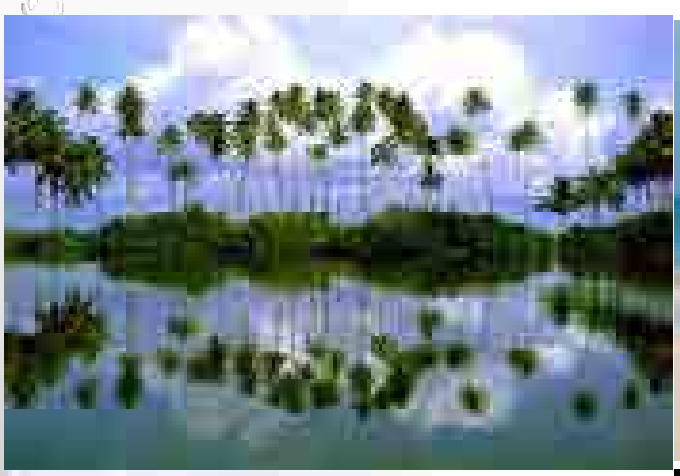
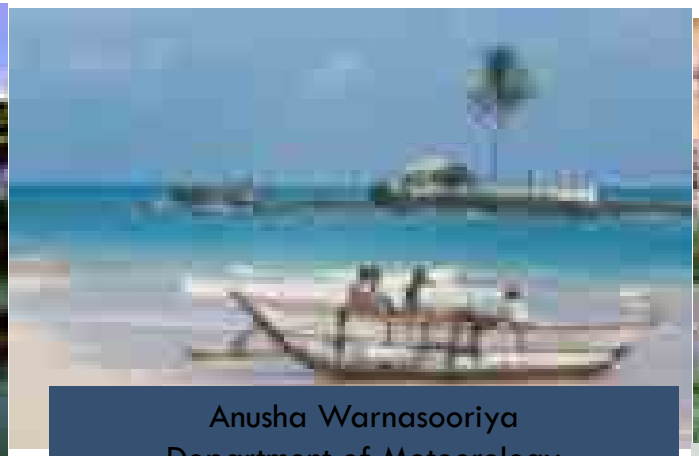
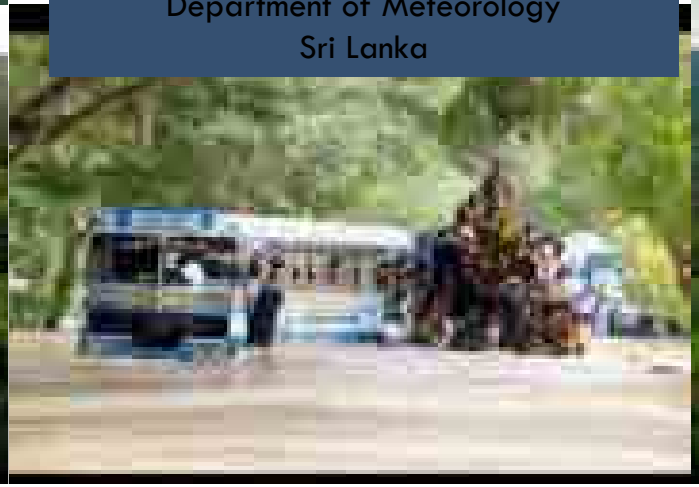
Seasonal Climate Forecasting for South Asia "
06-08 December 2017


Anusha Warnasooriya
Department of Meteorology
Sri Lanka

- **OUTLINE**

- 1. CLIMATE, GEOGRAPHY AND RAINY SEASONS OF SRI LANKA
- 2.RESPONSIBILITIES OF DEPARTMENT OF METEOROLOGY, SRI LANKA
- 3.EXPERIENCE FROM RESENT PAST FLOODS/ LANDSLIDES
- 4.CHALLENGES
- 4.DEVELOPMENT AND FUTURE PLANNING

Topography and Climate

Topography:

Sri Lanka Locates Between

(5 to 10) N and (79 to 82) E

Characterized by South Central Highlands

Mt. Pidurutalagala – 2524 m

Mild Climate

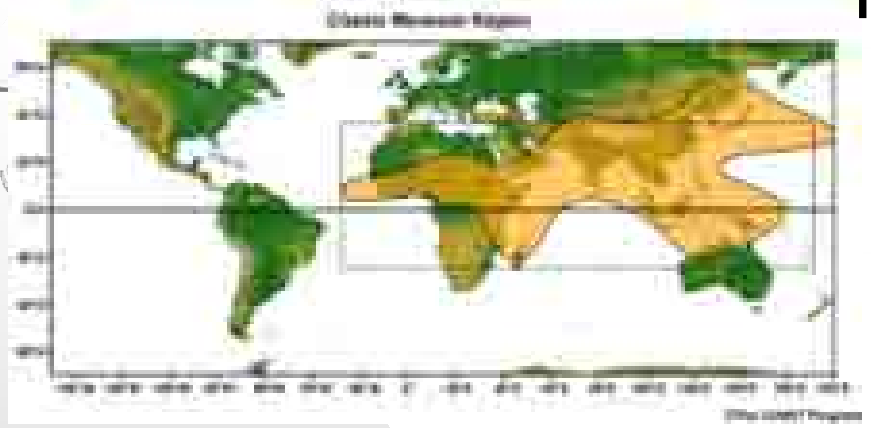
Average Rainfall: **1860 mm/year**

Range of rainfall: **950 – 6000 mm**

Mean Temperature: **27.5 C (lowlands)**

Lower Temperatures in the highlands

Tropical &Monsoonal

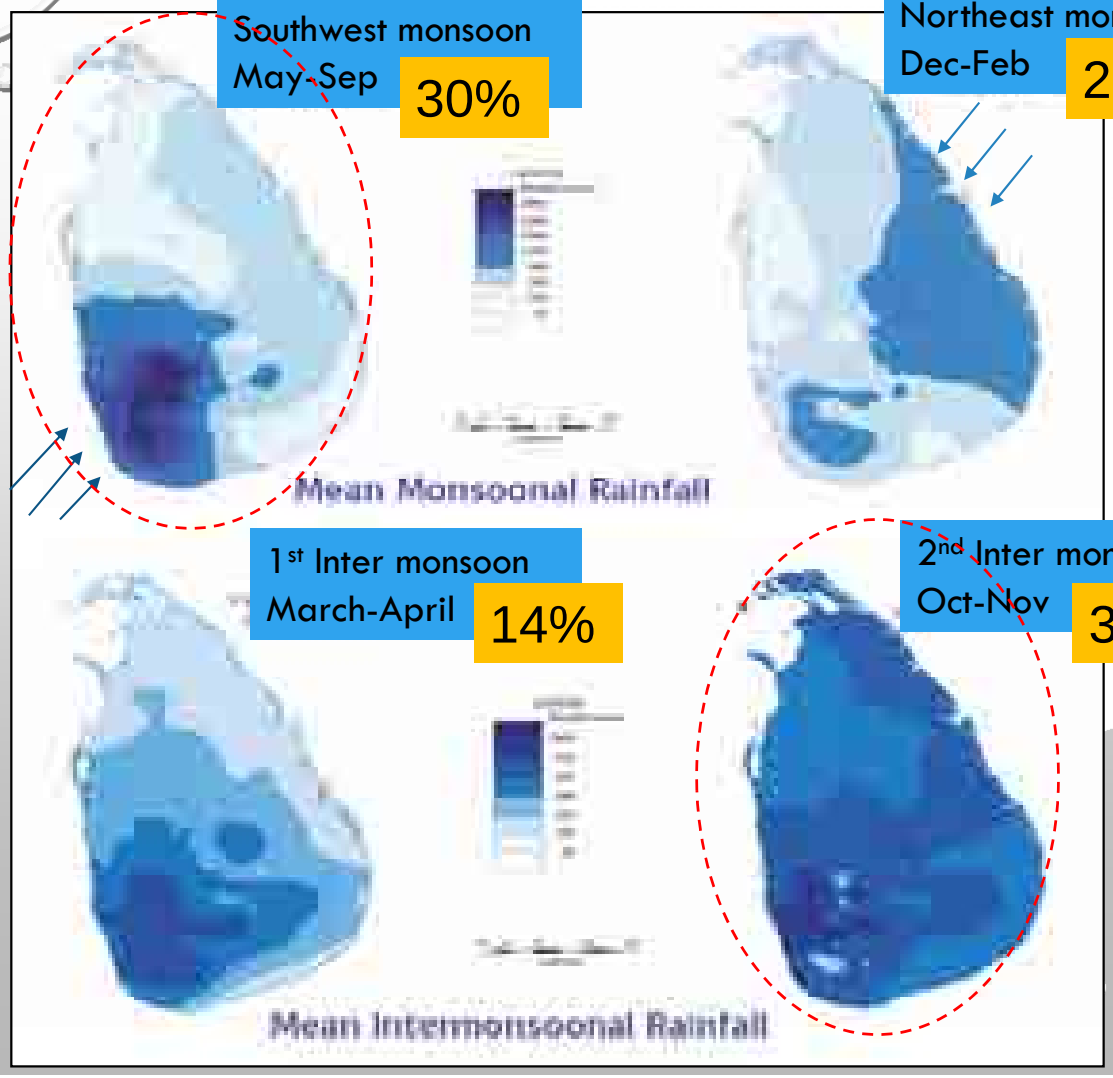


- **THE CLIMATE OF SRI LANKA IS ESSENTIALLY MONSOONAL, DOMINATED BY THE SOUTHWEST AND NORTHEAST MONSOONS, ON WHICH THE LIFE AND ECONOMY OF THE ISLAND IS CRITICALLY DEPENDENT.**

There are four Climatological Seasons

- Northeast Monsoon (December to February)
- 1st Inter Monsoon (March & April)
- Southwest Monsoon (May to September)
- 2nd Inter Monsoon (October & November)

SEASONAL RAINFALL DISTRIBUTION OF SRI LANKA



Department of Meteorology

Our Vision

A Centre of Excellence in weather and climate related services

Our Mission

To provide services pertaining to Meteorology, Aeronautical Meteorology, Ocean Meteorology, Hydro Meteorology, Agricultural Meteorology, Climatology and Astronomy to government agencies, private sector and the general public in keeping with national interest and international standards.

History of Meteorological Network in Sri Lanka (Important Mile Stones)

- 1861- Rain Gauge Network
- Temperature data are available early 1900's
- At the beginning meteorological service was under the Survey Department
- Independent institute (Department of Meteorology)- 1948
- Satellite image receiving System (NOAA USA) – 1973
- Automatic Weather System (JICA) – 2009
- INSAT(INDIA)/COMS (KOICA)/ FY2 (CHINA) Satellite Data Receiving Systems
- Himawari(Japan)satellite receiving system-2017

Meteorological Services of the Department of Meteorology

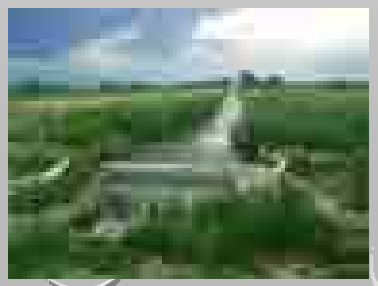
- Weather Forecasting Activities

1. Short Range

2. Medium Range

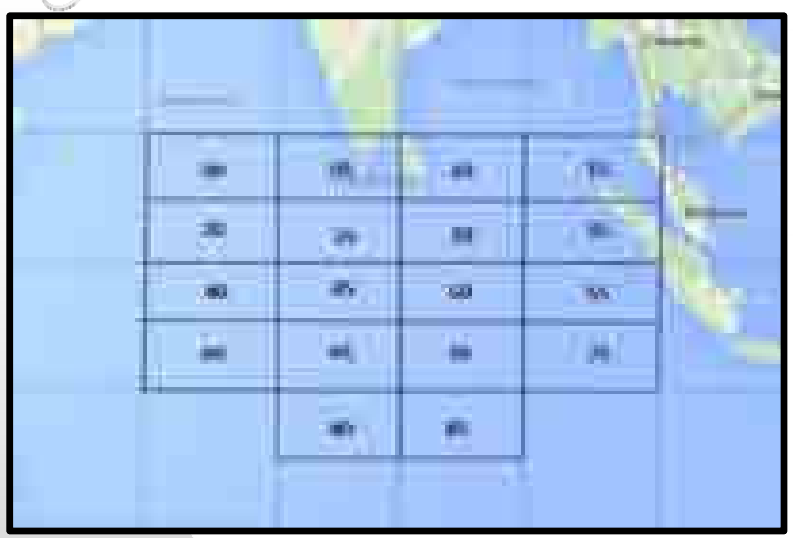
3. Long Range(Monthly/Seasonal)

Fax/email/web/media



Weather Forecast/warnings for Fishery and Navel communities

Fax/email/web



- Fleet forecast
- shipping report
- sea area forecast
- Indian ocean - multiday boats

10 DAY FORECAST FOR SOUTH WEST COASTAL AREAS

Issued at 5.00 p.m. on 20th July 2017

Marine Weather Division, National Meteorological Centre, Department of Meteorology

Date	Wind and Rainfall Forecast	Significant wave height	Wind Gust
2017.07.21	Several spells of light showers are likely(Especially in the morning)		
	Several spells of showers are likely (Especially in the morning)		

Aeronautical meteorological services

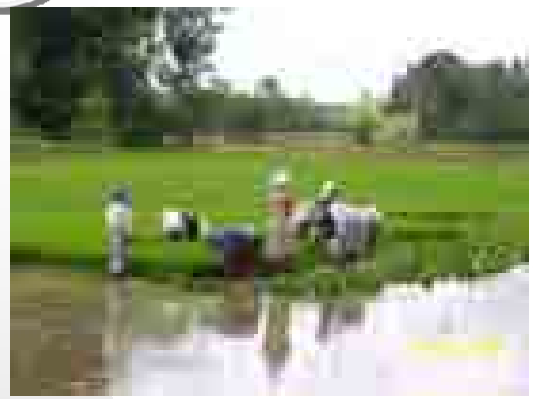
Aeronautical meteorological services

Terminal Aerodrome Forecasts (TAF)

Significant Weather Analysis

SIGMET (for Colombo FIR)

Through Aeronautical Fixed Telecommunication Network(AFTN)/AWOS/GTS



Agro Meteorological Services

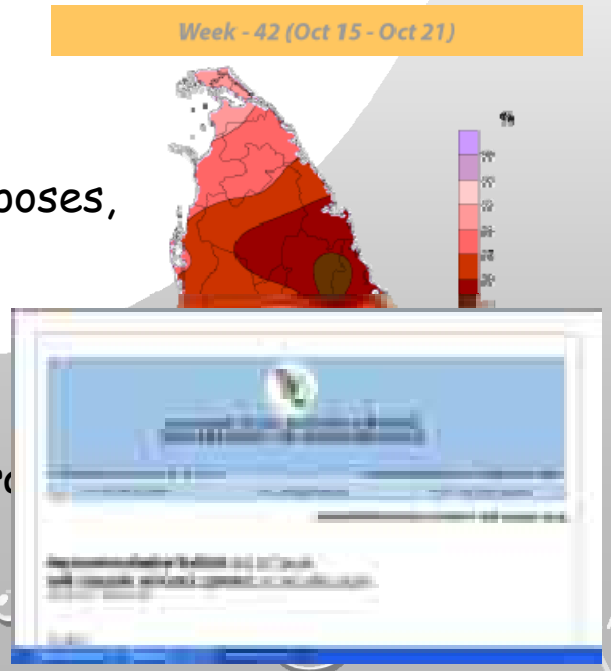
•Agro-meteorological network was started in Sri Lanka in 1973
•DOM has up to Forty Agro-meteorological stations island wide, collaboration with the certain institutions.

❑ Agro meteorological data

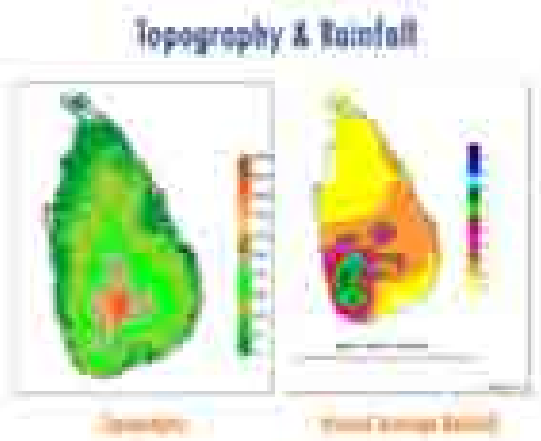
Data will provide for academic purposes, research and other relevant project

❑ Average predictions

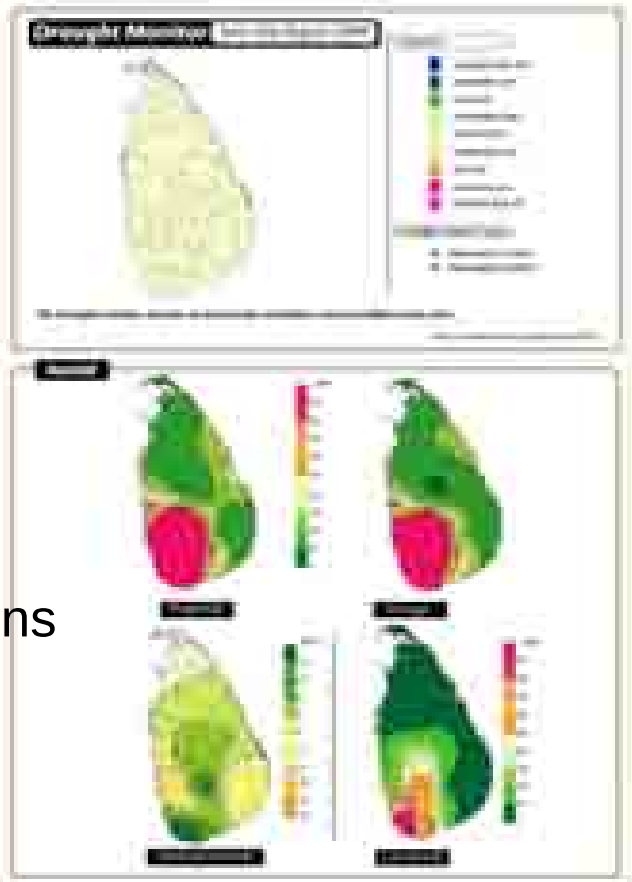
Weekly averages for Evaporation, Precipitation, Rela. Humidity, Sunshine dura
Max and Min Temperatures



WEB



Climatological Services

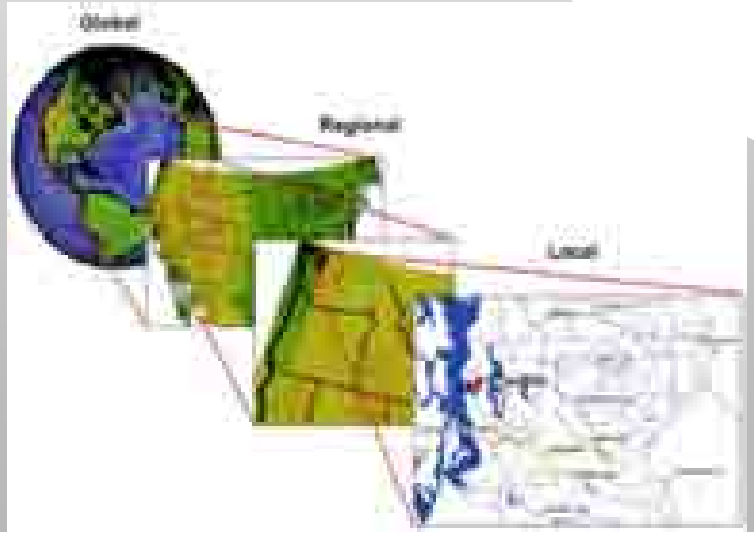


- Climatological means
- Climate Change activities
- Seasonal weather predictions
- El-Nino outlook

Global Climate Models
(Resolution low)

