The Relationship between Extratropical Cyclone Strength and Atmospheric River Intensity and Position

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Background

Extratropical Cyclone (EC): large scale low pressure weather systems in middle latitudes

Atmospheric River (AR): long and narrow corridor of strong water vapor transport

✓ ARs are often dynamically associated with EC

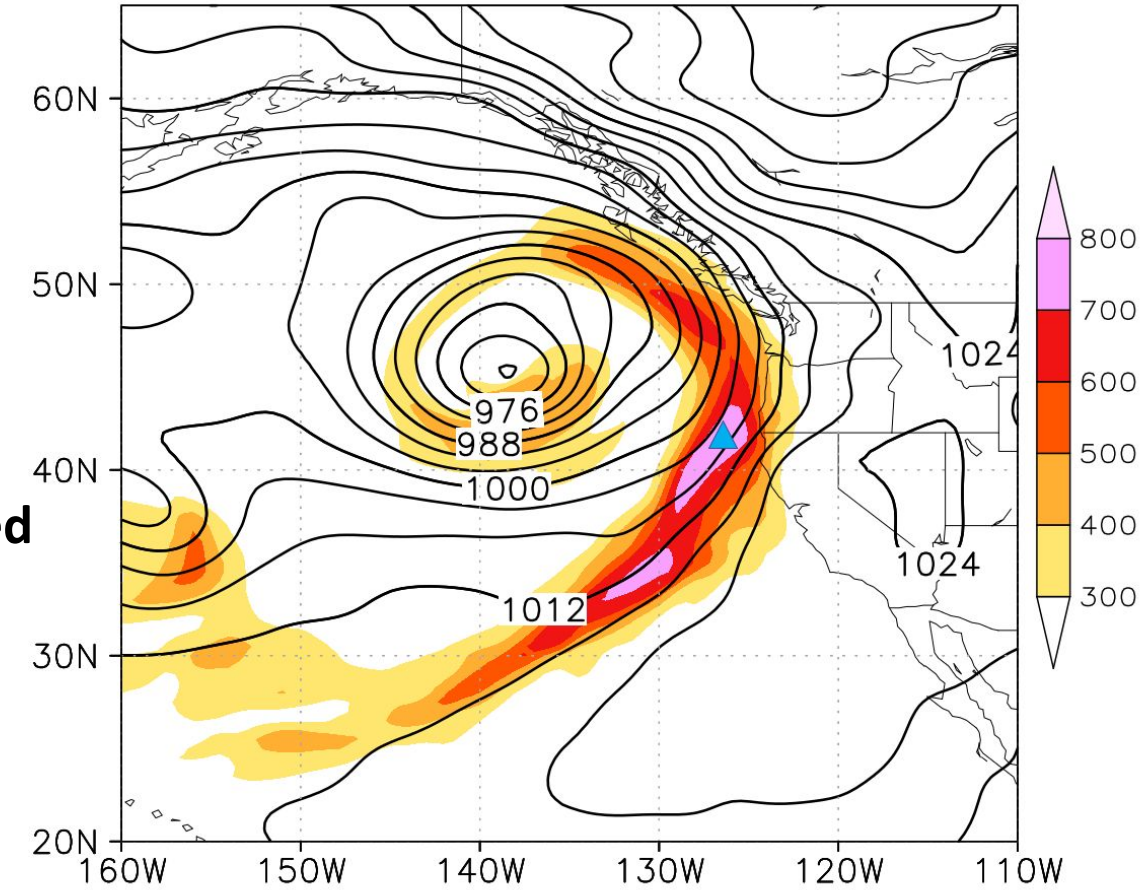
✓ ARs play a more direct role than ECs in precipitation

➢ *Statistical relationship between EC and AR?*

➢ *How does an EC modulate AR characteristics?*

➢ *Does an AR impact the EC development?*

…… many details are unexplored



colors: Integrated Water Vapor Transport (IVT, kg/m/s)
contours: Sea Level Pressure (SLP, hPa)

[the relationship between EC and AR over the U.S. West Coast]

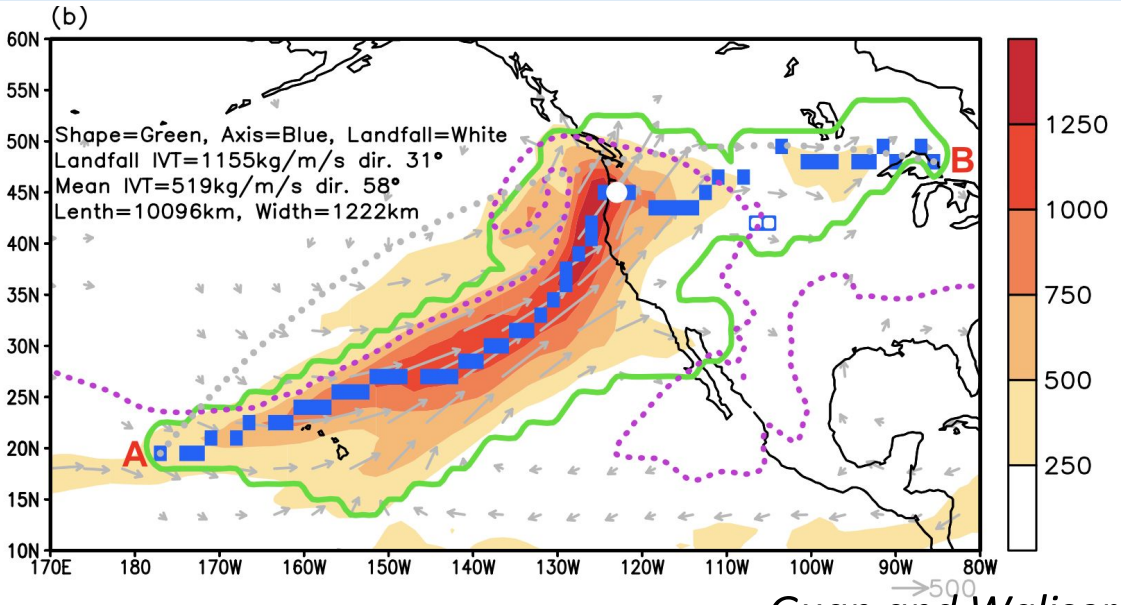
Data and Method

data

CFSR from NCEP

Climate **F**orecast **S**ystem **R**eanalysis

- 6-hourly; 0.5 X 0.5 degree
- 1979 – 2009
- 31 cool seasons (NOV-MAR)



Guan and Waliser, 2015

EC tracking

Hodges TRACK Scheme

(Hodges, 1994, 1995)

- based on 6-hourly **SLP**
- min. lifetime **24hours**
- min. moving distance **1000 km**

