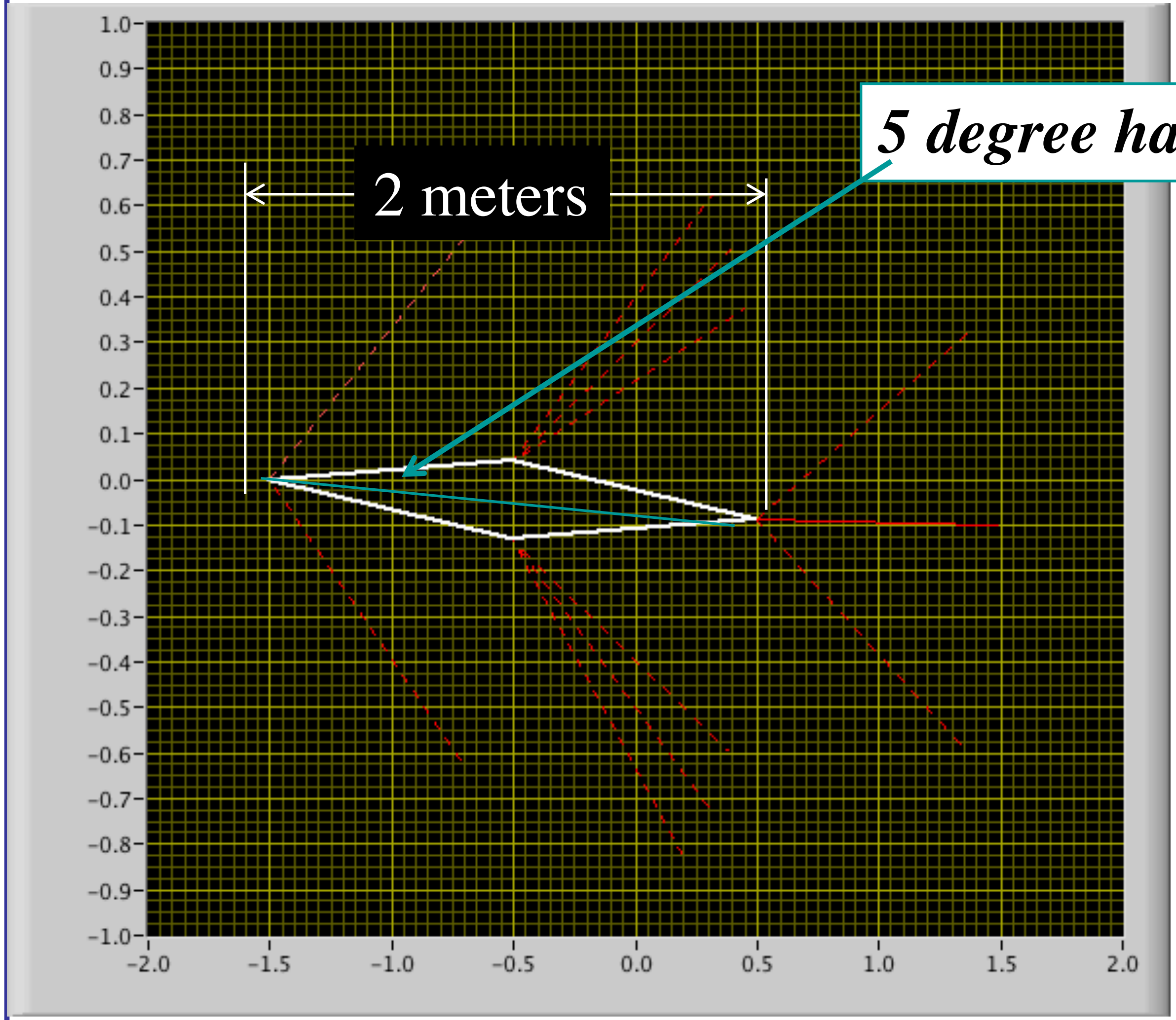
5-degree airfoil half-angle example



$$L/D = C_L/C_D$$

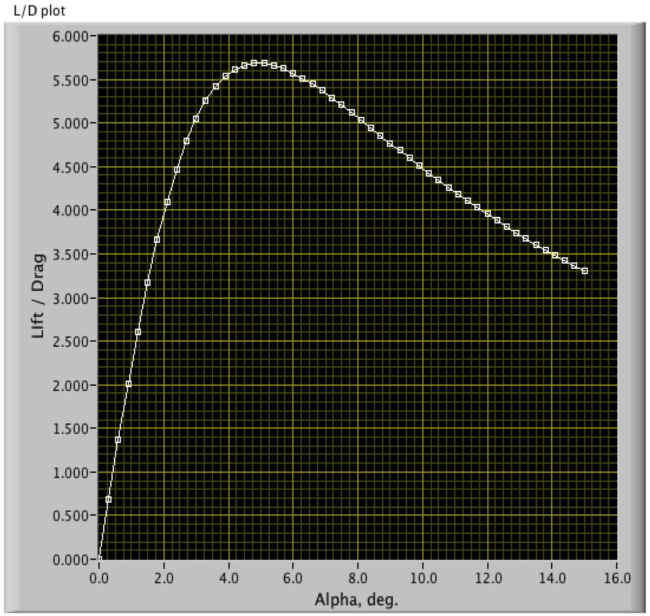
Loop for H=10, 20, 30, 40, 50 km

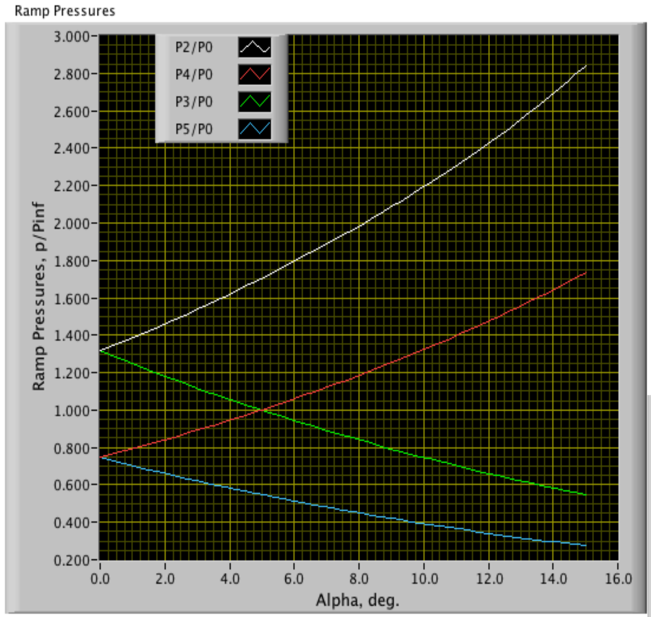
Sweep Mach Number
$1.25 < \text{Mach} \leq 10$

--Sweep α

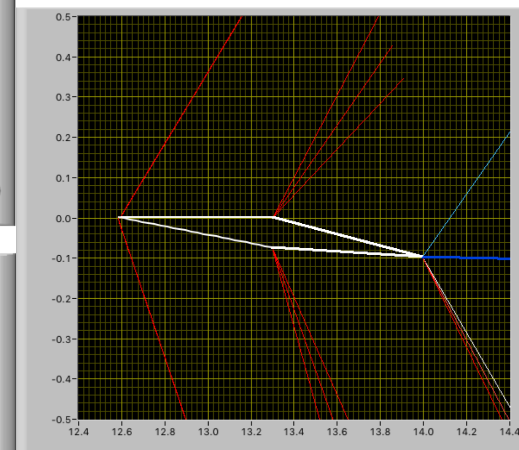
solve for C_L, C_D, L/D
plot L/D versus α
Find L/D max

