EFFECT OF ANTHROPOGENIC MOISTURE ON SHORT RANGE FORECASTS FOR THE LOS ANGELES BASIN

Michael McAtee
Rich Coleman
James Drake
Leslie Belsma

THE AEROSPACE CORPORATION

Outline

- Background
- Approach
- Moisture Sources
- Moisture Data Base Development
- Model Modification
- Results

Background

- Model optimization studies suggested that missing physical processes in NWP models limit the benefits in improved forecast accuracy from ingesting more satellite data.
- Runs we have done with both MM5 and WRF have shown peak summer daytime temperatures to be overestimated.
- Our hypothesis is that this is because anthropogenic “precipitation” from irrigation and domestic water use has not been included – or has been underrepresented – in the models.
- Our objective is to incorporate anthropogenic moisture sources in weather simulations/forecasts and to compare them with forecasts made without these sources to see how much difference they make.

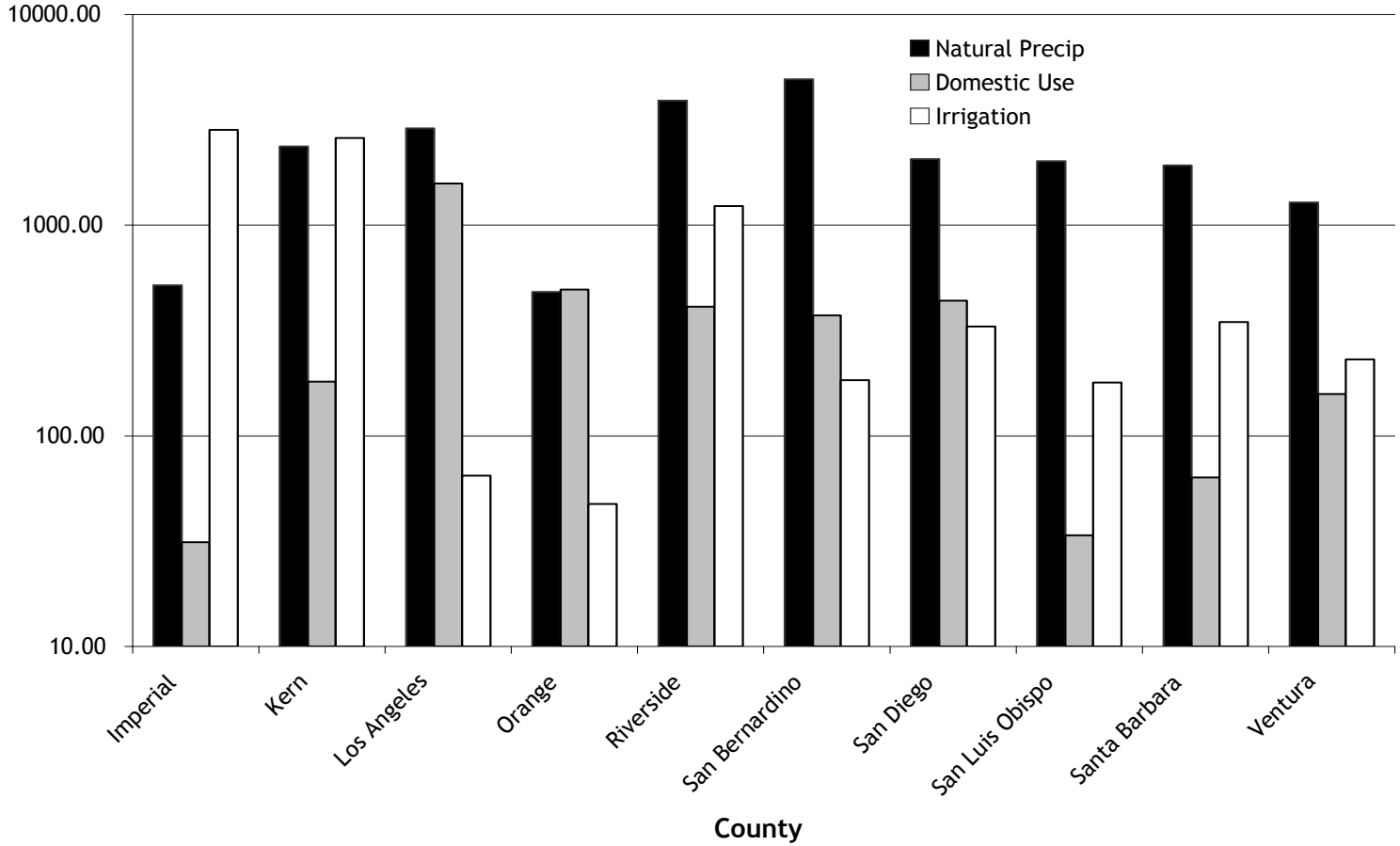
Approach

- Determine order of magnitude amount of moisture released by human activity
- Compare the amount of anthropogenic moisture to moisture from natural sources
- Determine the spatial and temporal (diurnal, seasonal) variation of anthropogenic moisture release
- Develop models of equivalent precipitation for each major anthropogenic moisture source
- Develop a static data base of LA basin anthropogenic moisture sources in a format compatible with WRF
- Modify WRF to ingest the anthropogenic moisture
- Compare high resolution (5km) forecasts with and without added moisture

