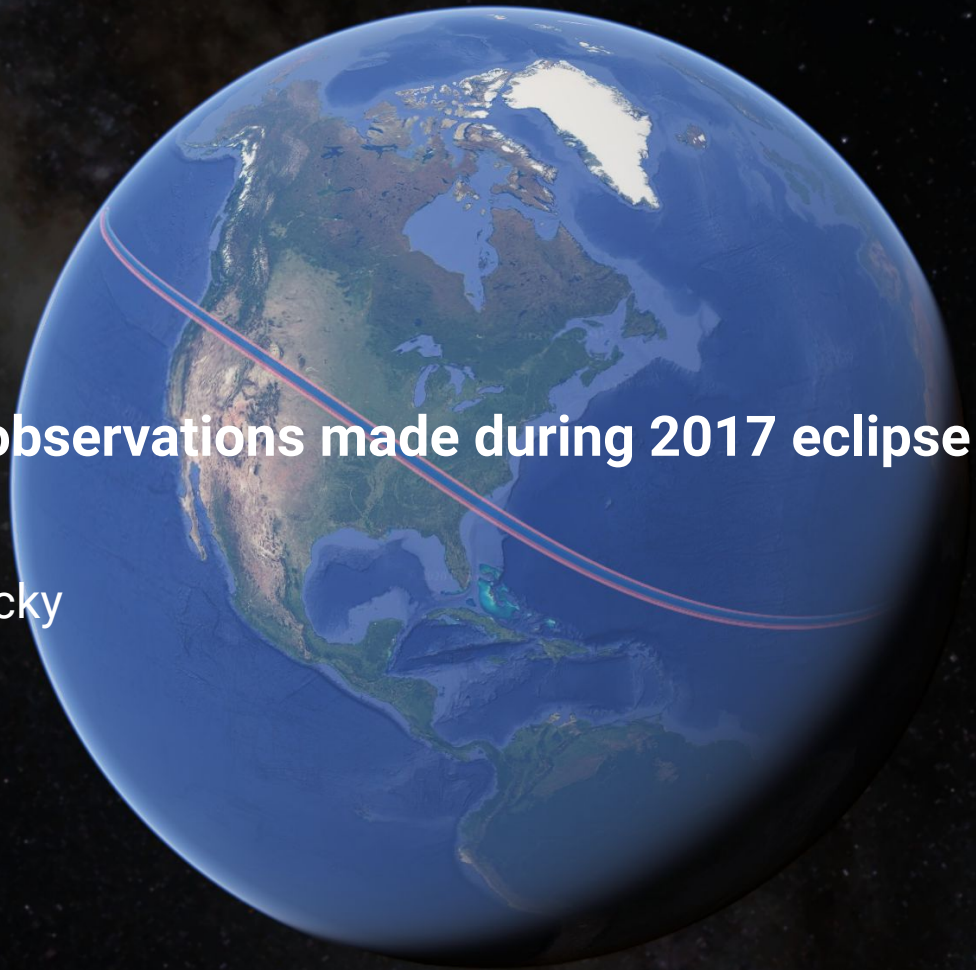
Comparing WRF model to observations made during 2017 eclipse

