

HyDIVE™ (Hydrogen Dynamic Infrastructure and Vehicle Evolution) model analysis

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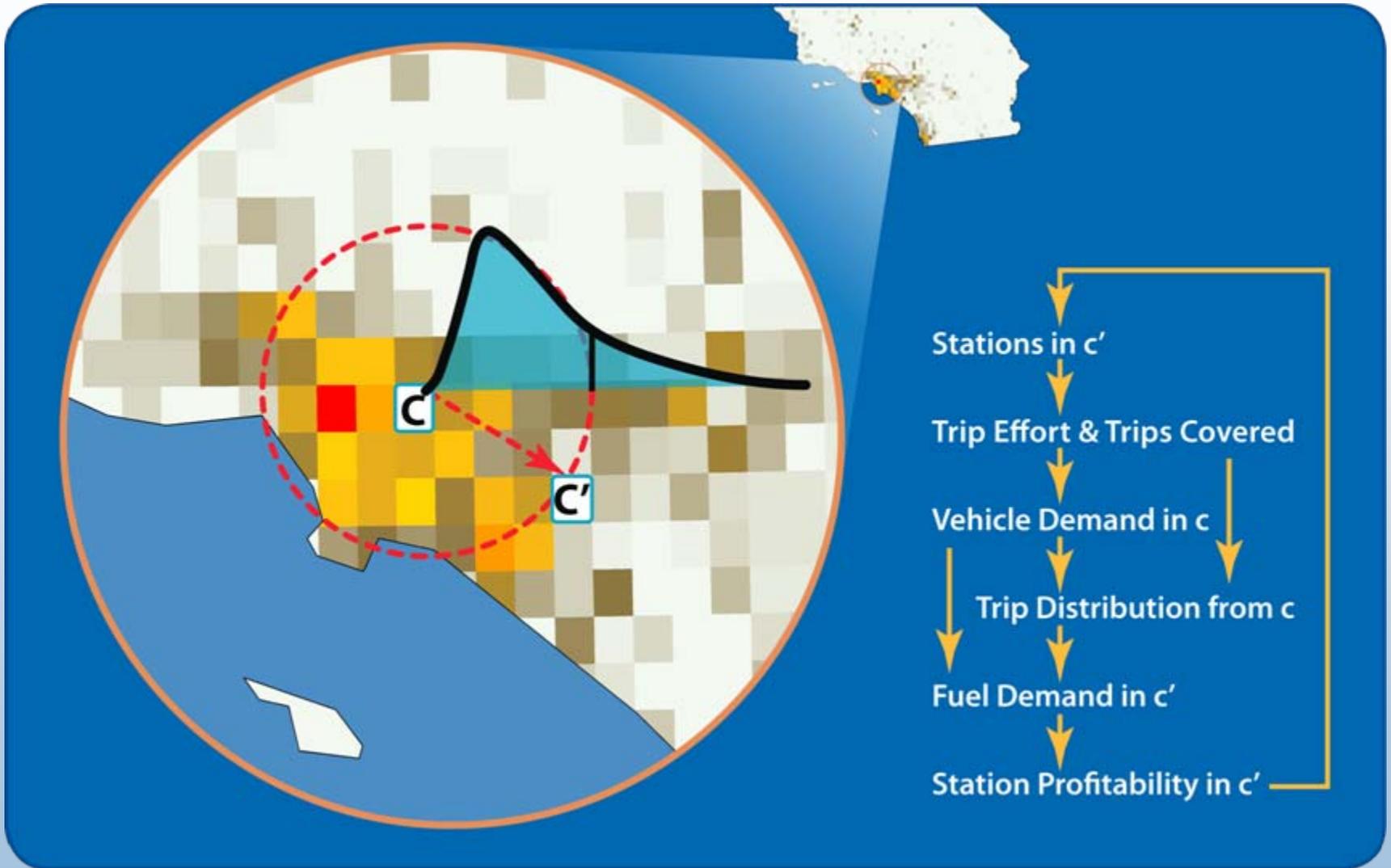
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Overview

- Brief overview of spatial, *dynamic* model
- Example intermediate *static* calculations
- Key unknowns, next step, and insights