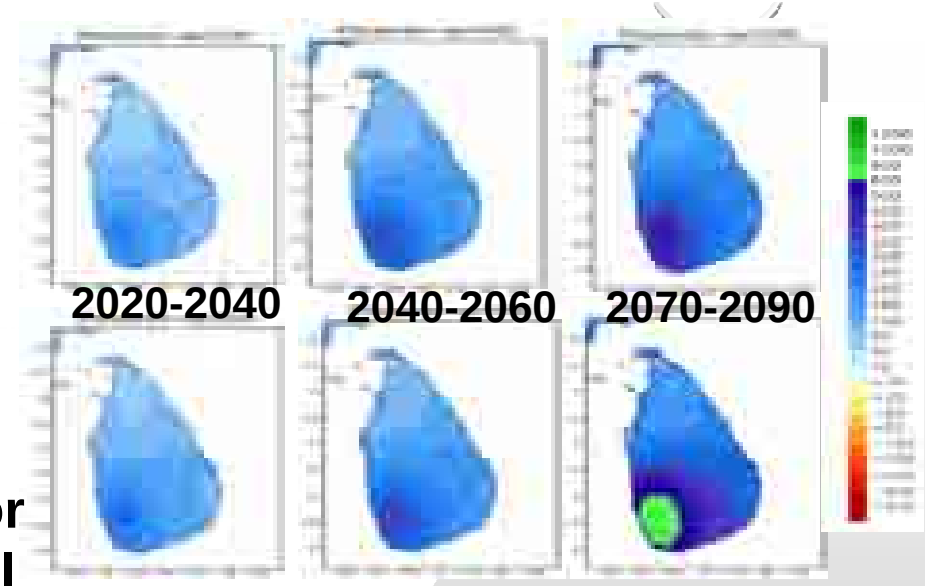
Downscaling Method

Statistical Downscaling

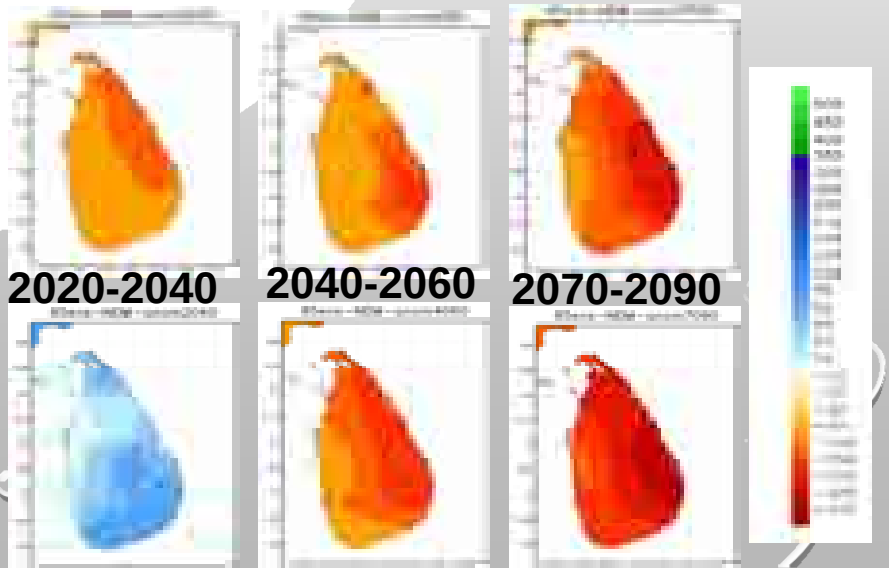


Future Climate Projection for Sri Lanka – High Emission And Moderate Emission Scenario

Multi-model Ensemble projection for SWM Rainfall

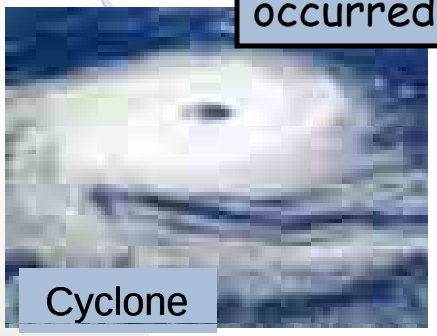


Multi-model Ensemble projection for NEM Rainfall



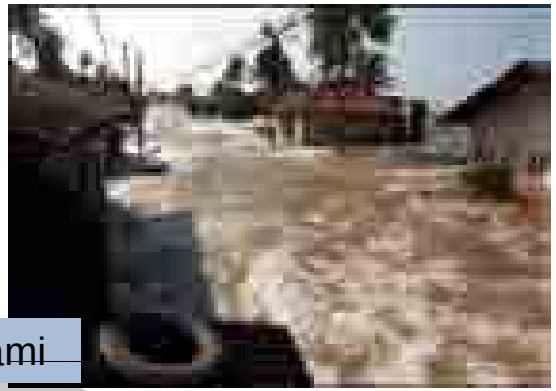
Over 80% of the natural disasters in Sri Lanka occurred due to the weather based phenomena

Natural Disasters in Sri Lanka

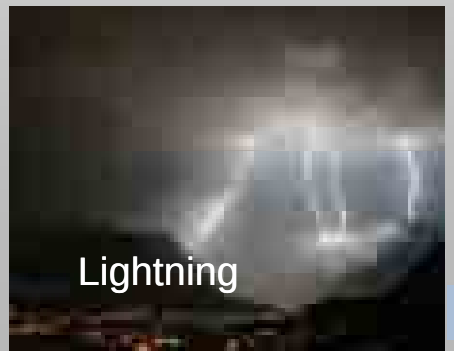

Cyclone


Land slides

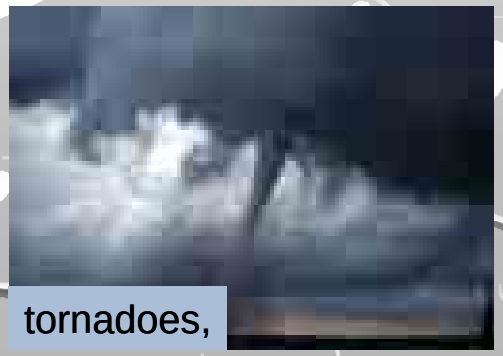

Tsunami




Drought


Lightning


Floods


tornadoes,

Recently observed weather related hazards

- Flood is becoming more frequent than Droughts events

year	Hazard
2010	Flood
2011	Flood/Drought
2012	Flood/Drought
2014	Flood/Drought
2015	Flood
2016	Flood/Drought
2017	Flood/Drought

Early Warning Process – Sri Lanka

Separate agencies are responsible for early warning in the case of different disasters.

Disaster	Responsible Agency for Early Warning
Cyclones and heavy rainfall/strong winds	Department of Meteorology
Floods	Irrigation Department
Landslides	National Building Research Organization
Tsunami	Department of Meteorology (with the consultation of Geological Survey and Mines Bureau)
Earthquakes	Geological Survey and Mines Bureau

Severe Weather Forecasts and Early Warning Services

- Tropical storms
- Heavy rain
- Strong winds
- Tsunami (after 2004 Tsunami)
- Thunderstorm/Lightning/Tornado…

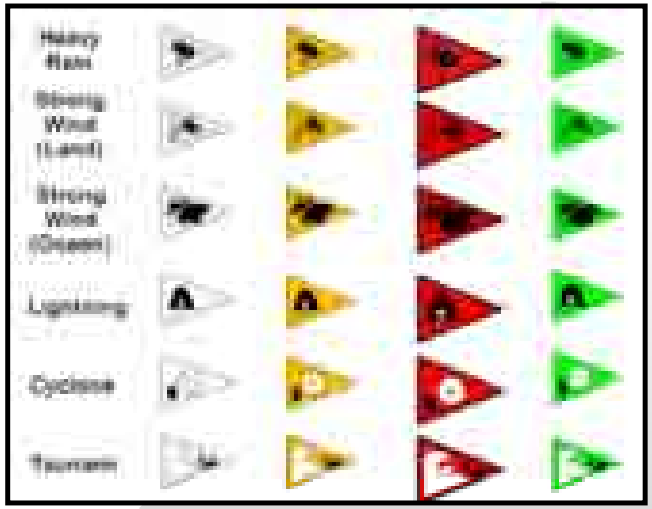
near future

Amount	Bulletin
Rainfall > 50 mm in 6 hrs and rainfall > 100 mm in 24 hrs	Alert/Advisory
Rainfall >150 mm in 24 hrs	Warning

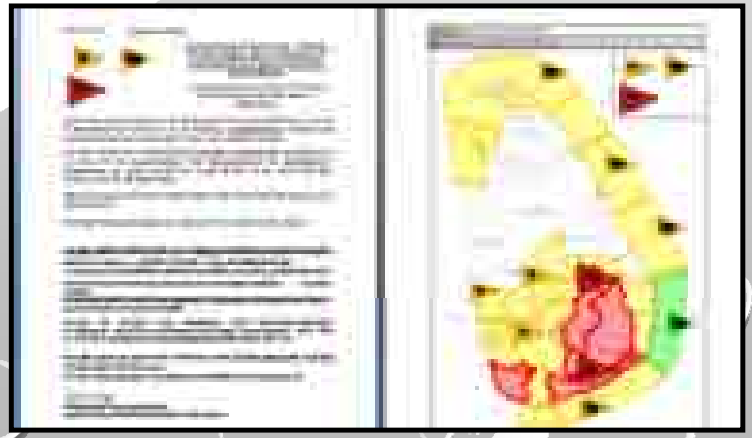
SOP

Procedure for issuing cyclone alert and warning

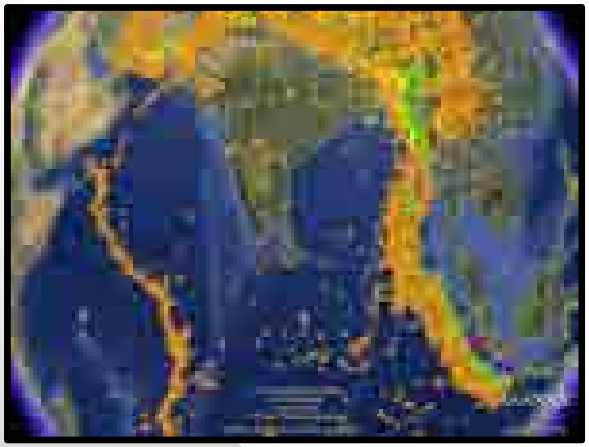
- **If cyclone is 600kms away from Sri Lanka ➔ Issue General Information bulletin**
- **If cyclone is 500kms away from Sri Lanka ➔ Cyclone alert (every 12 hrs)**
- **If cyclone is 300kms away from Sri Lanka ➔ Cyclone Warning (every 6 hrs)**
- **If cyclone is 200Kms away from Sri Lanka ➔ Cyclone Warning (every 3 hrs)**



Signal No	Colours	Description	Action Required
1	white	Potential area of possibility to development of vortex /disturbance / Cyclone has formed	Information only, Vessels at sea to be vigilant and avoid the area, Listen to media
2	Yellow	Cyclone has formed in the vicinity, raining and windy, sea rough (30-40kts, 50-80kmph)	Stay away from beach/sea, vessels in danger/be inside building
3	Orange	Cyclone has formed in the vicinity, very heavy rain with very strong winds, very rough seas (V > 40kts, 80kmph)	Be ready to leave weak buildings and low lying areas (flood prone areas), secure your home valuables
4	Red	Cyclone is expected to cross land,Very heavy rain/very strong winds (v>50kts,100kmph)	Evacuate to predesignated areas
5	Brown	Severe cyclone is expected to cross Very severe weather expected	Evacuate to predesignated areas
6	green	Cyclone warning cancellation/withdrawal bulletin	



WARNINGS FOR TSUNAMI

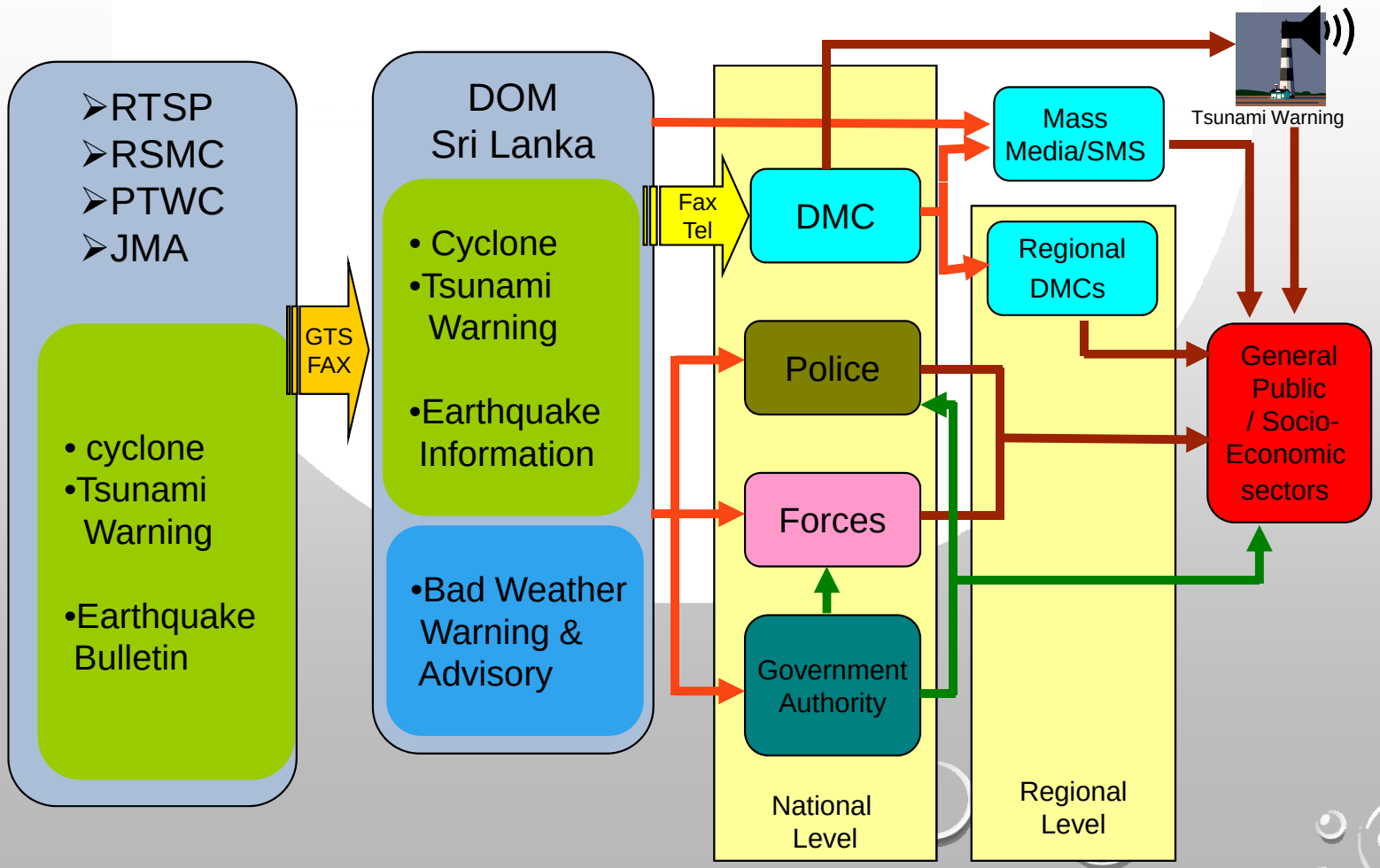


Regional Tsunami Warning Centers

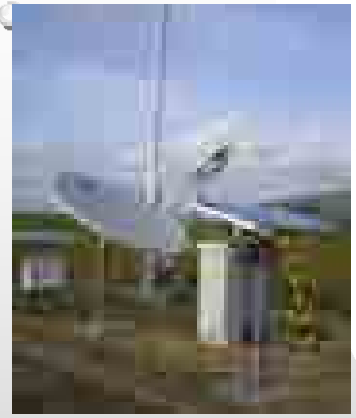
- INCOIS , India
- Tsunami Warning Center , Australia
- Meteorological, Climatologically and Geophysical Agency, Indonesia

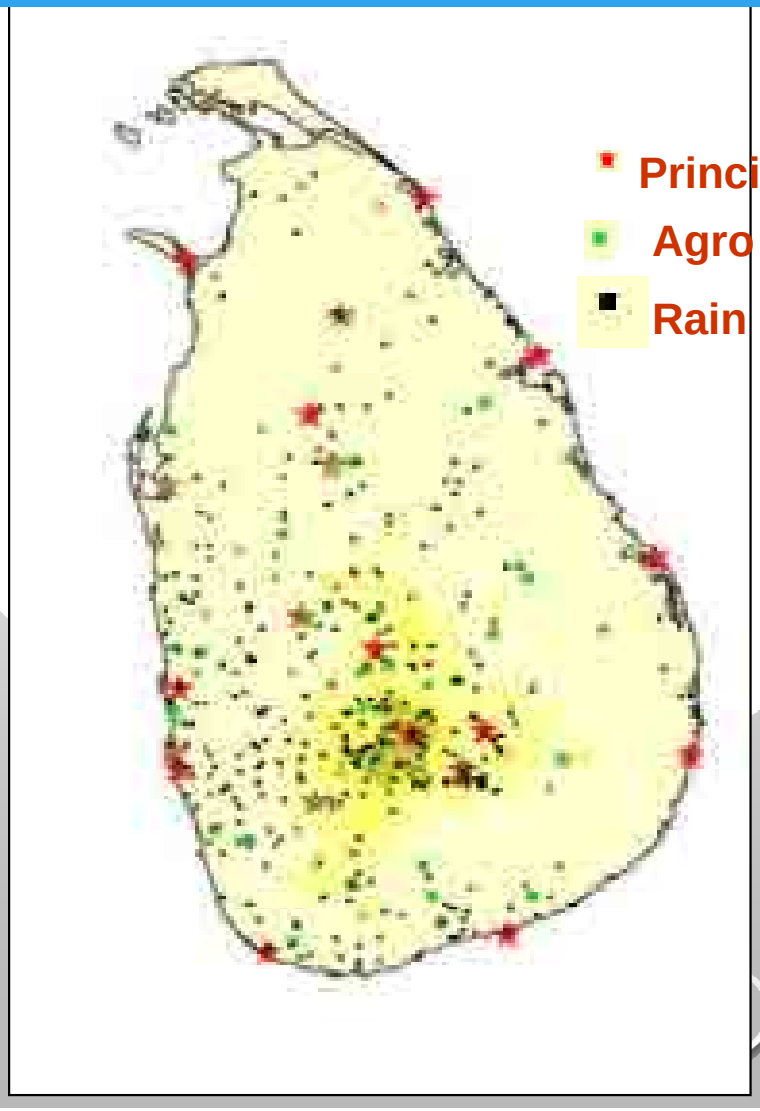
Magnitude of the Earth quake	Potential for Tsunami	Bulletin	Colour
< 6.5	No Tsunami threat	Information	white
6.5<M<7.5	Tsunami possible within 100km of the epicenter	Information	white
7.0<M<7.5	Potential for destructive Tsunami within 100km of the epicenter But Sri-Lanka is not in the area.	Watch	Amber
	Potential for destructive Tsunami within 100km of the epicenter But Sri Lanka is in the area	Warning	Red
7.6<M<7.8	Potential for destructive regional Tsunami. But Sri Lanka is not in the area	Information	White
	Potential for destructive regional Tsunami. But Sri Lanka is in the area.	Warning	Red
7.8<M	Potential for destructive ocean wide Tsunami. But Sri Lanka is in the area	Warning	Red
	Mega tsunami is expected wave height >3m	Very Sever Tsunami warning	Brown

Early Warning Dissemination System



Observation and Data Collection





- **Principal Meteorological Stations** 23
- **Agro meteorological Stations** 35
- **Rain gauge Stations** 520

Meteorological and Disaster Information Network donated by JICA it is consist of the Automatic Weather observation Station system (AWS)

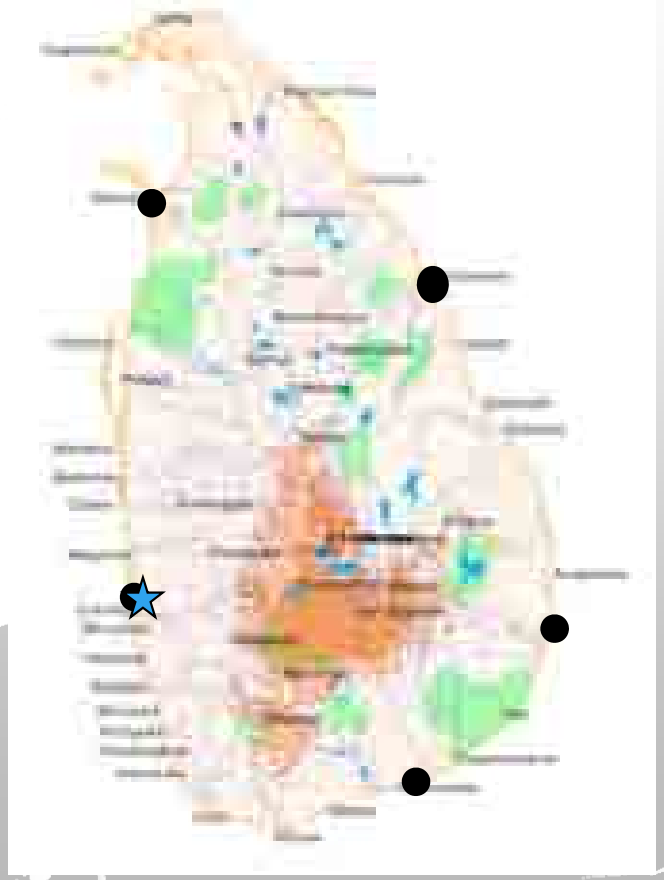
The AWS consists of 38 stations;
20-Synoptic Meteorological Stations
18 - Collaborator Stations

