A case study of coastal El Niño event in early 2017

110 - Persistent heavy rains from January to March over the northwestern part of South America -

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1. Introduction

Japan Meteorological Agency (JMA) issued a climate monitoring report in April 2017, regarding the persistent heavy rains from January to March over the northwestern part of South America (Fig. 1.). According to the official report, floods and landslides due to heavy rains in the region caused totally hundreds of fatalities in Colombia and Peru.

This widespread and persistent rainfall is supposed to be led by the strong coastal El Niño, which seems to be a rare phenomenon (2nd time since 1925) that sea surface temperature (SST) becomes far warmer than normal off the northwestern coast of South America but unlike normal El Niño, SST is not so warm in the central to eastern part of the equatorial Pacific (e.g. Takahashi et al. 2017, Fig. 2., Fig. 3.(a)).

We investigated how such SST anomalies were maintained, and evaluated the relationship between the atmospheric circulation and the heavy rains during this coastal El Niño event.

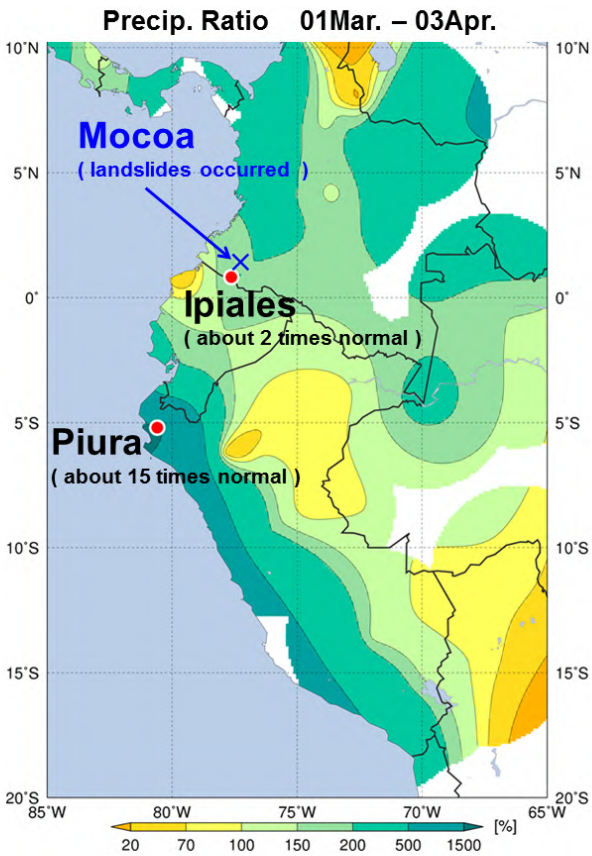


Fig. 1. Precipitation ratio in and around northwestern part of South America from 01Mar to 03Apr 2017.

