AS4.6

A novel global AR identification algorithm

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- Pan, M., & **Lu, M.*** (2019). A novel atmospheric river identification algorithm. *Water Resources Research*, 55, 6069– 6087. https://doi.org/10.1029/2018WR024407
- Pan, M., & **Lu, M.*** (submitted), East Asia Atmospheric River Catalog: Annual cycle, Transition Mechanism and Precipitation Predictability, *Geophysical Research Letters*

Global Interest of AR

- Intensive and persistent moisture transport for the Jan 1995 French flood

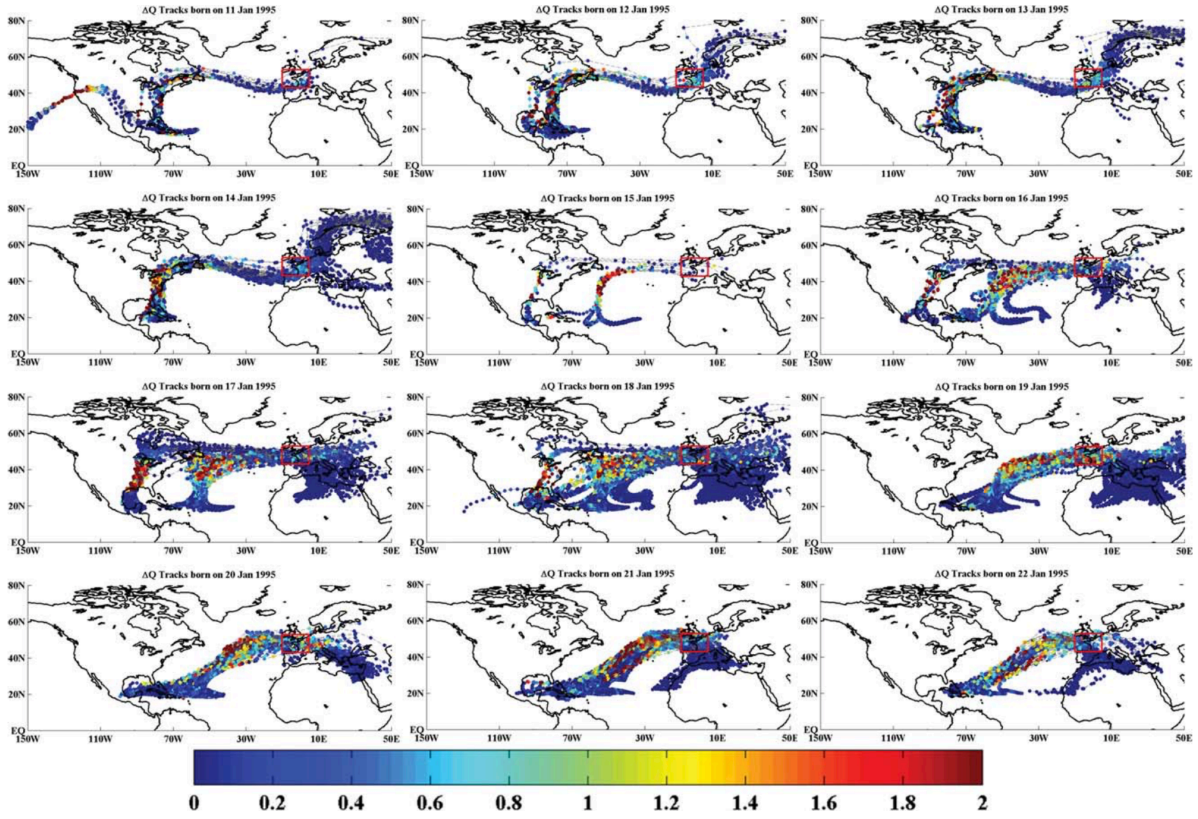
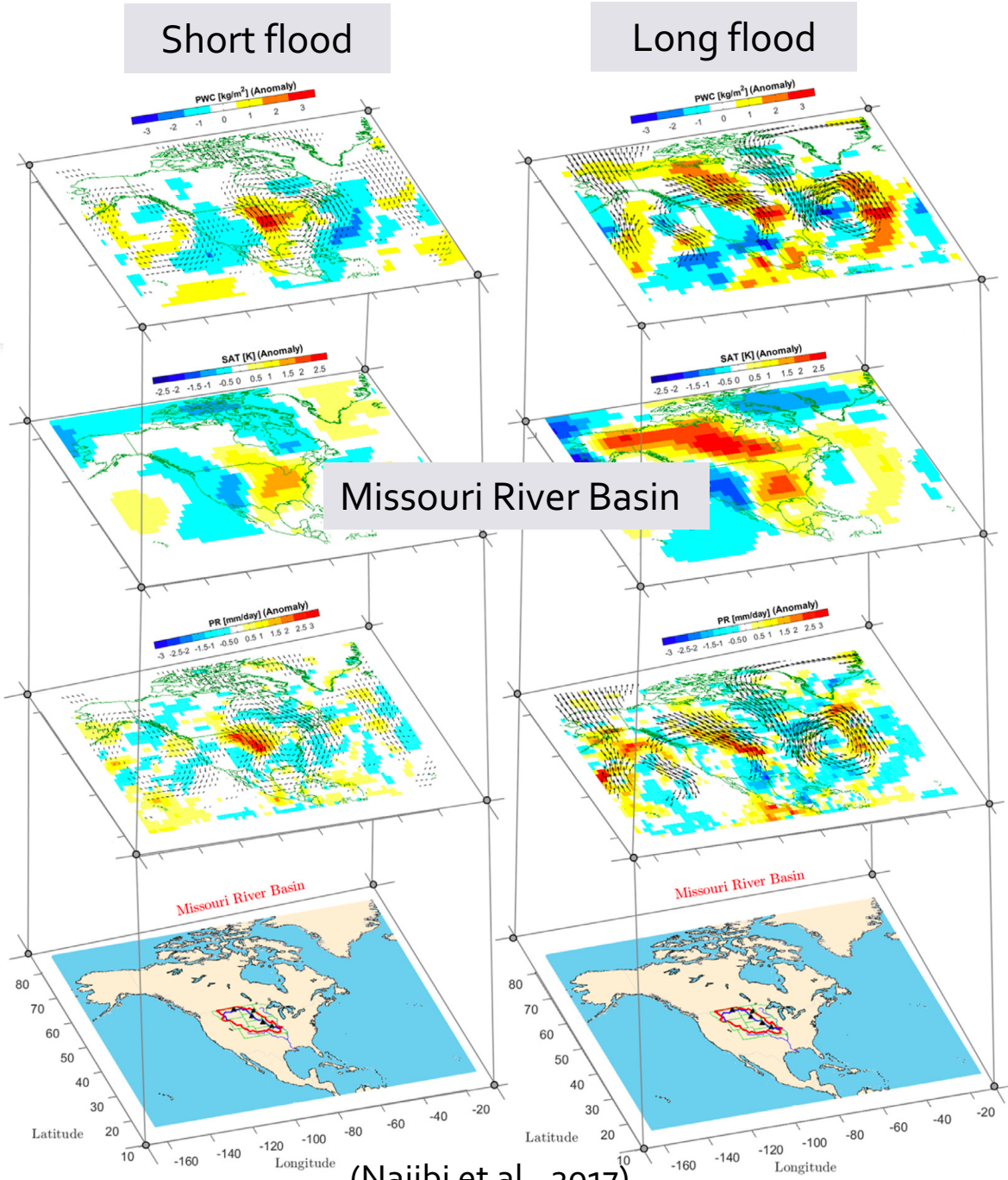


Figure 3. TME tracks born on the 11th to the 22nd of January (from left to right, then from top to bottom), colors depicting moisture release from the air parcel in the study area during heavy rainfall period from the 17th to the 28th of January in 1995. The red box highlights the flooded area. The color bar indicates the specific humidity change (g/kg).

(Lu et al., 2013)



(Najibi et al., 2017)

