Volcanic Effects in the Upper Atmosphere

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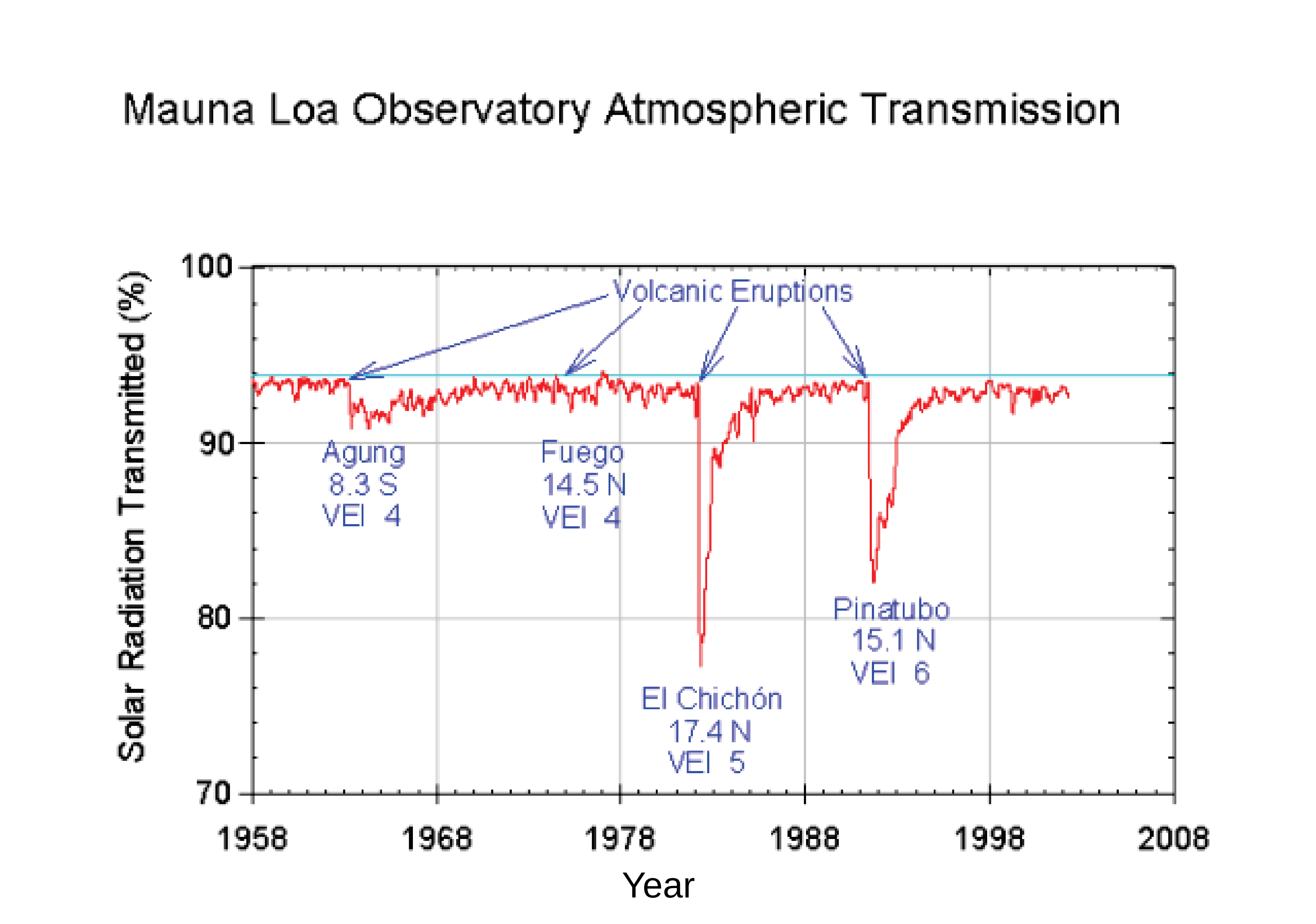
Outline

- Introduction
  - Background
  - Motivation
- Temperature Trend Models
  - General model & cross terms
- Potential Effects of Volcanic Activity in Data
- Conclusions & Future Work

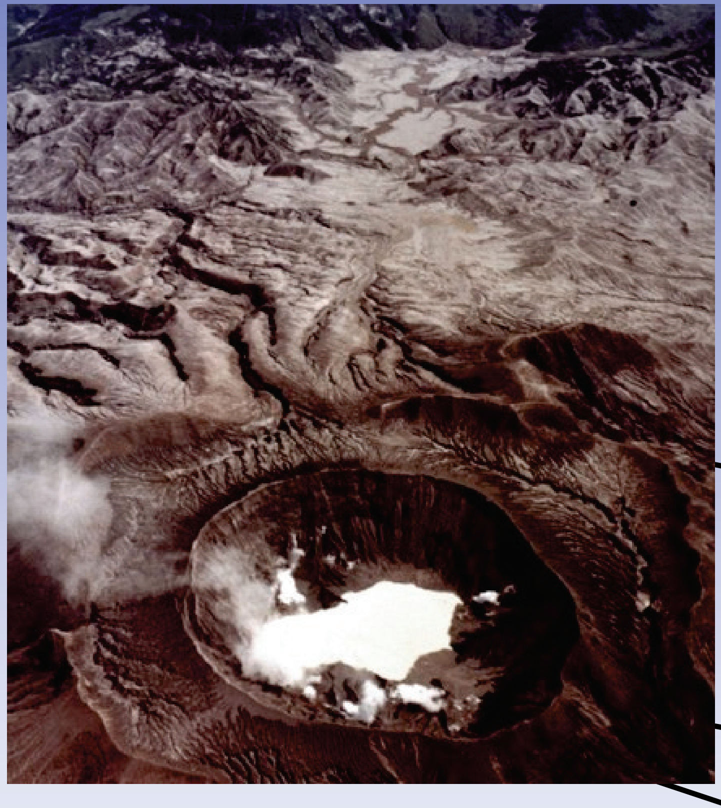
Volcanic Effects

- Massive volcanic eruptions can have global effects on the climate
  - Release significant amounts of aerosols into atmosphere
  - Mount Tambora (1815), Krakatoa (1883), and Novarupta (1912)
- Metrics of Effect
  - Dust Veil Index (DVI) vs. Volcanic Explosivity Index (VEI)
  - Highest DVI eruptions in the past 40 years were El Chichon (1982) and Pinatubo (1991)