Spatial, dynamic interdependence

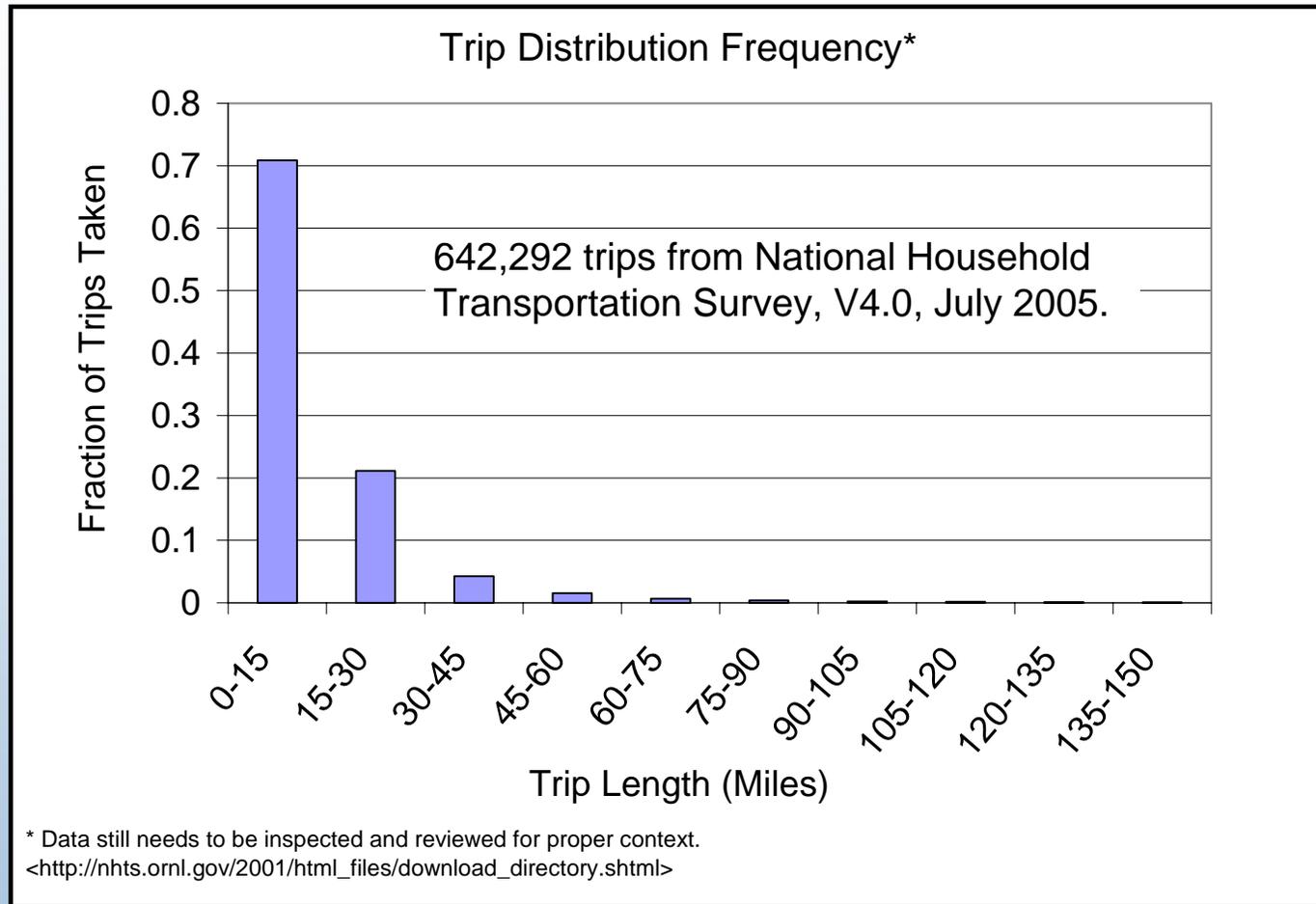


From Struben, Welch, Sterman (2006). See Struben (2006a) for detailed discussion of initial model.

Vehicle Utility

- Utility of vehicle for driving, which affects vehicle sales, will be affected by:
 - added drive time to limited refueling stations
 - time to refuel vehicle: f (refueling rate, “queue” time)
 - probability, cost of running out of fuel
- Above are endogenously calculated dynamically and spatially for different “trip lengths” (next 2 slides)
- Other vehicle attributes (e.g., price, performance, etc.) to be incorporated with future development.

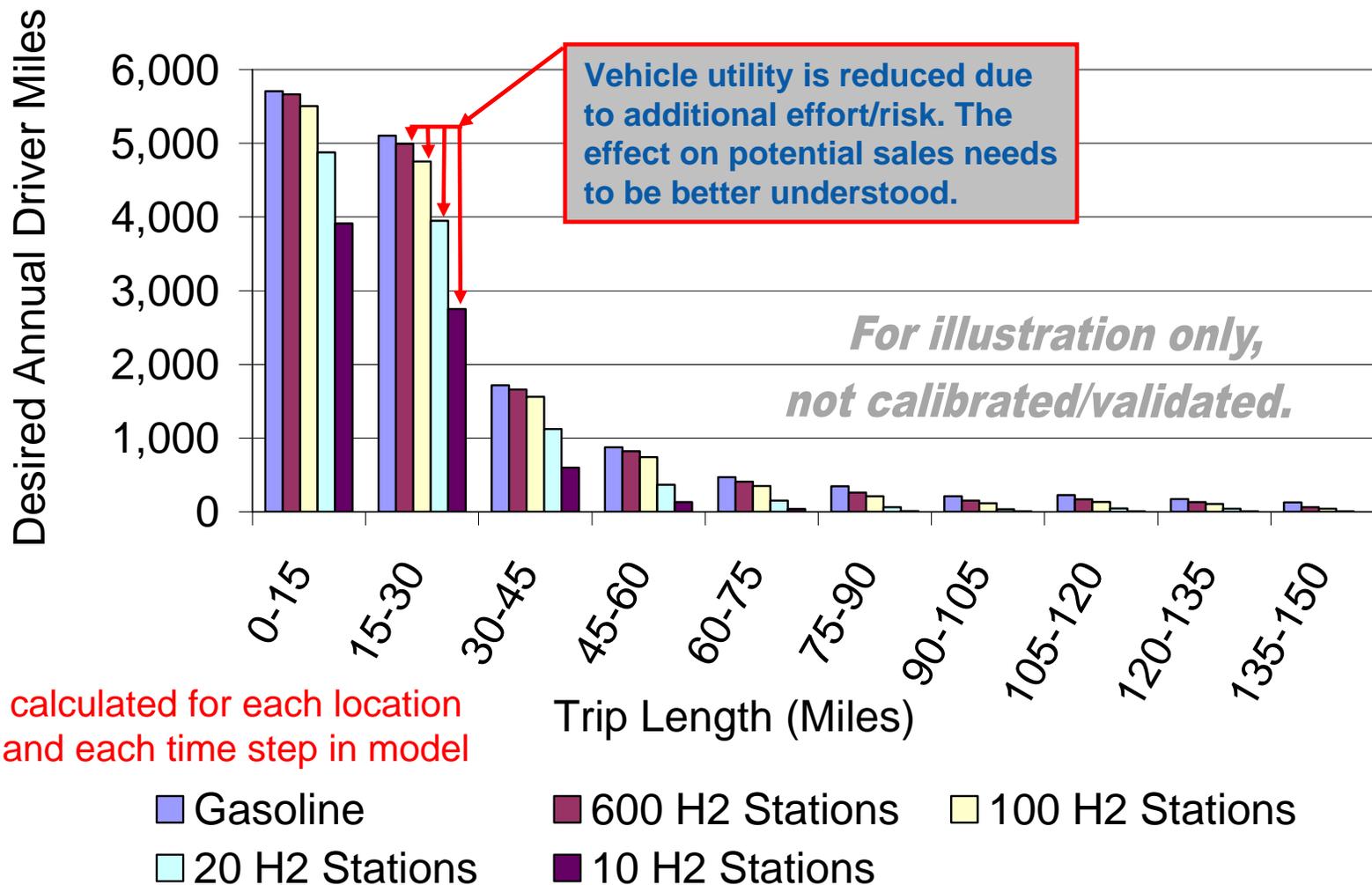
Trip distribution – a driver of spatial diffusion



