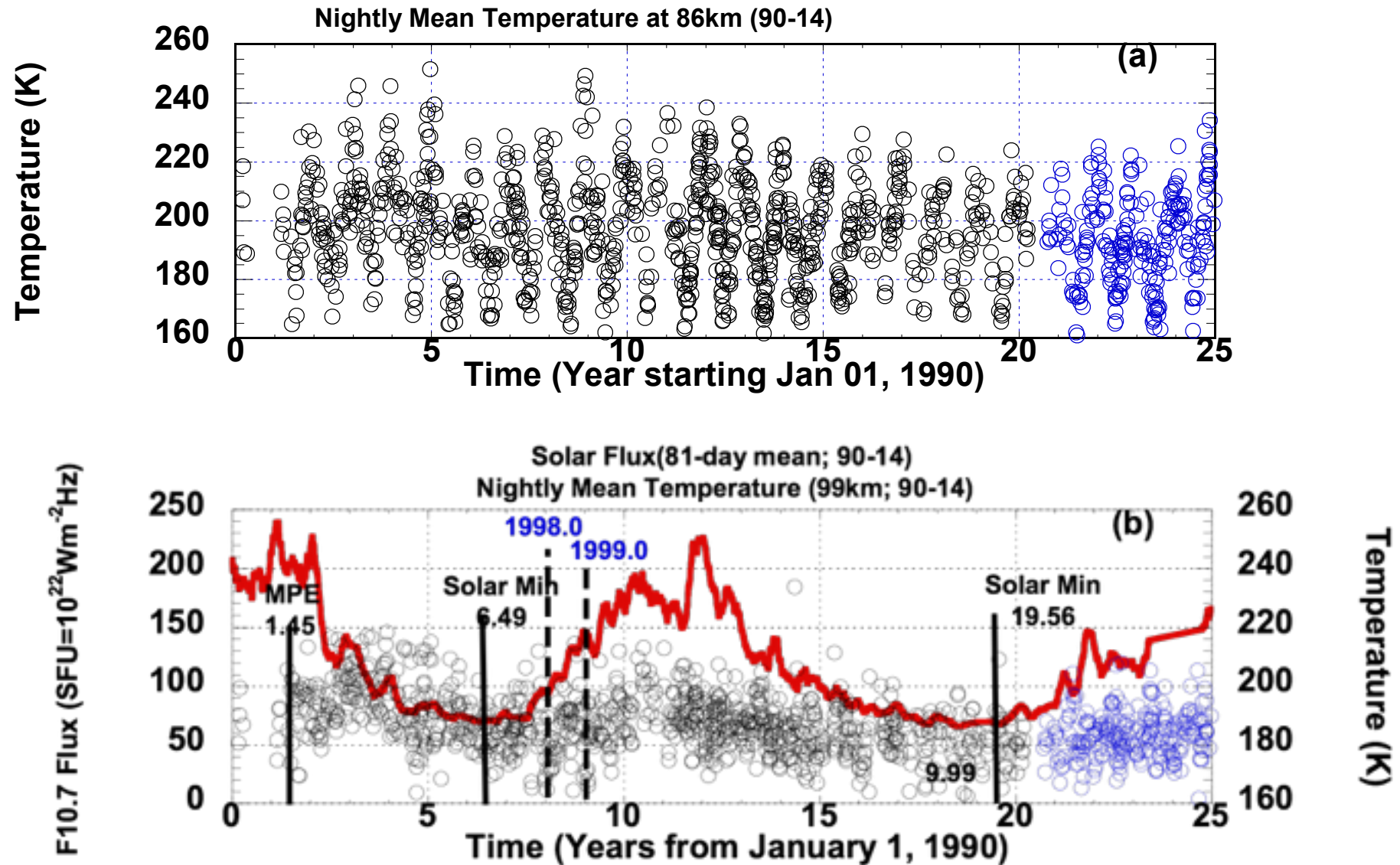


# Long-term midlatitude mesopause region temperature trend deduced from quarter century (1990–2014) Na lidar observations

C.-Y. She, D. A. Krueger, and T. Yuan

- Quarter-century observation with strong warming episode in the 1990s: 1990 - 2010 at CSU (41N, 105W) and 2010 - 2014 at USU (42N, 112W).
- This yields a cooling trend starting from an insignificant value of  $0.64 \pm 0.99 \text{ K / decade}$  at 85 km, increasing to a maximum between 91 and 93 km of  $2.8 \pm 0.58 \text{ K / decade}$ , decreasing to a warming trend above 103 km to 105 km.
- Difference between 11-parameter and 7-parameter regression analyses.
- To shed light on the nature of the warming episode, we show that the recently reported prolonged global surface temperature cooling after the Mt Pinatubo eruption can also be represented by the same response function with comparable life ( $\sim 7$  years).