100 Automated rain gauges are planning to install in 2018

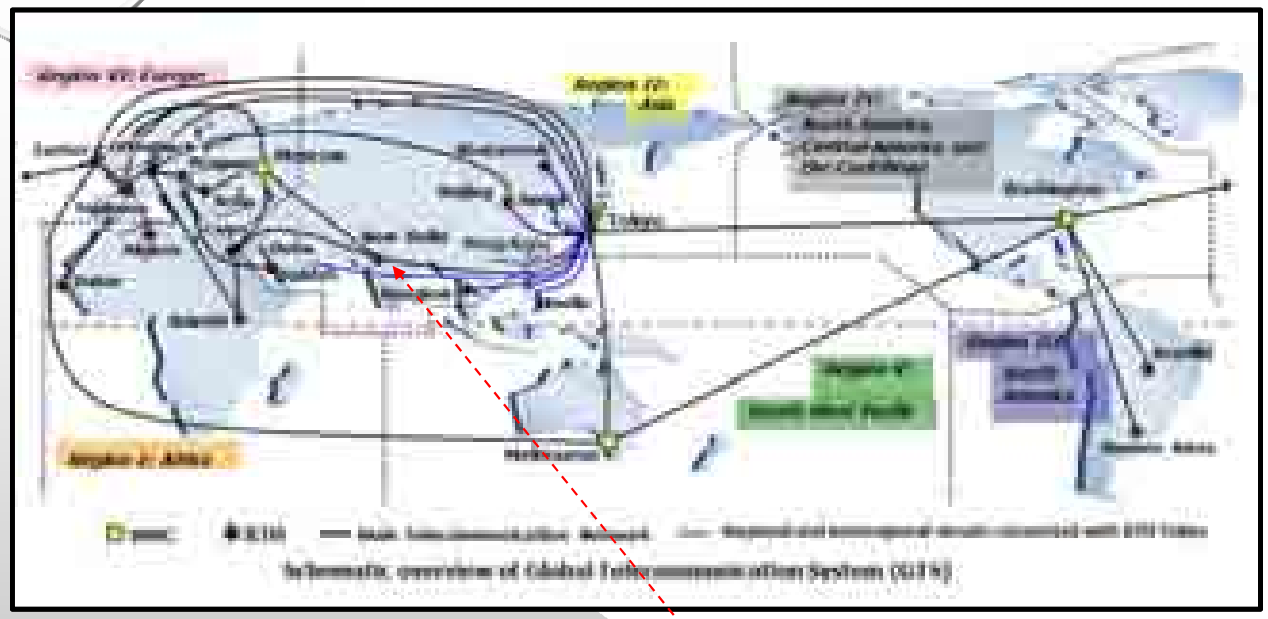
Upper Air Observations – Pilot balloon/ Radiosonde

PILOT BALLOON OBSERVATIONS

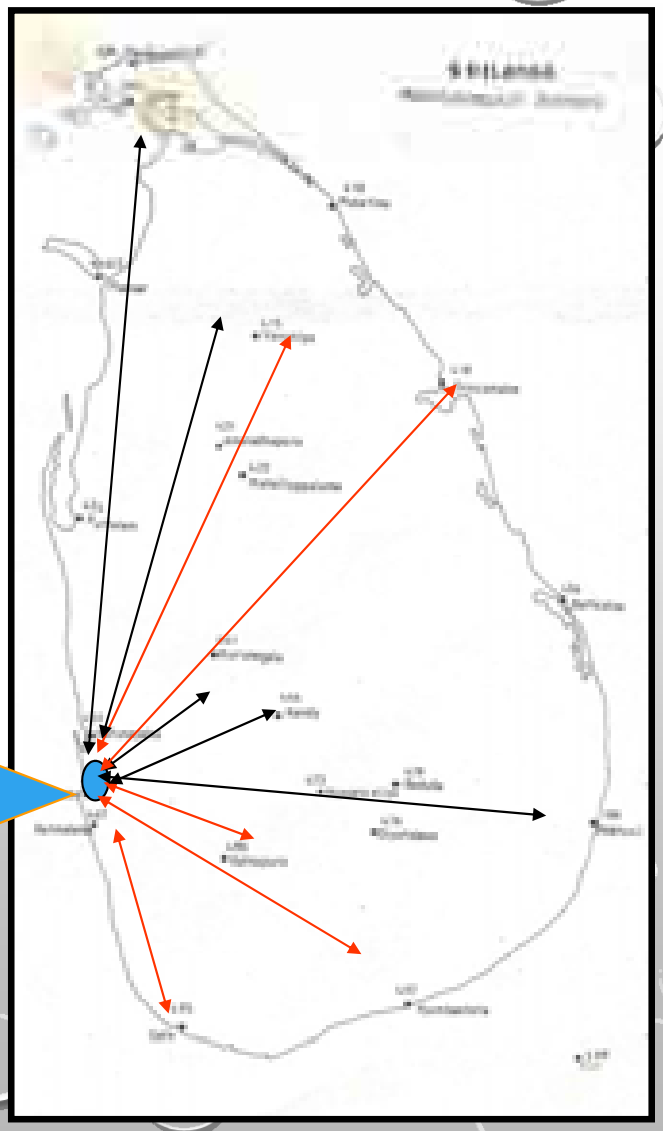
Radiosonde Observation



Data communication-GTS/MSS



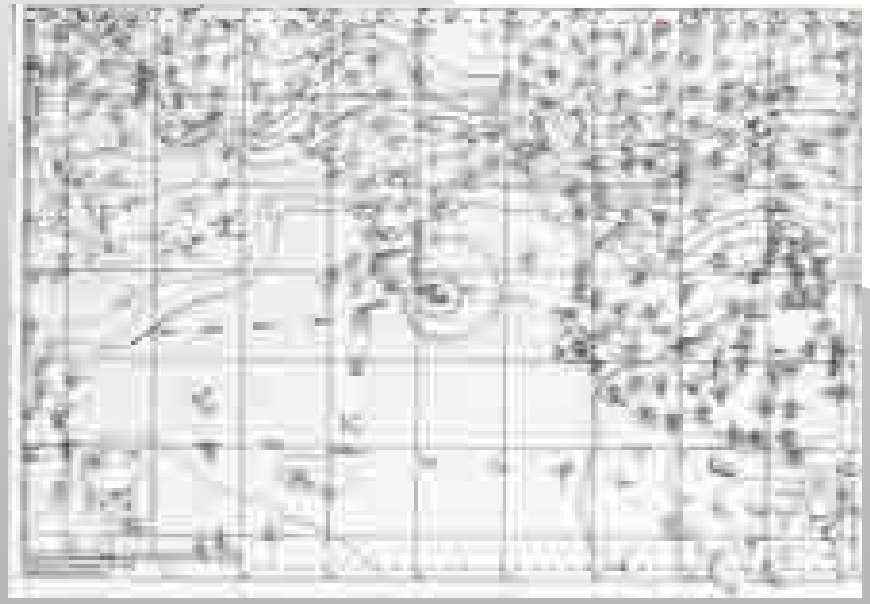
New Delhi



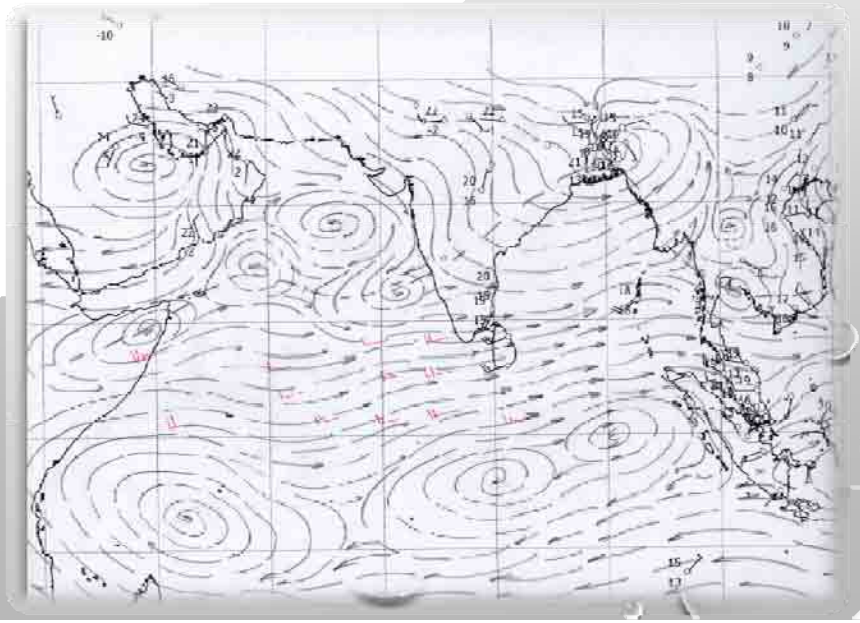
Transmission Control Protocol (TCP) and the Internet Protocol (IP)

Plotting and analyzing the data

Surface pressure pattern

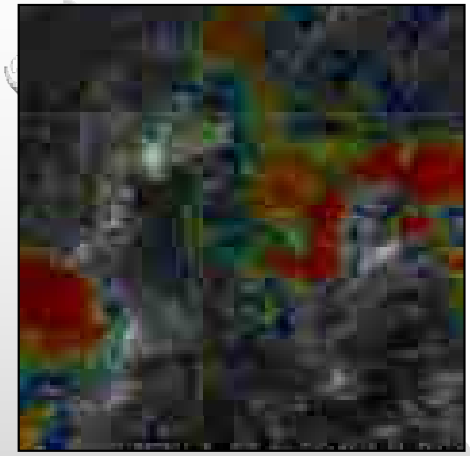


Upper air wind pattern

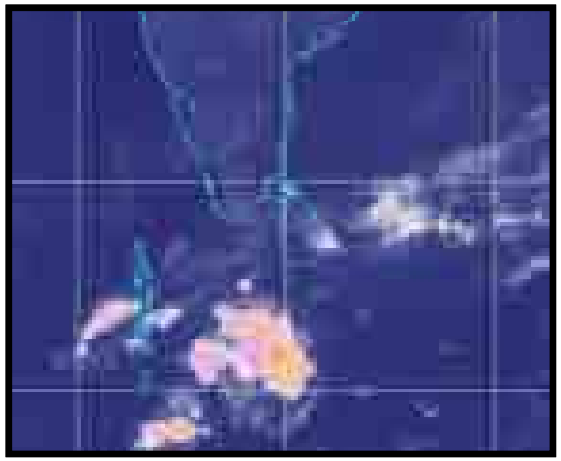


Satellite Products used in Forecasting

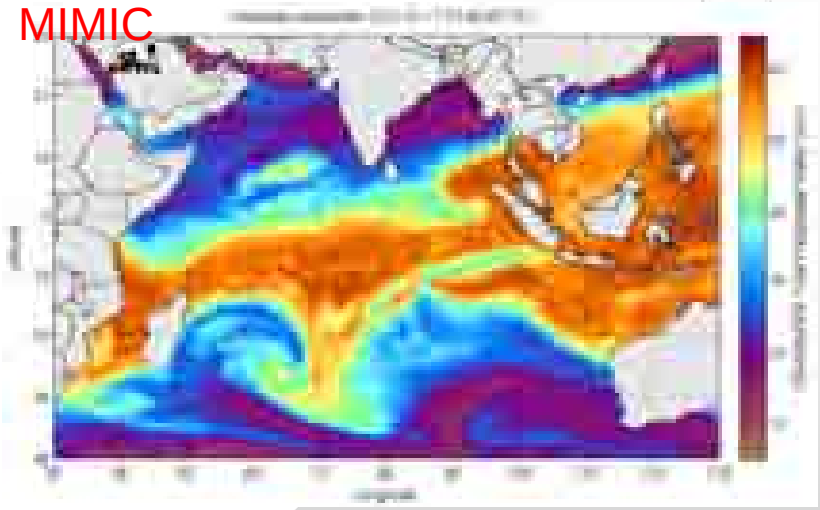
Himawari



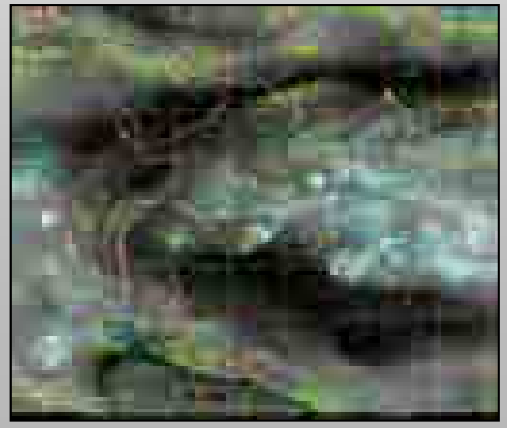
CMACAST



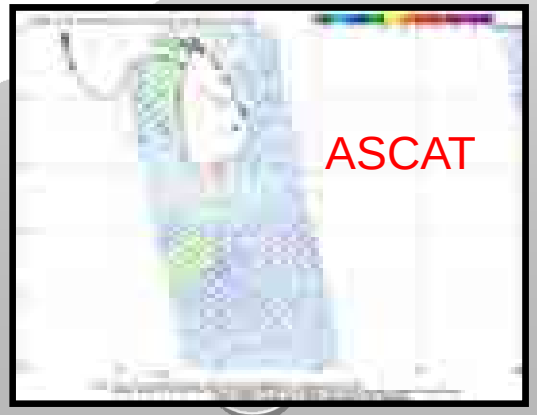
MIMIC



METEO-7



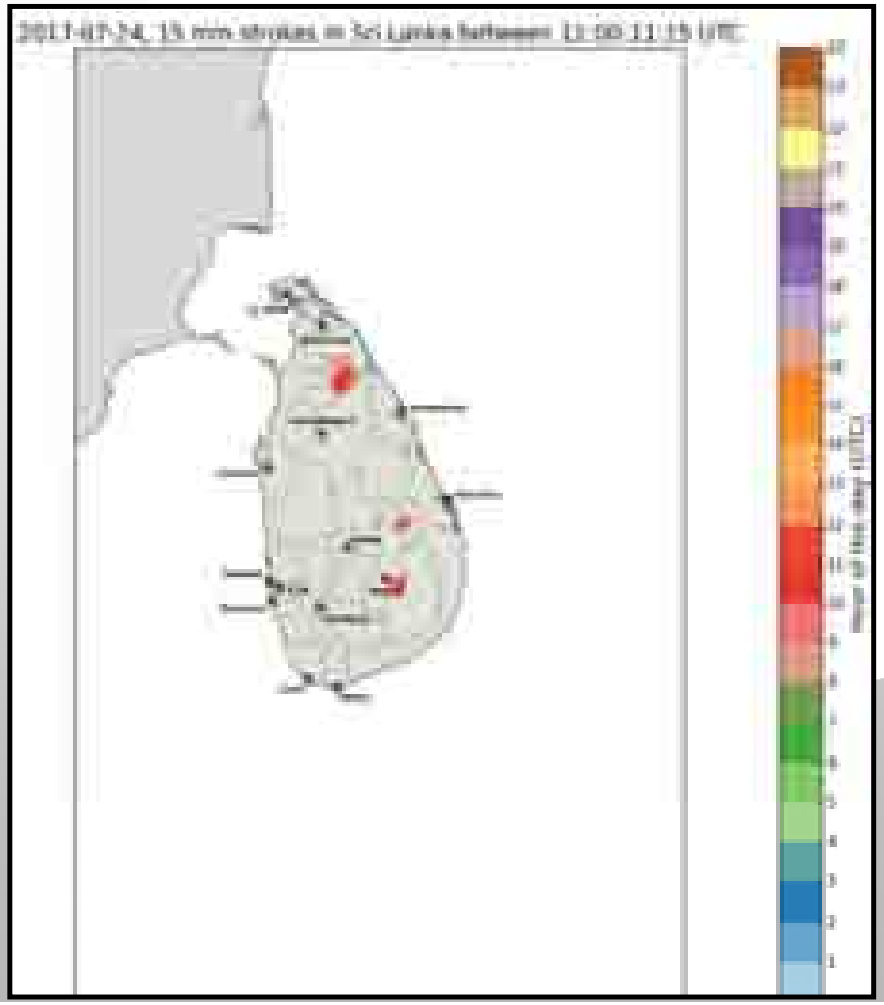
INSAT

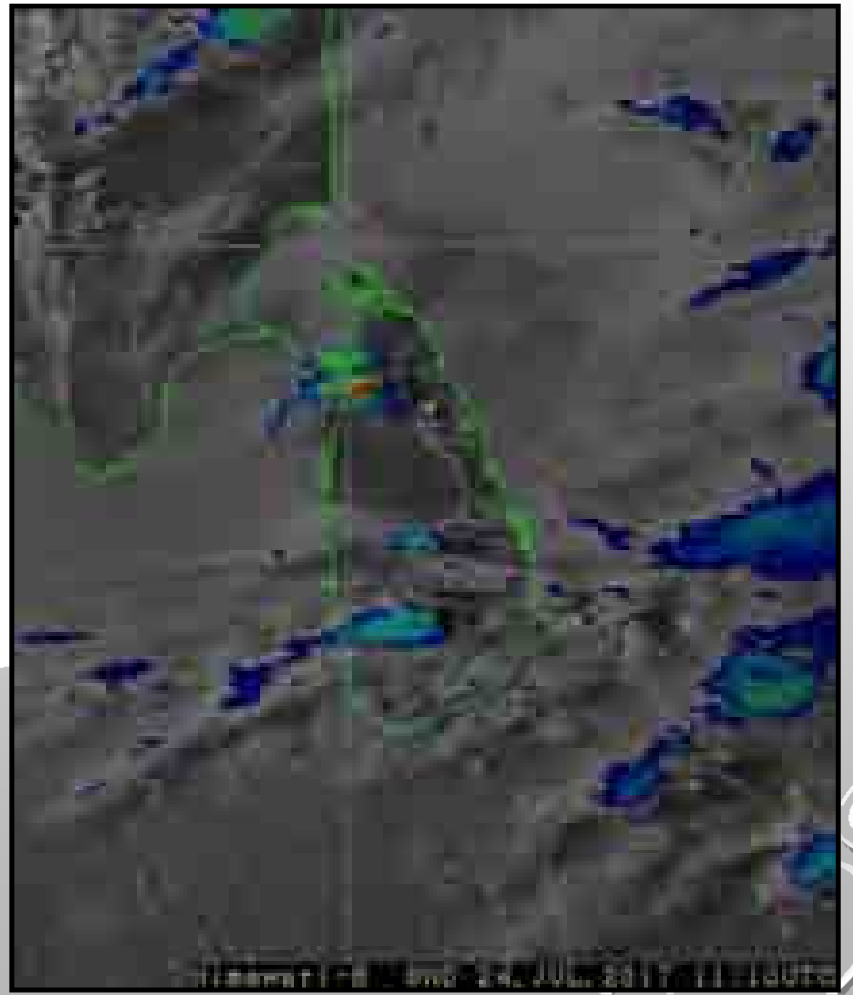


SATAID (JMA) as an analysis Tool…

- To identify cloud type it movements and further developments
- Vertical cross section of important meteorological parameters
- Analysis of tropical cyclone with Dvorak technique

Vaisala Lightning detection network(GLD 360)
lightning stroke during 15 min (11.00-11.15) UTC on 24th July 2017 and
Himawrai satellite image

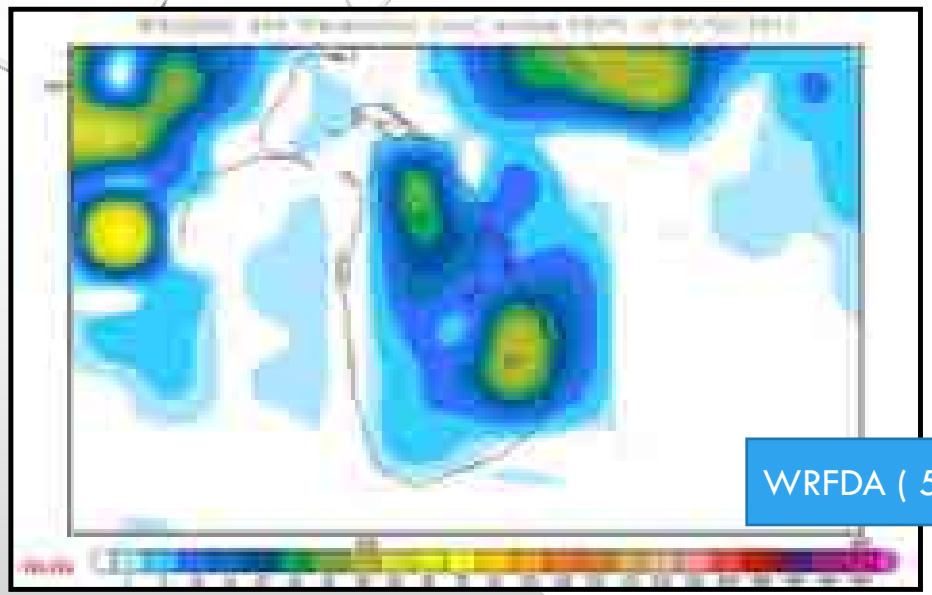




NUMERICAL WEATHER PREDICTION(NWP) ACTIVITIES IN THE DEPARTMENT

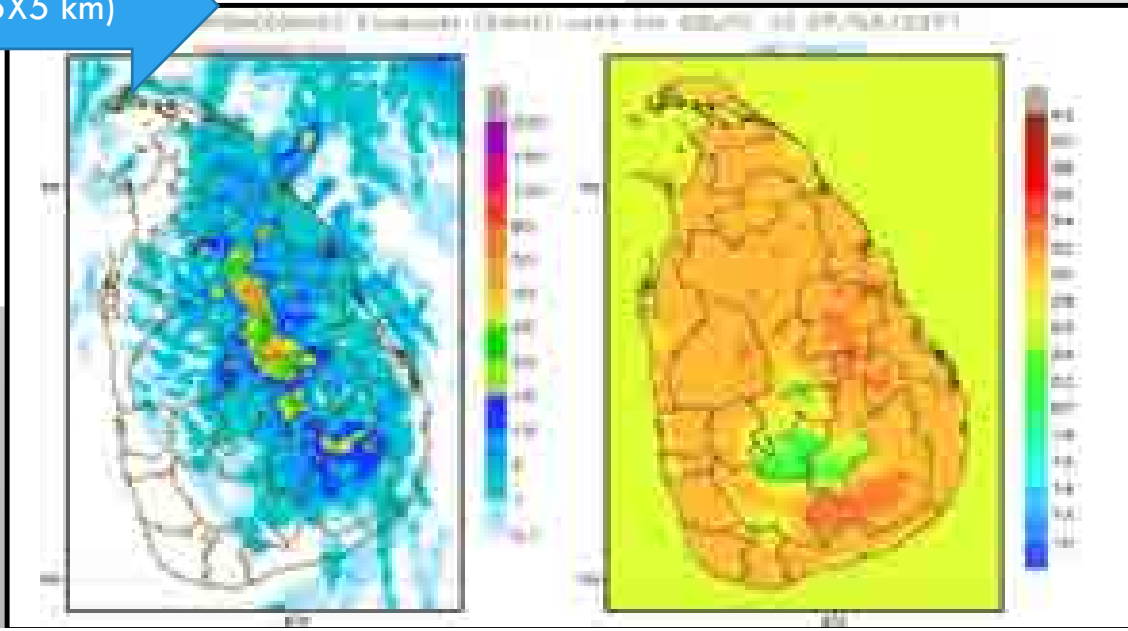
- Use of Weather Research and Forecasting model (WRF) and Data assimilation techniques (WRFDA)
- 2015 - 3D DA techniques was Introduced and trainings were given by India, Bangladesh, Japan, Korea

