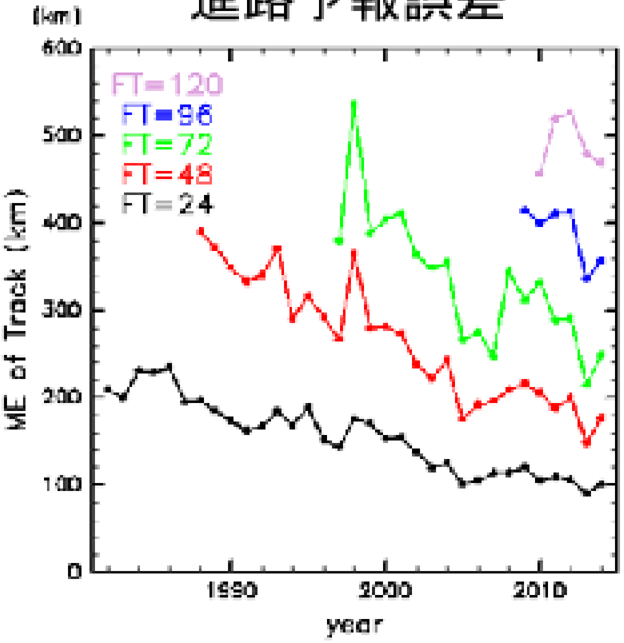
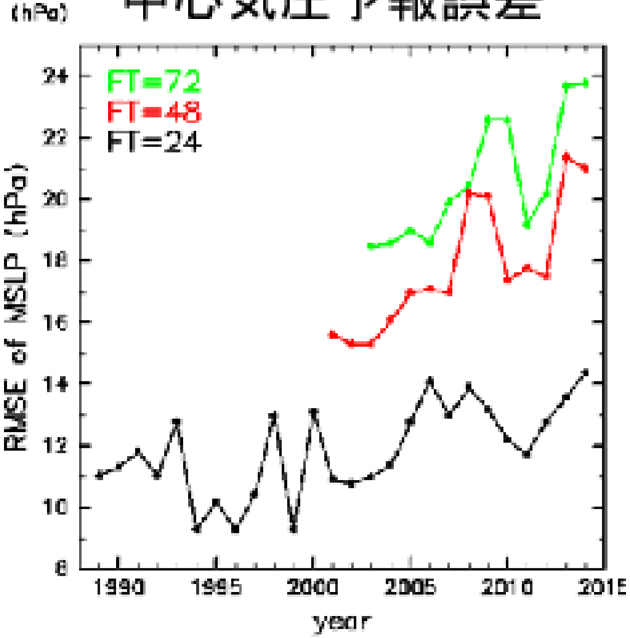
Part 5

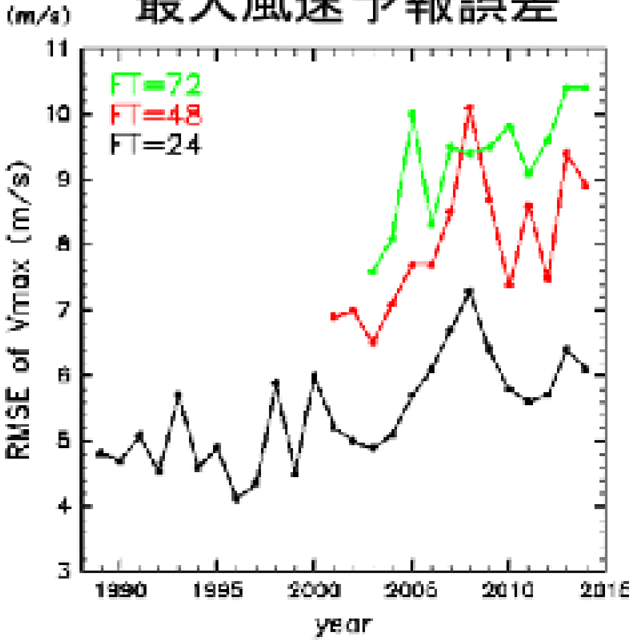
大気海洋結合モデルを用いた台風強度予測

研究の背景：RSMC Tokyoの予報誤差

- 中心気圧と最大風速に代表される強度予報の誤差は改善されていない。
- 進路予報が最も重要であることは言うまでもないが、強度予報も防災上非常に重要な情報である。
- 何とか強度予測を良くすることはできないか？


進路予報誤差

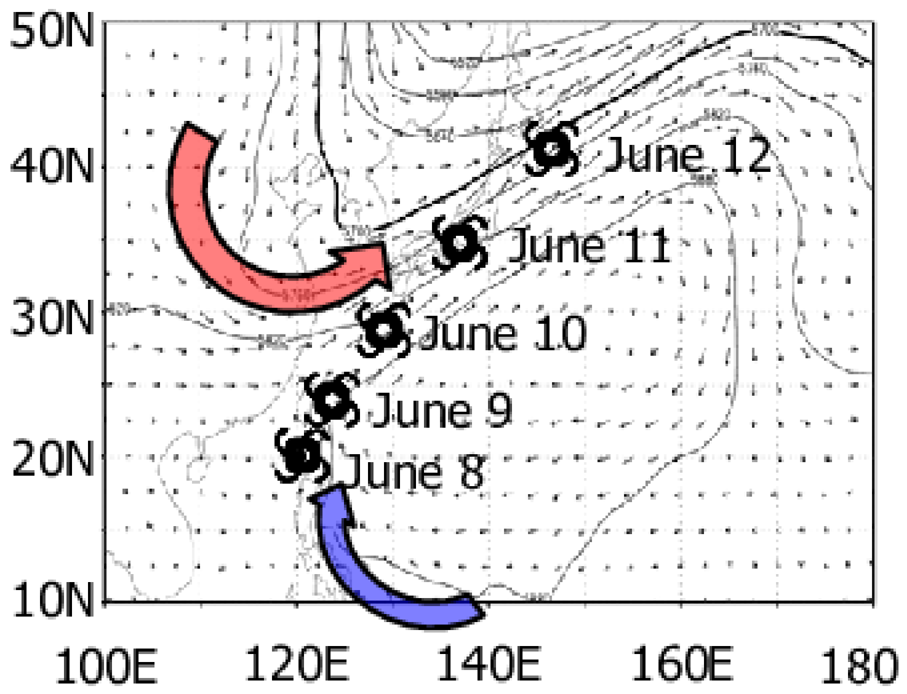

中心気圧予報誤差


最大風速予報誤差

(Ito et al. 2016, SOLA)

台風の進路予報と強度予報

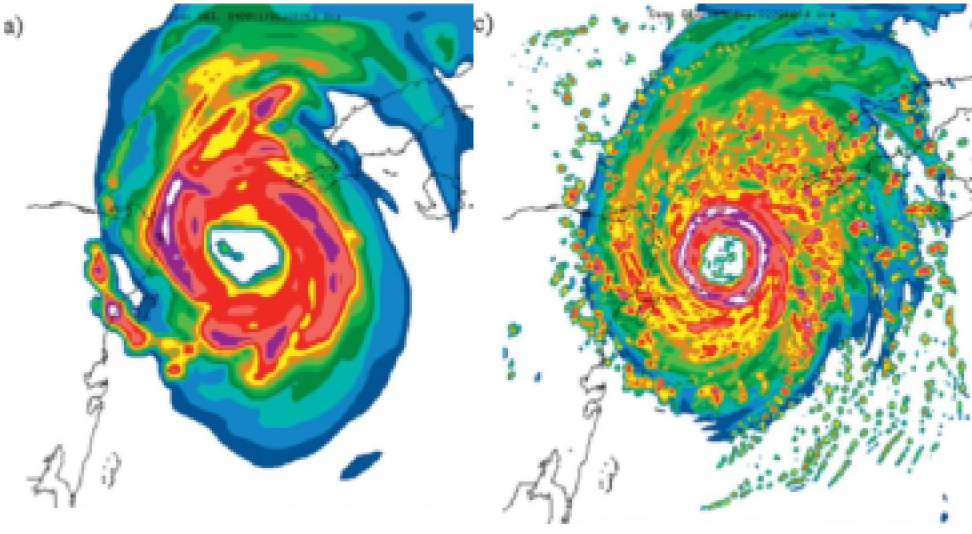
- ➢進路
 周囲の数百～千km地点の流れでおよそ決まる



(デジタル台風)

- ➢ 強度: 中心気圧・最大風速
 環境場に制約を受けつつ、内部コア力学が支配している

分解能を上げる



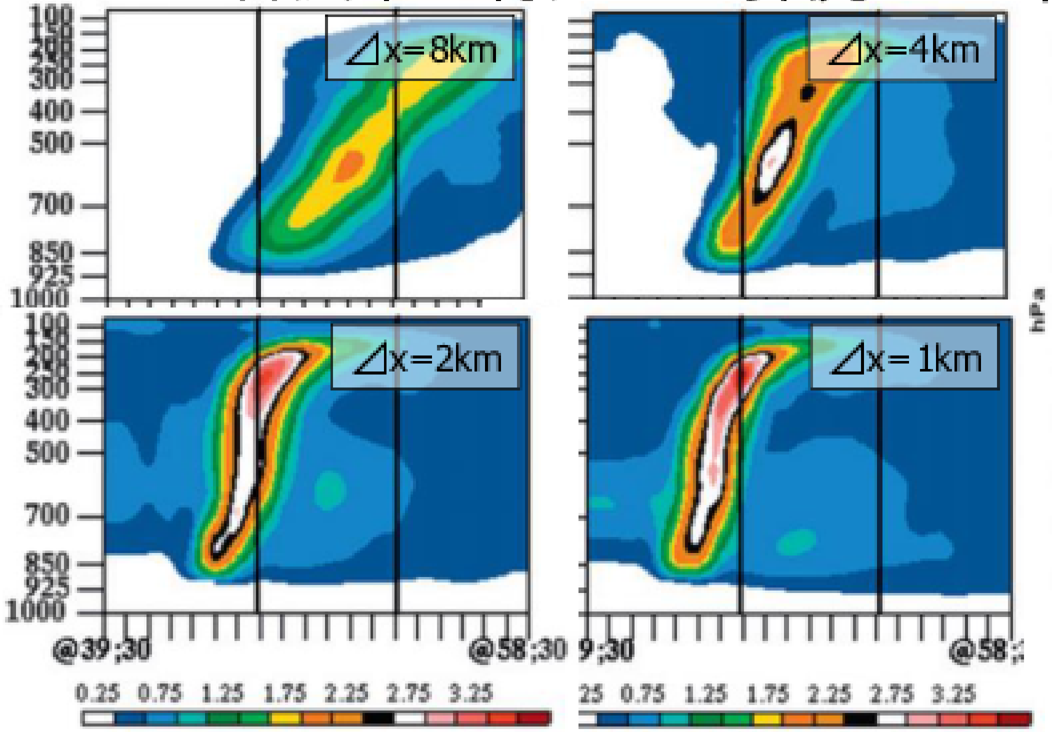
(GentryとLackmann, 2010)

