Sea Level Pressure Extrapolation Experiment

Presenting: Alex DesRosiers
Other Authors: Ian Sears, Paul Flaherty, Jack Parrish, Richard Henning, Michael Holmes, Jess Williams, And Brian Belson

Objectives

- Introduce Equation
- Describe Methodology
- Present Analysis/Results
- Conclusion
- Further Research

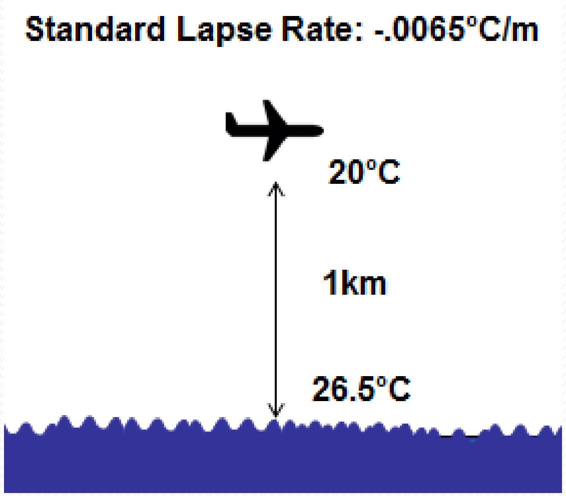
Question

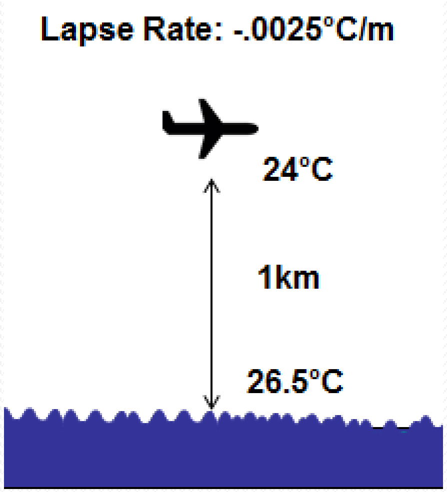
- Can the current AOC Extrapolated Sea Level Pressure Equation be improved upon by adjusting lapse rate?
- A Sea Level Pressure reading produces a rounded pressure to the mb and the equation should replicate it
- Why does this matter?

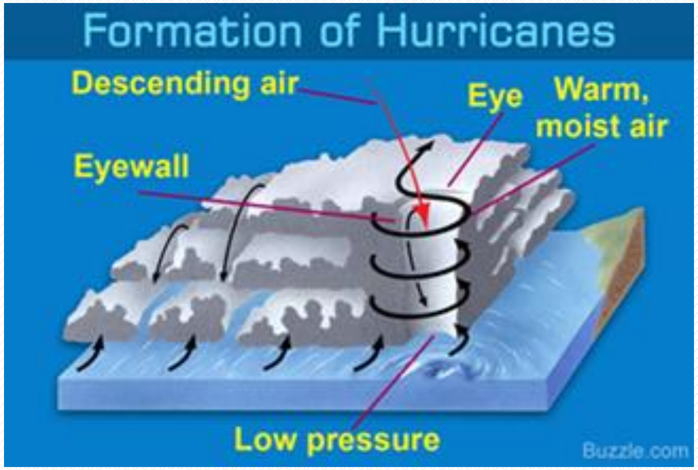
```
000
URNT12 KWBC 022244
VORTEX DATA MESSAGE  AL052016
A. 02/22:20:23Z
B. 16 deg 17 min N
  081 deg 45 min W
C. 700 mb 3075 m
D. 47 kt
E. 116 deg 28 nm
F. 198 deg 44 kt
G. 116 deg 28 nm
H. EXTRAP 997 mb
I. 11 C / 3083 m
J. 16 C / 3055 m
K. 7 C / NA
L. NA
M. NA
N. 12345 / 7
O. 1 / 1 nm
P. NOAA3 WA05A EARL OB 14
SLP EXTRAP FROM 10000FT
CURVED BANDING EAST AND NORTH
OCCASIONAL LIGHTNING
MAX OUTBOUND FL WIND AND MAX FL WIND 47 KT 276 / 3 NM 22:21:05Z
```

Hurricane Lapse Rate

- The lapse rate is a change in temperature with altitude
- The Standard Lapse rate is -6.5°C per km
- A hurricane is non standard due to subsidence and latent heat release make for warm air temps in eye
- A possible hurricane Lapse Rate is -2.5°C per km







The AOC Equation for Extrapolated Sea Level Pressure

- $\text{SLP}=1013.25\left[1-\frac{\left(PA-GA\frac{288.15-\Gamma std\times PA}{Tv}\right)}{\frac{288.15}{\Gamma std}}\right]^{\frac{g}{\Gamma std\times Rd}}$
- $PA=\frac{288.15}{\Gamma std}\left[1-\left(\frac{P_{stat}}{1013.25}\right)^{\frac{\Gamma std\times Rd}{g}}\right]$
- 7 instances of Standard Lapse Rate

Deriving a New Lapse Rate

- Needed a lapse rate unique to each storm
- Simple calculation to produce it on the fly
- Unique Lapse Rate = $\frac{(T_{surface} - Tf_{lightlevel})}{GA}$
- Substitute into equation at all points where lapse rate is used and see how it changes the extrapolated SLP

Generating Cases

- Needed Center Drops where SLP is ground truth
- Had to pull them from NHC reconnaissance archive
- Generated 104 total cases using Python, SQL, and Excel
- Cases come from 2014-2016 reconnaissance

Vortex Data Message (VDM)

```
000
URNT12 KWBC 171452
VORTEX DATA MESSAGE  AL082014
A. 17/14:23:40Z
B. 30 deg 09 min N
  066 deg 15 min W
C. NA
D. 84 kt
E. 320 deg 11 nm
F. 054 deg 81 kt
G. 323 deg 14 nm
H. 948 mb
I. 15 C / 2032 m
J. 17 C / 2759 m
K. 16 C / NA
L. OPEN S
M. C30
N. 12345 / 7
O. 1 / 3 nm
P. NOAA3 1108A GONZALO OB 17
MAX FL WIND 121 KT 039 / 23 NM 11:41:49Z
PENETRATION AT 8000 FT RADAR ALT
POOR RADAR PRESENTATION OF INNER EYEWALL
MULTIPLE OUTER BANDS NW SEMICIRCLE
CNTR DROPSONDE SFC WIND 140 / 10 KTS
```

