Set 1 of CERES Data Products

Miklos Zagoni

Budapest, Hungary

miklos.zagoni@t-online.hu

44th CERES Science Team Meeting

May 14, 2026, NASA LaRC, Hampton, VA.

Wielicki et al. (1996) (BAMS): Clouds and the Earth's Radiant Energy System (CERES)

"Obtaining surface fluxes from measured TOA fluxes, CERES investigations are examining two independent approaches"

Approach 1. Establishing direct relationships between TOA radiative fluxes and surface fluxes.
Approach 2. Surface fluxes can be calculated by radiative transfer computations.

CERES ATBD (Algorithm Theoretical Basis Document) **(Wielicki and Barkstrom 1996)**:

“CERES will provide two types of surface fluxes: *first*, a set which attempts to directly relate CERES TOA fluxes to surface fluxes; *second*, a set which uses observed properties to calculate surface, in-atmosphere and TOA radiative fluxes by radiative transfer model”. (Emphasis in the original)

Set 2 has been successfully generated by the Surface-Atmosphere Radiation Budget (SARB) Working Group.

Set 1 seems to be abandoned. Since no Direct TOA-Surface Relationships (DTSR) Working Group was established, I did the job.

Wielicki et al. (1996) refer to Li et al. (1993a) for SW, and for LW to **Inamdar and Ramanathan (1995**) and **Stephens et al. (1994)**.

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 99, NO. D9, PAGES 18,585–18,604, SEPTEMBER 20, 1994

Observations of the Earth's Radiation Budget in relation to atmospheric hydrology
4. Atmospheric column radiative cooling over the world's oceans

Graeme L. Stephens,[1] Anthony Slingo,[2] Mark J. Webb,[2] Peter J. Minnett,[3]
Peter H. Daum,[3] Lawrence Kleinman,[3] Ian Wittmeyer,[1] and David A.
Randall[1]

(Section 4)

4. Flux Ratios and a Simple Description of the Planetary Greenhouse Effect

$$\mu\frac{dI(\tau,\mu)}{d\tau} = I(\tau,\mu) - B(T) \qquad (1a)$$

$$-\mu\frac{dI(\tau,-\mu)}{d\tau} = I(\tau,-\mu) - B(T), \qquad (1b)$$

for upward ($F^{\uparrow}$) and downward ($F^{\downarrow}$) hemispheric fluxes leads to

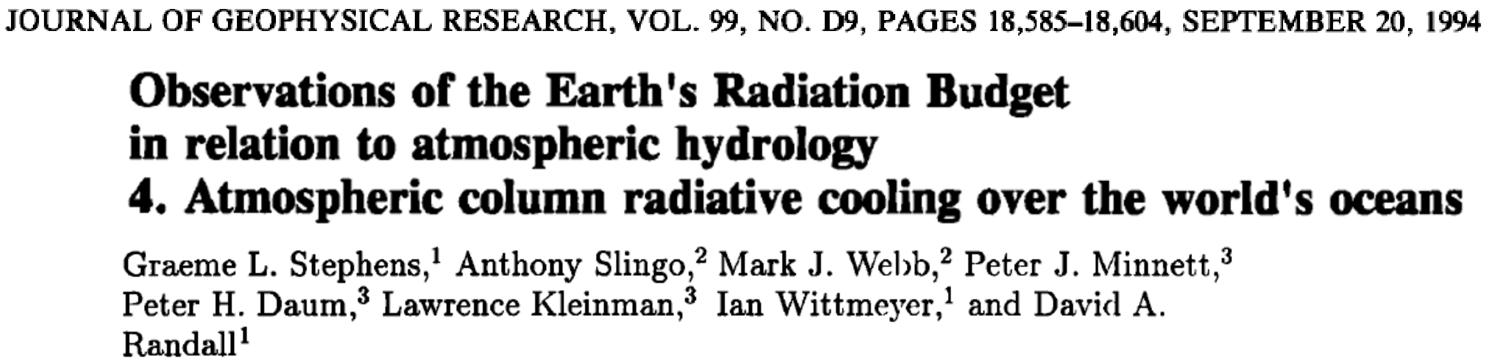
$$\frac{dF^{\uparrow}}{d\tilde{\tau}} = F^{\uparrow} - \pi B, \qquad (3a)$$

$$-\frac{dF^{\downarrow}}{d\tilde{\tau}} = F^{\downarrow} - \pi B, \qquad (3b)$$

The solution for upward (F↑) and downward (F↓) fluxes:

$$\sigma T_s^4 = \frac{F_\infty}{2}[2 + \tilde{\tau}_s] \qquad (5a)$$

$$F_g = F^{\downarrow}(\tilde{\tau}_s) = \frac{F_\infty}{2}\tilde{\tau}_s \qquad (5b)$$

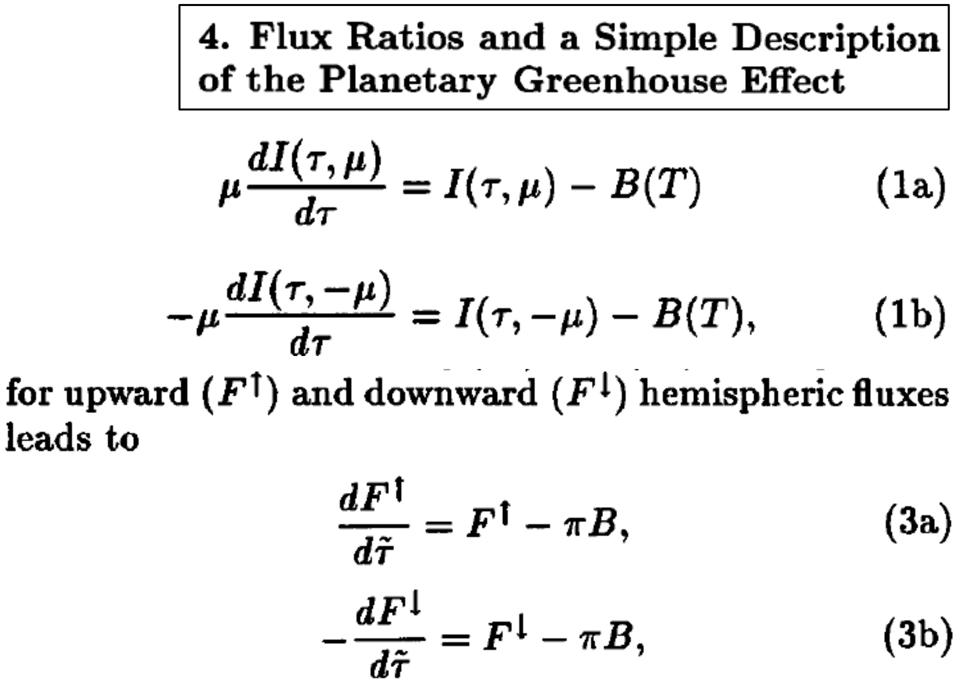


JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 99, NO. D9, PAGES 18,585–18,604, SEPTEMBER 20, 1994

Observations of the Earth's Radiation Budget in relation to atmospheric hydrology 4. Atmospheric column radiative cooling over the world's oceans

Graeme L. Stephens,[1] Anthony Slingo,[2] Mark J. Webb,[2] Peter J. Minnett,[3] Peter H. Daum,[3] Lawrence Kleinman,[3] Ian Wittmeyer,[1] and David A. Randall[1]

(Section 4)



4. Flux Ratios and a Simple Description of the Planetary Greenhouse Effect

$$\mu\frac{dI(\tau,\mu)}{d\tau} = I(\tau,\mu) - B(T) \qquad (1a)$$

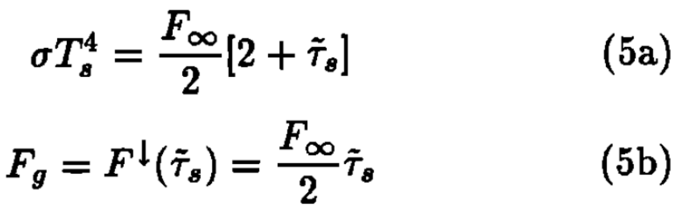
$$-\mu\frac{dI(\tau,-\mu)}{d\tau} = I(\tau,-\mu) - B(T), \qquad (1b)$$

for upward ($F^{\uparrow}$) and downward ($F^{\downarrow}$) hemispheric fluxes leads to

$$\frac{dF^{\uparrow}}{d\tilde{\tau}} = F^{\uparrow} - \pi B, \qquad (3a)$$

$$-\frac{dF^{\downarrow}}{d\tilde{\tau}} = F^{\downarrow} - \pi B, \qquad (3b)$$

The solution for upward (F↑) and downward (F↓) fluxes:



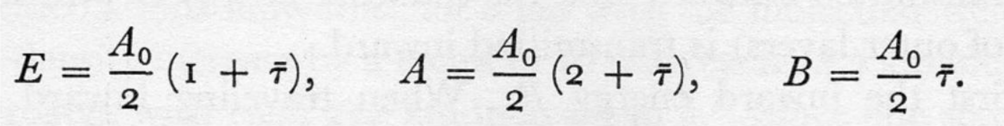
$$\sigma T_s^4 = \frac{F_\infty}{2}[2 + \tilde{\tau}_s] \qquad (5a)$$

$$F_g = F^{\downarrow}(\tilde{\tau}_s) = \frac{F_\infty}{2}\tilde{\tau}_s \qquad (5b)$$

With

$$F_0(\tau_S) = \sigma T_0^4 = \frac{F_\infty}{2}(1 + \tau_S)$$

which is Eq. (2) in Stephens et al. (1991), they are equivalent to the three terms in Schwarzschild's two-stream (1906, Eq. 11):



$$E = \frac{A_0}{2}(1 + \bar{\tau}), \qquad A = \frac{A_0}{2}(2 + \bar{\tau}), \qquad B = \frac{A_0}{2}\bar{\tau}.$$

These are TOA-surface flux ratios, but not *direct*, since they depend on atmospheric properties via τ.

But the difference of the middle and the first term is really direct:

$$A - E = \frac{A_0}{2} \quad <=>$$

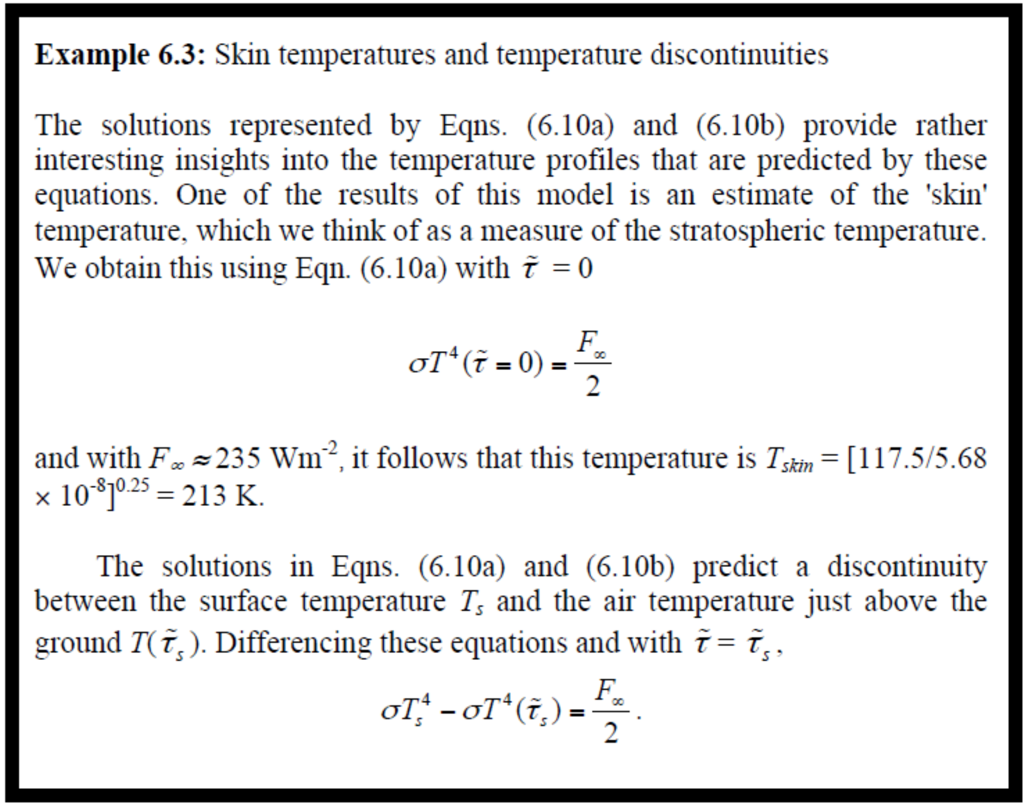
$$\boxed{\sigma T_S^4 - \sigma T_0^4 = \frac{F_\infty}{2}}$$

Eq. (1) of Set 1

Graeme L. Stephens: Radiative Transfer Notes AT 622

Colorado State University (1992-2013)

https://reef.atmos.colostate.edu/~odell/AT622/stephens_notes/AT622_section06.pdf



Example 6.3: Skin temperatures and temperature discontinuities

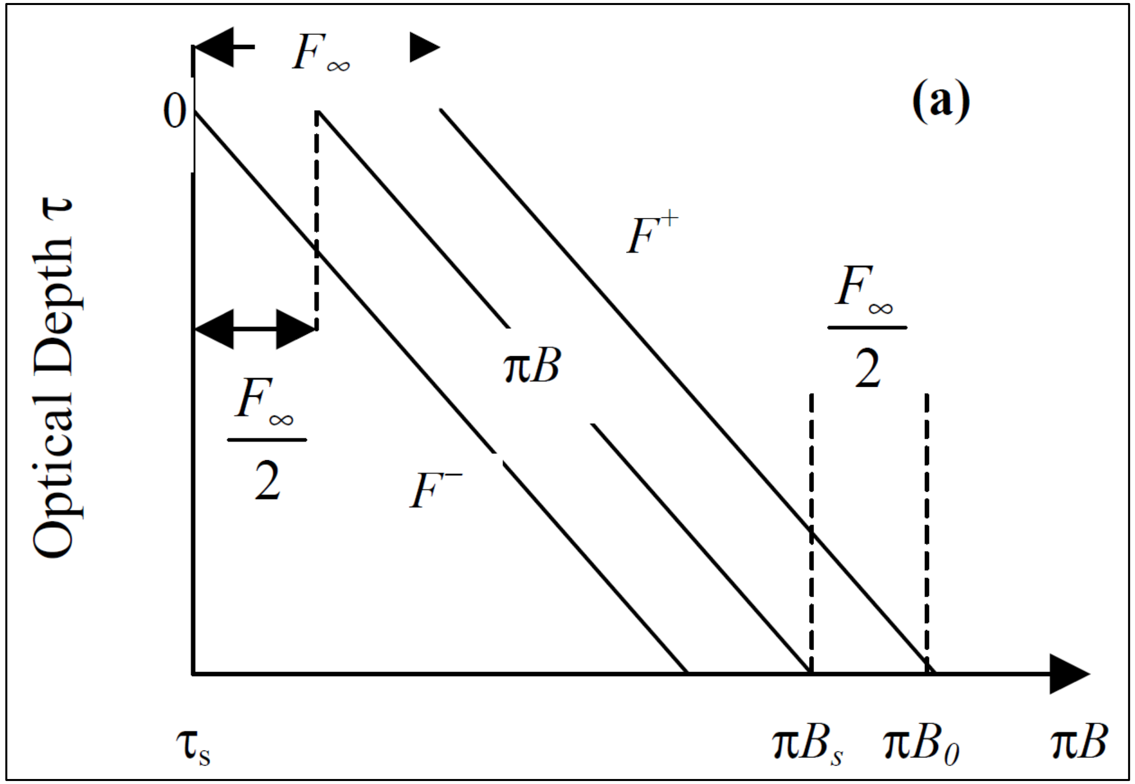
The solutions represented by Eqns. (6.10a) and (6.10b) provide rather interesting insights into the temperature profiles that are predicted by these equations. One of the results of this model is an estimate of the 'skin' temperature, which we think of as a measure of the stratospheric temperature. We obtain this using Eqn. (6.10a) with $\tilde{\tau} = 0$

$$\sigma T^4(\tilde{\tau} = 0) = \frac{F_\infty}{2}$$

and with $F_\infty \approx 235$ Wm^{-2}, it follows that this temperature is $T_{skin} = [117.5/5.68 \times 10^{-8}]^{0.25} = 213$ K.

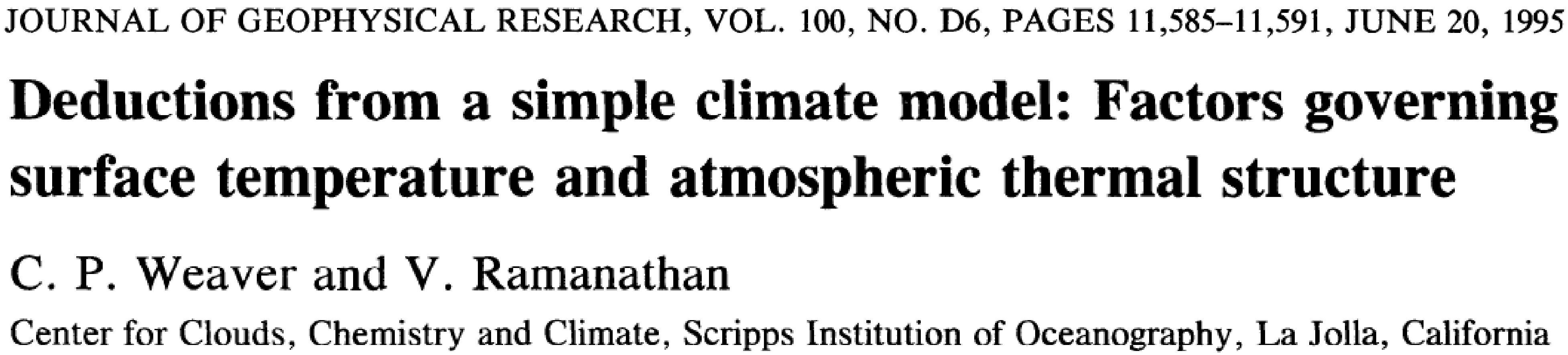
The solutions in Eqns. (6.10a) and (6.10b) predict a discontinuity between the surface temperature T_s and the air temperature just above the ground $T(\tilde{\tau}_s)$. Differencing these equations and with $\tilde{\tau} = \tilde{\tau}_s$,

$$\sigma T_s^4 - \sigma T^4(\tilde{\tau}_s) = \frac{F_\infty}{2}.$$



"This radiative equilibrium profile is unstable w.r.t. vertical motion and is destroyed by convection."

The surface has a net surplus of radiant energy compared to the bottom of the atmosphere, balanced by convection, being equal half of the effective emission in the clear-sky: $\sigma T_s^4 - \sigma T^4(\tau_s) = \frac{F_\infty}{2}$. Eq. (1) of Set 1

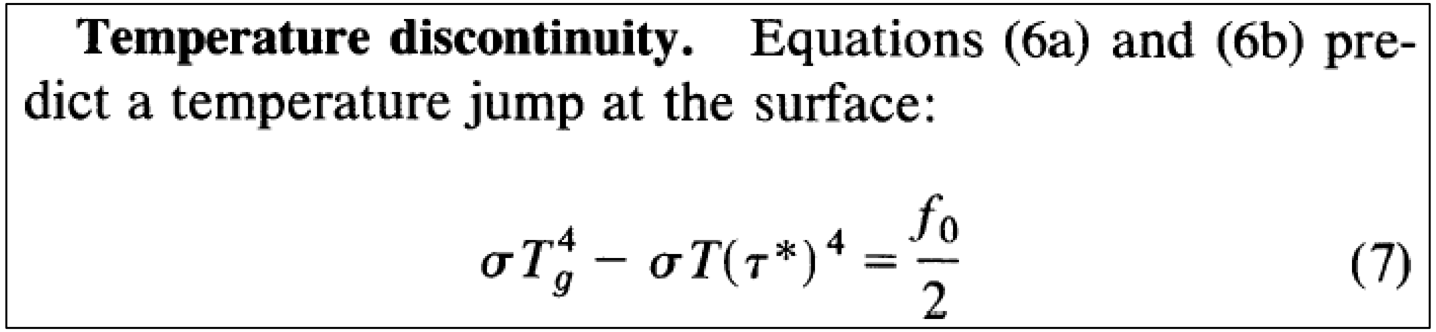


JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 100, NO. D6, PAGES 11,585–11,591, JUNE 20, 1995

Deductions from a simple climate model: Factors governing surface temperature and atmospheric thermal structure

C. P. Weaver and V. Ramanathan

Center for Clouds, Chemistry and Climate, Scripps Institution of Oceanography, La Jolla, California



Temperature discontinuity. Equations (6a) and (6b) predict a temperature jump at the surface:

$$\sigma T_g^4 - \sigma T(\tau^*)^4 = \frac{f_0}{2} \qquad (7)$$

Eq. (1) of Set 1

CERES EBAF-Surface Ed2.8 Data Quality Summary (March 27, 2015)

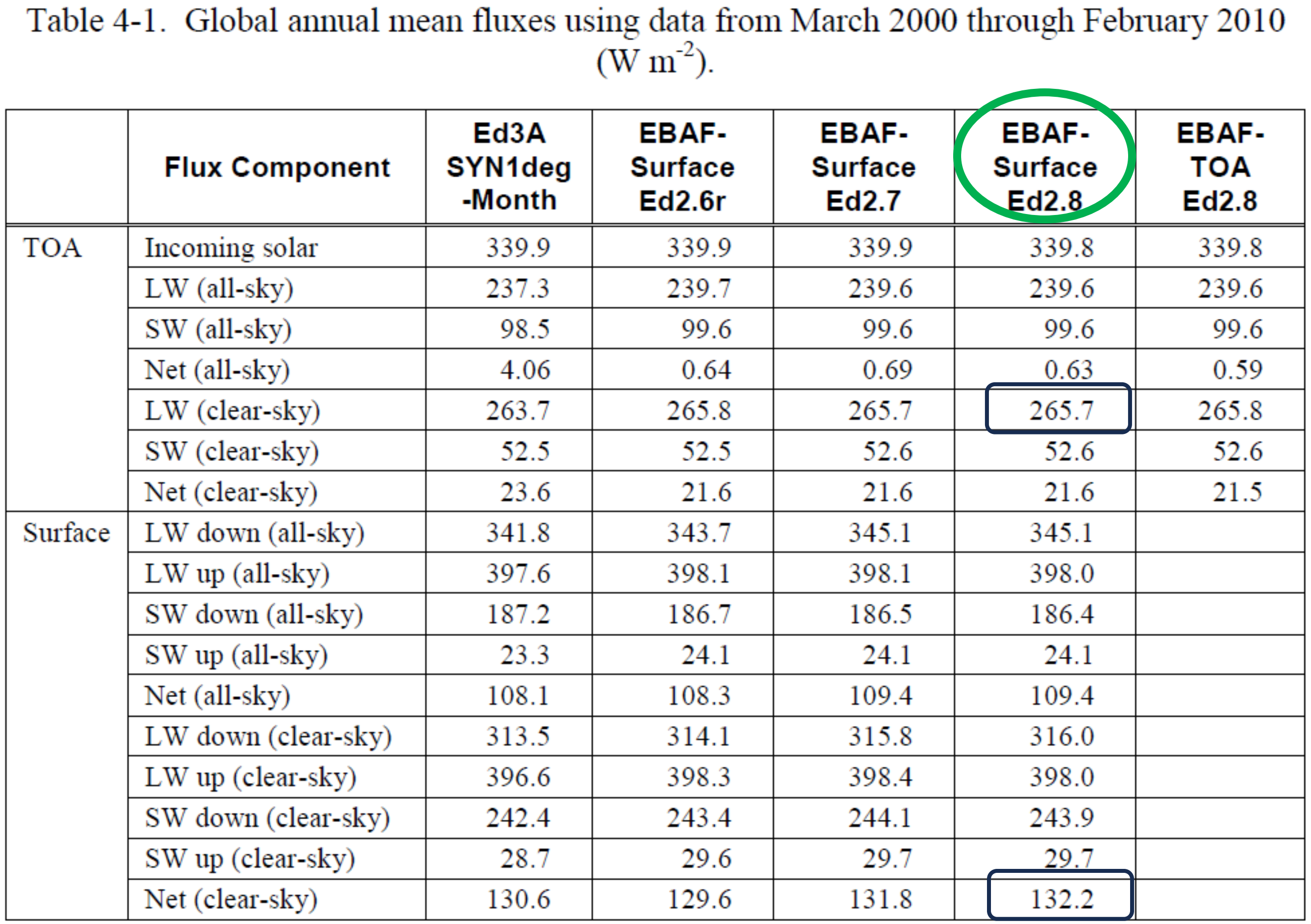


Table 4-1. Global annual mean fluxes using data from March 2000 through February 2010 (W m^{-2}).

