

Atmospheric River Life Cycles: Climatology and Interannual Variability

Yang Zhou and Hyemi Kim

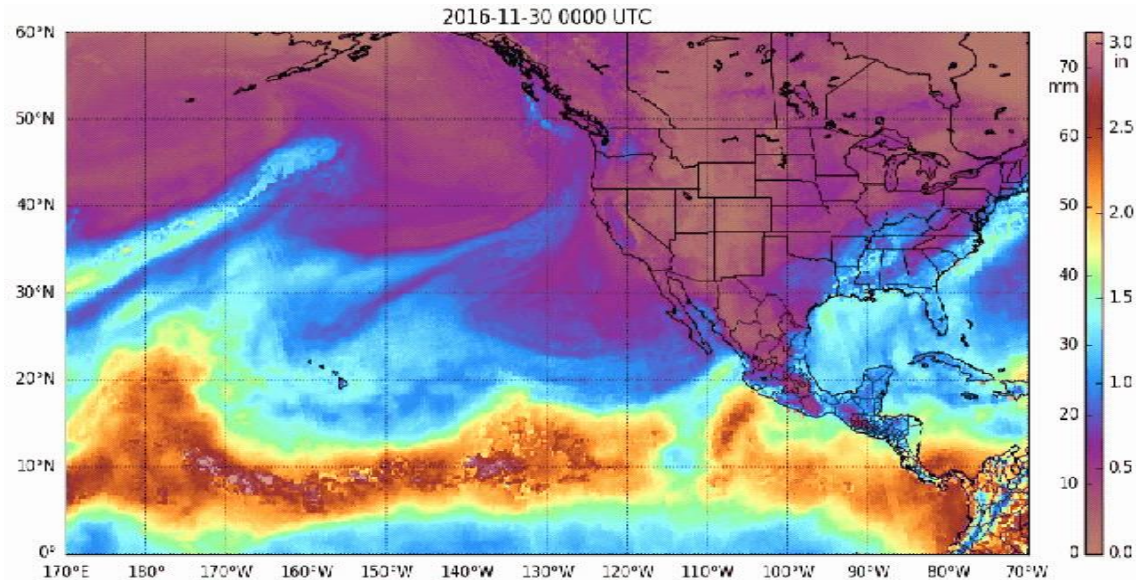
Stony Brook University



Stony Brook
University



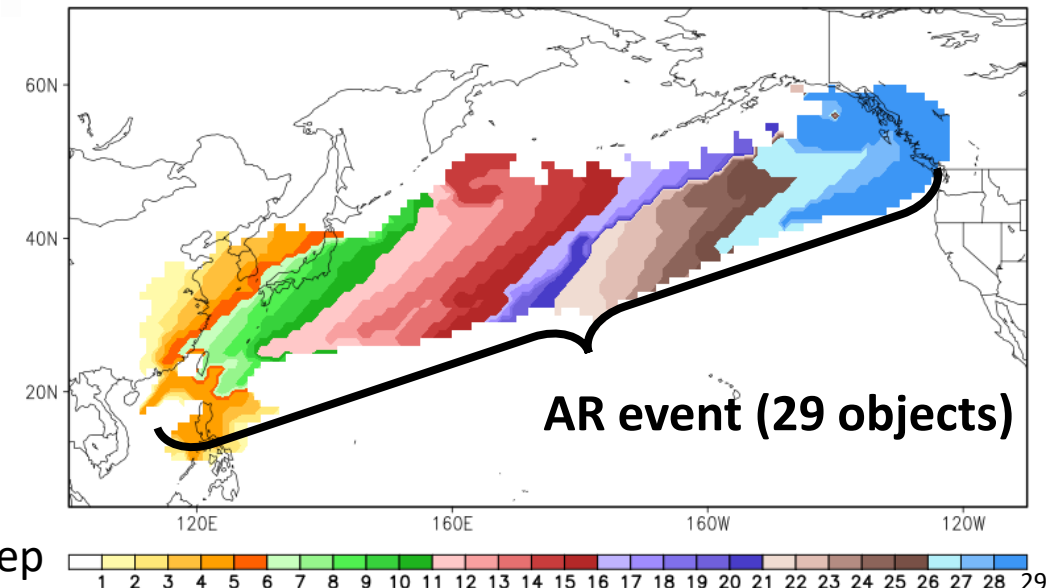
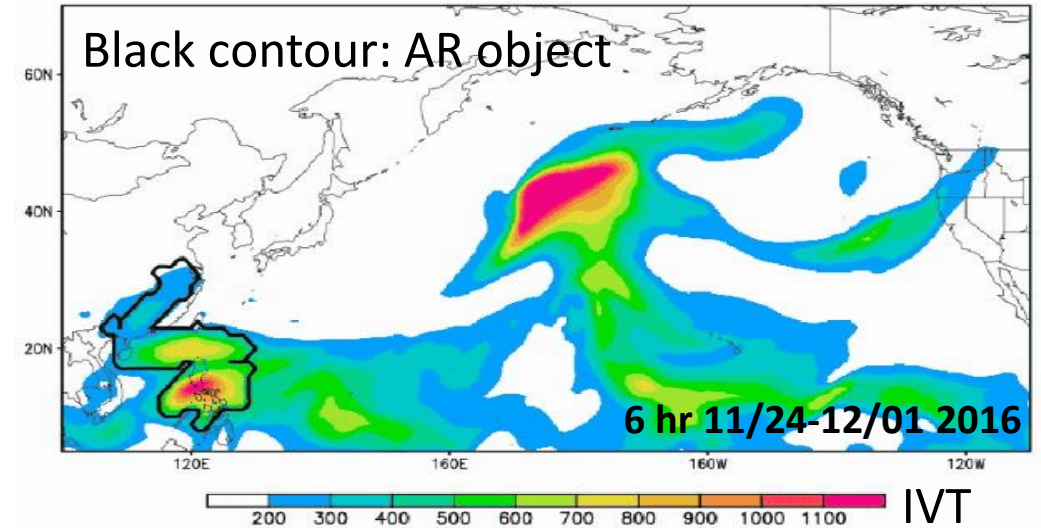
AR Events



Total precipitable water in Nov. 30-Dec.2, 2016.
(<ftp://ftp.ssec.wisc.edu/pub/mtpw2>)

- 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**)

Vertically-integrated vapor transport (IVT)



AR Tracking Algorithm

Input:

AR Objects

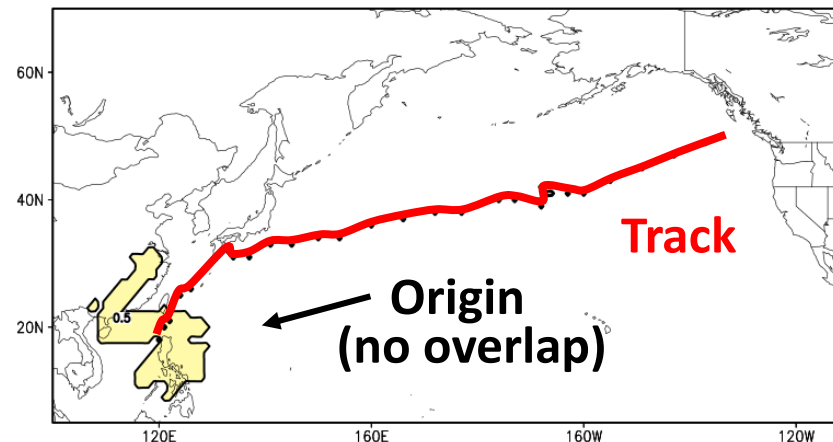
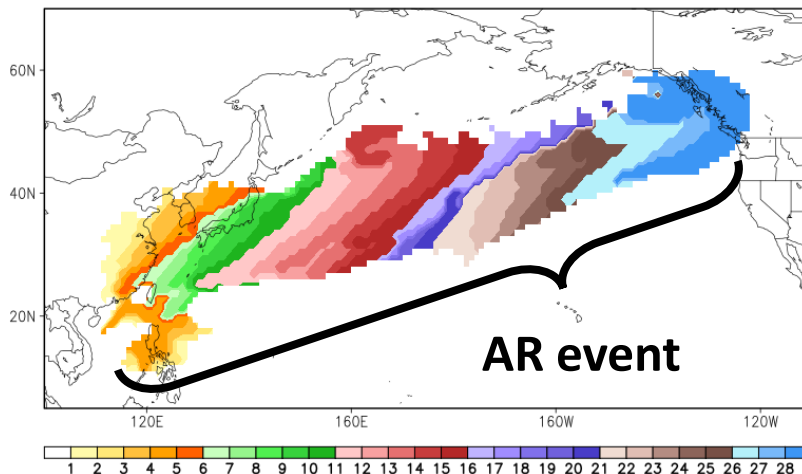
Step I:

Origin selection

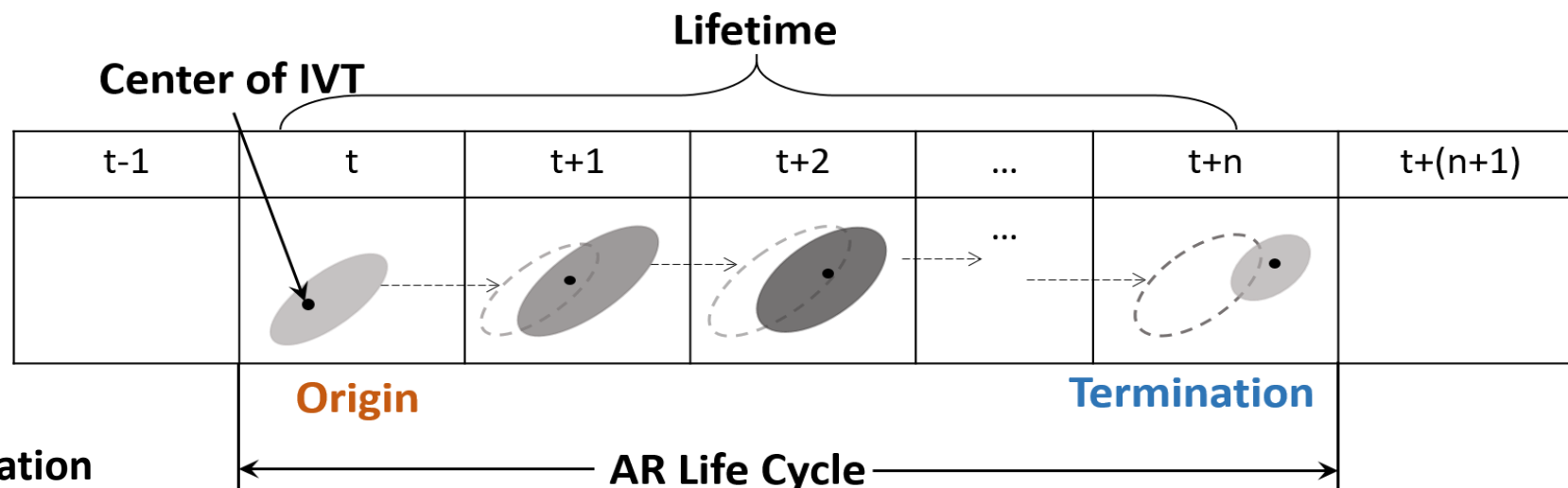
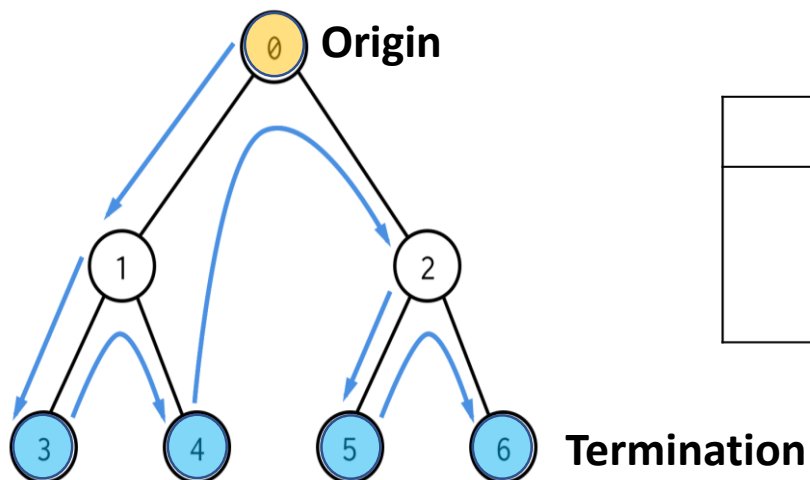
Step II:

Tracking ARs

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



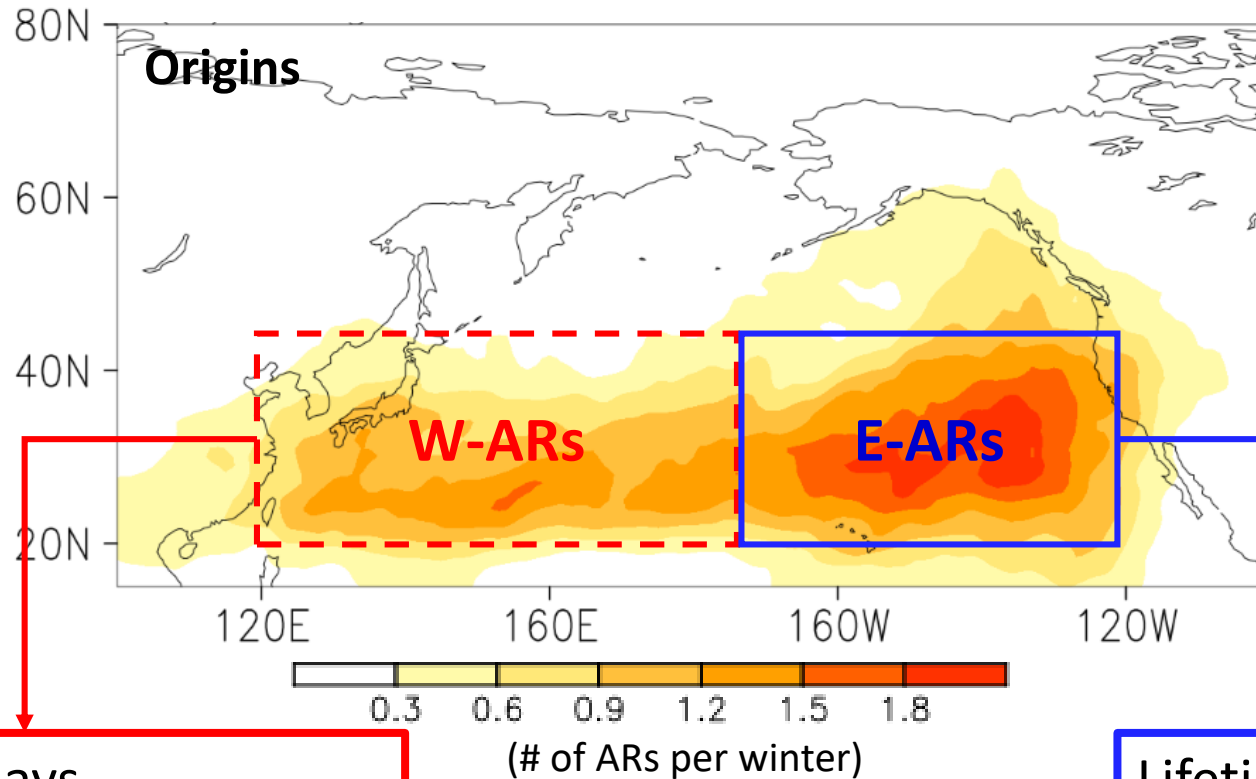
- A Depth-First Search process



- Zhou et al. (2018)

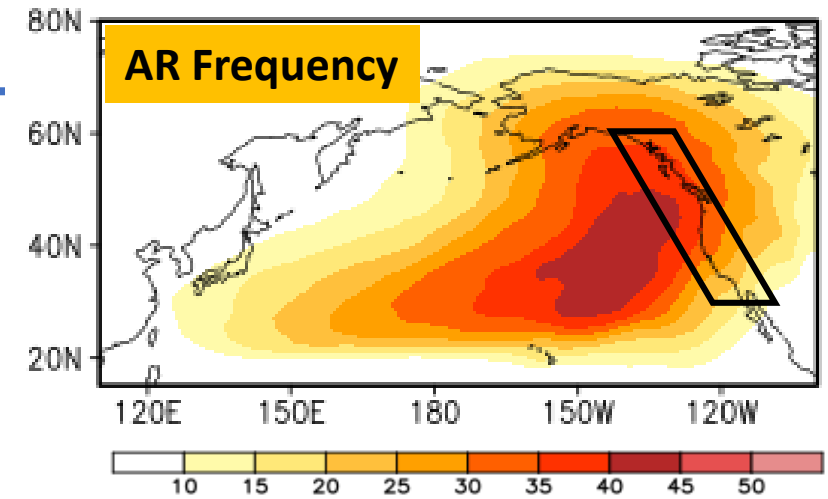
Landfalling ARs

- 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

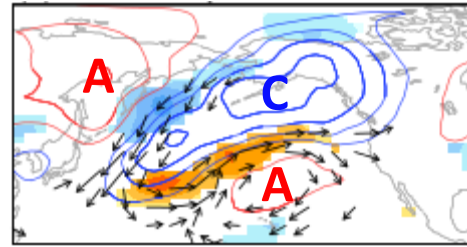
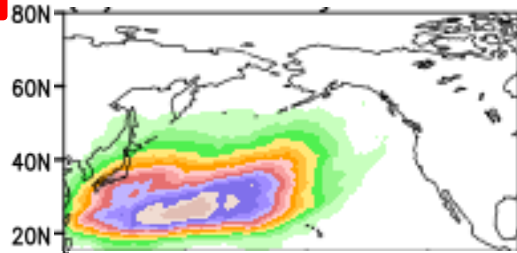
Dynamical Processes

W-ARs

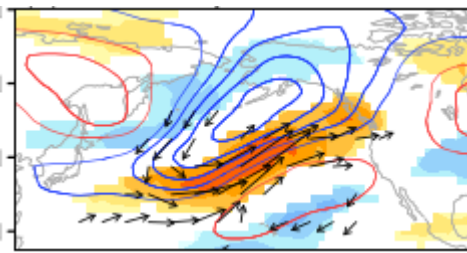
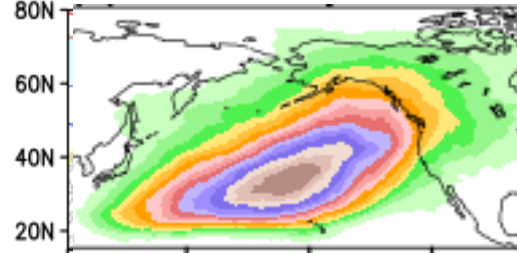
AR Frequency

Z500/U300/MF

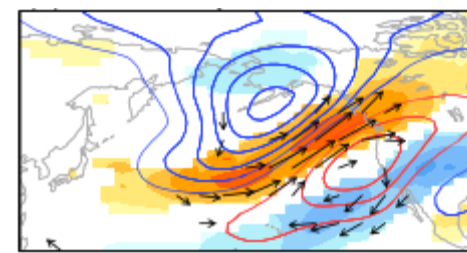
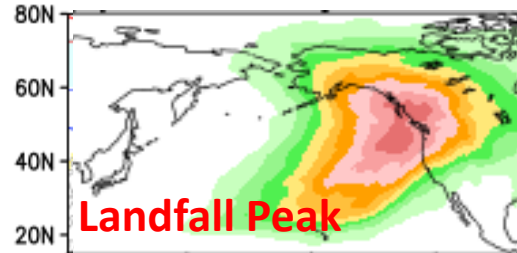
**Day 0
(Origins)**



