A real-time emergency response plan for accidental exposure of HNS over the sea near Korean Peninsula

Jiwon Oh[1], Sin-il Yang[1], Jai-Ho Oh[1], Moonjin Lee[2]

Department of Env. & Atmos. Sci., Pukyong National University, Busan, South Korea[1]
Korea Research Institute of Ship and Ocean engineering / KIOST, Daejeon, South Korea[1]
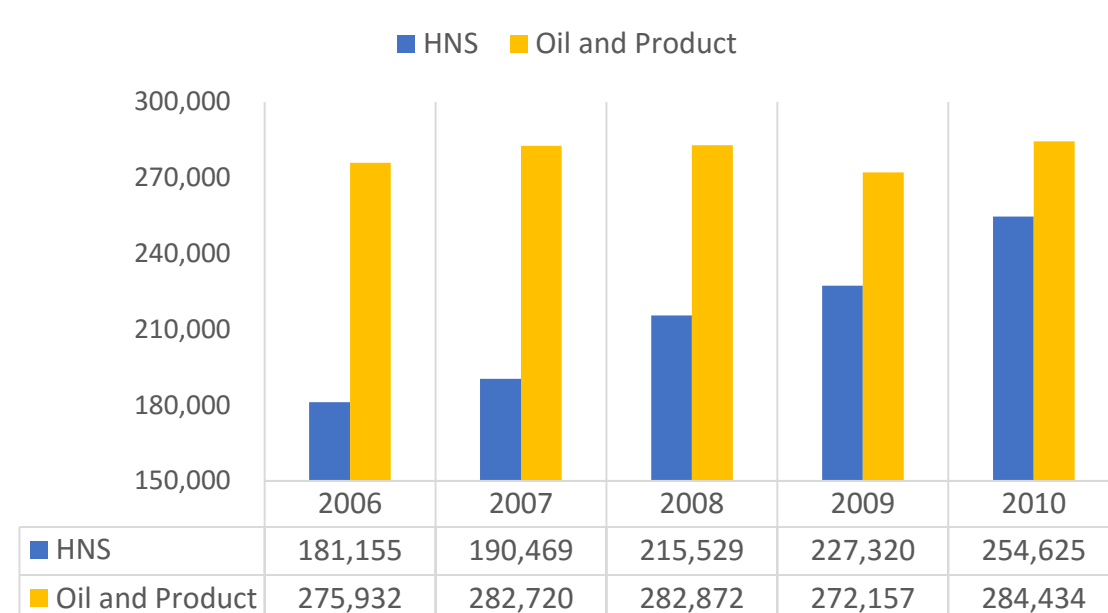
Introduction

Motivation

- HNS has a less time scale of existence in specific space than general gas emissions i.e., it spreads out reacting in air quickly (Koutsenko and Ross, AlChE/CCPS, 1994).
- Weather conditions greatly influence the diffusion of HNS above the sea, as there is no effect of topography or barrier.
- Sometimes after an incident, conditions degenerate due to bad weather.

- When the behavior of target chemicals have estimated, weather condition around accident site is an essential information to be considered.
- A real-time emergency response has to set up to figure out the spread of HNS ASAP.

Figure 1. HNS container on MV Hyundai Fortune explode and catch fire off the coast of Yemen in March 2006
Source : IOPC Funds HNS convention

Table 1. Trend of HNS Maritime Transportation in Korea[1])
Recently, hundreds of millions tones of HNS are transported by sea each year. It means the accidents regards HNS can occur a significant percentage.

	2006	2007	2008	2009	2010
HNS	181,155	190,469	215,529	227,320	254,625
Oil and Product	275,932	282,720	282,872	272,157	284,434

Source : SP-IDC(2006-2010) and KOMDI(2012)[1] Cho et al., Hazardous and Noxious Substances Risk Assessment and Accident Prevention Measures on Domestic Marine Transportation (2013)

Concept of the System

A real-time emergency response plan

- to monitor the diffusion of HNS exposed accidentally to the atmosphere from a chemical cargo ship
- in the sea near the Korean peninsula
- using WRF-chem V3.6