・台風強度の再現には、高解像度で計算する必要がある

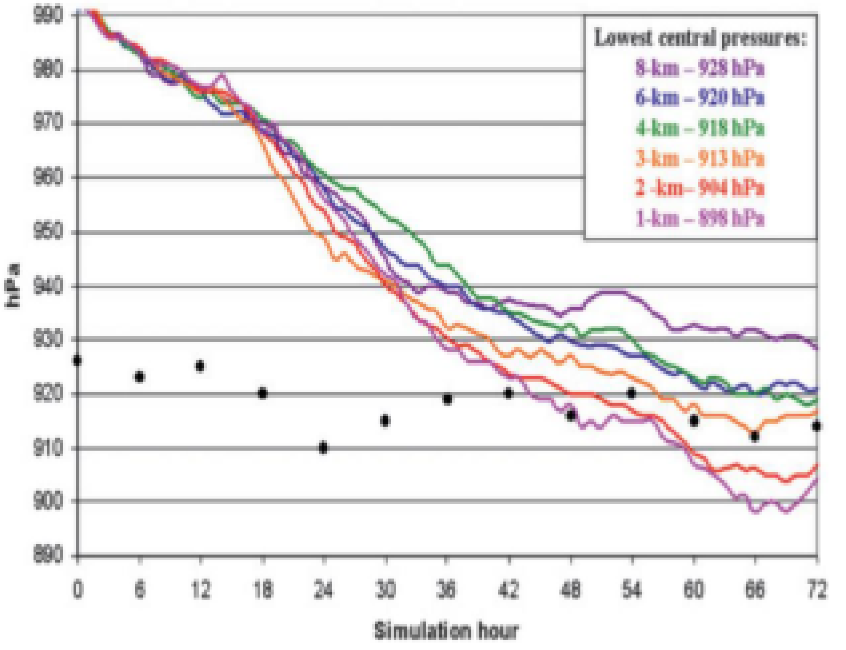
格子点間隔⊿xへの依存性

- 台風の壁雲は典型的には厚さ10kmほど。
- 台風強度は通常の台風なら⊿x≦5km、猛烈な台風ならば⊿x≦2kmで再現できそうである。

台風中心付近の上昇流



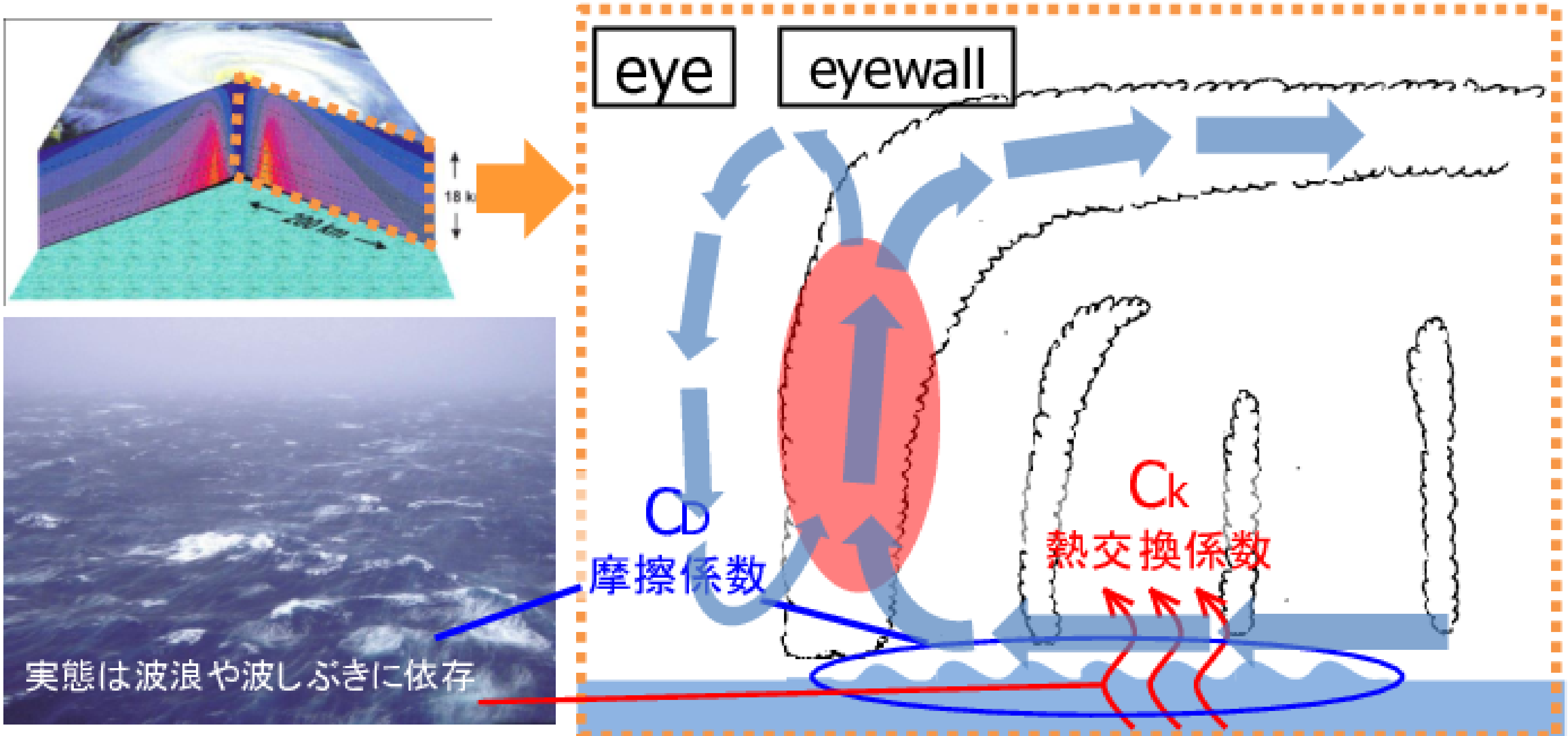
中心気圧の格子点間隔依存性



(Gentry and Lackmann, 2010)

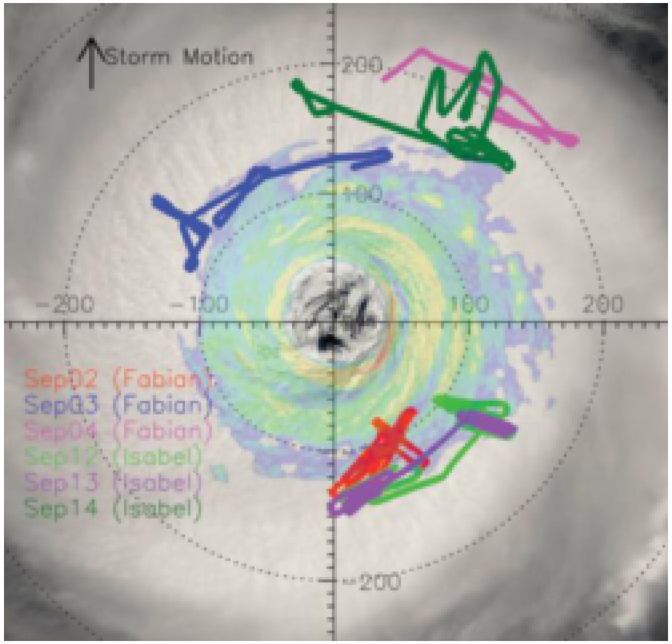
MPIを解釈する

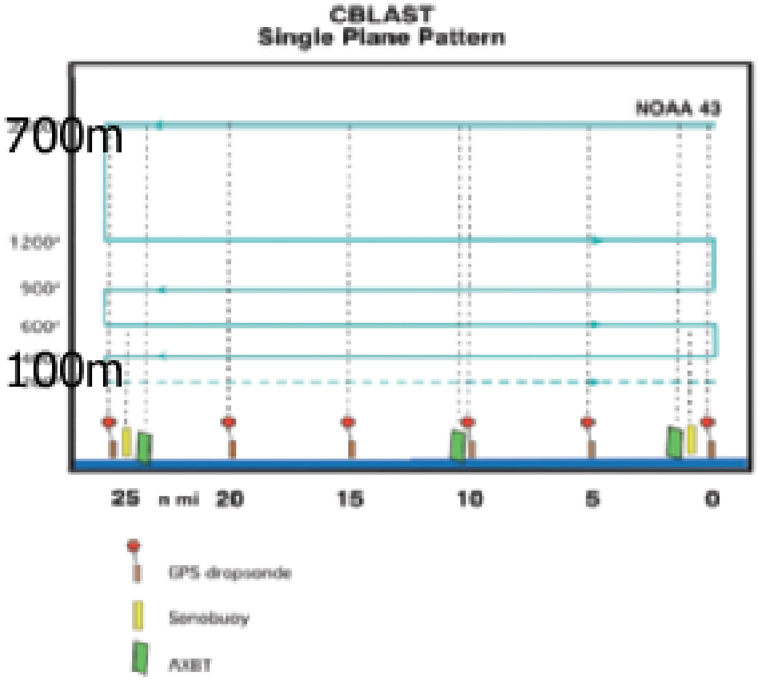
$$v^2 = \frac{C_k}{C_D}\left(T_b - T_{out}\right)\left(s^*_{SST} - s_b\right)$$



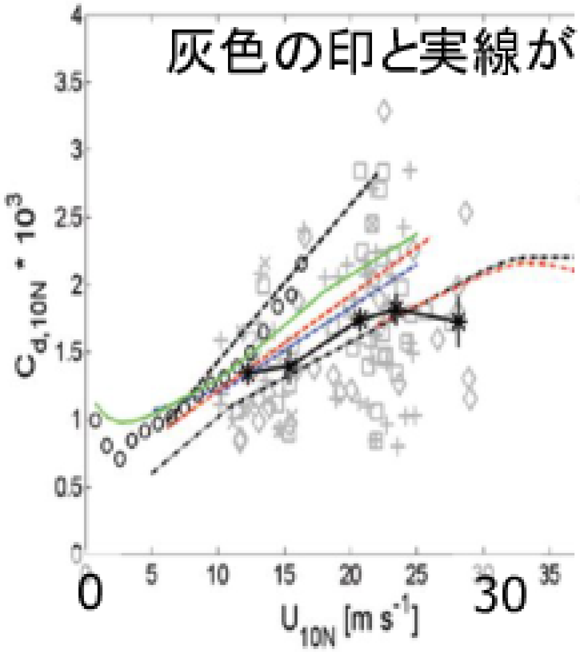
実態は波浪や波しぶきに依存

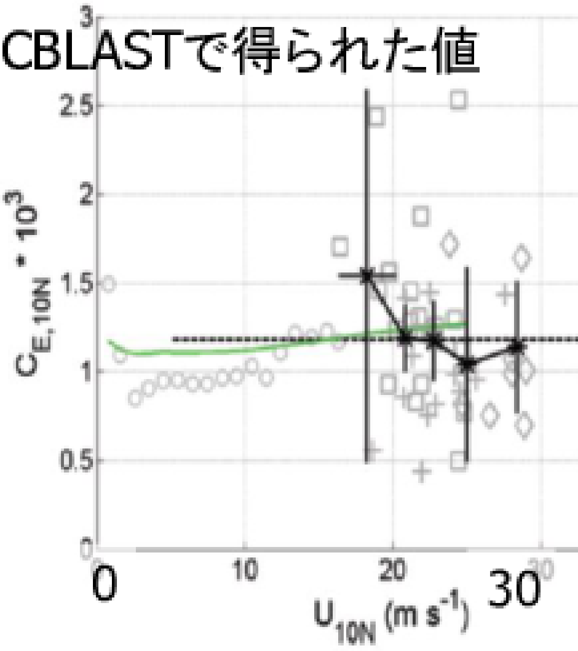
直接法による観測CBLAST(Black et al., 2007)



