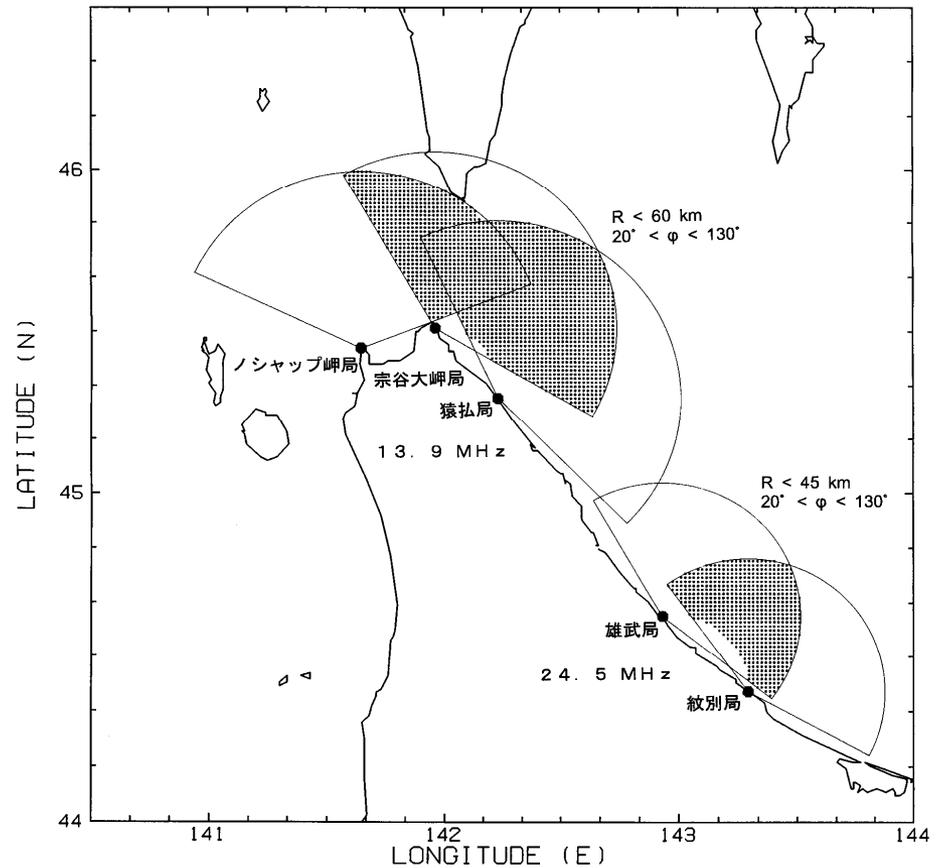
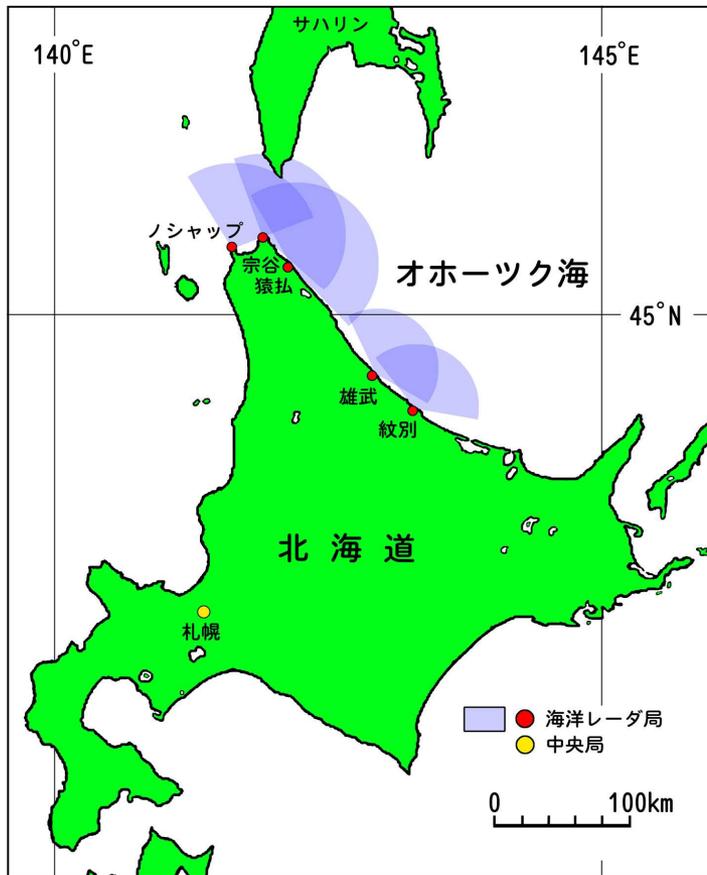


13MHz海洋レーダの混信について



江淵 直人・深町 康・大島 慶一郎・高塚 徹(北大低温研)・
勝呂 一彦・並木 義則(スリーエス・オーシャンネットワーク)・
B. Rector (CODAR Ocean Sensors)

北大低温研 短波海洋レーダシステム



ノシャップ岬, 宗谷大岬, 猿払, 雄武, 紋別の5局

HF Ocean Radar Stations

- CODAR SeaSonde/FMICW
- Center frequency: 13.946 MHz
- Detection range: 70 km
- Range resolution: 3.0 km
- Azimuth resolution: 5 deg.



Tx

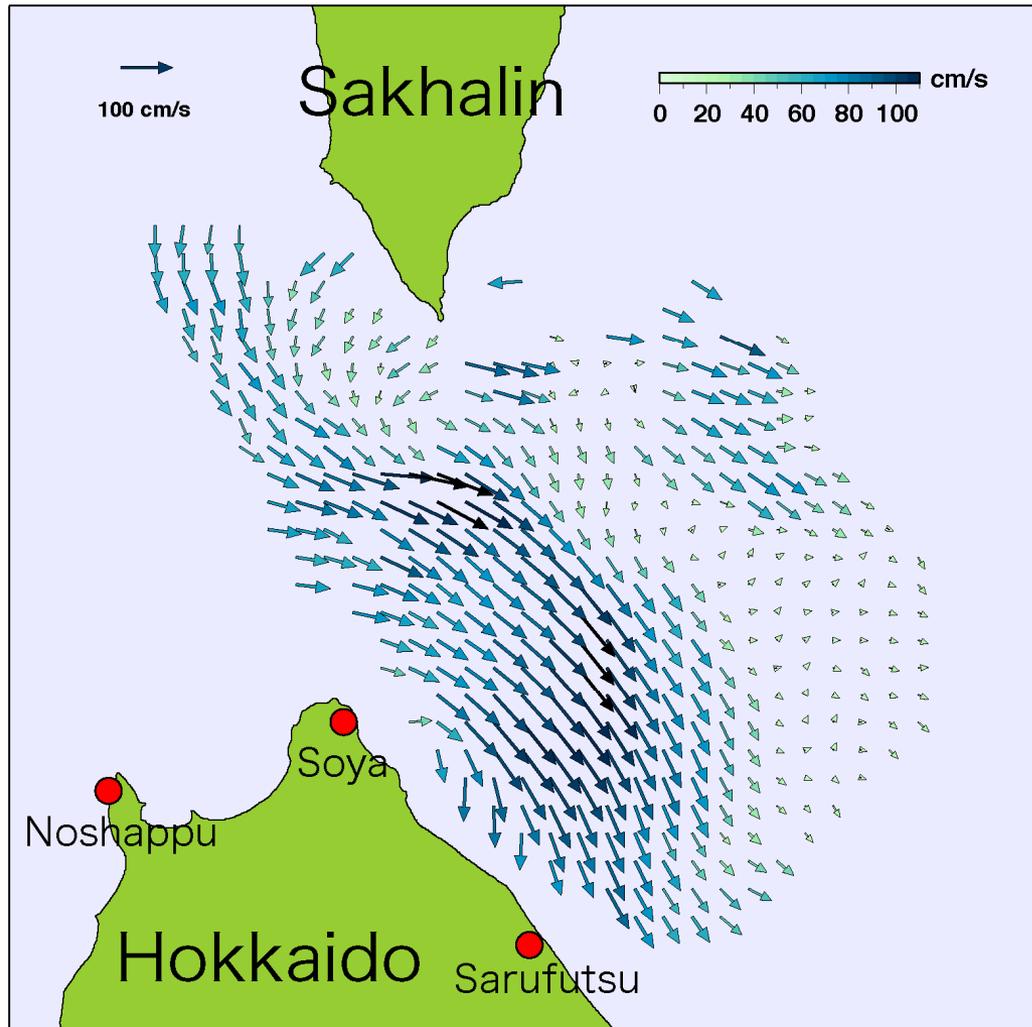


Rx



Instruments

海洋レーダによる表層流の観測例



2003年
8月17日20時

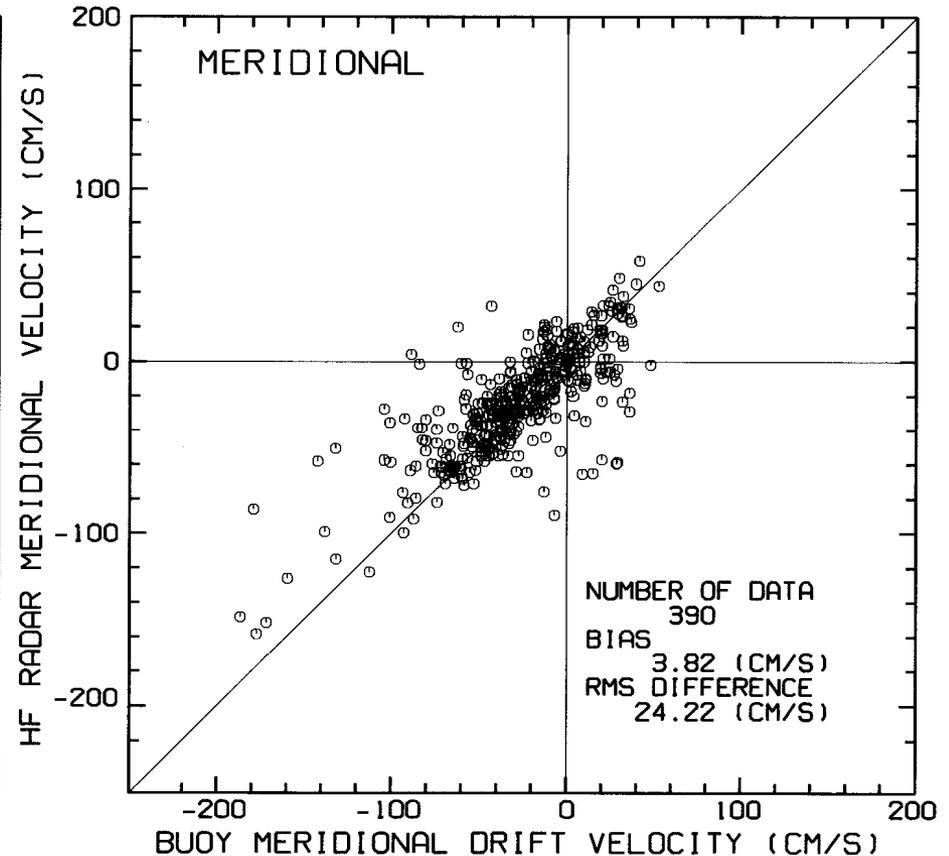
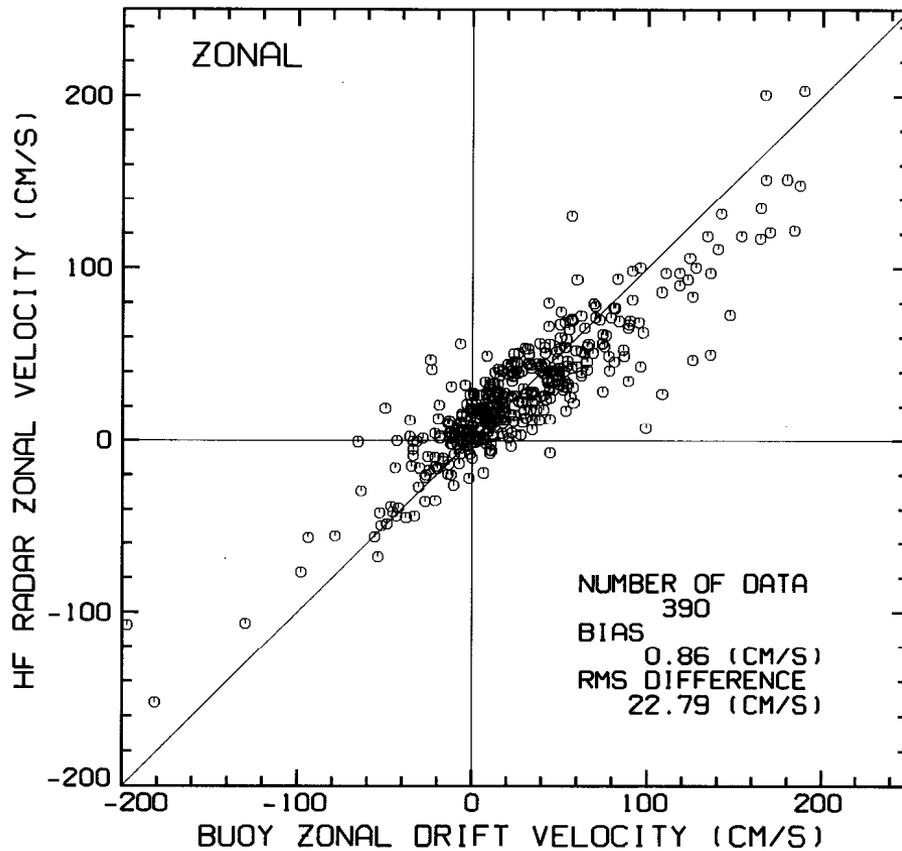
毎時のリアルタイムデータを公開中

<http://wwwoc.lowtem.hokudai.ac.jp/hf-radar/index.html>

現場観測データとの比較

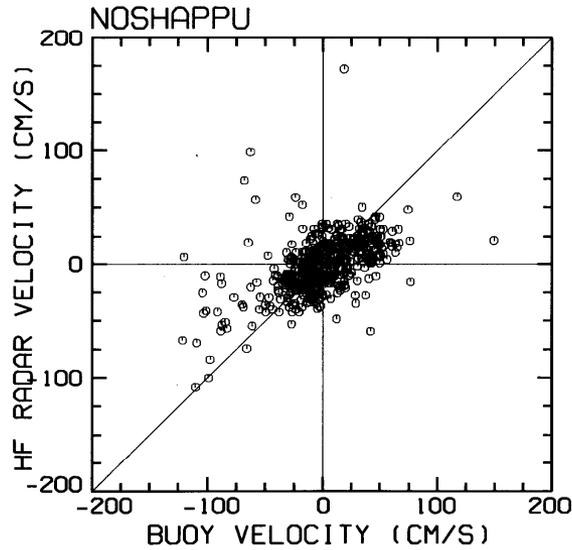
- 漂流ブイ
北大低温研(15基), 日水研(2基)
- 船舶搭載ADCP
海上保安庁(一管), 稚内水産試験場「北洋丸」
北大水産「うしお丸」
- 海底設置ADCP
浜頓別沖1点(2004.5~2005.5)
宗谷岬沖1点(2006.9~2008.7)

漂流ブイデータとの比較 (合成流速ベクトル)

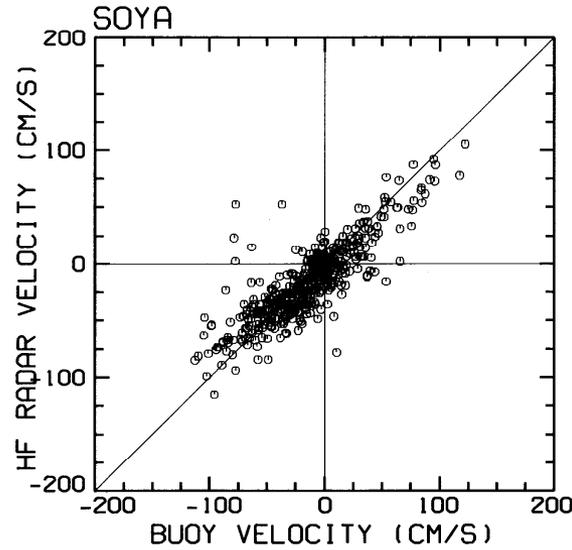


漂流ブイデータとの比較 (視線速度成分)

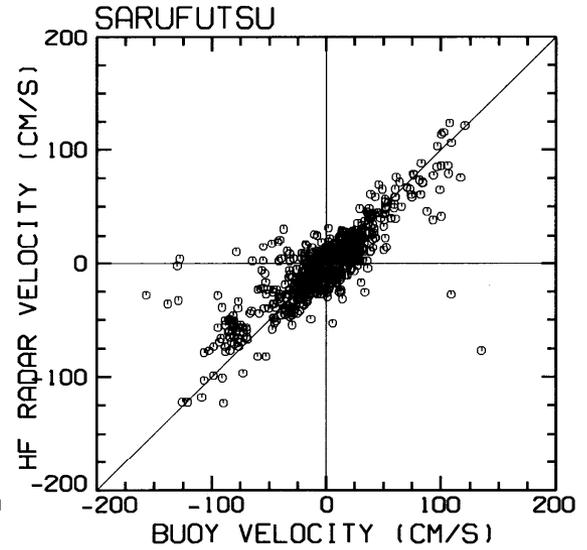
COMPARISON OF RADIAL VELOCITY



NUMBER OF DATA	509
BIAS (CM/S)	-1.08
RMS DIFFERENCE (CM/S)	29.03



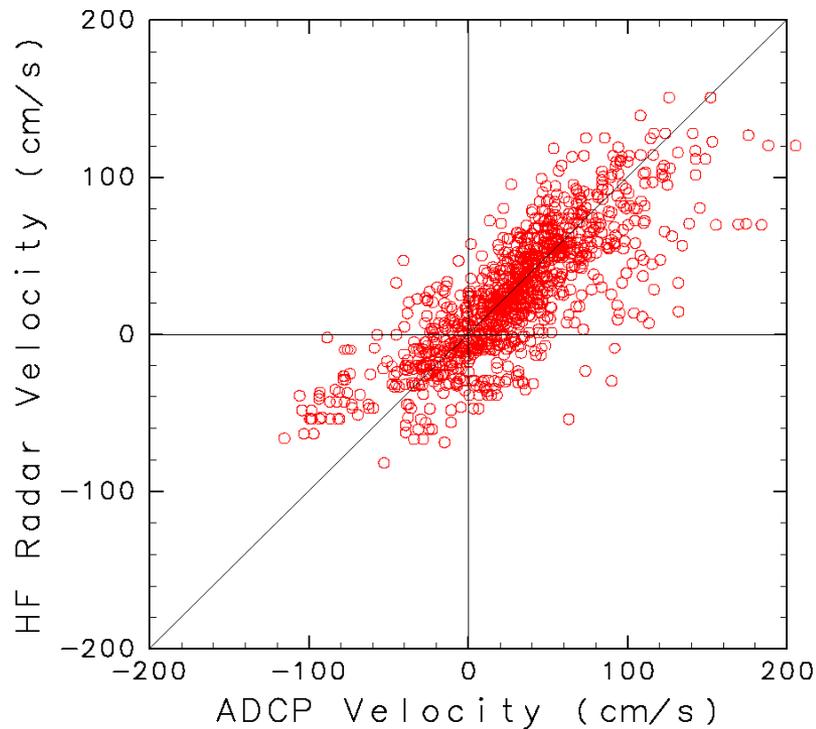
NUMBER OF DATA	433
BIAS (CM/S)	-2.14
RMS DIFFERENCE (CM/S)	21.17



