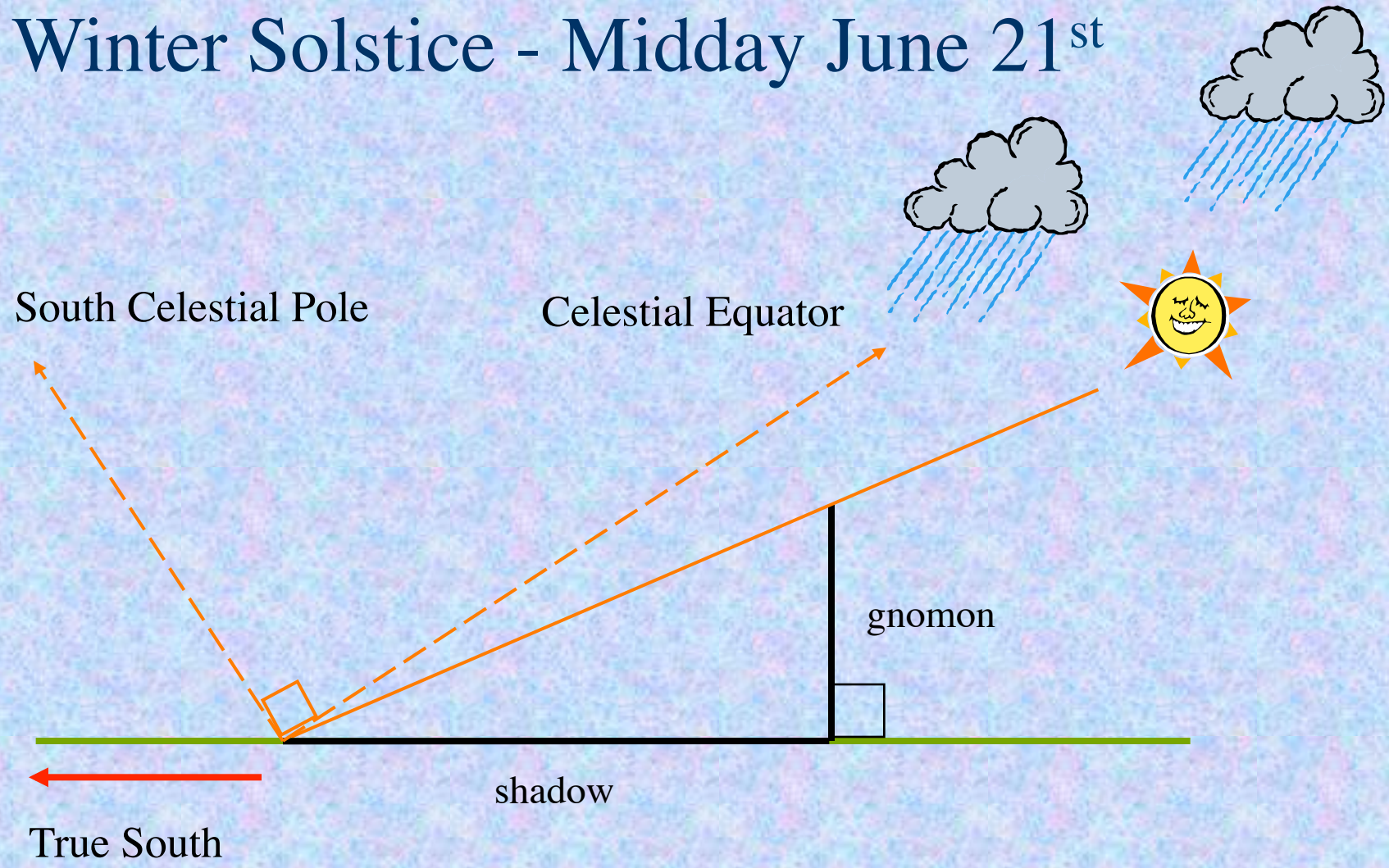
The Summer Solstice marks the day of the year with the most hours of daylight and the gnomon's shadow will be at its shortest for the year at midday.

