Easterly waves in the East Pacific during OTREC 2019 field campaign

L. Huaman, E. Maloney, C. Schumacher and G. N. Kiladis

East Pacific Intertropical convergence zone (ITCZ)

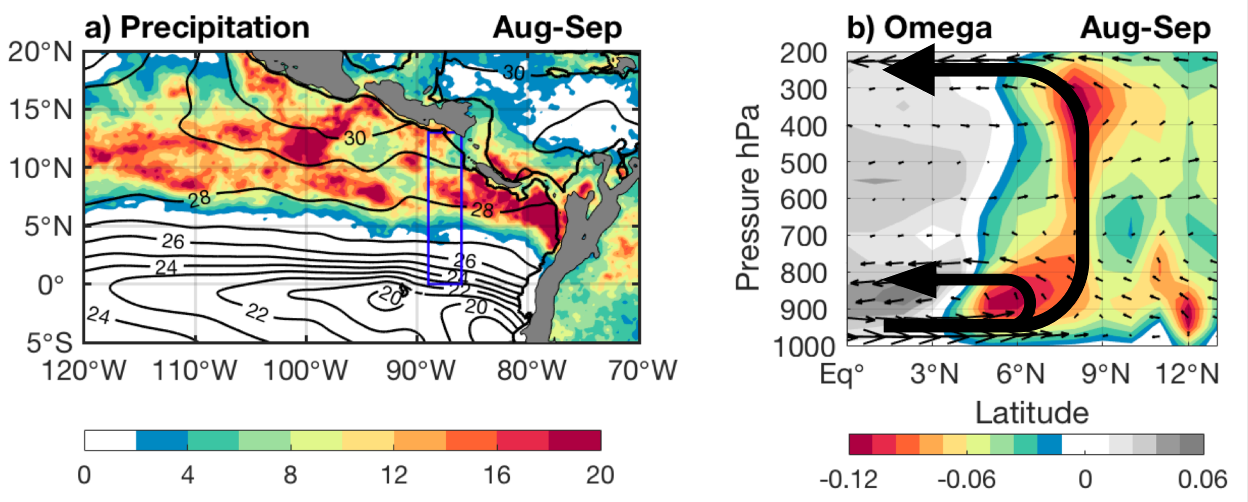
Synoptic Scales
Easterly waves (2-10 days)

Easterly waves (EWs) are prominent synoptic features in the ITCZ

Dominguez et al. (2020)
- EWs produce up to 50% of seasonal rainfall over the far East Pacific

Serra et al. (2008)
- Westward phase speeds of 11.3–13.6 m/s
- Maximum meridional wind anomalies at about 600 hPa

Large Scale
August-September 2019



- ITCZ located around 9°N over the warm pool
- Strong meridional SST gradient drives low-level convergence around 6°N (Lindzen and Nigam 1987, Zhang et al. 2004)

Main question:

How do Easterly waves interact with and modify the shallow and deep meridional circulations seen in the climatology over the east Pacific ITCZ?

Data:

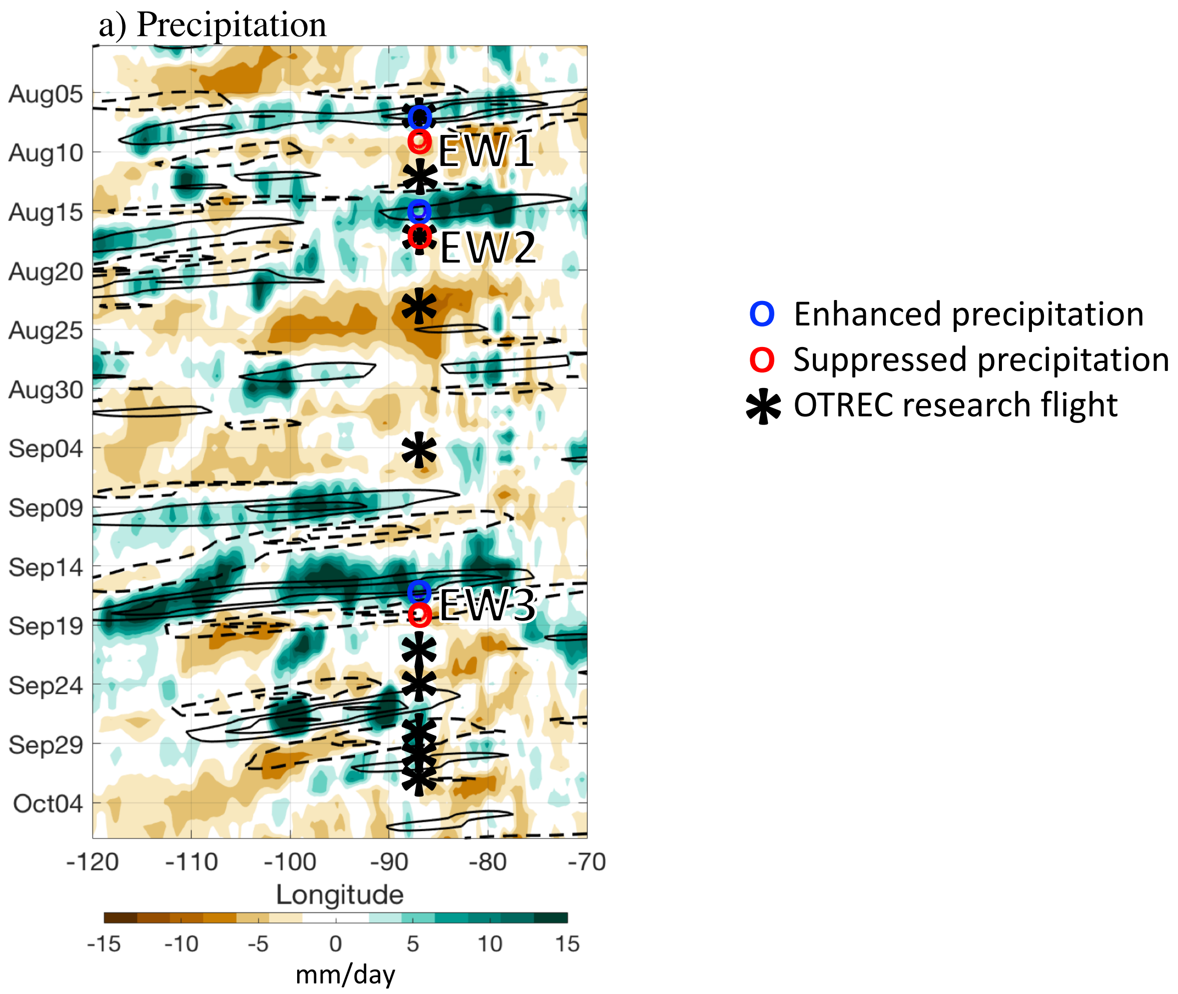
August 4th – October 2nd , 2019

- **OTREC** field campaign: dropsondes, Hiaper Cloud radar, Santa Cruz radiosondes
- **ERA5**: winds, temperature, humidity (Res. 0.28 ° x 0.28 °, regrided to 1° x 1°)
- **IMERG**: surface precipitation (Res. 0.25° x 0.25°)

Identification of Easterly Waves (EWs) during OTREC

Anomalies at 89°- 86°W, 3°- 11°N (OTREC Pacific box)

TD band (Frank and Roundy 2006) in contours
Wavenumber: -20 to 0
Period: 2.5 to 10 days



- Precipitation, vorticity and meridional winds suggest at least **3 EWs** during OTREC: 08/07, 08/15 and 09/16