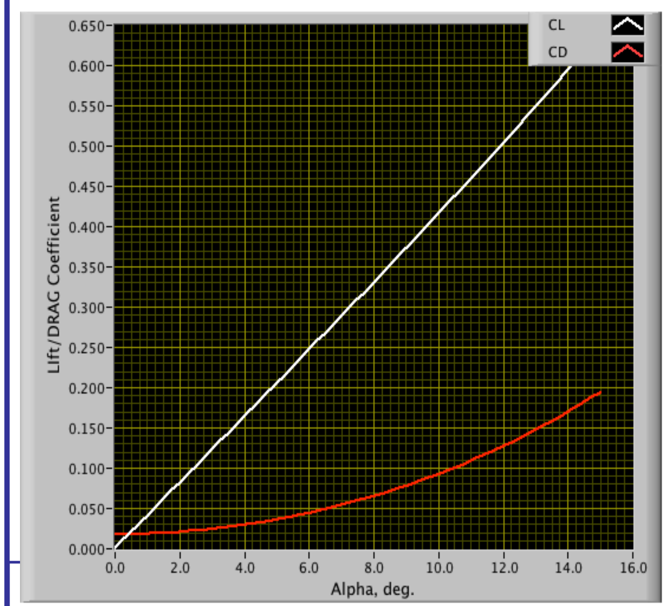
Inviscid L/D Plot vs Alpha

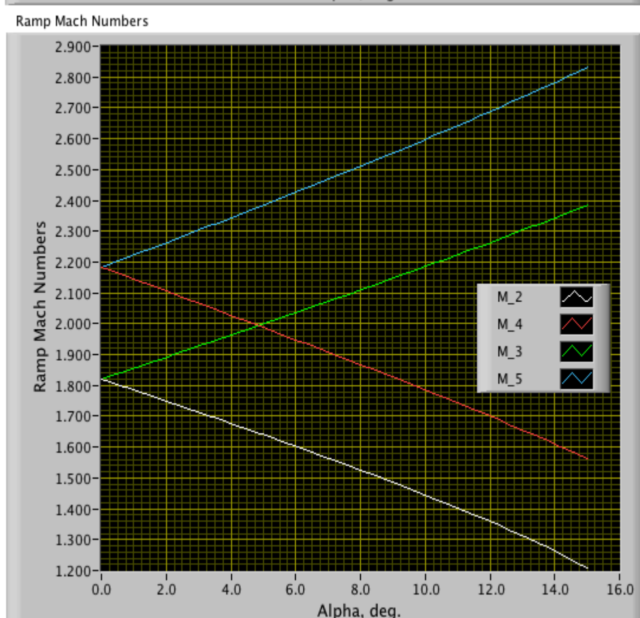




- Sweep Through Alpha
- Calculate Upper and Lower Pressure Distributions
- Calculate C_L, C_D Inviscid