AR detecting

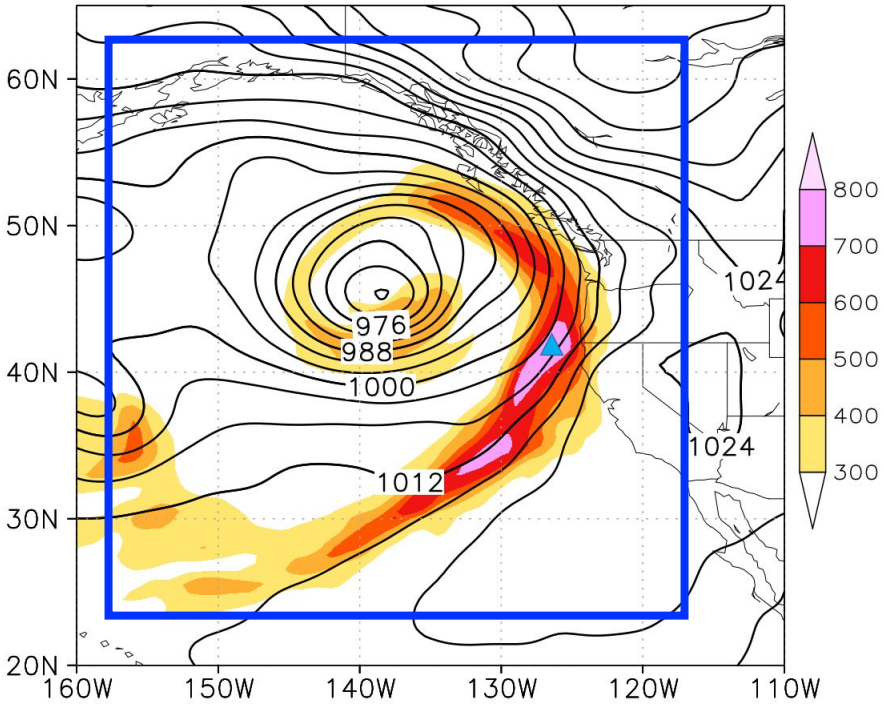
Guan's Global AR Detect Scheme

(Guan and Waliser, 2015)

- based on 6-hourly **IVT** (1000-200hPa)
- IVT > **85% percentile**
- Length **>** **2000 km**
- Length/Width ratio **>** **2**

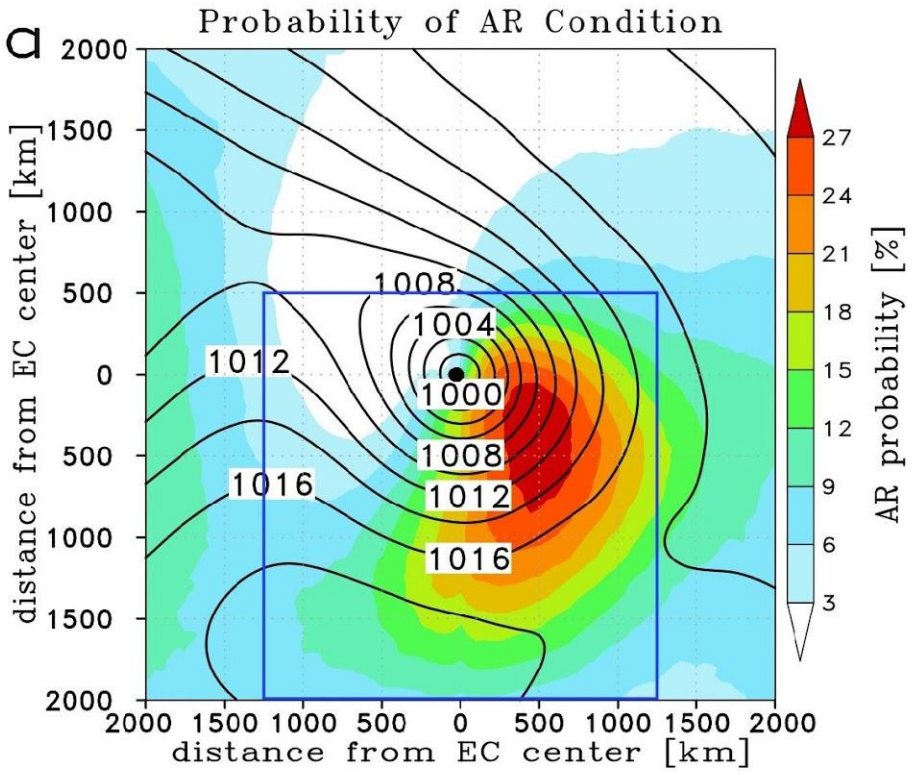
Methods: *AR/EC relative approach*

AR & EC
Relative Box
4000km X 4000km

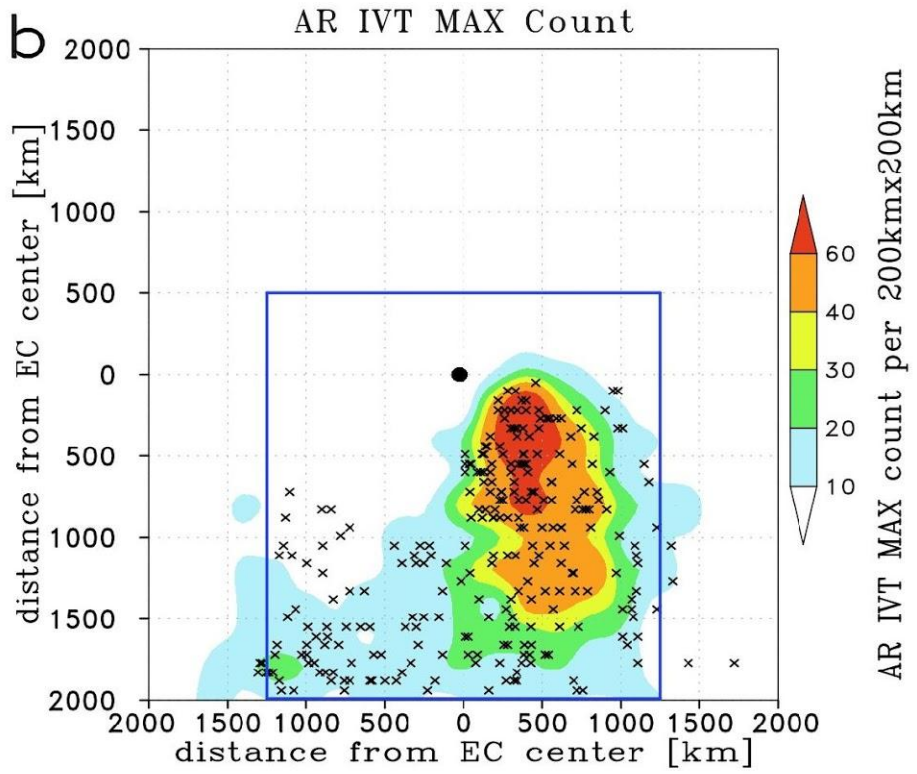


IVT (color, kg/m/s) & SLP (contour, hPa)

Results: *EC and AR on composite EC coordinate*



contour: SLP [hPa]



in 31 cool seasons

"x": IVT MAX positions for exceptional AR(>1250kg/m/s)

