Aquarius Calibration Analysis

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Overview

- **Performed several analyzes to verify aspects of the radiometer calibration**
  - **Linearity correction (backup)**
  - **Reflector emissivity (backup)**
  - **3rd Stokes calibration**
  - **Analysis of radiometer drift**
    - Gain/offset drift
    - Estimation of component contributions to the drift

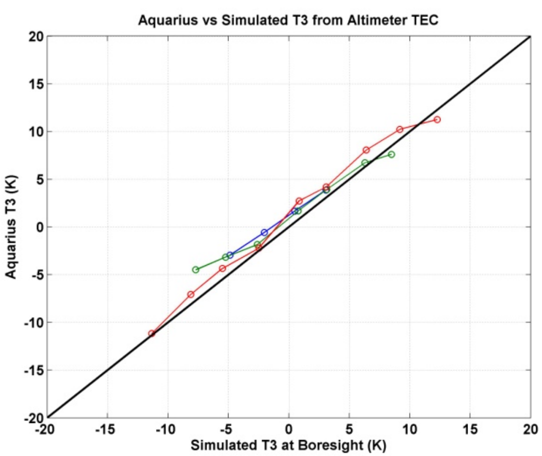
3rd Stokes Calibration

- At Jason-2/Aquarius co-locations, derived TEC from dual-frequency altimeter measurements
  - Uncertainty is altimeter TEC ~3TECu (Tseng et al., 2010)
  - No height scaling applied (impacts slope)
- Magnetic field vector from WMM2010
- Computed faraday rotation angle at boresight for each horn and simulated T3
  - Wind direction signal not accounted for
- Converted to simulated T3 to antenna temperature using pre-launch coupling matrix and post-launch coupling matrix provided by F. Wentz

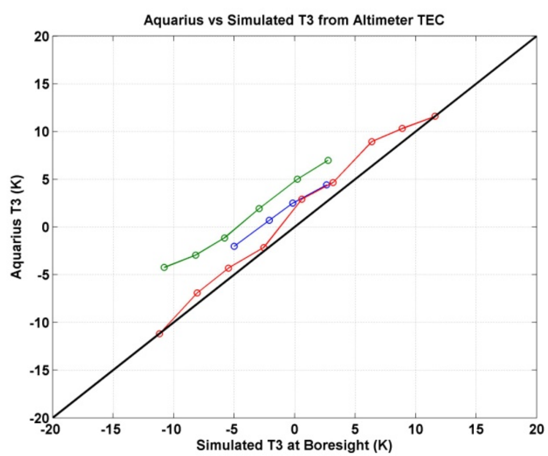
3rd Stokes Calibration

- 3rd stokes calibration improved with post-launch APC improved versus pre-launch
- Small bias remains, but questionable at this point how statistically significant it is

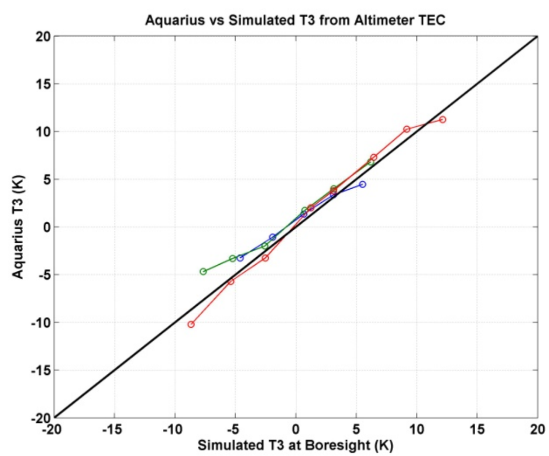
No APC



Pre-launch APC



Post-launch APC



Calibration Drift

- **Level of gain vs offset drift will depend on which components are changing**

$$\Delta T_B(T_B,t)=(T_B-T_{REF})\frac{\Delta T_{ND}(t,L,\Gamma)}{T_{ND}}+\Delta T_{Offset}(L,\Gamma)$$

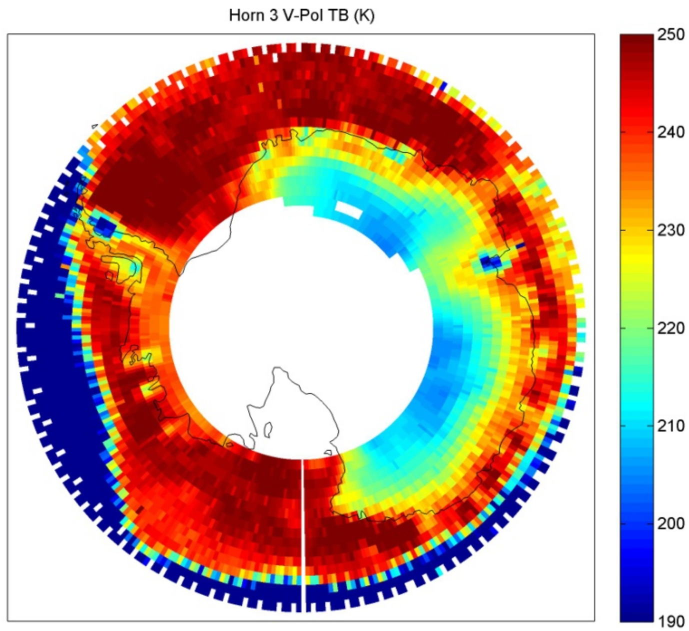
- **Example: Drift in noise diode brightness creates gain drift**
  - **Largest drift for cold TBs, small drift at warmer TBs**

$$\Delta T_B(T_B,t)=(T_B-T_{REF})\frac{\Delta T_{ND}(t)}{T_{ND}}$$

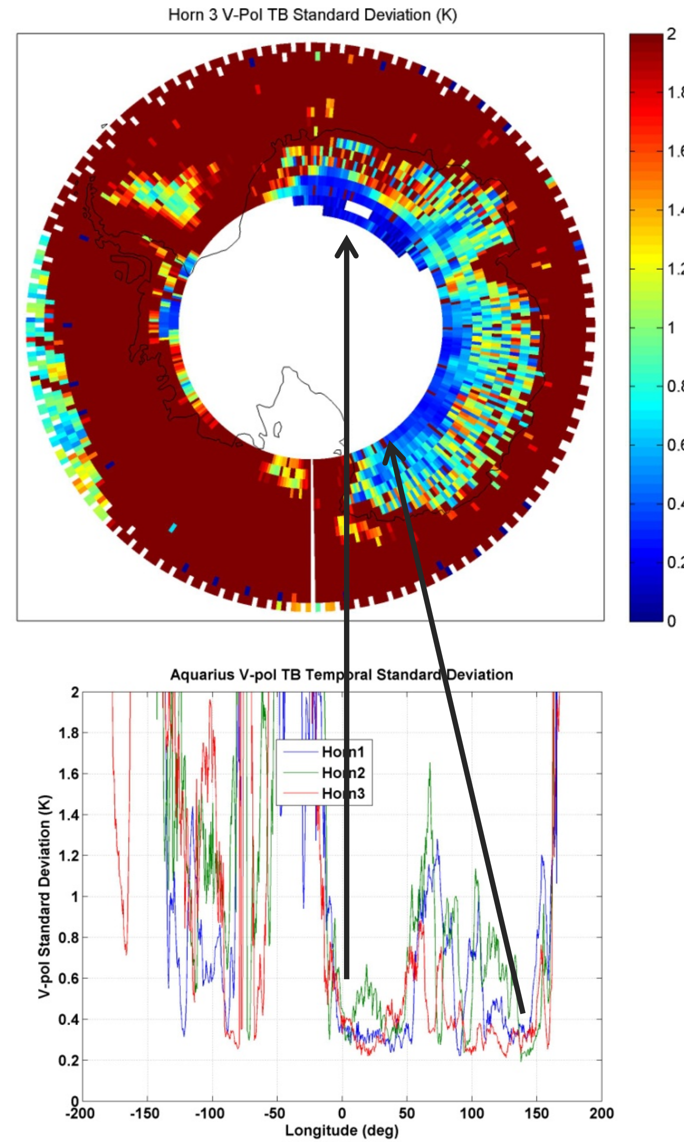
- **Seek stable regions over land and ice to assess drift at warmer TBs**
  - **Antarctica is currently the best option due to the near daily observations**
  - **Sahara and Amazon will be investigated as data record grows**

