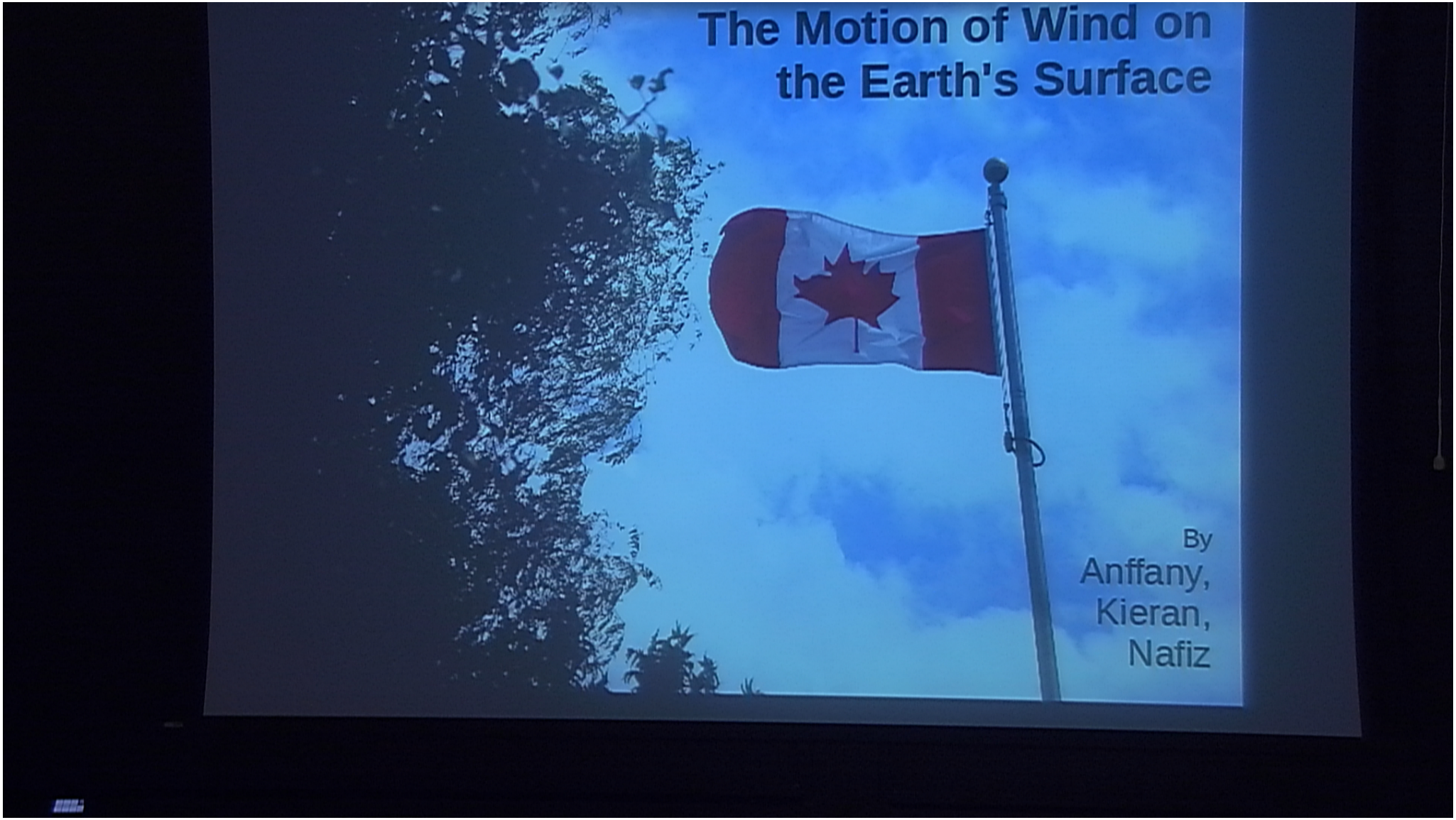
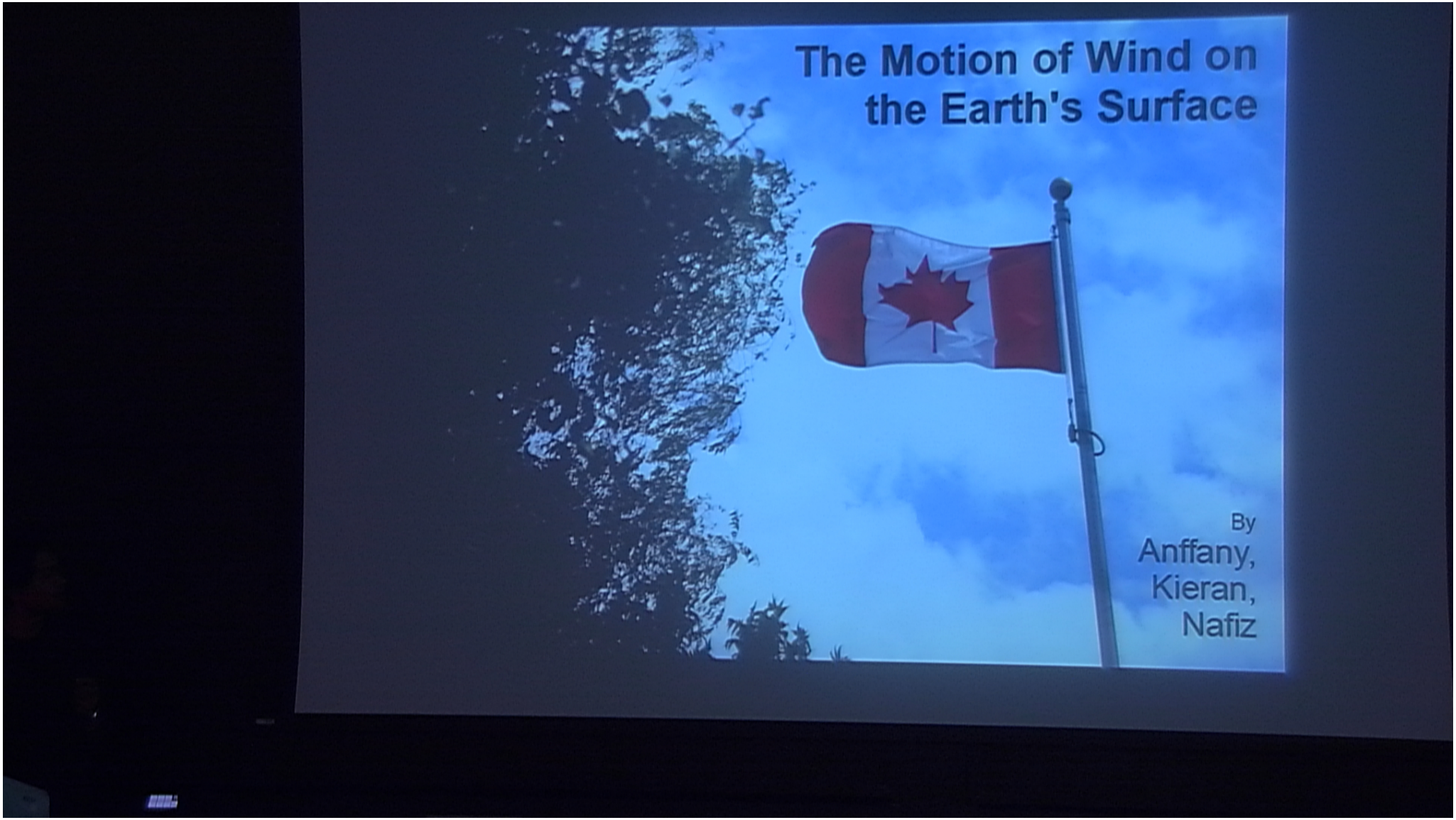
Title: 13/14 PSI - Student Presentations - 4

