GPS Meteorology at Japan Meteorological Agency

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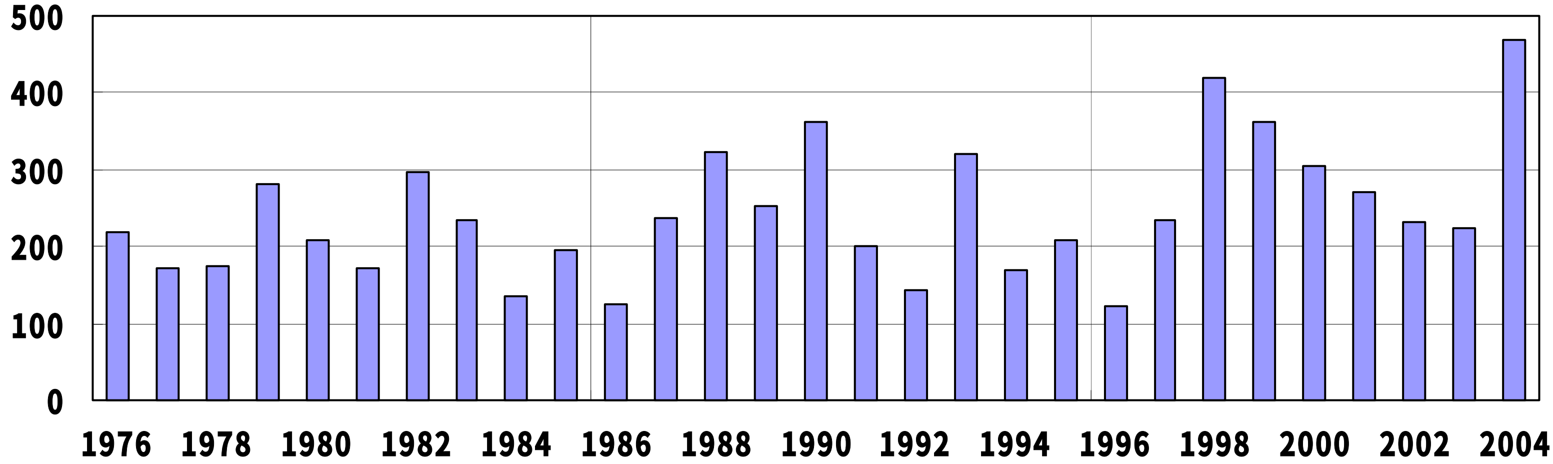
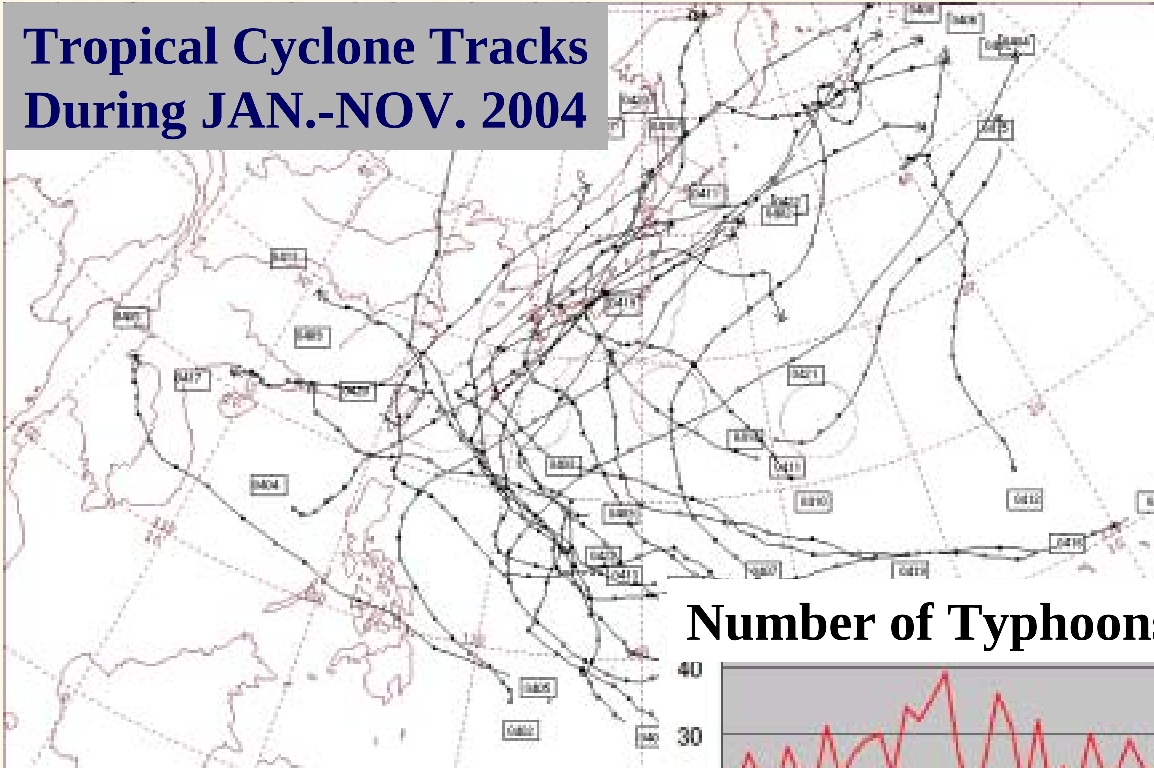
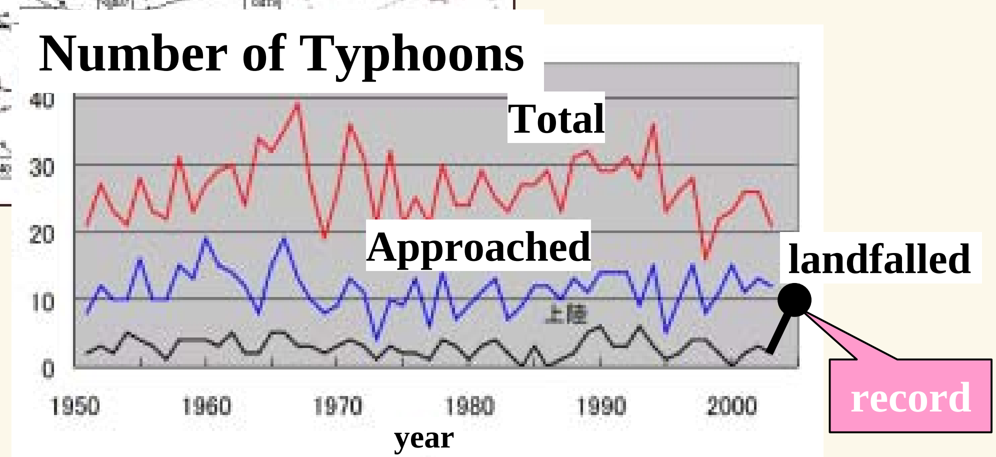
Increase of occurrence of severe rainfalls in recent years