Antarctica Analysis

Horn 3 V-pol Mean TB (K)

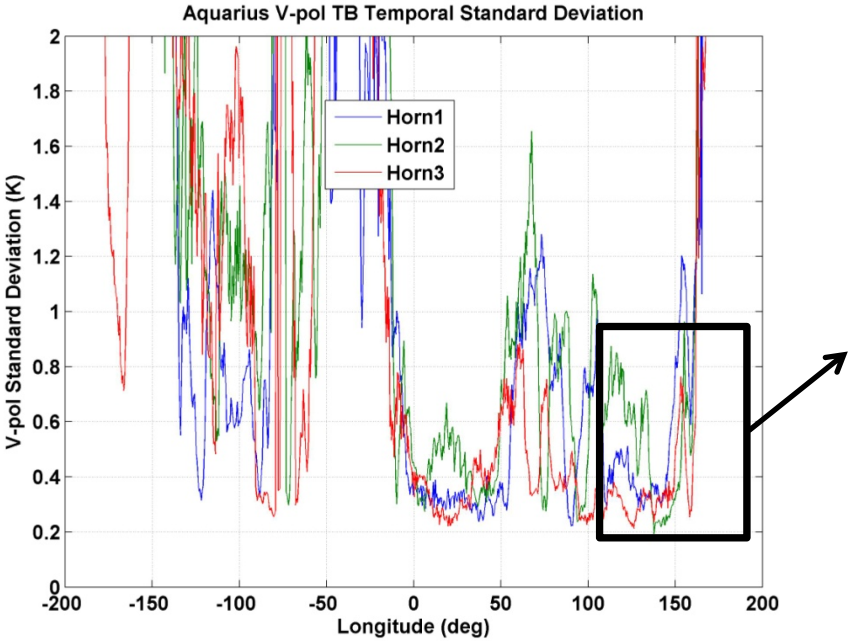


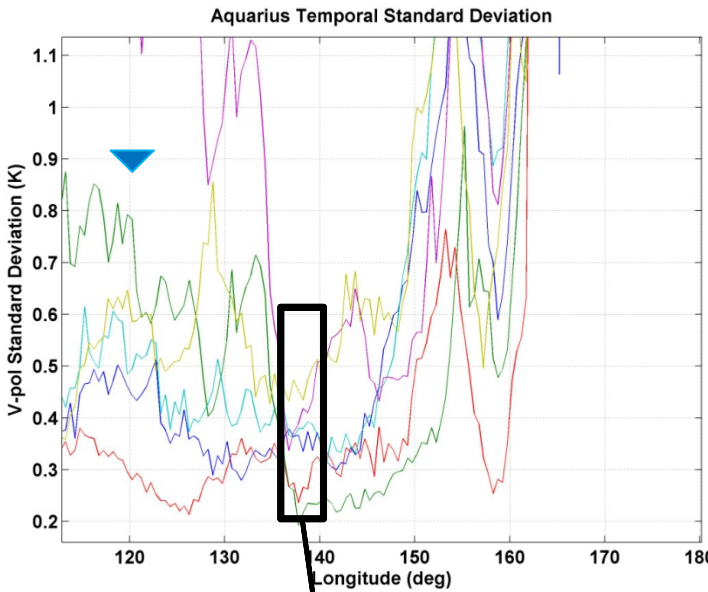
Horn 3 V-pol TB Std. Dev. (K)

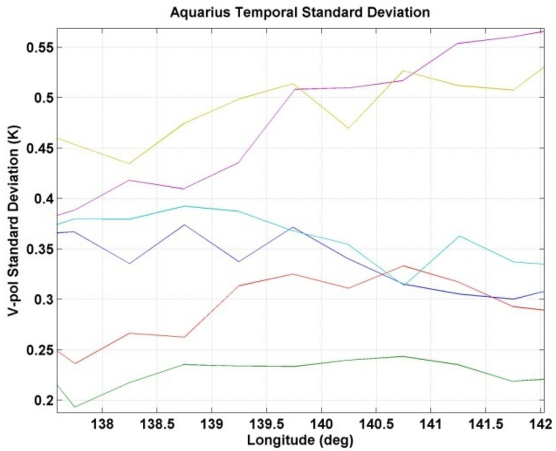


- Assessed spatial and temporal variability of Aquarius TBs over Antarctica
  - Temporal stability a combination of radiometer drift and ice TB stability
- Several regions show excellent temporal stability (~0.2K standard deviation over 2 months)

Antarctica Analysis







- Region near 140 E degrees longitude shows best temporal stability in all channels
- Removed longitudinally dependent mean and averaged data daily for 137.5^{o} < Lon < 142^{o} E and Lat < -76^{o} S
  - Assume ice TB is stable and evaluate residual time series for drift

Drift at Ice TBs

- **Level of gain vs offset drift will depend on which components are changing**

$$\Delta T_B(T_B,t) = (T_B - T_{REF})\frac{\Delta T_{ND}(t,L,\Gamma)}{T_{ND}} + \Delta T_{Offset}(L,\Gamma)$$

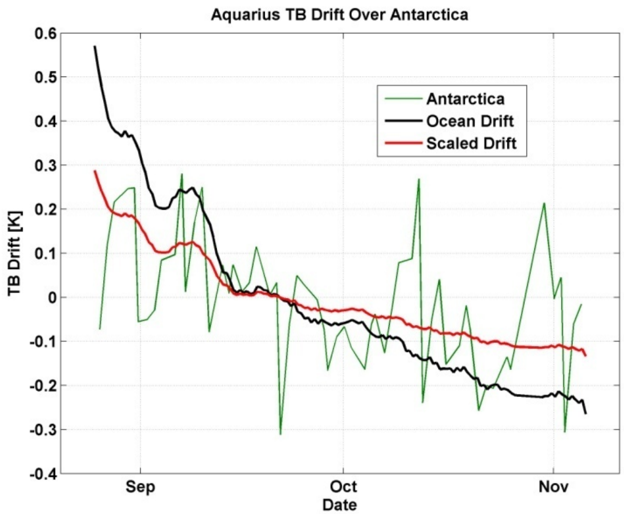
- **Example: Drift in noise diode brightness creates gain drift**
  - **Largest drift for cold TBs, small drift at warmer TBs**

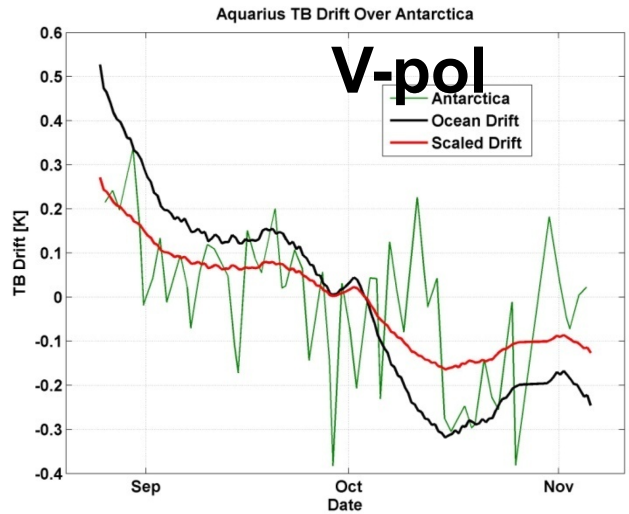
$$\Delta T_B(T_B,t) = (T_B - T_{REF})\frac{\Delta T_{ND}(t)}{T_{ND}}$$