Temp Drop Message

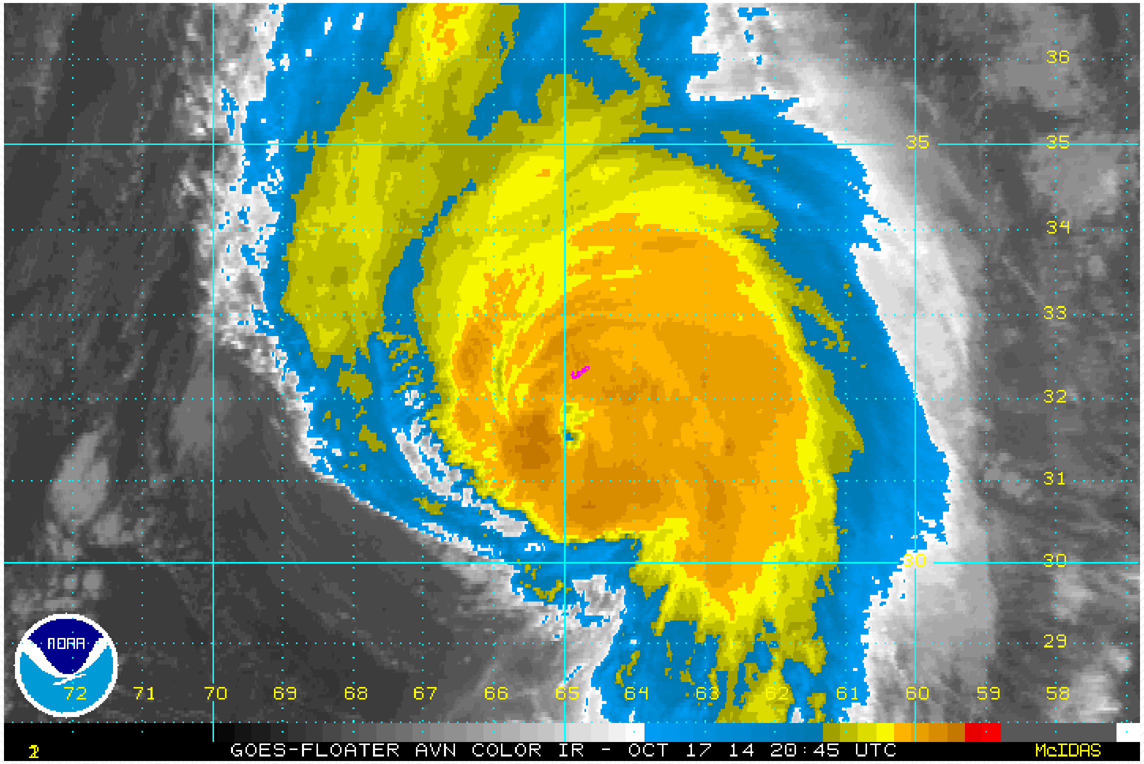
```
000
UZNT13 KWBC 171434
XXAA  67148 99302 70662 11506 99948 25807 14010 00/// ///// /////
92215 25207 18013 85959 22012 16509 88999 77999
31313 09608 81424
51515 10190 70636
61616 NOAA3 1108A GONZALO      OB 15
62626 EYE MBL WND 17510 AEV 07751 DLM WND 18508 947723 WL150 1501
0 084 REL 3016N06624W 142401 SPG 3017N06624W 142759 =
XXBB  67148 99302 70662 11506 00948 25807 11850 22012 22744 17629
33723 16603
21212 00948 14010 11926 17513 22890 19507 33868 16510 44850 16509
55834 15510 66820 18511 77723 27511
31313 09608 81424
51515 10190 70636
61616 NOAA3 1108A GONZALO      OB 15
62626 EYE MBL WND 17510 AEV 07751 DLM WND 18508 947723 WL150 1501
0 084 REL 3016N06624W 142401 SPG 3017N06624W 142759 =
```

High Density Observation (HDOB)

