

Atmospheric River Life Cycles: Climatology and Interannual Variability

Yang Zhou and Hyemi Kim

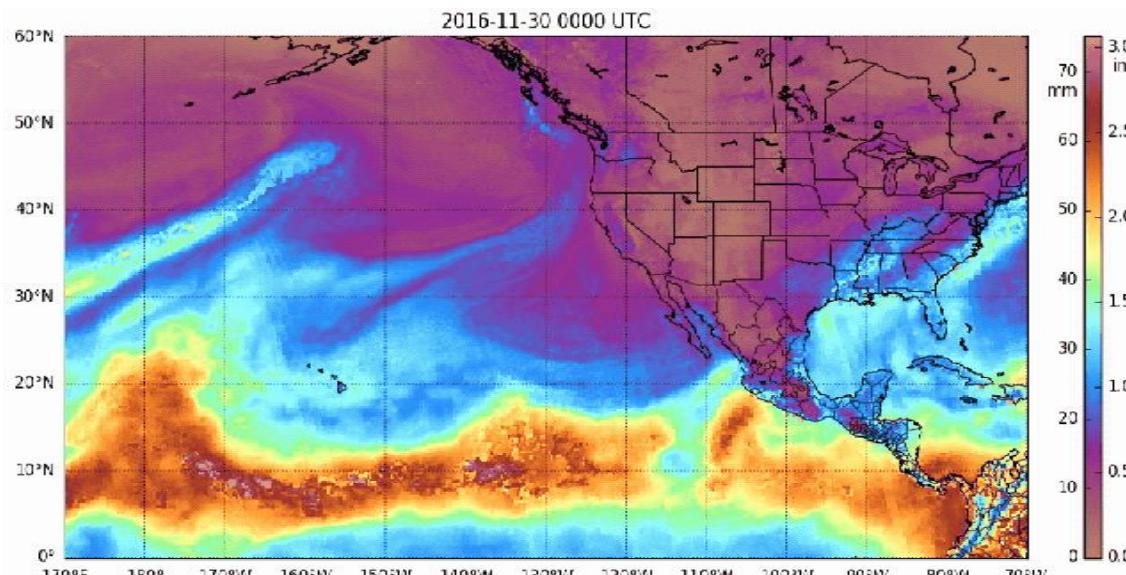
Stony Brook University



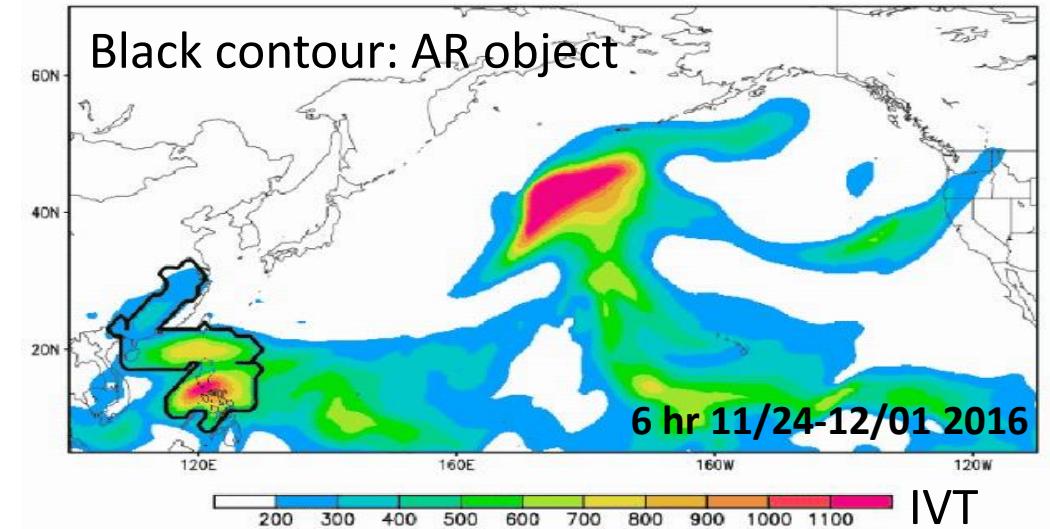
Stony Brook
University



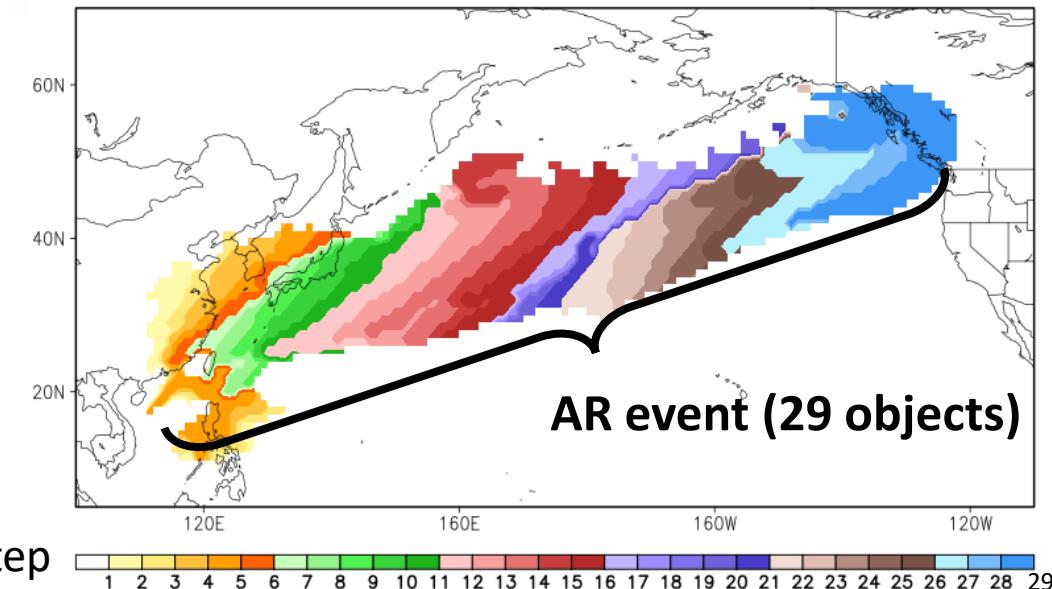
AR Events



Vertically-integrated vapor transport (IVT)



- AR objects: instantaneous areas of IVT (2D, lat, lon)
- The IVT event can be detected as multiple AR objects during consecutive time steps
- AR events: Series of spatiotemporally connected AR objects (3D, lat, lon, **time**)



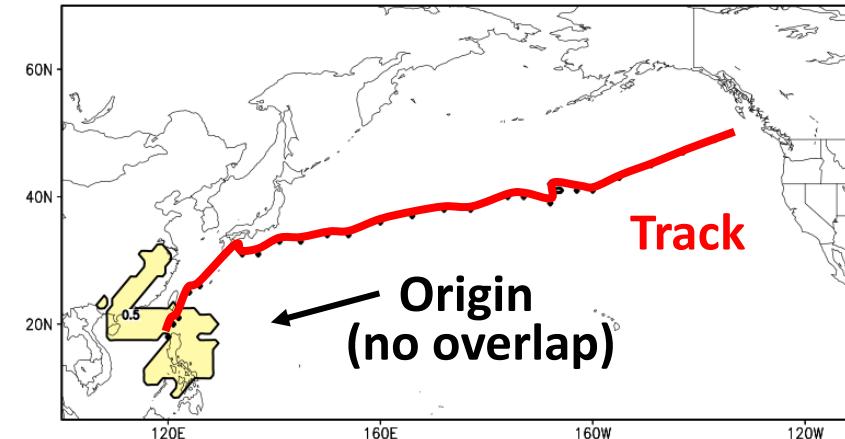
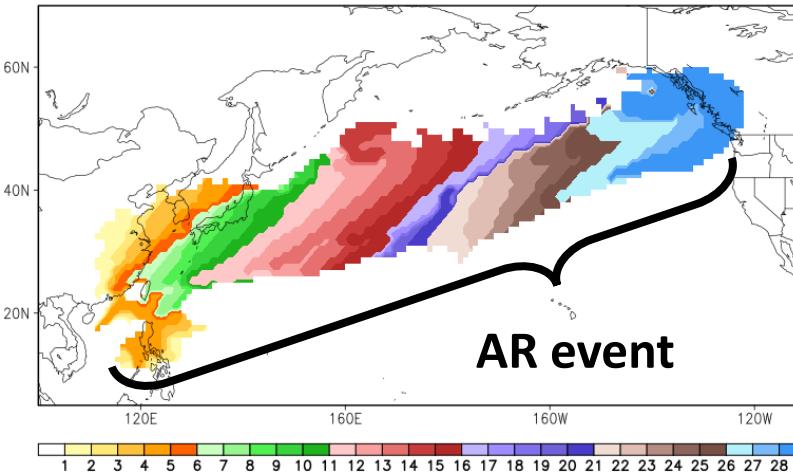
AR Tracking Algorithm

