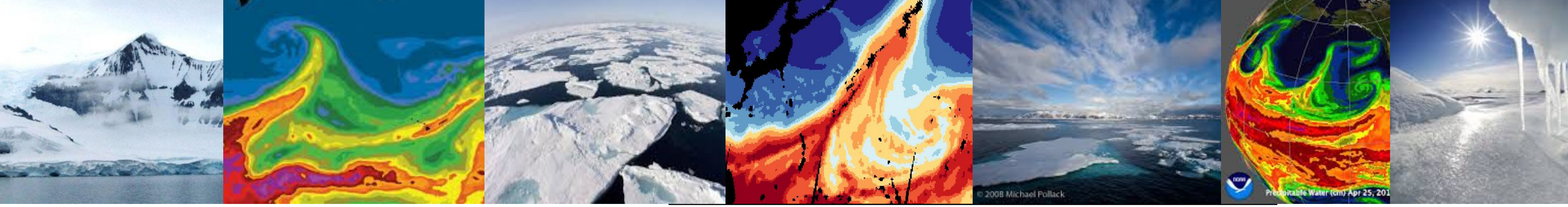

The Role of Atmospheric Rivers in Extratropical and Polar Hydroclimate

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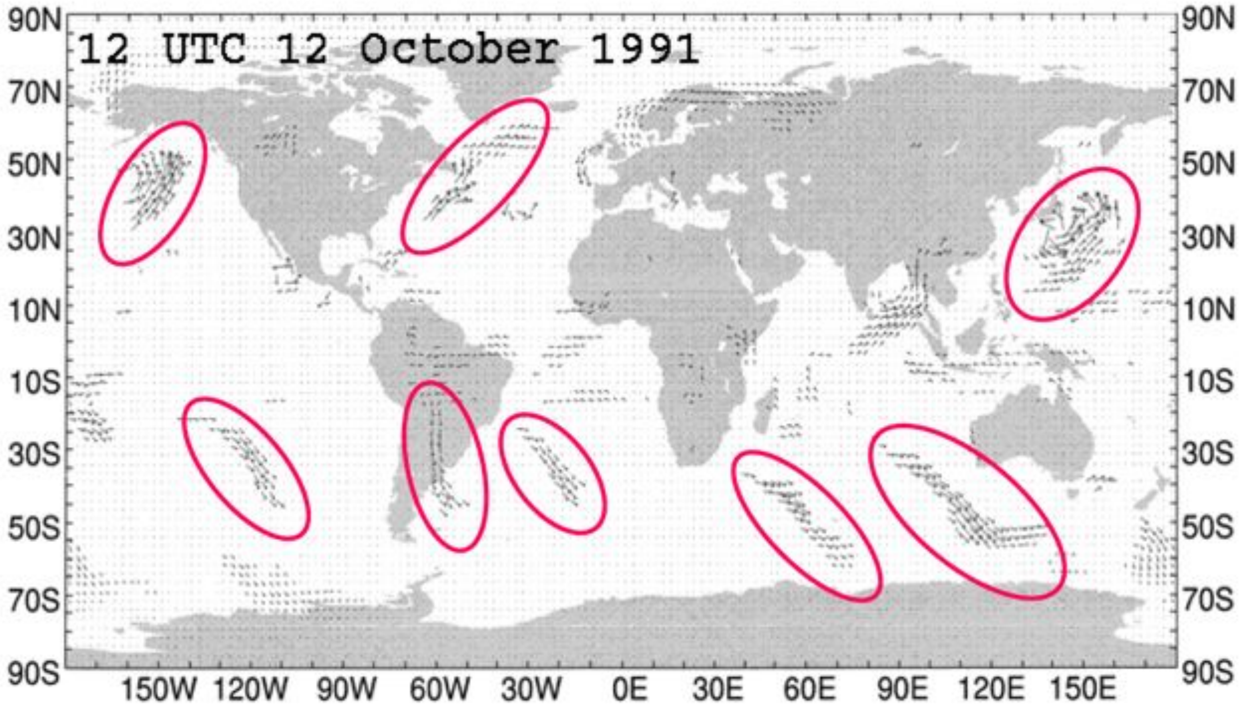
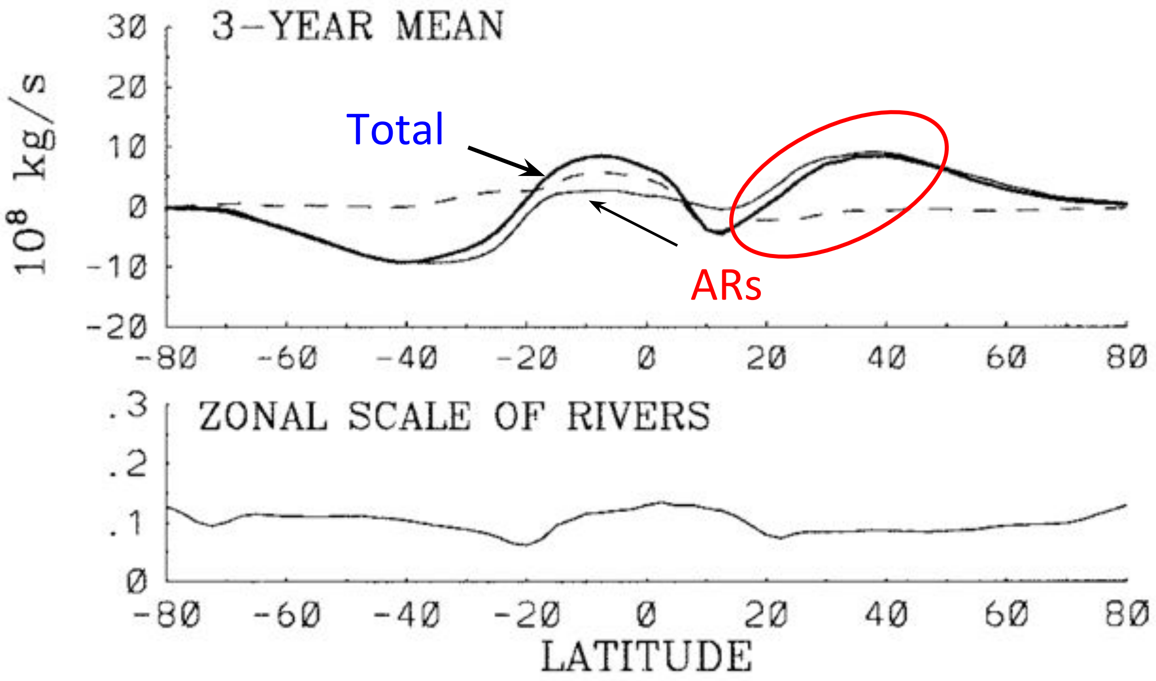
"Atmospheric Rivers"

