

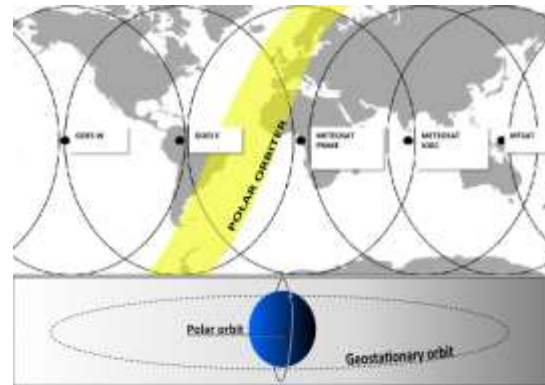
# Renewable Energy and Grid Integration

Dave Renné

*drenne@mac.com*

## NASA Energy Management Stakeholder Workshop

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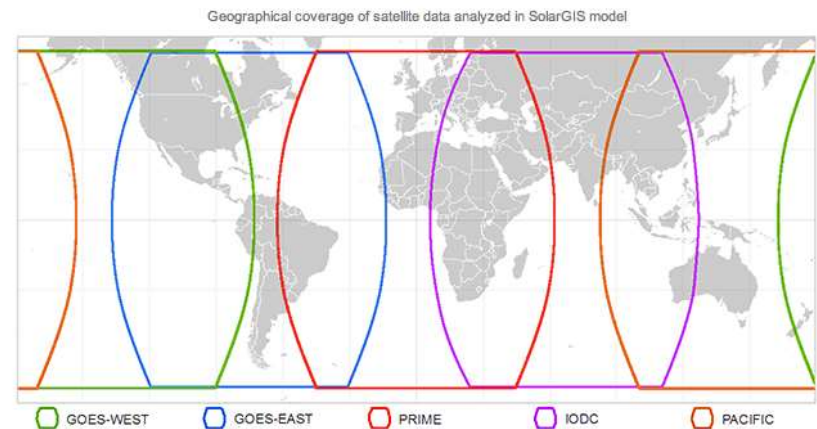
# Activities Related to Grid Integration

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- ISES: SEJ, Webinars, Conferences
- AMS REC: White papers, conference content
- IEA SHC Task 46: International collaborations
- Consulting: End use applications (ESMAP, IRENA, CPR)

# Solar Resource Modeling Using Satellites

- Application of Geostationary Satellite data to produce Cloud indices or properties;
- Application of radiative transfer schemes.
- Starting point is clear sky model.
- Other important parameters:
  - Atmospheric aerosols
  - Trace gases (including Water vapor)
  - Temperature
  - Terrain, land use
  - Snow Cover



Source: GeoModel Solar



# Wind Resource Modeling

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- Numerical Weather Prediction Models
  - Reanalysis data for initial conditions (MERRA)
- Downscaling using WRF
- DTM a key input
- For off-shore:
  - Scatterometer data (QuikSCAT, ASCAT)
  - Passive Microwave Radiometer (SSM/I)
- Need accurate data at specified heights in boundary layer
  - difficult to obtain from passive space observations

# Earth Observation Requirements - Solar

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## Satellite Data Products

- Geostationary Visible, IR Channels
- Less Common: Polar orbiting visible and IR channels
- MODIS (Aqua and Terra) -> MACC-II (for AOD)
- Water vapor (NOAA models)
- DTM Data (SRTM)
- Land Use/Land Form
- Use of additional 3-D Cloud information (shadows, etc.)

