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Canada

# Earth's global Energy budget

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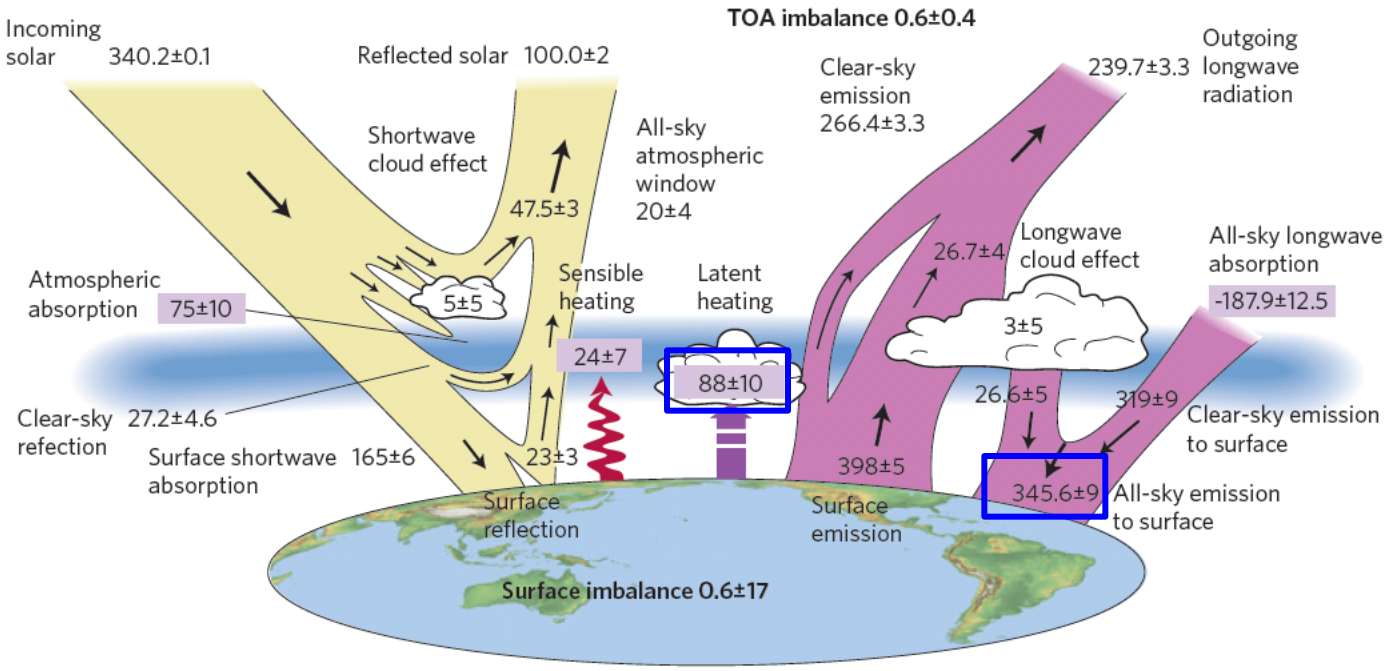
**2 July, 2015**

# Global annual mean (00-10) energy budget




**The global annual mean energy budget of Earth for the approximate period 2000–2010.** All fluxes are in $Wm^{-2}$.

***Stephens et al., 2012, an update on earth's energy balance in light of the latest global observations, Nature, geoscience. (ERBE, CERES, Argo Ocean Heat Content Observations)***

# DATA: ERA-interim

- 1979 ~2015
- resolutions (0.75º x 0.75º)
- Monthly mean (00Z,03Z,06Z,09Z,12Z ,15Z,18Z)
- Variables:

