

Continental patterns of bird migration linked to climate variability

Amin Dezfuli
NASA GSFC & SSAI

GEO Health Community of Practice
November 30, 2021



Escher 1938, retrieved from <https://www.nga.gov>

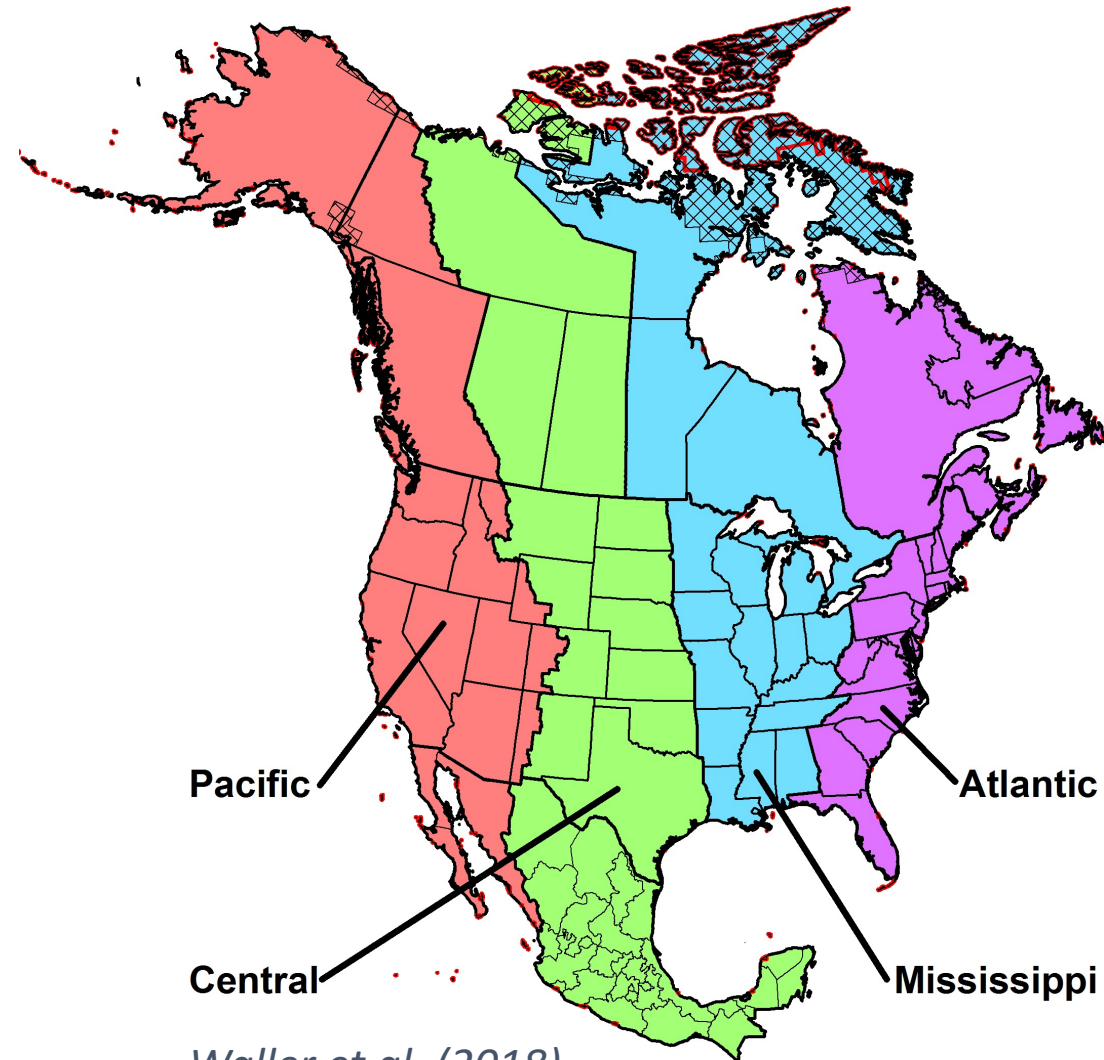
Co-authors: Kyle Horton, Benjamin Zuckerberg, Siegfried Schubert, and Michael Bosilovich

Also acknowledging: other members of the NASA's GMAO NCA group, Randal Koster, Allison Collow, Young-Kwon Lim, Natalie Thomas, and Anthony DeAngelis for their constructive comments.

Funding Support:

- Global Modeling and Assimilation Office (GMAO) Core funding, provided under NASA's Modeling, Analysis and Prediction (MAP) program.
- GMAO National Climate Assessment (NCA) enabling tools funded by NASA.

