



# An assimilation scheme for the retrieval of wind from Doppler radar data

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# The assimilation indeterminacy

**If to recover wind vector only by  
radial velocity**

**the indeterminacy is exist!**

**How to overcome the indeterminacy?——  
a difficult problem**





## The scheme of assimilating Doppler radar data

### The assimilated information included:

- The radial velocity (RV)
- The movement of radar echo

**The key: Transforming the movement of radar echo to a new radar measuring variable - "seeable velocity"(SV).**

### In the scheme:

The information of wind is added!

**To overcome the indeterminacy by combining RV and SV**

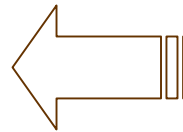




# How to apply radar observation variable?

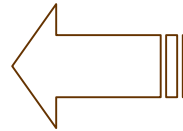
- **The relation between analyzed wind vector and radar observation:**

$$S(V_R) = \frac{x - x_c}{R} u + \frac{y - y_c}{R} v$$



**The relation between wind vector and radial velocity**

$$\frac{\partial S(I)}{\partial t} = -\frac{\partial S(I)}{\partial x} u - \frac{\partial S(I)}{\partial y} v$$



**The relation between wind vector and the change of radar echo**

**Here:  $V_r$  denotes the radial velocity,  $R$  denotes the distance between observation point  $(x, y)$  and radar station  $(X_c, Y_c)$ ,  $I$  denotes the intensity of radar echo,  $u$  and  $v$  denote the analyzed wind vector,  $S$  denotes the scale choosing operator.**





# Transform the observation variable

- define :  $R_x = \frac{x - x_c}{R}$  ,  $R_y = \frac{y - y_c}{R}$  ,  $V_{sR} = S(V_R)$

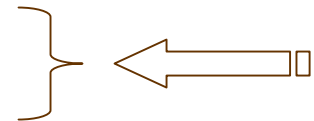
$$I_{sD} = \sqrt{\left(\frac{\partial S(I)}{\partial x}\right)^2 + \left(\frac{\partial S(I)}{\partial y}\right)^2}$$

$$I_{sx} = -\frac{\partial S(I)}{\partial x} / I_{sD} \quad , \quad I_{sy} = -\frac{\partial S(I)}{\partial y} / I_{sD} \quad , \quad I_{st} = \frac{\partial S(I)}{\partial t} / I_{sD}$$

- The chosen observation vector:

$$V_{sR} = R_x u + R_y v$$

$$I_{st} = I_{sx} u + I_{sy} v$$



The relation  
between wind  
vector and radar  
observation vector

- The observation operator:

$$\vec{R} = \begin{bmatrix} R_x \\ R_y \end{bmatrix} \quad \vec{I}_s = \begin{bmatrix} I_{sx} \\ I_{sy} \end{bmatrix}$$





## The advantage of “seeable velocity”

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- To differentiate the change of radar echo coming from advection (wind drift) or
- To calculate “seeable velocity” is very simple.





# tests

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**Some tests were performed by means of:**

- **Variation assimilation system -----  
CMA GRAPES-3Dvar**
- **Doppler radar data-----  
CINRAD data**





