Using GRUAN for calibration of microwave sounding satellites

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- Several Uses of GRUAN results:
  - Absolute temperature reference

    (current MSU/AMSU datasets have an undetermined, possibly location dependent, absolute bias of up to ~0.5K)

  - Tool to diagnose possible drifts in satellite sensors.

    Ideally, able to see calibration changes significantly less than 0.1K over large spatial scales (i.e. several stations averaged) over a period of a few months or a year.

  - Validate Diurnal Adjustments?
    - Uncertainty in correction for the diurnal cycle is an important (possibly dominant) source of error in MSU/AMSU trends
    - Intensive field campaigns with launches 6X per day would be useful.

Effects of different launch schedules

- Differences between satellite overpass time and sonde measurement time can cause differences in measured temperatures.

- Magnitude of these differences **is not accurately known.**

- Due to:
  - Synoptic weather events
  - Diurnal cycle

- Complex – depends on location, surface type, time of year, weather, etc.

Effects of different launch schedules
(very) preliminary study:

- Investigate the implications of the baseline (00Z, 12Z) launch schedule.

- Approach:
  - Model output to estimate temporal and spatial variability.

  - Presented here: Use hourly CCM3 output to characterize the effects of temporal variability for MSU Channel 2 (mid-troposphere)

  - Ultimate goal: “Fly” sondes through mesoscale model output to evaluate the effects of spatial and temporal variability and measurement “footprint” mismatch

Limitations of this study

(study is only intended to suggest a path forward….)

- CCM3 is on a coarse spatial and temporal grid – too smooth?
- Spatial mismatch effects not studied
- Sonde measurement duration not considered

➢ *Together, the above suggest that errors probably underestimated for short times (but see discussion of surface emission).*

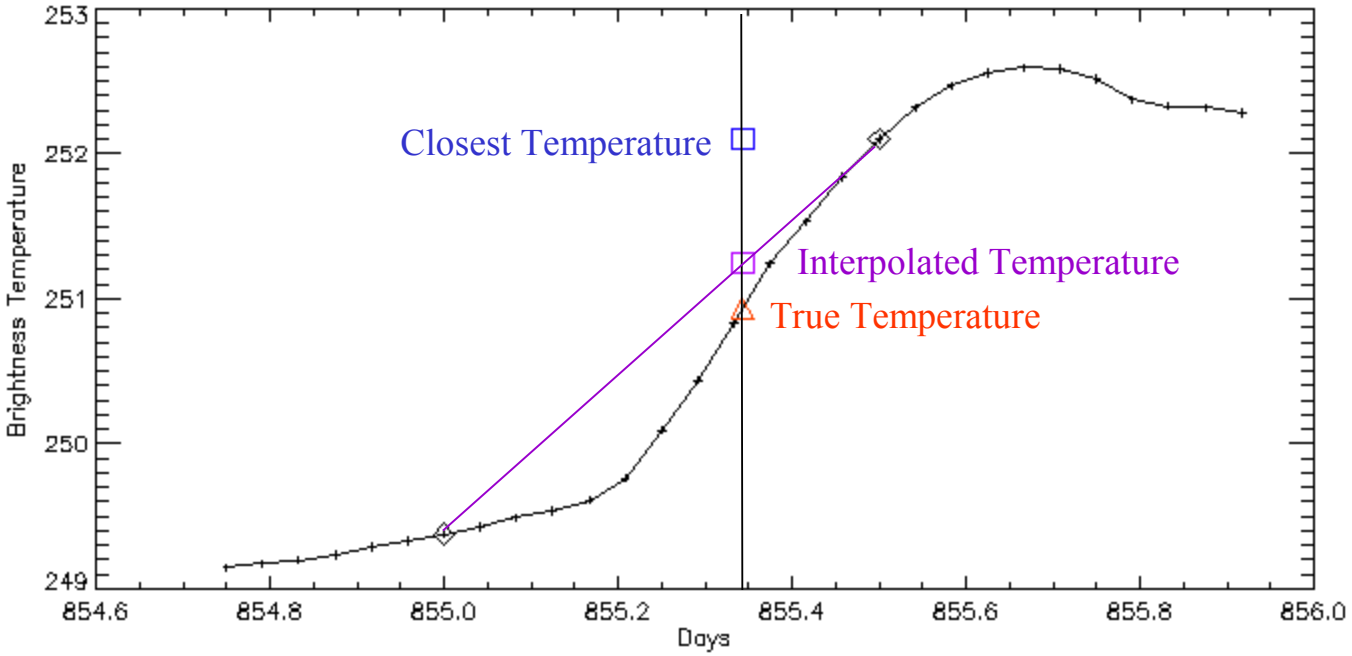
- No explicit adjustment for diurnal cycle.

