Small-scale Structure of Eastward-Propagating Precipitation Systems within a Supercloud Cluster during the MISMO IOP

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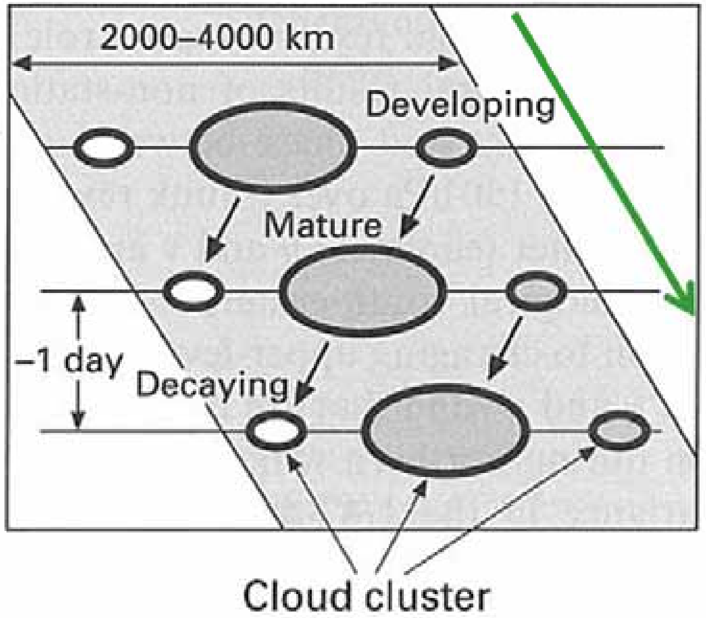
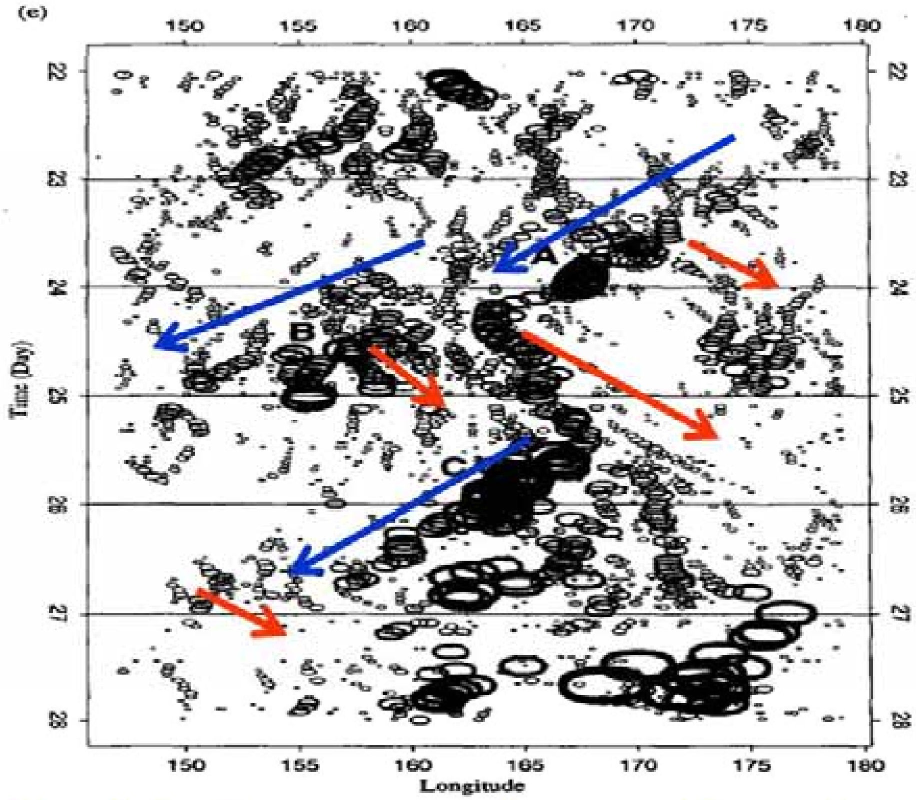
Background: hierarchy of cloud cluster

Synoptic-Scale → **Mesoscale**



Super cloud cluster (SCC)
propagating eastward
(Nakazawa 1988, JMSJ)



Cloud clusters propagating usually westward
but sometimes eastward
(Chen et al. 1996, JAS)

Disturbances related:

Kelvin wave *(Straub and Kiladis 2002, JAS)*	**Inertio-gravity wave** *(Takayabu et al. 1996, MWR)*	**???**

Topics and Goal

Topics

- Characteristics of clouds and radar echoes within a SCC observed during the MISMO IOP

  -- Eastward-propagating rainband (ER)

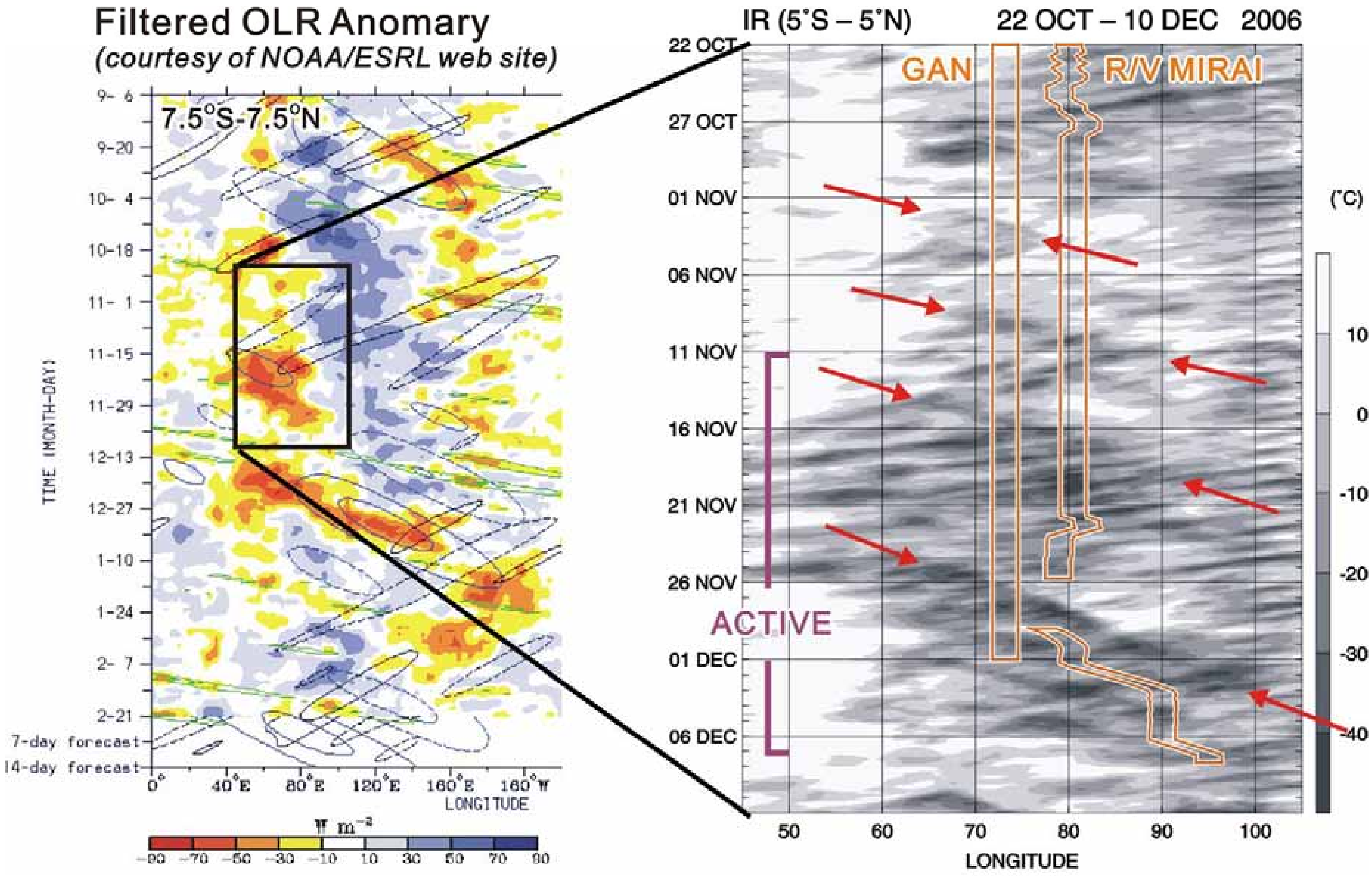
  -- Westward-propagating cloud shield (WS)

