

# UPDATE FROM THE GEWEX DATA **ANALYSIS** PANEL

... formerly GEWEX Data Assessments Panel  
... and before that GEWEX Radiation Panel



**Rémy Roca (CNRS)**

[remy.roca@legos.obs-mip.fr](mailto:remy.roca@legos.obs-mip.fr)

and

**Tristan L'Ecuyer (UW-AOS)**

[tristan@aos.wisc.edu](mailto:tristan@aos.wisc.edu)



THE UNIVERSITY  
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**WISCONSIN**  
MADISON



Next: GDAP Panel Meeting  
26-30 Nov. 2018, Lisbon, Portugal

# GEWEX Data and Analysis Panel (GDAP)

- Originated within the GEWEX project of the WCRP to bring together theoretical and experimental insights into the radiative interactions and climate feedbacks associated with cloud processes.
- GDAP is charged with answering the fundamental question: **How sensitive is the Earth's climate to changes in radiative and other forcings?**
- GDAP remains focused on understanding and **coordinating observations** of both incident and outgoing radiation, as well as advances in **radiative transfer methods** needed to understand these observations in the context of changing amounts of greenhouse gases, clouds, or aerosols in the atmosphere or by changing land surface properties.
- To make progress in the difficult area of understanding climate feedbacks, the GEWEX Data and Analysis Panel currently seeks to compile **consistent Water and Energy budgets** using calibrated, long term, global precipitation, radiative flux, and surface energy exchange datasets as well as the atmospheric and surface parameters that affect them.
- GDAP coordinates the **assessment** of existing and new parameters related to the global water and energy balance by comparing these to **quality-controlled surface benchmarks** and shorter term, higher quality data sets available from research missions.

# Motivating Questions

1. How can we better measure and characterize the state and the variations of the climate using satellite observations?
2. What are the changes in radiative forcing that cause climate change?
3. How do the interactions of radiation with changes of the internal state of the climate (*a.k.a. radiative feedbacks*) affect the climate's sensitivity?
4. How do the internal water exchange and transport processes in the climate (*a.k.a. water feedbacks*) affect the climate's sensitivity?

# The GDAP Activity Portfolio

- Sponsor *production and analysis* of satellite datasets (e.g. ISCCP, GPCP, SRB, SeaFlux, LandFlux)
- Oversee *dataset assessments* to provide critical uncertainty information for data records
  - Assess adequacy of current observing systems and identify gaps/future needs
- Support *ground based networks* (e.g. BSRN, GPCC)
- Act as an *interface* between GEWEX activities and datasets
  - PROES, GAP, other GEWEX panels (GLASS, GASS, and GHP)
  - New Earth's Energy Imbalance initiative
- *Represent* GEWEX at various WCRP meetings, WMO, and other requests
  - Outreach to various other bodies within WCRP
  - Strong links to WMO/CGMS working groups
    - GVAP meets during ITGW
    - Co-chair of ICWG is a member of GDAP
    - Joint IPWG/Assessment
  - Rémy Roca sits in WDAC
  - Coordinate with GCOS

# Updates on Core Activities: Assessments

## Application-centric Evaluation Key to Maximize Value of Assessments

- Recently completed GDAP *Water Vapor assessment* used to draft recommendations in the new Decadal Strategy
- Updated *Cloud assessment* with improved representation of active sensor observations is nearing completion
- *Aerosol assessment* is being resurrected
- Joint IPWG-GEWEX *Precipitation Assessment* is now underway
  - Specific attention to « high priority » regimes (arid, orographic, high-latitude)
  - Established links to GASS, GHP, GAP, etc. and modeling communities
  - Representation from NASA PMM, NOAA, JAXA, and European communities
  - Seeking agency support for comprehensive activity
- GDAP promotes a new comprehensive view on assessment
  - Document on good practices to be finalized this year: coordination between satellite flux developers to BSRN will serve as a model

# Common Theme

Ground-based networks are vital to uncertainty characterization

- BSRN is a great example:
  - Started under GEWEX Radiation Panel in response to the need for a surface radiation reference standard
  - Charge: to provide high-quality, traceable, reference surface radiation measurements in a variety of locations to support global radiation budget studies
  - New SI-traceable reference for downwelling LW irradiance being established
  - Critical reference for many products including GEWEX-sponsored SRB and ISCCP-FD

# E.g. The GEWEX Surface Radiation Budget (SRB) Product Version 4 (Paul Stackhouse et al.)

- Many updates:
  - Updated cloud inputs from ISCCP HXS
  - Adapted new MAC-2 aerosols
  - Implemented new monthly spectral surface emissivity product
  - Include diurnal SST variations
  - Land 2m T and q based on LandFlux
  - Oceanic 2m T and q consistent with SeaFlux

NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION + Visit NASA.gov

Global Energy and Water Exchanges Project  
**GEWEX** WCRP  
**SURFACE RADIATION BUDGET**

Home SRB Data Products Examples of SRB Data Access SRB Data

**Data**  
Access Data  
Data Format  
SRB Data Products  
Examples SRB Data  
Known Data Irregularities  
Alternate Data Access through MY NASA DATA (monthly and daily)

**Documentation**  
About SRB  
About GEWEX  
Global Geometry/Resolution  
Parameter Accuracy/Validation  
GEWEX/SRB Methodology  
SRB Publications  
Acknowledgments Please

**Related Links**  
Atmospheric Science Data Center  
LaRC Science Directorate  
Science Mission Directorate  
International Satellite Cloud Climatology Project (ISCCP)  
Global Energy and Water Exchanges (GEWEX)  
Earth Radiation Budget Experiment (ERBE)  
SRB Team Site (limited access)

**NASA/GEWEX Surface Radiation Budget (SRB) Project**  
SRB Rel. 3.0/3.1 Sfc Total Net Flux, 24 Yr Average for Oct

The Global Energy and Water Exchanges (GEWEX) is an integrated program of research, observations, and science activities with the goal of providing data sets to support accurate predictions of global and regional climate change. Research in the areas of Earth radiation budget, hydrometeorology, and modeling/prediction contribute to meeting the goal of GEWEX.

The NASA/GEWEX SRB project is a major component of the GEWEX radiation research. The objective of the NASA/GEWEX SRB project is to determine surface, top-of-atmosphere (TOA), and atmospheric shortwave (SW) and longwave (LW) radiative fluxes with the precision needed to predict transient climate variations and decadal-to-centennial climate trends.