Key to Poleward Moisture Transports

"Discovered/Coined" in the 1990's by Zhu and Newell



This first study concerned weather extremes that shape our global climate

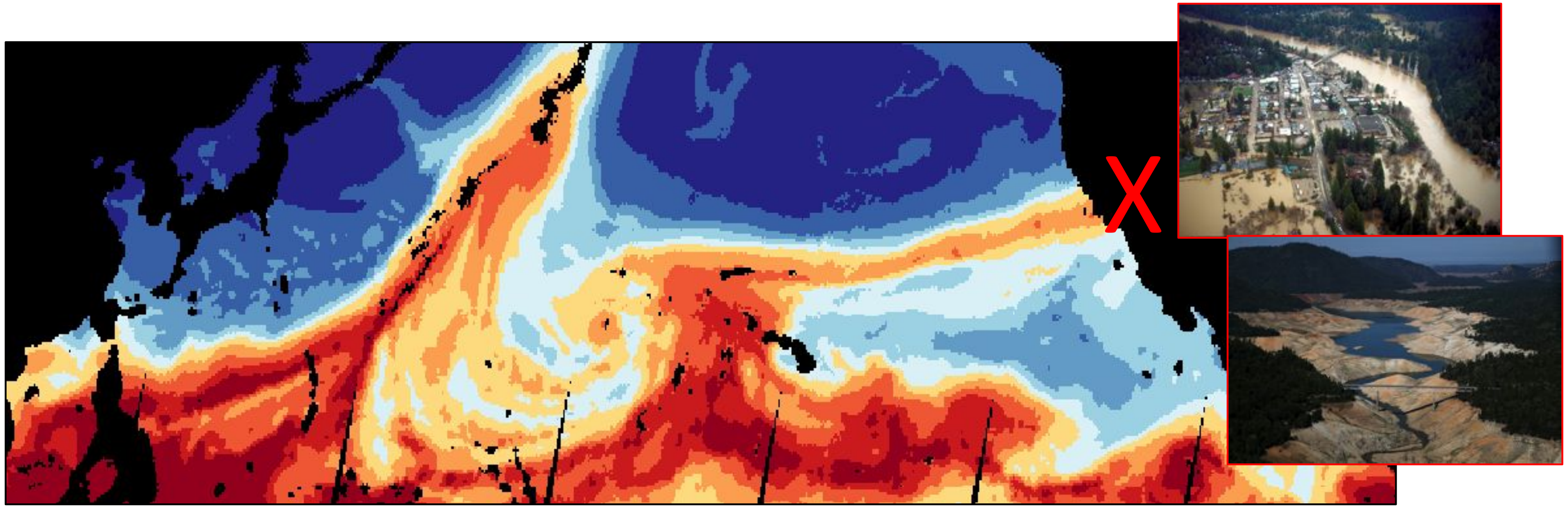


Over 90% of poleward moisture transport across midlatitudes is by ARs that take up only ~10% of the zonal circumference (Zhu and Newell 1998)

Source: Zhu & Newell, 1998

Atmospheric Rivers

Regional Impacts on Water Availability and Extremes



Since the Zhu and Newell, most AR research has focused on its **regional hydrometeorology concerns**– namely impacts on precipitation extremes, impacts on annual snowpack and water availability, flooding events, etc. (e.g. Dettinger et al., 2011; Guan et al., 2010, 2012, 2013; Ralph et al., 2006; 2011, 2013; Lavers & Villarini, 2013; Neiman et al., 2008a).

Atmospheric Rivers

Key to Poleward Moisture Transports

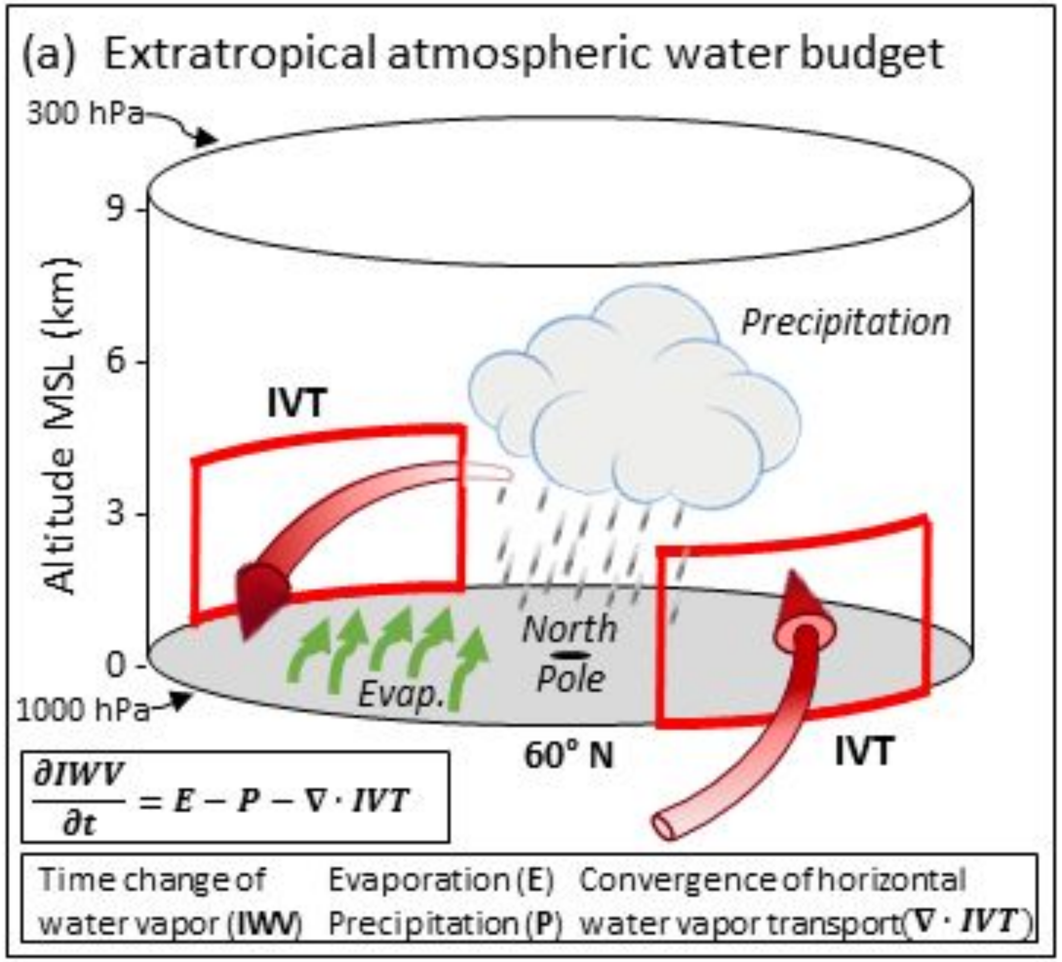
Suggests impacts on extra-tropical water vapor distributions, and thus extratropical water and energy distributions and hydroclimate – still to be quantified?

Study Questions and Experimental Setup

Our study quantifies the global climate impact of ARs, namely the role of the meridional transport of ARs on extratropical hydrology and climate.

With this relationship in mind, the following questions come to mind:

1. How does the meridional integrated vapor transport (IVT) across a given latitude relate to variations in P, E, and/or dIWV/dt in the region poleward?
2. To what degree do ARs account for this relationship?
3. How do these relationships vary depending on the given latitude and on timescale (e.g. annual, monthly, pentad, daily)?



Data and Methods

Data Name	Spatial	Temporal	Time Period	Parameter	Reference
MERRA2 (also ERA-I)	0.5º x 0.625º	6 hour	1997-2014	IVT*, IWV*, E, P	Gelaro et al., 2017
AR IVT Product**	0.5º x 0.625º	6 hour	1997-2014	AR IVT	Guan & Waliser, 2015

*Derived from q (specific humidity), and v (meridional wind direction) at p (pressure)
**Global Atmospheric River catalog containing the AR detection result from Guan and Waliser (2015) based on MERRA2 IVT.