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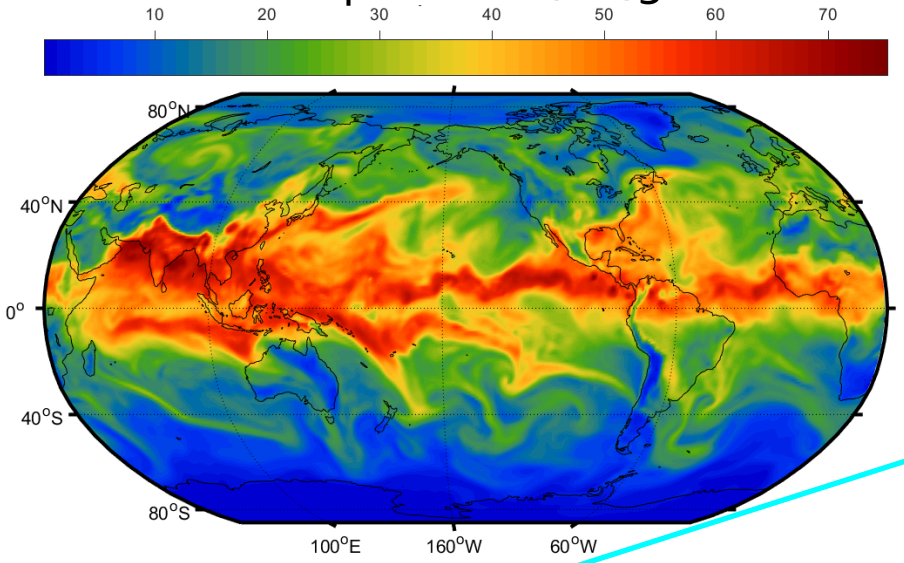
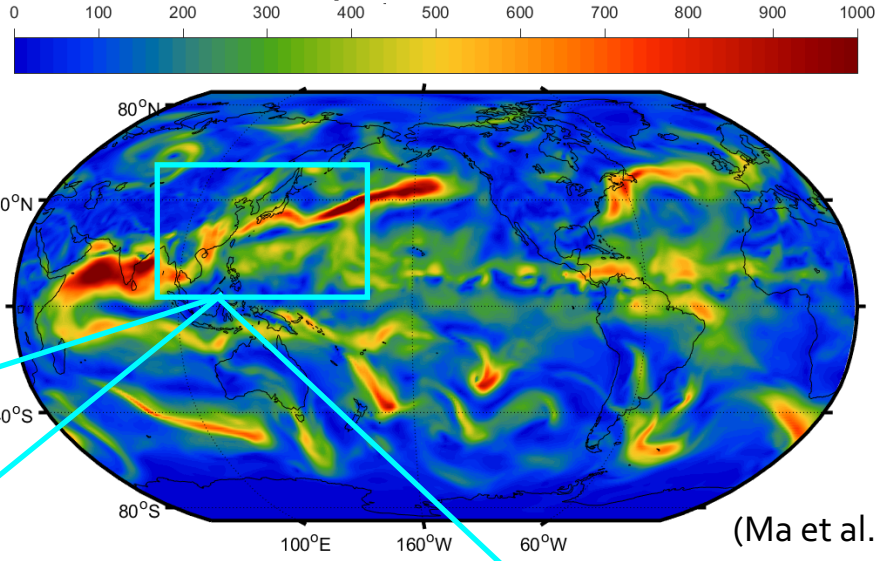
Global Interest of AR

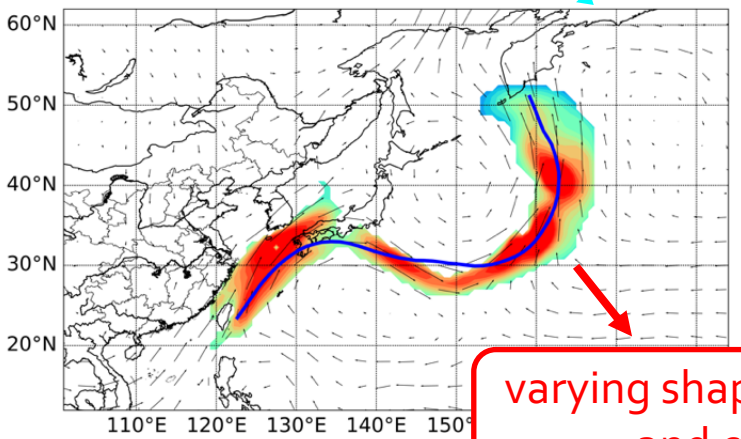
IWV Global Map on 2016/06/30 00UTC

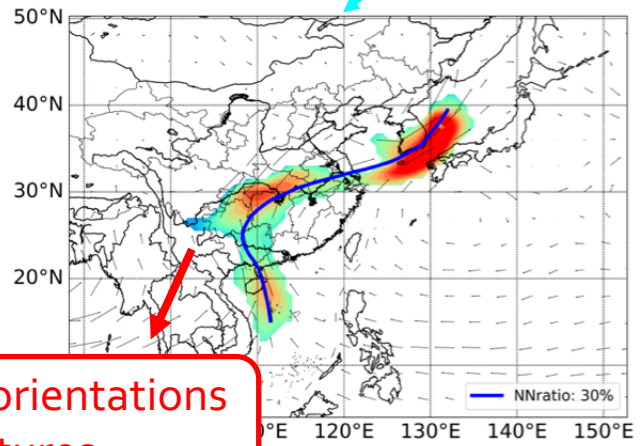


IVT Global Map on 2016/06/30 00UTC

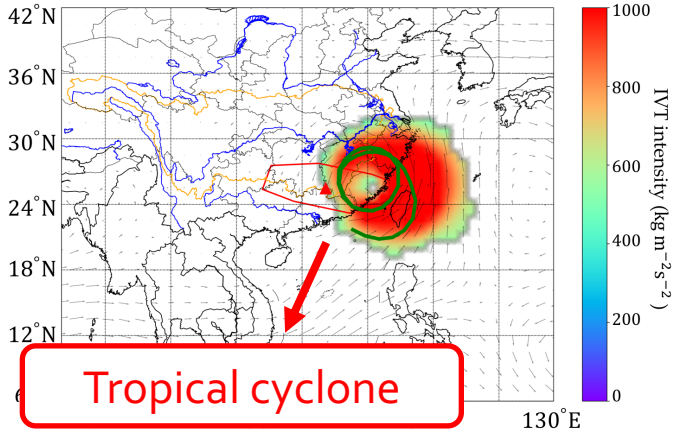


(Ma et al. 2018)





varying shapes, orientations and curvatures



Tropical cyclone

(Pan & Lu, 2019)

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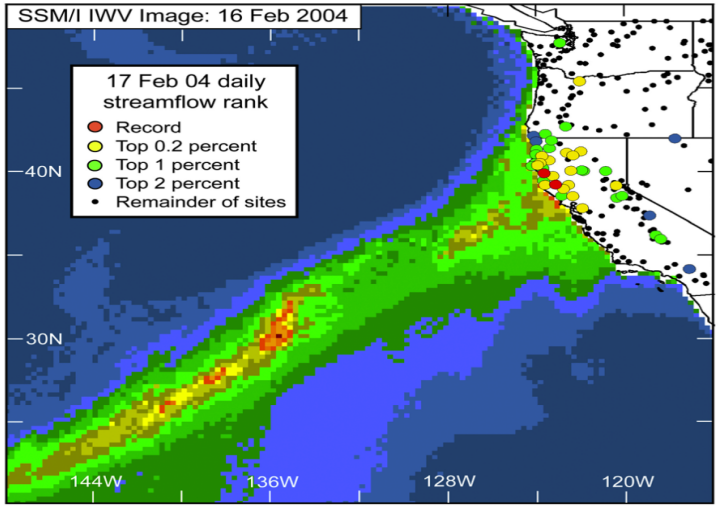
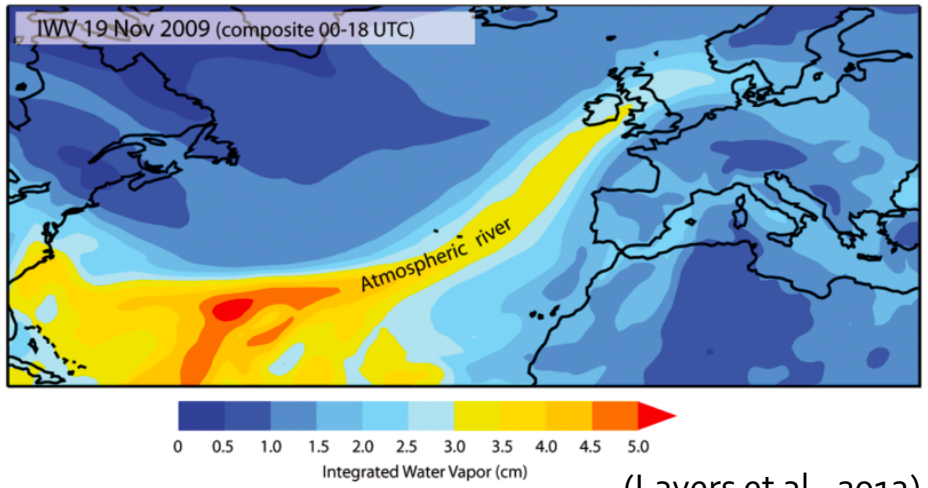
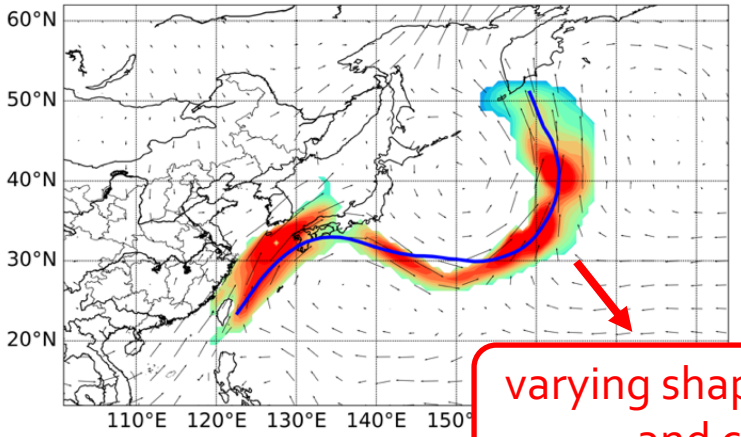
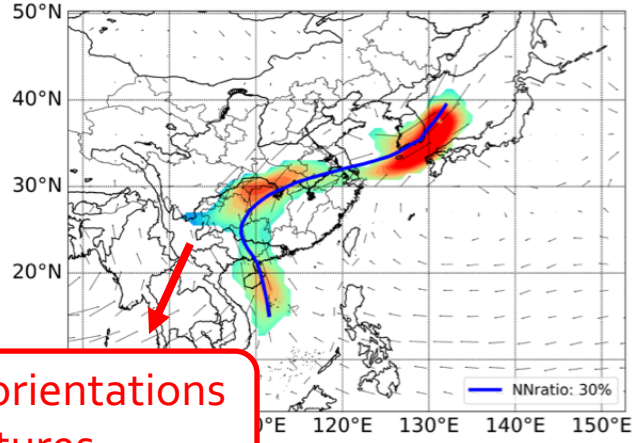