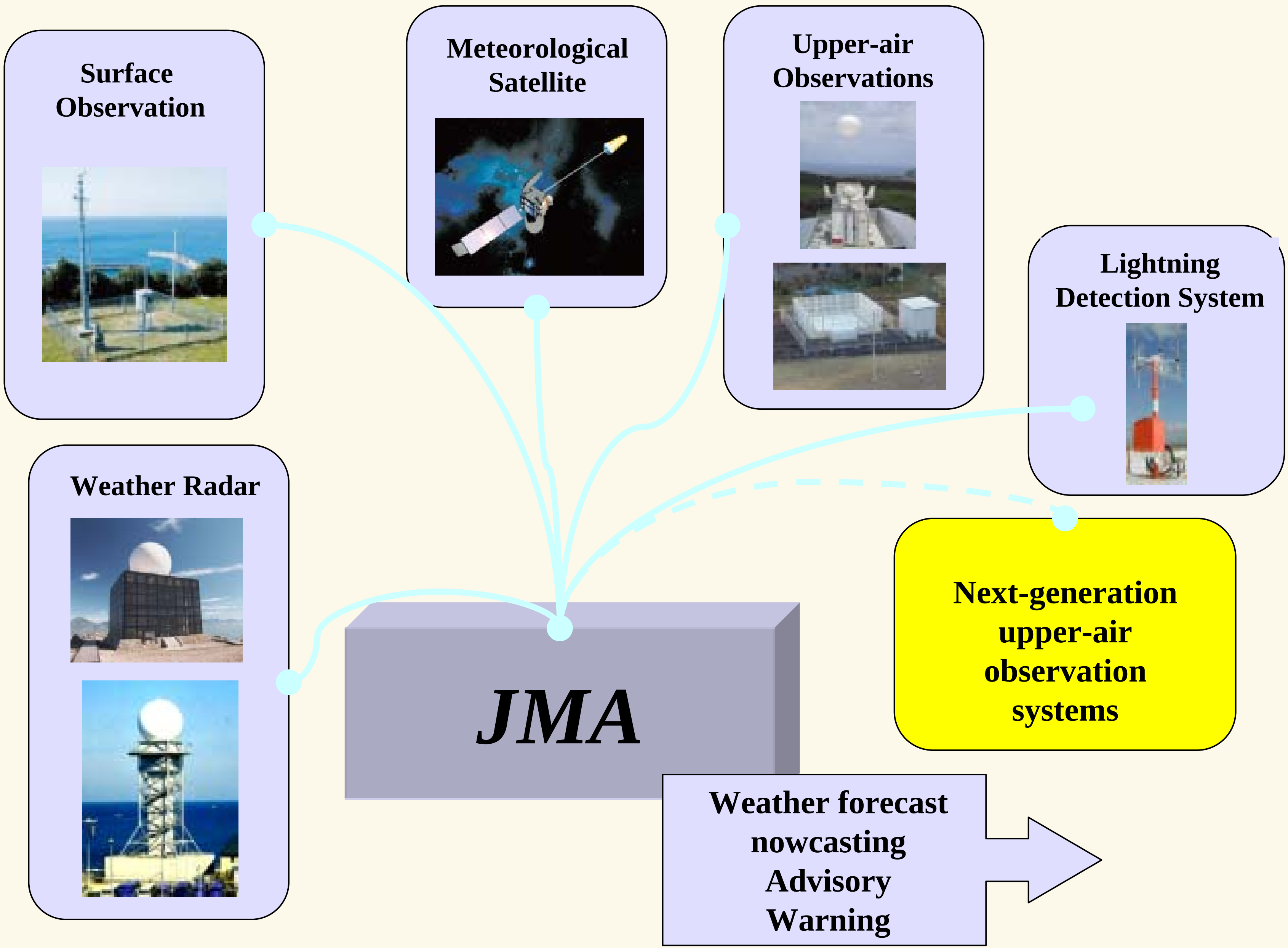
Number of heavy rainfall records exceeding 50mm/h observed in the JMA mesonet AMeDAS