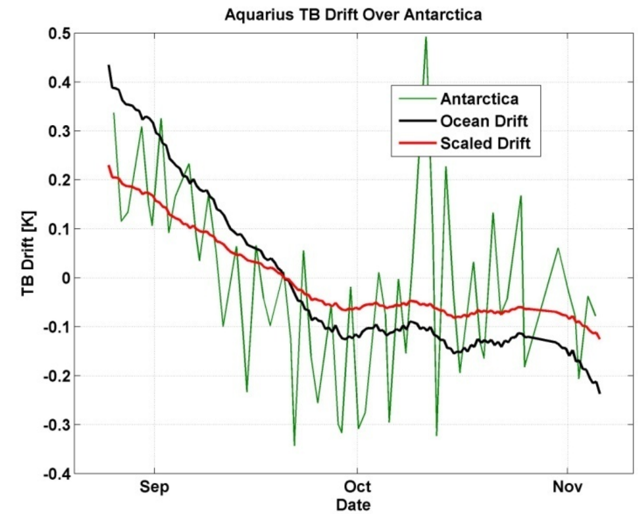
  - **ND drift will cause TB drift over Antarctica which is ~0.5 x ocean drift**

$$\frac{\Delta T_B(T_B \approx 200K,t)}{\Delta T_B(T_B \approx 100K,t)} = \frac{(200-300)}{(100-300)} \approx 0.5$$

V-pol

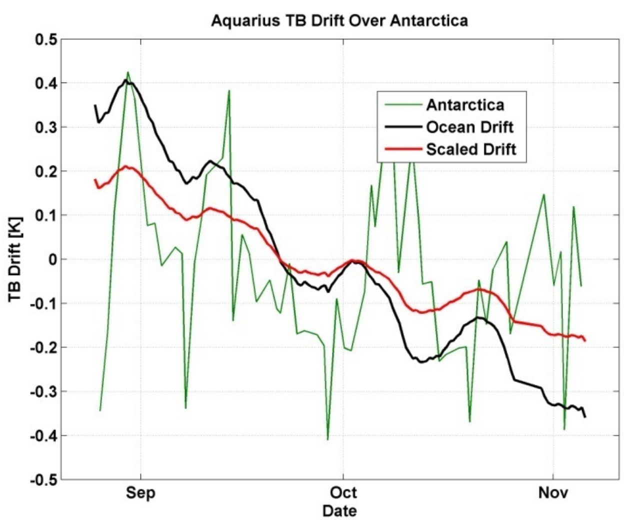


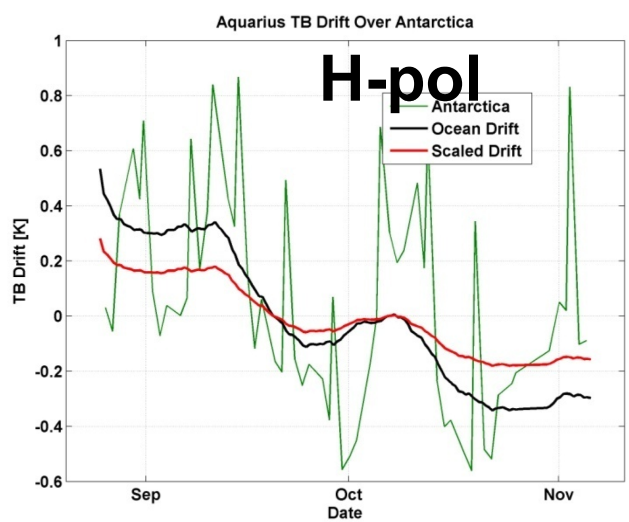


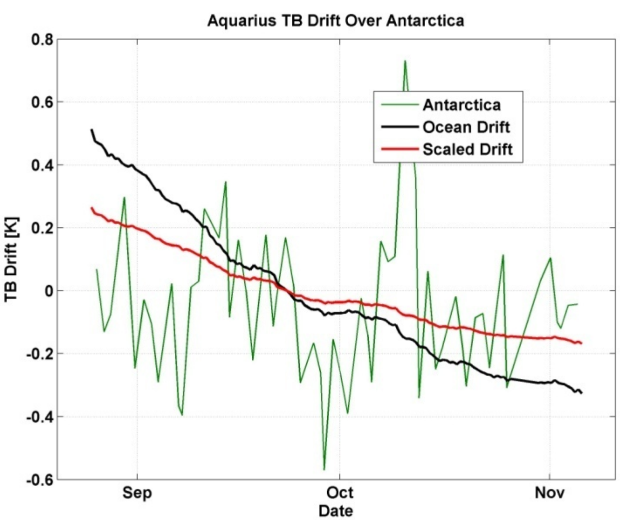


Horn1 **Horn2** **Horn3**

H-pol



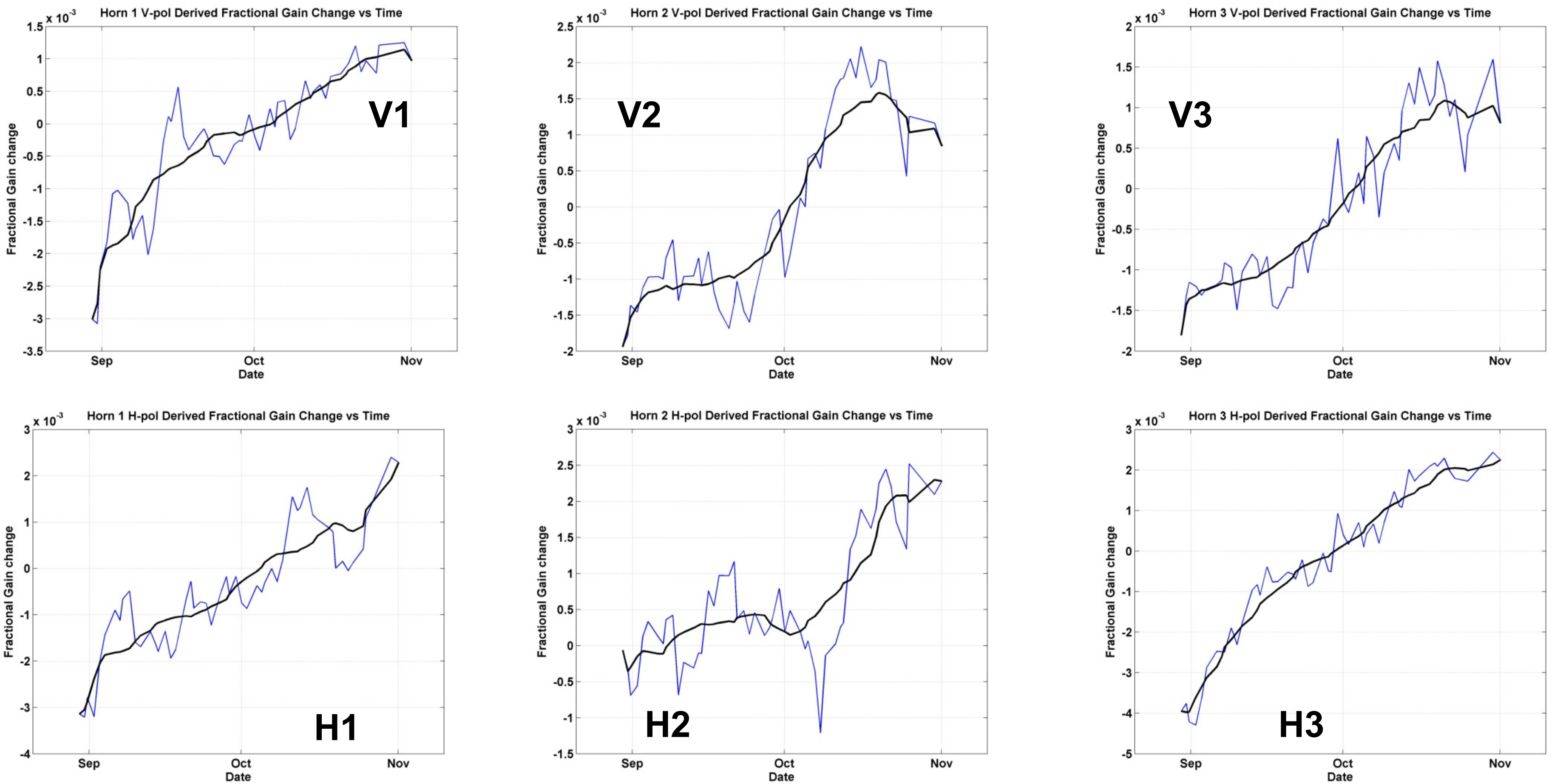




Derived Gain Drifts

$$\Delta T_B(T_B,t)=(T_B-T_{REF})\boxed{\frac{\Delta T_{ND}(t)}{T_{ND}}}+\Delta T_{Offset}(t)$$

