The Effects of Aerosols on California Climate

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MODIS Science Team Meeting

March 23, 2005

Scientific Question

What are the effects in California and the South Coast Air Basin of all anthropogenic particles and their gas precursors on

- rainfall
- winds
- pollution content of rainwater
- cloudiness
- near-surface air temperatures
- vertical temperature profiles
- relative humidity
- ultraviolet/total solar/thermal-infrared radiation

and how can MODIS data help evaluate these effects?

GATOR-GCMOM

- Gas processes
  - Emission
  - Photchemistry
  - Gas-to-particle conversion
  - Cloud removal
- Aerosol processes
  - Emission
  - Nucleation/condensation
  - Aerosol, cloud coagulation
  - Dissolution/chem./crystallization
  - Dry deposition/sedimentation
  - Rainout/washout
- Cloud processes (3-D clouds)
  - Described next page
- Radiative transfer
  - UV/visible/near-IR/thermal-IR
  - Scattering/absorption

    Gas Aerosol Hydrometeor
  - Predicted snow, ice, water albedos
- Meteorological processes
  - Velocity, geopotential, pressure
  - Water vapor, temperature, density
  - Turbulence
- Surface processes
  - Temperatures and water content of

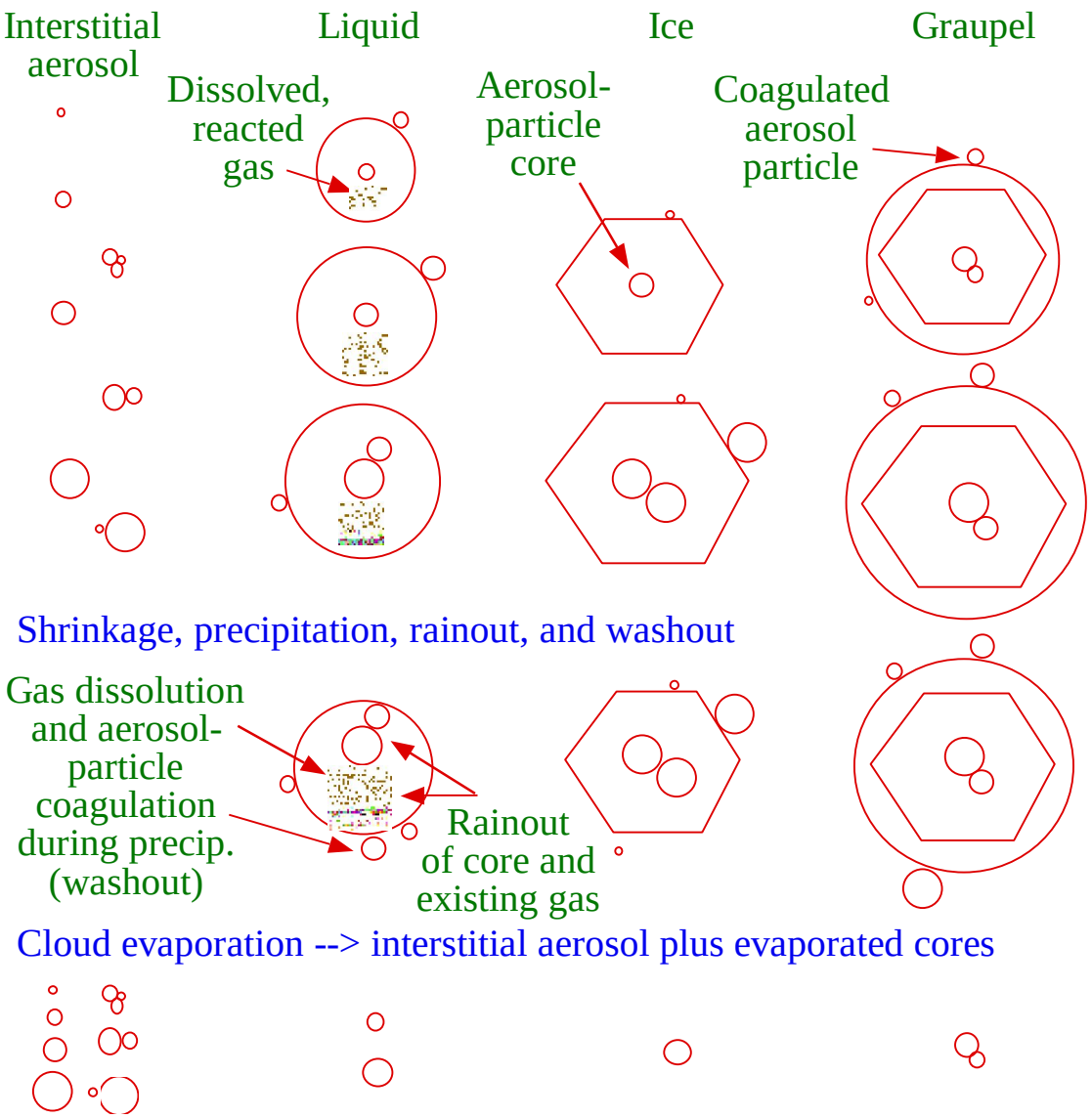
    Soil, Water, Snow, Sea ice,
    Vegetation, Roads, Roofs
  - 2-D ocean dynamics
  - 3-D ocean diffusion, chemistry
  - Ocean-atmosphere exchange

