Schumann Resonance: a latest wonder for climate forecast !

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Abstract

Enhanced tropical convection is associated with increased upper-tropospheric relative humidity. The positive co-relationship between deep convection and upper-tropospheric humidity is observed for both regional and temporal variations over a wide range of space and time scales. The regions of increased upper-tropospheric moisture are found to be strongly correlated with an enhanced greenhouse trapping, although the effects of lower-tropospheric moisture and temperature lapse rate are also observed to be important. The greenhouse effect of water vapour increases sharply when temperature increases, leading to a positive feed back for climate change.

Upper-tropospheric water-vapour (UTWV) variability and global lightning activity are closely linked suggesting that upper-tropospheric water-vapour changes can be inferred from the records of global lightning activity. The continental deep-convective thunderstorms could transport large amount of water vapour into the upper troposphere, which would dominate the variations of global UTWV while producing most of the lightning on Earth. Global lightning produces Schumann resonance modes, which are trapped in the Earth-ionospheric waveguide. As there are approximately 50-100 lightning flashes per second around the globe, the variability of the intensity of the Schumann resonances represents a continuous measure of the variability of global lightning activity which is dependent on UTWV.

Thus monitoring of SR would provide a tool for time-tracking UTWV changes which will contribute to a better understanding of the processes affecting climate change. The correlation between troposheric water content and Schumann Resonance field can be explored using data of several years, which is still lacking to the world researchers. From the observed nature of correlation of time series data, a model will be built which will be made useful to forecast the water vapour content from the observed value of Schumann Resonance data. Climatic condition would be forecasted using SR data with the sequence below:

SR data $\Rightarrow$ Water vapour content $\Rightarrow$ climate forecasting

1. Introduction

Water vapour is the principal greenhouse gas and plays pivotal role in regulating the Earth's climate because it is a dominant infrared absorber in the atmosphere. The relatively small amount of water vapour in the upper troposphere has a large impact on climate variation [1, 2, 3]. The impact of water vapour on climate arises primarily from the water vapour of the upper troposphere. In spite of its large importance, the upper tropospheric water vapour concentration has been rarely quantified in the past. Standard radiosonde humidity sensors are not much reliable at temperatures below -40°C [4, 5]. Satellite-borne sensors have provided informations about the mid and lower-tropospheric water vapour concentrations [6]. The global statistical information on relative humidity in the upper troposphere is unavailable. Conventional observations using radiosondes provide only limited spatial coverage and are questionable with respect to reliability in the upper troposphere. Consequently, a clear understanding of how changes in deep convection modify the moisture content of the upper troposphere has remained illusive. Variabilities of water vapor and clouds are central problems to global hydrological and energy cycles [7]. The latent heat release associated with phase transitions among gas, liquid and solid forms of water is one of the main modes of energy transport in the atmosphere. Besides their active roles in moist dynamics, water vapour and clouds both have important radiative effects [8].

Price showed that upper-tropospheric water-vapour variations can be inferred from the records of global lightning activity [9, 10]. Due to this, the continental thunderstorms could transport large amount of water-vapour into the upper troposphere which would dominate the variations of global UTWV while producing most of the lightning on Earth.

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Global lightning produces Schumann Resonance which can be recorded. Each lightning discharge emits electromagnetic radiation at all frequencies and in all directions. The lower the frequency of the radiation, the less the attenuation of the electromagnetic waves in the atmosphere, and the greater would be the propagation distance. At extremely low frequencies (1 - 100 Hz), the radiation can propagate a few times around the globe before dissipating. Barr et al. [11] described in detail the history and development of Schumann resonances. The SR are produced by electromagnetic radiation from lightning being trapped in the Earth-ionosphere waveguide. At extremely low frequencies (ELF), very little attenuation occurs, allowing these radio waves to propagate a few times around the globe before dissipating totally. Constructive interference produces standing resonant waves at around 8, 14, 20, 26, ….Hz, where the 8 Hz mode represents a wave with wavelength equal to the circumference of the Earth (40,000 km). As there are large number of lightning flashes per second around the globe, the changes of the intensity of the Schumann resonances represents a continuous measure of the changes of global lightning activity which is dependent on UTWV. It is Known that ELF data and NASA Water Vapour Project UTWV data are in good agreement with each other (correlation coefficient, r = 0.76) [9].

The sensitivity of this relationship implies that for every 0.25mm increase in UTWV (1% of total column), the ELF signal will increase by approximately 25%. A relatively simple and cheap method for continuously observing global lightning variability is the use of Schumann resonances. Thus monitoring of SR might provide a tool for time-tracking of the upper-tropospheric water-vapour changes which will be made useful to the processes involving climate change.

2. Retrieval of UTWV Concentration

Both lightning and Upper Tropospheric Water-Vapour are linked to the strength of the convection in the tropics. These are well-correlated. Schumann resonance (SR) intensity and UTWV are also well related. Such connection would exist because SR is one of the indicators of the Global Lightning Intensity. Global Lightning Intensity is connected with the zones of strong precipitation.

Thus the variation of SR Intensity during thunderstorm and other natural phenomena like Cyclone, Typhoon etc. if be recorded in the time series for long periods, from the nature of variations, the climatic change would be expected to be associated.

The retrieval of Tropospheric Water-Vapour concentration can be achieved through the continuous magnetic intensity measurements of SR spectra. During the existence of water-vapour, there will be a more charge separation followed by instantaneous recombination processes with the generation of EM radiation at the cost of thermal energy during the process of re-combination. These excess EM energy on the surface of the tropospheric zone will influence the SR magnetic records in a varying manner depending upon the intensity of charge separation process. This is similar to the physical situation that occurs in the production of sprites.