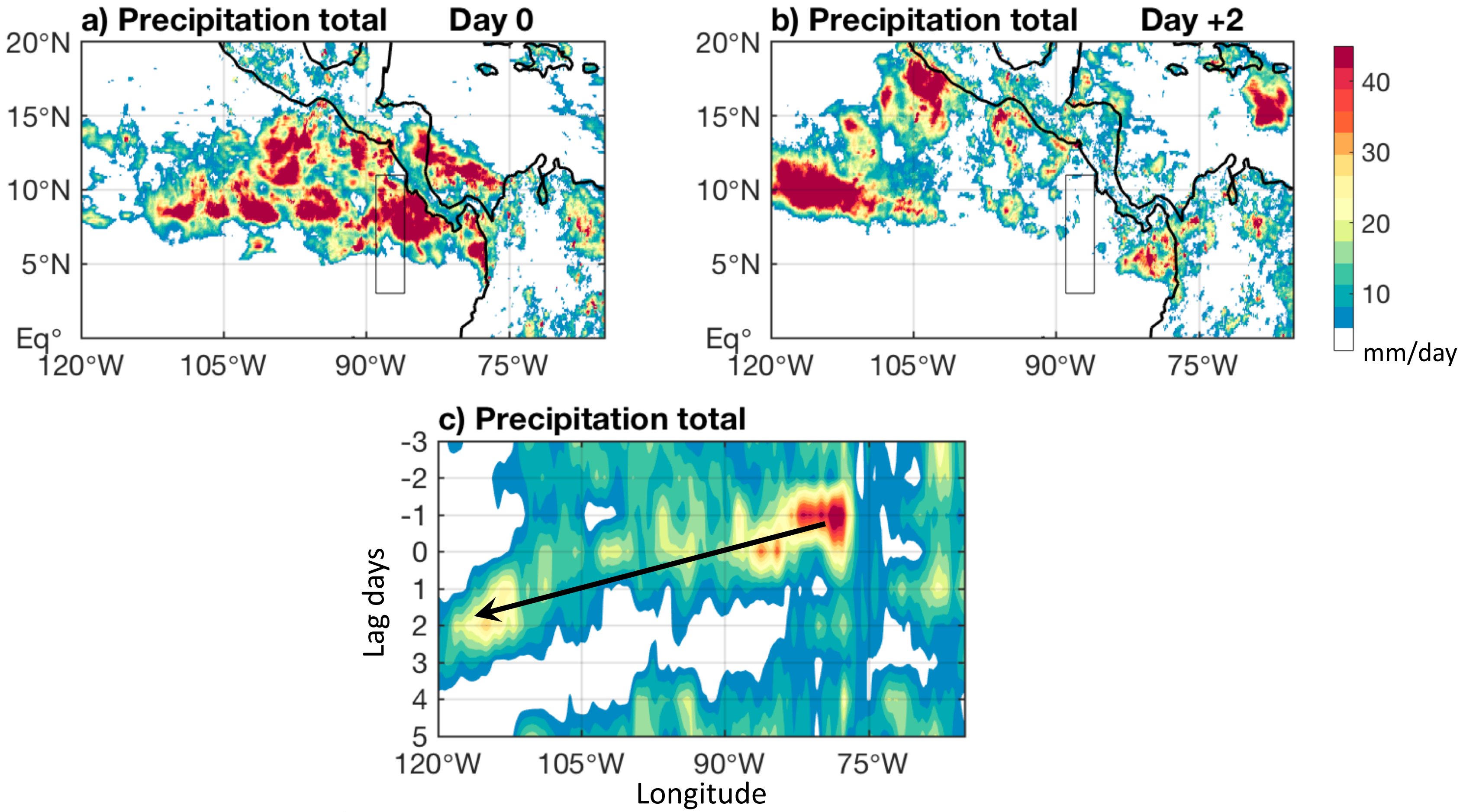
- Suppressed precipitation occurs two days after the enhanced precipitation

