The structure of convective activities on extreme rainfall observed on 2005/06 winter over tropical western Pacific

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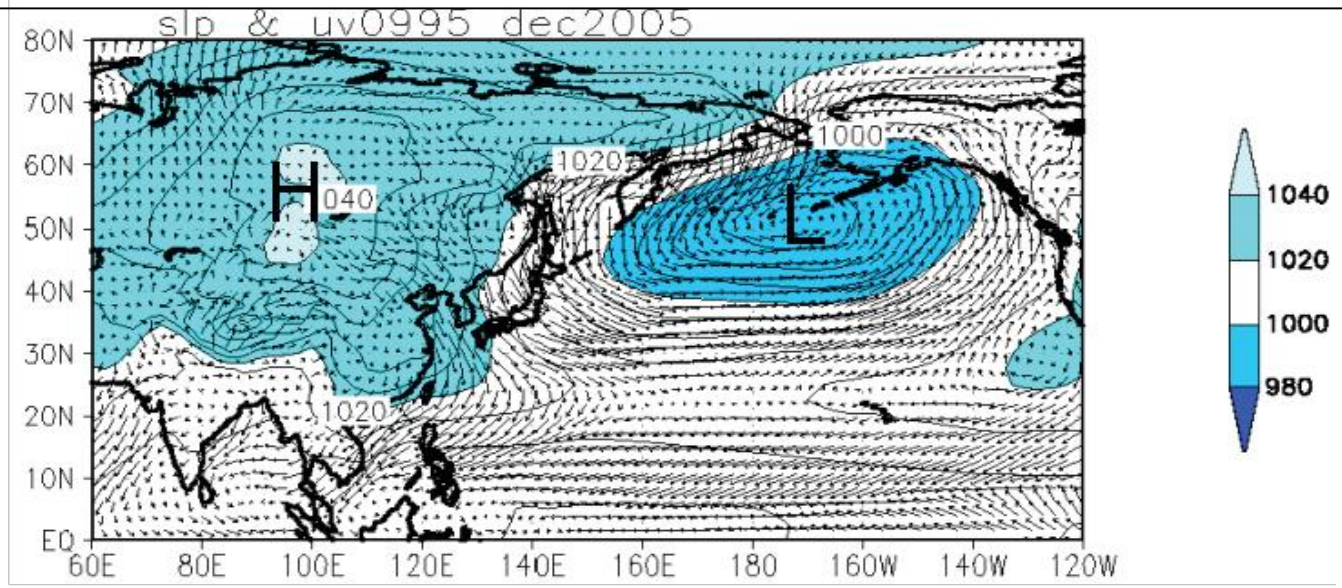
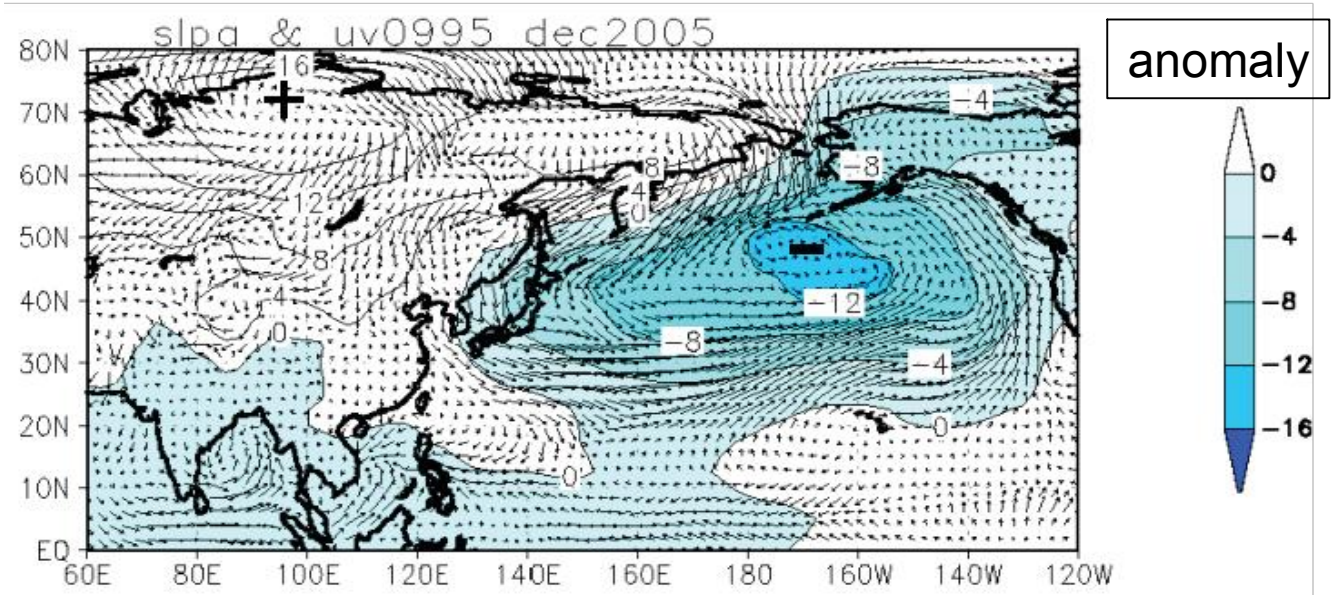
Introduction

- On 2005/06 winter, cold weather was observed over Northeast Asia.
- Extreme rainfall was observed at same period in Koror of Palau, where we are performing continuous observation.
- In this study, we investigated the feature of extreme rainfall and the structure of convective activities around Palau region over tropical western Pacific using fruitful amount of observation data.

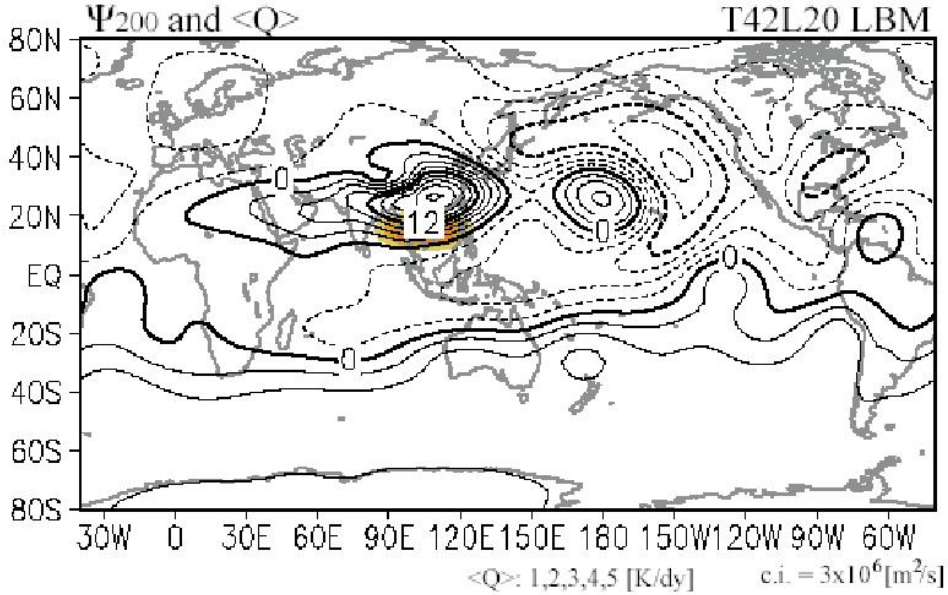
Sea level pressure and surface winds on Dec. 2005





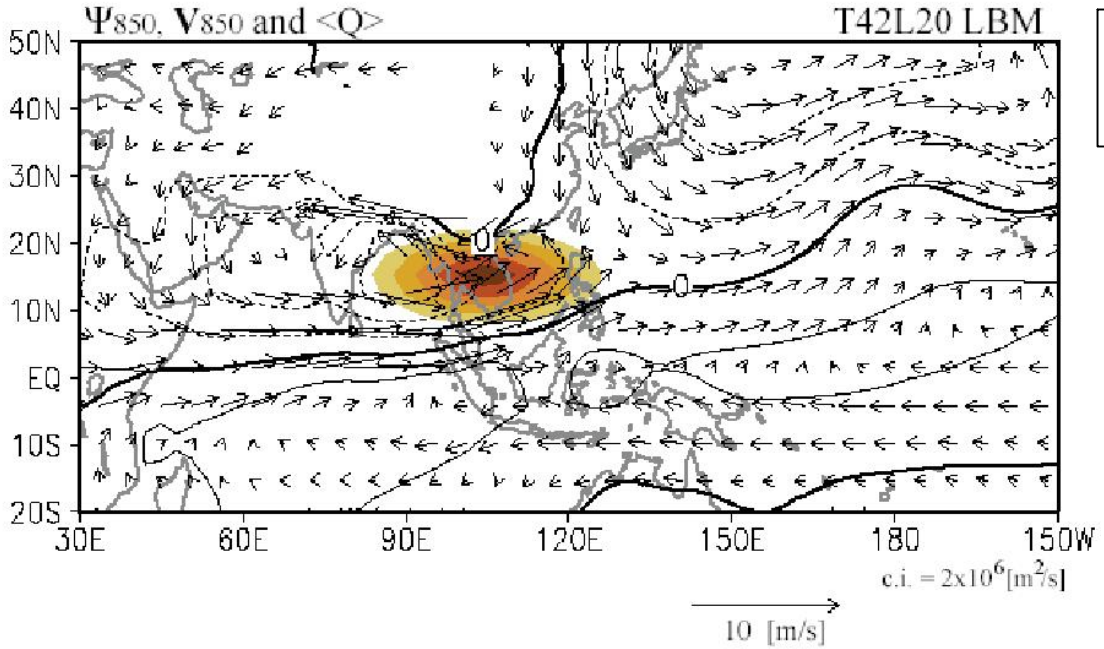
Maeda (2007)

Sensitivity experiment using linear AGCM (Watanabe and Kimoto 2000)



Color shading: latent heat source

200hPa stream function



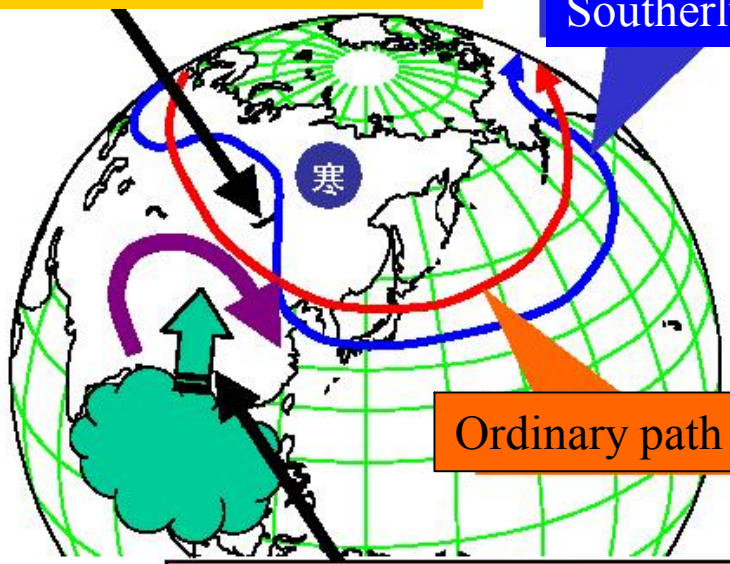
850hPa stream function
wind

Maeda (2007)

