

# Ocean Tides

David Pugh

Maritime Museum  
11 May 2019





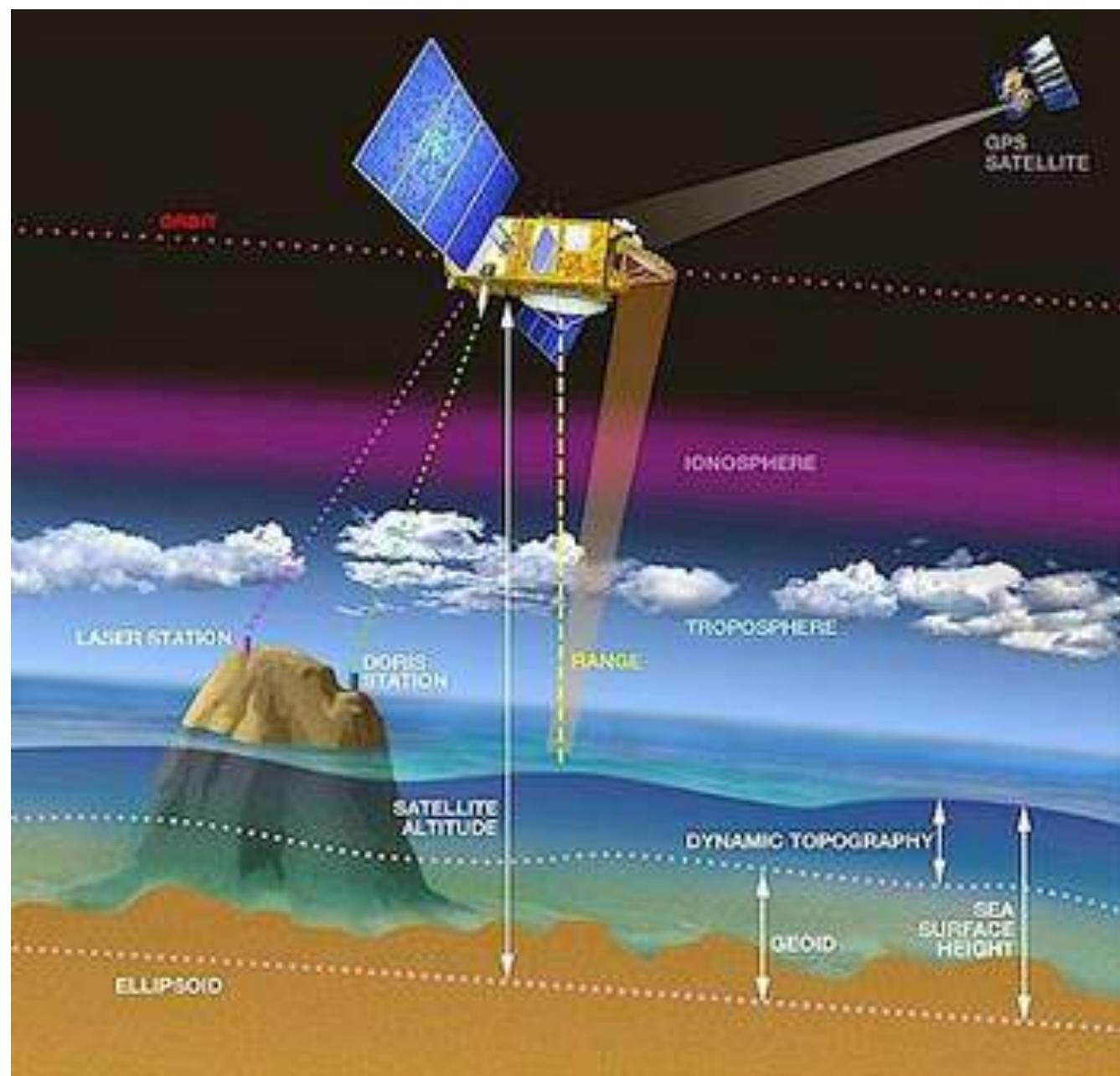


TIDAL DATUM  
AS TRANSFERRED IN 1896 FROM  
OLD DOCK SILL.

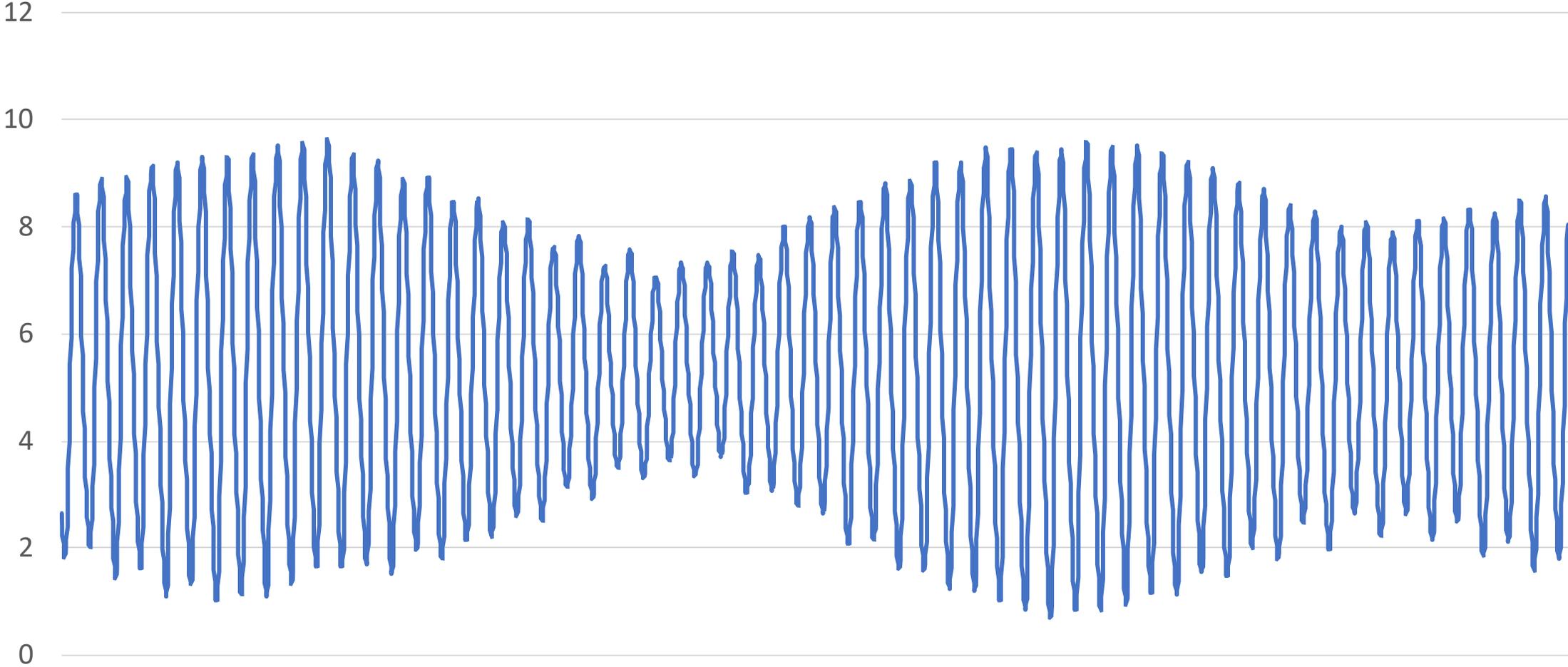
XXIV  
XXIII  
XXII  
XXI  
XX  
XIX  
XVIII