(Ralph et al., 2006)

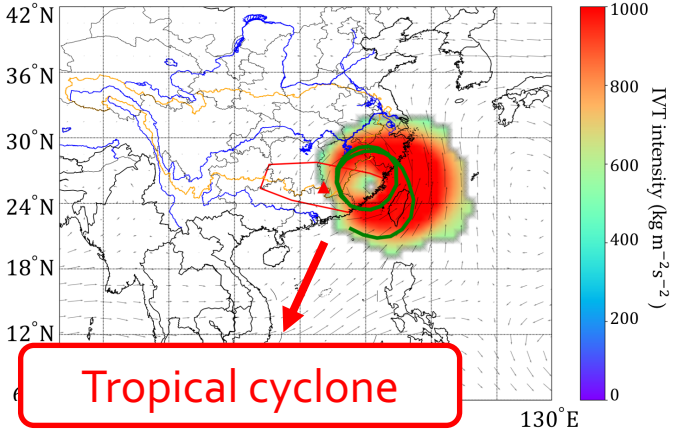


(Lavers et al., 2012)





varying shapes, orientations and curvatures



Tropical cyclone

(Pan & Lu, 2019)

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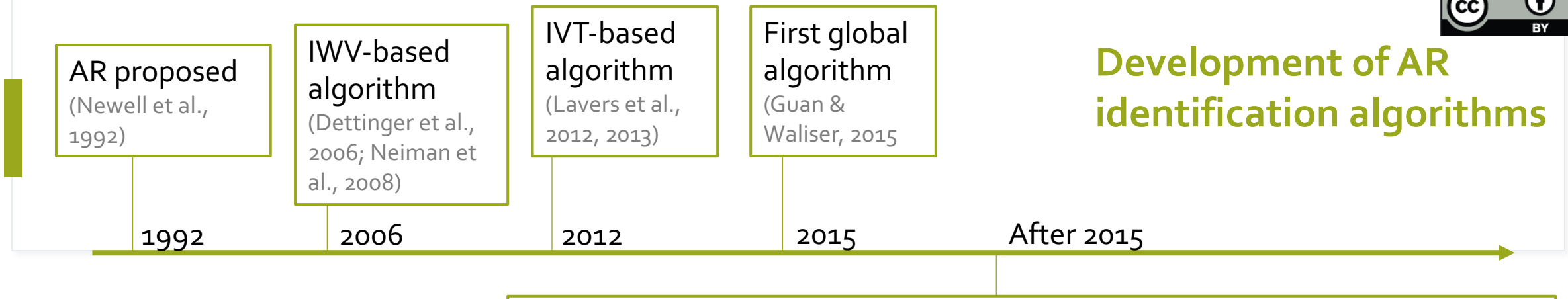
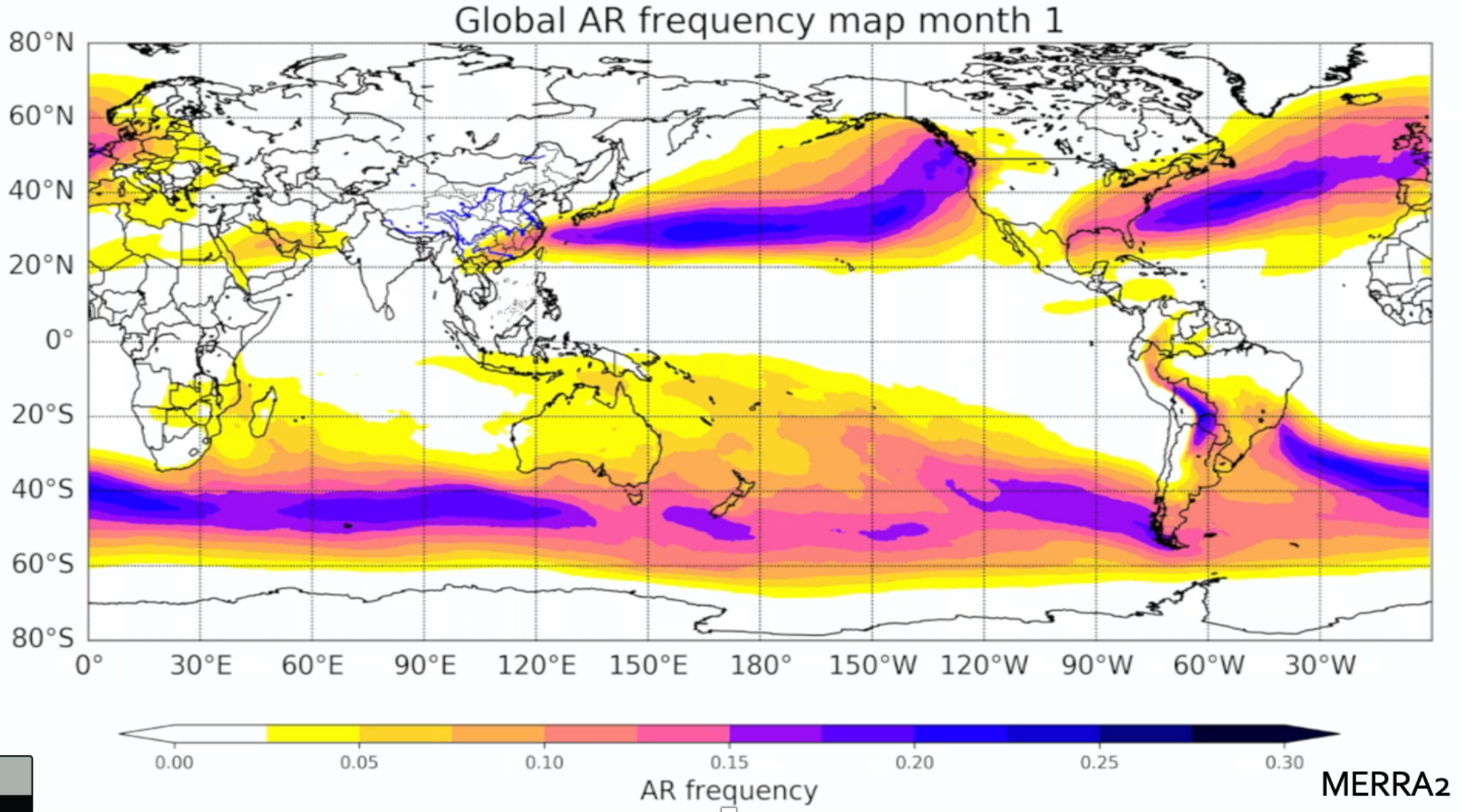
Development of AR identification algorithms



Motivation

- Robust algorithm applicable to East Asia
- Reliable metrics for ARs with varying shapes/orientations/curvatures
- Effective step to distinguish TC-like features
- AR "flavor"/structure analysis

In September 2019, we joined the ARTMIP project and contributed the AR global catalog (available at http://www.cgd.ucar.edu/projects/artmip/).



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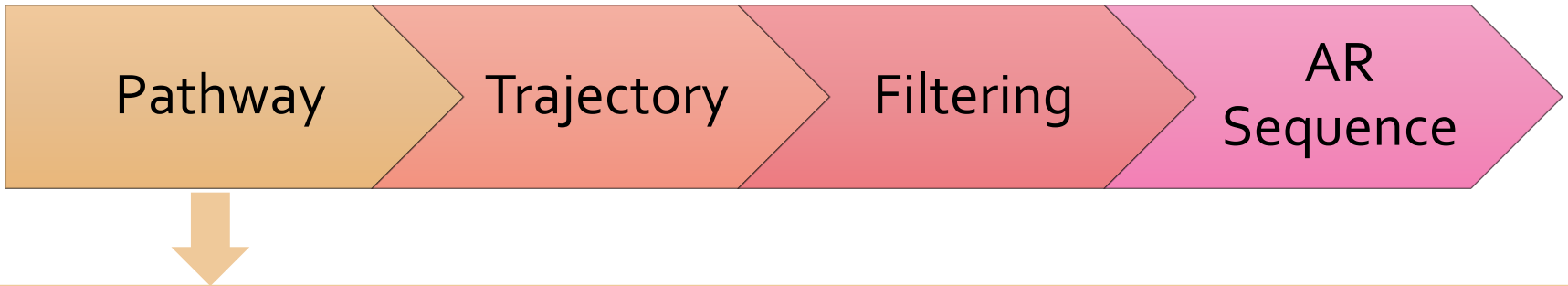
Quick Basics of the PanLu2.0

Pan & Lu, 2019;
Pan & Lu, 2020 (under review)

1. IVT based
2. 

Dual thresholds

- Local threshold: spatially smoothed (Gaussian Kernel density smoother) 85% IVT intensity quantile
- Regional threshold: 80% IVT quantile in the entire AR detection region
- Seasonality is considered by a three-month window for both monthly local & regional thresholds.