Increase of landfalls of typhoons in recent years

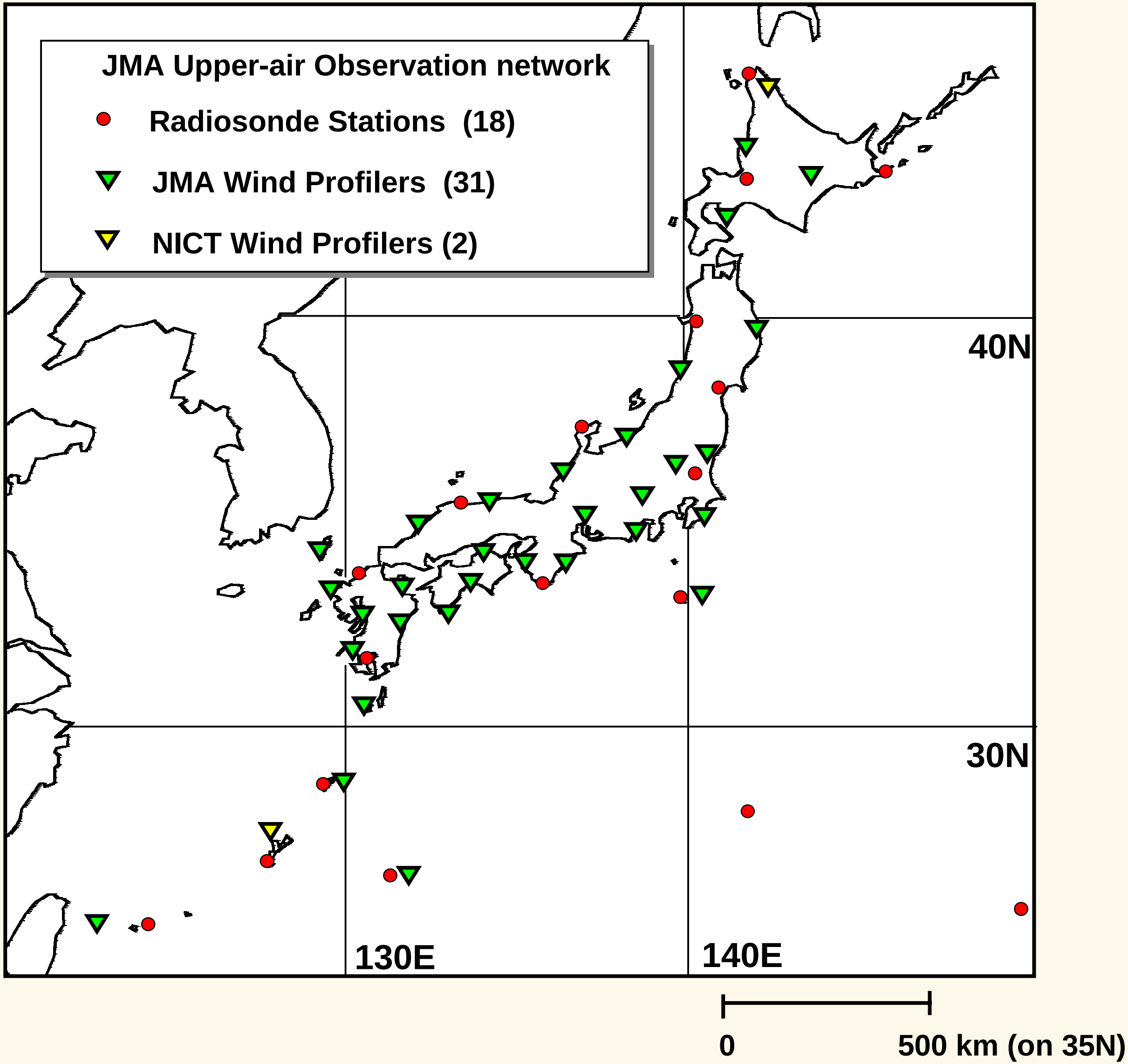




Modernization of weather observation systems of JMA



Upper-air Observation Network of Japan



Modernization of Upper-air Observation strategy at JMA

- **Start of automated radiosonde observation in 2003**
- **Operation of wind profiler network from 2000**
- **Replacement of conventional weather radars to Doppler radars from 2006**
- **Expansion use of satellites data in numerical weather prediction models including QuikSCAT, TRMM, Aqua, NOAA & Terra,**
- **Use of the ACRAS aircraft weather data of Japanese airlines from 2002,**
- **Experiments of operational use of GPS meteorology**
- **Test of other remote sensing techniques**

GPS Meteorology

- **Precipitable Water vapor (PWV) from delay of GPS signal**
- **Vertical profiling of temperature and water vapor using occultation techniques**