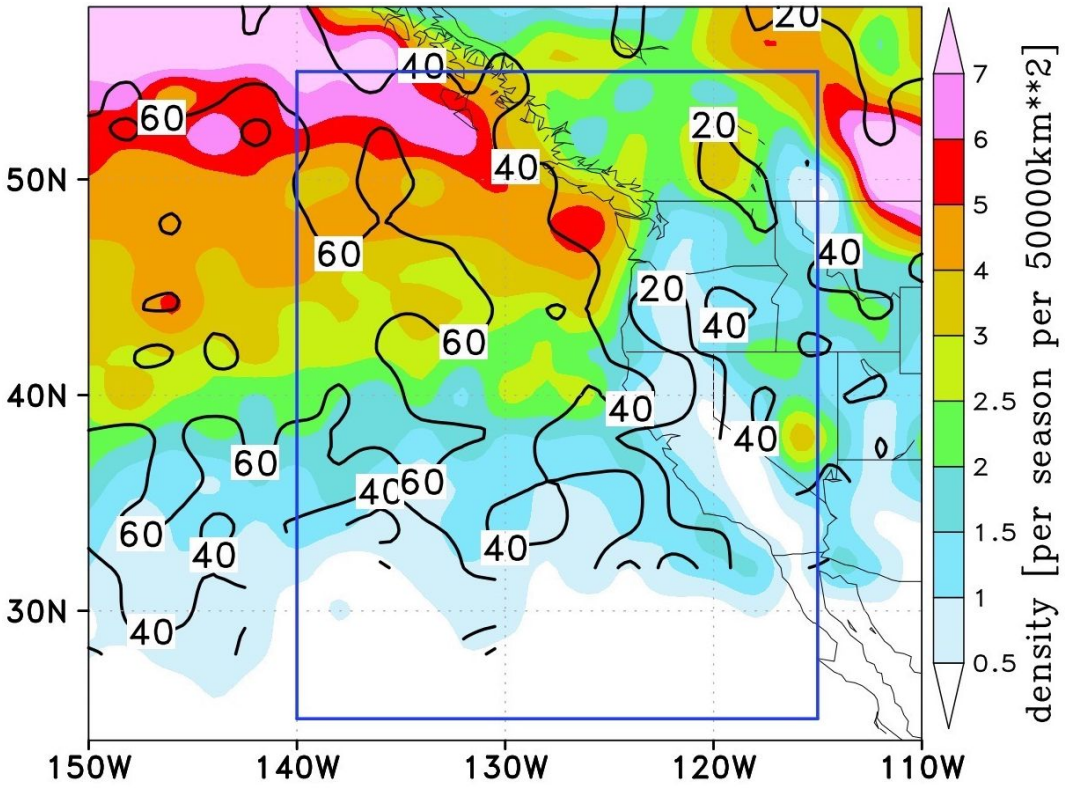
Step1: any part of AR is within the blue box

