Workshop Report No. 294 Vol.2

Evolving and Sustaining Ocean Best Practices Workshop IV
18; 21-25 & 30 Sep 2020 [Online]
Proceedings

Cronin, M.F.; Riihimaki, L.; Guerra, M.T.; Thompson, E.; Anderson, N.; Berk, P.; Bucholtz, A.; Connell, K.; diSarra, A.; Edson, J.; Farrar, T.; Fairall, C.; Hodges, G.; Lanconelli, C.; Lantz, K.; Meloni, D.; Michalsky, J.; Stalin, S.; Stanitski, D.; Swart, S.; Venkatesan, R. and Wendell, J. (2021) **Surface Radiation Community Working Group Report**. In: *Evolving and Sustaining Ocean Best Practices Workshop IV, 18; 21-25 & 30 Sep 2020 [Online]: Proceedings*, (eds Simpson, P., Pearlman, F. and Pearlman, J.). Paris, France, UNESCO, pp.98-111, (IOC Workshop Report No. 294, Vol. 2). DOI: https://doi.org/10.25607/OBP-1036)

Annex 10 Surface Radiation Working Group

1.1 Logistics

Co-Leads
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Sessions

Tuesday Sep 22 13:00-14:30 UTC (15' each block)

1. Laura Riihimaki Briefing
2. Anthony Bulchotz Briefing
3. Chris Fairall Briefing
4. Patrick Berk Briefing
5. R. Venkatesan Briefing
6. Summarize Best Practices

Wednesday Sep 23 13:00-14:30 UTC (15' each block)

1. Christian Lanconelli Briefing
2. Alcide di Sarra Briefing
3. Jim Edson Briefing
4. Tom Farrar Briefing
5. Summarize Best Practices
6. Plan way forward -- Best Practice Report and potential peer-reviewed paper for submission to BAMS or Frontiers in Marine Science.

Thursday Sep 24 16:00-17:00 UTC Synthesis of Recommendations, and plans for going forward.

Briefings addressed the following questions:

- What components of Surface Radiation are you measuring? and Why?
- How are you measuring Surface Radiation? What is your setup, including platform, & sensor sampling strategy?
- What is your calibration strategy?
- What particular challenges do you face making these measurements?
- What are your practices for overcoming these challenges and ensuring high
- quality measurements?

Working Group Leads and Participants

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
Meghan	Cronin	NOAA PMEL	USA	Meghan.F.Cronin@noaa.gov	0000-0002-4703-8132	Workshop co-lead, All
Elizabeth	Thompson	NOAA PSL	USA	Elizabeth.Thompson@noaa.gov		Workshop co-lead, Rapporteur
Maria Teresa	Guerra	Trinity College Dublin	Ireland	guerram@tcd.ie		Workshop co-lead, Section 5.4
Laura	Riihimaki	NOAA GML	USA	Laura.Riihimaki@noaa.gov		Workshop co-lead, All

Elizabeth Thompson acted as the Workshop Rapporteur

Panelists at session are listed in Table 10

Table 10 Panelists for Surface Radiation WG

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
Patrick	Berk	NOAA PMEL	USA	patrick.berk@noaa.gov		Section 4.2, 6.2, 7, 9
Anthony	Bucholtz	NPS	USA	anthony.bucholtz@nps.edu		Sections 4.2, 5.2, 6.2, 6.3, 9
Alcide	di Sarra	ENEA	Italy	alcide.disarra@enea.it	0000-0002-2405-2898	Section 4.2, 6.2, 6.3, 9

