**Final Report**

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**Results and Accomplishments**

In this single year project, we have systematically evaluate the realism and uncertainties of diabatic heating profiles produced by three recent global reanalyses (CSFR, ERA-Interim, MERRA). Diabatic heating profiles as direct output of temperature tendency related to diabatic processes (QT) are available from CFSR and MERRA. They were also estimated as residuals of the heat budget using grid data of temperature and wind (Q1). The main results are:

(1) Both Q1 and QT were compared to those based on sounding observations at eight locations of tropical field campaigns and compared themselves over the global domain in the absence of observations. The reanalysis-observation comparison revealed that diabatic heating profiles produced by the reanalyses match well with the observed at certain location, but not at others (Fig. 1). The limited availability of field observations is insufficient for a global assessment of the realism of the reanalysis heating profiles. The uncertainty in the reanalysis heating profiles must be estimated by comparing themselves.

(2) Diabatic heating profiles produced by the reanalyses were compared to themselves in different configurations: their zonal means, zonal means over the ocean and lands, respectively; their time means in the ITCZs and southern convergence zones of the Indian, Pacific, and Atlantic Oceans, in the monsoon regions, and in the storm tracks, and their seasonal cycle following the center of the ITCZs. They agree with each other in the gross features of zonal mean meridional distributions and contrast between single and double ITCZs. They appear to agree with each other better in the extratropics than in the tropics, and better over the ocean than land or coastal regions.

(3) The most significant disagreement among the reanalyses is the number and level of diabatic heating peaks. MERRA tends to produce three peaks, one in the boundary layer, one in the lower troposphere, and the third one in the upper troposphere. ERA-I often produces two peaks, in the lower and upper troposphere, respectively. CSFR most of the time produces only one peak, either in the lower troposphere or extending from lower to mid troposphere. This disagreement exists mainly in the tropics. Similar results were obtained from the ITCZ (Fig. 2) and southern convergence zones (not shown). The disagreement is striking in the seasonal cycle of the ITCZ (Fig. 3).

(3) It is suggested that the disagreement among the reanalyses in their diabatic heating profiles cannot be solely explained in terms of the cumulus parameterization schemes used in the data assimilation models. Different heating profiles can be produced by the

same reanalysis. The originally proposed work plan to further explore the reason for the disagreement in the reanalysis heating profiles was not funded in this one-year project. It will have to be tackled in a future project.

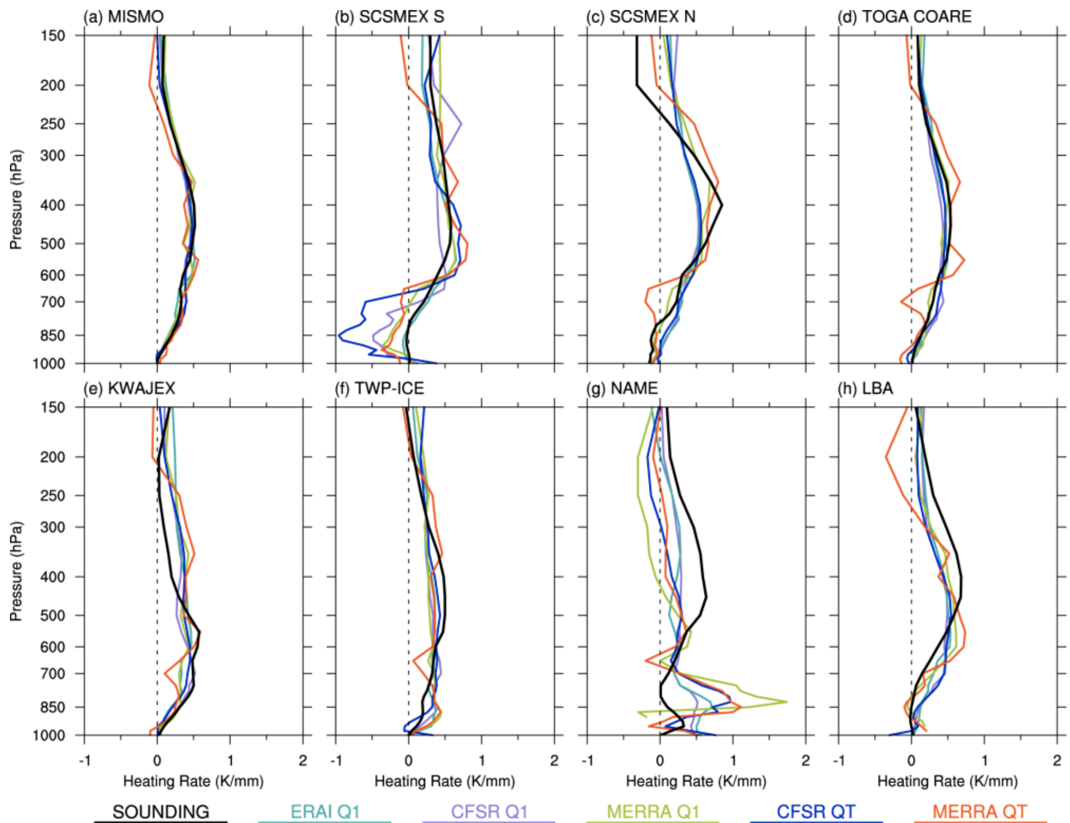


Figure 1 Normalized mean diabatic heating profiles (K $mm^{-1}$) from sounding observations and reanalyses at eight field campaign locations.