Horizontal and vertical structure of EWs using IMERG and ERA5

3 EWs average

Positive phase (+EW)
Enhanced precipitation

Negative phase (-EW)
Suppressed precipitation



EW zonal phase speed is 11.5 m/s

Horizontal and vertical structure of EWs using IMERG and ERA5

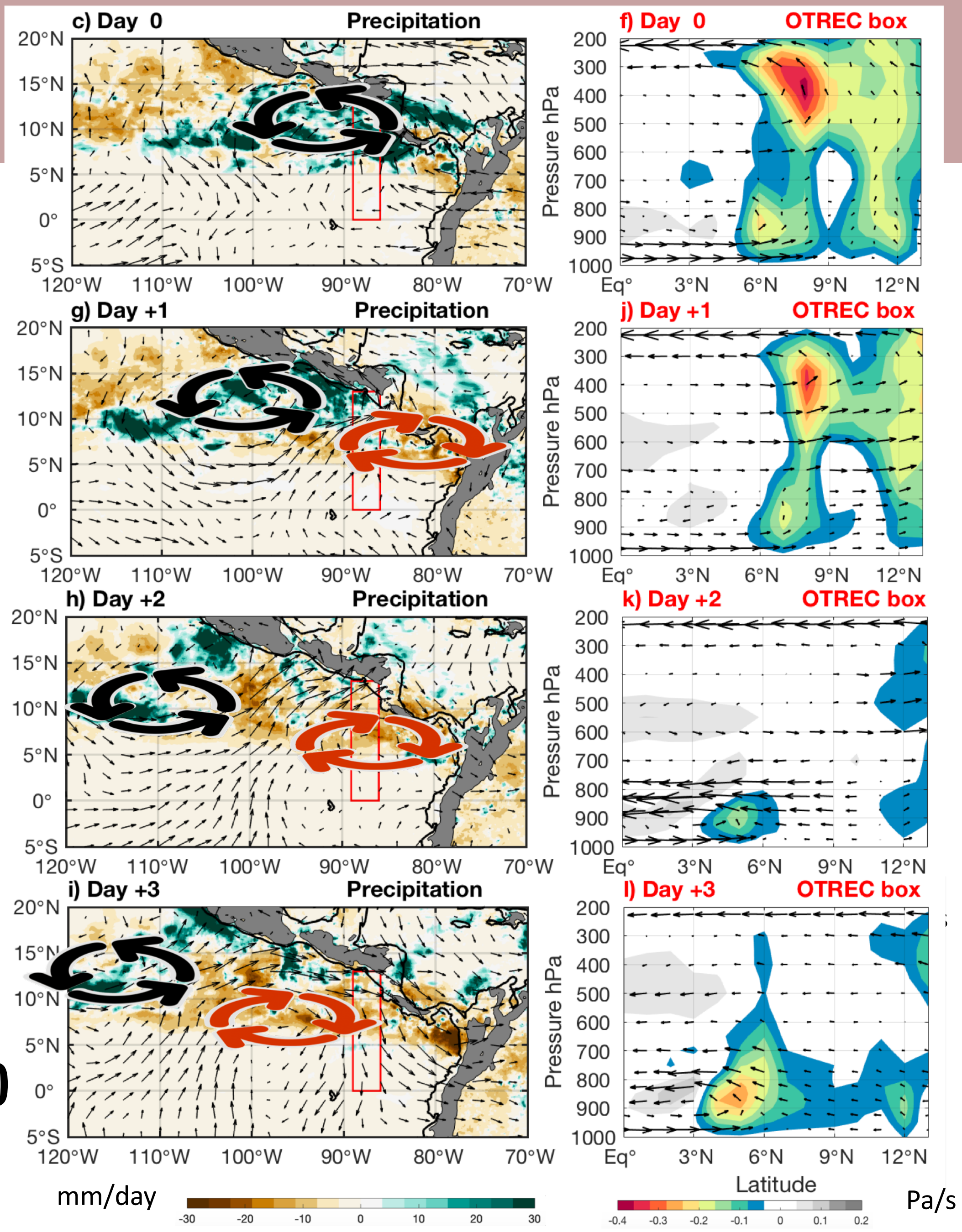
Day 0:
- Convection (+EW) around 90°W, deep circulation over the OTREC box

