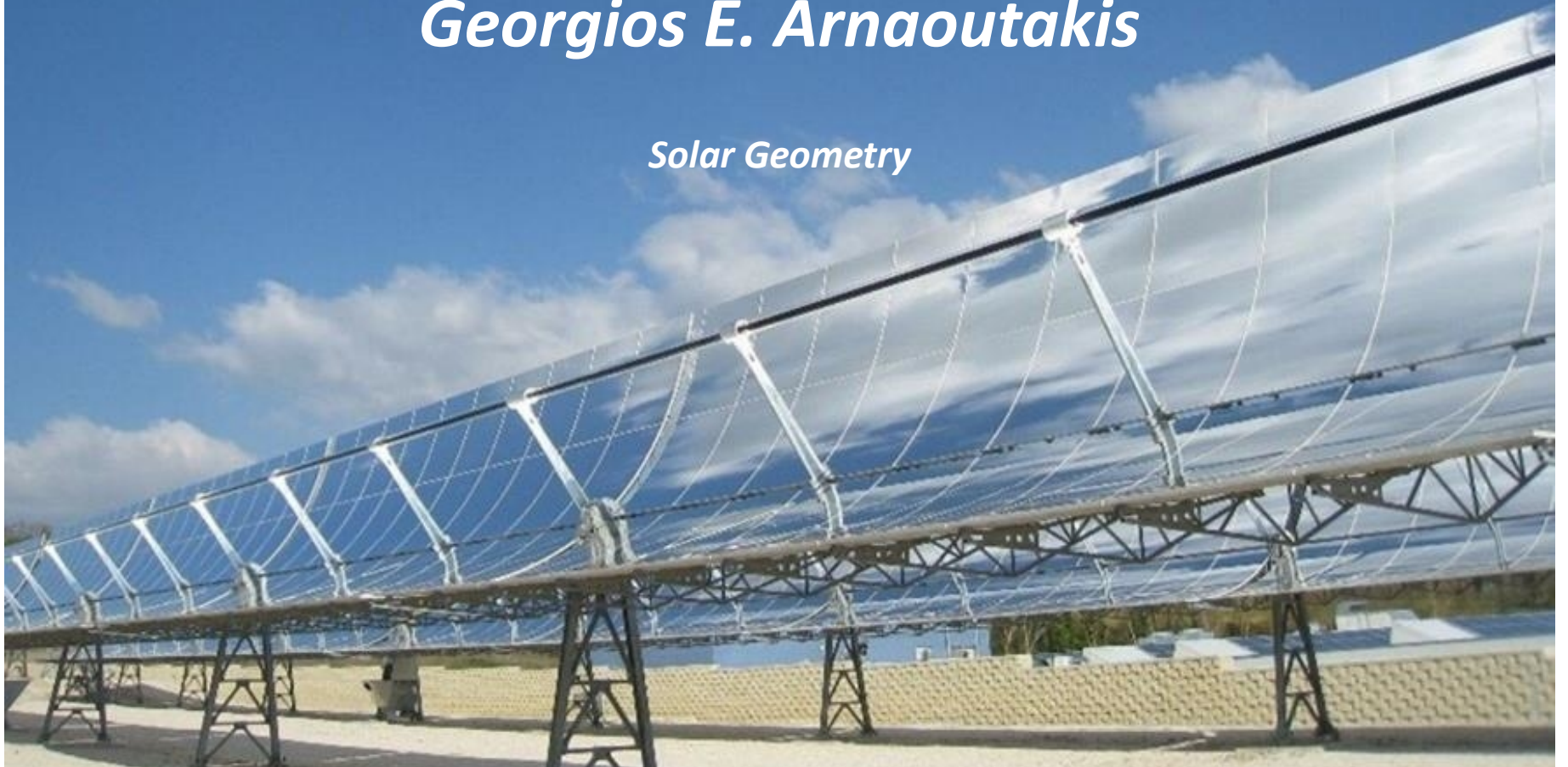


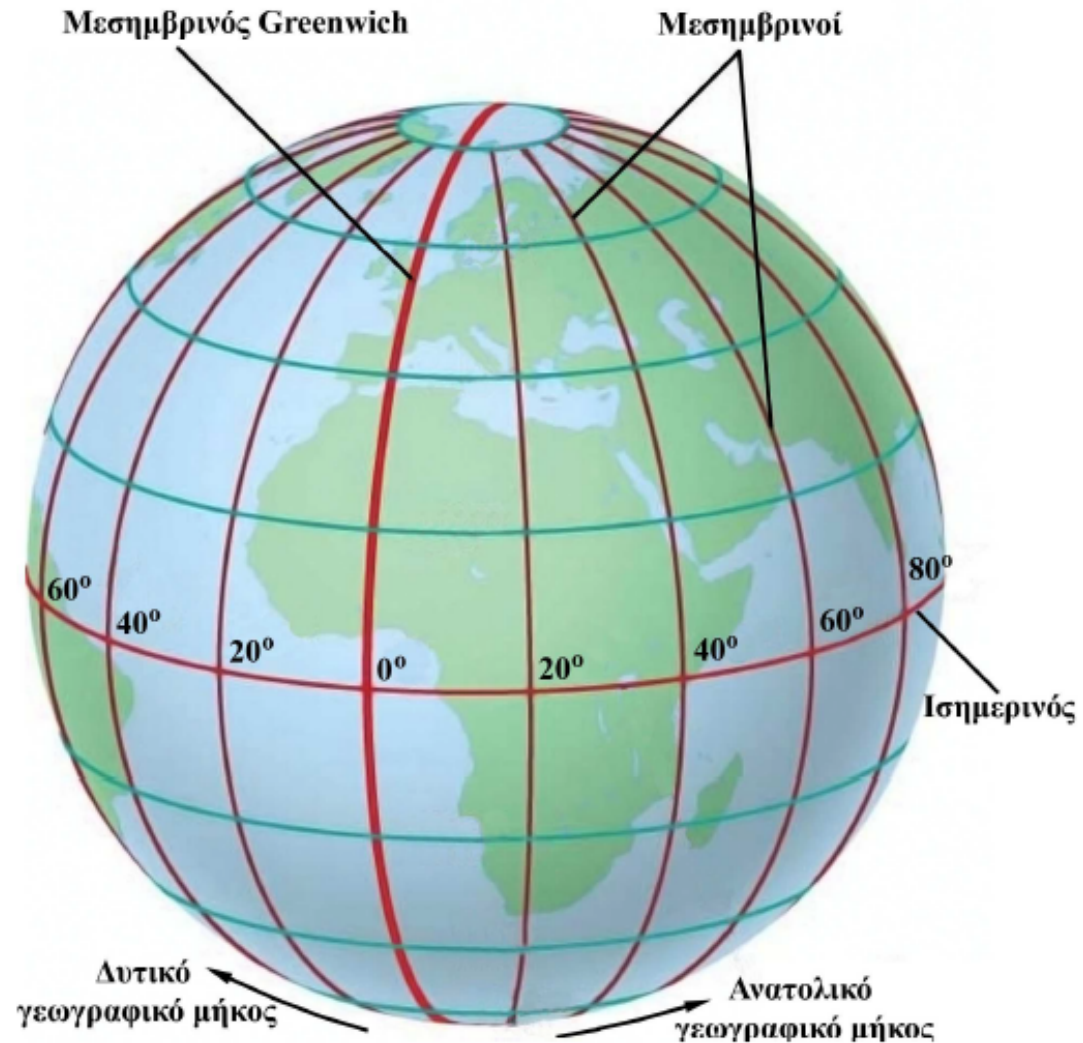
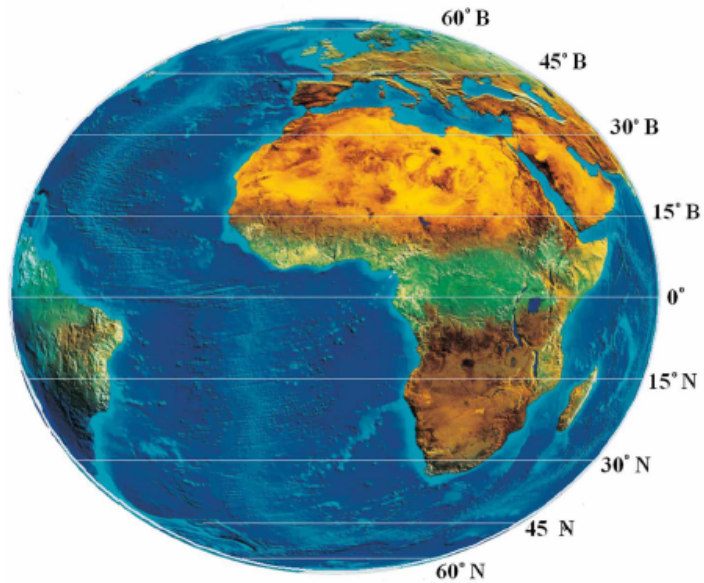
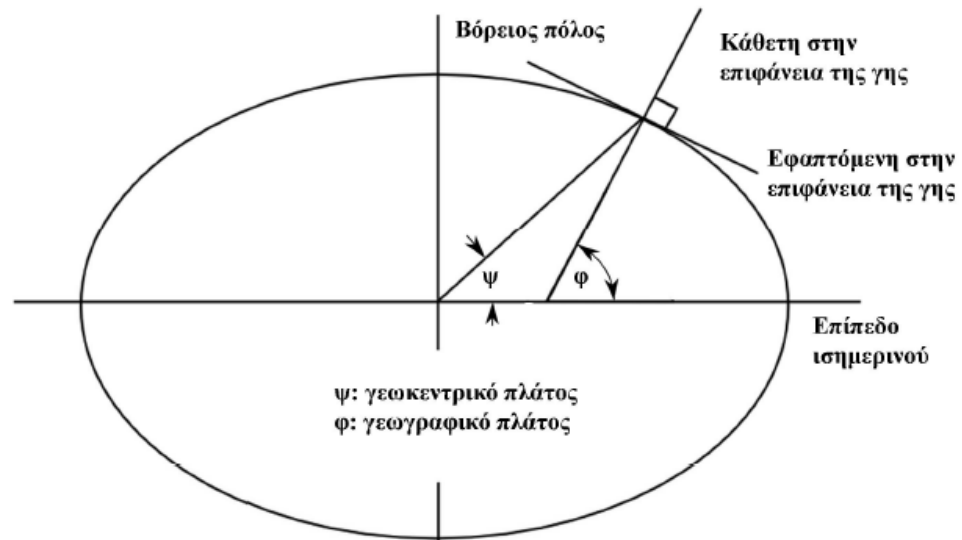
Solar Energy & Applications

