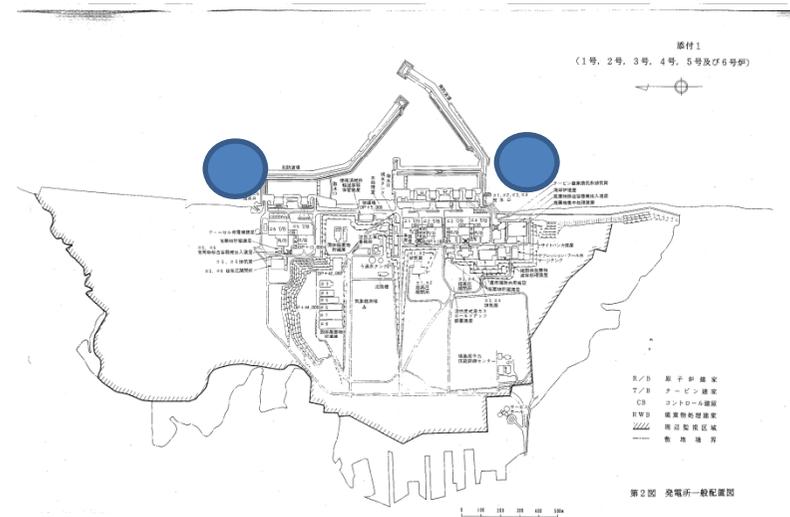
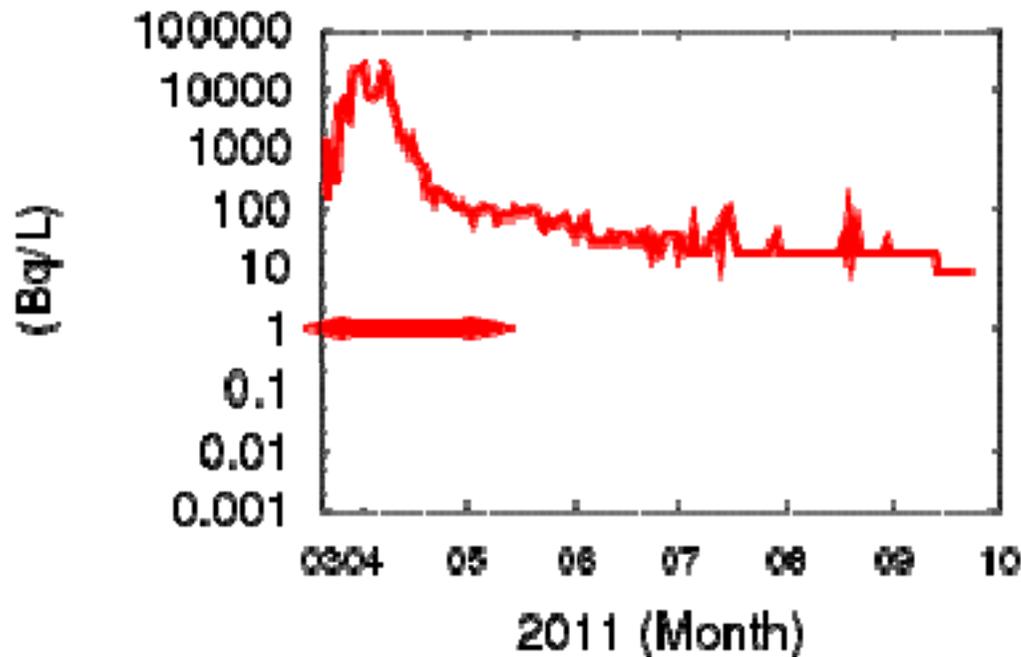


福島沖セシウム137拡散モデルのパラメータ推定

宮澤泰正(海洋研究開発機構)

F1前面観測値2点平均の時間変化

Cs137

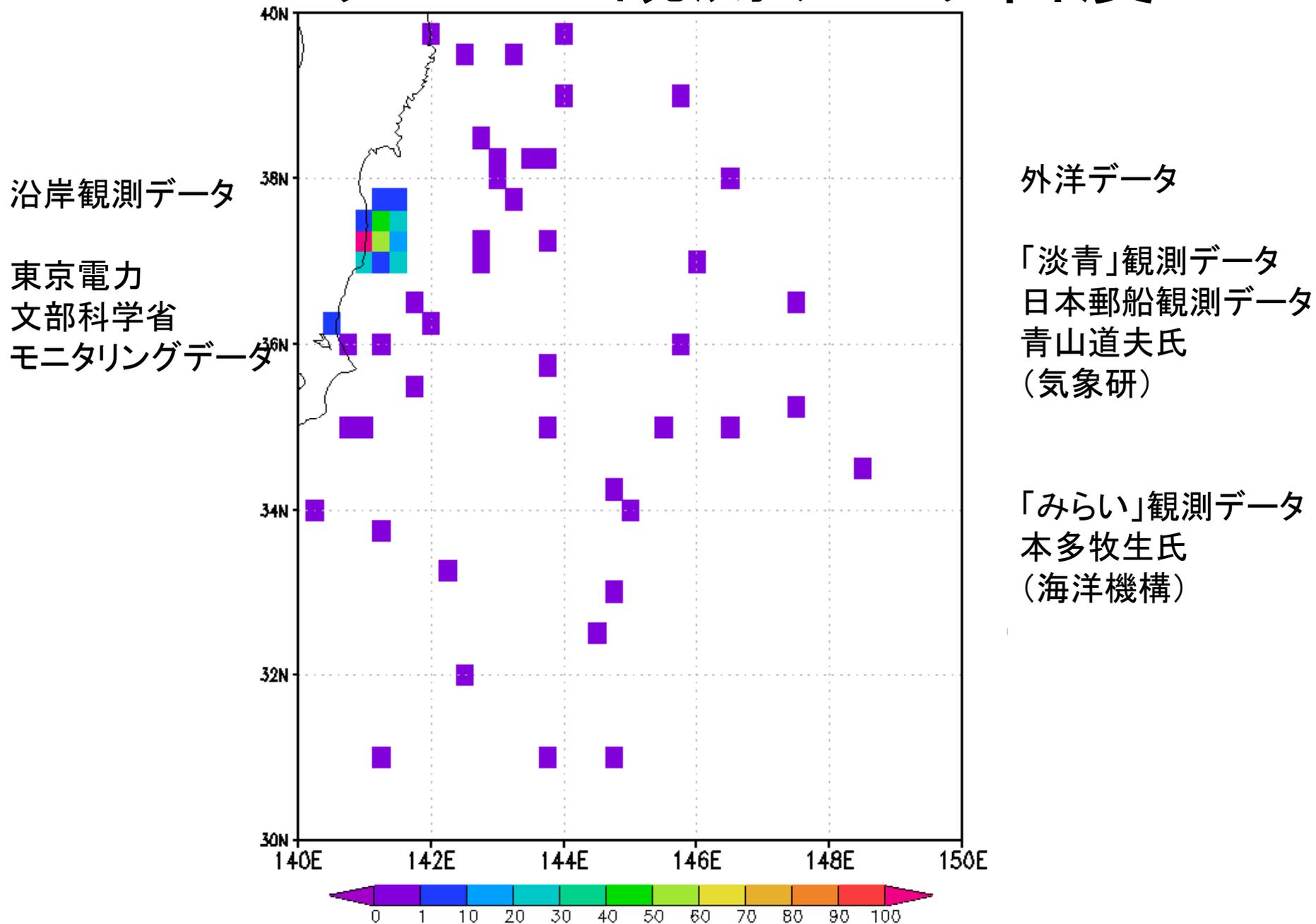


セシウム137海洋輸送シミュレーションと、観測データの解析

大気・海洋への放出が著しかったと考えられる、2011年3月から5月始めにかけてのセシウム137の海洋分散過程の解明

北西太平洋への直接流出量、及び大気沈着量の推定

セシウム137観測データ密度



Cs137 海洋輸送モデル

$$\frac{\partial C}{\partial t} = \text{ADV}(U, C) + \text{DIF}(U, C) - \lambda C + \langle \text{Source_term of direct emission} \rangle$$

$$\lambda = 0.693 / T_{\text{half}}$$

$$K_v \left. \frac{\partial C}{\partial Z} \right|_{z=0} = \text{atmospheric deposition flux}$$

U: JCOPE-T 1/36 deg. or JCOPE2 1/12 deg.