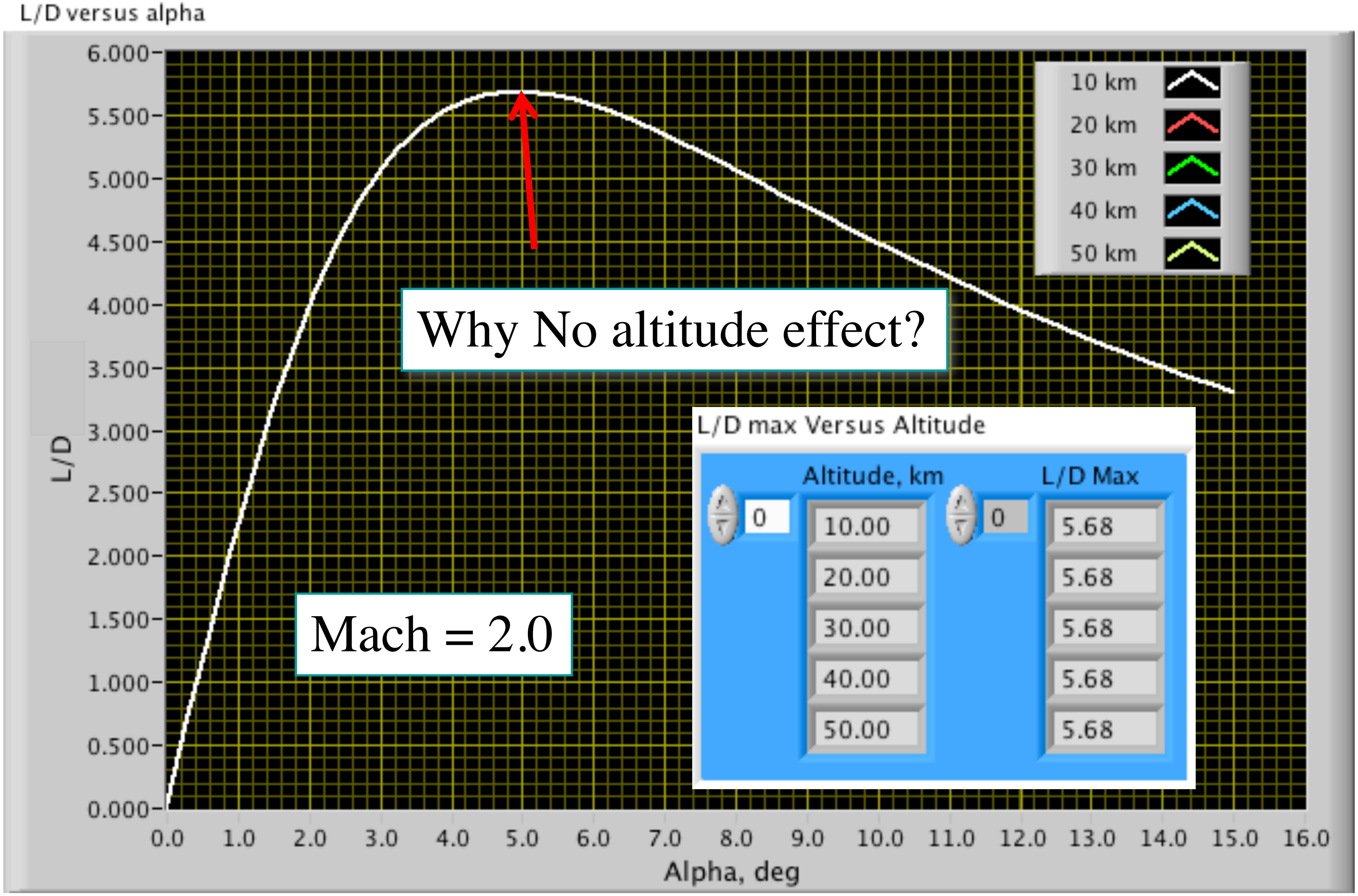




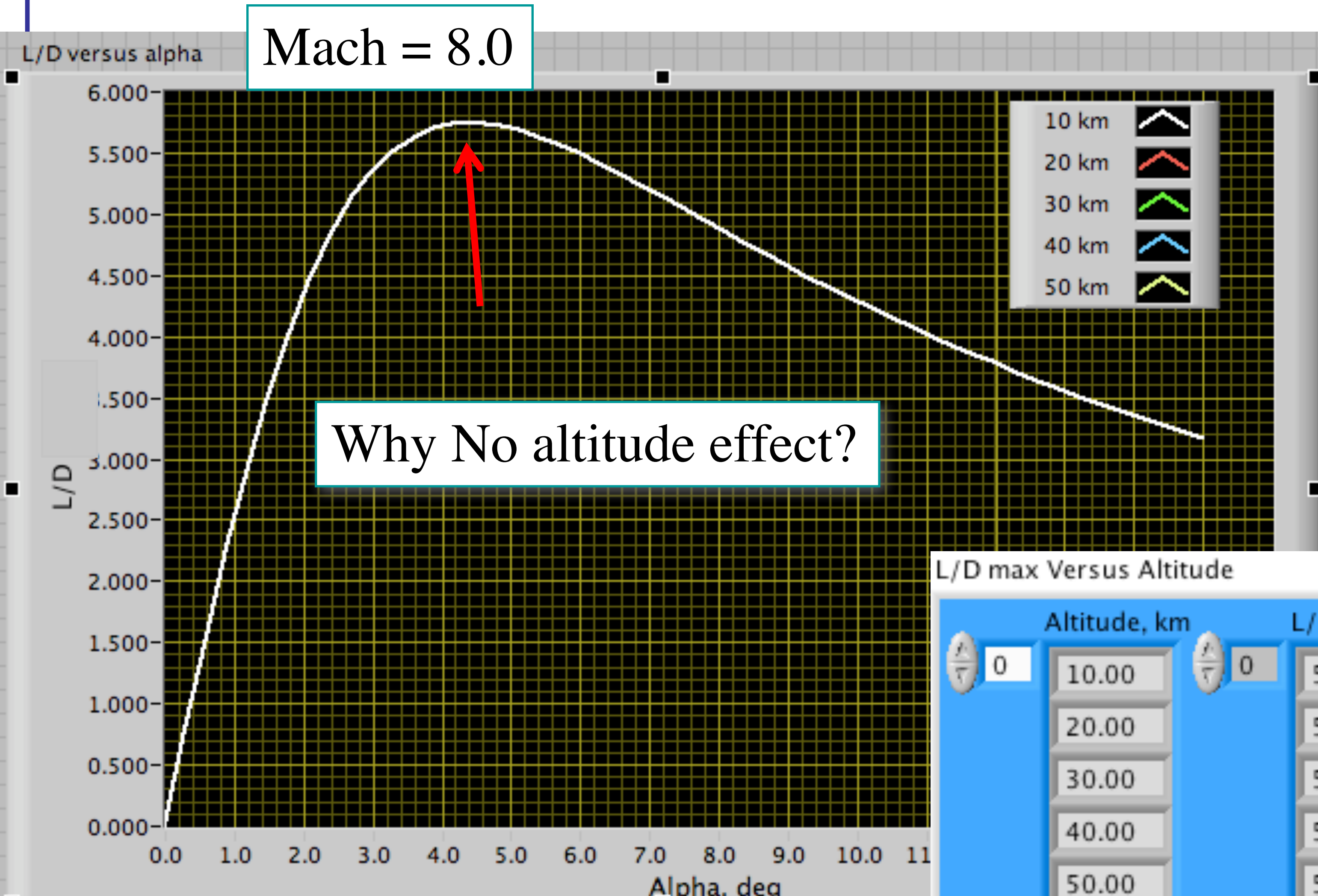


- Calculate L/D, Plot vs Alpha
- Pick L/D_{max}
- Repeat for each Mach Number

Inviscid L/D_{Max}



Inviscid L/D_{Max}

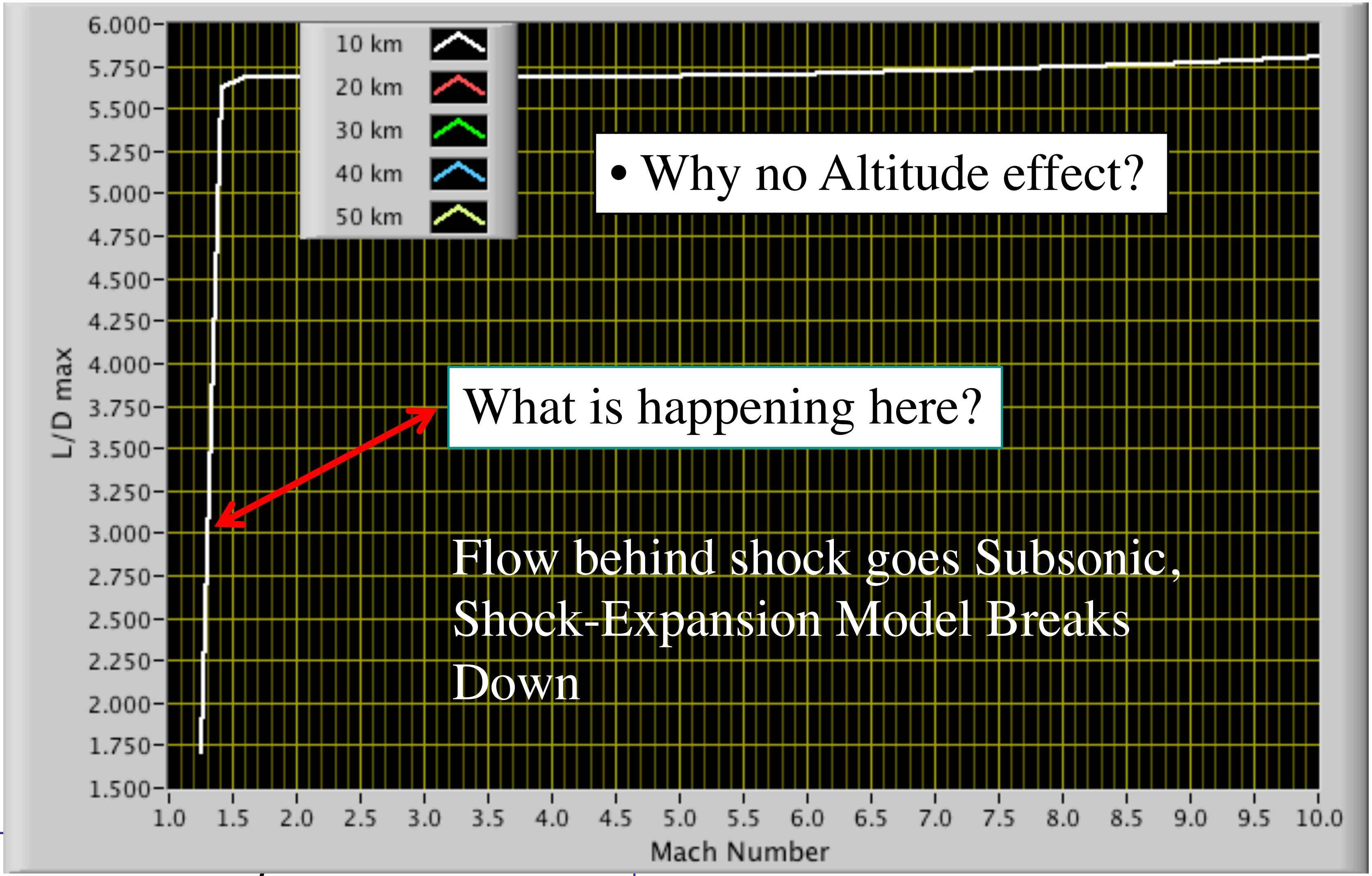


