

More frequent cloud-free sky and less surface solar radiation in China from 1955 to 2000

An article by

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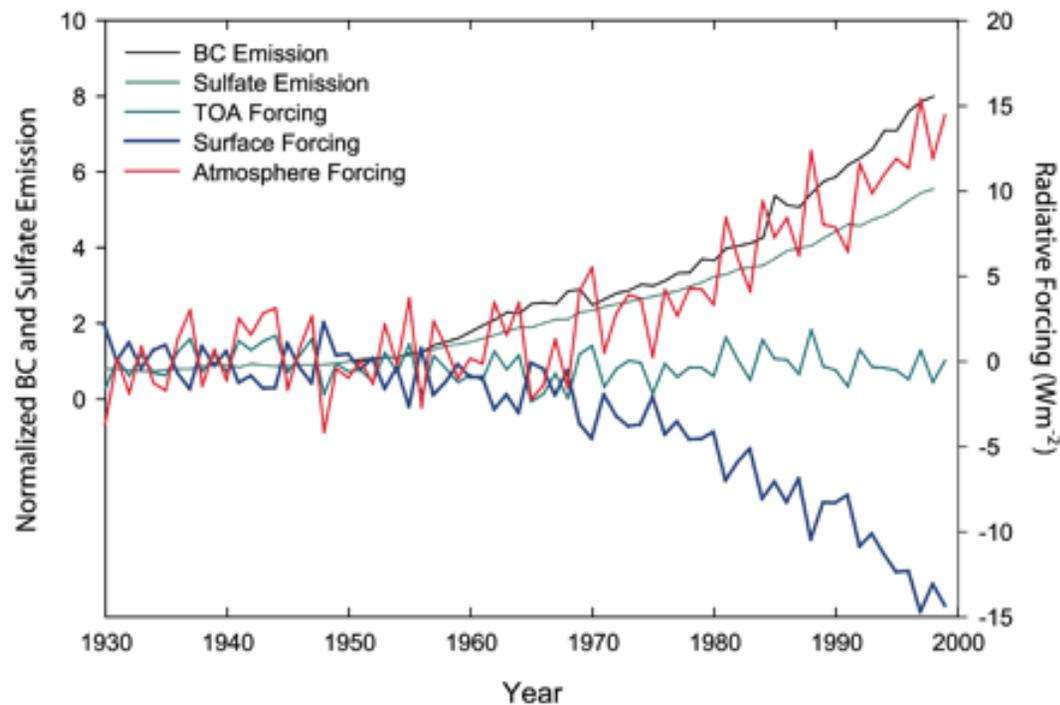
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The basis of the question

