An Overview of ARTMIP's Tier 2 Reanalysis Intercomparison: Uncertainty in the Detection of Atmospheric Rivers and their Associated Precipitation

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Introduction

- Developers of Atmospheric River Detection Tools (ARDTs) submitted binary tags of ARs in MERRA-2, ERA5, JRA-55 for the period of January 1980 through December 2019
- JRA-55 (all years) and ERA5 for 1980 through 1999 were optional
- Consensus AR = AR detected by at least 50% of ARDTs
- Science Questions:

1. How does the uncertainty in AR frequency among reanalyses compare to uncertainty in ARDTs?
2. How are diagnostics variables, such as precipitation, impacted by AR detection?

*Table 1: ARDT catalogs submitted for the Reanalysis Intercomparison. *Included full ERA5 period, †Included JRA-55*

Algorithm	Participant	Region
ARCONNECT_v2†	Eric Shearer	Global
ClimateNet_DL	Sol Kim	Global
GuanWaliser_v2*†	Bin Guan	Global
IDL_v2b*†	Ricardo Tomé	Western Europe, South Africa
Lora_v2	Juan Lora	Global
Mundhenk_v3*†	Kyle Nardi	Global
Payne*†	Ashley Payne	Western US
Reid500*†	Kimberley Reid	Global
Shields_v1*	Christine Shields	Western US, Western Europe
TempestLR*†	Beth McClenny	Global, except 15 S to 15 N
Wille_v2.4*	Jonathan Wille	Arctic, Antarctica

Conclusions

- Enhanced water vapor transport in MERRA-2 leads to increased detection of ARs in ARDTs with fixed thresholds
- Uncertainty due to ARDT is greater than uncertainty due to reanalysis except for the seasonal cycle of percent area
- Consensus ARs result in more precipitation due to ARs than the ensemble mean in the Pacific Northwest

Results: AR Detection Frequency

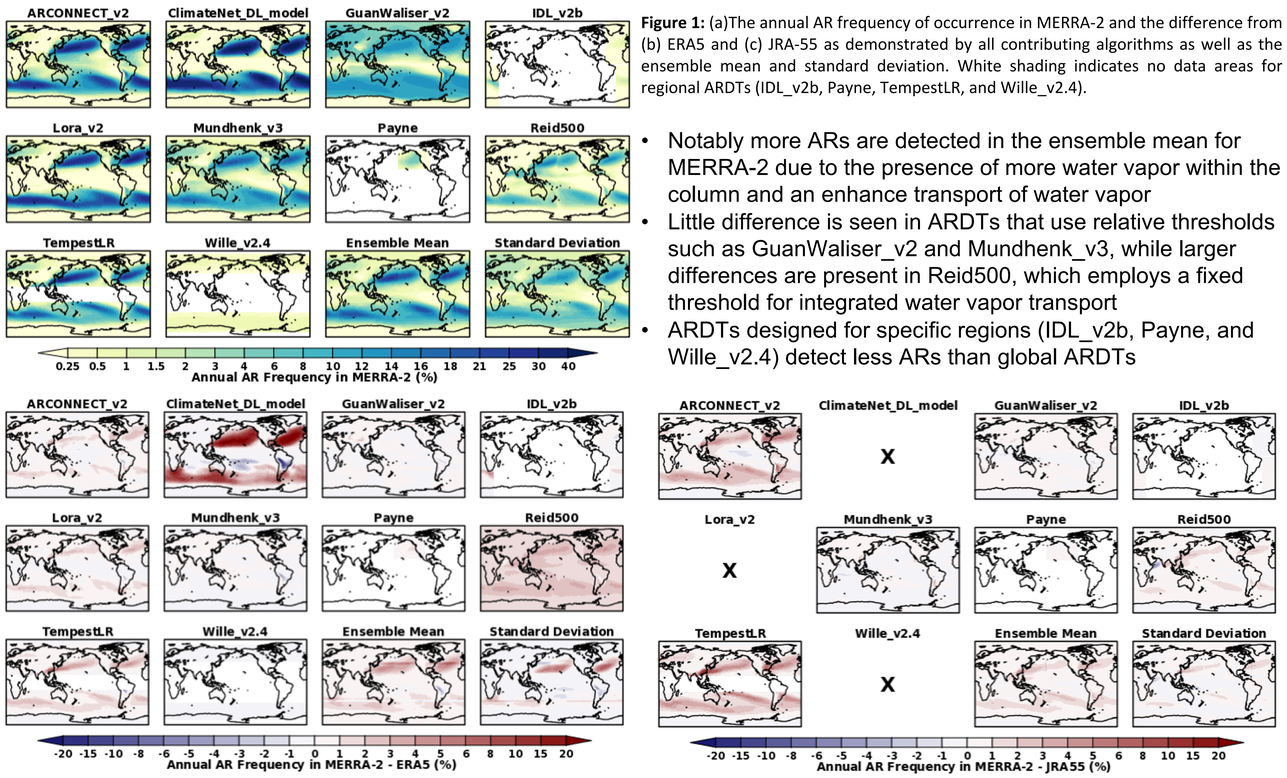

Figure 1: (a)The annual AR frequency of occurrence in MERRA-2 and the difference from (b) ERA5 and (c) JRA-55 as demonstrated by all contributing algorithms as well as the ensemble mean and standard deviation. White shading indicates no data areas for regional ARDTs (IDL_v2b, Payne, TempestLR, and Wille_v2.4).