- Composite horizontal and vertical structure of ER and WS using satellite microwave data, in addition to Doppler radar and upper-air data
- Relevance to past observational/numerical studies

Goal

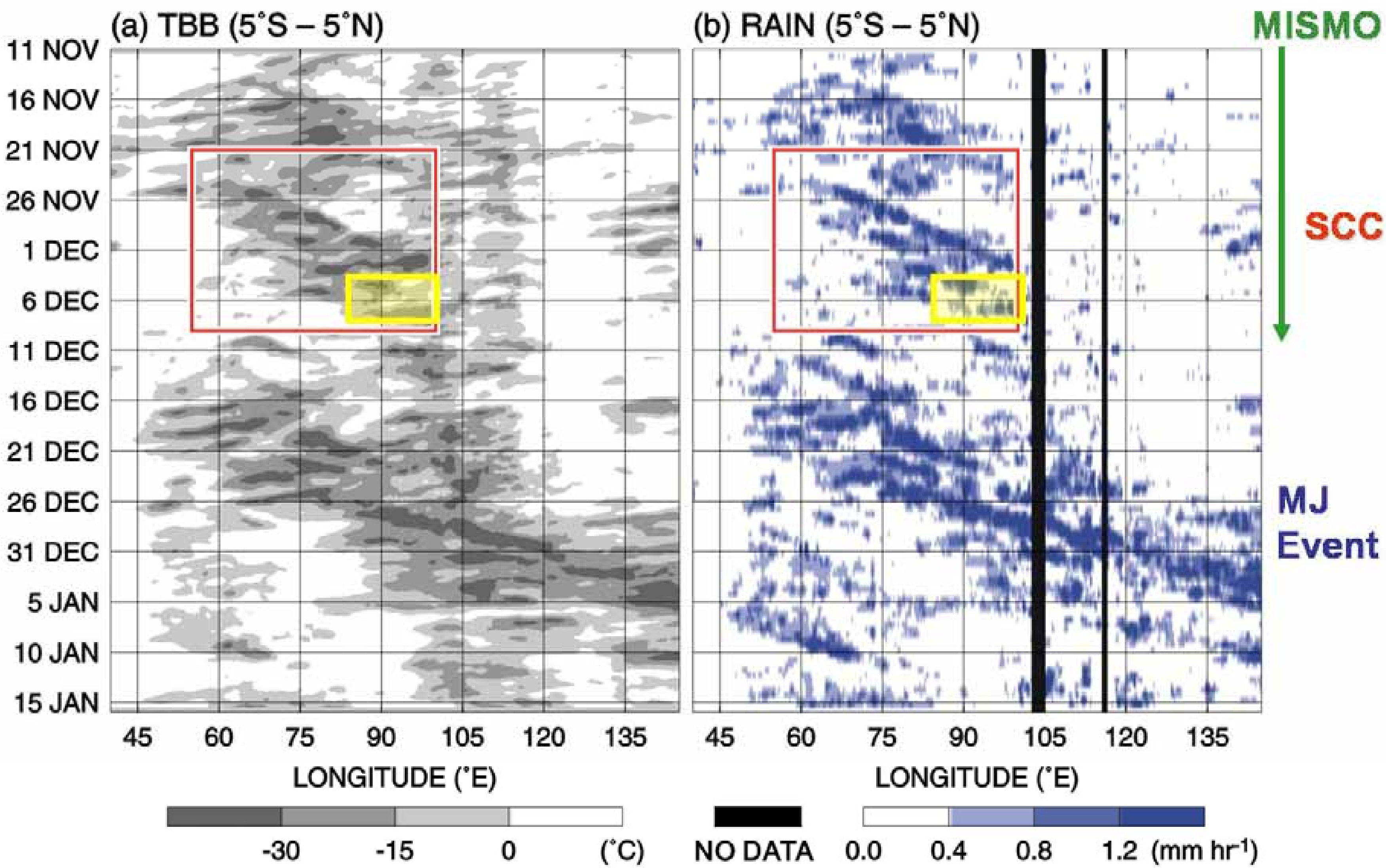
- To understand the mechanism of eastward/westward propagation of cloud clusters within a SCC

OLR and IR during MISMO



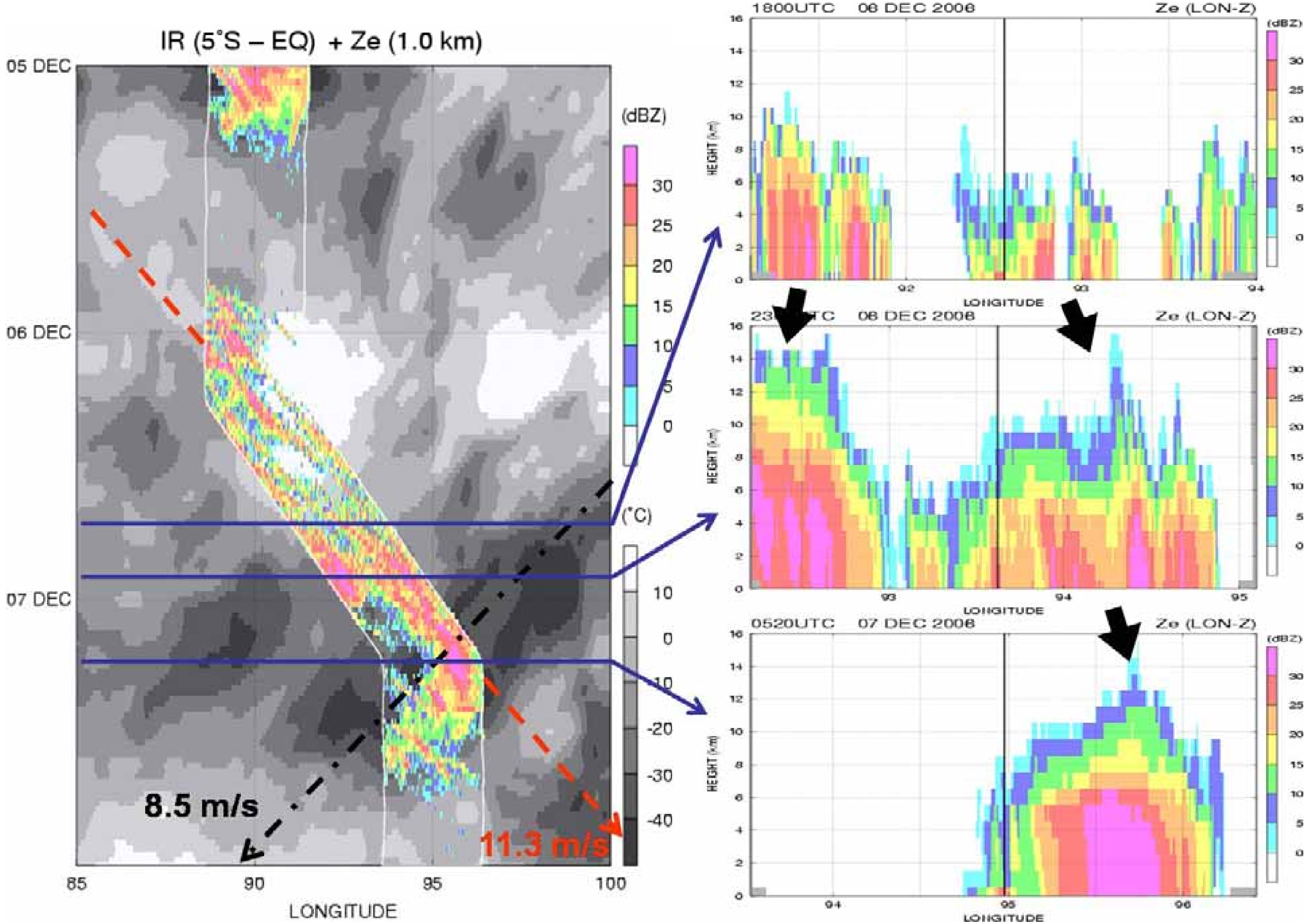
Eastward propagation of a cloud envelope (such as SCC) was observed 4 times.

