Terahertz Radiometry, Radiosonde, and Decadal trends in winter time S.P. precipitable water vapor

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Why study w.v. at the South Pole?

- Precipitation rate in Antarctica is linked to saturation water vapor pressure.
- Precipitation rates onto the Antarctic ice sheet affect the global mass balance of water.
- S.P. is the only interior Antarctic station with continuous upper air reporting since the late 1950s.
- Radio astronomy site (our original motivation)

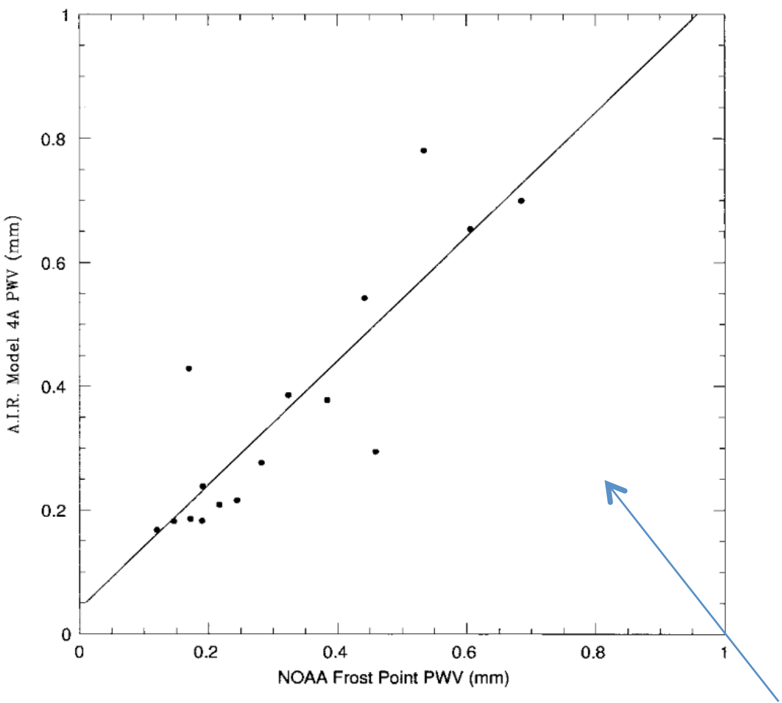
Older radiosondes types generally do not measure humidity well in extremely cold conditions.

Older types used:
VIZ, A.I.R. Model 3A, 4A, 5A
Visiala RS 80, RS 90

Current type: Vasiala RS-92

Can any of the old data be of use?

A.I.R. Model 4A (1991-1996) compared to the NOAA frost point hygrometer



Slope = 1.0
Intercept = 0.04

A.I.R. Model 4A compared to ground based mm-wave radiometry (1992)

Cross calibration of radiosonde and 230 GHz radiometry

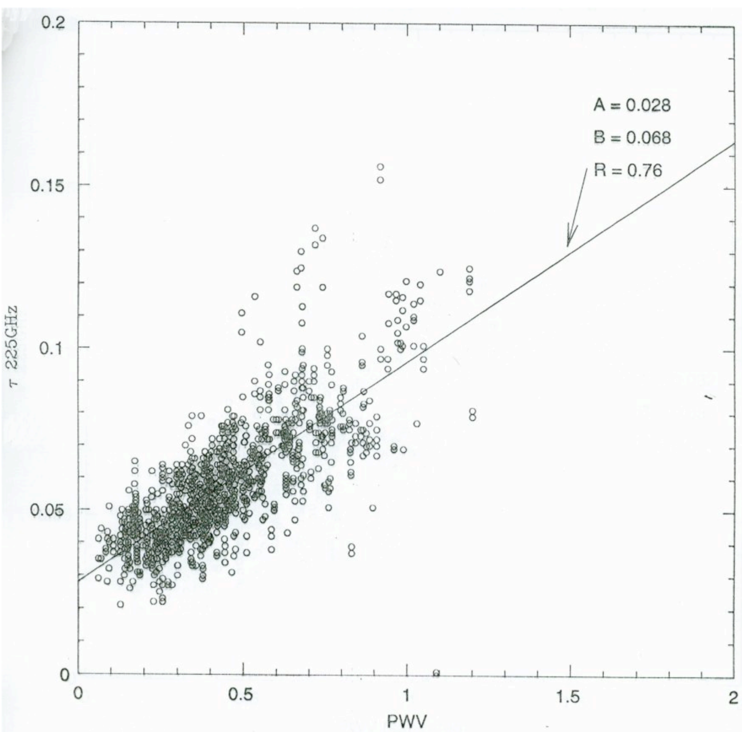


Figure at left used to express τ_0 as PWV. The result is compared to independent NOAA frost Point hygrometer (circles).

