Global Atmospheric Heat Distributions Observed From Space

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Abstract: This study focuses on the observations of global atmospheric heat distributions using satellite measurements. Major heat components such as radiation energy, latent heat and sensible heat are considered. The uncertainties and error sources are assessed. Results show that the atmospheric heat is basically balanced, and the observed patterns of radiation and latent heat from precipitation are clearly related to general circulation.

Key Words: radiation, latent heat, sensible heat, satellite observation

1. Introduction

Global atmospheric heat distributions represent the balance among major atmospheric energy components, and are a critical part of general circulations of the atmosphere. Recently Lin et al. [1] have assessed satellite measurements of global atmospheric energy balances, and found significant progresses in the satellite measurements of global energy cycle during recent years. All major heat components are considered. This study uses satellite observations of the radiation at the top of atmosphere (TOA) and surface as well as the surface latent and sensible heat to estimate global atmospheric heat distributions. Precipitation latent heat releases are also used and compared with surface latent heat fluxes. Major features of atmospheric heat distribution are obtained from current study.

2. Data Sets

The TOA and surface radiation data are from satellite measurements of ERBE, CERES, SRB, and ISCCP, and the surface latent and sensible heat fluxes over oceans are the retrievals of SSM/I measurements. Over land, due to a lack of observationally-based turbulent heat flux estimations [2] assimilated results from global land surface models are used as the baseline for surface latent and sensible heat partitioning. The latent and sensible heat fluxes are actually estimated from this partitioning with the constraint of satellite observed surface radiation fluxes, that is, the estimates of land surface latent and sensible heat fluxes are the results of forced balances of the radiation, turbulent heat, and land surface heat storage. The precipitation latent heat releases are estimated using satellite GPCP precipitation data. The precipitation latent heat is found to be consistent with surface latent heat into the atmosphere. All these data sets and estimates are used to assess the global atmospheric heat distributions and balancing.

Because of satellite data availability of broadband radiation observations and microwave measurements for sea surface turbulent fluxes, this study considers the atmospheric heat distributions from 1988 to 2004.

3. Results

Global annual means of the TOA net radiation are close to zero. The net radiative heat fluxes into the surface and the surface latent heat transported into the atmosphere are about 113 and 86 W/m^2, respectively. The estimated atmospheric and surface heat imbalances are about –8 ~ 9 W/m^2, values that are within the uncertainties of surface radiation and sea surface turbulent flux estimates and likely systematic biases in the analyzed observations. The potential significant additional absorption of solar radiation within the atmosphere suggested by previous studies does not appear to be required to balance the energy budget: the spurious heat imbalances in the current data are much smaller (about half) than those obtained previously and debated at about a decade ago. For long-term heat flux measurements, TOA radiation shows a clear relationship with the changes in the ocean heat storage. Most oceanic latent and sensible heat data have significant unrealistic long-term variations. Some satellite global estimates of marine latent heat fluxes from evaporation and precipitation measurements even exhibit potential correlations with sea surface temperature records. While satellite surface radiation data show no significant changes during the same time period. These differences in the variability of radiation and turbulence need to be reconciled. The uncertainties in current satellite data sets may limit our capability of fully closing the atmospheric energy cycle.

Figure 1 shows global distributions of TOA radiation with interannual variability over major continents and oceanic basins. The heat losses in high latitudes and over polar regions are mainly maintained by the heat gained from lower latitudes. Land areas have generally stronger heating and cooling effects than oceans.

The latent heat fluxes over the globe (Fig. 2) have significant different distributions from radiation distributions. The annual surface latent heat supply to the atmosphere is about 82 W/m^2. This latent heat, along with surface sensible heat flux to the atmosphere, is the main heat source to balance the atmospheric radiative cooling. The latent heat fluxes over oceans (Arctic is excluded) are more than twice as big as those over land and have about 20 W/m^2 variability from basin to basin for the long-term annual means. Surface latent heat (~ 40 W/m^2) generally has a fairly smooth continental-scale distribution over land except that from South America where excessively-moist environmental conditions enhance latent heat (or evaporation) exchanges (~ 80 W/m^2) between land surface and the atmosphere. Those latent heat exchanges are mainly maintained by surface net radiation (not shown here) which, as expected, has large variations from 60 to 120 W/m^2 over land at continental scales and rather uniform distributions (~ 125 W/m^2) over oceans at basin scales. Sensible heat, one of the major heat components of the atmospheric energy cycle, is significantly larger over land than that over oceans.

4. Conclusions

The observations of atmospheric radiative and sensible heat as well as latent heat from surface evaporation and precipitation depict vivid pictures of global heat balances and transports. Long-term measurements of these global heat components are critical for climate studies.

