

Comparison of MERRA-2 and ECCO-v4 ocean surface heat fluxes: Consequences of different forcing feedbacks on ocean circulation and implications for climate data assimilation

Ehud Strobach^{1,2,†}, Andrea Molod¹, Gael Forget³, Jean-Michel Campin³, Chris Hill³, Dimitris Menemenlis⁴ and Patrick Heimbach⁵

¹University of Maryland, ²NASA Goddard Space Flight Center, ³Massachusetts Institute of Technology, ⁴NASA Jet Propulsion Laboratory, ⁵University of Texas at Austin

† E-mail: ehud.strobach@nasa.gov



Web: essic.umd.edu/joom2

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1. Introduction

In coupled data-assimilation (DA), feedbacks between the ocean and the atmosphere are active, but, depending on the system “flavor”, they are constrained by the observations. We demonstrate that insights about coupled DA can be gained in an ocean only setup and using different forcing methods which act to limit some of the feedbacks and replace the constraining effect of observations in coupled DA.

2. Experimental Setup

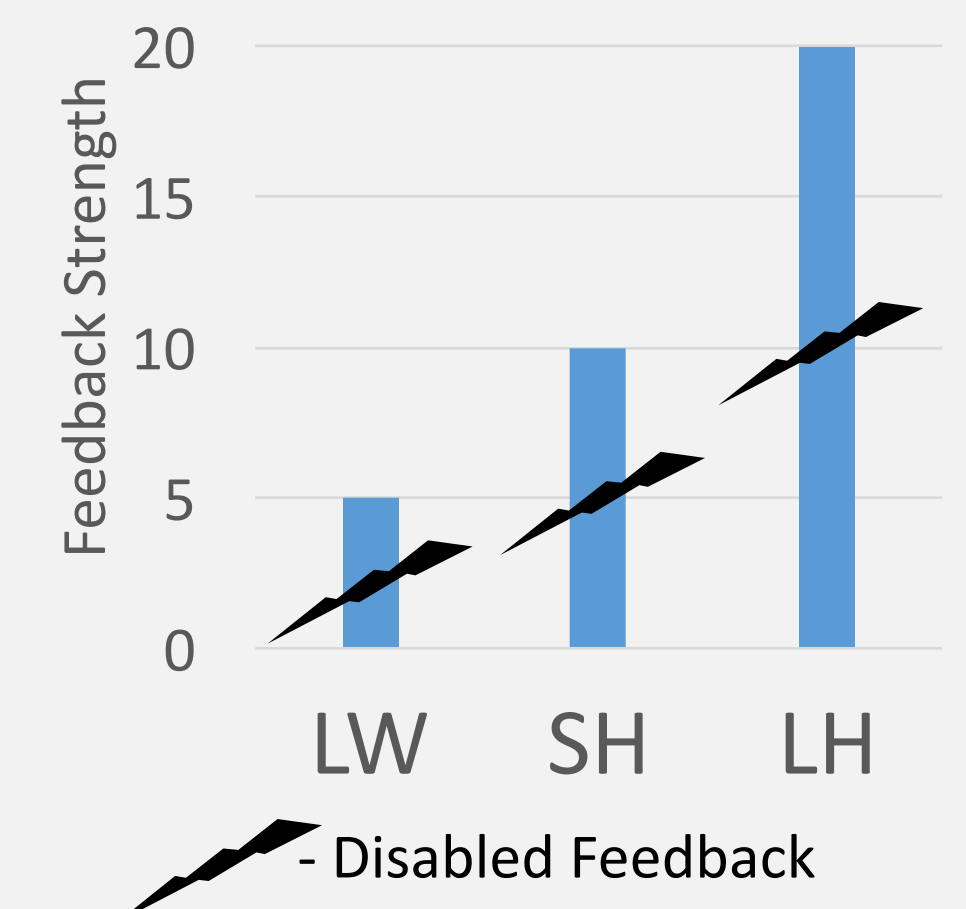
We ran MITgcm ocean model (ECCO-v4 underlying ocean model) forced with fields from MERRA-2 (for which GEOS is the underlying atmospheric model) between 1992 to 2011. Different forcing methods were used to imitate different “flavors” of a coupled GEOS-MITgcm DA system in an ocean-only setup. By doing so we were able to turn off different air-sea feedbacks which, in a coupled DA setup, are partially muted by the constraining observations. The set of experiments, therefore, represents a range of active feedbacks in different “flavors” of coupled data-assimilation systems.