10.1029/2018WR024407

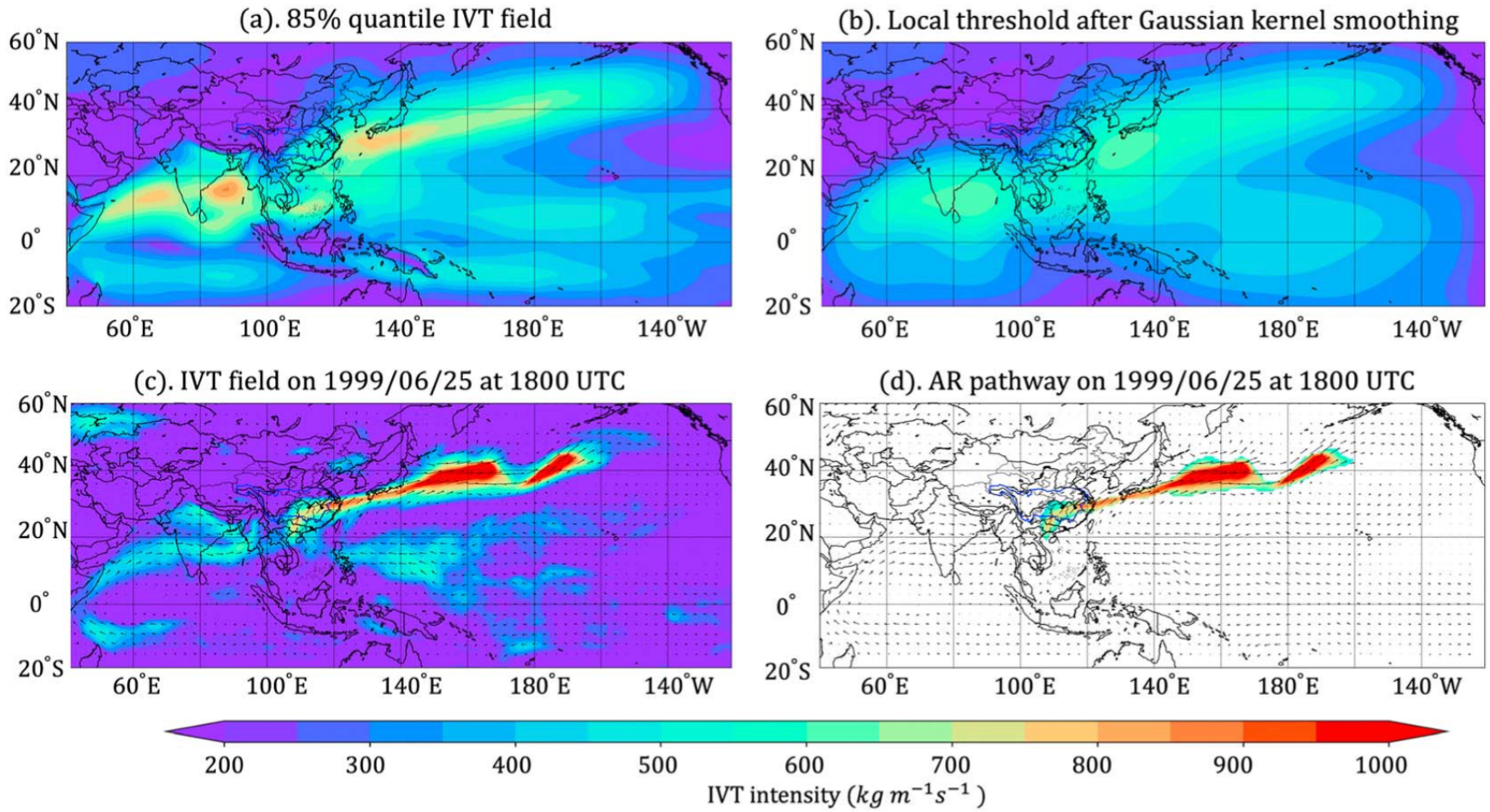


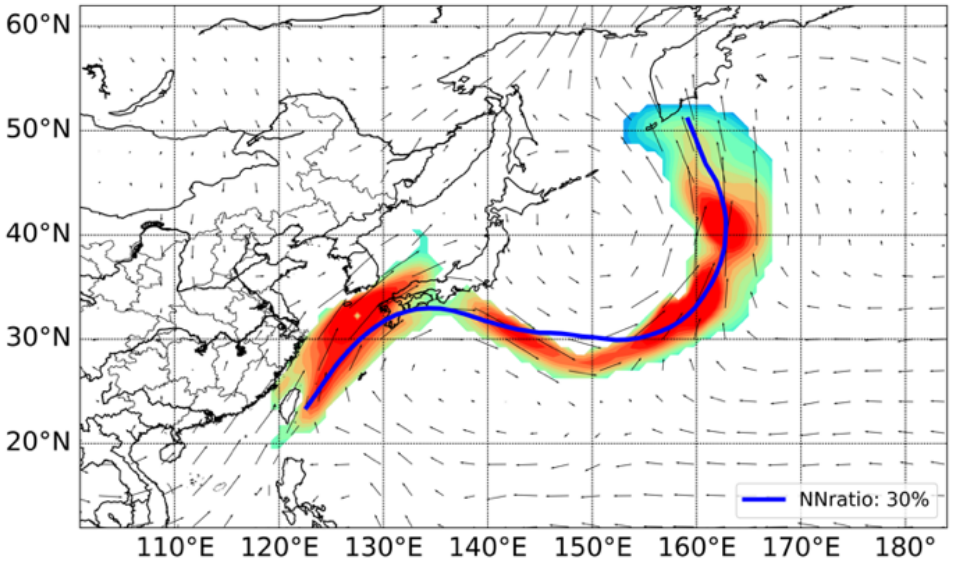
Figure 3. An example of AR pathway detection. (a) The 85% quantile IVT field in the AR detection region (40°E to 120°W, 20°S to 60°N). (b) The local threshold by applying the Gaussian kernel density smoothing to the 85% quantile of IVT field. (c) The IVT field on 25 June 1999 at 1800 UTC. (d) The detected AR pathway based on the IVT field in (c). AR = atmospheric river; IVT = integrated water vapor transport.

Quick Basics of the PanLu2.0

Pan & Lu, 2019;
Pan & Lu, 2020 (under review)

1. IVT based
2. Pathway → Trajectory → Filtering → AR Sequence

- "Nearest neighbors + K-means + local regression" inspired approach to search for next "centroid"
- Two directional (forward/backward) search by moving centroid along the weighted IVT direction



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Pathway → Trajectory → Filtering → AR Sequence

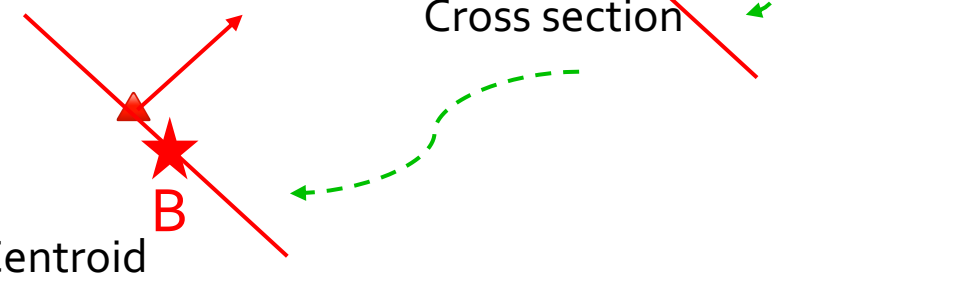
- "Nearest neighbors + K-means + local regression" inspired approach to search for next "centroid"
- Two directional (forward/backward) search by moving centroid along the weighted IVT direction