	Flux Component	Ed3A SYN1deg -Month	EBAF-Surface Ed2.6r	EBAF-Surface Ed2.7	EBAF-Surface Ed2.8	EBAF-TOA Ed2.8
TOA	Incoming solar	339.9	339.9	339.9	339.8	339.8
	LW (all-sky)	237.3	239.7	239.6	239.6	239.6
	SW (all-sky)	98.5	99.6	99.6	99.6	99.6
	Net (all-sky)	4.06	0.64	0.69	0.63	0.59
	LW (clear-sky)	263.7	265.8	265.7	265.7	265.8
	SW (clear-sky)	52.5	52.5	52.6	52.6	52.6
	Net (clear-sky)	23.6	21.6	21.6	21.6	21.5
Surface	LW down (all-sky)	341.8	343.7	345.1	345.1	
	LW up (all-sky)	397.6	398.1	398.1	398.0	
	SW down (all-sky)	187.2	186.7	186.5	186.4	
	SW up (all-sky)	23.3	24.1	24.1	24.1	
	Net (all-sky)	108.1	108.3	109.4	109.4	
	LW down (clear-sky)	313.5	314.1	315.8	316.0	
	LW up (clear-sky)	396.6	398.3	398.4	398.0	
	SW down (clear-sky)	242.4	243.4	244.1	243.9	
	SW up (clear-sky)	28.7	29.6	29.7	29.7	
	Net (clear-sky)	130.6	129.6	131.8	132.2	

Eq. (1) Surface Net (clear-sky) = TOA LW (clear-sky) /2

132.2 = 265.7 /2

CERES EBAF-Surface Ed2.8 Data Quality Summary (March 27, 2015)

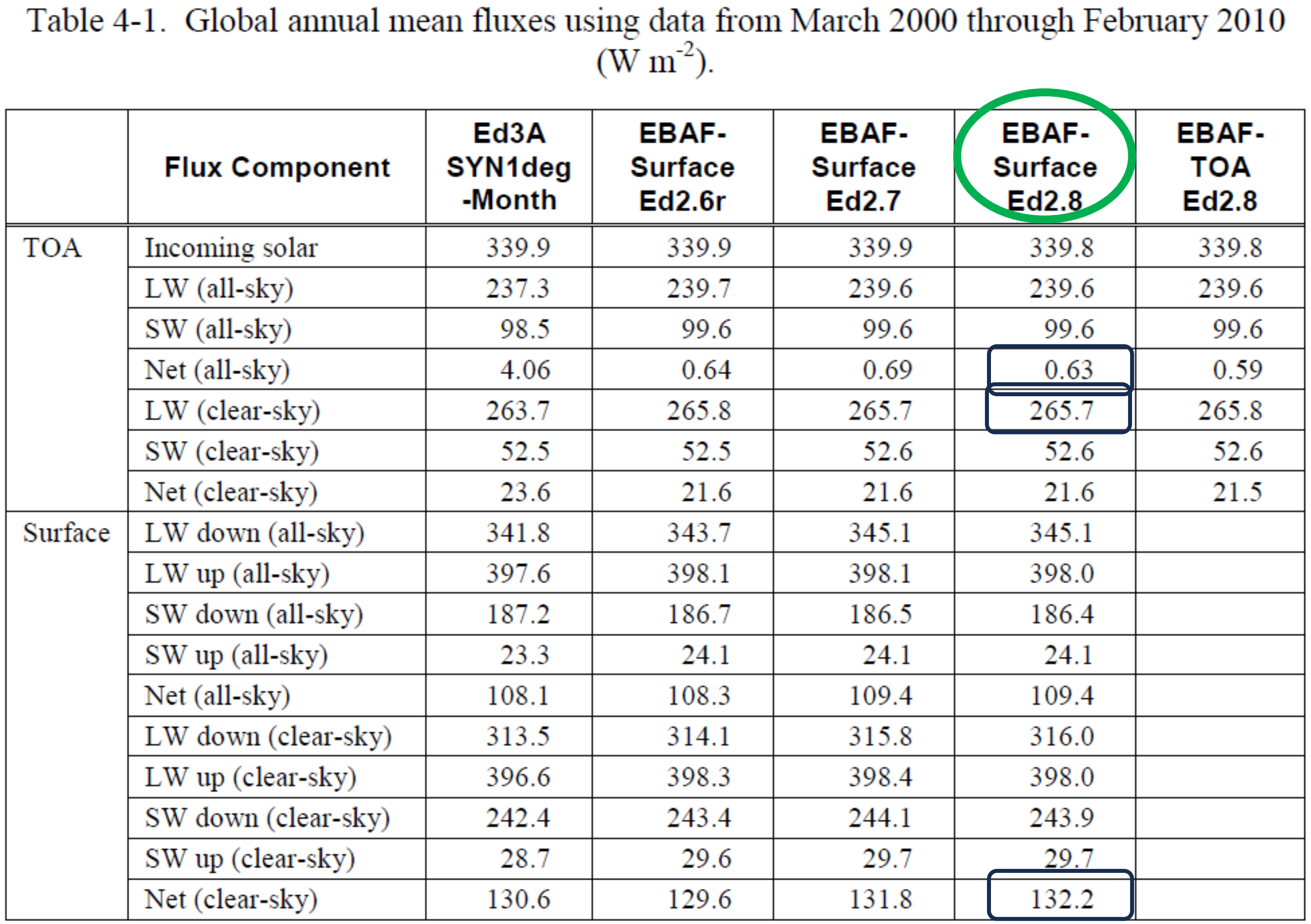


Table 4-1. Global annual mean fluxes using data from March 2000 through February 2010 ($W\ m^{-2}$).

	Flux Component	Ed3A SYN1deg -Month	EBAF-Surface Ed2.6r	EBAF-Surface Ed2.7	EBAF-Surface Ed2.8	EBAF-TOA Ed2.8
TOA	Incoming solar	339.9	339.9	339.9	339.8	339.8
	LW (all-sky)	237.3	239.7	239.6	239.6	239.6
	SW (all-sky)	98.5	99.6	99.6	99.6	99.6
	Net (all-sky)	4.06	0.64	0.69	0.63	0.59
	LW (clear-sky)	263.7	265.8	265.7	265.7	265.8
	SW (clear-sky)	52.5	52.5	52.6	52.6	52.6
	Net (clear-sky)	23.6	21.6	21.6	21.6	21.5
Surface	LW down (all-sky)	341.8	343.7	345.1	345.1	
	LW up (all-sky)	397.6	398.1	398.1	398.0	
	SW down (all-sky)	187.2	186.7	186.5	186.4	
	SW up (all-sky)	23.3	24.1	24.1	24.1	
	Net (all-sky)	108.1	108.3	109.4	109.4	
	LW down (clear-sky)	313.5	314.1	315.8	316.0	
	LW up (clear-sky)	396.6	398.3	398.4	398.0	
	SW down (clear-sky)	242.4	243.4	244.1	243.9	
	SW up (clear-sky)	28.7	29.6	29.7	29.7	
	Net (clear-sky)	130.6	129.6	131.8	132.2	

Eq. (1) Surface Net (clear-sky) = TOA LW (clear-sky) /2 – Net (all-sky)

132.2 = 265.7 /2 – 0.65 Wm^{-2}

Inamdar and Ramanathan (1997, Tellus)

On monitoring the atmospheric greenhouse effect from space

"2 quantities are used as a measure of the atmospheric greenhouse effect: (1) G_a, which is the reduction in the clear sky outgoing longwave radiation (OLR) due to the atmosphere; it is the radiative heating of the surface-atmosphere column; (2) G_a*, which is the back radiation from the atmosphere to the surface; it is the radiative heating of the surface by the atmosphere."

$$G_a = \sigma T(\tau^*)^4 - f_0$$

is the radiative heating of the surface-atmosphere column.

Eq. (1) says: The surface has a net surplus of radiant energy *compared to the bottom of the atmosphere*, balanced by convection, being equal OLR/2 in the clear-sky.

Eq. (2) follows from noting that the bottom of the atmosphere has also a net surplus of radiant energy *compared to the top-of-atmosphere, **called the greenhouse effect**,* balanced by the same convection as well, so this also equals $f_0/2$.

Using Eq. (1), $$G_a = \sigma T(\tau^*)^4 - f_0 = \mathrm{CONV} = \sigma T_g^4 - \sigma T(\tau^*)^4 = f_0/2.$$

Inamdar and Ramanathan (1997, Tellus)

On monitoring the atmospheric greenhouse effect from space

"2 quantities are used as a measure of the atmospheric greenhouse effect: (1) G_a, which is the reduction in the clear sky outgoing longwave radiation (OLR) due to the atmosphere; it is the radiative heating of the surface-atmosphere column; (2) G_a*, which is the back radiation from the atmosphere to the surface; it is the radiative heating of the surface by the atmosphere."

$$G_a = \sigma T(\tau^*)^4 - f_0$$

is the radiative heating of the surface-atmosphere column.

Eq. (1) says: The surface has a net surplus of radiant energy *compared to the bottom of the atmosphere*, balanced by convection, being equal OLR/2 in the clear-sky.

Eq. (2) follows from noting that the bottom of the atmosphere has also a net surplus of radiant energy *compared to the top-of-atmosphere,* ***called the greenhouse effect****,* balanced by the same convection as well, so this also equals $f_0/2$.

Using Eq. (1), $G_a = \sigma T(\tau^*)^4 - f_0 = \mathrm{CONV} = \sigma T_g^4 - \sigma T(\tau^*)^4 = f_0/2$.

From here, $\sigma T(\tau^*)^4 = 3f_0/2$ and $\sigma T_g^4 = 2f_0$ Eq. (2) of Set 1

that is, $g_a = G_a/\sigma T(\tau^*)^4 = 1/3$.

"the normalized g_a is 0.33, i.e., the atmosphere reduces the energy escaping to space by a factor of 1/3"
(Ramanathan and Inamdar 2006)

Eq. (1) derived from Eq. (2) in Hartmann

Global Physical Climatology, Academic Press (1994, 2016)

62 3 **Atmospheric Radiative Transfer and Climate**

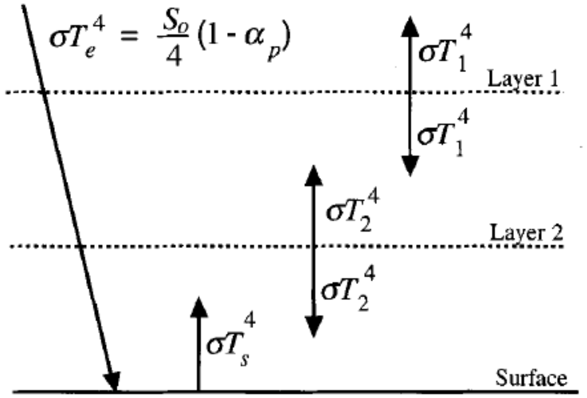


Fig. 3.10 Diagram of simple two-layer radiative equilibrium model for the atmosphere–Earth system, showing the fluxes of radiant energy.

And the balance at the surface is

$$\frac{S_0}{4}\left(1-\alpha_p\right)+\sigma T_2^4=\sigma T_s^4 \tag{3.50}$$

The critical effect of an atmosphere that absorbs and emits longwave radiation appears in (3.50). The energy supplied to the surface by the sun is augmented by a downward flux of longwave radiation from the atmosphere. This allows the surface temperature

3.9 **Clouds and Radiation** 63

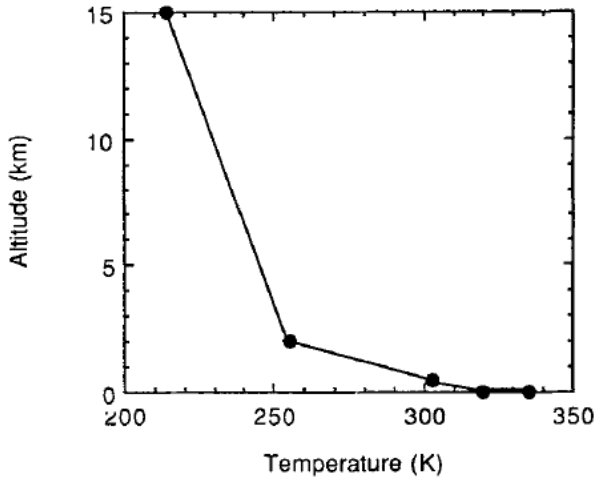


Fig. 3.11 Plot of temperature profile obtained from the simple two-level atmosphere radiative equilibrium model.

A thin layer of atmosphere near the surface absorbs a fraction ε of the emission from above and below and emits in both directions. The temperature of the air adjacent to the surface, T_{SA}, may be derived from the energy balance there.

$$\varepsilon\sigma T_s^4+\varepsilon\sigma T_2^4=2\varepsilon\sigma T_{\mathrm{SA}}^4 \tag{3.54}$$

$$\Rightarrow \sigma T_S^4 - \sigma T_{SA}^4 = \sigma T_e^4/2$$

CERES EBAF Ed2.8 Global means (Mar 2000 – Feb 2016)

Clear-sky

Rose et al., 27th STM (2017)

Eq. (1) Surface Net = TOA LW Up /2

244.06 – 29.74 + 316.27 – 398.40 = 265.59 /2 – 0.60 Wm^{-2}

Eq. (2) Surface Total = 2 × TOA LW Up

244.06 – 29.74 + 316.27 = 2 × 265.59 – 0.59 Wm^{-2}

Clear Sky	**Ed2.8**
TOA SW Insolation	339.87
TOA SW Up	*52.50*
TOA LW Up	*265.59*
SFC SW Down	244.06
SFC SW Up	29.74
SFC LW Down	316.27
SFC LW Up	398.40

CERES EBAF Ed2.8 Global means (Mar 2000 – Feb 2016)

Clear-sky

Rose et al., 27th STM (2017)

Eq. (1) Surface Net = TOA LW Up /2

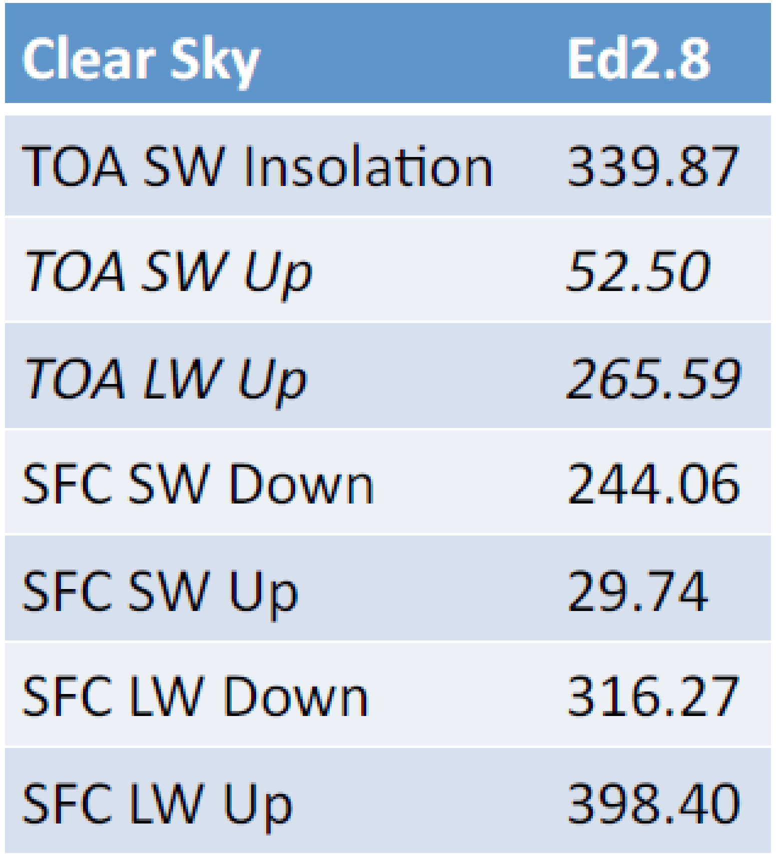
244.06 – 29.74 + 316.27 – 398.40 = 265.59 /2 – 0.60 Wm^{-2}

Eq. (2) Surface Total = 2 × TOA LW Up

244.06 – 29.74 + 316.27 = 2 × 265.59 – 0.59 Wm^{-2}

=> Surface LW Up = 3 × TOA LW Up /2

398.40 = 1.5 × 265.59 – 0.01 Wm^{-2}



Clear Sky	**Ed2.8**
TOA SW Insolation	339.87
TOA SW Up	*52.50*
TOA LW Up	*265.59*
SFC SW Down	244.06
SFC SW Up	29.74
SFC LW Down	316.27
SFC LW Up	398.40

CERES EBAF Ed2.8 Global means (Mar 2000 – Feb 2016)

Clear-sky

Rose et al., 27th STM (2017)

Eq. (1) Surface Net = TOA LW Up /2

244.06 – 29.74 + 316.27 – 398.40 = 265.59 /2 – 0.60 Wm^{-2}

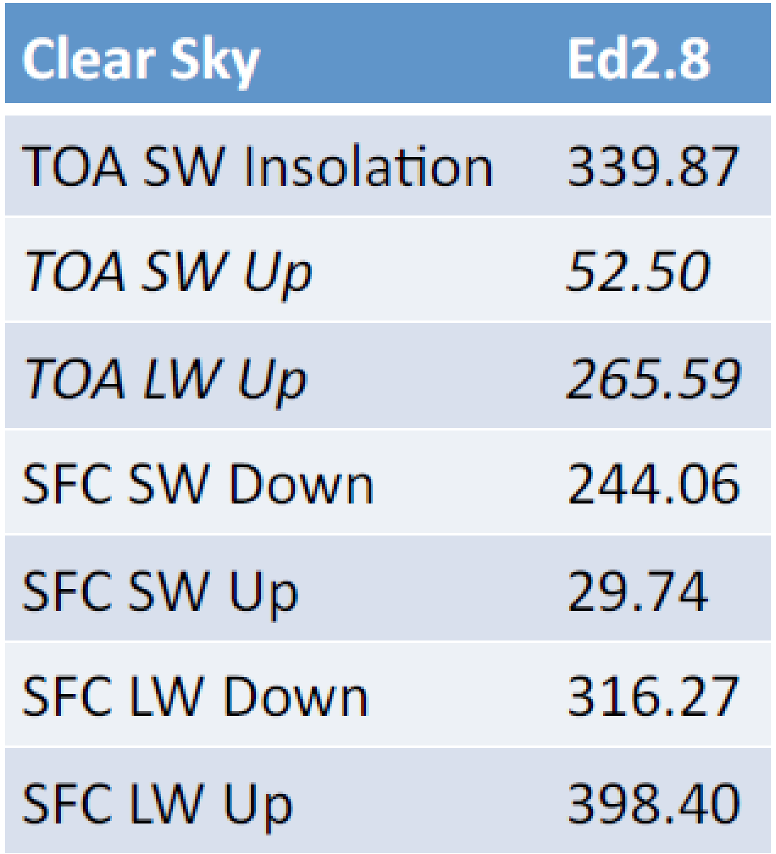
Eq. (2) Surface Total = 2 × TOA LW Up

244.06 – 29.74 + 316.27 = 2 × 265.59 – 0.59 Wm^{-2}

=> **Surface LW Up = 3 × TOA LW Up /2**

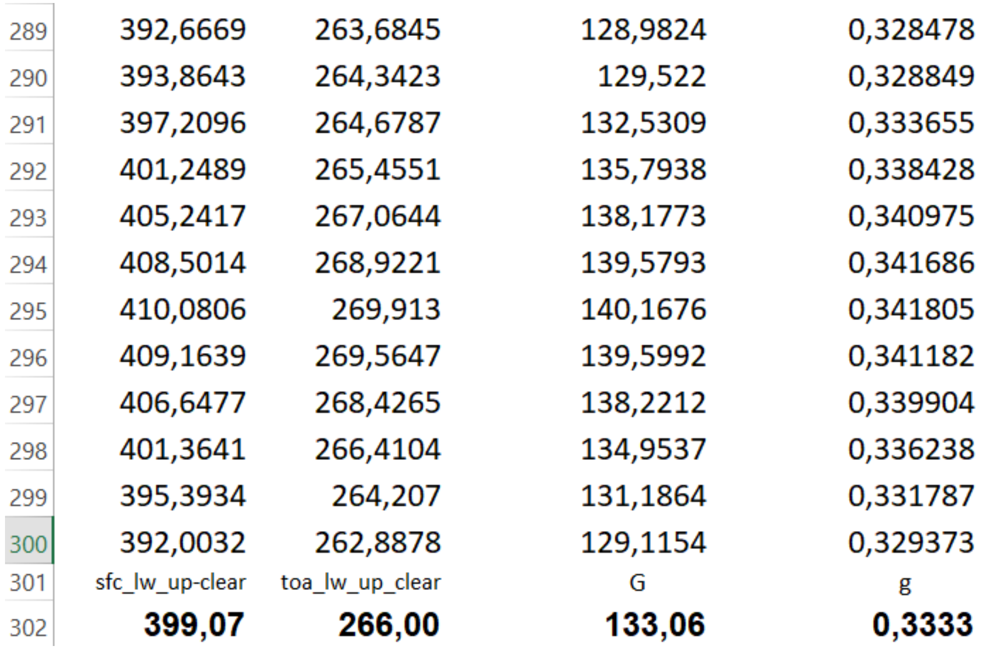
398.40 = 1.5 × 265.59 – 0.01 Wm^{-2}

Surface Net : TOA LW Up : SFC LW Up : Surface Total
1 : 2 : 3 : 4
For example
133 : 266 : 399 : 532 (Wm^{-2})