Meridional (N/S) IVT

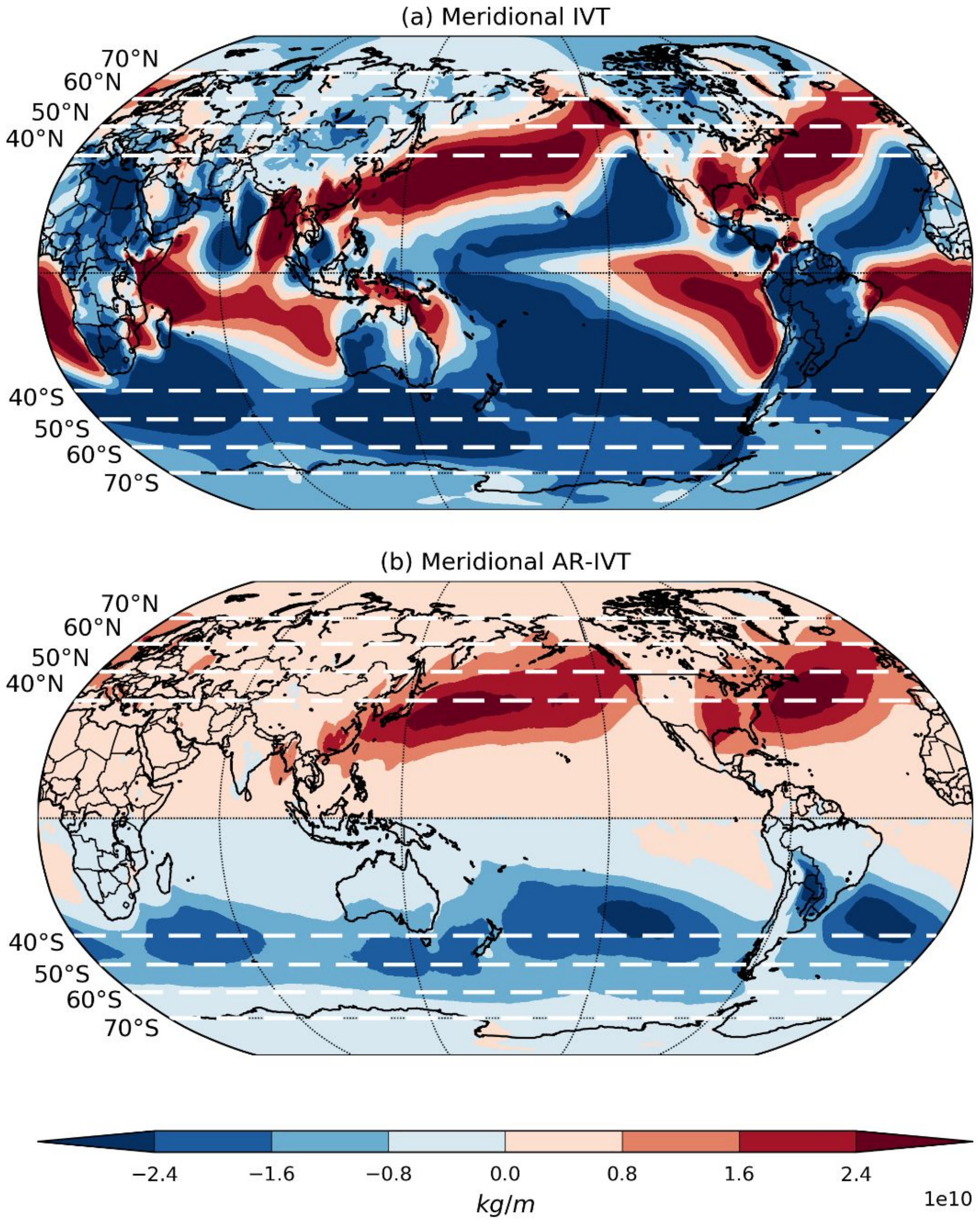
$$IVT_v = -\frac{1}{g}\int_{1000}^{300} qv\,dp$$

Integrated Water Vapor (IWV)

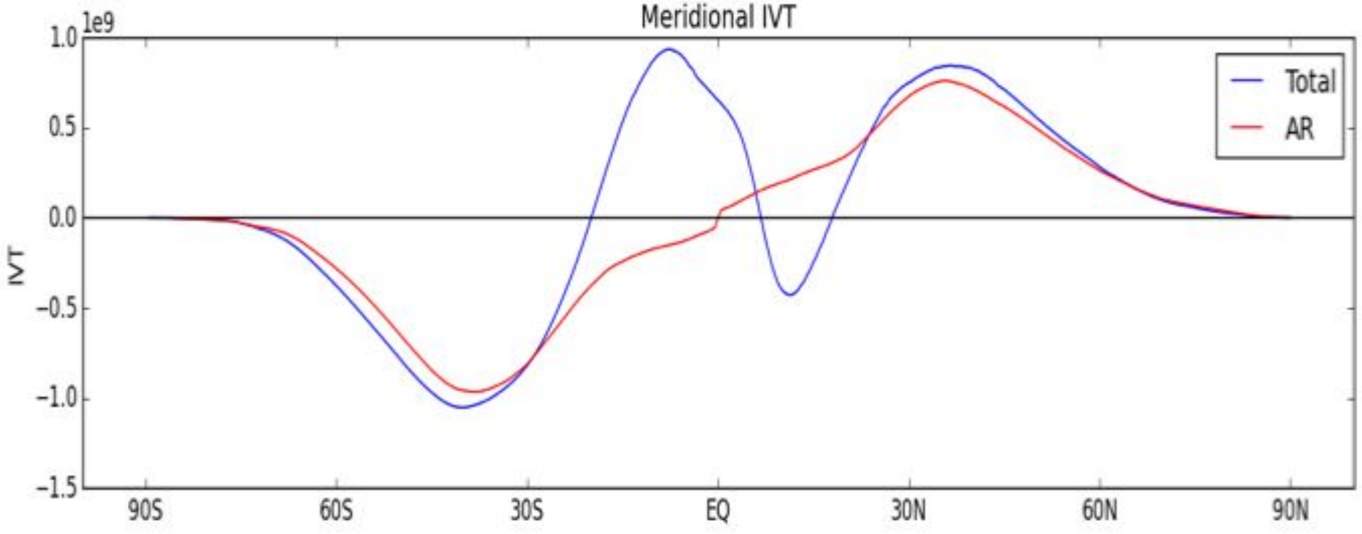
$$IWV = -\frac{1}{g}\int_{1000}^{300} q\,dp$$

$$\frac{\partial \boldsymbol{IWV}}{\partial \boldsymbol{t}} = \boldsymbol{E} - \boldsymbol{P} - \nabla \cdot \boldsymbol{IVT}$$