Day +1:
- Convection (+EW) around 100°W

Day +2:
- Convection (+EW) around 110°W, suppressed convection over the OTREC box and muted deep circulation
- Strong shallow circulation at 4°N

Day +3:
- Convection (+EW) around 115°W, suppressed convection over the OTREC box and muted deep circulation
- Strong shallow circulation and convection at 4°N

✓ **EW oriented southwest-northeast (Serra et al. 2008)**
✓ **Similar structure for the 3 individual events**



Impacts in the shallow and deep meridional circulation

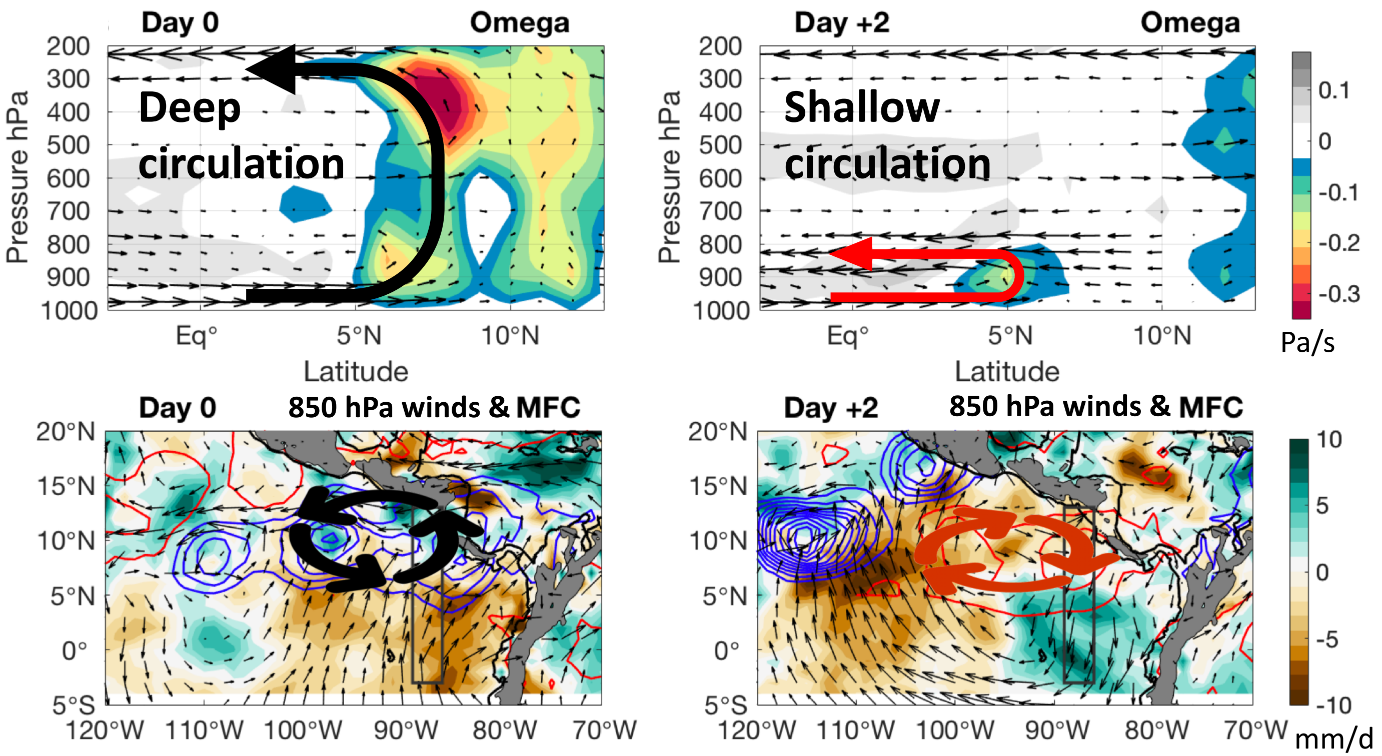
Day 0 (+EW):