Input:
AR Objects

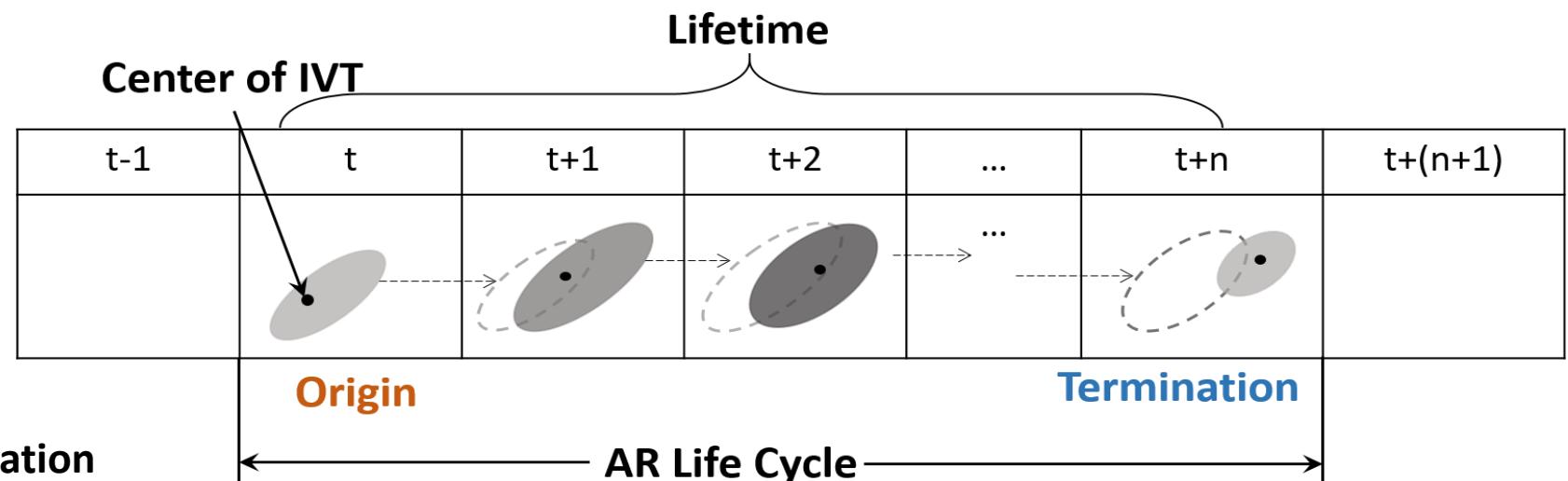
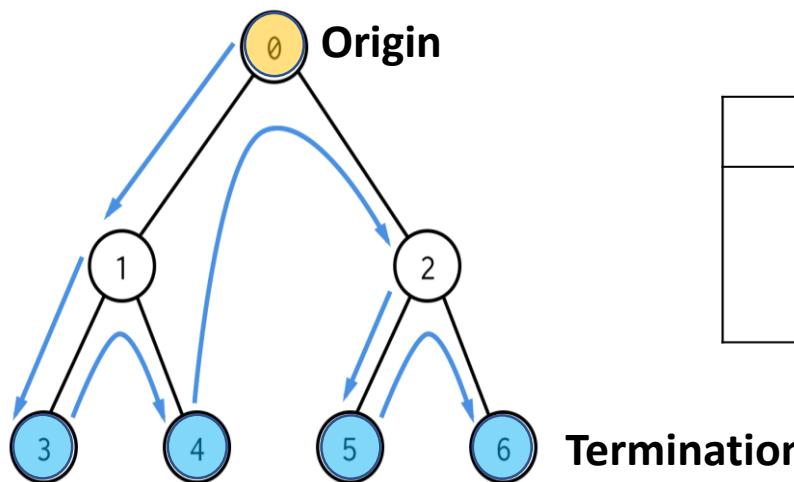
- ERA-Interim, 1° 6hr, NDJFM
- AR detection from Guan and Waliser (2015)

