

**The 19th Meeting of the IHO North Indian Ocean Hydrographic Commission (NIOHC)
to be held in Muscat, Oman on 25-28 March 2019**

http://www.iho.int/mtg_docs/rhc/NIOHC/NIOHC19/NIOHC19.htm

Agenda Item 24: Maritime Disasters Experience

**Report on the Intergovernmental Coordination Group for the Indian Ocean Tsunami
Warning and Mitigation System (ICG/IOTWMS)**

*Yuelong Miao, Chair ICG/IOTWMS Working Group 2 on Tsunami Detection, Warning and
Dissemination, and
Manager of Tsunami and Storm Surge, Australian Bureau of Meteorology*

*Srinivasa Kumar Tummala, Head of the Indian Ocean Tsunami Warning and Mitigation
System (IOTWMS) Secretariat*

UNESCO/IOC Indian Ocean Tsunami Warning and Mitigation System (IOTWMS)

1 Status

Following the 26 December 2004 tsunami, which killed over 230,000 people, displaced more than 1 million people and left a trail of destruction around the coasts of the Indian Ocean, the coastal nations of the Indian Ocean decided to design and implement an early warning system for the region and requested the Intergovernmental Oceanographic Commission (IOC) of UNESCO to form an Intergovernmental Coordination Group (ICG) for the Indian Ocean Tsunami Warning and Mitigation System (IOTWMS). This was formally established by Resolution XXIII-12 at the IOC Assembly in Paris, in June 2005 and a secretariat was established to provide administrative support and to coordinate the activities of the ICG/IOTWMS. The secretariat of the ICG/IOTWMS is hosted and supported by the Government of Australia at the IOC-UNESCO Perth Regional Programme Office located in the offices of the Bureau of Meteorology in Perth.

The IOTWMS is a fully integrated end-to-end warning system built on three pillars: tsunami risk assessment and mitigation; tsunami detection, warning and dissemination; and tsunami awareness and response. After several years of international collaboration and development, facilitated and coordinated by IOC-UNESCO, the IOTWMS became operational on 31st March 2013 with Tsunami Service Providers (TSPs) established by Australia, India and Indonesia providing independent tsunami advisory services to the Member States of the region. The TSPs now provide alerts to 28 Indian Ocean member states, reaching millions of people who had no access to such warnings way back in 2004.

Current and future work of the ICG/IOTWMS is focused towards system sustainment and enhancements, strengthening early warning in the North West Indian Ocean (Makran) region, as well as enhancing community awareness and response.

2 Coastal and Deep-Ocean Sea Level Data

The IOTWMS continues to rely on sea level data provided in real-time from coastal and deep-ocean sea level stations around the Indian Ocean to verify if a tsunami may have been generated by undersea earthquakes (see Figures 1 and 2). Not all earthquakes generate tsunamis, so it's vitally important (if time permits before arrival at the shore) to verify if a tsunami was generated and size of the tsunami before warnings are issued. This helps reduce the possibility of false alarms.