Georgios E. Arnaoutakis

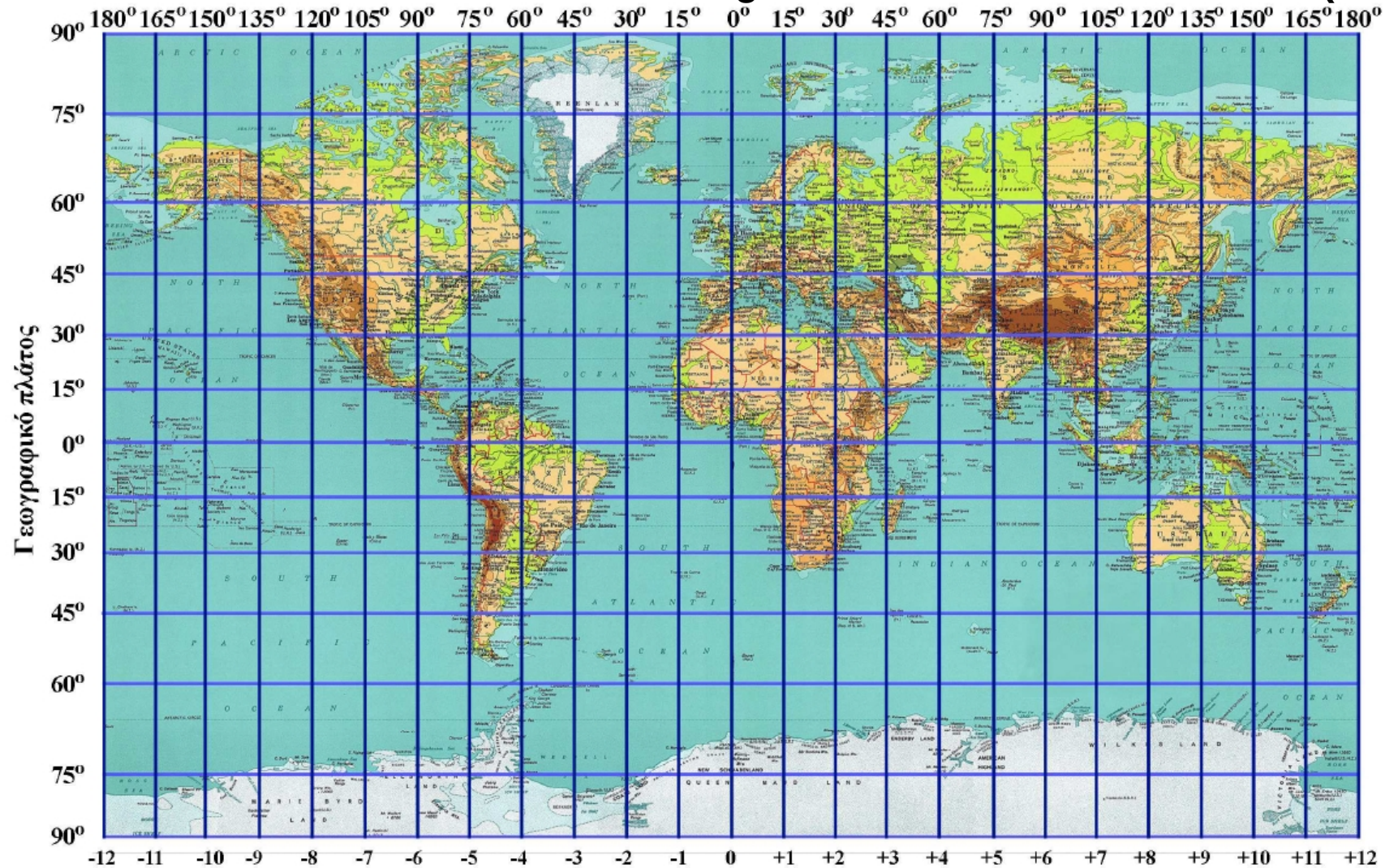
Solar Geometry



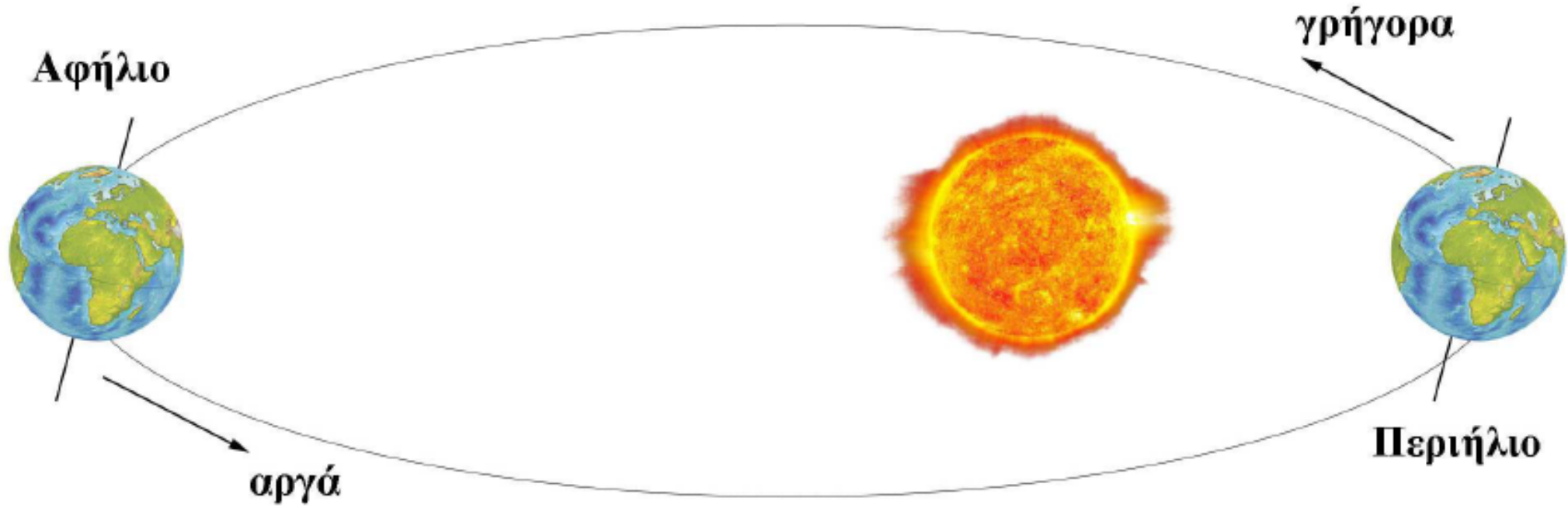
Longitude & Latitude

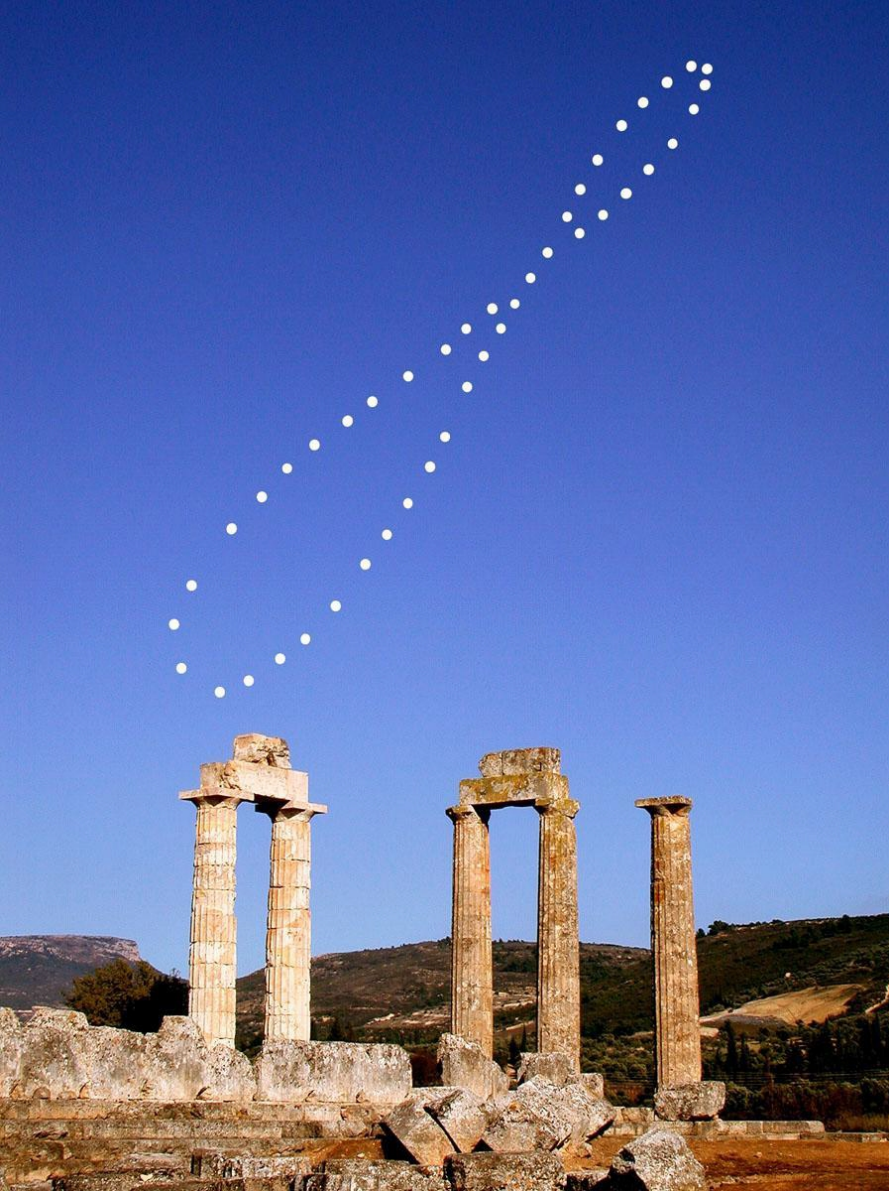


Longitude & Latitude & hour zones (Mercator)



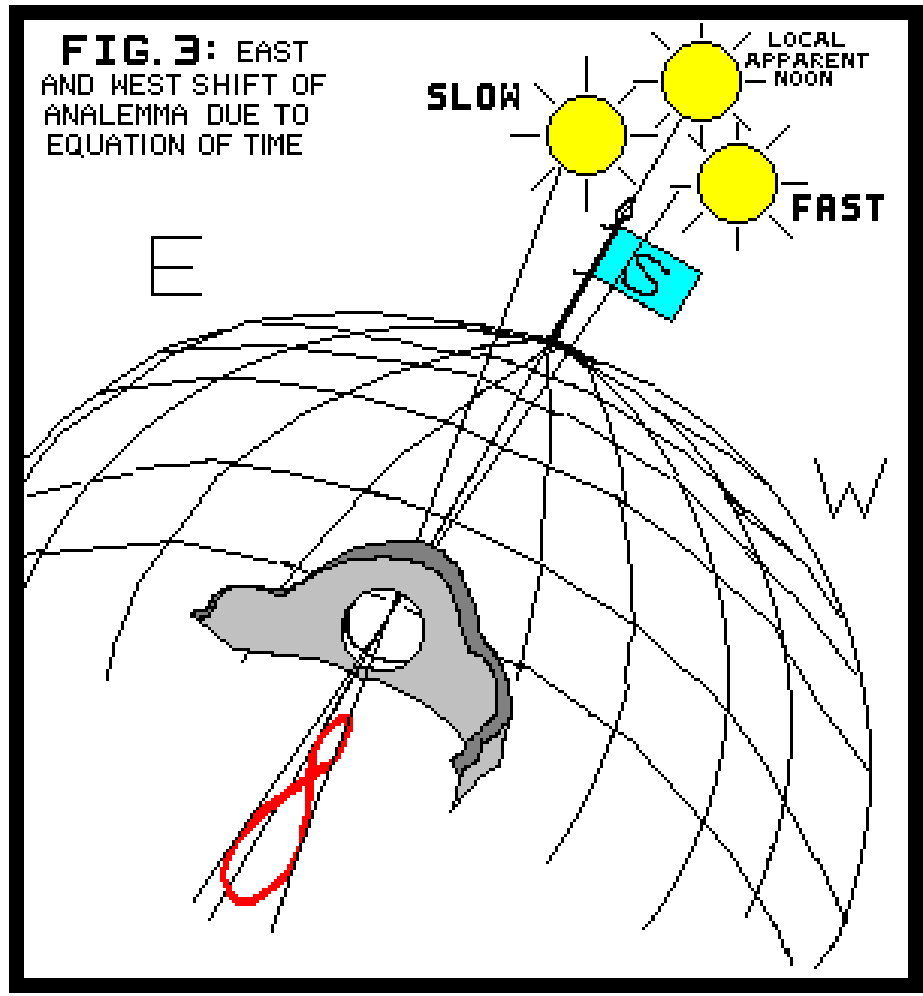
Αφήλιον - Aphelion & Περιήλιον - Perihelion





Ανάλημμα - Analemma

The diagram showing the position of the Sun in the sky as seen from a fixed location on Earth at the same mean solar time over the course of a year.



Equation of Time

$$E_t = 2,2918 \cdot [0,0075 + 0,1868 \cdot \cos(\Gamma) - 3,2077 \cdot \sin(\Gamma) - 1,4615 \cdot \cos(2\Gamma) - 4,089 \cdot \sin(2\Gamma)]$$

$$\Gamma = 360^\circ \cdot \frac{n-1}{365}$$

$$t_{\text{sol}} = t_{\text{loc-civ}} + \frac{E_t}{60}$$

$$t_{\text{sol}} = t_{\text{std}} + \frac{\lambda_{\text{std}} - \lambda_{\text{loc}}}{15} + \frac{E_t}{60}$$

t_{sol} : Solar time (h)