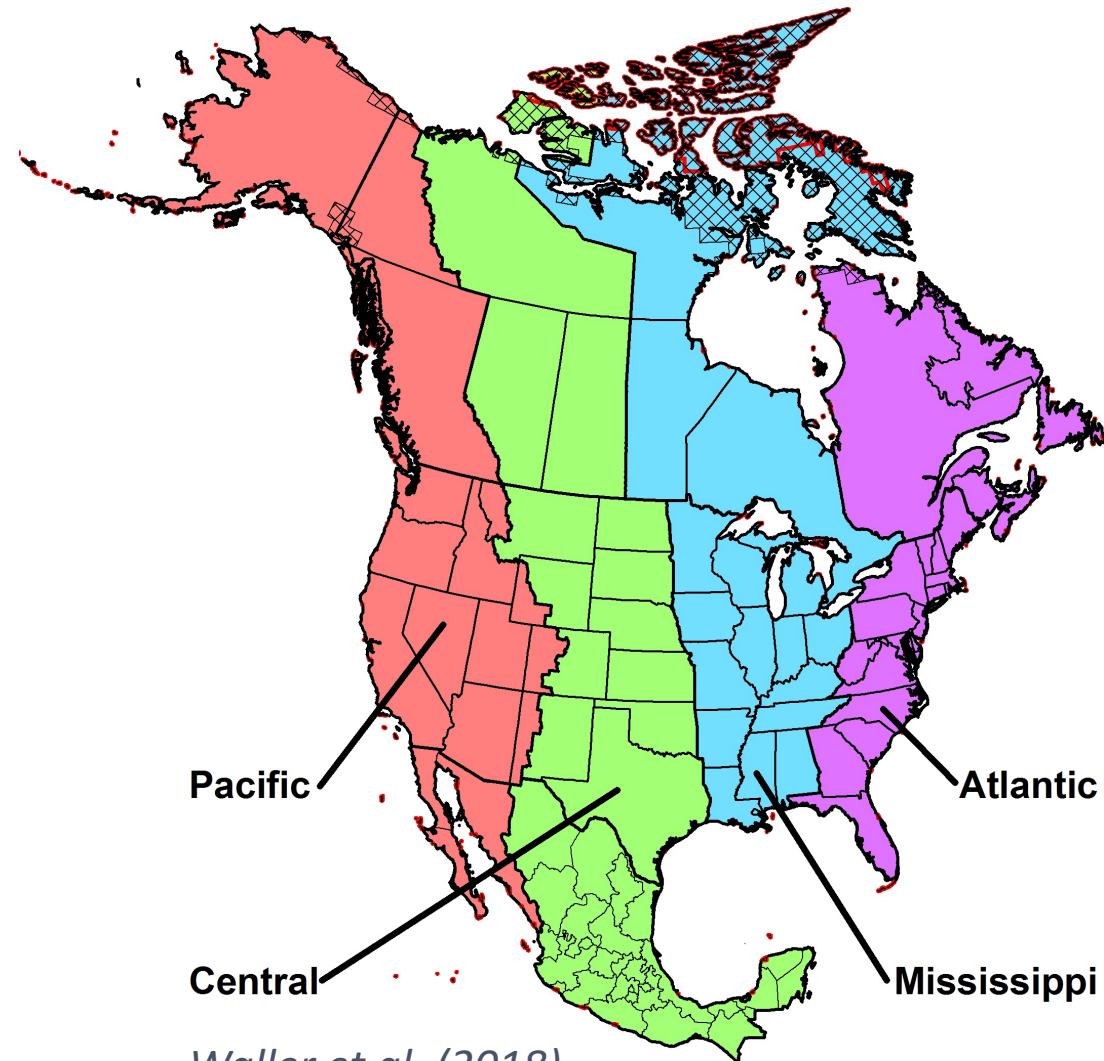
Bird migration flyways: background, shortcomings, and our approach



Waller et al. (2018)

- For ~100 years, for management purposes, the continental patterns of avian migration in North America have been described in the context of three or four primary flyways.
- This spatial approach fails to reflect a critical characterization of migration — phenology.
- Phenology: seasonal timing of key life cycle events.

Bird migration flyways: background, shortcomings, and our approach



Pacific

Atlantic

Central

Mississippi

Waller et al. (2018)

- The shortcoming was due to the lack of reliable continental-scale data.
- This gap is filled by analyzing unique radar-based data (NEXRAD) to quantify migration phenology.
- A new spatial concept for migration is introduced.
- Large-scale climatic mechanisms controlling the new spatial variability are explored.

Data

- **Bird migration:**

- Developed from NOAA's Next Generation Radar (NEXRAD) network, consisting of 143 stations across the U.S., using neural network algorithms (Lin et al. 2019).
- Median migration date (q50), defined as the date by which 50% of the cumulative passage occurred at each radar station

- **Meteorological data:**

- Temperature, geopotential height, and winds from NASA's MERRA-2 Reanalysis.