James	Edson	Woods Hole Oceanographic Institution	USA	jedson@whoi.edu		Sections 4.2, 5.3, 6.2, 6.3, 9
Chris	Fairall	NOAA PSL	USA	chris.fairall@noaa.gov		Section 4.2, 6.2, 6.3, 9
Tom	Farrar	Woods Hole Oceanographic Inst	USA	jfarrar@whoi.edu		Section 6.2, 6.3, 9
Christian	Lanconelli	European Commission Joint Research Centre (for BSRN)	Italy	christian.lanconelli@ec.europa.eu	0000-0002-9545-1255	Sections 6.1, 6.3, 7, 8
Laura	Riihimaki	NOAA GML	USA	laura.riihimaki@noaa.gov	0000-0002-1794-3860	All
R	Venkatesan	NIOT	India	dr.r.venkatesan@gmail.com	0000-0001-7386-1539	Section 6.2, 6.3

Other Participants are listed in Table *11*

Table 11 Other Participants to Surface Radiation WG

Given Name	Family Name	Affiliation	Country	email	ORCID if available	Contribution to Report (i.e. Section #, Cleanup, All)
Nathan	Anderson	NOAA PMEL	USA	nathan.anderson@noaa.gov		Section 8
Ken	Connell	NOAA-PMEL	USA	kenneth.connell@noaa.gov		Section 6.2, 6.3
Gary	Hodges	NOAA GML	USA	gary.hodges@noaa.gov		Section 7

Kathleen	Lantz	NOAA GML	USA	kathy.o.lantz@noaa.gov		Section 4.4, 5.2, 5.4, 6.3, 9
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Jim	Wendell	NOAA GML	USA	jim.wendell@noaa.gov		Section 7

1.2 Links to other WGs

Developing Training & Guidance WG – Our goal to expand the community of surface radiation observers, including from developing countries, is a driver for all of our recommendations. Our WG could benefit from this WG's best practice recommendations.

Uncertainty Quantification WG -- This WG could help us define useful uncertainty specifications that are at the core of metrology in all our above recommendations.

Fisheries WG, etc. – We will include decision trees for surface radiation observations for biological applications, as well as for heat budget applications.

Convergence WG – We welcome feedback and advice from this WG on how we present our best practice recommendations. Should these be part of the Ocean Best Practice System website? Or part of a new www.airseaobs.org website that is currently under development? This website is intended to help galvanize and highlight post-OceanObs19 activities (including development of best practices) related to improving and expanding air-sea interaction observations for the UN Decade of the Ocean Science for Sustainable Development.

Note: we expect that there are other synergies too.

1.3 Scope of Surface Radiation Community Consultation Working Group

Understanding and simulating cloud processes and their effect on the Earth's energy balance represents one of the major challenges for weather forecasts and climate predictions. Improved understanding of the surface radiation budget within models and from satellite observations will require direct observations of surface radiation over the ocean from the equator to polar latitudes, and from coastal to open ocean. Over the next decade the network of ocean surface radiation observations is expected to greatly expand as programs like Tropical Pacific Observing System (TPOS)-2020 are implemented and the use of novel surface platforms grows. In addition, surface radiation technology has rapidly advanced as solar power has gained wide-spread usage. It is thus critical to consider the challenges and best practices for making high quality surface radiation measurements from moving platforms, whether they be moored or drifting buoys, ships, autonomous surface vehicles, drones or aircraft.

As part of the Ocean Best Practices "Evolving and Sustaining OBPS Workshop IV: 18; 21-25 & 30 Sep 2020" a Community Consultation Working Group (WG) for Surface Radiation was formed. Panelists and participants included Surface Radiation practitioners of all levels from novices to gurus, and from both ocean and land-based surface radiation networks. During the first two sessions, panelists described their individual setups, challenges faced, and solutions to these challenges. During the final third session, a strategy was developed for the WG that would lead to consensus best practices for making Surface Radiation measurements from ocean platforms.

This report describes the workshop, the strategy developed by the WG for improving surface radiation measurements from moving platforms, and some consensus best practices. We hope that this WG will help bridge the ocean and land-based surface radiation networks so that ultimately the surface radiation reference station network can extend over the entire globe -- land, sea and ice.

1.4 Recommendations and Background

The following were deemed the top three-four recommendations for development of surface radiation methods and best practices. While this workshop report lists some of the best practices discussed during the workshop, further work will be needed to develop the best practices for submission in the OBPS repository.

