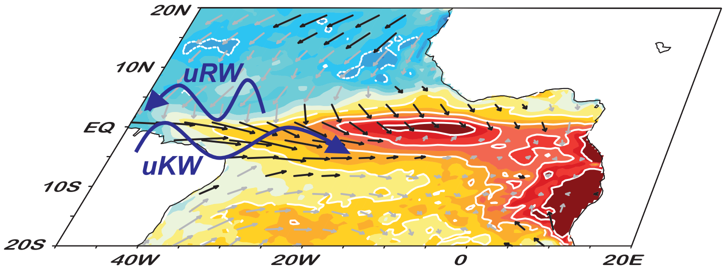
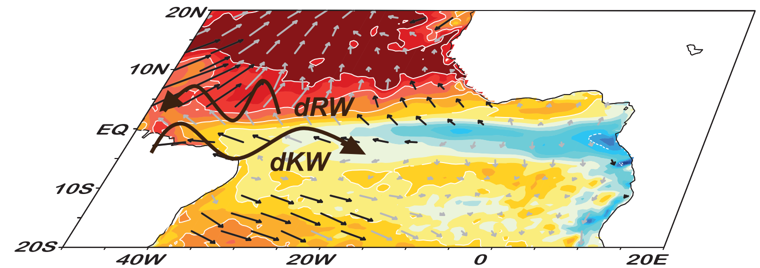
Response of the upper ocean circulation to tropical Atlantic interannual modes

Equatorial Mode



Meridional Mode



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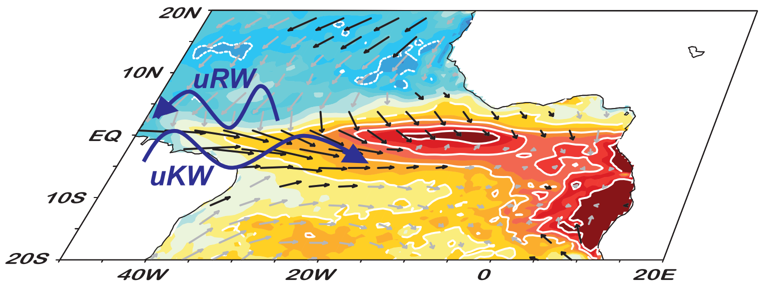
*This research was developed in the framework of MSCA-IF-FESTIVAL Project (grant agreement 797236)

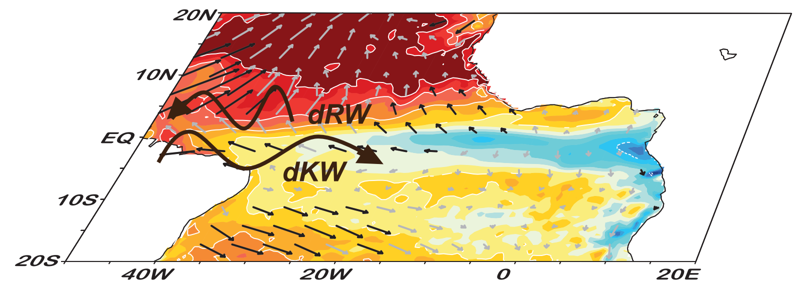
Objective

To provide a **more complete characterization of the changes in the tropical ocean circulation** associated with the emergence of MM and EM

Equatorial Mode



Meridional Mode



- **PCA analysis**

Tropical Atlantic SST anomalies in MAM and JJA for the period 1982-onwards

- **Regression and correlation maps** (90% confidence level)

Observational Datasets

OISST (Reynolds et al. 2002)
AVISO (https://www.aviso.altimetry.fr)
ERA5 (Hersbach et al. 2020)

Ocean Reanalyses

ORAS5 (Zuo et al. 2018)
SODA342 (Carton et al. 2018)
GLORYS2v4 (Carton et al. 2018)

Forced-ocean simulation

NEMOINT (Martín-Rey et al. 2019)

Indices for upper ocean circulation

Monthly anomalies of surface and subsurface (proxy isotherm 18ºC) zonal currents:

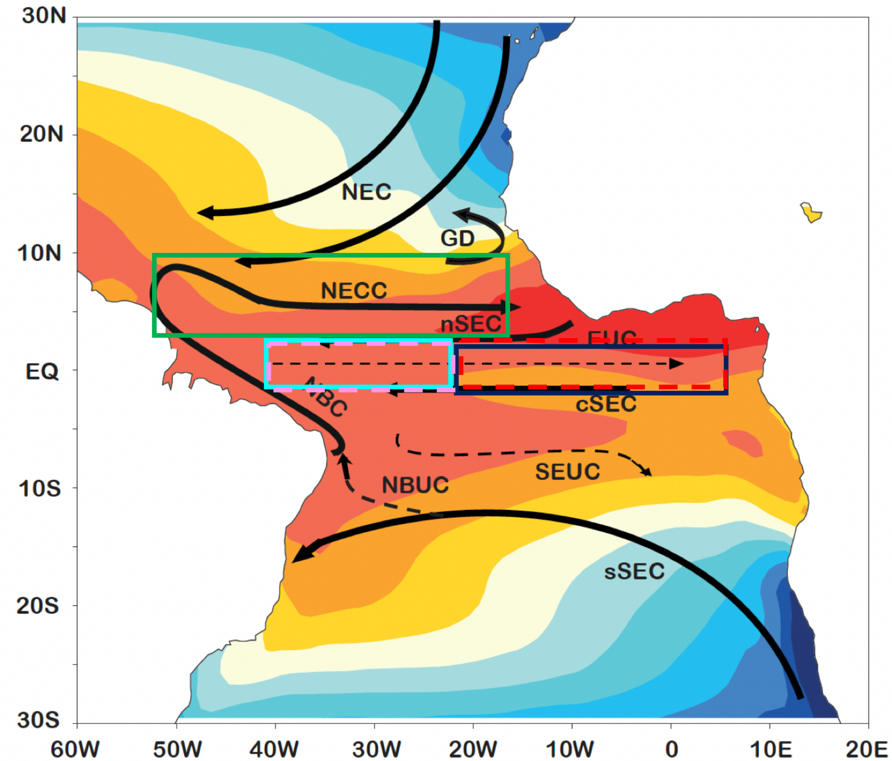
NECC [50°W-15°W, 4°N-10°N]

WEq-NSEC [40°W-20°W, 2°N-2°S]

EEq-NSEC [20°W-10°E, 2°N-2°S]

W-EUC[40°W-20°W, 2°N-2°S]

E-EUC[20°W-10°E, 2°N-2°S]



➢ Composite Analysis

PC exceeding ± 0.5 std in all datasets

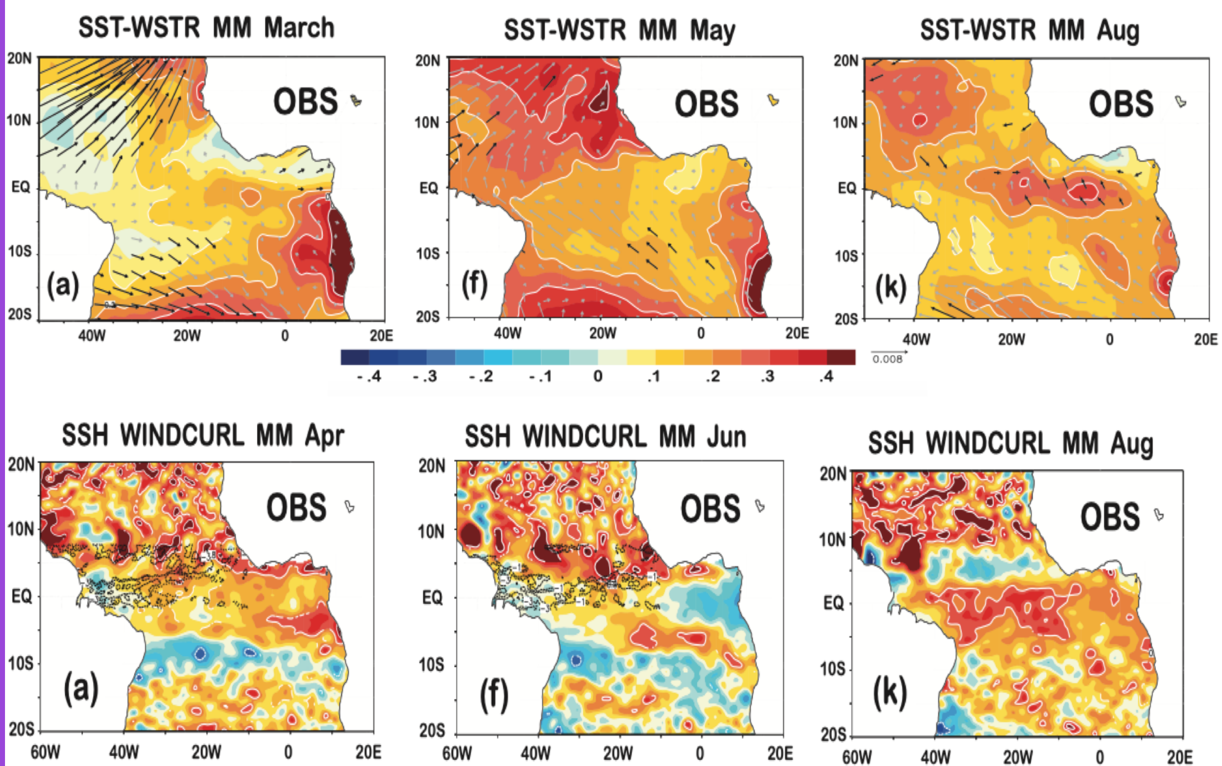
8 events for Equatorial Mode:
Positive EM: 1984, 1988, 1991, 1996, 1999, 2003
Negative EM: 1992, 1997.

10 events for Meridional Mode:
Positive MM: 1983, 1998, 2005, 2010
Negative MM: 1985, 1986, 1989, 1994, 1999, 2009.

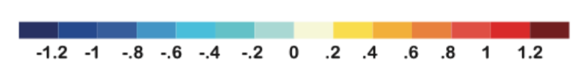
Assume linearity and ignore asymmetries:

Positive – negative events

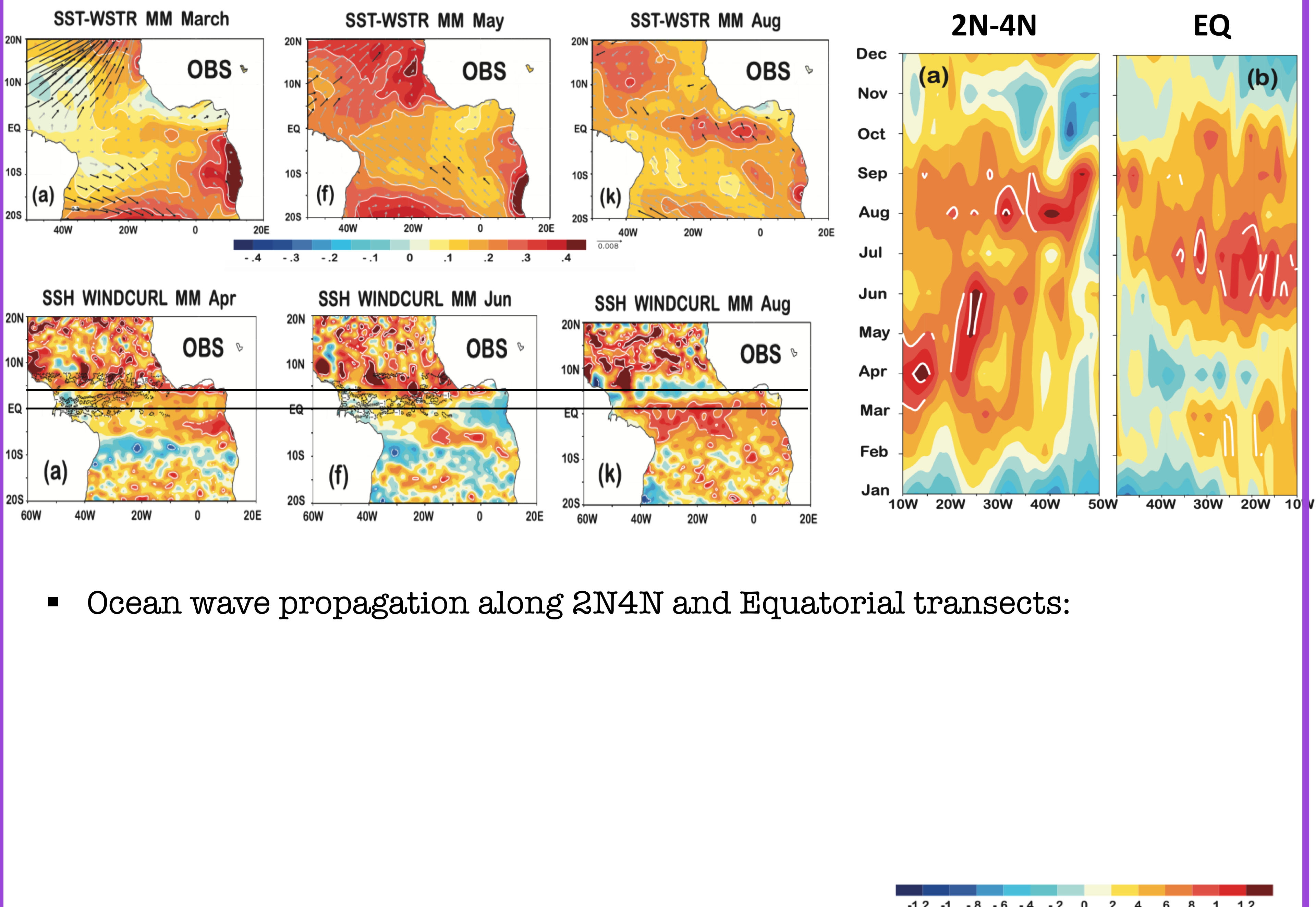
Meridional Mode



- Good agreement between datasets
- Interhemispheric SST pattern followed by equatorial warming
- Anomalous SSH elevation north of equator in spring and transferred to the equatorial band in summer