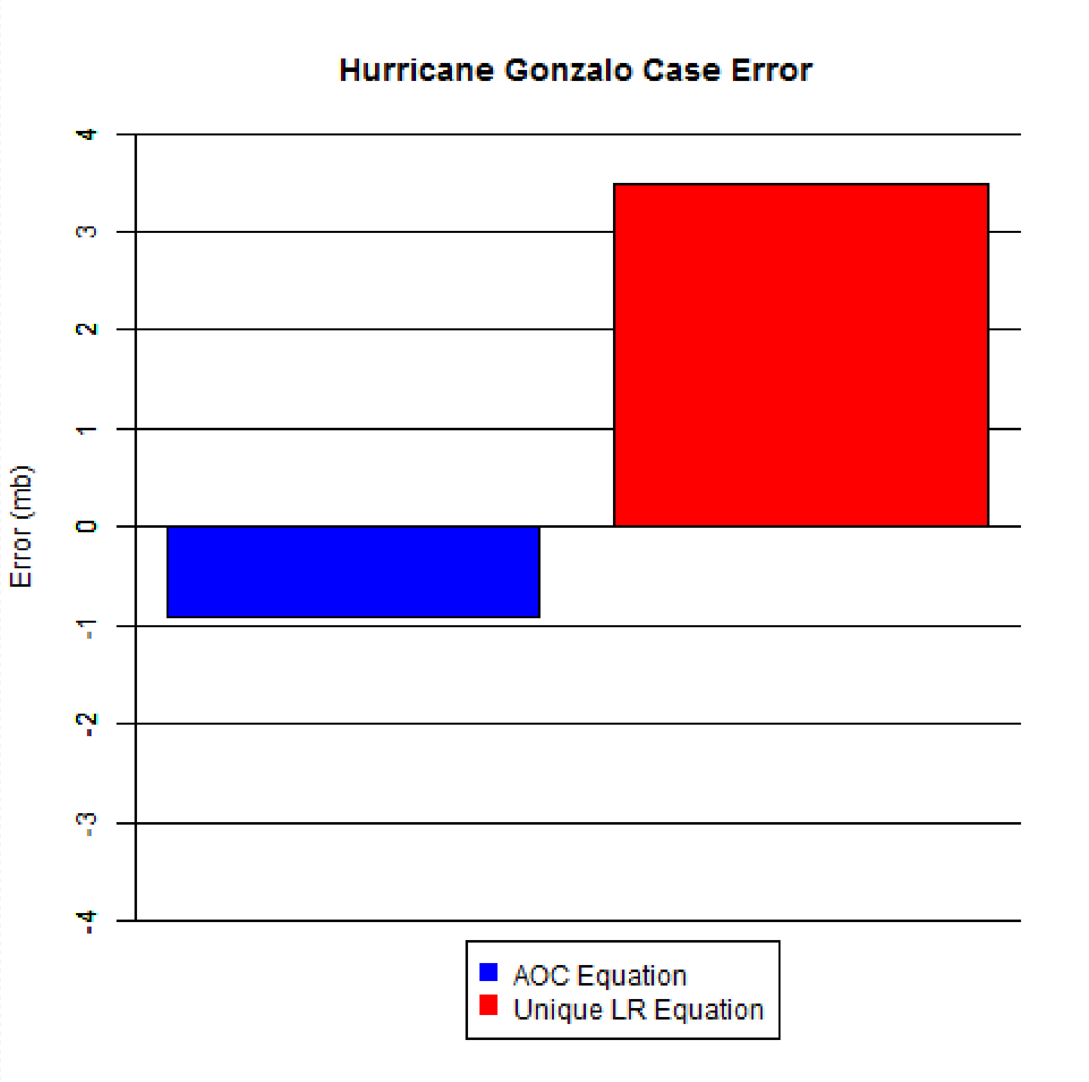
```
000
URNT15 KWBC 171432
NOAA3 1108A GONZALO             HDOB 35 20141017
142300 3011N 06618W 7231 02369 9477 +157 //// 034015 017 034 004 05
142330 3009N 06616W 7226 02373 9471 +160 //// 345010 014 026 006 05
142400 3009N 06614W 7229 02369 9464 +167 +165 272010 012 026 003 03
142430 3009N 06612W 7230 02366 9468 +160 //// 223015 016 024 003 05
142500 3007N 06612W 7226 02372 9467 +162 //// 239015 016 /// /// 05
142530 3006N 06614W 7233 02368 9469 +164 //// 268017 018 028 001 05
142600 3006N 06616W 7228 02372 9472 +160 //// 299015 016 031 000 01
142630 3006N 06618W 7228 02372 9476 +159 //// 323018 020 032 002 01
142700 3006N 06620W 7227 02385 9484 +161 //// 331028 031 034 001 01
142730 3006N 06623W 7211 02414 9494 +160 //// 326036 039 037 003 01
142800 3006N 06625W 7268 02355 9496 +174 +152 338048 051 049 002 00
142830 3006N 06627W 7276 02361 9511 +176 +154 340066 071 064 006 00
142900 3006N 06629W 7300 02348 9521 +188 +153 345084 087 077 010 00
142930 3006N 06631W 7320 02350 9555 +180 +141 344092 093 078 012 00
143000 3006N 06633W 7314 02382 9583 +179 +133 345090 092 070 008 00
143030 3006N 06635W 7326 02390 9615 +170 +134 344087 087 068 004 00
143100 3006N 06637W 7341 02398 9661 +148 +135 347084 086 064 005 00
143130 3006N 06639W 7356 02398 9684 +148 +131 349080 082 062 004 00
143200 3006N 06641W 7387 02379 9699 +153 +131 347076 078 062 004 00
143230 3007N 06643W 7402 02376 9718 +152 +133 346071 073 062 007 00
```

Sample Case: Hurricane Gonzalo

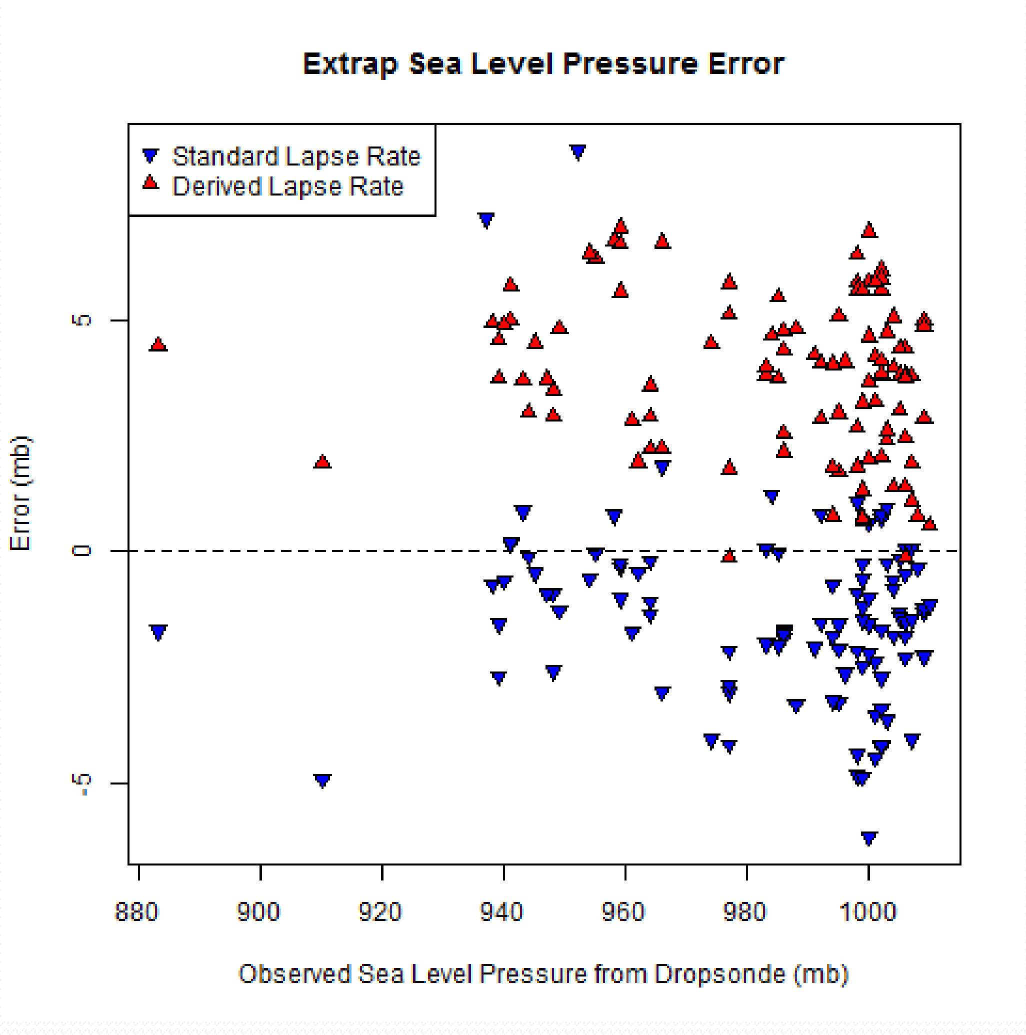
StaticPres	GeoAlt	AirTemp	DewPt	SLP	Tsurf	Storm	AirCraft	CenterID
722.9	2369	16.7	16.5	948	25.8	GONZALO	NOAA3	16