GFS(0.5X 0.5 degree ~ 50km X 50km) Initial image

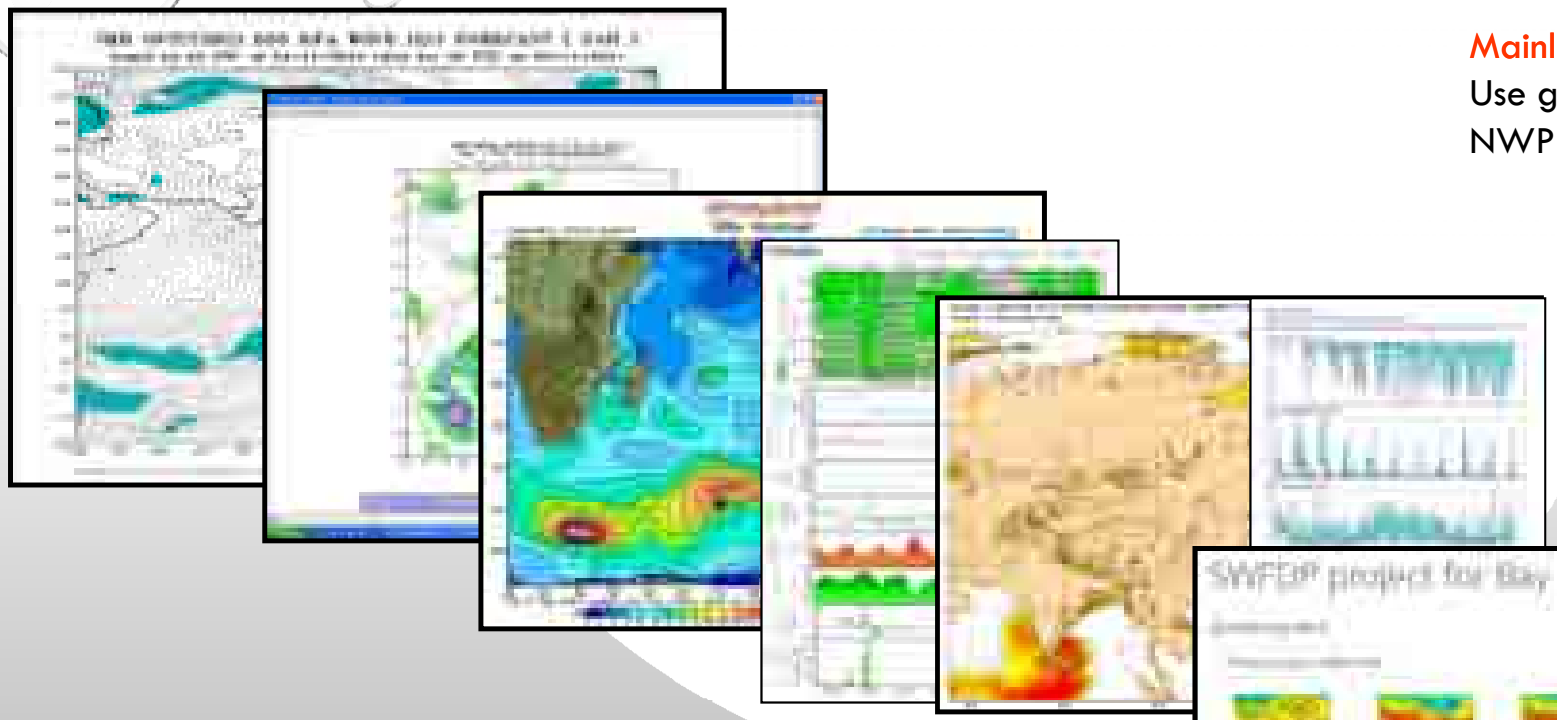


WRFDA (5X5 km)

WRFDA (5X5 km)

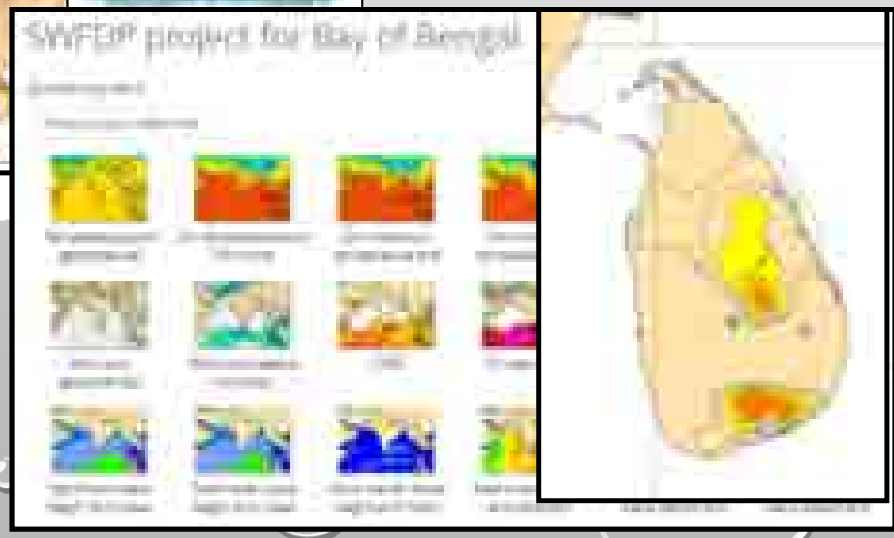


NWP out puts use in Short and medium range weather forecasting in DOM



Mainly Subjectively

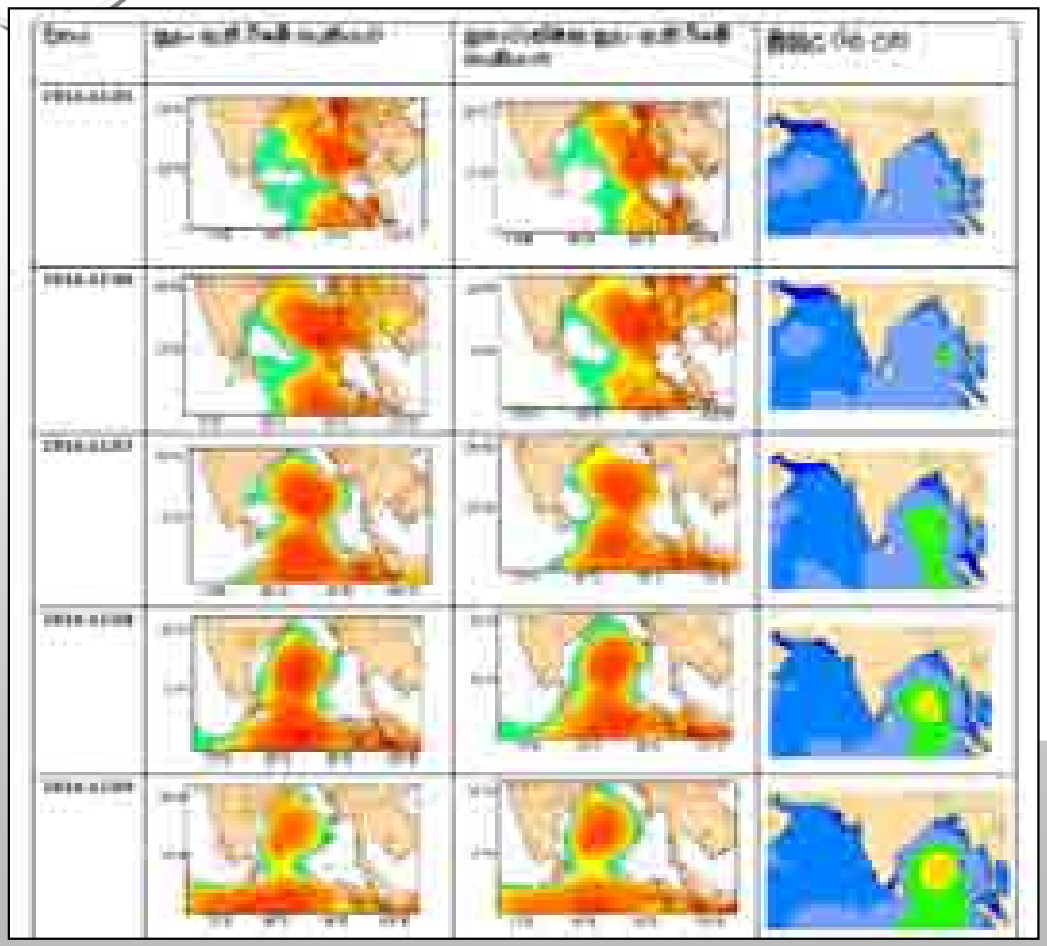
Use global reputed climate center"s NWP Model products as a tool



ECMWF data and products –Non commercial agreement from 1st July 2017

ECMWF/IMD/NCMRWF/JMA/NCEP

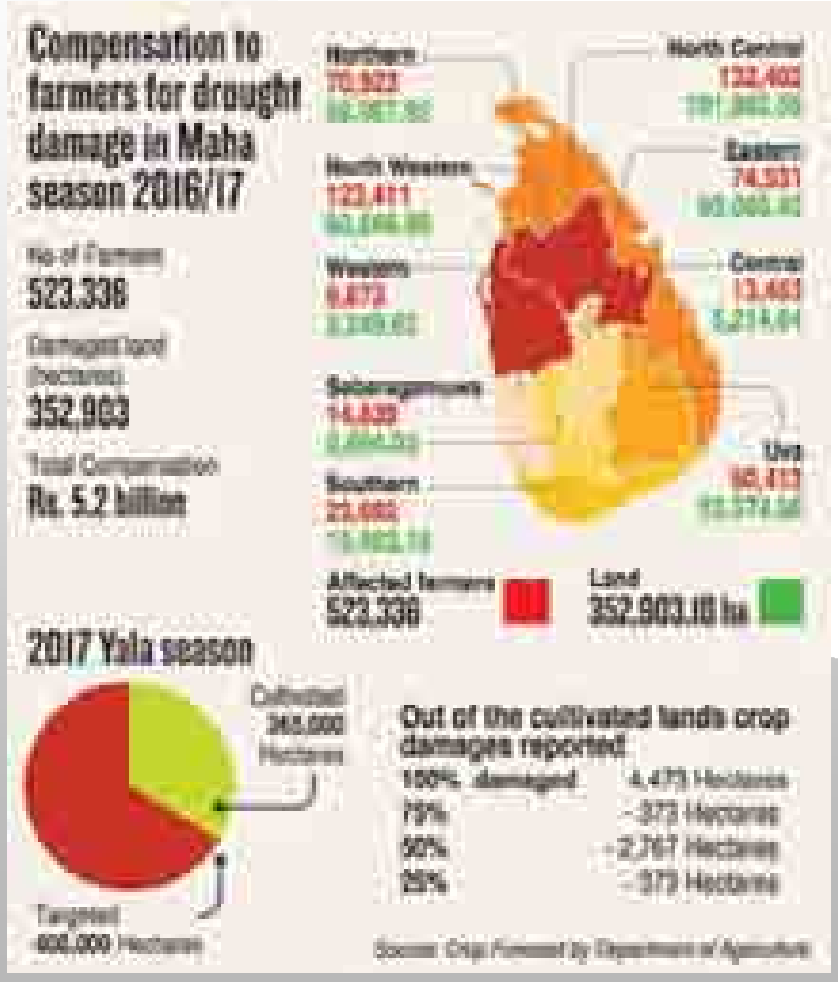
We issue this type of special weather bulletins during cyclone with the help of SWFDP –ECMWF model outputs



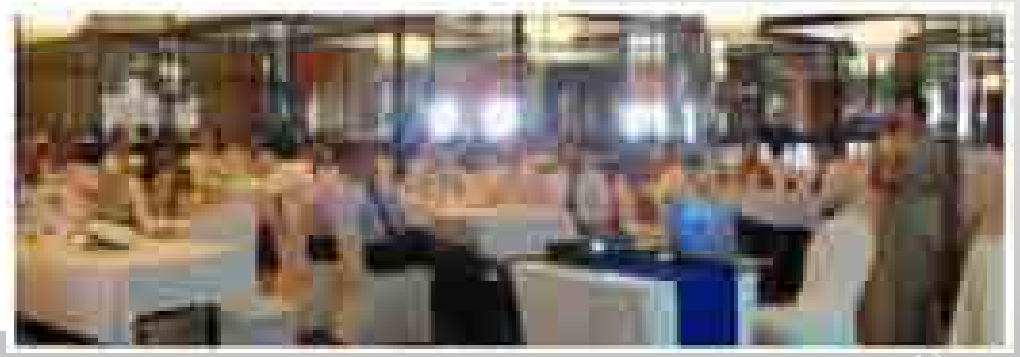
Through Department Web- 3 day forecast for general public

www.meteo.gov.lk

SEASONAL WEATHER FORECASTING IN SRI LANKA



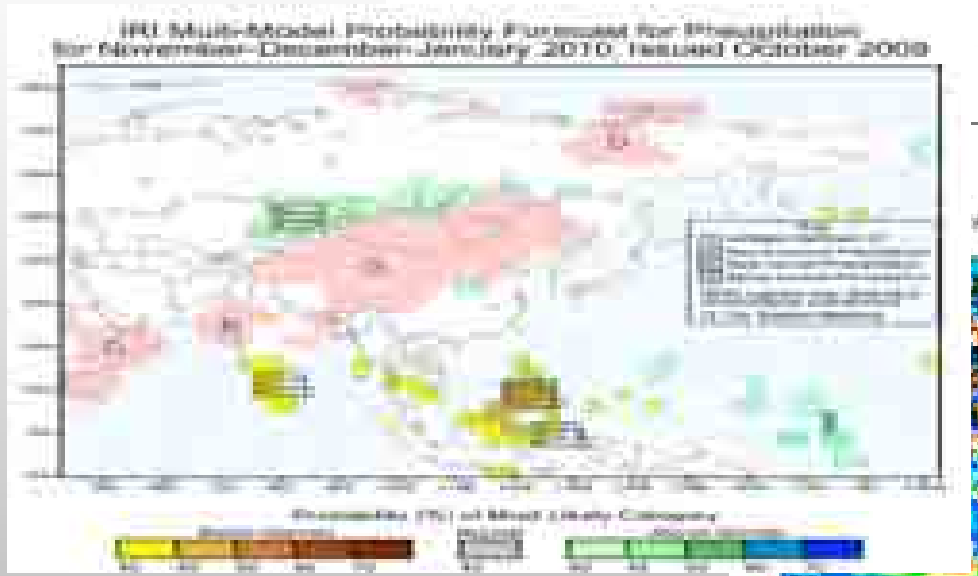
Two monsoon forums are conducted each and every year with the help of RIMES

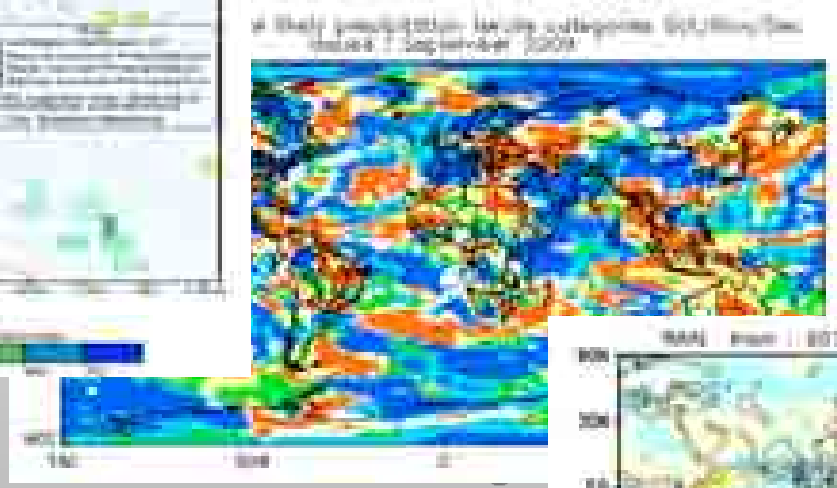


Seasonal forecasting in the Dept.

The International Research Institute for Climate and Society

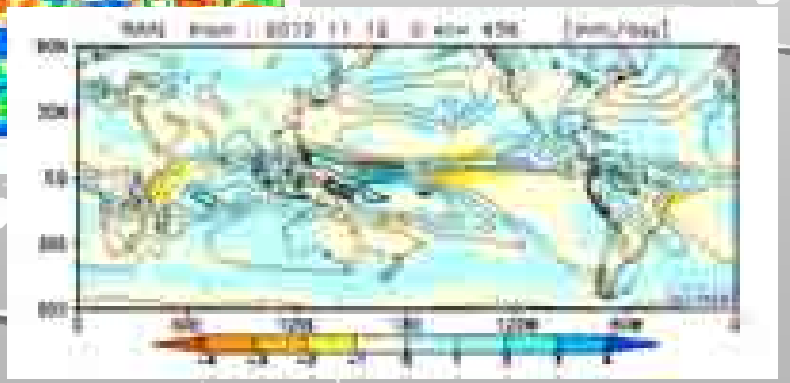
Use other climate centers NWP Model products as tools



