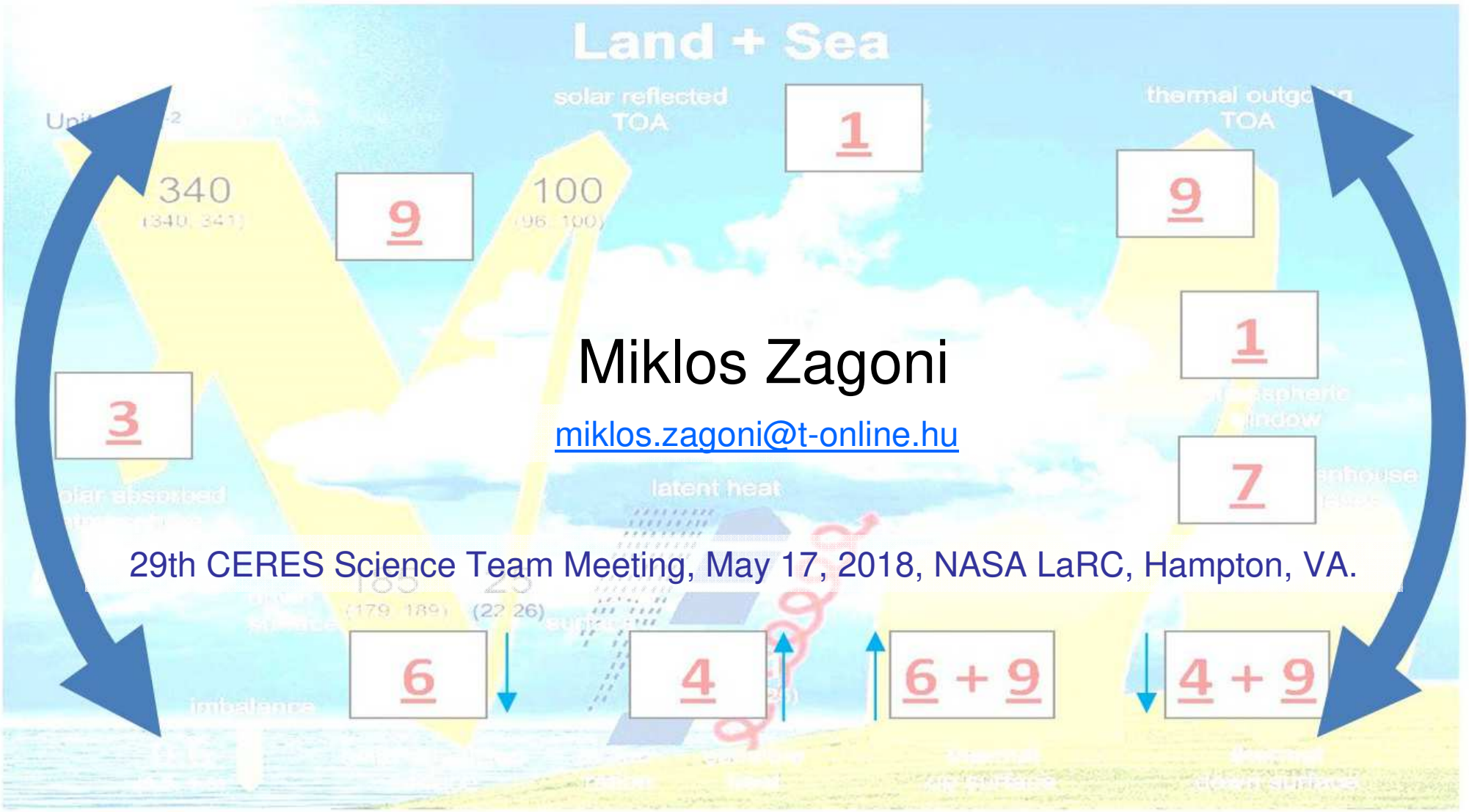
Patterns in the CERES Global Mean Data
Part 2: Physical basis



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"… establishing direct relationships between TOA radiative fluxes and surface fluxes and validating these parametrizations using actual surface radiative flux and TOA flux measurements" (Wielicki et al. 1996)

Reminder: Content of Part 1

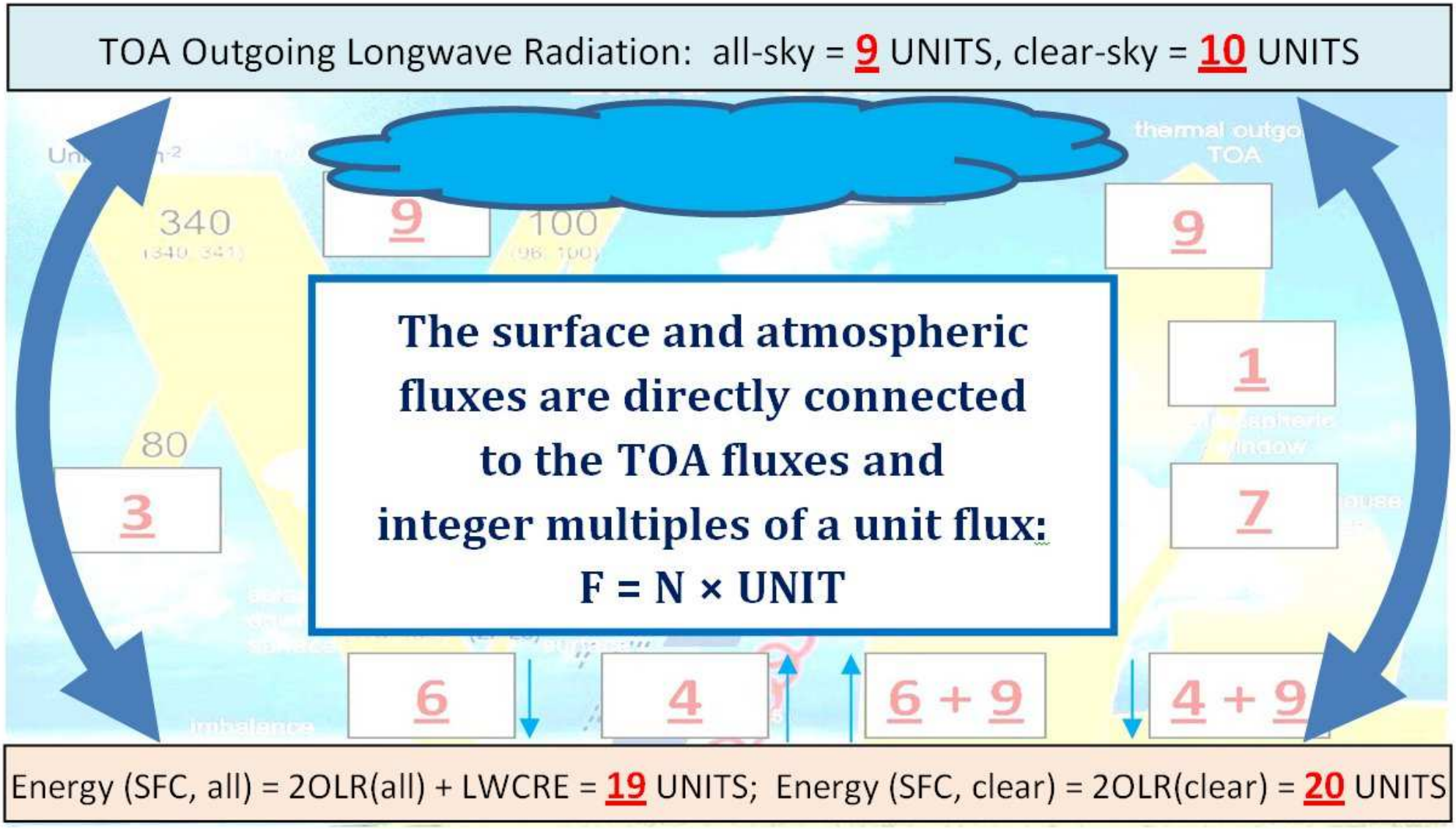
Patterns in the CERES Global Mean Data (2017 Fall STM):