# data at a chosen point

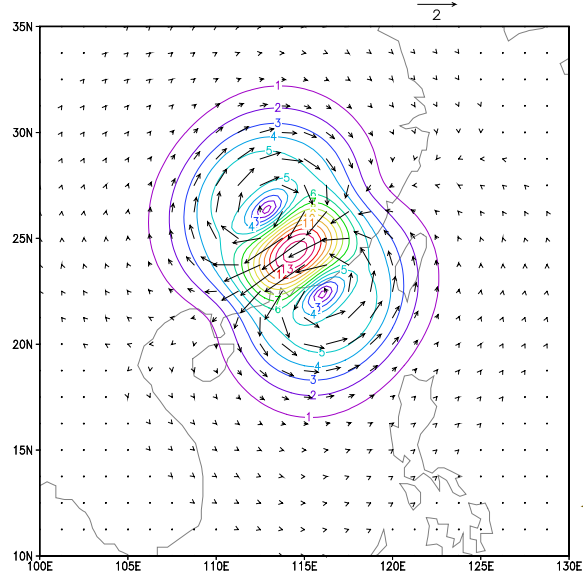
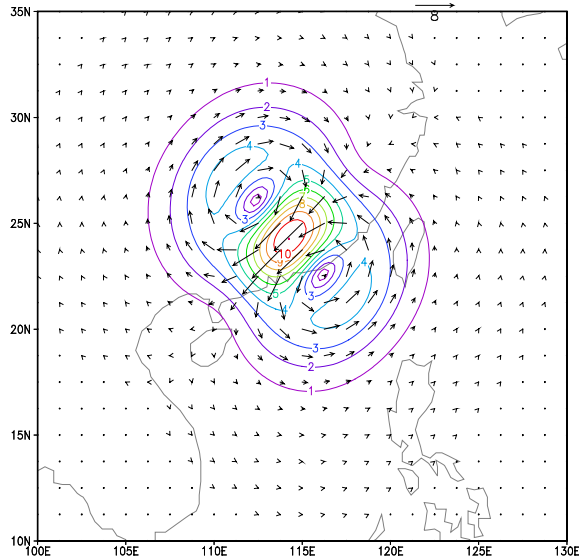
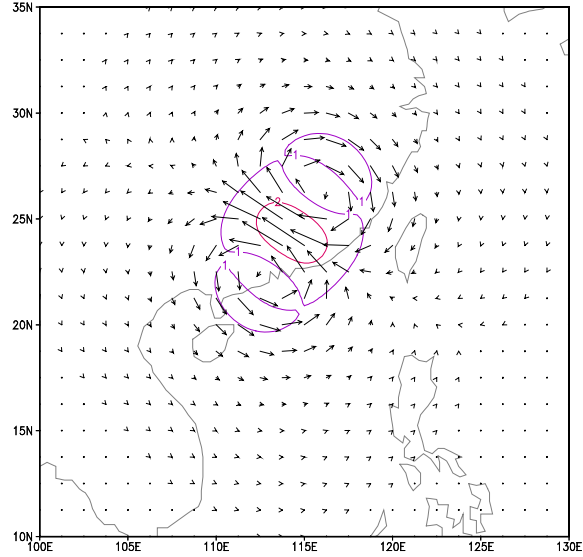
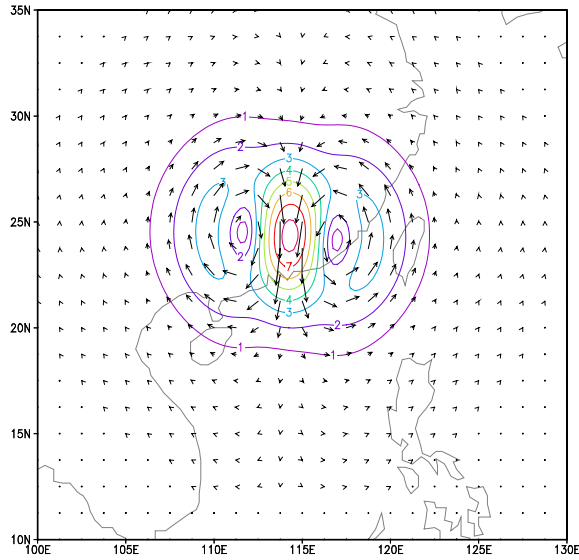
latitude: 24.35	longitude: 114.30	pressure: 700hPa	date: 02080500	
	Observation variable (m/ s)	component of operator (x)	component of operator (y)	error (m/s)
radial velocity	-8.76	0.068	0.998	1.0
Seeable velocity	-2.96	0.849	-.528	1.0

station: 59096		data: 02080500		
latitude	longitude	pressure	u	v
24.37	114.48	700hPa	-13.1	-9.2





The analyzed wind fields with the data at single point in the case of no background stream  
a:( left top)Assimilate radial velocity; b:( right top)Assimilate “seeable velocity”;  
c:( left bottom) Assimilate both radial velocity and “seeable velocity”; d:( right bottom)Assimilate sounding data





## Case: 1

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- **A vortex is near radar station.**
- **There are not strong shear of radial velocity.**