Global IVT and AR IVT

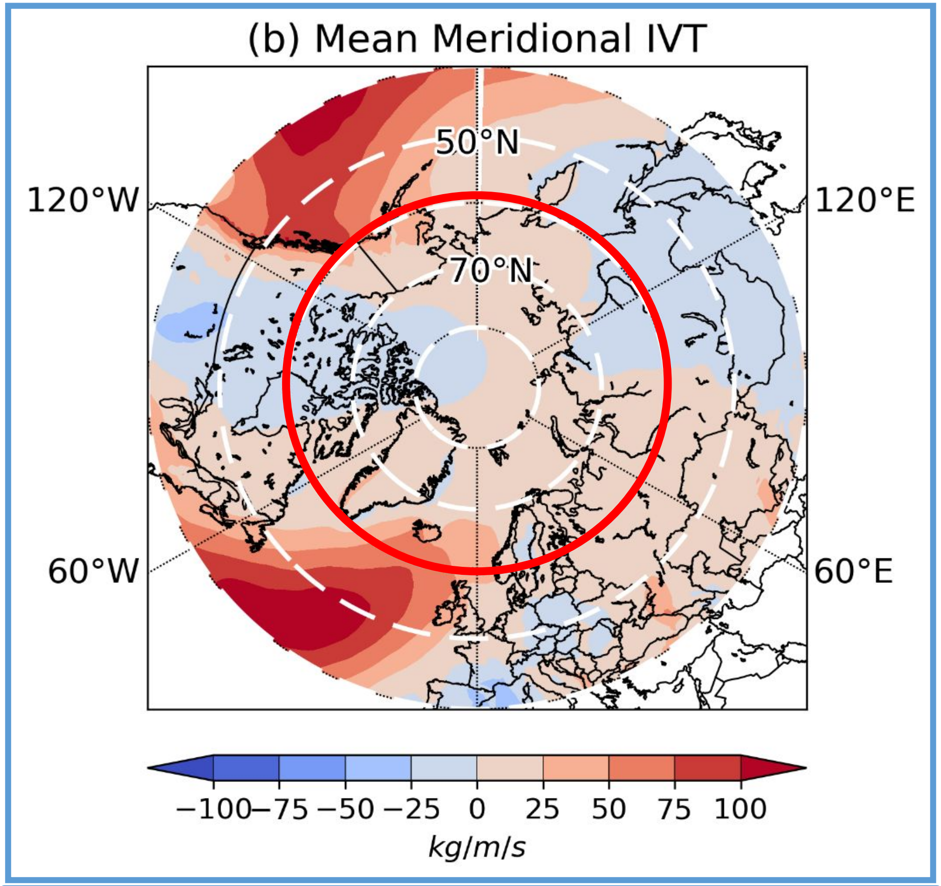


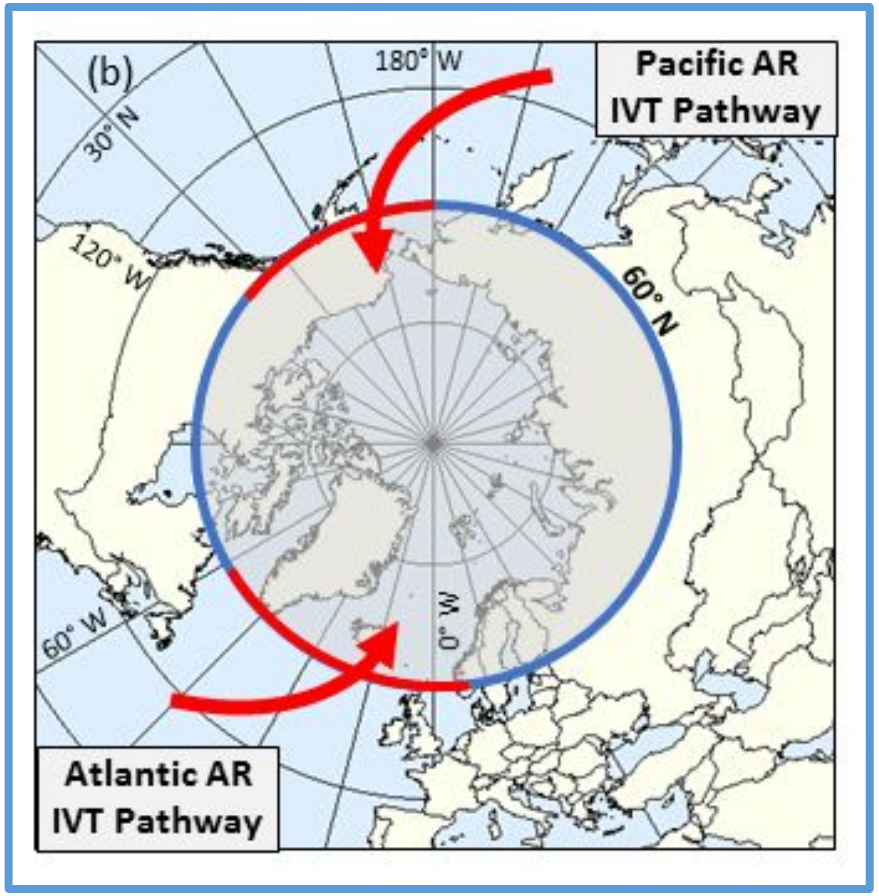
(left) *The total meridional IVT (top) and total AR related meridional IVT (bottom) at each grid cell for the period 1997 – 2014 (in kg m^{-1}).*
(below) *Average meridional IVT (blue line) and AR-IVT (red line) between 1997 and 2014 (in kg s^{-1}).*



As in Zhu and Newell (1998) and Guan and Waliser (2015), ARs accomplish most Poleward moisture transport.

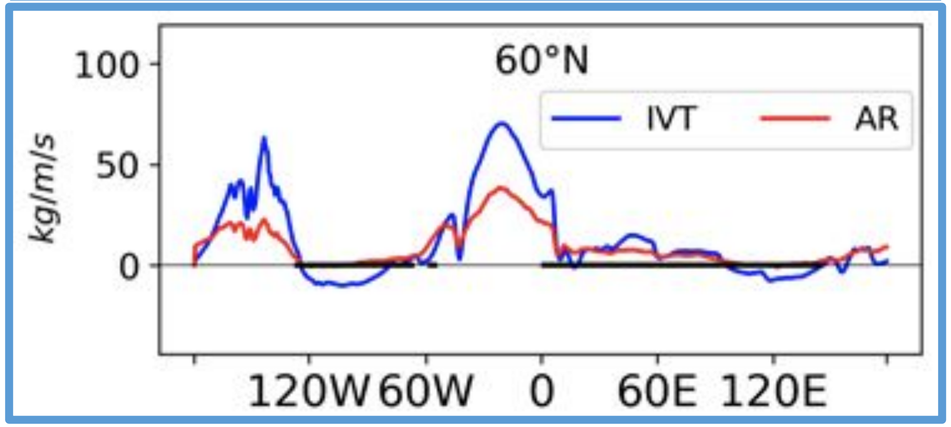
Winter Average IVT and AR-IVT





>90% of poleward IVT that crosses into Arctic occurs in these areas.

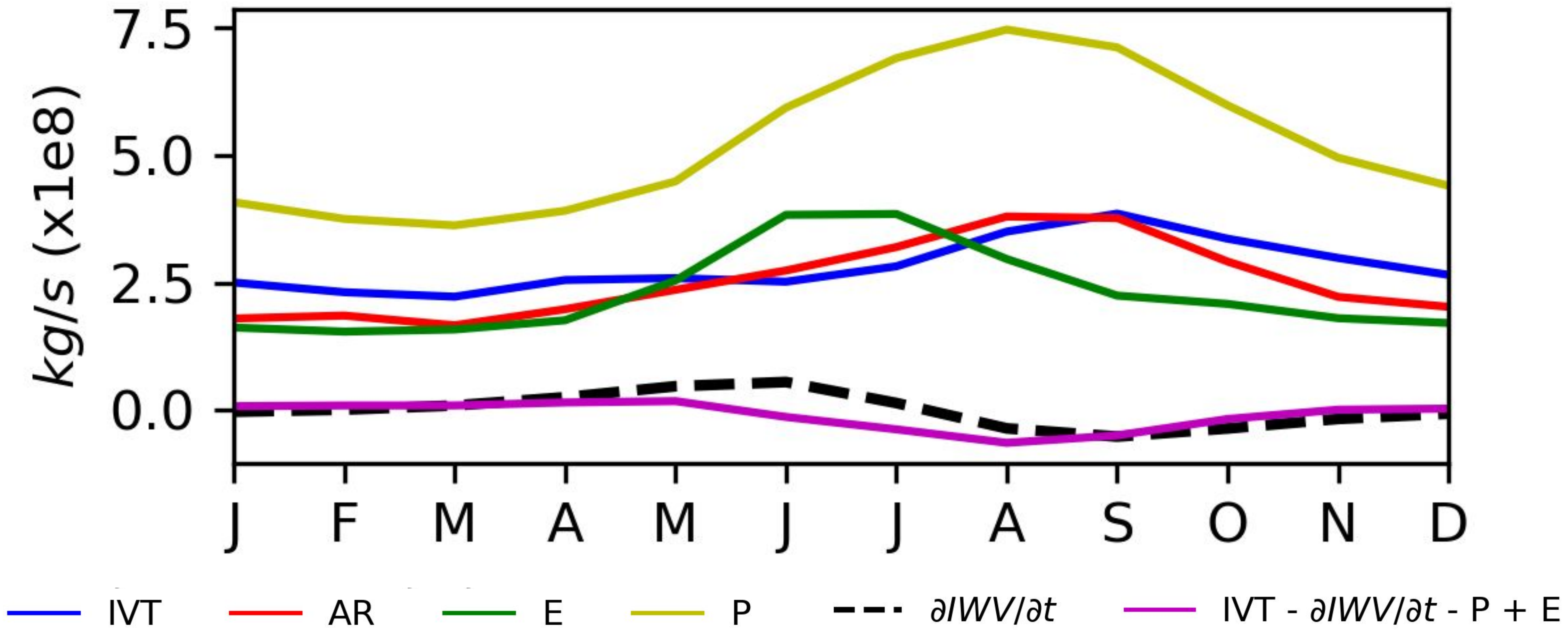
>60% occurs in ARs



- AR-IVT makes up the majority of total IVT
- During the winter season, AR-IVT makes up approximately 73% of total IVT at 60°N.
- IVT primarily occurs over oceanic regions