- **Five ‘rules’** (clear-sky and all-sky TOA/SFC relationships and integer ratios in the EBAF Ed2.8 and Ed4.0 data)
- An effectively **‘IR-closed’ model** (SW-transparent, LW-opaque, non-turbulent glass shell geometry)
- A **model data set** (EdMZ, with internal fluxes as integer multiples of a unit flux, F = N × UNIT, both for all- and clear)
- **Deduction** of EdMZ from the ‘closed shell’ geometry
- **Proof** of the basic equalities and flux integer ratios in several published global mean energy budget estimates.

Global means for March2000-February2016

All-sky CERES	EBAF Ed 4.0	EBAF Ed 2.8	Edition MZ	UNITS N	Ed MZ – Ed 4.0	Ed MZ – Ed 2.8	Ed 4.0 – Ed 2.8
TOA LW	240.1	239.6	240.1	9	0.0	0.5	0.5
SFC SW net	163.7	162.3	160.1	6	-3.6	-2.2	1.4
SFC LW down	345.0	345.2	346.8	13	1.8	1.6	-0.2
SFC (SW+LW) in	508.7	507.5	506.9	19	-1.8	-0.6	1.2
SFC LW up	398.3	398.3	400.2	15	1.9	1.9	0.0
SFC (SW+LW) net	110.3	109.2	106.7	4	-3.6	-2.5	1.1
2OLR + LWCRE	511.1	508.1	506.9	19	-4.2	-1.2	3.0
G	158.2	158.7	160.1	6	1.9	1.4	-0.5
Clear-sky CERES							
TOA LW	268.1	265.4	266.8	10	-1.3	1.4	2.7
SFC SW net	213.9	214.3	213.4	8	-0.5	-0.9	-0.4
SFC LW down	314.1	316.3	320.2	12	6.1	3.9	-2.2
SFC (SW+LW) in	528.0	530.6	533.6	20	5.6	3.0	-2.6
SFC LW up	397.6	398.4	400.2	15	2.6	1.8	-0.8
SFC (SW+LW) net	130.4	132.2	133.4	5	3.0	1.2	-1.8
2OLR	536.2	530.8	533.6	20	-2.6	2.8	5.4
G	129.5	133.0	133.4	5	3.9	0.4	-3.5
LW CRE							
TOA	28.0	25.8	26.68	1	-1.3	0.9	2.2
SFC	30.9	28.9	26.68	1	-4.2	-2.2	2.0

To be explained:

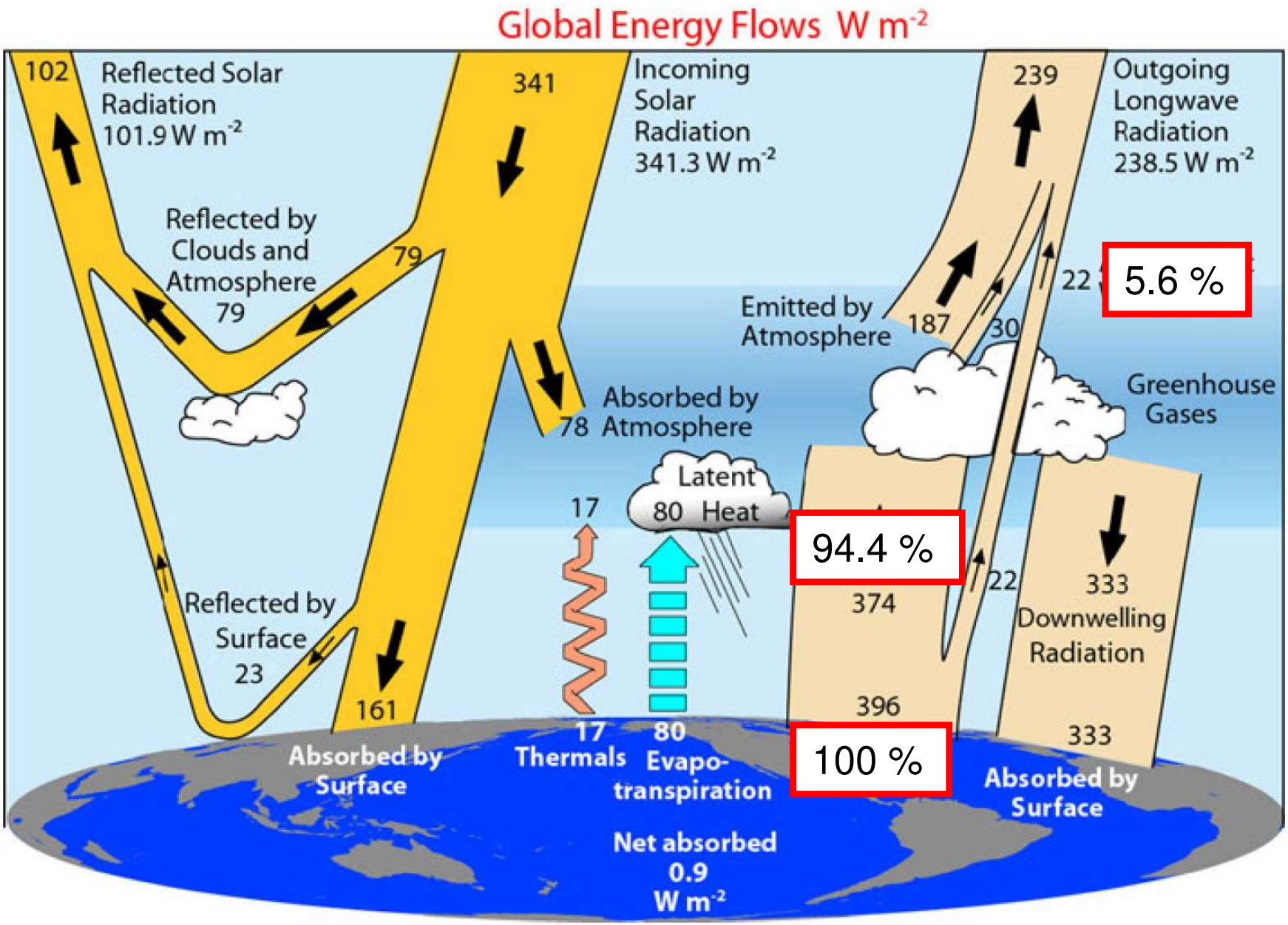


(i) Direct surface-TOA flux relationships, separately for all-sky and clear-sky

(ii) Small integer flux ratios (both for all-sky and clear-sky, interconnected)

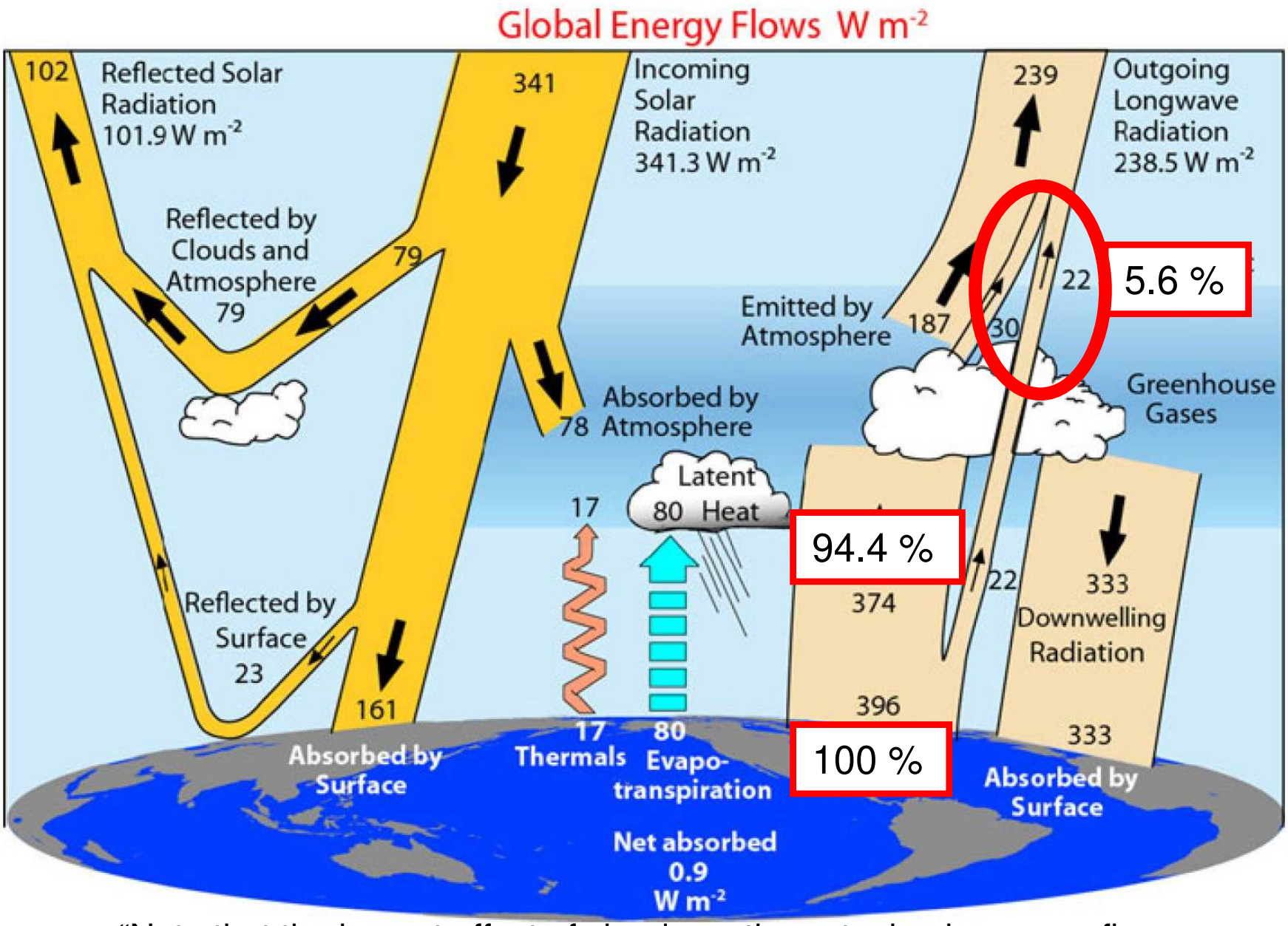
(iii) "Two/one" ratios in the SFC/TOA energy contents

Earth's atmosphere: almost IR-opaque (94%)