NUMBER OF DATA	714
BIAS (CM/S)	0.02
RMS DIFFERENCE (CM/S)	22.58

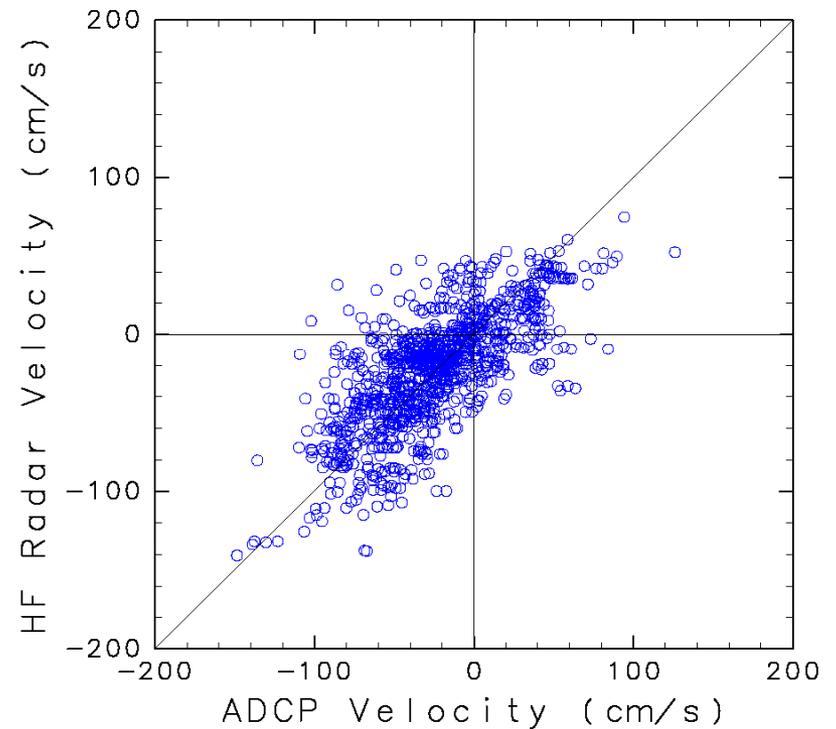
船舶ADCPデータとの比較 (合成流速ベクトル)

東西流速成分



データ数	1111
バイアス	-2.9 cm/s
残差の rms	27.8 cm/s

南北流速成分

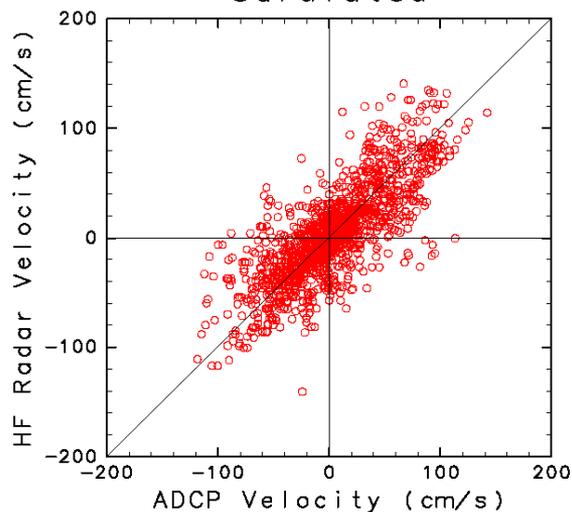


データ数	1111
バイアス	1.8 cm/s
残差の rms	27.7 cm/s

船舶ADCPデータとの比較 (視線速度成分)

猿払局

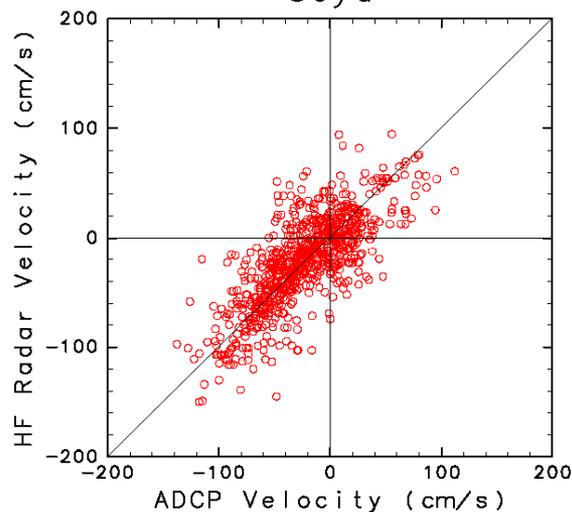
Sarufutsu



データ数 1537
バイアス 0.3 cm/s
残差の rms 27.5 cm/s

宗谷岬局

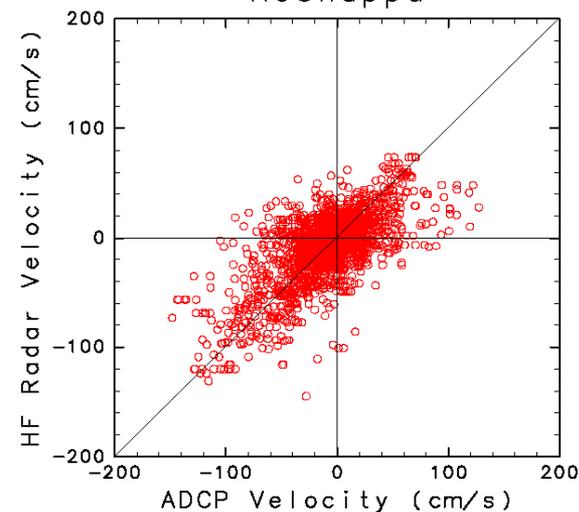
Soya



データ数 866
バイアス 1.8 cm/s
残差の rms 27.0 cm/s

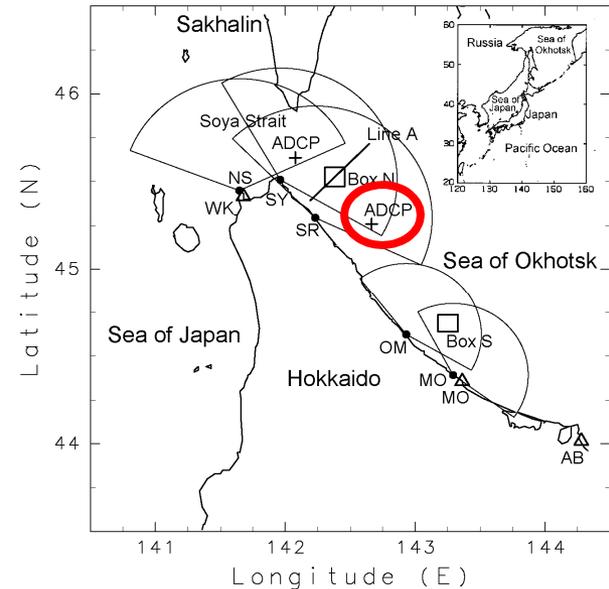
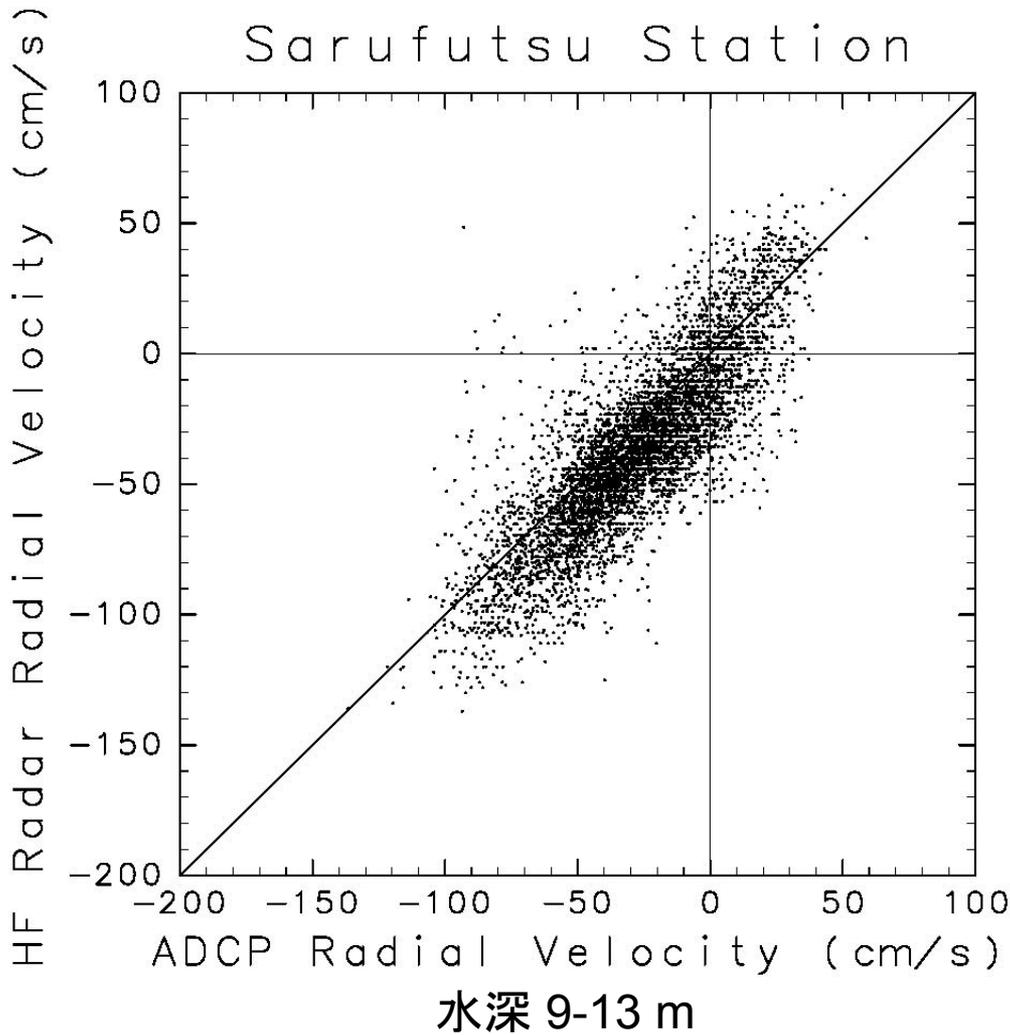
ノシャップ局

Noshappu

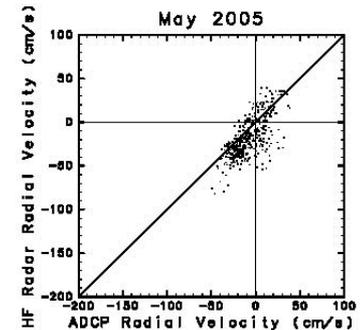
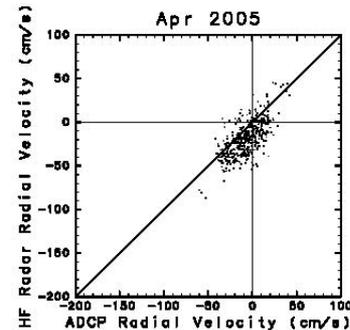
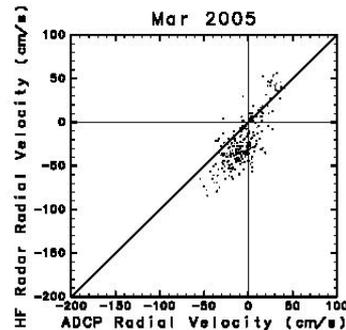
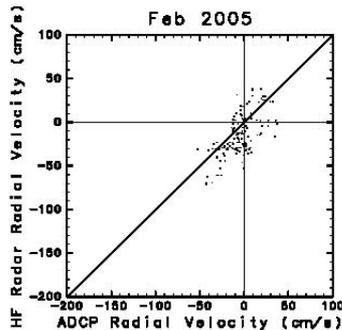
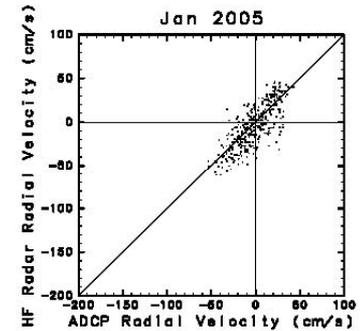
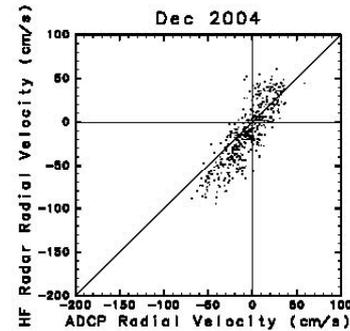
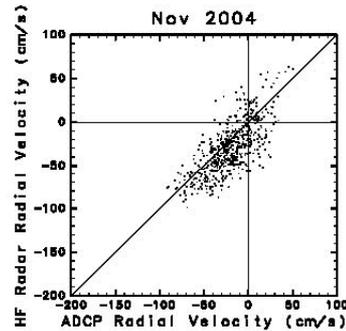
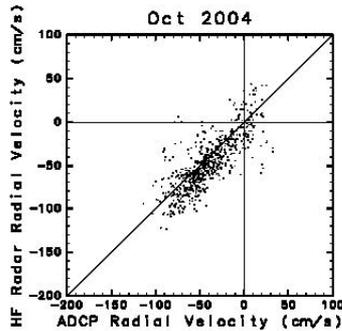
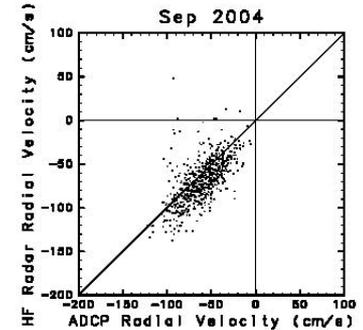
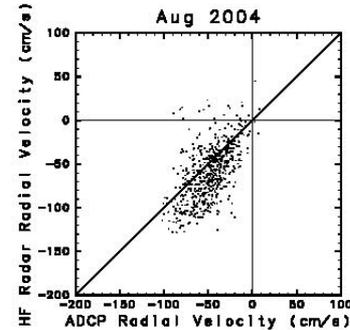
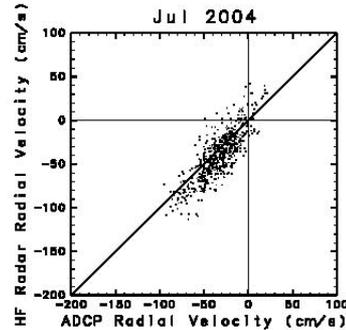
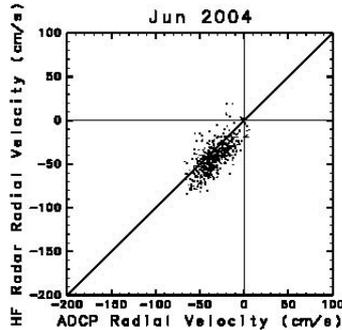