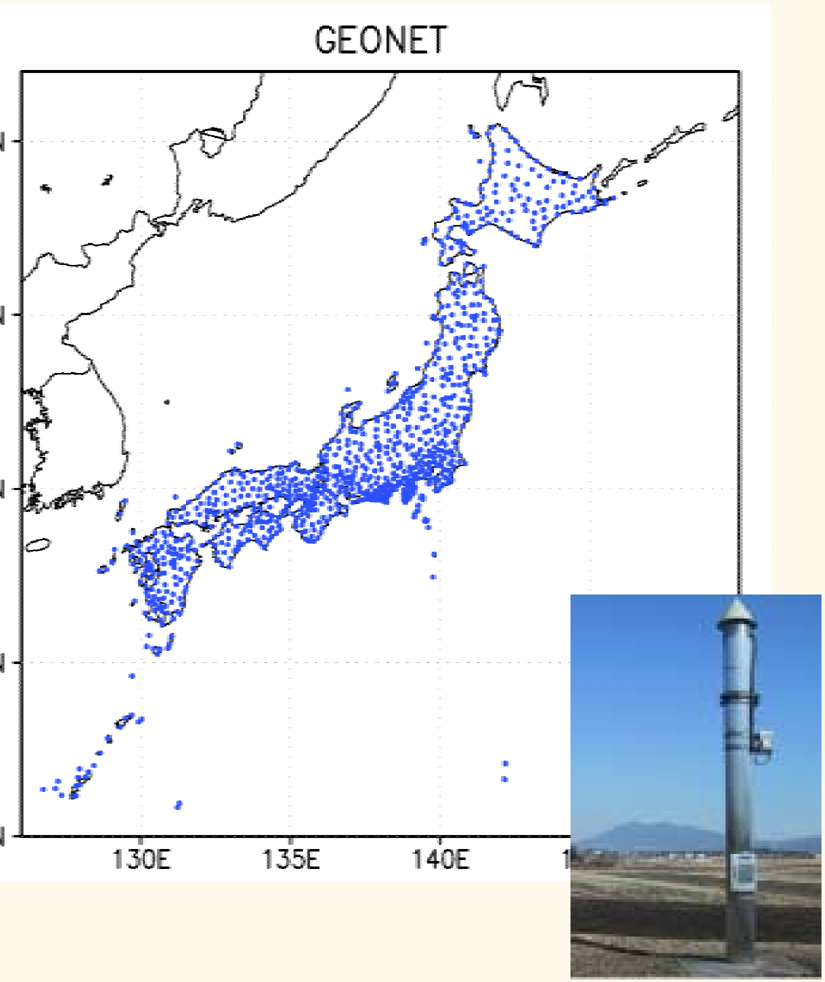
  - Down-looking technique

  - Space-borne occultation technique
- **Derivation of 3D water vapor fields with Tomography technique**

State of GPS Meteorology in Japan

- Precipitable water vapor (PWV) from GPS meteorology is ready to use in the operational numerical weather prediction.
- Vertical profiling of water vapor (temperature) using satellite-borne occultation technique is being examined to use in the operational numerical weather prediction.
- Vertical profiling of water vapor using down-looking technique is on the way of research.
- Derivation of 3D water vapor fields with Tomography technique is on the way of research.

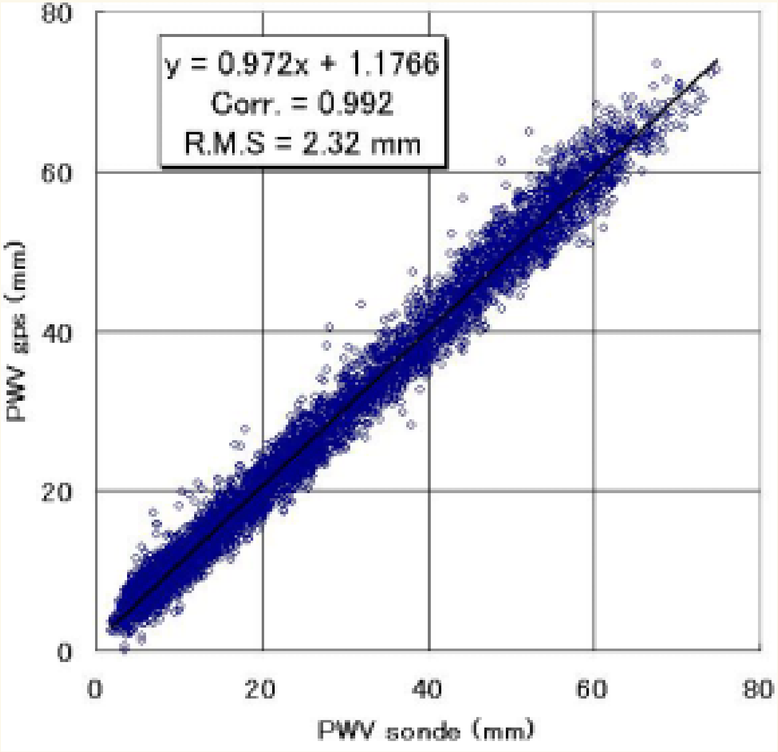
Status of GPS Meteorology in Japan



GEONET(GPS Earth Observation NETwork) is a GPS network operated by the Geographical Survey Institute, Japan. Approximately one thousand GPS receivers are located throughout Japan with a separation of 15-25km in order to monitor crustal deformation of the earth. GPS meteorology in Japan has been developed along with GEONET.

