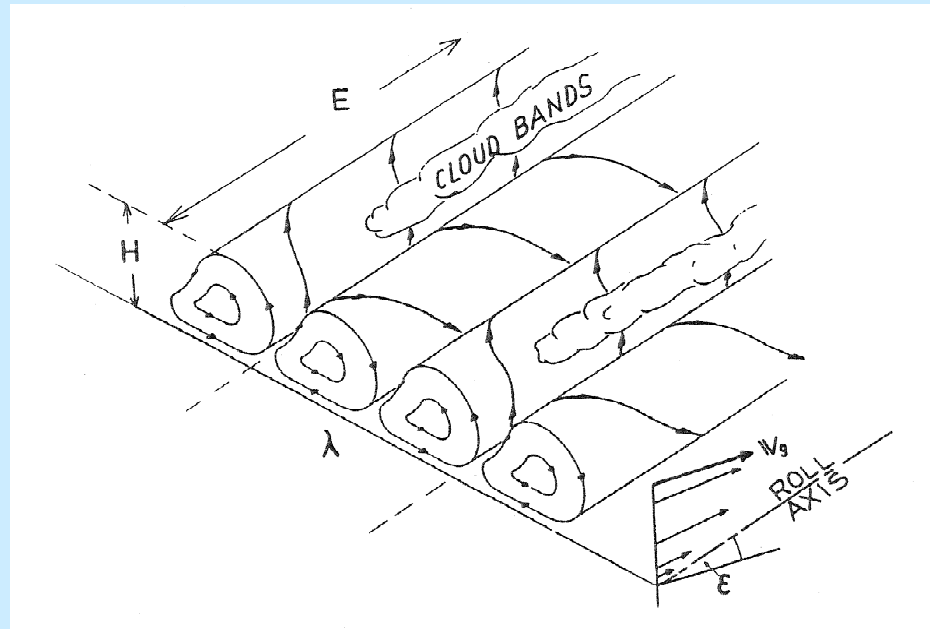# Verification of downscaling simulation of local wind by Doppler-Lidar Observations

T. Iwasaki. M. Sawada, K. Tamura, T. Sakai, W. Sha, T. Yamazaki, H., Iwai, S. Ishii, N. Tsunematsu, K. Mizutani, Y. Murayama, T. Itabe, I. Yamada, N. Matayoshi and D. Matsushima

Department of Geophysics, Tohoku University
National Institute of Information and Communication Technology   (NICT)
Electronic Navigation Research Institute   (ENRI)
Japan Aerospace Exploration Agency   (JAXA)
Chiba Institute of Technology

1. **Front Head & H. C. Roles of Sea Breeze**
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Image © 2007 TerraMetrics
Image © 2007 DigitalGlobe

© 2005 Google

Pointer 38°06'36.52" N 140°54'54.32" E   Streaming ||||||||| 100%   Eye alt 9694 ft

SPEC NICT / ENRI Lidars

NaI. Inst. of Comm. Tech. (NICT)

Mobile Station

Transceiver unit : Coherent Technologies Inc.
Scanner control & data processing system :
NICT

wavelength	2.012 μm
pulse repetition frequency	100 Hz
accumulated shot number	50
range resolution	90 m
minimum range	315 m
maximum range	~ 10 km
scan rate	2.0 deg/sec

Mobile Station for wind observations

Elec. Navi. Res. Inst.(ENRI)

Fixed Station

Transceiver unit : Mitsubishi Electric Corp.
Scanner control & data processing system :
Mitsubishi Electric Corp.

wavelength	1.54 μm
pulse repetition frequency	4000 Hz
accumulated shot number	500
range resolution	29.9 m
minimum range	80.0 m
maximum range	2472.0 m
scan rate	6.0 deg/sec

Wake Turbulence

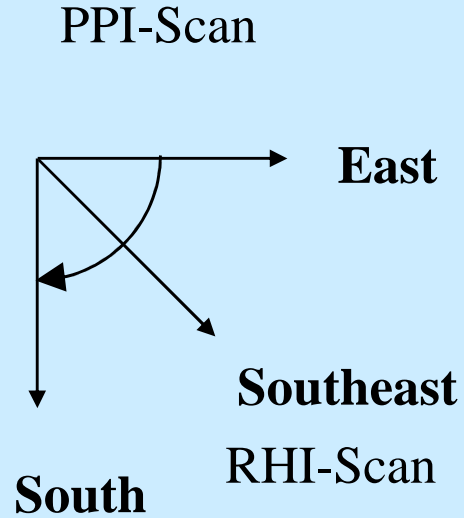# Dual Doppler wind Lidar Observations at Sendai Airport
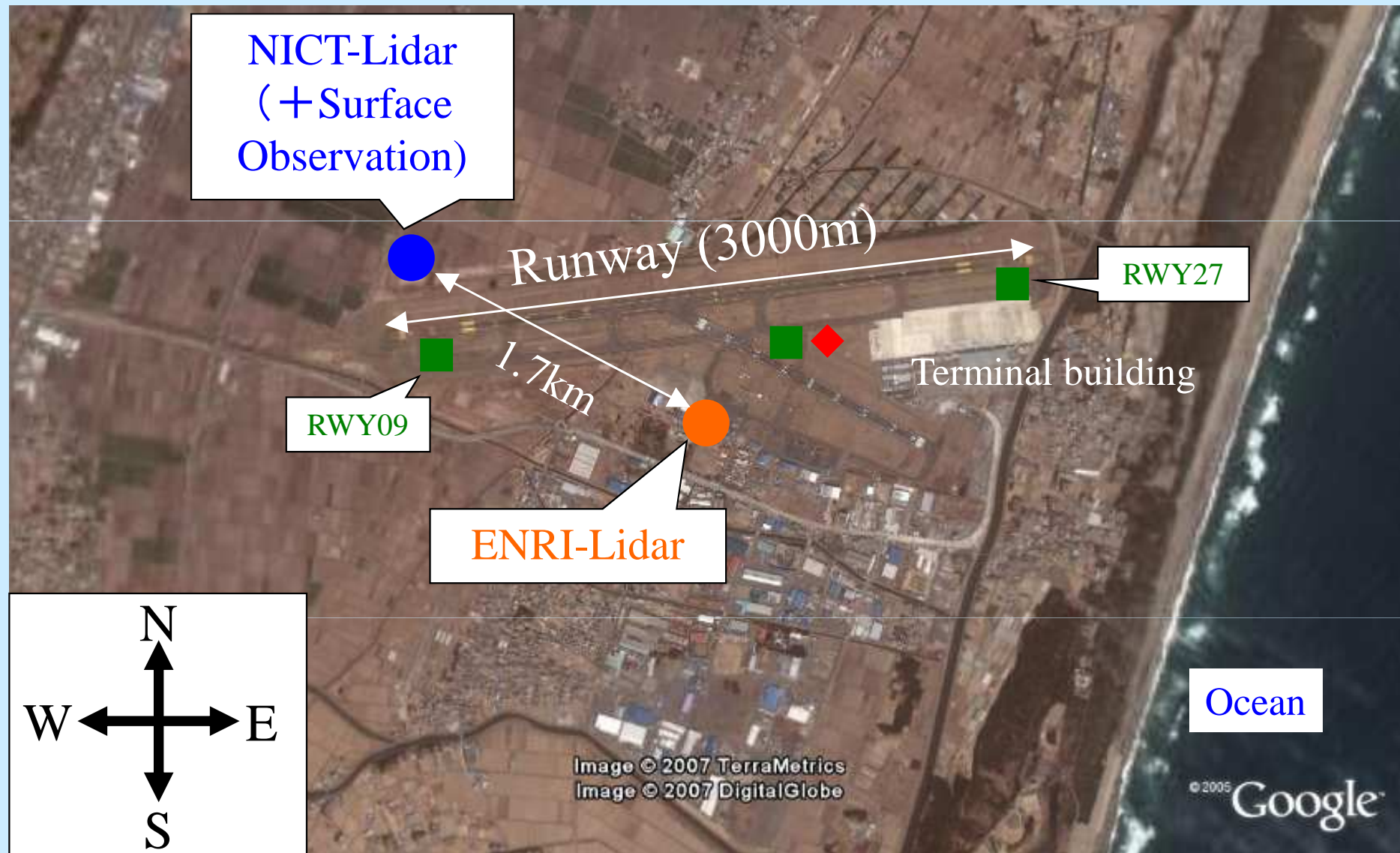
Passage of Seabreeze front

LOS(Line Of Sight) wind velocity

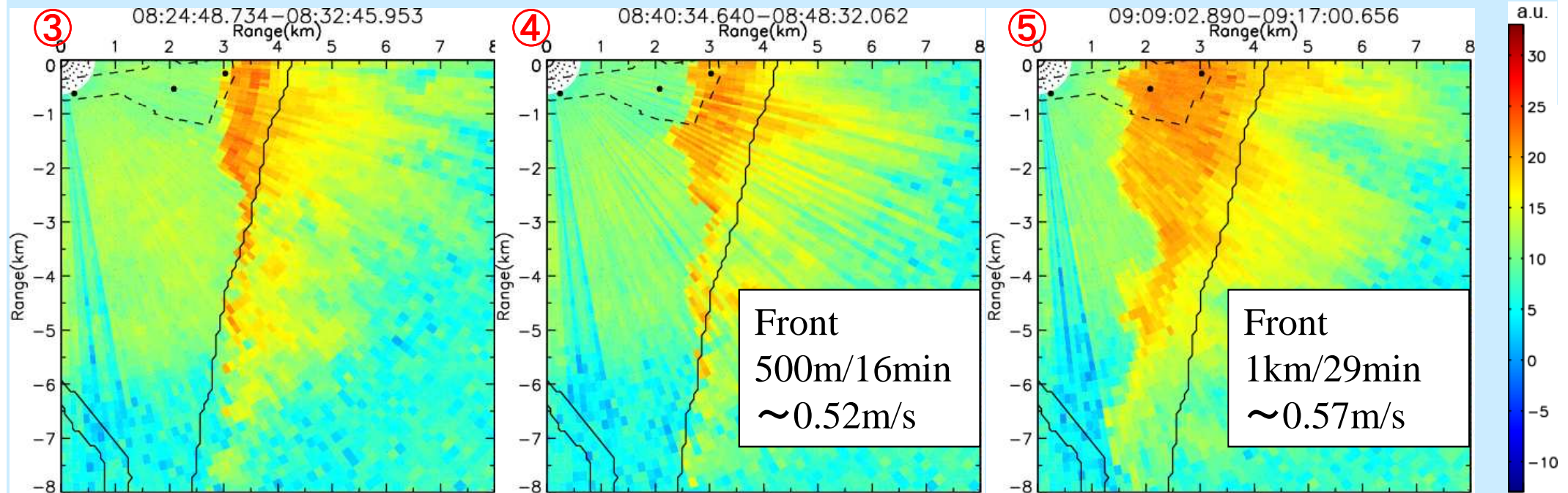PPI-Scan

East

Southeast

RHI-Scan

South
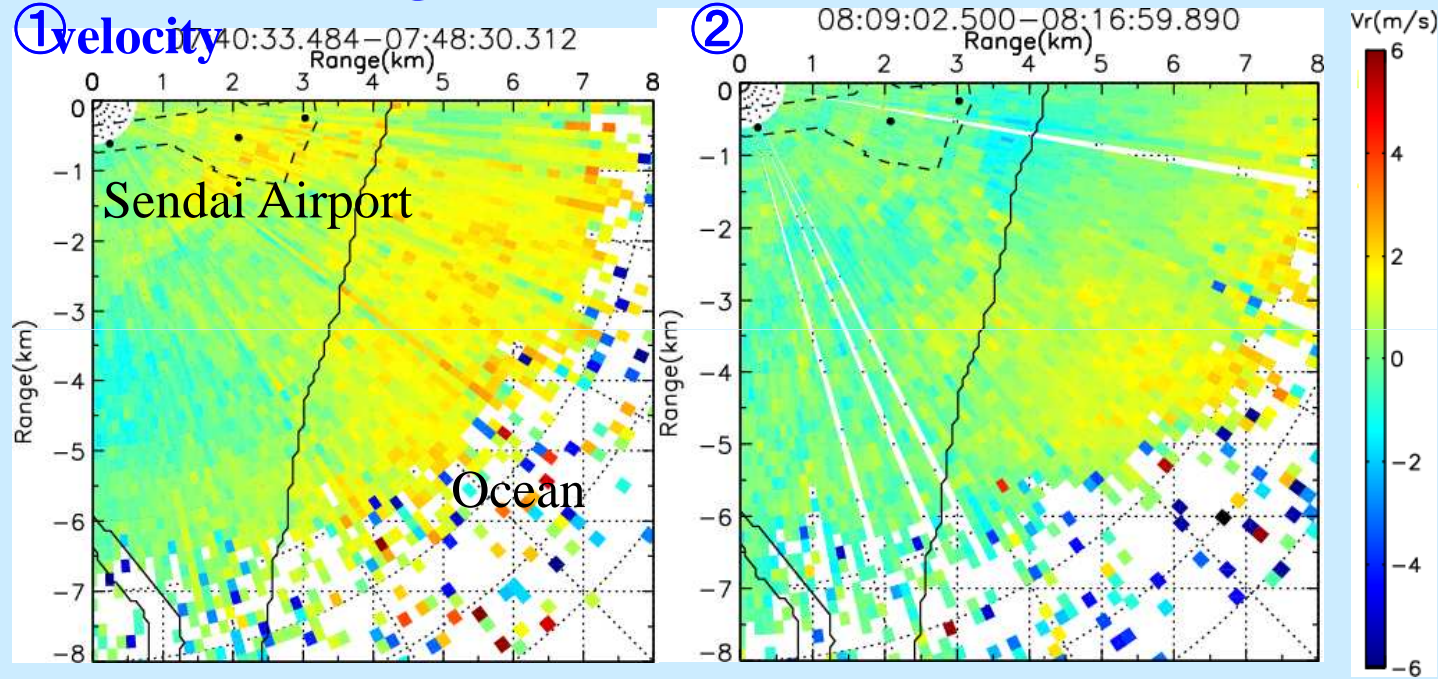
LOS wind
  tail wind (red)
  head wind (blue)

SN ratio
  high density (red)
  low density (blue)

SN-ratio indicates aerosol density

Provided by Iwai

Passage of Seabreeze front

③ 08:24:48.734−08:32:45.953

④ 08:40:34.640−08:48:32.062

Wind
2～3m/s

⑤ 09:09:02.890−09:17:00.656

Wind
～3m/s

Vr(m/s)