データ数 1949
バイアス 0.0 cm/s
残差の rms 27.6 cm/s

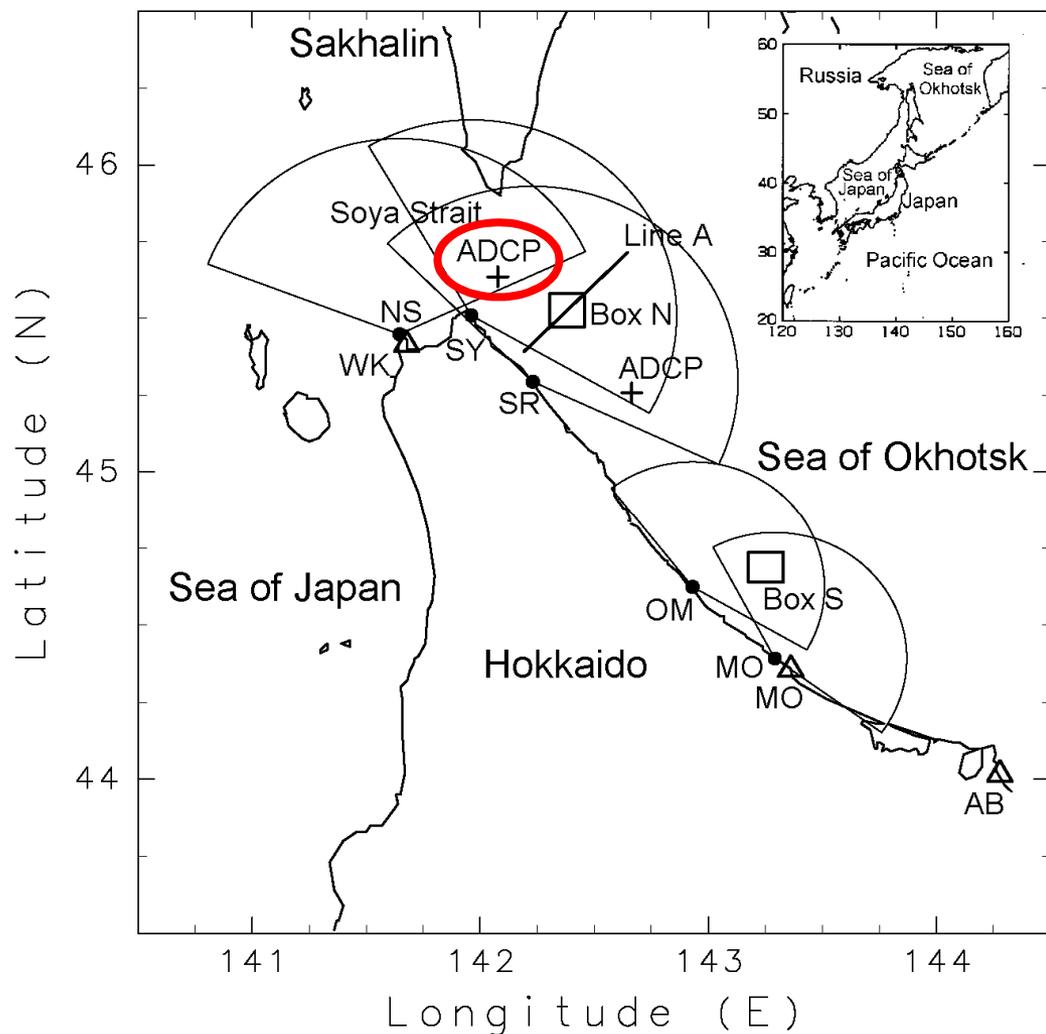
海底設置ADCPデータとの比較 (猿払局視線速度)



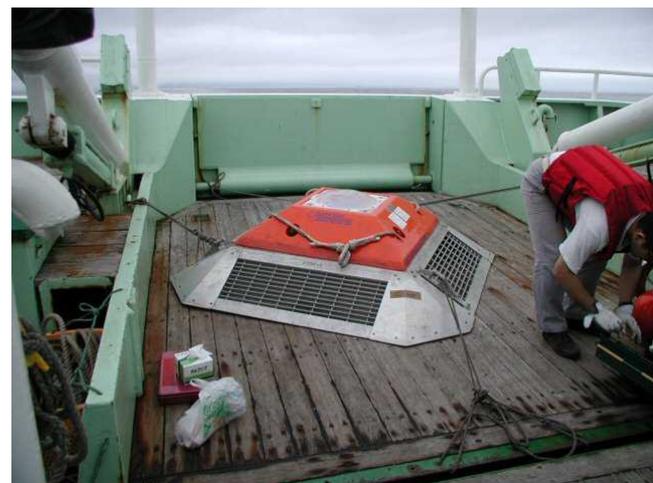
月別の海底設置ADCPデータとの比較 (猿払局視線速度)



宗谷海峡内での海底設置ADCP観測

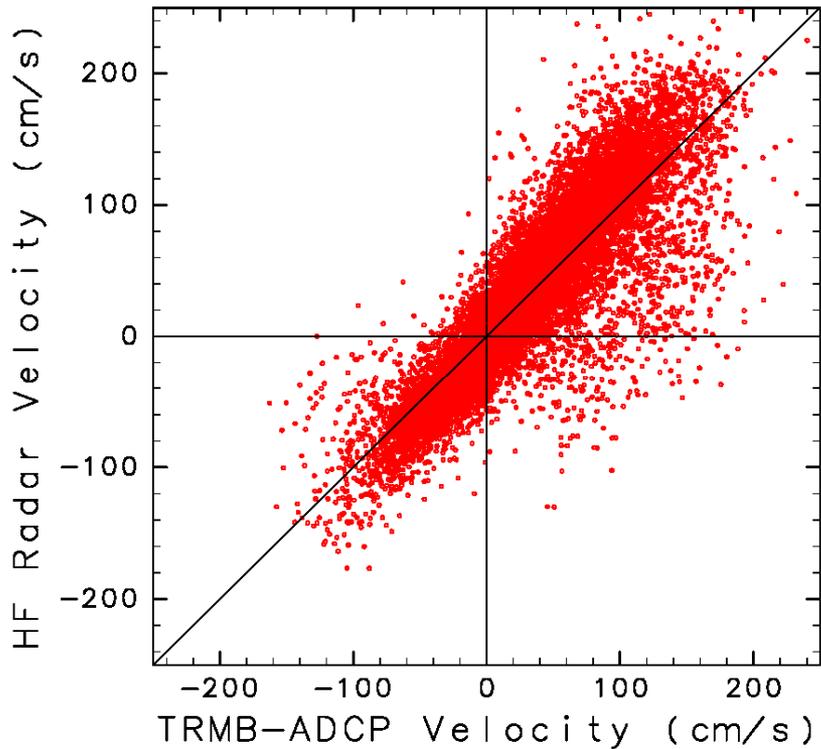


2006年9月～2008年7月
水深 51 m
毎時観測
2m bin
最浅層は 7.4-9.4 m

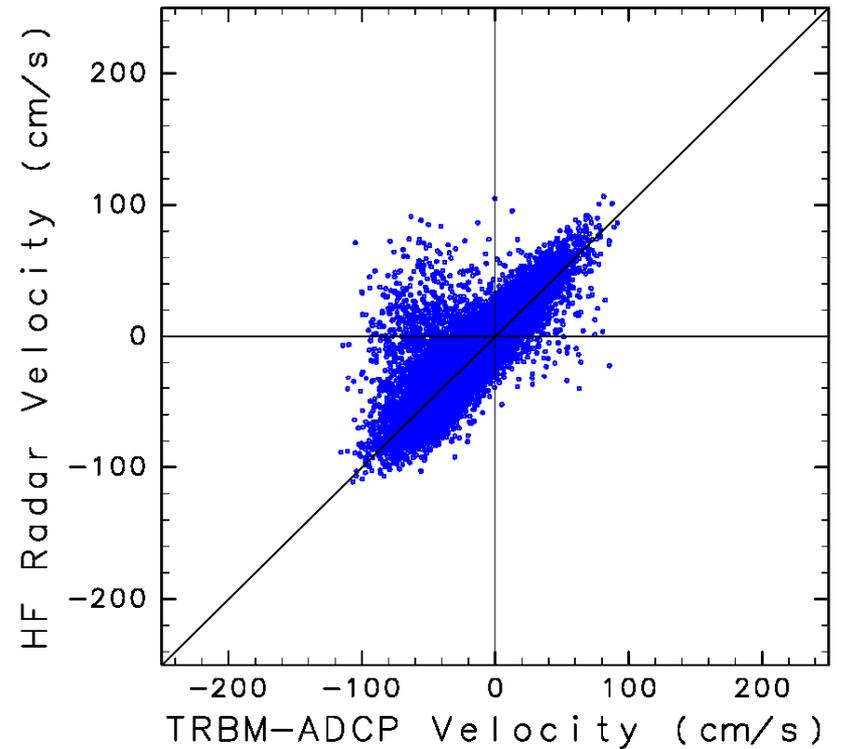


海底設置ADCPデータとの比較 (合成ベクトル)

東西流速成分



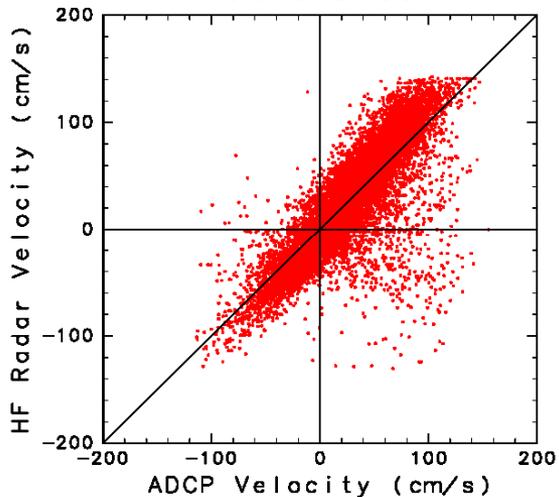
南北流速成分



海底設置ADCPデータとの比較 (視線速度成分)

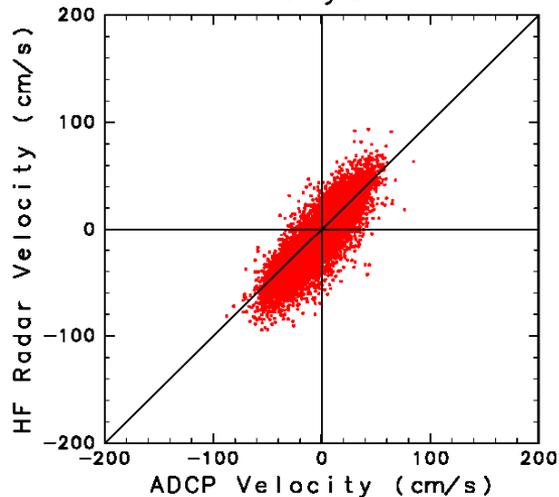
猿払局

Sarufutsu



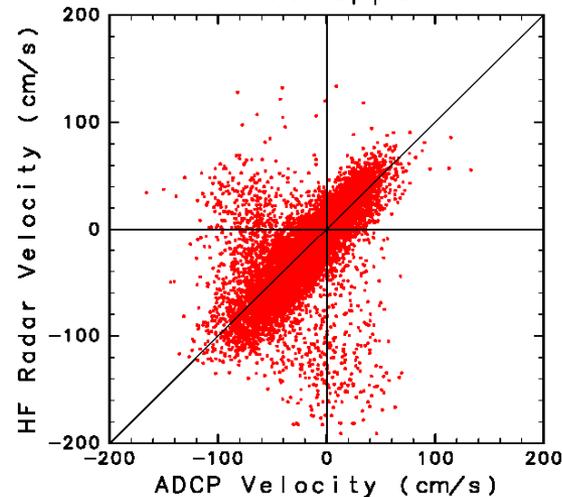
宗谷岬局

Soya



ノシャップ局

Noshappu

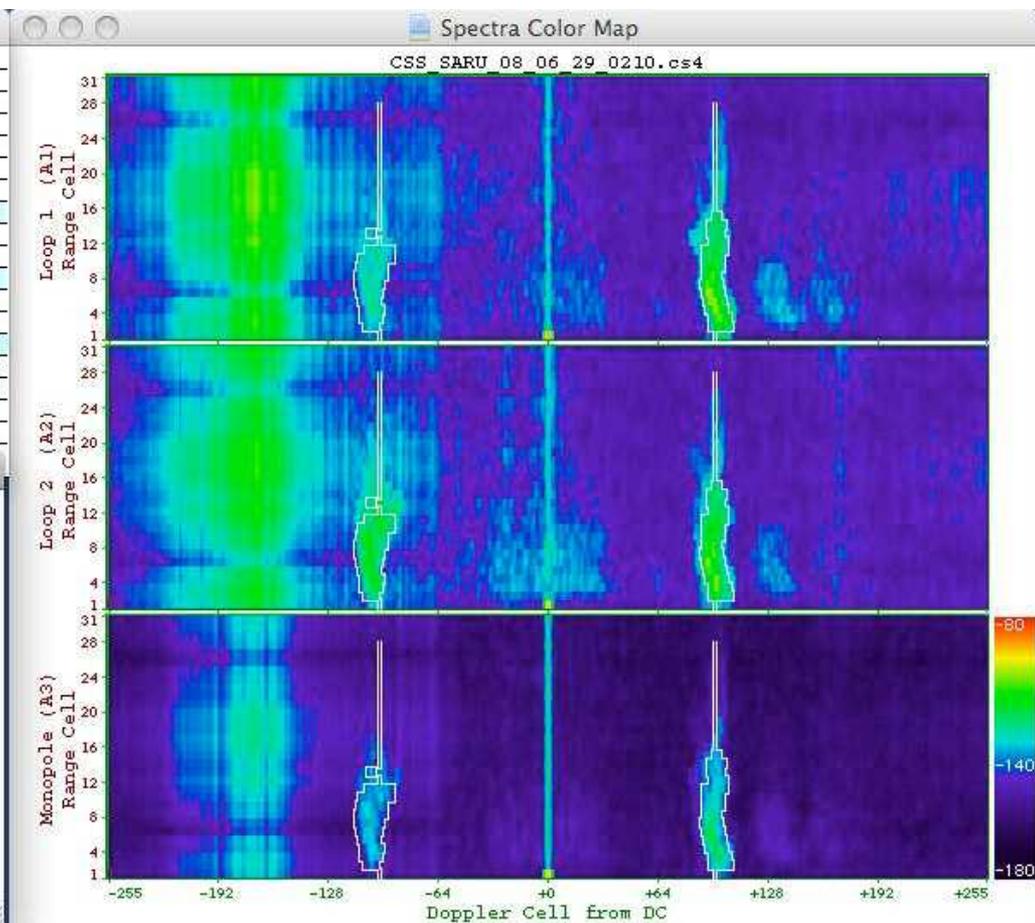
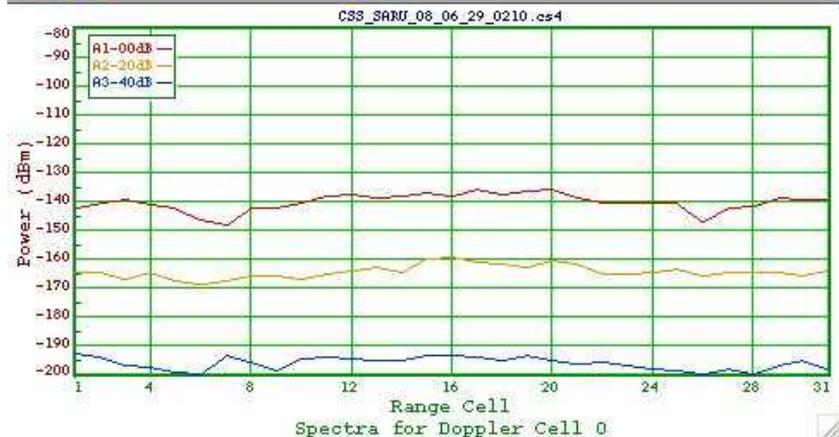


猿払局の混信状況 (2008年6月29日 02:10)

CSS_SARU_08_06_29_0210.cs4

File Valid	Selected Range 1 (3.034 km) (1.885 mi)
CS Version, Kind 4,2	Selected Doppler 0 -255(DC)
Site SARU	Current Velocity -661.1 cm/s
Date 06-29-2008 02:10:00	Doppler Velocity -10.71 m/s
Coverage 15 minutes	Left Bragg 157 -97.5(DC) FO [157,157]
Center Freq 13.946000 MHz	Right Bragg 353 +97.5(DC) FO [352,352]
Bandwidth -49.438477 kHz	SN1,NF1 -12.5dB, -129.0dBm
Sweep Rate 2.000000 Hz	SN2,NF2 -14.0dB, -130.4dBm
Range Cells 1 to 31	SN3,NF3 -8.8dB, -143.5dBm
Doppler Cells 512	A1 -141.5dBm, +1.8511E-11v
A3 Neg. Flagged 0 cells	A2 -144.4dBm, +9.6189E-12v
BTST1 12 -141.4 41.8 57.6	A3 -152.3dBm, +1.5384E-12v, 0.9923qf
BTST2 17 -141.7 44.5 55.7	A13 -149.1dB, -116.9° : -1.471E-12r, -2.900E-12i
BTST3 17 -155.0 43.9 55.7	A23 -151.4dB, 44.1° : +1.385E-12r, +1.340E-12i
Ave.Phases -66.4°, 62.8°	A12 -145.3dB, -102.7° : -1.607E-12r, -7.512E-12i
Ave.Ampls 0.0240, 0.0234	Phase Factor A12,A23 -75.1°, 62.7°
	Ampl. Factor A12,A23 999.0000, 999.0000

Doppler Slice



混信の到来方向の推定

Hokkaido University
SeaSonde Measurements

- ◎ NOSH局における予想方位
Report Interference (31データの平均値) は次の通りです。
Loop 1=5.996774194
Loop 2=5.490322581
より矢印のように推測しました。

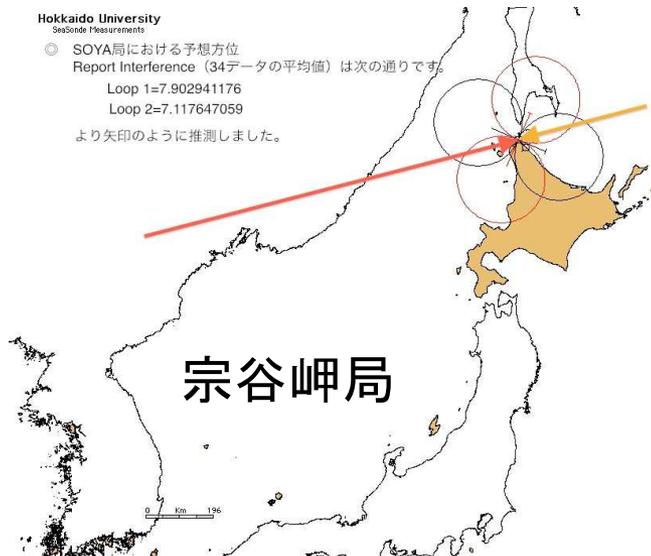
ノシャップ局



Hokkaido University
SeaSonde Measurements

- ◎ SOYA局における予想方位
Report Interference (34データの平均値) は次の通りです。
Loop 1=7.902941176
Loop 2=7.117647059
より矢印のように推測しました。

