Retrieving Decadal Trends from CLARREO IR Radiance Spectra – A Climate Model 100-year Simulation

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CLARREO Science Definition Team Meeting

University of Michigan

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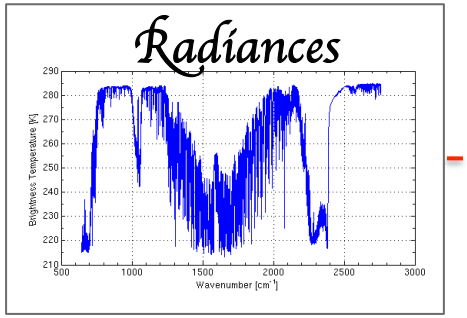
SSEC

CLARREO "Dual-Regression" Retrieval Algorithm*



Global clear soundings

Radiances (clear FM)

Clear-trained regression coefficients

Global cloudy soundings

Radiances (cloudy FM)
Cloud height classes

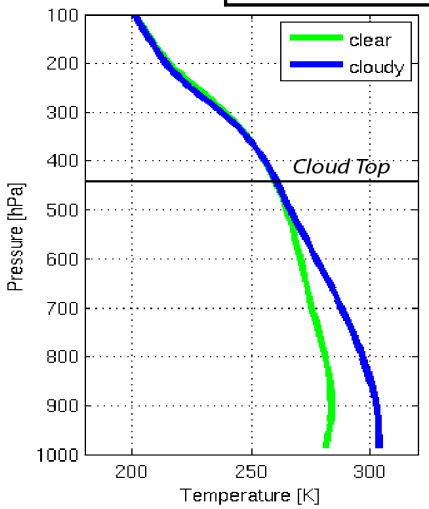
Cloud-trained regression coefficients

Theoretical Statistics

Radiance Observations

Clear-trained EOF regression retrieval

Cloud-trained EOF regression retrieval



Cloud Top Altitude
Level where $T_{cloudy} > T_{clear}$ for $p > p_{cld}$

Final Profile
Clear-trained above and cloud-trained Cloud Top

Temperature, Humidity and Ozone profiles, Surface and Cloud parameter at single FOV (0-2-km) resolution

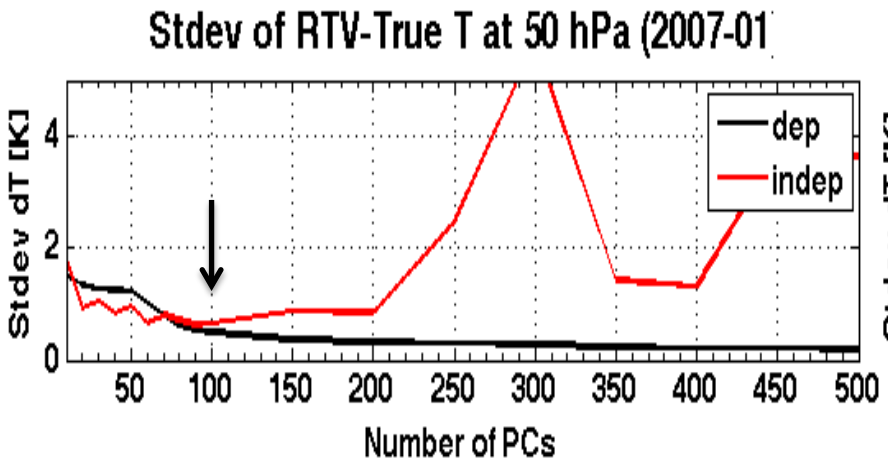
* Smith, W. L., E. Weisz, S. Kirev, D. K. Zhou, Z. Li, and E. E. Borbas (2012), Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances. *J. Appl. Meteor. Clim., 51*, Issue 8, 1455-1476.

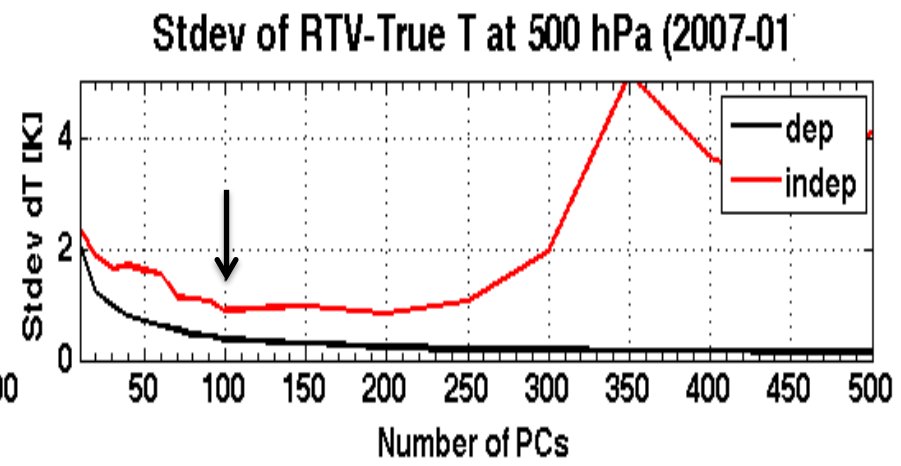
How Well Can We Retrieve Decadal Trends ?

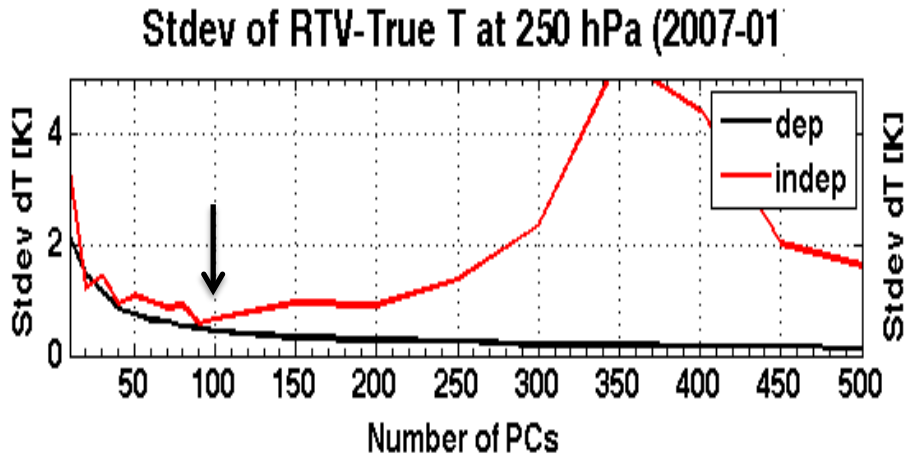
- **Use CCSM Climate Model 100-yr CO_2 Doubling OSSE***
- **Simulate CLARREO Radiance Spectra from Model Output**
  - Monthly Mean Atmospheric Profiles and Cloud and Surface Parameters for ~1.5 Deg. Grid from CCSM
  - PCRTM Produced Radiance Spectra
- **Perform DR Retrievals From Monthly Average CCSM Grid Point Radiances**
  - Clear Sky First (Results shown here)
  - All Sky Next (Results to be presented at next SDT)
- **DR Retrievals**
  - Dependent sample training statistics (2000–2100 Climate Statistics)
    - Uses subset of CCSM OSSE simulated radiances and associated surface and atmospheric variables
      - 36 randomly selected grid points per month = 43,200 samples)
      - 2000-2100 CO_2 variability (370 - 820 ppm)
  - Independent sample training statistics (No Climate Change Statistics)
    - Uses UW Direct Broadcast DR retrieval contemporary training data set
      - 2000-2015 CO_2 variability (370 - 400 ppm)