GATOR-GCMOM

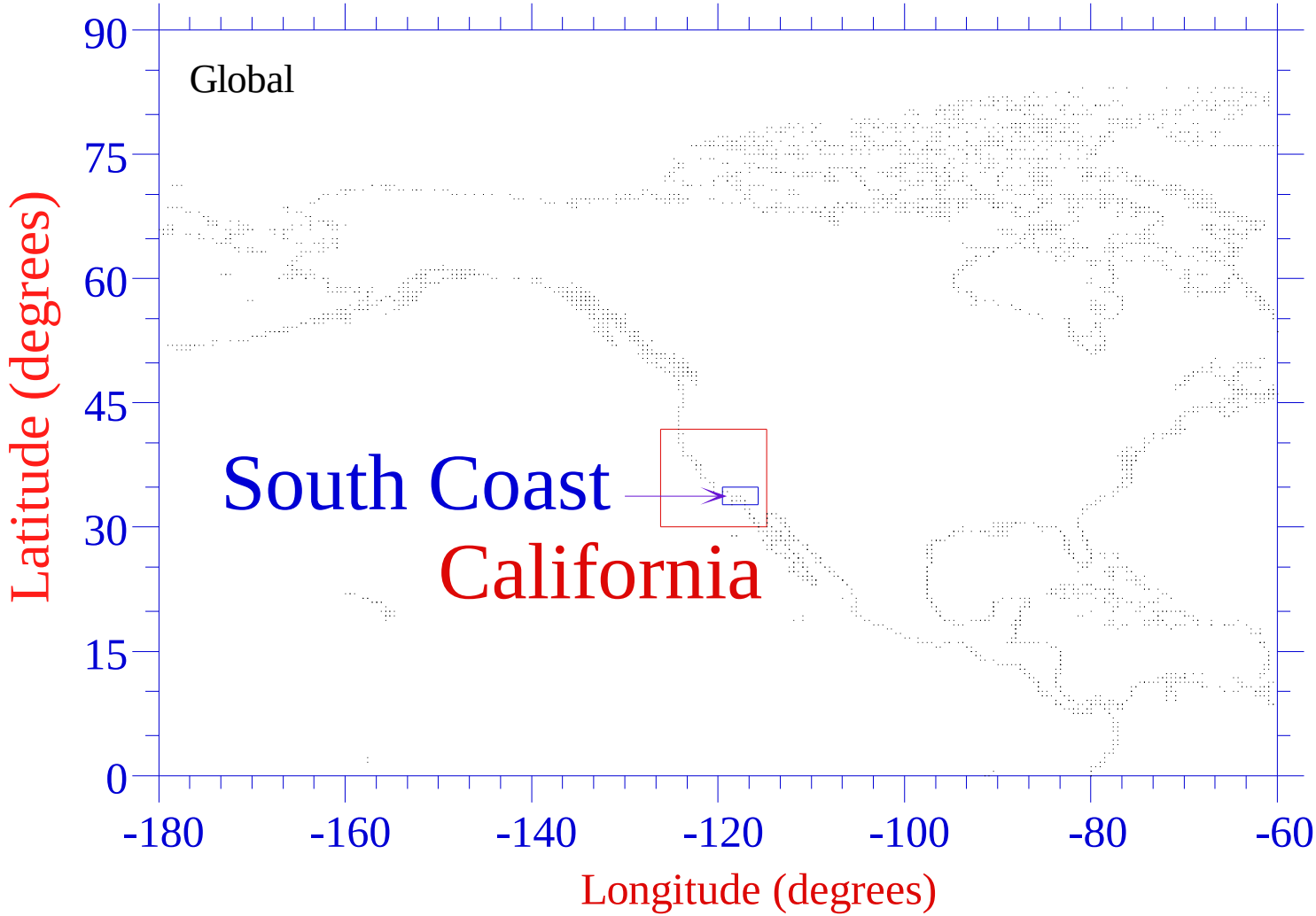
3-D size-resolved clouds form from size-resolved aerosols without parameterization or equilibrium assumption.

- Time-dependent, grid-scale clouds form and move in 3-D.
- Activation and growth/evaporation of size-resolved liquid and ice on size-resolved aerosol particles
- Homogeneous/heterogeneous/contact/evaporative freezing
- Size-resolved liquid-liquid, liquid-ice, liquid-graupel, ice-ice, ice-graupel, graupel-graupel coagulation.
- Size-resolved liquid-aerosol, ice-aerosol, graupel-aerosol coagulation and liquid drop breakup
- Size-resolved precipitation (including aerosol inclusions).
- Subcloud size-resolved evaporation/melting
- Lightning calculated from size-resolved bounceoffs
- Gas dissolution/aqueous chemistry
- Treats first and second indirect effects explicitly

