2026 Ocean Salinity Science & Technology Meeting

PennState College of Earth and Mineral Sciences | Department of Meteorology and Atmospheric Science

Sea Surface Salinity Signatures Precedent the Pineapple Express and the Implications for Rainfall Prediction Beyond Weather Time

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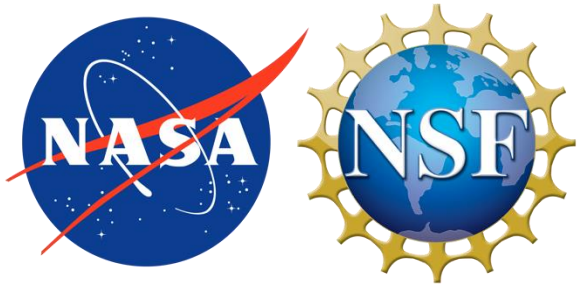
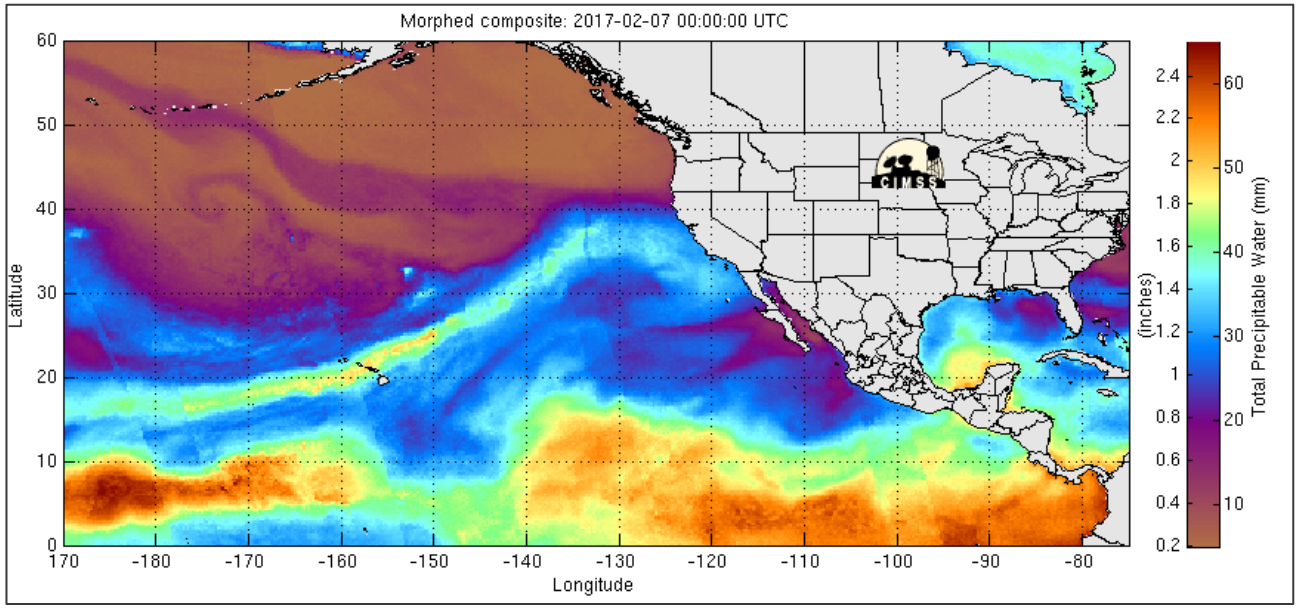
05-20-2026 | Seattle, WA