- GPS data from southern CA also being sought from SCAG. NHTS data to be inspected/reviewed.

Limited station coverage reduces driving convenience, which will affect sales & miles driven

Desired Annual Driver Miles vs. Trip Length

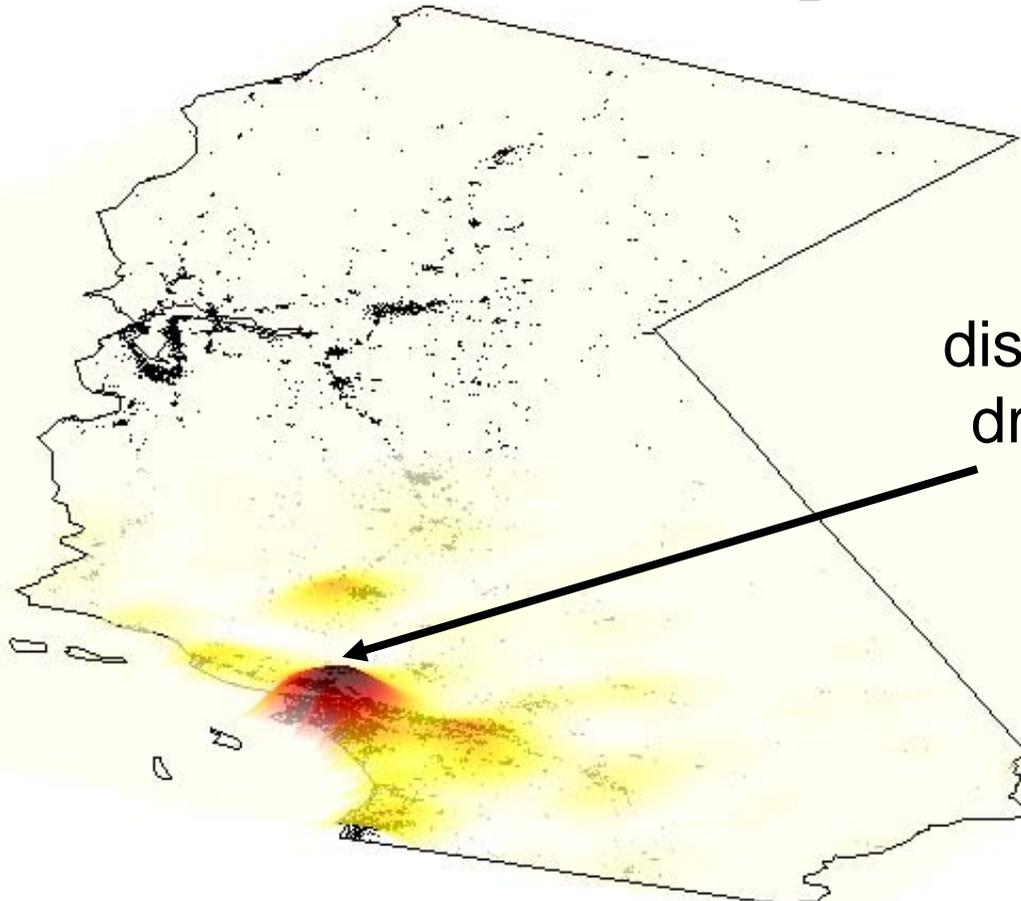


Insights and Questions

- Consumer sensitivity to reduced vehicle “utility” (due to limited coverage) is a major driver of dynamics, but not yet well understood.
- Spatial “diffusion” beyond urban areas may be difficult.
- The following slides illustrate how we are beginning to improve understanding the above.

Directional trip distribution now modeled

Additional drive time, refueling time, “out of fuel” risk are calculated based on level of H₂ station coverage