- Notably more ARs are detected in the ensemble mean for MERRA-2 due to the presence of more water vapor within the column and an enhance transport of water vapor
- Little difference is seen in ARDTs that use relative thresholds such as GuanWaliser_v2 and Mundhenk_v3, while larger differences are present in Reid500, which employs a fixed threshold for integrated water vapor transport
- ARDTs designed for specific regions (IDL_v2b, Payne, and Wille_v2.4) detect less ARs than global ARDTs

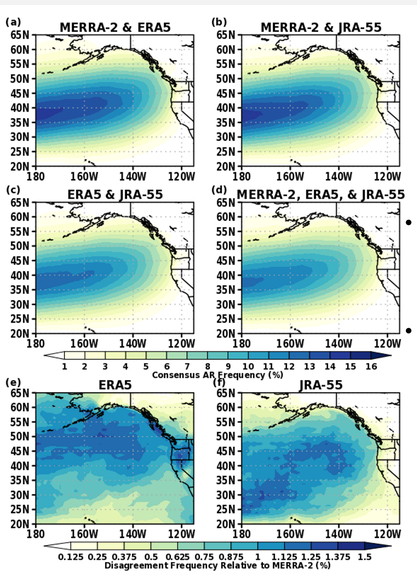

Figure 2: Frequency of agreement in the detection of a consensus AR in (a) MERRA-2 and ERA5, (b) MERRA-2 and JRA-55, (c) ERA5 and JRA-55 and (d) all three reanalysis as well as the frequency of a consensus AR detected in (e) ERA5 or (f) JRA-55 but not MERRA-2

- Maximum frequency of disagreement aligns with gradients in the AR track
- ERA5 has additional ARs to the north, while the pattern for disagreement in JRA-55 suggests ARs propagate at differing speeds or there are issues with differing temporal resolutions

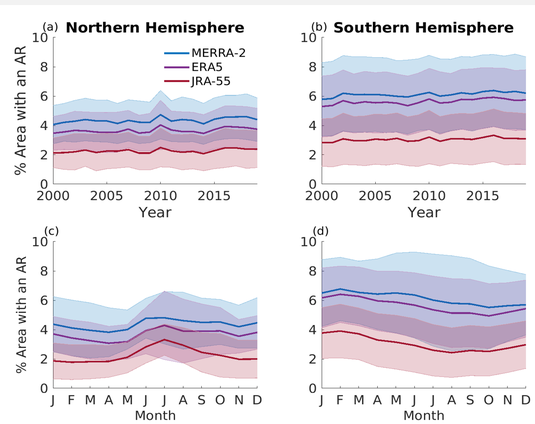

Figure 3: (a,b) Annual and (c,d) monthly mean time series of the percent area covered by ARs in the (a,c) northern hemisphere and (b,d) southern hemisphere. Shading represents plus and minus one standard deviation among the ARDTs.

- Diverging seasonal cycles among the ARDTs occur in both hemispheres, perhaps due to geometry requirements

Results: Precipitation

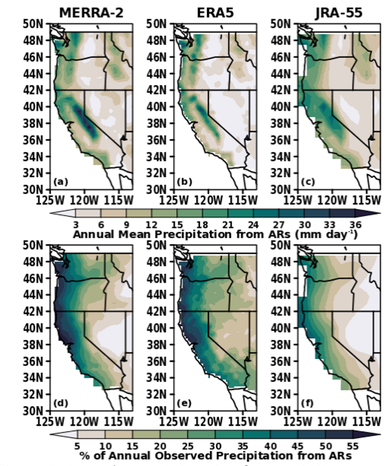

Figure 4: Annual mean intensity of precipitation associated with consensus ARs in (a) MERRA-2, (b) ERA5, and JRA-55 and (d-f) AR cumulative precipitation as a percentage of the total annual precipitation.

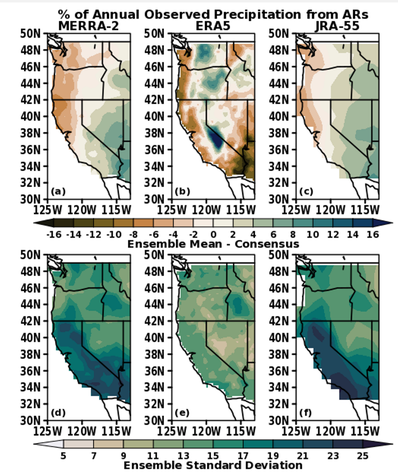

Figure 5: Ensemble mean percent of annual precipitation coinciding with detected ARs minus the precipitation from the consensus AR in (a) MERRA-2, (b) ERA5, and JRA-55 and (d-f) the standard deviation of the ensemble.

- Used CPC Unified Gauge-Based Analysis of Daily Precipitation over CONUS
- The standard deviation for precipitation is smallest in ERA5 due to a larger consensus agreement among the ARDTs for AR detection
- Artifacts present for ERA5 due some ARDTs only submitting 2000 onward amid a trend in precipitation over the region

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