Trend of global mean net atmospheric shortwave and longwave irradiances derived from CERES and MODIS observations

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Background

- From an energy balance perspective, global mean diabatic heating by precipitation matches with global mean net atmospheric total (shortwave + longwave) irradiance + surface sensible heat flux
- Climate models predict that global mean precipitation change is constrained by net atmospheric total irradiance change.
- The CERES team has produced over 24 years of net atmospheric irradiance data.
  - How is global net atmospheric total irradiance changing?
  - What is driving the change?
  - How do net atmospheric total irradiance and precipitation changes agree?

Outline of this talk

- Trend of global monthly shortwave, longwave and total net atmospheric irradiances derived from Edition 4.2 EBAF
- Analysis of contribution to the trends using a partial radiative perturbation method
- Global monthly anomaly time series of net atmospheric total irradiance, diabatic heating by precipitation, sensible heat flux, and dry static + kinetic energy tendencies.

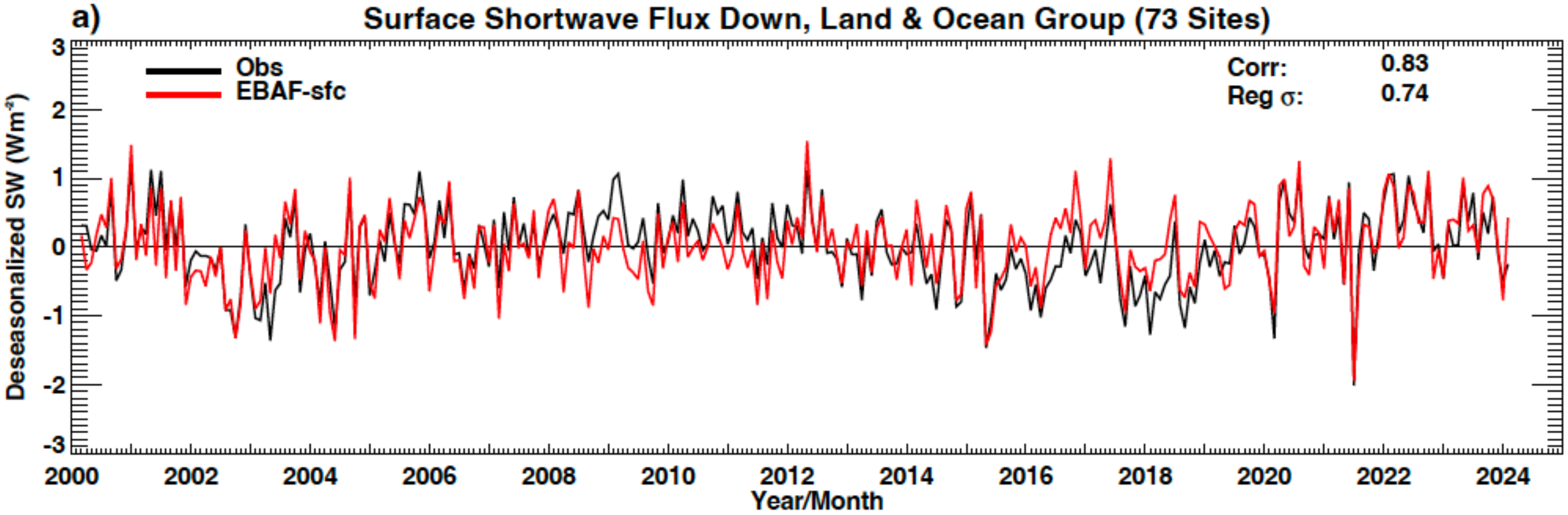
Data products used in this study

- Top-of-atmosphere and surface irradiances
  - Edition 4.2 EBAF from March 2000 through December 2023