(4) Comparisons of Q1 and QT from CFSR and MERRA indicate that Q1 is in general a good approximation of QT, although Q1 tends to underestimate the amplitude of QT and is smoother in its vertical profiles than QT (Figs. 2 and 3).

The results from this project suggest that diabatic heating from the recent reanalyses have to be used with caution. Their agreement does not indicate their realism. Their disagreement measure their uncertainties. Sounding observations are the only reliable means to estimate diabatic heating profiles. Their current sample size is too small for a global evaluation. Field campaigns deploying sounding arrays that allow the estimate of diabatic heating must be encouraged and continue in the tropics.

**Publication:**


Ling, J., and C. Zhang: Diabatic heating profiles in recent global reanalyses. J. Clim. Submitted.

Ling, J., and C. Zhang: Monsoon evolution of diabatic heating profiles in recent global reanalyses. In preparation.

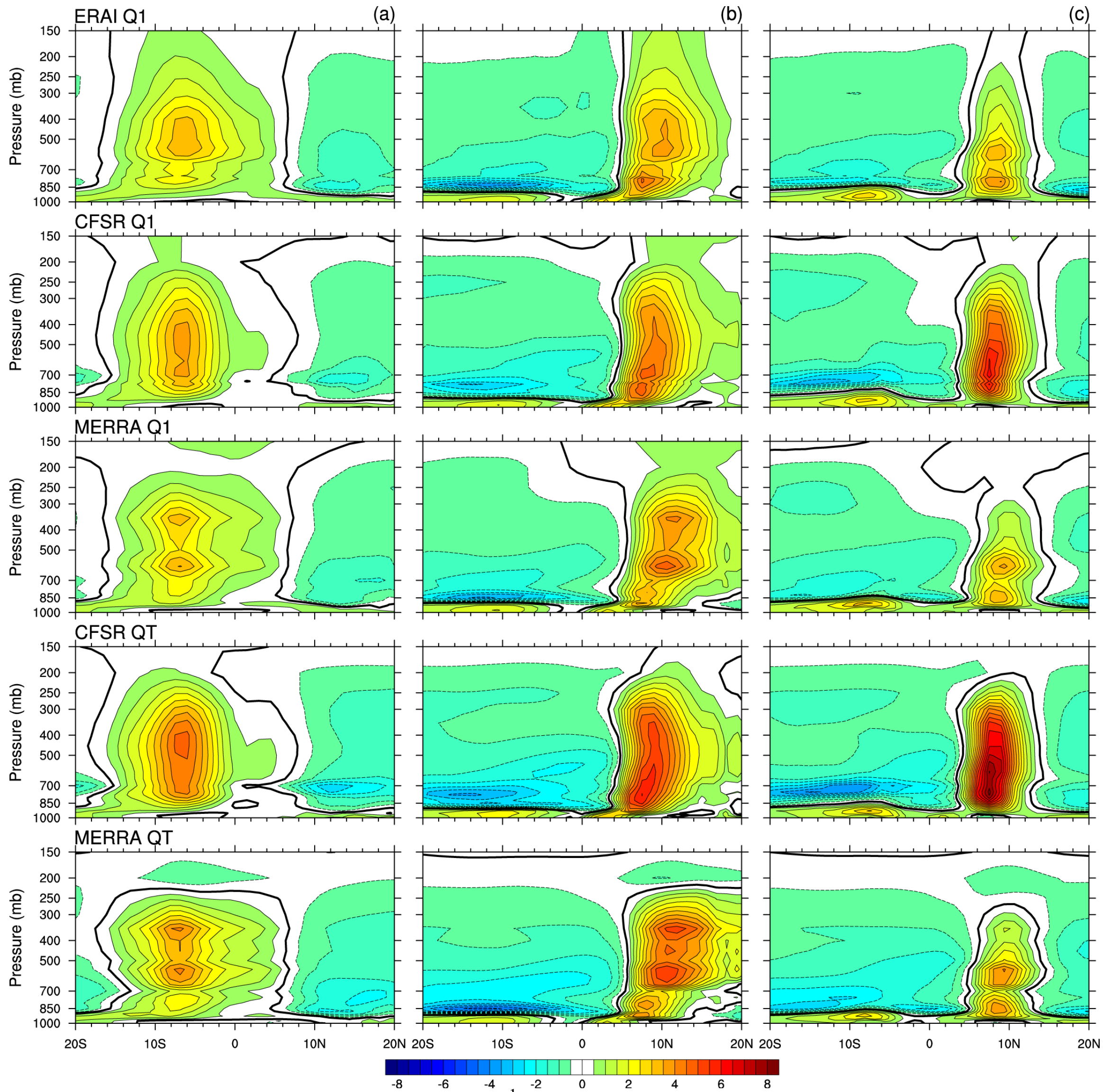