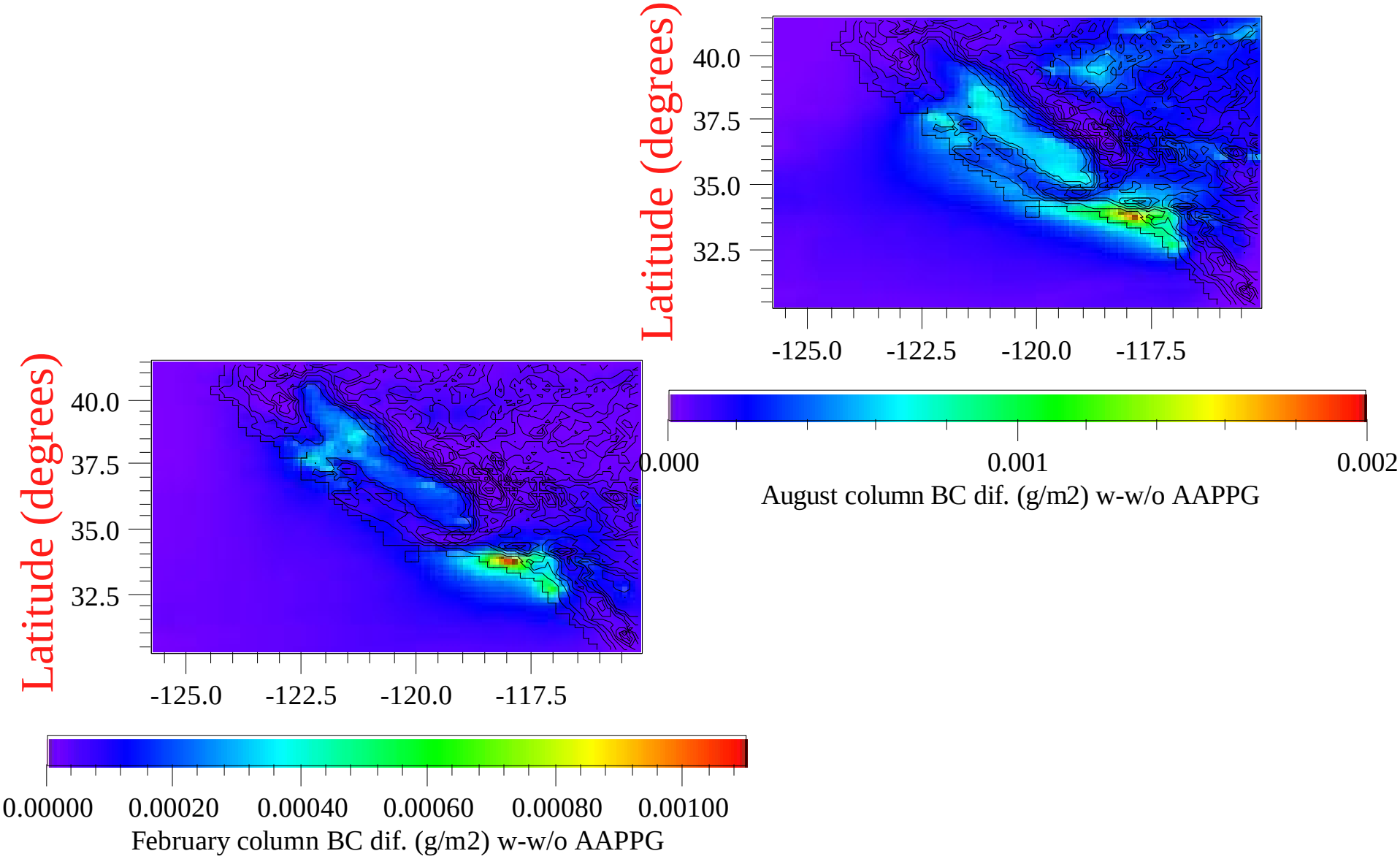
Aerosol-Cloud Interactions



Model Grids Treated for California Case



Feb/Aug BC Dif. w-w/o AAPPG



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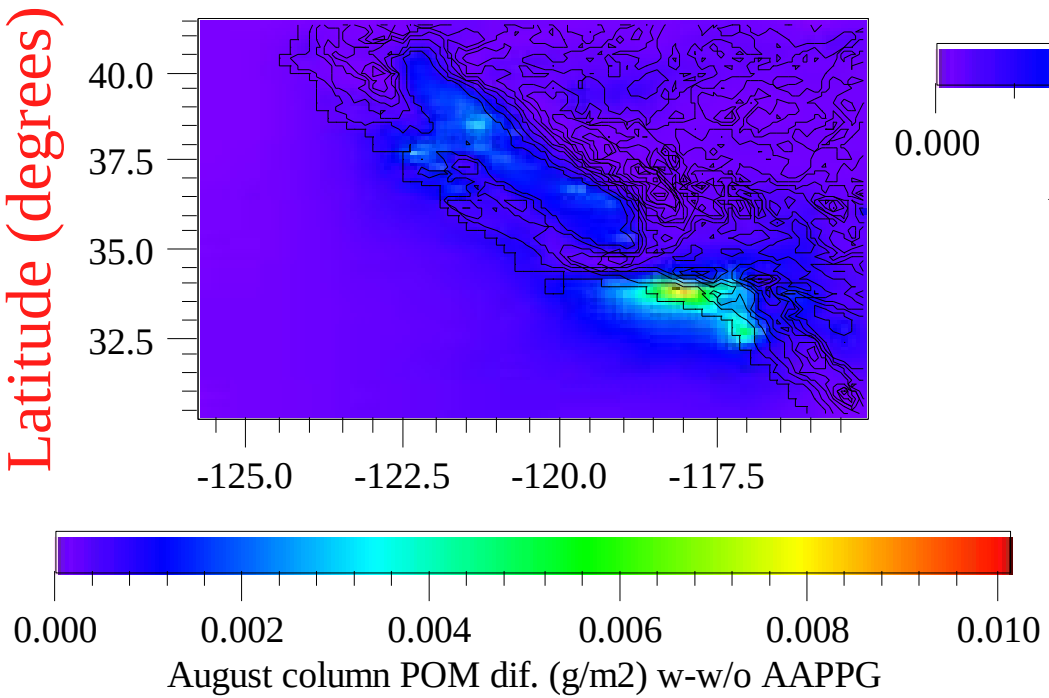