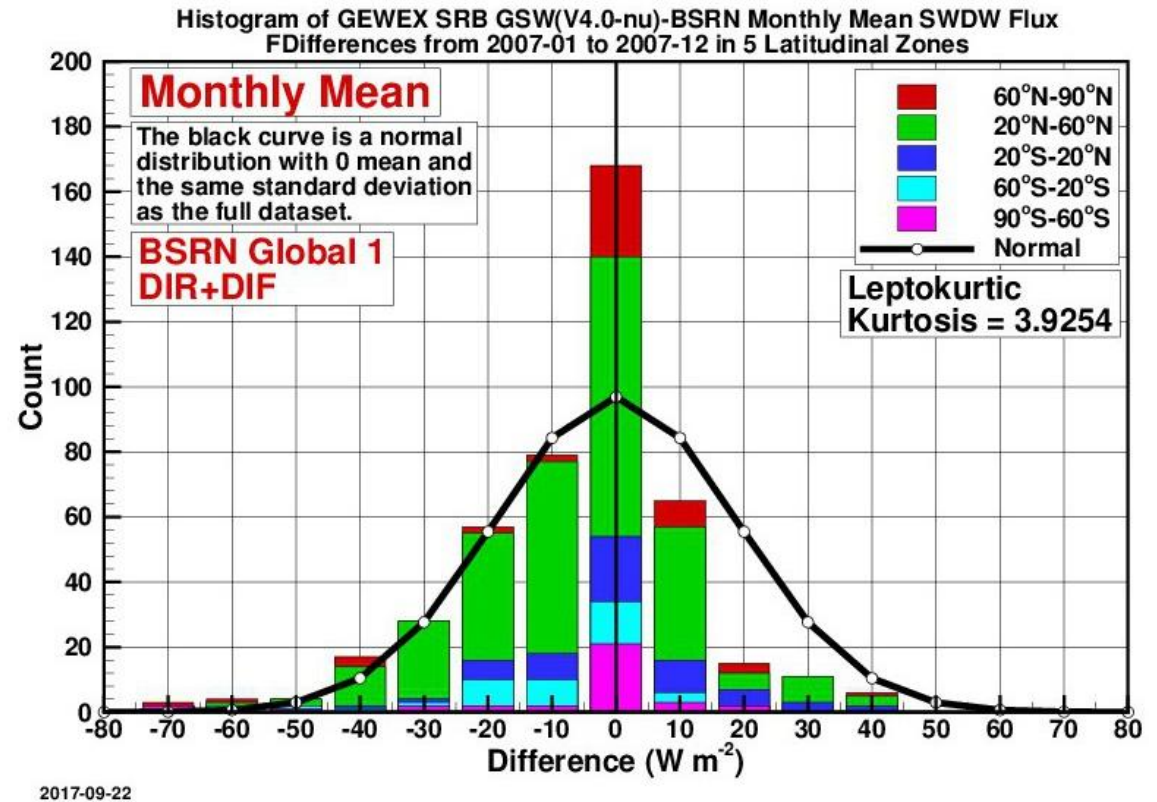
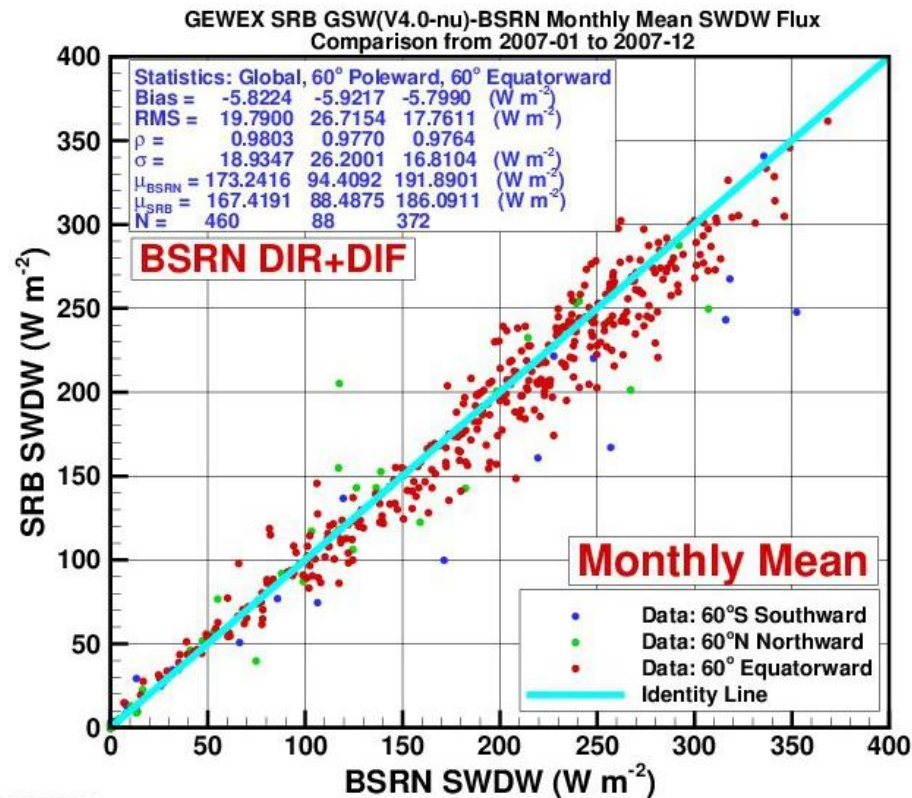
**Special Release Announcement**

The NASA/GEWEX SRB project team announces a modified version of the GEWEX Longwave data set. Denoted as version 3.1, this version corrects for a numerical instability issue that was found to affect a small number of 3 hourly grid box TOA outgoing and surface downward fluxes. The approximate number of grid boxes affected ranged from 7-12 (out of 8 hours x 30 days x 44016 total grid boxes) per month. The 3-hourly values in those instances were significantly in error but had little effect on daily, 3-hourly monthly and monthly averaged values. Users analyzing 3 hourly fields are advised to obtain the new data set. Please contact us if you have more specific questions.

<http://gewex-srb.larc.nasa.gov>

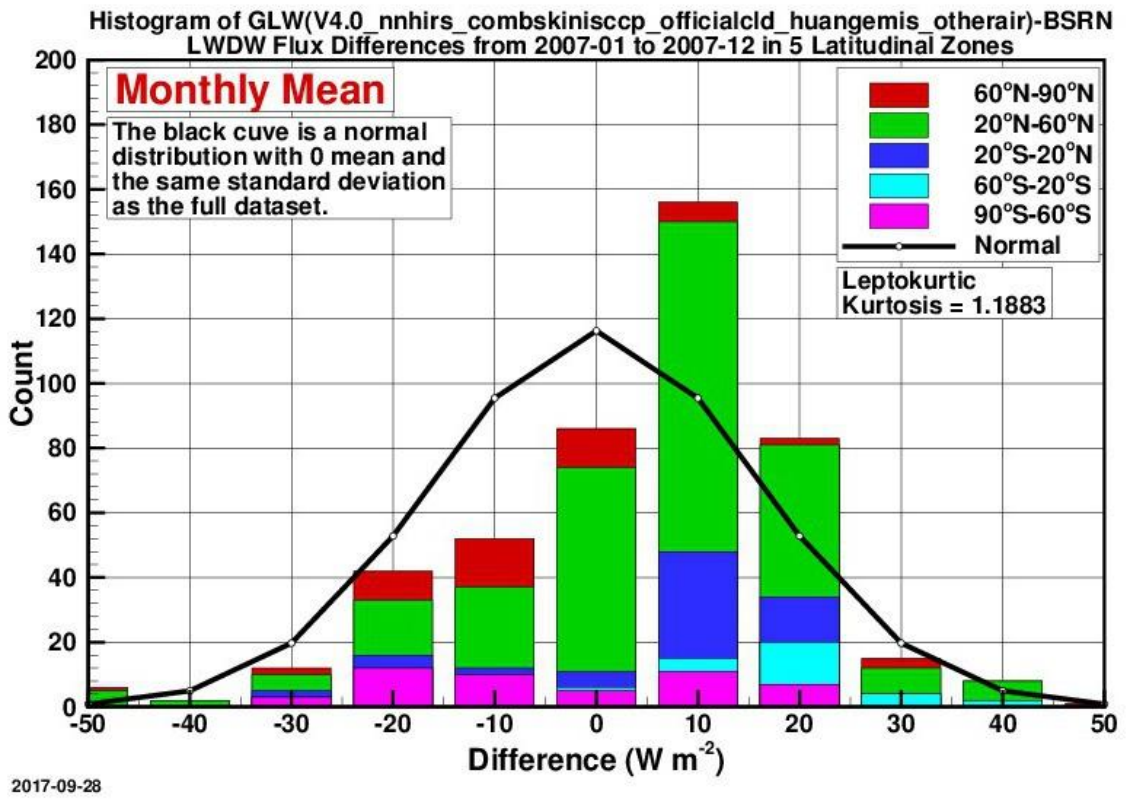
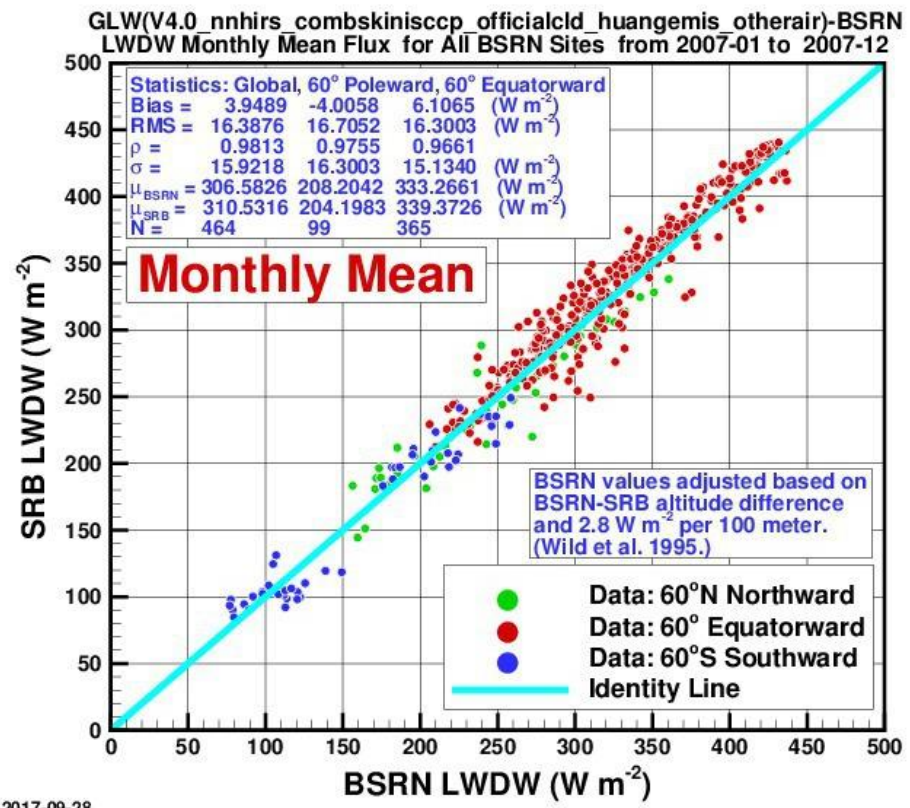