Step2: AR IVT maximum is within the blue box

the EC and AR are associated with each other

Results: *EC and AR on geographic map*

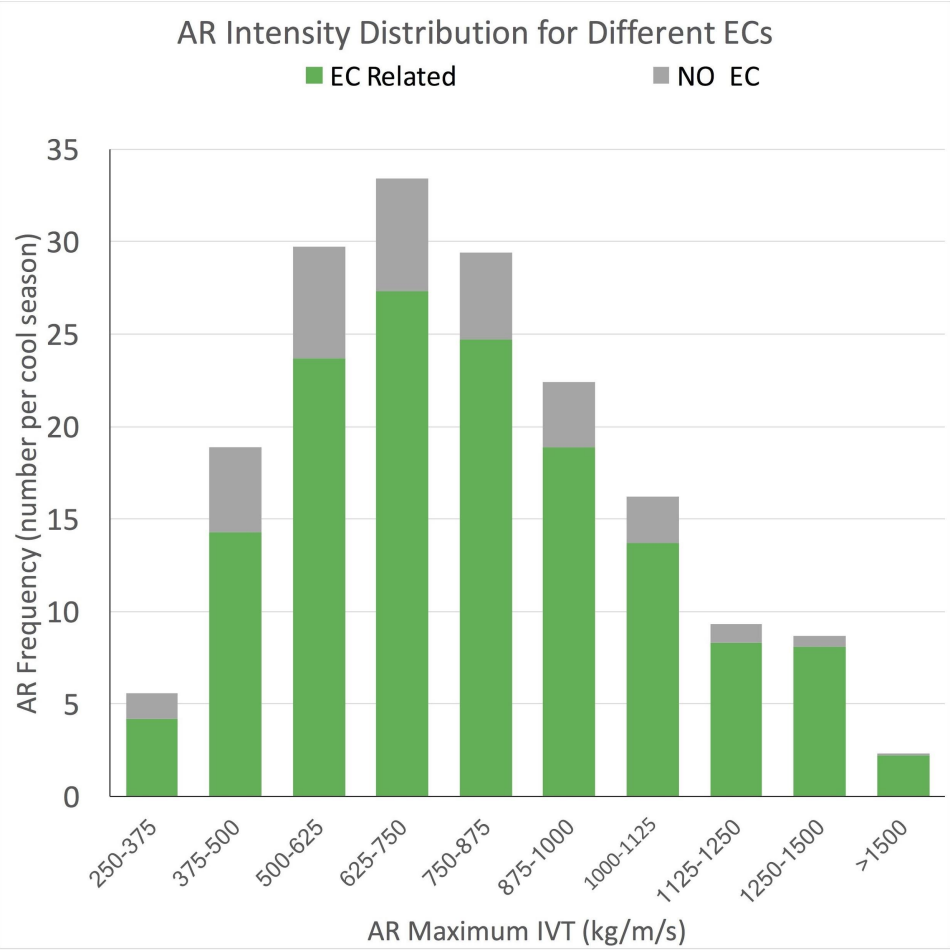
EC Center Density

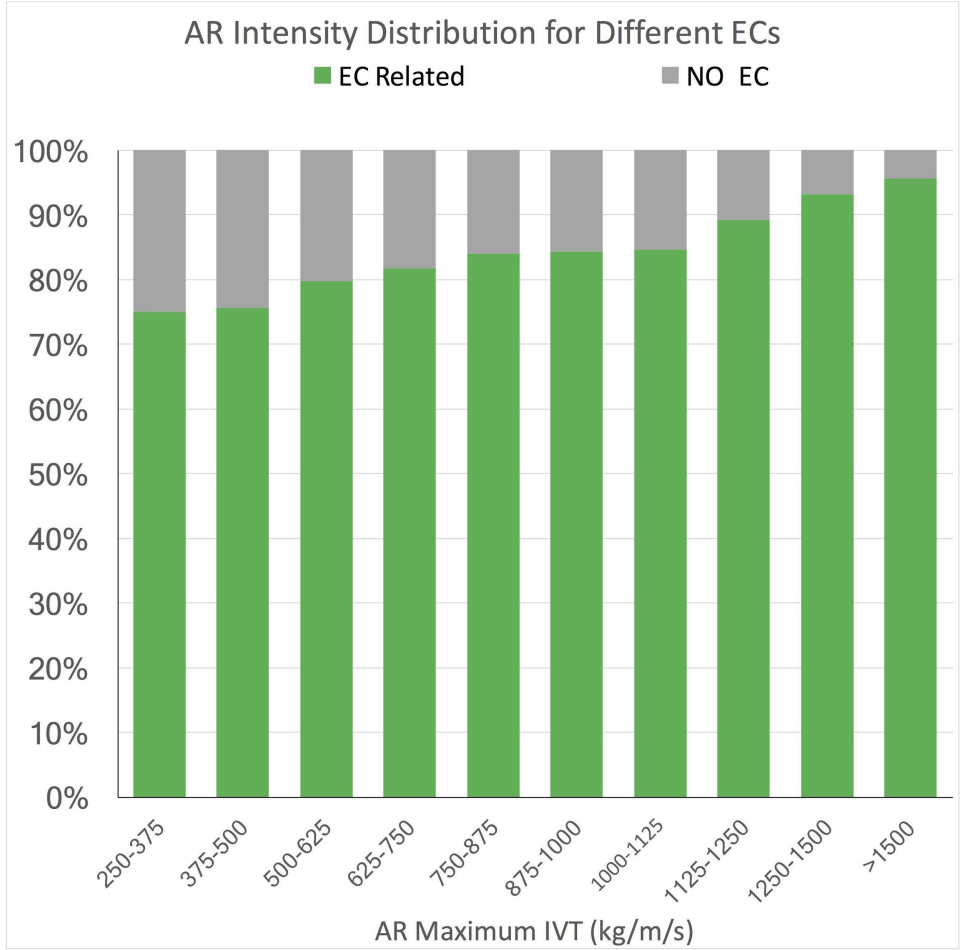


contours: percentage of EC associated with AR

20-60% ECs are associated with AR over U.S. West Coast

Results: *AR intensity distribution*



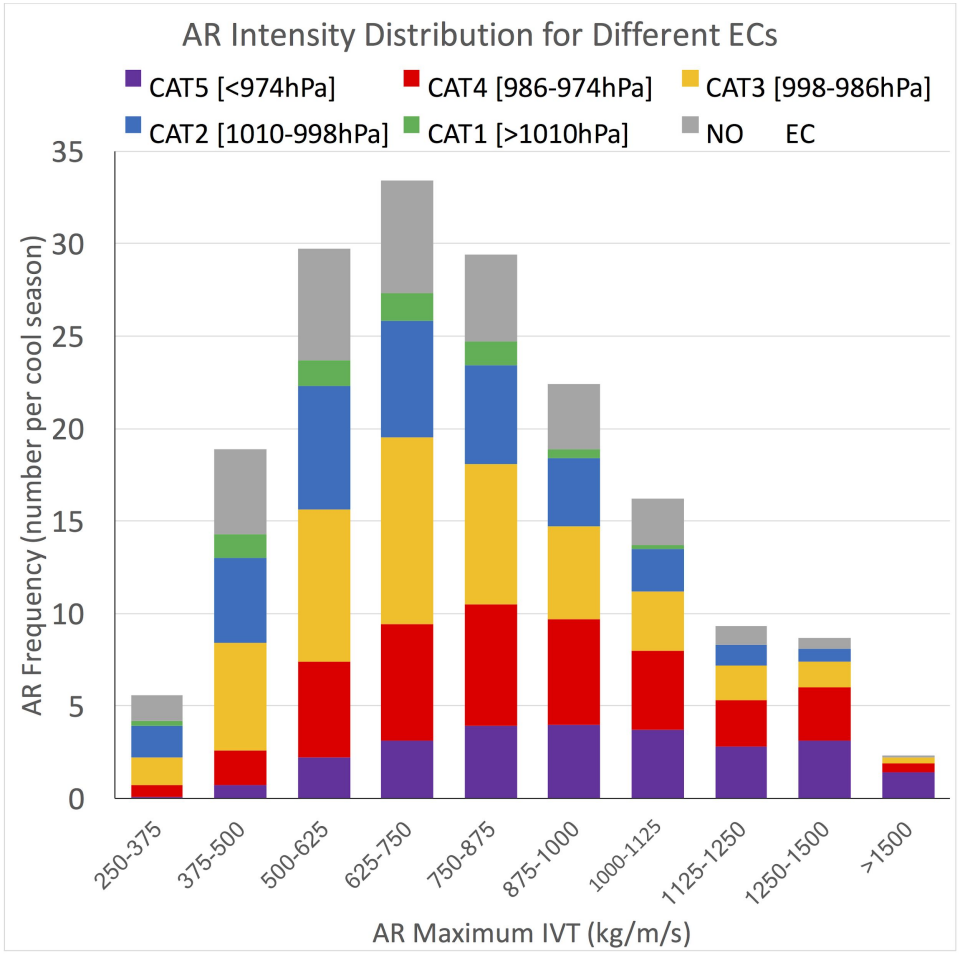


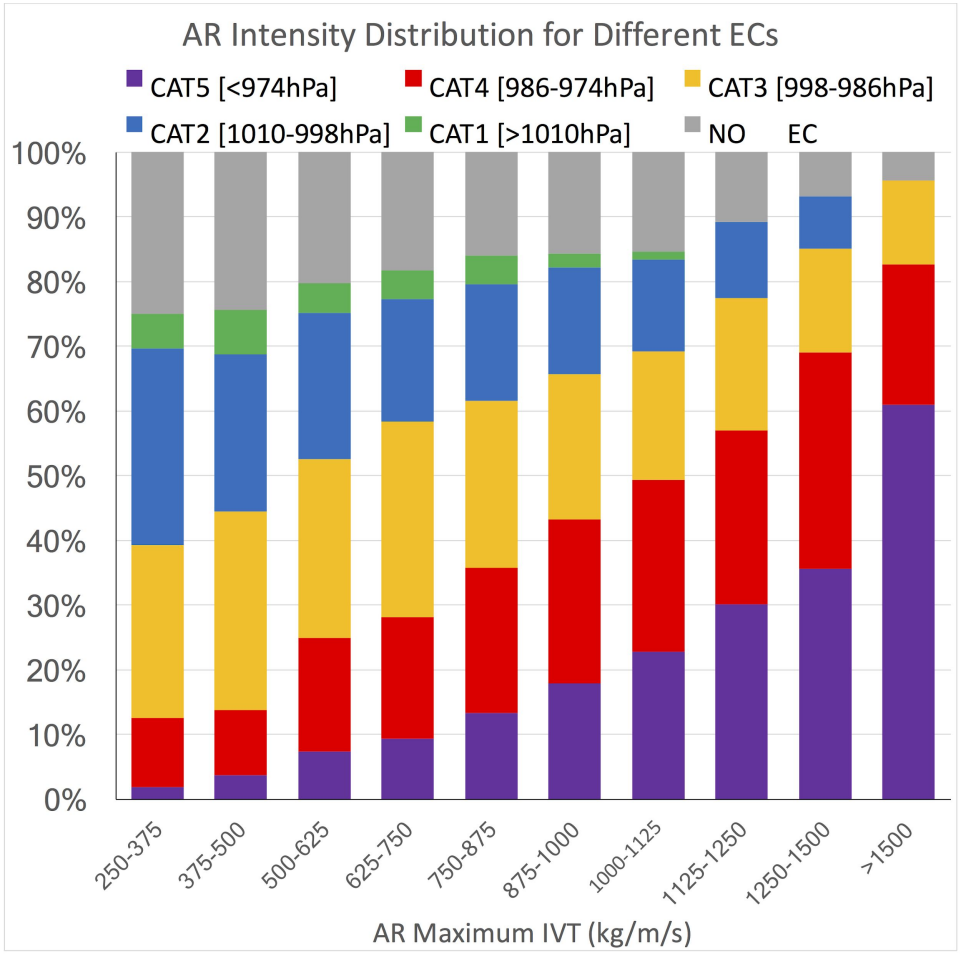
✓overall: ~82% ARs are associated with EC