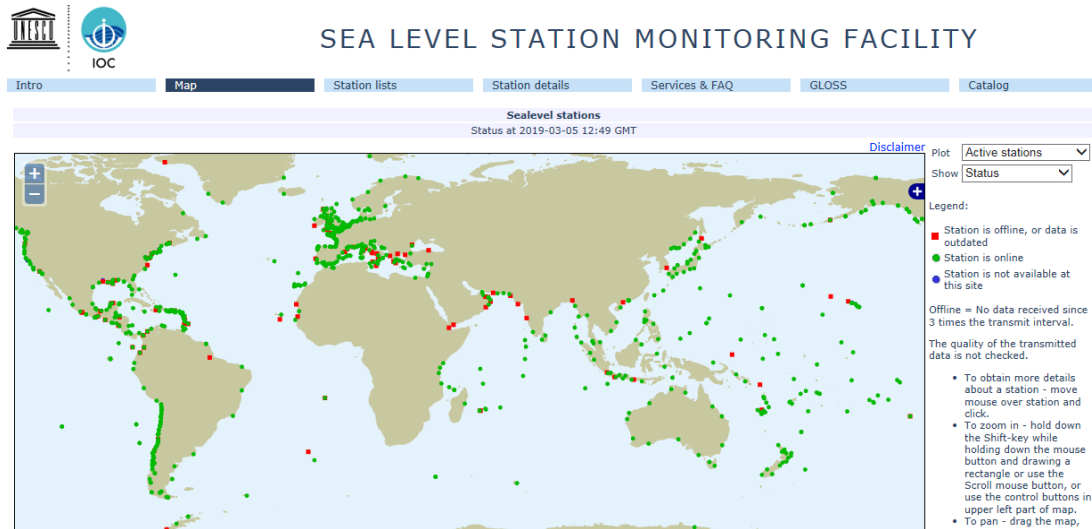


Figure 1: Coastal sea level stations reporting in real-time to TSPs and NTWCs on the Global Telecommunication System (GTS) of the World Meteorological Organisation (WMO as at 5 March 2019).

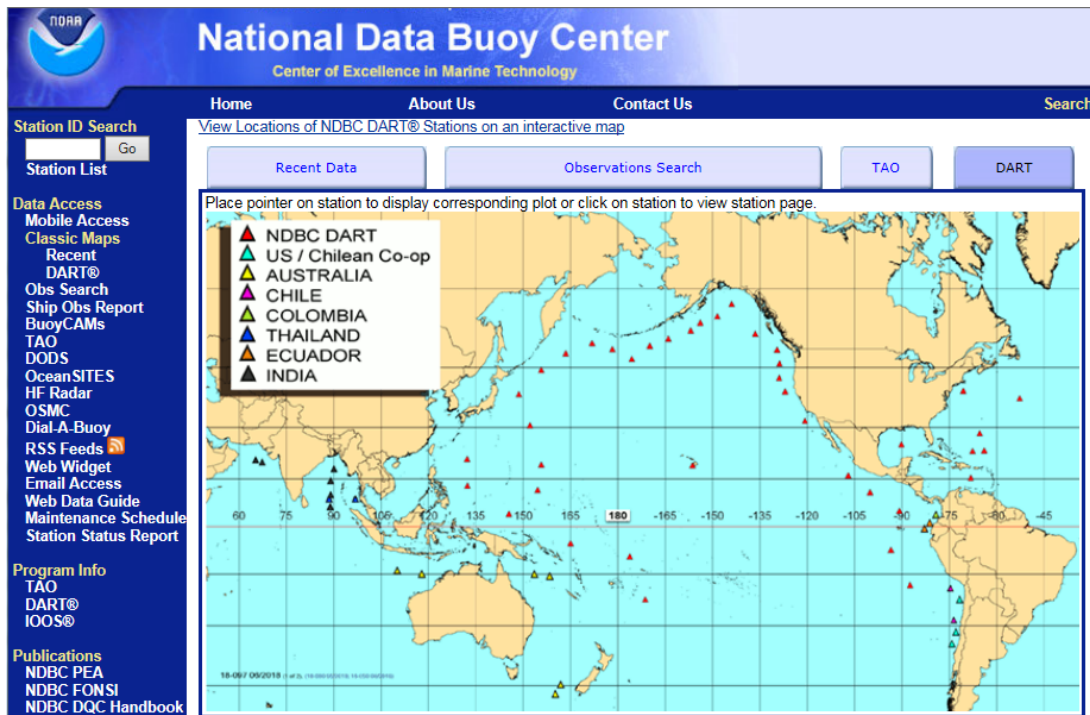


Figure 2: Locations of deep-ocean tsunami buoys providing critical sea level data in real-time to TSPs and NTWCs to assist tsunami warning decisions (as at 5 March 2019).

2.1 Greater Access to Tide Gauge Data in Real-Time to Support Tsunami Warnings

There still remains much more sea level information potentially available for assisting tsunami warning decisions than shown in Figure 1. This information is often collected with tide gauges by port and maritime authorities for shipping and navigation operations and not necessarily available in real-time to the Tsunami Service Providers. All port and maritime authorities are encouraged to make their sea level data available in real-time to ensure safety of maritime operations and minimise interruptions to trade routes. Please contact the UNESCO Intergovernmental Oceanographic Commission (IOC) Sea Level Station Monitoring Facility (info@ioc-sealevelmonitoring.org; copy sk.tummala@unesco.org) if you have sea level data you would like to share in real-time for tsunami warning purposes. Also note the sparse data around the east African coast and lower data density in some other areas.