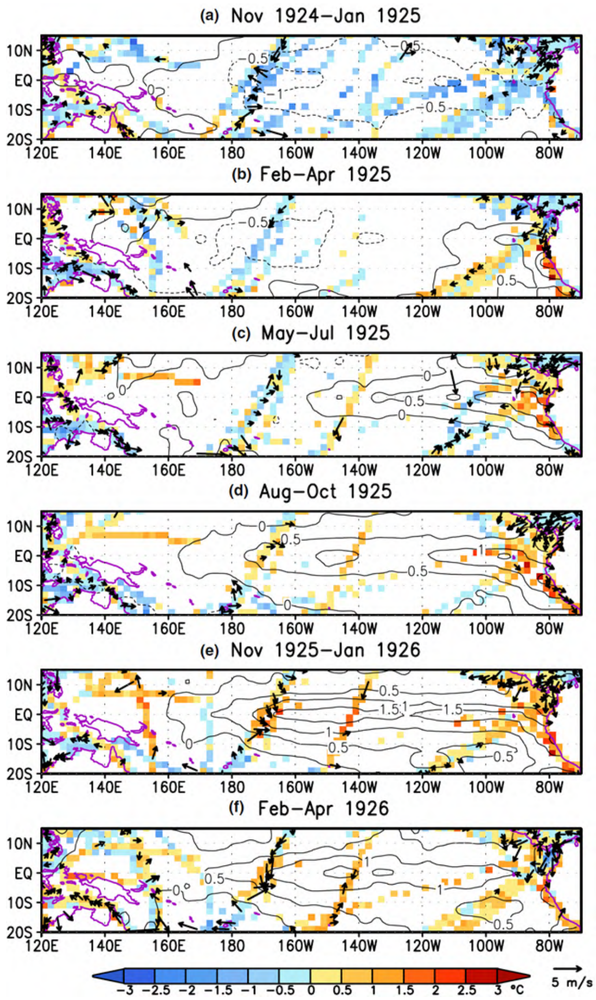


Fig. 2. Seasonal mean SST [°C] and surface wind vectors anomalies from ICOADS in and around 1925. Also shown is the SST anomaly reconstruction HadISST 1.1 (contours). Anomaly is defined as deviation from the normal defined as the average during the period from 1920 to 1939. From Takahashi et al. 2017.

2. Data

The data we used for Jan.-Mar. 2017 (JFM2017) were as follows.

- SYNOP messages received via GTS were used to calculate precipitation amount.
- To infer convective activities, we used outgoing longwave radiation (OLR) data provided by NOAA.
- COBE-SST dataset (Ishii et al. 2005) was used to diagnose SST.
- MOVE/MRI.COM-G2 global ocean dataset (Toyoda et al. 2013) was used to diagnose temperature and current in the ocean.

Climatological "normal" was defined as the 30-year average during the period from 1981 to 2010, and "anomalies" were defined as deviations from the normal.

