

Engineering of Nuclear Power Plants in India: Present and Future



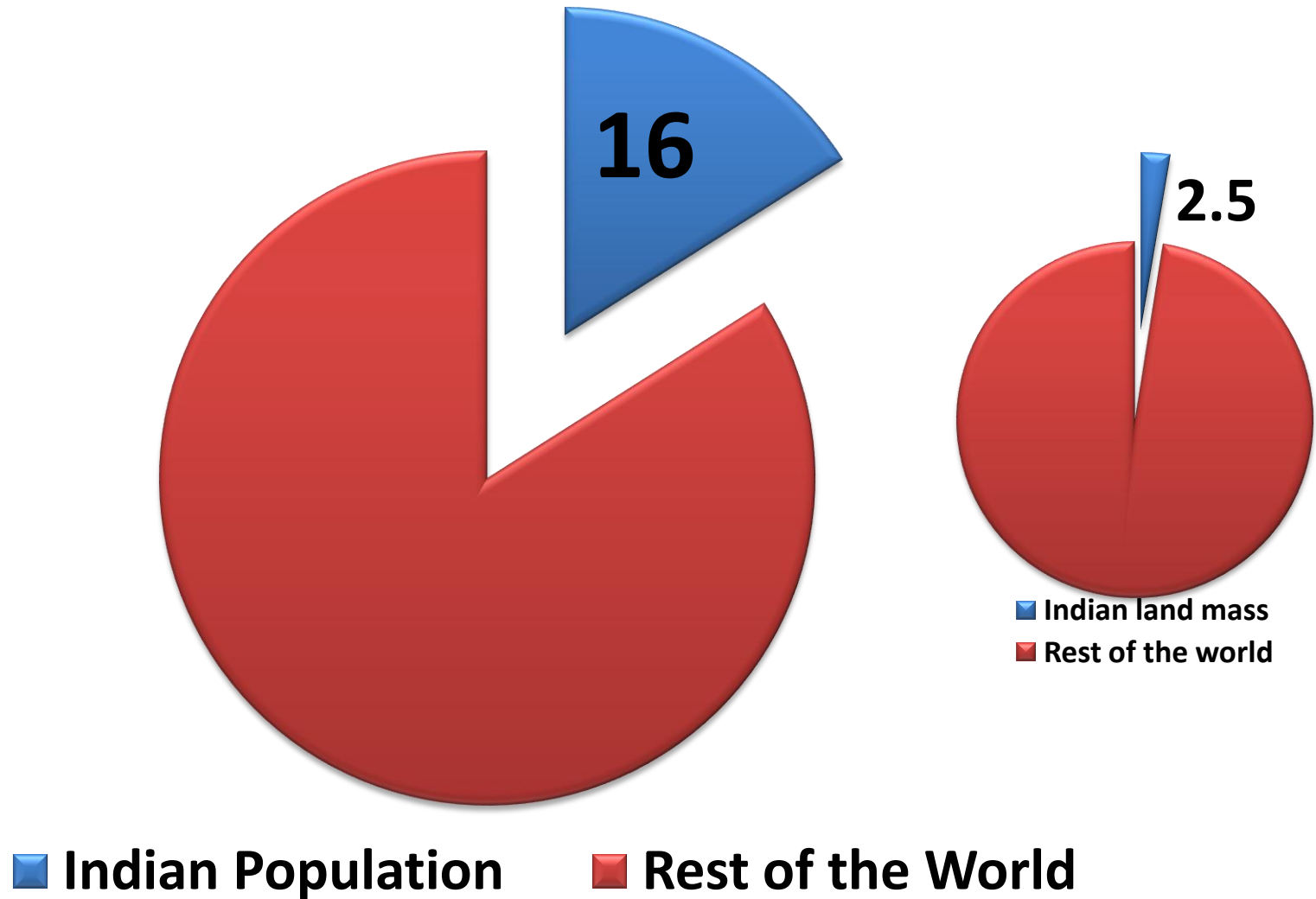
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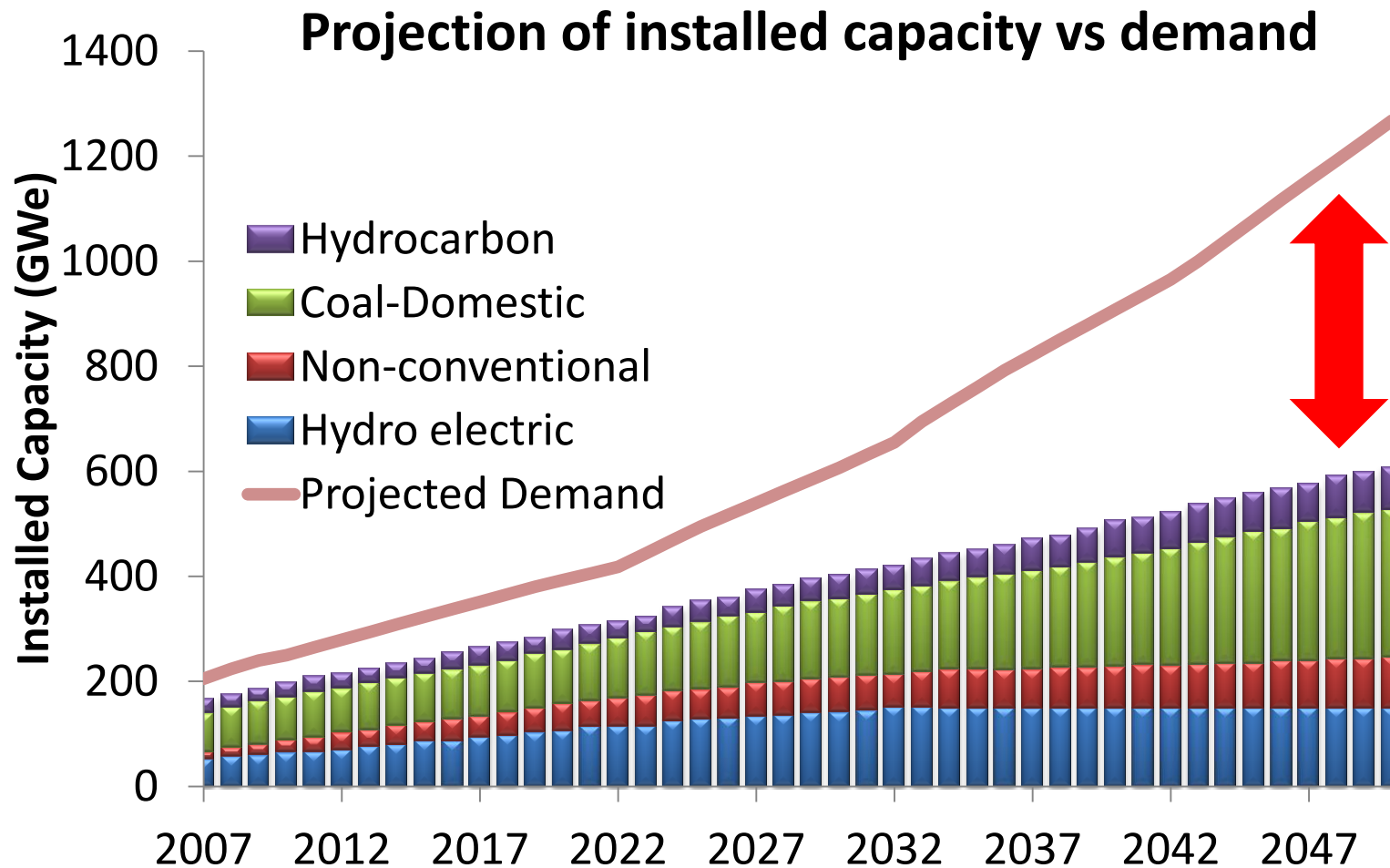
Layout