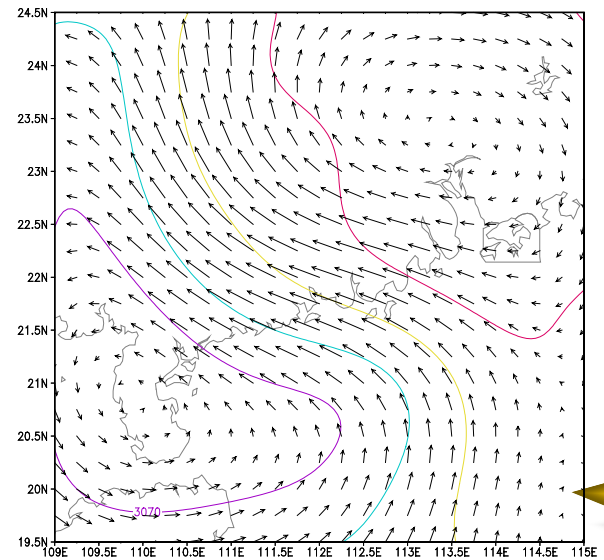
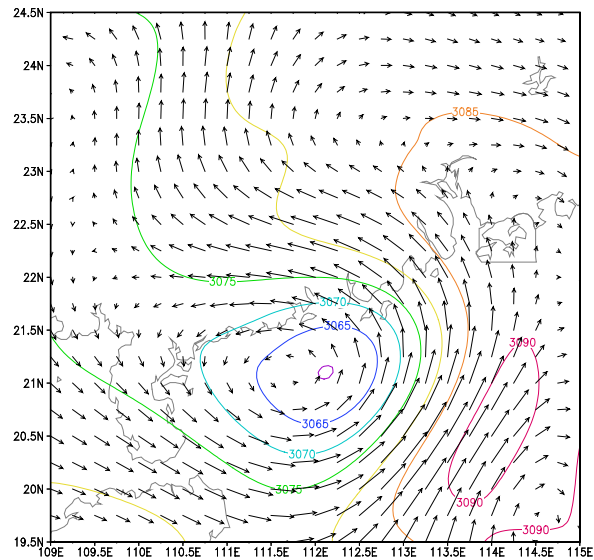
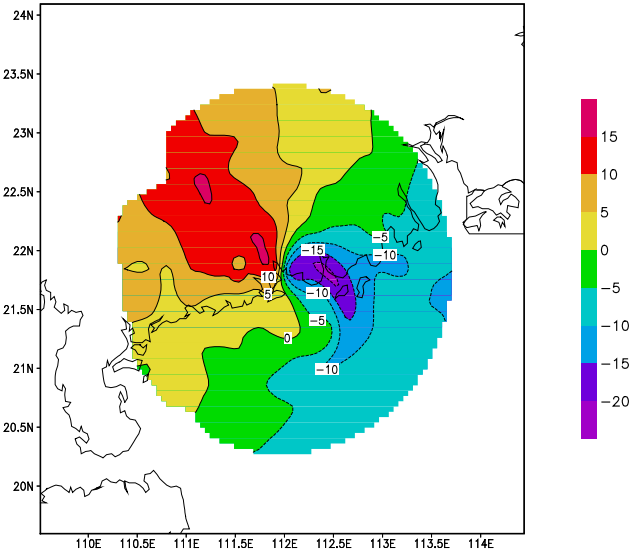
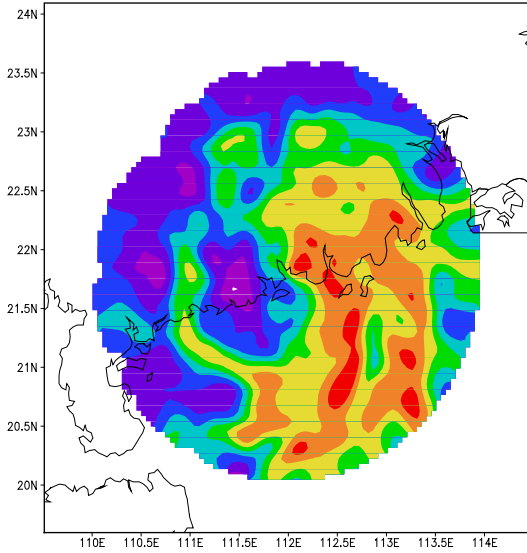


# Guangdong Yanjian radar data at 3km height(02091118UTC)

a:( left top) radar echo; b:( right top) radial velocity

The analyzed wind fields: c:( left bottom) Assimilate radial velocity

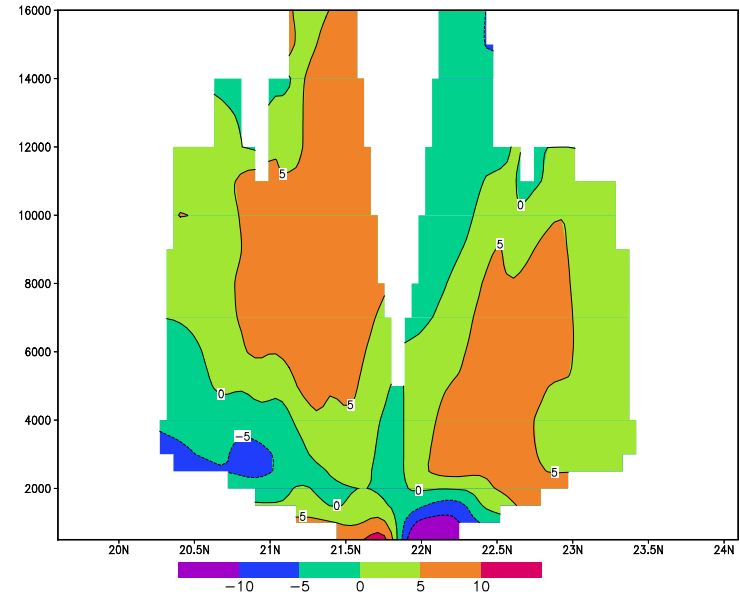
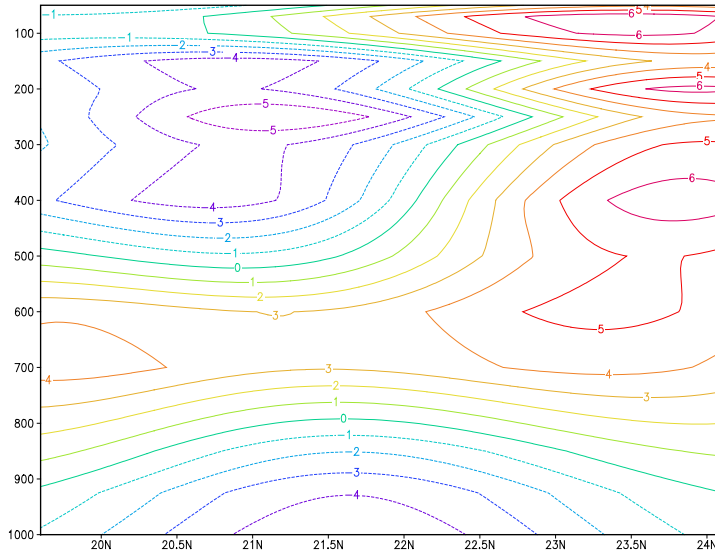
d:( right bottom) Assimilate both radial velocity and “seeable velocity”





