

Automated calculation of diagnosis and 7-day forecast of relative concentrations for assessing potential atmospheric releases from a nuclear power plant



Presented by: **M.Z.Božnar PhD**

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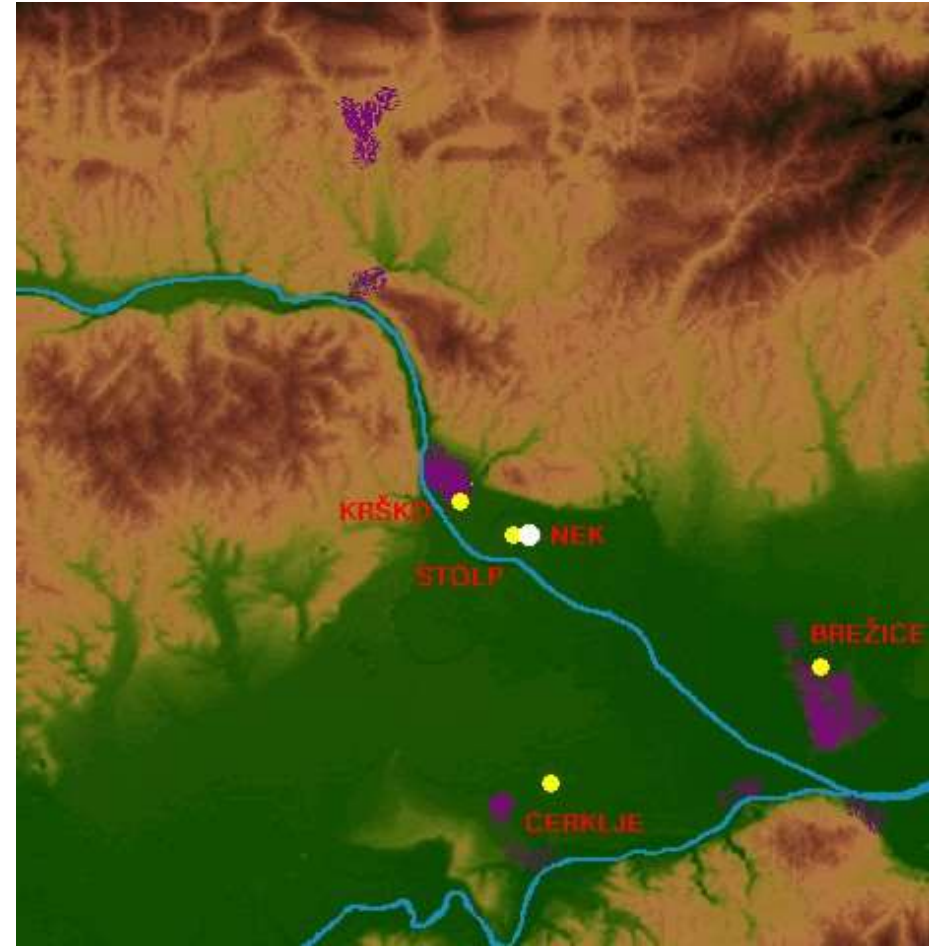
J. Kocijan, IJS

www.meis.si www.nek.si www.ijs.si



MAP OF KRŠKO BASIN

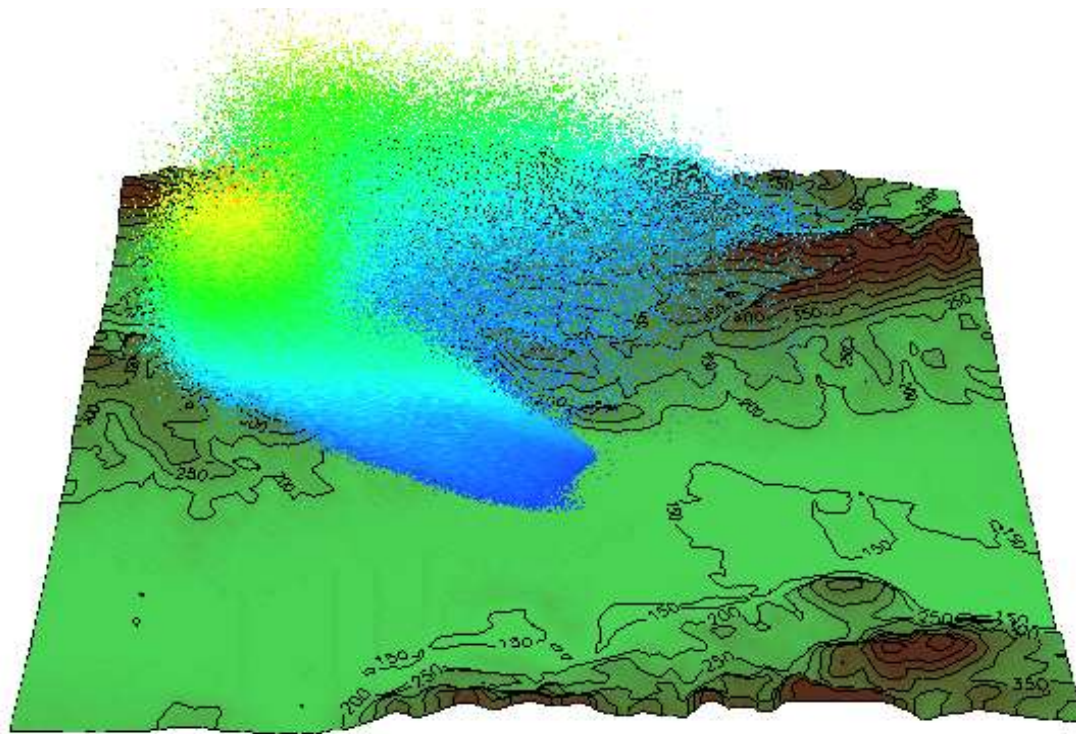
very complex terrain



WHY SHOULD WE MODEL

AIR POLLUTION DISPERSION?