Clear Sky	Ed2.8
TOA SW Insolation	339.87
TOA SW Up	*52.50*
TOA LW Up	*265.59*
SFC SW Down	244.06
SFC SW Up	29.74
SFC LW Down	316.27
SFC LW Up	398.40

CERES_EBAF_Ed4.2.1_v3_200101-202512.nc (7 Apr 2026)



289	392,6669	263,6845	128,9824	0,328478
290	393,8643	264,3423	129,522	0,328849
291	397,2096	264,6787	132,5309	0,333655
292	401,2489	265,4551	135,7938	0,338428
293	405,2417	267,0644	138,1773	0,340975
294	408,5014	268,9221	139,5793	0,341686
295	410,0806	269,913	140,1676	0,341805
296	409,1639	269,5647	139,5992	0,341182
297	406,6477	268,4265	138,2212	0,339904
298	401,3641	266,4104	134,9537	0,336238
299	395,3934	264,207	131,1864	0,331787
300	392,0032	262,8878	129,1154	0,329373
301	sfc_lw_up-clear	toa_lw_up_clear	G	g
302	**399,07**	**266,00**	**133,06**	**0,3333**

Clear-sky	N	Geometry	CERES
Surface LW up	**3**	399	399.07
TOA LW up	**2**	266	266.00
G	**1**	133	133.06
g	1/3	1/3	0.3333

Creating the all-sky versions

Eq. (1) R_N (clear) = **SFC** (SW down – SW up + LW down – LW up)(clear-sky) = **TOA** LW (clear-sky)/2

Eq. (2) R_T (clear) = **SFC** (SW down – SW up + LW down) (clear-sky) = **TOA** LW (clear-sky) × 2

Eq. (3) R_N (all) = **SFC** (SW down – SW up + LW down – LW up) (all-sky) = **TOA** [LW (all-sky – LWCRE])/2

Eq. (4) R_T (all) = **SFC** (SW down – SW up + LW down) (all-sky) = **TOA** LW (all-sky) × 2 + LWCRE

Verification of the four equations

CERES EBAF Ed4.1 Version 3, 22 years (April 2000 – March 2022) (Wm^{-2})

Eq. (1) SFC SW down – SW up + LW down – LW up (clear) = TOA LW (clear)/2
240.8680 – 29.0724 + 317.4049 – 398.5211 = 266.0122 /2 – 2.3267

Eq. (2) SFC SW down – SW up + LW down (clear) = 2 × TOA LW (clear)
240.8680 – 29.0724 + 317.4049 = 2 × 266.0122 – 2.8238

Eq. (3) SFC SW down – SW up + LW down – LW up (all) = [TOA LW (all) – LWCRE]/2
186.8544 – 23.1629 + 345.0108 – 398.7550 = (240.2450 – 25.7672)/2 + 2.7083

Eq. (4) SFC SW down – SW up + LW down (all) = 2 × TOA LW (all) + LWCRE
186.8544 – 23.1629 + 345.0108 = 2 × 240.2450 + 25.7672 + 2.4450

Mean 0.0007

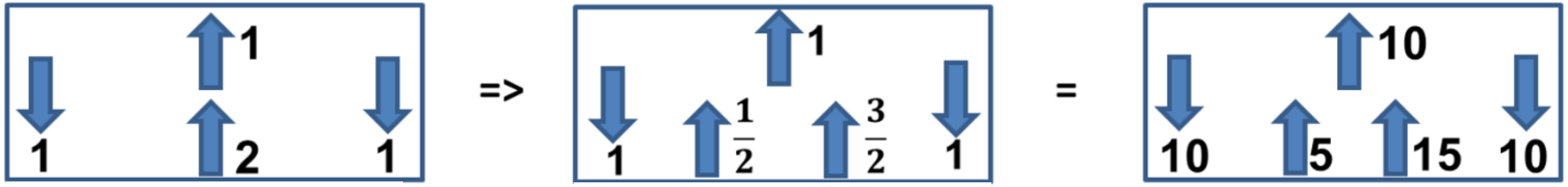
Verification of the four equations

CERES EBAF Ed4.1 Version 3, 22 years (April 2000 – March 2022) (Wm^{-2})
CERES EBAF Ed4.2.1 Version 3, 25 years (April 2000 – March 2025) (Wm^{-2})

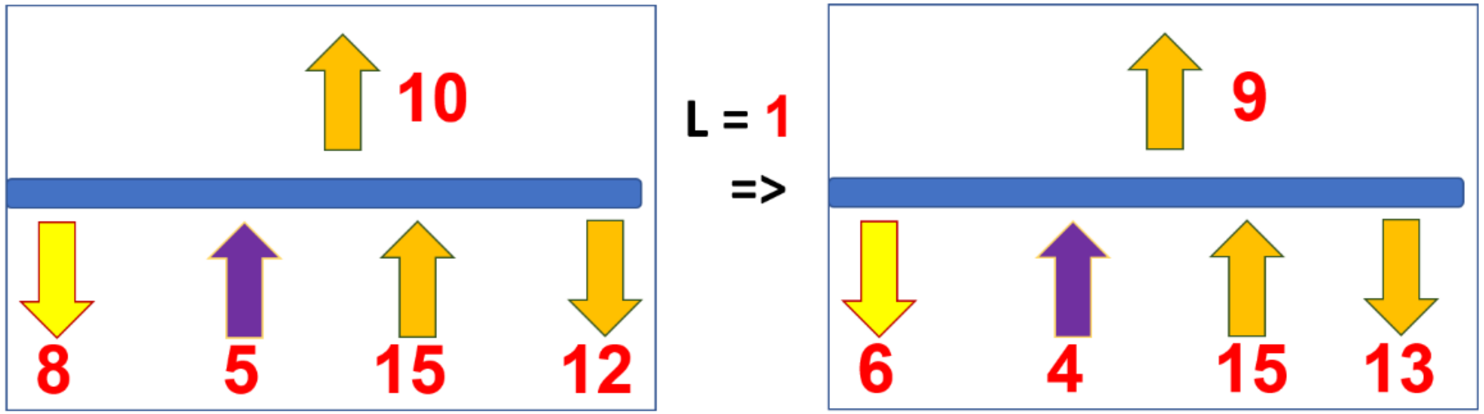
Eq. (1)	**SFC SW down – SW up + LW down – LW up**	**(clear)**	**= TOA LW (clear)/2**	
	240.8680 – 29.0724 + 317.4049 – 398.5211		**= 266.0122 /2**	**– 2.3267**
	240.4417 – 29.6710 + 318.2640 – 398.9301		**= 266.0004 /2**	**– 2.3531**
Eq. (2)	**SFC SW down – SW up + LW down**	**(clear)**	**= 2 × TOA LW (clear)**	
	240.8680 – 29.0724 + 317.4049		**= 2 × 266.0122**	**– 2.8238**
	240.4417 – 29.6710 + 318.2640		**= 2 × 266.0004**	**– 2.4236**
Eq. (3)	**SFC SW down – SW up + LW down – LW up**	**(all)**	**= [TOA LW (all) – LWCRE]/2**	
	186.8544 – 23.1629 + 345.0108 – 398.7550		**= (240.2450 – 25.7672)/2**	**+ 2.7083**
	187.1294 – 23.4327 + 346.4731 – 398.7367		**= (240.4417 – 25.5587)/2**	**+ 3.9915**
Eq. (4)	**SFC SW down – SW up + LW down**	**(all)**	**= 2 × TOA LW (all) + LWCRE**	
	186.8544 – 23.1629 + 345.0108		**= 2 × 240.2450 + 25.7672**	**+ 2.4450**
	187.1294 – 23.4327 + 346.4731		**= 2 × 240.4417 + 25.5587**	**+ 3.7276**
			Mean	**0.0007**
				0.7356

The N-numbers as solution of the equations

Pure geometry **1 : 2 : 3 : 4** No reference to GHGs



Eq.(2) SFC Tot = 2OLR (Clear-sky) Eq.(1) SFC Net = OLR/2



$$8 + 12 - 15 = 10\ /\ 2 \qquad 6 + 13 - 15 = (9 - 1)/2$$

$$8 + 12 = 10 \times 2 \qquad 6 + 13 = 9 \times 2 + 1$$

Eq. (1) SFC Net = OLR /2

Eq. (2) SFC Tot = 2OLR

Eq. (3) SFC Net = (OLR – L)/2

Eq. (4) SFC Tot = 2OLR + L

Clear-sky **All-sky**

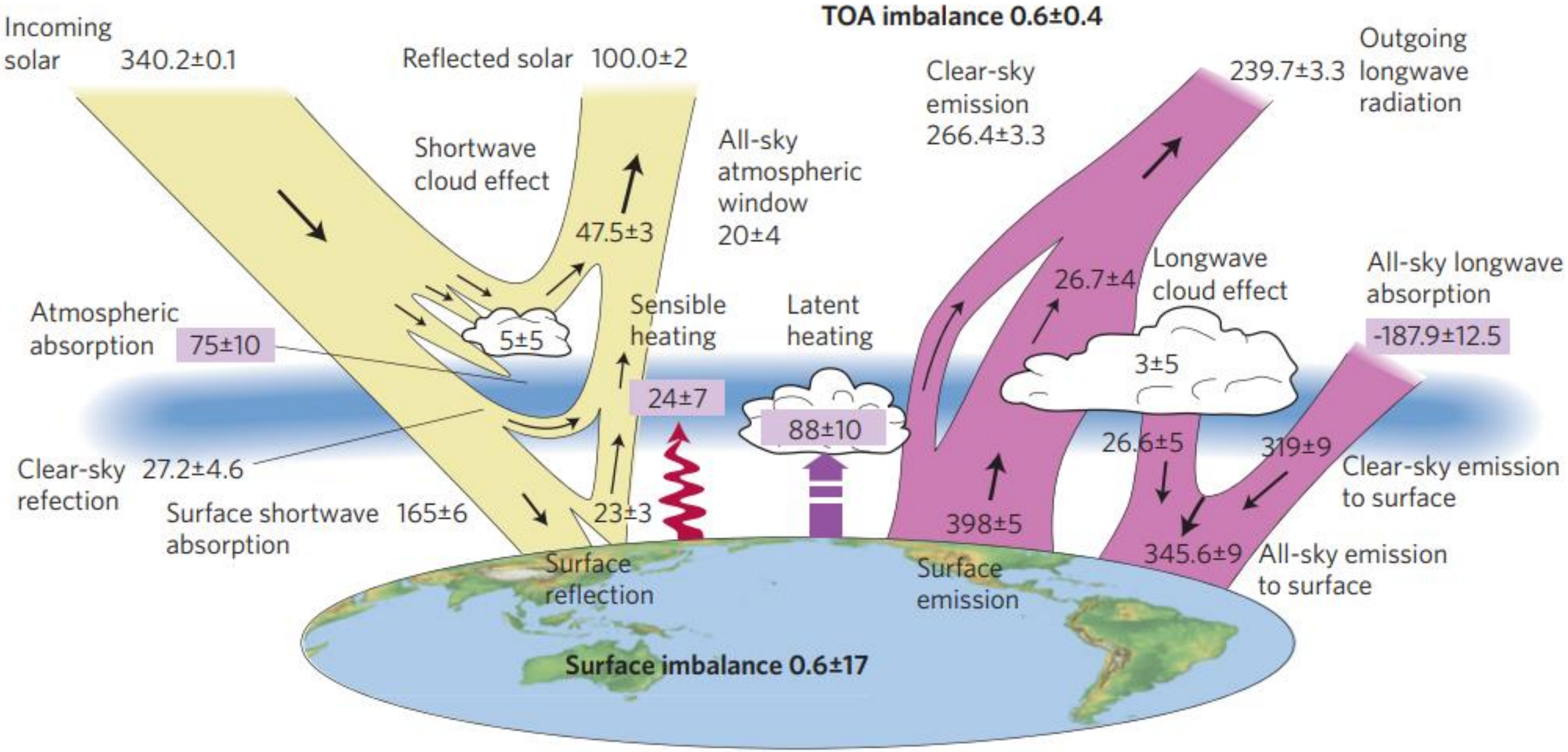
The flux components with LWCRE = 1

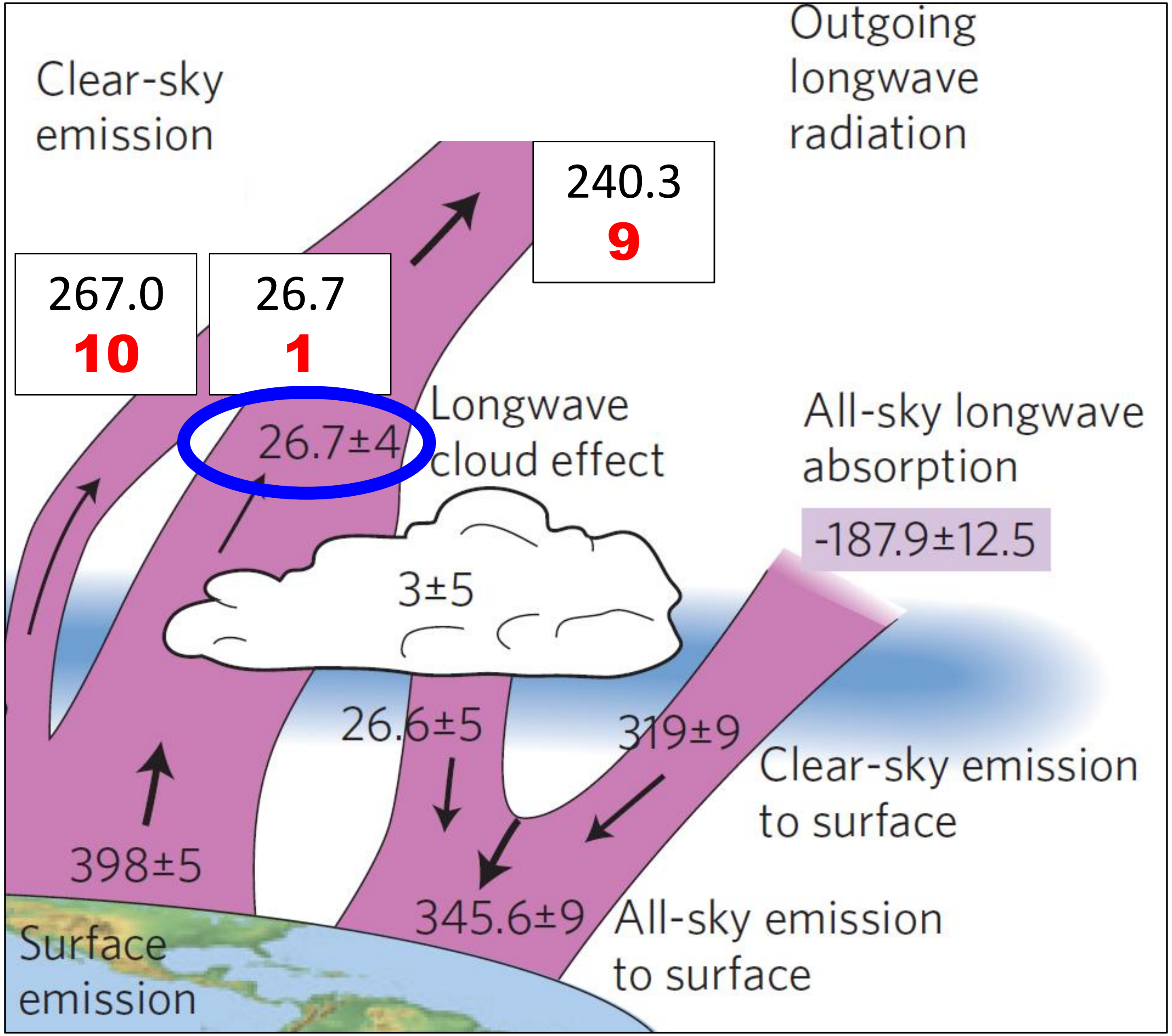
TOA LW	clear-sky =	10	TOA LW	all-sky =	9
SFC LW up	clear-sky =	15	SFC LW up	all-sky =	15
SFC LW down	clear-sky =	12	SFC LW down	all-sky =	13
SFC LW net	clear-sky =	–3	SFC LW net	all-sky =	–2
SFC SW net	clear-sky =	8	SFC SW net	all-sky =	6
SFC SW+LW net	clear-sky =	5	SFC SW+LW net	all-sky =	4
SFC SW+LW total	clear-sky =	20	SFC SW+LW total	all-sky =	19
G greenhouse effect	clear-sky =	5	G greenhouse effect	all-sky =	6
SWCRE (surface)	=	–2	LWCRE (surface, TOA)	=	1