L/D max Versus Altitude

Altitude, km	L/D Max
10.00	5.74
20.00	5.74
30.00	5.74
40.00	5.74
50.00	5.74

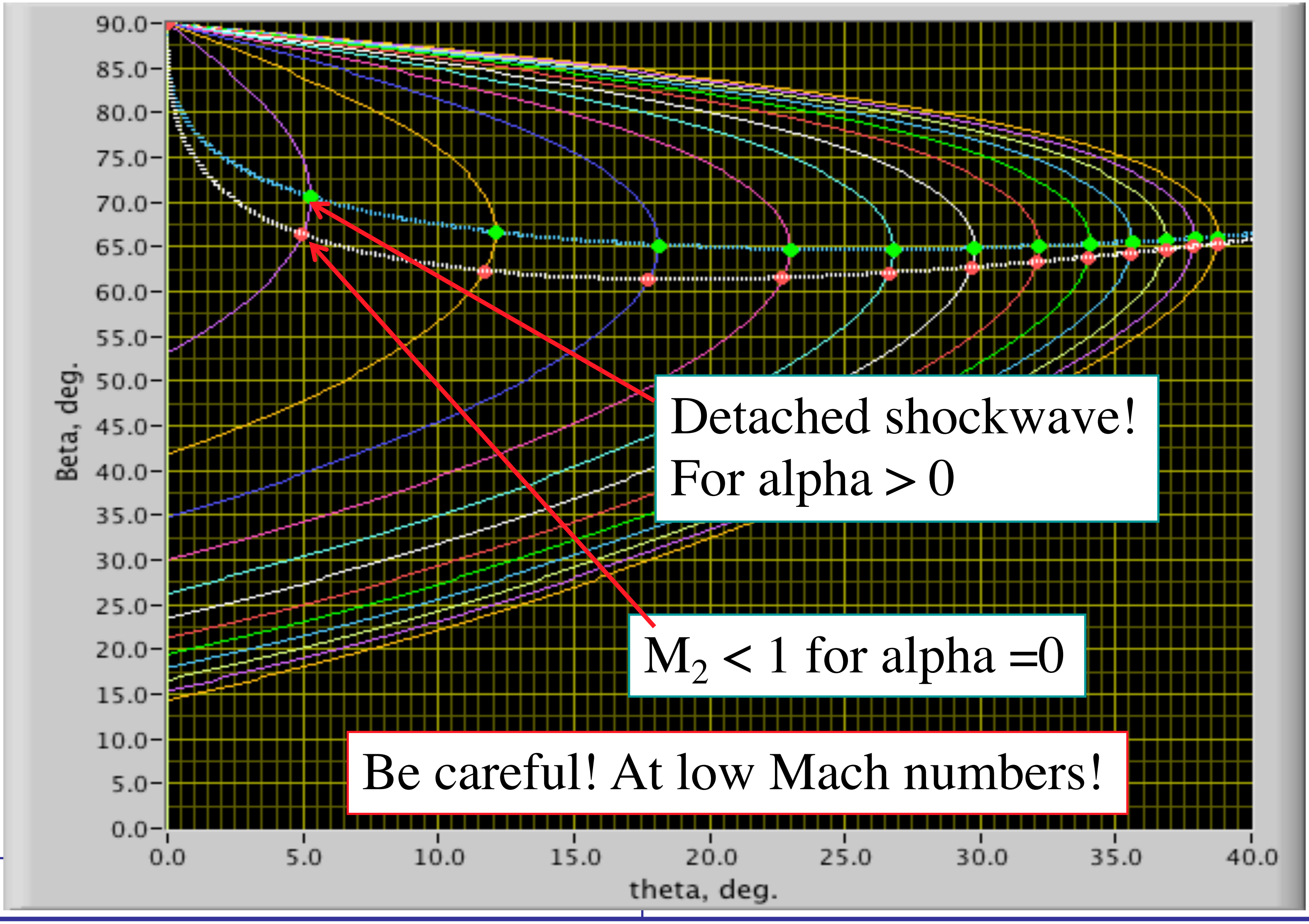
Inviscid L/D$_{Max}$ (continued)

- Inviscid Flow



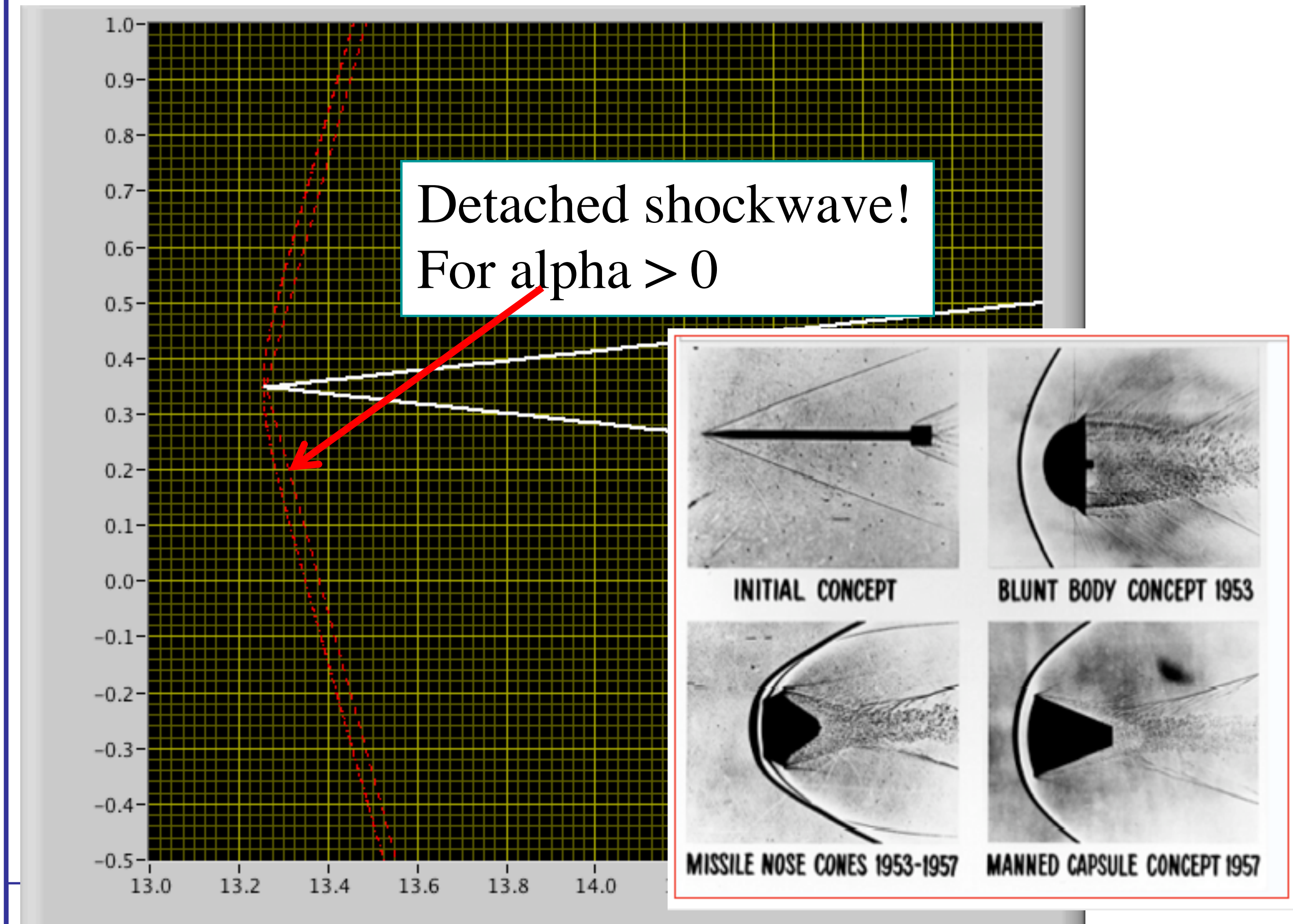
Inviscid L/D$_{Max}$(cont'd)