Identification of moisture sources

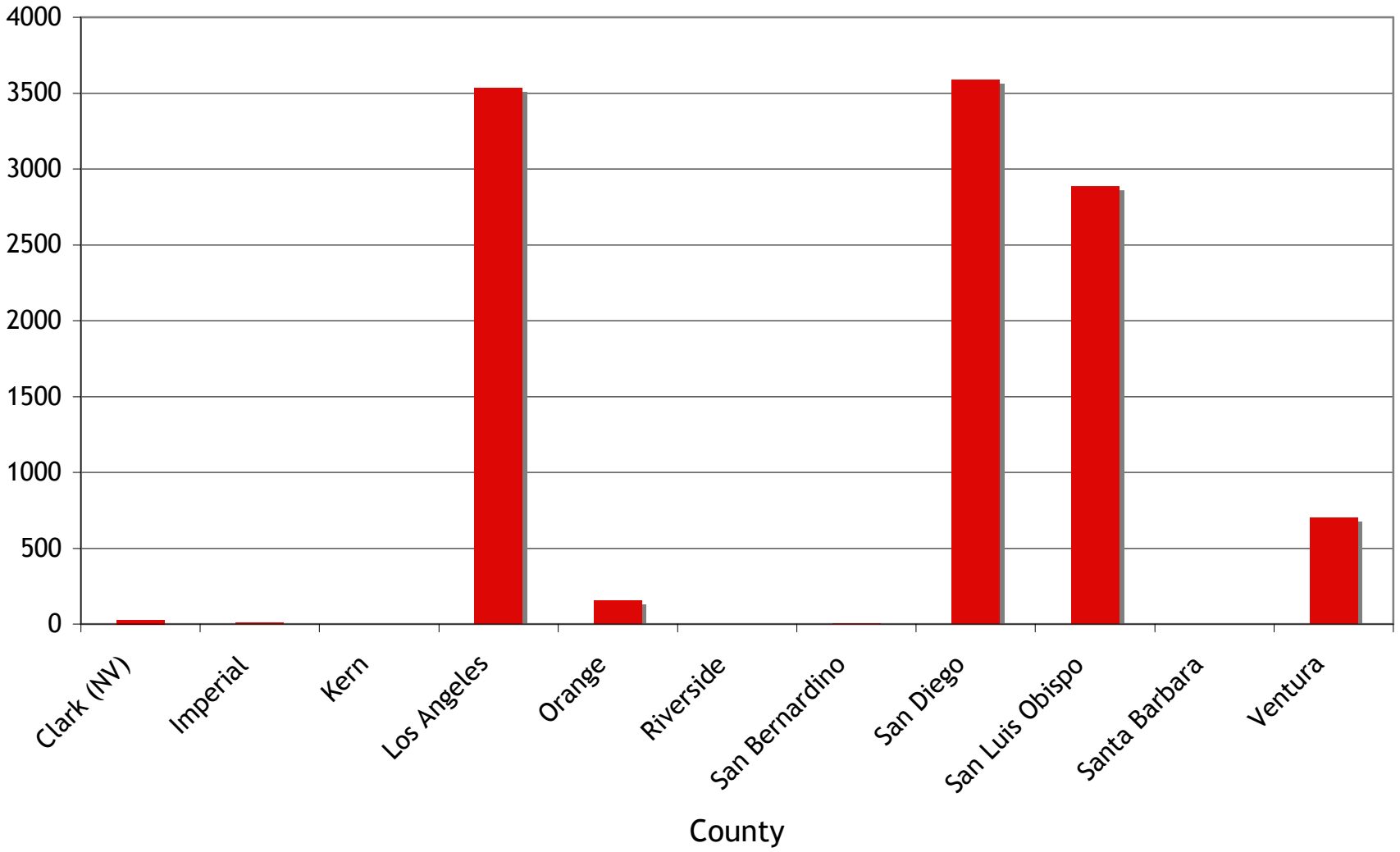
- Identified types of human water consumption and obtained estimates of total use
- Determined normal precipitation by counties of interest for comparison
- Subsequent chart shows natural and human-provided amounts for counties in our inner, 5-km resolution, domain
- Power plants not a part of this initial study but use very large amounts of water for cooling

Water provision (Mgal / day)