Step I:
Origin selection

Step II:
Tracking ARs

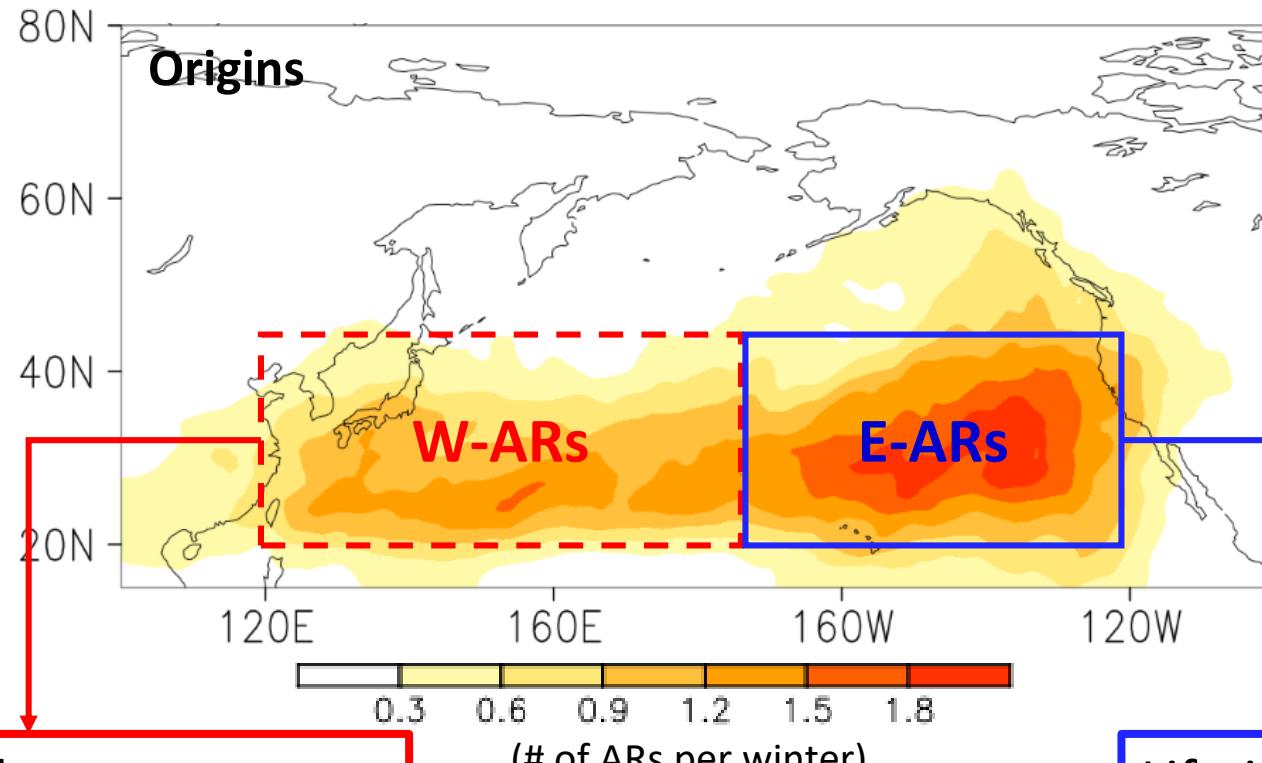


- A Depth-First Search process

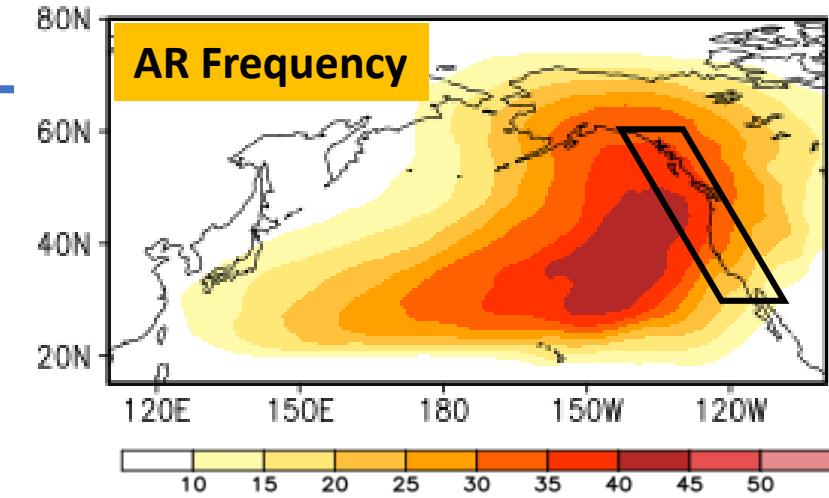


Landfalling ARs

- Landfalling ARs: AR events that landfall over **West Coast**
- 36 Landfalling ARs per cool season



Lifetime: **5.3** days
Mean intensity: **508** $\text{kg m}^{-1} \text{s}^{-1}$



Lifetime: **3.6** days
Mean intensity: **388** $\text{kg m}^{-1} \text{s}^{-1}$

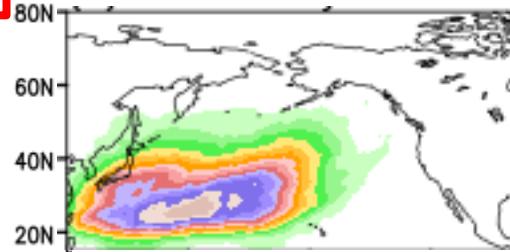
- W-ARs have **longer lifetime with stronger intensity** than E-ARs

Dynamical Processes

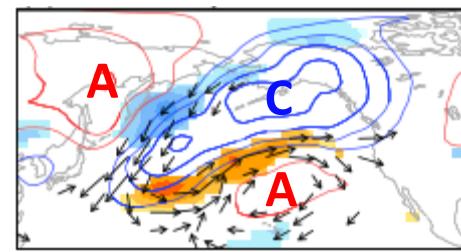
W-ARs

AR Frequency

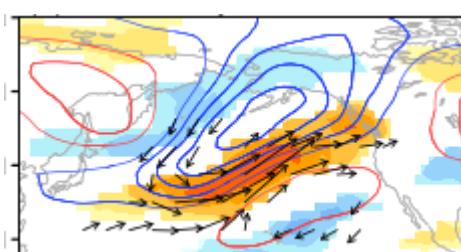
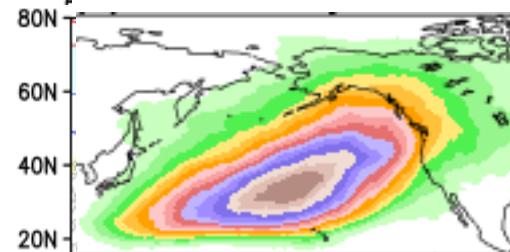
Day 0
(Origins)



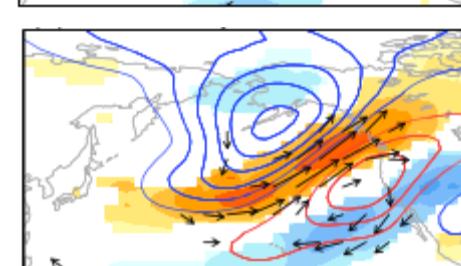
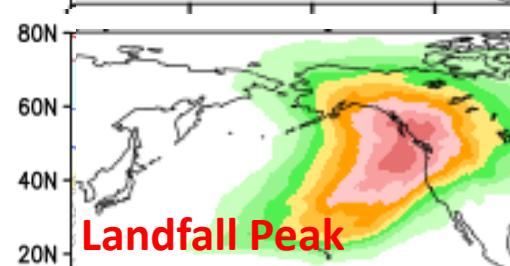
Z500/U300/MF



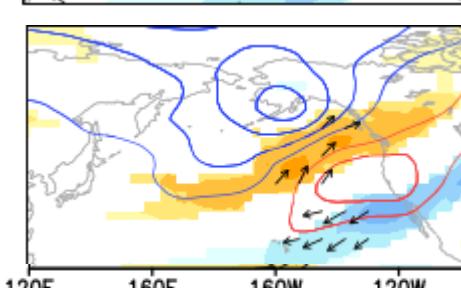
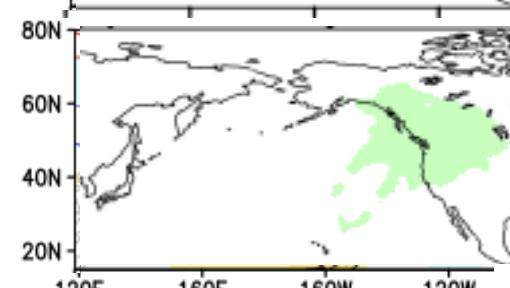
Day +2