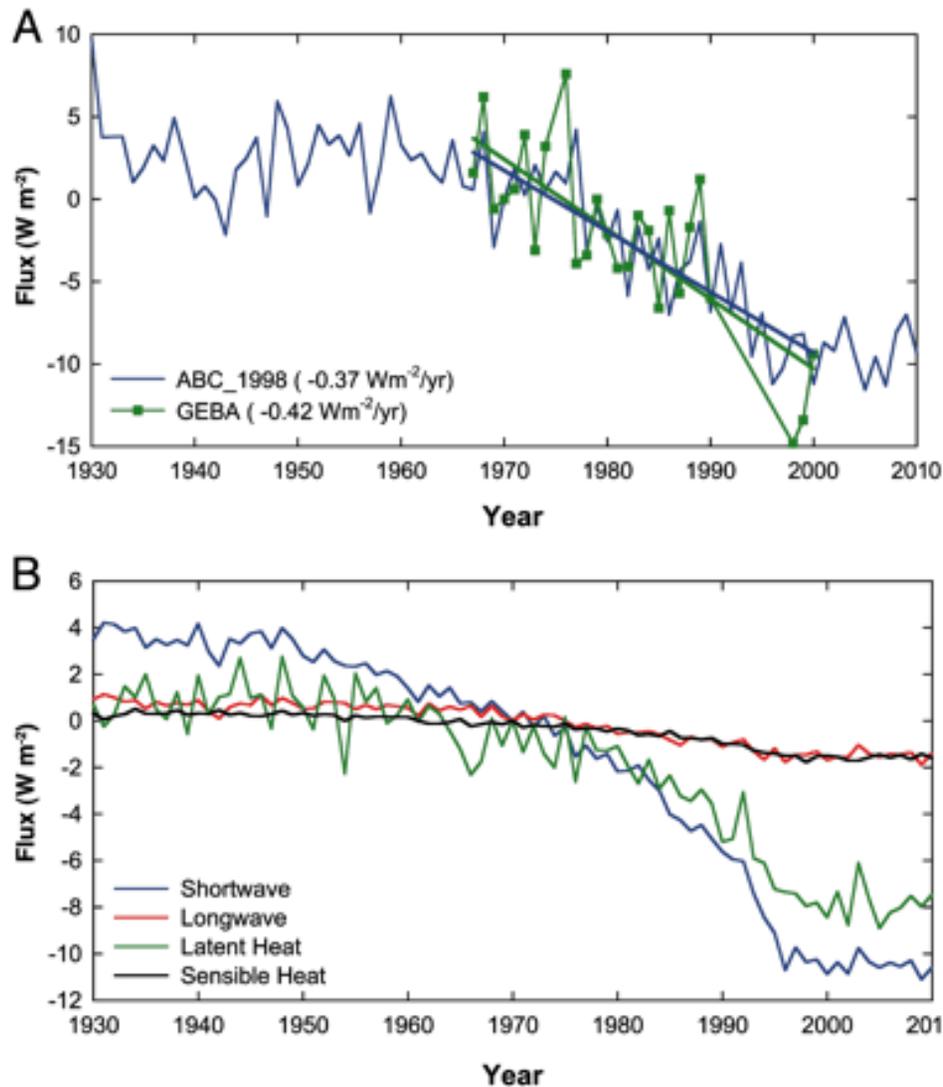
- Central and eastern China experienced cooling trends
- Attributed to decrease in daily maximum temperature
- Correlated observations
 - downward trend in sunshine duration, solar radiation and diurnal temperature
- Question: Increased cloud cover reducing sunlight and daytime temperatures? No.
 - In south Asia a study showed the impact of a 3 km thick brown haze formed during the dry season

Emissions and forcing terms for S Asia



- Published estimates of the emission of SO₂ (18) and BC (19) are normalized. The changes in the net solar fluxes at the surface, at top of the atmosphere and net solar heating of the atmosphere are taken from climate model (PCM) simulations. The forcing is for annual mean conditions for all of South Asia and NIO (0° to 30°N and 60°E to 100°E). The interannual variations in the forcing are due to variations in cloudiness. [Ramanathan et al 2005]