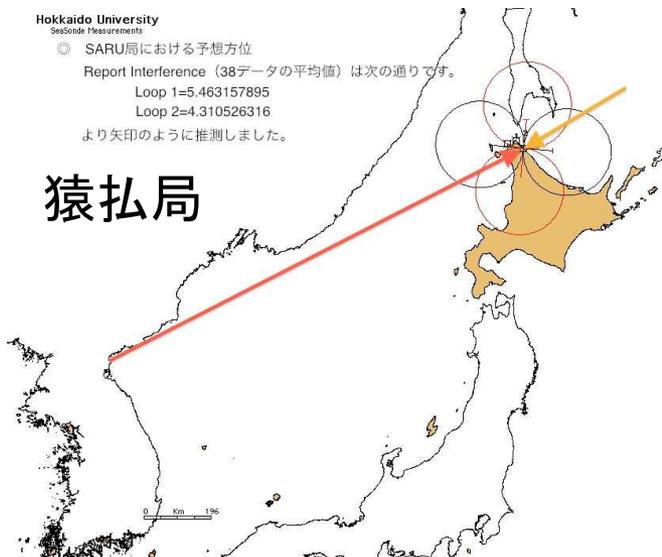
宗谷岬局



Hokkaido University
SeaSonde Measurements

- ◎ SARU局における予想方位
Report Interference (38データの平均値) は次の通りです。
Loop 1=5.463157895
Loop 2=4.310526316
より矢印のように推測しました。

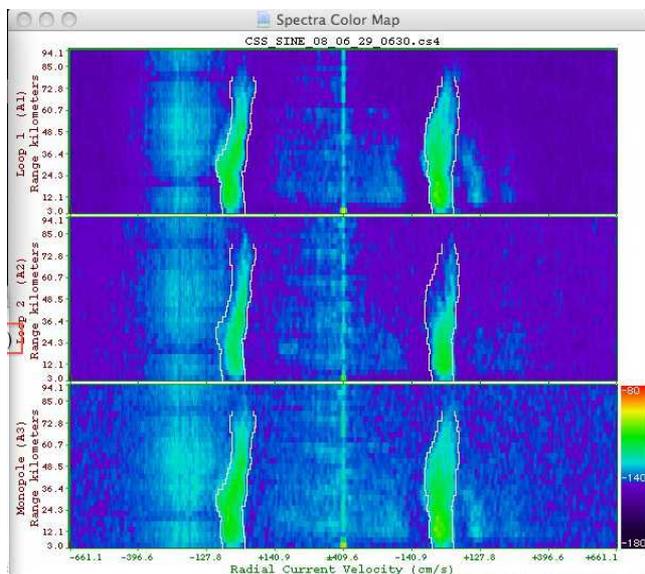
猿払局



朝鮮半島あたりが怪しい？

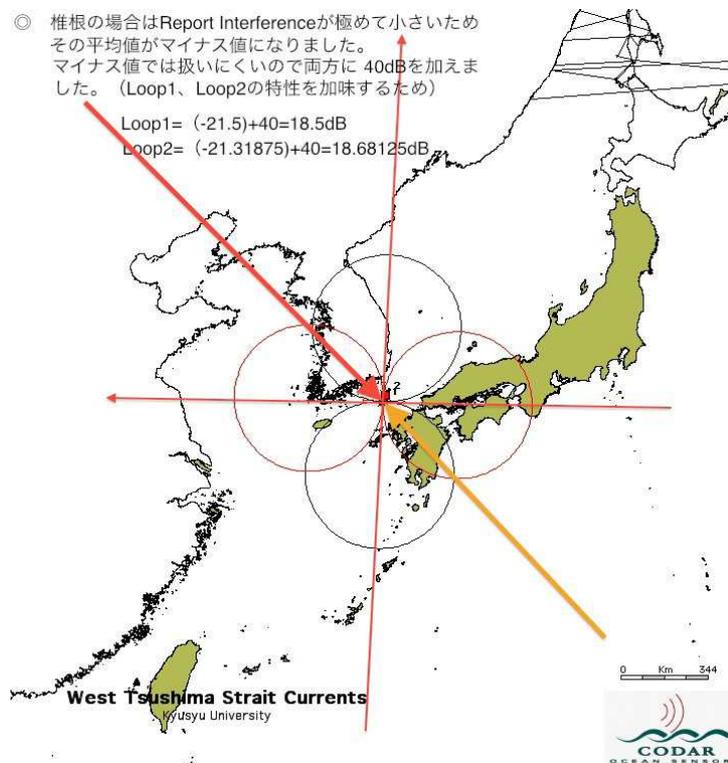
九大13MHz局の混信 (2008年6月29日)

椎根局のデータ



◎ 椎根の場合はReport Interferenceが極めて小さいためその平均値がマイナス値になりました。マイナス値では扱いきれないので両方に40dBを加えました。(Loop1、Loop2の特性を加味するため)

$$\text{Loop1} = (-21.5) + 40 = 18.5\text{dB}$$
$$\text{Loop2} = (-21.31875) + 40 = 18.68125\text{dB}$$

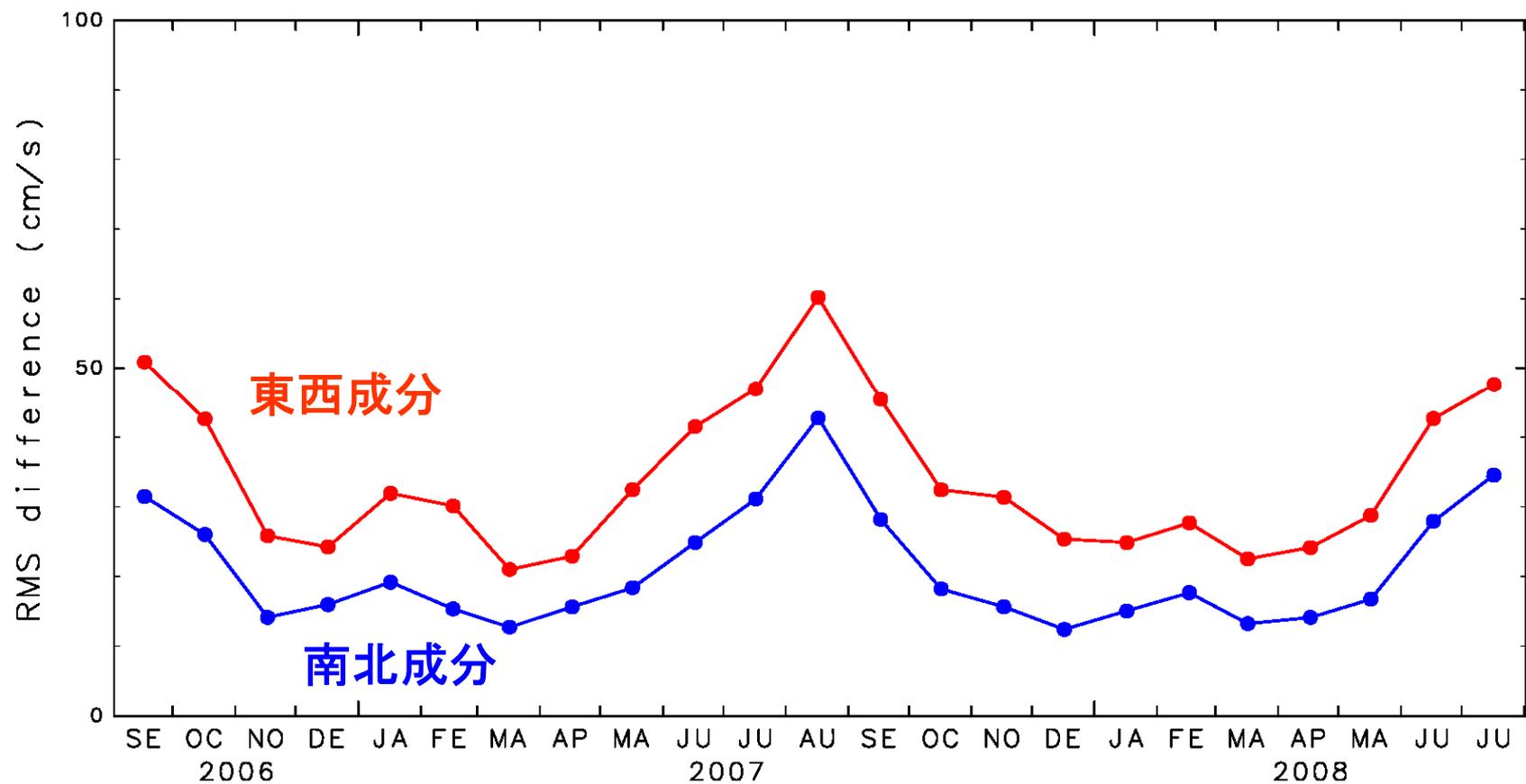


青海局は当日のCSSデータはなし。

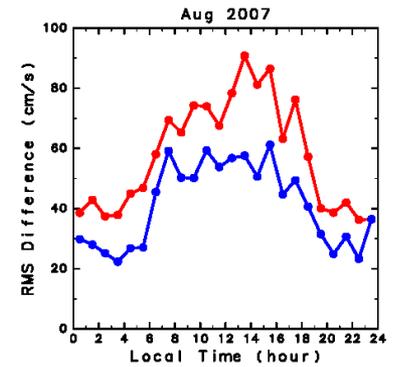
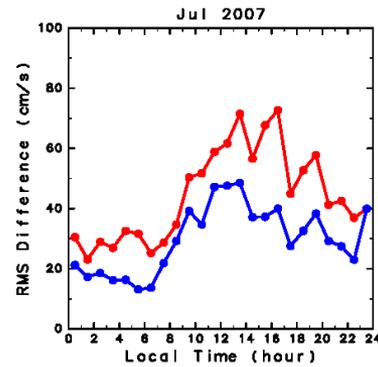
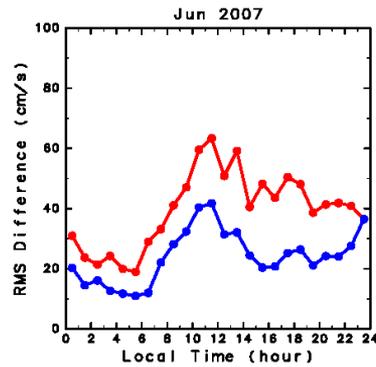
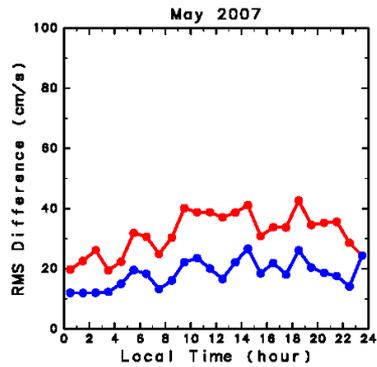
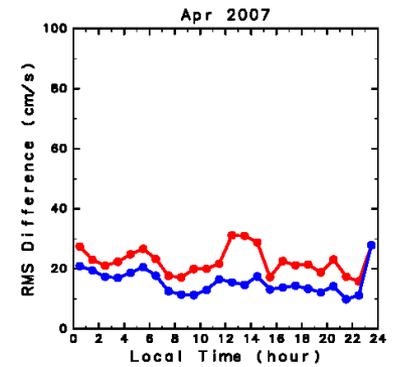
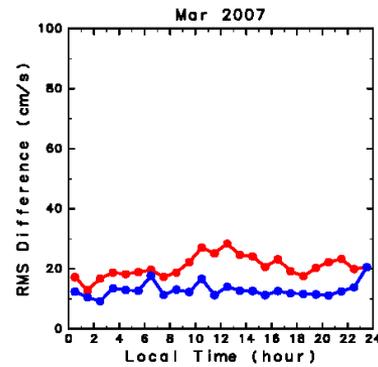
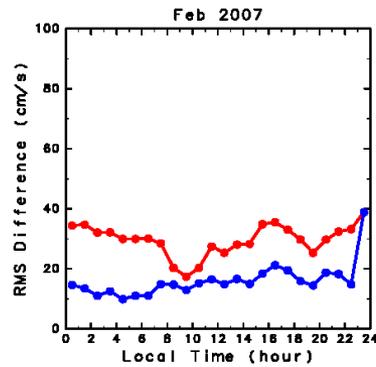
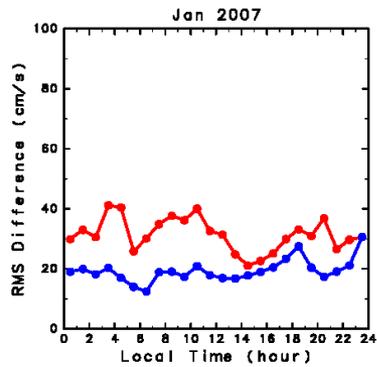
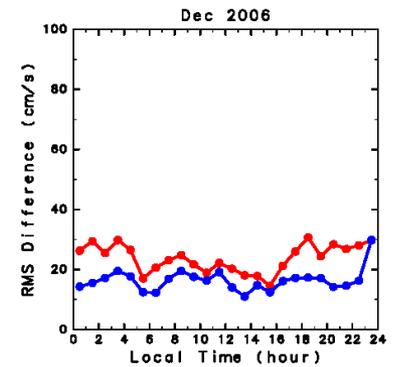
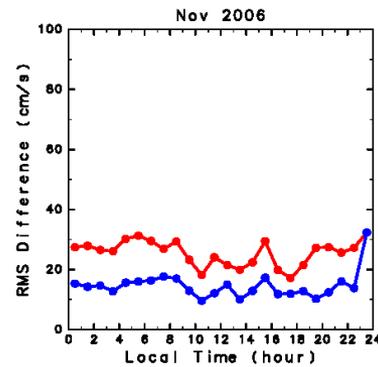
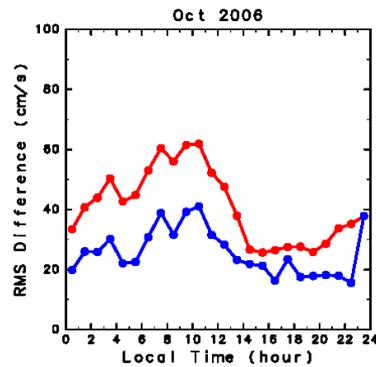
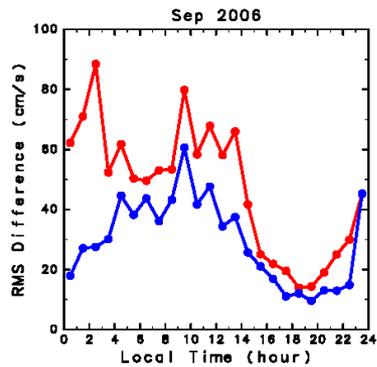
野良局はLoop1の特性とLoop2の特性に大きな違いがあるため方位推測を断念。

赤瀬鼻局と志賀島局は他の要因によるノイズが大きいため方位推測ができない。

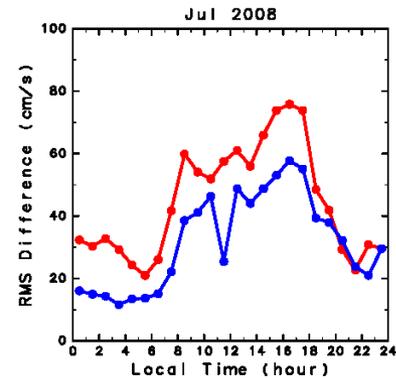
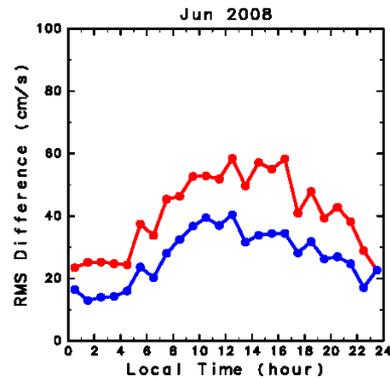
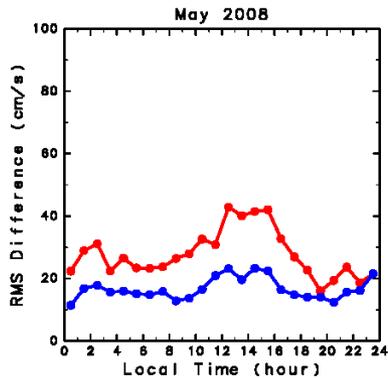
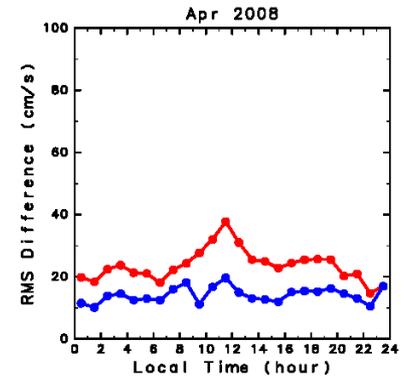
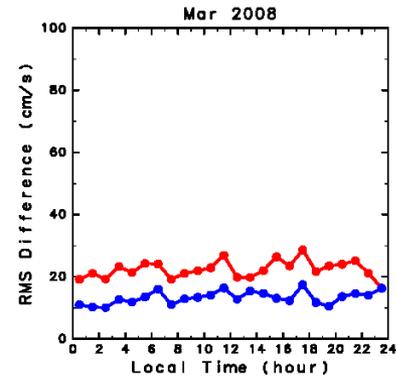
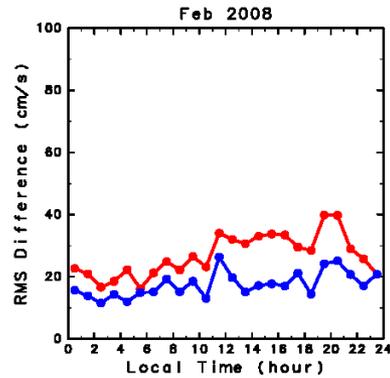
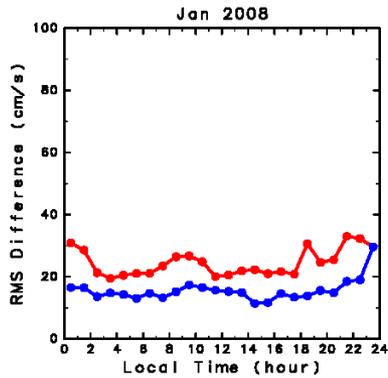
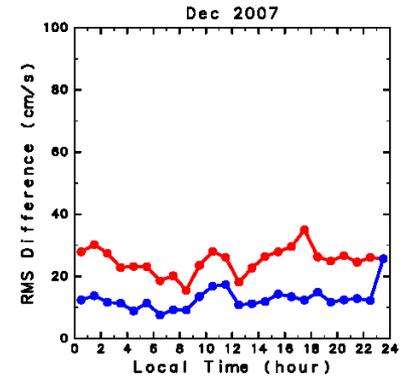
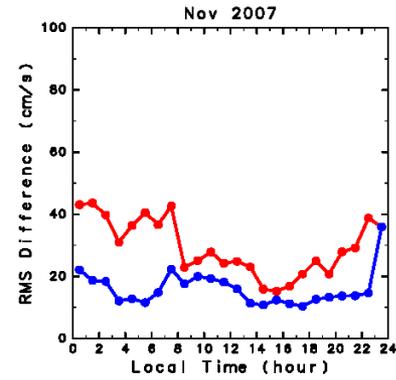
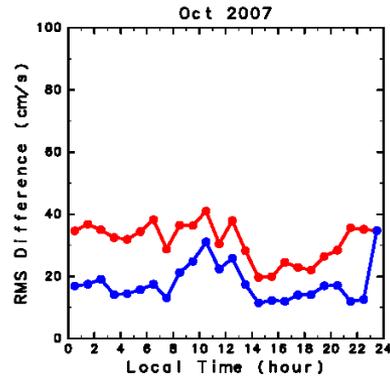
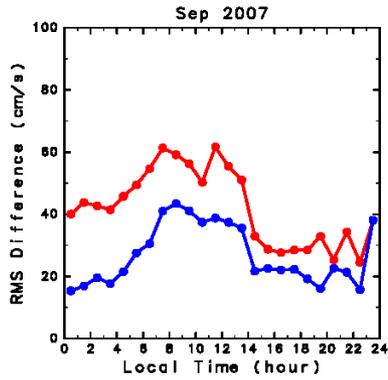
合成ベクトルの残差のRMSの時系列



