National Aeronautics and Space Administration

The Radiative Energy Budget of the Polar Atmosphere in Contemporary Reanalyses

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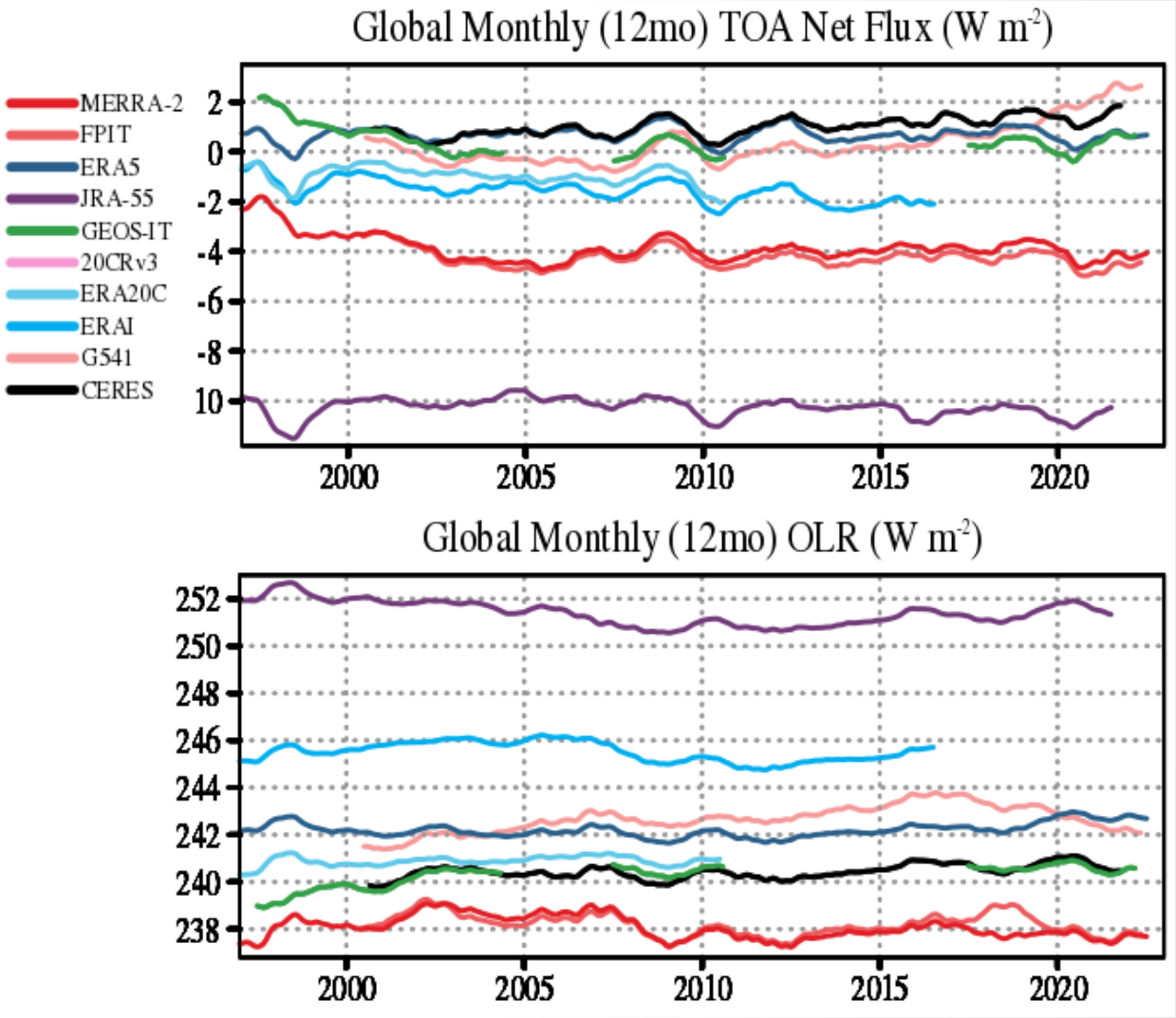
Recent GMAO Reanalysis Projects

- **PolarMERRA**: a development project with GMAO, Cryospheric Sciences Lab to assess & improve the representation of polar processes.

  As part of PolarMERRA, we wish to understand capabilities of contemporary reanalyses.

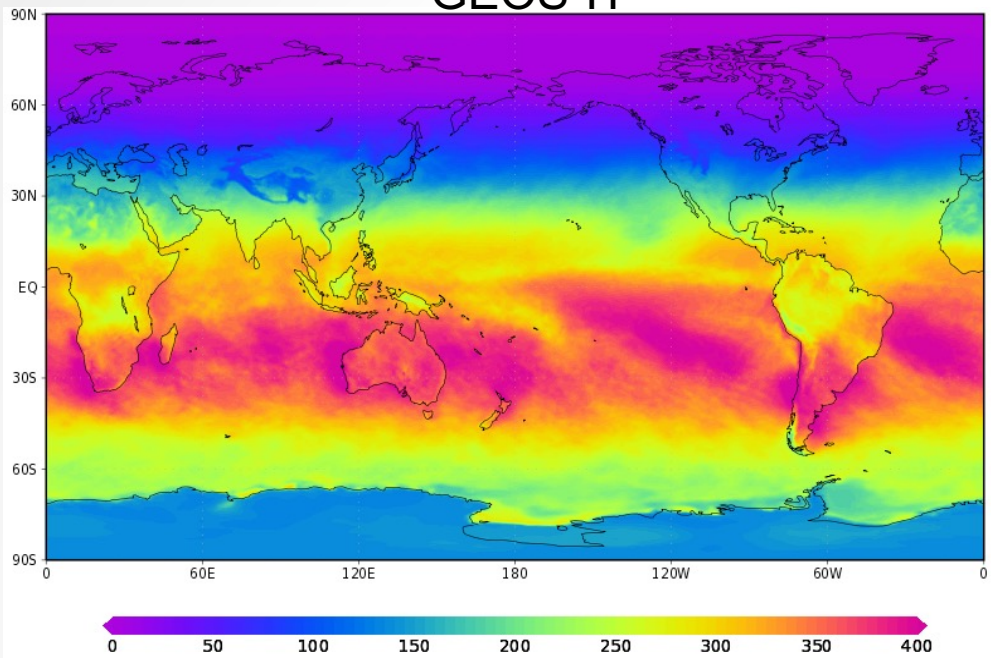
- **GEOS-IT**: 1998-present stable reanalysis product for instrument teams – distributed by GES DISC to IT teams, completion expected late summer/fall.

- **GEOS-R21C**: Enhanced reanalysis using all-sky radiance assimilation – later in 2023.