4. Conclusions

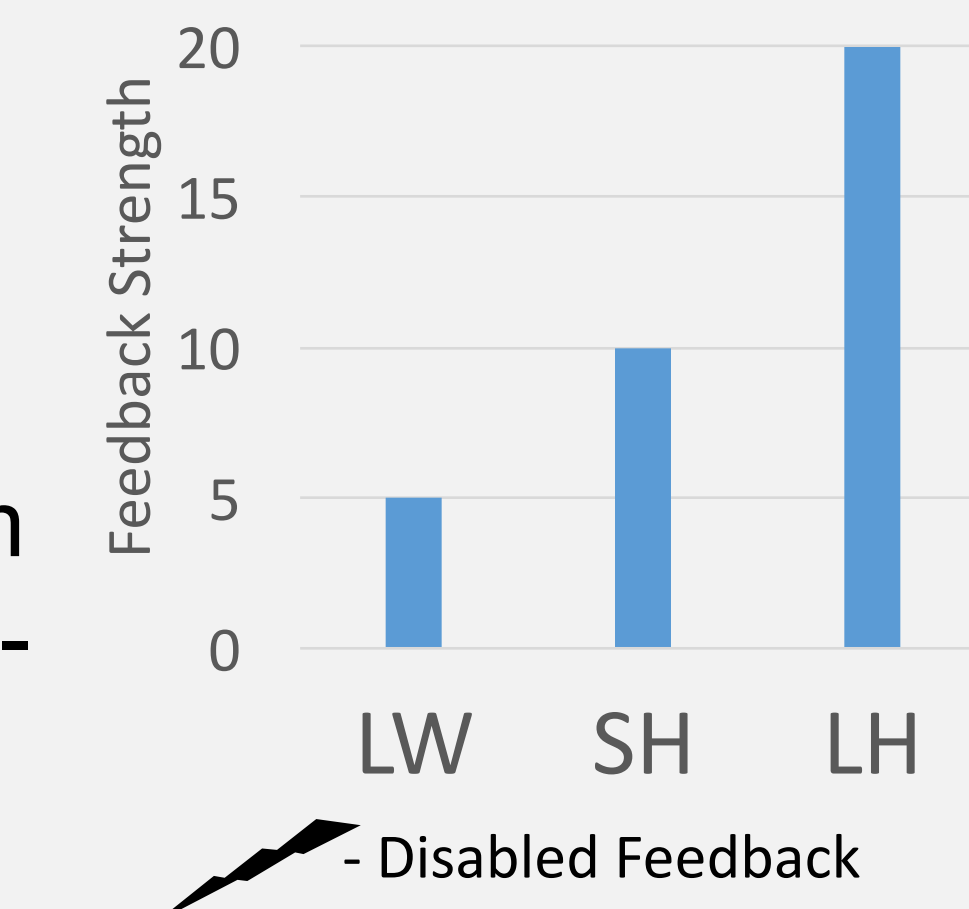
- Errors in the atmospheric DA are expected to propagate to different components of the ocean model in a coupled DA. The “flavor” of the DA system will determine where the errors propagate.
- The investigation of air-sea flux errors in the uncoupled components of the model can help anticipate and avoid errors in the coupled version of the system.