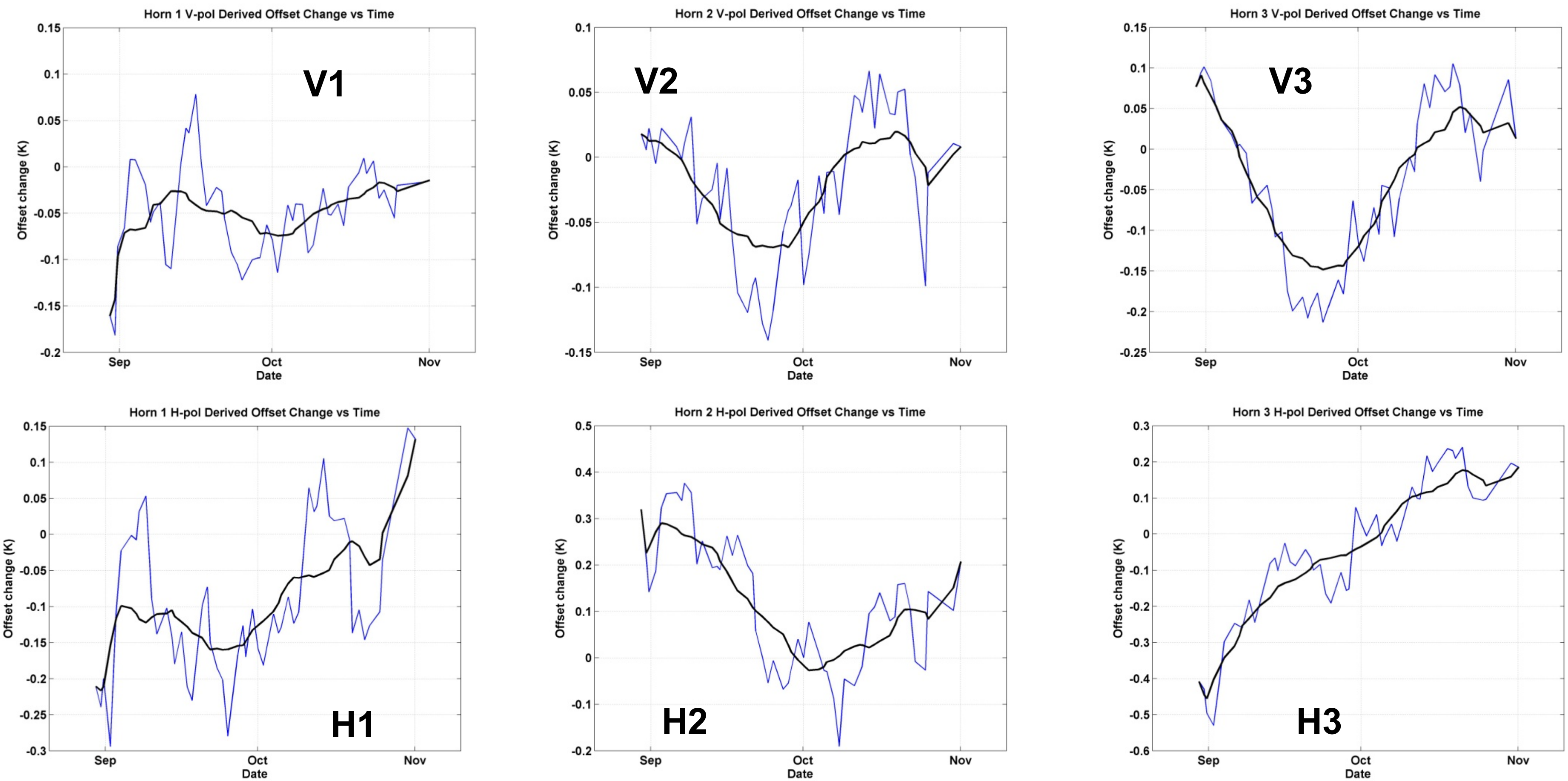
- Most of drift is explained by a gain drift (0.2-0.5% gain drift)



Derived Offset Drifts

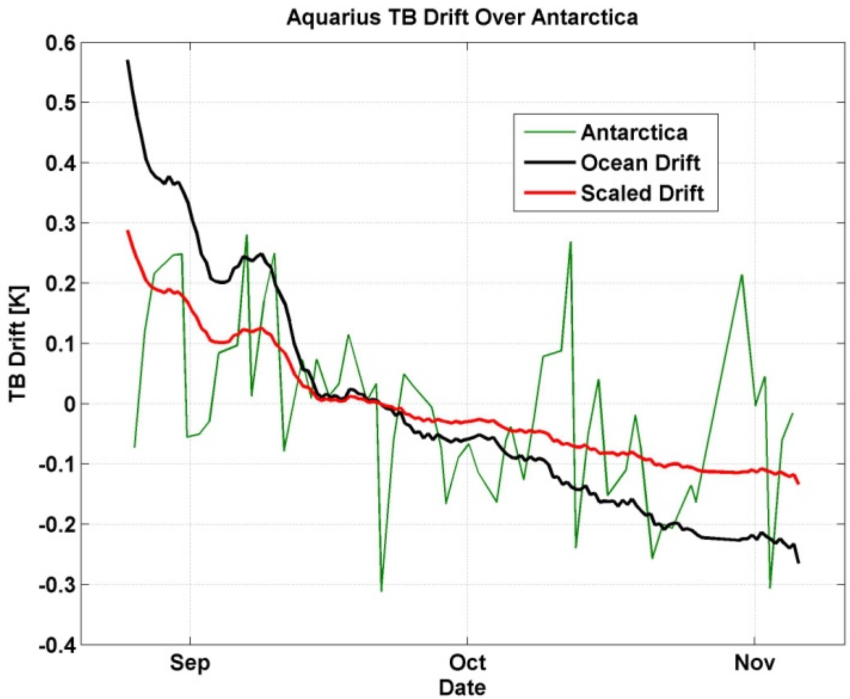
$$\Delta T_B(T_B,t) = (T_B - T_{REF})\frac{\Delta T_{ND}(t)}{T_{ND}} + \boxed{\Delta T_{Offset}(t)}$$

- Offset component of drift small compared to gain component (~0.1K)



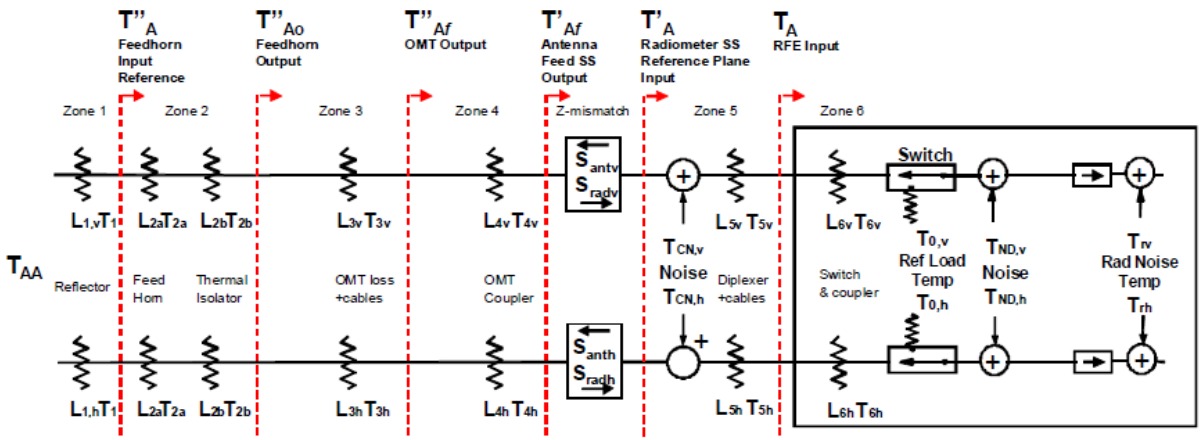
Drift at Ice TBs

- V-pol TBs over Antarctica suggest drift is mainly a gain drift
- H-pol TB time series noisier, but can similar conclusion can be drawn
- Suggests that a correction approach that applies a constant time dependent bias will introduce a drift for warmer TBs