Note the logarithmic scale

Domain 2 Power Generation Water Consumption



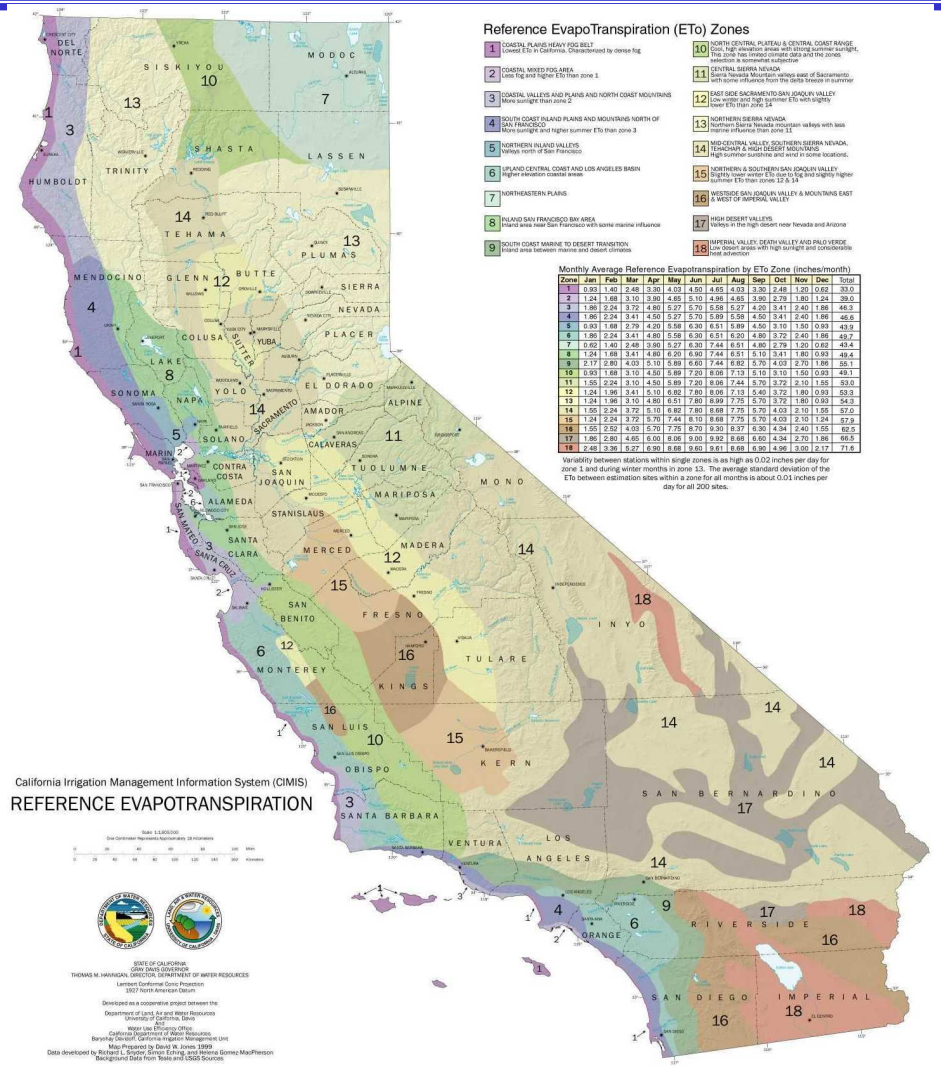
Data Sources

- Precipitation data
  - Western Regional Climate Center - Western US Historical Summaries (Individual Stations)
- Water usage
  - USGS Circular 1268, “Estimated Use of Water in the United States County-Level Data for 2000”
  - USGS “Guidelines for Water Use Estimates”
- Power plant locations and output
  - 2005 DOE Electric Information Administration (EIA) Form EIA-860, "Annual Electric Generator Report”

Temporal variation of anthropogenic water

- The USGS data are only annual averages.
- Water use at least throughout the year is needed.
- Consideration of approaches led to data gathered and analyzed by the state of California Department of Water Resources (DWR).
- DWR, in cooperation with UC, Davis, manages a network of 177 automated weather stations under the California Irrigation Management Information System (CIMIS) program.
  - CIMIS automated stations collect data at 60 second intervals, and average it for hourly and daily periods.
  - Data are ingested in an evapotranspiration model.
  - DWR has compiled monthly and annual evapotranspiration amounts for a set of 18 zones that cover California

Evapotranspiration Zones of California

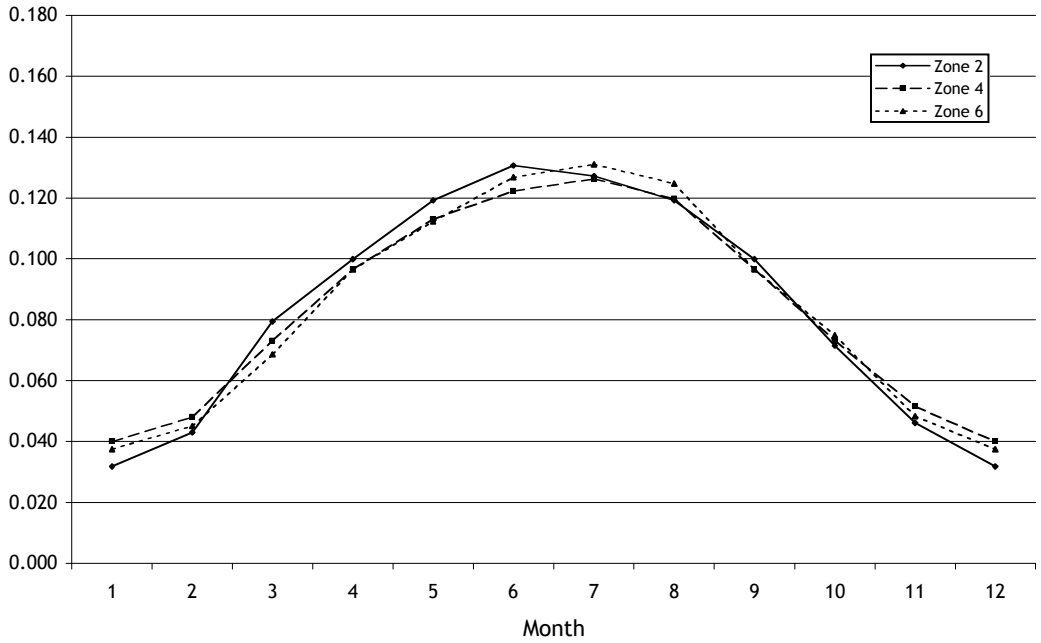


(Reprinted courtesy of CIMIS.)

THE AEROSPACE CORPORATION

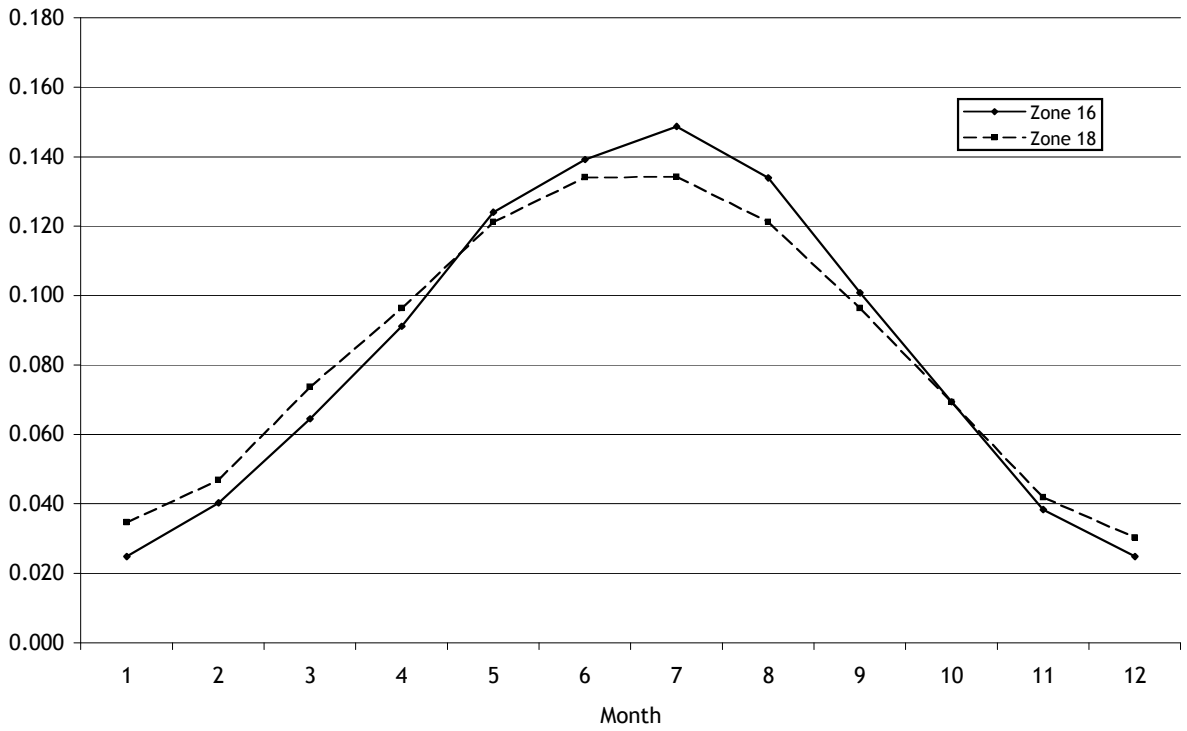
Temporal Variation of Evapotranspiration