Schematic diagram for explaining cold winter on December 2005

Continuous cold air mass
Flow along the meander
Of westerly jet

Westerly jet meandered
Southerly during Dec. 2005



Ordinary path of westerly jet

Northern hemisphere circulation
during December 2005

Active tropical convections
Intensified meander of westerly jet
→induces more cold air mass inflow

Meander of westerly jet

Japan Meteorological Agency (2006)

Data

Rainfall

NOAA 30 stations (1945-2006)

JAMSTEC 5 stations (2000-2006)

South Sea Bureau monthly report 7 stations (1923-1941)

(data: available more than 90% within a year, month, if it relocated within 1‘ (about 2km), regards as a same site, take into account homogeneity after Buishand (1982))

Peleliu observation site (2001-06)

Rain gauge, GPS: precipitable water. Ceilometer: cloud amount

Aimeliik observation site (2003-2006)

Wind profiler: horizontal wind profile

Koror NWS radiosonde (2005)

Satellite data (2005-06)

SSM/I precipitable water $0.25^\circ \times 0.25^\circ$

QuikSCAT surface wind $0.25^\circ \times 0.25^\circ$

TRMM 3G68 near surface rain $0.5^\circ \times 0.5^\circ$

MTSAT TBB $0.05^\circ \times 0.05^\circ$

South Sea Bureau monthly report (July 1923-Dec. 1941)

South Sea Bureau weather station (at present Koror)

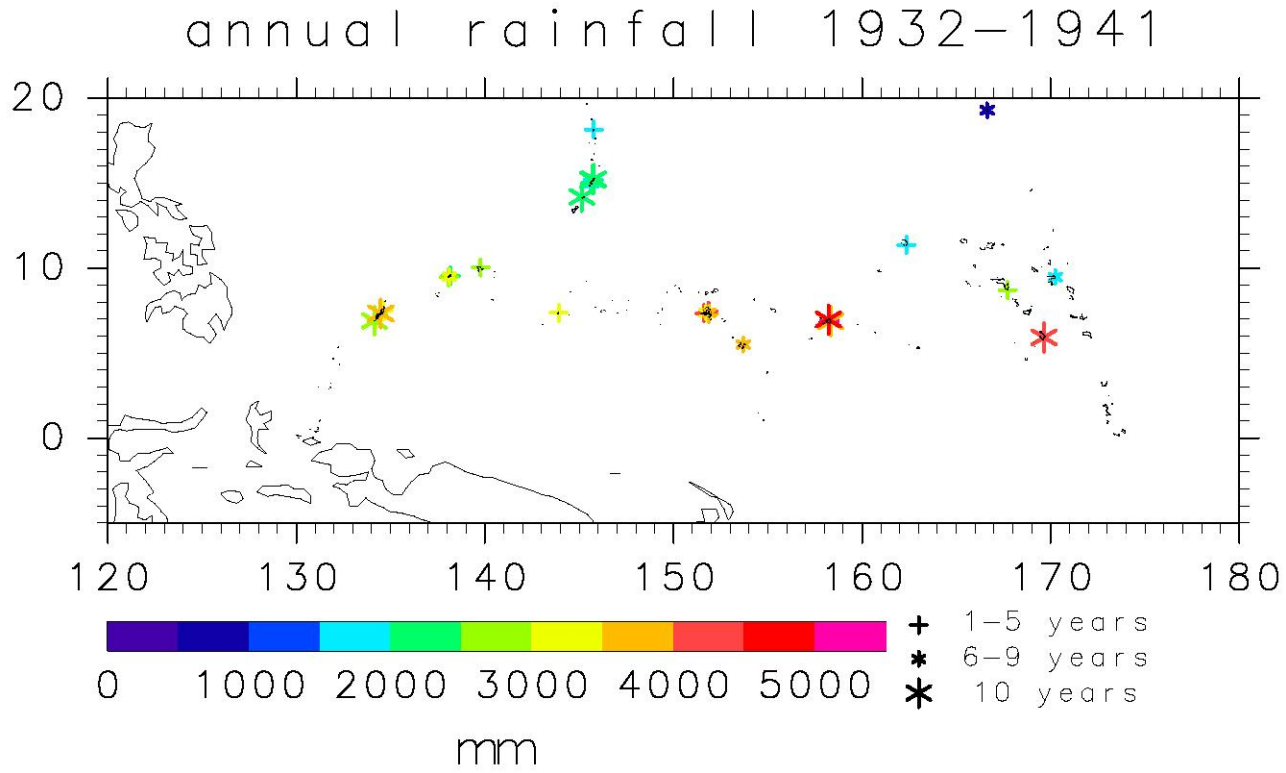
hourly-daily: surface T, RH, pressure, wind, cloud amount, cloud type, precipitation, visibility, radiation, soil temperature, evaporation

Weather stations 10 sites 2hourly-daily

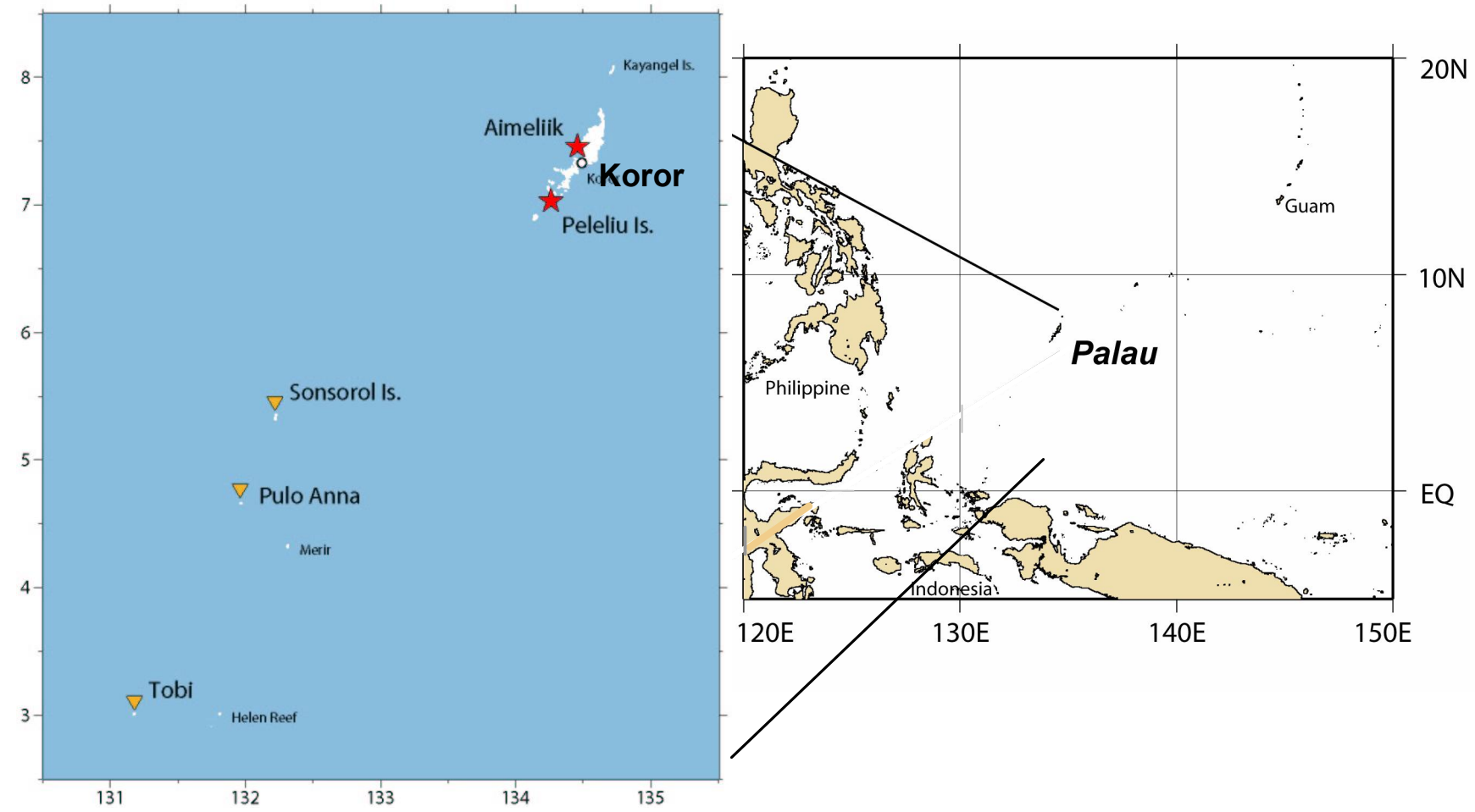
Trusted observation sites (Elementary schools etc.) 31 sites

daily: surface T, RH, pressure, wind, precipitation

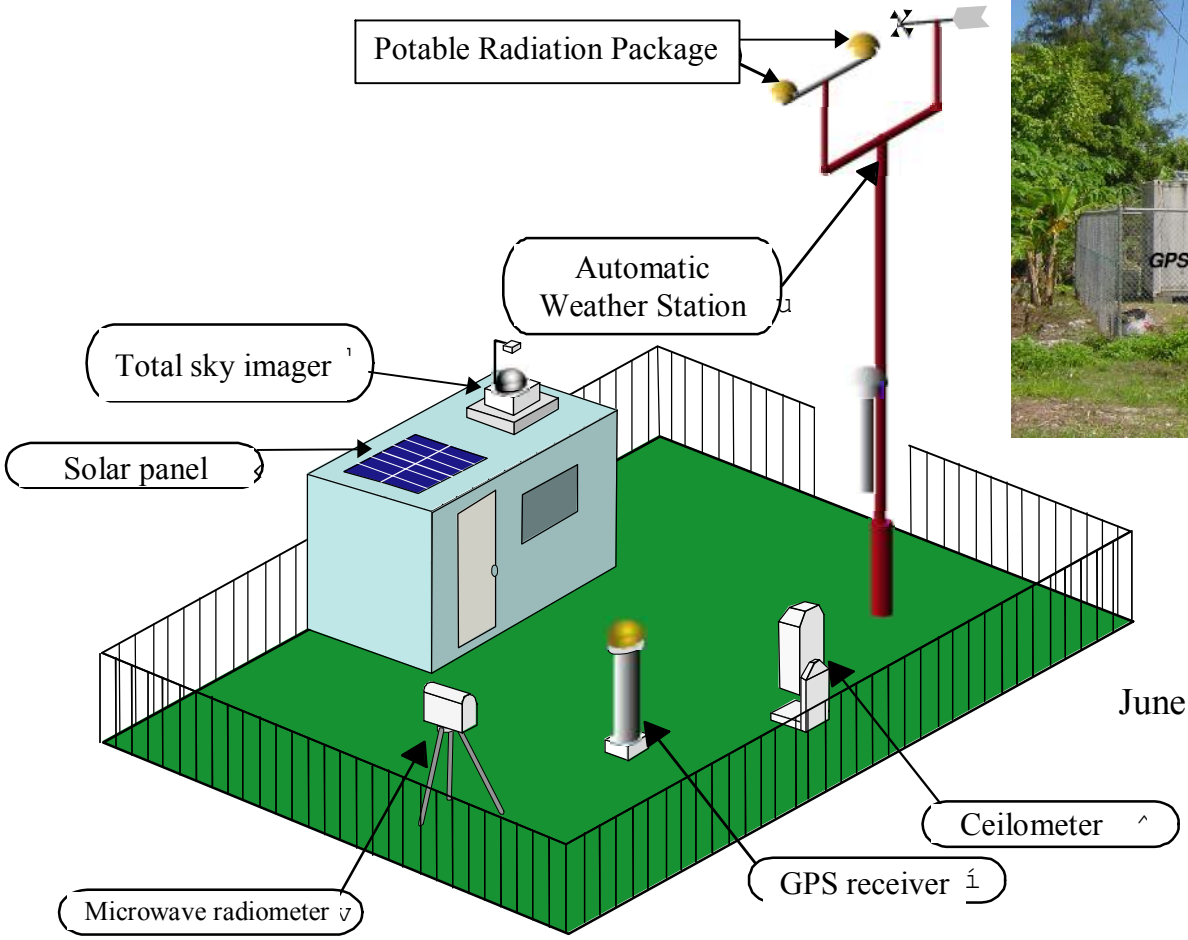
daily precipitation data were converted into electronic files (Mar.2007)