- Inviscid Flow



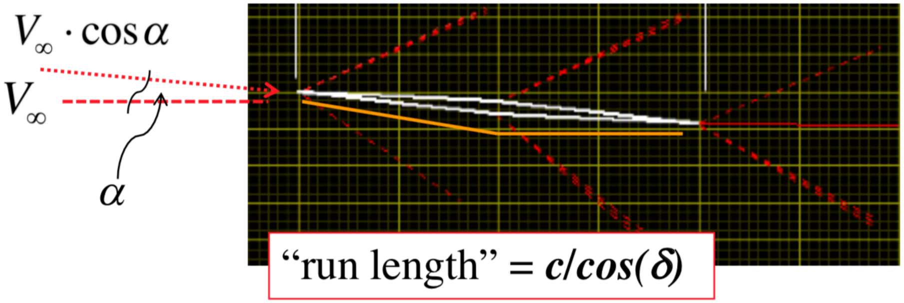
Inviscid L/D$_{Max}$(concluded)

- Inviscid Flow



Skin Friction Effect on L/D_{Max}

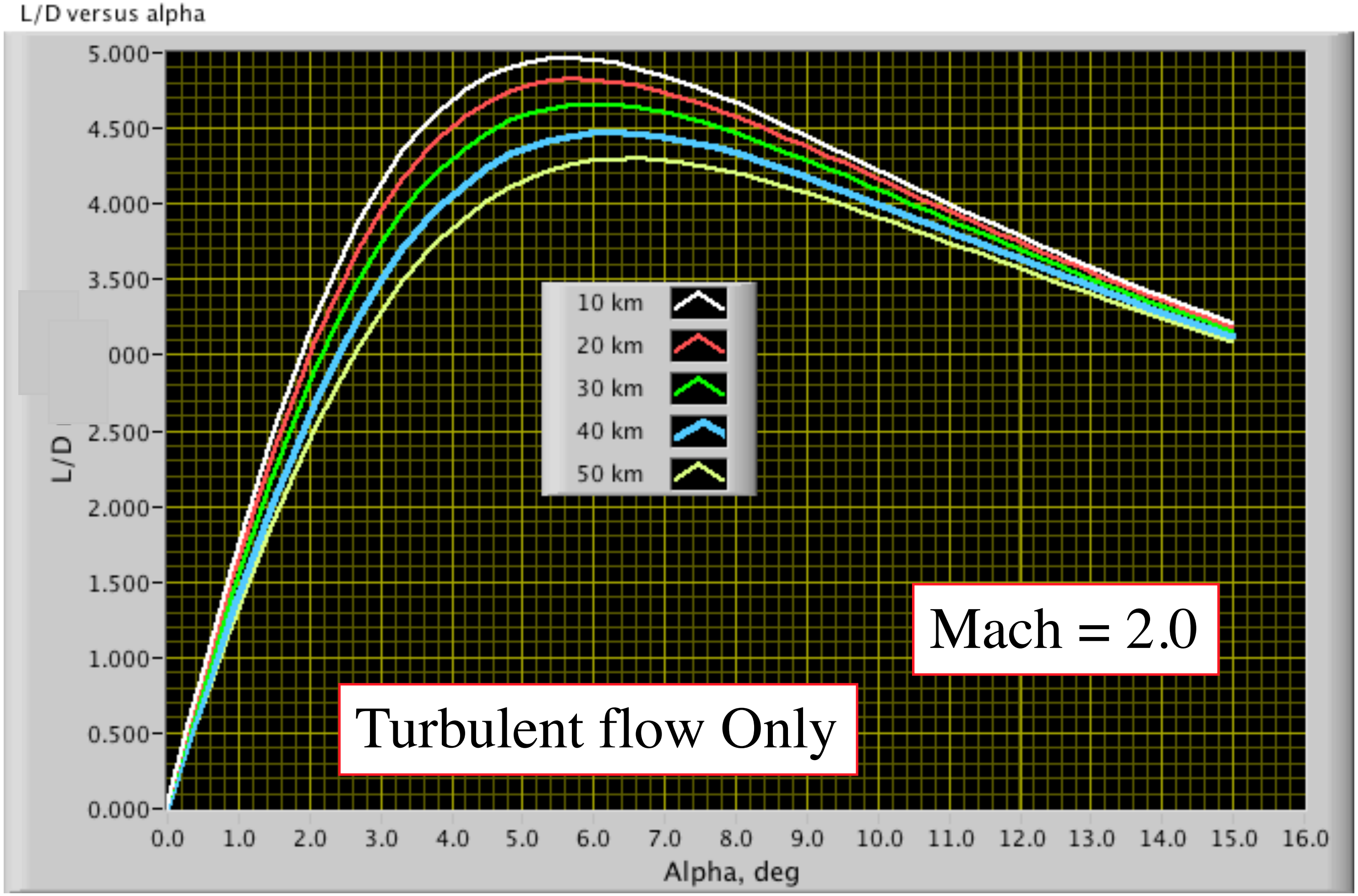
$$\left(L/D\right)_{\substack{\max \\ Visc}} = \frac{C_{L@\alpha_{max}}}{C_{D_{@\alpha_{max}}} + C_{D_{visc}}} = \frac{C_{L@\alpha_{max}}}{C_{D_{@\alpha_{max}}} + \frac{2}{\cos\delta}\cdot C_{D_F}} \rightarrow C_{D_F} = f\left(R_{e_\infty}, T_\infty, T_{avg}\right)$$



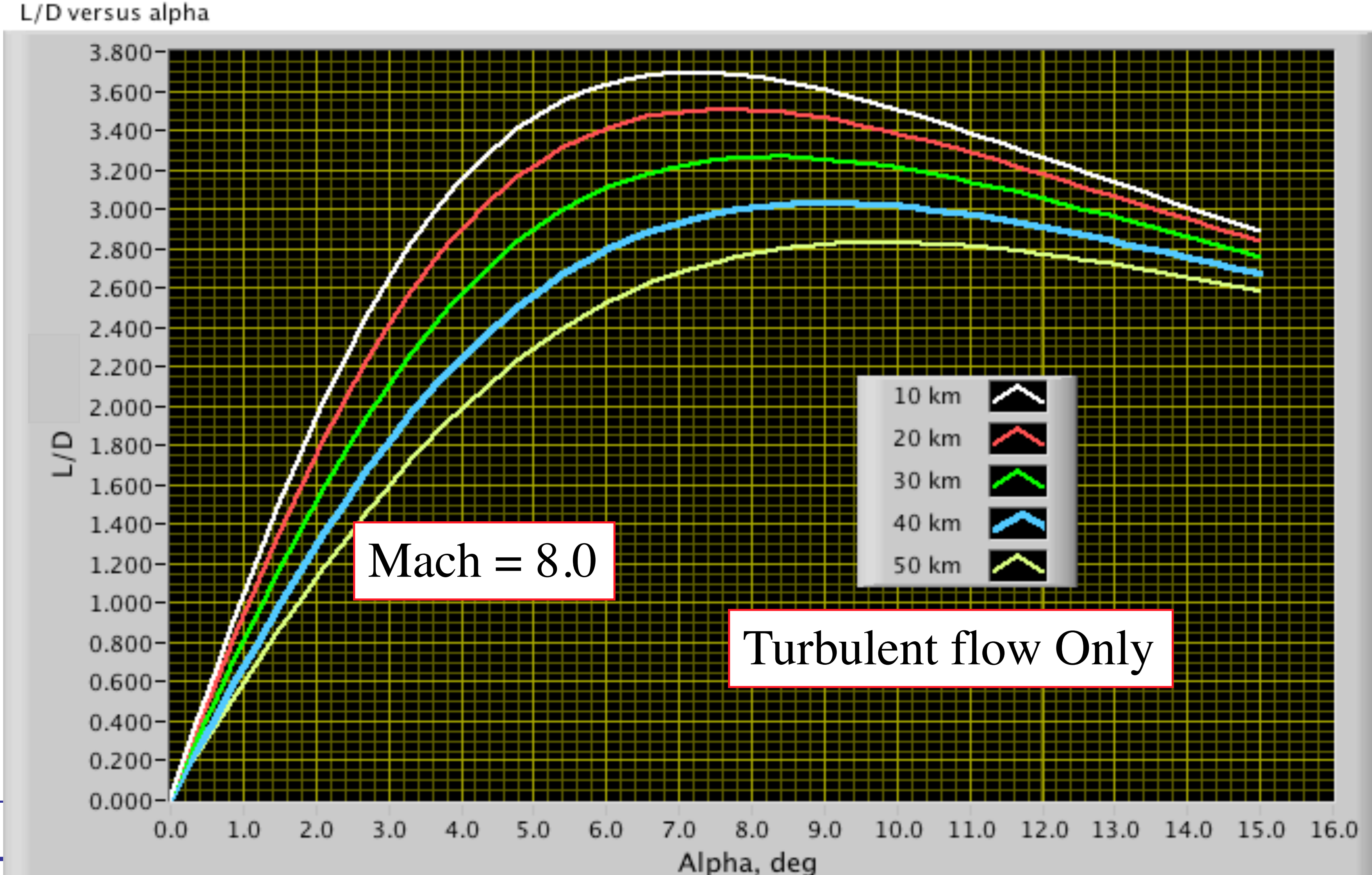
Wing has two sides that contribute to skin drag