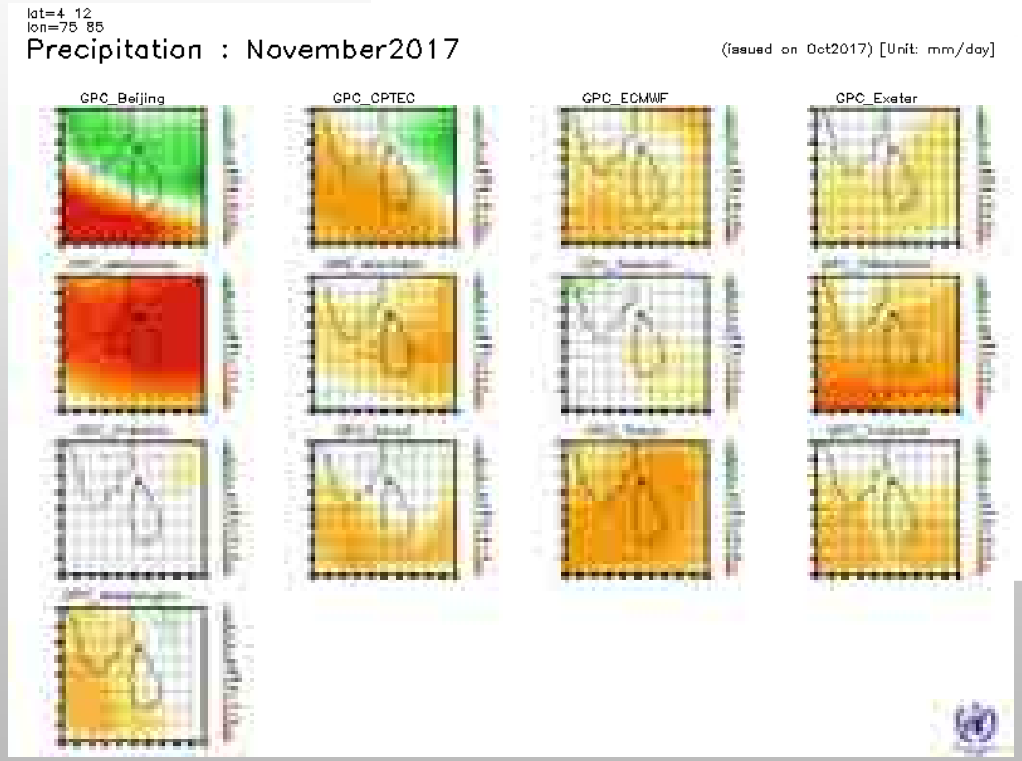


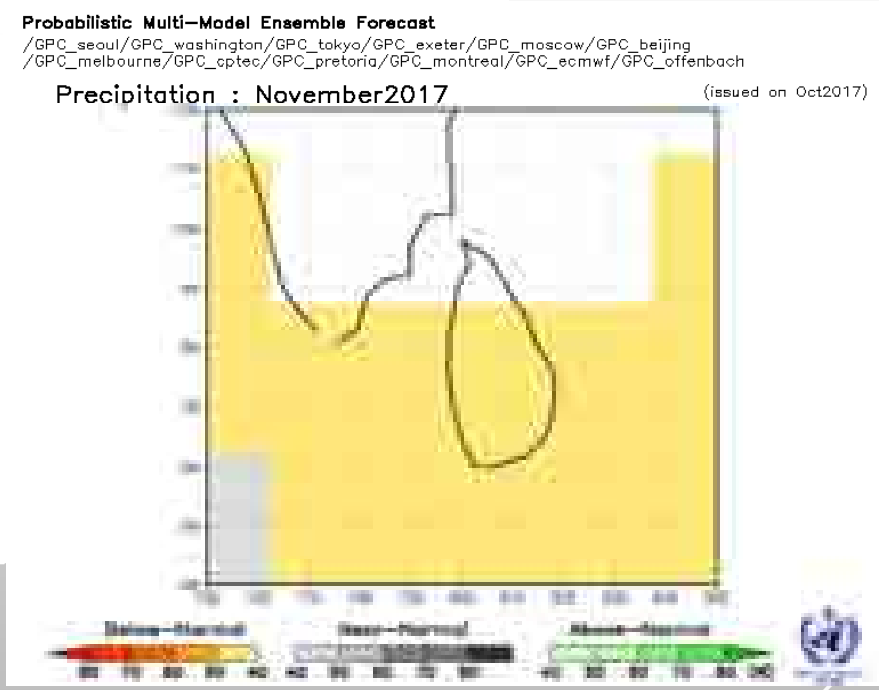
UK Met Office

JMA



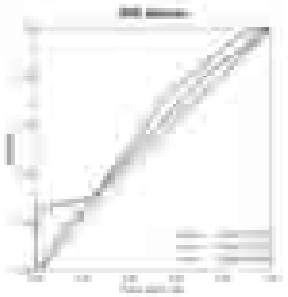
Forecasts from different climate models- November 2017

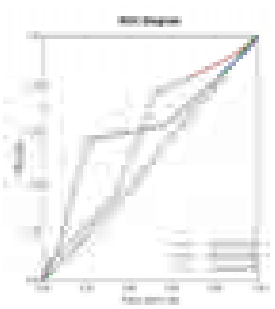


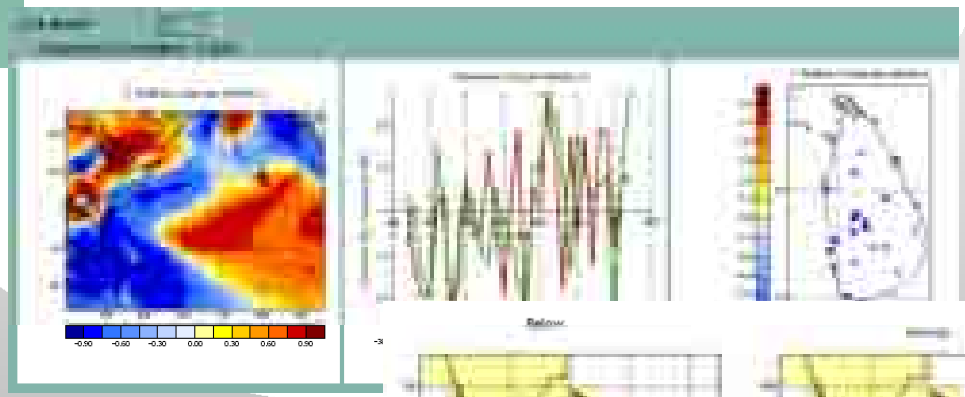


WMO-designated GCPs

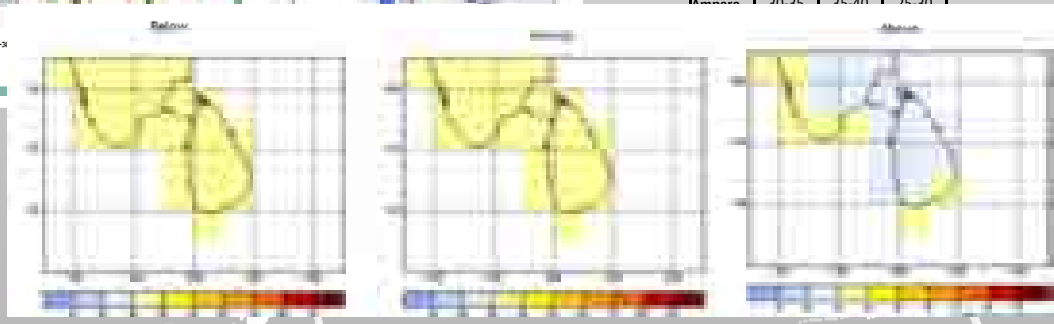
CPT (CLIMATE PREDICTION TOOL) FORECAST





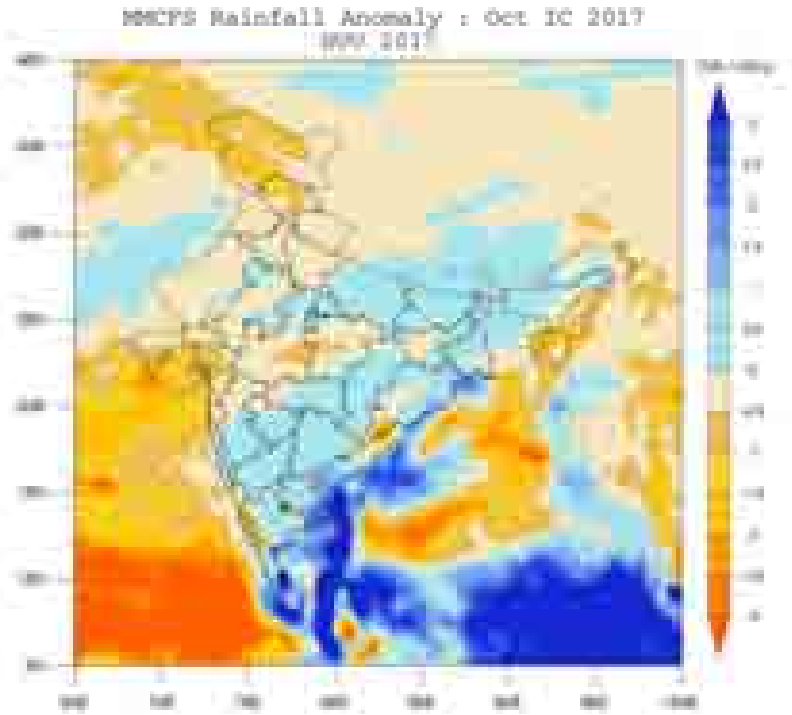


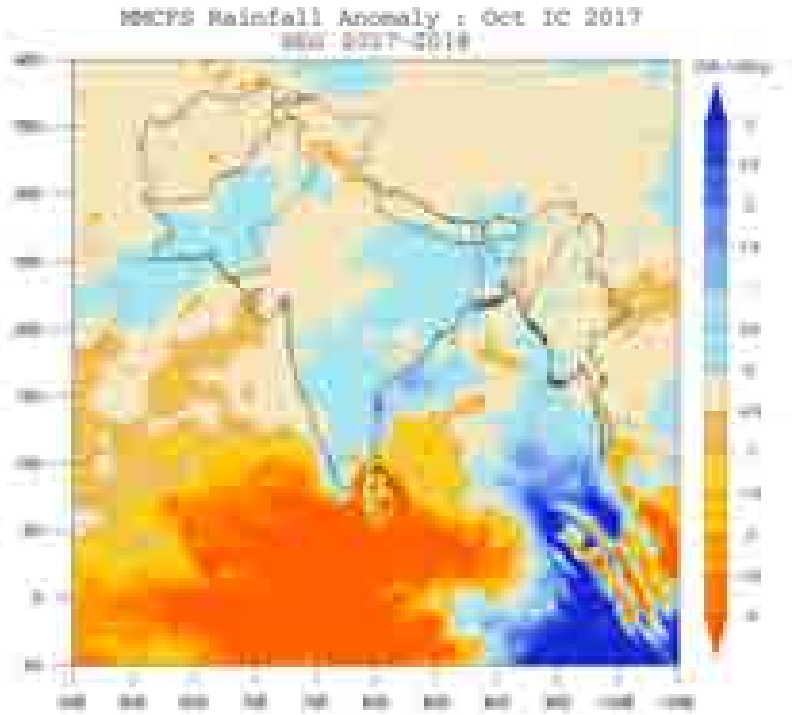
District		Probability %	
	Below	Normal	Above
Colombo	35-40	35-40	20-25
Kalutara	35-40	35-40	20-25
Gampaha	35-40	35-40	20-25
Ratnapura	35-40	35-40	20-25
Kegalle	35-40	35-40	20-25
Kandy	35-40	35-40	20-25
Nuwara Eliya	35-40	35-40	20-25
Galle	30-35	35-40	25-30
Matara	30-35	30-35	30-35
Hambantota	30-35	30-35	30-35
Anuradhapura	30-35	30-35	30-35
Polonnaruwa	30-35	35-40	25-30
Kurunegala	30-35	35-40	25-30
Mannar	30-35	30-35	30-35
Jaffna	30-35	35-40	25-30
Puttalam	30-35	35-40	25-30
Batticaloa	30-35	35-40	25-30
Trincomalee	30-35	35-40	25-30
Vavuniya	30-35	35-40	25-30
Badulla	30-35	35-40	25-30
Monaragala	30-35	35-40	25-30
Matale	30-35	35-40	25-30
Ampara	30-35	35-40	25-30



Canonical correlation analysis
Predictor : CFS U850 Hindcast
CFS V850 Hindcast
Predictant : District Rainfall
GPCC 1x1 data
Goodness Index = 0.25 , 0.2

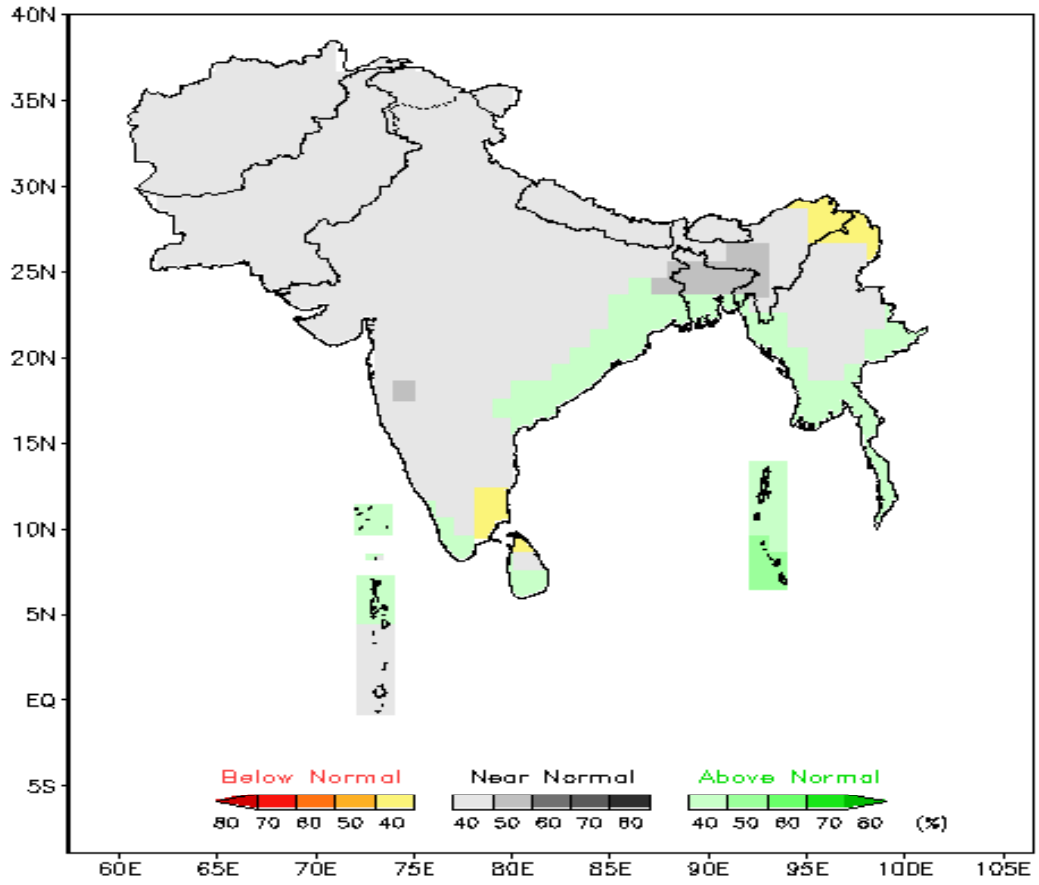
Climate Prediction and Monitoring-IMD,Pune





South Asian Climate Outlook Forum(SASCOF) held on 25-27 September 2017 in Maldives

SASCOF



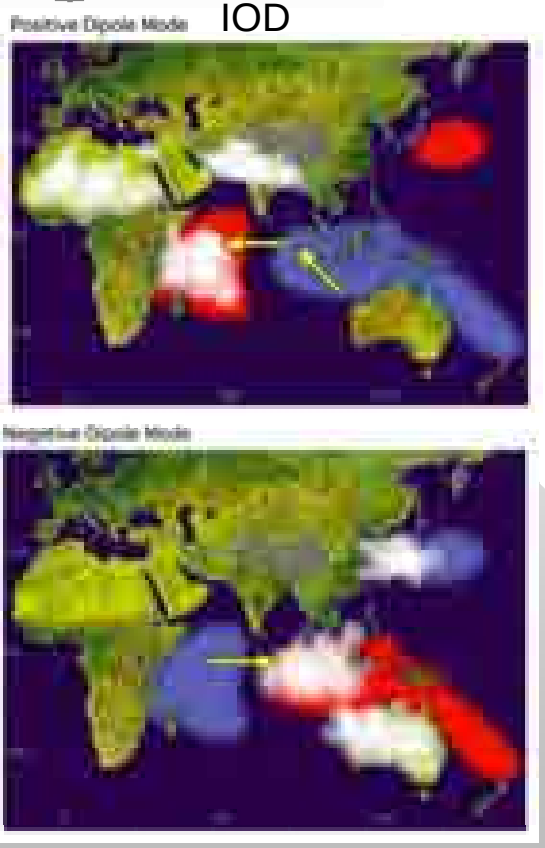
SUMMARY

SUMMARY of MODEL FORECAST for SRI LANKA

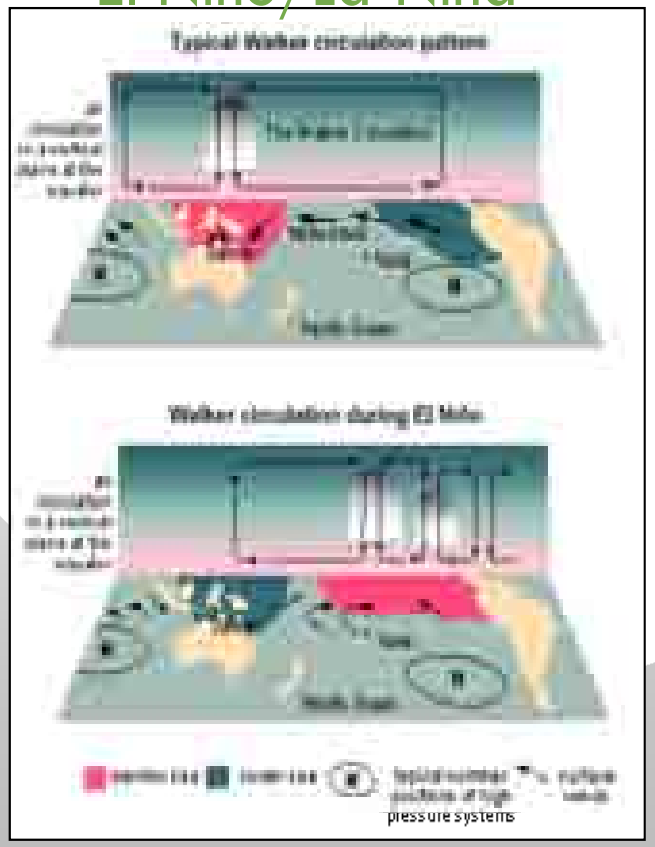
MR Model	IITM CFSV2	NCEP CFS-2	ECMWF	APEC	EURO SIP	JMA	INDIA	UKMO	WMO LC MME	CPT	FINAL
-2	BN	No Sig	No Sig	BN	No Sig	BN	BN	BN	BN	No Sig	BN/N/AN 40/35/25

- Sri Lankan climate is influenced by temperature patterns in the Indian Oceans as well as Pacific ocean.

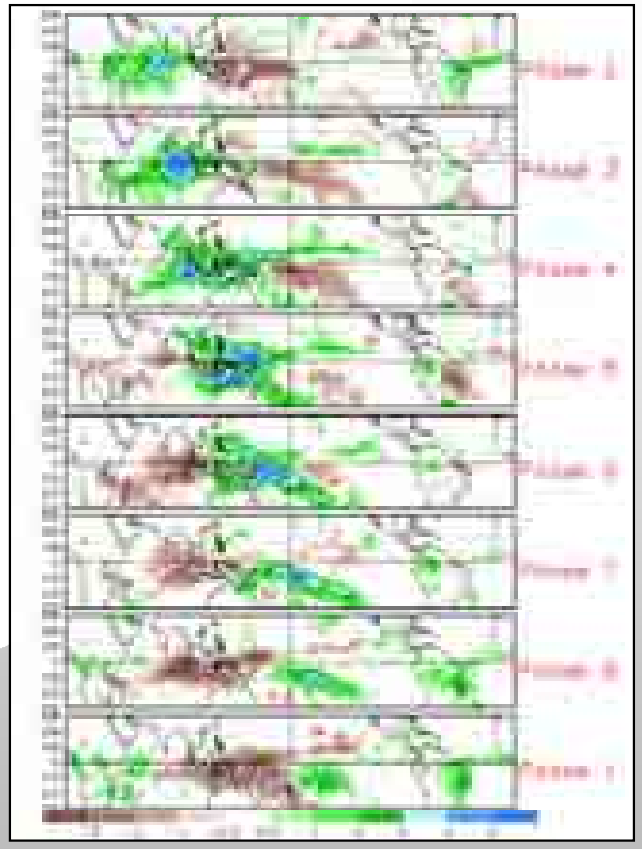
IOD



El Nino/La-Nina



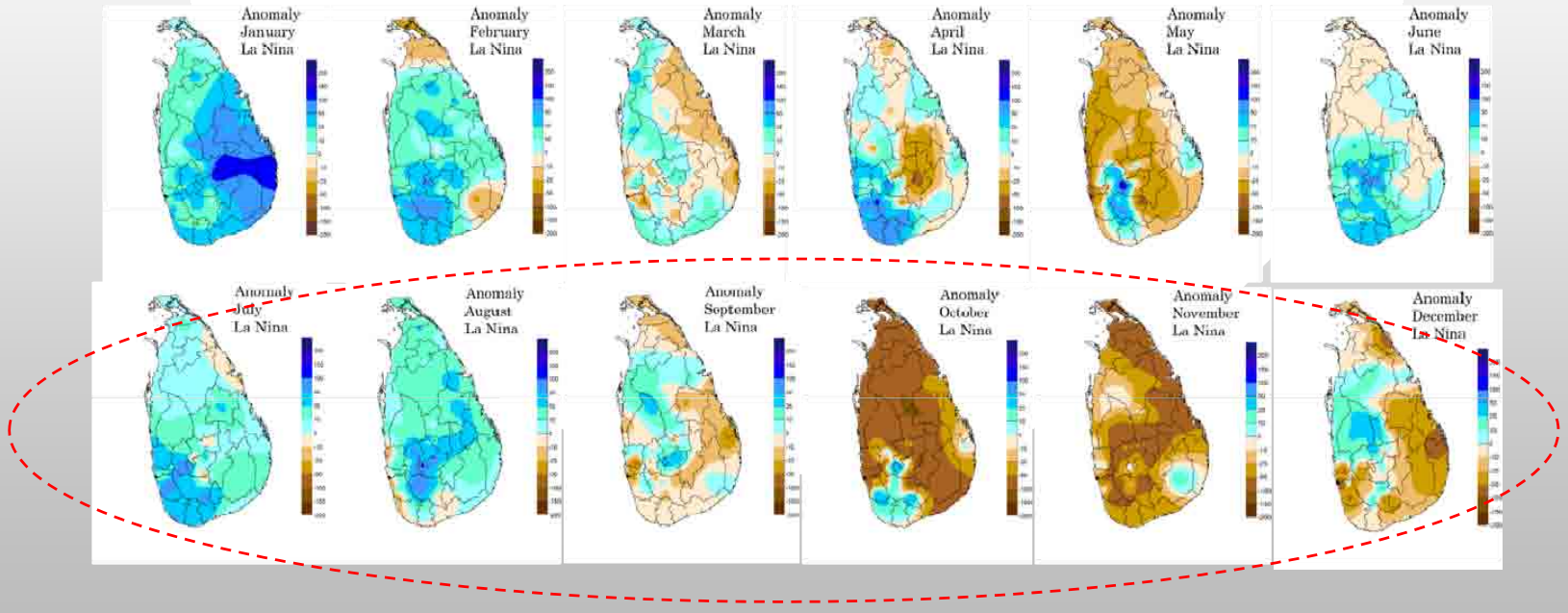
Madden-Julian Oscillation(MJO)



