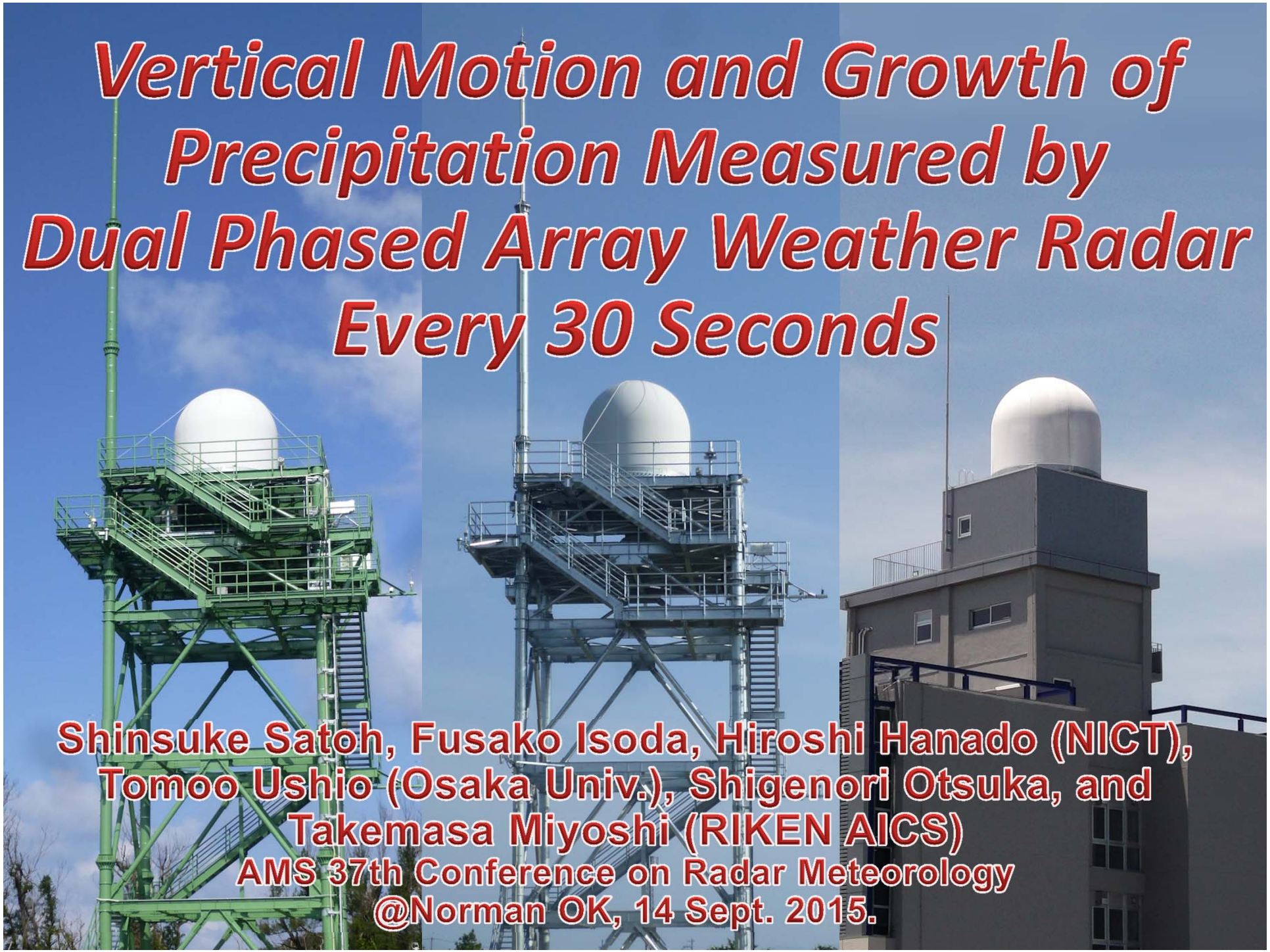


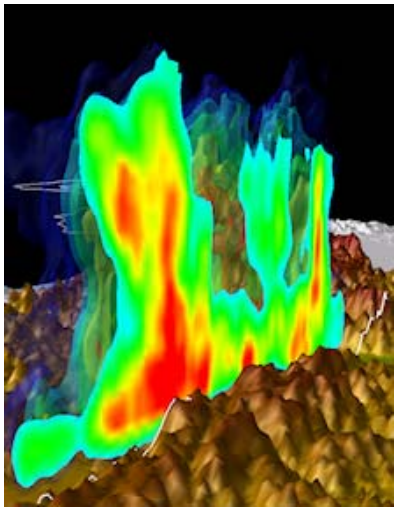
Vertical Motion and Growth of Precipitation Measured by Dual Phased Array Weather Radar Every 30 Seconds

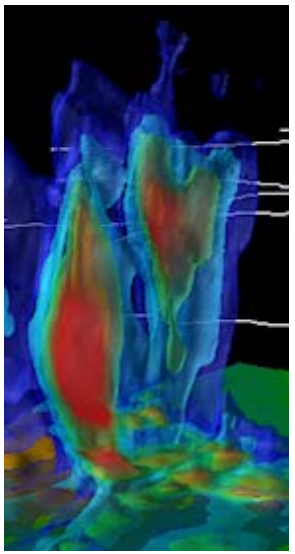
Shinsuke Satoh, Fusako Isoda, Hiroshi Hanado (NICT),
Tomoo Ushio (Osaka Univ.), Shigenori Otsuka, and
Takemasa Miyoshi (RIKEN AICS)

AMS 37th Conference on Radar Meteorology
@Norman OK, 14 Sept. 2015.

Introduction

- We developed the X-band Phased Array Weather Radar (PAWR) to watch and predict severe weather disasters caused by localized heavy rainfalls or tornadoes. The PAWR measures 3-dimentional fine structure of rainfall with 100 m range resolution and about 100 elevation angles in 30 seconds.
- The first PAWR was installed at Osaka University, Suita in 2012. The second and third PAWRs were install at NICT advanced ICT Research Institute Kobe and NICT Okinawa electromagnetic technology center in March 2014, respectively.
- In this study, vertical motion and growth of precipitation in a cumulonimbus cloud are investigated using both 3D radar echo images every 30 seconds and 3D wind vectors derived from dual-Doppler analysis.