③ 08:24:48.734−08:32:45.953

④ 08:40:34.640−08:48:32.062

Front
500m/16min
～0.52m/s

⑤ 09:09:02.890−09:17:00.656

Front
1km/29min
～0.57m/s

a.u.
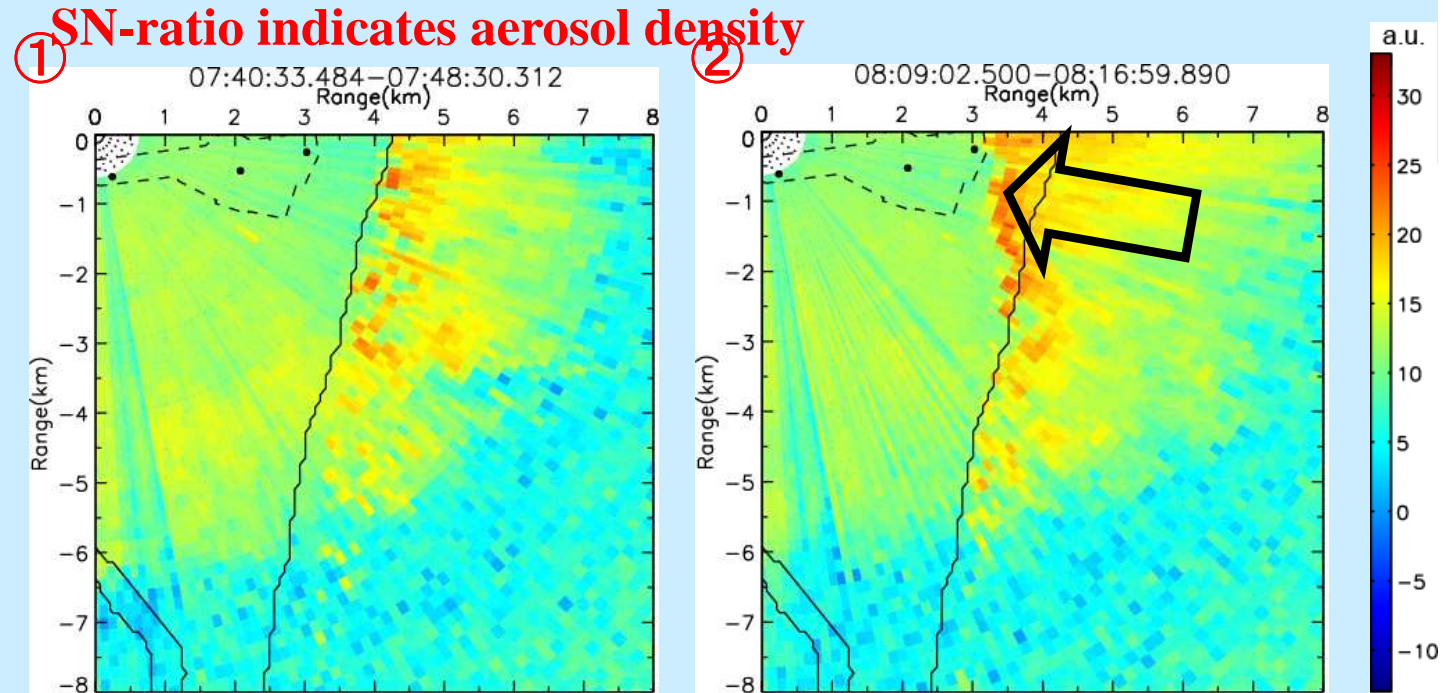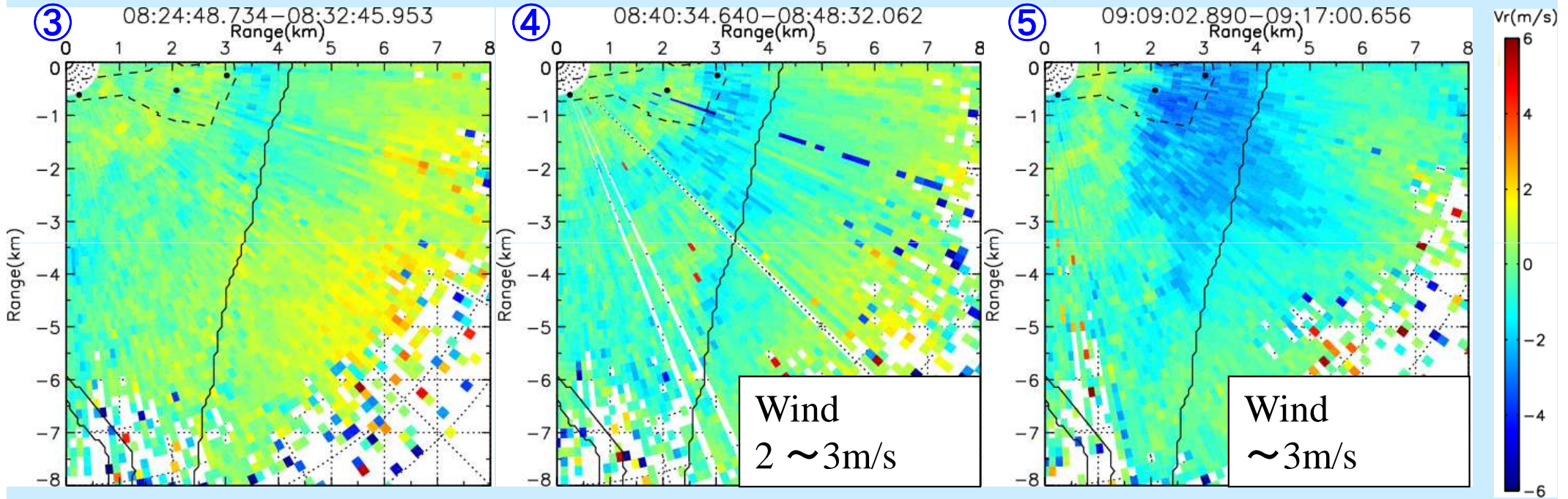
Passage of Seabreeze front

By Iwai

Wind
4 ～5m/s

Front
1km/15min
～1.11m/s
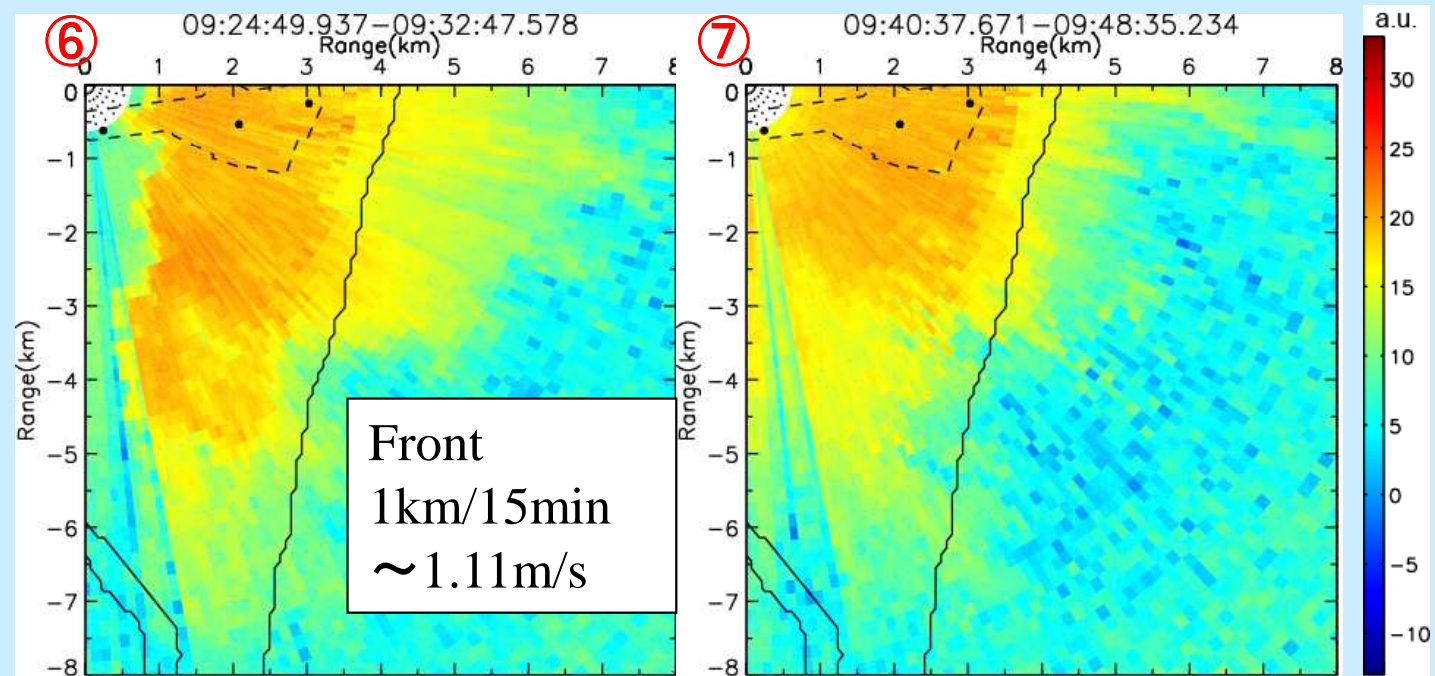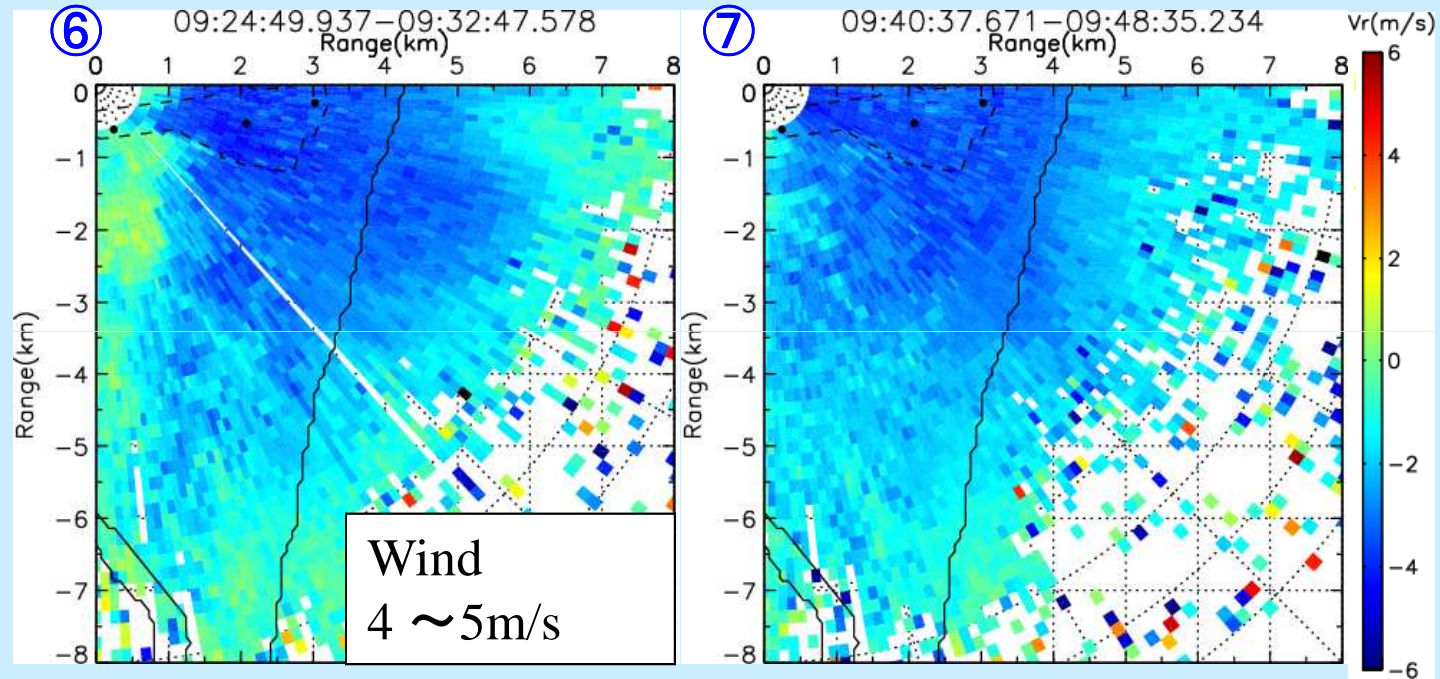
Cross section of LOS wind Simulations v.s. Observation

By Tamura

: 1.5km_ori‥ **15:00**
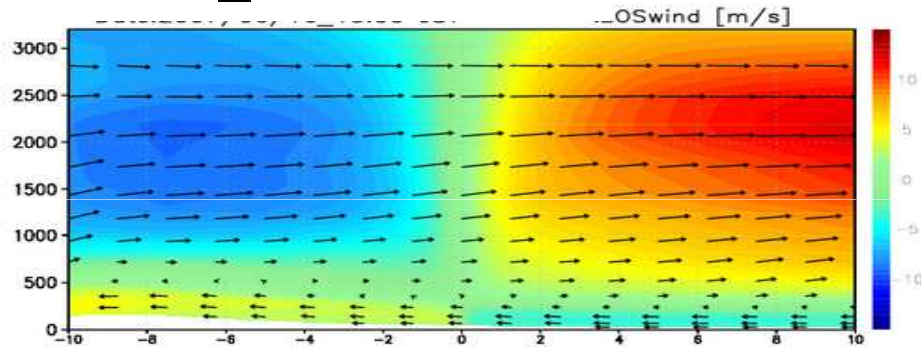
: 1.5km_v82‥ **15:00**
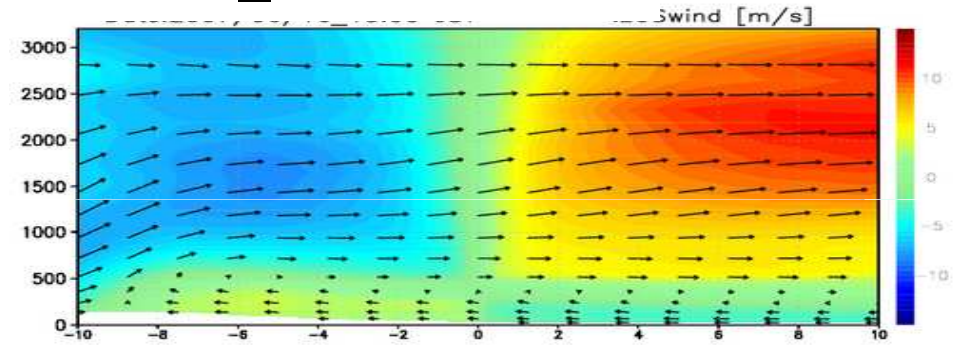
: 400m_ori‥ **15:00**
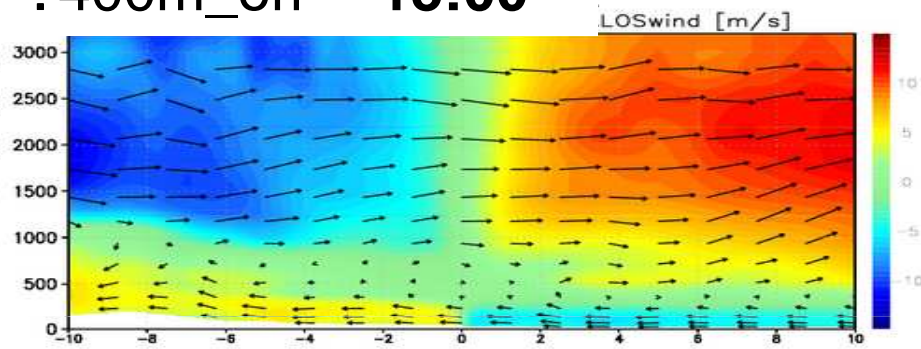
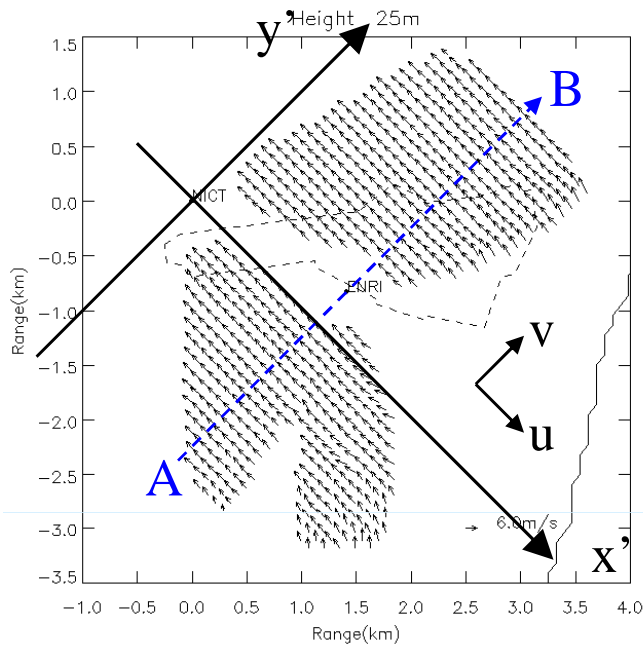: 400m_v82‥ **15:00**
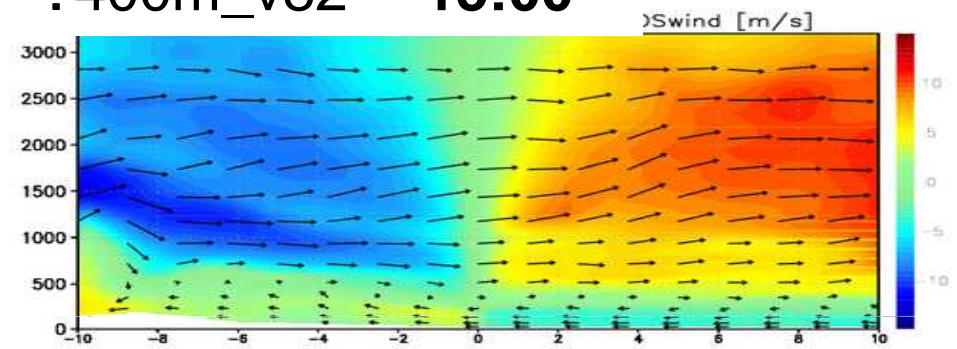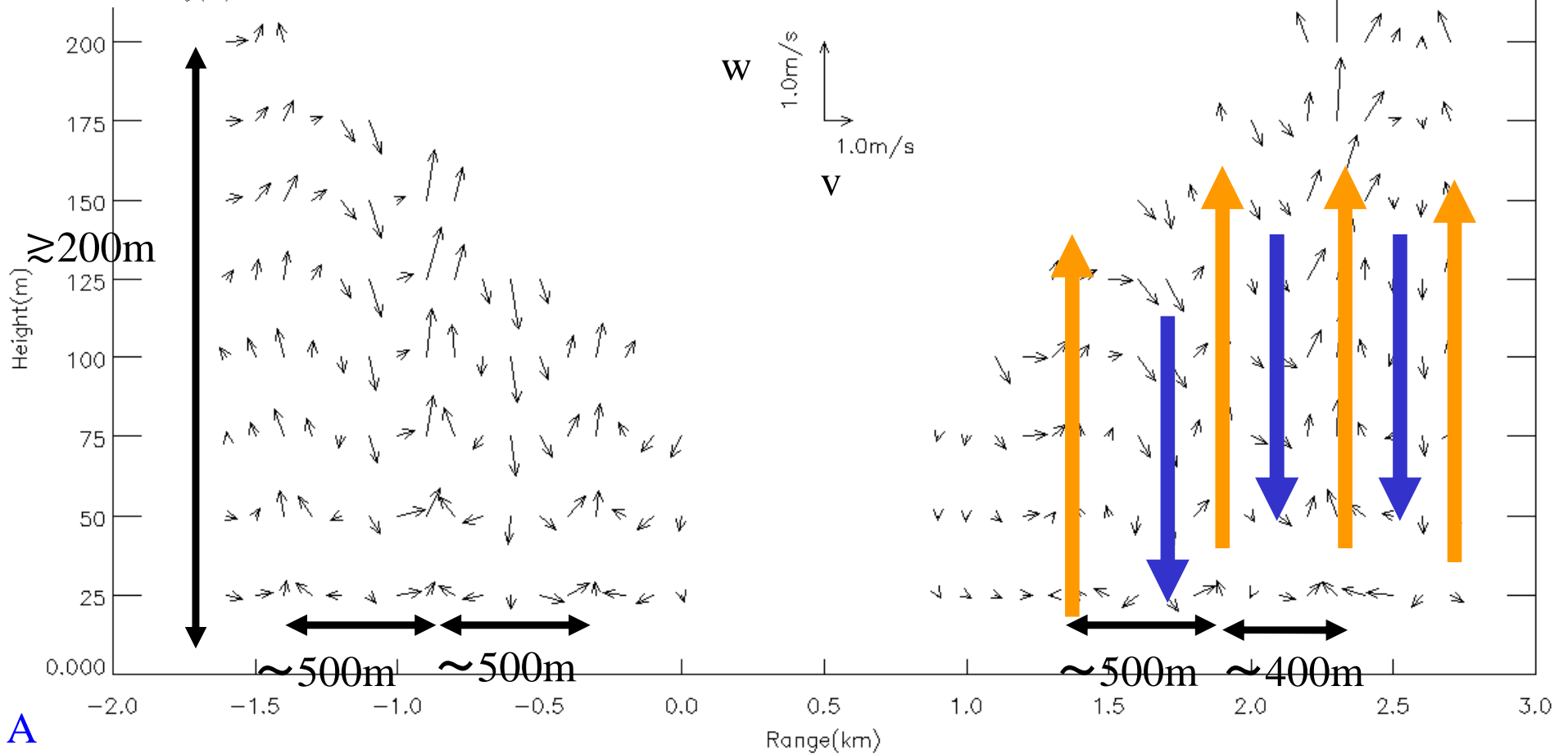