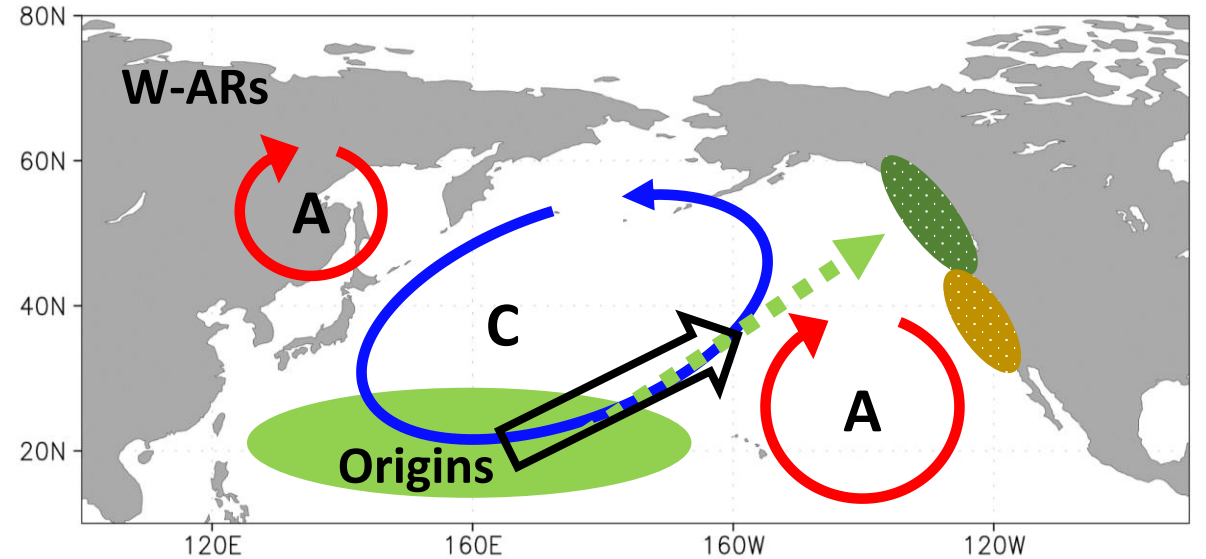
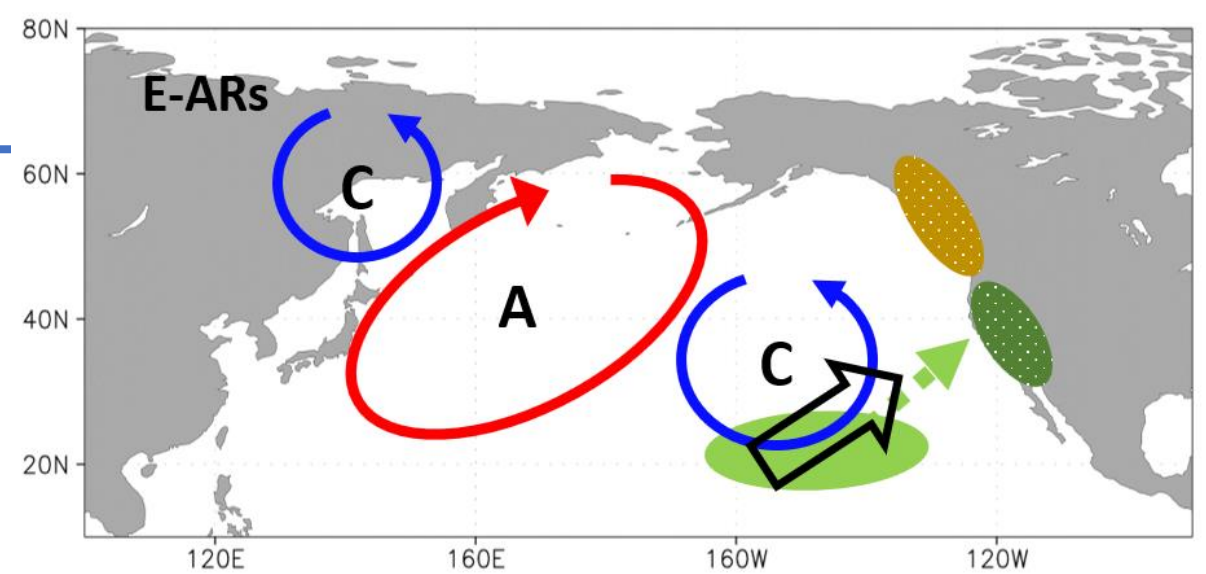
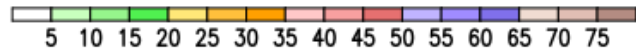
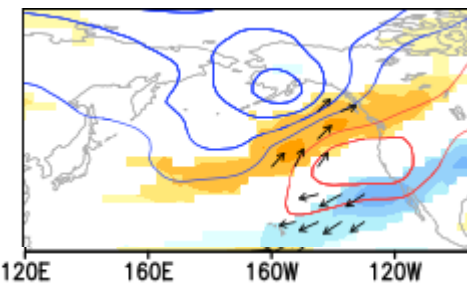
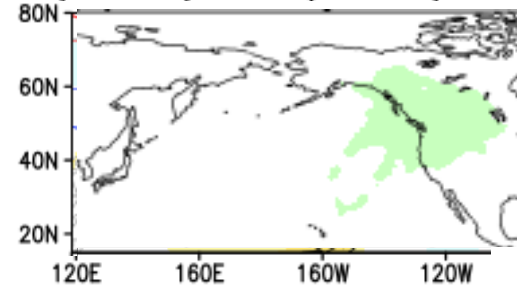
Day +2



