A few notes on Climate and Weather and the Atmosphere

Some good material in Stull, R., 2017: "Practical Meteorology: An Algebra-based Survey of Atmospheric Science" -version 1.02b. Univ. of British Columbia. 940 pages. isbn 978-0-88865-283-6.

Free! and available at https://www.eoas.ubc.ca/books/Practical_Meteorology/

ATMOSPHERIC BASICS

Classical Newtonian physics can be used to describe atmospheric behavior. Namely, air motions obey Newton's laws of dynamics. Heat satisfies the laws of thermodynamics. Air mass and moisture are conserved. When applied to a fluid such as air, these physical processes describe **fluid mechanics**. **Meteorology** is the study of the fluid mechanics, physics, and chemistry of Earth's atmosphere.

https://en.wikipedia.org/wiki/Newton's_laws_of_motion

1)A body remains at rest, or in motion at a constant speed in a straight line, unless acted upon by a force.

2)When a body is acted upon by a net force, the body's acceleration multiplied by its mass is equal to the net force.

3) If two bodies exert forces on each other, these forces have the same magnitude but opposite directions.

Bodies? Point masses, Rigid bodies, can rotate, Continua, elastic solids, fluids

https://en.wikipedia.org/wiki/Laws_of_thermodynamics - work and heat

Heat, diffusion (laminar and turbulent) of, plus radiation (absorption, scattering), latent heat issues (vapor, liquid, solid H2O).

Climate and Weather - both same physics, both need observed data, and models.

Atmospheric Models. Numerical Weather Prediction. Equations of motion and thermodynamics ...

My simple "toy" model of a cloud layer

$$\frac{\partial U}{\partial t} = f(V - V_g) - \frac{\partial < uw >}{\partial z}, \qquad \frac{\partial V}{\partial t} = f(U_g - U) - \frac{\partial < vw >}{\partial z} \tag{1}$$

$$\frac{\partial \Theta}{\partial t} = -\frac{\partial < w\theta >}{\partial z} + (RFDIV + LHT)/(\rho c_p) \tag{2}$$

$$\frac{\partial E}{\partial t} = P_s + P_b - \varepsilon - \frac{\partial < we >}{\partial z} \tag{3}$$

$$\frac{\partial Q}{\partial t} = -\frac{\partial < wq >}{\partial z} - \Delta Q, \tag{5a}$$

and

$$\frac{\partial QL}{\partial t} = -\frac{\partial <wql>}{\partial z} - \frac{\partial (W_s QL)}{\partial z} + \Delta Q. \tag{5b}$$

and results .....

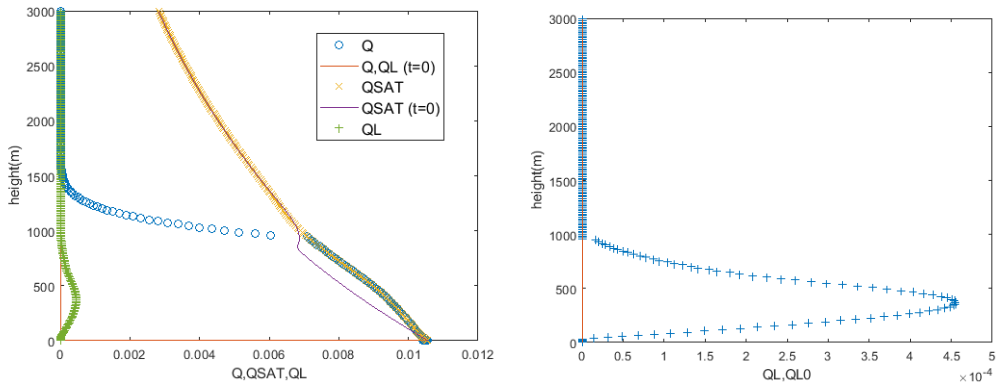
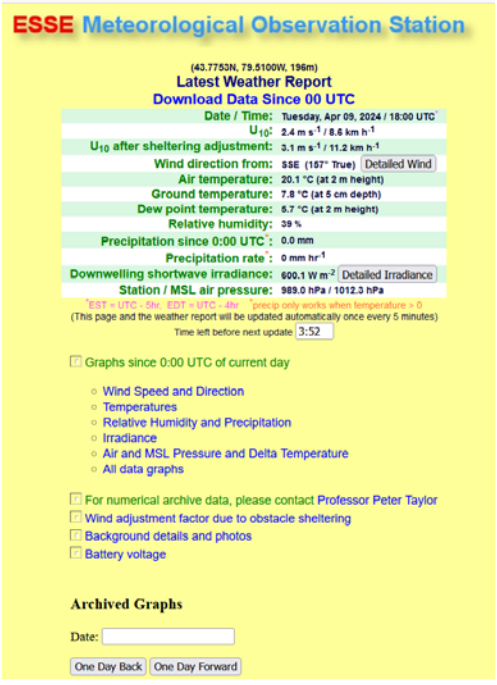


Figure 6 Results after 5 days over a water surface. Thin lines define the initial conditions (Equilibrium profiles from Figure 5) and o,+,x symols are values after 120 hours over a water surface with $Q(z = 0) = QSAT$ (288K)

but let's talk about ...

Observing the atmosphere. In situ and remotely, from ground level or satellite.