References:

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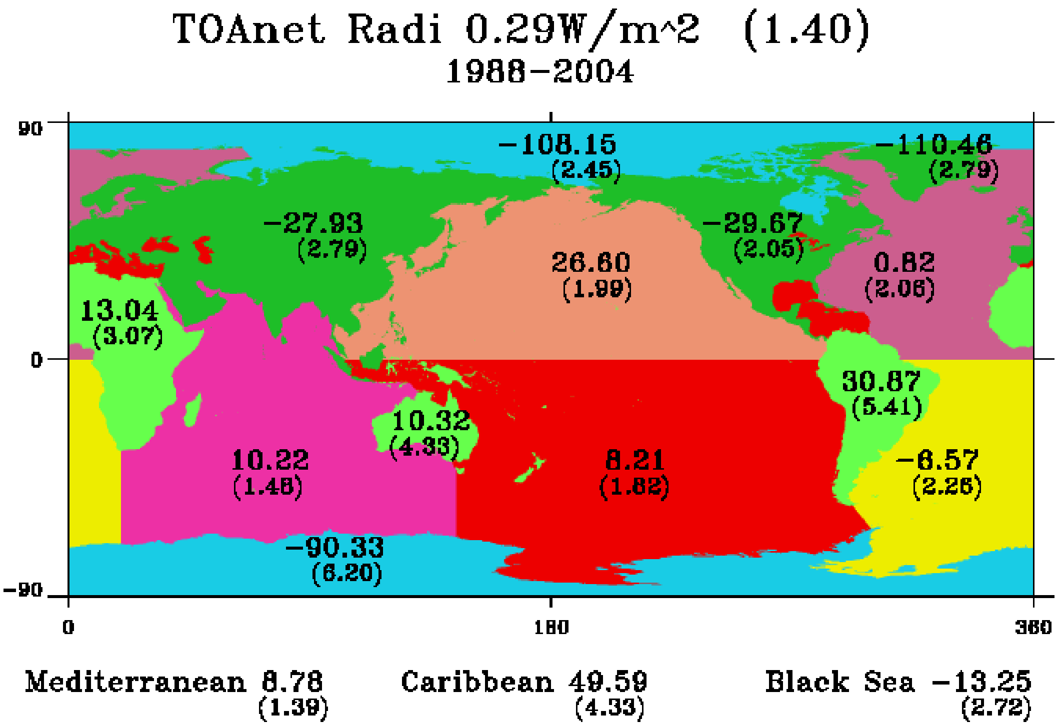

Fig. 1 Global distributions of TOA net radiation heating and interannual variability over major continents and oceanic basins. The numbers are annual means with their standard deviations.

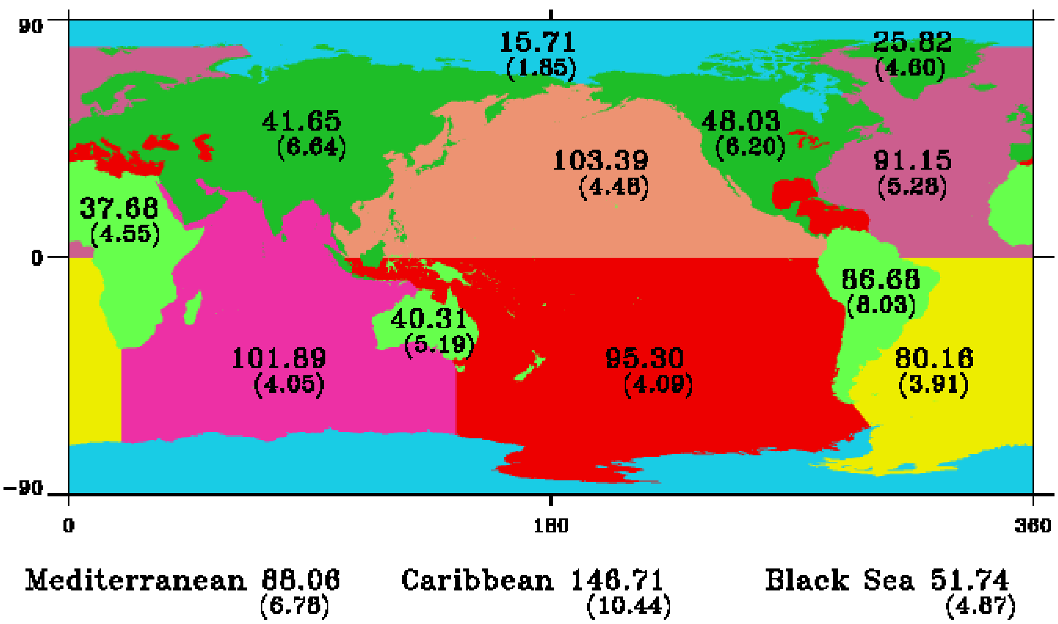

Fig. 2 Global distributions of latent heat fluxes and their interannual variations over major continents and oceanic basins. The numbers are annual means with their standard deviations.