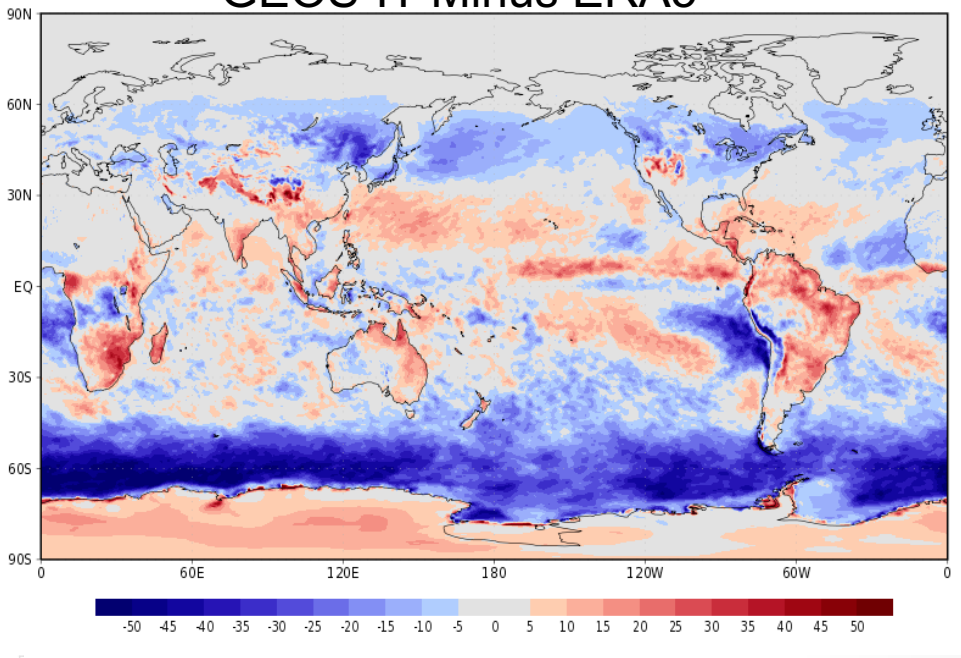


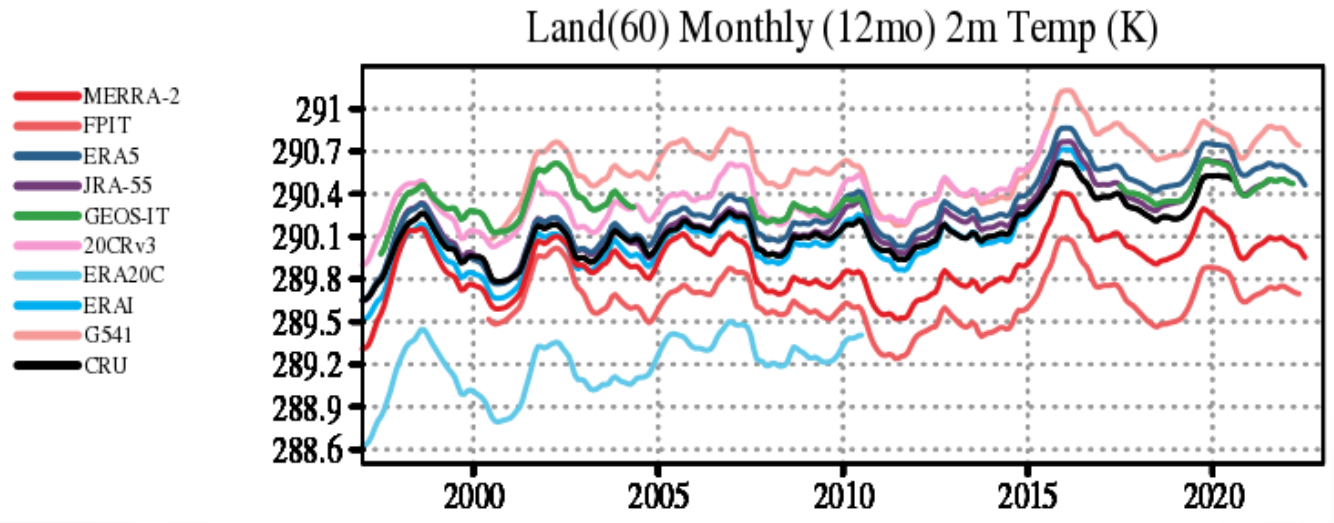
TOA Net Shortwave Flux DJF 2019/2020 [W m^{-2}]