Day +5

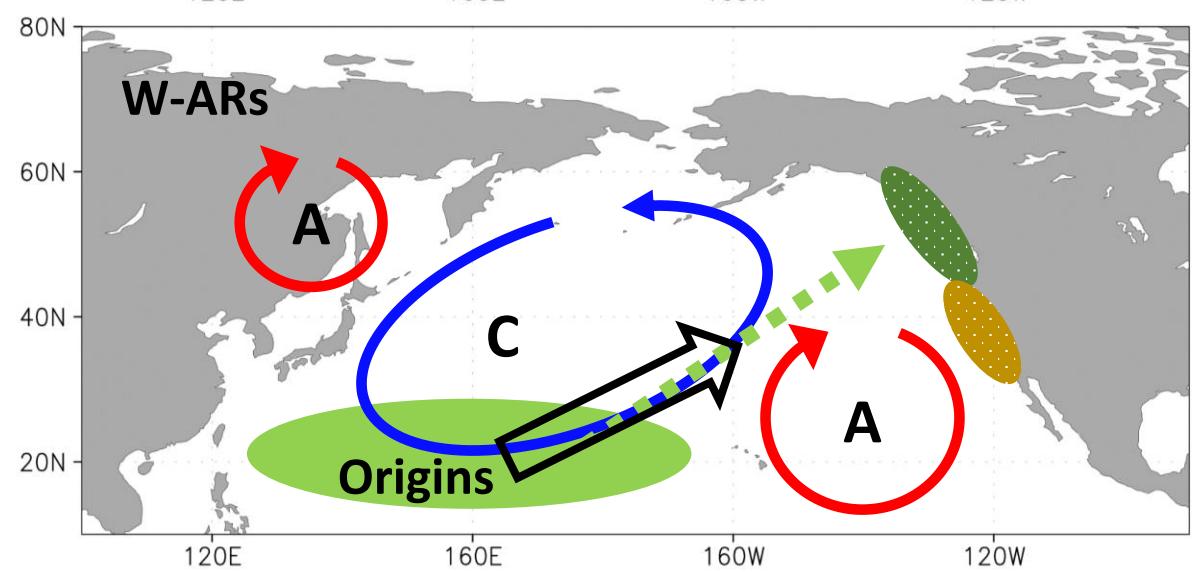
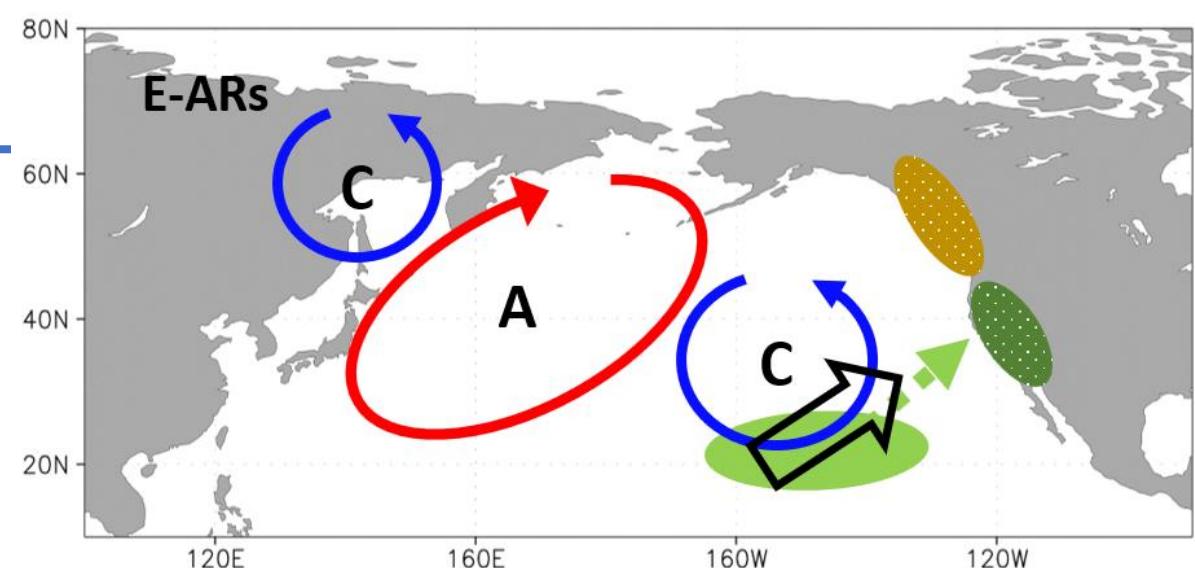


Day +8



5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

-6 -5 -4 -3 -2 -1 1 2 3 4 5 6 100



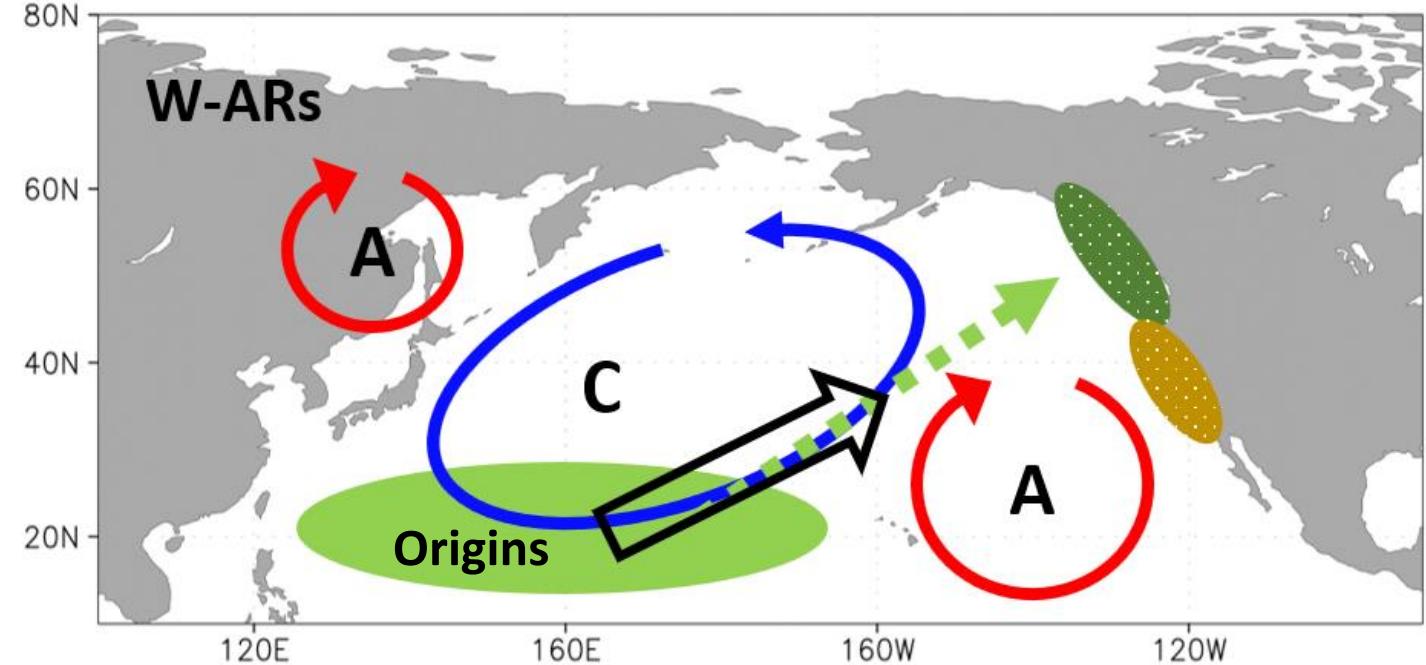
→ : Enhanced jet
→ : Propagation track
: AR origins
: More rain
: Less rain