Horizontal diffusion: Smagorinsky(1963) 's parameterization

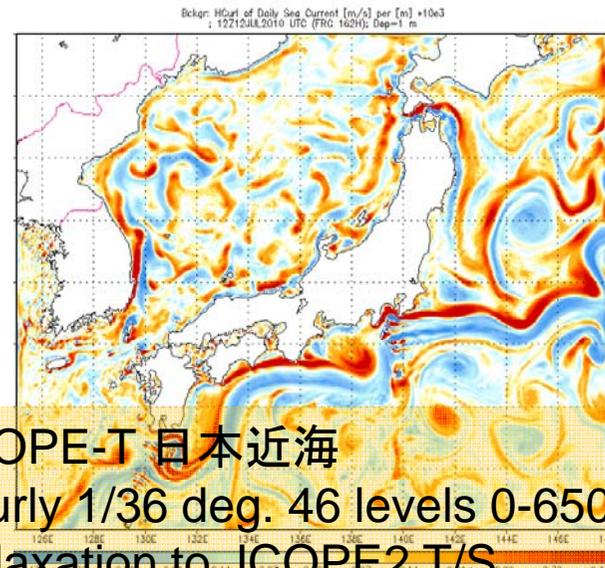
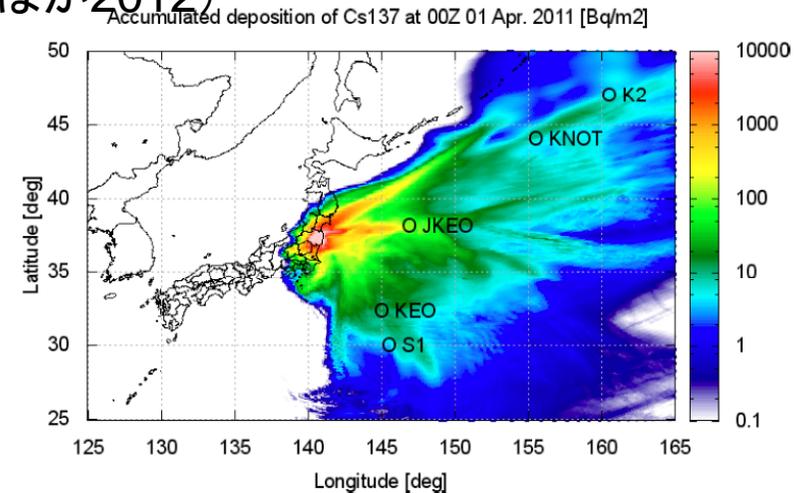
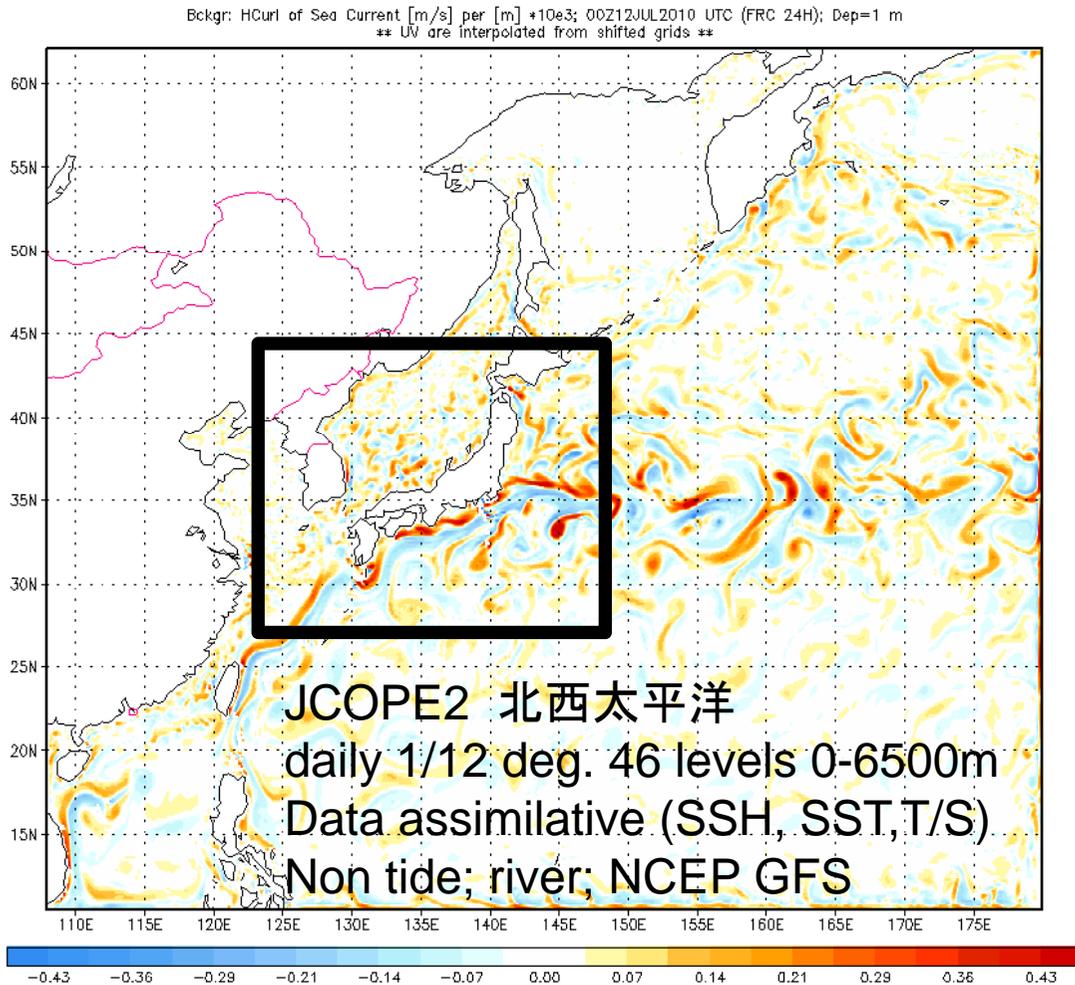
Vertical diffusion : Mellor-Yamada-Blumberg (1974; 2004)'s turbulent model

Deposition:

JAMSTEC Atmospheric Quality Forecast system
(Honda et al. 2012; 滝川氏報告)

大気・海洋輸送モデル

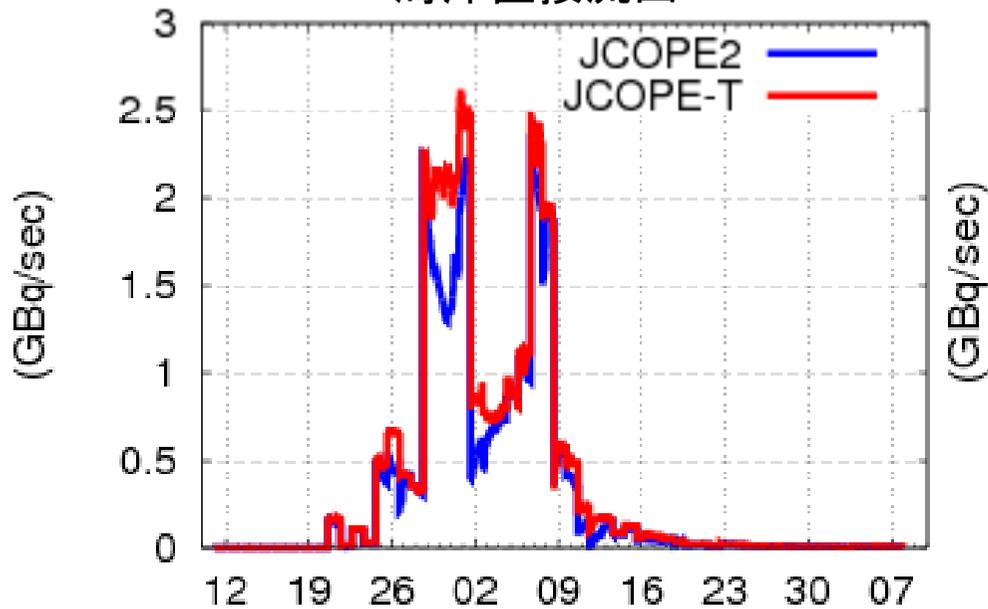
WRF based atmospheric dispersion model
(滝川ほか2012)



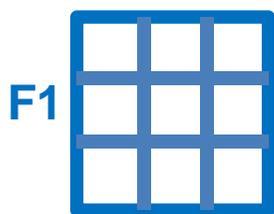
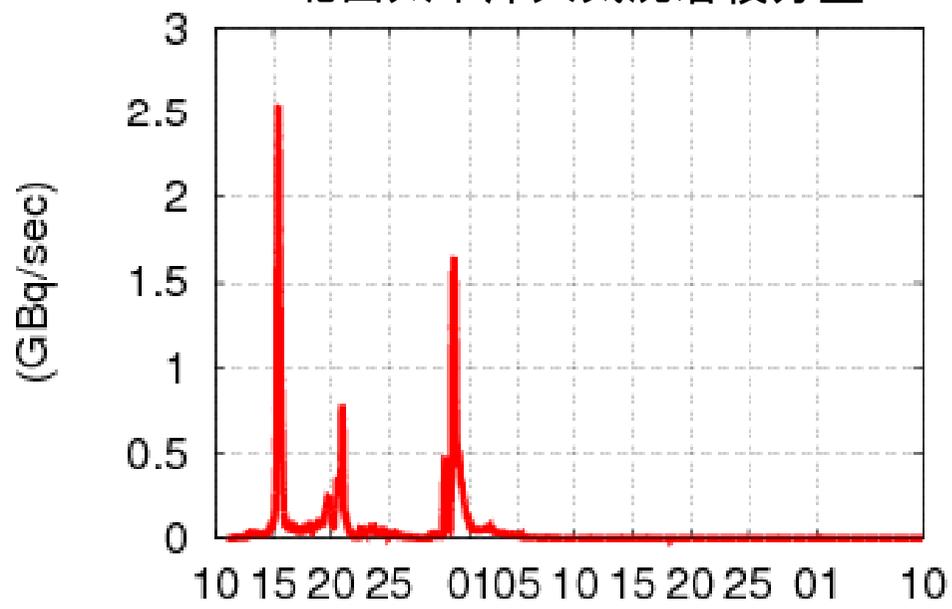
JCOPE-T 日本近海
hourly 1/36 deg. 46 levels 0-6500m
Relaxation to JCOPE2 T/S
Tide, River included; JMA MSM

放出量仮定

海洋直接流出



北西太平洋大気沈着積分量



3km

9km

JCOPE-T (3km)

$$(C_{obs} - C(x, y, z, t)) \frac{\Delta x \Delta y \Delta z}{T_s}$$

JCOPE2 (9km)

$$\left(\frac{1}{9} C_{obs} - C(x, y, z, t)\right) \frac{\Delta x \Delta y \Delta z}{T_s}$$

$T_s = 36$ hours

JCOPE-T: 1.9 PBq (14.8 PBq; $T_s = 1$ hour)

