

README file for TICOSONDE SO₂ archive

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ABSTRACT: This archive includes data and pdf profile plots for ozone (O₃) and derived sulfur dioxide (SO₂) from dual-sonde launches by the NASA Ticosonde project at the Universidad de Costa Rica. Included are the initial launch on 3 February 2012 and the ongoing series of dual sonde launches that commenced on 26 July 2013 up through the launch on 9 September 2019. This dataset now comprises 69 launches.

All data files follow the SHADOZ data format and were prepared by Ticosonde Co-I Dr. Gary Morris of St. Edwards University from TICOSONDE data files produced by the STRATO ozonesonde flight processing software of Co-I Dr. Holger Vömel of the NCAR Earth Observations Laboratory.

INTRODUCTION

The Ticosonde project of water vapor-ozone and ozone balloon soundings in Costa Rica commenced in July 2005 and is ongoing. In February 2012, a successful demonstration was made of the dual sounding technique [Morris *et al.*, 2010] to measure SO₂ emissions from nearby Turrialba Volcano; regular dual soundings commenced the following year. It is these dual soundings which are archived here.* Morris *et al.* [2018] provide a summary of the dual-sonde measurement of SO₂ in Costa Rica from 2012 – 2017 including comparisons of SO₂ columns with satellite overpass data.

MEASUREMENT AND LAUNCH DETAILS

The dual-sonde balloon payloads used by Ticosonde are comprised of a pair of ECC ozone sondes and an Intermet IMet-1-RSB radiosonde. One of the two ozone sondes measures the ambient airstream. If that

* Users interested in TICOSONDE water vapor soundings and ozone soundings alone can find those respective data files archived at the Network for Detection of Atmospheric Composition Change (NDACC, <http://www.ndsc.ncep.noaa.gov/data/>) and in the SHADOZ archive at World Ozone and Ultraviolet Radiation Data Center (WOUDC, <http://woudc.org>).

air stream contains SO₂, the instrument reports [O₃] – [SO₂] for all [SO₂] < [O₃] and 0 for [SO₂] ≥ [O₃]. A filter that scrubs SO₂ but passes O₃ is installed at the inlet of the other sonde, which thus measures [O₃]. The SO₂ mixing ratio is then derived from the difference of the two reported ECC “ozone” measurements.

Since early 2011, Ticosonde launches have been made from CICANUM GasLab on the research campus of the Universidad de Costa Rica (UCR) in San Pedro. The dual sondes are released by the GasLab staff under the direction of Ticosonde Co-I Dr. Jorge Andrés Díaz. The UCR team also prepares the sonde payload and delivers the data to Dr. Vömel and Dr. Morris for processing immediately post-flight.

Given the priority given to validation for these soundings, the Ticosonde project has tried to launch the dual sondes when there is both a high likelihood of encountering a volcanic SO₂ plume and obtaining a profile within the field of view of either OMI on Aura, OMPS on Suomi NPP or TROPOMI on Sentinel 5P. Through late 2017, priority was given to validation of OMI retrievals, and validation opportunities were severely limited by the spread of the OMI row anomaly. With the advent of TROPOMI, this limitation on usable overpasses was removed.

FILE FORMAT: The columns in the data files correspond to the following variables and units

Time	sec	Elapsed time
Press	hPa	Ambient pressure
Alt,	km	Geopotential altitude
Temp	°C	Ambient temperature
RH	%	Radiosonde ambient relative humidity over liquid water
O3	mPa,	Ozone partial pressure
O3	ppmv	Ozone mixing ratio
O3	Dobson units	Ozone column density
W Dir	degrees	Wind direction
W Spd	ms ⁻¹	Wind speed
T pump	°C	Ozonesonde pump temperature
I O3	µA	Ozonesonde sensor current
SO2	ppbv	Sulfur dioxide mixing ratio
GPS Lon	degrees	GPS Longitude
GPS Lat	degrees	GPS Latitude
GPS Alt	km	GPS Altitude

TICOSONDE PARTNERS

Since its inception in 2004, Ticosonde has been a collaborative effort between NASA and partners in Costa Rica and Germany including the Universidad Nacional Autónoma (UNA), the Universidad de Costa Rica (UCR), the Instituto Meteorológico Nacional (IMN), the Centro Nacional de Alta Tecnología (CeNAT),

all in Costa Rica, and the Lindenberg Observatory of the Deutscher Wetterdienst. In the United States, the Ticosonde is a partnership between the Universities Space Research Association, the NASA Goddard Space Flight Center, the National Center for Atmospheric Research, St. Edwards University, the NOAA Environmental Sciences Research Laboratory, the Cooperative Institute for Research in Environmental Sciences at the University of Colorado, and NASA Ames Research Center and Valparaiso University. Financial support for Ticosonde at NASA has been provided by the Upper Atmospheric Research Program, the Aura science program, and the Radiation Sciences Program.

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