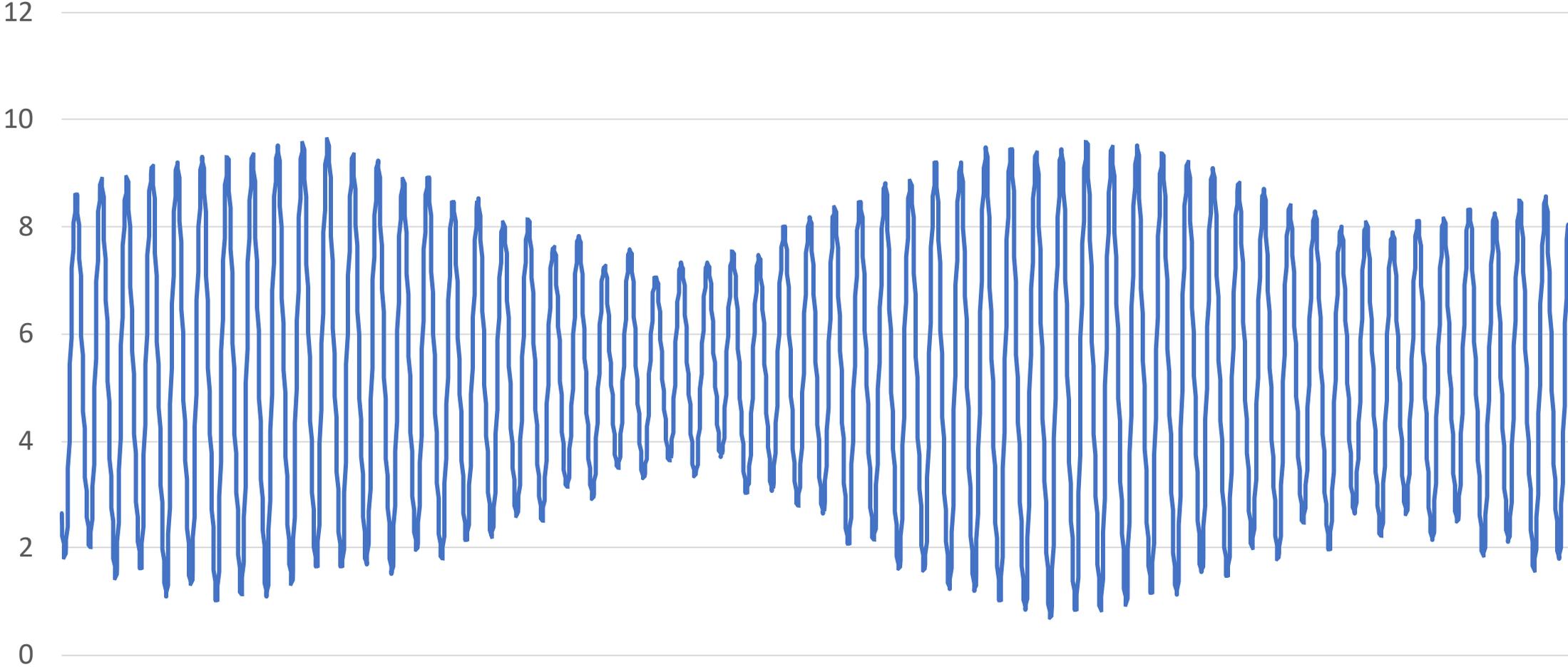


# Liverpool Tides March-April 2018



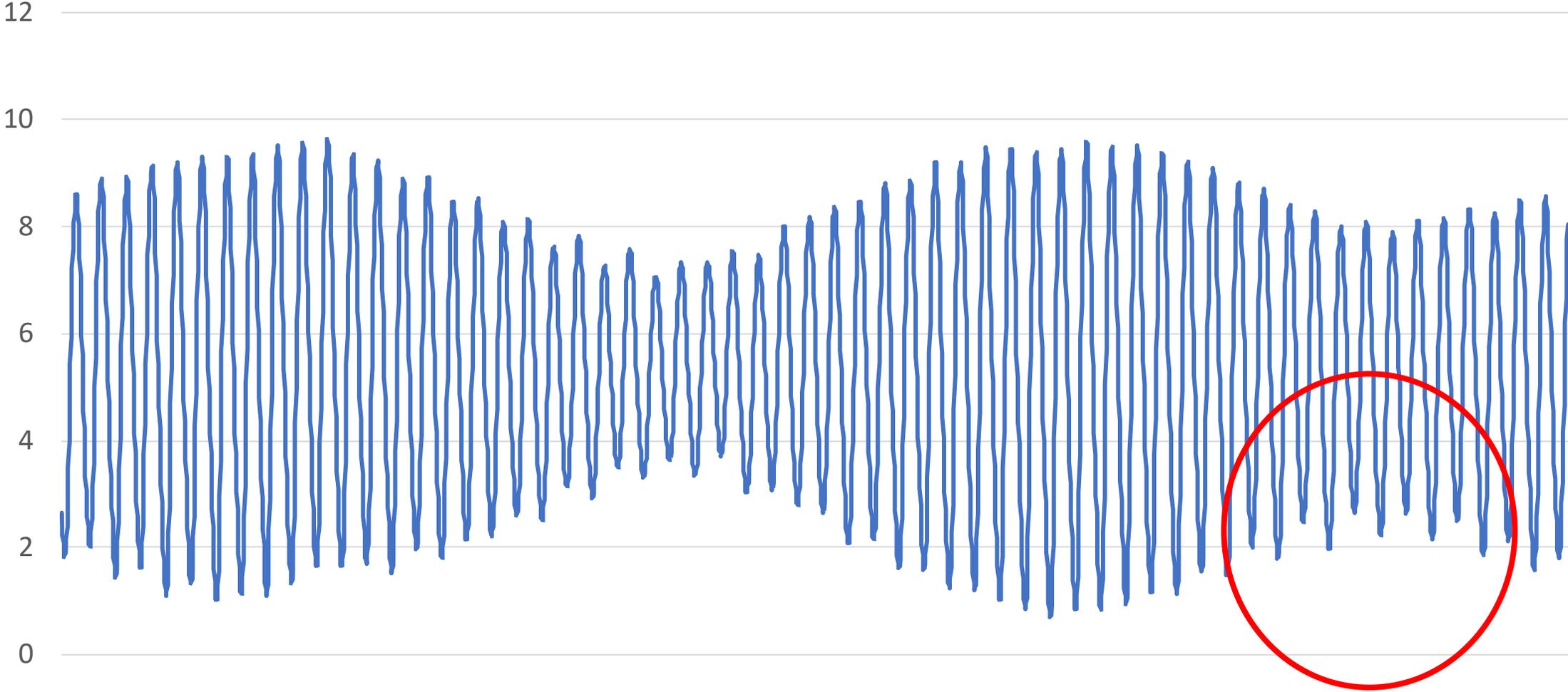
Average time from High Water to High Water is 12 hours and 25 minutes

