EMRAS II PROJECT – Tritium Accidents Group

Fourth Meeting

Modeling Aquatic Process in the tropics

Exercise - Tritium Release from an imaginary CANDU: HTO dispersion on actual PWRs tropical aquatic estuary - Importance of hydrodynamics

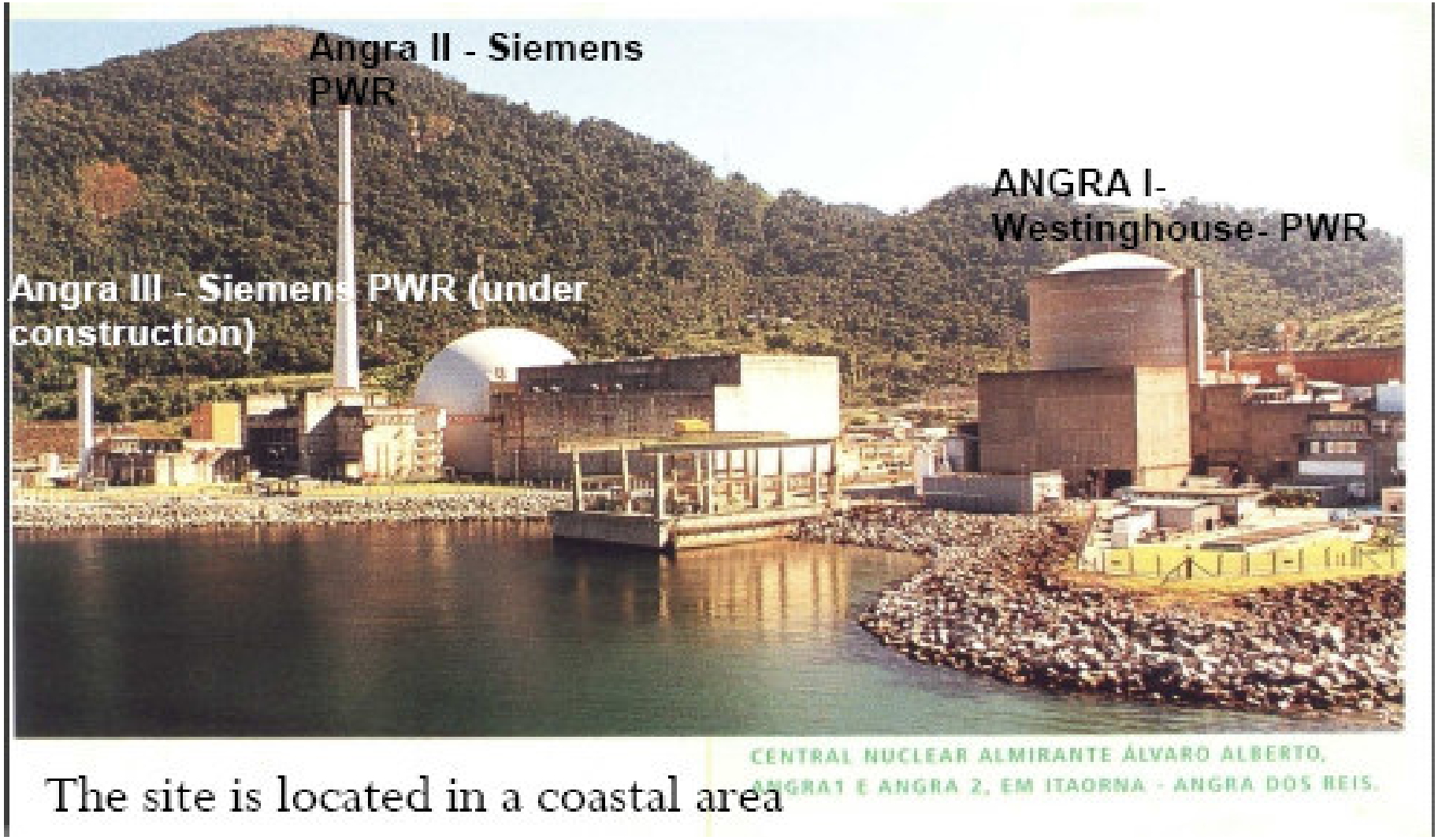
What are the real problem for nuclear in Brazil at the moment ?

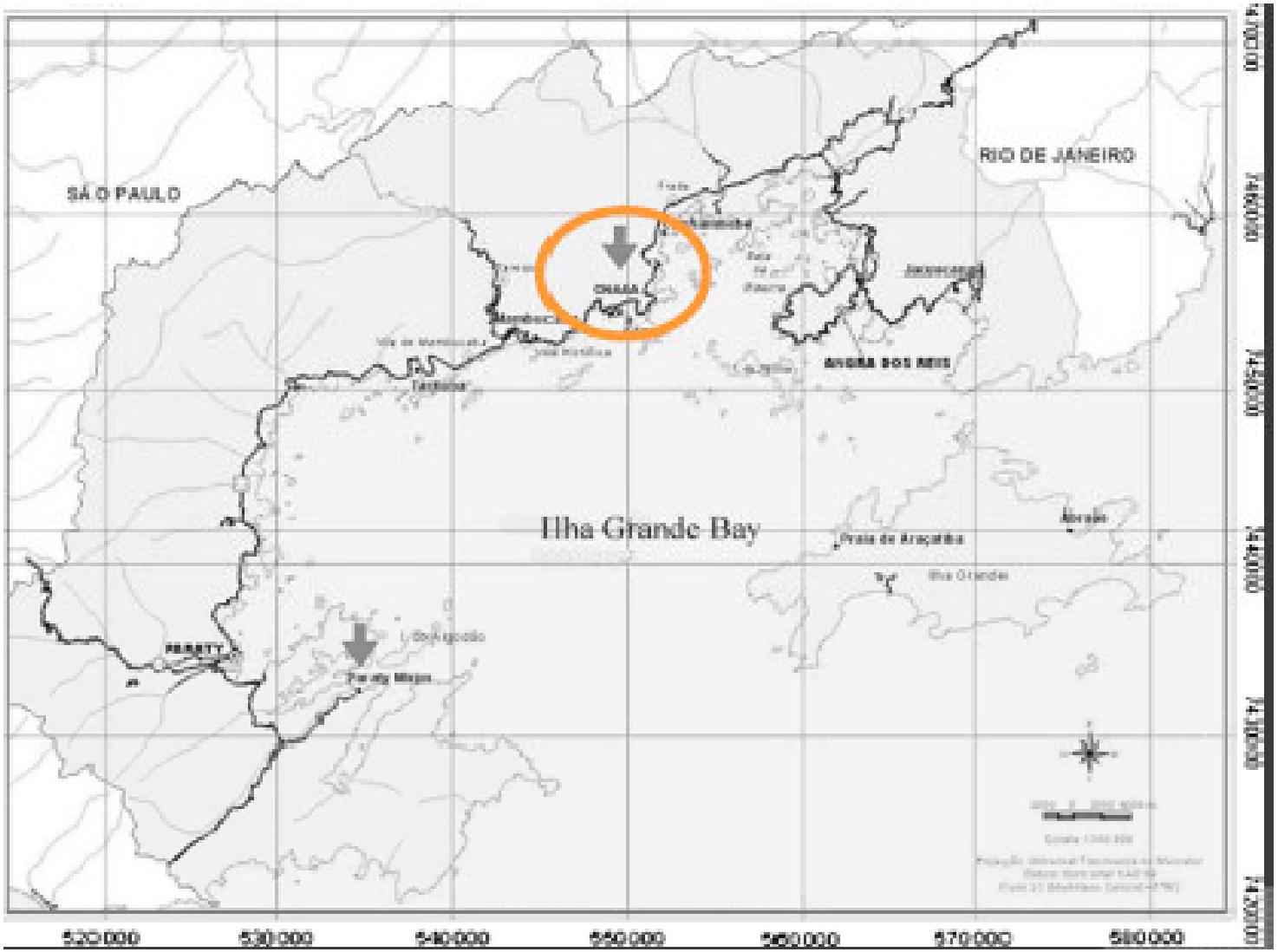
Data gaps and special features in tropical sites

IEN INSTITUTO DE engenharia nuclear

CNEN Comissão Nacional de Energia Nuclear

Brazilian Nuclear Power Plants at Angra dos Reis (Rio de Janeiro) owned by Eletronuclear (ETN), subsidiary of Eletrobrás a mixed economy and open capital stock corporation (Shares are traded at São Paulo, NY and Madrid). Brazilian federal government is the majority stockholder





The Ilha Grande Bay supplies water to nuclear plants, afterward the liquid effluents are discharged in another place of the bay

Dose Assessment

- Aquatic and atmospheric effluents are released into environment.
- A dose model was specially developed to the site by ETN/COPPE which is based on Safety Series 57
- The main exposure pathways are:
  - External exposure: from clouds, radioactivity deposited on the ground and sand beach (sea sediments)
  - Internal exposure: Inhalation and Sea food ingestion;

Dose Assessment

- Representative person concept was adopted, since a Critical Group could not be identified
- There were chosen representative persons from three age ranges (0 to 5;6 to 15;16 to 70 years)
- The parameters of food consumption and land use were assessed by local surveys;
- Some local parameters, e.g. wind velocity and direction, bioacumulation and soil to plant transfer factors, were used in the model

Aquatic Pathway – Hydrodinamics and Transport Modelling

- The mathematical models to represent hydrodinamics and contaminant transport in water bodies are generaly based on conceptual laws or principles expressed by differential equations
- Numerical or Numerical-Analytical models translate mathematical equations to computational language (e.g. finite differences,finite elements or probabilistic models) and has high predictive power and little loss of information
- The uncertainty can be largely reduced with calibration process and model validation
- For these reasons, the recommendation to move from box-model hydrological models (with high uncertainty level) to hydrodinamic process-oriented numerical modelling should be considered as an important issue for tritium assessment

Database System for Environmental Hydrodinamics (SisBAHIA)

- System of computational modelling applied to hydrodinamical circulation and advection-difusion contaminant transport in natural water bodies under different metereological, fluvial, lacustrine or oceanographic scenarios
- Continued Developed by the Program on Coastal and Ocenographic Engineering of Federal University of Rio de Janeiro (Prof. Rosman) since 1987

Modeling Environmental Impact in Aquatics

- Validated models are unique source of information to management and action planning for water bodies, because allow to analyze three fundamental interest features :

1. Hydrodynamics→ assess changes in movement quantity {mass x velocity} that generate variations in water level and currents.

2. Water Quality→ assess the transport of substances and change of water quality

3. Sedimentologic Process → asses the erosion, transport and deposition of sediments that generate morphologic or morphodynamic change.

Reliability of the models

- Digital Modeling of the Terrain – Validation Level 1
  - ❖ Assure that water body geometry implemented in the system is correct and suitable with the condition prevailing during the phase of measurements. Assure the discretization scale are suitable with the feature to be addressed.

