

# Impacts of the Atlantic Multidecadal Variability on tropical climate and tropical cyclone activity

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and

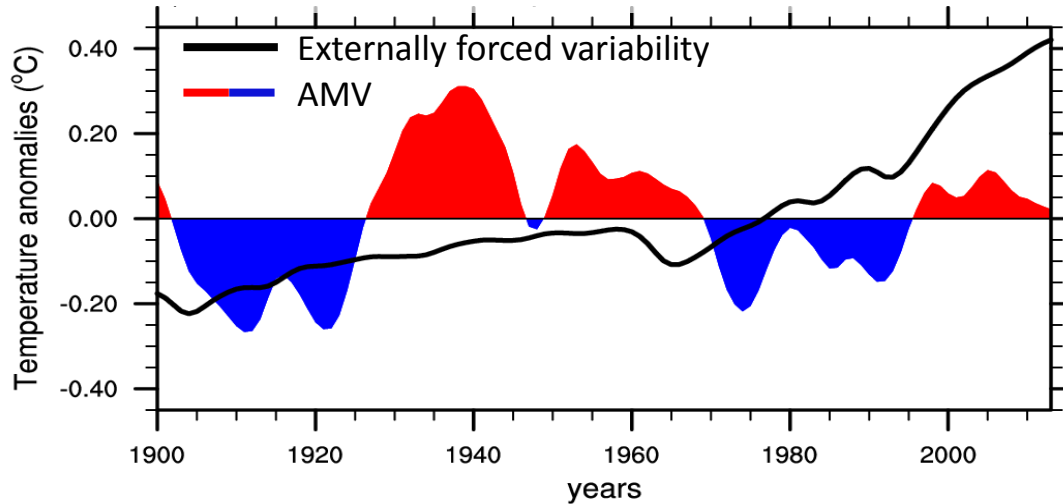
Fred Castruccio, Steve Yeager, Gokhan Danabasoglu

LEFE IMAGO AMOC conference, May 4<sup>th</sup> 2017

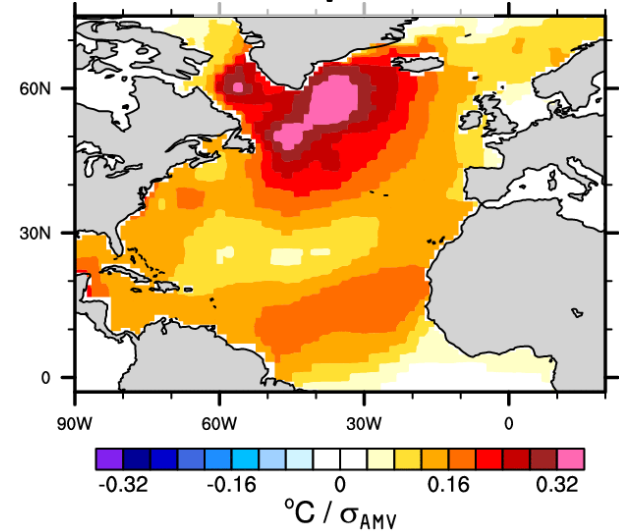


# AMV impacts on climate

**AMV time series** (Ting et al. 2009)



**AMV pattern**

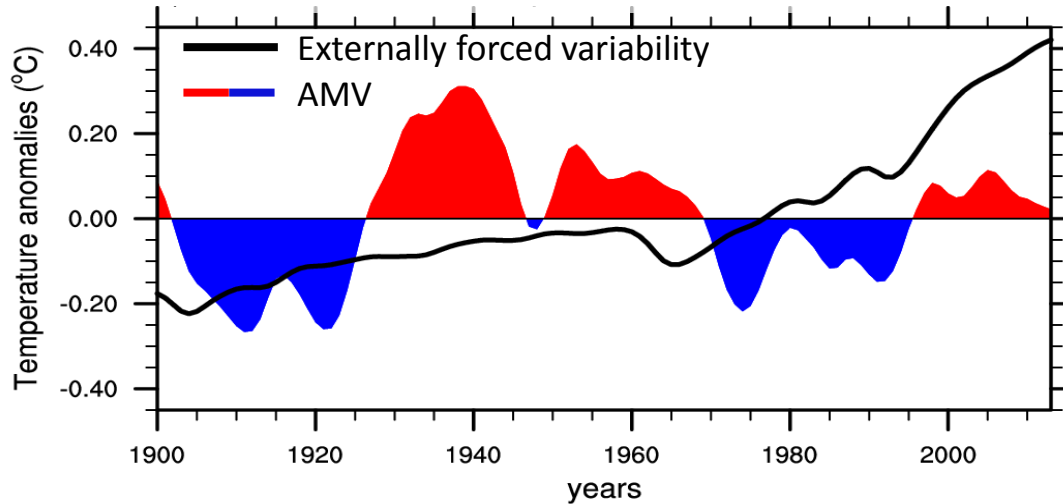


## Atlantic Multidecadal Variability (AMV)

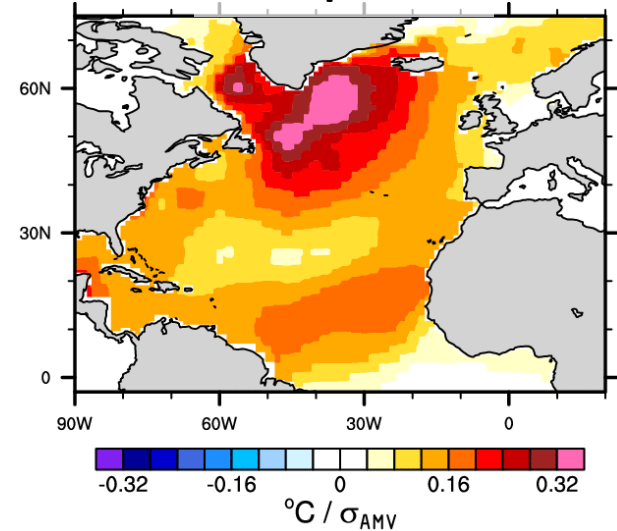
- Droughts over North and South America
- European summer temperature
- Sahel drought
- Arctic sea-ice
- Occurrence of weather extremes
- Tropical cyclone activity
- Hiatus

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## Atlantic Multidecadal Variability (AMV)

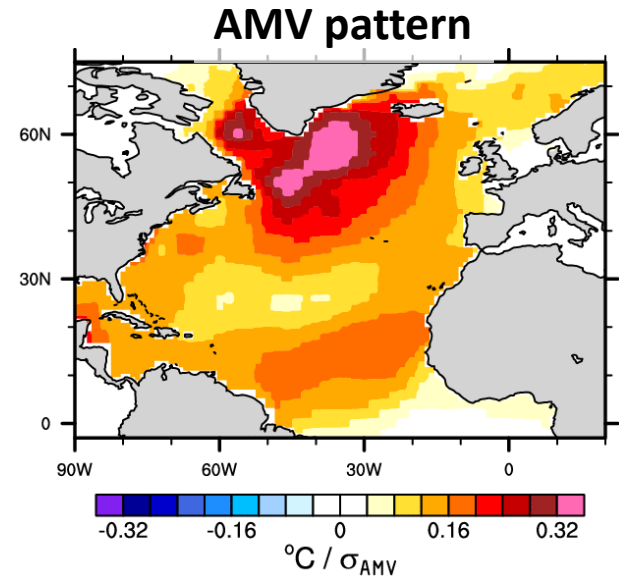
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- **Tropical cyclone activity**
- **Hiatus**

# Experimental design

North Atlantic SSTs (5°N-70°N) restored to the **observed AMV pattern** with a 5/15-day restoring time scale

**10yr long large ensemble** experiments

**Free ocean-ice-land-atmosphere interactions** outside the Atlantic



**AMV+** ensemble: daily North Atlantic SST  daily Climatology + **AMV pattern**

**AMV-** ensemble: daily North Atlantic SST  daily Climatology - **AMV pattern**

4 climate models

GFDL-CM2.1 = 1° ocean / **200km** atmo → 100 members

NCAR-CESM1 = 1° ocean / **100km** atmo → 30 members

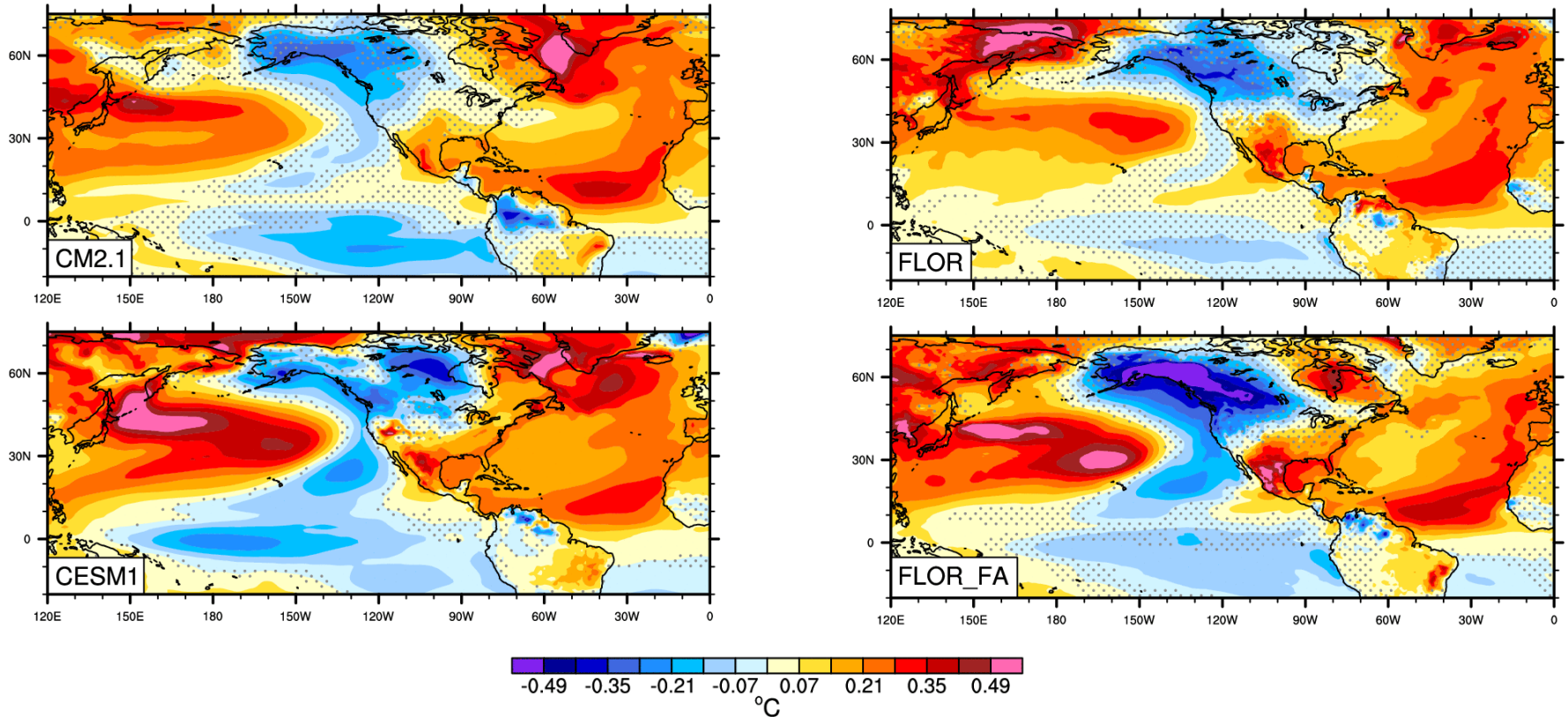
GFDL-FLOR = 1° ocean / **50km** atmo → 50 members

