Fukushima nuclear disaster after the 11 March 2011 earthquake and tsunami.

Discussion of work by Godae OceanView groups

I) Simulations by Japan Atomic Energy Agency (JAEA) using nuclear dispersion models on the global ocean analysis systems, Multivariate Ocean Variational Estimation (MOVE) for the North Pacific and North West Pacific, by Meteorological Research Institute (MRI) at Japan Meteorological Agency;

II) Simulations by NCEP/NOAA: a) using numerical drifters on the NOAA Global Real-Time Ocean Forecast System (RTOFS-Global); b) using a 3D tracer simulation, through a regional ocean model for episodic tracer, RTOFS-ET;

III) Work by Mercator Ocean and University of Toulouse, on dispersion of pollution at basin scale, a) using simulated Lagrangian particles on the Mercator Ocean analysis and forecasting system, and b) using the SIROCCO ocean model for dispersion of particles.
I) Simulations by Japan Atomic Energy Agency (JAEA) using nuclear dispersion models on the global ocean analysis systems, Multivariate Ocean Variational Estimation (MOVE) for the North Pacific and North West Pacific, by Meteorological Research Institute (MRI) at Japan Meteorological Agency;
• Kamachi (MRI) et al;
• Kawamura (JAEA) et al; poster.
Oceanic dispersion simulations for $^{134}$Cs and $^{137}$Cs after the Fukushima disaster, utilizing:

Oceanic currents from reanalysis, from Multivariate Ocean Variational Estimation (MOVE) MOVE-NP and MOVE-WNP($0.1^\circ$) of JMA/MRI.

Source terms from atmospheric deposition: from atmospheric model WSPEEDI-II, by JAEA, with nuclear dispersion model (GEARN), estimate wet-dry deposition into sea surface. Released amount to atmosphere: Terada et al. 2012.


Nuclear dispersion model: Sea-GEARN by JAEA
Lagrangian particles, horizontal resolution $0.1^\circ$. In different simulations, Cs was either treated as fully dissolved material or with interaction between dissolved-suspension-sediment phases. Alternative to Lagrangian particles: finite difference model.
Kawamura et al., this session, poster: Numerical experiments on dispersion of radionuclides in the ocean.

$^{134}\text{Cs}$, Comparison with observations, June 2011

- $^{134}\text{Cs}$: 
  - May 2011: Obs. by Buesseler et al., 2012
  - Nov 2012: Obs. by Kaeriyama et al., 2013

$^{137}\text{Cs}$
Validation of Distribution of $^{137}$Cs Concentration (2011/4–5)

Correlation of $^{137}$Cs concentration at the surface between observation by Honda et al. (2012) and simulation.
Validation of Distribution of $^{137}\text{Cs}$ Concentration (2011/4–5)

Surface Cs–137 concentration (2011/4–5)

Correlation

Calculated surface Cs–137 (Bq/L)

Observed surface Cs–137 (Bq/L)

$^{134}\text{Cs}$

$^{137}\text{Cs}$

JAEA-MRI

http://www.mri-jma.go.jp/Topics/hotyouhi/houtyouhi Sea.html
Deposition of $^{137}$Cs, from 2011/3 Fukushima Daiichi Nuclear Power Plant, is mainly in the north-east and south-east directions from Fukushima, onto the sea-surface, and dispersed in the Pacific. Its concentration is, in 2011/10 (half year after the earthquake), diluted into the order of 0.01 Bq/L. (The concentration is now under background level in 2013)

Directly released $^{137}$Cs into the ocean is advected eastward along the Kuroshio Extension. It shall be mixed and diluted by mesoscale eddies, and arrive at 170°W after one year (2012/3)

Issues are unknown source information, unknown coastal process, and related modeling-assimilation

International coordination will be established in the framework of JCOMM/TT-MEER under WMO-IOC; the Task Team collaborates IAEA; Japanese system is developed by JAEA and JMA/MRI
II) Simulations by NCEP/NOAA, using:

a) numerical drifters on the NOAA Global Real-Time Ocean Forecast System (RTOFS-Global);

b) 3D tracer simulation, through a regional ocean model for episodic tracer, RTOFS-ET;
NCEP/NWS/NOAA simulations

II a) Ocean plume simulations:


First particle tracking products delivered to the governmental Inter-agency Working Group, 4 weeks after the first significant release of radionuclides. First quantitative offshore contamination estimates delivered in approximately 6 weeks.