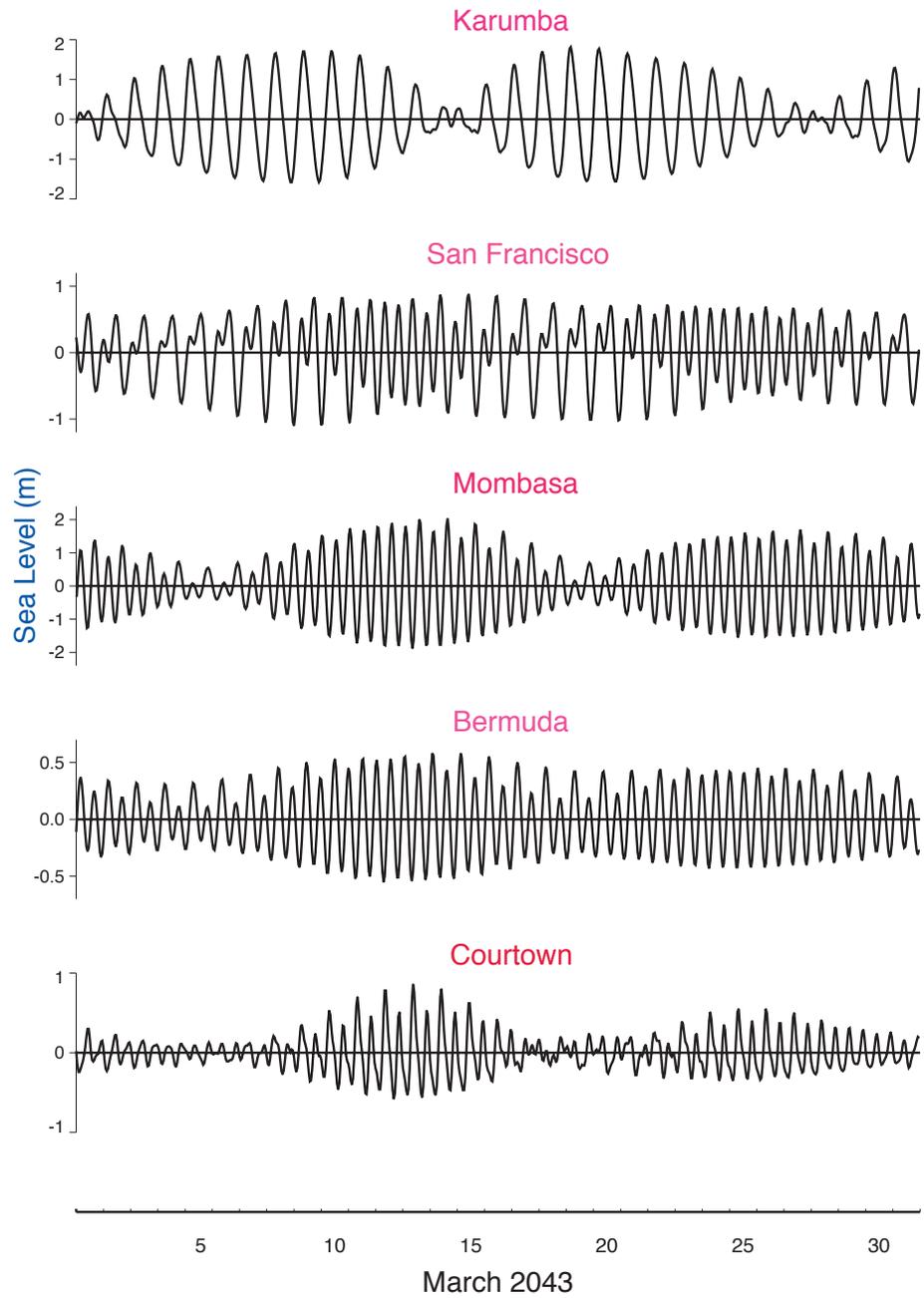
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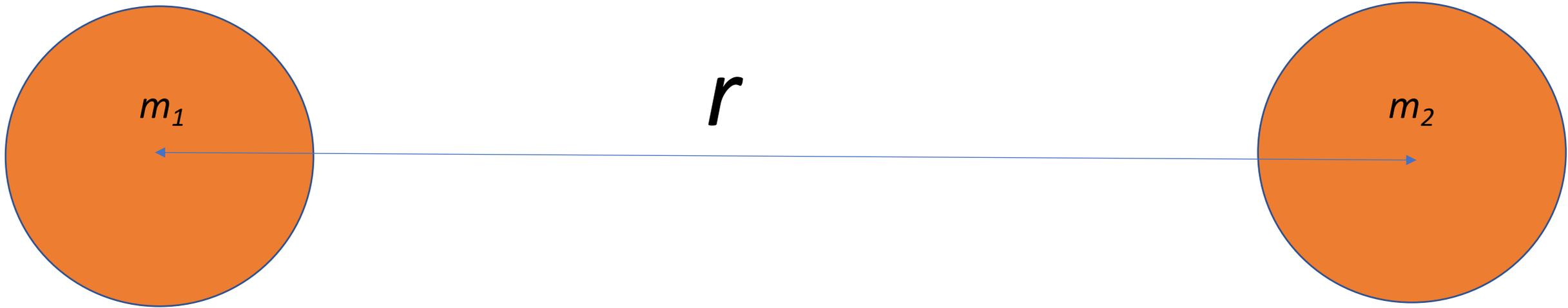
14 days