- HISTORY
 - DIAGNOSIS
- ➔
- 7 DAYS FUTURE



AFTER ACCIDENT

OR

BEFORE ACCIDENT?

AIR POLLUTION DISPERSION MODELLING

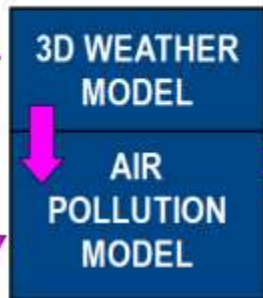
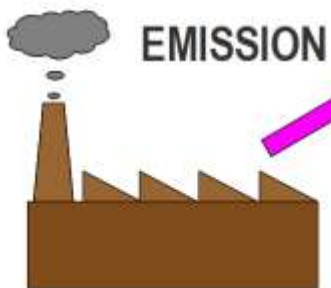
Relative concentr. X/Q



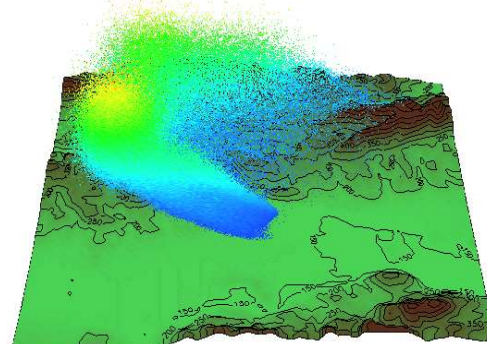
Released source term



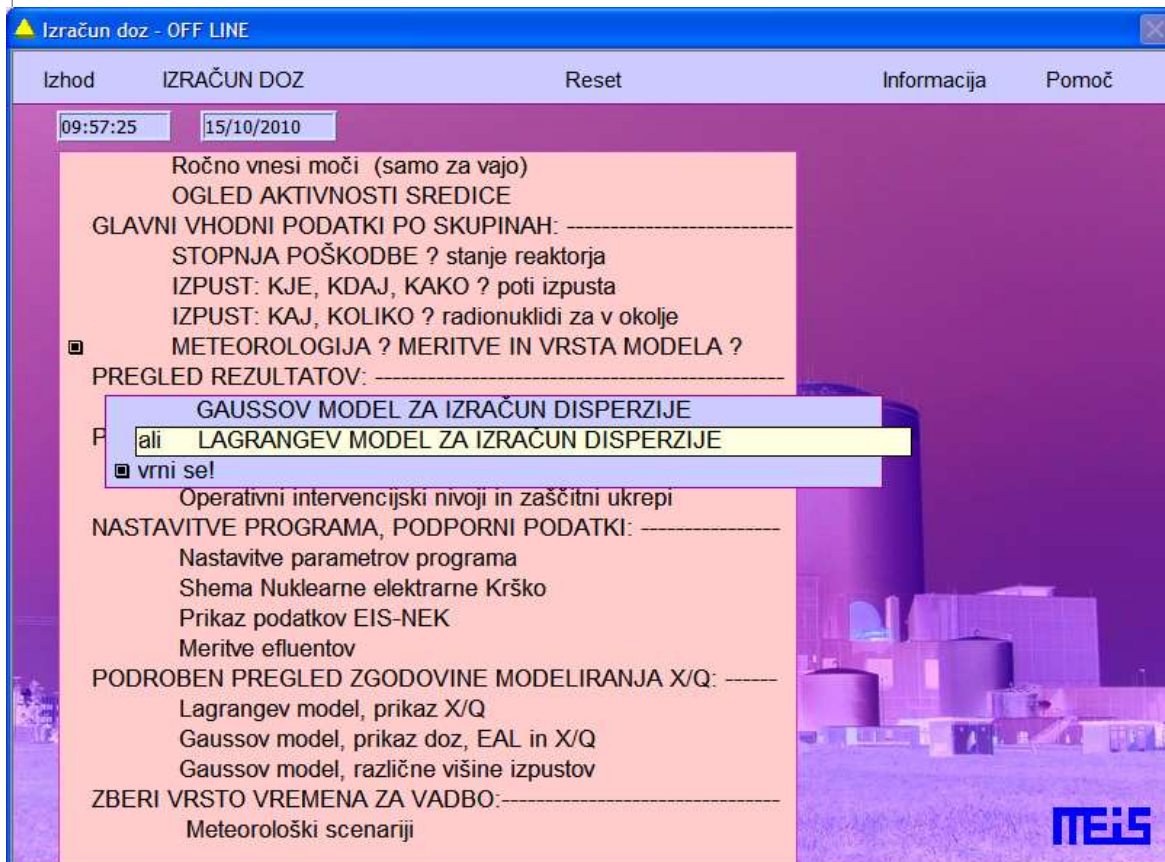
envir. concentrations
of radionuclides



AMBIENT
CONCENTRATIONS



„DOZE“ SW



**HOW TO
AUTOMATE THIS
PROCES OF
DISPERSION
CALCULATION?**

SYSTEM should be:

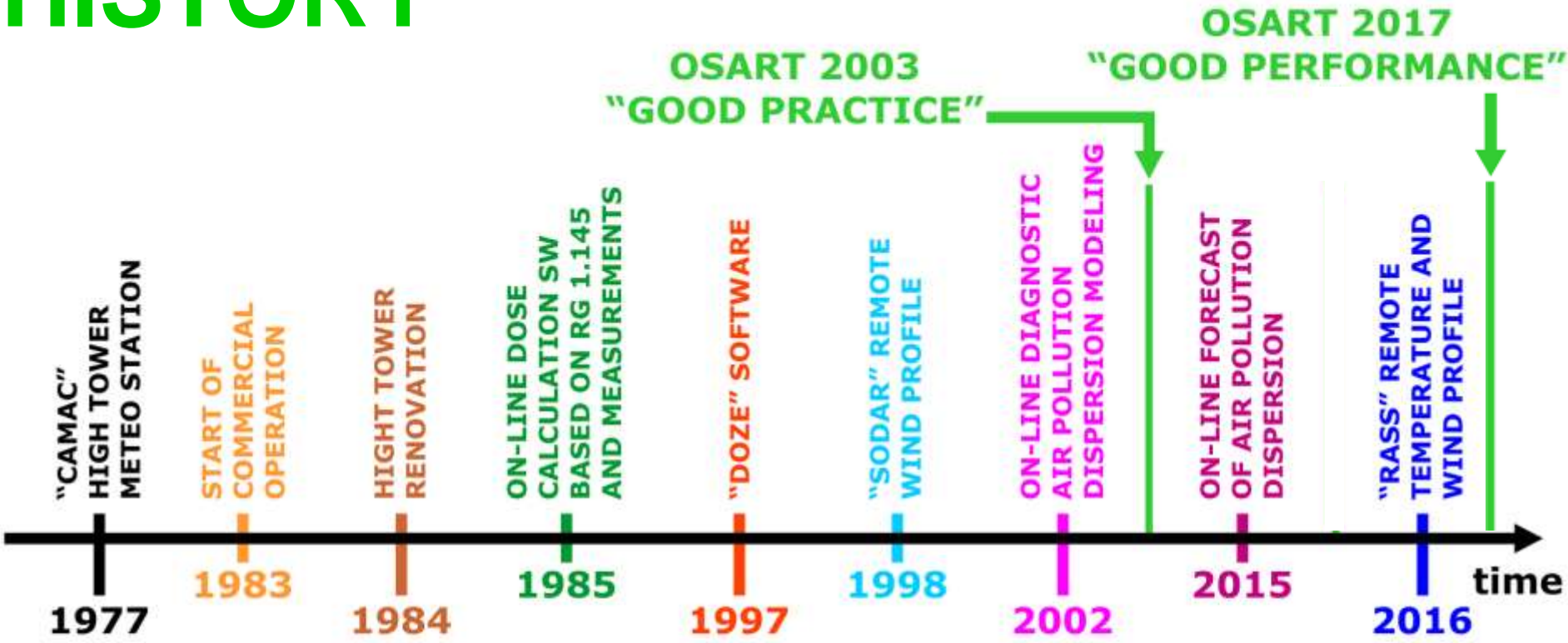
- **AUTOMATIC**
- **ON-LINE**
- **WELL MAINTANED**
- **QUALITY**

CONTROLLED:

- **automatic**
- **heuristic**



HISTORY



MEASUREMENTS:
4 ground level meteo stations,
"SODAR", "RASS"

ON-LINE DIAGNOSTIC AIR POLLUTION DISPERSION MODELING:
25 km x 25 km, 1/2 h,
250 m x 250 m cells,
6 emission sources

METEOROLOGICAL FORECAST:
once per day: 7 days, 2 km cells, 1/2 h

AIR POLLUTION DISPERSION FORECAST:
once per day: 7 days, 1/2 h,
6 emission sources



METEO STATION „TOWER“ 1977, 1984, 2000



METEO SENSORS



SODAR (1998) ->> RASS (2016)



Air pollution dispersion modelling for NPP Krško surroundings

UP TO 2015:

based on

meteorological measurements

(diagnostic mode)

**Using numerical Lagrangean
particle model**

Spray (from Arianet)

Air pollution dispersion modelling

FROM 2015:

based on

numerical weather forecast

NWP

AIR POLLUTION DISPERSION FORECAST **for 7 DAYS**

Using numerical Lagrangean particle model

based on

WEATHER FORECAST

since 2015

every 1/2h, 2/24/7,
in automatic mode, all the time

WEATHER FORECAST

**FINE RESOLUTION
OVER COMPLEX TERRAIN**

**half hour step,
2 km grid cell size**

WEATHER FORECAST

WRF Weather Research & Forecast model,
ARW (Advanced Research WRF), NCAR,

**INPUTS FROM
GLOBAL METEOROLOGICAL MODEL:
GFS (NCEP, USA)**

KRŠKO CONFIGURATION:

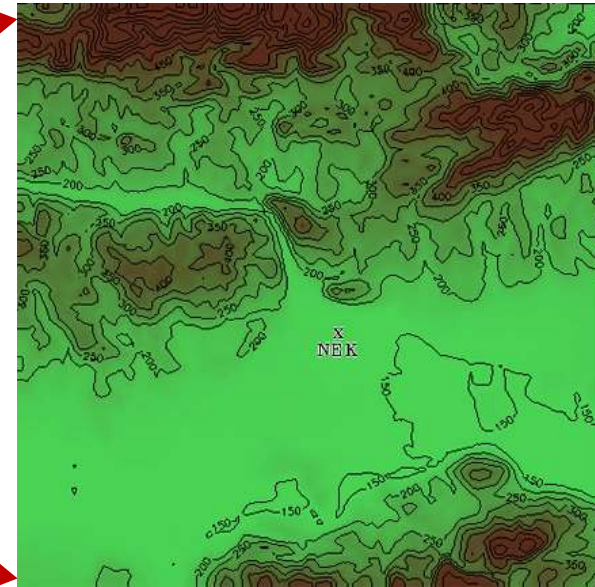
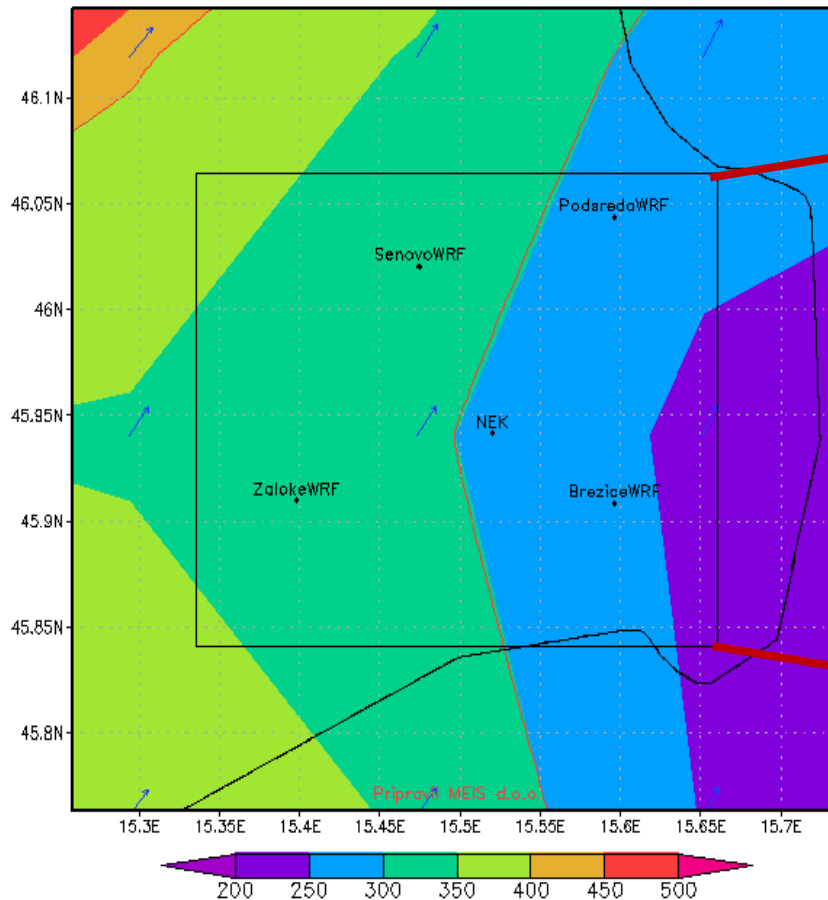
- 2 domains
- 7 days

