Kalpakkam is a coastal site. Location: 12.5576° N, 80.1754° E. Diurnal variation in wind flow. Power Reactors: PHWR (2 x 220MW) and PFBR (500MW). Off-site emergency calls for ONERS.
ONERS: Objectives & Salient Features

Objectives:
• Mitigate the Radiological risk to the public.
• Quick projection of the plume dose and forecast.
• Facilitate quick operation with user friendly software.
• Dissemination of decision-actions.

Salient Features:
- ONERS – an online GIS based DSS. Designed completely in open source GIS framework. It uses client-server architecture.
- Source-Term model and associated environmental radiation monitoring network and Online Meteorological Observations.
- Forecast of winds, rainfall and other met parameters.
- Air concentration/deposition/dose profiles computed using dispersion models SPEEDI and FLEXPART.
- Spatial data on various themes like Village/district boundaries, land-use & cover, transport routes, water bodies etc.
- Integration of dispersion model results with spatial and non-spatial database using overlay tools.
- Performs spatial query and analysis using GIS to generate scenarios from present to future for effective utility in ERM.
- Suggests prompt interventions/counter measures.

Software Architecture employed in ONERS
Client server architecture ➔ easy to access from remote location
Generic shape file for Spatial data base ➔ Most common GIS format.
MYSQL for database ➔ Most widely used.
CGI-BIN Map Server for web GIS ➔ No proprietary GIS
PHP Map Scripts ➔ No proprietary GIS language.
Open Source Linux ➔ No dependency on proprietary libraries

ONERS is designed according to AERB Safety guidelines (AERB / SG/EP-2; 1999)
ONERS DSS inputs are: accident source term, met. observations and weather forecast, spatial database and the dispersion model predictions.

- **Source Term**
- **Meteorological Inputs**
  - Weather Forecasts (WRF)
  - Meteorological Observations
- **Spatial Data of site**
  - Spatial Data (Terrain, Land Use Villages, Soil data, Transport routes)
- **Attribute Data** (Infrastructure, Shelters, Hospitals, Civil offices etc)
- **GIS Integration, Query Analysis**
- **Dispersion Model & Dose Module**
- **Query Results, Reports, Visualization & Counter Measure**
Weather Model (WRF) is customized for Kalpakkam site to assimilate local and national meteorological observations & Suitable model physics to provide accurate meteorological condition around the site in a 100 km range.

**Implementation of weather & Dispersion Models**

WRF model implemented at a high resolution (2km) using triple-nested domains and run on HPC.
- Forecasts from WRF used to predict plume in 100km range using FLEXPART-WRF
- SPEEDI for local range 12.5 km with local met data

**Implementation of Dose Assessment Module**

- Cloud dose computed by point Kernel method
- Inhalation dose computed using time integrated conc. of particulates & breathing rate.
- Deposition dose computed by time integrated total deposited activity
Online Nuclear Emergency Response System:
Integrated Meteorological Observation Facility for KALPAKKAM Site

Site specific data gathered for understanding the atmospheric phenomena for dispersion studies

Real-time Observations of Met Data (Edaiyur site)

GPS Sonde: Pressure, Temp. RH% and Wind velocity at 10m interval upto 35km

SONIC ANEMOMETER: 10Hz Wind flow Sampling Sensible heat and Momentum flux

DOPPLER SODAR: Acoustic Remote sensing method Measures wind and turbulence components up to a height of 600m

AWS: Hourly observations (WS, WD, RH, Temp, Pressure and Rainfall)
DSS requires real time radiation monitoring data for source term calculation.

Seven numbers of Environmental Gamma Dose Loggers (EGDL) and the data is received through LAN.

13 Autonomous Gamma Dose Logger (AGDL) with SOLAR power deployed in remote location and data received through RF.

Real time dose rates are input to DSS for SOURCE TERM calculation.
ONERS: Source Term Module ‘ASTER’
(Assessment of Source-Term for Emergency Response) & Validation

**ASTER Architecture**

- **Input from data files**
  - Real-time met. observations
- **Measured gamma dose rates**
- **Met. observations**

- **Dispersion Module (SPEEDI)**
  - Wind Field
  - Particle dispersion

- **Source-Term Module**
  - Dose Evaluation using Point-Kernel Method for 1Bq/s
  - Calculation of Source term at all receptors

- **Statistics**
  - Selection of detectors within ±15deg of wind direction
  - Application of Pivot statistics to obtain average source-term

- **Output & Archival of data**
  - Values of Source-Term for each 10-min interval
  - Source-Term history for each day

**Validation of Source-Term model with routine release data of Ar-41 from MAPS for 2014**

ASTER predicted source-term agrees with actual releases within a factor of 4

Q is source term in Bq/sec
n – number of gamma detectors
Ci – Measured dose at detector ‘i’
Di – Dose dilution factor computed by SPEEDI

\[ Q = \frac{1}{n} \sum_{i=1}^{n} \left( C_i D_i^{-1} \right) \]
ONERS: Forecasts of wind, rain fall, surface temperature at three regions
Meteorological observation at Anupuram and Edaiyur stations