Main Ship Routes

- the major ports of chemicals traded by ship in Korea from 2011 to 2015 (SP-IDC): *Incheon, Daesan, Busan, Ulsan, Gwangyang*
- Create 12 ship routes in a straight line considering the chemical cargo volume between five major ports and China (or Japan) ports nearby Korea.
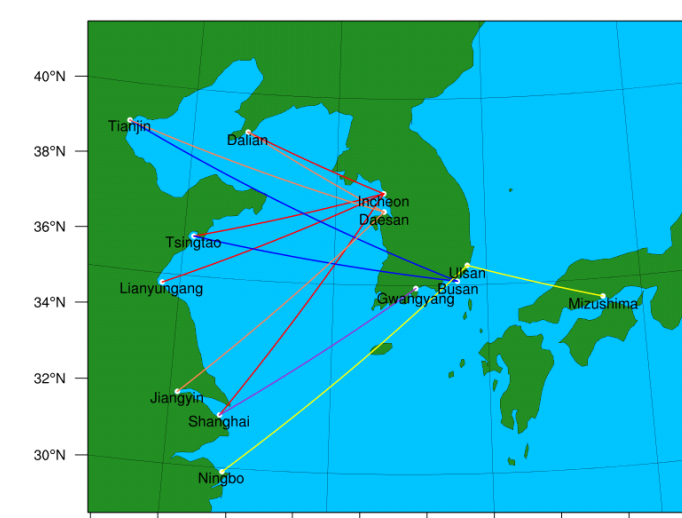
Figure 2. The 12 ship routes from Korean major port to nearby China and Japan considering chemical cargo volume

Domain Configuration

9km x 9km Main Domain (D01) → 3km x 3km Sub Domain (D02) → 1km x 1km Detailed Domain (D03)

(a)

Figure 3. (a) Downscaling step (b) Main domain and sub-domain configuration

215
3 km x 3 km
9 km x 9 km
181
(b)

- ✓ Main domain : large domain over the sea near the Korea
- ✓ Each small domains : representing domain per each 12 ship routes
- ✓ detailed domain is determined each simulation

Method

How to find accident point on grid point in simulation

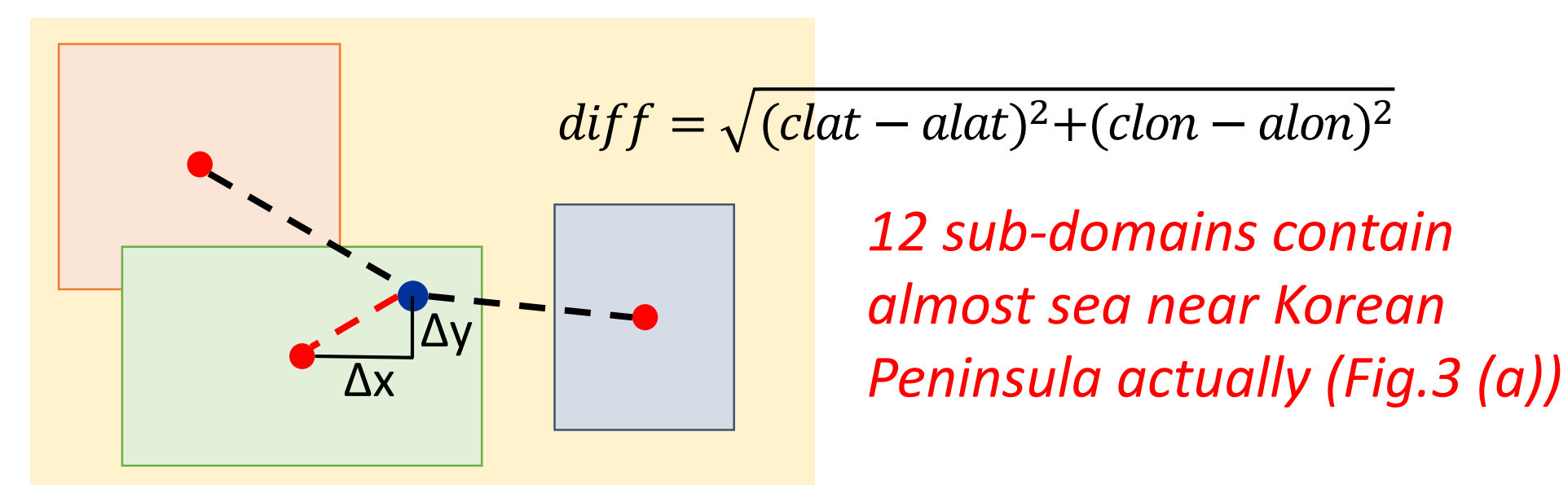- The emergency system have two main processes