- Bigger domain 22 x 22 cells, 14 km resol. ½ hour,
- Smaller domain 22 x 22 cells, 2 km resol. ½ hour,



TERRAIN PRESENTATION

bigger domain



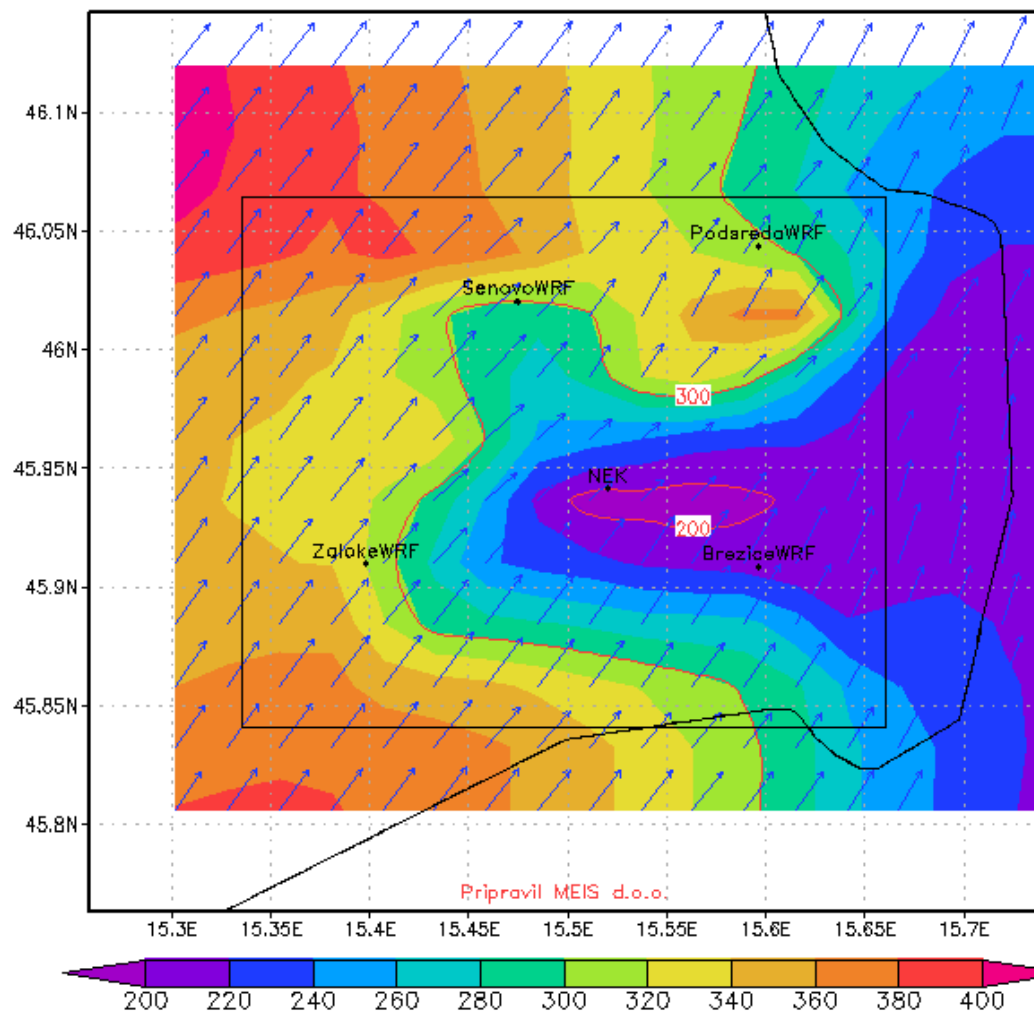
CELL: 250m

CELL: 14km

TERRAIN PRESENTATION

smaller domain

CELL: 2km



Profiles from WRF
forecast



Mass consist. Model
MINERVE
and
Num.Lagr.part.model
SPRAY



RELATIVE CONC. CONCEPT:

X/Q , C/Q , D/Q

AIR, CLOUD SHINE, DEPOSITION



6 sources: plant vent., ejector, ground release, steam release, passive filters(2x)