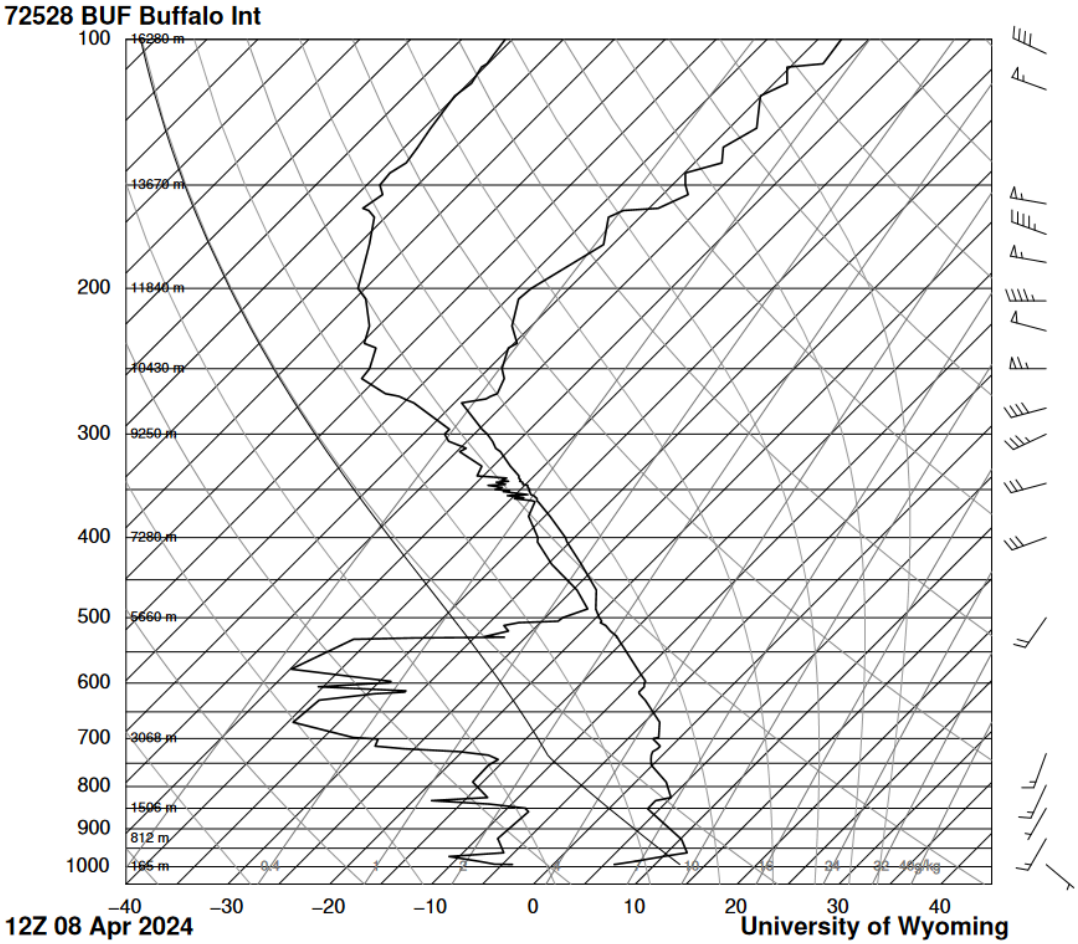
Initially erected 2002, added 4 component radiation 2005. Data posted every 5 min at: https://www.yorku.ca/pat/weatherStation/index.php



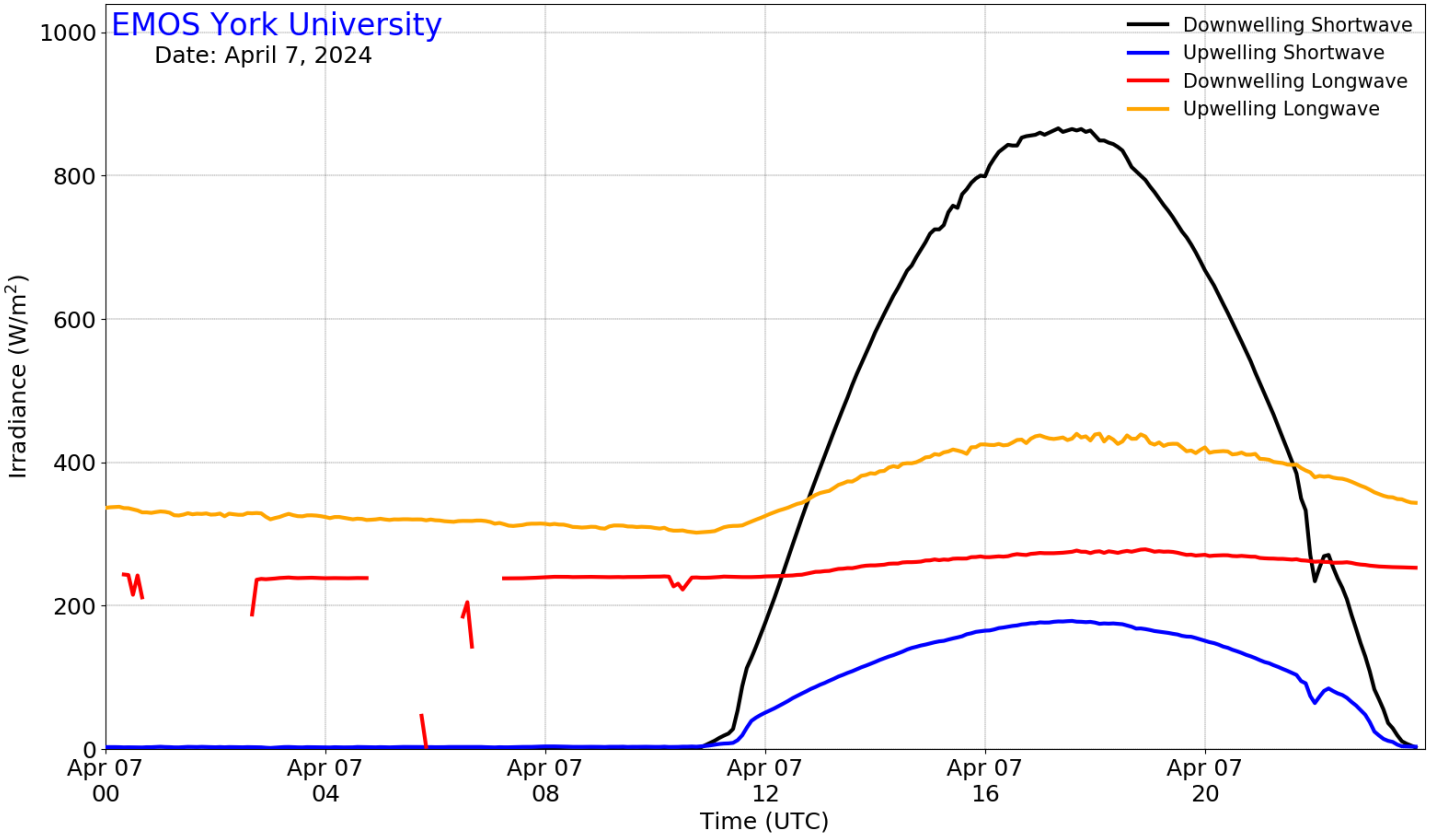
Other "In Situ" measurements - radiosondes. Data available at http://weather.uwyo.edu/upperair/sounding.html