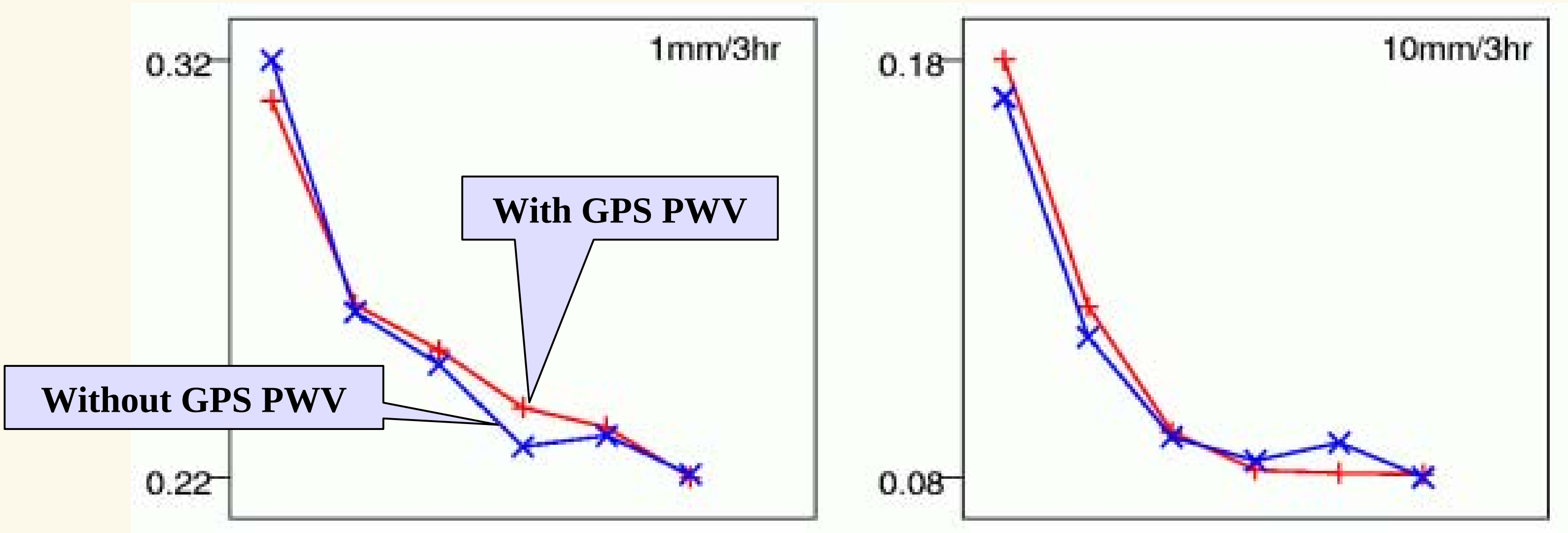
Accuracy of GPS-derived PWV

- **Comparison between GPS-derived PWV and Radiosonde-derived PWV during June 1999 to May 2000.**
- **GPS-derived PWVs are estimated with Non-real time data processing using accurate information on orbits of GPS satellites.**



Experiment of data assimilation of GPS PWV to numerical weather prediction (2)

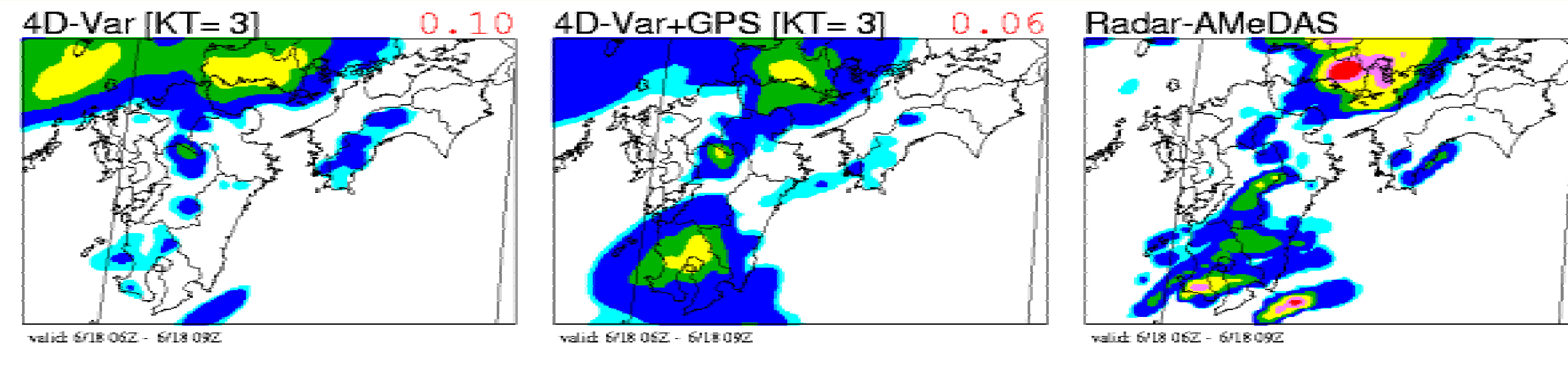
- **A statistical score of, however, showed that the impact of GPS PWV was almost neutral.**
- **One of the reasons might to be that the GPS sites were sparsely distributed compared to the rainfall systems.**
- **Another reason was lack of vertical profile of water vapor.**



Threat scores of three-hours precipitation forecasts by MSM.

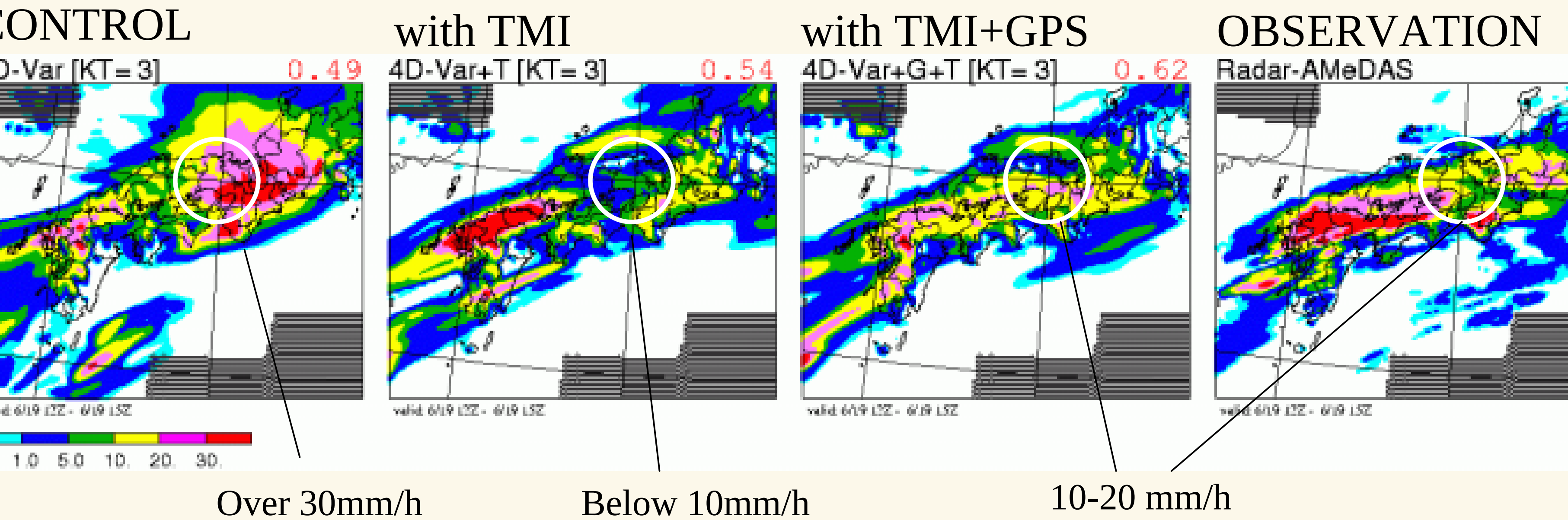
Experiment of data assimilation of GPS PWV to numerical weather prediction (1)

