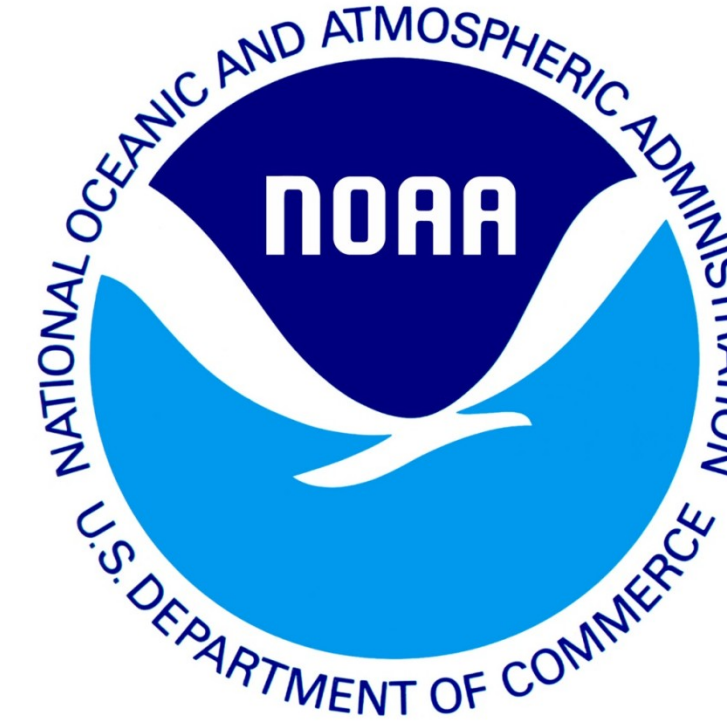




Ocean Plume and Tracer Modeling for the Fukushima Dai'ichi Event at NOAA

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NCEP/NWS deployed particle tracing to predict the movement of radionuclides in the ocean shortly after the Japanese Nuclear disaster near Fukushima. Daily nowcast and forecast fields from 1/12 HYCOM (RTOFS-Global) model output were used to track inert particles at the ocean surface, assuming that the surface behavior is reasonably representative for the ocean mixed layer, and that the radionuclides will mostly be contained in and distributed by the upper mixed layer of the ocean. Full tracer computations capability of HYCOM has also been used to predict the dispersion of radionuclides in a nested North West Pacific sub-region model within RTOFS-Global. The initializations and boundary conditions of the nested sub-region were incrementally updated daily from the nowcast fields of the global model. These tracer forecasts will be implemented at NCEP operations this calendar year.

Part I: INITIAL RESPONSE AFTER THE MARCH 11 2011 FUKUSHIMA-DAIICHI NUCLEAR POWER PLANT ACCIDENT

Immediately after the accident, we released idealized **synthetic surface particles** in the North Western Pacific, advected by the 3-meter depth velocity fields of the global RTOFS simulation. This helped identify both potentially safe areas in the Pacific, and areas of potential exposure on the time scales of weeks to months..

GLOBAL RTOFS (Real Time Ocean Forecast System)

- First global eddy-resolving ocean forecast system at NOAA/NCEP. Result of a strong partnership with NAVO/NRL.
- HYCOM (Hybrid Coordinate Ocean Model) configuration: 1/12° horizontal grid, with an Arctic patch. Hindcast of two days advanced with Global Data Assimilation System (GDAS) forcing and 6 forecast days with Global Forecast System (GFS) forcing.
- The initialization (at NAVO) is based on a MVOI scheme, developed by the U.S. Navy, and assimilates daily observations (T,S,U,V, sea surface height) in a sequential incremental update cycle .

