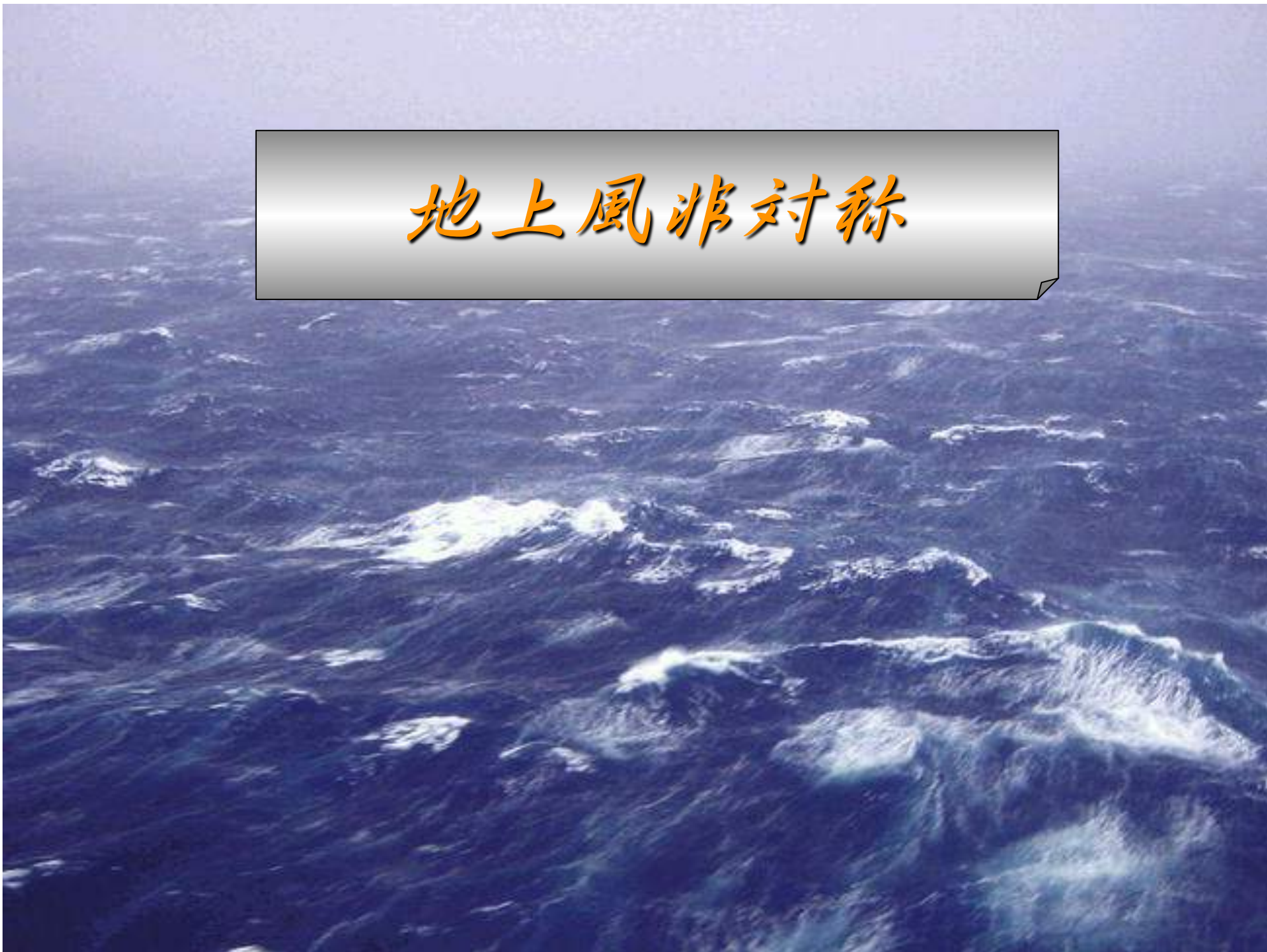


地上風非对称

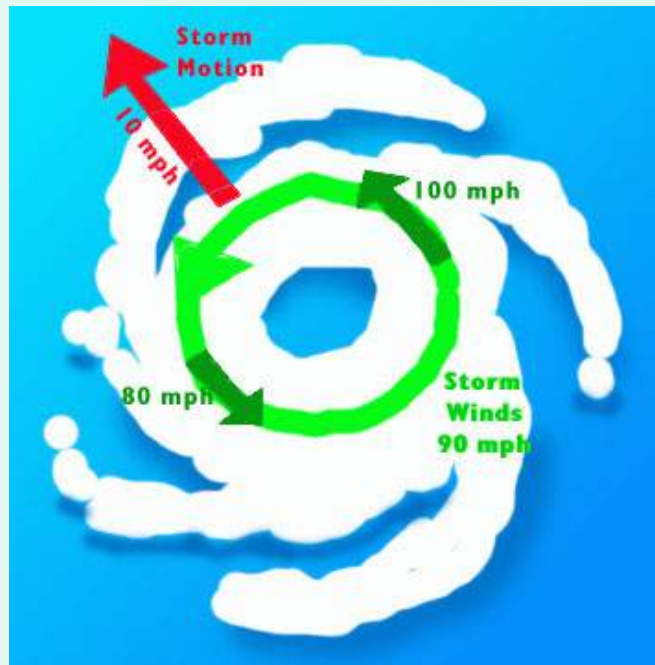


移動方向右（左）側でより風が強い（弱い）

from HRD/FAQ

Question. Why are the strongest winds in a hurricane typically on the right side of the storm?

Answer. In general, the strongest winds in a hurricane are found on the right side of the storm because the motion of the hurricane also contributes to its swirling winds. A hurricane with a 90 mph winds while stationary would have winds up to 100 mph on the right side and only 80 mph on the left side if it began moving (any direction) at 10 mph. 下



Emanuel et al. (2004) 下

To account for the contribution of the storm's translation speed to the maximum wind speed, we subtract a specified fraction of the former from the latter, to obtain the purely circular component of the maximum wind speed. Experience has shown that subtracting the full translation speed from the reported maximum wind speed often results in a system that is too weak. Here we take the specified fraction to be 0.4. In subsequent comparisons of model and observed wind speed, this contribution from the translation speed is added back to the model output. 下

❖ Parametric wind modelへの台風移動効果の導入例(

Xie et al. (2006) 下

$$V = V_s + 0.5V_{trans} \sin \beta$$

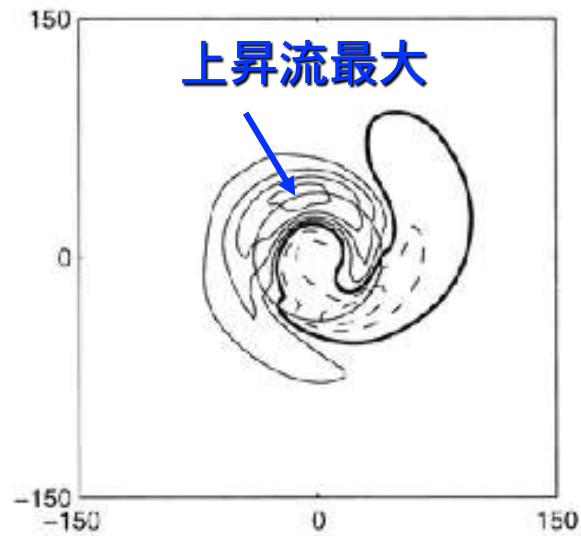
MacAfee et al. (2006) 下

$$V = \left\{ (-V_s \cos \beta)^2 + \left[V_s \sin \beta + \frac{V_{trans} r_{max} r}{r_{max}^2 + r^2} \right]^2 \right\}^{1/2}$$

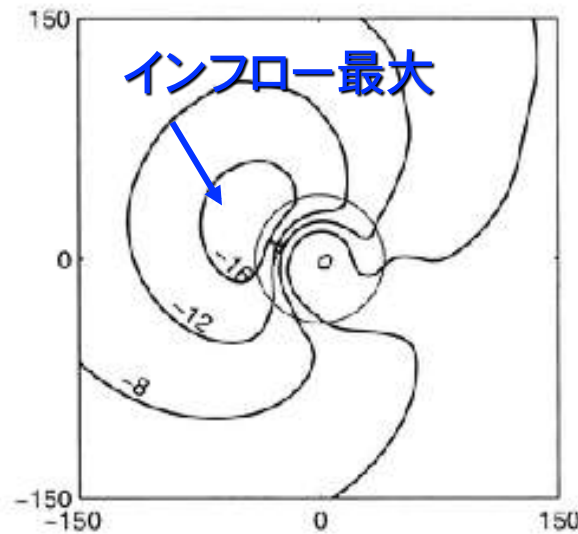
台風移動に伴う非対称摩擦の影響のみを調べた数値実験の結果

Kepert and Wang (2001)

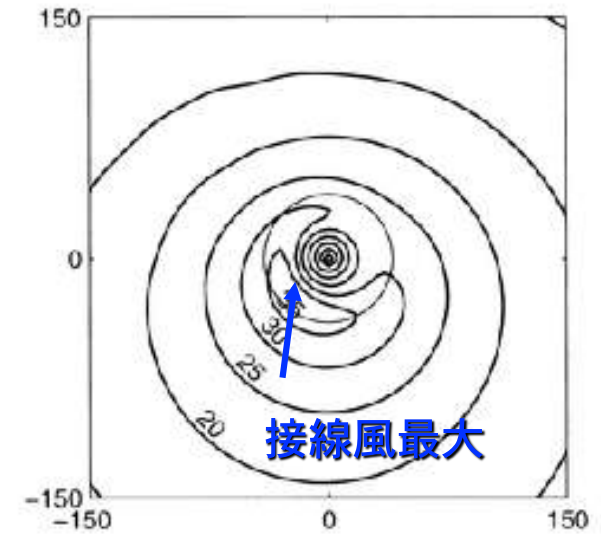
← 5m/s



2km高度での鉛直流



移動に相対的な動径風



移動に相対的な接線風

◆ 台風渦の移動速度が同程度の場合について
境界層内の風分布に対する環境風の鉛直構造
の影響を調べる

初期の環境風が異なる3通りの実験を実施

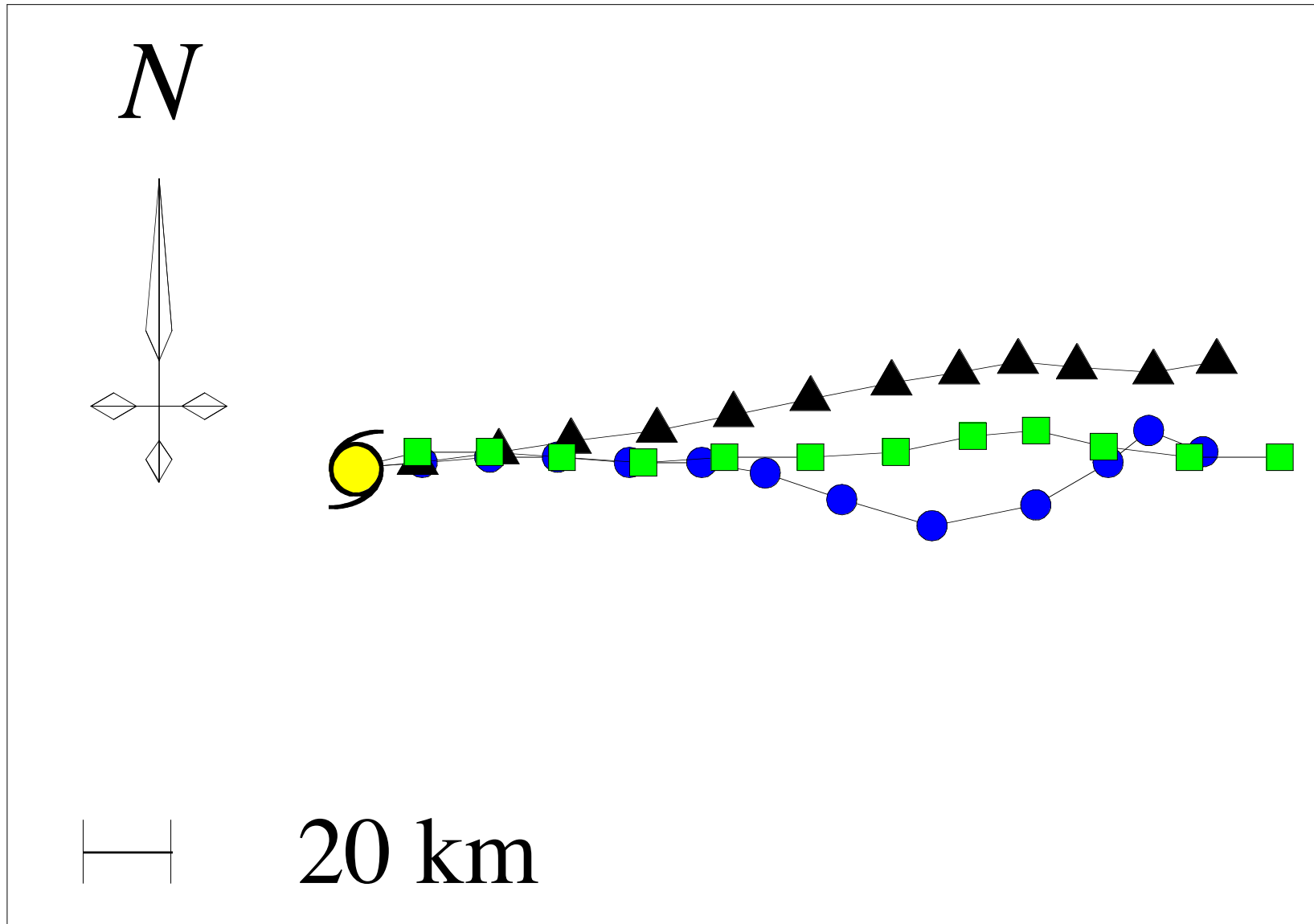
NSH: 水平鉛直に一樣 (4.2m/s)

SH1: 風向は西風で風速は高さとともに増加

SH2: 風速は一定で風向は南西風(下層)
から北西風(上層)へと徐々に変化

* 200-850 hPaで評価したシアーの大きさは9m/s (SH1)
および6m/s (SH2)

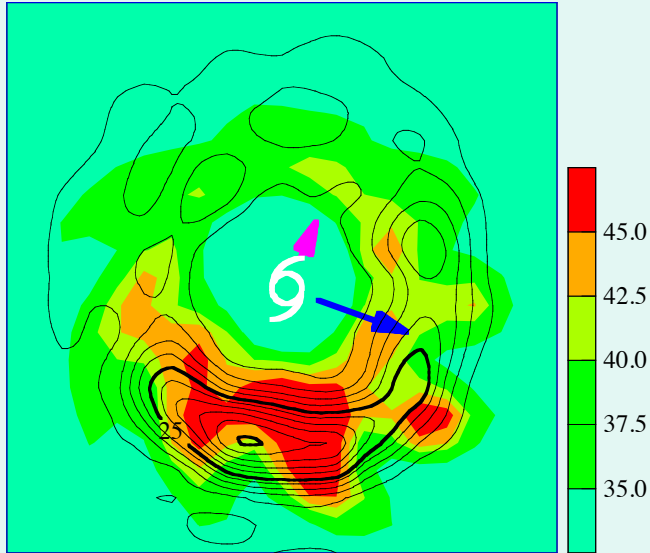
Vertical Shear Exp. FT=0-12HR



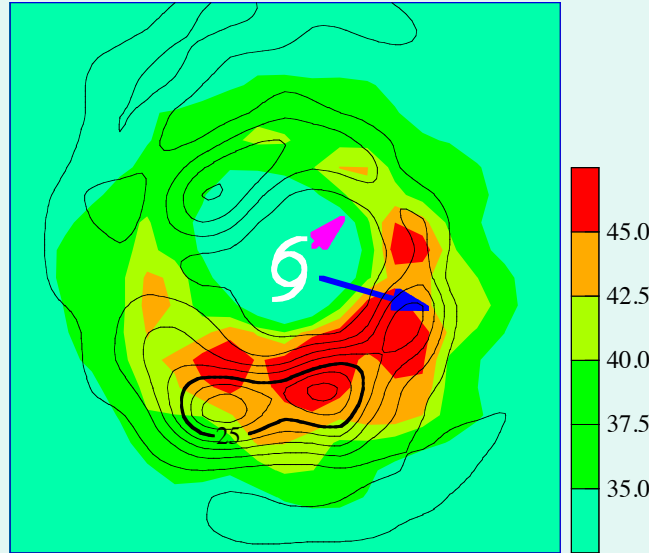
● : NSH ▲ : SH1 ■ : SH2

NSH (シアー無し)