Suita
in 2012

Kobe
in 2014

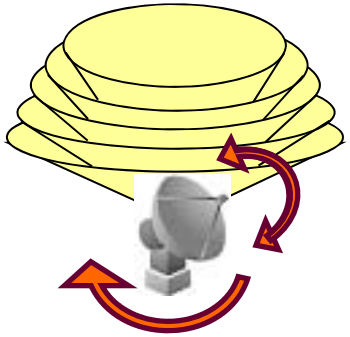
Okinawa
in 2014

MRI@ Tsukuba
in 2015

? MP-PAR

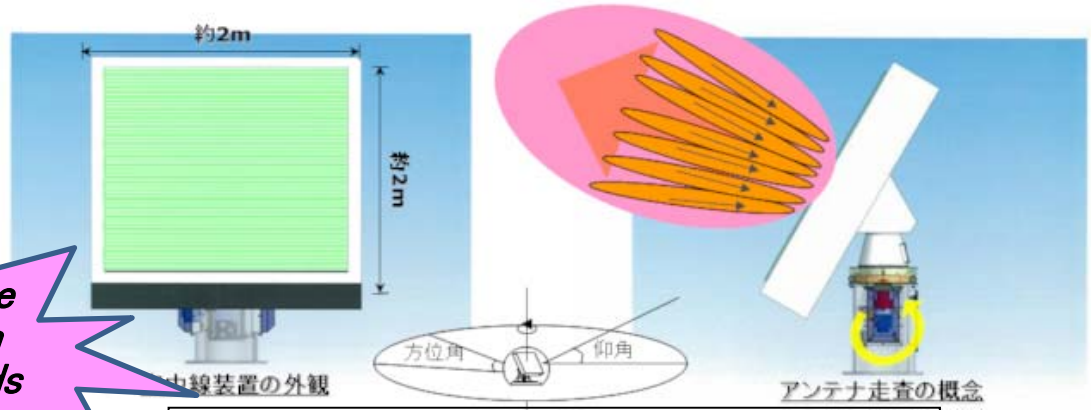
Tokyo?
in 2017 → See Poster #16

Phased Array Weather Radar (PAWR)



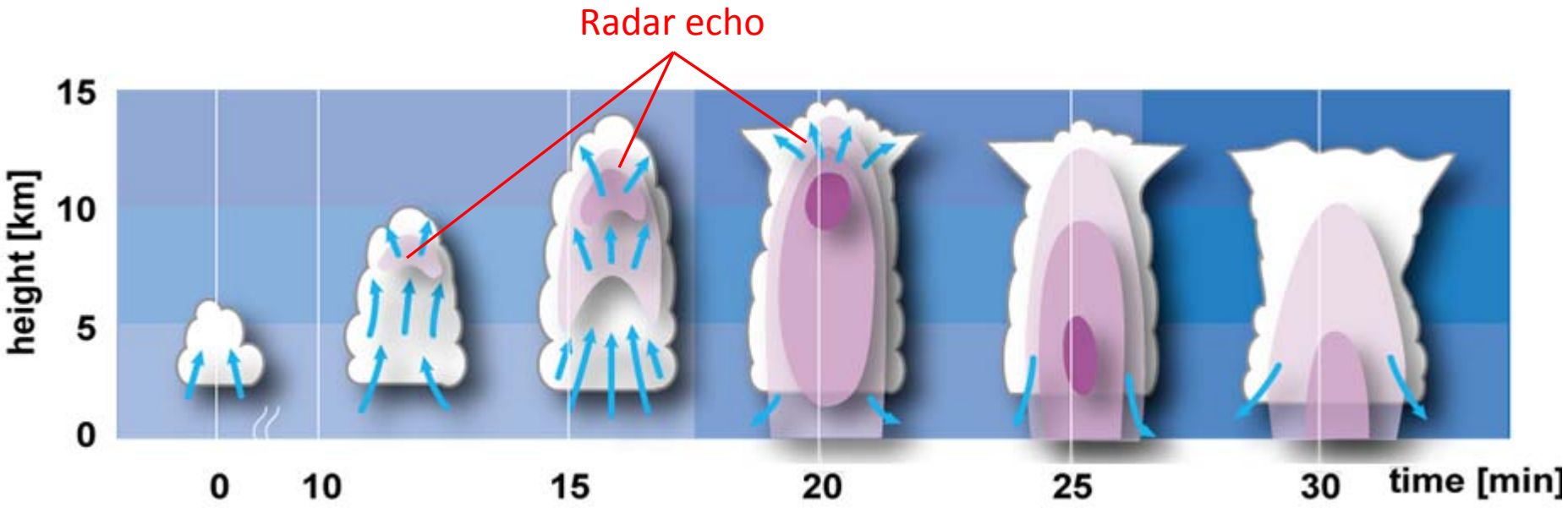
3-dim measurement using
a parabolic antenna (150 m,
15 EL angles in 5 min)

3-dim. dense observation in 30 seconds

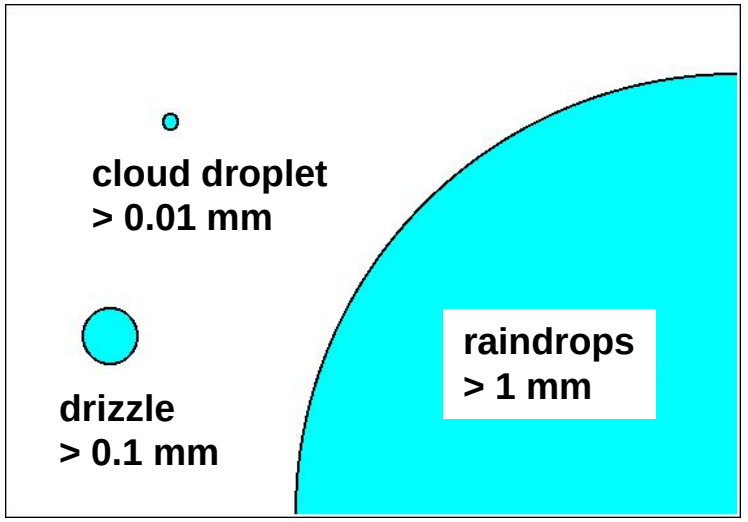


3-dim measurement using 128 slot-array antennas
with fan-beam transmitting and DBF receiving.
(100 m, 100 EL angles in 30 sec)