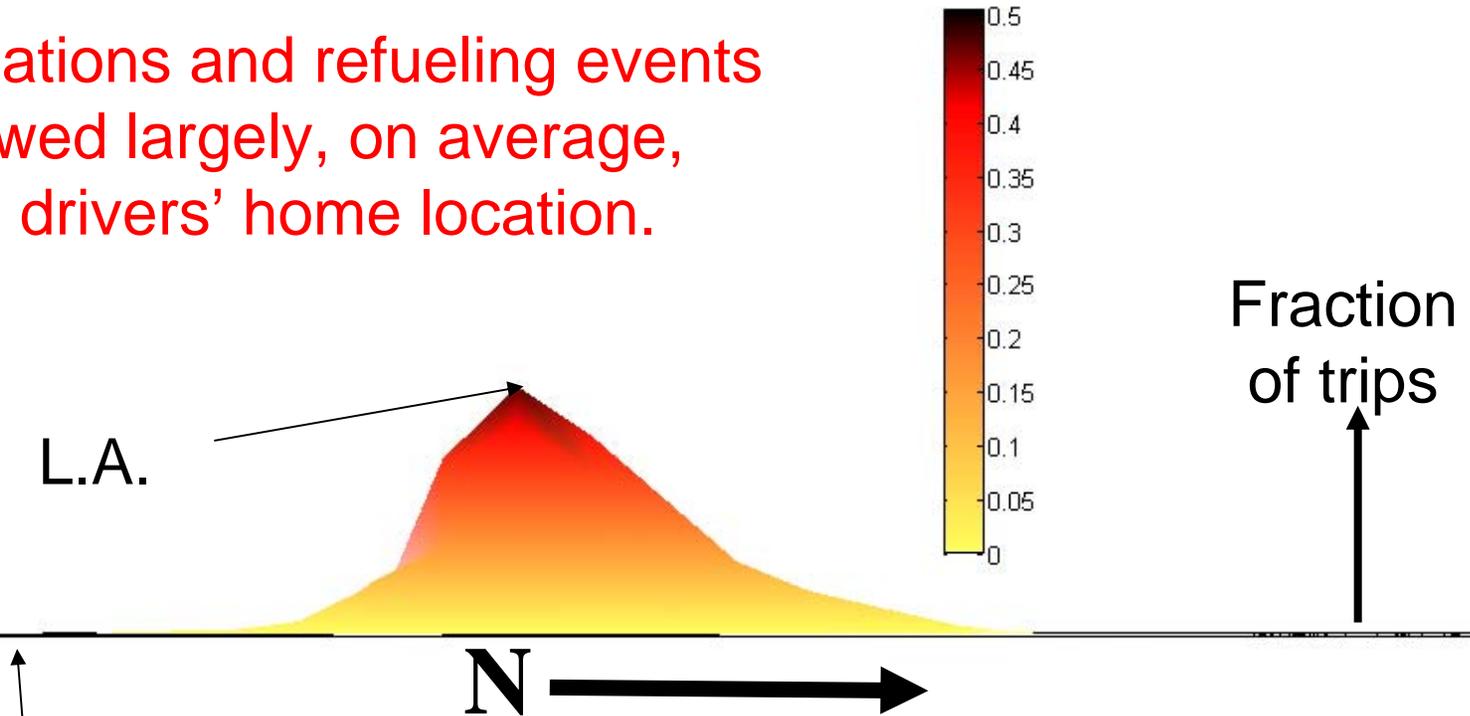


Example trip distribution for one driver living here

Station profitability/growth are calculated based on endogenously calculated vehicle demand and trip distribution

Trip distribution affects station profitability

Trip destinations and refueling events are skewed largely, on average, toward drivers' home location.