# Validating Downwelling SW Against BSRN



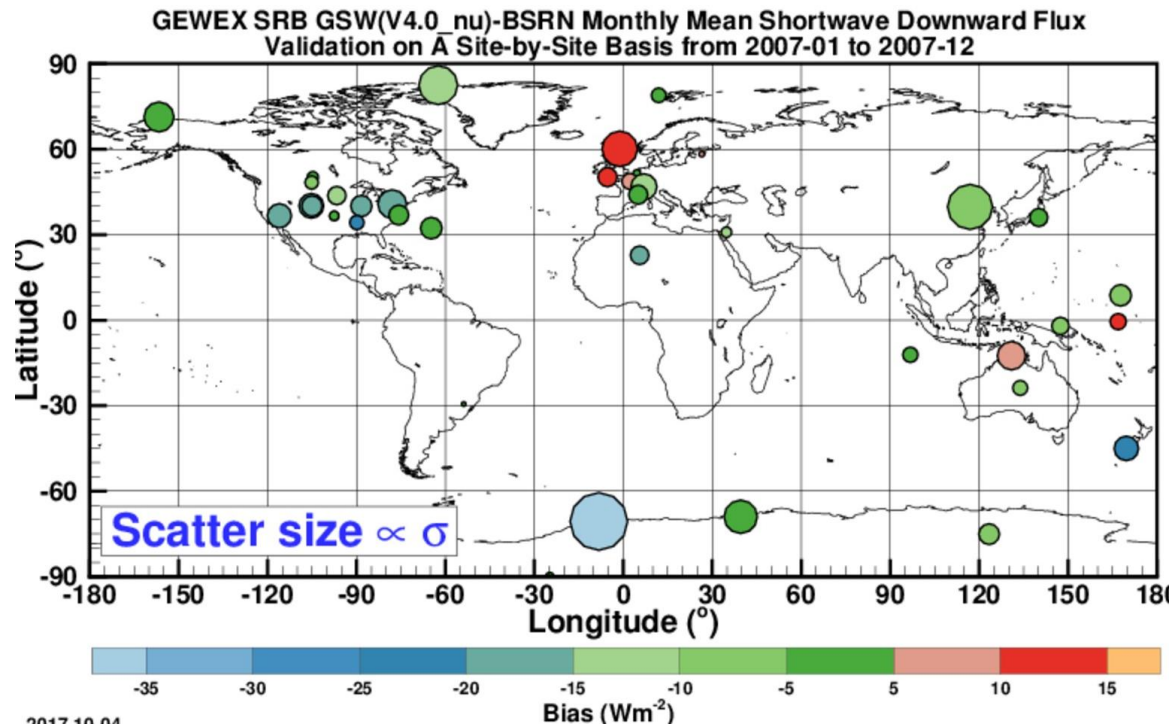
BSRN monthly mean shortwave downward flux comparison statistics for the period from 2007-01 to 2007-12.

# Downwelling LW

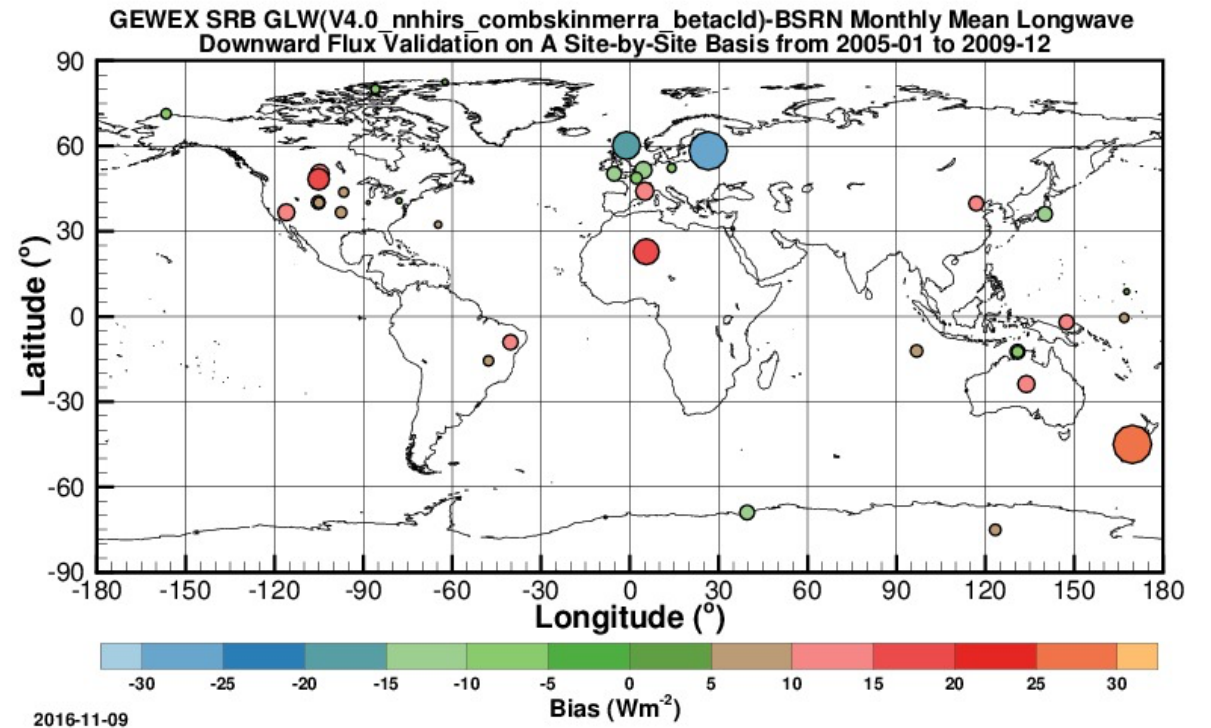


BSRN monthly mean longwave downward flux comparison statistics for the period from 2007-01 to 2007-12.