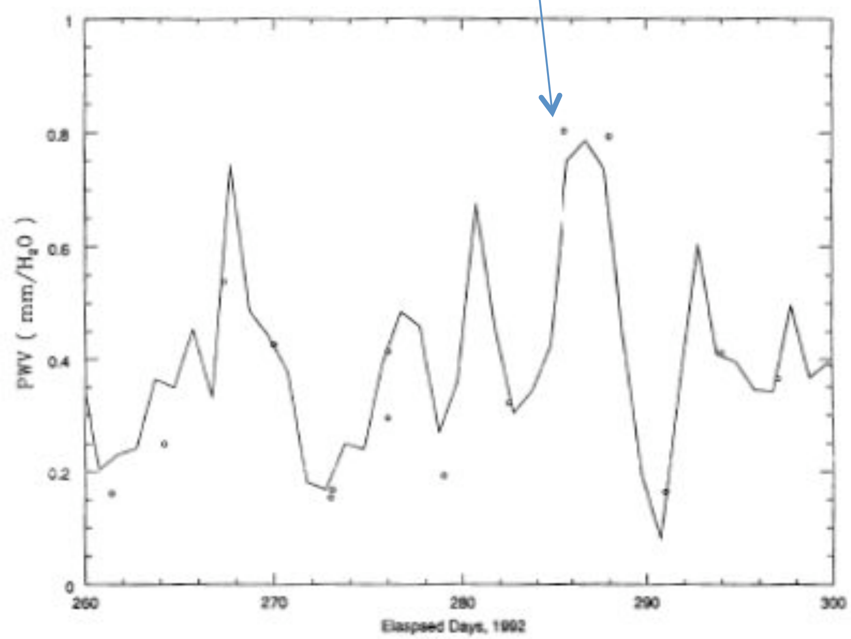


Figure 5: *PWV* derived from τ versus elapsed days (solid line). Also shown are the *PWV* derived from NOAA ozonesonde observations (open circles). The *PWV* derived from τ were based on daily averages of τ and were calibrated from comparison to routine upper air observations as described in the text and shown graphically in Fig. 3. The *PWV* derived from NOAA ozonesondes (open circles) were independent measurements.

Model 4A compared to sub-mm radiometery (1995)

