Overview of Techniques for Estimating Surface Solar Radiation from Satellites

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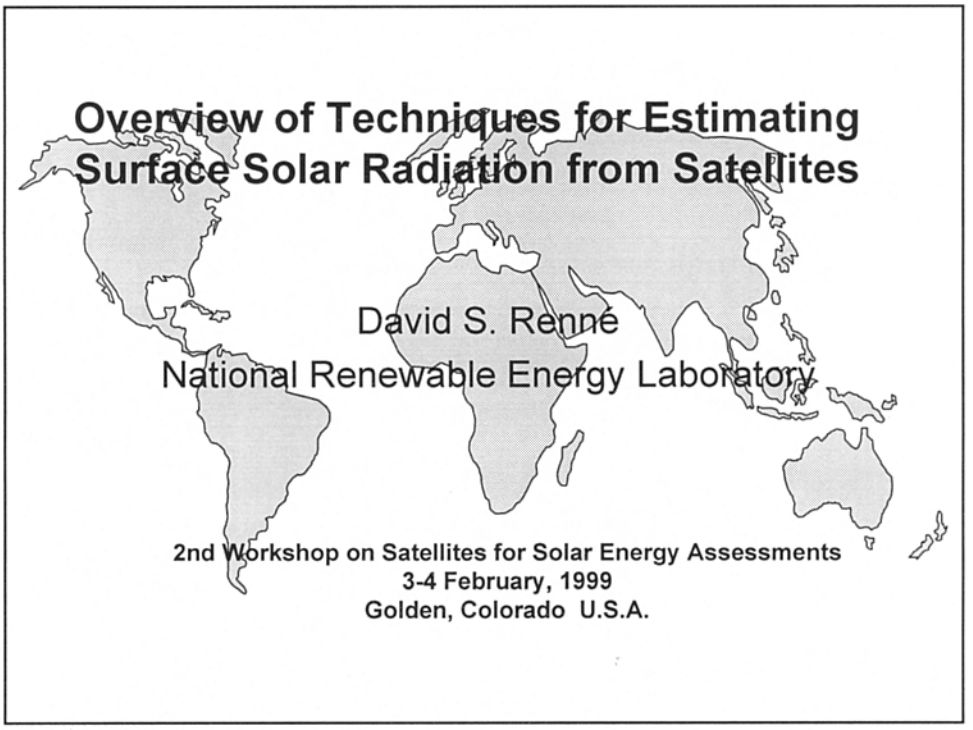
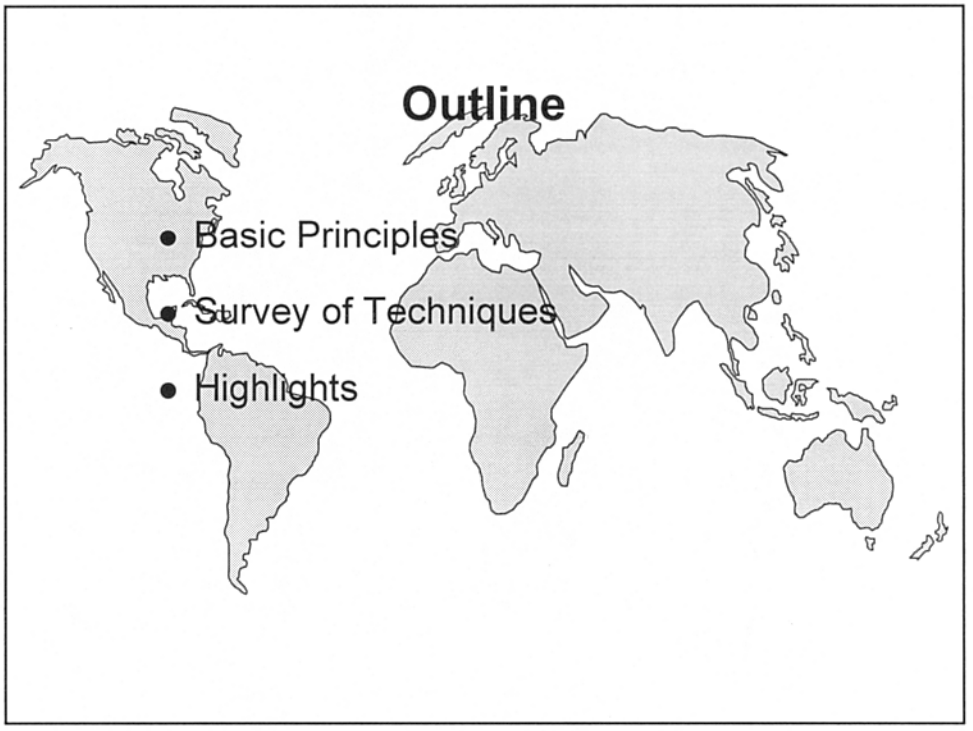
This presentation provides a summary of the use of satellite technology, originally developed for purposes of understanding weather and climate, in determining the distribution and characteristics of the solar resource around the world. Satellite technology allows us to view large areas of the earth's surface at any given time, and provide detailed, high-resolution data on the surface and cloud conditions over these areas. For the past 20 years, researchers involved in satellite image processing have been developing ways of estimating the downward solar flux at the earth's surface from the information "seen" at the satellite platform. This has resulted in new information about the distribution and characteristics of the solar resource that could never be obtained from the limited ground network that is currently available around the world. Such information contributes to the expansion of solar technologies, and for determining new applications of solar technologies in configurations not deemed possible twenty years ago, because of the then lack of key information. The presentation includes a look at why a quantitative understanding of the solar resource is necessary for successful and cost-effective deployment of solar technologies. The main empirical and physical approaches used to convert imagery collected at the satellite to estimates of surface solar flux, and the uncertainties associated with these estimates are reviewed. For the global horizontal solar resource it is seen that, under a variety of conditions, monthly-average daily total satellite-derived estimates can compare with surface measurements to within 10% or so, or even better under clear-sky conditions. The differences between satellite and ground observations can increase under partly cloudy conditions, over coastal or snow-covered areas, or for shorter than monthly averaging times.