Observation 17:26
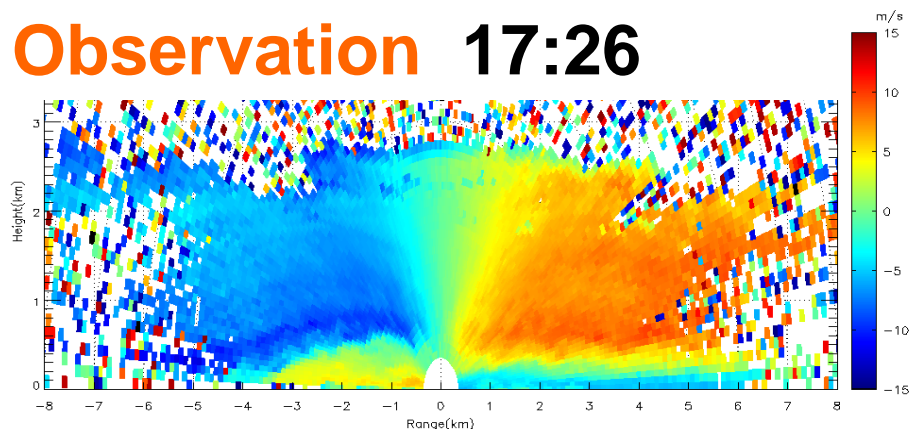
: 100m_v82‥ **15:00**
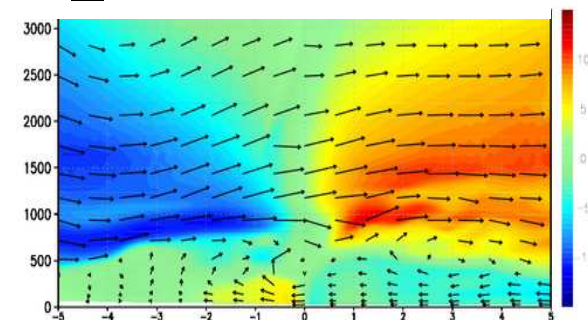
Seabreeze

Dual Doppler Lidar Observation

Height$\gtrsim$200m
Length$\lambda\sim$500m
Aspect ratioλ/H$\lesssim$2.5

Iwai et al., 2008

Verification of model simulation with CDL
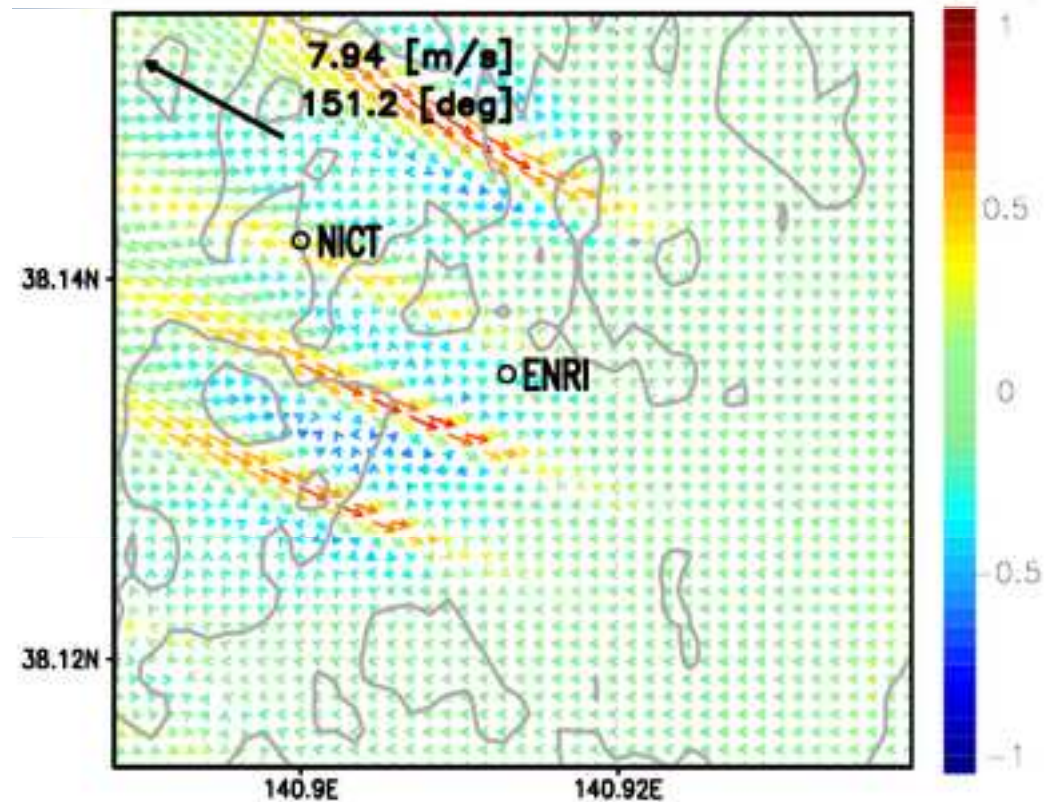
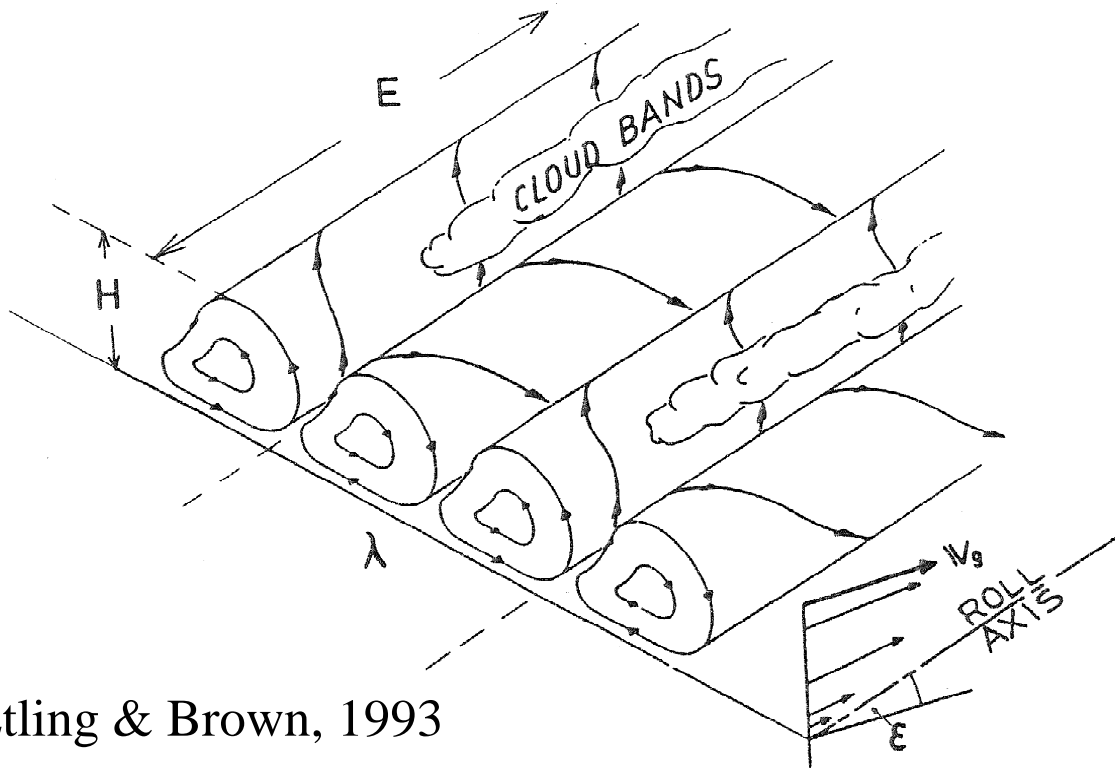■ **Horizontal wind deviation（U',V'）＋ Vertical wind（W）** :

Dual CDL Observation □　　□ **DS³（dx=100m）**

(c) 125 m AGL

6.57 m s⁻¹
132.9°

NICT

ENRI

u' :1 m s⁻¹
v' :1 m s⁻¹
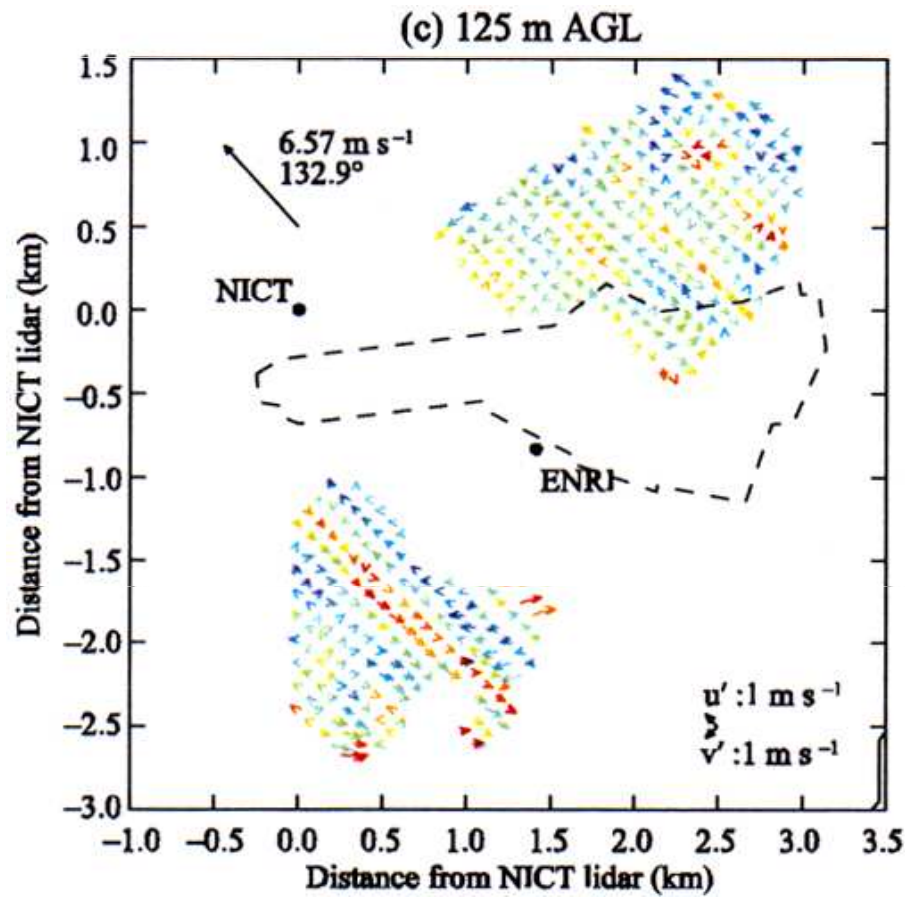
Distance from NICT lidar (km)

Date:2007/06/19_13:00 JST

.AGL: 125[m]
.(U",V")& W[m/s]

7.94 [m/s]
151.2 [deg]

NICT

ENRI

Horizontal convective roll

E

CLOUD BANDS

H

λ

Vg

ROLL AXIS

ε

Etling & Brown, 1993

・weakly unstable
・vertical wind shear

vertical extent	H	1–2 km
wavelength	λ	2–20 km
aspect ratio	λ/H	2–15
downstream extent	E	10–1000 km
orientation of roll axis to mean wind	ε	−20° to +30°
life time	τ	1–72 h