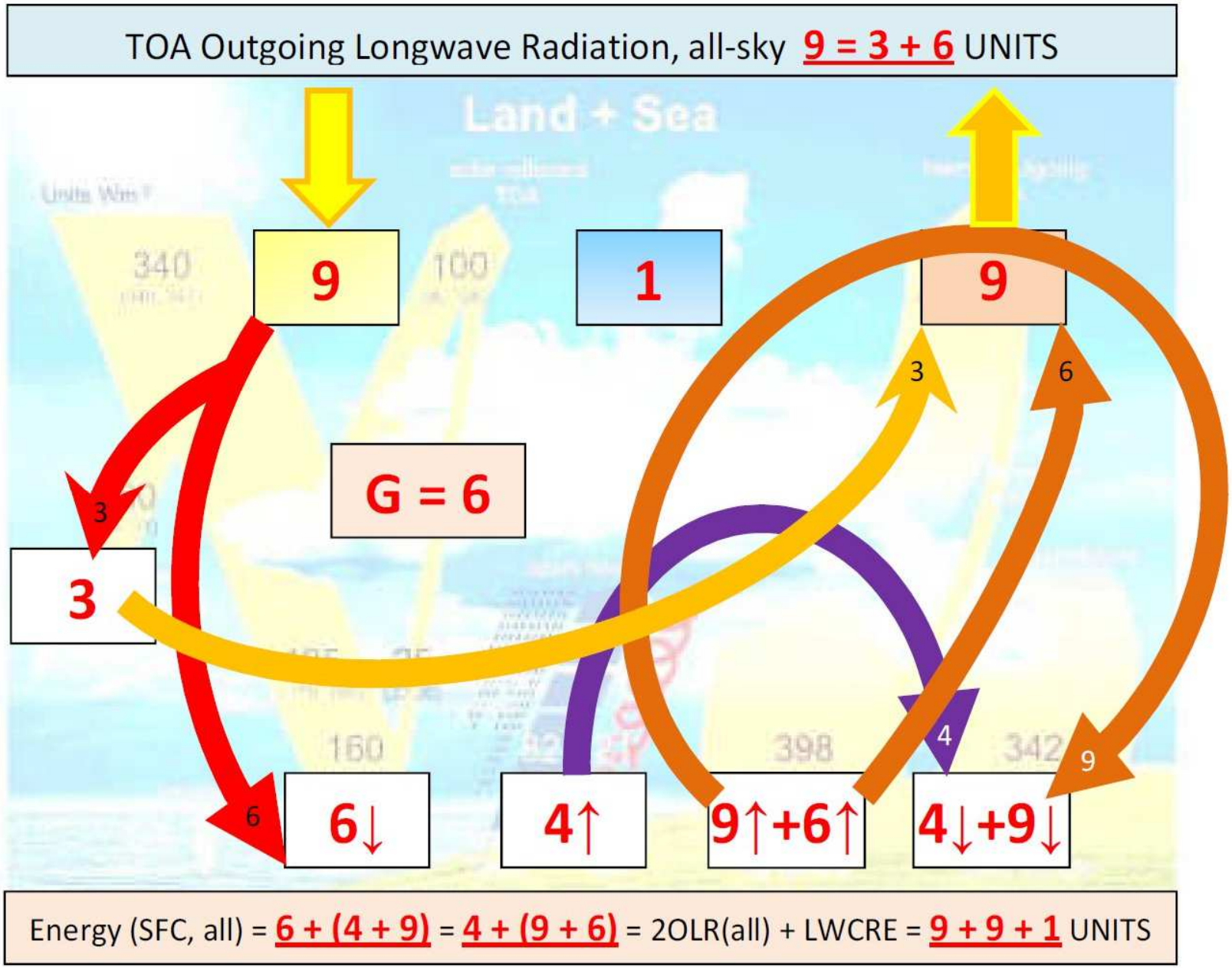
Trenberth-Fasullo (2012)

The opacity gap can be closed by the blanketing effect of clouds



"Note that the largest effect of clouds on the outgoing longwave flux is in the atmospheric window (8–12 mm)." (Kiehl-Trenberth 1997)

The resulted flux structure: closed shell geometry (max diff ~ 4 Wm^{-2})



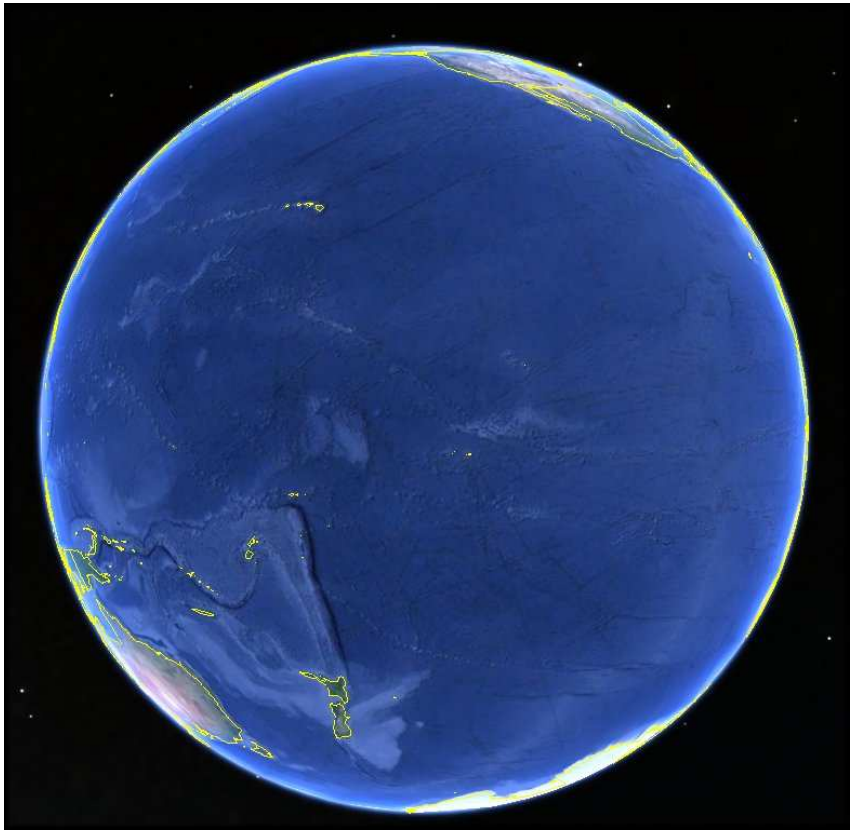
Closed shell? Why? Physical basis

Are there unrecognized constraints?

An inconclusive explanation in 25 points

Ocean Hemisphere

(Google Earth)



1. Earth is a quasi aqua-planet

Its blue surface …

2. … is **full of greenhouse gases** (H_2O and CO_2); there is **no material limit** to obey a **minimum / maximum principle**;
3. The **principle of least action** (energy minimum) requires the **highest possible rate of cooling** of a warm surface in a cold environment.
4. The highest possible surface cooling rate **maximizes** evaporation and convection from the surface: **LH + SH = max**.

The maximized LH + SH …

5. produces **maximized supply** of greenhouse gas (H_2O) into the atmosphere;
6. This tends to **maximize** the greenhouse effect
7. But at the same time, by maximized surface cooling, to **minimize** the greenhouse effect.
8. **LH** fuels both the **increase and decrease of G**.
9. These **contradicting** requirements must have reached an equilibrium billion years ago.
   There is nothing arbitrary here;
   God doesn’t play dice with our climate.

