The attached results are based on combining and co-locating the observational data from the AMSU-microwave radiometer (surface and temperature profile in the atmosphere), the atmospheric infrared sounder, AIRS, (water vapor distribution in the atmosphere, relative humidity...) on Aqua satellite, Cloudsat radar altimeter (clouds height and reflectivity), and Calipso laser altimeter instruments (clouds type) for climate study.

Cloudsat radar allows us to obtain the vertical profile/reflectivity as well as cloud class types (in conjunction with the laser altimeter on Calipso) of the atmosphere over a small swath (1.4 km x 2.5 km) at a given latitude. The AIRS instrument provides the vertical profile of the atmosphere over large swath. This profile includes the water vapor mass mixing ratio, saturation mass mixing ratio, temperature, and pressure... The relative humidity and precipitable water vapor have been calculated from some of these measurements. Both Cloudsat and AIRS are on A-Train orbit in which near simultaneous measurements (see below) of the vertical profile of the atmosphere is obtained.
The followings are presented:

- Cloud geographical distributions for mid-latitude and subtropics that occur:
  1. Summer 2006 (3-day, 40 orbits of Cloudsat-AIRS S/C instruments around Earth) and,
  2. Winter 2006 (3-day, 40 orbits of Cloudsat-AIRS S/C instruments around Earth).

- 1000 mb-700mb of Winter 2006/subtropics cloud type distribution analysis results for:
  1. Mean water vapor mass mixing ratio vs Mean atmospheric temperature
  2. Mean precipitable water vapor vs Mean atmospheric temperature

- 1000 mb-700mb of Summer 2006/subtropics cloud type distribution analysis results for:
  1. Mean water vapor mass mixing ratio vs Mean atmospheric temperature
  2. Mean precipitable water vapor vs Mean atmospheric temperature

- For a given cloud types (e.g. Cirrus (Ci), Altostratus (As), Altocumulus (Ac), Stratus (St), Stratocumulus (Sc), Cumulus (Cu), Nimbostratus (Ns) and Cumulonimbus (Cb) and underlying boundary layer conditions (1000mb-700mb) represented by the mean atmospheric parameters, cloud distribution structures analysis are presented:

  1. No. of times cloud types at mean precipitable water vapor / winter subtropics
  2. No. of times cloud types at mean precipitable water vapor / summer subtropics
  3. No. of times cloud types at mean H2O vapor mass mixing ratio / summer / mid-latitude,
     tropics- north (north of the equator), subtropics, and tropics-south (south of the equator).
  4. No. of times cloud types at mean H2O vapor mass mixing ratio / summer / mid-latitude, tropics- north (north of the equator), subtropics, and tropics-south (south of the equator).
Tropics South/ Water vapor saturation mass mixing ratio (gr/ kg dry air)

Tropics-North/ Saturation mass mixing ratio (gr/Kg dry air)
Sub-Tropics North/Water Vapor mass Saturation mixing ratio (gr/ kg dry air)

Mid Latitude/Water vapor saturation mass mixing ratio (gr/ kg dry air)
The following water vapor mass mixing ratio, mass saturation mixing ratio, temperature, and relative humidity vertical profile are taken at a given latitude where max radar reflectivity’s are observed:
<table>
<thead>
<tr>
<th>Region</th>
<th>Max Radar Reflectivity (dBz)</th>
<th>Latitude (deg)</th>
<th>Cloud Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropics - N</td>
<td>8.54</td>
<td>-3.326</td>
<td>6</td>
<td>Sc</td>
</tr>
<tr>
<td>Tropics - S</td>
<td>8.0</td>
<td>+7.412</td>
<td>6</td>
<td>Sc</td>
</tr>
<tr>
<td>Subtropics - N</td>
<td>19.13</td>
<td>+8.33</td>
<td>9</td>
<td>Cb</td>
</tr>
<tr>
<td>Mid-Latitude - N</td>
<td>10.29</td>
<td>+33.014</td>
<td>9</td>
<td>Cb</td>
</tr>
</tbody>
</table>
Winter 2006/ Mid-latitude/Western pacific
Cirrus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Cirrus cloud geographical distribution
Winter 2006/ Mid-latitude/Western pacific
Altostratus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Altostratus cloud geographical distribution
Winter 2006/ Mid-latitude/Western pacific
Altocumulus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Altocumulus cloud geographical distribution
Winter 2006/ Mid-latitude/Western pacific
Stratocumulus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Stratocumulus cloud geographical distribution
Winter 2006/ Mid-latitude/Western pacific
Cumulus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Cumulus cloud geographical distribution
Winter 2006/ Mid-latitude/Western pacific
Cumulonimbus cloud geographical distribution