Day +5



Day +8



: Enhanced jet

: Propagation track

: AR origins

: More rain

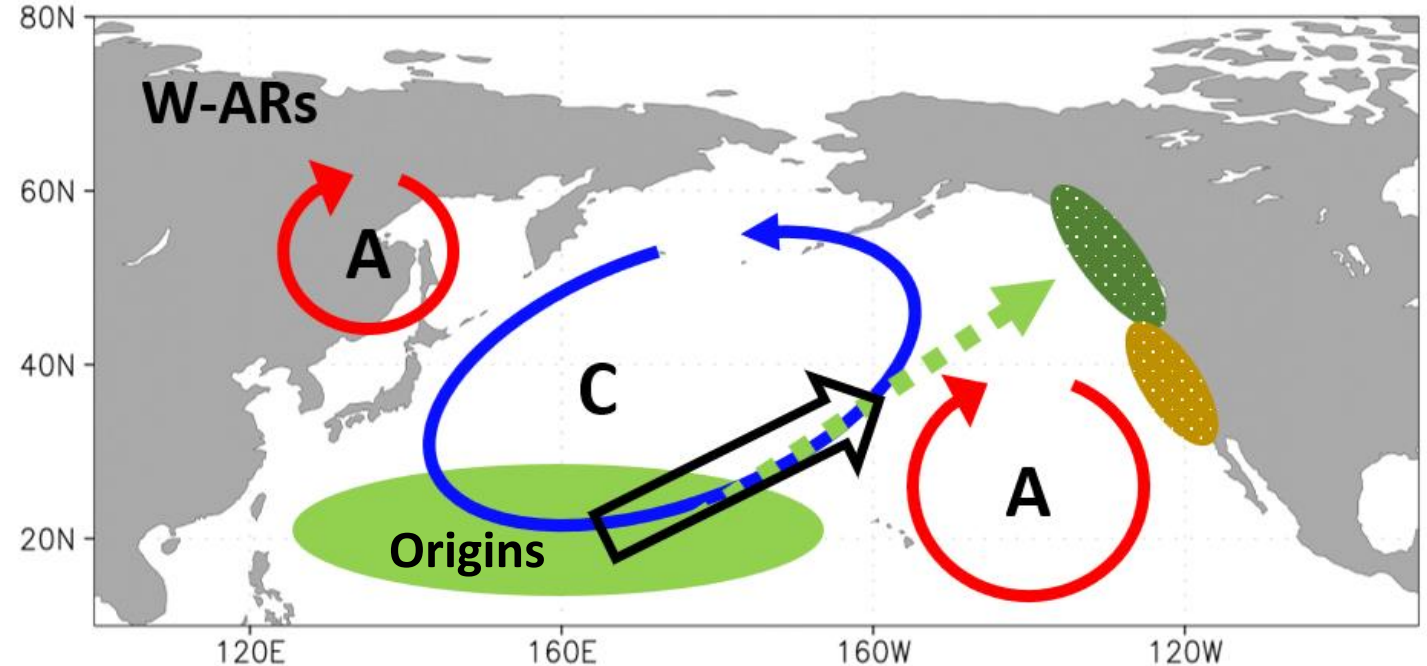
: Less rain

Interannual Variability

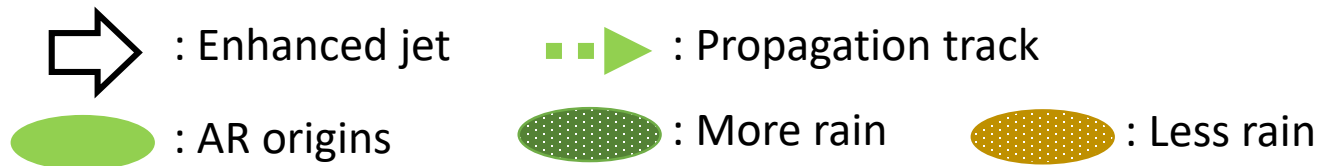
- Accumulated AR Intensity (ARI) index

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

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



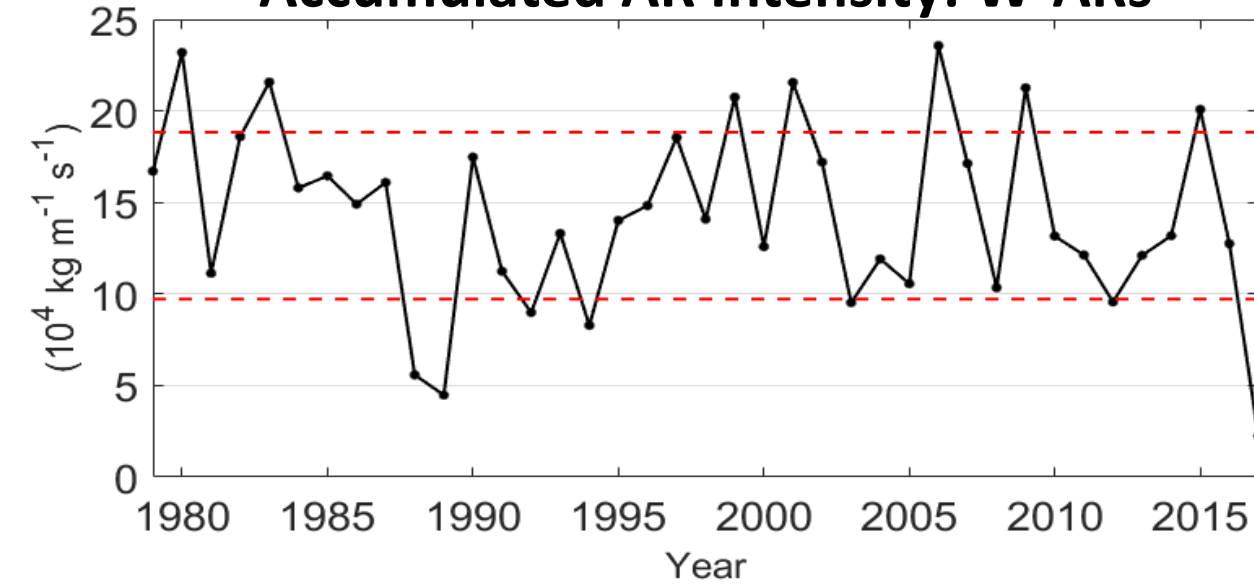
- ARI represents the accumulated W-ARs activity in a season



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

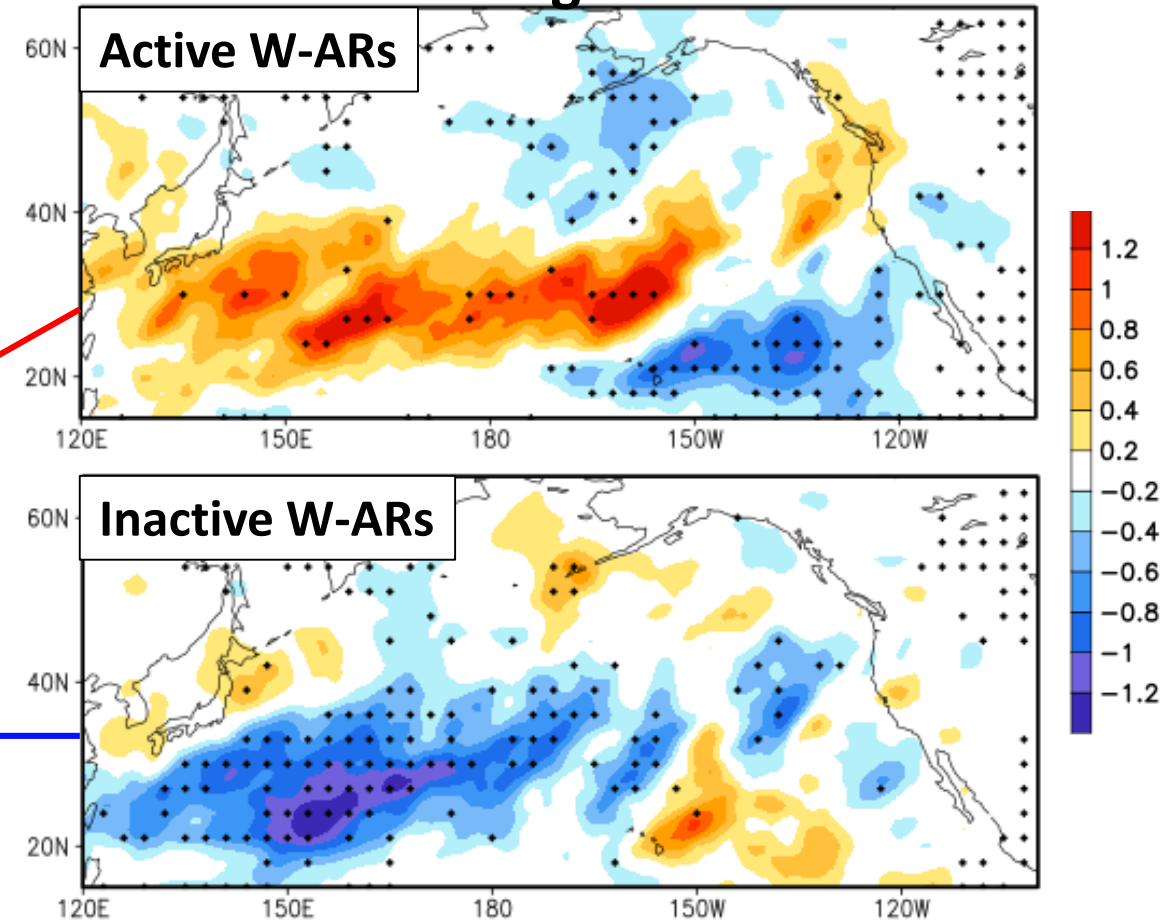
W-AR number: **6**

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.