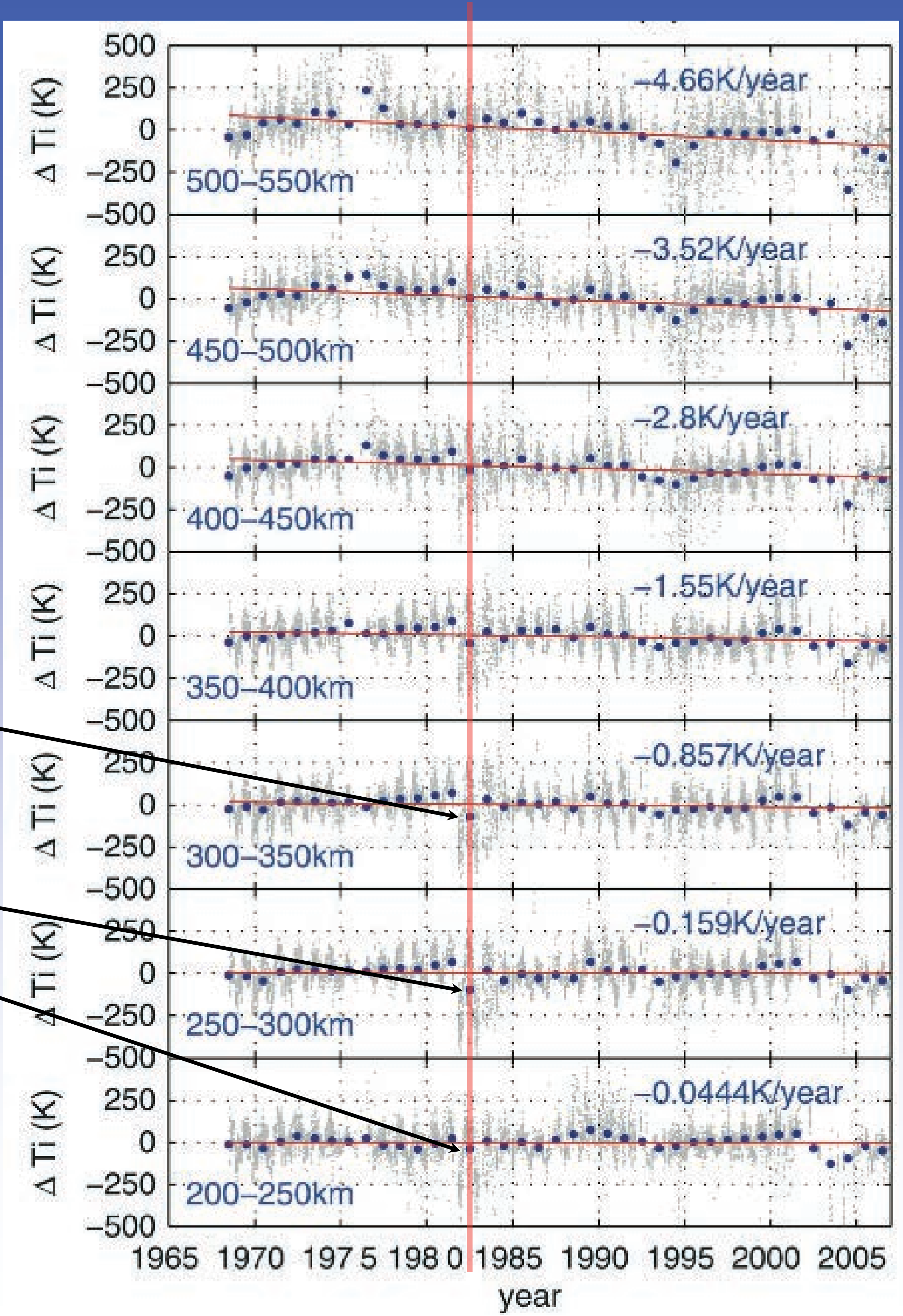
Global Cooling Effect



Potential Signals?



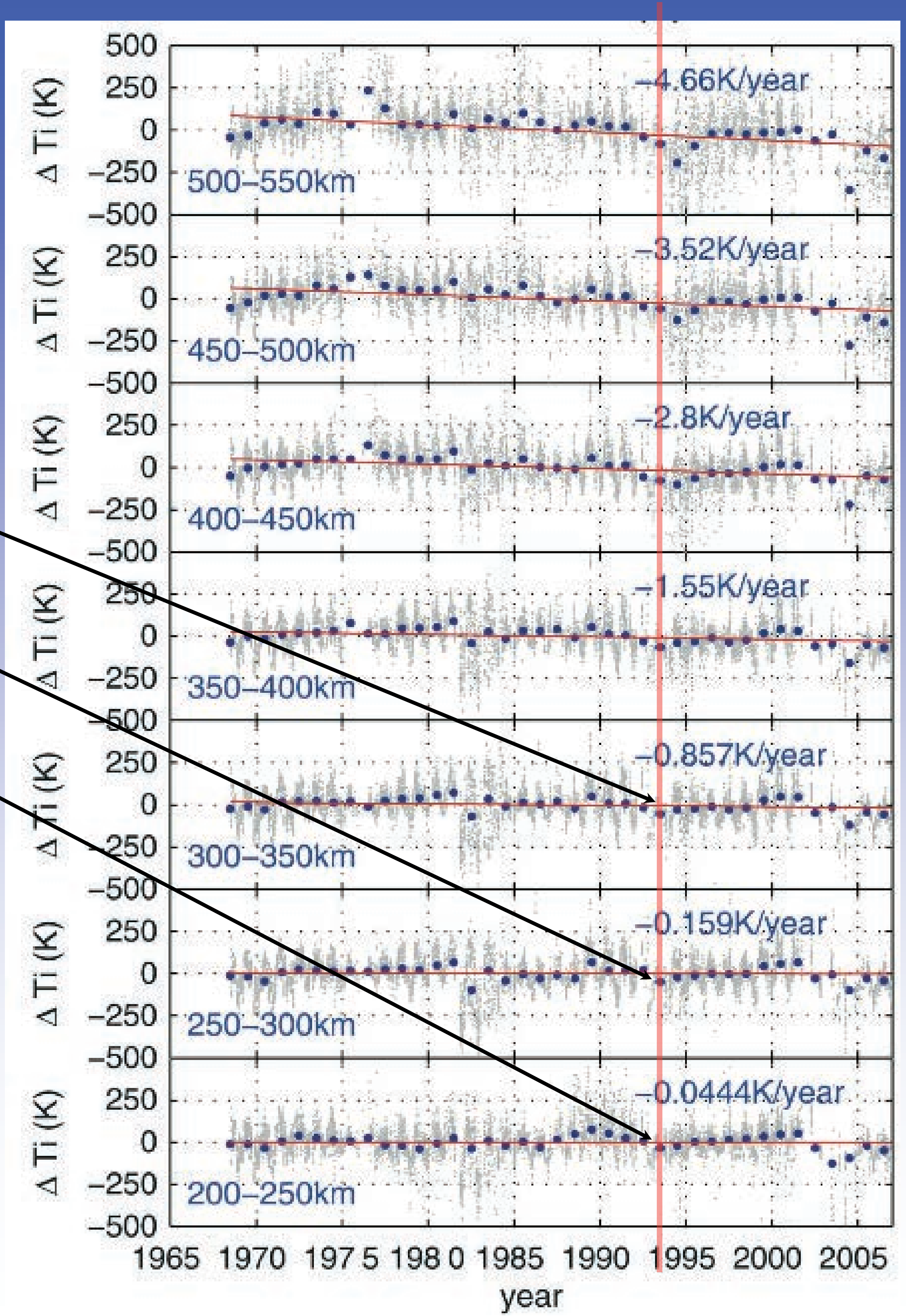
El Chichon
Date: March 28,1982
Location: Francisco Leon, Mexico (17N, 93W)
DVI: 336



Zhang et. al (2013)

Potential Signals?

Pinatubo
Date: June 15, 1991
Location: Pampanga, Phillipines (15N, 120E)
DVI: 500



Zhang et. al (2013)