READ and FIND

- Read a *date, time, location* which required for simulation
- Find the pre-set sub-domain nearest to the accident site
- Calculate the start point *(i, j_parent)* of detailed domain

SET UP and RUN

- Write the namelist(dates, time, domain information, etc.)
- Run WRF-chem

All processes run automatically just after input date, time, accident point.

- **The accident point (alat, alon) should be provided as DMS value**
- information of 12 domains are already stored respectively
  - i_parent_start, j_parent_start, e_sn and e_we
  - *(clat(i), clon(i))* : center latitude and longitude (degree)
- diff : shortest distance from *(alat, alon)* to *(clat, clon)*

$$diff = \sqrt{(clat - alat)^2 + (clon - alon)^2}$$

12 sub-domains contain almost sea near Korean Peninsula actually (Fig.3 (a))

(continued)

- the information of selected sub-domain will be typed in next step
- convert degree to km considering that length of 1° is different according to latitude
- **calculate start point in the detailed domain(d03)** with 1km grid resolution against sub-domain(d02) that its parent domain
- detailed domain grid point number is **100** (e_sn, e_we)

Table 3. The length of latitude and longitude per 1° according to latitude (from 25° to 50°)

The bold letters representing mid-latitude region are used to calculate detailed domain i_parent_start and j_parent_start in this program.

unit : km(per 1°)

Latitude	Lat. length	Lon. length
25°	110.773	100.95
30°	**110.852**	**96.486**
35°	110.941	91.288
40°	111.035	85.394
45°	111.132	78.847
50°	111.229	71.696

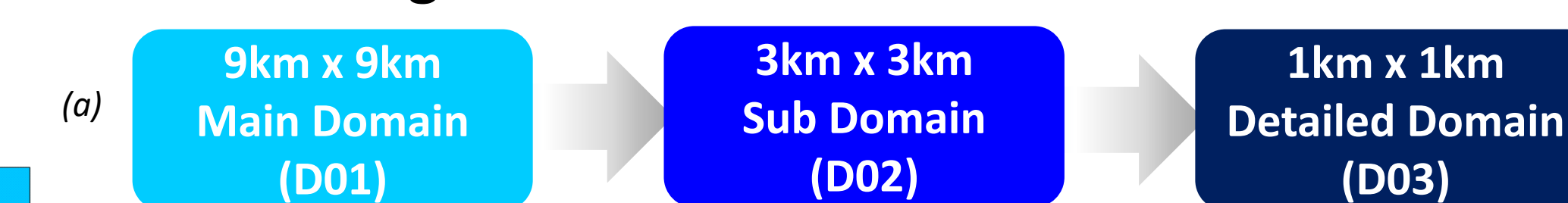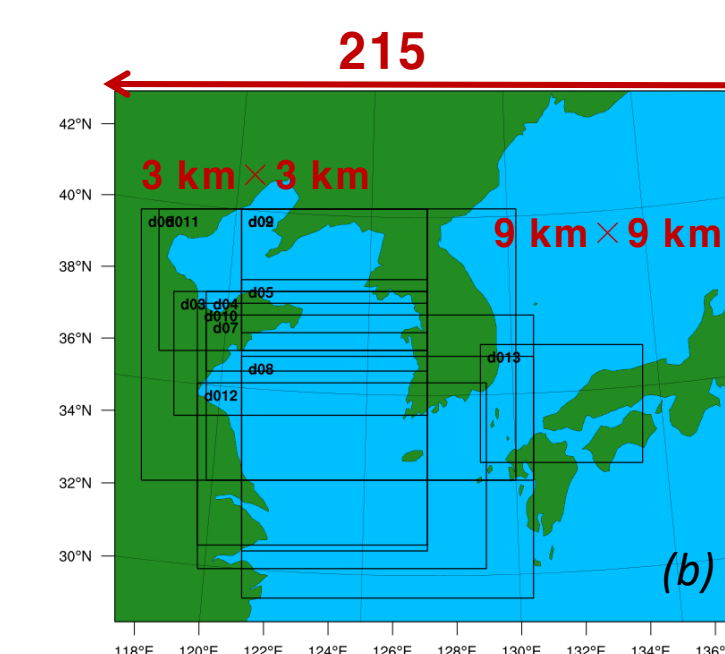### Domain Examples