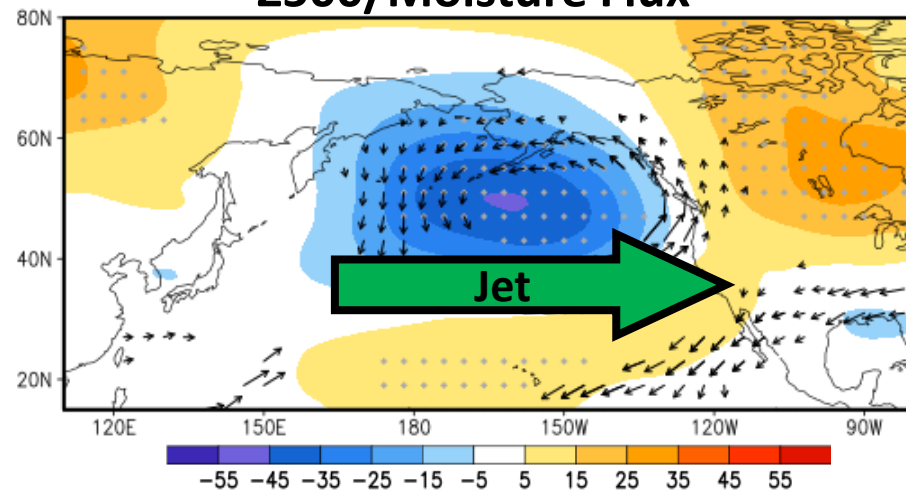
Origins



Interannual Variability

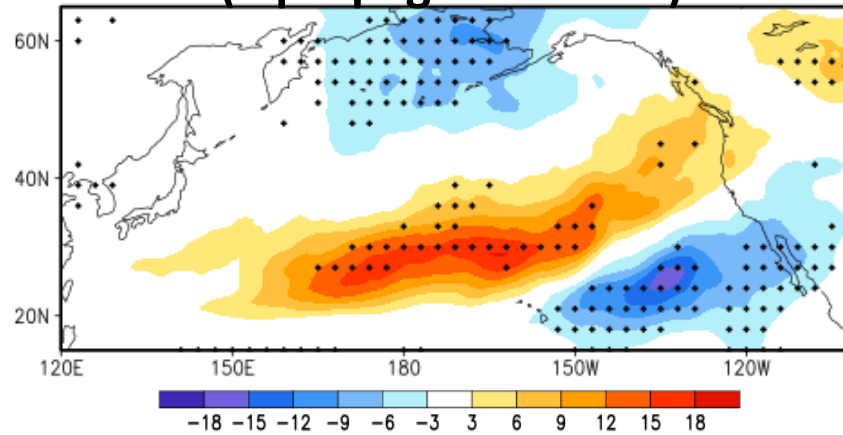
Active W-ARs

Z500/Moisture Flux



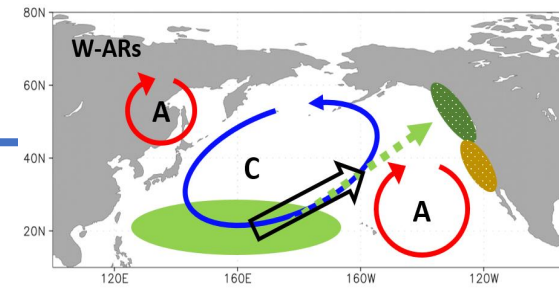
- Deepened Aleutian Low
- Enhanced subtropical jet
- Corr with PNA: 0.56

AR Frequency (\approx propagation track)

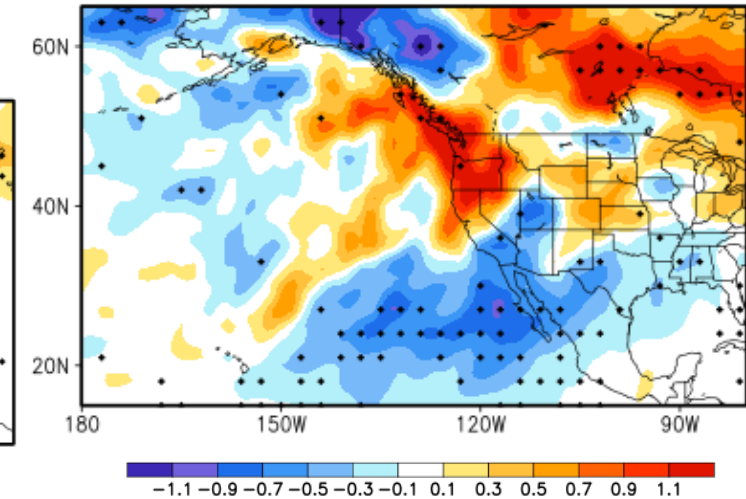


- Increased W-AR activity over subtropics

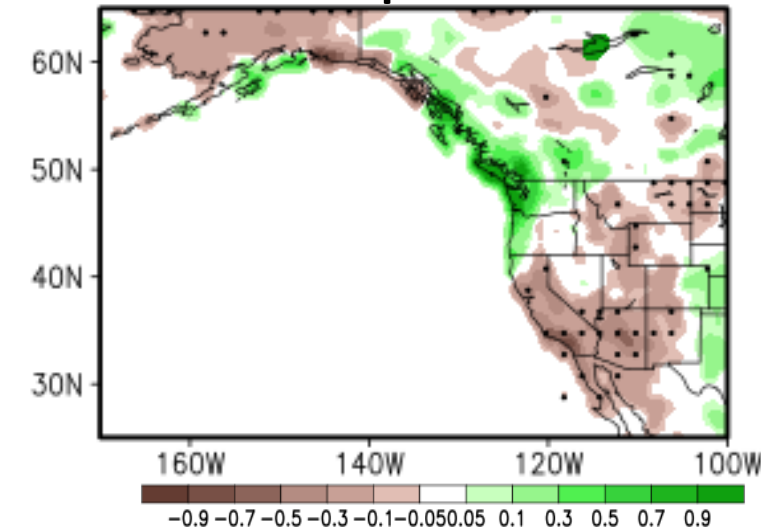
- More landfalling ARs over the north of West Coast
- More rain over Northwest US
- Less rain over Southwest US