1.4.1 Three-to-four top recommendations

1. Develop a decision tree for different surface radiation applications that provide recommendations for

a. choice of sensors,

b. best practices for handling of sensors and installation setup,

c. best practices for calibrating sensors and processing/post-processing data, and

d. sanity checks and tests for goodness of data.

2. Develop plans to expand land-based calibration facilities to handle ocean-based radiation sensors

3. (tie with 4) Develop recommendations for standardizing modifications to sensor electronic and housing for marine application. Share these recommendations with industry to allow for broader usage of sensors for marine applications

4. (tie with 3) Develop plans for field intercomparisons of different surface radiation platforms at testbed sites that can act as high-quality reference time series. Example testbed sites might include the Lampedusa Oceanographic Observatory, which is 15 km from the Lampedusa Atmospheric Observatory (Di Sarra et al. 2019), or the Air-Sea Interaction Tower (ASIT) offshore of Martha's Vineyard (Edson et al. 2016).

These consensus recommendations, and the key steps for making progress for creating and evolving methods and maturing these to best practices, are described in more detail in the following sections.

1.4.2 What are the challenges?

- If the sensor is not level, error in solar radiation is introduced due to the effective zenith angle of the solar direct beam.
- Moving platform changes effective zenith angle of solar direct beam. Waves (rocking) leads to high frequency variance in the tilts, while wind and currents, and platform navigation can lead to mean and variable tilts.
- Shadowing and reflection introduce errors in the solar irradiance
- Warm/cold objects in the field of view introduce errors in the IR irradiance.
- Condensation on the inside of the dome occurs when the desiccant is saturated. This leads to errors similar to dew formation, a particular problem for IR sensors because the condensation is not visible.
- Environmental contamination of the optics leads to errors, including from: Dust, dew, ice crystals, sea salt, guano, bird butts
- Input for data loggers must be amplified before digitization in some systems. As a result, "plug and play" sensors are not available, leading to a serious impediment for widespread usage by new groups.
- Lack of calibration "facilities" -- Calibration reference not always available or may be of poor quality.

1.4.3 What are the success stories?

Tilt correction:

Some success has been achieved using active leveling platforms to provide stability on moving platforms, primarily used on ships and aircraft (presentations by Chris Fairall & Anthony Bucholz)

A post-processing tilt correction methodology using the SPN1 radiometer to measure direct and diffuse components (Long et al. 2010) has been deployed on aircraft, ships, and autonomous vehicles (presentations by Laura Riihimaki, Anthony Bucholz, and Patrick Berk)

When averaging over longer time periods some sites show little overall bias (di Sarra et al., 2019; presentation by Alcide di Sarra)

Cleaning:

Two methodologies under development for automated cleaning which could help solve this challenge (presentations by Alcide di Sarra and James Edson)

1.4.4 List of papers showing performance of different sensors

One of the discussions of lessons learned from the land-based radiometer community is the potential to choose sensors that minimize the problems of a solar zenith angle response to instrument sensitivity, that have accurate spectral response sensitivity to wavelength region of interest, and a thermal offset caused by infrared loss to improve the accuracy of measurements. This collection of papers includes comparisons of the performance of different sensors as a first step towards creating decision trees for sensor choice in different environments.

1.5 Decision Trees for Choice of Sensors

In this section, we lay out the basic framework for the decision trees for different applications. A table of possible sensors with accuracies and sensor sampling frequency etc. could be very useful as a quick guide. While there are sensitivities to naming manufacturer products, the goal

is to be practical about sensor recommendations based on actual performance as identified in the literature. Overall, it was recognized that technology has improved and newer technology has advantages over older technology. The land-based surface radiation community has also done studies verifying the specifications of different radiation sensors. Thus, rather than duplicate this work, our WG will try to identify these studies and incorporate their lessons into the Ocean Best Practices.