LABCOATS 2020 Mini-Con
Isaac Rowe, University of Kentucky



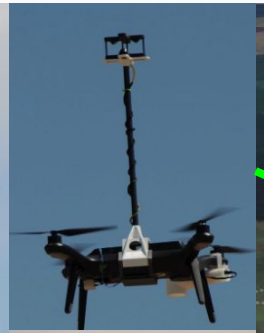
Outline

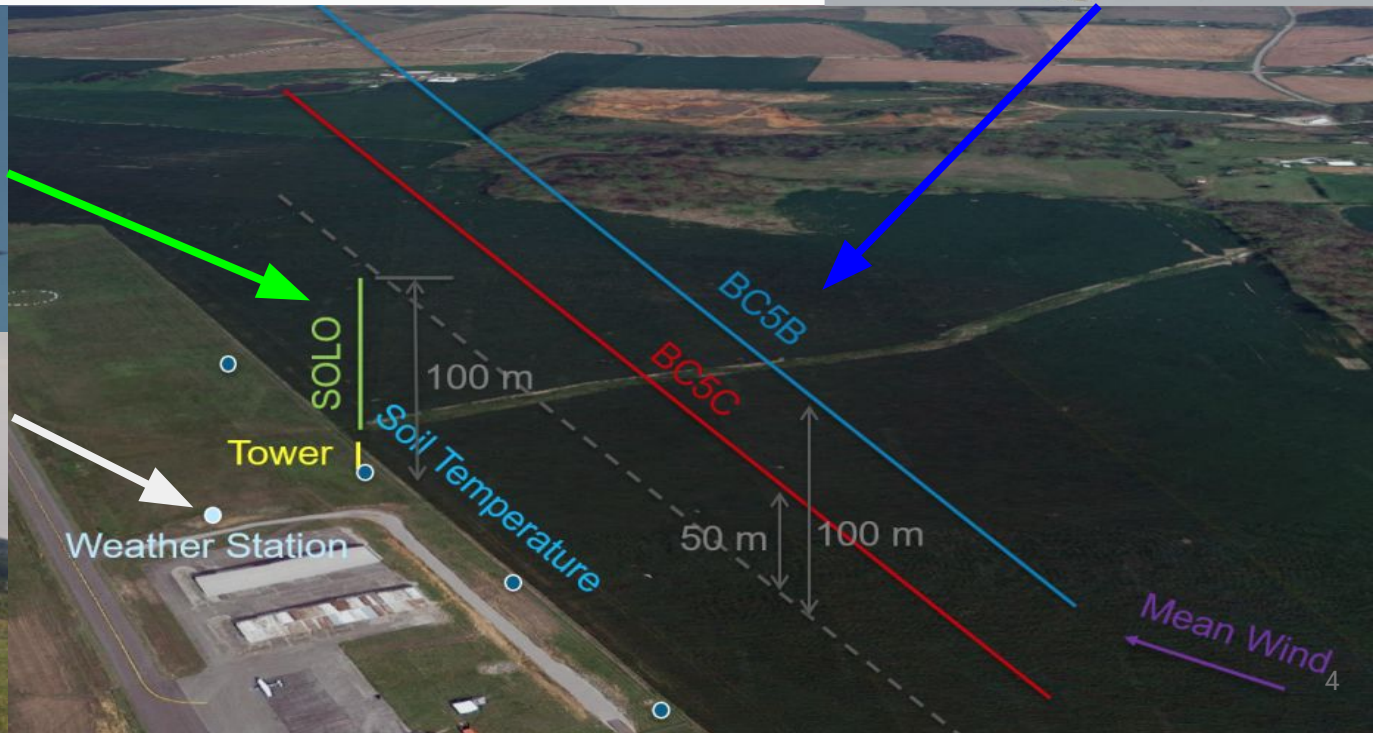
1. Overview of the 2017 eclipse
2. Installing WRF on an HPC system
3. Running the WRF simulation
4. Comparison of simulation to measurements
5. Conclusions and future work

2017 Eclipse from Russellville, KY: ~80 km from point of greatest eclipse

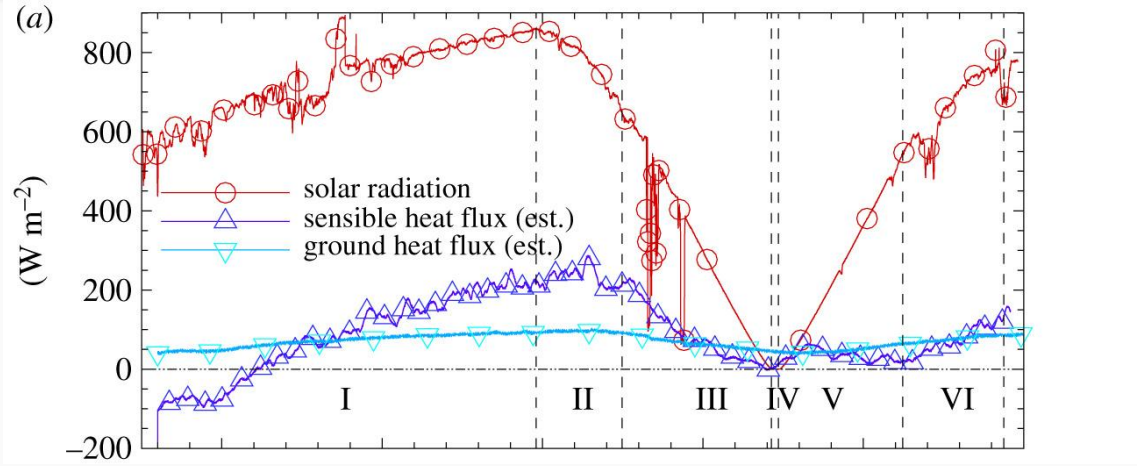
Observations from 2017 | Instruments

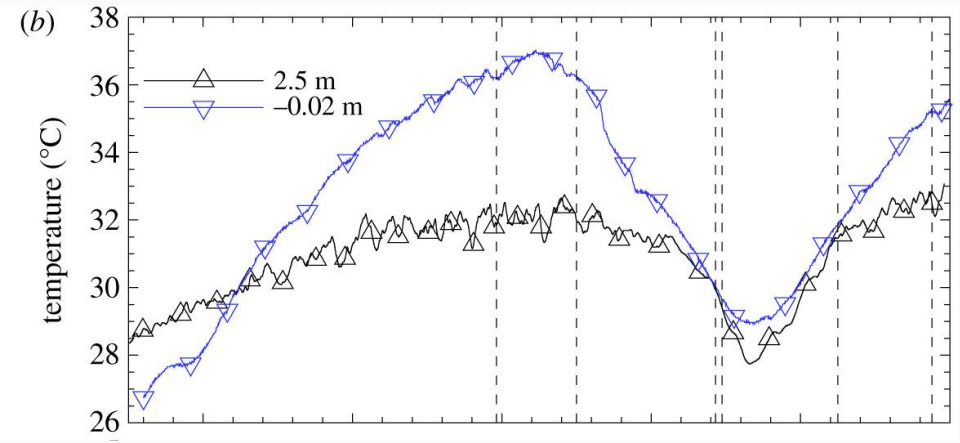
Measurements made with 5 types of systems:
fixed-wing UAVs, rotorcraft UAV, weather station, soil temperature sensors, sonic anemometer tower.