GFDL-FLOR\_FA = GFDL-FLOR + surface flux adjustment to reduce mean SST bias

**Protocol adopted for DCPD component C of CMIP6** (Boer et al. GMD 2016)

# AMV impacts on Pacific

DJFM - T2m

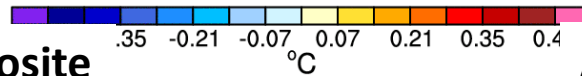
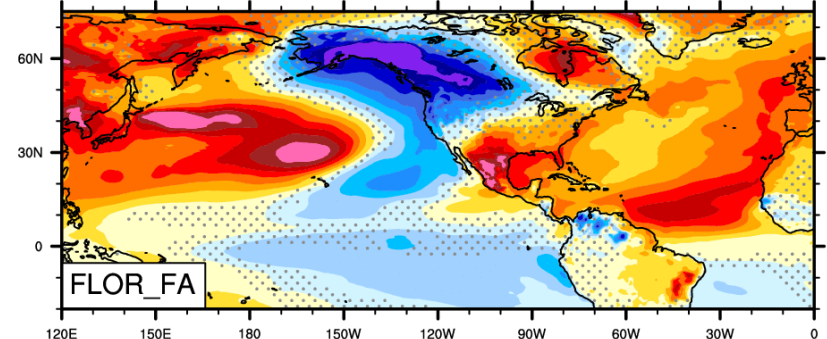
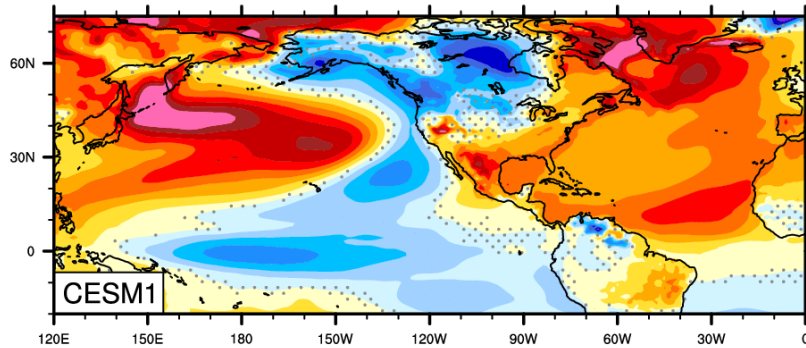
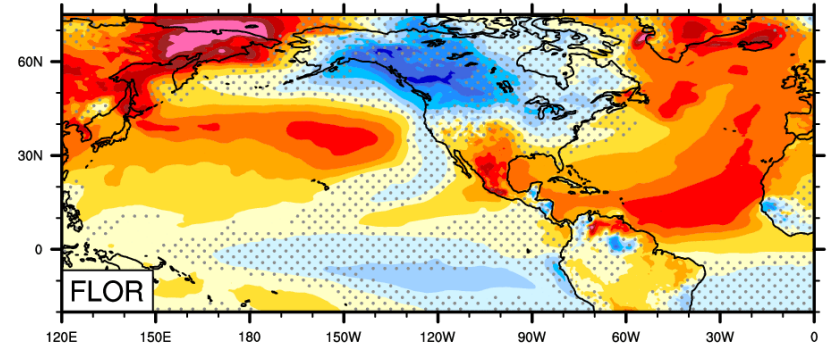
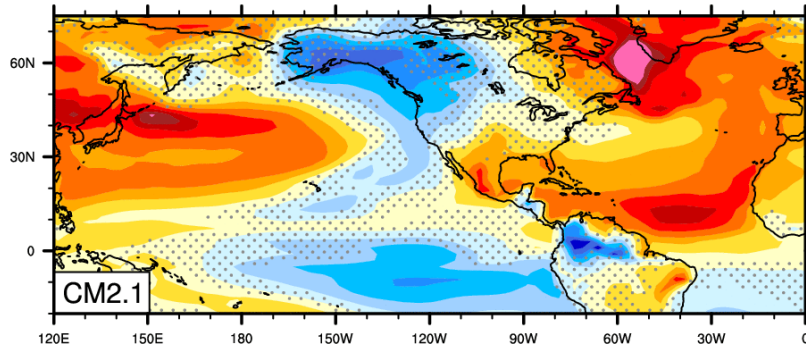


Response  
AMV+ minus AMV-

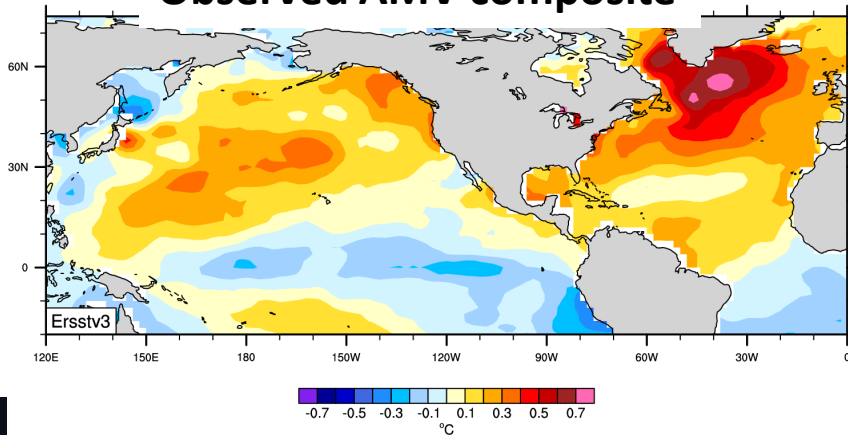
AMV+ leads negative phase of  
Pacific Decadal Oscillation

# AMV impacts on Pacific

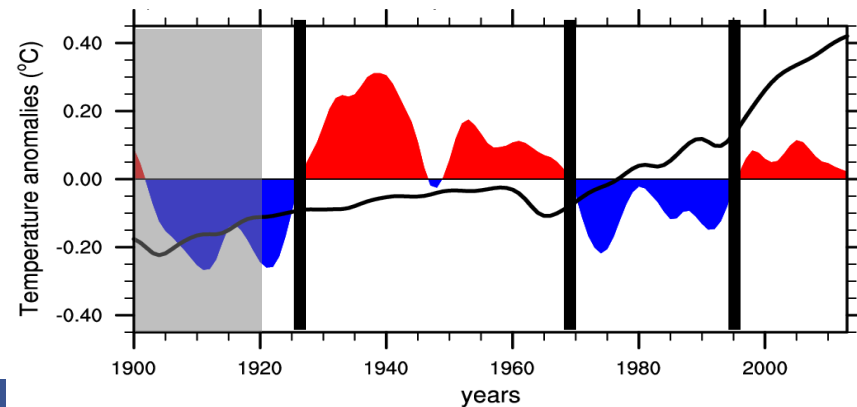
DJFM - T2m



Observed AMV composite



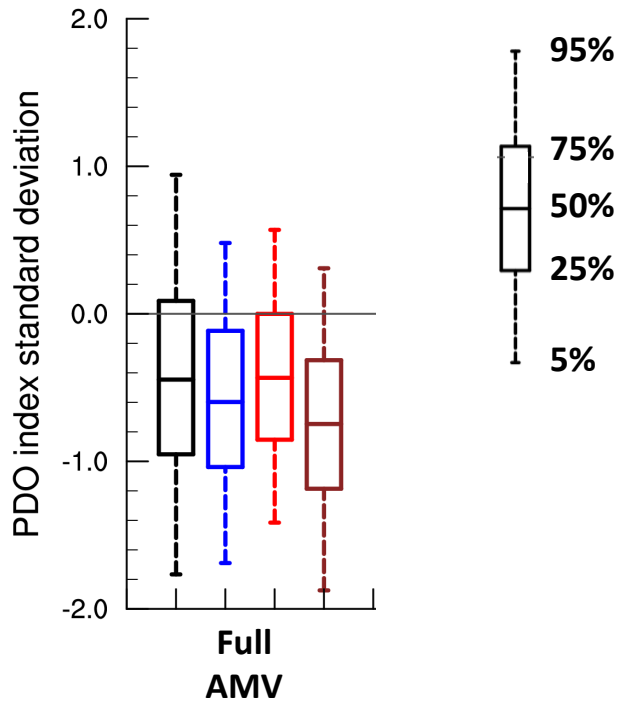
AMV time series (Ting et al. 2009)