Interannual Variability

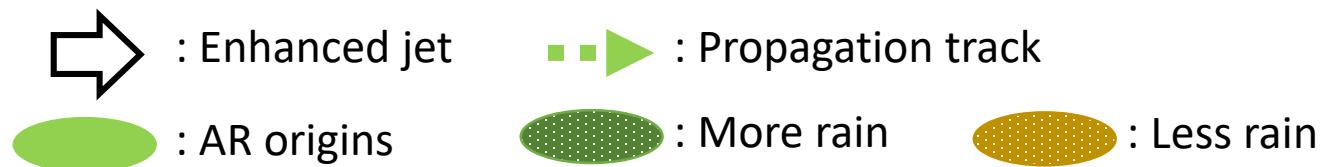
- Accumulated AR Intensity (ARI) index

$$ARI = \sum_{i=1}^{i=N} \sum_{t=1}^{t=T_i} [IVT(t)]_i$$

AR number (origins) Lifetime (duration of track) Intensity



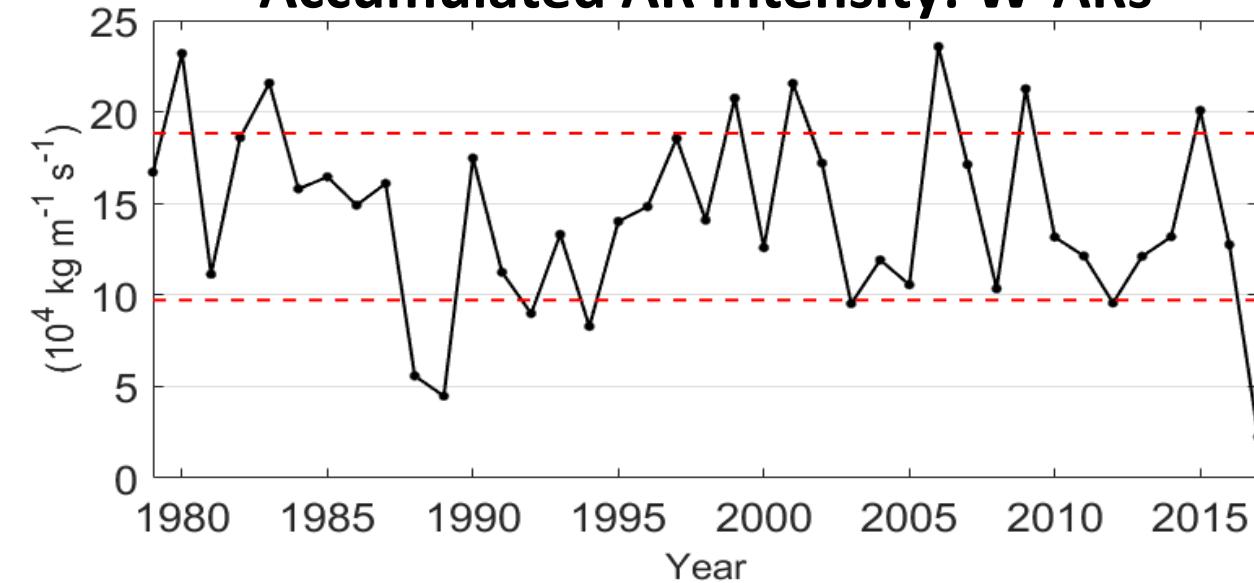
- ARI represents the accumulated W-ARs activity in a season



- The **number** of W-ARs has dominant contribution to ARI (Corr=0.95)

Interannual Variability

Accumulated AR Intensity: W-ARs



W-AR number: 19

Mean ARI: $21.71 \times 10^{-4} \text{ kg m}^{-1} \text{ s}^{-1}$

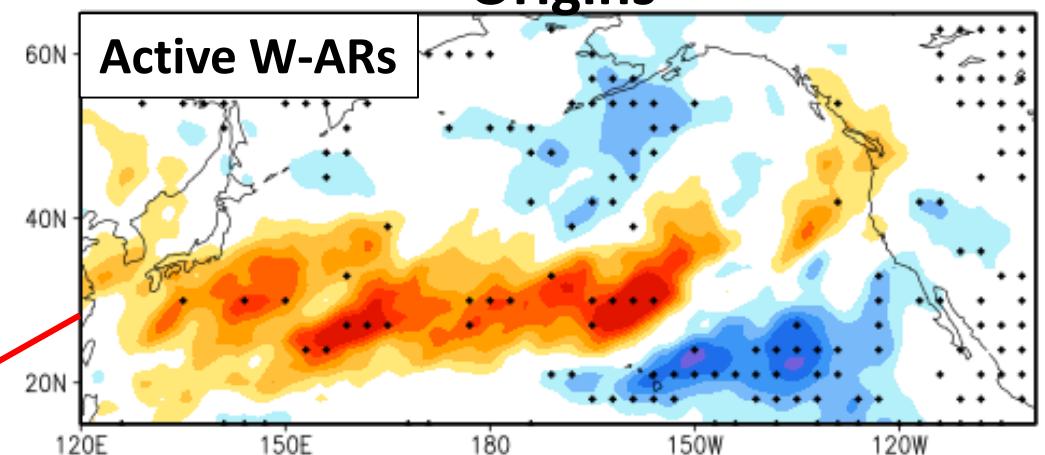
W-AR number: 6

Mean ARI: $6.95 \times 10^{-4} \text{ kg m}^{-1} \text{ s}^{-1}$

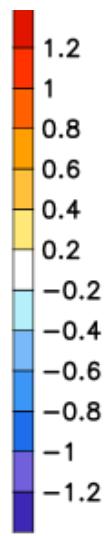
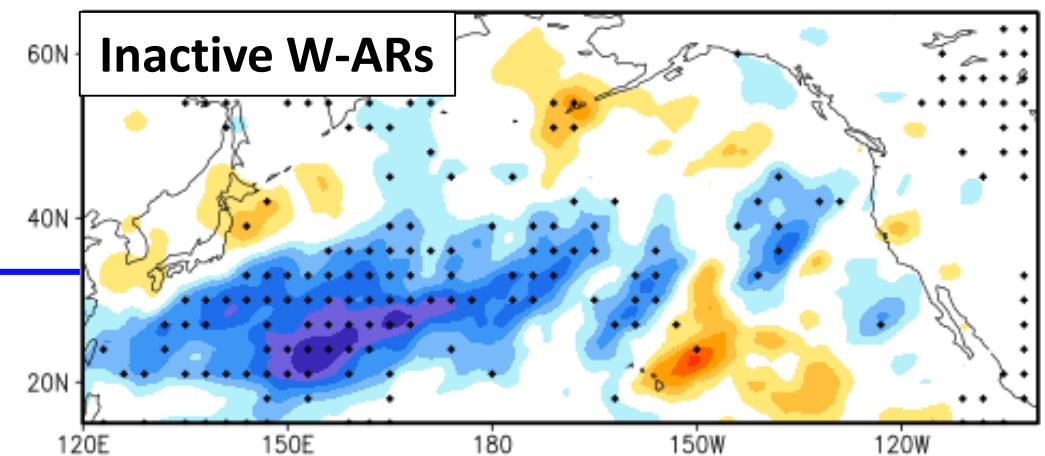
Active winters:

- W-AR number is **2 times higher** than inactive winters.