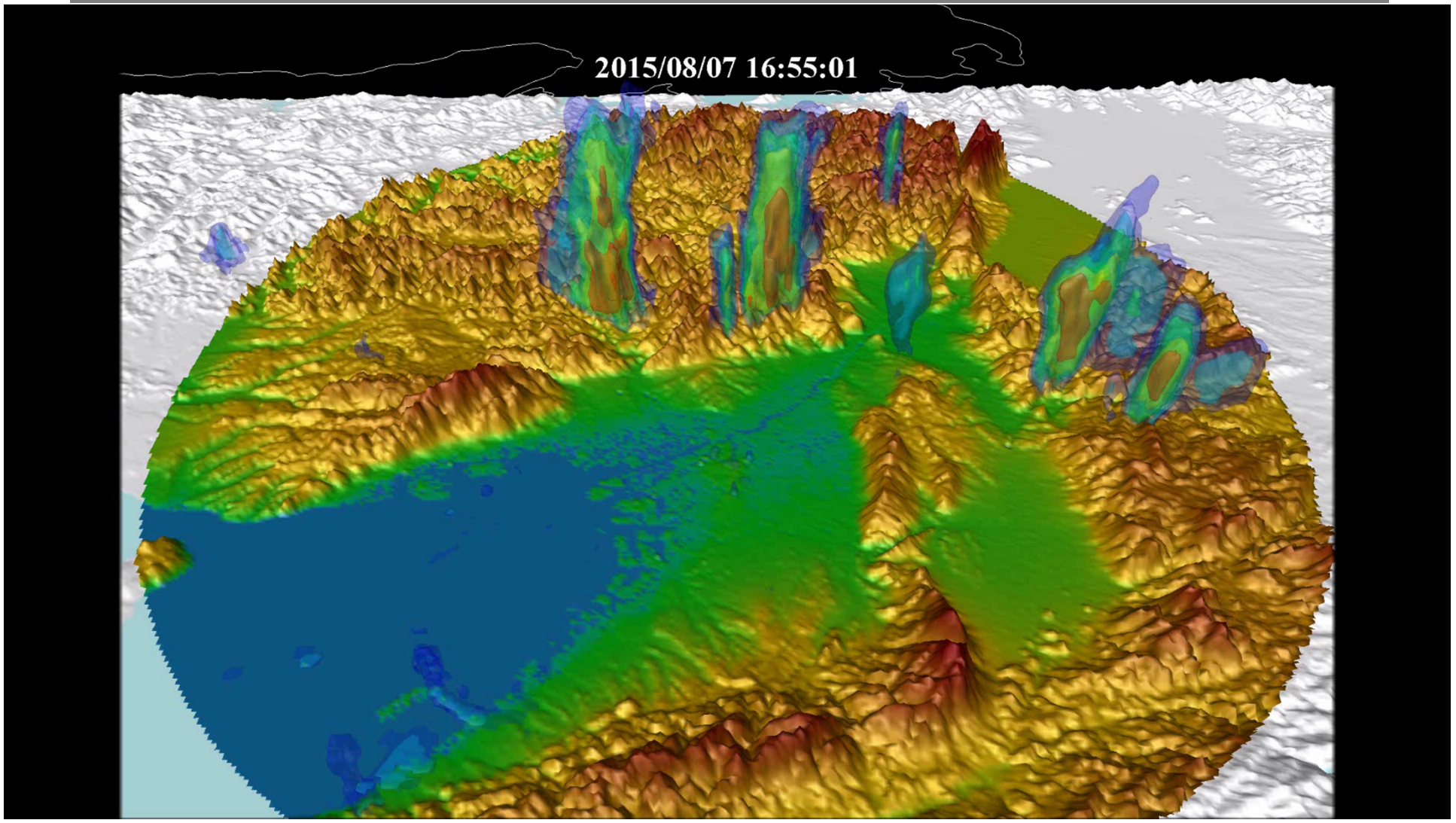
Precipitation development in a cumulonimbus



(1) growth of cloud droplets in cumulus updrafts
(2) increase of droplet size in upper levels
(3) large droplets detected by radar (first echo)
(4) raindrops falls to the ground at a rate of 4-5 km in 10 min.
(5) The life time of a cumulus cloud is 30-60 min.



3D Visualization of precipitation development

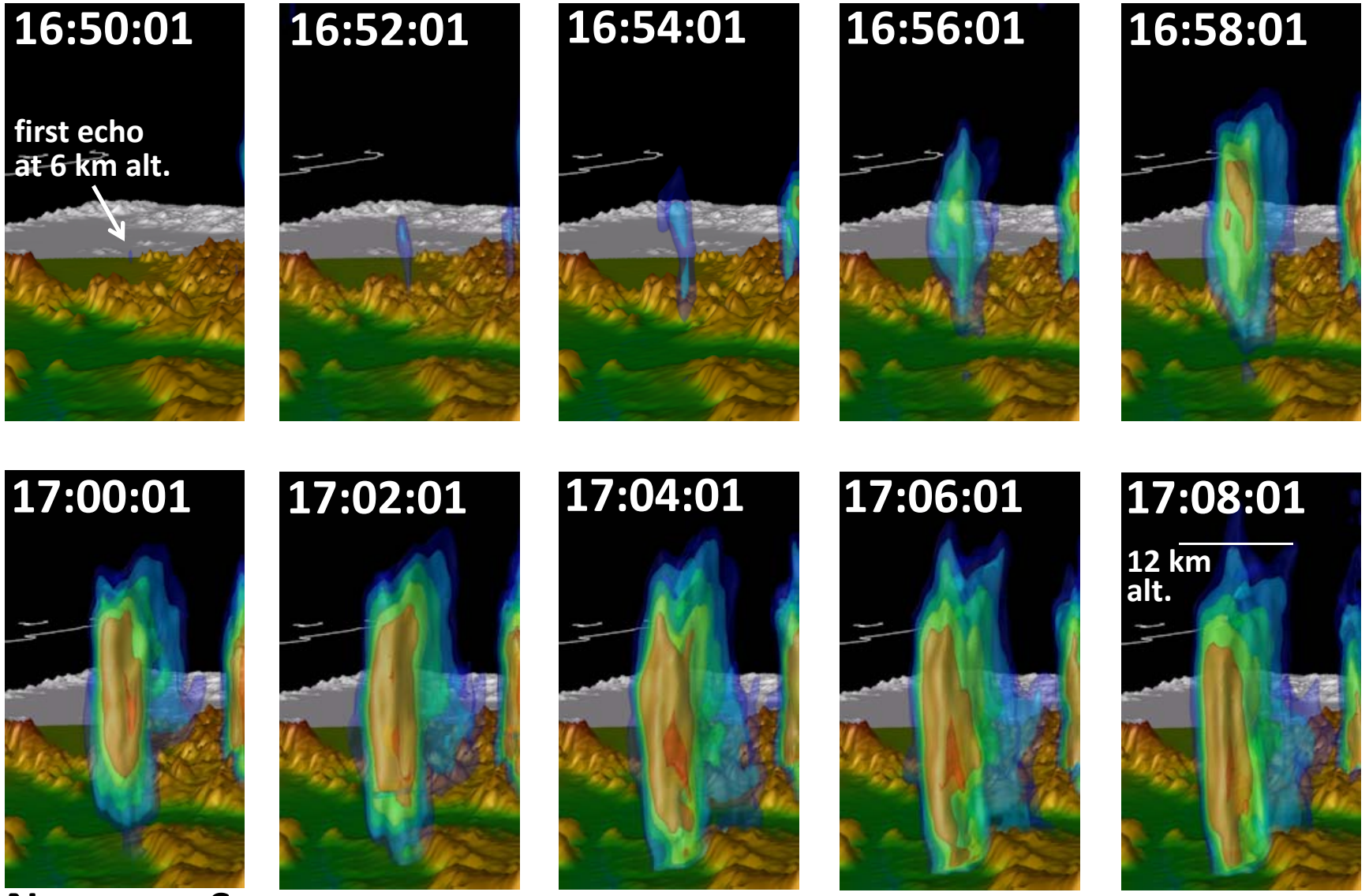


3-dimensional distribution of precipitation observed by Suita PAWR. Localized rainfalls from 16:55 to 17:59 JST, 07 Aug. 2015 showed by 3D animation every 30 second. (60 km in radius, 250 m grid size.)