3. Results

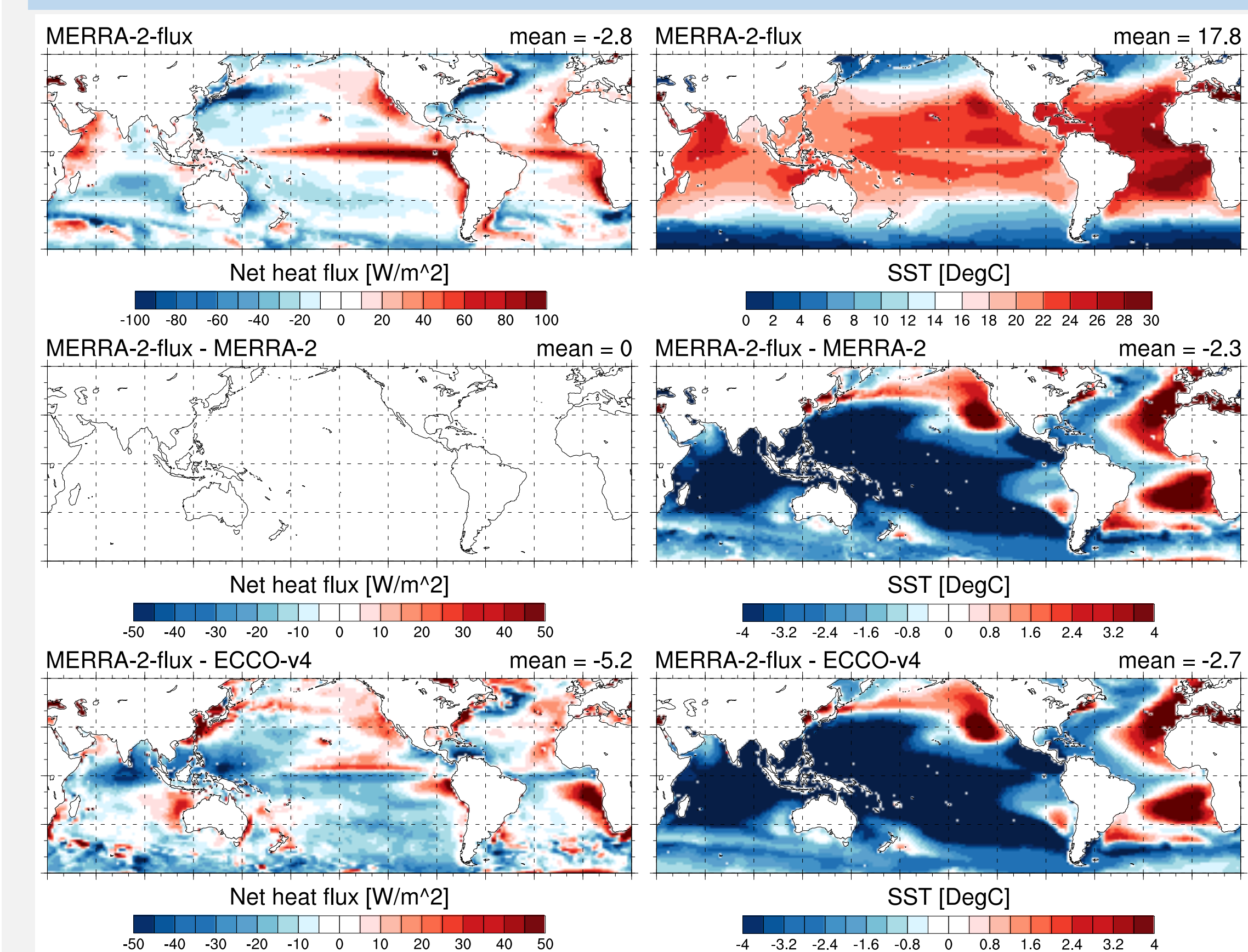
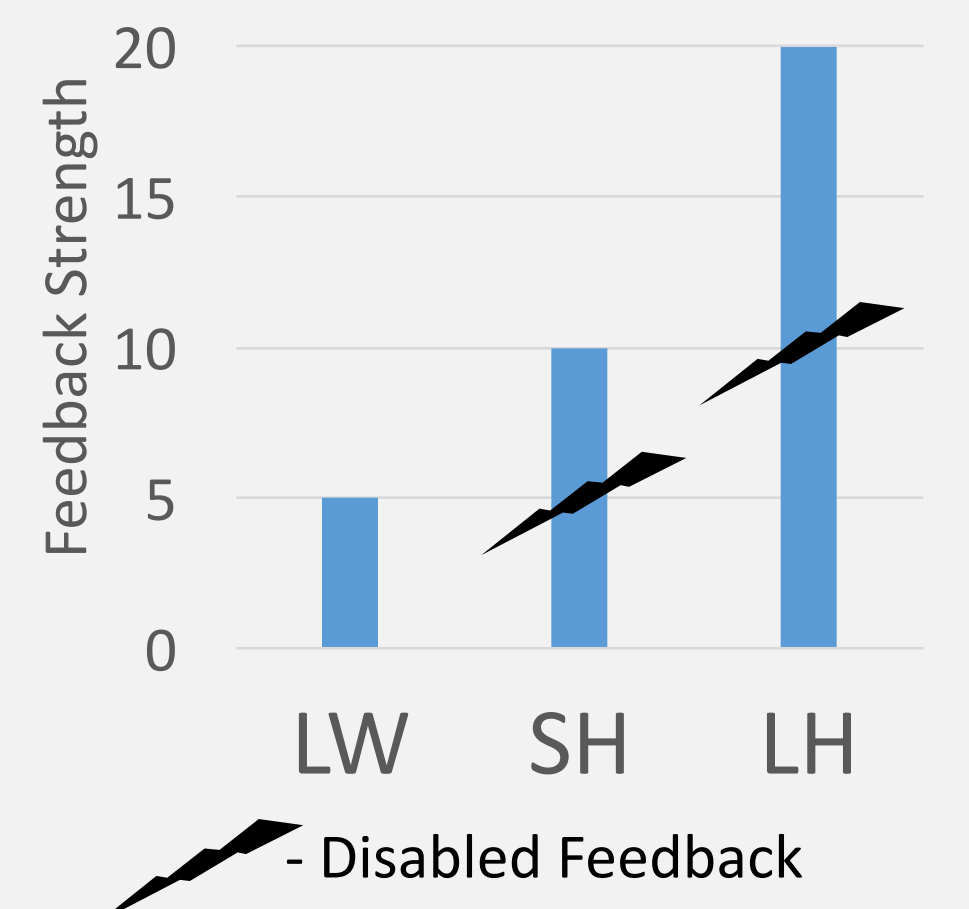
MERRA-2-flux
MITgcm forced with MERRA-2 surface fluxes
MERRA-2-flux can be seen as an amplification of the errors that will propagate from the atmosphere to the ocean in a strongly constrained coupled DA system.