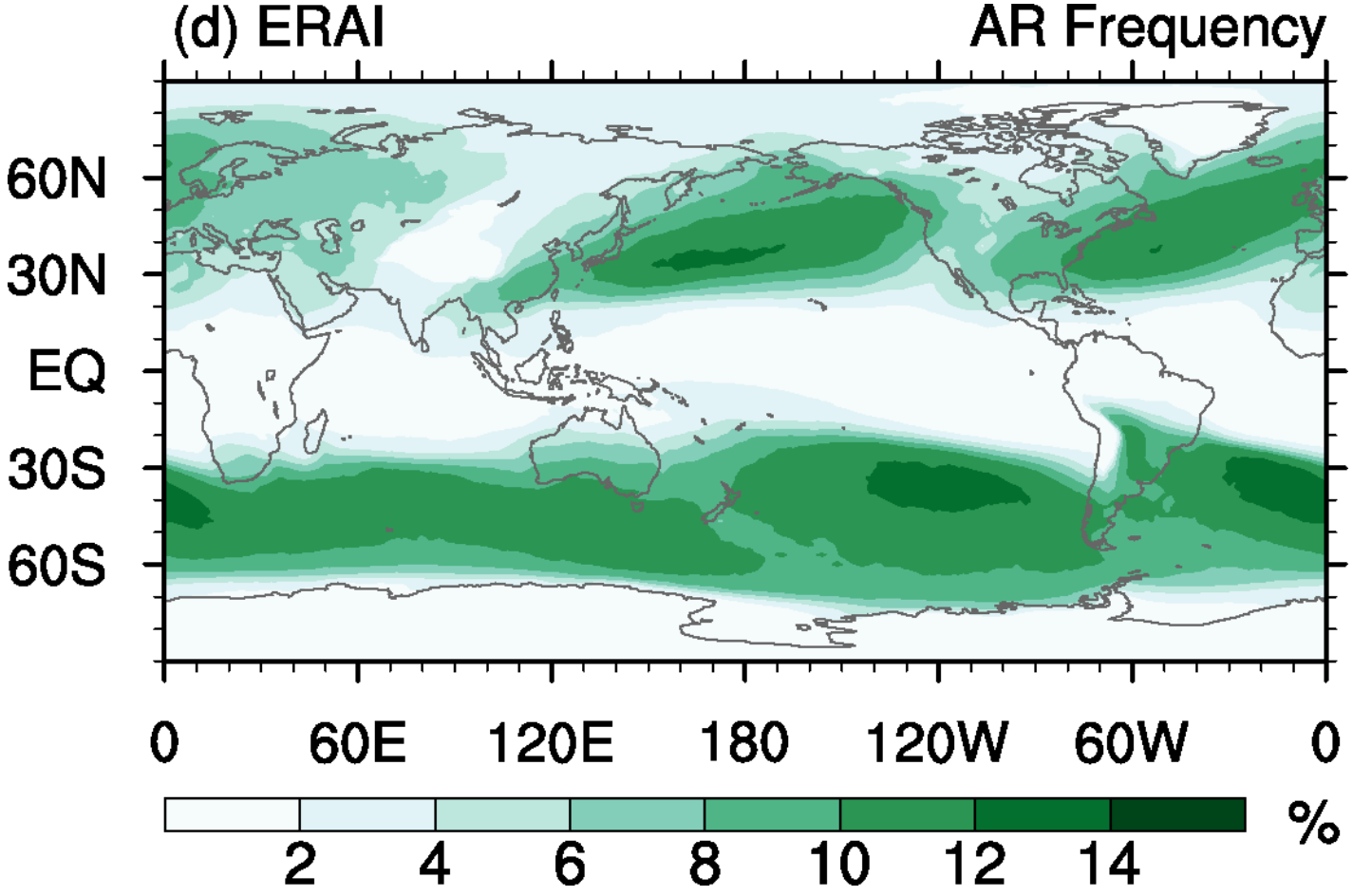
Background: atmospheric rivers

- Atmospheric Rivers (ARs) are long, narrow regions of high moisture transport (Chapman et al., 2019)
  - > 2,000 km long and < 1,000 km wide
- Responsible for 90% of poleward moisture transport while only covering 10% of the globe at any given time (Guan and Waliser, 2015)
- Produces large amounts of precipitation, leading to flooding and hazardous winds (Waliser and Guan, 2017)



Credit: Cooperative Institute for Meteorological Satellite Studies

Presence of ARs across the globe



Zhang et al. 2021

- ARs detected using Guan and Waliser (2015) algorithm
  - Most frequently occur over the mid-latitudes
  - Synoptic-scale phenomenon: occur within the warm sector in front of the leading cold front of an extratropical cyclone (Zhu and Newell, 1998; Newman et al., 2012; Dacre et al., 2015; Lavers and Villarini, 2014)