IR and Microwave Rain in Nov-Jan 2006

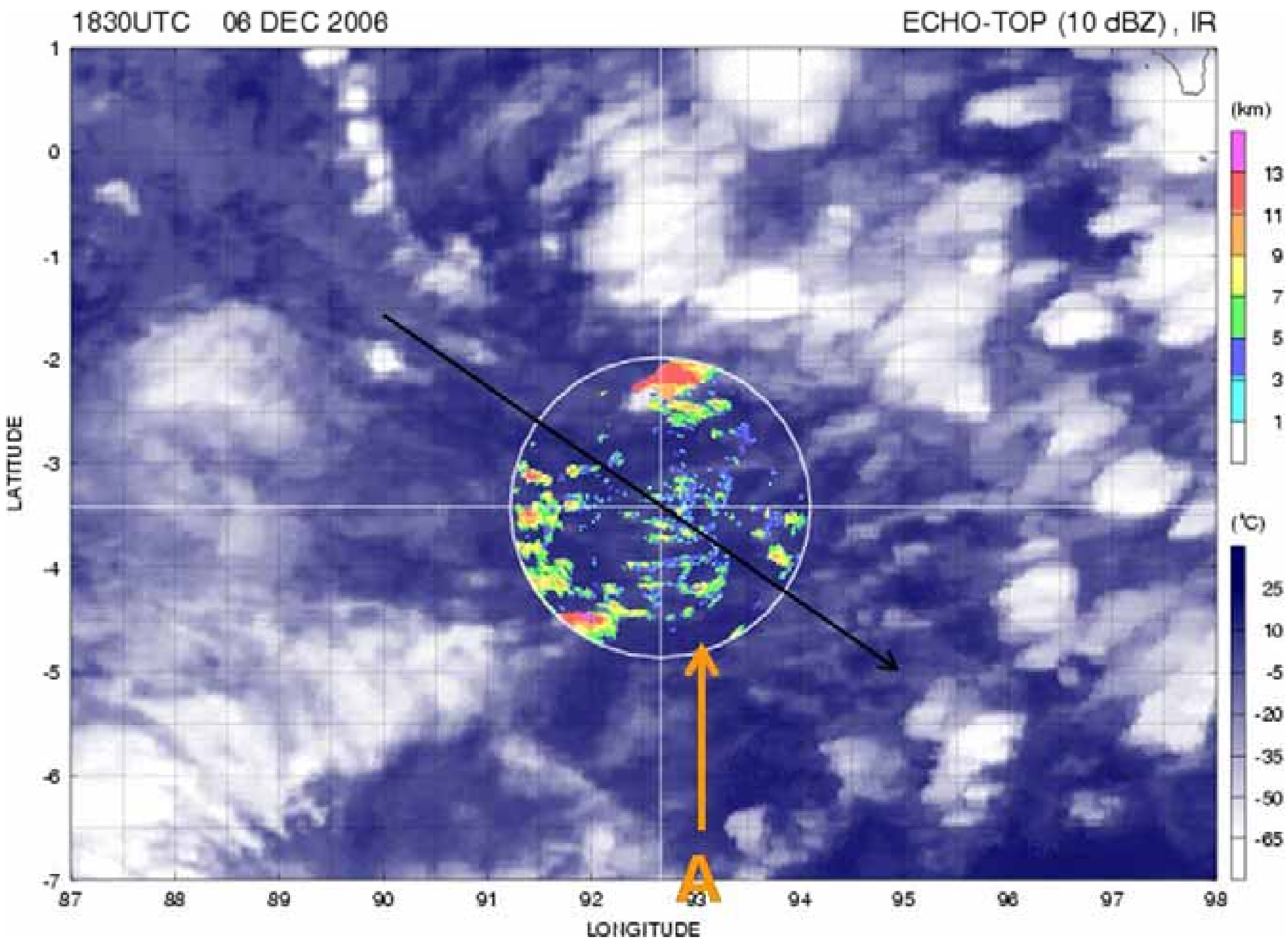


- **Eastward propagation is dominant in rainfall** during a MISMO SCC while **westward propagation is prevalent in upper cloud shields**
- Similar characteristics in the Dec-Jan MJ event

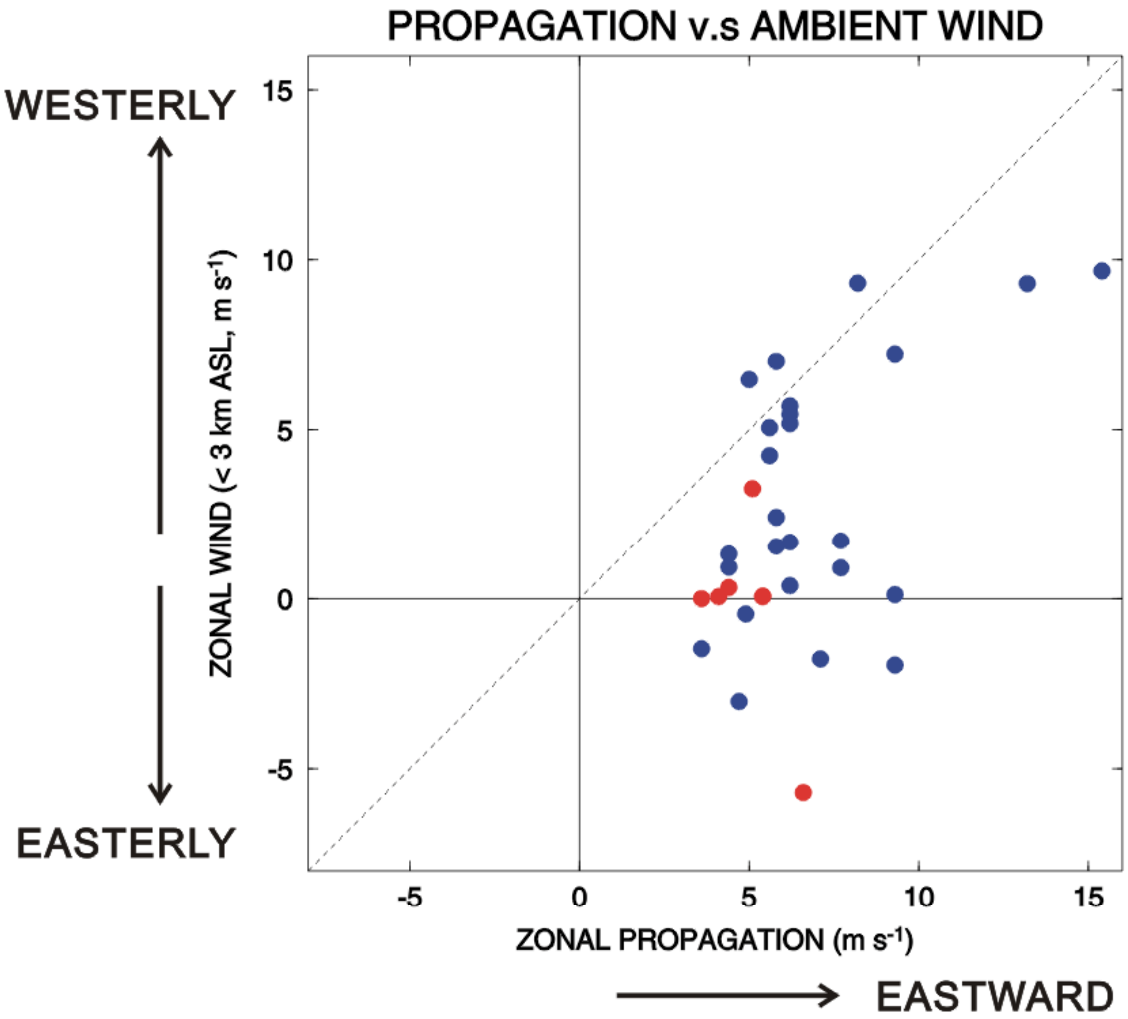
Long Eastward Propagation (6-7 Dec. 2006)



Horizontal Distributions (6-7 Dec. 2006)