**Similar results for S. Hemisphere*

Annual Cycle at 60°N



Climatological Annual Cycle shows precipitation (yellow) supported roughly half by evaporation (green) and half by IVT (blue) most of which is AR related (red).

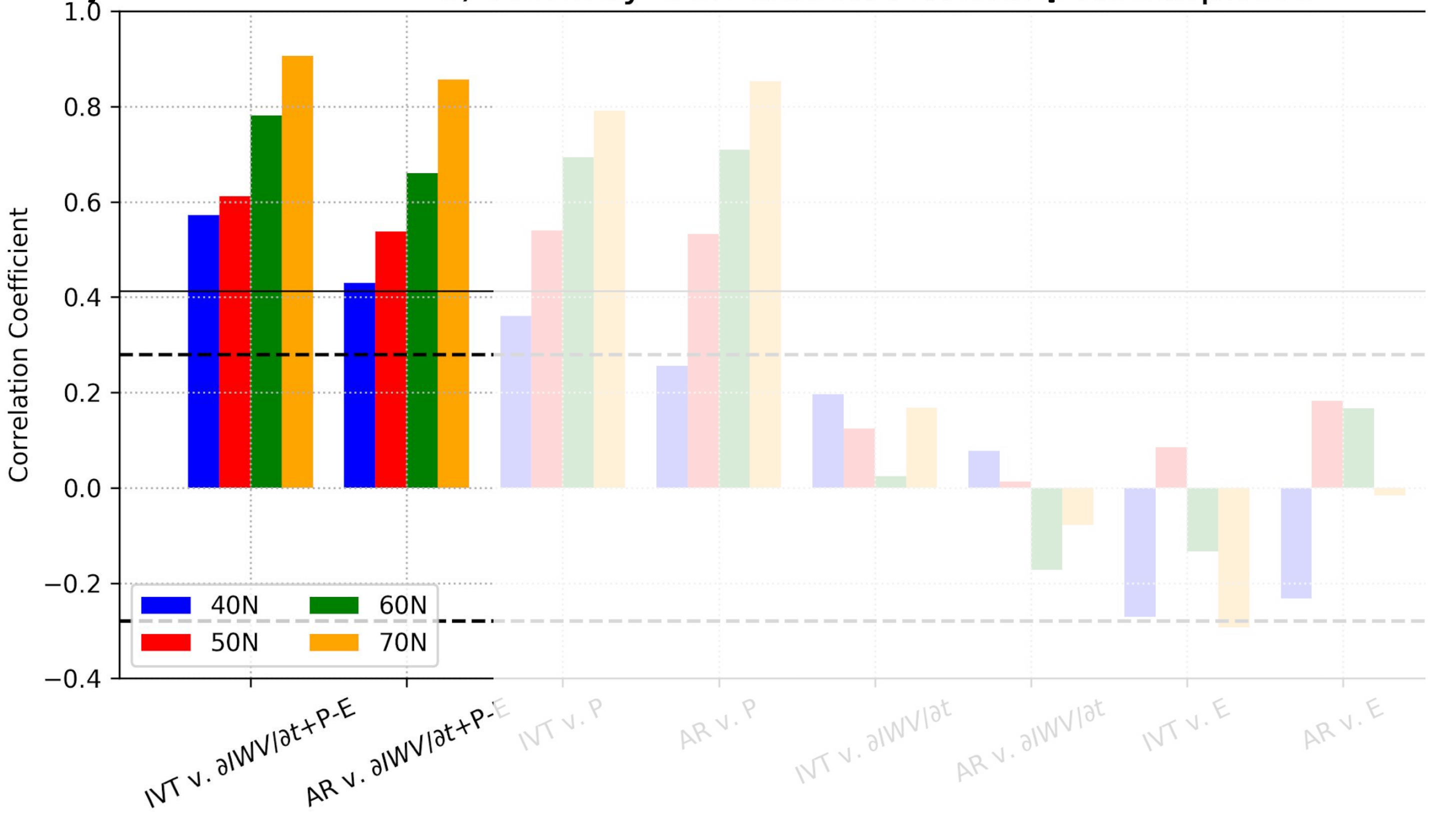
**Similar results for S. Hemisphere*

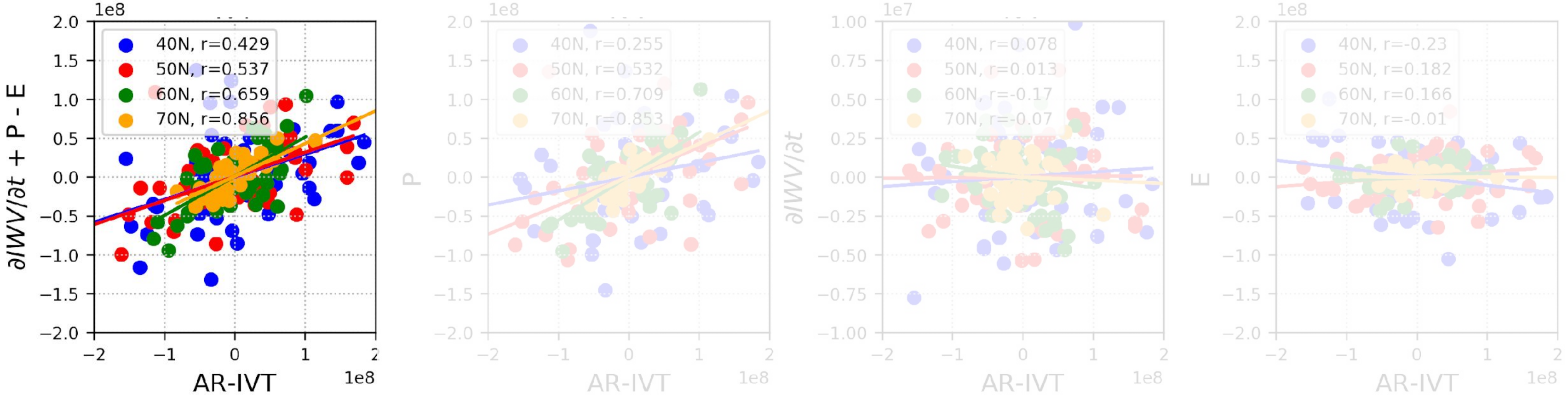
Monthly Anomaly Correlations - Northern Hemisphere

Water Budget

IVT = P – E + Δ IWV

➢ For monthly anomalies, IVT is the main driver of the sum of the spatially-averaged atmospheric water budget terms with AR-IVT being a significant contributor.