Methods

- Use radiative transfer to compute MSU 2 brightness temperature from hourly CCM3 output.
- Surface emission is included.
- Compute mean bias and standard deviation for different measurement time differences.
- Test the benefit of linear interpolation (in time) of sonde measurements to satellite overpass time.
- Important feature: *Diurnal cycle for MSU 2 is dominated by surface and near surface emission over land areas. Diurnal cycle is small over oceans.*

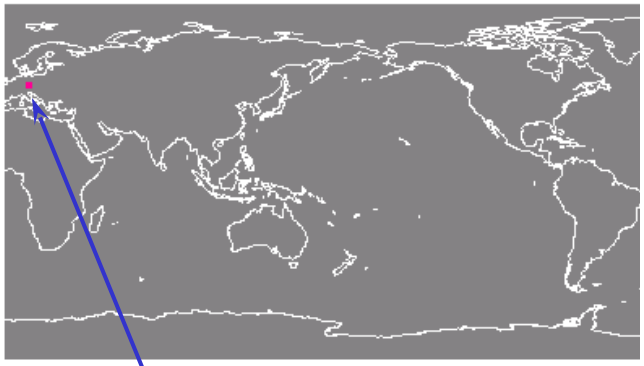
Differences between MSU channel 2 temperatures at sonde launch times and satellite overpass Time

Black line: MSU Channel 2 temperatures calculated from hourly CCM3 model output

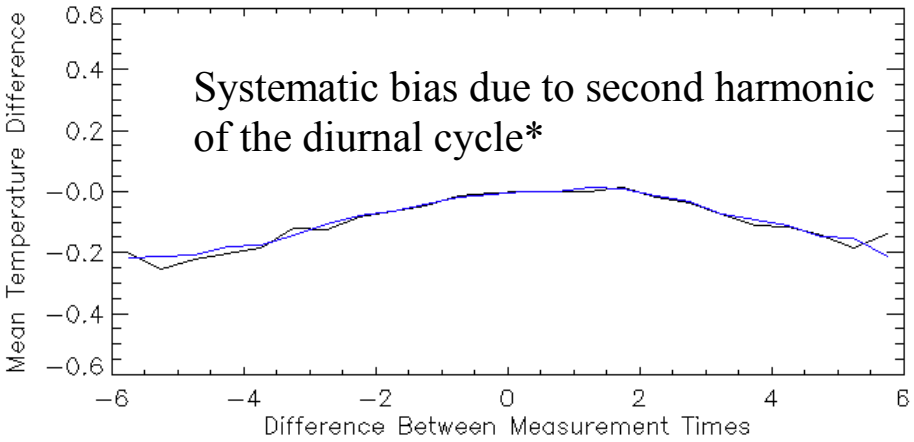


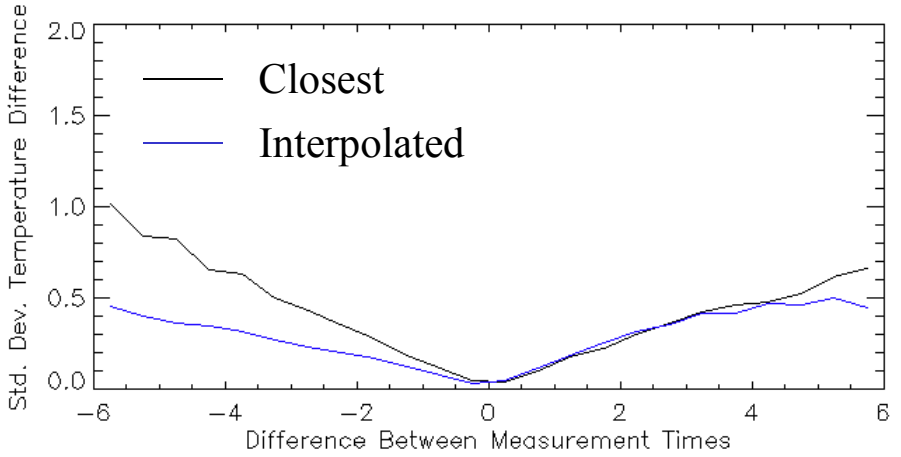
Interpolation usually reduces error, but not always.