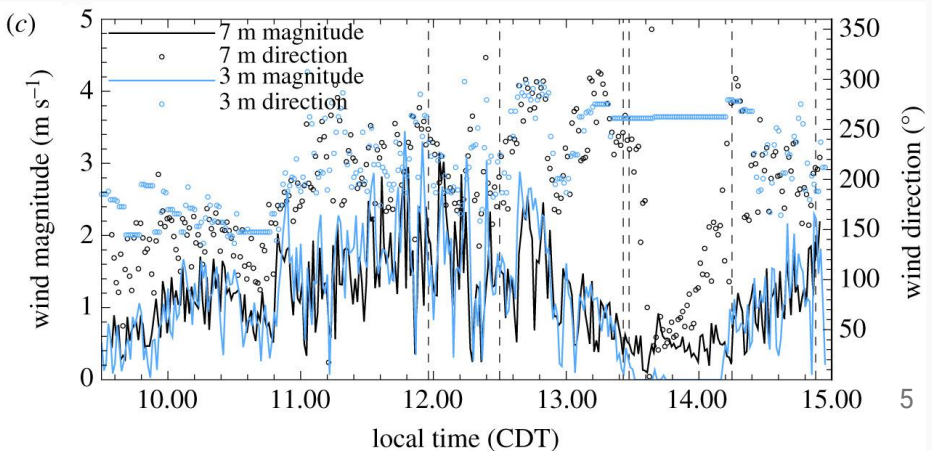




Observations from 2017 | Fixed Instruments

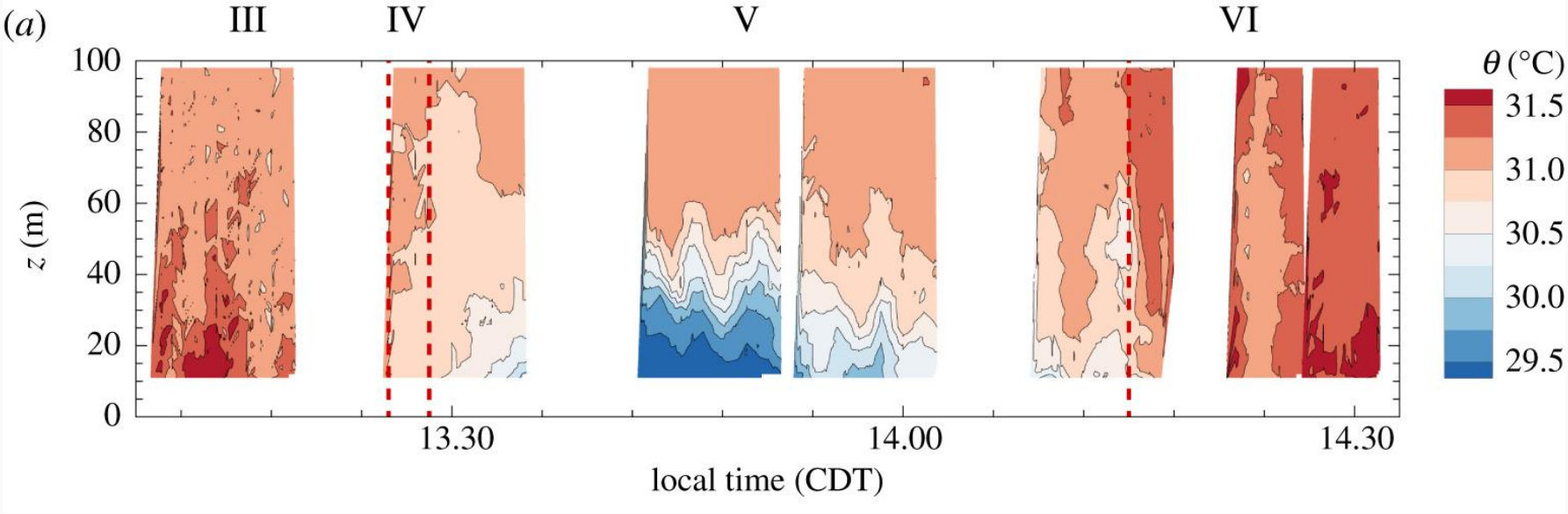






Observations from 2017 | Profile Data

Evidence of formation of Stable layer, Kelvin-Helmholtz waves, and nocturnal jet after totality.



Why do we need a high performance computer to run WRF?

Disk Space:
Terrestrial input data: 29 GB
Meteorological input data: 1.2 GB
Hi-Res output data for 1.4km^2 area: 15 GB

Processing:
102x102 gridded course domain
5 nested domains at 5x resolution, 1/5 timestep
18 hour simulation, 40 second coarse timestep

My Macbook with an dual-core processor: **Would consume 20% of entire hard drive, take approximately 17 days to complete!***

*Extremely rough estimate. Fact checks welcome.