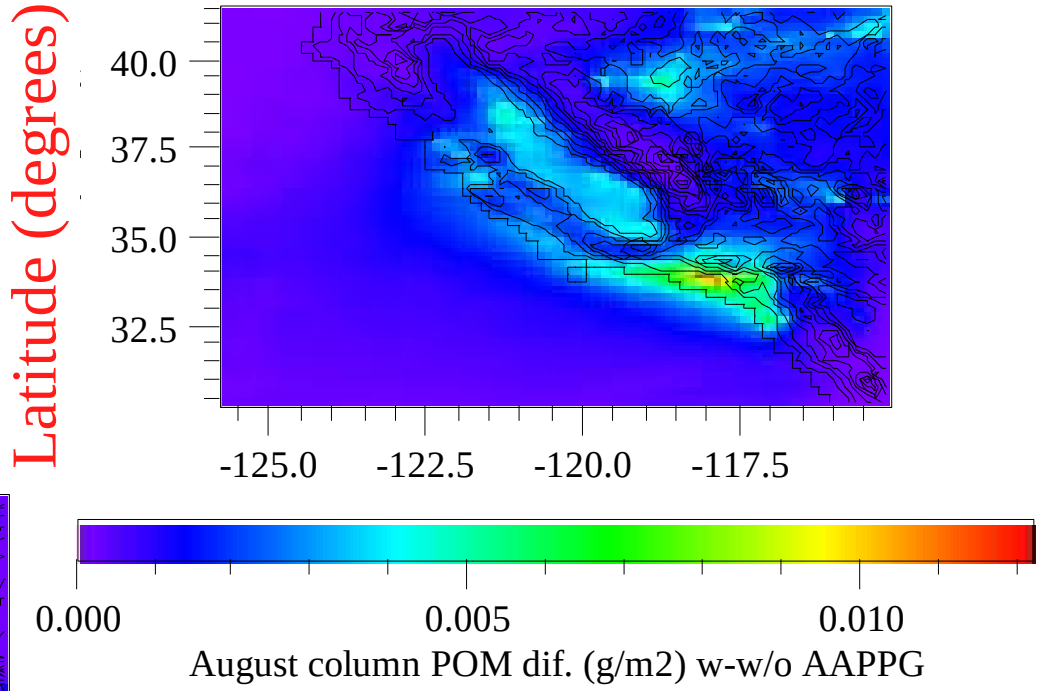

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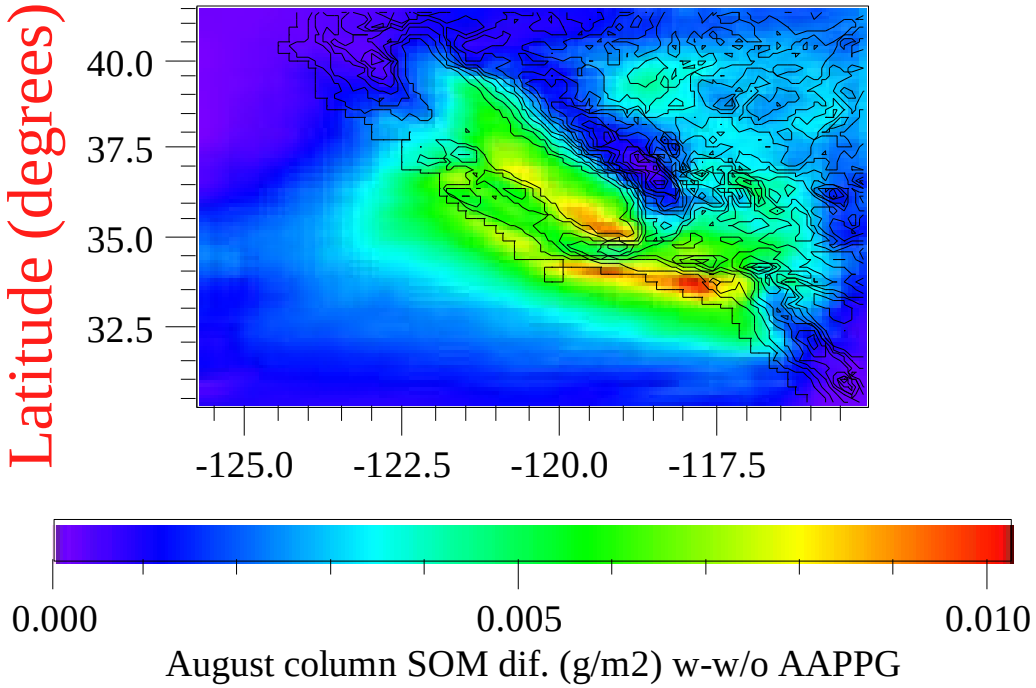
