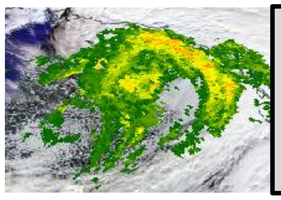

The Representation of Precipitation in Extratropical Cyclones in MERRA-2 and IMERG

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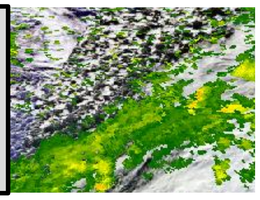


INTRODUCTION

Extratropical cyclones (ETC) = important source of precipitation in mid-latitudes but no consensus on evolution in a warming climate, i.e. more or less precipitation? Most GCMs predict rain too frequently with rates when occurring that are too small. Problem found also within ETCs.

=> Need observational constraint to help pinpoint processes that need improvement in GCMs

Here: Created GPM-ETC database = GPM precipitation retrievals associated with ETCs with both CMB and IMERG: https://data.giss.nasa.gov/storms/obs-ETC

⇒ Use database to composite midlatitude precipitation in Extratropical Cyclones to evaluate MERRA-2 and other models

Method:

1. Average IMERG gridded precipitation to match MERRA-2 spatial and temporal resolution: 0.625° x 0.5° x 1hr
2. Project precipitation rate retrievals (including zero precip.) into rectangular grid centered on cyclone centers of 70 km resolution, equal area: for IMERG and MERRA-2
3. Remove grid cells with land, sea ice and adjust MERRA-2 precipitation to remove snowfall.
4. Impose same threshold for miniimum precipitation using formula of Tan et al (2017): 0.025 mm/hr, i.e. if P < 0.025 then P=0 mm/hr
5. Average total precipitation, rain rate when raining and count precipitation occurrence, all cyclones in 30-60 N/S band, all seasons

1. Cyclone-centered composites of precipitation

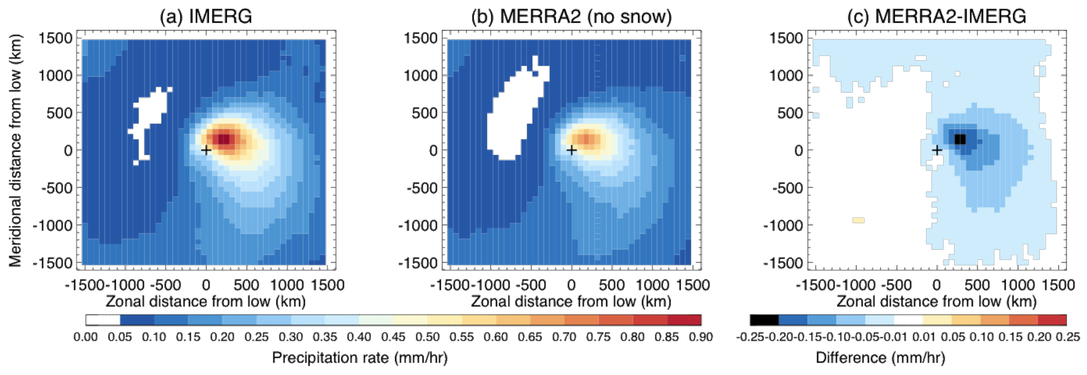


Fig. 1: IMERG vs MERRA-2
Similar distribution of precipitation in cyclones, small differences: MERRA-2 predicts similar rain west of the low, less rain east of the low in WCB, bias less than 0.25 mm/hr

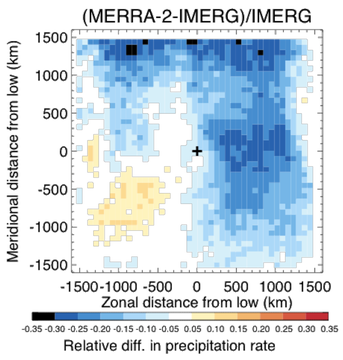


Fig. 2: Relative difference (normalized to IMERG)
Warm frontal/WCB region: large amoutn of precipitation: MERRA-2 < IMERG
Cold sector/polar edge: low precipitation, MERRA-2 < IMERG
Post-cold frontal quadrant: low precipitation, MERRA-2 > IMERG
=> Differences caused by rain rate or frequency of occurrence of precipitation?

