Primary Cosmic Ray Group

Hiroko Miyahara (ICRR)

Scientific objectives

- Mechanism of long-term variations of solar dynamo (11yrs, 22yrs, 1000 yrs, 2000 yrs)
- Long-term changes in the heliospheric environment and incident Galactic Cosmic Rays (GCRs)
- Response of climate system to the GCRs variations (decadal to millennial)
- Effects of GCRs on cloud micro physics

Collaborators

- Univ. of Tokyo (7)
- Yamagata Univ. (4)
- Tokyo Tech (3)
- JAMSTEC (2)
- Nagoya Univ. (2)
- Osaka City Univ. (2)
- Natl. Inst. Polar Research (1)
- NAOJ (1)
- Hirosaki Univ. (1)
- Shinshu Univ. (1)
- Osaka Pref. Univ. (1)
- Aichi Univ. Tech. (1)
- Chubu Univ. (1)
- NASA/Goddard Space Flight Center, USA (2)
- Tata Inst. Fundamental Research, India (1)
- Jomo Kenyatta Univ. of Agriculture and Technology, Kenya (2)
- Kimathi University, Kenya (2)
- Kenya Meteorological Department, Kenya (1)

(35 members in total)

Experiments and Instruments

- Cosmogenic nuclide measurements

  Tree-ring C-14 (annual resolution)

  Antarctic Ice core Be-10 (annual resolution)

  Accelerator Mass Spectrometers at Univ. Tokyo and Yamagata Univ. are used.

- Paleo-climate reconstructions

  Tree-ring Oxygen-18 (annual resolution, Relative Humidity (RH) index)

  Tree-ring Carbon-13 (annual resolution, Temperature index)

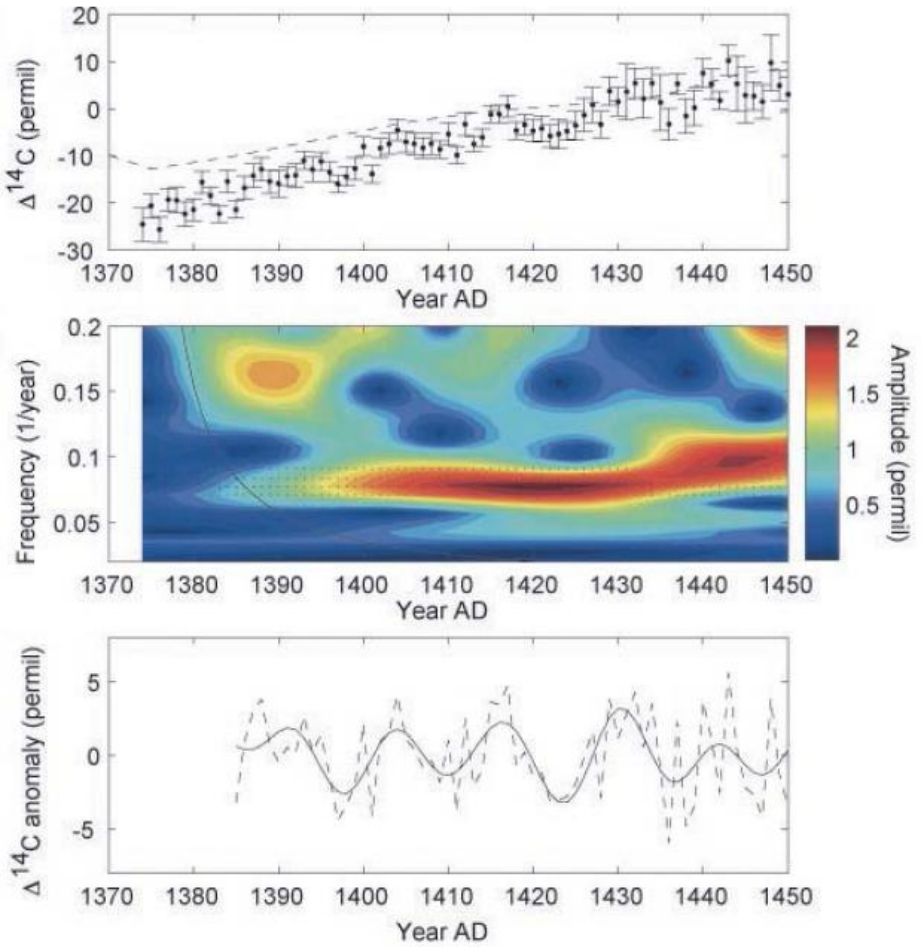
  TCEA Isotope ratio mass spectrometers at Tokyo Tech. and Nagoya Univ. are used.