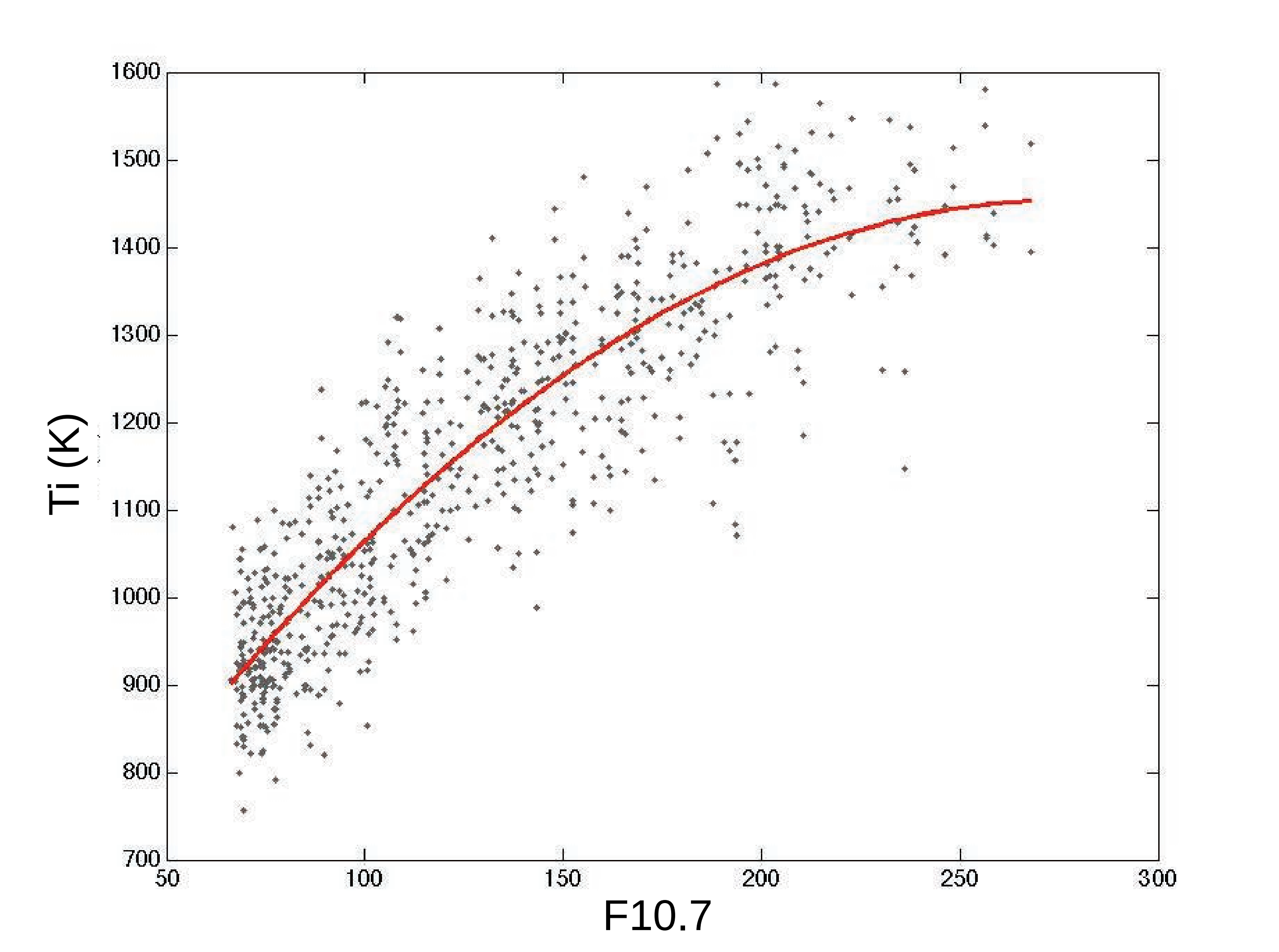
Data and Methods

- Ion temperature data from 3 ISRs (Millstone Hill, Sondrestrom, St. Santin)
  - Millstone Hill (42N, 71W)
    - 1968 - Present
  - Sondrestrom (67N, 50W)
    - 1991 - Present
  - St. Santin (44N, 2E)
    - 1966 - 1987
- Neutral density from satellite drag data
- Applied a modified long-term trend model to subtract out solar (F10.7) and geomagnetic (AP index) effects

Temperature Trend Model

	Fit	Parameter
Background	Constant	N/A
Solar	Quadrati c	F10.7
Geomagneti c	Linear	AP
Trend	Linear	Time (years)
Cross-term	Linear	F10.7 x Time

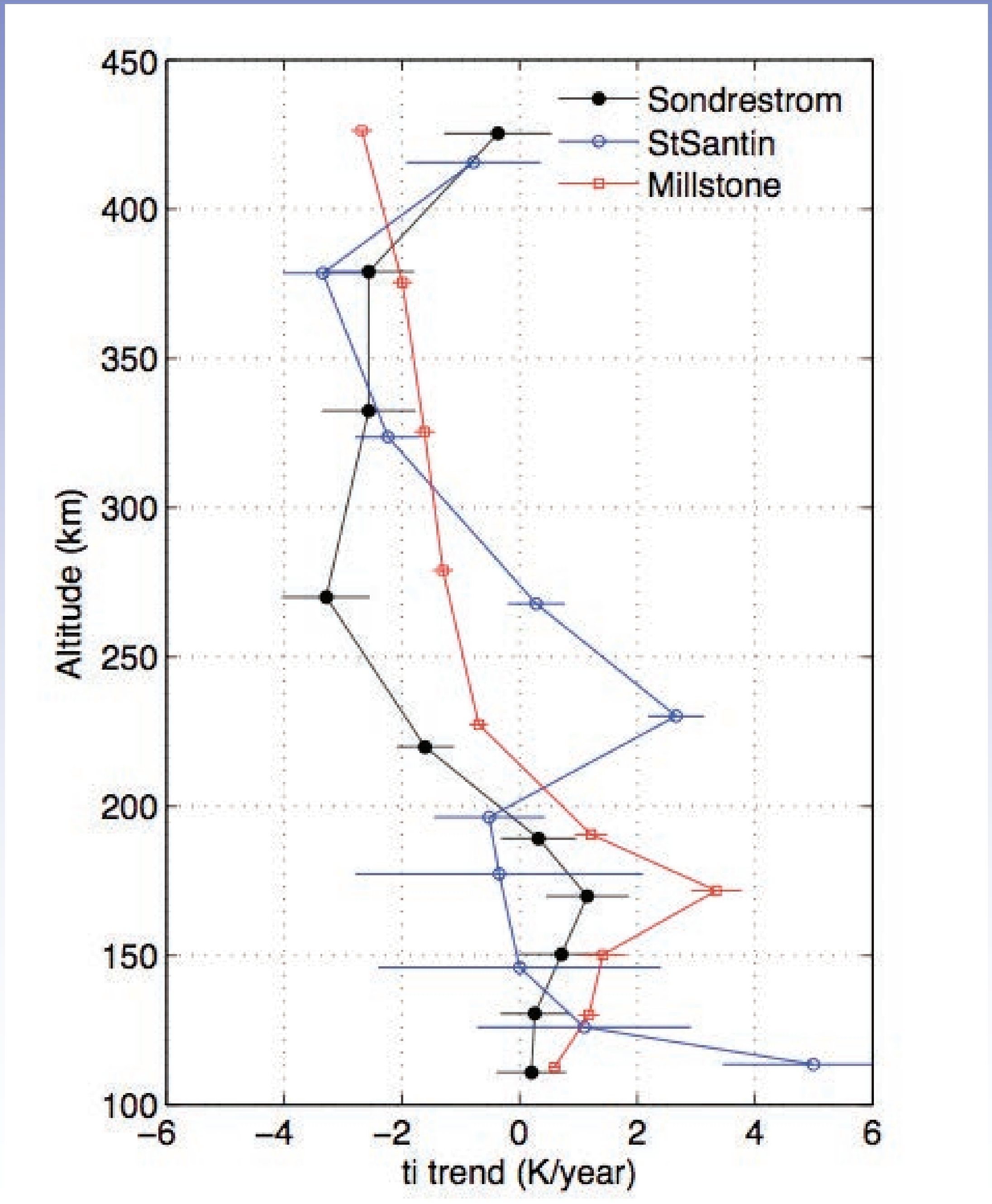
- Data from years of high AP and F10.7 was excluded
- Monthly medians were taken and fit to the trend equation