Autumn Equinox - Midday March 22nd



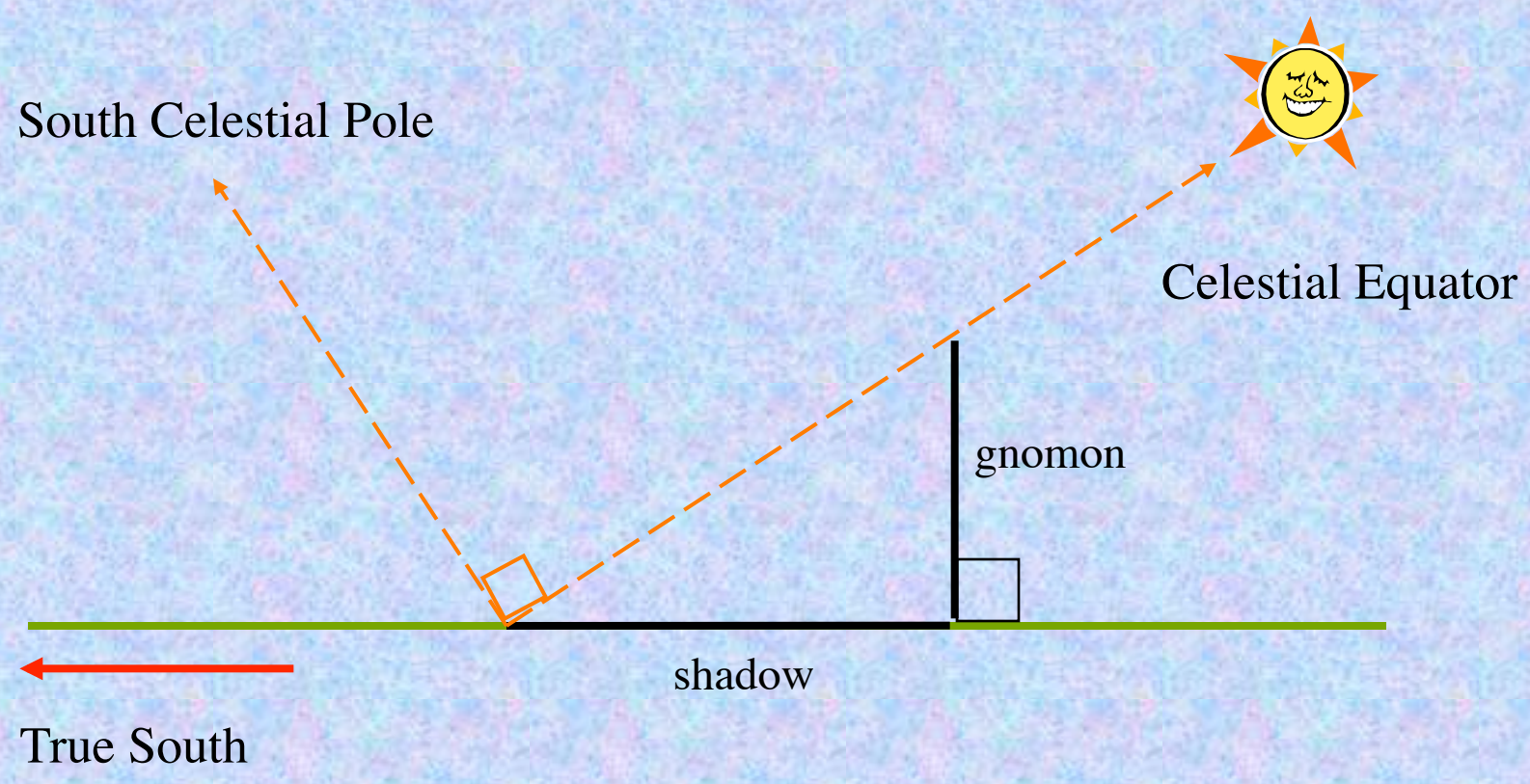
At the Autumn and Spring Equinoxes the hours of daylight and night are equal in length.

Winter Solstice - Midday June 21st



The Winter Solstice marks the day of the year with the least hours of daylight and the gnomon's midday shadow will be at its longest for the year.

