Measuring solar radiation from a swaying balloon platform

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Motivation

- Solar radiation in the atmosphere is a key quantity, as it quantifies the energy input, and varies with atmospheric properties, e.g. trace constituents (water vapour, ozone..), and, very substantially, cloud
- Radiosondes with solar radiation measurements, provide better resolution of cloud than conventional thermodynamic measurements, and accurate corrections for radiation errors in radiosonde air temperature measurements
- However, **radiosonde motion** (swing and spin) precludes accurate solar radiation measurements
- Radiosonde motion correction is explored here



Radiosonde solar radiation measurements



Philipona et al, JTech, 2013



semiconductor photodiodes provide small, fast and inexpensive sensors

•VTB8440B photodiode senses 300 to 720nm, with infrared filter

K.A. Nicoll and R.G. Harrison, Balloon-borne disposable radiometer *Rev Sci Instrum* **83**, 025111 (2012) doi: 10.1063/1.3685252









Adding orientation sensing

Uses a **Bosch BNO055 absolute orientation sensor**, 9-DOF, from accelerometers, magnetometers and gyroscopes, at up to 16Hz

- Test system for a radiosonde: self-contained with two photodiode amplifiers and a pressure sensor, squeezed into a 35mm film cannister
- Powered by a CR2 Li battery (3V), stepped up to 5V
- Data sampled at 1s using Ardulog and SD card











D2





Adapted from: K.A. Nicoll and R.G. Harrison, <u>Balloon-borne disposable</u> radiometer *Rev Sci Instrum* **83**, 025111 (2012) doi: 10.1063/1.3685252

Surface calibration



Balloon-carried test flight

Photodiodes pointing upwards





9th July 2024 from Reading

- Long (40m) string used beneath balloon
- Equipment recovery planned, with tracker

Flight



52.5

52.0

ιΩ

δ

51.0

50.5

-2

lat (°N)

Recovery



generated ~7.5Mb of data

2



...using coordinate transforms

Applying orientation corrections (descent)

- Raw data from sensor
- Maximum value in 20m vertical segments
- Correction for solar elevation and radiosonde swing
- Smoothed (leastsquares) correction for solar azimuth and radiosonde spin



Conclusions

- Orientation data from a 9-DOF sensor can improve solar radiation measurements, and potentially other position-dependent airborne sensors (air temperature, electric field, cosmic rays...)
- Radiosondes are under-used as scientific platforms: even operational radiosondes can readily provide additional measurements, especially as sophisticated sensors become cheaper

R.G. Harrison, Measuring electrical properties of the lower troposphere using enhanced meteorological radiosondes, *Geosci. Instrum. Method. Data Syst.* 11, 37–57, 2022 <u>https://doi.org/10.5194/gi-11-37-2022</u>



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