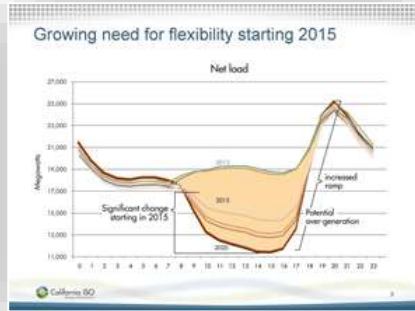
## Other Important Data Products

- MERRA, MERRA-2
- Aeronet

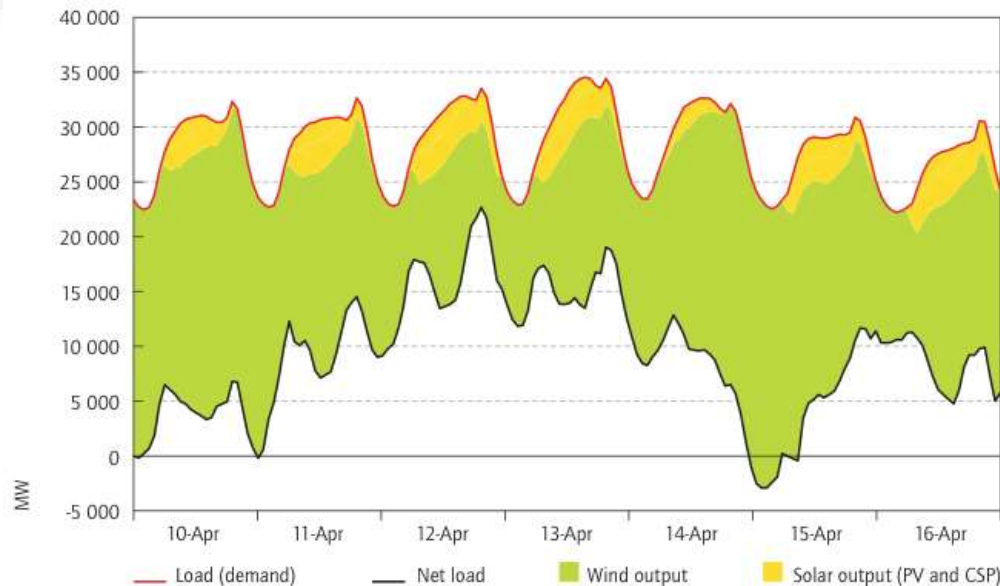
# The Growth of Solar Requires Utility Flexibility

## High Penetration Solutions:

- Load Shaping (e.g. DSM)
- Storage
- Resource Synergies (wind + solar)
- Solar Forecasting