Date: Aug 16, 2013 03:30 PM

URL: http://pirsa.org/13080039

Abstract:


The Motion of Wind on the Earth's Surface
By
Anffany,
Kieran,
Nafiz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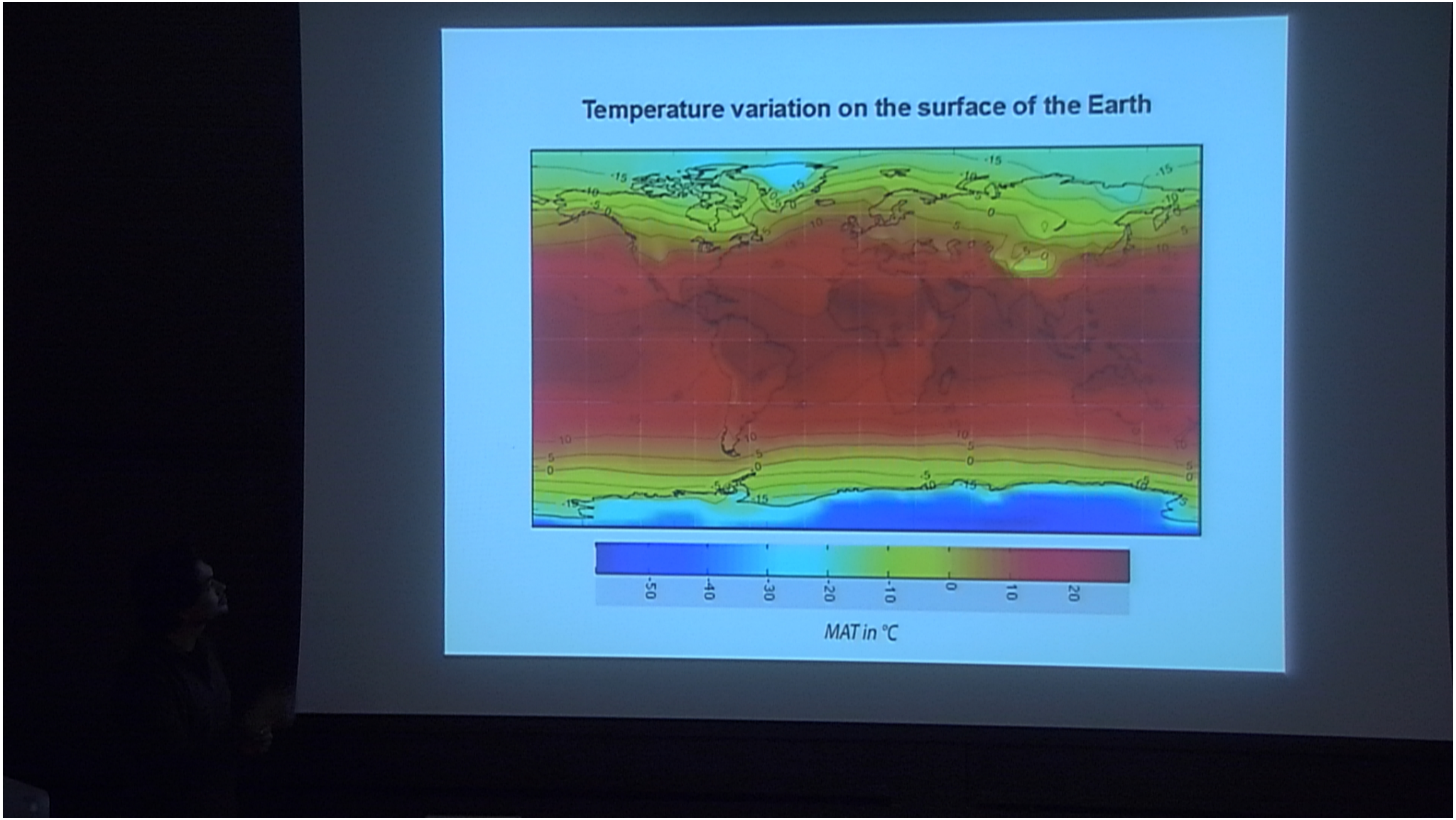
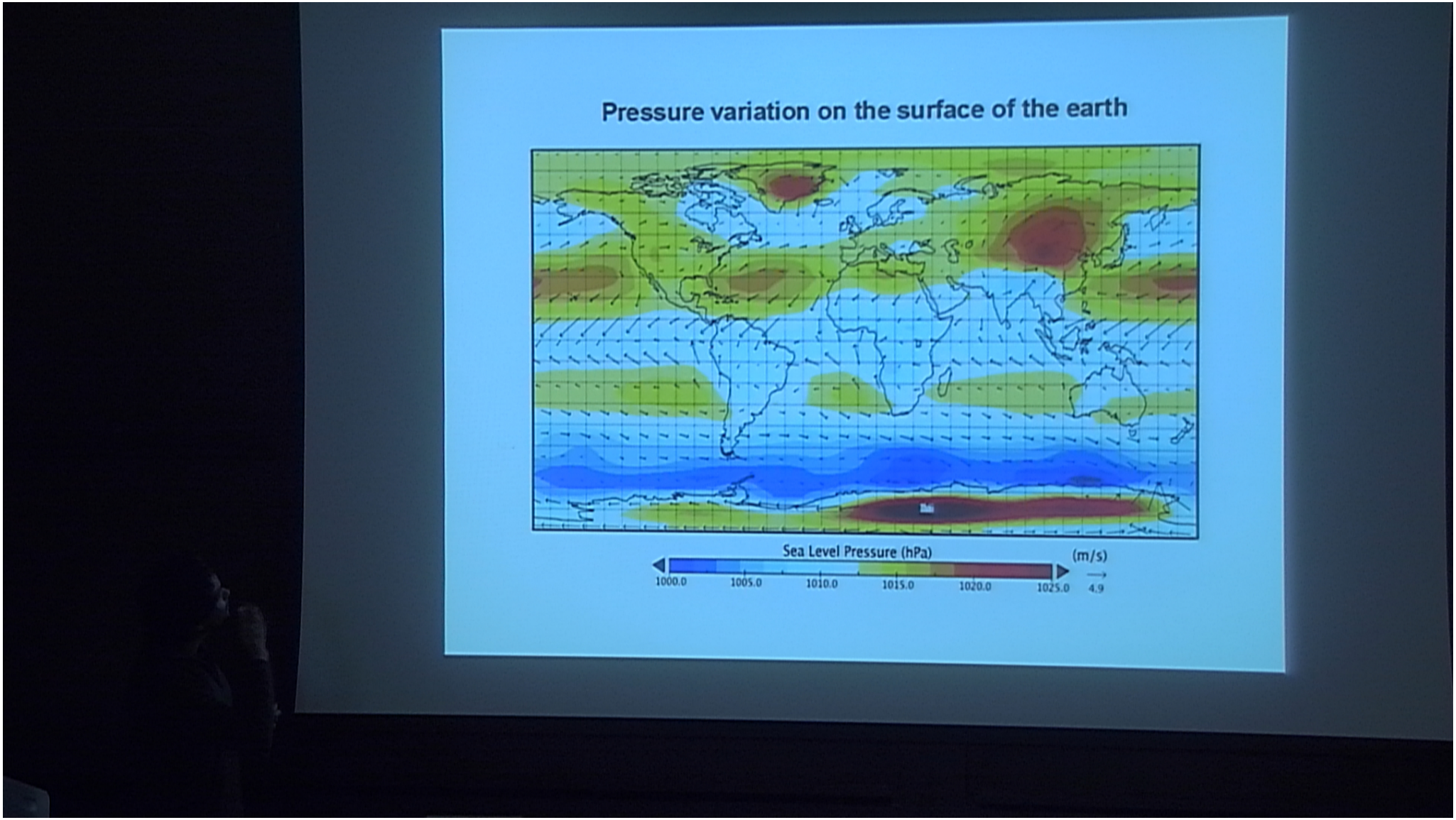
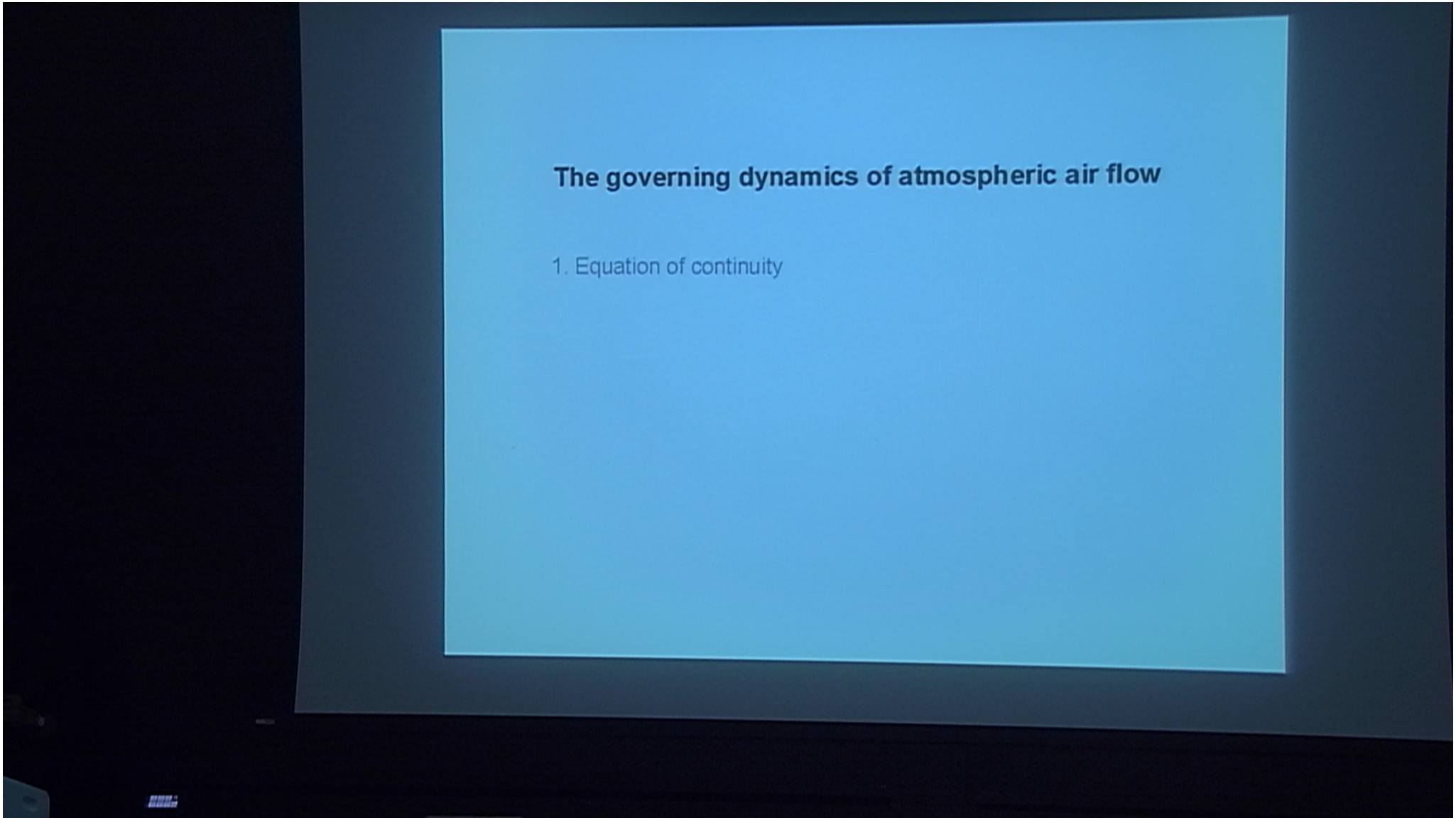