2.2 Vandalism of Deep-Ocean Tsunami Monitoring Buoys

In general damaged ocean observing systems cause loss of critical ocean data, degraded forecasts of high seas and coastal weather, ocean temperature and currents for navigation and safe operation of vessels at sea. Damages can result in high cost of repair or replacement and undermine confidence in tsunami warning systems. This could result in significant loss of life and property, as well as costly evacuations and dangerous future complacency of communities in response to false tsunami warnings.

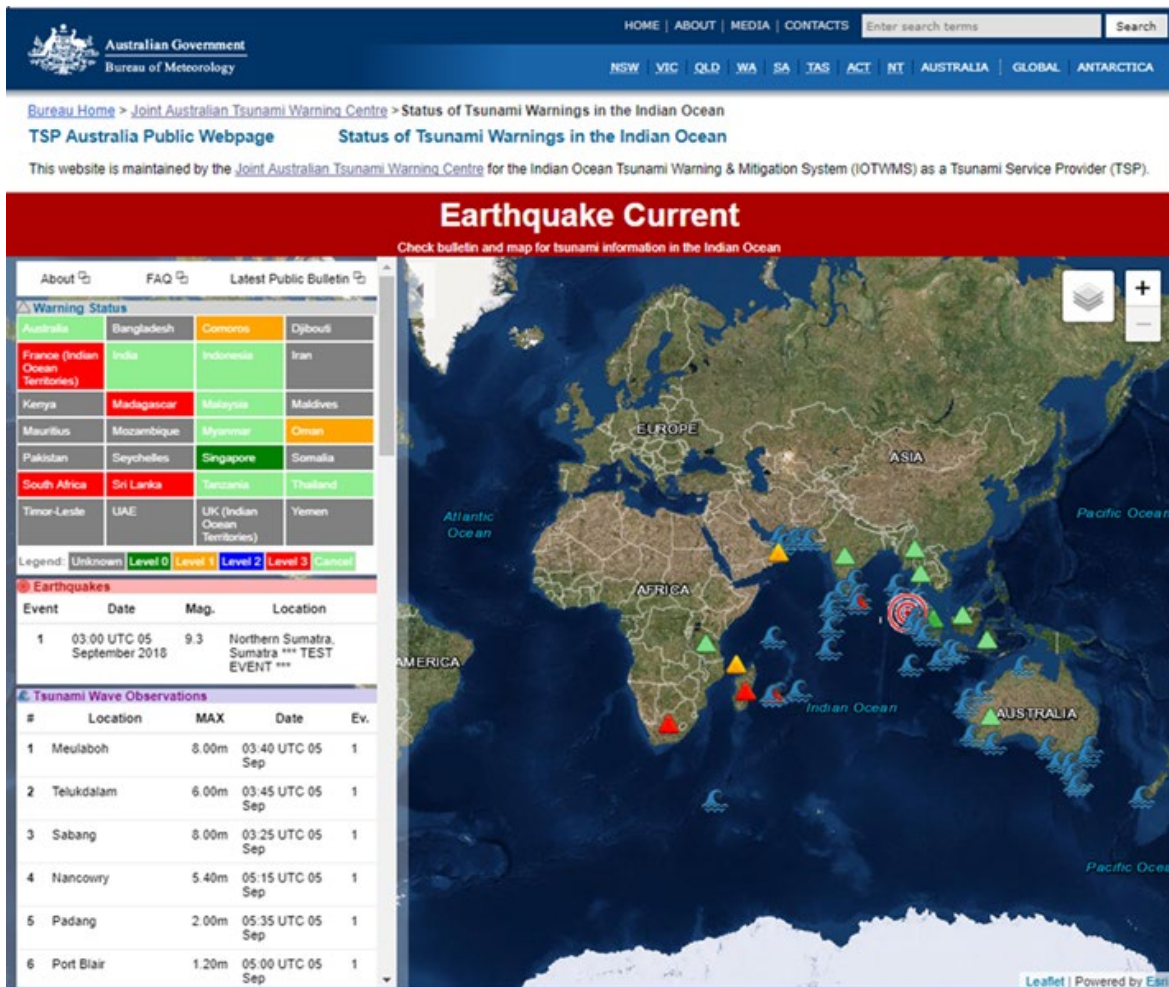
The tsunami warning community are deeply concerned that the rate of damage continues to be relatively high to deep-ocean tsunami monitoring buoys (often referred to as tsunameters or DARTs). They are not only used to help warn communities directly in the path of a passing tsunami, but all buoys are used by tsunami warning centres to verify the generation and propagation of a tsunami across the entire Indian Ocean during an event. They are all compared to the basin-wide forecasts to help validate the forecast model, as well as the initial assumptions of the sea floor deformation due to the undersea earthquake that generally causes tsunamis.