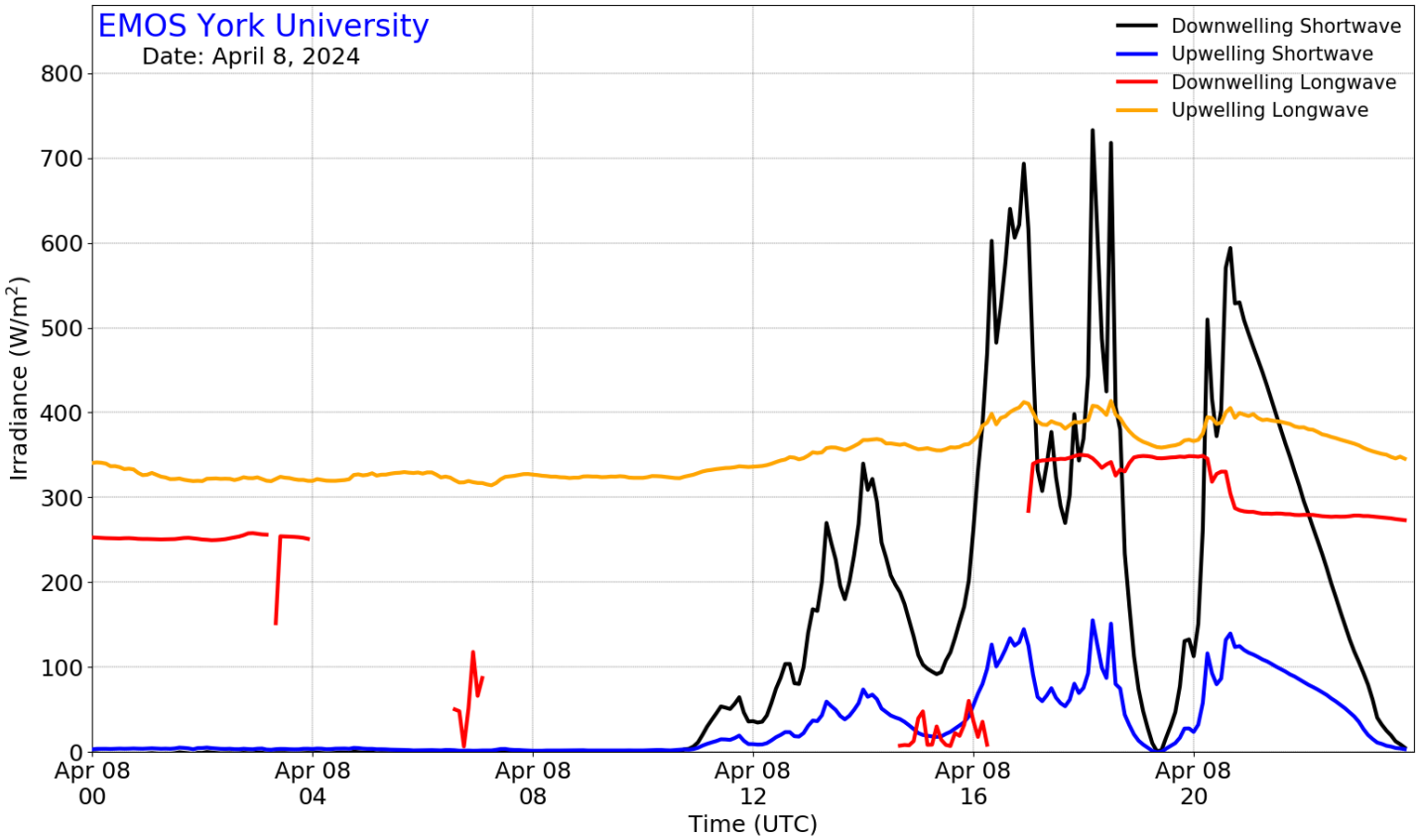
https://sableislandinstitute.org/mscs-aerological-program-ends/
MSC's Aerological Program Ends After 75 Years of Service – WSA Sable Island 1944-2019