- Observation system experiments were made with the JMA mesoscale model (MSM) with GPS PWV for rainfall events in Baiu season and in summer season (Nakamura et al., 2004).
- Remarkable improvements were seen in some cases.



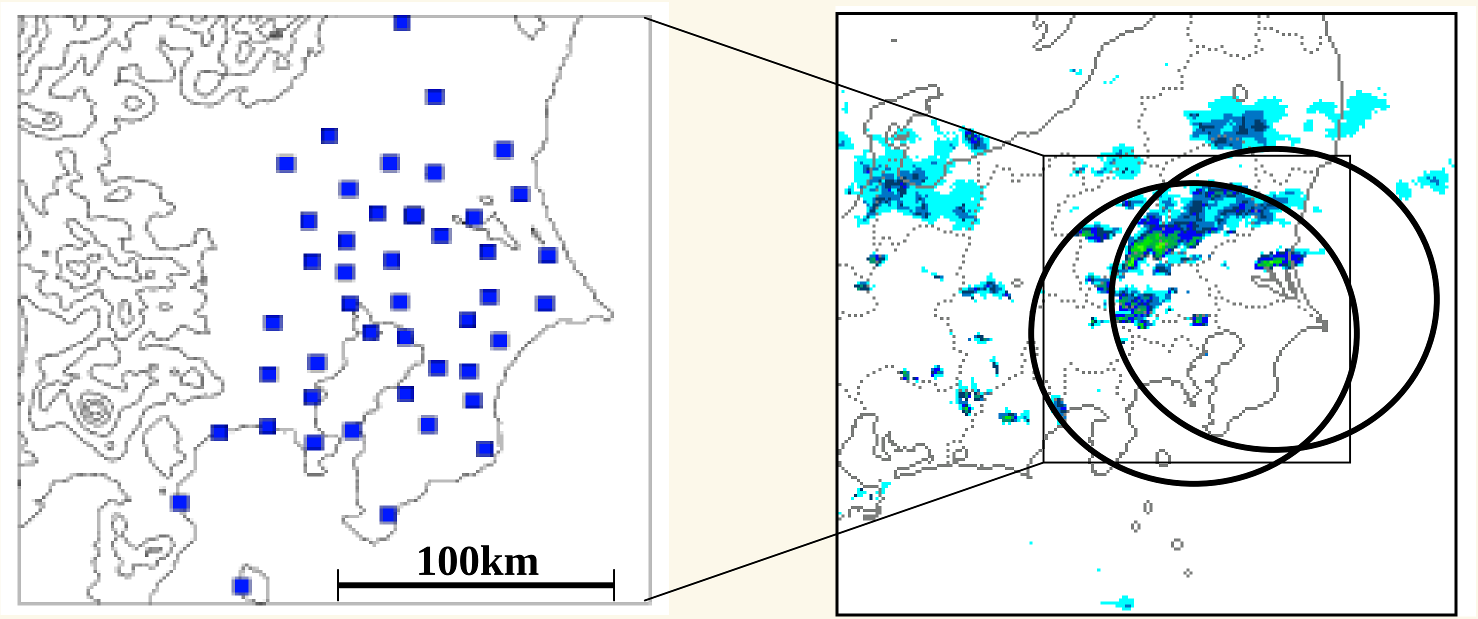
Impact of GPS PWV and TMI PWV on numerical weather prediction

- Observation system experiments were made with the mesoscale model (MSM) using GPS PWV over land and TMI (TRMM Micowave Imager) PWV over ocean (Koizumi et al., 2004).
- The complementary use of GPS PWV and TMI PWV can improve accuracy of numerical weather prediction.



