Using the Crosspolar Power Technique for Zdr Calibration for S-Pol During PECAN

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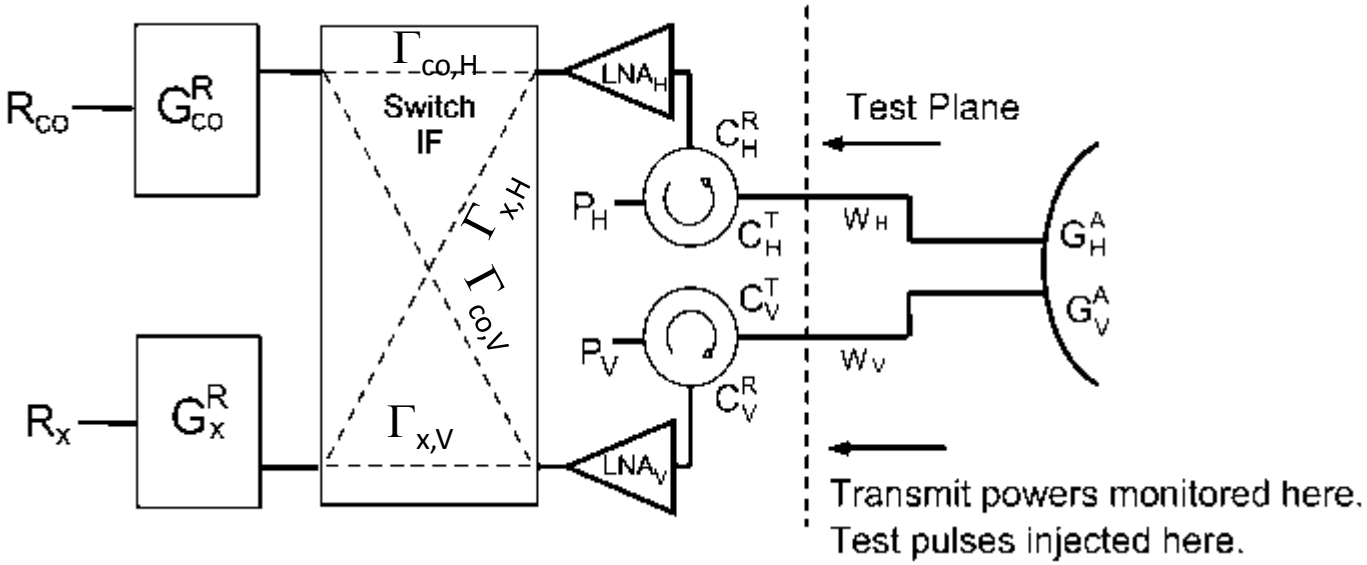
S-Pol Block Diagram



CP Z_{dr} Calibration

Z_{dr} intrinsic

$$Z_{dr}^{m} = \frac{P_H C_H^T W_H^2 (G_H^A)^2 C_H^R G_H^R \mathbf{G}_{xo,H} \left\langle |S_{HH}|^2 \right\rangle}{P_V C_V^T W_V^2 (G_V^A)^2 C_V^R G_V^R \mathbf{G}_{xo,V} \left\langle |S_{VV}|^2 \right\rangle}$$

Bias

Crosspolar powers

Tx power, Circulator V, Tx, Circulator H, receive, Switch, H to cross

$$\frac{R_{HVHV}}{R_{VHVH}} = \frac{P_V C_V^T C_H^R \mathbf{G}_{x,H} \left\langle |S_{HV}|^2 \right\rangle}{P_H C_H^T C_V^R \mathbf{G}_{x,V} \left\langle |S_{VH}|^2 \right\rangle}$$

transmit power, receiver

Sun measurement

Waveguide V, Antenna gain V, Circulator V, receive

$$S_1 S_2 = \frac{(W_V G_V^A C_V^R)^2 \mathbf{G}_{x,V} \mathbf{G}_{xo,V}}{(W_H G_H^A C_H^R)^2 \mathbf{G}_{x,H} \mathbf{G}_{xo,H}}$$

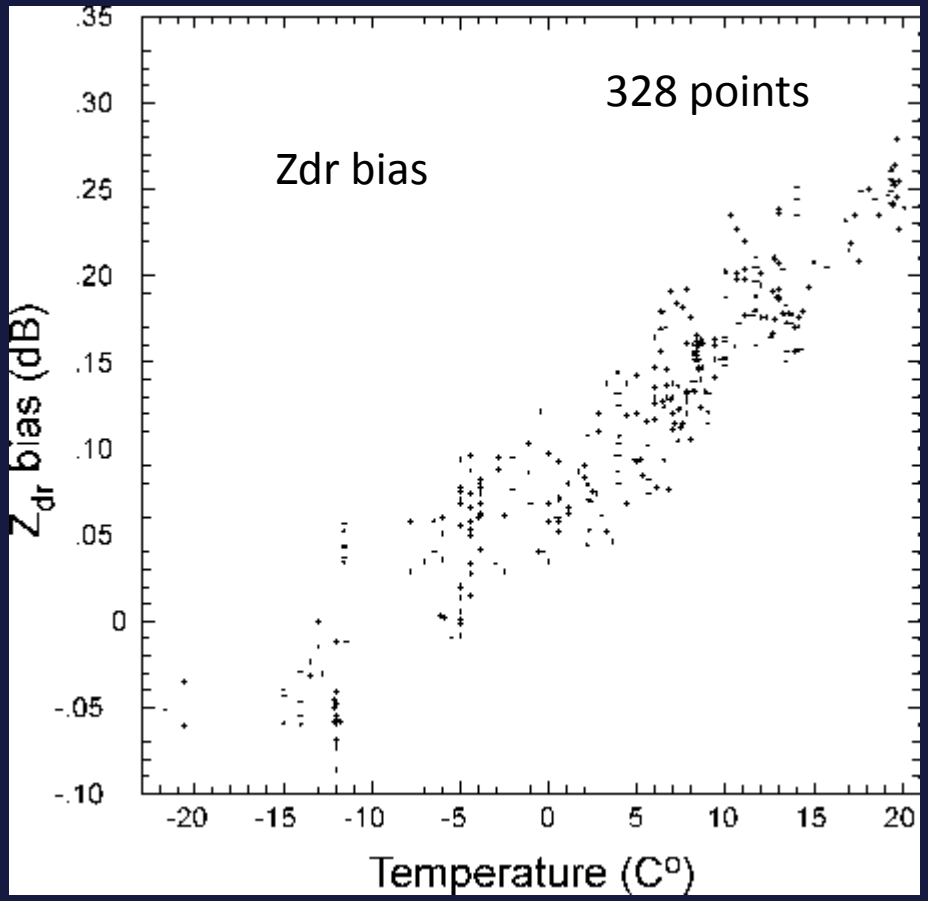
antenna and receiver

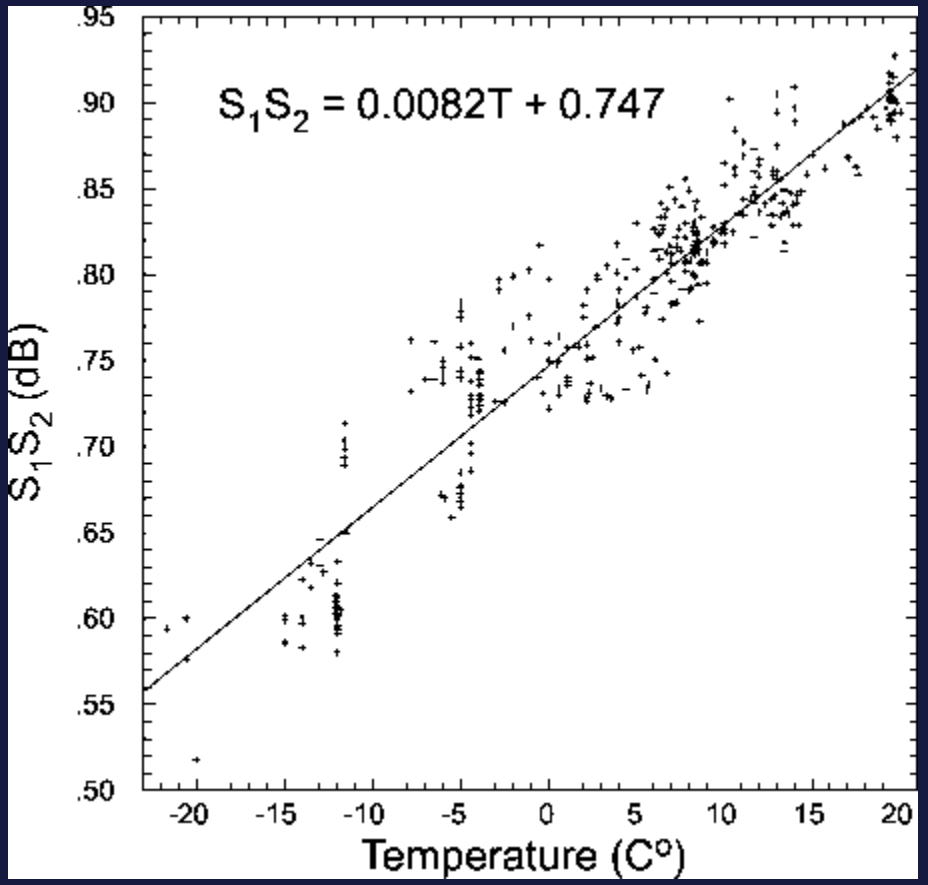
$$Z_{dr} = Z_{dr}^{m} S_1 S_2 \frac{R_{HVHV}}{R_{VHVH}}$$