$$\left(L/D\right)_{\substack{\max \\ Visc}} = \frac{C_{L@\alpha_{max}} \Big/ C_{D_{@\alpha_{max}}}}{1 + \frac{2}{\cos\delta}\cdot\frac{C_{D_F}}{C_{D_{@\alpha_{max}}}}} = \frac{\left(L/D\right)_{\substack{\max \\ Inviscid}}}{1 + \frac{2}{\cos\delta}\cdot\frac{C_{D_F}}{\left(C_{D_{@\alpha_{max}}}\right)_{Inviscid}}}$$

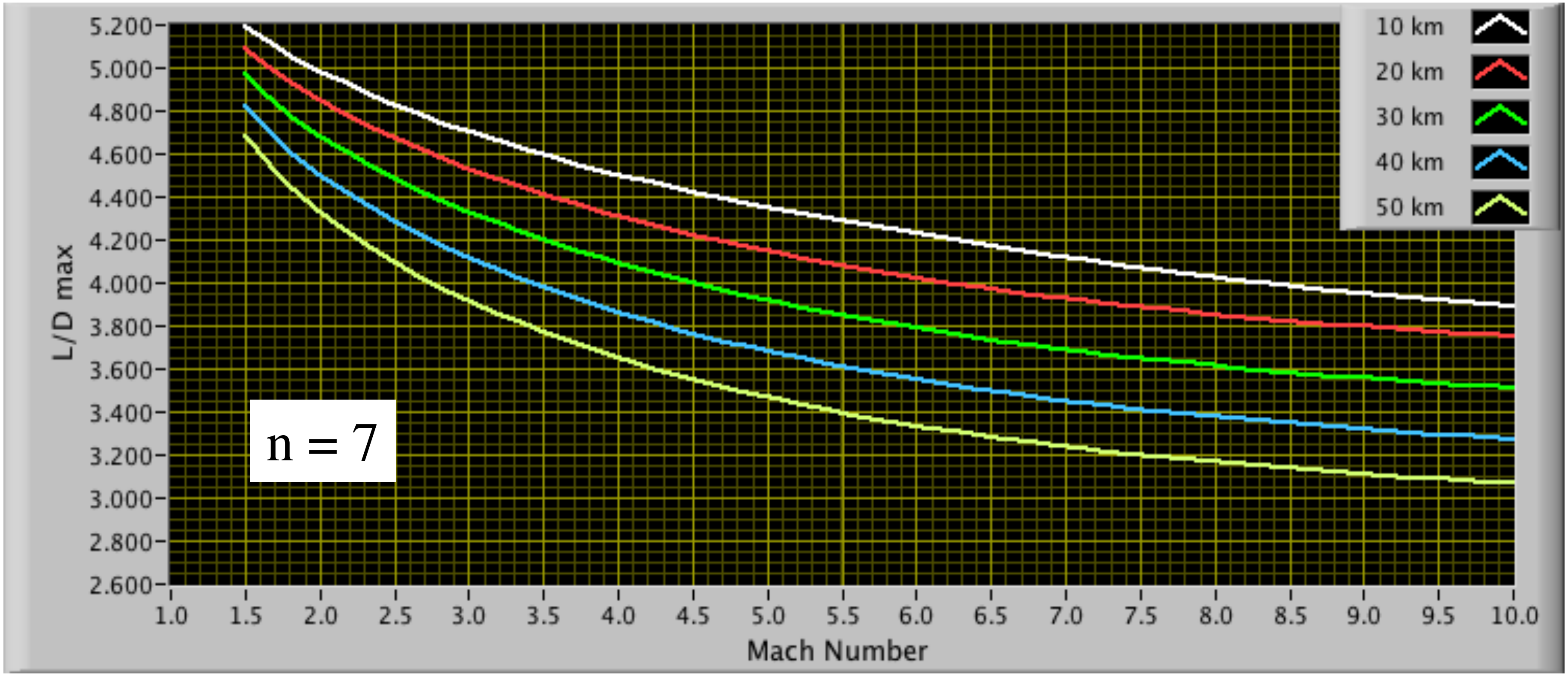
Alpha for CL_{max} changes with altitude for Viscous Flow Conditions