- **Strong deep circulation** in the ITCZ associated with positive MFC convergence
- **Muted shallow circulation**

Day +2 (-EW):

- The meridional overturning circulation at 850 hPa is part of the EW horizontal structure
- **Suppressed deep circulation** and convection in the ITCZ axis associated with negative MFC convergence
- Positive MCF advection in the south of the ITCZ may **enhance shallow circulation** and convection

✓ **Similar structure for the 3 individual events**



Moisture flux convergence (MFC) vertically integrated

$$\text{MFC} = -\nabla \cdot (q\mathbf{V}_h) = -\mathbf{V}_h \cdot \nabla q - q\nabla \cdot \mathbf{V}_h ,$$

$$\text{MFC} = \underbrace{-u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y}}_{\text{advection term}} \underbrace{-q\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)}_{\text{convergence term}} .$$

advection term (Shaded)

convergence term (Contours)
Blue: + values
Red: - values

Impacts in the shallow and deep meridional circulation

OTREC Research flight (RF) during Easterly waves

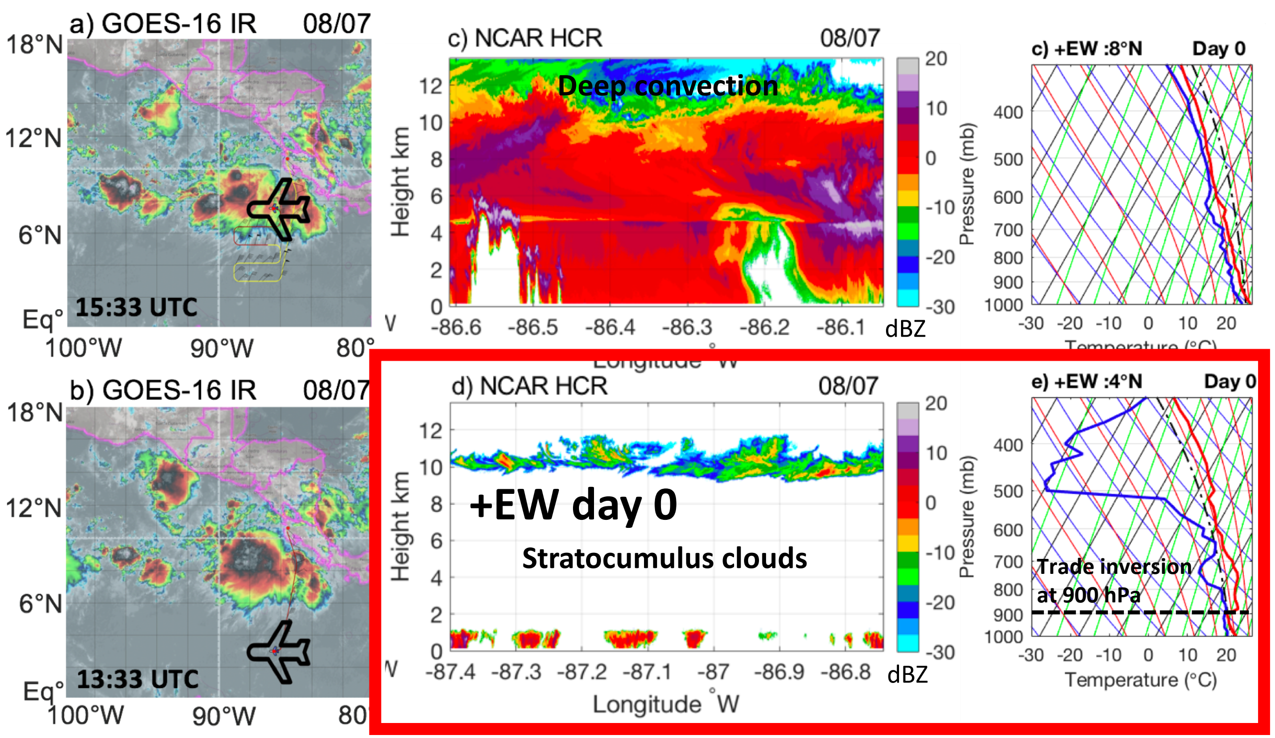
RF 1: 08/07 (enhanced convection +EW)