GEOS-IT



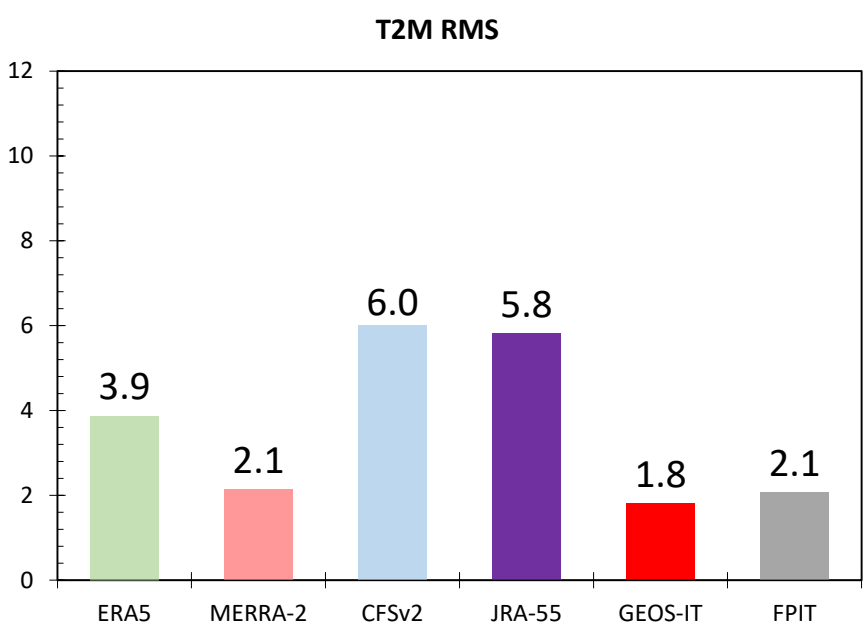
GEOS-IT Minus ERA5



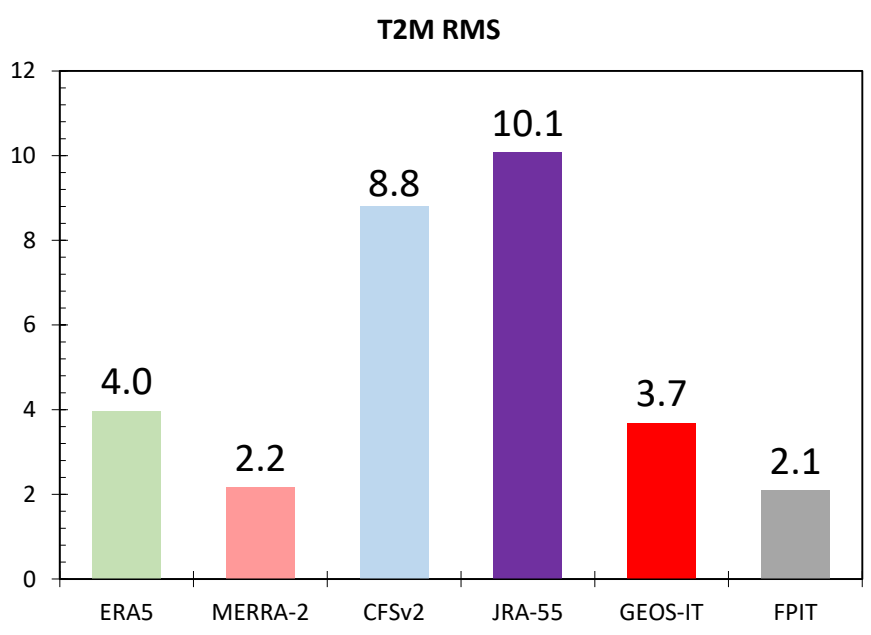


2-m Temperature Differences

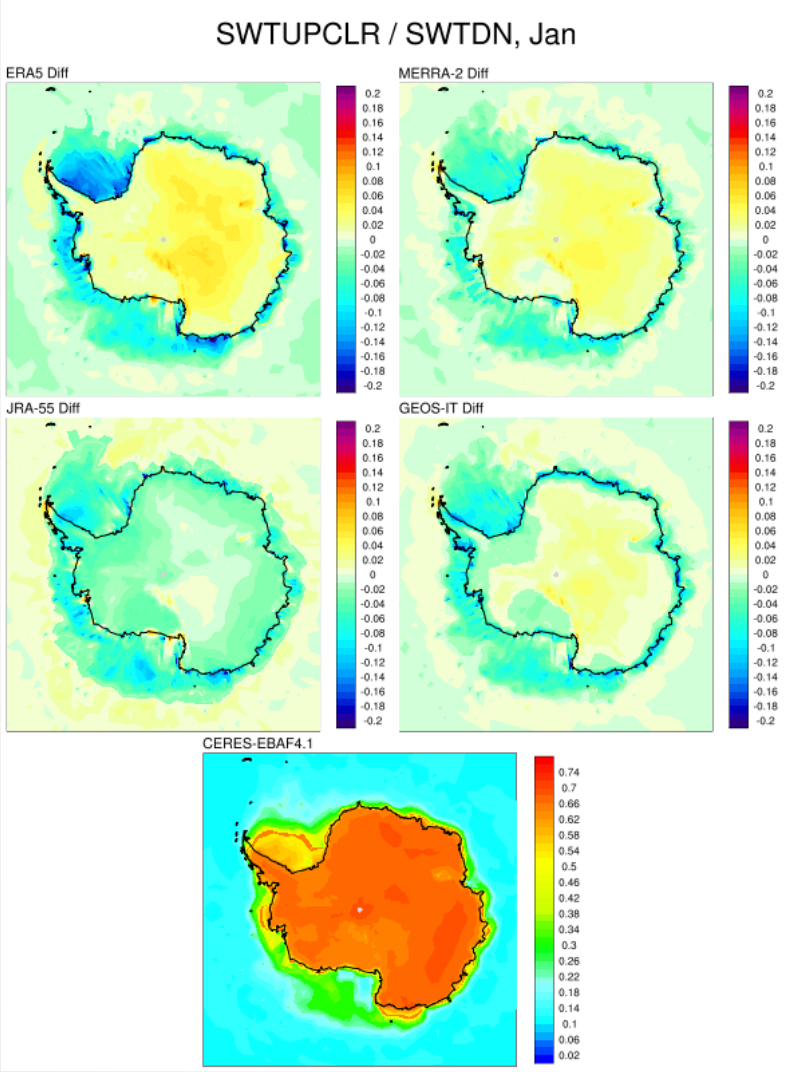
South Pole – Annual RMS With Station Values [K]

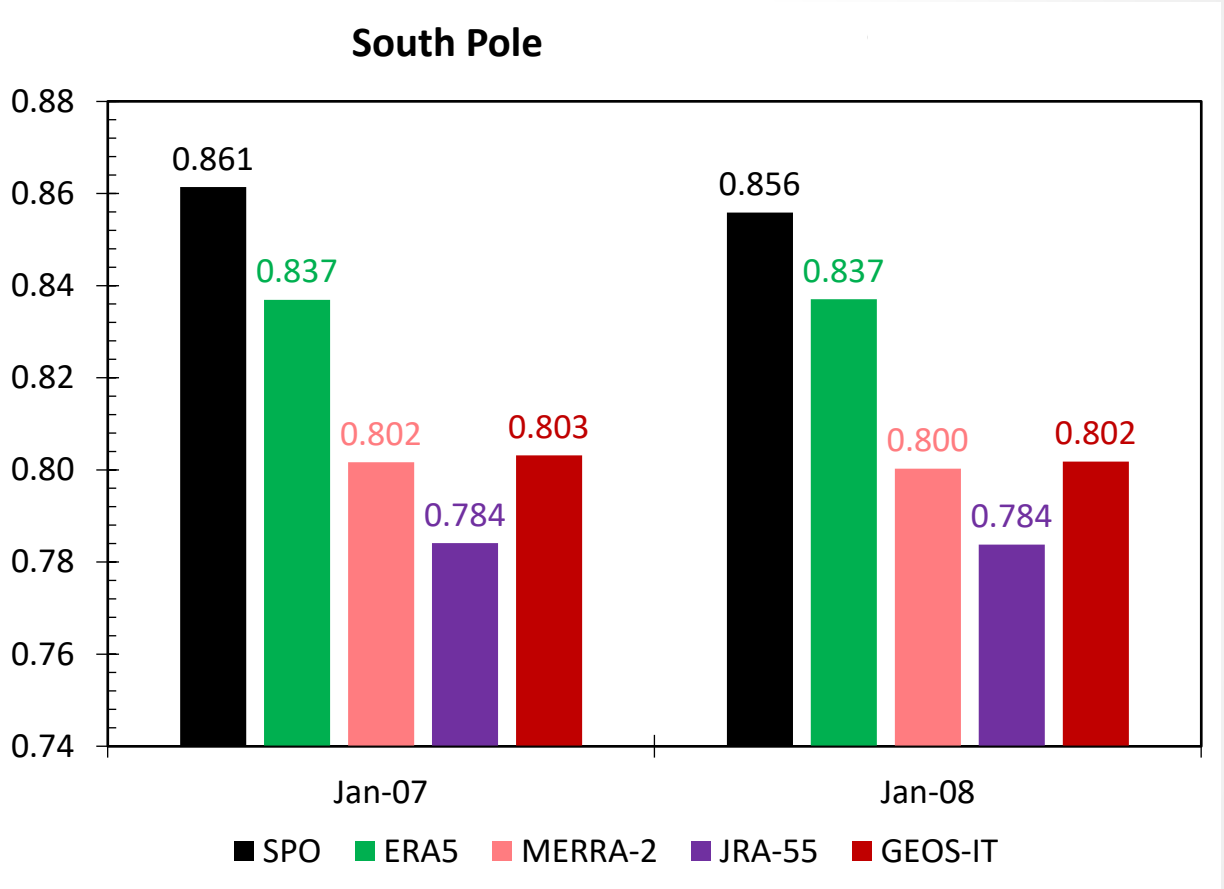


Vostok – Annual RMS With Station Values [K]