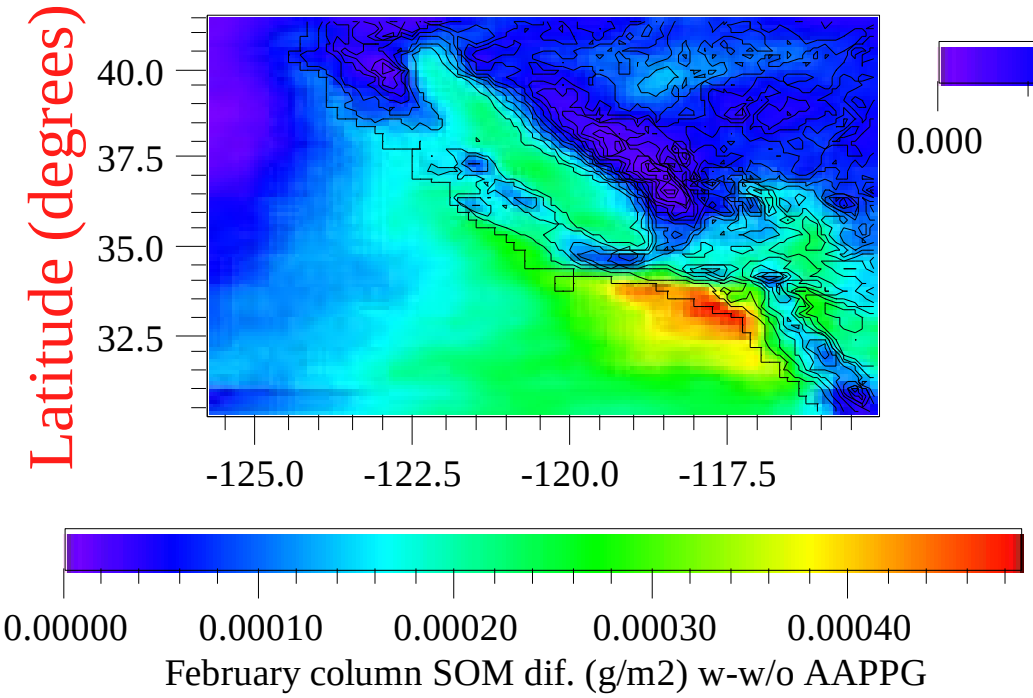
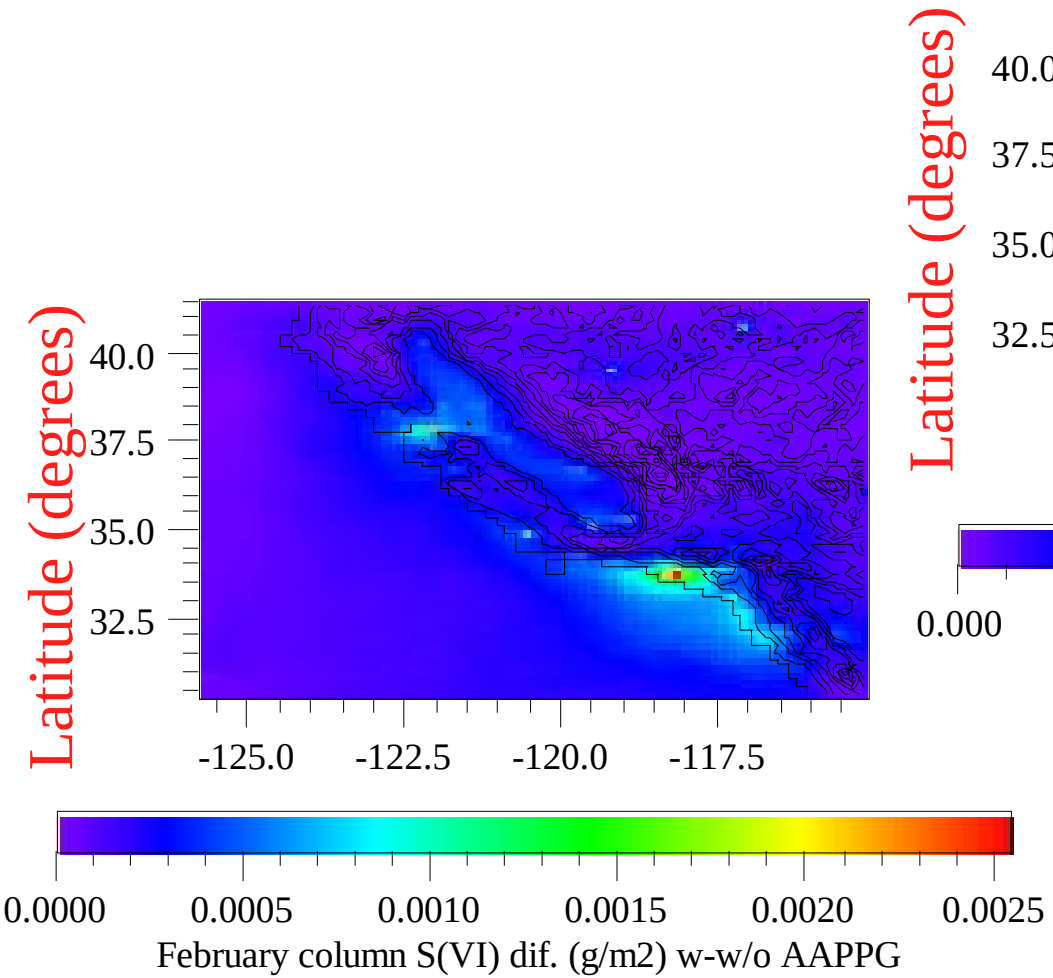
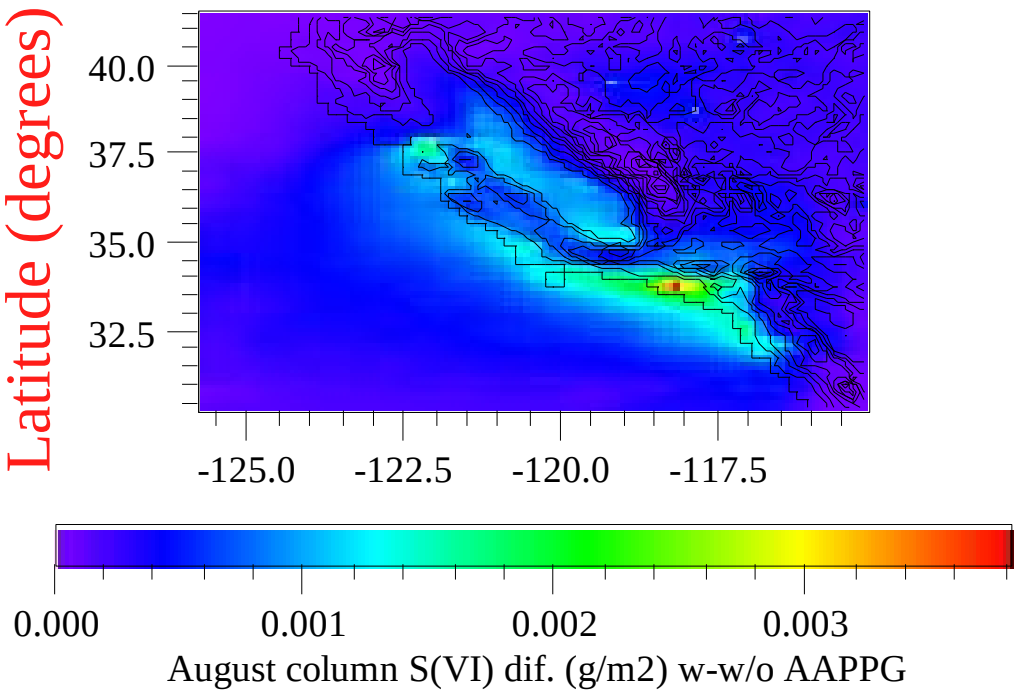