▲A Initial search point

● Selected nearest neighbors

✖ Not selected points

Weighted IVT direction

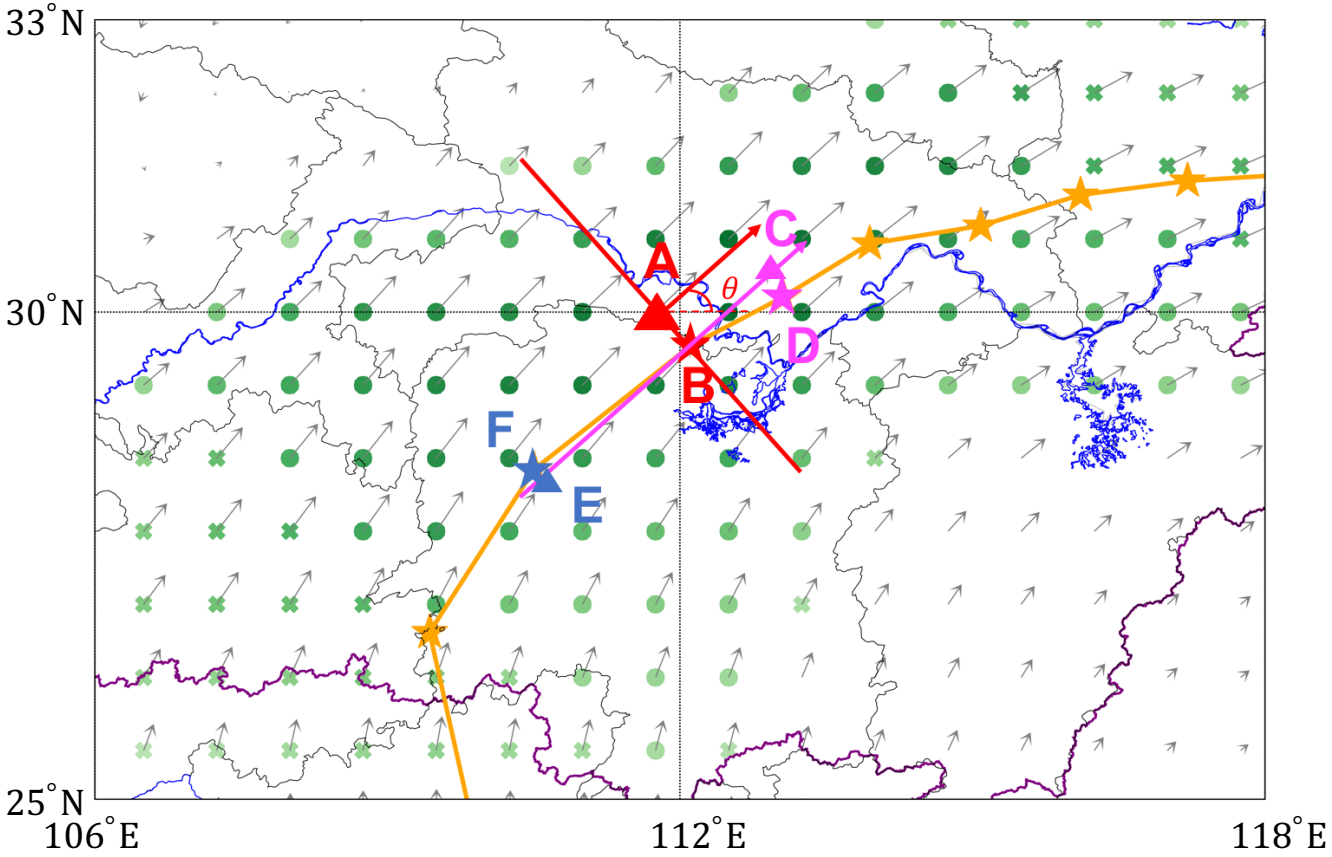


▲C forward new search point

▲E backward new search point

★D new forward centroid

★F new backward centroid



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Quick Basics of the PanLu2.0

Pan & Lu, 2019;
Pan & Lu, 2020 (under review)

1. IVT based
2. Pathway → Trajectory → Filtering → AR Sequence

- Spatial and temporal continuity

- Computer geometric metrics:

length, width, **LWratio,** **turning angle series (α_i, $\alpha_{sum} = \sum_{i=2}^{n-1} \alpha_i$)**

- Eliminate ARs

whose length < 2000km, or LWratio < 2 or any α_{sum}>360°

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Pathway → Trajectory → Filtering → AR Sequence

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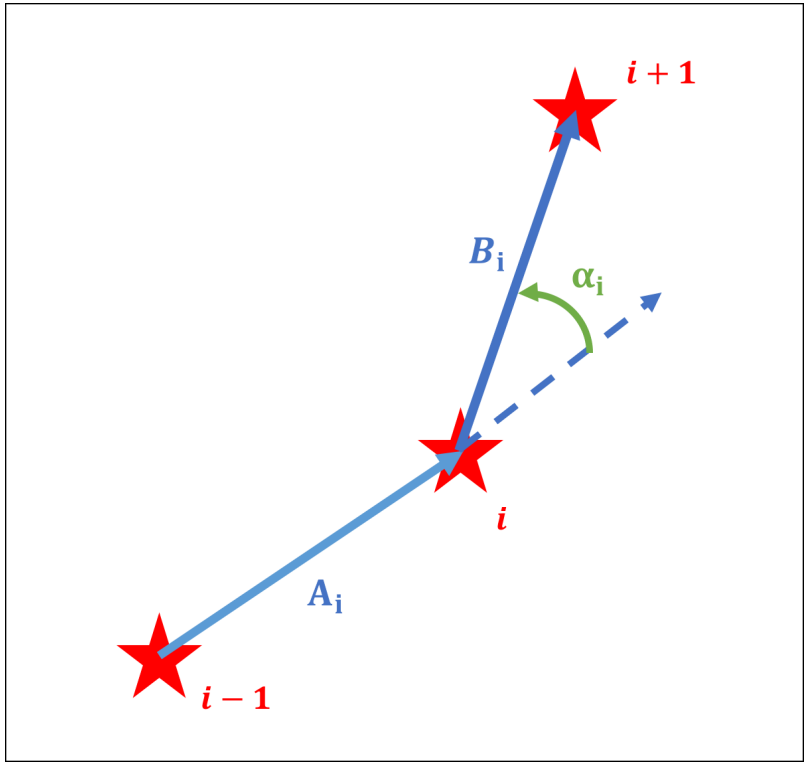
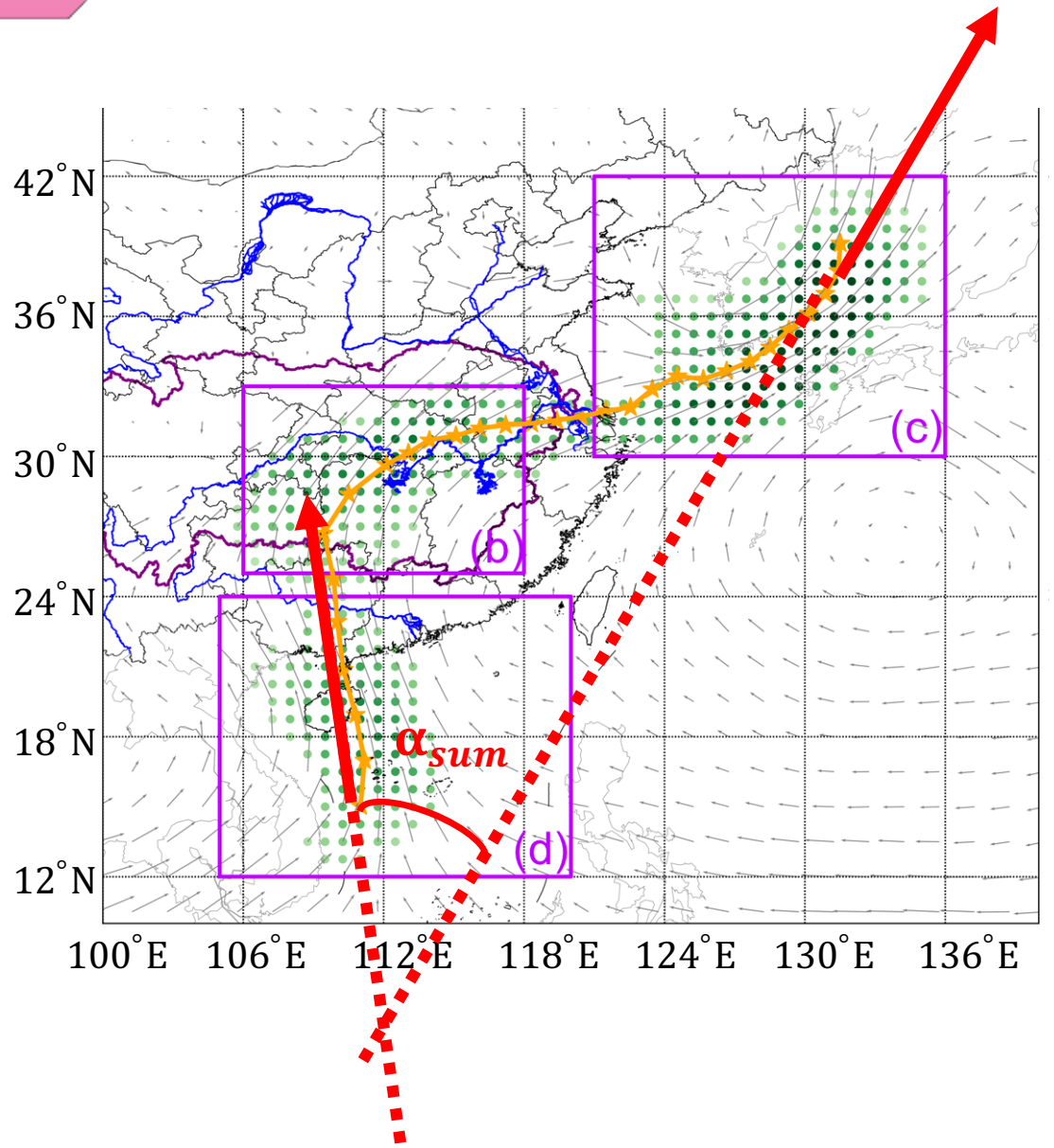
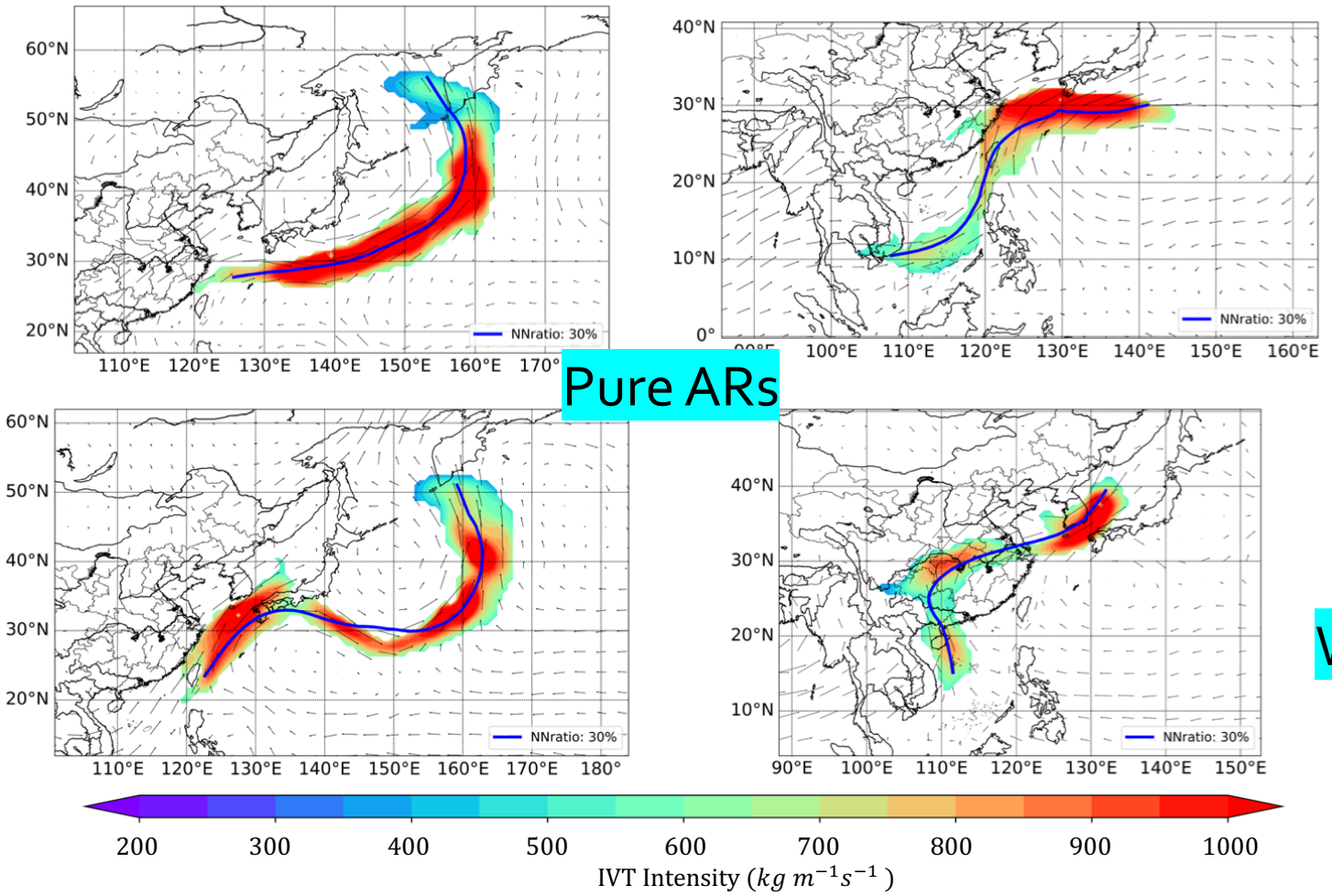
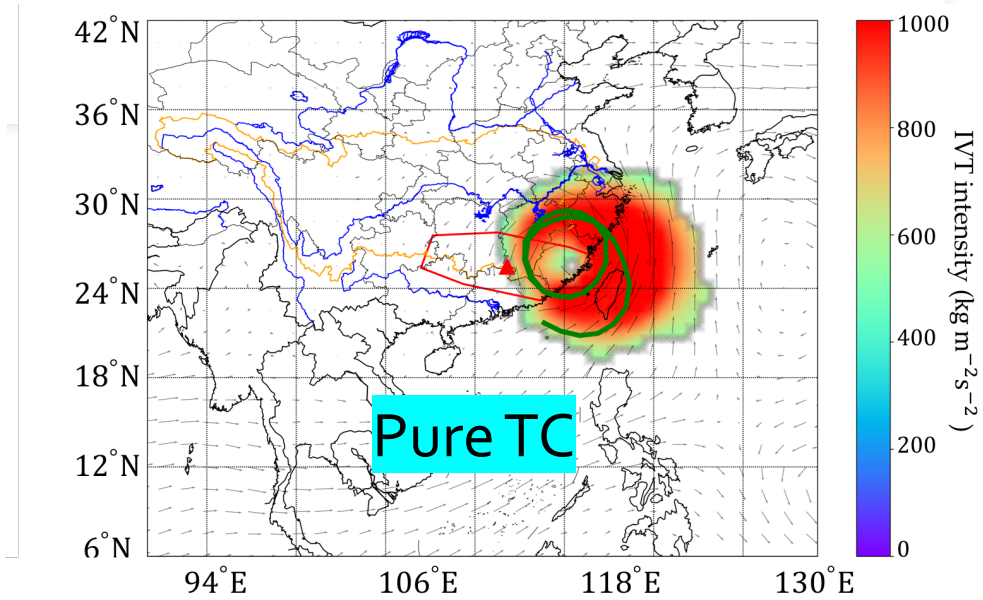