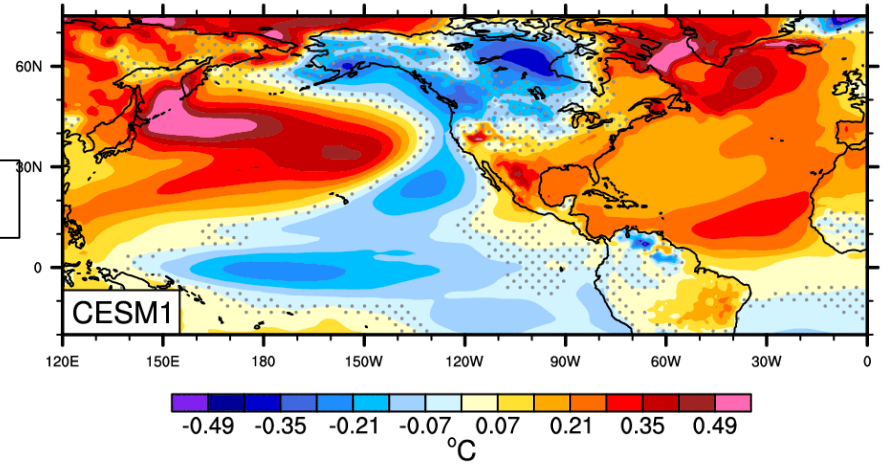
# Origins of AMV impacts on Pacific

PDO response



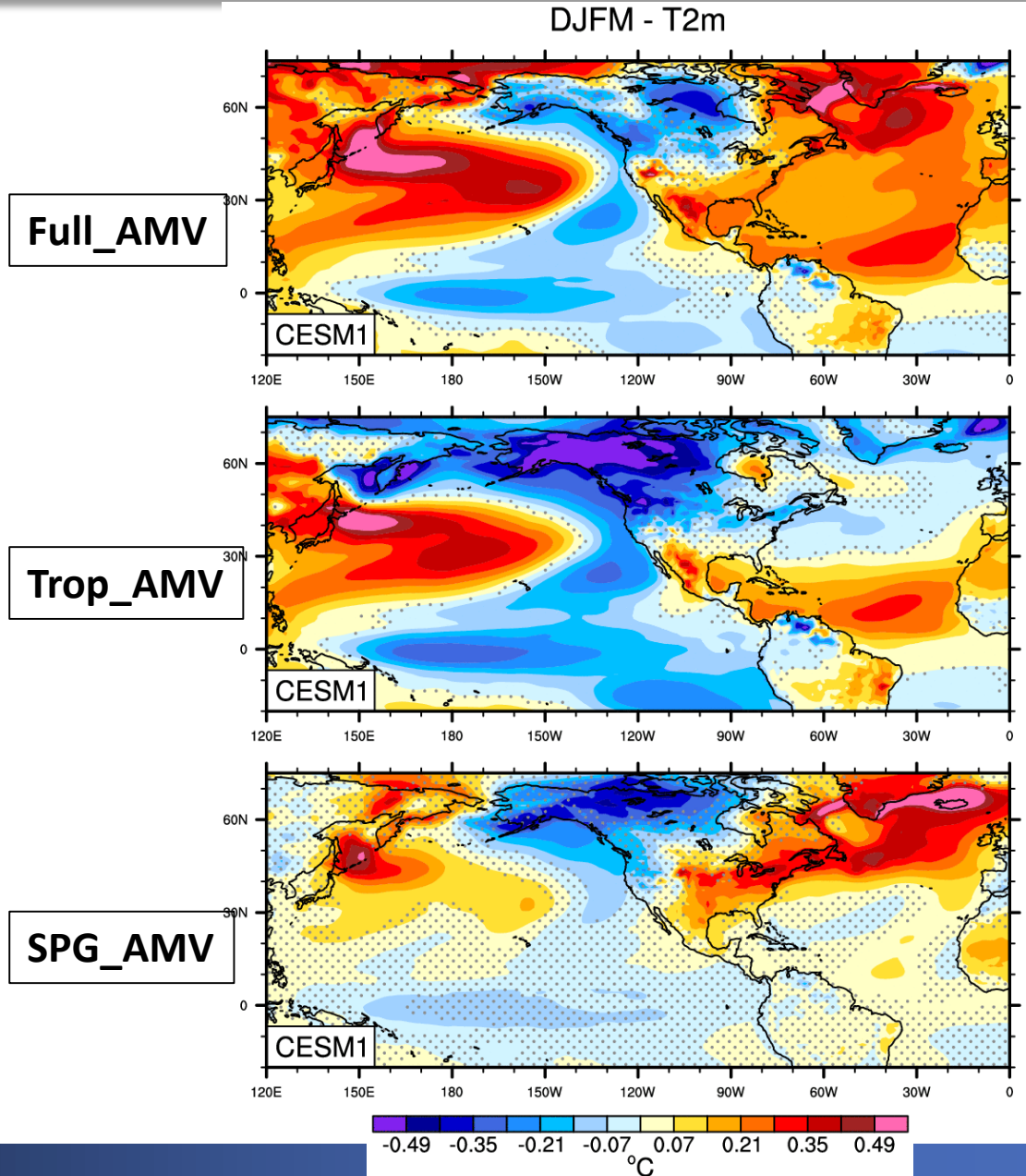
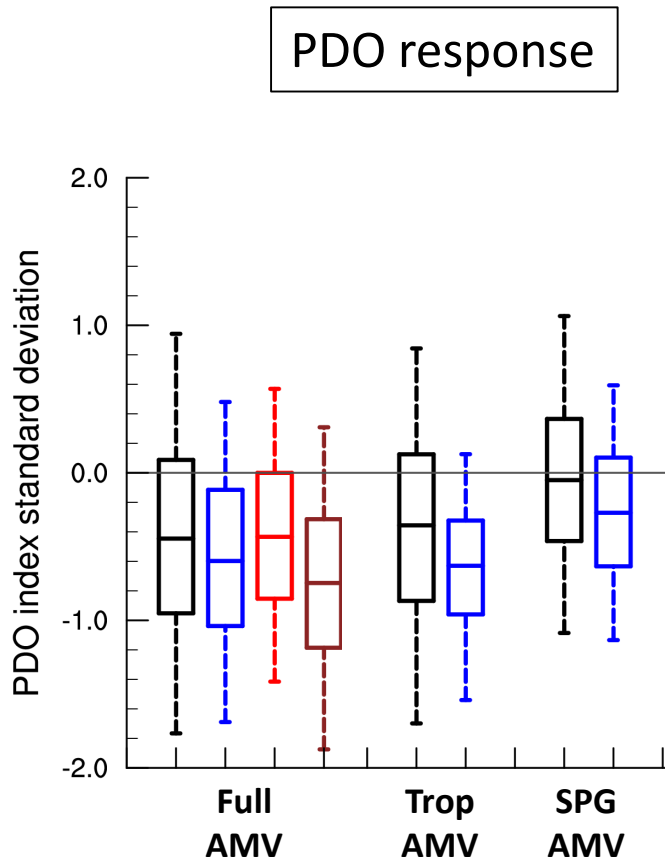
Full\_AMV

DJFM - T2m



CM2.1  
CESM1  
FLOR  
FLOR\_FA

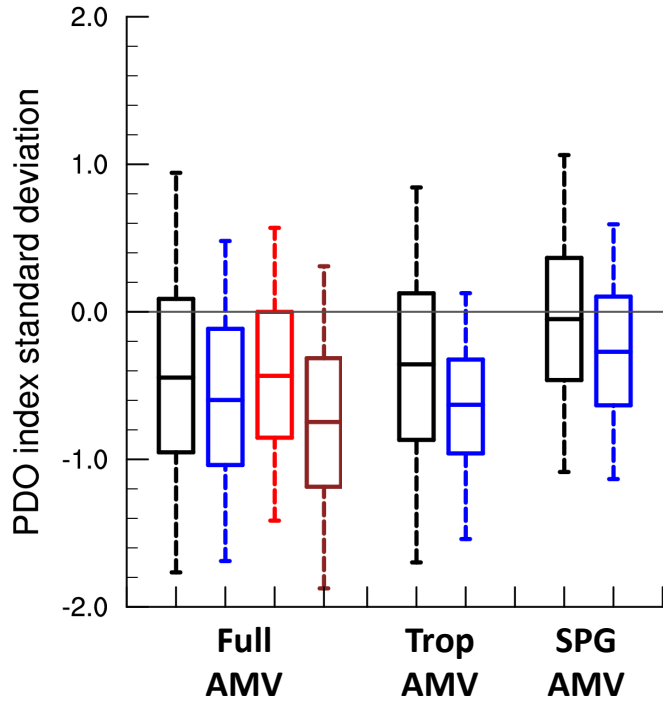
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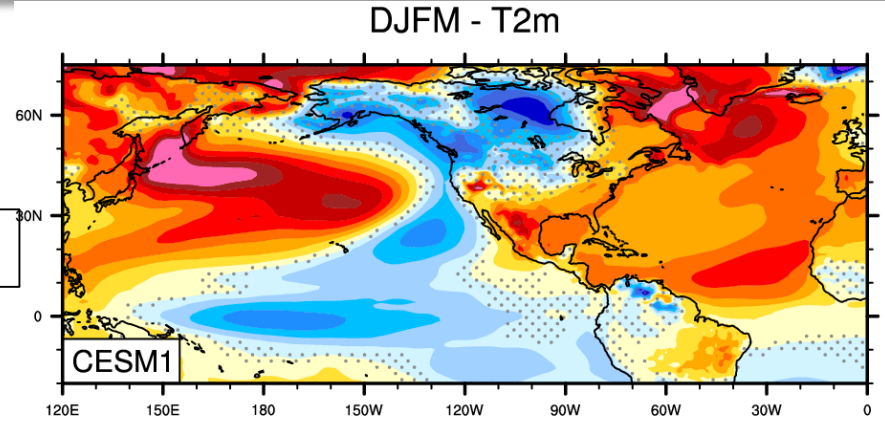
PDO response



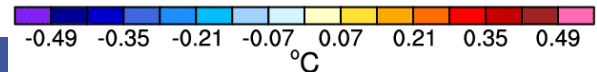
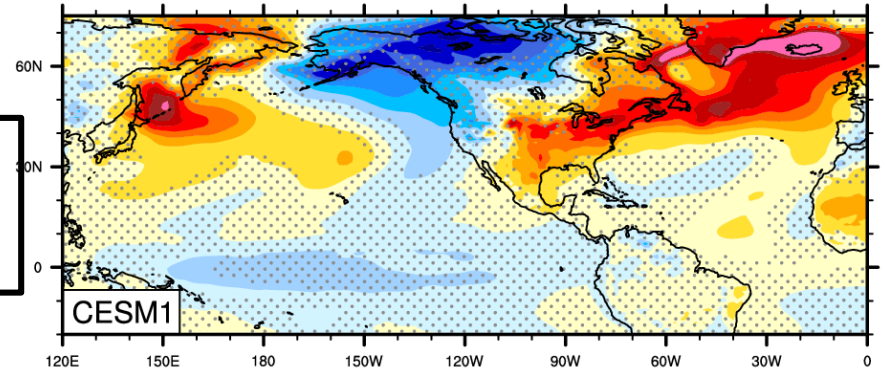
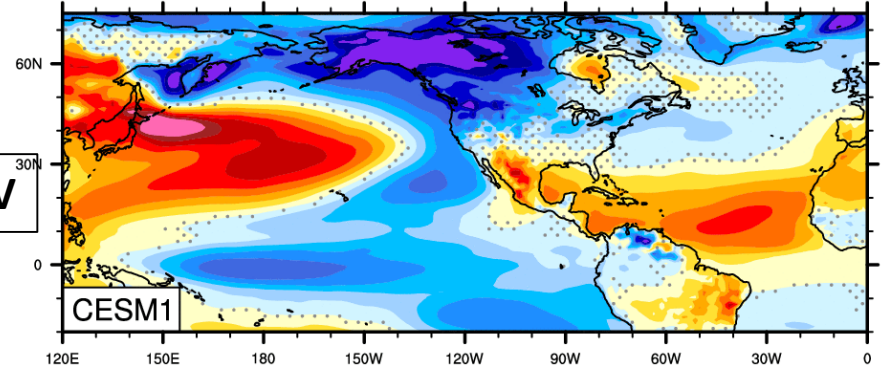
CM2.1  
 CESM1  
 FLOR  
 FLOR\_FA