The deep-ocean tsunami monitoring buoys mostly consist of a bottom pressure sensing unit deployed on the sea floor (at a depth of between 2000 – 6000 m) that measures the tsunami wave-height and a surface buoy with satellite telecommunication capability to transmit the information to tsunami warning centres around the world. Damage can take many forms including ship impact damage, incidental damage (e.g., fouling from fishing lines, nets or cables), damage from direct exploitation of moorings as fish aggregation devices, intentional damage, and theft of entire systems or component parts. Accidental damage or vandalism often happens to the surface buoy, rendering the system non-operational. Fish often aggregate around the surface buoys feeding on the marine growth, which in turn attract fishermen. Vessels tying up to the buoys can accidentally or purposefully (after fish collected) damage the surface buoy and its instrumentation. The surface buoys are moored to the sea floor, so fishing lines can also snag and cut these mooring lines, leaving the surface buoys to float well out of range of the subsurface units.

3 Regional Tsunami Threat Information for Indian Ocean

An enhanced system of three Tsunami Service Providers (TSPs - operated by Australia, India and Indonesia) has been in place since 2013, with the three TSPs providing official tsunami threat information to the 28 National Tsunami Warning Centres (NTWCs) in the Indian Ocean. The NTWCs use this information to determine and issue warnings for their coastal communities at risk, as is their sovereign responsibility. The three TSPs do not issue tsunami warnings for other countries other than their own, in their capacity as also NTWCs. The TSPs will publish on their respective web sites the warning status of each country as provided by each NTWC through an online feedback form. This helps to avoid conflicting information being issued to communities, which may lead to inappropriate responses. In some countries the NTWCs are simply national Tsunami Warning Focal Points (TWFPs) with no analysis capability, which refer the TSP threat information to the emergency response authorities for national action.

In Sep 2018, just prior to the Indian Ocean wide tsunami drill, IOWave18 exercise, TSP Australia launched its comprehensive public webpage at www.bom.gov.au/tsunami/iotwms which was successfully tested during the exercise, displaying the simulated warning status as reported by the NTWCs, the public bulletin, as well as information about the earthquake and sea level observations on the interactive map. An IOWave18 example can be found below.



Once NTWCs in each country have analysed the potential tsunami threat information from all available sources they choose to consider (from every/selected TSPs and/or own NTWC), as mentioned above they will decide and issue warnings to their national, regional and local

authorities and communities as part of their sovereign responsibility. Port and maritime authorities will usually be in receipt of national tsunami warnings and will be involved in deciding and organising an appropriate response for port and shipping operations. For promulgation of tsunami threat information and warnings to ships on the high seas, please Section 3.4

3.1 Tsunami Events in the Indian Ocean

Fortunately, undersea earthquakes, which generate tsunamis large enough to create significant impacts, are relatively rare in the Indian Ocean. In the past year of 2018 though, two deadly tsunami events in Indonesia provided sobering reminder to us all that tsunami risk is real in the Indian Ocean and more needs to be done to save lives and protect assets.