- Two cases in 2004 HNS spill accidents

ship route 2

36°45'N

122°31'E

ship route 7

34°39'N

127°57'E

Figure 4. (a) Accident Point 36°45'N, 122°31'E

Figure 4. (b) Accident Point 34°39'N, 127°57'E

Conclusion

Virtual Accident Simulation

- initial data : NCEP FNL (Final) Operational Global Analysis data (1°x 1°, 6hourly)
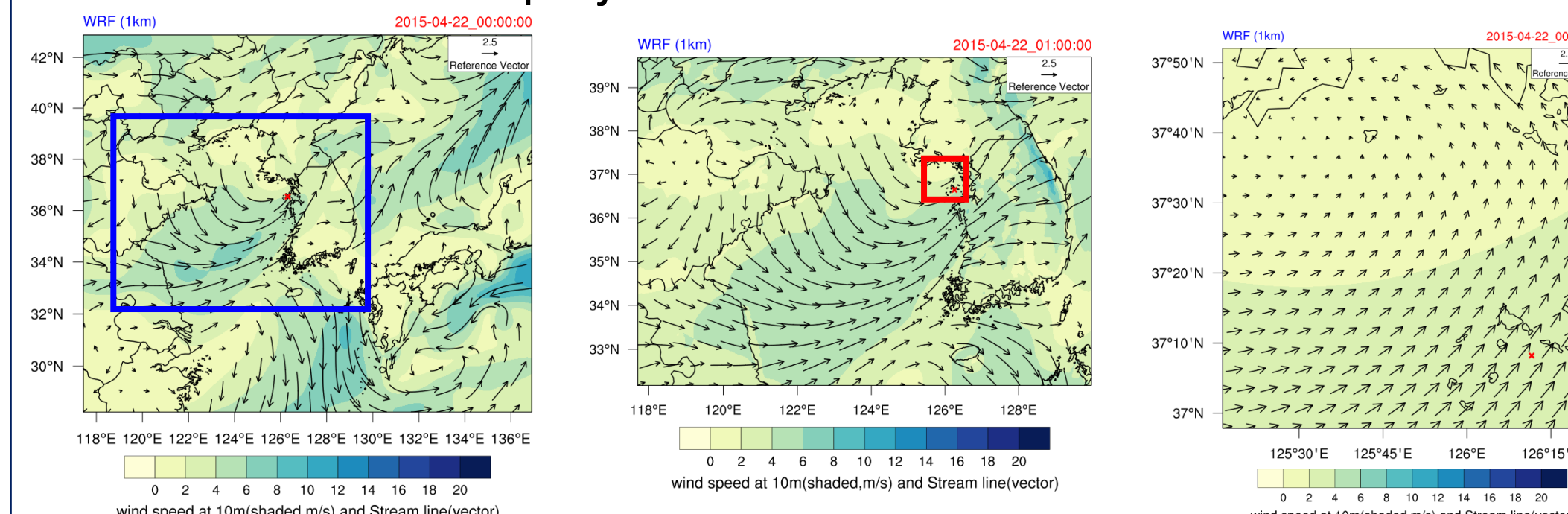- emission boundary : C-IFS-TM5 NRT (Near-Real-Time) of ECMWF's MACC project