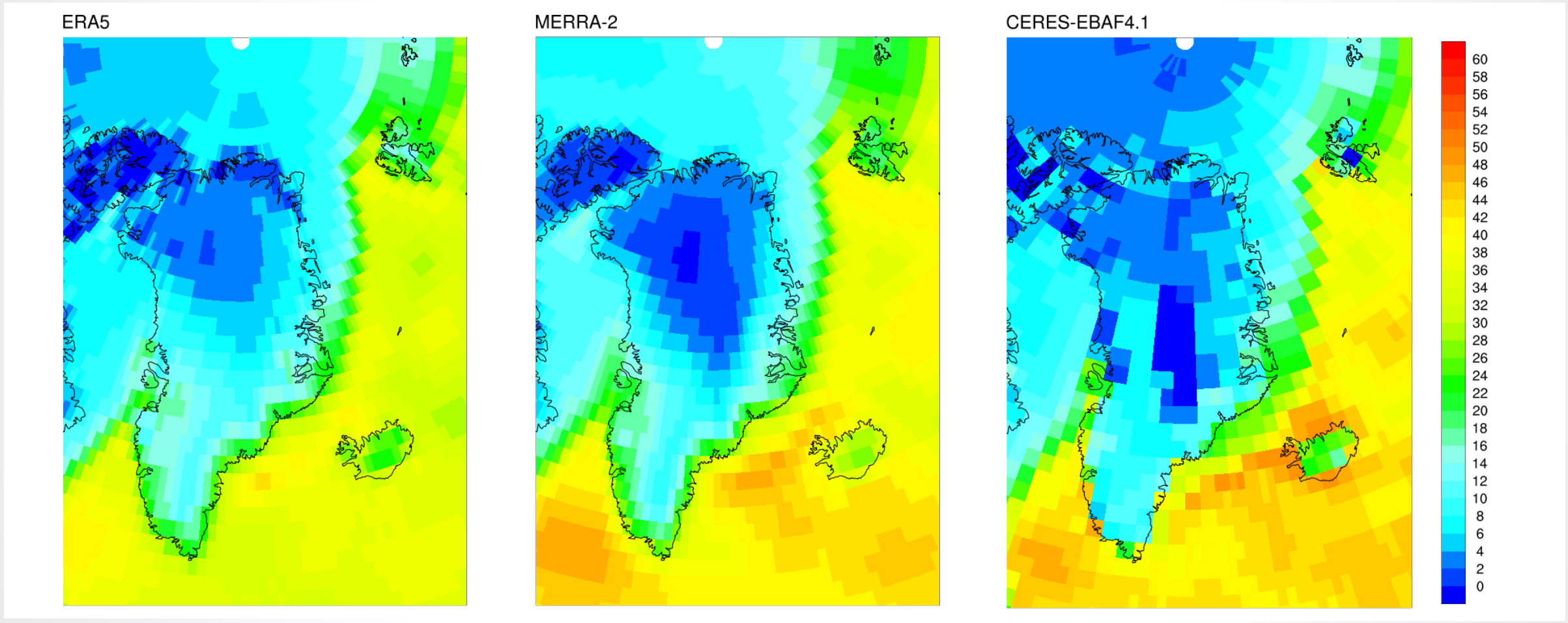


Albedo Comparison – Preliminary, Using Available Years from GEOS-IT





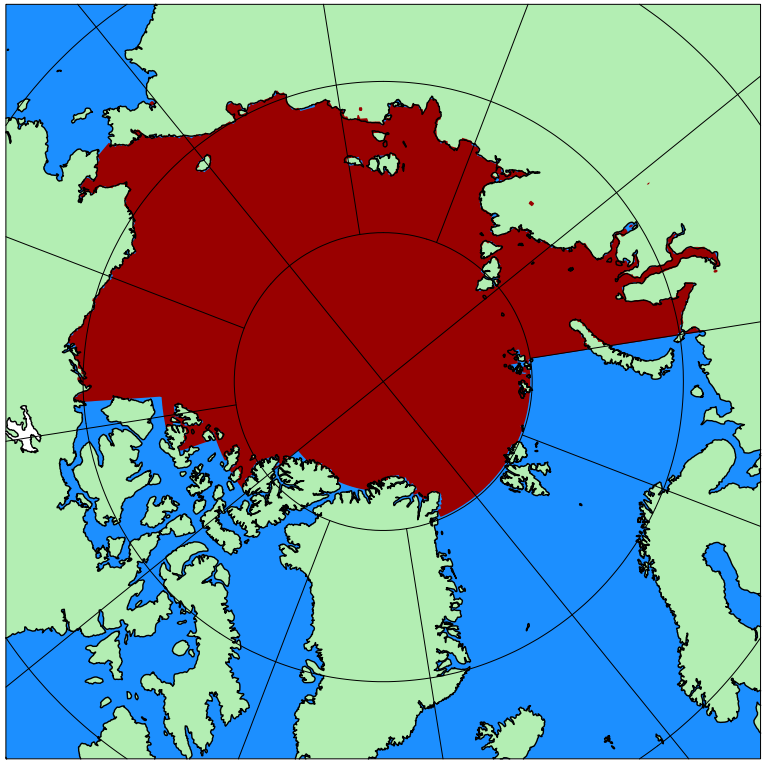
January Upwelling Longwave, Clear-Sky Minus Total [W m^{-2}]