- Ocean model: analysis and prediction, RTOFS-Global, using initial conditions from the analysis of 2 days before the model run by the U.S. Navy (NAVO, Stennis, MS). RTOFS-Global is run with NCEP forcing for 2 days before the present, and then for 6 forecast days.
- Numerical drifters on the RTOFS-Global velocities.
M. Kamachi (MRI)’s presentation
Dispersion Simulation of Released $^{137}$Cs from
Fukushima Daiichi Nuclear Power Plant
after 2011/3/11
H. Kawamura$^1$, T.Kobayashi$^1$, Y. Furuno$^1$, N. Usui$^2$, 
& M. Kamachi$^2$

$^1$JAEA (Japan Atomic Energy Agency)
$^2$JMA/MRI

Methods of Numerical Simulation

- **Nuclear Dispersion Model (SEA-GEARN)**
  - Lagrangian particle model developed by JAEA
  - Include interaction among dissolved-, suspension-, bottom sedimentary-phases
  - Include radioactive decay ($^{137}$Cs=30yr)
  - Horizontal resolution 0.1°
  - **Ocean current: realistic assimilation**
    (MOVE/MRI.COM-WNP of JMA/MRI)
II a) Plume simulations; Tolman et al., Sept 2013

Plume density, particles seeded in a grid near Fukushima; day 22 after first seeding.

Activity for $^{137}$Cs, from Lagrangian particles and HYSPLIT version 1 deposition (DOE-HYSPLIT), particles initialized at deposition time/space locations.
II b) 3D tracer simulation, through a regional ocean model for episodic tracer, RTOFS-ET for the North West Pacific:


- HYCOM with one tracer for $^{137}$ Cs, with no decay (2-3 year simulation)
- Initialization and lateral boundary conditions from RTOFS-Global analysis; no other data constraint.
- Atmospheric deposition from HYSPLIT version 3, sources Nuclear Safety Commission (NSC, Japan)
- Direct ocean discharge from ROMS model at NOAA-NOS (by Lanerolle, Masumoto et al 2012).

Part of the tracer is advected-diffused below the mixed layer

~25% increase in 2 years, tracer 400-1000m

March 2011-May 2013
**137 Cs concentration**

- **Apr 27, 2011, detail**
  - Max $10 \times 10^3$ Bq/m$^3$ or 10 Bq/l

- **Jun 15, 2011, detail**
  - Max 3 Bq/l

- **Sep 15, 2011, max 0.04 Bq/l**

- **Dec 15, 2011, max 0.03 Bq/l**

- **Dec 15, 2012, max 0.008 Bq/l**

(NOAA)
III) Work by Mercator Ocean and University of Toulouse, on dispersion of pollution at basin scale, a) using simulated Lagrangian particles on the Mercator Ocean analysis and forecasting system, and b) using the SIROCCO ocean model for dispersion of particles.
a) MERCATOR PSY4: analysis and forecasting for North Pacific Circulation from the Global ocean system.

- Good simulation of North West Pacific circulation
- Global ocean model, 1/12 ° degree
- Data assimilation based on SEEK filter,
- assimilates satellite Sea Level Anomaly and SST, and in-situ T,S profiles
- Analysis and 7 day forecast
- Successful validation of sea surface velocities with drifting buoy velocities.

See poster by C. Derval on Mercator Ocean Service)
C. Derval (poster).

Lagrangian drift of water particles originated in Fukushima, March 12, 2011

- Computed from the analysis of the global system, using a computational tool (ARIANE) by Blanke, B, Raynaud, S, JPO 27, 1038-1053.

**August 2011**

SIMU3: Particles positions [0–30m] for 2011/08/30

Shading levels:
- depths in [0.0, 30.0] – (15 points)
  - Min = 0.00, Max = 2.42, Int = 0.04
$^{137}\text{Cs (Bq/l) near Japan, March 20-24, 2011, from direct release, initialized with NCOM model.}$

137Cs (Bq/l) near Japan, March 20-24, 2011, from direct release, initialized with NCOM model. 

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**Poster by C. Derval**

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L. Toulouse
Model tracer and observations, **April 21-30 2011**.

Models by:
- CRIEPI, Japan, Tsumune
- JAEA, Kawamura
- JCOPET, Miyazawa
- SIROCCO, Toulouse U, Estournel
- NOAA, Lanerolle
(Kamachi; Kawamura et al)

[Summary]

• Issues are unknown source information, unknown coastal process, and related modeling-assimilation
The NCOM model is run by the Navy routinely for Japanese waters, and since March 6 was available at NCEP’s Ocean Prediction Center (OPC). The routine NCOM has 3.5 km grid spacing, and a 1km horizontal grid spacing model near Fukushima was nested by the Navy.