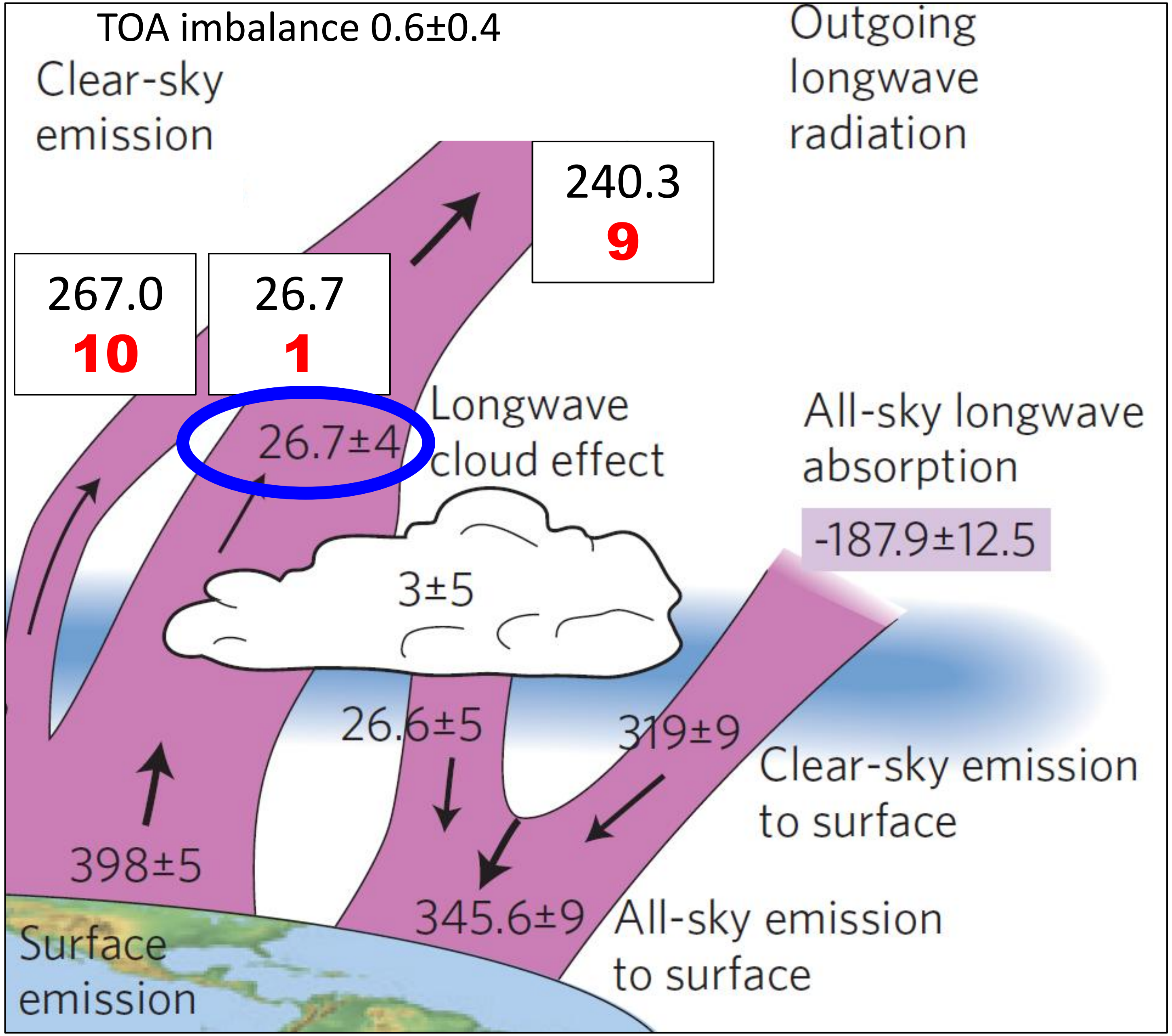
The flux components with LWCRE = 1

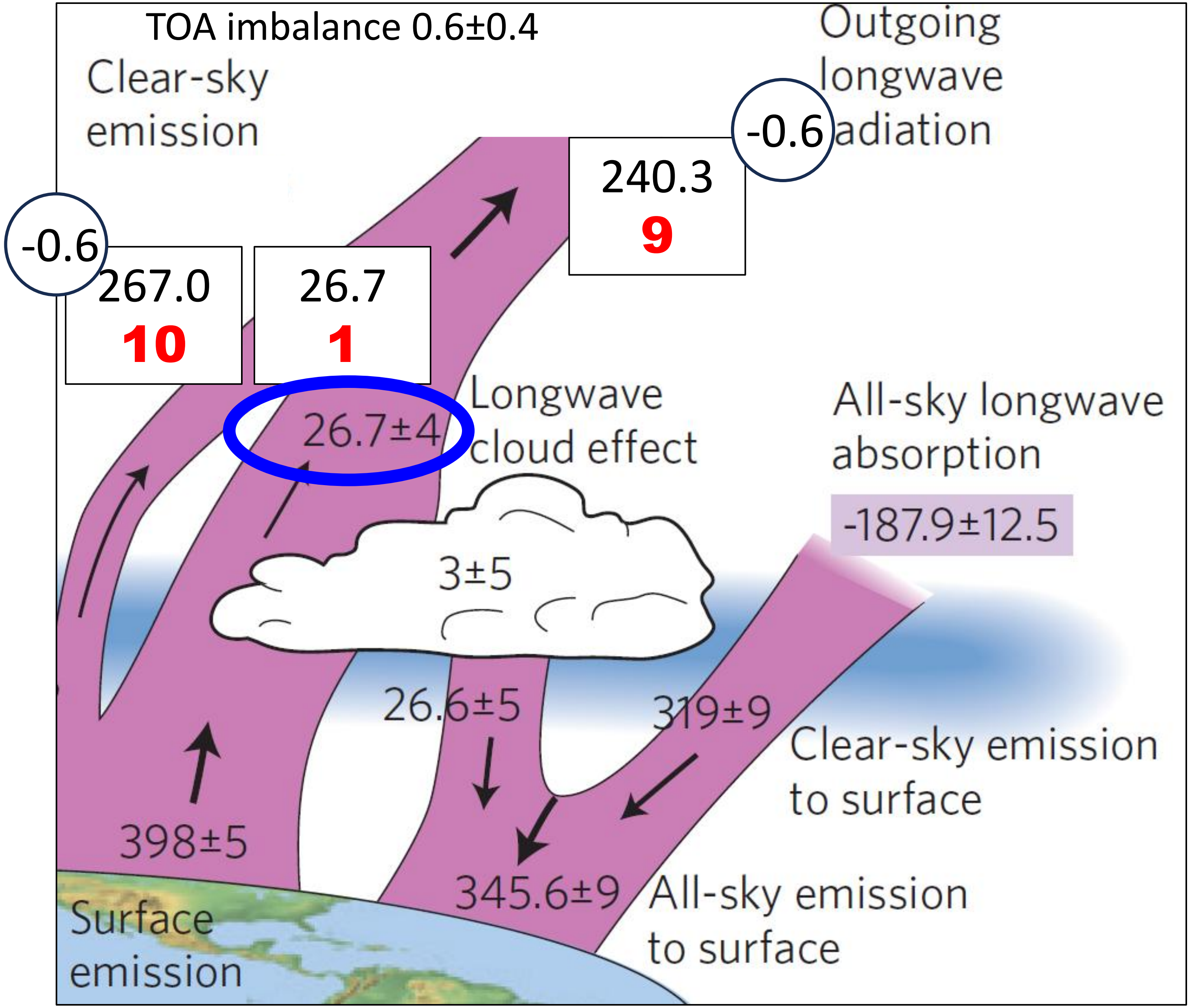
TOA LW clear-sky = **10**

TOA LW all-sky = **9**

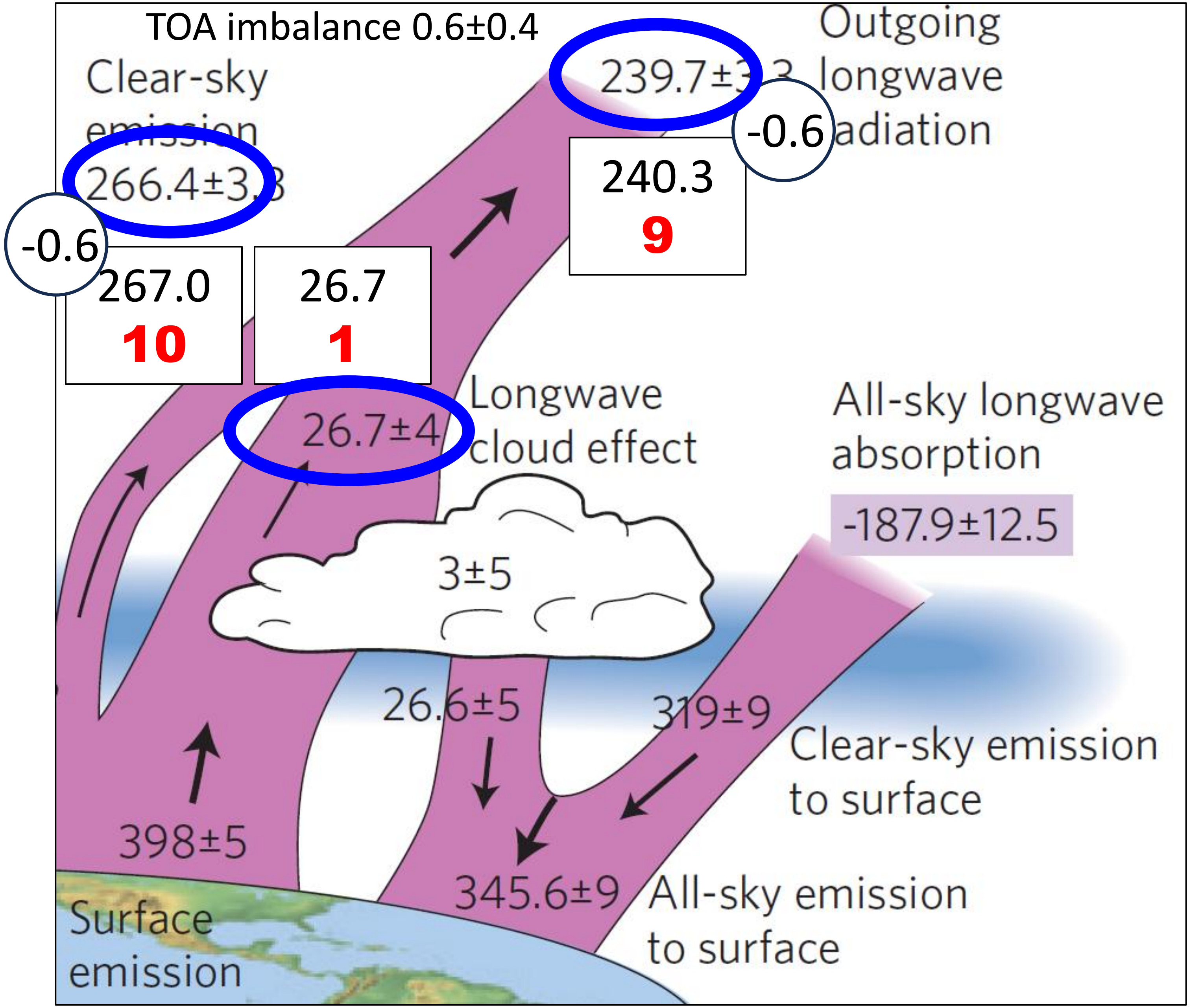

TOA imbalance 0.6±0.4
Incoming solar 340.2±0.1
Reflected solar 100.0±2
Shortwave cloud effect
47.5±3
All-sky atmospheric window 20±4
Clear-sky emission 266.4±3.3
239.7±3.3 Outgoing longwave radiation
5±5
Atmospheric absorption 75±10
Sensible heating
24±7
Latent heating
88±10
26.7±4
Longwave cloud effect
3±5
All-sky longwave absorption
-187.9±12.5
Clear-sky refection 27.2±4.6
Surface shortwave absorption 165±6
23±3
Surface reflection
398±5
Surface emission
26.6±5
319±9
Clear-sky emission to surface
345.6±9 All-sky emission to surface
Surface imbalance 0.6±17


Clear-sky emission
Outgoing longwave radiation
240.3
9
267.0
10
26.7
1
26.7±4
Longwave cloud effect
All-sky longwave absorption
-187.9±12.5
3±5
26.6±5
319±9
Clear-sky emission to surface
398±5
345.6±9
All-sky emission to surface
Surface emission


TOA imbalance 0.6±0.4
Clear-sky emission
Outgoing longwave radiation
240.3
9
267.0
10
26.7
1
26.7±4
Longwave cloud effect
All-sky longwave absorption
-187.9±12.5
3±5
26.6±5
319±9
Clear-sky emission to surface
398±5
345.6±9
All-sky emission to surface
Surface emission


TOA imbalance 0.6±0.4
Clear-sky emission
Outgoing longwave radiation
-0.6
240.3
9
-0.6
267.0
10
26.7
1
26.7±4
Longwave cloud effect
All-sky longwave absorption
-187.9±12.5
3±5
26.6±5
319±9
Clear-sky emission to surface
398±5
345.6±9
All-sky emission to surface
Surface emission

Stephens et al. (2012)



The flux components with LWCRE = 1

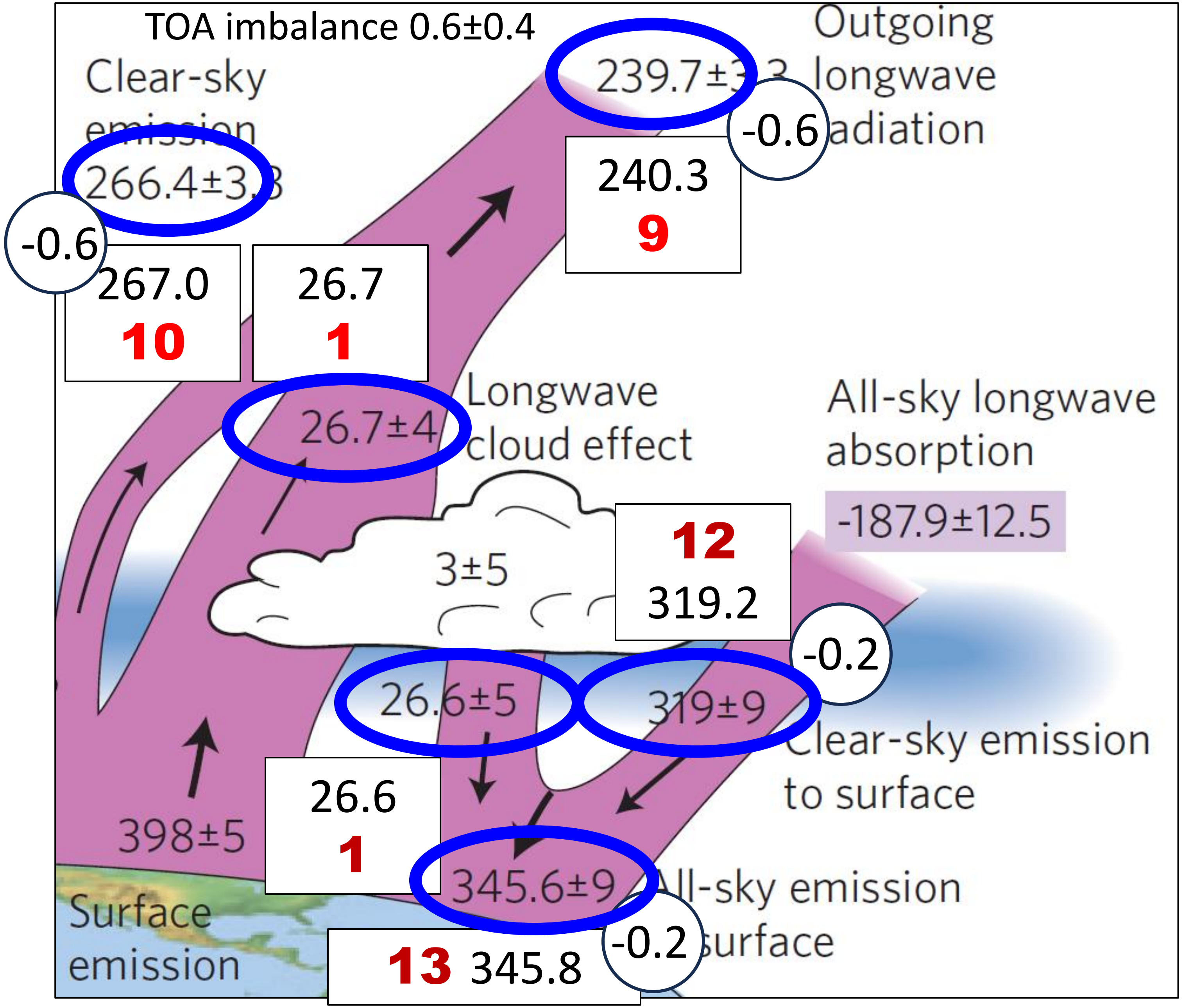
TOA LW clear-sky = **10**

SFC LW down clear-sky = **12**

TOA LW all-sky = **9**

SFC LW down all-sky = **13**

Stephens et al. (2012)



-0.6

267.0
10

26.7
1

240.3
9

-0.6

12
319.2

-0.2

26.6
1

13 345.8

-0.2

The flux components with LWCRE = 1

TOA LW clear-sky = **10**

SFC LW down clear-sky = **12**

SFC LW up clear-sky = **15**

ATM LW cooling clear-sky = **-7**

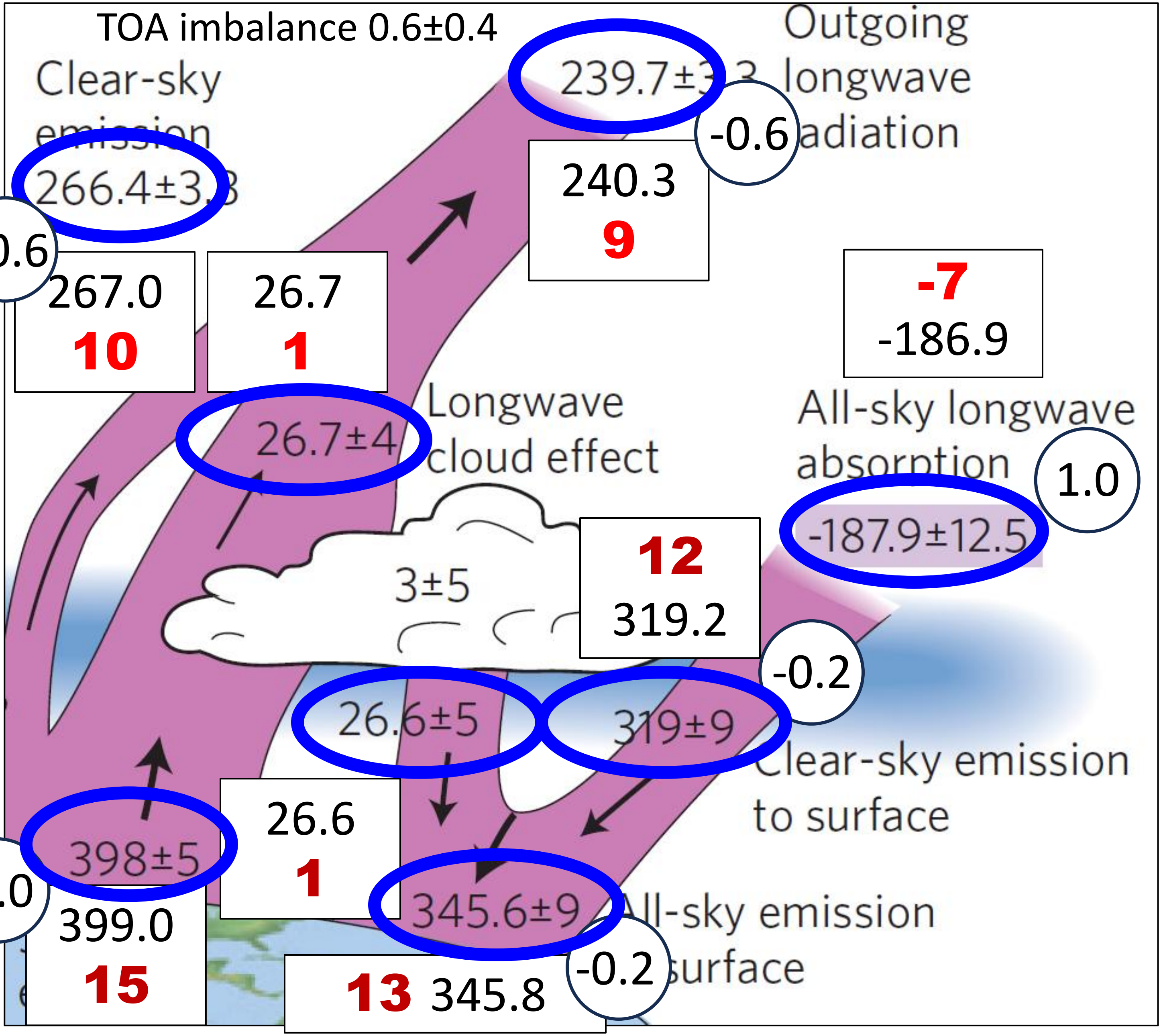
TOA LW all-sky = **9**

SFC LW down all-sky = **13**

SFC LW up all-sky = **15**

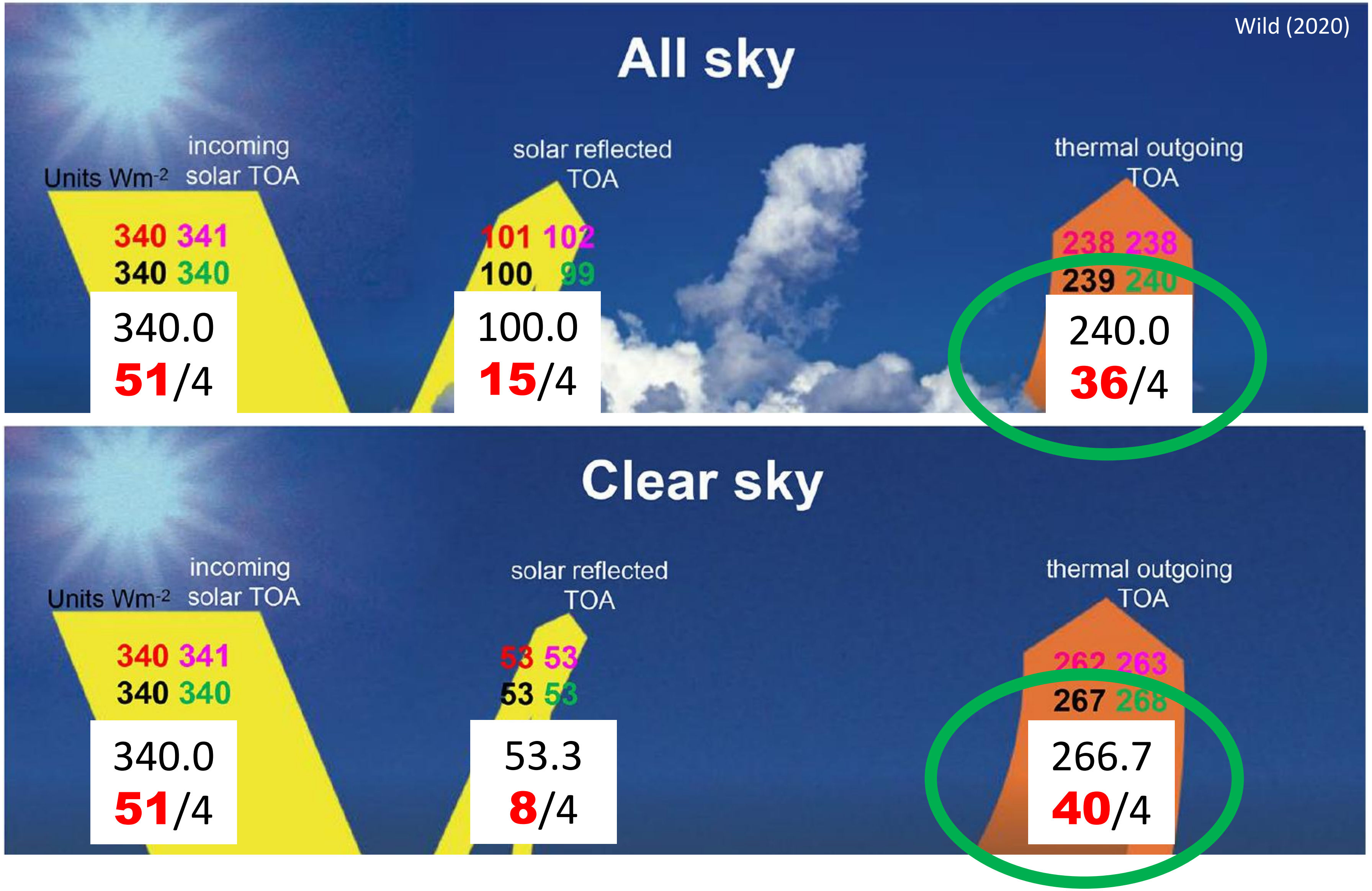
ATM LW cooling all-sky = **-7**

Stephens et al. (2012)