# Data: Nightly Mean Temperatures



# Fit Function:

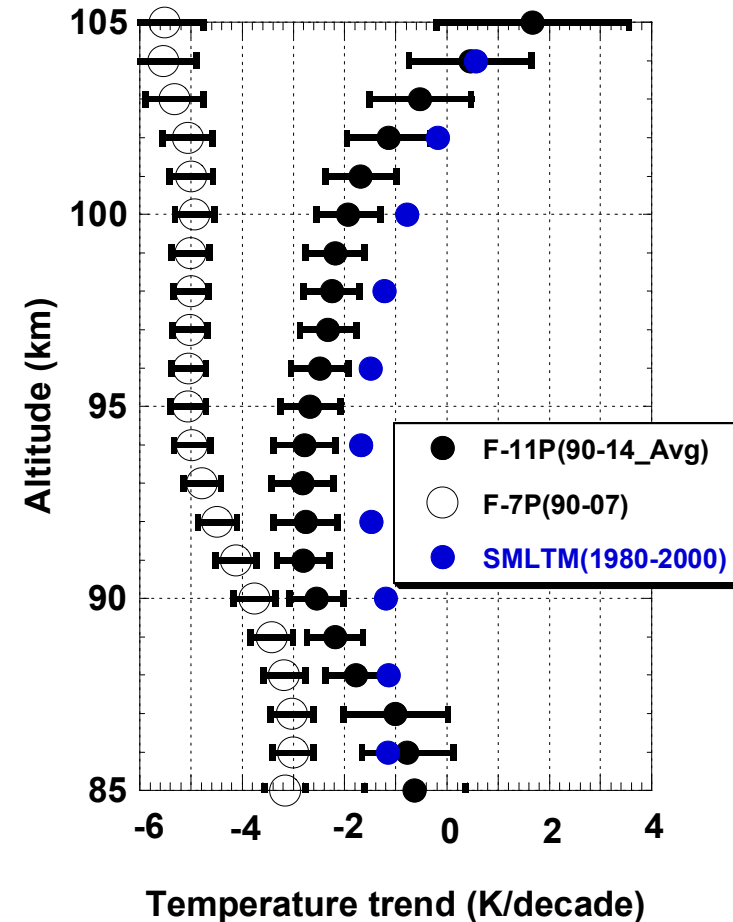
$$T(z, t) = T_{fit}(z, t) + T_{Res}(z, t);$$

$$T_{fit}(z, t) = \alpha(z) + A_1(z) \cos(2\pi t) + B_1(z) \sin(2\pi t) \\ + A_2(z) \cos(4\pi t) + B_2(z) \sin(4\pi t) \\ + \beta(z)t + \gamma(z)P(z, t) + \delta(z)Q_{81}(t);$$

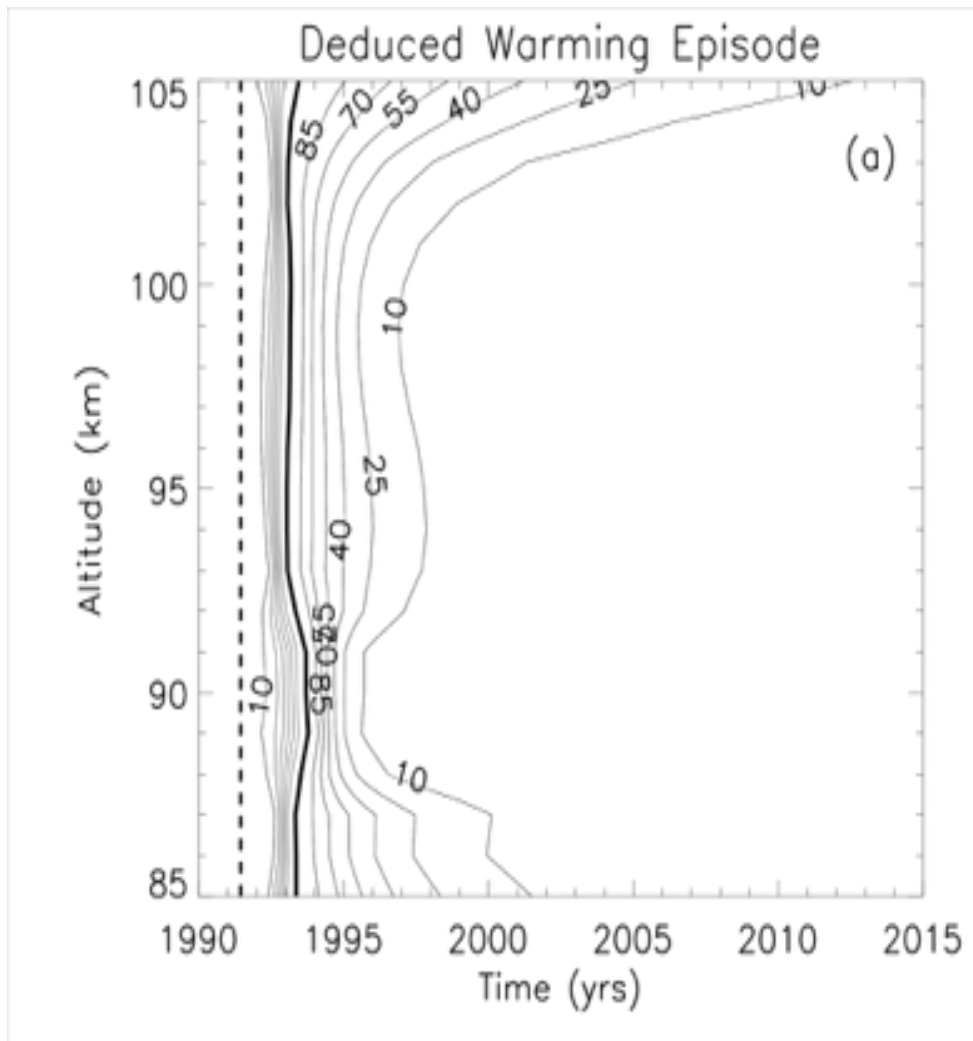
$$P(z, t) = 2 / \left\{ \exp(t_0 - t) / t_1 + \exp(t - t_0) / t_2 \right\}$$