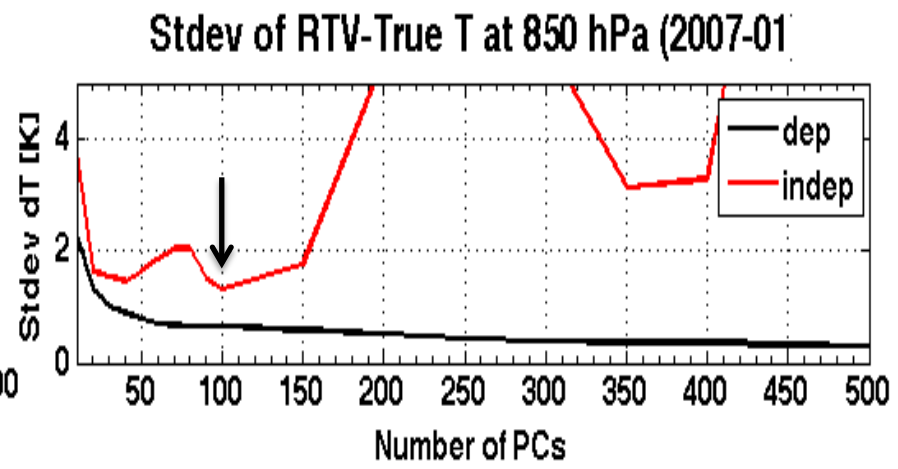
- Data provided by D. R. Feldman, CLARREO SDT