..... X/Q FORECAST

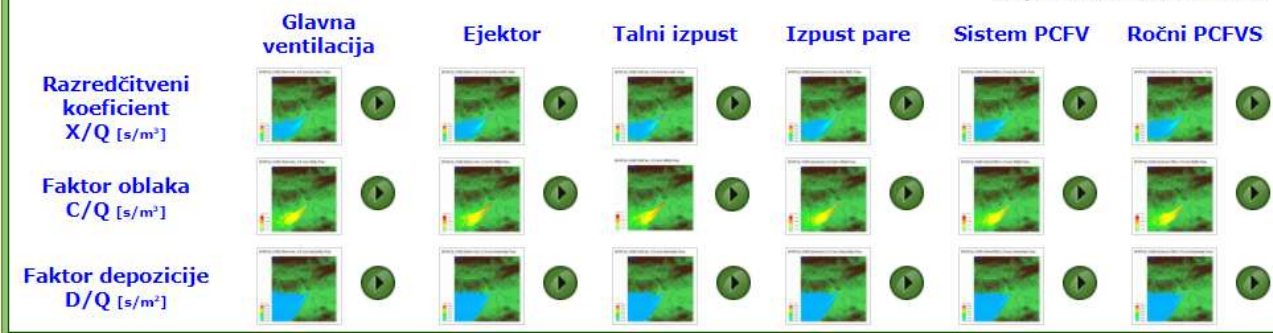
results on WWW for authorised users

Modeliranje disperzije NEK

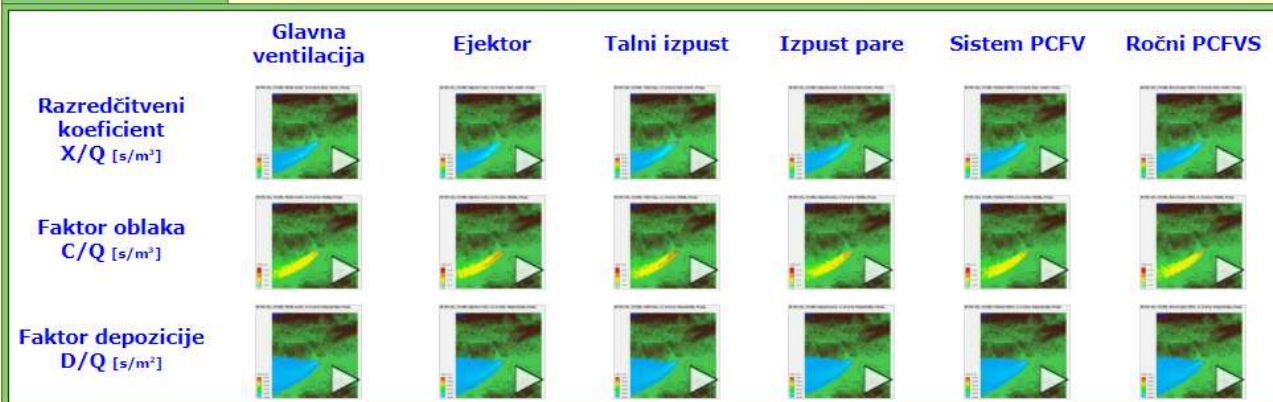
Diagnoza

Prognoza 24 ur

15:00 29. 05. 2021 (zimski čas)
(zaključek intervala)
za podrobnosti kliknite sličico



Prognoza - kratka (3h)