残差のRMSの日変化

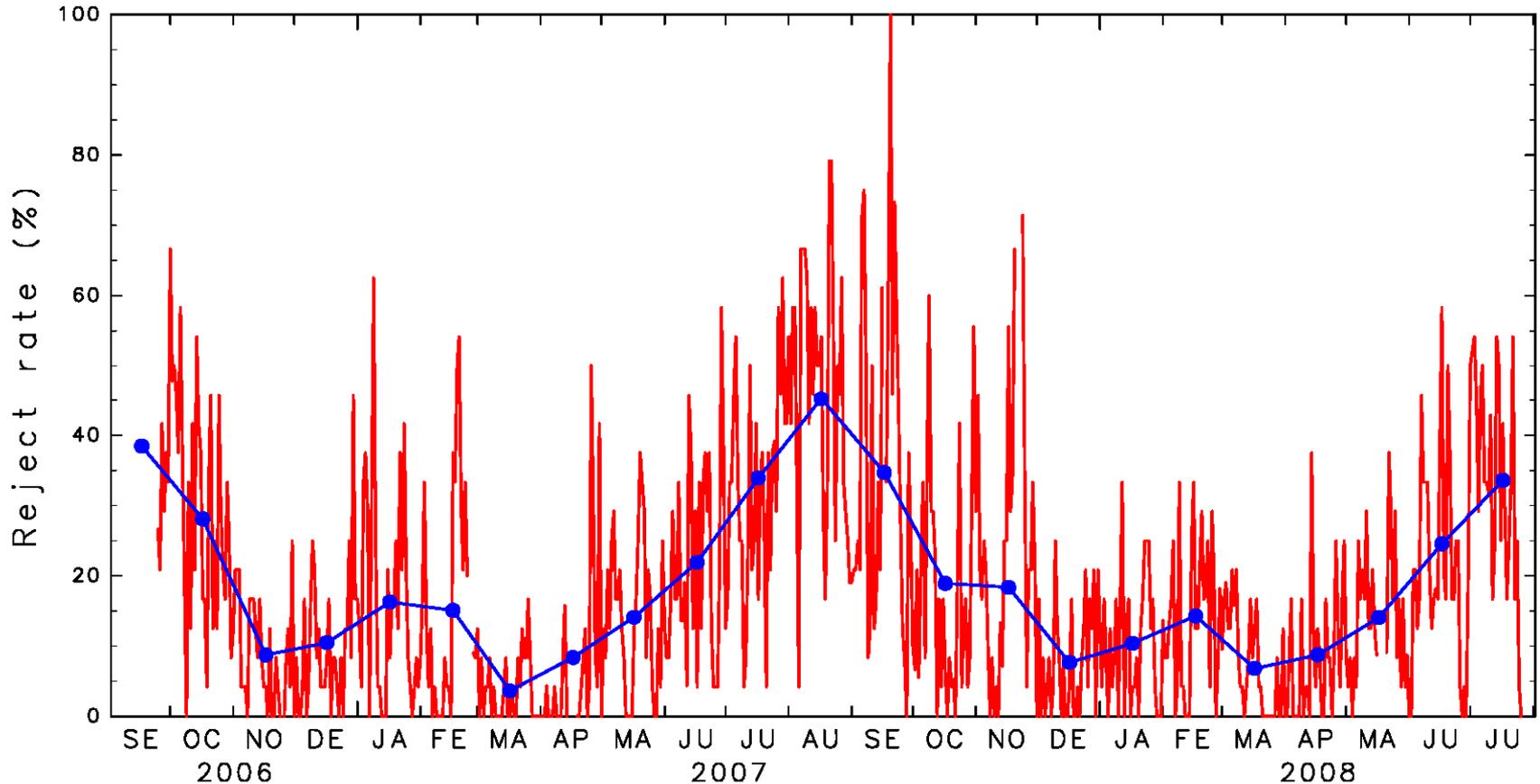


残差のRMSの日変化

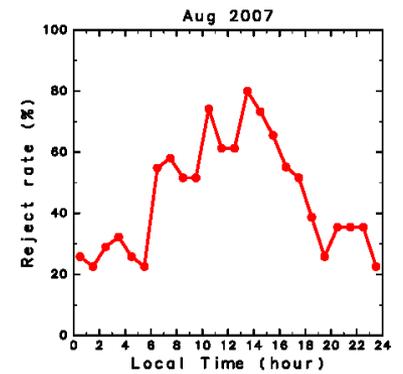
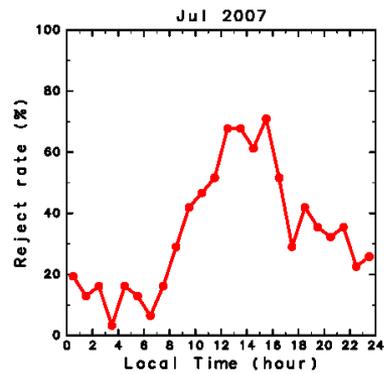
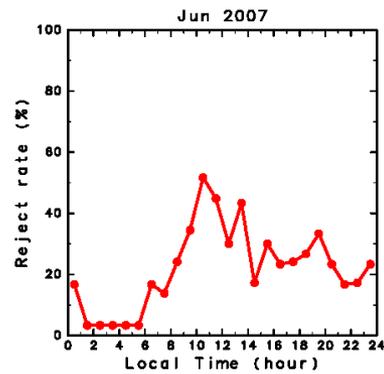
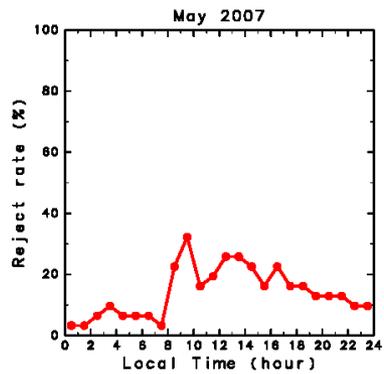
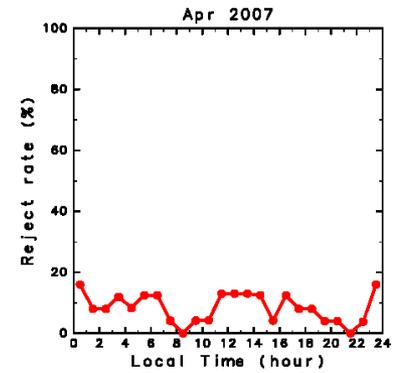
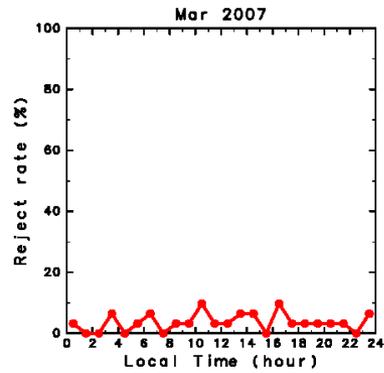
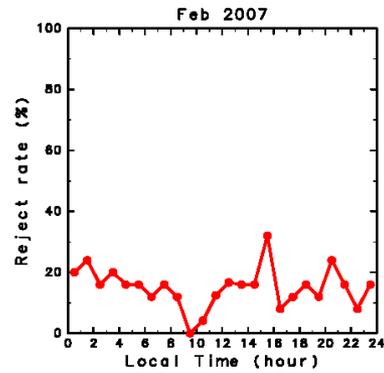
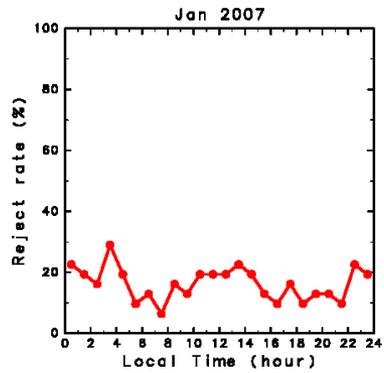
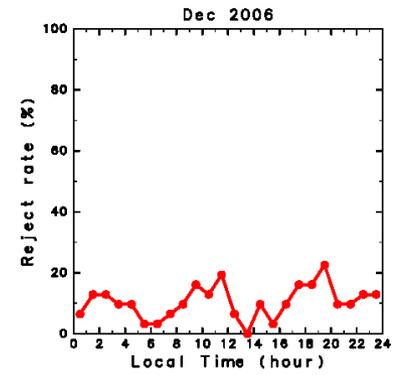
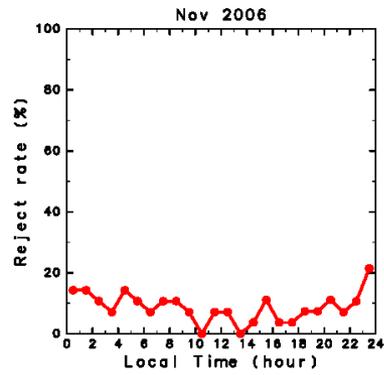
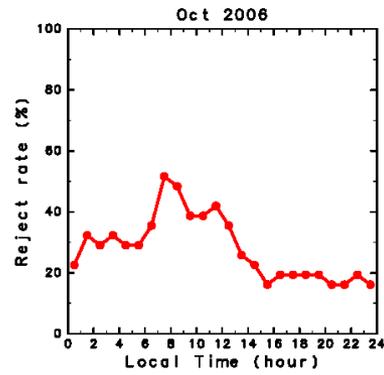
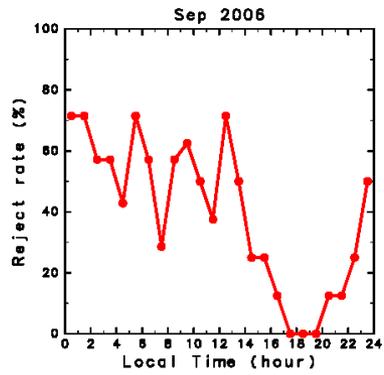


混信データの除去率

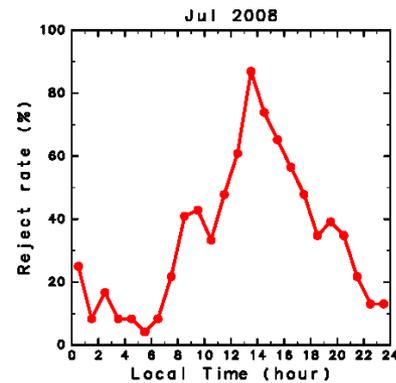
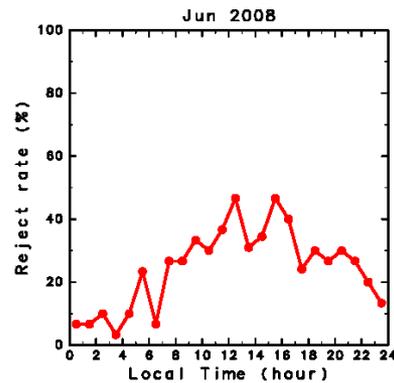
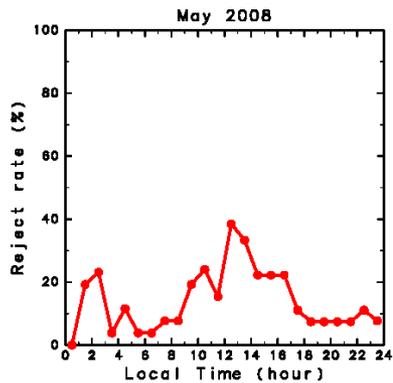
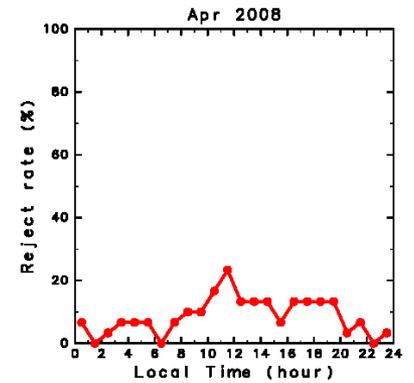
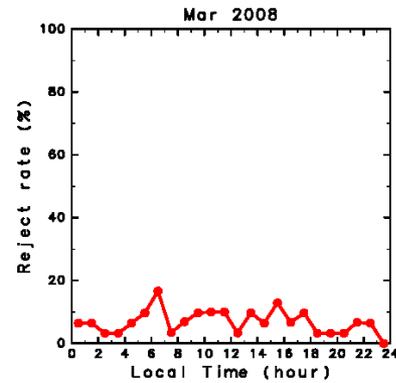
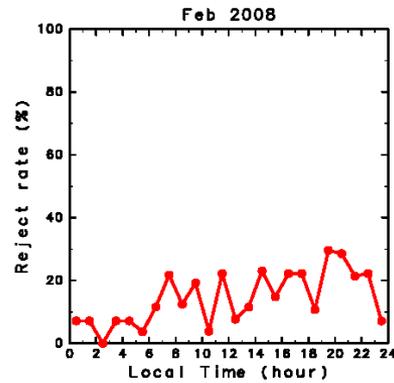
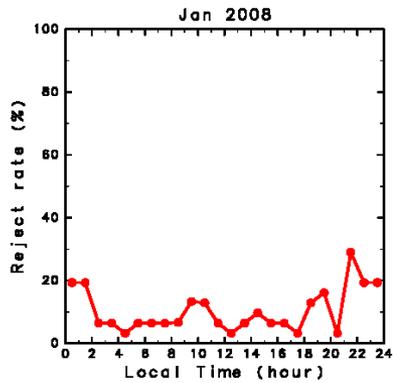
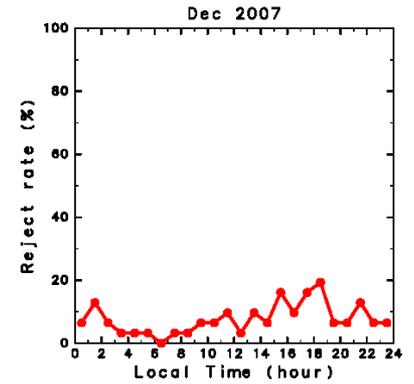
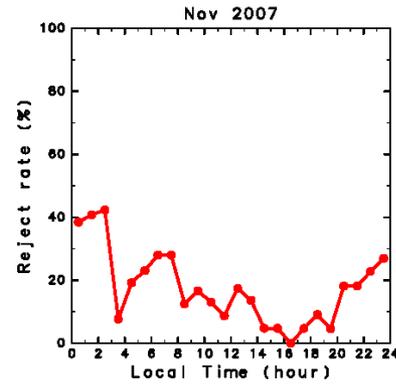
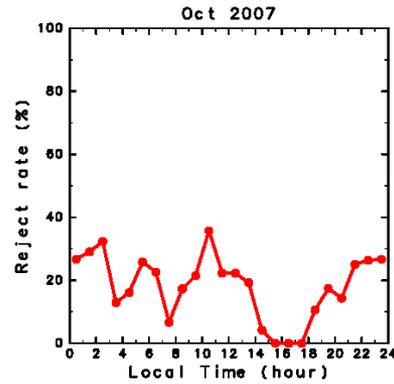
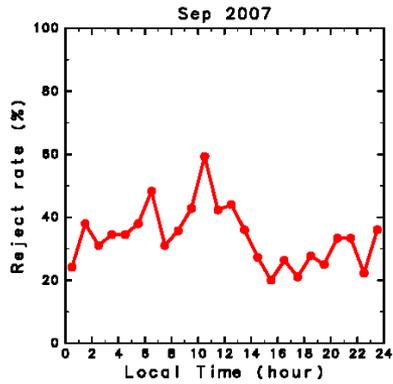
比較的混信が少ないと思われる12月～4月のデータをもとに東西成分, 南北成分のrms差を計算し, その2倍を超えるデータを混信データとして除去した.