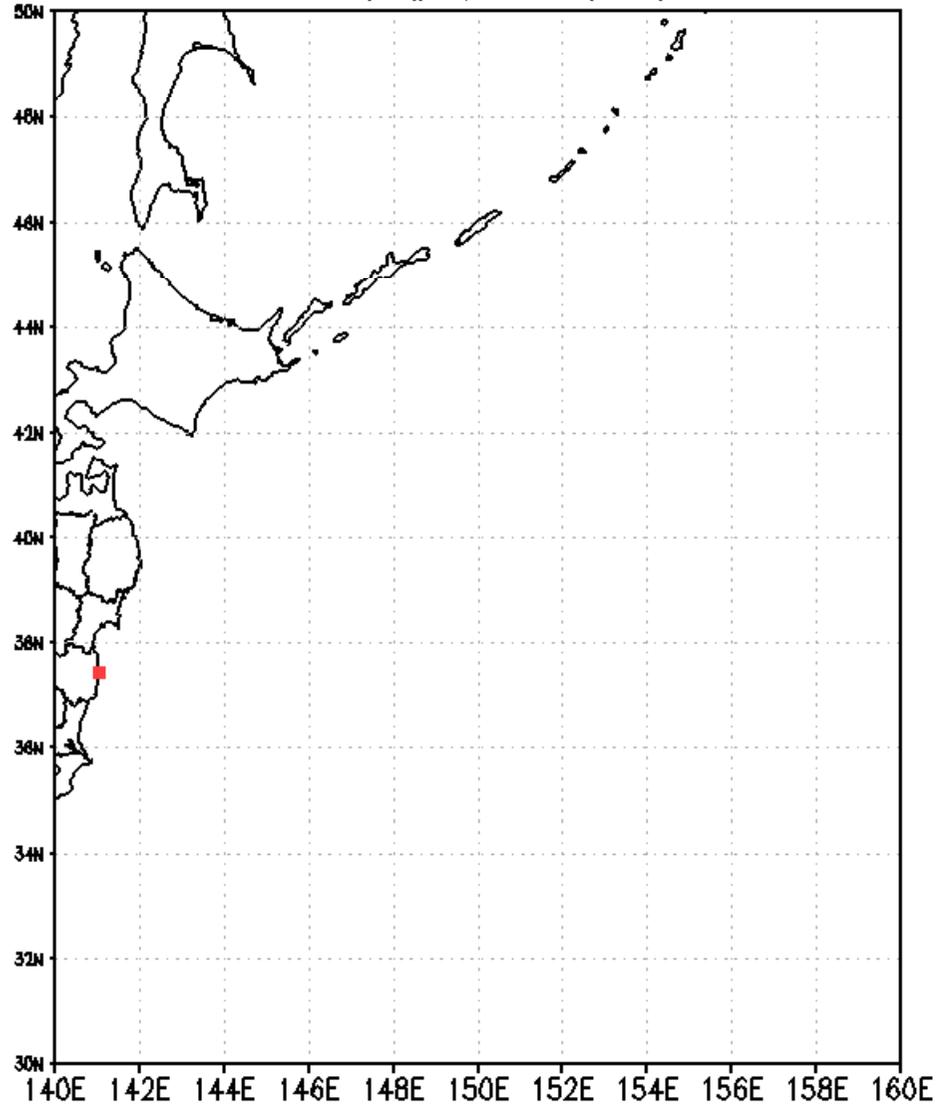
JCOPE2: 1.6 PBq

Atmospheric deposition
integrated over North Western
Pacific

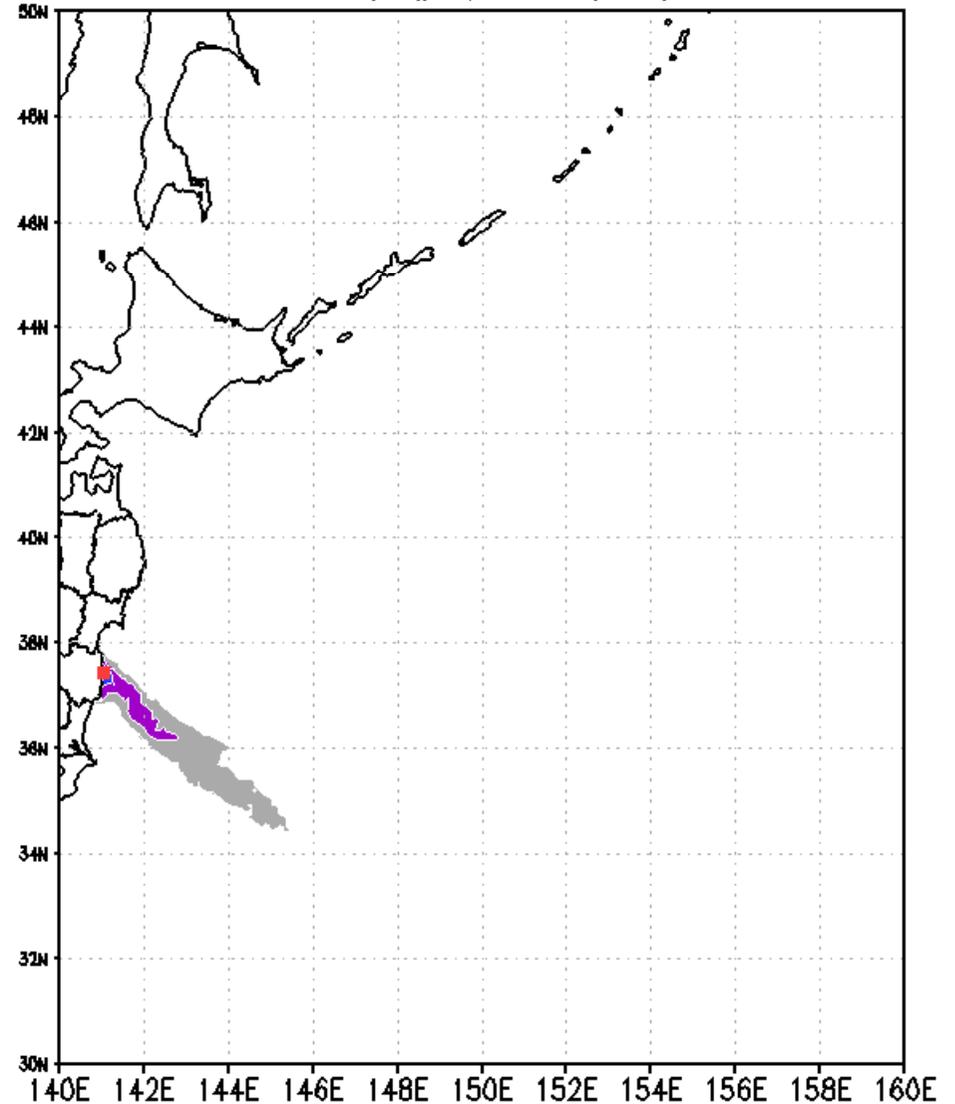
0.3 PBq

JCOPE2シミュレーション

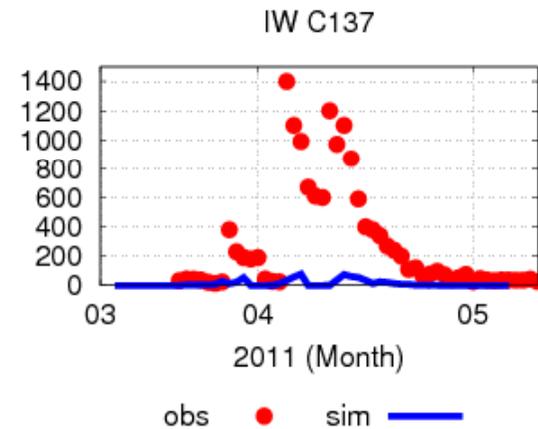
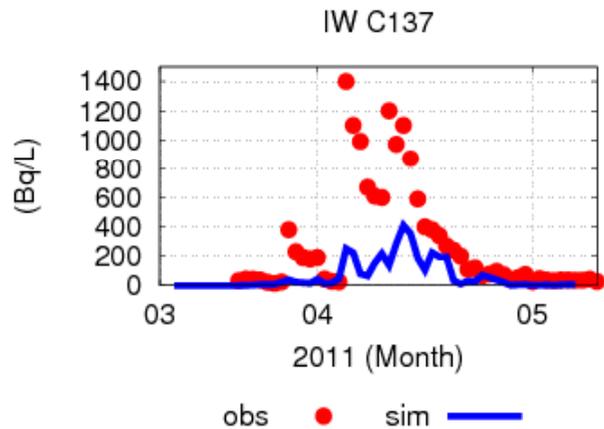
直接流出のみ
Cs137 (Bq/L) 2011/03/12



直接流出+大気沈着
Cs137 (Bq/L) 2011/03/12



モデル再現性

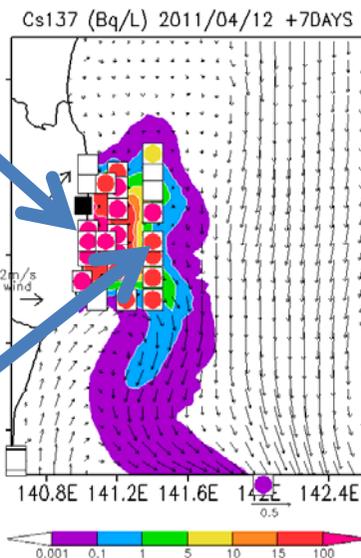


Along the coast

JCOPE-T
(no atmospheric deposition)

Less diffusive

Offshore

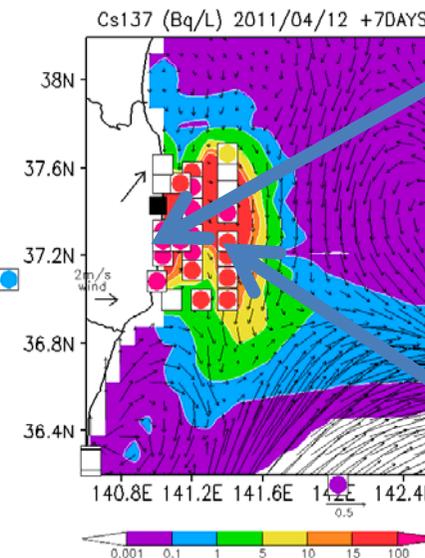


Along the coast

JCOPE2
(no atmospheric deposition)

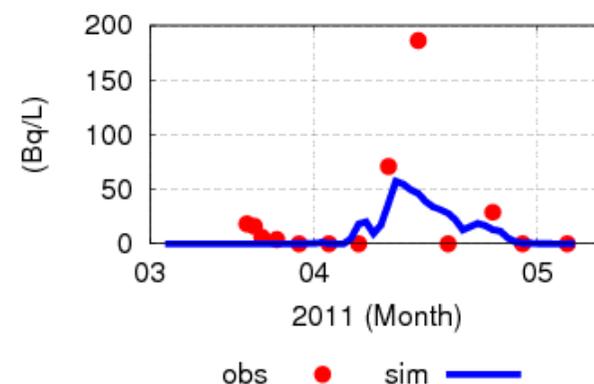
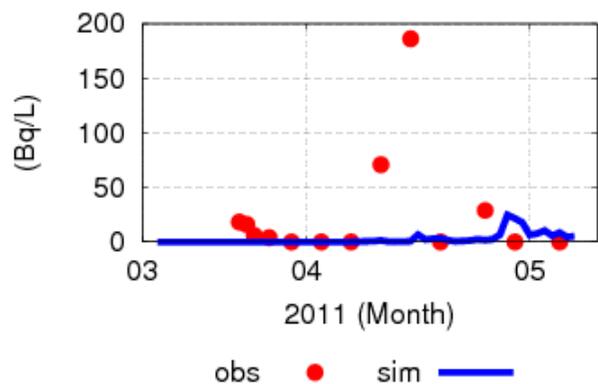
More diffusive