  incoming/net solar radiation at TOA,

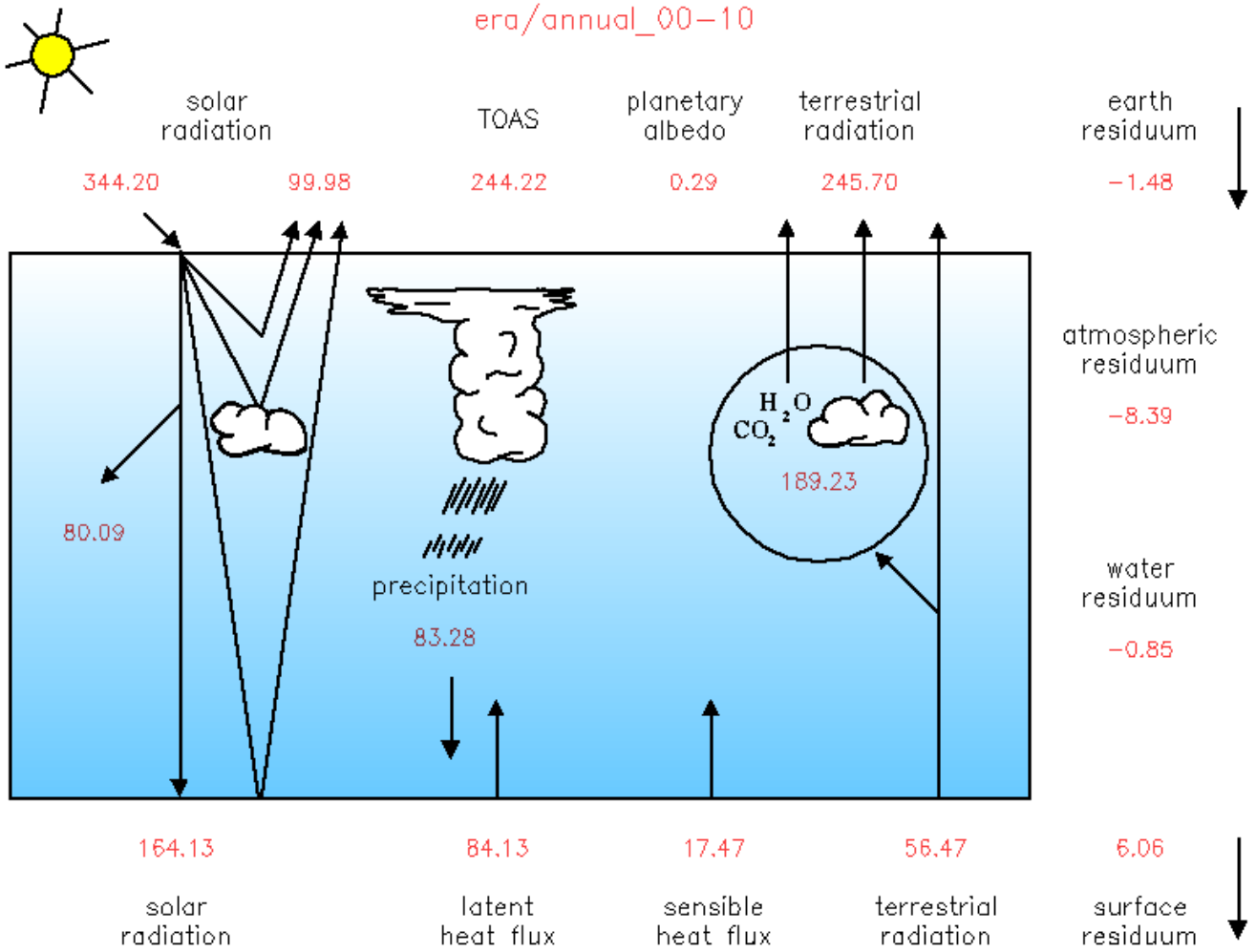
  outgoing LW radiation at TOA,

  surface sensible/latent heat flux,

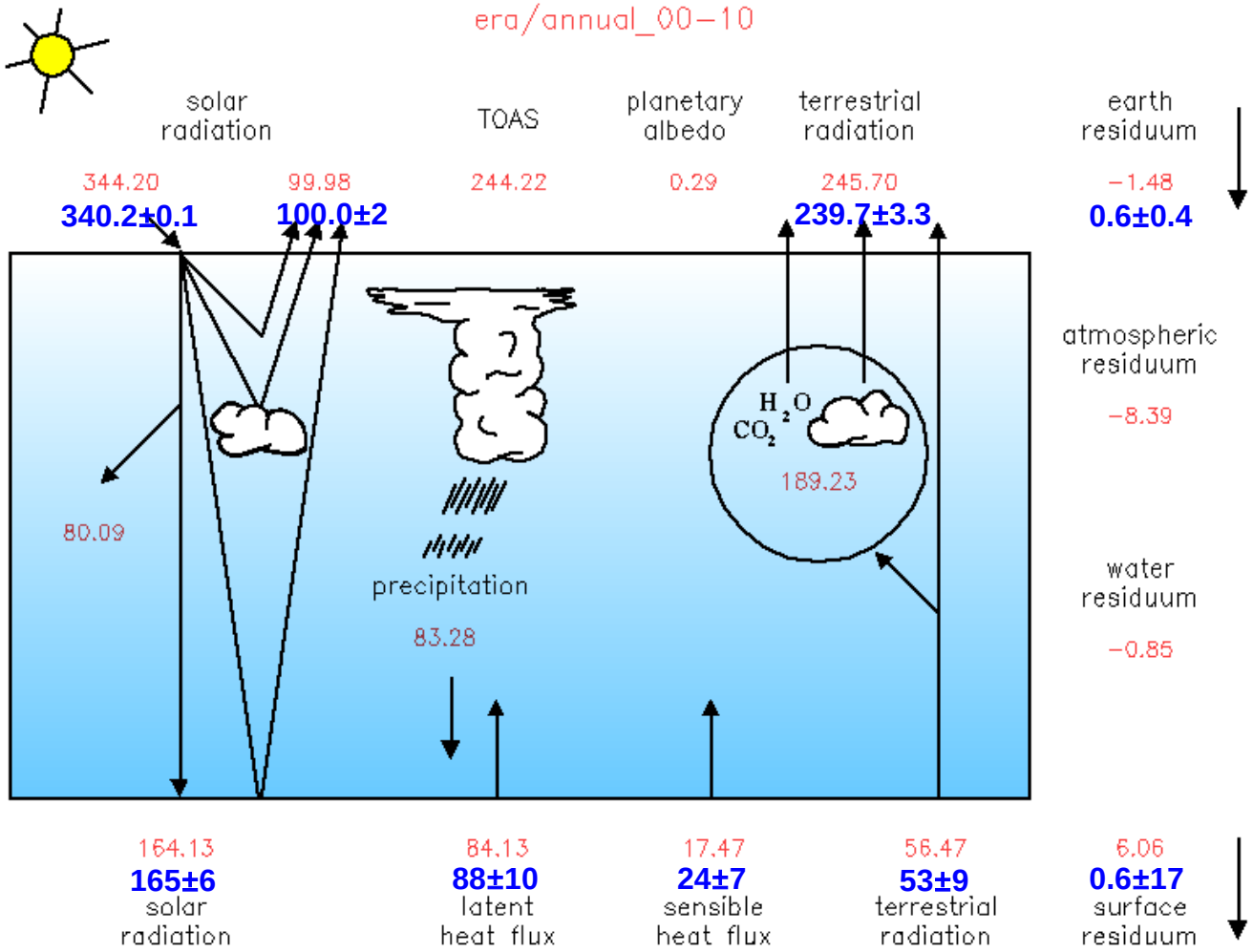
  surface net solar radiation,

  precipitation

# Global annual mean (00-10) ERA-interim



# Global annual mean (00-10) ERA-interim



# GEM-members 13,14,15,16,17,18,19

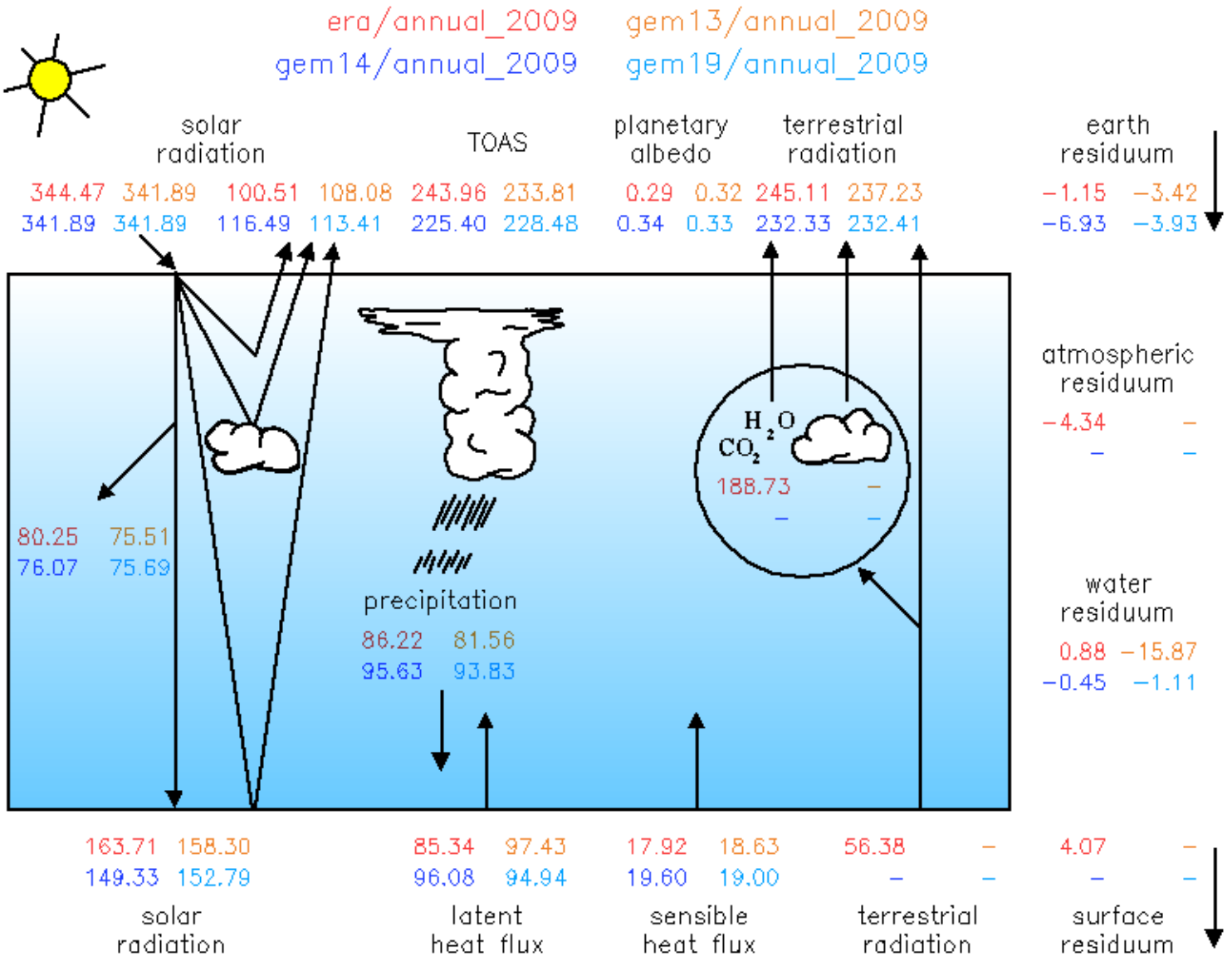
**GEM version: 480a7**
**Date origin: 2009012800_000**

**Simulation time: 400 days**

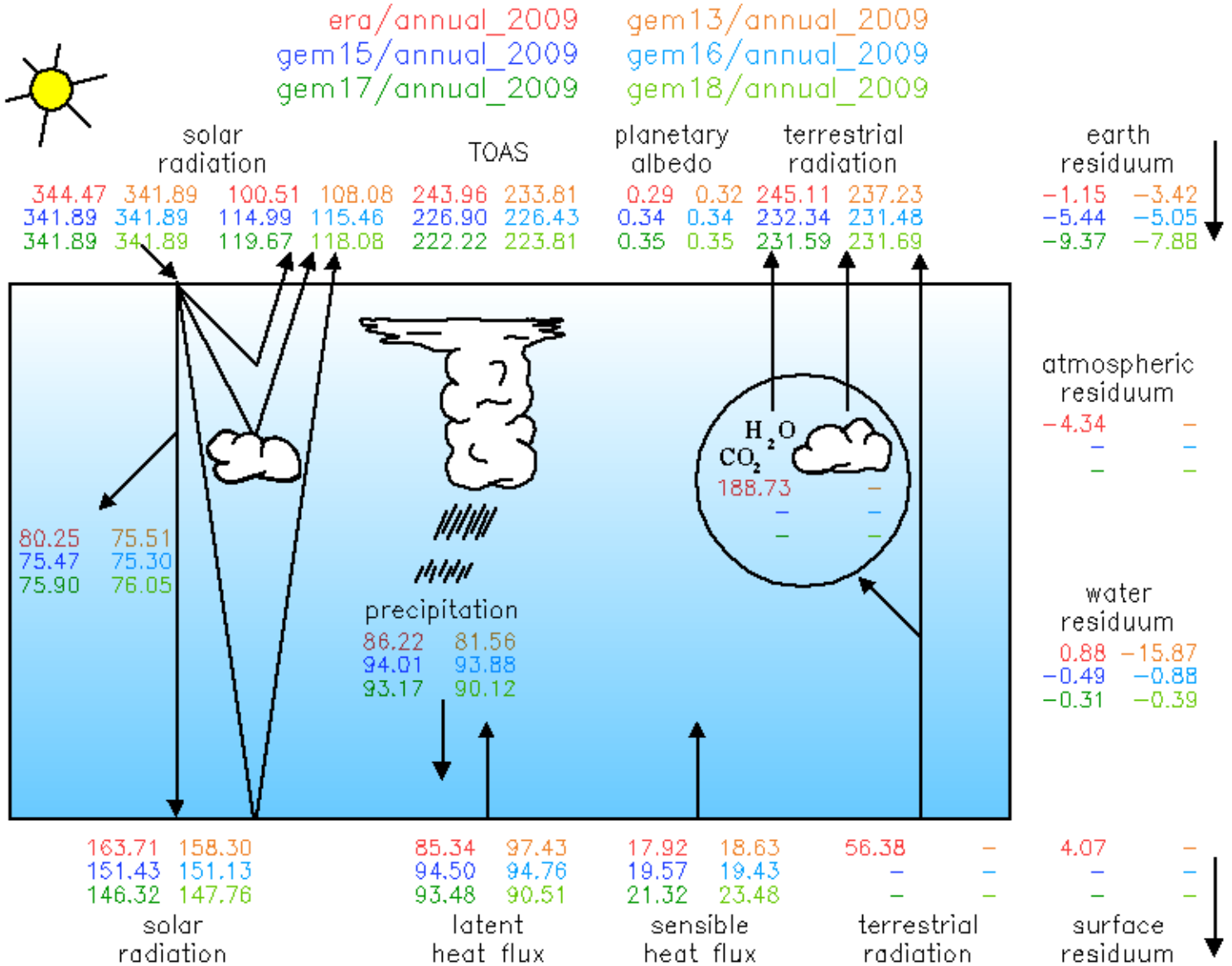
**Members:**

- **GEM13 ctl**
- **GEM14 pack1 *(wload+qsat+z0trdps+z0tlat+diusst+ktrsnt)***
- **GEM15 pack1+Z0T-exmwf**
- **GEM16 pack1+Z0T-exmwf+CMT**
- **GEM17 pack1+Z0T-exmwf+CMT+Blackadar**
- **GEM18 pack1+Z0T-exmwf+CMT+Blackadar+conres-reduc**
- **GEM19 pack1+conres=nil**

# Global annual mean (Mar, 2009-2010)

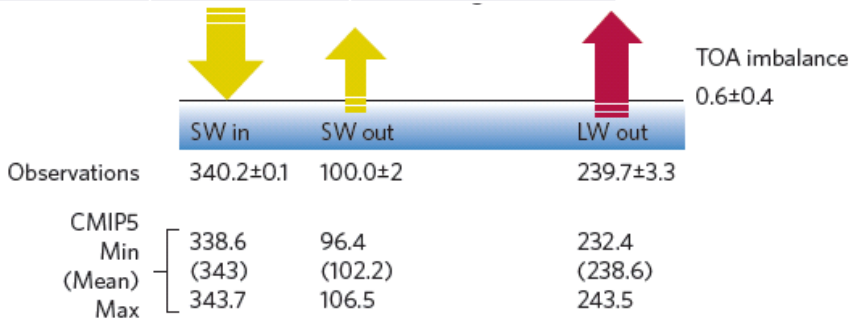


# Global annual mean (Mar, 2009-2010)



# TOA annual mean radiation budget (2009-2010)

| Global | Solar in | Solar out | Albedo | TOA Net solar | OLR | TOA Imbalance |
|---|---|---|---|---|---|---|
| ERA-int | 344.47 | 100.51 | 0.29 | 243.96 | 245.11 | -1.15 |
| GEM13 | 341.89 | 108.08 | 0.32 | 233.81 | 237.23 | -3.42 |
| GEM14 | 341.89 | 116.49 | 0.34 | 225.40 | 232.33 | -6.93 |
| GEM15 | 341.89 | 114.99 | 0.34 | 226.90 | 232.34 | -5.44 |
| GEM16 | 341.89 | 115.46 | 0.34 | 226.43 | 231.48 | -5.05 |
| GEM17 | 341.89 | 119.67 | 0.35 | 222.22 | 231.59 | -9.37 |
| GEM18 | 341.89 | 118.08 | 0.35 | 223.81 | 231.69 | -7.88 |
| GEM19 | 341.89 | 113.41 | 0.33 | 228.48 | 232.41 | -3.93 |