Extension: TOA

We already have OLR(all) = 9 = 36/4 and OLR(clear) = 10 = 40/4



340.0
51/4

100.0
15/4

240.0
36/4

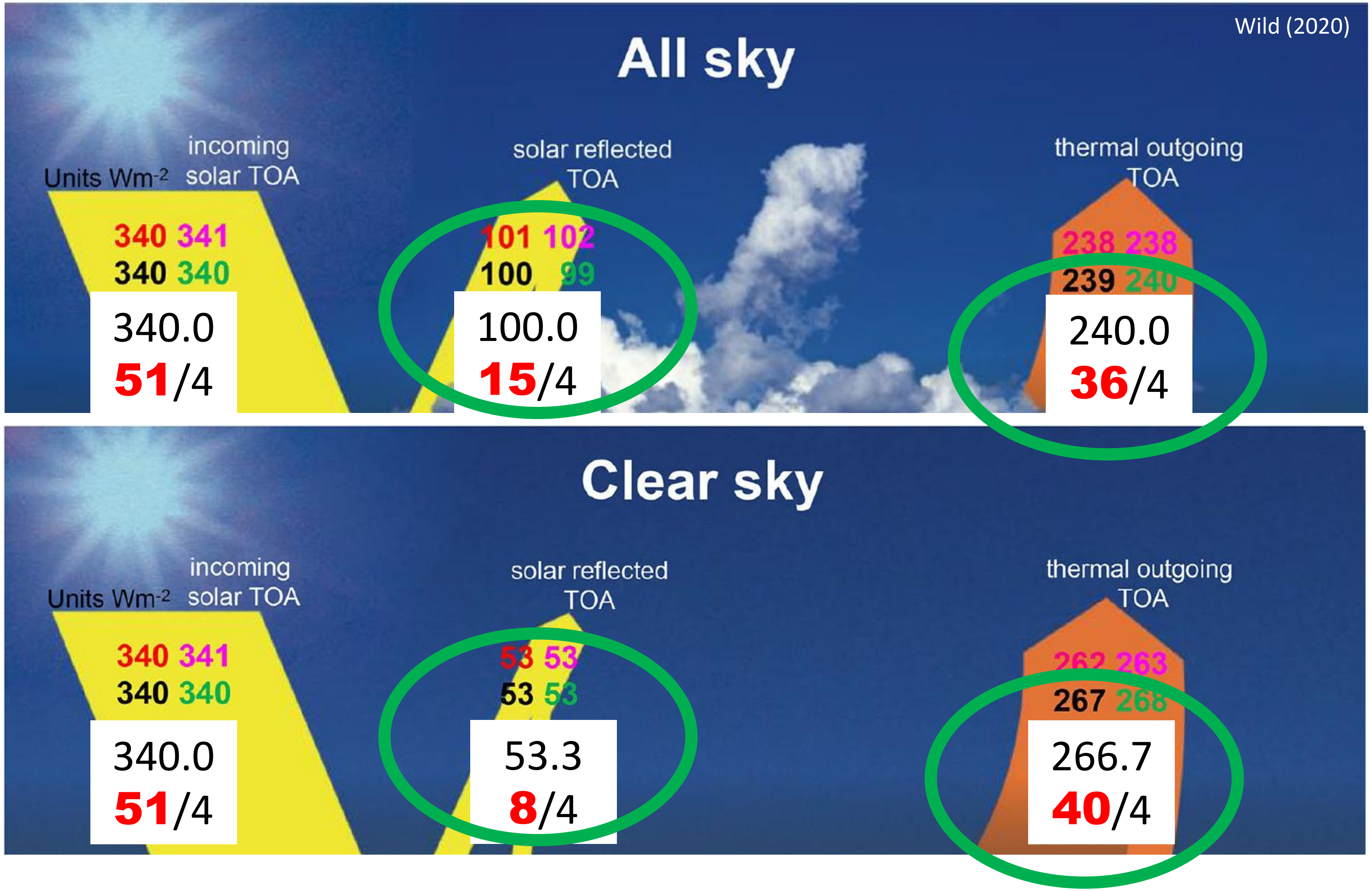
340.0
51/4

53.3
8/4

266.7
40/4

Extension: TOA

We observe RSW(all) = **15**/4 and RSW(clear) = **2** = **8**/4

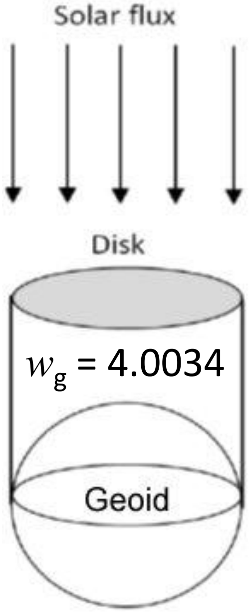


Extension: TOA

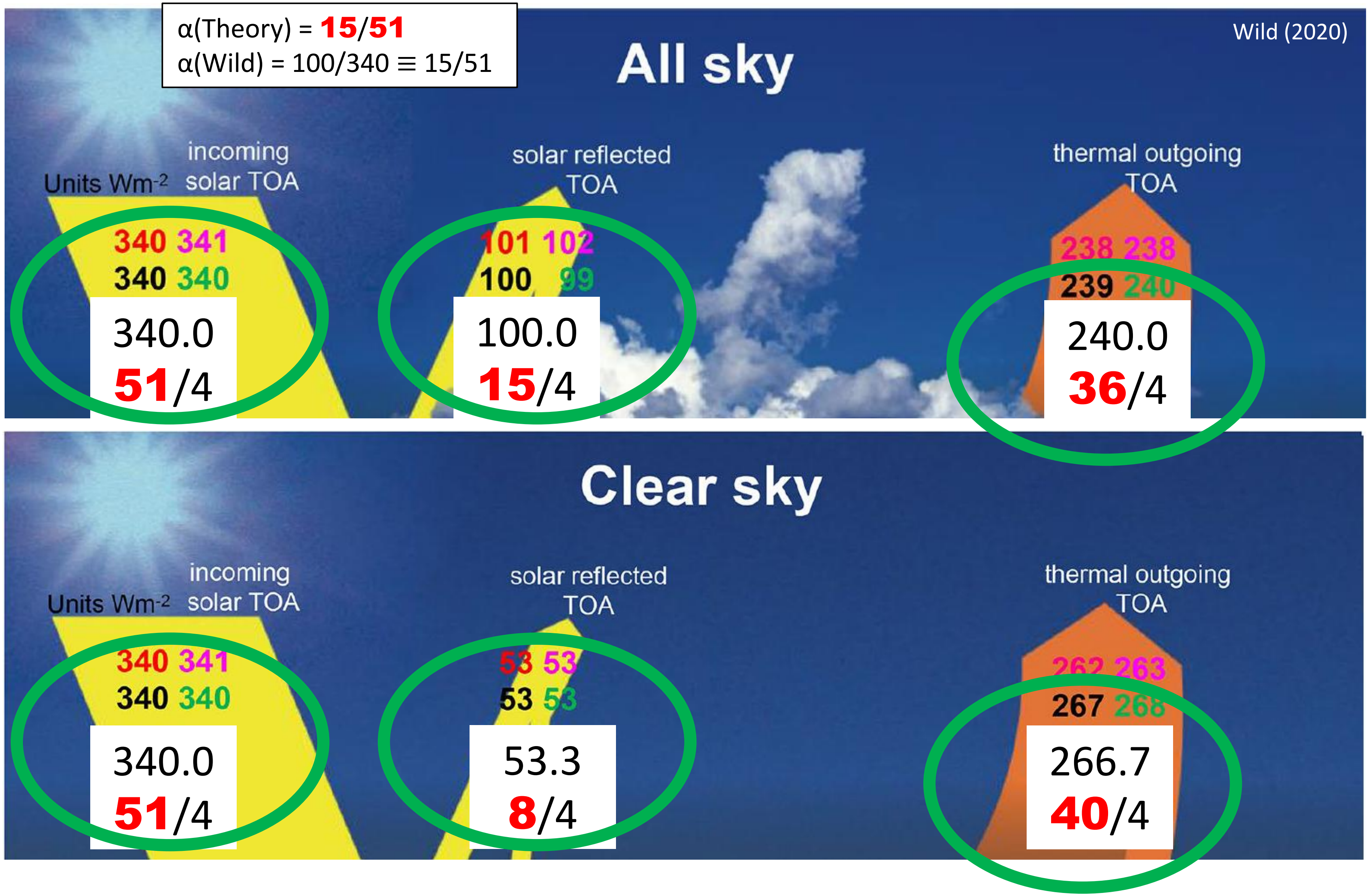
We infer ISR = **51**/4 and TSI = **51** => $\alpha_p = 15/51$

The only input parameter is TSI

51



α(Theory) = **15**/**51**
α(Wild) = 100/340 ≡ 15/51



340.0
51/4

100.0
15/4

240.0
36/4

340.0
51/4

53.3
8/4

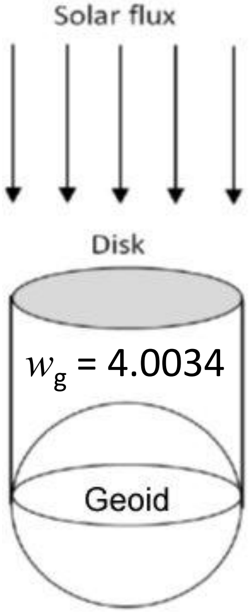
266.7
40/4

Extension: TOA

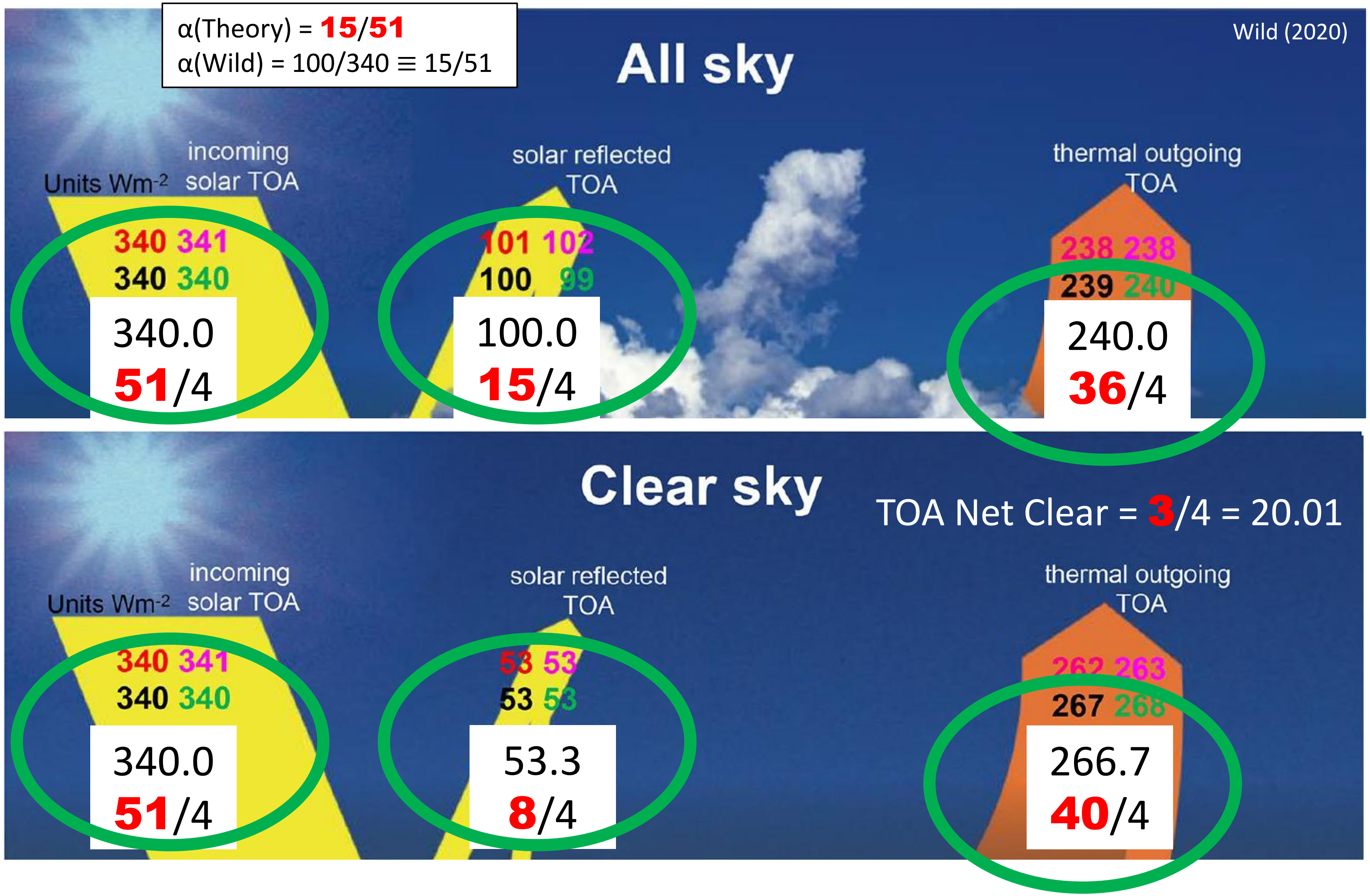
We infer TOA Net Clear = **3**/4 and TOA Net CRE = –**3**/4 = –20.01 Wm^{-2}

The only input parameter is TSI

51



1 = 26.684 ± 0.01 Wm^{-2}



α(Theory) = **15**/**51**
α(Wild) = 100/340 ≡ 15/51

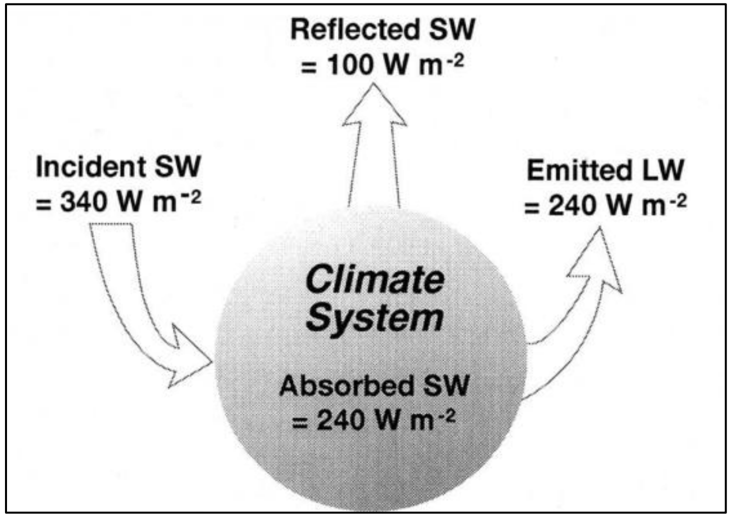
TOA Net Clear = **3**/4 = 20.01

TOA All-sky, Albedo and TOA NET CRE were exact already in 1995

Mission to Planet Earth: Role of Clouds and Radiation in Climate

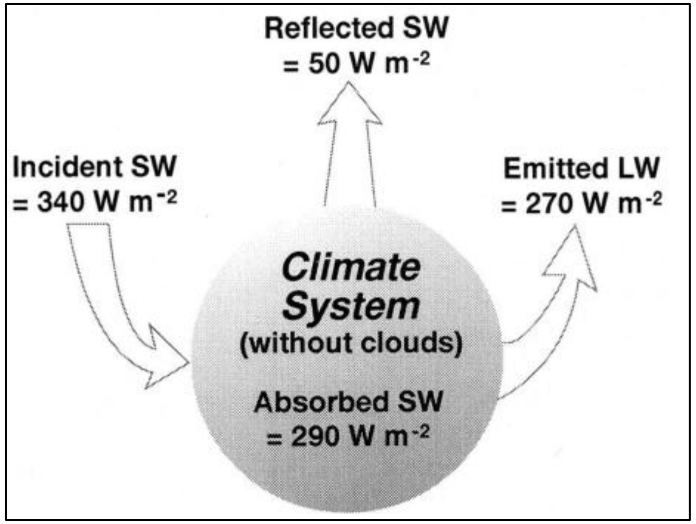
Bruce A. Wielicki,*
Robert D. Cess,+
Michael D. King,#
David A. Randall,@
and Edwin F. Harrison*

α(Theory) = **15**/**51**
α(Wielicki) = 100/340 ≡ 15/51



All-sky

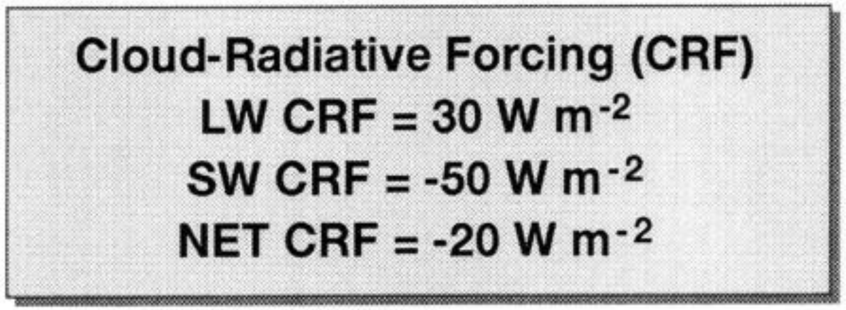
Incident SW = 340 Wm^{-2} = **51**/4
Reflected SW = 100 Wm^{-2} = **15**/4
Absorbed SW = 240 Wm^{-2} = **36**/4
Emitted LW = 240 Wm^{-2} = **36**/4



Clear-sky

Incident SW = 340 Wm^{-2} = **51**/4
Reflected SW= 53.33 Wm^{-2} = **8**/4
Absorbed SW= 286.67 Wm^{-2} = **43**/4
Emitted LW = 266.66Wm^{-2} = **40**/4

LW CRF = 26.68 Wm^{-2} = **1**
SW CRF = -46.69 Wm^{-2} = -**7**/4
NET CRF = -20.01 Wm^{-2} = -**3**/4

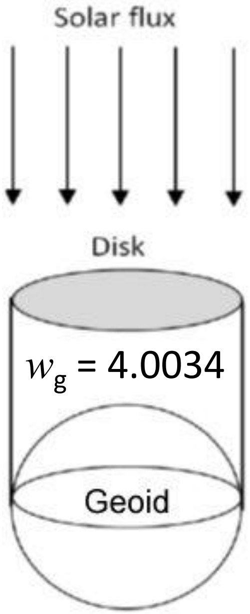


Cloud-Radiative Forcing (CRF)
LW CRF = 30 W m^{-2}
SW CRF = -50 W m^{-2}
NET CRF = -20 W m^{-2}

Extension: Surface SW down all-sky

The only input parameter is TSI

51



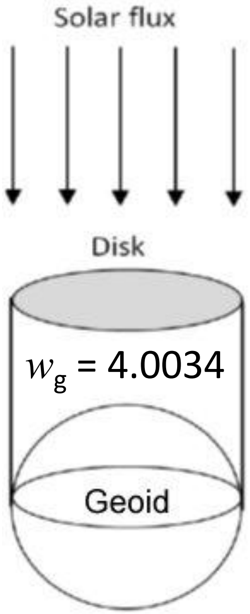
1 = 26.684 ± 0.01 Wm^{-2}

Set 2

Surface			Kato et al. (2025) Edition 4.2	Kato et al. (2025) Edition 4.1
SW down all			187.0	186.6

The only input parameter is TSI

51



1 = 26.684 ± 0.01 Wm^{-2}

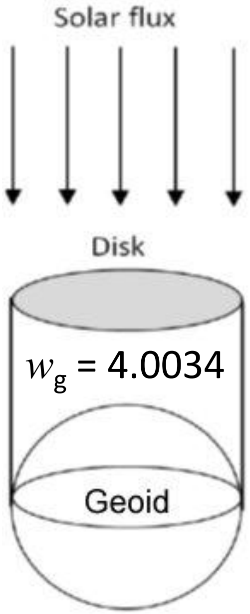
Extension: Surface SW down all-sky

	Set 1		Set 2	
Surface	**N**	**N** × Unit	Kato et al. (2025) Edition 4.2	Kato et al. (2025) Edition 4.1
SW down all	**7**	186.79	187.0	186.6

Extension: Surface SW down clear-sky

The only input parameter is TSI

51



1 = 26.684 ± 0.01 Wm^{-2}

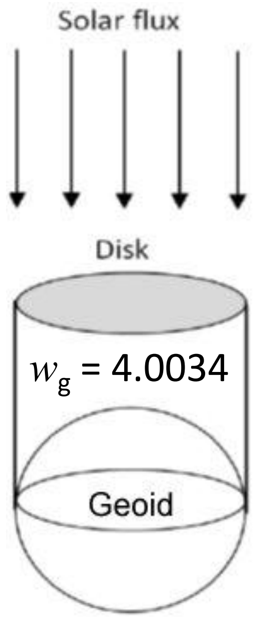
Set 2

Surface	**N**	**N** × Unit	Kato et al. (2025) Edition 4.2	Kato et al. (2025) Edition 4.1
SW down all	**7**	186.79	187.0	186.6
SW down clear			241.1	240.7

Extension: Surface SW down clear-sky

The only input parameter is TSI

51



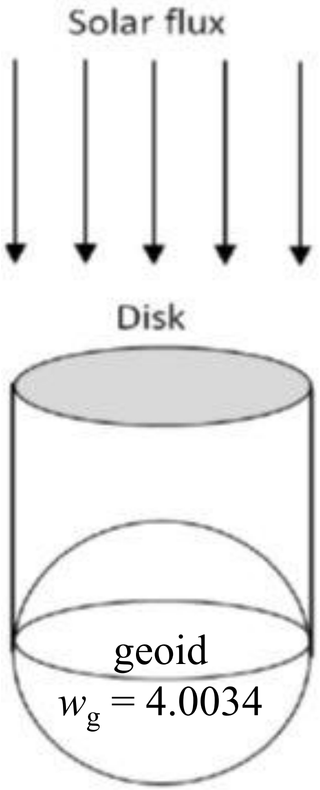
1 = 26.684 ± 0.01 Wm^{-2}

	Set 1		Set 2	
Surface	**N**	**N** × Unit	Kato et al. (2025) Edition 4.2	Kato et al. (2025) Edition 4.1
SW down all	**7**	186.79	187.0	186.6
SW down clear	**9**	240.16	241.1	240.7

Set 1 and Set 2 of CERES Data Products, TOA

The only input parameter

51

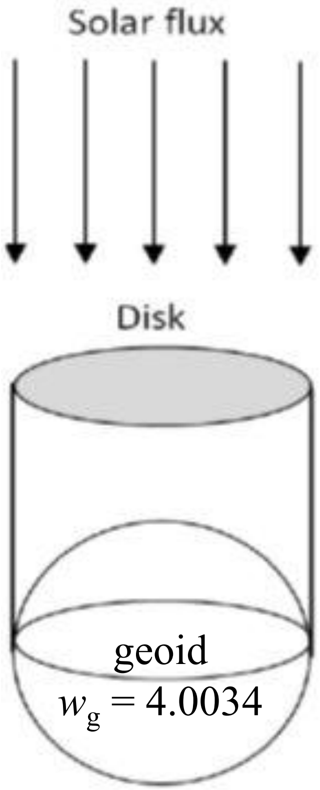


1 = 26.684 Wm^{-2}	**Set 1**		**Set 2**	**Difference**
TOA	**N**	**N** × Unit	EBAF Ed4.2.1_v3 Jan 2001 – Dec 2025	**Set 2 – Set 1 (Wm^{-2})**
Solar	**51**/4	340.22	340.22	**0.00**
SW up clear	**8**/4	53.37	53.73	**0.36**
LW up clear	**40**/4	266.84	266.00	**-0.84**
Net clear	**3**/4	20.01	20.49	**0.48**
SW up all	**15**/4	100.06	98.83	**-1.23**
LW up all	**36**/4	240.15	240.48	**0.33**
Net all	**0**	0	0.90	**0.90**
SW CRE	**–7**/4	-46.70	-45.10	**1.60**
LW CRE	**4**/4	26.684	25.52	**-1.17**
Net CRE	**–3**/4	-20.01	-19.58	**0.43**