Equilibrium dynamics

10. Within their **common limit** of zero and OLR,
11. $0 \leq (LH + SH) \leq OLR$; $0 \leq G \leq OLR$
    their **common equilibrium state** might be at:
12. LH + SH = SFC Net = G = ULW – OLR = **OLR/2**.
13. **EBAF Ed4**: SFC SW + LW net = 130.4 W/m^2
14. **EBAF Ed4**: G = ULW – OLR = 129.5 W/m^2
15. My proposed theoretical equilibrium is at
    SFC Net = G = OLR/2 = 133 W/m^2;

Ed4.0, clear-sky, G = SFC Net

G =SFC Net - Diff	ULW clear	OLR clear	G clear	SFC Net	Diff
CLIM 1	388.08	265.08	123	139.01	16.01
CLIM 2	389.63	265.27	124.36	137.49	13.13
CLIM 3	393.06	266.02	127.04	132.44	5.4
CLIM 4	397.64	267.04	130.6	126.25	-4.35
CLIM 5	402.18	268.99	133.19	121.41	-11.78
CLIM 6	405.9	271	134.9	122.11	-12.79
CLIM 7	407.29	272	135.29	124.59	-10.7
CLIM 8	406.4	271.71	134.69	127.49	-7.2
CLIM 9	402.83	270.36	132.47	129.98	-2.49
CLIM 10	397.57	268.14	129.43	132.33	2.9
CLIM 11	392	265.95	126.05	134.61	8.56
CLIM 12	388.69	264.91	123.78	137.19	13.41
Average	**397.606**	**268.039**	**129.57**	**130.41**	**0.84**

G = ULW – OLR = 397.6 – 268.1 = **129.5** W m^{-2}

SFC Net = SW in + LW in – ULW = 213.9 + 314.1 – 397.6 = **130.4** W m^{-2}

Go ahead for the **clear-sky window**:

16. The highest SFC **turbulent** cooling leads to the wettest atmosphere = the **narrowest** WIN
17. The highest SFC **radiative** cooling (directly to space) wants the **widest** window.
18. Again, these two **contradicting** requirements (G and WIN go **against** each other) must have reached a dynamic equilibrium at:
19. $0 \leq G \leq OLR \Rightarrow$ **$G = OLR/2$**
20. $0 \leq WIN \leq G \Rightarrow$ **$WIN = G/2 = OLR/4$**.

Costa and Shine (2012) LBL RT

- ULW = 386 Wm^{-2}
- OLR = 259 Wm^{-2}
- ATM = 194 Wm^{-2}
- G = 127 Wm^{-2}
- WIN = 65 Wm^{-2}

Clear-sky:

2 OLR = E(SFC)
2 G = OLR
2 WIN = G
2 ATM = ULW

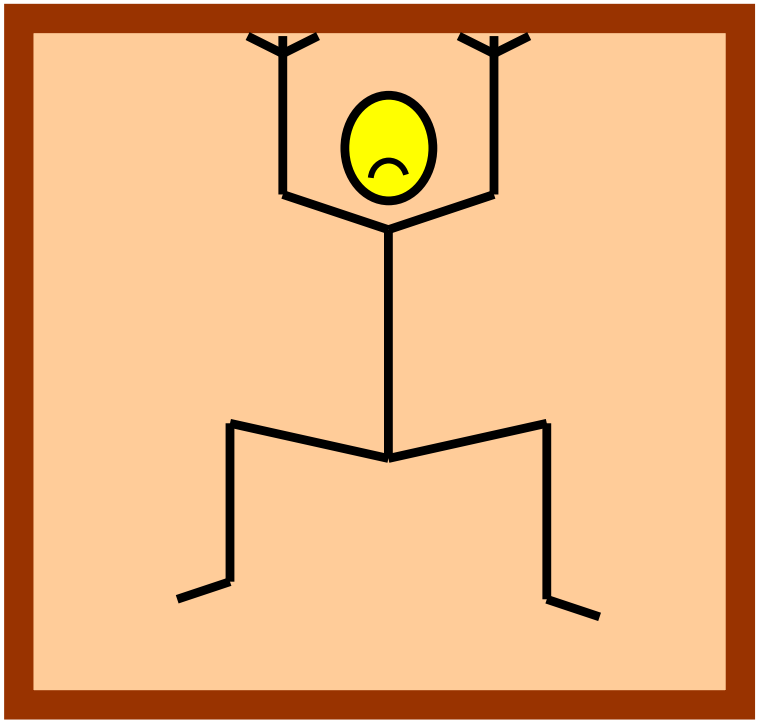
		WIN	G	ATM	OLR	ULW	2OLR
CS12	=	65	127	194	259	386	518
Pattern	=	65 /	130 /	195 /	260 /	390 /	520
Integer ratios:		**1 /**	**2 /**	**3 /**	**4 /**	**6 /**	**8**
Diff (Wm^{-2})	=	0	3	1	1	4	2

All-sky: the energetic role of clouds

21. The system has an extra free variable here: cloud area fraction.
22. **To maximize heat-trapping,** the **blanketing effect of clouds** should **close the open atmospheric window**.
23. LH, G, WIN and LWCRE play the **same contradiction / equilibrium dynamics as earlier**, with the resulting idealized LH = G/2 and WIN = LWCRE constraints.
24. From a surface perspective, **what is lost in the all-sky window is gained back by the greenhouse effect of clouds**, so the surface sees an **effectively IR-opaque** ceiling above itself.
25. The resulting radiation is then awaited to be a **wave propagation in a cavity**, with LWCRE-modulated wave packets (**integer multiple wave numbers):** **F = N × UNIT**.