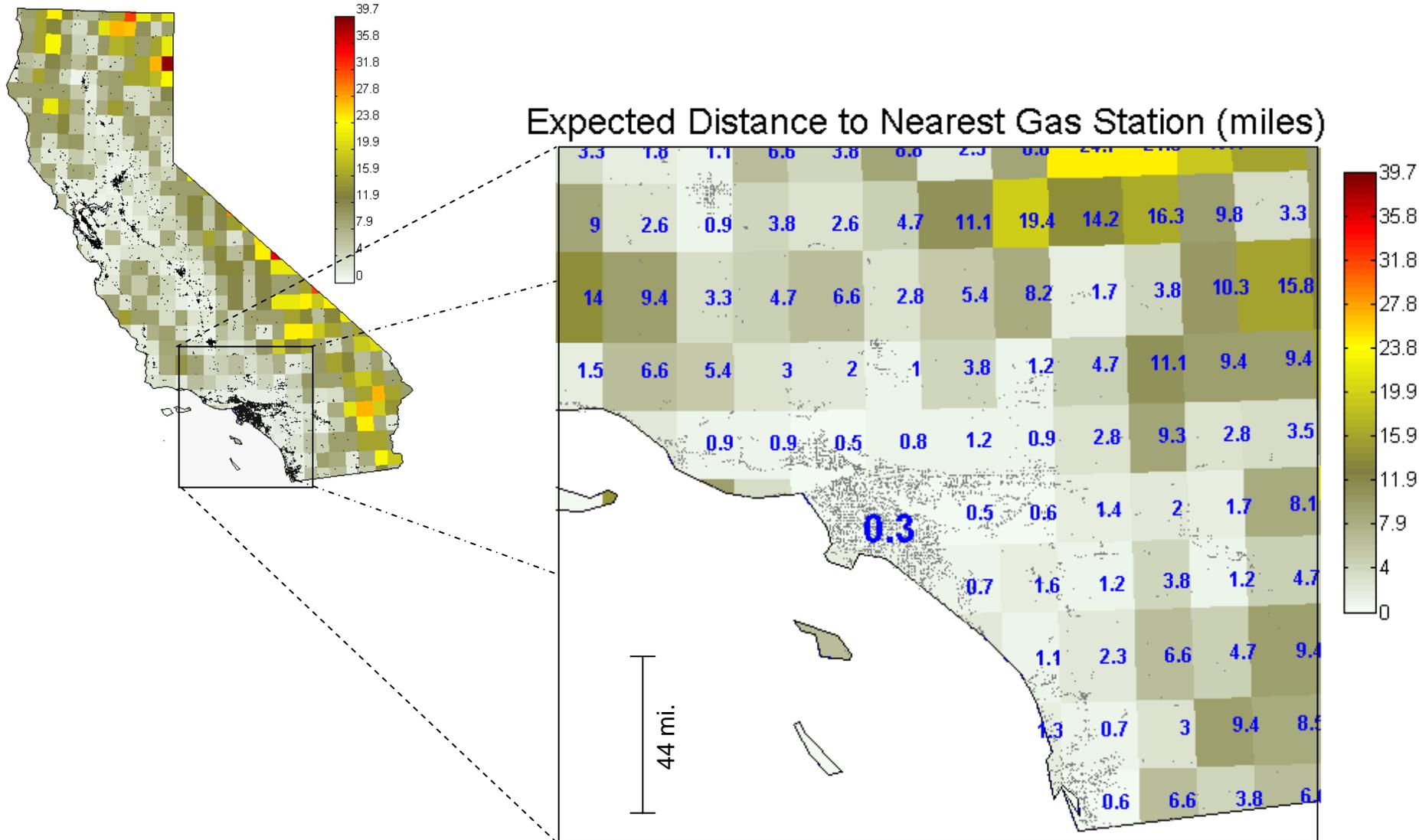


Profitability difficult for stations far from vehicle owners

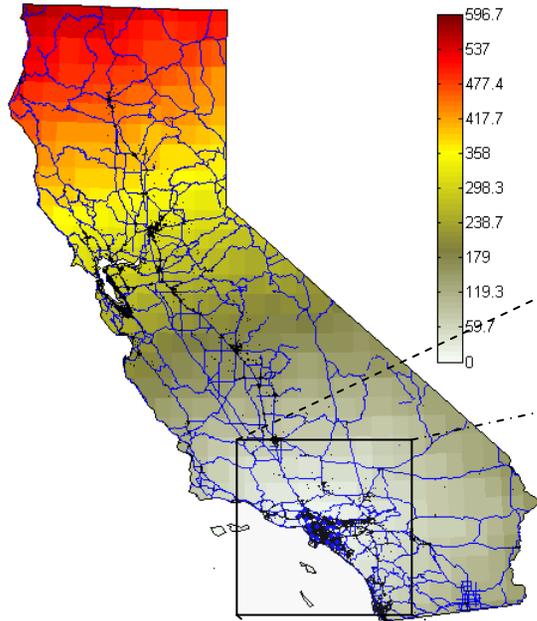
Advantage: large % of refuelings are “covered” by stations close to drivers

Disadvantage: stations far from drivers' home location may be required for adequate utility, but may be very unprofitable.

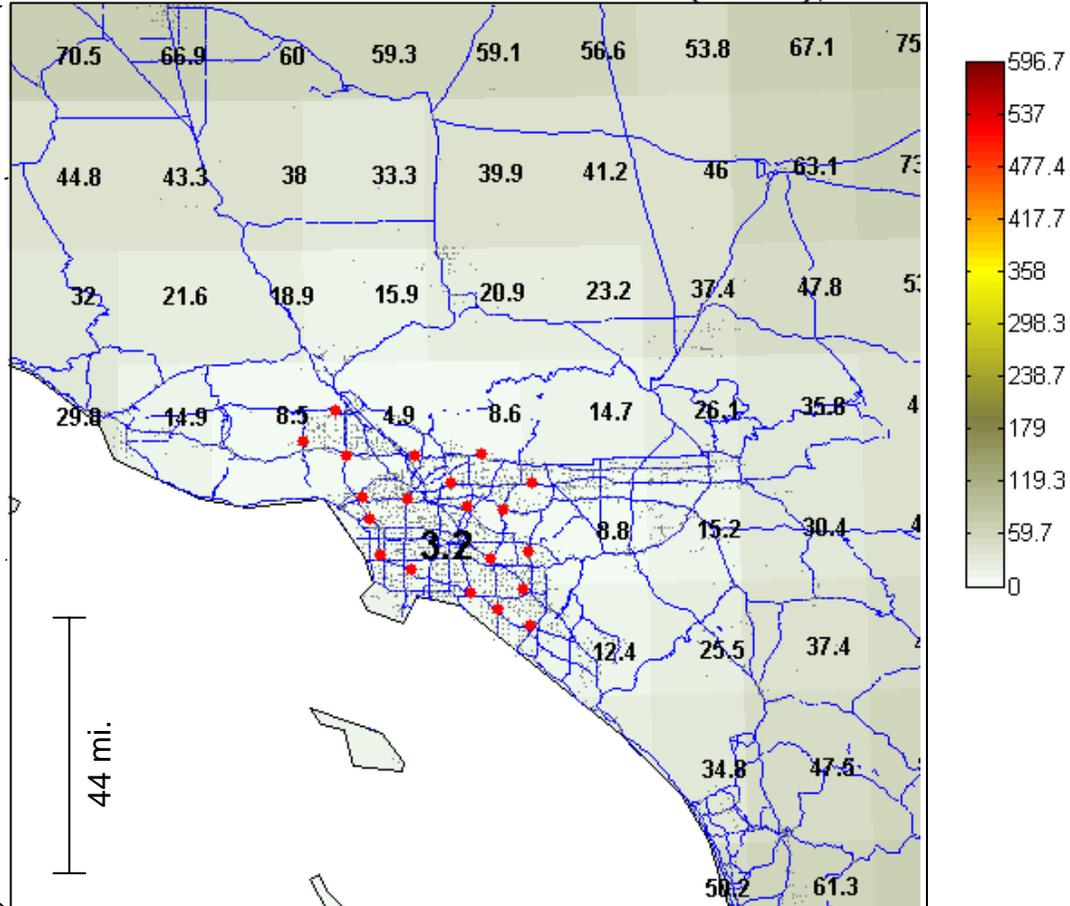
Expected Distance to Nearest Gasoline Station



Example: Extra Distance to Nearest H₂ Station (20 Stations)