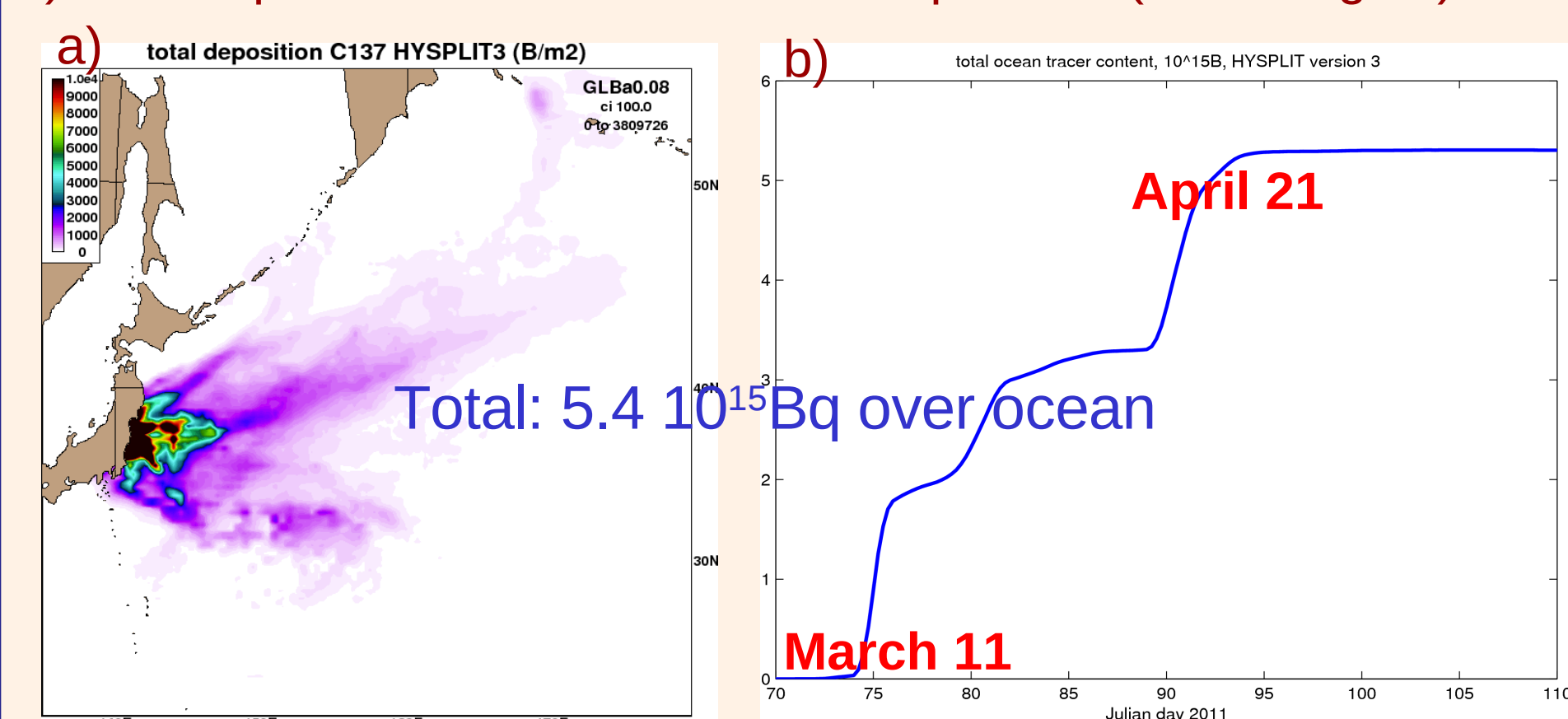
Part II: REGIONAL TRACER DISPERSION MODEL FOR THE WESTERN PACIFIC RTOFS_ET_WPA (Episodic Tracer for the Western Pacific)

- First operational ocean dispersion model at NCEP/NWS
- Component of a future ecosystem prediction model
- Multiple applications: oil spills, radionuclides, etc
- Prototype for quick disaster/event response

- Regional model, 1/12° grid, nested to Global RTOFS nowcasts.
- Regional model run in forecast mode.
- Global Data Assimilation System (GDAS) forcing.
- HYCOM source 2.2.36tr forced with atmospheric deposition of tracers.
- Deposition from NOAA/ARL's HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) for Cs-137 from 03/12/11 – 04/21/11.
- Direct ocean discharge added from NOAA/NOS ROMS (Regional Ocean Modeling System) coastal model on April 26 2011, normalized to 4.5PB of total discharge of Cs-137.