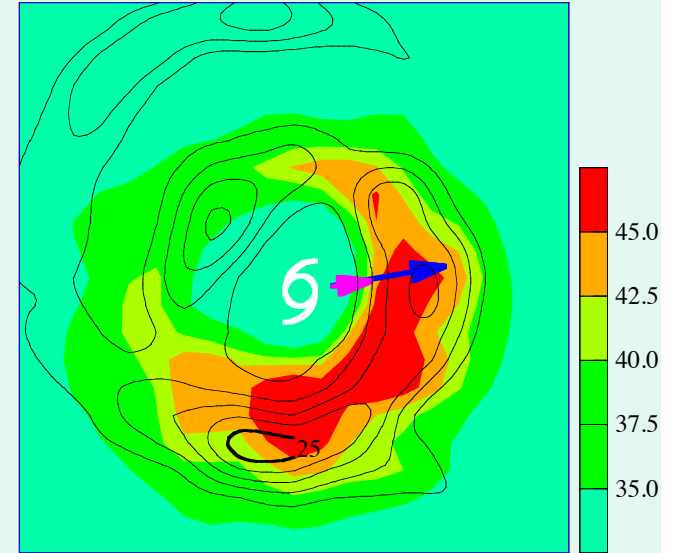
FORECAST HOUR = 7



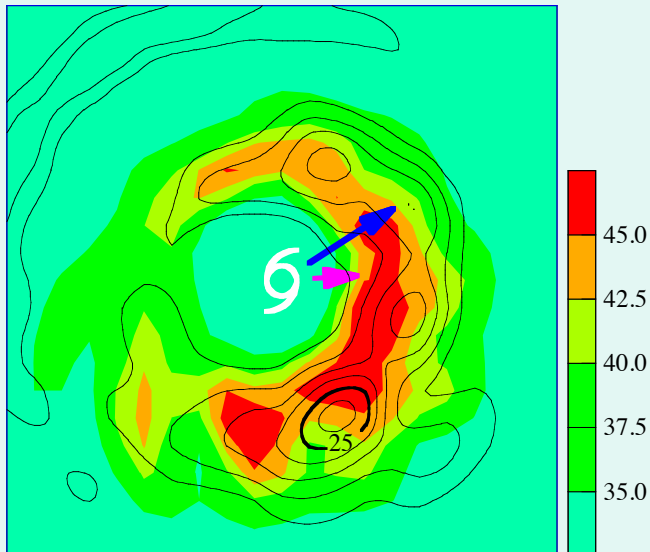
FORECAST HOUR = 8



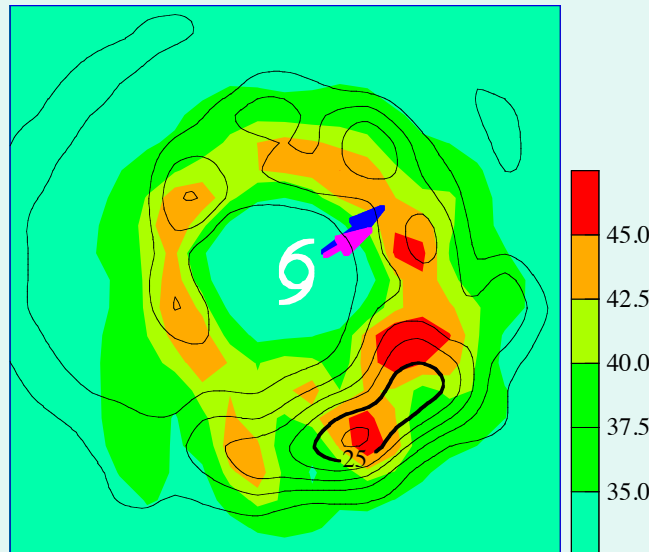
FORECAST HOUR = 9



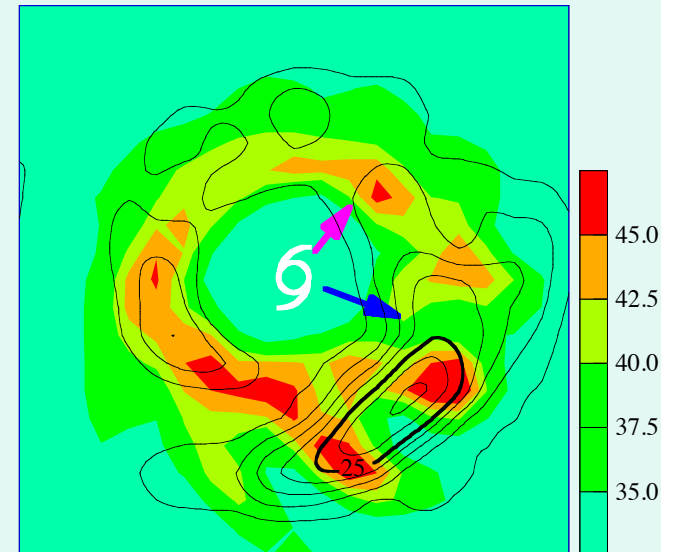
FORECAST HOUR = 10



FORECAST HOUR = 11

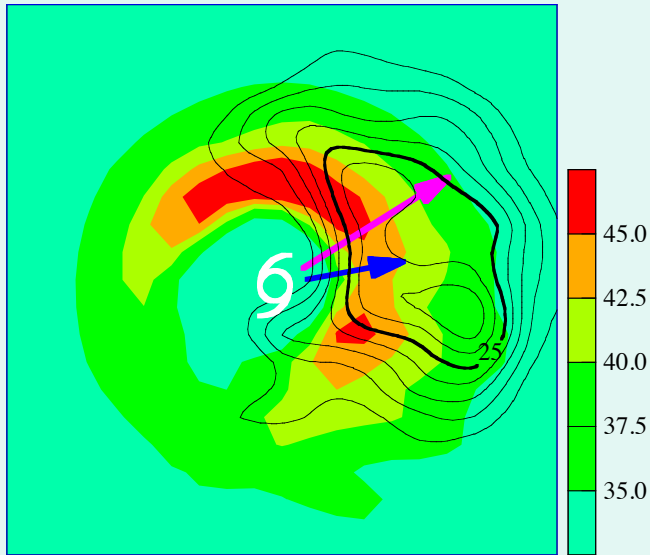


FORECAST HOUR = 12

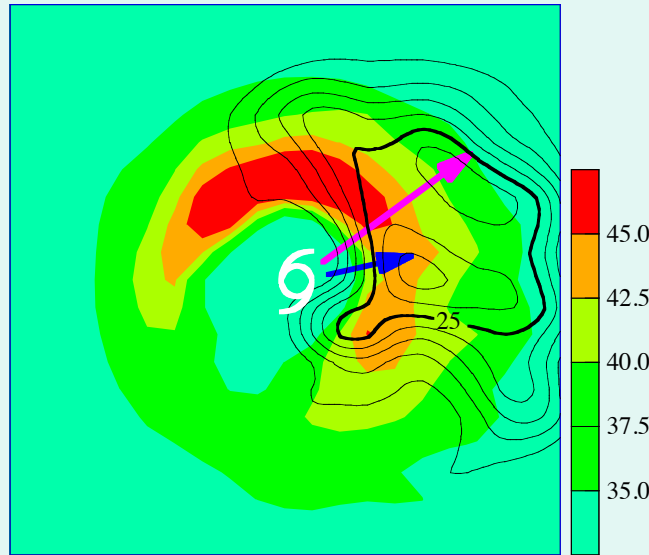


SH1 (風速シアー)

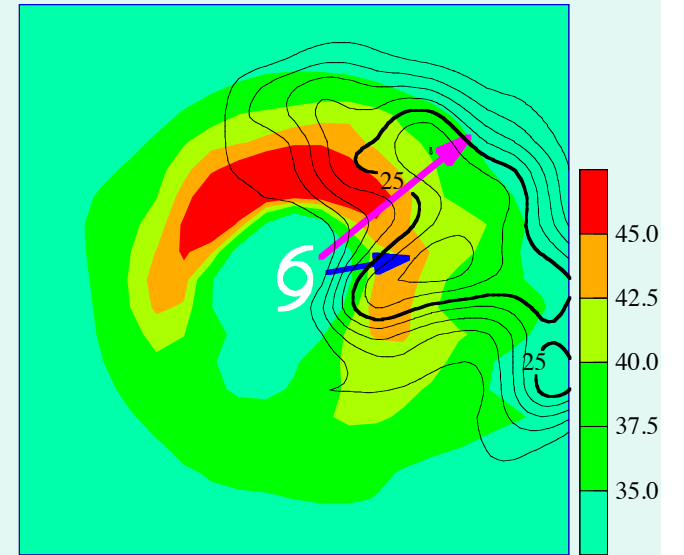
FORECAST HOUR = 7



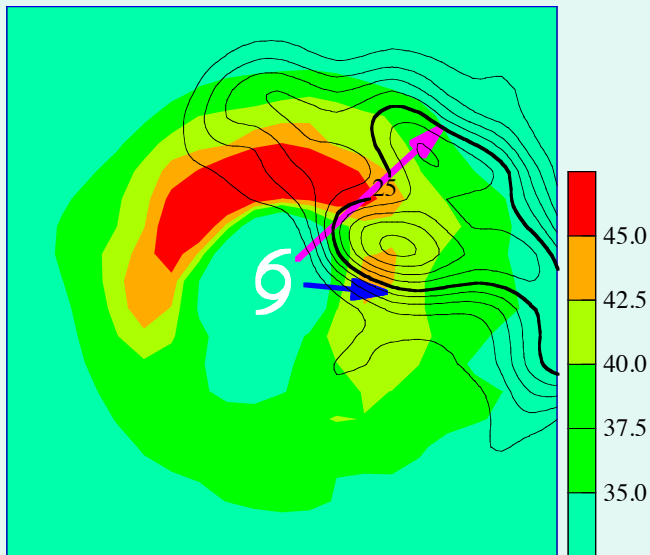
FORECAST HOUR = 8



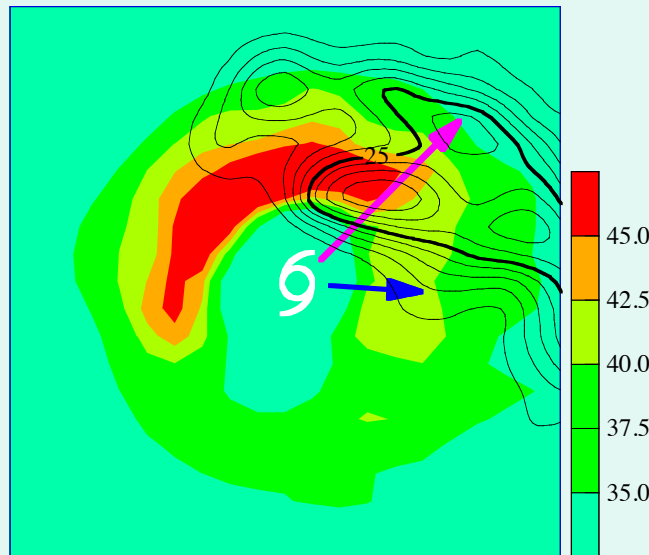
FORECAST HOUR = 9



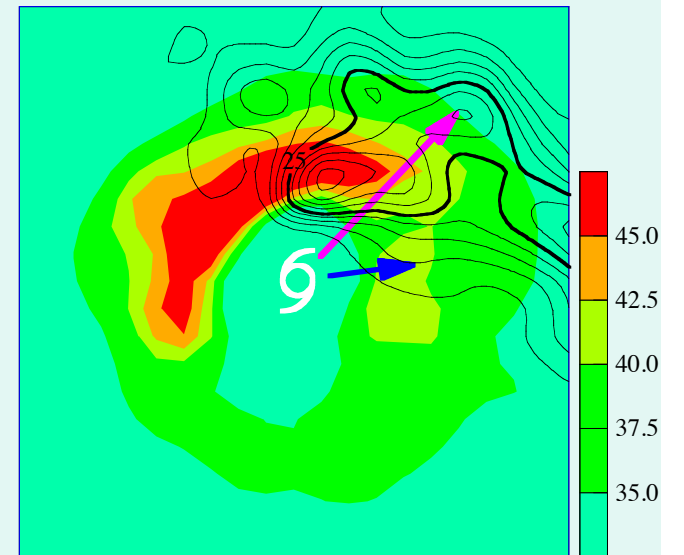
FORECAST HOUR = 10



FORECAST HOUR = 11

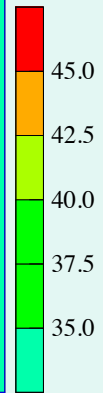
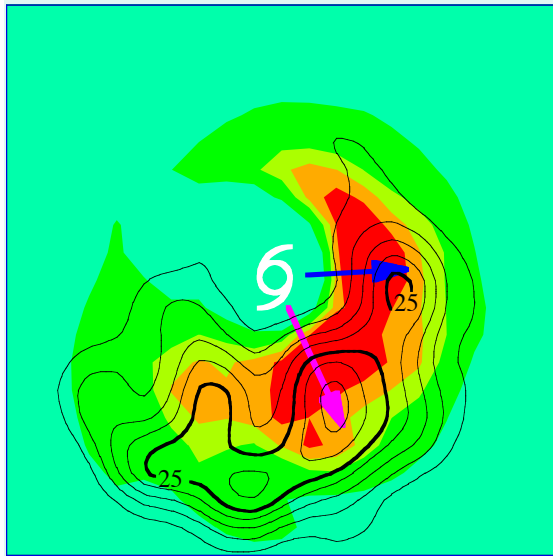


FORECAST HOUR = 12

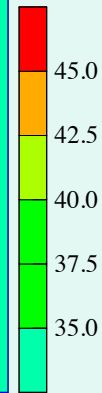
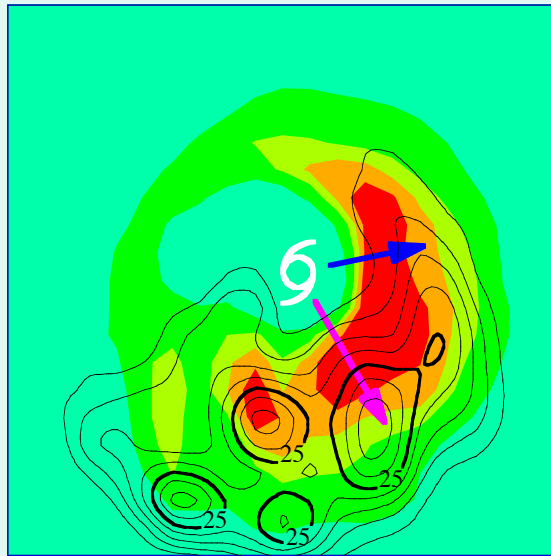


SH2 (風向シアー)

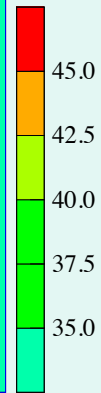
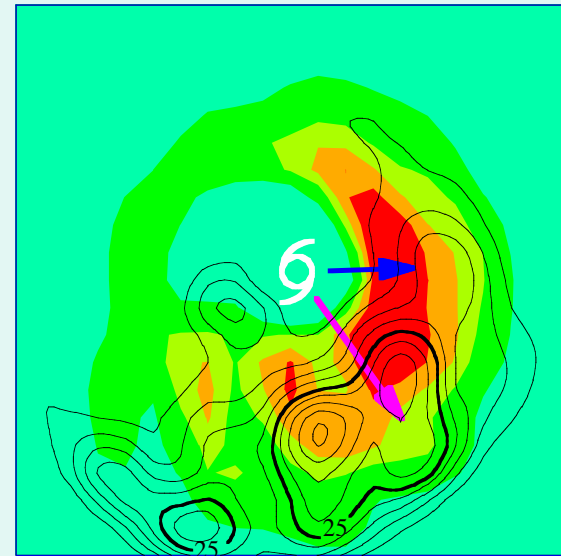
FORECAST HOUR = 7



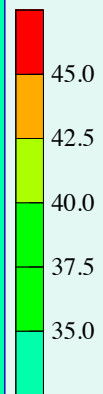
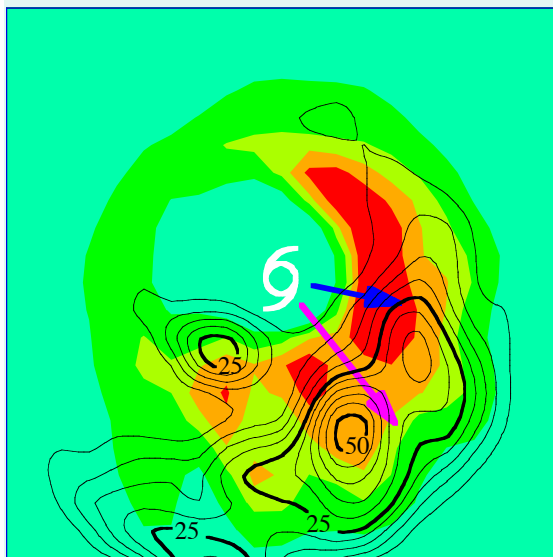
FORECAST HOUR = 8



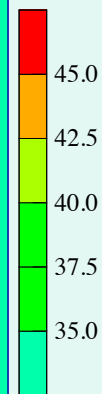
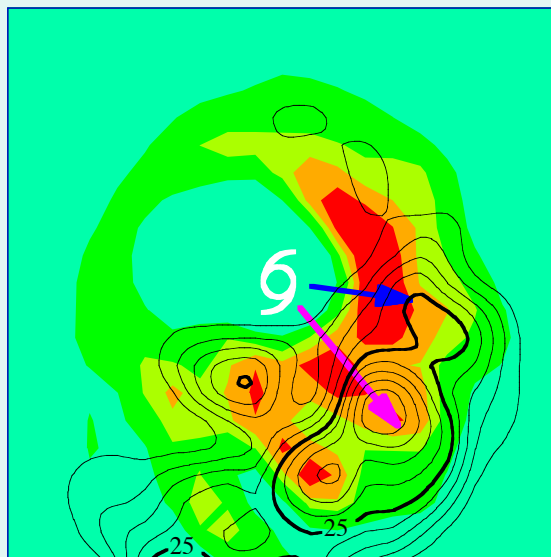
FORECAST HOUR = 9



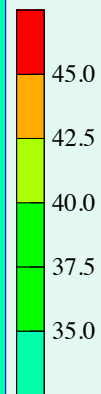
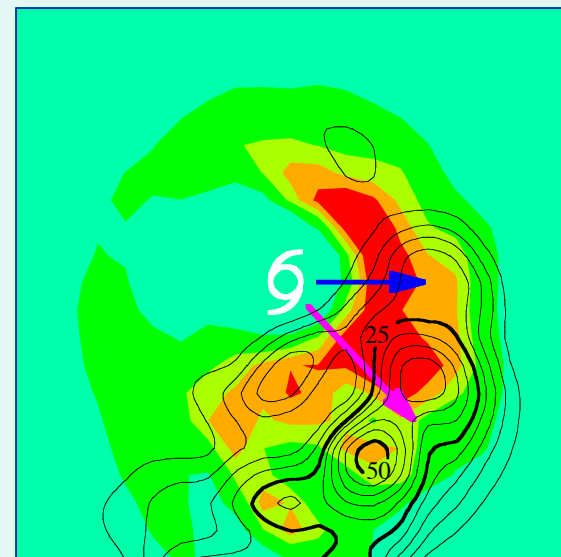
FORECAST HOUR = 10