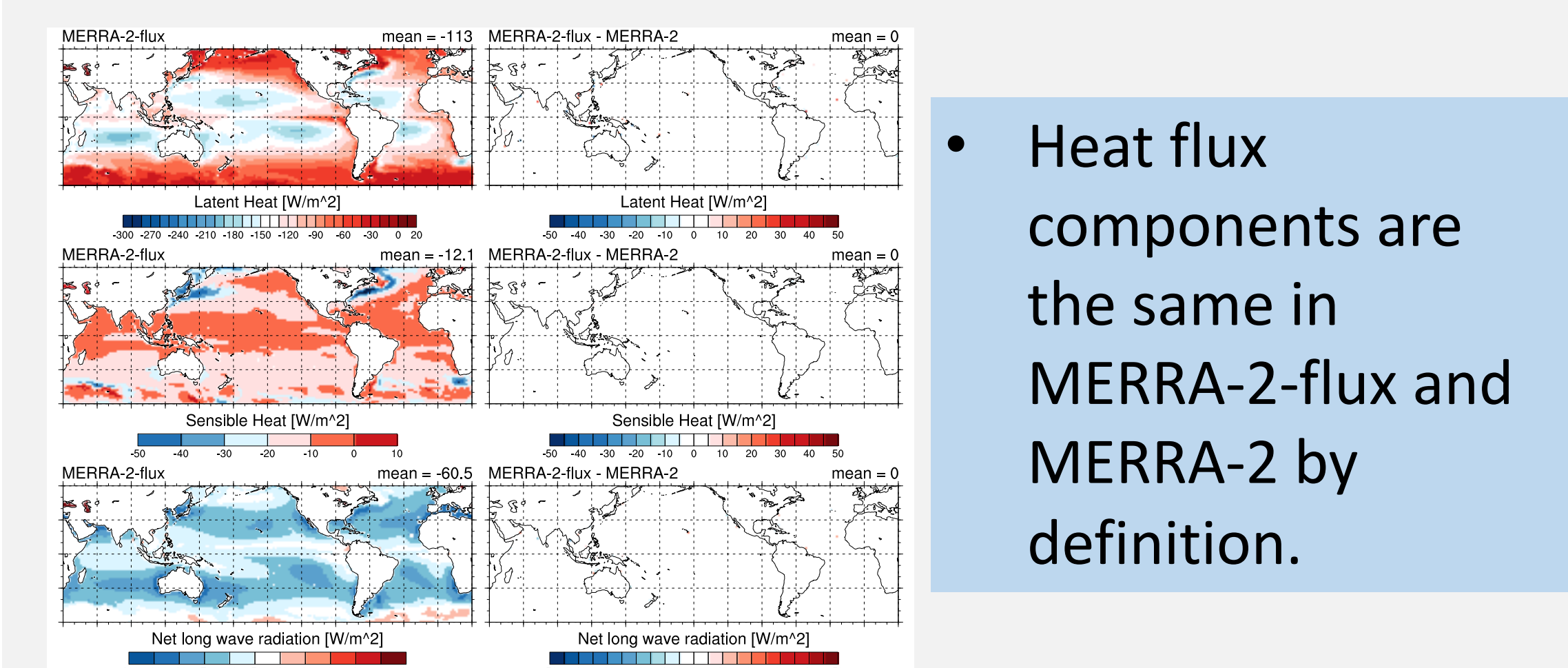
MERRA-2-state
MITgcm forced with MERRA-2 state variables
MERRA-2-state can be seen as a coupled DA system that is less constrained (more active feedbacks) than the system represented in the MERRA-2-flux experiment.