- We allocated the annual irrigation and domestic use amounts according to the monthly profiles of evapotranspiration statistics
- Examples from two counties: Orange County, on the coast



Temporal Variation of Evapotranspiration

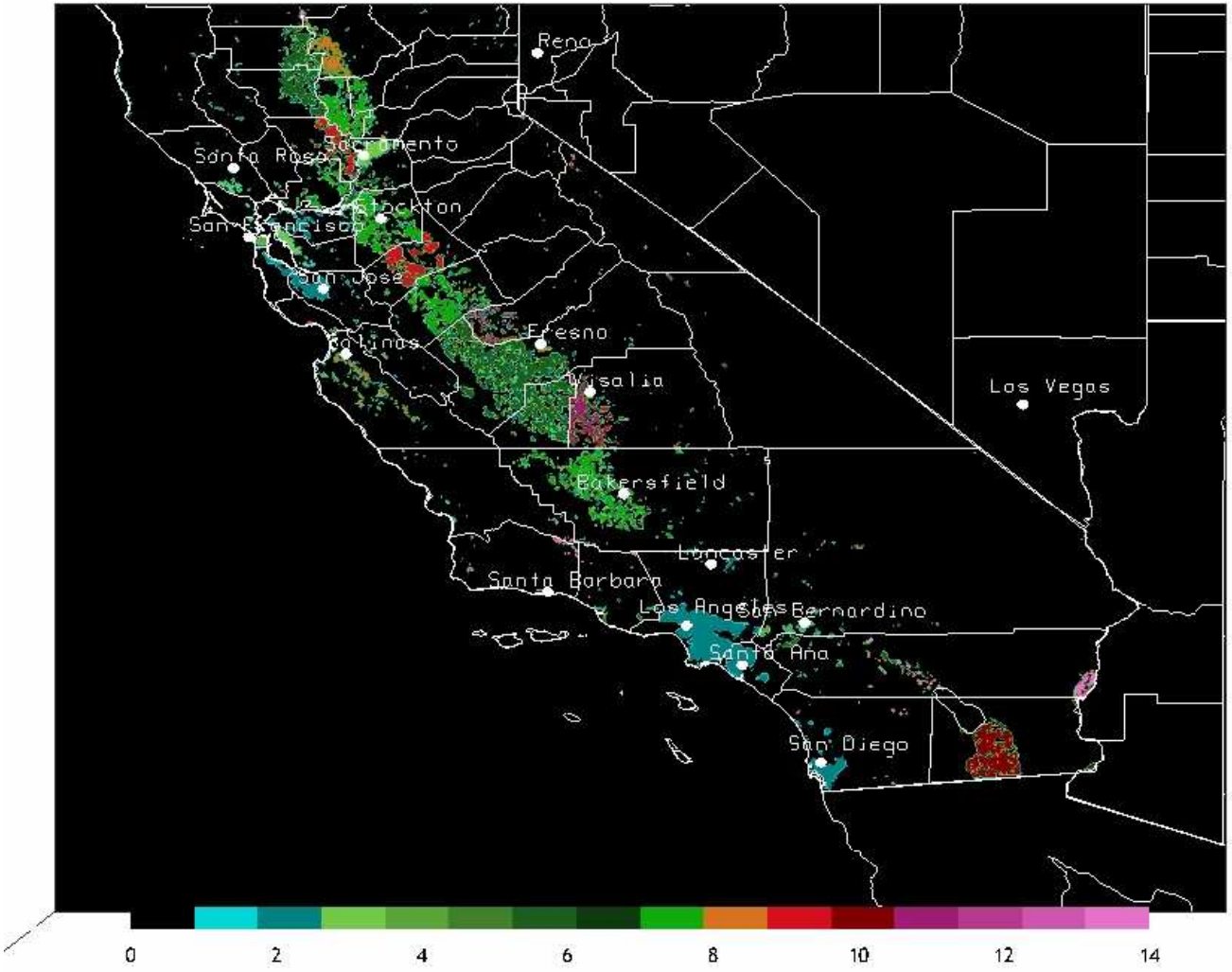
- Imperial, an inland county



Spatial Distribution of Anthropogenic Moisture

- We distributed the moisture spatially using satellite-derived land-use data.
- Decided to use the same land-use data as WRF itself, which has 30’ resolution and 24 categories.
- Four categories of irrigated croplands and one of urban land use
- Area-weighted average monthly fraction of evapotranspiration developed separately for urban and irrigated lands.
- The fraction was used to divide the total anthropogenic moisture available and distribute it in space.