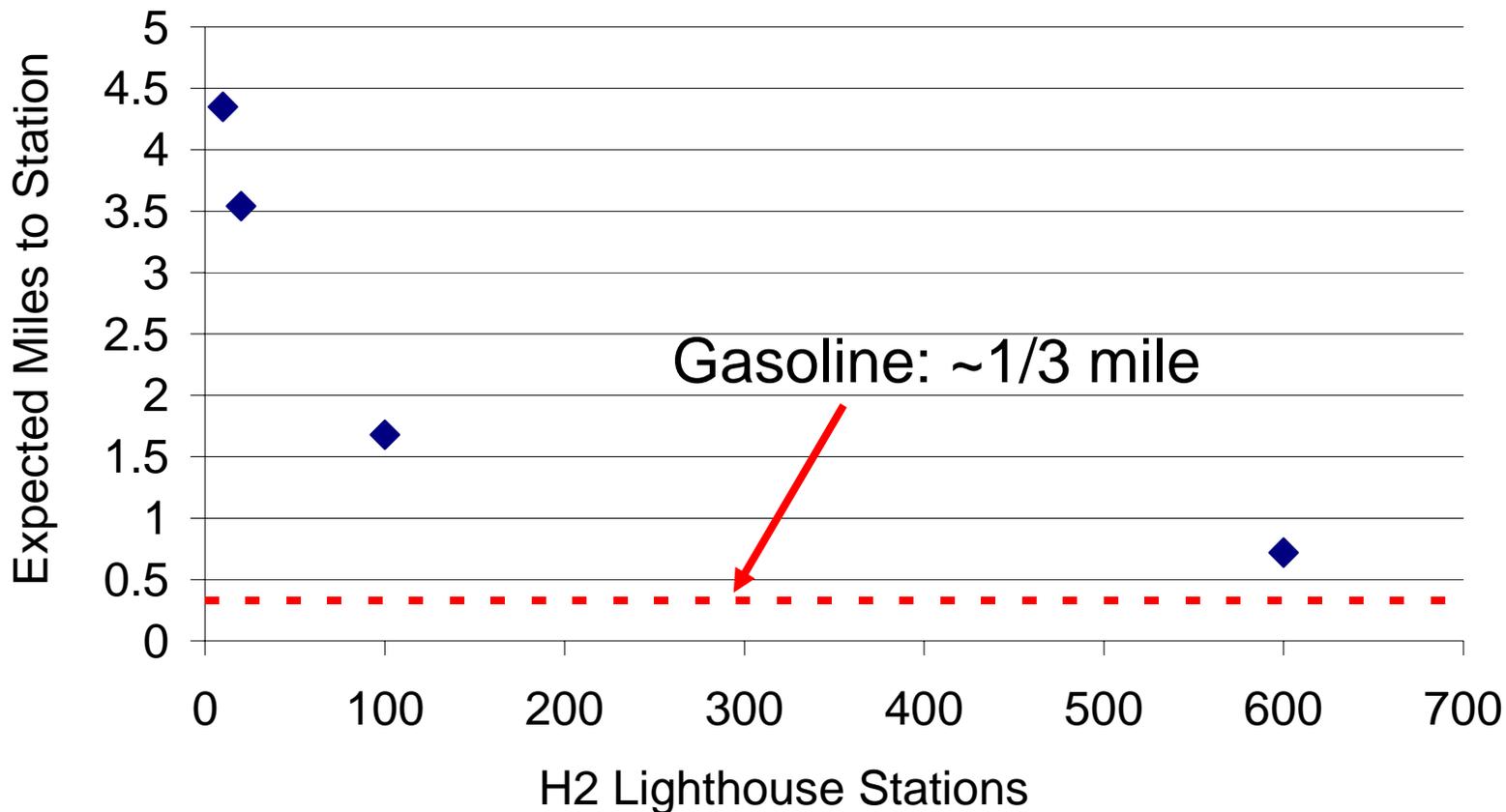
"Extra" Distance to Nearest H₂ Station (miles), 20 Stations



Extra "time" to station readily calculable assuming an average speed of travel (currently use a constant value, but could relax if spatial data are obtained)

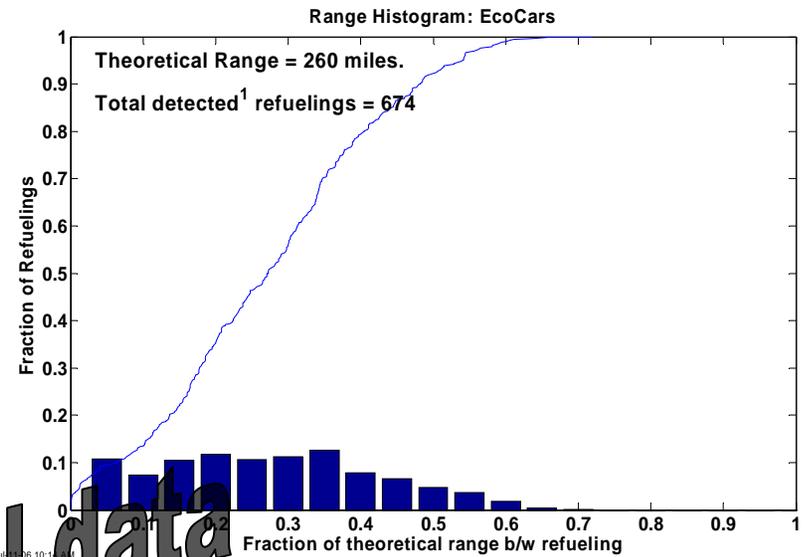
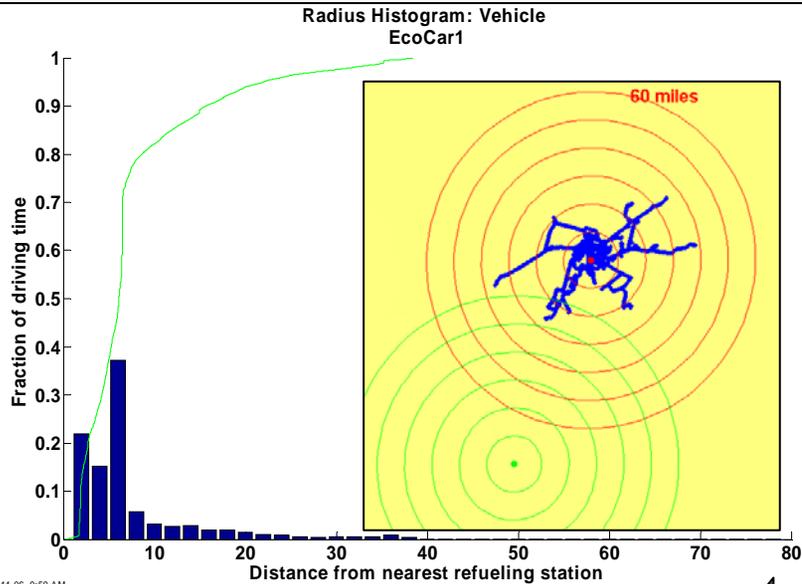
Expected Distance to Nearest Station