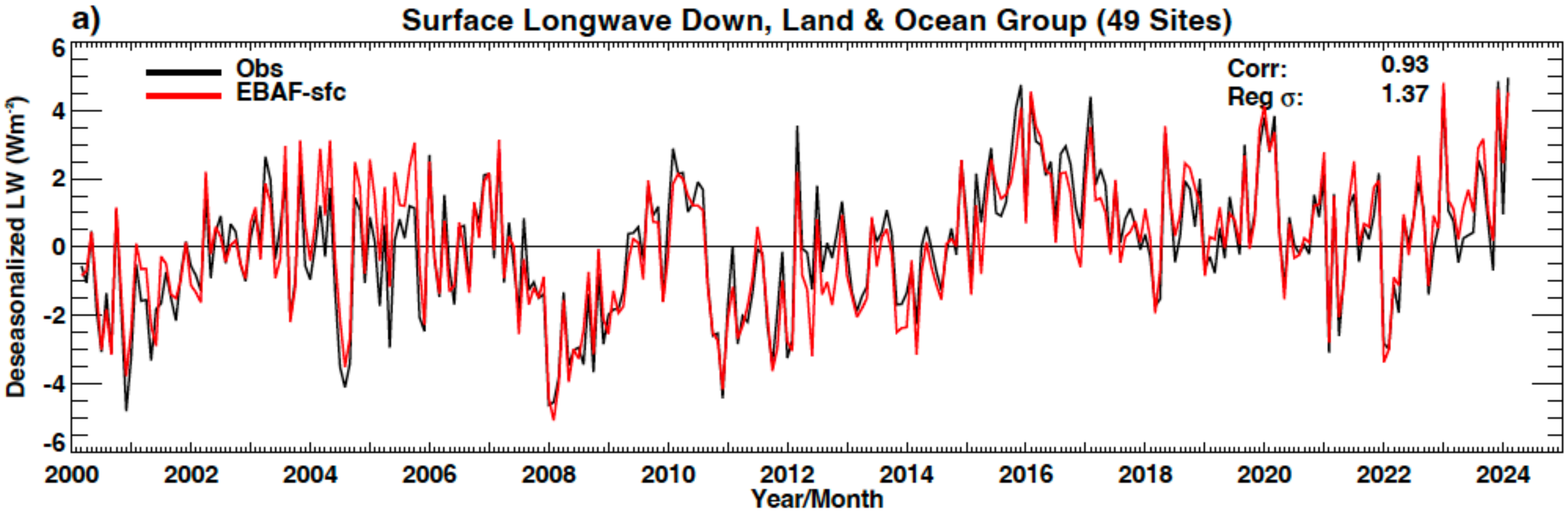
- Precipitation
  - Version 3.2 Global Precipitation Climatology Project (GPCP) data product
  - Use the enthalpy of vaporization at 0 °C to compute diabatic heating
- Sensible heat flux and dry static and kinetic energy tendencies
  - ERA5