Linear theory
Aspect ratio 2〜3
Seabreeze
H ≒200m   λ≒500m

Resolution dependence dx = 300～100 m

田村他

dx=300m （**dx=200m**） **dx=100m**

☐ **Domain**

（*area; about12 ×8km*）

90×70   100×80   190×170
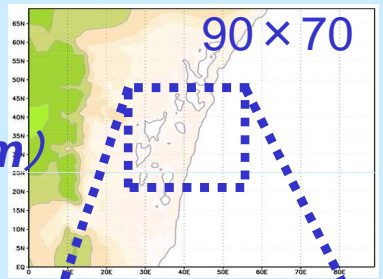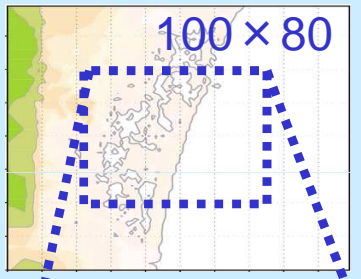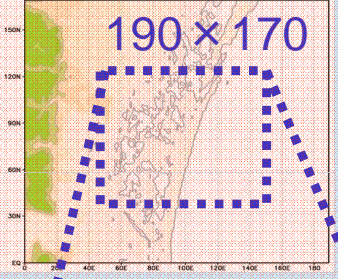
☐ **Horizontal**

☐ w

（*60° 2.5km*）

0.2m/s

CDL（NICT）

-0.2m/s
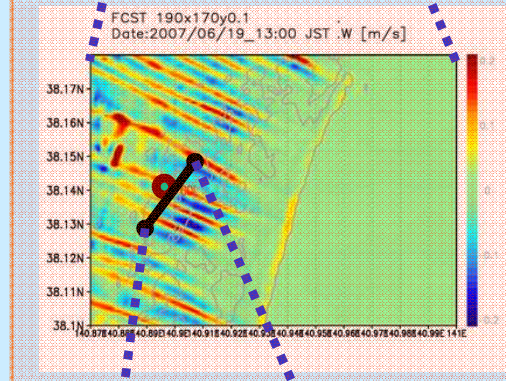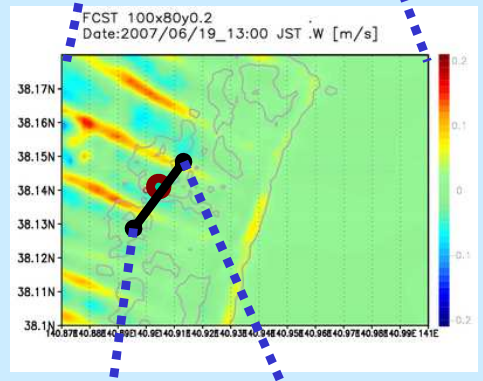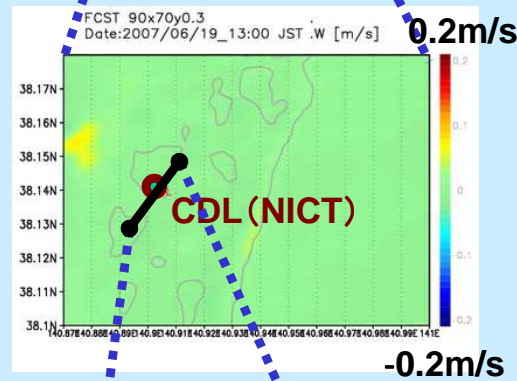
☐ **Cross Sec.**

☐ w

☐ **projection**

0.8m/s

-0.8m/s
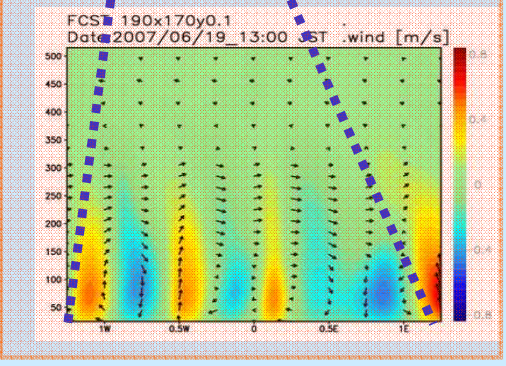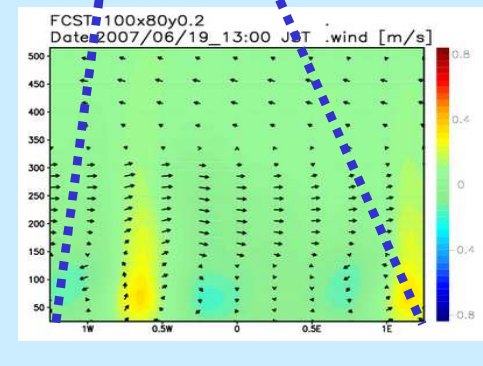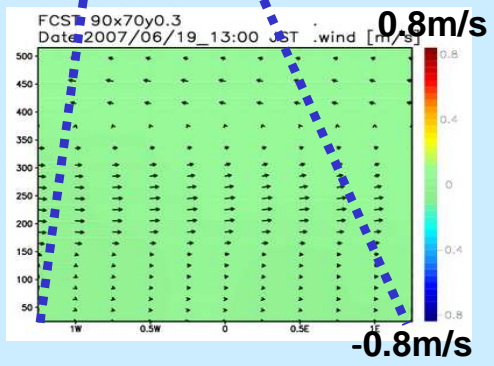
■Down-Scaling

By Tamura

■ dx=100 ⇒50 ⇒ 25m

dx=50m

☐ **Domain**

dx=100m

（*Area; about12 ×8km*）

CDL（NICT）

290x210

dx=25m

400x280
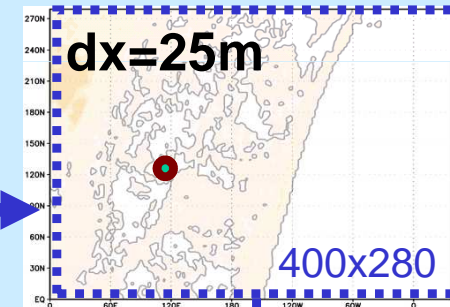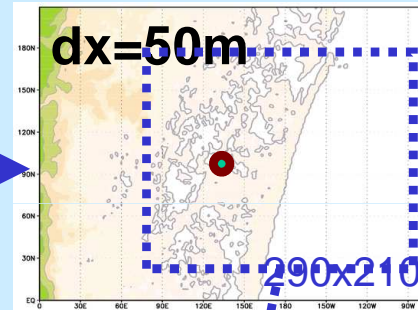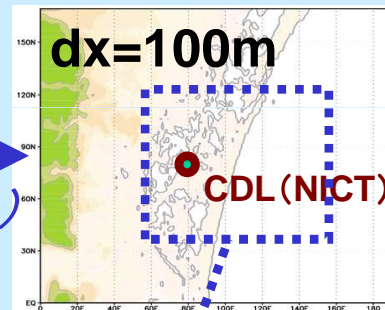
☐ **Hor.**

☐ W）

（*60° 2.5km*）
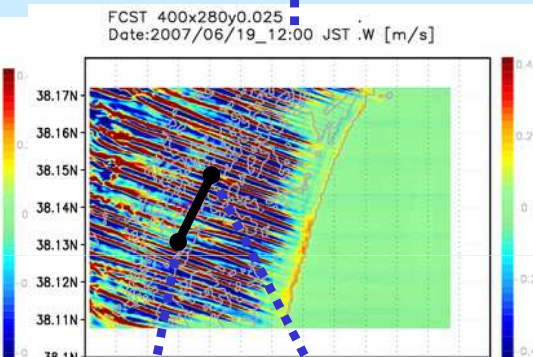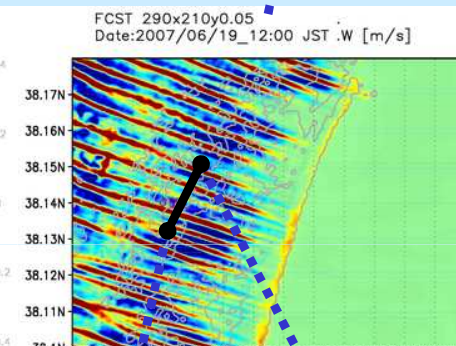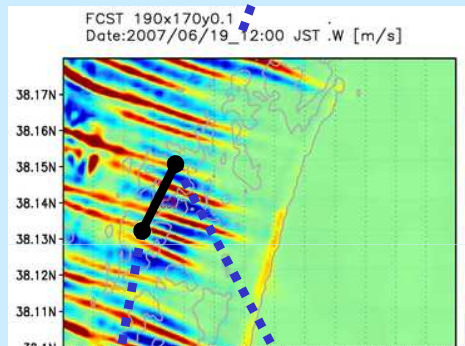
☐ **Cross Sec.**

☐ Ver.

☐ Projection

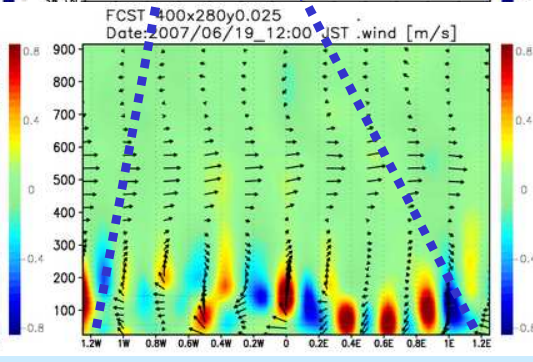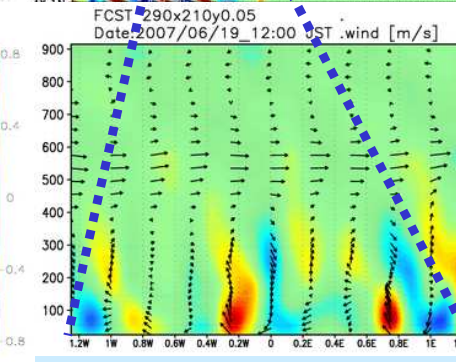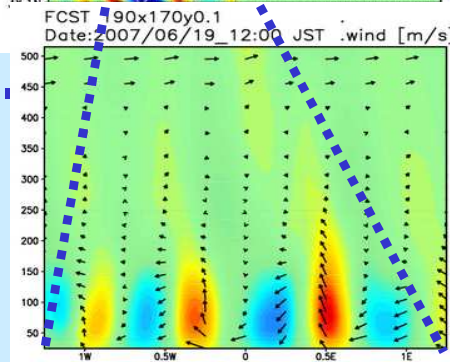1. **Front Head & H. C. Roles of Sea Breeze**

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   Down-scale Simulation of Event

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Image © 2007 TerraMetrics
Image © 2007 DigitalGlobe

©2005 Google

Pointer 38°06'36.52" N 140°54'54.32" E   Streaming |||||||||| 100%   Eye alt   9694 ft

Accident in Narita Airport

Fedex 80 (MD-11)

Fedex plane crashed on landing in Narita Airport at about 6.50 on March 23, 2009.

Strong vertical wind shear occurred in the downstream from the mountain range and reduced the plane lifting power.

A cold front passed over the airport accompanying turbulences

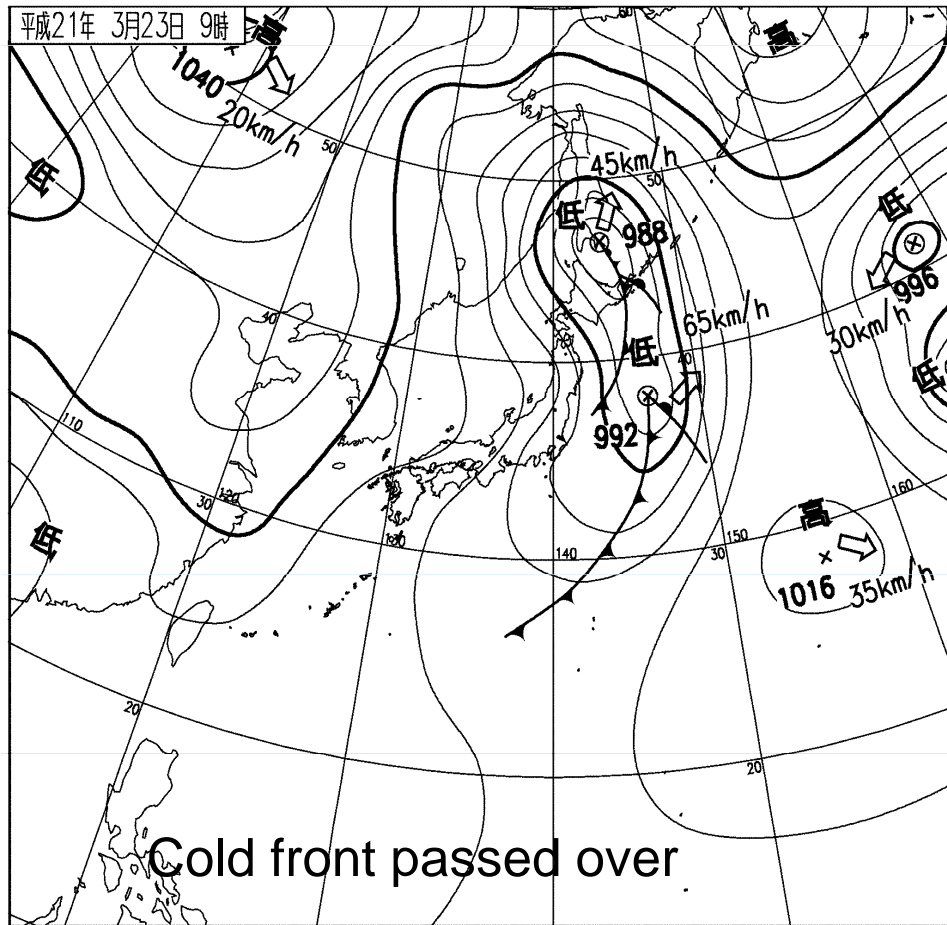Two streams met near the airport and the horizontal shear generated turbulences.
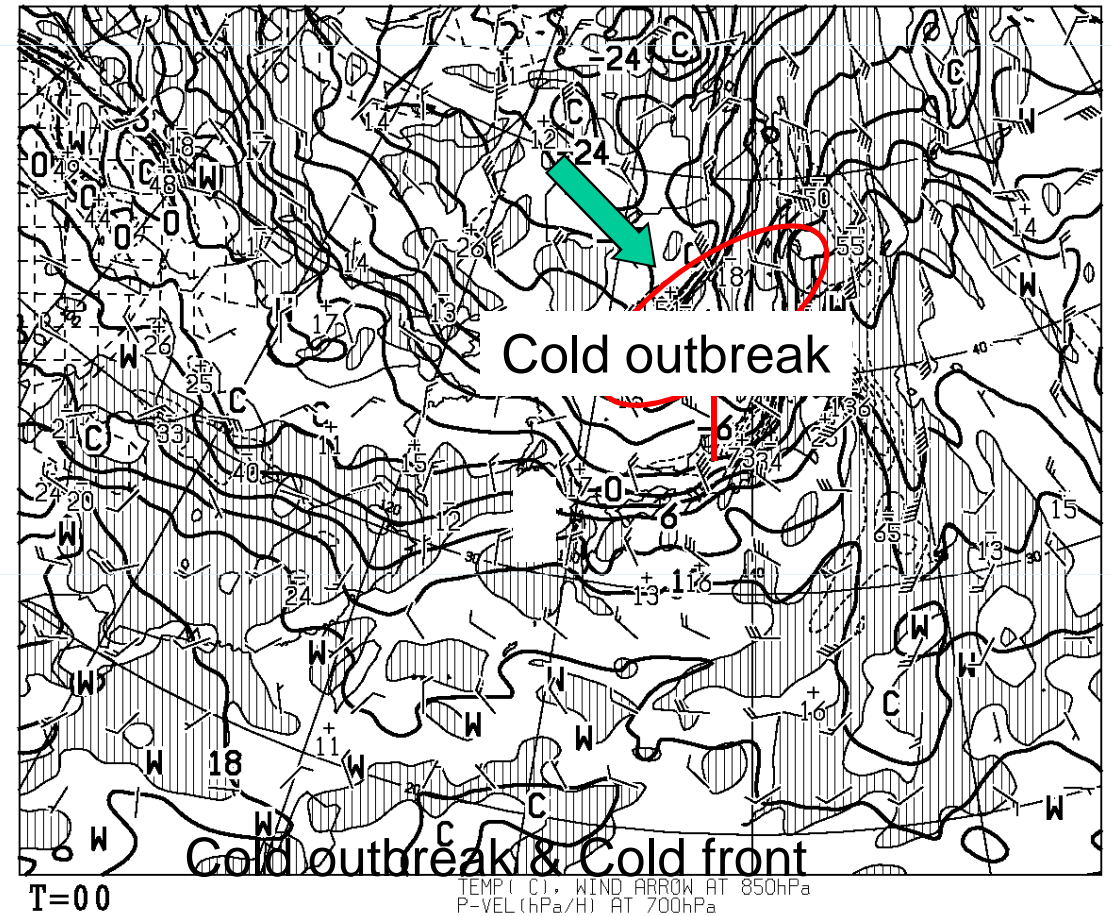