- Electricity demand in India and role of Nuclear Energy
- NPPs : Design philosophy
- External events : Lessons learnt
- Challenges

Introduction



Introduction...



Introduction...

Stage-1

- PHWR based NPPs (Natural UO_2)



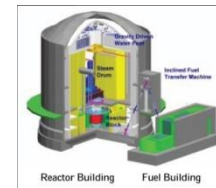
Stage-2

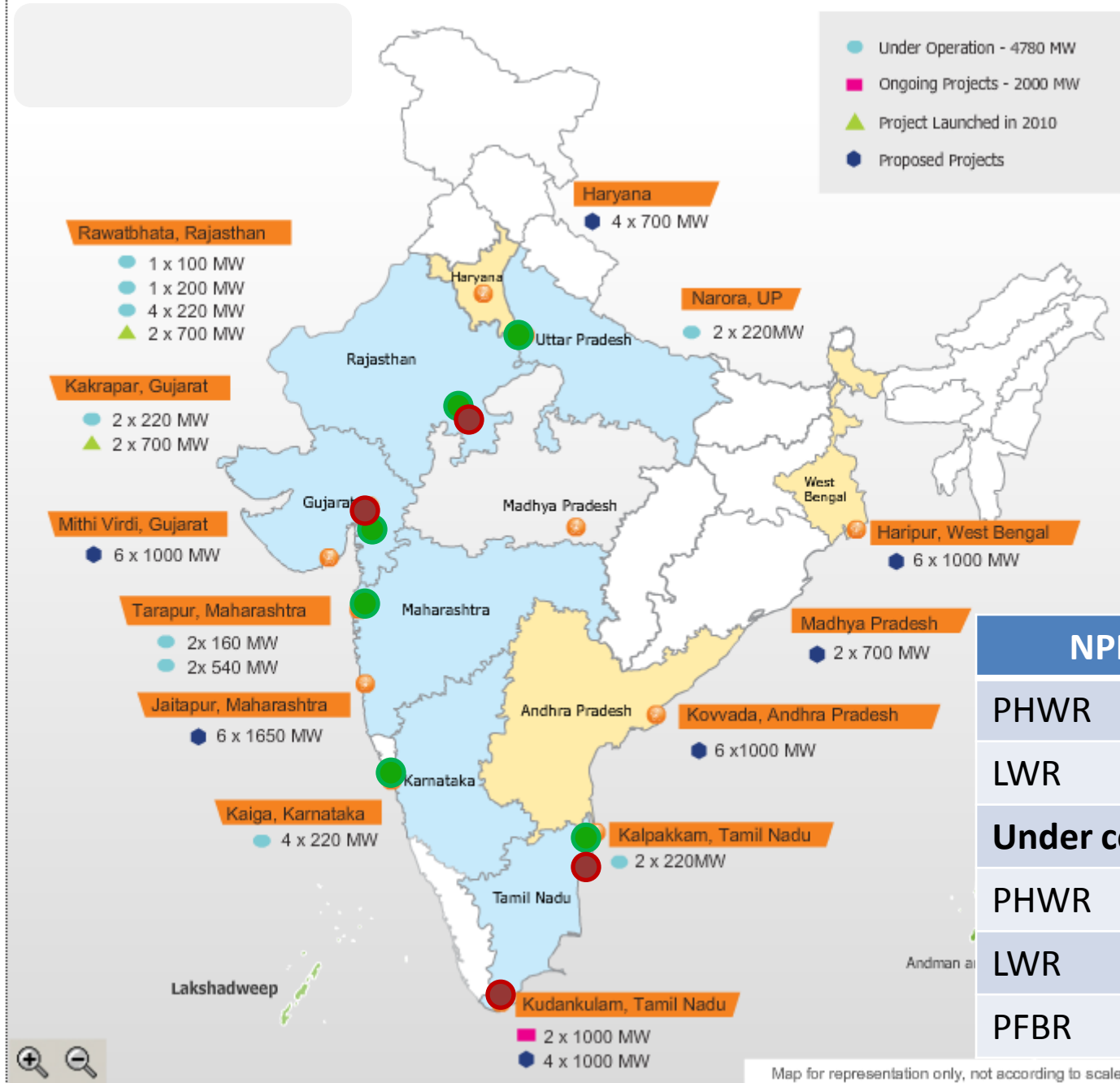
- Plutonium based breeder reactors (FBRs)



Stage-3

- Thorium based reactors





NPP	Number
PHWR	18
LWR	2
Under constr.	
PHWR	4
LWR	2
PFBR	1

Map for representation only, not according to scale.

General design principles

- System Requirements
 - **Related to operation**
 - **Related to safety** under postulated accident scenarios
 - Shutdown,
 - decay heat removal,
 - containment of activity
- Structural
 - Should withstand all design loads (Dead and live loads, Earthquake, wind, flood, temperature, pressure, etc)

General design principles ...

- **System design philosophy**
 - **Defense -in-depth** : Multiple layers of protection
 - **Redundancy** : Essential + Stand-by (e.g. DGs)
 - **Diversity**
 - **Fail safe concept**

General design principles ...

- Design basis events
 - Internal
 - External

External Events in NPP design



Natural

- Earthquake
- **Flood**
- Wind,...

} **Return
period**



Human induced

- Explosion
- Toxic gas release
- Fire,...