Contributions to Radiometer Drift

- **Seek to identify the most likely sources of the calibration drift in order to apply a suitable correction at the appropriate level in processing**
  - **Robust over the radiometer's dynamic range**

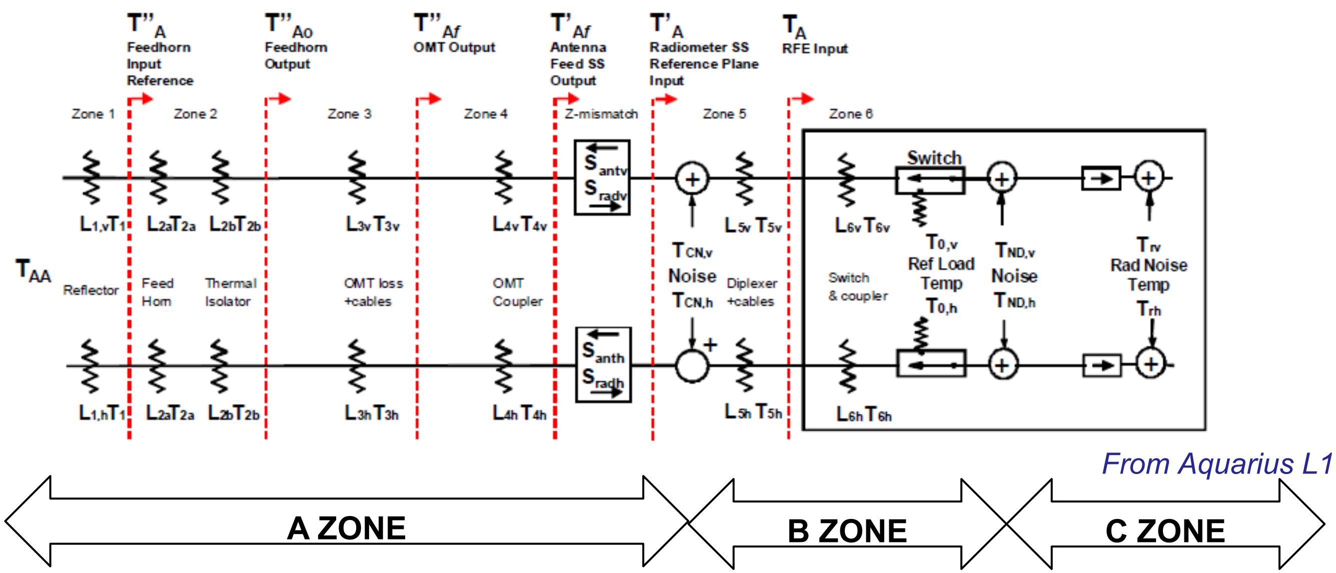


From Aquarius L1 ATBD

Contributions to Radiometer Drift

- We can group calibration changes into those that are due to CND or ND drift; those that are due to changes upstream of the CND; and those that are due to changes between the CND and ND

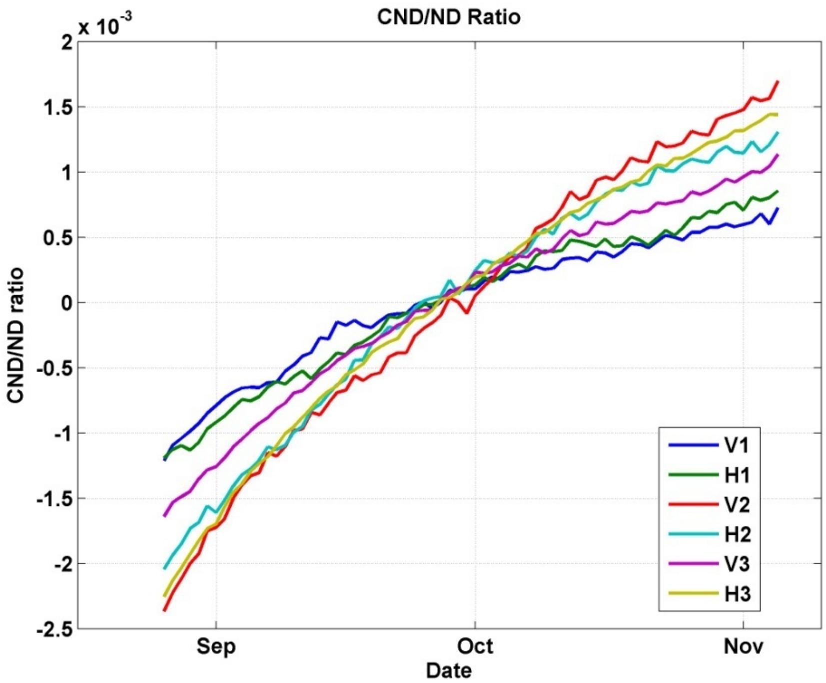
- Everything downstream of the internal ND is calibrated out
  - Drift in the ND brightness at the coupler port will create a gain error in the TAs and will show up in the CND/ND ratio
  - Changes in a losses or reflections between the CND and ND will create gain and offset changes and will show up in CND/ND ratio (e.g. will be characterized by CND)
  - Changes in the relative match looking into the switch in both positions will show up in the NDA/NDR ratio
  - Changes upstream of the CND are outside of the calibration loop and will show up in the TA-TAsim comparisons (may show up in the NDA/NDR ratio if it is a reflection change)

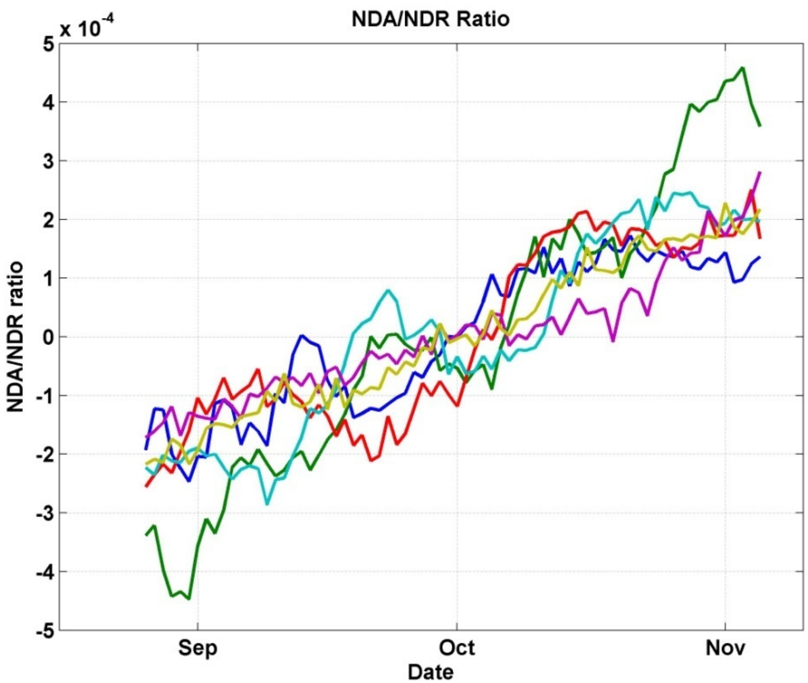


From Aquarius L1 ATBD

ND Ratios

- **Antarctic analysis suggests drift is mostly due to a gain change**
- **CND/ND ratio shows ~0.15-0.4% relative gain change which could be due to change in ND, CND and/or component in between**