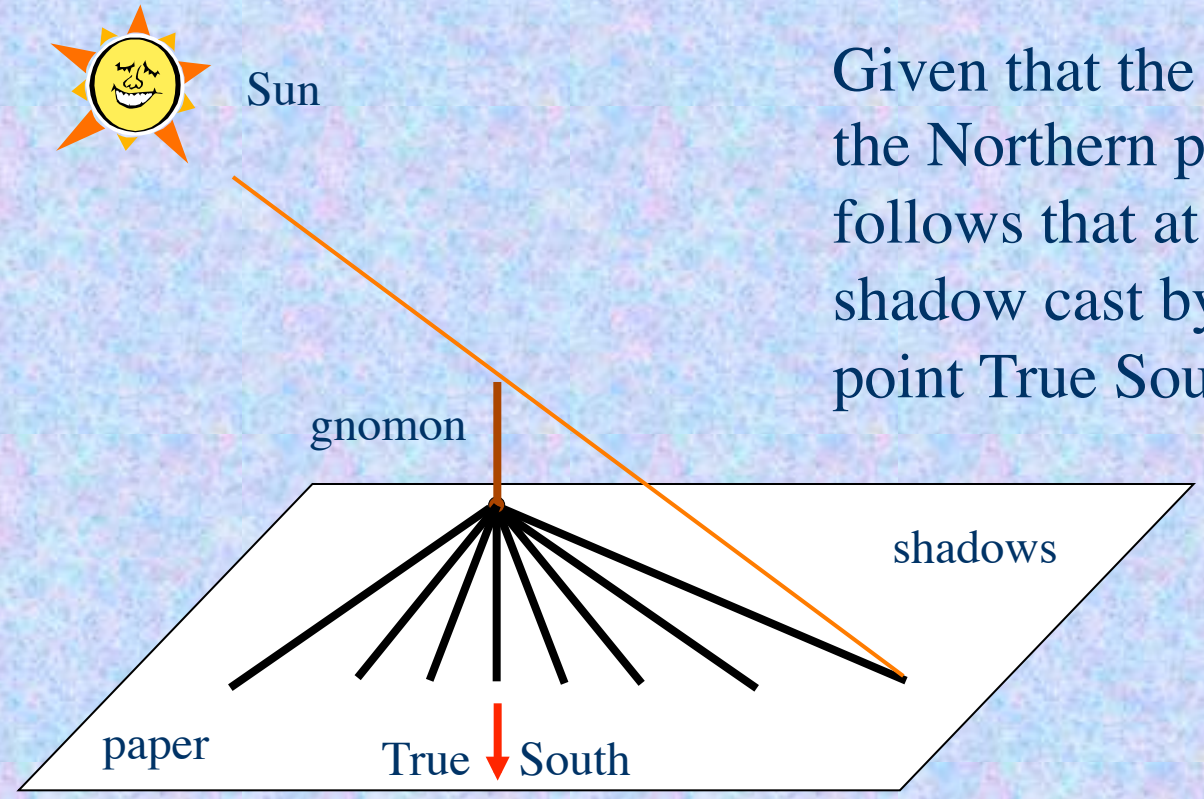
Spring Equinox - Midday September 21st



At the Autumn and Spring Equinoxes the hours of daylight and night are equal in length.