- **Normalized Difference Vegetation Index (NDVI):**

- NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) collection 6

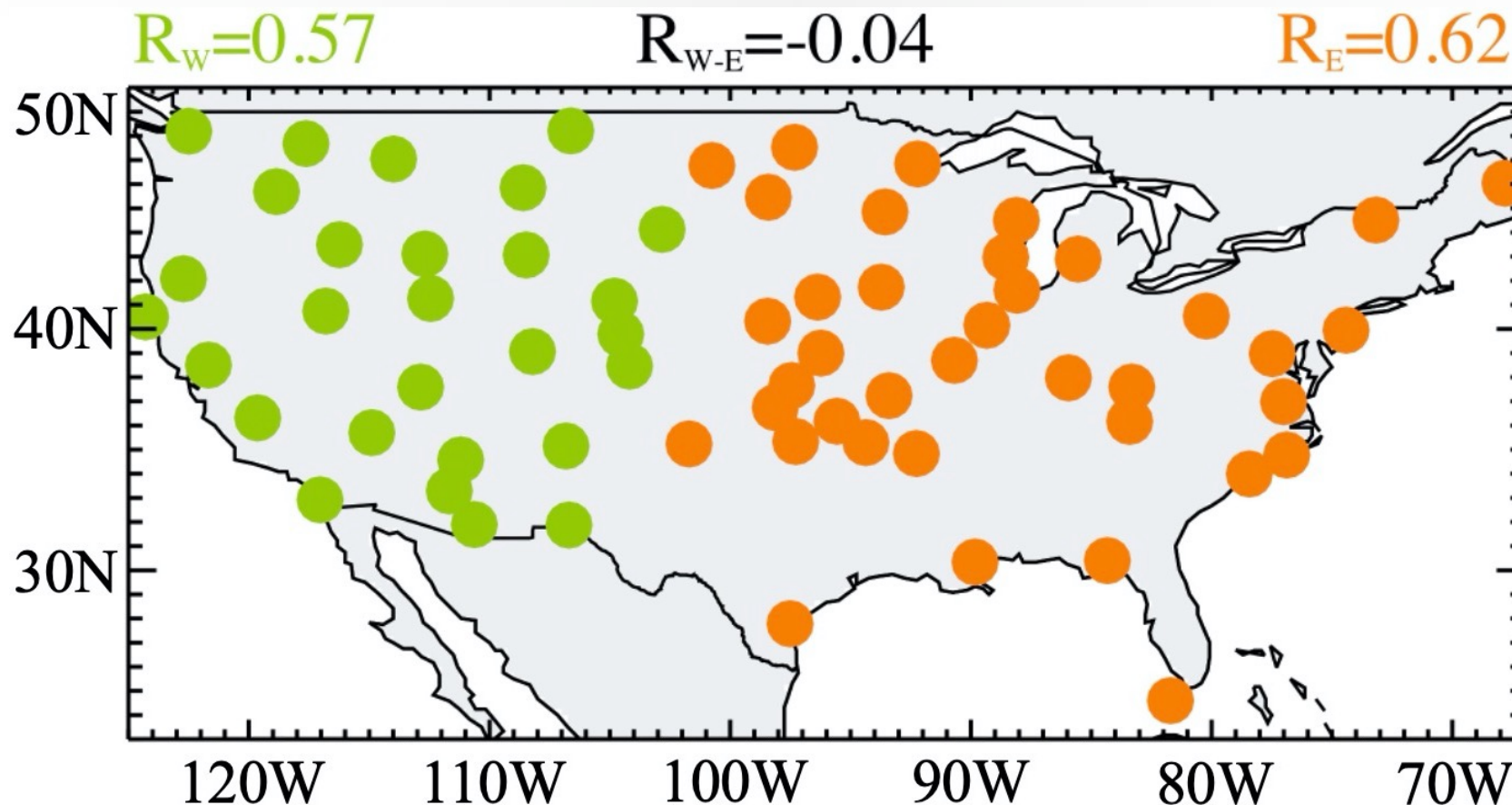
- **Sea Surface Temperature (SST)**

- OISST (NOAA Optimum Interpolation SST V2)