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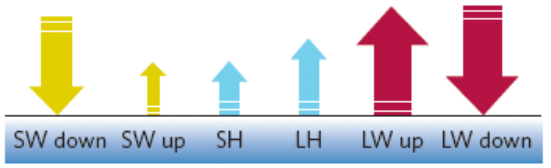
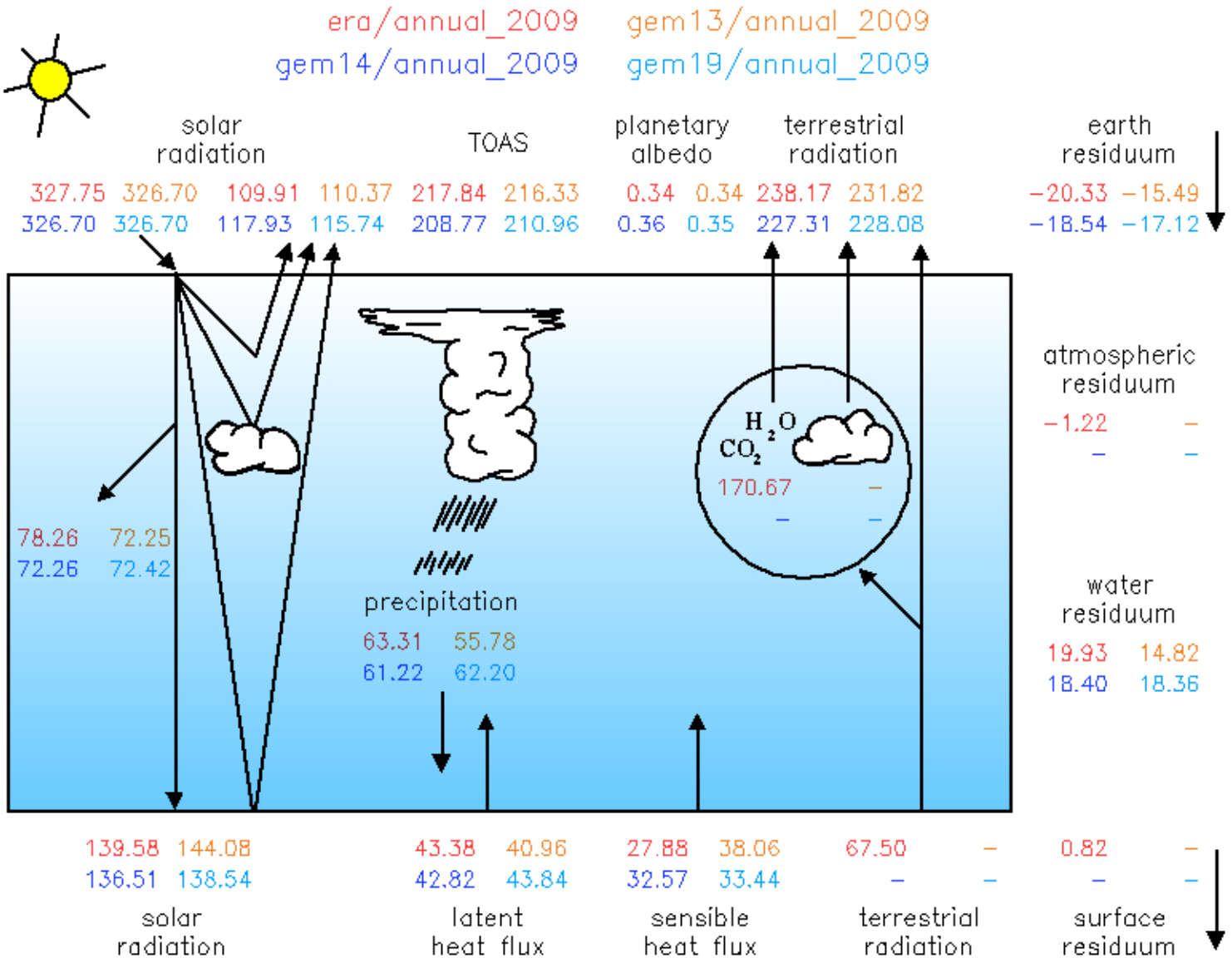
# Surface component of the budget (2009-2010)

| Global | Solar absorb | SH | LH evapor | Precip | LW rad up | LW rad down | Net LW | Surface imbalance |
|---|---|---|---|---|---|---|---|---|
| ERA-int | 163.71 | 17.92 | 85.34 | 86.22 | | 341.86 | 56.38 | 4.07 |
| GEM13 | 158.30 | 18.63 | 97.43 | 81.56 | | 345.46 | | |
| GEM14 | 149.33 | 19.60 | 96.08 | 95.63 | | 348.04 | | |
| GEM15 | 151.43 | 19.57 | 94.50 | 94.01 | | 345.82 | | |
| GEM16 | 151.13 | 19.43 | 94.76 | 93.88 | | 345.13 | | |
| GEM17 | 146.32 | 21.32 | 93.48 | 93.17 | | 346.80 | | |
| GEM18 | 147.76 | 23.48 | 90.51 | 90.12 | | 346.55 | | |
| GEM19 | 152.79 | 19.00 | 94.94 | 93.83 | | 346.49 | | |

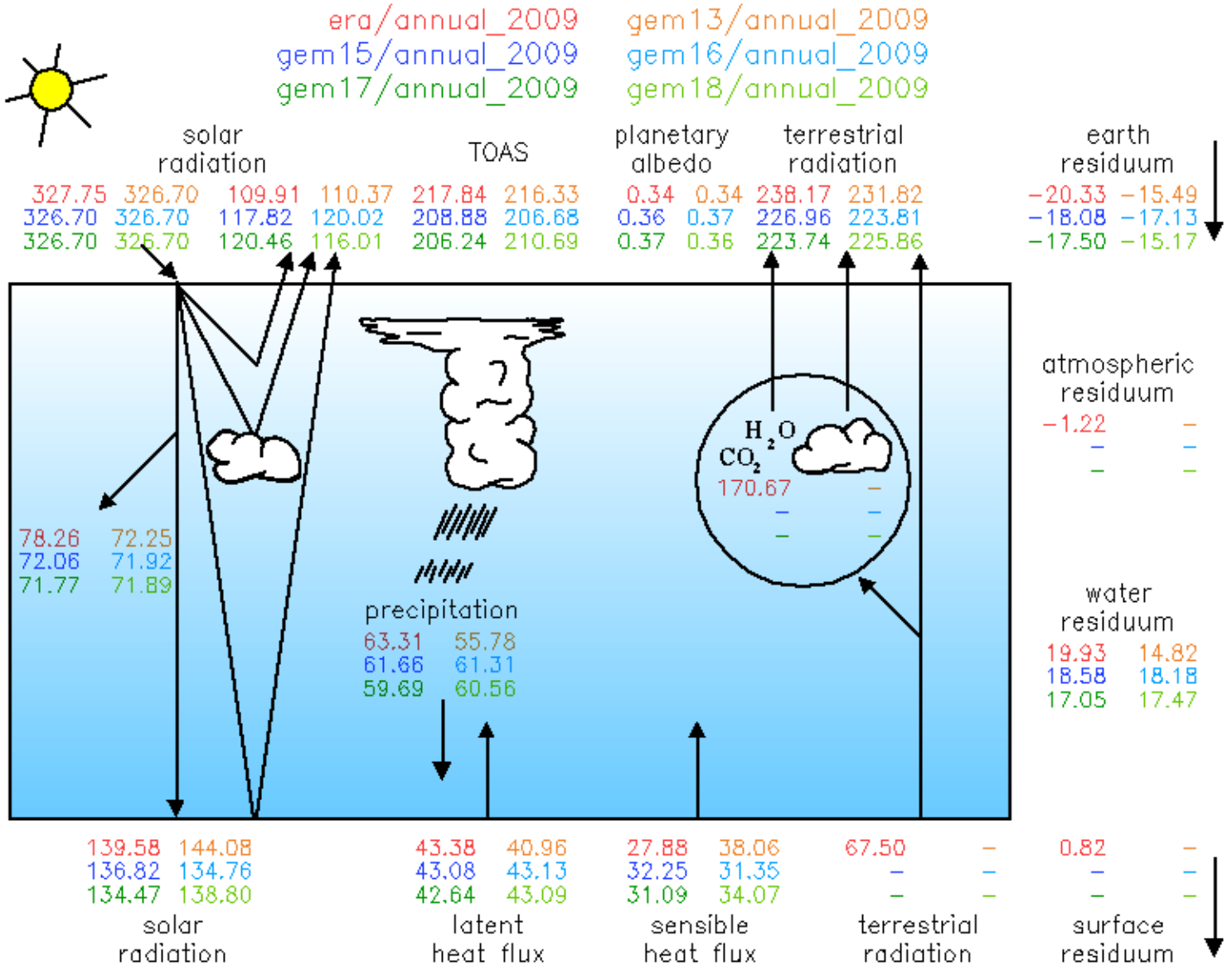


| | SW down | SW up | SH | LH | LW up | LW down | Surface imbalance |
|---|---|---|---|---|---|---|---|
| Observations | 188±6 | 23±3 | 24±7 | 88±10 | 398±5 | 345.6±9 | 0.6±17 |
| CMIP5 | | | | | | | |
| Min | 181.9 | 21.1 | 17.6 | 78.4 | 391.9 | 326.4 | |
| (Mean) | (190.3) | (24.9) | (20.9) | (85.8) | (397.5) | (339.7) | |
| Max | 196.2 | 30.3 | 27.8 | 93.6 | 398.1 | 347.0 | |

# Global land annual mean (Mar, 2009-2010)



# Global land annual mean (Mar, 2009-2010)



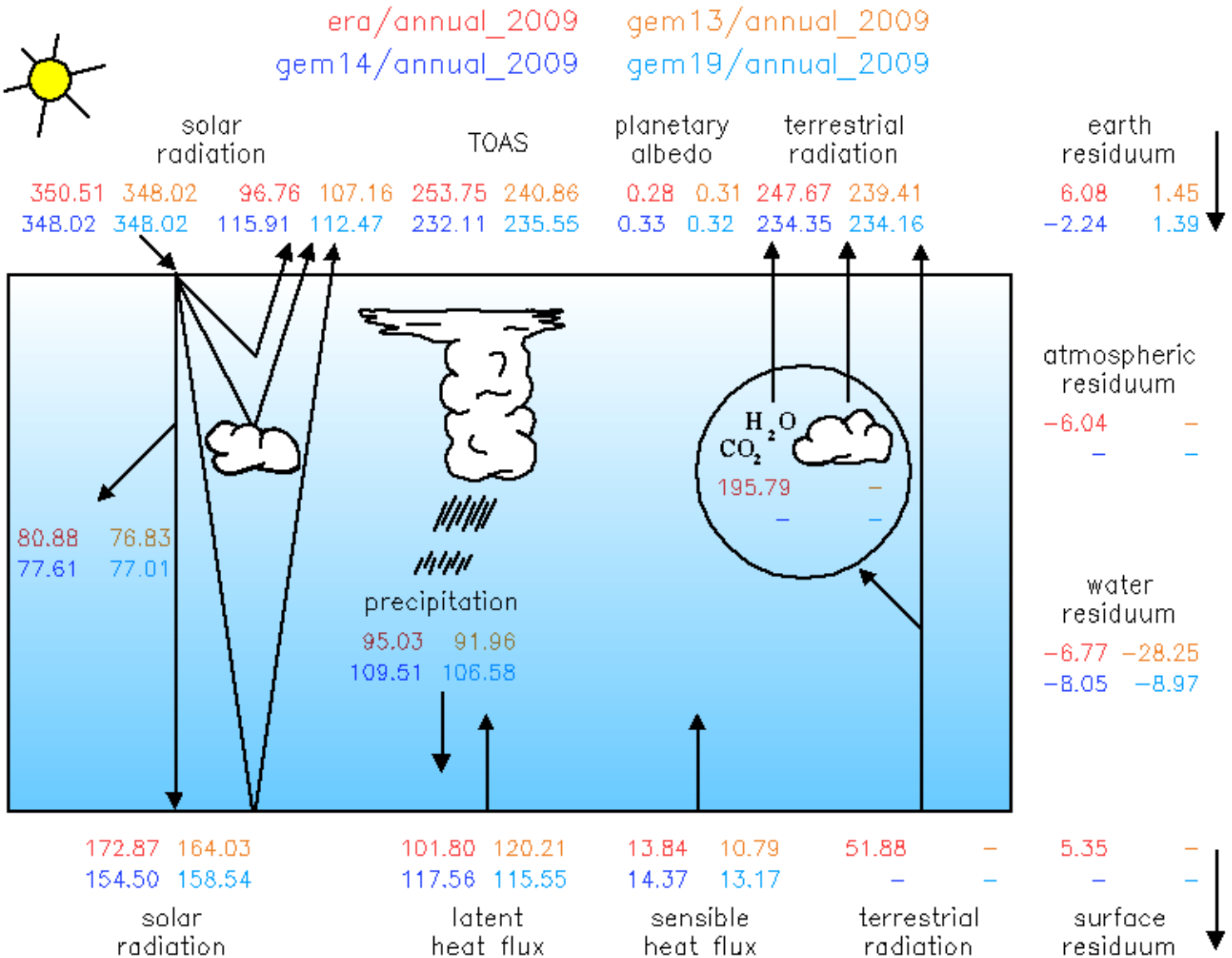
# TOA annual mean radiation budget (land)

| Land | Solar in | Solar out | Albedo | TOA Net solar | OLR | TOA Imbalance |
|---|---|---|---|---|---|---|
| ERA-int | 327.75 | 109.91 | 0.34 | 217.84 | 238.17 | -20.33 |
| GEM13 | 326.70 | 110.37 | 0.34 | 216.33 | 231.82 | -15.49 |
| GEM14 | 326.70 | 117.93 | 0.36 | 208.77 | 227.31 | -18.54 |
| GEM15 | 326.70 | 117.82 | 0.36 | 208.88 | 226.96 | -18.08 |
| GEM16 | 326.70 | 120.02 | 0.37 | 206.68 | 223.81 | -17.13 |
| GEM17 | 326.70 | 120.46 | 0.37 | 206.24 | 223.74 | -17.50 |
| GEM18 | 326.70 | 116.01 | 0.36 | 210.69 | 225.86 | -15.17 |
| GEM19 | 326.70 | 115.74 | 0.35 | 210.96 | 228.08 | -17.12 |