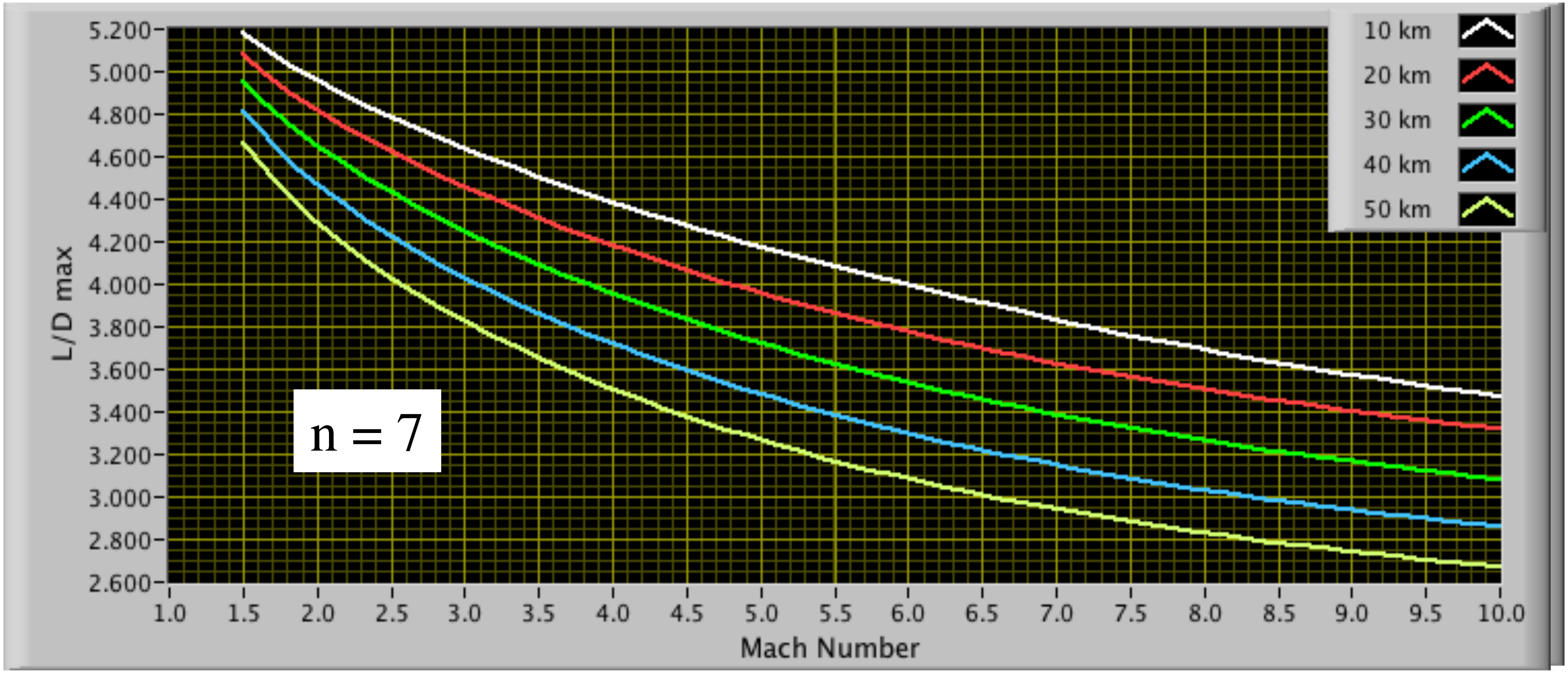
Alpha for CL_{max} changes with altitude for Viscous Flow Conditions



Viscous Flow, Turbulent Only, no Compressibility



Viscous Flow, Turbulent Only, Compressibility Corrected



Relationship Between Freestream Mach Number and Reynold's Number

$$M_\infty = \frac{V_\infty}{\sqrt{\gamma \cdot R_g \cdot T_\infty}}$$

$$R_{e_\infty} = \left(\frac{\rho_\infty \cdot V_\infty}{\mu_\infty}\right) \cdot \left(\frac{c}{\cos\delta}\right)$$

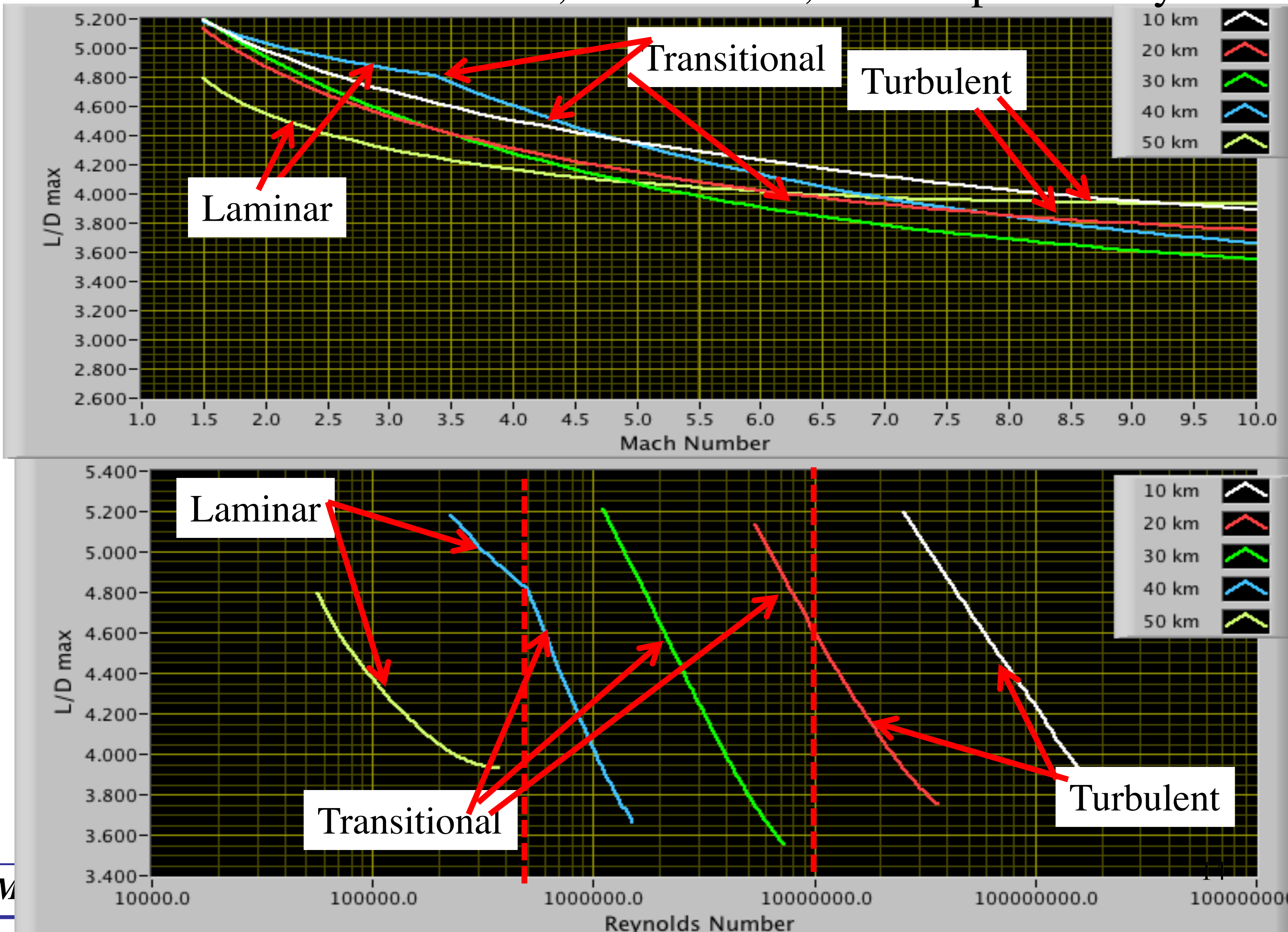
$$\rightarrow \frac{R_{e_\infty}}{M_\infty} = \left(\frac{P_\infty \cdot V_\infty}{R_g \cdot T_\infty \cdot \mu_\infty}\right) \cdot \left(\frac{c}{\cos\delta}\right) \cdot \frac{\sqrt{\gamma \cdot R_g \cdot T_\infty}}{V_\infty} = \left(\frac{P_\infty}{\mu_\infty} \cdot \sqrt{\frac{\gamma}{R_g \cdot T_\infty}}\right) \cdot \left(\frac{c}{\cos\delta}\right)$$

$$\boxed{R_{e_\infty} = \left(\frac{P_\infty}{\mu_\infty} \cdot \sqrt{\frac{\gamma}{R_g \cdot T_\infty}}\right) \cdot \left(\frac{c}{\cos\delta}\right) \cdot M_\infty}$$