- Shallow stratocumulus clouds below 1km/900 hPa

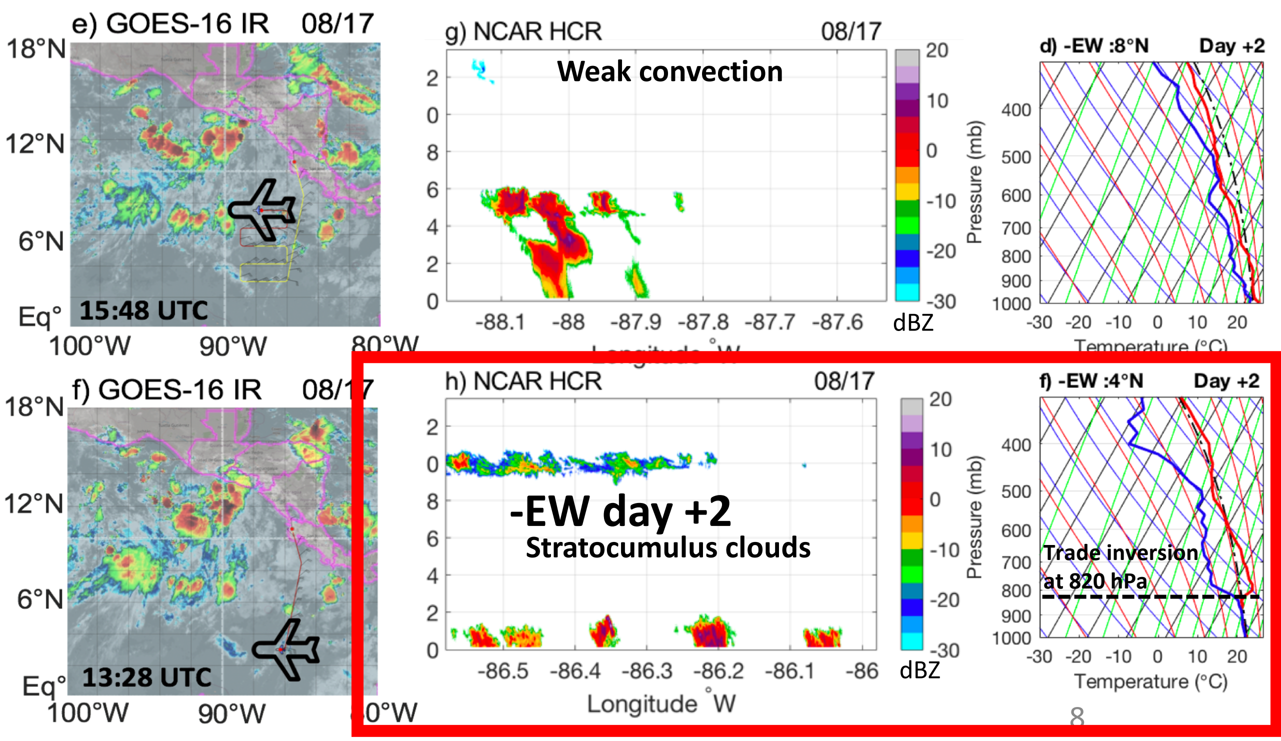
RF 5: 08/17 (suppressed convection -EW)

- Some shallow structures in the southern part of the OTREC box below 1.5 km/850 hPa