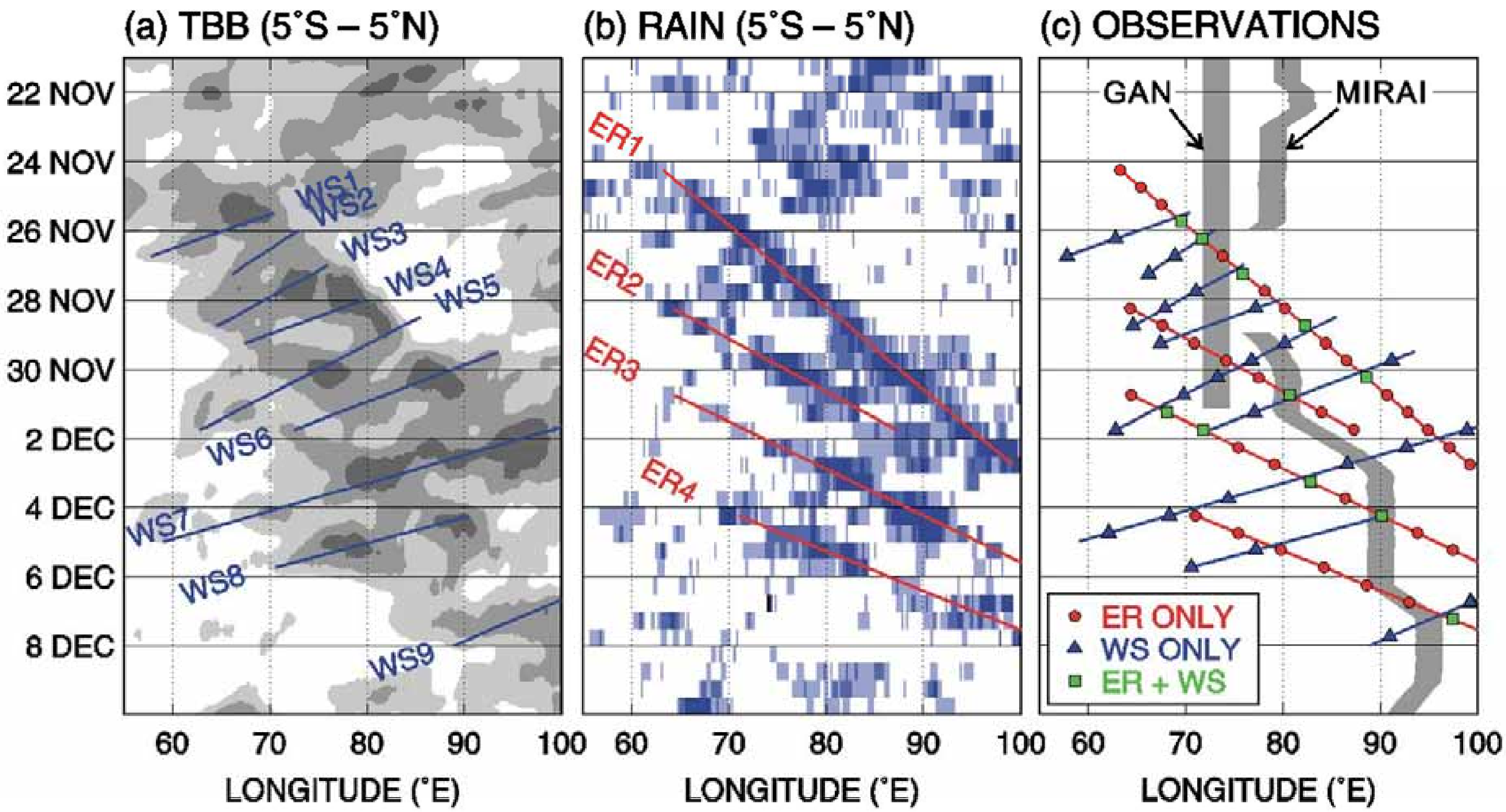
Propagation Speed vs. Background Wind



Faster propagation than ambient wind (< 3 km).

(implying some driving force other than background wind)

Classification and Composite



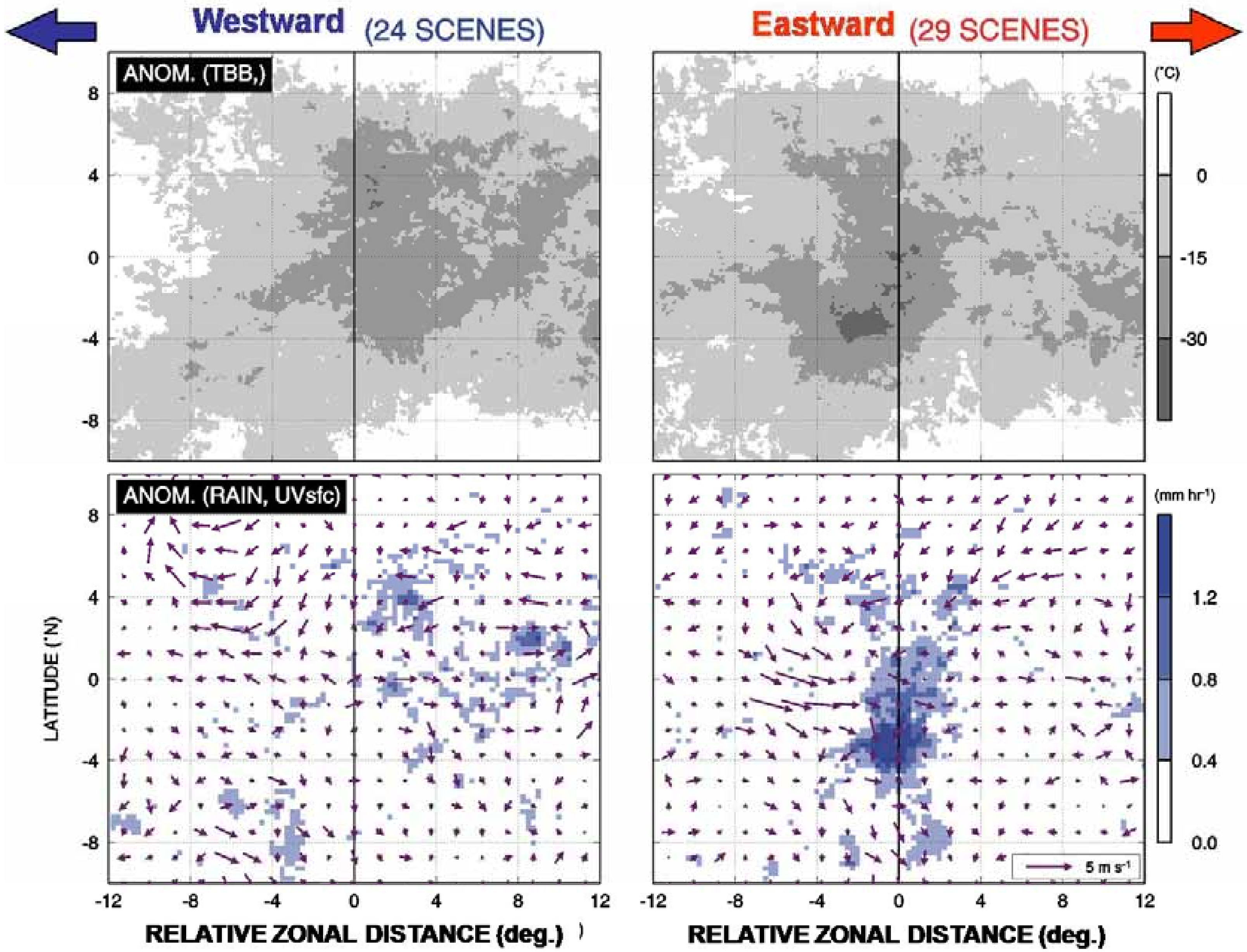
Westward-propagating cloud shield (WS1-9)

Eastward-propagating rainband (ER1-4)

Intersection point (ER+WS)

Composite onto a X'-Y-Z coordinate relative to the longitude of either ER or WS to obtain mean structure