MERRA-2-turb
MITgcm forced with MERRA-2 turbulent fluxes
MERRA-2-turb may reflect a “compromise” state between the ocean and the atmosphere in a coupled DA system.



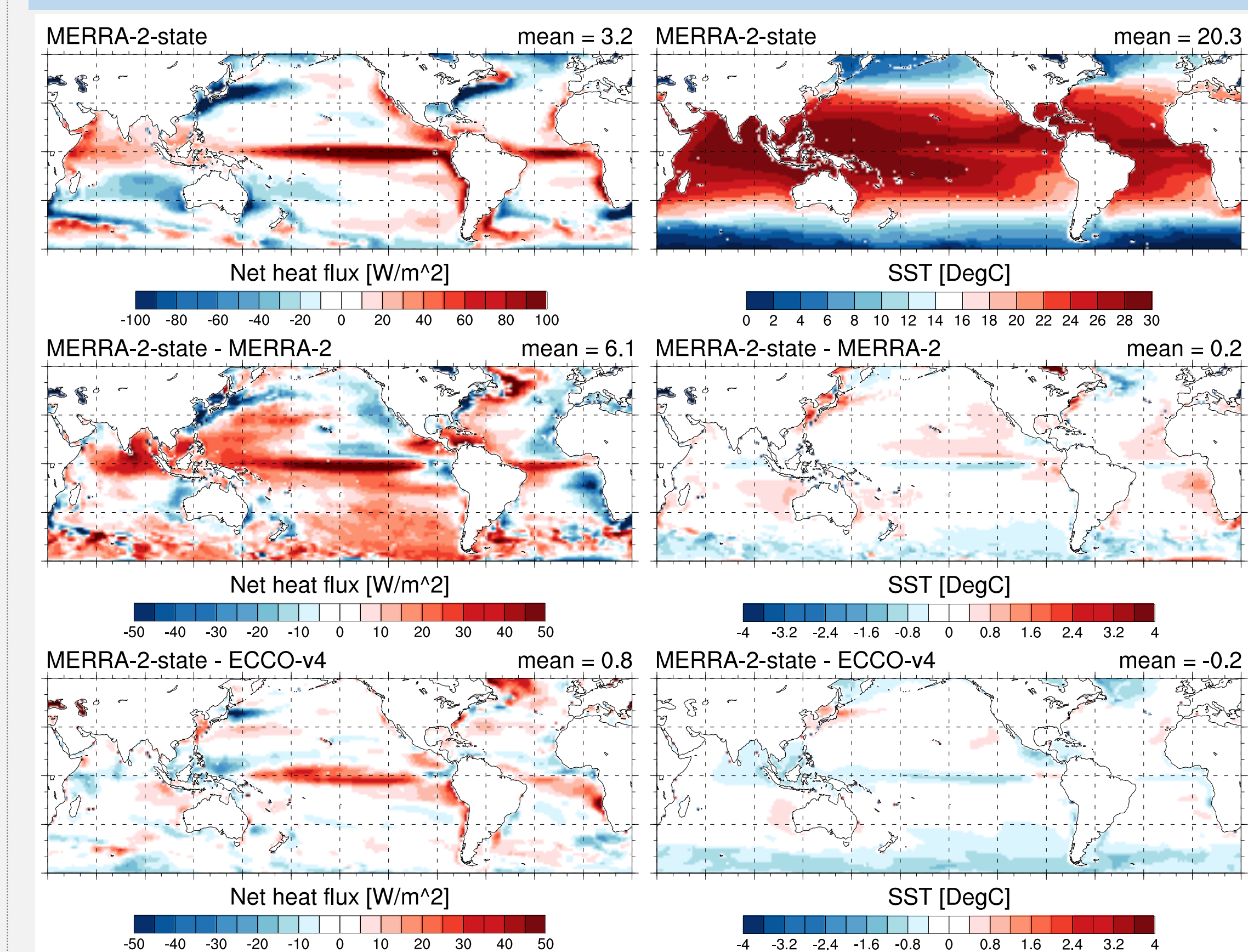
20-year average of net surface heat flux (upper left) and SST (upper right); difference between MERRA-2-flux and the original MERRA-2 fields (middle); and difference between the MERRA-2-flux the ECCO-v4 fields (lower).