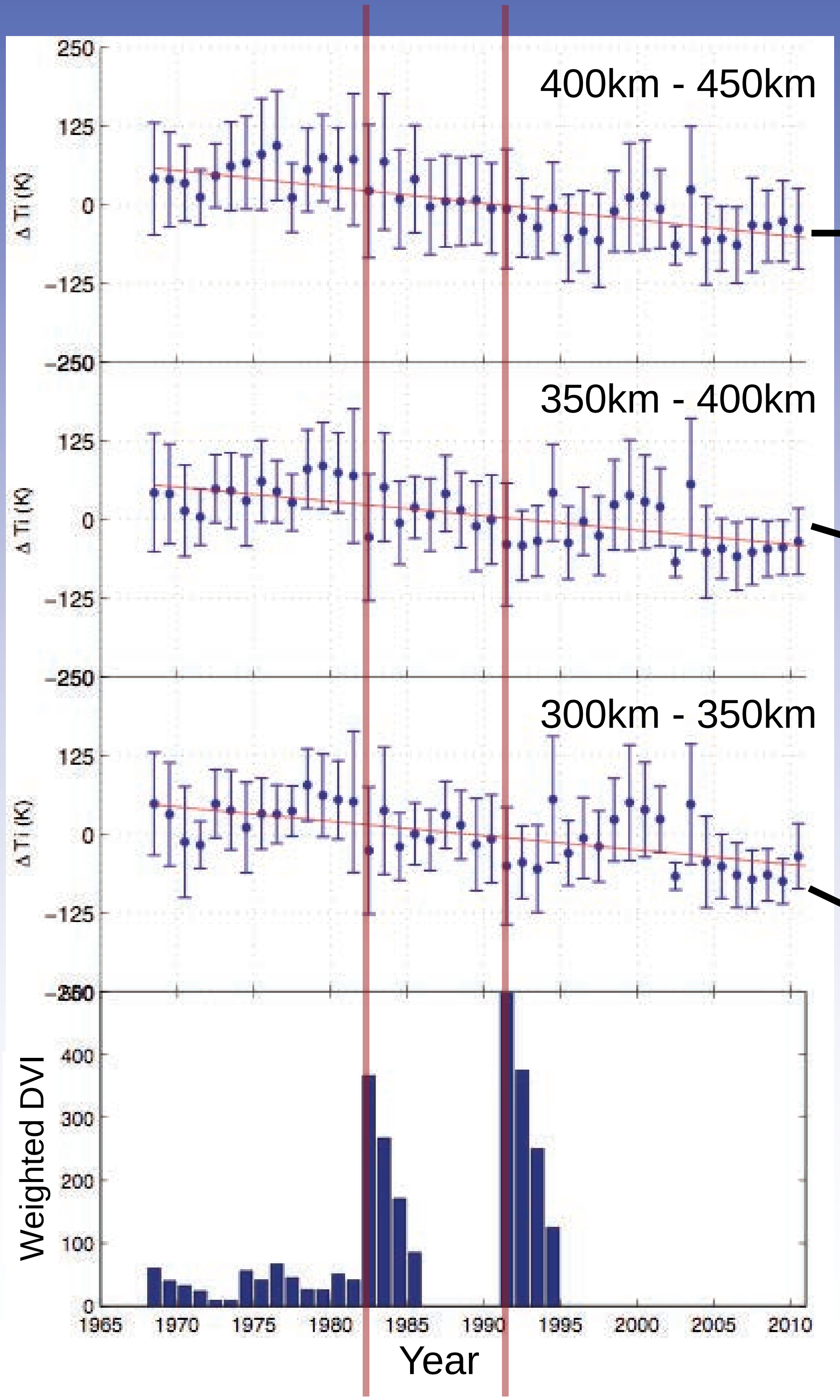
ISR Sites

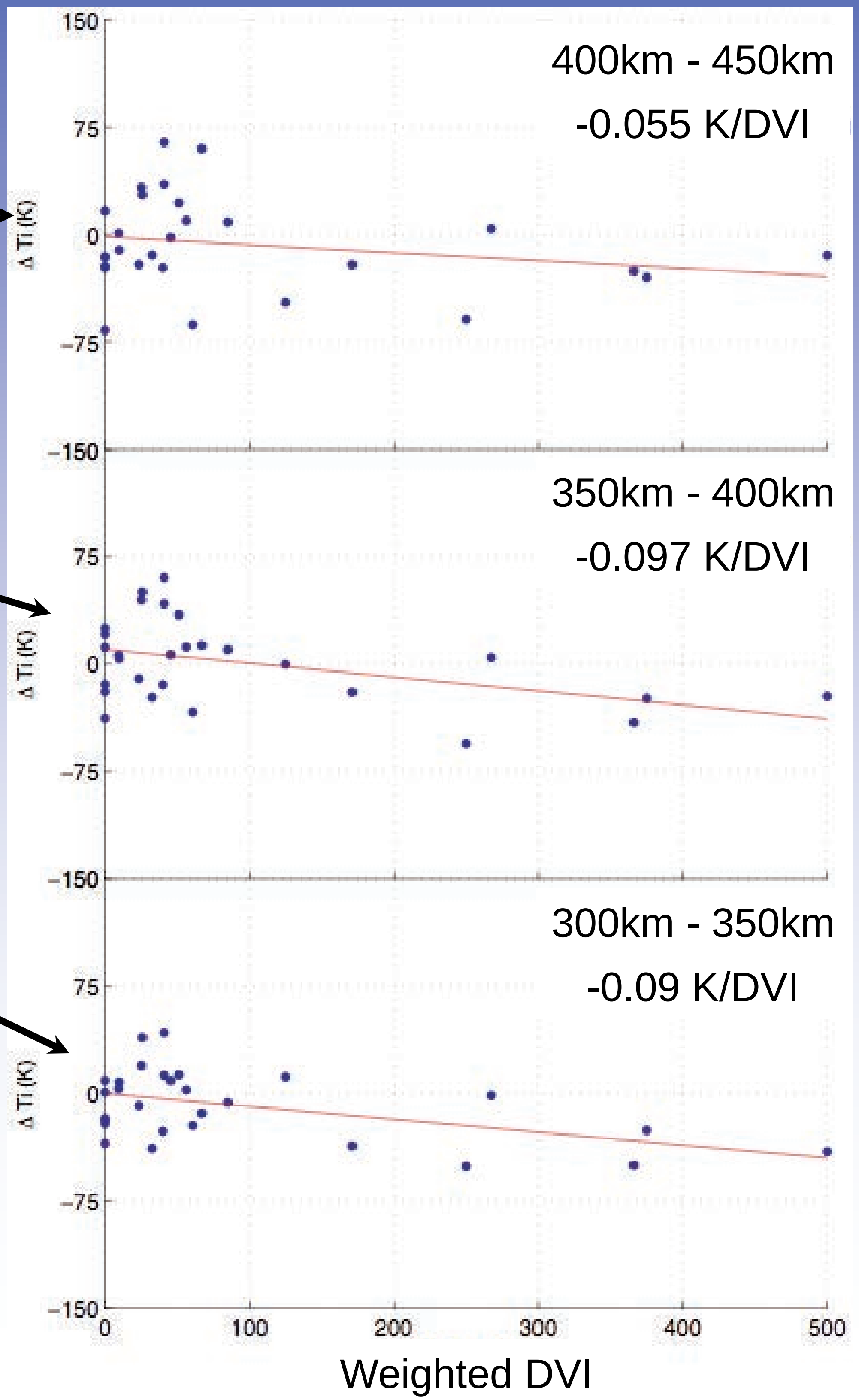
- Qualitative agreement between Sondrestrom and Millstone trends
  - Behavior agrees with expectations
- Discrepancies with St. Santin may be given by:
  - Data gaps
  - Different trend values before the mid 1980s

Daytime altitude profiles (SLT 12 ± 2.5)