External Events in NPP design



Inland

- Precipitation
- Flood in river/lake
- Dam break



Coastal

- * Cyclone
- * Tsunami

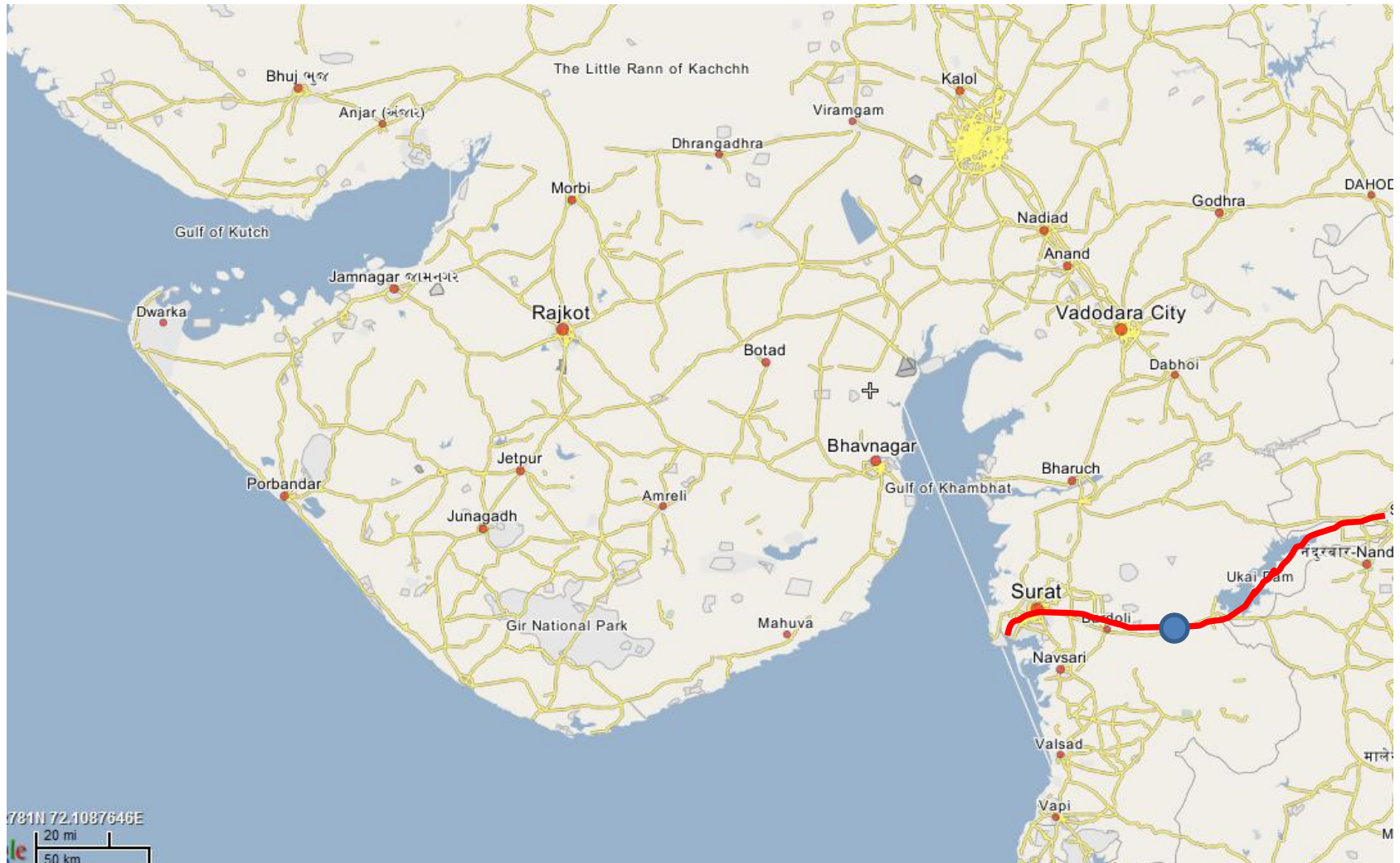
Return period for design basis flood : 1000 years