Zdr bias versus Air Temperature

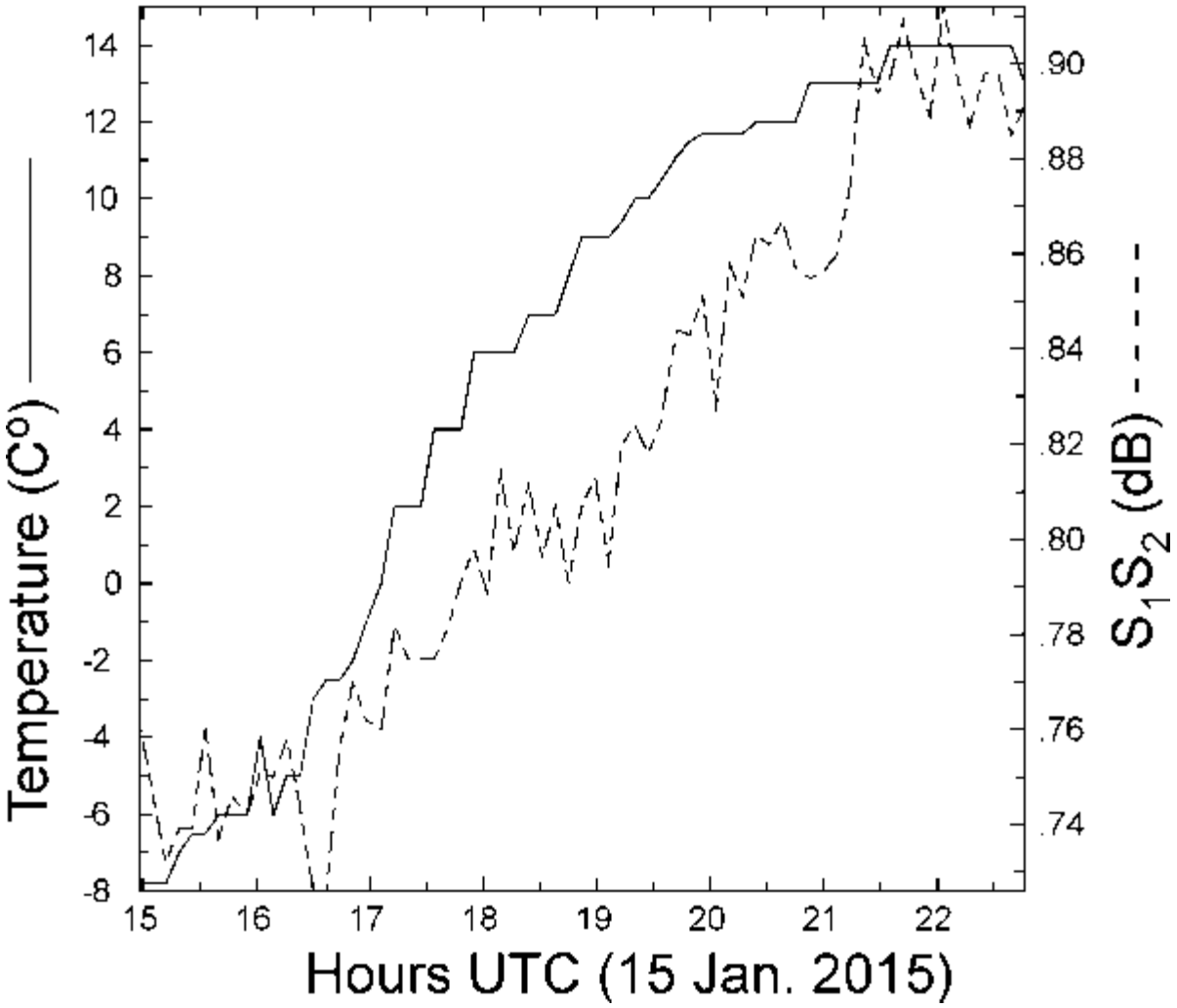
Data gathered at FRONT

December 24, 26, 2014 , January 9, 10, 11,12, 15, and Feb. 6, 22, 27, 2015



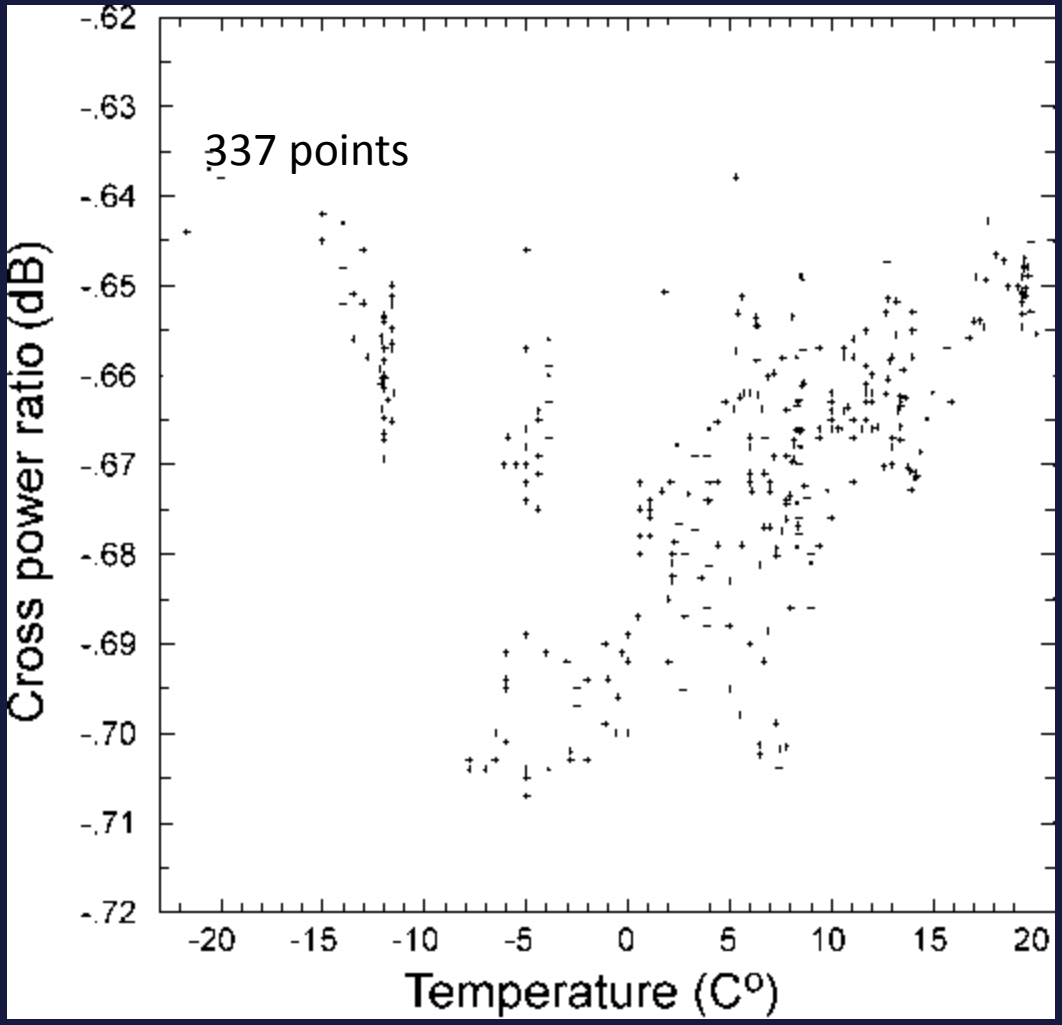


Temperature and S_1S_2



Crosspolar Power Ratio

Not correlated with outside temperature but could be a function of circulator temperature. Note only 0.1 dB vertical scale.