Observational fields of Republic of Palau

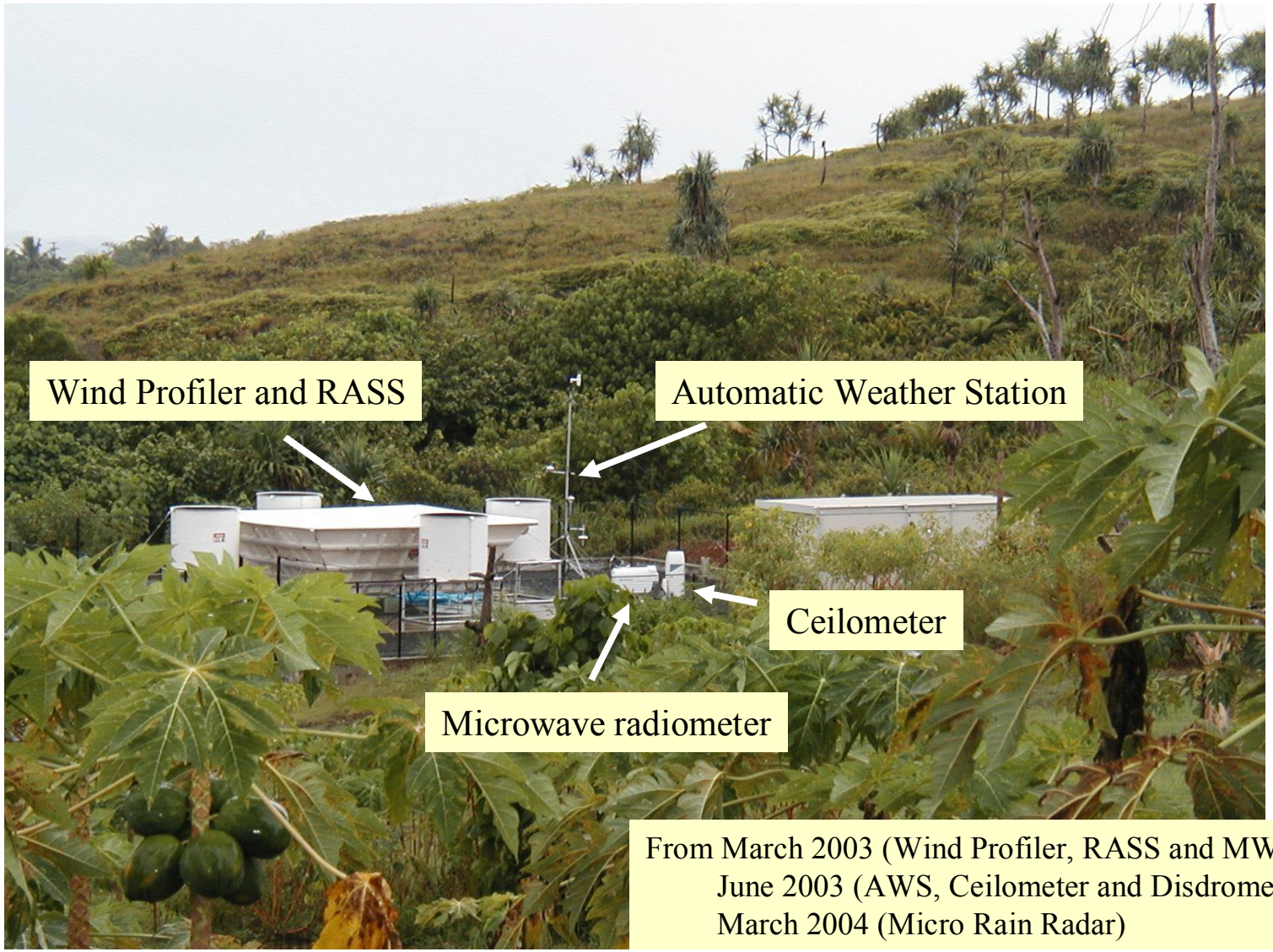


Observation site at Peleliu



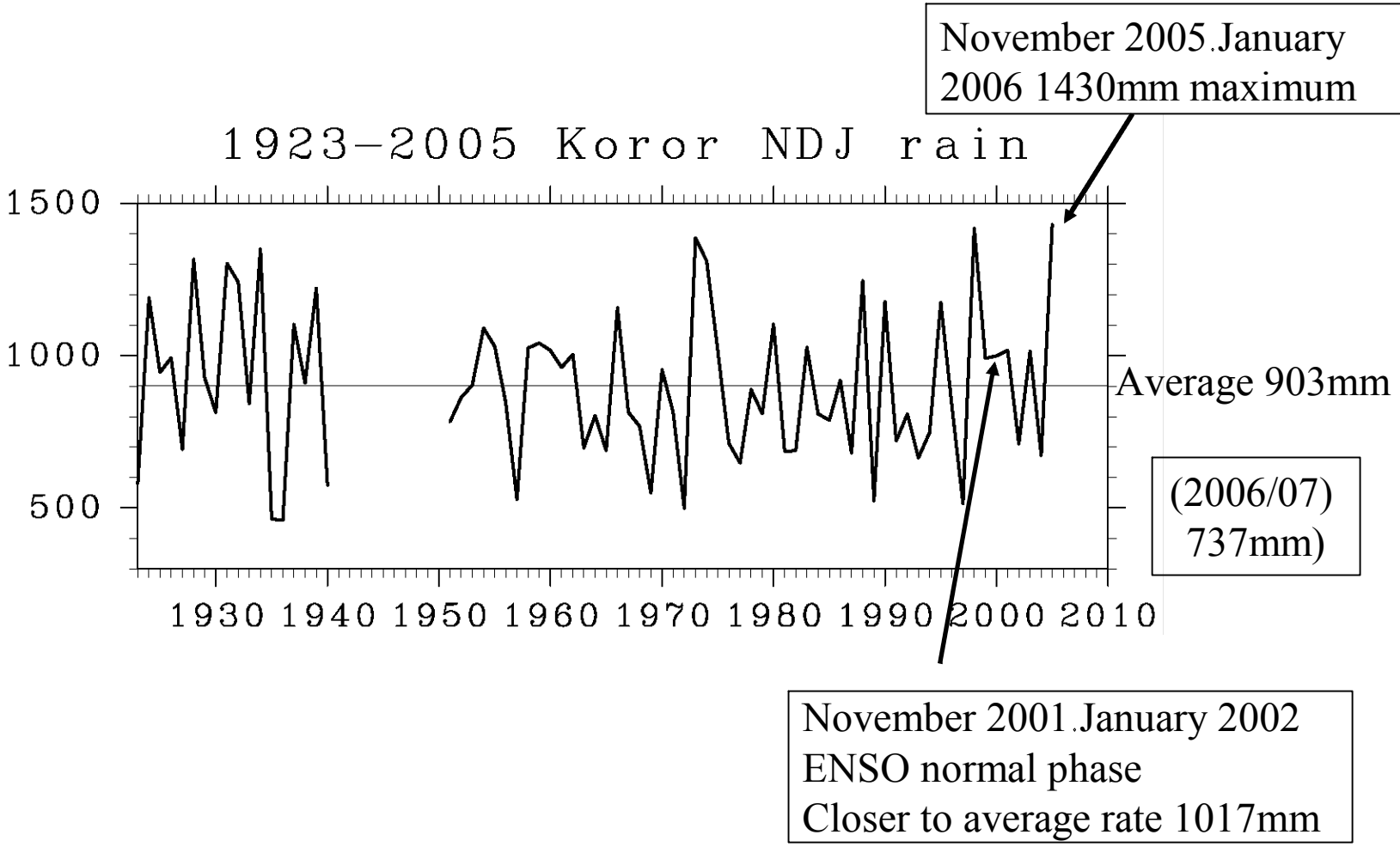
From
November 2000 (AWS, GPS)
June 2001-Feb 2003 , May 2005-(Ceilometer)
October 2001 (TSI, PRP)
December 2001-Oct 2002 (MWR)
Mar 2005- (Disdrometer)