7 parameter analysis vs.  
11 parameter analysis

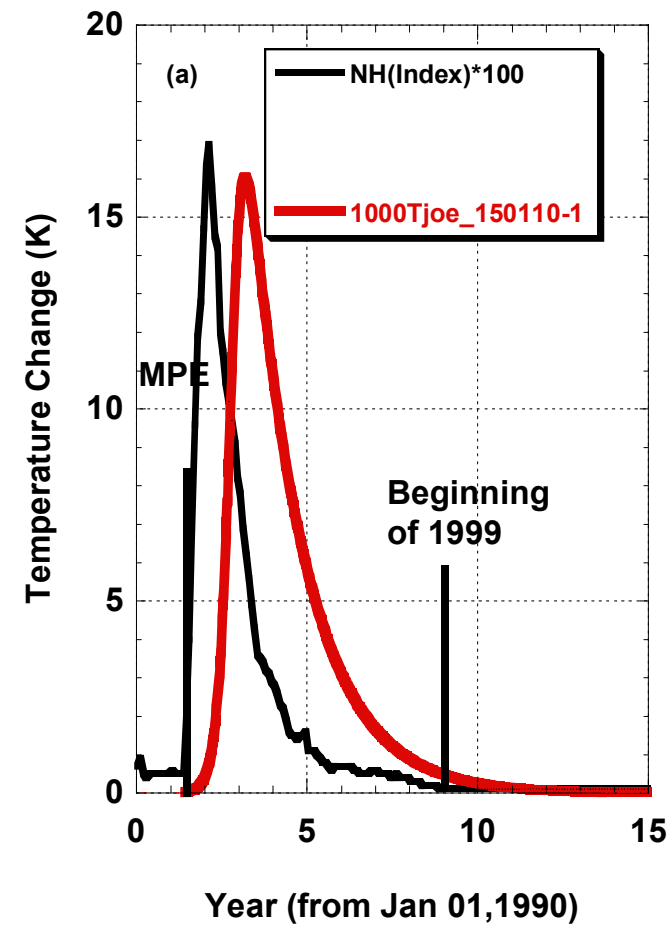
# Trend results



- Peak-normalized Warming Response