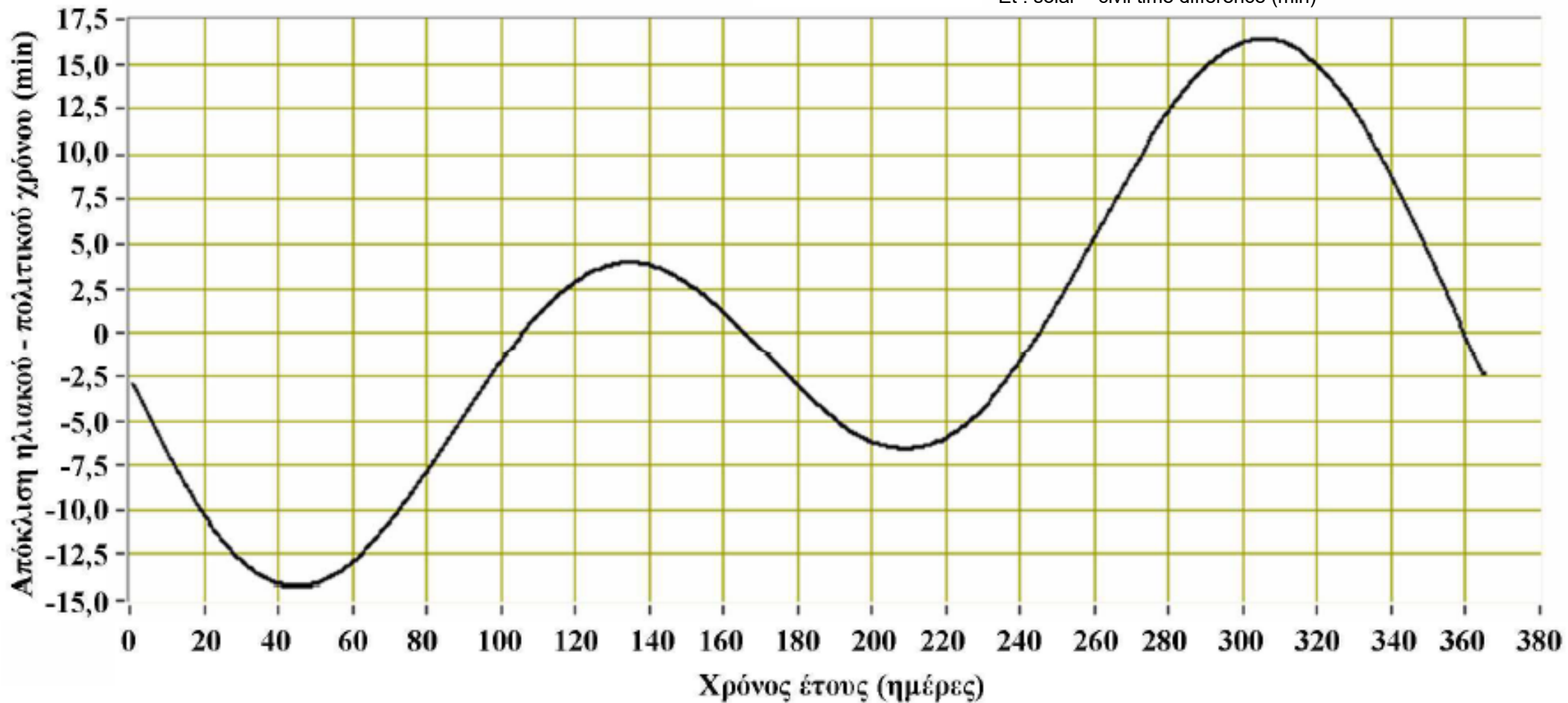
$t_{\text{loc-civ}}$: local civil time (h)

t_{std} : Greenwich zone time (h)

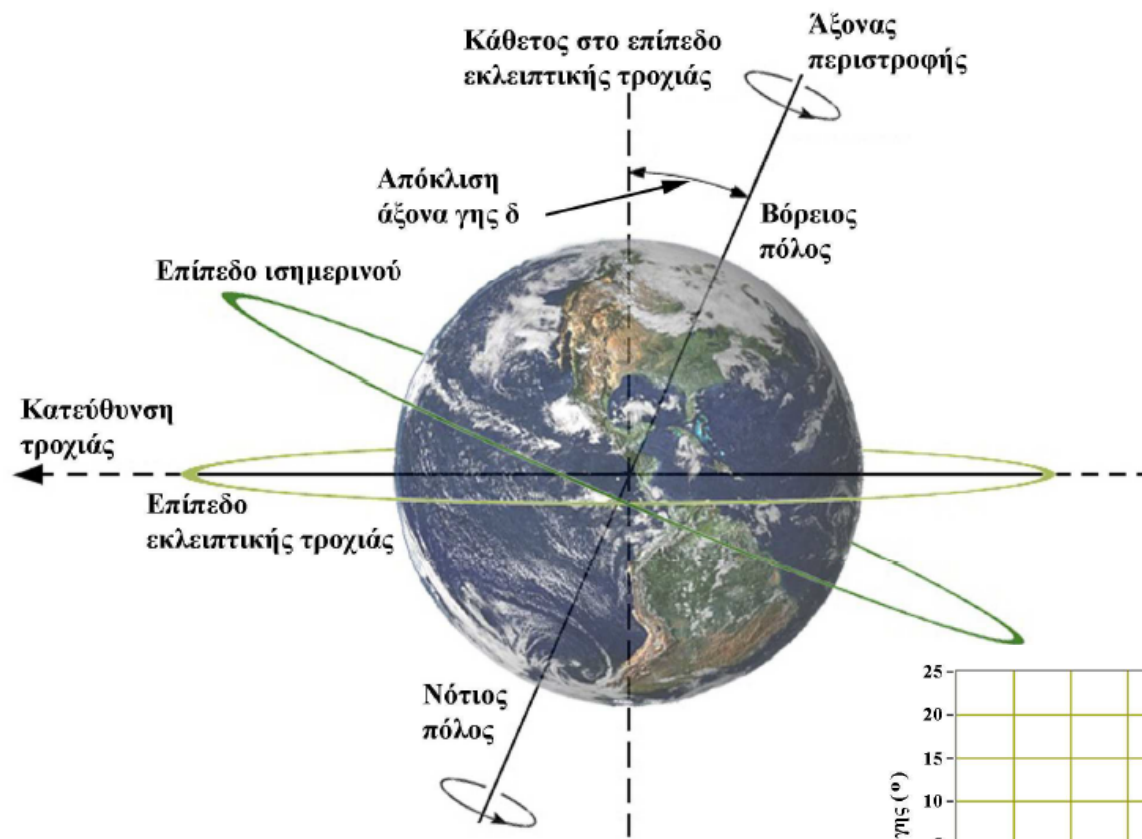
λ_{loc} : longitude (deg)

λ_{std} : zone time (deg) taken +pos W of Greenwich and -neg E

E_t : solar – civil time difference (min)