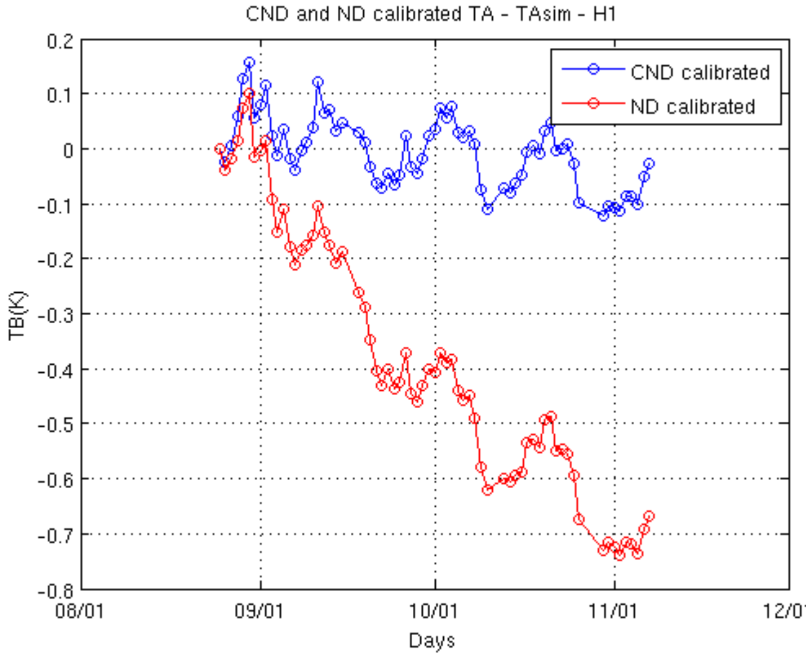




ND and CND TA Calibration

- **Can determine relative stability of ND and CND by comparing end-to-end calibration to TAsim**
  - **Calibrate radiometric counts using Tnd and Tcnd (referenced to Tnd plane)**

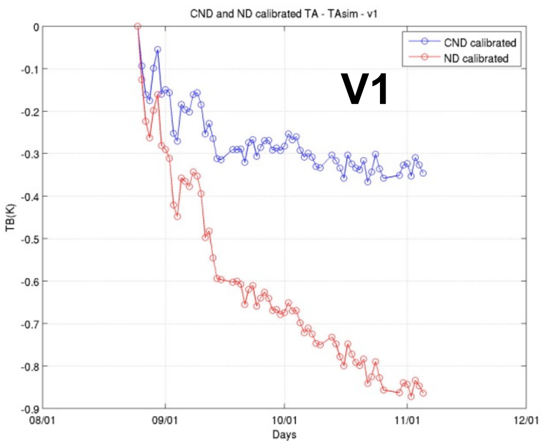
- **This gives two time series. Drifts from the C-zone are calibrated out in the Tnd time series and drifts from the B+C zone are calibrated out in the Tcnd time series**

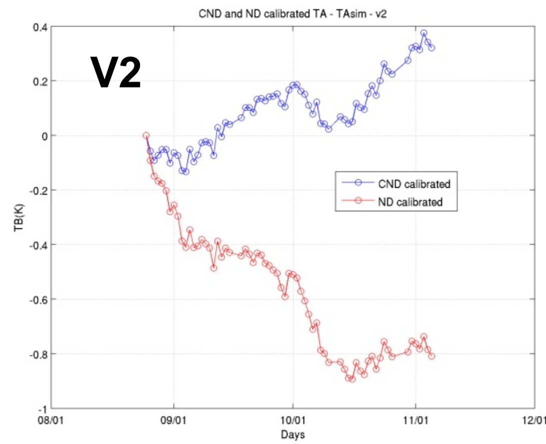


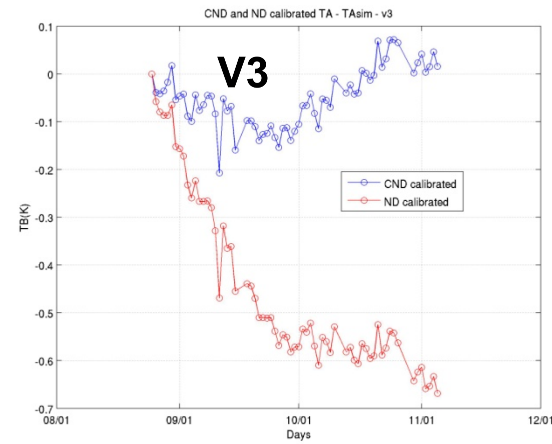
ND and CND TA Calibration compared to TAsim

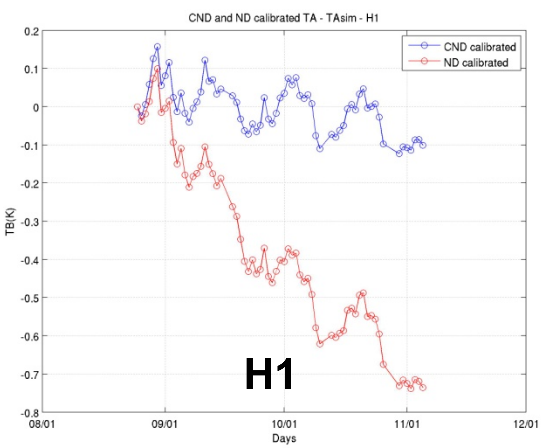
- **CND calibration reduces drift significantly (to ~0.1K level), suggesting that most of the change is due to the ND or a gain change downstream of the CND**

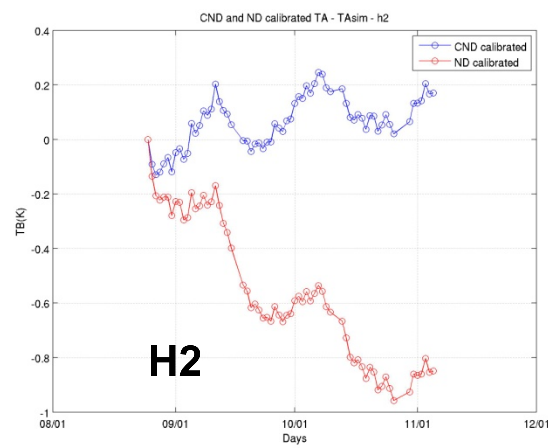
- **Remaining drift in CND calibration is due to changes in CND or changes in the A-zone**