Setting up WRF on an HPC System

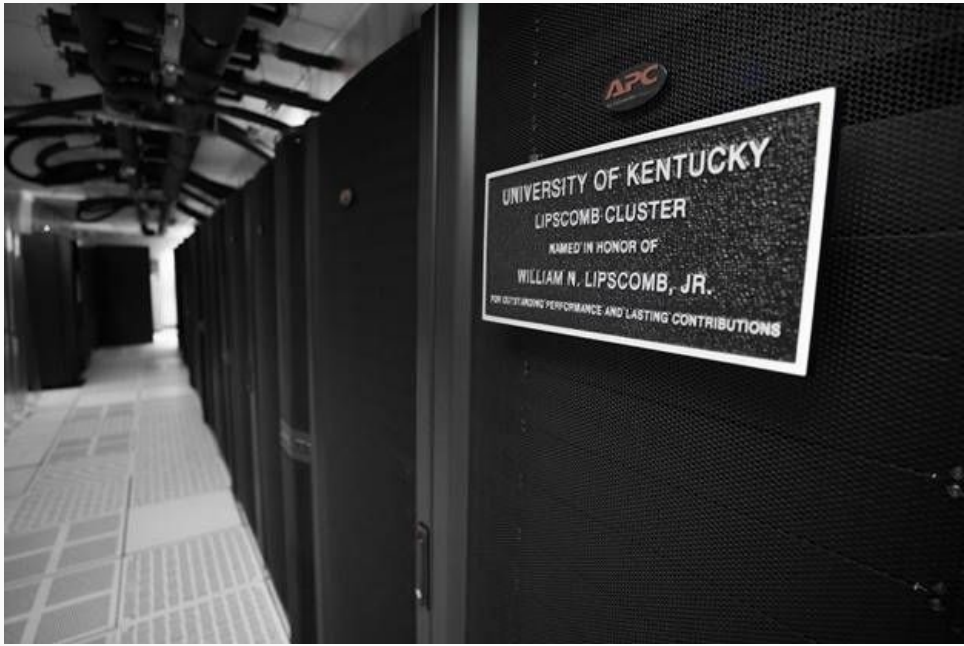
- Updated WRF-Eclipse source code from WRF 3.8 (2016) to WRF 4.2 (2020).
  - Merged changes from Montornès with more recent updates to radiation modelling.
- Built from source for distributed memory parallel execution.
- Discovered inconsistencies in published documentation.
  - Updates in how dependencies are distributed have broken build process.
  - Not readily compatible with modern HPC application management tools (ie, *lmod*).
  - *How bad is it?* EasyBuild's prime example #1 of hard-to-install scientific software is WRF.
- Created SLURM job scripts to automate data prep and simulation across many cores -now provided as examples to new users

HPC Software Milestone

The University of Kentucky Lipscomb Computing Cluster now has the following tools available for use:

- WRF 4.2
- NCL
- wrf-python

..as well as scripts for custom WRF builds (such as WRF-eclipse)