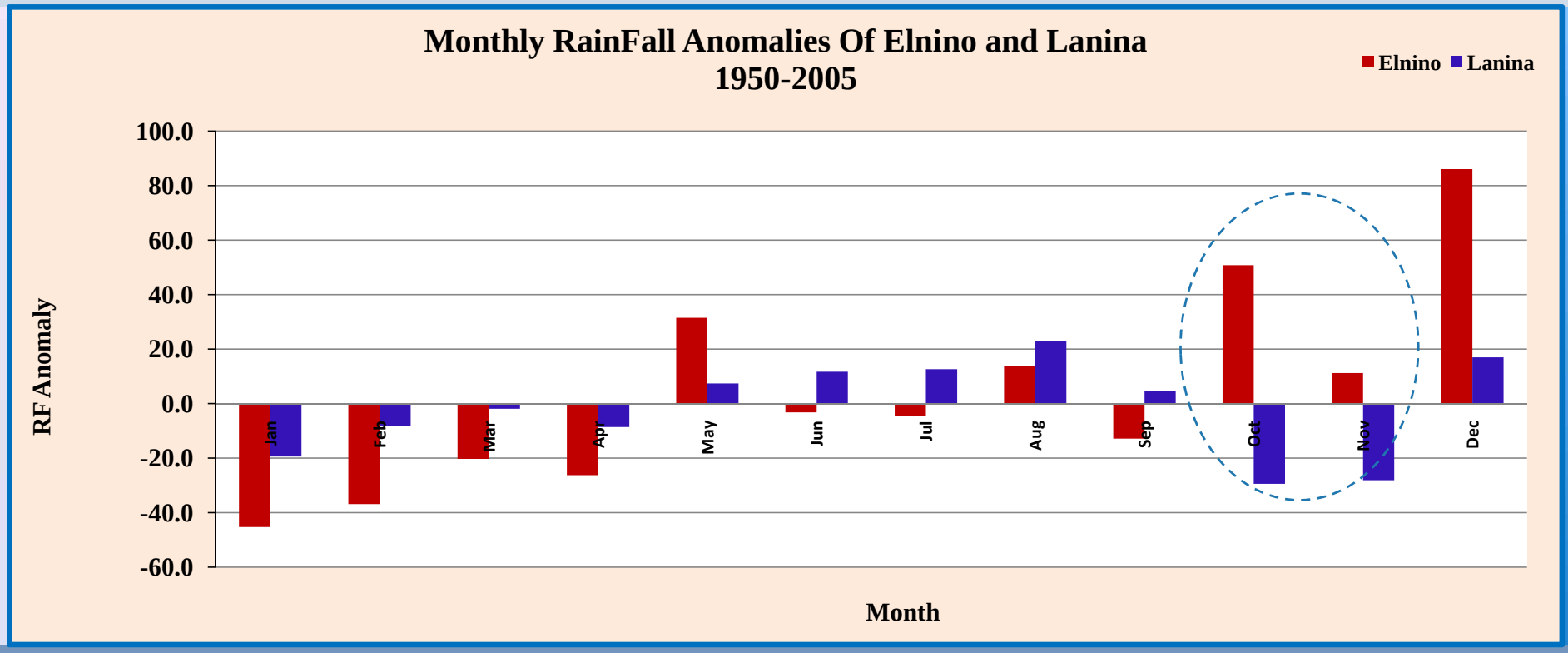
- ENSO /Indian Ocean Dipole(IOD) MJO, Kelvin wave..etc

Monthly average Rainfall anomaly During La Nina

Anomaly composites maps for La Nina years



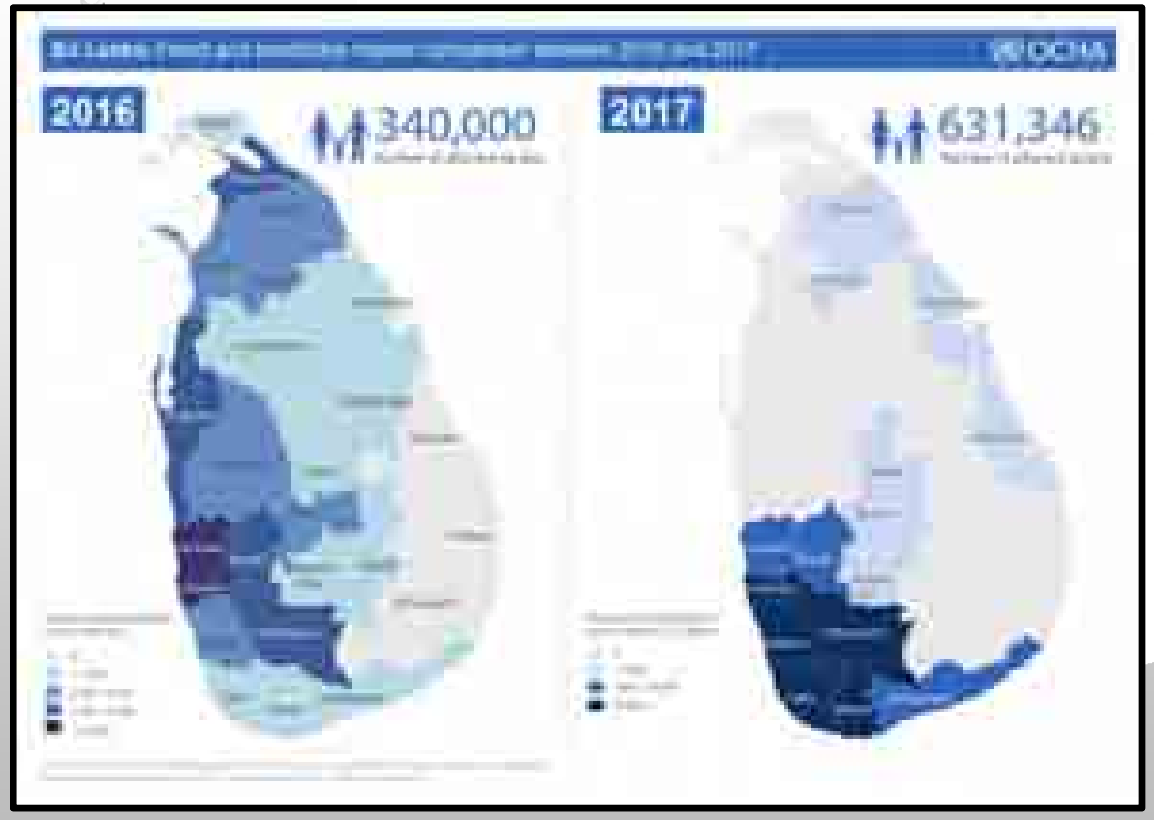
Courtesy research division


Monthly RainFall Anomalies Of Elnino and Lanina
1950-2005
Elnino
Lanina
RF Anomaly
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Recent experiences and challenges

ORKCHI -as a Depression- made a damage to southern part of Sri Lanka

Impact of basic stages of Cyclones during 2016/2017



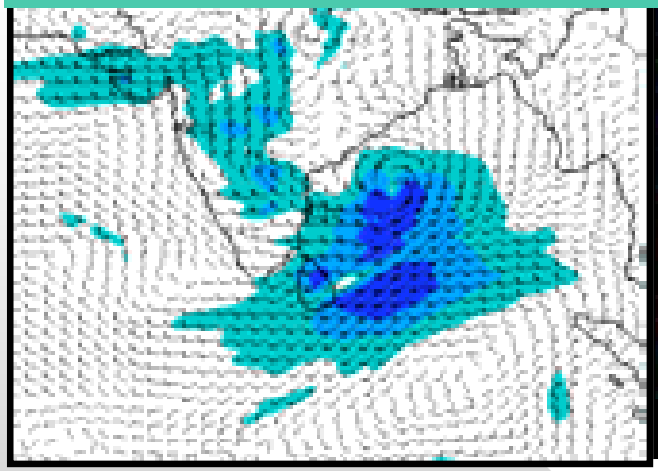
Source-UNOCHA

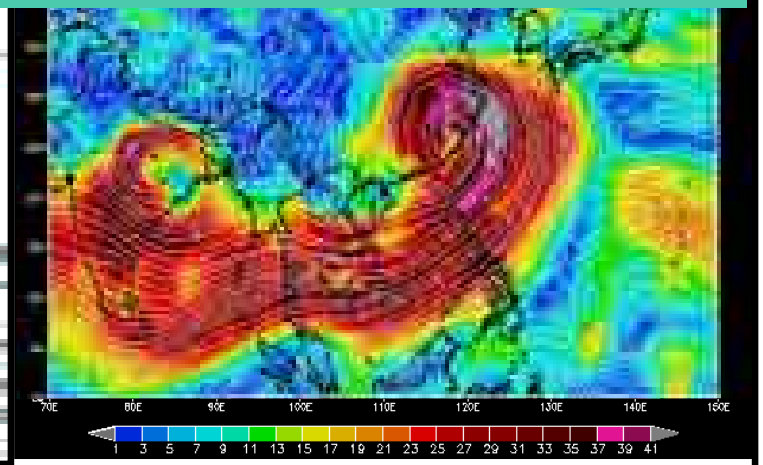
- Two consecutive years floods in same month of May
- caused massive land slide and flood in South Western part of the country
- made significant damage to our

Vigorous Onset of Southwest monsoon 2017

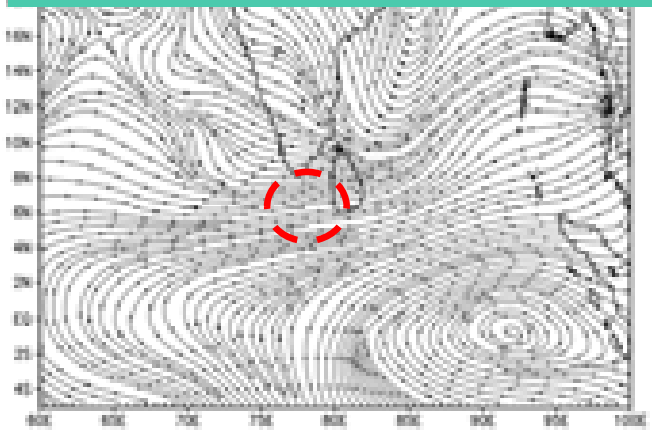
Southwest monsoon (Windy and showery) condition can be enhanced by

1.disturbances/low pressure systems /cyclones in the Bay of Bengal / Typhoons in Pacific ocean

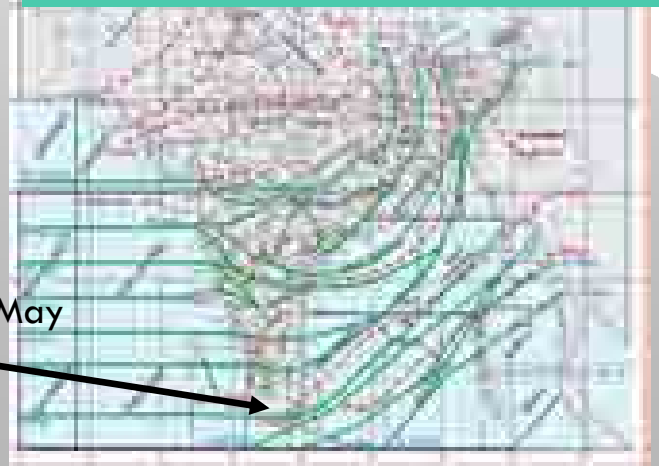




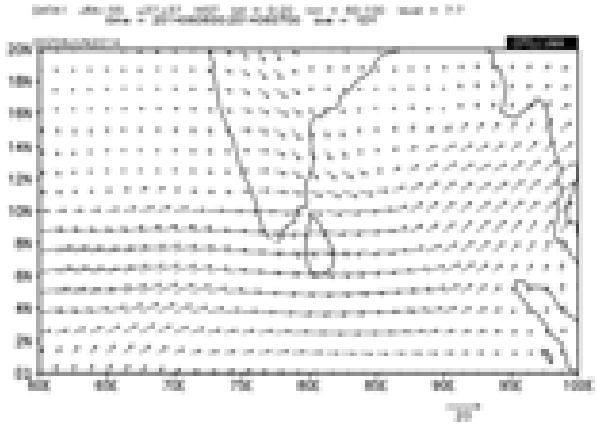
2.wind convergence /trough to the west/southwest



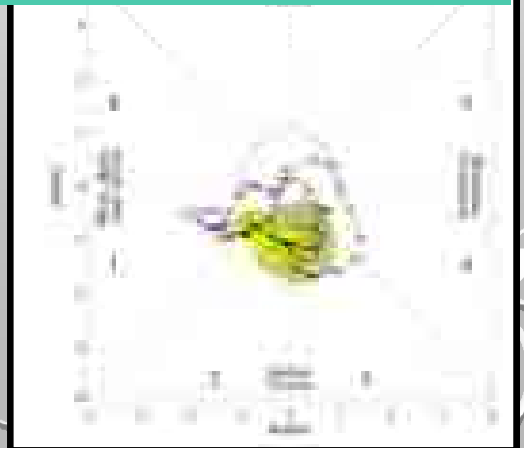
3.Monsoon trough(ITCZ) close/over SL



Low level Jet



4. Madden- Julian Oscillation

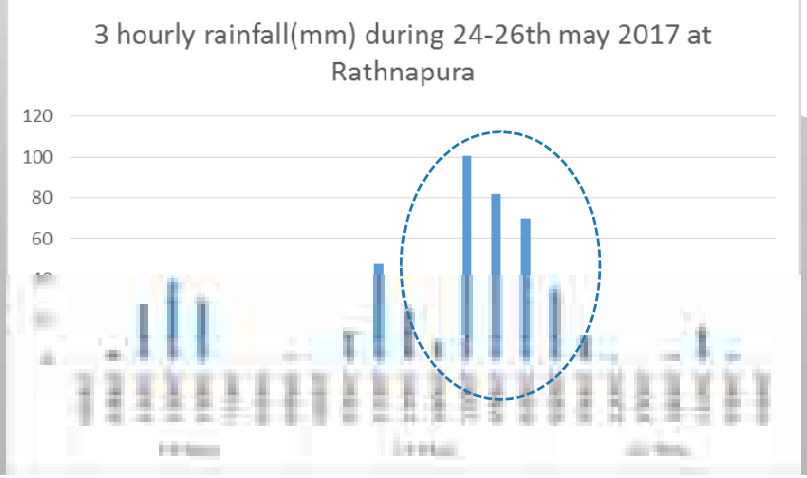


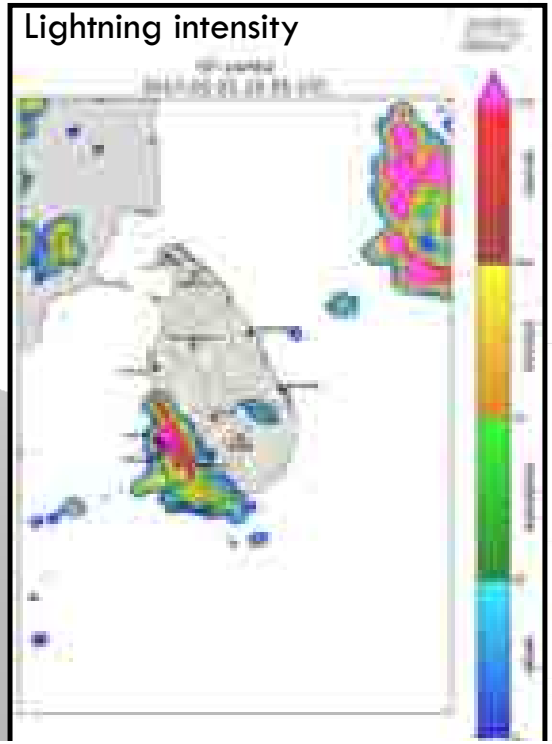
1st Case

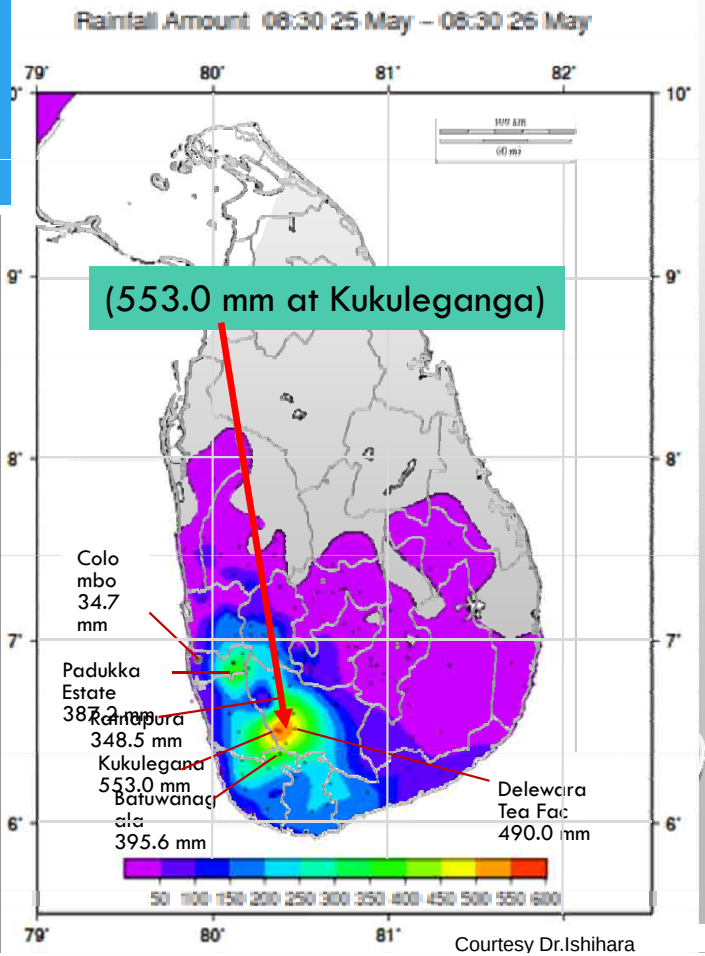
On 25th May 2017 extremely heavy rainfall caused flood and landslides

553.0mm within 24hrs- 3rd highest in DOM rainfall records

Around 224 deaths
(missing 75)
6,70,000 peoples are affected (source DMC)

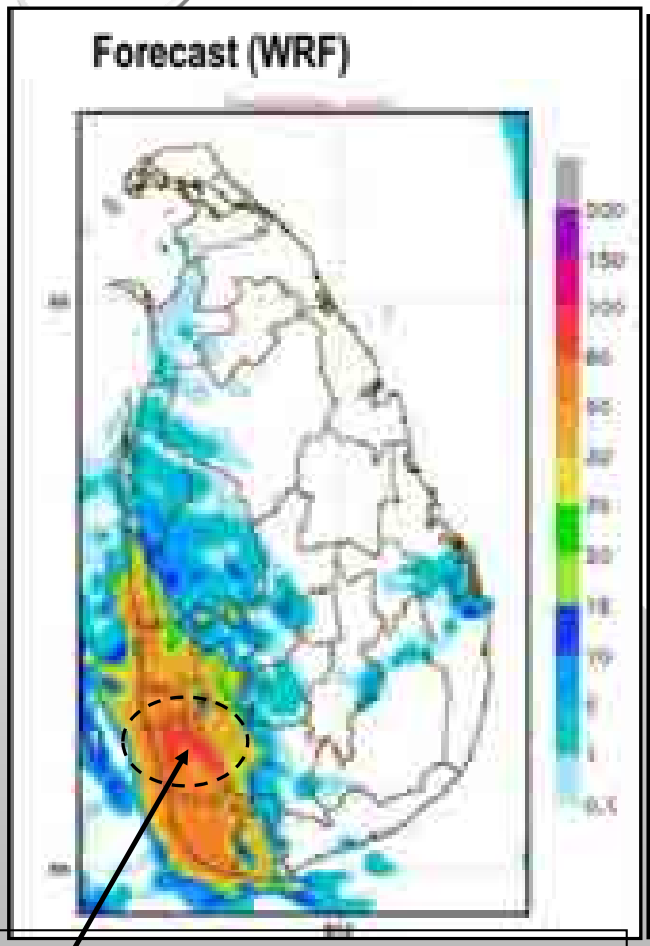






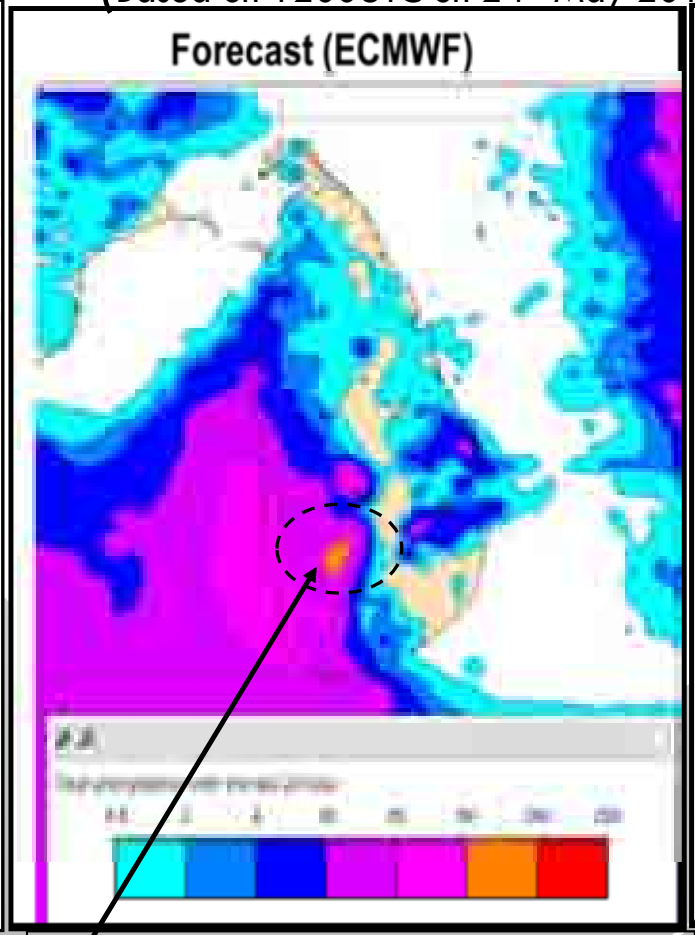
NWP model rainfall Forecast for 25th May 2017 by WRFDA(5km) and ECMWF