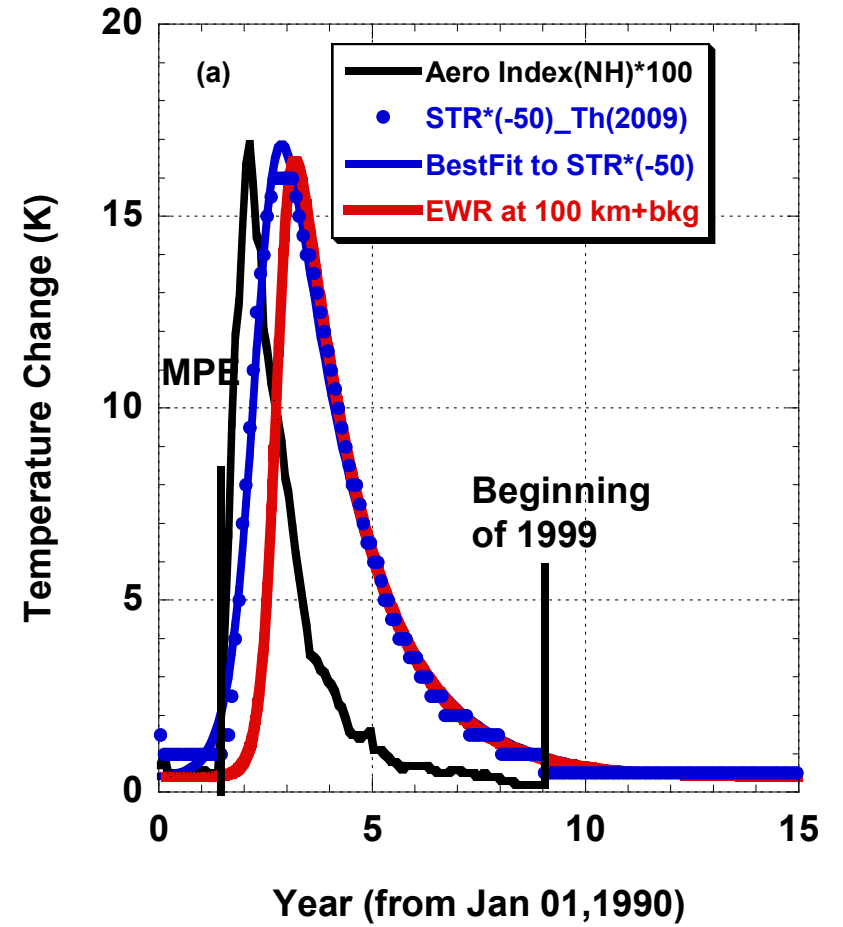
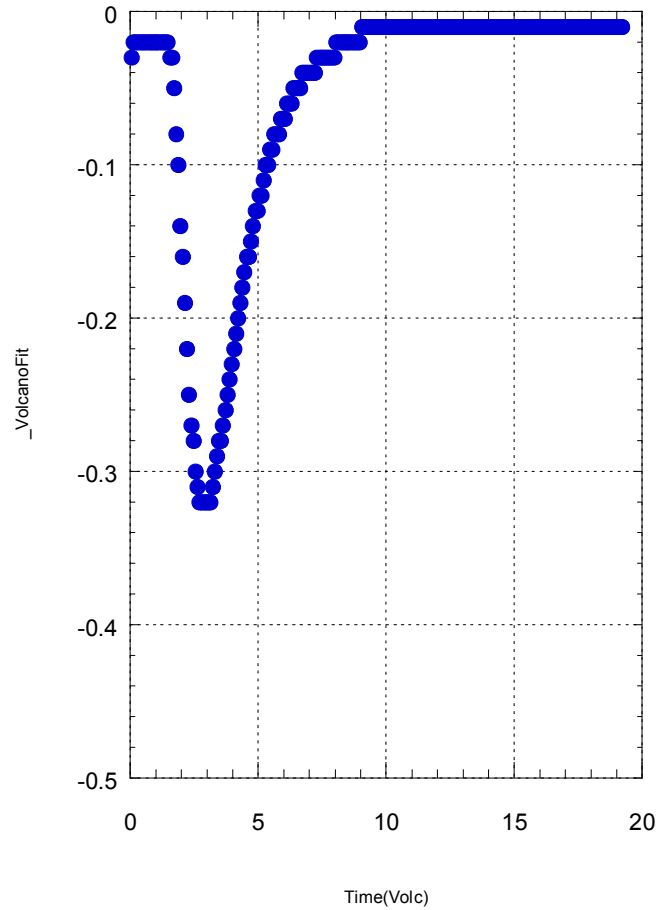
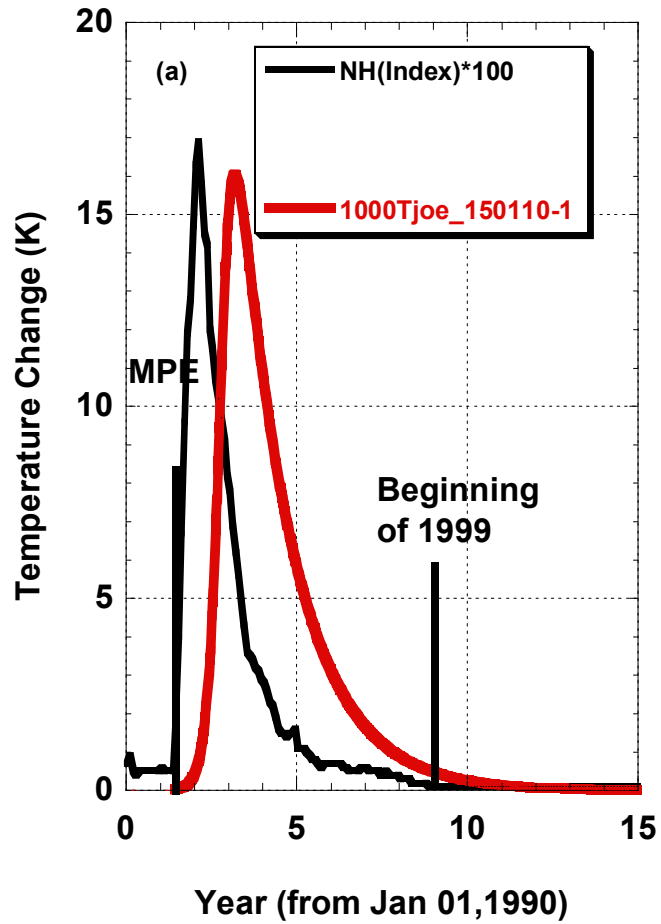