First Attempt at Improvement

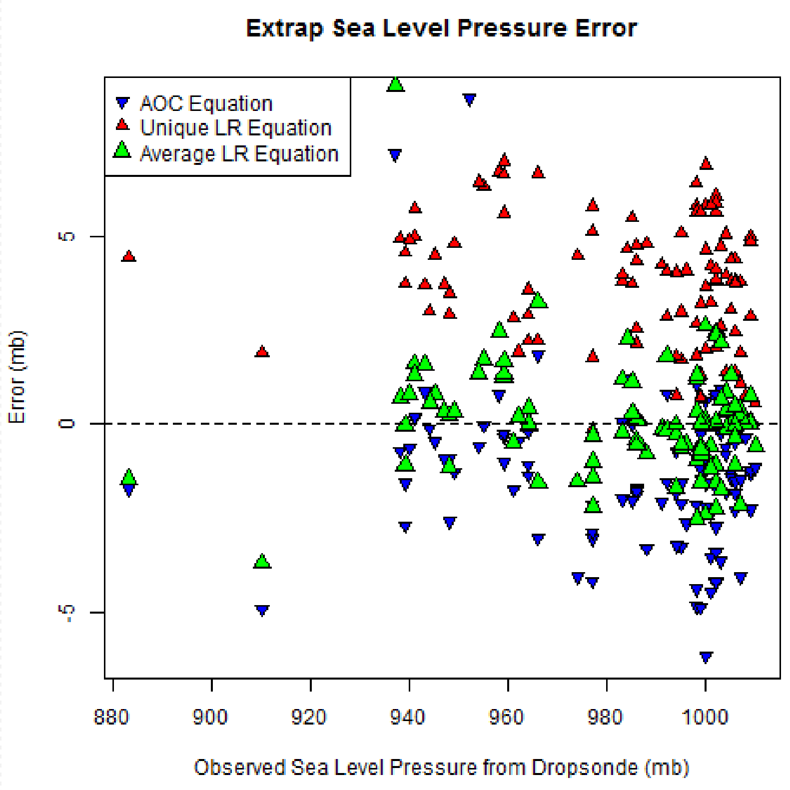


Systematically Over/Underestimating



Finding the Middle

- Calculate new average lapse rate
- New Lapse Rate = $\frac{(Unique\ Lapse\ Rate + Standard\ Lapse\ Rate)}{2}$
- Plug new Lapse Rate back into equation
- Results brought us closer to ground truth