✓strong ARs (>750kg/m/s): >80% are associated with EC

✓exceptional ARs (>1250kg/m/s): >90% are associated with EC

Results: *AR intensity distribution*

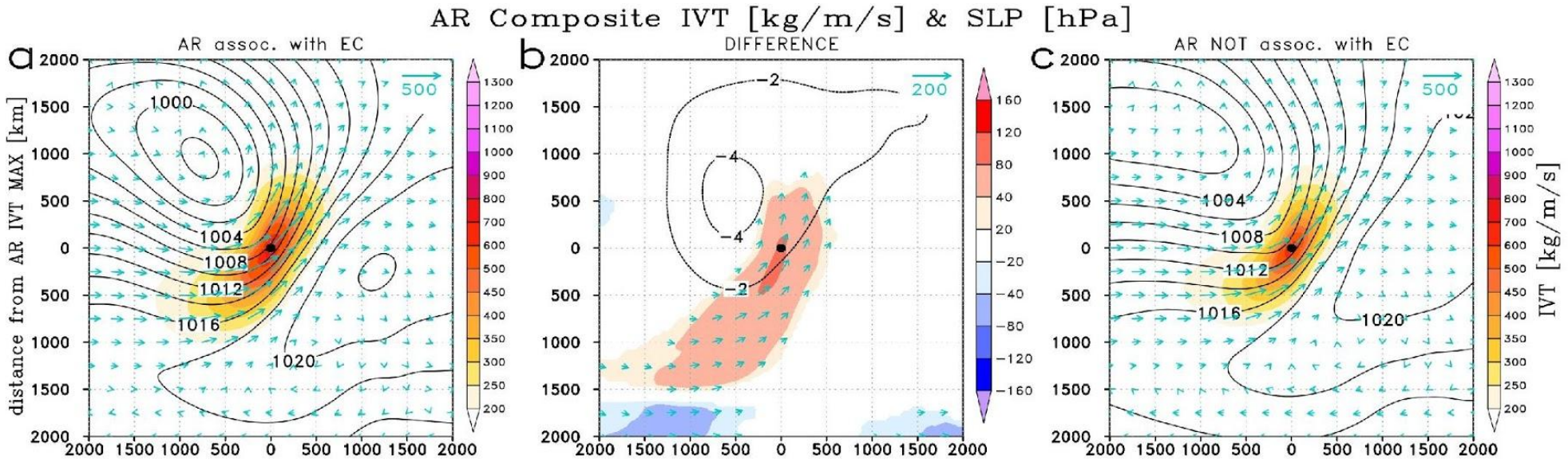




✓the AR intensity is proportional to the related EC intensity

✓the EC is not the only factor controlling the AR intensity

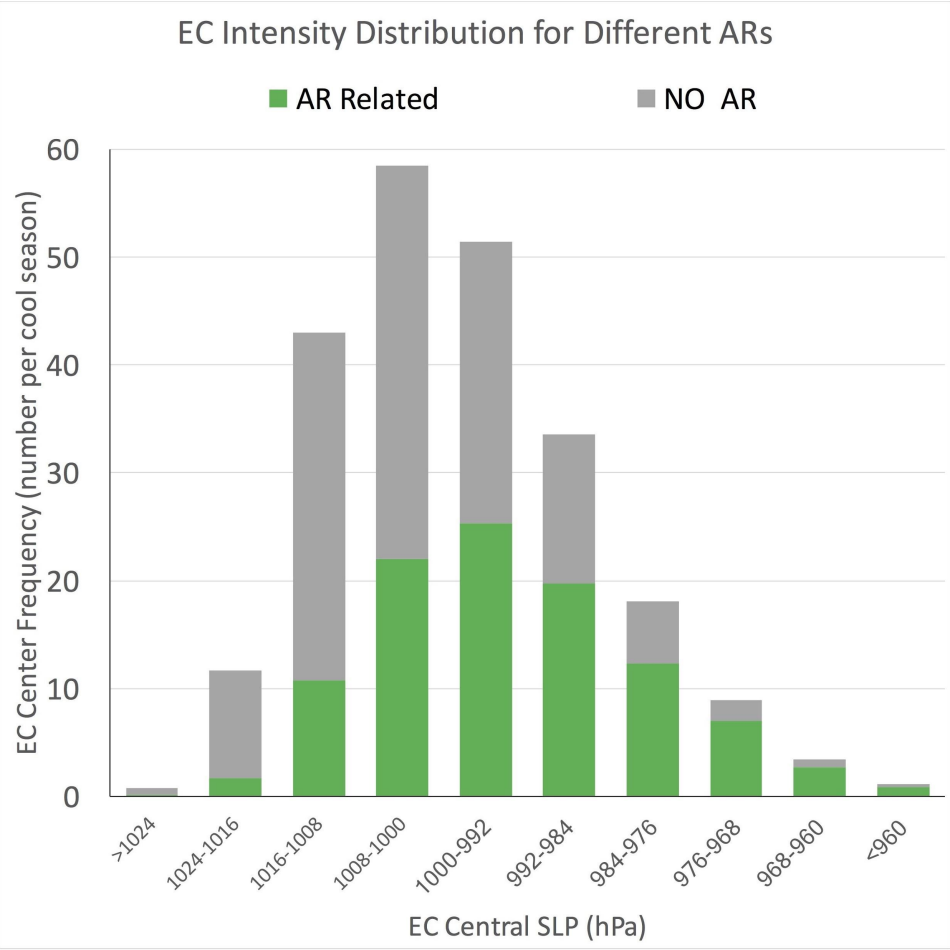
Results: *different ARs conditional on ECs*