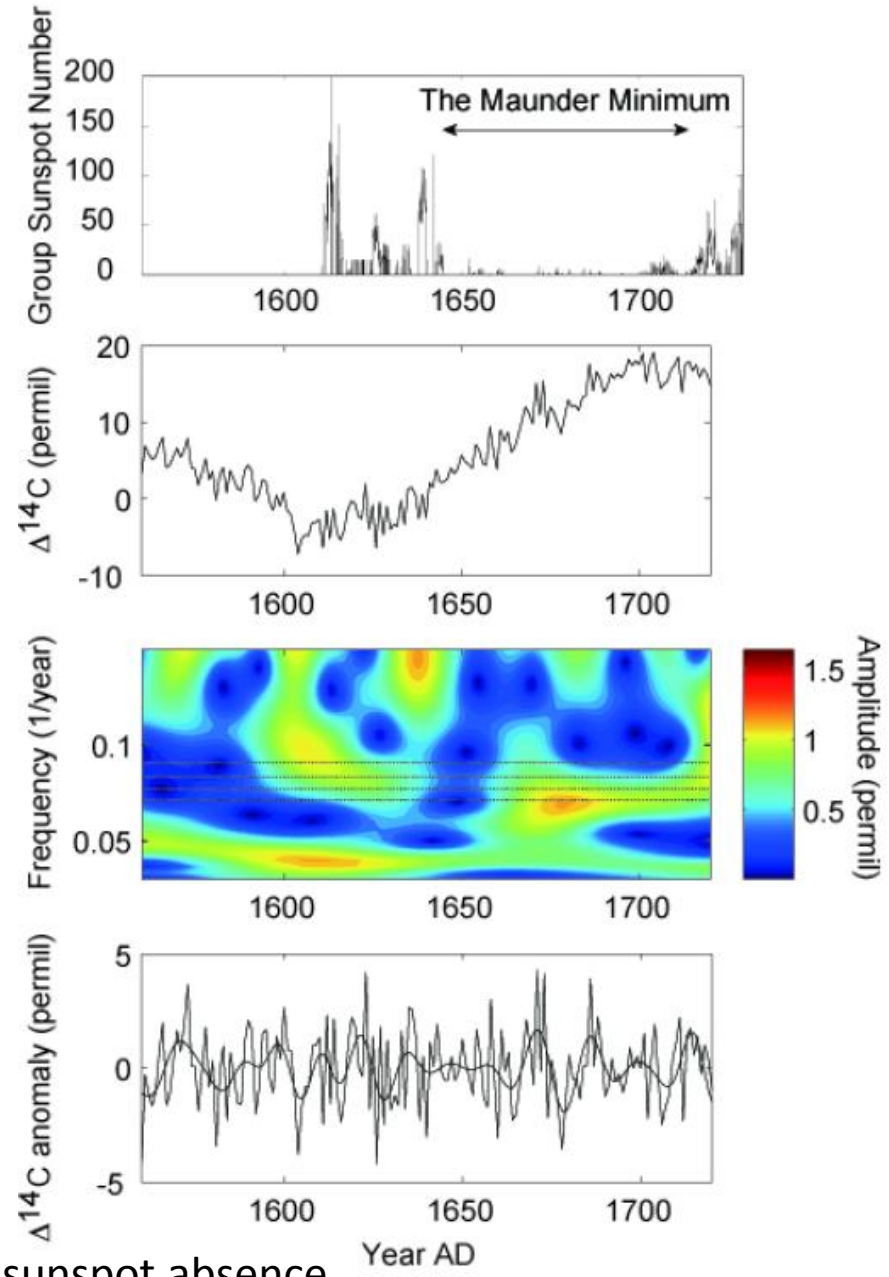
- Observation of cloud properties

  All sky camera for monitoring the tropical convective cloud activities in relation to solar flares & Forbush Decrease events (as R&D for future LIDAR/Satellite observations of clouds)