Fedex (Wikipedia)

From Nishinippon Shinbun
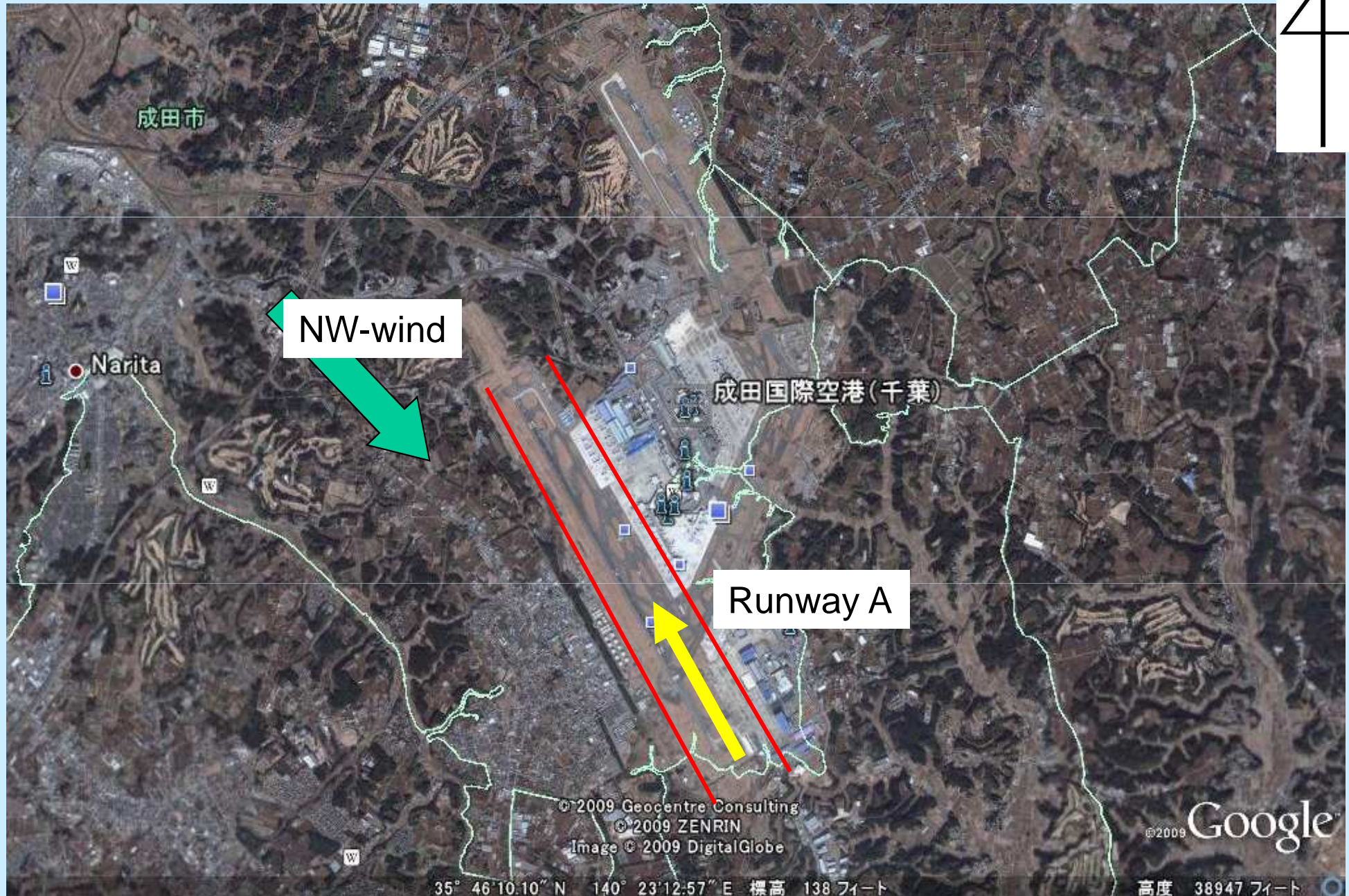
Weather chart at 9:00

Synoptic chart

T (contour) and ω（shade）@850hPa

平成21年 3月23日 9時

1040
20km/h
45km/h
988
65km/h
992
1016 35km/h

Cold front passed over

Cold outbreak

Cold outbreak & Cold front

T＝00

TEMP(C), WIND ARROW AT 850hPa
P-VEL(hPa/H) AT 700hPa

Narita Airport

NW-wind

Runway A

Experimental procedure

- Model : MRI/JMA-NHM)
- Initial & Lateral : JMS-Meso Analysis (MSM)

$\varDelta$x	4km(125×125)	1.5km(300×300)	0.5km(150×150)
Vertical layers	38 (dz=40~760m)	52 (dz=10~510m)	82 (dz=5~405m)
PBL	MY3	Deardorff	Deardorff

計算領域　　**dx=4.0km**　　　　　　**dx=1.5km**　　　　　　**dx=0.5km**
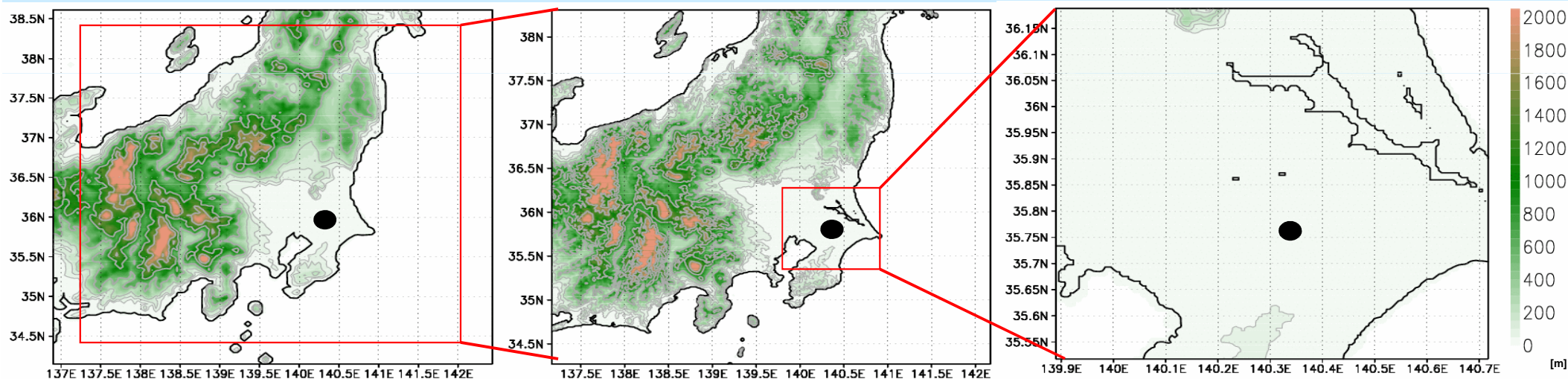
● :成田空港

Vertical wind profile

cross(36.5,139.6)(35.4,141.0) wind speed 3/23 07JST

u10;v10 3/23 07JST
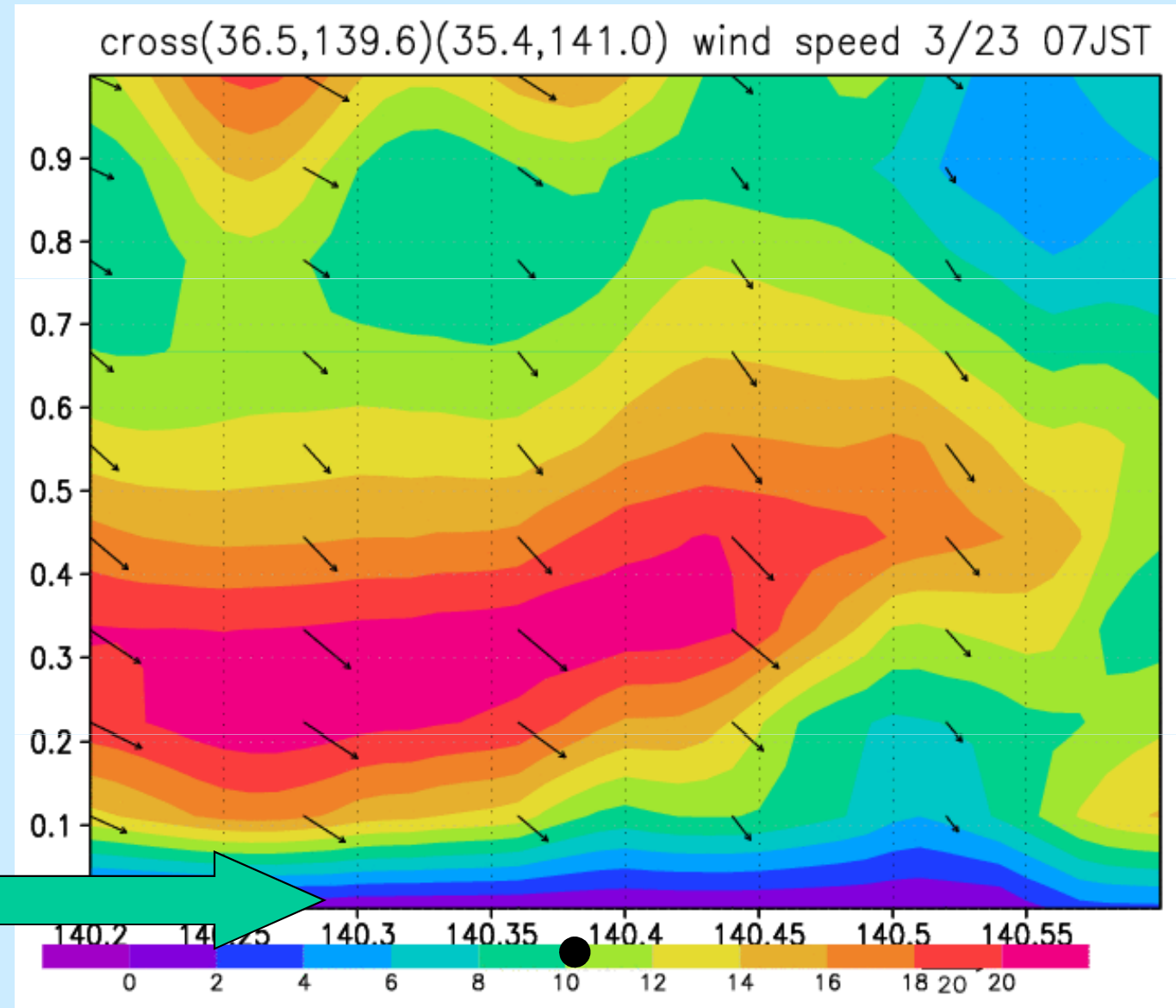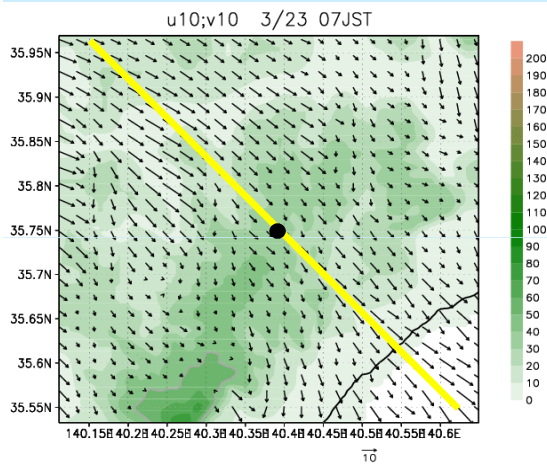
Strong wind shear

Color：wind velocity
Arrow：horizontal wind vector   dx= 0.5km
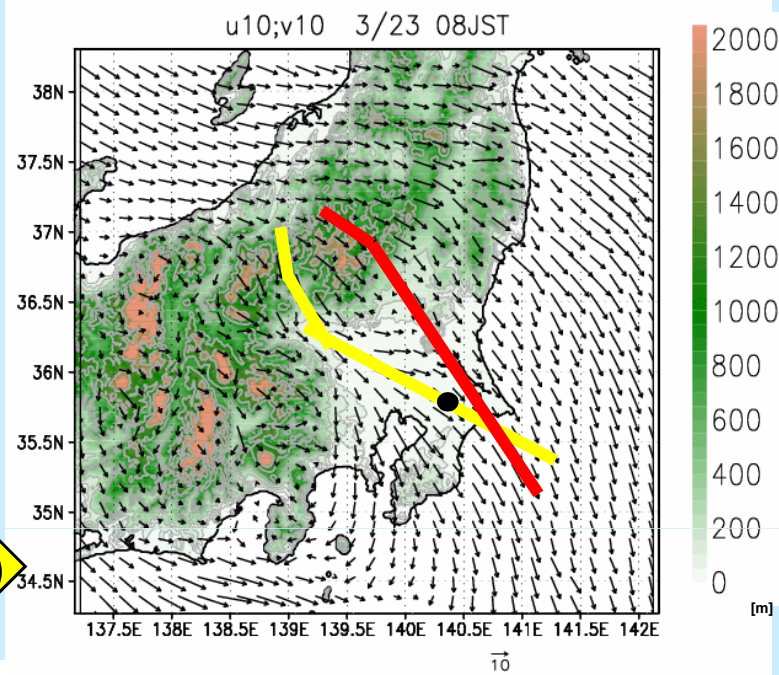
Surface wind (dx=1.5km)

u10;v10   3/23 00:00JST
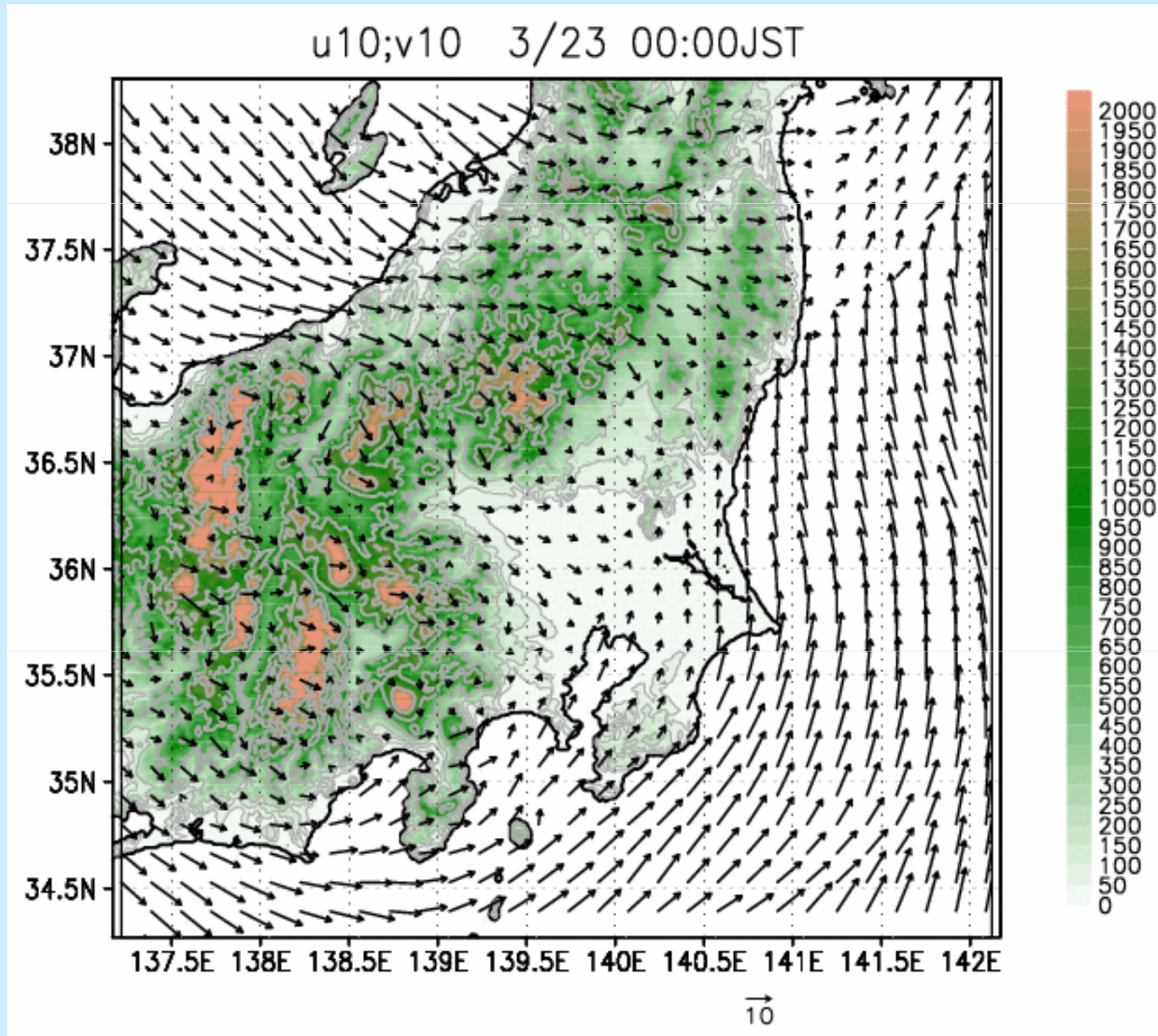
Head of gravity current just arrived.