Decline in surface radiation in S Asia

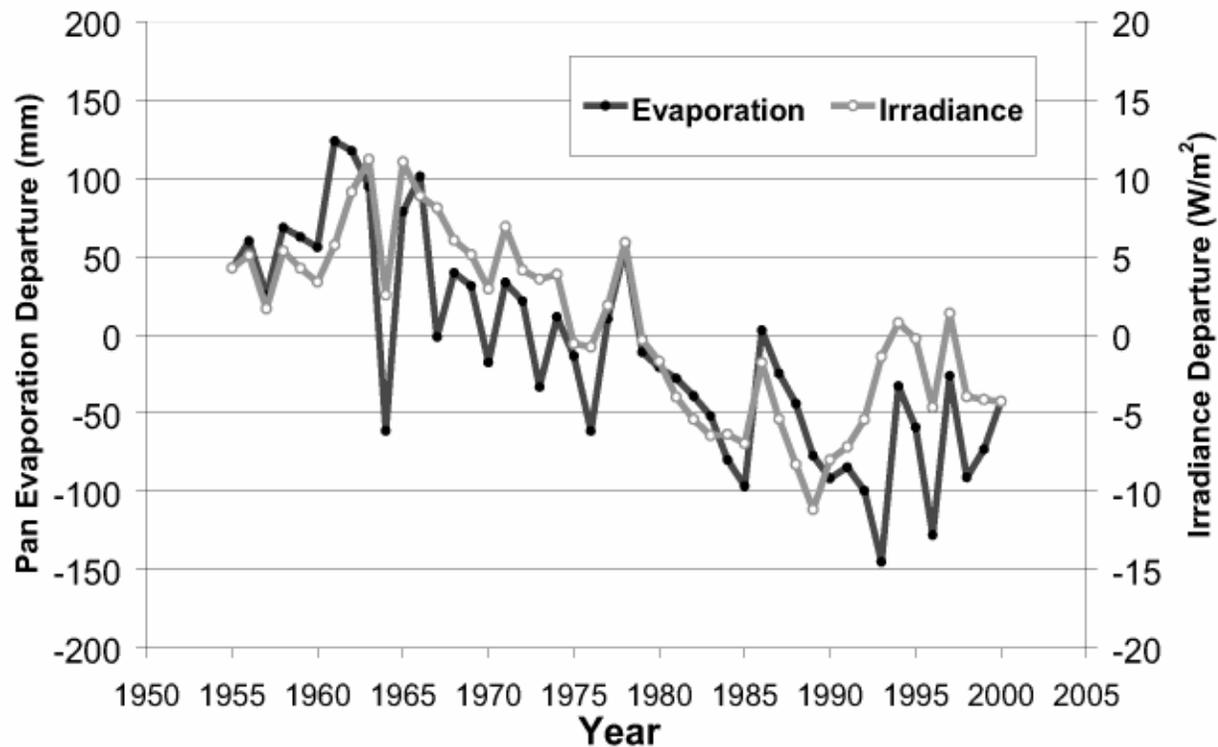


- Time series of surface heat budget terms.
- (A) Simulated (blue) and observed (green) annual mean solar fluxes for India at the surface. The fluxes are for average cloud conditions. The simulations are averaged over 5°N to 25°N and from 70°E to 90°E . The observed values are from 10 surface stations distributed between eastern, western, northern, and southern India. The trend in Global Energy Budget Archive is $-0.42 \text{ W}\cdot\text{m}^{-2}$ per year, and the trend in the ABC_1998 run is $-0.37 \text{ W}\cdot\text{m}^{-2}$ per year.
- (B) The simulated annual mean surface heat budget for the Indian Ocean
- [Ramanathan et al 2005]

Defining parameters and approach

- Defining more reliable cloud cover observation data
 - Total cloud cover (TCC)
 - Cloud free days defined as $TCC < 10\%$
 - Overcast sky defined as $TCC > 90\%$
 - Low cloud cover (LCC)
- 85 stations passed criteria of 537 stations considered
- Evaluate spatial and temporal trends