**Similar results for S. Hemisphere*

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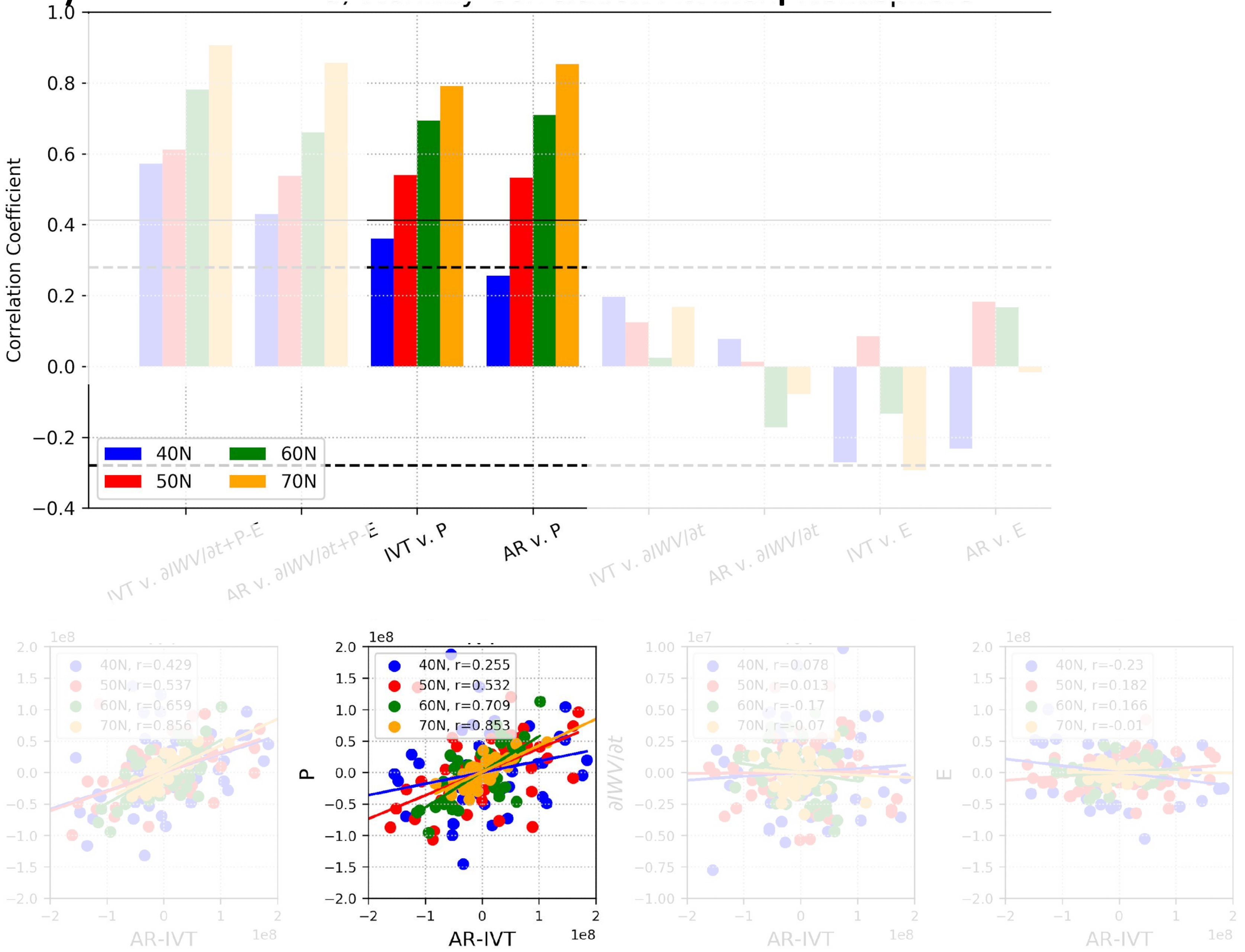