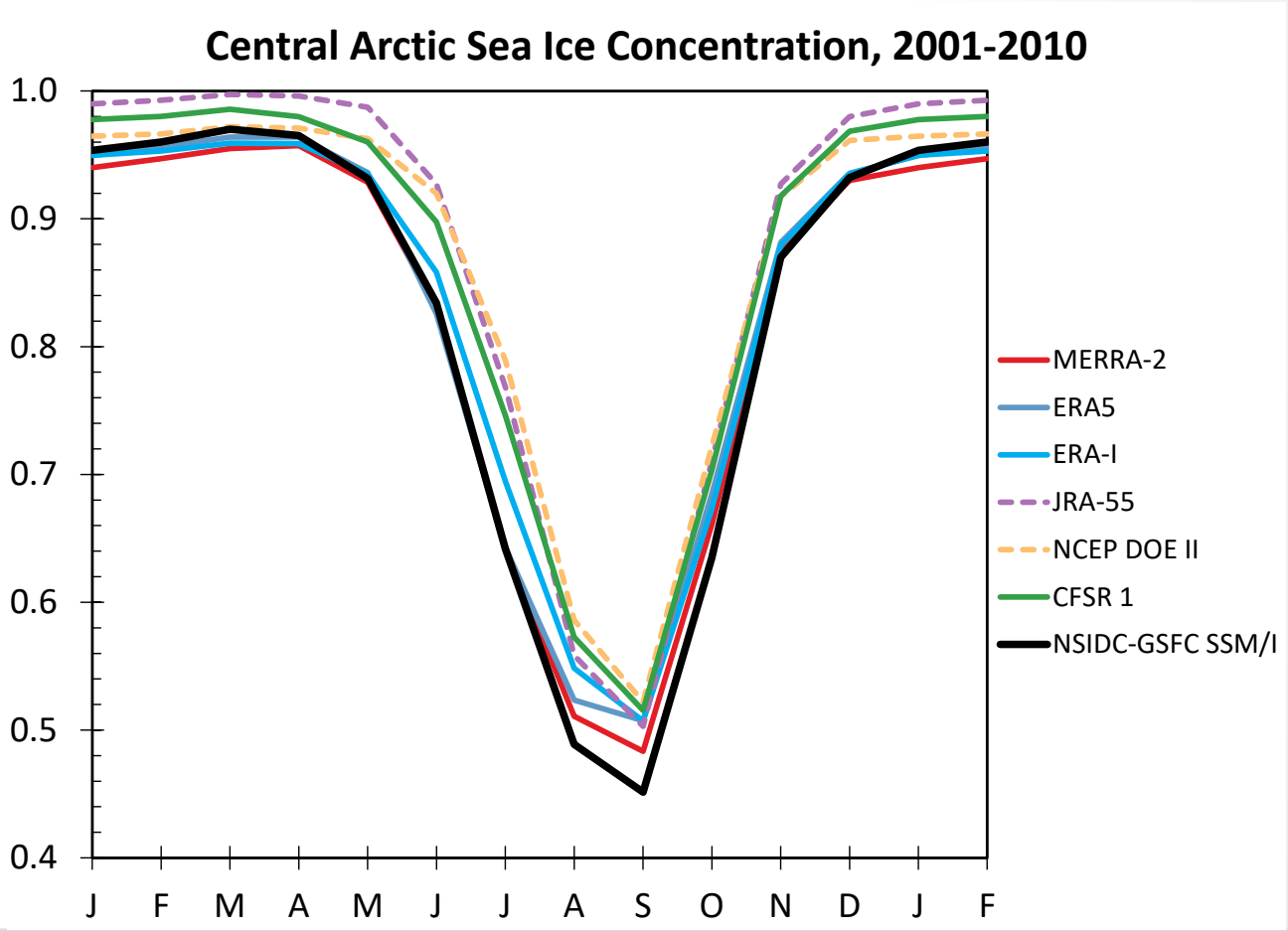
Reanalyses in the Arctic

- How well do reanalyses radiative fluxes compare with observations in polar regions - e.g., the Arctic,
- What is the variability of TOA radiative fluxes in evolving Arctic conditions?

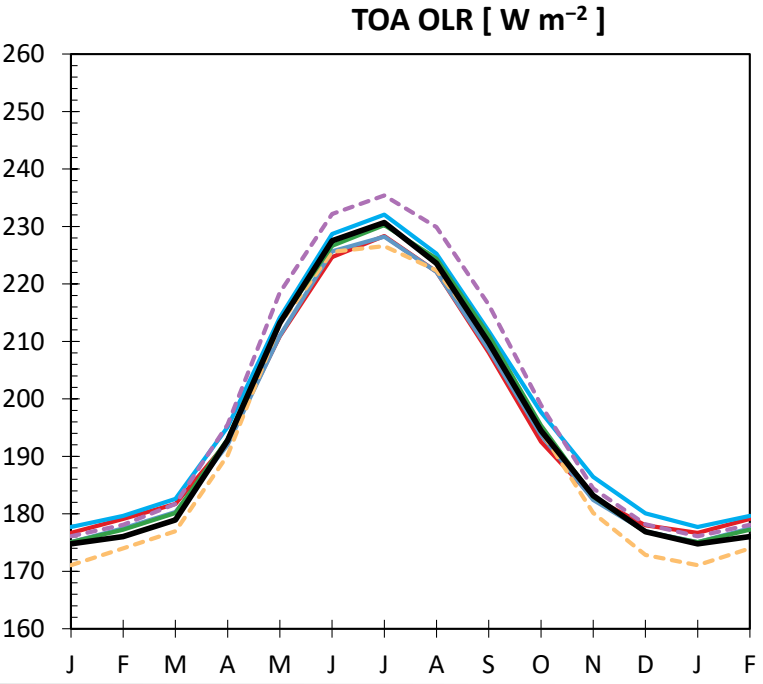
Central Arctic Ocean averaging domain.



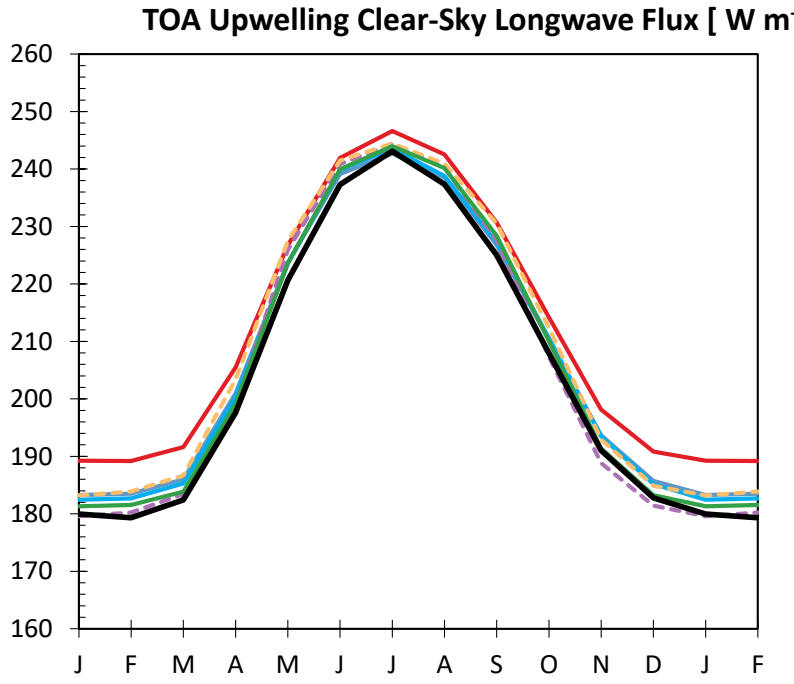
- *Approximates the maximum satellite-era summer ice extent.*
- *Excludes land surfaces.*