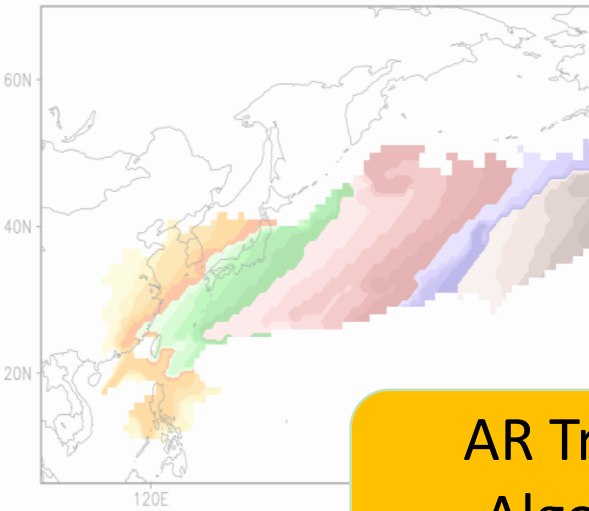
Termination



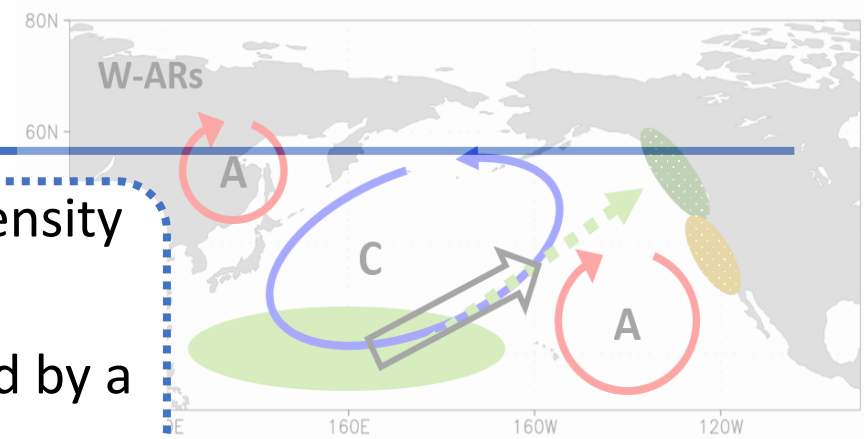
Precipitation



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



AR Tracking
Algorithm
(Zhou et al. 2018)

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

Dynamical
Processes

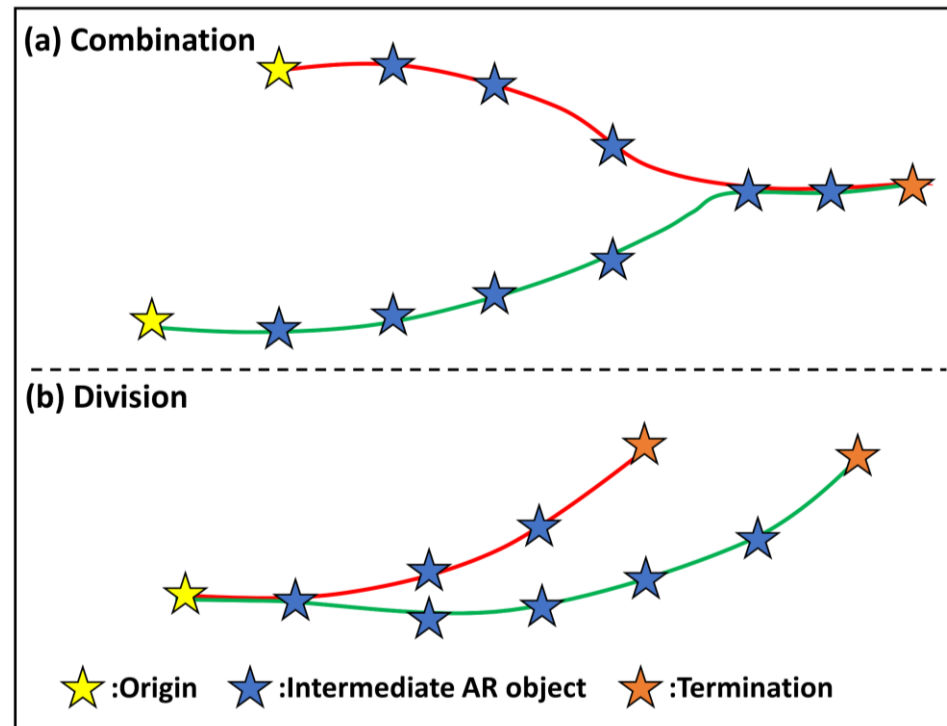
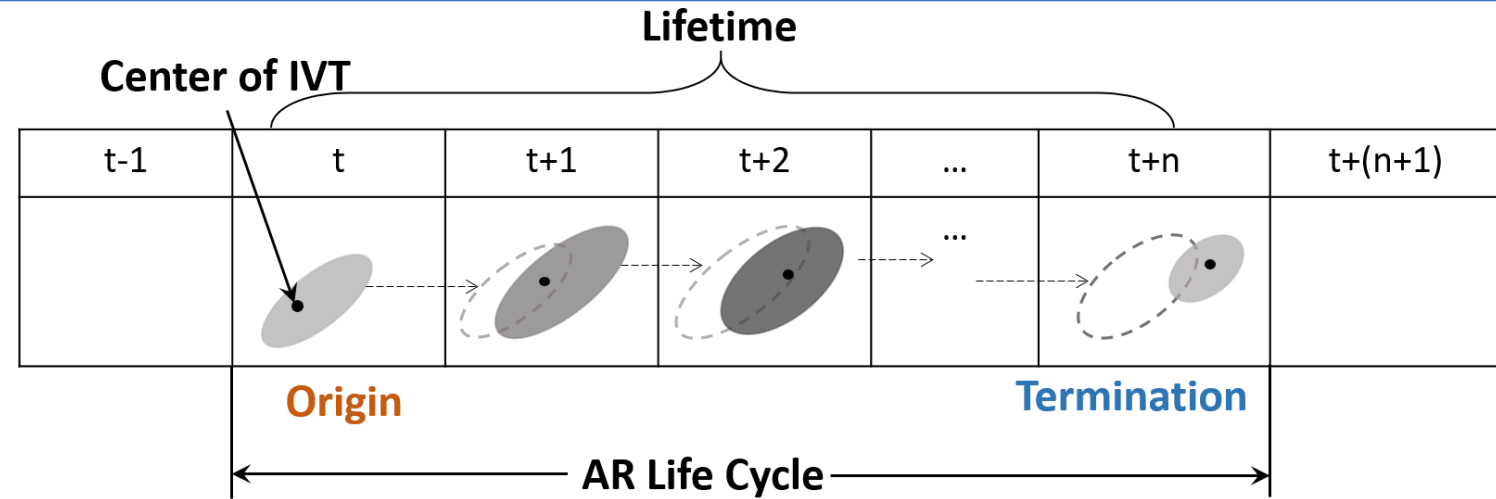
- **ARI index** describes the overall AR activity of a period
- The activity of W-ARs is positively related to **PNA**
- Active W-ARs → **More rain** in Northwest US and British Columbia and **less rain** in Southwest US

Interannual
Variability

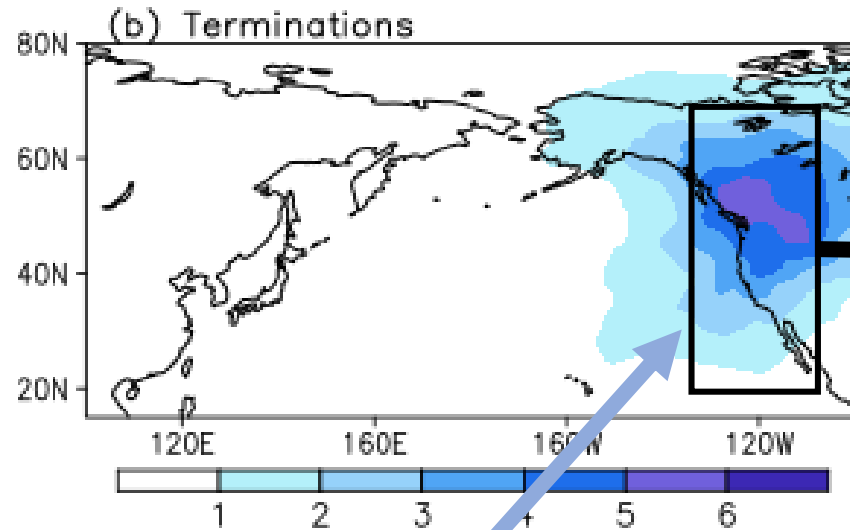
Thank you!

