Sea Level Pressure Extrapolation Experiment

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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?
Hurricane Lapse Rate

- The lapse rate is a change in temperature with altitude.
- The Standard Lapse rate is \(-6.5^\circ C\) 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 \(-2.5^\circ C\) per km.
The AOC Equation for Extrapolated Sea Level Pressure

- \( SLP = 1013.25 \left[ 1 - \frac{(PA - GA \frac{288.15 - \Gamma_{std} \times PA}{Tv})}{288.15 - \frac{\Gamma_{std}}{\Gamma_{std}}} \right] \frac{g}{\Gamma_{std} \times Rd} \)

- \( PA = \frac{288.15}{\Gamma_{std}} \left[ 1 - \left( \frac{P_{stat}}{1013.25} \right) \frac{\Gamma_{std} \times Rd}{g} \right] \)

- 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 = \( \frac{(T_{surface} - T_{f_{lightlevel}})}{GA} \)

- 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
# High Density Observation (HDOB)

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Sample Case: Hurricane Gonzalo

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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

![Graph showing Hurricane Gonzalo Case Error]

- AOC Equation
- Unique LR Equation
- Average LR Equation
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 outperform each other at different pressure ranges
Questions