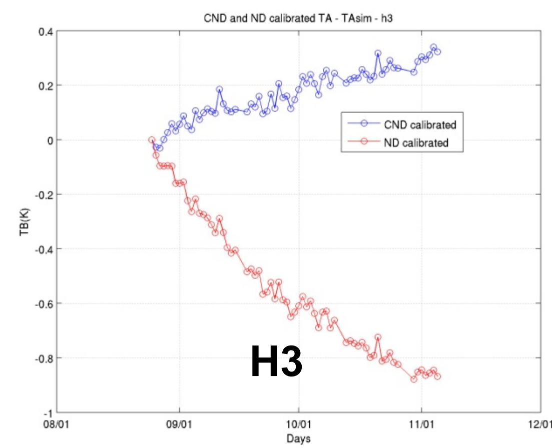






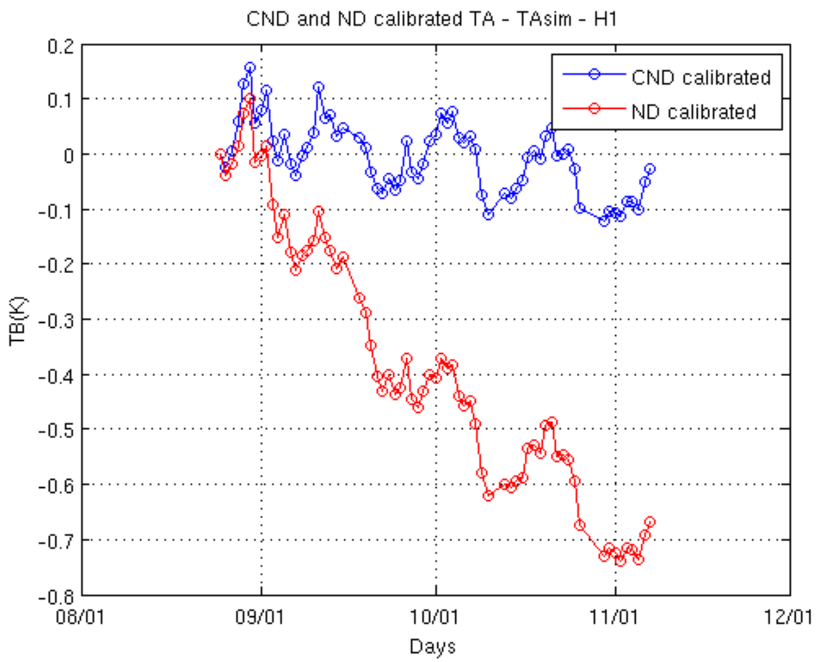


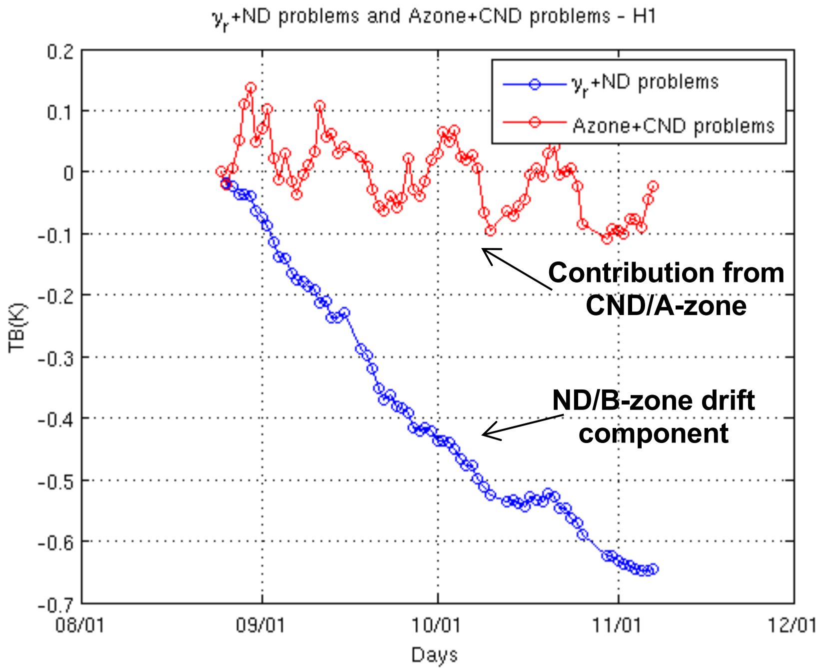




Common Drift

- **CND calibrated Ta-Tsim has drift due to A-zone and CND**
- **ND calibrated Ta-Tsim has drift due to A-zone, B-zone and ND**
  - **Extracting common component in CND and ND drifts results in separating out the component A-zone changes and B-zone+ND changes**



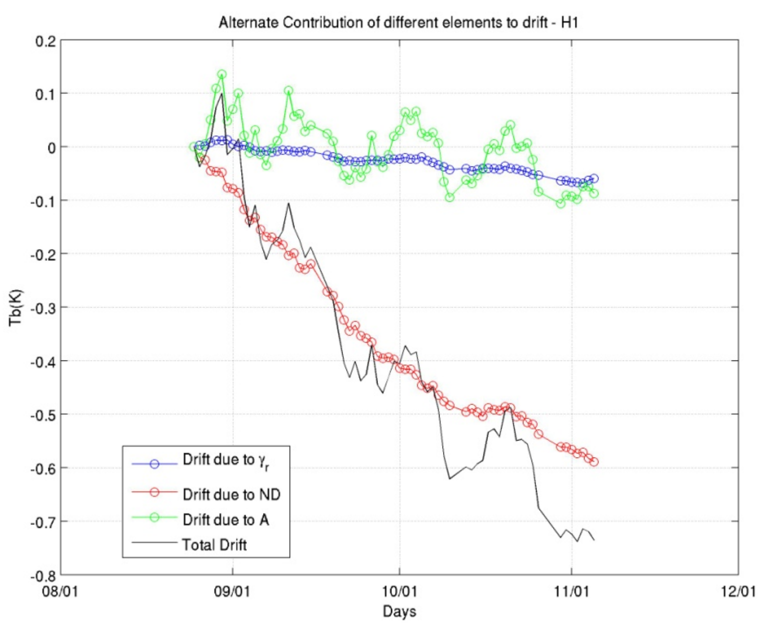


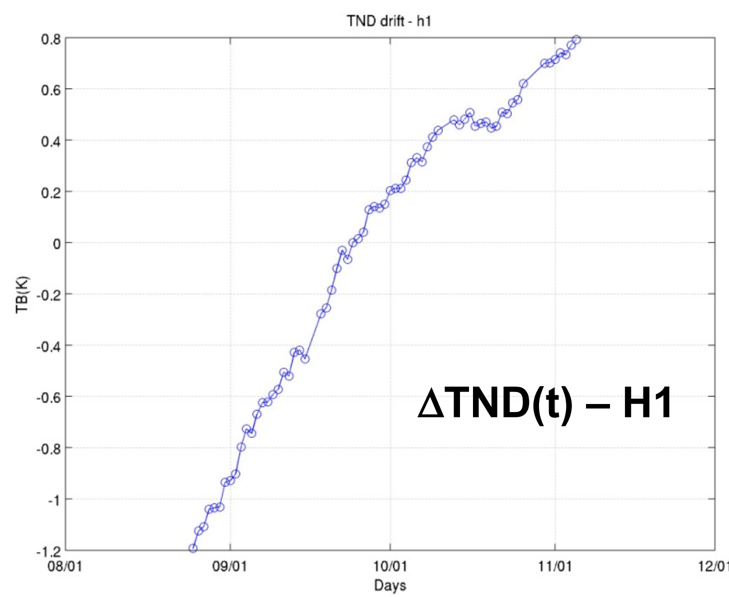
Separating out Reflection and ND Contributions

- **Estimate change in reflection coefficient in antenna position using NDA/NDR ratio**
  - This ratio is proportional to reflection from B-zone, reflection from switch in reference position as shown:-

$$\frac{ND(ant)}{ND(DL)} = \frac{Tnd(1 + D\Gamma_R)}{Tnd(1 + D\Gamma_{RER})}$$

- **Assuming constant directivity and reflection in reference load position, the reflection change in the antenna position can be estimated to get the ND contribution to the drift**





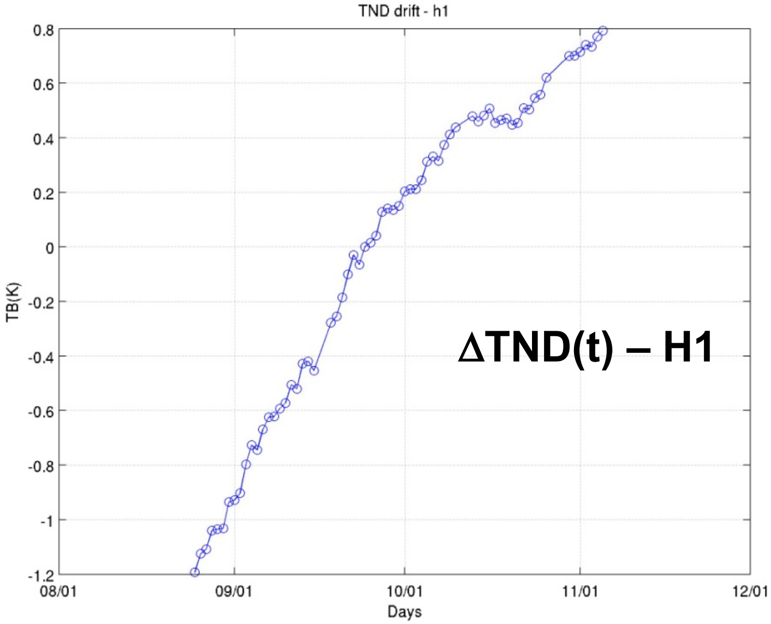
Summary

- Objective was to identify the most likely sources of the calibration drift in order to apply a suitable correction at the appropriate level in processing
- Analyzed drift over ocean and Antarctica to separate out overall gain and offset components of drift
  - Suggests drift is mostly due to a gain change (e.g. largest drift at coldest TBs)
- Analysis of relative stability of TA calibrated from CND and ND compared to TAsim shows changes mostly downstream of the CND
  - Separation of the drift into components indicates that the drift appears to be largely from a drift in the internal ND brightness
  - Analysis indicates smaller changes upstream of the CND
  - Computed relative ND changes consistent with gain variation estimates from Antarctica analysis

Next Steps

- **Determine L1 coefficient changes based on analysis**
  - **e.g. noise diode brightness time series, front loss changes**