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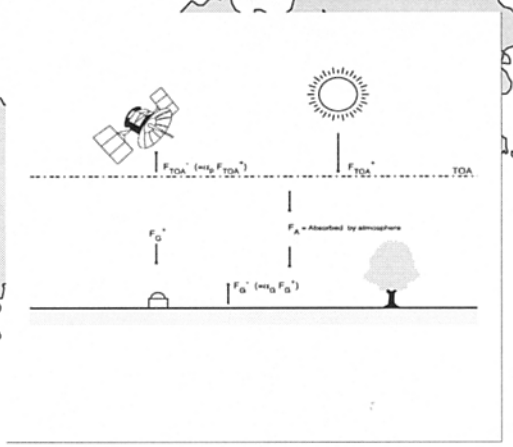
The Fritz, Rao and Weinstein (1964) Relationship

$$F_{TOA}^{+} - F_{TOA}^{-} = F_G^{+}(1 - \alpha_G) + F_A$$

α_G = ground albedo



Sources of Solar Beam Attenuation

- Clouds
- Aerosols
- Water Vapor
- Rayleigh Scattering
- Ozone
- Other Atmospheric Gases

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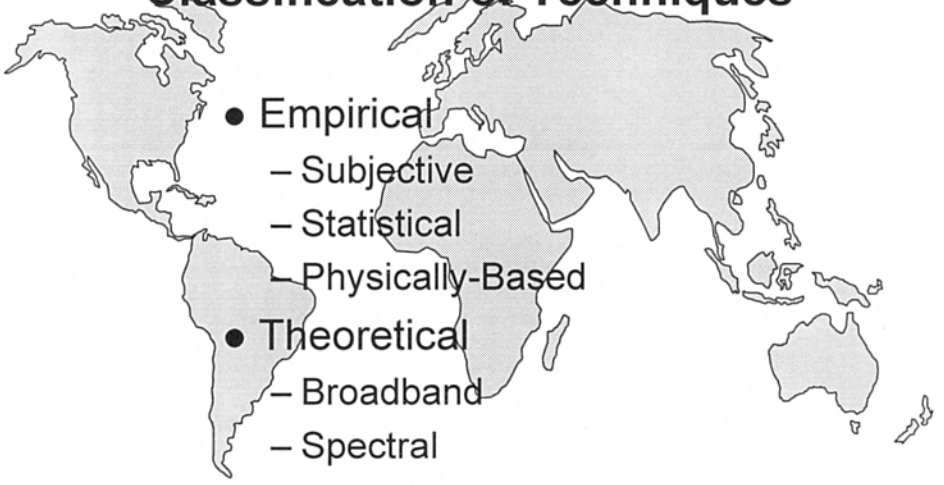
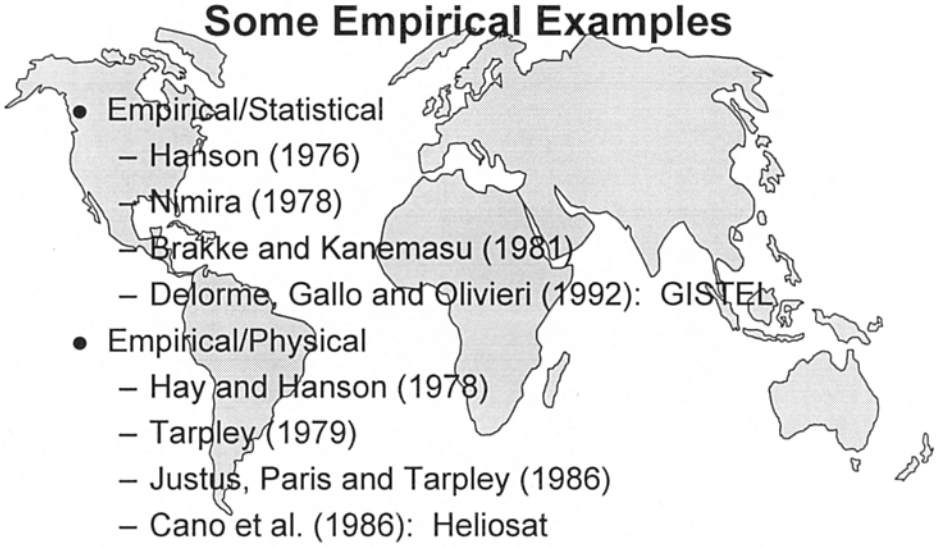
Classification of Techniques



- Empirical
  - Subjective
  - Statistical
  - Physically-Based
- Theoretical
  - Broadband
  - Spectral

Some Empirical Examples



- Empirical/Statistical
  - Hanson (1976)
  - Nimira (1978)
  - Brakke and Kanemasu (1981)
  - Delorme, Gallo and Olivieri (1992): GISTEL
- Empirical/Physical
  - Hay and Hanson (1978)
  - Tarpley (1979)
  - Justus, Paris and Tarpley (1986)
  - Cano et al. (1986): Heliosat