Figure 5. Wind speed at 10m (shaded, m/s) and Stream line (vector) on domain 1 to 3 from left to right
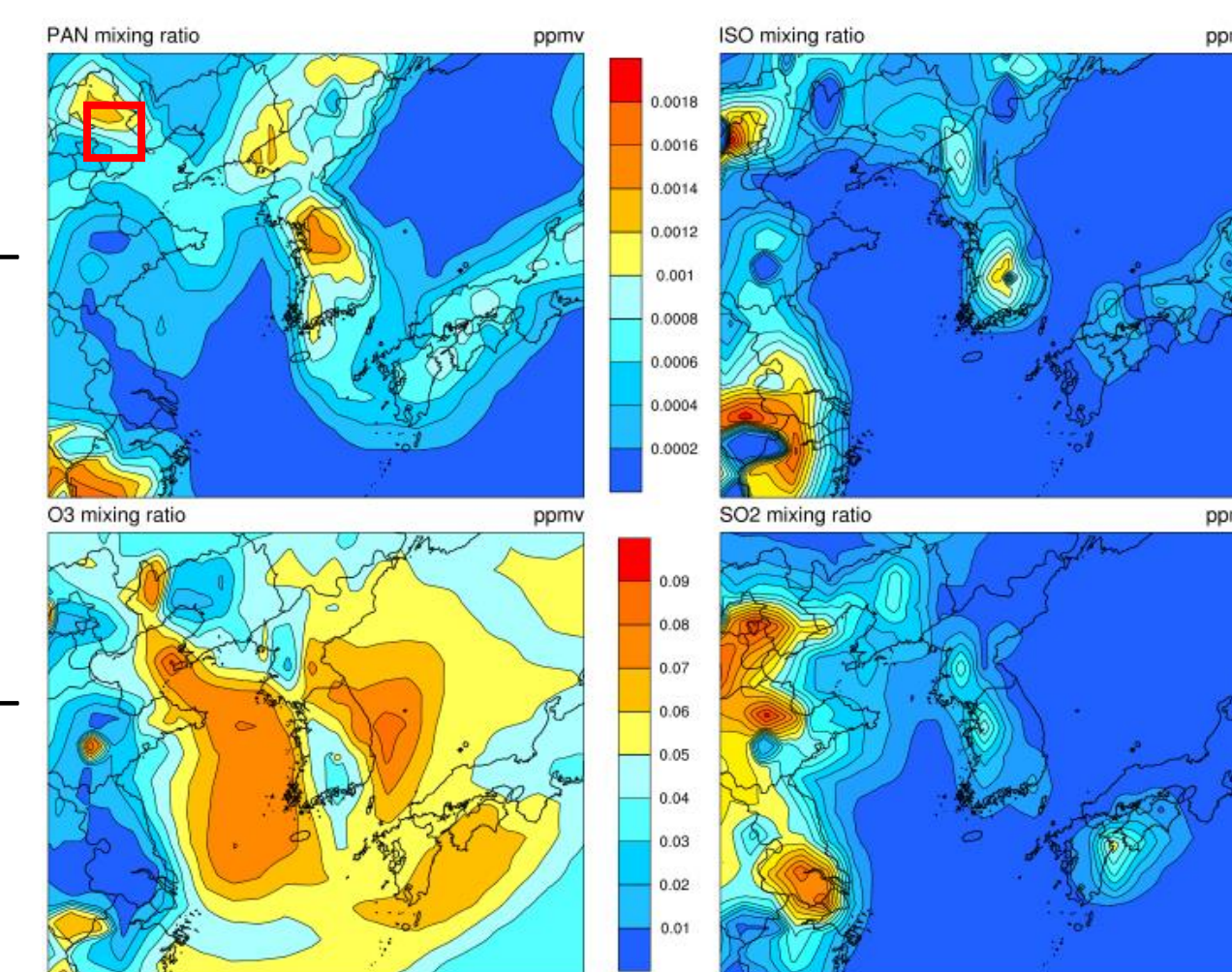The accident point is near Incheon Port.

case1 (Fig. 5)
- accident point : 37° 15' N 126° 19' E
- date : 2015. 04. 22. 00UTC – 04. 25. 00UTC

case2 (Fig. 6)
- accident point : 39° 2' N 119° 00' E
- date : 2015. 08. 13. 00UTC – 08. 13. 06UTC

Figure 6. Mixing ratio of Peroxyacetyl nitrate, Isoprene, Ozone and Sulfur dioxide in atmosphere (d01)