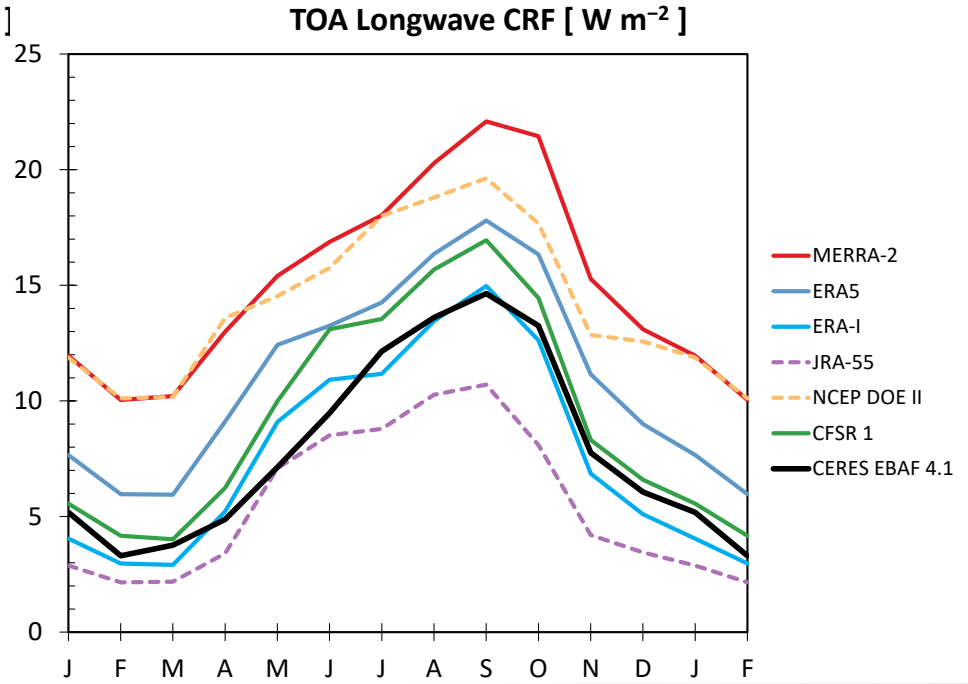
Arctic TOA Longwave Fluxes



$F_{TOA}^{\uparrow}(A_c)$

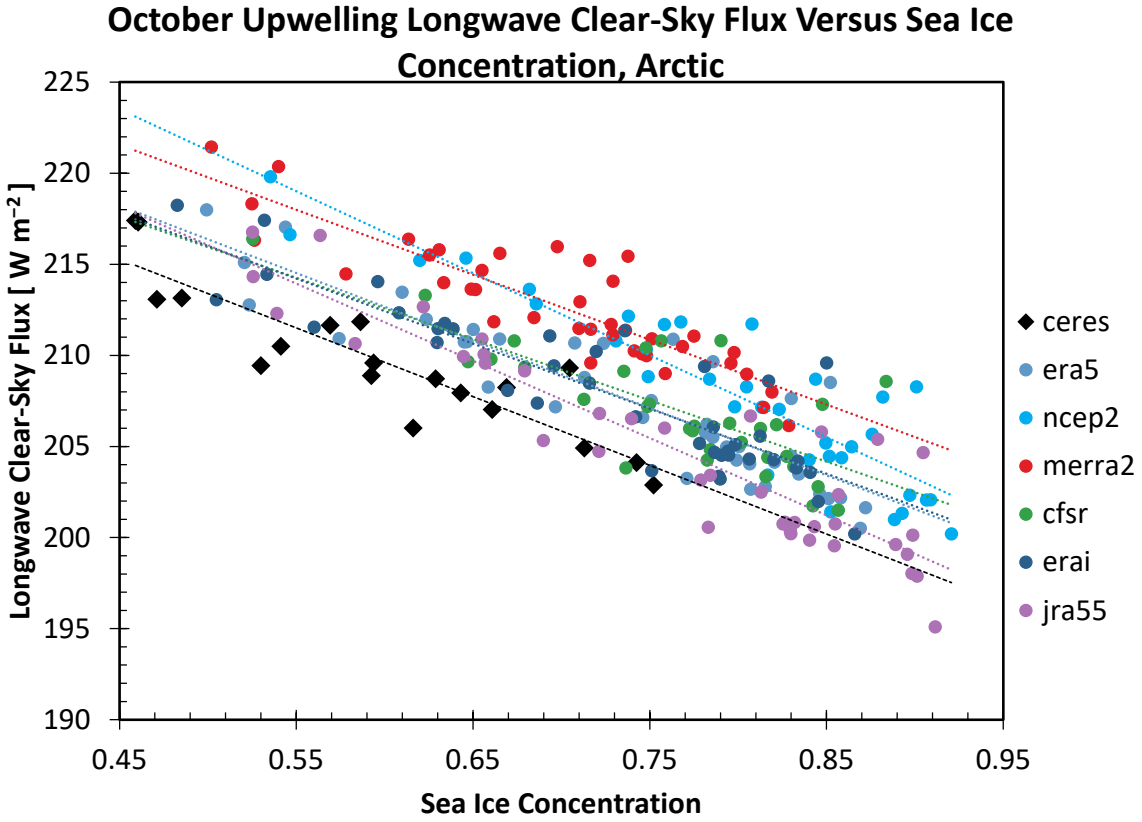


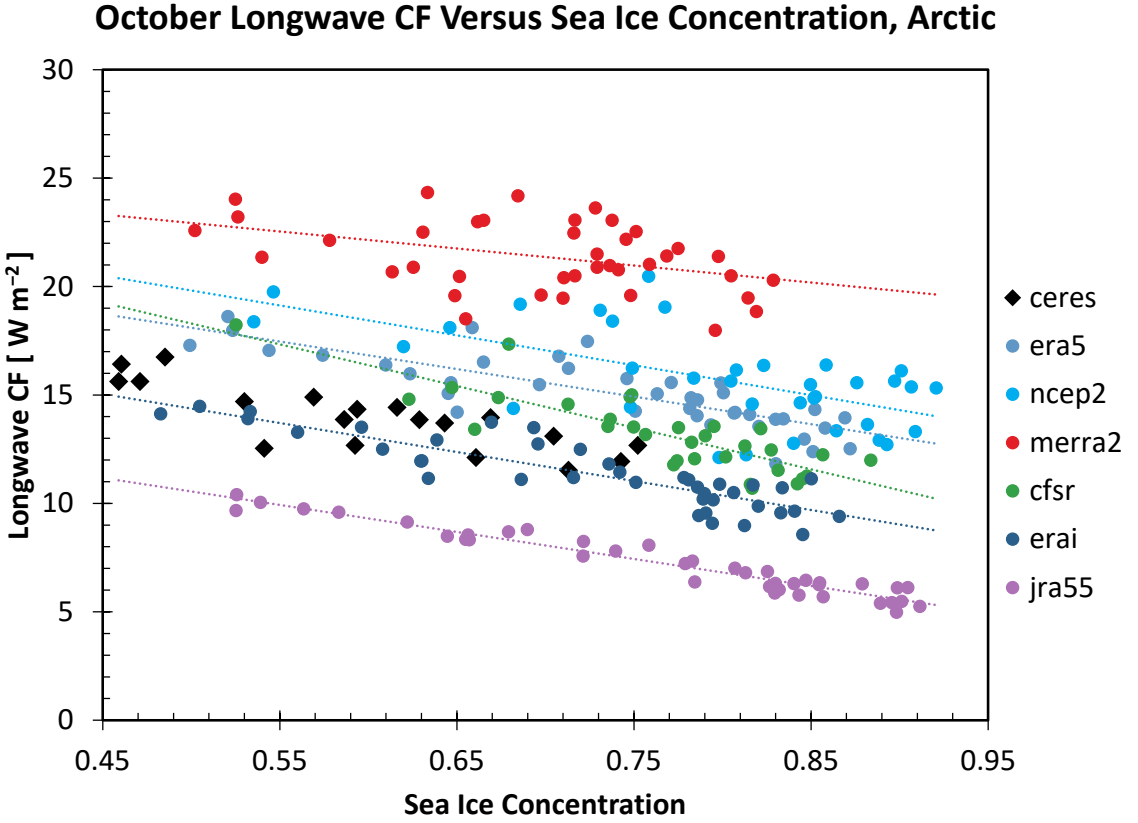
$F_{TOA}^{\uparrow}(0)$



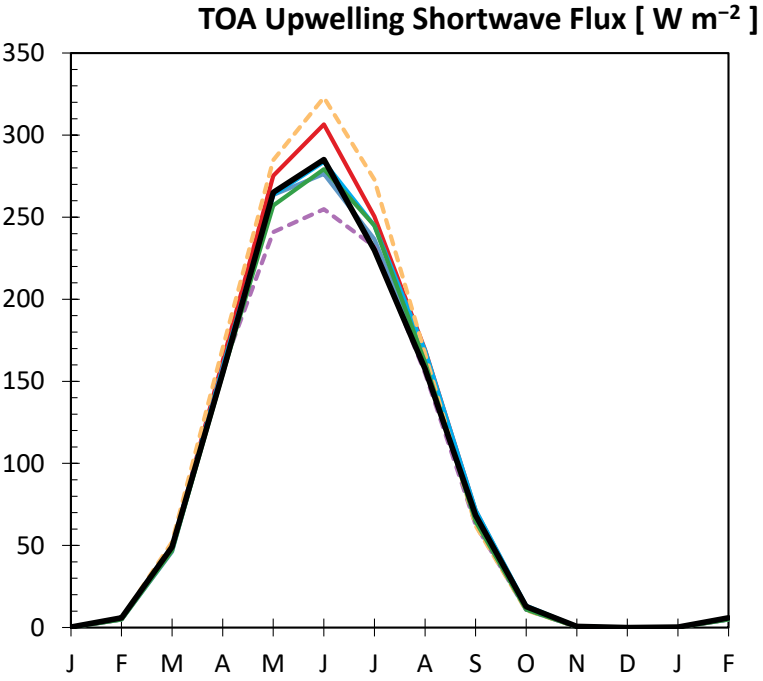
$CF_{LW} = F_{TOA}^{\uparrow}(0) - F_{TOA}^{\uparrow}(A_c)$