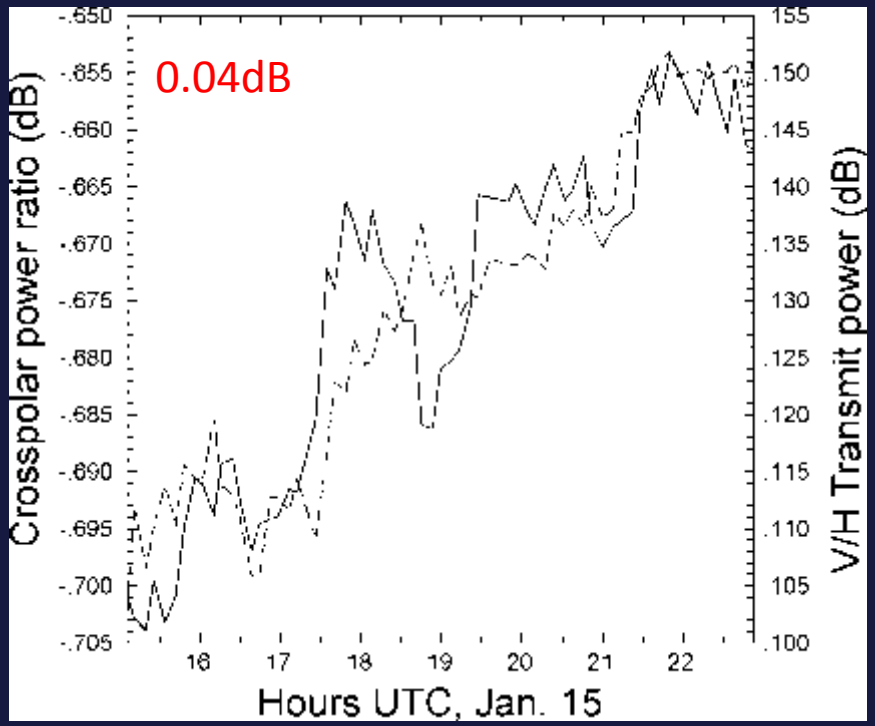


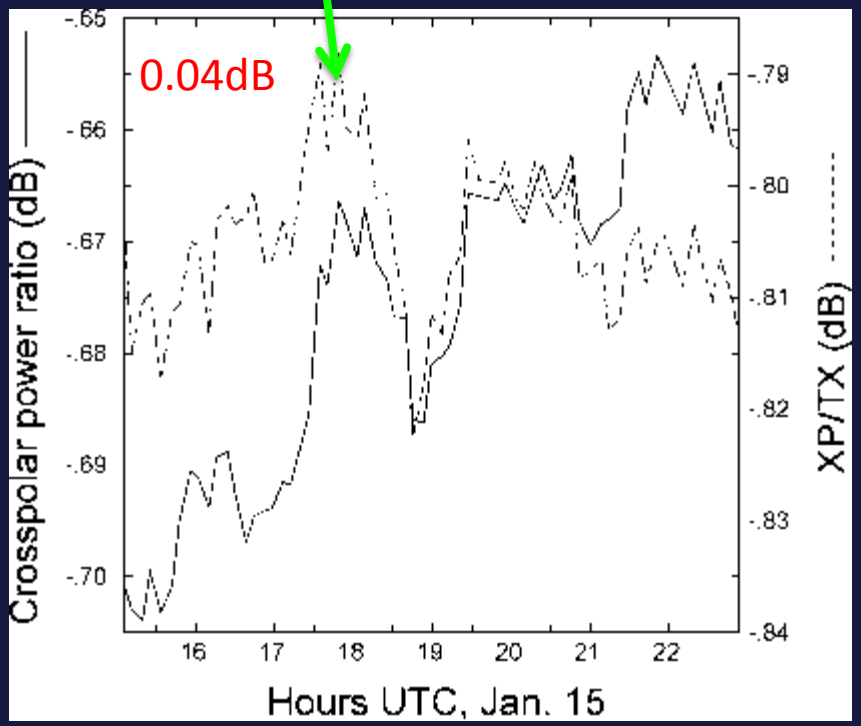
Transmit Power and Crosspolar power ratio

$$P_{TX} = \frac{P_v C_v^T}{P_h C_h^T}$$

$$\frac{R_{hvhv}}{R_{vhvh}} = \frac{P_v C_v^T C_h^R \Gamma_{x,H}}{P_h C_h^T C_v^R \Gamma_{x,V}}$$

(LNAs, circulators)





The transmit power varies (0.05dB) and the LNAs 0.02dB

Zdr Bias and Temperature

- Thus, the primary source of Zdr variation is from the test plane out through the antenna
- In comparison, the active portion of receiver path varies little!!
- The S_1S_2 ratio tracks the antenna caused variation plus the variations cause by receiver path from the test plane to the IF switch (LNAs, circulators, demodulator)
- The CP-ratio tracks variation cause by the receiver and the transmit V/H power ratio

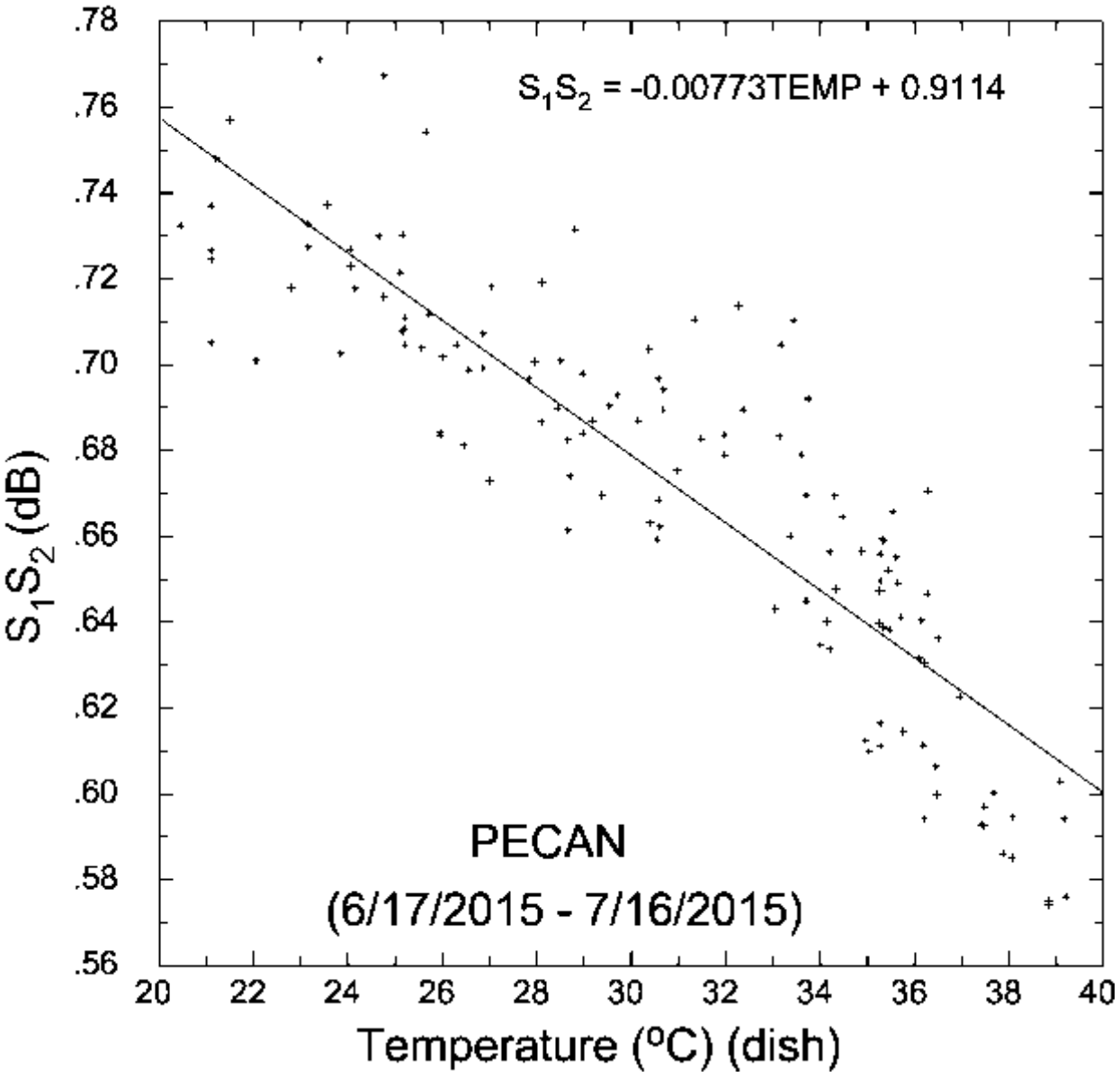
Measurements Consistent, But….

- Verification with other data?
- Very, very little good vertical pointing data in the winter
- S-Pol staff had not seen this before
- We usually use one Zdr calibration for an entire experiment
- Skeptics

Zdr Calibration for PECAN

- Placed 5 temperature probes on the S-Pol antenna: +/- 45, 135 degrees and one on the feed horn
- S-Pol system was “unstable” for the first two weeks of PECAN: new rotary joint, trig amp, a motor MOV (Metal Oxide Varistor), air conditioner unit repair
- Finally after 15 June, S-Pol was in a “steady state”

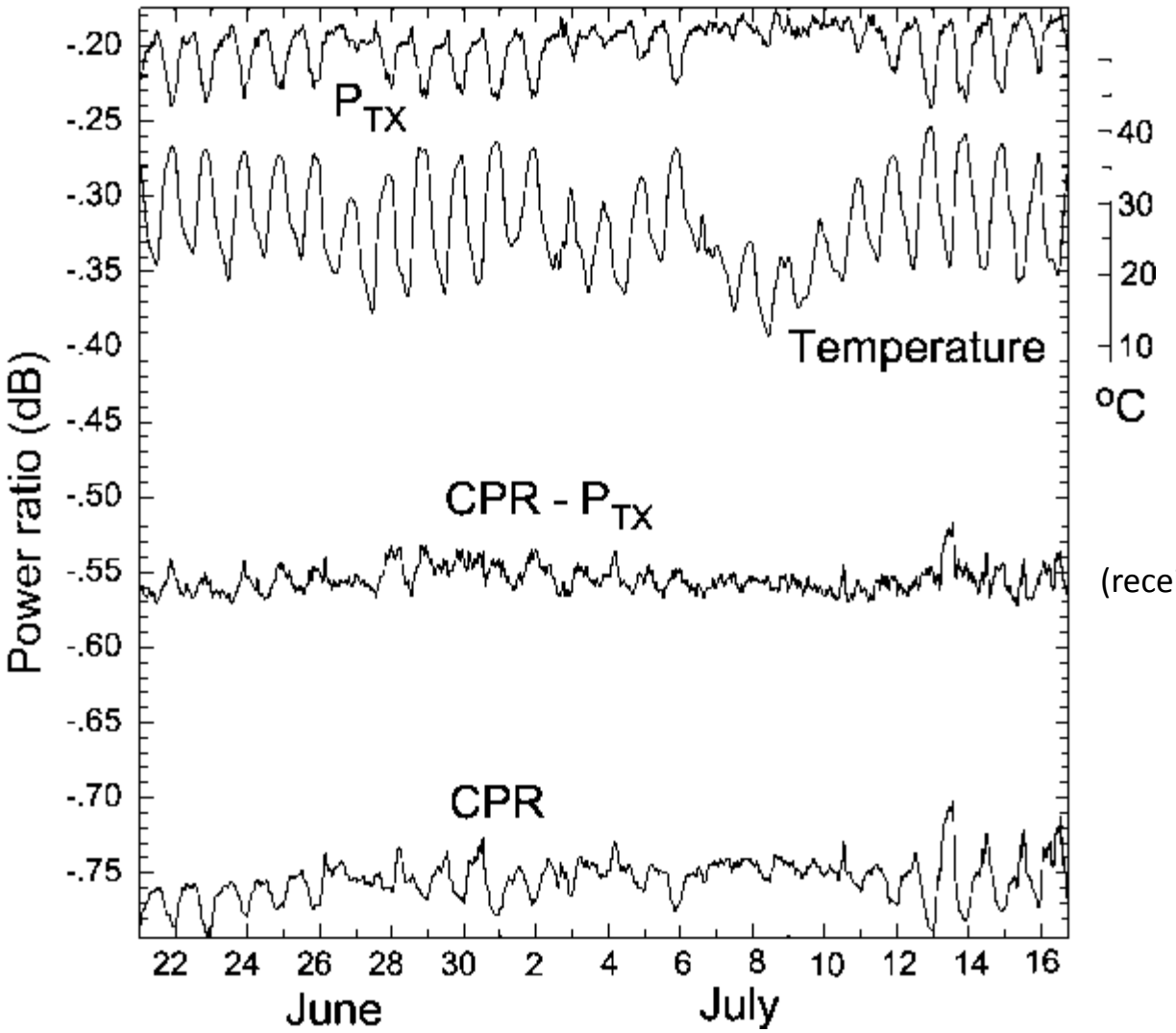
S_1S_2 versus dish temperature regression curve



