



OPTIMUM FIXED ORIENTATIONS CONSIDERING DAY-AHEAD MARKET ENERGY PRICING IN CALIFORNIA

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Fixed Orientations

Convention:

- Due south azimuth
- Latitude tilt

Recent Studies (Lave [1] , Schroder [2]):

- Optimum tilts and azimuths varied by up to 10° from latitude tilt, especially in coastal regions
- Energy gains over latitude tilt were minimal

[1] Lave M, Kleissl J. Optimum fixed orientations and benefits of tracking for capturing solar radiation in the continental United States. *Renewable Energy* 2011; 36:1145-1152.

[2] Schroder, S. Determination of annual optimal altitude and azimuth angles of fixed tilt solar collectors in the continental United States using the National Solar Radiation Database, in *Proceedings of the ASES National Solar Conference, May 2011.*



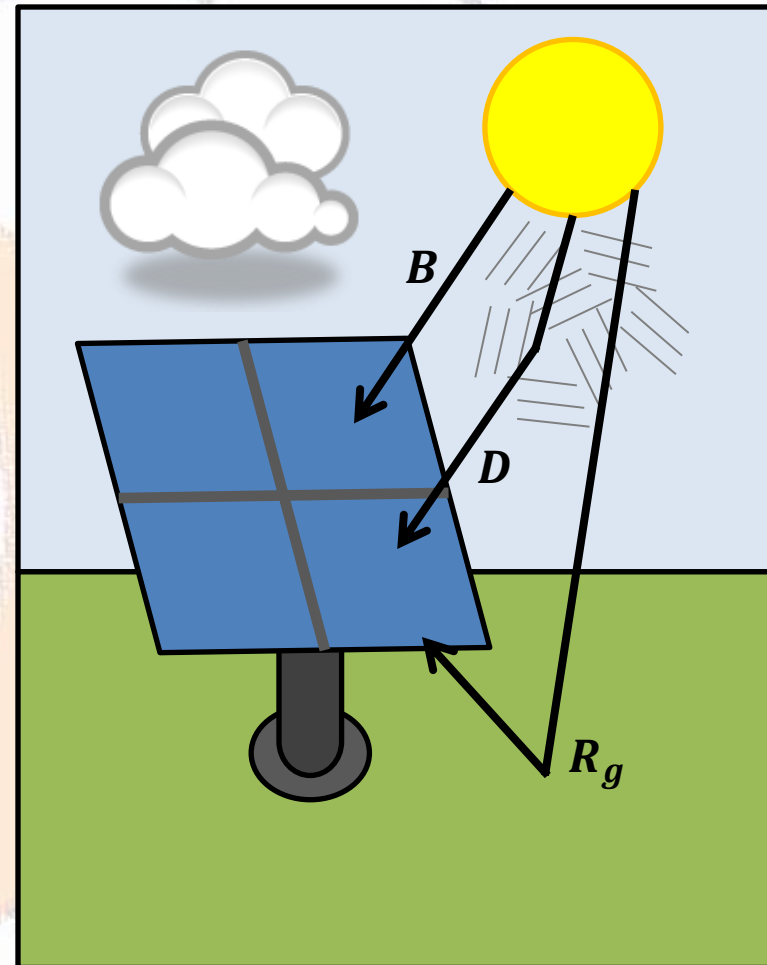
Optimized Fixed Orientations

Considering Irradiance

- Irradiance data was obtained from SolarAnywhere database:
 - 1 x 1 km resolution
 - 30-min GHI, DNI, DHI
- Used Page [3] model to obtain GI