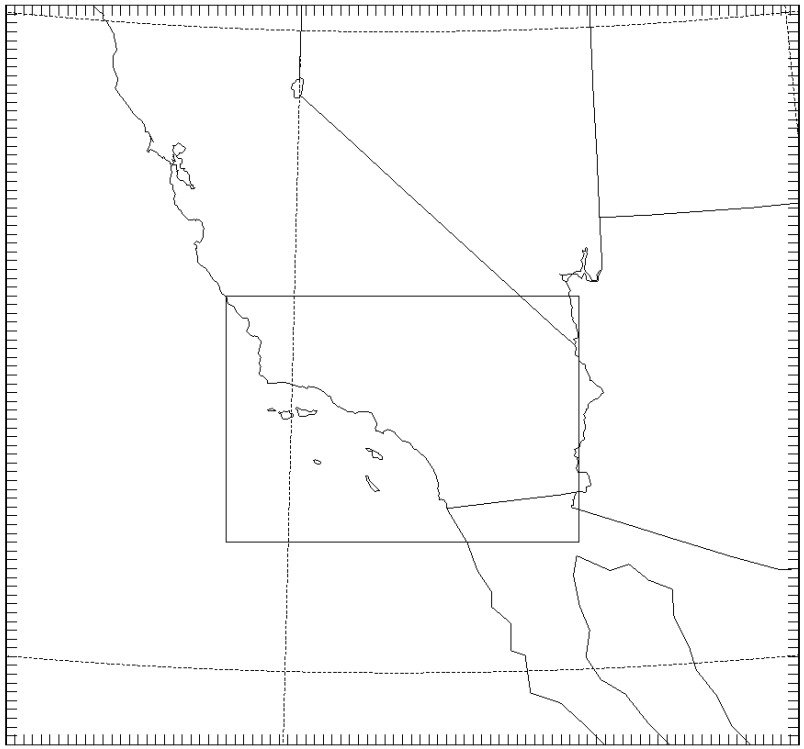
Example of Monthly Anthropogenic Moisture - July



THE AEROSPACE CORPORATION

Model, Configuration, and Domain

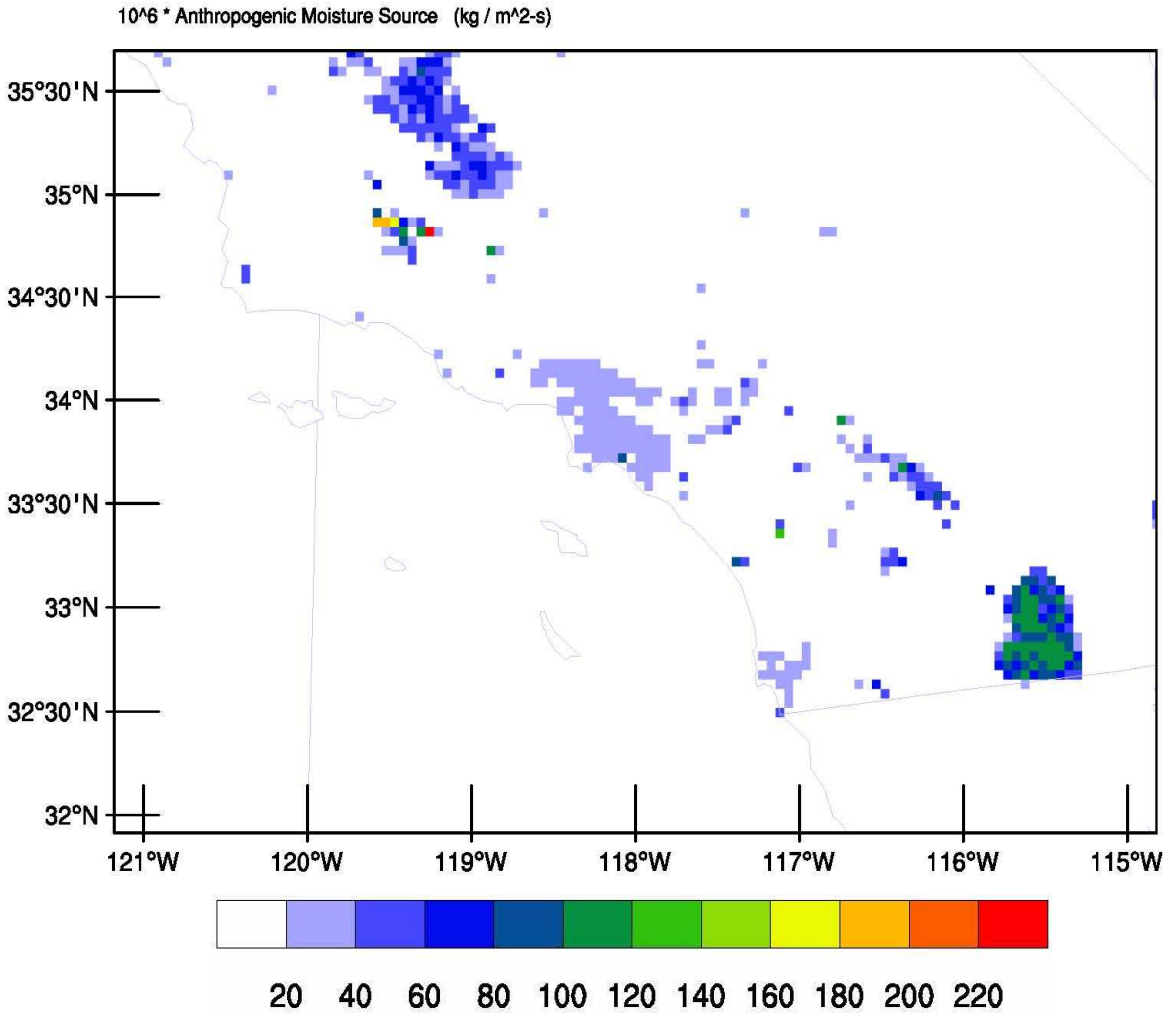
- WRF (ARW) Version 2.2
  - ETA-TKE PBL scheme
  - NOAH Land Surface Model (4-soil layers)
  - 5-km grid on inner domain, 15-km grid on outer domain, initialized with 30’ (0.9 km) terrain data
  - Inner and outer domains interact
  - 37 vertical levels; model top is 100 hPa
  - Rapid Radiative Transfer Model (RRTM) with recalculation every 30 min
  - Grell’s cumulus parameterization only in the outer domain
  - Initial- and lateral boundary-conditions from the NCEP North American Model at 40 km
  - Urban canopy submodel on for consistency with setup for control runs