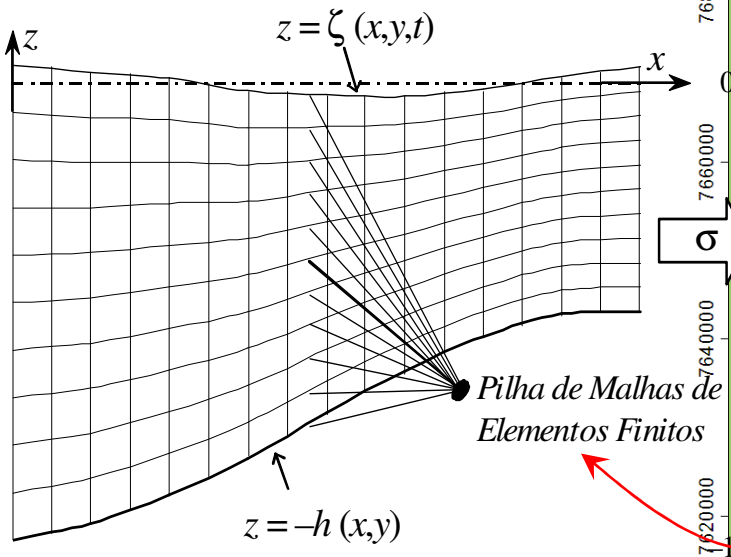
- ➢ Hydrodynamic Modeling - Validation Level 2:
  - ❖ Assure that boundary conditions of the water flow e.g. water level, winds, fluvial discharges, are correctly implemented in the model and are suitable with the condition prevailing during the phase of measurements of elevation and currents.

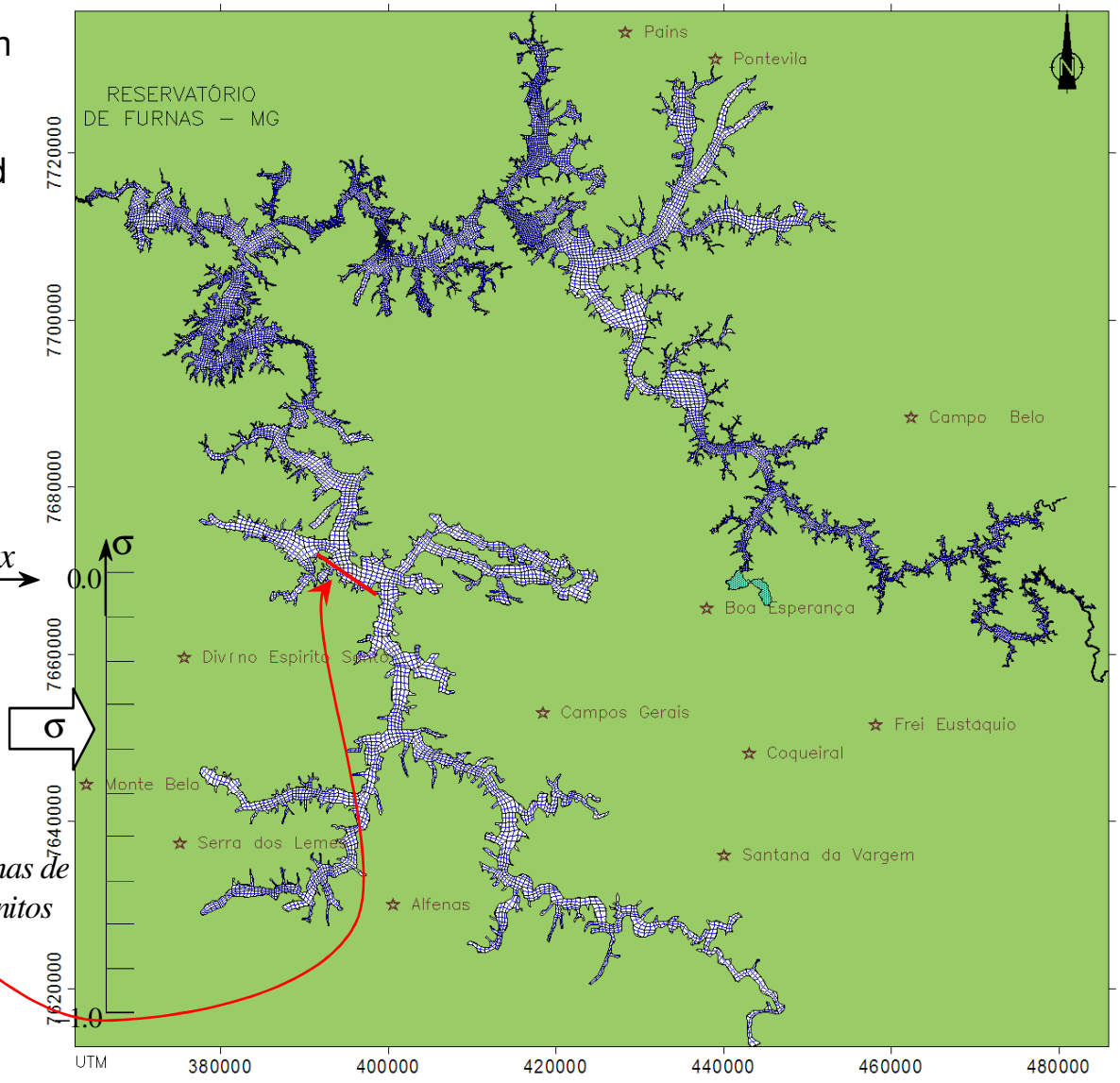
- ➢ Transport of substances and water quality parameters – Validation Level 3
  - ❖ Assure that intensity of contaminant sources, kinetic reactions parameters and others are correctly implemented in the model and suitable with the prevailing during the phase of measurements of concentrations and loads.

Discretization: finite elements in (*x, y*) and surfaces σ; finite differences in *z* e *t*

The figure showed a pile of 21 meshes with 24253 water columns in 4599×21 biquadratic elements. In each column can be defined N levels, usualy between 20 and 30

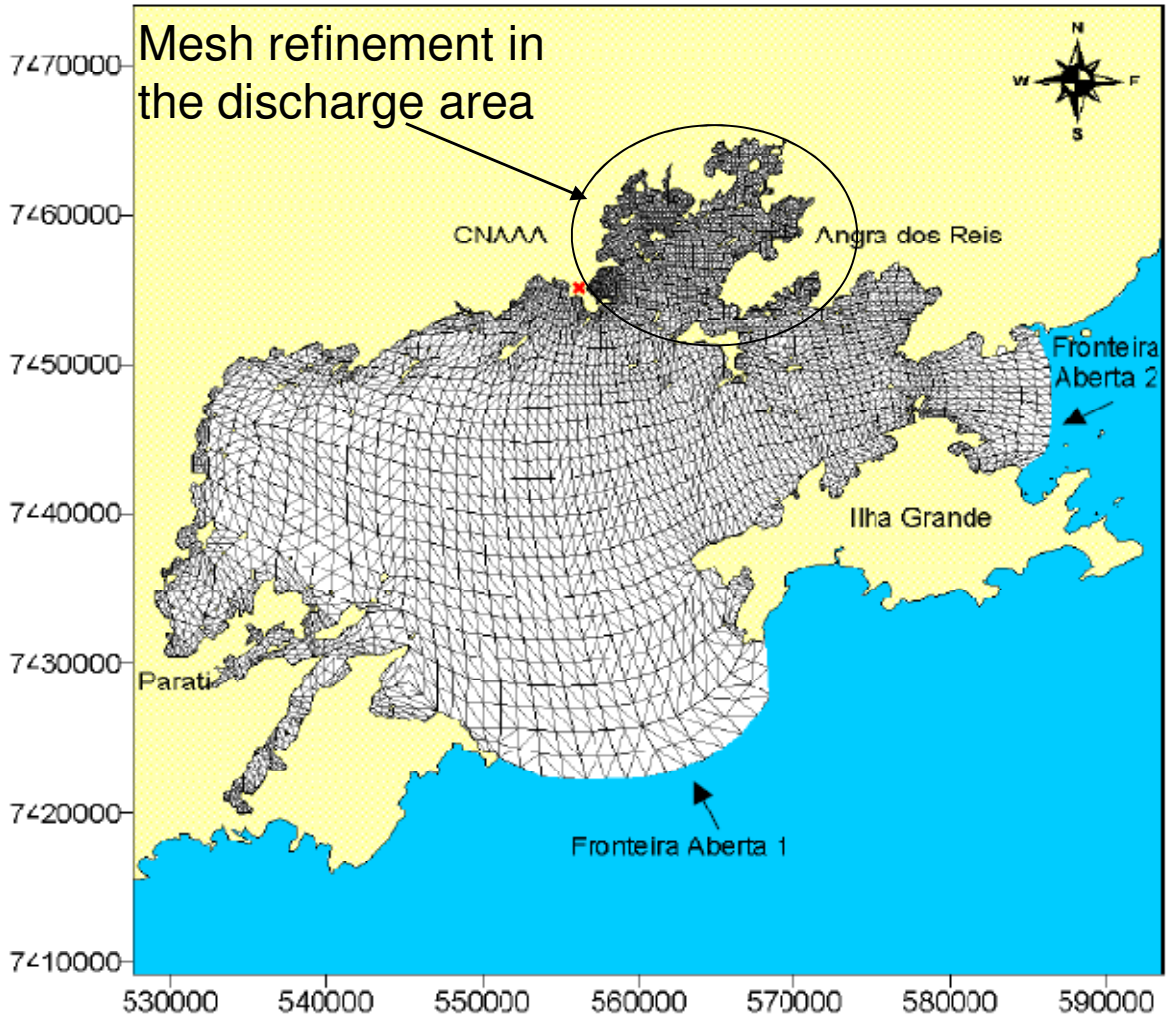
For N = 21 → ~510.000 points of discretization >1.500.000 unknown parameters by time step of calculation.





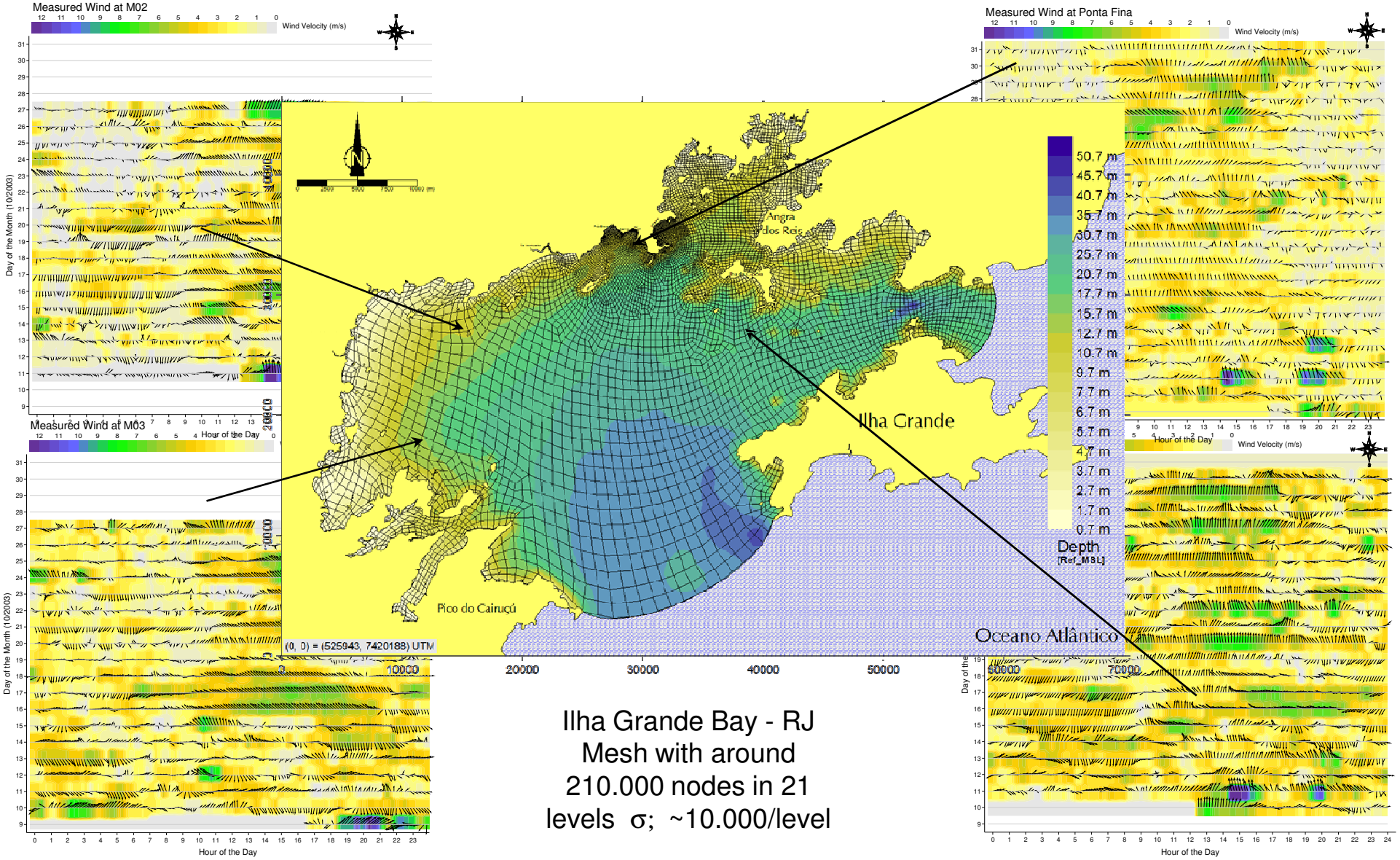
ILHA GRANDE BAY 2DH DOMAIN FOR H-3 DISPERSION MODELING

Discretization with a mesh containing 1163 finite elements (quadratic squares) and 5403 knots.