**Tropical part of AMV  
 forces Pacific response**

Full\_AMV

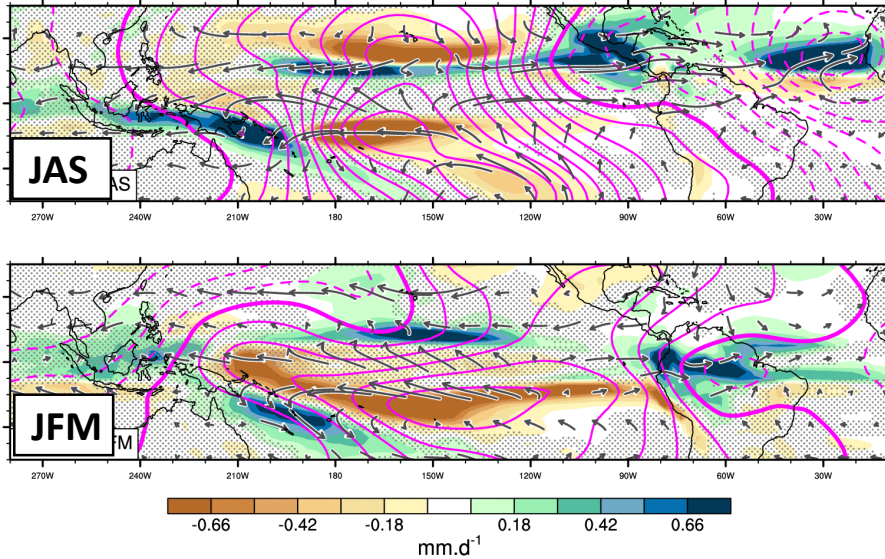


Trop\_AMV



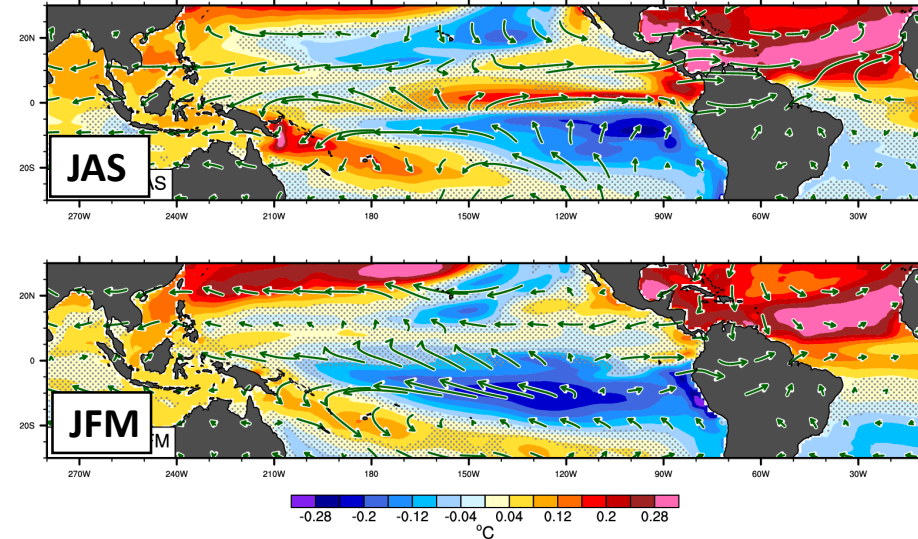
# AMV impacts on Pacific: mechanism

## CM2.1 – Full\_AMV



Colors: precipitation  
Contours: velocity potential@200hPa (wind divergence)  
Arrows: wind@850hPa

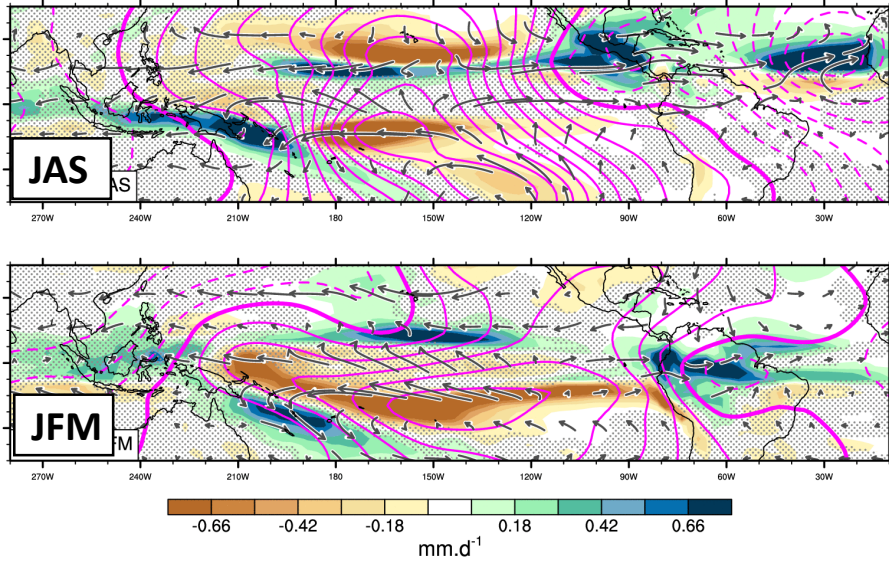
## CM2.1 – Full\_AMV



Colors: SST  
Arrows: wind@850hPa

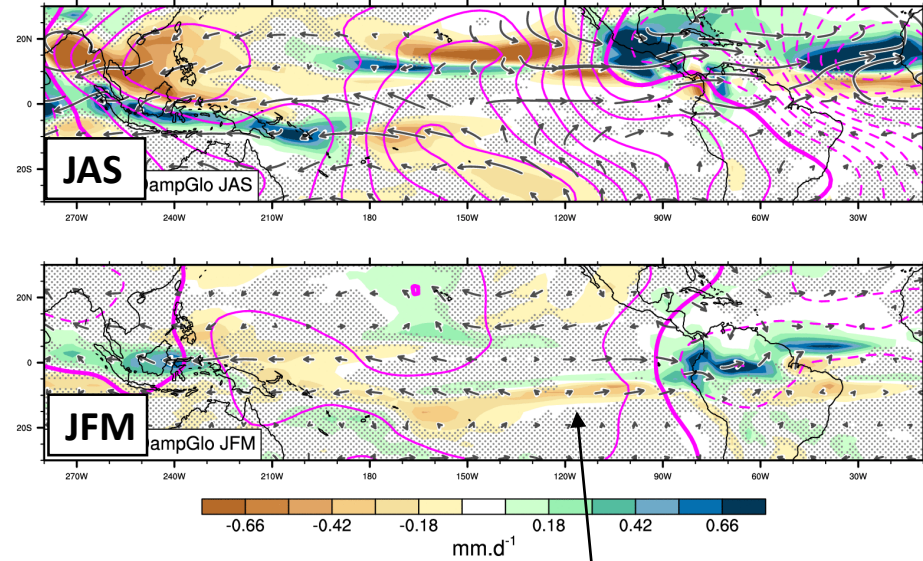
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## CM2.1 – Damped\_Global\_AMV



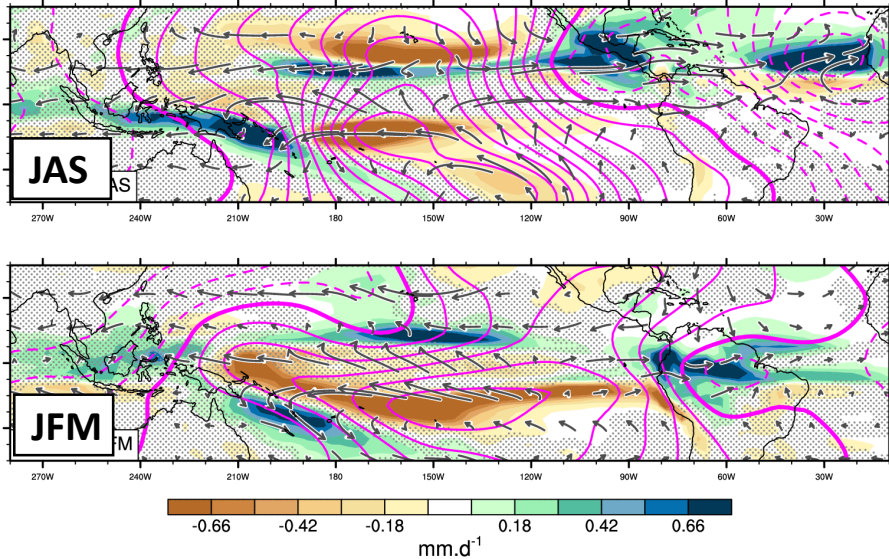
Colors: precipitation  
Contours: velocity potential@200hPa  
Arrows: wind@850hPa

**SST restored to its climatology**



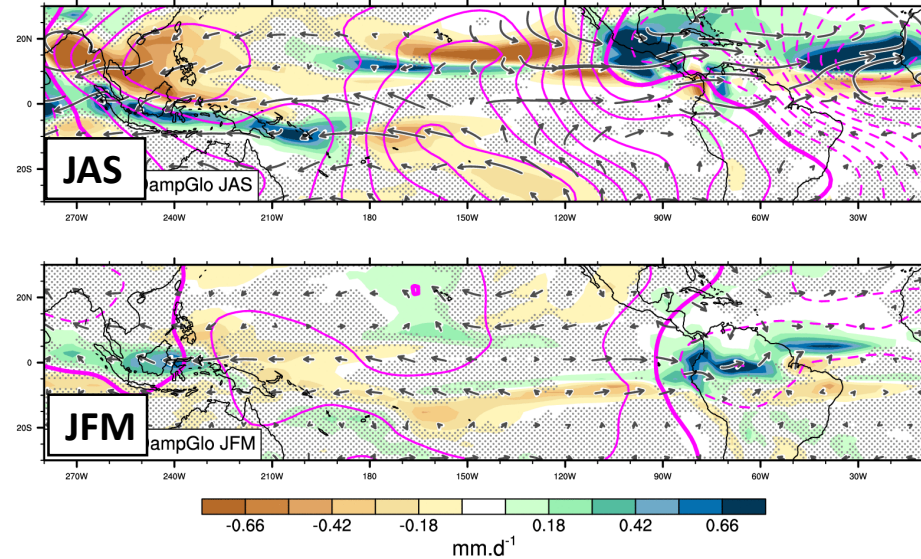
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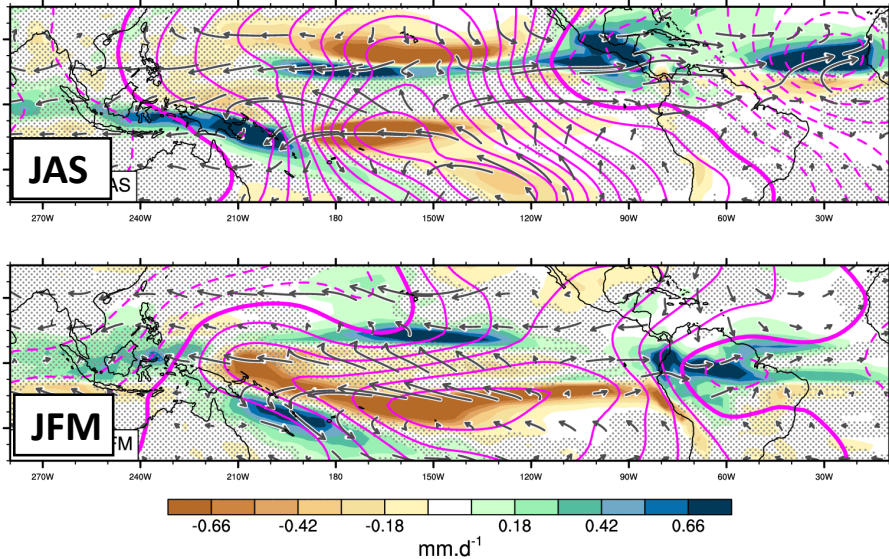