Significant results

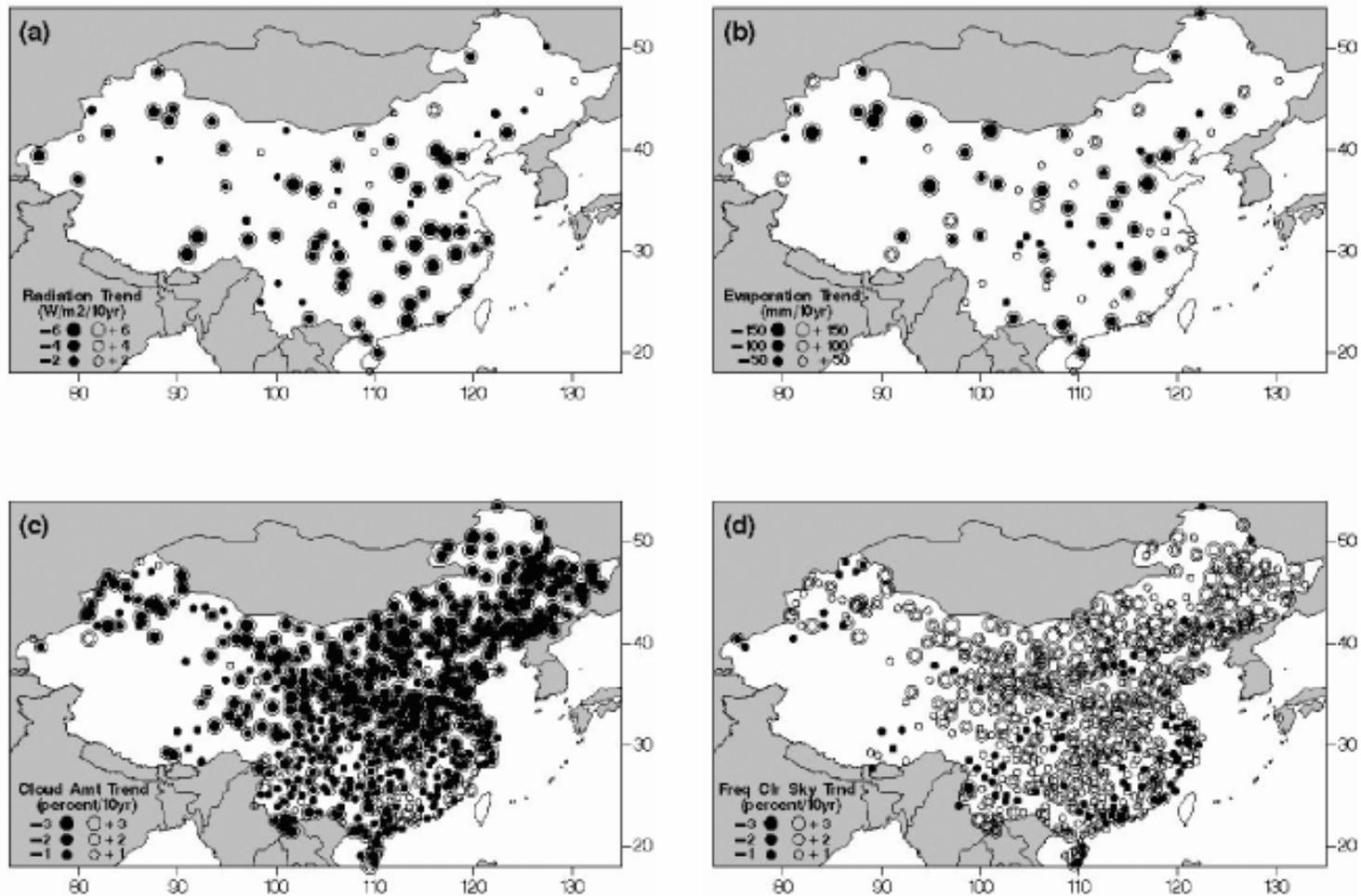


- 2.2% per decade average decline over all stations
 - -39mm per decade of pan evaporation