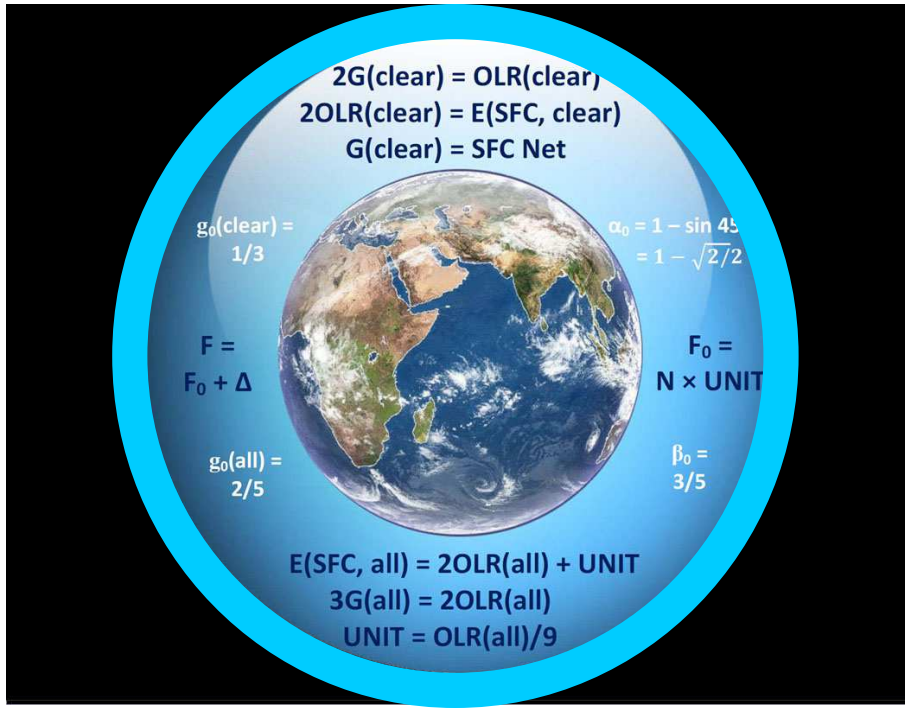
Climatic inertial system

You cannot lift an elevator from the inside



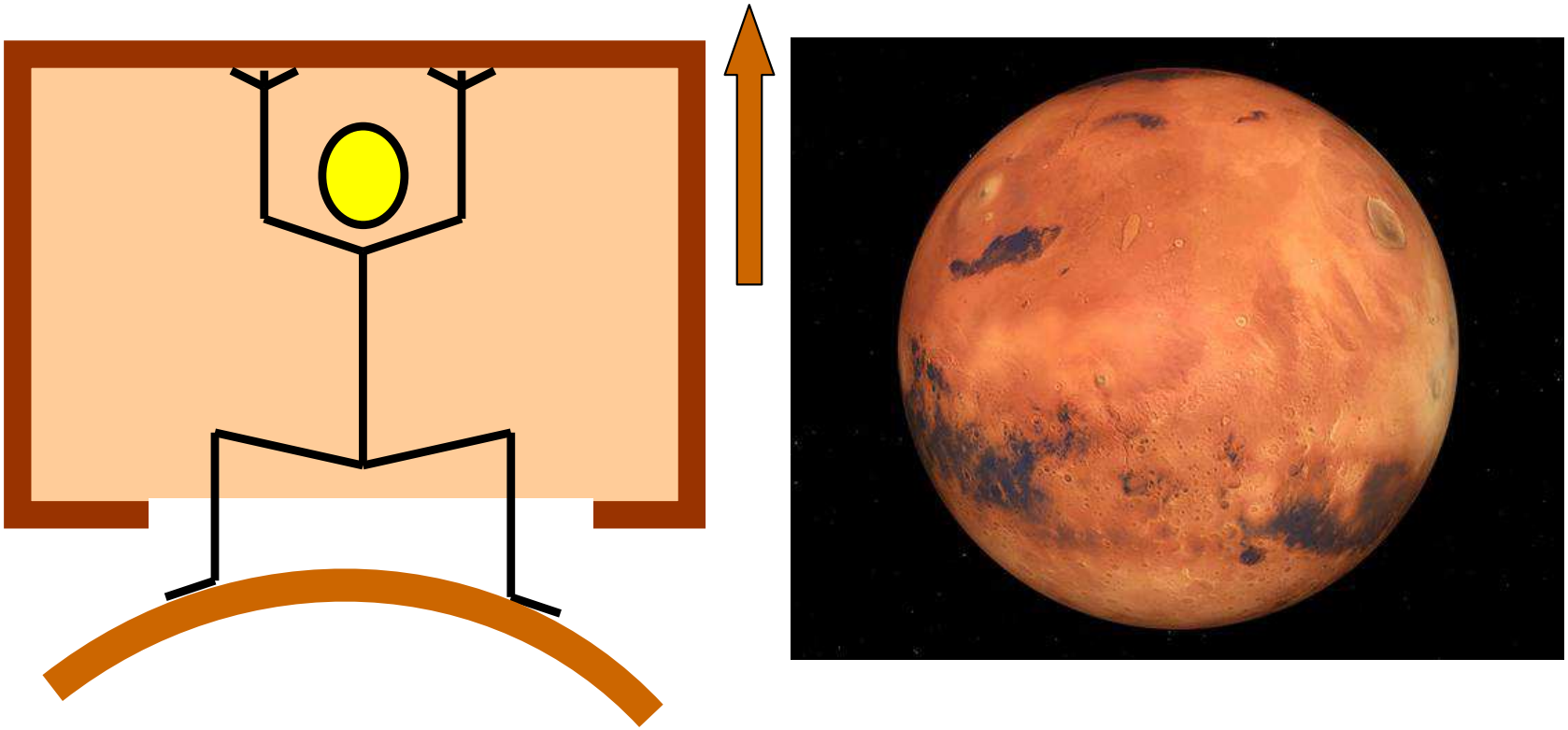
Mechanical inertial system