Colors: precipitation  
Contours: velocity potential@200hPa  
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**Winter Tropical Pacific response = lagged adjustment to summer AMV forcing**

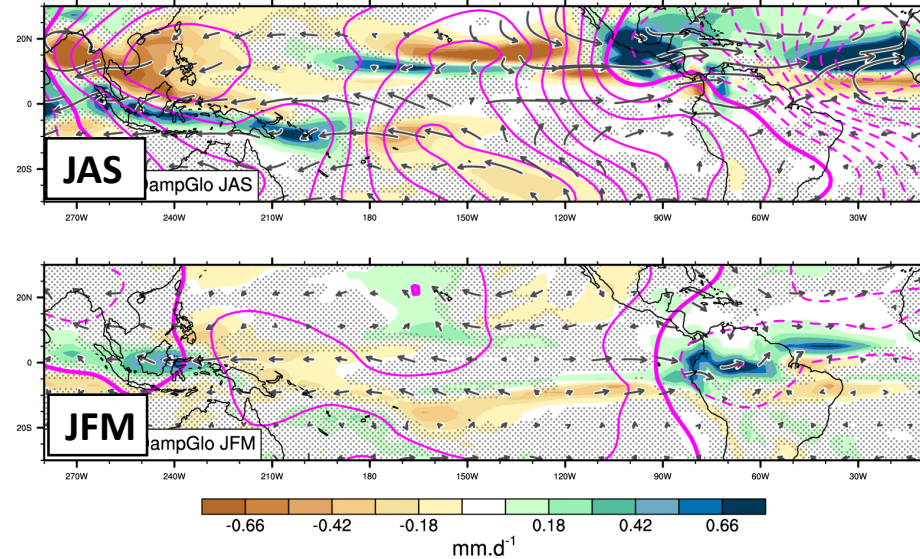
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**Winter Tropical Pacific response = lagged adjustment to summer AMV forcing**

Cf. Li et al. 2015: Atlantic-induced pan-tropical climate change over the past three decades + McGregor et al. 2014, Kucharski et al. 2012, 2015

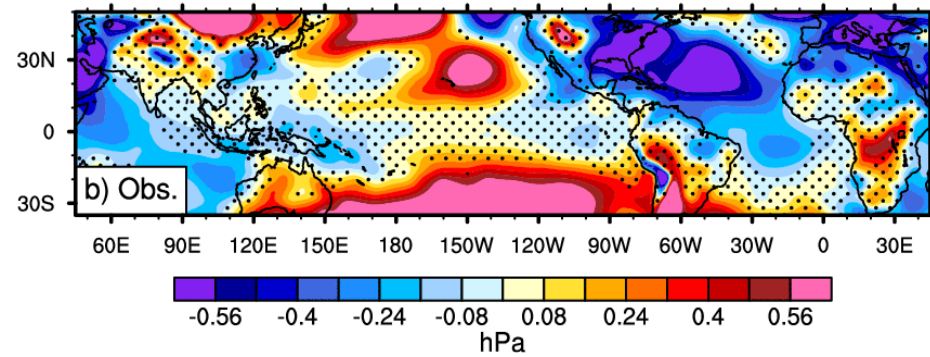
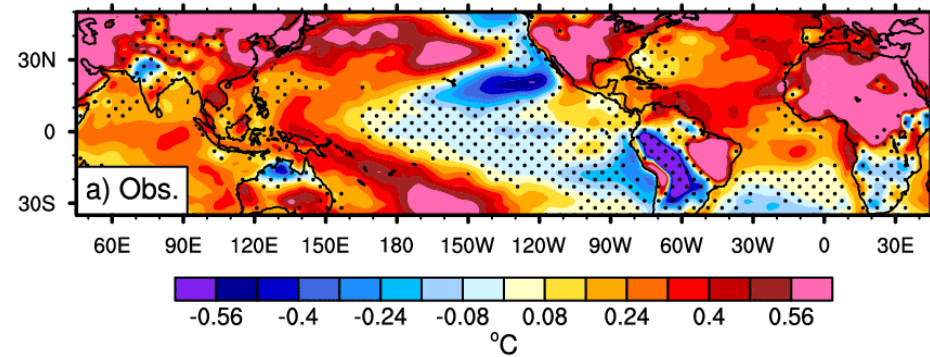
# **AMV impacts on Tropical Cyclones**



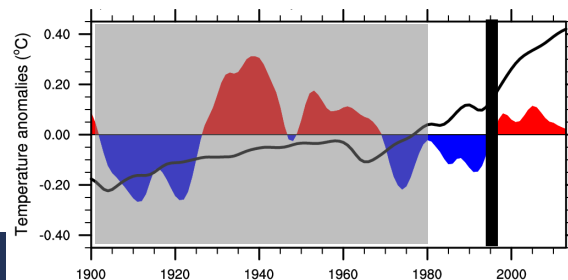
# AMV impacts on Tropical Cyclones

MJJASON tas

MJJASON slp



**Obs = ( ERAI + NCEP + JRA + MERRA ) / 4.**  
Stippling = 4 datasets **do not** show same sign

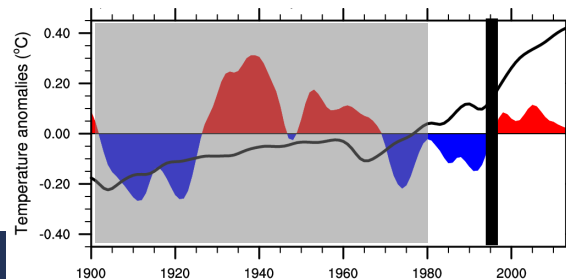
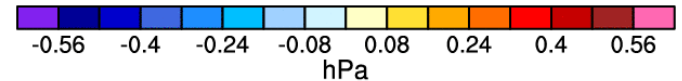
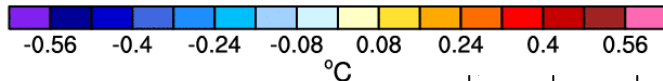
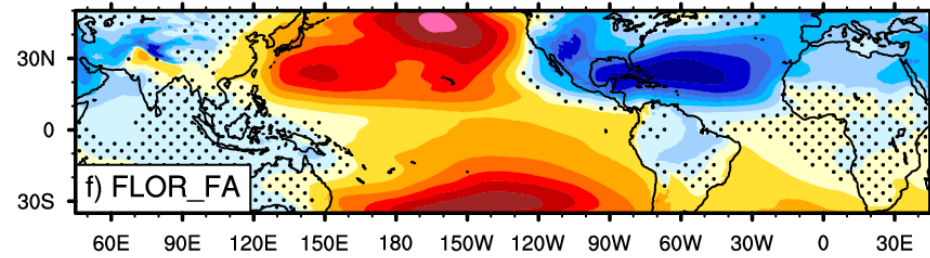
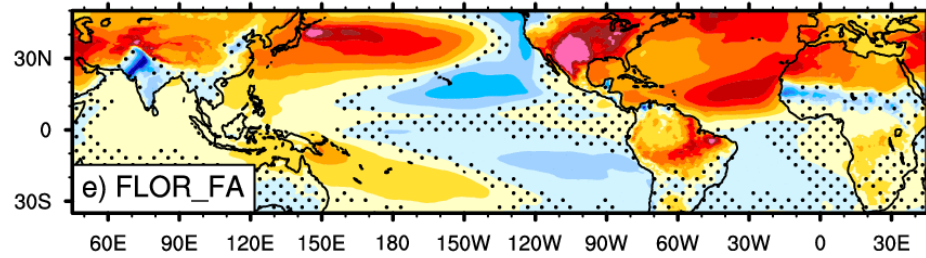
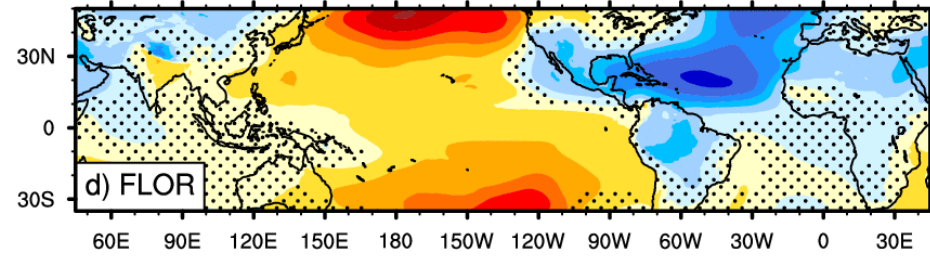
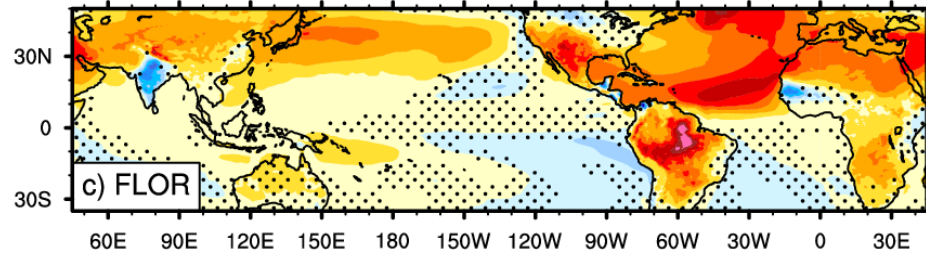
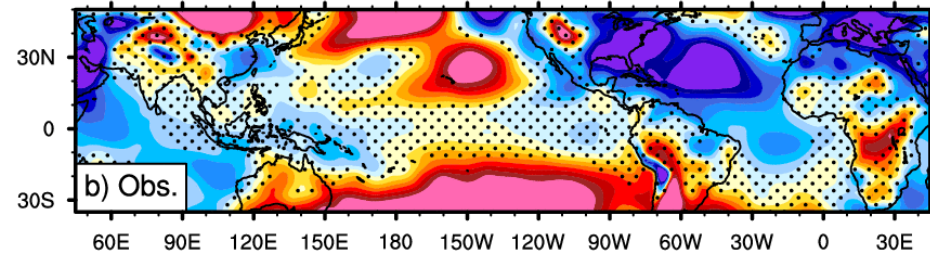
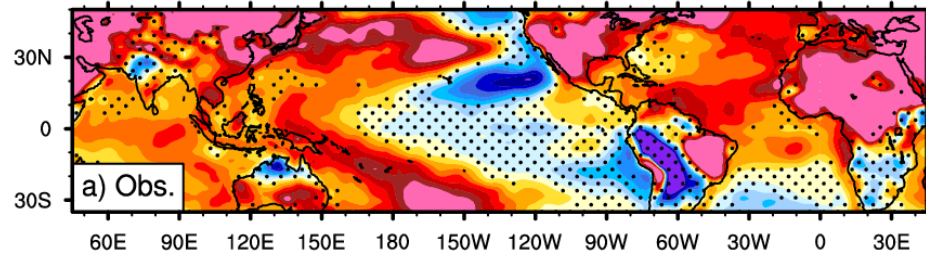