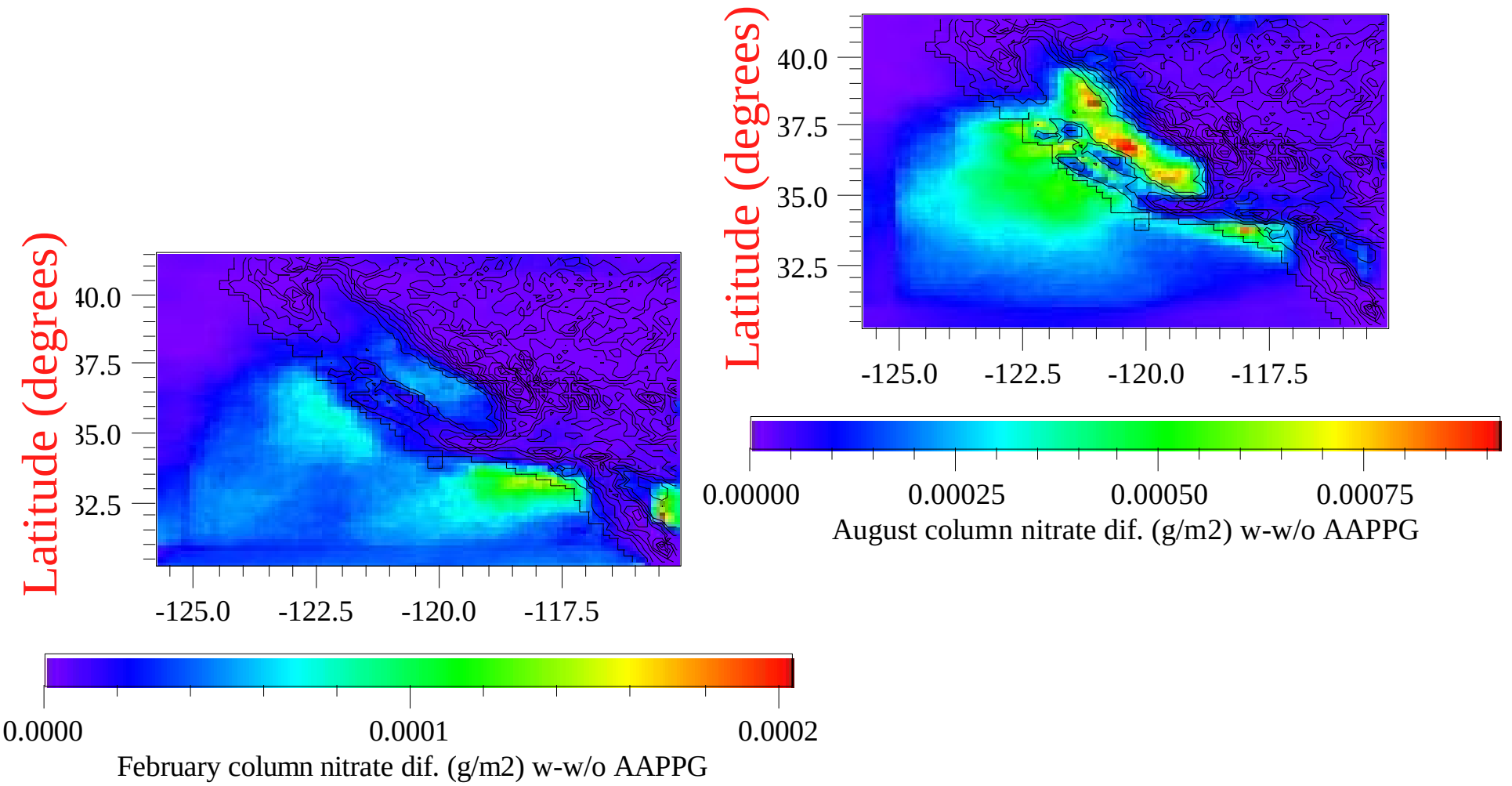


Feb/Aug S(VI) Dif. w-w/o AAPPG

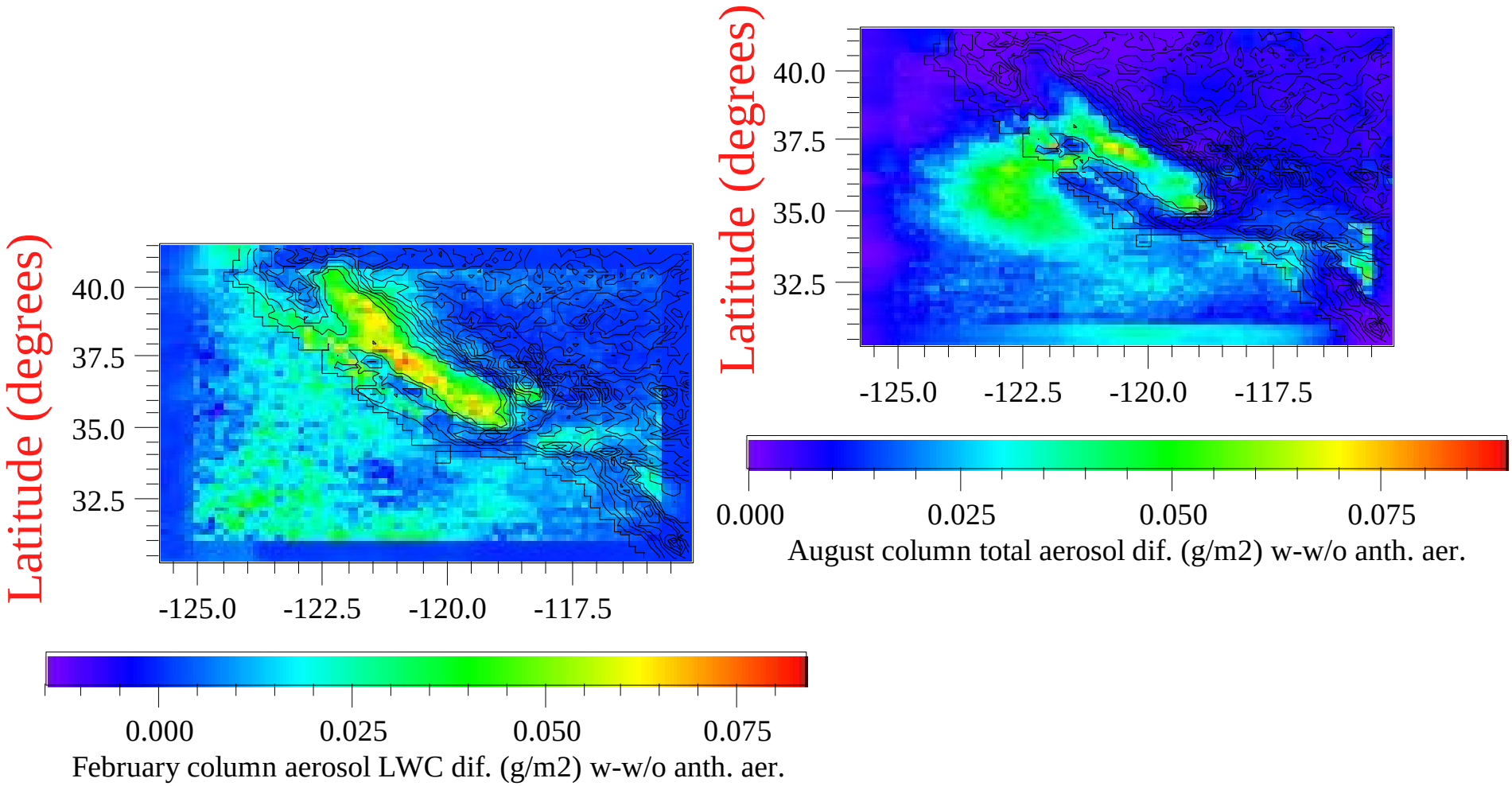




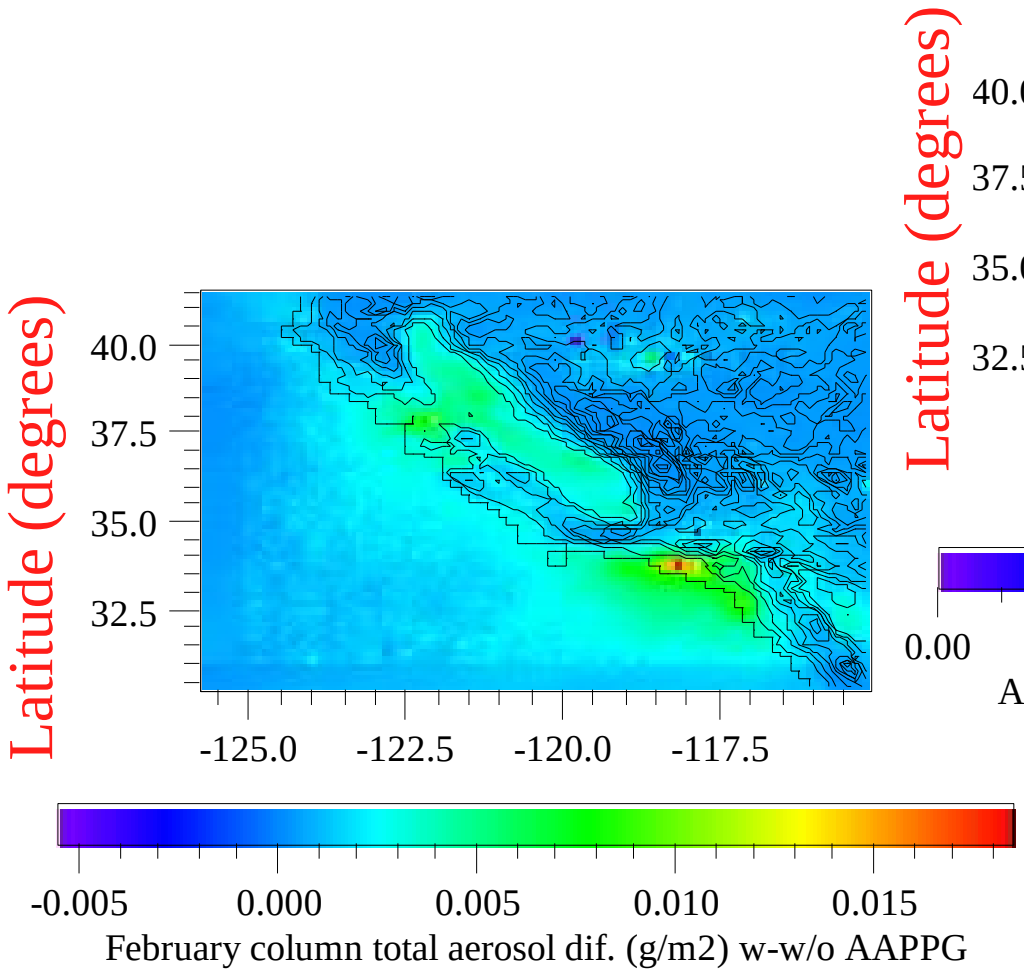