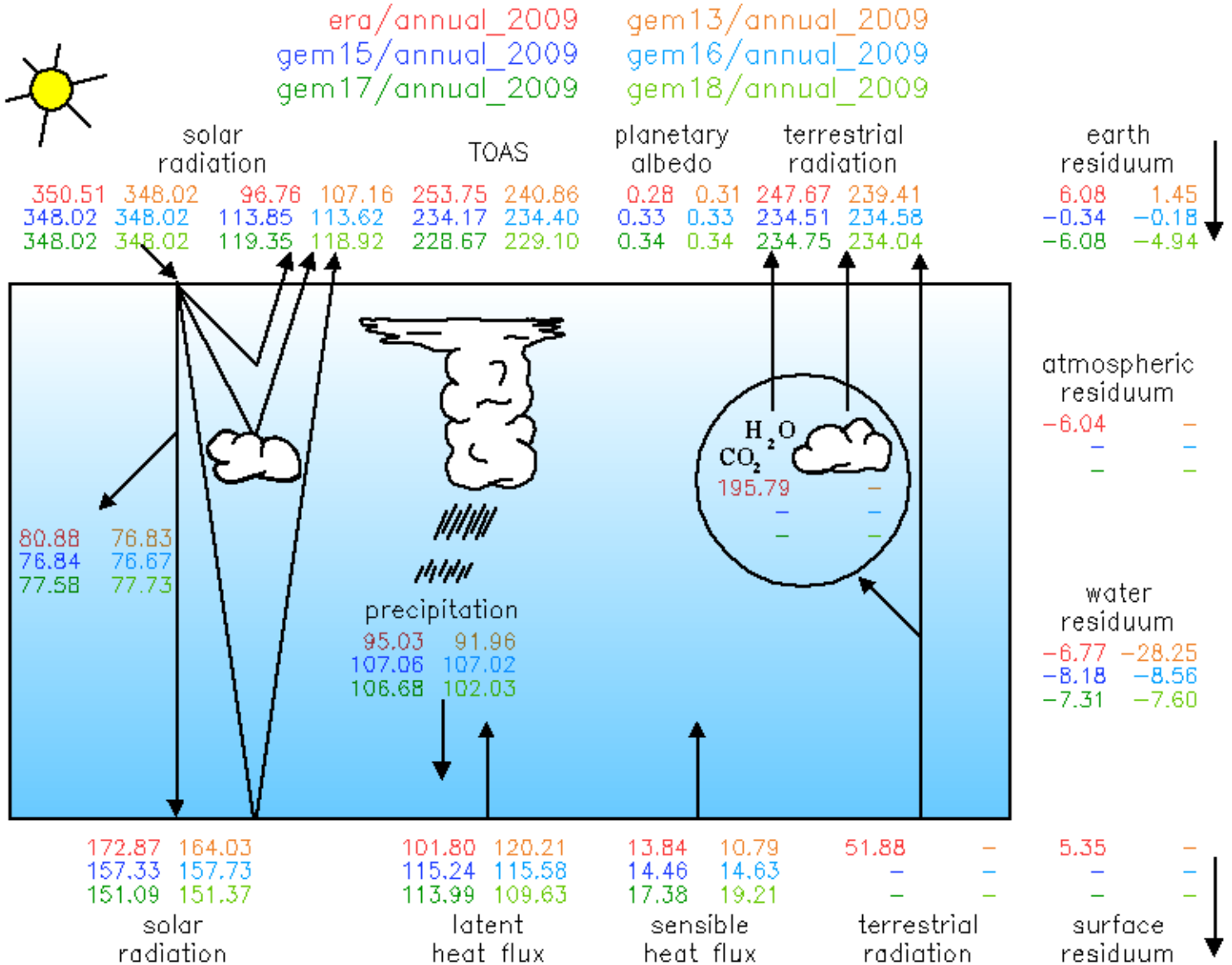
# Surface component of the budget (land)

| Land | Solar absorb | SH | LH evapor | Precip | LW rad up | LW rad down | Net LW | Surface imbalance |
|---|---|---|---|---|---|---|---|---|
| ERA-int | 139.58 | 27.88 | 43.38 | 63.31 | | 302.53 | 67.50 | 0.82 |
| GEM13 | 144.08 | 38.06 | 40.96 | 55.78 | | 307.63 | | |
| GEM14 | 136.51 | 32.57 | 42.82 | 61.22 | | 307.40 | | |
| GEM15 | 136.82 | 32.25 | 43.08 | 61.66 | | 306.56 | | |
| GEM16 | 134.76 | 31.35 | 43.13 | 61.31 | | 305.72 | | |
| GEM17 | 134.47 | 31.09 | 42.64 | 59.69 | | 306.46 | | |
| GEM18 | 138.80 | 34.07 | 43.09 | 60.56 | | 303.24 | | |
| GEM19 | 138.54 | 33.44 | 43.84 | 62.20 | | 306.20 | | |

# Global ocean annual mean (Mar, 2009-2010)



# Global ocean annual mean (Mar, 2009-2010)



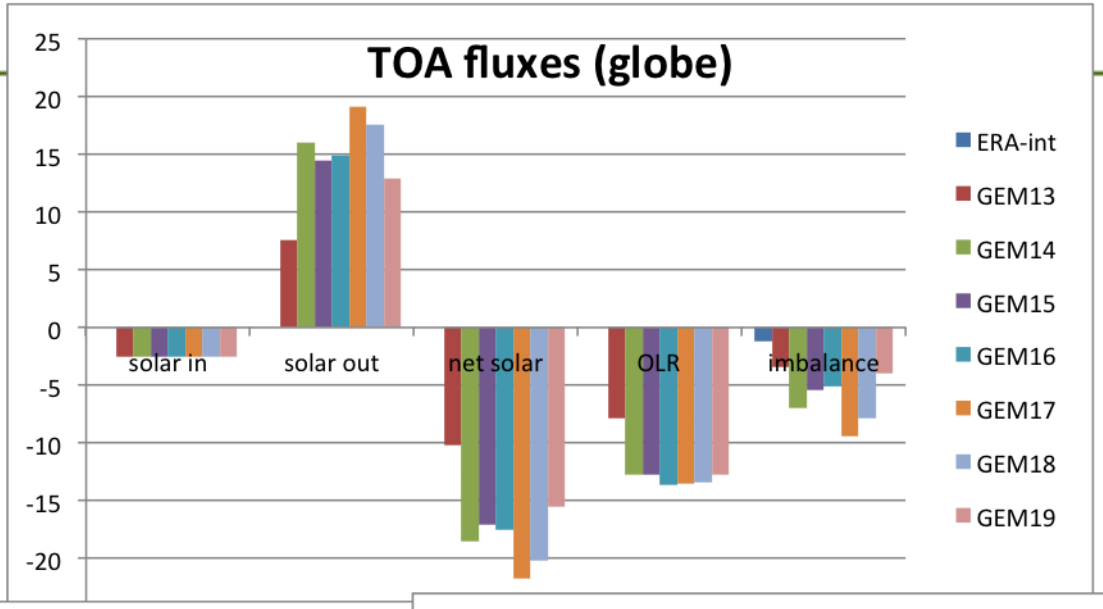
# TOA annual mean radiation budget (ocean)

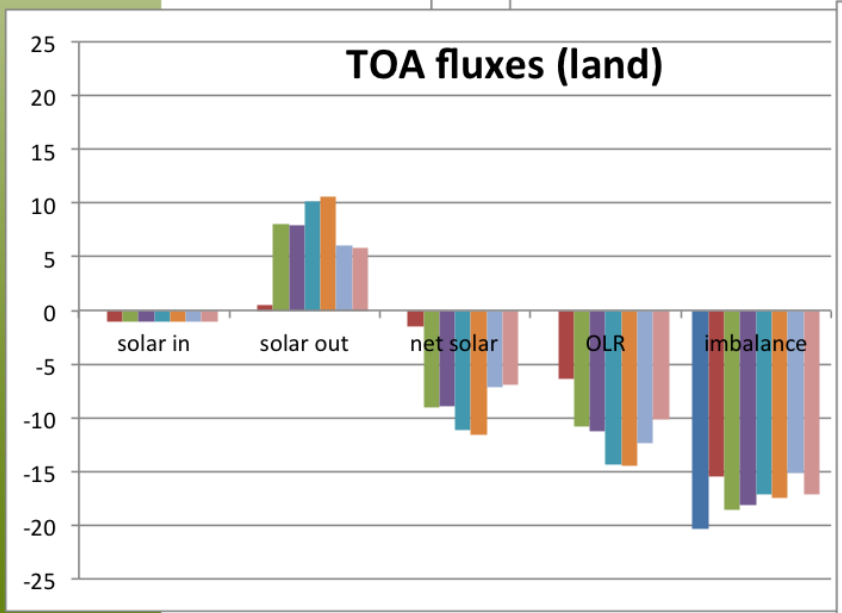
| Ocean | Solar in | Solar out | Albedo | TOA Net solar | OLR | TOA Imbalance |
|---|---|---|---|---|---|---|
| ERA-int | 350.51 | 96.76 | 0.28 | 253.75 | 247.67 | 6.08 |
| GEM13 | 348.02 | 107.16 | 0.31 | 240.86 | 239.41 | 1.45 |
| GEM14 | 348.02 | 115.91 | 0.33 | 232.11 | 234.35 | -2.24 |
| GEM15 | 348.02 | 113.85 | 0.33 | 234.17 | 234.51 | -0.34 |
| GEM16 | 348.02 | 113.62 | 0.33 | 234.40 | 234.58 | -0.18 |
| GEM17 | 348.02 | 119.35 | 0.34 | 228.67 | 234.75 | -6.08 |
| GEM18 | 348.02 | 118.92 | 0.34 | 229.10 | 234.04 | -4.94 |
| GEM19 | 348.02 | 112.47 | 0.32 | 235.55 | 234.16 | 1.39 |