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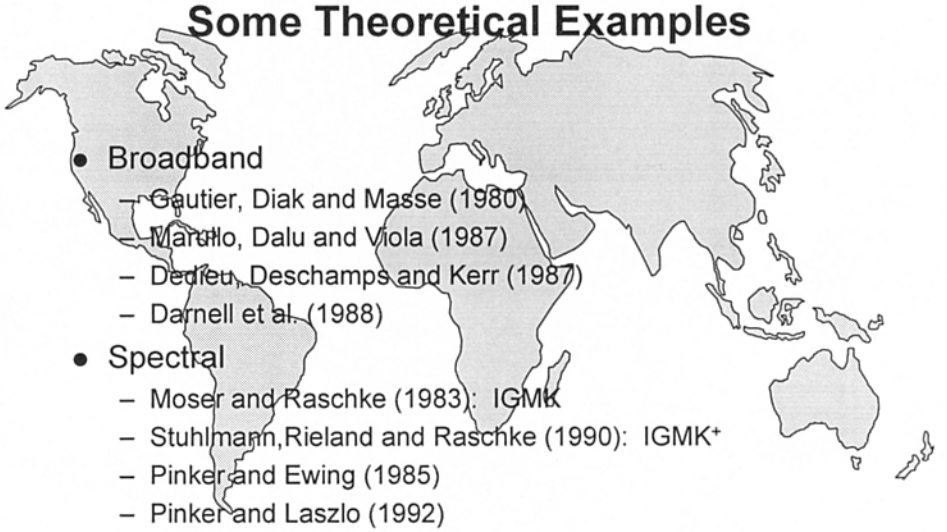
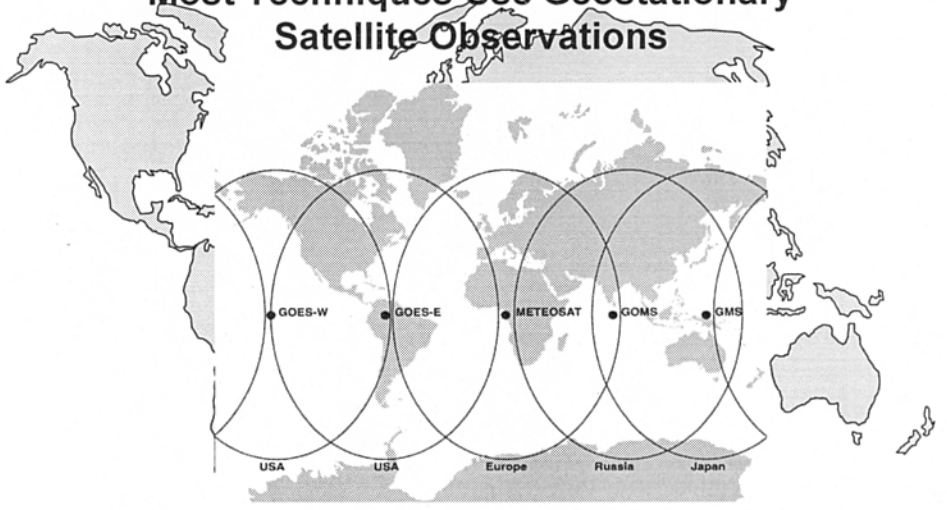
Some Theoretical Examples



- Broadband
  - Gautier, Diak and Masse (1980)
  - Marullo, Dalu and Viola (1987)
  - Dedieu, Deschamps and Kerr (1987)
  - Darnell et al. (1988)
- Spectral
  - Moser and Raschke (1983): IGMK
  - Stuhlmann,Rieland and Raschke (1990): IGMK+
  - Pinker and Ewing (1985)
  - Pinker and Laszlo (1992)

Most Techniques Use Geostationary Satellite Observations



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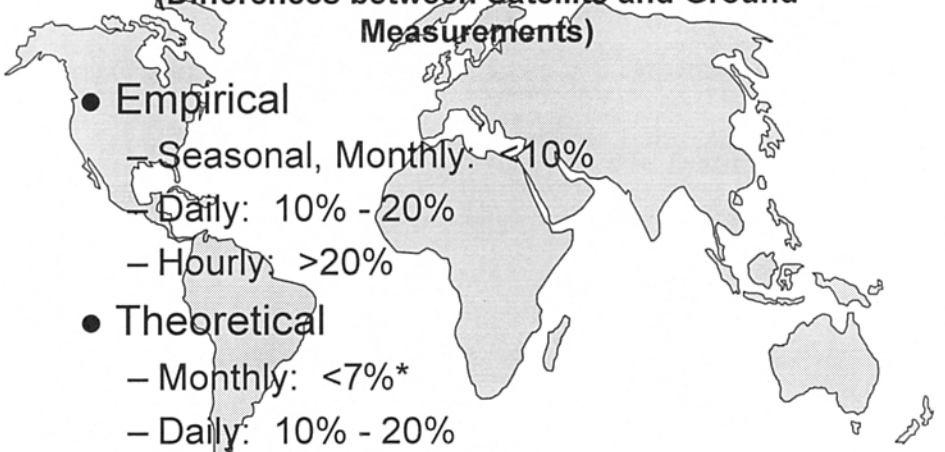
Summary of Results