**Obs = 1996-2011 vs 1980-1995**

# AMV impacts on Tropical Cyclones

MJJASON tas

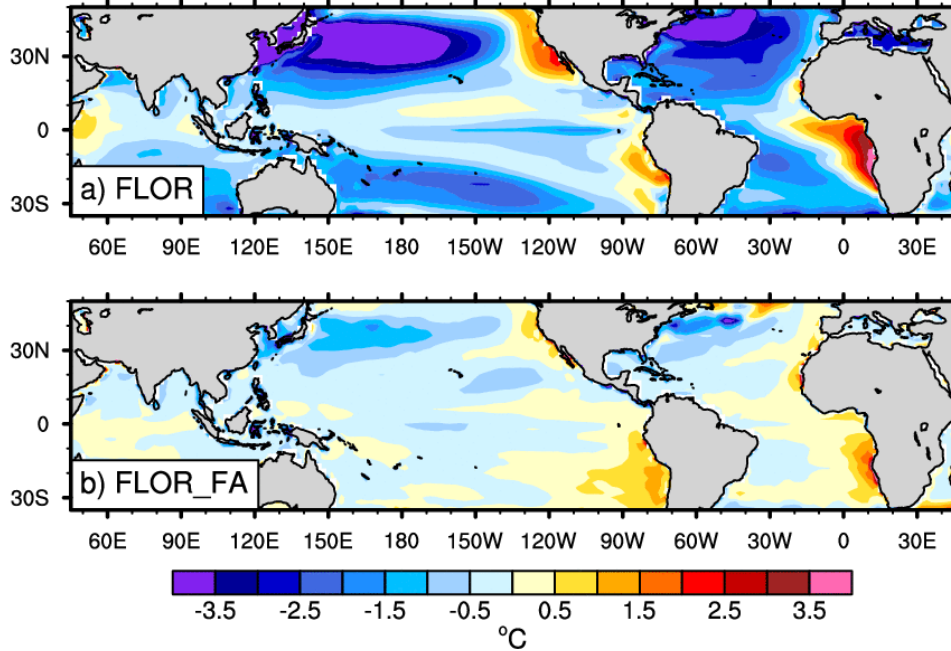
MJJASON slp



Obs = 1996-2011 vs 1980-1995

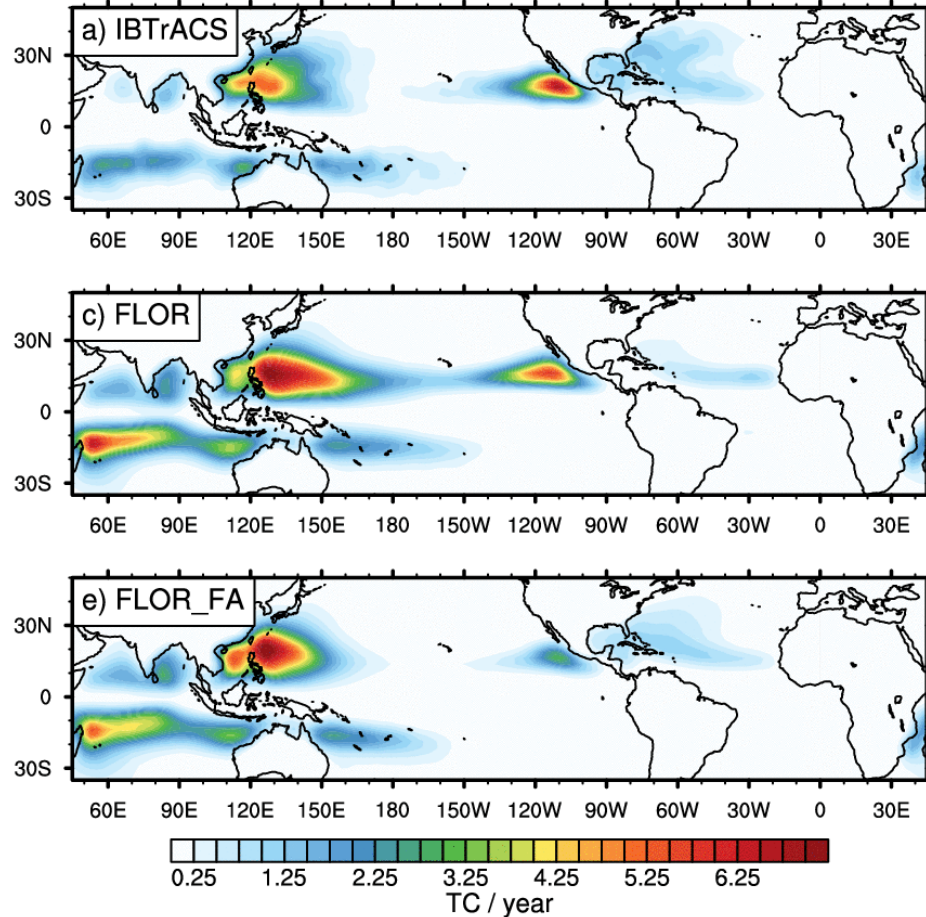
# AMV impacts on Tropical Cyclones

MJJASON sst biases



# AMV impacts on Tropical Cyclones

## MJJASON Tropical Cyclone density

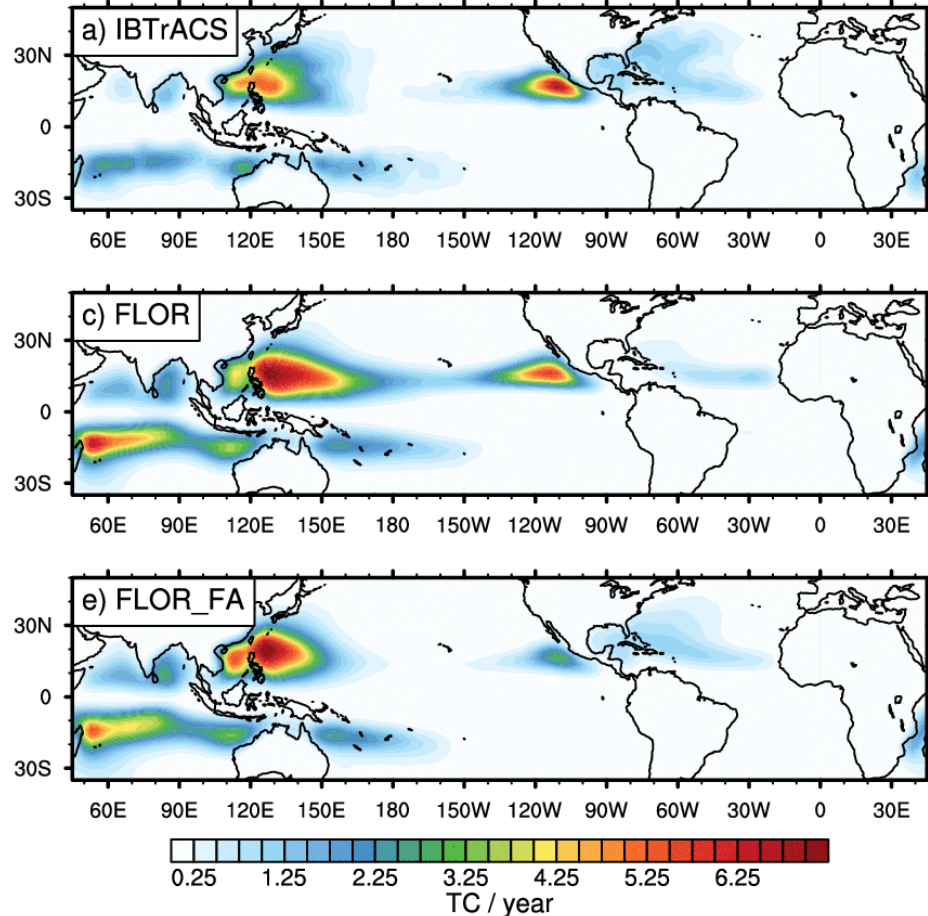


**Climatology**



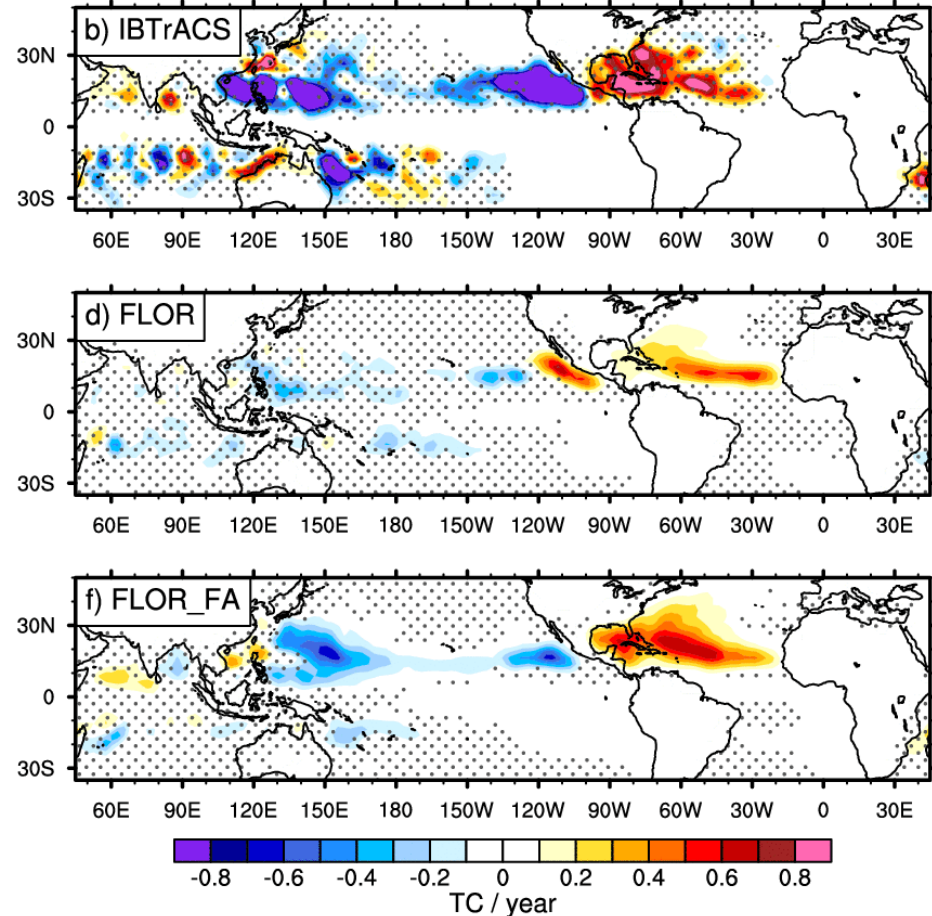
# AMV impacts on Tropical Cyclones

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**Climatology**

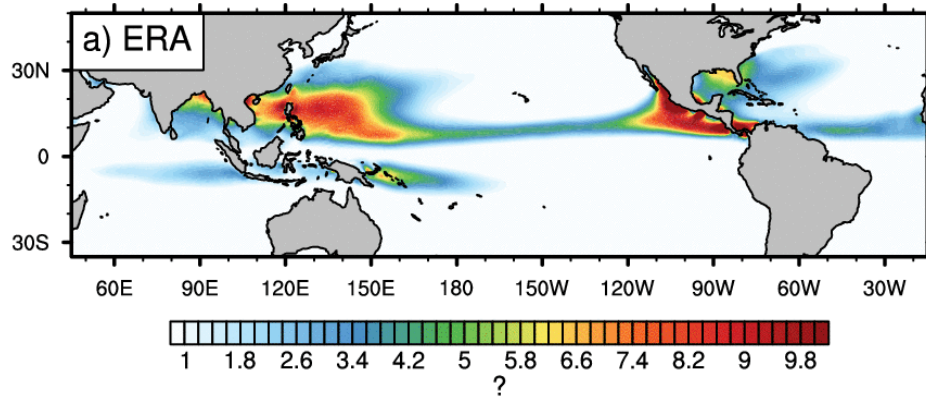
## Difference AMV+ - AMV-



**Obs = 1996-2011 vs 1980-1995**

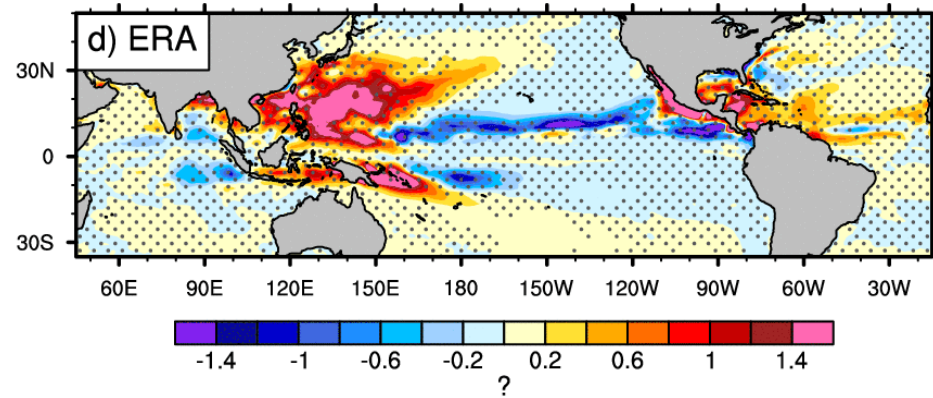
# AMV impacts on Tropical Cyclones

Climatological MJJASON GPI



**Climatology**

MJJASON GPI AMV+ - AMV-