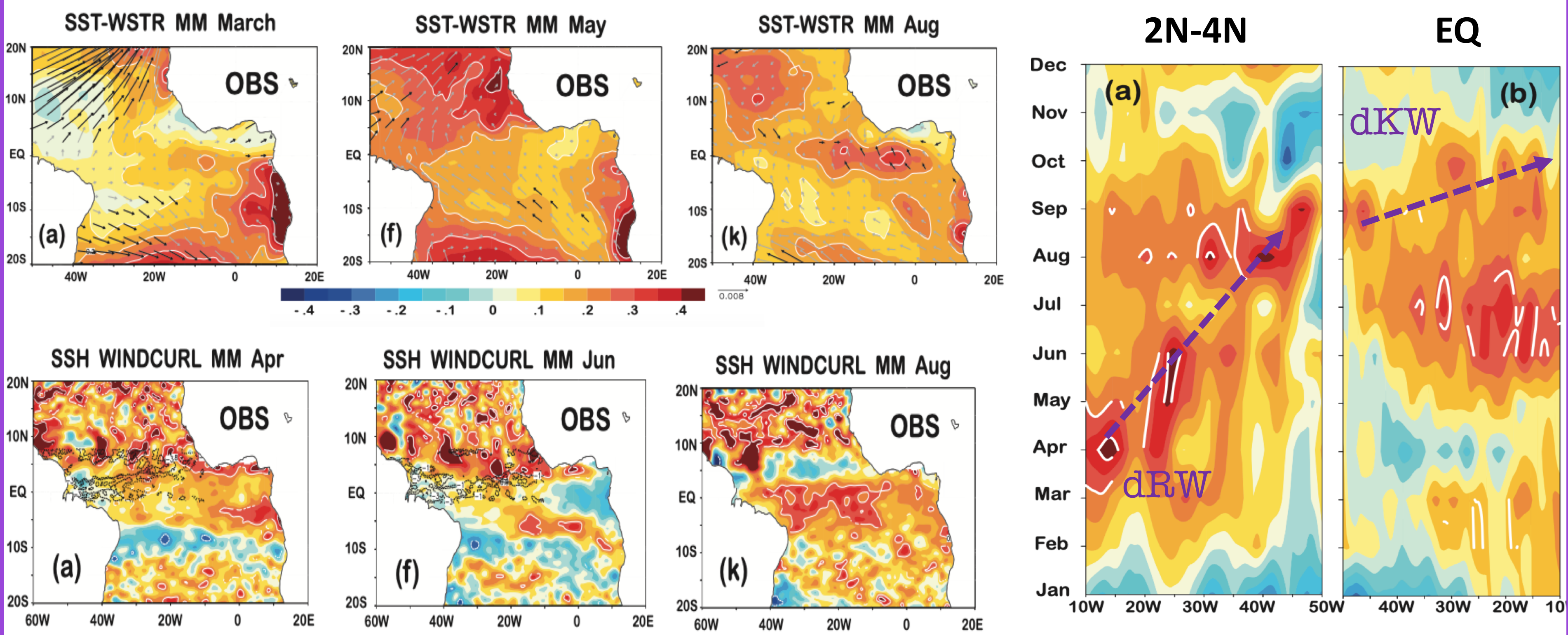


Meridional Mode



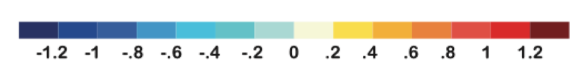
- Ocean wave propagation along 2N4N and Equatorial transects:

Meridional Mode

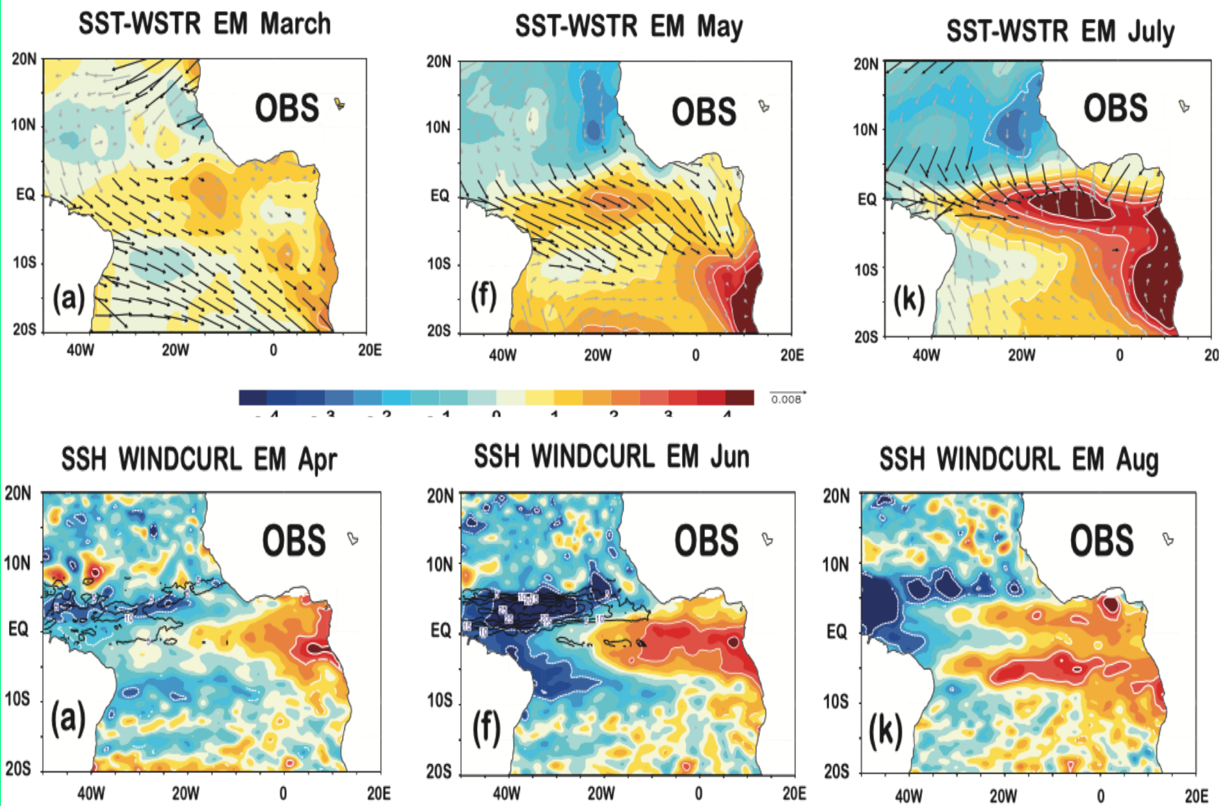


- Ocean wave propagation along 2N4N and Equatorial transects:
  - **Downwelling RW** propagating westward from spring to summer
  - The dRW is boundary reflected into **equatorial dKW** in August
  - The RW-reflected mechanism seems to **favor a positive MM-positive EM connection**

    (Foltz & McPhaden 2010; Martín-Rey and Lazar 2019)

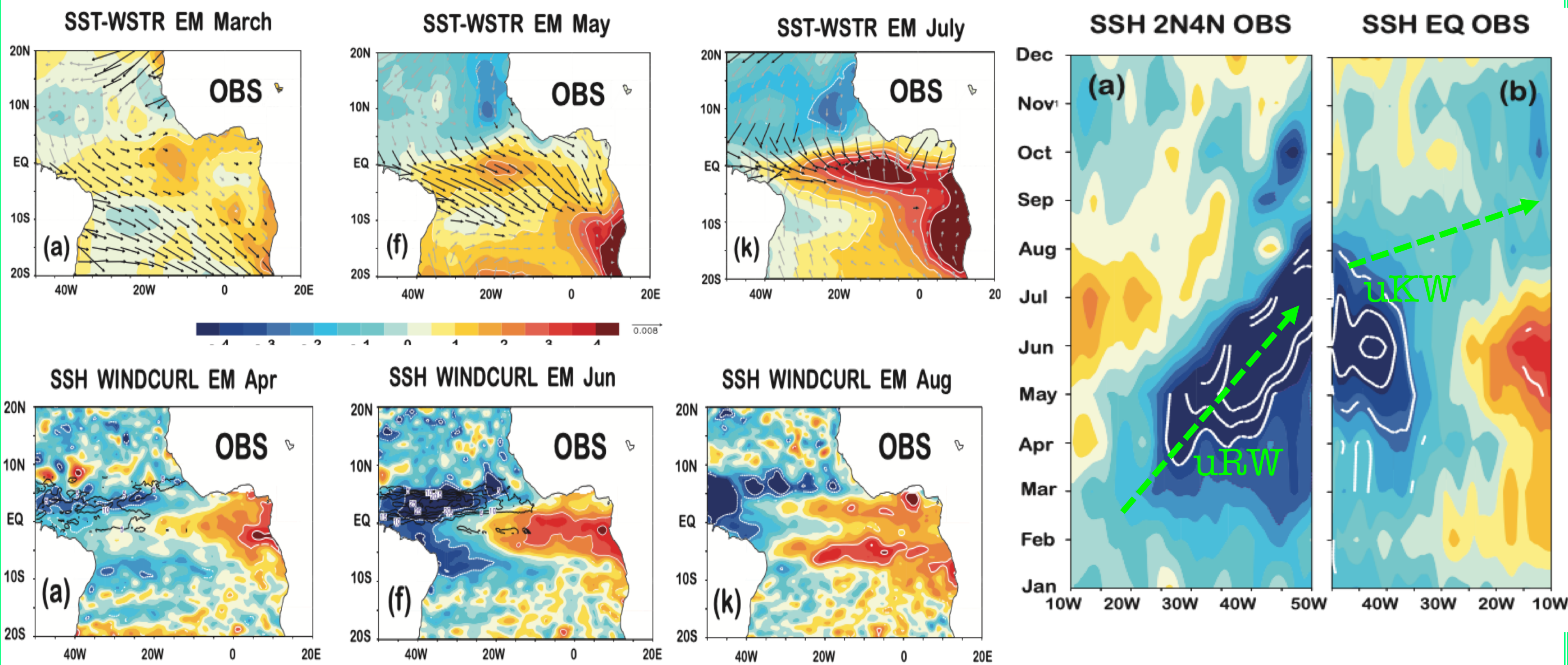


Equatorial Mode



- Good agreement between datasets
- Warm tongue pattern developed in boreal summer
- Anomalous SSH diminution north of equator in spring and transferred to the equatorial band in summer season