Scientific results

- Cosmogenic nuclide measurements





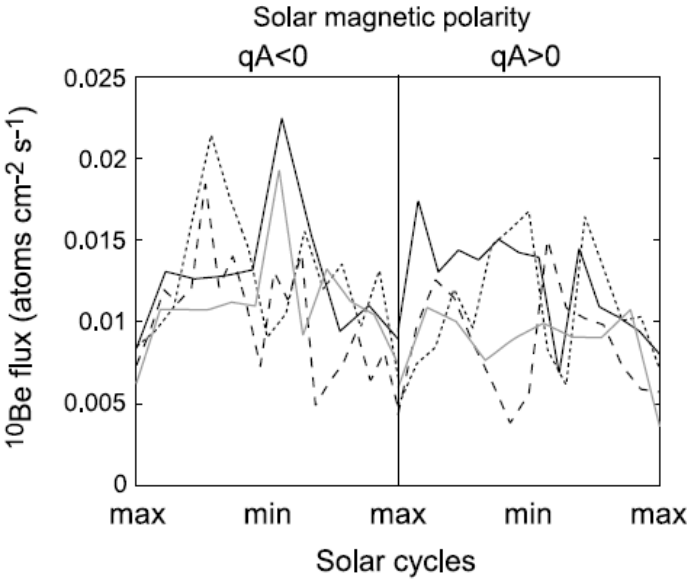
Our findings

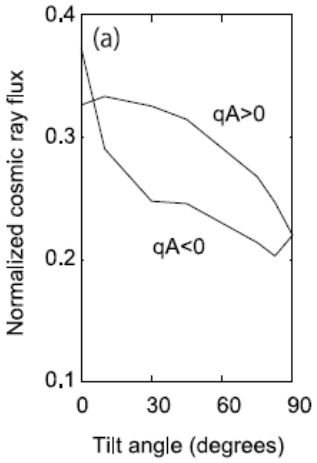
- 14-year solar cycles at the periods of prolonged sunspot absence
- 28-year magnetic polarity reversals
- Two lengthened solar cycles before the onset of events

Miyahara et al., 2004; 2008; 2010

Scientific results

- Cosmogenic nuclide measurements





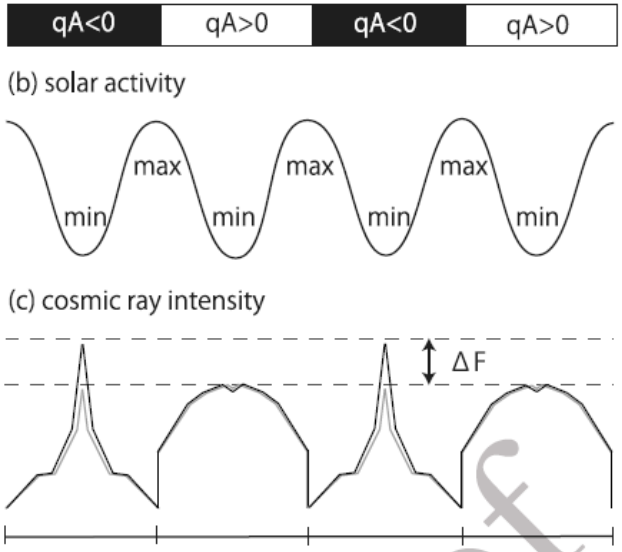


Figure 4. A schematic illustration summarizing the theoretically suggested time profile of incident cosmic rays at the Earth. (a) Incident cosmic rays at the Earth calculated based on standard drift theory for qA > 0 and qA < 0 phases as a function of the tilt angle of heliospheric current sheet [*Kota and Jokipii*, 2001]. (b) Solar activity cycles and (c) the predicted time profile of incident cosmic rays where black line is for the case when the tilt angle reached to 0 degrees at solar cycle minima and to 75 degrees at cycle maxima, while gray line is for the case when the tilt angle reaches only to 5 degrees at cycle minima, which is usual for present observational era. The anomaly ΔF (ratio of maximal flux at qA < 0 to maximal flux at qA > 0) as predicted by stand drift theories is about 15–20%, whereas the observed in ^{10}Be flux is about 30–40%.