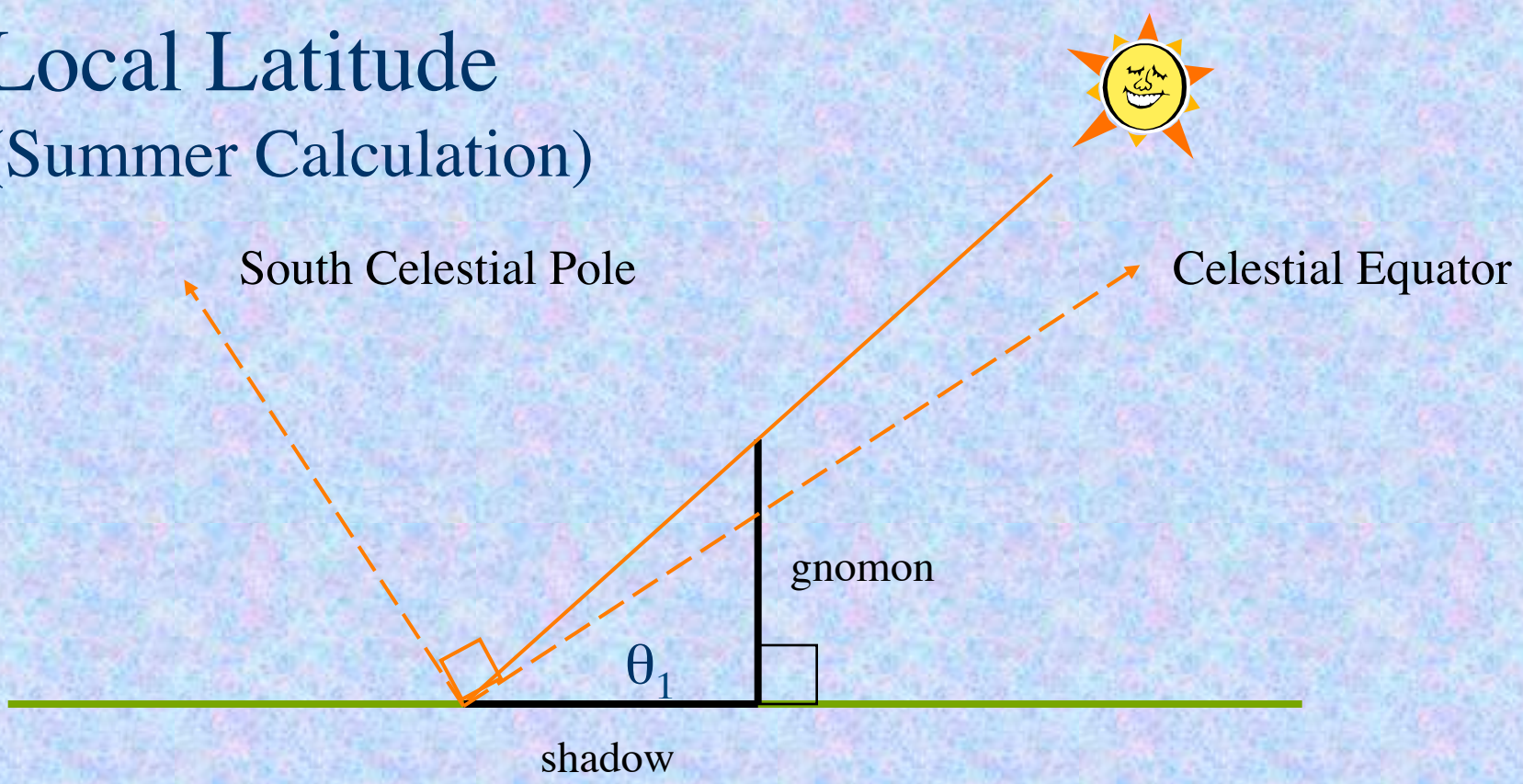
Local Midday & True North South

By recording the position of the gnomon's shadow at regular intervals a relatively accurate determination of the time of local midday can be obtained when the shadow is at its shortest.



Given that the Sun appears in the Northern part of our sky it follows that at local midday the shadow cast by the gnomon will point True South.

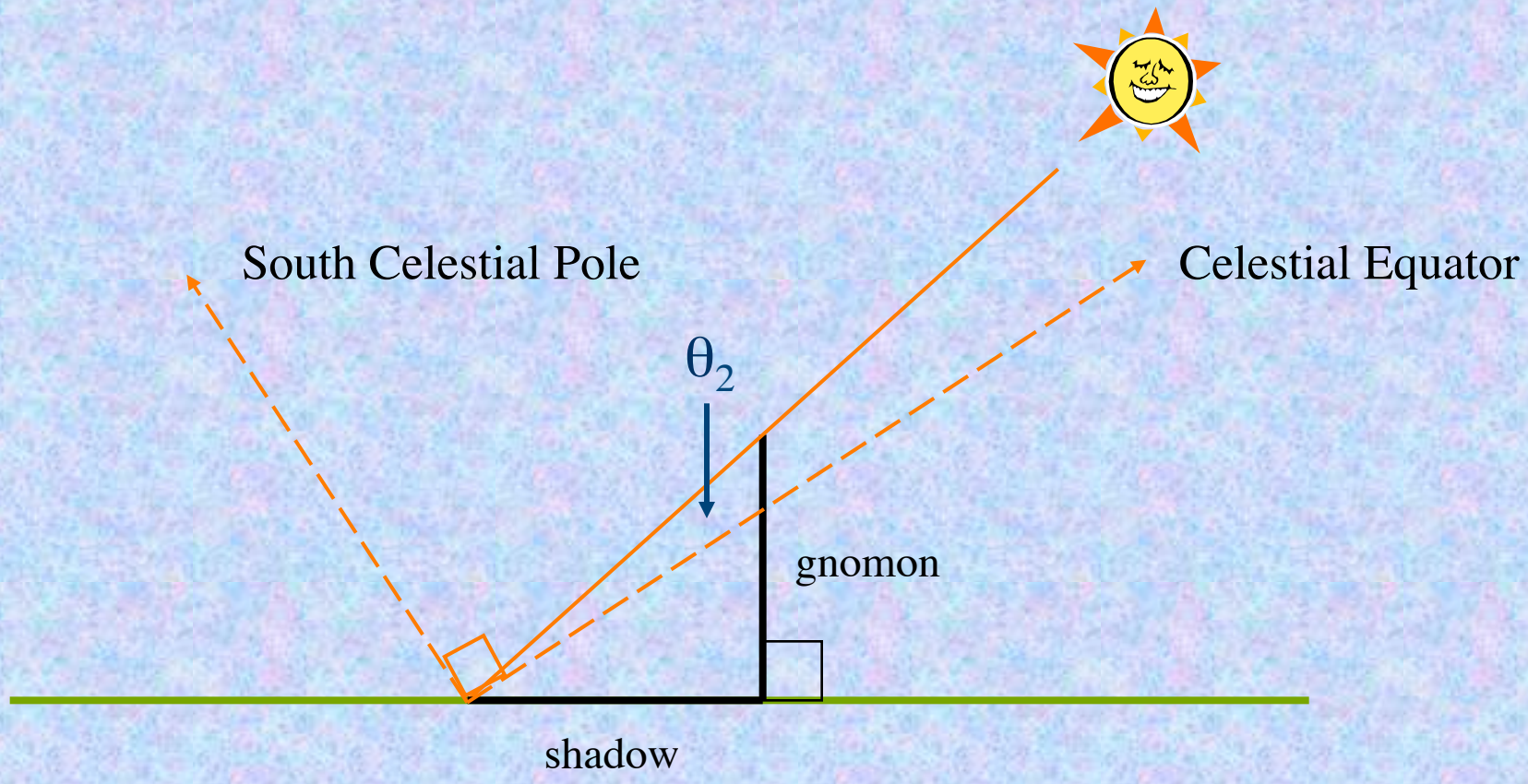
Local Latitude
(Summer Calculation)