2. Cyclone-centered composites of precipitation rate when raining

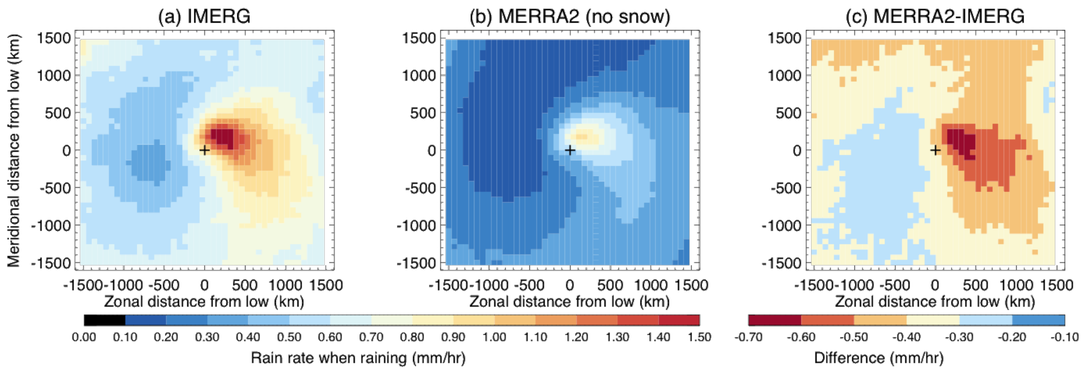


Fig. 3: Precipitation rate when raining
Where MERRA-2 < IMERG: rate MERRA-2 < IMERG, up to 0.7 mm/hr difference
Where MERRA-2 > IMERG, rate also less in MERRA-2, but bias smaller

3. Cyclone-centered composites of frequency of occurrence of precipitation

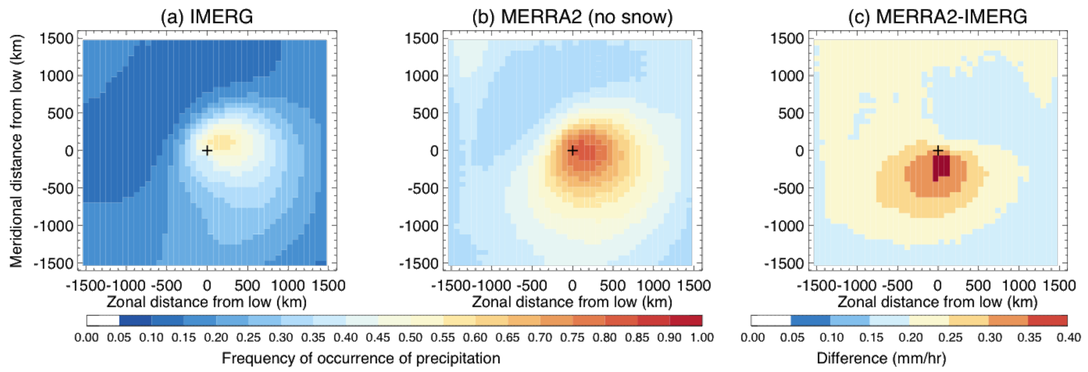
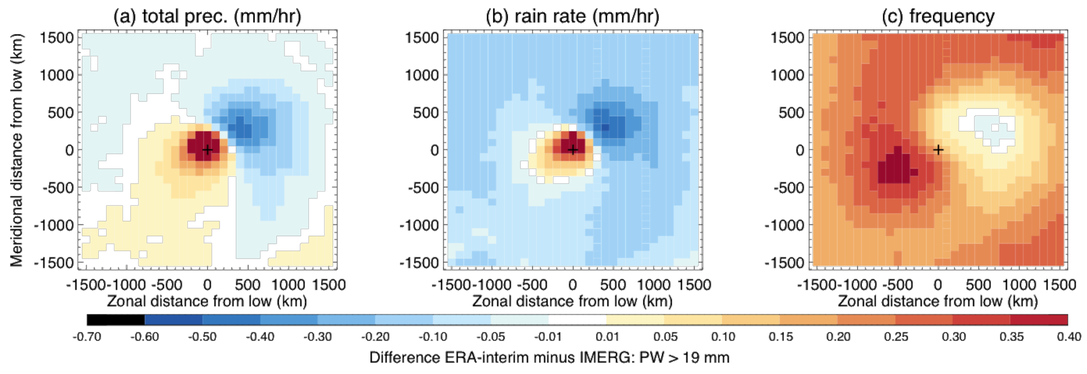


Fig. 4: Frequency of occurrence of precipitation
MERRA-2 frequency > IMERG everywhere, with largest difference west/equatorward of the low => explains MERRA-2 > IMERG there.

Fig. 5: ERA-interim vs IMERG
Cold sector contrast larger for ERA-i, with rates also larger (cyclones with mean PW > 19 mm to avoid snowfall issue)



4. Discussion

- Warm front: MERRA-2 may underestimate rain rates where they are largest
- Cold sector/PCF: MERRA-2 overpredicts precipitation occurrence where rare and light
- Cold sector/polar edge: frozen precipitation either missed by IMERG or phase misdiagnosed by MERRA-2 => comparison probably impossible
- Similarities found for ERA-interim , but biases less in warm front and larger in cold sector (below)
- Next: use same method to test free-running GCMs (no longer comparing the same cyclones)