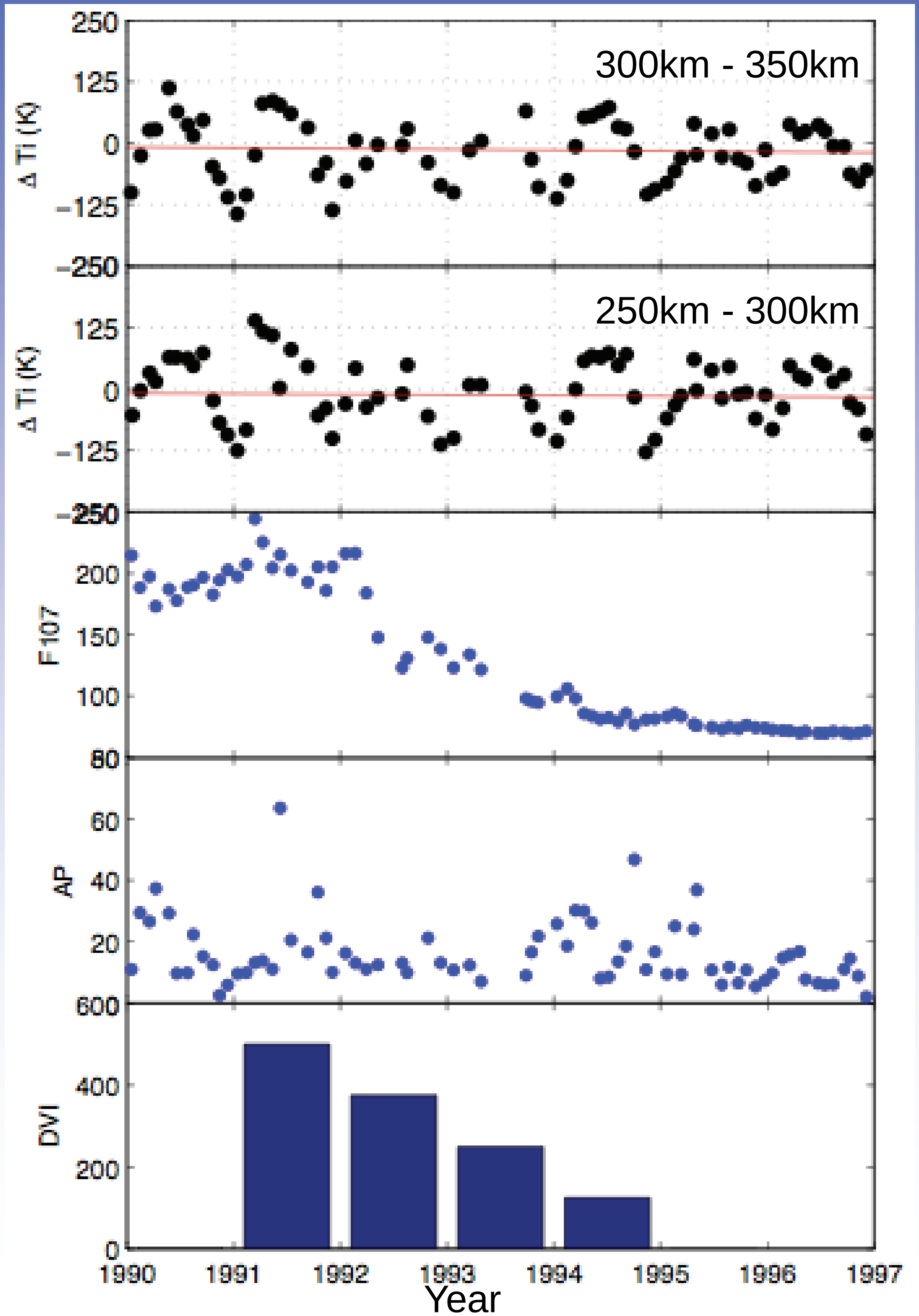
Ti residuals & DVI at Millstone





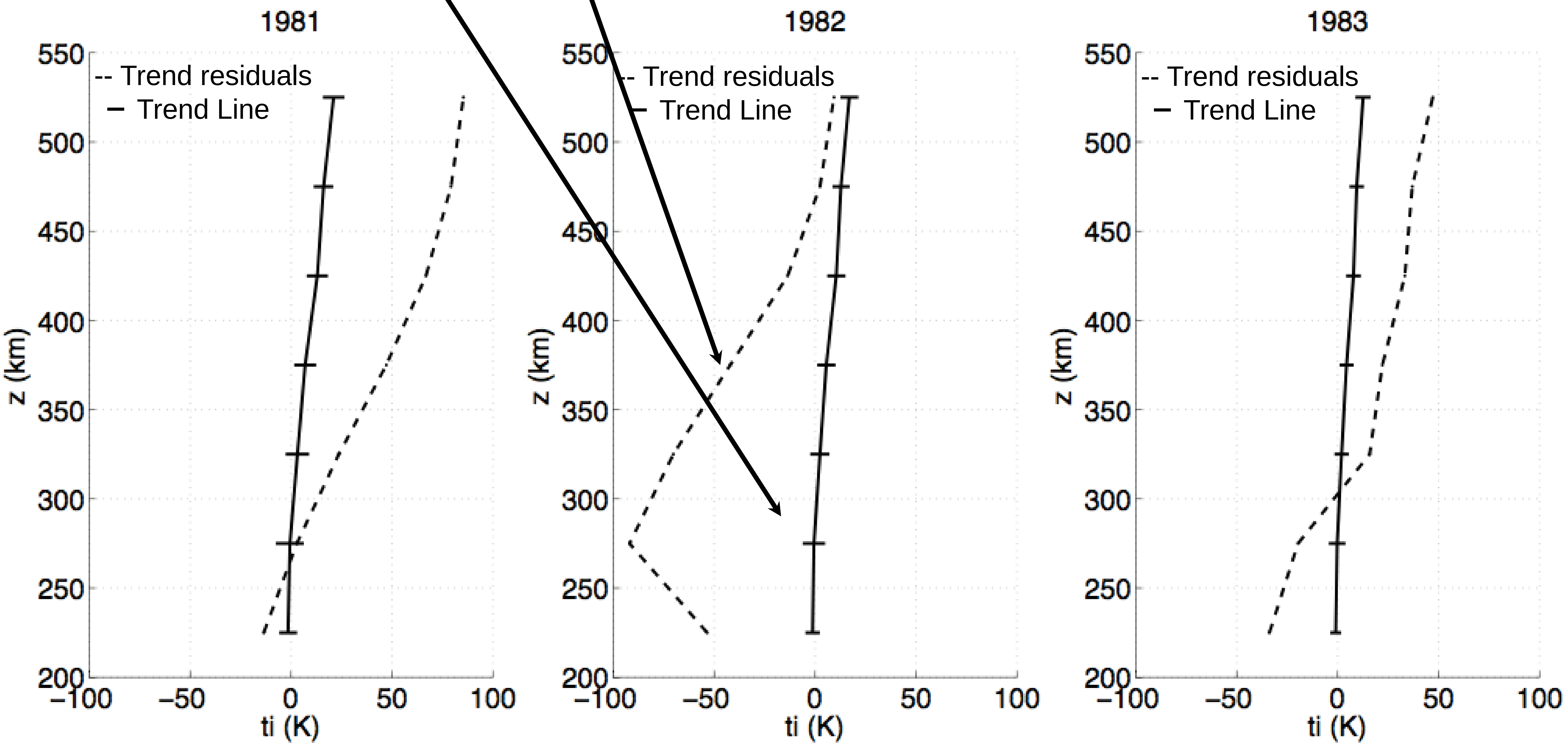
Sources of uncertainties

- Millstone Hill (right) has strong data coverage
  - Not necessarily true for Sondrestrom and St. Santin
- Causes of scatter
  - Seasonal variations (shown)
  - Diurnal variations (not shown)
  - Data gaps



Altitude Profiles at Millstone

El Chichon Eruption



Summary Table

	ISR Site	Time Delay(years)	Residuals (K) at	
			275km	425km
El Chichon	Millstone	0	-91 ± 183	-16 ± 148
	St. Santin	0	-82 ± 43	N/A
Pinatubo	Millstone	2	-45 ± 68	-61 ± 79
	Sondrestrom	3	1 ± 84	41 ± 156

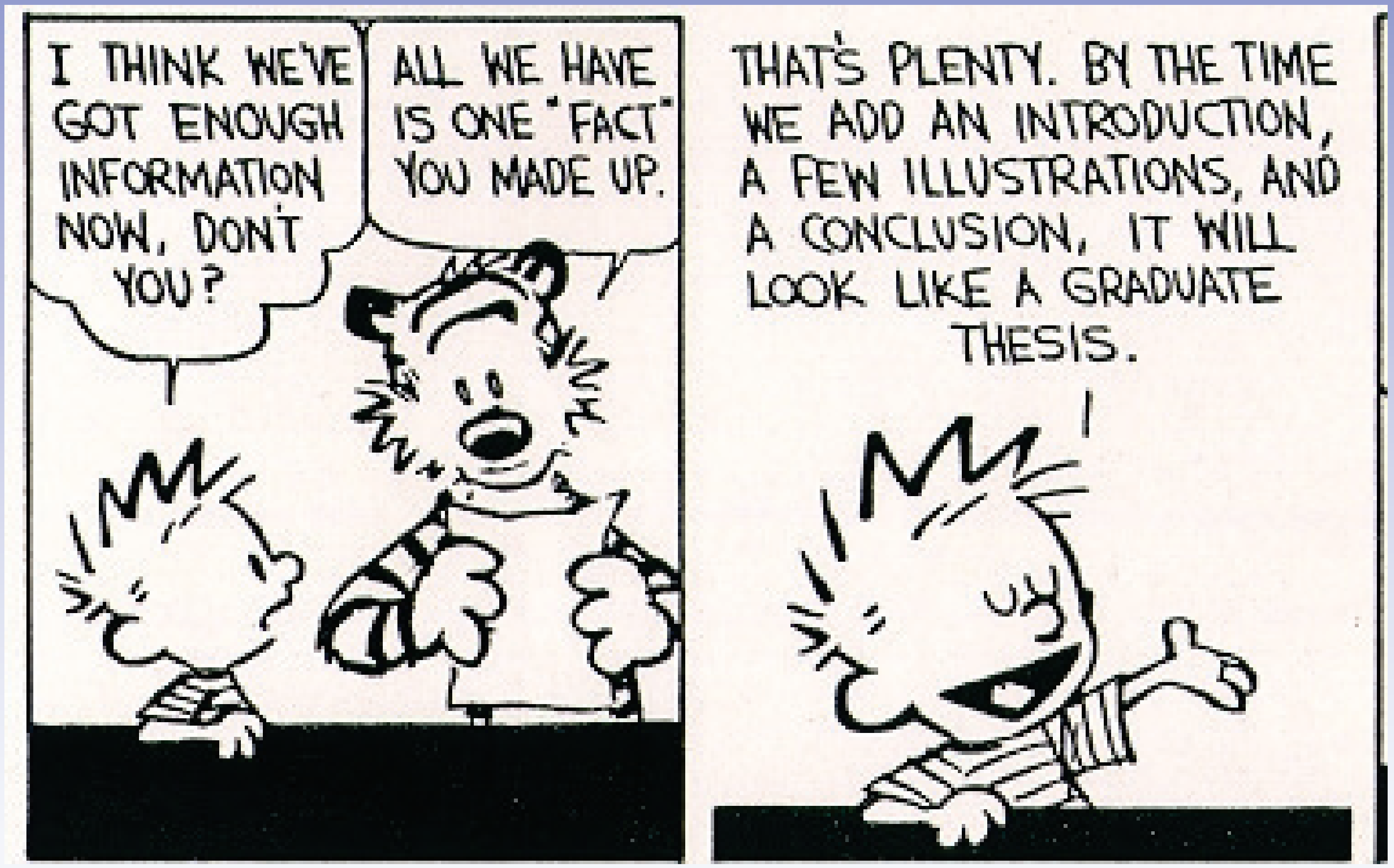
Conclusions

- Small potential variations can be seen from volcanic activity
  - Potential effects from El Chichon can be seen in St. Santin and Millstone Hill
  - Potential effects from the Pinatubo eruption can be seen in Millstone Hill, but not as clearly in Sondrestrom
  - Satellite drag data had small dips corresponding to the eruptions, but geomagnetic activity overshadowed residuals
- Future work needs to be done on refining model and testing the significance of these events
- Bigger question is what are the theoretical effects of volcanic activity at these altitudes?