1.5.1 Decision Tree for downwelling solar and IR radiation for heat budget applications

This section describes the decision tree for the choice of both primary and ancillary sensors for measuring downwelling solar and IR radiation specifically for heat budget applications. The choices depend upon the following considerations:

Is power limited?

Typically, power is not a limiting factor for large platforms such as ships or aircrafts, but is a limiting factor for smaller platforms such as buoys. In some cases, power is harvested from the sun or wind so that power is limited for some sensor choices but not for others. Thus, it is important that the decision tree for the sensor choices specify the power requirements.

- Active gimbal can be used to stabilize sensor
- Leaves room for new potential technologies like automated washing or heating/ventilation in environments that may require it.

Is the platform stable or not?

Longwave Radiation is relatively isotropically distributed so its sampling is less sensitive to platform motion. However, this is not the case with shortwave radiation, except under very diffuse conditions. Most ocean platforms are not stable. In some cases, however, such as with ships and aircraft, shortwave radiation sensors can be leveled using active gimbaling. This section will describe recommendations for gimbals and shortwave radiation sensors when it is not possible to keep the sensor level. These decisions will depend upon not only the degree of tilt, but also in some cases, the sensor's motion characteristics. For example, a buoy rocking in waves is less of an issue than a persistent tilt due to wind, currents or navigational changes to the platform. In general, when the sensor is not level and is moving, shortwave radiation should be measured with:

- Fast response shortwave irradiance sensors that also measure diffuse component (from which can derive and correct for platform motion) may be effective
  - IMU for measuring platform motion -- pitch and roll should be measured with accuracy of a few tenths of a degree at no slower than 1 Hz
- Check solar radiation leakage of IR sensors

Does the sensor experience extreme cold temperatures (or extreme heat)?

In extreme cold environments, ice can form on the domes, leading to measurement errors.

In land-based networks, this is often

- mitigated by ventilation and sometimes heating
- Some sensors, such as the SPN1 have internal heaters which mitigate this problem in some environments

Lessons can be learned from an Arctic radiometer comparison campaign held in Utqiaġvik, Alaska (Cox et al. 2020)

Decision Tree for Upwelling solar (i.e., albedo) Albedo is a challenging measurement to make over oceans, but needed for direct evaluation of satellite data and parameterization-based approaches for estimation. Aircraft measurements may be an effective approach to provide these measurements and evaluate the quality of surface-based measurements made from buoys or other platforms.

Decision Tree for Upwelling IR (i.e., Skin temperature)

Ideally, the skin temperature is measured directly with downward looking radiometers that are corrected for reflected radiation by a separate upward looking device or the same device that is occasionally rotated to look upwards. More typically, a thermistor is used to measure the temperature at some depth. Thermistors that can be towed very close to the sea surface (i.e., a sea-snake) require an adjustment for cool skin. Thermistors at depth (i.e., from a surface mooring) often require correction for diurnal warming and then adjustment for cool skin. A vertical array of temperature sensors may help with the warm layer but not the cool skin.

Downwelling solar radiation for biological application

The biological community is also in need of high-quality observations of surface radiation with wavelengths in a spectral range critical for photosynthesis, e.g. PAR and UVB sensors. These types of sensors differ from those used for heat budget analyses and therefore a separate decision tree.

1.5.2 Other Best Practices

These best practices typically apply to all applications and therefore are not included in the decision trees for different applications. It is emphasized that throughout this section, the best practices described here should be considered as preliminary. Further work is needed to determine the consensus best practice.

Recommended Sampling

- 1-minute averages of 1-Hz data is standard for the Baseline Surface Radiation Network (BSRN)
- Perhaps different frequency and averages for different variables (Tom Farrar mentioned the various averaging that can take place 10 second values into 1 min averages versus an instantaneous sample per minute, etc.)
- Also, the working group may recommend for the minimum sampling requirement i.e. Sample Rate, Sample Period, Sample Time (UTC), and Stored Data Interval for radiation measurement. Globally, each buoy operator follows their own sampling technique, this needs to be standardized.
- Sampling for tilt correction should be high, at 1 Hz or greater in order to adequately capture the range of motion of the platform. If tilt correction is not performed, then ranges of uncertainties could be calculated for different averaging times as a guide to how to use the data.