Feb/Aug NO_3^- Dif. w-w/o AAPPG

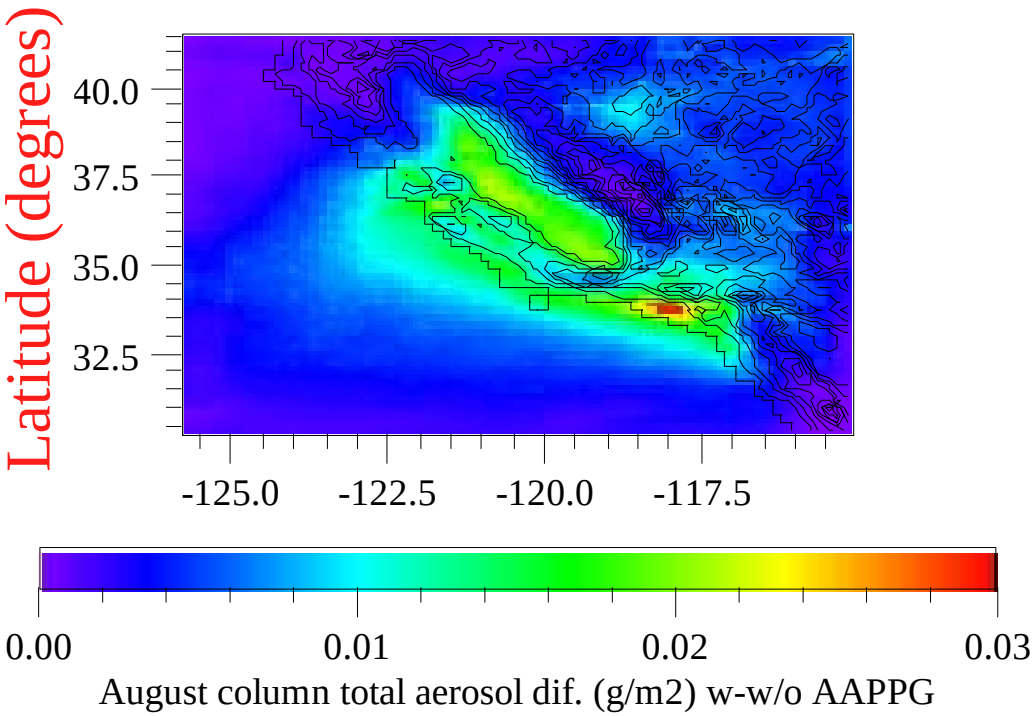


Feb/Aug Aerosol LWC Dif. w-w/o AAPPG

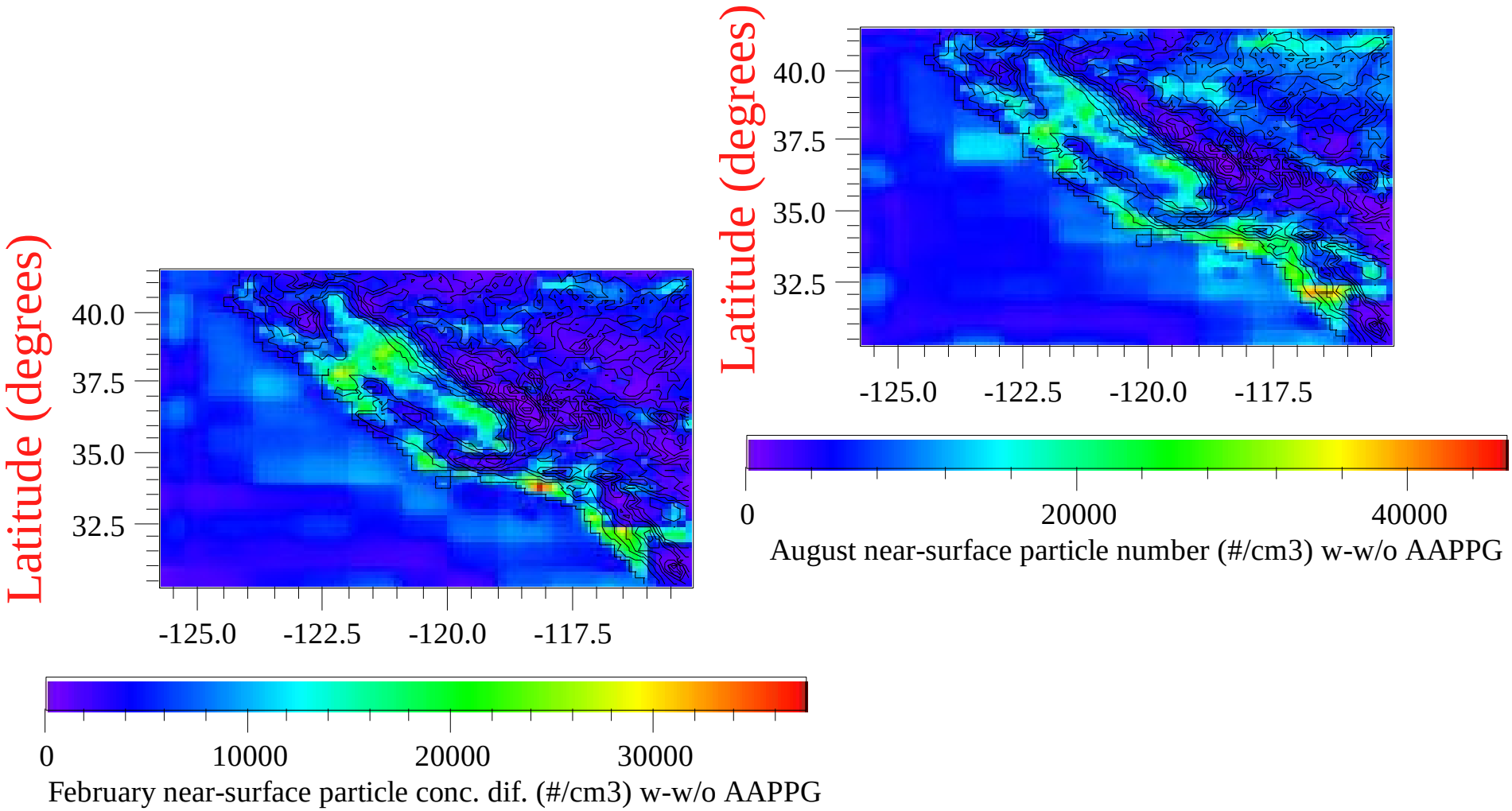