Observation site at Aimeliik

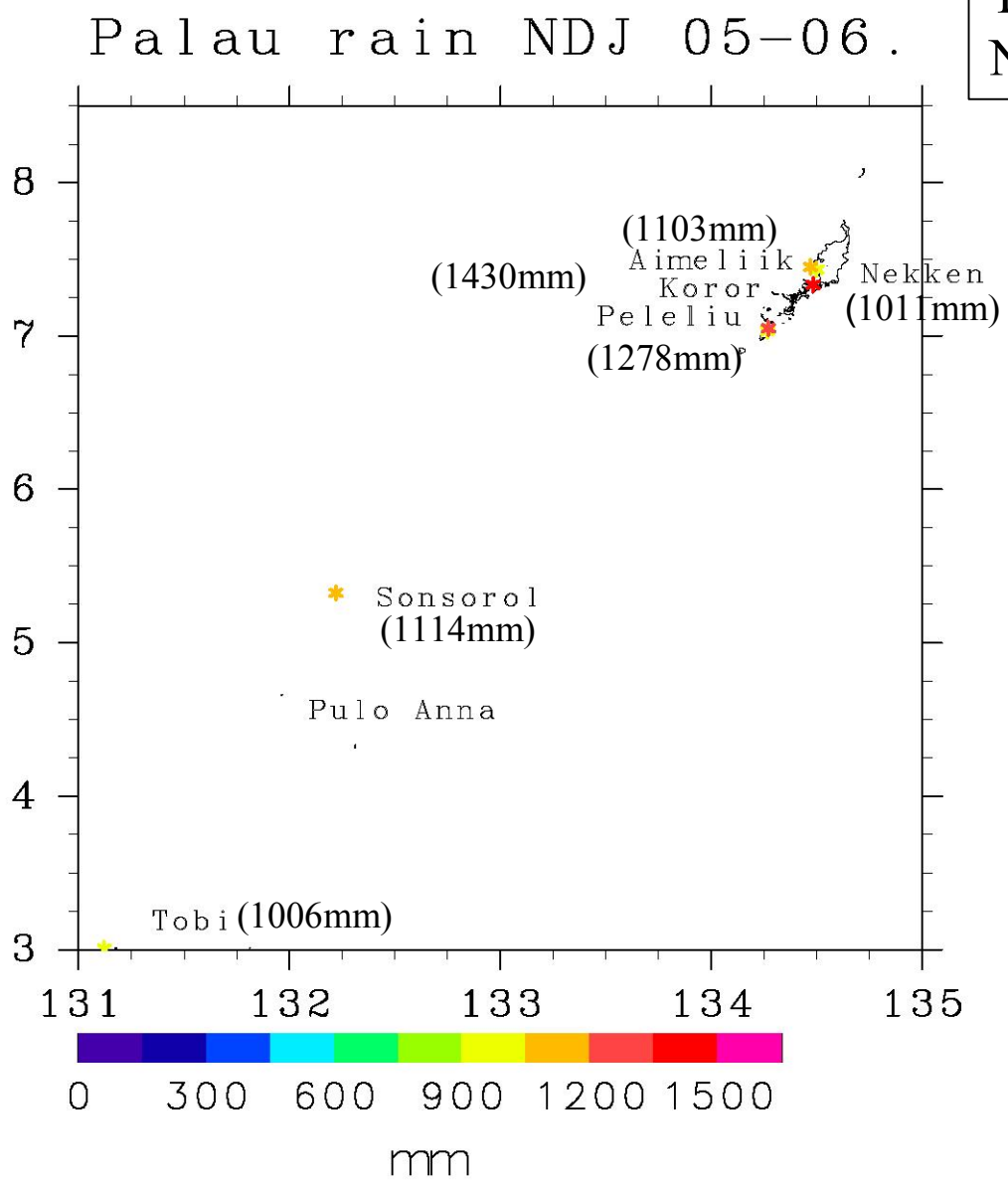


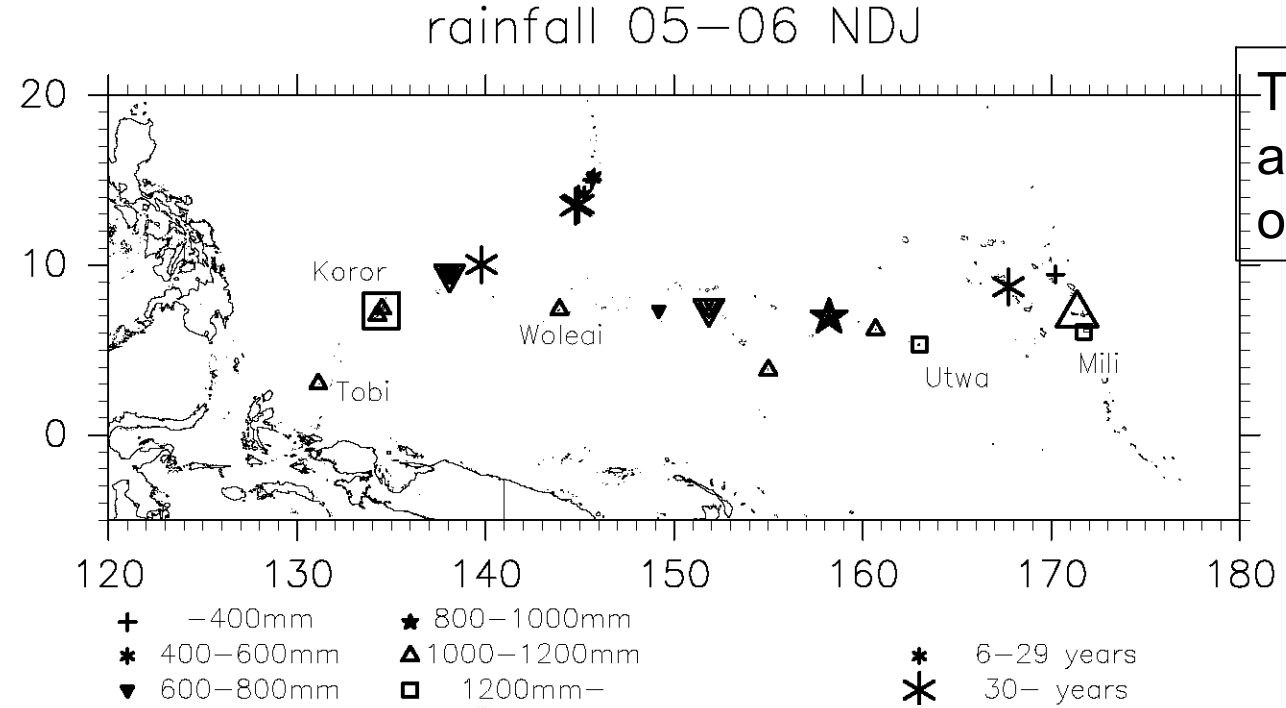
From March 2003 (Wind Profiler, RASS and MWR)
June 2003 (AWS, Ceilometer and Disdrometer)
March 2004 (Micro Rain Radar)

Koror Three months accumulated rainfall.November to January)

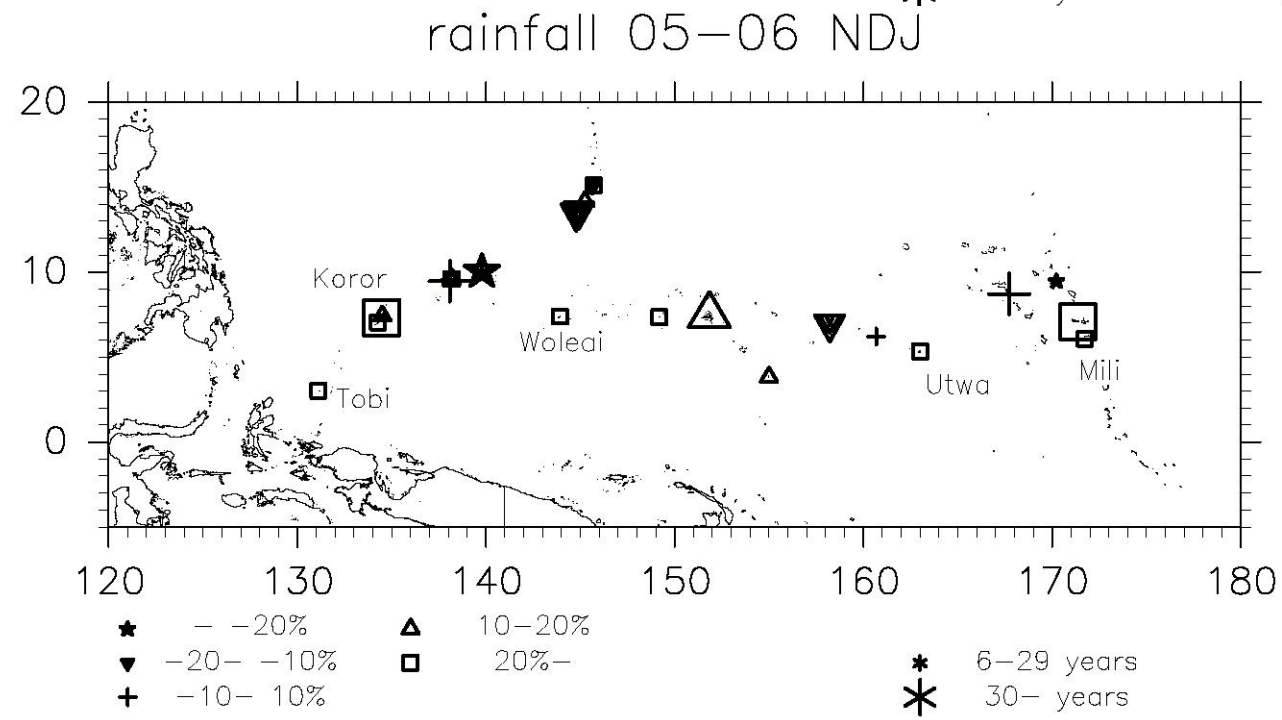


Three months rainfall
November 2005.January 2006





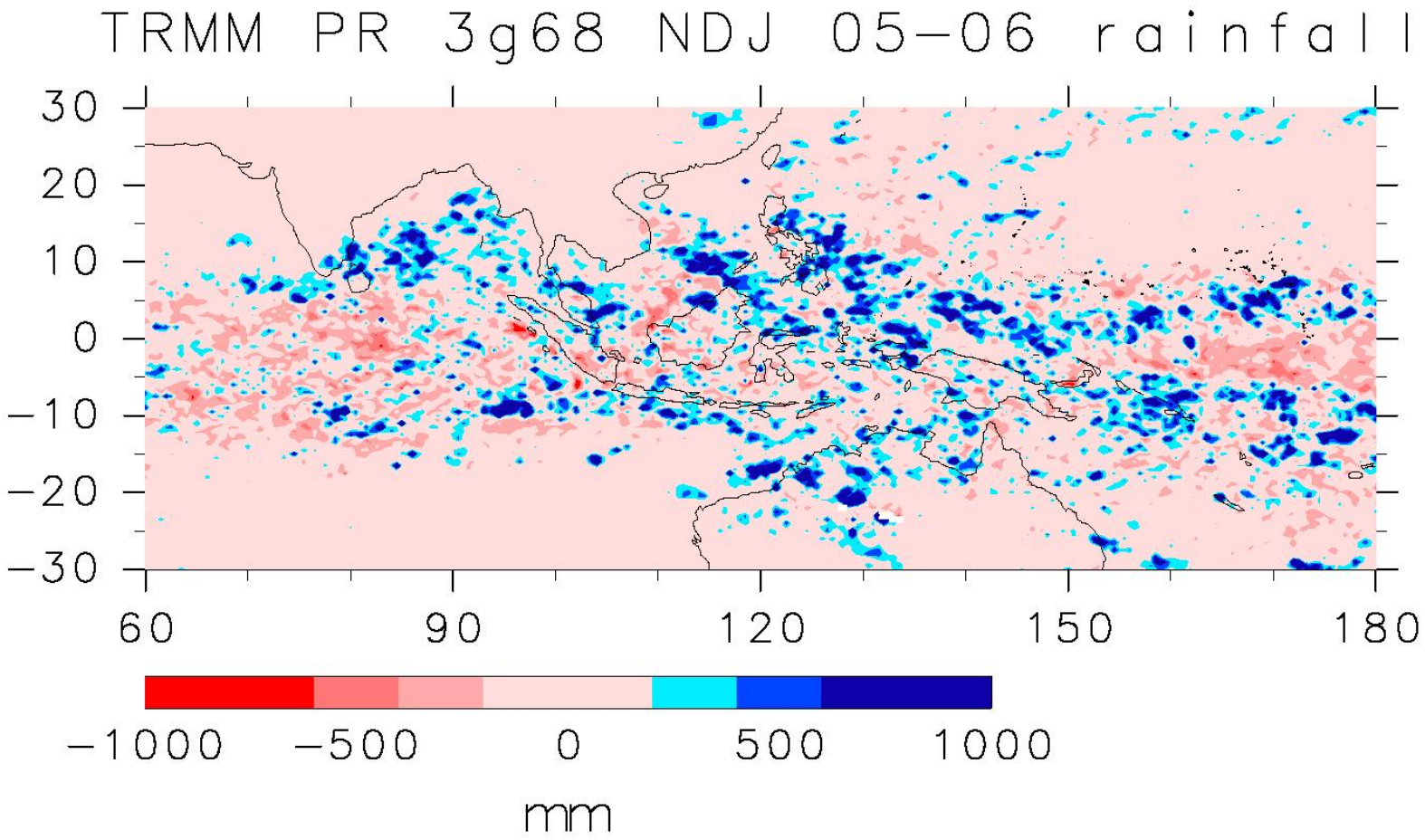
Three months rainfall NDJ and anomaly over western Pacific