Offshore



30K04 C137

30K04 C137



発電所周辺直接流出フラックスの比較

南北方向が卓越 (陸棚波動・河川)

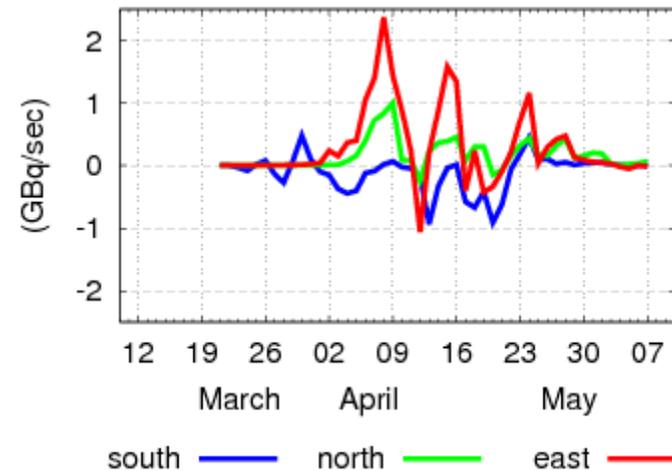
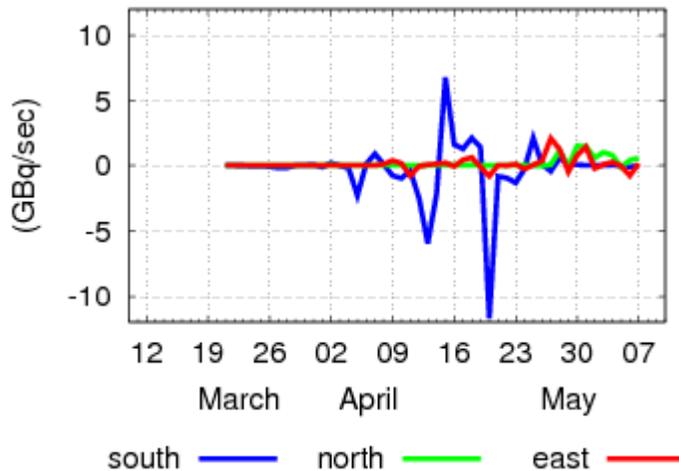
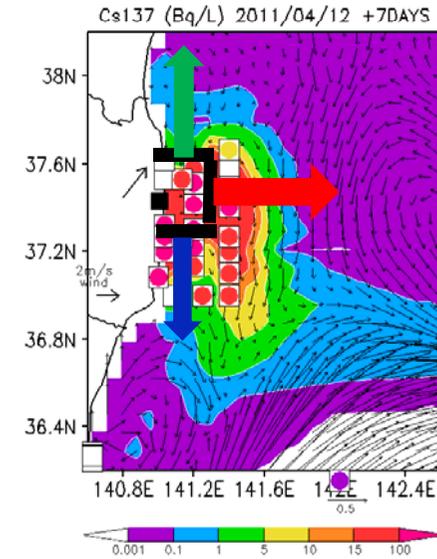
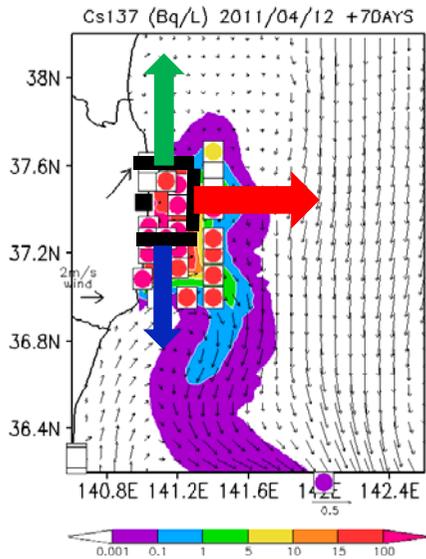
東西方向が卓越 (拡散的)

JCOPE-T

JCOPE2

3km格子
気象庁MSM
河川流出あり
潮汐あり

9km格子
NCEPGFS
河川流出なし
潮汐なし



海流モデルの再現性

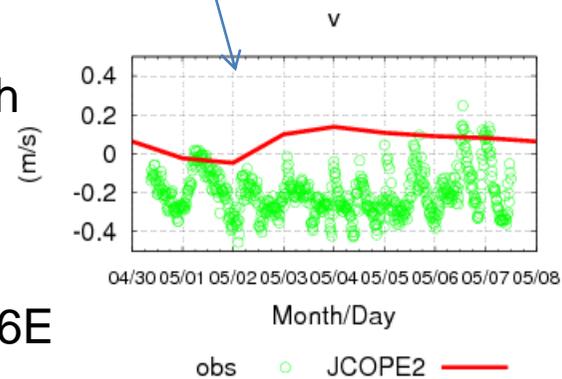
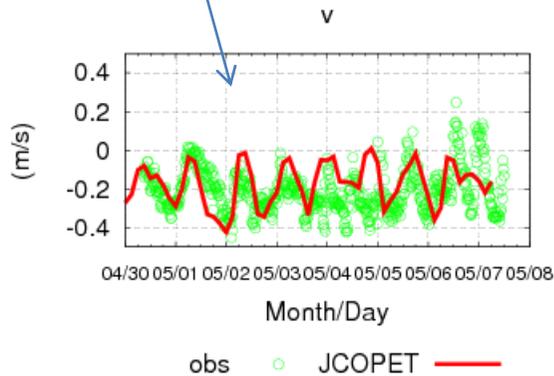
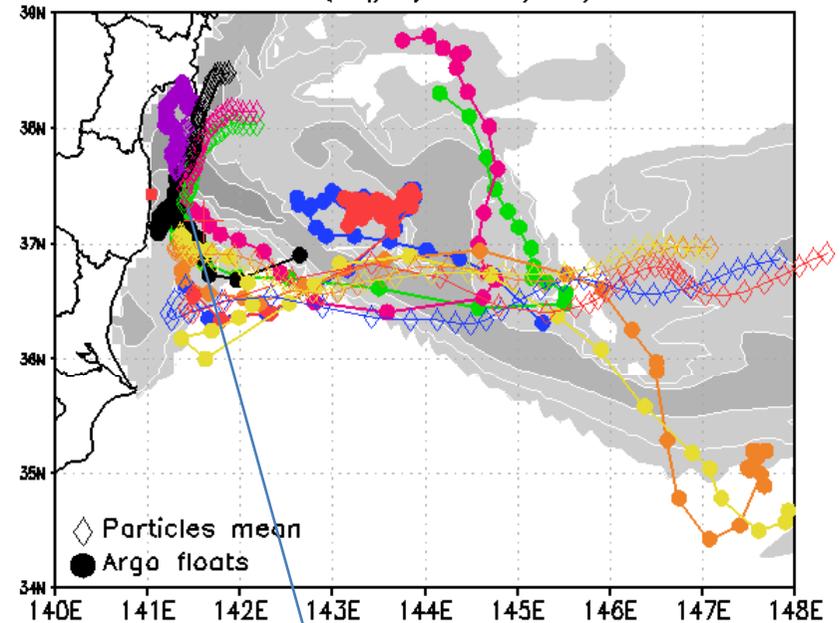
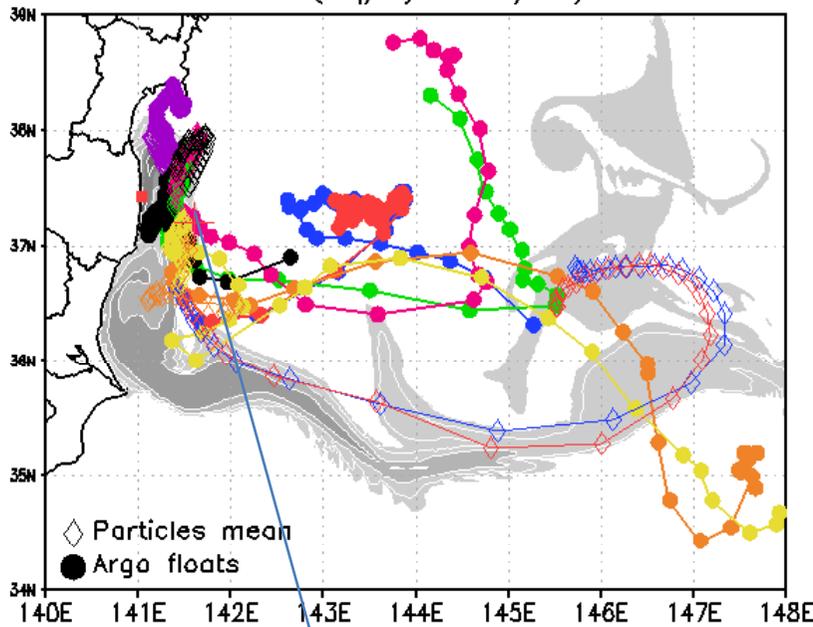
JCOPE-T