Flooding incident at Kakrapar site

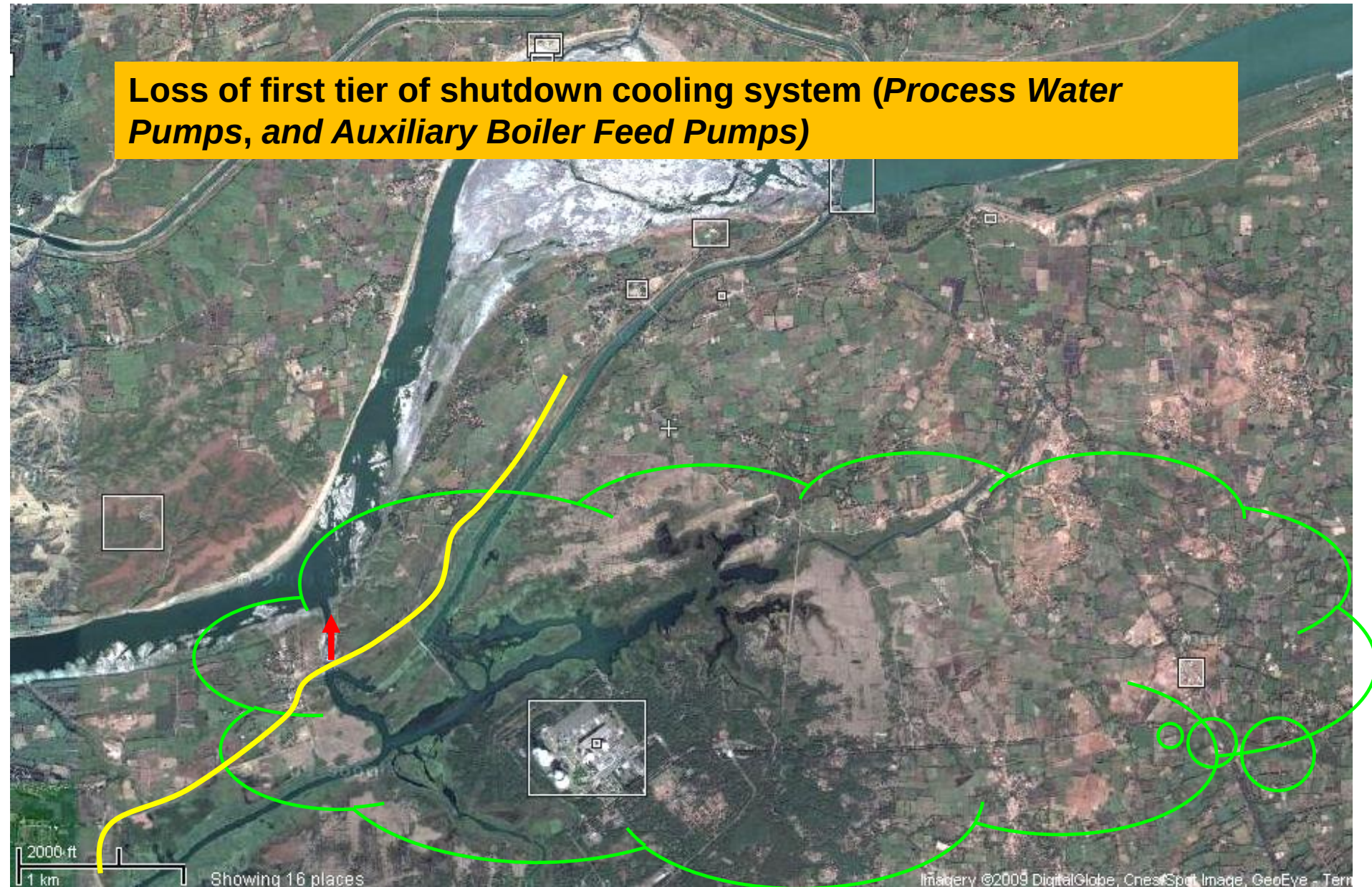
- Precipitation of 470mm in 15 Hrs (June 15-16, 1994)
- Twin unit PHWR, 220MWe
- Unit #1 under shutdown, & Unit#2 under commissioning