Basic data for modeling

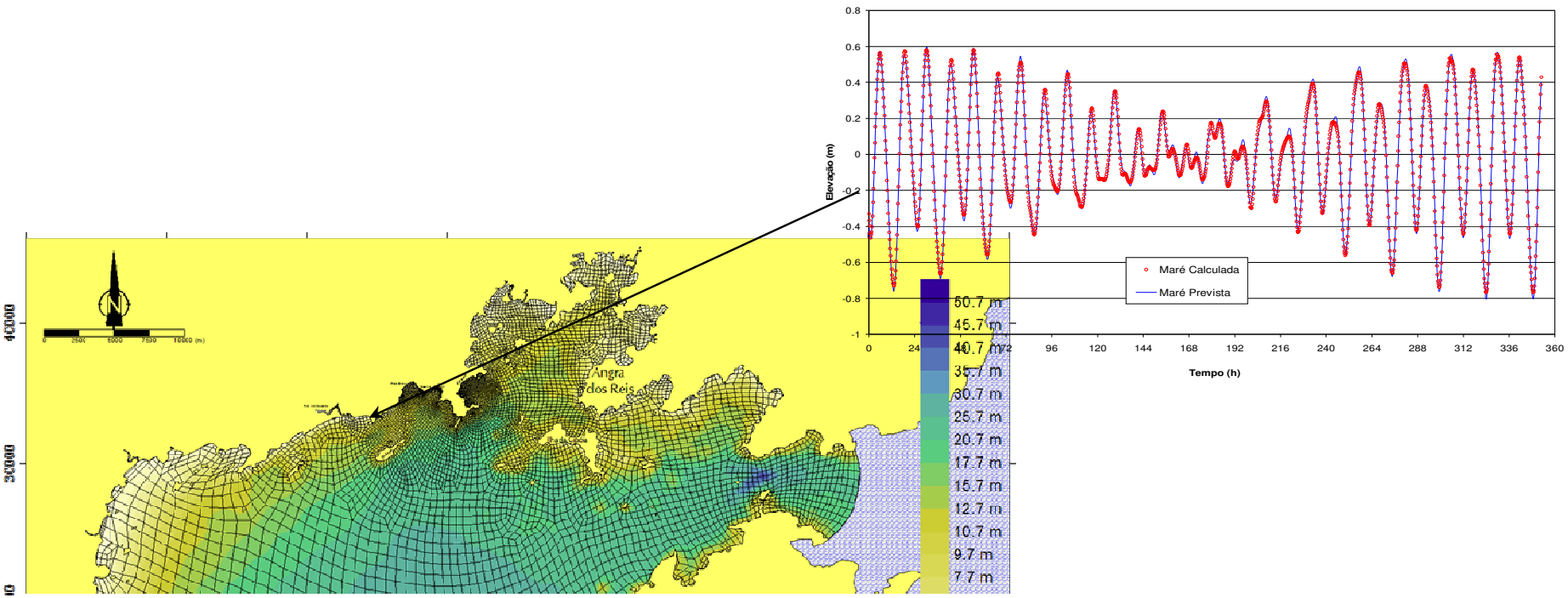
Wind variable in time and space are generate by the model form the measured data

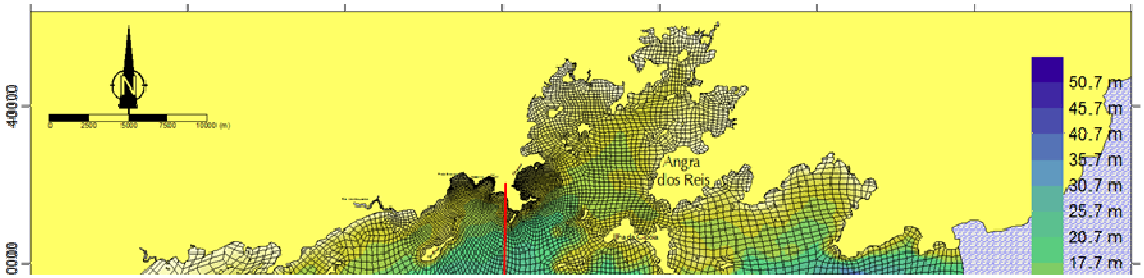


Ilha Grande Bay - RJ
Mesh with around
210.000 nodes in 21
levels σ; ~10.000/level

Basic data for modeling

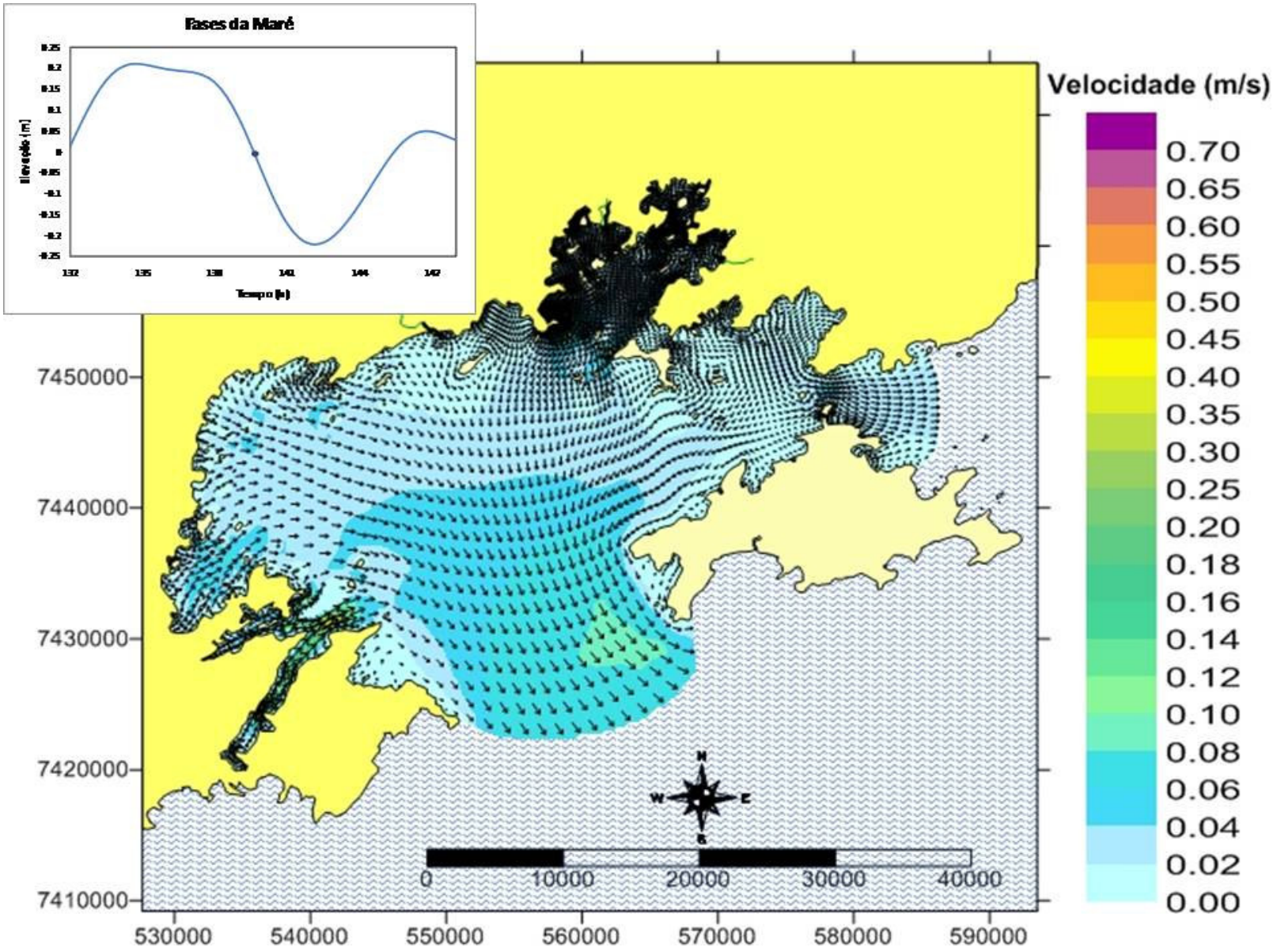
Tide analysis generated by SisBAHIA – Comparison with mesured data