## Max Response



# Thomson et al., 2009

ThomsonVol-Aero\_MOD



## Fit Function:

$$T(z, t) = T_{fit}(z, t) + T_{Res}(z, t);$$

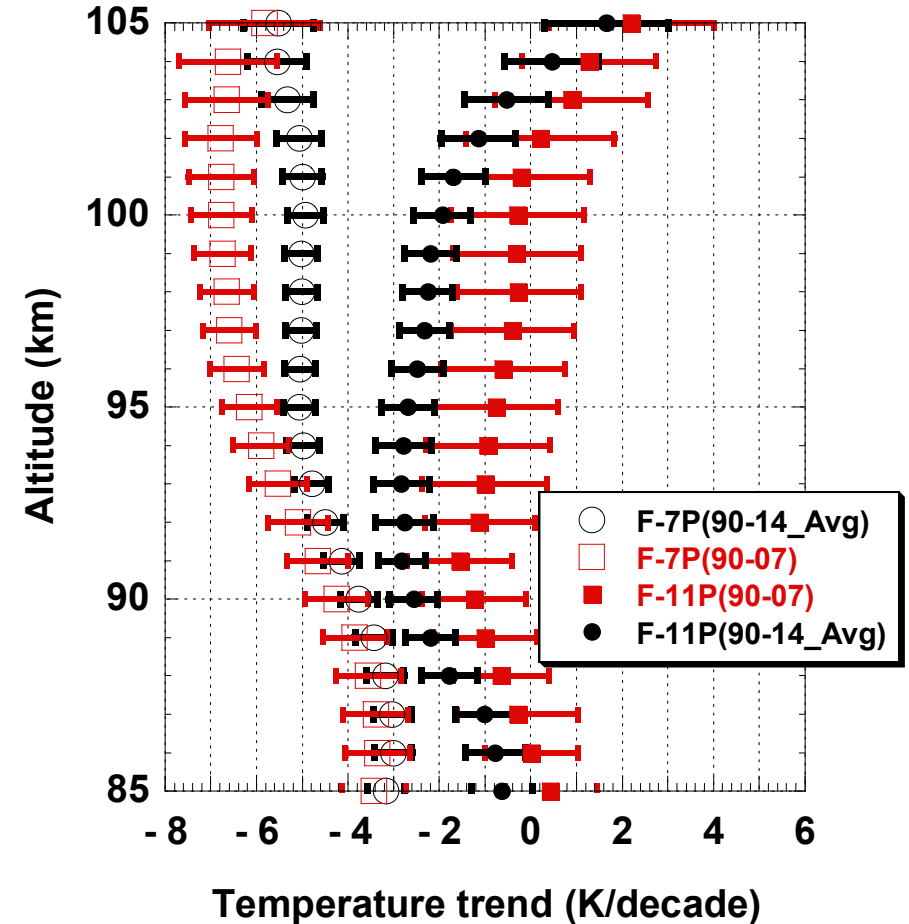
$$T_{fit}(z, t) = \alpha(z) + A_1(z) \cos(2\pi t) + B_1(z) \sin(2\pi t) \\ + A_2(z) \cos(4\pi t) + B_2(z) \sin(4\pi t) \\ + \beta(z)t + \gamma(z)P(z, t) + \delta(z)Q_{81}(t);$$

$$P(z, t) = 2 / \left\{ \exp(t_0 - t) / t_1 + \exp(t - t_0) / t_2 \right\}$$

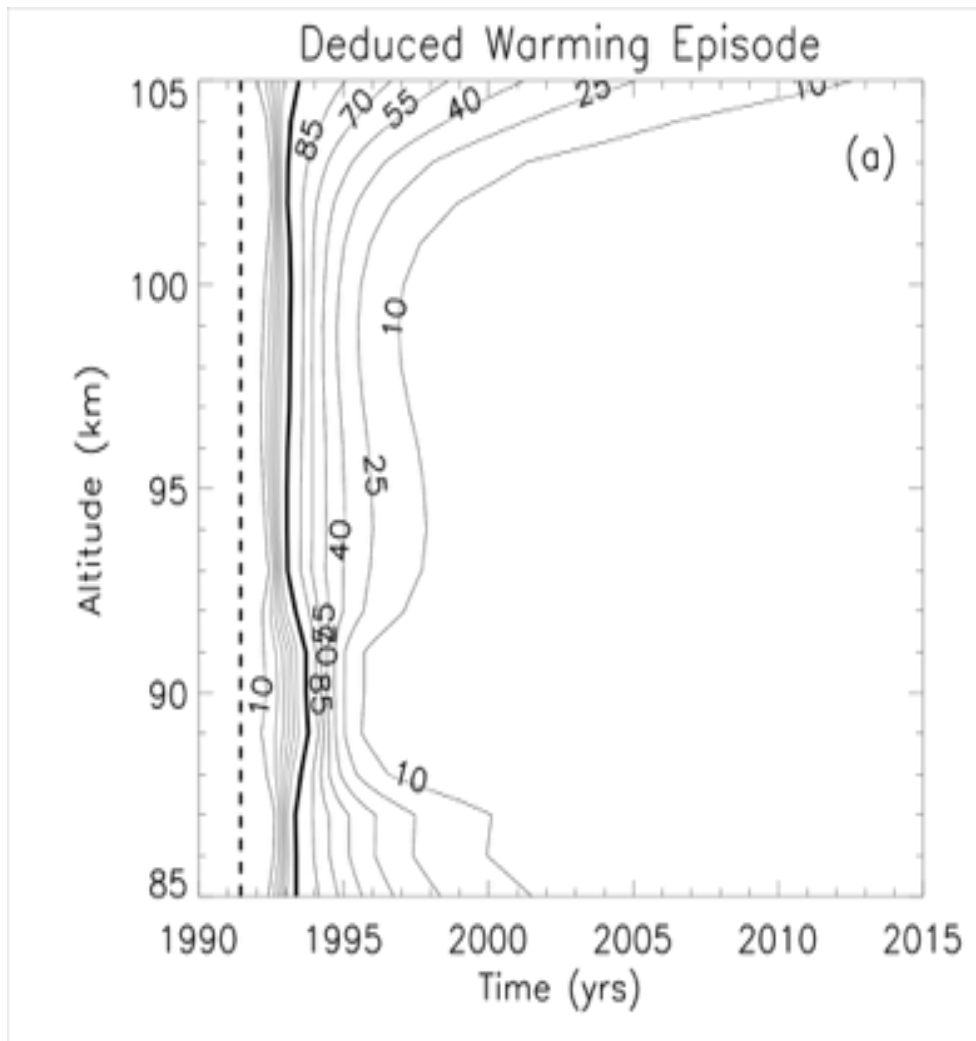
7 parameter analysis vs.  
11 parameter analysis