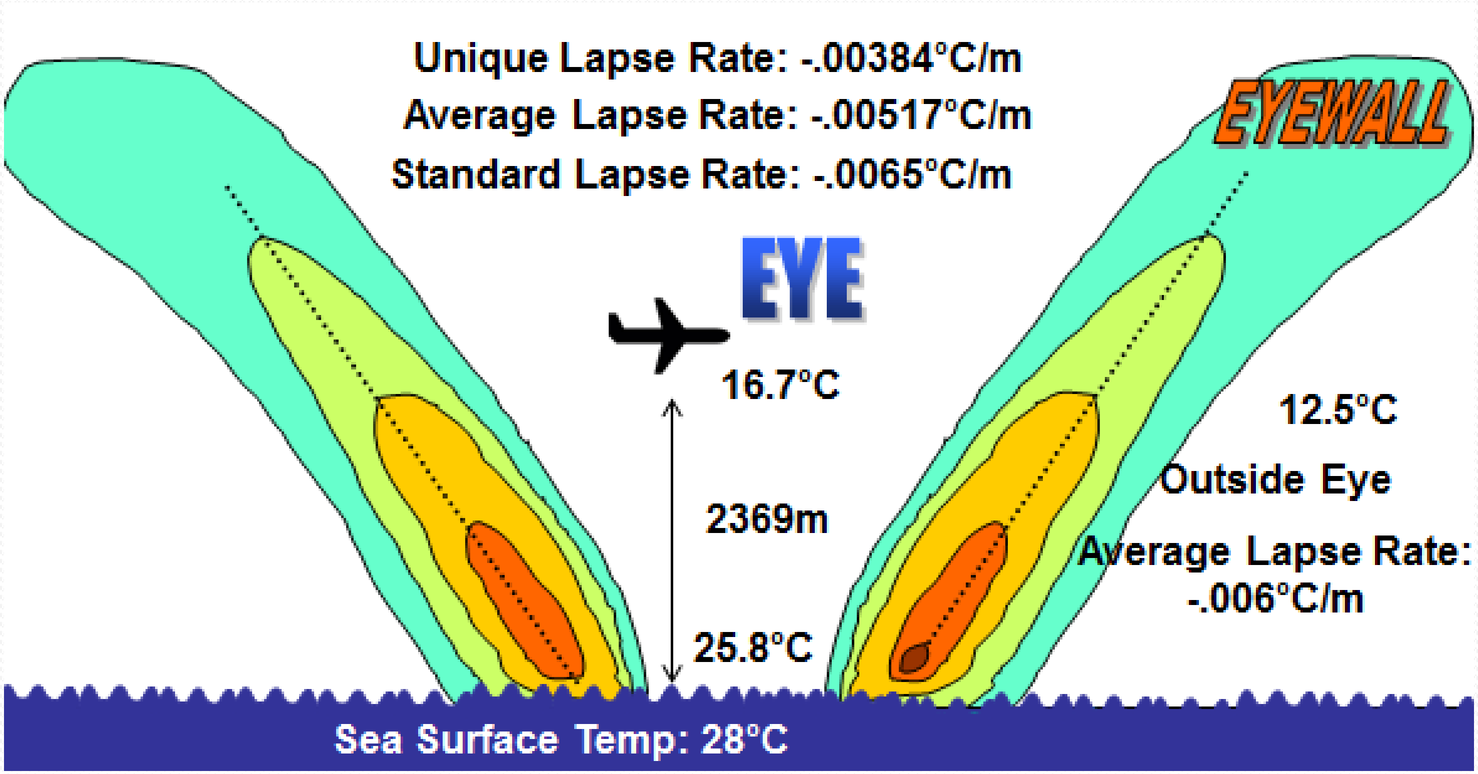


Possible Sources of Error

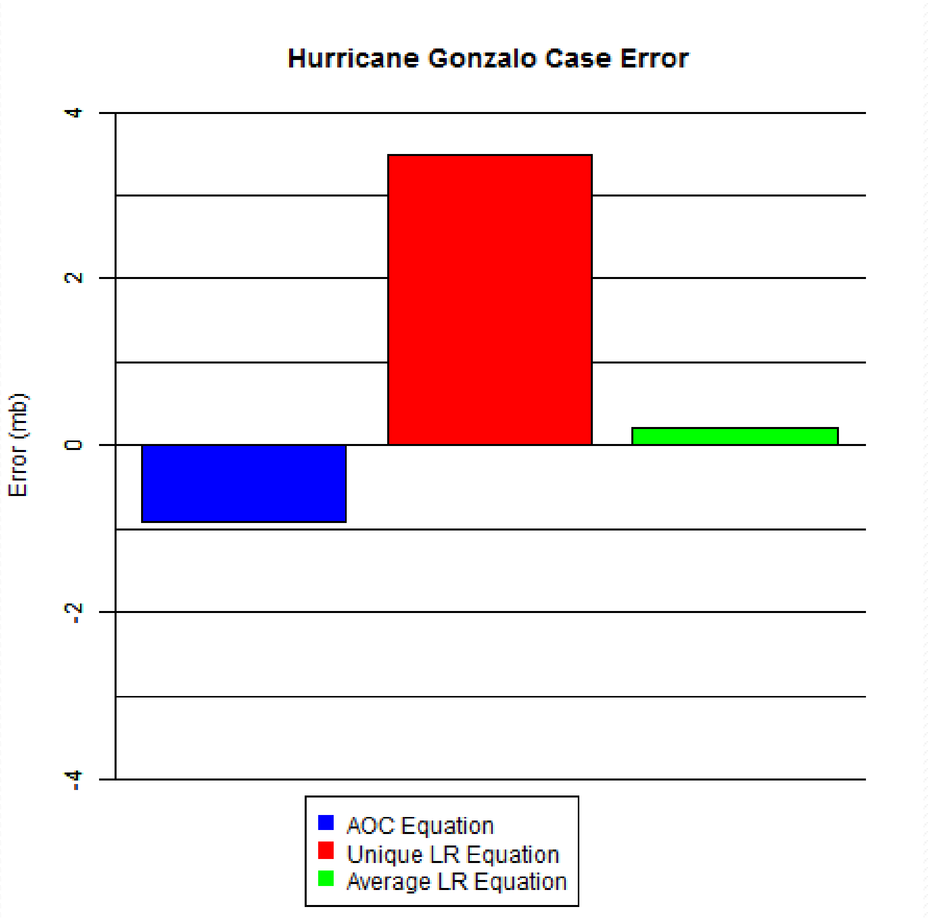
- Dropsonde does not always fall directly through column extrapolation was made from
- Sea Surface Temperatures are higher than the last sonde measured air temperatures
  - The calculated lapse rate does not account for that difference in temperature
  - Averaging it with the standard lapse rate brings it closer to ground truth