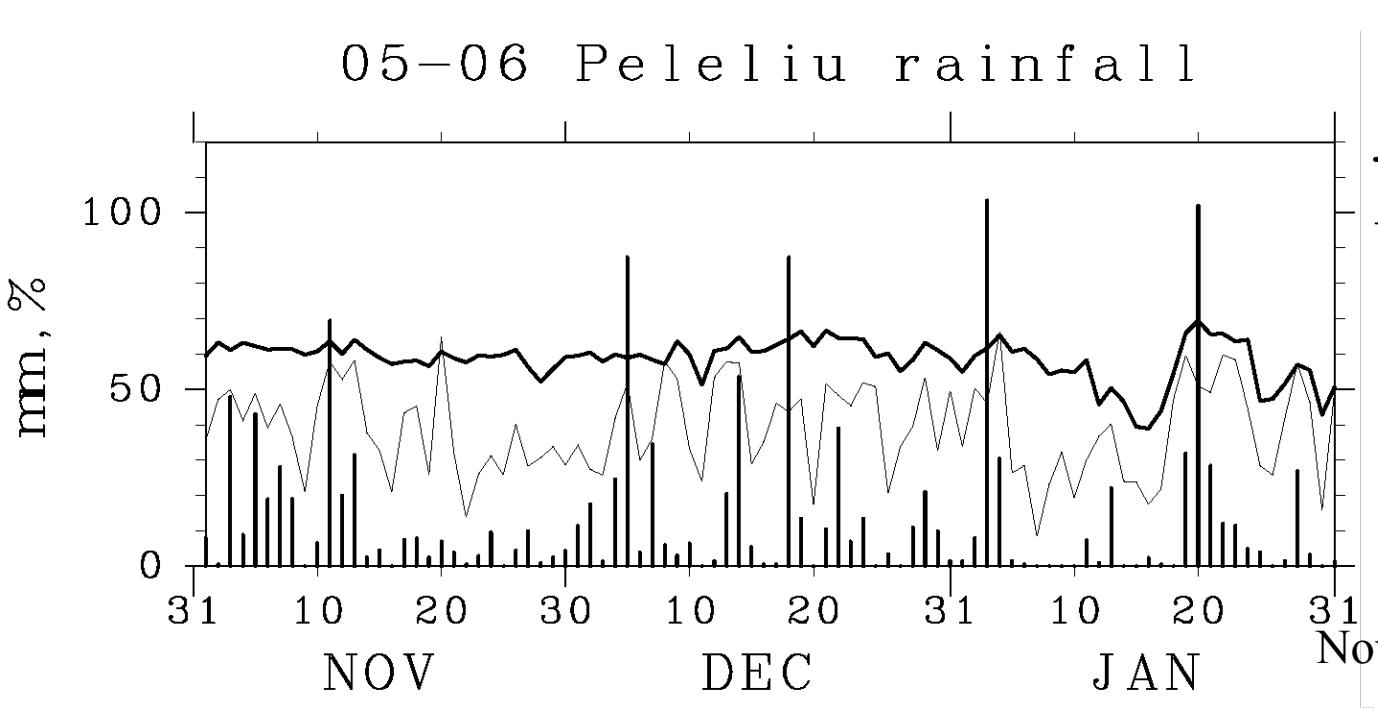


anomaly

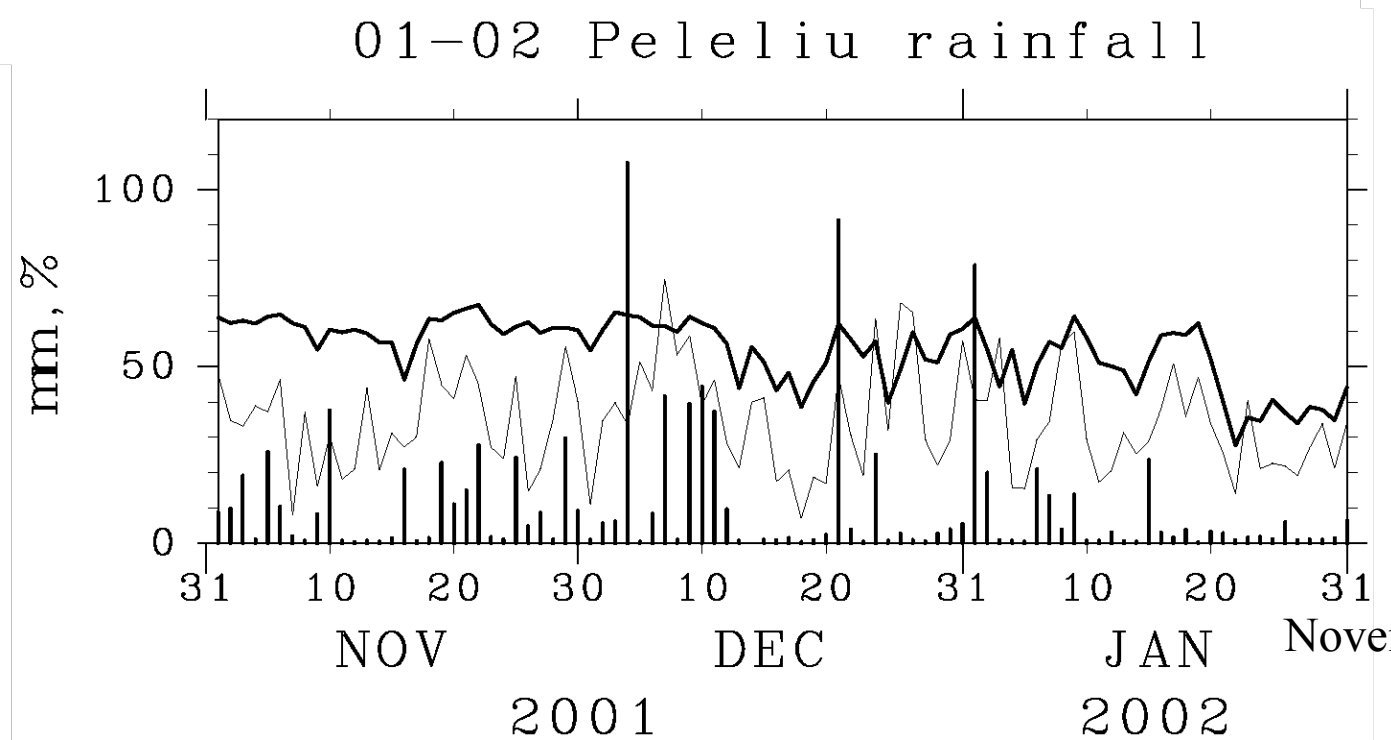
TRMM 3G68 three months precipitation November 2005.January 2006

anomaly from 98.05 NDJ average

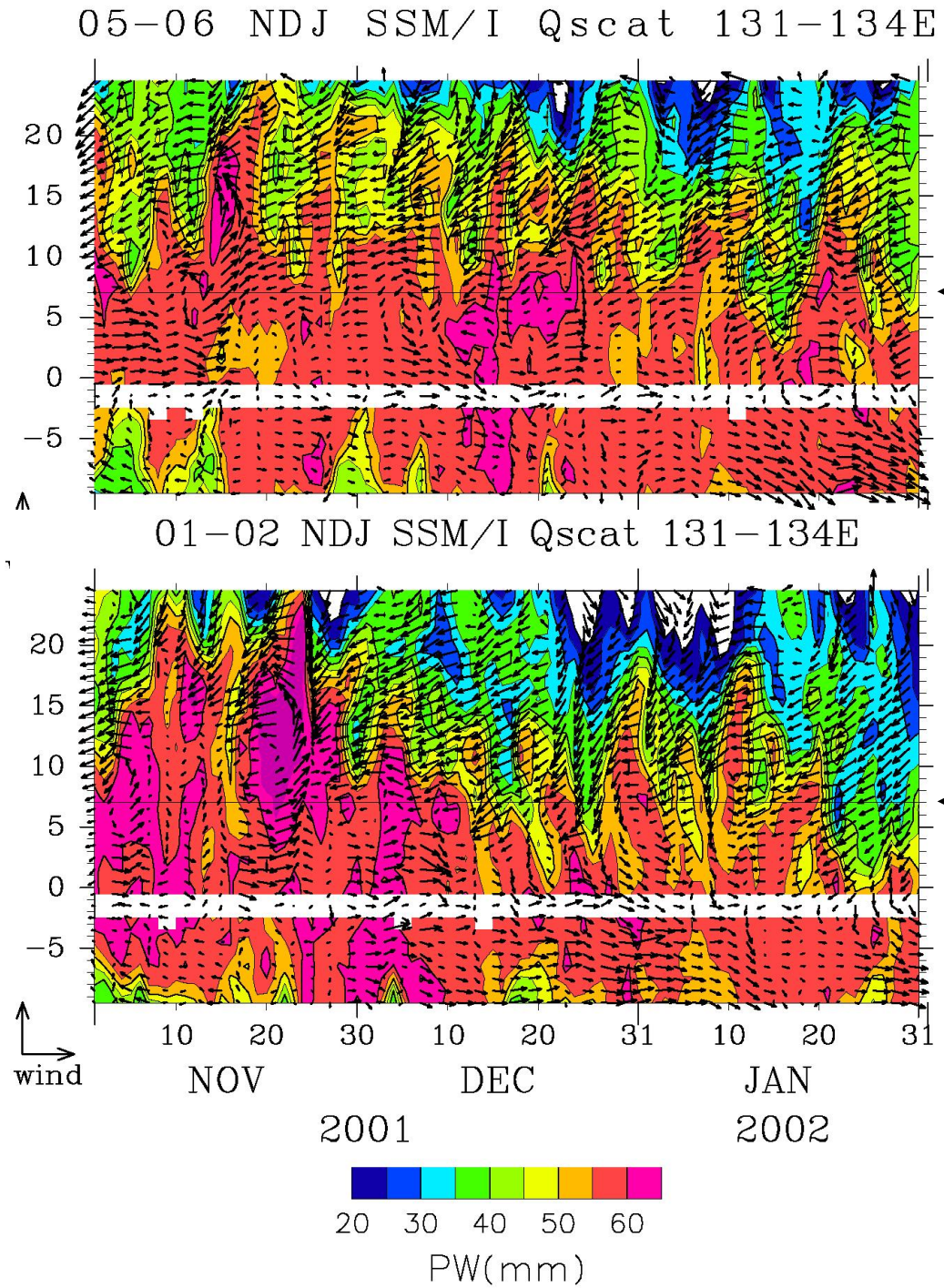




November 2005-January 2006



November 2001.January 2002



Meridional cross section of precipitable water (SSM/I), surface wind (Qscat)