# Regional Comparisons → Identifying Error Sources



Downwelling SW



Downwelling LW

# Discussion Points Related to BSRN

- Reiterated value of BSRN as calibration standard for global surface radiation products and studies
- Strong support for ongoing efforts to establish absolute IR calibration standards
- Request from global surface radiation product developers for BSRN sites to add 2m temperature and humidity to standard BSRN observation suite
- Need to establish accuracy standards for oceanic (buoy) sites
  - GDAP could oversee a community survey to define current capabilities and reasonable target
  - Follow-up workshop to define standards
- GDAP to assist in the search for the next BSRN Project Manager

# New Activities within GDAP

Continuing a Key Climate Data Record: ISCCP-Next Generation

A New Vertically-Resolved Radiative Flux Assessment

New Comprehensive Precipitation Assessment

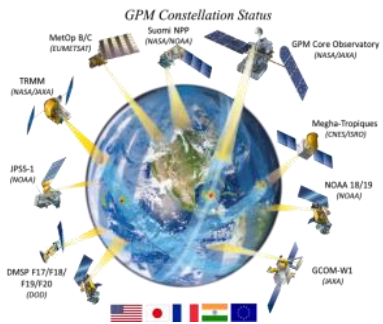
Consistency as a Way of Life

# A New GDAP Vision

Consistency as a way of life

An integrated approach to energy-water-mass consistency based on refined uncertainty characterization

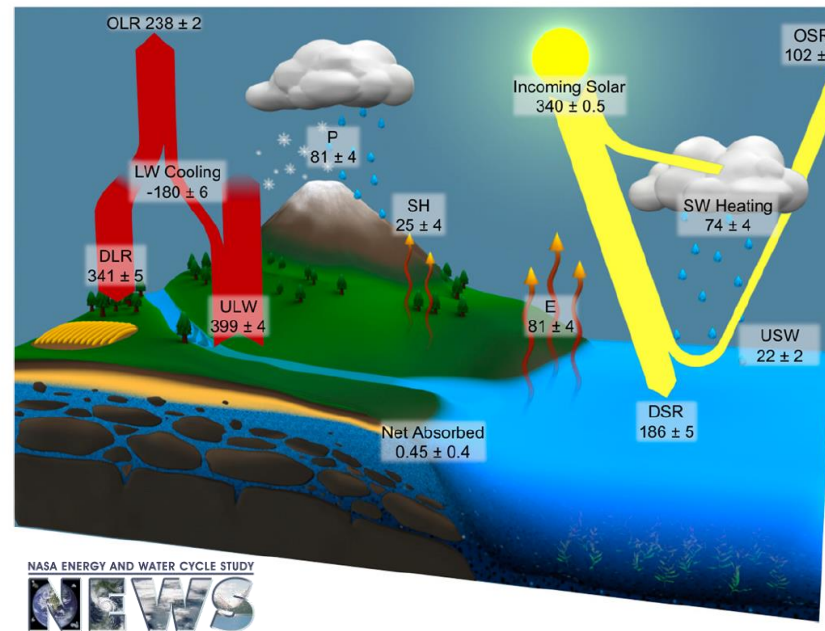
## Precipitation



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L'ECUYER ET AL.

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## Sea level



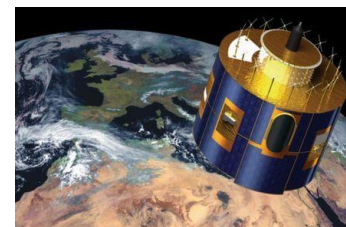
## Radiation



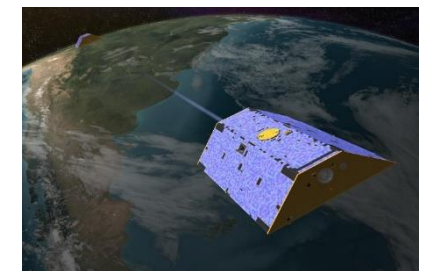
## Surface Flux



## Cloud



## Gravimetry



# Related Activities

## GEWEX Integrated Dataset

- GEWEX sponsored or supported datasets on a common 1°, 3-hourly, equal-area grid
- Supports regional water and energy budget closure analyses
- User workshop in Spain in 2019

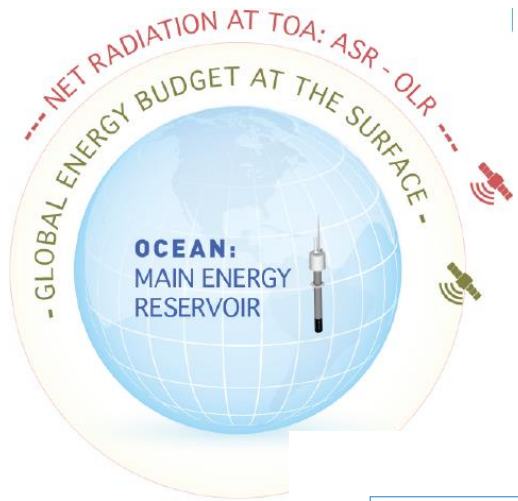
## Integrated Surface Water and Energy Assessments

- Advance land-ET and surface radiation measurements by explicitly linking to new/proposed land surface temperature, soil moisture, terrestrial water storage, and ground heat storage assessment activities

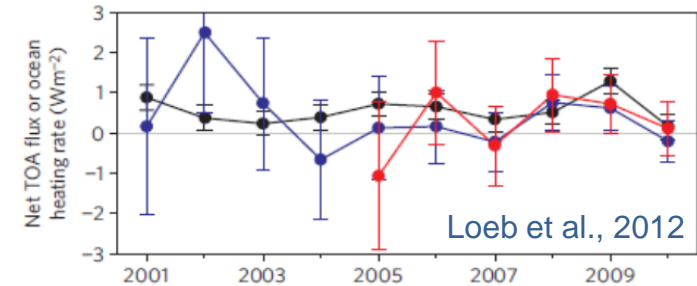
## Earth's Energy Imbalance

- Grew out of CLIVAR CONCEPT-HEAT and NASA NEWS
- Integrated assessment of methods for quantifying fundamental driver of climate and reconciling top-of-atmosphere vs. surface perspectives

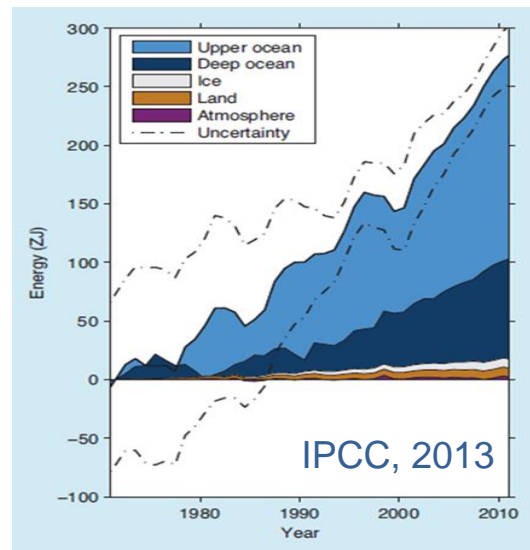
# E.g. Quantifying Earth's Energy Imbalance