"Expected" Distance to Nearest Station*
(for most "station dense" cell in LA -- 16x22 mi. cells)

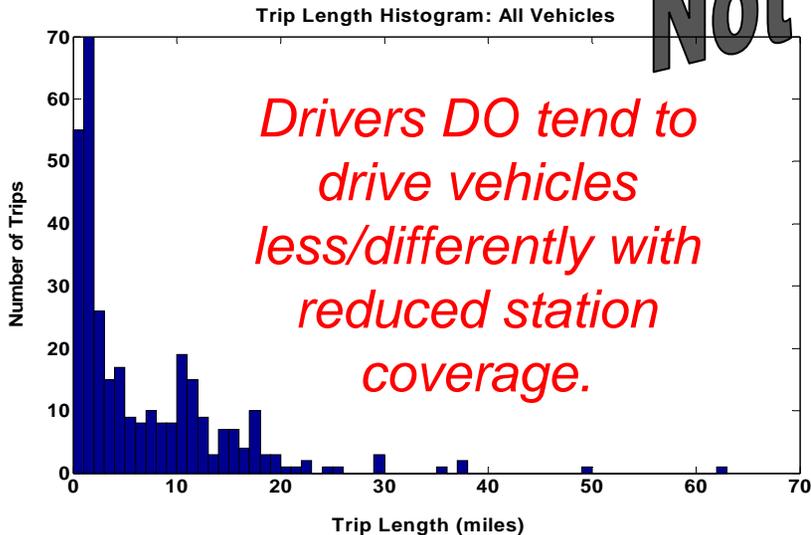


* Probabilistic distance to nearest station, which is a function of station density within each cell and across adjacent cells.

Potential calibration data – Hydrogen Learning Demonstration Project



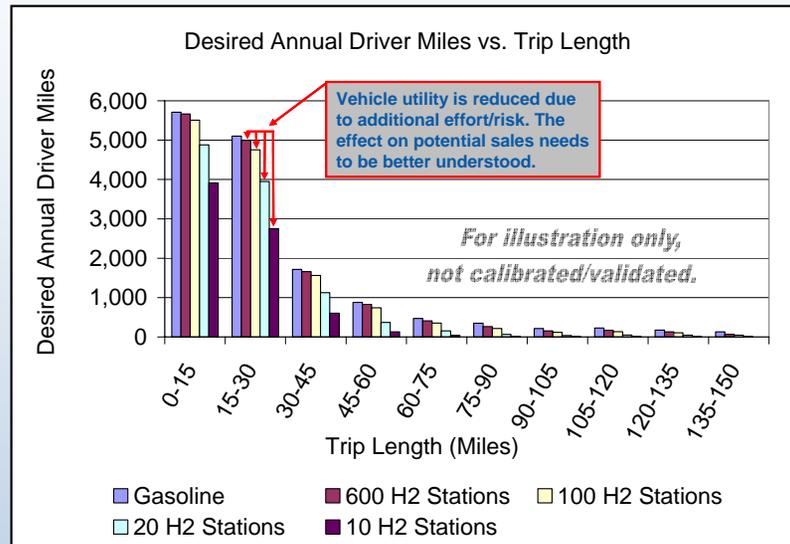
Not real data



Analysis of learning demo driving behavior could be useful for calibration (if future industry approval is obtained), particularly for low levels of station coverage.

Unknowns and next steps

- **Unknown:** purchasing sensitivity to reduced vehicle utility



f (additional drive time, additional refueling time, “out of fuel” risk)

- **Next Steps:**

- discrete choice analysis techniques envisioned to be used for quantification of this sensitivity (collaborate with auto OEMs)
- broaden model boundary, include additional relevant dynamics
- policy/strategy analysis