Flooding incident at Kakrapar site



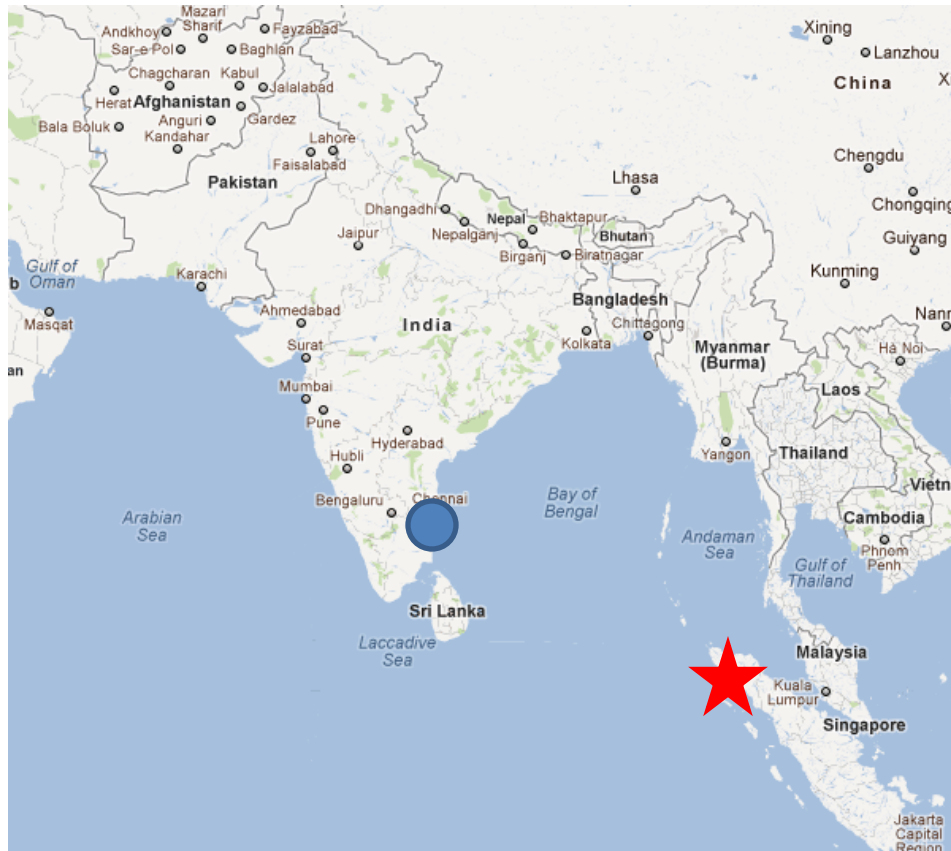
Loss of first tier of shutdown cooling system (*Process Water Pumps, and Auxiliary Boiler Feed Pumps*)



Lessons learnt : generic & site specific

- Minimise penetrations below grade level
- Revised safety analysis
 - Postulating multiple/ progressive failures in the flood protection measures
 - This formed basis for operator actions
- Periodic maintenance of gates, lake level alarms at control room, etc

Indian Ocean tsunami-2004



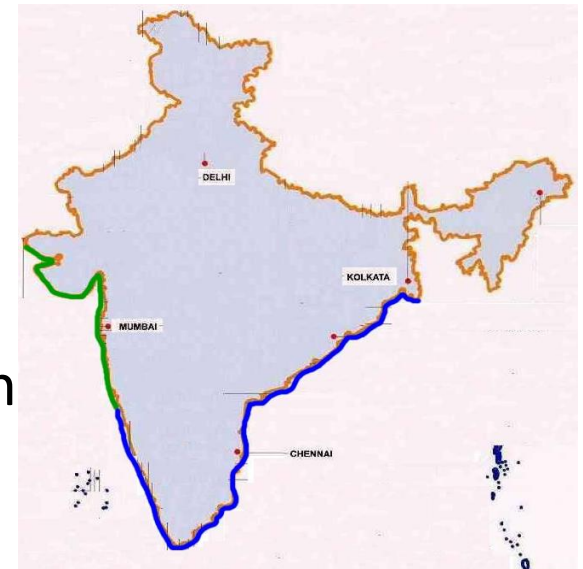
- Kalpakkam
 - PFBR : 500 Mwe
 - MAPS : 2X220MWe