FORECAST HOUR = 11

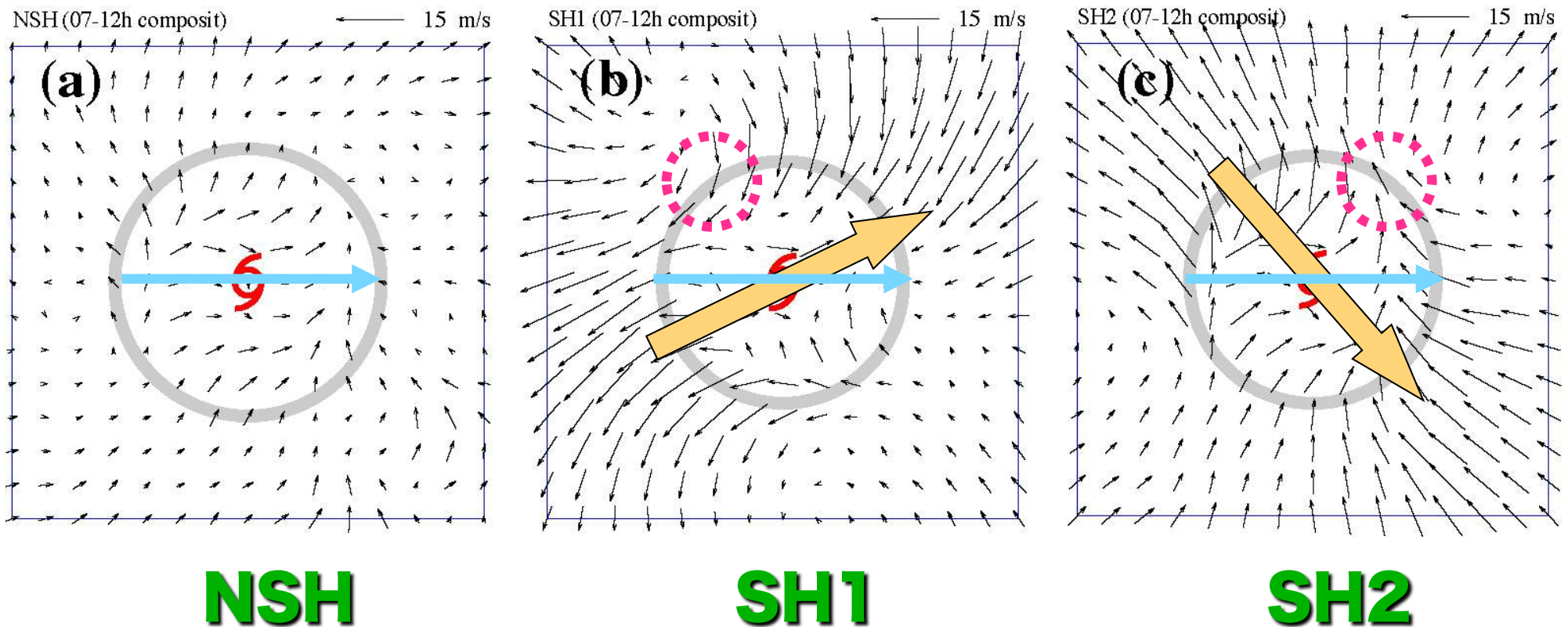


FORECAST HOUR = 12



モデル最下層の風の非対称成分

(理想実験6~12hのコンポジット)

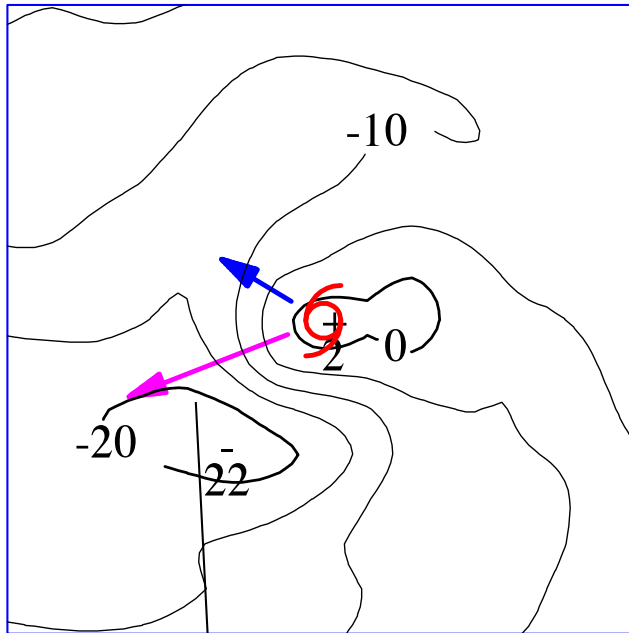


接線風はダウンシアー左側で増加

地上風動徑・接線成分 (from Chaba's simulation) 下

動徑風

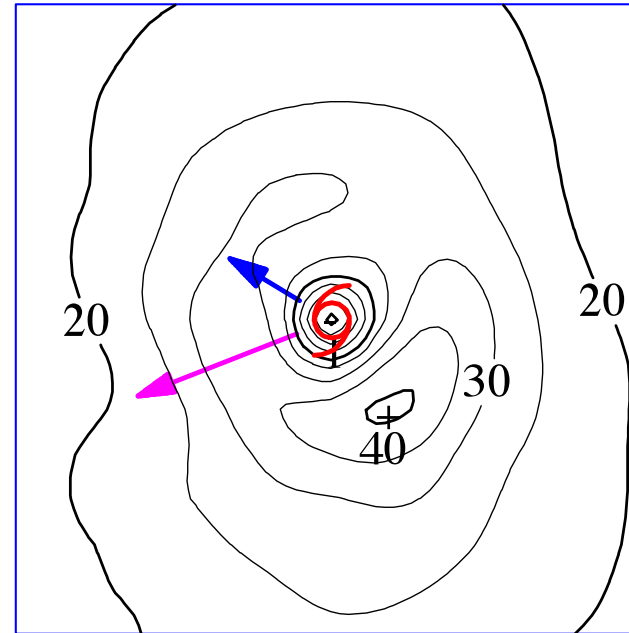
24 - 30 h



Tangential winds are more strongly accelerated in the stronger inflow region

接線風

24 - 30 h



Under the assumption that WN1 wind fields are quasi-steady in storm-relative coordinates, tangential winds are expected to be strongest 90 degree downwind of maximum inflow

移動座標系での運動方程式動径成分

$$\left(\frac{\partial u}{\partial t}\right)_1 = -u_1 \frac{\partial u_0}{\partial r} - u_0 \frac{\partial u_1}{\partial r} - \frac{v_0}{r} \frac{\partial u_1}{\partial \lambda} - w_1 \frac{\partial u_0}{\partial z} - w_0 \frac{\partial u_1}{\partial z} + \left(f_0 + \frac{2v_0}{r}\right)v_1 - \left(\frac{1}{\rho} \frac{\partial p}{\partial r}\right)_1 - f_0 (c_x \sin \lambda - c_y \cos \lambda) + F_{u1} + N_{u1}$$

radius	lhs	1	2	3	4	5	6	7	8	9	10
RMW	16.7	25.7	20.9	80.9	7.5	2.2	101.0	27.5	2.4	22.2	20.8
RMW/2	18.5	8.7	11.2	41.6	8.5	3.7	86.4	8.7	2.4	13.4	22.4

移動座標系での運動方程式接線成分

$$\left(\frac{\partial v}{\partial t}\right)_1 = -u_0 \frac{\partial v_1}{\partial r} - u_0 \frac{v_1}{r} - \frac{v_0}{r} \frac{\partial v_1}{\partial \lambda} - w_1 \frac{\partial v_0}{\partial z} - w_0 \frac{\partial v_1}{\partial z} - \left(f_0 + \frac{v_0}{r} + \frac{\partial v_0}{\partial r}\right) u_1 - \left(\frac{1}{\rho r} \frac{\partial p}{\partial \lambda}\right)_1 - f_0 (c_y \sin \lambda + c_x \cos \lambda) + F_{v1} + N_{v1}$$

radius	lhs	1	2	3	4	5	6	7	8	9	10
RMW	10.8	16.2	14.0	49.3	8.1	4.5	87.5	16.9	2.4	15.5	16.4
RMW/2	15.1	8.8	5.3	42.5	2.8	3.2	75.3	6.9	2.4	13.2	23.7

Ad hoc Simplification of Momentum Equations

Radial Components

$$\underbrace{\frac{v_0}{r} \frac{\partial u_1}{\partial \lambda}}_{\text{Term}_3} - \underbrace{\left(f_0 + \frac{2v_0}{r} \right) v_1}_{\text{Term}_6} \approx 0$$

Tangential Components

$$\underbrace{\frac{v_0}{r} \frac{\partial v_1}{\partial \lambda}}_{\text{Term}_3} - \underbrace{\left(f_0 + \frac{v_0}{r} + \frac{\partial v_0}{\partial r} \right) u_1}_{\text{Term}_6} \approx 0$$

Continuity Equation

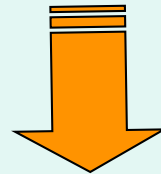
$$\frac{1}{r} \frac{\partial}{\partial r} (ru) + \frac{1}{r} \frac{\partial v}{\partial \lambda} + \frac{\partial w}{\partial z} = 0$$

Relationship between WN1 wind asymmetries 下

Mass Continuity Equation under the Boussinesq approx.



Momentum Equations in the storm-centered cylindrical coordinate system with an ad-hoc simplification



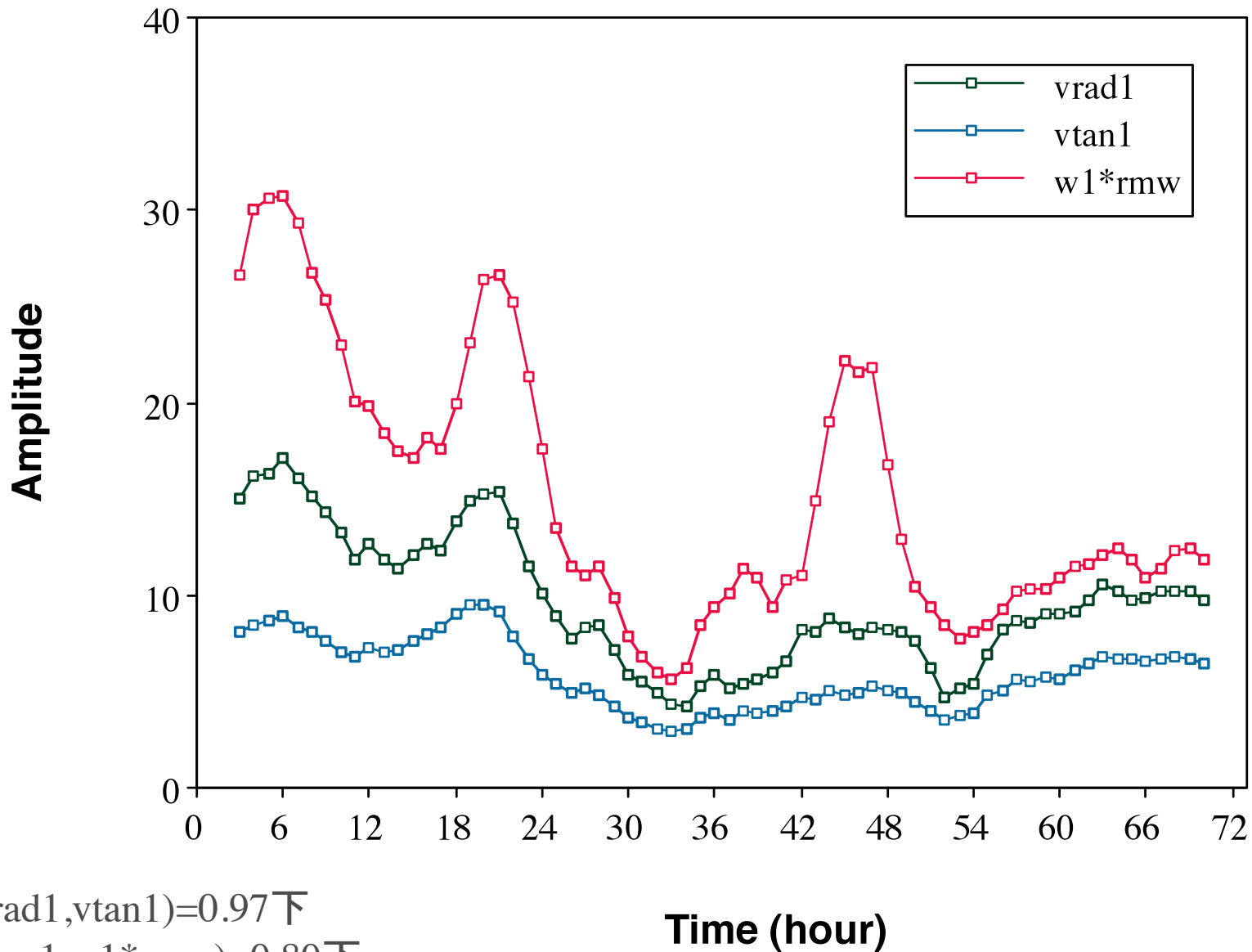
$$v_{am} = \frac{r_m}{(3\alpha - 1)h} w_{am}$$
$$u_{am} = \alpha v_{am}$$

Amplitude

$$\mu_u = \mu_v + 90^\circ$$
$$\mu_v = \mu_w + 90^\circ$$

Phase

実データ実験（振幅比較）

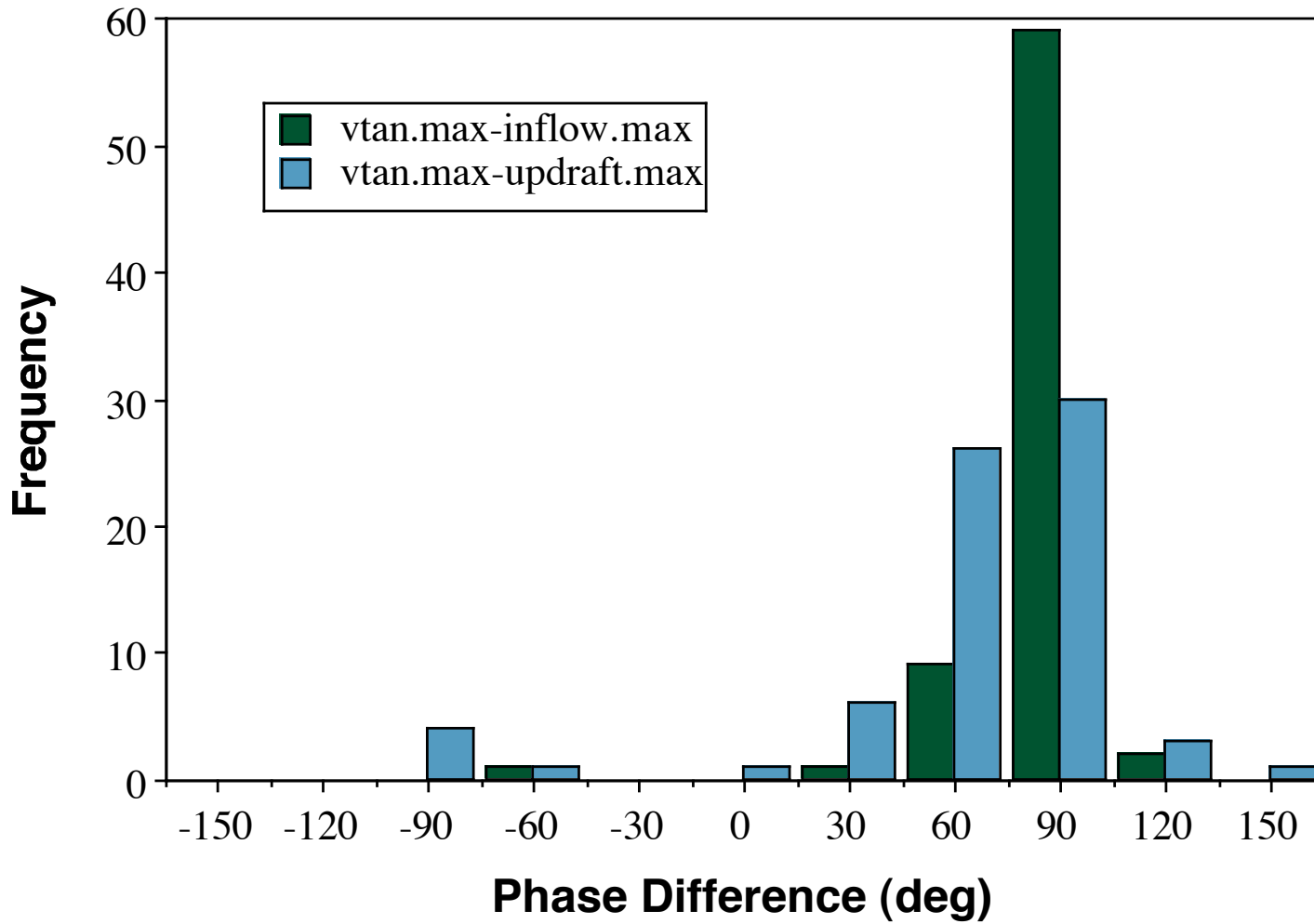


c.c.(vrad1,vtan1)=0.97下

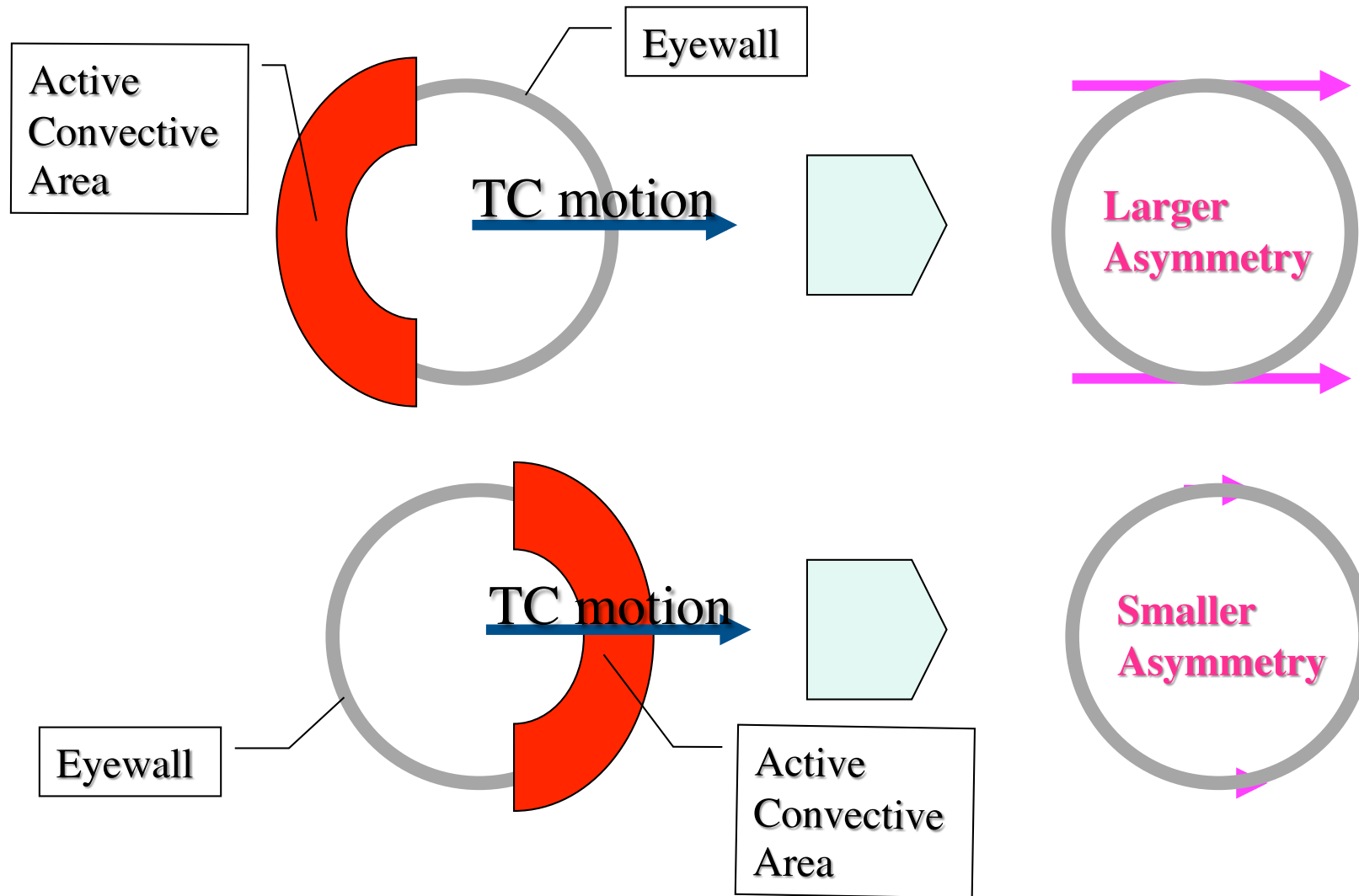
c.c.(vtan1,w1*rmw)=0.80下

Time (hour)