# The vertical section along 112° E ( pass by the radar)

a:( left top) The longitudinal component of analyzed wind; b:( left bottom) radial I velocity;





## Case:2

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- **A vortex is far from radar station.**
- **There are a strong shear of radial velocity.**

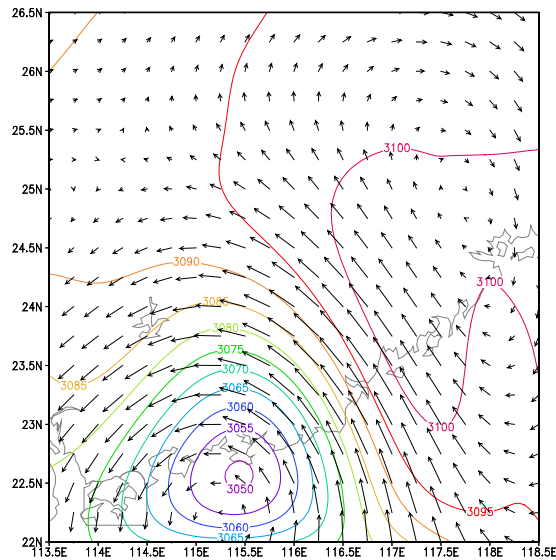
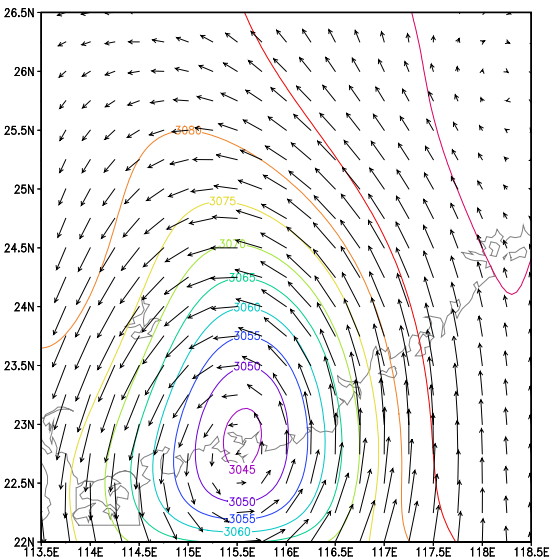
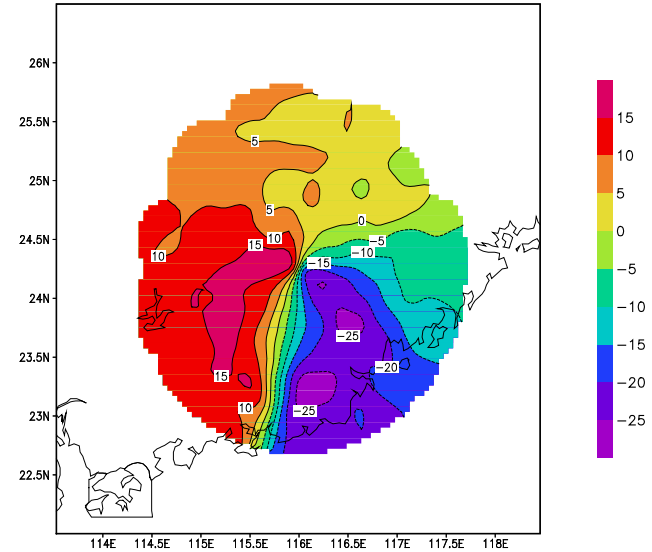
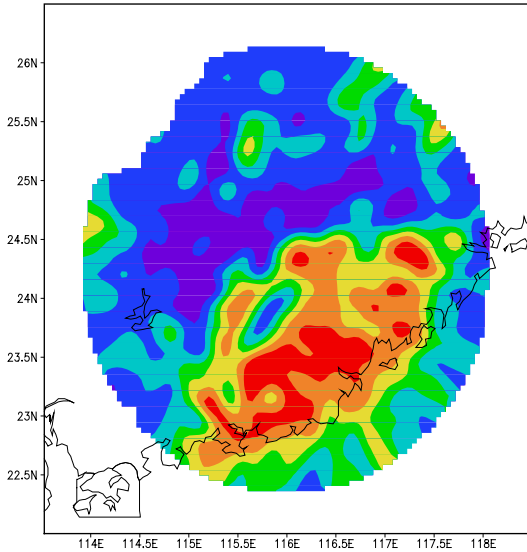




# Guangdong Meizhou radar data at 3km height(02080500UTC)

a:( left top) radar echo; b:( right top) radial velocity

The analyzed wind fields: c:( left bottom)Assimilate radial velocity; d:( left bottom) Assimilate both radial velocity and “seeable velocity”





## Case:3

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- **The background current is almost parallel.**
- **The meso-scale convection is occurring.**