- **Climate indices:**

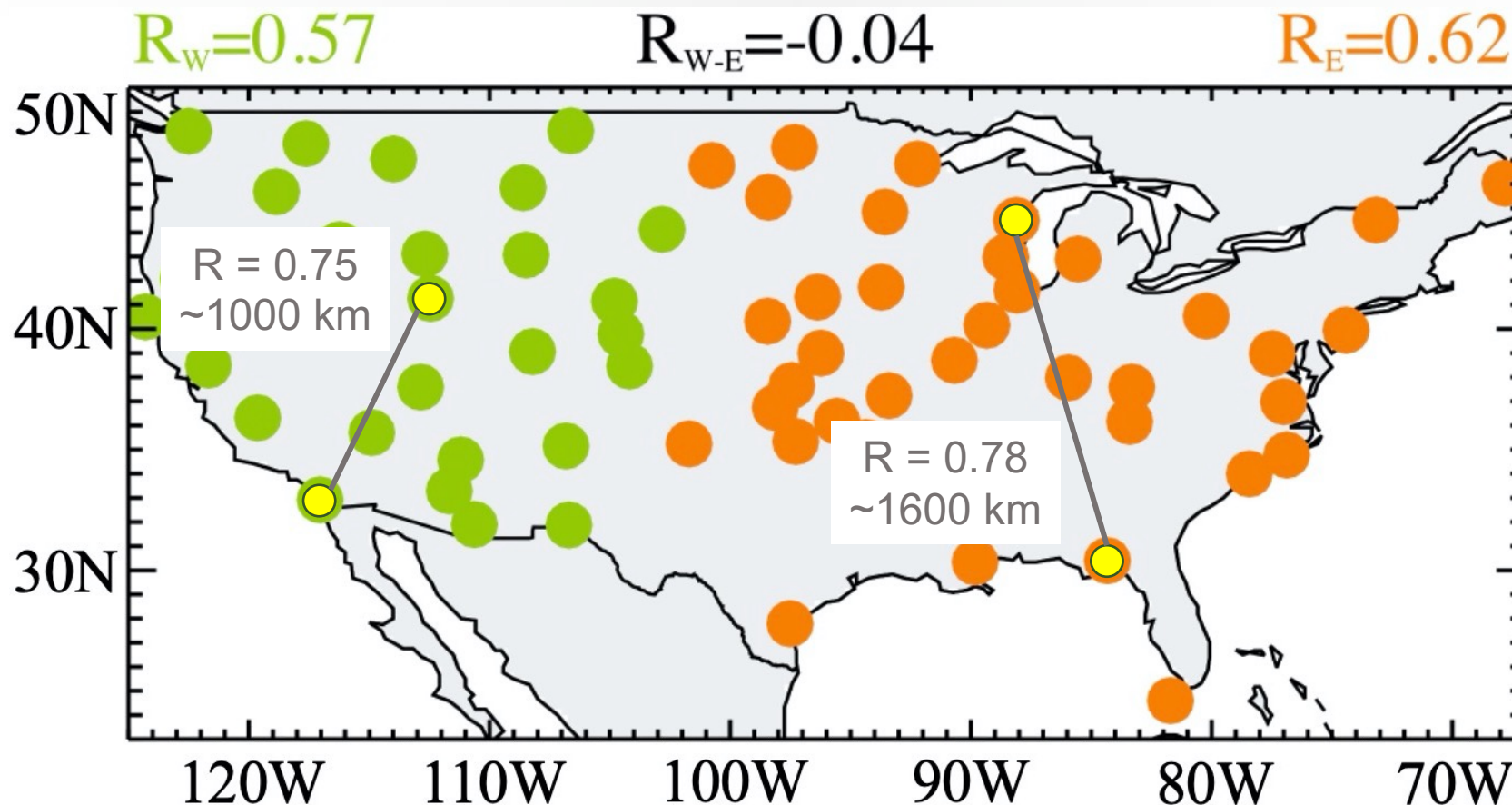
- NOAA's Physical Science Laboratory

Regionalization based on interannual variability of bird migration



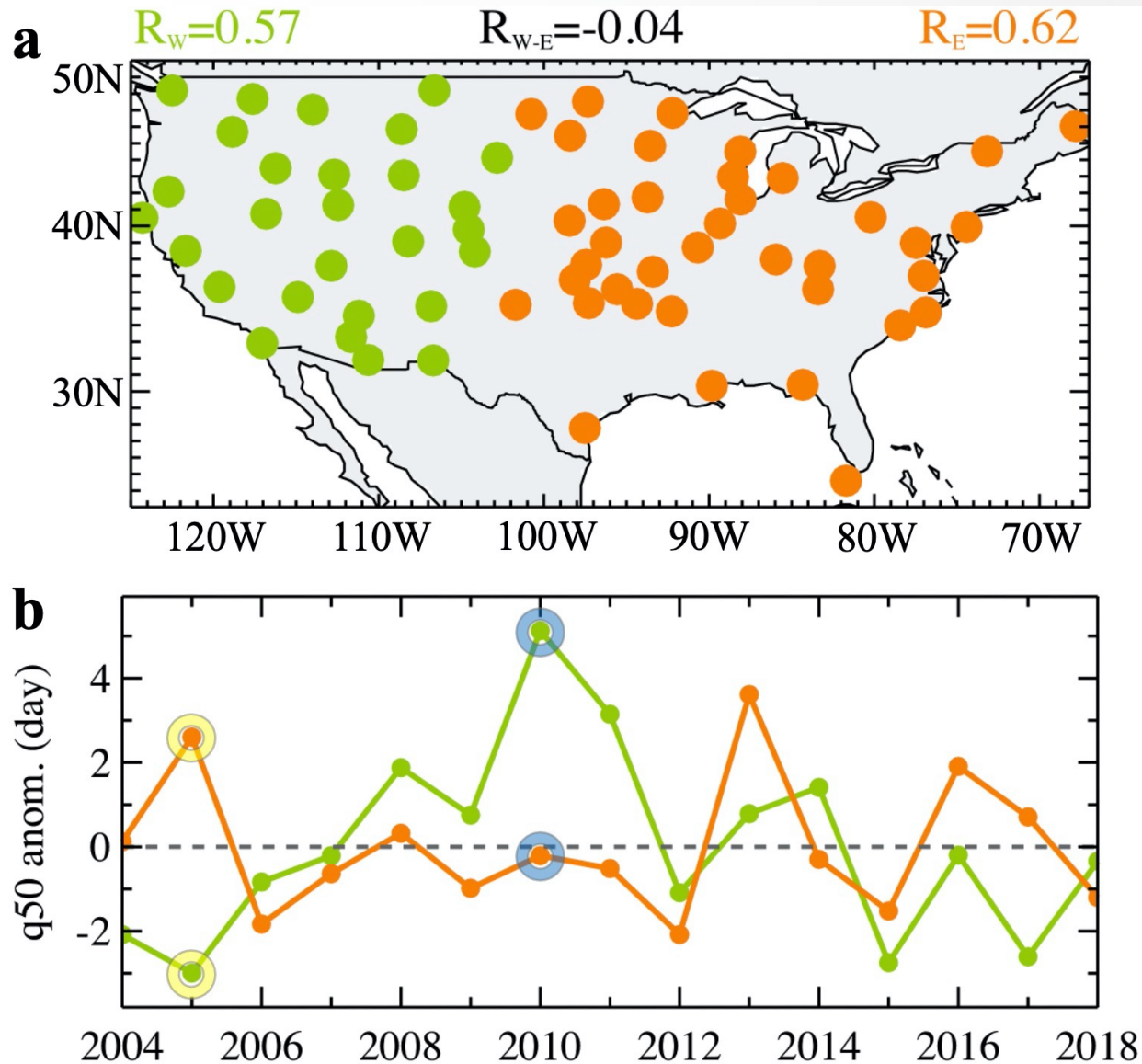
- Two regions are identified: each is homogeneous with a specific interannual variability.
- Two-region pattern is intrinsically different from the previous three- and four-flyway strategies, both in how it has been achieved and its applications.