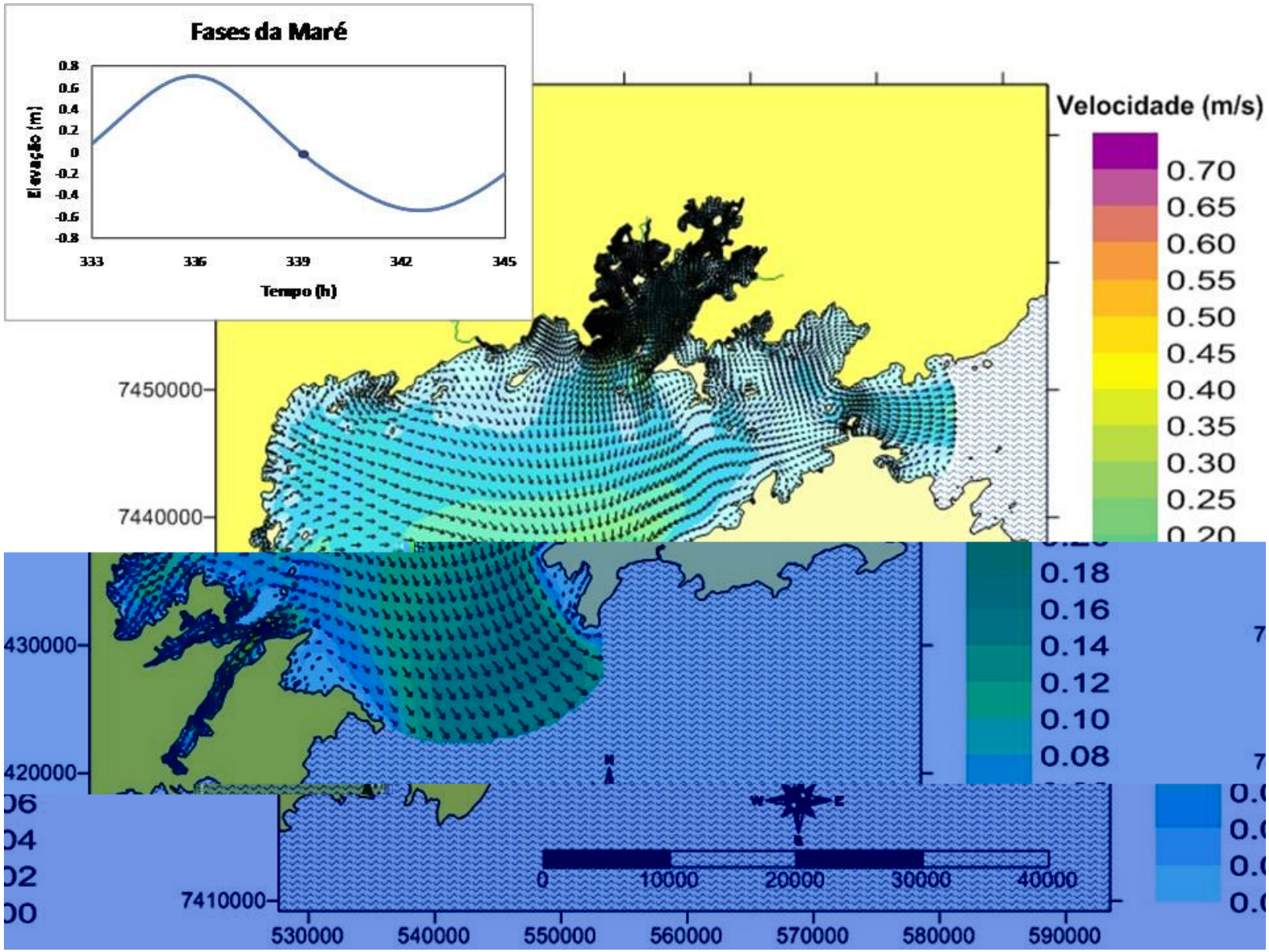


Examples

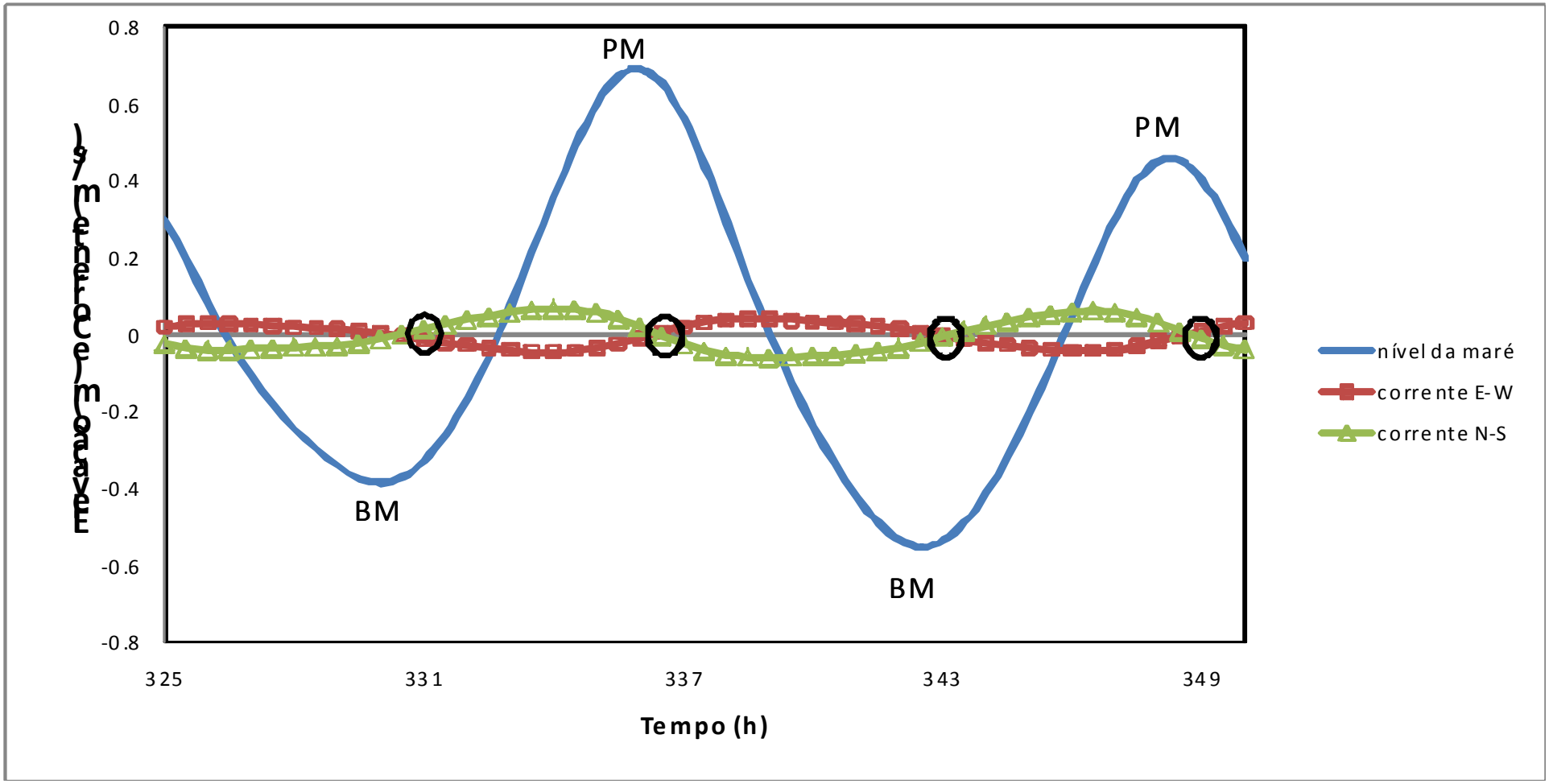
Field velocities and current direction for the instant of ebb stocking-tide (140 hours of simulation) in neap tide cycle



Field velocities and current direction for the instant of ebb stocking-tide (339 hours of simulation) in spring tide cycle



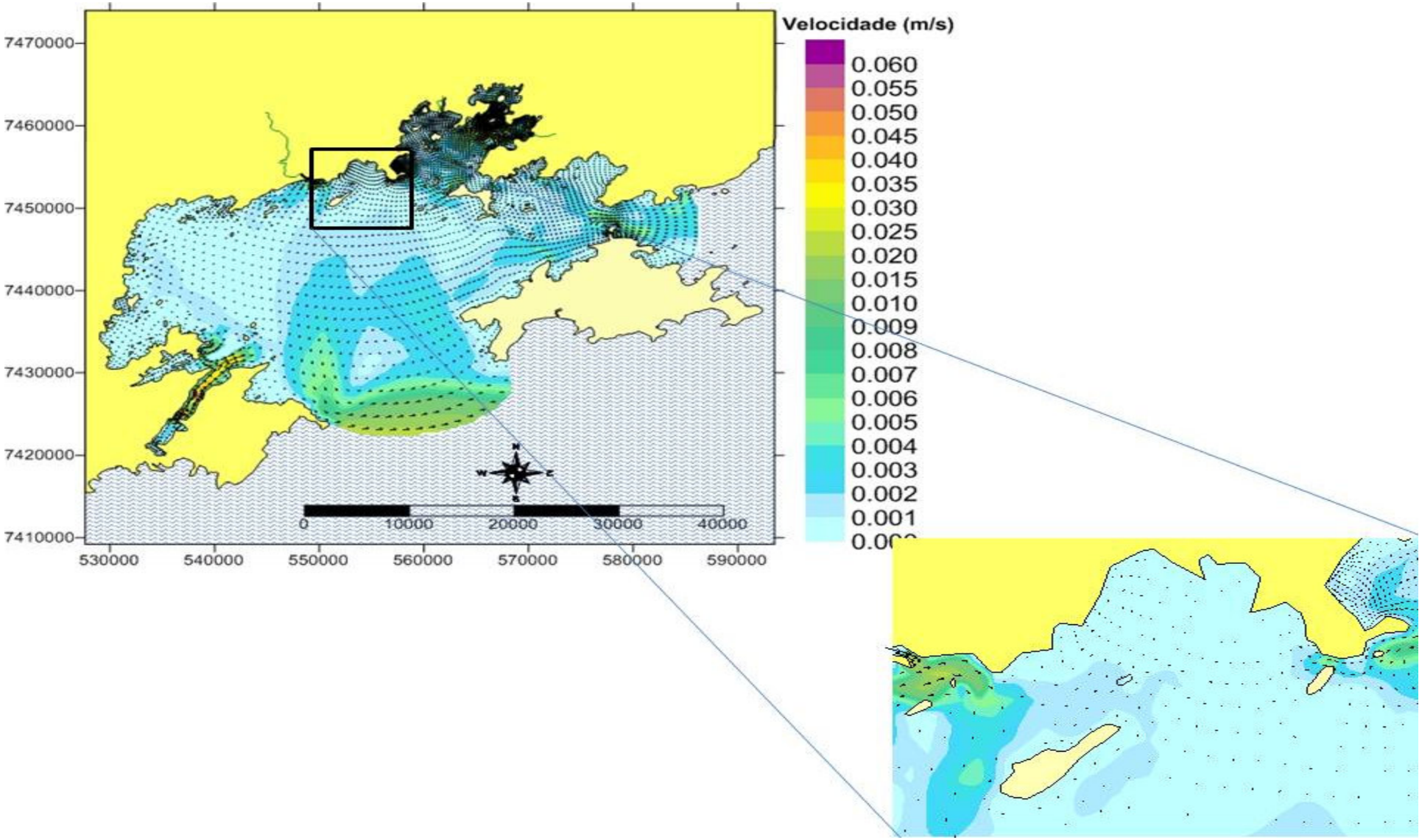
Vertical (elevation) and Horizontal (currents) Tide cycles in Ilha Grande Bay shows the stationary behavior of the tide wave. It is observed that slacks; i.e. the inversion of flood currents and ebb currents occur just after the high tide (PM) or low tide (BM)