I infer that Set 1 is exact and Set 2 is accurate

The only input parameter

51

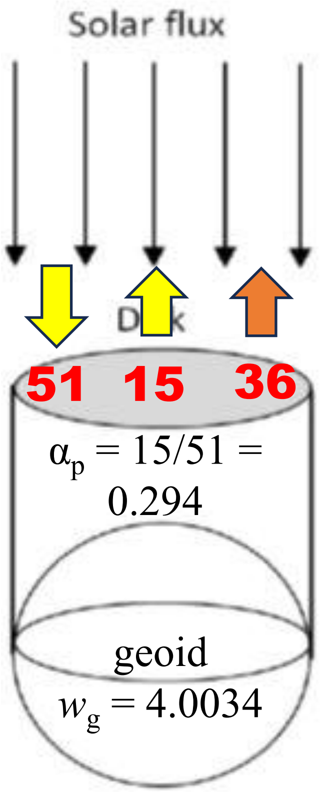


1 = 26.684 Wm^{-2}	**Set 1**		**Set 2**	**Difference**
TOA	**N**	**N** × Unit	EBAF Ed4.2.1_v3 Jan 2001 – Dec 2025	**Set 2 – Set 1 (Wm^{-2})**
Solar	**51**/4	340.22	340.22	0.00
SW up clear	**8**/4	53.37	53.73	**0.36**
LW up clear	**40**/4	266.84	266.00	**-0.84**
Net clear	**3**/4	20.01	20.49	**0.48**
SW up all	**15**/4	100.06	98.83	**-1.23**
LW up all	**36**/4	240.15	240.48	**0.33**
Net all	**0**	0	0.90	**0.90**
SW CRE	**–7**/4	-46.70	-45.10	**1.60**
LW CRE	**4**/4	26.684	25.52	**-1.17**
Net CRE	**–3**/4	-20.01	-19.58	**0.43**

Notice that Set 1 TOA works on the disk

The only input parameter

51

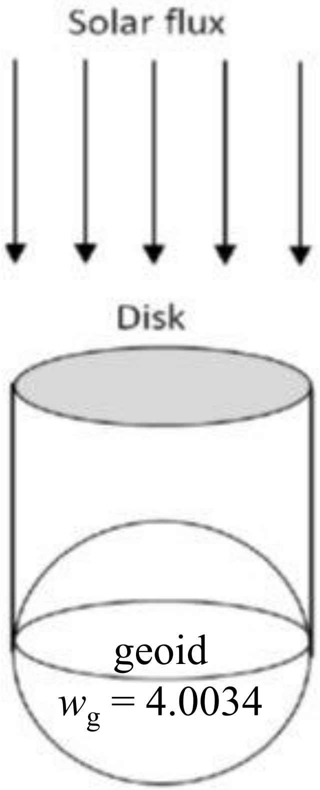


1 $= 26.684\ \mathrm{Wm^{-2}}$	**Set 1**		**Set 2**	**Difference**
TOA	**N**	**N** × Unit	EBAF Ed4.2.1_v3 Jan 2001 – Dec 2025	**Set 2 – Set 1 ($\mathrm{Wm^{-2}}$)**
Solar	**51**/4	340.22	340.22	0.00
SW up clear	**8**/4	53.37	53.73	**0.36**
LW up clear	**40**/4	266.84	266.00	**-0.84**
Net clear	**3**/4	20.01	20.49	**0.48**
SW up all	**15**/4	100.06	98.83	**-1.23**
LW up all	**36**/4	240.15	240.48	**0.33**
Net all	**0**	0	0.90	**0.90**
SW CRE	**–7**/4	-46.70	-45.10	**1.60**
LW CRE	**4**/4	26.684	25.52	**-1.17**
Net CRE	**–3**/4	-20.01	-19.58	**0.43**

Set 1 and Set 2 of CERES Data Products, Surface

The only input parameter

51



1 = 26.684 Wm^{-2}	**Set 1**		**Set 2**	**Difference**
Surface	**N**	**N** × Unit	EBAF Ed4.2.1 Jan 2001 – Dec 2025	**Set 2 – Set 1 (Wm^{-2})**
SW down clear	**9**	240.15	240.94	**0.79**
SW up clear	**1**	26.68	29.63	**2.95**
SW net clear	**8**	213.46	211.31	**-2.15**
LW down clear	**12**	320.20	318.43	**-1.77**
LW up clear	**15**	400.25	399.07	**-1.18**
LW net clear	**-3**	-80.05	-80.64	**-0.59**
Total net clear	**5**	133.42	130.67	**-2.75**
SW down all	**7**	186.78	187.12	**0.34**
SW up all	**1**	26.68	23.40	**-3.28**
SW net all	**6**	160.10	163.72	**3.62**
LW down all	**13**	346.84	346.60	**-0.24**
LW up all	**15**	400.20	398.87	**-1.33**
LW net all	**-2**	-53.37	-52.28	**1.09**
Total net all	**4**	106.73	111.44	**4.71**

If Libera will be a *"wohltemperierte Klavier"* => Set 3

A well-calibrated instrument

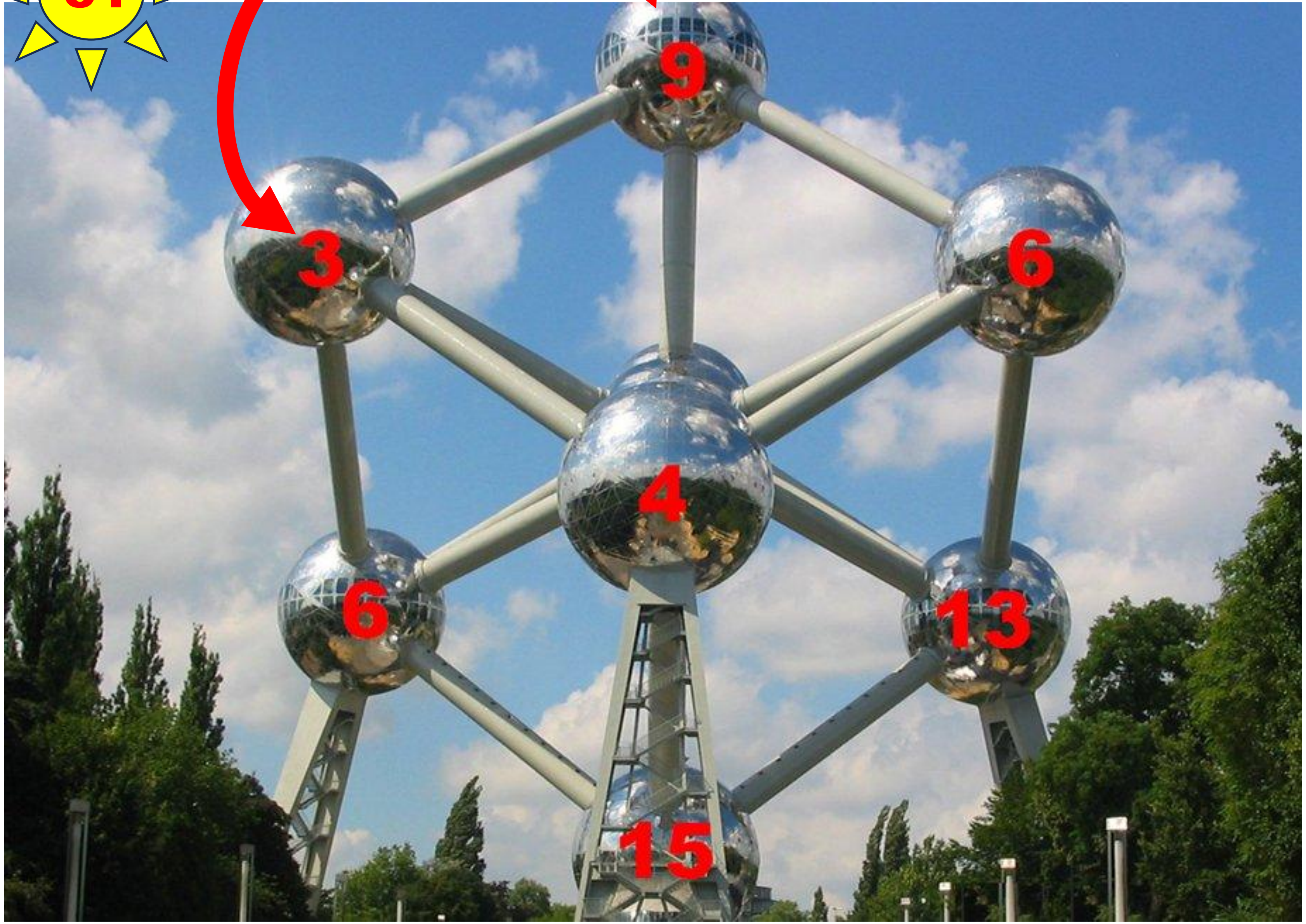
1 = 26.684 Wm^{-2}	**Set 1**		**Set 2**	**Set 3**	**= Set 2 - Set 1**
TOA	**N**	**N** × Unit	Libera ?	**Difference = Absolute Magnitude !!!**	
Solar	**51**/4	340.22	340.22	0.00	Zero (by def.)
SW up clear	**8**/4	53.37	53.73	+ 0.36	Clear-sky SW Deviation
LW up clear	**40**/4	266.84	266.00	– 0.84	Clear-sky LW Deviation
Net clear	**3**/4	20.01	20.49	+ 0.48	Net Clear-sky Deviation
SW up all	**15**/4	100.06	98.83	– 1.23	All-sky SW Deviation
LW up all	**36**/4	240.15	240.48	+ 0.33	All-sky LW Deviation
Net all	**0**	0	0.90	+ 0.90	Net All-sky Deviation ("EEI")
SW CRE	**–7**/4	-46.70	-45.10	+ 1.60	SW CRE Deviation
LW CRE	**4**/4	26.684	25.52	– 1.17	LW CRE Deviation
Net CRE	**–3**/4	-20.01	-19.58	+ 0.43	Net CRE Deviation

If Libera will be a well-calibrated instrument, it will measure absolute deviations from the equilibrium positions.

51

Set 1

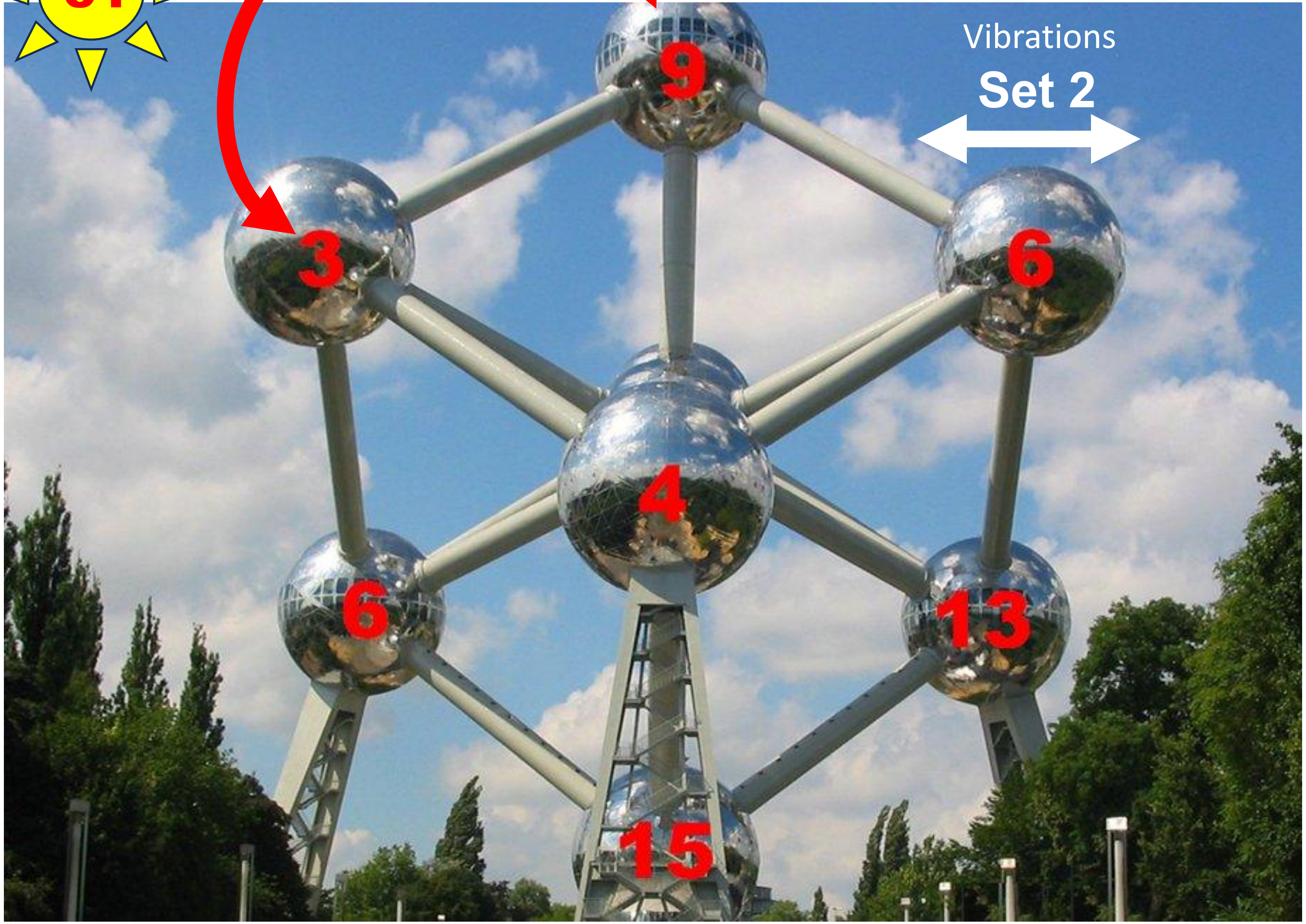
Equilibrium positions



51

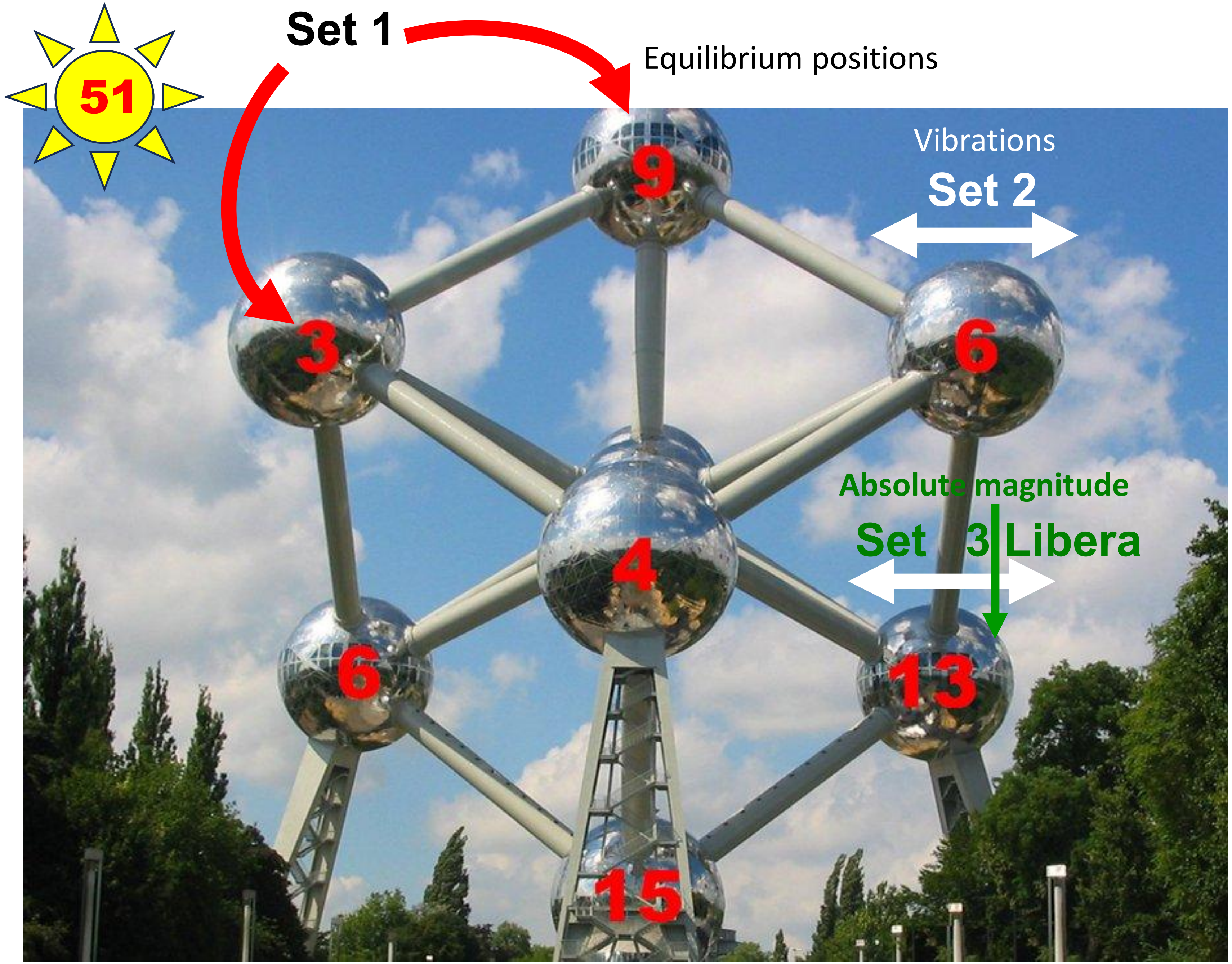
Set 1

Equilibrium positions



Vibrations

Set 2



Set 1

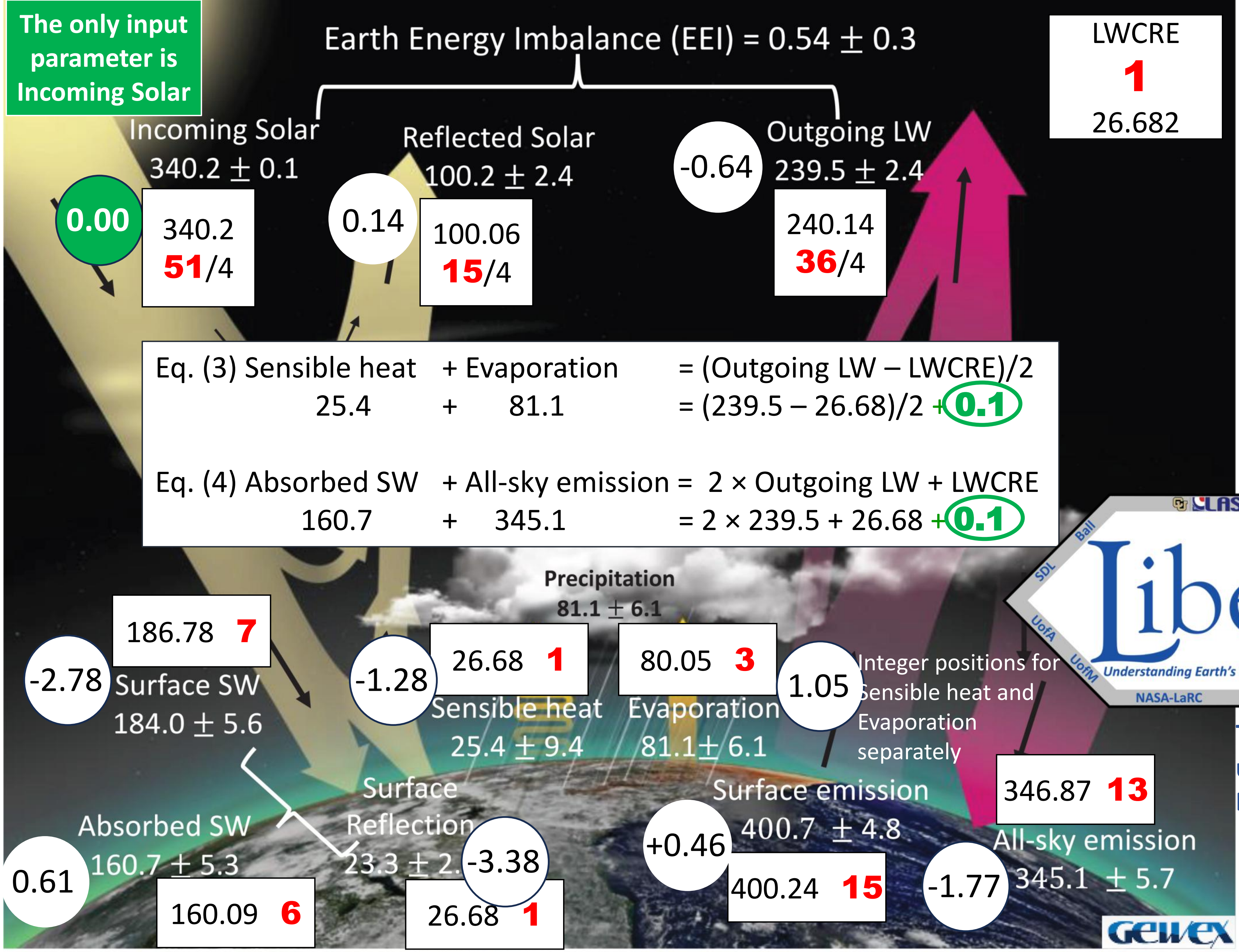
Equilibrium positions

Vibrations

Set 2

Absolute magnitude

Set 3 Libera



The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

Incoming Solar 340.2 ± 0.1

0.00

340.2
51/4

Reflected Solar 100.2 ± 2.4

0.14

100.06
15/4

Outgoing LW 239.5 ± 2.4

-0.64

240.14
36/4

LWCRE
1
26.682

Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + **0.1**

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + **0.1**

Precipitation
81.1 ± 6.1

186.78 **7**

-2.78

Surface SW
184.0 ± 5.6

-1.28

26.68 **1**

Sensible heat
25.4 ± 9.4

80.05 **3**

Evaporation
81.1 ± 6.1

1.05

Integer positions for Sensible heat and Evaporation separately

Surface emission
400.7 ± 4.8

+0.46

400.24 **15**

346.87 **13**

All-sky emission
345.1 ± 5.7

-1.77

Surface Reflection
23.3 ± 2.