Winter 2006/ Subtropics/Western pacific
Cumulonimbus cloud geographical distribution
Summer 2006/ Mid-latitude/Western pacific
Cirrus cloud geographical distribution

Summer 2006/ Subtropics/Western pacific
Cirrus cloud geographical distribution
Summer 2006/ Mid-latitude/Western pacific
Altostratus cloud geographical distribution

Summer 2006/ Subtropics/Western pacific
Altostratus cloud geographical distribution
Summer 2006/ Mid-latitude/Western pacific
Stratocumulus cloud geographical distribution

[Graph showing stratocumulus cloud geographical distribution in mid-latitude/Western Pacific]

Summer 2006/ Subtropics/Western pacific
Stratocumulus cloud geographical distribution

[Graph showing stratocumulus cloud geographical distribution in subtropics/Western Pacific]
Summer 2006/ Mid-latitude/Western pacific
Cumulonimbus cloud geographical distribution

Summer 2006/ Subtropics/Western pacific
Cumulonimbus cloud geographical distribution
Mean water vapor mass mixing ratio

vs

Mean atmospheric temperature

Winter/western pacific
Winter 2006/Subtropics- Western pacific

Ci- cloud type distribution

1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific
As- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific
St- cloud type distribution
1000 mb - 700 mb

Mean water vapor mass mixing ratio (gr/kg air)

Mean atmospheric temperature (kelvins)
Winter 2006/Subtropics- Western pacific

Sc- cloud type distribution
1000 mb - 700 mb

Mean water vapor mass mixing ratio (gr/kg air)
Mean atmospheric temperature (kelvins)
Winter 2006/Subtropics- Western pacific
Cu- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific

Ns- cloud type distribution
1000 mb - 700 mb

Mean atmospheric temperature (kelvins)
Mean water vapor mass mixing ratio (gr/kg air)
Winter 2006/Subtropics - Western Pacific
Cb - cloud type distribution
1000 mb - 700 mb

Mean water vapor mass mixing ratio (g/kg air)

Mean atmospheric temperature (kelvins)

220 240 260 280 300 320

0 5 10 15 20 25 30

Mean water vapor mass mixing ratio (g/kg air)
Mean Precipitable water vapor
vs
Mean atmospheric temperature

Winter/western pacific
Winter 2006/Subtropics- Western pacific
Ci- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific

As- cloud type distribution

1000 mb - 700 mb
Winter 2006/Subtropics - Western pacific
Ac- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics - Western Pacific

St- cloud type distribution

1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific

Sc- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific

Cu- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific
Ns- cloud type distribution
1000 mb - 700 mb
Winter 2006/Subtropics- Western pacific
Cb- cloud type distribution
1000 mb - 700 mb
Mean water vapor mass mixing ratio
vs
Mean atmospheric temperature
Summer /western pacific
Summer 2006/Subtropic-North
Ci- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
As- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Ac- cloud type distribution
1000 mb - 700 mb

Mean water vapor mass mixing ratio (gr/kg air)
Mean atmospheric temperature (kelvins)
Summer 2006/Subtropic-North
St- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Sc- cloud type distribution
1000 mb - 700 mb

Mean water vapor mass mixing ratio (gr/kg air)

Mean atmospheric temperature (kelvins)
Summer 2006/Subtropic-North

Cu- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Ns- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Cb- cloud type distribution
1000 mb - 700 mb
Mean Precipitable water vapor
vs
Mean atmospheric temperature