Color: Potential temperature
Contour: wind velocity   (dx=1.5km)
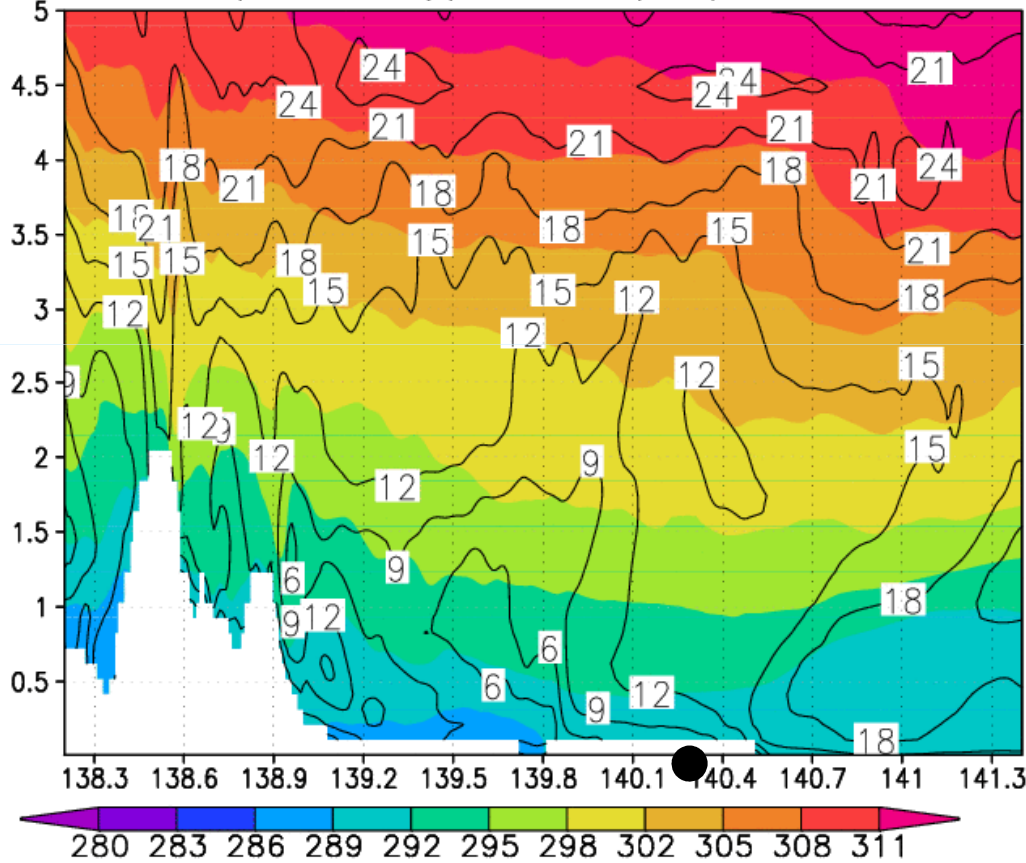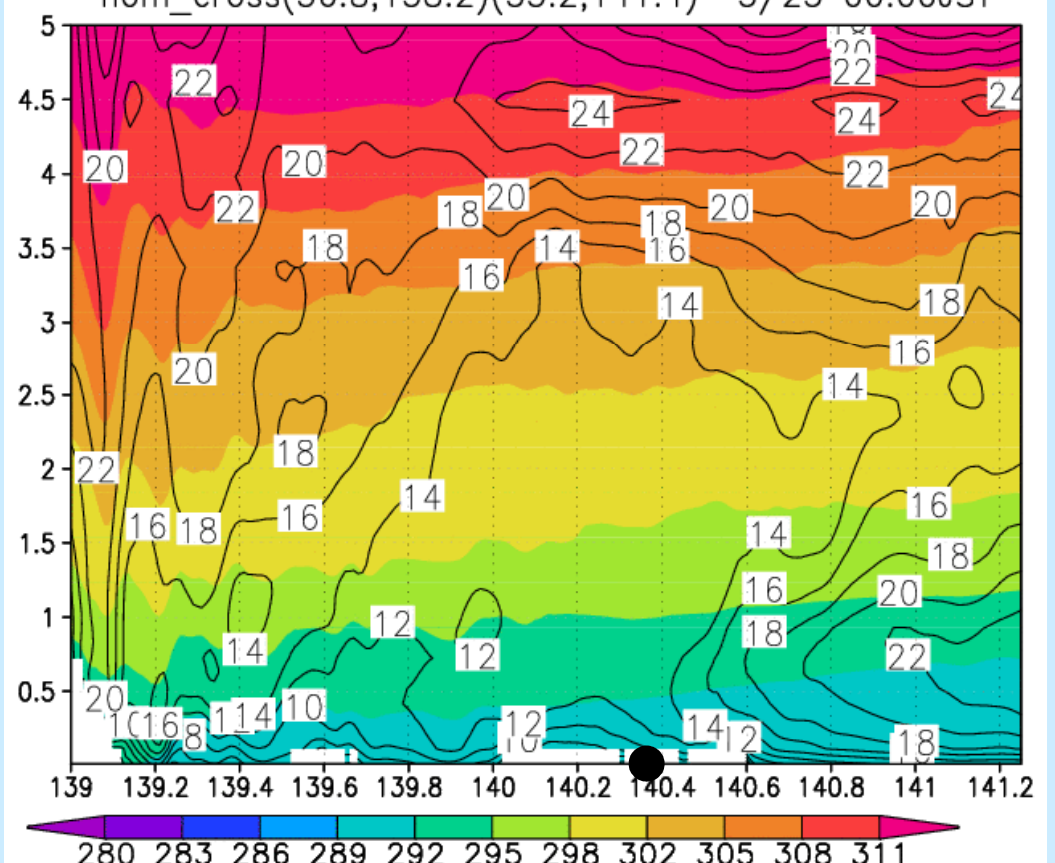
Confluent two cold streams

pt z=0.5km   3/23 00JST

Color: potential temperature
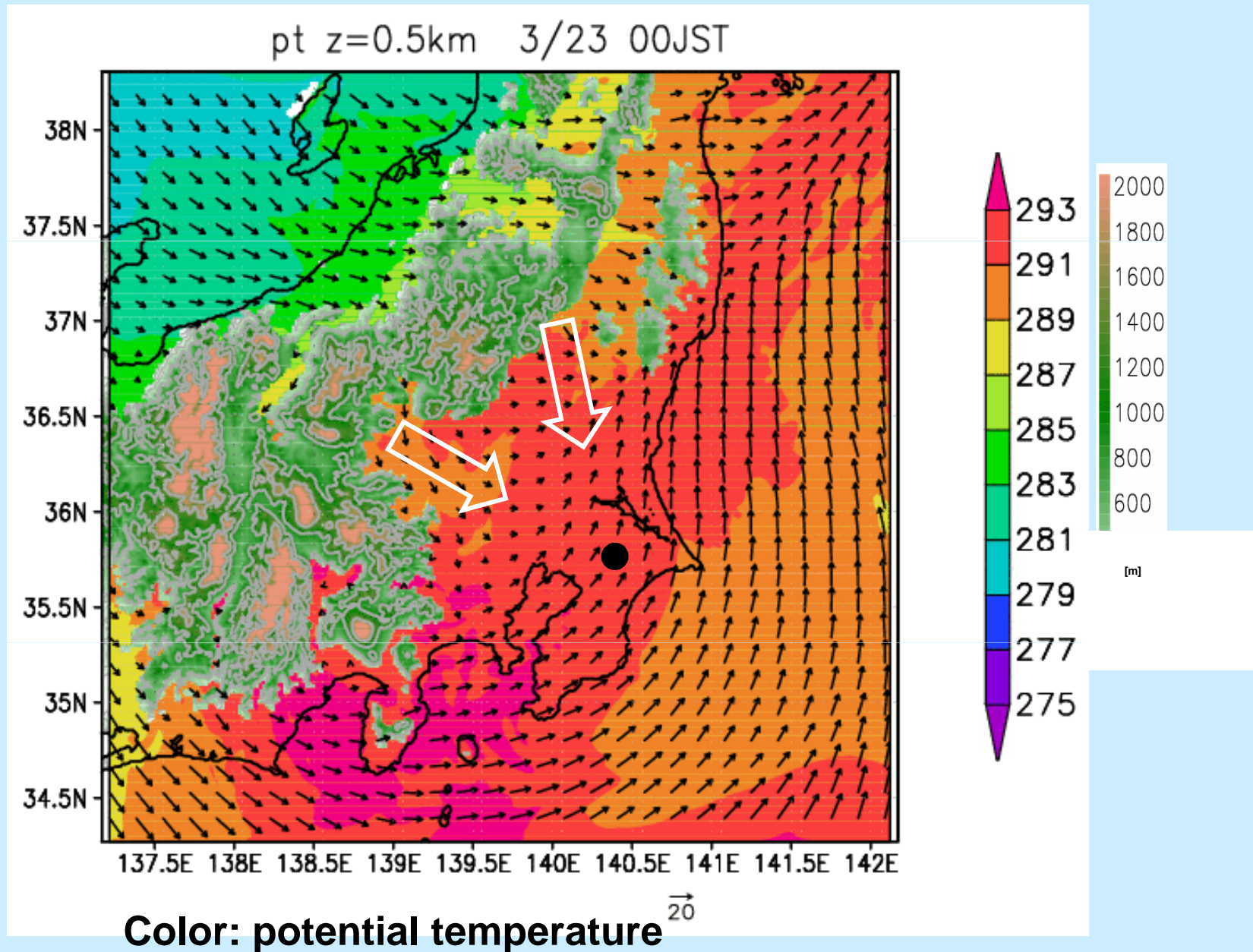
Turbulent kinetic energy at 0.5 km

dx=1.5km
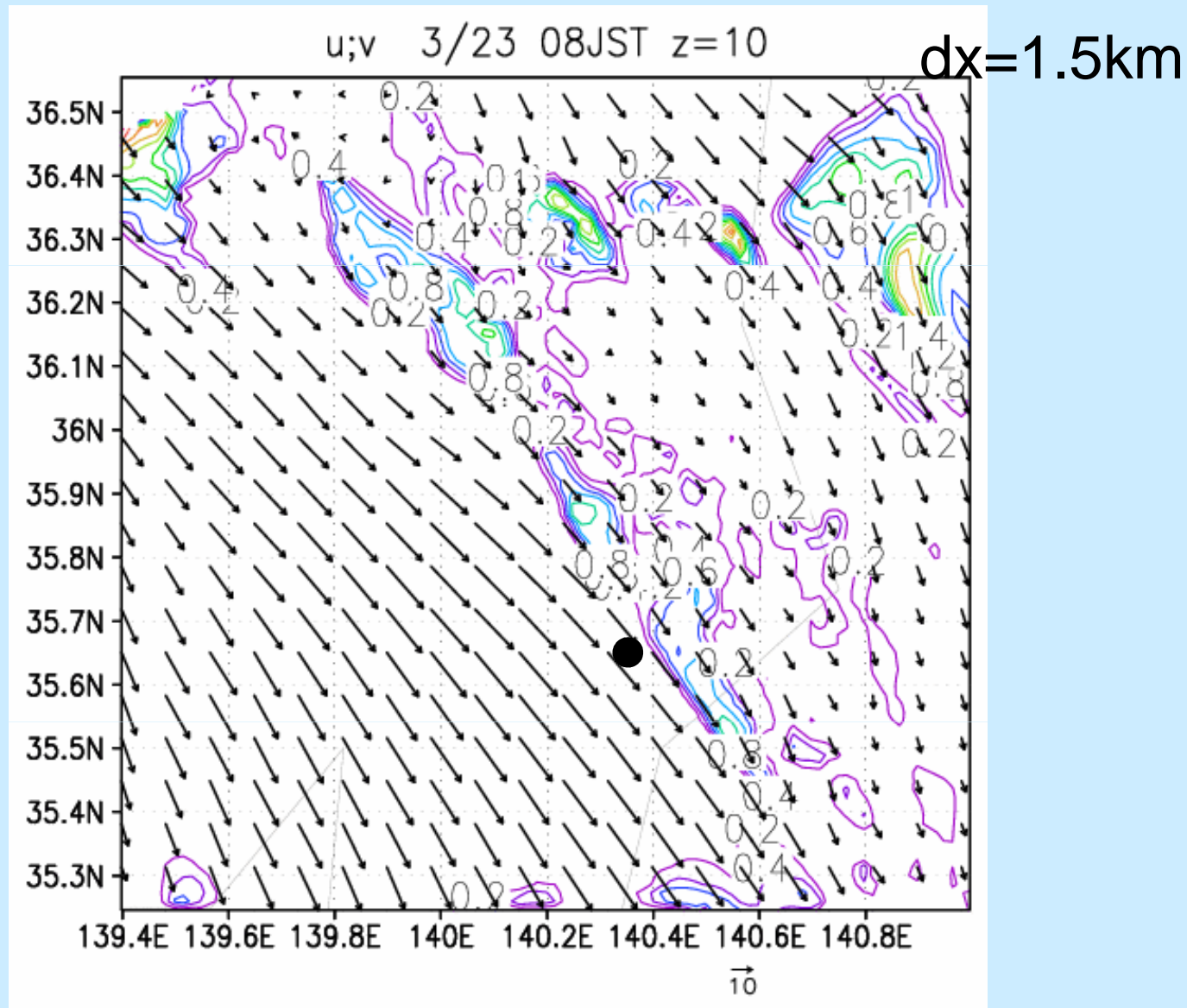
Large amount of turbulent kinetic energy is located
near the horizontal wind shear

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Image © 2007 TerraMetrics
Image © 2007 DigitalGlobe

©2005 Google

Pointer 38°06'36.52" N 140°54'54.32" E   Streaming ||||||||| 100%   Eye alt   9694 ft