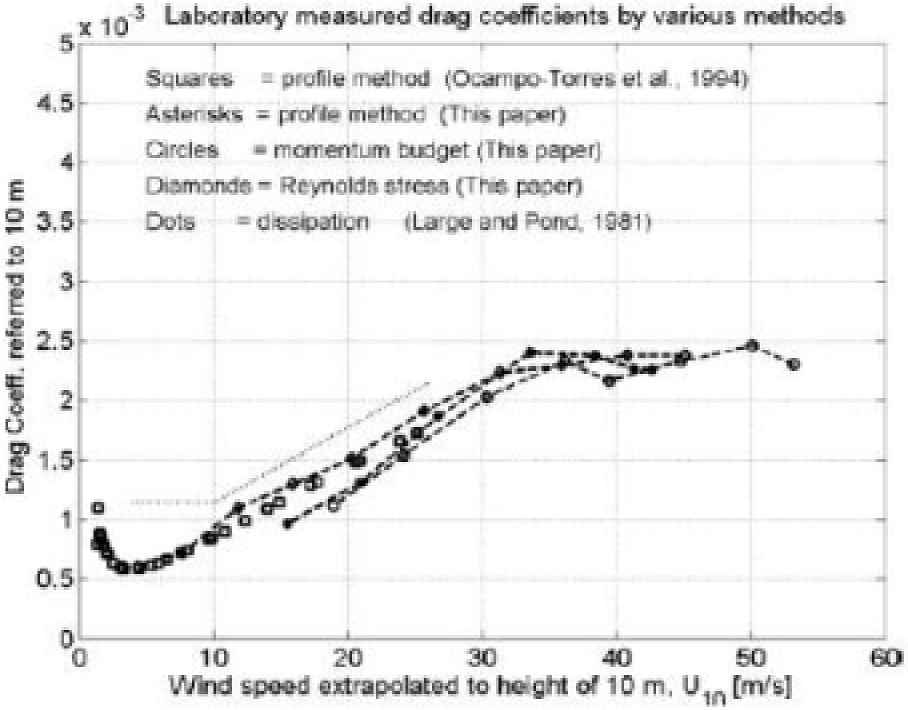


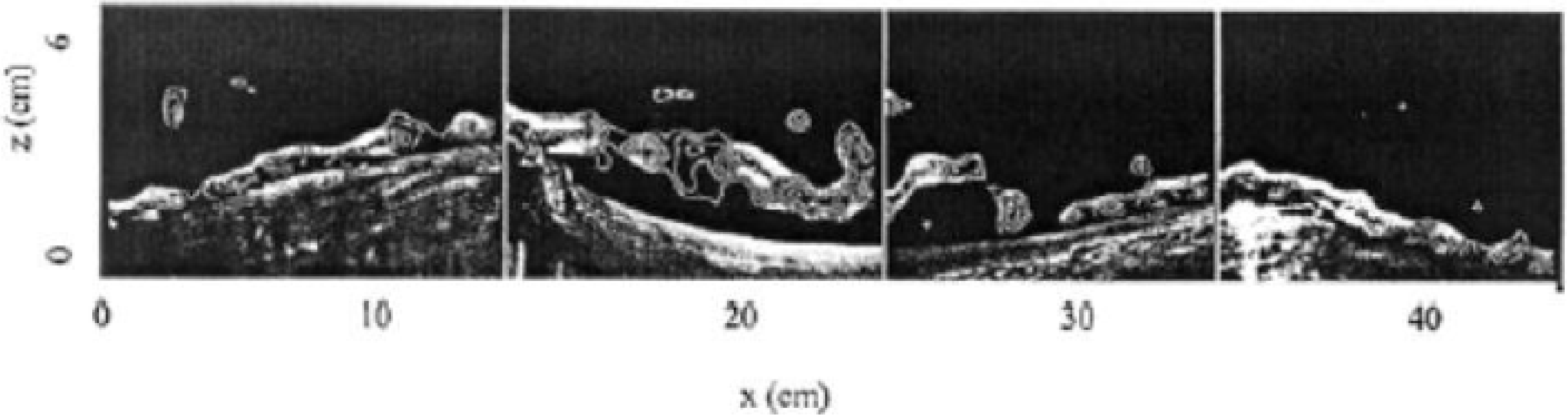
灰色の印と実線がCBLASTで得られた値

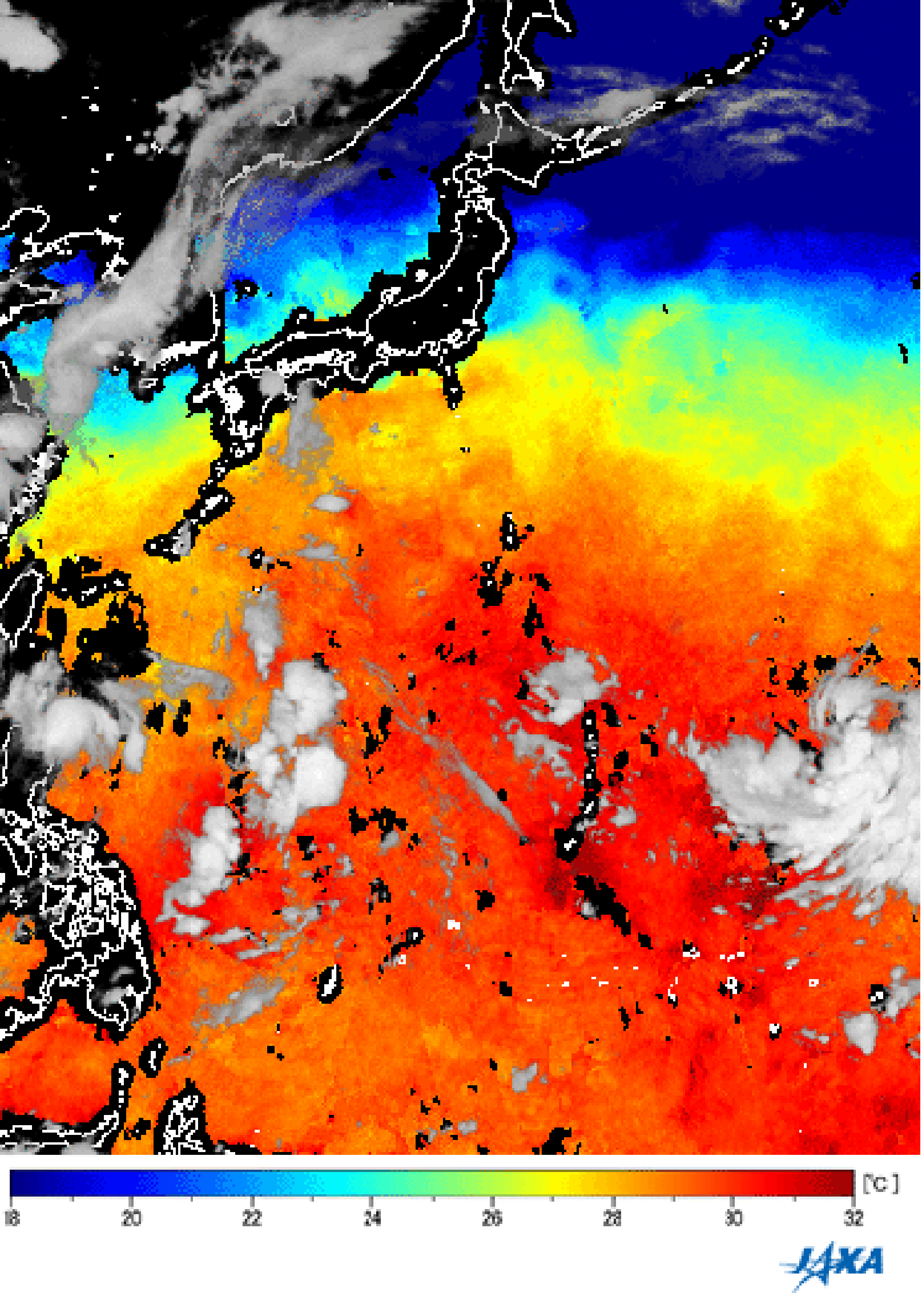




室内実験:Donelan et al.(2004)



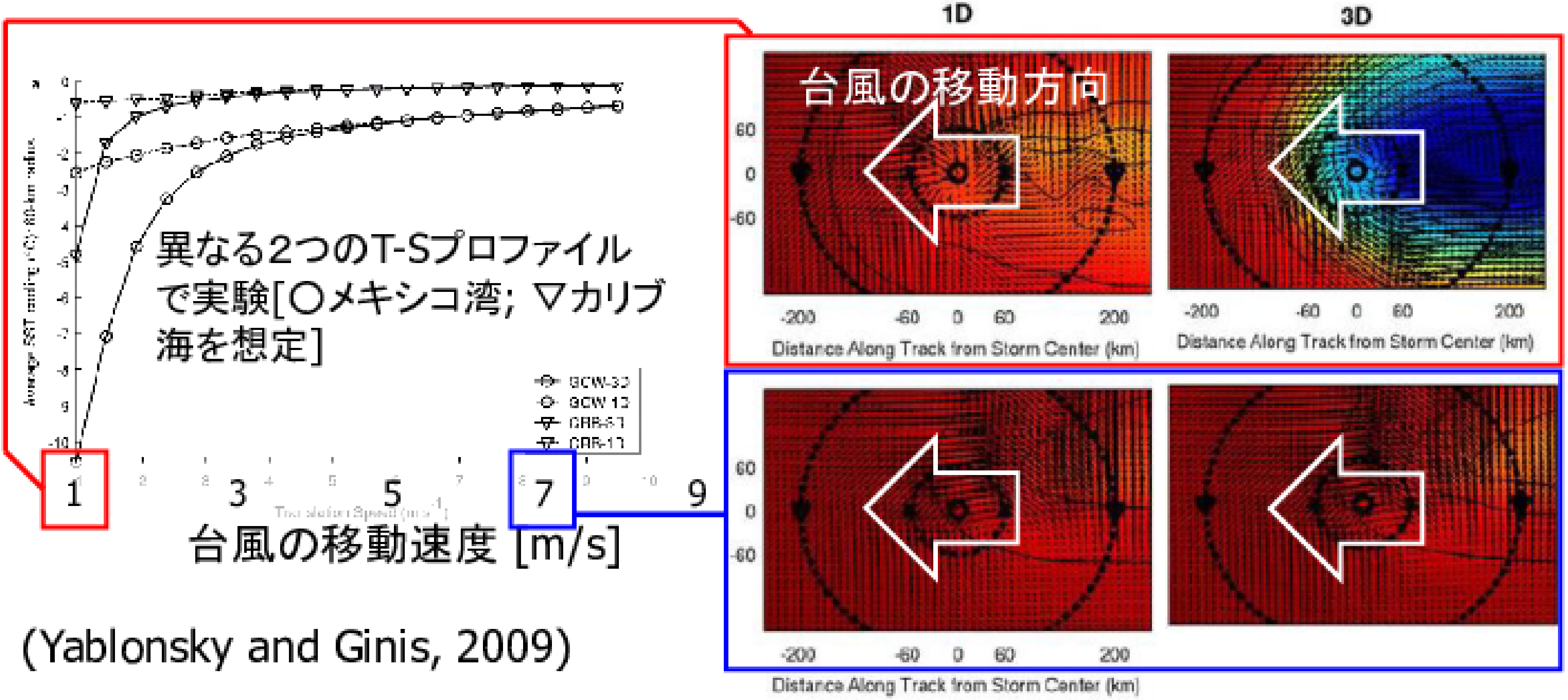




2011年台風6号
SST(MTSAT)

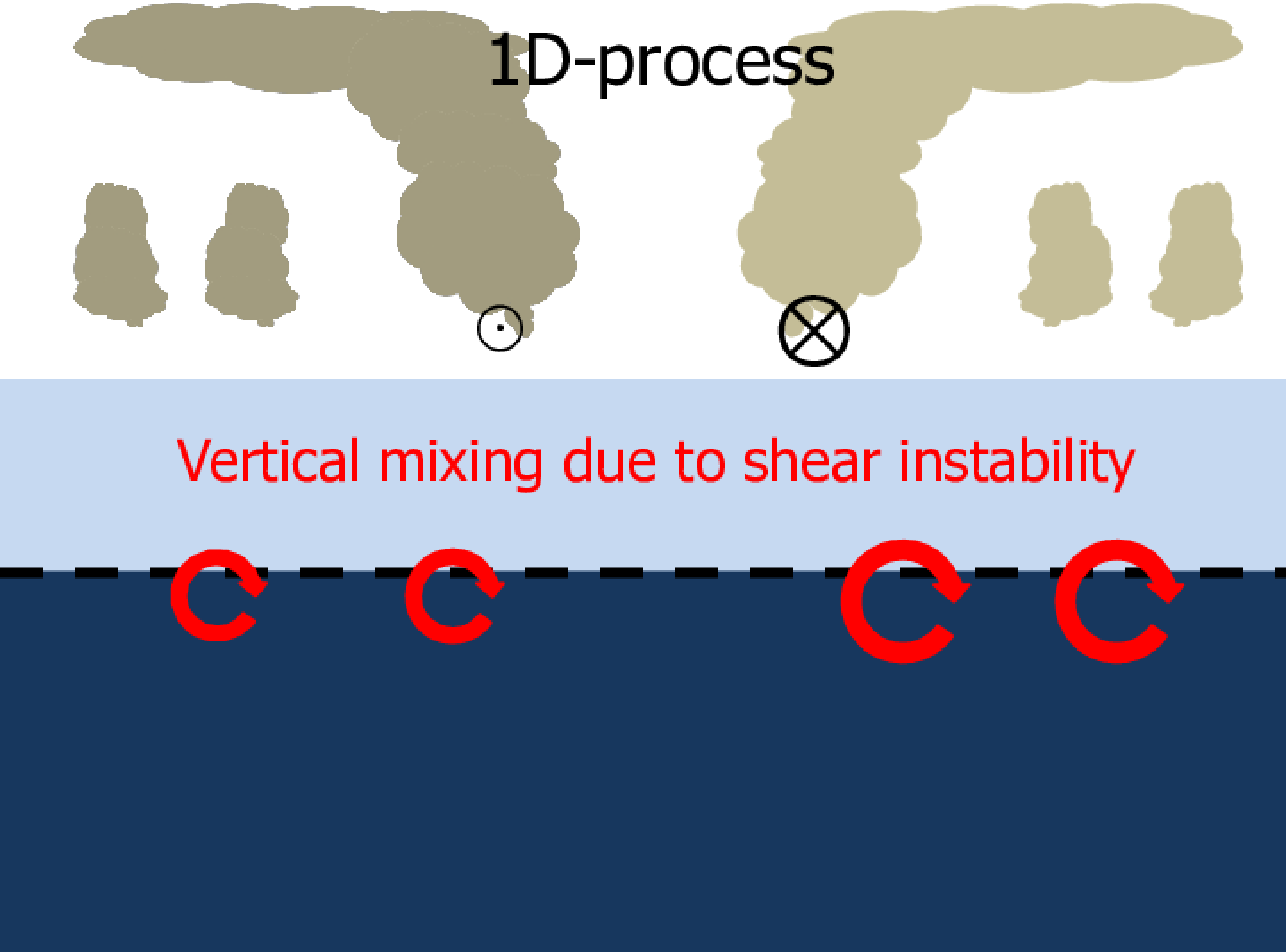
鉛直１次元モデルと３次元モデルとの比較

- 台風を模した風の分布に対する平均SST低下
- 台風の移動速度が5 m/s以上のときには、鉛直1次元過程で近似しても、中心付近の平均海面水温低下を近似できるが、ゆっくり移動する台風ではエクマン湧昇などの3次元過程が効く.