「除去率」の日変化



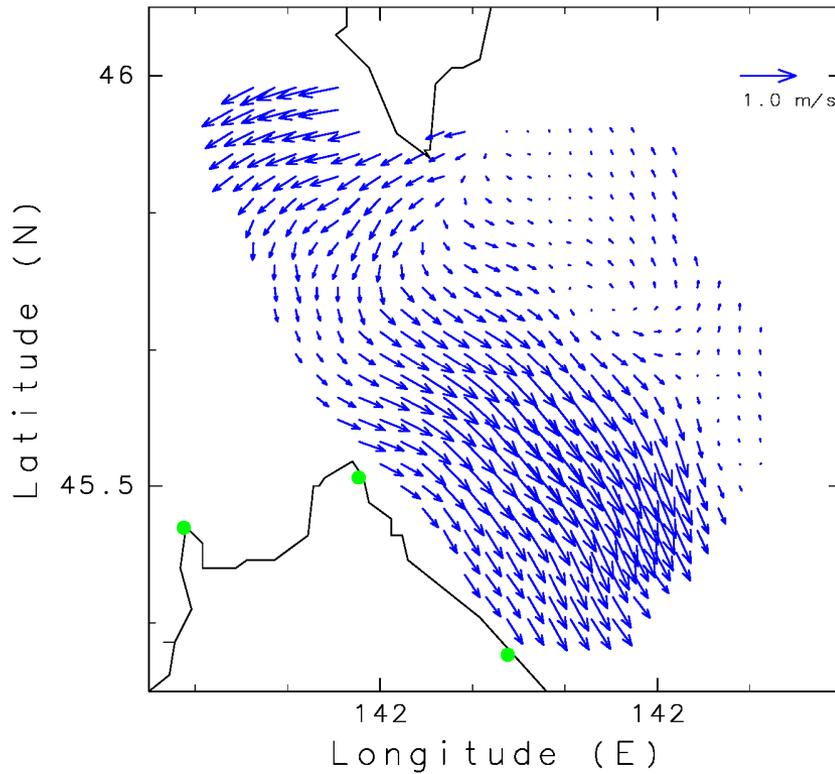
「除去率」の日変化



「混信除去」の効果 (月平均流速場)

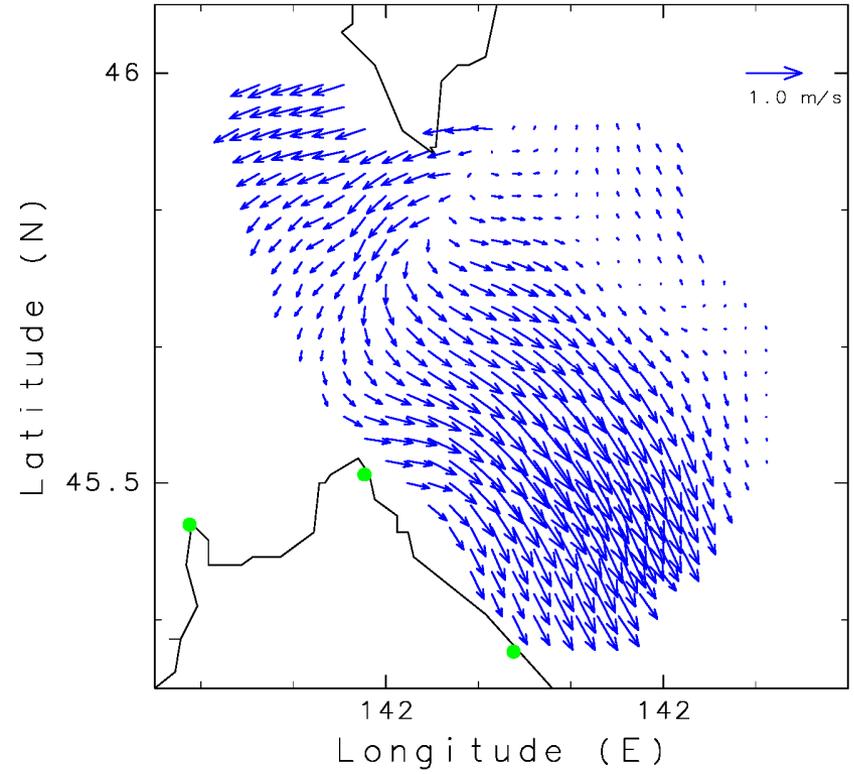
除去後

Sep 2006

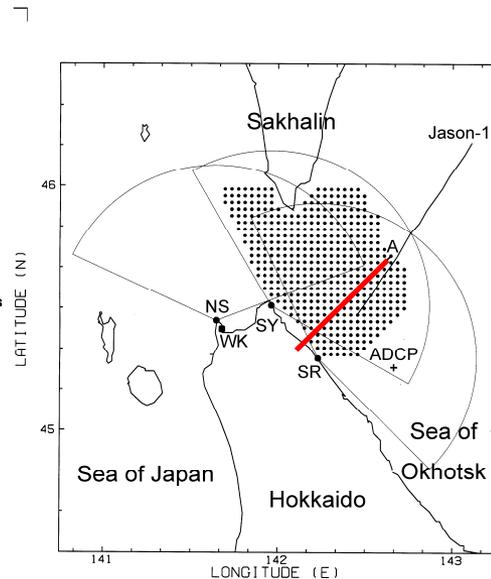
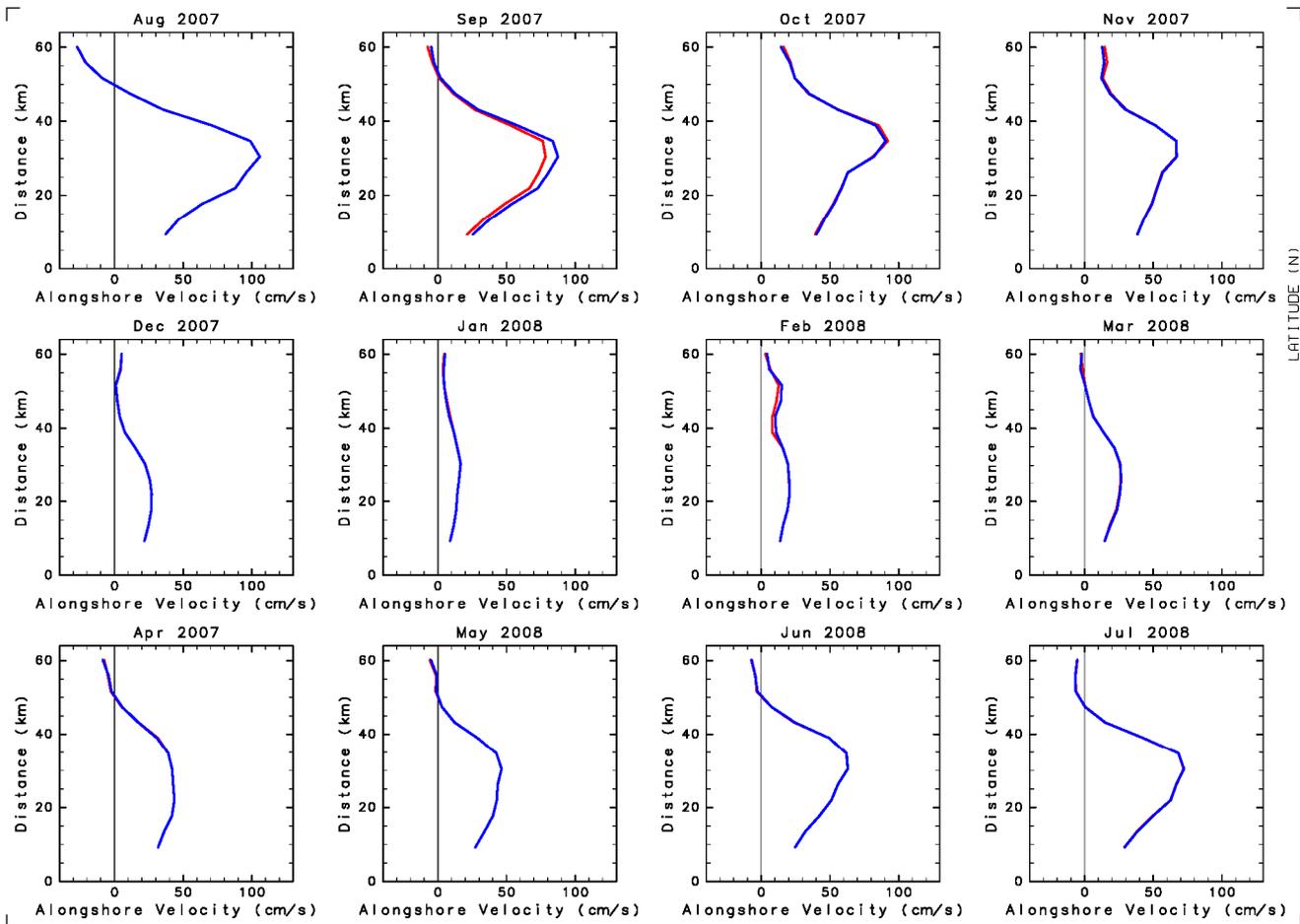


除去前

Sep 2006

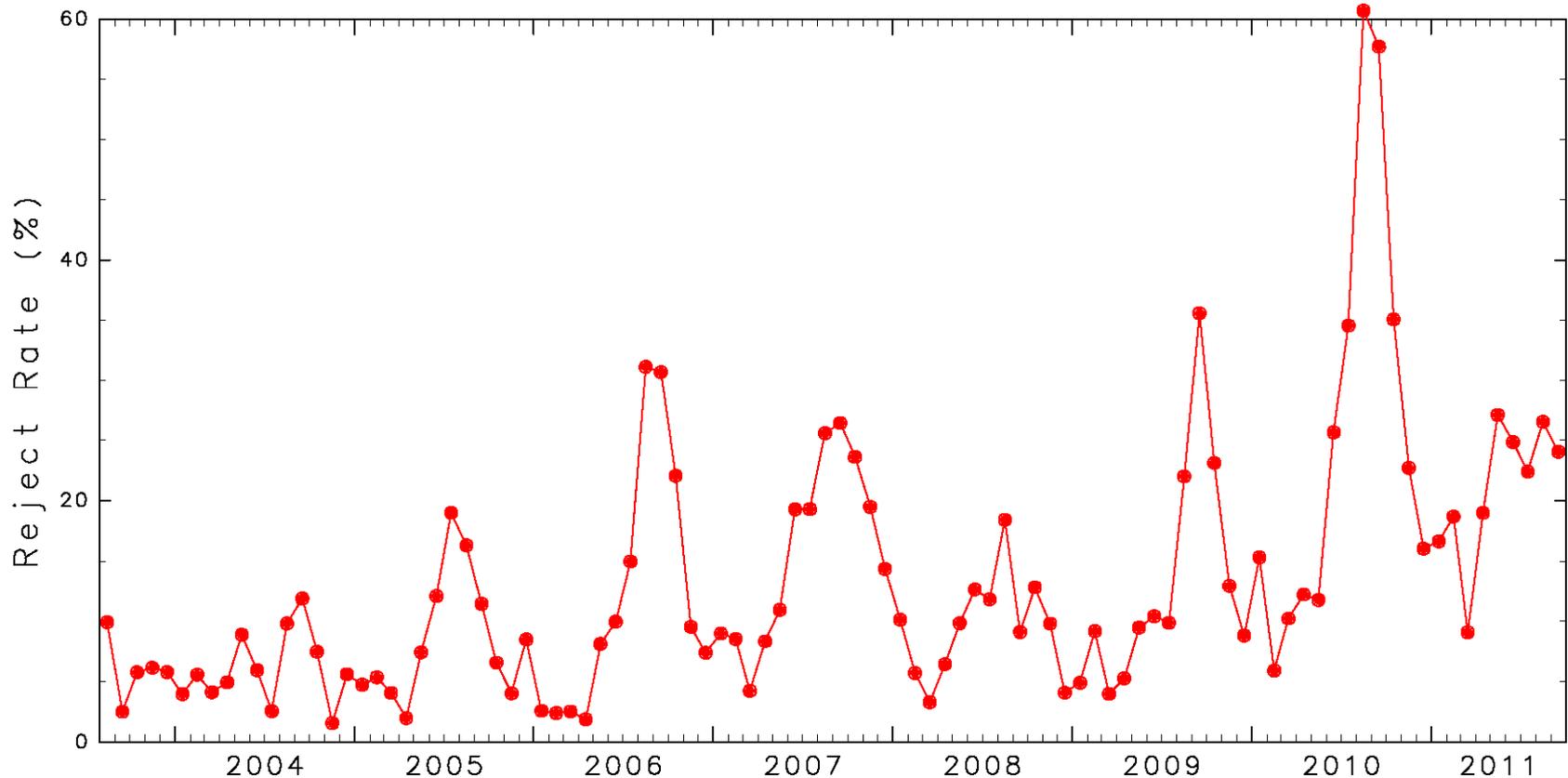


「混信除去」の効果 (月平均流速プロファイル)



月平均「除去率」の時系列

- 海洋レーダの全期間でADCPデータがあるわけではない
- ルーチンのデータ処理では、異常値を時空間の $3\sigma/2.5\sigma$ チェックで除いている



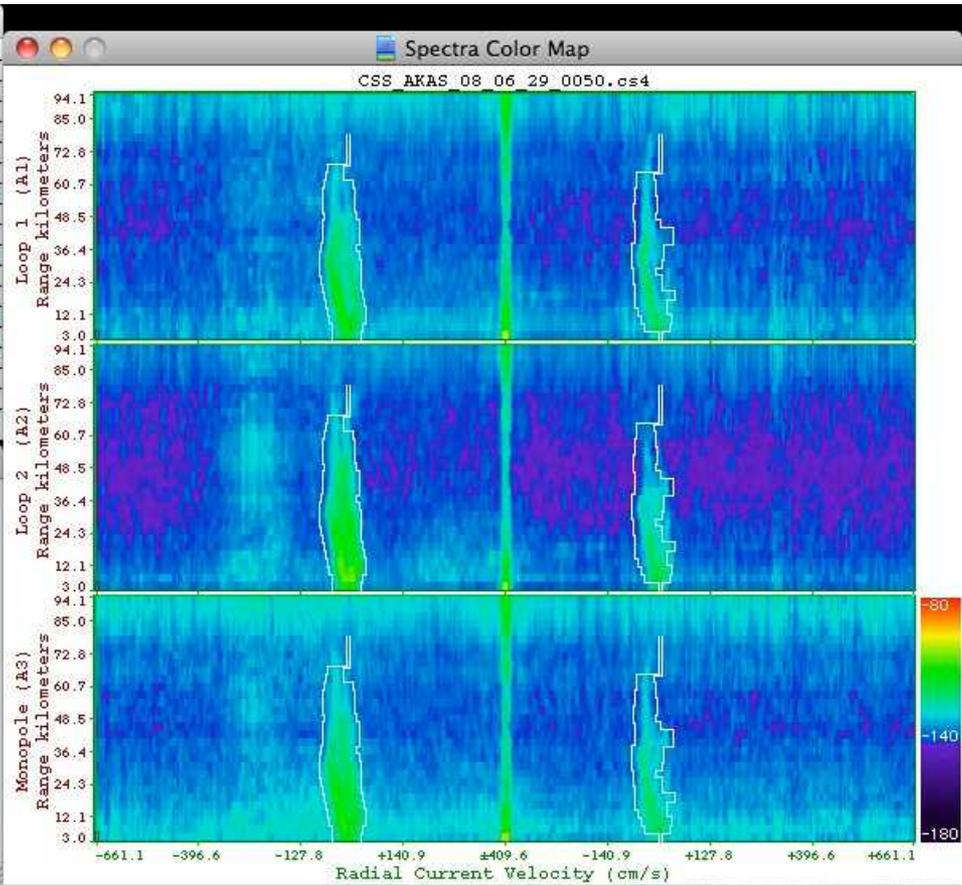
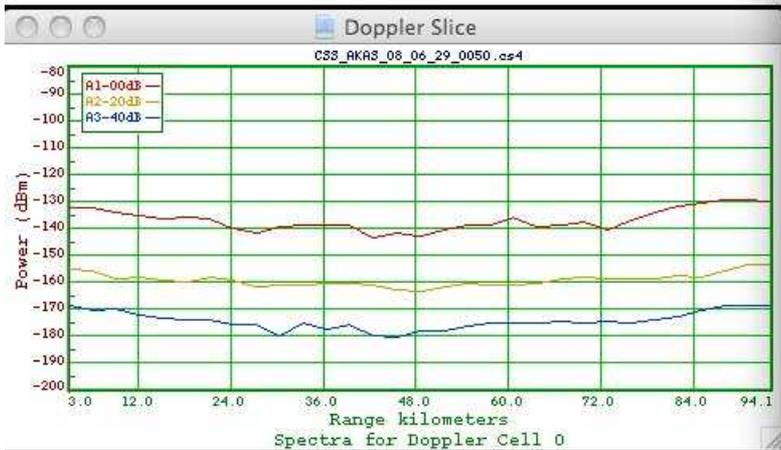
まとめ

- 海底設置ADCPデータとの比較により、混信が原因と考えられる異常値が見つかった。
- 到来方向は朝鮮半島～大陸付近と推定される。
- 混信は夏季の日中に多く発生する。
- 月平均スケールの流速場を与える影響は、現時点では、あまり大きくないと考えられる。