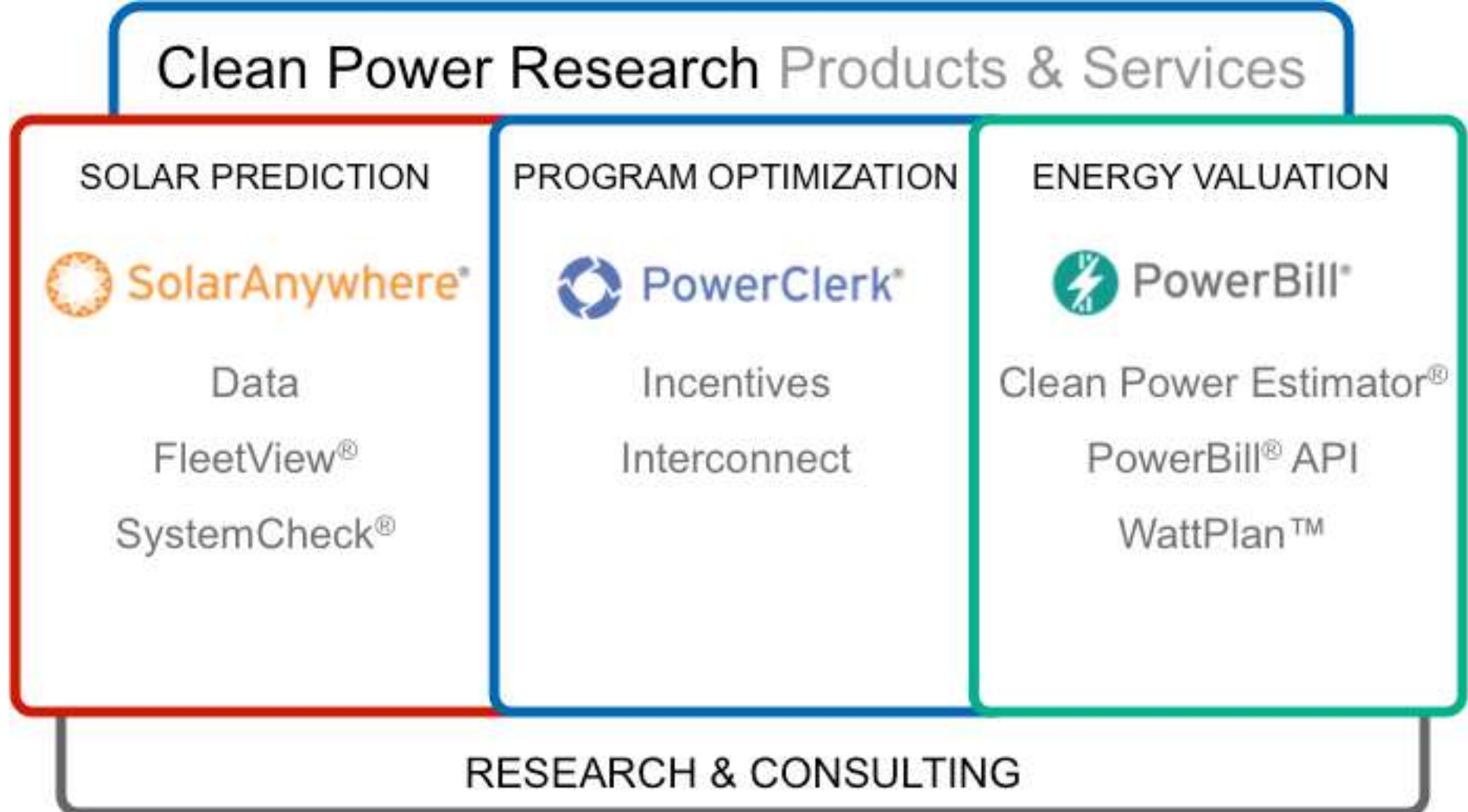


Source: CAISO

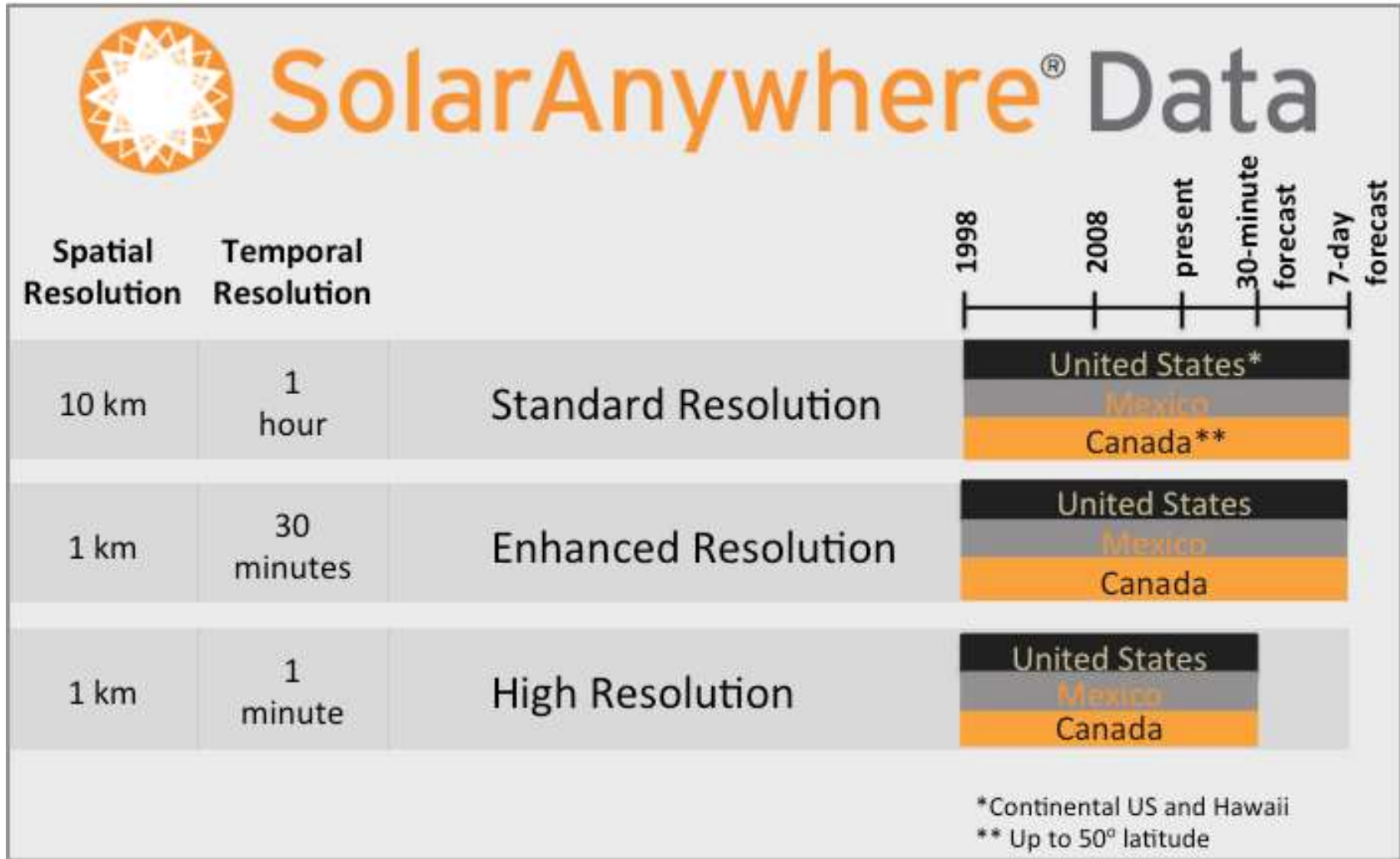


Source: IEA, "Harnessing Variable Renewables"