$$GI = B + D + R_g$$

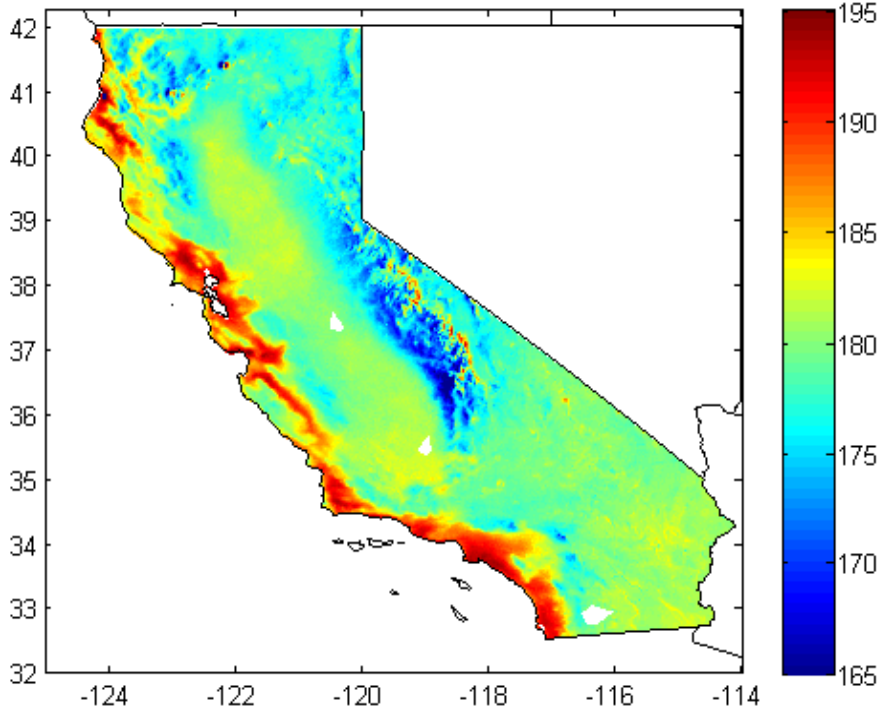
- Maximized total half-hourly irradiance over the year to determine optimum fixed orientation