CSS_AKAS_08_06_29_0050.cs4

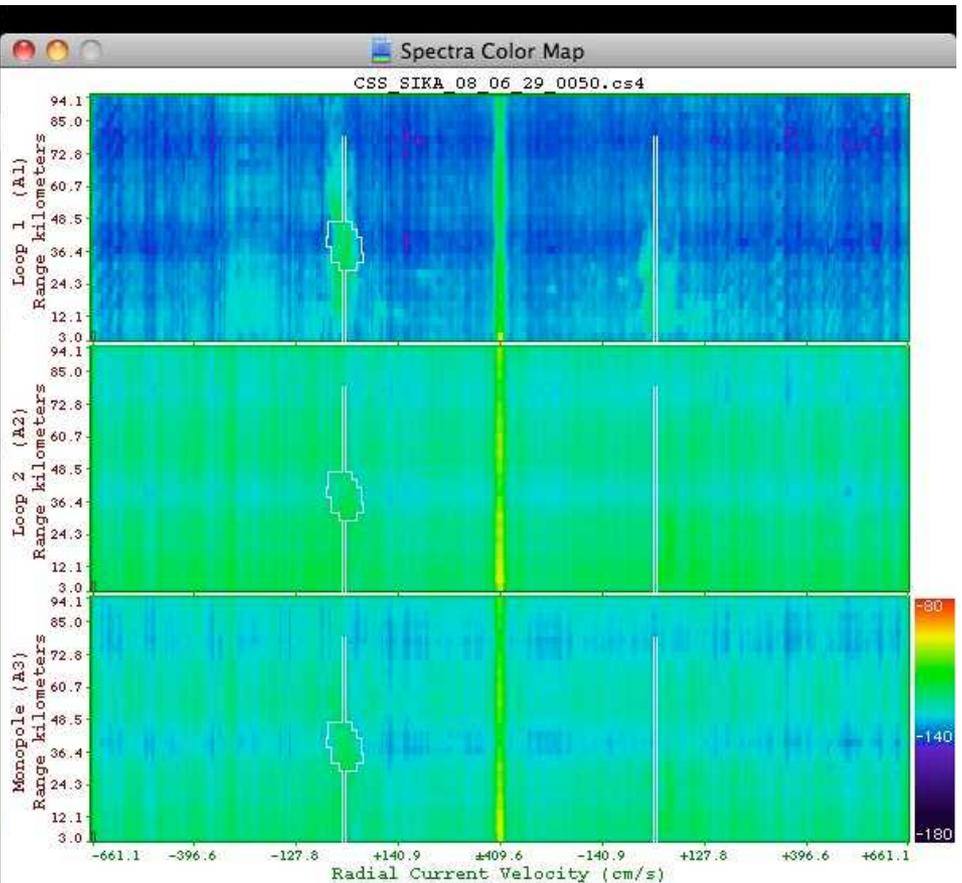
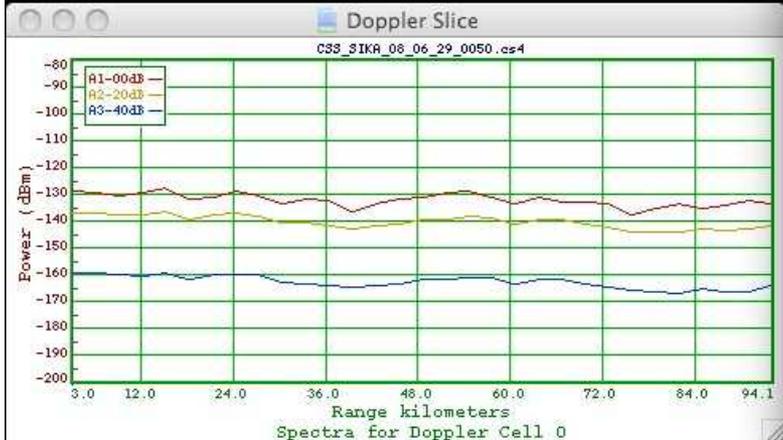
CSS_AKAS_08_06_29_0050.cs4

File Valid	Selected Range 1 (3.034 km) (1.885 mi)
CS Version,Kind 4,2	Selected Doppler 0 -255(DC)
Site AKAS	Current Velocity -661.1 cm/s
Date 06-29-2008 00:50:00	Doppler Velocity -10.71 m/s
Coverage 15 minutes	Left Bragg 157 -97.5(DC) FO [148,164]
Center Freq 13.946000 MHz	Right Bragg 353 +97.5(DC) FO [352,352]
Bandwidth -49.438477 kHz	SN1,NF1 -0.2dB , -131.8dBm
Sweep Rate 2.000000 Hz	SN2,NF2 +0.4dB , -135.3dBm
Range Cells 1 to 31	SN3,NF3 +0.3dB , -128.6dBm
Doppler Cells 512	A1 -132.0dBm , +1.6460E-10v
A3 Neg. Flagged 1 cells	A2 -134.9dBm , +8.5242E-11v
BTST1 11 -134.9 35.9 -5.1	A3 -128.4dBm , +3.8206E-10v, 0.8848qf
BTST2 14 -137.5 41.3 26.5	A13 -131.5dB, 20.8° : +1.754E-10r, +6.653E-11i
BTST3 11 -133.1 35.5 -2.9	A23 -133.6dB, -151.7° : -1.010E-10r, -5.444E-11i
Ave.Phases 31.4°, 44.9°	A12 -135.3dB, -174.4° : -7.677E-11r, -7.573E-12i
Ave.Ampls 0.6518, 0.2392	Phase Factor A12,A23 43.8° , 27.6°
	Ampl. Factor A12,A23 0.6201 , 0.2651



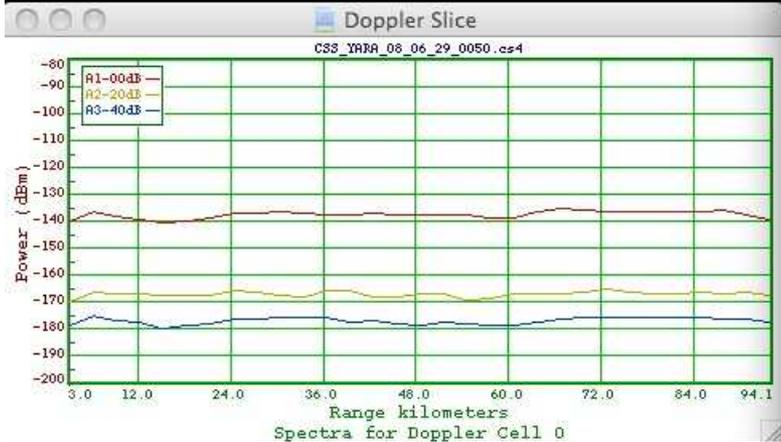
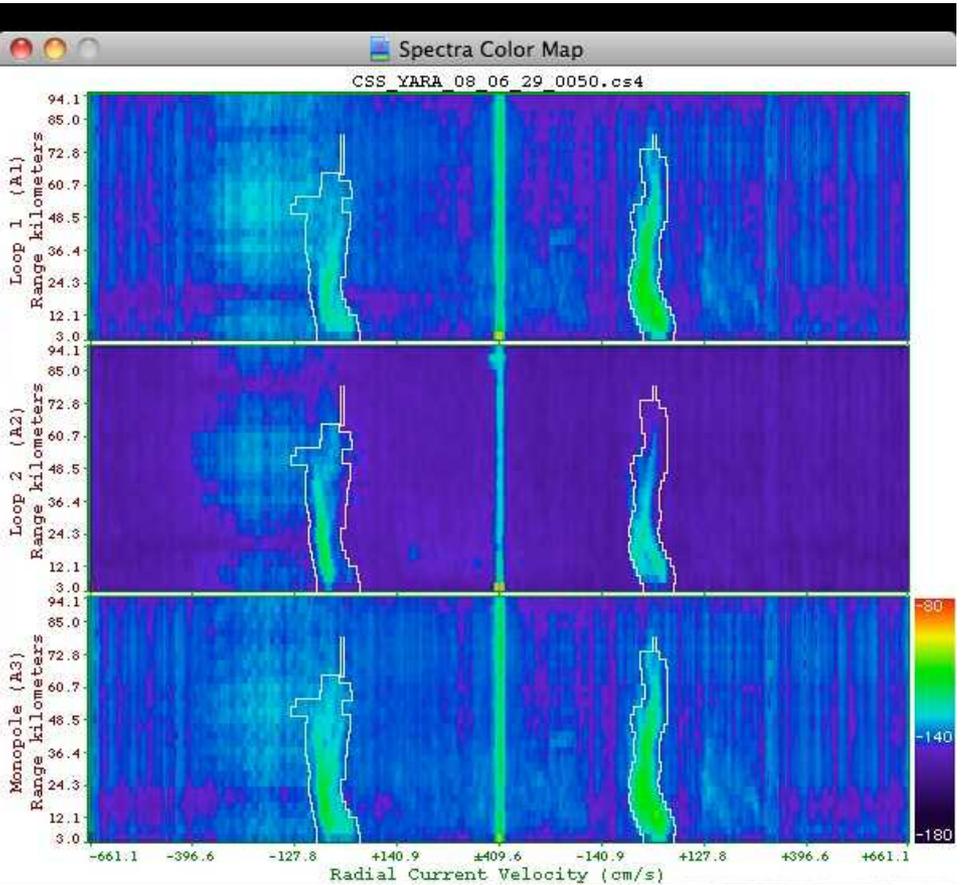
CSS_SIKA_08_06_29_0050.cs4

File Valid	Selected Range 1 (3.034 km) (1.885 mi)
CS Version, Kind 4,2	Selected Doppler 0 -255(DC)
Site SIKR	Current Velocity -661.1 cm/s
Date 06-29-2008 00:50:00	Doppler Velocity -10.71 m/s
Coverage 15 minutes	Left Bragg 157 -97.5(DC) FO [157,157]
Center Freq 13.946000 MHz	Right Bragg 353 +97.5(DC) FO [352,352]
Bandwidth +49.438477 kHz	SN1,NF1 +3.1dB, -131.1dBm
Sweep Rate 2.000000 Hz	SN2,NF2 +2.2dB, -118.5dBm
Range Cells 1 to 31	SN3,NF3 +2.4dB, -121.2dBm
Doppler Cells 512	A1 -128.0dBm, +4.2102E-10v
A3 Neg. Flagged 0 cells	A2 -116.3dBm, +6.1972E-09v
BTST1 10 -134.0 33.1 -3.0	A3 -118.9dBm, +3.4266E-09v, 0.8848qf
BTST2 0 -122.8 -200.0 -200.0	A13 -123.5dB, 177.9° : -1.173E-09r, +4.235E-11i
BTST3 5 -125.4 22.6 -200.0	A23 -117.6dB, -23.6° : +4.216E-09r, -1.844E-09i
Ave.Phases -176.3°, -20.4°	A12 -122.2dB, -158.5° : -1.473E-09r, -5.796E-10i
Ave.Ampls 999.0000, 999.0000	Phase Factor A12,A23 171.5°, -44.2°
	Ampl. Factor A12,A23 999.0000, 999.0000



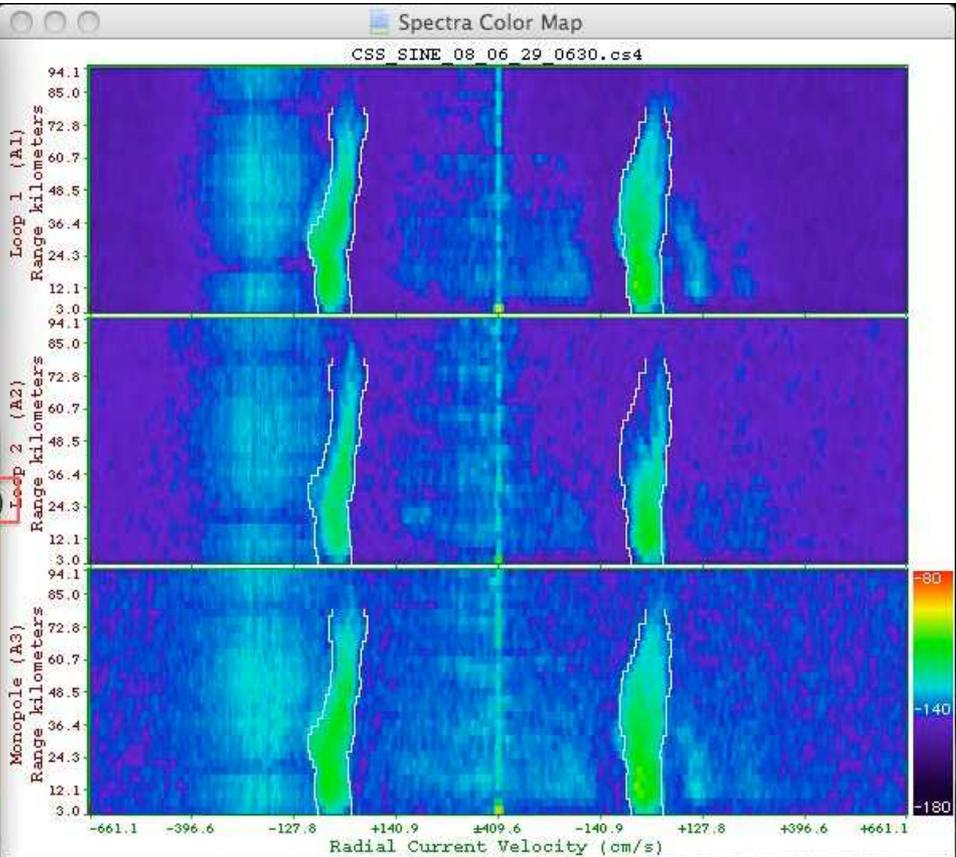
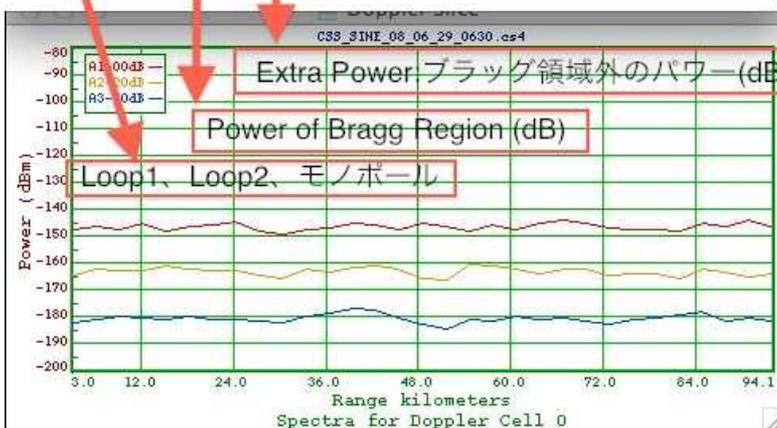
CSS_YARA_08_06_29_0050.cs4

File Valid	Selected Range 1 (3.034 km) (1.885 mi)
CS Version, Kind 4,2	Selected Doppler 0 -255(DC)
Site YARRA	Current Velocity -661.1 cm/s
Date 06-29-2008 00:50:00	Doppler Velocity -10.71 m/s
Coverage 15 minutes	Left Bragg 157 -97.5(DC) FO [142,167]
Center Freq 13.945000 MHz	Right Bragg 353 +97.5(DC) FO [346,363]
Bandwidth -49.438477 kHz	SN1,NF1 +1.5dB, -140.9dBm
Sweep Rate 2.000000 Hz	SN2,NF2 -2.4dB, -147.0dBm
Range Cells 1 to 31	SN3,NF3 +1.8dB, -140.2dBm
Doppler Cells 512	A1 -139.4dBm, +2.9964E-11v
A3 Neg. Flagged 0 cells	A2 -149.5dBm, +2.9676E-12v
BTST1 10 -138.4 38.3 20.7	A3 -138.4dBm, +3.8028E-11v, 1.0000qf
BTST2 16 -145.9 39.9 33.6	A13 -139.1dB, -56.0° : +1.808E-11r, -2.684E-11i
BTST3 13 -137.7 40.2 -3.6	A23 -145.1dB, -24.4° : +7.428E-12r, -3.371E-12i
Ave. Phases -56.0°, -22.0°	A12 -145.6dB, -30.2° : +6.199E-12r, -3.615E-12i
Ave. Ampls 1.1288, 1.2048	Phase Factor A12,A23 -144.7°, 115.3°
	Ampl. Factor A12,A23 1.0951, 0.9800



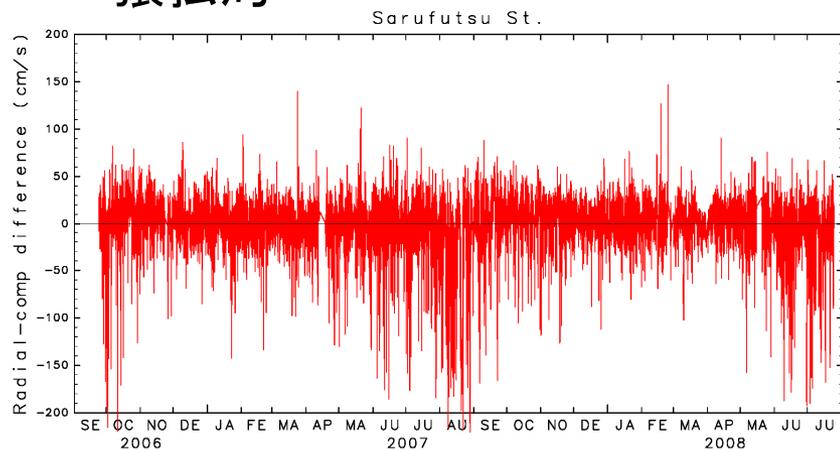
CSS_SINE_08_06_29_0630.cs4

File Valid	Selected Range 1 (3.034 km) (1.885 mi)
CS Version, Kind 4, 2	Selected Doppler 0 -255(DC)
Site SINE	Current Velocity -661.1 cm/s
Date 06-29-2008 06:30:00	Doppler Velocity -10.71 m/s
Coverage 15 minutes	Left Bragg 157 -97.5(DC) FO [143,162]
Center Freq 13.945000 MHz	Right Bragg 353 +97.5(DC) FO [339,357]
Bandwidth -49.438477 kHz	SN1, NF1 -1.6dB, -145.2dBm
Sweep Rate 2.000000 Hz	SN2, NF2 -2.0dB, -142.1dBm
Range Cells 1 to 31	SN3, NF3 -2.5dB, -139.3dBm
Doppler Cells 512	A1 -146.8dBm, +5.5011E-12v
R3 Req. Flagged 179 cells	A2 -144.1dBm, +1.0130E-11v
BTST1 19 -142.3 45.1 34.1	A3 -141.8dBm, +1.7544E-11v, 1.0000qf
BTST2 13 -140.3 40.0 26.0	A13 -154.6dB, 6.0° : +9.071E-13r, +9.514E-14i
BTST3 19 -137.3 43.6 22.5	A23 -145.3dB, 34.7° : +6.363E-12r, +4.405E-12i
Ave. Phases -168.7°, 142.2°	A12 -154.5dB, -58.5° : +4.903E-13r, -8.007E-13i
Ave. Rmpls 1.1165, 0.9044	Phase Factor A12, A23 -170.2°, 114.3°
	Rmpl. Factor A12, A23 1.2866, 0.5929