Evaluation of EBAF downward irradiance with surface observations

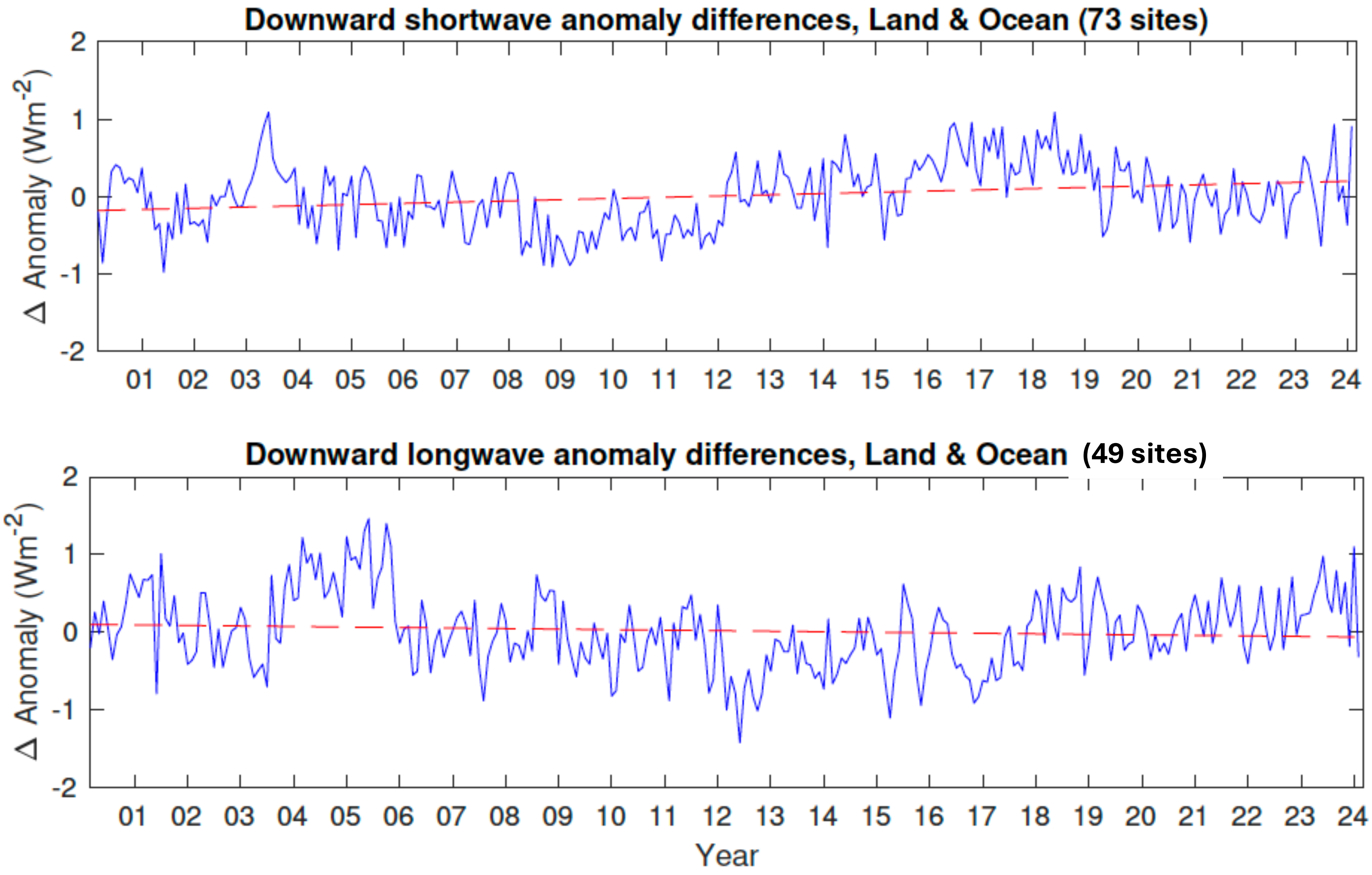
Downward shortwave



Downward longwave



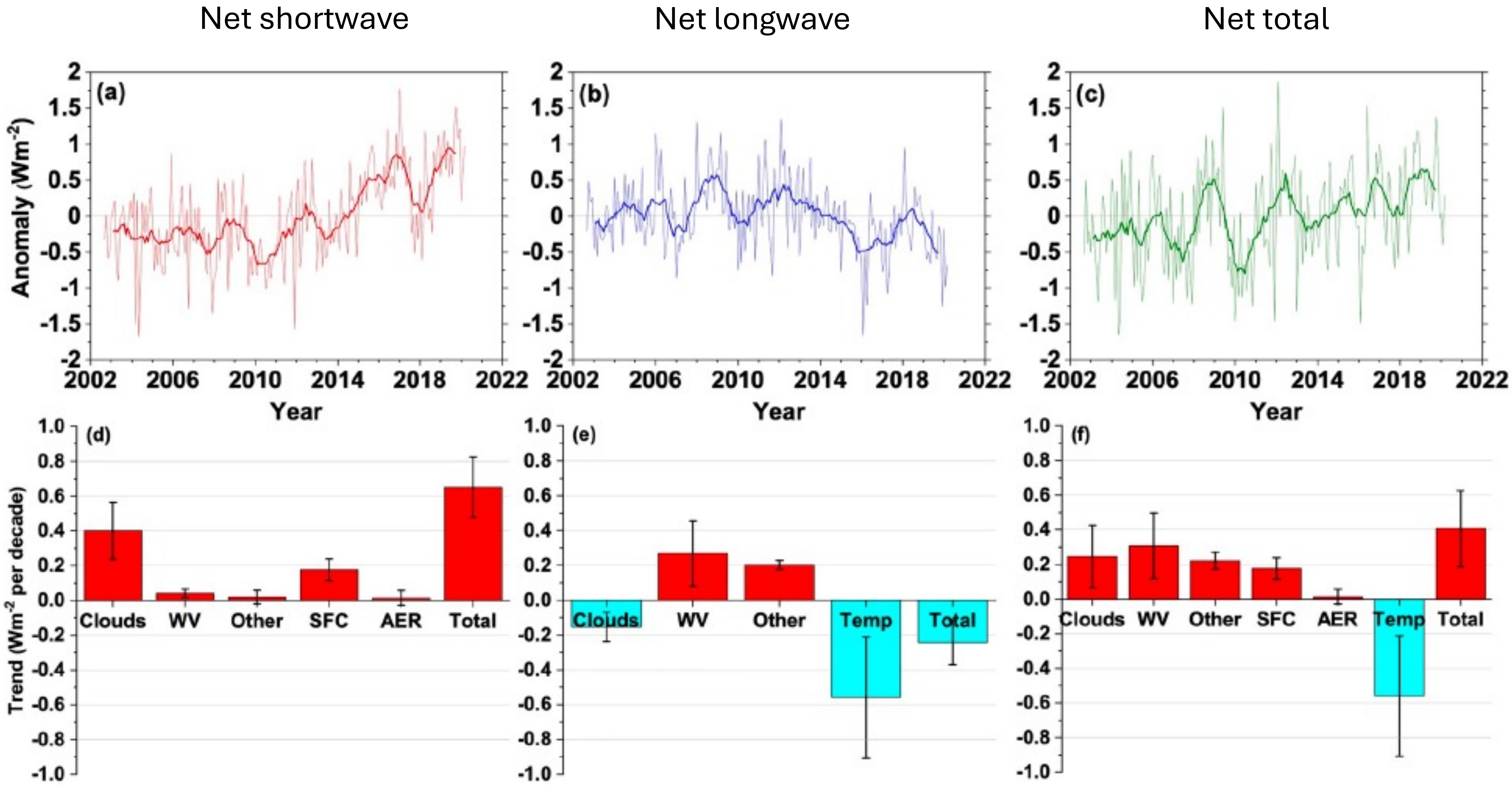
Difference of anomalies: EBAF - Observed