17 year-long data (1990 - 2007) vs.  
25 year-long data (1990 - 2014)

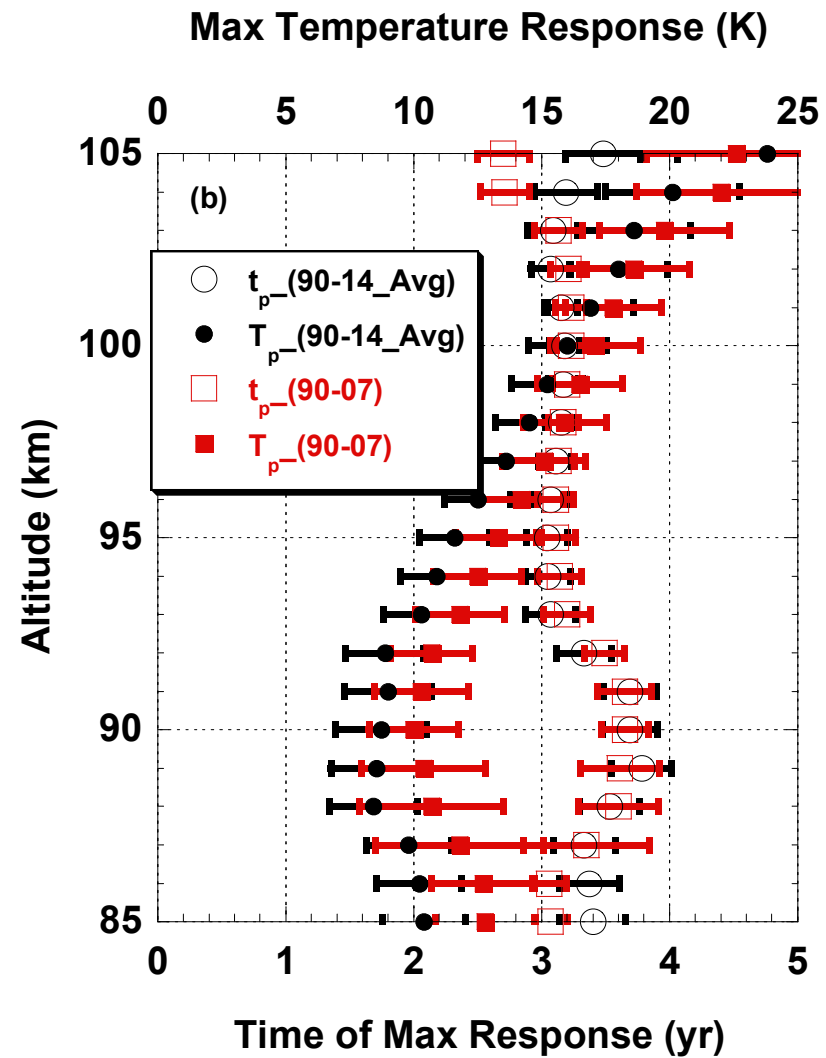
## Trend results



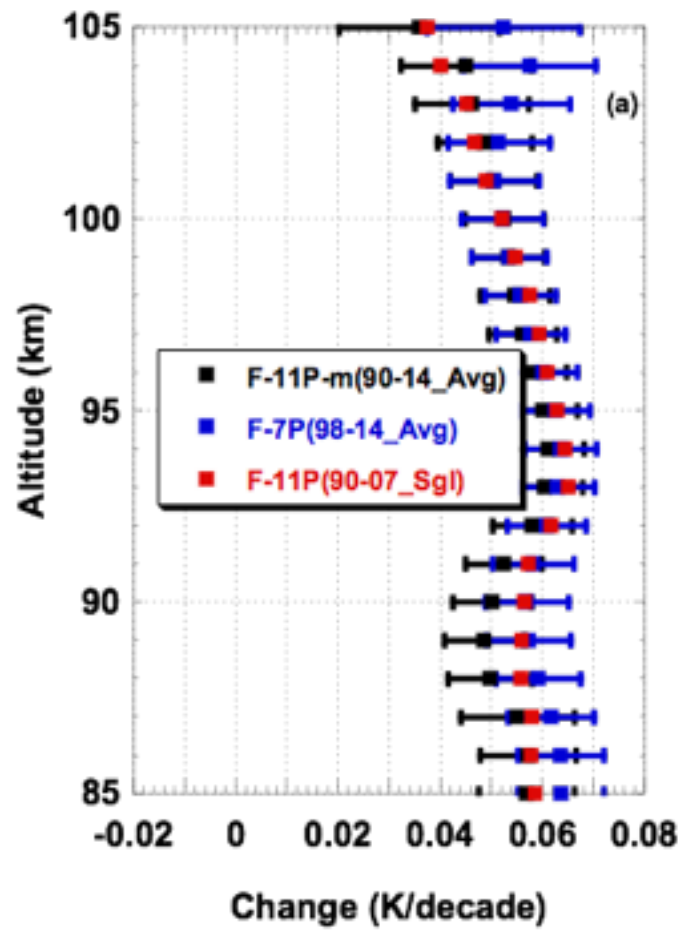
- Peak-normalized Warming Response



## Max Response

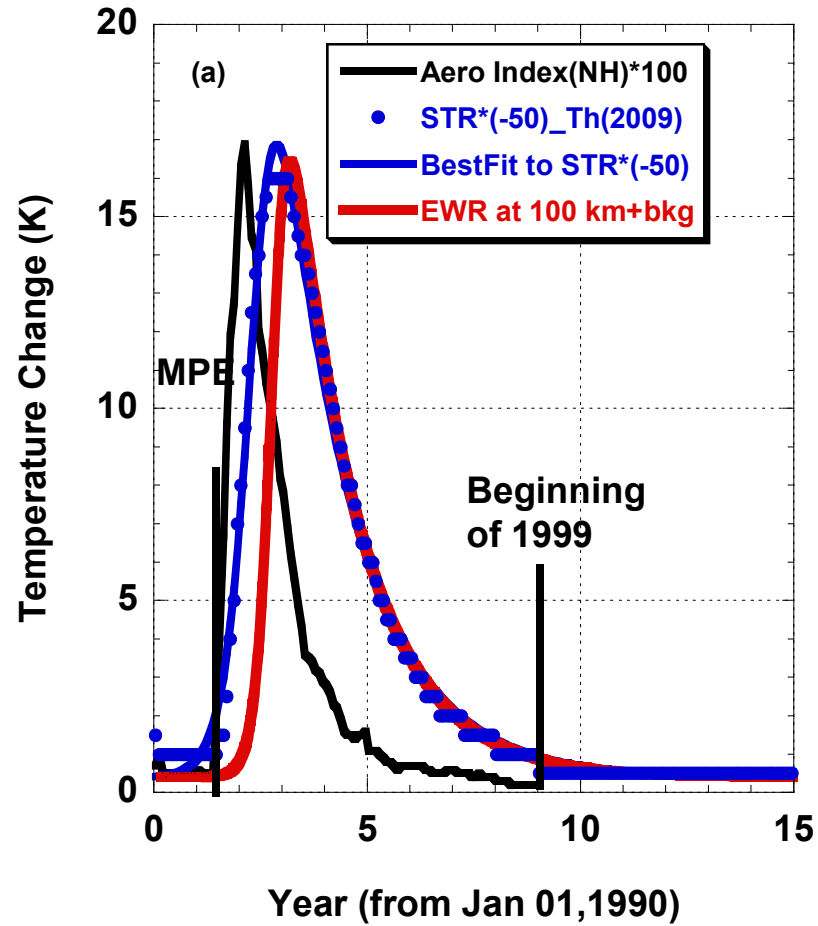


# Solar Response

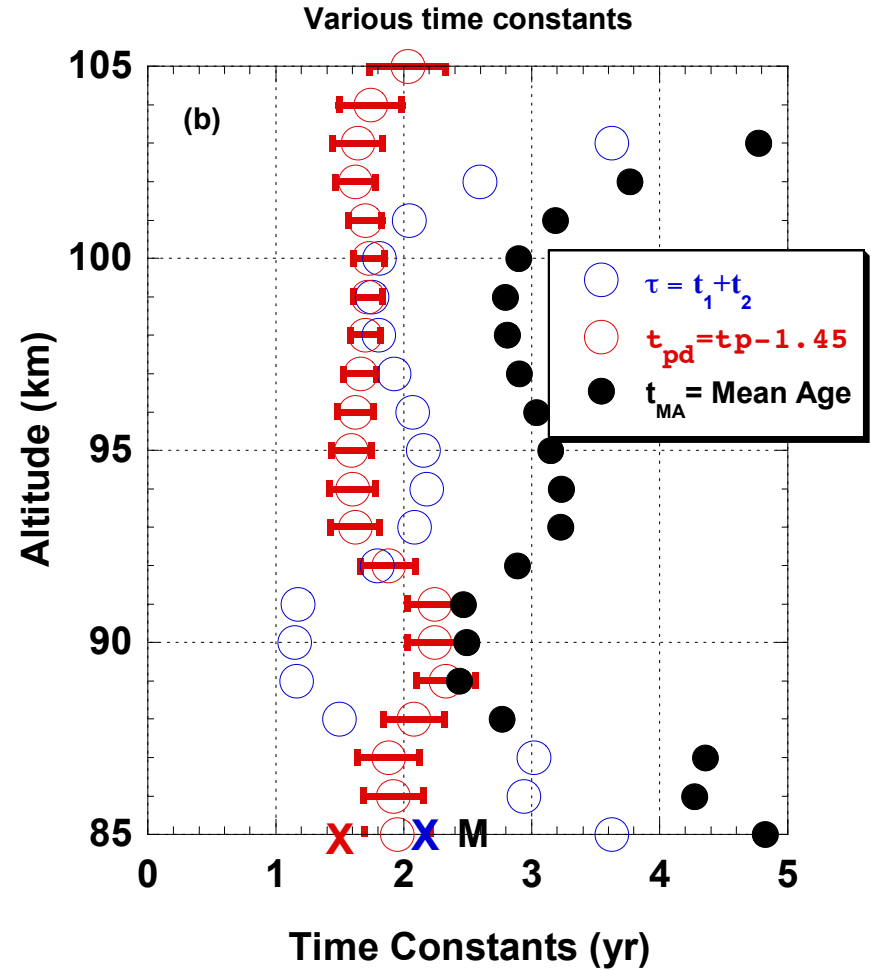