# End-Use Products for Grid Integration (CPR Examples)



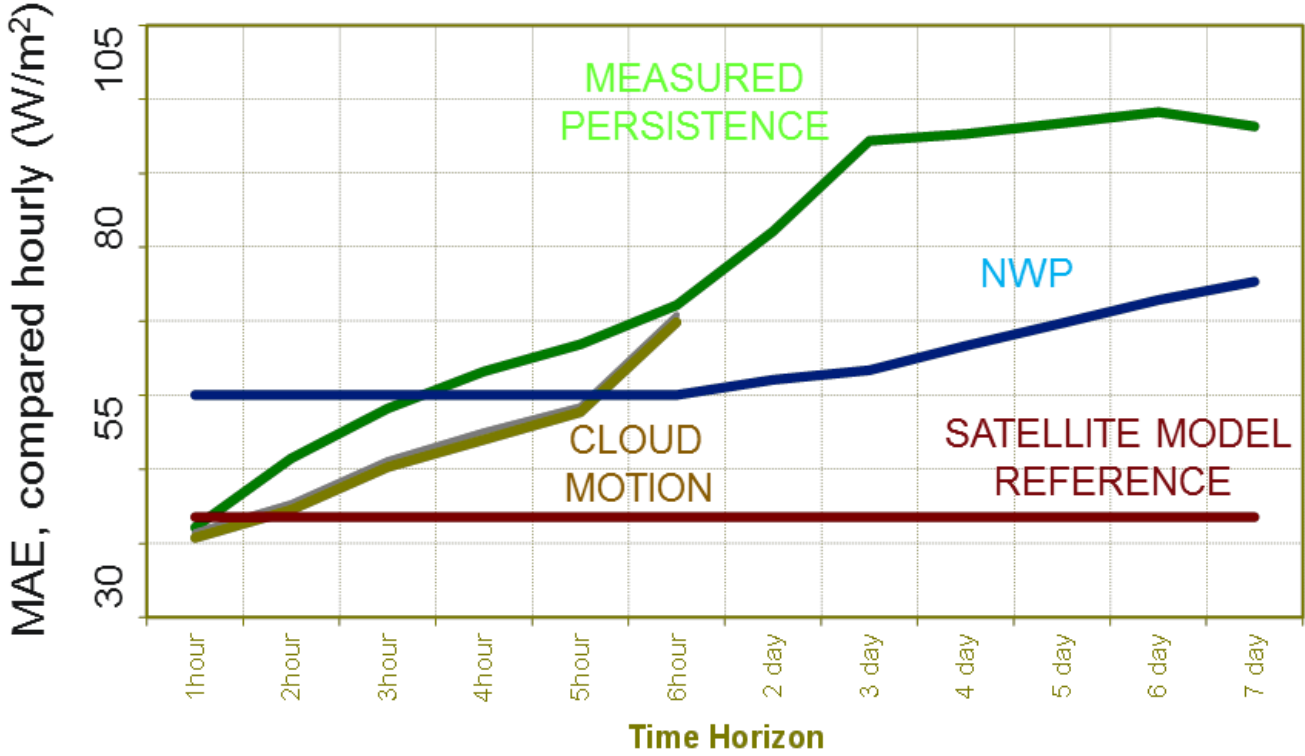
# End-Use Products for Grid Integration (CPR Examples)