Recommended sensor/system modification

One of the major recommendations was to develop recommendations for standardizing modifications to sensor electronics and housing for marine application. Share these recommendations with industry to allow for broader usage of sensors for marine applications. Currently, modifications are performed to:

- Provide custom gain stages to amplify Thermopile sensor.
- Provide highly accurate thermistor readings on case & dome (PIR only).
- Minimize self-heating through low-power circuitry.
- Provide digital serial communications between the sensor and control systems.
- Custom sealed plastic housing (vs metal) to minimize thermal absorption and ensure sensor is ocean-ready (IP68+).
- The use of radiation shields and aspiration on accuracy is still an open question.
- Allow data to be logged. Manufacturers should be encouraged to give inbuilt data logger along with radiometer, although this may lead to larger power requirements. In some cases, sensors are part of a larger met system and don't require independent logging. Both options should be possible.

Capacity building needs to be undertaken as a priority. Field expertise is too often developed in a hard way. For new users the collection of additional or auxiliary data is very unclear. Many don't know that collecting a particular extra data can be used later to correct for issues with the target shortwave or longwave radiation observation. The WG hopes to clarify these best practices and recommendations.

Recommended Handling, Setup and Maintenance

Best practices for handling, setup and maintenance form part of the top major recommendations of the WG (#1b: Develop a decision tree for different surface radiation applications that provide best practice recommendations for handling of sensors, installation setup and maintenance). Here we provide some thoughts raised during the workshop. Further work is needed to determine the consensus best practices.

- Needs to change desiccant, pack very carefully, Galvanic corrosion and damage to fragile radiation shield

- Sensor output voltages can be very small, so selection of data loggers (sensitivity, stability, calibration requirements) and electronics for signal conditioning and digitizing requires some care.
- Aspiration in moist environments: not ventilated on ship, but someone physically cleans them every day. Ventilation removes dew, which may be an issue in coastal regions where fog can develop.
- Position on highest point to avoid shadows, but there are more subtle, yet important recommendations on this - e.g., if space constraints make it impossible to avoid having objects in the field of view of the radiometer, consider the cosine response of the sensor (i.e., have the object as low in the radiometer's field of view as possible) and consider the reflectivity/emissivity of the object.
- Clean with soft cloth, if possible.
- Cleaning in general… very interesting discussions yesterday on the apparent lack of dirt impact on SW versus the LW sensors. Of course, we could clean as much as possible but sometimes this is very tricky due to numerous reasons (e.g. cannot access ship met-mast due to weather/radar etc.). If we had some recommendations, we could better estimate the frequency of cleaning (at the moment I'm not sure if this should be daily versus weekly versus even monthly!). In land-based networks we clean daily when possible, and weekly, if possible, at more remote sites where daily cleaning is not feasible. On a ship I suspect the instruments would benefit from a daily cleaning given the challenging conditions.

1.6 Recommended Calibration Strategy

Best practices for calibration strategies form part of the top major recommendations of the WG (#1c: Develop a decision tree for different surface radiation applications that provide best practice recommendations for calibration strategy and post-processing). In addition, the second major recommendation (#2) of this WG is to expand land-based calibration facilities to handle ocean-based radiation sensors.