Atmospheric Deposition from HYSPLIT

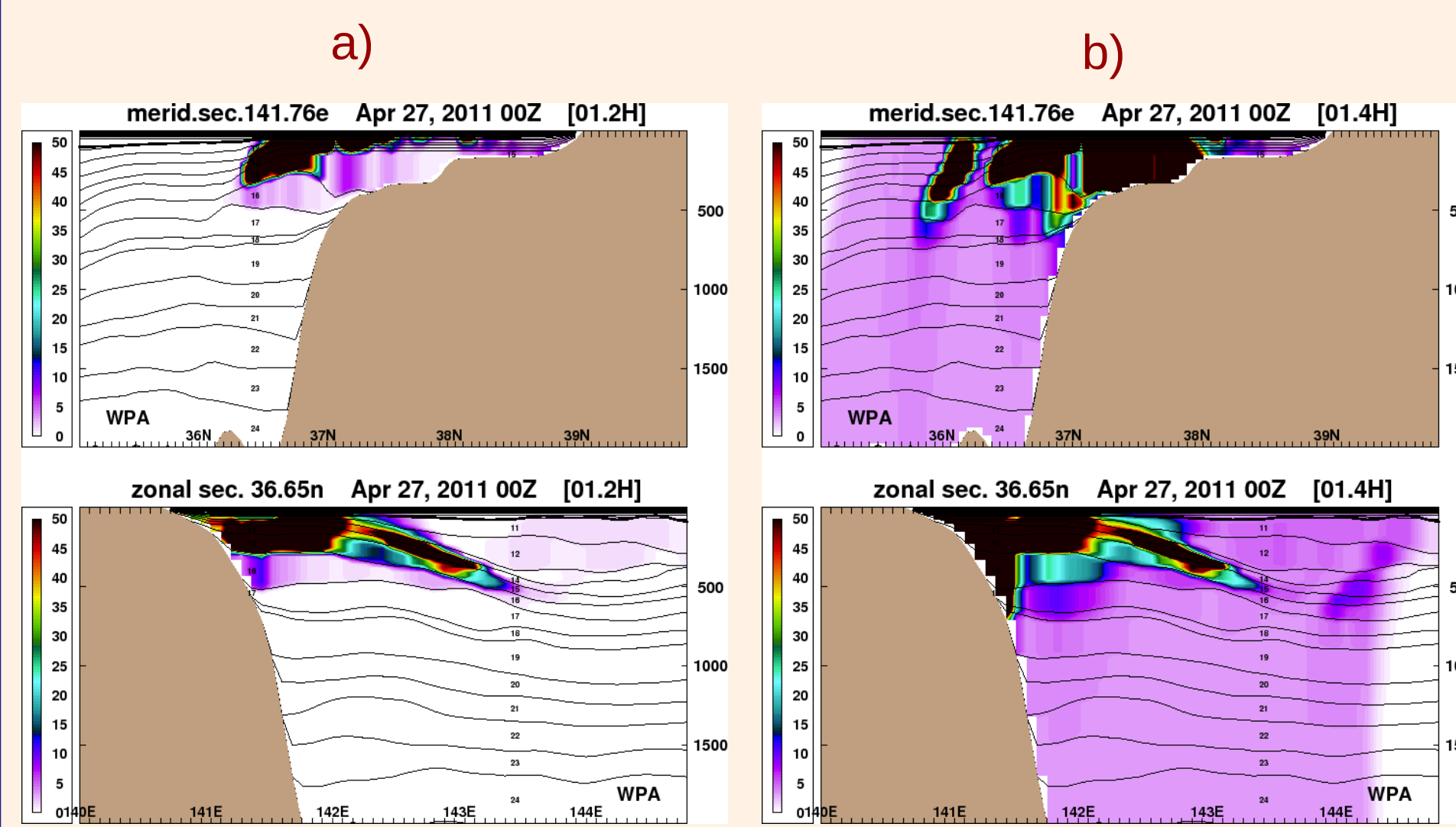
- a) Total deposition, spatial distribution (for all times);
- b) Time dependence of accumulated deposition (entire region).



Addition of direct coastal ocean discharge from ROMS simulations

- a) Atmospheric deposition (HYSPLIT) only;
- b) Atmospheric and coastal input (HYSPLIT+ROMS).

Total Cs-137: ~2PBq before discharge; 6.5PBq after discharge.