Regionalization based on interannual variability of bird migration



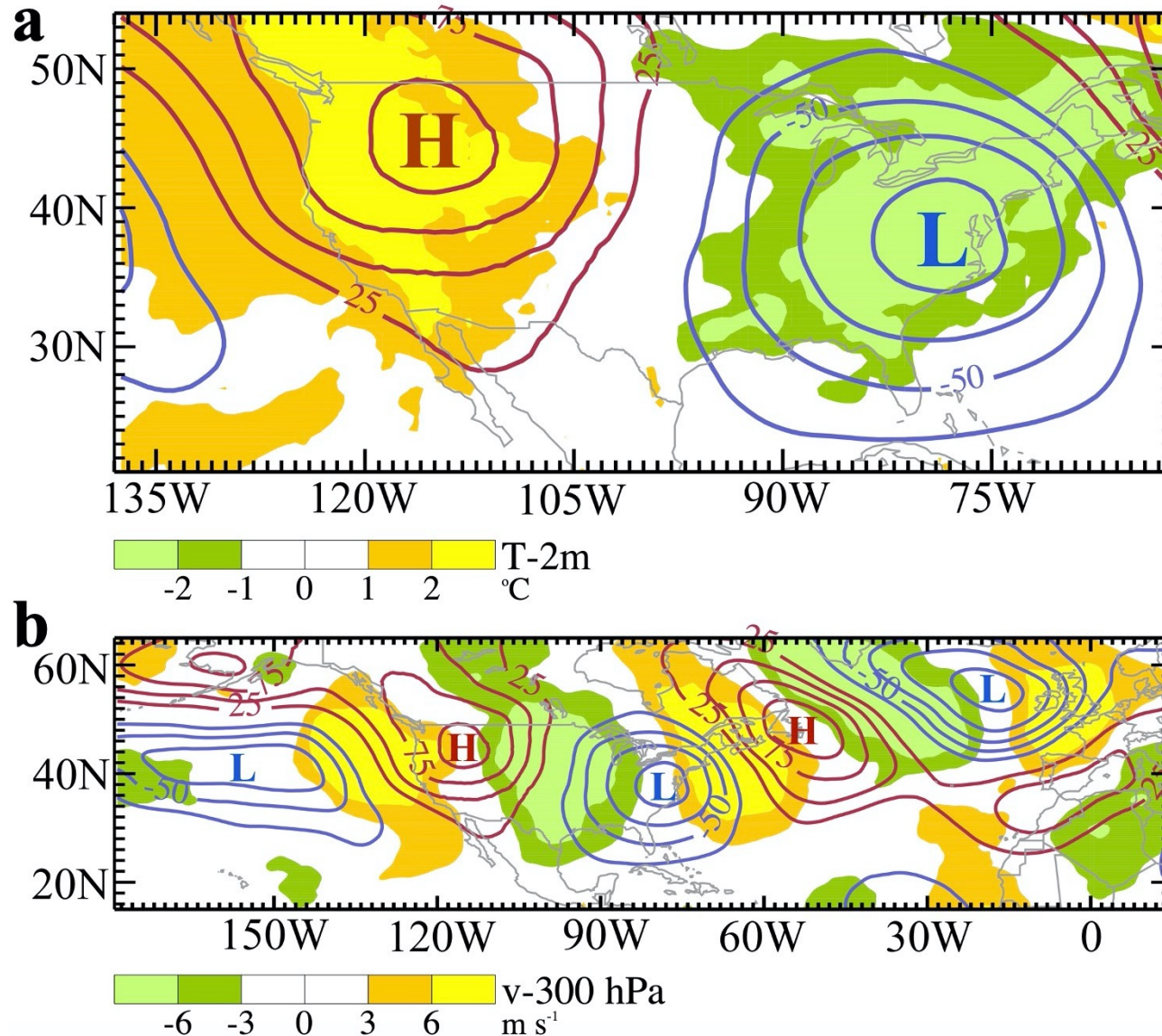
- Two regions are identified: each is homogeneous with a specific interannual variability.
- Two-region pattern is intrinsically different from the previous three- and four-flyway strategies, both in how it has been achieved and its applications.

Why does the two-region approach matter?