Summer/western pacific
Summer 2006/Subtropic-North
Ci- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
As-cloud type distribution
1000 mb - 700 mb

Mean atmospheric temperature (kelvins)

Mean precipitable water vapor (mm)
Summer 2006/Subtropic-North
Ac- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
St- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Sc- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Cu- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Ns- cloud type distribution
1000 mb - 700 mb
Summer 2006/Subtropic-North
Cb- cloud type distribution
1000 mb - 700 mb
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times Ci clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times Ac clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb
Winter 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times Ns clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Summer 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times Ci clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Summer 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times As clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Summer 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb
Summer 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb
Summer 2006/ Subtropics
Precipitable water vapor/ Western pacific
1000 mb - 700 mb

No. of times Cu clouds at mean precipitable water vapor

Mean precipitable water vapor (mm)
Cirrus cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
As cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb
Ac cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb
Sc cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb

No. of times Sc. clouds at mean water vapor
Cu cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb
Ns cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb

No. of times Ns clouds at mean water vapor

Mean water vapor mass mixing ratio (gr/Kg)
Cb cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Winter 2006
1000 mb - 700 mb
Subtropics/Winter

Stratocumulus clouds types dominate the subtropics in the western pacific in the winter. The condition for their occurrence is pronounced where the mean water vapor mass mixing ratio of the boundary layer (1000mb-700mb) falls mostly between 5-10gr/kg air and 10-15 gr/kg air.
Cirrus cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
As cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Ac cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Sc cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb

No. of times Sc. clouds at mean water vapor
Cu cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Ns cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Cb cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Cirrus cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
As cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Ac cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
St cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Sc cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb

No. of times Sc. clouds at mean water vapor

Mean water vapor mass mixing ratio (gr/Kg)
Cu cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb

No. of times Cu clouds at mean water vapor

Mean water vapor mass mixing ratio (gr/Kg)
Ns cloud/Tropics-North
Mean water vapor mass mixing ratio
Western Pacific/winter 2006
1000 mb - 700 mb
Cb cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb

No. of times Cb clouds at mean water vapor

Mean water vapor mass mixing ratio (gr/Kg)
Cirrus cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
As cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/winter 2006
1000 mb - 700 mb
Ac cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
St cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Sc cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Cu cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Ns cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Cb cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ winter 2006
1000 mb - 700 mb
Cirrus cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
As cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Ac cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
St cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cu cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western Pacific/ Summer 2006
1000 mb - 700 mb
Ns cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western Pacific/ Summer 2006
1000 mb - 700 mb
Cb cloud/Mid-Latitude
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Subtropics/Summer

- Cirrus, Altocumulus, Stratocumulus clouds types dominate the subtropics in the western pacific with Stratocumulus clouds (low level clouds) is the most dominant in that region. The condition for their occurrence is pronounced where the mean water vapor mass mixing ratio of the boundary layer (1000mb-700mb) falls mostly between 10-15 gr/kg air.

- Altostratus and cumulus clouds are relatively with less occurrence (50-100) where the mean water vapor mass mixing ratio of the boundary layer (1000mb-700mb) falls mostly between 10-15 gr/kg air.

- Stratus, Nimbostratus and Cumulonimbus clouds are with least occurrence (less than 25) in the western pacific.
Cirrus cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Ac cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
St cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Sc cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/Summer 2006
1000 mb - 700 mb
Cu cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Ns cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cb cloud/Subtropics
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cirrus cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
As cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Ac cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
St cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Sc cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cu cloud/Tropics-North
Mean water vapor mass mixing ratio
Western Pacific/Summer 2006
1000 mb - 700 mb
Ns cloud/Tropics-North
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cb cloud/Tropics-North
Mean water vapor mass mixing ratio
Western Pacific/ Summer 2006
1000 mb - 700 mb
Cirrus cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
As cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Ac cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
St cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Sc cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cu cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb
Cb cloud/Tropics-South
Mean water vapor mass mixing ratio
Western pacific/ Summer 2006
1000 mb - 700 mb