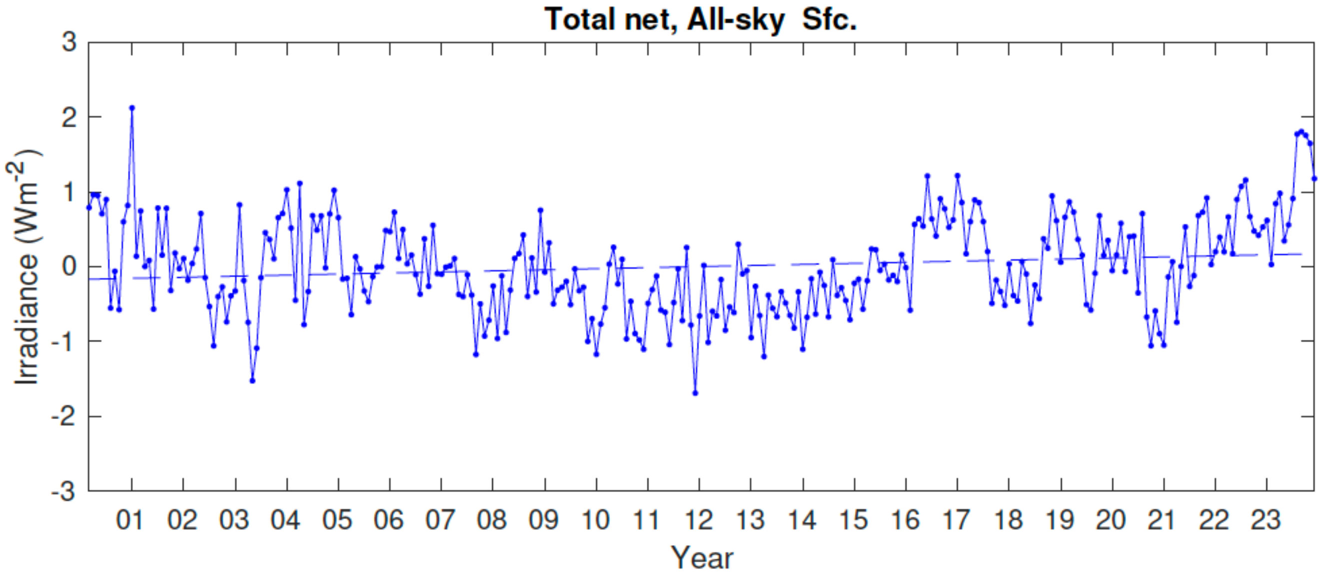
0.16 ± 0.13 Wm^{-2} dec^{-1}

-0.07 ± 0.16 Wm^{-2} dec^{-1}

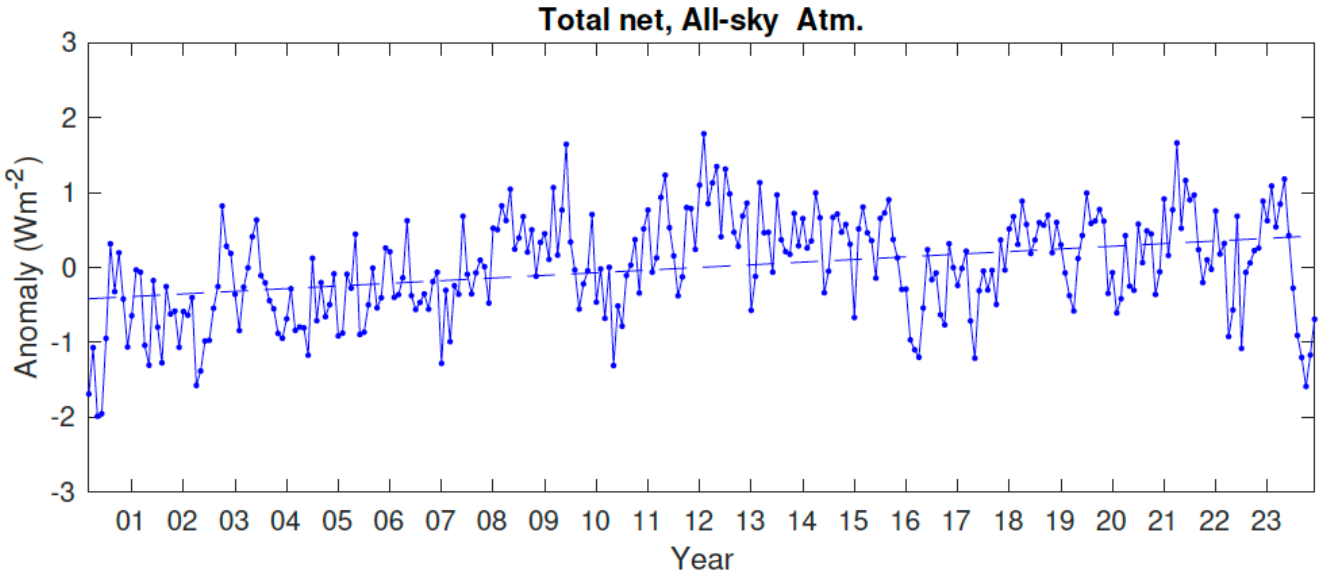
Contribution to TOA net irradiance trends (Loeb et al. 2021)