Acknowledgements

- Shunrong Zhang and John Holt
- KT Paul, Phil Erickson, Vincent Fish, and Heidi Johnson
- Everyone at MIT Haystack
- The other REU Students

Questions?


I THINK WE'VE GOT ENOUGH INFORMATION NOW, DON'T YOU?
ALL WE HAVE IS ONE "FACT" YOU MADE UP.
THAT'S PLENTY. BY THE TIME WE ADD AN INTRODUCTION, A FEW ILLUSTRATIONS, AND A CONCLUSION, IT WILL LOOK LIKE A GRADUATE THESIS.

References

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Appendix

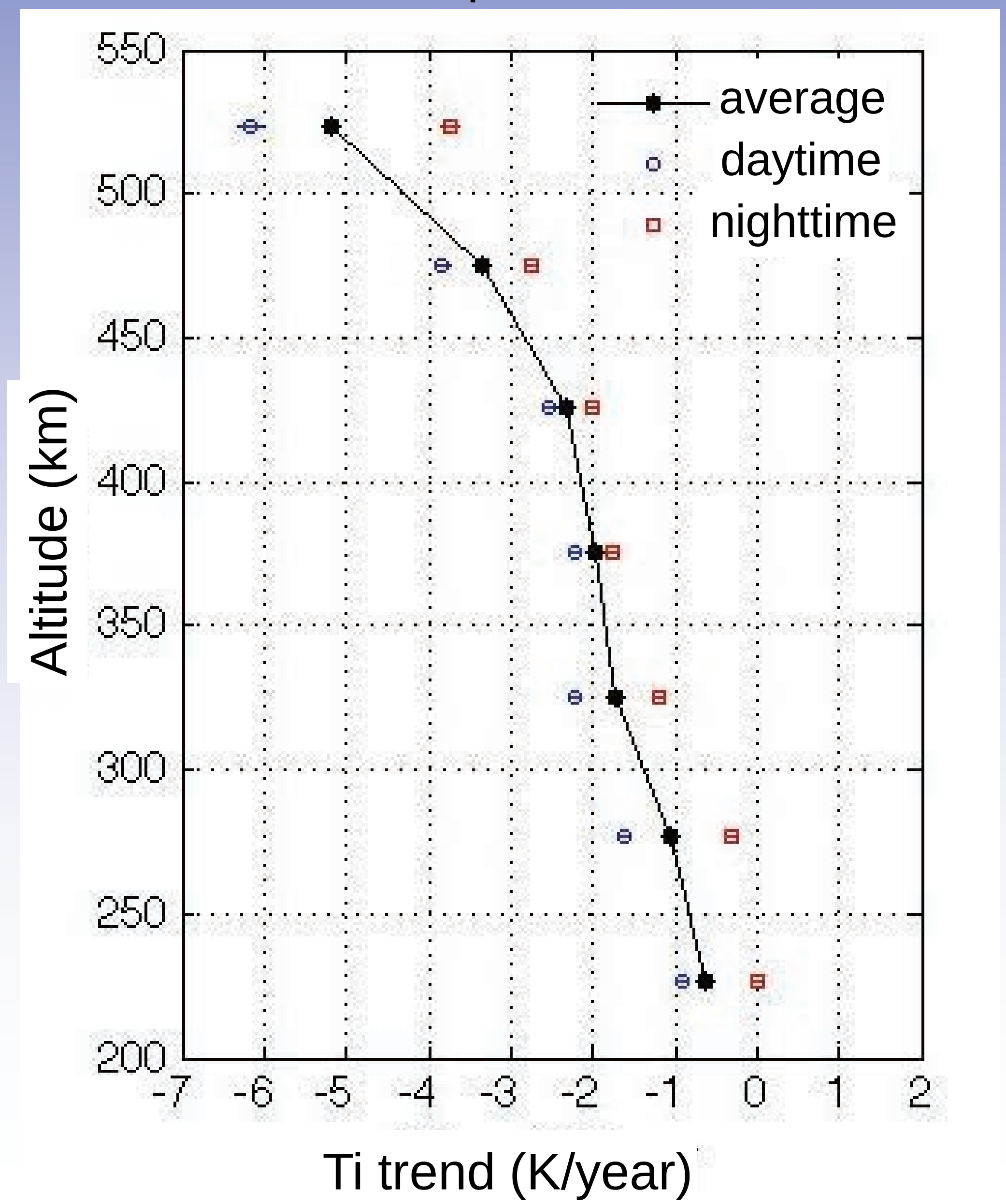
Spline Fitting

- Instead of binning by altitude and time, modes are integrated over a month to find a median
- Then, a spline fit is applied to nodes on the altitude vs. Ti graph and a continuous plot is made
- Since there is no binning of data, seasonal terms may be added

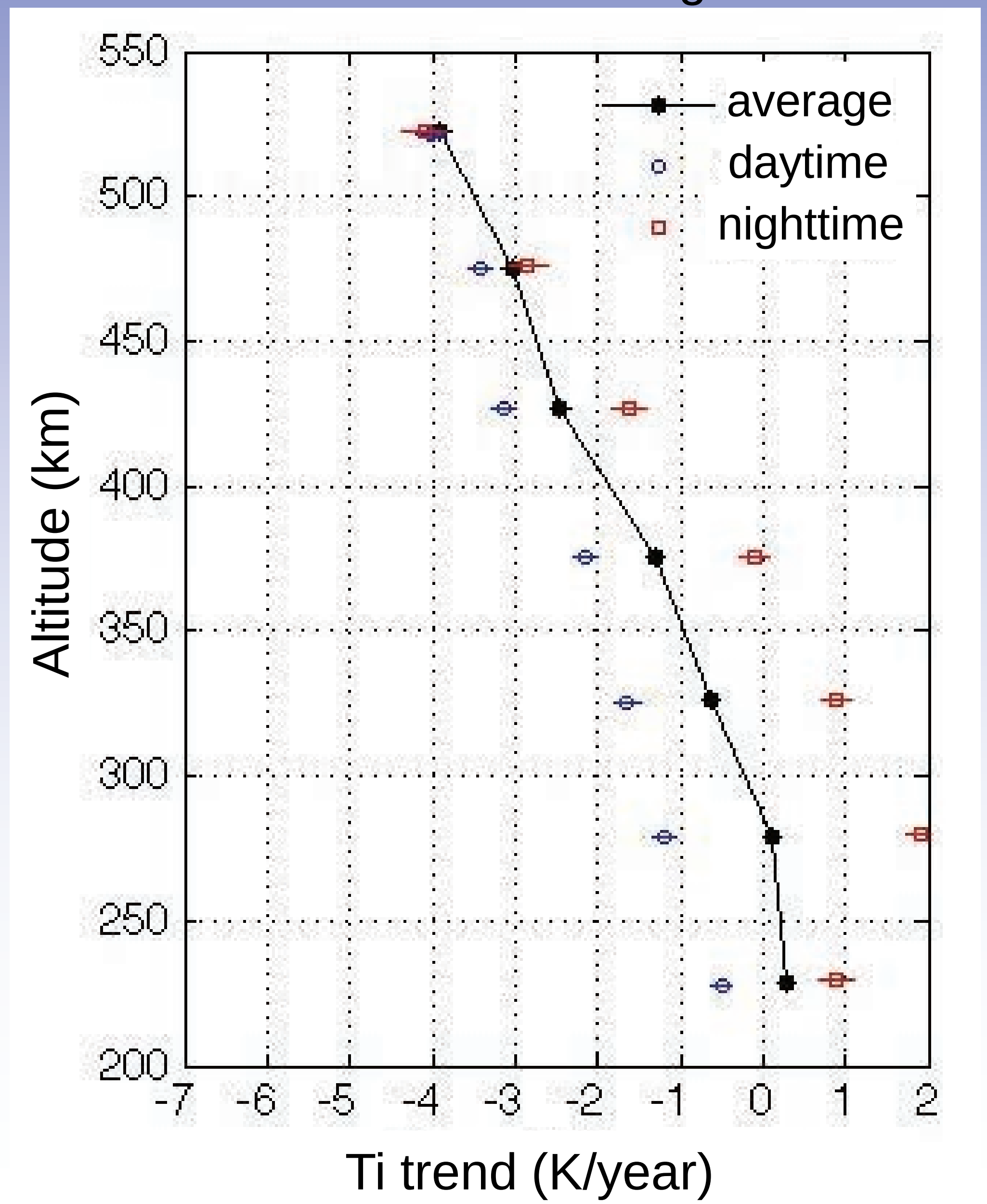
$$T_i = A + b(Y - \overline{Y}) + c(F - \overline{F}) + d(F - \bar{F})^2$$
$$e(AP - \overline{AP}) + +d\sin(2\pi t) + e\cos(2\pi t) + f\sin(2\pi t) +$$
$$g\cos(4\pi t) + h(F * t)$$