# Real time monitoring system for low-level wind-shears and turbulences

1. Fronts and turbulences on the upstream side of the airport are detected by Doppler Lidar.

2. They are properly introduced into the analysis through Four-Dimensional Data Assimilation*.

3. Very short-range forecast is performed with high resolution Down-Scale model.

* Local Ensemble Transform Kalman Filter (LETKF) is used, where perturbations are prepared from ensemble forecasts of outer model.
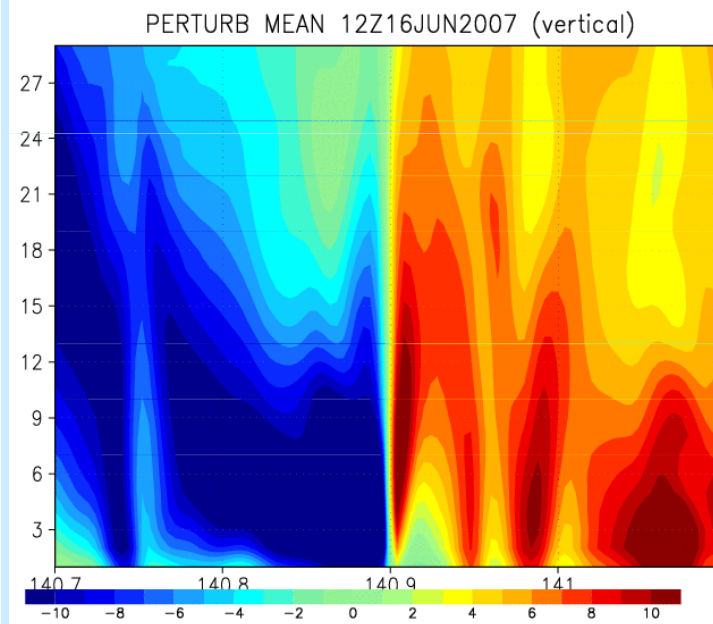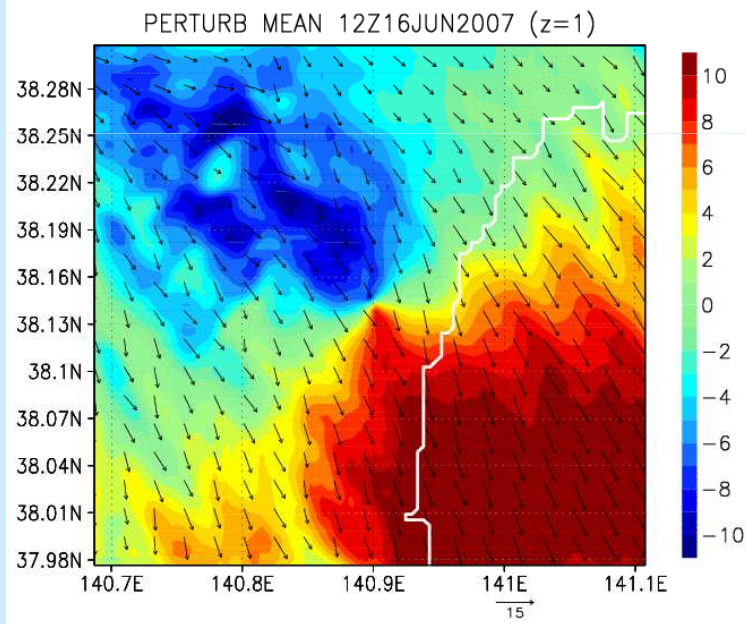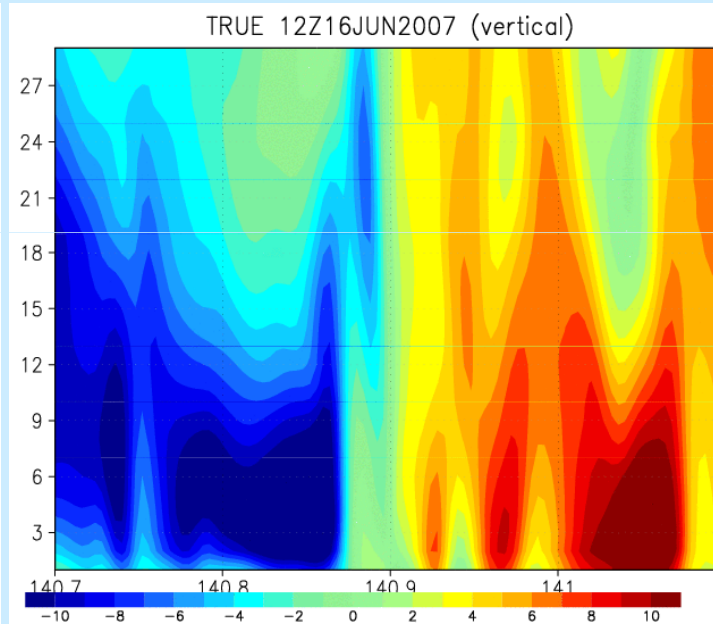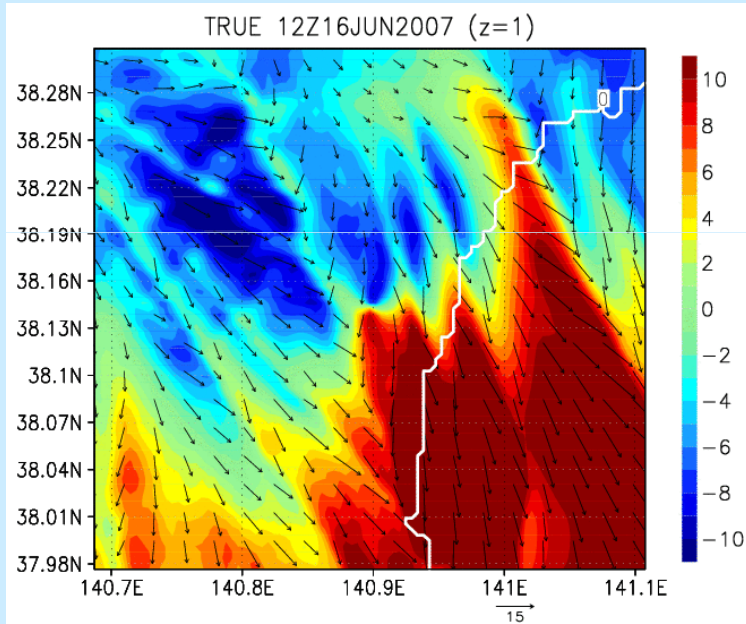
OSSE

LETKF

Doppler Lidar is situated on center of domain.
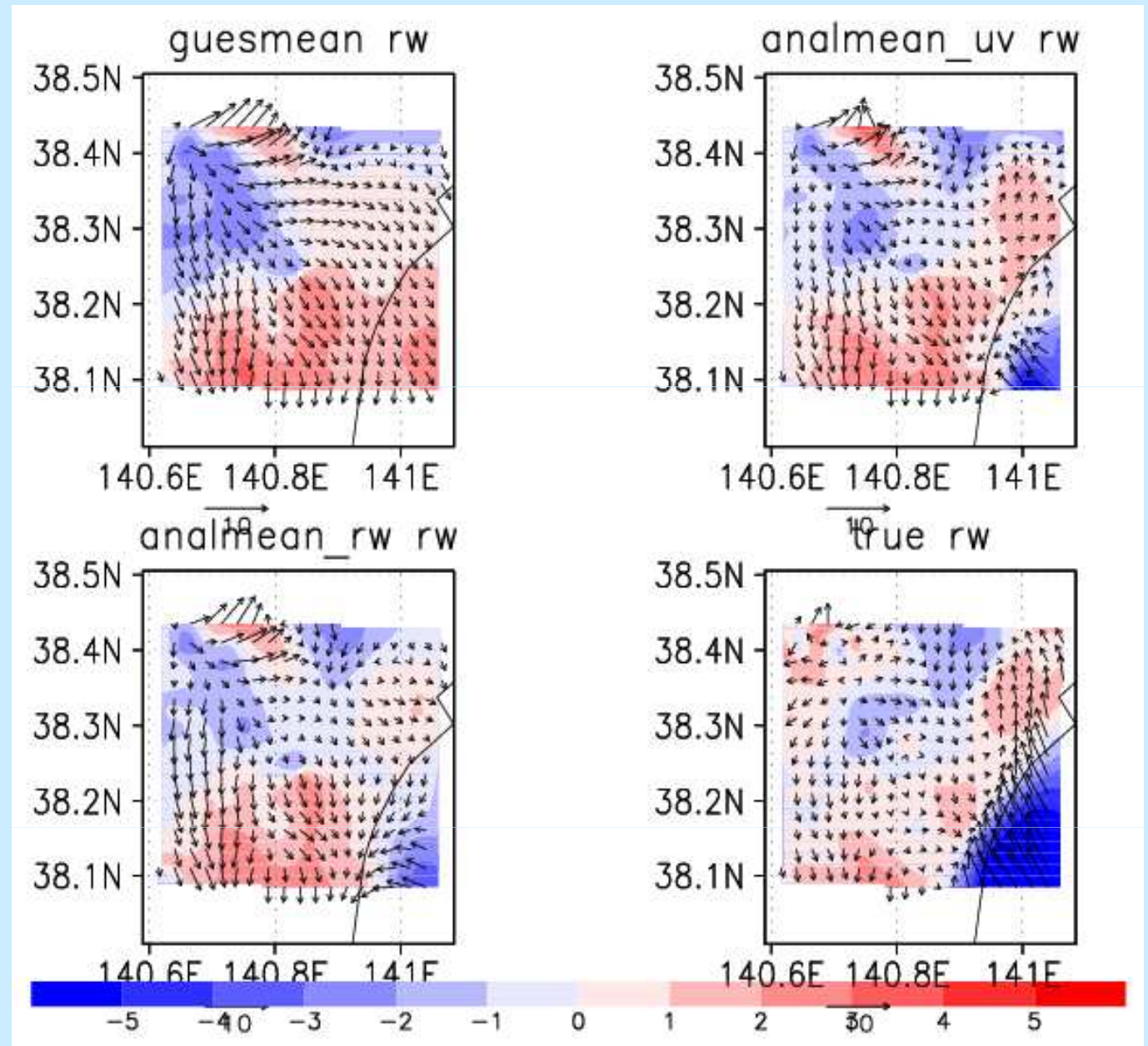
Color : Line of Sight (LOS) wind at the lowest level

LETKF

0.4km解像度

Top: Truth

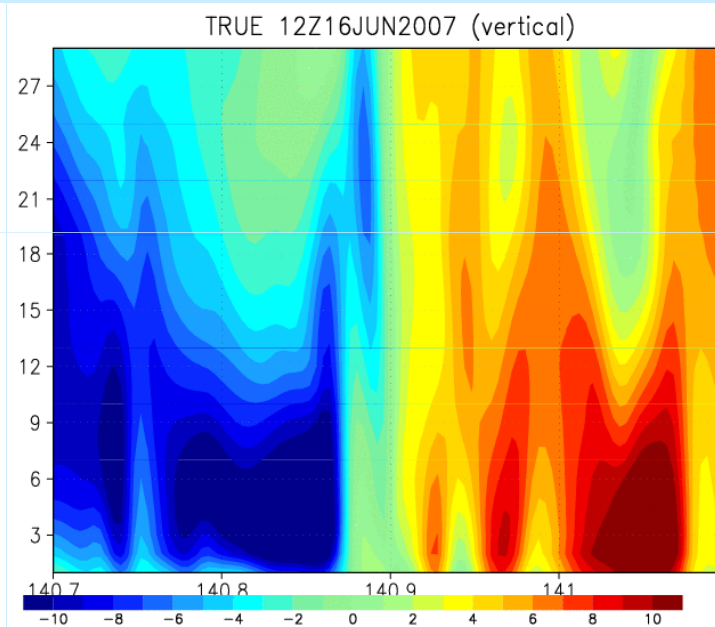**Bot.: without Obs.**

Color: LOS wind

Experiment ③ LETKF
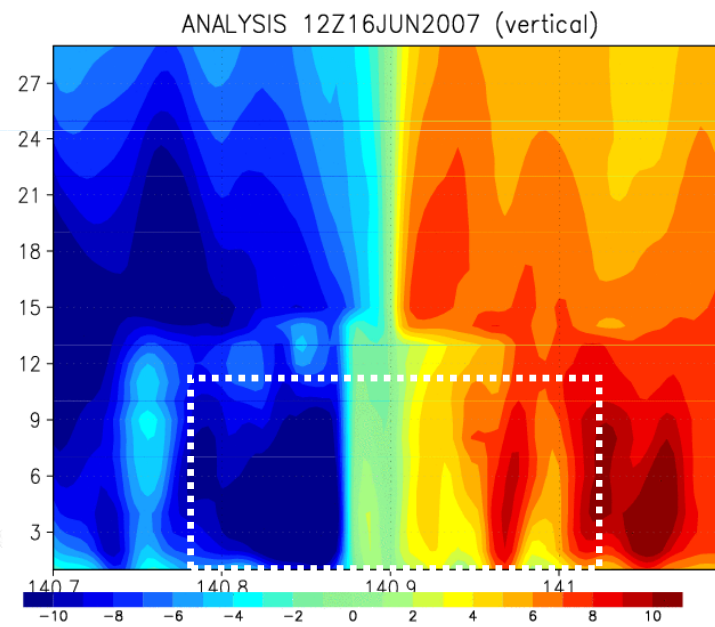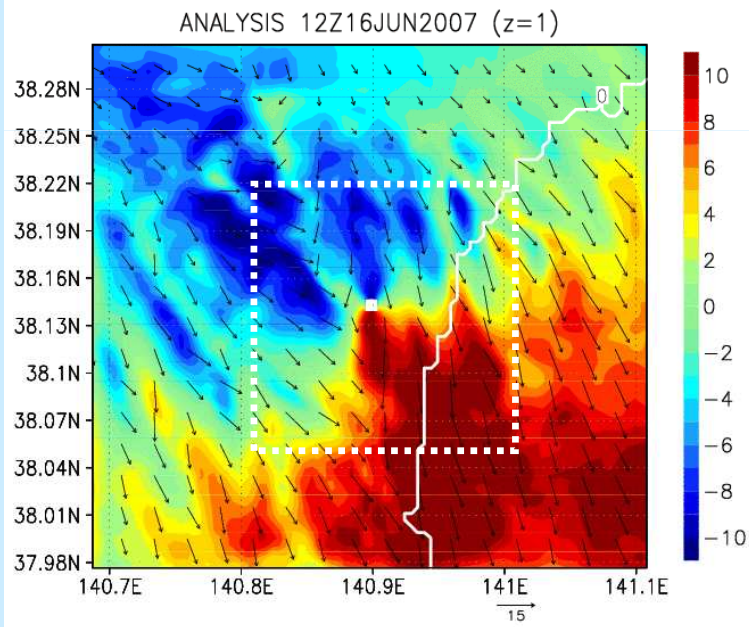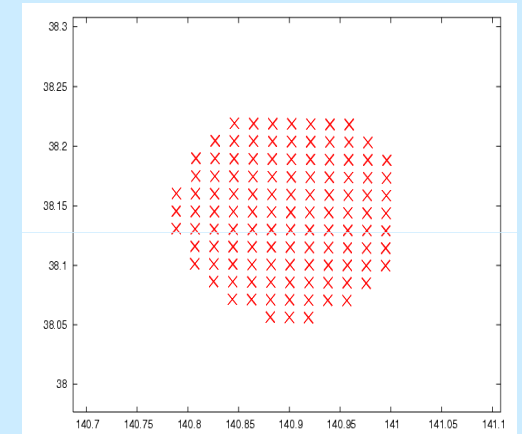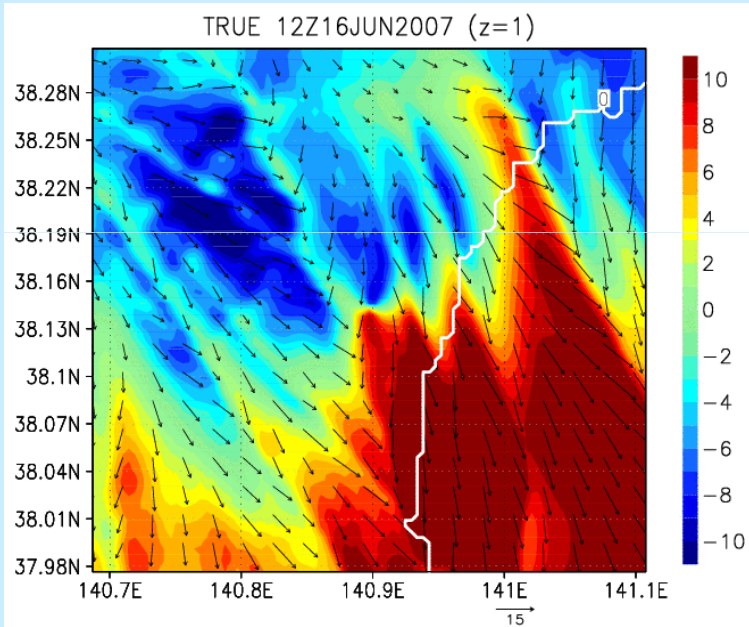
Top: Truth

Bot.: without Obs.