# Response to MPE

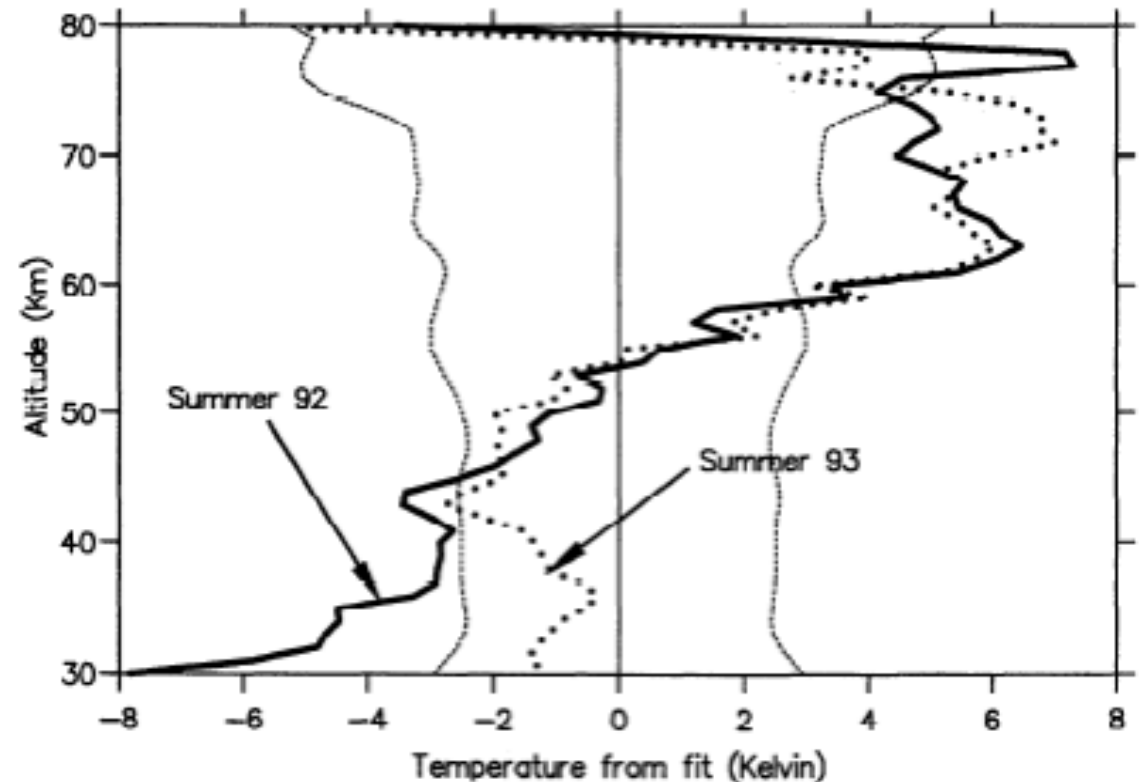


# Various Response Times



Keckhut, P., Hauchecorne, A., and Chanin, M. L.: Midlatitude longterm variability of the middle atmosphere: trends and cyclic and episodic changes. *J. Geophys. Res.*, 100, 18887-18897, 1995.

A significant warming of 6 k in the mesosphere is observed in summer 1992 and 1993. This large change could be due to aerosols injected in the stratosphere by the Mount Pinatubo Eruption.



**Figure 9.** Vertical profile of the residual term (data minus model-fitting data for 1979–1991) for summer 1992 measurements (solid line) and summer 1993 measurements (dotted line). Dashed lines show summer standard deviation.