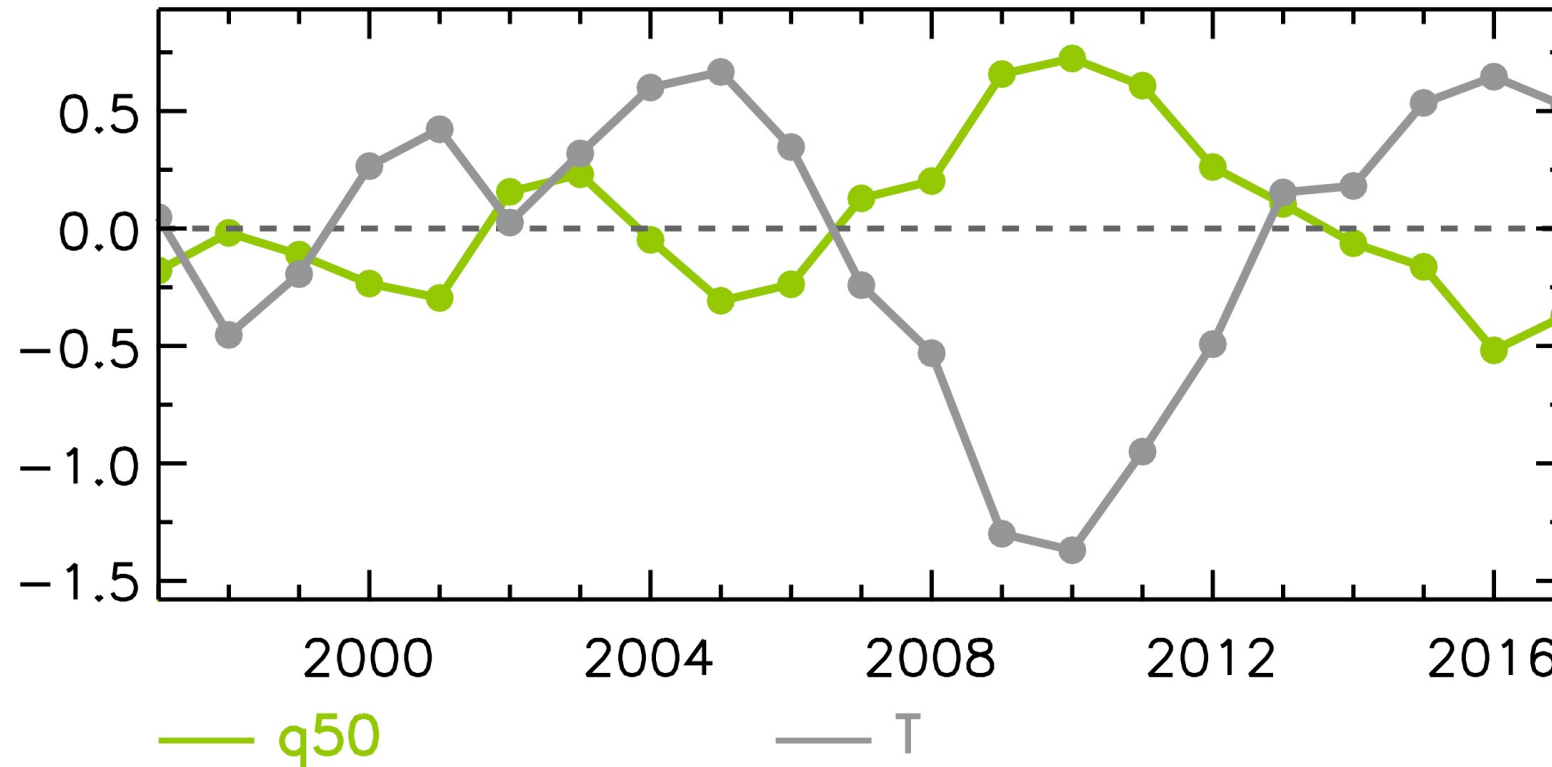
- Enables us to identify the region-specific drivers of interannual variability (e.g., climatic phenomena) of bird migration at the continental scale.
- Detects years with opposite anomalies and investigates why.
- Identifies large-scale temporal characteristics, e.g., std. deviation: 2.4 days in West vs. 1.7 days in East

Rossby waves control the avian migration



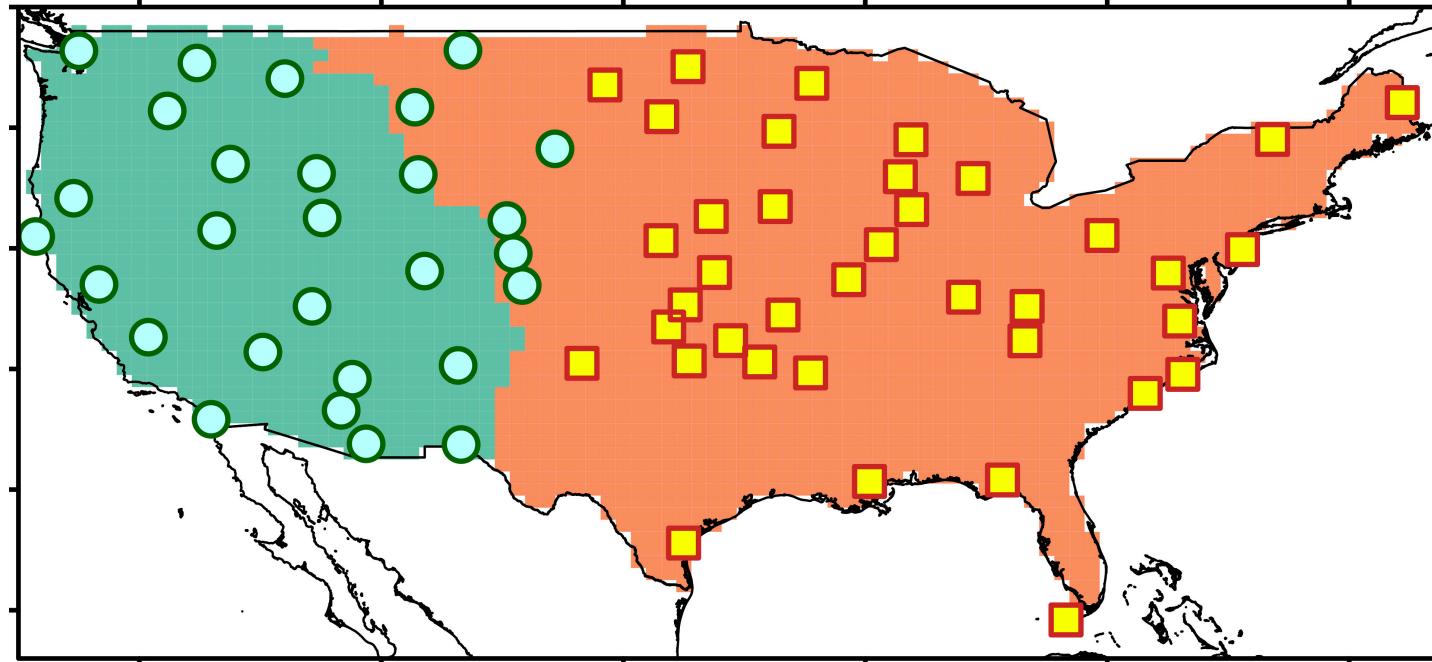
- Patterns of GHT (300 hPa) & temperature for 2005 minus 2010 identify atmospheric Rossby wave.
- Using GHT & meridional wind, Rossby wave train is traced back to the Pacific.