Optimal Number of PCS for Retrievals

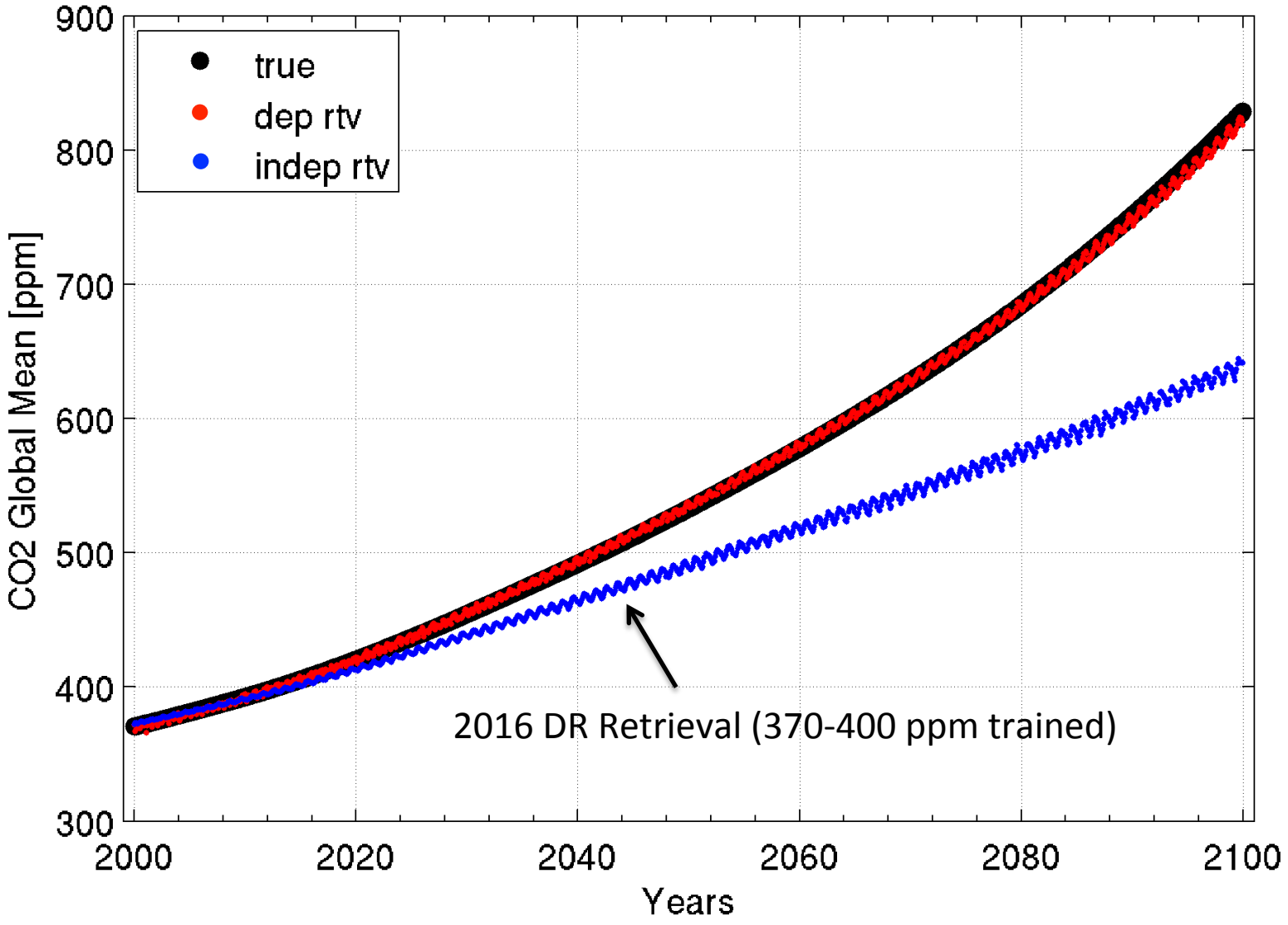




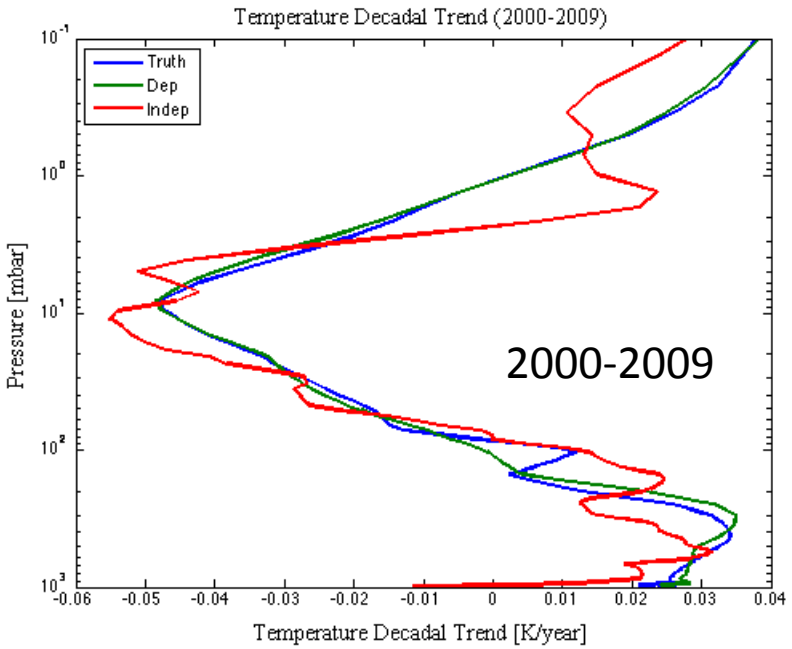


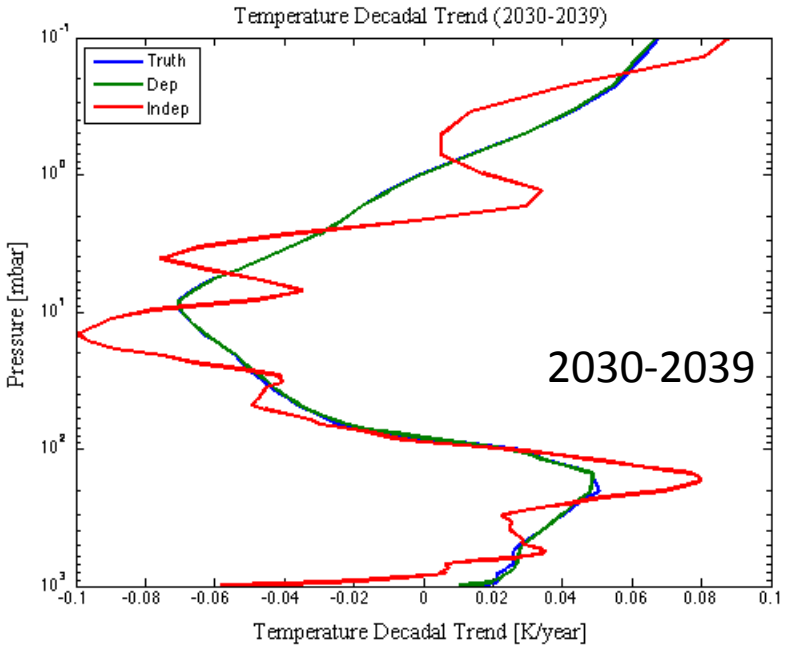


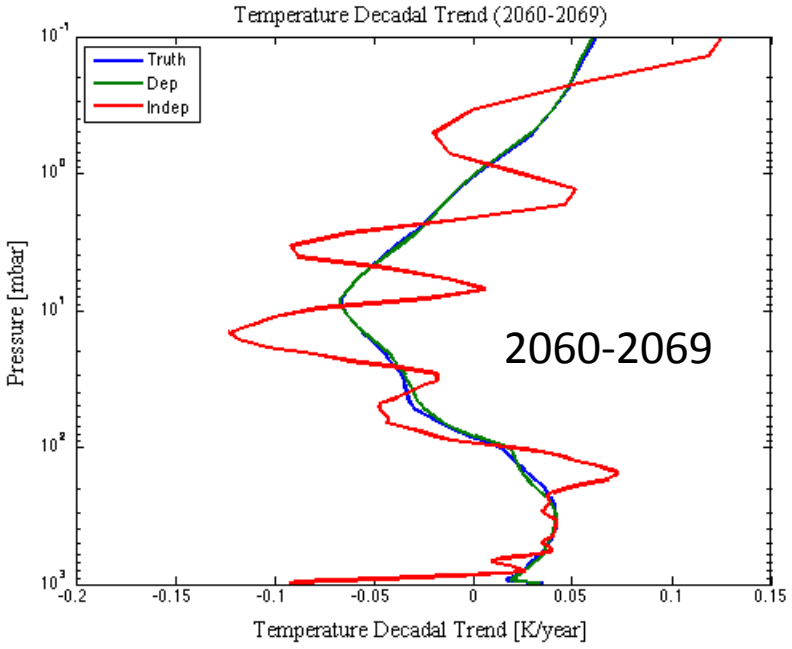
CO_2 Predictability

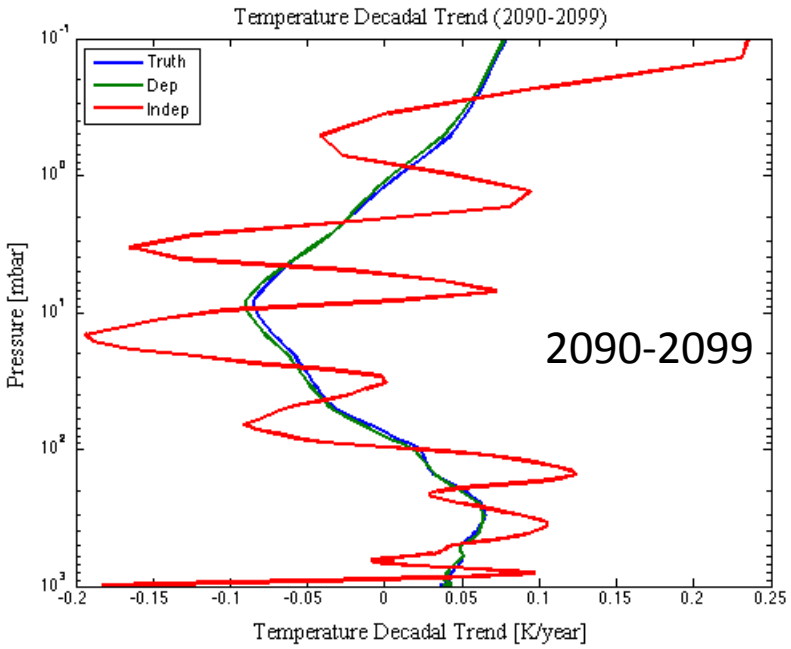


Global Annual Decadal Trend (K/yr)