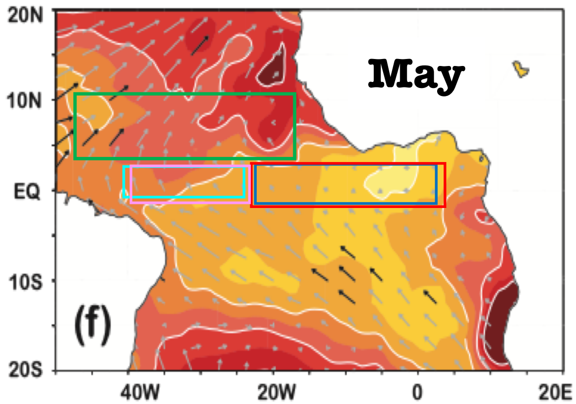
Equatorial Mode

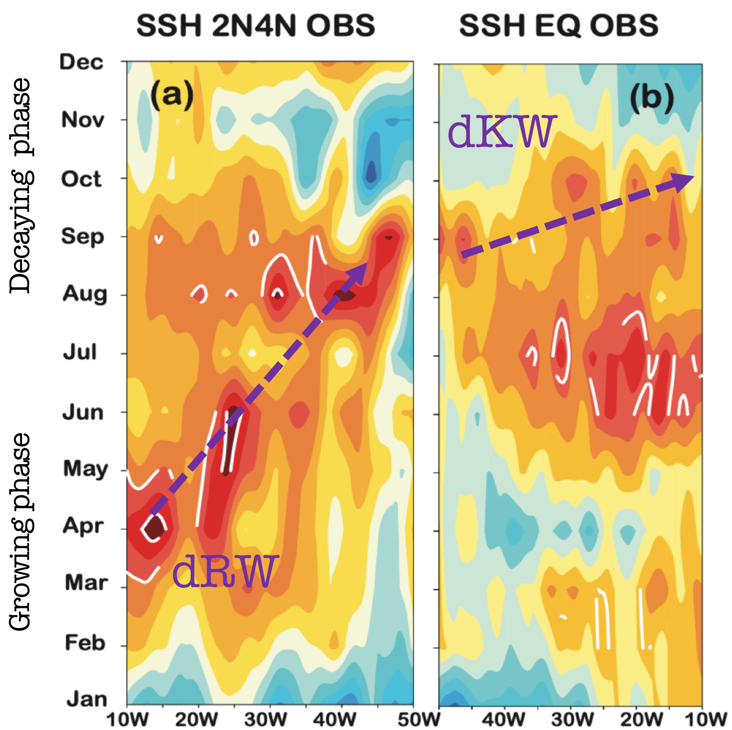


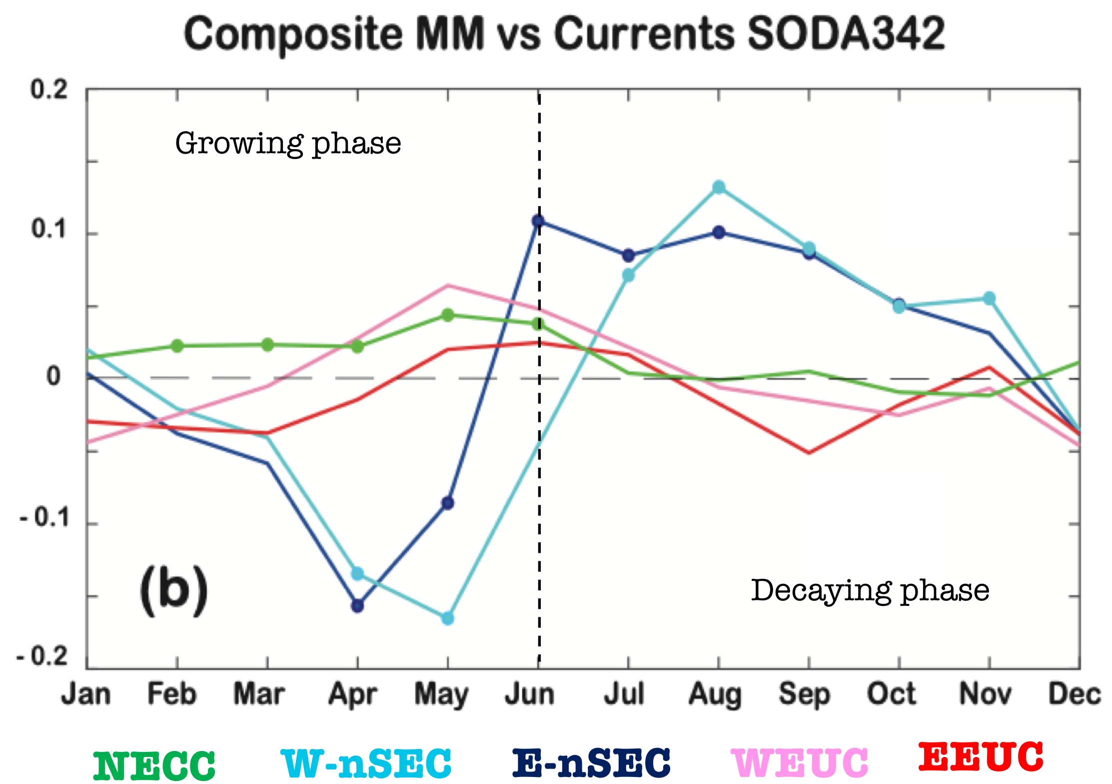
- Ocean wave propagation along 2N4N and Equatorial transects:
  - **Upwelling RW** propagating westward from spring to summer
  - The dRW is boundary reflected into **equatorial uKW** in August
  - The RW-reflected mechanism seems to **favor the termination of EM**

(Martín-Rey et al 2019)

Meridional Mode



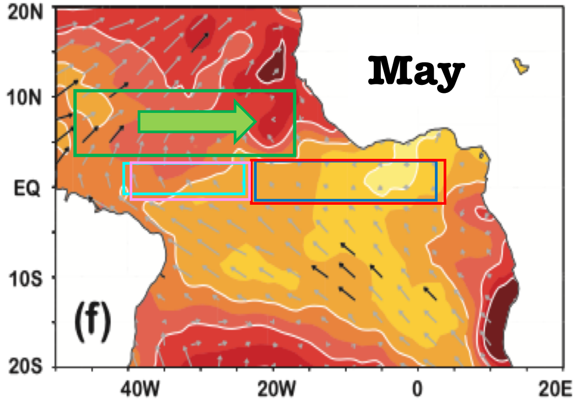




Units: cm/s

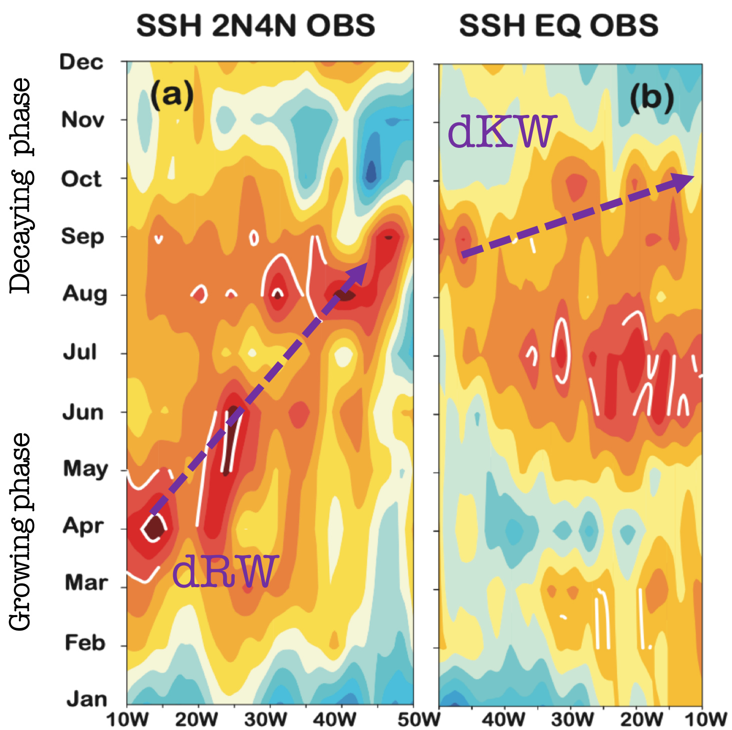
Dots: significant values at 90%

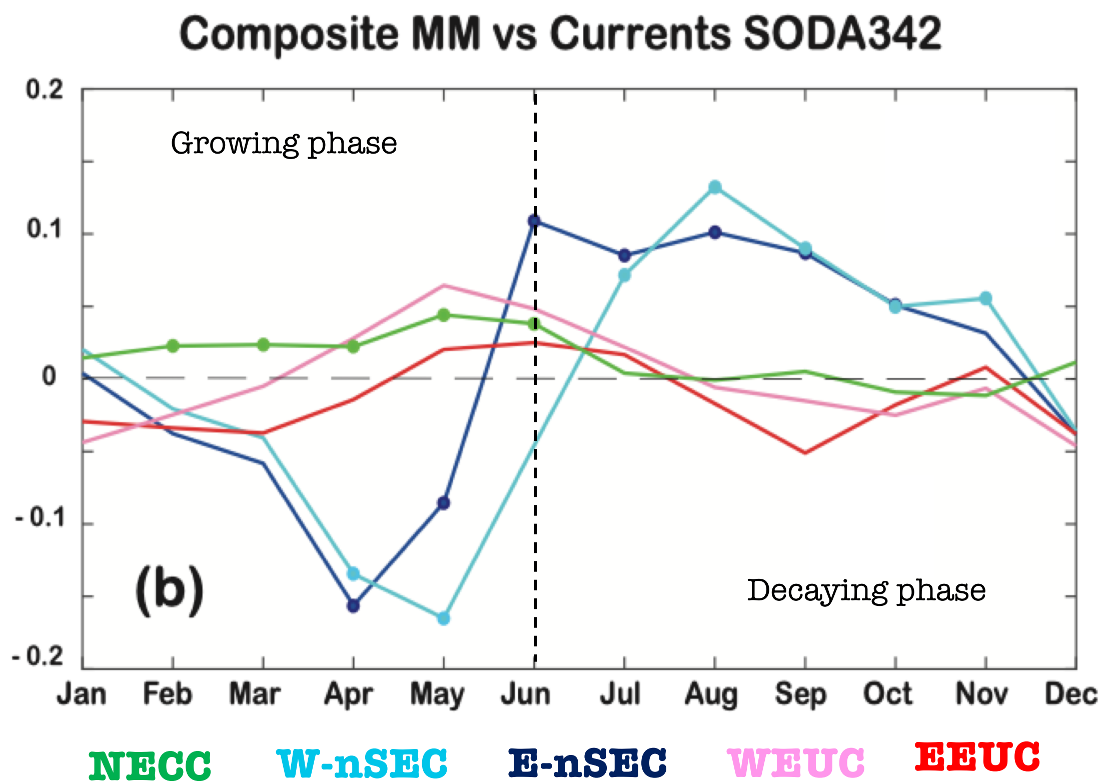
Meridional Mode



Developing phase:

- **NECC** strengthened

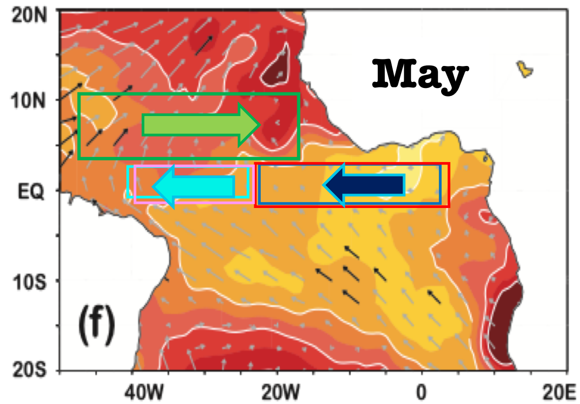




Units: cm/s

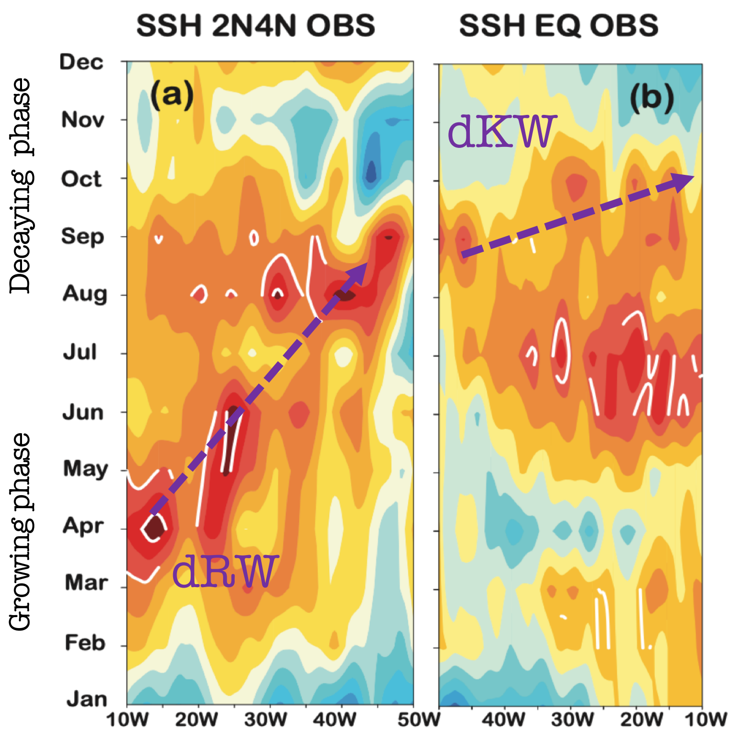
Dots: significant values at 90%

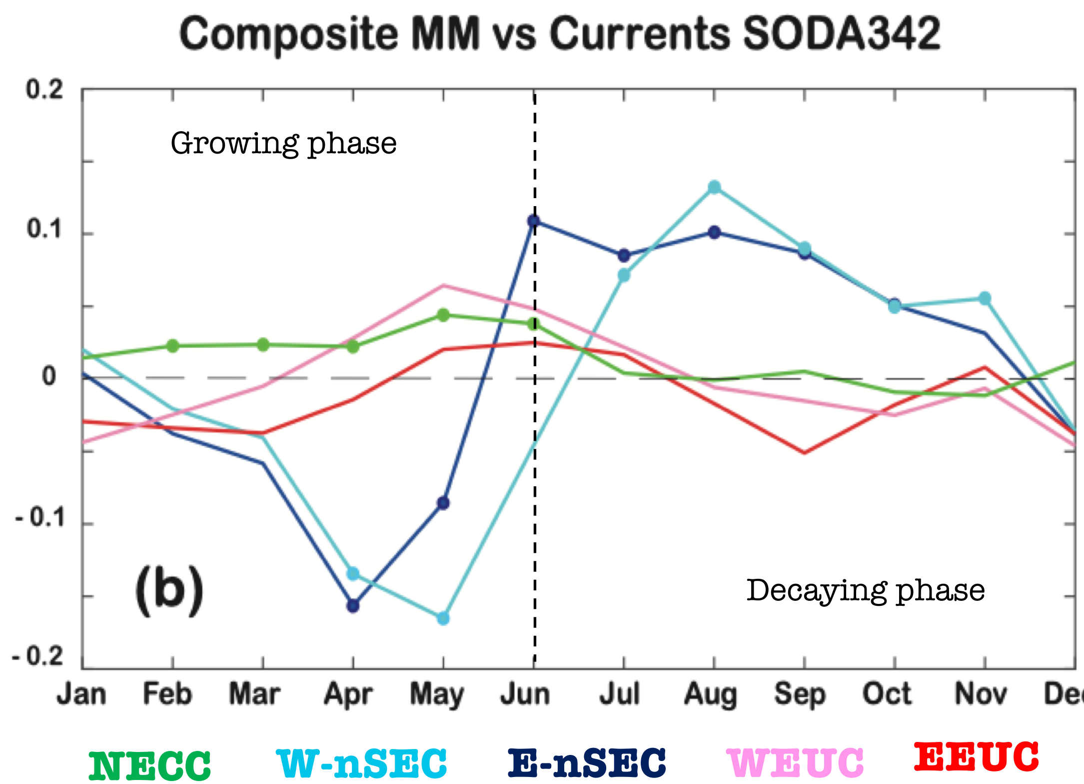
Meridional Mode



Developing phase:

- **NECC** strengthened
- **E-nSEC** and **W-nSEC** strengthened

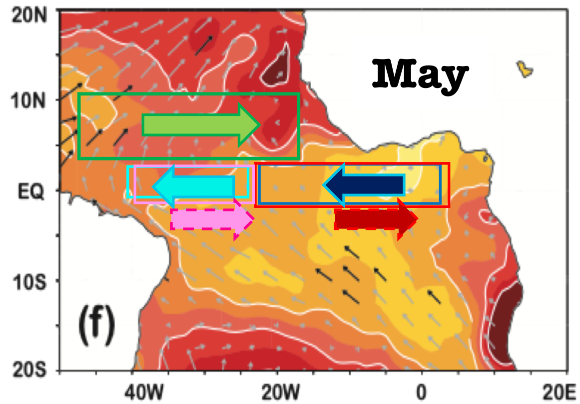




Units: cm/s

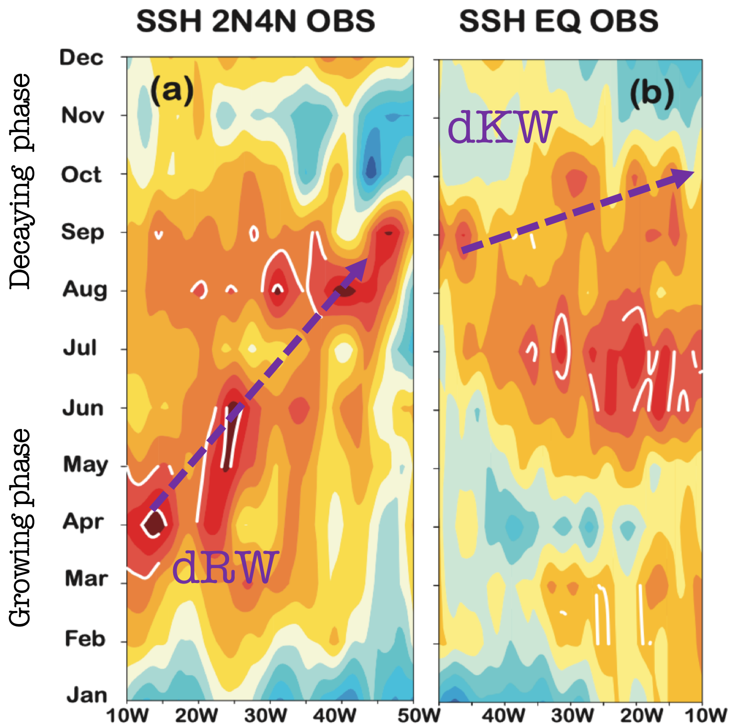
Dots: significant values at 90%

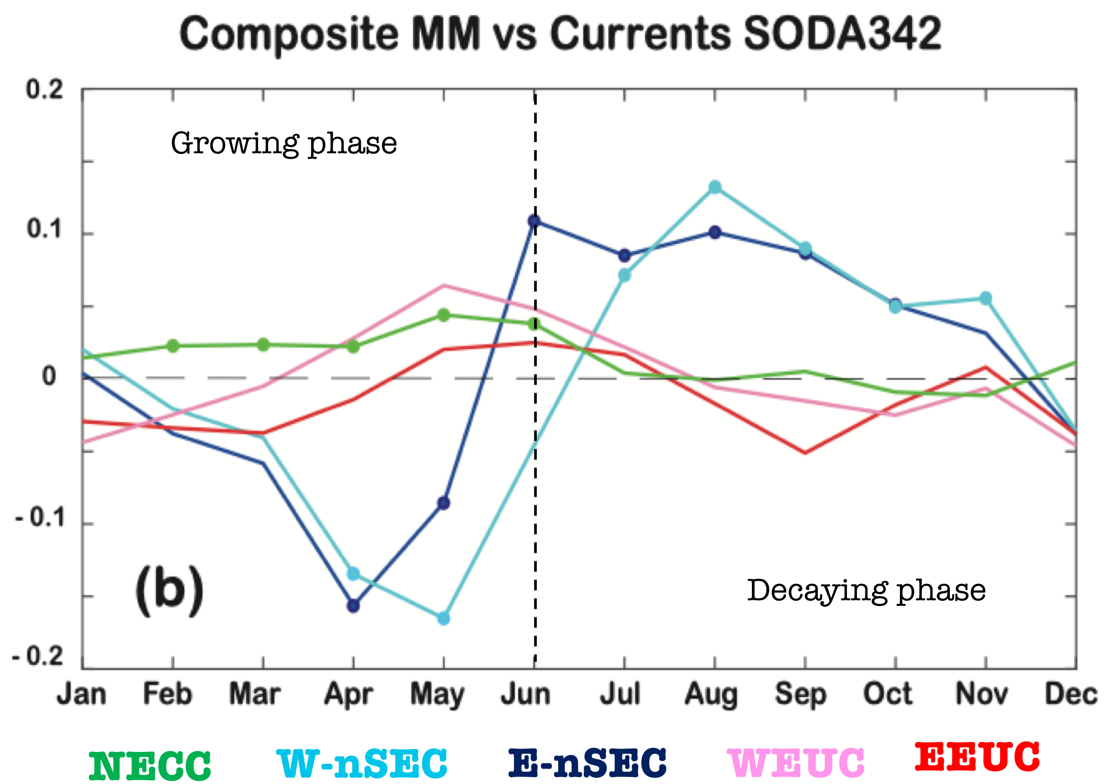
Meridional Mode



Developing phase:

- **NECC** strengthened
- **E-nSEC** and **W-nSEC** strengthened
- **E-EUC** and **W-EUC** strengthened





Units: cm/s

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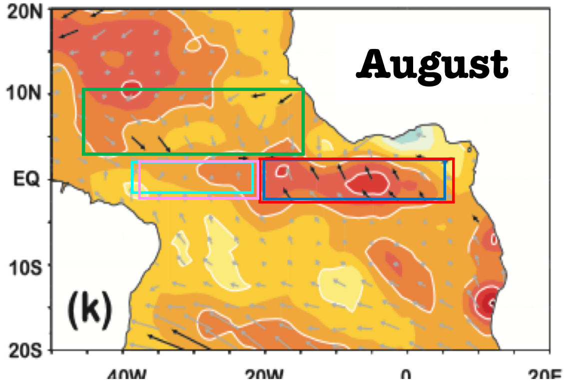
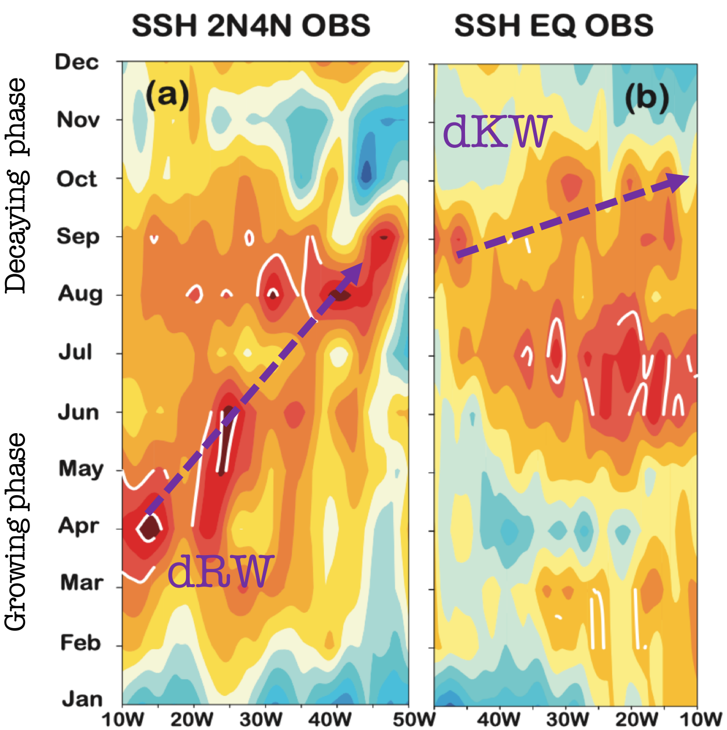
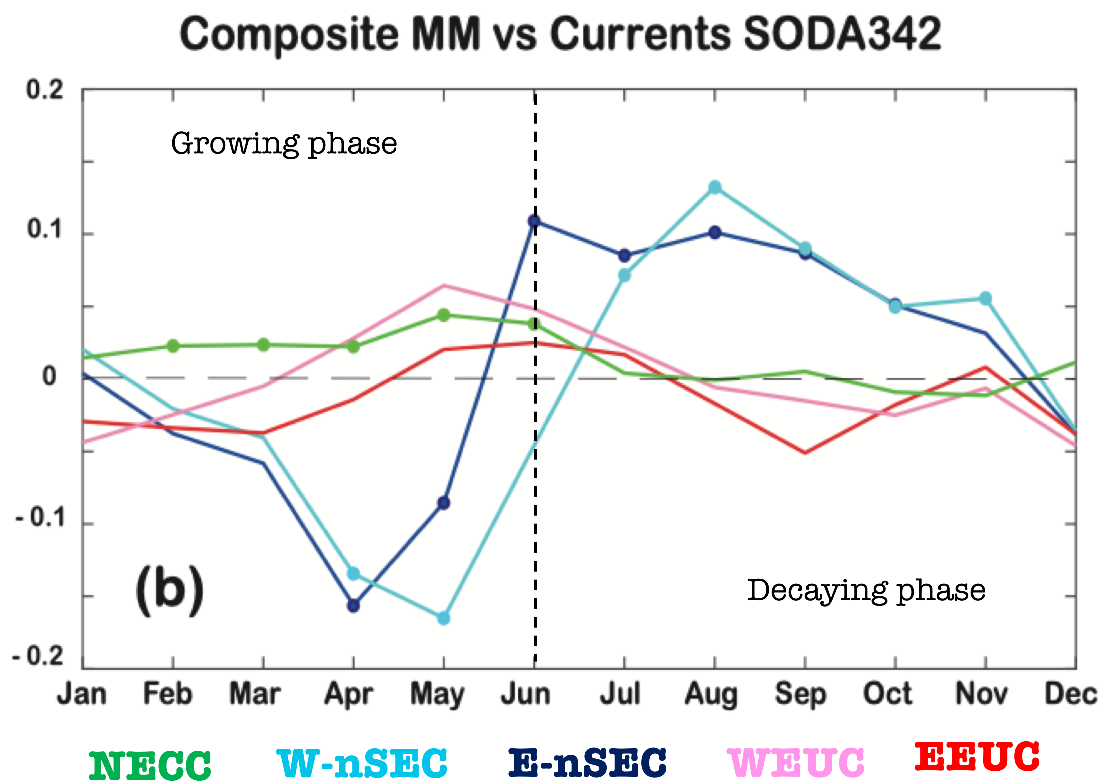
Meridional Mode