Origins

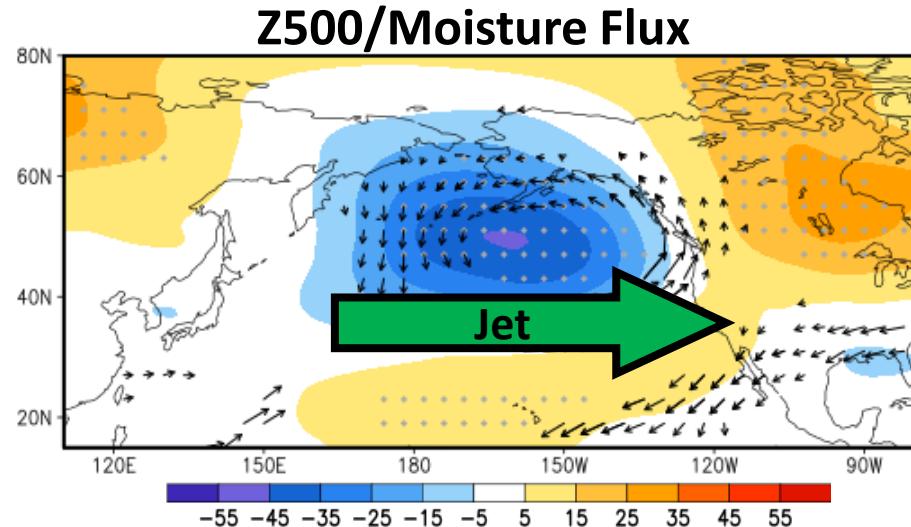


Inactive W-ARs

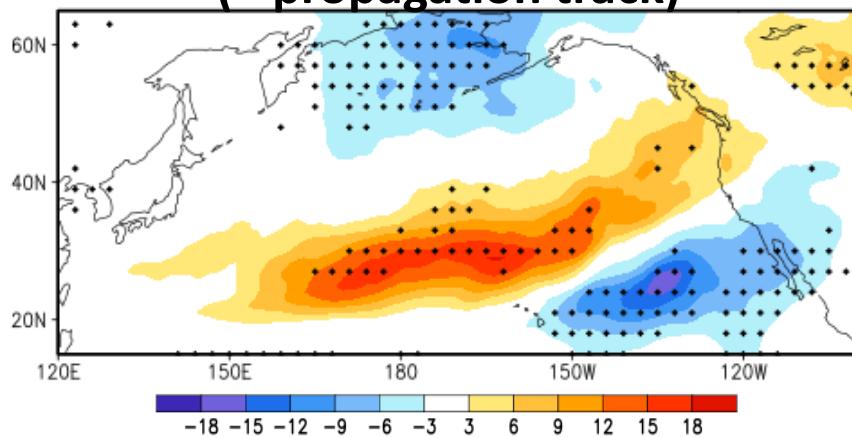


Interannual Variability

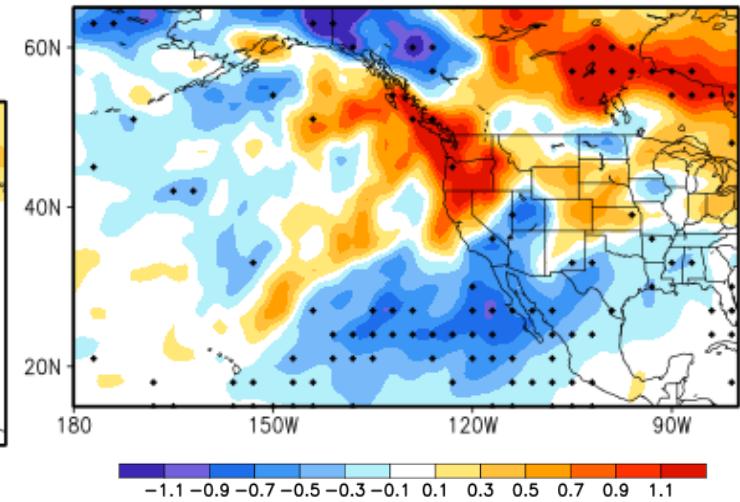
Active W-ARs



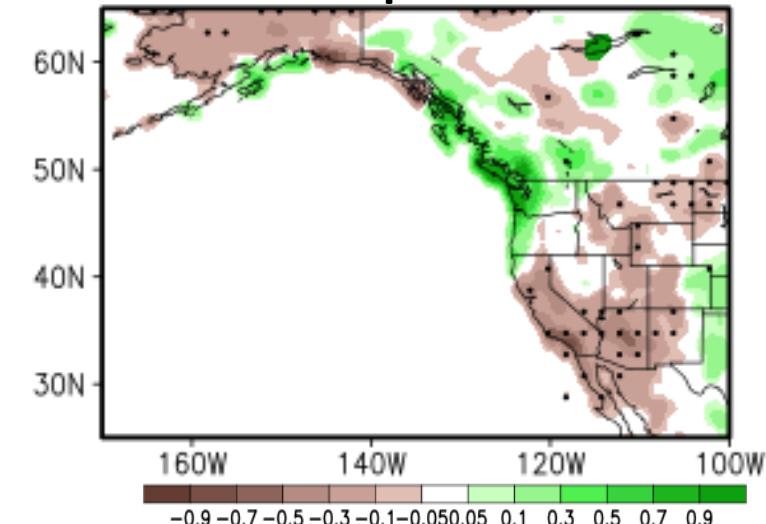
AR Frequency
(≈ propagation track)



Termination



Precipitation

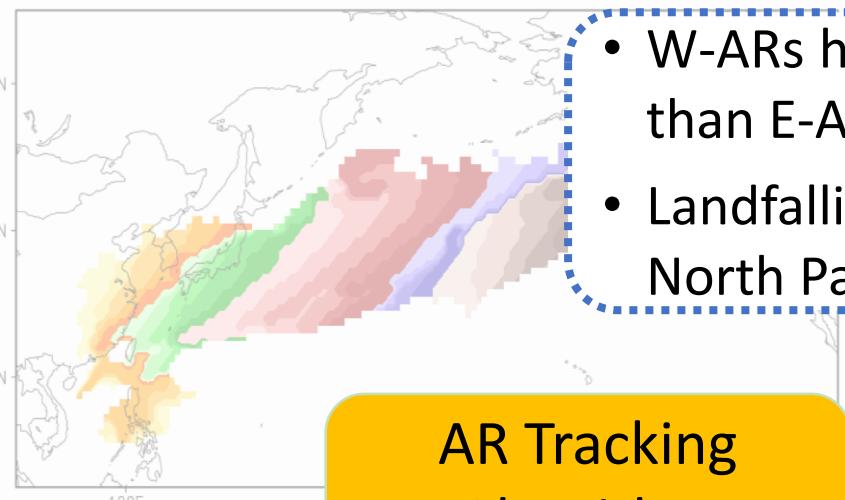


- Deepened Aleutian Low
- Enhanced subtropical jet
- Corr with PNA: 0.56

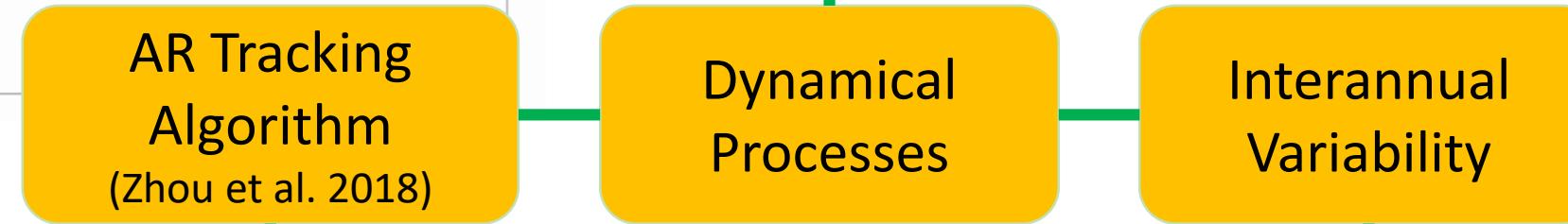
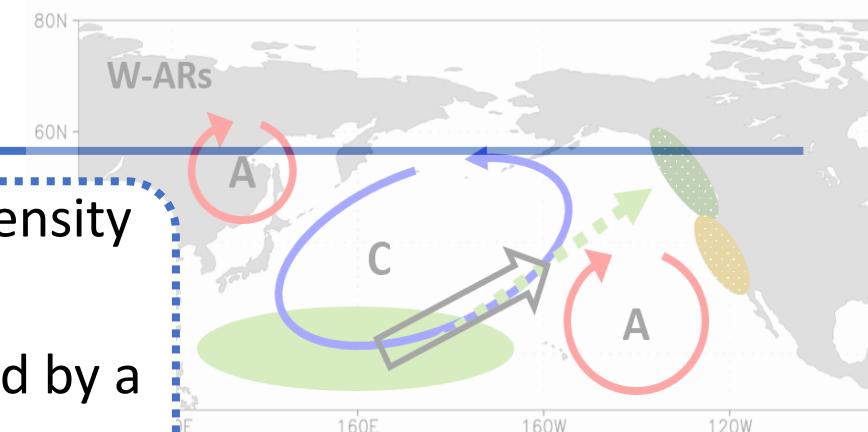
- Increased W-AR activity over subtropics

- More landfalling ARs over the north of West Coast
- More rain over Northwest US
- Less rain over Southwest US

Summary



- W-ARs have **longer lifetime, stronger intensity** than E-ARs
- Landfalling ARs to West Coast are induced by a North Pacific **stationary wave pattern**