Surface, and net atmosphere trend

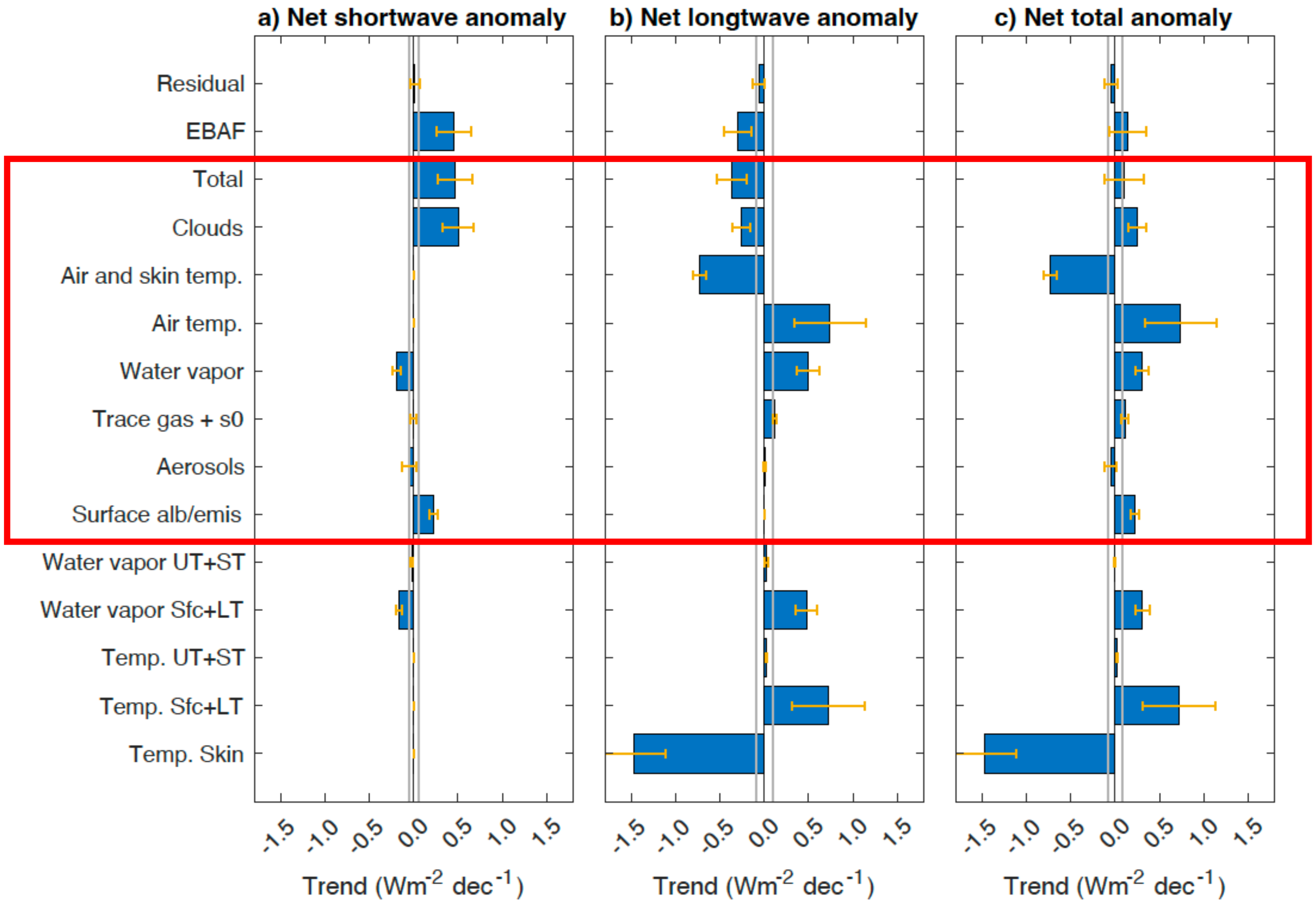


Net shortwave
0.45±0.19 Wm^{-2} dec^{-1}
Net longwave
-0.31±0.15 Wm^{-2} dec^{-1}
Net total
0.14±0.21 Wm^{-2} dec^{-1}