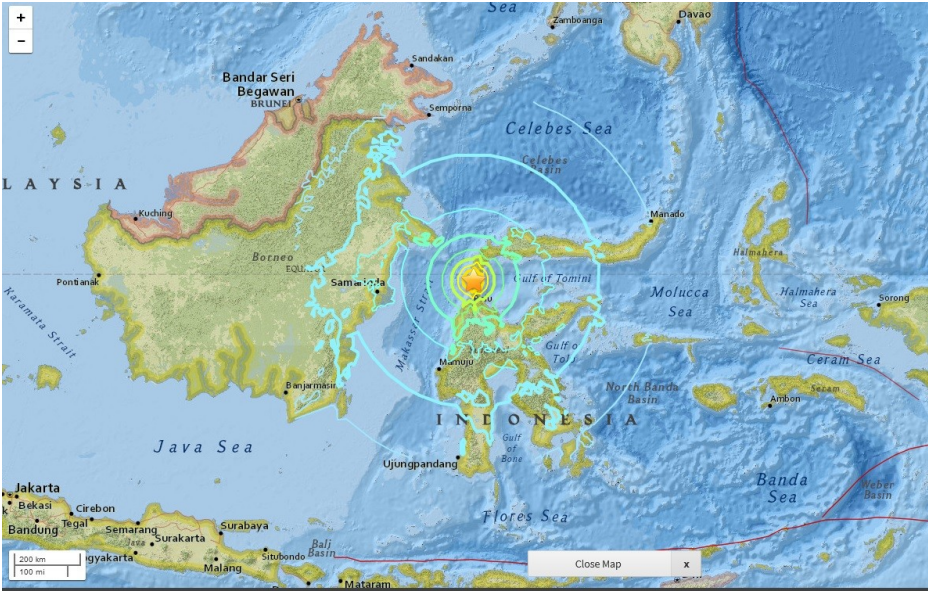
On 28 Sep 2018, a Mag 7.5 shallow, large earthquake struck in the Sulawesi region of Indonesia (see map below), with the epicentre located 77 km away from the provincial capital Palu. This event was preceded by a sequence of foreshocks, the largest of which was a magnitude 6.1 tremor that occurred earlier that day.

This event caused severe liquefaction and destructive local tsunami with 2100 deaths, 680 missing, 4,612 injured, and 78,994 displaced.

The exact cause of tsunami is still being investigated but could be due to a complex mix of Strike Slip Earthquake itself and the resulting Coastal/Submarine Landslides.

Although tsunami warning was issued by the Indonesian national tsunami warning centre at BMKG within 5 minutes of the earthquake, the message did not reach the affected communities due to damage to the communication infrastructure by the previous earthquake. Tsunami waves of 3 – 6 metres arrived within 3 – 4 minutes from the earthquake. In such a local tsunami case, public awareness to respond to natural signs becomes very important.

Due to the epicentre located just outside the IOTWMS Area of Services, there was no action required from any of the three TSPs.



Map taken from the USGS Website <https://earthquake.usgs.gov/earthquakes/eventpage/us1000h3p4/executive>

On 22 Dec 2018, another destructive local tsunami with significant loss of life of more than 400 was generated in Sunda Strait (see map below). This time though, it was triggered by the eruption of Anak Krakatau and the subsequent flank collapse into the Java Sea.



This tsunami event was not known until many hours after it happened. No warnings was issued by BMKG, nor was there action from three TSPs. It remains a global challenge with efforts continuing to provide early tsunami warning for volcanically triggered tsunami events such as this.

3.2 Training Workshops

Each year the ICG/IOTWMS organises a Standard Operating Procedures (SOP) Workshop for NTWCs and DMOs from each country around the Indian Ocean. It can also include national or regional media. The objective is to train national authorities through desktop exercises how to make best use of information generated by the TSPs, as well as to assist NTWCs and DMOs to develop and test their national SOPs for use during real events, exercises and drills. In June 2018 the workshop was held in Hyderabad, India at TSP-India's facilities. In Sep 2017 another SOP workshop was held in Jakarta at TSP-Indonesia's facilities. The Sep 2017 workshop was preceded by a workshop on Indian Ocean Tsunami Ready (IOTR) that came up with guidelines for pilot implementation of IOTR which is a community performance-based recognition programme. A Post-IOWave18 exercise review workshop was organised in Nov 2018 in Jakarta at TSP-Indonesia's facilities, where the exercise achievements and areas for improvement from all participating Member States were shared and documented.

Since Nov 2017, ICG/IOTWMS also conducted three Courses on the Training on Tsunami Evacuation Maps, Plans and Procedures (TEMPP) to provide interested NTWCs and DMOs with methodologies and tools to create tsunami inundation maps and evacuation maps for their respective countries. In the process of developing these maps, the need for high-resolution

bathymetry data became apparent in many countries. This requirement needs should be emphasised at the NIO-HC meeting.