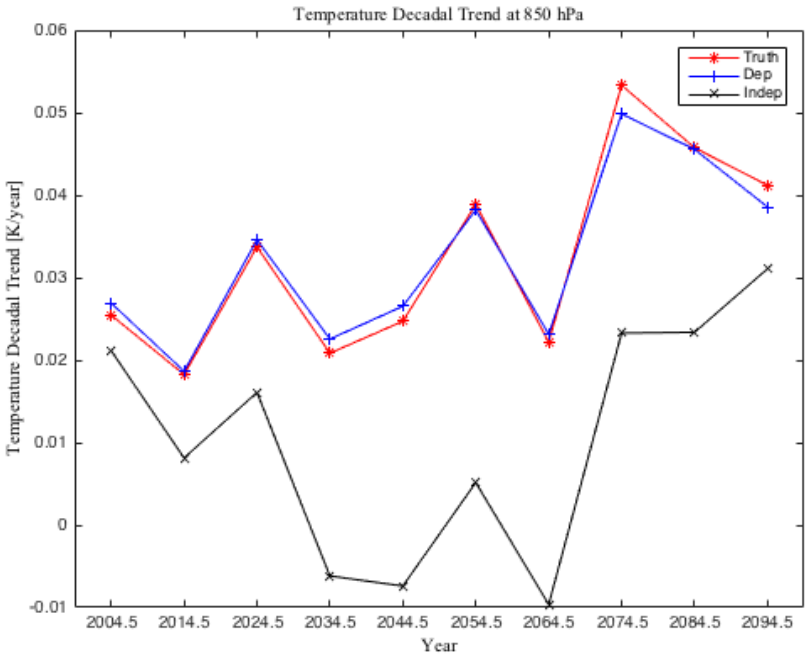


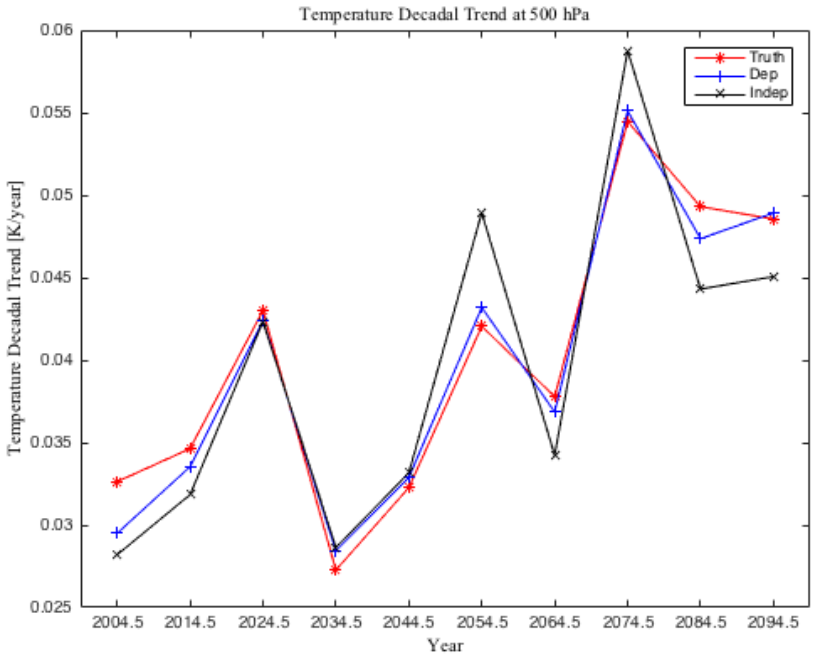


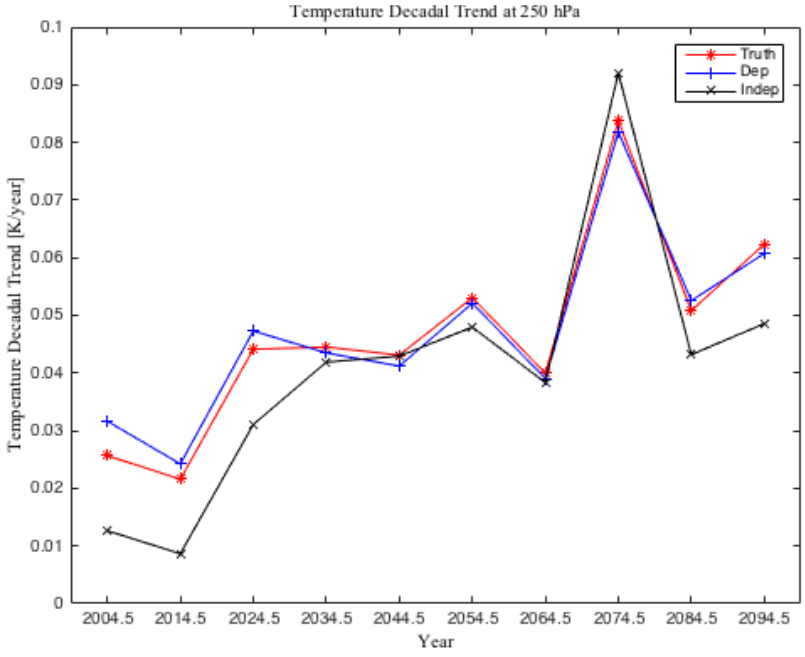


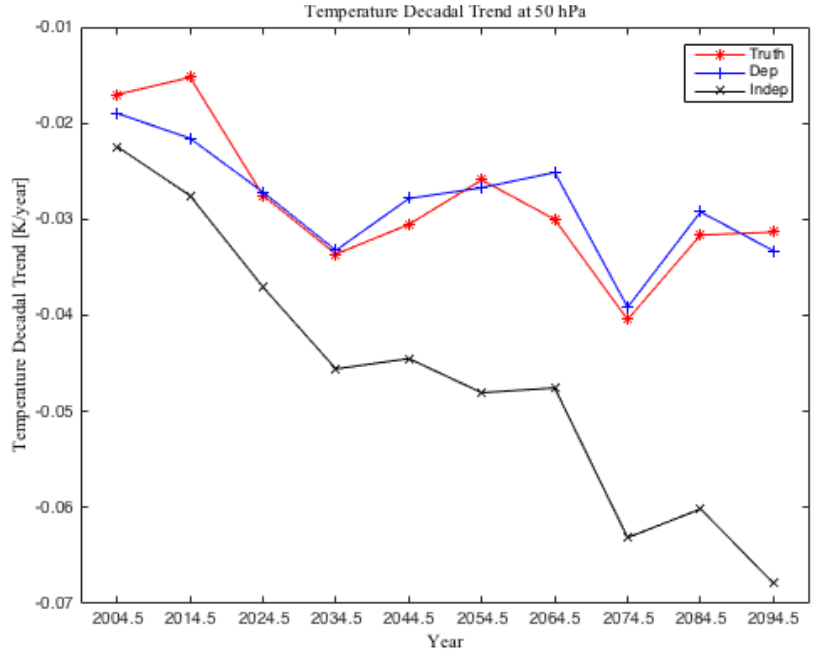


Global Decade Mean Temperature Trends (K/yr)

