SA33B-2004

Extending the Purple Crow Lidar Temperature Climatology Above 100 km Altitude Using an Inversion Approach

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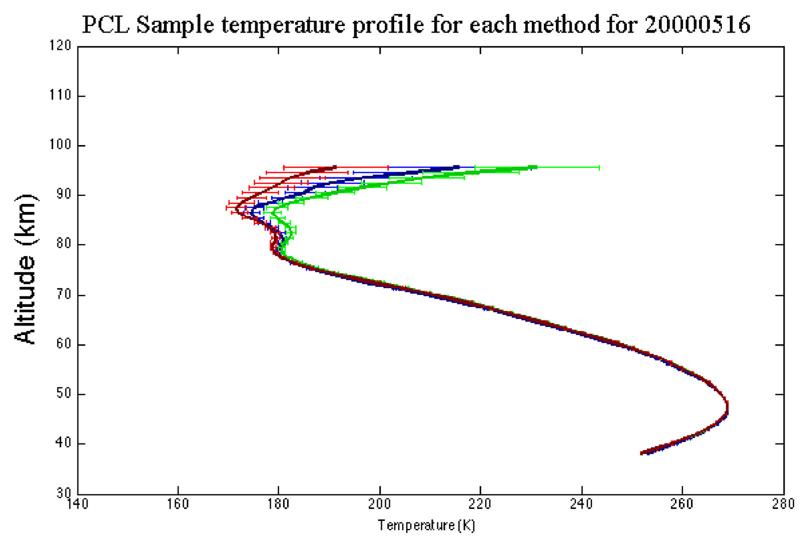
Temperature retrievals methods

- Chanin and Hauchecorne algorithm (CH method)
  - Uses the Ideal Gas Law with the assumption of hydrostatic equilibrium, with integration from the top to the bottom.
  - Integration requires the assumption of a pressure at the top altitude (pressure seeding).
  - Deficiency: Top 10 to 15 km of temperature profiles need to be rejected due to uncertainties in the pressure assumption.
- Inversion approch of Khanna et al.*
  - Uses grid search optimization to find temperatures. Still requires integration of a density profile.
  - Advantage: Using seed pressure at bottom so temperatures at the greatest altitudes are relatively insensitive to the choice of bottom seed pressure.

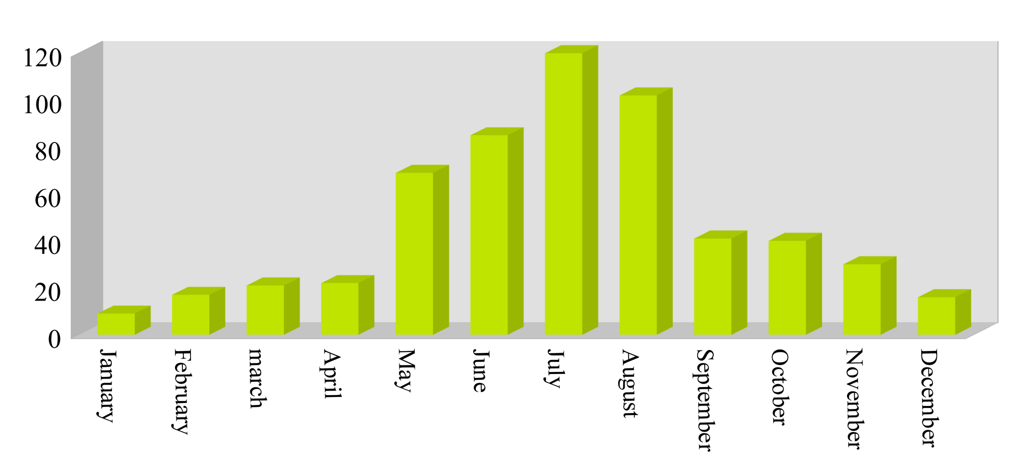
Red line: CH method with pressure assumption
Green line: CH method with temperature assumption
Blue line: Inversion method