Low-frequency variability in bird migration & temperature



- Negative correlation ($R = -0.79$, $p < .00005$) between temperature and arrival date of migratory birds over the **western U.S.**
- Warmer temperature → earlier arrival in spring

Similar spatial variability for bird migration & temperature



- Climate regions obtained objectively based on similarity in interannual variability of Mar-Apr-May temperature.
- Open-source *R* package, *HiClimR*, is used (Badr et al. 2015).
- Consistent with two-region pattern from bird migration variability.

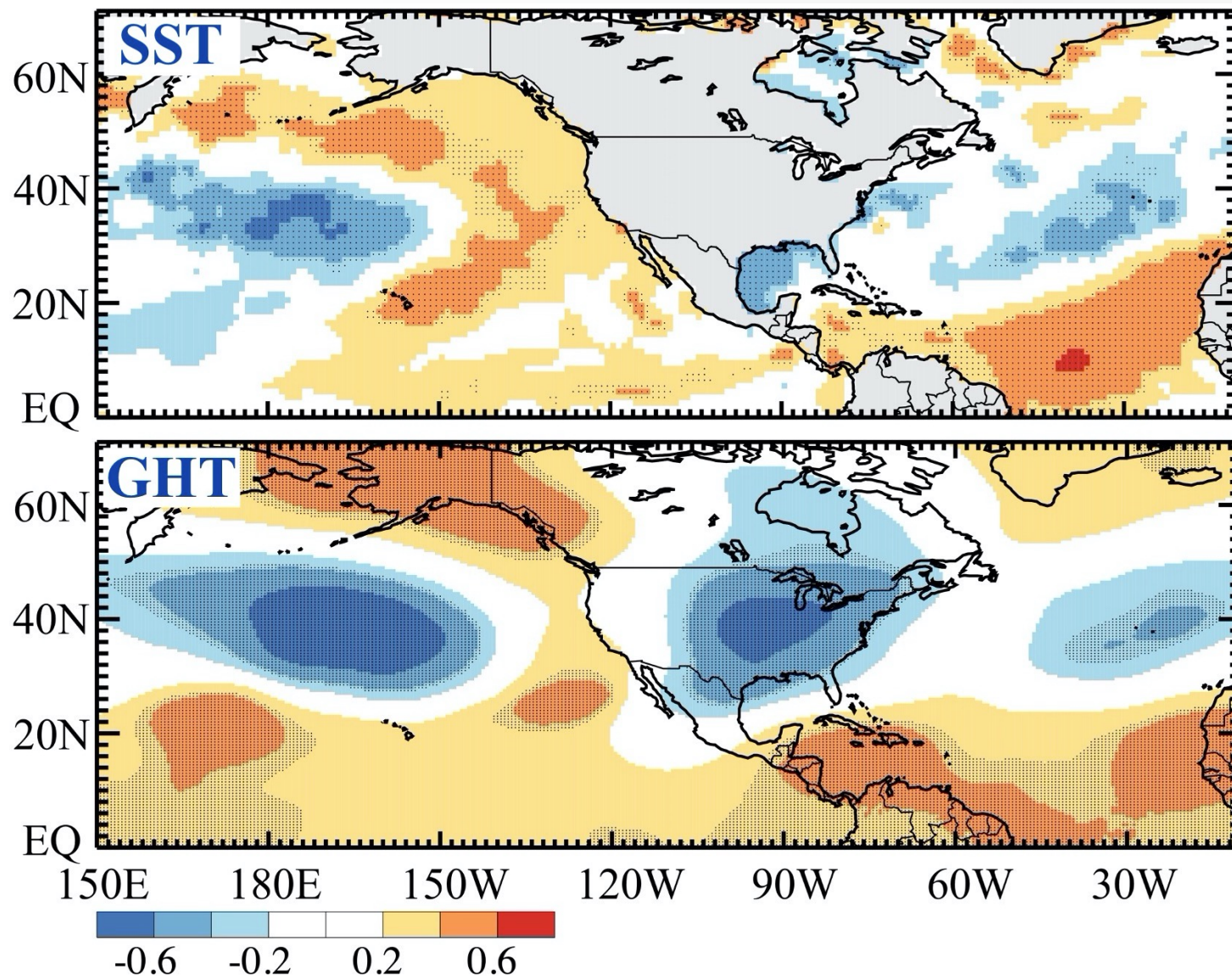
Correlation between regional mean q50 and climate indices

Climate Index	West/East	2004-2018	1996-2018
T-2m	W	-.83 (.0009)	-.79 (.00005)
	E	-.55 (.0784)	-.56 (.0175)
NDVI	W	-.63 (.0413)	-.50 (.1015)*
	E	-.17	-.12
Nino3.4	W	-.33	-.24
	E	.28	.30
EP/NP	W	-.37	-.17
	E	.55 (.0784)	.58 (.0175)
PDO	W	-.35	-.29
	E	.31	.42 (.0644)
AO	W	-.02	.00
	E	-.60 (.0784)	-.50 (.0262)
NTA	W	.34	.21
	E	.49 (.1115)	.52 (.0257)

* For 2000-2018.