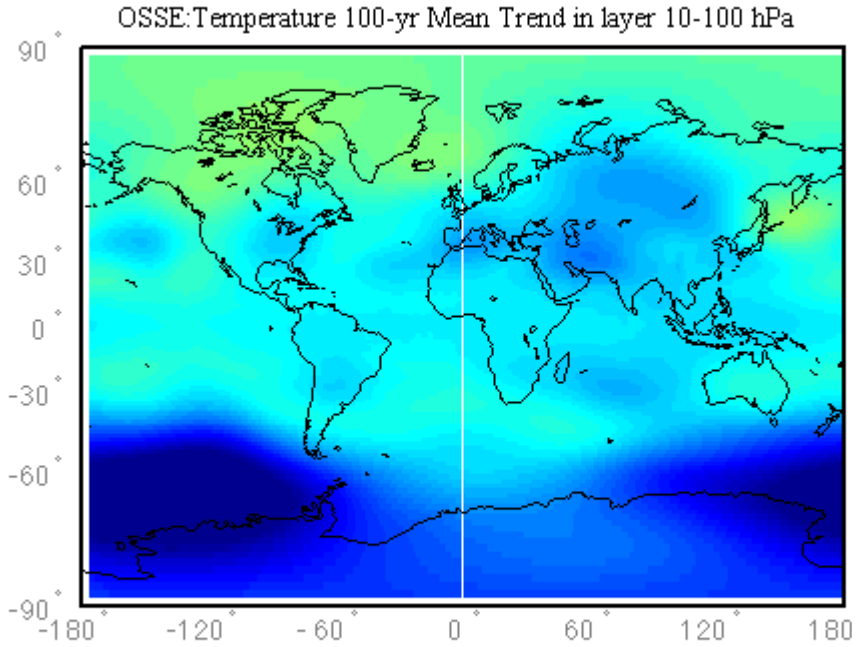


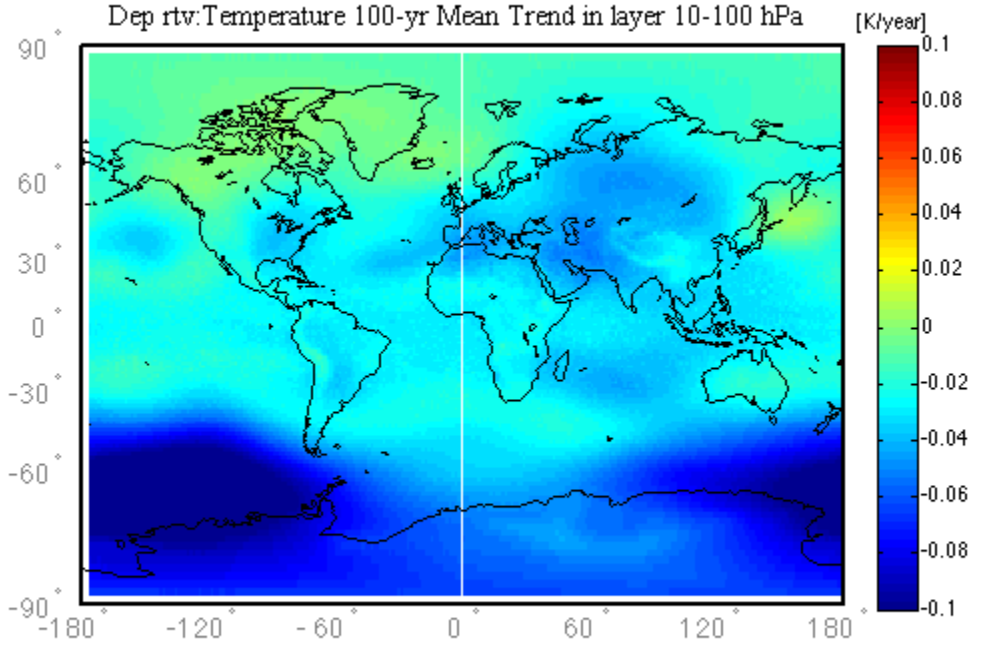


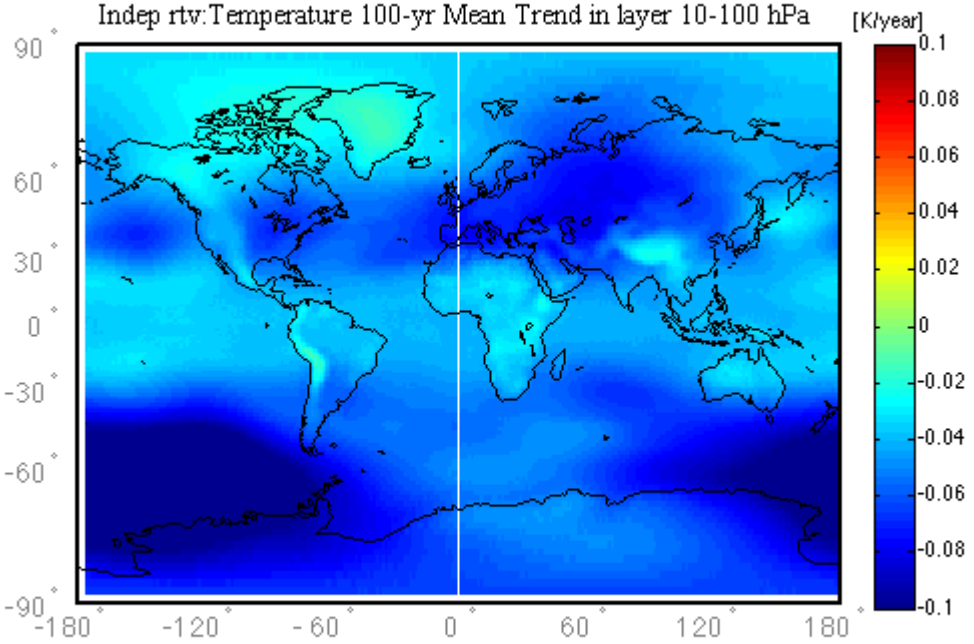


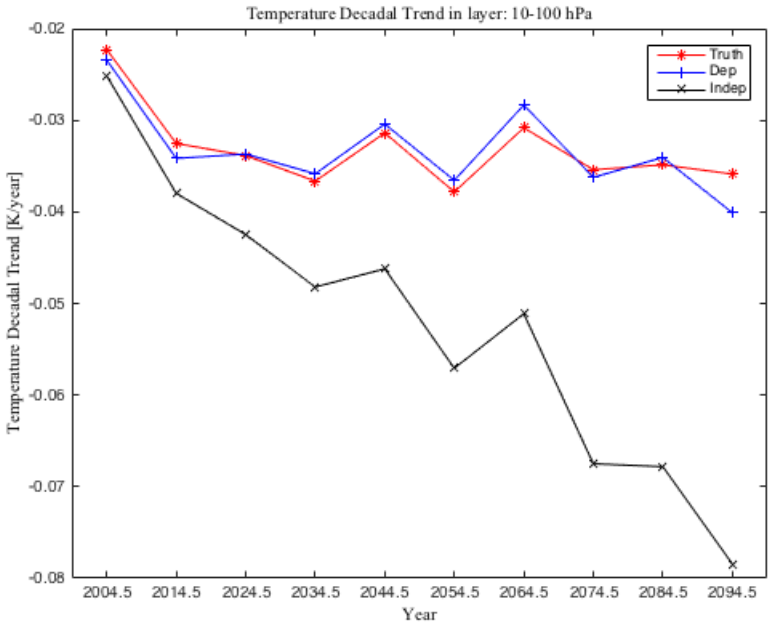


10-100 hPa 100-yr Mean Decadal Trend (K/yr)