Regional effects

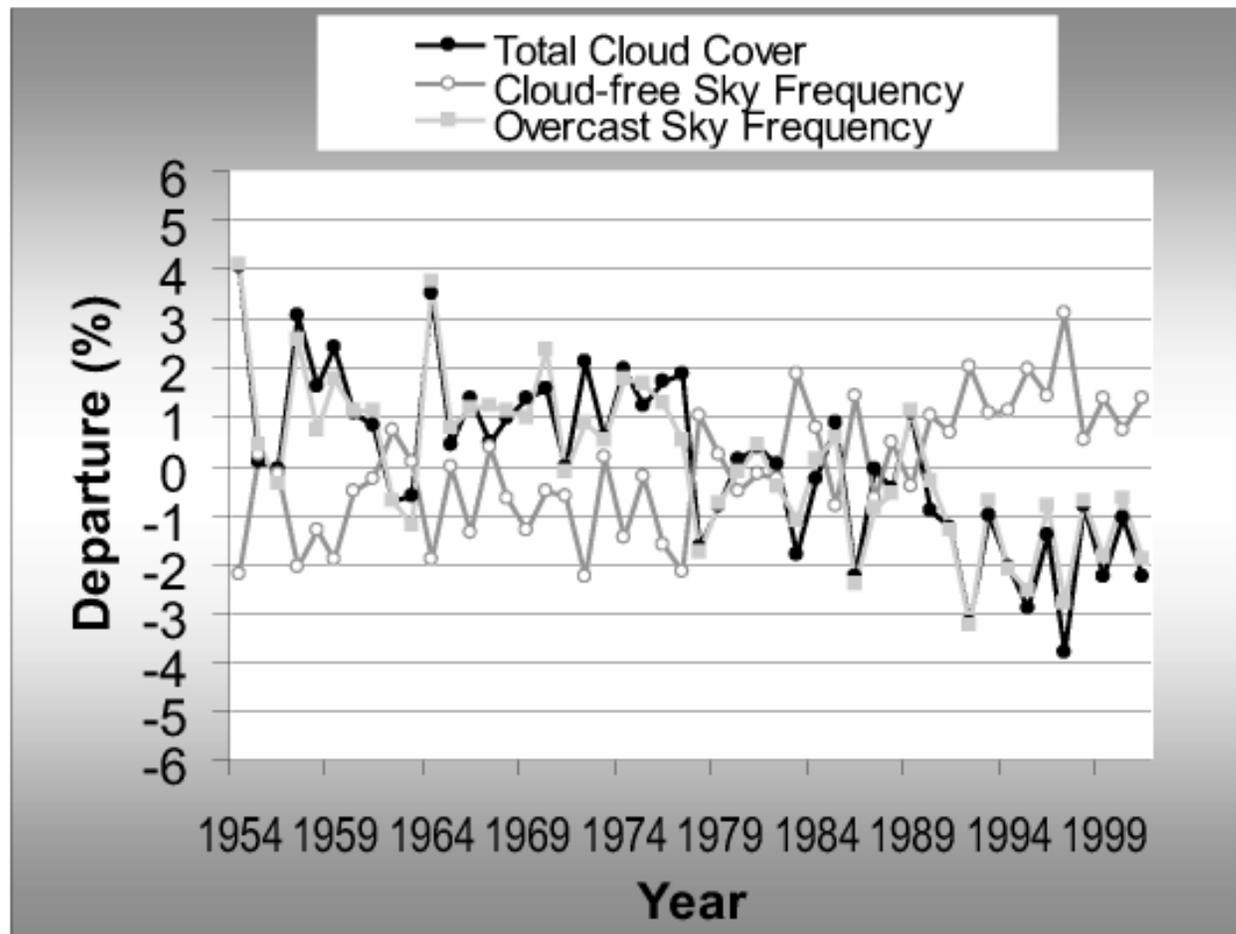
- 1-3% per decade in TCC
- Different trends in Yangtze-Delta region and southern China
 - Pan evaporation also effected by relative humidity and surface temperature
- Southern China seasonal variations different sign
 - Increasing trends winter and spring, and decreasing summer and fall
- Consistent trend when all stations data considered and when LCC considered

Trends in regional effects



- (a) Radiation trend (b) evaporation (c) clouds (d) frequency of clear sky

Looking for validation



- Frequency of occurrence of cloud-free sky (FCFS)

Results in the environmental system of China

- Increased aerosol forcing results in solar dimming at the surface
- Increased solar dimming results in less pan evaporation
- Correlated with reduction in cloud cover and surface temperatures

Paper concludes with two open questions

- Trends of solar radiation and pollutant emissions do not match in the 1990s
- Indirect aerosol effect argues for increased cloud cover for increased aerosols
 - Observed in ship tracks
 - Demonstrates specific local conditions need to be considered
 - Atmospheric stability and moisture which are controlled by large scale circulation

Comments

- Aerosol measurements trends
 - Overall aerosols given but timeline of aerosol trends would be valuable
- Connection between increased aerosols and decreased solar irradiance not conclusive
 - Cites previous work showing decreased sunshine duration, reduced visibility, elevated aerosol optical depth
- Provocative paper
 - Avoids aerosol trends issues