Spline fit vs. Median Binning

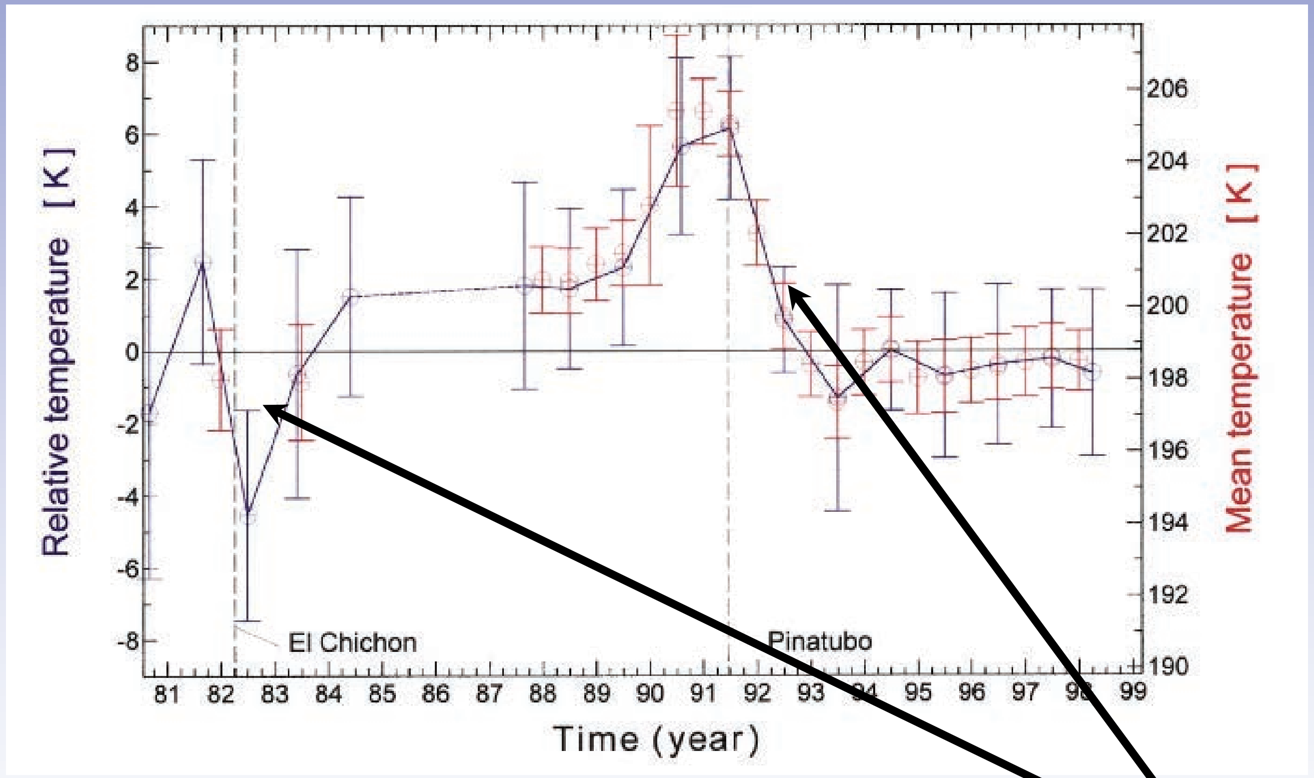
Spline Fit



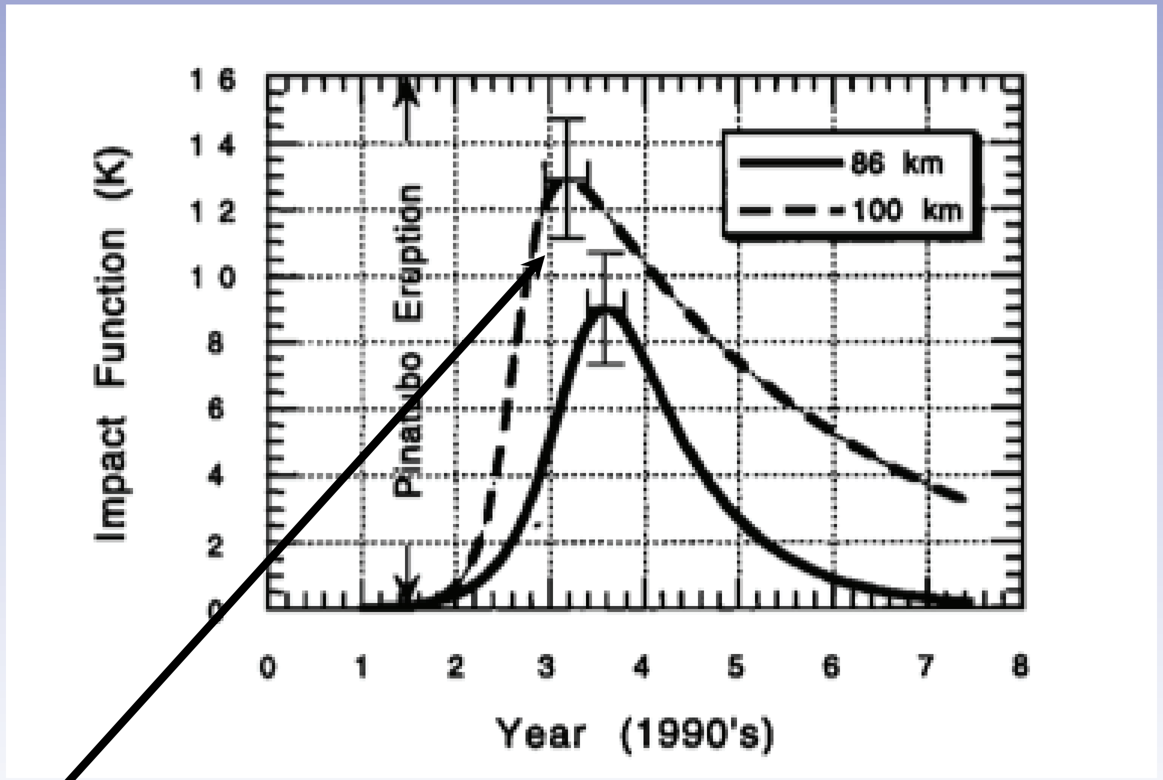
Median Binning



Effects in the MLT Region



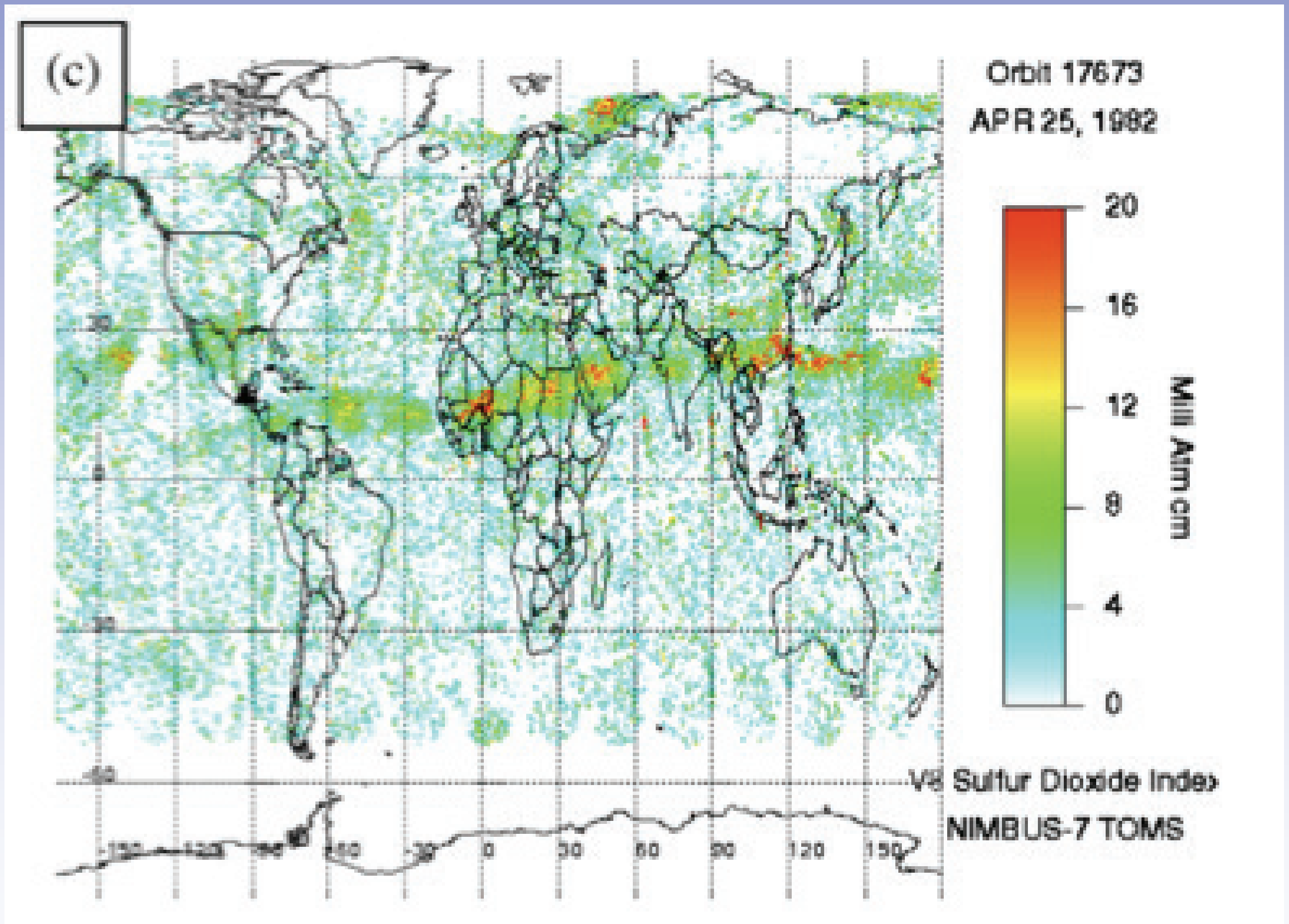
Bittner et. al (2002)