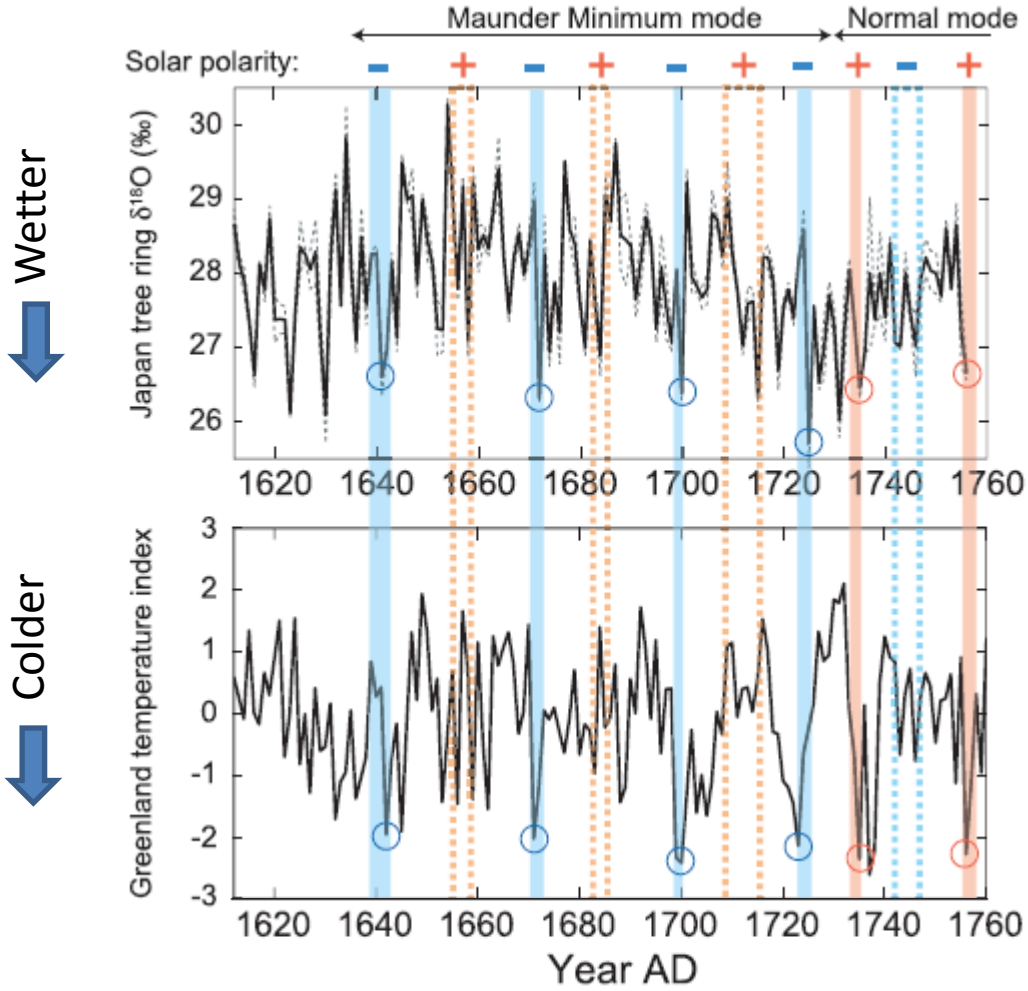
Our findings

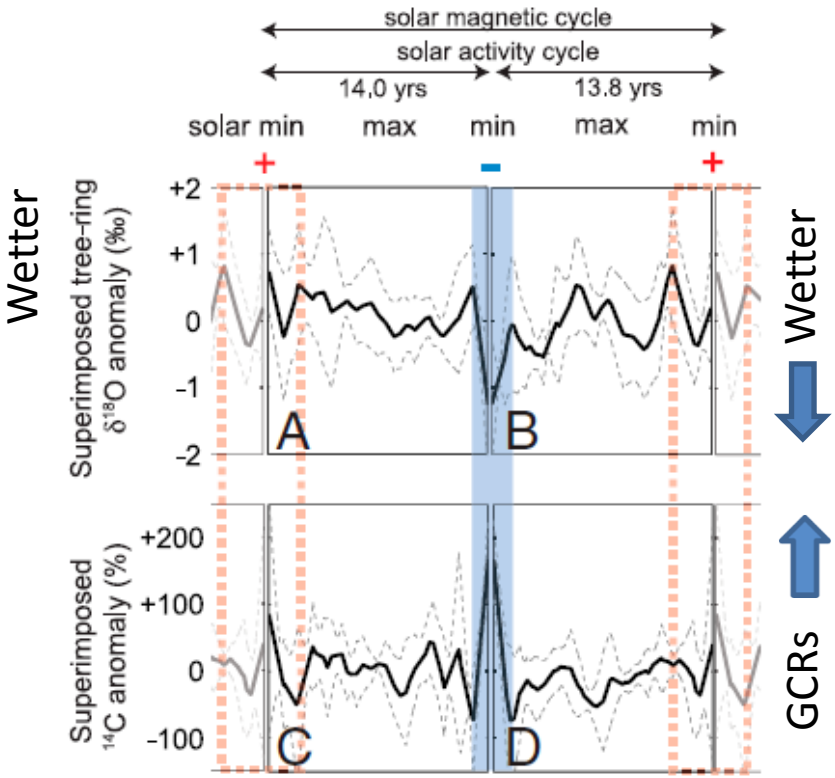
- Amplified GCR Hale cycles at the Maunder Minimum (AD1645-1715)
- 40% enhancement at the cycle minima of qA<0
  (possibly due to more flattened heliospheric current sheet)
- Possible contribution of heliosheath