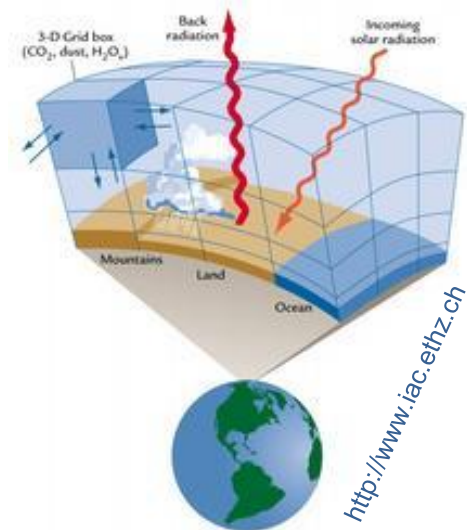
## Radiation at TOA



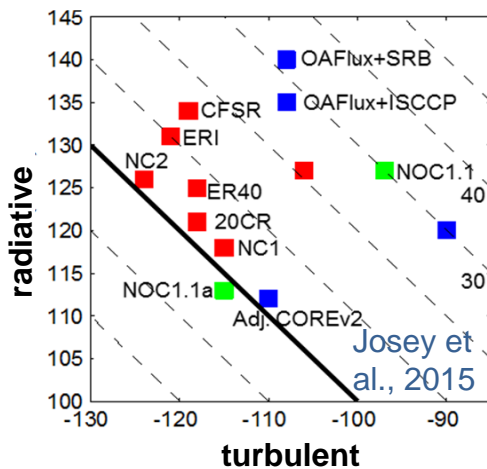
## Storage Inventory (OHC)



## Hindcast and Climate Projection



## Surface Flux







Joint WCRP/CLIVAR/GEWEX:  
« Synergy community on the Earth energy imbalance »  
13-15 Nov 2018, Toulouse, France

**Overall goal:**

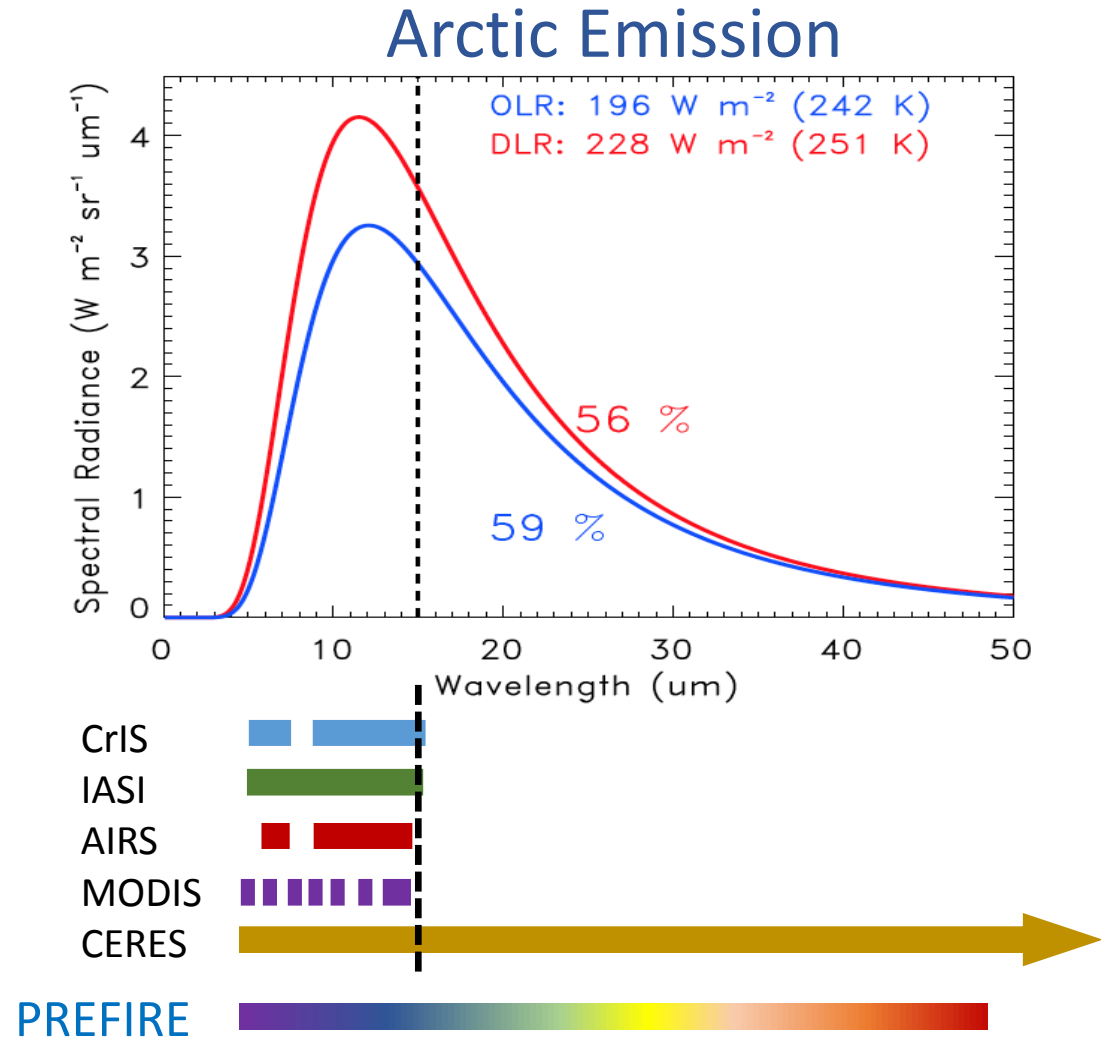
Strengthen and extend the synergy community on the Earth's energy imbalance aiming to discuss cross-links between the different WCRP core programs, in particular between CLIVAR and GEWEX, but also including CliC.

**Expected outcomes:**

The workshop will identify research goals and opportunities on the Earth's energy imbalance, and synthesize and focus the various aspects across WCRP. A main outcome may include the discussion and reporting on how the CONCEPT-HEAT activity could evolve into a WCRP topic.

# Another New Dimension

- **Spectrally-resolved Fluxes:** Dissecting climate feedbacks through their spectral signatures
  - Spectral surface emissivity
  - Water vapor
  - Ice clouds
- Renewed focus on far infrared
  - PREFIRE, TIC-FIRE, FORUM
- Measurements for calibrating (e.g. fraction of LW > 15 microns) will soon be needed



# The Polar Radiant Energy in the Far InfraRed Experiment (PREFIRE)

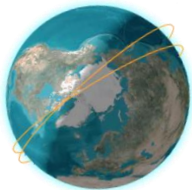
*Revealing fluctuations in Earth's thermostat by capturing the full spectrum of Arctic radiant energy*

Principal Investigator: Tristan L'Ecuyer, UW-Madison

Project Scientist: Brian Drouin, JPL/CalTech

## PREFIRE Hypotheses

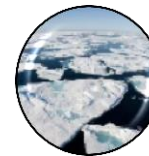
1. Time-varying errors in far-infrared emissivities and atmospheric greenhouse effects (GHE) bias estimates of energy exchanges between the surface and the atmosphere in the Arctic.
2. These errors are responsible for a large fraction of the spread in projected rates of Arctic warming, sea ice loss, ice sheet melt, and sea level rise.