Temperature variation on the surface of the Earth
-50
-40
-30
-20
-10
0
10
20
MAT in °C


Pressure variation on the surface of the earth
Sea Level Pressure (hPa)
(m/s)
1000.0
1005.0
1010.0
1015.0
1020.0
1025.0
4.9


The governing dynamics of atmospheric air flow
1. Equation of continuity

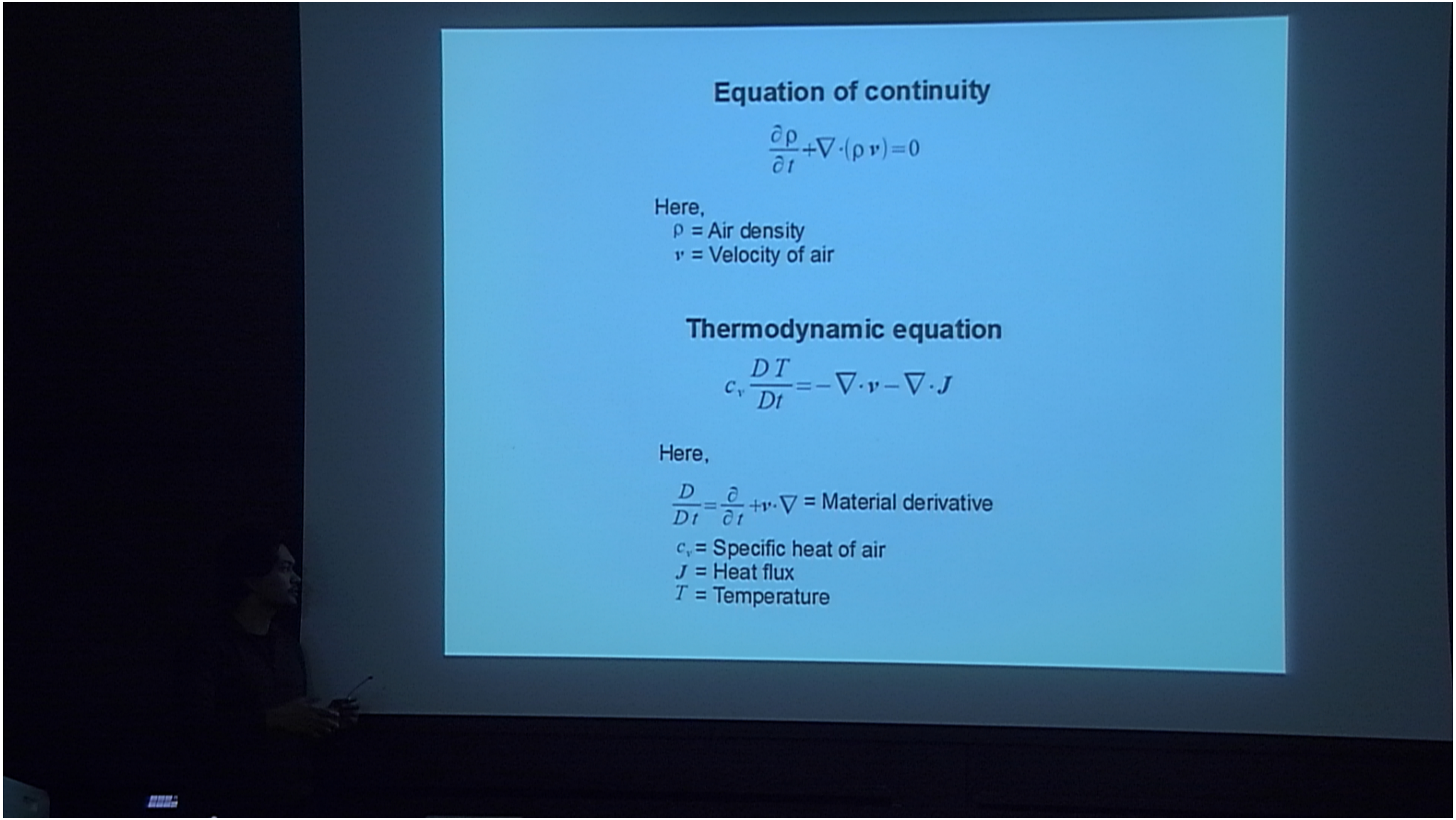
Equation of continuity

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \, \mathbf{v}) = 0$$

Here,

ρ = Air density

$\mathbf{v}$ = Velocity of air


Equation of continuity
$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$
Here,
ρ = Air density
v = Velocity of air
Thermodynamic equation
$c_v \frac{DT}{Dt} = -\nabla \cdot \mathbf{v} - \nabla \cdot J$
Here,
$\frac{D}{Dt} = \frac{\partial}{\partial t} + \mathbf{v} \cdot \nabla$ = Material derivative
c_v = Specific heat of air
J = Heat flux
T = Temperature