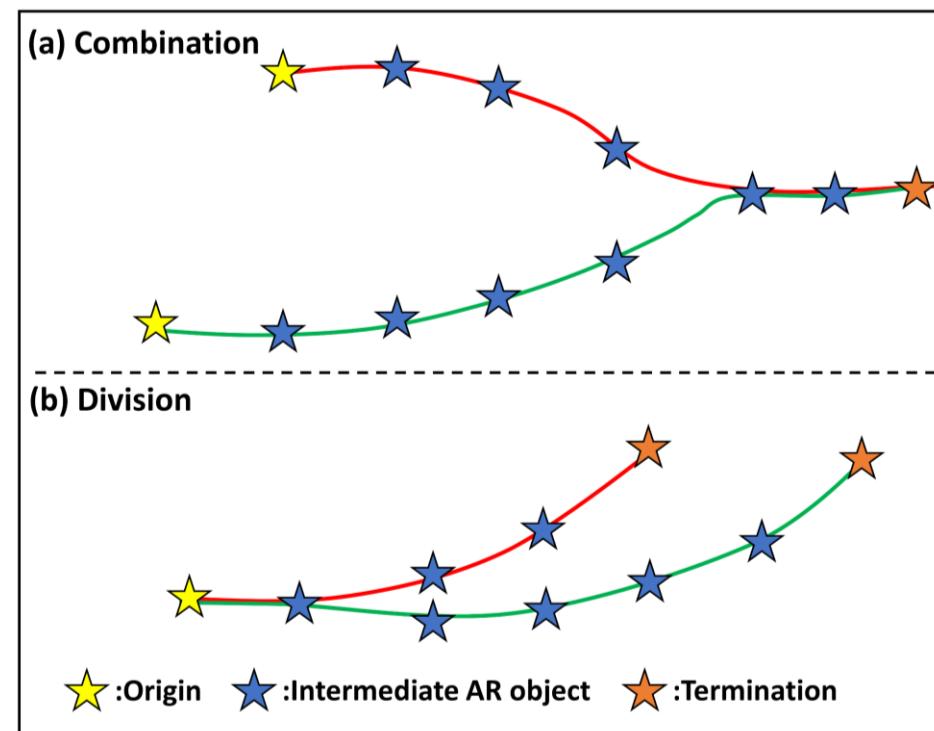
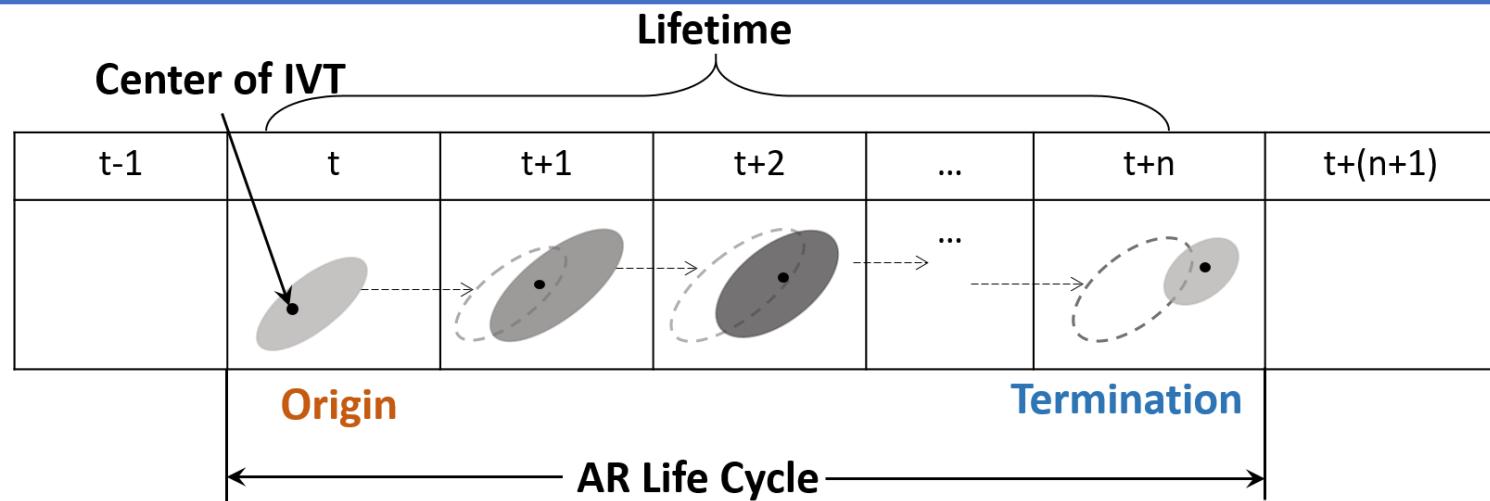
- Track the **entire life cycle** of AR events
- Record AR characteristics

- **ARI index** describes the overall AR activity of a period
- The activity of W-ARs is positively related to **PNA**
- Active W-ARs → **More rain** in Northwest US and British Columbia and **less rain** in Southwest US

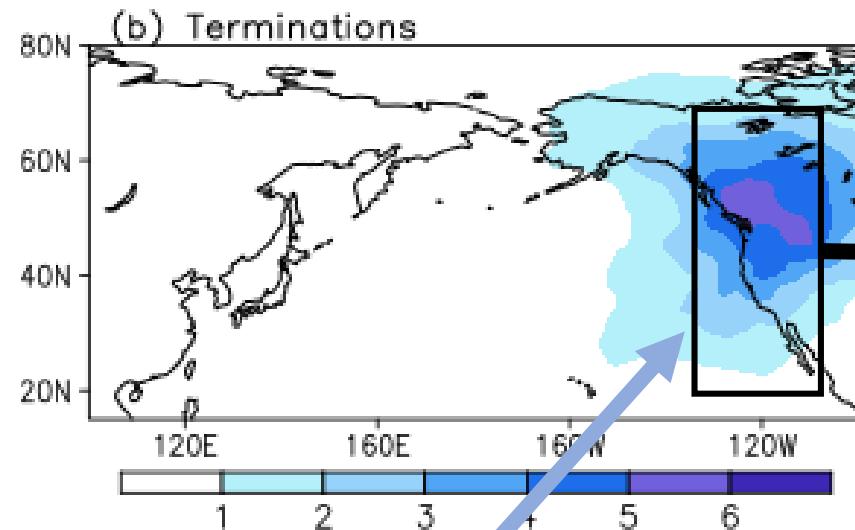
Thank you!

Appendix

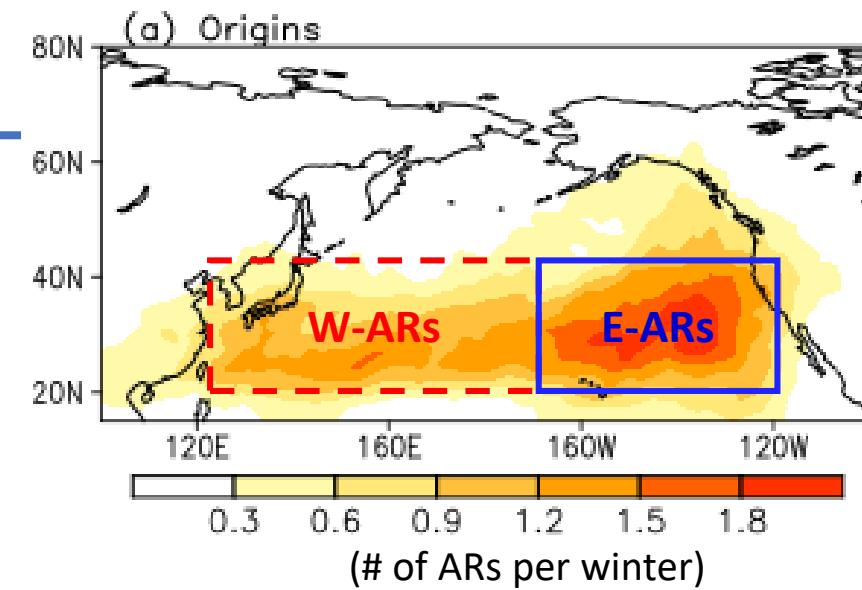
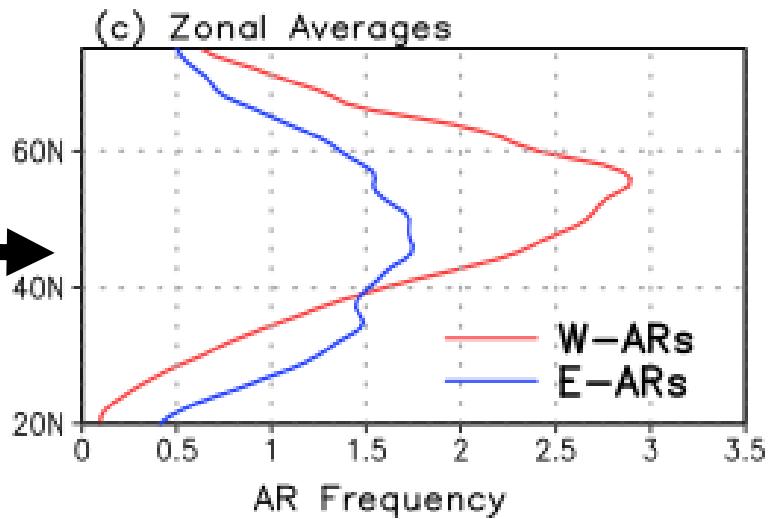
Merging and Splitting