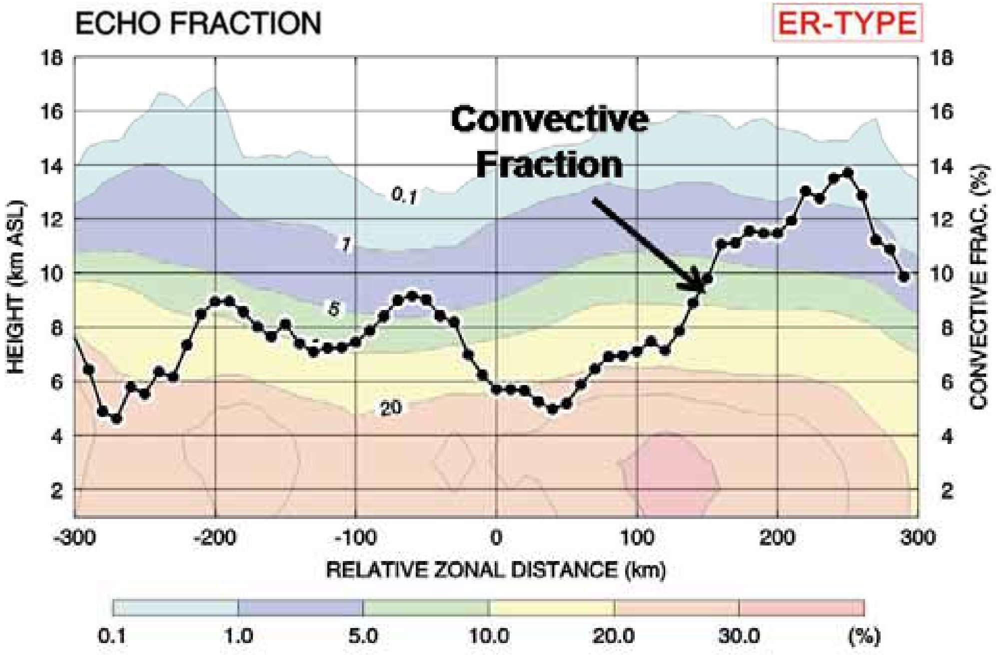
Composite Horizontal Structure

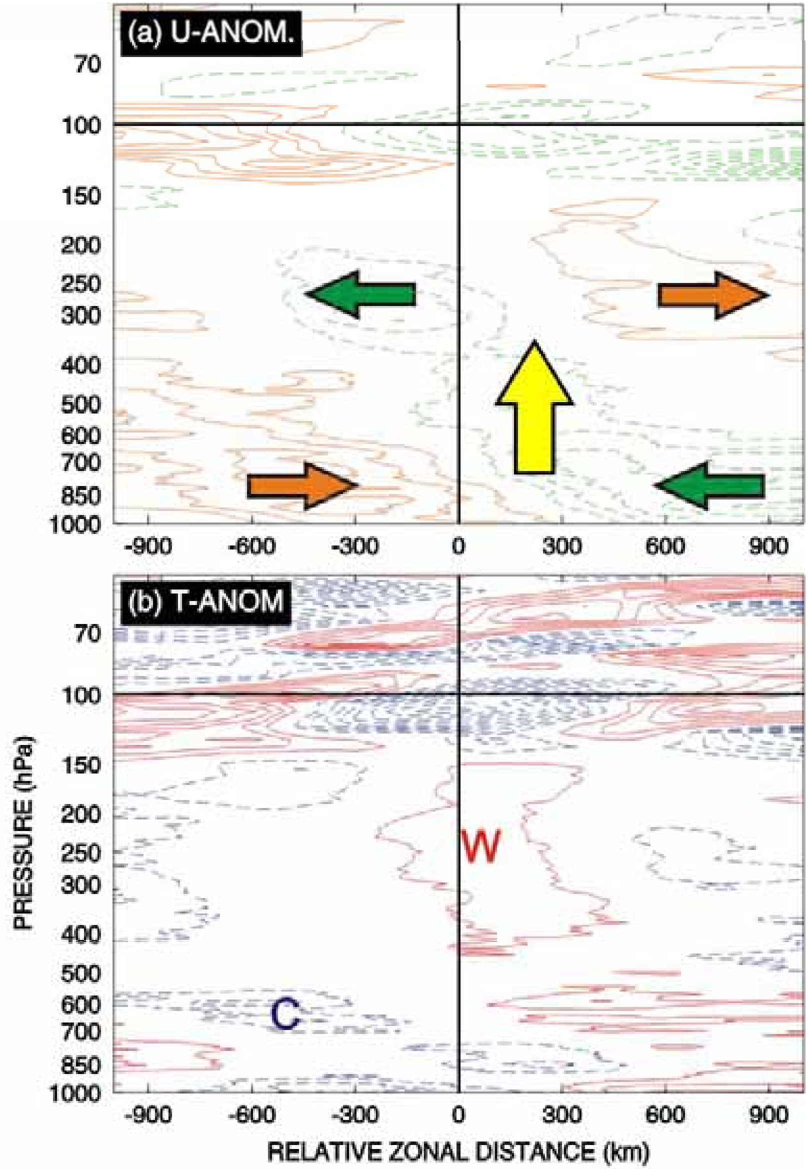


Scattered rain with divergence

Rainband with zonal convergence

Composite Vertical Structure (Eastward)

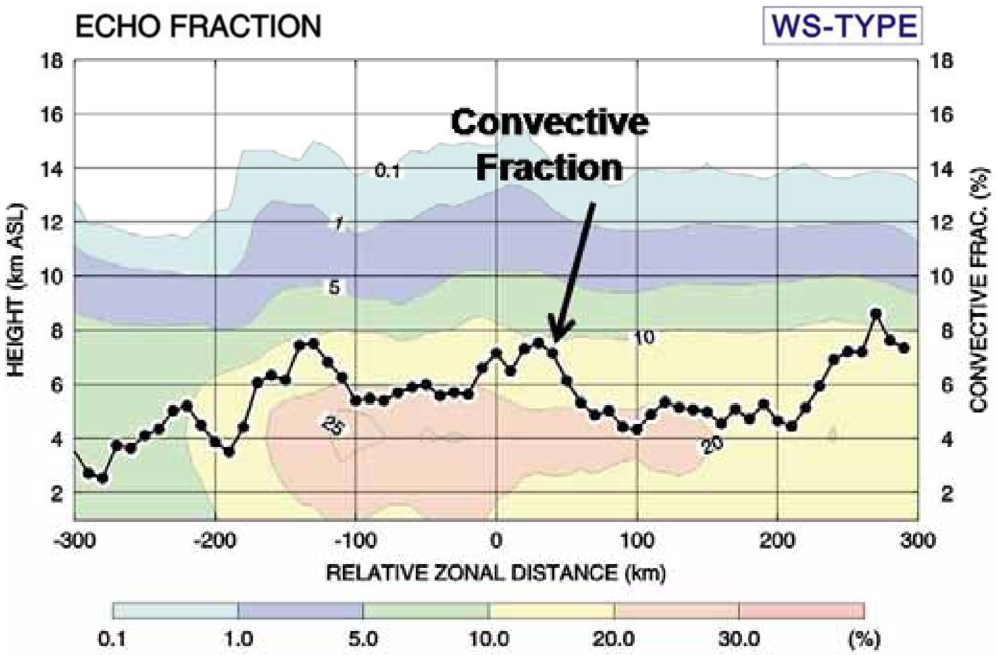


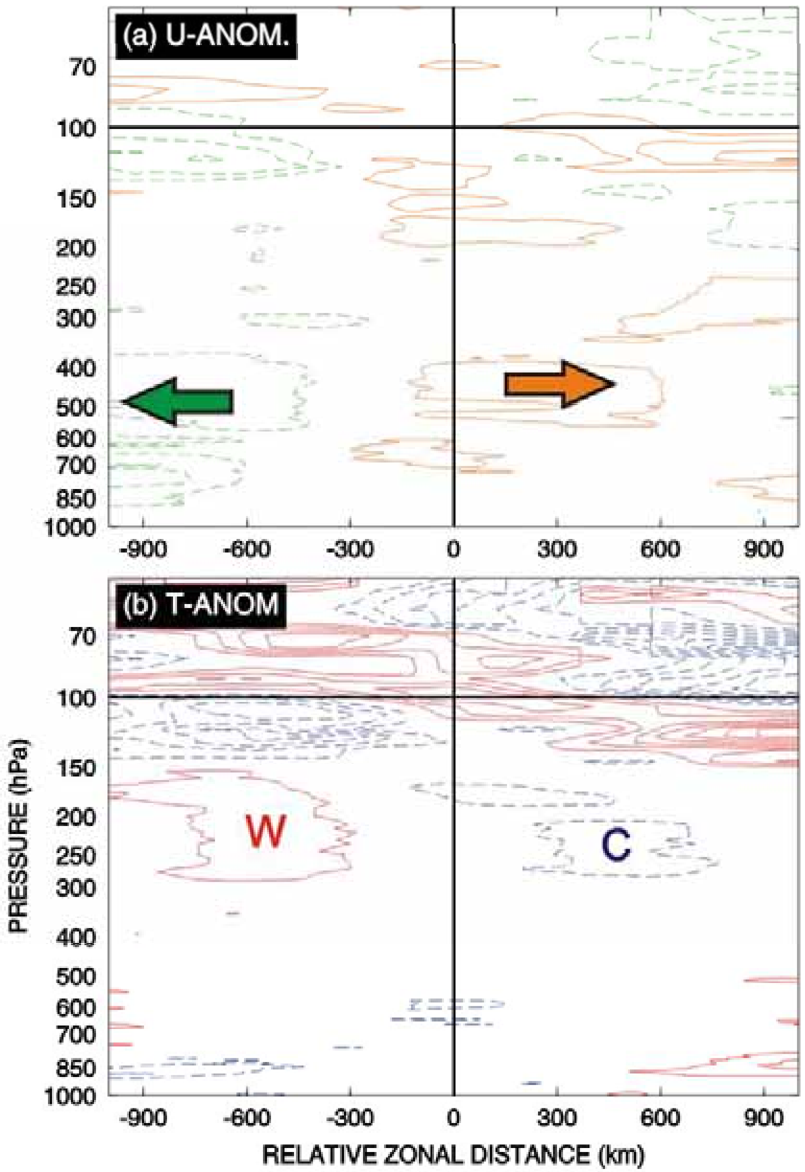


- Large fraction of radar echo in the fore side in the lower troposphere, with large convective fraction.
- Shallow updraft in the fore side
- Warm anomary near 300 hPa