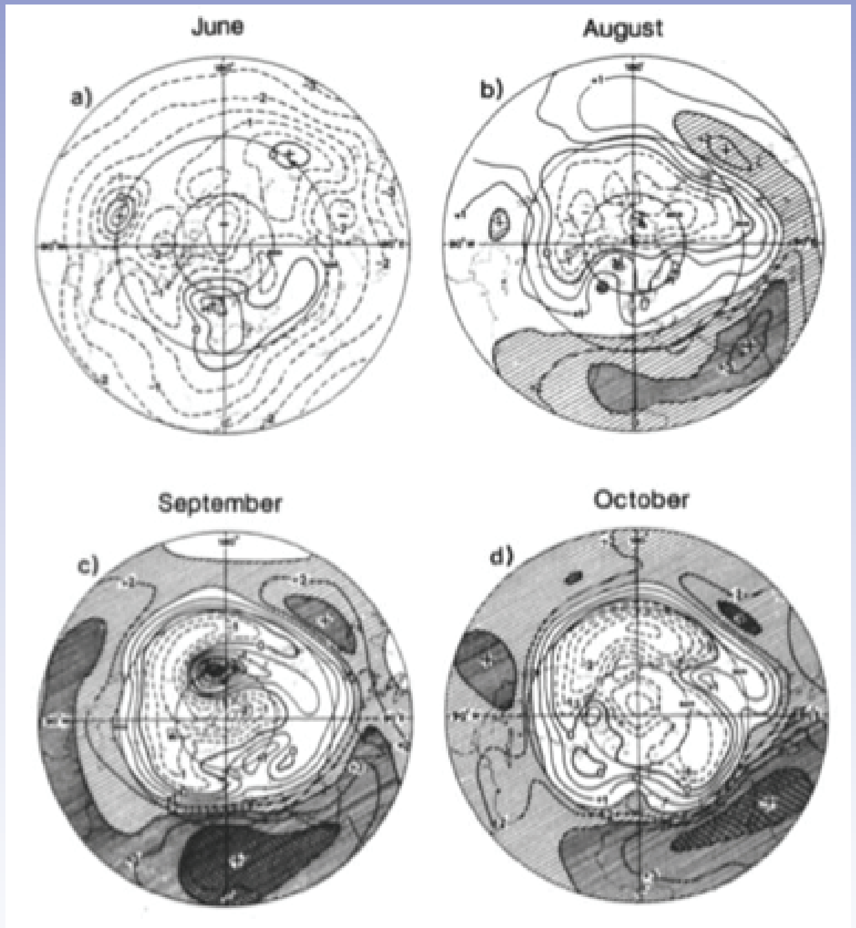
She et. al (1998)

INCONSISTENT!

Propagation of Aerosols

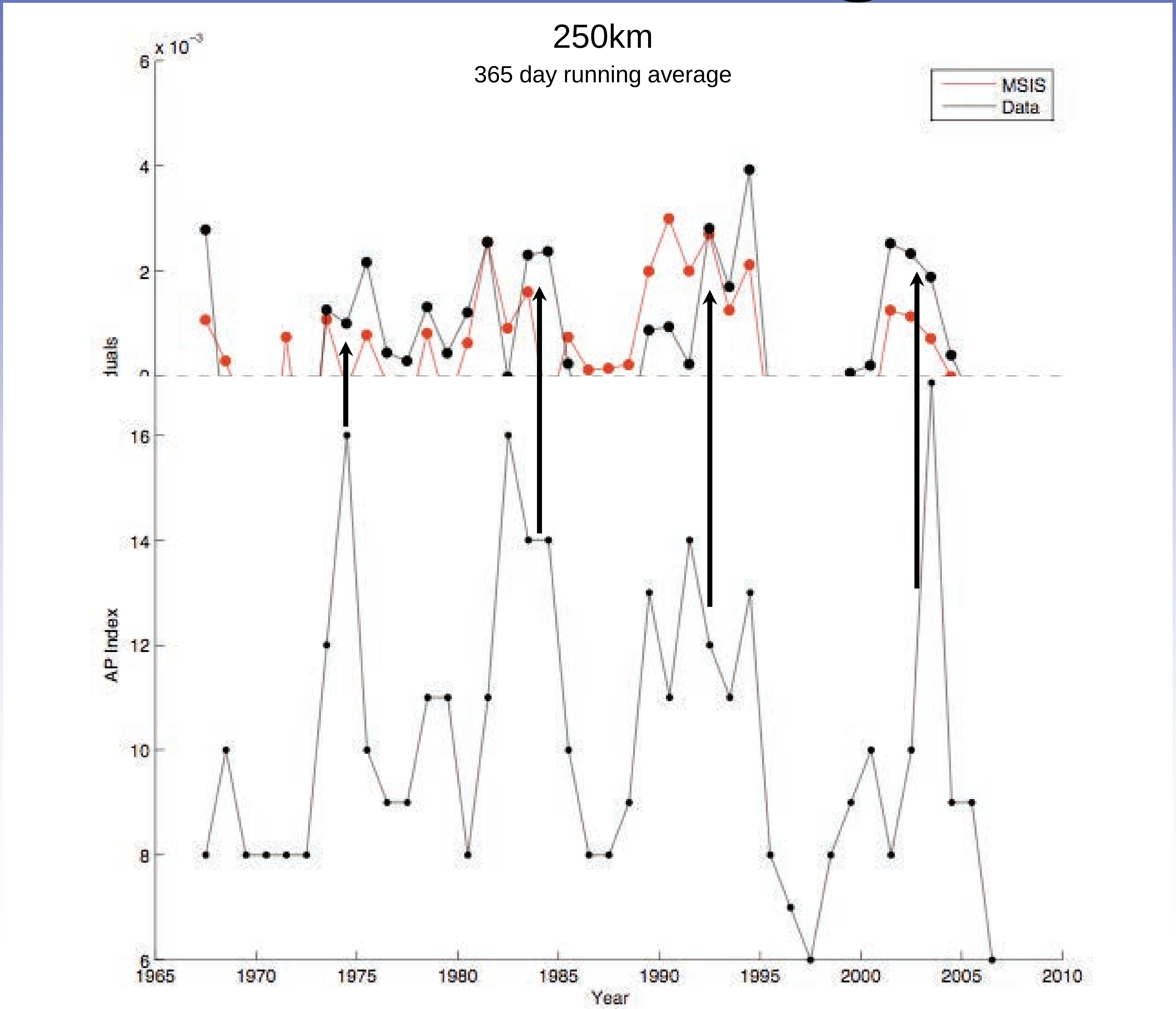


Krueger et. al (2008)



Labitzke & McCormick (1992)

Satellite Drag Data



Pinatubo Eruption Profiles