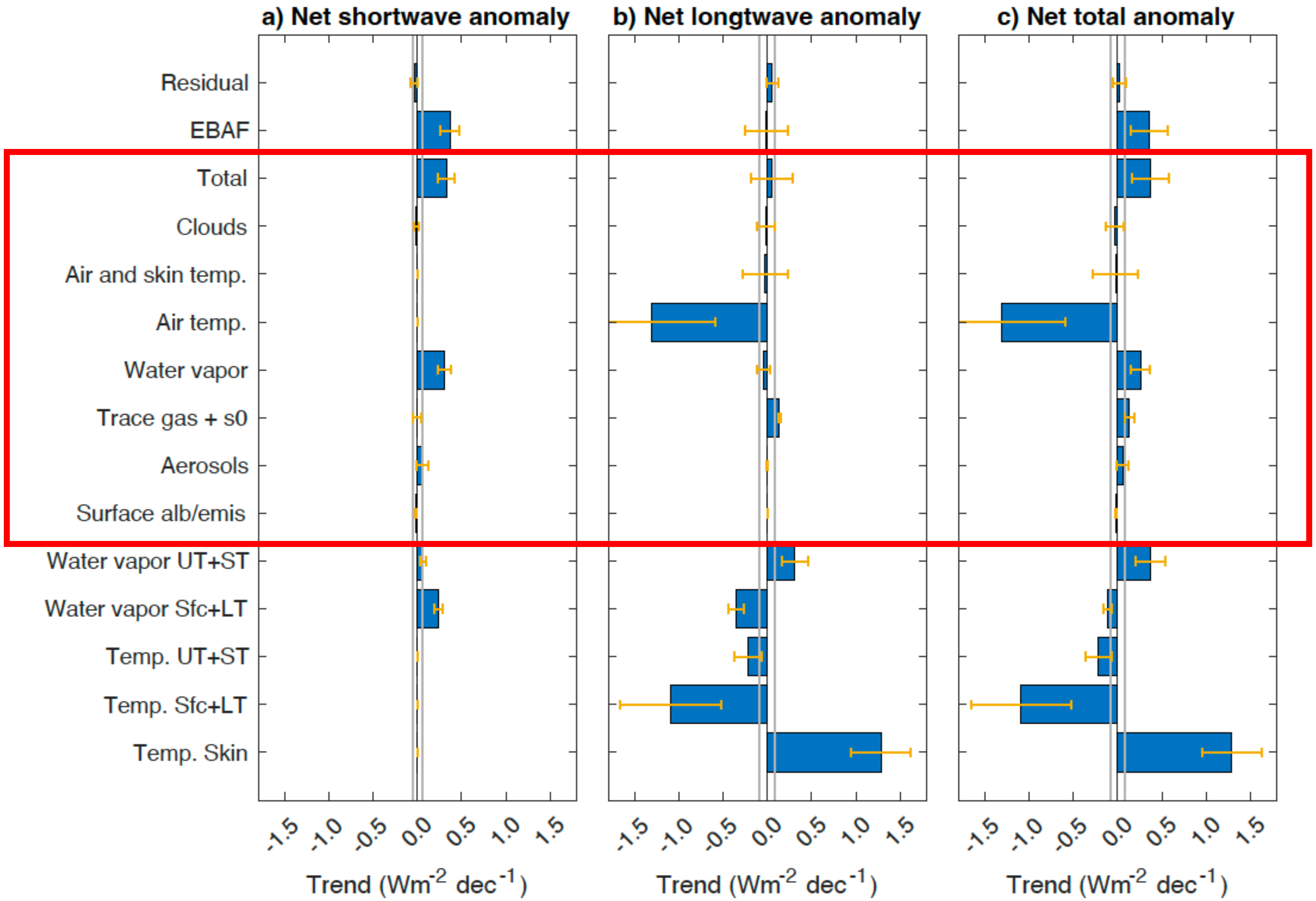


Net shortwave
0.37±0.11 Wm^{-2} dec^{-1}
Net longwave
-0.01±0.25 Wm^{-2} dec^{-1}
Net total
0.36±0.21 Wm^{-2} dec^{-1}