Simulated Cs-137 concentration from HYCOM (RTOFS_ET_WPA) with atmospheric (HYSPLIT) deposition, and coastal (ROMS) input during April 25 - December 31, 2011

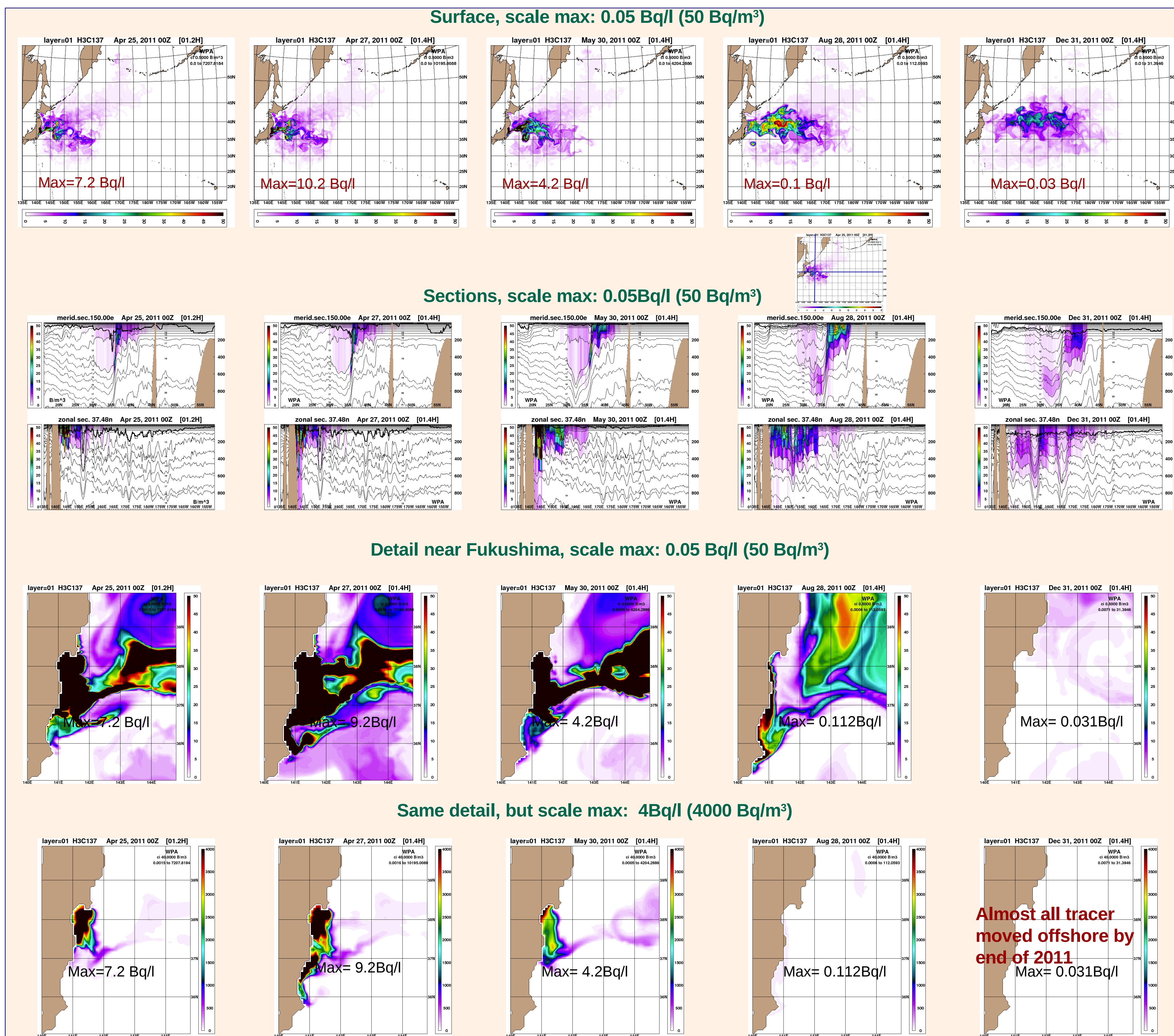
April 25, after end of Atmospheric deposition.
Total Cs-137: 5.4PBq