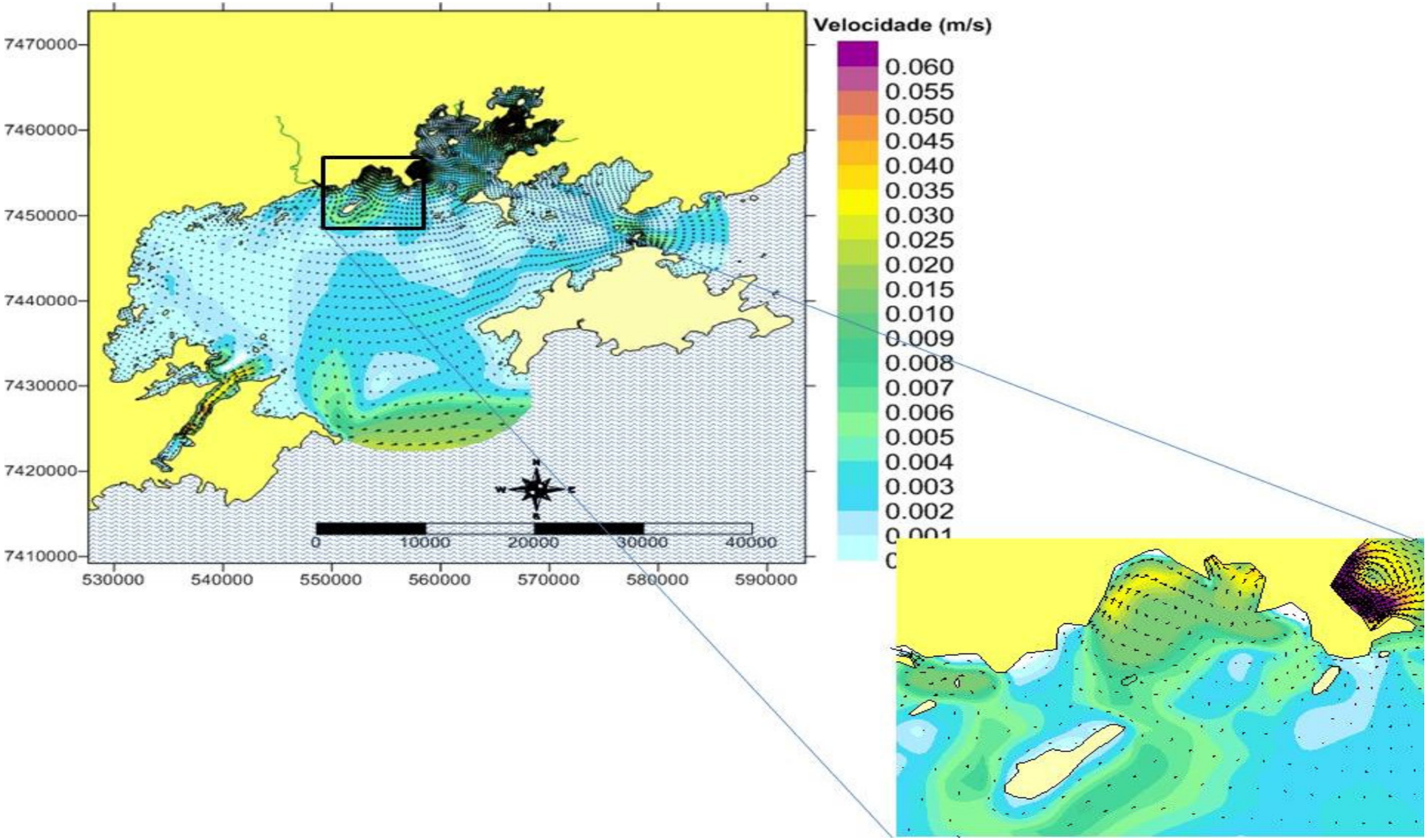
Two Hydrodynamic Scenarios

1) Shuttle down all plants
2) Keep the other two PWR operating with reception and discharge of seawater

Eulerian residual currents along one day of spring tide for scenario 1, corresponding to the time interval between 324 and 348 hours of simulation



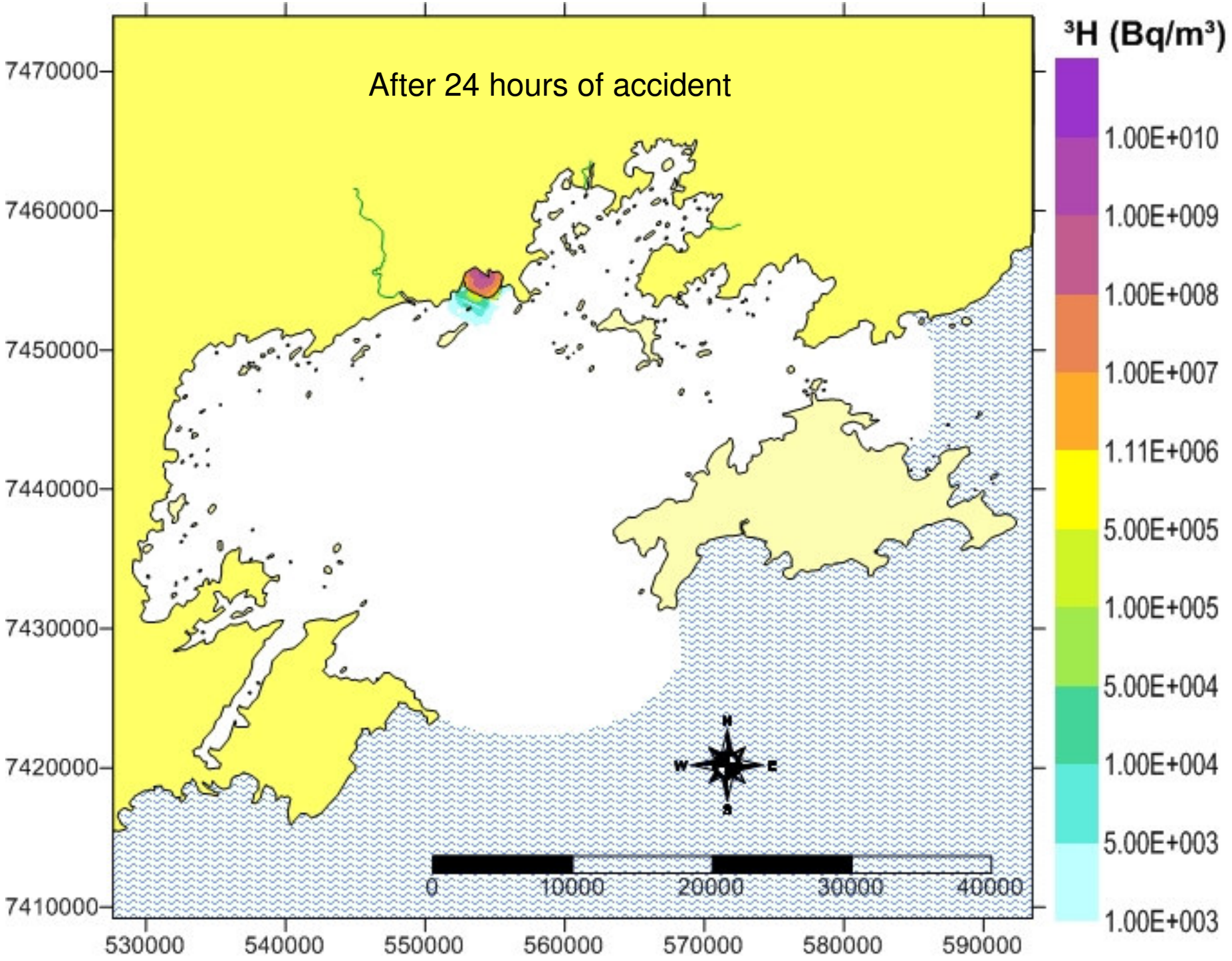
Eulerian residual currents along one day of spring tide for scenario 2, corresponding to the time interval between 324 and 348 hours of simulation