November 2005.January 2006

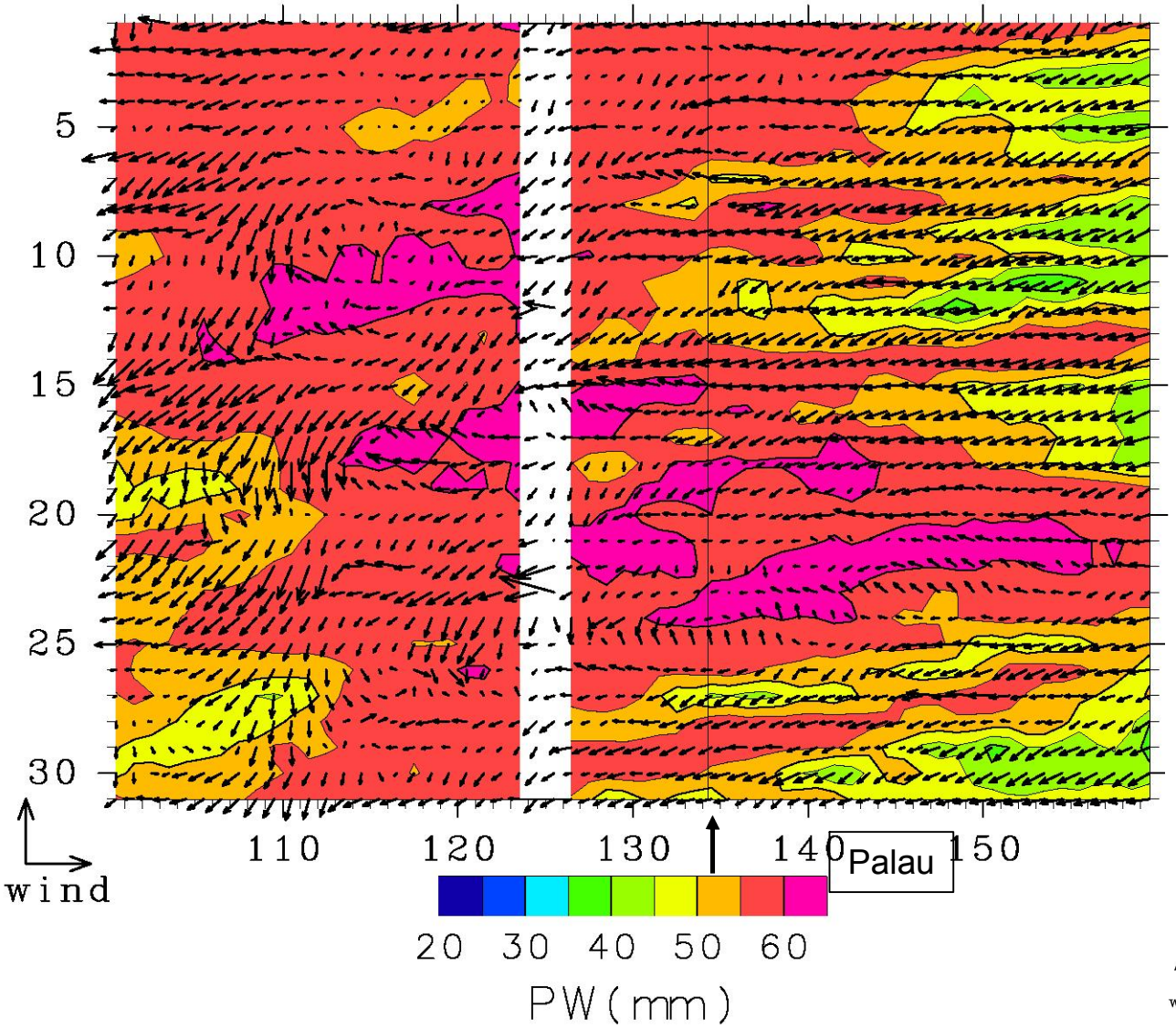
← Palau

November 2001.January 2002

← Palau

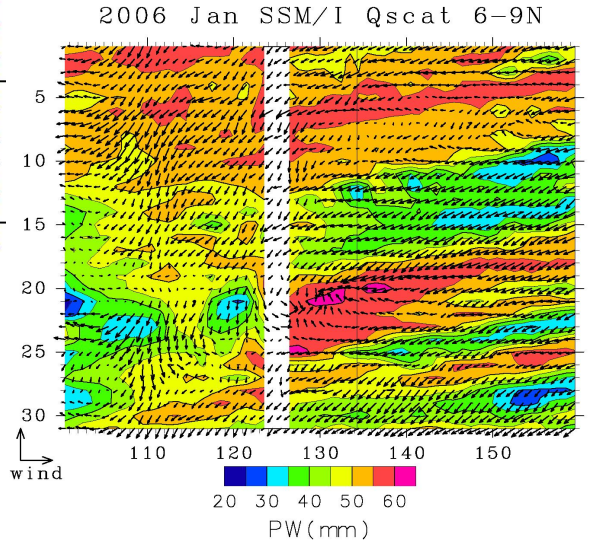
Zonal cross section of precipitable water (SSM/I), surface wind (Qscat)