**Similar results for S. Hemisphere*

Monthly Anomaly Correlations - Northern Hemisphere

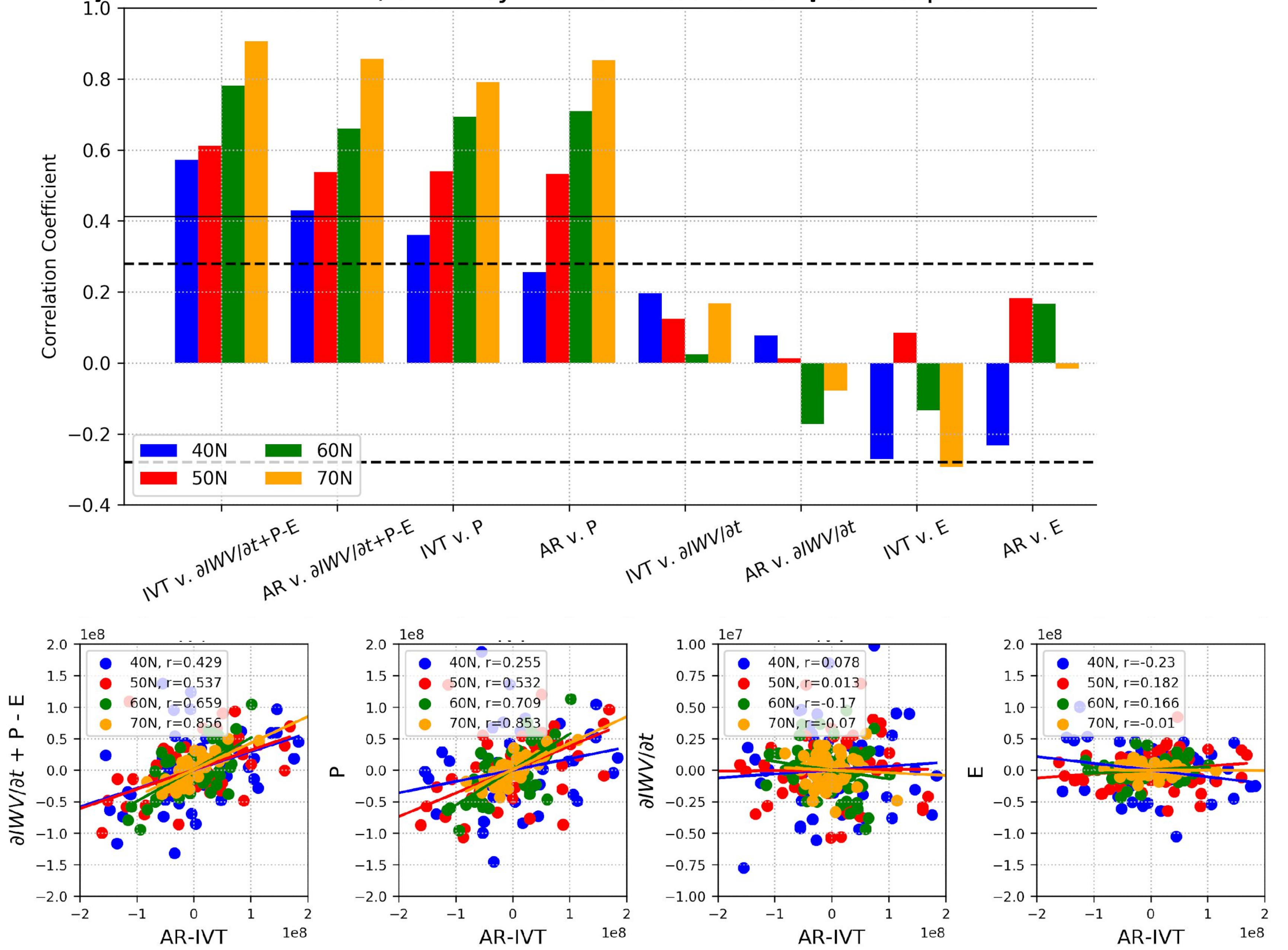
Water Budget

IVT = P – E + Δ IWV

IVT ~ P

AR-IVT ~ P

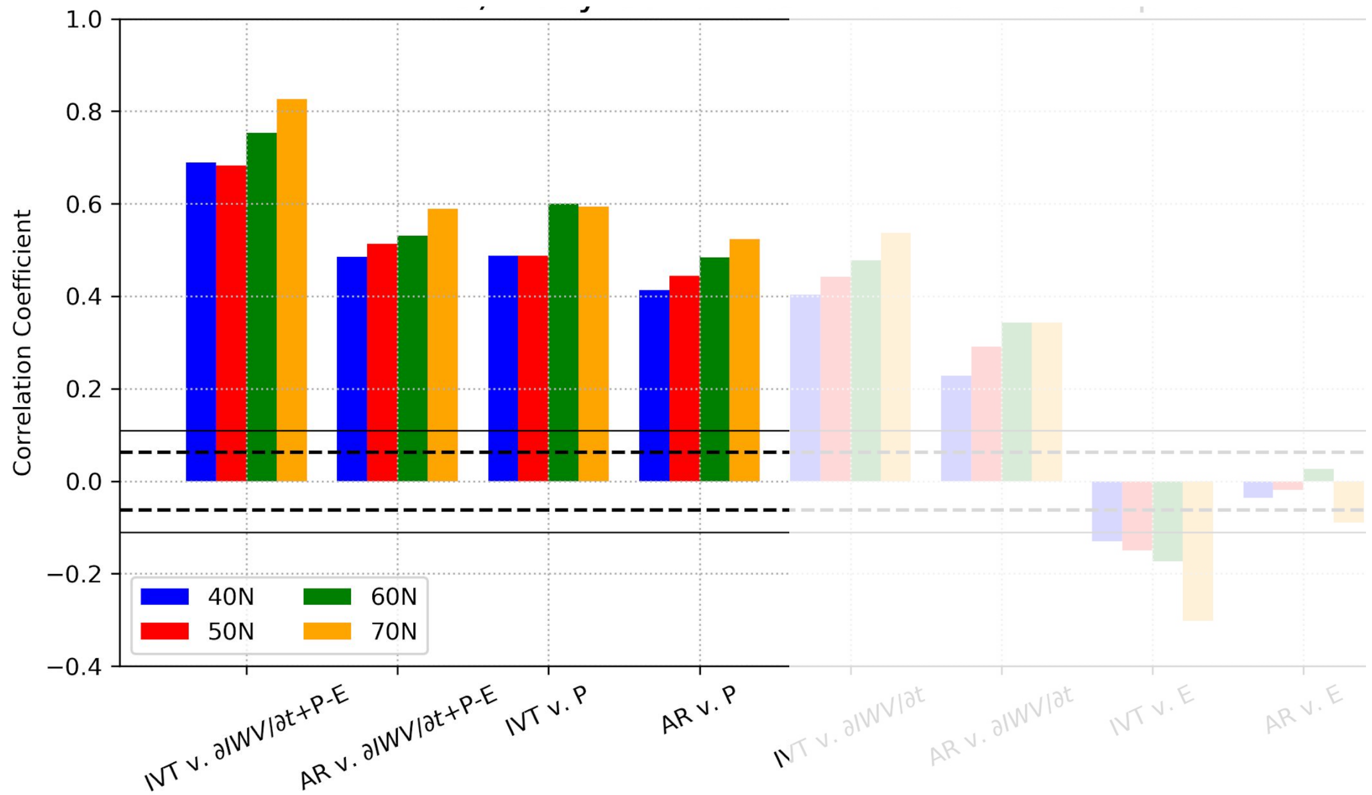
- For monthly anomalies, IVT is the main driver of the sum of the spatially-averaged atmospheric water budget terms with AR-IVT being a significant contributor.
- Precipitation contributes ~65% to the atmospheric water budget, while evaporation and dIWV/dt contribute the other 35%.

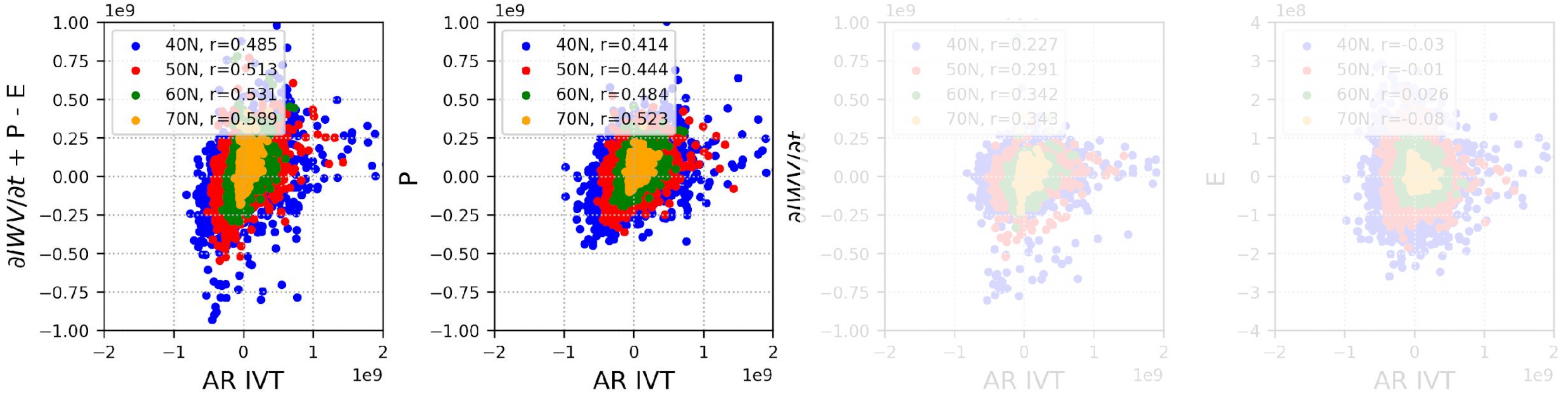


Similar results for S. Hemisphere

Daily Anomaly Correlations - Northern Hemisphere

- Daily anomalies also show that IVT is the main driver of precipitation variations, with AR-IVT being a significant contributor in both hemispheres.

