FINAL REPORT PROGRAM LEFE

Program LEFE/ CHAT	Étude de la turbulence petite échelle et ozone dans la TTL à l'aide de mesures radar et ballon.	**Years 2015 – 2017**

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Context: The stratospheric-tropospheric exchanges are of primary importance in the equatorial atmosphere, but the contribution of small-scale turbulence generated by, e.g., Kelvin wave breaking is still poorly known. Concurrent observations from clear air radars and radiosondes were expected to provide new insights.

Objectives / scientific questions: The LEFE program funded various types of radiosondes utilized during a field campaign at the EAR Observatory (Kototabang, Indonesia) in December 2015. The purpose was to evaluate the performances of new methods for studying turbulence and its impact on vertical ozone distribution in the tropical tropopause layer (TTL) with a VHF radar and radiosondes.

Main results: A field campaign was carried out from 03 Dec to 13 December 2015. The so-called VHF (47 MHz) EAR radar was operating in various modes of observations for different projects conducted by several laboratories. We applied a range imaging technique using frequency diversity for high range resolution. For this occasion, we refined the data processing for improving the results obtained from this observational mode. We processed all the data collected during the campaign (10 days) (Figure 1) and we estimated various atmospheric parameters (vertical and horizontal winds, wind shears, vertical velocity of precipitations, stability, spectral width broadening due to turbulence, etc). The stability parameters derived from radiosondes revealed that the radar echoes in range imaging mode were mainly due to thin stable layers in the TTL during the campaign. No significant turbulence event was detected in the TTL despite clear evidence of propagating Kelvin waves (see Figure 2), believed to be one of the major sources of turbulence through wave breaking. Contrary to several previous studies (e.g., Fujiwara et al., 2003; Mega et al., 2010), the amplitude of the Kelvin wave at the altitude of 15-16 km was rather small during the experiment (a few m/s instead of a few tens of m/s). The zonal wind anomaly was smaller than the intrinsic zonal phase speed, preventing breaking at a critical level. Therefore, the possible ubiquity of Kelvin waves does not ensure strong turbulence events in the TTL and the occurrence of these events is still largely unknown.
In addition, the performance of the radar was not enough for retrieving some atmospheric parameters in the TTL due to the lack of sensitivity in absence of turbulence. The analyses could not permit us to validate the methods developed in the past for estimating turbulence parameters from the combination of radiosonde and radar data. However, the campaign provided unique data. They are being used for a quantitative estimation of the performance of the range imaging technique (not validated from independent observations with EAR until now) and for studying the small-scale stratification (temperature gradient sheets) in the TTL in presence of Kelvin waves.

Figure 1

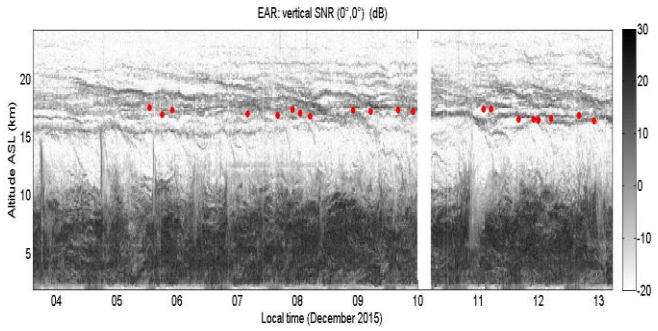

Figure 2

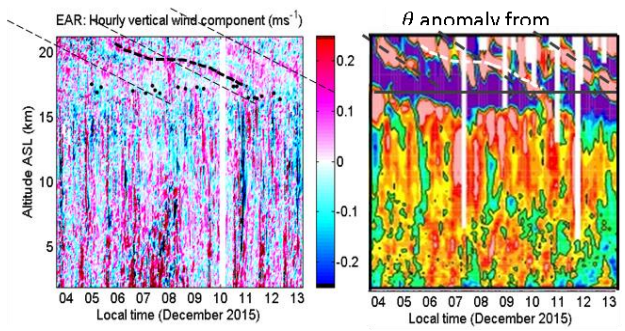

Figure 1: Height-time cross-section of signal to noise ratio (SNR) at vertical incidence measured by EAR during the whole observation campaign. The red dots indicate the altitudes of the cold point tropopause (CPT) according to the radiosondes launched at the radar site. The layers of enhanced echoes above ~15 km were due to partial reflection from thin stable layers associated with weak turbulence. The absence of "tropopause jump", as shown, e.g., by Fujiwara et al. (2003) is one of the numerous clues indicating the absence of Kelvin wave breaking during the campaign.

Figure 2: (Left) Radar image of vertical velocity W (m/s) in the troposphere and in the TTL. CPT is shown by the black dots. (Right): Potential temperature θ anomalies obtained from radiosondes. The W and θ anomalies in the TTL reveal features consistent with a propagating Kelvin wave.

Future of the project: The project was expected to be a first exploratory campaign in Indonesia in the context of the Strateole (LMD) project devoted to TTL dynamics and chemistry. In addition to relatively unfruitful results, the burdensome procedures for getting visa in Indonesia (in principle, two weeks on site in addition to a long pre-qualification via Internet before the departure) can discourage the best will.

Nombre de publications, de communications et de thèses
(citer au maximum 5 publications en lien direct avec le projet)

(communication) :

H. Luce, *Radar and in situ observations in the TTL*, Humanosphere Science School (HSS), Medan, North Sumatra, October 18-19, 2018. (website for the meeting organized in 2017: http://situs.opi.lipi.go.id/hss2017/)