WEATHER FORECAST..... X/Q

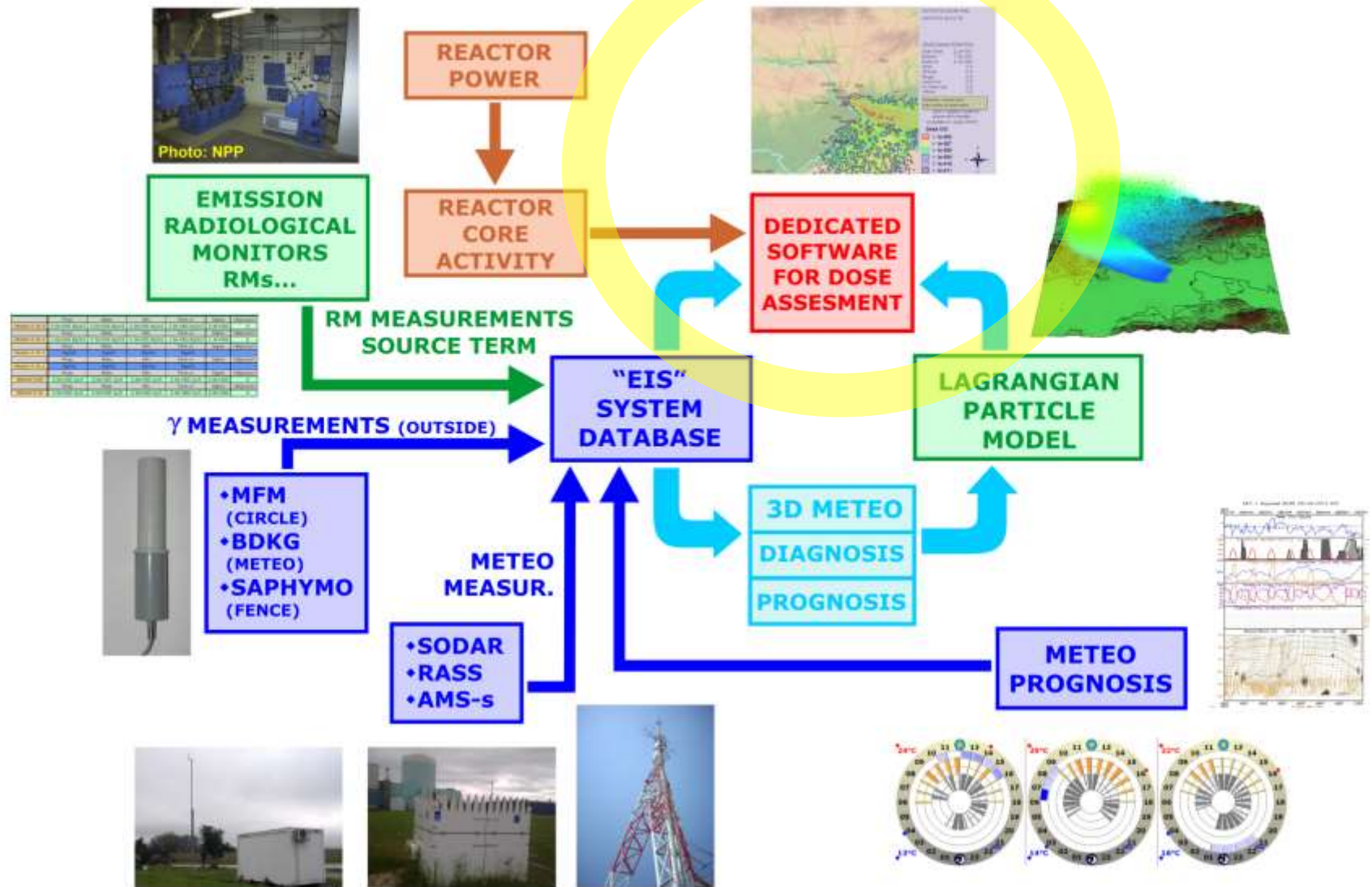
GFS once / day to MEIS

MEIS centre: 7 days X/Q calculation

MEIS => KRŠKO NPP once / day

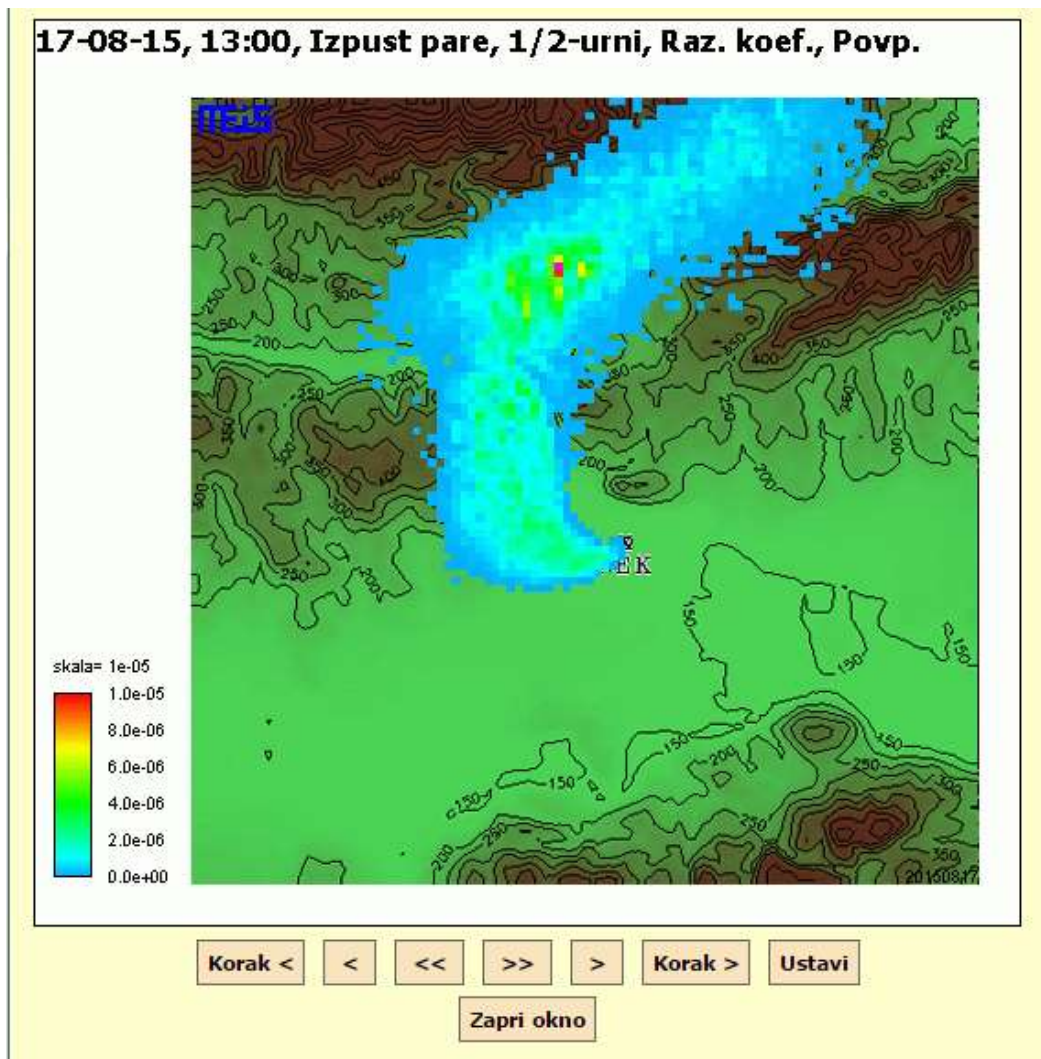
+ results on WWW

ENVIRONMENTAL EXPERT SYSTEM NPP KRŠKO



WEATHER FORECAST..... X/Q

results on WWW as video



X/Q FORECAST at Krško NPP

Integrated into „DOZE“ SW

Seamless

from diagnosis to forecast

ali LAGRANGEV MODEL ZA IZRAČUN DISPERZIJE

Izhod Izberi merilno postajo Pomoč

12/25/59 19/01/2015 **OPOZORILO: Vsi časi v programu so zimskil!**

Izmerjeni meteorološki podatki

Izvor podatkov: AMP Stolp

Konec merilnega intervala: 12:00 19/01/15

Hitrost vetra (m/s): 0.9

Veter iz smeri (st): 189

Stabilnost atmos.(PG razredi): A Močno nestabilno

Kvaliteta Lagrangevega modela je (1-5): 5
Ocena 5 pomeni odlično, 4 pravdobro, ..., 1 pa nezadostno