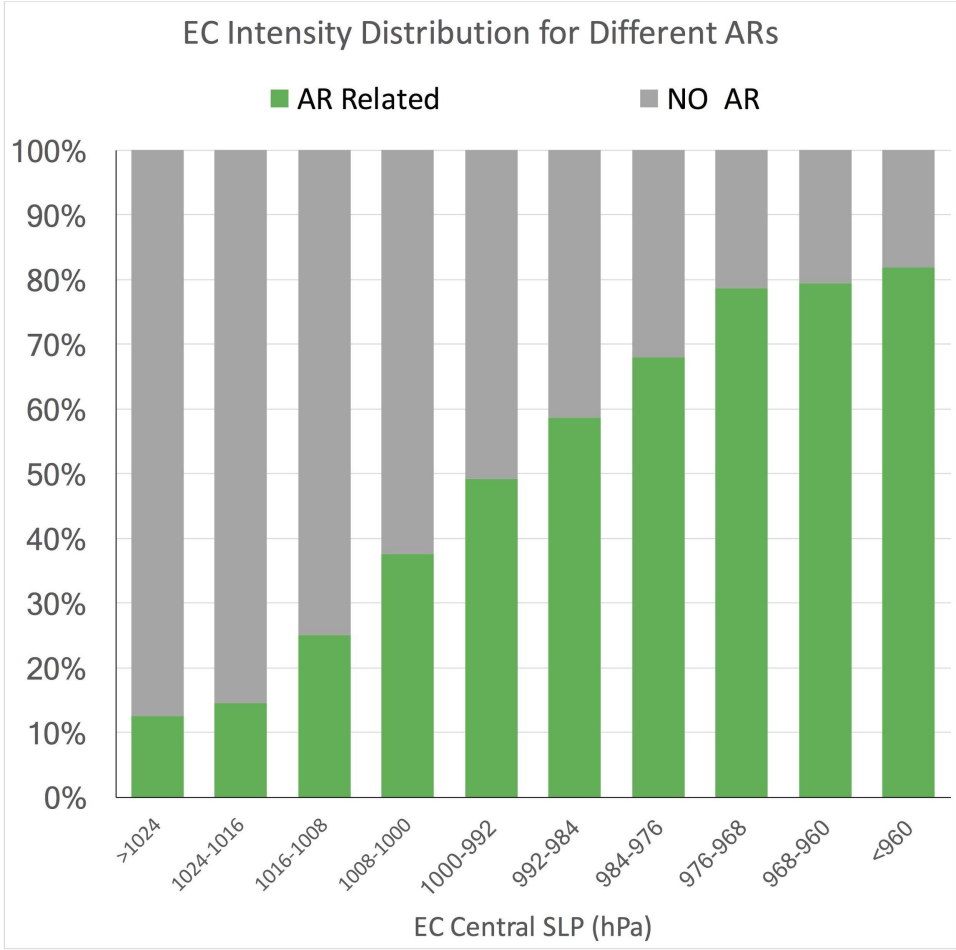


<u>ARs assoc. with EC</u>

- 4hPa deeper low center
- 10-20% stronger IVT mainly meridional IVT

Results: *EC strength distribution*



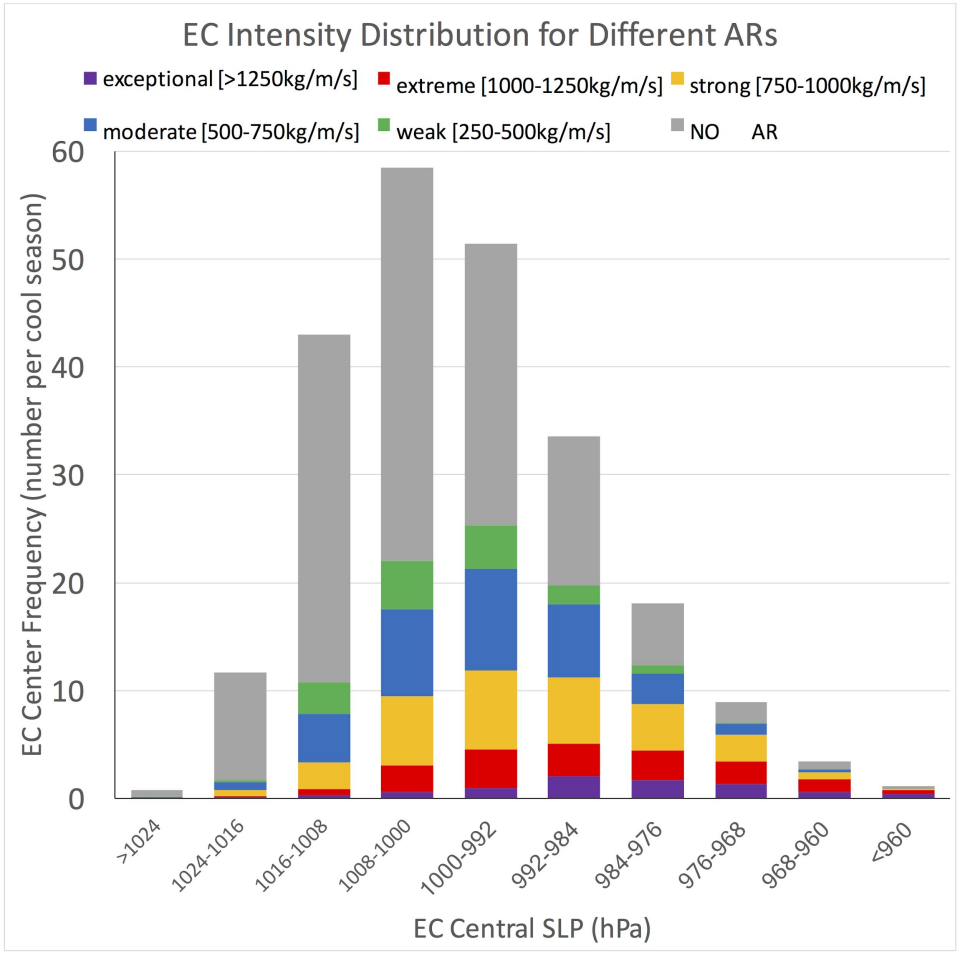


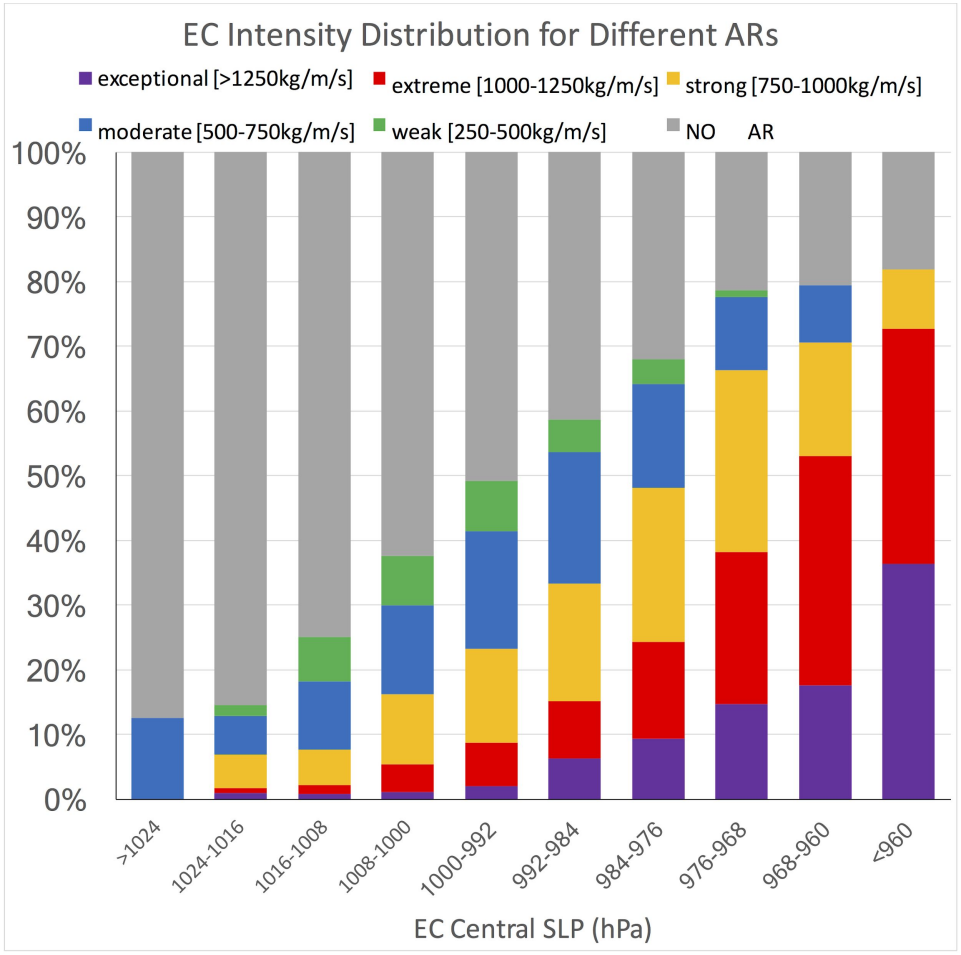
✓overall: only 45% ECs are associated with AR