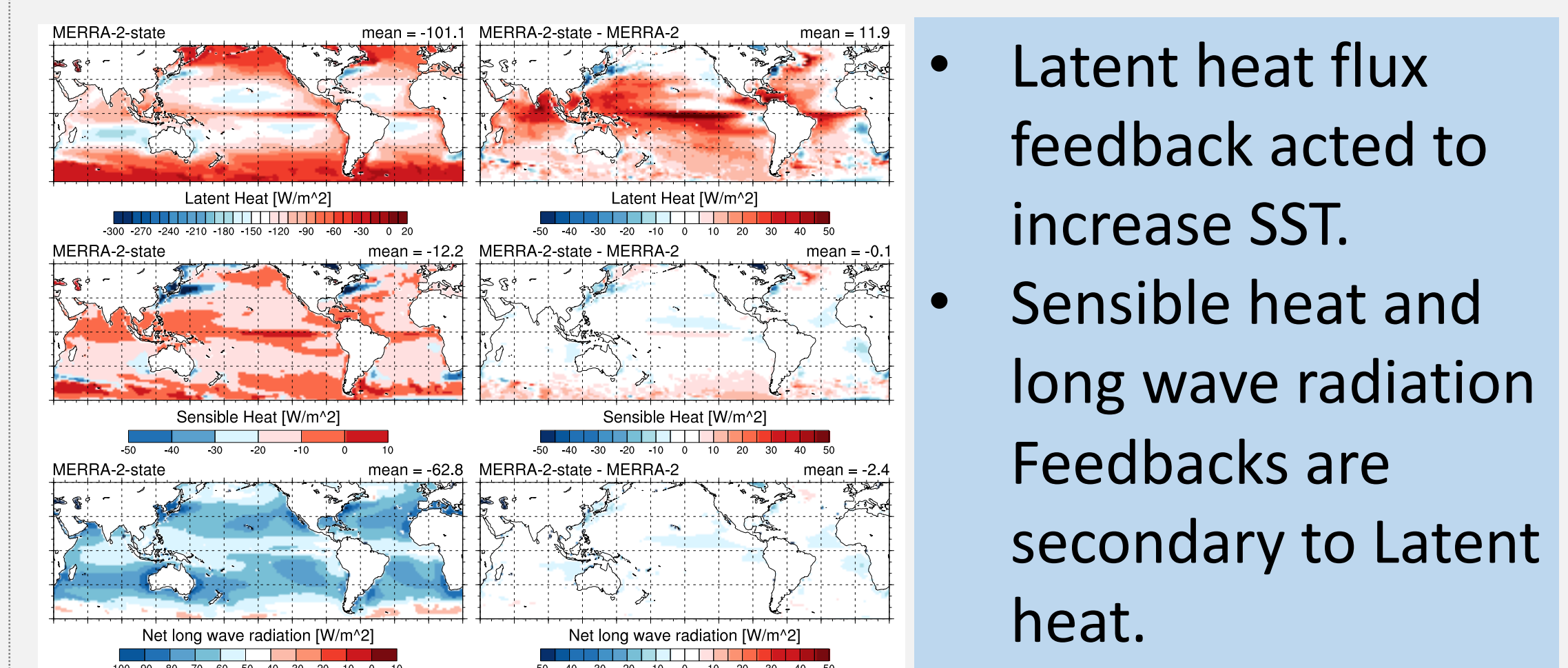
MERRA-2-flux 20-year average of latent heat, sensible heat and net long wave. The first column shows MERRA-2-flux fluxes, the second column shows MERRA-2-flux minus the original MERRA-2 fluxes, and the third column shows MERRA-2-flux minus ECCO-v4 fluxes.

- Heat flux components are the same in MERRA-2-flux and MERRA-2 by definition.

SST restored but errors propagated to the water cycle resulted global sea-level increase by 2.7m (not shown).