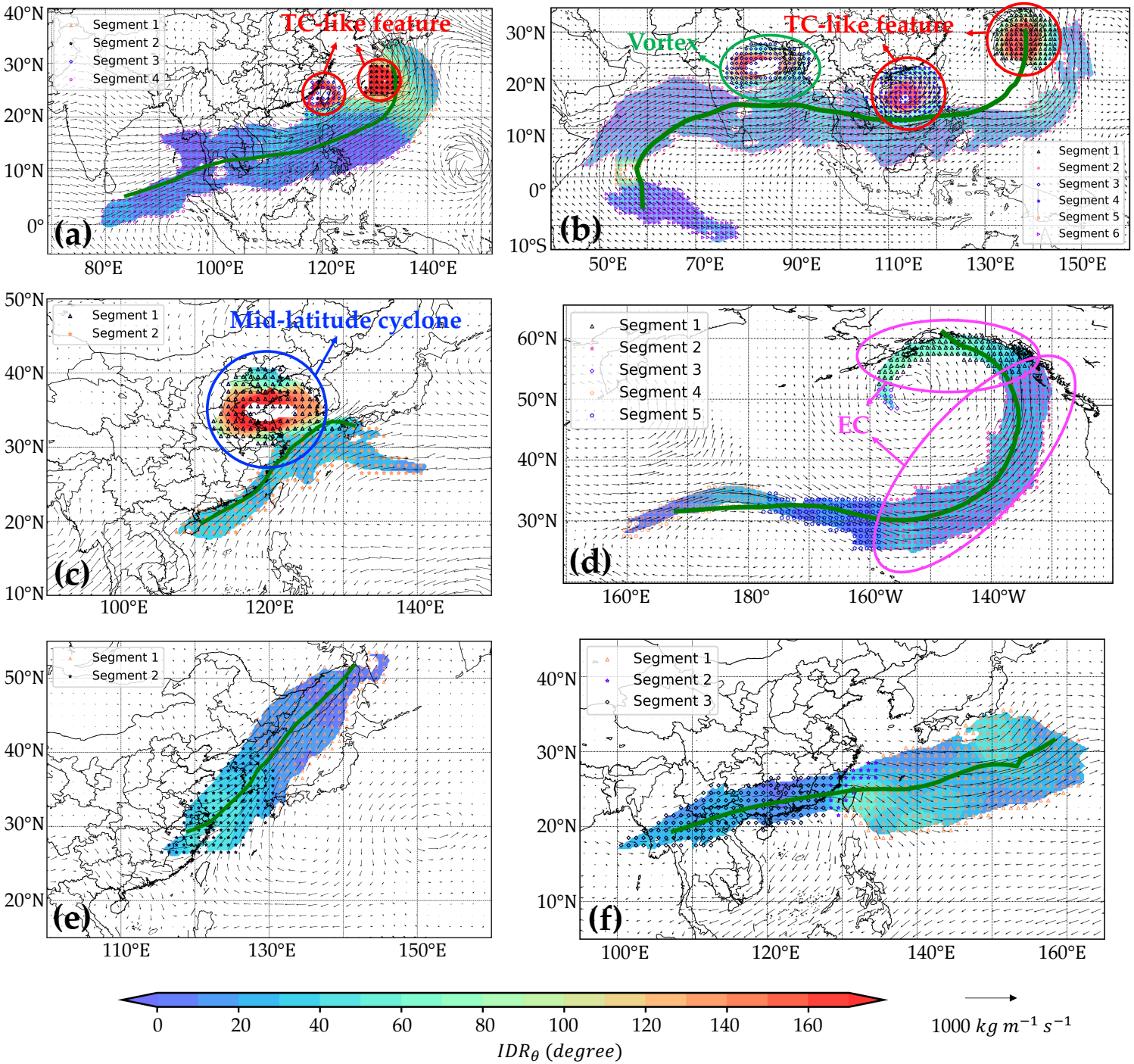
Performance

❖Smooth curve that captures the varying shape/curvature of various ARs





What about ARs with different "flavors"?