Cross calibration of radiosonde and 493 GHz radiometry

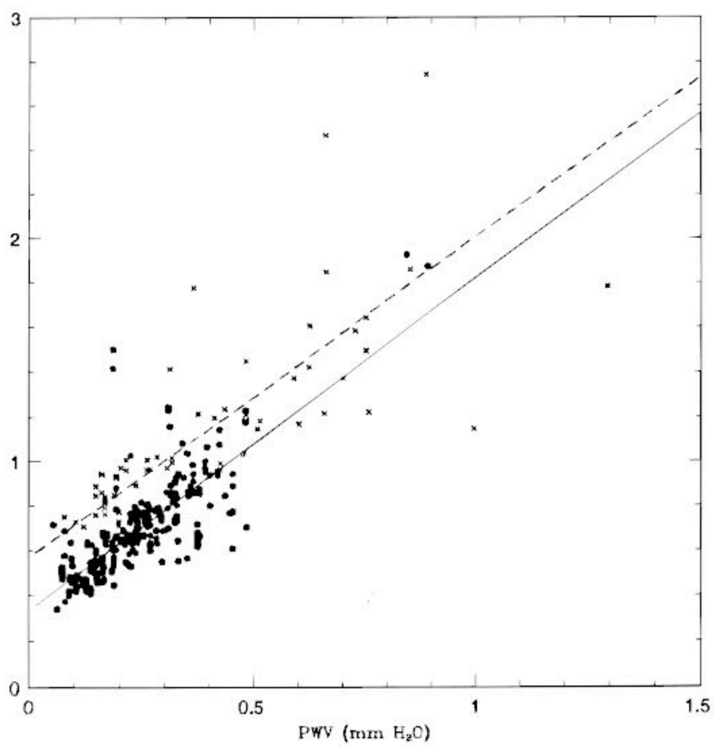
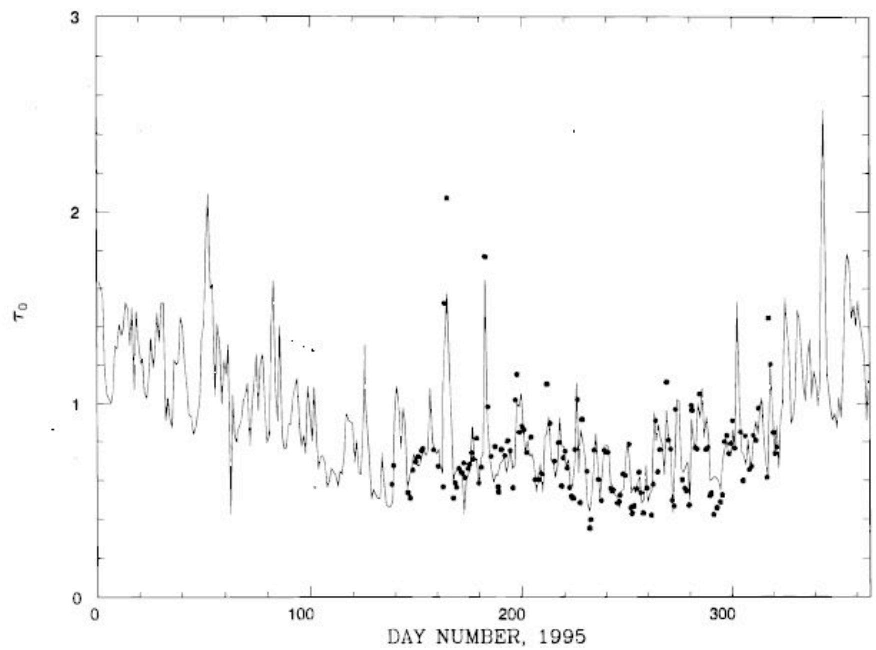


FIG. 4.—492 GHz zenith opacity, obtained from AST/RO skydip measurements, plotted as a function of precipitable water vapor, as determined by balloon radiosonde. *Crosses*: 490.66 GHz opacity; *dashed line* is the best fit of eq. (5), with $a = 0.57$, $b = 1.44$. *Solid circles*: 493.66 GHz opacity; *solid line* is the best fit of eq. (5), with $a = 0.33$, $b = 1.49$.