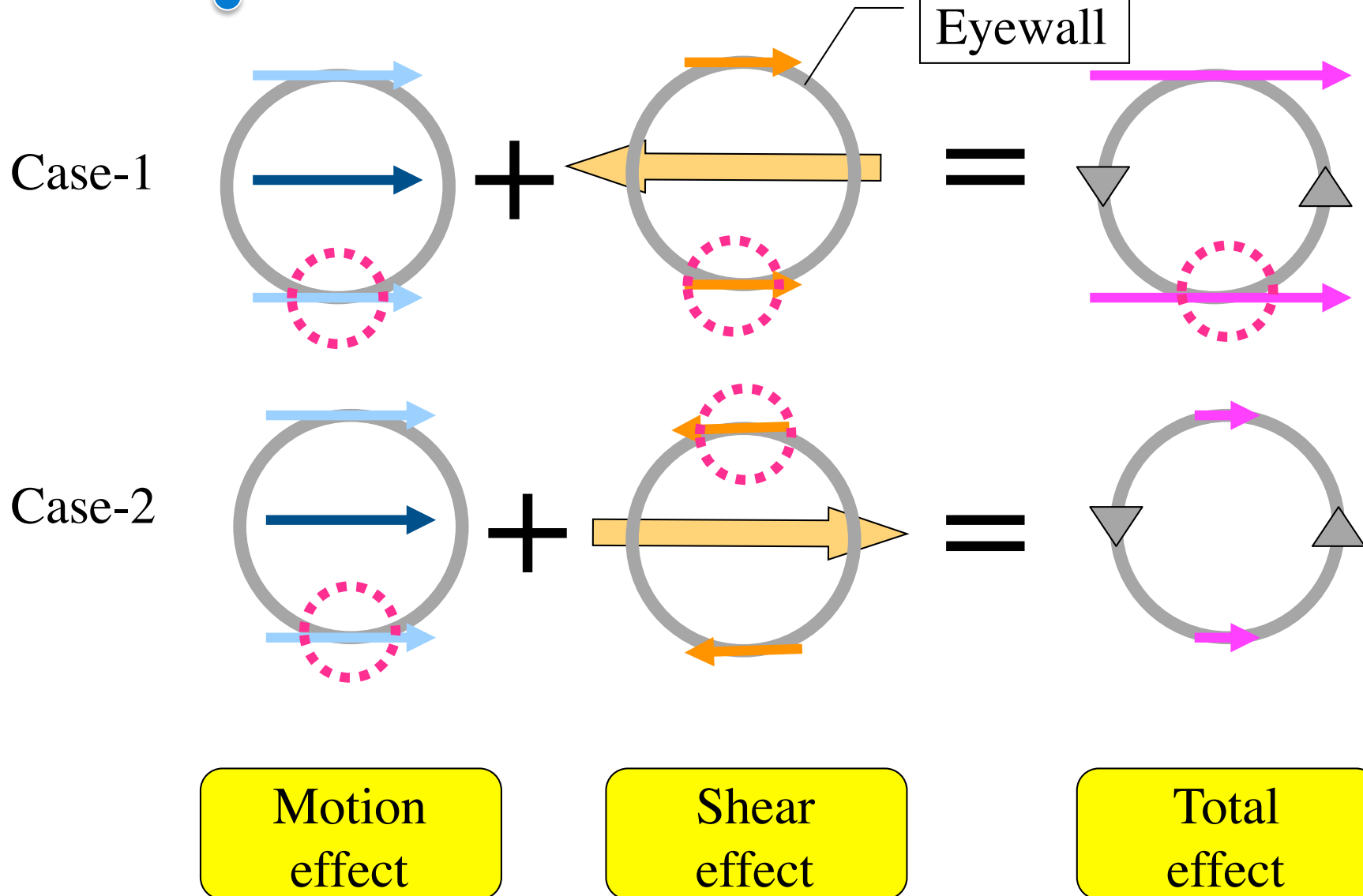
実データ実験 (位相関係)