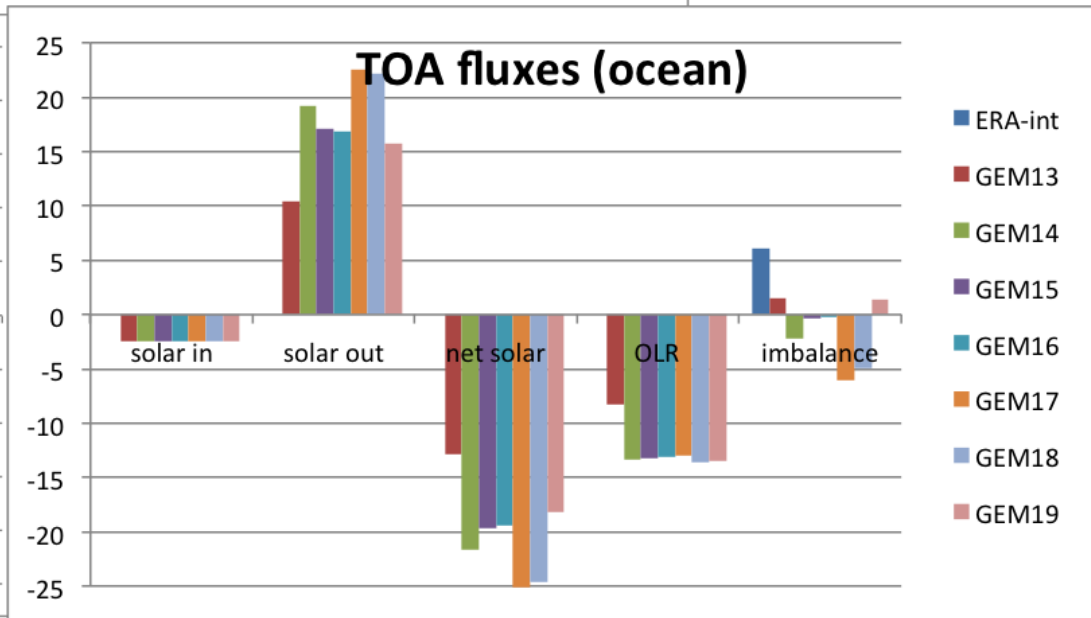
# Surface component of the budget (ocean)

| Ocean | Solar absorb | SH | LH Evapor | Precip | LW rad up | LW rad down | Net LW | Surface imbalance |
|---|---|---|---|---|---|---|---|---|
| ERA-int | 172.87 | 13.84 | 101.80 | 95.03 | | 357.05 | 51.88 | 5.35 |
| GEM13 | 164.03 | 10.79 | 120.21 | 91.98 | | 360.71 | | |
| GEM14 | 154.50 | 14.37 | 117.56 | 109.51 | | 364.43 | | |
| GEM15 | 157.33 | 14.46 | 115.24 | 107.06 | | 361.65 | | |
| GEM16 | 157.73 | 14.63 | 115.58 | 107.02 | | 361.02 | | |
| GEM17 | 151.09 | 17.38 | 113.99 | 106.68 | | 363.07 | | |
| GEM18 | 151.37 | 19.21 | 109.63 | 102.03 | | 364.01 | | |
| GEM19 | 158.54 | 13.17 | 115.55 | 106.58 | | 362.74 | | |

# TOA annual mean fluxes (globe, land, ocean)

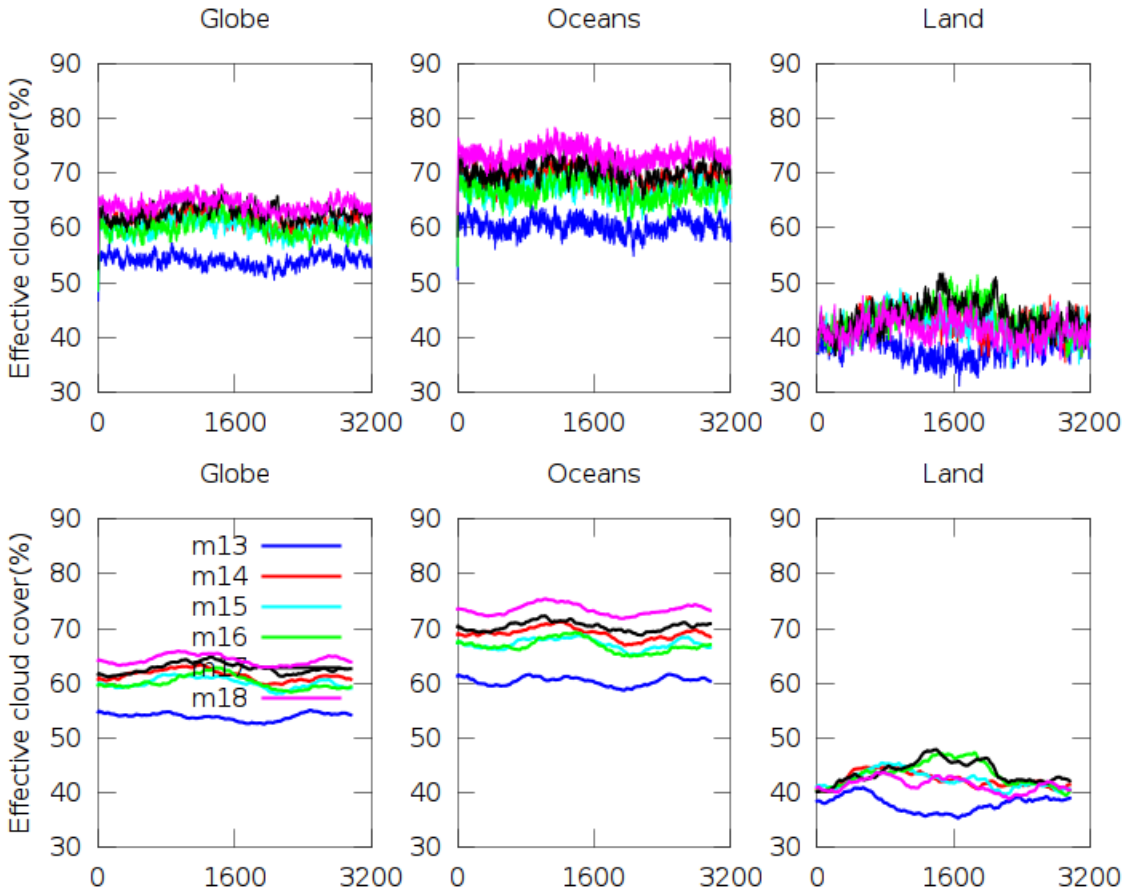


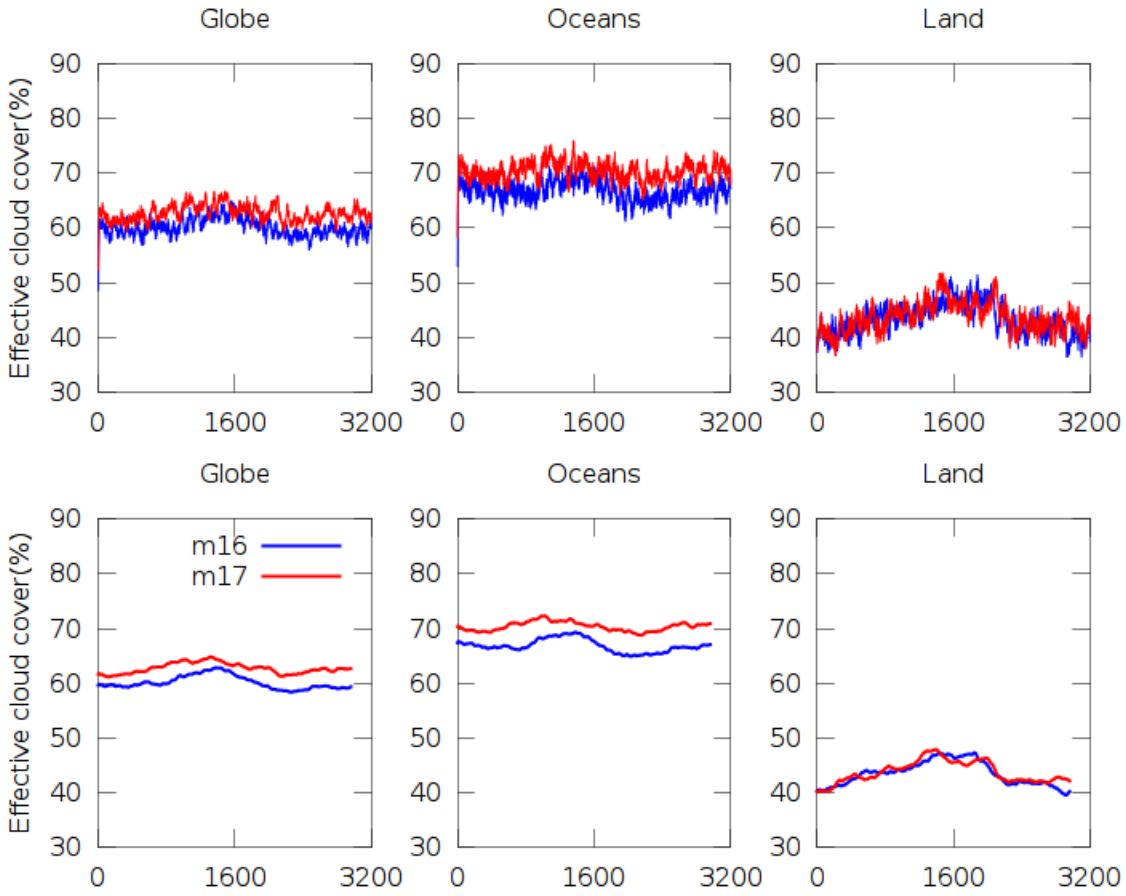
# TOA annual mean fluxes (globe, land, ocean)

## Effective cloud cover

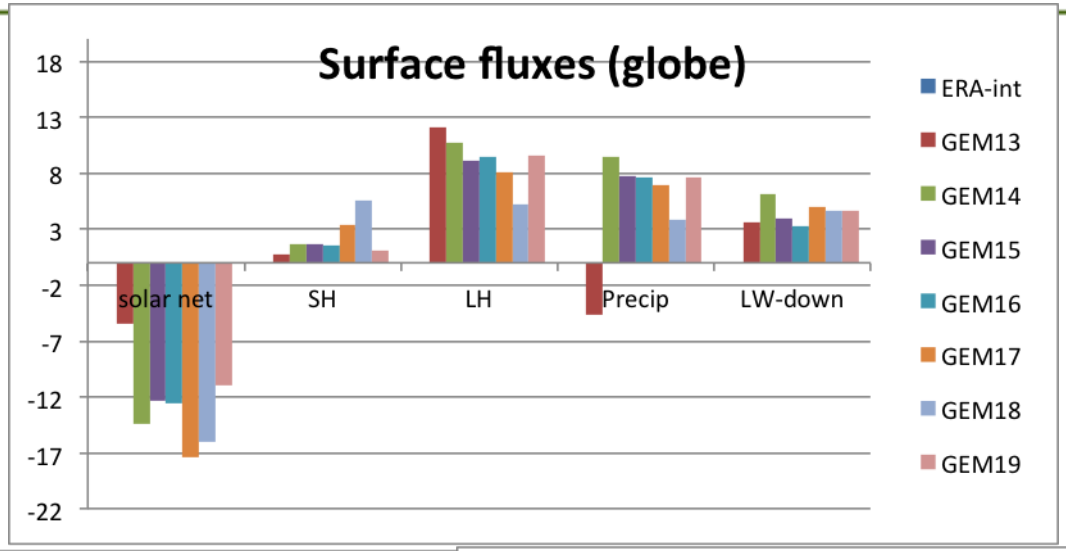


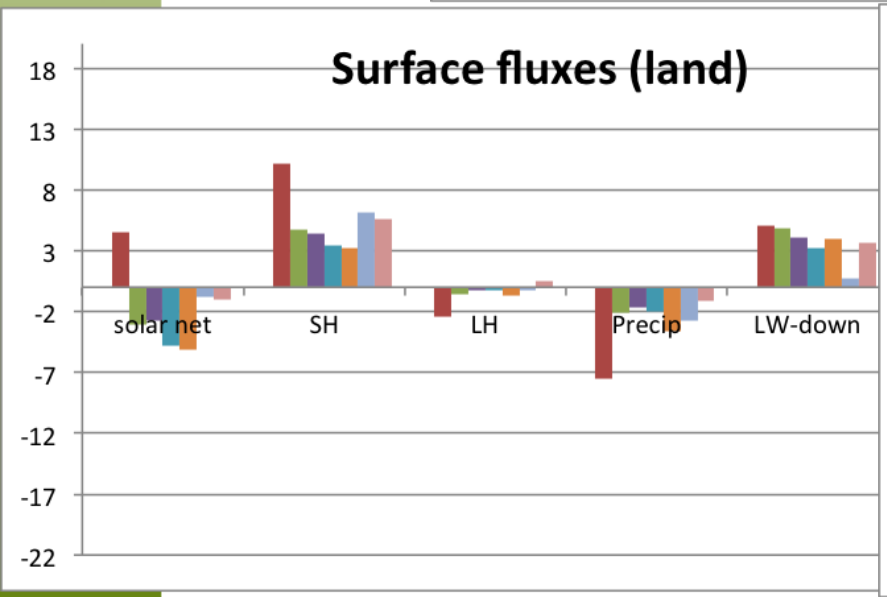
# TOA annual mean fluxes (globe, land, ocean)