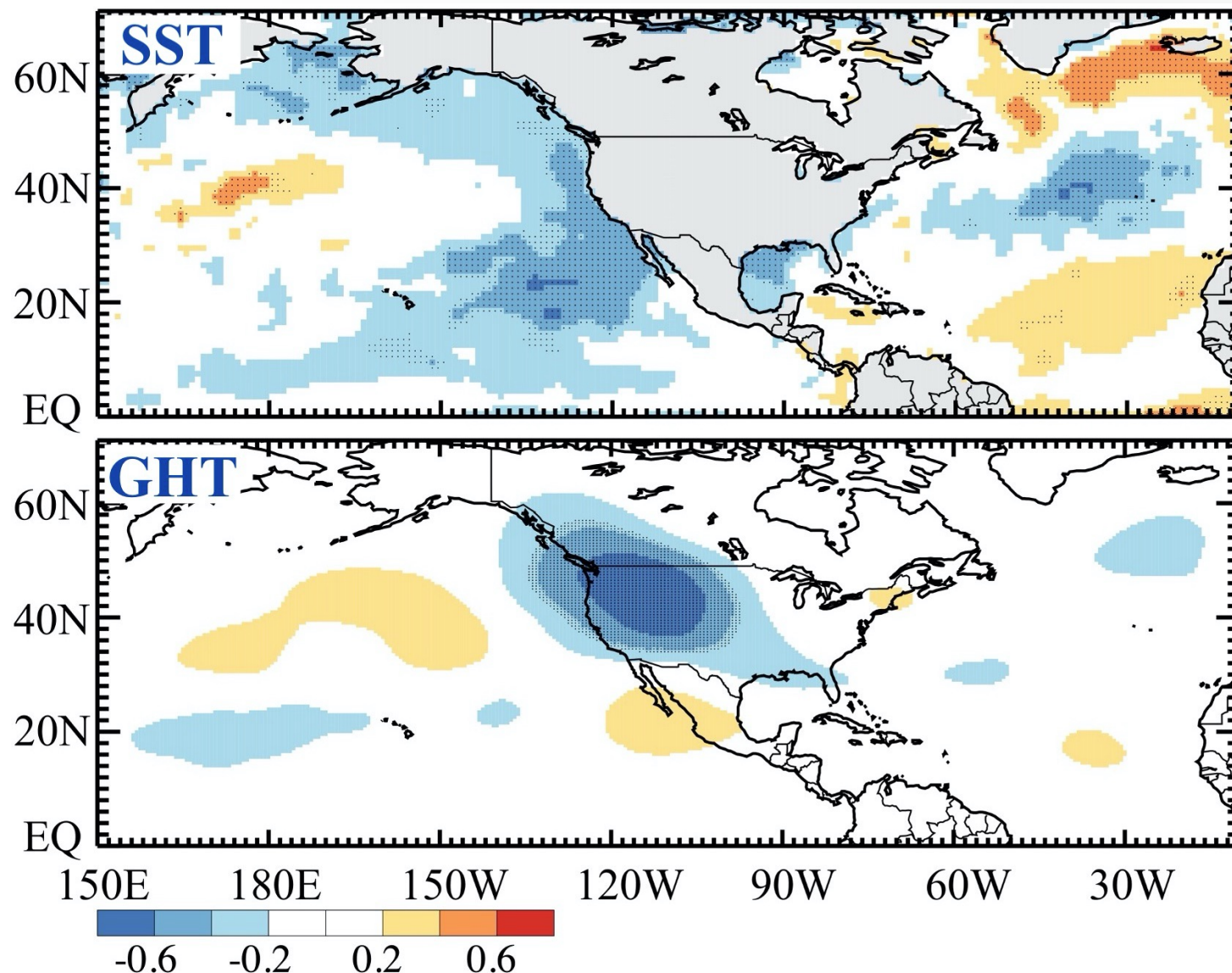
- Time-series of seasonal (March-April-May) means are used for climate indices are.
- Note difference between western and eastern regions.

Role of climate modes in avian migration: Eastern U.S.



- Pattern correlations between migration arrival date & SST (top) and GHT (bottom):
- Patterns associated with the East Pacific-North Pacific (EP/NP) and North Tropical Atlantic (NTA) stand out.
- Impact of SST is likely reflected through Rossby waves that are excited over the tropical Pacific.

Role of climate modes in avian migration: Western U.S.



- Generally weaker and more spatially limited (than eastern region) link to large-scale climatic feature like Rossby waves.
- High correlations with adjacent waters, which likely affect the region through temperature advection.

Conclusions & Future Work

- CONUS is divided into two regions based on interannual variability of bird migration.
- The new approach is conceptually different from traditional three- and four-flyway strategies.
- Western and eastern regions show different links to climate variability.
- Eastern U.S. shows significant relationships with several climate modes of variability consistent with atmospheric Rossby wave patterns.
- Western U.S. shows a strong link to regional temperature and adjacent waters.
- **Future directions:**
- Using CMIP6 model outputs to investigate potential changes in bird migration patterns driven by future changes of climate phenomena.

Reference: Dezfuli, A., Horton, K.G., Zuckerberg, B., Bosilovich, M.G. and Schubert, S.D., 2021. Continental patterns of bird migration linked to climate variability. *Bull. Amer. Meteor. Soc.*, (accepted), <https://doi.org/10.1175/BAMS-D-21-0220.1>

THANK YOU!