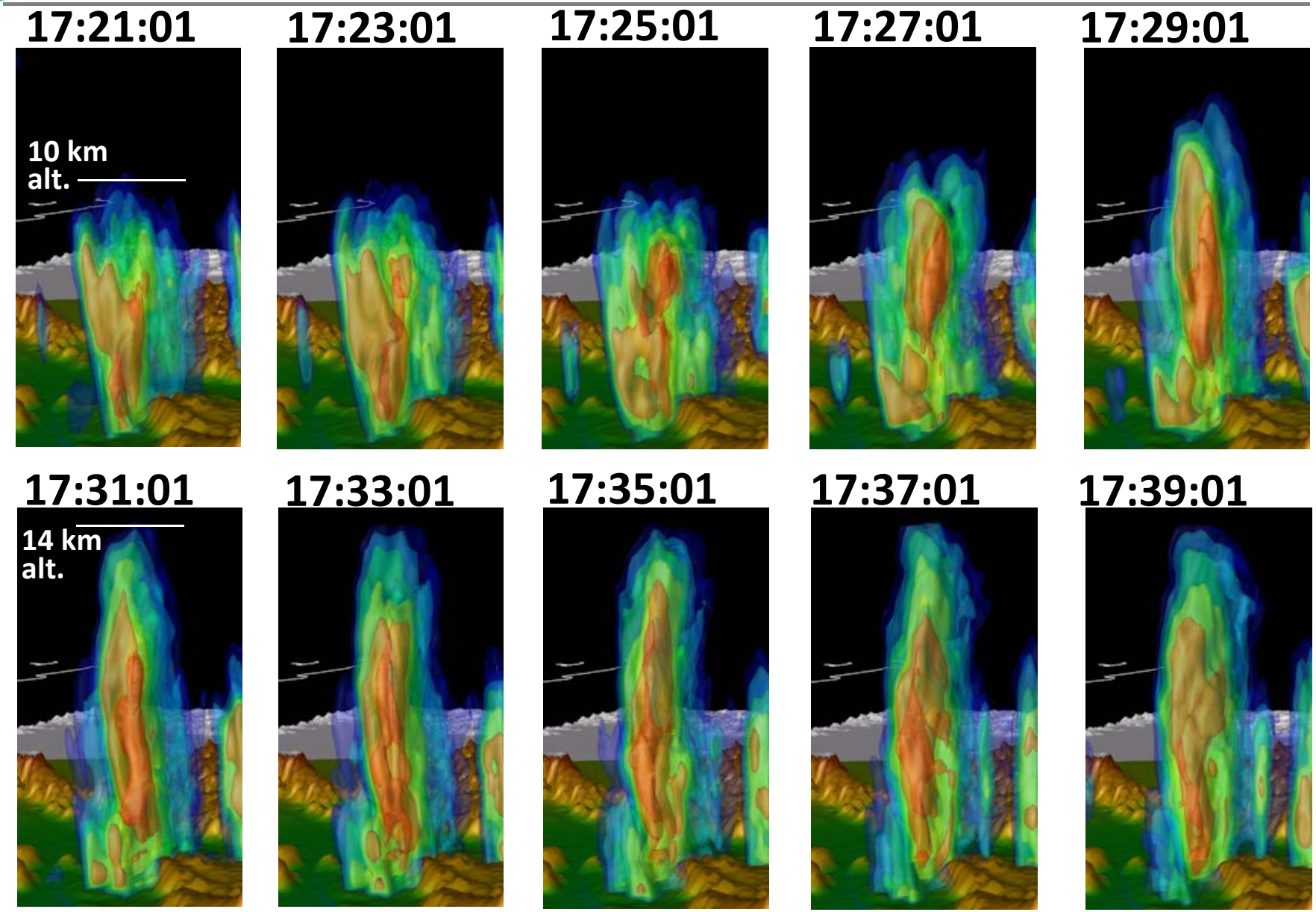
10fps → 300x speed

Precipitation growth from a first echo

(07Aug2015)



Precipitation growth again (07Aug2015)



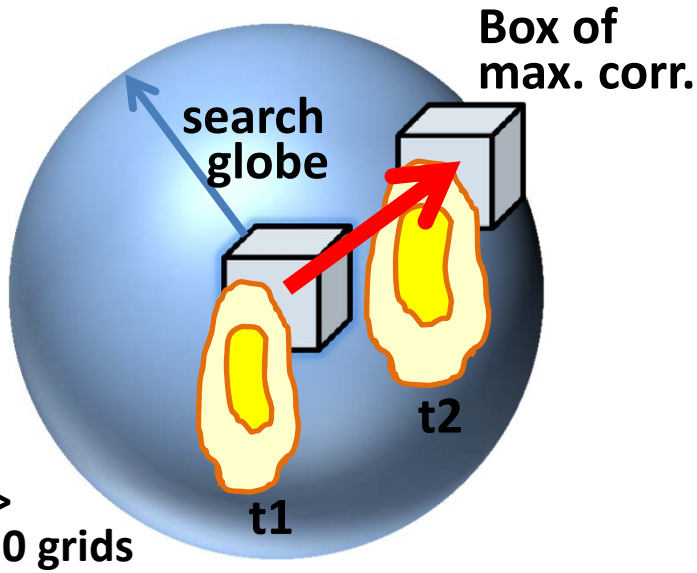
3D TREC analysis

TREC (by Rinehart and Garvey, 1978)

- Tracking Radar Echoes by Correlation
- to get horizontal (2D) motion vectors

COTREC (by Li et al., 1995) --- not use in this study

- Continuity of TREC
- Practical nowcasting



<default param.>
search radius = 10 grids
comparison box = 5x5x5 grids

Resolution of motion vector (grid size vs temporal diff.)

grid size	30sec	60sec	120sec (2 min)	240sec (4 min)
62.5 m	2.1 m/s	1.05 m/s	0.52 m/s	0.26 m/s
125 m	4.2 m/s	2.1 m/s	1.05 m/s	0.52 m/s
250 m	8.3 m/s	4.2 m/s	2.1 m/s	1.05 m/s