→ **Prevalence of shallow convective heating in the fore side**

Composite Verical Structure (Westward)

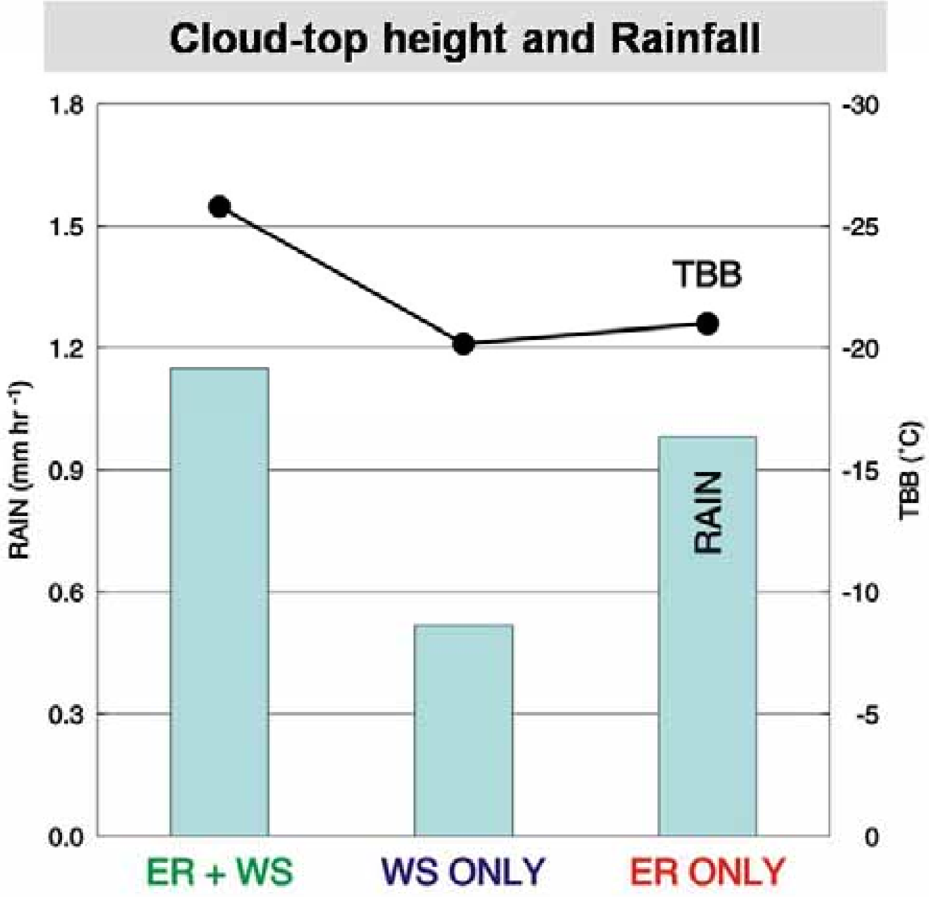


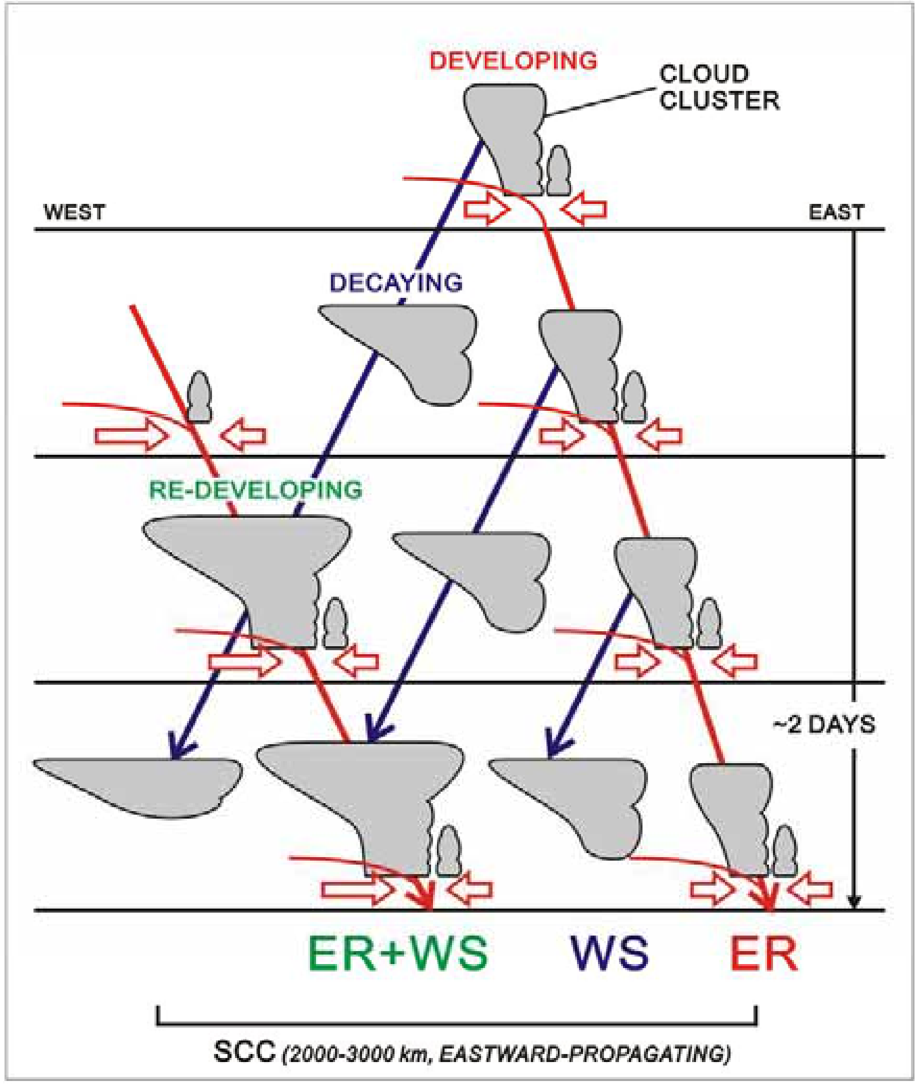


- **Large fraction of radar echo near melting level, with small convective fraction**
- **Small variation in zonal direction**
- **Weak divergence in lower/middle troposphere**