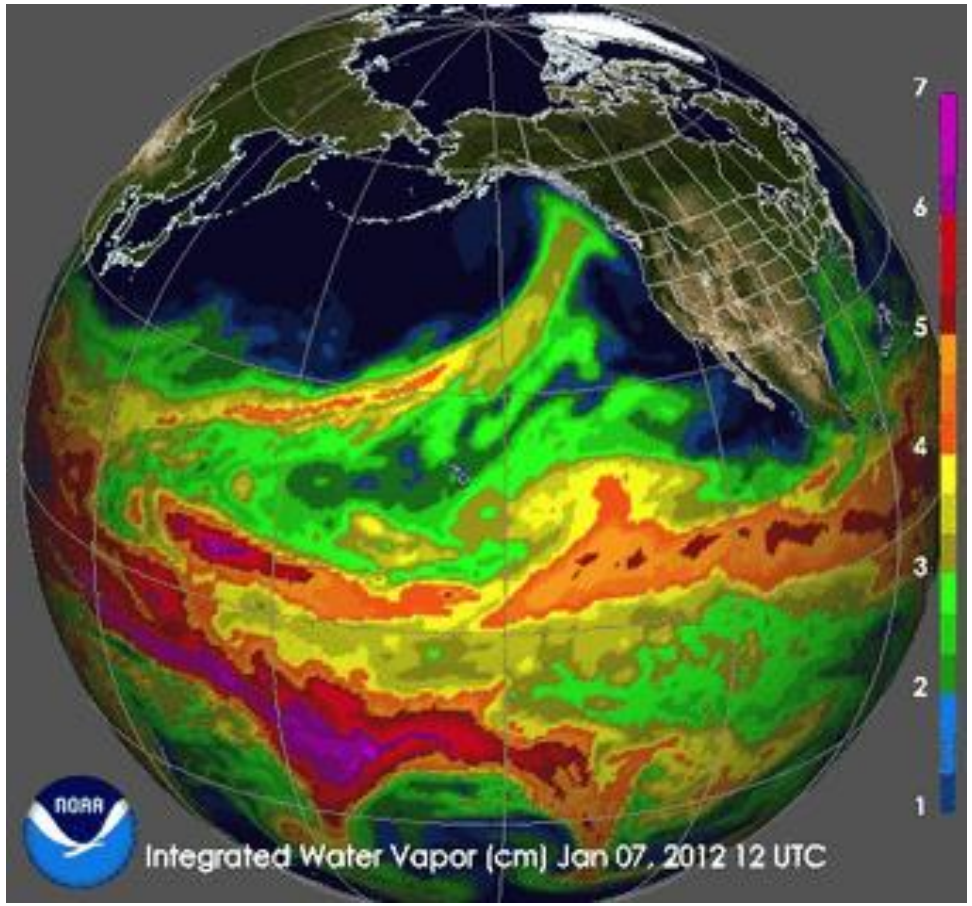
Research questions

- As a conveyor between oceanic evaporation and terrestrial precipitation, do the AR events collectively leave an imprint on sea surface salinity (SSS)?