Solar Declination

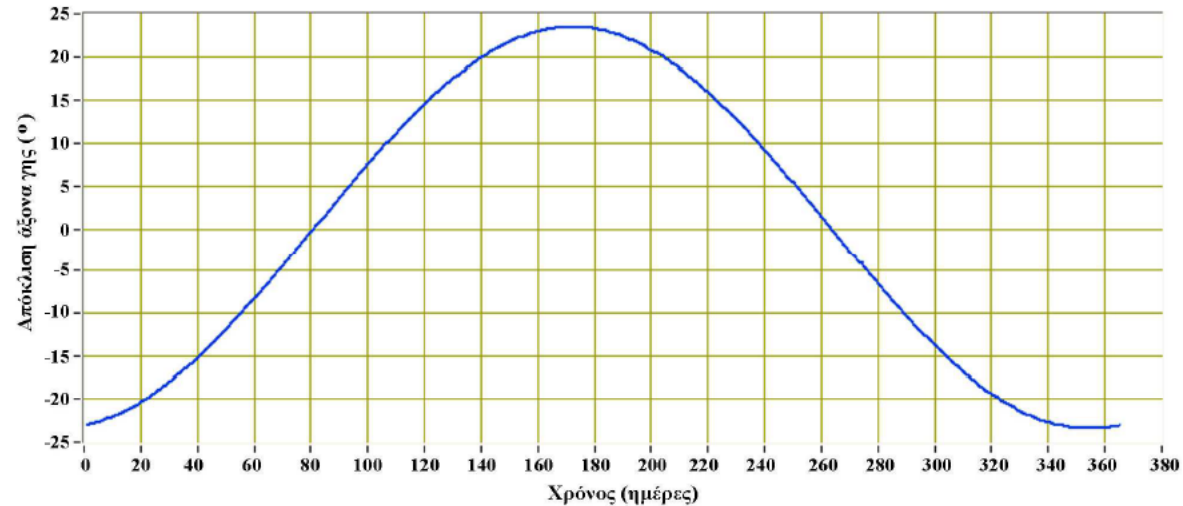


$$\delta = 23,45 \cdot \sin \frac{360 \cdot (n + 284)}{365}$$

where n is the day of the year
(n = 1 on the 1st January)

$$\delta = 23,45 \cdot \sin \frac{360 \cdot (m + 284 \cdot 24)}{365 \cdot 24}$$

where m the hour of the year
(m = 1 for the 1st hour of the year).