Hypothesis for asymmetric components of near-surface tangential winds

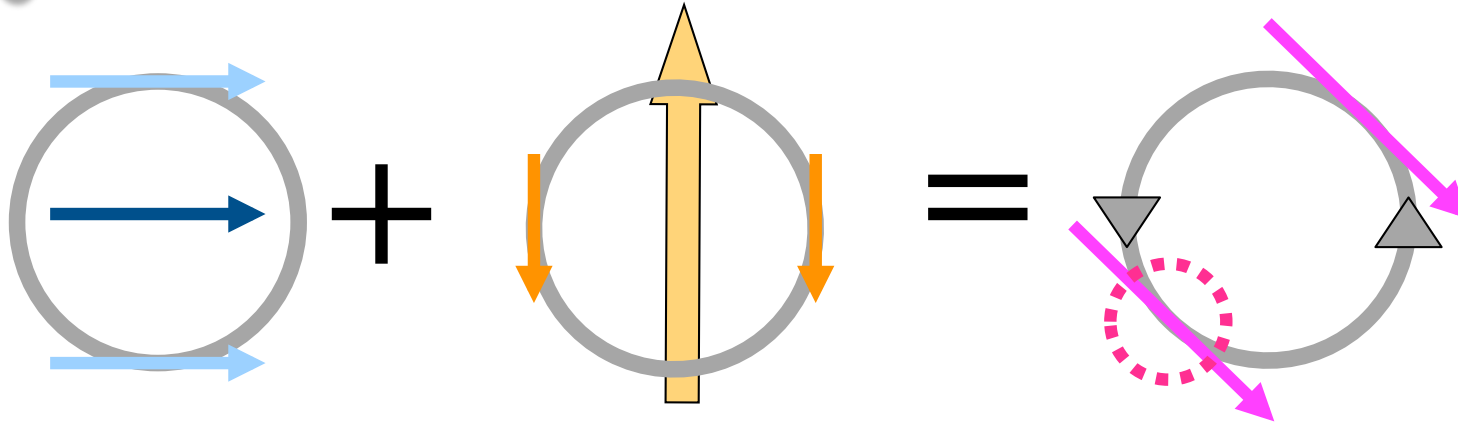


Hypothesis for asymmetric components of near-surface tangential winds

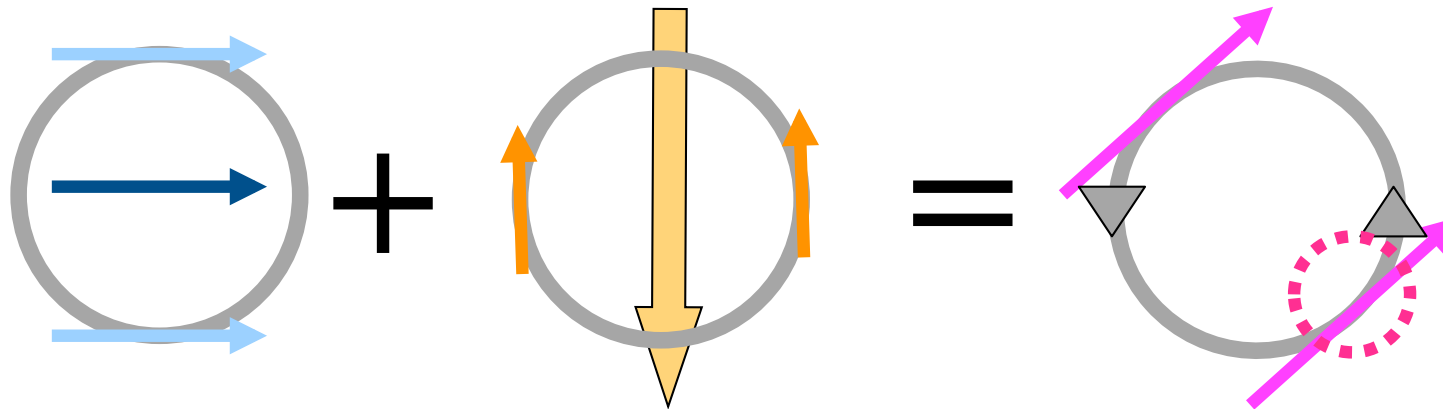


Hypothesis for asymmetric components of near-surface tangential winds

Case-3



Case-4



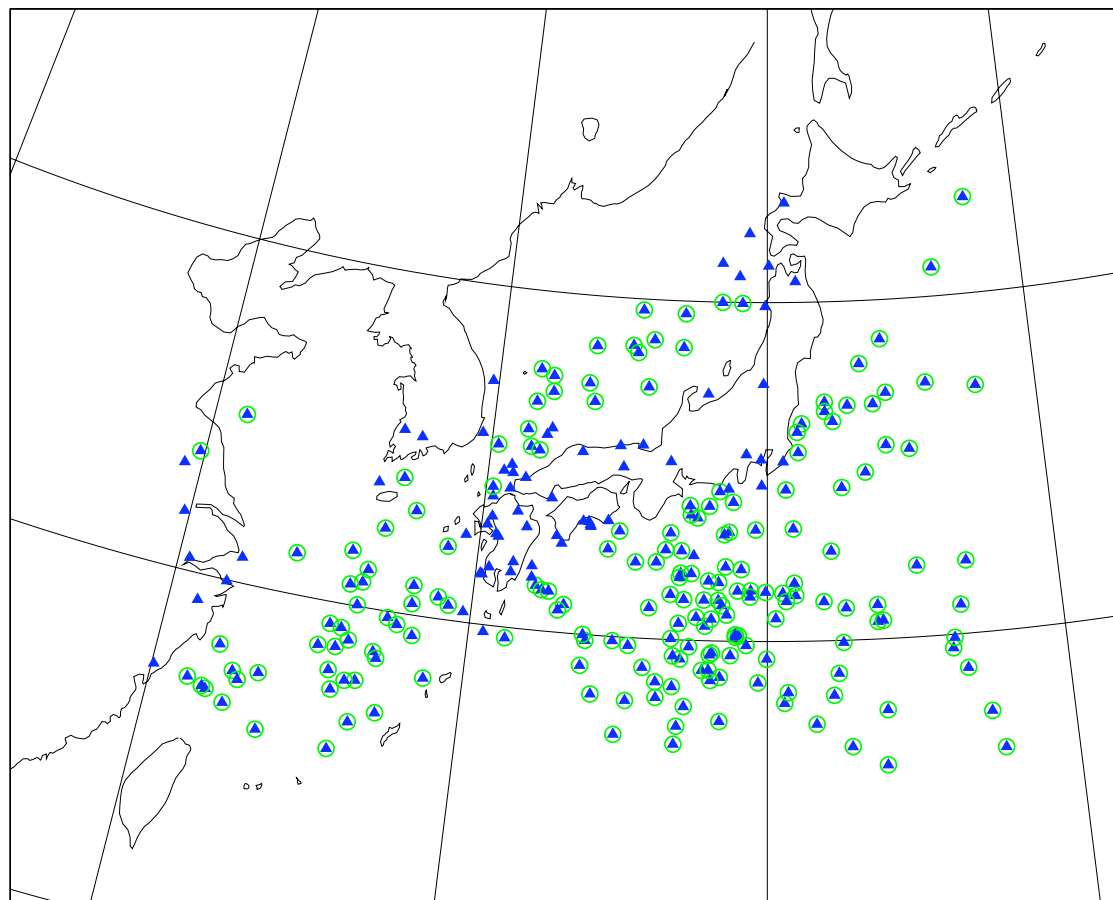
Motion
effect

Shear
effect

Total
effect

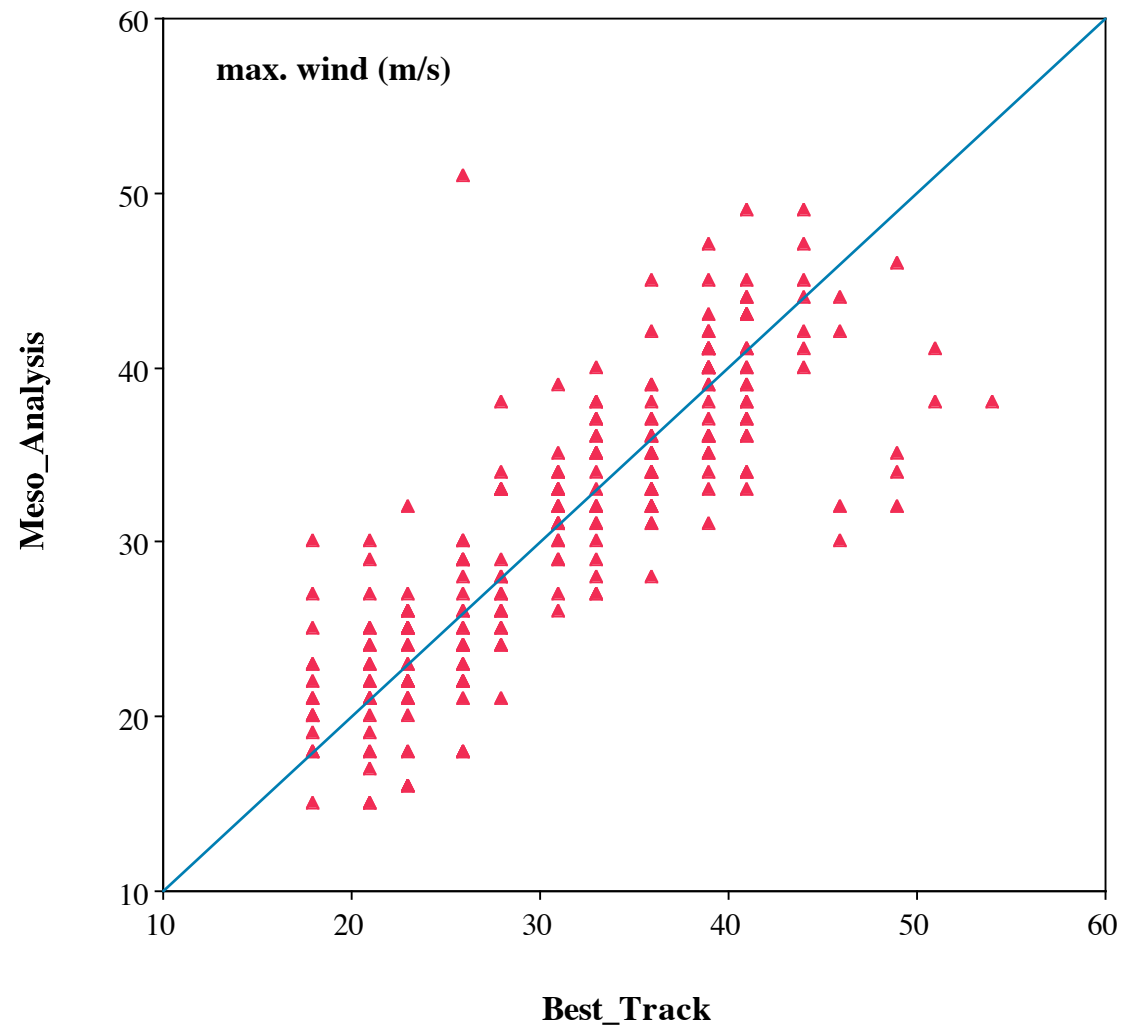
気象庁メソ解析値を利用した検証

(渦軸傾斜254事例, 地上風非対称190事例) 下



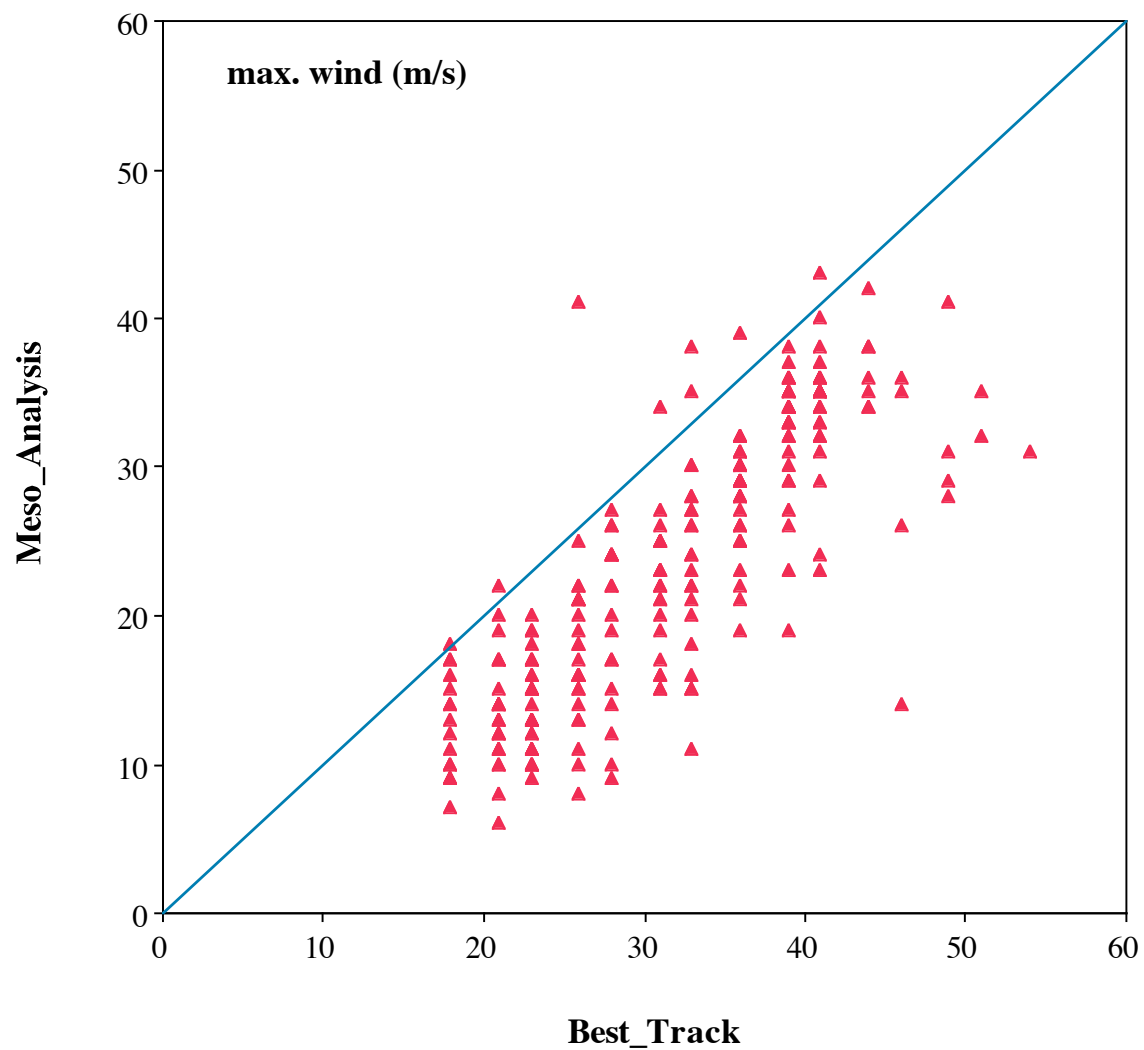
2004-2007年の台風シーズン(

最大風速 (メソ解析vsベストトラック)

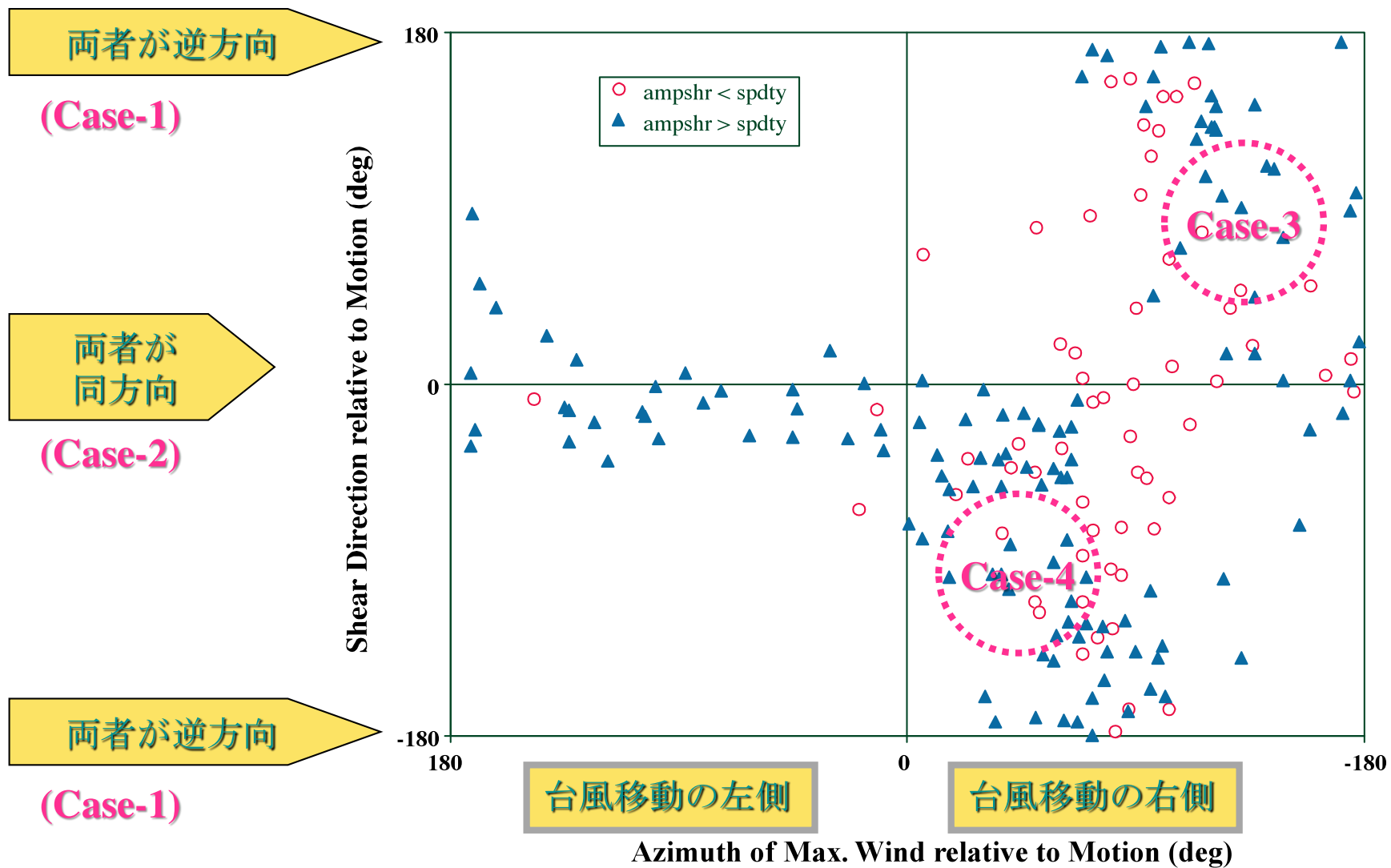


最大風速（メソ解析vsベストトラック）

（メソ解析については軸対称成分）（



接線風最大の出現方位と鉛直シアーの関係

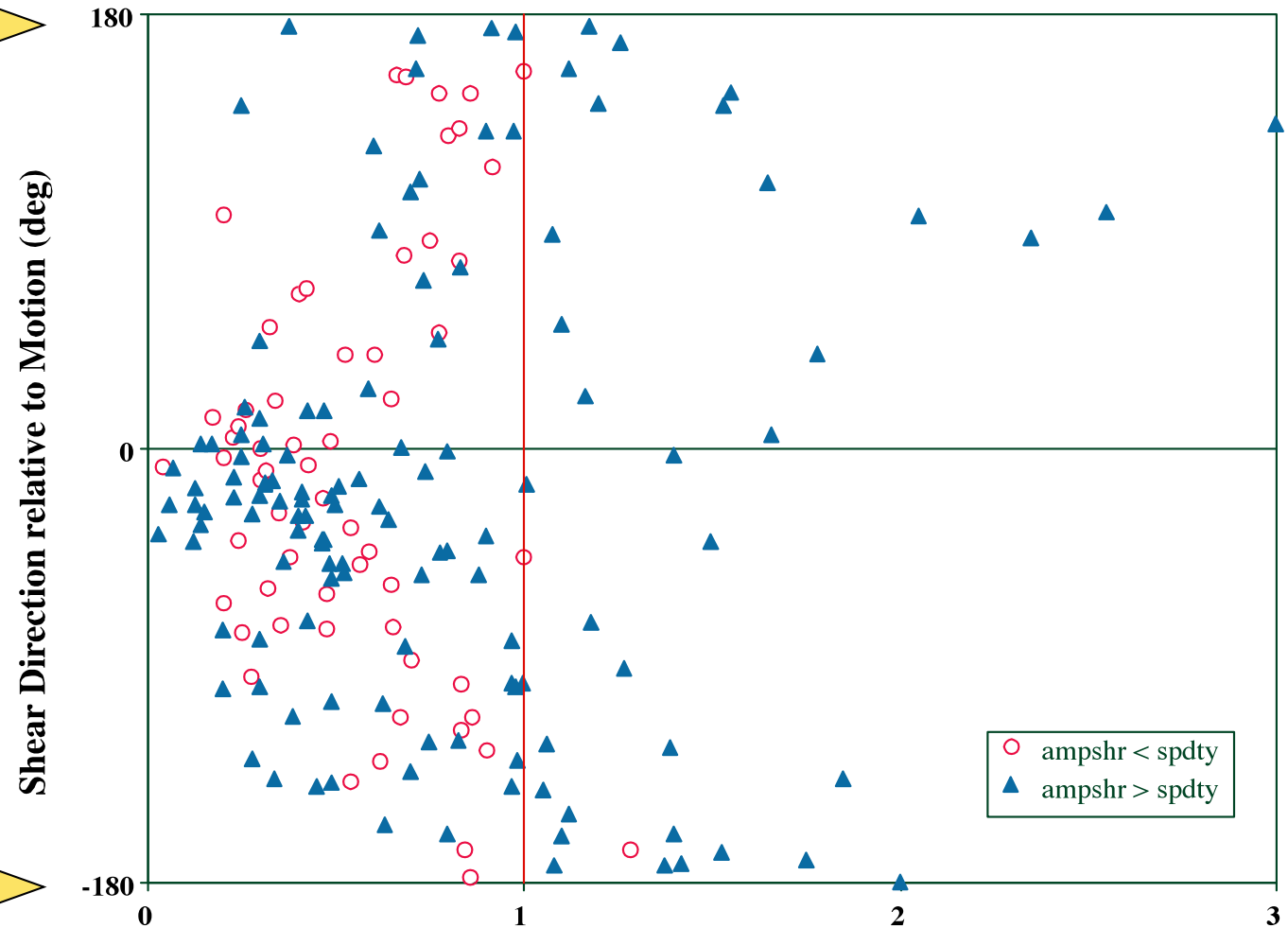


非対称接線風振幅の方向差への依存性

両者が逆方向

両者が同方向

両者が逆方向



Amplitude of WN1 tangential Wind Asymmetry normalized by TC Translation Speed

風速分布の具体事例

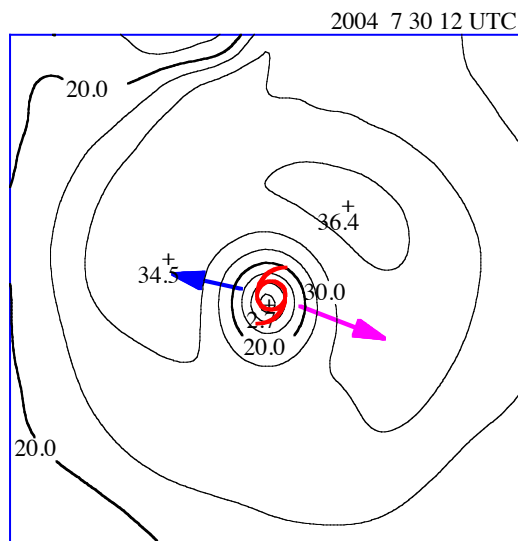
下記の条件を満たす事例のみに着目

- 最大風速半径が50~80kmの範囲内にある
- 最大風速が30m/sより大きい
- シアーの大きさと移動速度がともに5~15m/sの範囲内にある

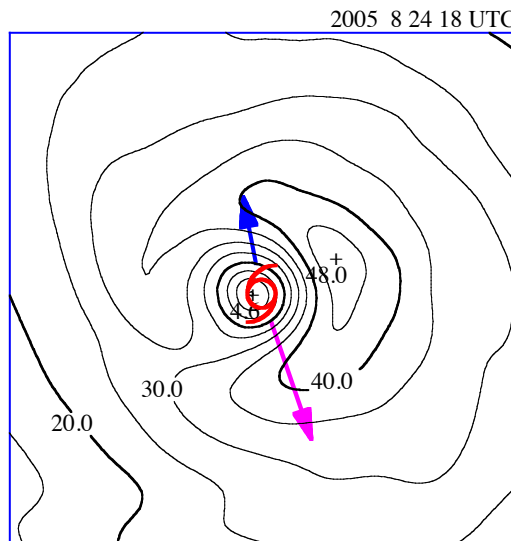


これらの条件を課すことにより190→33事例

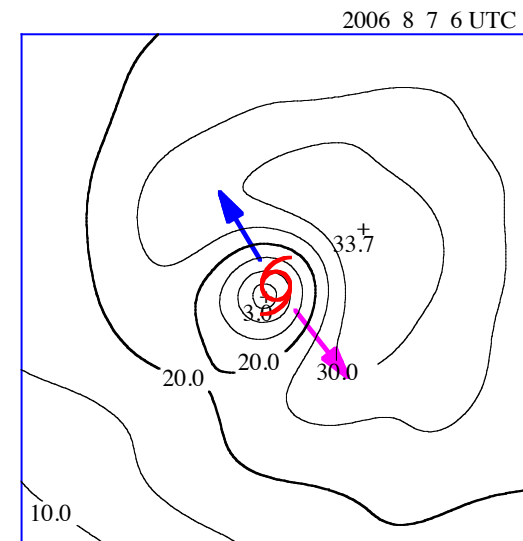
風速分布 (シアアの向きと移動方向が逆)



T0410 (NAMTHEUN)

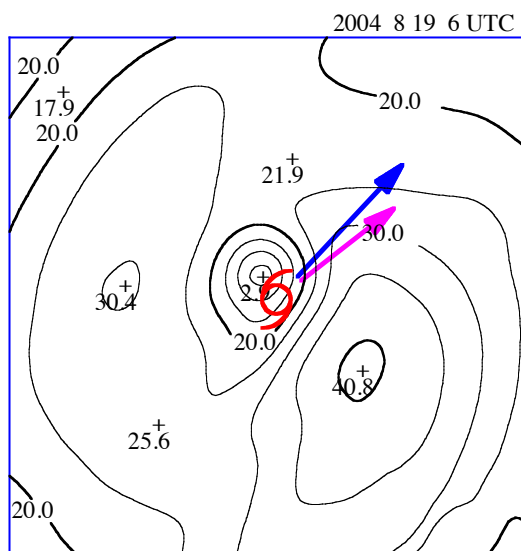


T0511 (MAWAR)

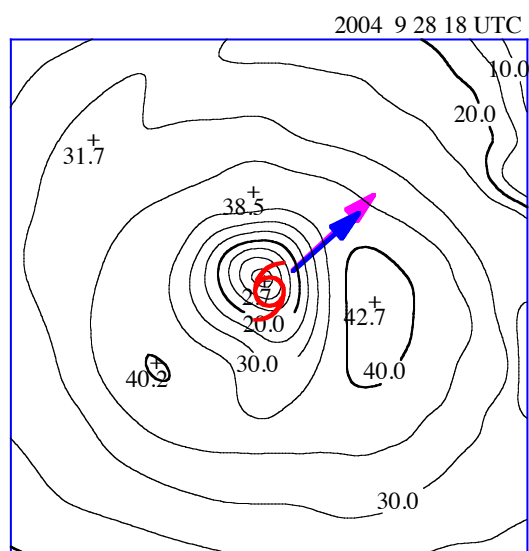


T0607 (MARIA)

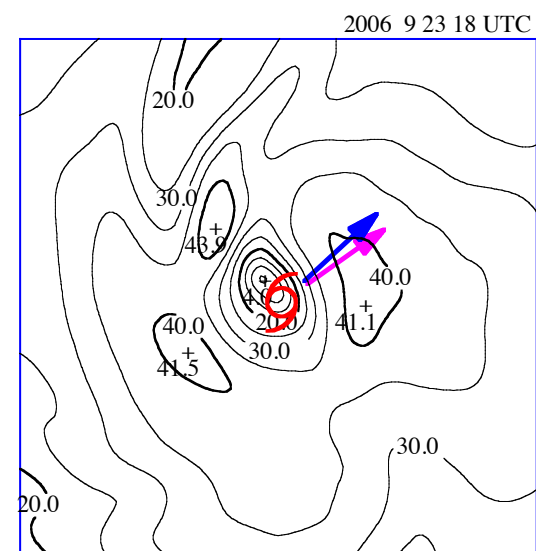
風速分布 (シアーの向きと移動方向が同じ)



T0415 (MEGI)