Solid line: τ_0 from radiosonde

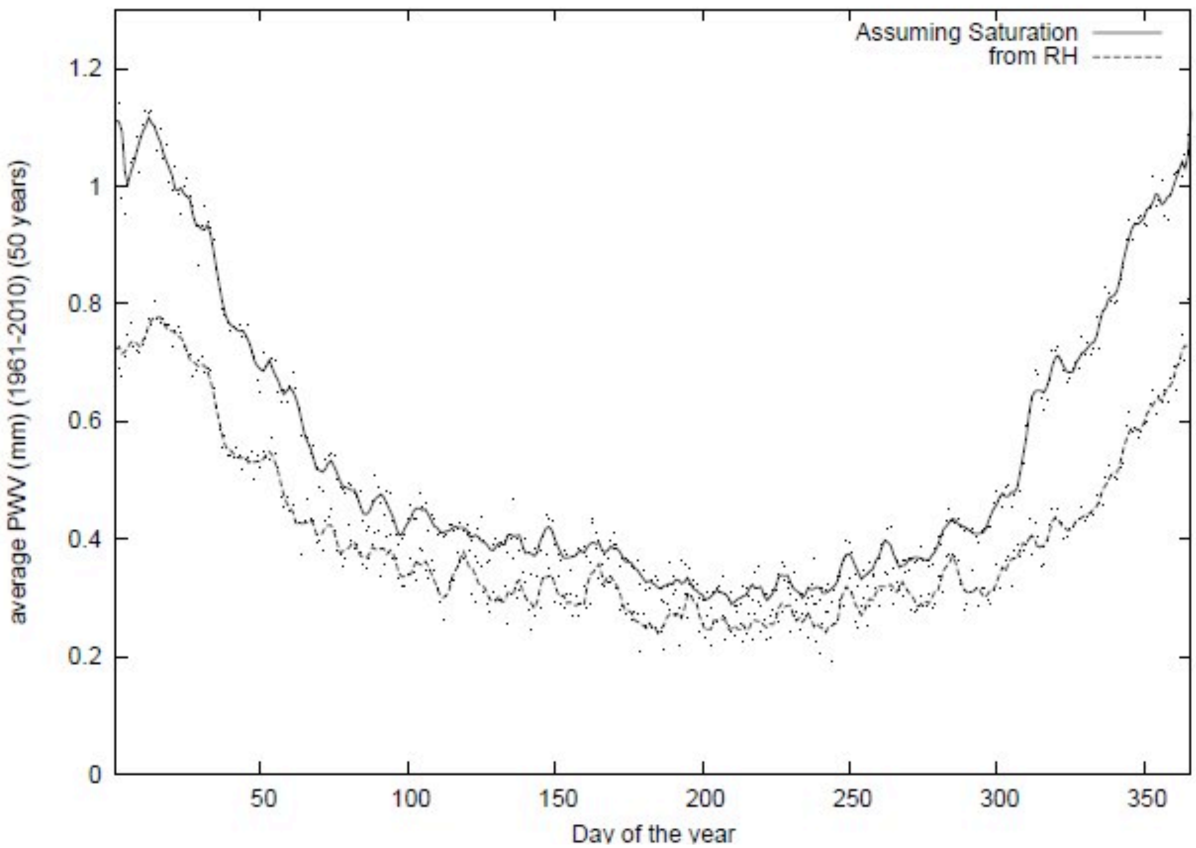
Dots: τ_0 from radiometry

Validation of A.I.R Model 4A for measuring PWV (used 1991-1996)

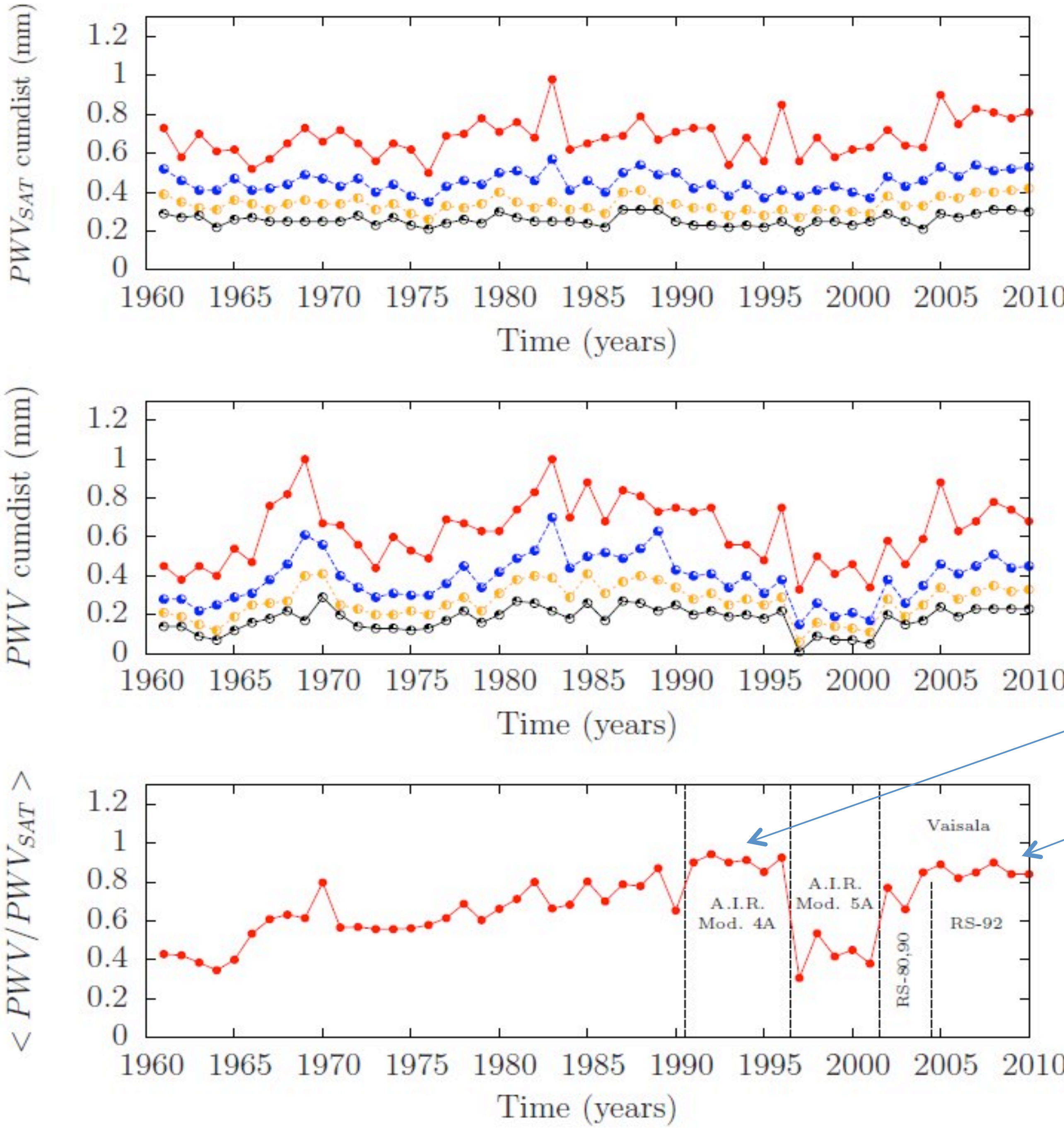
1. Comparison to NOAA frost point hygrometer showed that A.I.R. Model 4A was responsive to PWV and calibration was surprisingly good.