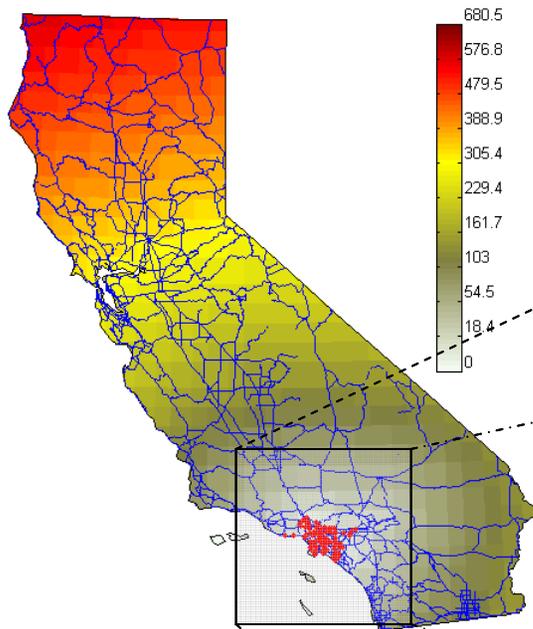
Insights and Questions

- Incentives may need to differ for urban, rural, intercity, or interstate stations to avoid over/under subsidization.
- Difficult to satisfy simultaneously high % “coverage” for vehicle owners *and* profitability for station owners.
- Consumer sensitivity to reduced vehicle “utility” (due to limited coverage) is a major driver of dynamics, but not yet well understood.
- Spatial “diffusion” beyond urban areas may be difficult ... could require continued gov’t/market “seeding” in different cities/states (e.g., intercity/interstate/regional networks).
- Early in model development process. Additional development and analysis of consumer sensitivity to driving convenience measures will shed more light.

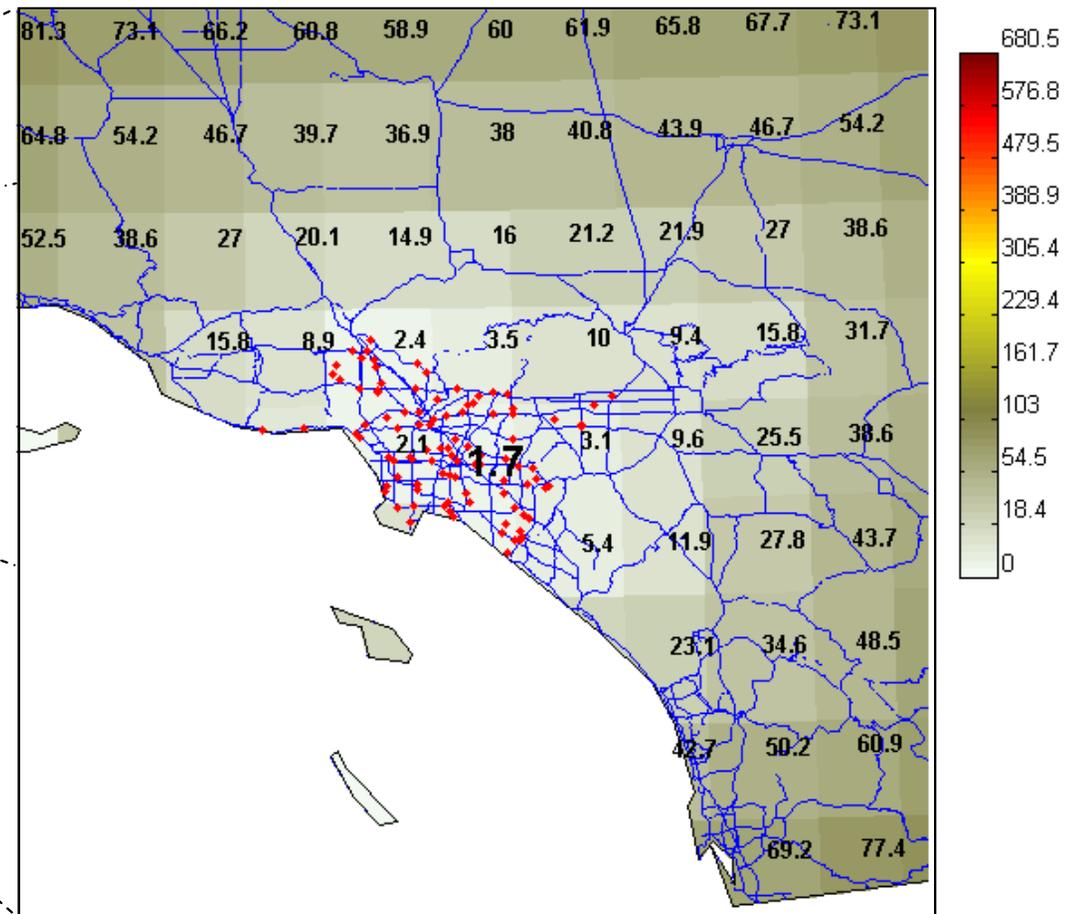
Related References

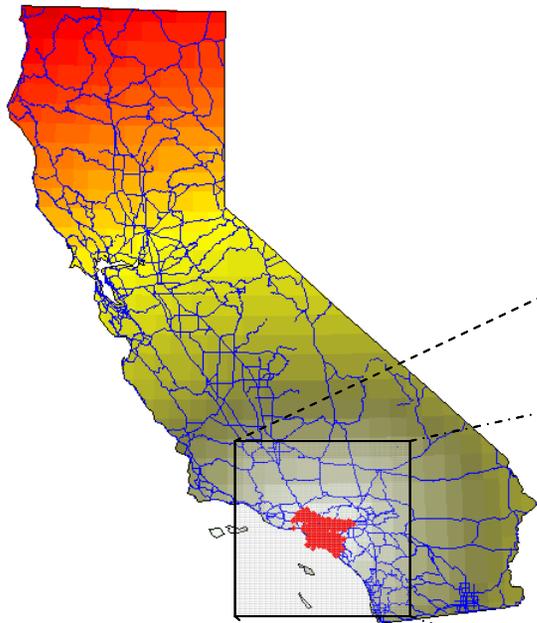
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Backup Slides



Expected Distance to Nearest Station (miles) - 100 Stations





Expected Distance to Nearest Station (miles) - 600 Stations