(Based on 1200UTC on 24th May 2017)



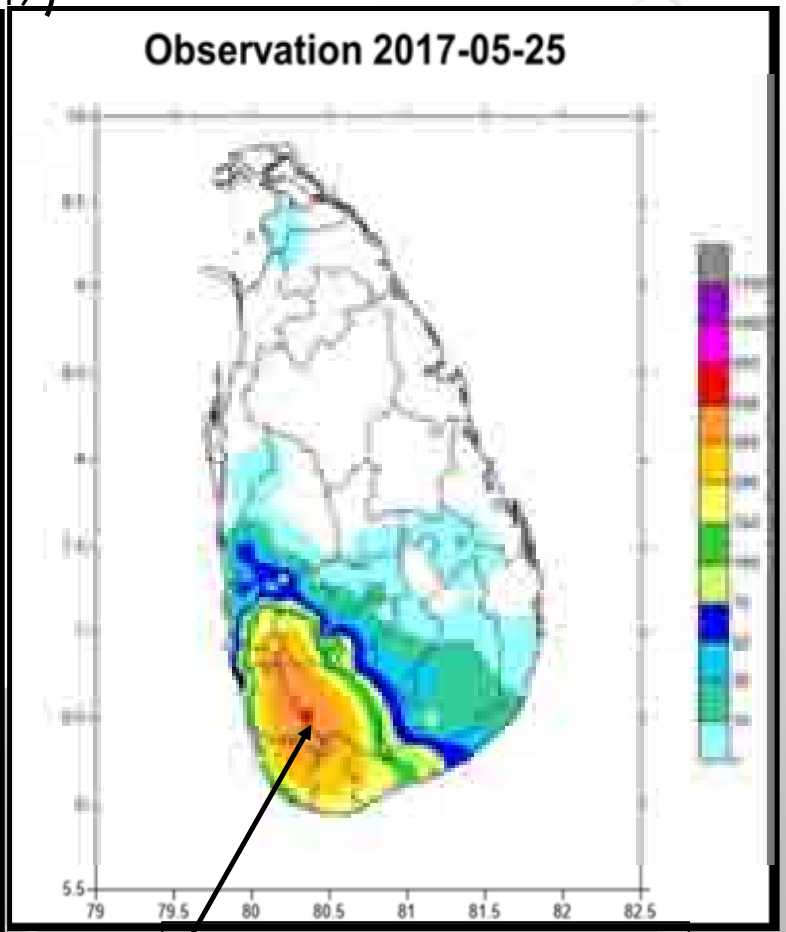
Predicted Maximum rainfall for 25th

80-100 mm



Predicted Maximum rainfall for 25th

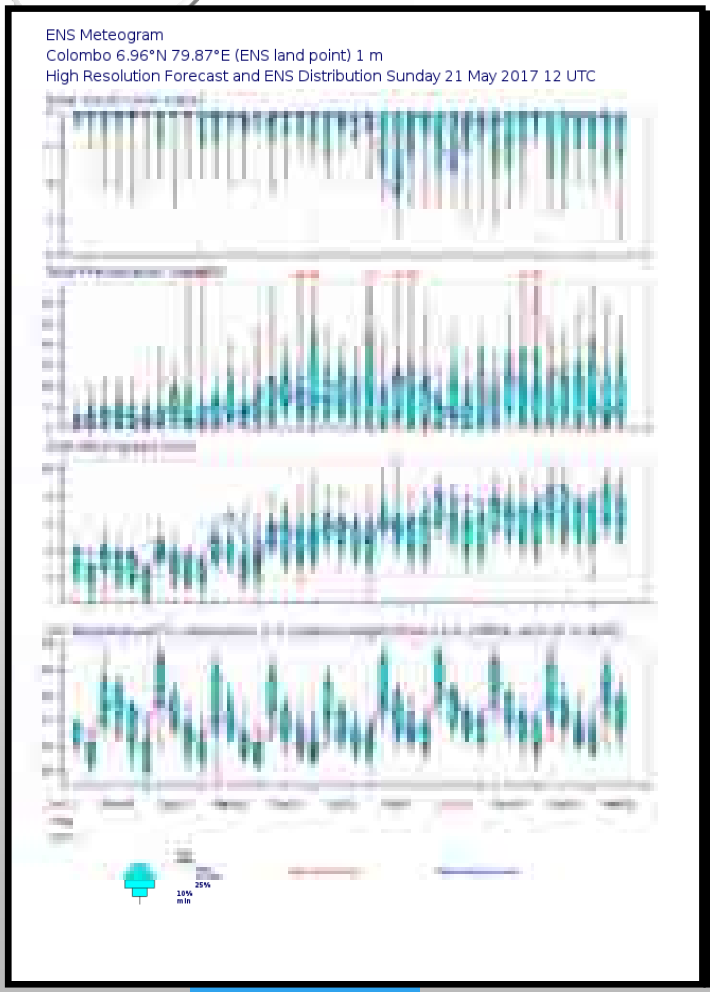
50-100 mm



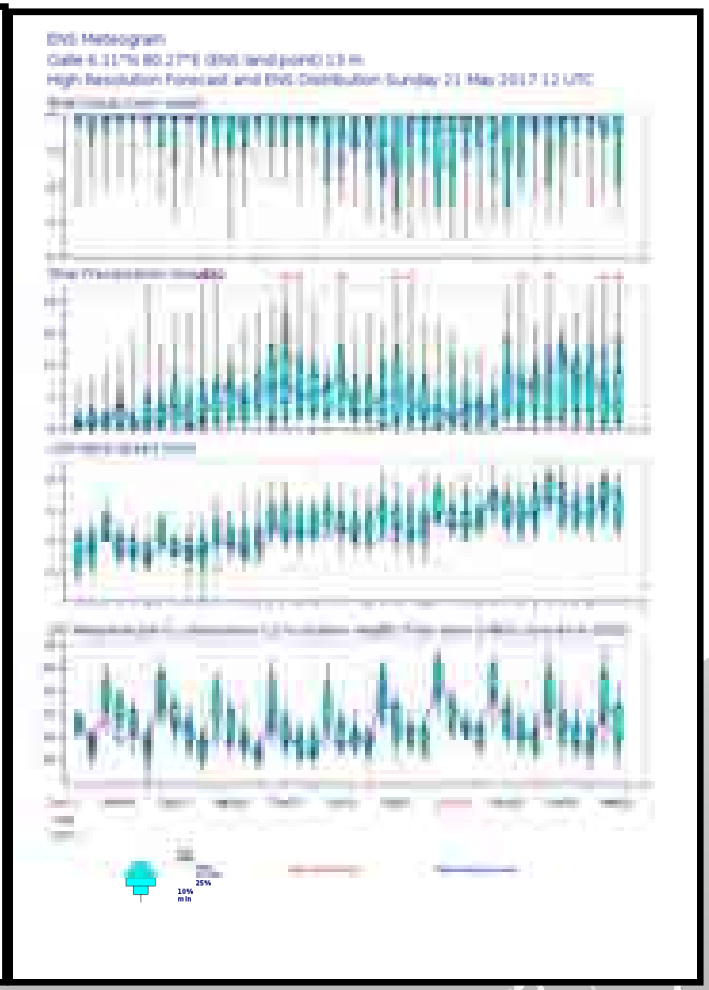
Observed rainfall on 25th

553.5 mm

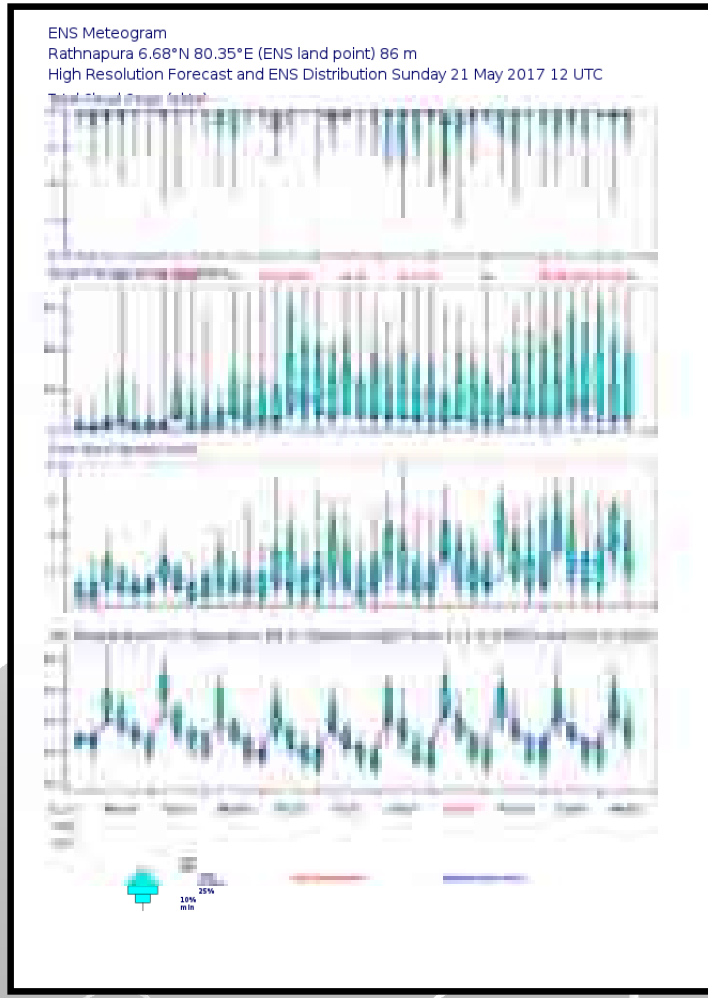
Onset of SW monsoon 2017-10 day forecast from ECMWF



Colombo



Galle

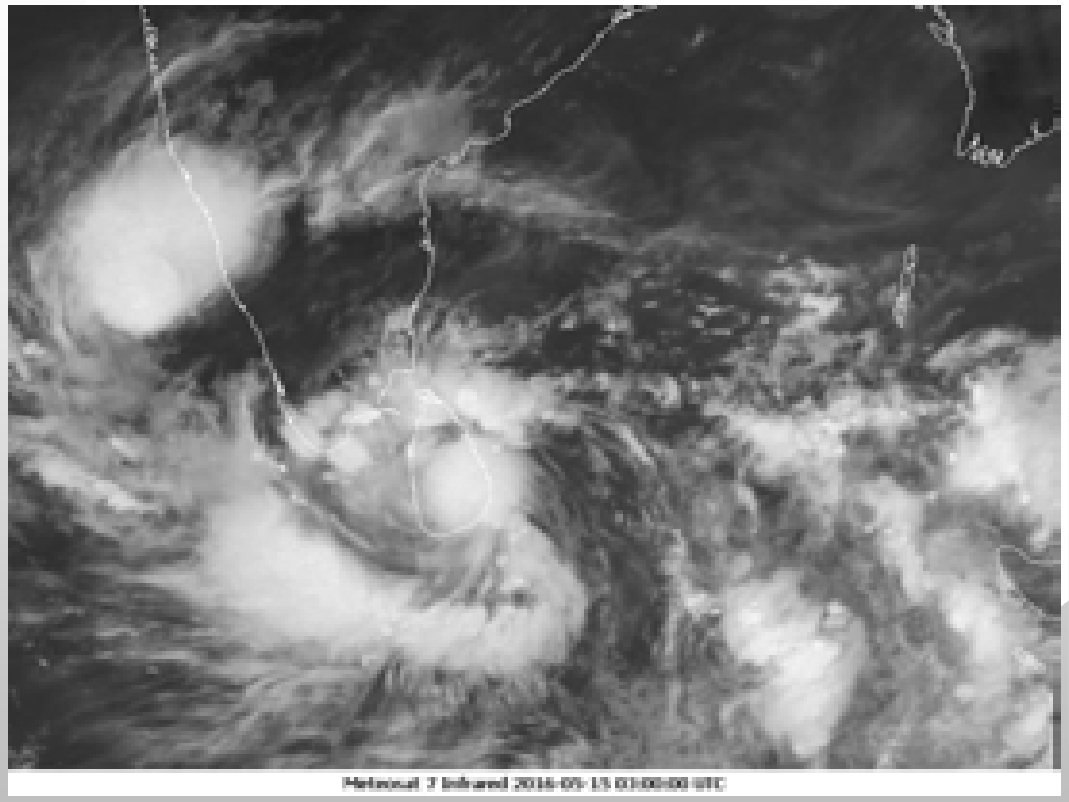


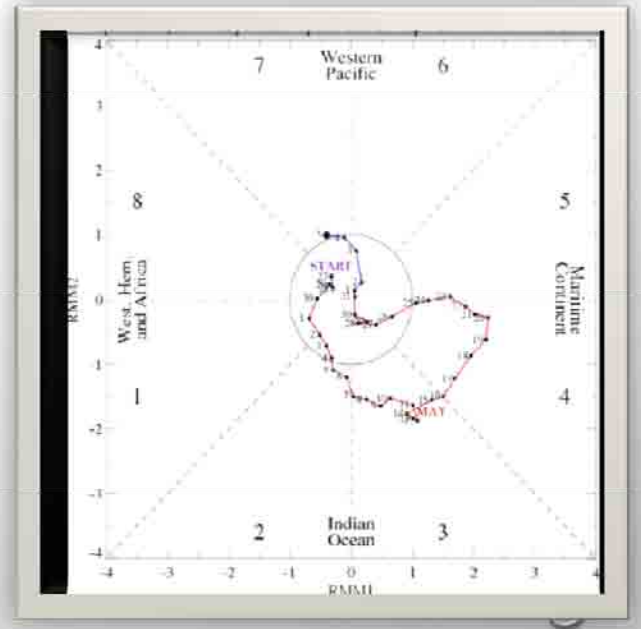
Rathnapura

2nd Case

“ROANU “cyclone- 14-17th May 2016

Massive flood and land slide due to ROANU Cyclone

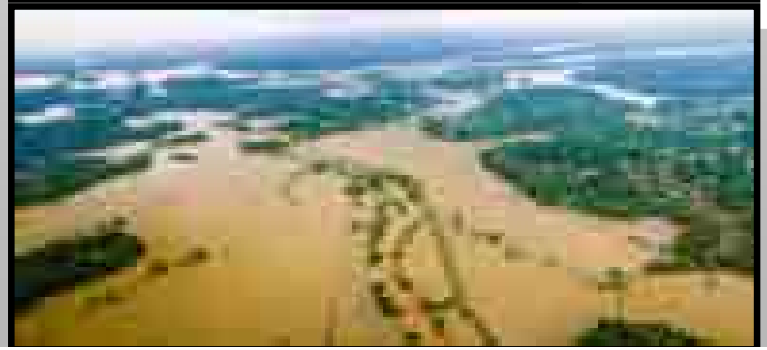




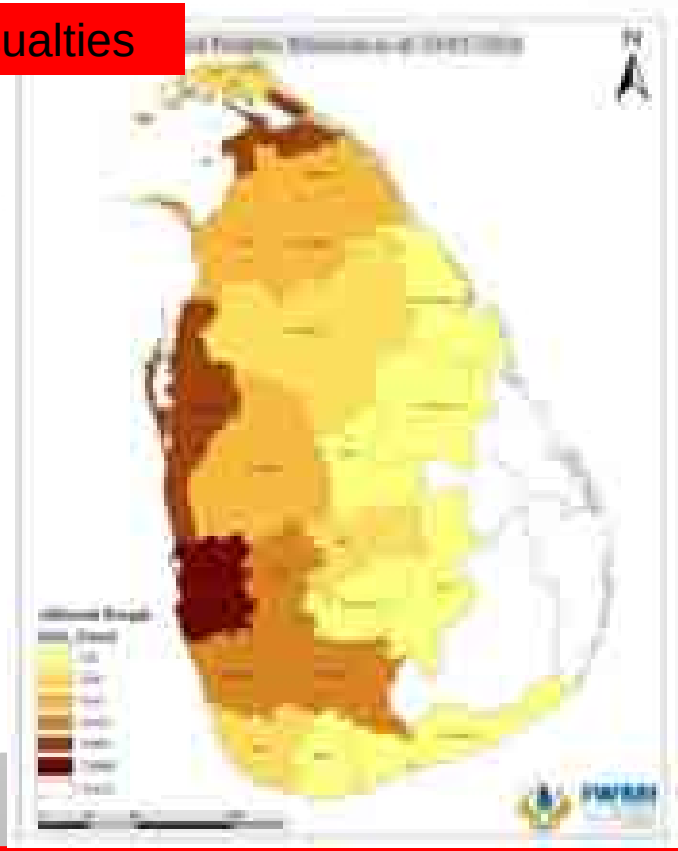
Cyclone “ROANU” was the first tropical cyclone of the 2016 in North Indian Ocean season

2nd Case ctd…

Massive flood and land slide due to Ronu Cyclone 14-17 May 2016



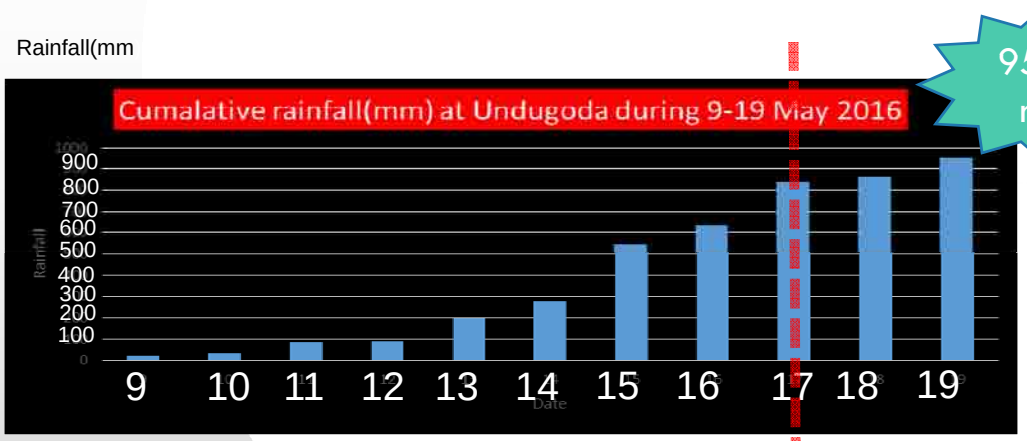
More than 200 casualties



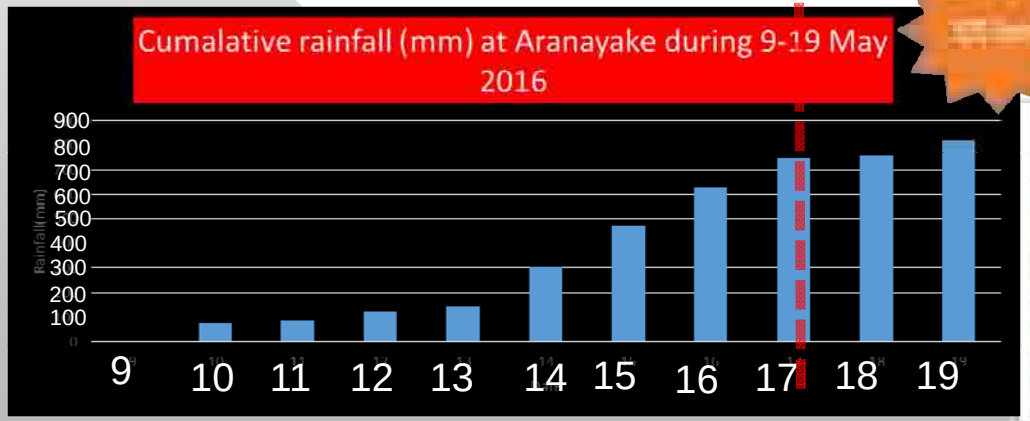
Damage-250–280 billion rupees
(US $1.7–2 billion)