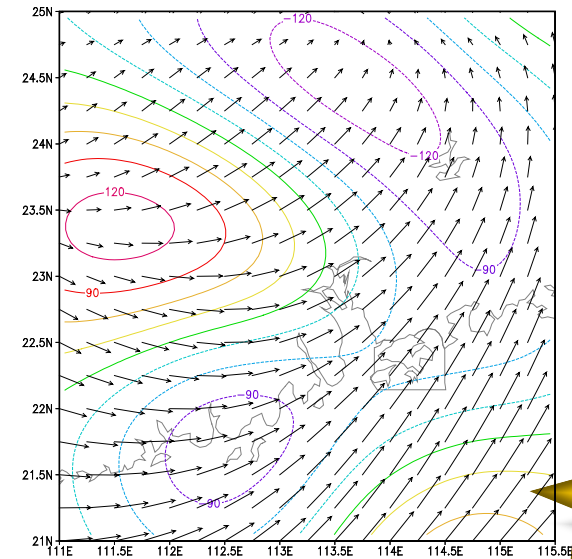
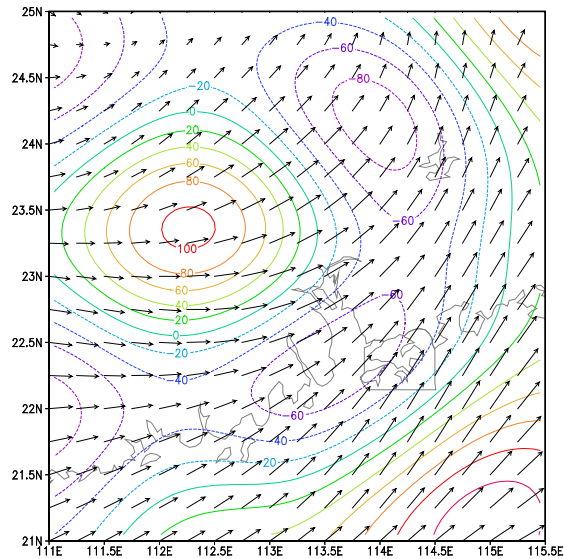
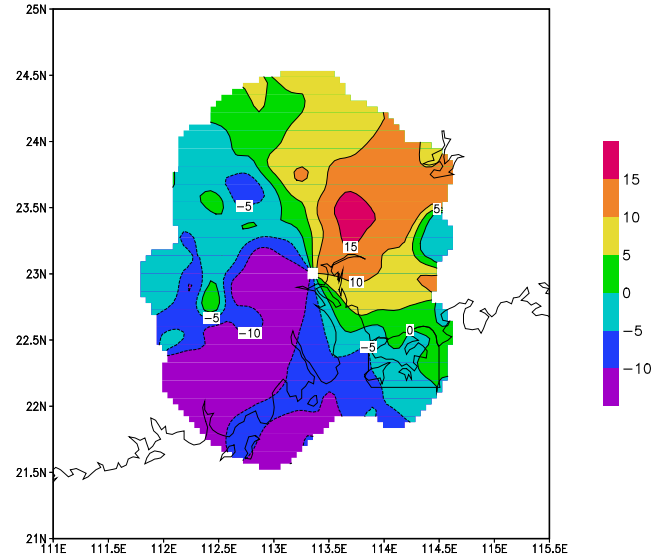
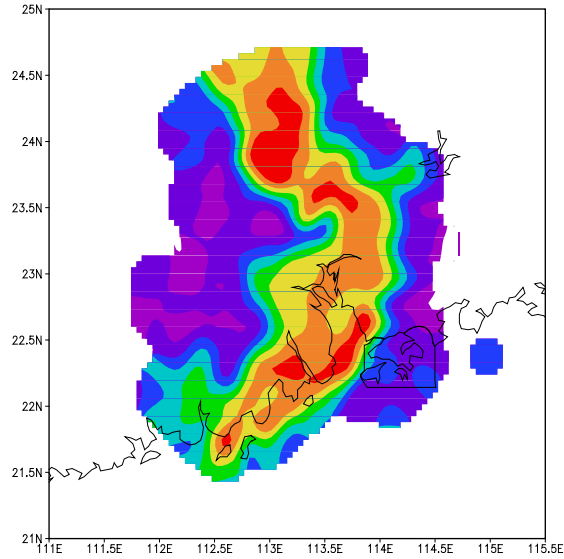


# Guangdong Guangzhou radar data at 3km height(03061012UTC)

a:( left top) radar echo; b:( right top) radial velocity

The analyzed wind vector and divergence c:( left bottom)Assimilate radial velocity