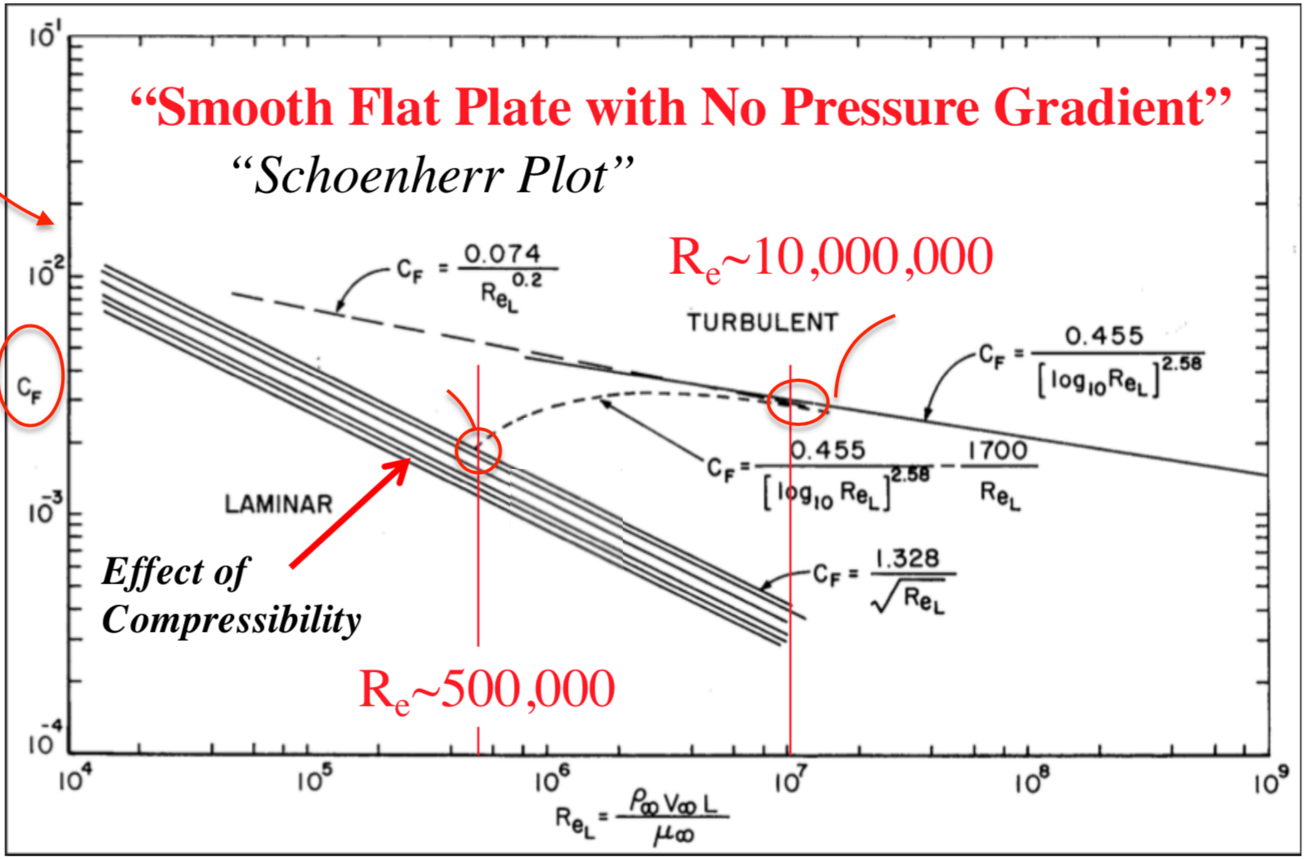
Altitude effects

Scale effects

Viscous Flow, Transitional, no Compressibility



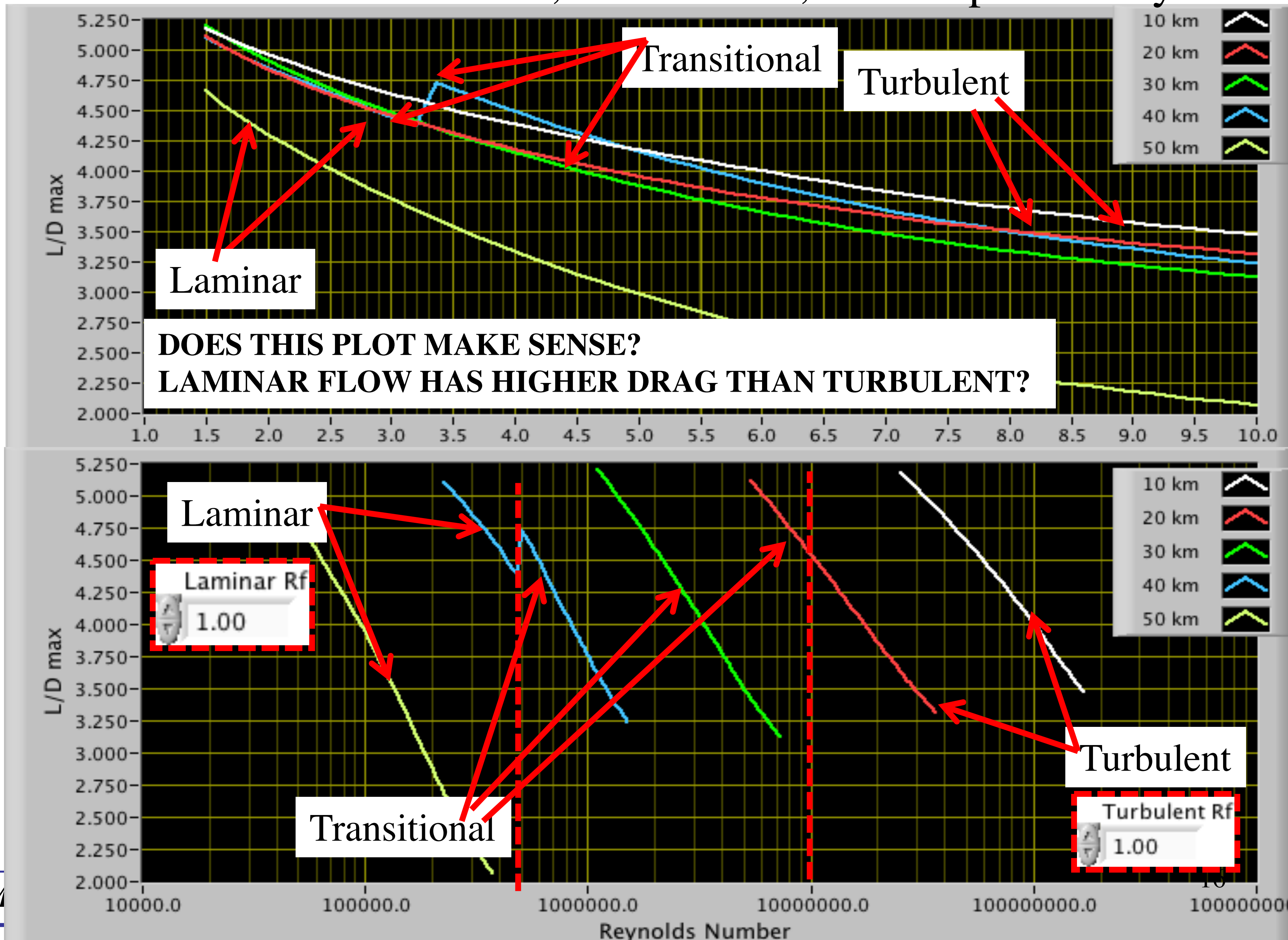
Viscous Flow with Allowable B.L. Transition



Reynold's Number also Effects the Type of Boundary Layer

- ***Laminar***
- ***Transitional***
- ***Turbulent***

Viscous Flow, Transitional, w/ Compressibility



Viscous Flow, Transitional, Compressibility Corrected