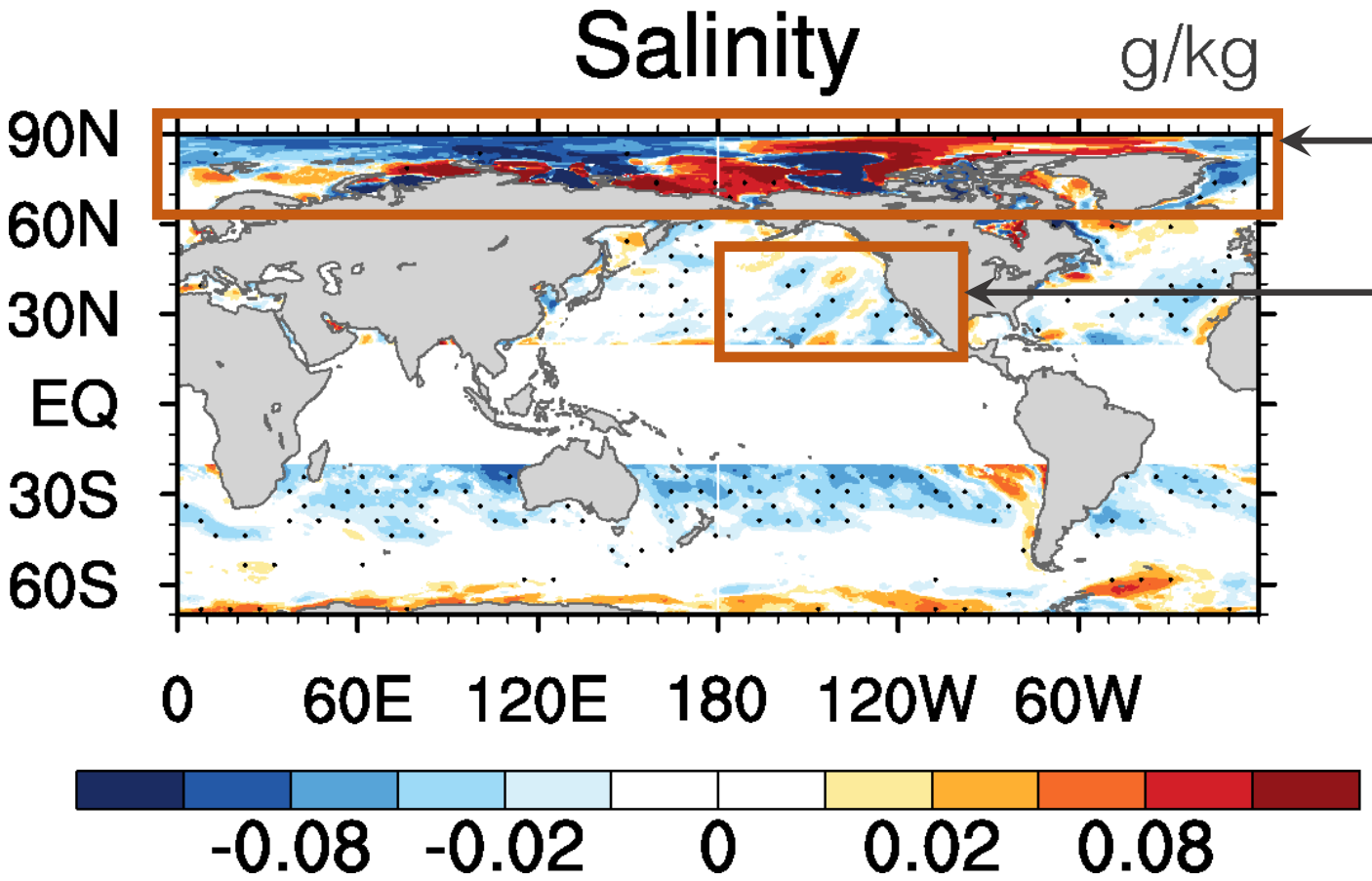
  Hypothesis 1: The ARs derives moisture from ocean evaporation, and given the dynamic features of extratropical cyclones, **above normal** SSS will be observed outside of ARs.

