# $F = F_0 + \Delta F$ Global energy budget, flux integer tables and the greenhouse effect of clouds $F_0 = N \times UNIT$

**GREENHOUSE METRICS UNITS**

| | | | | | |
|---|---|---|---|---|---|
| G(all) – G(clear) | = OLR(clear) – OLR(all) | = LWCRE | ≡ 1 UNIT = 26.68 $Wm^{-2}$ | ⇨ ULW = 15 | OLR(clear) = 10 G(clear) = 5 |
| G(cloudy) – G(clear) | = OLR(clear) – OLR(cloudy) | = LWCRE / $\beta_0$ | ≡ 1 UNIT = 44.47 $Wm^{-2}$ | ⇨ ULW = 9 | OLR(clear) = 6 G(clear) = 3 |
| 1 / $f_0$(all) = 1 ; | 1 / $f_0$(clear) = 1 | = STI(clear) | ≡ 1 UNIT = 66.70 $Wm^{-2}$ | ⇨ ULW = 6 | OLR(clear) = 4 G(clear) = 2 |

## $F_0$ RELATIONSHIPS

- E(SFC, all) = 2OLR(all) + LWCRE = OLR(all) + OLR(clear)

  E(SFC, cloudy) = OLR(cloudy) + OLR(clear)

  E(SFC, clear) = 2OLR(clear)

- Solar absorbed by surface serves the energy content of the all-sky greenhouse effect.

- The cloud-covered part of the surface radiates as much energy as in the outgoing longwave radiation: ULW × $\beta_{eff}$ = OLR(all)

- 'Cooling to space':

  All-sky: LWQ + CTS(atm) = 0, LWQ + CTS(all) = LWCRE.

  Cloudy sky: $\beta_{eff}$ × [LWQ + CTS(atm, cloudy)] = –LWCRE /5

  Clear-sky: (1 – $\beta_{eff}$) × [LWQ + CTS(clear)] = LWCRE / 5

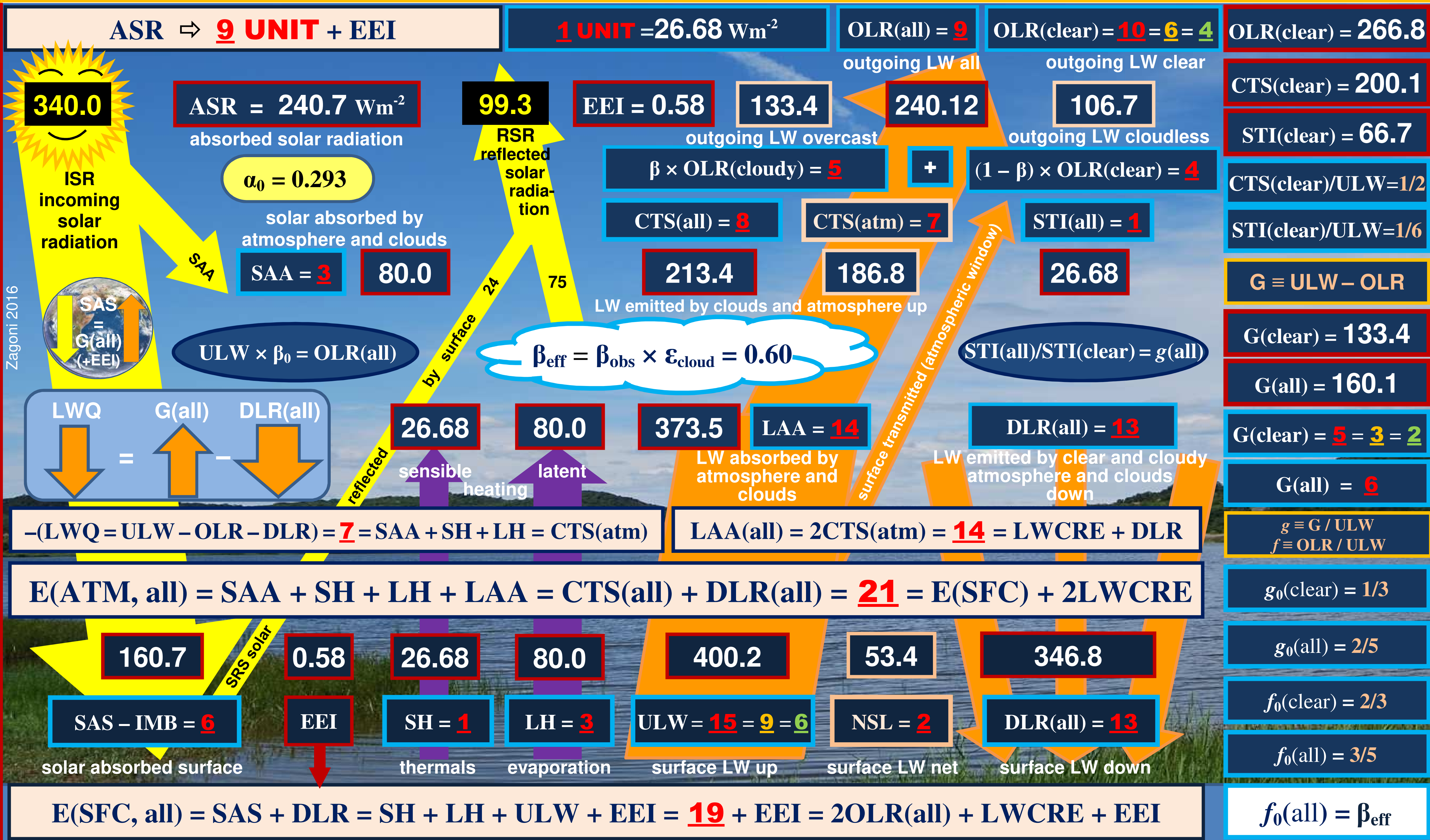
- The effective LW-opaque single-layer cloud area fraction is equal to the all-sky transfer function, $\beta_{eff} = f_0$(all), and $f_0$(all) × $f_0$(clear) = $g_0$(all).

