

## ***Interactive comment on “Tilt error in cryospheric surface radiation measurements at high latitudes: a model study” by W. S. Bogren et al.***

**C. S. Zender (Referee)**

zender@uci.edu

Received and published: 4 January 2016

### **General Comments**

This manuscript presents a model sensitivity study of idealized broadband shortwave radiometers to mounting platform tilt over idealized snow surfaces. After a short introduction to the theory of tilt, three figures summarize the results. The manuscript and figures are clear and straightforward.

Tilt-bias is an important topic. Snow researchers and climatologists struggle to obtain accurate shortwave flux and albedo measurements over snow-covered surfaces due to the many problems of measuring these quantities in harsh conditions by instruments

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



that are often unattended. However, the manuscript unintentionally exaggerates the role of tilt-bias by considering only clear sky (not cloudy sky) conditions. And nowhere does the manuscript show an observed albedo before or after adjustment for tilt-bias. This makes it difficult to gauge just how important the tilt bias is relative to all the other noise, model, and calibration biases. For these reasons I recommend revising the manuscript in two major and one minor way(s) described below.

## Specific Comments

The Figures are clear and easy to understand. Well done. Practitioners in the field will no doubt use these as motivation to obtain the best leveling possible.

The manuscript quotes Stroeve et al. (2006) that leveling errors dominate snow albedo measurement errors. On this basis the manuscript restricts itself to a theoretical quantification of that error, especially at the large zenith angles appropriate to polar environments. However, the Stroeve et al. claim is unverified until/unless someone examines actual AWS albedo measurements and show that removing the tilt-induced bias consistently eliminates at least half the error (e.g., versus a “known good” calibrated measurement like BSRN or some other metric). Has this been done? This manuscript would be more interesting if it showed readers how much better a tilt-adjusted albedo looks than a raw albedo from actual measurements. The inclusion of measurements would also add balance to this model study.

p. 4364: The manuscript mentions some effects of cloud cover, but the authors chose not to include more results because “the values are entirely dependent on the definition of many separate parameters controlling the properties of the cloud cover.” I disagree with this decision and think the manuscript would be more interesting if it presented results for homogeneous cloud cover. The manuscript is a sensitivity study that already makes numerous assumptions (flat snow, Lambertian albedo, no aerosols). Snow-covered surfaces in the arctic are often cloud-covered, and ignoring that aspect inflates

C2627

TCD

9, C2626–C2628, 2016

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



the AWS tilt-errors relative to their all-sky values. It takes instrument teams months of planning, days of installation, and sometimes years of maintenance to collect their measurements. They (an TC readers) deserve a model-sensitivity study that attempts to replicate the field conditions to greatest extent possible. I suggest you expand the study to include tilt-sensitivity to some arguably representative plane-parallel 100% cloudy conditions. Apparently you have already done the calculations, so it would be a matter of incorporating them into the manuscript. Then you will have more carefully bounded the tilt problem for your readers.

p. 4366: “Sensors for monitoring orientation” (like inclinometers) are helpful though not required to ascertain (and thus adjust for) tilt. Our manuscript currently in review in The Cryosphere demonstrates how to estimate tilt angles from tilt-biased broadband radiometer measurements (with adequate temporal resolution) in clear-sky conditions. The method is called RIGB (Retrospective, Iterative, Geometry-Based). It is “retrospective” because it works with (sub-daily clear-sky) timeseries measurements already taken, and its tilt-adjusted values have lower biases than measurements from AWS without and with (!) inclinometers (that can have their own problems). Please include in the Discussion “non-invasive” methods such as RIGB which can adjust for tilt without (and with!) the added expense and complication of additional instrumentation.

## Technical Corrections

None

Interactive comment on The Cryosphere Discuss., 9, 4355, 2015.

TCD

9, C2626–C2628, 2016

Interactive  
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