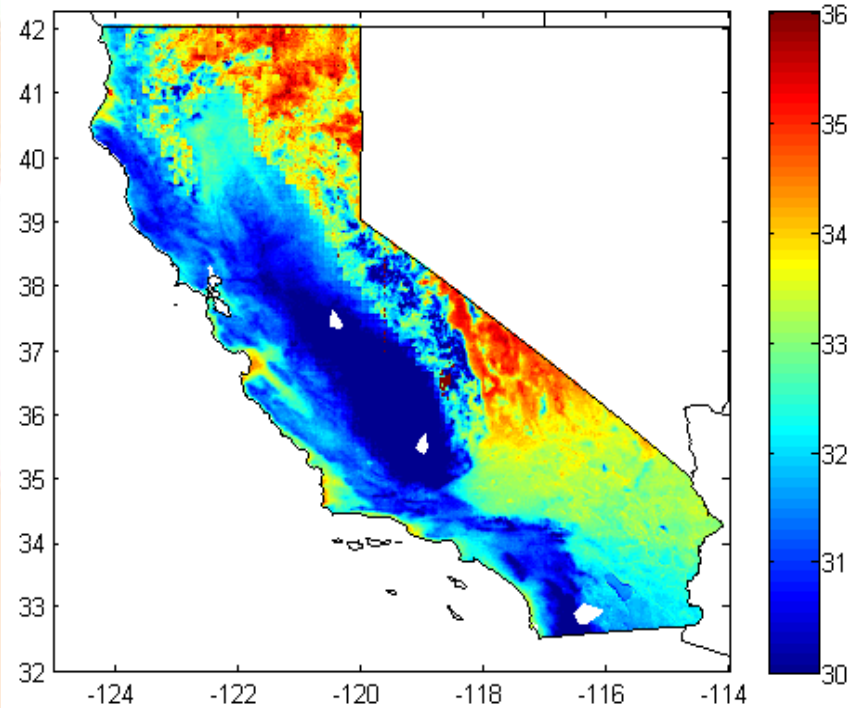
Optimized Fixed Orientations

Considering Irradiance

Azimuth



Tilt





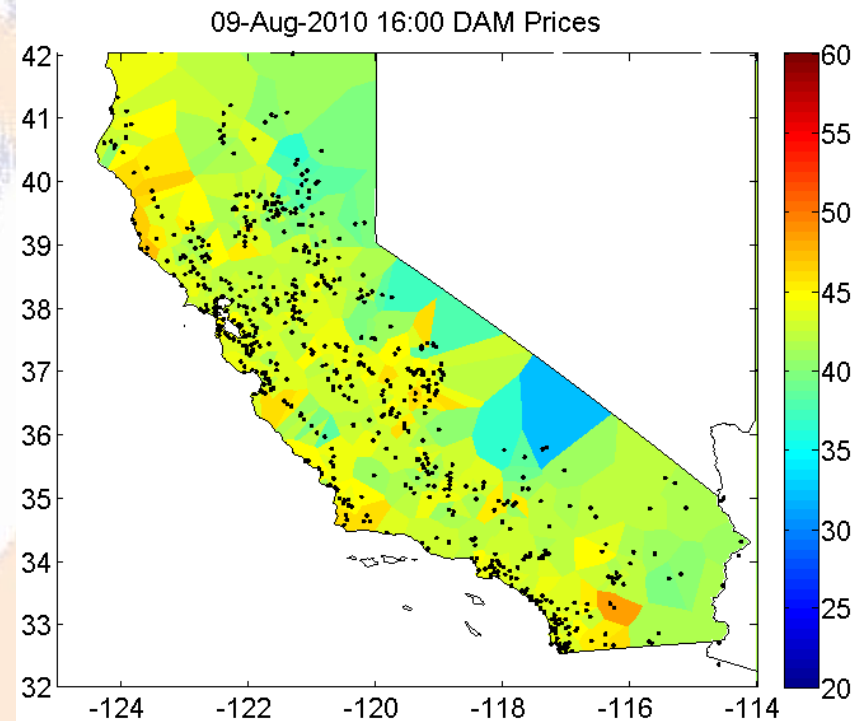
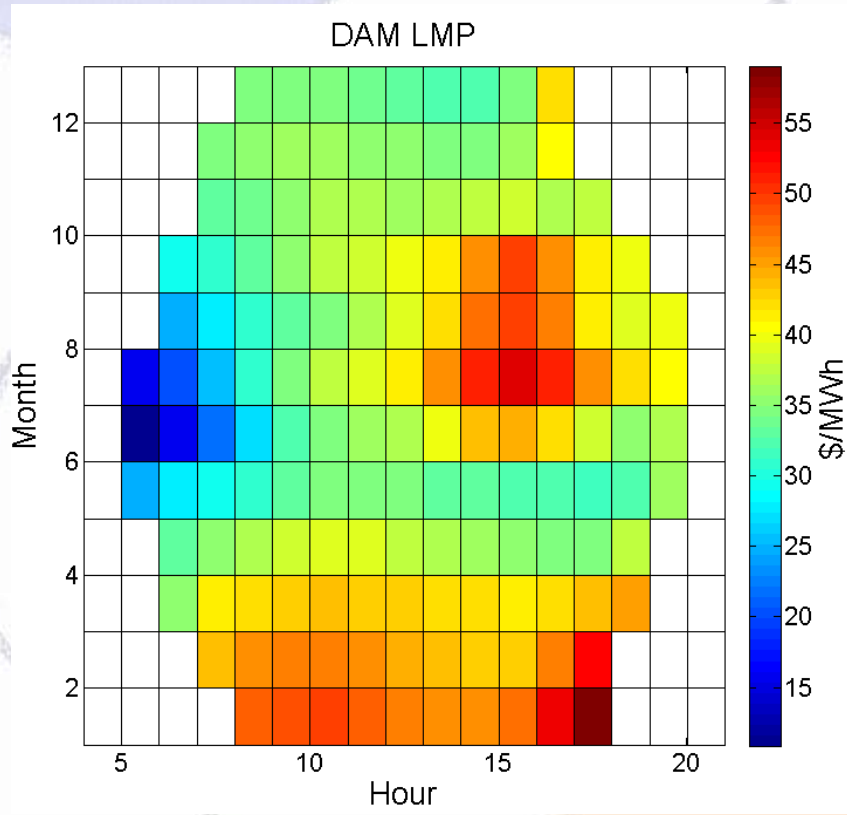
Optimized Fixed Orientations