<u>Step 1</u>

Calculate θ_1, the angle of elevation between the shadow's end and the top of the gnomon.

$$\theta_1 = \tan^{-1}\left(\frac{\text{gnomon height}}{\text{shadow length}}\right)$$

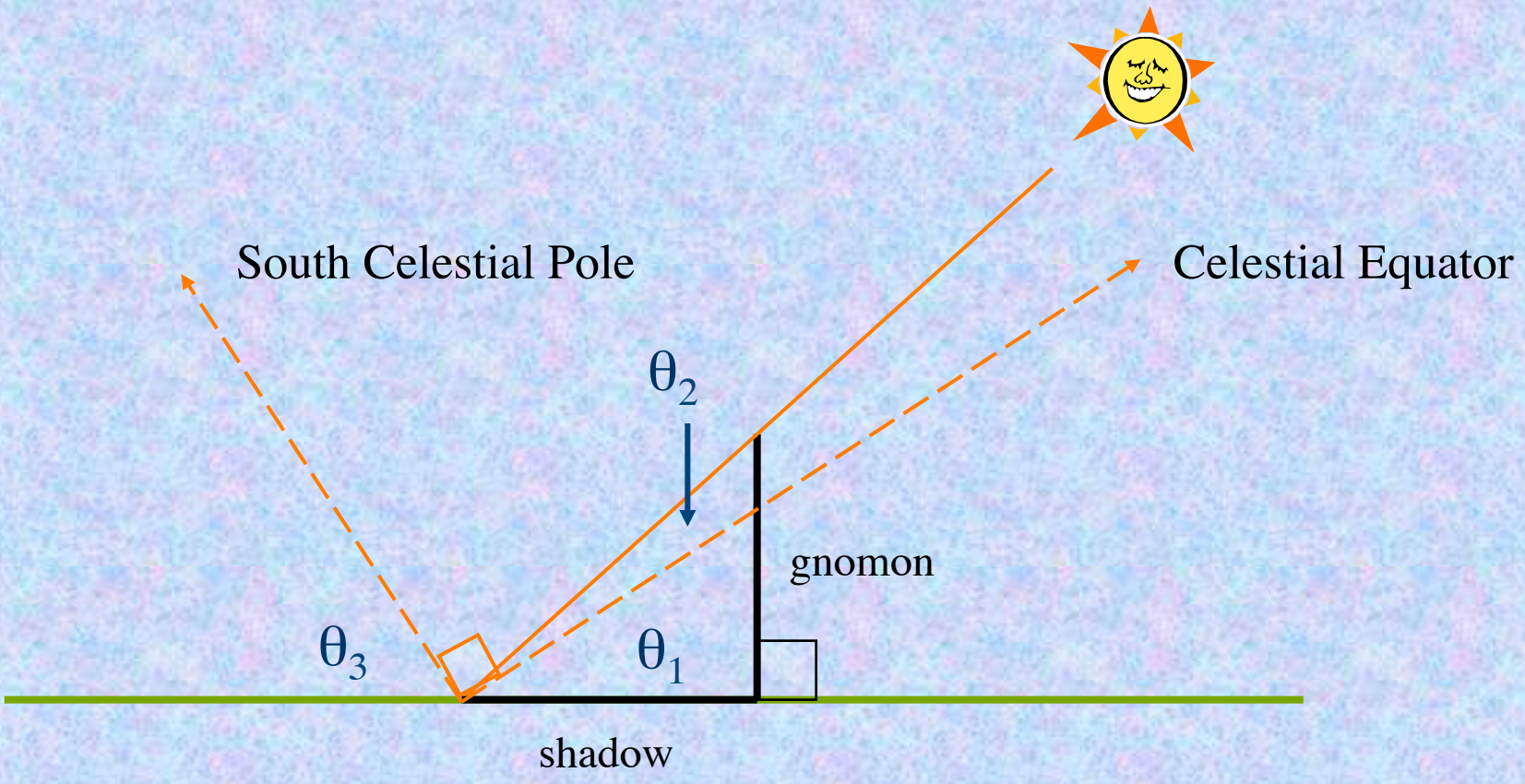


<u>Step 2</u>

Determine θ_2, the angle of the Sun's declination. This is the Sun's angular distance from the Celestial Equator. It can be obtained from a book containing astronomical data or online.

