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A method to recover longwave radiation measurements corrupted by a bad thermistor

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Background

Longwave irradiance is derived using three signals from a Pyrgeometer:

- Thermopile voltage
- Temperature of the instrument (T_c)
- Temperature of the dome (T_d)

$$LW = \frac{\text{Thermopile voltage}}{C} + \sigma T_c^4 - k\sigma (T_d^4 - T_c^4)$$

clear	~18%	~81%	~1%
overcast	~7%	~93%	< 1%

The instrument case temperature (T_c) accounts for over 80% of the longwave signal

Thermistor errors cause large longwave errors because of the 4th power effect

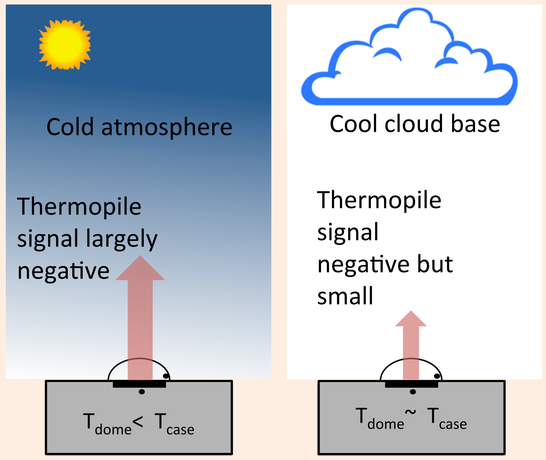
For example:
1°C T_c error will cause ~22 Wm^{-2} error in LW
1°C T_d error will cause ~16 Wm^{-2} error in LW

Motivation

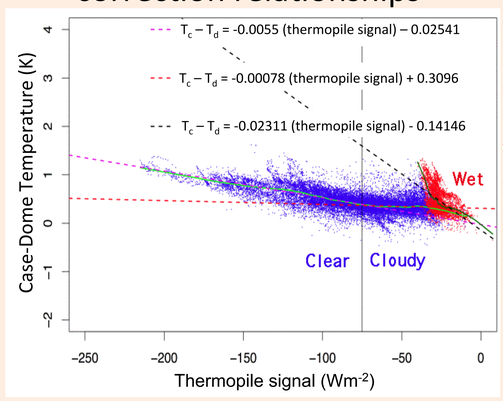
- Pyrgeometer thermistor errors in can go unnoticed for months
- Thermistor problems persist when errors are small (< 1°C) and not readily perceptible in data QC
- Subtle pyrgeometer thermistor errors result in significant longwave irradiance errors
- The ability to recover longwave data tainted by bad thermistor measurements serves to preserve long term data records

Correction method

Basis for the recovery method is that the case-dome temperature difference is related to the thermopile signal

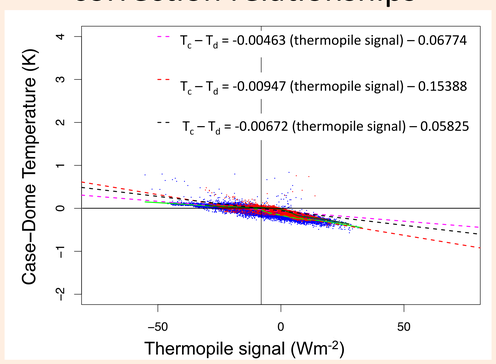


Up-looking pyrgeometer linear correction relationships



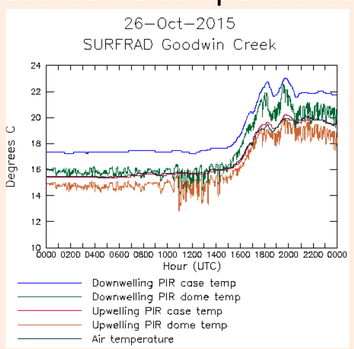
Wet mode:
RH > 80%
$T_c - T_{sky\_BB} < 6°K$

Down-looking pyrgeometer linear correction relationships

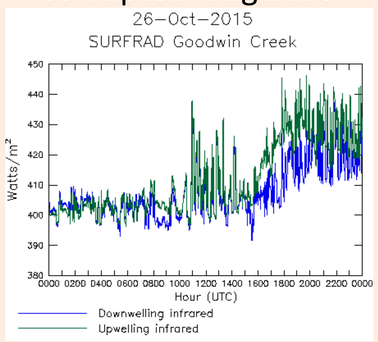


Results

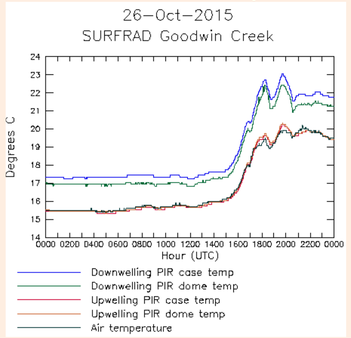
Bad dome temperatures



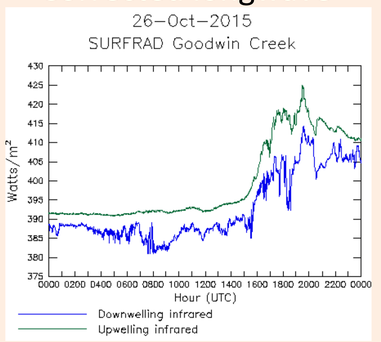
Corrupted longwave



Modeled dome temperatures

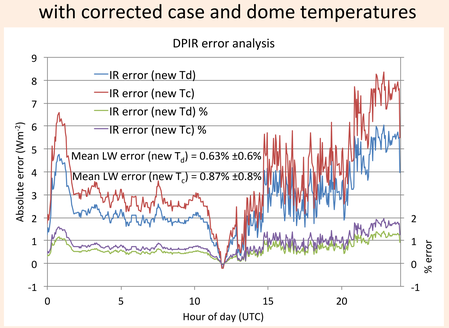


Corrected longwave

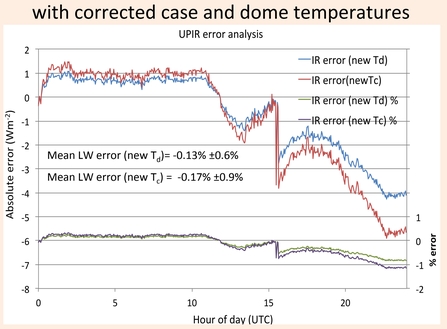


Errors associated with correction method

Up-looking pyrgeometer LW errors associated with corrected case and dome temperatures



Down-looking pyrgeometer LW errors associated with corrected case and dome temperatures



Summary

- Method is instrument dependent and one of the two thermistors must be good
- Period of normal operation is necessary to develop correction relationships
- Up-looking pyrgeometer case temperature recovery introduces ~0.9% (± 0.8%) additional uncertainty to the longwave retrieval
- Up-looking pyrgeometer dome temperature recovery introduces ~0.6% (± 0.6%) additional uncertainty to the longwave retrieval
- Added uncertainty associated with down-looking pyrgeometer case and dome temperature recovery is much less