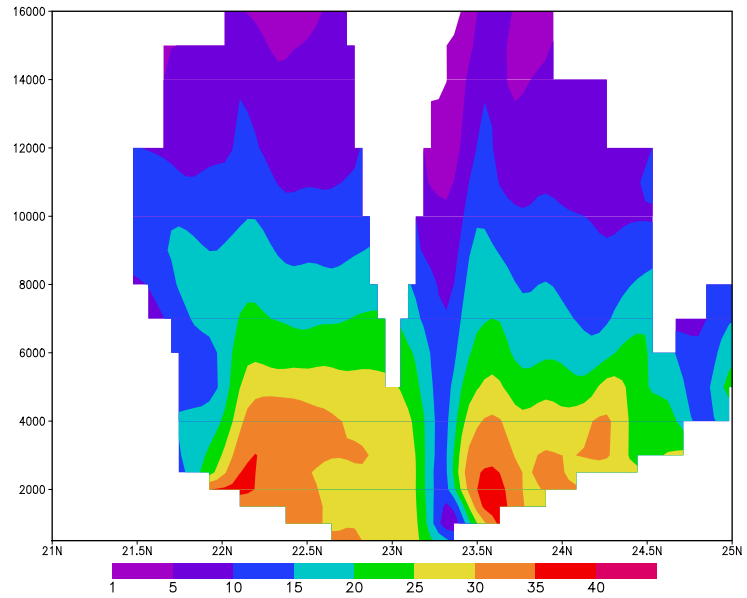
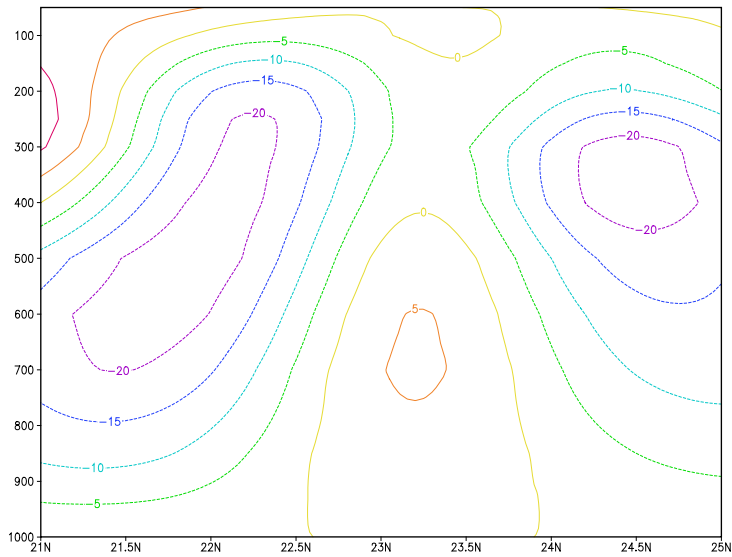
d:( left bottom) Assimilate both radial velocity and “seeable velocity”





# The vertical section along 113.35° E ( pass by the radar)

a:( left) vertical I velocity (X10-3 hPa/s) ; b:( right) radar echo





## Case: 4

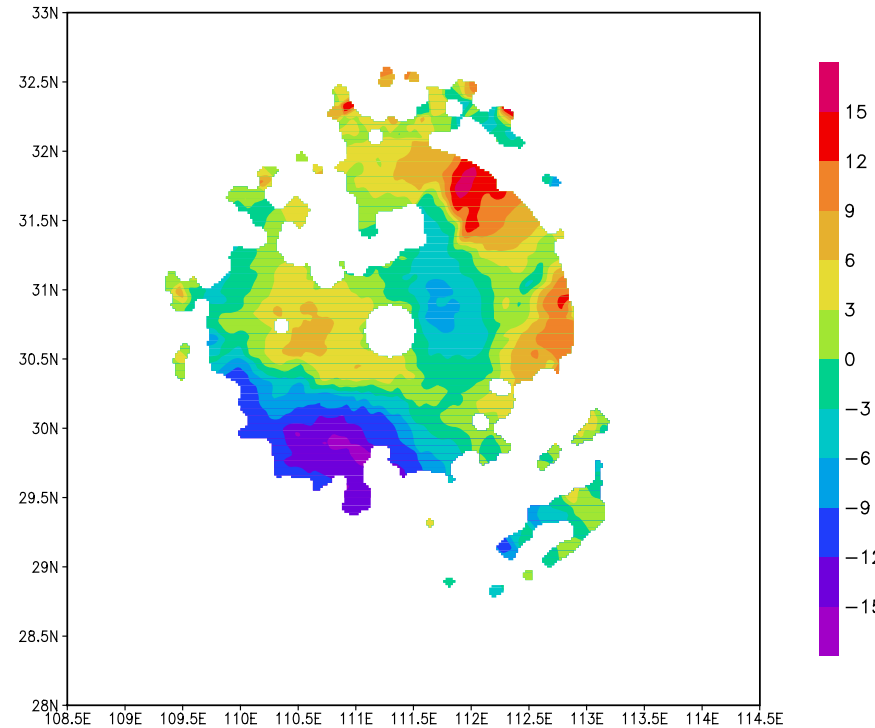
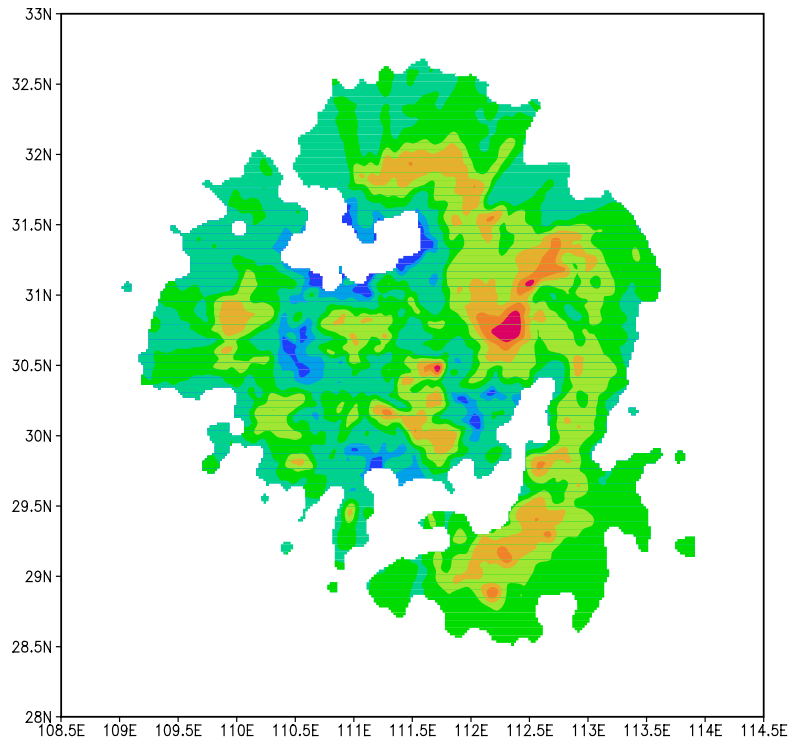
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- **The convective cloud cluster is occurring in the front shear line.**