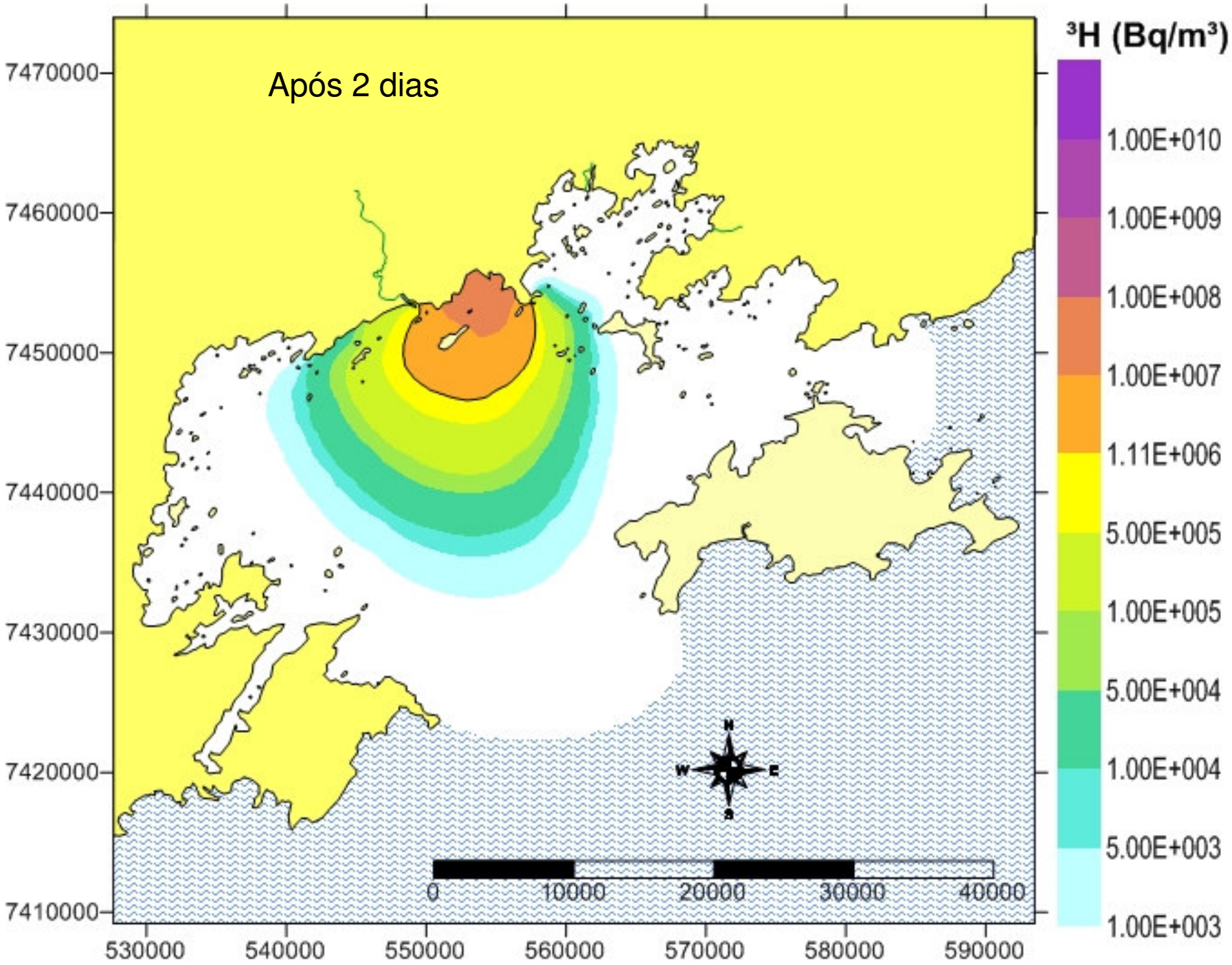


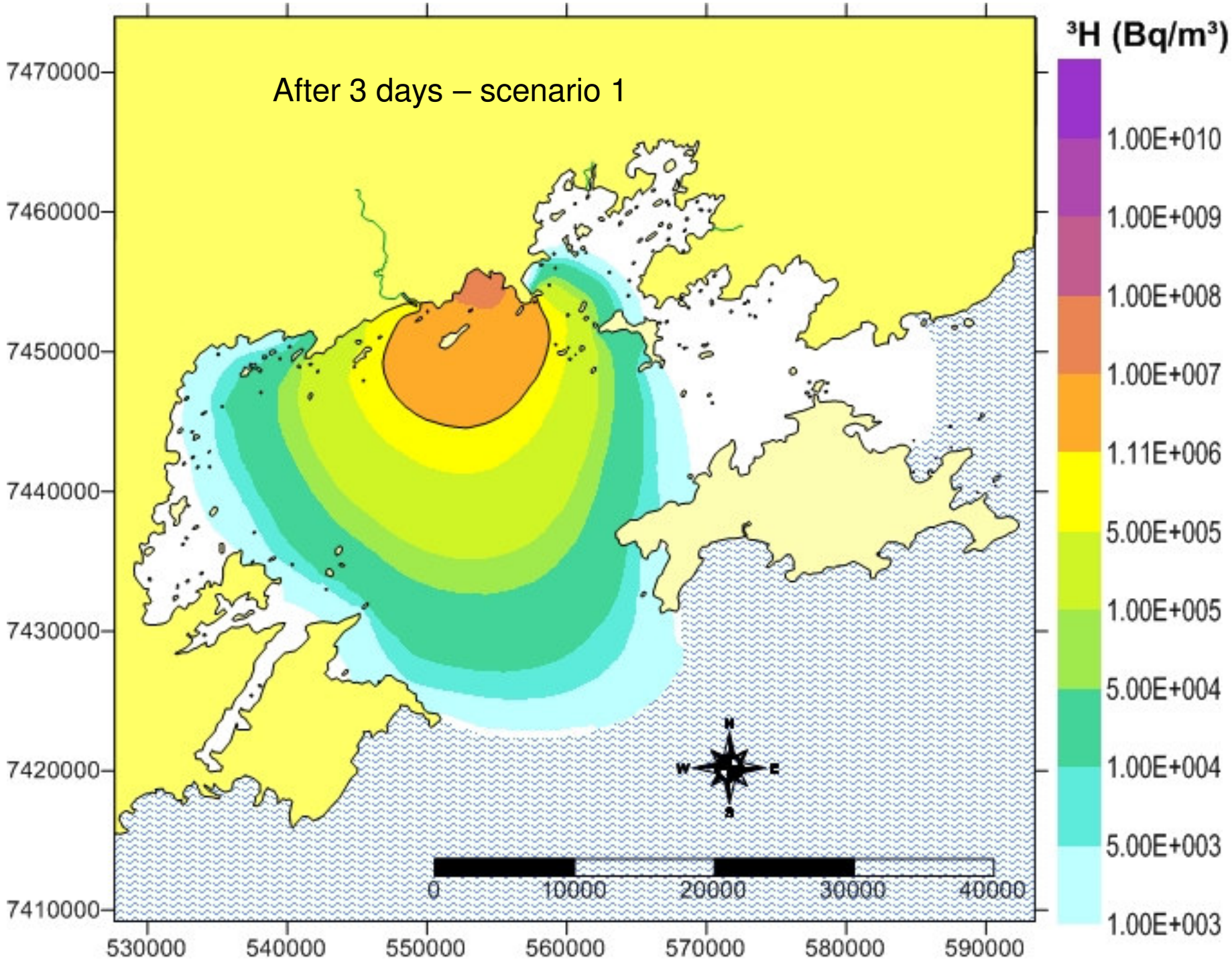
MODELING OF TRITIUM DISPERSION FROM HYPOTHETICAL NUCLEAR ACCIDENTAL RELEASE

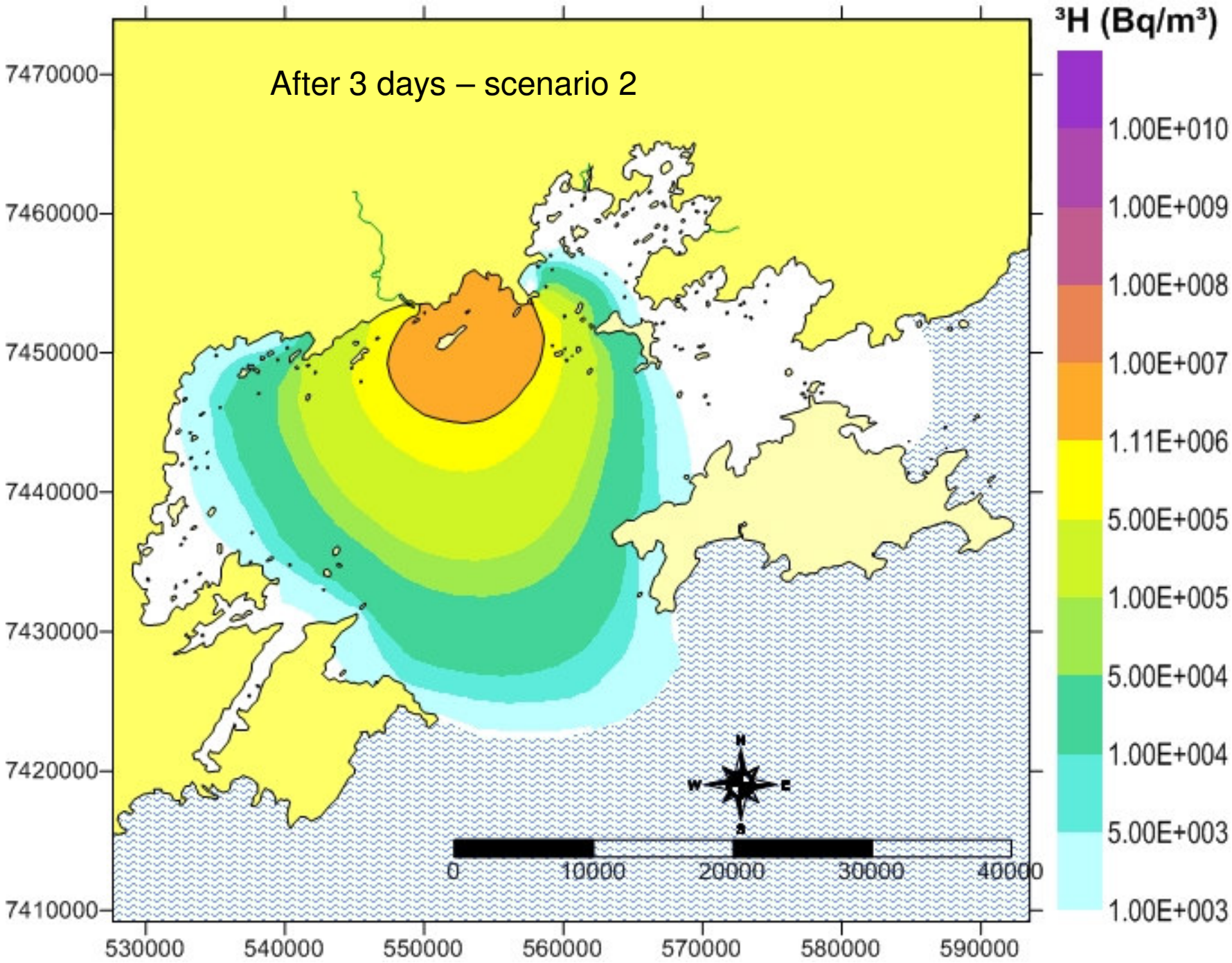
MASTER DEGREE THESIS – DUARTE, 2010

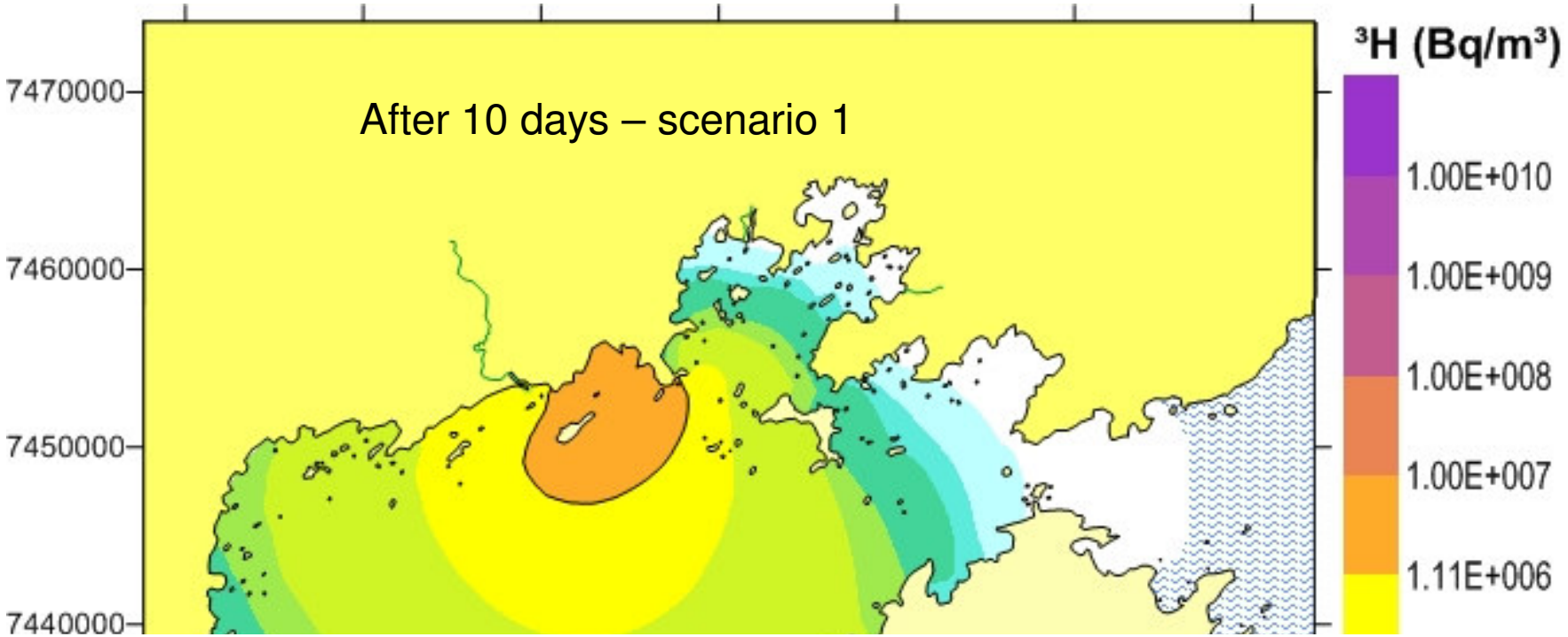
Simulation of dispersion of the half of tritium inventory tio (37 PBq) from a CANDU6 reactor in Ilha Grande Bay, after a LOCA event