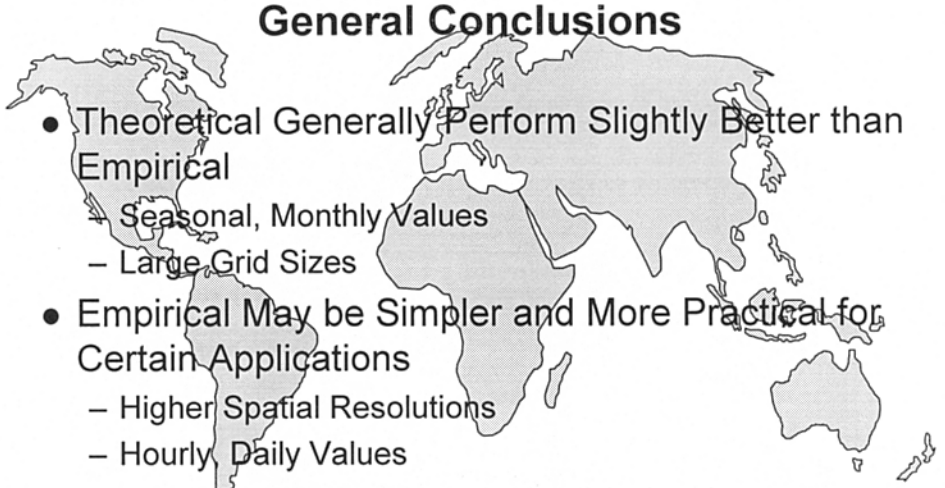
(Differences between Satellite and Ground Measurements)



- Empirical
  - Seasonal, Monthly: <10%
  - Daily: 10% - 20%
  - Hourly: >20%
- Theoretical
  - Monthly: <7%*
  - Daily: 10% - 20%
  - Hourly: 20%

*Higher in some cases, e.g. using Meteosat for Brazil

General Conclusions



- Theoretical Generally Perform Slightly Better than Empirical
  - Seasonal, Monthly Values
  - Large Grid Sizes
- Empirical May be Simpler and More Practical for Certain Applications
  - Higher Spatial Resolutions
  - Hourly, Daily Values
- Surface Measurements for Validation Important

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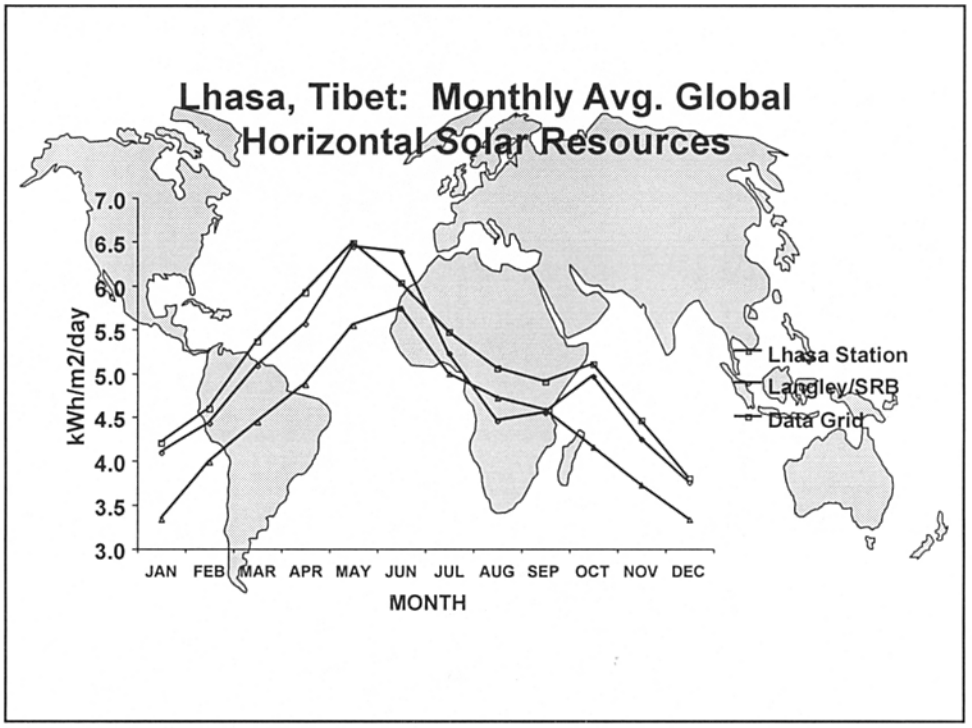

