Extending the Calibration Traceability of Longwave Radiation Time-Series (ExTrac)

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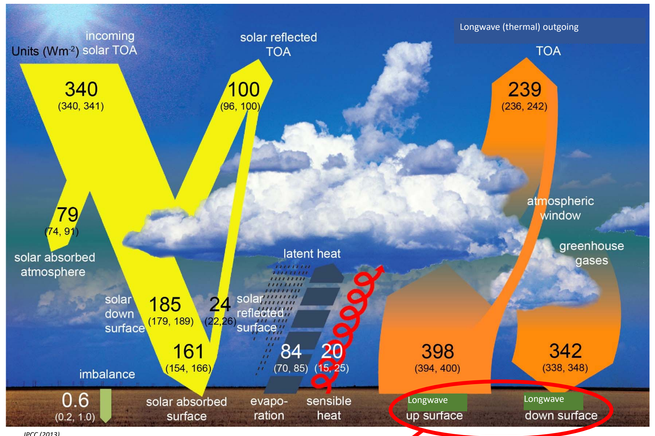
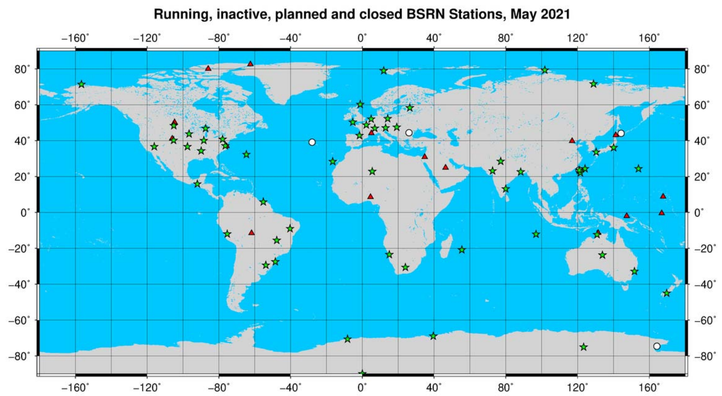
Earths Radiation Budget: The Role of Longwave Radiation at the Earth's Surface



IPCC (2013)

- Longwave radiation is part of a list of Essential Climate Variables (ECVs) which are deemed by GCOS as being critical to the characterisation of Earth's climate.
- Downward/upward longwave radiation (DLR/ULR) at the surface is measured with pyrgeometers.
- Ground-based calibration with World Infrared Standard Group (WISG) of pyrgeometers at PMOD/WRC, Davos.

Baseline Surface Radiation Network



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The central archive of the Baseline Surface Radiation Network (bsrn.awi.de) is hosted by the World Radiation Monitoring Centre (WRMC). In 2004, BSRN was designated as the global baseline network for surface radiation of GCOS.

Rationale and Aims of the ExTrac Project

Rationale

- BSRN DLR timeseries may need to be revised in the future due to a revision of the WISG scale (*Gröbner et al*., 2014; *CIMO,* 2018). This is not trivial as the DLR equation is non-linear.
- Scale revision may result in an increase in DLR (*Nyeki et al*., 2017):

  ~5.1 W.m^{-2} clear-sky sites

  0.7 – 1.3 W.m^{-2} cloudy sites
- If raw pyrgeometer data is still available and the pyrgeometer calibration is traceable to the WISG, then timeseries at each BSRN station could be re-determined. However, this may not be the case due to IT issues or loss of a knowledge-base.

Aims

- Investigate whether a methodology can be applied to retrieve the original raw pyrgeometer data at BSRN stations using archived DLR and ambient temperature.
- To prevent the loss of legacy data and ensure future availability when traceability and instrumental issues have been resolved by the research community.
- In order to extend the traceability of BSRN longwave time-series to the World Infrared Standard Group (WISG) at PMOD/WRC, up to 10 pyrgeometers from MeteoSwiss and BSRN will be calibrated as part of our in-kind contribution.