# End-Use Products for Grid Integration (CPR Examples)

## NWP and Satellite cloud motion forecasts error as a function of time horizon



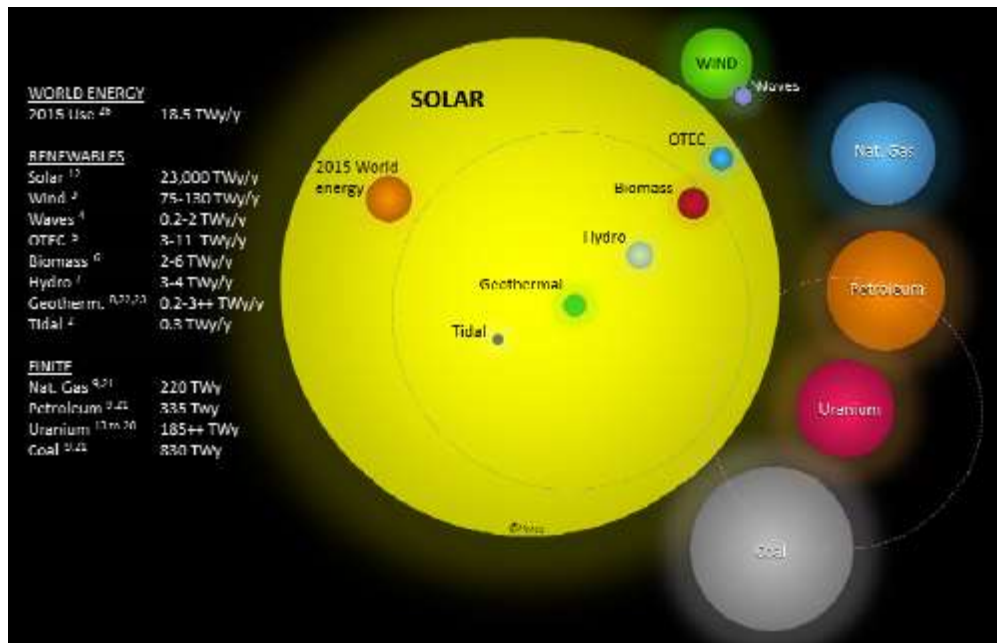
# Issues

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- Coordination of EO activities: GEO, ConnectinGEO, Copernicus, ENEON, etc.
- “Connecting the dots”: GEO, AMS/REC, IEA Implementing Agreements, ESMAP, IRENA, ..., etc.
- MERRA, MERRA-2, GOES-R
  - MERRA used in MCP for wind, which has generated billions in investments
- NASA Role in WRF; WRF-Solar
- NASA Role in Climate Change (Trends, interannual variability, future conditions)
- Do not reinvent the wheel: collaborate with DOE/EERE and industry

# Thank You!

Dave Renné  
drenne@mac.com



Source: Marc and Richard Perez (Go to [www.ises.org](http://www.ises.org) or [www.iea-shc.org](http://www.iea-shc.org))