Momentum equation

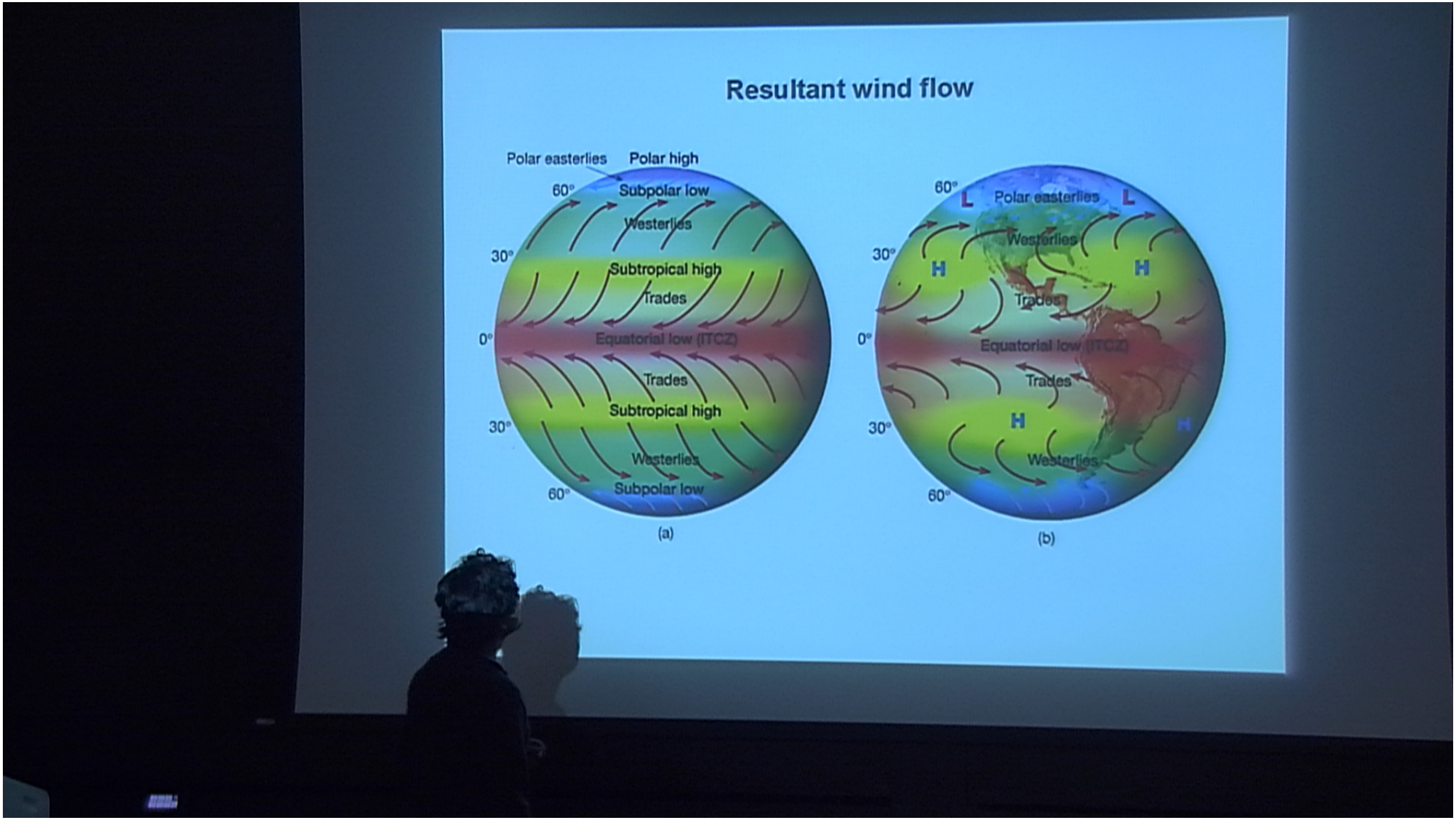
The Navier-Stokes equation: $\rho \frac{Dv}{Dt} = -\nabla p + f$

Where,
p = Pressure
f = All other forces

Force, $f = \rho g - 2\Omega \times v + D$

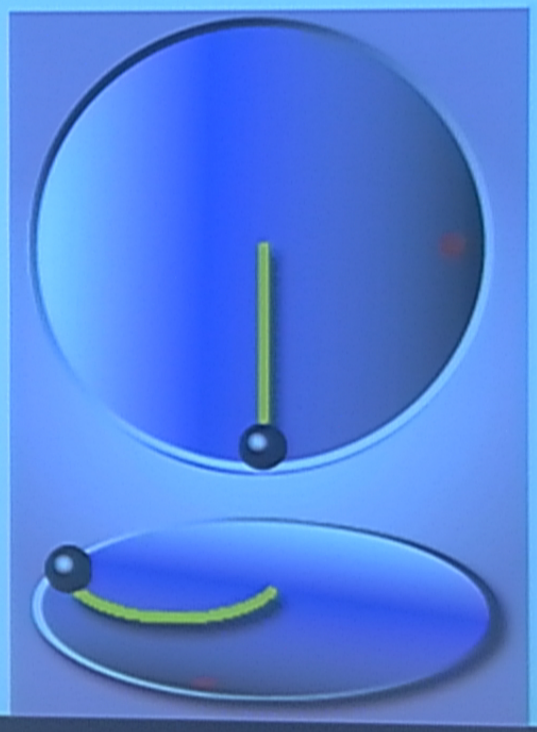
Gravitational force | Coriolis force | Frictional force

Where,
g = Gravitational acceleration
Ω = Angular velocity of earth


Resultant wind flow
Polar easterlies
Polar high
60°
Subpolar low
Westerlies
30°
Subtropical high
Trades
0°
Equatorial low (ITCZ)
Trades
30°
Subtropical high
Westerlies
60°
Subpolar low
(a)
60°
L
Polar easterlies
L
Westerlies
30°
H
H
Trades
0°
Equatorial low (ITCZ)
Trades
30°
H
H
Westerlies
60°
(b)

Coriolis Effect – where from?

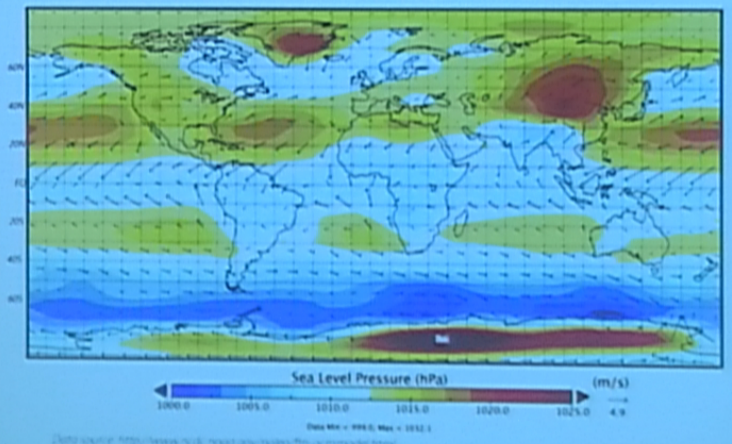
$$F_C = -2\,m\,\Omega \times v$$



Coriolis Effect – on Earth frame

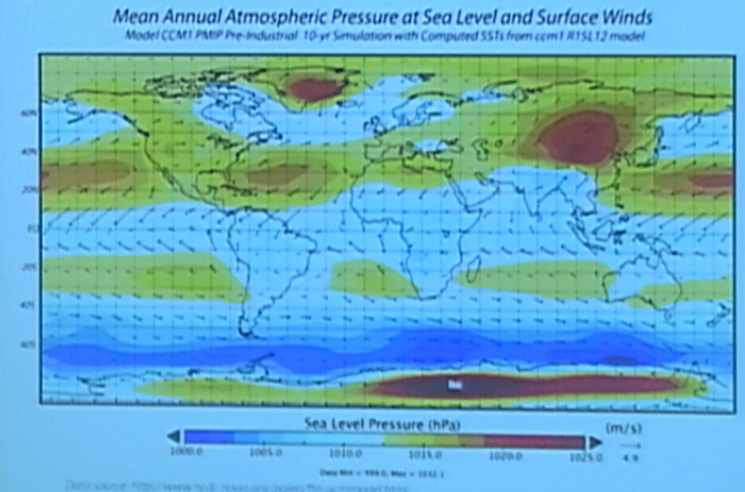
Clockwise winds in Northern Hemisphere
Counterclockwise winds in Southern Hemisphere