→ **Prevalence of stratiform rain**

Intensification during a Merger

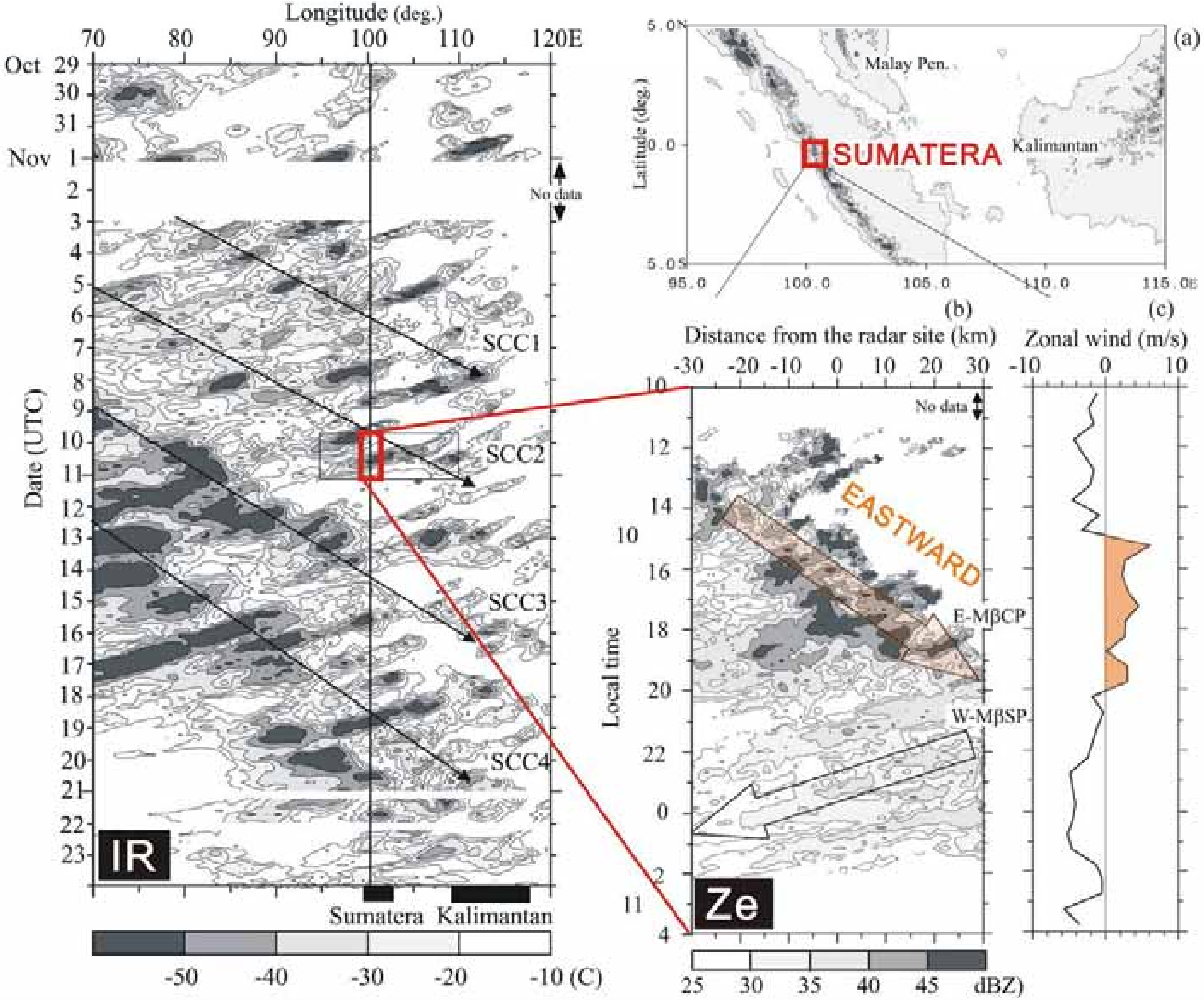




- Increases in the rainfall and cloud-top height during **the merger of ER and WS**.

→ Suggesting an interaction of **upward motion (by ER)** with **moist environment (by WS)**.

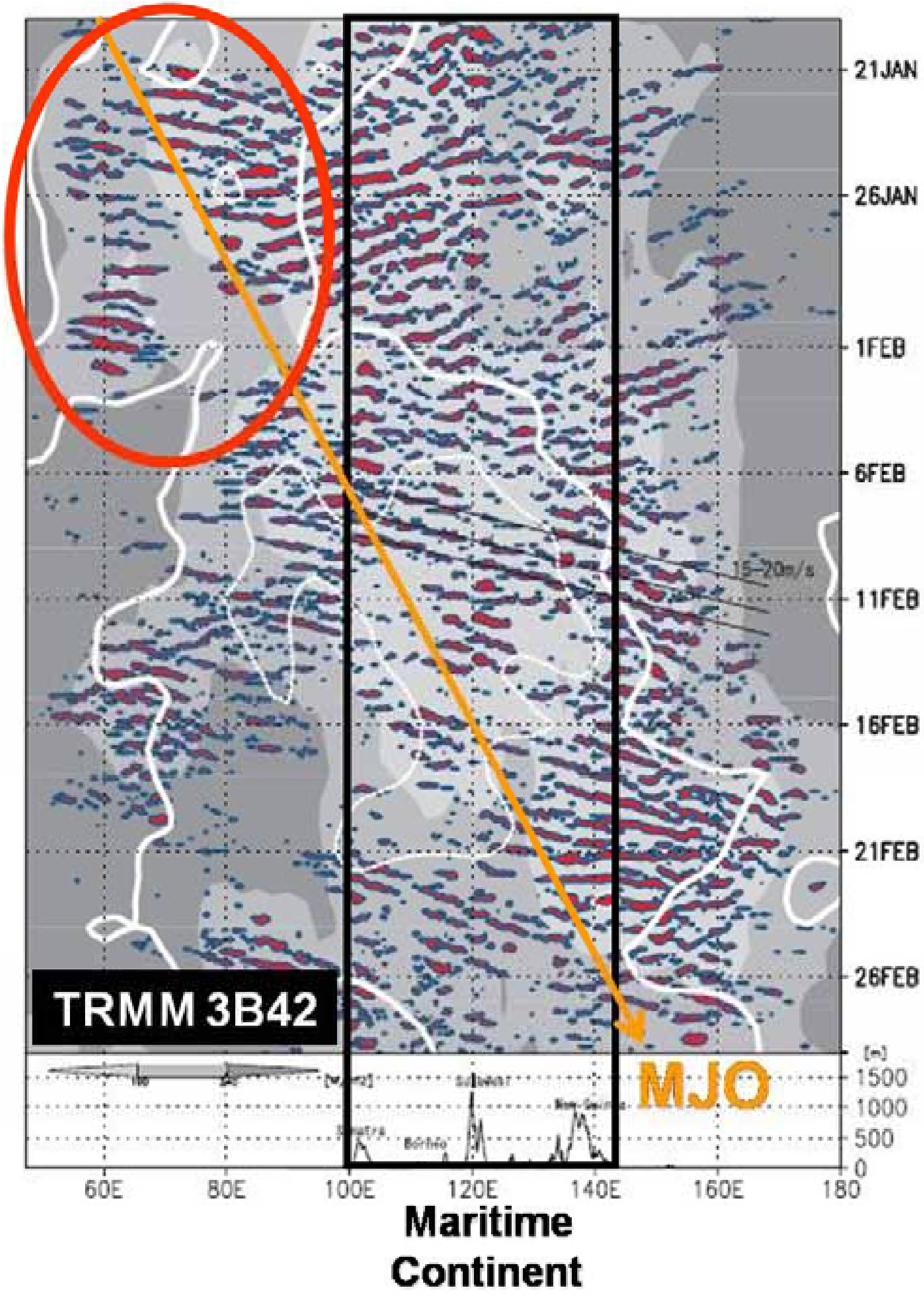
Eastward Propagation over Sumatera



Shibagaki et al. (2006, *Mon. Wea. Rev.*):

Eastward propagating radar echoes is considered to be associated with a wind change due to local circulation over the mountain range.

Eastward Propagation over the Maritime Continent



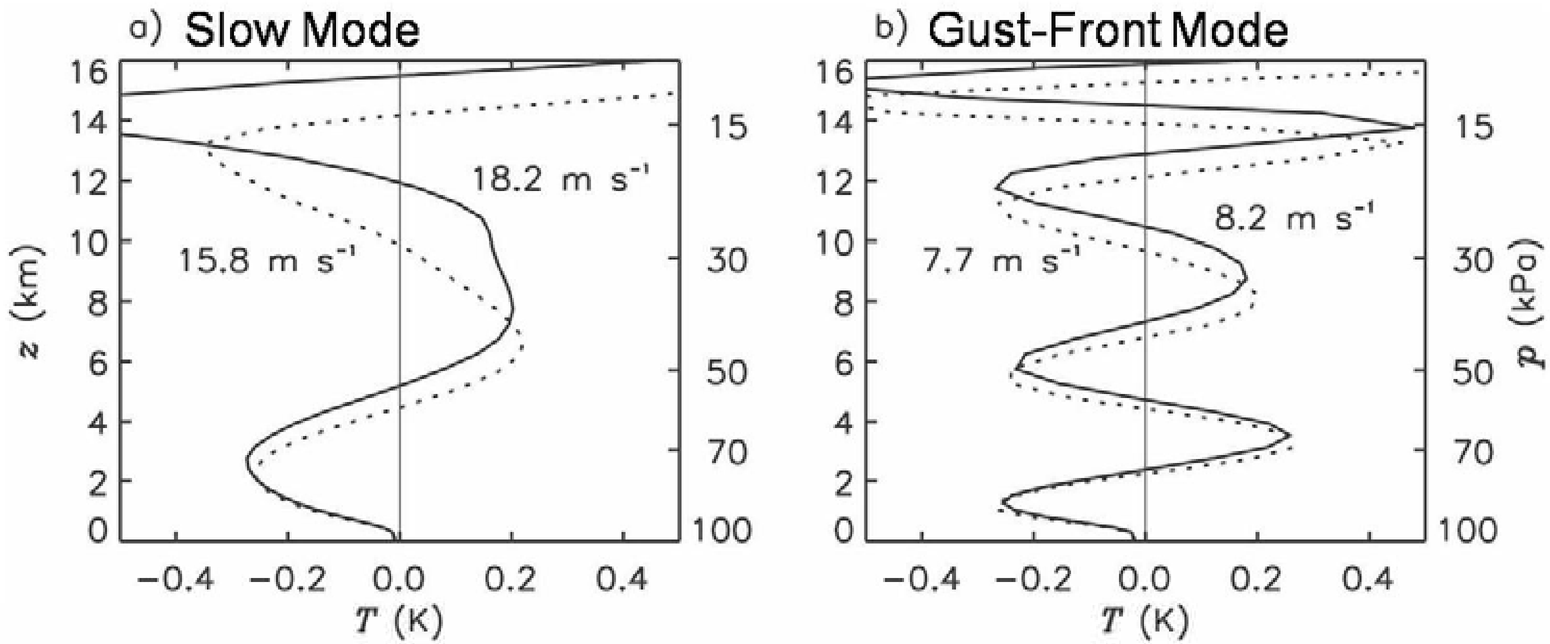
Ichinawa and Yasunari (2007, *GRL*):