JCOPE2

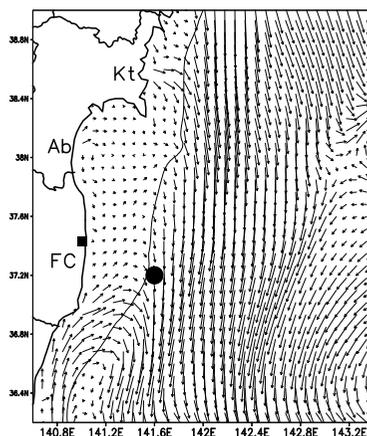
JAMSTEC緊急展開アルゴフロート軌跡と、粒子追跡実験結果の比較

Cs137 (Bq/L) 2011/05/06

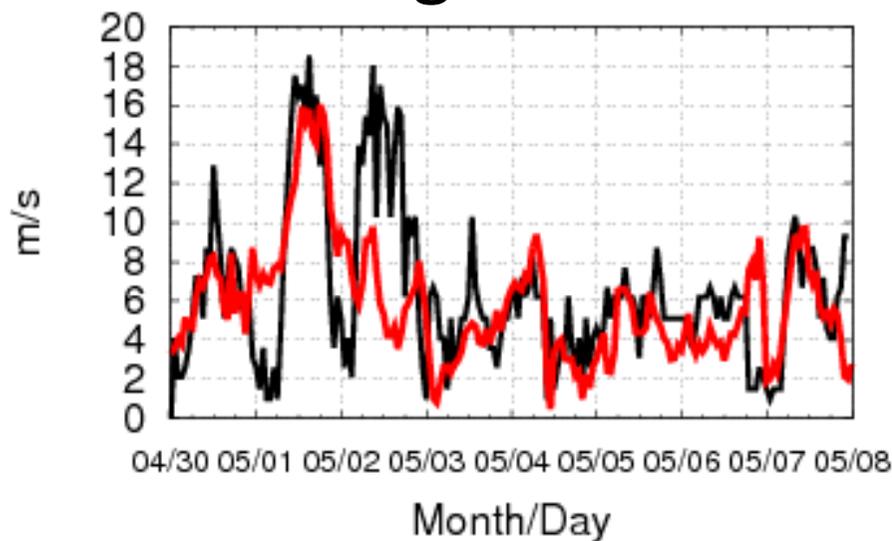
Cs137 (Bq/L) 2011/05/06



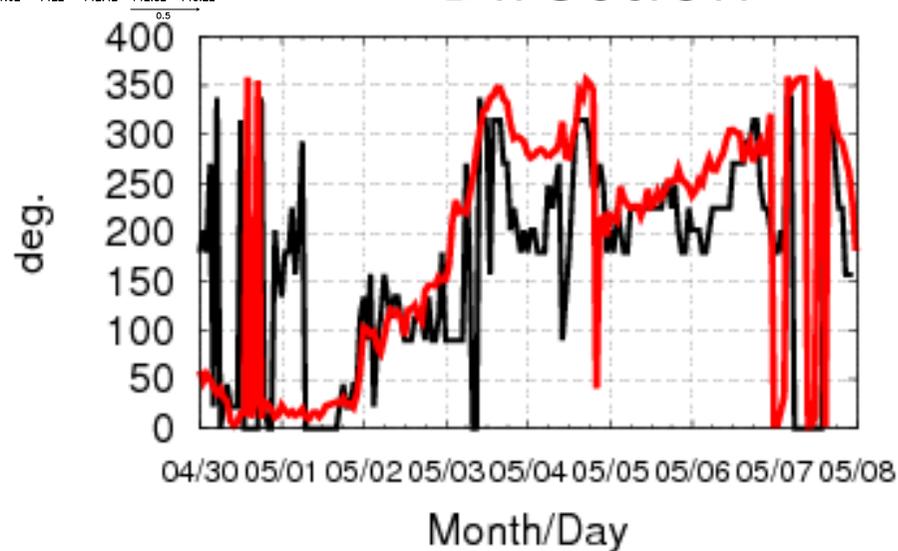
海流を駆動する海上風の再現性



Magnitude



Direction



obs — msm —

obs — msm —

海自観測艦「わかさ」における観測と、気象庁MSMデータとの比較
37.4N, 141.6E

グリーン関数法によるパラメータ推定

$$\begin{pmatrix} y_1^o \\ \cdot \\ \cdot \\ y_N^o \end{pmatrix} = \begin{pmatrix} G_{11} & G_{12} \\ \cdot & \cdot \\ \cdot & \cdot \\ G_{N1} & G_{N2} \end{pmatrix} \begin{pmatrix} \Delta\eta_1 \\ \Delta\eta_2 \end{pmatrix} + \begin{pmatrix} x_1^b \\ \cdot \\ \cdot \\ x_N^b \end{pmatrix} + \vec{\varepsilon}$$

Perturbation value Base value
 $G_{nm} \equiv \frac{(x_n^s - x_n^o)}{\Delta P_m^s}$

\vec{y} : field observation data

$$\min. \quad (\vec{y} - G\overrightarrow{\Delta\eta} - \vec{x})^t R^{-1} (\vec{y} - G\overrightarrow{\Delta\eta} - \vec{x})$$

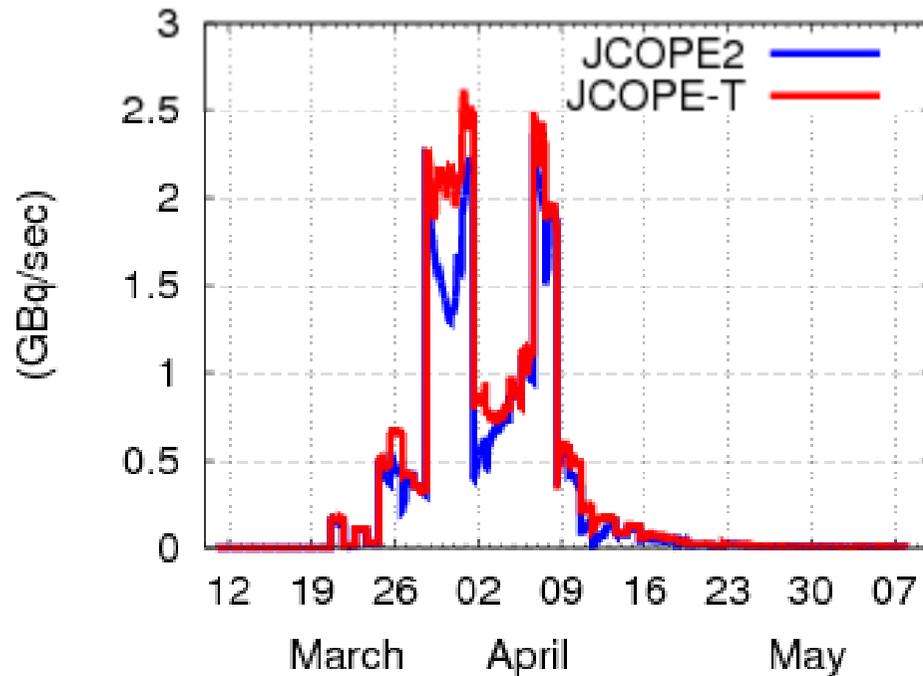
Optimized parameter perturbation $\overrightarrow{\Delta\eta}_{opt} = PG^T R^{-1} (\vec{y} - \vec{x})$

Error covariance of parameters $P \equiv (G^T R^{-1} G)^{-1}$

(Menemenlis et al., 2005)

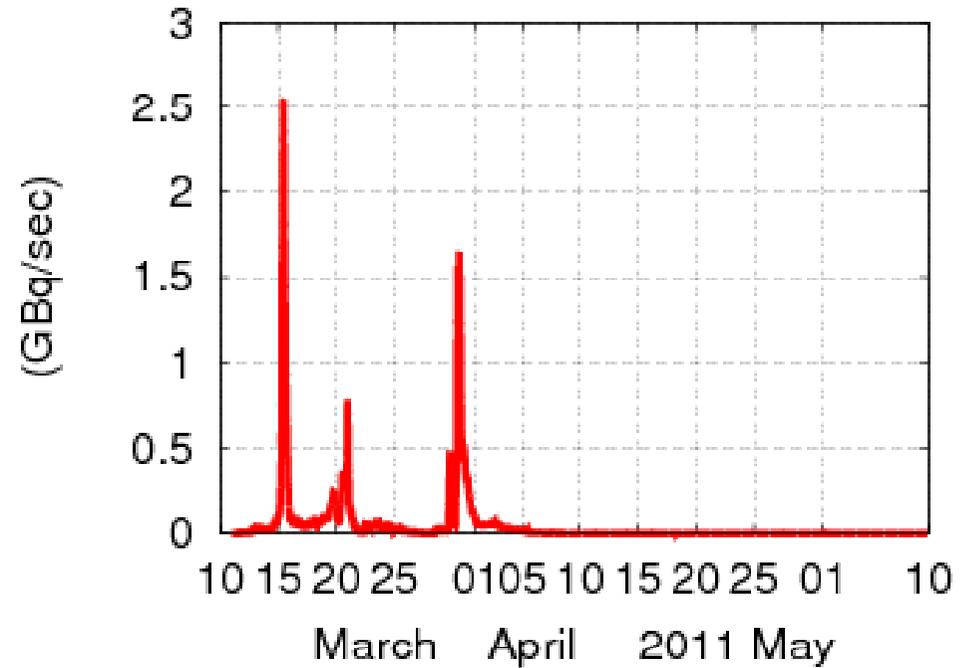
放出量パラメータ感度実験

JCOPE2, JCOPE-Tともに基本ケースは「大気沈着なし」



Original value x (1 + Perturbation_O)
Perturbation_O = 1

Total amount of the perturbation
experiment is 1.9 x 2 PBq for JCOPE-T
(1.6 x 2 PBq for JCOPE2)



Original value x (1 + Perturbation_A)
Perturbation_A = 1

Total amount of the perturbation
experiment is 0.3 x 2 PBq

Background concentration is 0.001 Bq/L

観測誤差

2011/03/21-2011/05/06

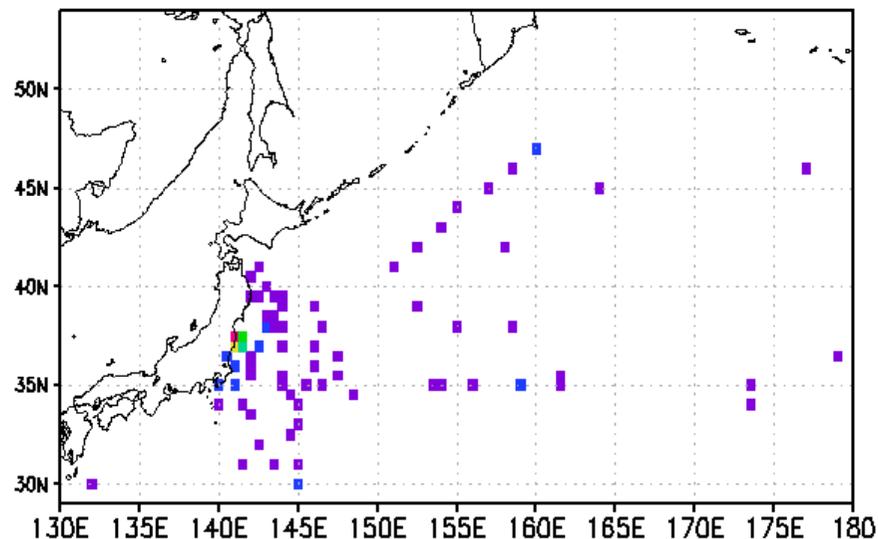
東電モニタリングデータ: 5Bq/L (検出限界値: 15 Bq/L)