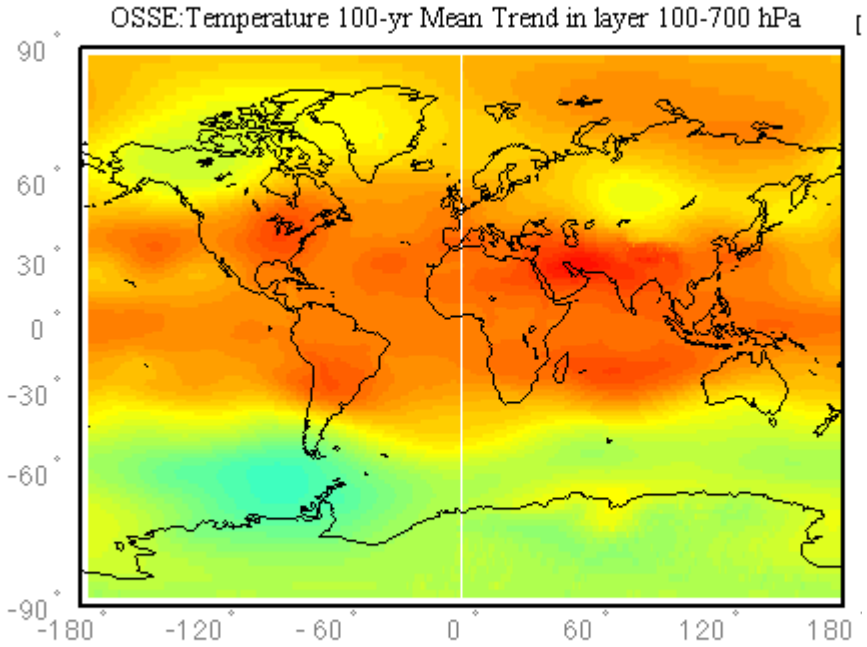


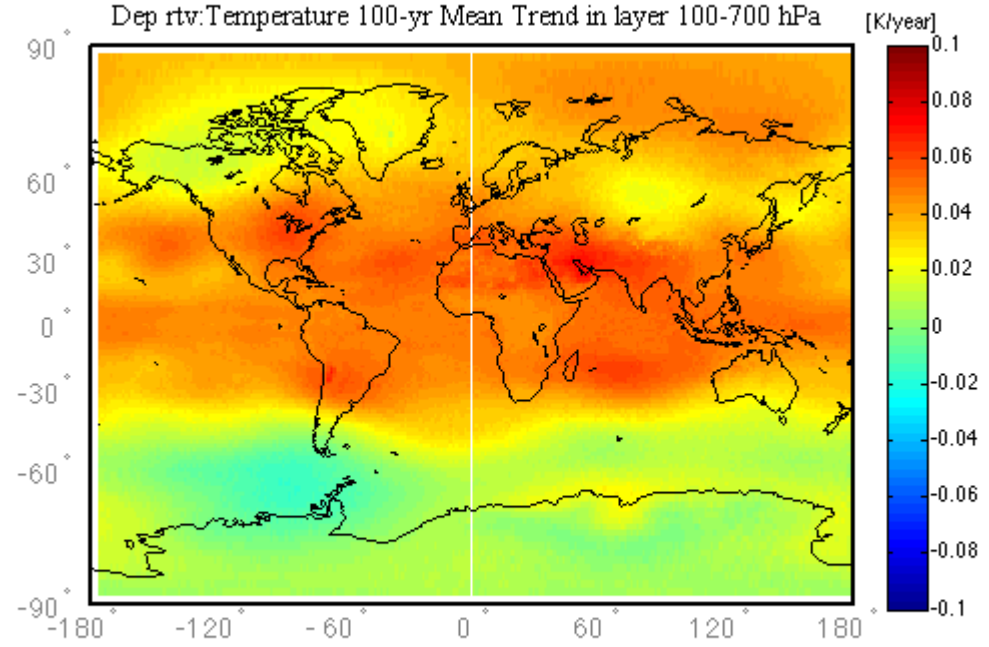


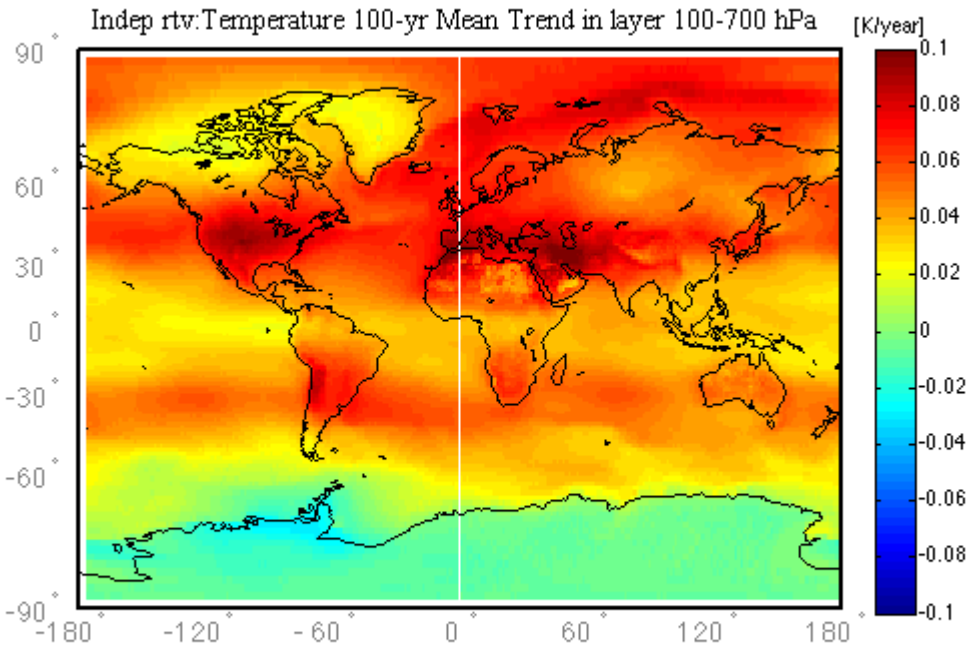


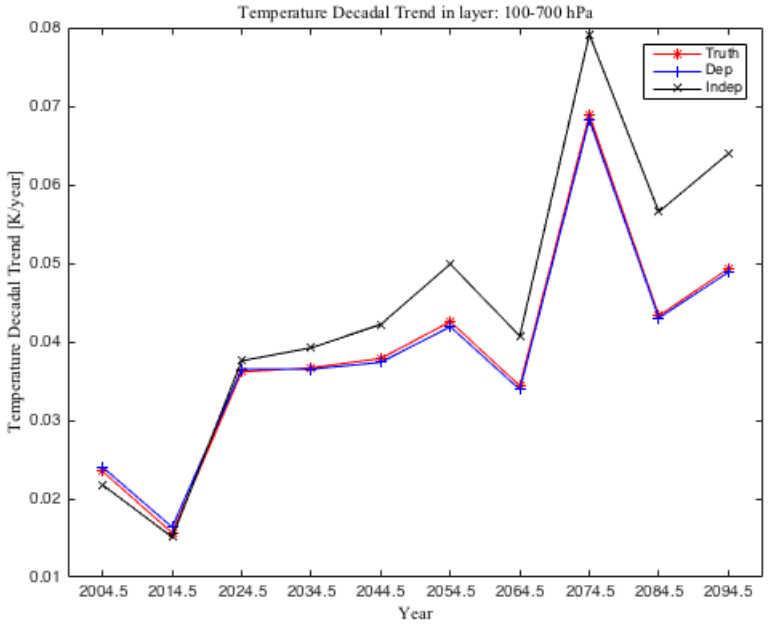


100-700 hPa 100-yr Mean Decadal Trend (K/yr)