Άξονας
περιστροφής

Κάθετος στο επίπεδο
εκλειπτικής τροχιάς

$\delta = 23,45^\circ$

Αρκτικός κύκλος

Τροπικός του καρκίνου

Ισημερινός

$\delta = 66,55^\circ$

$\delta = 23,45^\circ$

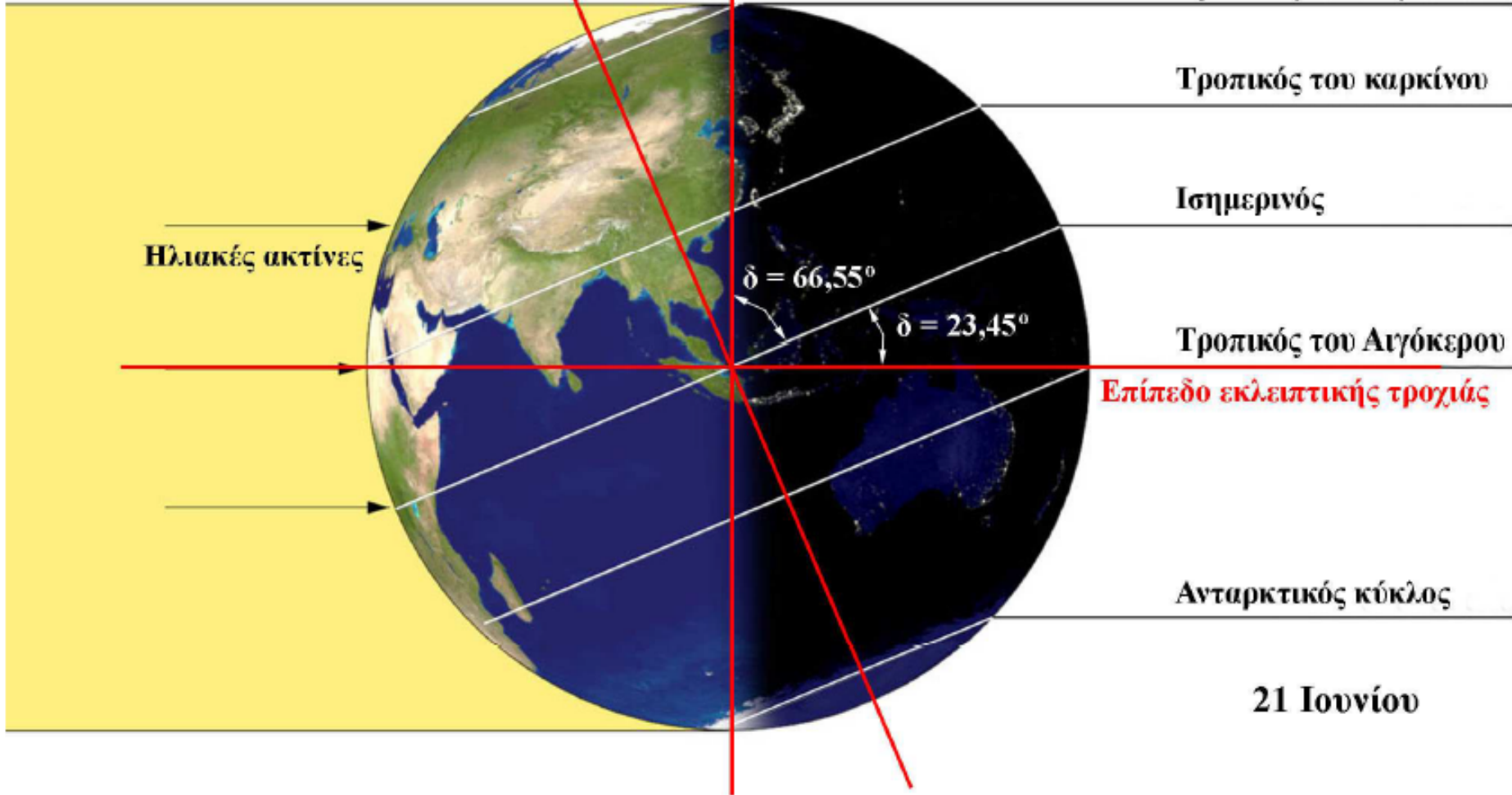
Τροπικός του Αιγόκερου

Επίπεδο εκλειπτικής τροχιάς

Ανταρκτικός κύκλος

Ηλιακές ακτίνες

21 Ιουνίου



Κάθετος στο επίπεδο
εκλειπτικής τροχιάς

Άξονας
περιστροφής

$\delta = 23,45^\circ$

Αρκτικός κύκλος

Τροπικός του καρκίνου

Επίπεδο εκλειπτικής τροχιάς

Ισημερινός