✓relatively weak (>1000hPa) ECs: ~35% are associated with AR

✓relatively deep (<976hPa) ECs: ~80% are associated with AR

Results: *EC strength distribution*

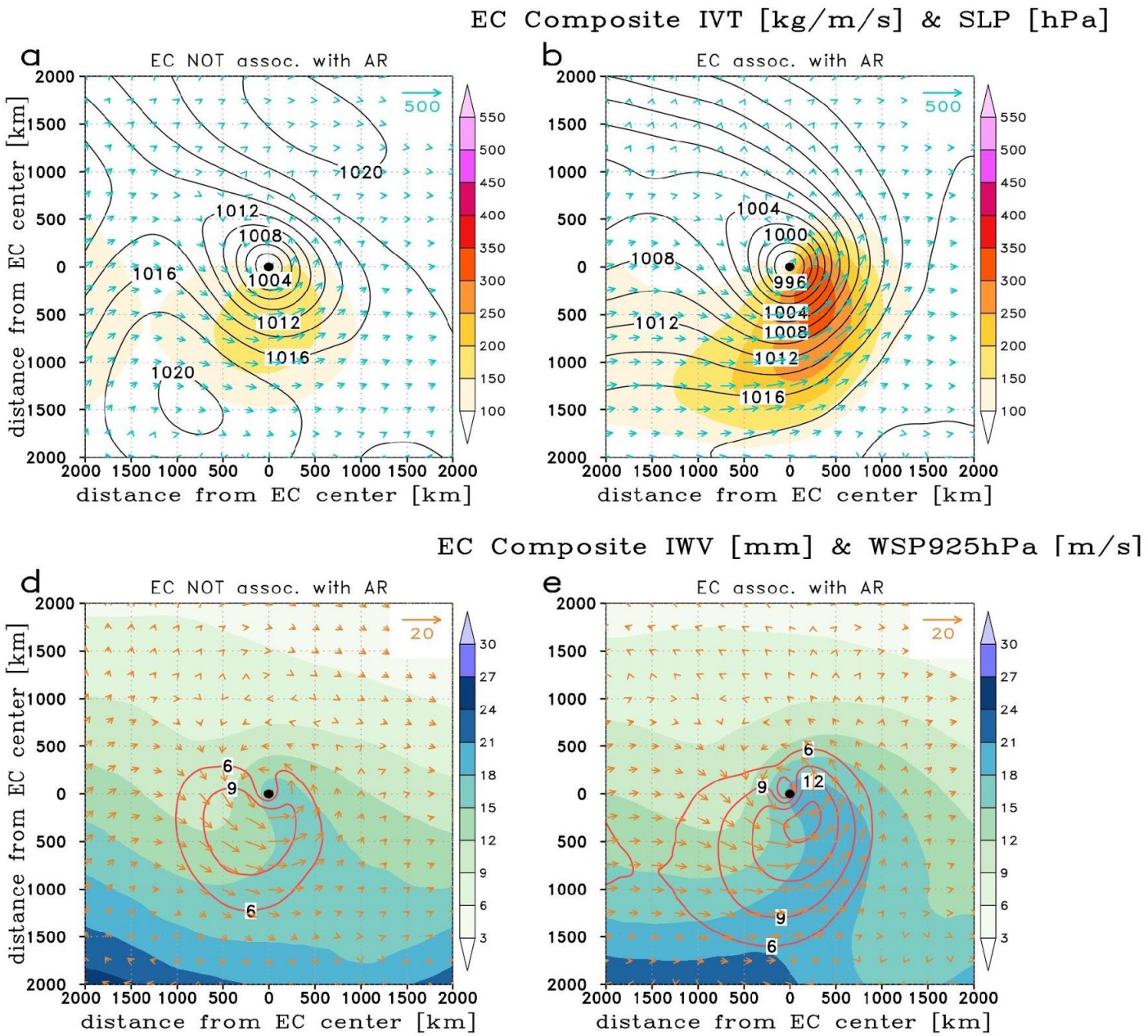




✓the EC strength and AR intensity are positively correlated

✓deeper ECs are more likely to be associated with an AR and an stronger AR

Results: *different ECs with respect to ARs*



IVT [kg/m/s]

ECs not assoc. with AR

- central SLP 1002hPa
- high SLP at southwest

ECs assoc. with AR

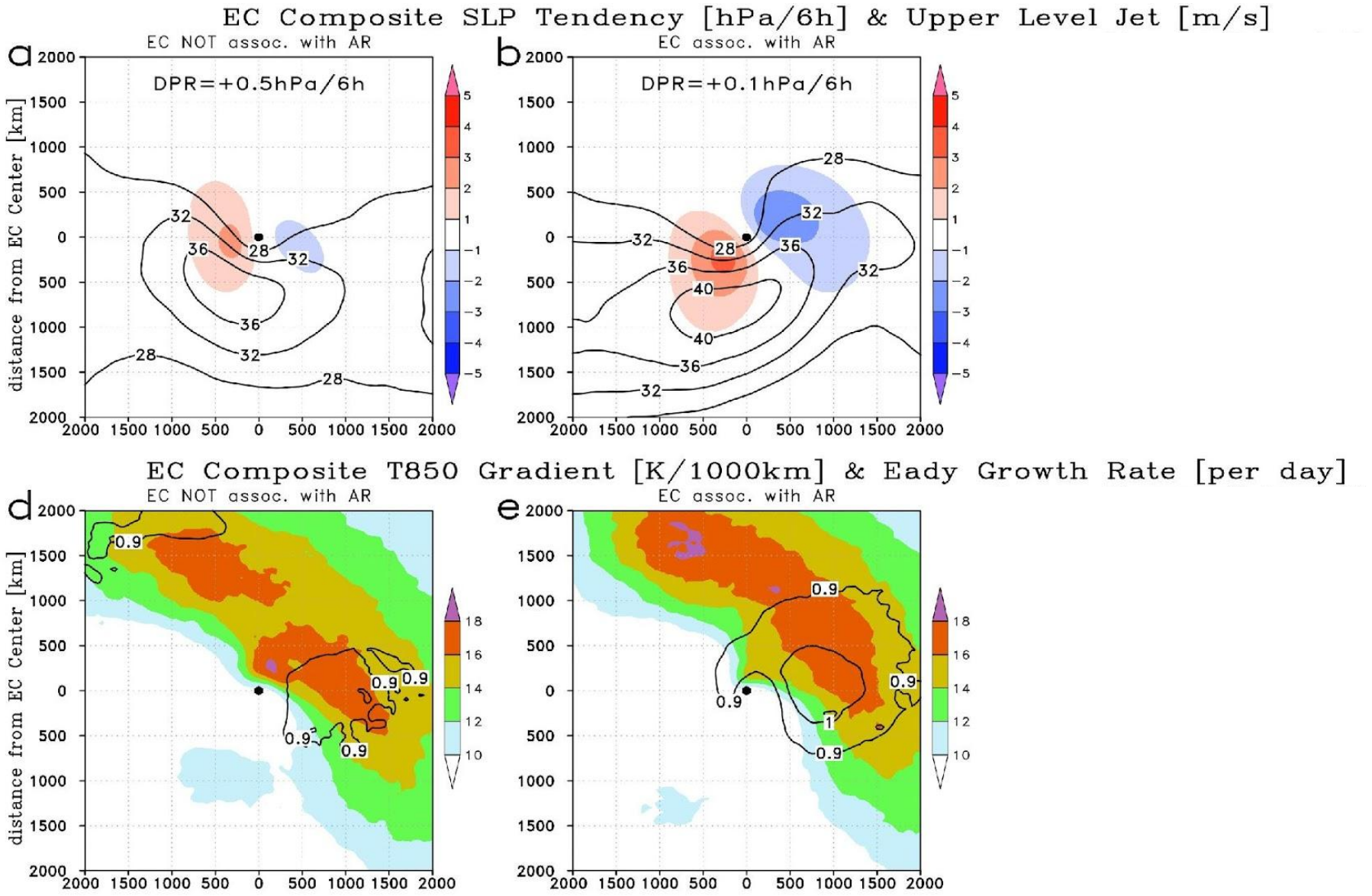
- central SLP 994hPa
- high SLP at southeast
- strong wind overlapped with high IWV