- Can the SSS signature be utilized as a predictor of AR beyond weather time scale (7 days)?

  Hypothesis 2: SSS is a natural low-pass filter of weather events, which could be utilized as a **predictor** of AR beyond 7 days.



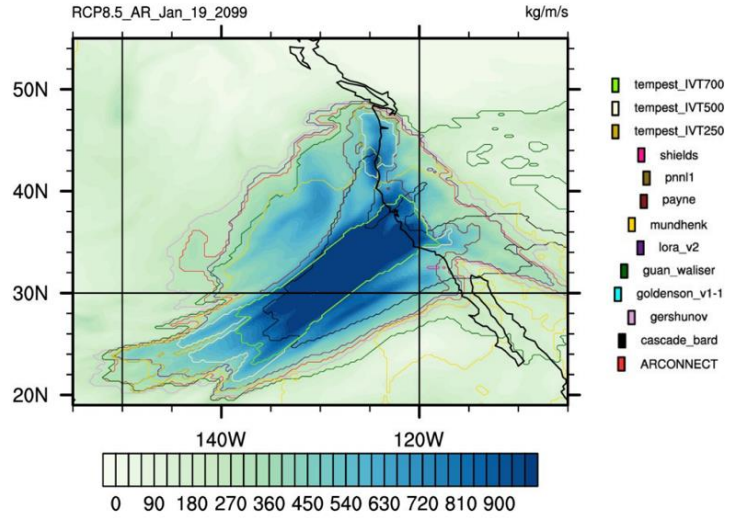
Imprint of ARs on sea surface salinity



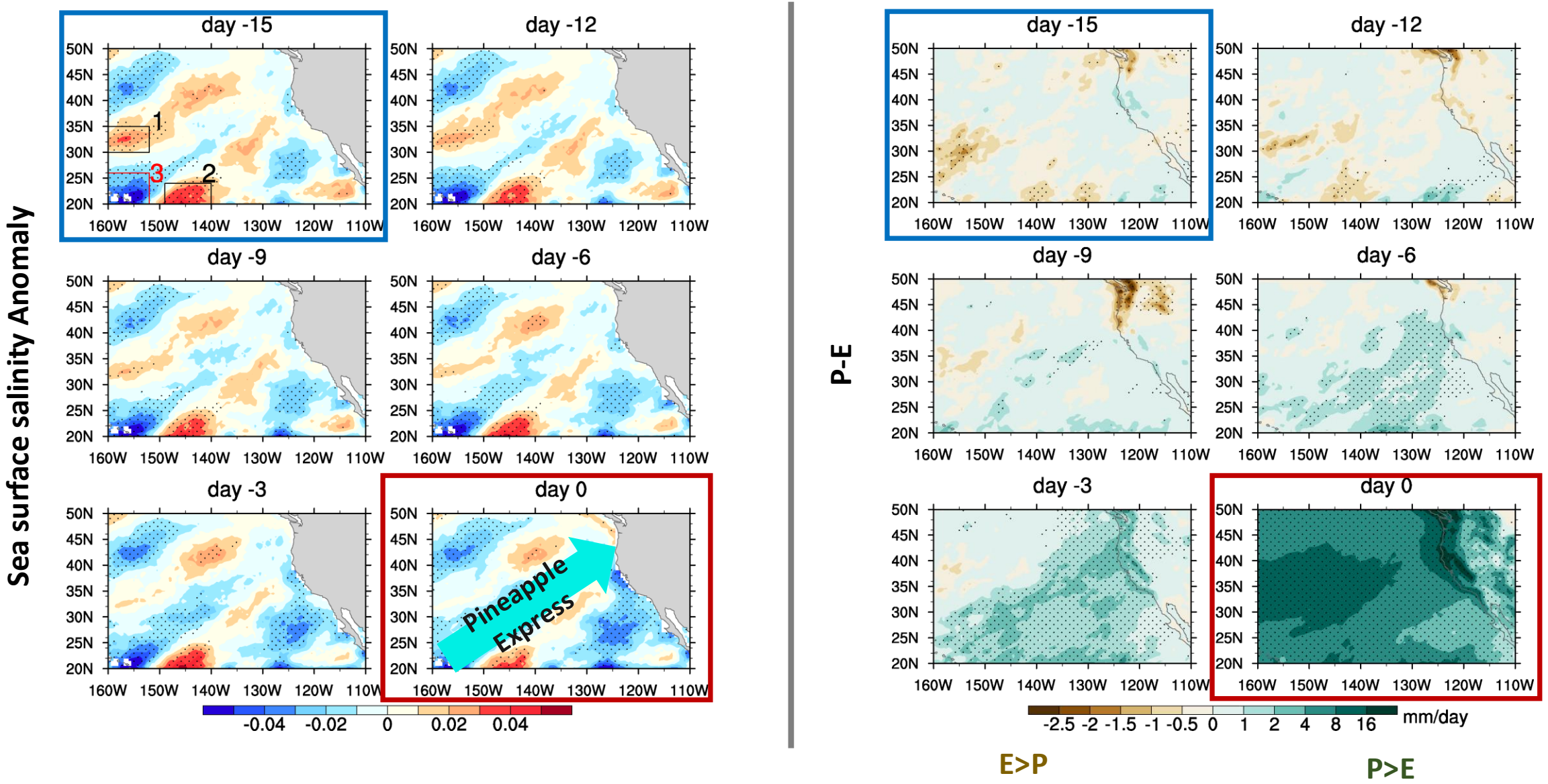
Arctic ARs:

Impacts sea ice extent (Zhang et al. 2023; 2025)