文部科学省モニタリングデータ: 3Bq/L (検出限界値: 10 Bq/L)

みらいクルーズデータ: 0.005Bq/L-0.001Bq/L

淡青クルーズデータ: 0.09Bq/L

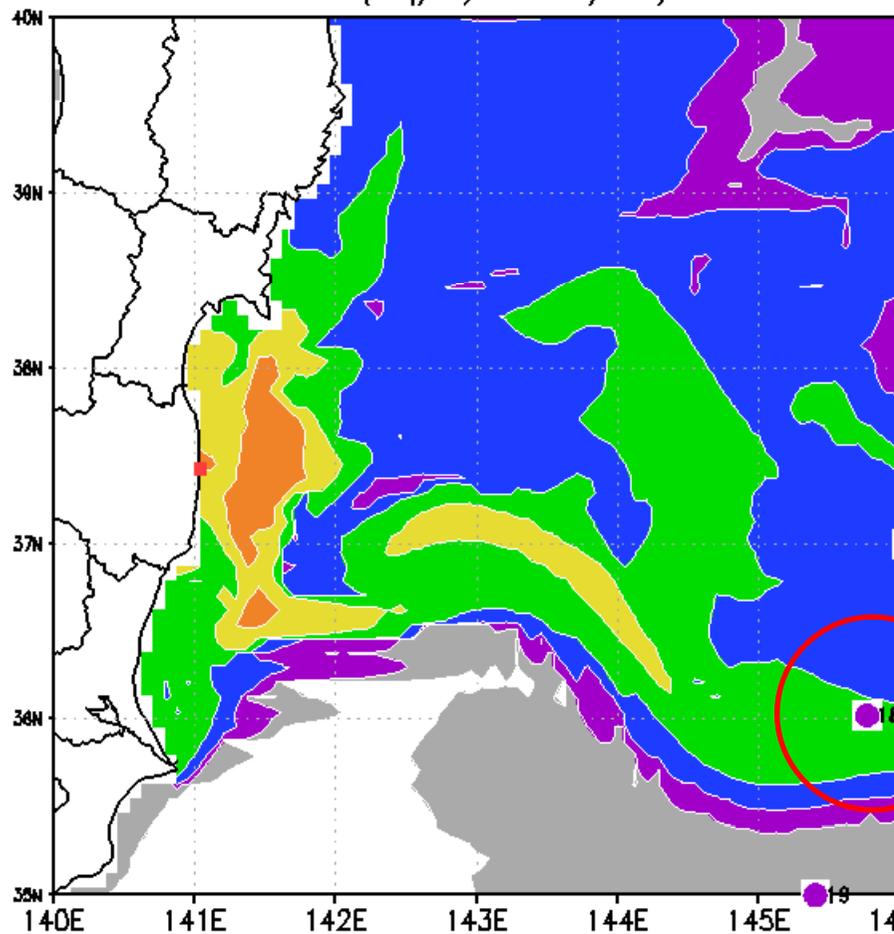
日本郵船データ: 0.06Bq/L-0.00012Bq/L



黒潮続流位置に関する誤差

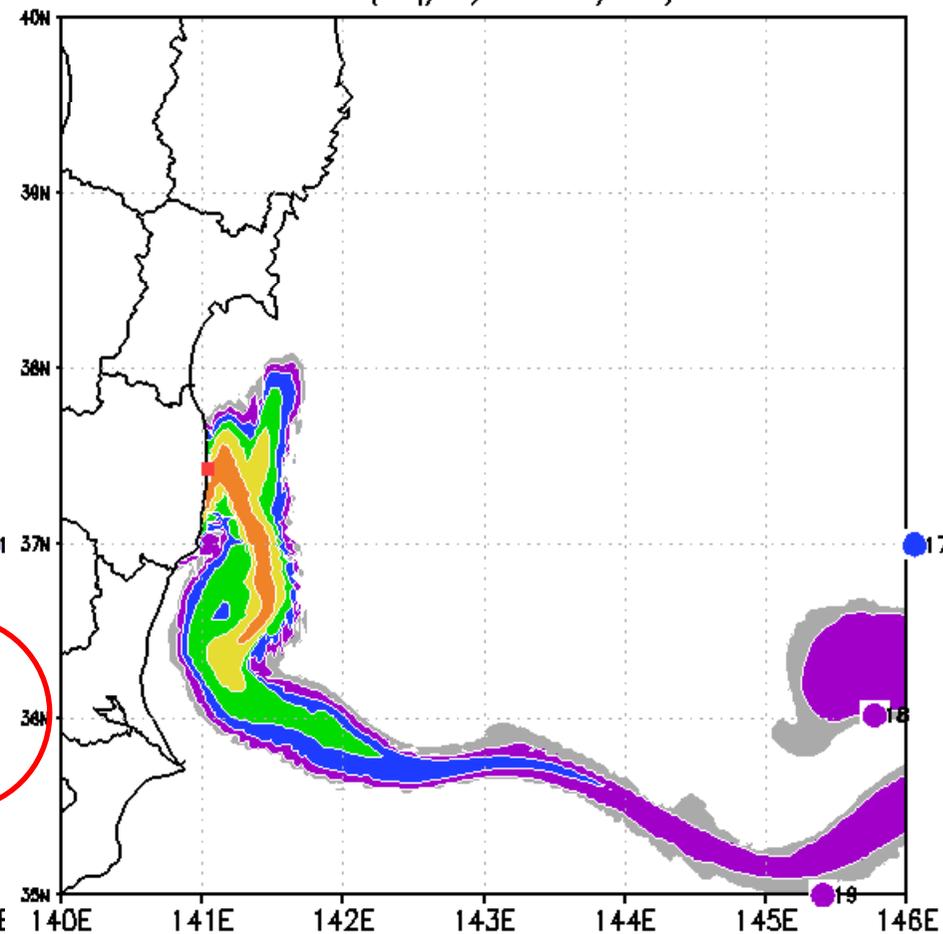
JCOPE2

Cs137 (Bq/L) 2011/04/26



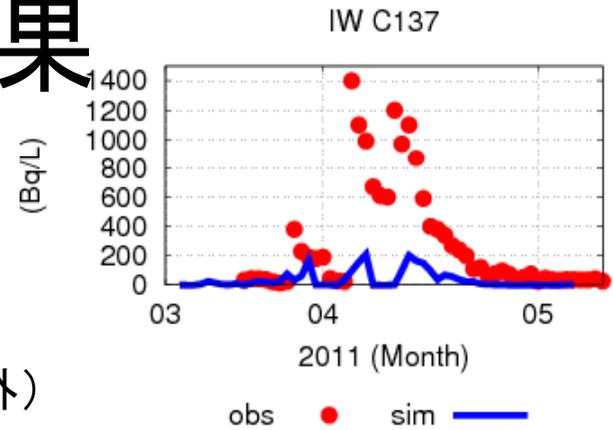
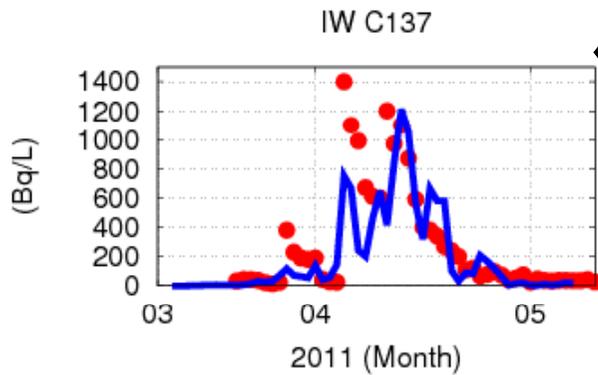
JCOPE-T

Cs137 (Bq/L) 2011/04/26



「みらい」観測点18は、JCOPE2による推定から除く

放出量調整結果



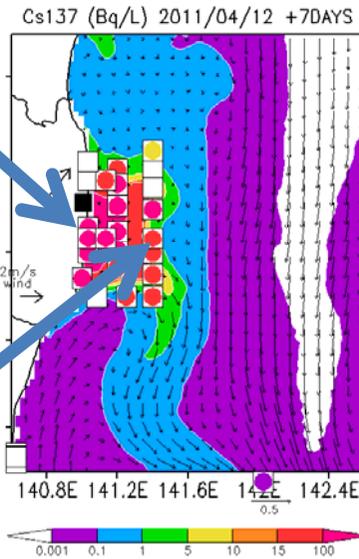
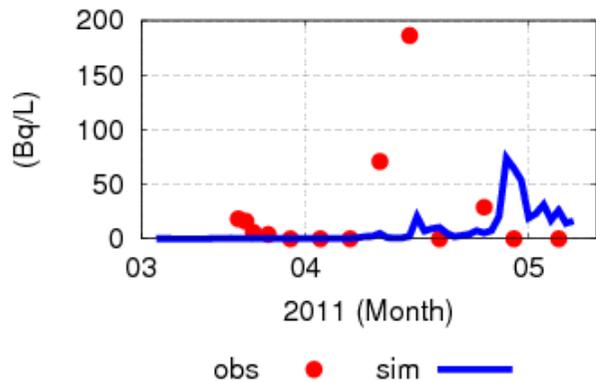
JCOPE2の場合は、
F2, 岩沢海岸データを
を推定に用いない。
(「拡散的」なので、再現対象外)