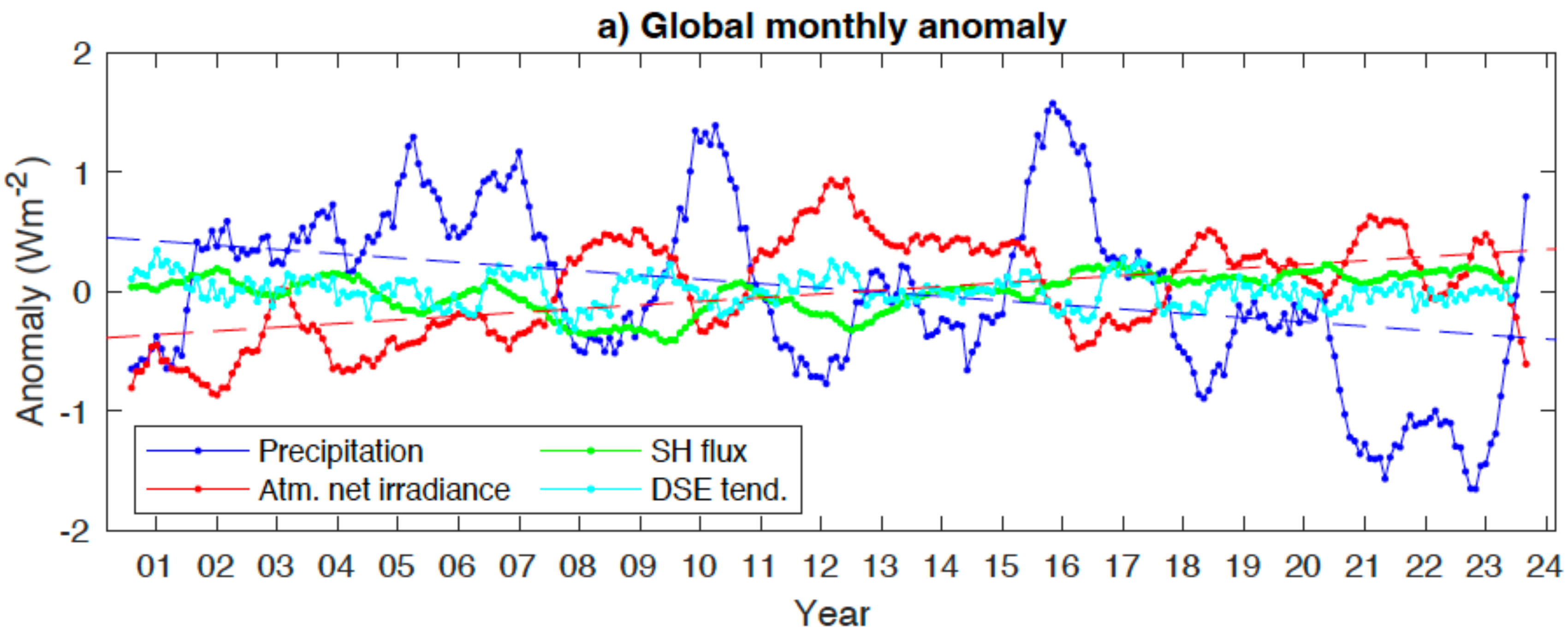
Contributions to global mean surface irradiance trend (all-sky)

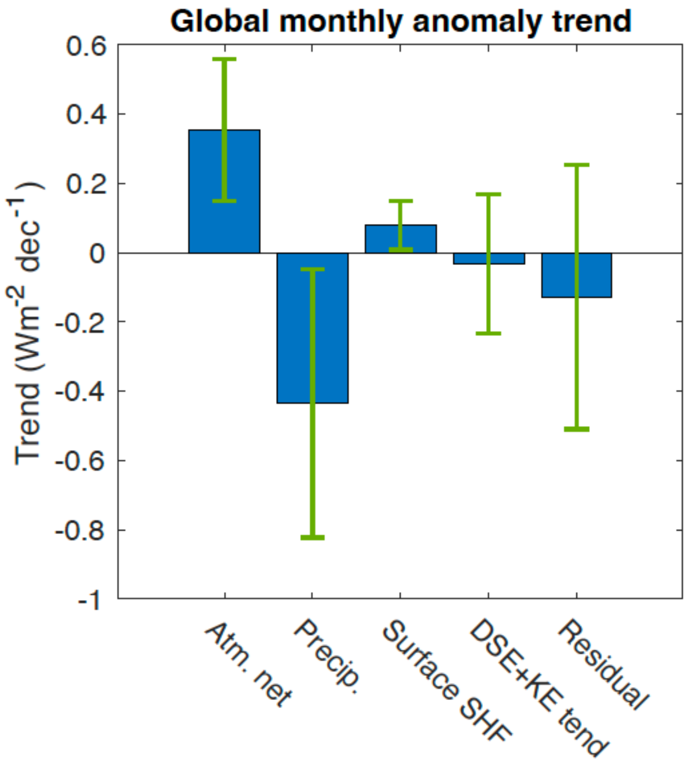


Contributions to global mean atmospheric irradiance trend (all-sky)