April 27, after ROMS direct discharge
Total Cs-137: 10PBq

May 30
No extra sources after Apr.27

Aug 28

Dec 31

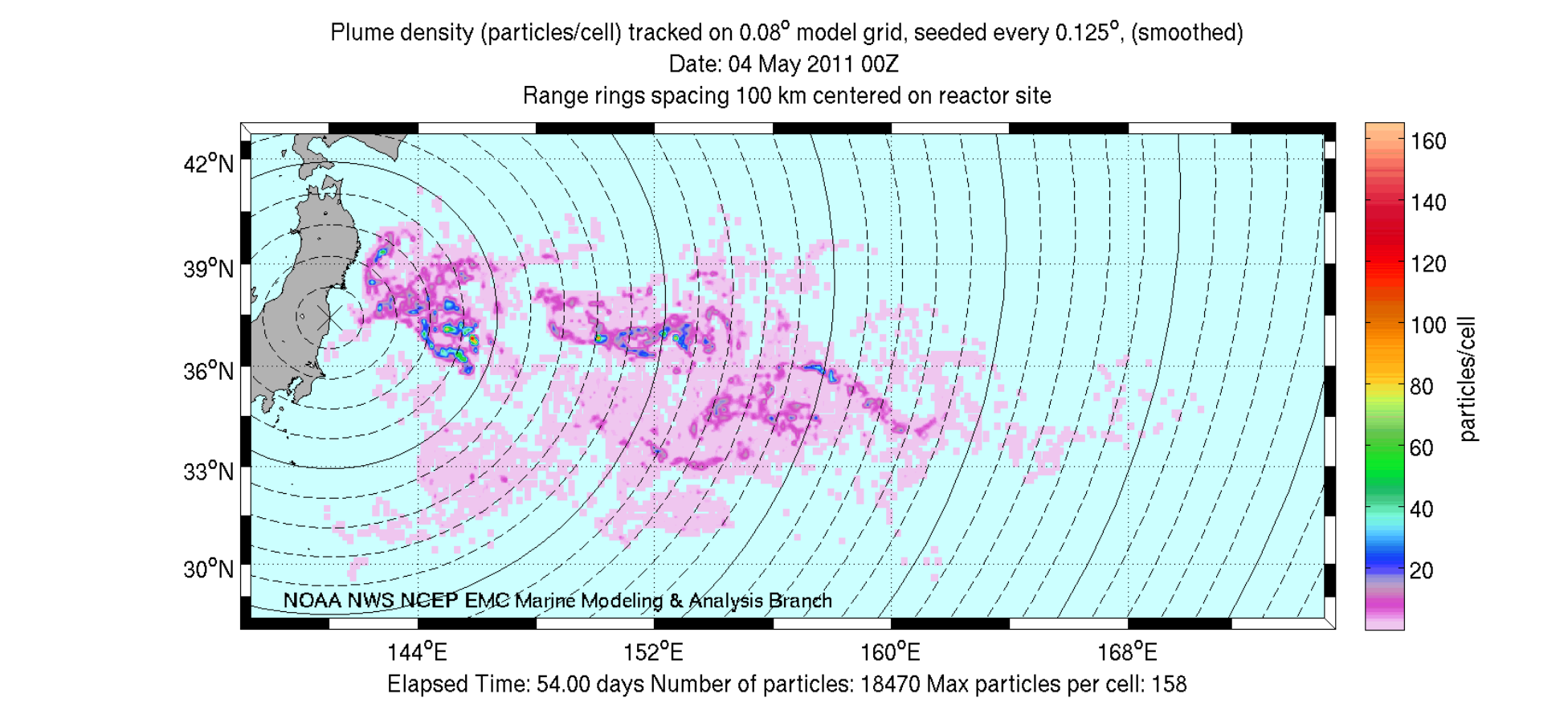


Summary

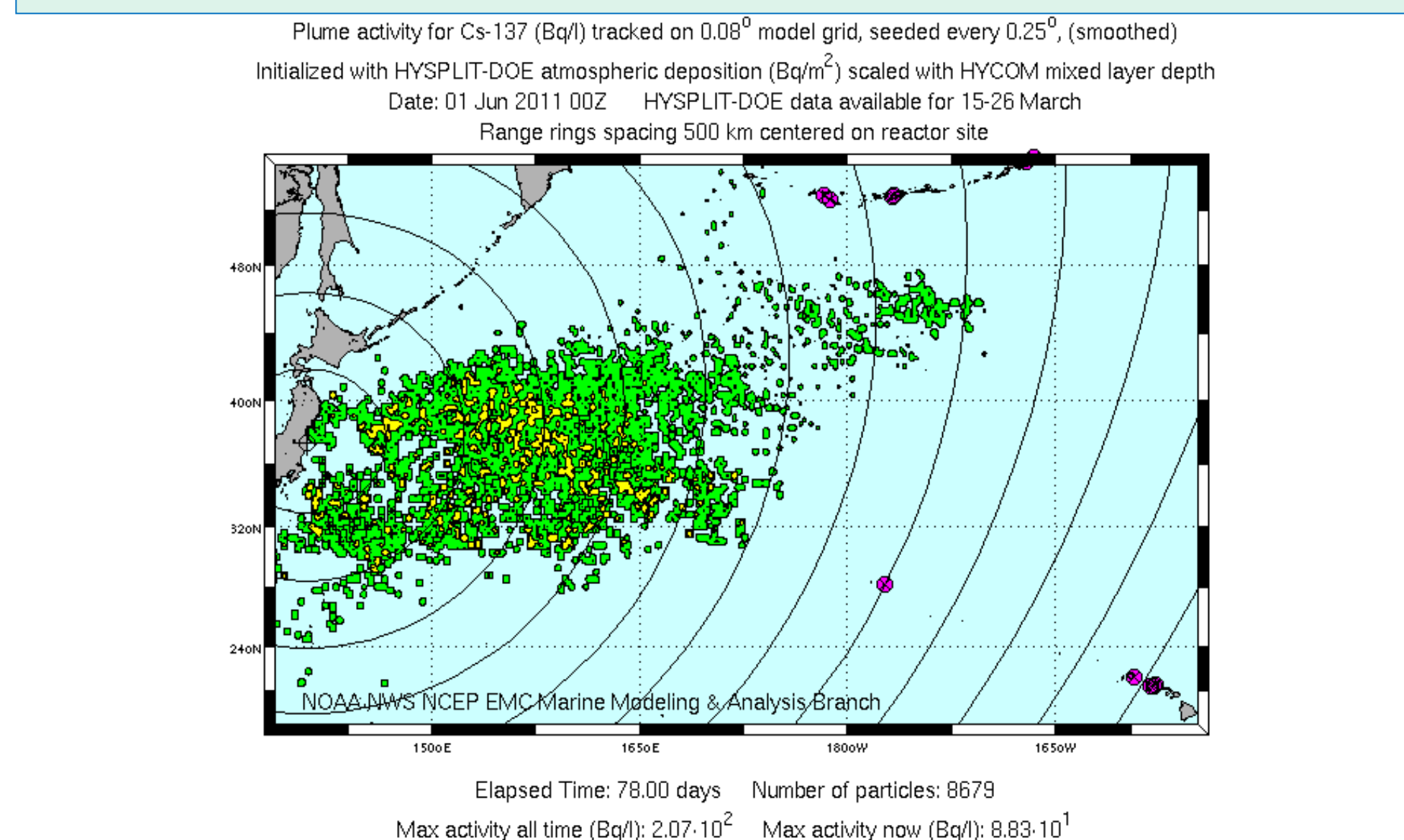
- Initial plume density products immediately after disaster based on particle tracking and atmospheric depositions from HYSPLIT.
- Full three-dimensional tracer modeling for Cs-137 with atmospheric deposition from HYSPLIT (5.4PBq over the ocean).
- Added direct coastal discharge on April 27, 2011 (from ROMS, renormalized) of 4.5PB.
- Tracer concentration was followed, as the tracer patch disperses and slowly moves to the east.

Future plans

- Implementation in **NCEP operations by end of 2012**. Serves as prototype for operational ocean forecasts addressing needs of disaster risk reduction for coastal zones as well as safety-related marine meteorological services for the open ocean.
- Include **extra tracer sources**, e.g., from river and land discharge, as they become available.
- Test of incremental update algorithms for tracers, **updating the physical variables** to the daily nowcasts, and **tracers** by using covariances with observation-constrained physical variables.



The above figure represents plume density on 4th May 2011 based on particles released near the Japanese coast and advected by surface currents eastwards into the Pacific ocean. These estimates were used for real time assessment of dispersion of radionuclides In weeks and months soon after the Fukushima disaster.



A second line of products were also generated which included sources of radionuclide deposition (Cs-137, I-131) on the ocean surface from atmospheric fallout. These were used to embed particles in the simulations and generate plume activity in real time. One such example is shown above for June 1st 2011 for Cs-137.