2. Radiometry independently showed that A.I.R. Model 4A was responsive to PWV.

Lower Atmosphere generally near saturation in winter time



Since the winter time atmosphere is near to saturation, the temperature profile can be used infer PWV as follows.....

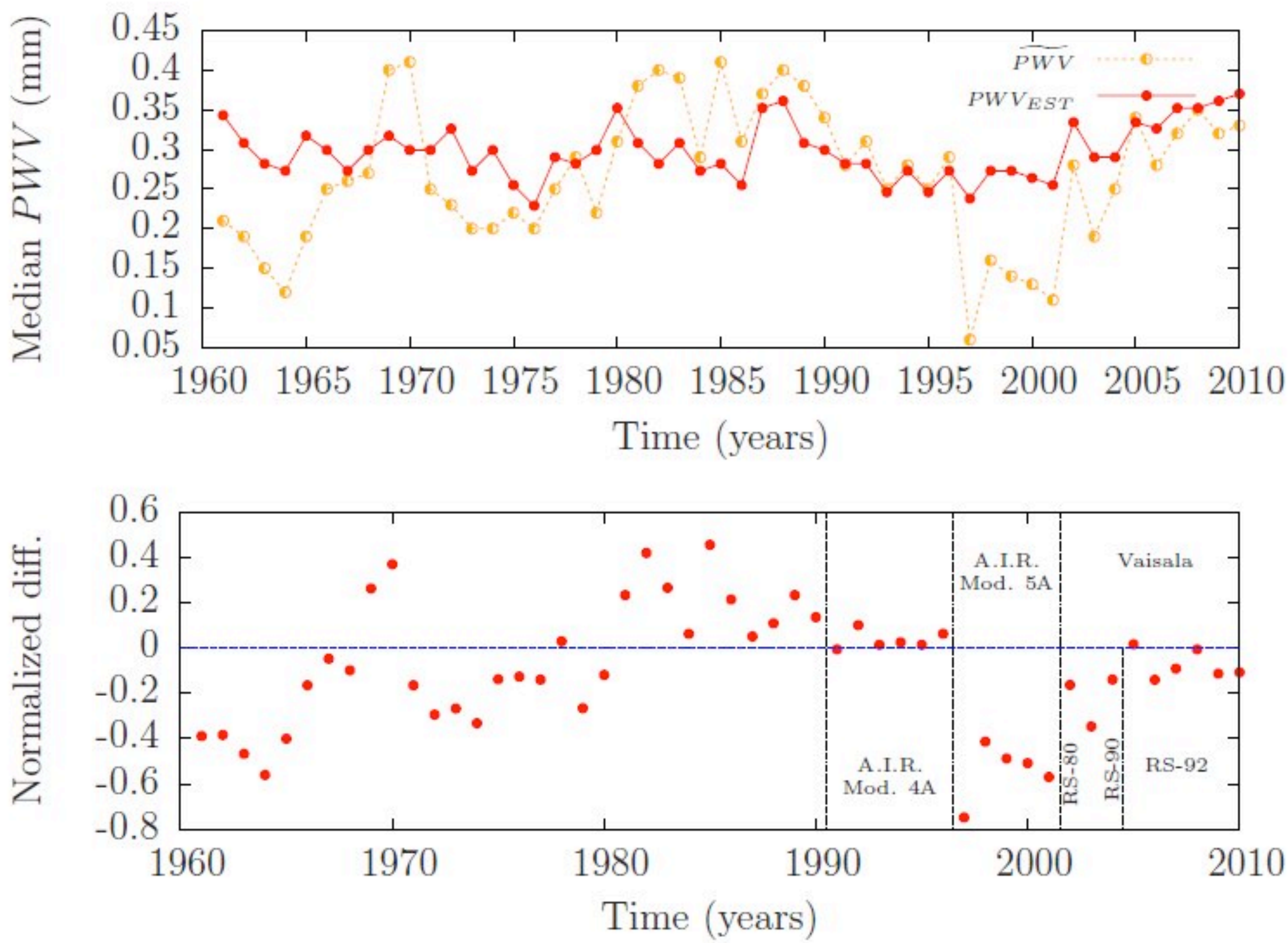


Red: 95th percentile
Blue: 75th percentile
Gold: 50th per. (Median)
Black: 25th percentile