# Liverpool Tides March-April 2018



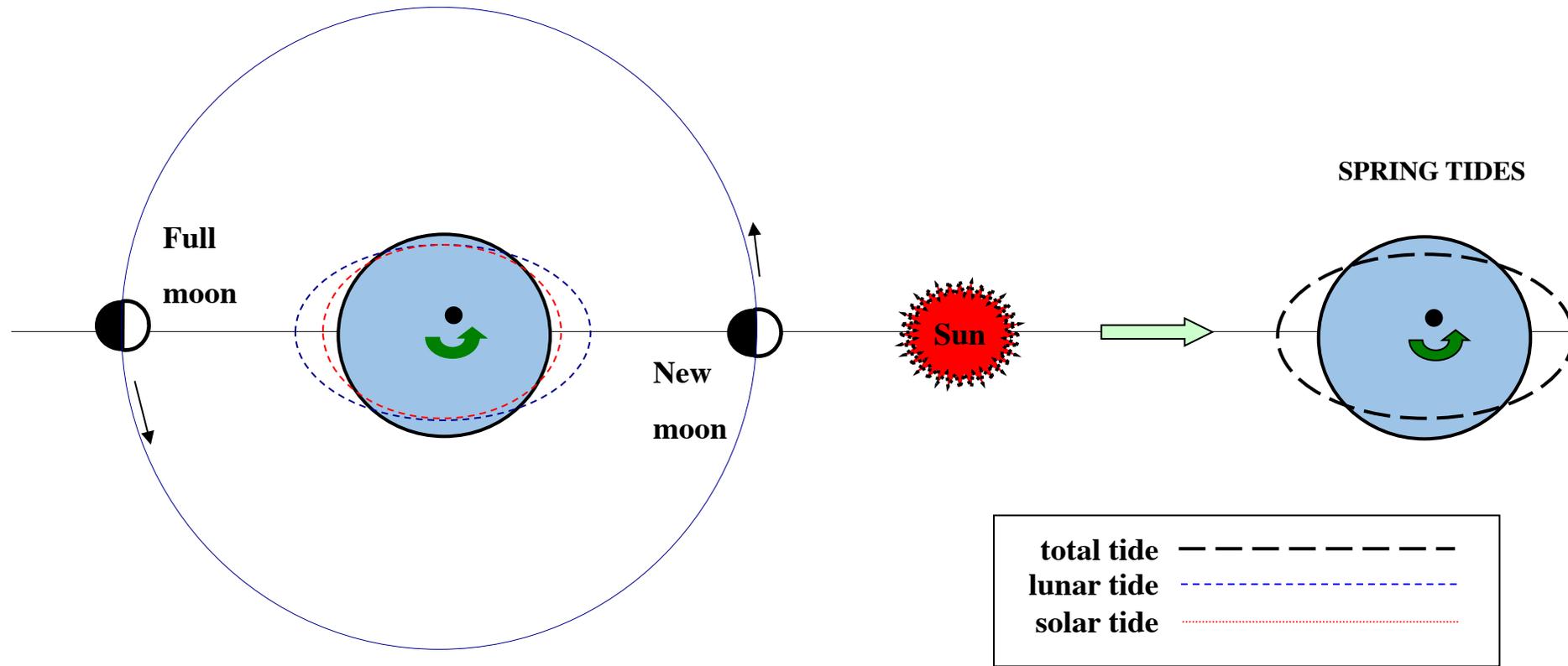


1687 Newton's Law of Gravitational Attraction



$$Force = G \frac{m_2 m_1}{r^2}$$



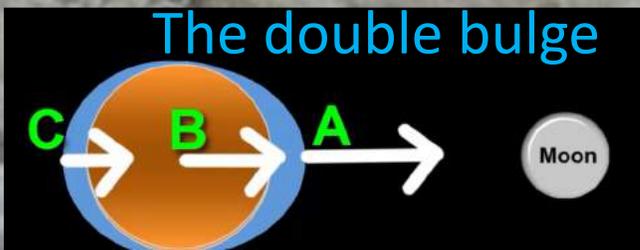


a)