Pineapple Express



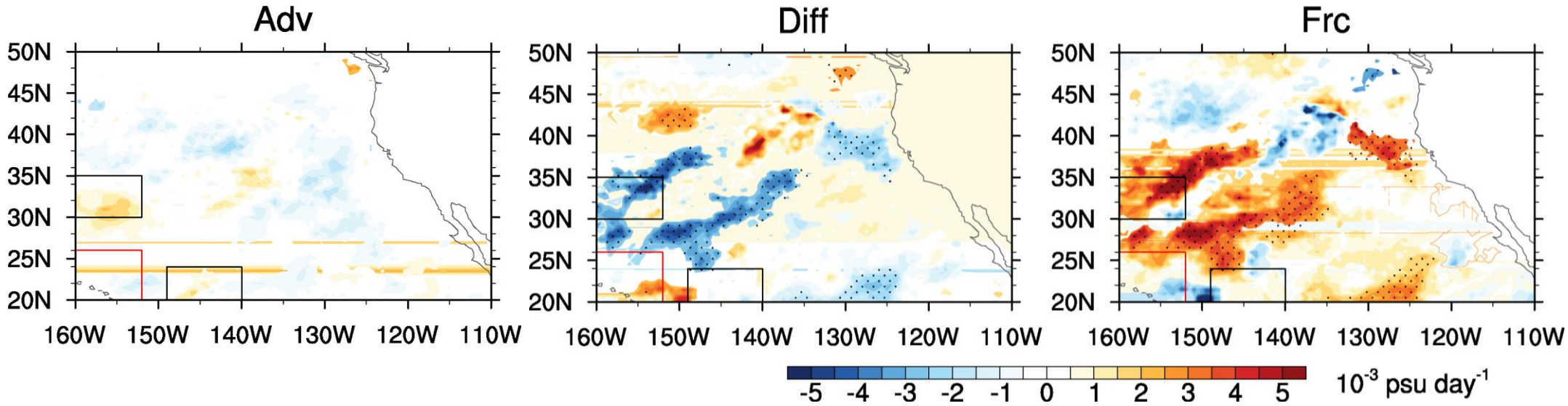
Precedent SSSA and moisture fluxes



Mixed layer salinity budget

$$\frac{\partial S}{\partial t} = -\nabla \cdot (\vec{u}S) - \nabla \cdot \vec{F}_{diff} + F_{forcing}$$

Right-hand-side terms 2 weeks prior to AR events



Implications to Western US heavy rain

Geophysical Research Letters

RESEARCH LETTER

10.1029/2018GL079293

Key Points:

- We search globally for teleconnections between autumn-lead sea surface salinity (SSS) and winter precipitation in southwestern United States (SWUS)