December 2005
Zonal average along 6-9N

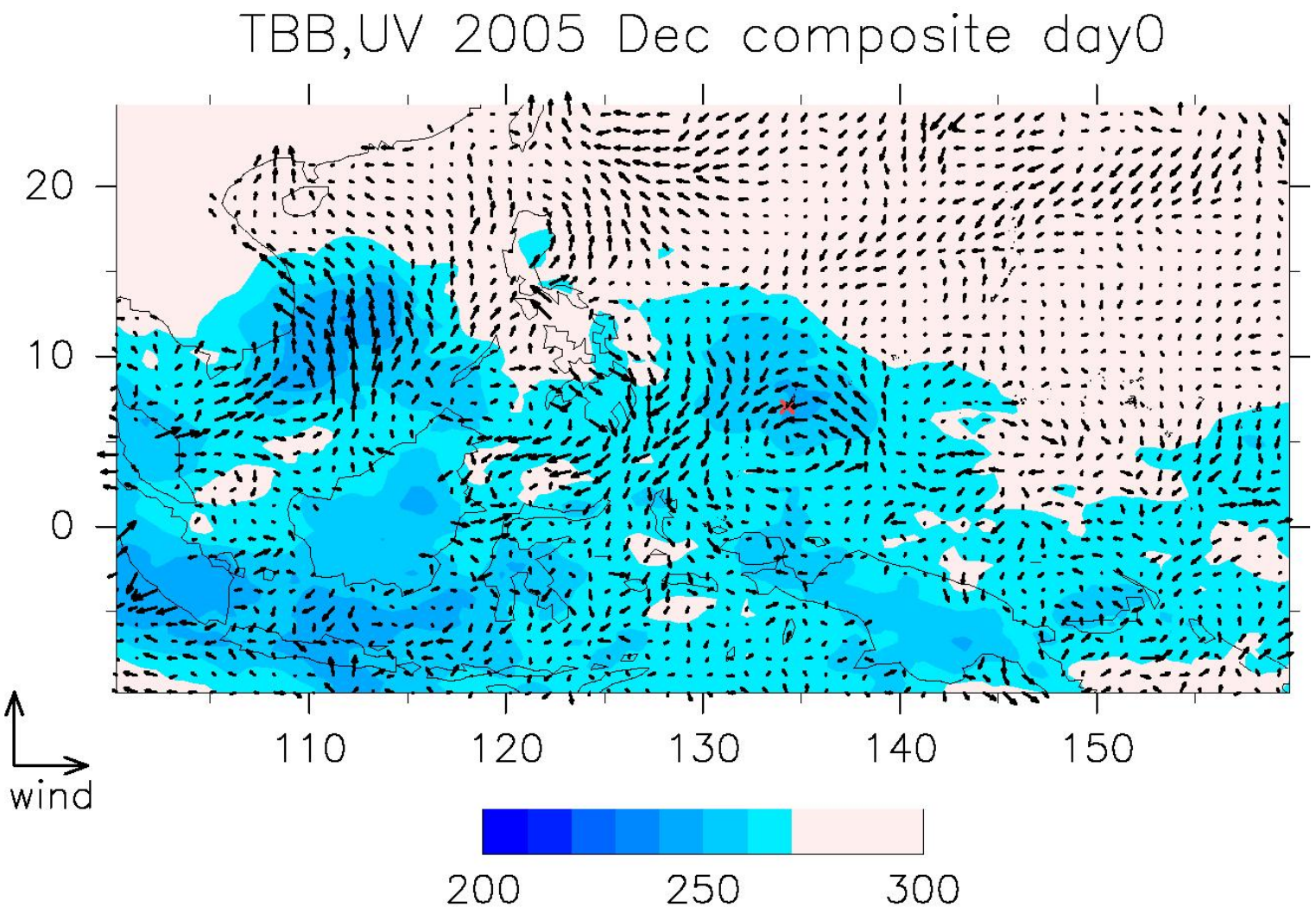


made a composite on
Dec. 4, 9, 14, 19, 24, 29

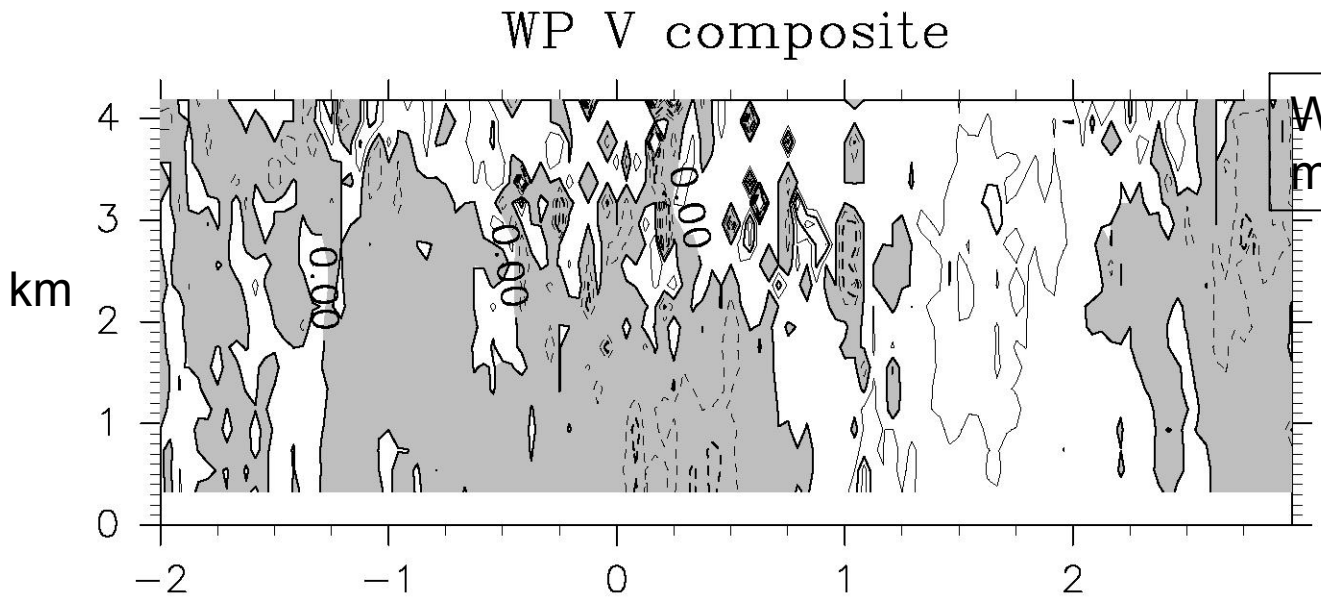
January 2006



Composite of 5-day-period disturbances

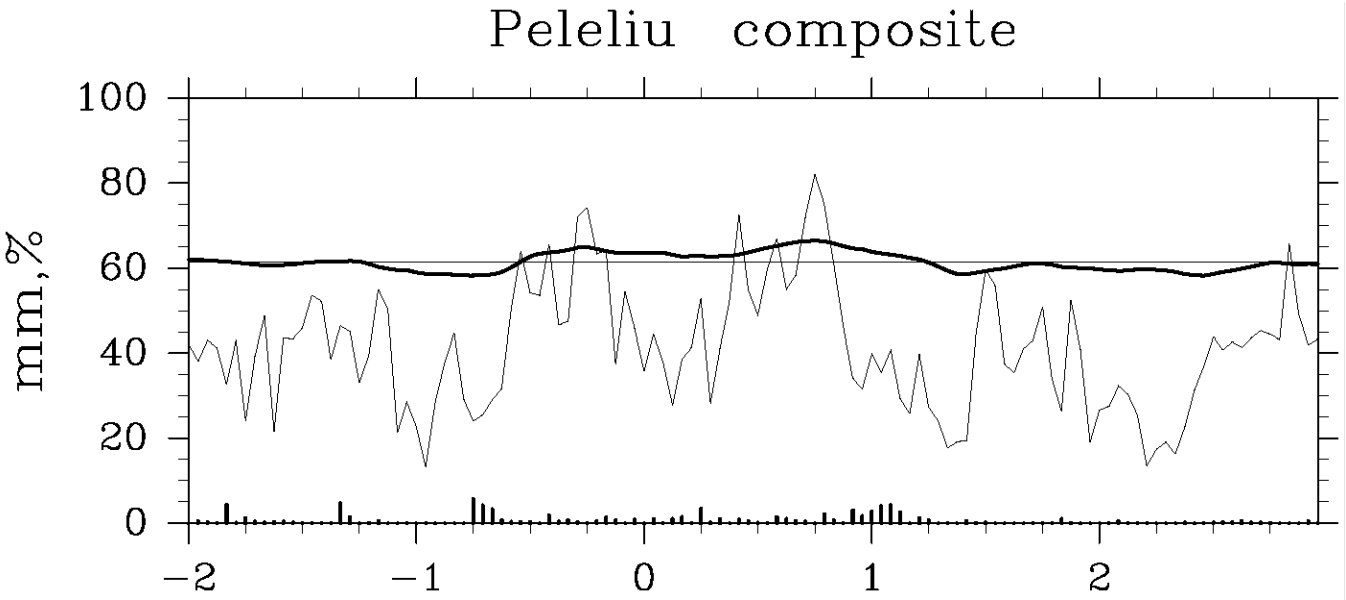


Composite of wind profile, rainfall, cloud amount, precipitable water



Wind profiler
meridional wind anomaly

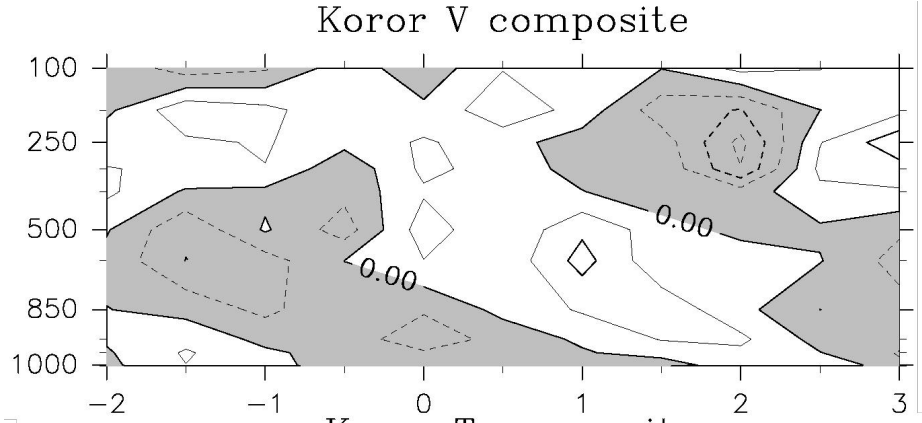
Day lags



Precipitable water

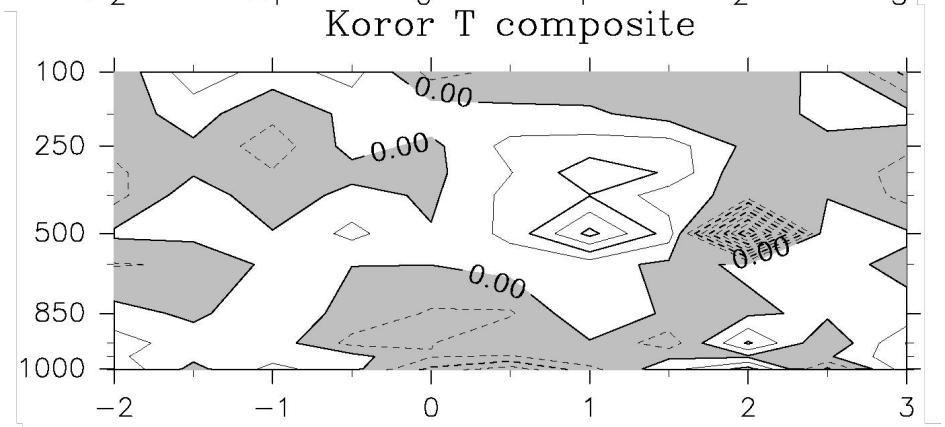
Cloud amount

precipitation

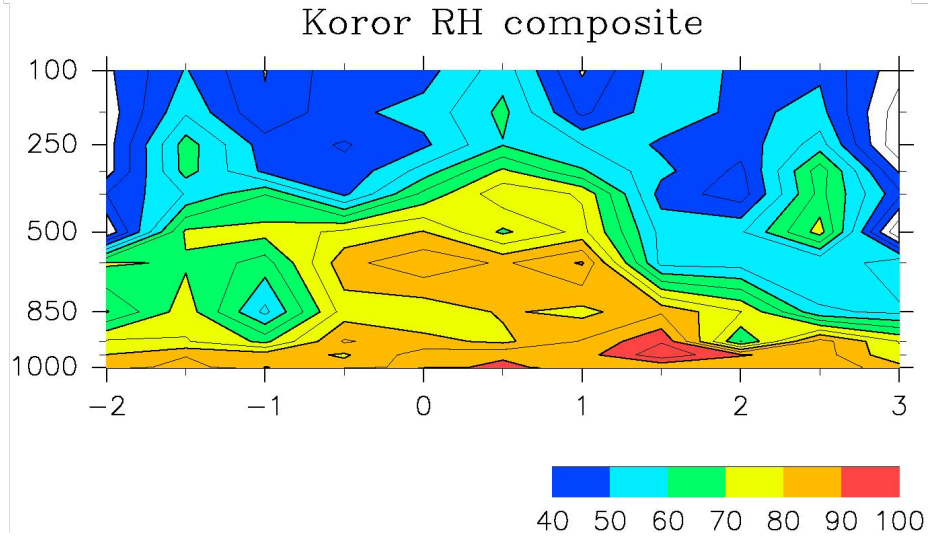


Composite of wind, temperature, relative humidity profile by Koror raindiosonde

meridional wind anomaly



temperature anomaly



relative humidity

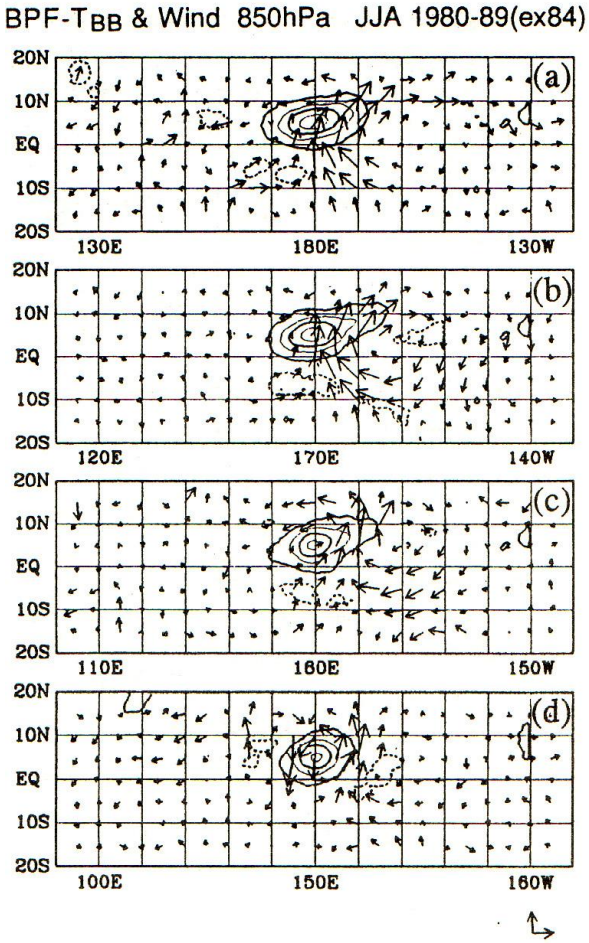


Fig. 9. Horizontal features at DAY0 of 1980–89 (ex. 84) composites of BPF-T_{BB} and BPF-wind at 850 hPa at the base points at 5°N on (a) dateline, (b) 170°E, (c) 160°E and (d) 150°E. Instances of active convection at each base point were chosen as composite reference points, DAY0. The number of composited elements were (a) 110, (b) 125, (c) 116, (d) 107, respectively. Solid contours indicate a negative T_{BB} anomaly with intervals of 2.5K. Arrows depicted at the bottom of figures correspond to a 0.6 m/s wind vector.