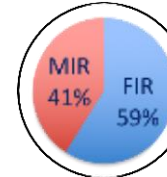
**PREFIRE** will document, for the first time, variability in spectral fluxes from 5-45  $\mu\text{m}$  on hourly to seasonal timescales.



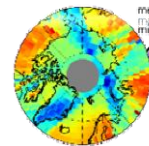
**Two 3U CubeSats** in distinct 470–650 km altitude, near-polar ( $82^\circ$ - $98^\circ$  inclination) orbit each carrying a miniaturized IR spectrometer, covering 0-45  $\mu\text{m}$  at 0.84  $\mu\text{m}$  spectral resolution, operating for one seasonal cycle (a year).



The Arctic is Earth's thermostat. It regulates the climate by venting excess energy received in the tropics.



Nearly 60% of Arctic emission occurs at wavelengths  $> 15 \mu\text{m}$  (FIR) that have never been systematically measured.



PREFIRE improves Arctic climate predictions by anchoring spectral FIR emission and atmospheric GHE



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Jet Propulsion Laboratory  
California Institute of Technology



Space Dynamics  
LABORATORY  
Utah State University Research Foundation



University of Colorado Boulder

UNIVERSITY OF MICHIGAN

Back up Slides

# Contributors to GDAP Mission

**Panel members**

- Rémy Roca, chair
- Tristan L'Ecuyer, vice-chair
- Wouter Dorigo
- Andrew Heidinger
- Seiji Kato
- Christian Kummerow
- Hirohiko Masunaga
- Isabel Trigo
- Claudia Stubenrauch
- Tianjun Zhou

**Renewing some members**  
**SSG suggests land DA experts**

**Invited members**

- Graeme Stephens, SSG Chair
- Sonia Seneviratne, SSG Chair
- Peter van Oevelen, IGPO
- William Rossow, Founder

« **GEWEX** » datasets production

- Paul Stackhouse
- Bob Adler
- Stefan Kinne
- Carlos Jimenez
- Caroll Ann Clayson
- Bill Rossow and NOAA NCEI
- P Brown and C Kummerow

- Surface Radiation Budget (SRB)
- Global Precipitation Climatology Project (GPCP)
- Global Aerosol Climatology Project (GACP)
- LandFlux
- Seaflux
- ISCCP
- GEWEX Merged and Integrated Product

**Ground data network**

- Wouter Dorigo ISMN
- A. Becker and Udo Schneider (DWD) GPCC
- Chuck Long (NOAA) BSRN
- Jim Mather (ARM) ARM

« **GEWEX** » Assessments

- Claudia Stubenrauch (CNRS) Clouds
- Marc Schröder (DWD) Water Vapor
- Jeffrey Reid (NRL) Aerosols
- Hirohiko Masunaga Precipitation

**GEWEX PROES**

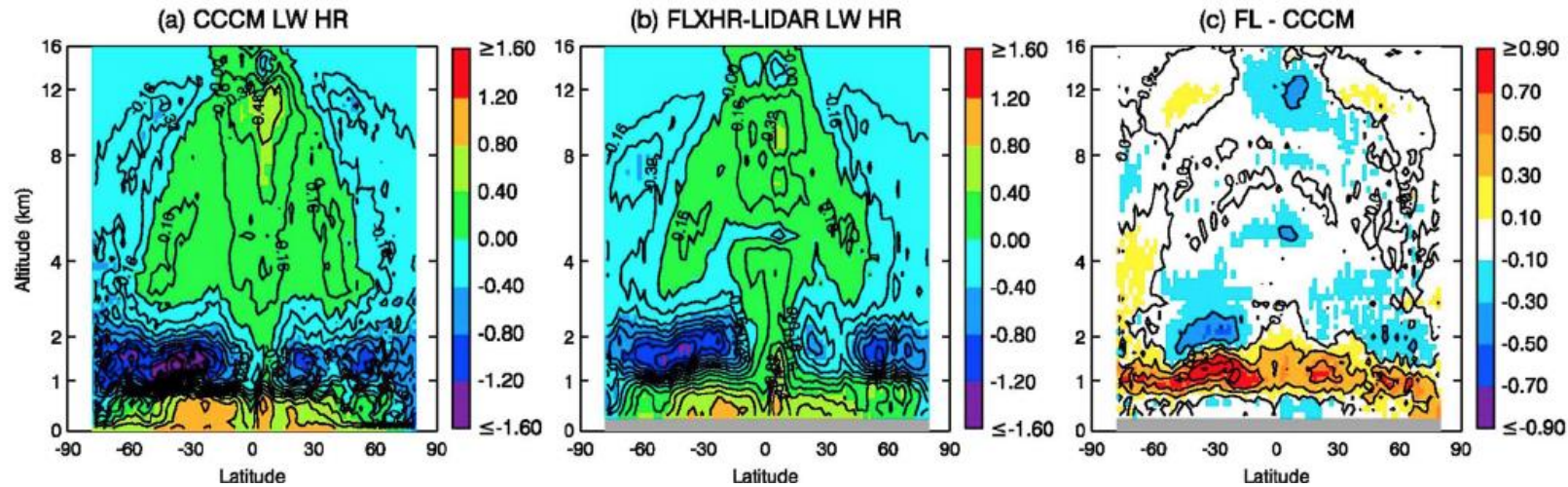
- Claudia Stubenrauch (CNRS) UTCC
- Sue Van Den Heever (CSU) GAP

# Next Generation Satellite Cloud and Radiation Climate Records (ISCCP-Next Generation)

## Continuing a Key Climate Data Record: ISCCP-NG

- Cloud properties and associated radiative fluxes constitute a core geophysical climate record
- Goal: generate a calibrated, global, 10-channel, multi-parameter cloud dataset at 3 km with 30 minute coverage
- Coordination between NASA and NOAA activity to maximize scientific benefits of new geostationary and low-earth orbiting satellites
- GDAP supporting the formation of a team to develop a unified analysis approach built around the current geostationary radiance data record augmented by MODIS/VIIRS and sounder cloud information
  - Agency support for a series of international workshops
  - Multi-institutional (multi-national) processing chain similar to ISCCP is encouraged
  - Target 2021 for initial implementation
  - BSRN will continue to be key reference for anchoring surface flux estimates

# Radiative Flux Assessment v2.0



Ham et al, 2017

- New vertical structure information from spaceborne active sensors motivates revisiting the Radiative Flux Assessment
- New cloud base, multi-layer cloud, and cloud vertical structure information is causing surface longwave radiation estimates to be revised (increased) – the validity of these adjustments and the associated vertical flux profiles need to be anchored against surface measurements