useful for speed-up calculation of TREC

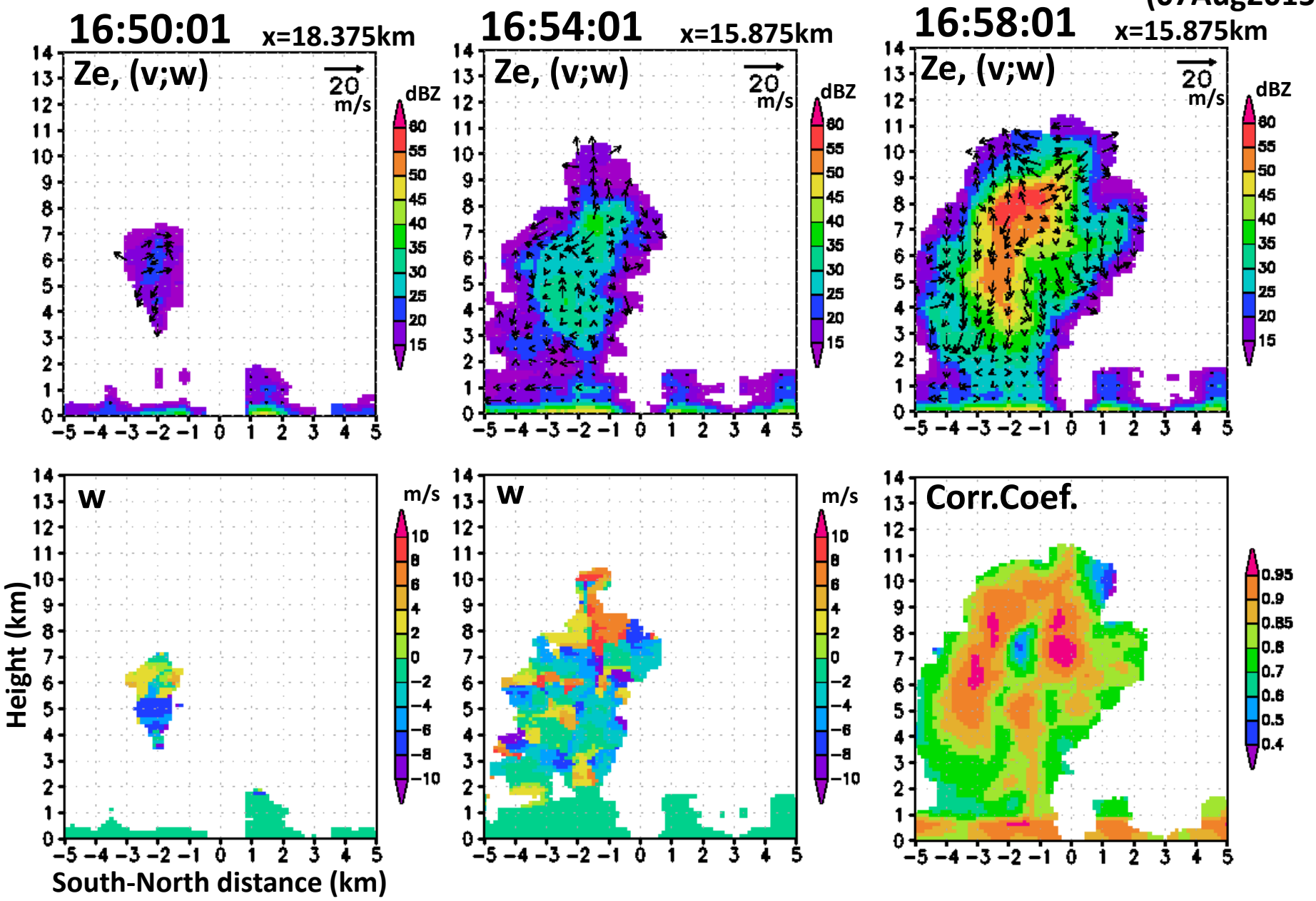
applied in this study

general 2D-TREC for conventional radar

Refer: 12A.5 Three-dimensional precipitation nowcasting with rapid and dense PAWR observations (by Otsuka et al.)

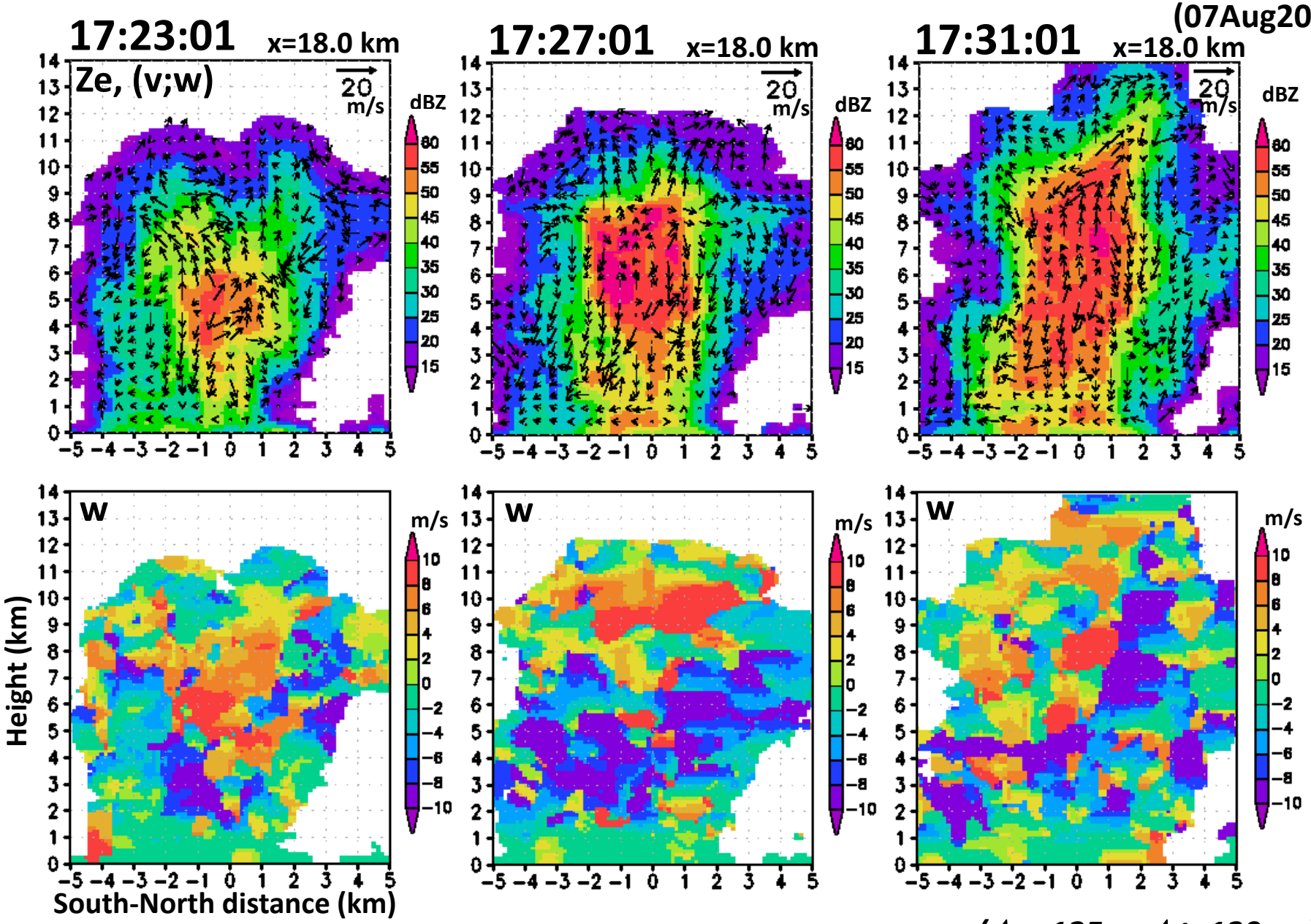
Results of 3D TREC (Δ z=125m, Δ t=120sec)

(07Aug2015)



Results of 3D TREC (growth again)