Summary
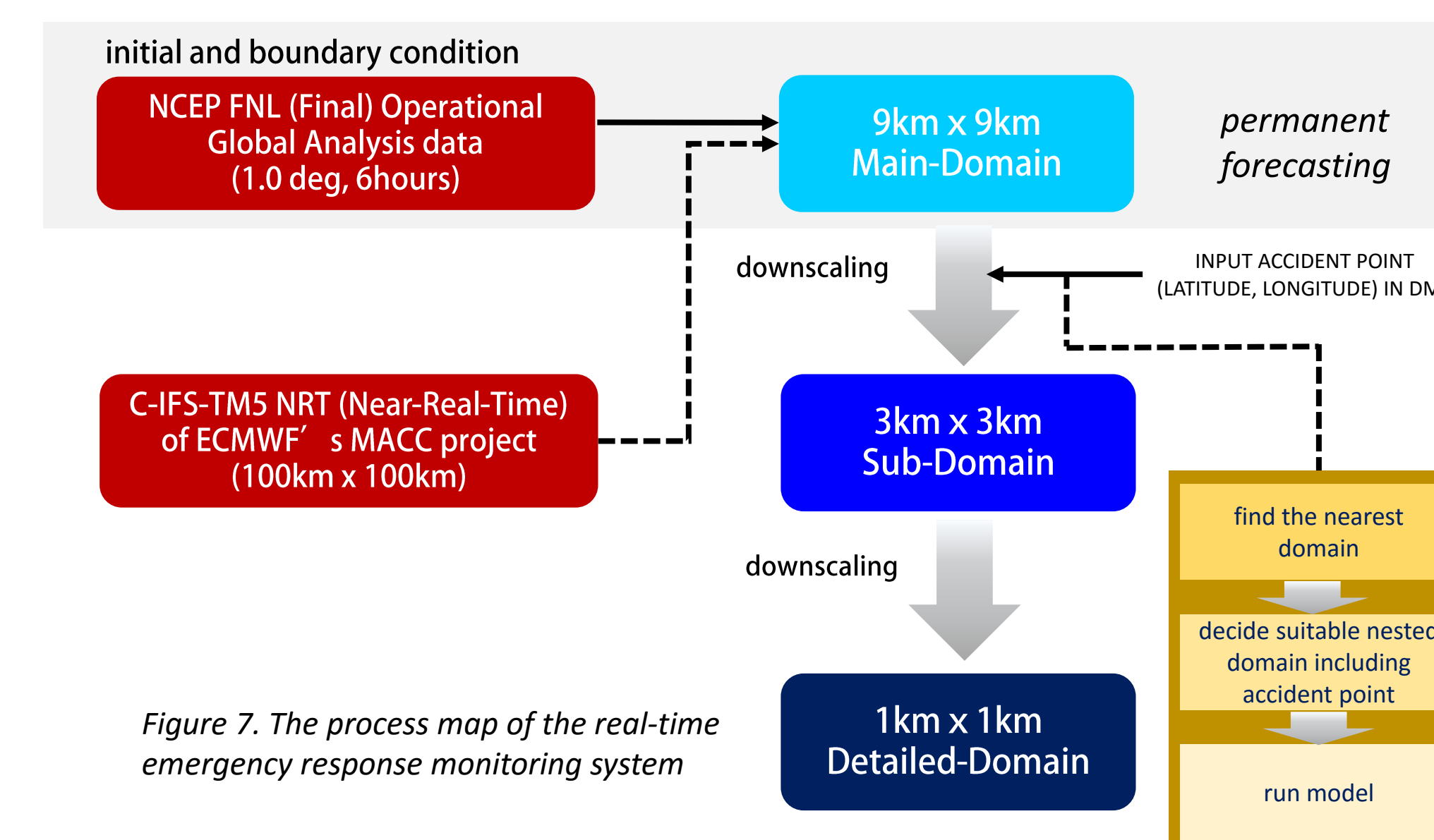
initial and boundary condition

Figure 7. The process map of the real-time emergency response monitoring system

- A real-time monitoring system displays weather condition on the main domain which covers large area nearby Korean Peninsula.
- When an HNS spill accident occurs, the system downscales to sub-domain with 3 km grid resolution and simulates not only weather but also chemical conditions on a region expected to be harmful and to forecast direction of spread.
- More detailed domain is supposed to be used to lay out the correspondence task and safety of rescue team who are nearby accident point by simulating precipitation, wind direction and speed, etc.