PanLu2.0

AR database

Segmentation

- Based on IDR_θ coherence/discordant
- Image segmentation

AR catalogue

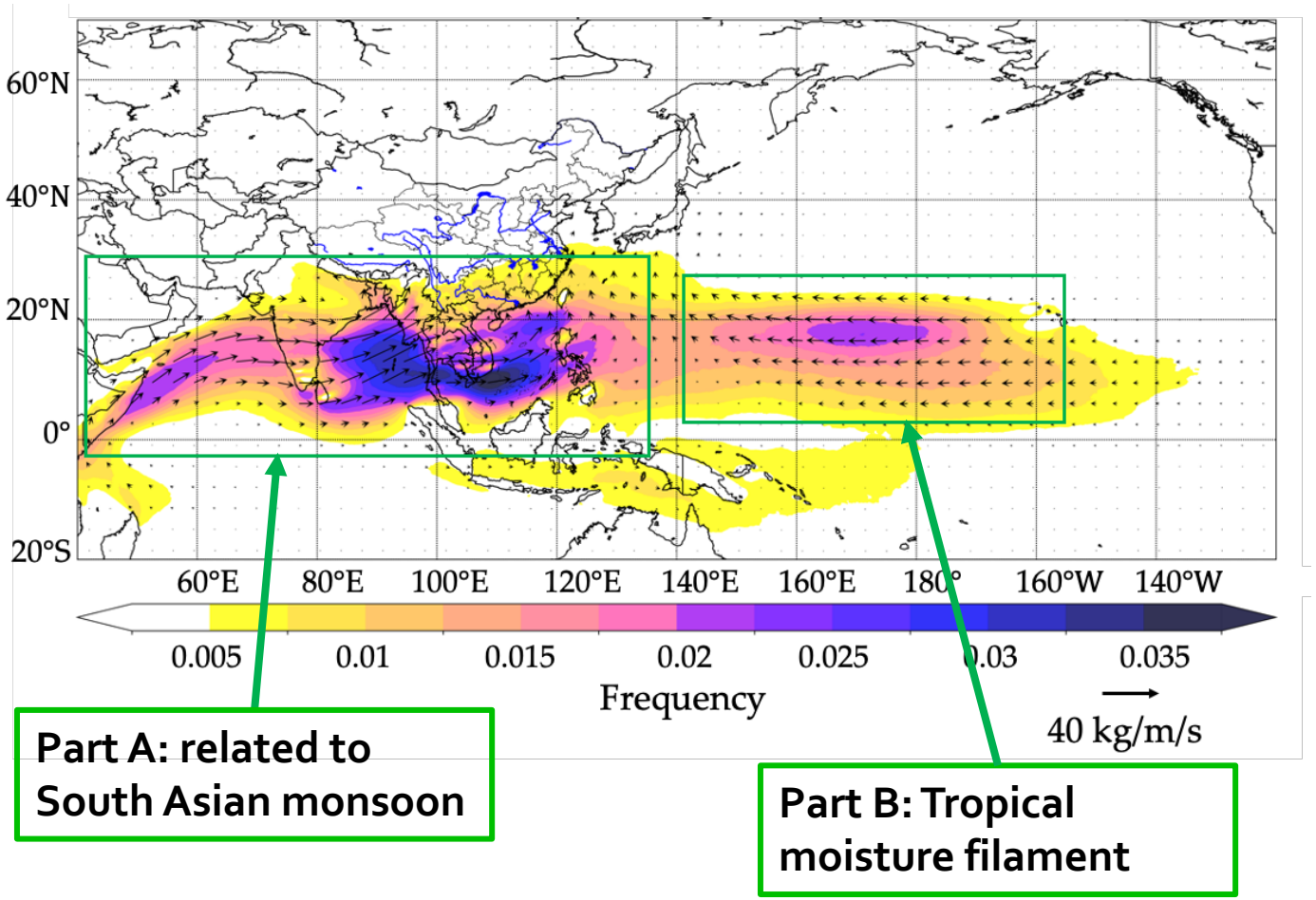
- Localized & segmental metrics
- Classic geometric metrics

EA AR catalog in Pan & Lu 2020 (under review)

Some reminders

1. Differentiate TMFs from ARs
   - When we apply some previous methods by others to EA
   1. IVT direction based → midlatitudes ARs are discarded
   2. AR location → ARs from south Asian summer monsoon region with substantial poleward moisture transport is discarded; ITCZ seasonal shift is not considered

TMF Elimination



- We implement a two-step criterion to distinguish TMFs from ARs.

1). Marginal extratropical components despite of their IVT directions

2). Long residency in tropics and limited poleward component, which reserves the Part A and eliminate Part B successfully

Why should we care the internal structure of AR?

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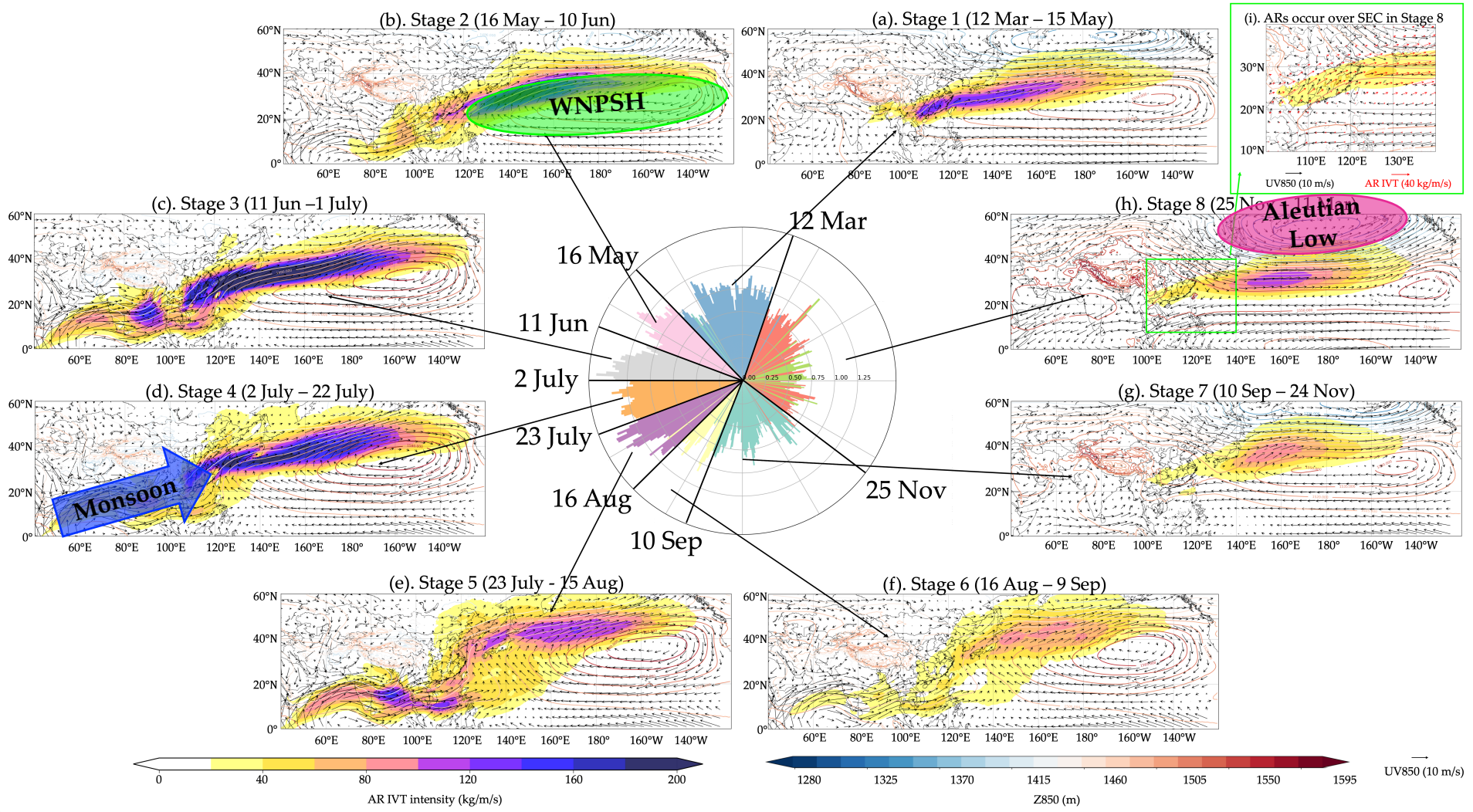
> *"We believe that distinguishing these systems thus understanding the underlying physical mechanism are tantamount to the identification of AR." (Pan & Lu, 2020)*



Climatological Annual Cycle:

WNPSH

→ (Cheng, Lu* and Dai, 2019)

Aleutian Low

Monsoon

→ (Dai, Cheng and Lu*, 2020)