Some of the major actions

- Re-construction of raft (PFBR)
- Coastal protection measures at PFBR
- Tsunami warning system : Site/National
- Tsunami hazard assessment
 - Existing guidelines formulated in year 1990

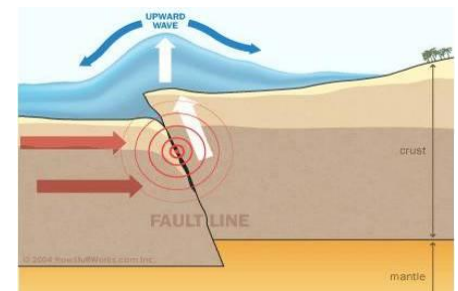
Tsunami Hazard Assessment (THA) Initiatives

- Initiatives by
 - BARC, NPCIL
 - NGRI, NIO, IIT, NDMA
- AERB
 - Collaborative research with IAEA
 - THA of Indian coast
 - Towards revision of regulatory guidelines

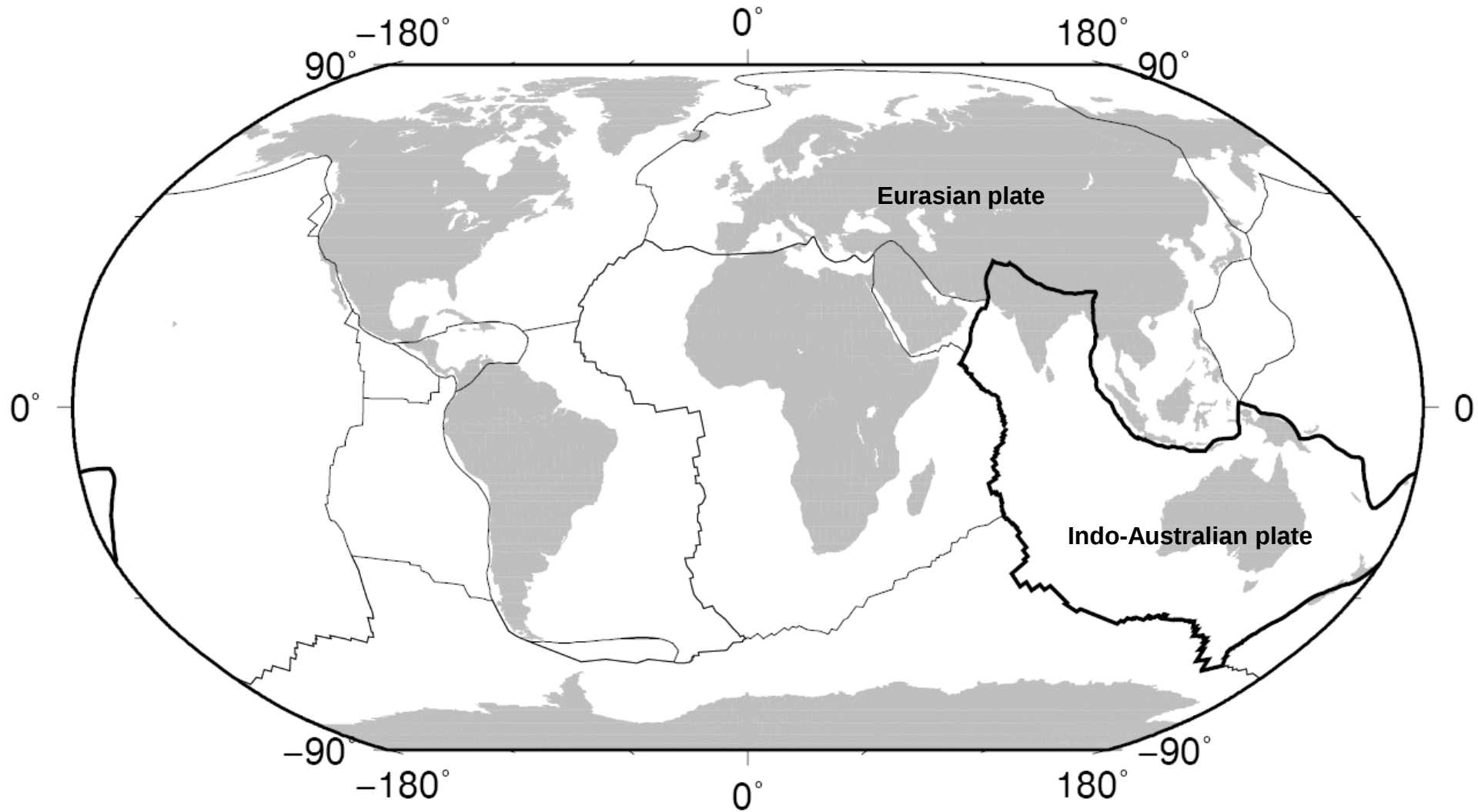


Basic steps in THA

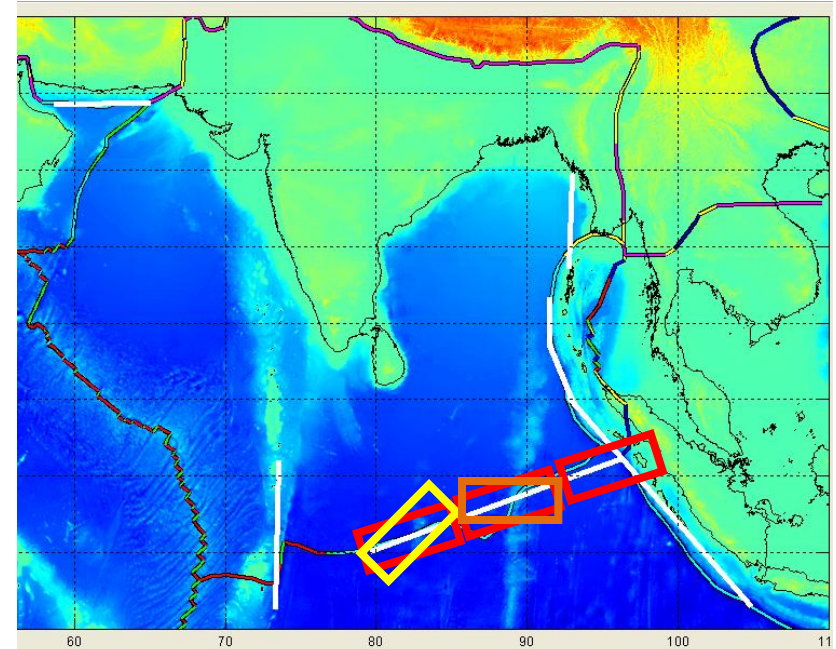
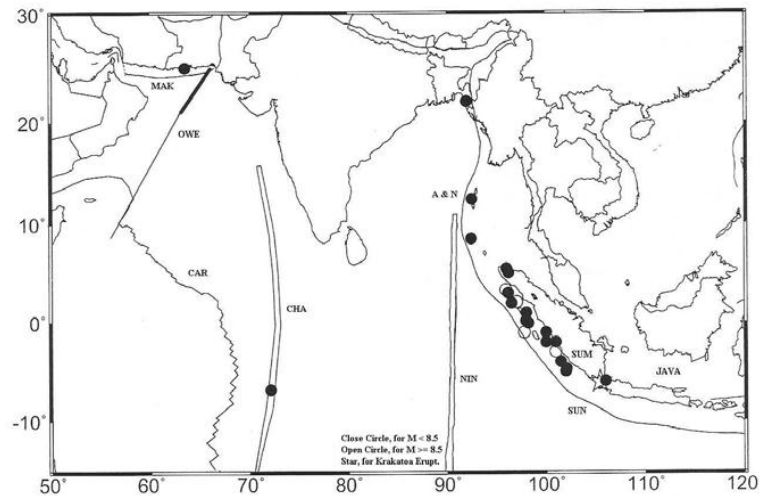
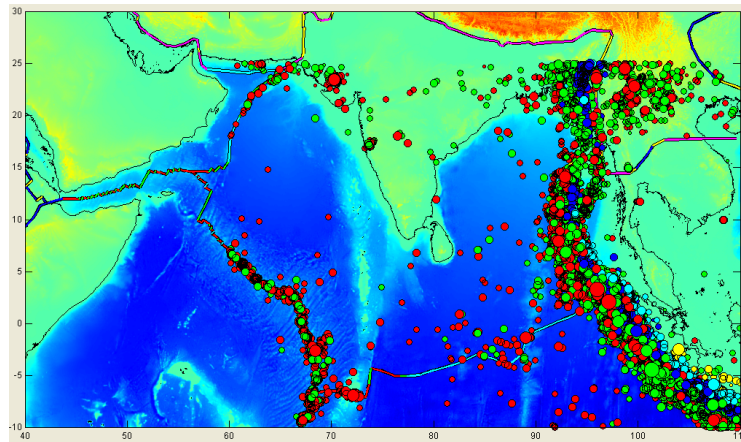
- Identification of tsunamigenic sources
- Estimation of maximum earthquake potential
- Numerical evaluation of tsunami heights using
 - Rupture area parameters
 - Length, width, slip, strike, dip, depth
 - Uncertainty analysis
 - Bathymetry data