Ratio = 0.91

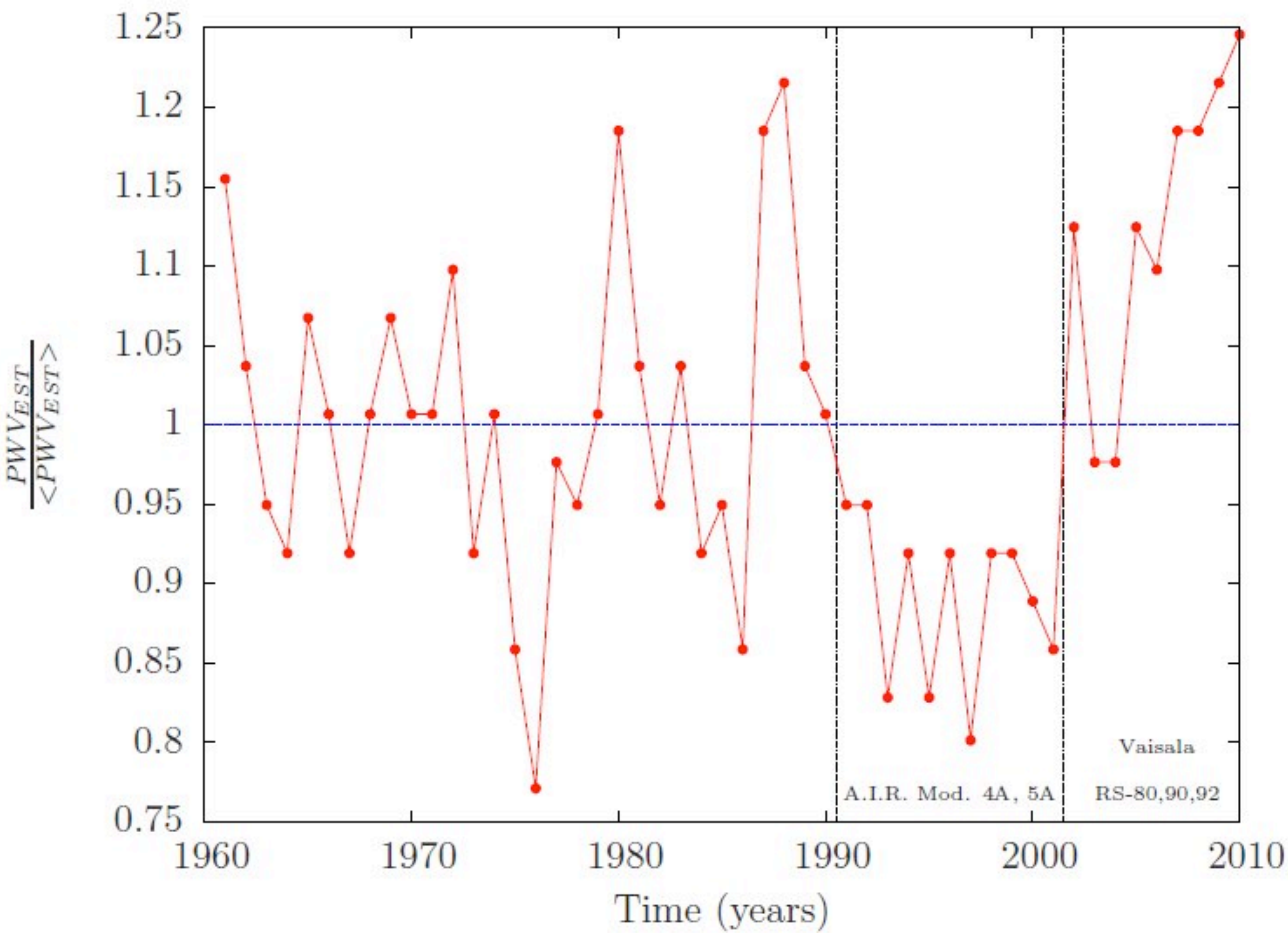
Ratio = 0.86

PWV_est = 0.88 * PWV_sat (Red line)