E.g. http://www.wsanford.com/~wsanford/exo/sundials/DEC_Sun.html

θ_2 = Sun's Declination Angle



<u>Step 3</u>

Calculate θ_3, the angle of elevation between the horizon and the South Celestial Pole. θ_3 corresponds to your local latitude.

$$\theta_3 = 180^o - 90^o - (\theta_1 - \theta_2) \qquad \text{or} \qquad \theta_3 = 90^o - (\theta_1 - \theta_2)$$

Sample Summer Calculation

Place:	Barjarg, Victoria
Date:	December 27th 2003
Sun's Declination:	23.32° South
Gnomon Height:	15.7 cm
Shadow Length:	3.9 cm

$$\theta_1 = \tan^{-1}\left(\frac{15.7}{3.9}\right)$$

$$\theta_1 = 76.05^\circ$$

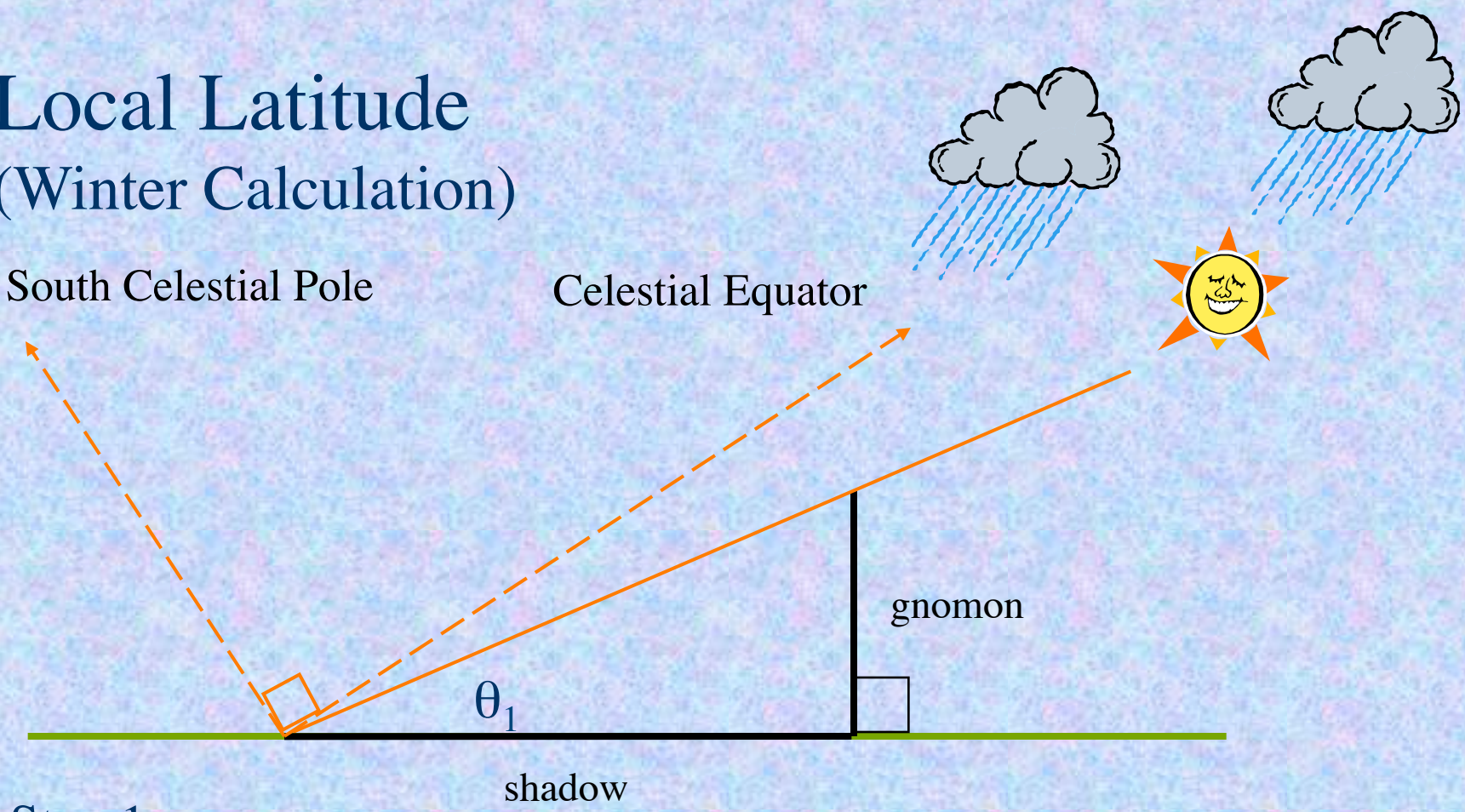
$$\theta_3 = 90^\circ - (\theta_1 - \theta_2)$$

$$\theta_3 = 90^\circ - (76.05^\circ - 23.32^\circ)$$

$$\theta_3 = 37.27^\circ$$

So Barjarg's Latitude is 37.27° South.