- From a surface perspective, the energy being lost in the all-sky atmospheric window is gained back by the greenhouse effct of clouds: LWCRE = STI(all) = (1 – $\beta_{eff}$) × STI(clear).

- A 'grid' albedo position = $\alpha_0 = 1 - \sin 45° = 1 - \sqrt{2}/2$

- F observed data ⇨

- Their sources ⇨




## Integer tables of Earth's energy flows. $F_0$ values in unit flux:

**ALL-SKY = 26.68 $Wm^{-2}$**

| | | |
|---|---|---|
| STI(all) | = 1 | = 26.68 |
| LWCRE | = 1 | = 26.68 |
| SH | = 1 | = 26.68 |
| NSL(all) | = 2 | = 53.4 |
| LH | = 3 | = 80.0 |
| SAA(all) | = 3 | = 80.0 |
| G(clear) | = 5 | = 133.4 |
| G(all) | = 6 | = 160.1 |
| SAS(all) | = 6 | = 160.1 |
| –LWQ | = 7 | = 186.8 |
| CTS(atm) | = 7 | = 186.8 |
| CTS(all) | = 8 | = 213.4 |
| OLR(all) | = 9 | = 240.1 |
| OLR(clear) | = 10 | = 266.8 |
| DLR(clear) | = 12 | = 320.2 |
| DLR(all) | = 13 | = 346.8 |
| LAA(all) | = 14 | = 373.5 |
| ULW | = 15 | = 400.2 |

**CLOUDY = 44.47 $Wm^{-2}$**

| | | |
|---|---|---|
| STI(cloudy) | = 0 | |
| LWCRE / $\beta_{eff}$ | = 1 | = 44.47 |
| (SH+LH)(cloudy) | = 2 | = 88.94 |
| G(clear) | = 3 | = 133.4 |
| G(cloudy) | = 4 | = 177.9 |
| CTS(atm, cloudy) | = 4 | = 177.9 |
| CTS(all, cloudy) | = 5 | = 222.3 |
| OLR(cloudy) | = 5 | = 222.3 |
| OLR(clear) | = 6 | = 266.8 |
| LAA(cloudy) | = 9 | = 400.2 |
| ULW | = 9 | = 400.2 |

**CLEAR-SKY = 66.7 $Wm^{-2}$**

| | | |
|---|---|---|
| STI(clear) | = 1 | = 66.7 |
| (SH + LH)(clear) | = 2 | = 133.4 |
| G(clear) | = 2 | = 133.4 |
| CTS(clear) | = 3 | = 200.1 |
| OLR(clear) | = 4 | = 266.8 |
| LAA(clear) | = 5 | = 333.5 |
| ULW | = 6 | = 400.2 |

$\Delta F < \pm 1\sigma$

**CLEAR-SKY WEIGHTED CONTRIBUTION**

$f$(clear) = OLR(clear) / ULW = 2/3 ⇨ STI(clear) = 1; G(clear) = 2; CTS(clear) = 3; OLR(clear) = 4; LAA(clear) = 5; ULW = 6

(1–β) × G(clear) = 2; (1–β) × CTS(clear) = 3; (1–β)×OLR(clear) = 4; (1–β) × LAA(clear)=G(clear) = 5 ; (1 – β) × ULW = G(all) = 6

LWQ + CTS(clear) = LWCRE / 2 = + 13.3 $Wm^{-2}$; (1–β) × [LWQ + CTS(clear)] = LWCRE / 5 = 1 / 5 = + 5.34 $Wm^{-2}$

**CLOUDY WEIGHTED CONTRIBUTION**

$f$(cloudy) = OLR(cloudy)/ULW = 5/9 ⇨ G(clear) = 3; CTS(atm, cloudy)= G(cloudy)= 4; OLR(cloudy)= 5; OLR(clear)= 6; ULW = 9

β × G(cloudy) = 4 ; β × CTS(atm, cloudy) = 4 ; β × OLR(cloudy) = 5 ; β × LAA(cloudy) = OLR(all) = 9 ; β × ULW = OLR(all) = 9

LWQ + CTS(atm, cloudy) = – LWCRE / 3 = – 8.86 $Wm^{-2}$; β × [LWQ + CTS(atm, cloudy)] = – LWCRE / 5 = – 1 / 5 = – 5.34 $Wm^{-2}$

| | | | | |
|---|---|---|---|---|
| LWQ = – 186.8 ± 6<br>SAS = 160.1 ± 5 | SH = 25 ± 4<br>LH = 81 ± 4 | ULW = 398.3 ± 4 Net SFC LW = 53.4 ±5<br>OLR(all) = 240.1 ± 2 OLR(clear) =268.1 ± 3 | DLR = 345.0 ± 5<br>STI(clear) = 66 ± 2 | $\beta_{eff}$ = 0.58 ± 0.02<br>$g$(clear) = 1/3 |
| CERES EBAF Ed4.0<br>Wild et al. (2015) | L'Ecuyer et al. (2015) | CERES EBAF Ed4.0<br>Wild et al. (2015) | CERES EBAF Ed4.0<br>Costa and Shine (2012) | CERES SYN1deg Ed4<br>Ramanathan (2006) |