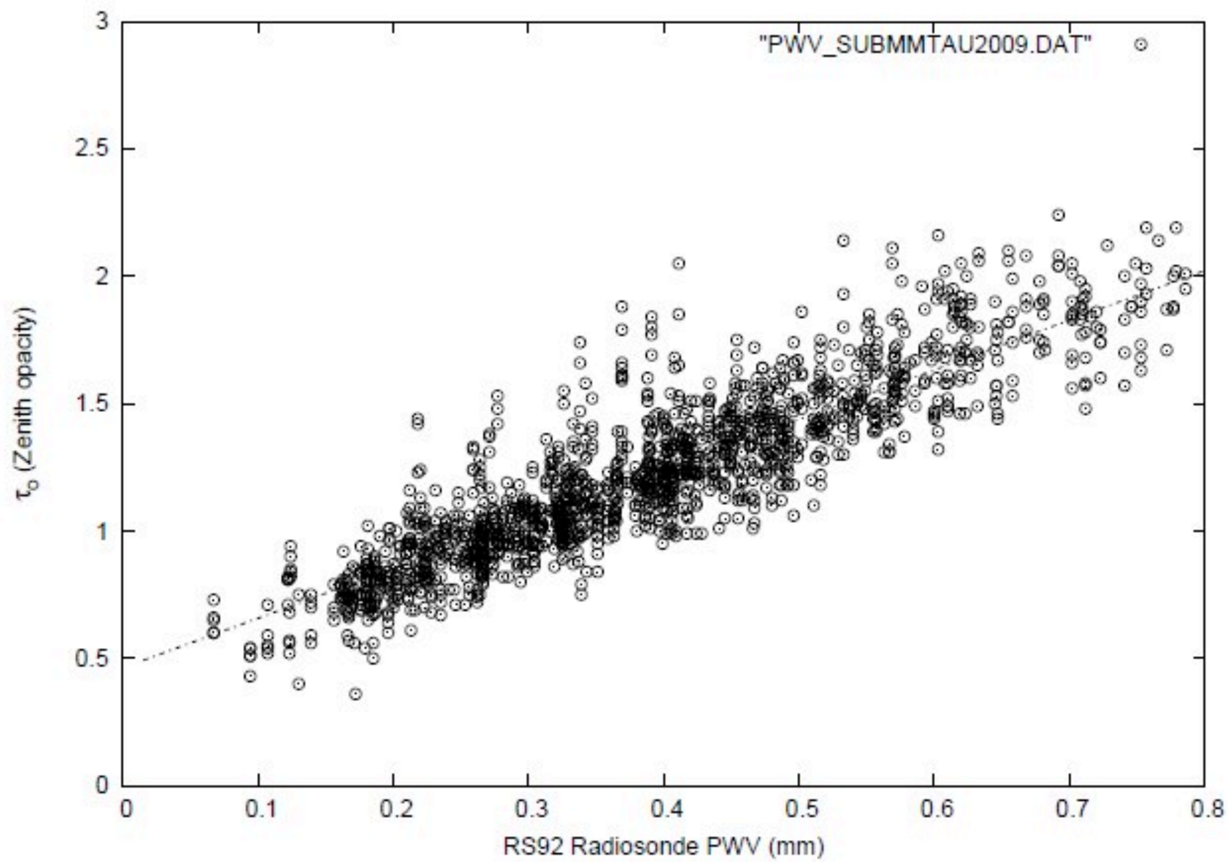


Normalized Diff = (PWV – PWV_est)/<PWV_est>, <PWV_est> = 50year Av

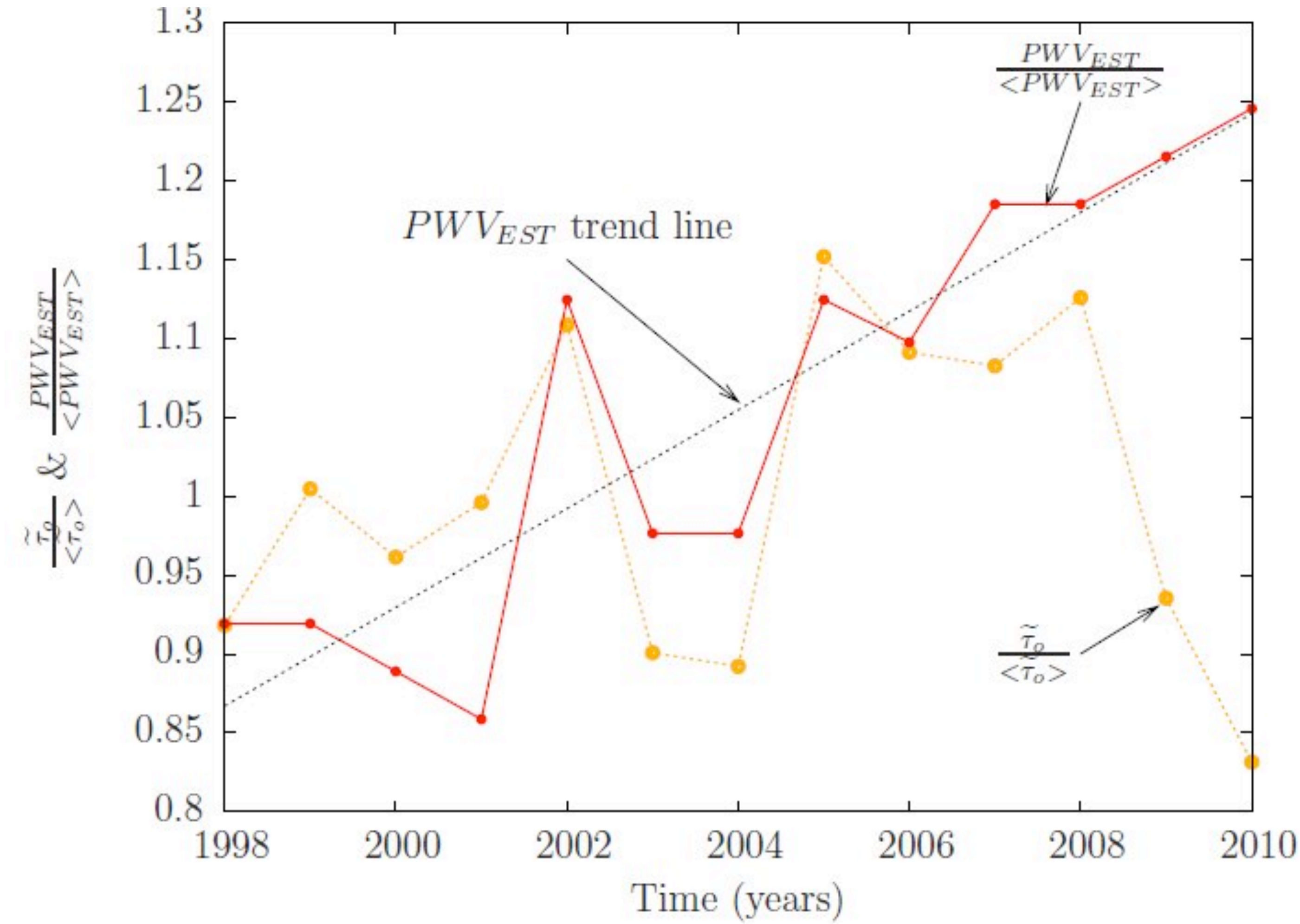
Decadal trends inferred from PWV_est



Radiometry at 960GHz ($\lambda = 0.37$mm) performed from 1998 to 2010



Radiosonde (red) & 960GHz radiometer data (gold)



Conclusions

A.I.R Model 4A (1991 - 1996) probably could reliably measure PWV.

PWV_est = 0.88 * PWV_sat can be a useful rule of thumb for estimating winter time PWV.

PWV_est could provide a cross check/ reality check on winter time Radiosonde hygrometer derived PWV and radiometer performance.

Both PWV_est and 850GHz τ_o(thru 2008) indicate a recent increasing trend in PWV.

References…

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Applied Optics, **1994***, 33*, 1095-1099

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