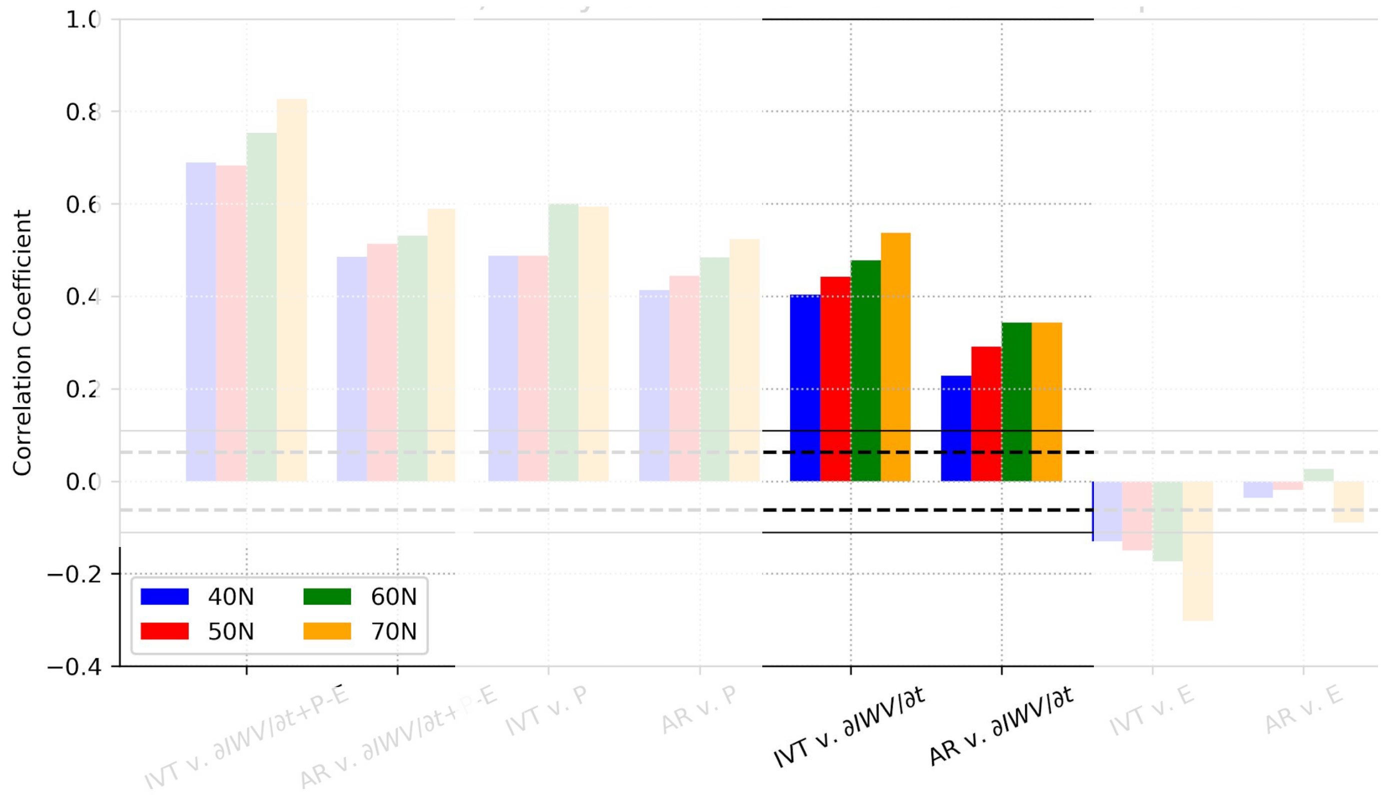


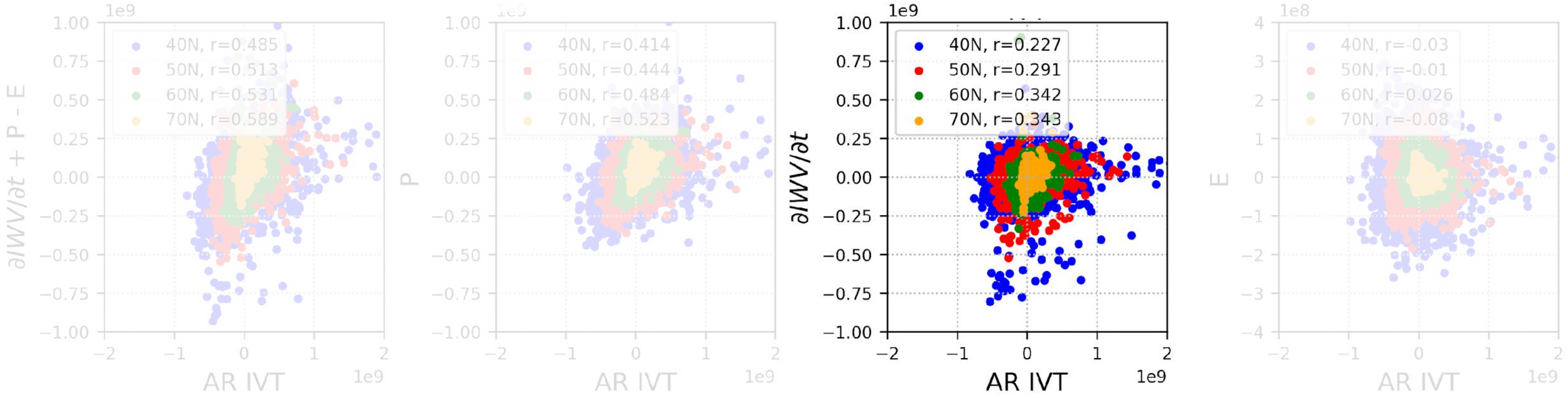


**Similar results for S. Hemisphere*

Daily Anomaly Correlations - Northern Hemisphere

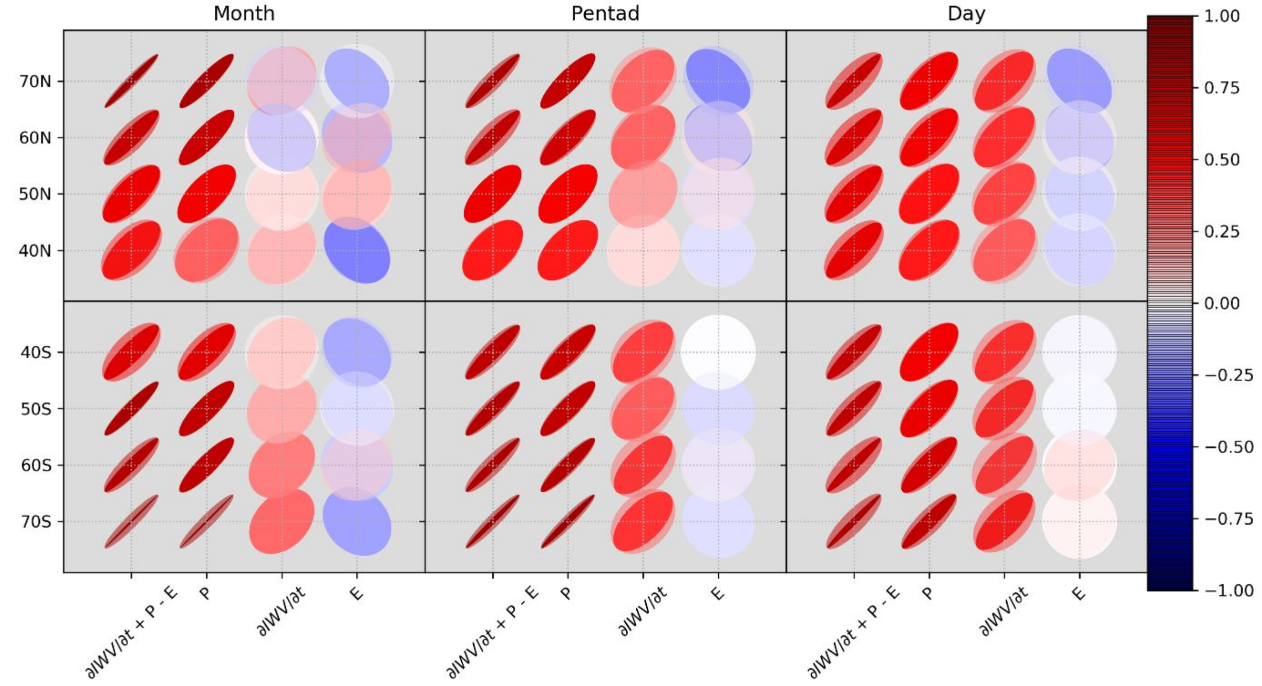
- Daily anomalies also show that IVT is the main driver of precipitation variations, with AR-IVT being a significant contributor in both hemispheres.
- The relationship between dIWV/dt and total IVT is the highest at the daily timescale, compared to all the other timescales.





**Similar results for S. Hemisphere*

Summary



**Similar results for S. Hemisphere*

These results demonstrate the important role of episodic, extreme water vapor transports by ARs in modulating extratropical and polar hydroclimate.

- On the monthly timescale, AR-IVT is responsible for 44% of the variations in the spatially averaged atmospheric water budget at 60°N.
- Compared to monthly and pentad, the relationship between dIWV/dt and total IVT is the highest at the daily timescale.
- At all timescales, precipitation makes up the largest proportion of the spatially averaged atmospheric water budget.
- On an annual scale, precipitation is supported half by evaporation, and half by meridional IVT, most of which is AR related.
- During the winter season, AR-IVT makes up approximately 73% of total IVT at 60° N