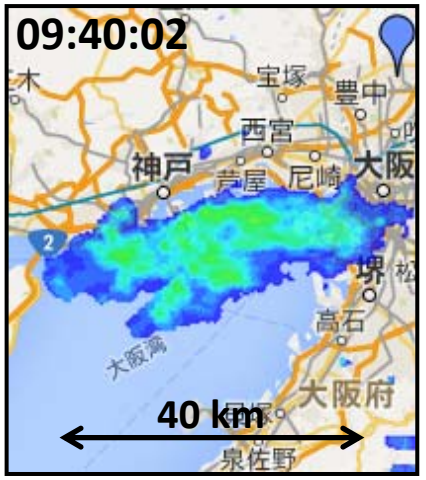
(07Aug2015)

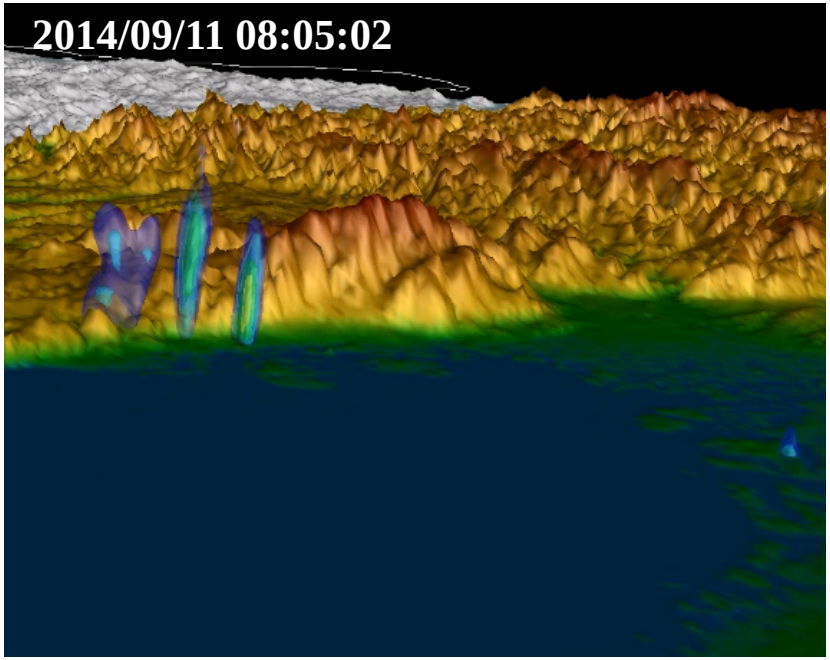


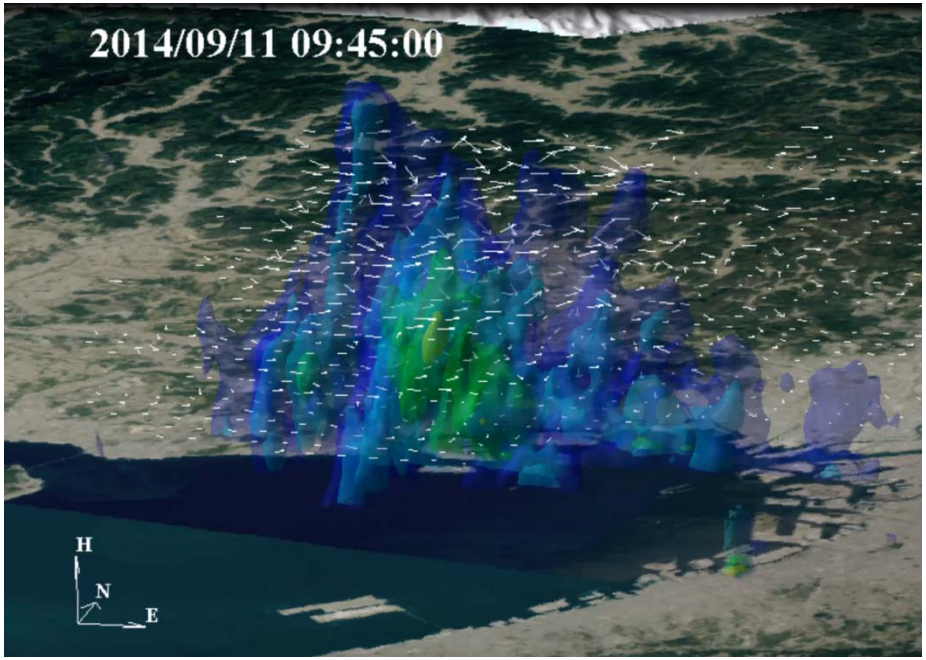
(Δ z=125m, Δ t=120sec)

Observation range of Kobe & Suita PAWR

Developing convective cloud (8:00-10:00, Sep 11, 2014)