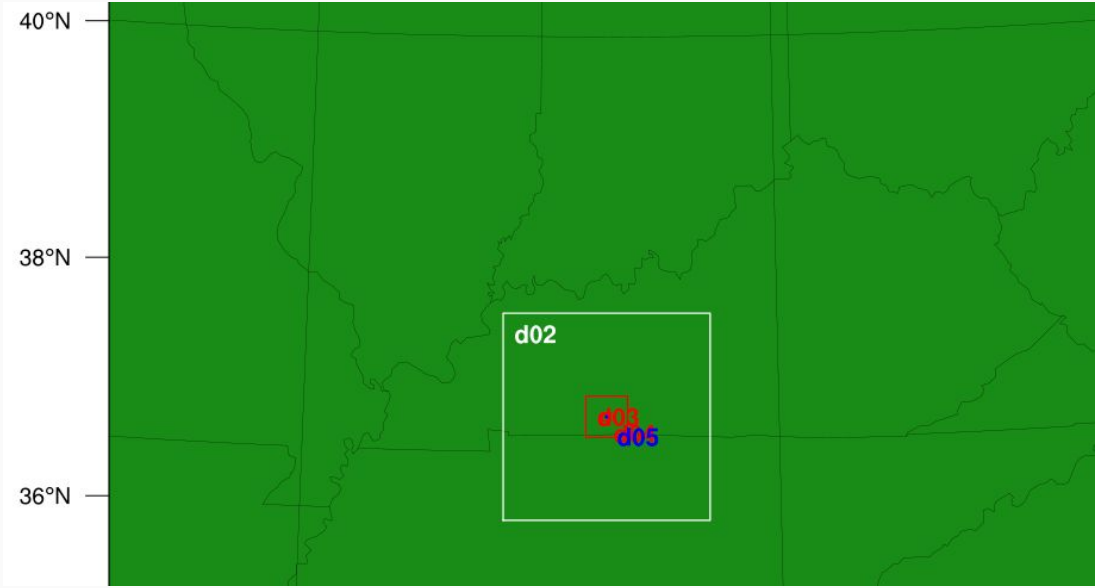
WRF Simulation

Input Data: NCEP GDAS/FNL 0.25 Degree

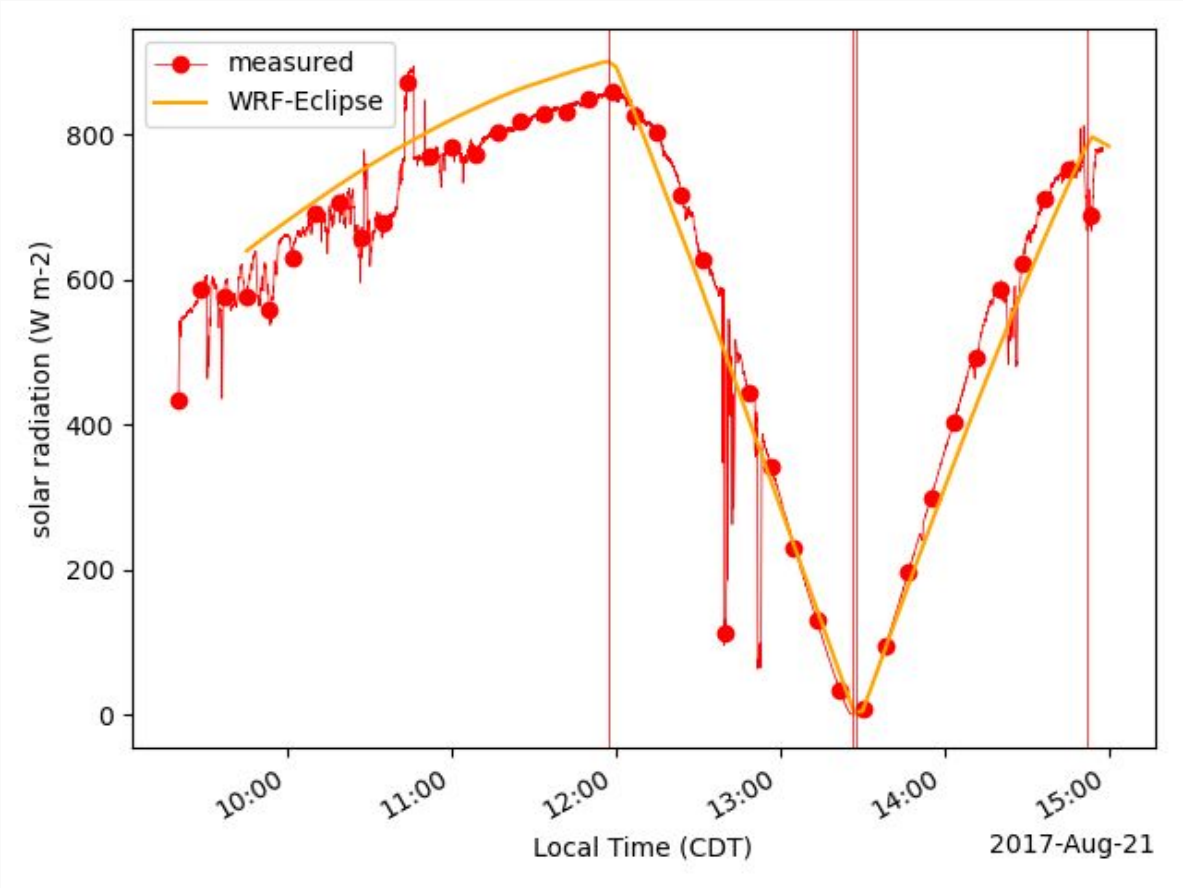
Fine domain: 14.4 m horizontal resolution, 50 vertical layers