Origins and Terminations



Terminations accumulate at higher latitudes



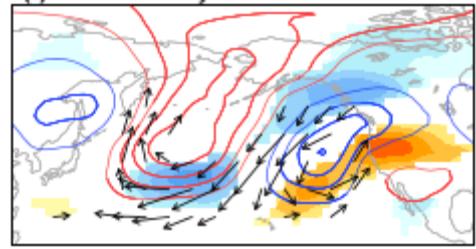
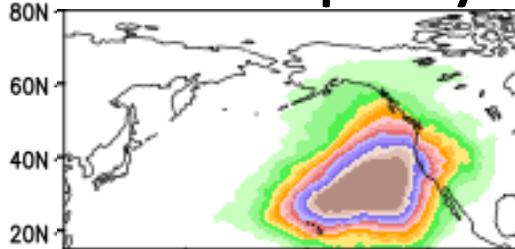
- Most W-ARs landfall near 55°N
- E-ARs show evenly distributed termination frequency

Dynamical Processes

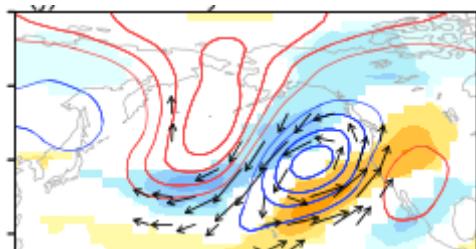
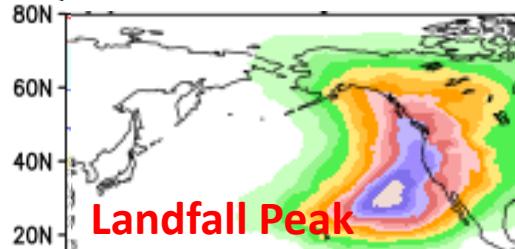
E-ARs



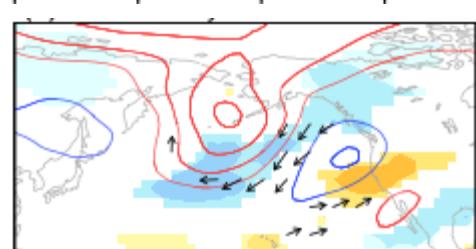
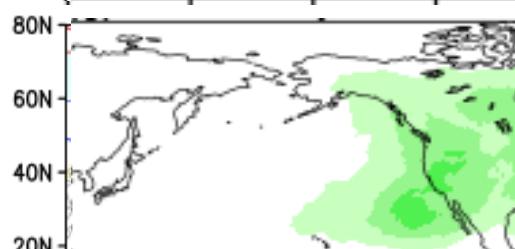
Day 0 (Origins)



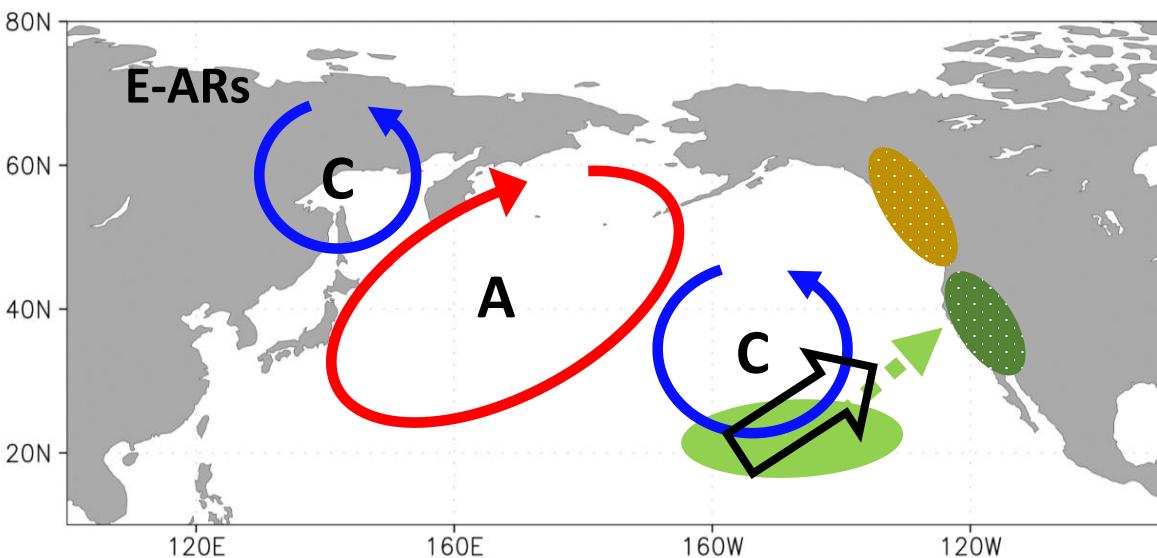
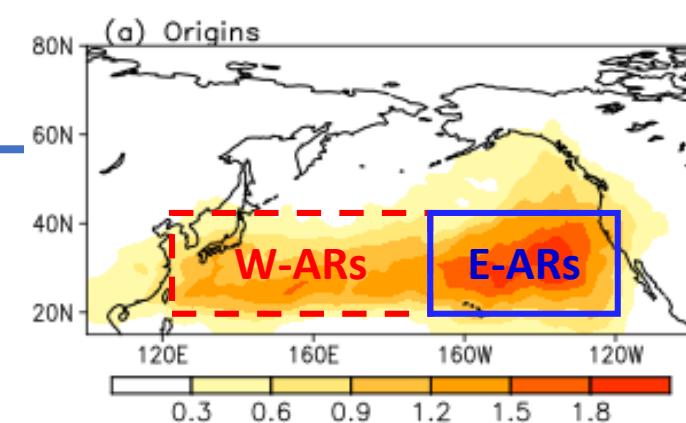
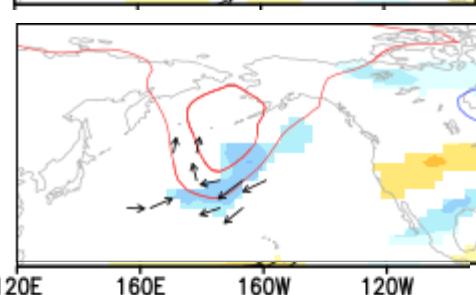
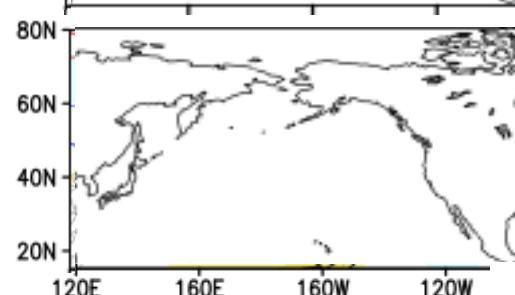
Day +2



Day +5



Day +8



A black arrow pointing to the right, indicating the direction of the next step in the process.

: Enhanced jet

AR origins

→ : AR propagation direction

 : Wet anomaly

: Dry anomaly