Application of the CP Zdr Method

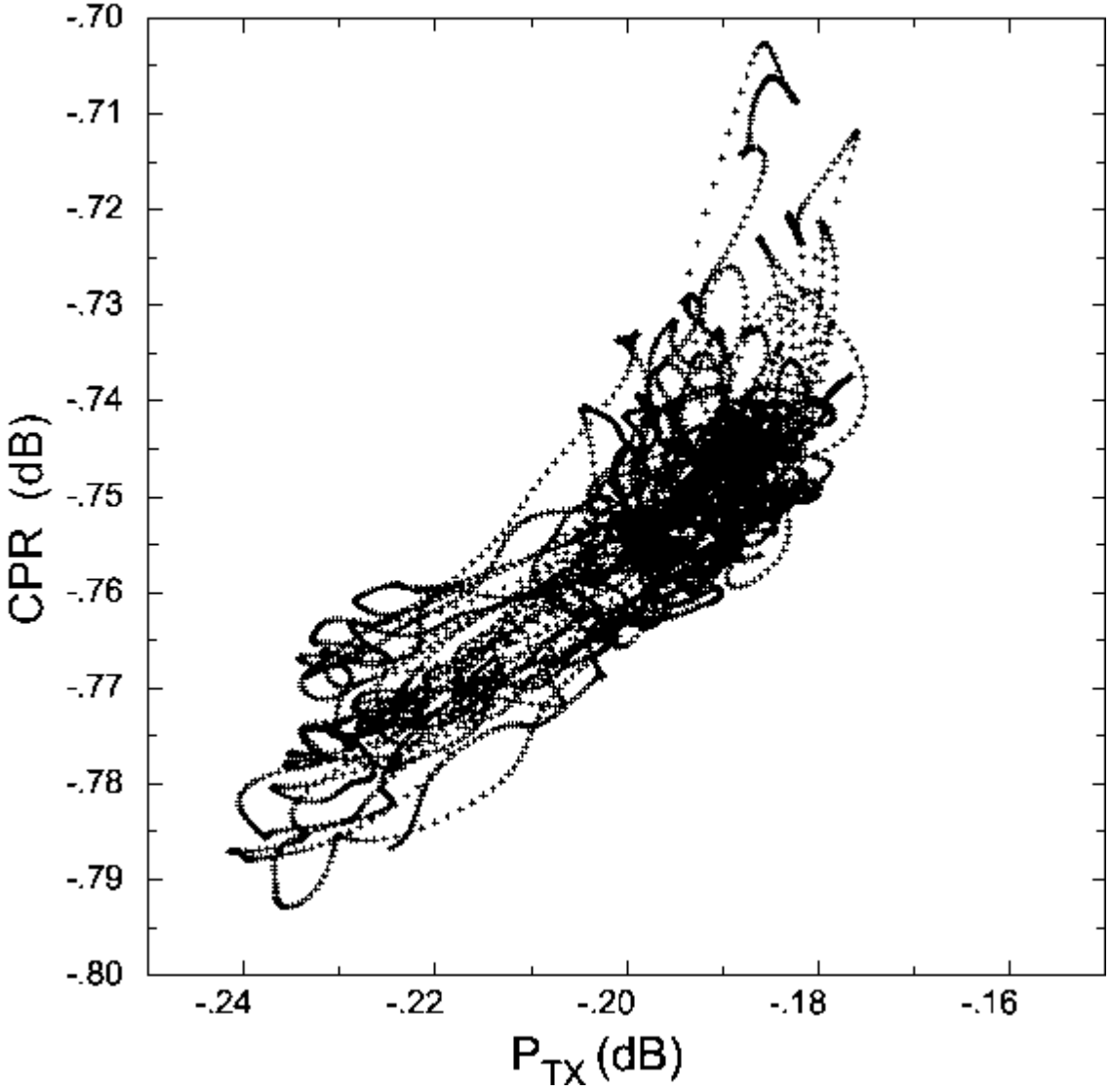
- There are not sufficient solar scans to calibrate Zdr
- Solution is to use the S_1S_2 regression curve along with the temperature record and the CP ratio from the PPI and RHI scans.

Components of the Crosspolar Power Zdr Calibration



(receiver variations)

Scatter Plot of the CPR versus Transmit V/H Power



Interesting, but How About Verification?

- Compare to VP cals
- Do the meteorological measurements show evidence of the temperature variations?

Comparison to Vertical Pointing 26 June

VP data

time	#pts	mean	STD	dish temp
2015-06-26 08:28:12	95962	0.012	0.16	20.5 C
2015-06-26 08:32:15	94395	-0.002	0.16	20.5 C

(3AM local)

CP ratio

2015-06-26 08:24:56 -0.7496 dB
2015-06-26 08:37:09 -0.7577 dB

Zdr_corr= S1S2 + CPR = -0.00773*TEMP + 0.911419 - 0.7537

Zdr_corr = 0.7526 – 0.7537 = -0.001 dB

2 July Data VP Data

time	#pts	mean	STD	dish temp
2015-07-02 14:03:32	106781	0.012	0.14	23.7 C
2015-07-02 14:07:34	106183	0.038	0.12	22.5 C
2015-07-02 14:11:37	110529	0.002	0.11	22.5 C

Time

2015-07-02 14:00:00 XP-ratio = -0.7596 dB

S1S2 = -0.00773*TEMP + 0.911419 = 0.7282

Remember: Zdr-corr = -VP data bias)

Zdr-corr = 0.7282- 0.7596 = -0.0314

14 July VP Data

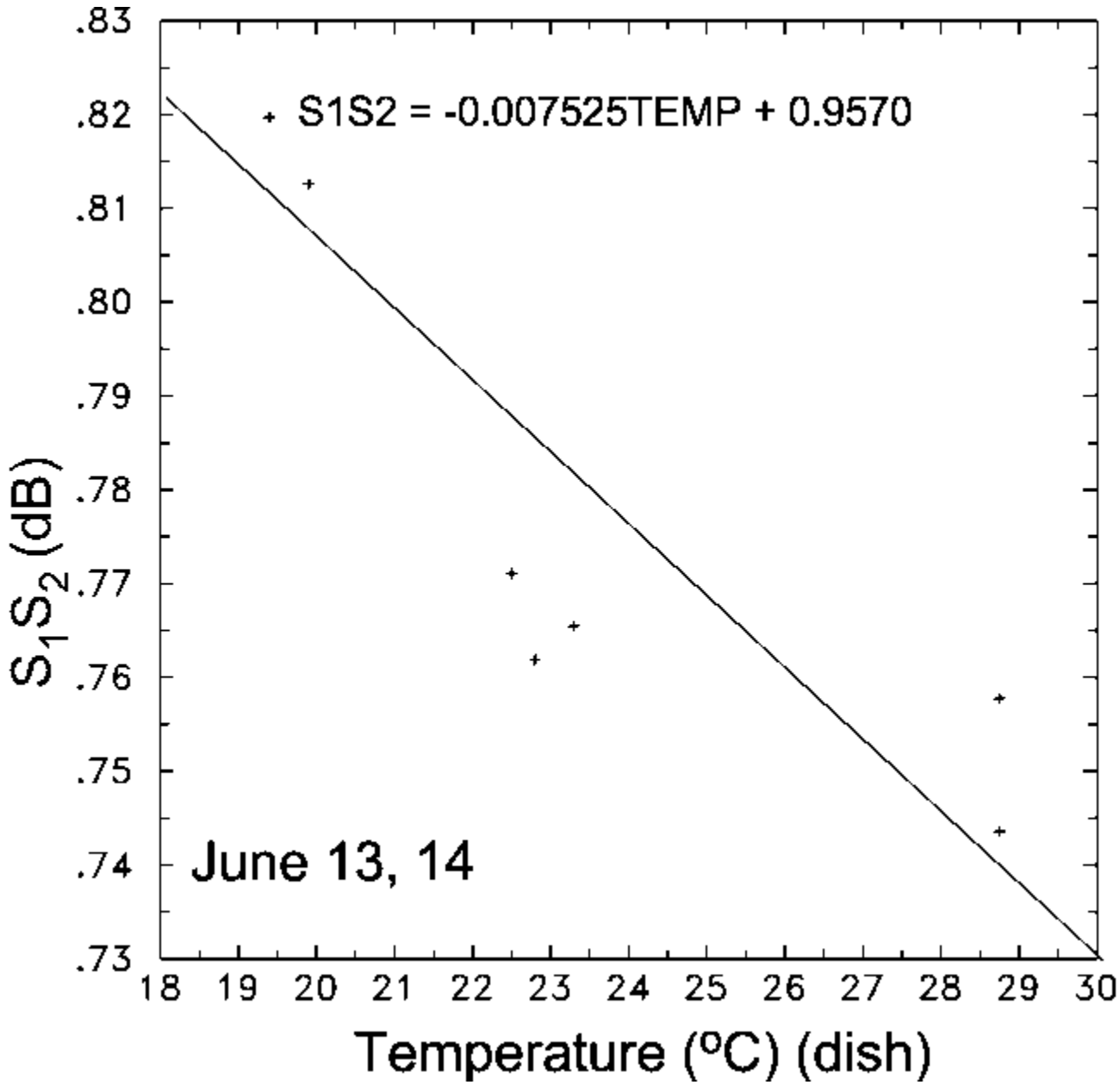
time	#pts	mean	STD	dish temp
2015-07-14 00:33:50	98705	0.153	0.14	34.2
2015-07-14 00:37:53	52402	0.152	0.14	34.0
2015-07-14 01:04:14	120482	0.137	0.12	33.4