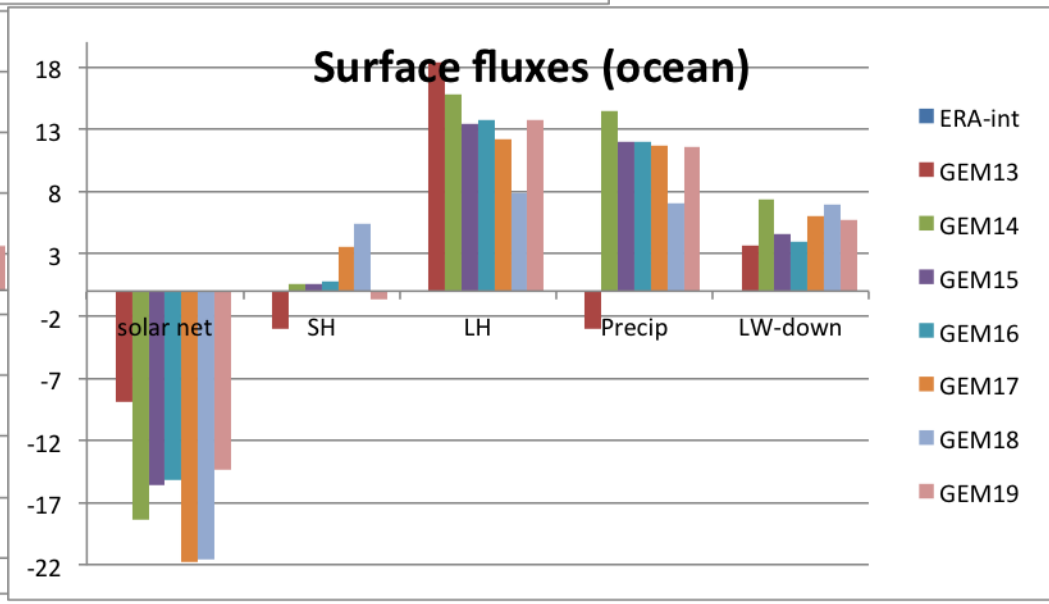
## Effective cloud cover



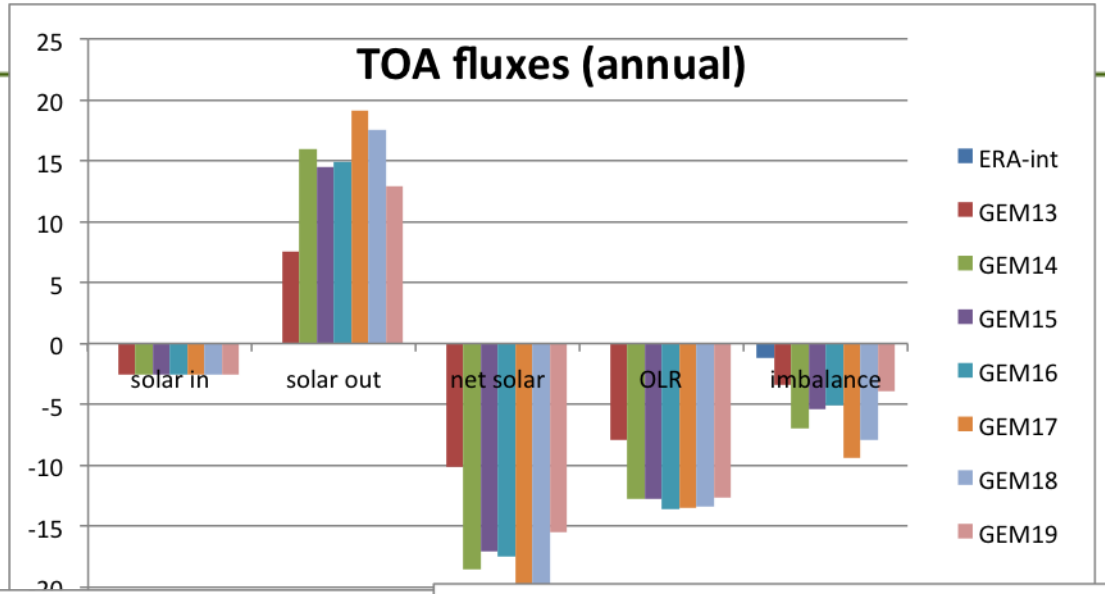
# Surface component (globe, land, ocean)

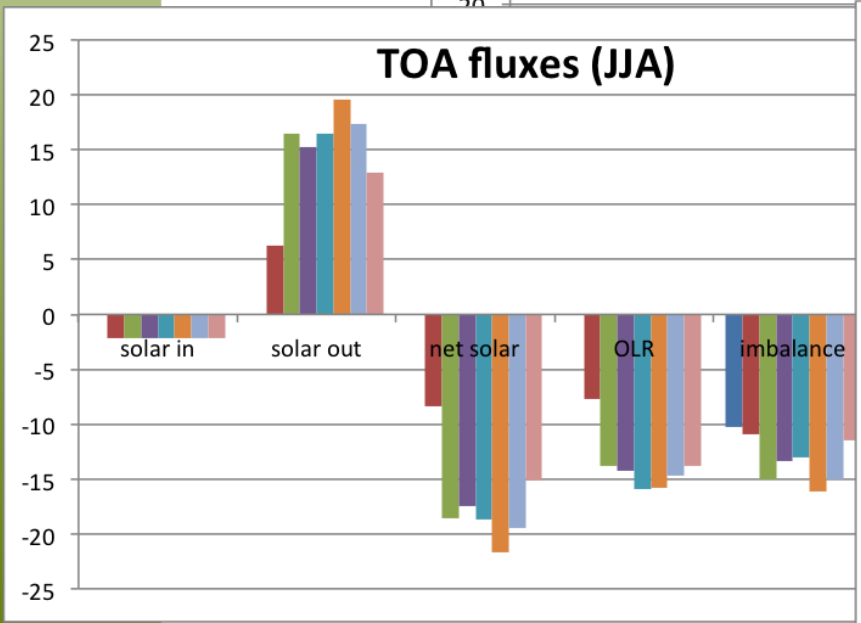


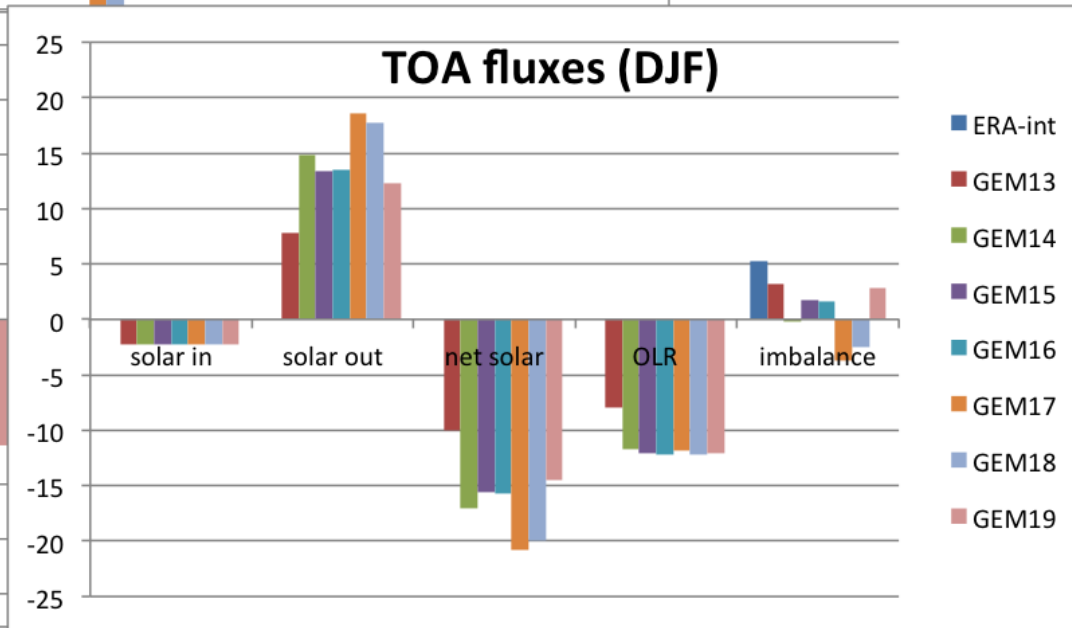



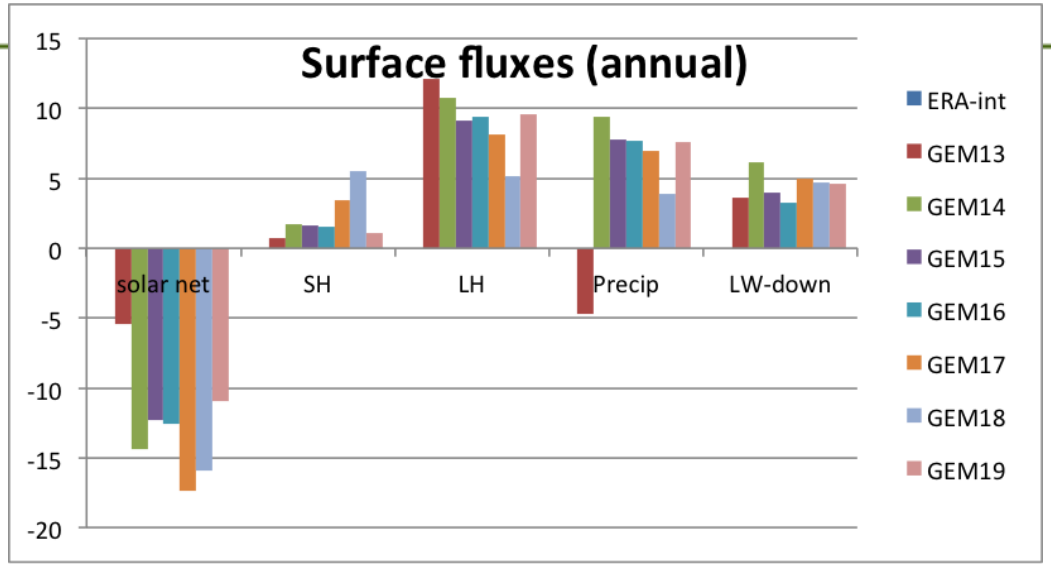
# TOA global radiation fluxes (annual, JJA, DJF)