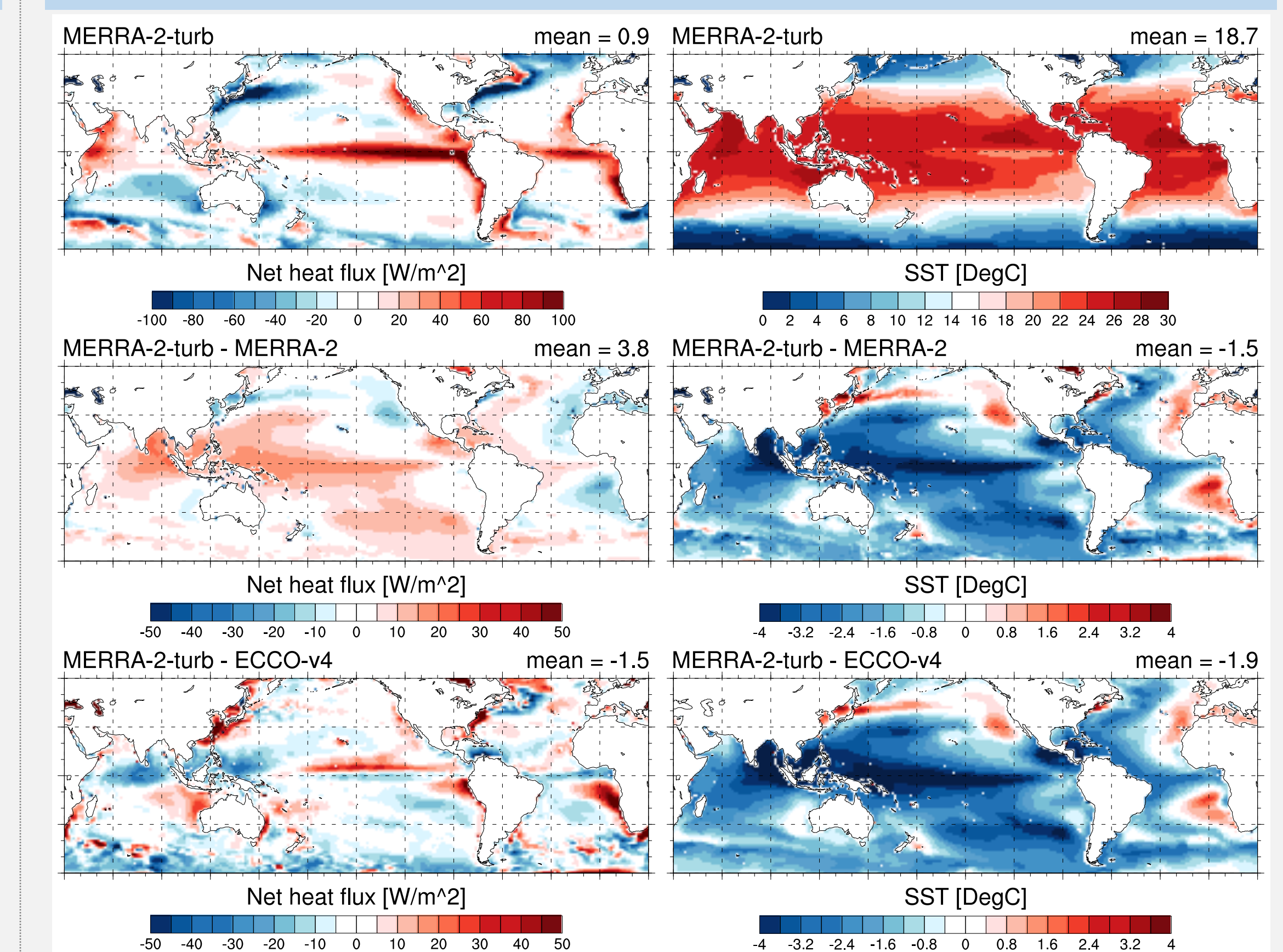
20-year average of net surface heat flux (upper left) and SST (upper right); difference between MERRA-2-state and the original MERRA-2 fields (middle); and difference between the MERRA-2-state the ECCO-v4 fields (lower).