Tsunamigenic sources



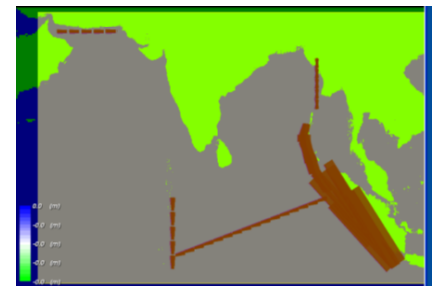
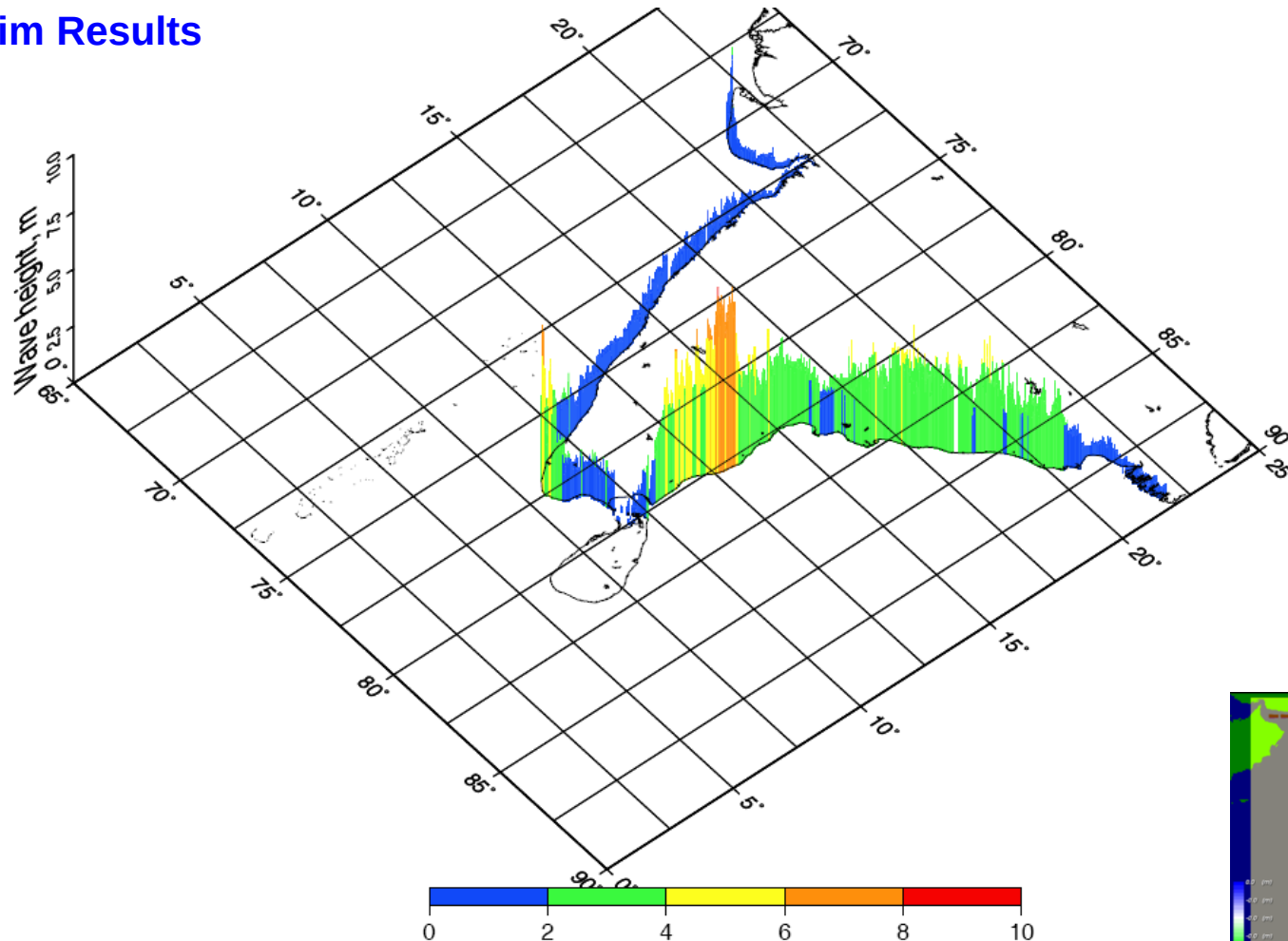
Maximum sources & potential



Numerical evaluation...

Wave heights :

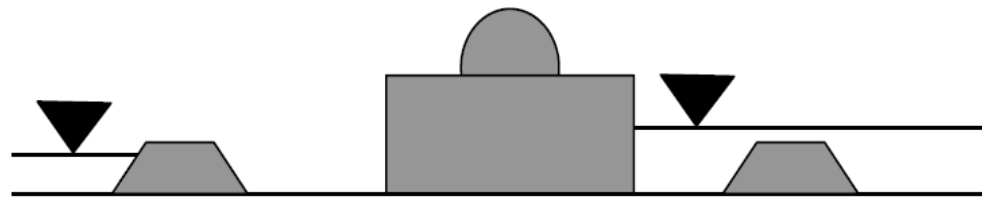
Interim Results



2012 Feb 23 12:12:16 Plot of wave heights

Challenges

- Consideration of beyond design basis events
 1. Common cause failures from external events
 2. Vulnerability against cliff edge effects



Flood beyond design basis

3. Safety assessment for extended station black out

Challenges...

- Climate change : impact on meteorological and hydrological parameters

Thank you