# Precipitation Assessment: Joint IPWG-GEWEX Effort

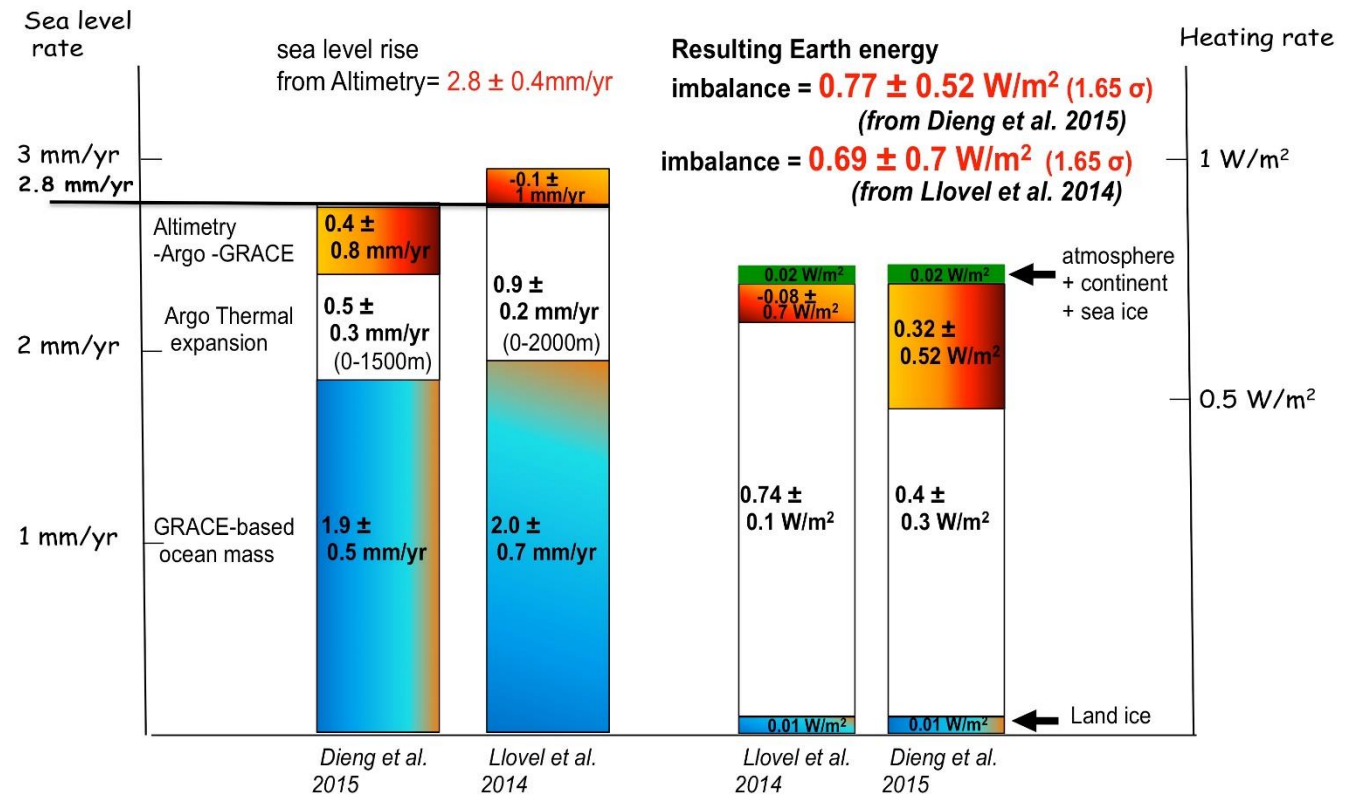
#	Name	Leads	Short description
1	Standard quality assessment	T. Kubota and H. Masunaga	catalogue with summary descriptions; intercomparisons; regime sorted statistics; quality & traceability (including WDAC doc+ FIDUCEO)
2	Uncertainty	J. Turk and P. Kirstetter	uncertainty metrics (detection, estimation); intrinsic uncertainty (sensitivity); algorithm limitations;
3	Consistency	A. Beranghi and D.B. Shin	water and energy budgets consistency; regional budgets; ancillary datasets (description and assessment for robustness)
4	Evaluation of analysis data from numerical models	H.J. Kim and G. Balsamo	performance metrics; model scales (spatial and temporal)
5	Ground based data	C. Kidd and S. Durden	sources (including weather radar where available); calibration and uncertainty characterization of sources, including polarimetric ground radars
6	Validation at weather scales in regions without ground measurements	R. Ferraro	consistency with other remotely sensed data at weather scales; consistency with reanalysis
7	Variability and trends	F.J. Tapiador	sub-seasonal, seasonal, annual, inter-annual; extremes and the ability to capture them faithfully; correlation with climate indices;
8	End users applications	Z. Haddad and G. Huffman	phenomenological assessment (consistency with agricultural indices, etc); latency issues;
9	Recommendations to algorithms developers	G. Huffman and Z. Haddad	assessment of assumptions underlying the algorithms , including retrievals from ground measurements (physical validation);
10	Programmatic recommendations	G. Stephens and V. Levizzani	product sensitivity to satellite constellation configuration; sensitivity to instrument capability and performance , including ground /airborne instruments product sensitivity to satellite constellation configuration; sensitivity to instrument capability and performance , including ground/airborne instruments



# Recent Advances from Satellite Gravimetry and Altimetry Measurements

- Sea level (from satellite altimetry) minus ocean mass (from space gravimetry) provides a satellite-based alternative to Argo for estimating OHC
- The current best estimate of the OHC change from satellite is  $0.7 \pm 0.5 \text{ Wm}^{-2}$  over 2005-2013
- GDAP endorses expansion of this activity to regional and shorter timescales as part of a new EEI-themed energy budget assessment.

Sea level budget and Earth Energy imbalance : 2005-2013



Courtesy of B. Meyssignac

# SRB v4 Inputs

General Inputs	Release 3	Integrated Product
Total Solar Irradiance	Constant mean full ephemeris for annual variability	Daily SORCE normalized time series with full ephemeris
Trace Gases – O3	TOMS, TOVS, SMOBA blend	TOMS, TOVS, OMI blend from ISCCP; with vertical profiles from GOZCARDS
Other Gases	Single values	GISS GCM; NOAA
Surface elevation	GTOPO30 remapped	GTOPO30 remapped
Land Vegetation Cover Map	IGBP remapped to 1x1	Revised IGBP (w/ GISS)
Snow/ice cover	ISCCP snow/ice	ISCCP snow/ice
Surface albedo/emissivity	VIS radiance w/ aerosol; IGBP surface types for spectral albedo/spectral emissivity	VIS radiance w/ aerosol; IGBP surface types for spectral albedo; Huang et al (2016, JAS) monthly spectral emissivity
Aerosols	SW – MATCH climatology	MAC v1 (evaluated v2)
Skin Temperature/Near Surface T/q	Blended ISCCP & GEOS-4	ISCCP retrieved (TSCOMP); MERRA 2, Princeton HIRS LST, and SeaFlux CDR (v2)
Meteorological Profiles	GEOS-4 reanalysis	nnHIRS (ISCCP produced data that fills, grids and adds diurnal cycle to HIRS retrievals)
Radiance & Cloud Retrieval	ISCCP DX	ISCCP HXS