2nd Case ctd…

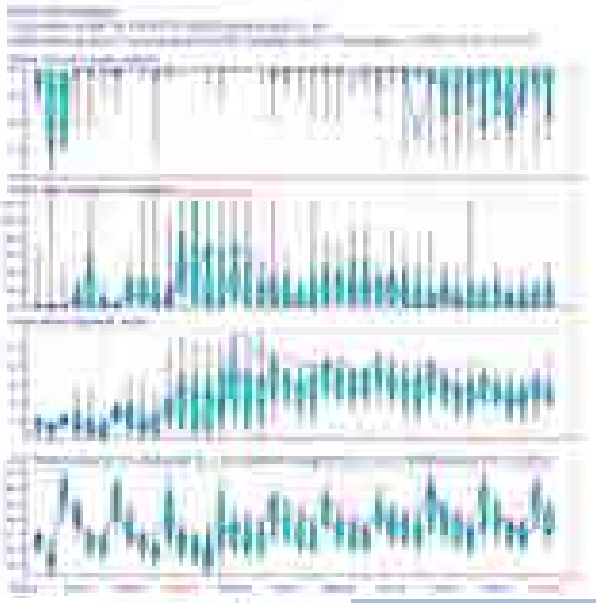
Two Massive landslides occurred western slopes of the Central hills



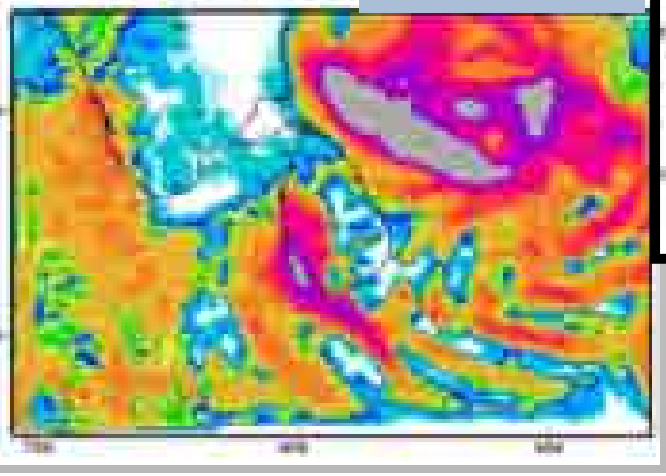
952.3 mm



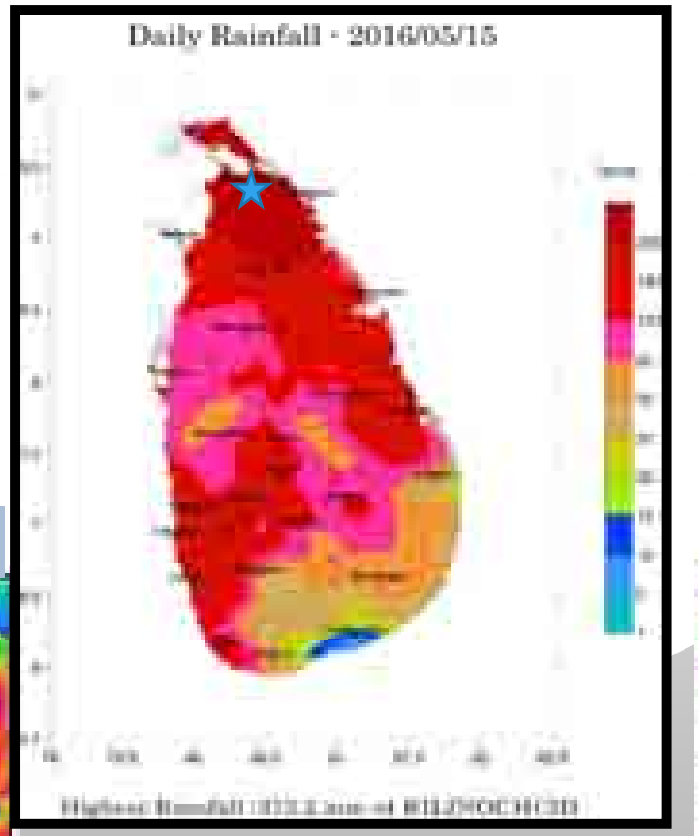
NWP out puts and observations 15th May 2016



WRF-15Km

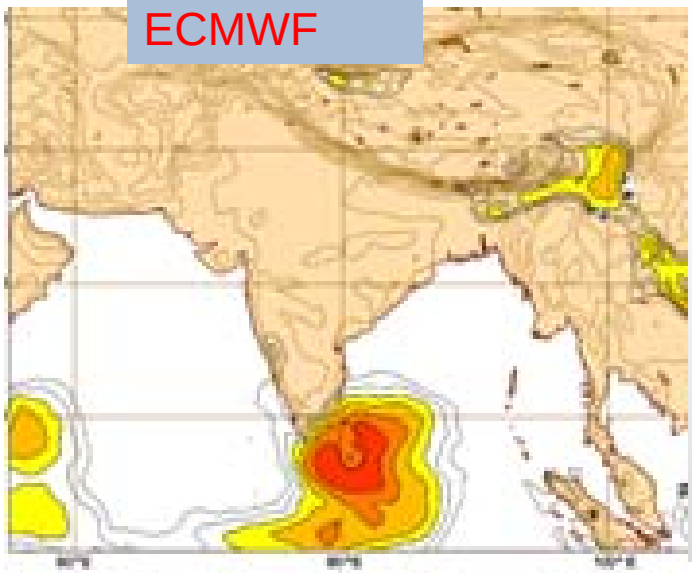


observation

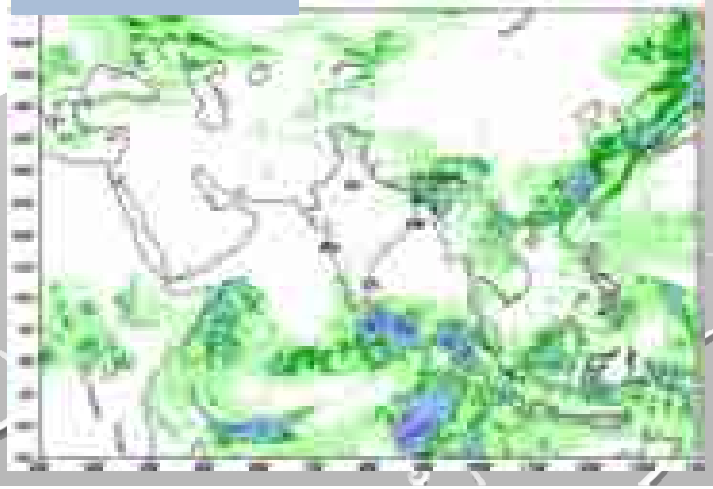


Maximum was 373.2mm
at Kilinochchi

ECMWF

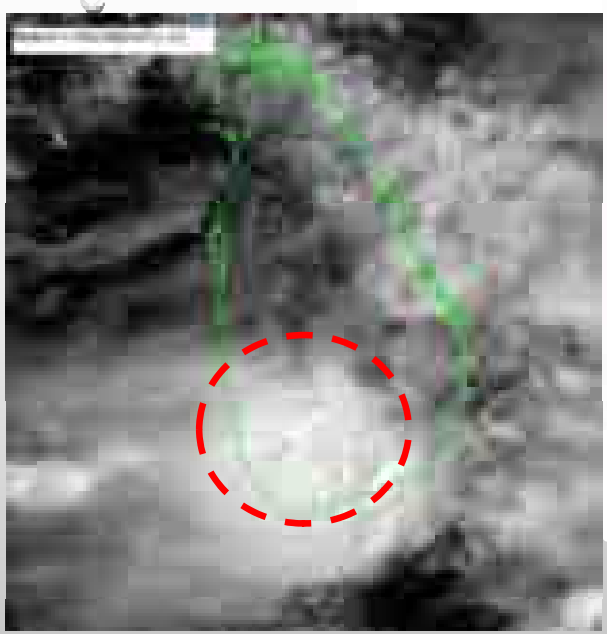


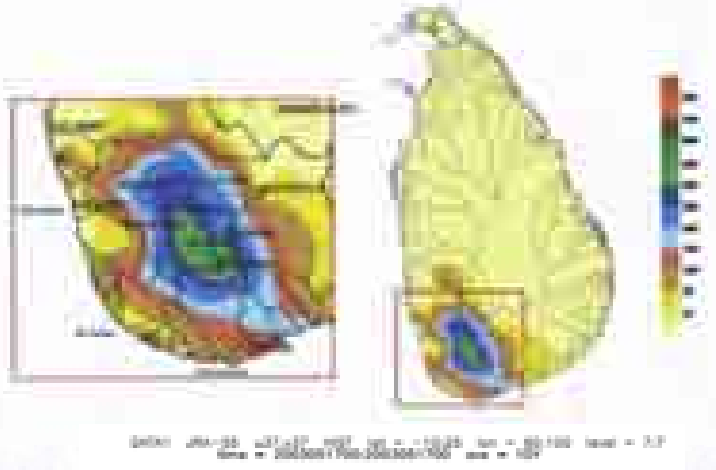
NCMRWF

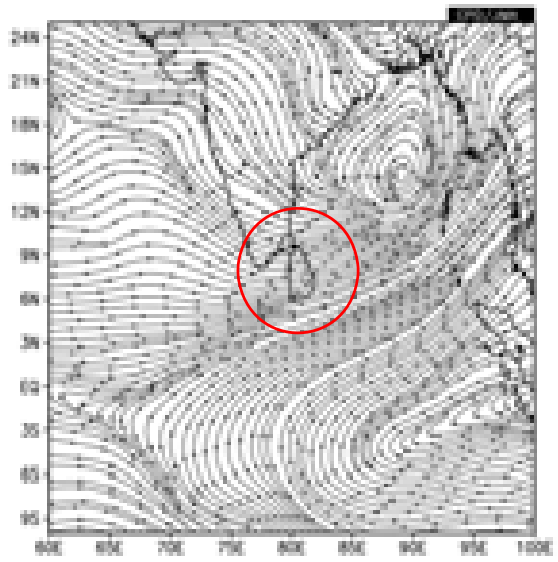


3rd Case

Sri Lanka received 2nd highest rainfall (730mm during 24hrs) on 17th May 2003



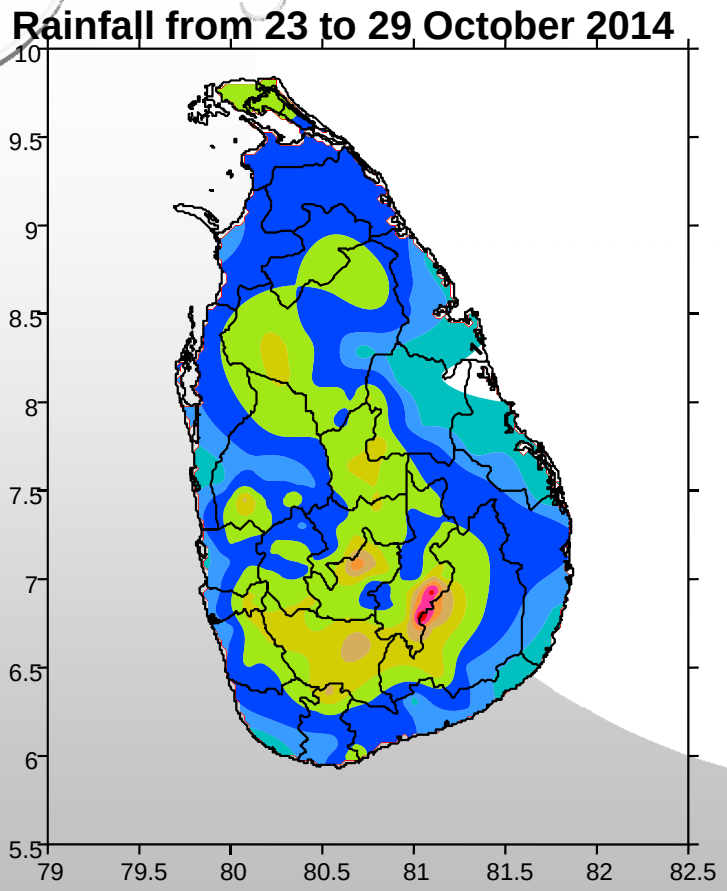




No of Deaths-293

3rd Case

Meeriabadda, Massive land slide



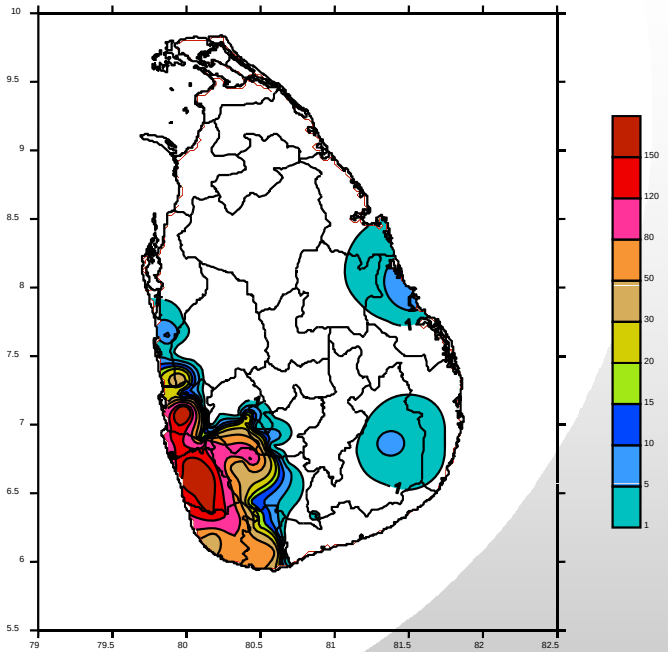
30 deaths

•Continues afternoon thundershowers triggered floods and land slides at some places during the month. A massive land slide occurred at Meeriabadda, Poonagala area on 29th. (More than 700mm rainfall had been received during 15- 28th at Poonagala rainfall station) and caused more than 30 deaths.

4th Case…..

Heavy Rainfall on 01st June 2014

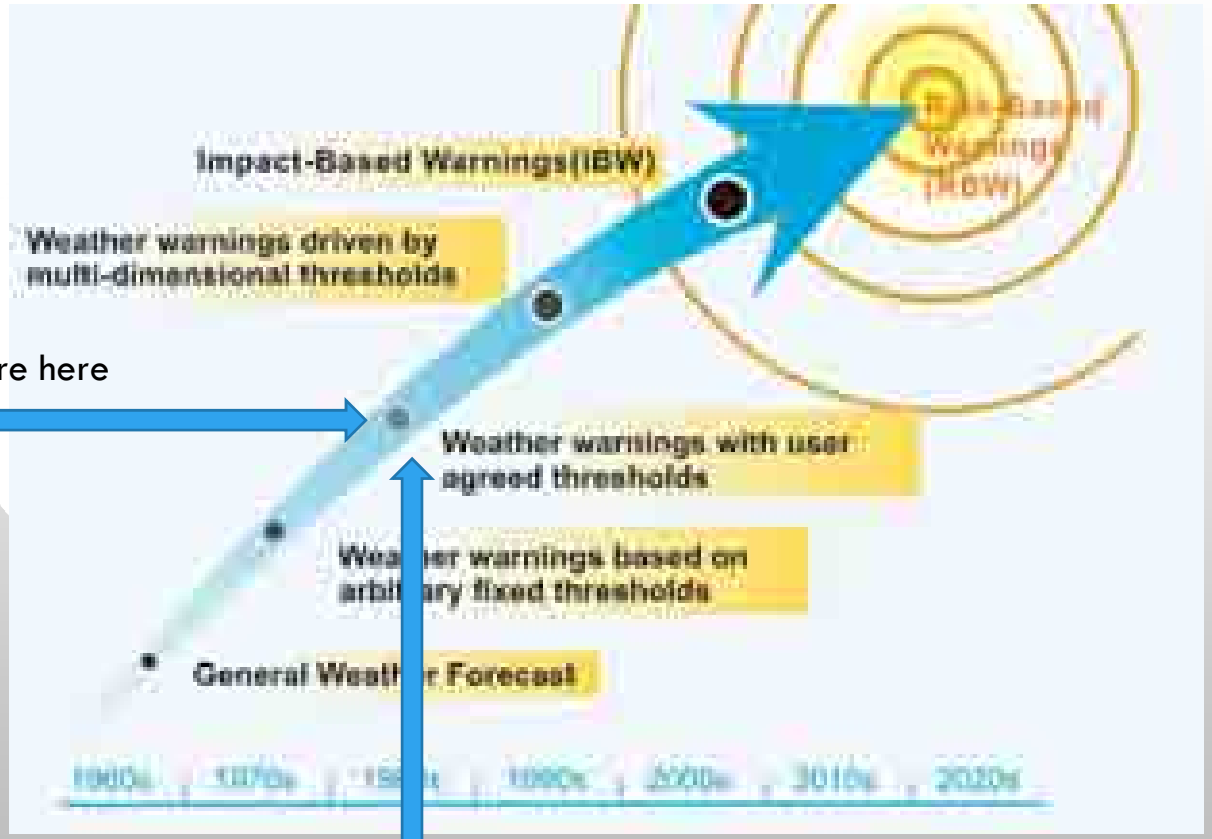
Agalawatta- 443.8mm



No of affected people	110,743
No of death	6
Fully damaged Houses	294
Partially damage houses	1,850

Challenges are ……

1. Attitudes of the general public
2. AS a tropical country closer to EQ
3. Geography
4. Surrounded by vast Oceanic area/interaction between ocean and land
5. Lack of Conventional data



Source : WMO

Important for better Public Weather Service (PWS)/ early warnings for DRR

To fulfill these requirements A project proposal was submitted (first one was submitted in 2011) and approved by the Government.

To Enhance

- Data observation/Communication network
- Weather Forecasting/Early Warning system
- Human resource development

As a first step funds for data/NWP outputs from ECMWF will be provided from July 2017 for 2 years

Improving weather forecasting/ warning system and Public Weather Services

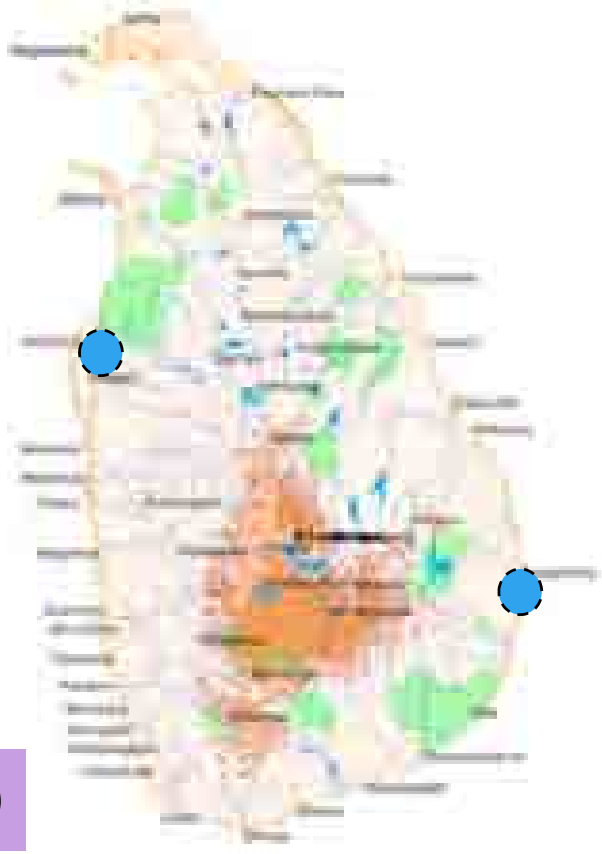
Most Important thing- Human Resource Development and capacity Building (improvemen of research side is highly needed)

At present- 2017

Category	Promoted Without Degree	Basic degree with Physics and Mathematics	Diploma in Meteorology	MSc in Meteorology	Phd in Meteorology
Meteorologists	6	12	7	9 +(3 doing Masters)	1

Two Doppler radars will be granted by JICA

due to start in 2018



due to complete in 2020

Project/Programme	Target outcomes	Start Year
Climate Smart Agriculture	Food Security	2018
Smart Meteorological Grid System (SMGS)	Online availability of Gridded Climate Data for free of charge	2018/2019
Integrated Water Management under (Green climate Fund	Resilient to Climate Change	2018
Install Ocean Buoy	Availability of ocean meteorological data	2018
Initial stages of Establishment of RIMES Regional Hub		2019
Develop a Meteorological app for 1.General Public/Fishery Community/Agriculture Community	Disaster reduction	2018
Establish a Lightning Centre	lightning related research	2018
Impact Based weather Forecast		2018
Real Time Ocean Information for Naval and Fishery community		
Climate change resilience for sustainable development	disaster risk reduction and disaster management, social protection and adaptation strategies be part of a broader development framework	2018
Meteorological Research and Training Unit (MRTU)	Separate institute affiliated to the Department of Meteorology	


Thank you