Τροπικός του Αιγόκερου

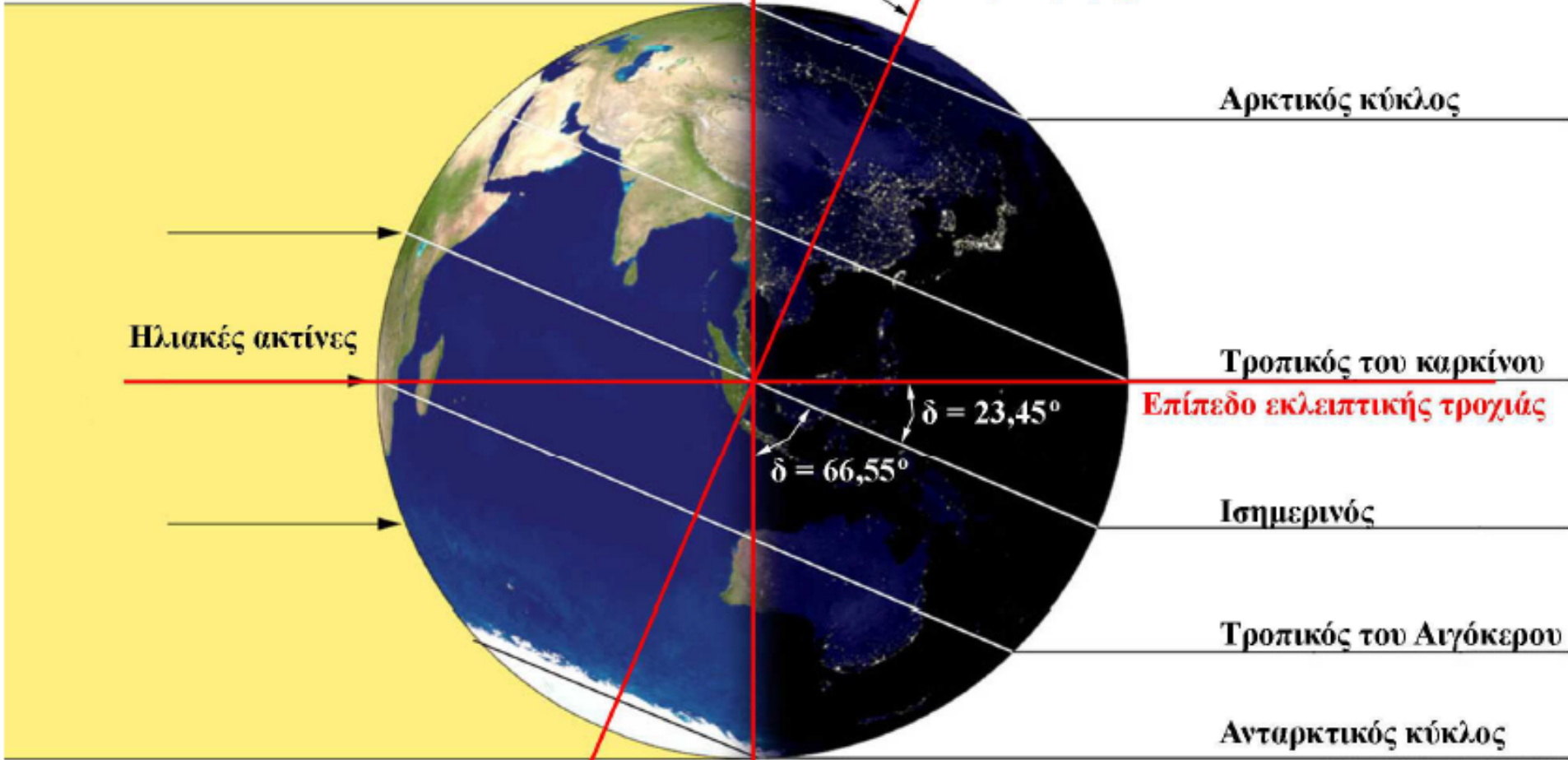
Ανταρκτικός κύκλος

Ηλιακές ακτίνες

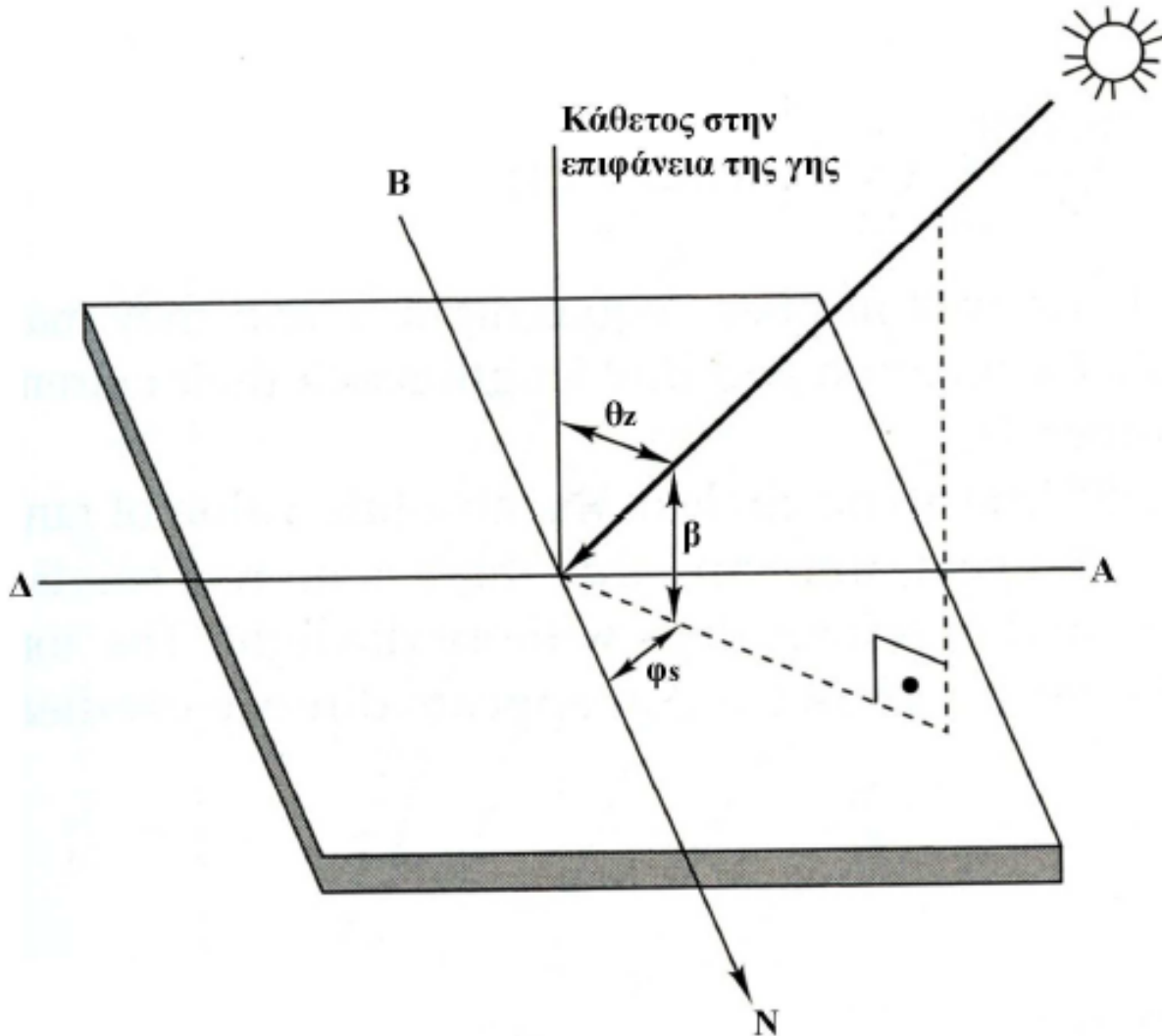
$\delta = 23,45^\circ$

$\delta = 66,55^\circ$

21 Δεκεμβρίου



Solar ecliptic angles



Solar elevation angle β

$$\sin(\beta) = \cos(\varphi) \cdot \cos(\delta) \cdot \cos(\omega) + \sin(\varphi) \cdot \sin(\delta)$$

Solar Zenith (αποκορύφωμα) angle θ_z

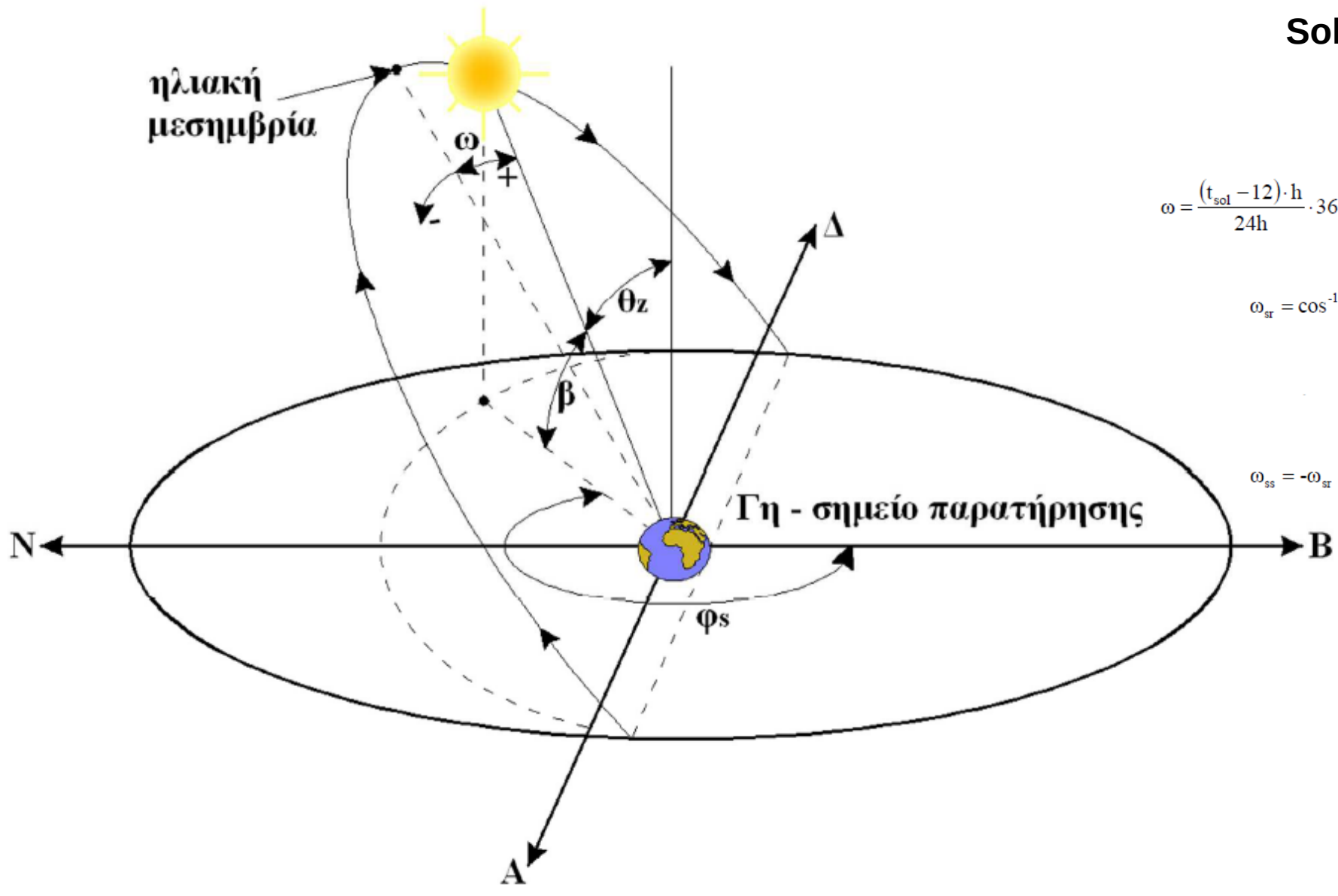
$$\beta + \theta_z = 90$$

Solar Azimuth φ_s

(الْمُتَوَاتِرَات) ((al) as-sumuut = the direction)

$$\sin(\varphi_s) = \frac{\cos(\delta) \cdot \sin(\omega)}{\cos(\beta)}$$

Solar Hour angle



$$\omega = \frac{(t_{sol} - 12) \cdot h}{24h} \cdot 360^\circ \Leftrightarrow \omega = (t_{sol} - 12) \cdot 15^\circ$$

$$\omega_{sr} = \cos^{-1}[-\tan(\varphi) \cdot \tan(\delta)]$$

$$\omega_{ss} = -\omega_{sr} = -\cos^{-1}[-\tan(\varphi) \cdot \tan(\delta)]$$

$$t_{sr} = 12 - \frac{24}{360} \cdot \omega_{sr}$$

$$t_{ss} = 12 - \frac{24}{360} \cdot \omega_{ss}$$