Simulated from 1am - 7pm CDT for ~11 hours of spin-up

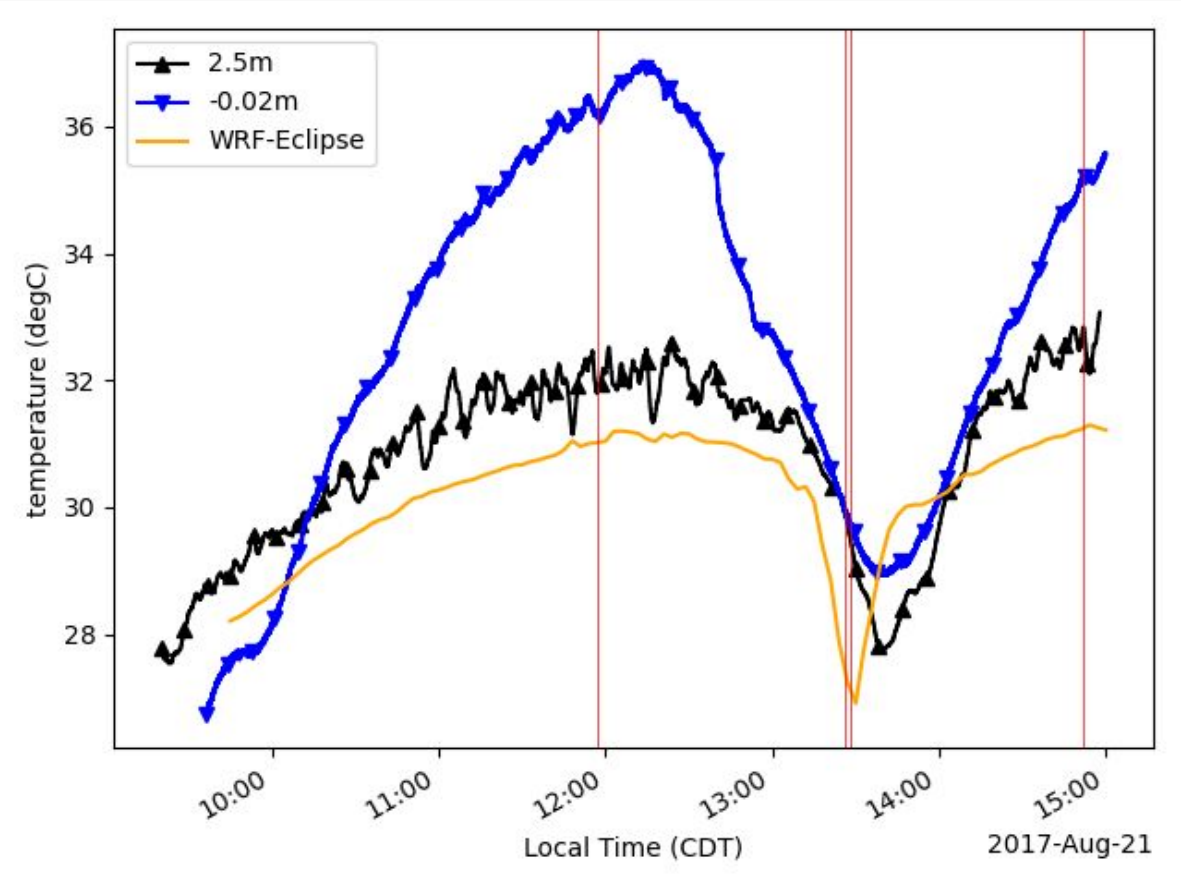
Physics options courtesy of C. Spangrude