Considering DAM Pricing

- Used Day-ahead market (DAM) prices from 602 price nodes from the CAISO Open Access Same-time Information System (OASIS) database
- Assumed power output was perfectly forecasted and sold into the DAM such that there was no settlement in the real-time market (RTM)
- Maximized total half-hourly revenue over the year to determine optimum fixed orientation

Optimized Fixed Orientations

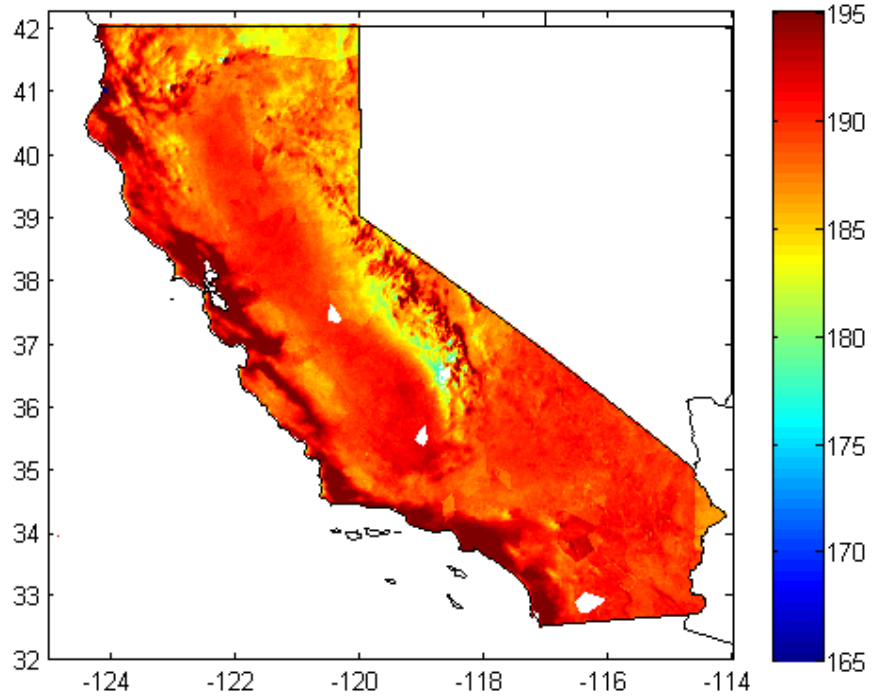