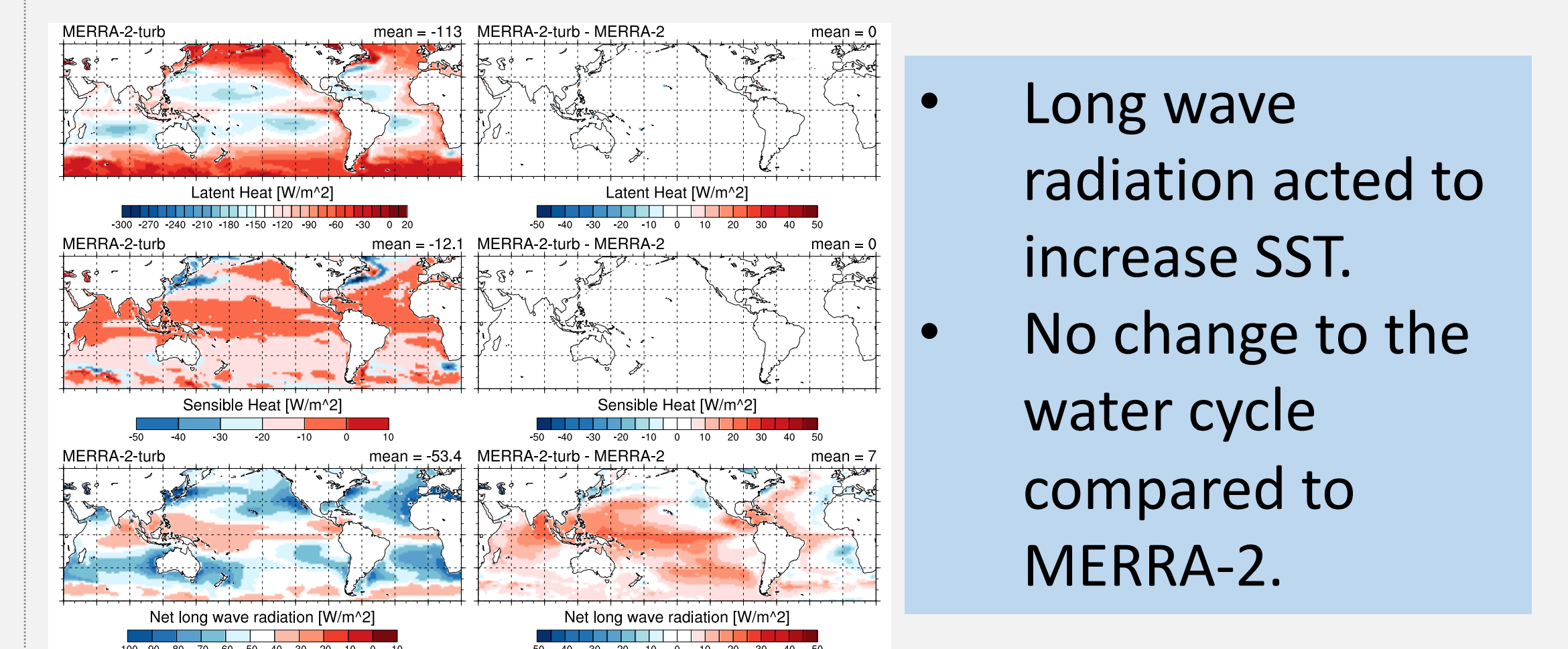
MERRA-2-state 20-year average of latent heat, sensible heat and net long wave. The first column shows MERRA-2-state fluxes, the second column shows MERRA-2-state minus the original MERRA-2 fluxes, and the third column shows MERRA-2-state minus ECCO-v4 fluxes.

- Latent heat flux feedback acted to increase SST.
- Sensible heat and long wave radiation Feedbacks are secondary to Latent heat.

Better SST compared with MERR-2-flux and no change in the water cycle compared with MERRA-2 reanalysis.



20-year average of net surface heat flux (upper left) and SST (upper right); difference between MERRA-2-turb and the original MERRA-2 fields (middle); and difference between the MERRA-2-turb the ECCO-v4 fields (lower).



MERRA-2-turb 20-year average of latent heat, sensible heat and net long wave. The first column shows MERRA-2-turb fluxes, the second column shows MERRA-2-turb minus the original MERRA-2 fluxes, and the third column shows MERRA-2-turb minus ECCO-v4 fluxes.

- Long wave radiation acted to increase SST.
- No change to the water cycle compared to MERRA-2.



Nomenclature

- MERRA-2: Modern-Era Retrospective analysis for Research and Applications, Version 2 (NASA GMAO atmospheric reanalysis)
- GEOS: Goddard Earth Observing System Model – MERRA-2 underlying atmospheric model
- ECCO-v4: Estimating the Circulation and Climate of the Ocean Version 4 (ocean state estimate)
- MITgcm: Massachusetts Institute of Technology general circulation model – ECCO-v4 underlying ocean model



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