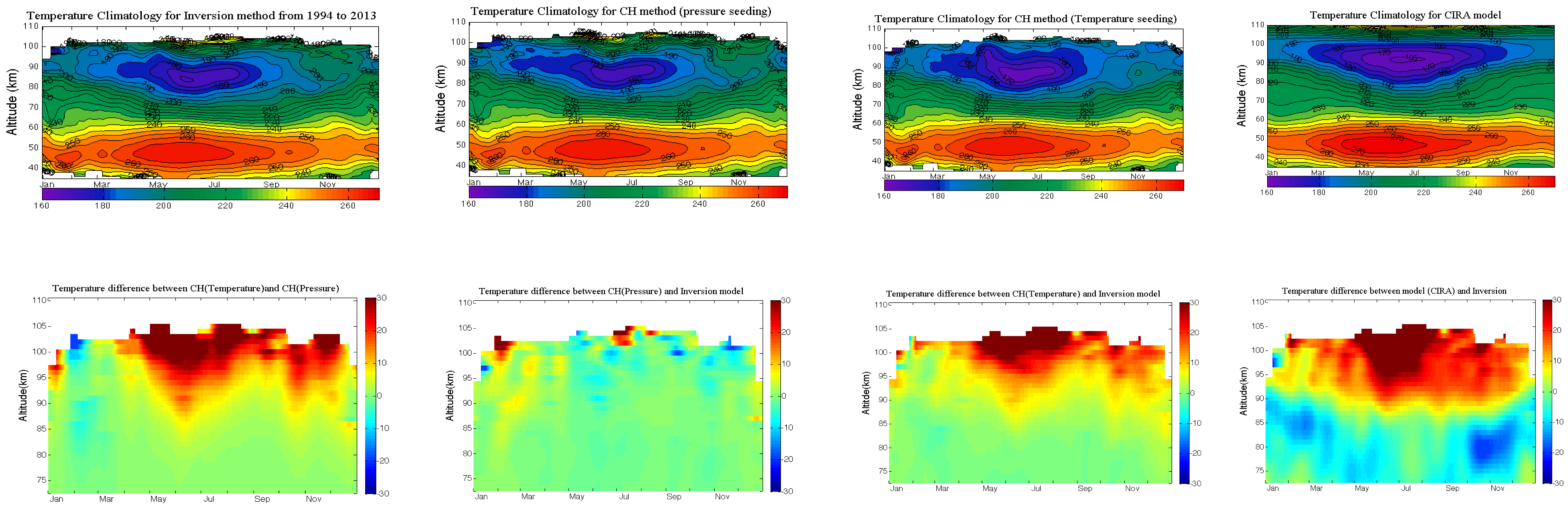
Available Measurements

This climatology is based on Rayleigh-scatter temperature measurements made by the Purple Crow Lidar (PCL) research facility during the period from 1994 to 2013. Until 2010 the PCL was located near The University of Western Ontario at the Delaware Observatory; in 2010 it was moved about 25 km northeast to Western's Environmental Research Station (aka Echo Base).

Number of nights used to form temperature climatology
Total number of nights: 572



Results: Climatology by CH and Inversion methods and CIRA model



Methodology

Argall and Sica (2007)** used the CH method to produce a climatology of the Purple Crow Lidar measurements from 1994 to 2004. Their methodology is used for this climatology. Nightly averaged measurements are used that satisfy the following conditions.

- Signal-to-noise ratio grater than 2.
- The temperature profile exists to at least 95 km.
- The statistical uncertainty is less than 25 K at the greatest altitudes.
- The vertical resolution of the unsmoothed measurements is 1008 m. The temperature profiles are then smoothed with a low-pass filter.

References

*Khanna, J., J. Bandoro, R. J. Sica, and C. T. McElroy (2012), New technique for retrieval of atmospheric temperature profiles from Rayleigh-scatter lidar measurements using nonlinear inversion, Appl. Opt., 51(33), 7945â€“7952, doi:10.1364/AO.51.007945.

**Argall, P. S., and R. J. Sica (2007), A comparison of Rayleigh and sodium lidar temperature climatologies, Ann. Geophys., 25(1), 27–35.

Summary

1. The requirement for a seed pressure at the top of the atmosphere introduces a systematic uncertainty in the mesosphere and lower thermosphere of 10's of degrees.
2. No independent measurements exist on a routine basis to constrain the choice of upper seed pressure.
3. Integrating from the bottom of the profile more highly constrains the choice of seed pressure (as the geophysical variability is lower in the stratosphere than the thermosphere), in addition to allowing the possibility of using pressure measurements from routine radiosonde flights.
4. The CIRA-86 model is too warm above 90 km and too cold between 75 to 90 km compared to the measurements.
5. The results using the inversion approach show for this case study using the pressure from the CIRA model with the CH method is closer to the actual temperature then using the temperature from the CIRA model.

We are continuing to work on improving the temperature retrieval algorithm using an inversion approach.

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Thanks to the CREATE, NSERC and university of Western Ontario for support and providing the funds and research facility for this research.