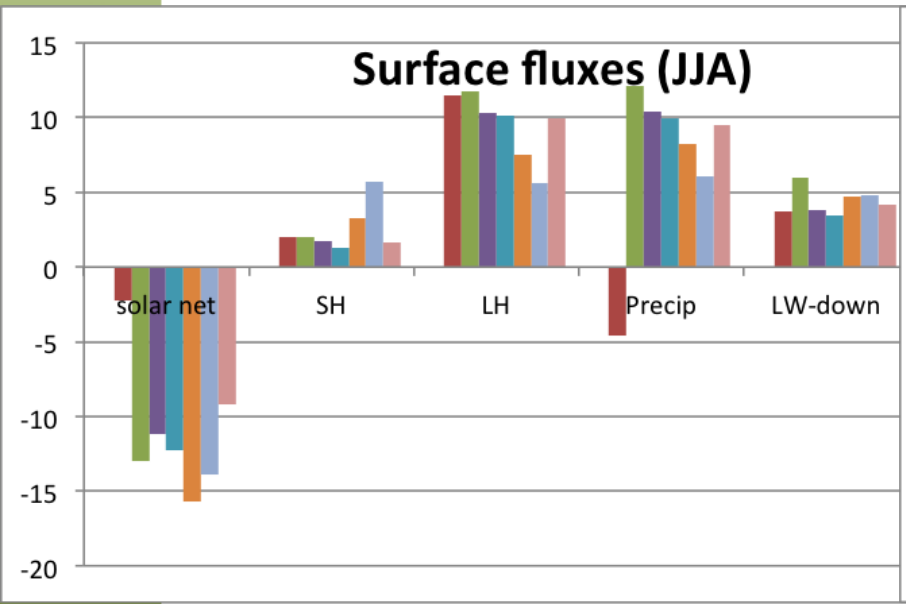


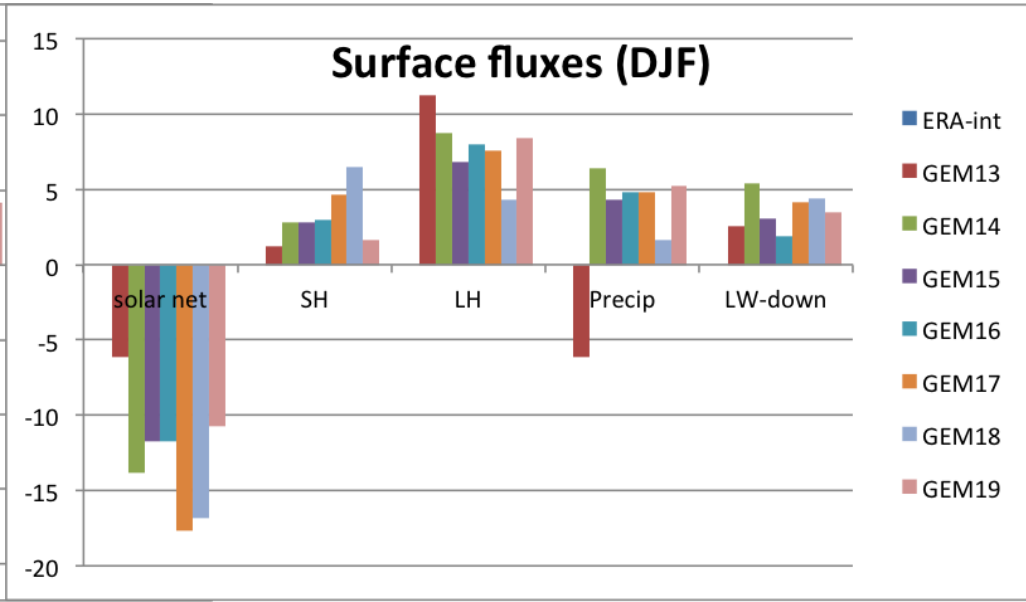



# Surface component (annual, JJA, DJF)



# Concluding remarks

## TOA

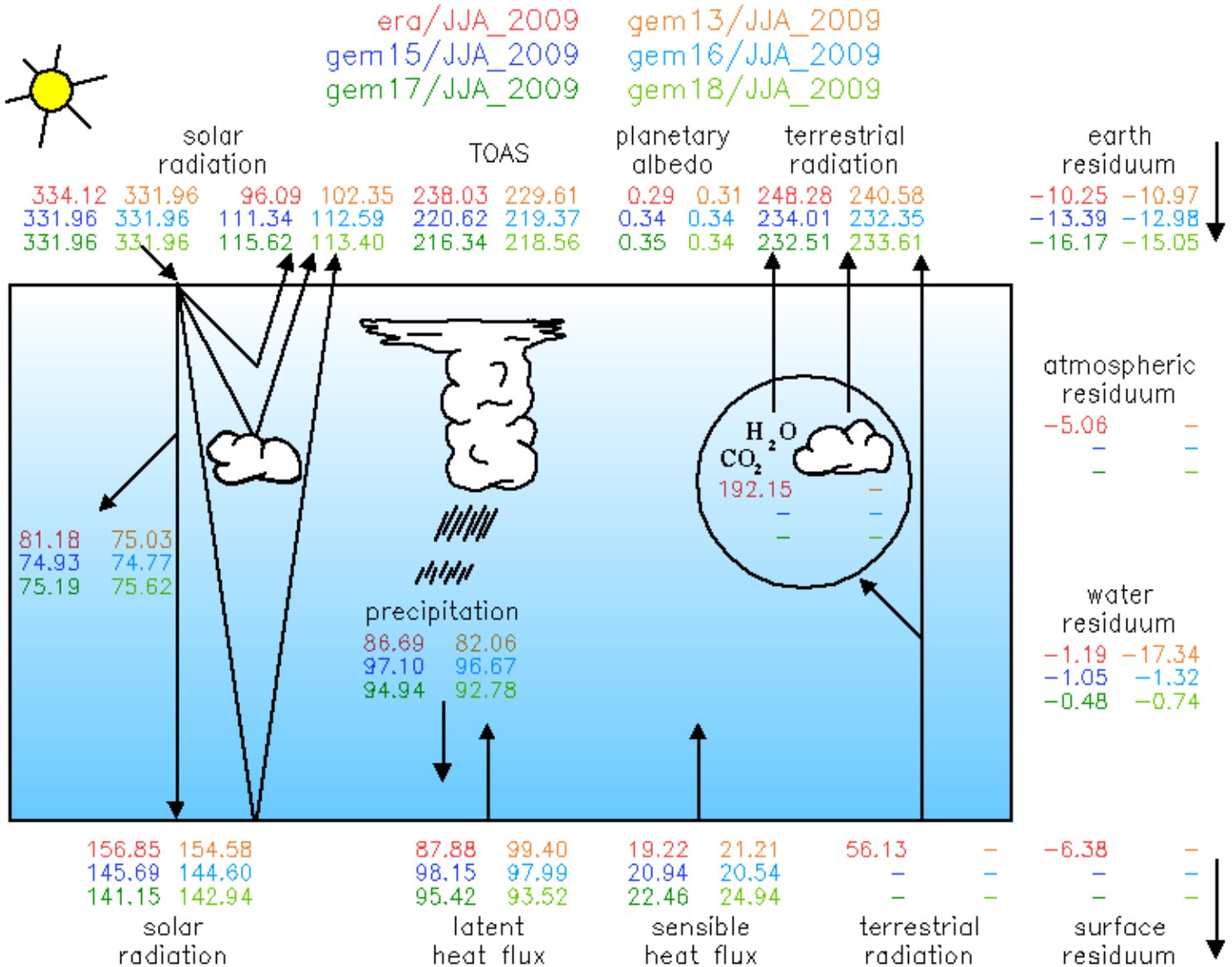
- more reflected solar radiation (especially over ocean), and less outgoing LW radiation;
- Blackadar scheme increased cloud cover, outgoing LW radiation, especially over ocean;
- Energy imbalance is relatively small from GEM13 (ctl) & 19 (ctrl without conres);
- More imbalance at TOA in summer than in winter

## Surface

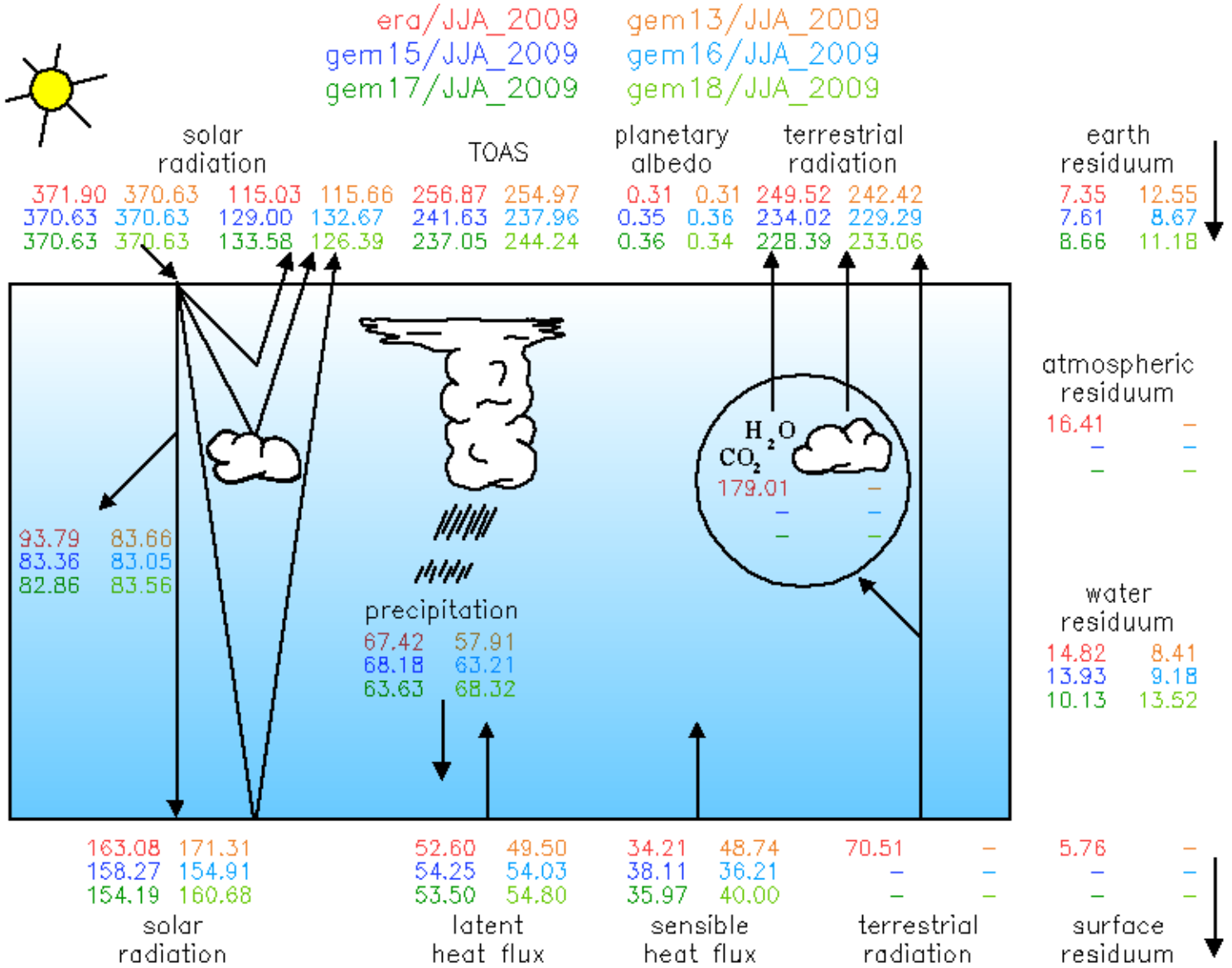
- GEM13 (ctl) less precipitation, but more latent heat flux, mainly over ocean; GEM13+, increased precipitation/LH, improved water budget.;
- With reduced conres, less precipitation over ocean/globe;
- Less absorbed solar radiation at surface for all gem results;