Miyahara et al., 2009;
Kataoka, Miyahara & Steinhilber, 2012

Scientific results

- Paleo-climate reconstructions





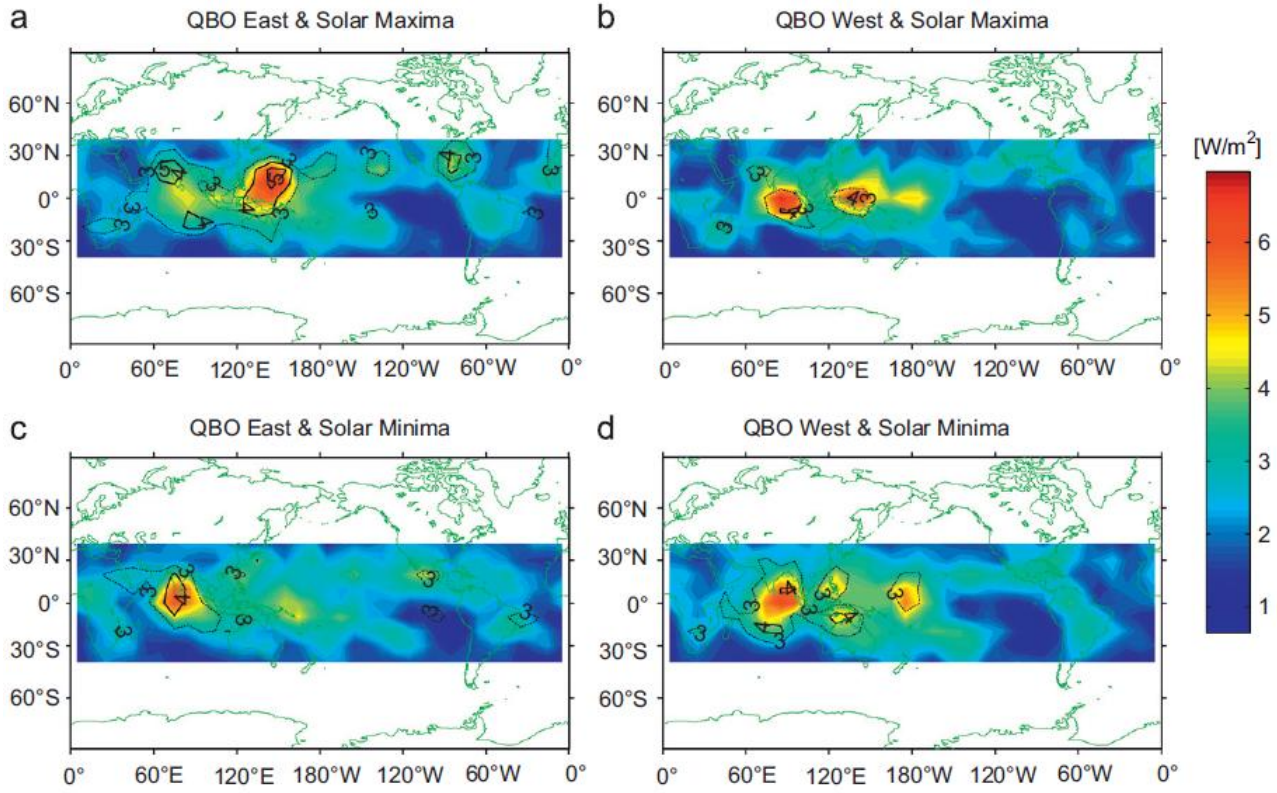
Our findings

- Dependence of climate on solar magnetic polarity (Hale cycle) at the Maunder Minimum
- Synchronized response over the northern hemisphere

Yamaguchi, Yokoyama & Miyahara et al., PNAS 2010

Scientific results and R&D for future observation

- Observation of cloud properties



27-day period in cloud height (Outgoing Longwave Radiation)