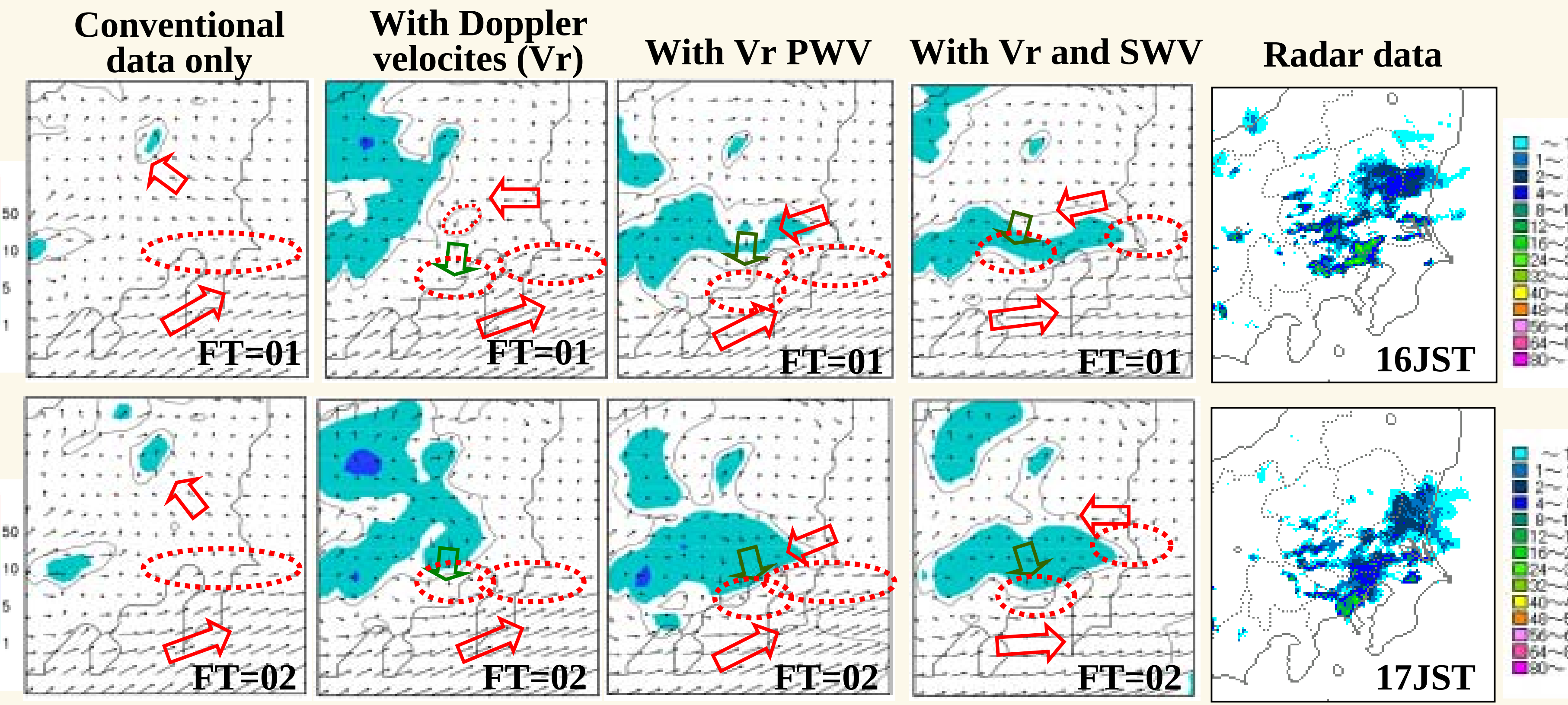
Impact of GPS-derived water vapor and radial wind from Doppler radars on numerical weather prediction (1)

- Observation system experiments were made with the mesoscale model using GPS PWV, GPS-derived slant water vapor (SWV) and radial components of wind from two Doppler radars (Seko et al., 2004) .



Impact of GPS-derived water vapor and radial wind from Doppler radars on numerical weather prediction (2)

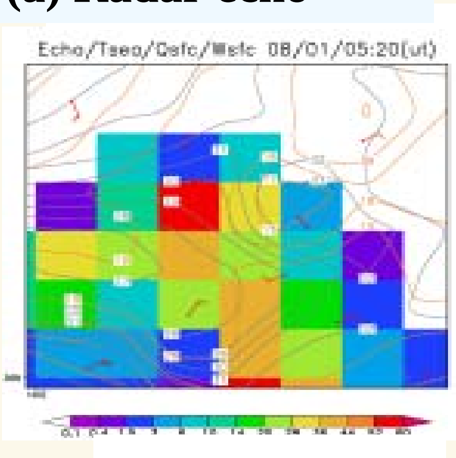
- In case of a severe thunder storm, simultaneously assimilating of GPS-derived water vapor (PWV and SWV) and radial wind from Doppler radars reproduced the rainfall area, because low-level convergence was accurately predicted using the data.



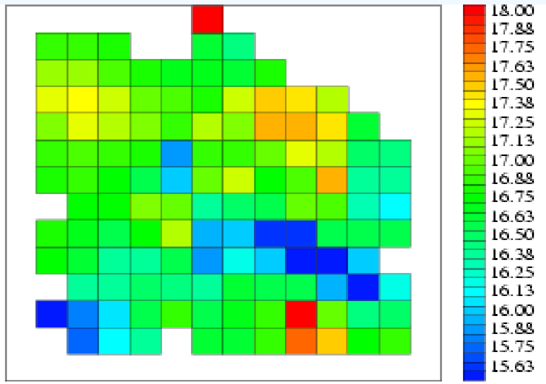
3D distribution of water vapor derived from GPS tomography technique

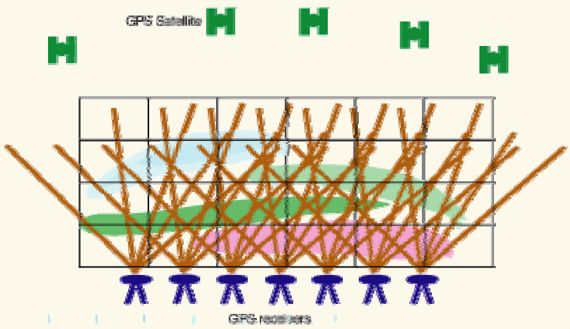
3D distribution of water vapor in a thunderstorm was estimated using 75 GPS receivers in the area of 20 km square around Tsukuba (Seko, et al, 2004).