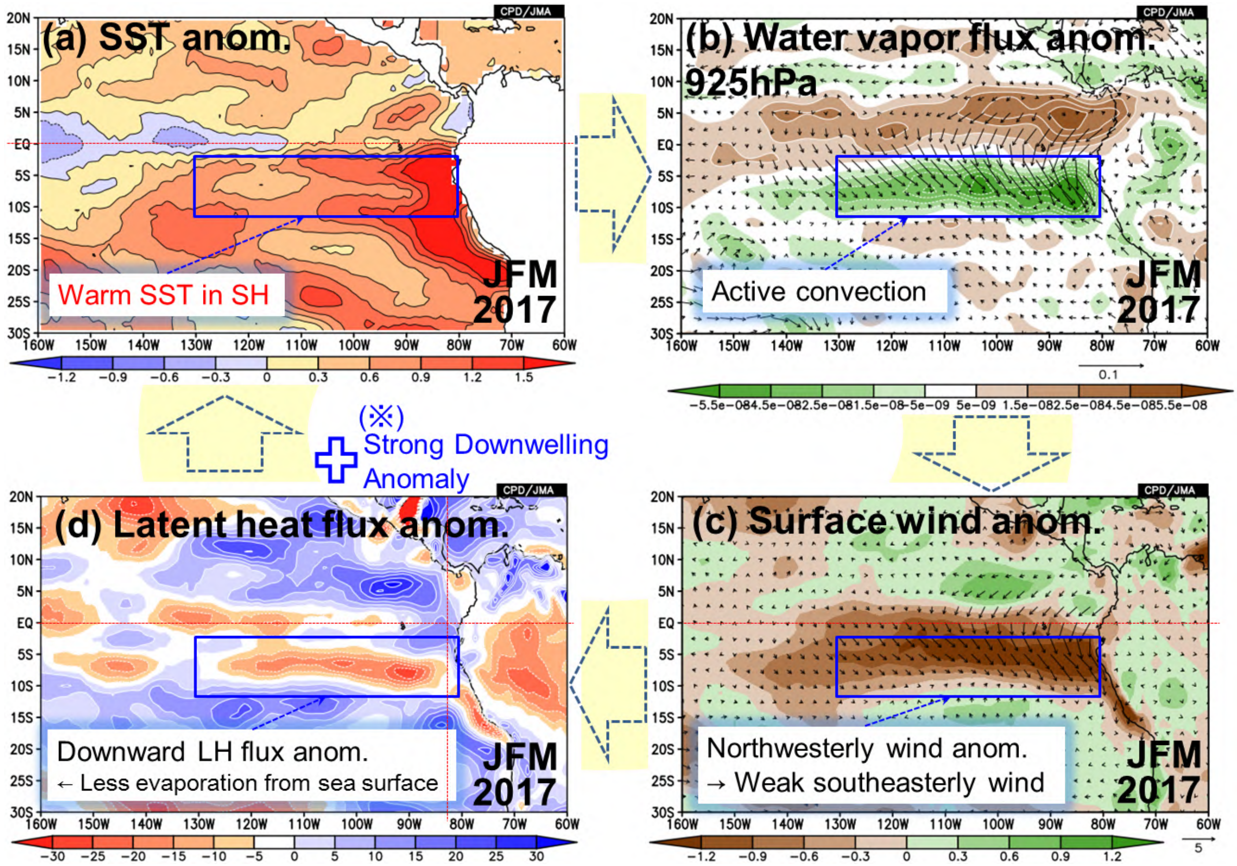
3. Results of analysis

3.1 Atmospheric circulations and SSTs in JFM2017

Fig. 3.(a) shows that SSTs near the coast of Peru were significantly higher than normal in JFM2017.

In the tropics, there exists an approximate threshold SST for the activation of deep convection (e.g. Xie and Philander 1994, Xie 1996). About one month earlier than usual, SSTs near the coast of Peru became warmer than about 27°C in mid-January (Fig. 4.), which were favorable for active convection. Since then, the strong coastal El Niño persisted until early April.

The reason why high SSTs and active convection continued can be considered from Fig. 3.(a)-(d) as follows.



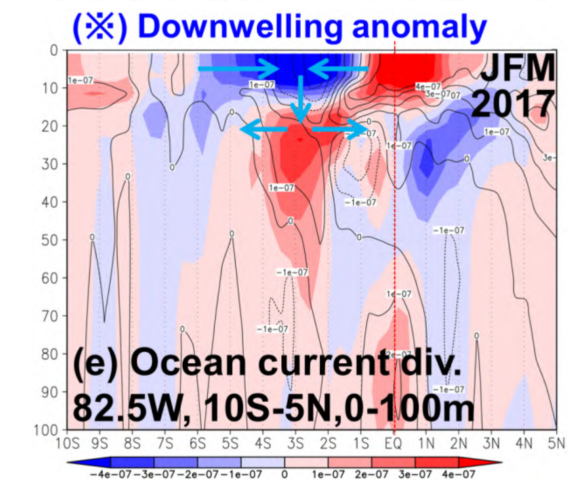


Fig. 3. (a) SST [°C], (b) Water vapor flux at 925hPa [kg/kg m/s] and its divergence [kg/kg/s],
(c) Surface wind and wind speed [m/s], (d) Latent heat flux [W/m^2] , anomaly in JFM2017.
(e) Ocean current divergence [s^{-1}] (contour) and its anomaly (shade) along 82.5W in JFM2017.

After SSTs became warmer than about 27°C, active convection induced northwesterly wind anomalies (Fig. 3.(b)), which weakened trade winds in part of the eastern equatorial Pacific in the Southern Hemisphere (Fig. 3.(c)). Weak trade winds suppressed the evaporation from the sea surface (Fig. 3.(d)) -- i.e., latent heat flux from the sea surface were weakened, which in turn kept the SST warmer-than-normal (Fig. 3.(a)). This positive wind-evaporation-SST (WES) feedback (Xie and Philander 1994, Xie 1996) mainly maintained the high SSTs and active convection, which led the widespread and persistent rainfall over the northwestern part of South America. Downwelling (or weak upwelling) in the ocean surface layer close to the coast of Peru also contributed to the high SST

(Fig. 3.(e)).