Example: Temperate Land



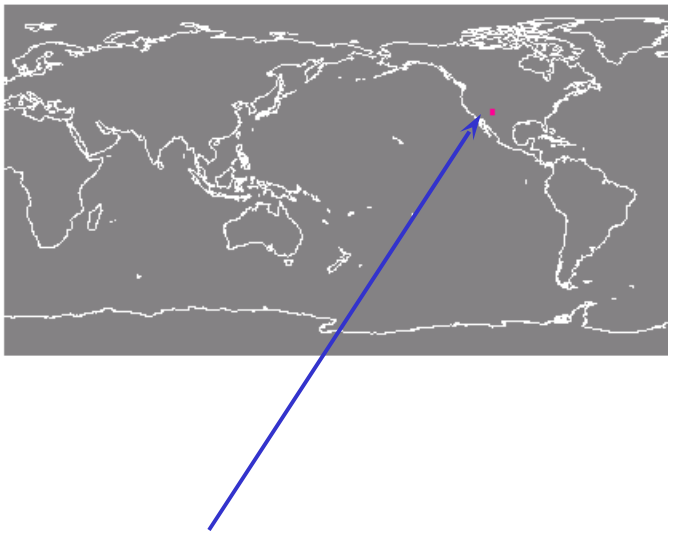
Location





*2nd harmonic is the dominant source of drift in MSU/AMSU datasets too

Example: Arid Land



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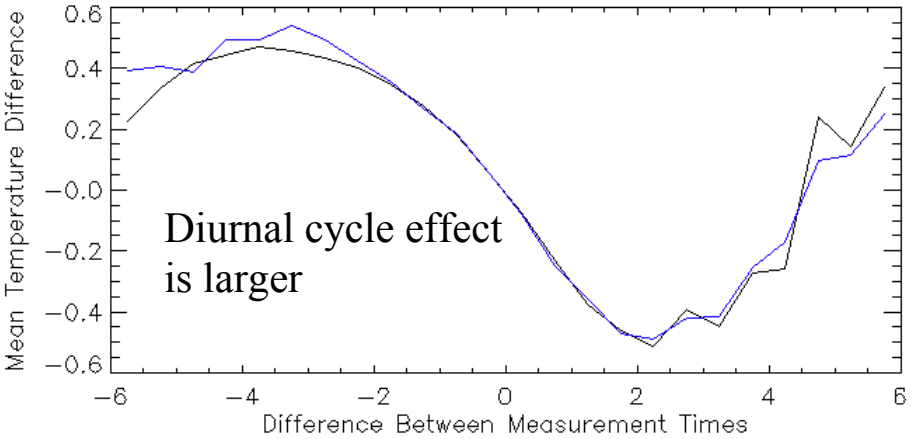
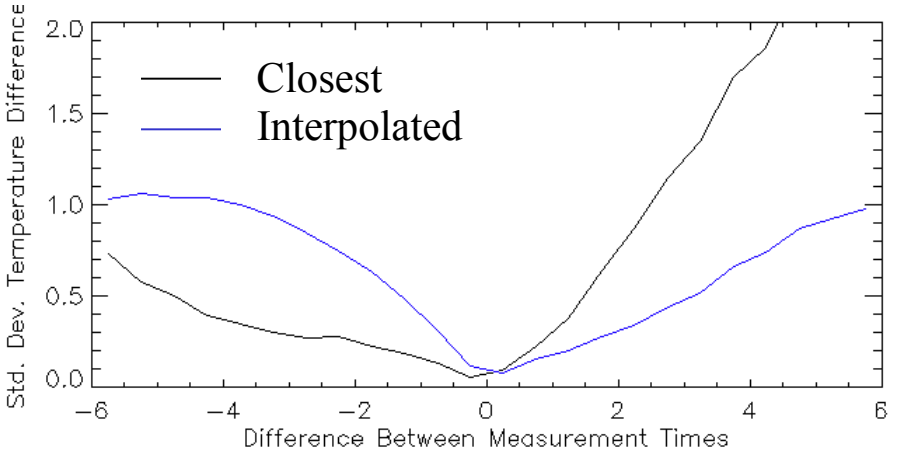
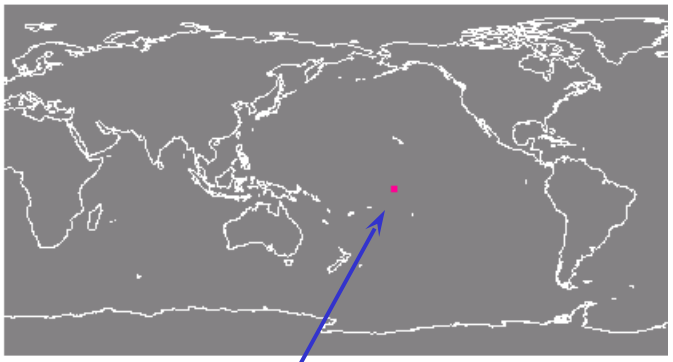
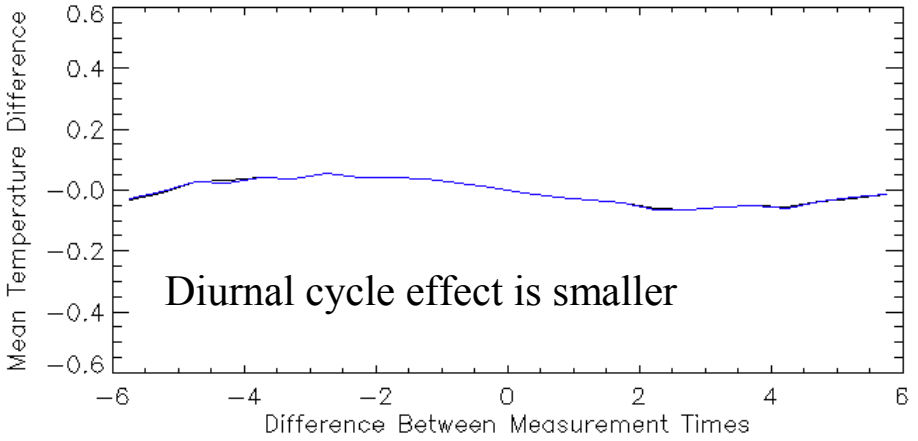