…

Synoptic scale

EC

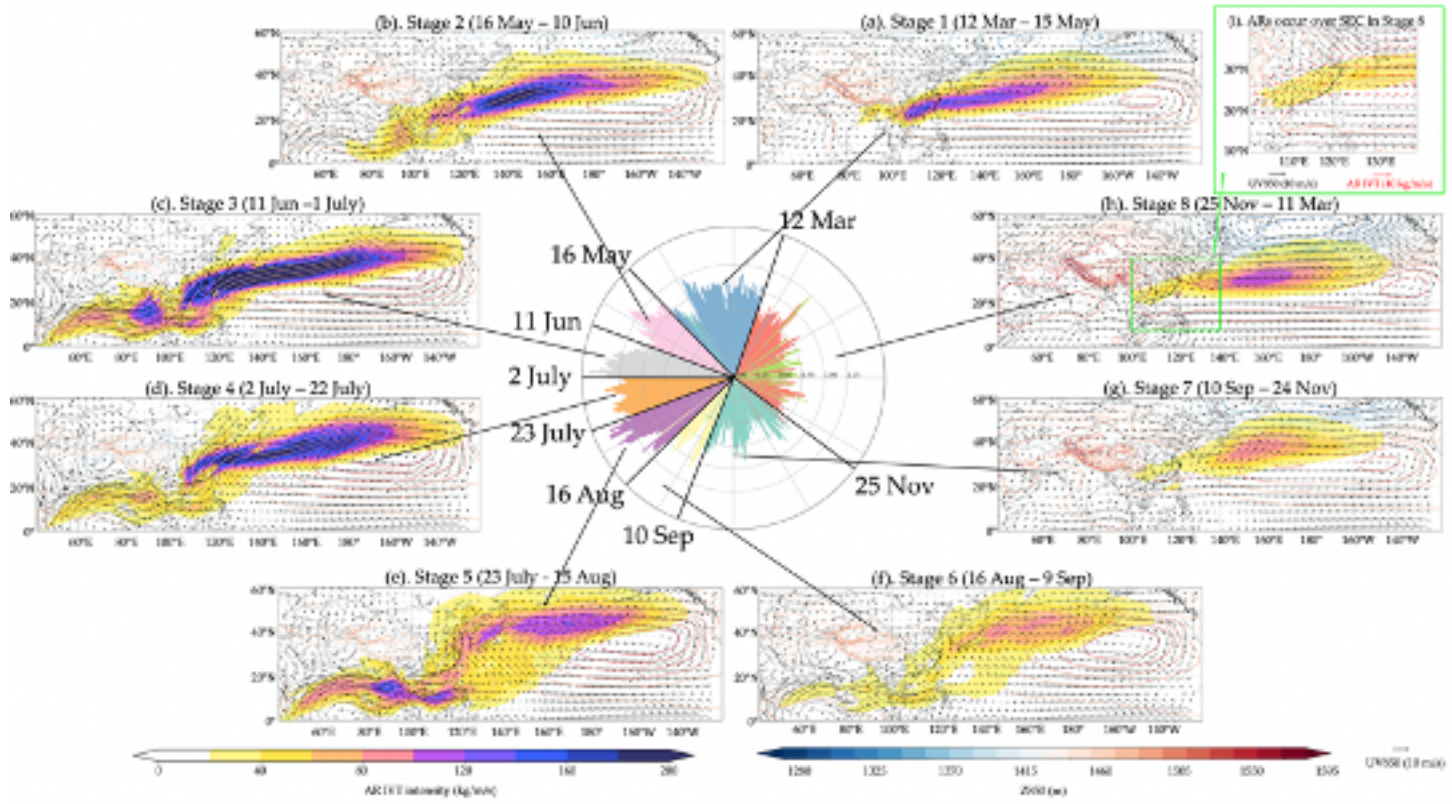
TC

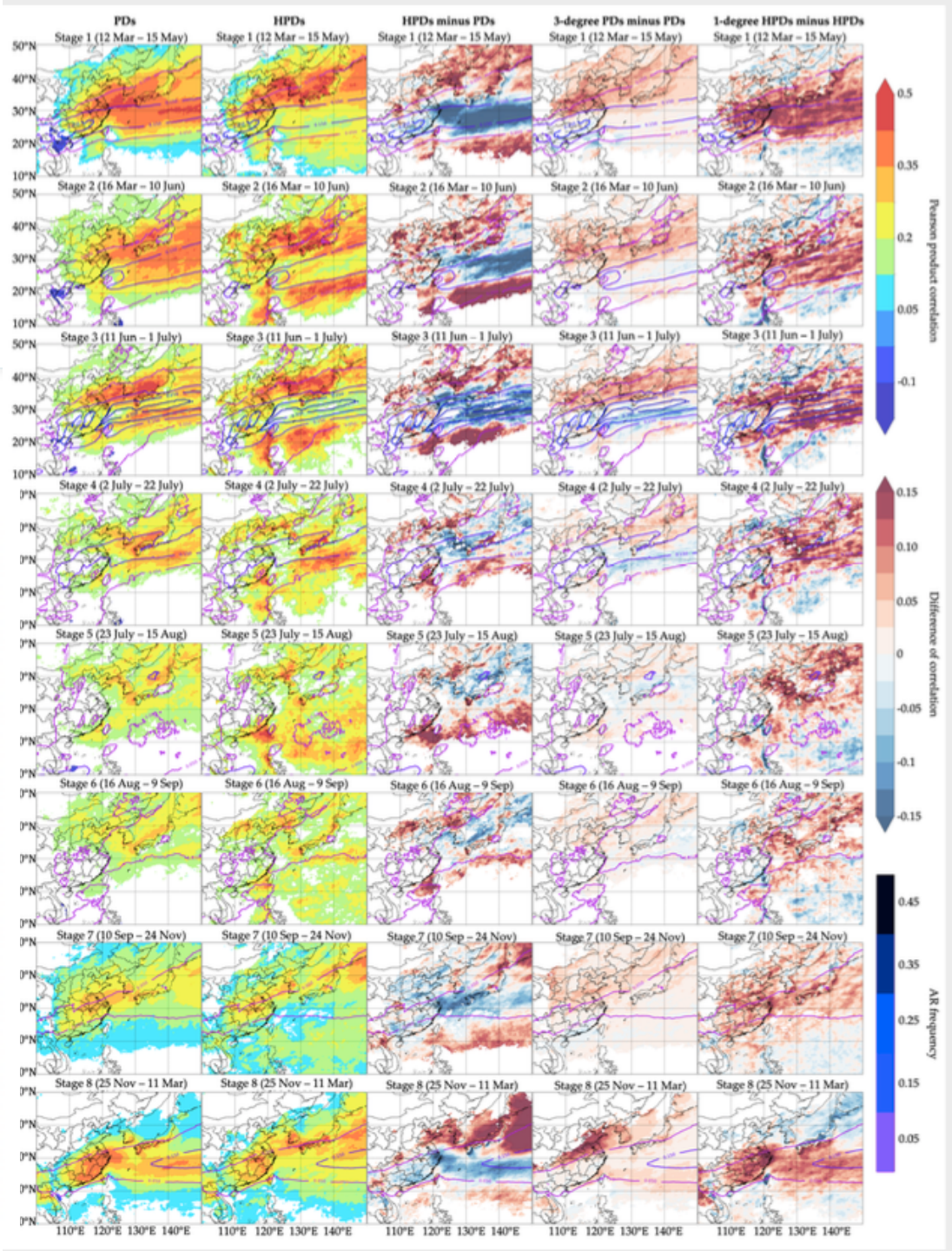
→ (Lu* and Xiong, 2019)

Fronts

…

Parallel live chat on *AS4.6 EA AR: Annual Cycle, Transitional Mechanism and Precipitation Predictability,* by Pan & Lu





Our related studies

1. Mengxin Pan and Mengqian Lu* (2019), "*A Novel Atmospheric River Identification Algorithm*", *Water Resources Research*, 2019, 55: 6069-6087, https://doi:10.1029/2018WR024407
2. Tat Fan Cheng, Mengqian Lu*, Lun Dai (2019), "*The Zonal Oscillation and the Driving Mechanisms of the Extreme western North Pacific Subtropical High and its impacts on East Asia Summer Precipitation*" *Journal of Climate*, 32(10), 3025–3050, https://doi.org/10.1175/JCLI-D-18-0076.1
3. Lun Dai, Tat Fan Cheng and Mengqian Lu* (2020), "*Summer Rainfall Predictability in Southeast China*", *Water Resources Research*, 56, e2019WR025515. https://doi.org/10.1029/2019WR025515
4. Nasser Najibi*, Naresh Devineni and Mengqian Lu (2017), "*Hydroclimate Drivers and Atmospheric Teleconnections of Long Duration Floods: An Application to Large Reservoirs in the Missouri River Basin*", *Advances in Water Resources*, 100, 153-167, https://doi.org/10.1016/j.advwatres.2016.12.004
5. Mengqian Lu*, Upmanu Lall, Aurélien Schwartz and Hyun-Han Kwon (2013), "*Precipitation predictability associated with tropical moisture exports and circulation patterns for a major flood in France in 1995*", *Water Resources Research*, 49, 6381–6392, https://doi.org/10.1002/wrcr.20512
6. Yingzhao Ma*, Mengqian Lu, Haonan Chen, Mengxin Pan, and Yang Hong (2018), "*Atmospheric moisture transport versus precipitation across the Tibetan Plateau: a mini-review and current challenges*", *Atmospheric Research*. 209, 50-58, https://doi.org/10.1016/j.atmosres.2018.03.015