IWV [mm]

ECs assoc. with Except. AR

- central SLP 984hPa
- anticyclone at southeast close to EC center
- subtropical/tropical moisture source

Results: *different ECs – dynamic processes*



SLP Tendency [hPa/6h]

ECs not assoc. with AR

- central SLP +0.5 hPa/6h
- upper-level jet 36 m/s
- Eady MAX 0.9 day^{-1}

ECs assoc. with AR

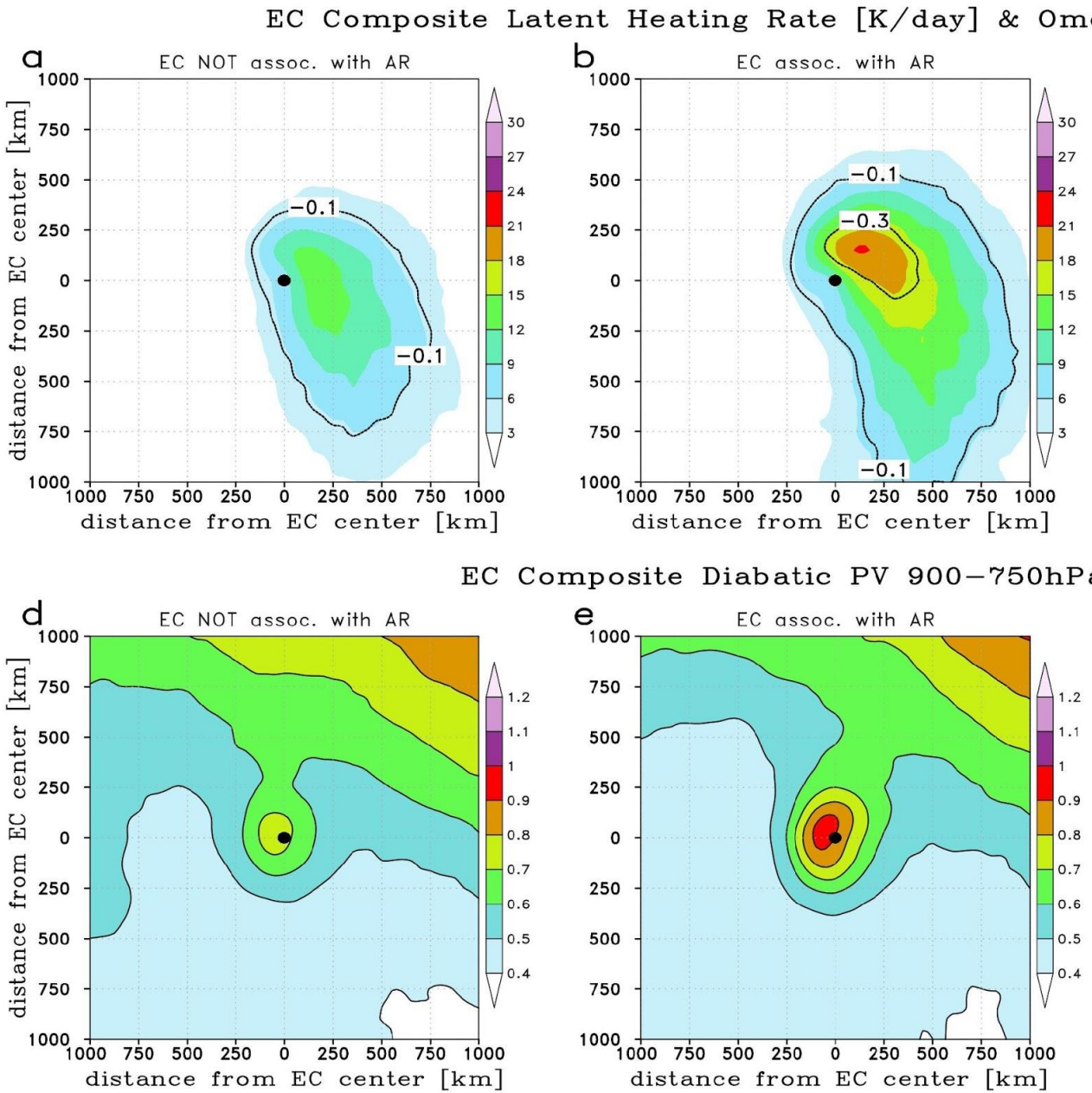
- central SLP +0.1 hPa/6h
- upper-level jet 40 m/s
- Eady MAX 1.0 day^{-1}

T850 Gradient [K/1000km]

ECs assoc. with Except. AR

- central SLP -1.1 hPa/6h
- upper-level jet 48 m/s
- Eady MAX 1.1 day^{-1}

Results: *different ECs – diabatic processes*



Latent Heating Rate [K/day]

ECs not assoc. with AR

- omega 0.1-0.2 Pa/s
- latent heating 13 K/day
- diabatic PV 0.7 PVU

ECs assoc. with AR

- omega 0.1-0.3 Pa/s
- latent heating 20 K/day
- diabatic PV 0.9 PVU

Diabatic PV 900−750hPa [PVU]

ECs assoc. with Except. AR

- omega 0.1-0.5 Pa/s
- latent heating 30 K/day
- diabatic PV 1.1 PVU

Conclusion

Extratropical Cyclone (EC) and Atmospheric River (AR) over the U.S. West Coast

- 82% of ARs are associated with an EC while only 45% ECs have a paired AR.
- Neither the location nor the intensity of an AR can be simply determined by an EC.
- ECs often intensifies AR with stronger wind-driven meridional water vapor transport, while the southeastern anticyclone is also important to the AR intensity.
- ARs can provide sufficient water vapor to enhance the precipitation (and thus latent heat release), contributing to the EC deepening.