**GEM19 – pack1+conres=nil ☺**

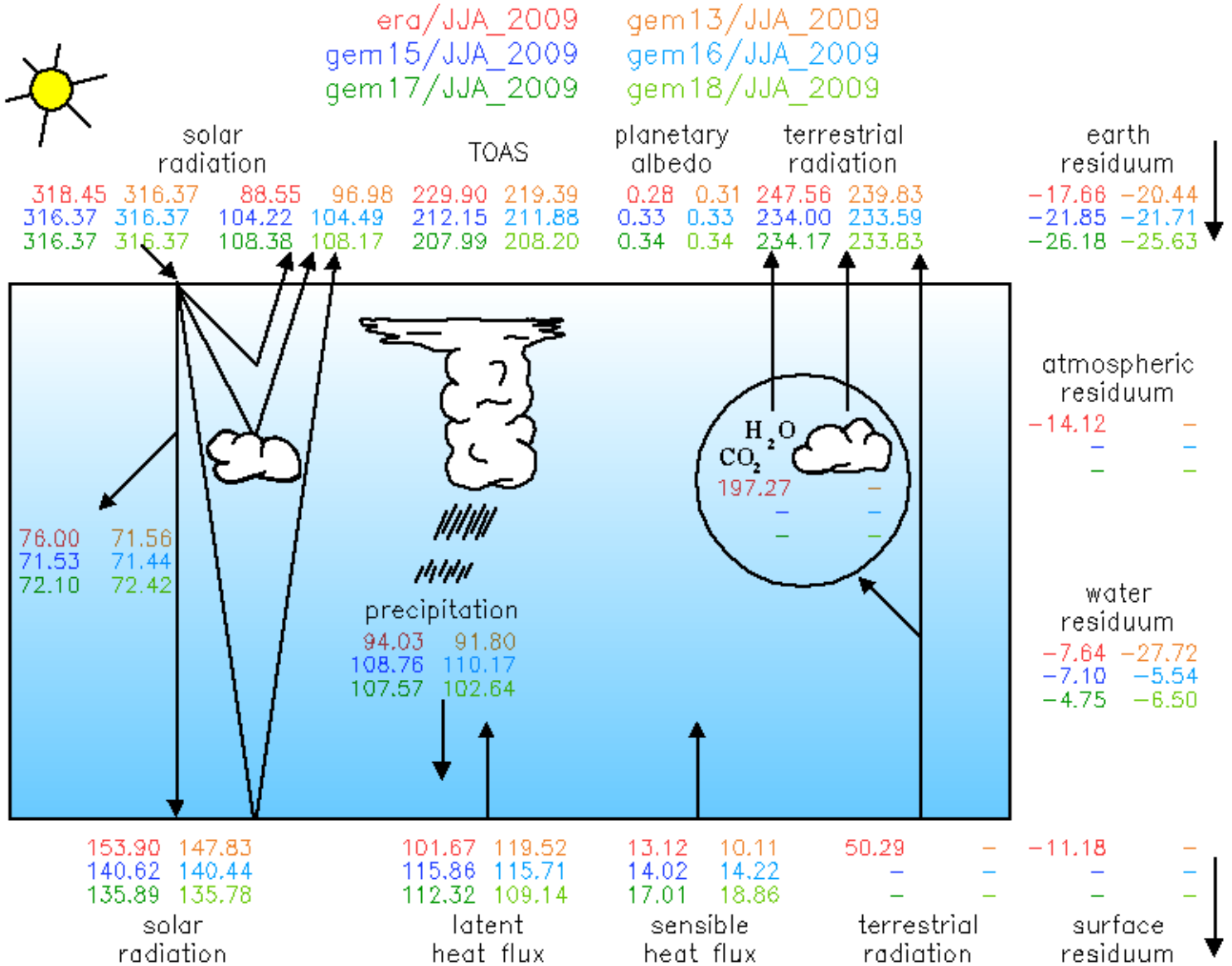
# Global mean ( JJA 2009 )



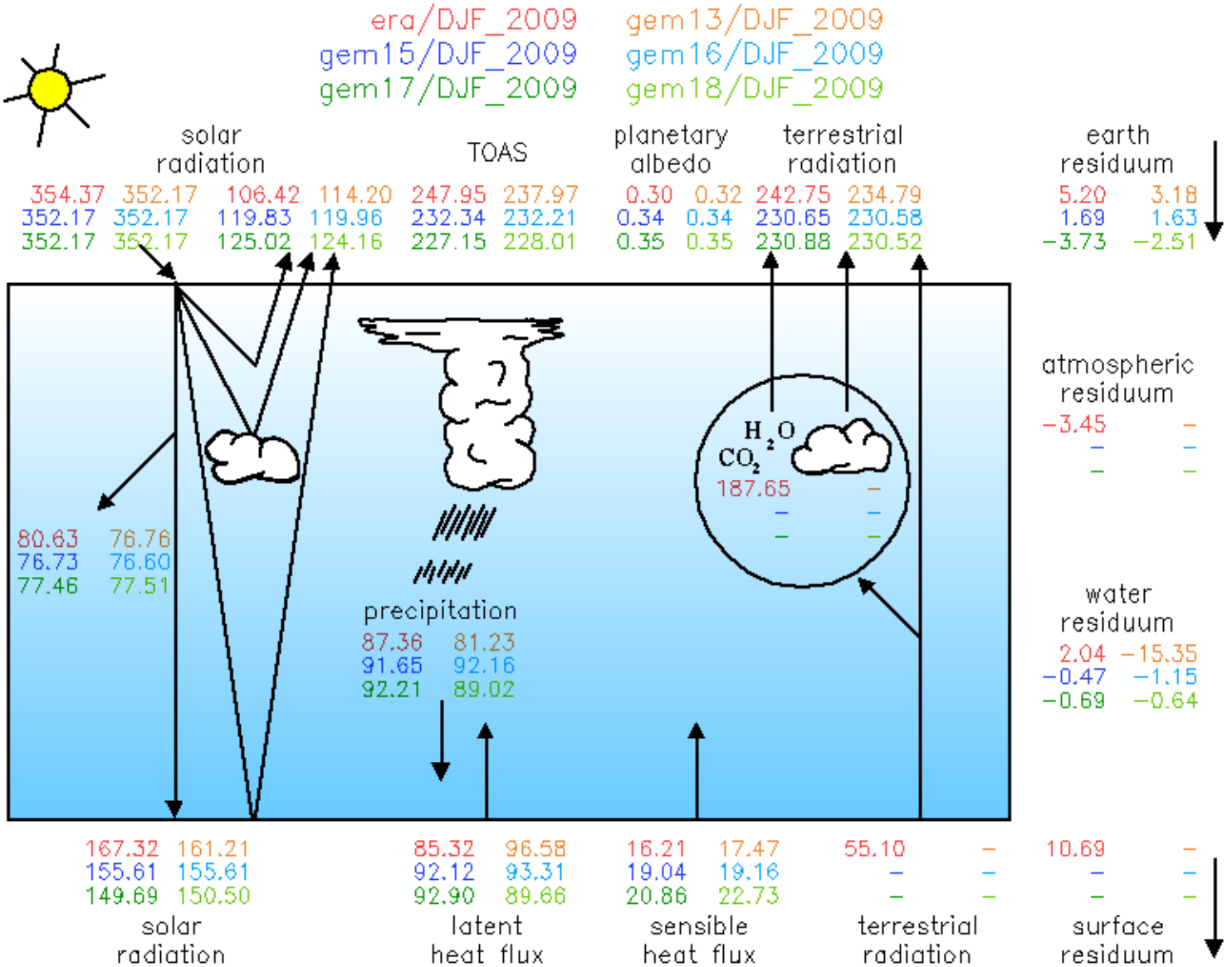
# Global land mean ( JJA 2009 )



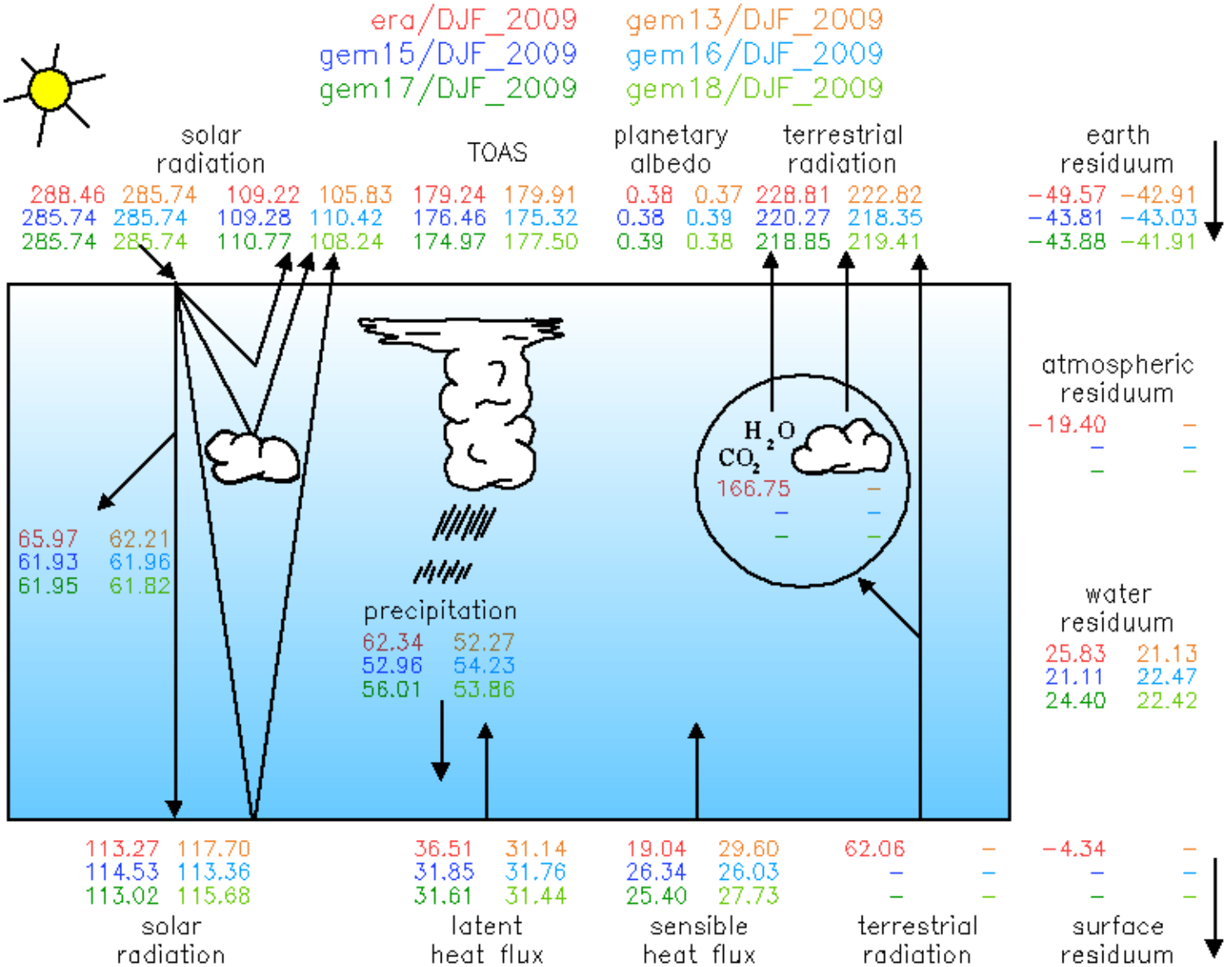
# Global ocean mean ( JJA 2009 )



# Global mean ( DJF 2009 )



# Global land mean ( DJF 2009 )



# Global ocean mean ( DJF 2009 )