Horizontal and vertical structure of easterly wave disturbances

Takayabu and Nitta (1993)

Convective activity

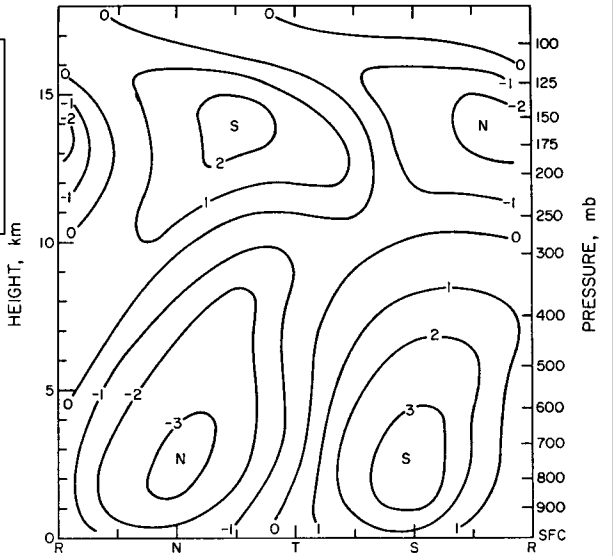


Fig. 4. Composite diagram of meridional wind speed (m sec^{-1}) for KEP. The letters R, N, T and S refer to the ridge, north wind, trough and south wind regions, respectively, of the wave as defined by its structure in the lower troposphere.

Meridional wind

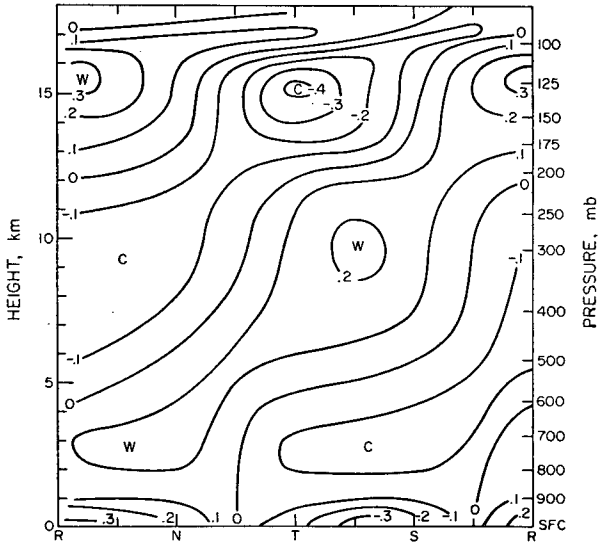


Fig. 5. Composite diagram of temperature deviations (°C) at various levels from their respective mean values at KEP. Refer to Fig. 4 for further explanation.

temperature

Relative humidity

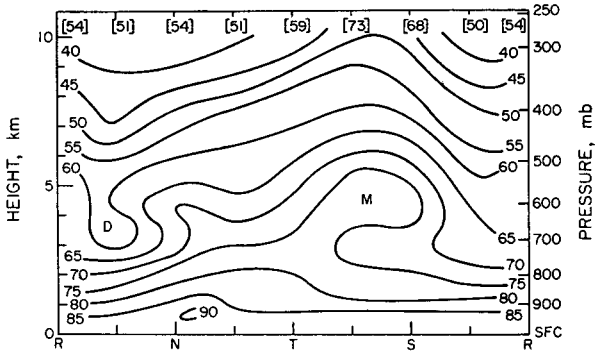


Fig. 6. Composite diagram of relative humidity for KEP. Values in brackets at the top are for saturation with respect to ice. Refer to Fig. 4 for further explanation.

Reed and Recker (1971)

Summary

- Cold weather and heavy snowfall were observed in Japan and Northeast Asia on December 2005. The meander of westerly jet was affected by the active convections over Bay of Bengal to Philippines Sea.
- Extreme rainfall was observed over Palau and spread widely zonal over off-equatorial region of western Pacific on 2005/06 winter.
- ENSO was weak La Nina phase. In contrast, rainfall over equatorial region was relatively weaker compared to off-equatorial region.
- Comparing to 2001/02 winter, high precipitable water was observed continuously and convection was active during December 2005 over Palau region. It was due to the northward shift of active convections associated with MJO.
- Internal structure of westward propagating five-day- period systems was observed within MJO at off-equatorial region.
- The structure of five-day-period systems shows that horizontal scale is about 1000km and meridional wind reverses the direction during its passage. These structures resemble to easterly wave disturbances.

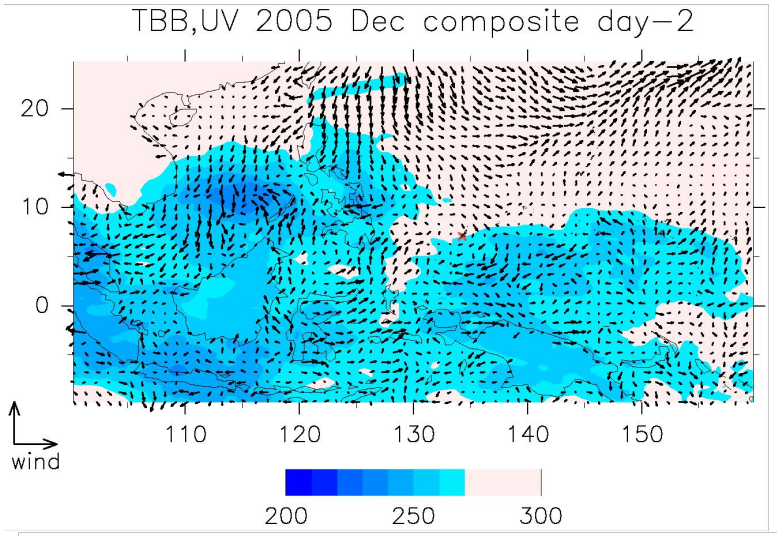
Further discussions

- How rare or often is the 5-day-period disturbances observed in ISO?
- 5-day-period disturbances will change their structures when they reached South China Sea influenced by cold surge.

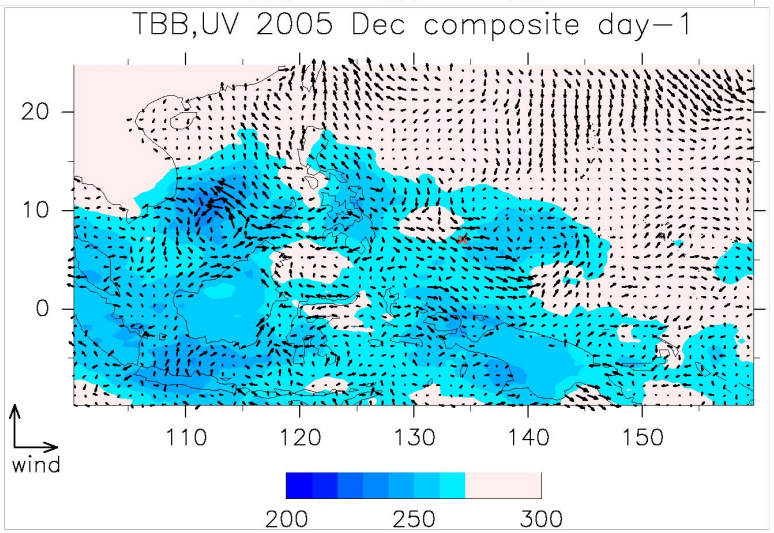
  Some disturbances were developed to tropical depression.

  How does they change their structures?

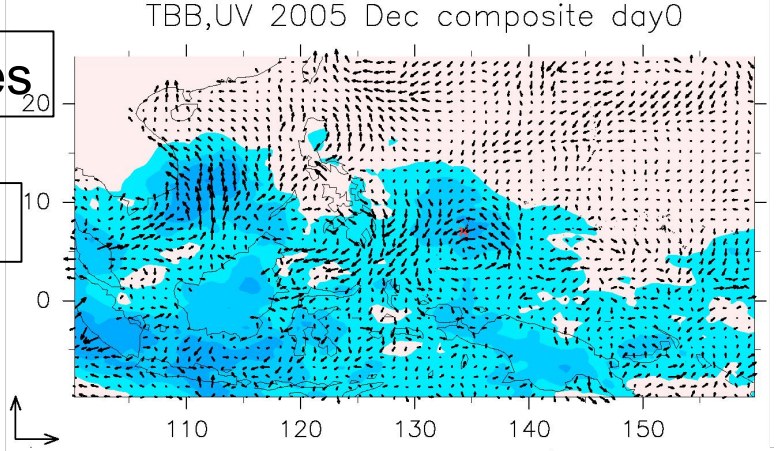
Composite of 5-day-period disturbances



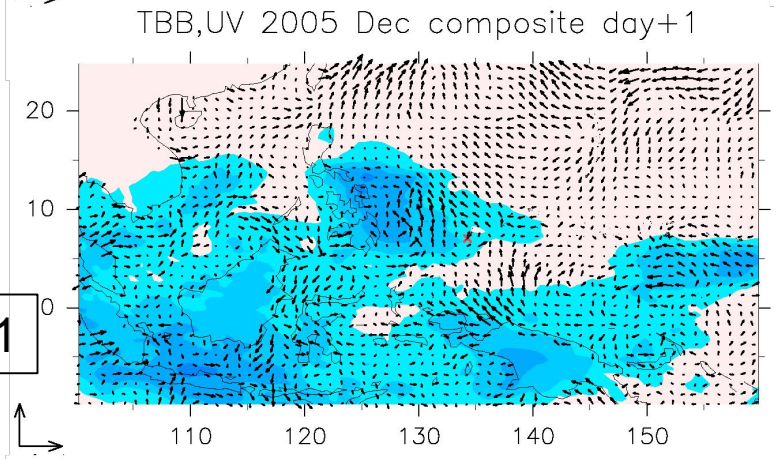
day-2



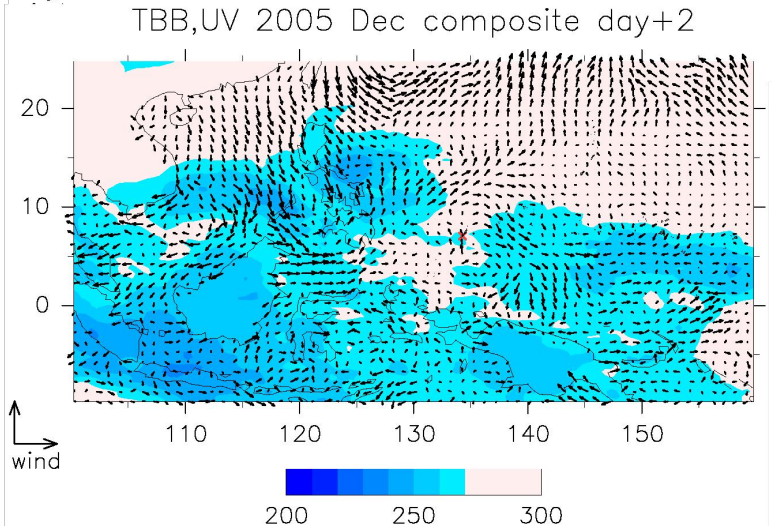
day-1



day0



day+1



day+2