Figure 2 Time mean diabatic heating (K $day^{-1}$) averaged zonally over (left column) the Indian Ocean (60 - 90°E) in January, (middle) the eastern Pacific (90 - 120° W) in July, and (right) the Atlantic Ocean (20 - 40° W) in August for (from top panel to bottom) ERAI Q1, CFSR Q1, MERRA Q1, CFSR QT and MERRA QT. Thick contours for zeros, and positive values highlighted by the warm colors.

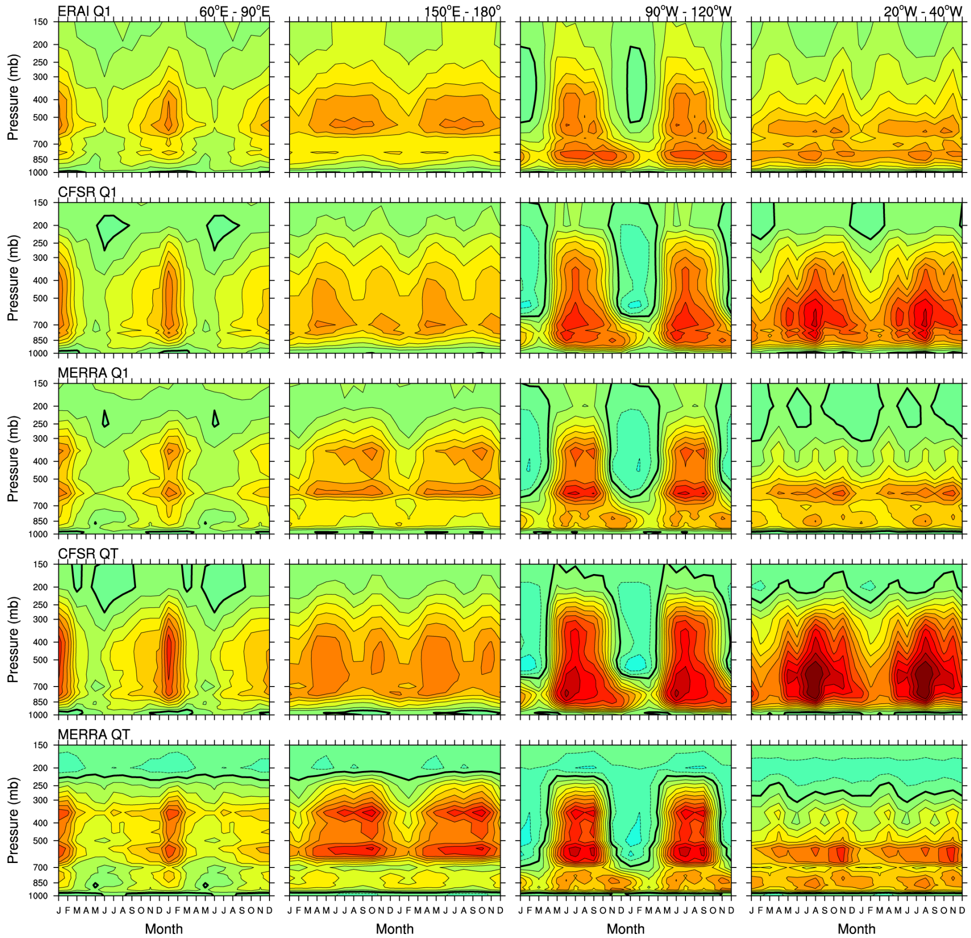


Figure 3 Lagrangian double seasonal cycles of ITCZ heating profiles from (top to bottom rows) ERAI Q1, CFSR Q1, MERRA Q1, CFSR QT and MERRA QT (interval 0.5 K $day^{-1}$) zonally averaged over (from left column to right) the Indian Ocean (60 - 90°E), western and central Pacific (150°E - 180°), eastern Pacific (90 - 120°W), and Atlantic Ocean (20 - 40°W) following the latitudes of the ITCZ centers in each month. Thick contours for zeros, and positive values highlighted by the warm colors.

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