Weather and Dispersion Forecast
You will find weather and dispersion pattern of air borne radioactive release (considering a hypothetical accidental release of 1GBq-5000GBq with 1-2 day-1 release of EDT in the base case scenario)
1. Current weather parameters at Kalapakkam site. Current phase pattern in Kalapakkam region (12-hr period)
2. Dynamic forecast of today’s weather and radioactive plume for 24h to identify which would be the affected area even after the release stops after a few hours
In the spatial domain:
1. Kalapakkam region (10km radius)
2. Chemical region (90km radius around Kalapakkam)
3. Southern peninsular region

Accumulated rainfall mm in TN/AP region 48h on 5th oct 2015
Surface temp forecast 48h in Kalpakkam region
Plume forecast 24h for hypothetical release.
Current Met observation at Anupuram Oct 5, 2015 17:30 IST

Southern peninsula Surface wind forecast after 48h on Oct 5, 2015

IAEA EPR Conference 2015
Various thematic layers (village, district, land use, soils etc.) are generated from satellite imagery and field surveys. The spatial data are converted to shape files.
Spatial query of exposure dose at 10h

Spatial query of exposure dose at 40h

Multi-criteria query and generation of report with inputs of populations, dose, infrastructure details (hospitals, safety shelters, evacuation roots, transportation etc.)

Spatial Query of Emergency Domains

ONERS: Spatial Query of Emergency Domains

Spatial Query of exposure dose for a hypothetical accidental scenario (10^{12} Bq/s on Oct. 5, 2015) & Visualization of emergency domains– Sheltering, Evacuation and Prophylaxis
ONERS: Identification of Safe Areas for Sheltering

- Spatial Query supports identification of safe areas using forecast plume up to 48 h in advance
- Displays safe areas in a 15km radius of the accident zone.
- Provides details of villages in the safe domain along with available infrastructure and civil offices
VALIDATION OF NUMERICAL MODELS IN ONERS
Round Robin Exercise on Flow field Modeling at Kalpakkam

- Atmospheric models with various physics option for Kalpakkam site validated with benchmark observations in 3-simulation domains (WRF-ARW)
- Meteorological field experiments conducted at Kalpakkam to generate benchmark observations

Simulation Domains of RRE

• RMSE, bias are 2 ms-1, 1.8 ms-1 in ws, 1.9 C, 0.56 C in temp. 17%, 10% in RH%.
• PBL diffusion schemes (level 2.5 Mellor-Yamada, and first order Hong Pan) identified as best turbulence models.
• Improvements are with 3DVAR about 1 ms-1 in ws, 0.5 C in temp and 5% in RH%.
• Most of the uncertainty in the simulated winds of 2-4 ms-1 and 20 deg in direction arises with a sea breeze change which is not properly simulated.
Sodium Aerosol Dispersion experiment

Identified Met condition

Wind direction analysis

Type of Instrument | No.
--- | ---
Aerosol Spectrometer (OPC) | 02
QCM | 01
Andersen Sampler | 04
Filter paper sampler | 25
HV Sampler (Staplex type) | 16
Wet Sampler | 20
Glass plates | 60

- Maximum Concn (Expt.): 0.09 mg/m³ for 50 kg fire. CFD predicted an order higher concentration.
- Overall, all models could locate the area of maximum concentration & depositions.
- Both Flexpart and SPEEDI provided more reliable estimates.

**SF6 Tracer Release Experiment**

- SF6 tracer used for experiments. Gas Chromatography for Analysis
- RF-based Air Sampler Systems used.
- Three set of experiments conducted.
- Large scale experiments are being conducted

Field deployment of Air Samplers

Simulated SF6 Concentration (in ppbv) using Flexpart

Simulated and measured plume centerline concentration of SF6

Samplers & locations in Google map
The Fukushima accident: A real case to test and validate the numerical models used in ONERS-DSS for predicting the plume trajectory and radiation dose in the public domain.

- Regional scale simulation was performed with WRF-FLEXPART modeling system at a high horizontal grid resolution for the accident period (Srinivas et al 2012, Atmos Envi).
- With comparison of observation data from 40 met stations, the model could reproduce the time-varying pressure, wind flow pattern at Fukushima during the accident.
- Simulated dispersion of noble gases (Xe133) and particulates (Cs137, Cs134, I131) Deposited activity was spread mainly in the northwest, west-northwest, and south-southwest sectors from the site.

Validation of Simulated external air dose pattern (in μSv/h) due to ground deposition of Cs-137 in and around Fukushima Dai-ichi NPP with Measurements.

Source term obtained from Stohl et al 2012

Computed air dose is found to agree with observation within a factor of 10 for 75% of observation spots.
- GIS based ‘ONERS’ - implemented for Kalpakkam.
- It has useful query and analysis tools.
- It is based on site met observations & high resolution Weather Forecast and Dispersion Models.
- The met forecasts made locally at required spatial resolutions.
- A source-term ‘ASTER’ implemented in DSS & validated.
- The numerical models are validated extensively.

The ONERS used for the offsite emergency exercise for KALPAKKAM.

ONERS available at internet http://oners.igcar.gov.in