Along the coast

JCOPE-T

Offshore

30K04 C137

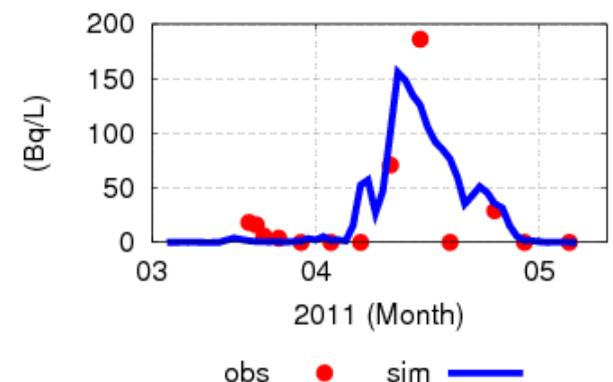
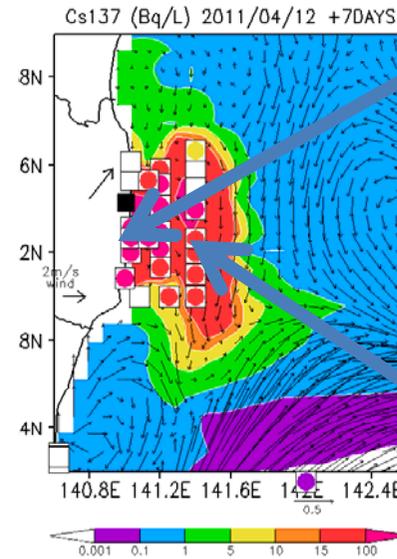


Along the coast

JCOPE2

Offshore

30K04 C137



推定結果

2011/03/21-2011/05/06

JCOPE-T 直接流出 5.6 PBq (5.4PBq: 03/26-)
大気沈着 1.5PBq (北西太平洋)

大気沈着を考慮しない場合 直接流出 5.6PBq
F2, 岩沢海岸データを除いた場合 直接流出 4.0PBq
大気沈着 1.2PBq

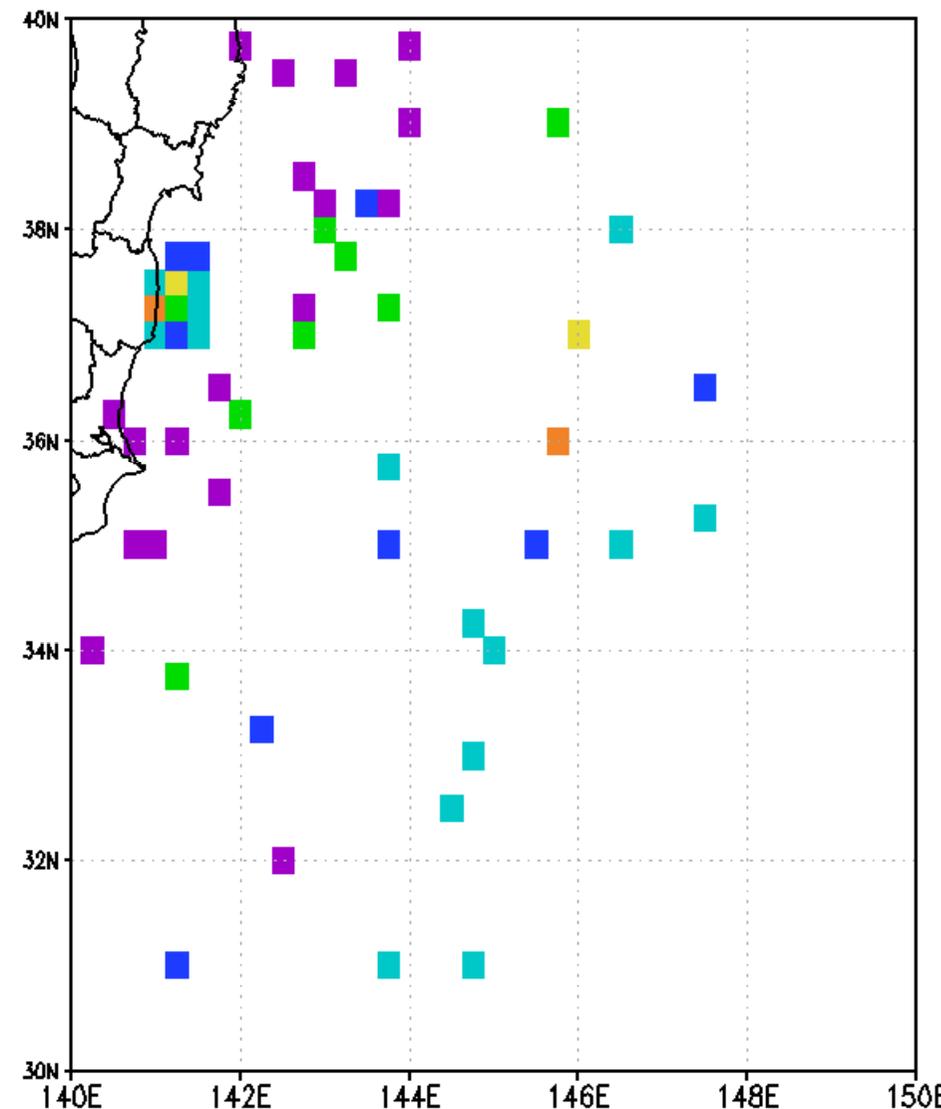
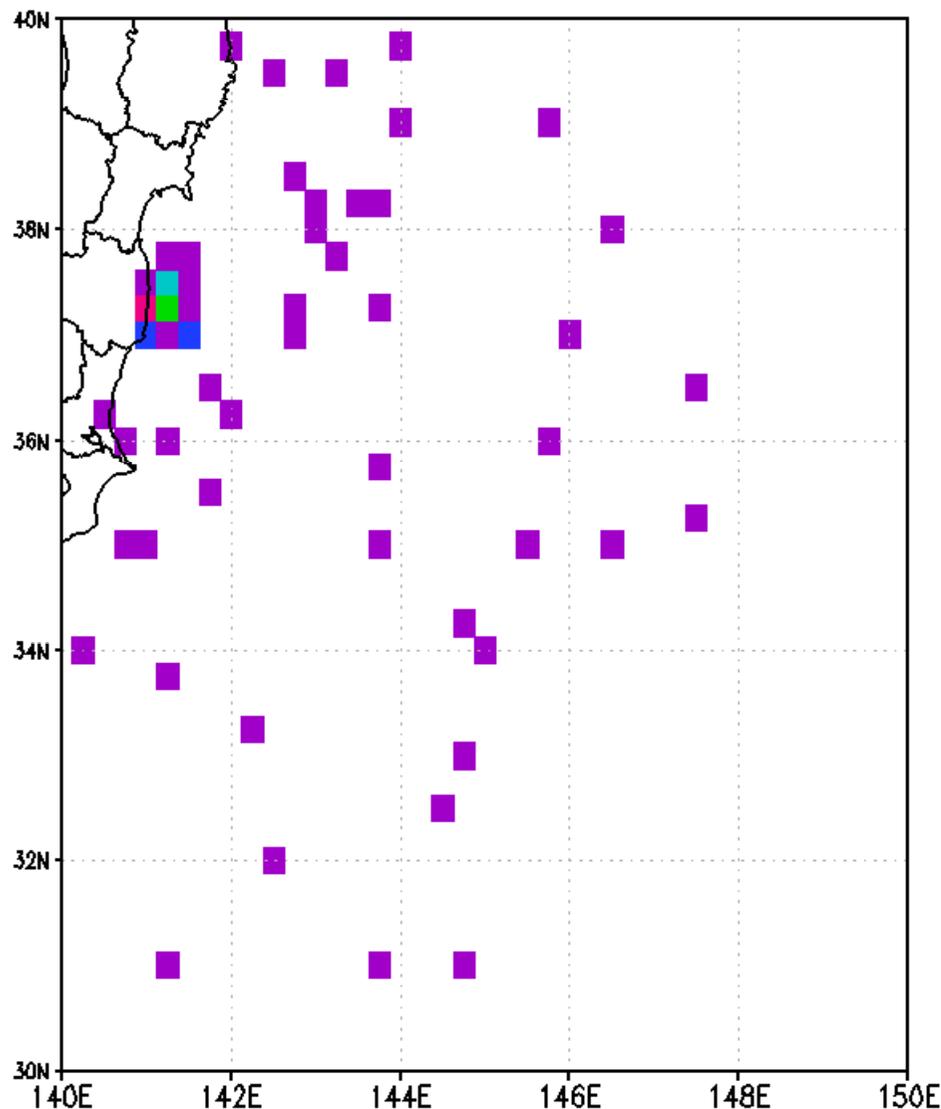
JCOPE2 直接流出 4.2 PBq (4.0PBq: 03/26-)
大気沈着 1.2PBq (北西太平洋)

大気沈着を考慮しない場合 直接流出 4.4PBq
F2, 岩沢海岸データを加えた場合 直接流出 12.7PBq
大気沈着 1.6PBq
みらい18データを加えた場合 直接流出 0.8PBq
大気沈着 0.7PBq

放出量推定に対する各観測点の寄与

JCOPE-T 直接流出量 (%)