- Ideal: Outdoor calibration against sensor traceable to the World Radiometric Reference (WRR)
  - This calibration can be performed whenever the sun reaches an elevation of 45 degrees or solar-zenith angle is less than 45 degrees. This limits the time of year/location for acceptable high quality outdoor calibrations.
- Comparison with shaded pyrgeometer for LW irradiance
  - The LW should be calibrated against three standards of the same model that have been calibrated at the World Radiation Center in Davos
- Pre, during and post deployments calibration procedures/opportunities.
  - The ideal is to calibrate using the component sum of direct normal (DNI) and diffuse horizontal (DHI) measured separately: DNI*cos(Solar Zenith Angle) + DHI to compare to sensor under calibration
- Can anything be done during the actual deployment to get a reference to something (e.g. on a ship cover a certain radiometer for a period of time to get a zero count?)
  - Measurements should be acquired 24/7 and the nighttime can be used to get a rough estimate of the zero offset
- For moving platforms where cleaning can't be done, should post calibration be done pre-cleaning?
  - Yes, however, the calibration for a sensor that is subject to salt spray and rain will be constantly changing. See thoughts below.

The post-cal-before-clean idea requires responses to two questions:

1. Do salts and contaminants build up at a measurable rate over time, and
2. Do salts reach a quasi-steady-state fairly quickly in a deployment?

If these answers are not known then a post-calibration should be performed before cleaning. Formalizing further, it should be rolled into an experiment. To answer the above questions, it is recommended that instruments are removed from buoys at, say, 1, 2 ,3...12-month intervals and then calibrated pre- and post-cleaning. If a general relationship with time deployed vs attenuated signal can be developed that is a reasonable outcome. This assumes that the outcome of the post-cal-before-cleaning effort could be dropped and the relationship applied as a general correction for all instruments.

- How important is calibrating case/dome temp on PIR? To what precision (1.0C,0.1C, 0.01C?). Calibration should be better than 0.1 C. A 0.1 C error in dome T is about

  2.5 W/m^2. Generic calibration formulae often yield temperature errors of 0.5 C with Eppleys.
  - The thermistors are 0.1 degree C interchangeable. The original manufacturer (YSI) specified this down to -40 C, but the new manufacturer changed the spec to -20 C.
- The question about precision should refer to the deviation from the curve that we use to calculate temperature from the thermistor resistance.

1.7 Recommended Sanity Checks and Post-Processing

The following sanity checks and post-processing tips were discussed during the workshop. Further work is needed to develop community consensus.

- Filter out sample when tilt > 10 degrees.
- Zenith angle correction for moving platform
- Fairall et al. “fix” for cosine issue when using Eppley factory calibrations: Calibration coefficient is set at 45 deg incidence. But when the sun is directly overhead, the instrument is 3% more sensitive; you get a slight over estimation of solar flux at noon. This correction however was not clear to all and might be two different things. One issue is that the Eppley factory calibration doesn't necessarily match a calibration at 45 degrees, and a calibration factor could be added to adjust for that. The second is that the cosine response of an Eppley PSP (particularly the older model over the newer SPP) is not flat. This can be corrected for somewhat if characterized, though most folks in the land-based community don't do that correction because PSP measurements are usually a secondary measurement. Further information is needed for a full understanding of this proposed correction.
- QC/QA to be implemented, as far as the radiation components needed to perform a certain test are available (see Long and Shi, 2008 in references). At least PPL/ERL.
- Pyranometer offset correction using NetIR (at least). For modern instruments it may not be necessary but check nighttime offset signal. Further information can be found in the 2018 BSRN presentation: https://www.esrl.noaa.gov/gmd/grad/meetings/BSRN2018_documents/Th3_Pyranometer_intercomparison_Wang.pdf
- Sensitivity as S(T), dependence of S from air/body temperature

- "Sanity Checks" should be performed, including comparison to climatological expectations. For solar radiation, a semi-theoretical estimate of clear-sky solar radiation provides a good constraint, and it can often reveal the existence of mean tilts in the radiometer (because radiation will be systematically higher or lower than expected, with a dependence on time of day).
  - Someone mentioned an SWR sanity check against top-of-atmosphere incoming radiation (although OCS has seen some reflection/refraction cases).
  - For LWR, the Stefan-Boltzmann equation can provide a possible upper limit. I'd be interested in opinions here, as it may not be a hard threshold -- if a warmer layer exists above the sensor, values over sigma*T^4 (T as measured by sfc inst) may be realistic?
- Could we recommend the top priority studies we can undertake with existing or new data to deal with radiometer quality/uncertainty etc.? The long WHOI datasets can already test many things in this area... like cleaning/dirt impacts on different radiation measurements, etc etc. Maybe this is out of scope to propose?