# Relative sizes and separations

			Km	ratios
	Sun		695500	109
	Earth		6378	1
	moon		1737	0.272
	earth-moon		384400	60
	sun-earth		149600000	23456

# Scale demonstration



Applying the Cosine Law to the triangle defined by OPM in Figure 3.4:

$$MP^2 = a^2 + R_l^2 - 2aR_l \cos \phi$$

we have:

$$\Omega_p = -\frac{Gm_l}{R_l} \left[ 1 - 2\frac{a}{R_l} \cos \phi + \frac{a^2}{R_l^2} \right]^{-\frac{1}{2}}$$

which may be expanded as a series of Legendre polynomials:

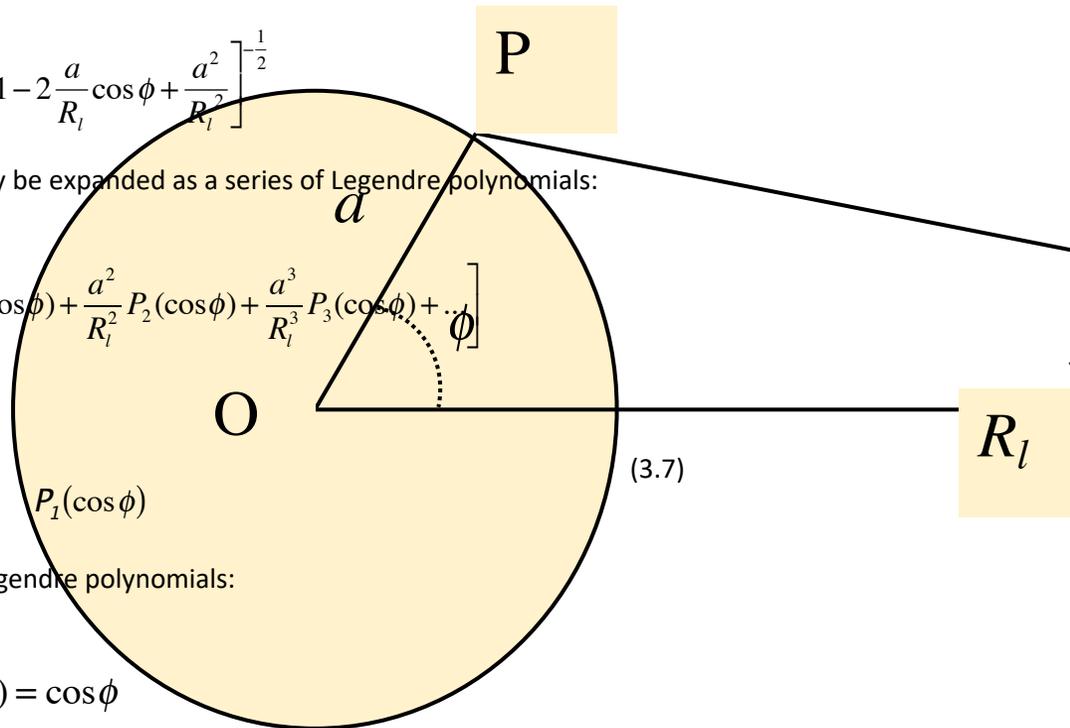
$$\left[ 1 + \frac{a}{R_l} P_1(\cos \phi) + \frac{a^2}{R_l^2} P_2(\cos \phi) + \frac{a^3}{R_l^3} P_3(\cos \phi) + \dots \right]$$

The terms  $P_1(\cos \phi)$  etc. are Legendre polynomials:

$$P_1(\cos \phi) = \cos \phi$$

$$P_2(\cos \phi) = \frac{1}{2} (3 \cos^2 \phi - 1)$$

$$P_3(\cos \phi) = \frac{1}{2} (5 \cos^3 \phi - 3 \cos \phi)$$



(3.7)

the projected vector along OM, yields a gradient of potential:

$$-\frac{\partial \Omega_p}{\partial (a \cos \phi)} = -\frac{Gm_l}{R_l^2}$$

The effective tide generating potential is therefore written as:

$$\Omega_p = -\frac{1}{2} Gm_l \frac{a^2}{R_l^3} (3 \cos^2 \phi - 1)$$

The force on the unit mass at P corresponding to the potential may be resolved with two components

Vertically upwards:

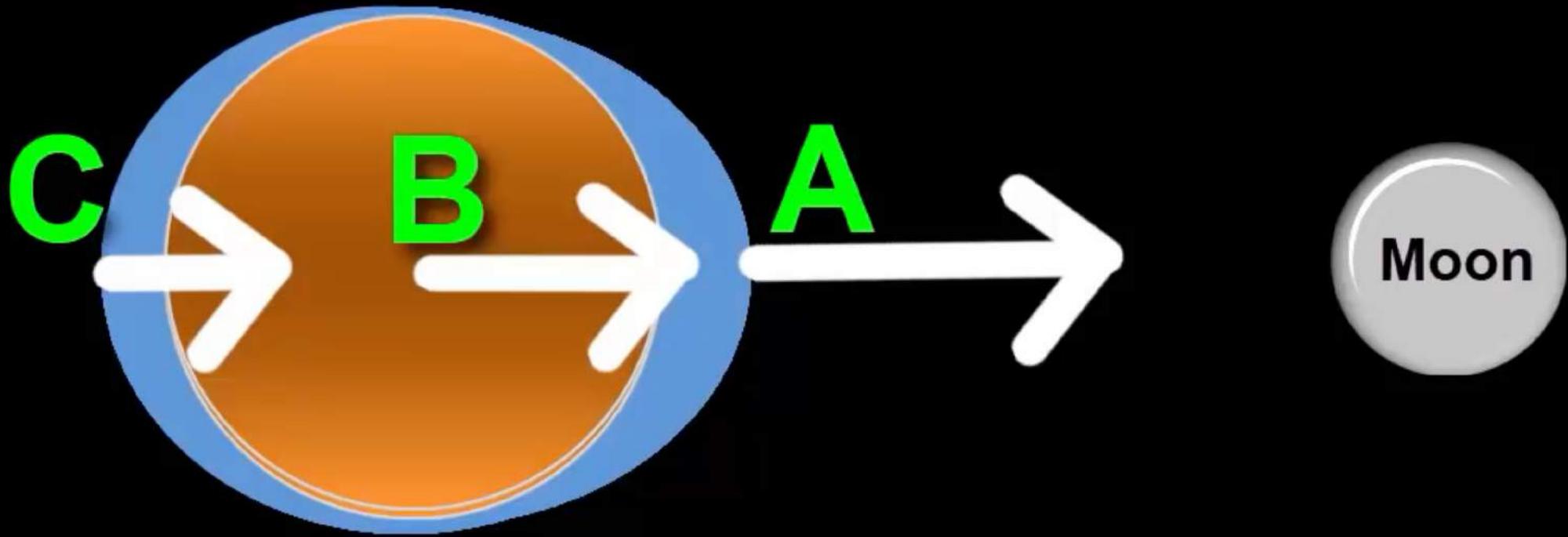
$$-\frac{\partial \Omega_p}{\partial a} = -2g\Lambda_l \left( \cos^2 \phi - \frac{1}{3} \right)$$