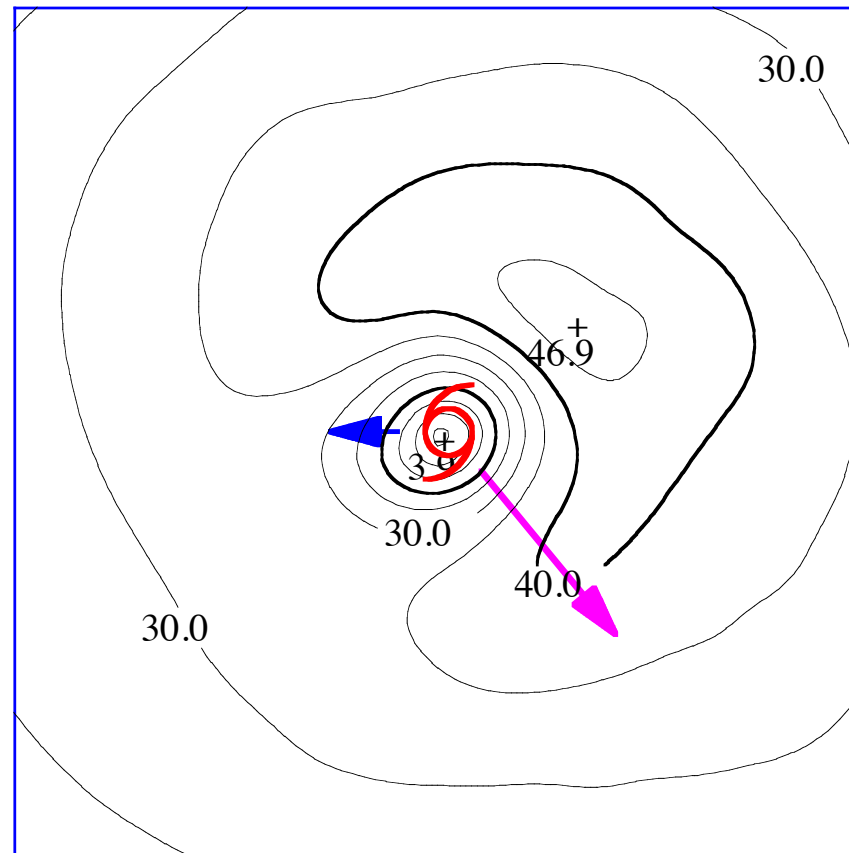
T0421 (MEARI)



T0614 (YAGI)

風速分布 (シアーが卓越)

2004 7 29 18 UTC



T0410 (NAMTHEUN)

QuikSCATデータを用いた解析

● 地上風、降水強度:RSS社公開データ

期間:1999~2008年

解像度:0.25緯度経度

短所:解像度が粗い

降水の悪影響

風向が低精度

内挿台風中心位置の使用

長所:モデルフリー

熱帯域もカバー

*RMW=50~150km

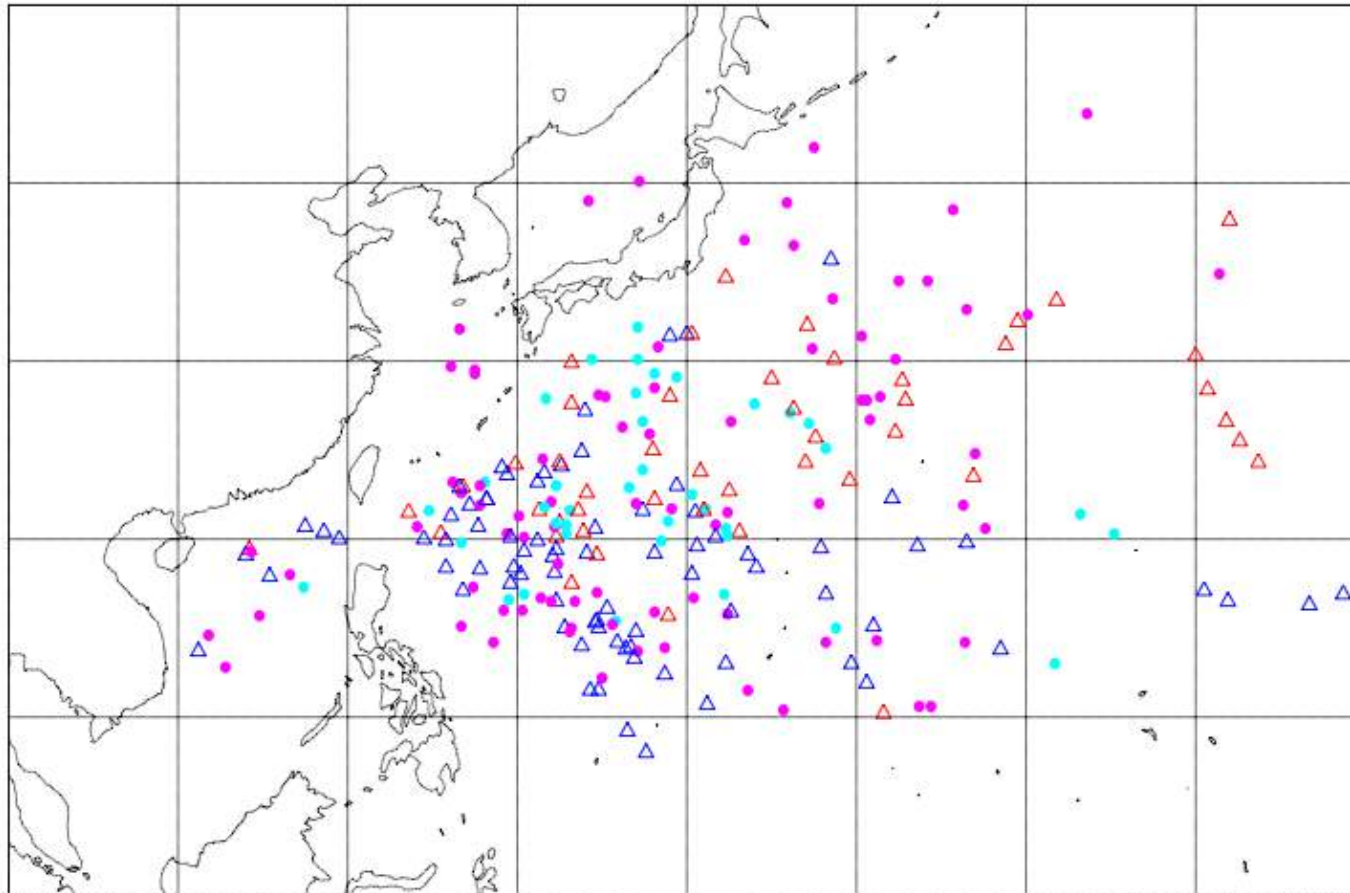
● 環境風の鉛直シアー:気象庁全球解析

期間:2004~2007年

解像度:1.25緯度経度

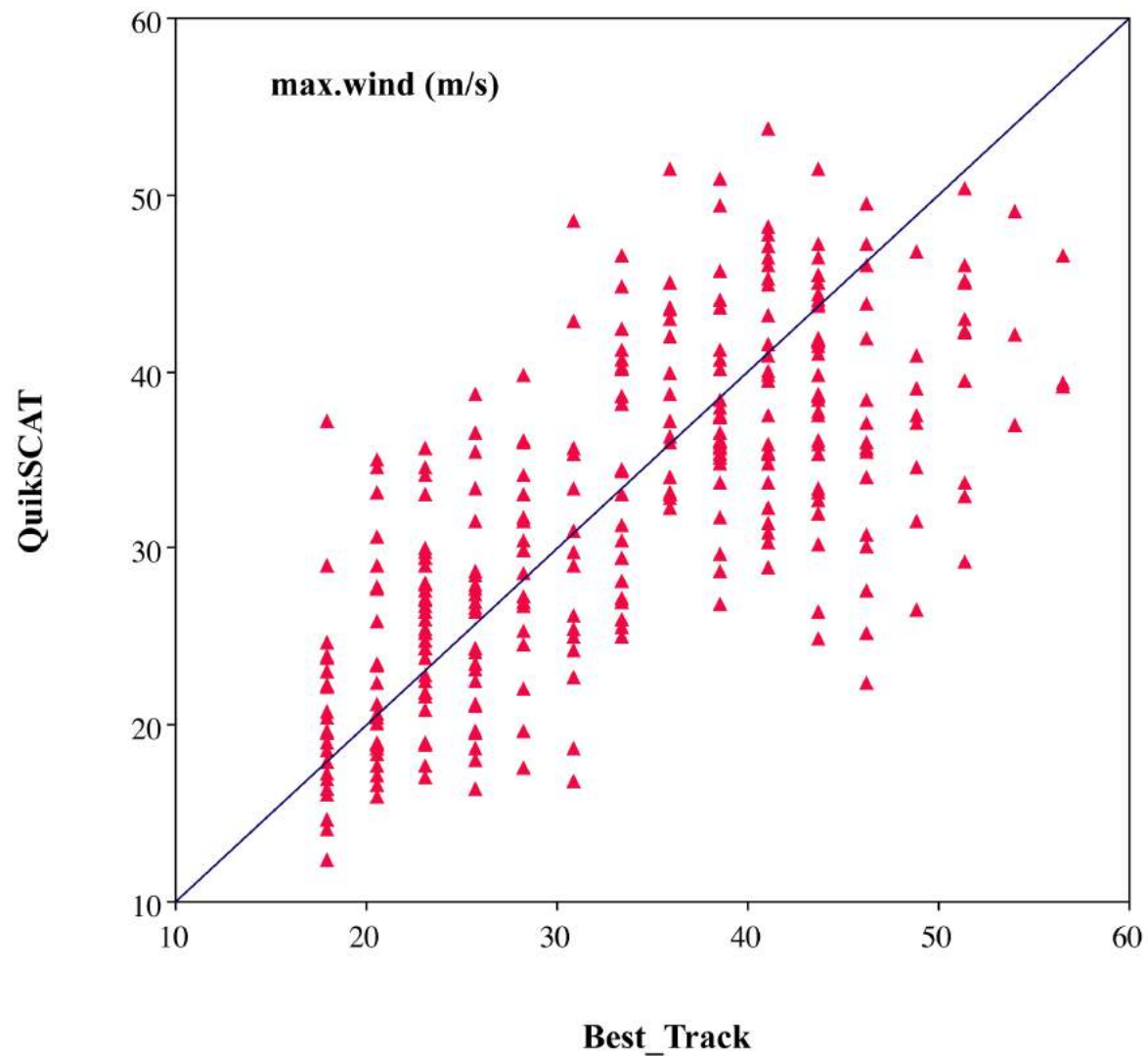
*半径300km平均風(200hPa-850hPa)

シアー解析に用いた台風事例 (252事例)

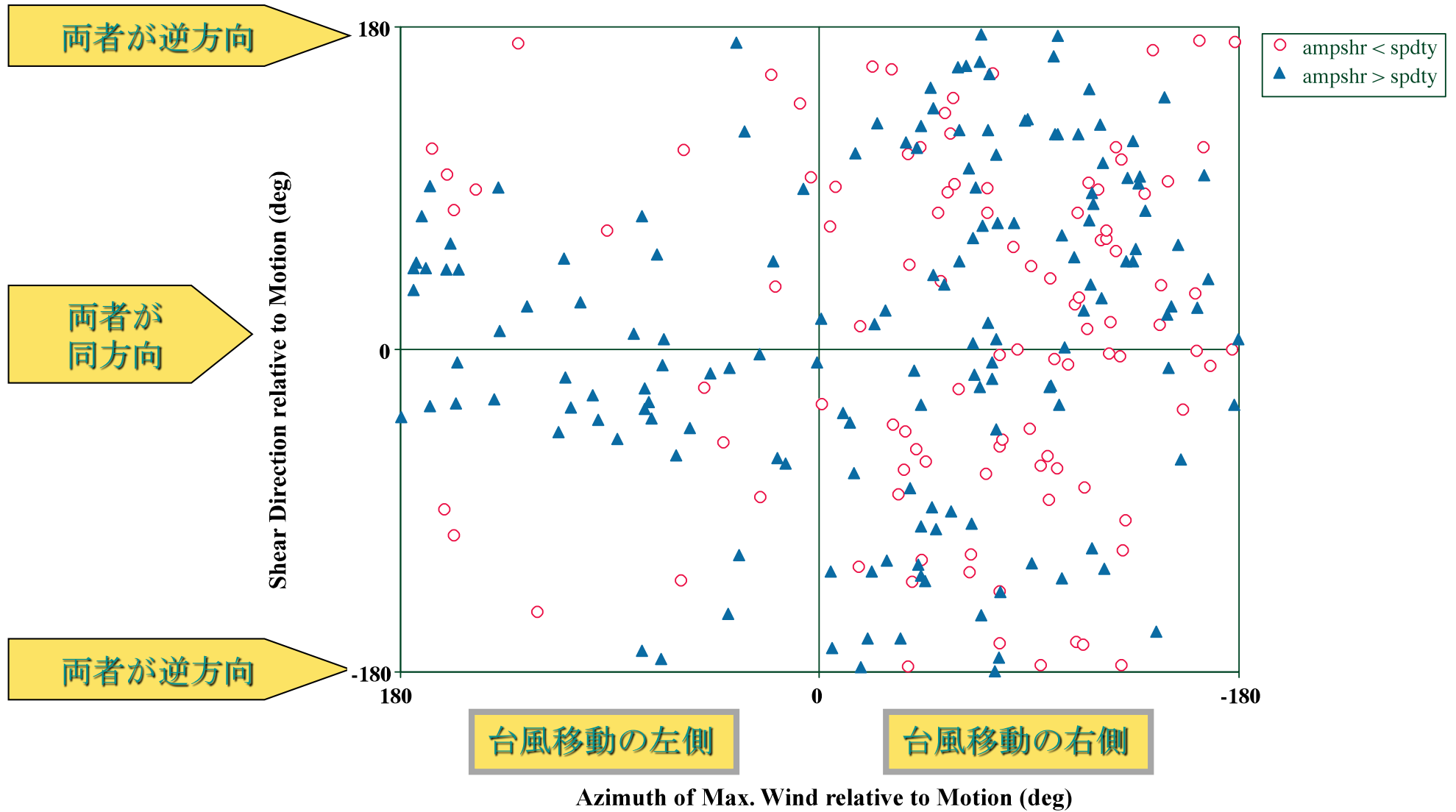


2004-2007 typhoon seasons (

最大風速 (QuikSCAT .vs. Best-track)