Considering DAM Pricing



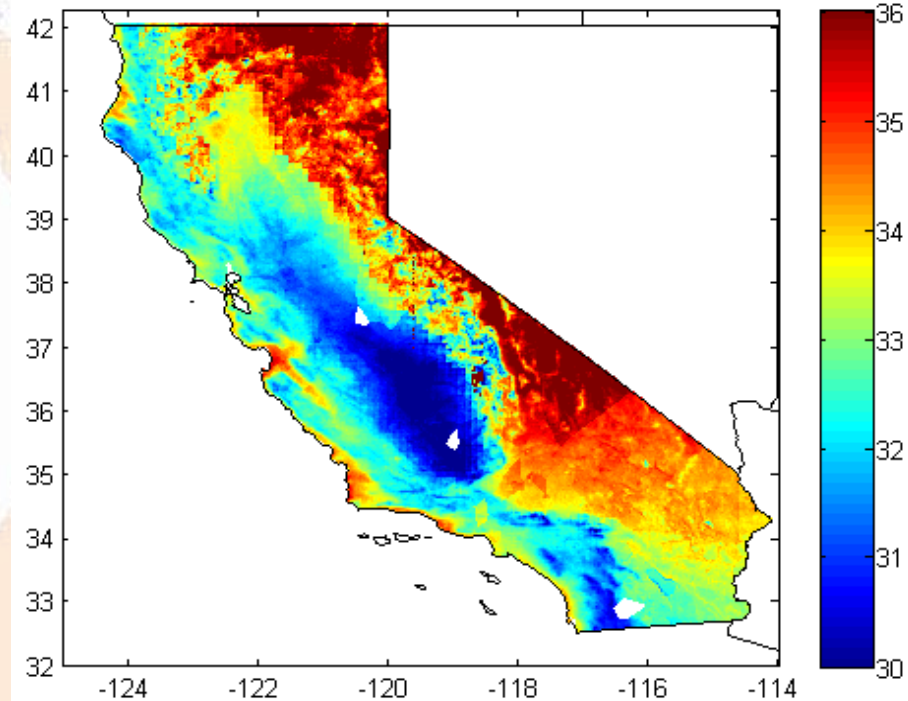
Optimized Fixed Orientations

Considering DAM Pricing

Azimuth

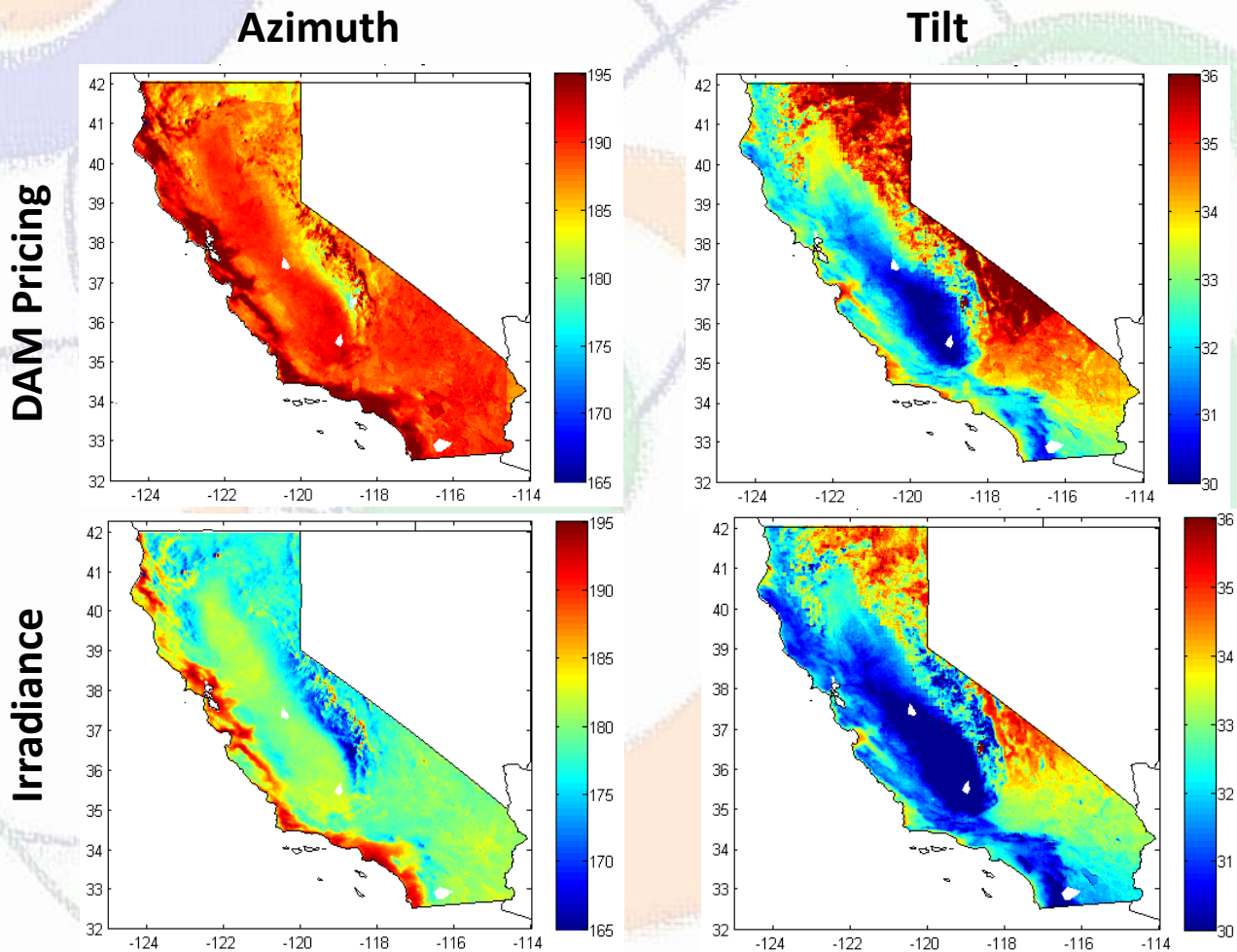


Tilt



Optimized Fixed Orientations

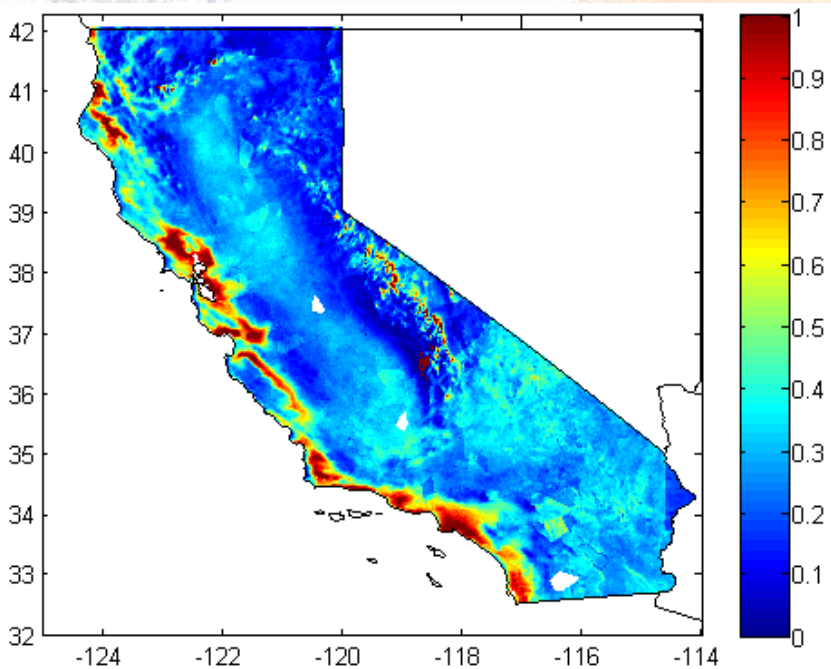
Comparing Irradiance versus DAM Pricing



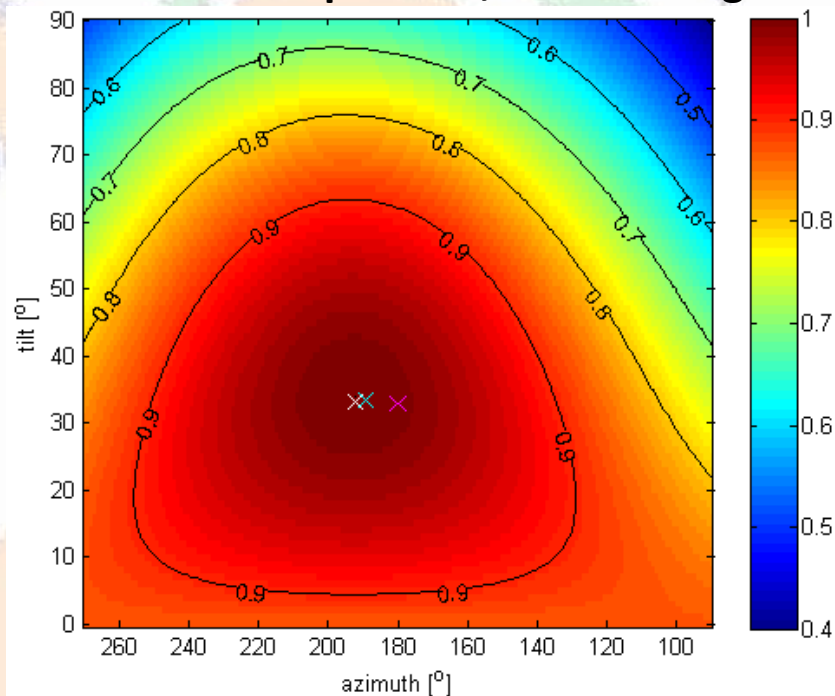
Optimized Fixed Orientations

Sensitivity to Fixed Orientation

% Increase in yearly revenue from latitude tilt to DAM optimum