Izbran model: Izpust iz glavne ventilacije

Oddaljenost (m): 1500 baza: PROGNOZA - SQL

Faktor redčenja (s/m3): -Inf Čas izpusta: 11:30 13/10/2014 Čas izračuna modela: 12:00 22/01/2015

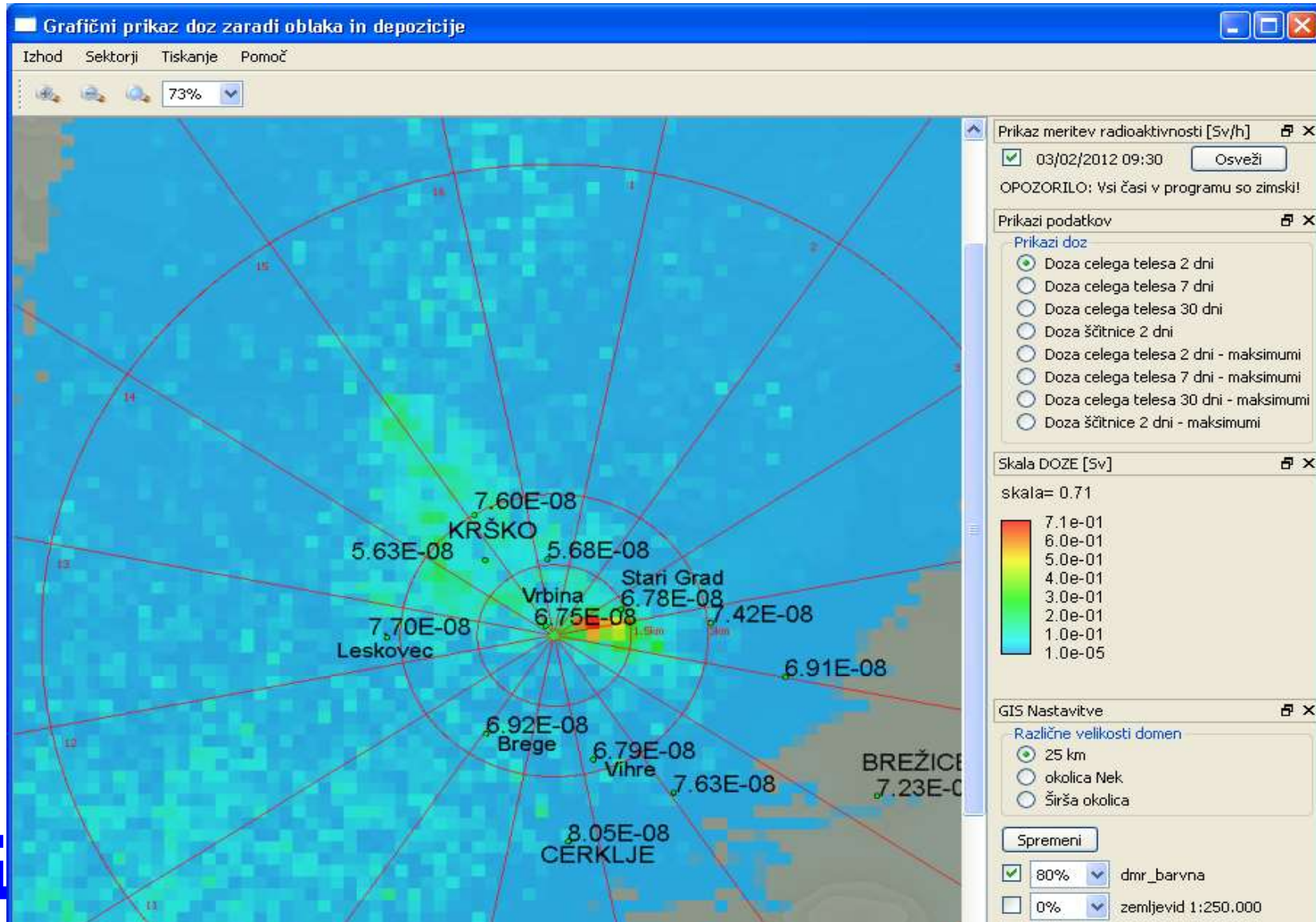
Ure povprečevanja: 1 **Izračunaj!**

Navedena izbira se upošteva naprej DA NE

Poglej podatke!