GOES 16 IR | **HCR radar** | **Dropsondes**



GOES 16 IR | **HCR radar** | **Dropsondes**



Impacts in the shallow and deep meridional circulation

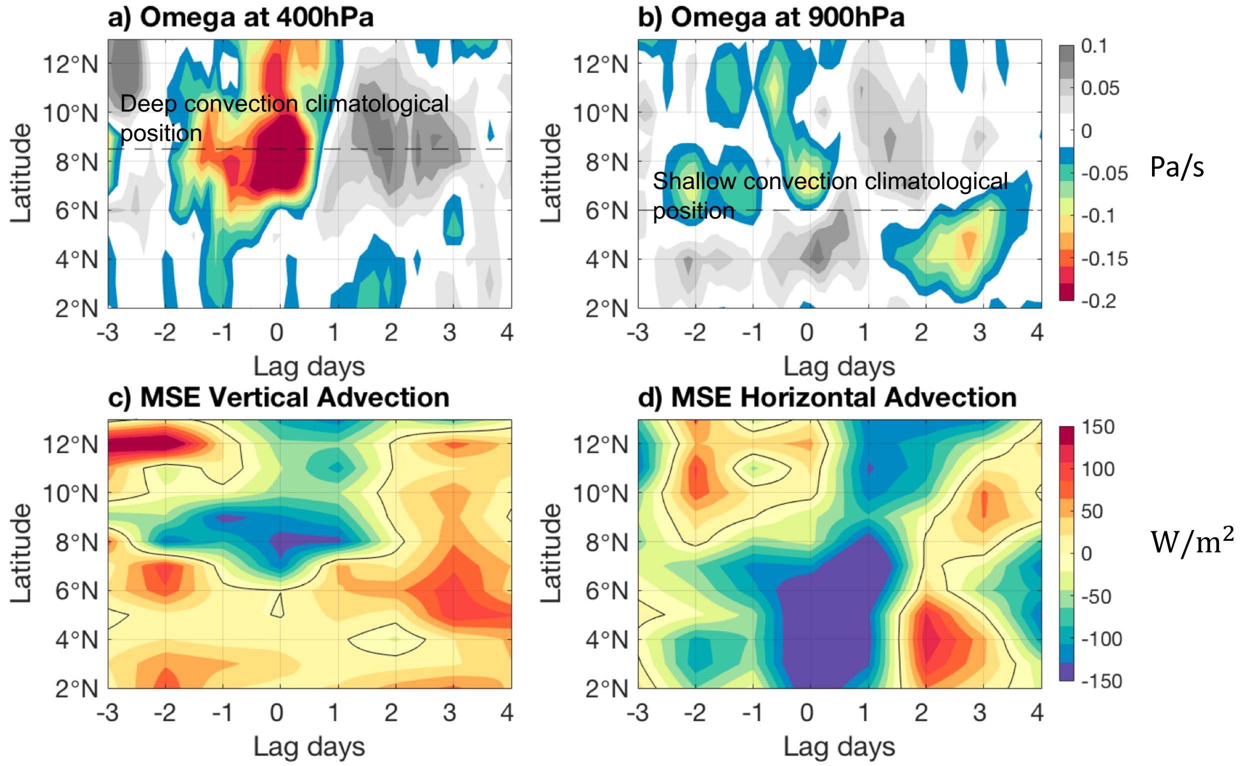
The moist static energy (MSE) provides an idea of the shape of the vertical motion profile in the ITCZ (Back and Bretherton 2006)

Deep Convection (9°N) at day 0:

- Export of MSE (top-heavy ITCZ)
- Negative horizontal advection of MSE

Shallow convection (5°N) at day +2 and +3:

- Import of MSE (bottom-heavy ITCZ)
- Positive horizontal advection of MSE



Conclusions

The climatological deep and shallow circulations are modified during the passage of Easterly waves in the East Pacific:

- The convective part of the EW enhances deep circulation at day 0 and is associated with the export of MSE and MFC convergence
- The suppressed part of the EW enhances the shallow circulation at day +2. The shallow overturning flow at 850 hPa is linked to the anticyclonic circulation of the EW. The MFC advection and import of MSE drive shallow convection over the southern part of the ITCZ