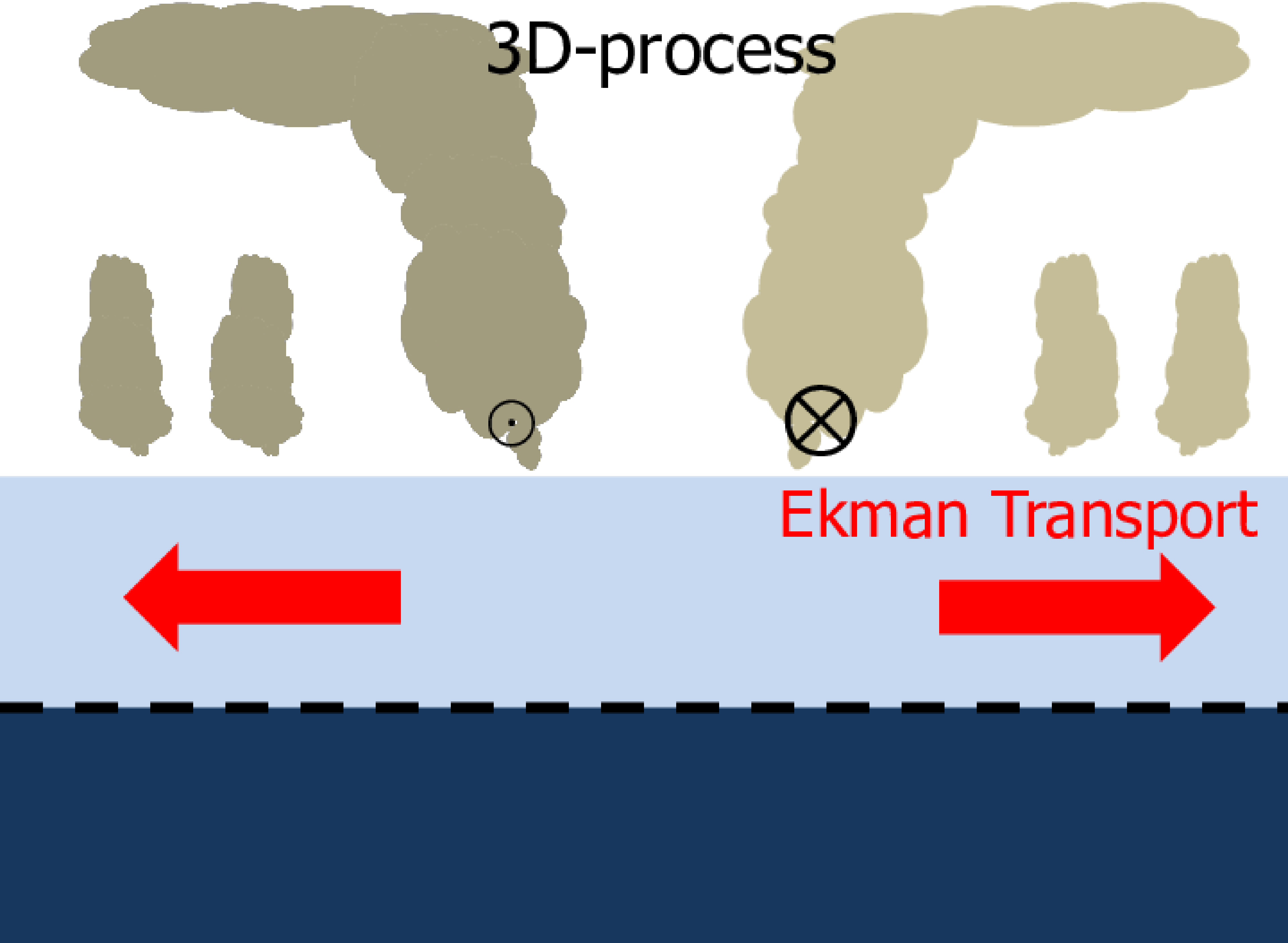
異なる2つのT-Sプロファイルで実験[○メキシコ湾; ▽カリブ海を想定]

(Yablonsky and Ginis, 2009)



1D-process

Vertical mixing due to shear instability

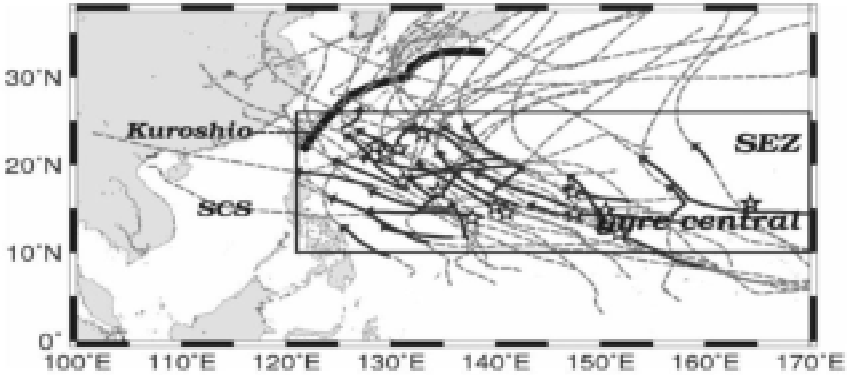


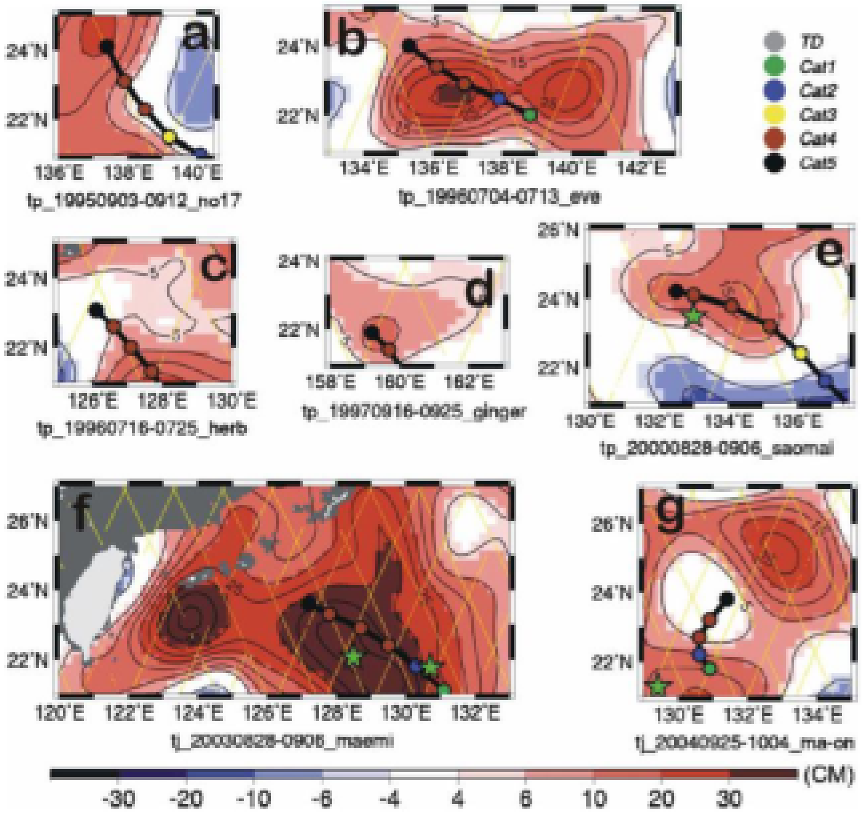
3D-process

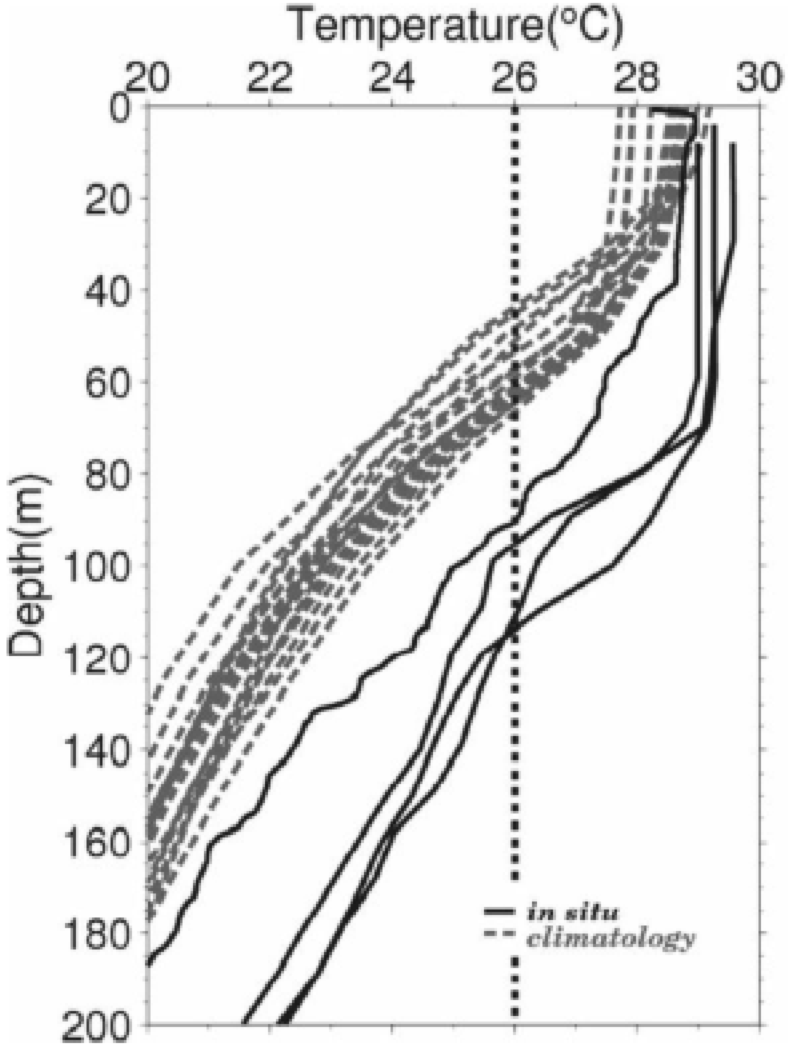
Ekman Transport

海洋応答の大気へのフィードバック

海洋内部の構造が台風強度変化に重要



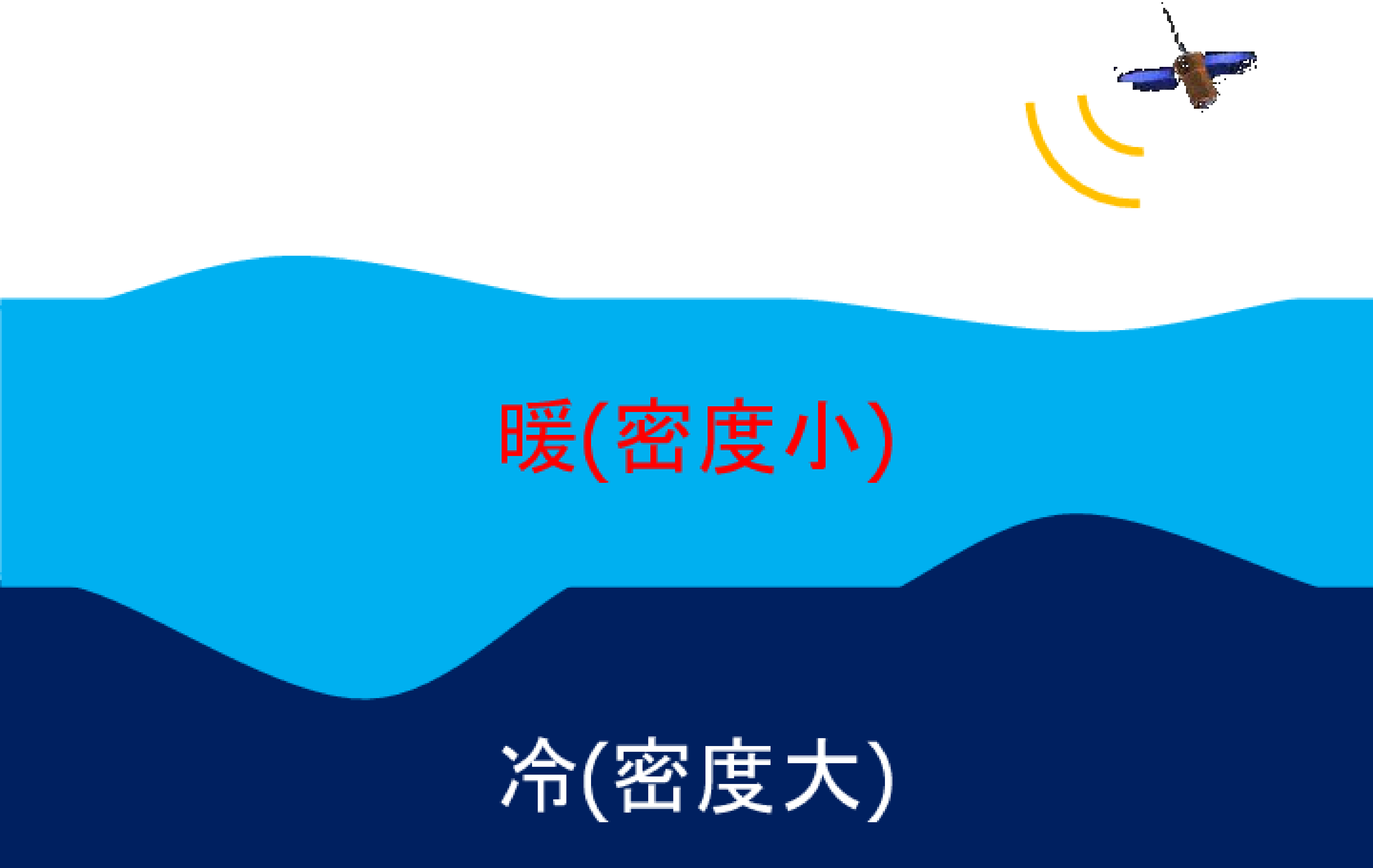




海洋の温暖渦➔台風にとってのBooster

(Lin et al., 2008)