DOSE CALCULATION - 2D

different types of presentation



DOSE CALCULATION - 2D

different types of presentation

▲ Predvidene doze zaradi oblaka in depozicije

Izhod Pomoc

14:13:46 15/10/2007

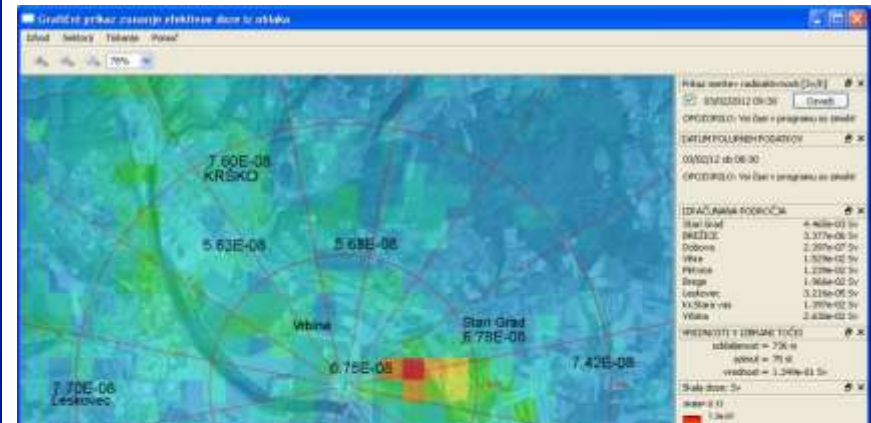
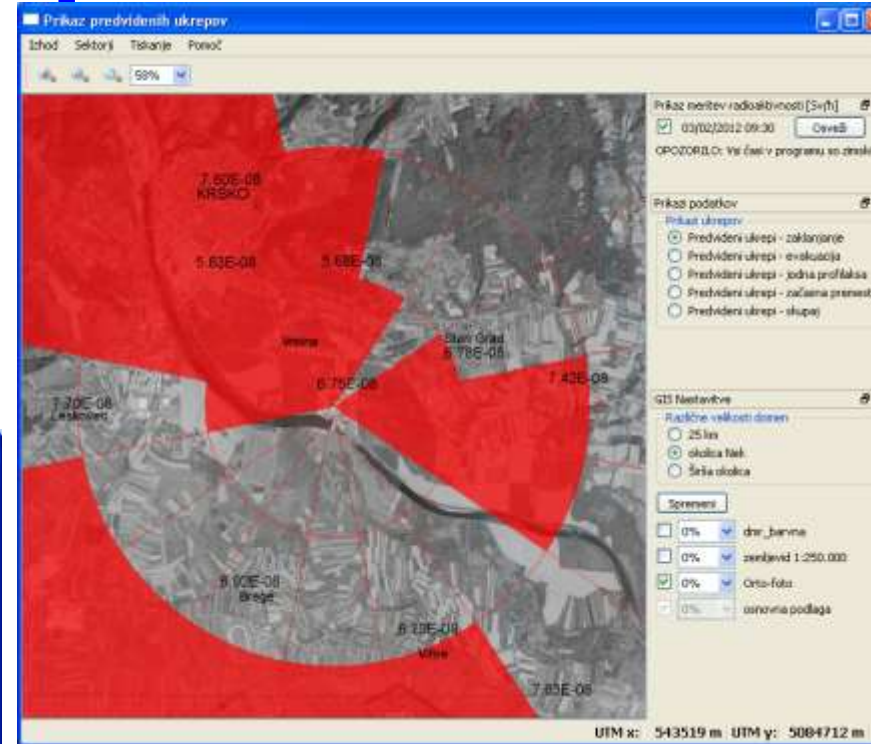
razdalja (km)	ef. doza 2 dni (Sv)	ef. doza 7 dni (Sv)	ef. doza 30 dni (Sv)	d.ščitnice 2 dni (Sv)
0.5	2.56E-9	6.71E-9	1.82E-8	4.11E-12
1.5	2.87E-9	5.65E-9	1.33E-8	1.27E-11
3.0	1.98E-9	3.28E-9	6.87E-9	1.14E-11
10.0	1.76E-9	2.17E-9	3.33E-9	1.33E-11

▲ Maksimalne doze po sektorjih

Datoteka Pomoc

	ef. doza 2 dni (Sv) < 1.5 km	ef. doza 7 dni (Sv) < 1.5 km	ef. doza 30 dni (Sv) < 1.5 km	d.ščitnice 2 dni (Sv) < 1.5 km	ef. doza 2 dni (Sv) 1.5km-3km	ef. doza 7 dni (Sv) 1.5km-3km	ef. doza 30 dni (Sv) 1.5km-3km	d.ščitnice 2 dni (Sv) 1.5km-3km	ef. doza 2 dni (Sv) 3km-10km
Sektor 01	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 02	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 03	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 04	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 05	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 06	1.57e-07	4.34e-07	9.94e-07	2.84e-09	2.66e-03	2.66e-03	2.68e-03	4.33e-02	0.00e+00
Sektor 07	1.93e-02	1.93e-02	1.95e-02	3.14e-01	9.65e-03	9.69e-03	9.76e-03	1.57e-01	0.00e+00
Sektor 08	3.63e-02	3.64e-02	3.66e-02	5.90e-01	1.66e-02	1.67e-02	1.68e-02	2.71e-01	0.00e+00
Sektor 09	3.96e-02	3.98e-02	4.01e-02	6.45e-01	2.03e-02	2.04e-02	2.06e-02	3.30e-01	2.04e-06
Sektor 10	5.25e-02	5.61e-02	6.88e-02	8.24e-01	3.34e-02	3.40e-02	3.77e-02	5.43e-01	3.96e-02
Sektor 11	6.73e-02	7.98e-02	1.14e-01	9.92e-01	7.47e-02	8.40e-02	1.03e-01	1.13e+00	9.70e-02
Sektor 12	5.31e-02	6.31e-02	8.32e-02	7.75e-01	6.95e-02	7.62e-02	8.97e-02	1.07e+00	8.60e-02
Sektor 13	1.55e-06	4.31e-06	9.87e-06	2.82e-08	8.19e-05	2.27e-04	5.20e-04	1.49e-06	4.52e-04
Sektor 14	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 15	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Sektor 16	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00

Predvideni ukrepi: ■ zaklanjanje ■ evakuacija ■ jedna profilaksa ■ začasna premestitev



??? computer network
System failure  ???

X/Q FORECAST at Krško
Redundancy is important:

- last transferred forecast are used
 - or **WWW for remote usage**
in human readable form

RESULTS

- better planning
- better preparedness
- possible measures
for improvement of actions
- better NWP 😊 for workers

IMPORTANT -

VALIDATION:

**METEO - WRF:
ON-SITE,**

DISPERSION - SPRAY:

ŠOŠTANJ-91 DATA SET



Integrated system for population dose calculation and decision making on protection measures in case of an accident with air emissions in a nuclear power plant

Primož Mlakar ^a  , Marija Zlata Božnar ^a, Boštjan Grašič ^a, Borut Breznik ^b

^a MEIS d.o.o., Mali Vrh pri Šmarju, Slovenia

^b Nuklearna elektrarna Krško, d.o.o., Krško, Slovenia

Received 16 November 2018, Revised 19 February 2019, Accepted 19 February 2019, Available online 20 February 2019.

Editor: Pavlos Kassomenos

Thank you !





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