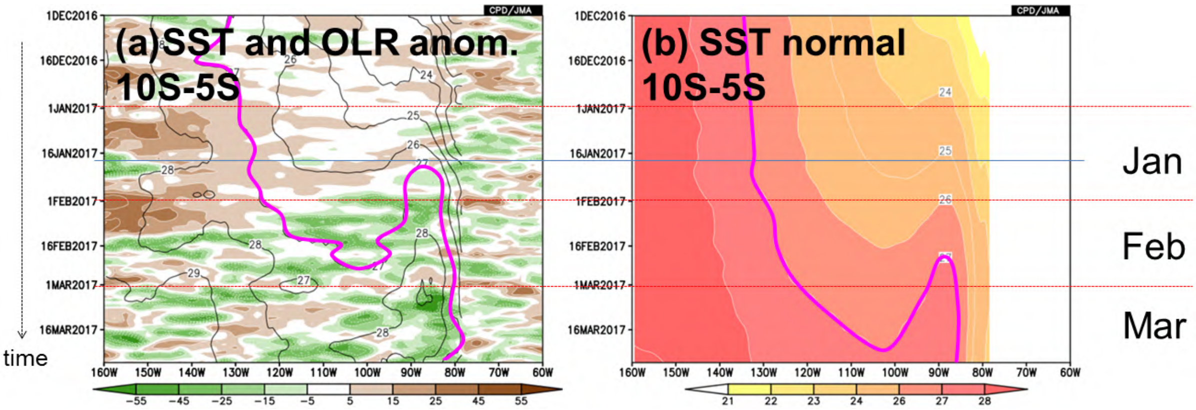


Fig. 4. Time-Longitude cross section of (a) SST [°C] (contour) and OLR anomaly [W/m2] (shade) in JFM2017, (b) SST [°C] normal in JFM, averaged over 10S-5S. Pink lines show 27°C.

3.2 Statistical analysis

We calculated precipitation amount using SYNOP messages in and around Peru from 1997 to 2017(Fig. 5.). Precipitation over Peru in JFM2017 was the 3rd largest since 1997 after 2012, 1998 (a strong ENSO year).

Here we show the regressions of SST and OLR onto the precipitation over Peru in JFM from 1997 to 2017(Fig. 6.). Precipitation amount over Peru in JFM seems to have associations with the warmer-than-normal SST near the northwestern coast of South America and the enhanced convective activities over the eastern equatorial Pacific, which is consistent with the SST and OLR analysis data in 2017.

4. Summary and future tasks

We tried to understand the maintenance mechanism of the coastal El Niño in early 2017, which led widespread and persistent rainfall over the northwestern part of South America.

It was maintained by WES feedback (rather than Bjerknes feedback) after SSTs became warmer than about 27°C about one month earlier than usual. Downwelling (or weak upwelling) close to the coast of Peru also contributed.

From statistical analysis, we showed that precipitation amount over Peru in JFM seems to have associations with the warmer-than-normal SST near the northwestern coast of South America and the enhanced convective activities over the eastern