海面高度の情報→貯熱量の大小

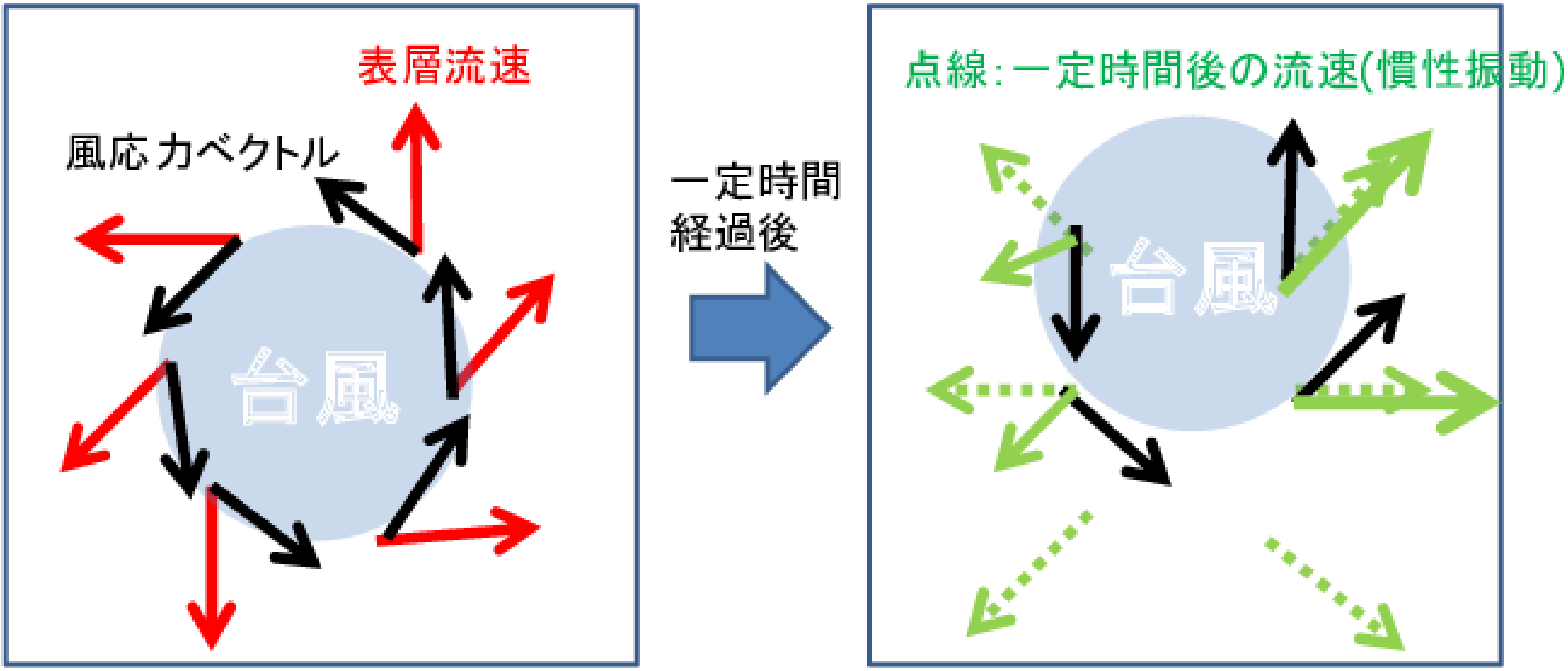


なぜ流速が進行方向の右側で強いのか？

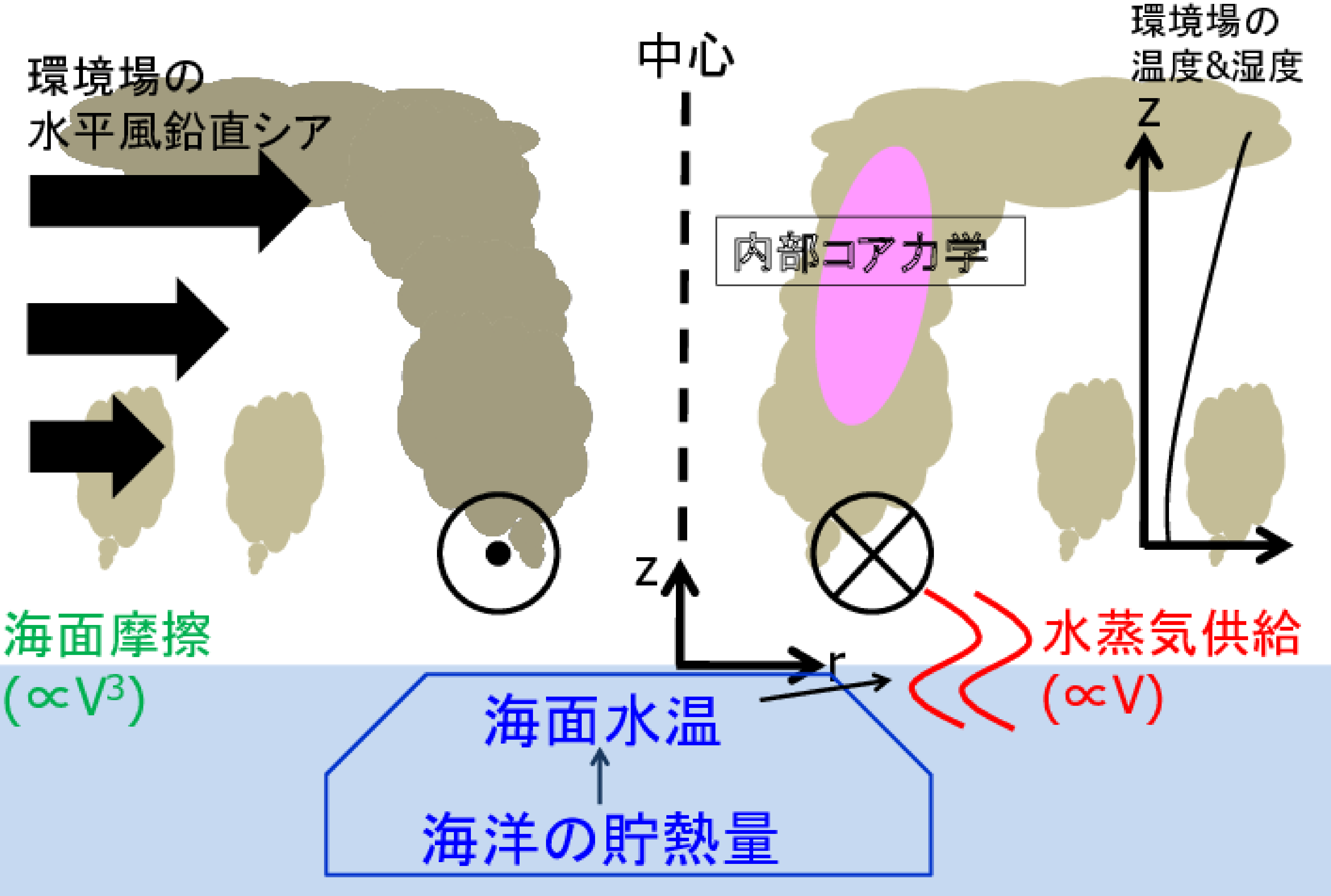
- 流れが近慣性流であることを考えると，進行方向の右側では流速が大きく発散場を形成することがわかる。

（黒：風応力ベクトル，赤：表層流速，緑：一定時間を経た表層流速）

⇒流速が強いとシア不安定が起きやすく，発散場に伴う強い上昇流が生じやすくなり，SSTは大きく下がる



台風強度に影響する要素



環境場の
水平風鉛直シア

中心

環境場の
温度&湿度

内部コア力学

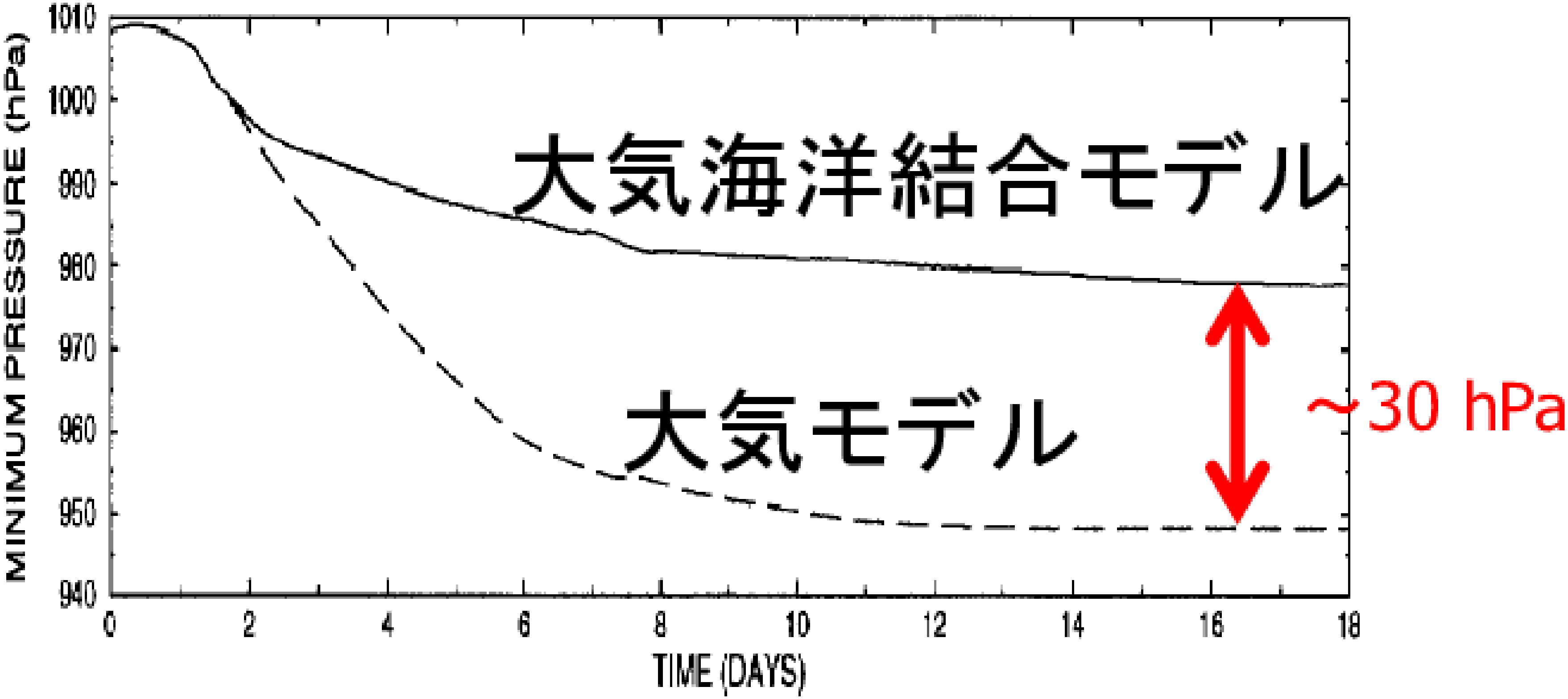
海面摩擦
(∝V^3)

水蒸気供給
(∝V)

海面水温

海洋の貯熱量

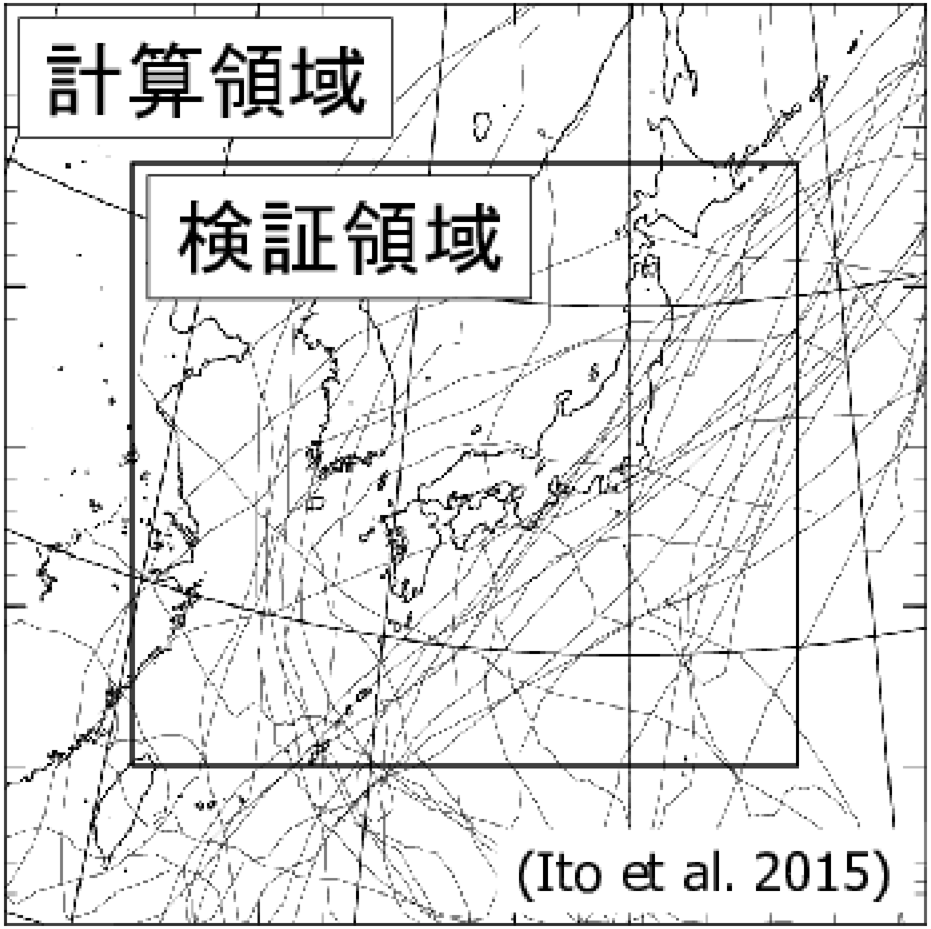
大気モデルと大気海洋結合モデルでは台風強度が全然違う



(Schade and Emanuel, 1999)