接線風最大の出現方位と鉛直シアーの関係

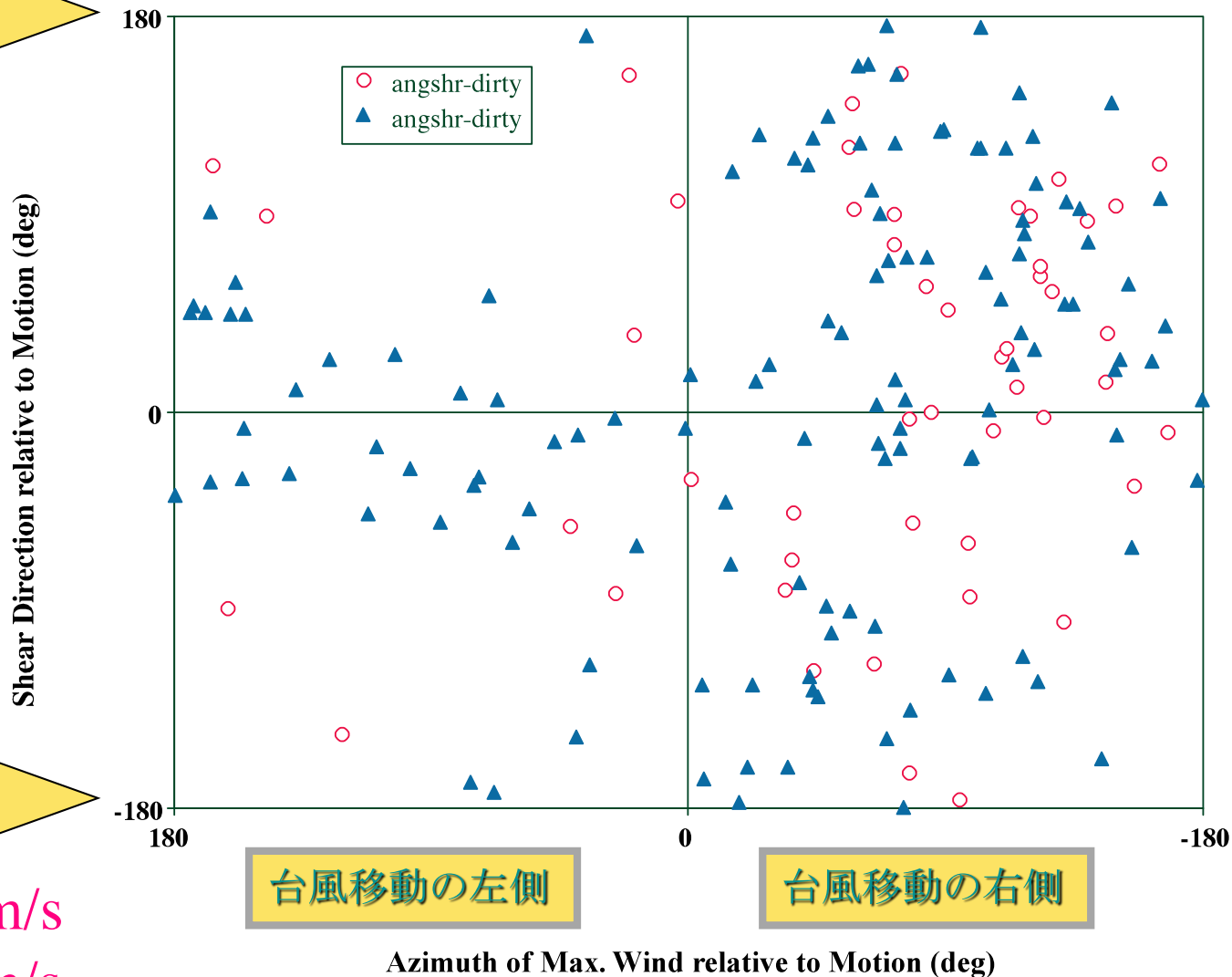


接線風最大の出現方位と鉛直シアーの関係

両者が逆方向

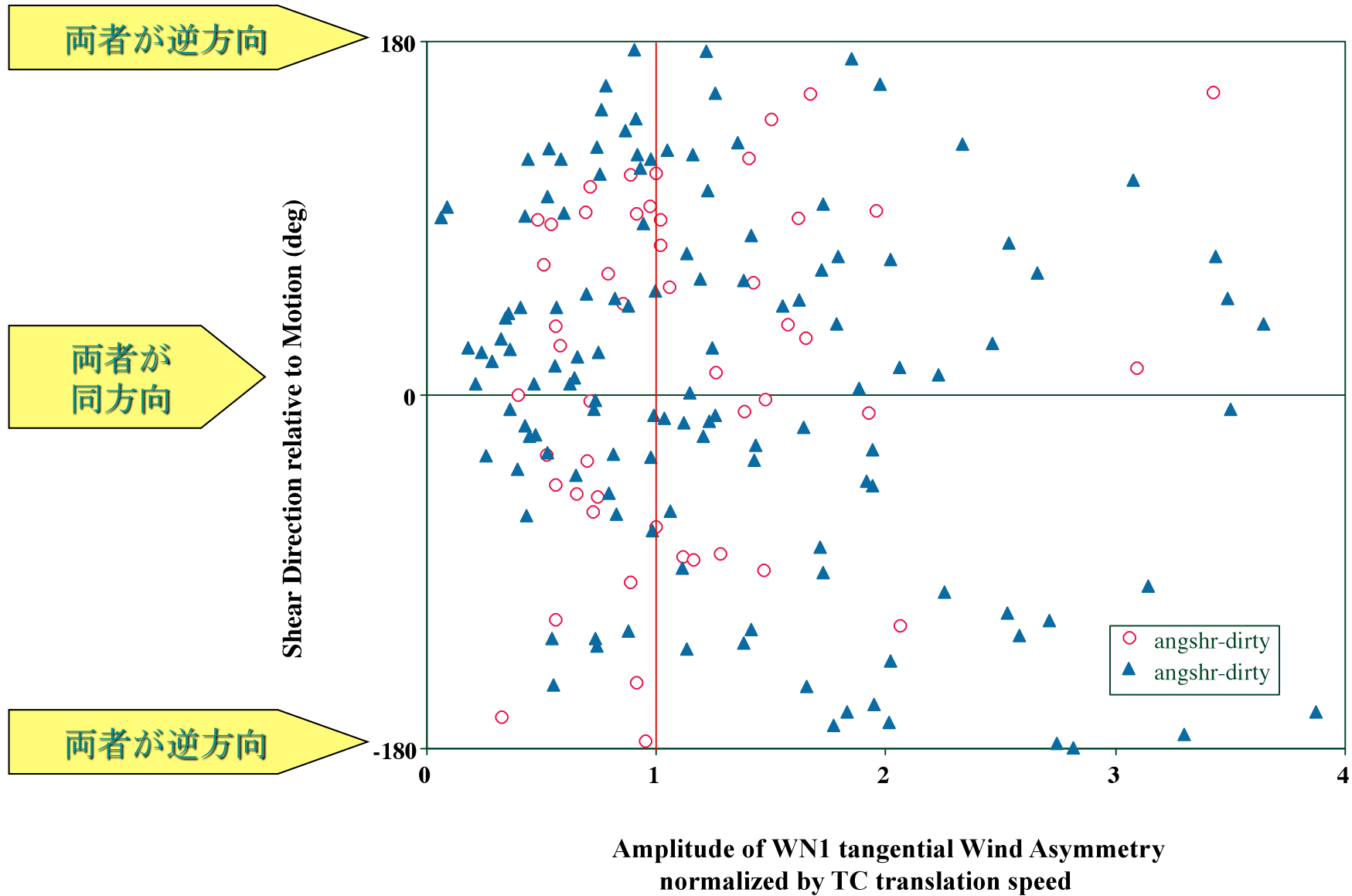
両者が
同方向

両者が逆方向

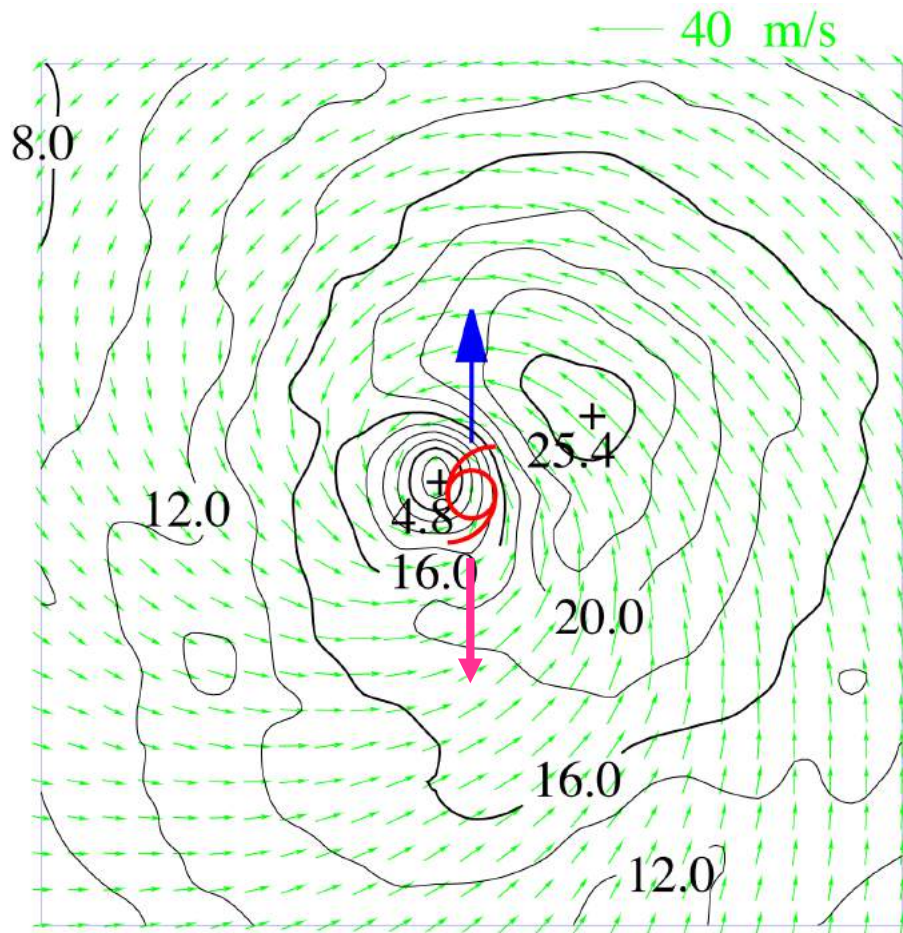


ampshr > 3m/s
spdty > 3m/s

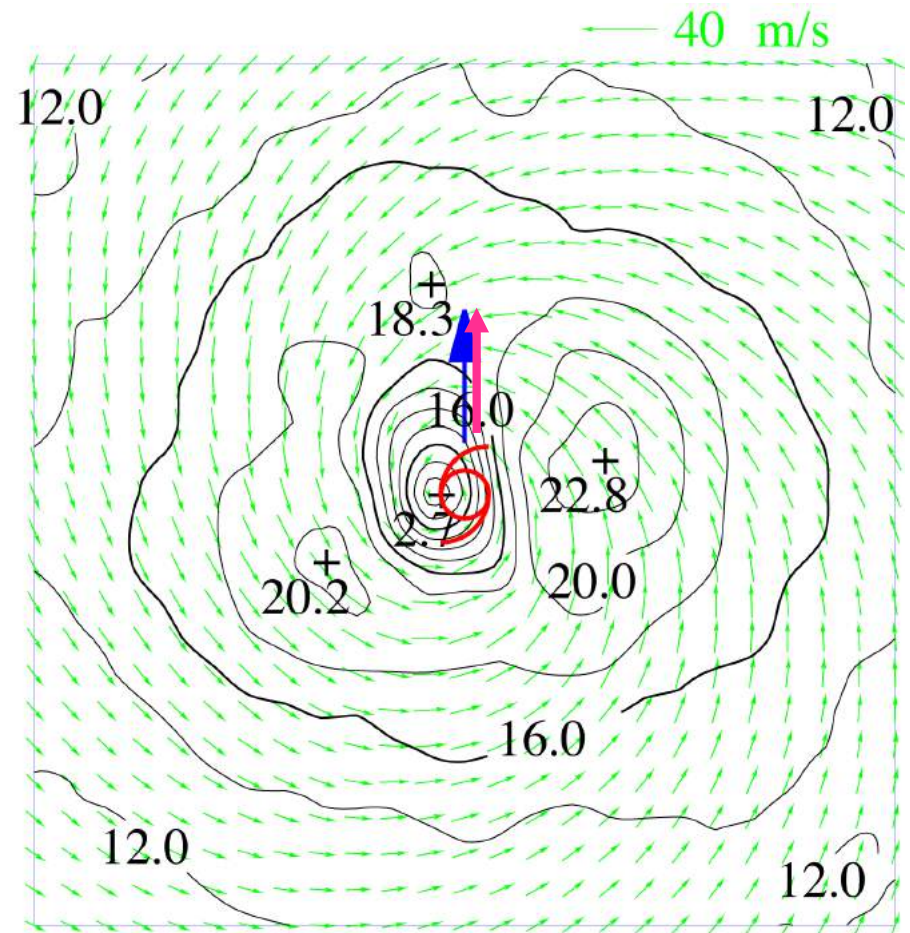
非対称接線風振幅の方向差への依存性



QuikSCAT 風のコンポジット (移動方向を揃えたもの)

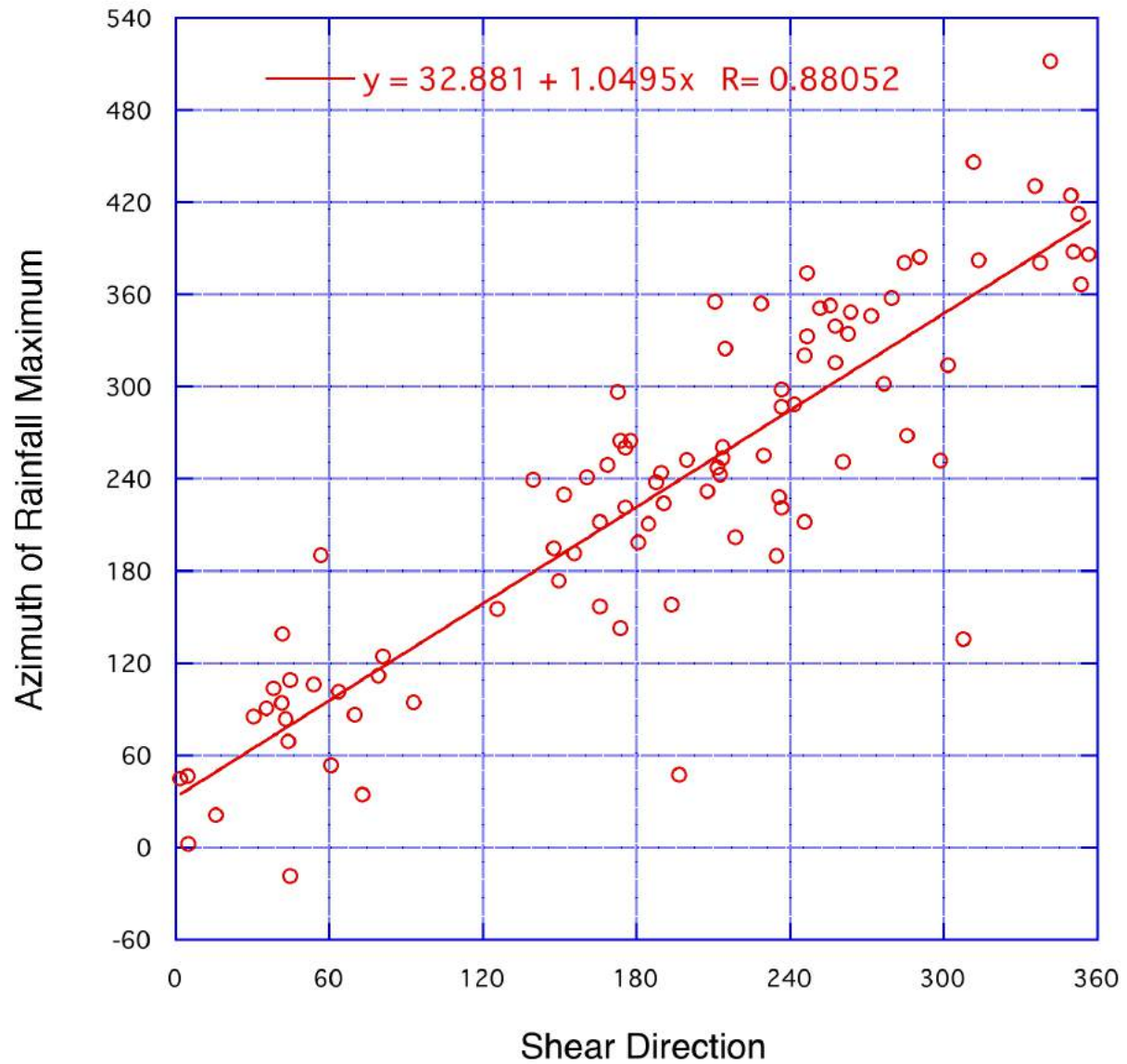


(37)



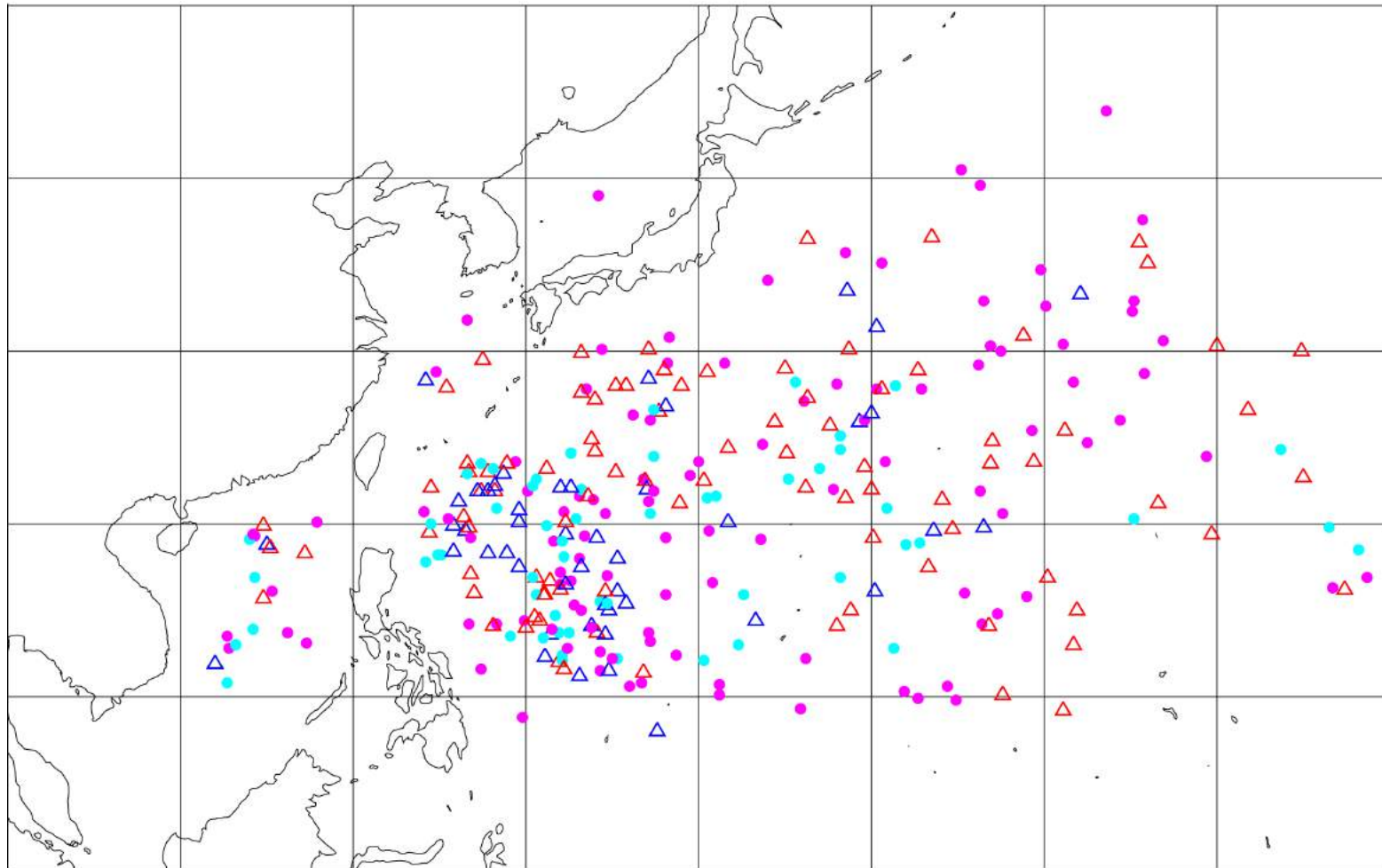
(65)