# YiChan radar data ( 2002072212 )



● Elevation: 1.45

left: radar echo; right: radial velocity





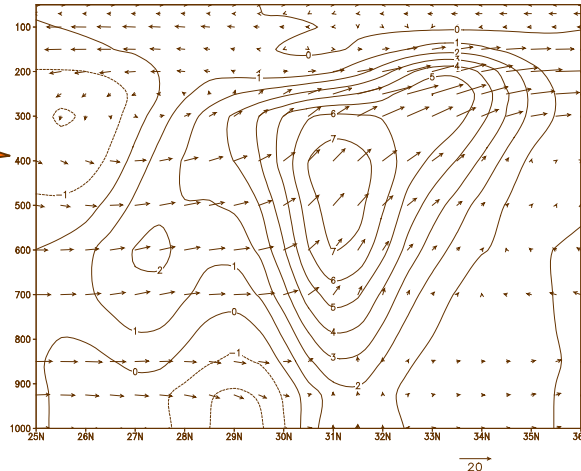
Strong convection



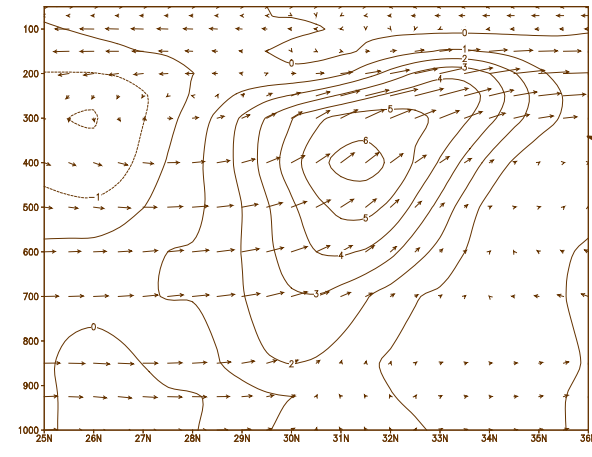
Assimilation radar data:

The structure of convective system is reasonable more than that of none radar !  
The vertical motion is strengthened !

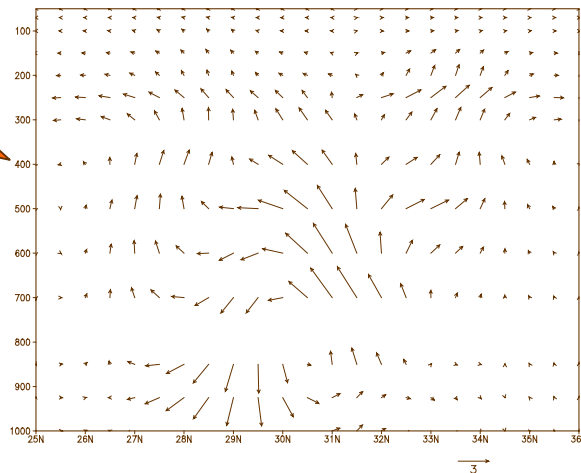
with Radar data



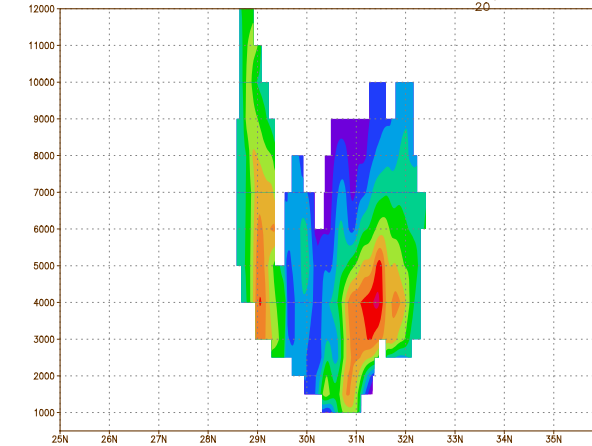
None radar data



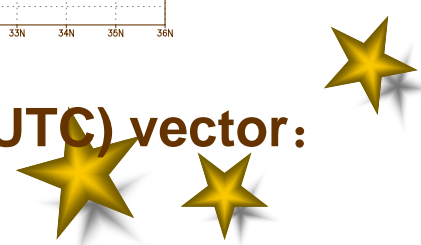
The vertical circulation in incremental fields