Arctic TOA Longwave Fluxes

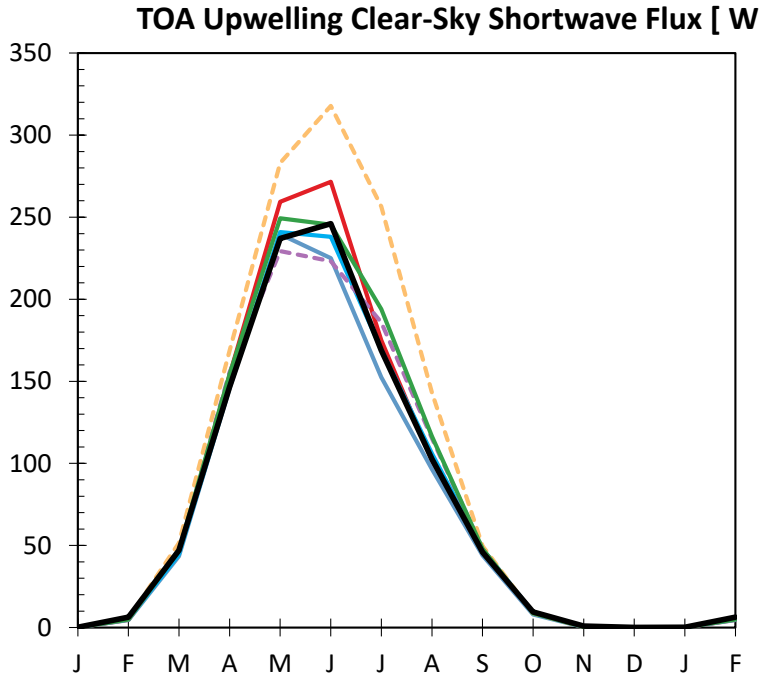




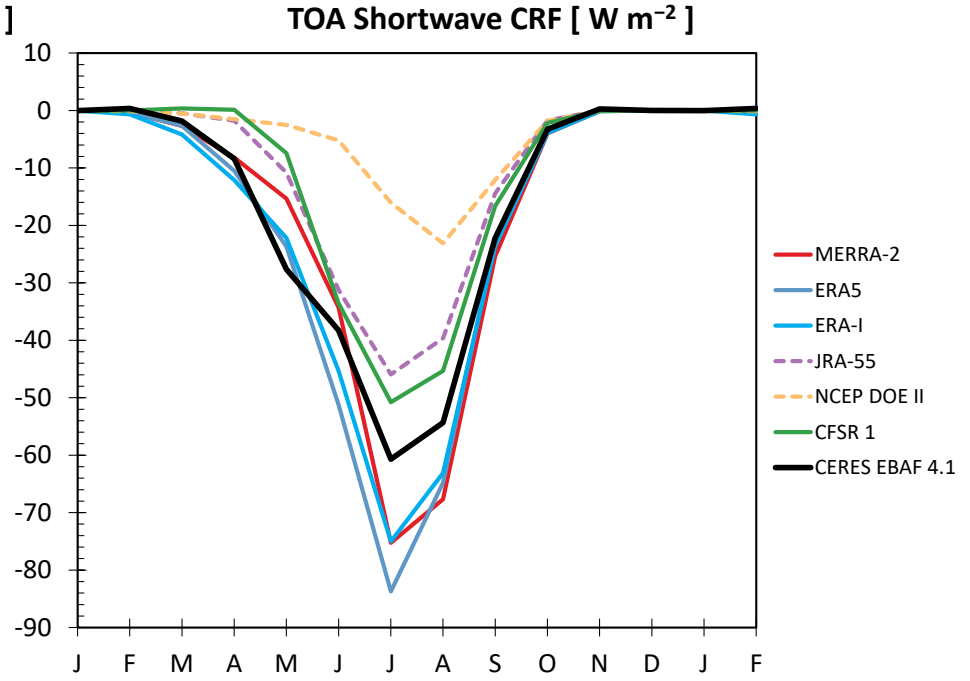
Arctic TOA Shortwave Fluxes



$Q^{\uparrow}_{TOA}(A_c)$

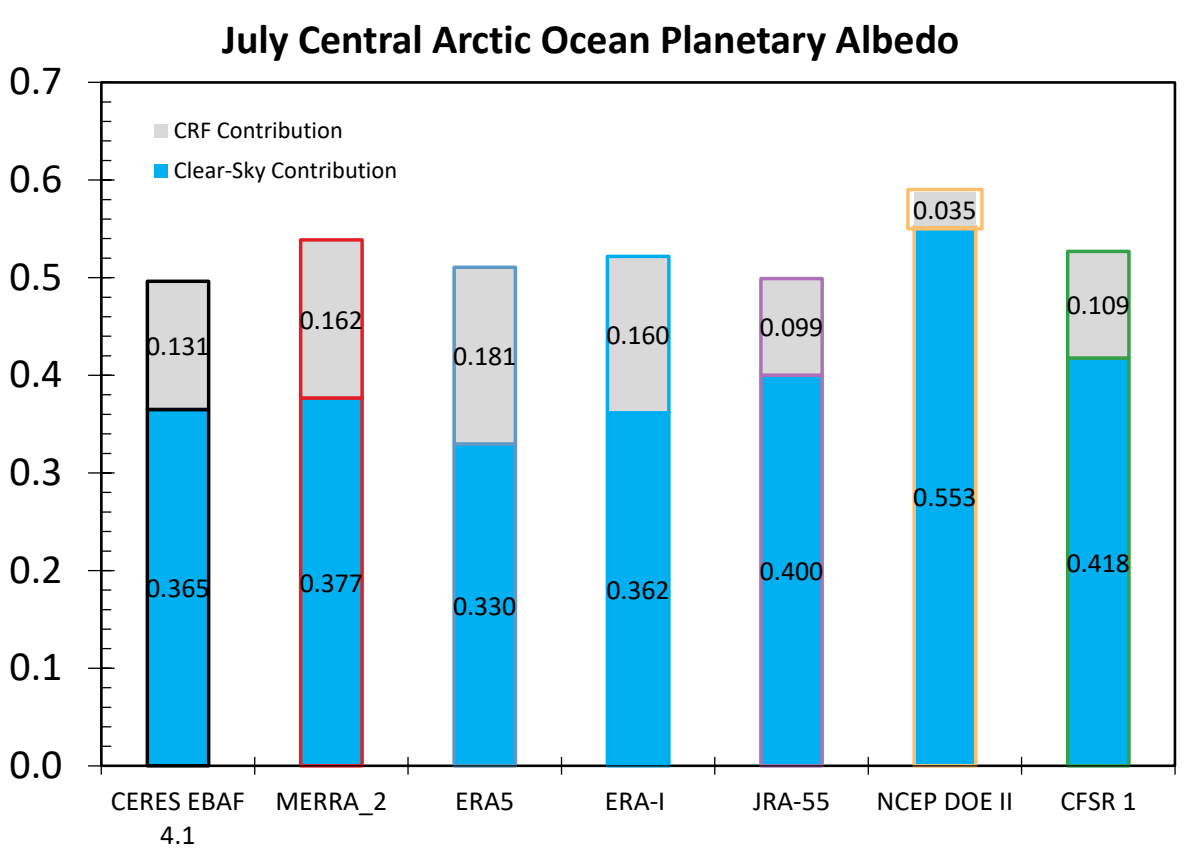


$Q^{\uparrow}_{TOA}(0)$

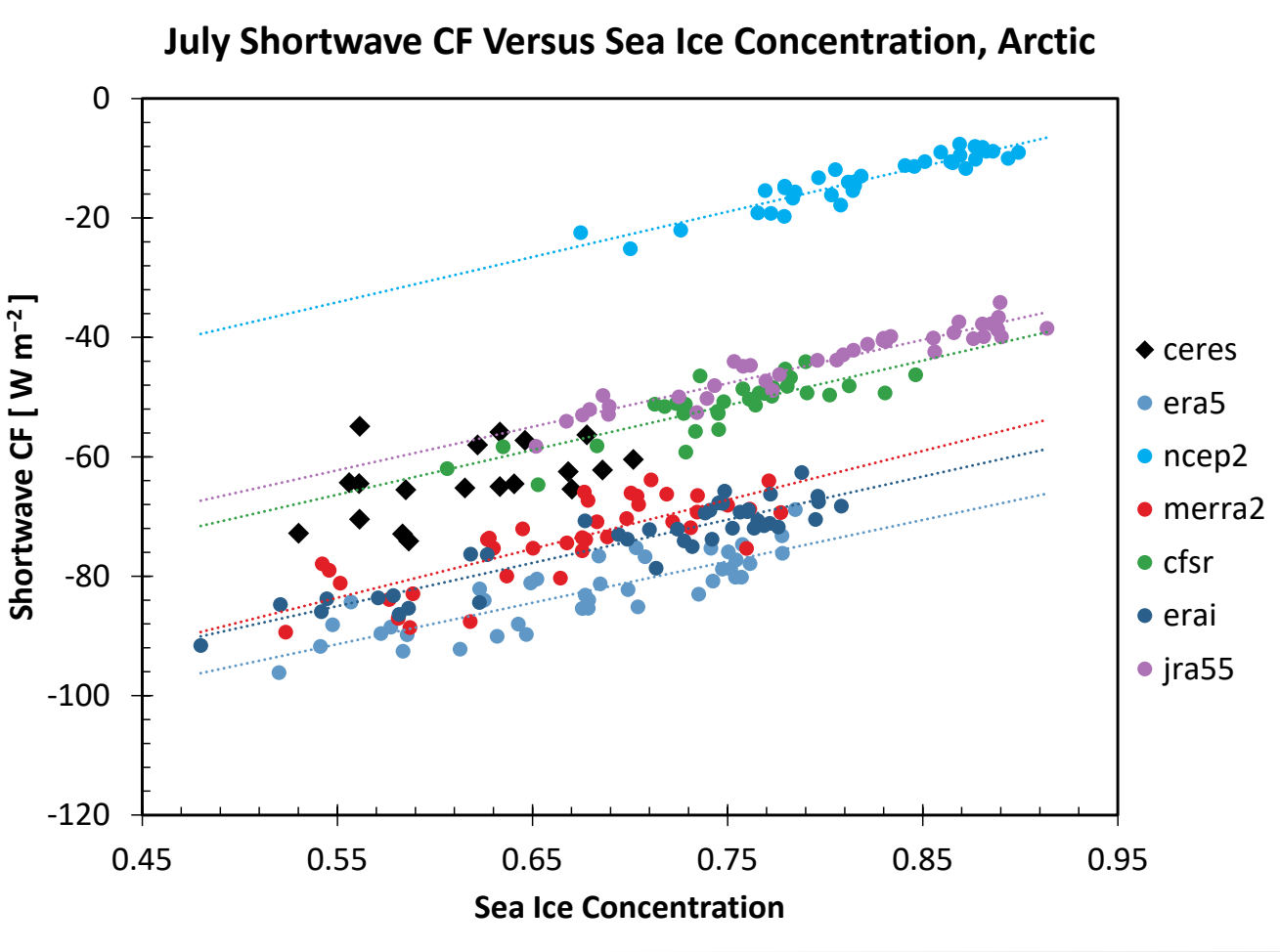


$$CF_{SW} = Q^{\uparrow}_{TOA}(0) - Q^{\uparrow}_{TOA}(A_c)$$

Arctic TOA Shortwave Fluxes



$$\alpha_{TOT} = {Q^{\uparrow}_{TOA}(A_c)}\Big/{Q^{\downarrow}_{TOA}} = \alpha_{CLR} + \alpha_{CF}$$



Summary

- Initial evaluation suggests GEOS-IT has an improved representation of global TOA fluxes and land surface temperatures as compared with earlier GMAO products.
- Contemporary atmospheric reanalyses have a wide variety of representations of sea ice cover – in ice fraction and albedo.
- Reanalyses and CERES EBAF suggest a strong relation between sea ice cover and TOA upwelling longwave fluxes. With decreasing ice cover, both the LW clear-sky and the cloud forcing increase linearly.
- Reanalyses denote a wide range of values for upwelling TOA shortwave fluxes. The range of clear-sky SW flux values is approximately 100 W m^{-2} in July.
- Reanalyses suggest a partial SW cloud forcing compensation for decreasing ice cover. The CERES EBAF 4.1 record, in tandem with the NSIDC SSMI sea ice record suggest a smaller compensation, with less certainty.