3.3 Tsunami Exercises, Drills and Communication Tests

Every two years the ICG/IOTWMS coordinates the running of an Indian Ocean exercise and drill. The objectives of the exercises are to evaluate and improve the effectiveness of IOTWMS and its operational TSPs, NTWCs, and Disaster Management Organisations (DMOs), in responding to potentially destructive tsunamis. It also provides an opportunity for Indian Ocean countries to test their communication methods and review their SOPs, tsunami emergency response plans and tsunami emergency preparedness.

The latest exercise (named IOWAVE18) took place 4-5 September 2018. This followed on from another very successful IOWave16 further two years ago. Dr. Yuelong Miao from Australia led the coordination of both exercises for the IOTWMS as the exercise Task Team Chair. All 24 active Member States in the IOTWMS took part in IOWave18 with 11 countries also conducting community evacuation drills involving some 116,000 people. Every six months communications tests are formally performed between each TSP and the 28 NTWCs across the Indian Ocean to ensure contact information is up-to-date and communications channels are fully operational.

3.4 Tsunami Warnings for Shipping and Safe Navigation

For vessels on the high seas it is important to receive tsunami warning information to avoid potentially damaged ports and waters not safe to navigate. Vessels in port should also receive tsunami warning information from local harbour and ports authorities, who will have been warned by their NTWC. Business Contingency Management plans for port operations may need to be enacted by ports and harbours under threat, affecting loading and unloading.

After the 2004 tsunami disaster the International Maritime Organization (IMO) decided that it needs to provide better dissemination of tsunami advices to shipping through official channels that are coordinated globally as part of the Global Maritime Distress & Safety System (GMDSS) including satellite broadcasts via INMARSAT and the coast radio NAVTEX service. That decision cut across existing coordination arrangements put in place under the auspices of IOC and WMO.

The UNESCO/IOC Working Group on Tsunami and Other hazards related to sea level Warnings and mitigation Systems (TOWS-WG) has responsibility for establishing guidelines and standards for tsunami warnings globally. Its Task Team on Tsunami Watch Operations (TTTWO, Dr. Miao is aa IOTWMS representative of) has just developed an agreed template with the IHO/IMO/WMO Sub-Committee on the World-Wide Navigational Warning Service (WWNWS-SC). The designated 24/7 TSPs in the major ocean basins will be encouraged to produce the tailored tsunami threat advice based on the agreed template. The interested NAVAREA Coordinators can then subscribe to this new service and forward to shipping in their Areas.

4 Decisions from the 12th Session of the ICG/IOTWMS relevant to the NIO-HC

The ICG/IOTWMS meets biennially, with its most recent meeting held in Iran 9-12 Mar 2019 http://ioc-tsunami.org/index.php?option=com_oe&task=viewEventRecord&eventID=2334.

Some important decisions/recommendations relevant to the NIO-HC include:

- Recognised the technical challenges involved in early warning of atypical tsunamis (landslide & volcanic source) and resolved to investigate methods of detection for such events, including enhancement of observing networks
- Noted with concern, the likely failure of a number of sea level stations in the Indian Ocean on 06 April 2019 due to GPS timing issues in the data loggers and urged Member States to take corrective measures to mitigate the impact
- Encouraged Member States to collect high-resolution coastal bathymetry and topography data for improved characterisation of tsunami and other coastal hazards and risks, and promote sharing of this data to the extent possible
- Noted continued occurrences of vandalism of tsunami buoys in the Indian Ocean.
- Advocate World Tsunami Awareness Day 2019 among Member States and highlight target [d] of the Sendai Framework, with an emphasis on reducing disaster damage to critical infrastructure including ports, harbors, etc.
- Implement TSP messages for maritime community
- Organise Indian Ocean Wave exercise, IOWave20 in 2020.

5 Contacts for Further Information on IOTWMS:

Dr. Yuelong Miao

Manager for Tsunami and Storm Surge
Australian Bureau of Meteorology
PO Box 1289 Melbourne Vic 3001,
Australia
Tel: +61 3 9669 4110
Fax: 61 3 9669 4695
Email: yuelong.miao@bom.gov.au

Dr. Srinivasa Kumar Tummala

Head of Indian Ocean Tsunami Warning and Mitigation System (IOTWMS) Secretariat
IOC UNESCO Intergovernmental Coordination Group
PO Box 1370
Level 3, 1 Ord Street
West Perth, WA 6872
Australia
Tel: +61-8-9226 0191
Fax: +61-8-9263 2261
Email: sk.tummala@unesco.org