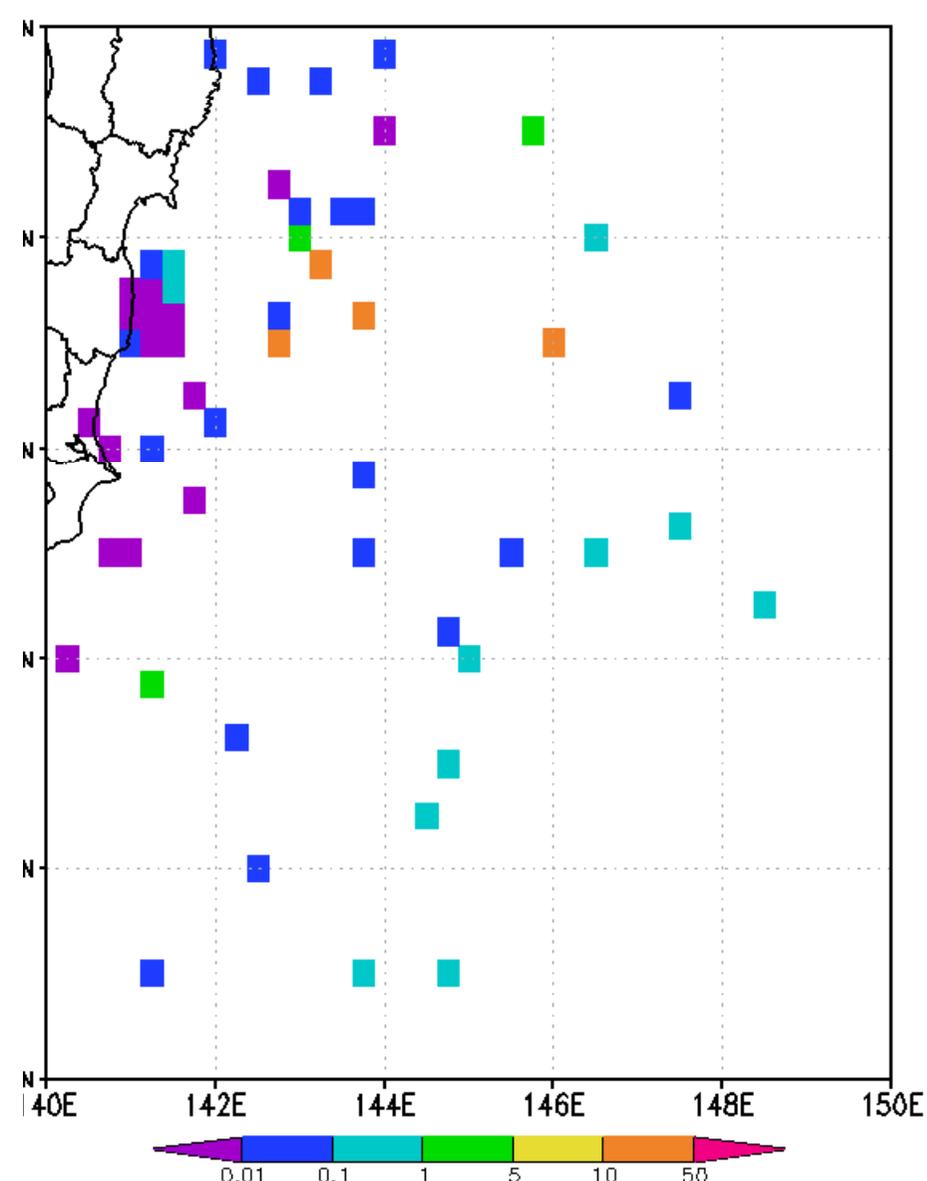
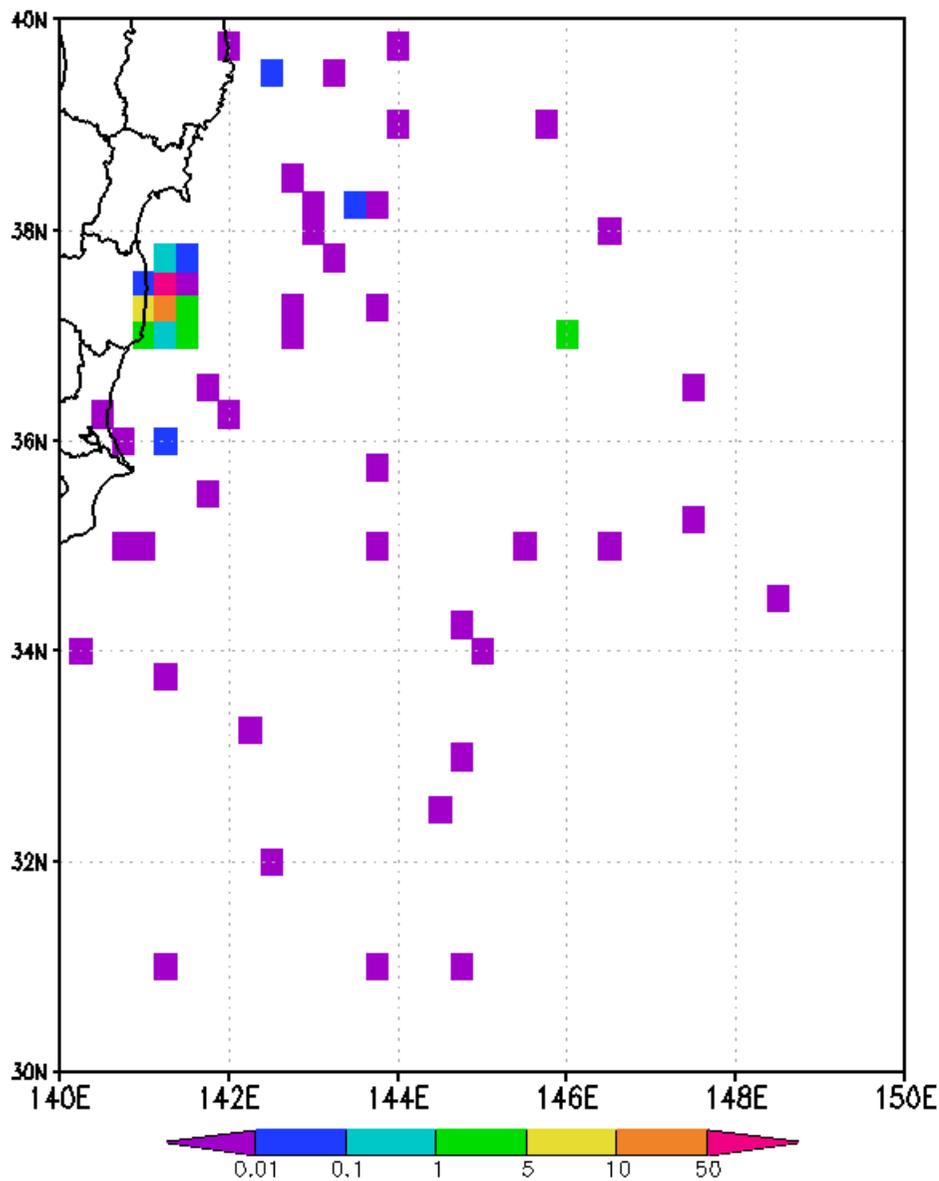
JCOPE-T 大気沈着量 (%)



放出量推定に対する各観測点の寄与

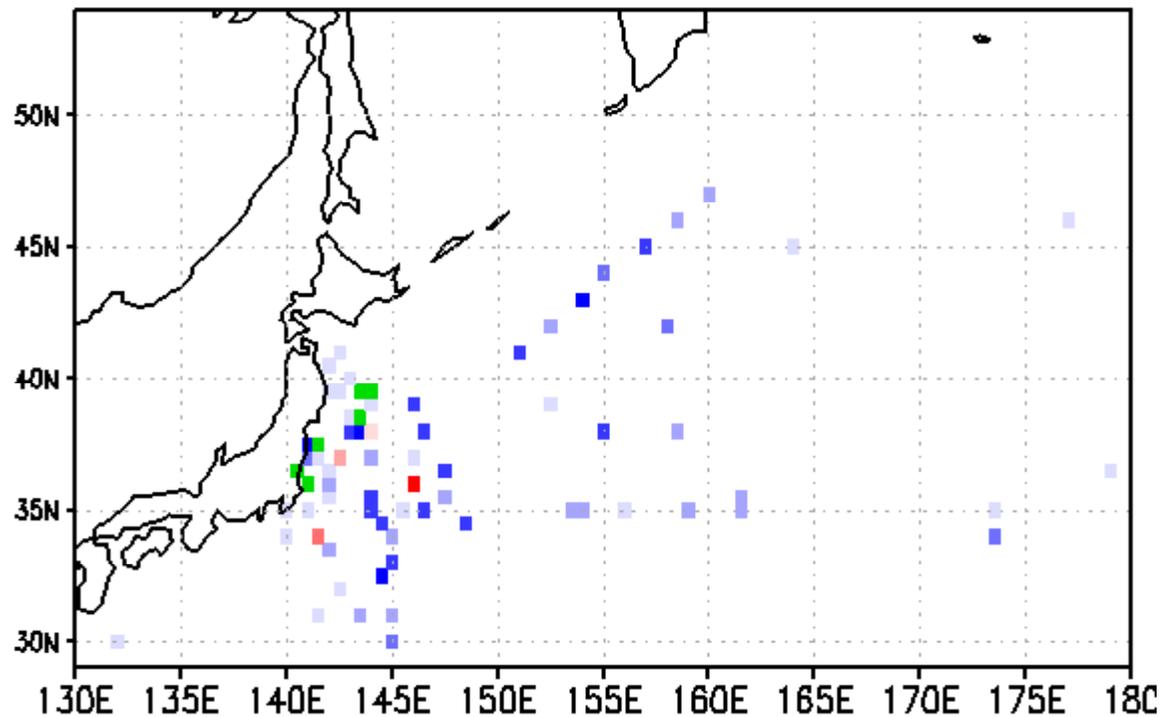
JCOPE2 直接流出量 (%)

JCOPE2 大気沈着量 (%)



データに対するバイアス

JCOPE2放出量調整後・観測誤差で最適化



大気沈着量は過小評価？

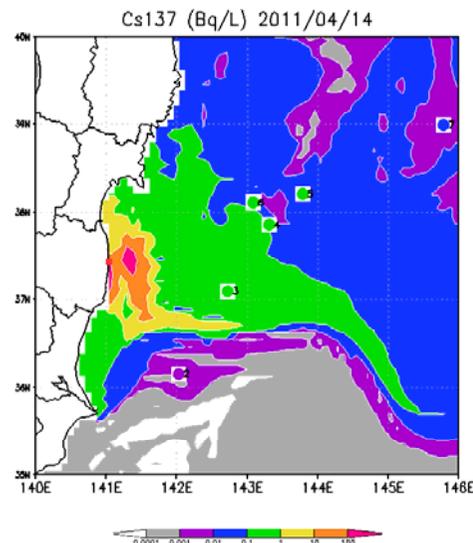
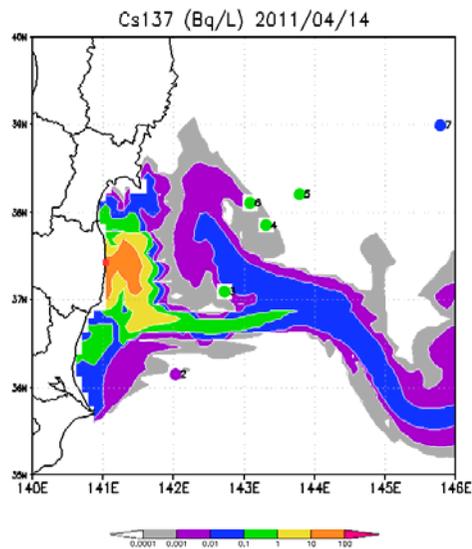


「みらい」データと推定分布 4/14

放出量調整前 (大気なし)

放出量調整後 (大気あり)

JCOPE2



JCOPE-T