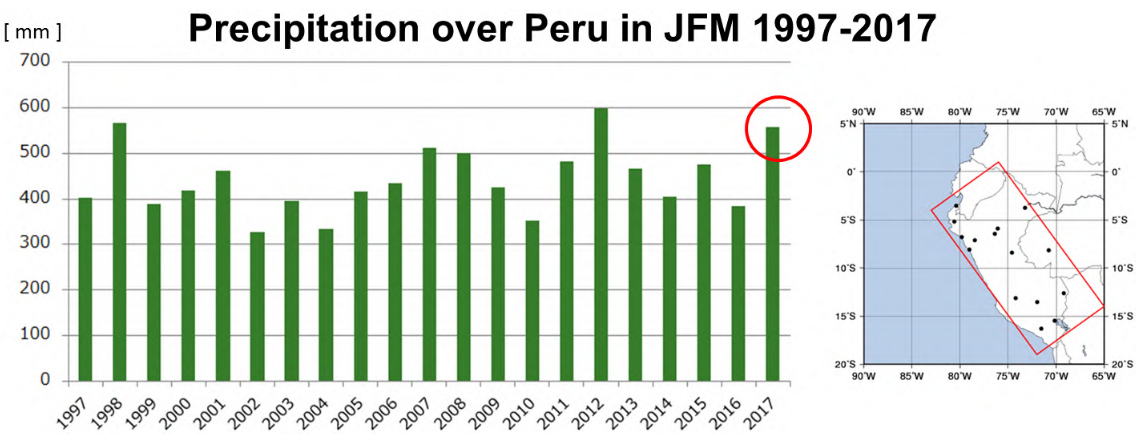


Fig. 5. Precipitation amount over Peru in JFM 1997-2017 using SYNOP messages

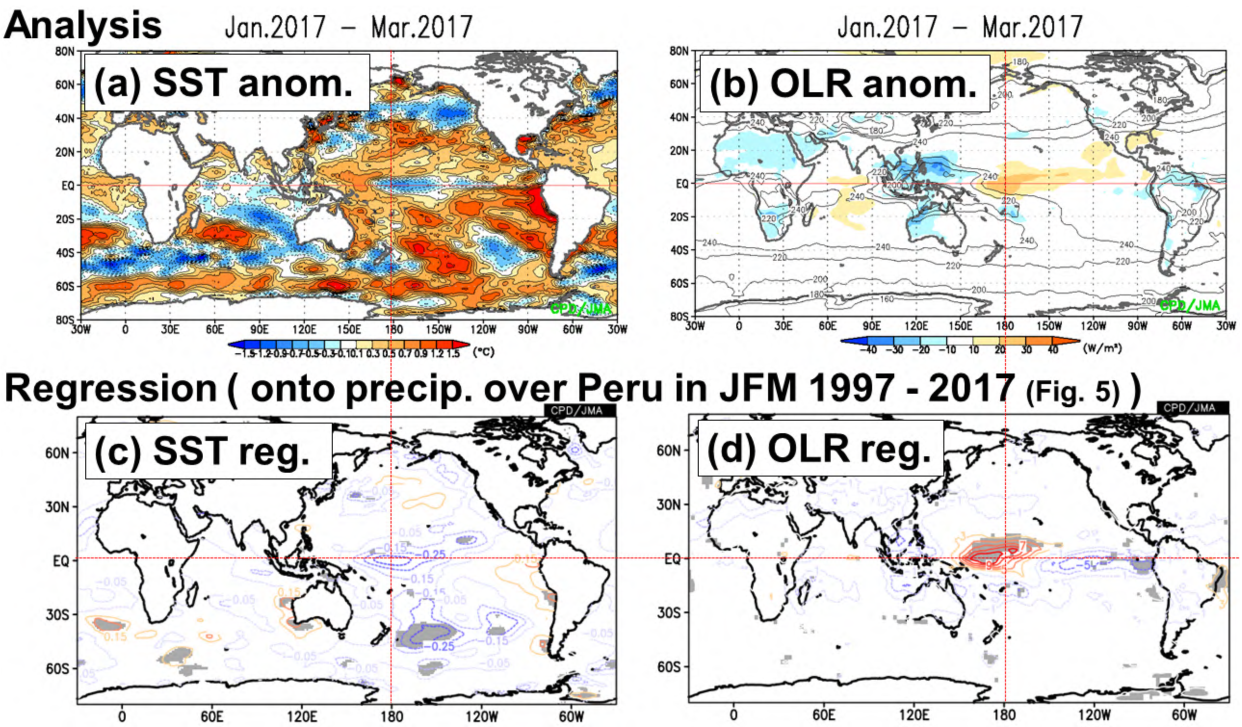


Fig. 6. (a), (b): Analysis of (a) SST [℃], (b) OLR anomaly [W/m2] in JFM2017.
(c), (d): Regression of (c) SST, (d) OLR onto precipitation over Peru in JFM from 1997 to 2017.
Areas exceeding the significance level (95%, one side) are shaded in gray.

equatorial Pacific. However, we also showed that precipitation amount over Peru in JFM seems to have associations with the cooler-than-normal SST and the suppressed convective activities near the dateline in the equatorial Pacific, which is also consistent with the SST and OLR analysis data in 2017 (Fig. 6.). Takahashi et al. (2017) also showed that the annual mean Piura river discharge seems to have associations with the cooler-than-normal SST near (or west of) the dateline in the tropical Pacific. We think that investigation on the relation between the precipitation amount over Peru and the negative SST anomaly near dateline is a subject for the future.

References

Ishii, M., A. Shouji, S. Sugimoto, and T. Matsumoto, 2005: Objective Analyses of Sea-Surface Temperature and Marine Meteorological Variables for the 20th Century using ICOADS and the Kobe Collection. Int. J. Climatol., 25, 865-879.

Kobayashi, S. et al., 2015: The JRA-55 Reanalysis: General specifications and basic characteristics. J. Meteor. Soc. Japan., 93, 5-48.

Takahashi, K., and A. G. Martinez, 2017: The very strong coastal El Niño in 1925 in the far-eastern Pacific. Climate Dynamics. https://doi.org/10.1007/s00382-017-3702-1

Toyoda, T., Y. Fujii, T. Yasuda, N. Usui, T. Iwao, T. Kuragano, and M. Kamachi, 2013: Improved analysis of seasonal-interannual fields using a global ocean data assimilation system. Theoretical and Applied Mechanics Japan, 61, 31-48.

Xie, S. -P., 1996: Westward propagation of latitudinal asymmetry in a coupled ocean-atmosphere model. Journal of Atmospheric Science 53: 3236-3250.

Xie, S. -P., and S. G. H. Philander, 1994: A coupled ocean-atmosphere model of relevance to the ITCZ in the eastern Pacific. Tellus 46A: 340-350.