高解像度大気海洋結合モデルの開発

- GSM: 気象庁全球大気モデル(⊿x～20km)
- AMSM: 気象庁非静力学大気モデルJMA-NHM(⊿x=5km)
- CMSM: AMSM + 1D-Ocean (⊿x=5km)



(Ito et al. 2015)

➢ 対象

2009/04-2012/09に検証領域を通過した全ての台風(34個)

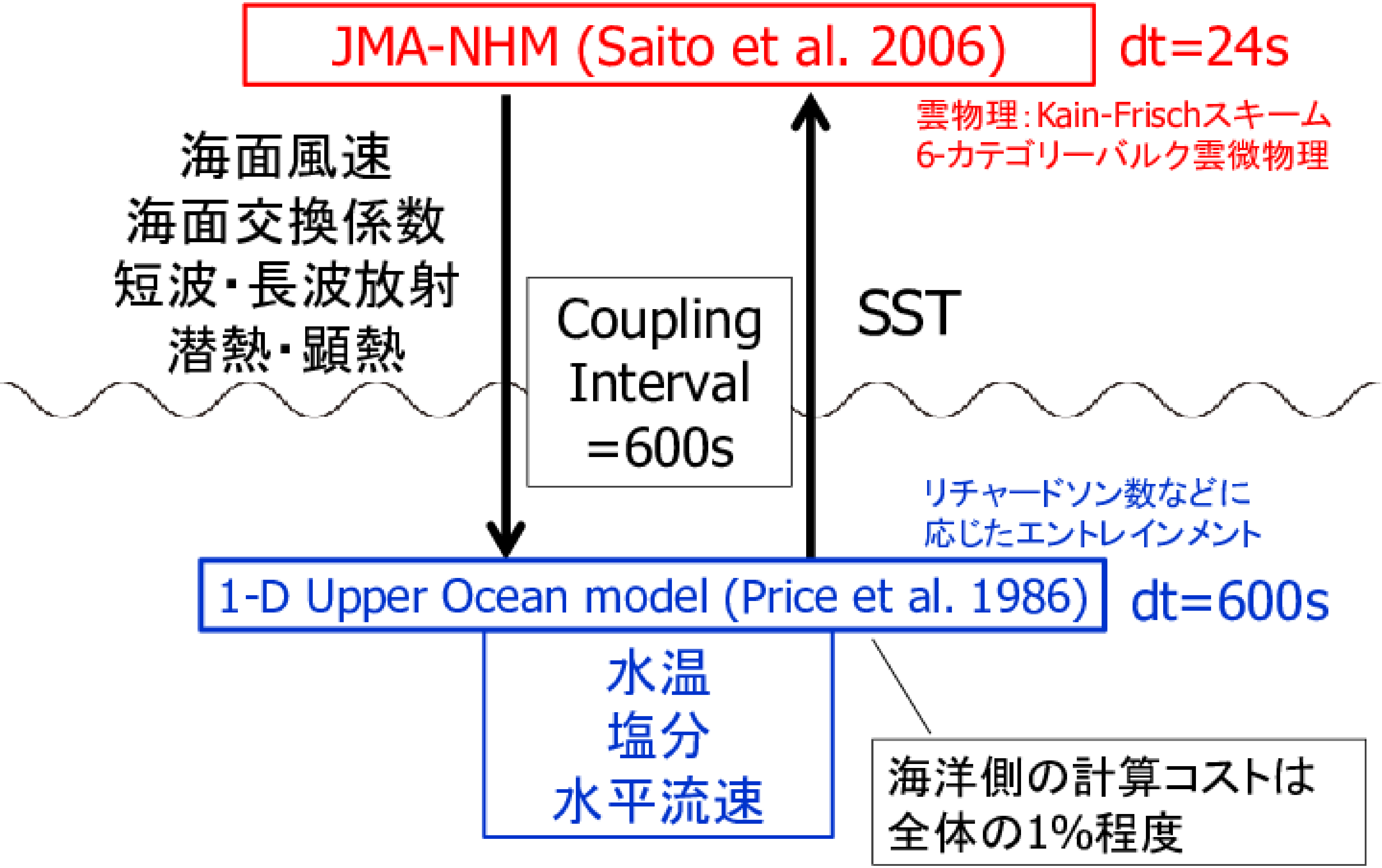
➢ 予報実験

6時間おきに3日間予報を開始。(各281回；**京の5%で1.5日**)

➢ 海洋側の初期値(CMSM)

水温(混合層内)=MGDSST
水温(混合層底部以深)
　=MGDSST+気候値偏差
流速=0.0 m/s

CMSMにおける結合の方法



JMA-NHM (Saito et al. 2006)

dt=24s

雲物理：Kain-Frischスキーム
6-カテゴリーバルク雲微物理

海面風速
海面交換係数
短波・長波放射
潜熱・顕熱

Coupling
Interval
=600s

SST

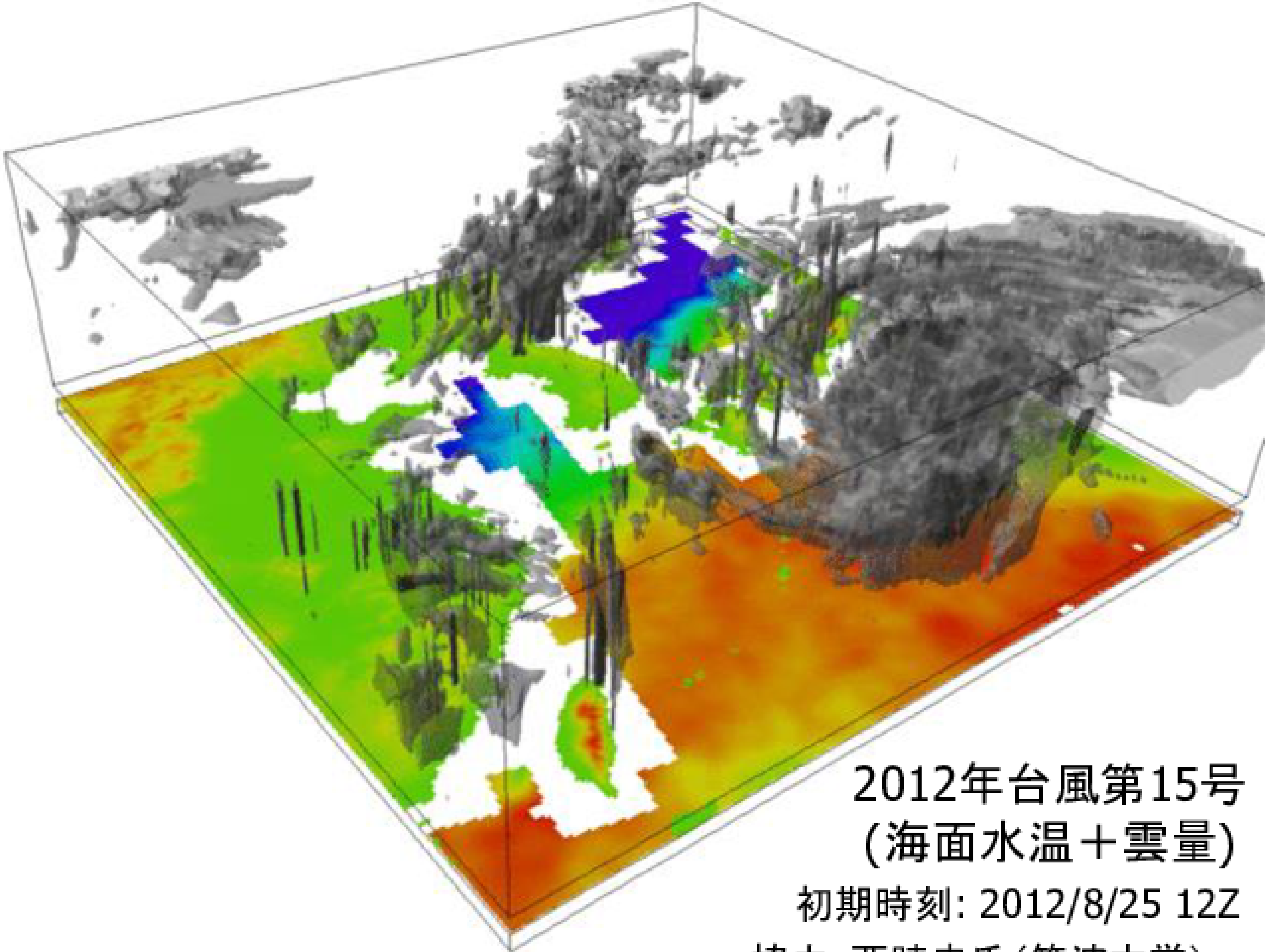
リチャードソン数などに
応じたエントレインメント

1-D Upper Ocean model (Price et al. 1986)

dt=600s

水温
塩分
水平流速

海洋側の計算コストは
全体の1%程度



2012年台風第15号
(海面水温＋雲量)

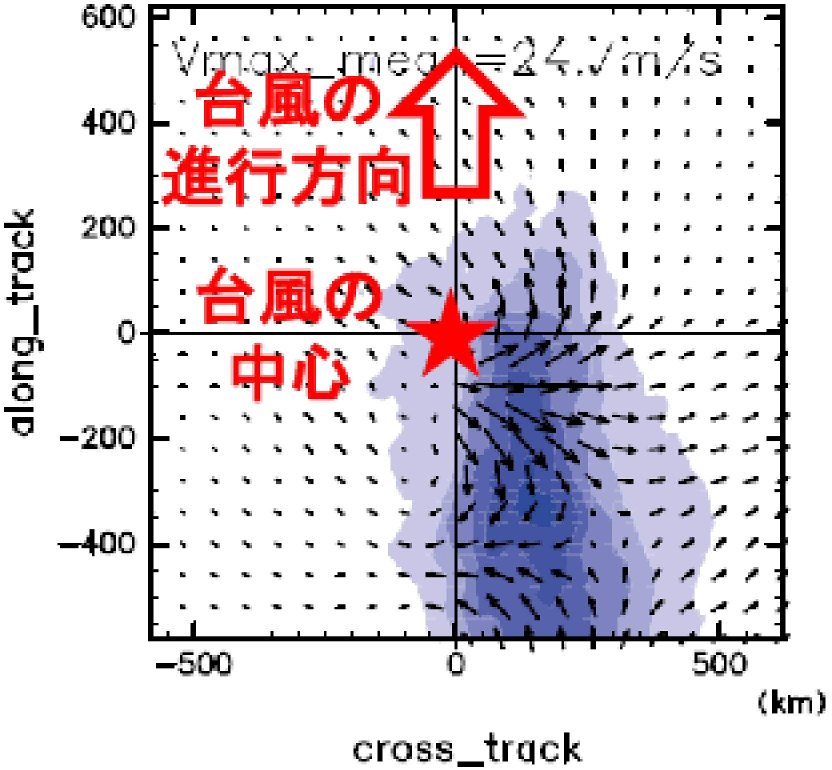
初期時刻: 2012/8/25 12Z

協力:西暁史氏(筑波大学)

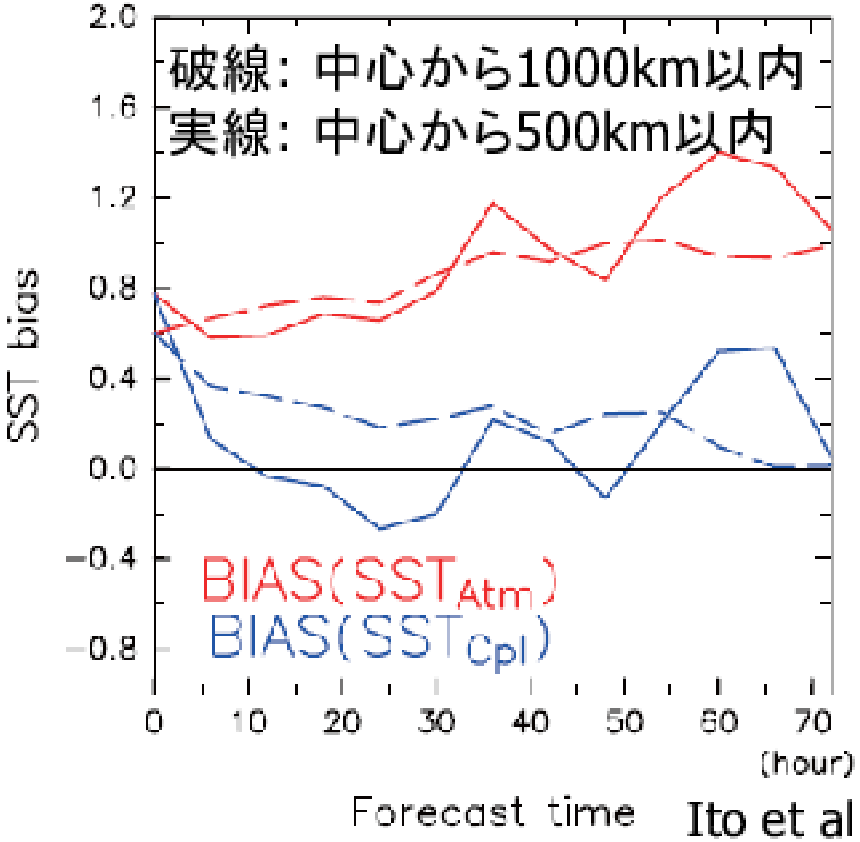
海面水温のバリデーション (vs ARGO)