2015-07-14 00:40:13 XP-ratio = -0.7688

S1S2 = -0.00773TEMP + 0.911419 = 0.649

Zdr-corr = 0.649 - 0.769 = -0.12

S_1S_2 Regression Fit June 13, 14



June 14, CP – VP Compare

VP data

date			mean	STD	temperature
2015-06-14	20:15:13	89849	-0.145	0.14	20.75 C
2015-06-14	20:19:16	42726	-0.142	0.18	20.5 C
2015-06-14	20:50:54	21035	-0.140	0.22	19.2 C

Regression Curve

S1S2 = -0.007525TEMP + 0.9570

CP-ratio

2015-06-14	20:09:00	3278	-0.6949
2015-06-14	20:20:18	2660	-0.6770
2015-06-14	20:55:59	3720	-0.6870

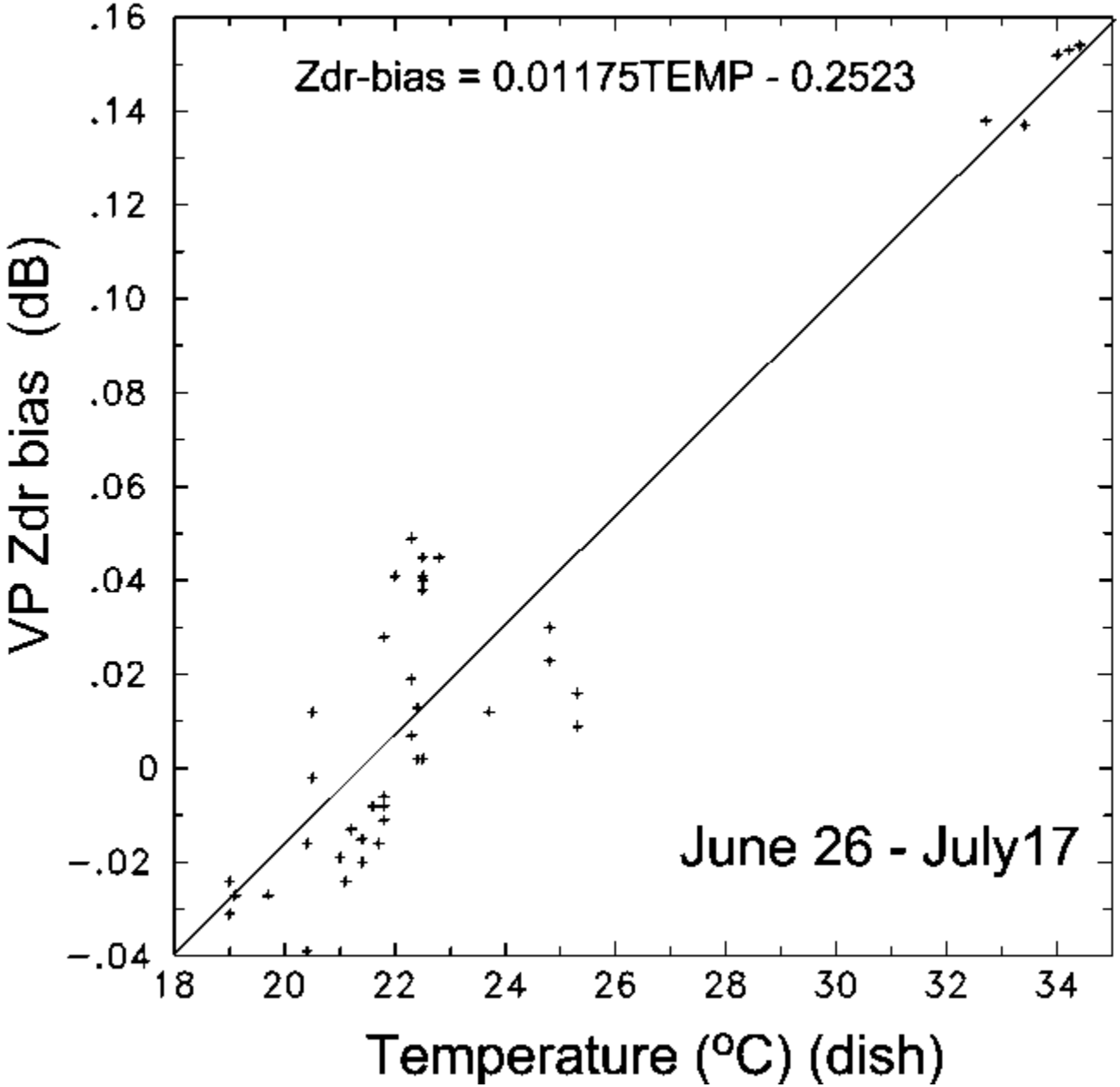
Zdr-corr = S1S2 + CP-ratio

Zdr-corr = 0.121
0.123
0.133

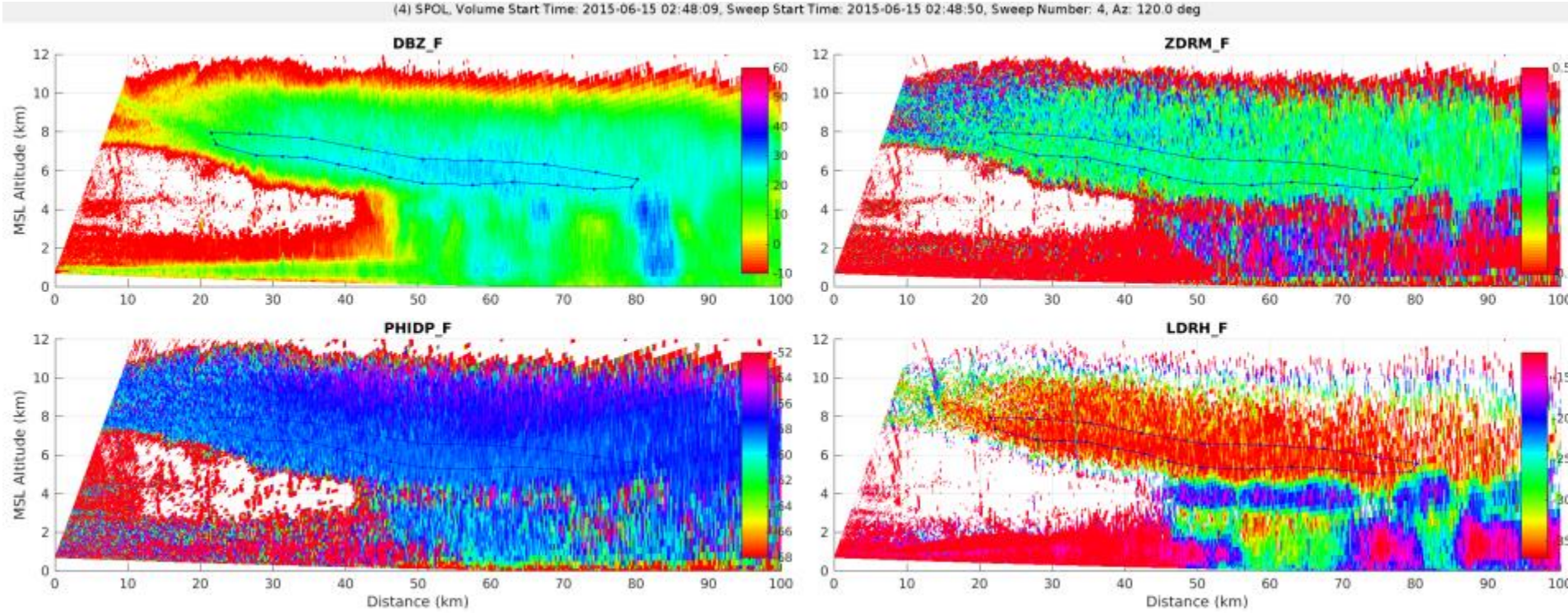
For dish temps. 20.75C
20.5C
19.2C

CP Versus VP Agrees Very Well, for All PECAN VP DATA

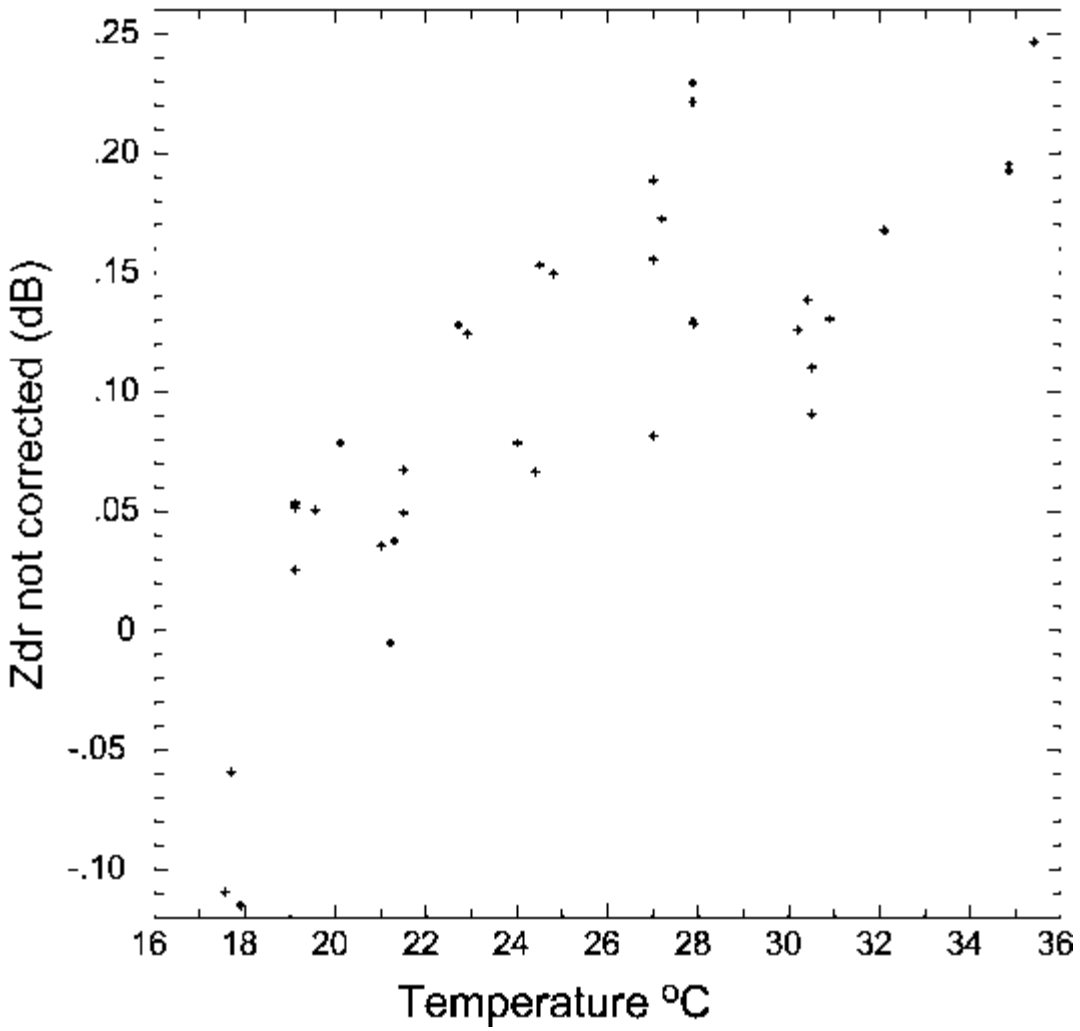
The Regression Curve for VP Zdr Bias Data



Such Zdr variance should be seen in the ice phase



Zdr in Ice Phase (manual)

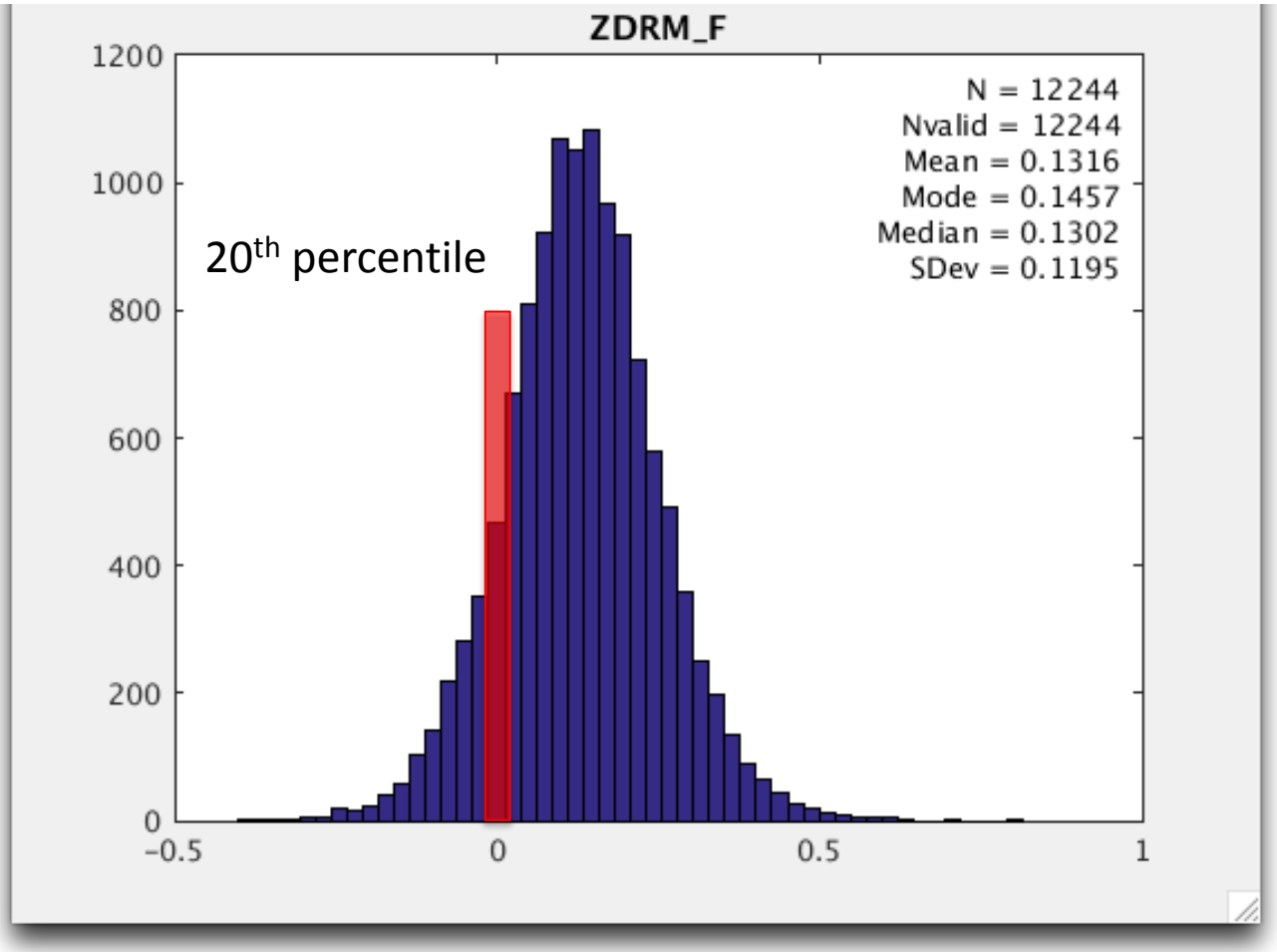


Zdr in Ice Phase

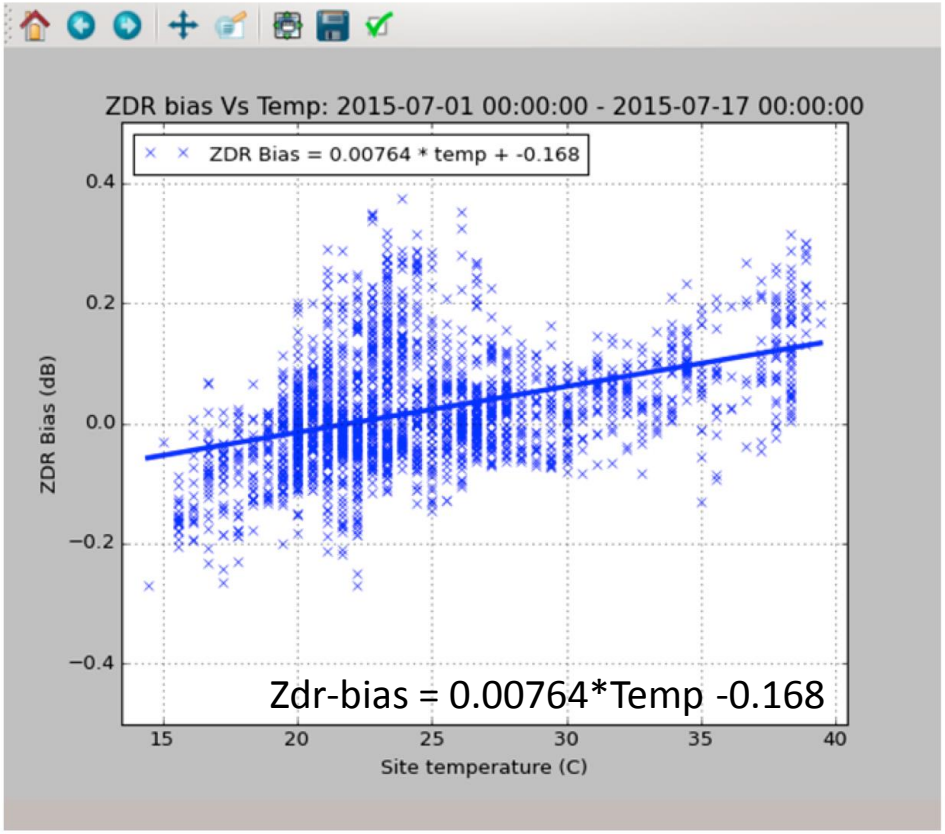
Could this be automated?