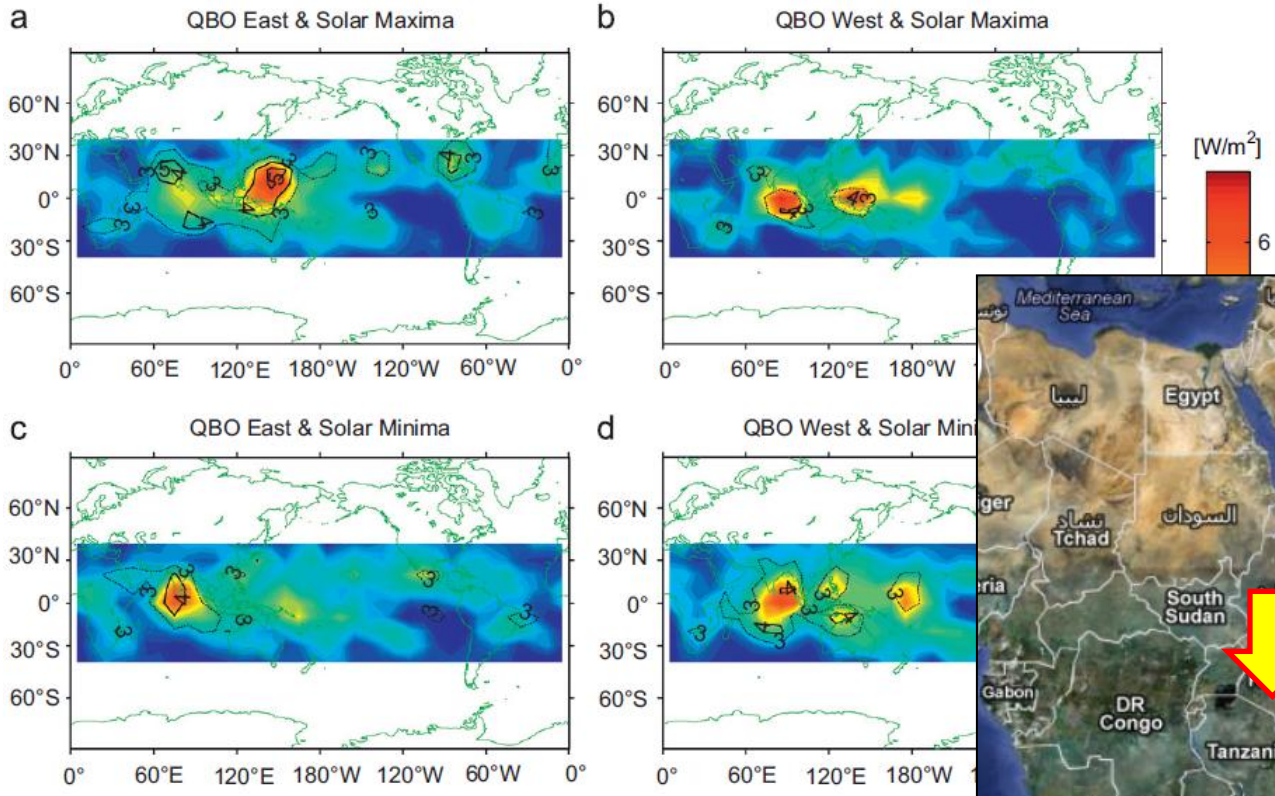
Our findings

- Localized influence of 27-day solar rotational period on tropical convective cloud activities
- Dependence on 11-yr solar cycles & Quasi Biennial Oscillation in stratospheric wind direction

Takahashi et al., 2010, Hong & Miyahara et all., 2011

Scientific results and R&D for future observation

- Observation of cloud properties



27-day period in cloud height (Outgoing Longwave Ra

(Nairobi Kenya,
Nyeri Kenya,
Mt. Ooty India)

Our findings

- Localized influence of 27-day solar rotational period on tropical convective cloud activities
- Dependence on 11-yr solar cycles & Quasi Biennial Oscillation in stratospheric wind direction

Takahashi et al., 2010, Hong & Miyahara et all., 2011

Current status & Future prospect of GCR-climate research

- Evidences of cosmic-ray impact on climate from paleo-climate reconstructions (Maunder Minimum, Geomagnetic reversal, Galactic spiral arms)
- Experimental support for cosmic-ray impact on the production of cloud condensation nuclei by "cloud" chamber (e.g. CLOUD experiment @CERN)
- Observations of altitude distributions of the density of cloud condensation nuclei & particle size constrain the mechanisms of GCR impact