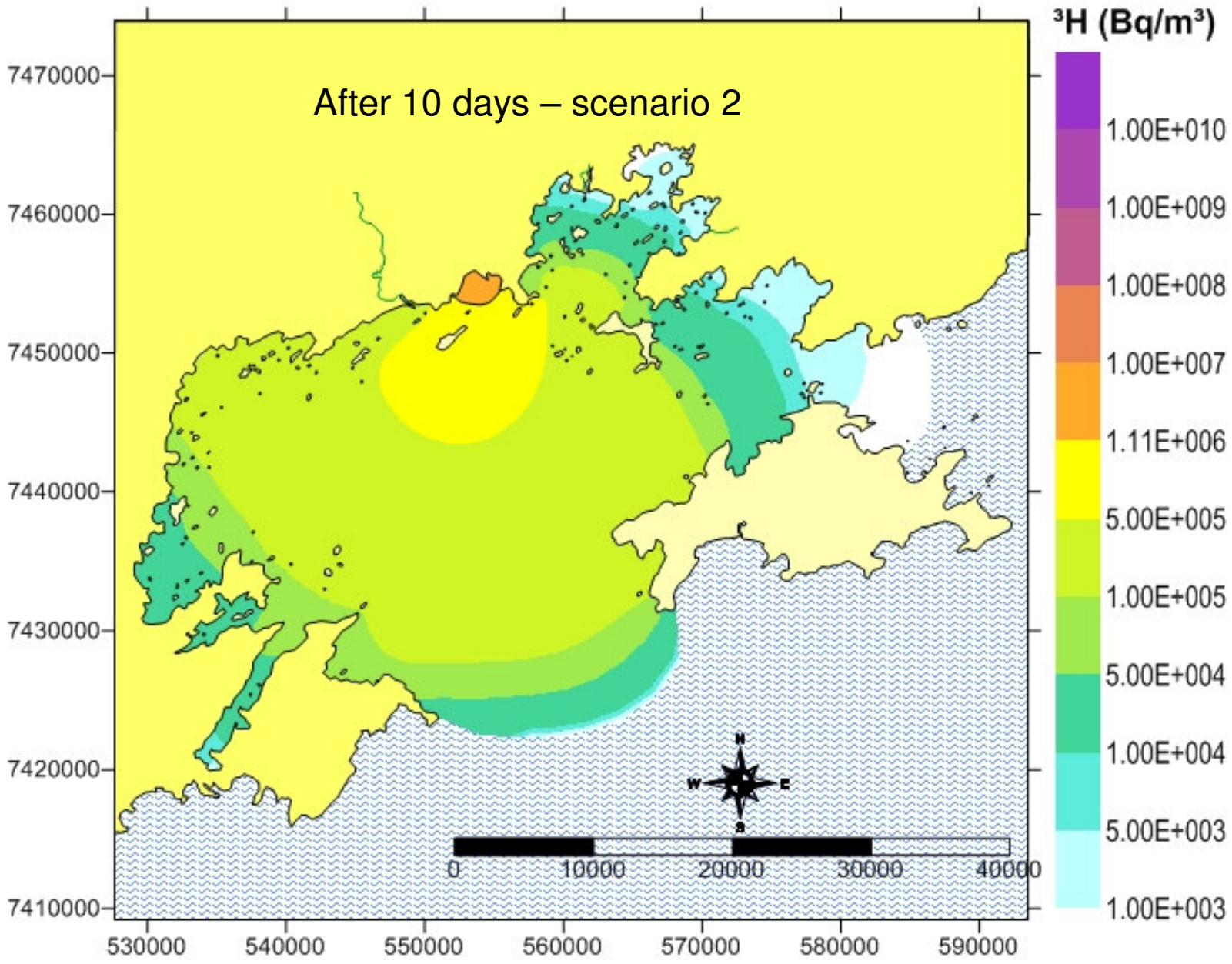

After 24 hours of accident
^{3}H (Bq/m^3)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000

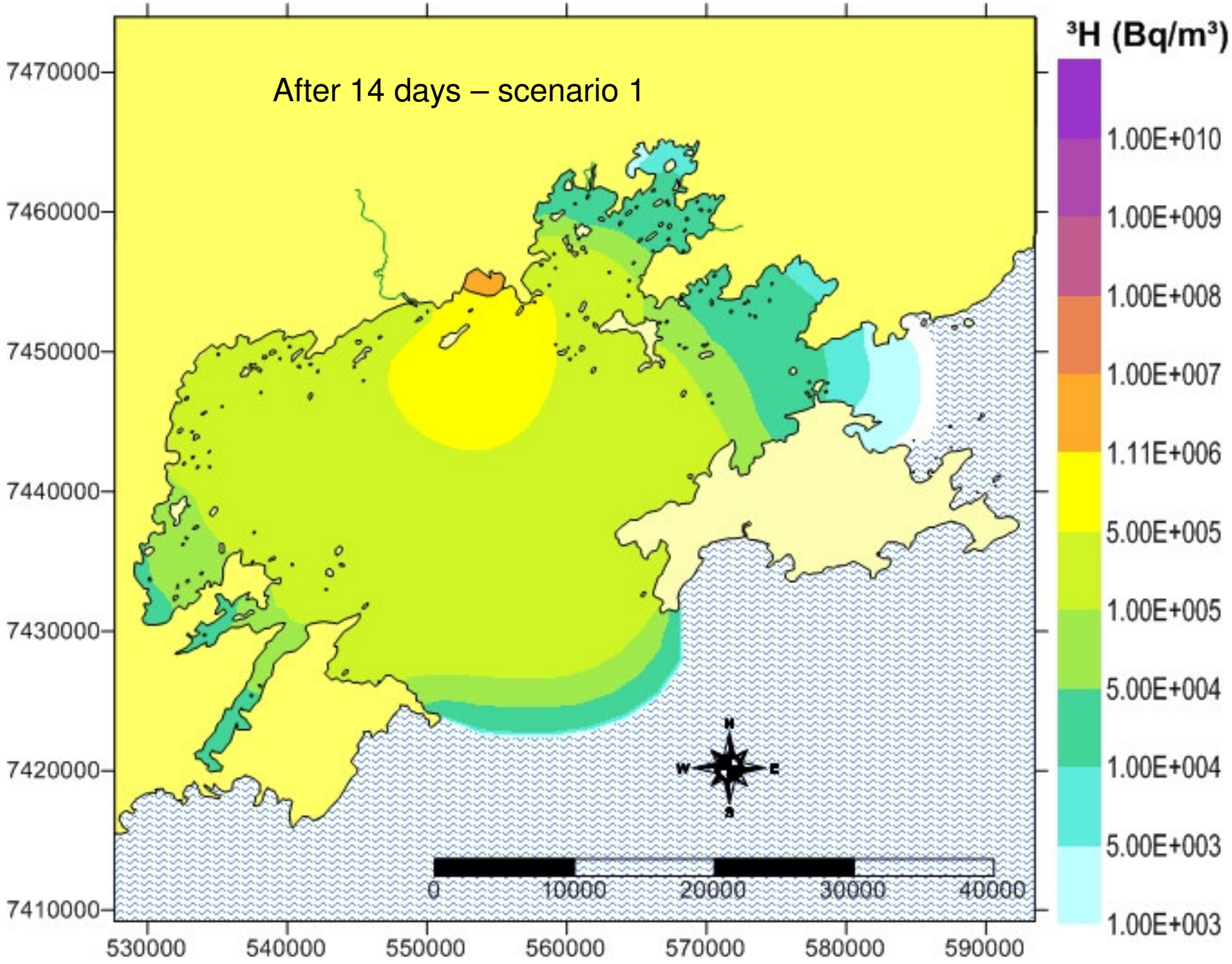

Após 2 dias
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000

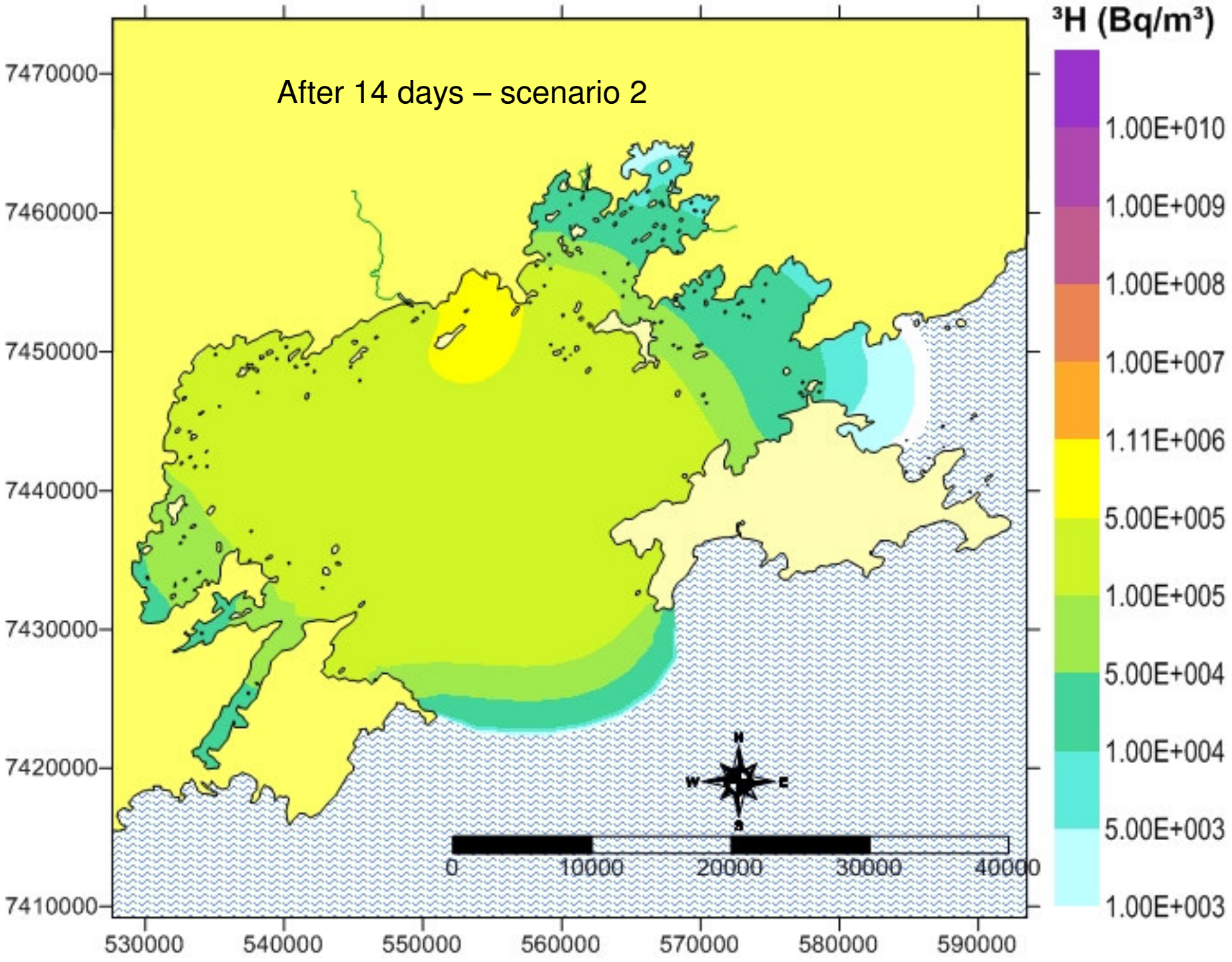

After 3 days – scenario 1
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000