-3.38

26.68 **1**

Absorbed SW
160.7 ± 5.3

0.61

160.09 **6**

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

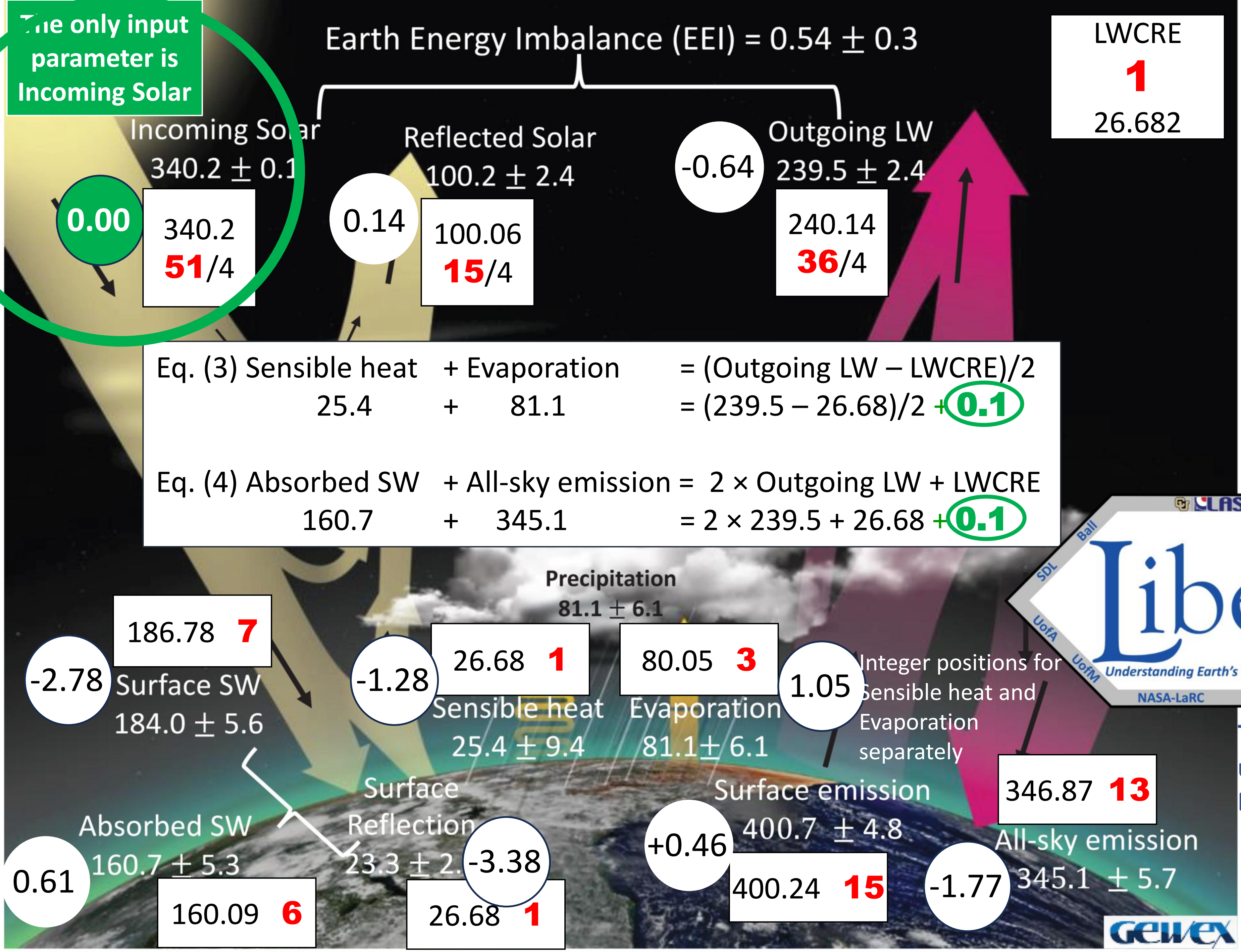
Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX



The only input parameter is Incoming Solar

Eq. (3) Sensible heat	+ Evaporation	= (Outgoing LW – LWCRE)/2
25.4	+ 81.1	= (239.5 – 26.68)/2 + **0.1**
Eq. (4) Absorbed SW	+ All-sky emission	= 2 × Outgoing LW + LWCRE
160.7	+ 345.1	= 2 × 239.5 + 26.68 + **0.1**

Integer positions for Sensible heat and Evaporation separately

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

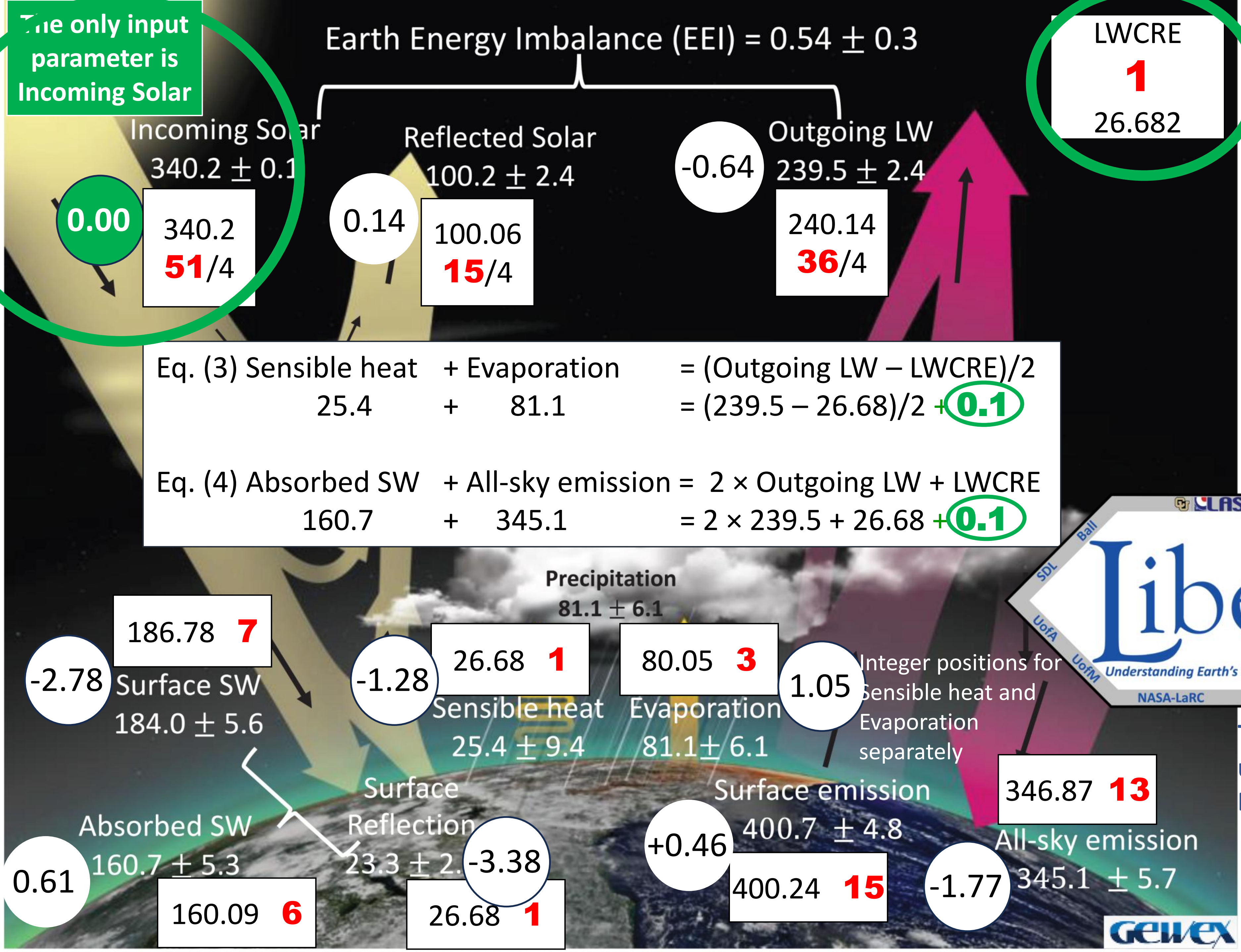
Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar



Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2

25.4 + 81.1 = (239.5 – 26.68)/2 + 0.1

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE

160.7 + 345.1 = 2 × 239.5 + 26.68 + 0.1

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

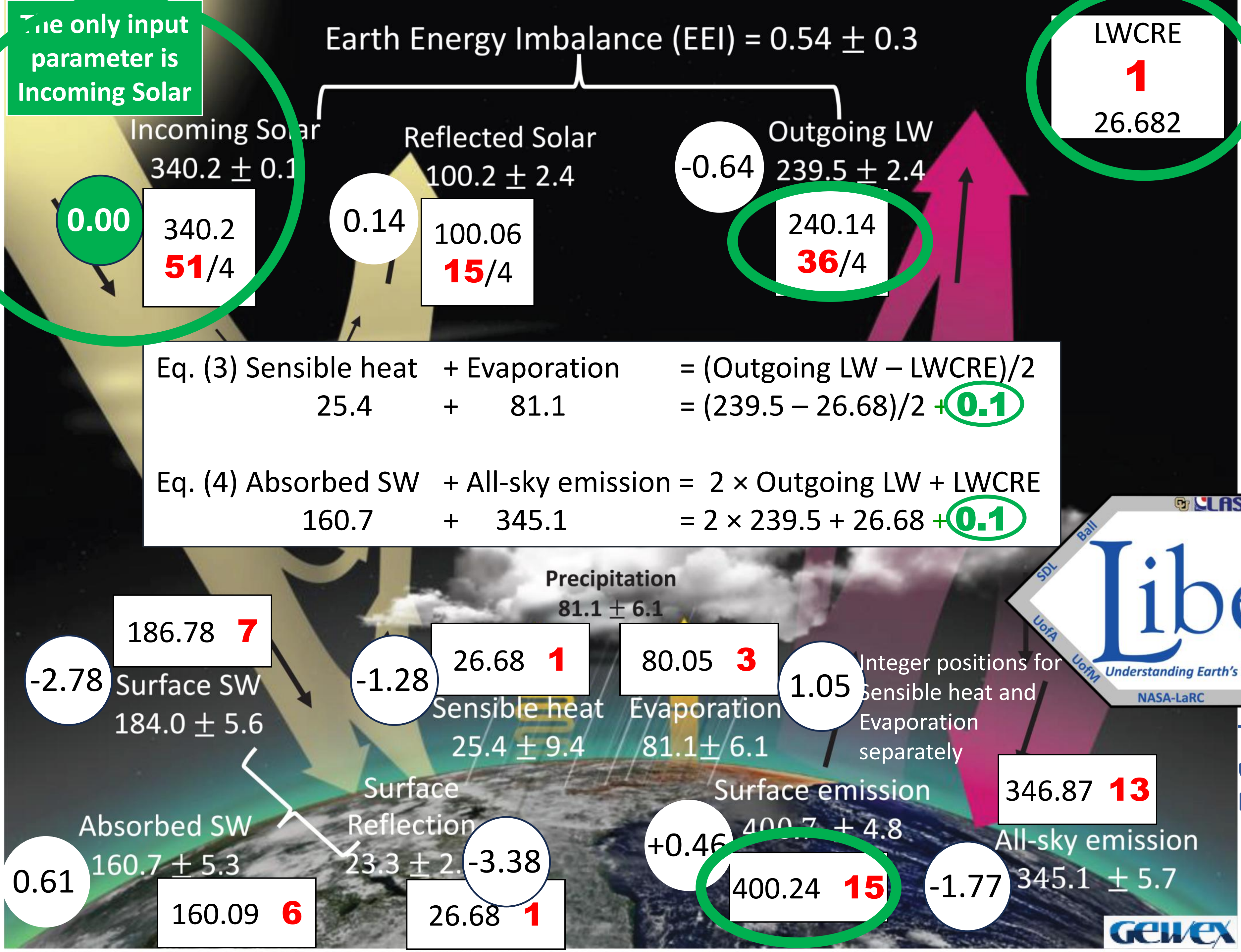
Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX



The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

Incoming Solar
340.2 ± 0.1

0.00

340.2
51/4

Reflected Solar
100.2 ± 2.4

0.14

100.06
15/4

-0.64

Outgoing LW
239.5 ± 2.4

240.14
36/4

LWCRE
1
26.682

Eq. (3) Sensible heat	+ Evaporation	= (Outgoing LW – LWCRE)/2
25.4	+ 81.1	= (239.5 – 26.68)/2 + **0.1**
Eq. (4) Absorbed SW	+ All-sky emission	= 2 × Outgoing LW + LWCRE
160.7	+ 345.1	= 2 × 239.5 + 26.68 + **0.1**

Precipitation
81.1 ± 6.1

-2.78

186.78 **7**

Surface SW
184.0 ± 5.6

-1.28

26.68 **1**

Sensible heat
25.4 ± 9.4

80.05 **3**

Evaporation
81.1 ± 6.1

1.05

Integer positions for Sensible heat and Evaporation separately

Surface emission
400.7 ± 4.8

+0.46

400.24 **15**

346.87 **13**

All-sky emission
345.1 ± 5.7

-1.77

Absorbed SW
160.7 ± 5.3

0.61

160.09 **6**

Surface Reflection
23.3 ± 2.

-3.38

26.68 **1**

GEWEX

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

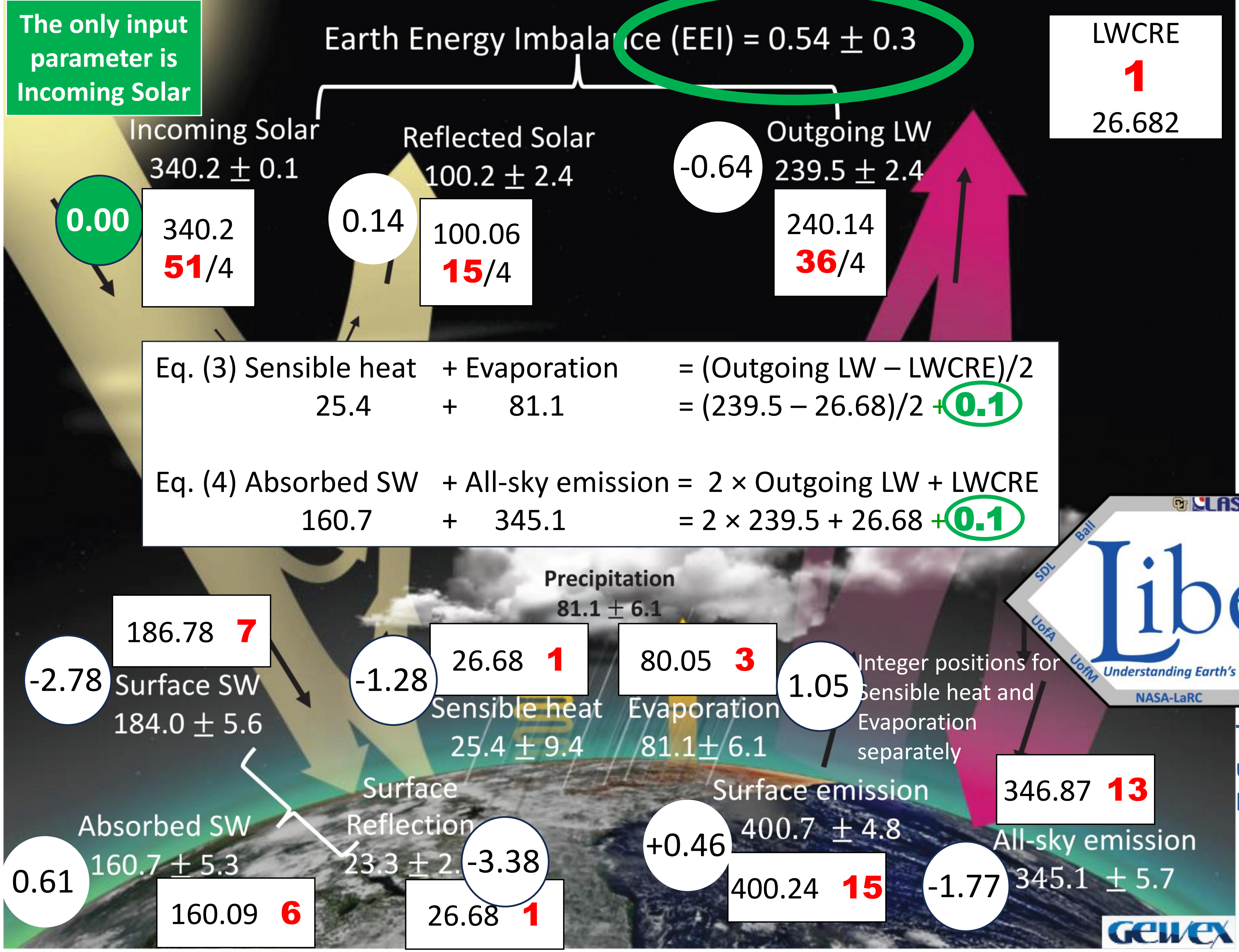
Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

LASP
Ball
NIST
SDL
NOAA
Libera
UofA
LBNL
UofM
Understanding Earth's Energy Budget
CSU
NASA-LaRC
JPL

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX



The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

LWCRE
1
26.682

Incoming Solar
340.2 ± 0.1

0.00

340.2
51/4

0.14

Reflected Solar
100.2 ± 2.4

100.06
15/4

-0.64

Outgoing LW
239.5 ± 2.4

240.14
36/4

Eq. (3) Sensible heat	+ Evaporation	= (Outgoing LW – LWCRE)/2
25.4	+ 81.1	= (239.5 – 26.68)/2 + **0.1**
Eq. (4) Absorbed SW	+ All-sky emission	= 2 × Outgoing LW + LWCRE
160.7	+ 345.1	= 2 × 239.5 + 26.68 + **0.1**

Precipitation
81.1 ± 6.1

186.78 **7**

-2.78

Surface SW
184.0 ± 5.6

-1.28

26.68 **1**

Sensible heat
25.4 ± 9.4

80.05 **3**

Evaporation
81.1 ± 6.1

1.05

Integer positions for Sensible heat and Evaporation separately

346.87 **13**

Surface emission
400.7 ± 4.8

+0.46

400.24 **15**

All-sky emission
345.1 ± 5.7

-1.77

Absorbed SW
160.7 ± 5.3

0.61

160.09 **6**

Surface Reflection
23.3 ± 2.

-3.38

26.68 **1**

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

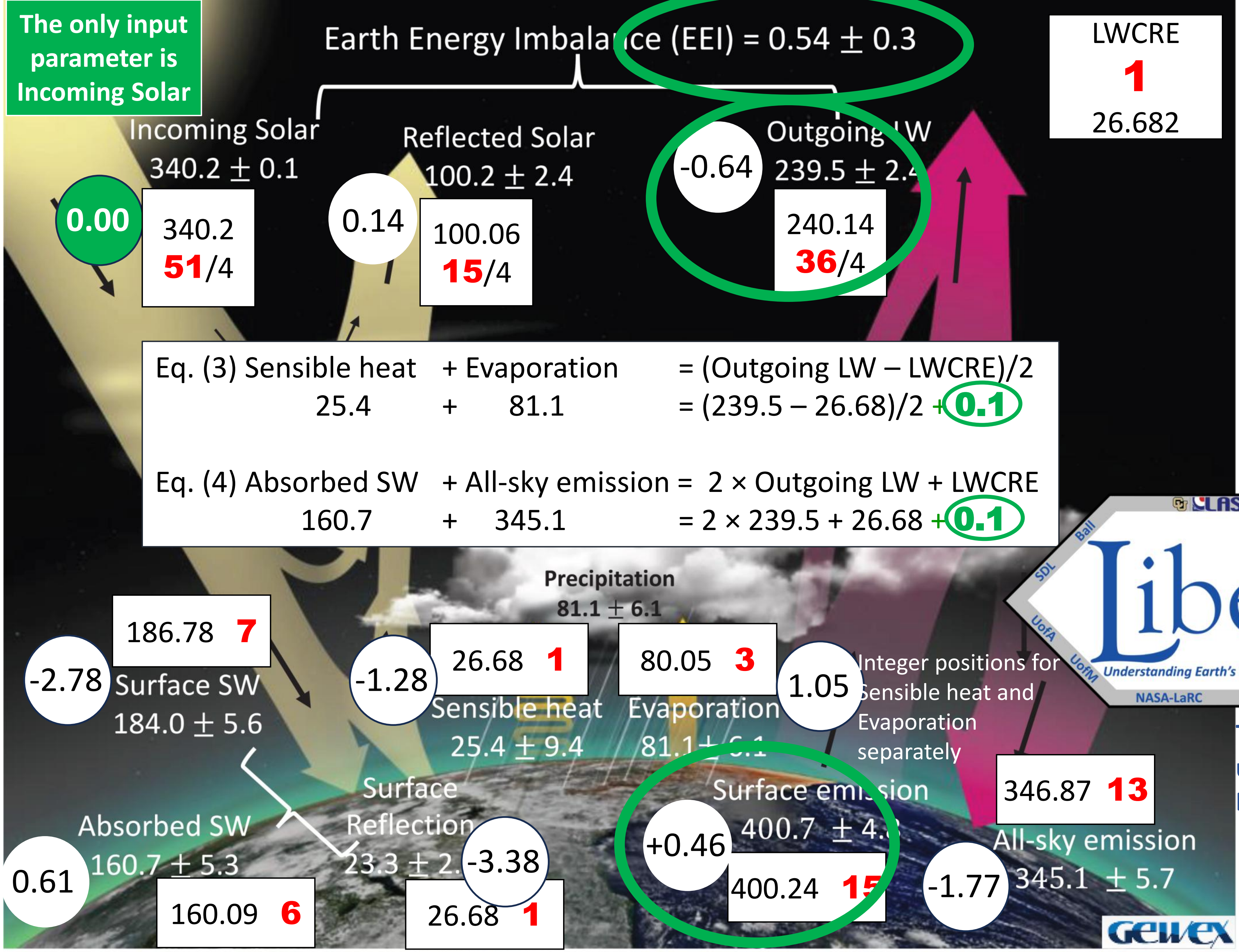
Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar



LWCRE
1
26.682

0.00 | 340.2 **51**/4

0.14 | 100.06 **15**/4

-0.64 | 240.14 **36**/4

Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + **0.1**

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + **0.1**

-2.78 | 186.78 **7**

-1.28 | 26.68 **1**

80.05 **3** | 1.05

Integer positions for Sensible heat and Evaporation separately

0.61 | 160.09 **6**

-3.38 | 26.68 **1**

+0.46 | 400.24 **15**

346.87 **13** | -1.77

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

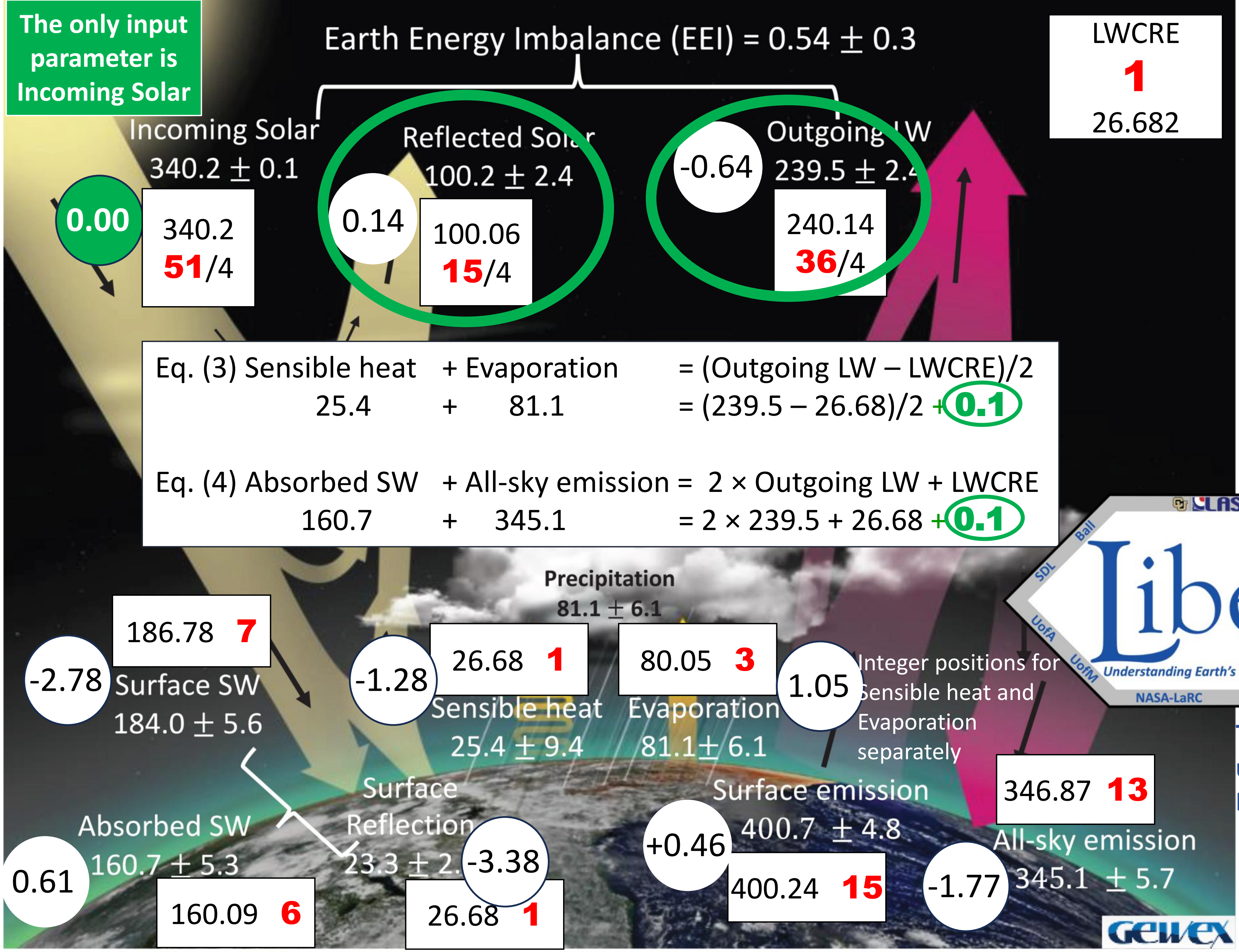
This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

LWCRE
1
26.682



Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + **0.1**

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + **0.1**

Integer positions for Sensible heat and Evaporation separately

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

LWCRE
1
26.682

N positions are exact

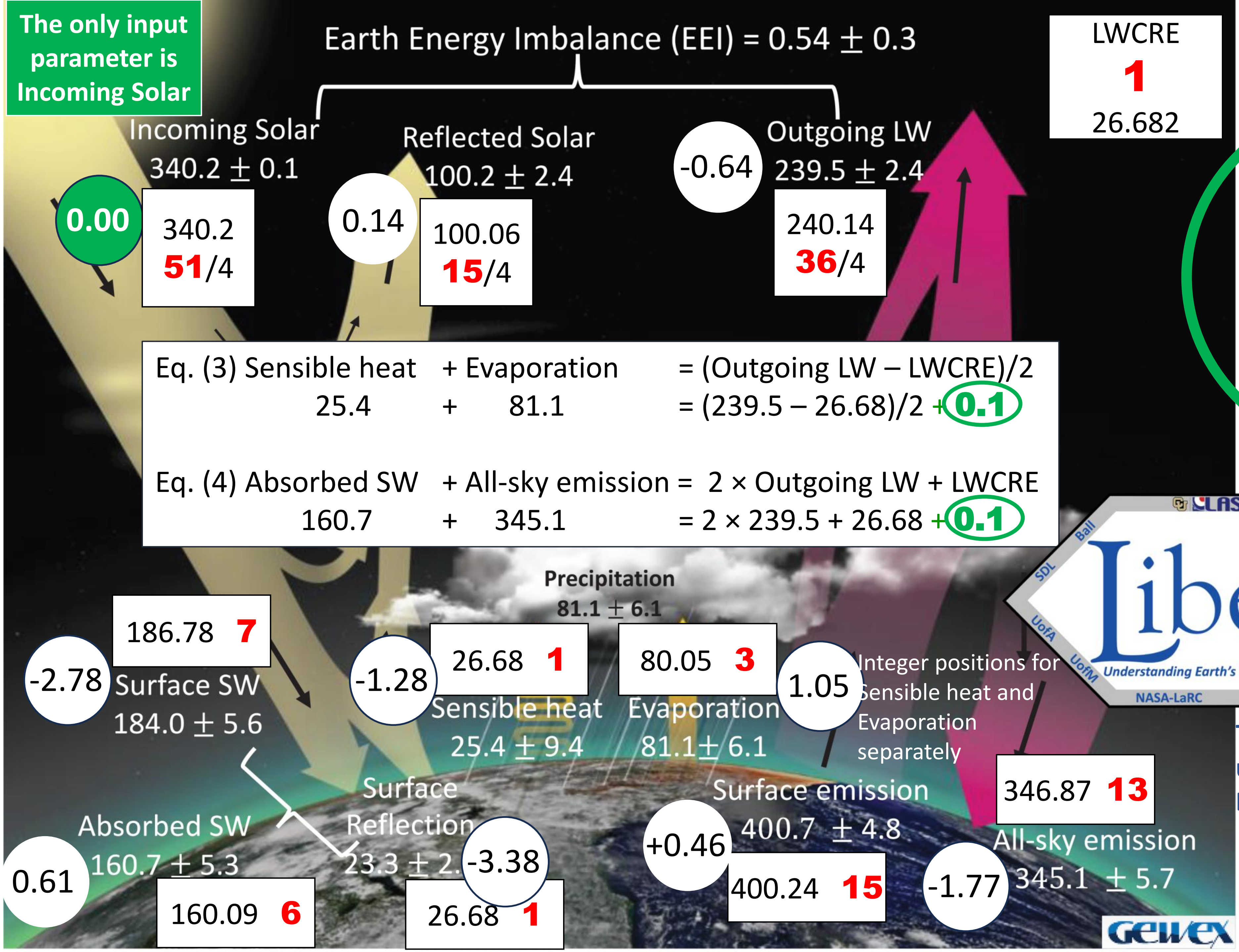
Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact



Incoming Solar
340.2 ± 0.1

0.00

340.2
51/4

Reflected Solar
100.2 ± 2.4

0.14

100.06
15/4

-0.64

Outgoing LW
239.5 ± 2.4

240.14
36/4

Eq. (3) Sensible heat	+ Evaporation	= (Outgoing LW – LWCRE)/2
25.4	+ 81.1	= (239.5 – 26.68)/2 + **0.1**
Eq. (4) Absorbed SW	+ All-sky emission =	2 × Outgoing LW + LWCRE
160.7	+ 345.1	= 2 × 239.5 + 26.68 + **0.1**

Precipitation
81.1 ± 6.1

186.78 **7**

-2.78

Surface SW
184.0 ± 5.6

-1.28

26.68 **1**

Sensible heat
25.4 ± 9.4

80.05 **3**

Evaporation
81.1 ± 6.1

1.05

Integer positions for Sensible heat and Evaporation separately

346.87 **13**

Surface Reflection
23.3 ± 2.

-3.38

26.68 **1**

Absorbed SW
160.7 ± 5.3

0.61

160.09 **6**

+0.46

Surface emission
400.7 ± 4.8

400.24 **15**

-1.77

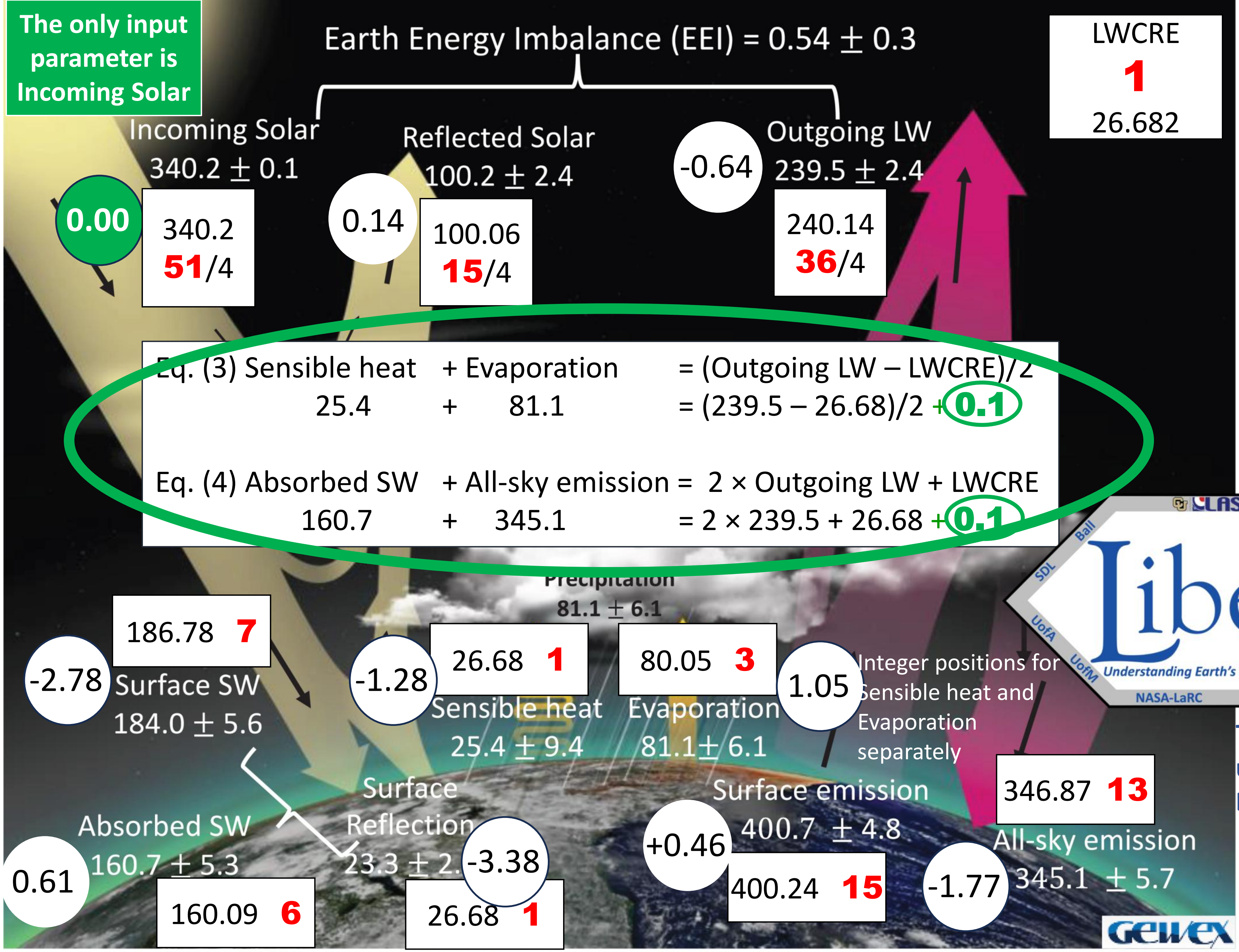
All-sky emission
345.1 ± 5.7

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3



Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + 0.1

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + 0.1

Integer positions for Sensible heat and Evaporation separately

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

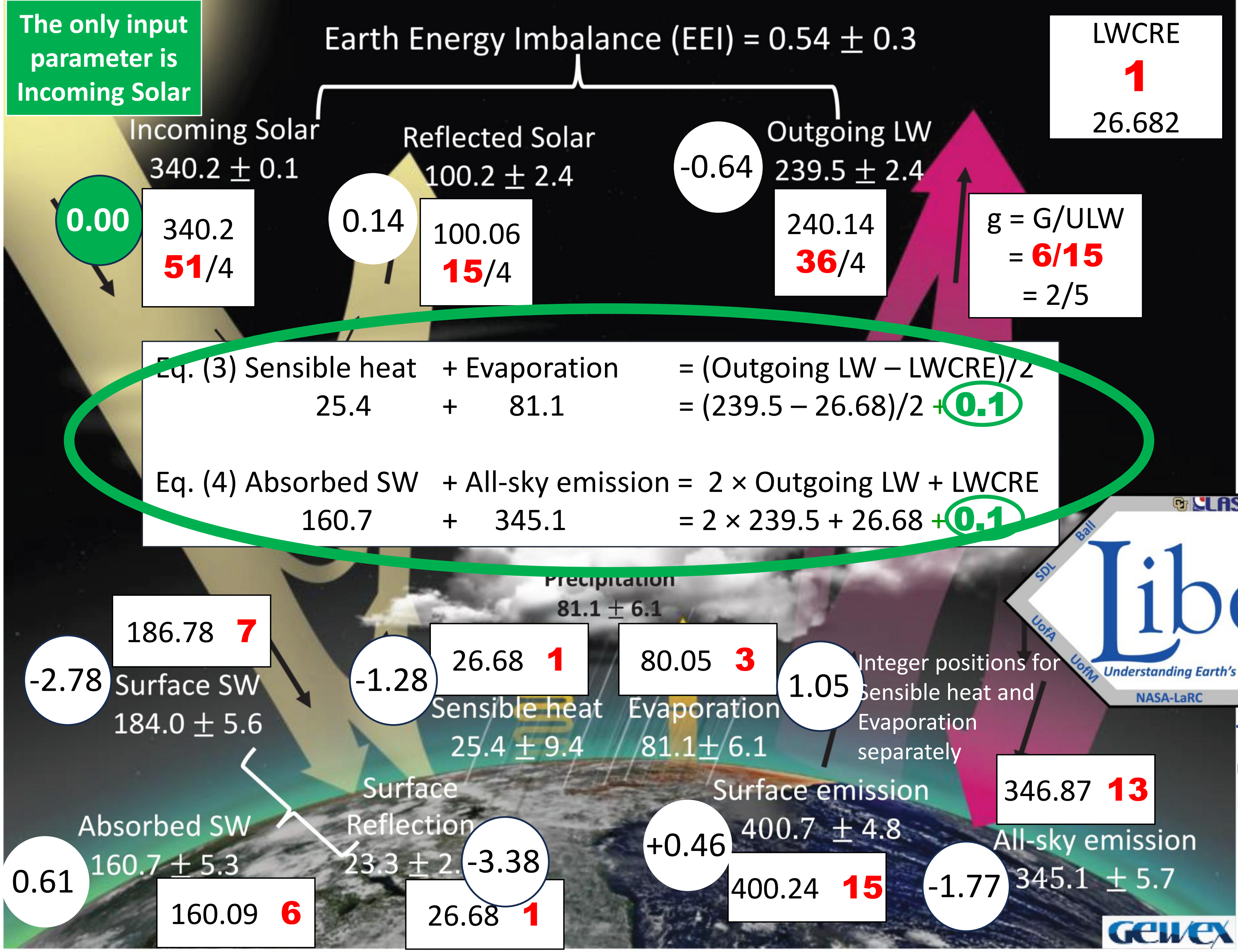
This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3

LWCRE
1
26.682



Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + **0.1**

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + **0.1**

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

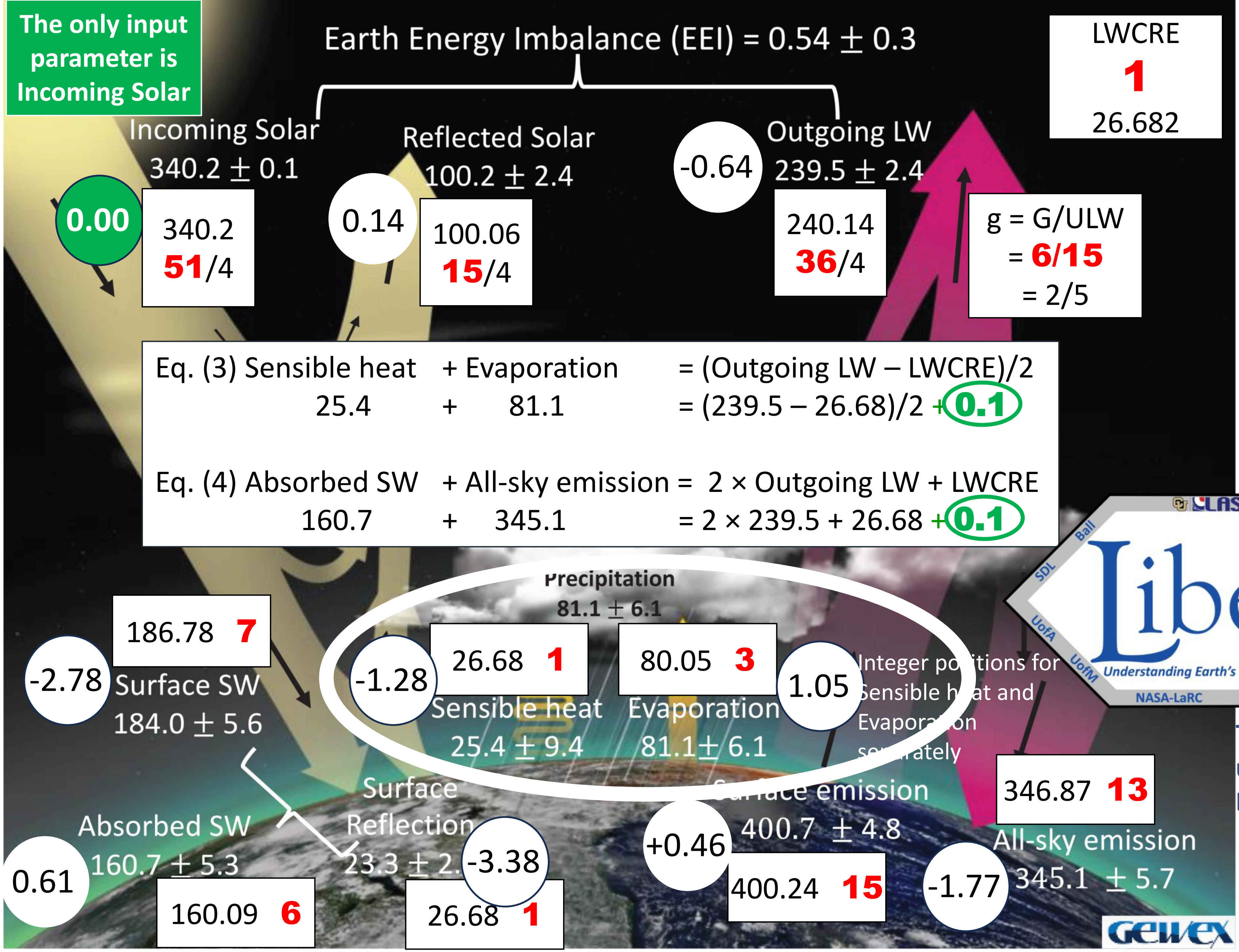
Equations are exact

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

The only input parameter is Incoming Solar

Earth Energy Imbalance (EEI) = 0.54 ± 0.3



Eq. (3) Sensible heat + Evaporation = (Outgoing LW – LWCRE)/2
25.4 + 81.1 = (239.5 – 26.68)/2 + 0.1

Eq. (4) Absorbed SW + All-sky emission = 2 × Outgoing LW + LWCRE
160.7 + 345.1 = 2 × 239.5 + 26.68 + 0.1

N positions are exact

Stephens et al. (2023, BAMS):

"the surface energy balance relation Rn = LE + H "

Stephens (1992):
Rn = OLR/2 (clear-sky)

Eq. (3):
Rn = (OLR – LWCRE) /2 (all-sky)

Equations are exact

Libera
Understanding Earth's Energy Budget

This is our recent understanding of Earth's Energy Budget

Stephens et al. (2023, BAMS)
30 Years of GEWEX

Summary: 30 Years of CERES
Wielicki et al. (1996) (BAMS)

CERES Data Products

Set 1

Stephens et al. (1994) =>

$$R_N = \sigma T_S{}^4 - \sigma T_0{}^4 = \text{CONV} = \frac{F_\infty}{2} \qquad \text{Eq. (1)}$$

Inamdar and Ramanathan (1994) =>

$$G_a = \sigma T(\tau^*)^4 - f_0 = \text{CONV} = \sigma T_g{}^4 - \sigma T(\tau^*)^4 = f_0/2 \qquad \text{Eq. (2)}$$

Eq. (1) & Eq. (2) => g_a (clear) = 1/3
All-sky extension g_a (all) = 2/5

Solar Extension: TSI = **51**
=> LWCRE = **1**

g_a(clear) = **5/15**, g_a(all) = **6/15**
α_p = **15/51** = 0.294

EEI = ΔASR – ΔOLR
ΔF = Set 2 – Set 1

Set 2

EBAF Edition 4.2.1 V3 (01/2001 — 12/2025)

Ramanathan and Inamdar (2006): $g_a = 1/3$

g_a (clear) = 0.3333
g_a (all) = 0.397
α_p = 0.291

ISR = 340.22 Wm^{-2}
w_g = 4.0034 => TSI = 1362.04 Wm^{-2}

1 = 26.684 Wm^{-2}

EEI = (241.38 – 240.15) – (240.48 – 240.15) = 0.90 Wm^{-2}

Deviation for each flux component = Observed – Equilibrium