Appendix

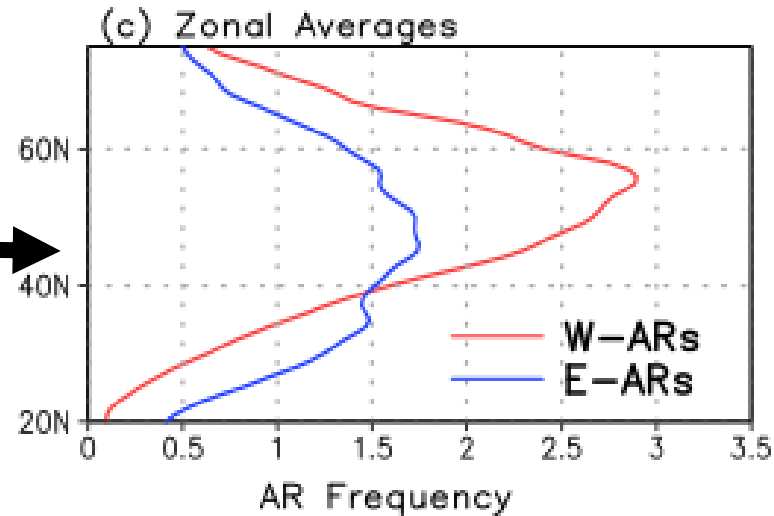
Merging and Splitting



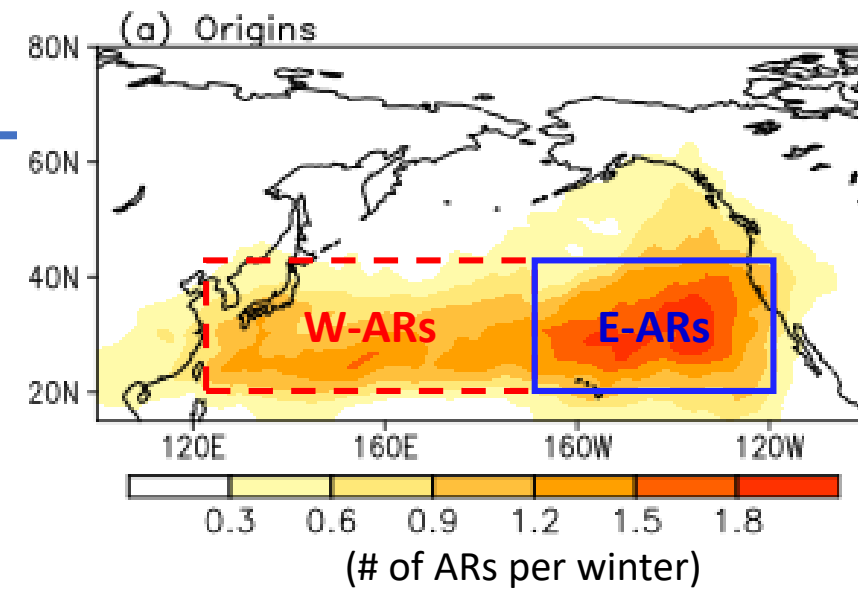
Origins and Terminations



Terminations accumulate at higher latitudes



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



Dynamical Processes

E-ARs

AR Frequency

Z500/U300/MF

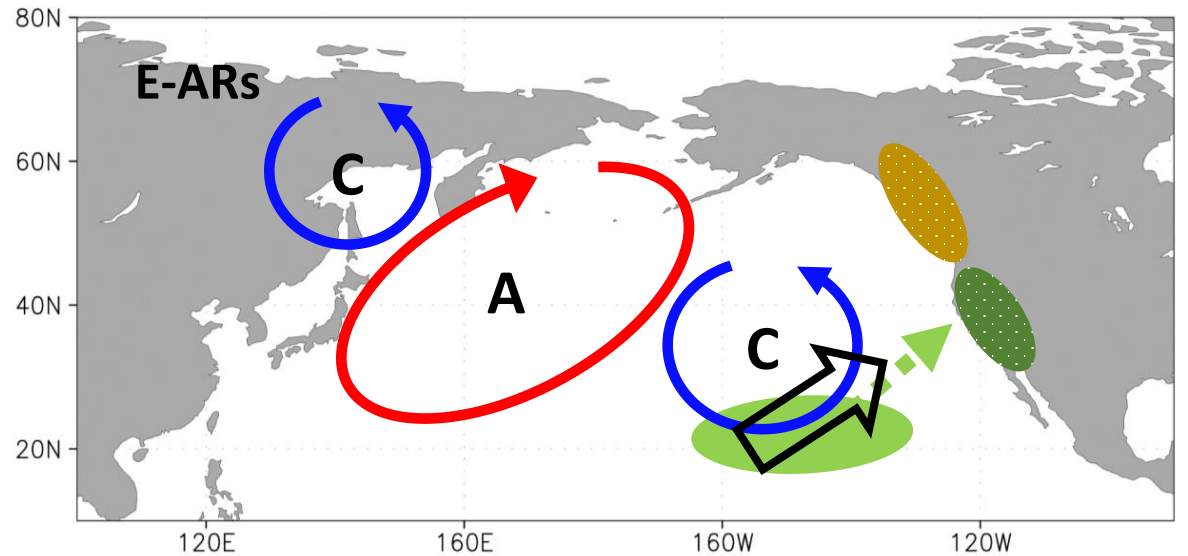
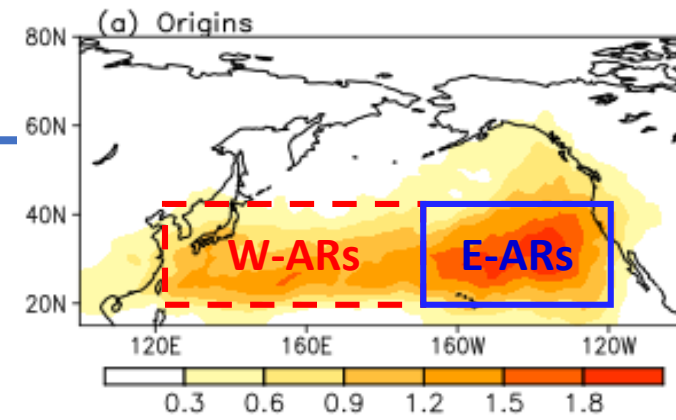
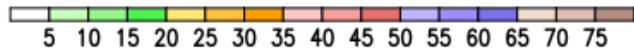
Day 0
(Origins)

Day +2

Landfall Peak

Day +5

Day +8



➡ : Enhanced jet

● : AR origins

➡ : AR propagation direction

● : Wet anomaly

● : Dry anomaly