Closest sounding to Toronto is

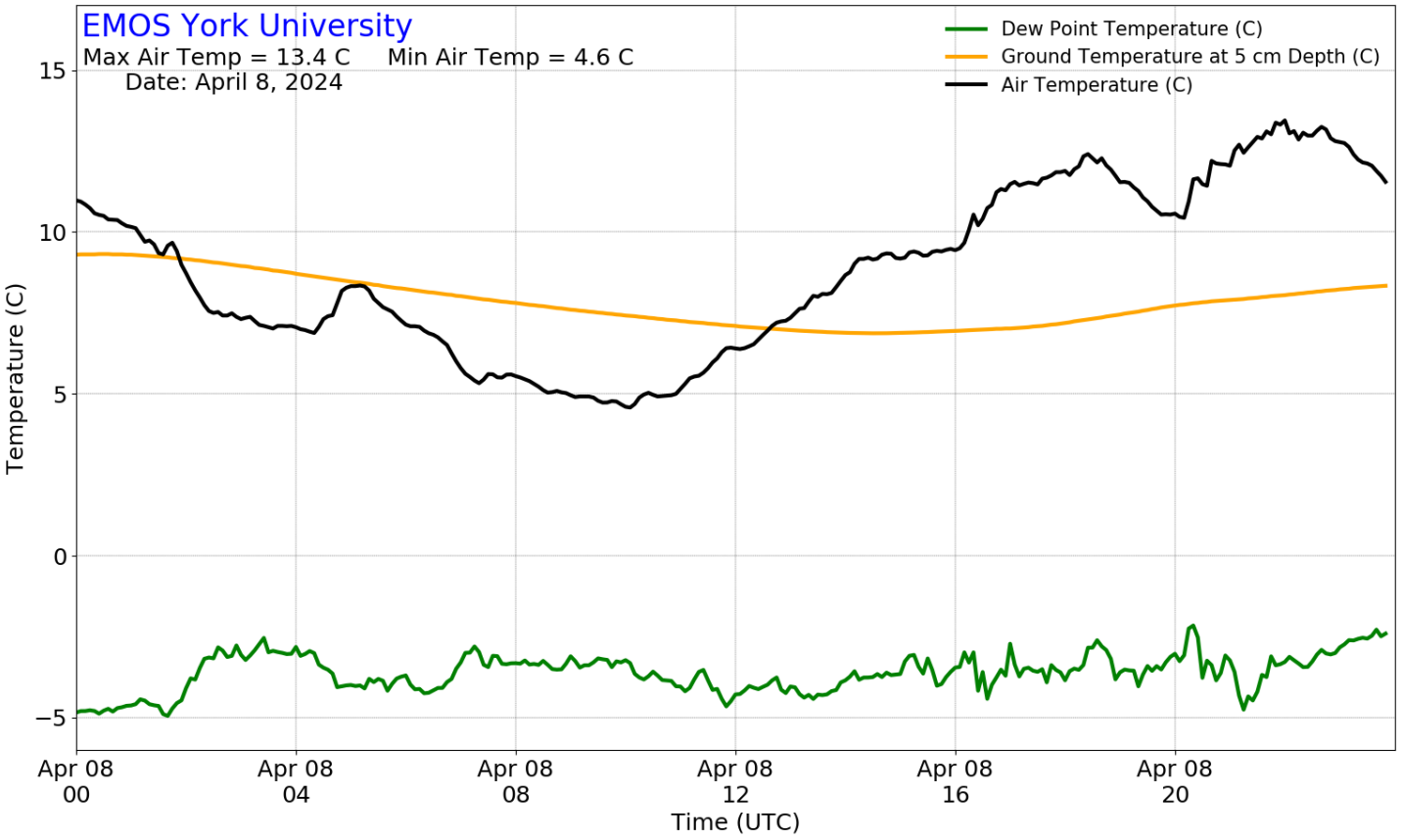


Why April 8?