Yearly revenue at fixed orientation over DAM optimum, for San Diego



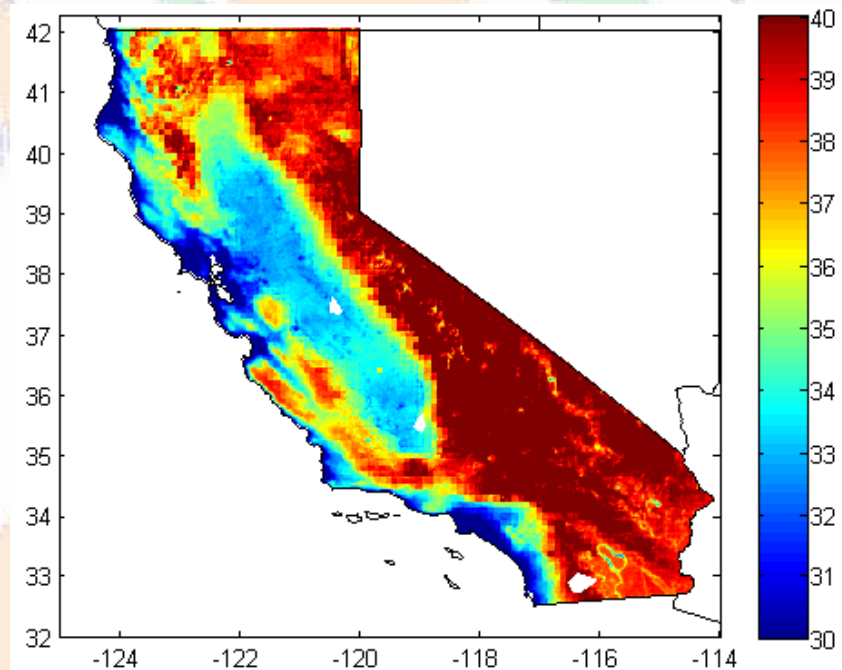
- DAM pricing
- Irradiance
- Latitude tilt

Optimized Fixed Orientations

Dual-axis tracking

- Significant gains in yearly revenue when using dual-axis tracking over latitude tilt fixed orientation
- Similar to energy gains associated when using dual-axis tracking over latitude tilt fixed orientation
- Doesn't factor in additional start-up and maintenance costs of a dual-axis system

% Increase in yearly revenue from convention to dual-axis tracking





Conclusions

- Optimum fixed orientations considering DAM pricing are up to 15° W of due south and vary from latitude tilt by up to 5°
- However, increase in yearly revenue for optimum fixed orientations considering DAM pricing is small (less than 1%) compared to latitude tilt



Acknowledgements



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Thank You!