- SSS can skillfully explain variability in winter precipitation patterns in SWUS
- SSS-based models can outperform traditional SST-based climate indices in predictability of winter SWUS precipitation

Global Search for Autumn-Lead Sea Surface Salinity Predictors of Winter Precipitation in Southwestern United States

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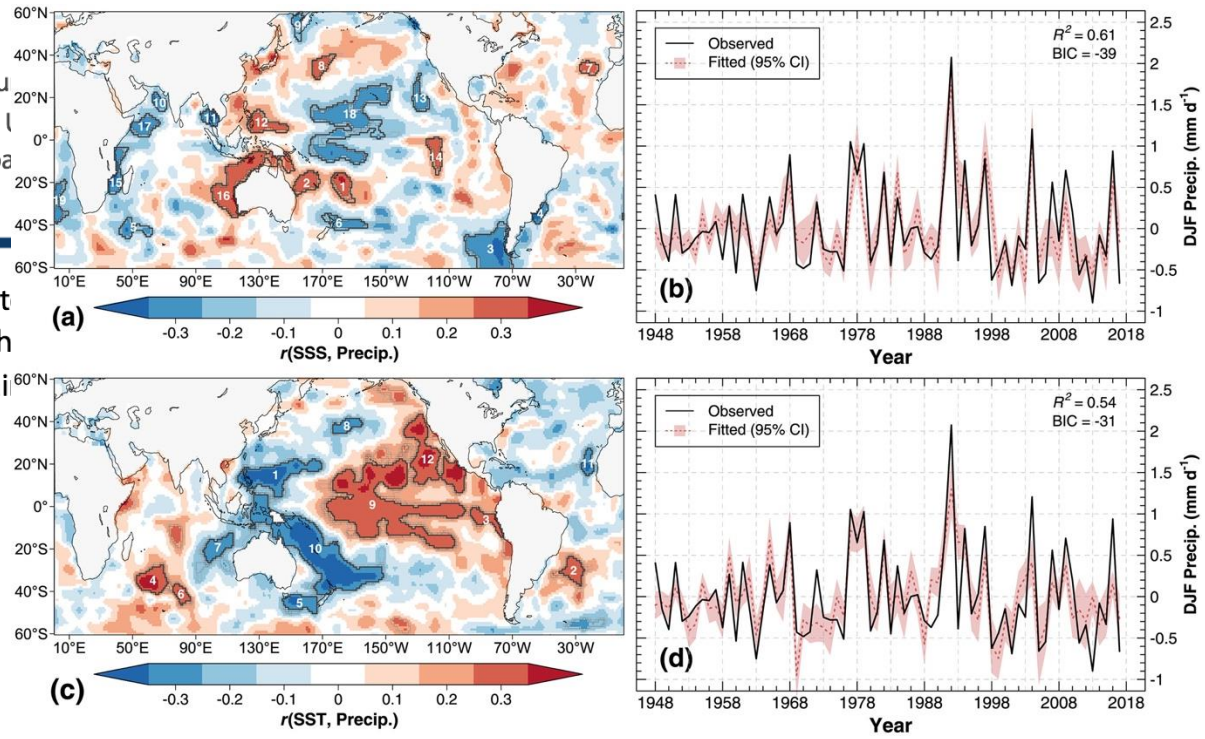
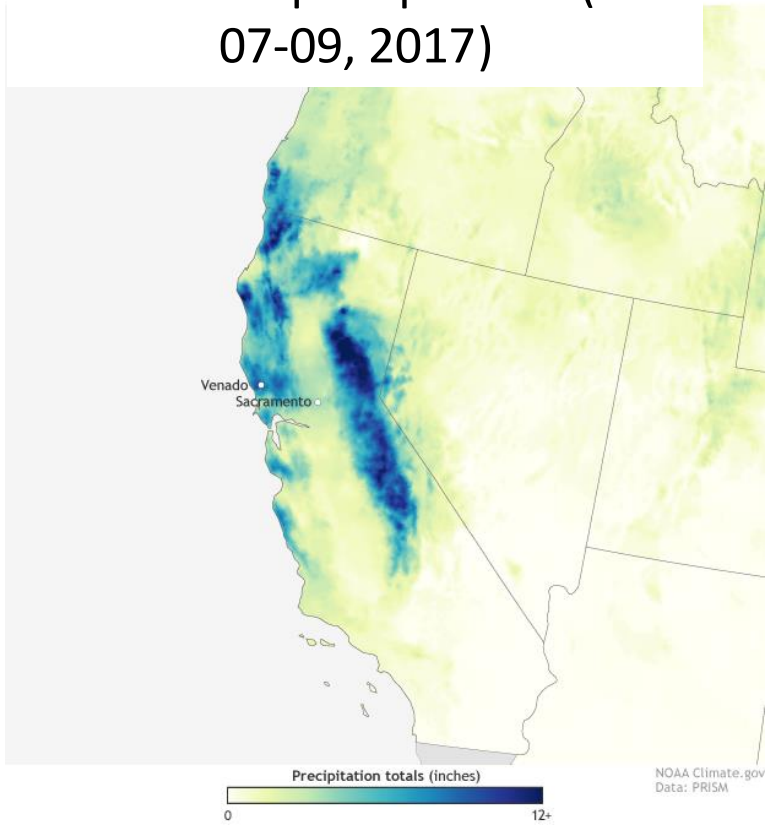
Abstract Sea surface salinity (SSS) is sensitive t
to changes in the oceanic water cycle. Through th
water cycle, SSS can be used as an indicator of rai