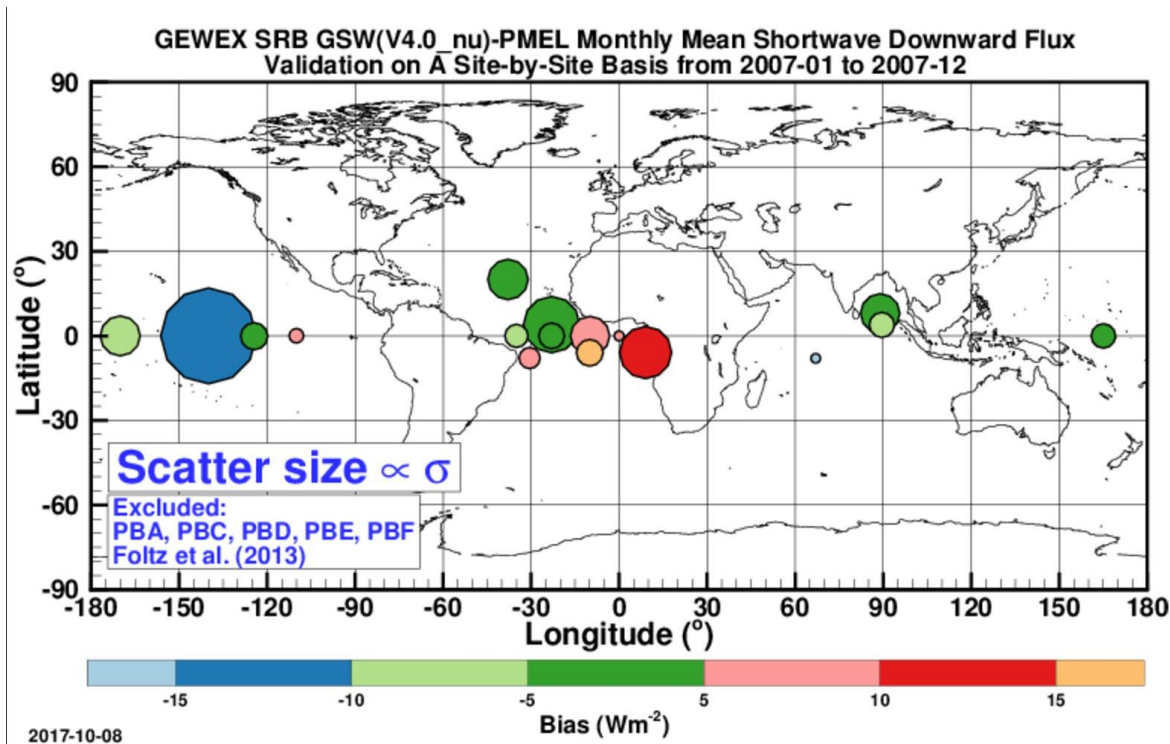
# SRB Release 3 Data Products

(Spatial Resolution: 1° x 1°; 7/83 – 12/07)

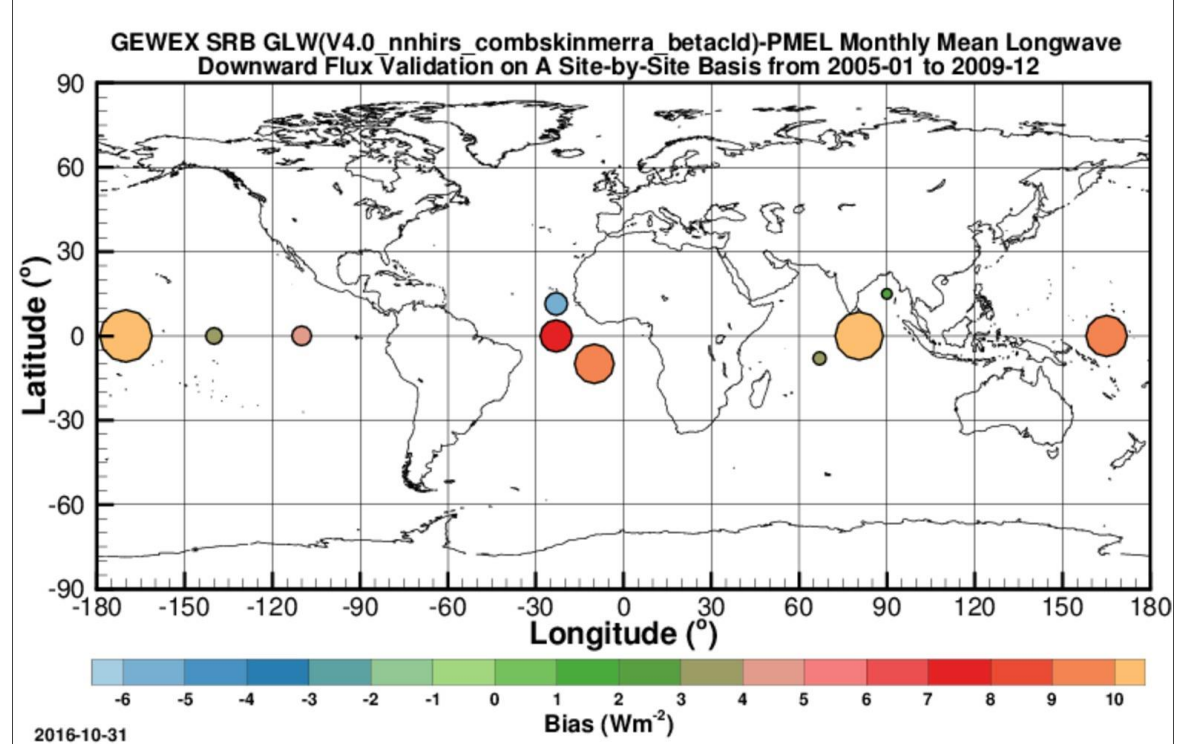
<b>Data Types</b>	<b>Model Name</b>	<b>Temporal Resolution</b>	<b>Parameters</b>
<b>SW</b>	GEWEX SW (Pinker/Laszlo) (v3.0)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged (UTC and local sun time)	All-sky: Surface down, up, PAR down; TOA Down, Up
			Clear-Sky: Surface Down, Up; TOA Up
	LPSA (Staylor/ Gupta) (v3.0)	Daily, Monthly	All-sky: Surface Down, Net, and Albedo
			Clear-sky: Surface Down
<b>LW</b>	GEWEX LW (Fu/Liou/ Stackhouse) (v3.1)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged	All-sky and clear-sky: TOA up; Surface Up and Down
	LPLA (Gupta) (v3.0)	3-hourly, Monthly Averaged 3-hourly, Daily and Monthly Averaged	All-sky Surface Downward, Net; Cloud Radiative Forcing
<b>Input Property</b>	CLDPROPS	3-Hourly	Surface emissivity, skin temperature, atmospheric profile; cloud phase, fraction, optical depth and LWC

Note: The LPSA and LPLA algorithms are also used in CERES Surface-Only

# SRB v4 vs. PMEL Ocean Buoy



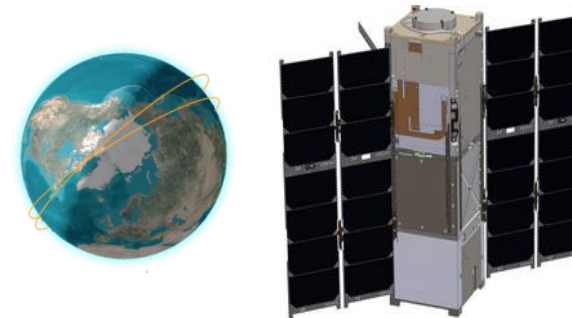
Downwelling SW



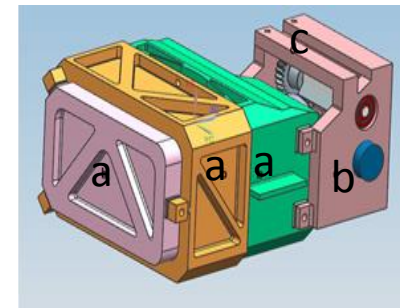
Downwelling LW

# PREFIRE Mission Details

- Two 3-U CubeSats in asynchronous polar orbits
  - ▣ Power subsystem, attitude control, command and data handling, high data rate telecommunications
  - ▣ Solar panels configured to minimize thermal variations
  
- Thermal IR Spectrometer (TIRS)
  - ▣ [Ambient temperature](#) FIR spectral imager
  - ▣ Thermopile focal plane
  - ▣ Offner architecture: 0.97 kg and fits within 1U
  - ▣ Shaped groove grating (Silicon with gold plating)



Thermal Infrared Spectrometer



a - Optical bench assembly  
 b - Calibration motor assembly  
 c - Calibration target

Thermopile array	Spectral resolution	Spatial coverage	Mass	Data rate	Power peak/avg
64 × 16 pixels	0.84 μm from 0–45 μm	16 cross-track pixels with 1.2° footprints	0.97 kg	35 kbps	6.74 / 1.74 W

# Anticipated Sampling of FIR Spectral Signatures