Decaying phase:

- **NECC** tends to zero

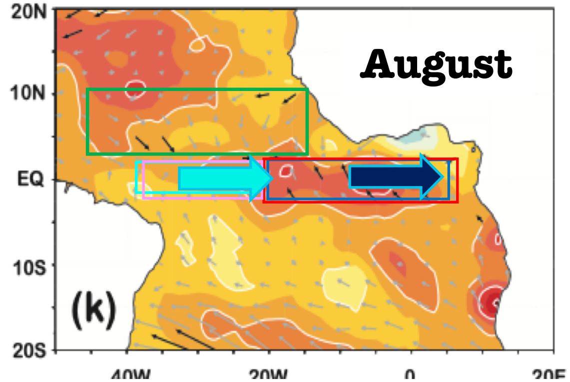




Units: cm/s

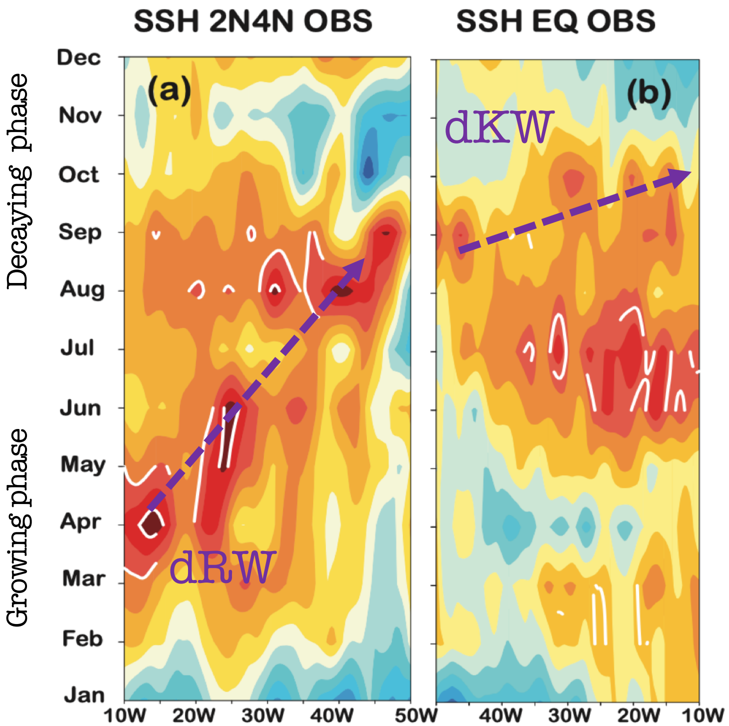
Dots: significant values at 90%

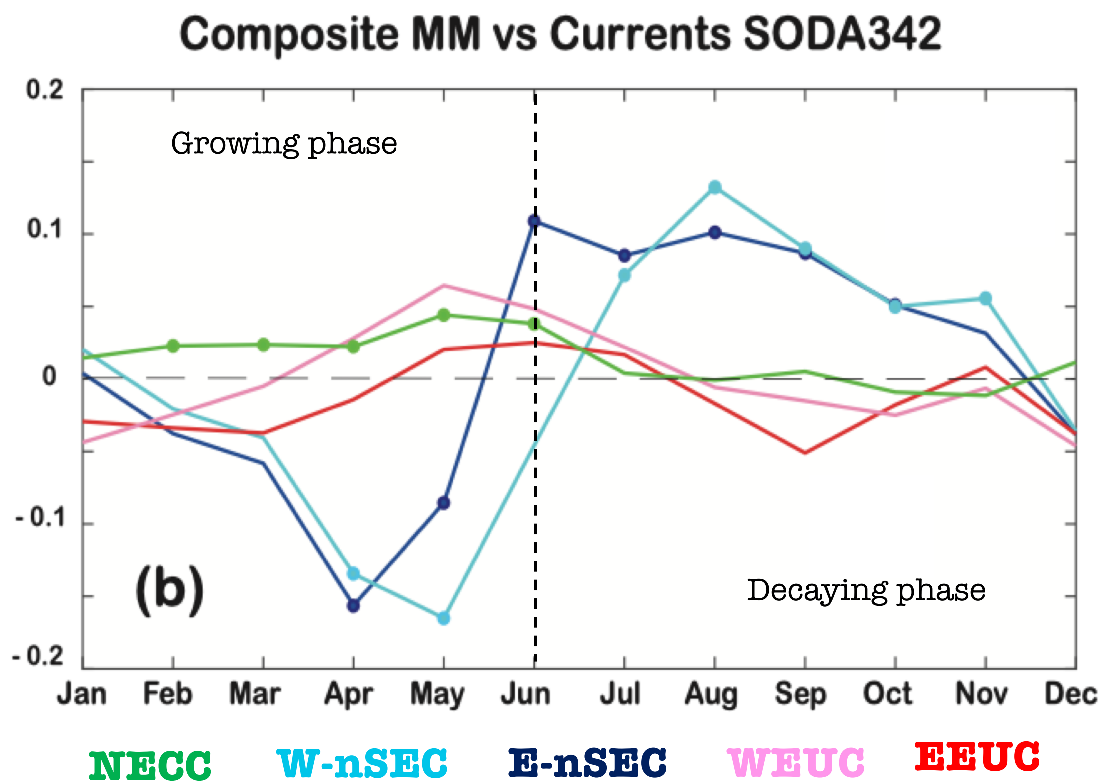
Meridional Mode



Decaying phase:

- **NECC** tends to zero
- **E-nSEC** and **W-nSEC** weakened

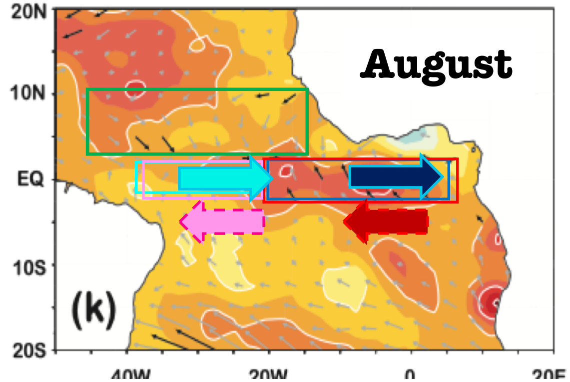




Units: cm/s

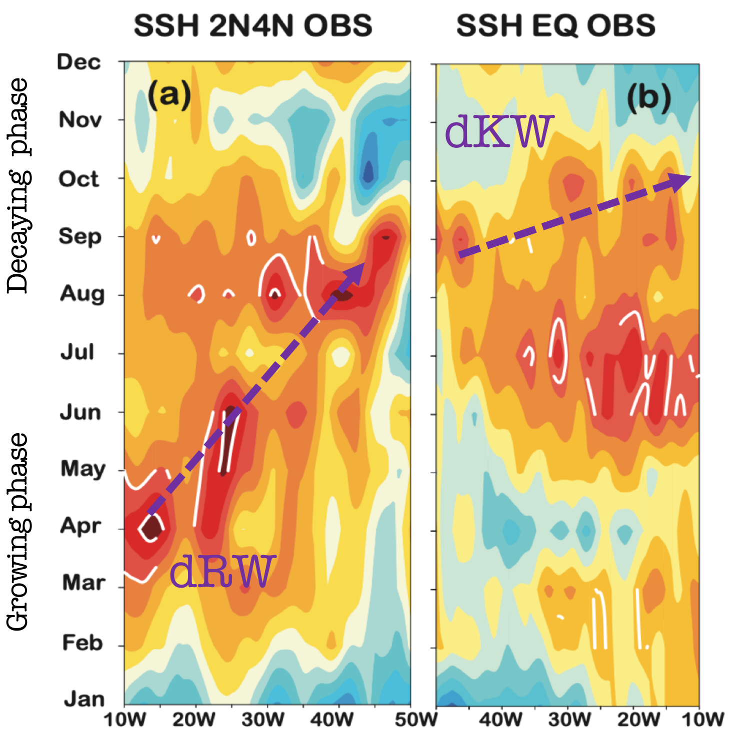
Dots: significant values at 90%

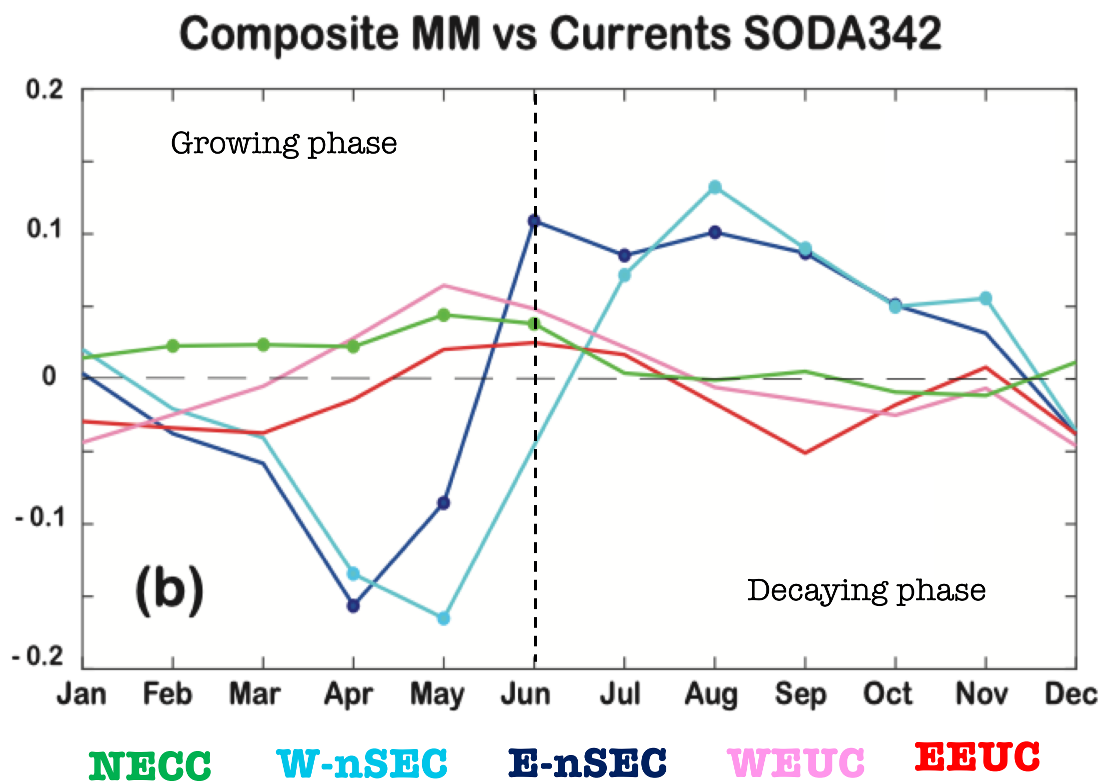
Meridional Mode



Decaying phase:

- **NECC** tends to zero
- **E-nSEC** and **W-nSEC** weakened
- **E-EUC** and **W-EUC** weakened

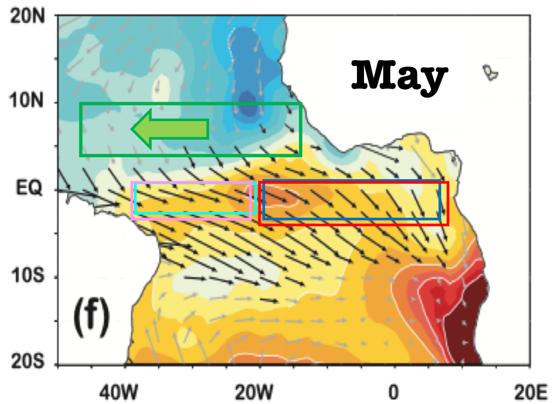




Units: cm/s

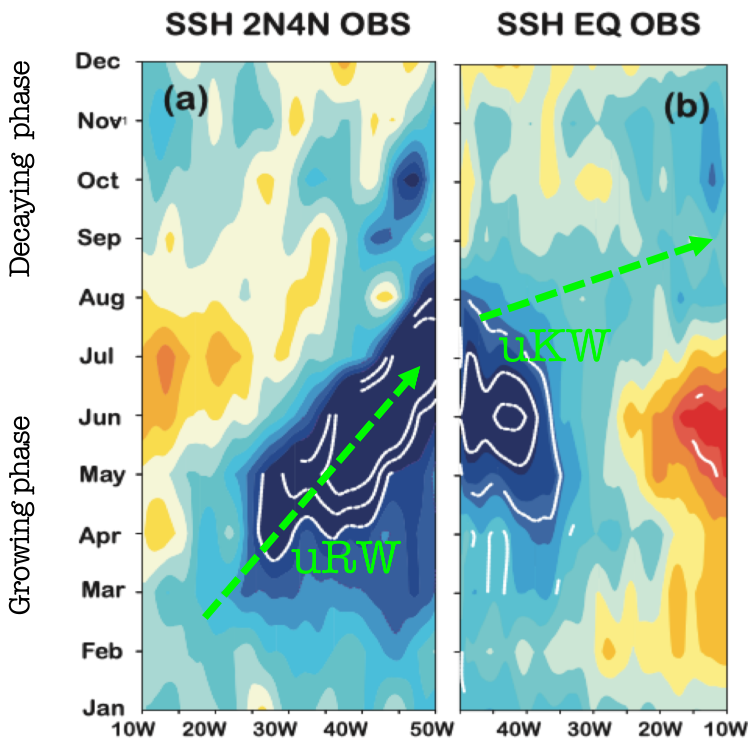
Dots: significant values at 90%

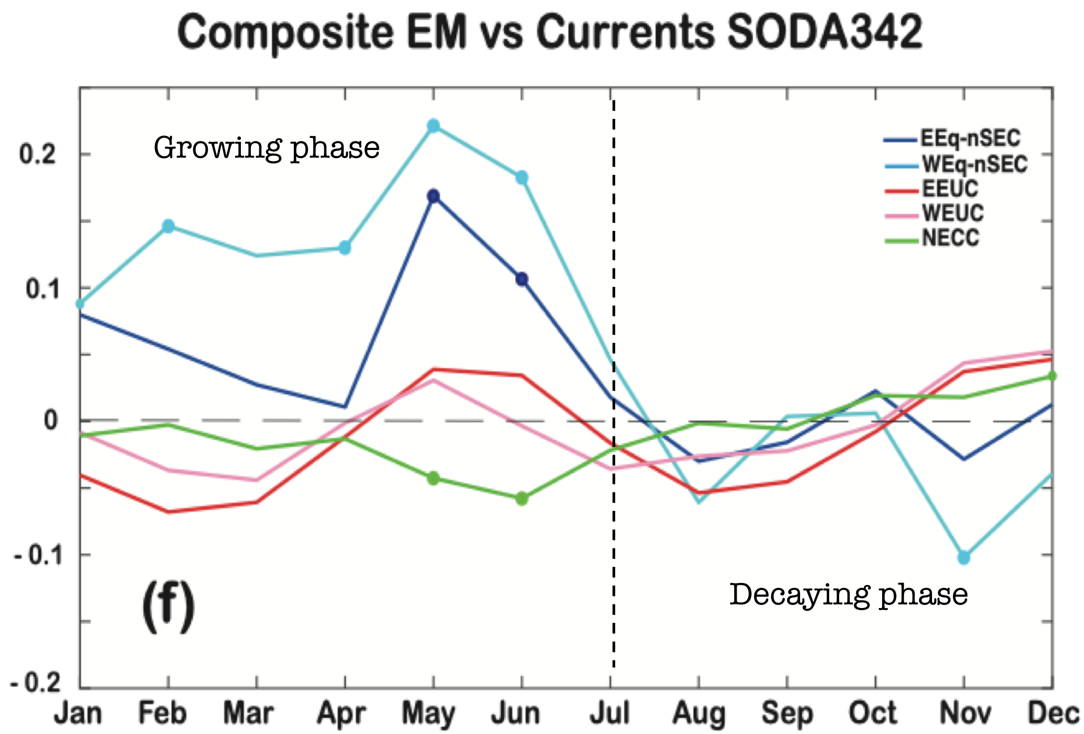
Equatorial Mode



Developing phase:

- **NECC** weakened



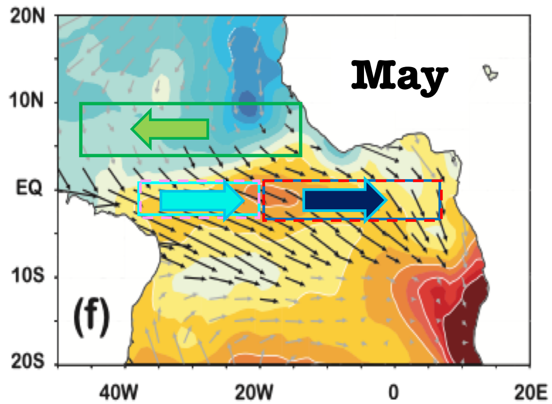


NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

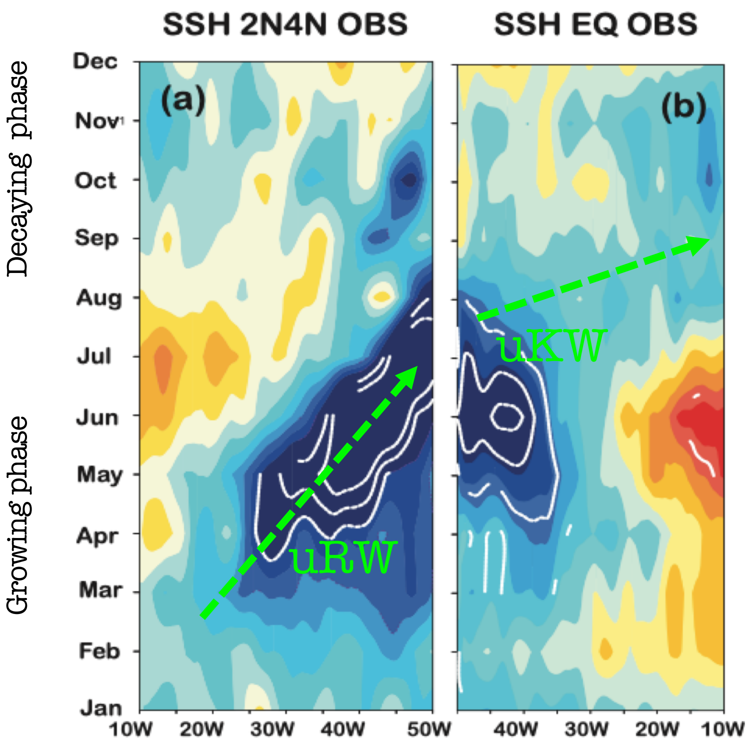
Dots: significant values at 90%

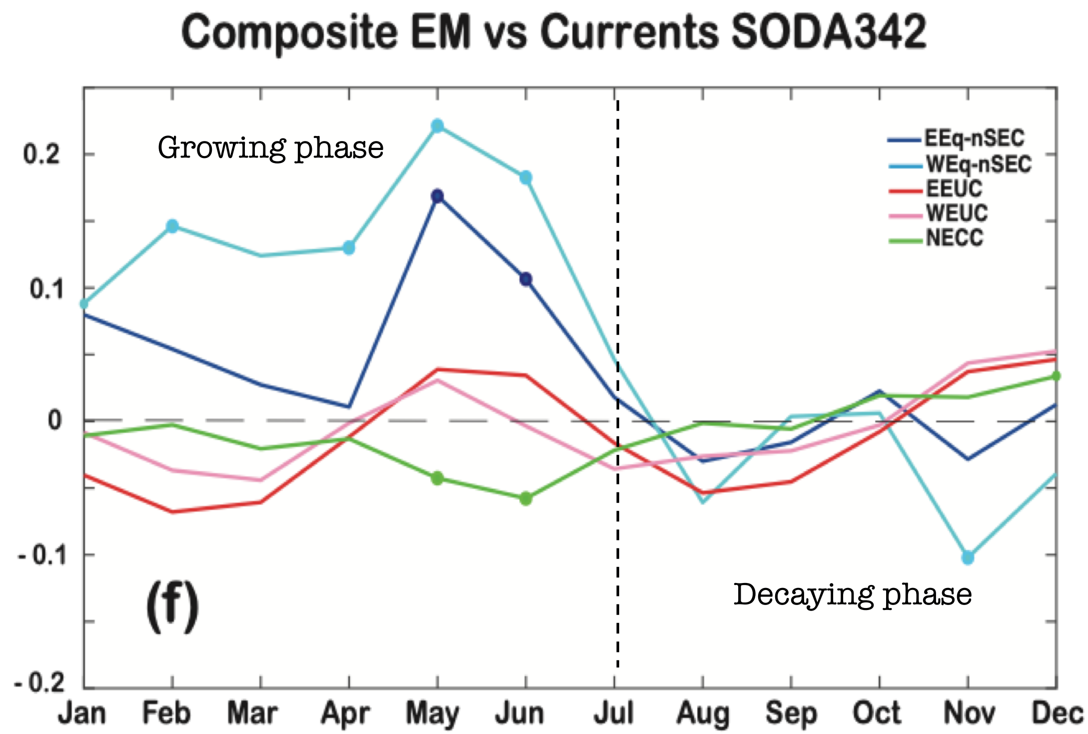
Equatorial Mode



Developing phase:

- **NECC** weakened
- **E-nSEC** and **W-nSEC** weakened



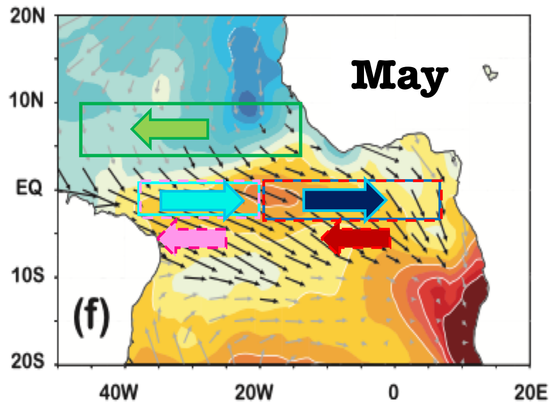


NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

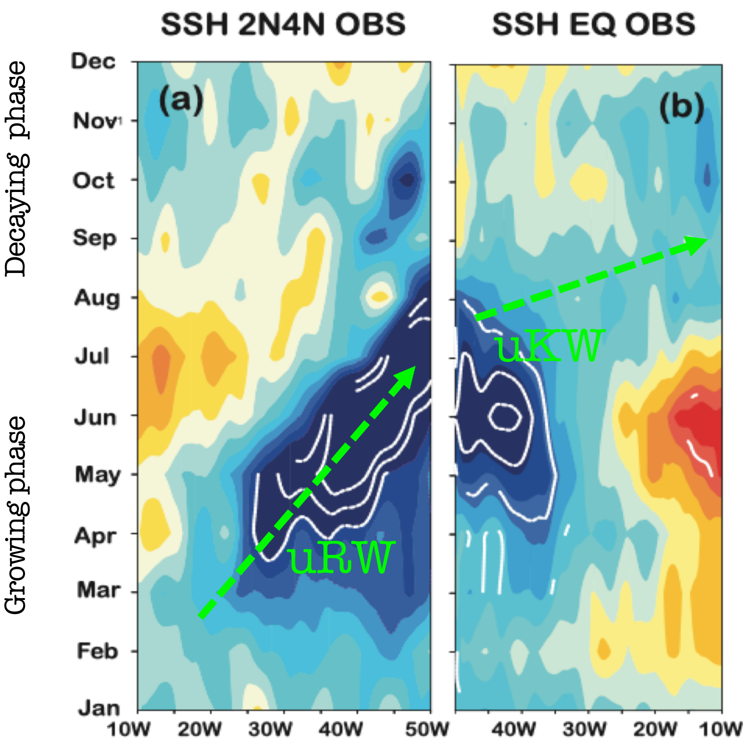
Dots: significant values at 90%

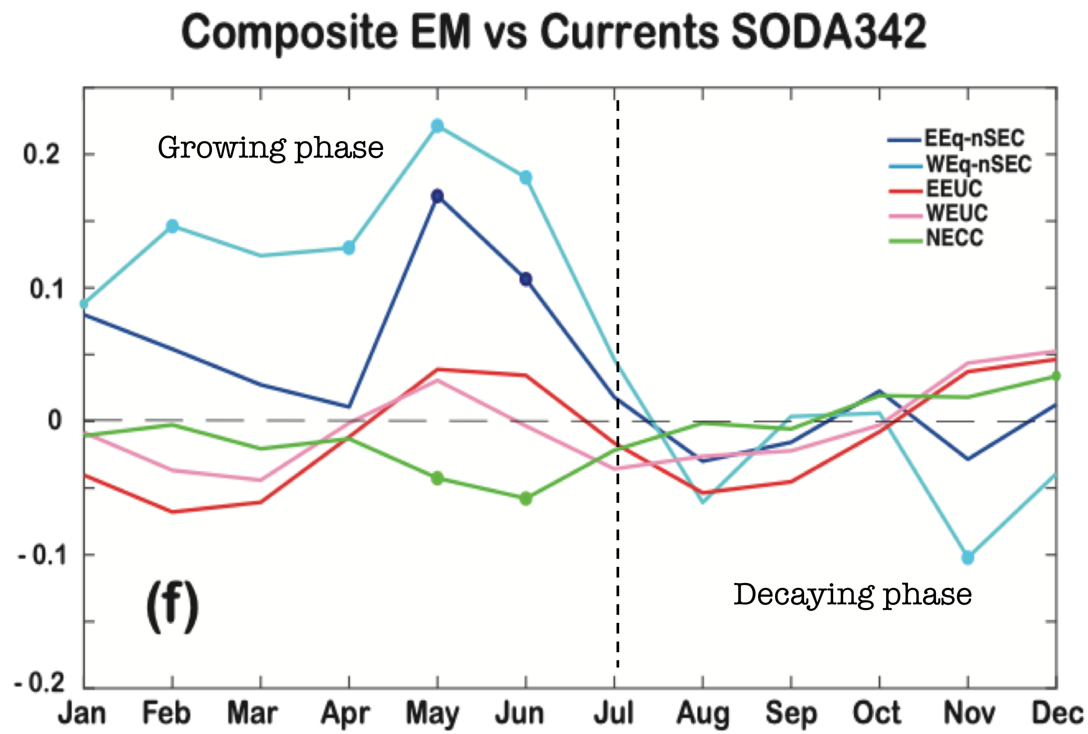
Equatorial Mode



Developing phase:

- **NECC** weakened
- **E-nSEC** and **W-nSEC** weakened
- **E-EUC** and **W-EUC** weakened



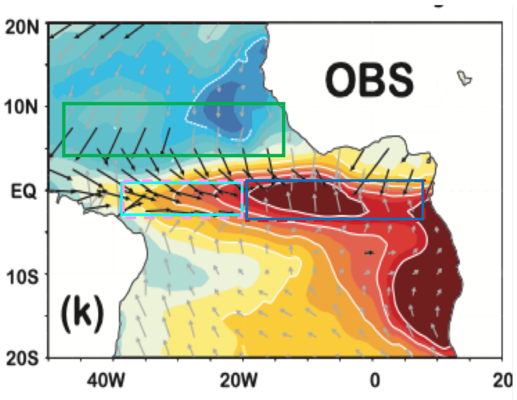


NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

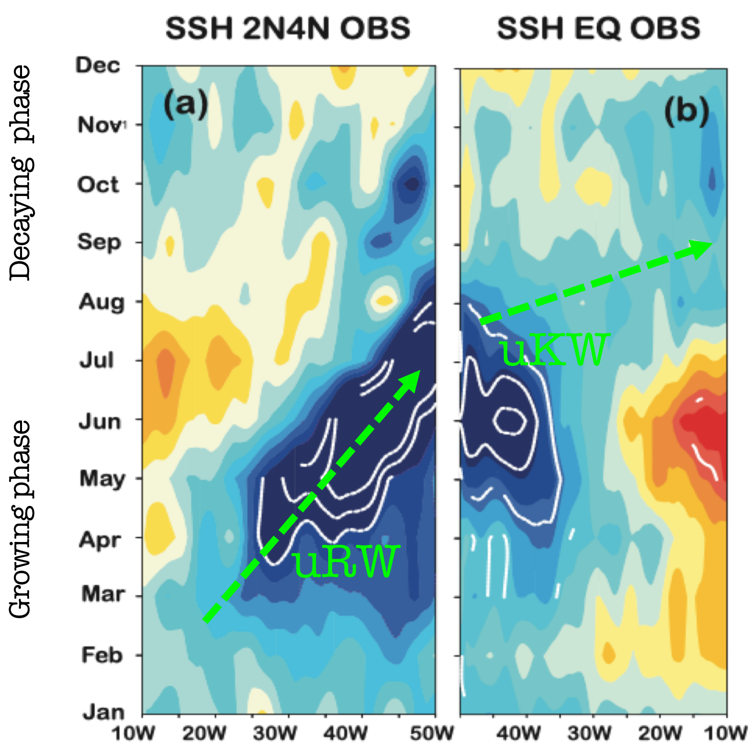
Dots: significant values at 90%

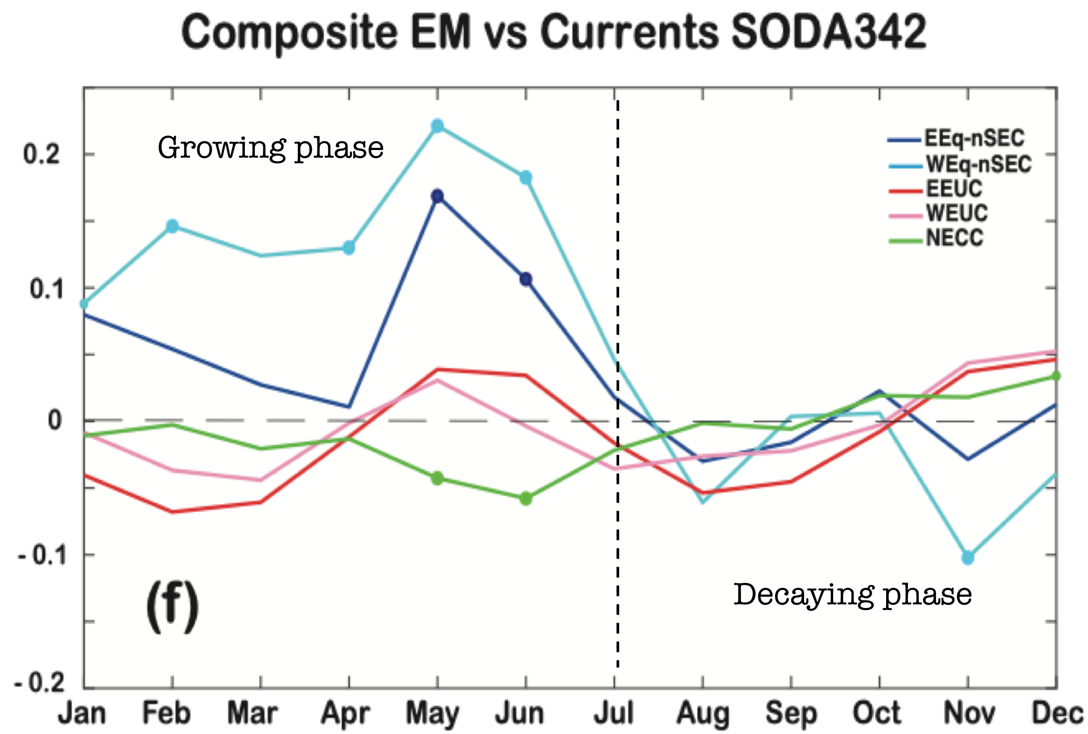
Equatorial Mode



Decaying phase:

- **NECC** tends to zero



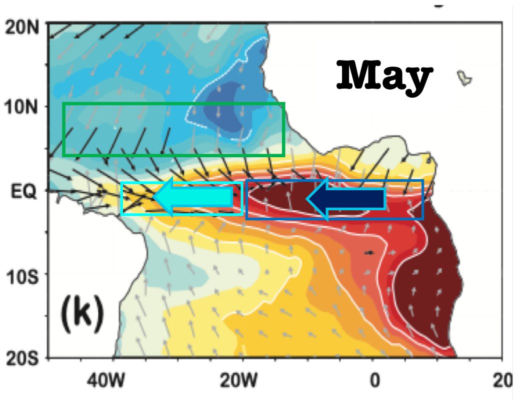


NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

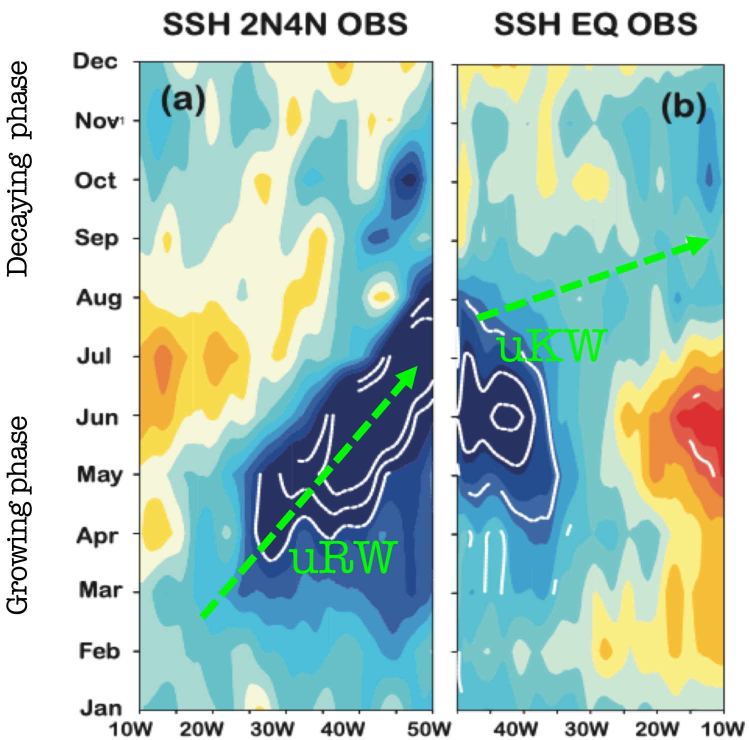
Dots: significant values at 90%

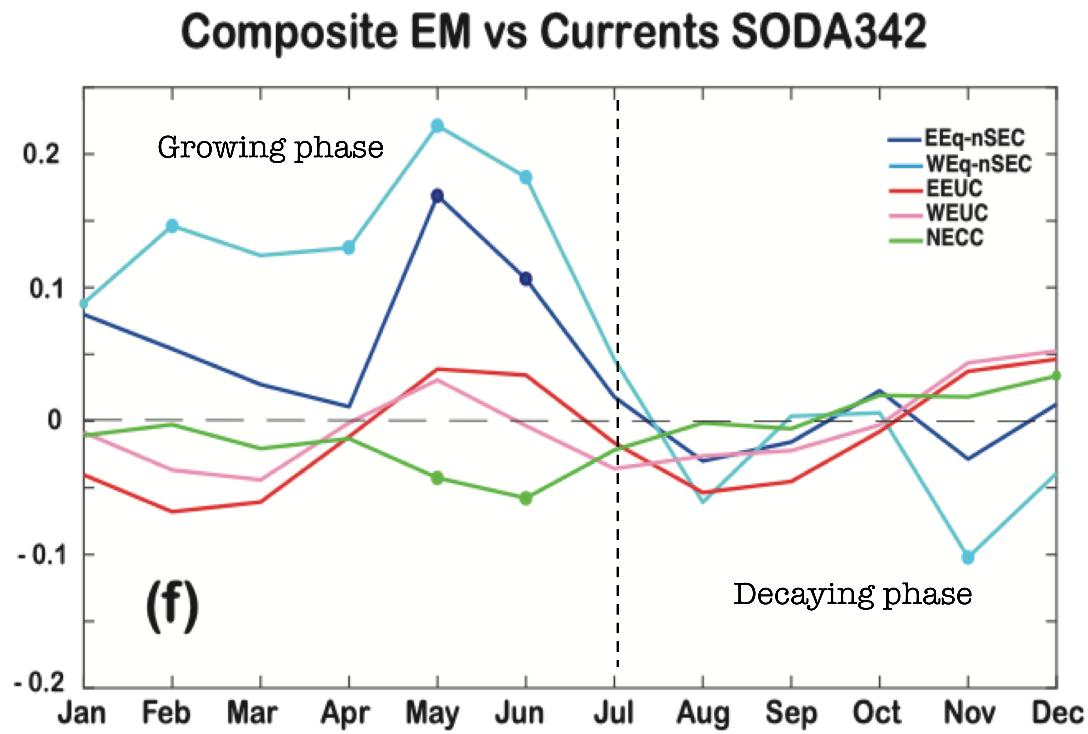
Equatorial Mode



Decaying phase:

- **NECC** tends to zero
- **E-nSEC** and **W-nSEC** reinforced



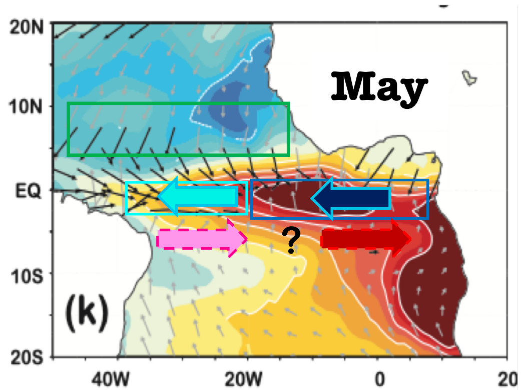


NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

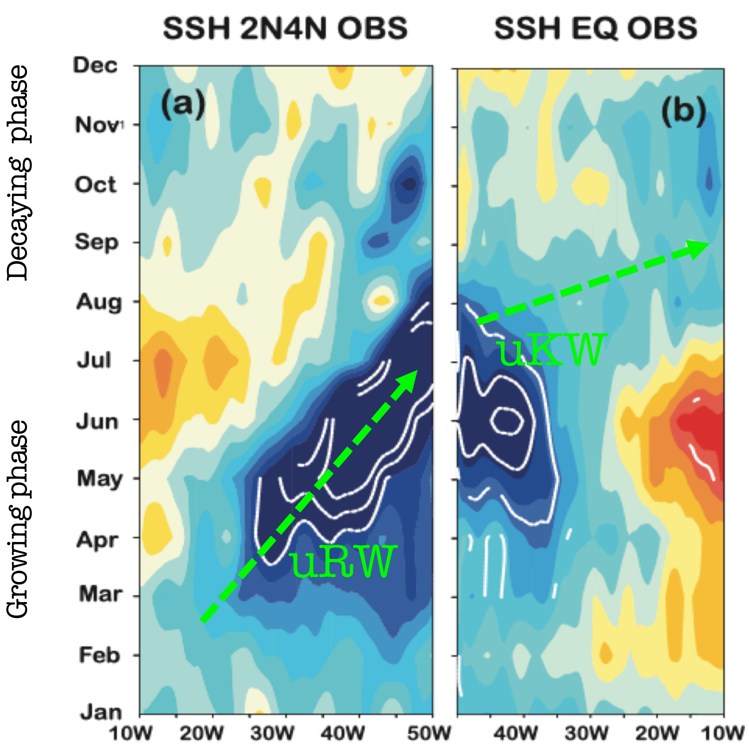
Dots: significant values at 90%

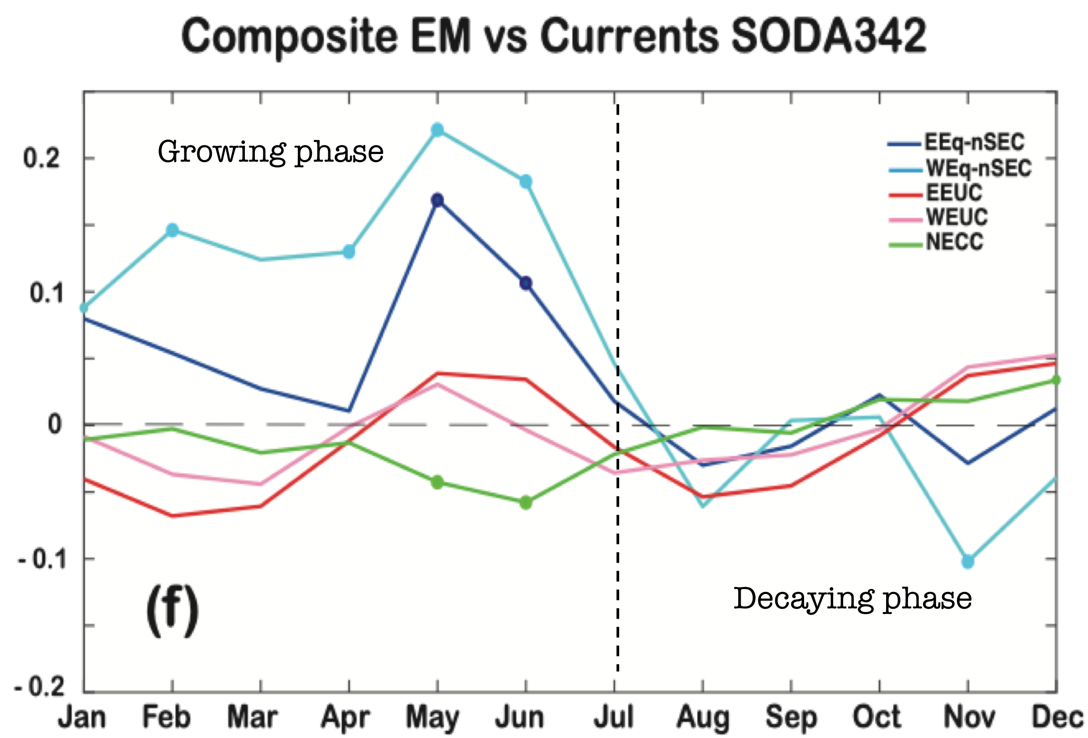
Equatorial Mode



Decaying phase:

- **NECC** tends to zero
- **E-nSEC** and **W-nSEC** reinforced
- **E-EUC** and **W-EUC** reinforced (discrepancies between datasets)





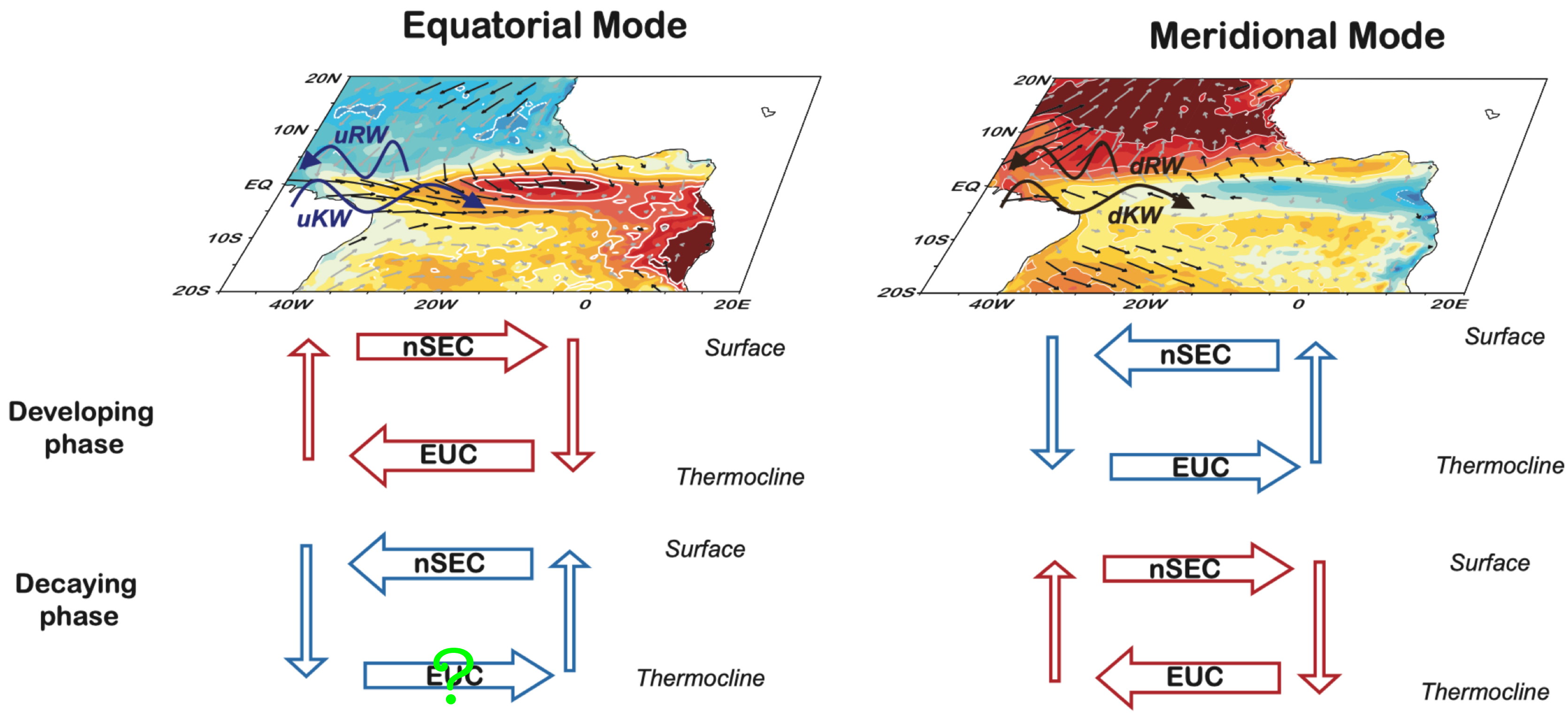
NECC **W-nSEC** **E-nSEC** **WEUC** **EEUC**

Units: cm/s

Dots: significant values at 90%

Conclusions

The emergence of MM and EM alters the surface and subsurface ocean circulation via the propagation of oceanic waves.



Not only the RW-reflected mechanism but also additional local and remote forcings contribute to EUC variability (Brandt et al. 2011; Richter et al. 2013)

Martín-Rey M , I Vallès-Casanova and JL Pelegrí (2022). Response of the upper ocean circulation to tropical Atlantic interannual modes (under review)

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