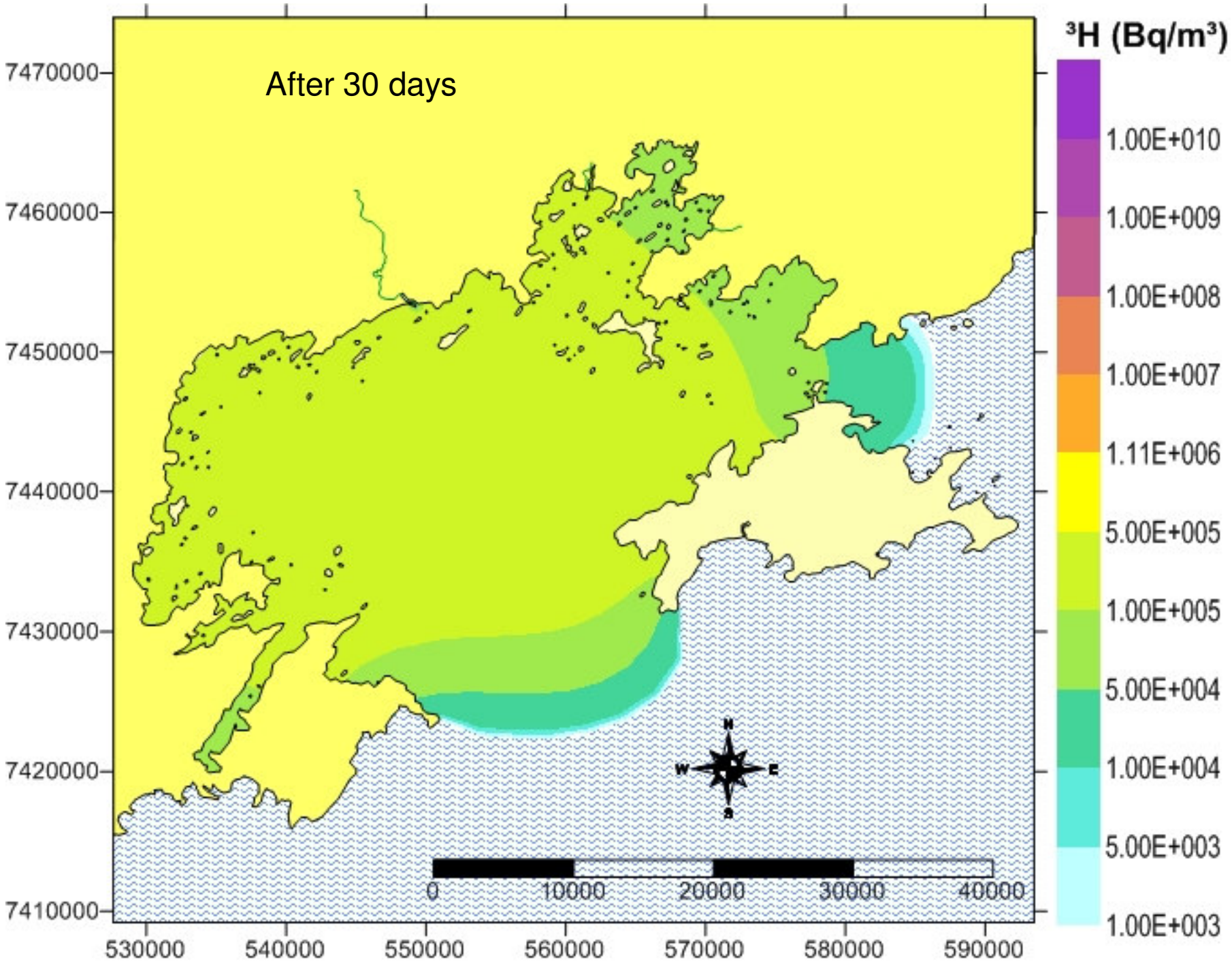

After 3 days – scenario 2
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000

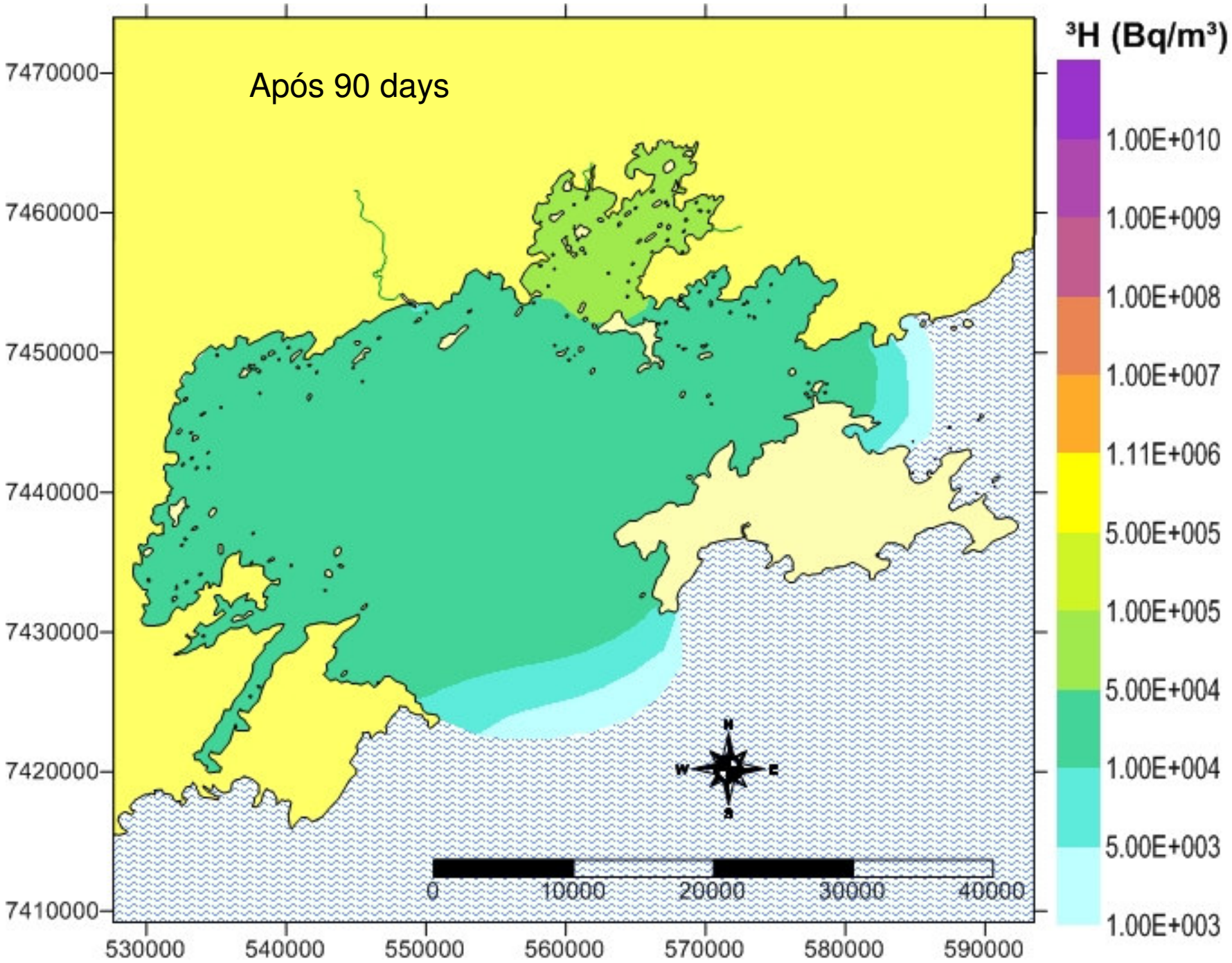

After 10 days – scenario 1
7470000
7460000
7450000
7440000
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006

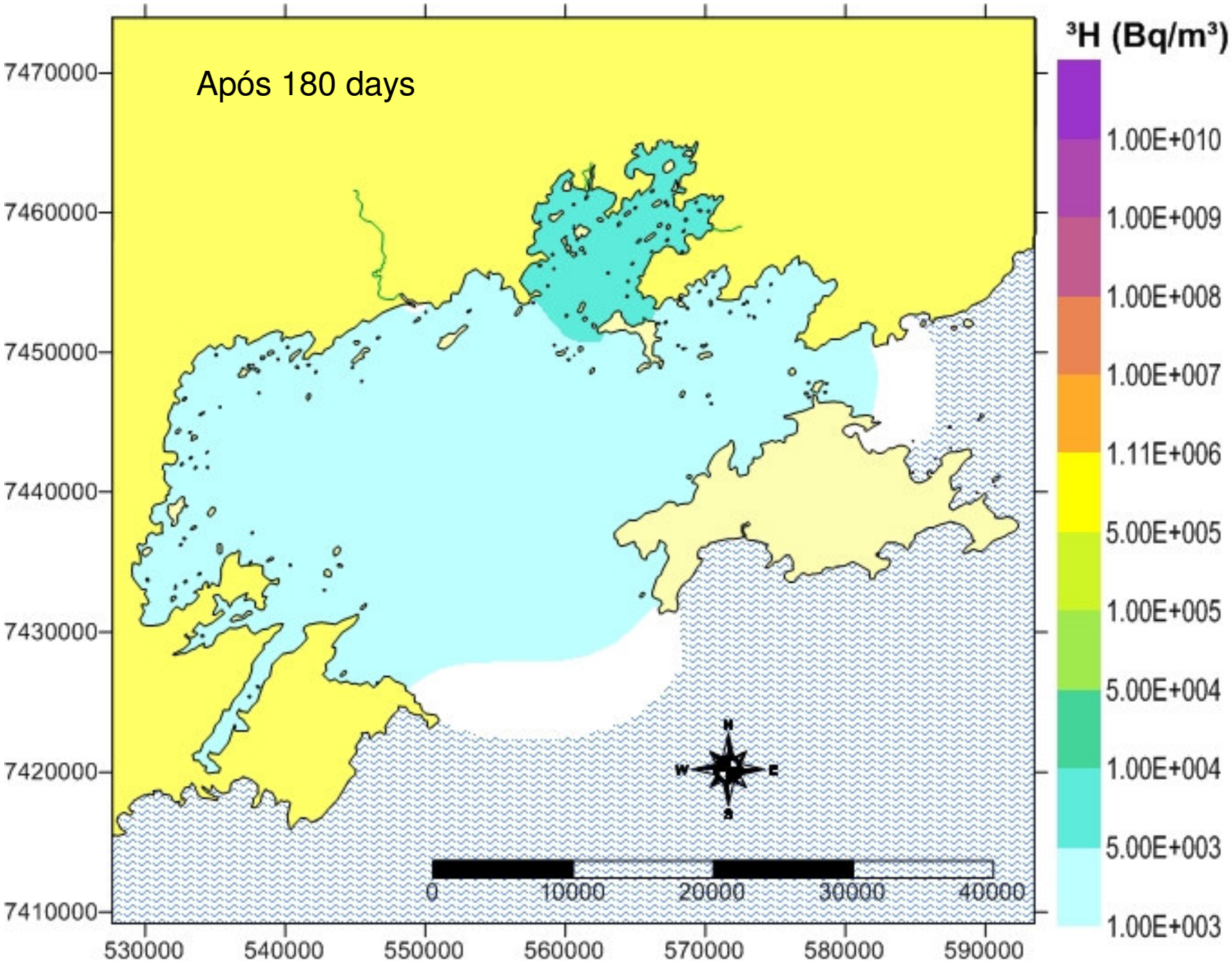

After 10 days – scenario 2
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000


After 14 days – scenario 1
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000


After 14 days – scenario 2
³H (Bq/m³)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000


After 30 days
^{3}H (Bq/m^3)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000


Após 90 days
^{3}H (Bq/m^3)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000


Após 180 days
^{3}H (Bq/m^3)
1.00E+010
1.00E+009
1.00E+008
1.00E+007
1.11E+006
5.00E+005
1.00E+005
5.00E+004
1.00E+004
5.00E+003
1.00E+003
7470000
7460000
7450000
7440000
7430000
7420000
7410000
530000
540000
550000
560000
570000
580000
590000
N
W
E
S
0
10000
20000
30000
40000

Several Parameters to work with bioenergetics have to be customized for tropics, for instance:

Phytoplancton growth rate (light and temperature moderator)

All parameters for fish bioenergetics

Consideration on move from oligo-mezotrophic to eutrophic aquatic ecosystems

What are the real problem for nuclear in Brazil now?

That Modeling and Experimental Science Can Really Help

Lot of pressures of the segments of society to impair the building licesing of the third NPP

Now, anti-nuclear in Brasil has a powerful ally: The Public Ministry Affairs

What are the menaces now ? Use IAEA guidelines to create political facts

Public Ministry demands a study plan for severe accidents (including core melting) with the consequences of radionuclide release into the environment

Political debates are in course now but It is possible that the nuclear development in Brazil could phase out if a series of public civil actions were deployed by the minsitry and other organizations

WHAT IS TO BE DONE

- Transfer factors for tropical seafood– several studies were made in Brazil for terrestrial pathway but almost nothing in aquatics
- Establish an information network about seafood consumption by local population of the affected areas (Ilha Grande Bay and potential sites of northeast)
- Experiments on Fish bioenergetic in the tropics will need training and support of other laboratories (e.g. Monaco Radioecology Lab can train personnel)
- Modelling Tritium speciation in presence of organic colloids to simulate the production of DOT and OBT formation in the water (new multi-propose reactor for radiopharmacy and possible organic labelled compounds)

Thanks for your attention

Merci pour votre attention

flamego@ien.gov.br