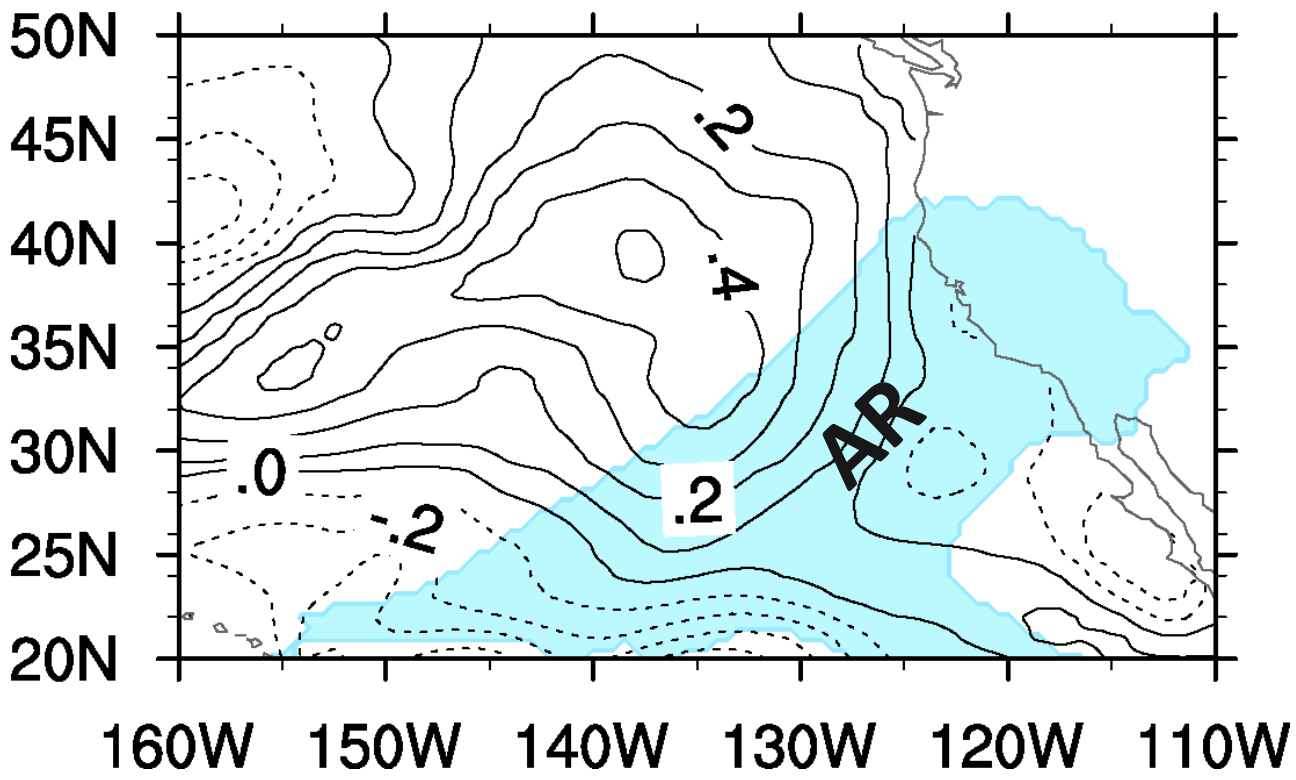


The 2016/2017 California flooding

Cumulative precipitation (Jan. 07-09, 2017)



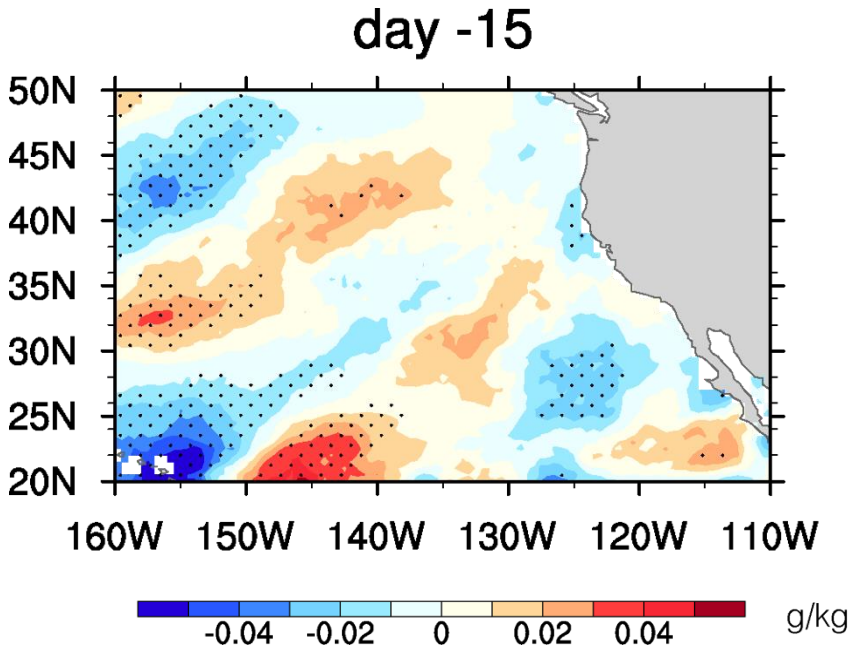
SSSA (2 weeks lead)



Conclusions

- As a conveyor between oceanic evaporation and terrestrial precipitation, do the AR events collectively leave an imprint on sea surface salinity (SSS)?

  - The passage of ARs leaves an imprint on SSS:
    Arctic ocean: Sea ice (?)
    Pineapple Express: increased E-P and above normal SSS on both sides of the ARs 2 weeks prior.



- Can the SSS signature be utilized as a predictor of AR beyond weather time? (ongoing research)

  - Case study of 2016/2017 California flooding suggest the identified SSSA could be a valuable predictor of Pineapple Express and the AR-induced extreme precipitation.

Thank you!

Liu, T., R. W. Schmitt, L. Li (2018): Global search for autumn-lead sea surface salinity predictors of winter precipitation in southwestern United States. *Geophys. Res. Letts.*, ***45***, 8445-8454.

Li, L., R. W. Schmitt, C. C. Ummenhofer (2022): Skillful long-lead prediction of summertime heavy rainfall in the US Midwest from sea surface salinity. *Geophys. Res. Letts*., **49**, e2022GL098554.

Zhang, P., R. W. Schmitt, and L. Li (2026): Imprints of Atmospheric River on sea surface salinity: implications for S2S prediction of heavy precipitation over the US Western Coast. *Submitted to Gephys. Res. Letts.*

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