Radar echo

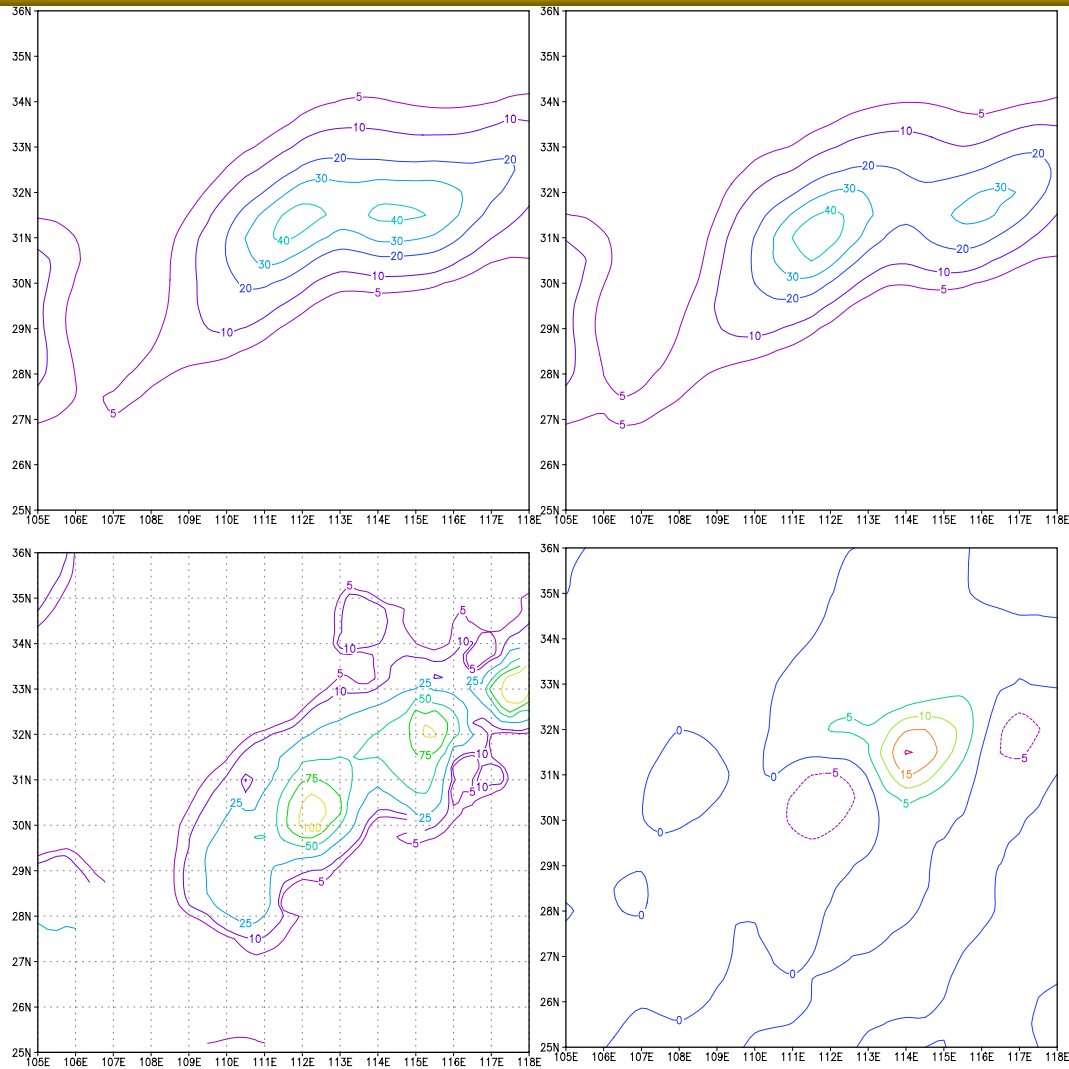


- The vertical section along 112° E (02072212 UTC) vector:  $V - W$  ; isoline: vertical velocity ( X-1000)





# simulation test



- The simulation precipitation (12 hour)  
a(left top): assimilation radar data; b(right top): none radar data
- c(left bottom):real rainfall; d(right bottom):the incremental rainfall by assimilating radar data





# conclusion

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**The test results showed:**

- **The scheme of retrieval of wind fields by three-dimension variation assimilation was available and effectual .**
- **The scheme was useful to form initial fields of model, it is beneficial to meso-scale numerical weather prediction.**





end

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- Suggest?

Thanks !