The measurement of water-vapour concentrations by means of equipment on a satellite is one of the most recent alternatives to ground-based measurements. Satellites fly over every point of the Earth within the time frame of a couple of days, and can therefore give full coverage of the global water-vapour concentration over the Earth's surface.

ENVISAT : Envisat – MERIS, Envisat – MIPAS and Envisat - SCIAMACHY
Data availability : ESA
For information on ENVISAT data products and availability, one can see http://envisat.esa.int/dataproducts/.
NEODC/BADC
Data from MERIS, MIPAS, GOMOS and SCIAMACHY are available from the NEODC to registered users.

3. Study of Schumann Resonance

For the observations of Schumann resonance spectra, centrally circular square-loop antenna has been erected on the ground at a vast bare land nearby Kolkata. Two such loops have been mounted on wooden structures connected in series and their effective gain is increased beyond 5 dB with this arrangement. A wide-band very low input voltage sensitive and low frequency sensitive receiver has been designed, which can detect input signals from 100 μV to 500 μV.

First the raw data are stored in time domain. Then the data signals are passed through different filters designed in the programme. The outputs of these are stored and the discrete Fourier transform (DFT) of the receiver data are performed by using fast Fourier algorithm to get the result in the frequency domain. Different peaks of Schumann resonance are observed around. The results bear resemblance with earlier work done in this field.

The monthly intensity variations due to global thunderstorm activities obtained from Schumann resonance amplitude have been investigated. It is seen that the intensity fluctuation of SR modes is directly related to the variation of thunderstorm activity. Intensity reaches maximum value during summer, which agrees with the results of earlier works. The influences of global thunderstorm activity zones for the three modes of SR are different, for which the annual intensity variations at these two latitudes are different. The global variations of thunderstorm activity centers throughout the year introduce fluctuations in dielectric property and anisotropic conductivity within the cavity. Thus, there will be variations of source-receiver distance as well as the activity of the centers at the receiver which generally introduce seasonal and temporal frequency shifts in the different SR mode, particularly in the first mode. The results obtained have been compared with those by other stations around the world.

4. Discussion

Despite its low measured value, upper tropospheric humidity (UTH) plays an important role in the trapping of longwave radiation emitted from the Earth and may have a strong influence on greenhouse warming. Whether UTH plays a positive or negative role in greenhouse warming is still under debate [1, 2, 12,] and most of these studies focussed on tropical areas and very few explorations are made on extratropical regions. Although water vapor integrated over the atmospheric column can be accurately derived over the ocean from the Special Sensor Microwave Imager (SSMI) [13], measuring UTH in a global basis is difficult. Recently, preliminary measurements of UTH by the microwave Limb Sounder (MLS) on the Upper Atmosphere Research Satellite (UARS) are available [14]. While the geographical distribution of the greenhouse effect over the tropical oceans is mainly controlled by the local sea surface temperature (SST), the cause of greenhouse warming distribution is more complicated over midlatitude oceans. Despite the fact that the water vapor distribution in the extratropical upper troposphere is much smaller than that in the tropics and in the lower troposphere, the analysis of UTH data obtained from the MLS reveals the importance of water vapor in trapping the Earth's longwave radiation. It was found that the UTH from the MLS is enhanced over the storm tracks in the North Pacific and North Atlantic, collocating with an increase in the greenhouse warming. The mechanism of observed enhancement in UTH over the storm tracks seems to be associated with the increase in the amount of deep convective clouds. Schumann resonance observations also show a strong correlation with upper troposphere water vapour which, further emphasizes the temperature-dependence of thunderstorms, and, possibly, electrified shower clouds. So, from long term data of Schumann resonance, it will be possible to know the trend of change of global status of UTWV/UTH. Such a change may be used to predict climatic change to occur. For this purpose, as we feel, still no complete model exists. Hence, it is a future task to the researchers to establish models which can be used to predict the trend of climate change on the basis of SR data collected over a long term. It is apparent that such a model should involve surface temperature data which are easily available throughout the world.

Except some short term variation due to solar flares or due to solar proton events, the SR variations are independent of centre of observations. Hence the SR can be monitored from a single position. Furthermore, simultaneous measurements of ELF on opposite sides of the globe show remarkable agreement. Figure 1 shows Schumann Resonance as a global parameter [15].

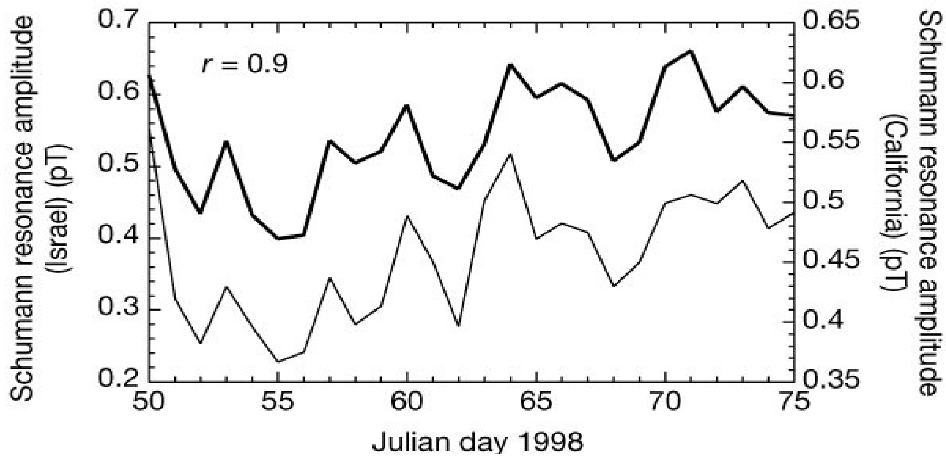

Figure 1. Schumann Resonance as a global parameter [9]

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