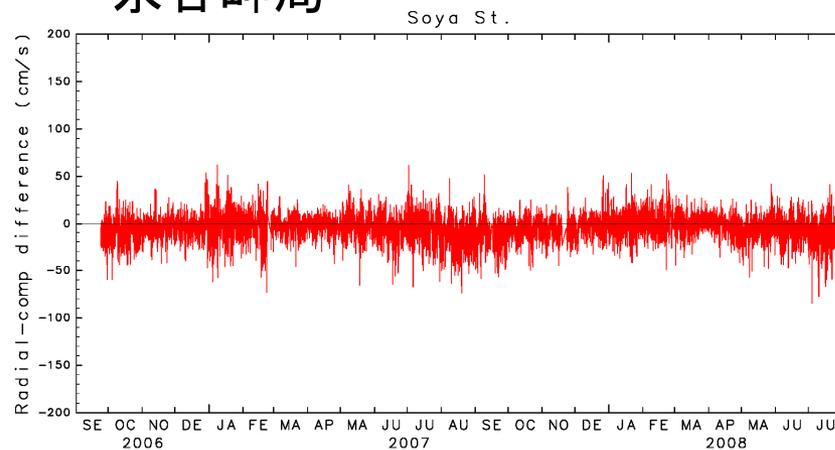


各局の視線速度差の時系列

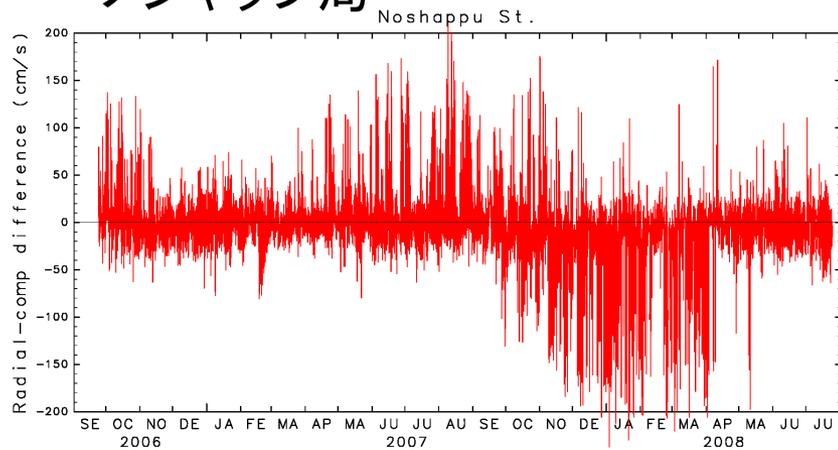
猿払局



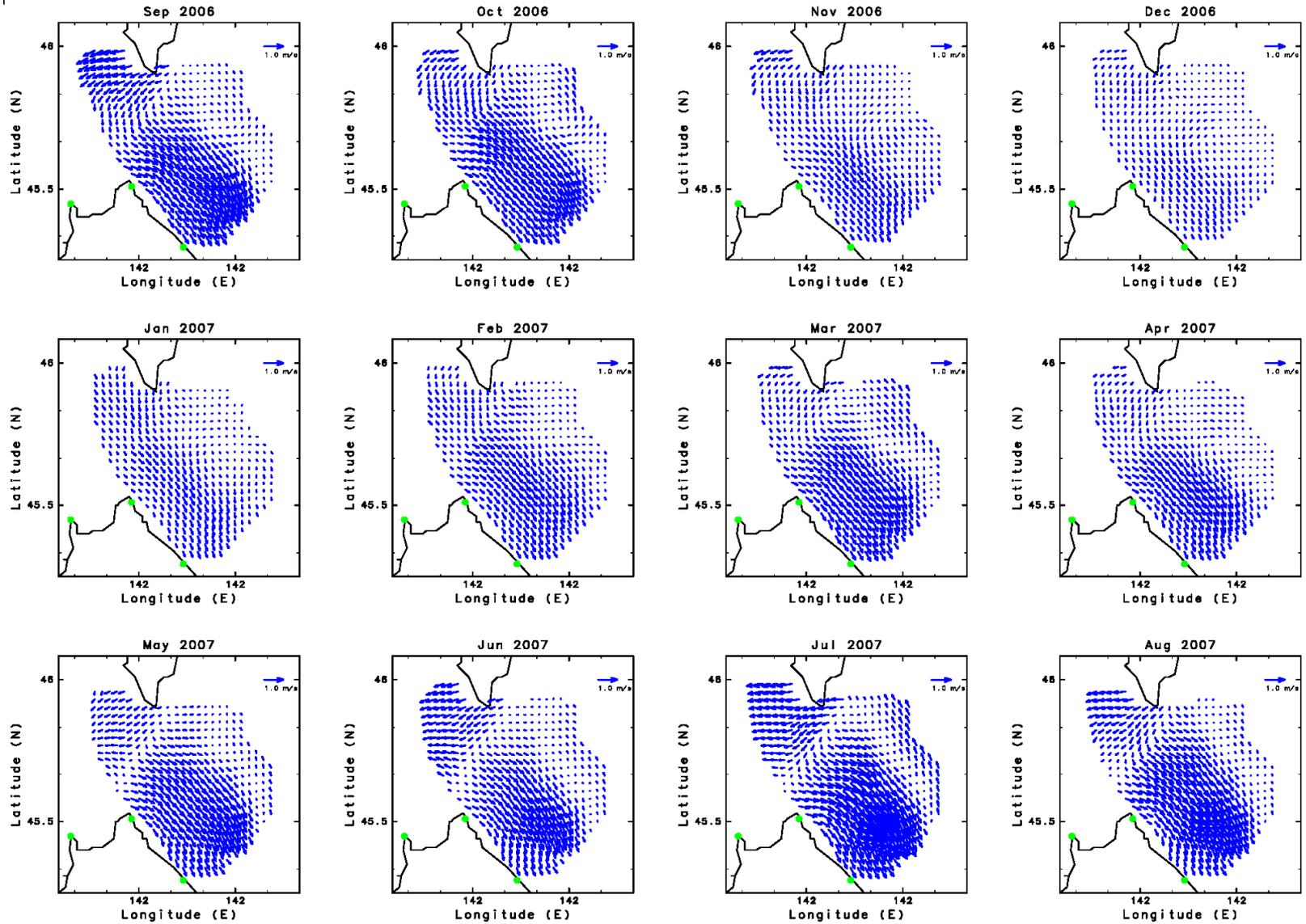
宗谷岬局



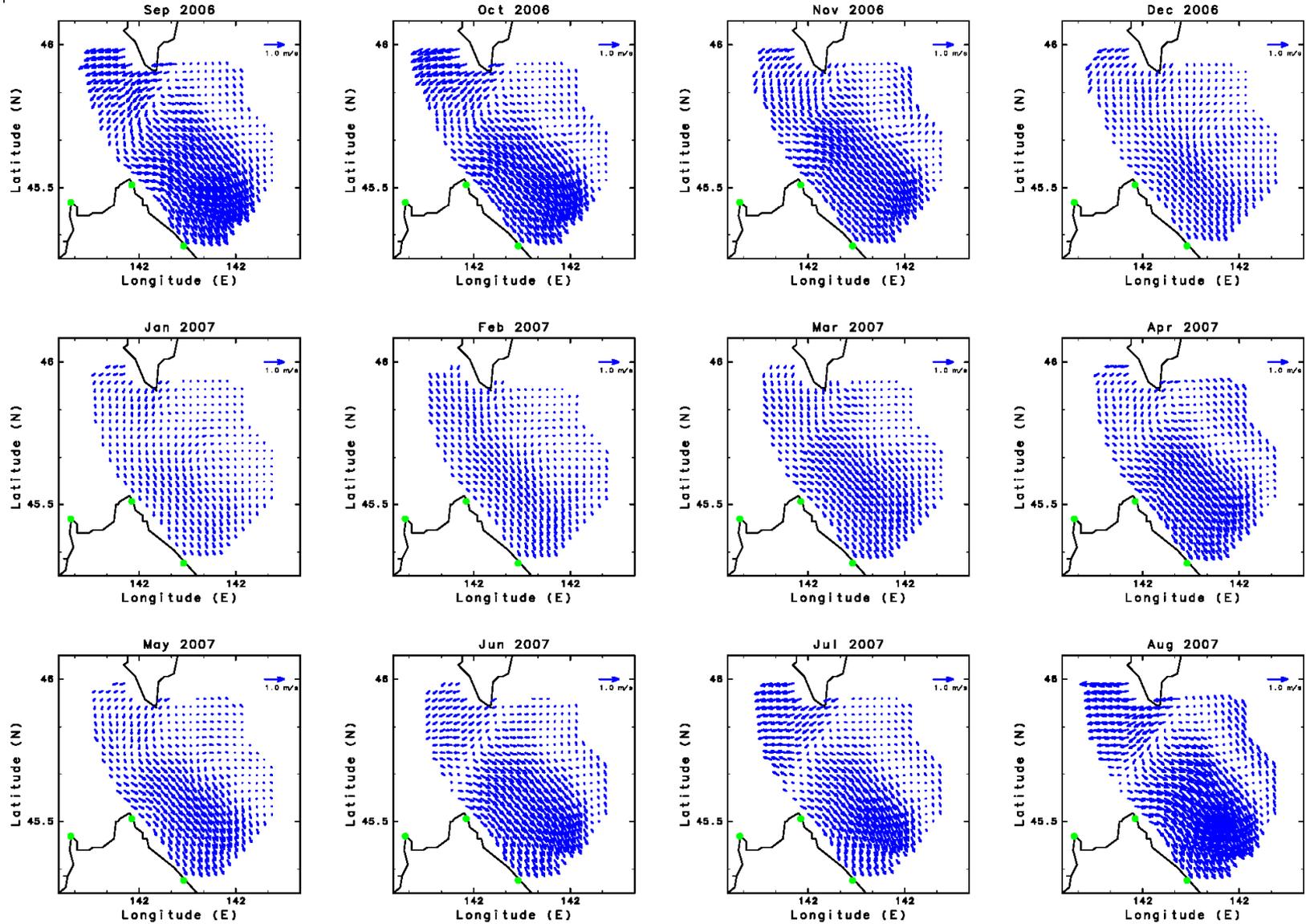
ノシャップ局



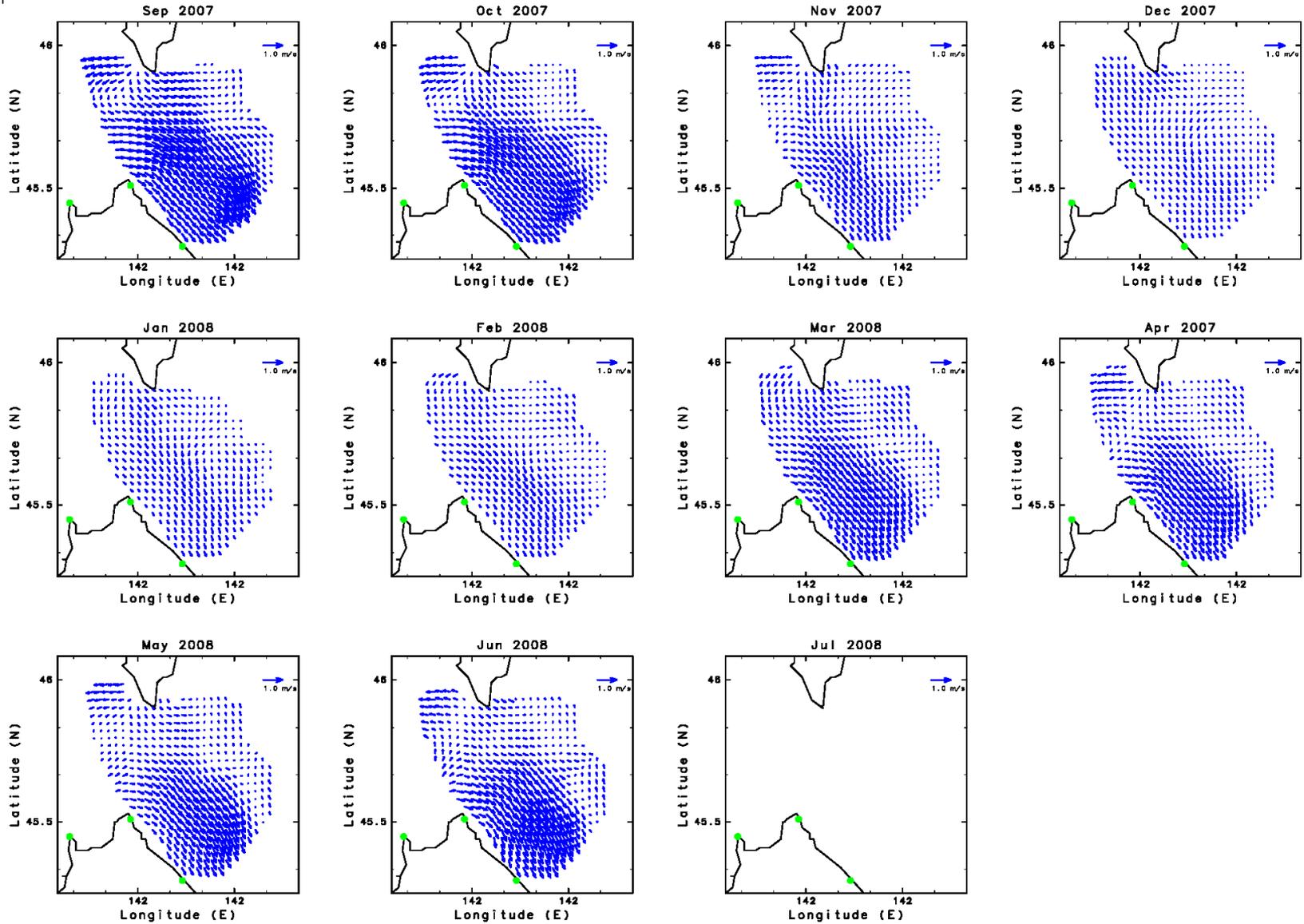
除去後



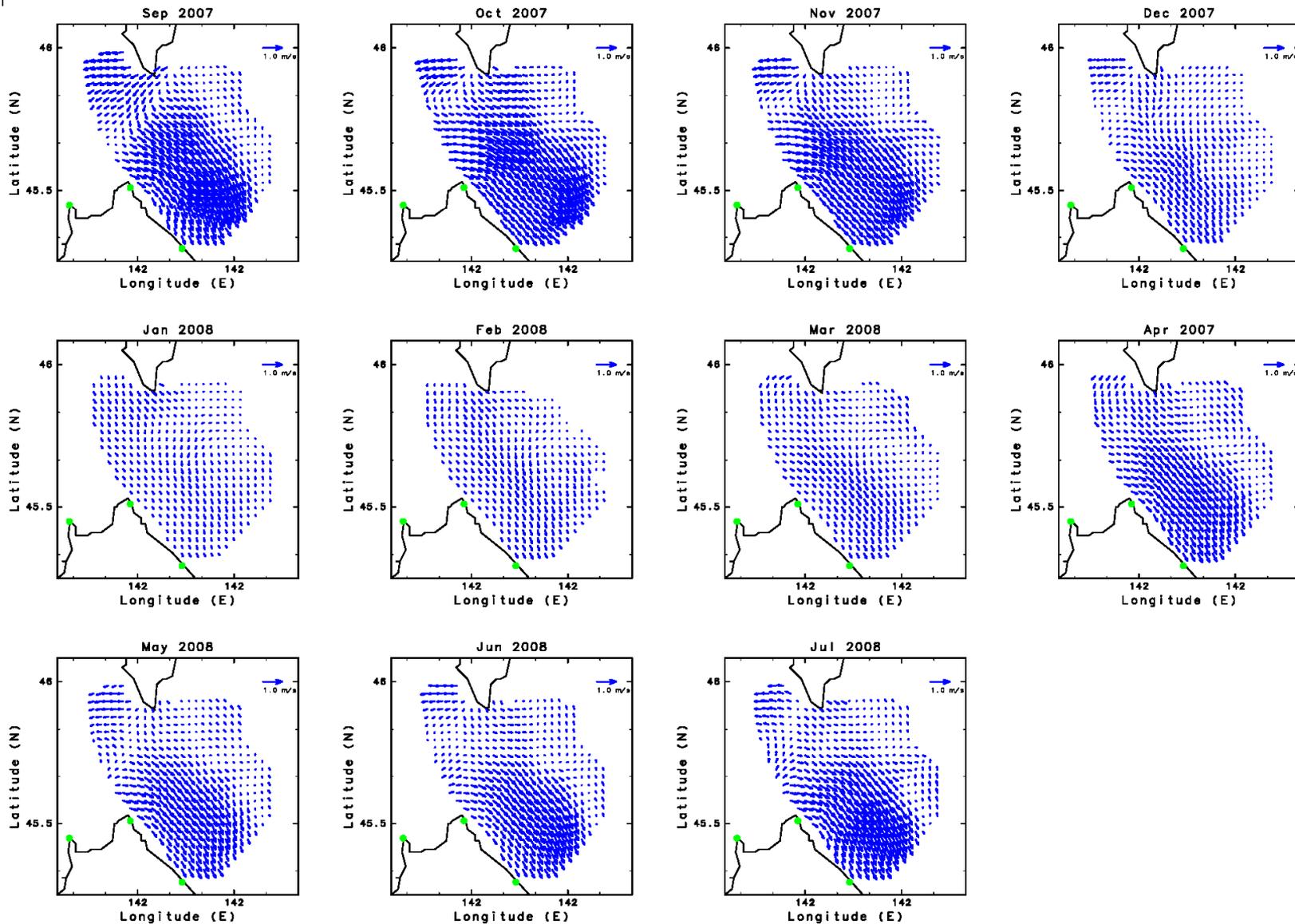
除去前



除去後



除去前



浜鬼志別沖の流速プロファイルの年々変動