- CMSMで計算されたSSTにはほとんどバイアスがない
- GSM & AMSMで使うMGDSSTには1 Kほどの正バイアス
  ⇒ 27日以下のスケールをノイズとして落とすため？

SST低下のコンポジット



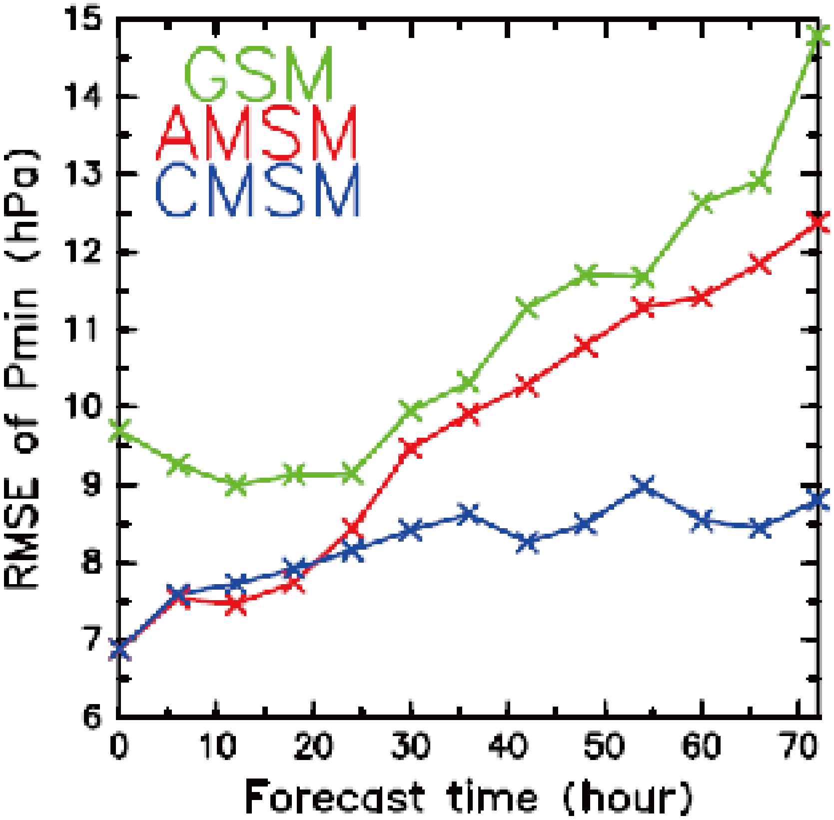
台風中心付近でのSSTバイアス

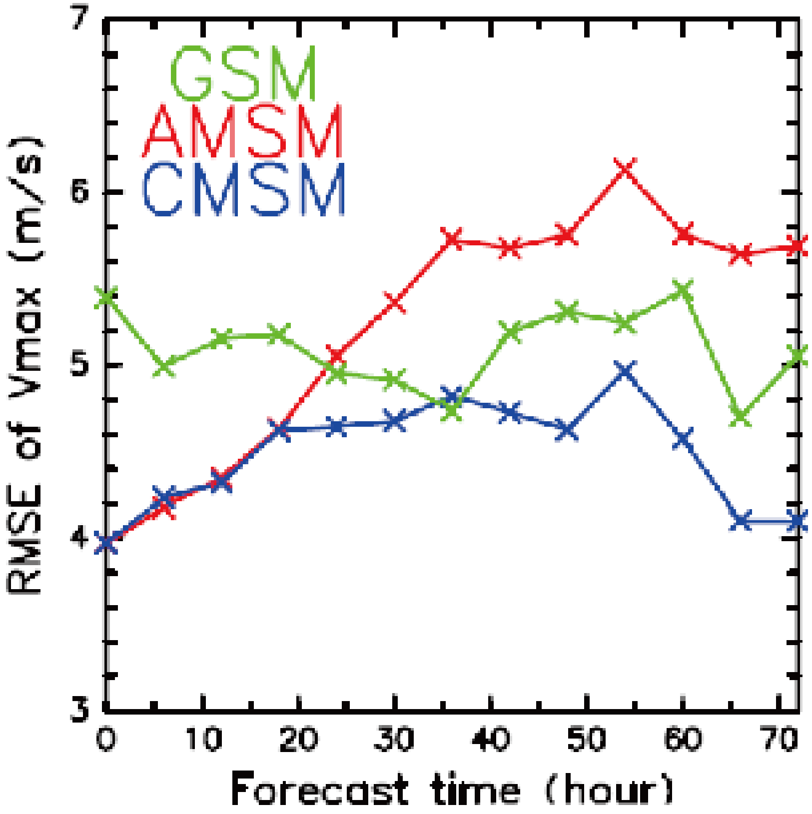


Ito et al. 2015

台風の強度予報成績

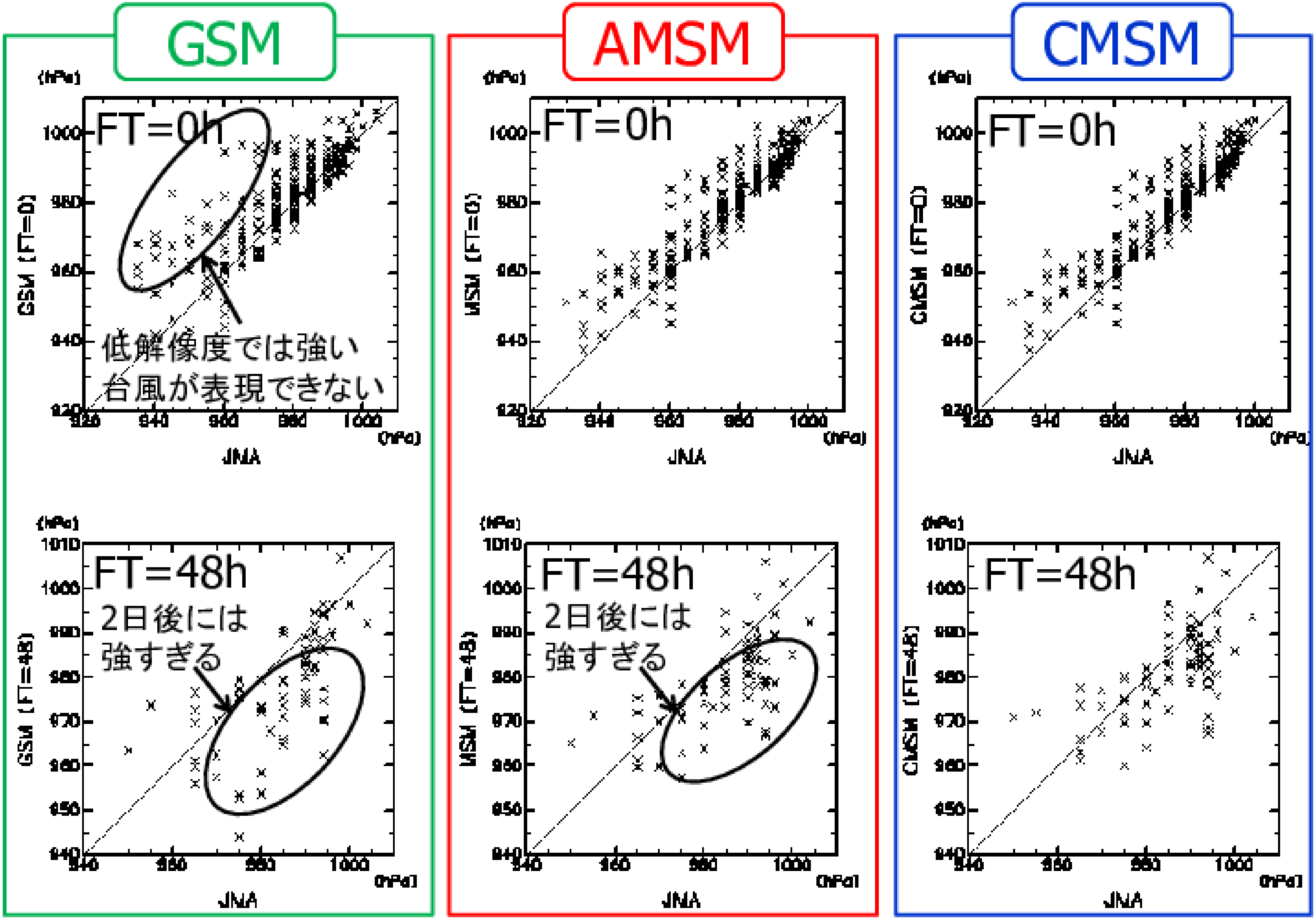
- CMSMはGSMやAMSMよりも中心気圧や最大風速の2日予測という観点で約20%ほどよい.
- CMSMの優位性は予報時間が長くなるほど目立つ。


中心気圧のRMSE


最大風速のRMSE

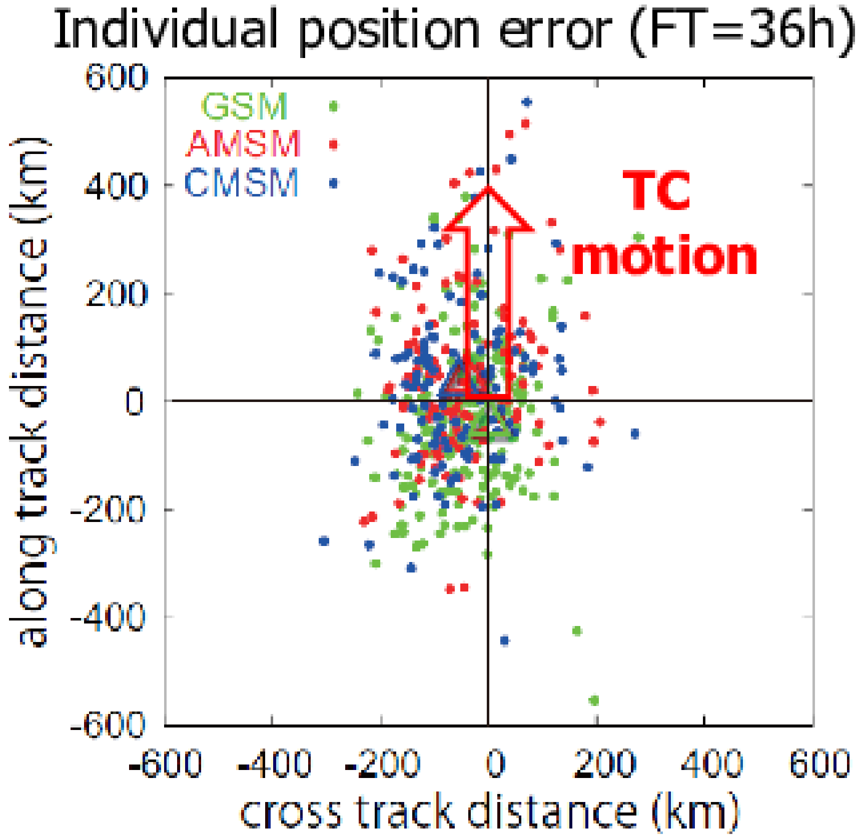
(Ito et al. 2015)