Horizontally in the direction of increasing:

$$-\frac{\partial \Omega_p}{a \partial \phi} = -g\Lambda_l \sin 2\phi$$

Earth

Moon

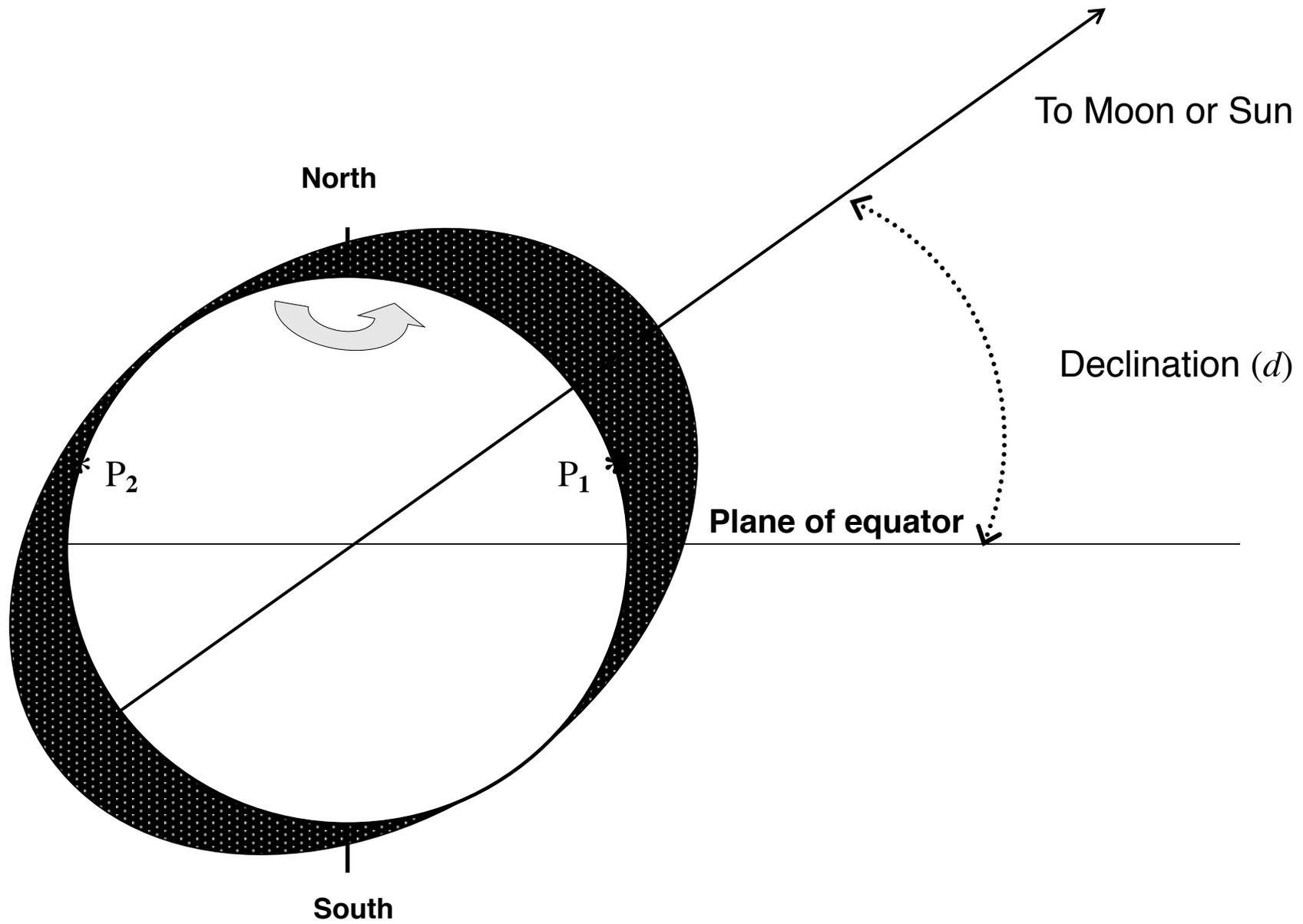


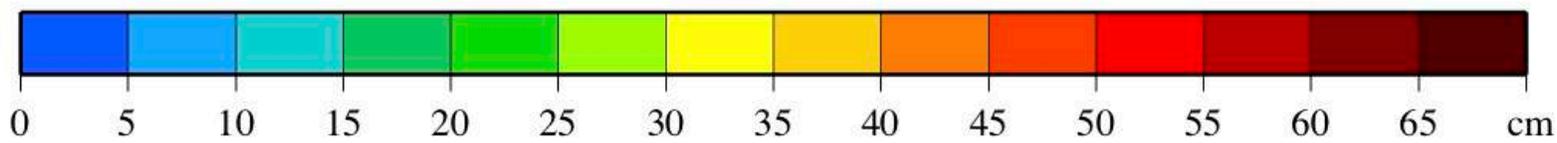
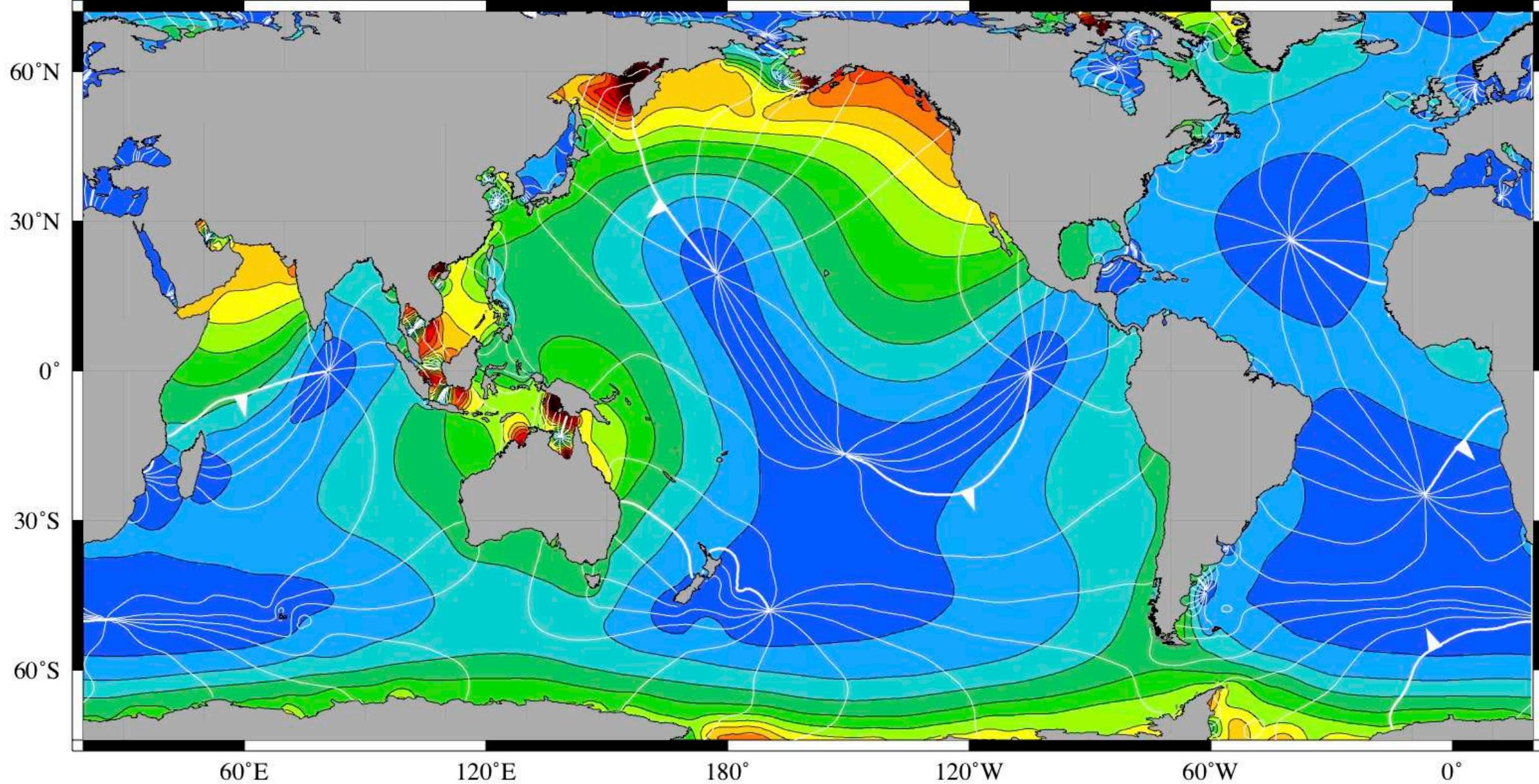