Model Modifications

- We modified the WRF database known as the Registry to add:
  - the field the anthropogenic moisture source for the middle of each month of the year;
  - and the instantaneous field at each simulation time, which is derived from the former field by linear temporal interpolation.
- We also modified the NOAH LSM subroutines to add the anthropogenic moisture to any natural liquid precipitation at the surface.

Anthropogenic “precipitation” rate, Inner Domain

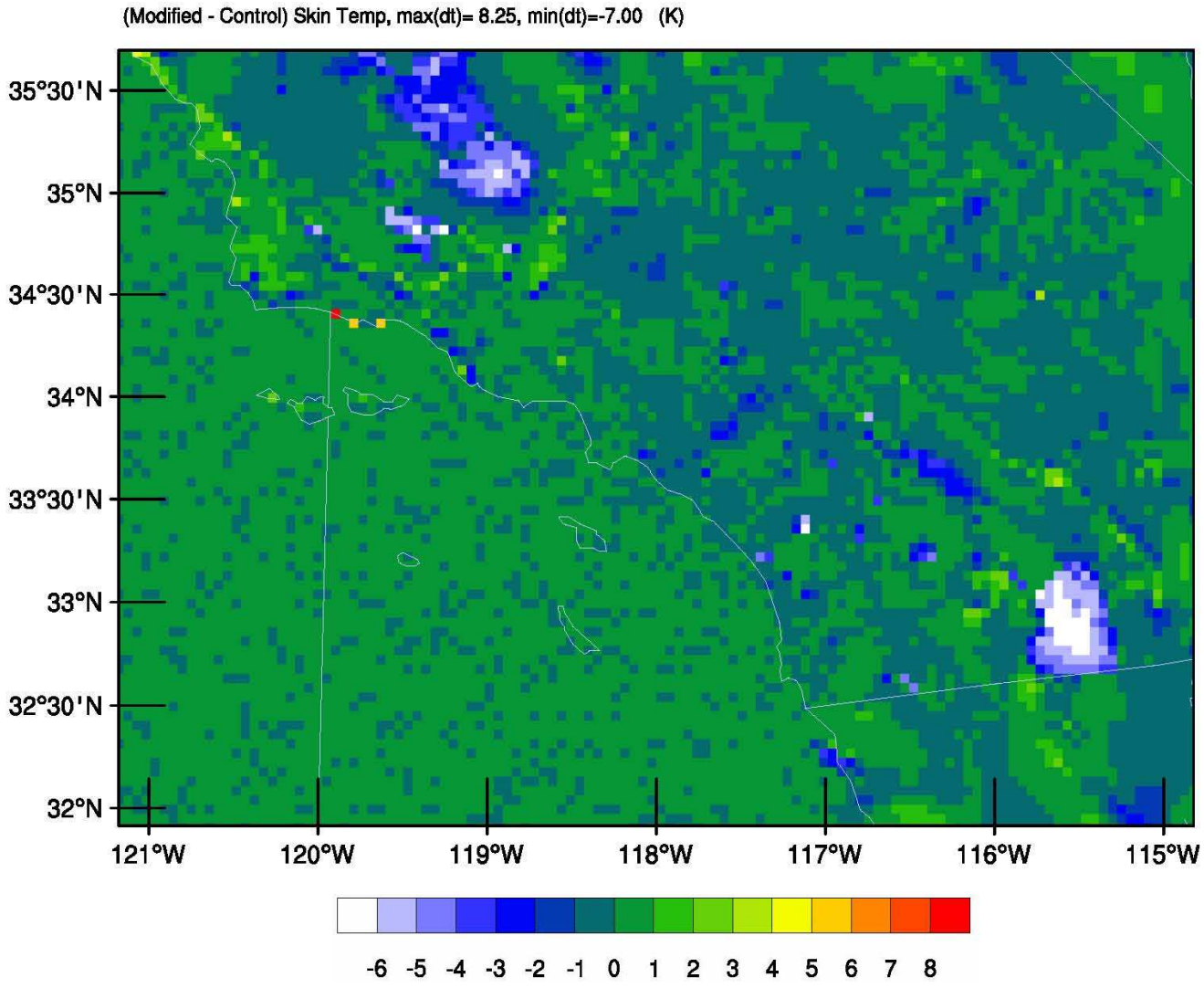


Results

- Qualitative Quick look - Compare Skin Temperature and 2-Meter Temperature field with and without anthropogenic moisture