Color: LOS wind

Problems

1. How to make ensemble members for DS.
*Lateral boundary conditions should be optimized.
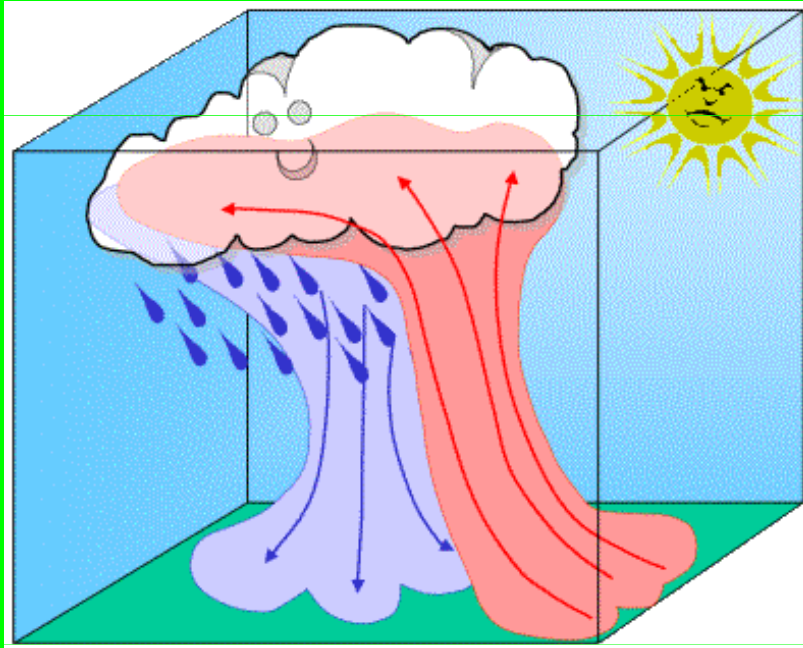
2. How to tune the localization parameter.
*It sometimes degrades dynamic consistency.

3. How to consider spatial scales of observations.
*Background covariance may depend on scales of motions.

International Workshop on Non-Hydrostatic Numerical Models

17-19, November, 2010
Sendai, Japan

Organized by
MSJ Research Subcommittee on NHM

More information will be available in January, 2010.

***Hosted by* Tohoku University**
Contact: nhm-ws@wind.geophys.tohoku.ac.jp

Papers for this workshop will be solicited on all aspects related to non-hydrostatic numerical models（NHM), such as dynamical cores, physics parameterizations, observational systems, data assimilation, predictability, severe weather simulations and applications. This also emphasizes case studies of heavy precipitations, tropical cyclones and other sever events.
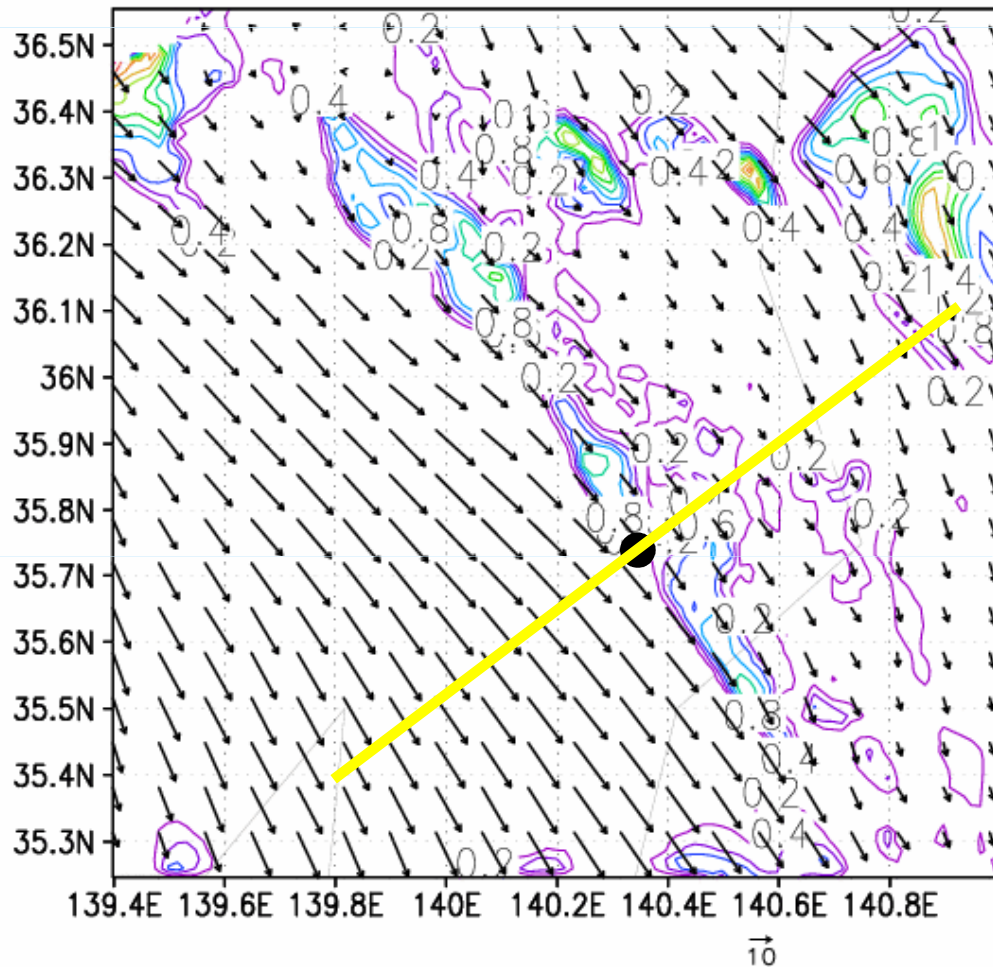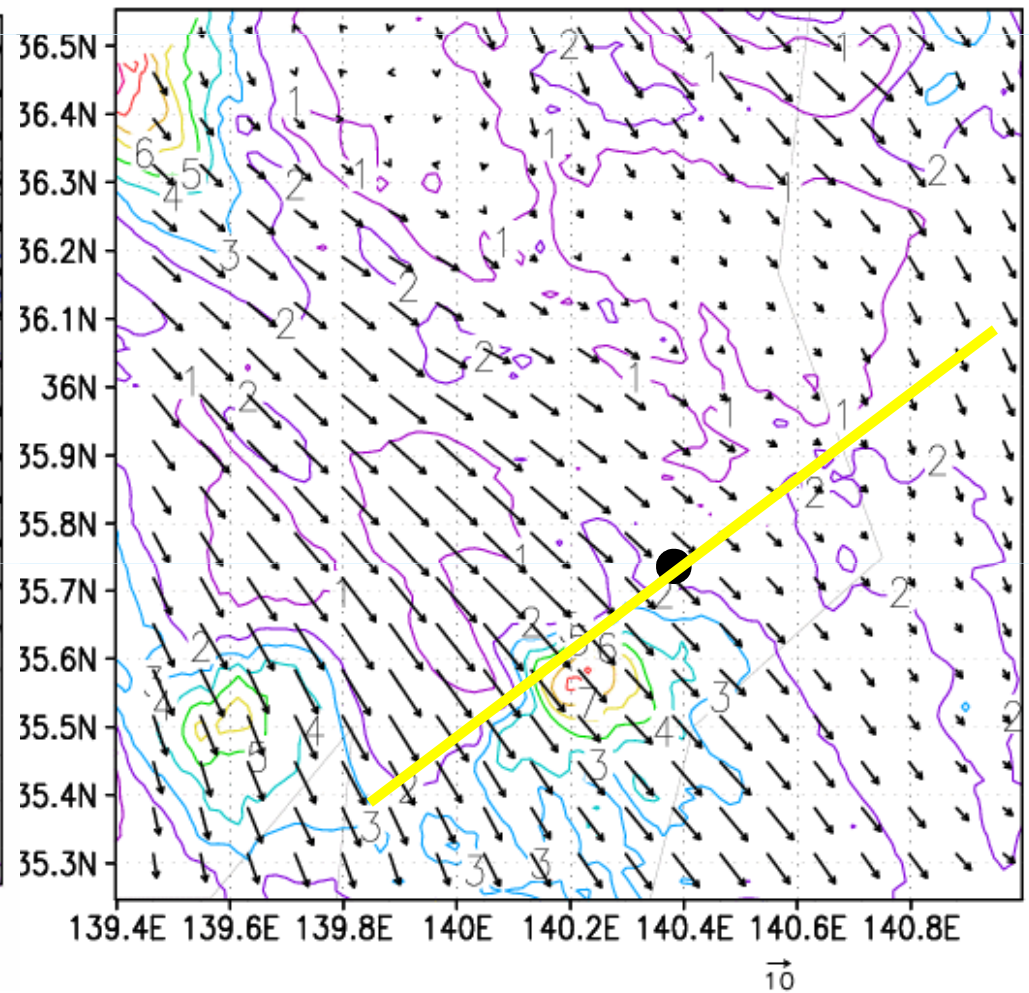
Impact of PBL scheme
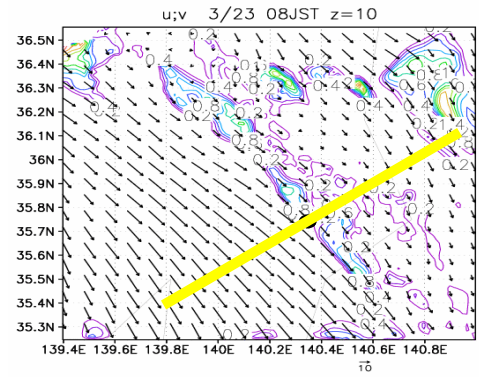
高度0.5km

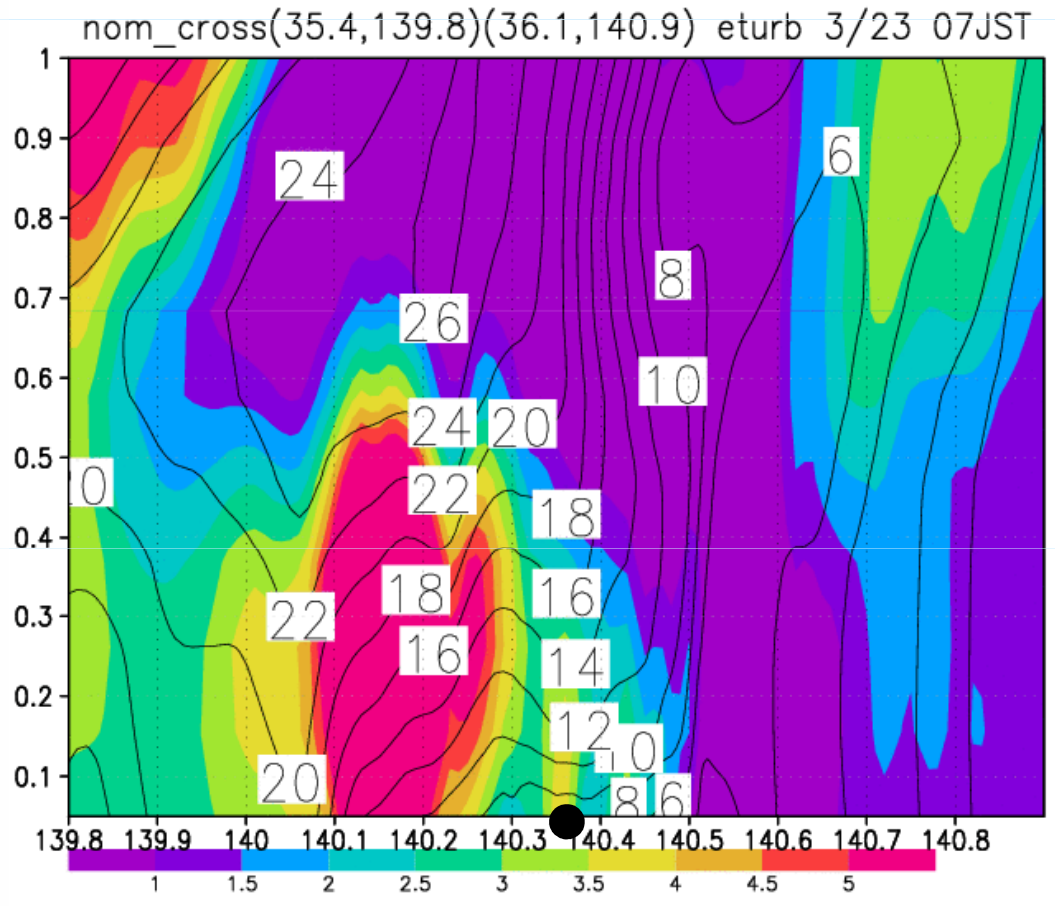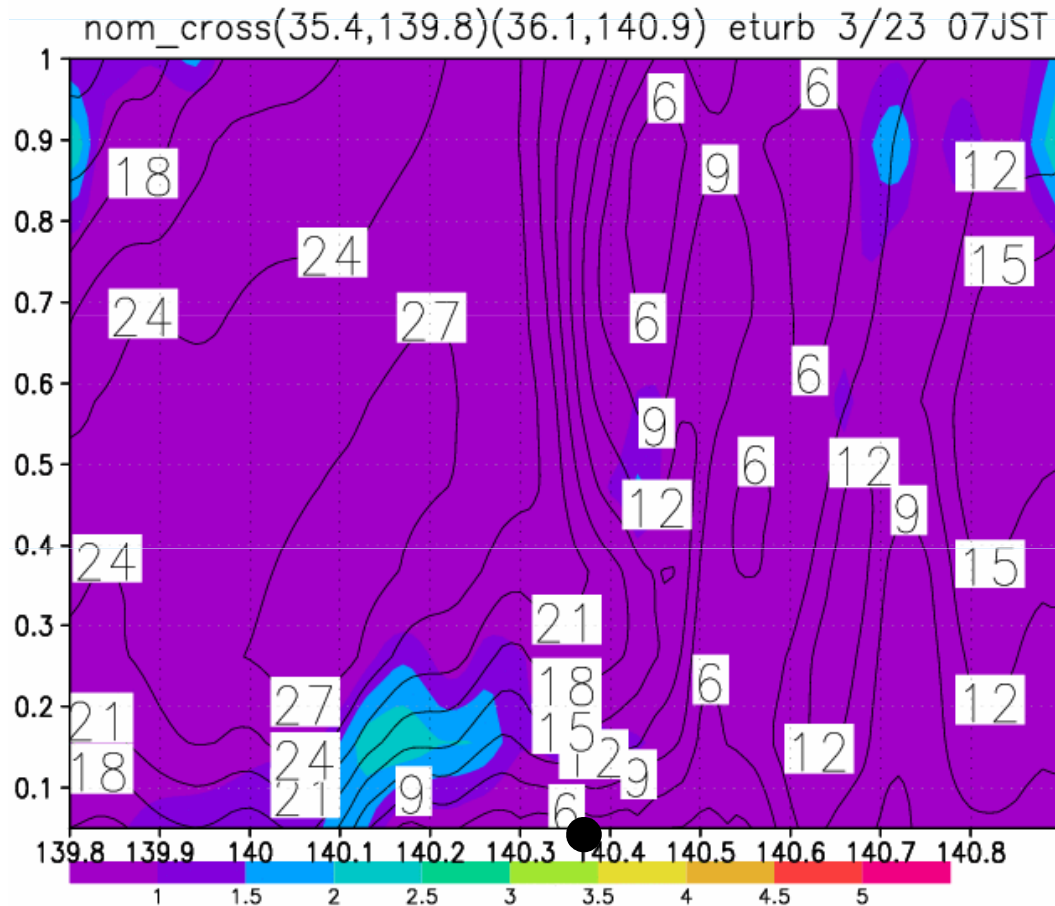Deardorff   dx=1.5km   MY3

Wind velocity (contour) & Turbulent kinetic energy (color)

Deardorff

MY3

dx=1.5km