Local Latitude
(Winter Calculation)



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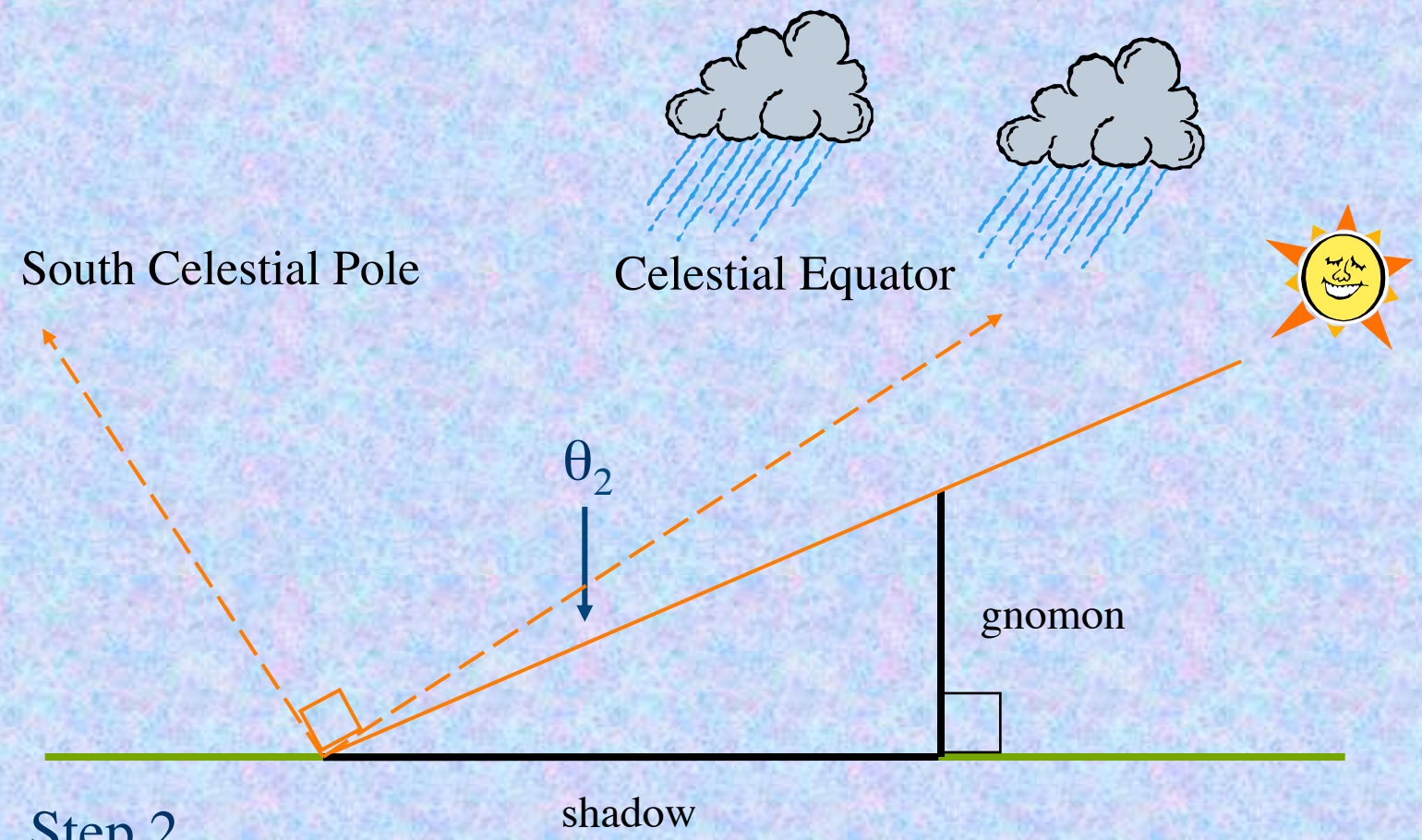
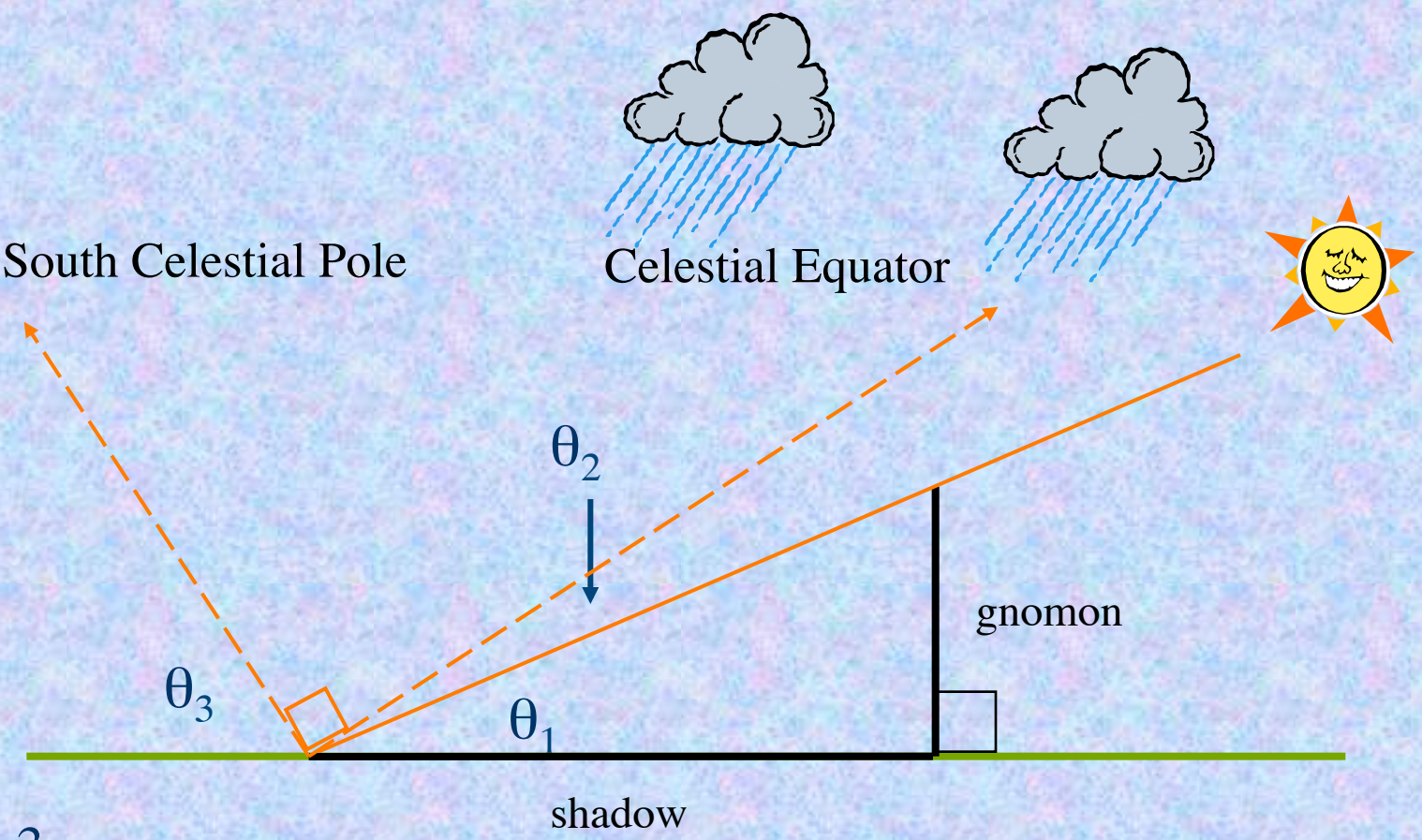


<u>Step 2</u>

Determine θ_2, the angle of the Sun's declination. This is the Sun's angular distance from the Celestial Equator, it can be obtained from a book containing astronomical data.

θ_2 = Sun's Declination Angle



<u>Step 3</u>

Calculate θ_3, the angle of elevation between the horizon and the South Celestial Pole. θ_3 corresponds to your local latitude.

$$\theta_3 = 180^o - 90^o - (\theta_1 + \theta_2) \qquad \text{or} \qquad \theta_3 = 90^o - (\theta_1 + \theta_2)$$

Sample Winter Calculation

Place:	Stanley, Tasmania
Date:	May 18th 2003
Sun's Declination:	19.57° North
Gnomon Height:	14.0 cm
Shadow Length:	24.6 cm

$$\theta_1 = \tan^{-1}\left(\frac{14.0}{24.6}\right)$$

$$\theta_1 = 29.64^\circ$$

$$\theta_3 = 90^\circ - (\theta_1 + \theta_2)$$

$$\theta_3 = 90^\circ - (29.64^\circ + 19.57^\circ)$$

$$\theta_3 = 40.79^\circ$$

So Stanley's latitude is 40.79° South.