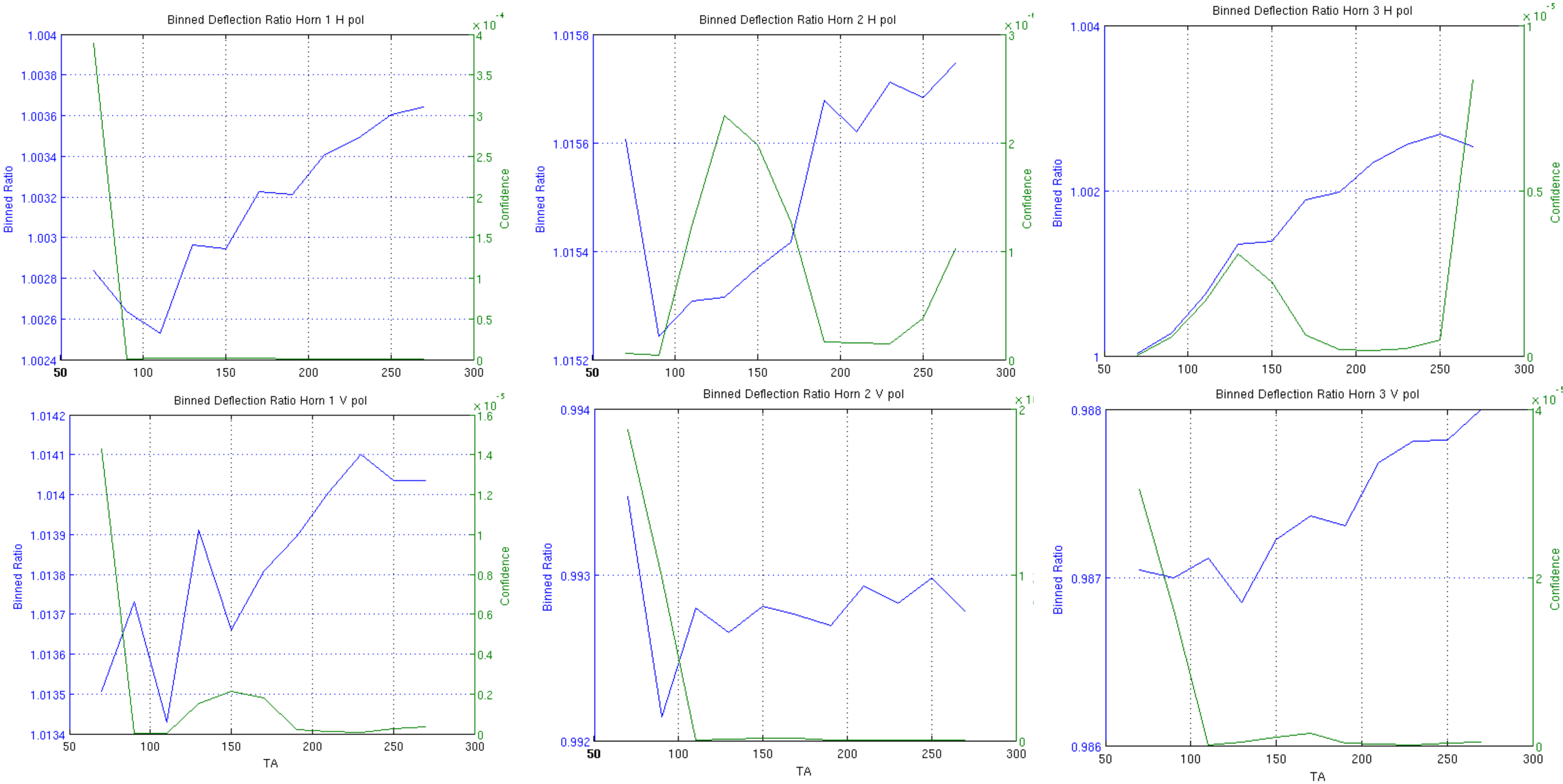
- **Reprocess data and repeat analysis of drift over ocean and Antarctica to verify that the drift is removed over both TB ranges**
  - **Cold sky data will also be analyzed as a good constraining case**



Backup

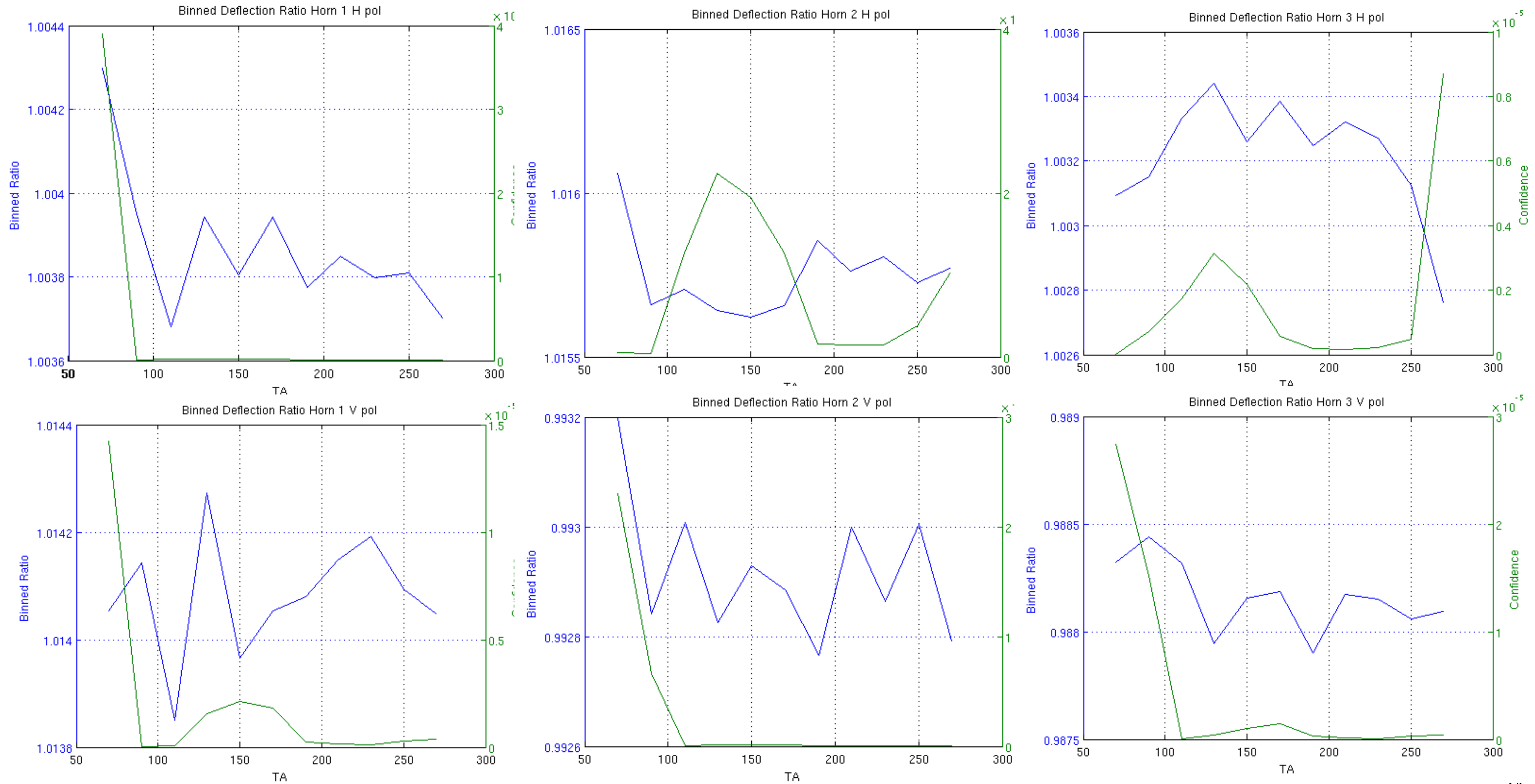
ND (load/ant) ratio w/o correction

- Ratio of Noise diode deflection over antenna vs deflection over dicke load
- Binned into various antenna temperatures
- Non linearity correction not done



ND (load/ant) ratio w/ correction

- Ratio of Noise diode deflection over antenna vs deflection over dicke load
- Binned into various antenna temperatures
- Non linearity correction done



Reflector Emissivity

- Reflector emissivity can be estimated by plotting TA-TAsim to (TA-Treflector) and estimating slope
- No significant dependence found