You cannot lift Earth's energetic state from the inside

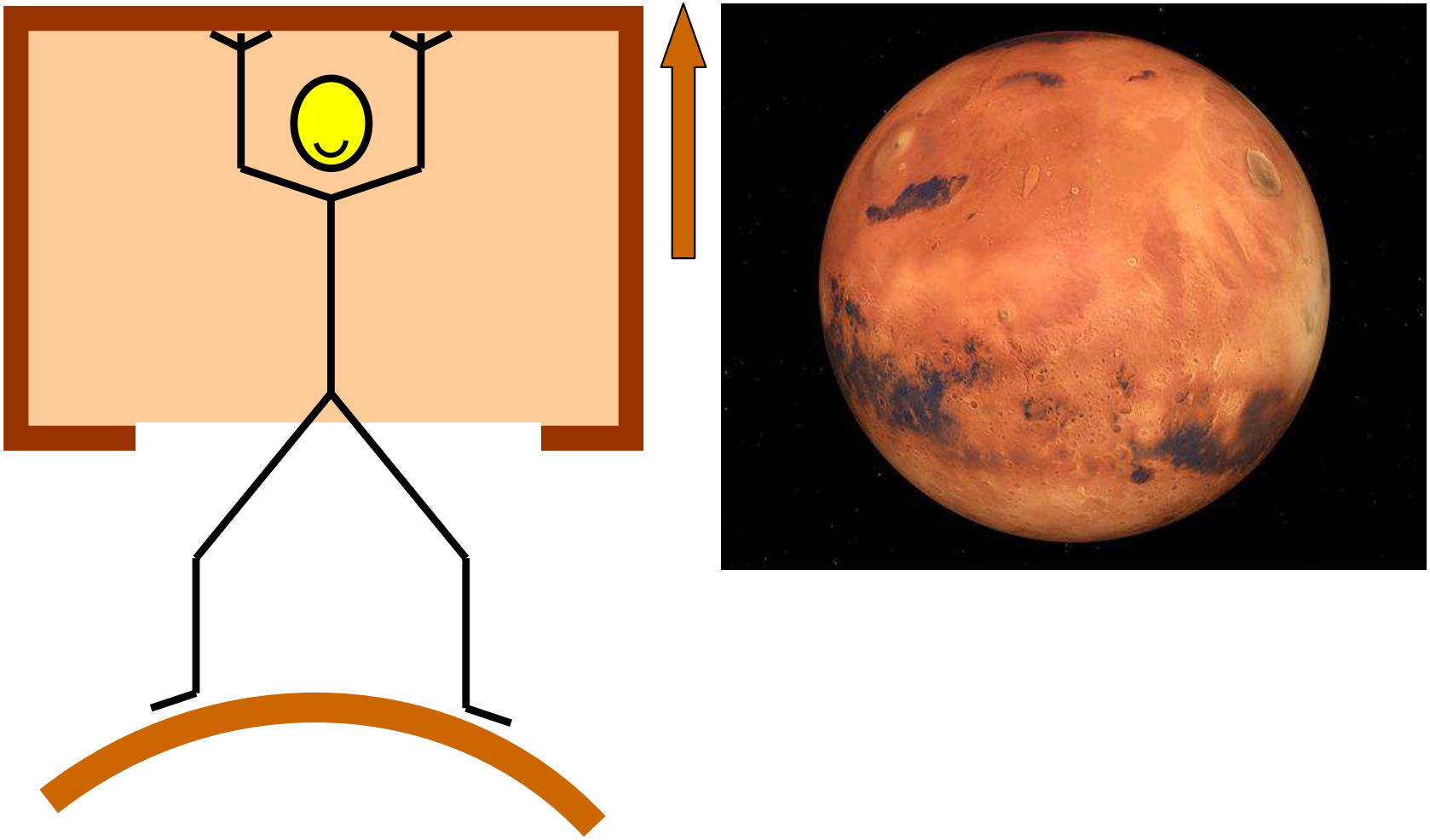


Climatic inertial system

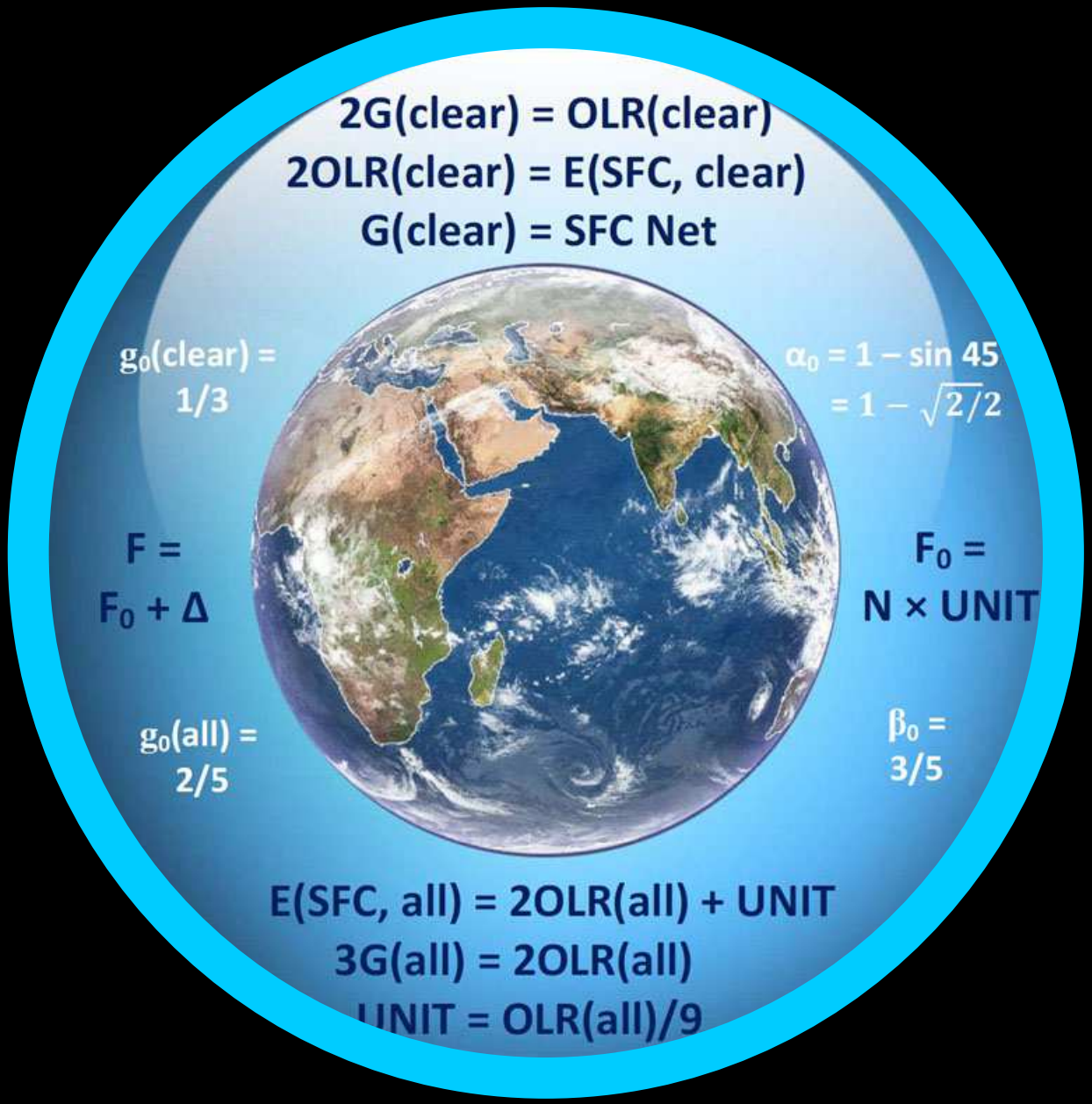
Mars is not a “closed system”