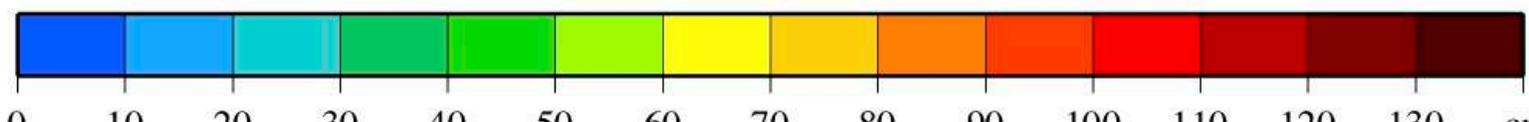
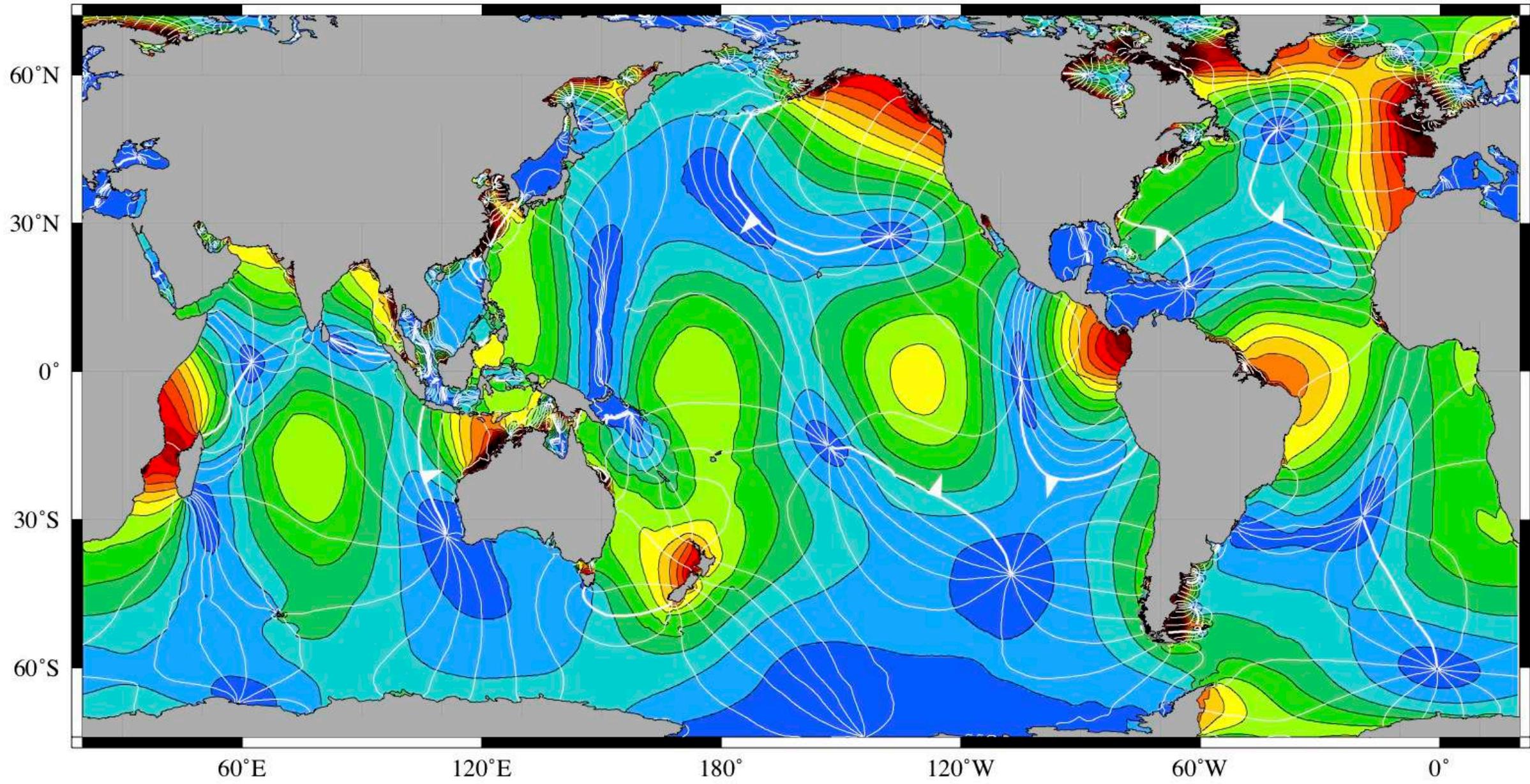
Spring  
Tide

New  
Moon









A high-speed, close-up photograph of a large splash of water. The water is turbulent and white with foam, creating a complex, organic shape. In the center of the splash, a person's head is visible, partially obscured by the water. The background is a dark, overcast sky. The overall scene conveys a sense of intense action and natural power.

World's biggest tides?



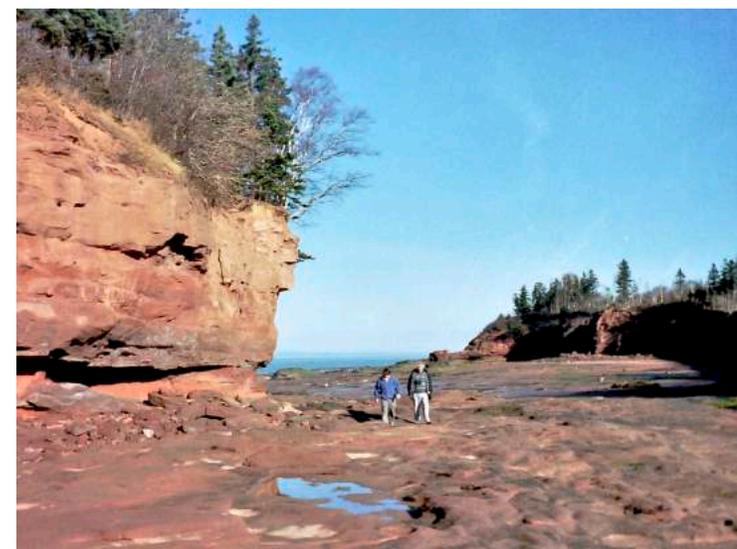


Maximum range 16.0 m



Baie aux Feuilles  
Ungava Bay

Maximum range 15.8 m



Burncoat Head  
Bay of Fundy

A high-speed photograph of a person splashing in water, with the text "Are tides changing?" overlaid in red. The water is splashing upwards and outwards, creating a dynamic and energetic scene. The person's head and shoulders are visible, partially obscured by the water spray. The background is a dark, overcast sky, suggesting an outdoor setting. The overall mood is one of surprise or discovery.

Are tides changing?

Are tides changing?

St Helena 1761-1971 less than 2% **RANGE** amplitude

Ireland 1842 to 2015 **TIME** changes less than 5 minutes



Liverpool **high waters** Philip Woodworth increase 0.5 m from 1768 to 2000

William Hutchinson, Dockmaster



The background of the slide is a large, dynamic splash of water, showing intricate patterns of white foam and clear droplets against a darker blue-grey background. On the right side, there is a circular inset that provides a magnified view of a splash, highlighting the complex, crystalline structures of the water droplets and the dark silhouette of a person's head and shoulders within the water.

With acknowledgements to Kelly  
Kemp, Eaglesby State School,  
Queensland

Web movie material

And www common domain images

A photograph of a person standing on a wide, sandy beach, looking out at the ocean. The person is silhouetted against the bright, shimmering water. The sky is overcast with grey clouds. In the distance, a few small figures can be seen on the beach. The overall mood is contemplative and serene.

**Ocean Tides**

**The End**

**Maritime Museum  
11 May 2019**