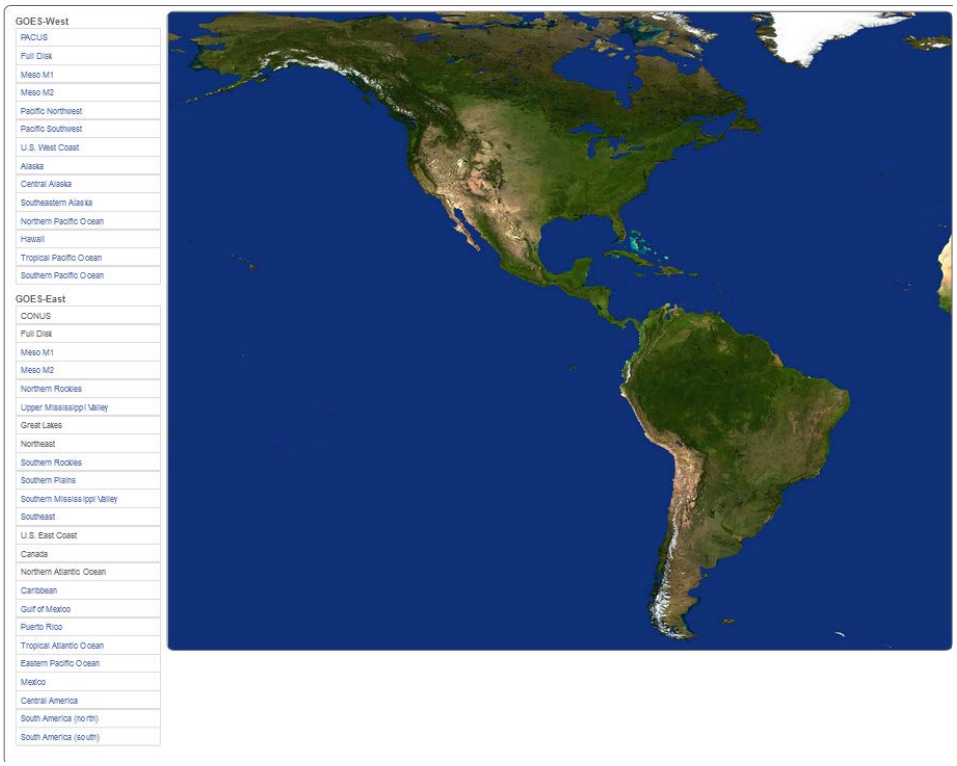


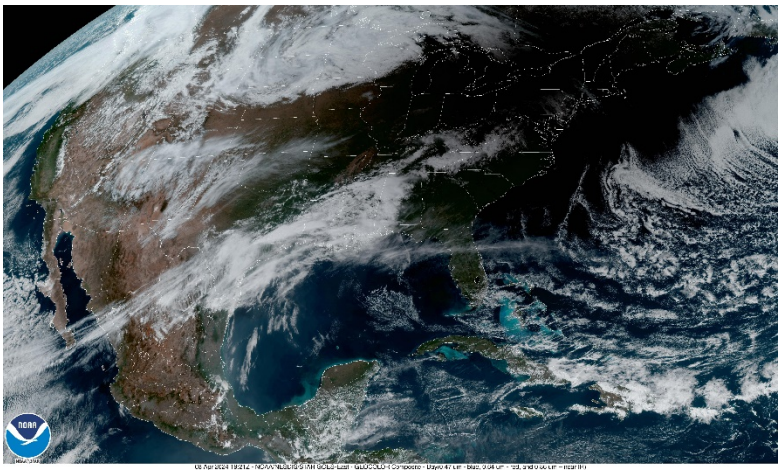


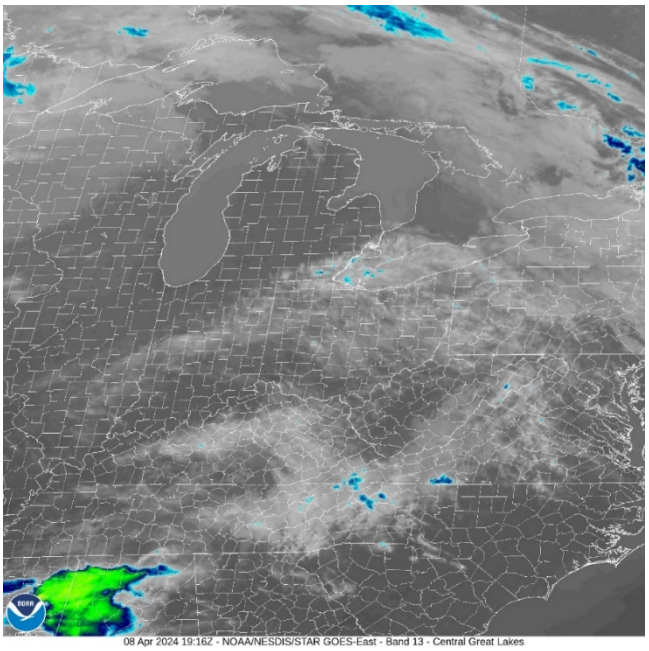
https://www.yorku.ca/pat/weatherStation/index.php Can you see the impact of the eclipse? and of clouds?