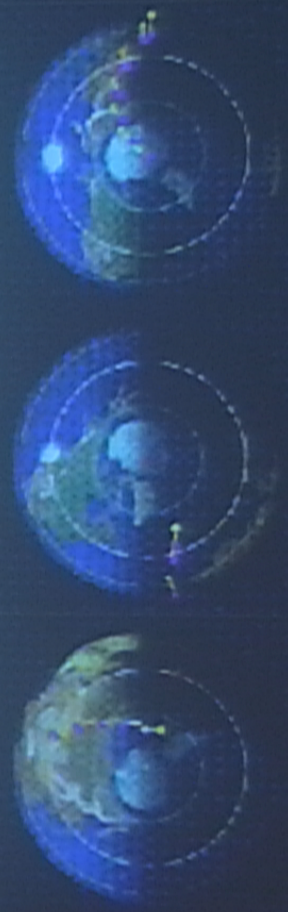
Mean Annual Atmospheric Pressure at Sea Level and Surface Winds
Model CCM1 PMIP Pre-Industrial 10-yr Simulation with Computed SSTs from ccm1 R15L12 model



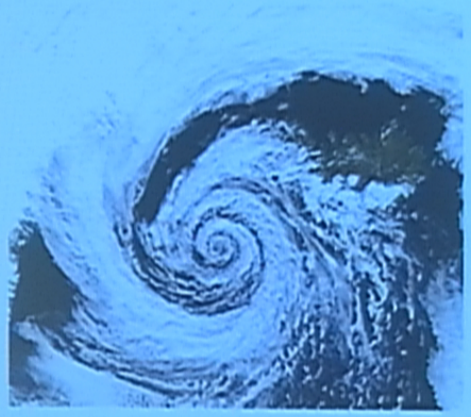
Coriolis Effect – on Earth frame

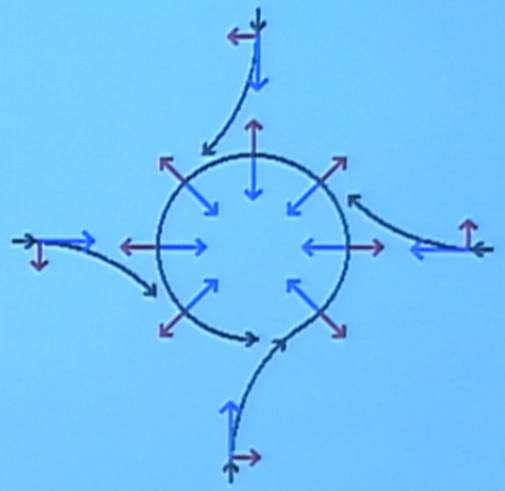
Clockwise winds in Northern Hemisphere
Counterclockwise winds in Southern Hemisphere





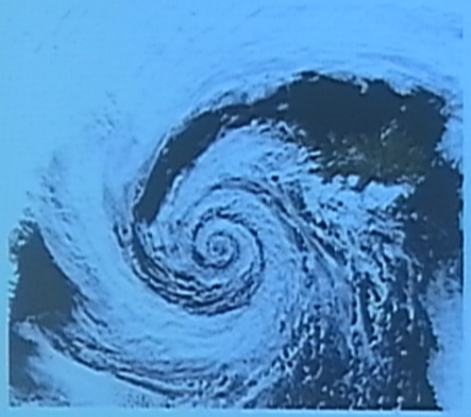
Coriolis Effect – cyclone

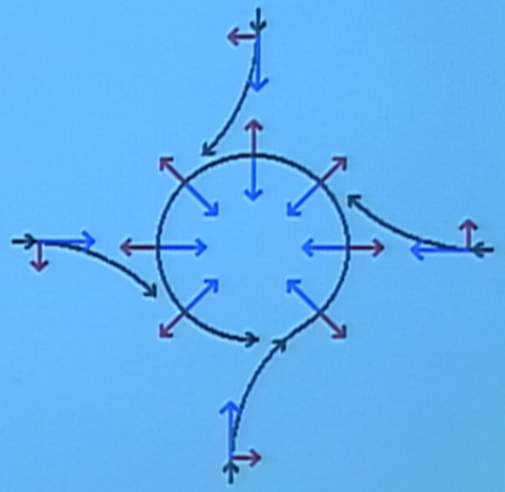




Blue: Pressure-gradient force
Red: Coriolis force

Coriolis Effect – cyclone





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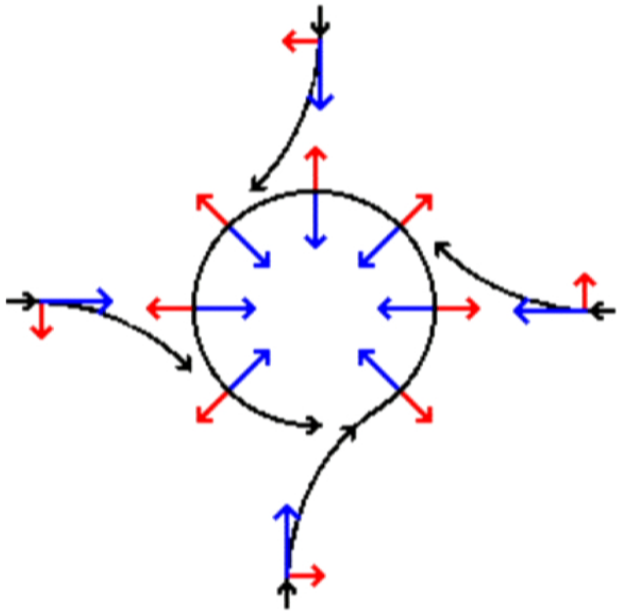
Coriolis Effect – cyclone