The Martian atmosphere is very IR-leaky



Earth's atmosphere is effectively IR-closed



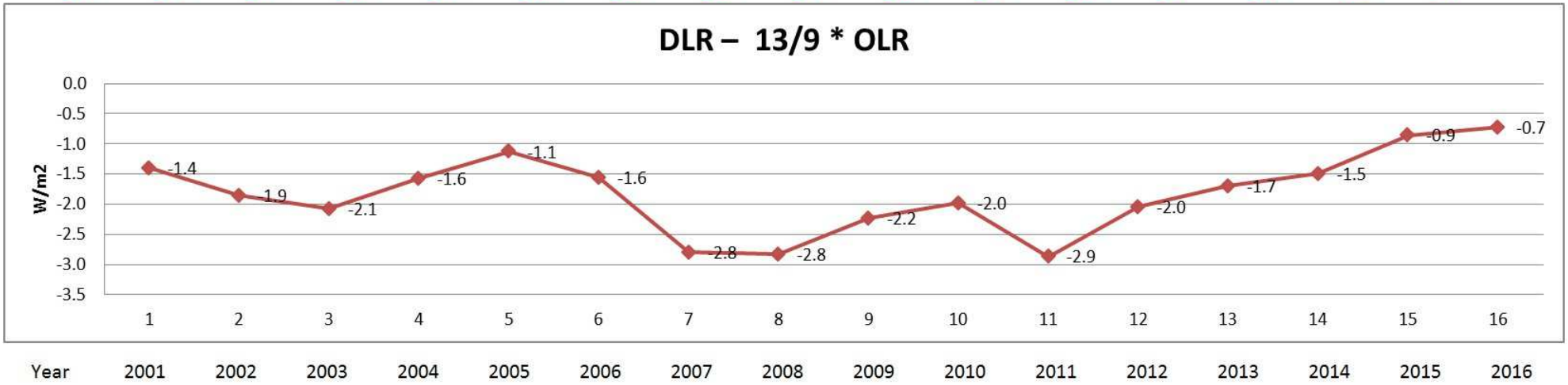
The proof of the pudding is in the eating

Time series CERES EBAF Ed4.0 OLR and DLR for 2001-2016

Year	OLR(all-sky)	DLR(all-sky)	13*OLR(all-sky)/9	Diff
2001	239.81	344.98	346.39	1.41
2002	240.32	345.28	347.13	1.85
2003	240.46	345.26	347.34	2.08
2004	240.05	345.18	346.75	1.57
2005	240.31	345.98	347.11	1.13
2006	240.01	345.13	346.69	1.56
2007	240.46	344.54	347.34	2.80
2008	239.73	343.44	346.28	2.84
2009	239.93	344.34	346.57	2.23
2010	240.38	345.23	347.21	1.98
2011	240.03	343.84	346.70	2.86
2012	239.83	344.38	346.42	2.04
2013	240.15	345.18	346.88	1.70
2014	240.22	345.49	346.99	1.50
2015	240.48	346.50	347.35	0.85
2016	240.67	346.92	347.64	0.72

DLR fluctuates around, or slightly below, its annual pattern position of 13 × OLR/9

346.4	347.1	347.3	346.7	347.1	346.7	347.3	346.3	346.6	347.2	346.7	346.4	346.9	347.0	347.4	347.6
-1.4	-1.9	-2.1	-1.6	-1.1	-1.6	-2.8	-2.8	-2.2	-2.0	-2.9	-2.0	-1.7	-1.5	-0.9	-0.7



Ed4.0 OLR(all-sky) = 240.14 W/m² => (× 13/9) =>
EdMZ DLR(all-sky) = 346.87 W/m².

30 Wm^{-2} increase in DLR would falsify EdMZ,

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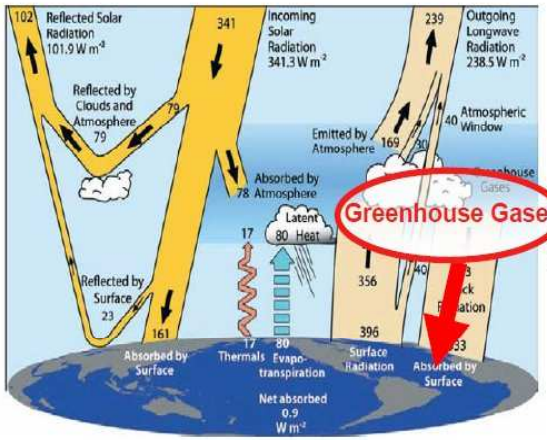
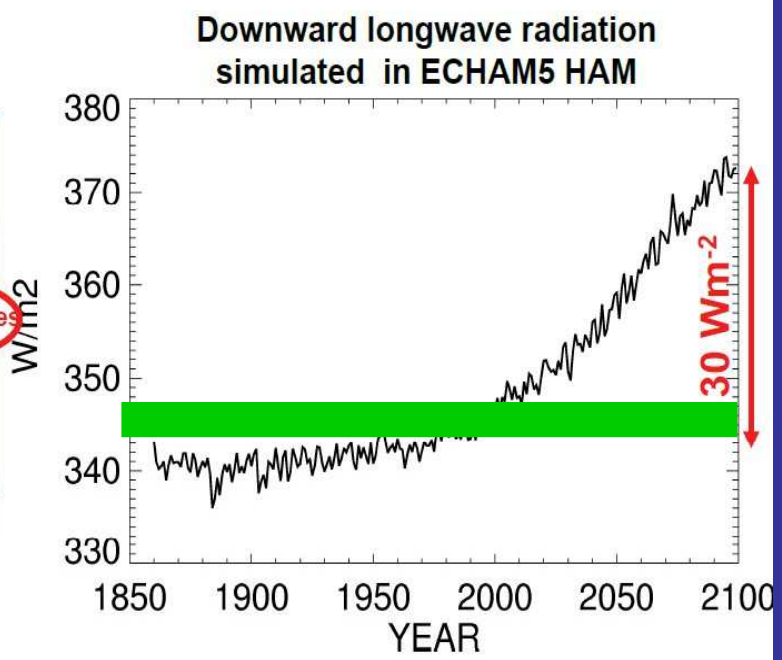
Changes in downward longwave radiation





- most directly affected by changes in atmospheric greenhouse gases
- expected to undergo largest change of all radiative fluxes: 30 Wm^{-2} over 21th century
- **Expected to go with OLR.**

Model-projected increase:

3 Wm^{-2}/decade

EdMZ DLR = OLR × (13/9)

EdMZ DLR would falsify models.