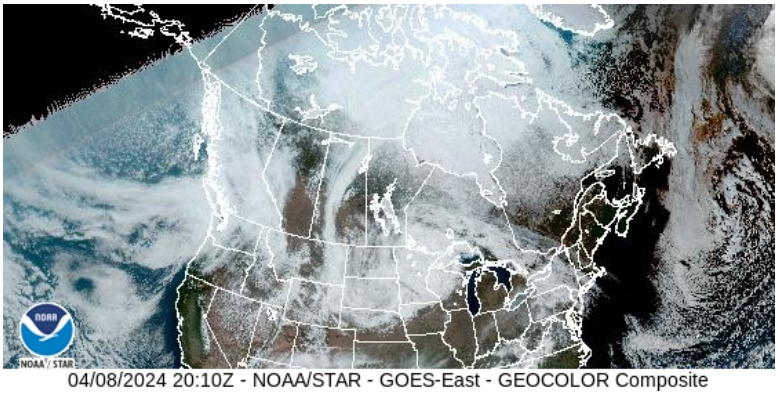


Sensing. GOES imagery. https://www.star.nesdis.noaa.gov/GOES/



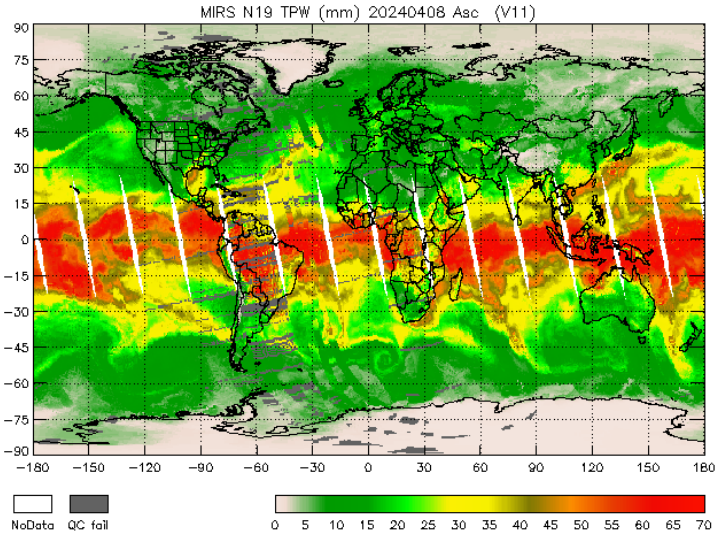


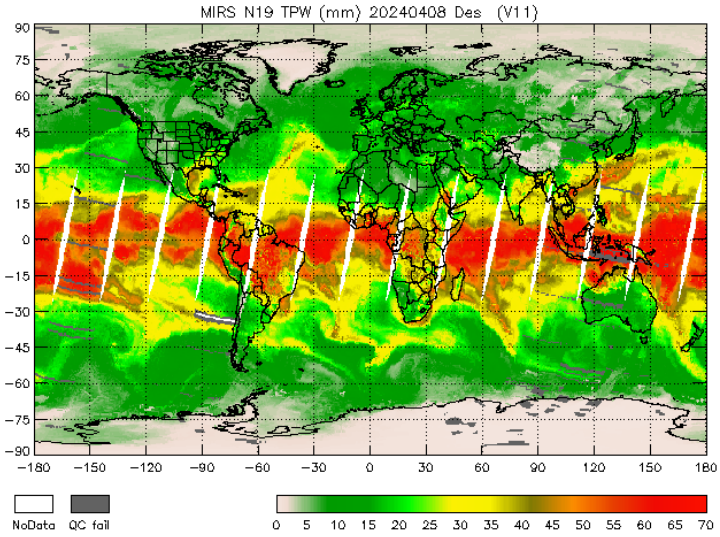




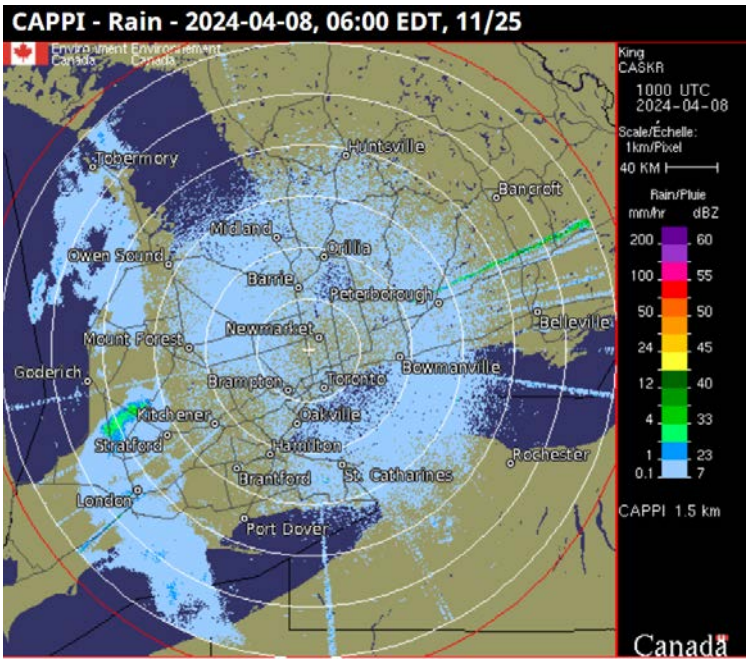
04/08/2024 20:10Z - NOAA/STAR - GOES-East - GEOCOLOR Composite

POES satellites - "Atmospheric Rivers"





See https://www.ospo.noaa.gov/Products/atmosphere/mirs/tpw.html



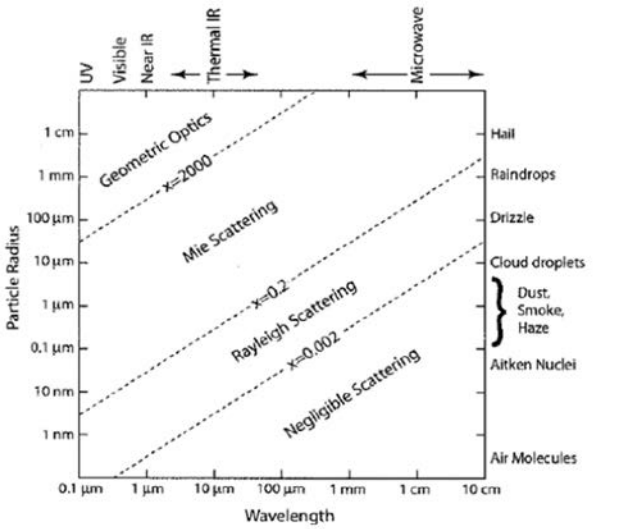


Fig. 12.1: Relationship between particle size, radiation wavelength and scattering behavior for atmospheric particles. Diagonal dashed lines represent rough boundaries between scattering regimes.

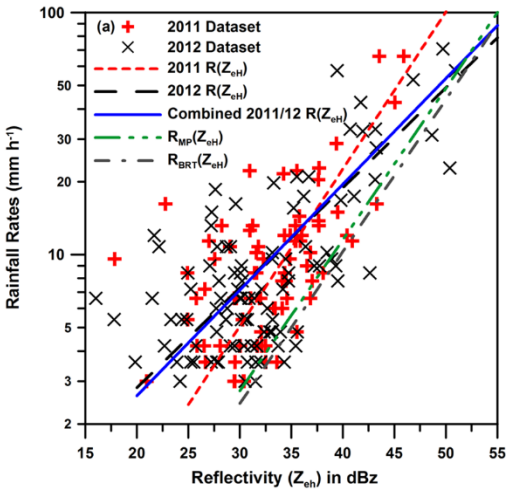
From: https://climate.weather.gc.ca/radar/index_e.html

$$P_r = \underbrace{\frac{1.22^2 0.55^2 10^{-18}\pi^7 c}{1024 \log_e(2)}}_{\text{Constants}} \underbrace{\frac{P_t \tau D_a^2}{\lambda^4}}_{\substack{\text{Radar} \\ \text{parameters}}} \underbrace{\frac{T(0,r)^2}{r^2}}_{\text{Path}} \underbrace{|K|^2 Z}_{\substack{\text{Target} \\ \text{properties}}}, \qquad (3.2)$$

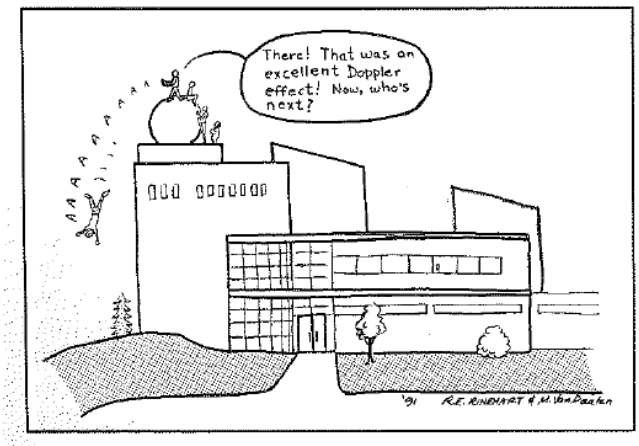
where P_t is the power of the transmit pulse and τ its duration, D_a is the diameter of the antenna, T is the transmittance of the atmosphere along the path between the radar at range 0 and the sampling volume at range r, and $|K|^2$ is the dielectric constant of the scatterers and is related to the complex index of refraction of the hydrometeor $n(\lambda)$ via

$$|K|^2 = \left| \frac{n(\lambda)^2 - 1}{n(\lambda)^2 + 2} \right|^2. \qquad (3.3)$$