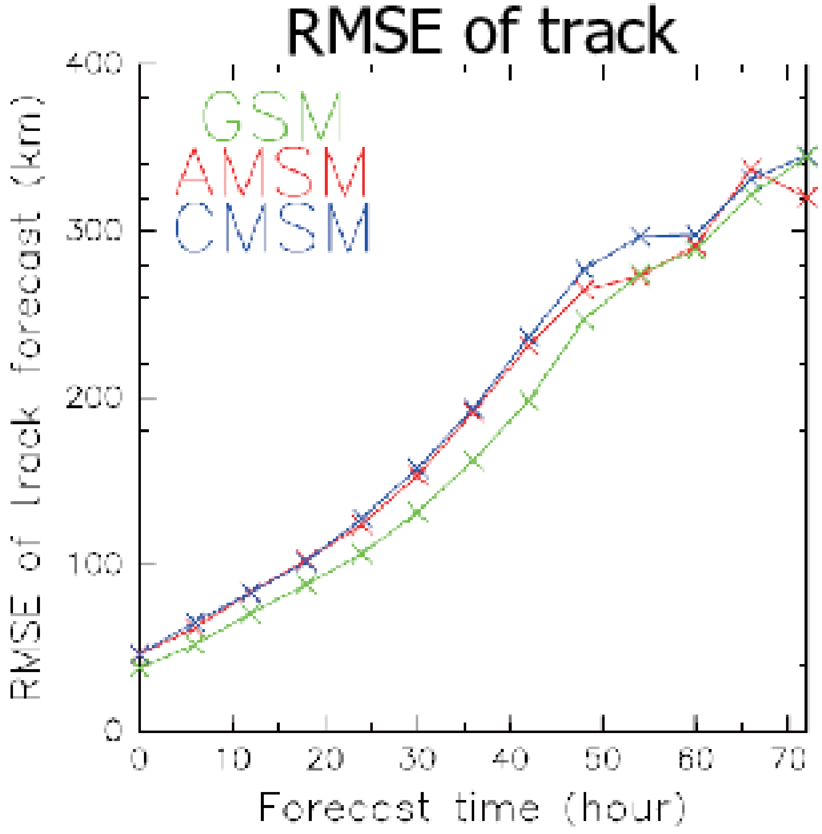
中心気圧 (x軸: RSMC Tokyo best track, y軸: モデル結果)



進路予報への影響

- 海洋モデルを結合すると、平均して台風の進路の10-20 km左側へ変位する(FT=24-48 h)。
- しかし、結合によって台風の進路予報が大きく改善するということはなかった。

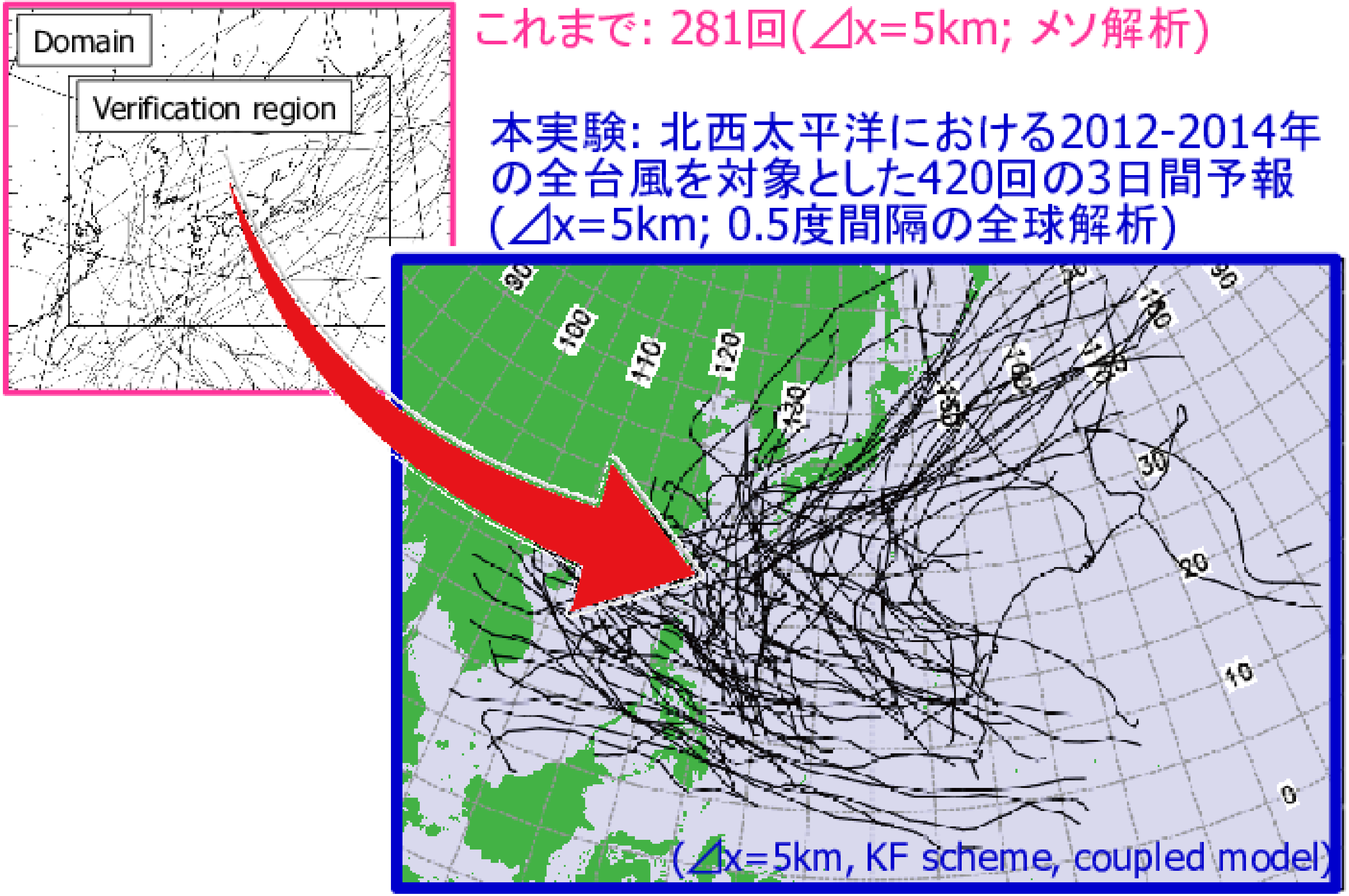




最近の進展(1)：北西太平洋全域ラン

これまで: 281回(⊿x=5km; メソ解析)

本実験: 北西太平洋における2012-2014年の全台風を対象とした420回の3日間予報(⊿x=5km; 0.5度間隔の全球解析)

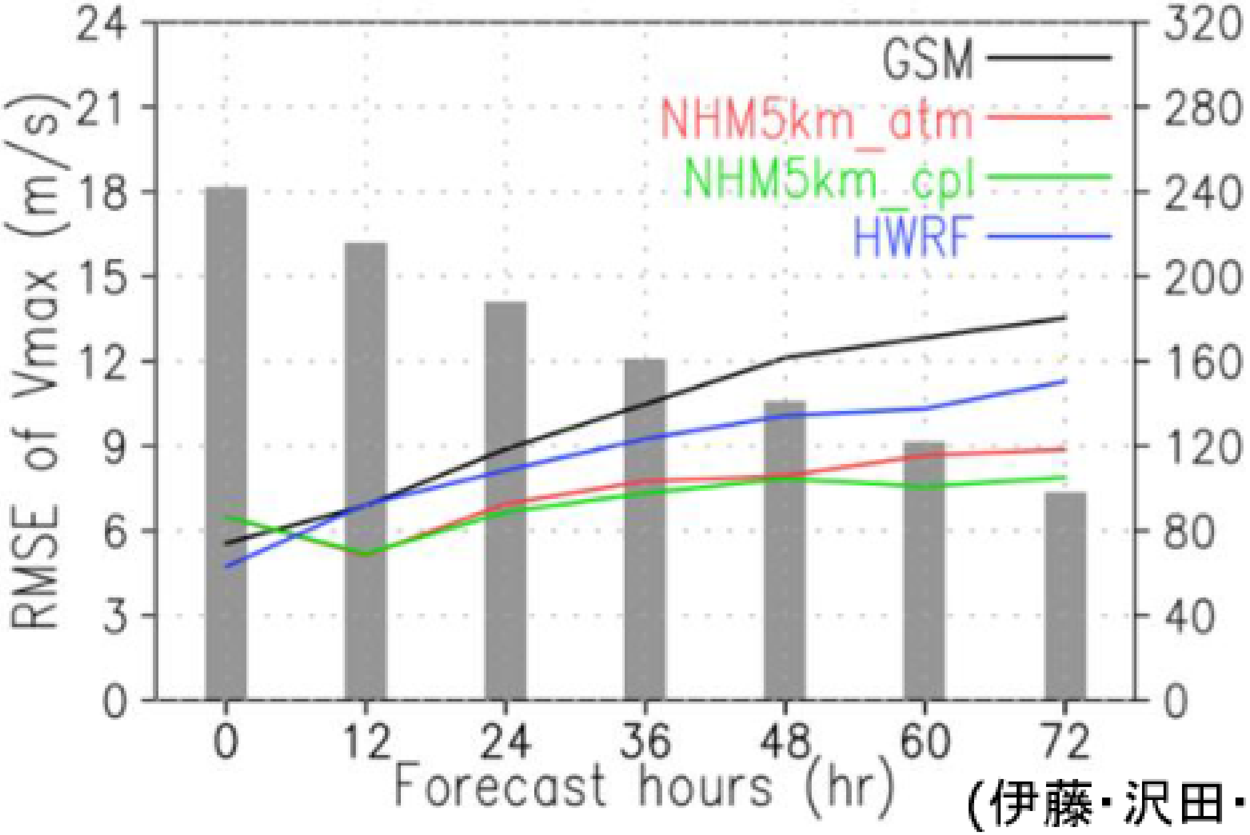


(⊿x=5km, KF scheme, coupled model)

最大風速の予測誤差

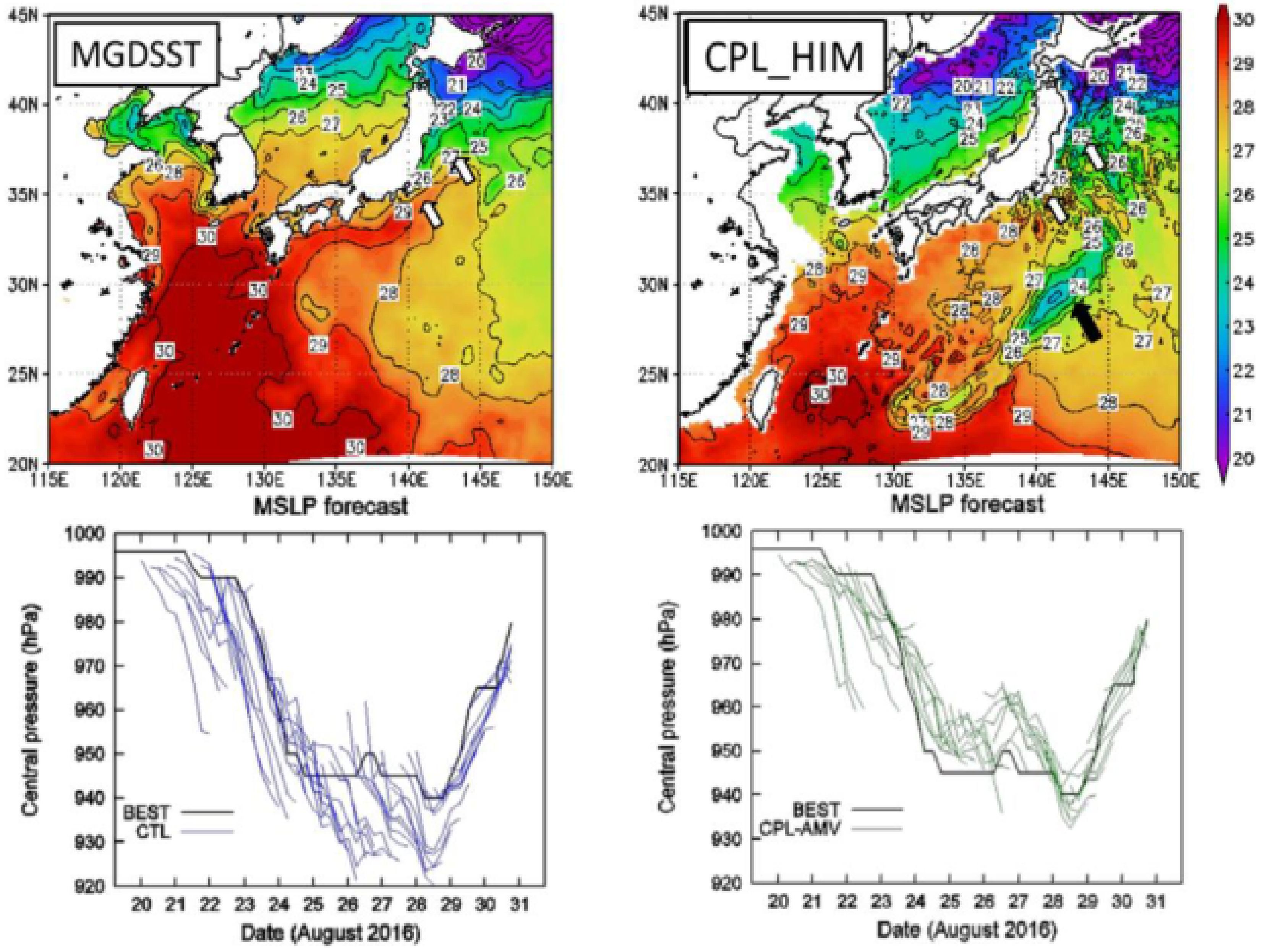
- 結合版NHMは予測精度がかなり良い。
- ただし、結果は指標(中心気圧・最大風速)に依存し、どのベストトラックに対して測るかで大きく異なる。

RMSE of Vmax (RSMC)



(伊藤・沢田・山口, submitted)

最近の進展(2)：大気海洋結合LETKF



(国井ら, 気象研・琉球大・JAMSTECプレスリリース, 2017/01)

Part 5はここまで

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