**Obs = 1996-2011 vs 1980-1995**

GPI = Genesis Potential Index (Camargo et al. 2007)

→ empirical formula to estimate large scale background impacts on TC formation

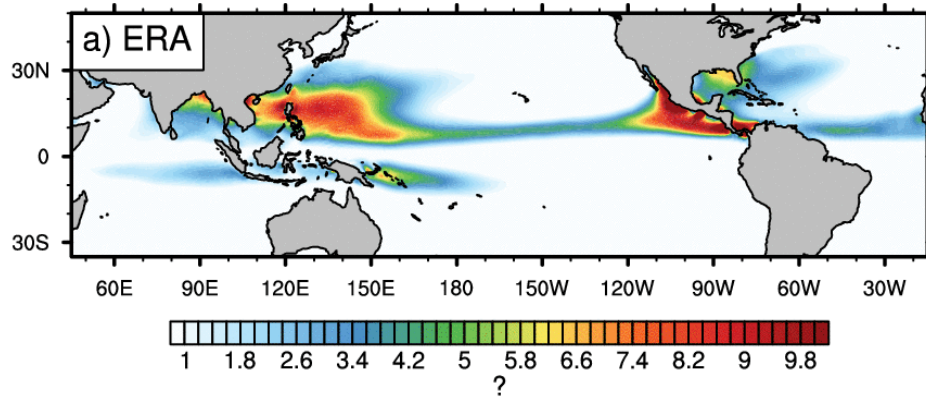
$$GPI = |10^5 \eta|^{3/2} \left( \frac{\mathcal{H}}{50} \right)^3 \left( \frac{V_{pot}}{70} \right)^3 (1 + 0.1 V_{shear})^{-2}$$

Abs. Vort. x Relative Humidity x Vmax(SST) x Wind Shear



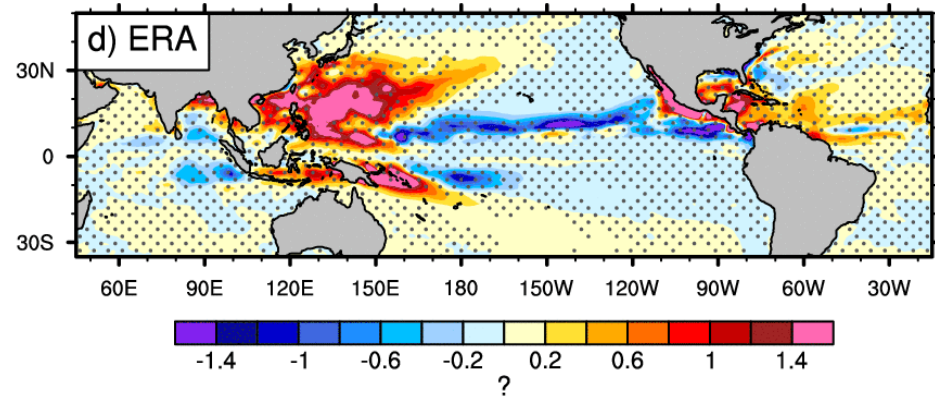
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Climatological MJJASON GPI

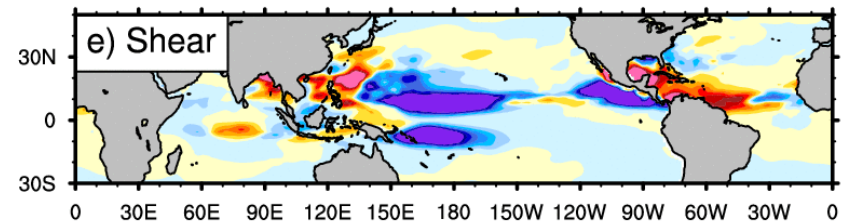
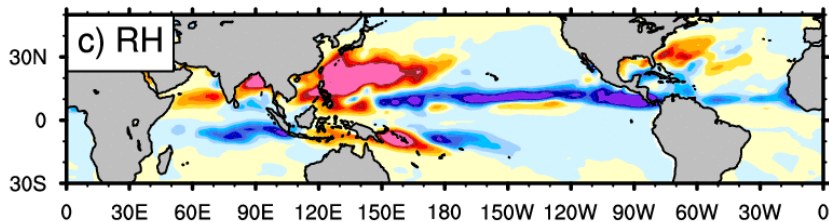
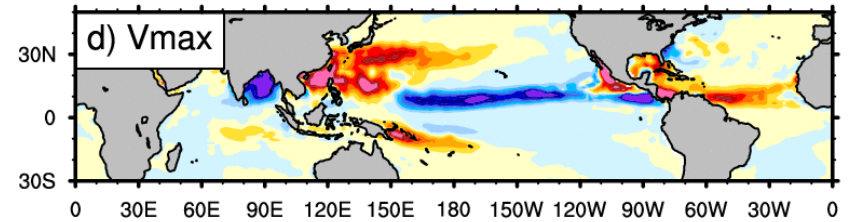
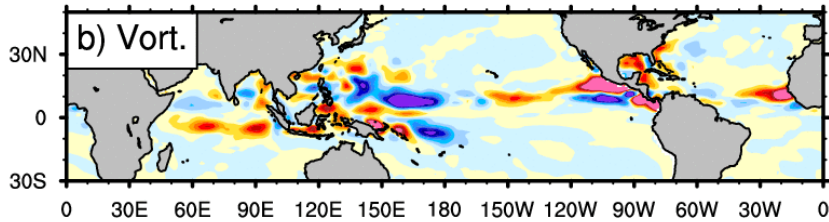


**Climatology**

MJJASON GPI AMV+ - AMV-

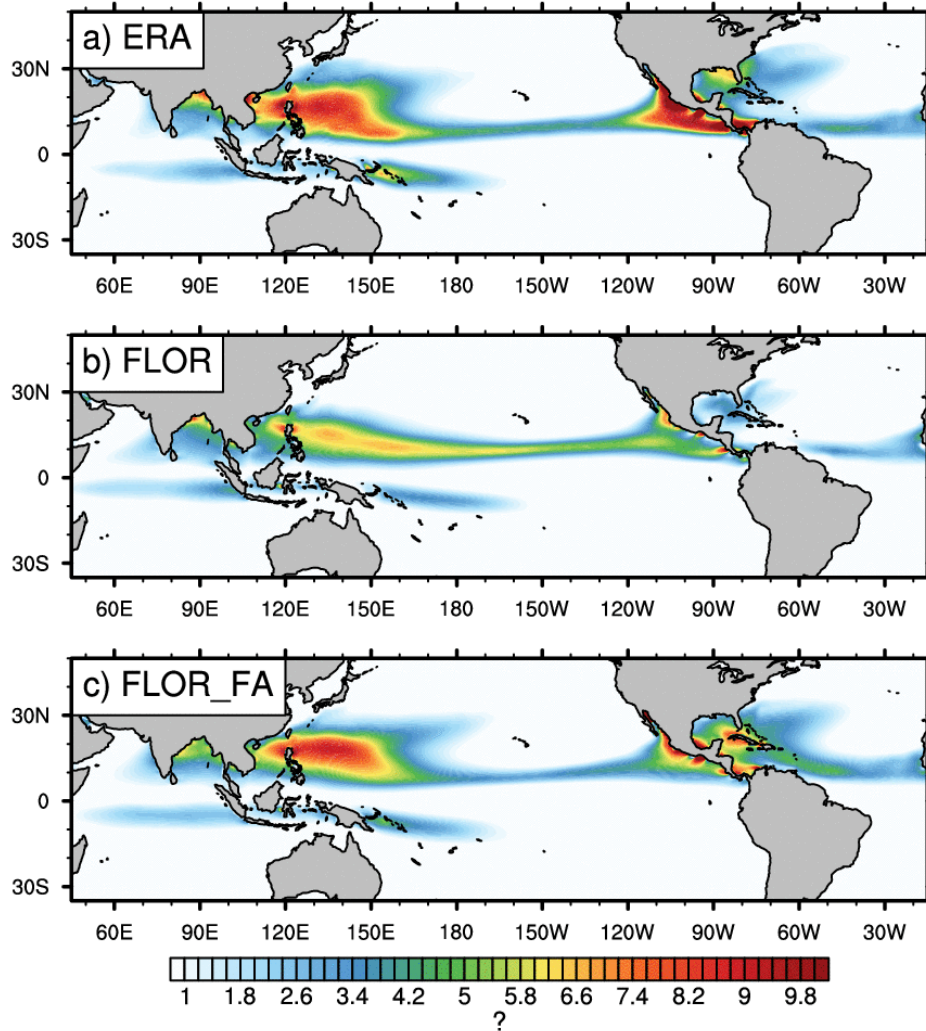


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# AMV impacts on Tropical Cyclones