Determination of Downward Longwave Radiation (DLR) with Ground-Based Pyrgeometers

Extended Albrecht and Cox equation

$$DLR = \frac{U}{C}\left(1 + k_1\sigma T_b^3\right) + k_2\sigma T_b^4 - k_3\sigma(T_b^4 - T_b^4) \qquad \text{Eq. 1}$$

- DLR = [W.m^{-2}], U = pyrgeometer voltage, C = calibration factor [V.W^{-1}.m^2]
  σ = 5.670e-8 = Stefan-Boltzmann constant [W.m^{-2}.K^{-4}]
- T_b = pyrgeometer body temperature, T_d = dome temperature
- k_1 = correction for sensor non-linearity, k_2 = correction for body T, k_3 = dome correction

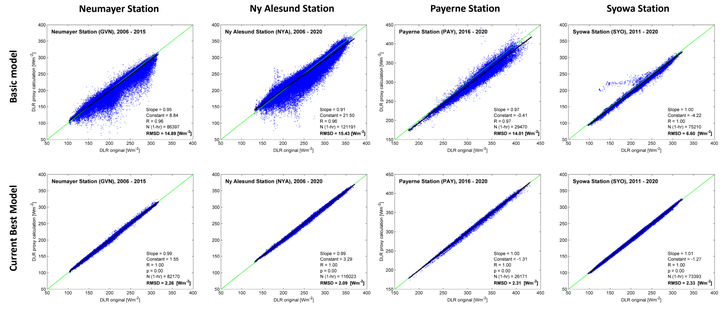
Method to retrieve "raw" data from pyrgeometers

- Train a station-specific algorithm using: 1) BSRN archives of DLR, DSR, and standard meteorological parameters and, 2) original pyrgeometer data.
- Step 1: T_b, T_d are used to construct $T_{b\ proxy}$ and $T_{d\ proxy}$ from ambient temperature, T_{2m}
- Step 2: Using $DLR_{original}$ from BSRN archives in Eq. 1 → $U_{retrieved}$
- Comparing original with retrieved data: We could compare T_b and $T_{b\ proxy}$, T_d and $T_{d\ proxy}$, U and $U_{retrieved}$ using the root-mean-square deviation (RMSD) as a statistic.
- However, more informative to compare $DLR_{original}$ with $DLR_{proxy\ calculation}$ (using U in Eq. 1)

Preliminary Results for BSRN Stations

How good is the agreement between the original and retrieved data?

- Four BSRN DLR time-series used so far to train an algorithm: Neumayer (GVN; Antarctica), Ny Alesund (NYA; Arctic), Payerne (PAY; Switzerland), Syowa (SYO; Antarctica)
- Basic Model: direct replacement of T_b with T_{2m} → RMSD too high.
- Current Best Model: RMSD values at all 4 stations < 2.3 Wm^{-2}.



Conclusions and Outlook

Conclusions

- RMSD agreement of $DLR_{original}$ vs $DLR_{proxy\ calculation}$ (<2.3 Wm^{-2}) is lower than the standard uncertainty of DLR measurements (~4.0 Wm^{-2}).
- So far, only data with a 1-hr resolution can be retrieved to within the DLR measurement uncertainty. BSRN archive data is 1-min data.
- If pyrgeometer ventilation units have been stably operated in the past, then $U_{retrieved}$, $T_{b\ proxy}$ and $T_{d\ proxy}$ could be tentatively retrieved at BSRN stations where the original raw data is no longer available. Training of a site-specific algorithm would be necessary, in a similar manner to that demonstrated here for GVN, NYA, PAY and SYO stations.

Outlook

- Station time-series waiting to be processed:
  - South Pole (Antartica), Barrow (Arctic), Alert (Arctic), Payerne (<2011), Syowa (<2011)
- ExTrac methods and results to be submitted as a technical report to CIMO and/or as a literature paper.

Acknowledgement

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