1.8 Interoperability Experiments

The WG recommends that plans be developed for field intercomparisons of different surface radiation platforms at testbed sites that can act as high-quality reference time series. Example testbed sites might include the Lampedusa Oceanographic Observatory, which is 15 km from the Lampedusa Atmospheric Observatory (Di Sarra et al. 2019), or the Air-Sea Interaction Tower (ASIT) offshore of Martha's Vineyard (Edson et al. 2016).

Some of the potential experiments that could help determine uncertainties for measurements in the field are tests for:

- The impact of buoy motion on data quality, what are the long-term
- The impact of lack of cleaning on data quality
- The quantitative effect of buoy structures on the measurements due to shading in the SW and emission in the LW
- Testing the effectiveness of potential automated cleaning and ventilation systems and their reliability in unattended ocean-based systems
- Testing our ability to measure albedo from buoys and technical challenges to doing so.

1.9 The UN Decade of Ocean Science for Sustainable Development (Ocean Decade)

SCOR Working Group #162 for the development of an Observing Air-Sea Interactions Strategy (OASIS) has recently been formed to harmonize nearly 3-dozen OceanObs19 Community Strategy Papers relevant to air-sea interaction. One goal of this strategy will be to work through the UNDOS to massively expand the surface radiation network (as well as other surface variables). Developing Best Practices is part of this strategy. At present net surface heat flux is measured at only 20 OceanSITES reference stations. This is in part because there are fewer long-term measurements of downwelling longwave radiation than downwelling solar radiation. Part of the expansion will occur through enhancement of existing moorings. For example, through efforts such as the Tropical Pacific Observing System (TPOS)-2020, all TPOS moorings will be enhanced, thereby expanding the TPOS network of surface radiation from 4 sites to more than

50. Likewise, if a network of Unmanned Surface Vehicles and other mobile and drifting platforms is developed through UNDOS, we hope that these platforms will carry surface radiation sensors.

1.10 Future collaborations

Surface Radiation WG thanks the organizers of the IOC OBPS Workshop IV for giving us the forum to develop these best practices. The Surface Radiation community has been fractured, with little overlap between land-based and ocean-based groups. This is now changing. We hope that through working with IOC OBPS, ocean surface radiation will move towards being a standard measurement and ultimately part of a global network of air-sea interaction observations. Interoperability, through standardized best practices, is a fundamental premise of having a network of observations. Therefore, the Surface Radiation community would like to continue working with the IOC OBPS for development of a global network of surface radiation observations.

We envision this Community Consultation WG continuing as an ongoing WG, with growing membership. Organization can be provided through the newly forming Observing Air-Sea Interaction Strategy (OASIS) and the Baseline Surface Radiation Network (BSRN). The OASIS website: www.airseaobs.org is currently under construction.

One of the first tasks of this WG will be to share these recommendations for best practices widely by drafting a peer-reviewed manuscript (for example a BAMS article) based upon this report. We hope that this WG will also act as a bridge between the land-based and ocean-based surface radiation communities. We note that most of the literature showing performance statistics for different sensors is written primarily by land-based networks. Likewise, the existing calibration facilities at present have been developed to serve the land-based community. Our recommendation for intercomparison experiments at ocean-land testbed sites will bridge the ocean-land divide by using nearshore and land-based tower reference stations. At present, sensors and packaging are often modified by the individual groups. This is a barrier for many smaller groups, particularly in the developing world. After the best practices are standardized, it would be helpful to have industry adopt these modifications so that the sensors and packaging could be used off the shelf. Ultimately, we hope that the network of surface radiation reference stations will extend across the entire globe.

1.11 Relevant References

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