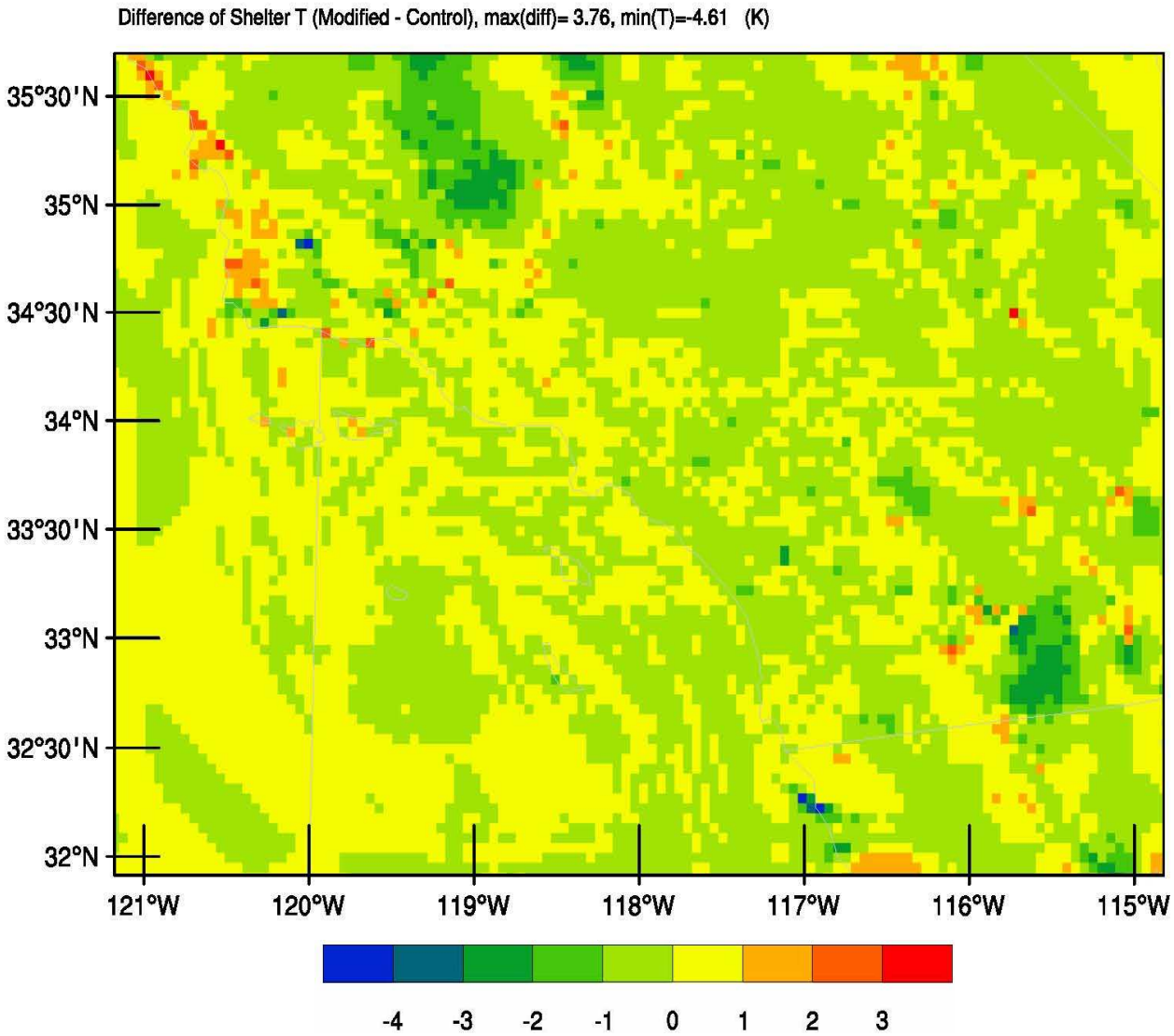
- Quantification of the Impact – Preliminary Results
  - Compare differences between “with anthropogenic” runs (modified) and “without anthropogenic” runs (control) for 23 days between 1 July 2007 and 7 August 2007
  - Verify with- and without- runs against 2-m Temperature observations (T2)