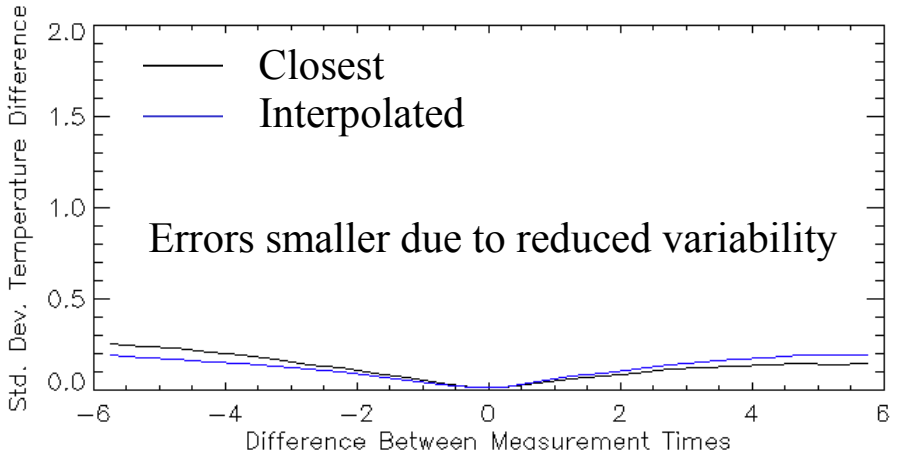


Example: Tropical Ocean



Location





Discussion points

- For mid-latitudes, a given location is measured ~30 times per month by a near-nadir view.
  - 0.5K/sqrt(30) = 0.091 (so random errors are not too bad for typical locations/time differences)
  - Tropics measured less often, but less variability so even less error
- However: for polar orbiters:
  - For a given earth location and Local Equator Crossing Time (LECT), the time difference is fixed, so
    - Mean biases due to the diurnal cycle **don't average out**, and
    - Mean biases due to the diurnal cycle are **seasonally modulated**, making things complicated.
  - For a given satellite/LECT, some locations will be better than others due to differences in this constant timing difference.

Discussion points: Diurnal Cycle

- Obviously, we can do a better job removing the diurnal cycle that I've done here.
- BUT, the diurnal cycle is not that well known
  - Important (perhaps dominant) source of error in MSU/AMSU trends.
  - Actual diurnal cycle varies depending on clouds, so diurnal correction using climatology will not eliminate variability.
  - I'm uncomfortable having sounder calibration critically dependent on yet another diurnal adjustment.

Discussion points: Surface Emission

- For MSU channel 2 / AMSU channel 5 (mid troposphere) the surface weight is ~10% for land.
- For MSU/AMSU TLT (lower troposphere) the surface weight is ~15-20%.
- How much difference is there between the “microwave skin temperature” and the surface temperature in the sonde measurement?? (I’d guess up to several K for some clear-sky conditions)
- This could be an important source of additional uncertainty (several tenths of a degree K)
- Do any planned stations have additional instrumentation to characterize skin temp?
- Oceans – surface contribution 50% less, less diurnal variability, surface well characterized.

Preliminary Conclusions

- Launch on (or just before) overpass is likely to be beneficial, but perhaps not critical.
- Skin temperature effects may be important for tropospheric channels.
- Sites on isolated small islands **very important**
  - Reduced diurnal cycle
  - Surface emission better characterized
  - Also critical for absolute calibration of microwave precipitable water measurements (SSM/I, AMSR, and follow-on sensors), which only work over water. (I think these are probably the most accurate satellite measurements we have, but I can't prove it!)
- Need to perform analysis with more appropriate model results – I'm looking for a few years of mesoscale output at a few representative locations.