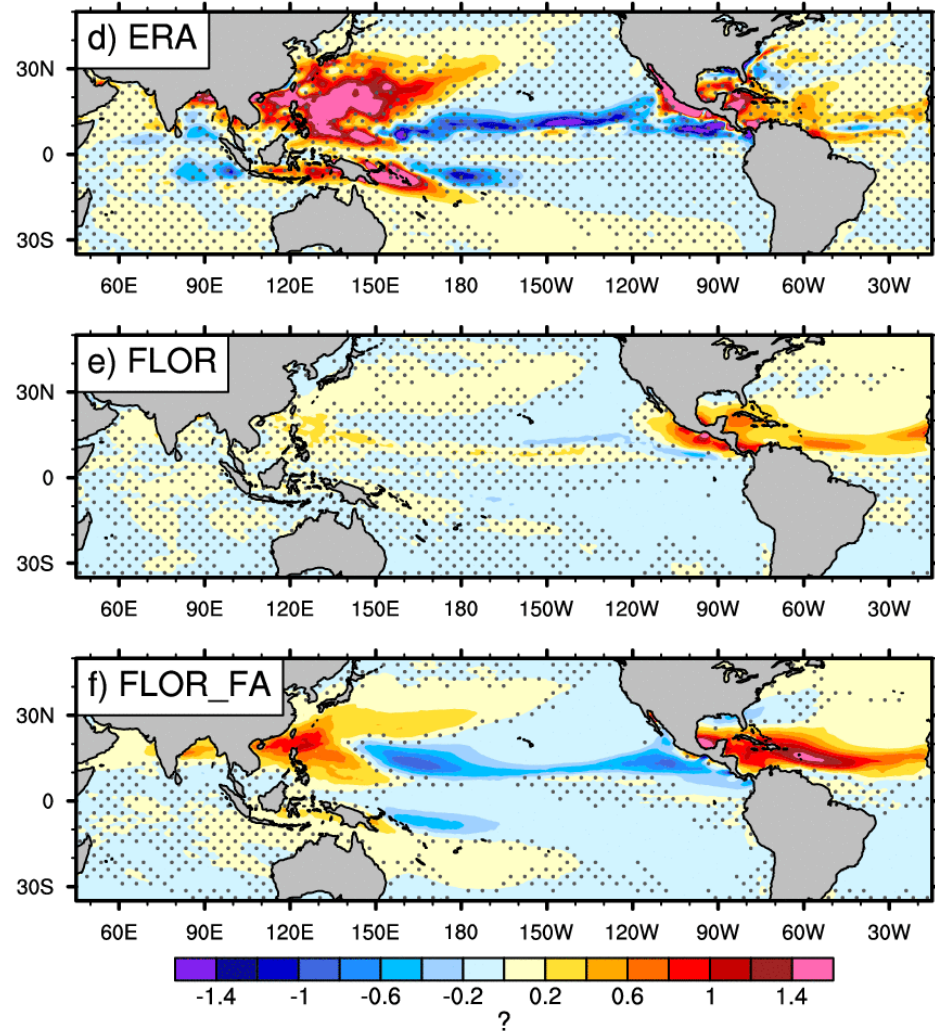
Climatological MJJASON GPI



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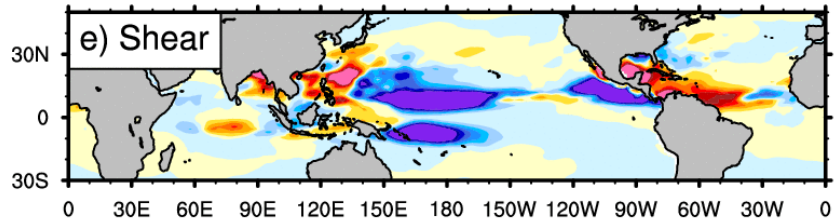
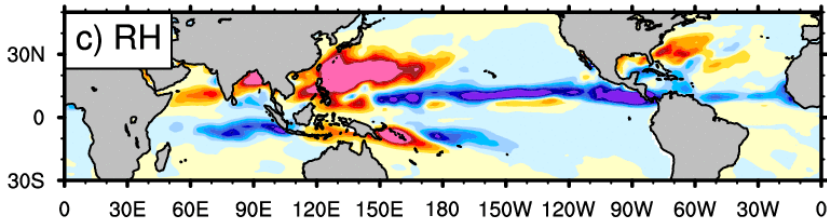
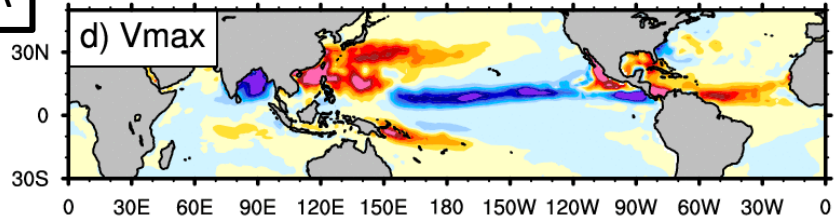
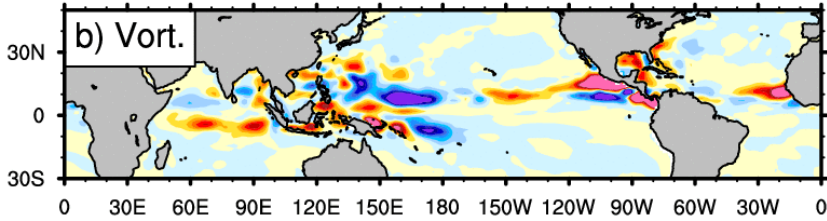
MJJASON GPI AMV+ - AMV-



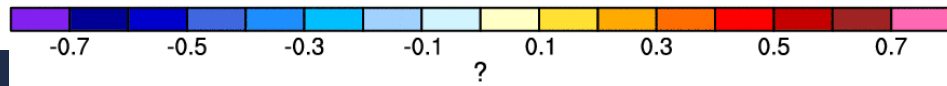
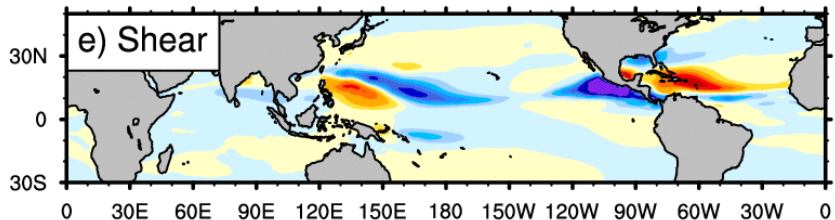
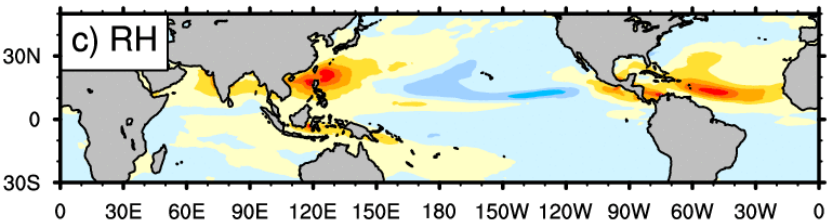
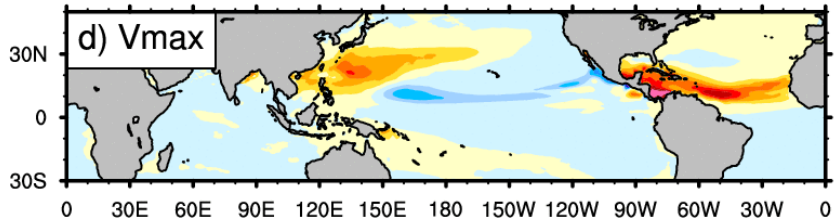
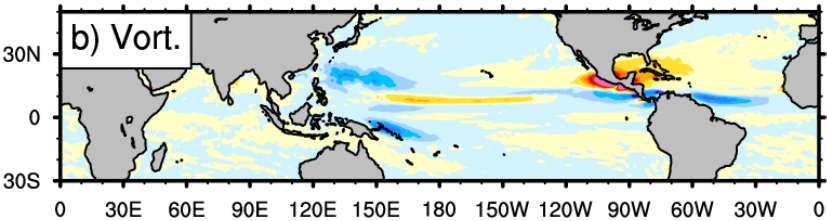
**Obs = 1996-2011 vs 1980-1995**

# AMV impacts on Tropical Cyclones

ERA



FLOR\_FA





# Conclusion

- AMV+ drives PDO- responses.  
Tropical Atlantic = main driver of these teleconnections.
- La-Nina like response during winter:
  - delayed adjustment to summertime Walker circulation changes
  - ➔ Need coupled model to capture such a response.

## Similar impacts between CM2.1, CESM1, FLOR, FLOR\_FA

- AMV+ drives TC+ over Atlantic and TC- over Pacific:
  - Due to SST and Wind Shear changes

## Need to correct mean SST biases to capture the observed signal

Ruprich-Robert et al. (2017): *Assessing the climate impacts of the observed AMV using the GFDL-CM2.1 and NCAR CESM1 global coupled models.* **J. Clim.**

Ruprich-Robert et al. (2017): Impacts of the Atlantic Multidecadal Variability on tropical climate and tropical cyclone activity. *In prep.*

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**Thank you!**

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