Adjusted Lapse Rate

- Sea Surface Temperature must be accounted for

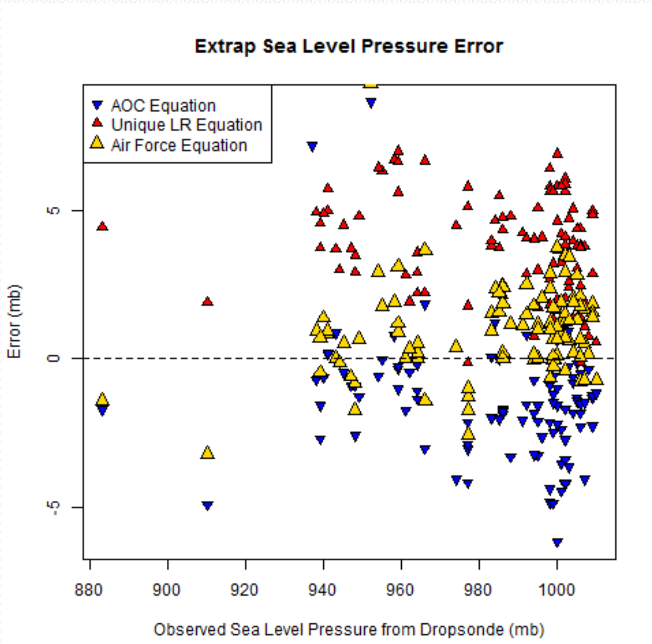


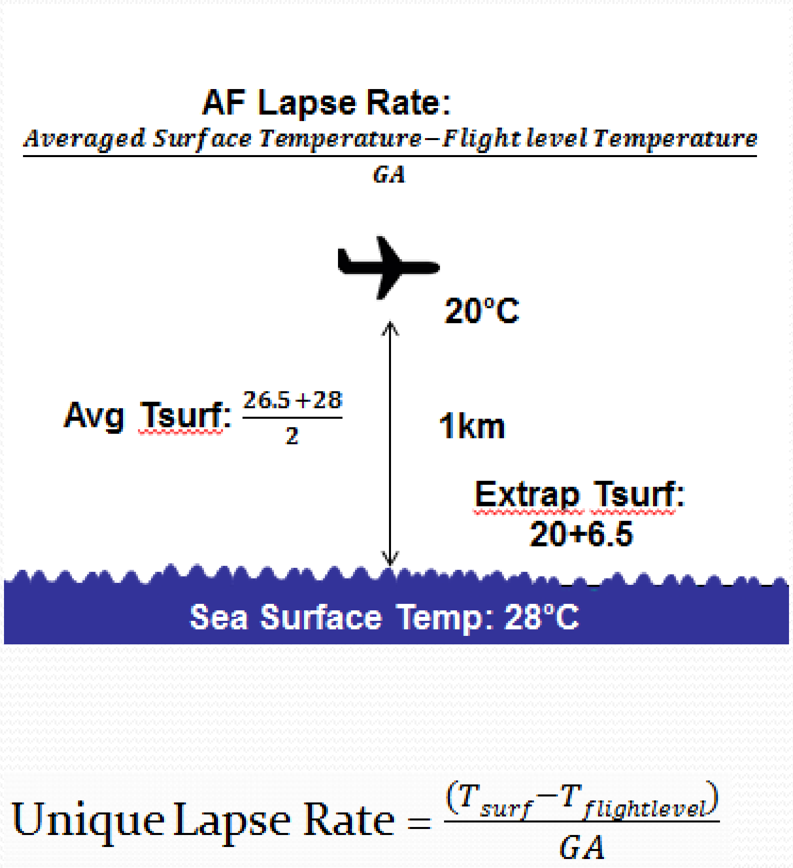
Average Lapse Rate Improvement



The Air Force Equation

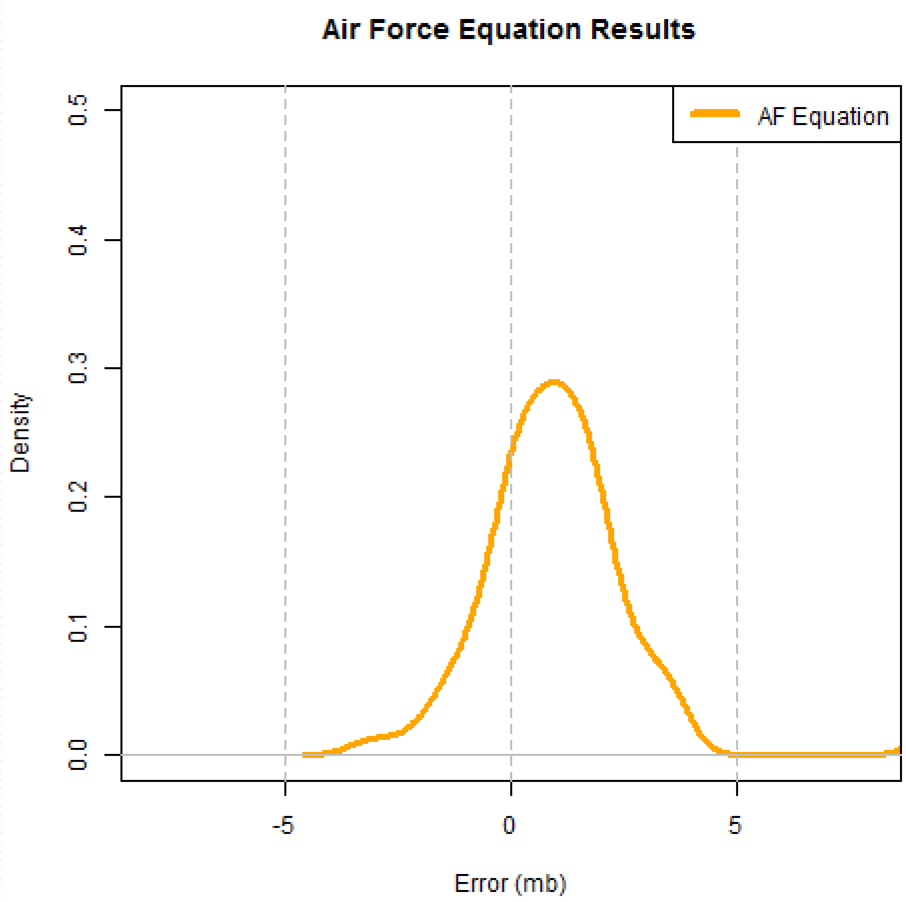
- The AF equation also creates a unique lapse rate for each storm
  - Slightly different method