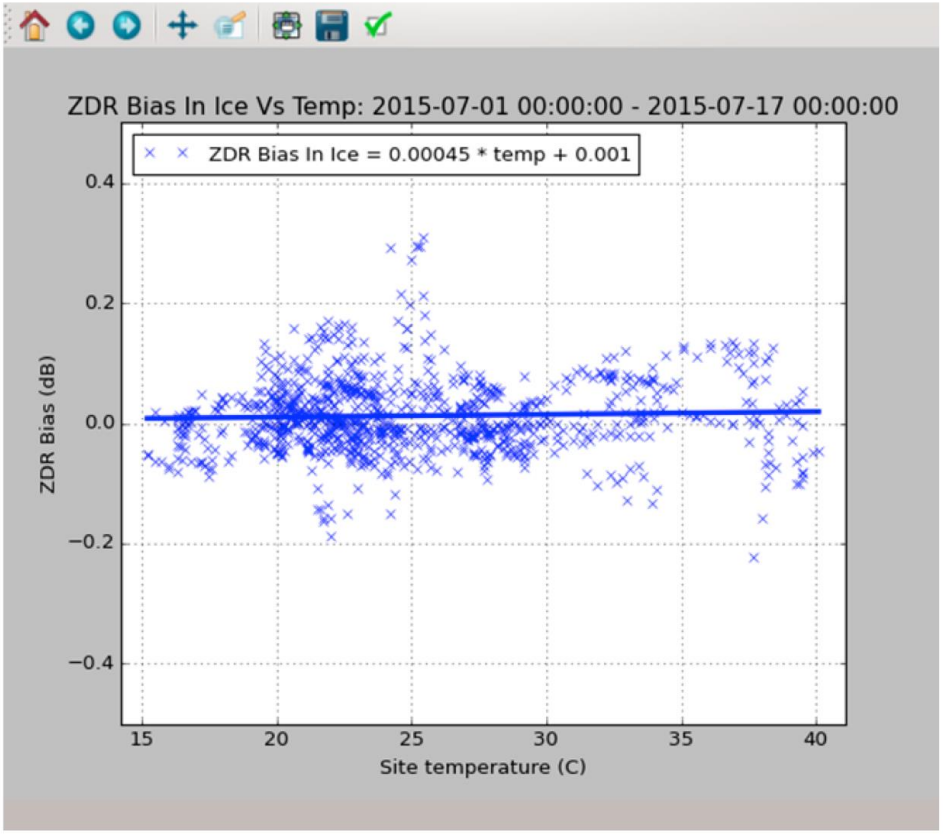
Use PID to identify irregular ice and dry snow categories and use a variety of thresholds