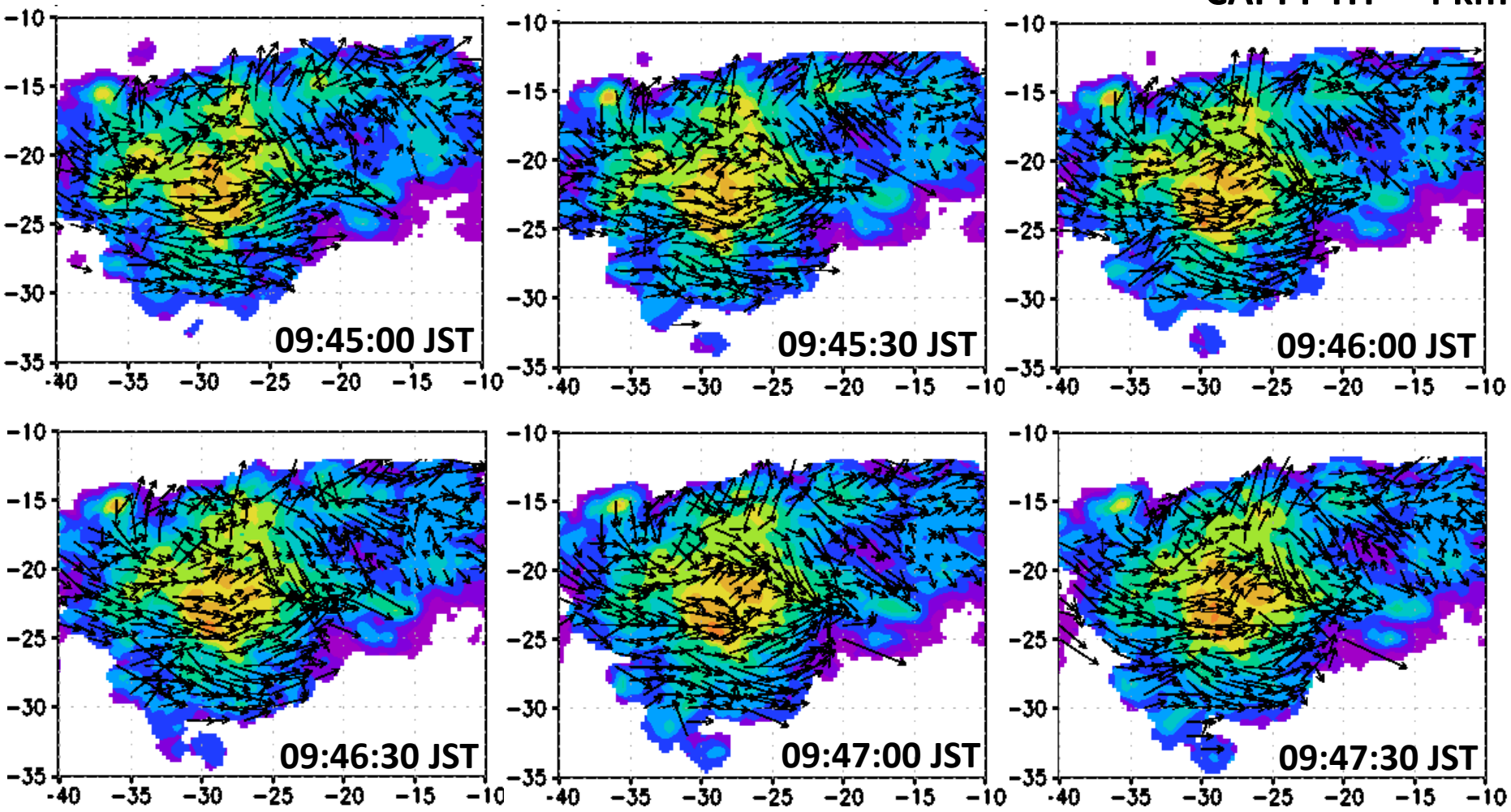






Dual-Doppler analysis every 30 seconds

CAPPI HT = 4 km

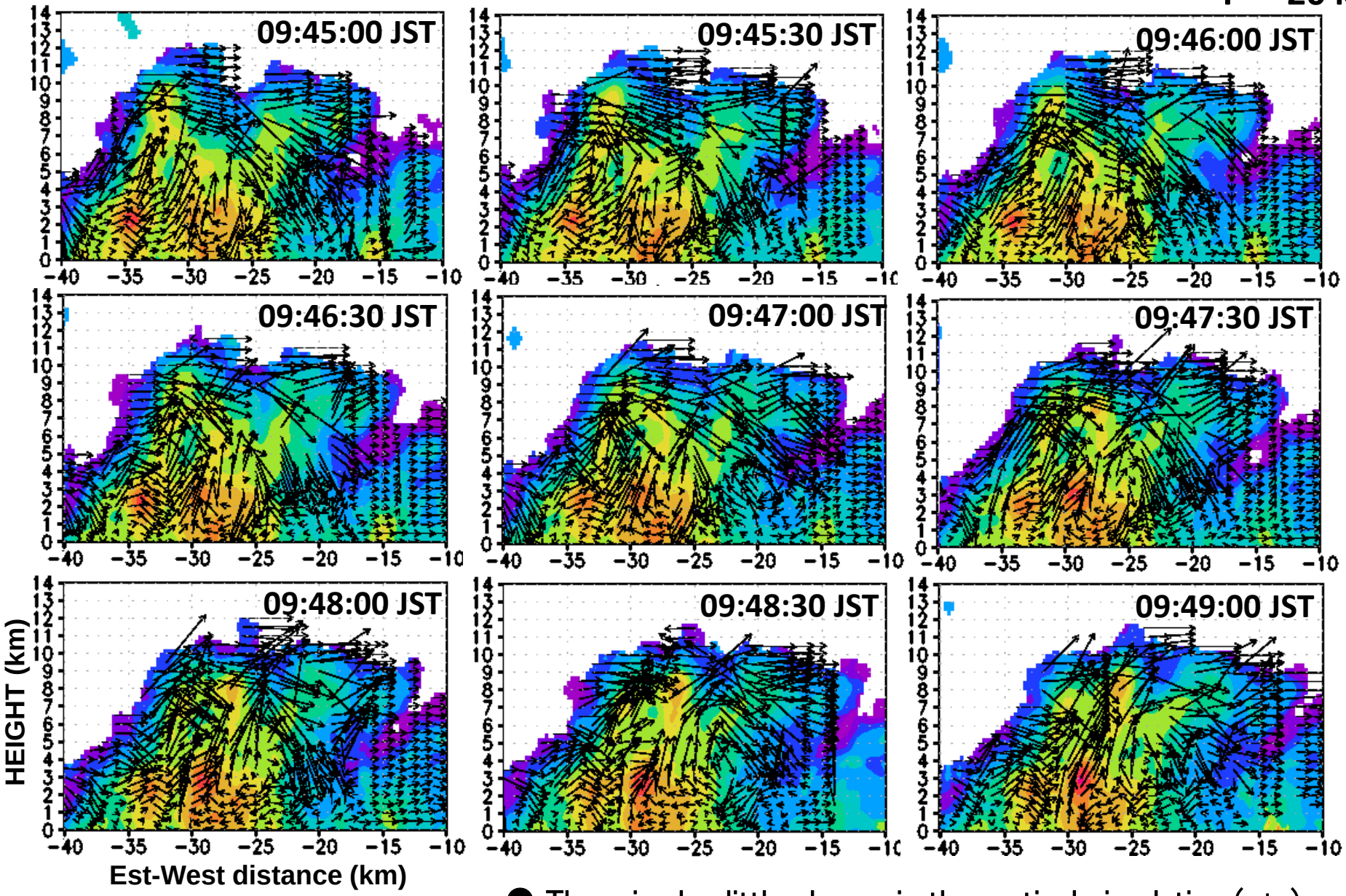


Sep 11, 2014

- Distribution of the horizontal wind vectors (u;v) changes little in appearance in a few minutes, but, the precipitation core is growing around x=−30, Y=−24km.
- There are many noisy data because the data QC has not been done.