シアーと降水最大の方位の関係



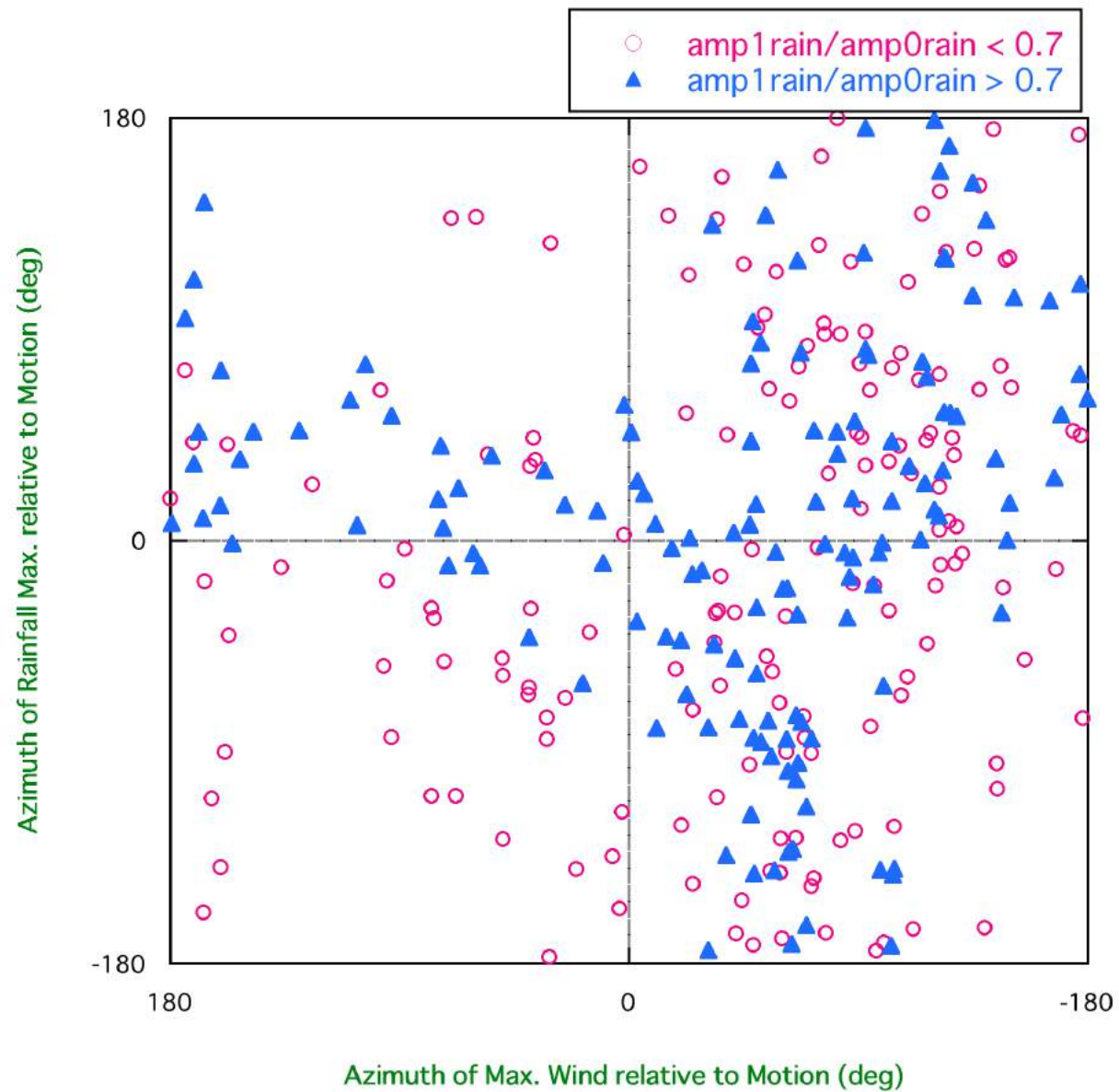
降水非対称解析に用いた台風事例 (307事例)

red triangle : $-180 < DD < -90$, blue triangle : $-90 < DD < 0$, red circle : $0 < DD < 90$, blue circle : $90 < DD < 180$

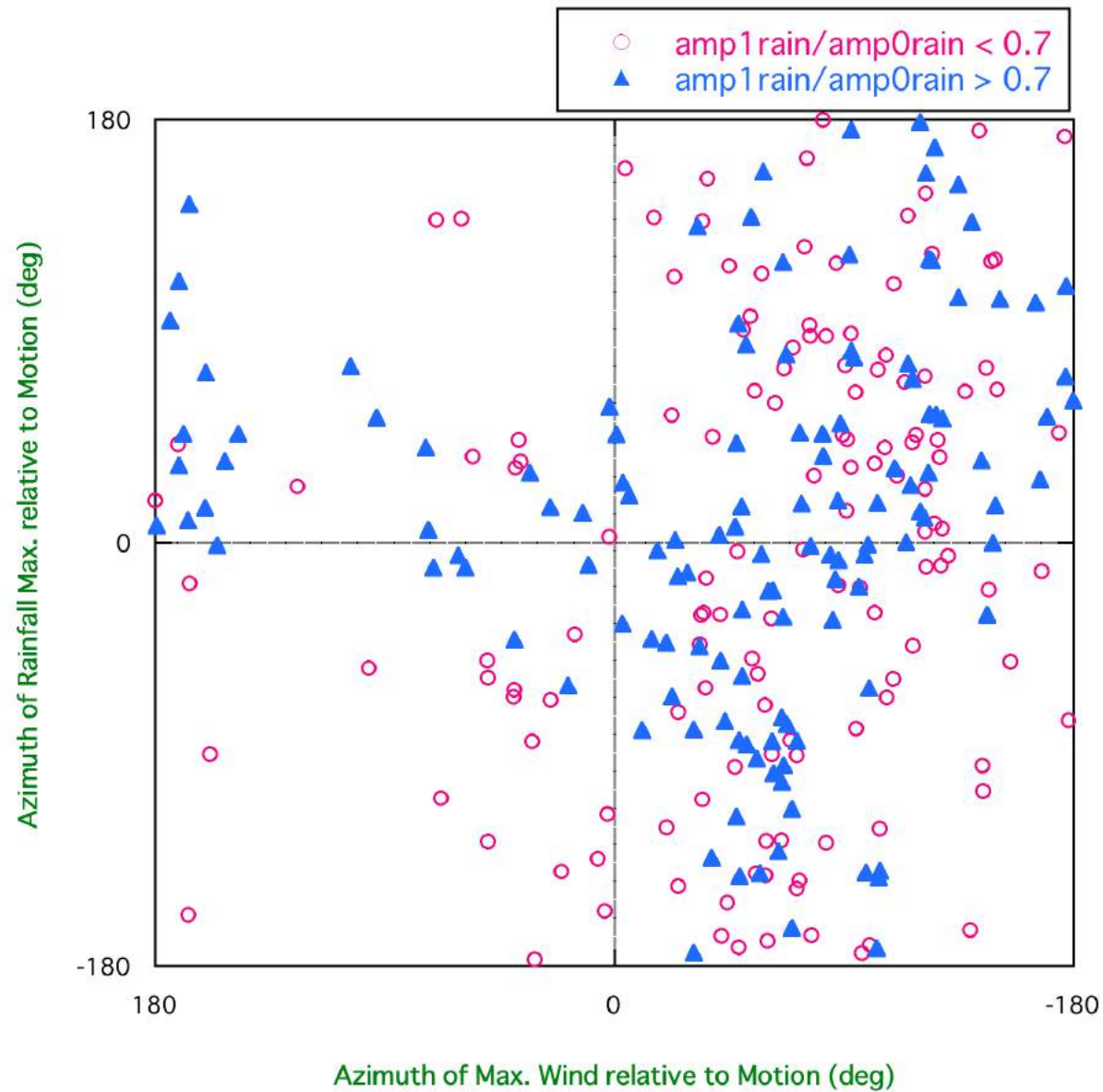


1999 to 2008下

接線風最大と降水最大の出現方位の関係

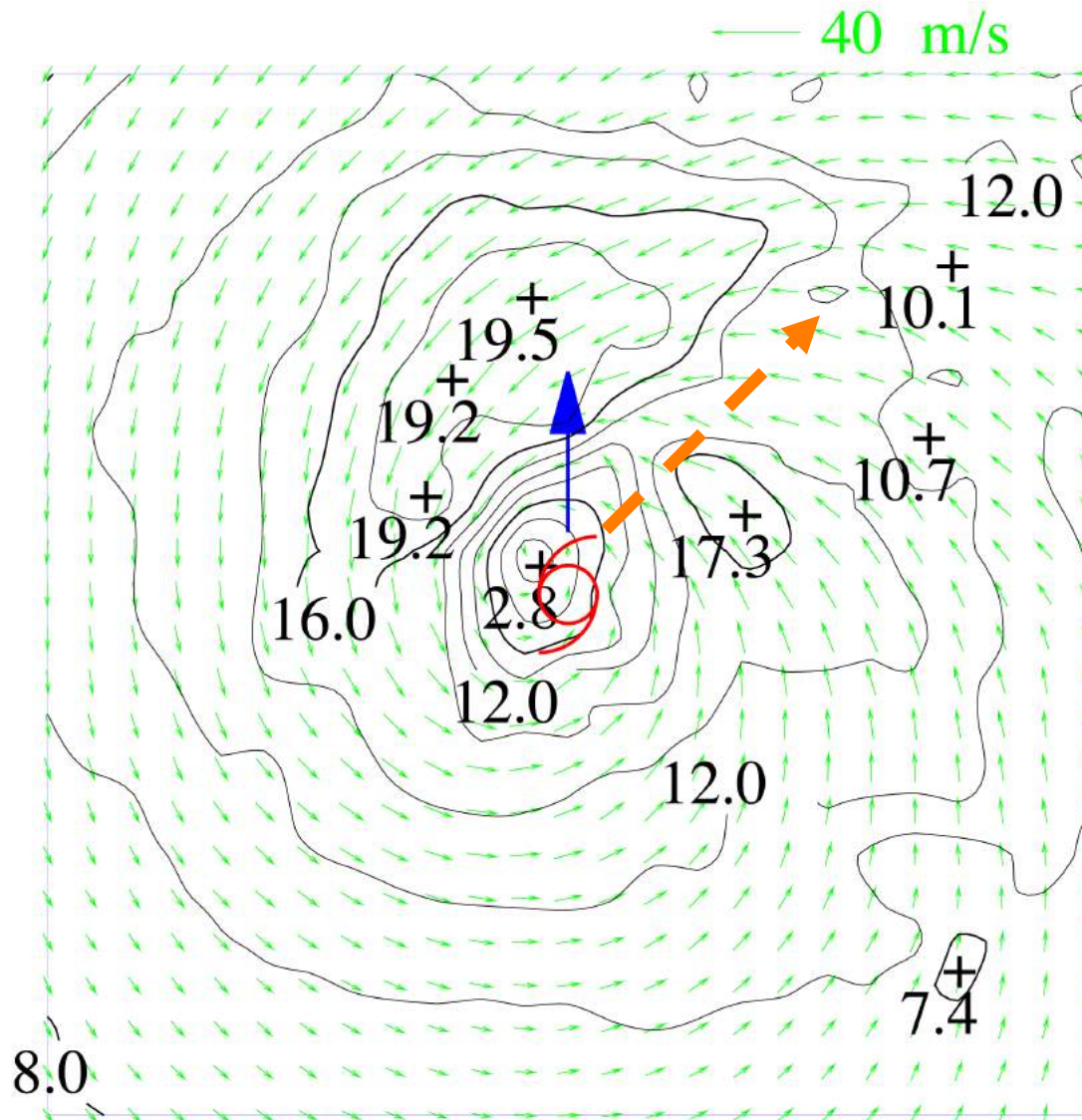


接線風最大と降水最大の出現方位の関係



spdy>3m/s

QuikSCAT 風のコンポジット (降水最大の方位を揃えたもの)

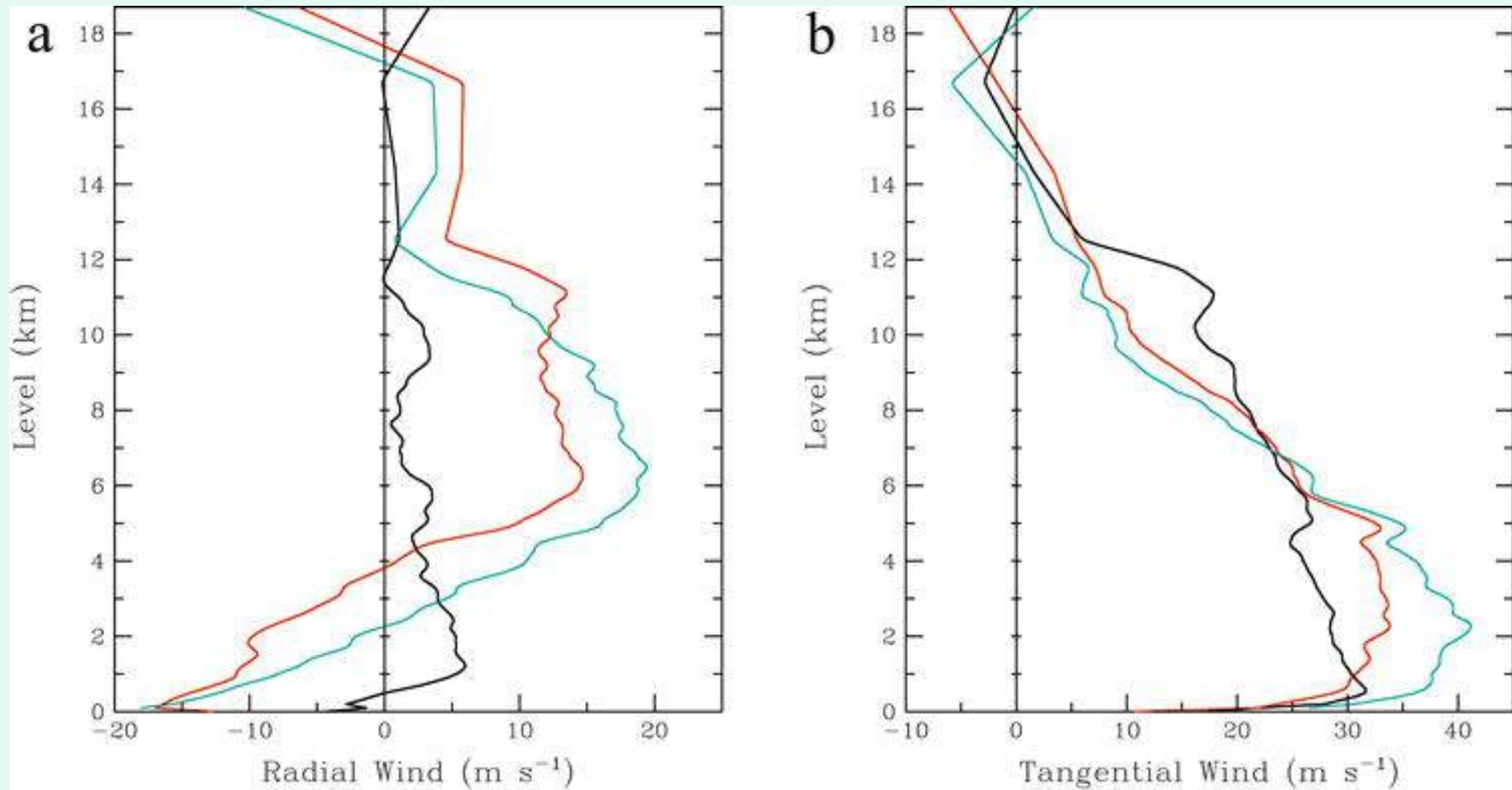


TC中の竜巻発生も環境風の鉛直シアーに関係？

Molinari and Vollaro (2008) によれば、TC中では動径風が高度とともに増加する所(下層に大きなインフローがありclockwise-turning hodographとなる所)で大きな **helicity** が期待される。下

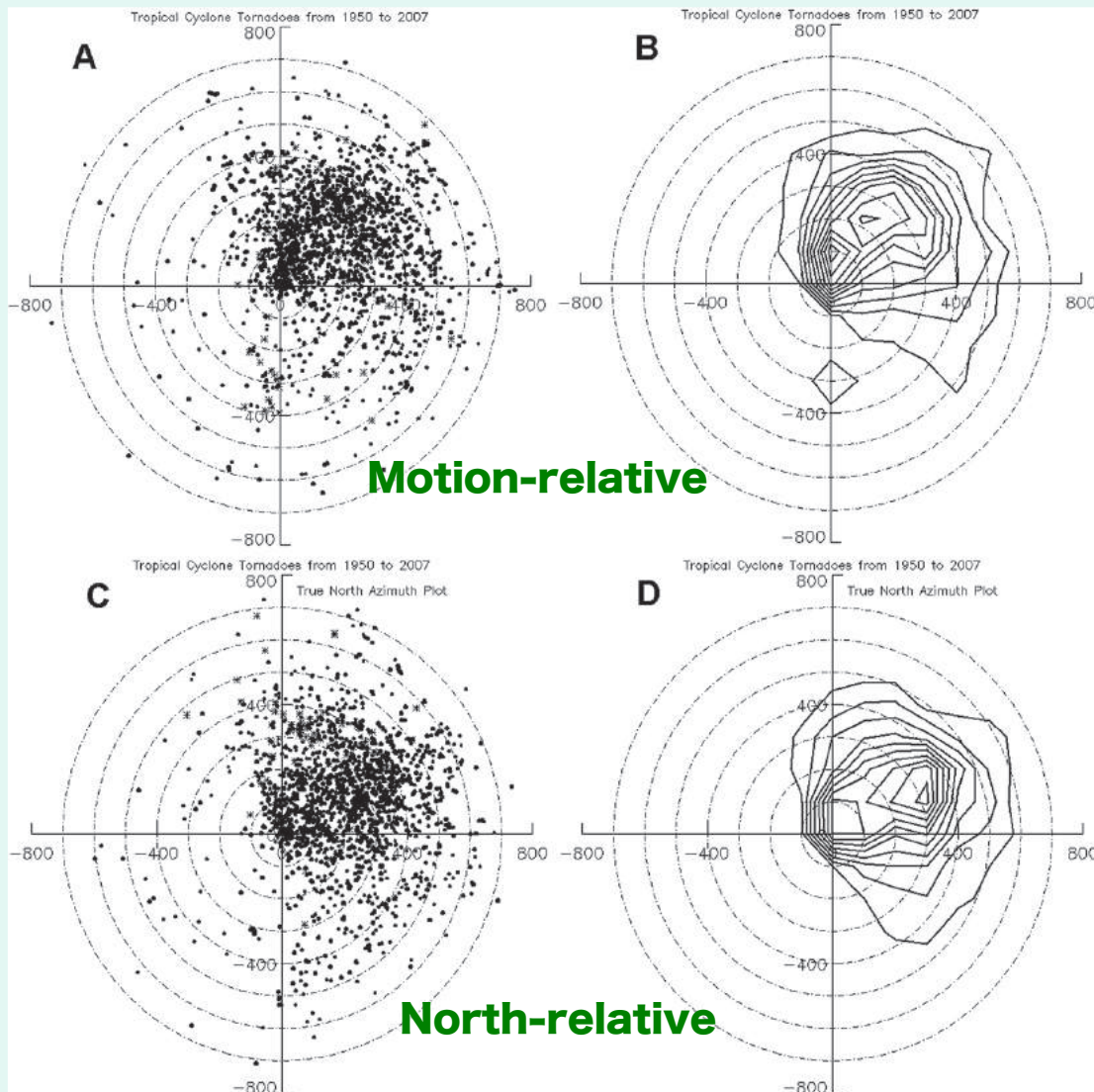
$$H_{TOT} = -v_r \frac{\partial v_\lambda}{\partial z} + v_\lambda \frac{\partial v_r}{\partial z}$$

MV08下



Vertical distribution of (a) radial and (b) tangential velocities (m s⁻¹) averaged over the seven upshear sondes (black), the six downshear sondes (red), and the four sondes nearest the deep cells (cyan).下

Schultz and Cecil (2009) 下



Cecil and Schultz (2010) 下