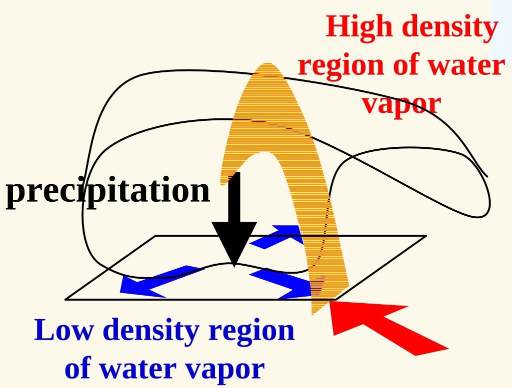
(a) Radar echo



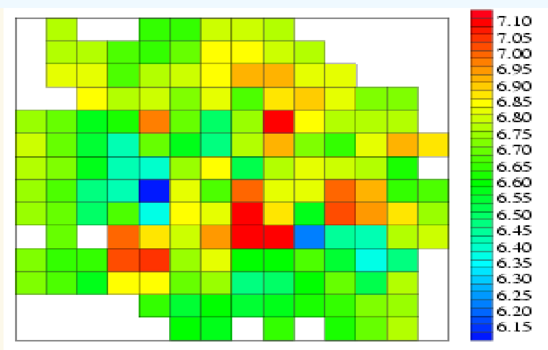
(b) water vapor in the layer of 0-1km







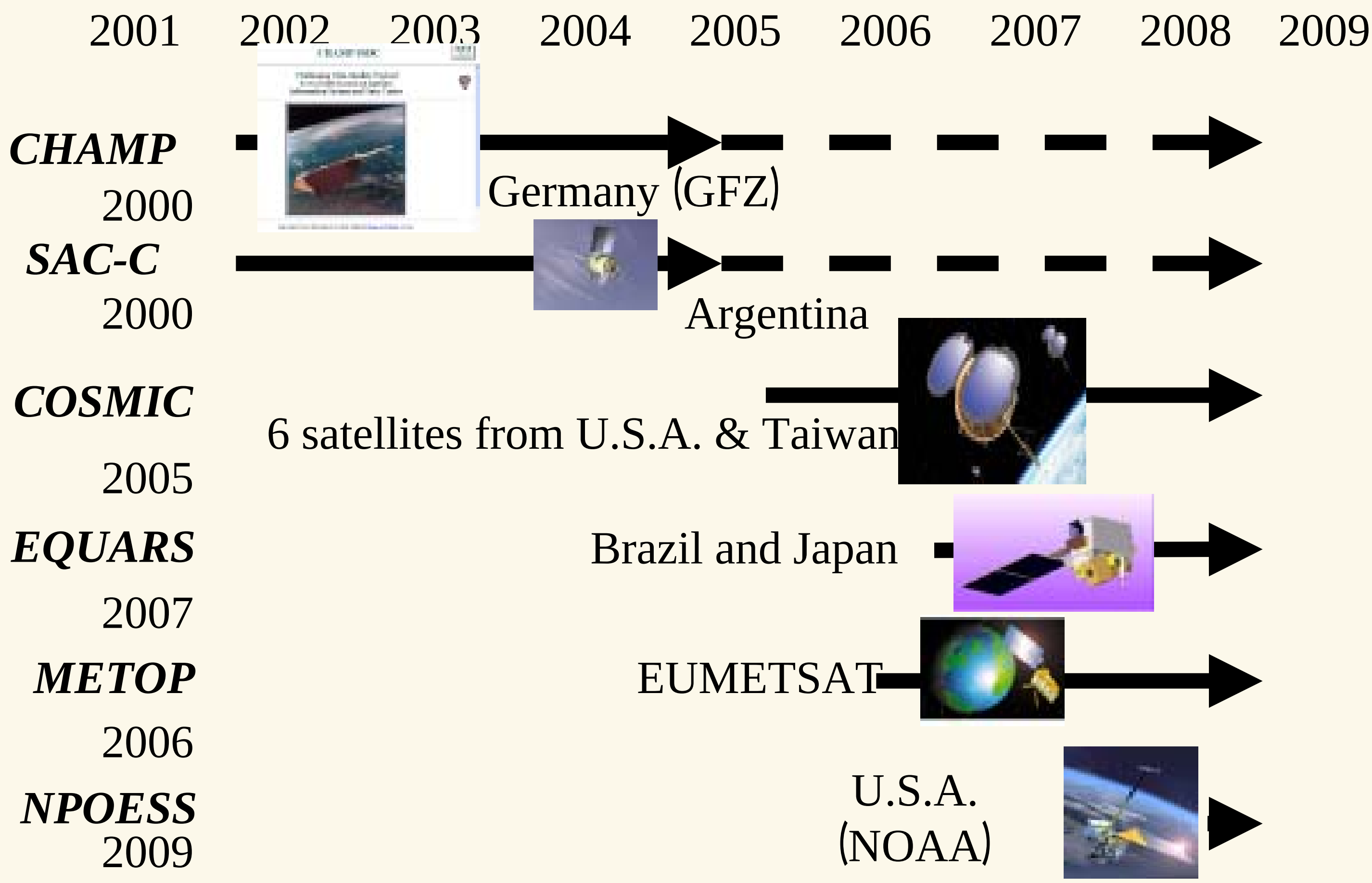
(c) water vapor in the layer of 3-4km



- Amount of water vapor in the rainfall area at the lowest level is small associated with low temperature.
- Amount of water vapor in the updraft area at the middle levels are large.

Space-borne GPS occultation technique

Vertical profiling of water vapor and temperature using space-borne occultation technique is being examined to use in the global numerical model of JMA in accordance with launching of new satellites. It is expected that accuracy of forecasts in data-sparse regions will be improved.



Issues for operational use of GPS meteorology

- to obtain GPS signal from GPS stations in real-time,
- to obtain accurate information on orbits of the GPS satellites,
- to obtain vertical profile of water vapor particularly at the lower troposphere for numerical prediction of severe rainfall events,
- to obtain distribution water vapor over ocean.