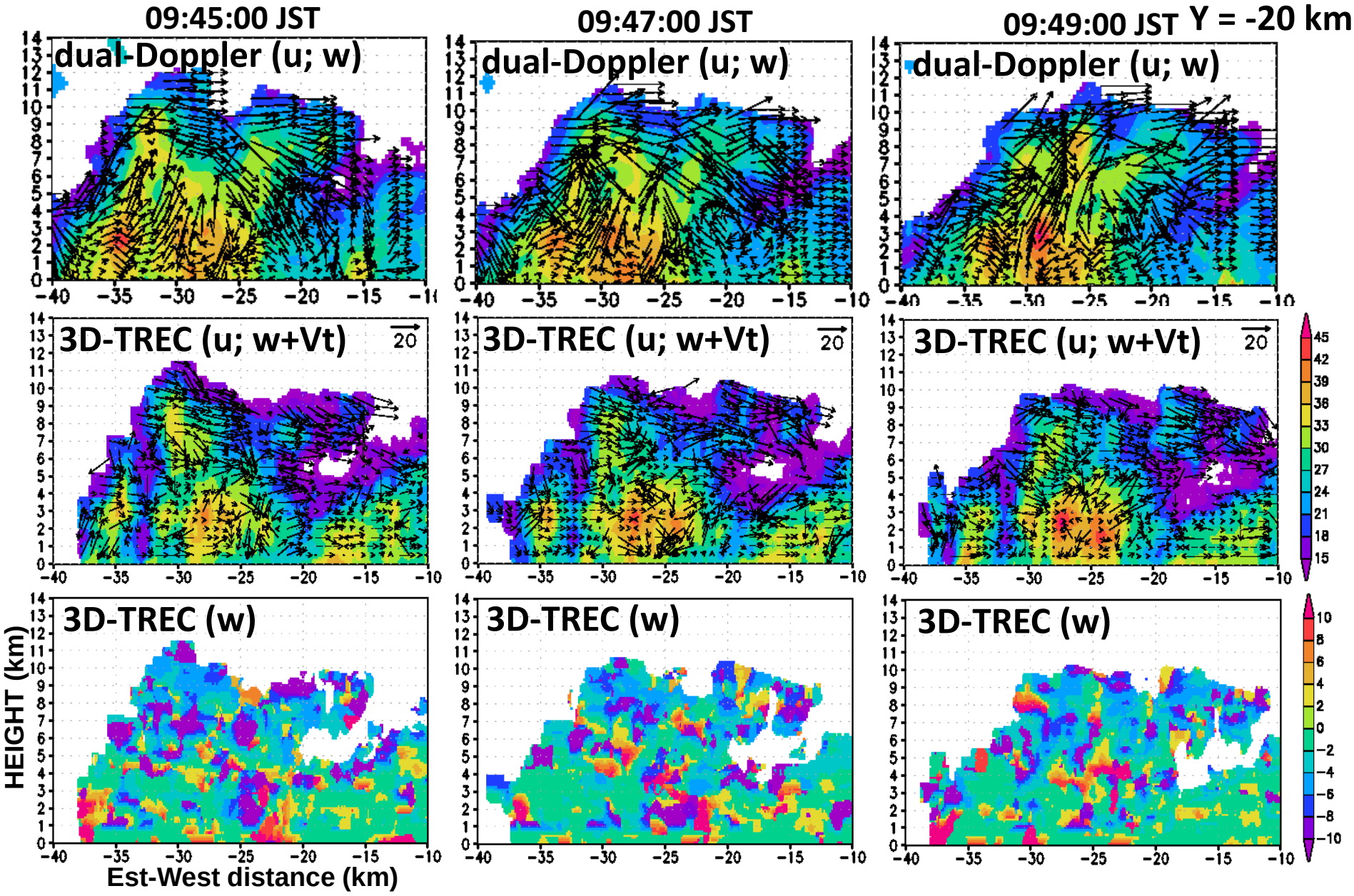
Dual-Doppler analysis every 30 seconds

Y = -20 km



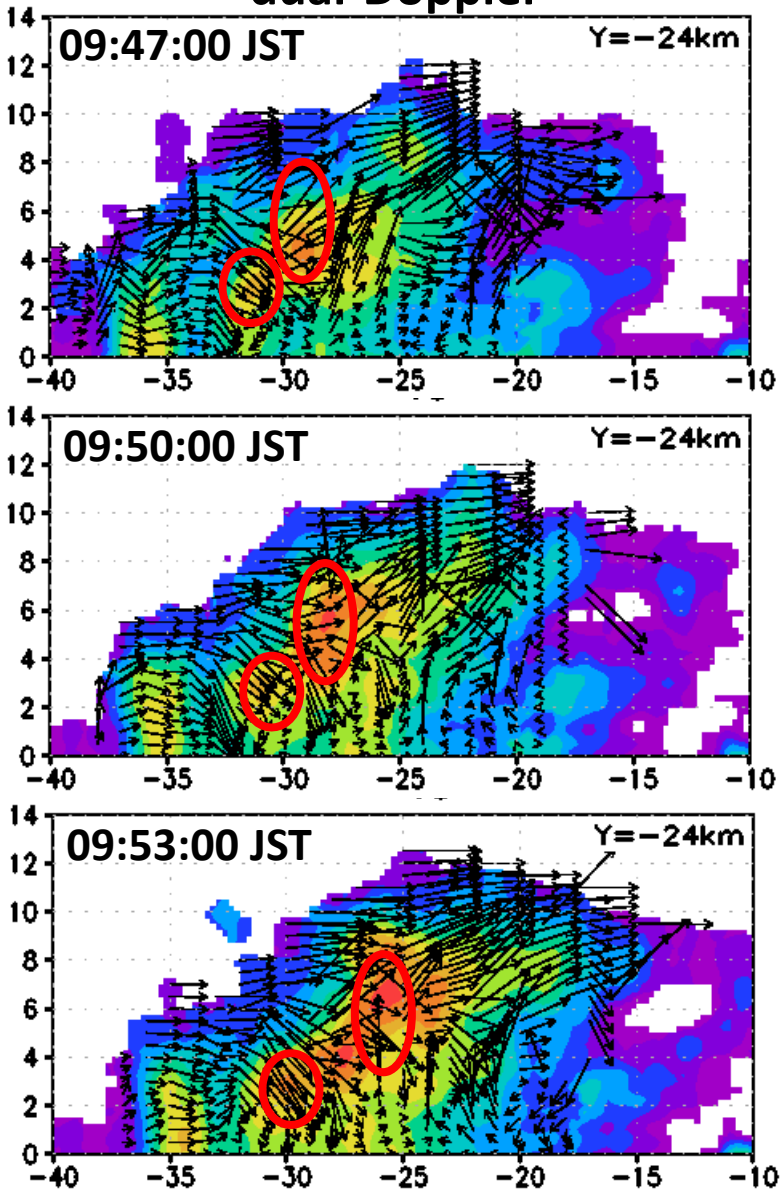
● There is also little change in the vertical circulation (u+v).

Dual-Doppler vs 3D-TREC



Vertical Motion and Growth of Precip.

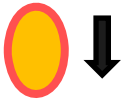
dual-Doppler



In strong updrafts (> 6 m/s),
the precipitation moves upward with growth

vertical motion:
w + Vt > 0

In downdrafts (or weak updrafts),
the precipitation falls to the ground



vertical motion:
w + Vt < 0

where,
w: vertical winds (derived from dual-Doppler),
Vt: terminal fall velocity of precipitation (from Ze),
and the vertical motion of the precipitation should be determined using 3D TREC (Tracking Radar Echoes by Correlation) algorithm.

3D TREC vectors include growth/decay of precipitation. On the other hand, dual-Doppler vectors express environmental wind fields because w is calculated from the continuity equation.

Summary

- **The phased array weather radar (PAWR) measures precipitation development from the first echo appearance with high spatial-temporal resolution (100 m, 100 EL angles, 30 seconds).**
- **3D-TREC algorithm reveals the vertical motion and growth of precipitation. Every 30 seconds data will be useful to speed-up calculation of TREC.**
- **Dual-Doppler analysis shows that wind vectors in the convective circulation every 30 seconds, that are maintained for at least several minutes.**
- **Precipitation is basically growing in the updraft region, although the vertical motion calculated by 3D-TREC is different from the dual-Doppler vertical wind.**