Example Zdr in “Ice” Histogram

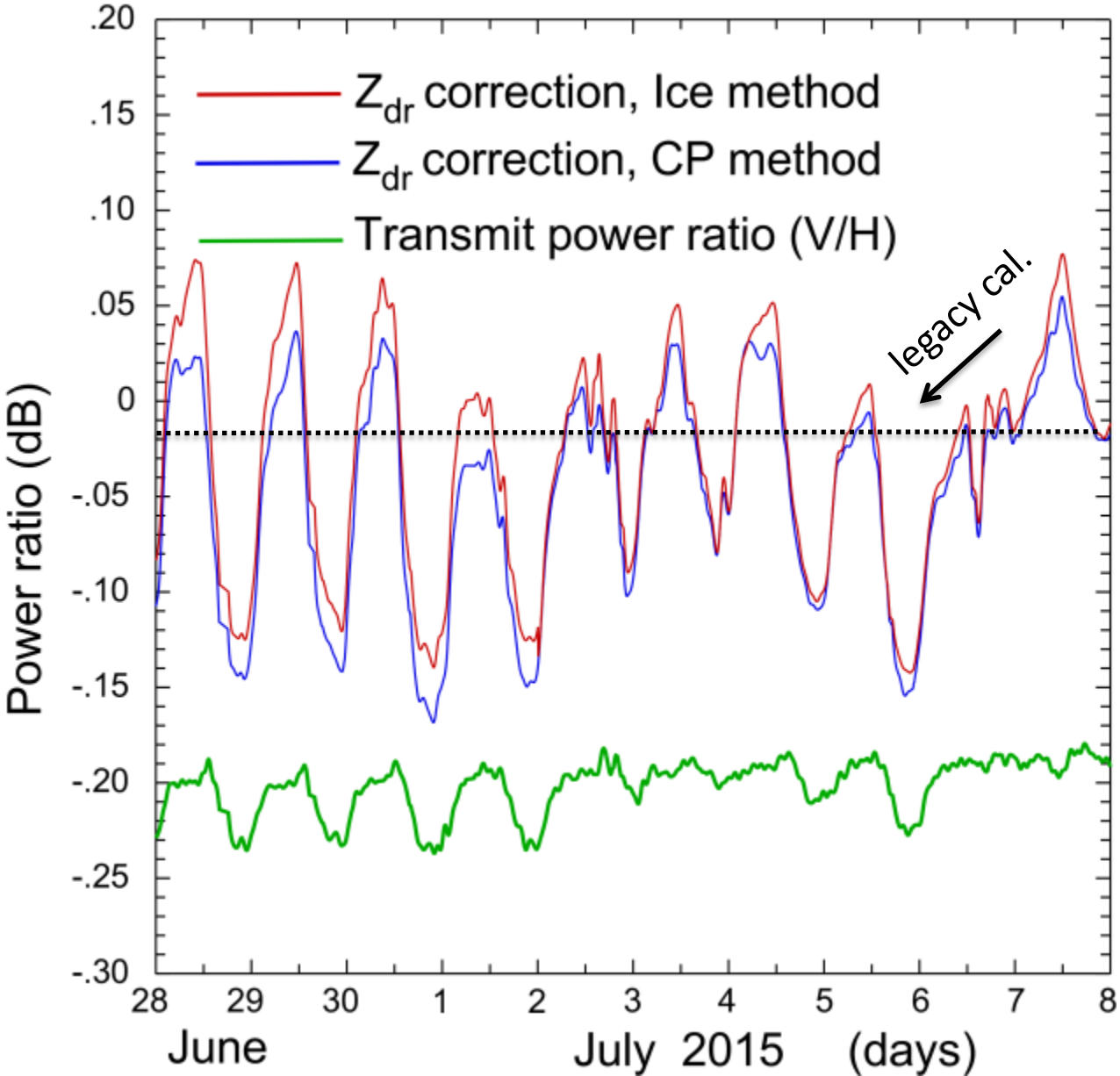


Zdr in Ice Versus Temperature

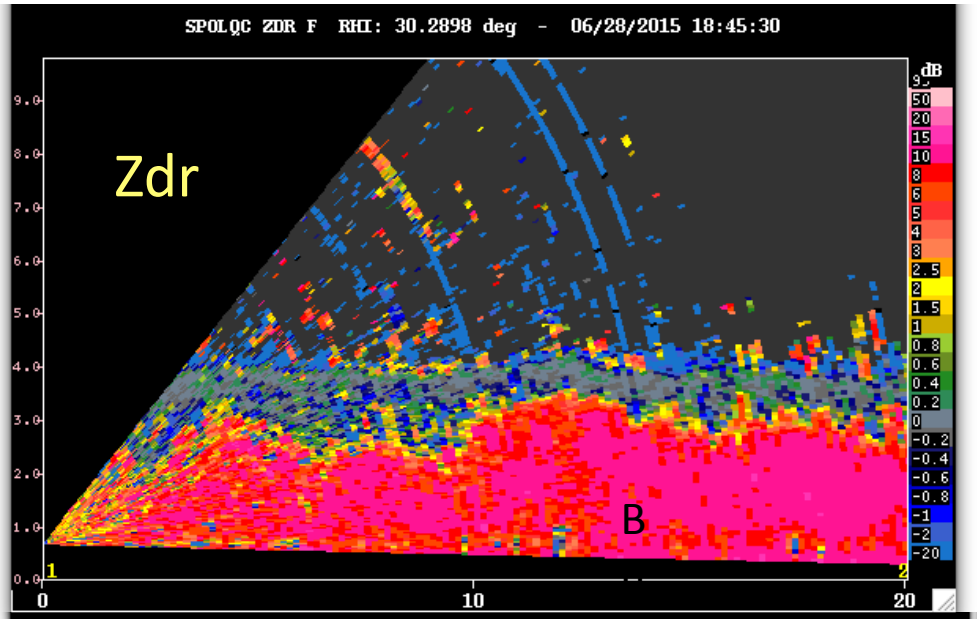




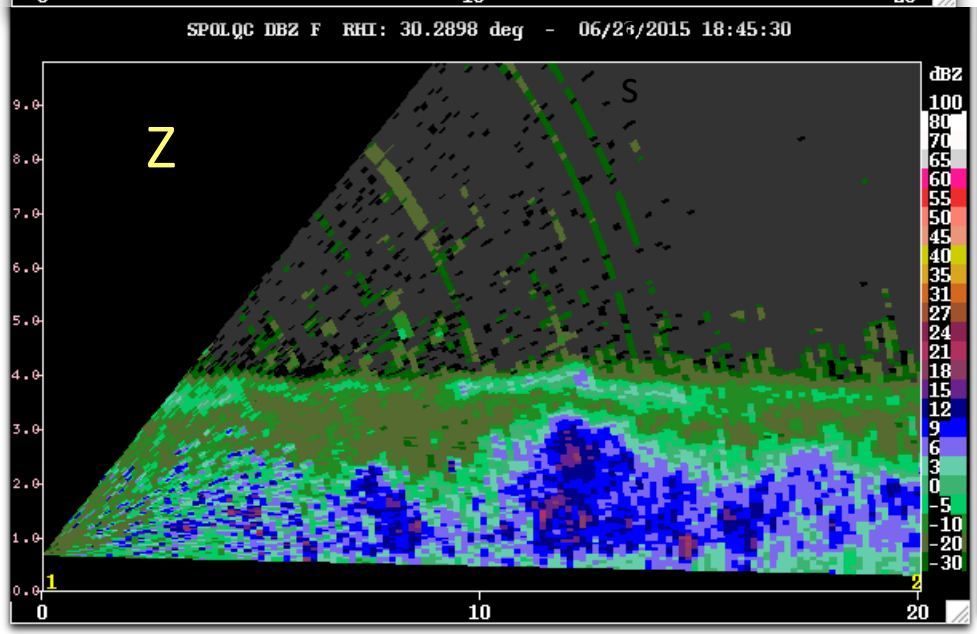
PECAN Zdr Calibration: CP versus Ice

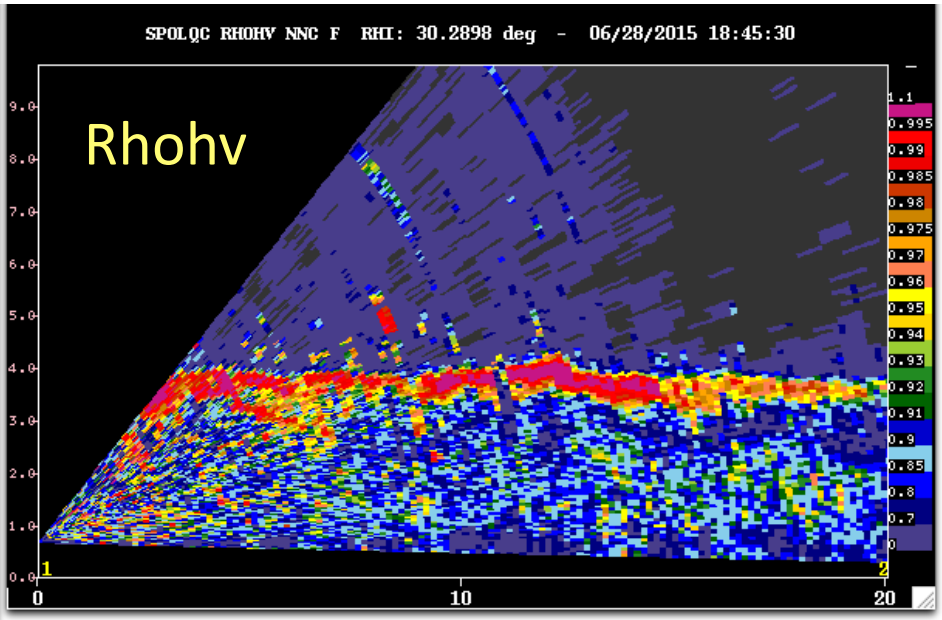


Similar Bragg Analysis is Possible



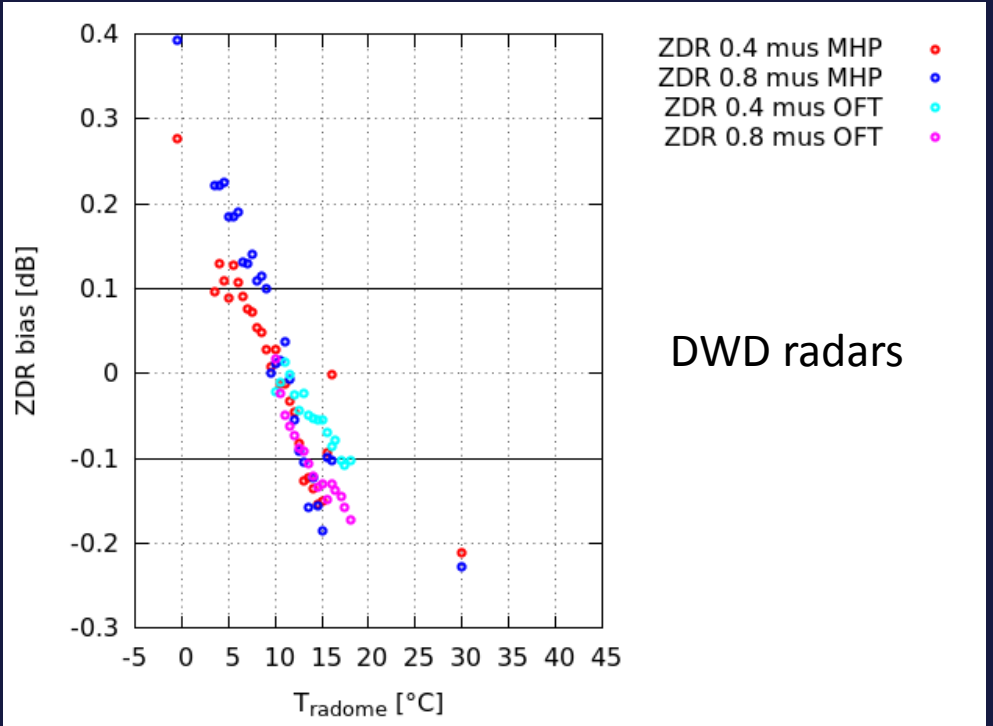
Advantage is that we “ground truth” for the “Bragg” identified scatter.





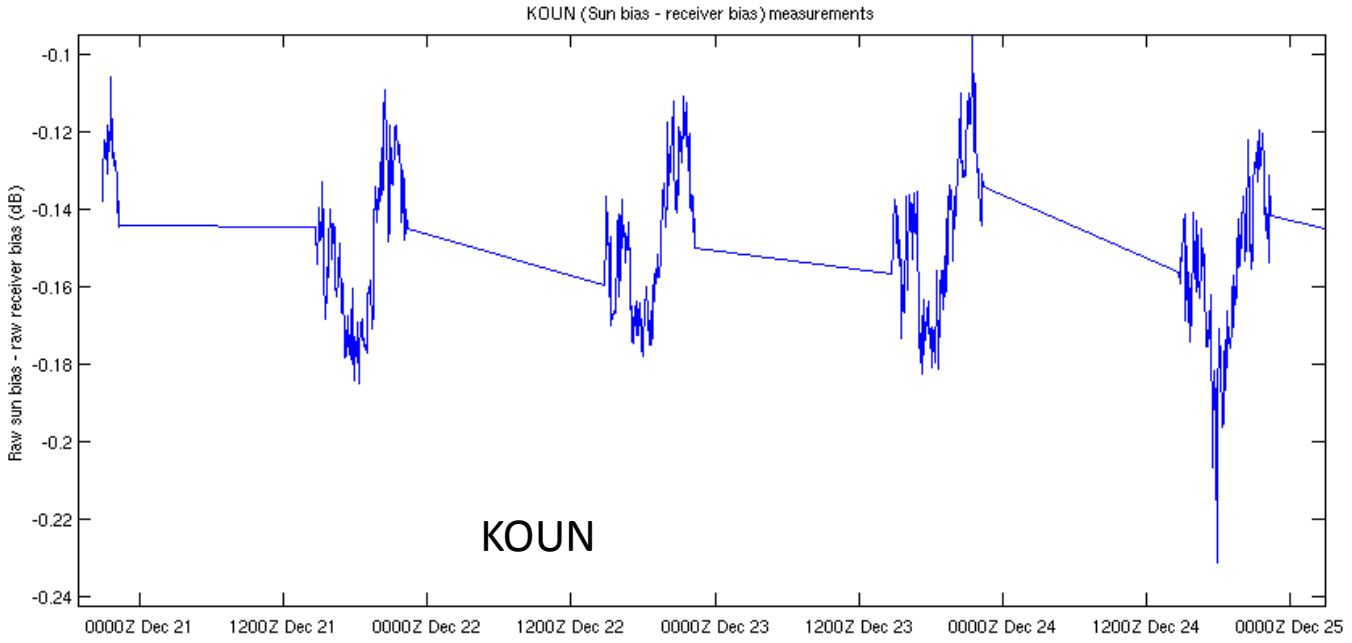
Summary

- At least for S-Pol, Zdr is a function of ambient temperature
  - The characteristics of the antenna change – likely thermal expansion
- The CP technique can be used to correct for this dependency
- Measurements in ice can be used for Zdr calibration. Accuracy???
- This technique can be used on NEXRAD
- Bragg scatter and self-consistency (Z-Zdr-Phidp) are also under investigation (automated)



DWD radars

Evidence exist for Zdr temperature dependence in other radars



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