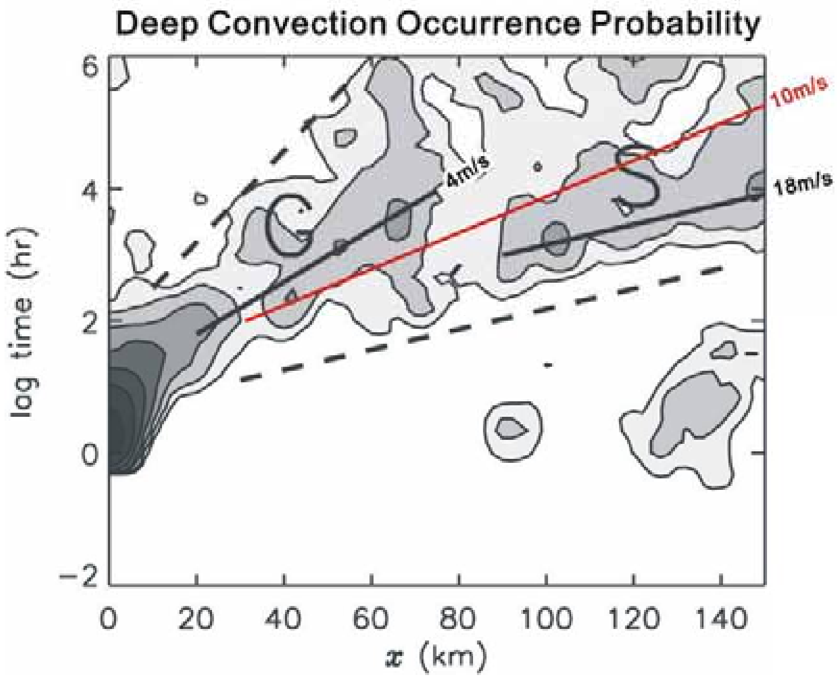
- Prevalence of eastward-propagating diurnal disturbances as an internal structure of large-scale convection system of MJO.
- Eastward penetration results in a sudden shift of the convection center from the western part of the islands to the east.
- Role of **diurnal cycle over and around the major islands** in the MJO propagation over the Maritime Continent.

However…

- Eastward propagation is also seen over the Indian Ocean.
  - → Precipitation area seems to propagate eastward whether islands exists or not.

Eastward Propagation in 2-D Cloud-Resolving Simulation

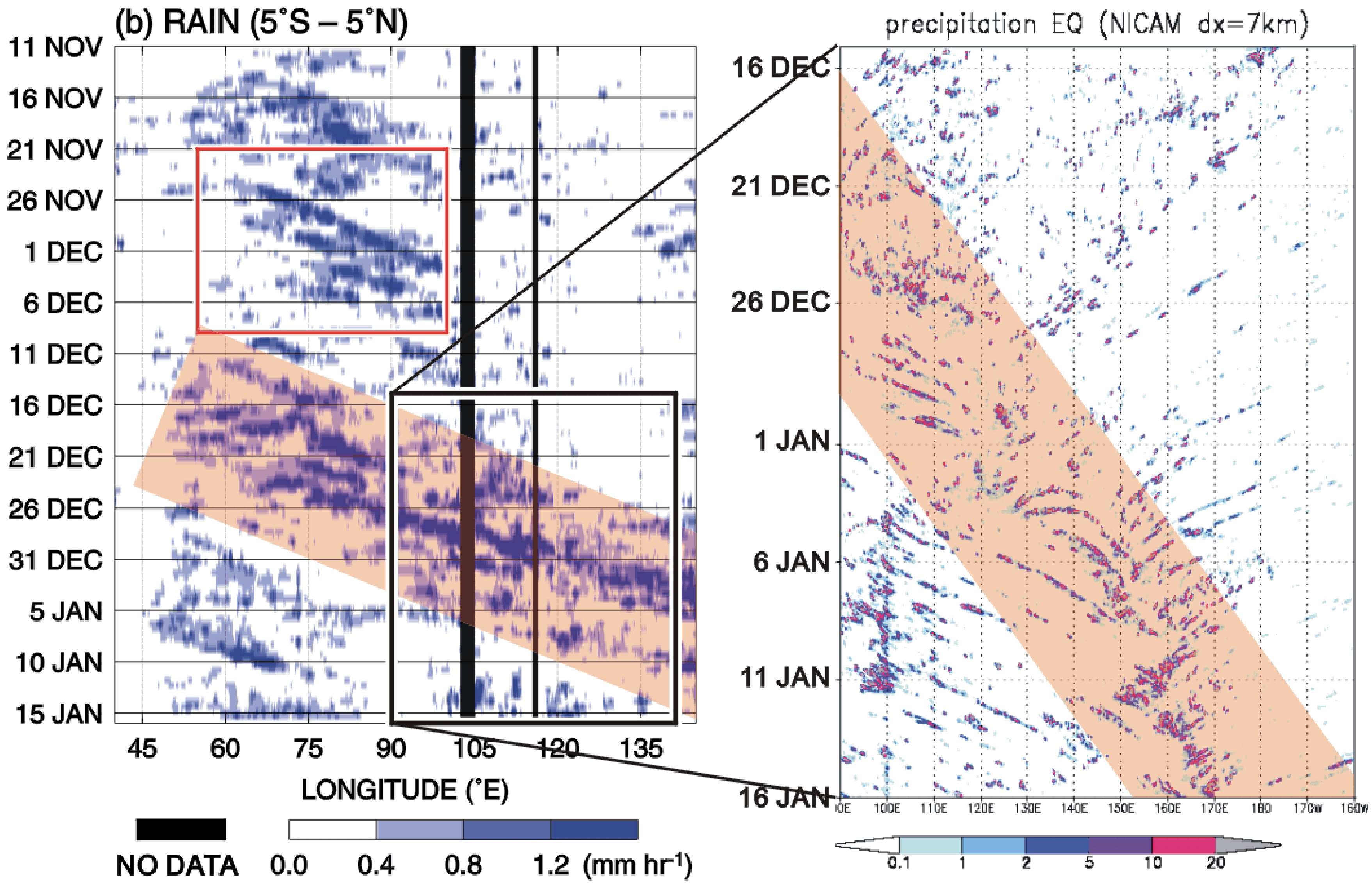




Tulich and Mapes (2008, *MWR*):

- Slow gravity waves excited by shallow heating/cooling
- Propagation of deep convective occurrence probability
- Waves can propagate both eastward and westward under the condition of no backgroud wind

Eastward Propagation in a NICAM Simulation



Nasuno et al. (2008, *JMSJ*, in revision)

Dynamics of eastward propagation may be clarified using the NICAM simulation results.

Summary

Coexistence of eastward-propagating rainbands (ER) with westward-propagating cloud shields (WS) was observed in a supercloud cluster (SCC) during the MISMO IOP. Following characteristics were clarified in this study:

- ER has the horizontal scale of 500 km (zonal) x1000 km (meridional), with shallow convective updraft in the fore (eastern) side.
- WS mainly consists of stratiform cloud in the upper level.
- Convection can be intensified when ER merges with WS.

Although ER has been studied over the Maritime Continent and has been related with local circulation over islands, our study indicates rainbands can propagate even over the ocean.

Kelvin wave and slow gravity wave are candidates of the dynamical mechanism of ERs.

NICAM simulations of the Dec-2006 Madden-Julian event may be useful for revealing the mechanism of ERs.


Questions or
Comments?