The fundamental equations that govern atmospheric flow are quite complex, reflecting the large number of factors that contribute to the wind patterns we observe. However, this lecture has adopted a simplification that is usually reasonable for the large-scale features of average flow in tropical latitudes. This simplification reduces the problem to the wind flow that is given by the balance between the pressure gradient force, the Coriolis force, and a retarding friction force that acts to try and decelerate the wind, with a magnitude that is proportional to the wind speed. The fundamental equations of motion for the atmosphere, that are rooted Newtonian physics and dynamics, can then be written

$$u = \frac{-kP_x - fP_y}{r\,(k^2 + f^2)} \quad , \quad v = \frac{-kP_y + fP_x}{r\,(k^2 + f^2)}$$

Where (units given below conform to the international system of units (SI) so that the values can be used in the above equation):

u is the wind speed in ms^{-1} in the west-to-east direction, referred to as the zonal wind
v is the wind speed in ms^{-1} in the south-to-north direction, referred to as the meridional wind

k is a coefficient of surface resistance, defining the decelerating effect of friction on the flow. Over open ocean in the low latitude tropics, a typical value is about $1.5\text{x}10^{-5}s^{-1}$

f is the Coriolois force, given by $2\ \Omega \sin(\phi)$ where Ω is the rotation rate of the earth ($7.292\text{x}10^{-5}$ rad s^{-1}) and ϕ is a latitude on the earth.

r is the density of air—standard value at sea-level is 1.225 kg m^{-3}

$\mathbf{P_x}$ is the pressure gradient in the west-to-east direction
$\mathbf{P_y}$ is the pressure gradient in the south-to-north direction

For the schematic example in Fig. 1.5, P_x is calculated based on the expected lower surface pressure over the warmer region of SST, and the expected higher surface pressure over the cold SST. Assuming the change in SST is 2 degrees Kelvin over a distance of 2,000,000m, and assuming that the lowest 3,000m of the atmosphere is well mixed, this will give an expected pressure difference of -250 Pa (-2.5 mb) over the 2,000,000m which implies a pressure gradient of $-1.25\text{x}10^{-4}$ Pa m^{-1}

In the schematic example (Fig. 1.5) there is no change in SST in the north-south direction, so there is no expected change in surface pressure in this direction, such that P_y is zero.

These values of P_x , P_y can be put in the equations for ***u***, ***v*** to calculate the surface wind expected given the prevailing SST pattern, assuming the other values for variables given in the above definitions.