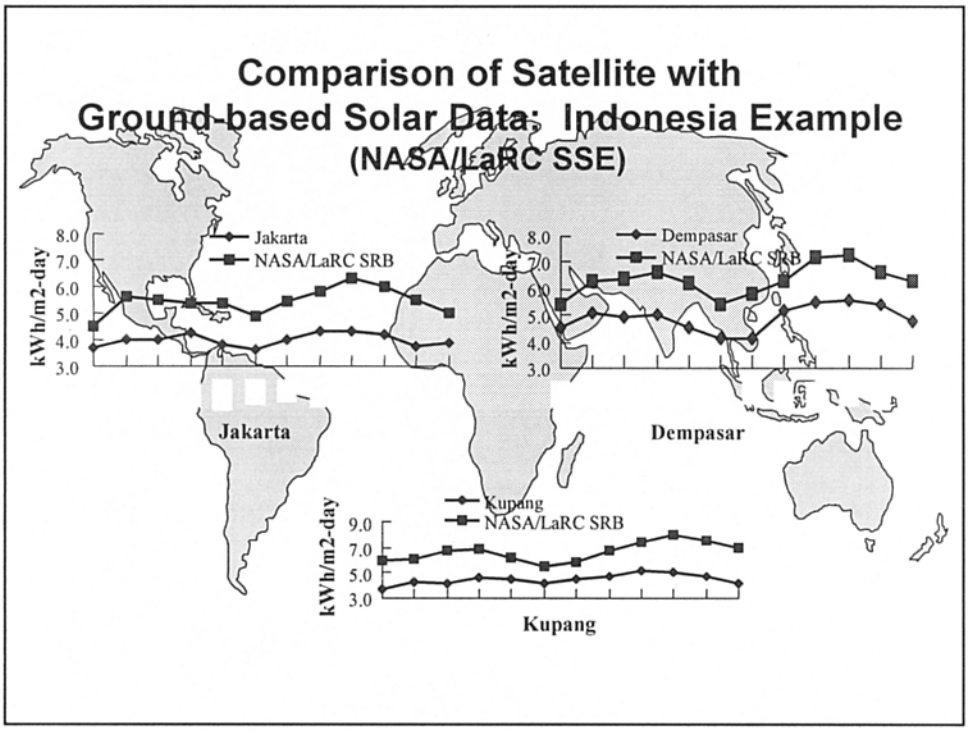

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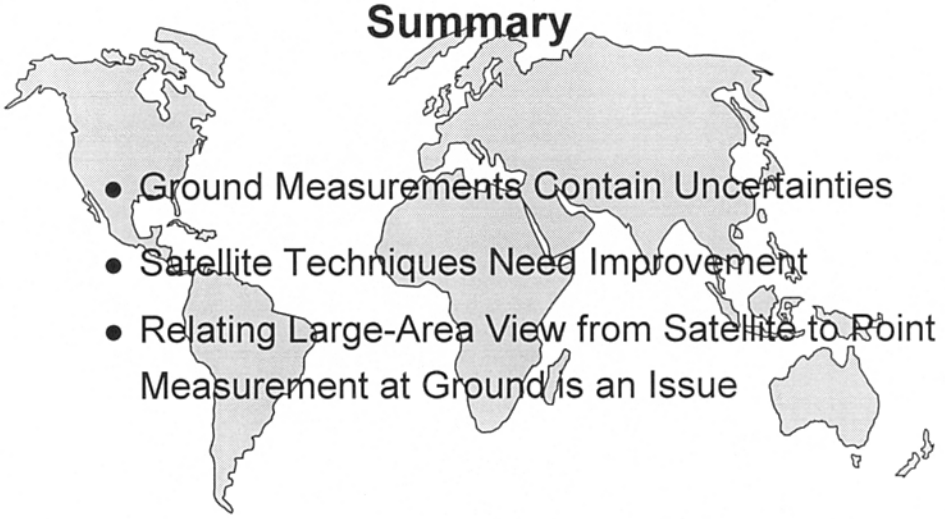
Summary



- Ground Measurements Contain Uncertainties
- Satellite Techniques Need Improvement
- Relating Large-Area View from Satellite to Point Measurement at Ground is an Issue

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