Then you need a Z-R relationship,

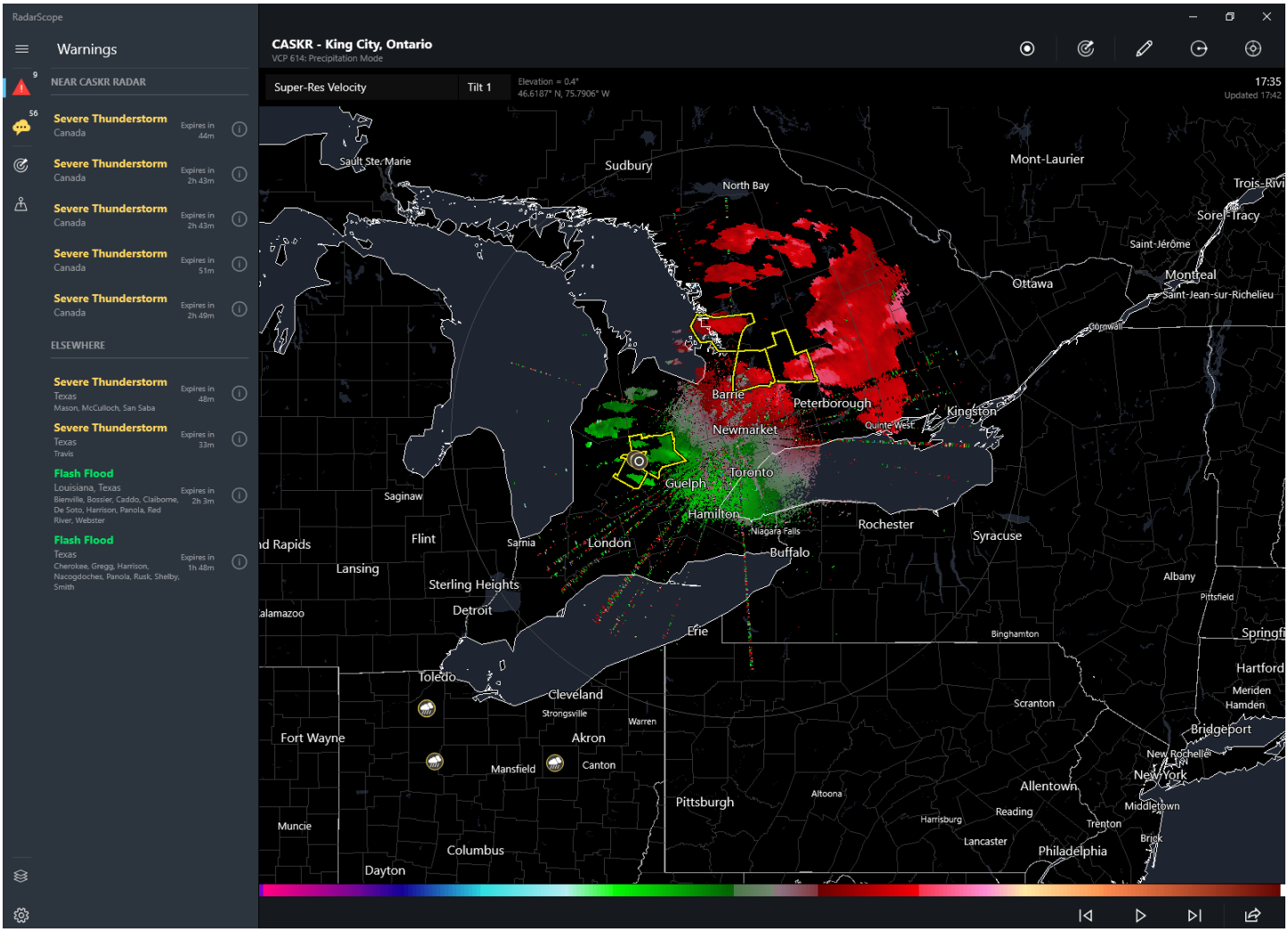


Weather radar can also measure winds, or at least a component.



from Doppler shift in frequency. Cartoon from

Rinehart - Radar for Meteorologists

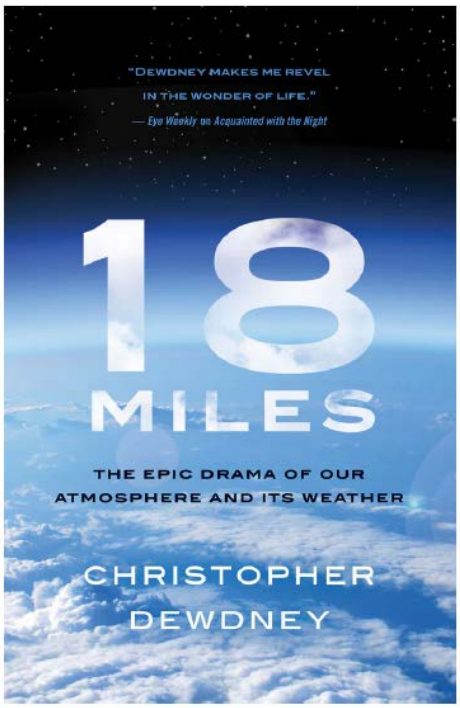


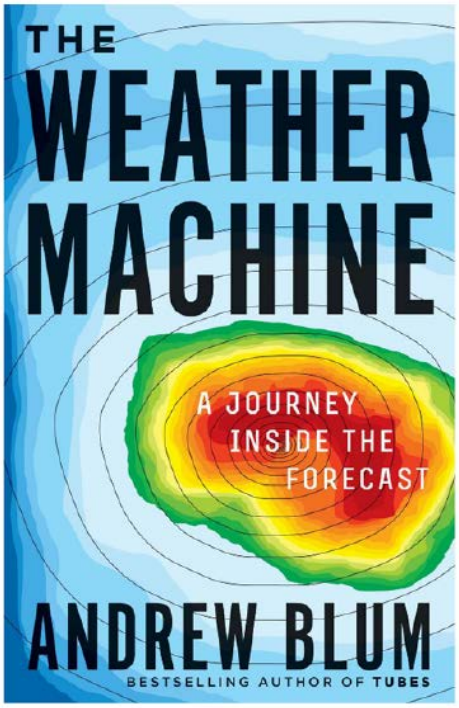
Rainfall - a key component of climate change, droughts and floods, rain or snow at polar latitudes.