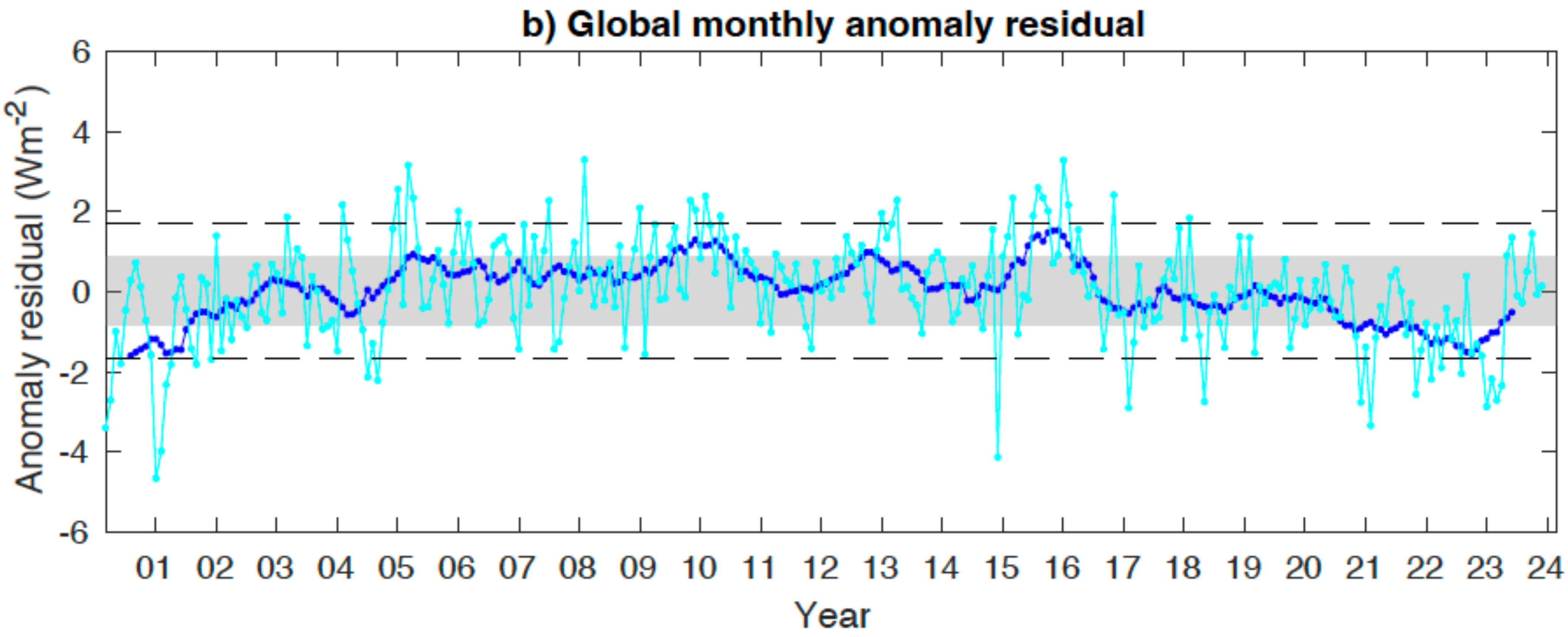


Anomalies time series of atm irradiance, precipitation, sensible heat flux, and dry static+kinetic energy tendency





Global atmospheric energy balance: anomalies



Summary and conclusions

- The correlation coefficients of EBAF and observed anomalies for 73 sites are 0.83 for downward shortwave and 0.93 for downward longwave irradiance anomalies.
- The trend of the time series differences are 0.16±0.13 Wm dec-1 for downward shortwave and -0.07±0.16 Wm-2 dec-1 for downward longwave irradiance anomaly differences.
- Contributions from water vapor and air and skin temperatures to net atmospheric longwave irradiance are largely canceled out so that the net atmospheric total irradiance trend appears to be driven by shortwave irradiance anomalies
- Trend of global met atmospheric total irradiance is 0.36 ± 0.21 Wm^{-2} dec^{-1} and trend of diabatic heating by precipitation is -0.43±0.39 Wm^{-2} dec^{-1}.