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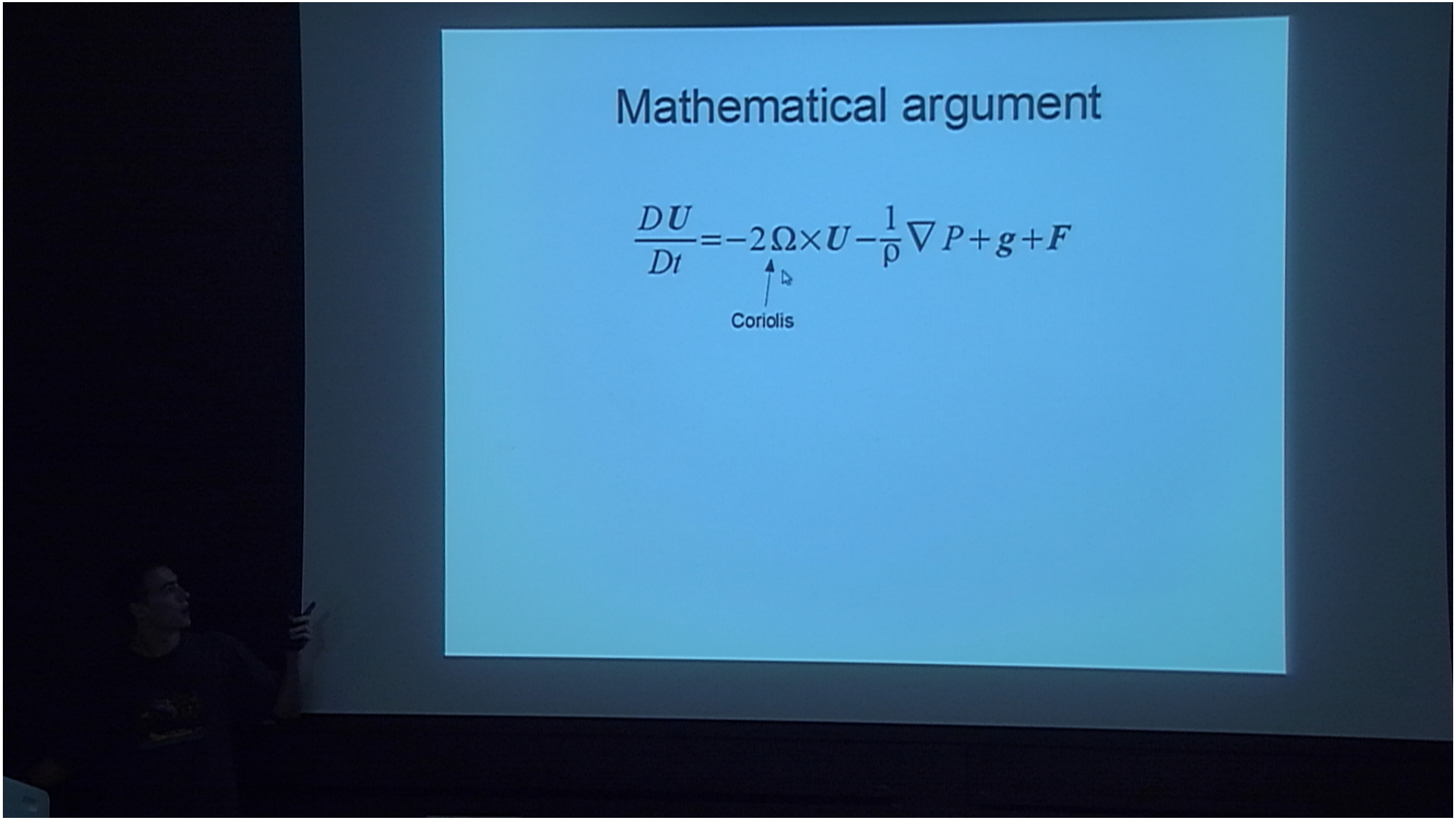
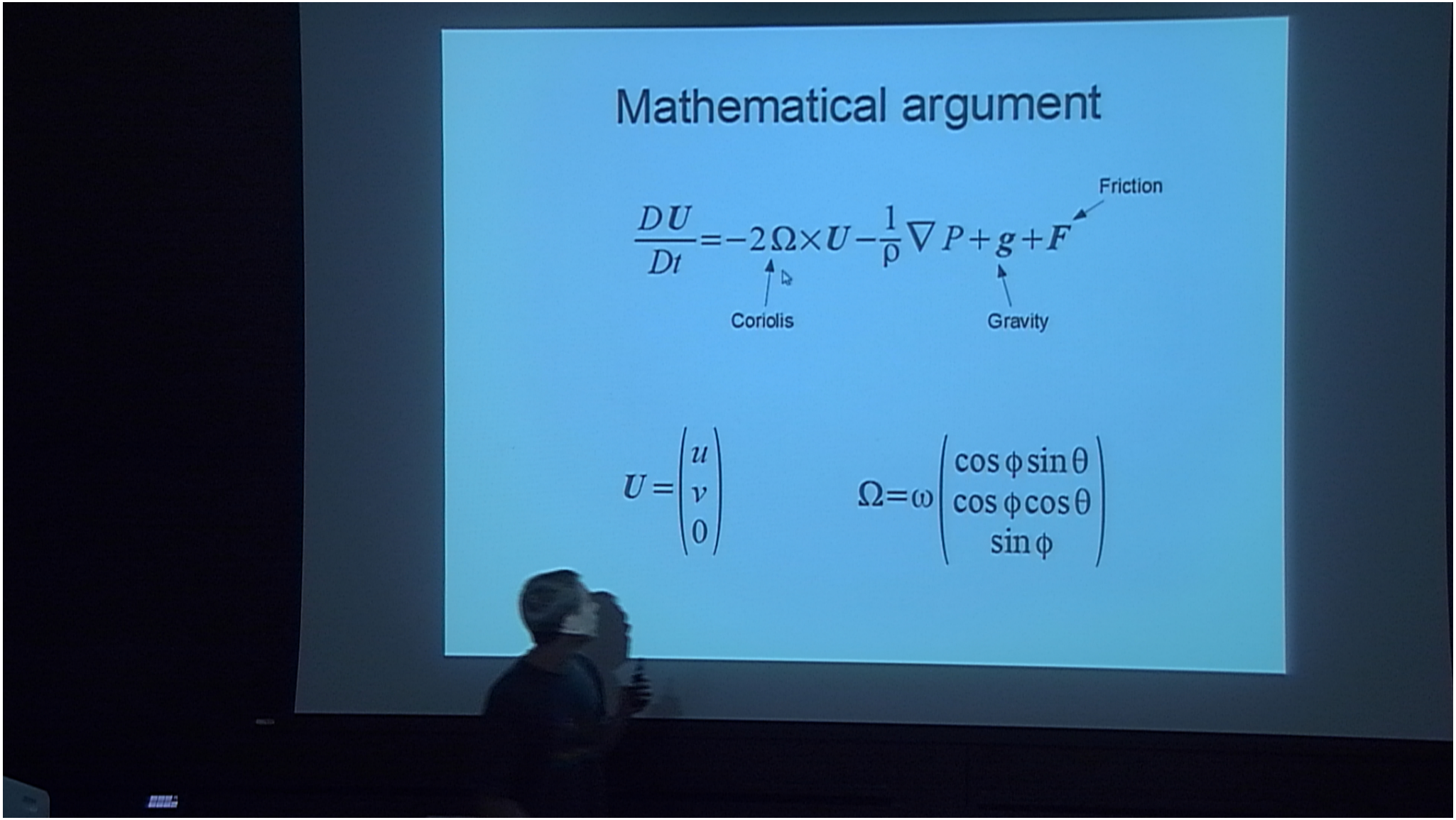
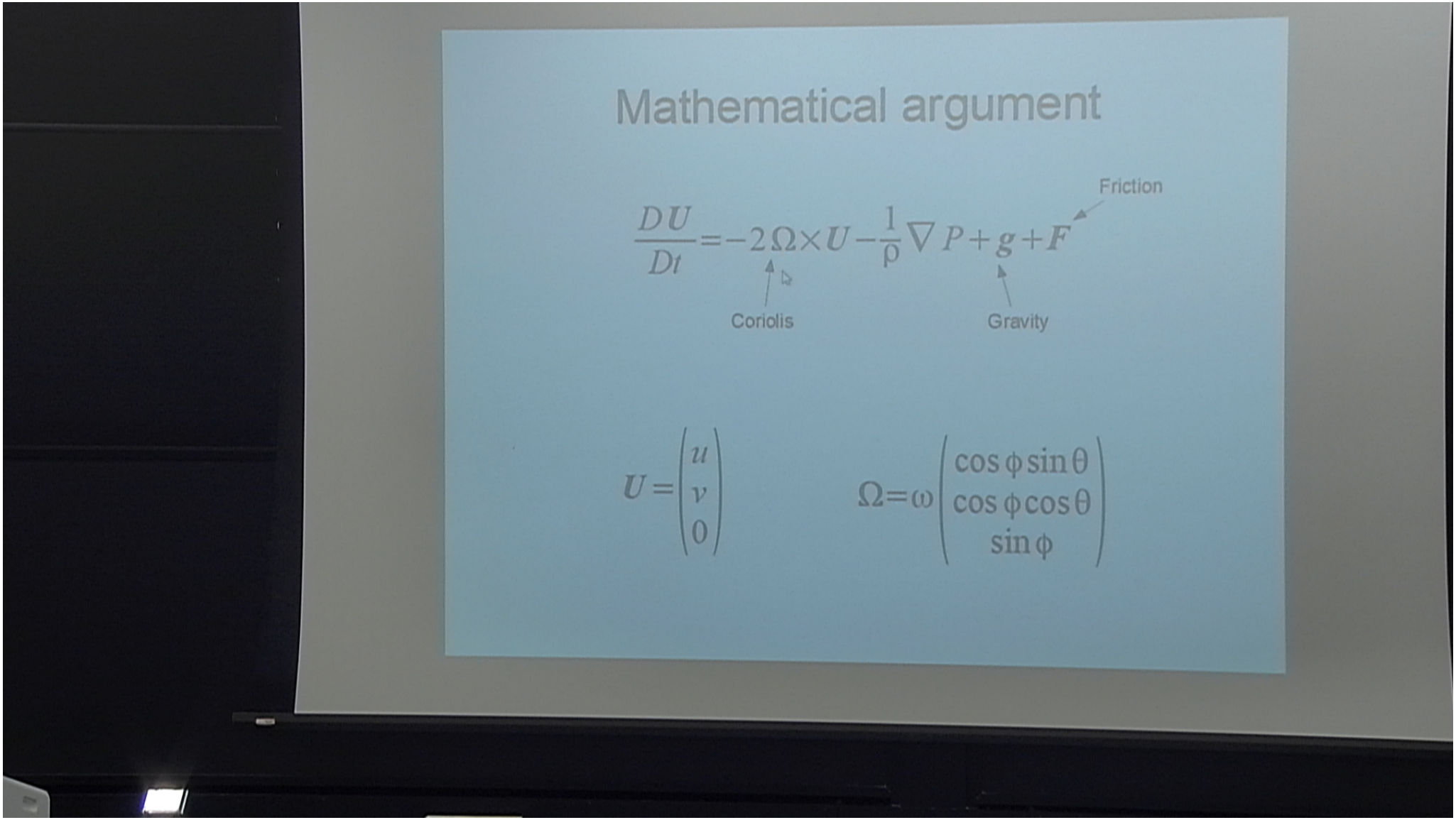

Mathematical argument
$\frac{DU}{Dt} = -2\Omega \times U - \frac{1}{\rho}\nabla P + g + F$
Coriolis


Mathematical argument
$\frac{DU}{Dt} = -2\Omega \times U - \frac{1}{\rho}\nabla P + g + F$
Friction
Coriolis
Gravity
$U = \begin{pmatrix} u \\ v \\ 0 \end{pmatrix}$
$\Omega = \omega \begin{pmatrix} \cos\phi \sin\theta \\ \cos\phi \cos\theta \\ \sin\phi \end{pmatrix}$


Mathematical argument
$\frac{DU}{Dt} = -2\Omega \times U - \frac{1}{\rho}\nabla P + g + F$
Friction
Coriolis
Gravity
$U = \begin{pmatrix} u \\ v \\ 0 \end{pmatrix}$
$\Omega = \omega \begin{pmatrix} \cos\phi \sin\theta \\ \cos\phi \cos\theta \\ \sin\phi \end{pmatrix}$