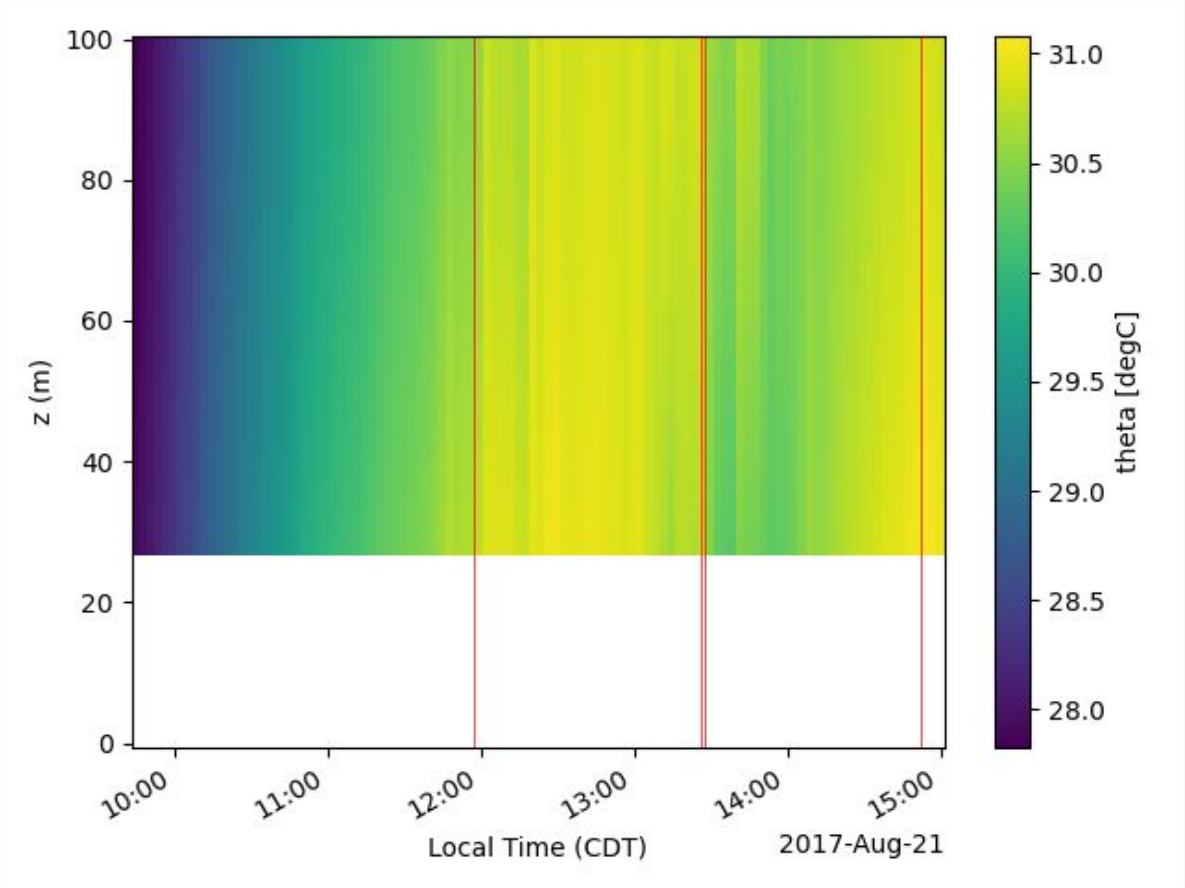
Results | Solar Radiation



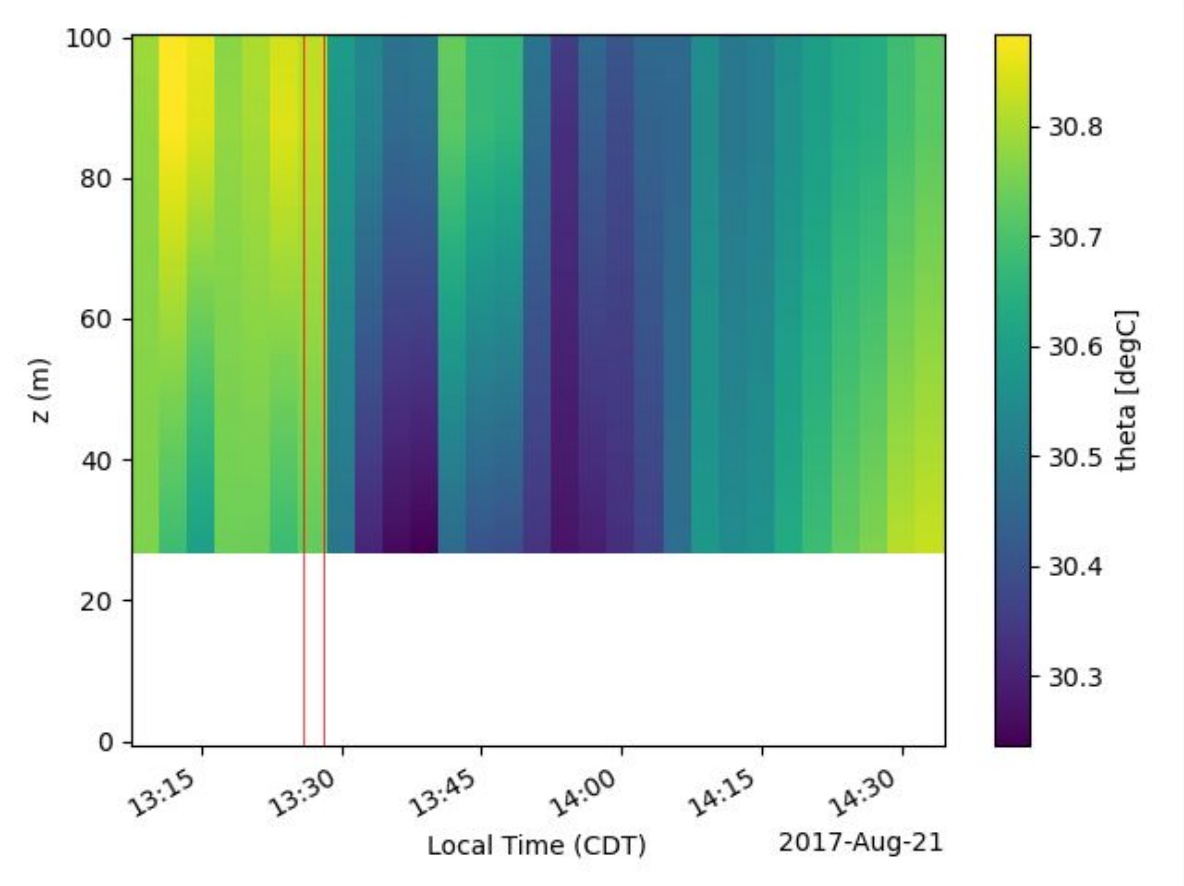
Results | Temperature



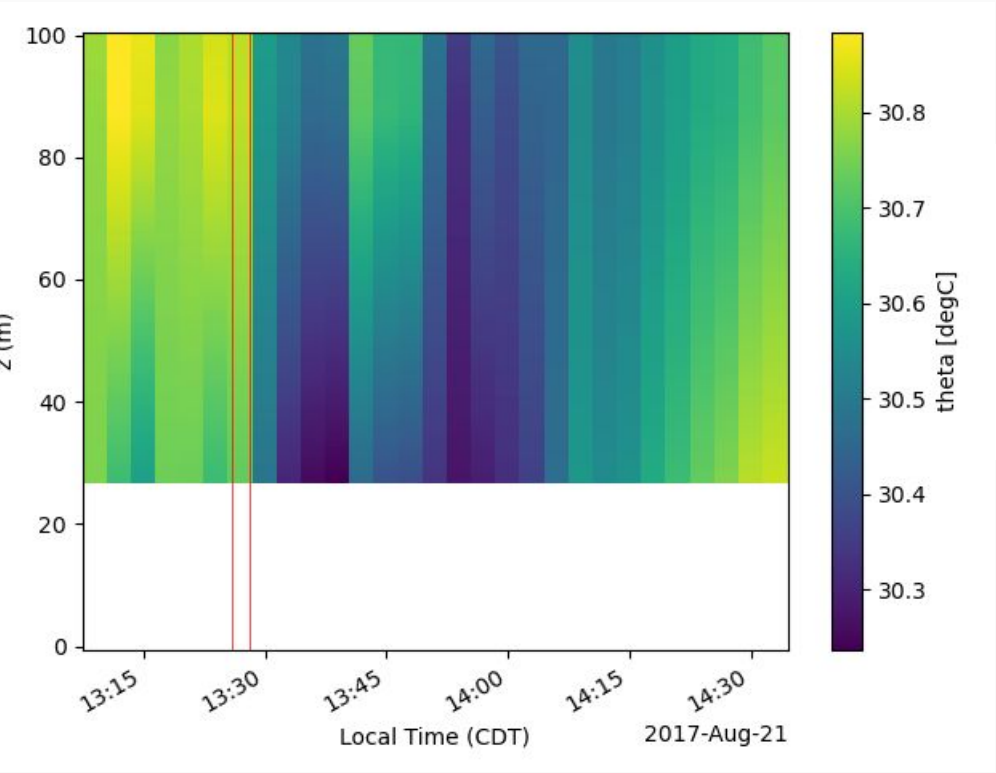
Results | Temperature Profile

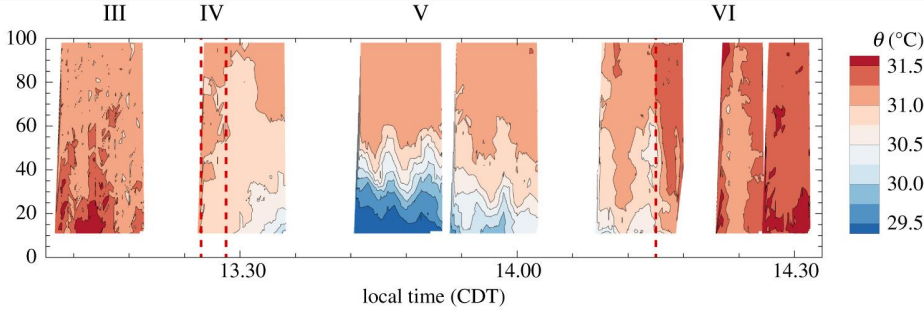


Results | Temperature Profile Inset



Results | Temperature Profile Comparison





Future work

- Apply WRF best practices to improve quality of simulation.
- More systematic study of physics options in WRF model to determine lack of vertical layering.
- Repeat simulation with more vertical layers for higher resolution and better interpolation near surface.
- Compare simulation with data gathered by fixed-wing UAV.
- Compare additional parameters, such as wind speed and direction.
- Investigate how to incorporate UAV and surface observations into WRF model with DART.
- Export WRF data to Tecplot for additional analysis.

Learn more

Scan the QR codes or visit the links for more background and data

Bailey 2019 Paper	Full paper data
Full WRF data	Plots
Montornès WRF-eclipse paper	Spangrude WRF-eclipse and 2019 Eclipse Poster

Credits

Special thanks to those who provided me with guidance and support:

- Dr. Sean Bailey
- Dr. Suzanne Smith
- Sujit Sinha
- Vikram Gazula
- Carl Spangrude

Citations

Eclipse Imagery: NASA https://eclipse2017.nasa.gov/static/img/eclipse-maps/ky_full.jpg

Original Papers:

Bailey Sean C. C., Canter Caleb A., Sama Michael P., Houston Adam L. and Smith Suzanne Weaver. 2019 Unmanned aerial vehicles reveal the impact of a total solar eclipse on the atmospheric surface layer. *Proc. R. Soc. A*. **475:** 20190212 https://doi.org/10.1098/rspa.2019.0212

WRF-Eclipse Paper:

Montornès, A., Codina, B., Zack, J. W., and Sola, Y.: Implementation of Bessel's method for solar eclipses prediction in the WRF-ARW model, *Atmos. Chem. Phys.*, 16, 5949–5967, https://doi.org/10.5194/acp-16-5949-2016, 2016.

Citations

WRF-eclipse vs. 2019 eclipse:

Carl Spangrude, Deborah Ross, Jennifer Fowler, Thomas Colligan & Jaxen Godfrey (2019), Validating the WRF Montornès et al. Eclipse Module With The July 2, 2019 Total Solar Eclipse [A31M-2886]. Presented at 2019 Fall Meeting, AGU, San Francisco, CA, 9-13 Dec.

Computer fire image:

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