Clouds - critical for global albedo - how much sunlight gets backscattered (reflected) into space? Role in absorbing and re-emitting long wave radiation.

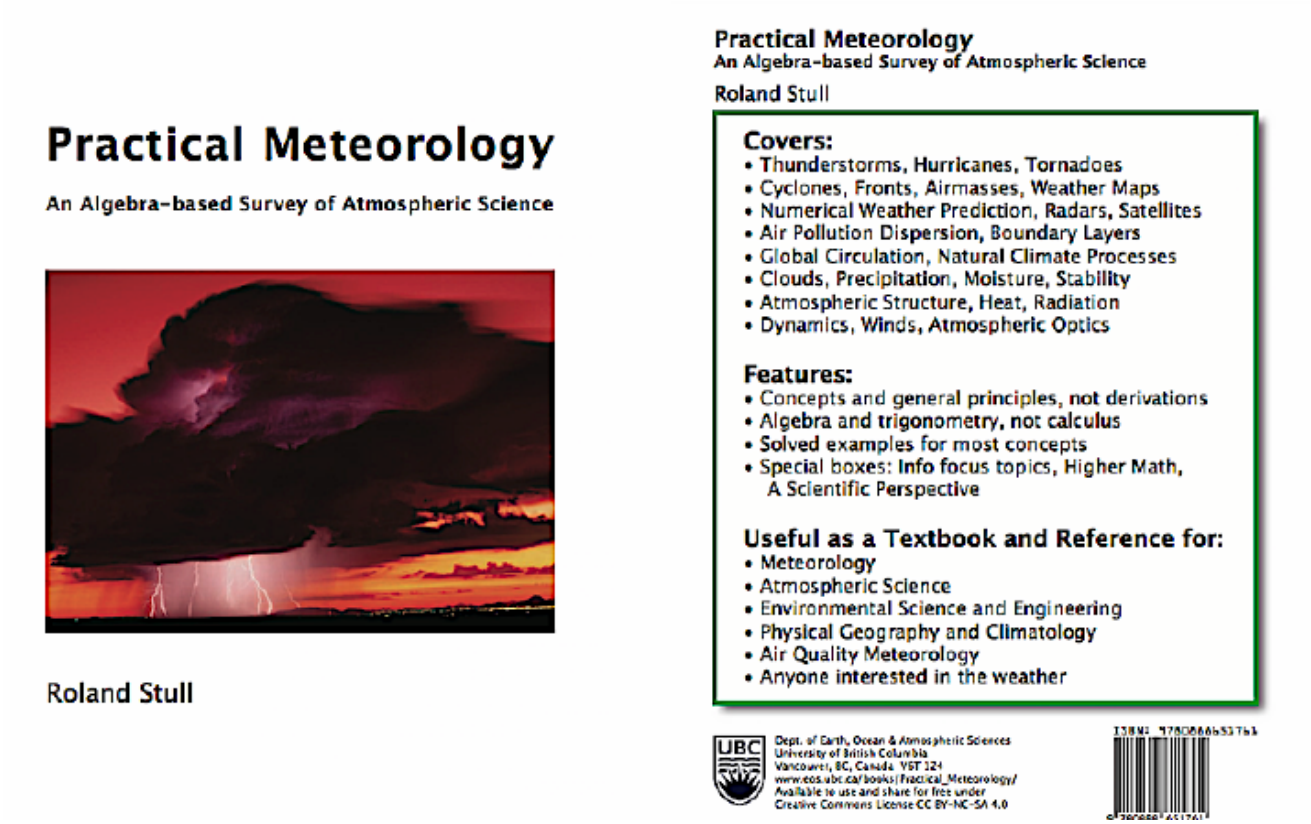
There are University undergraduate programs in atmospheric science. Dalhousie, McGill, UQAM, York. Manitoba, UBC. Also some content, and graduate work at U of Toronto (Physics), and several other places.

Two good background books on Atmospheric Science Issues. Note Christopher Dewdney is a Toronto poet, who teaches at York.





And a very good, and free, text that I send students to look at for some material in most of my courses. https://www.eoas.ubc.ca/books/Practical_Meteorology/



Here are some of the courses that you could take at York, Plus Math and Physics courses, GenEd requirements and other possibilities.

Course	Title
LE/ESSE 1011 3.00	Introduction to Atmospheric Science
LE/ESSE 1012 3.00	The Earth Environment
LE/ESSE 1410 6.00	Natural, Technological and Human-induced Disasters
LE/ESSE 2010 3.00	Introductory Meteorology
LE/ESSE 2020 3.00	Introduction to Climate Science
LE/ESSE 2030 3.00	Planetary Geophysics
LE/ESSE 2470 3.00	Introduction to Continuum Mechanics
LE/ESSE 3020 3.00	Global Geophysics and Geodesy
LE/ESSE 3030 3.00	Atmospheric Radiation and Thermodynamics
LE/ESSE 3040 3.00	Atmospheric Dynamics I
LE/ESSE 3130 3.00	Introductory Atmospheric Chemistry
LE/ESSE 3280 3.00	Physics of the Space Environment
LE/ESSE 3600 3.00	Geographical Information Systems (GIS) and Spatial Analysis
LE/ESSE 4000 3.00	Research Project
LE/ESSE 4020 3.00	Time Series and Spectral Analysis
LE/ESSE 4050 3.00	Synoptic Meteorology I
LE/ESSE 4051 3.00	Synoptic Meteorology II
LE/ESSE 4120 3.00	Cloud Physics and Radar Meteorology
LE/ESSE 4130 3.00	Atmospheric Dynamics II
LE/ESSE 4140 3.00	Numerical Weather Prediction
LE/ESSE 4160 3.00	Climate Variability and Climate Change
LE/ESSE 4220 3.00	Remote Sensing of the Earth's Surface
LE/ESSE 4230 3.00	Remote Sensing of the Atmosphere

You will be encouraged to become a member of YASC - the active and enthusiastic York Atmospheric Science Club, https://www.yorku.ca/yasc/