Skin Temperature Difference (modified – control) 17Z July 4 2007

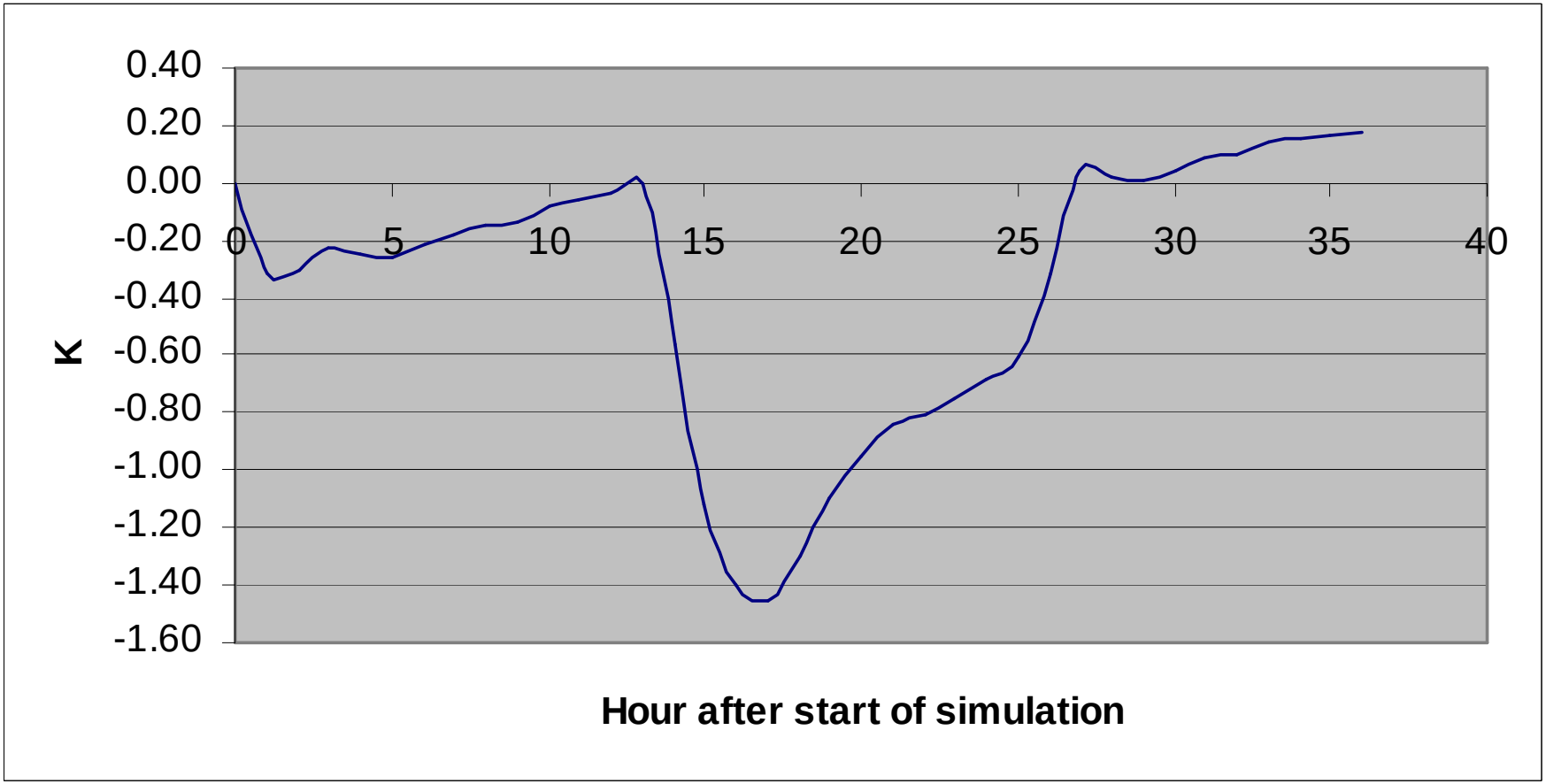


THE AEROSPACE CORPORATION

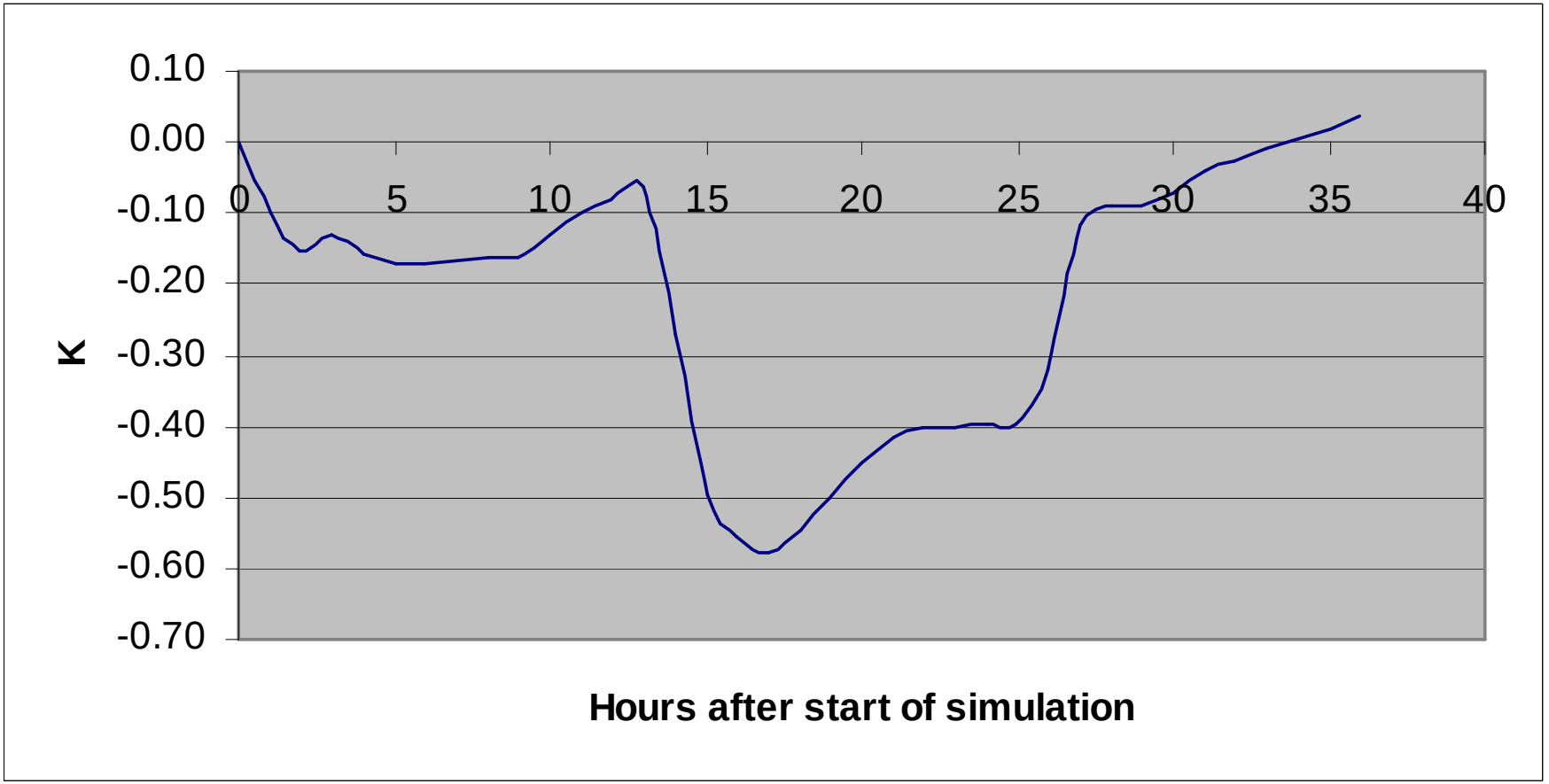
2-Meter Temperature Difference (modified – control) 17Z July 4 2007



Average Difference in Skin Temperatures over Anthropogenic Water Sources, Domain 2



Average Difference in 2-m Temperatures over Anthropogenic Water Sources, Domain 2



Plans

- Verify 2-Meter Temperature against observations only over anthropogenic moisture areas and all of inner domain
- Verify 2-Meter Specific Humidity over anthropogenic moisture areas and all of inner domain
- Incorporate a sub-model to represent moisture from power plants and qualitatively assess the impact

Questions?