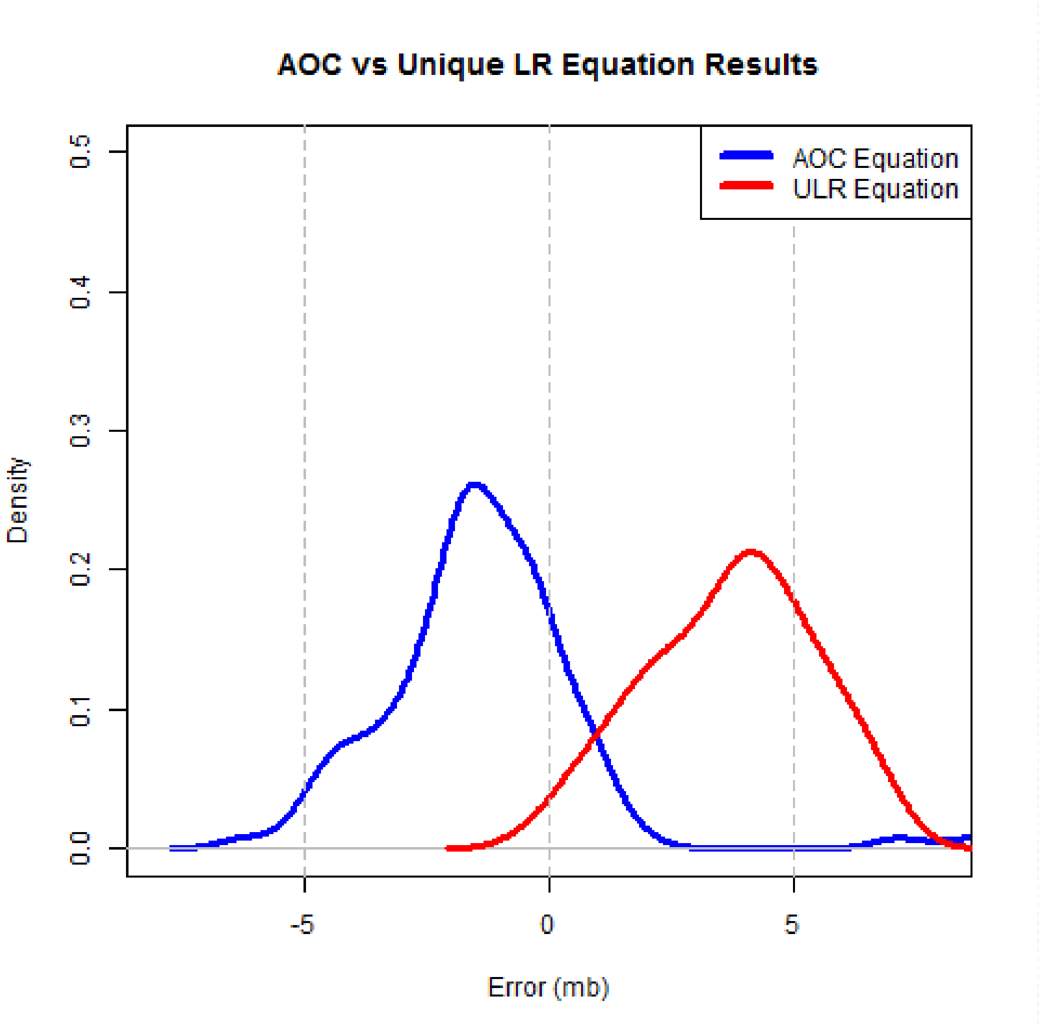


Results

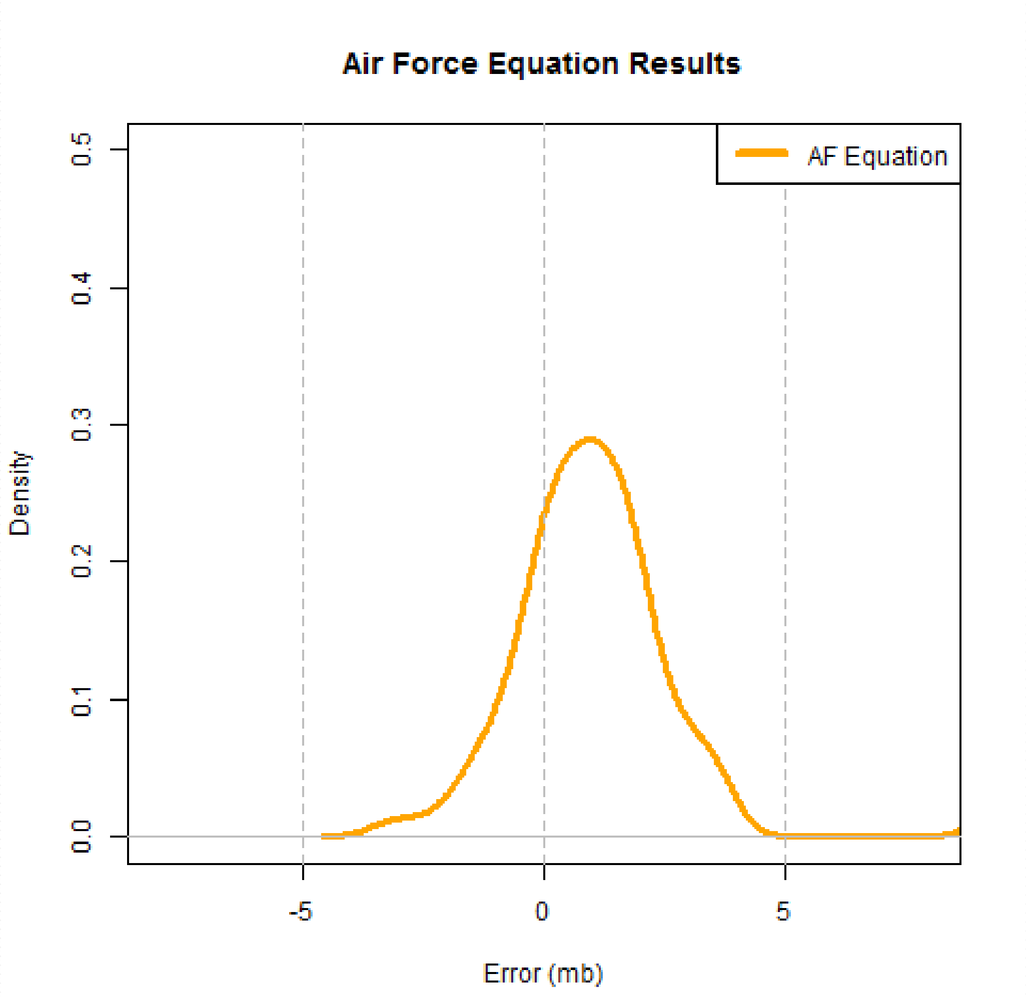
- A smoothed density plot line was added for the resulting errors of all of the equations.
- This allows them to be plotted together showing their differences in **accuracy** and **precision**