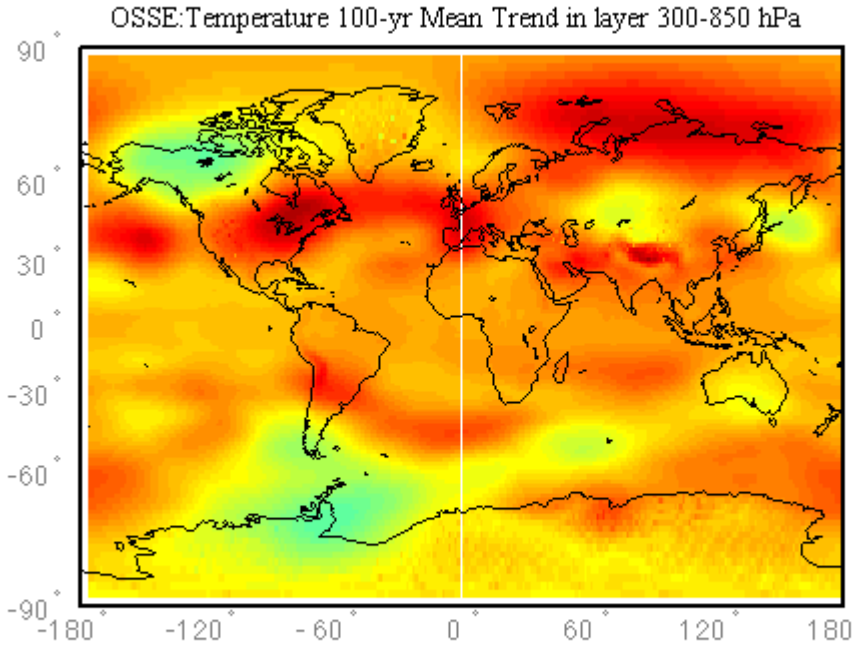


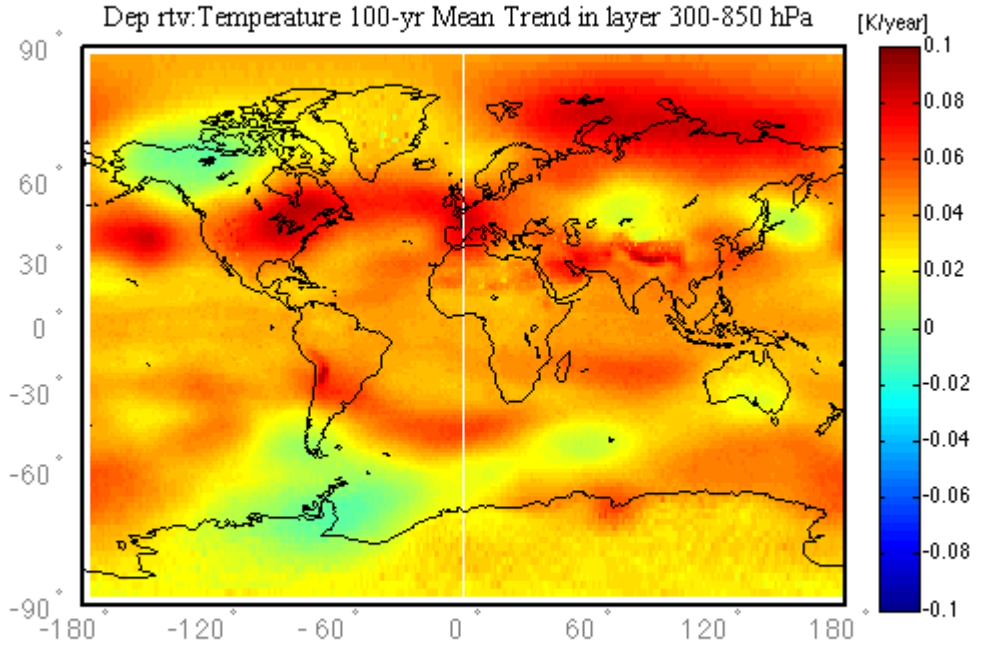


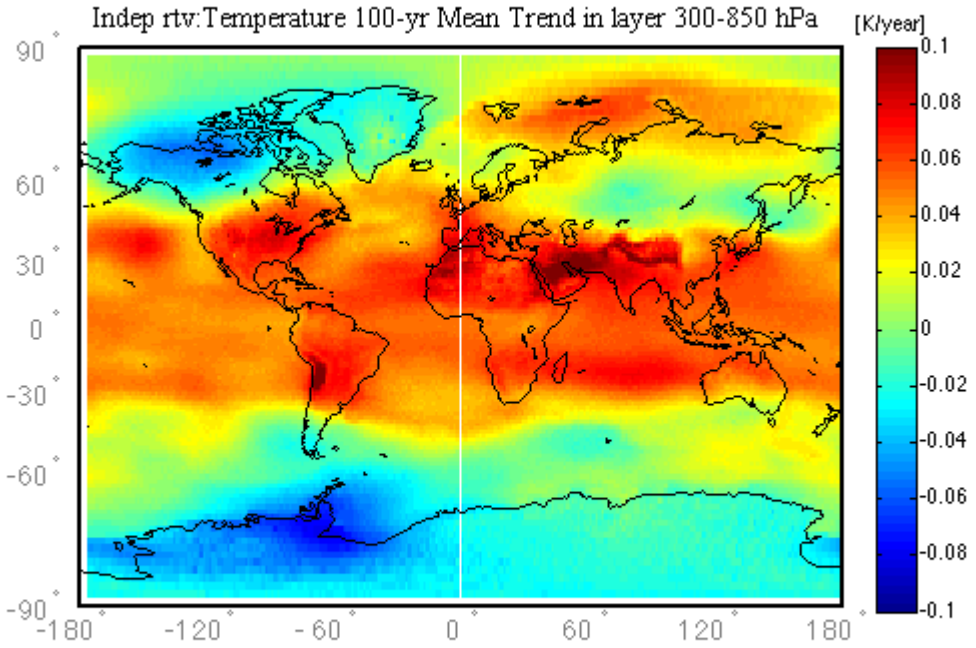


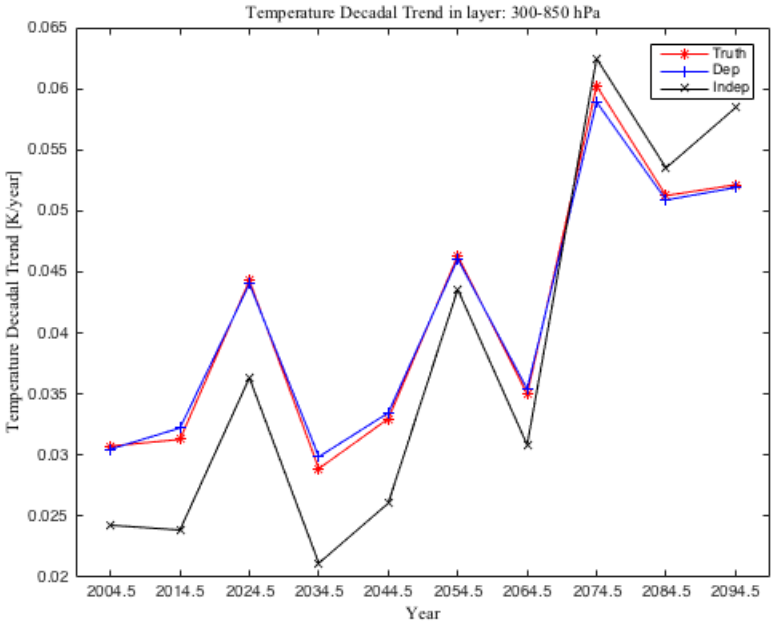


350-850 hPa 100-yr Mean Decadal Trend (K/yr)

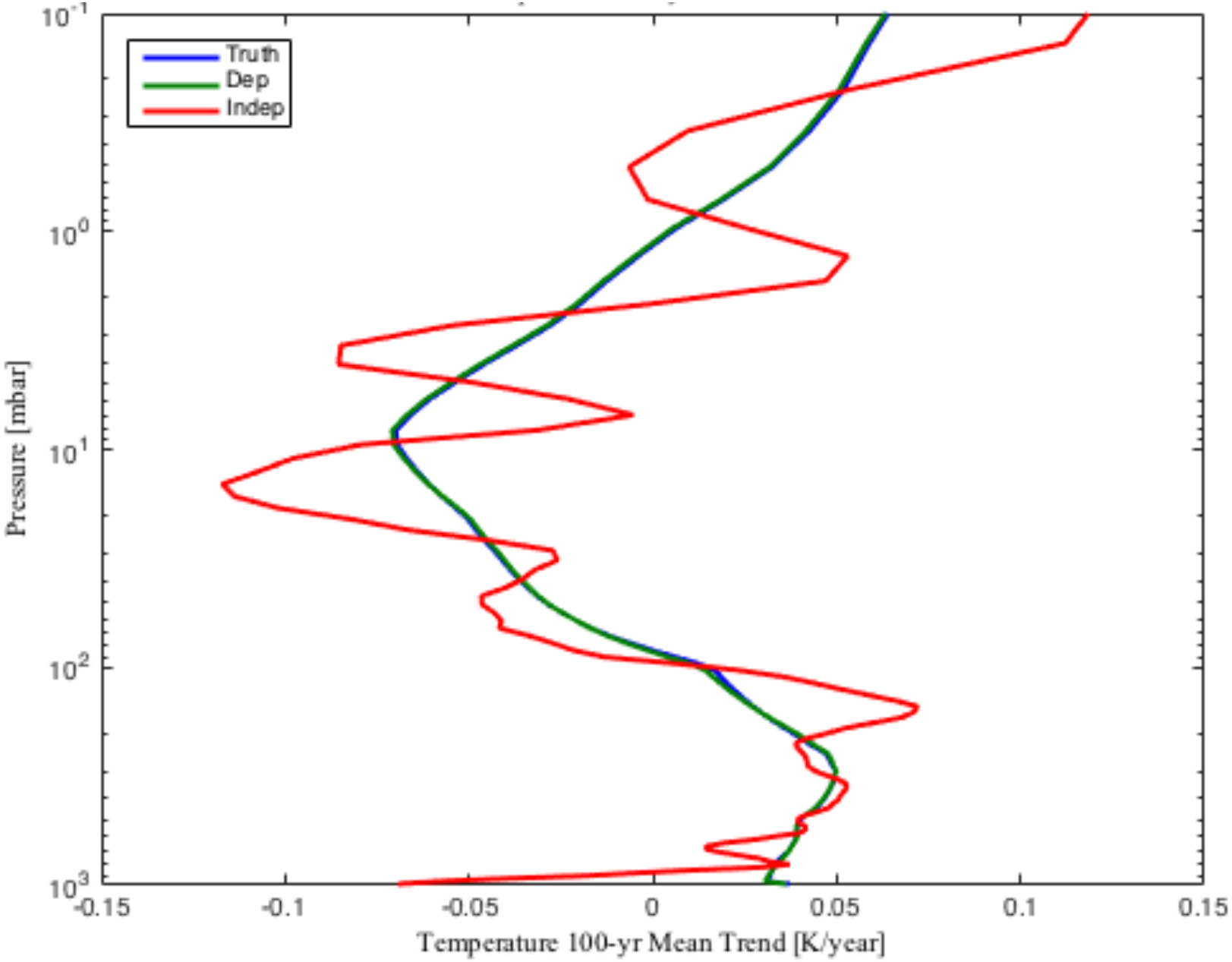








100-yr Mean Decadal Trend (K/yr)



Conclusions

- Linear Regression Retrieval Model Capable of Predicting Climate Trends Near Perfectly, Assuming No Forward Model Error and Clear Sky Conditions

- 100-yr Decadal Climate Trends Can Be Predicted With Reduced Skill Using A Current Weather Trained Linear Regression Model
  - Although Retrieval Vertical Profile Instability Errors Result, It is Believed That They Can Be Alleviated If Standard Numerical Matrix Conditioning Is Applied

Next Steps

- **Improving the Independent Retrieval**
  - Increase CO_2 Variance to cover the 100-yr range
  - Stabilize inverse by adding small amount of noise (e.g., 0.05 K) to the independent and dependent sample radiances prior the computation of the regression coefficients. This will also account for random error component of the forward radiative transfer model induced error of the monthly averaged calculated radiances used to train the linear DR retrieval.
- **Compute All-sky Radiances and Retrievals**
  - Use Climate Model Cloud Parameters in PCRTM
    - Compute radiance for each cloud height (Low, Mid, High) including CLDICE, CLDLIQ, GCLLWP, ICEFRAC, ICLDLWP, TGCLDIWP, TGCLDLWP, CLDTOT, CLD, Cld Pres, Cld OPD, etc.)
  - Apply DR Cloud Height Classification to OSSE Radiances for production of the cloud height classified regression coefficients for Dependent retrieval (Independent as in DBS)
  - Perform DR retrievals for each cloud height category
  - Produce final all-sky retrieval as the cloud fraction weighted average of the individual cloud height classified retrievals
  - Validate Dependent and Independent Sample Based Retrievals:
    - T, CldP, CldOPD, H_2O, O_3, CO_2, CH_4, N_2O, T_s, Em_s