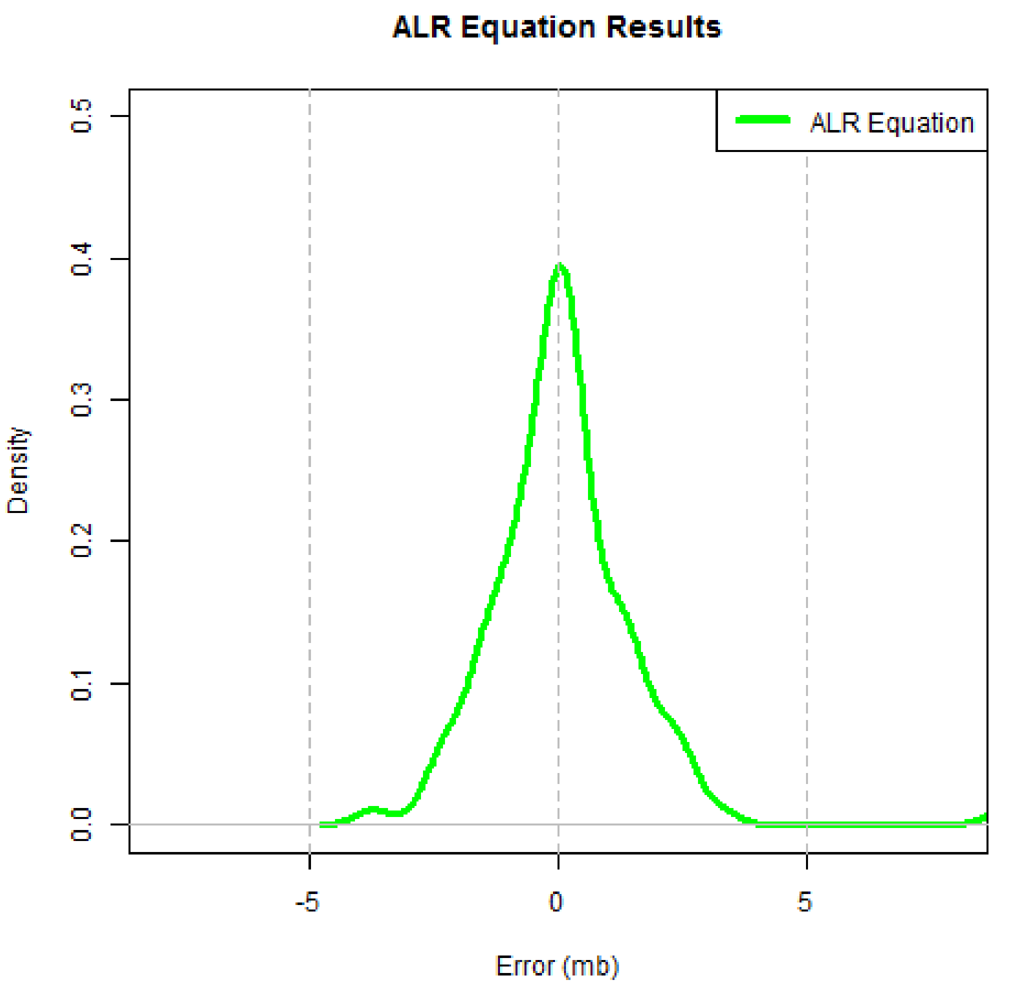
Original AOC Equation and Derived Lapse Rate Equation



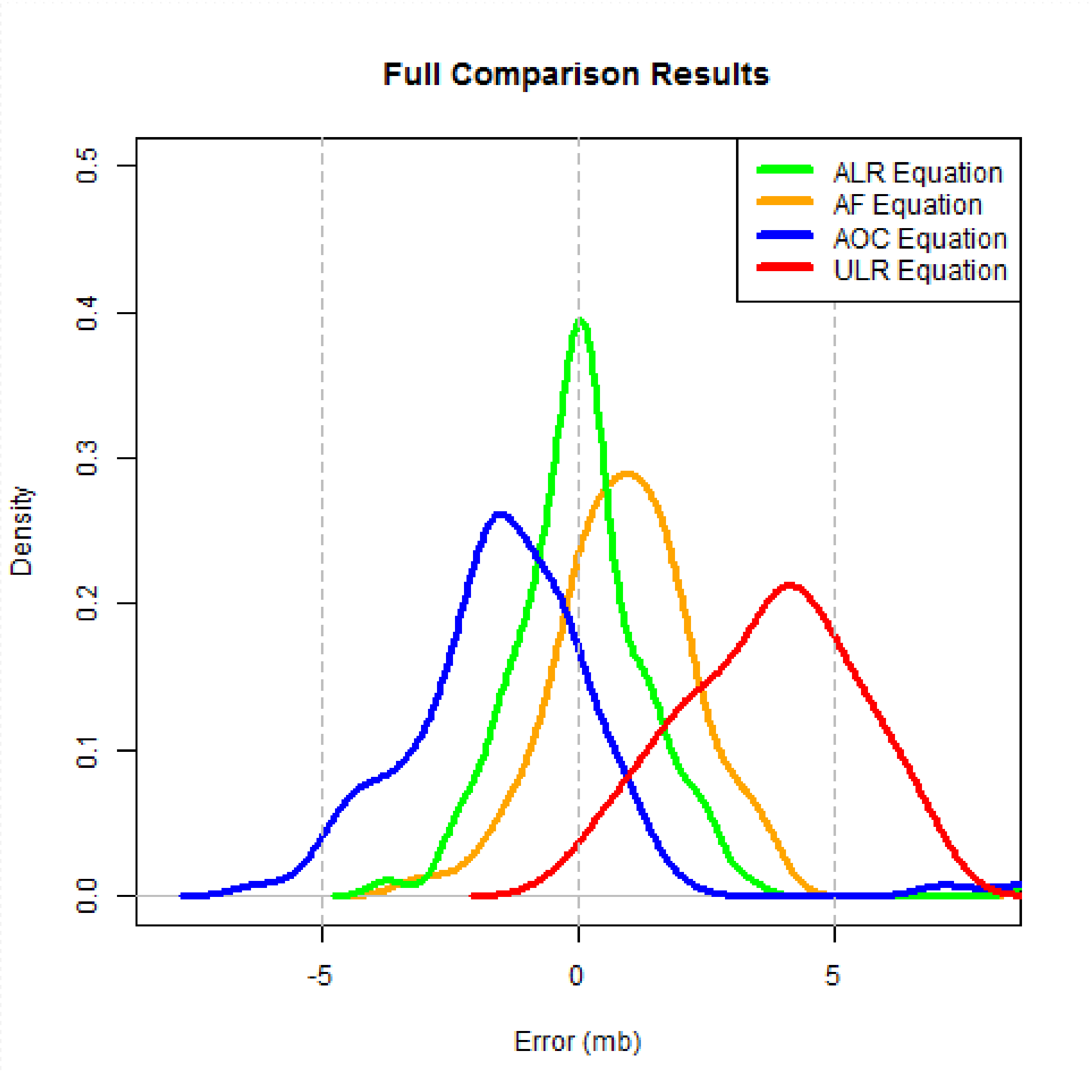
Air Force Results



Average Lapse Rate Results



All Methods Compared



Conclusions

- In our 104 case experiment, the Average Lapse Rate calculation outperformed all others
- If additional data show the current equation being less accurate, updating the equation would be valuable

Further Research

- Expanding the data set is important to solidifying these findings
- Creating consistency between the Air Force and NOAA would be challenging but valuable
- Exploring a weighted average technique
- Examine if Air Force or Average Lapse Rate equations out-perform each other at different pressure ranges

Questions