Feb/Aug Total Column Aerosol Mass Dif. w-w/o AAPPG

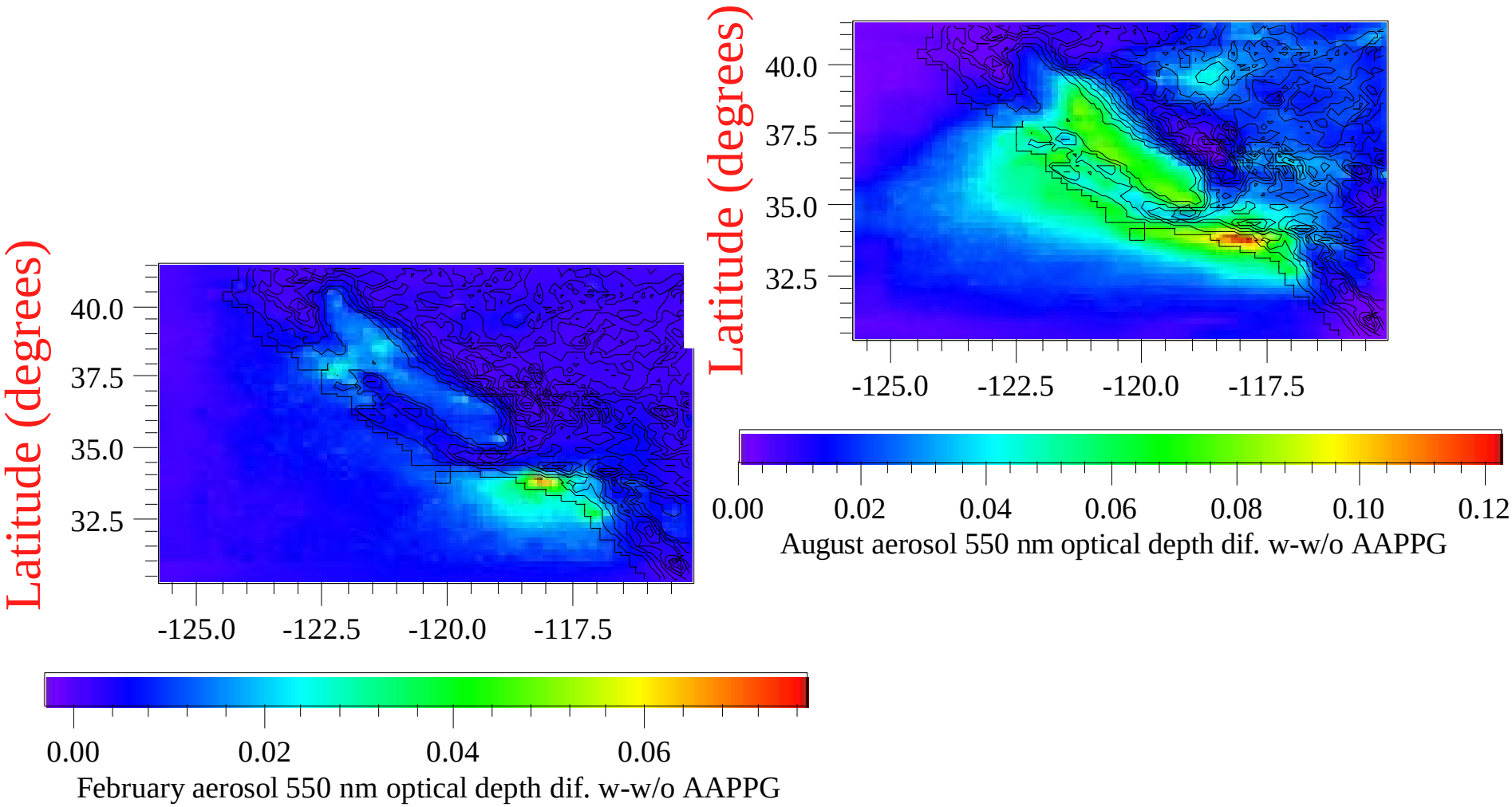




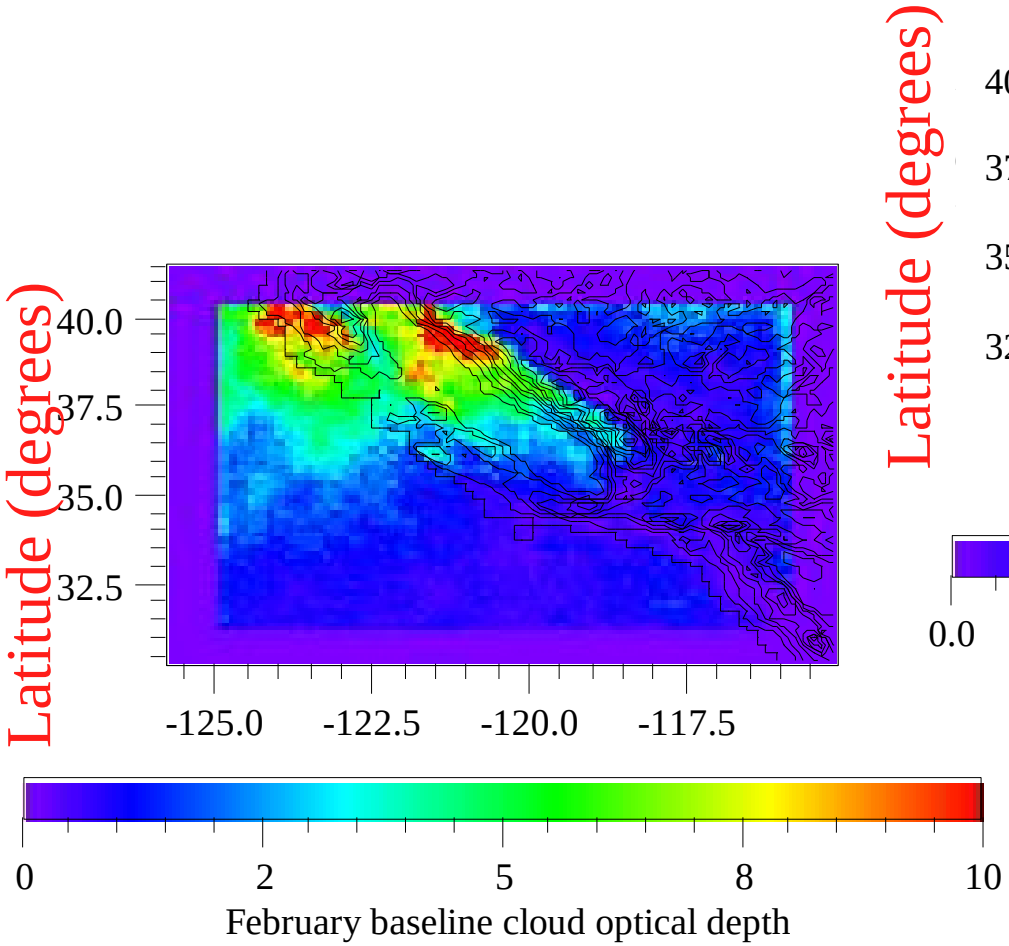
Feb/Aug Near-Surface Aerosol Number Dif. w-w/o AAPPG

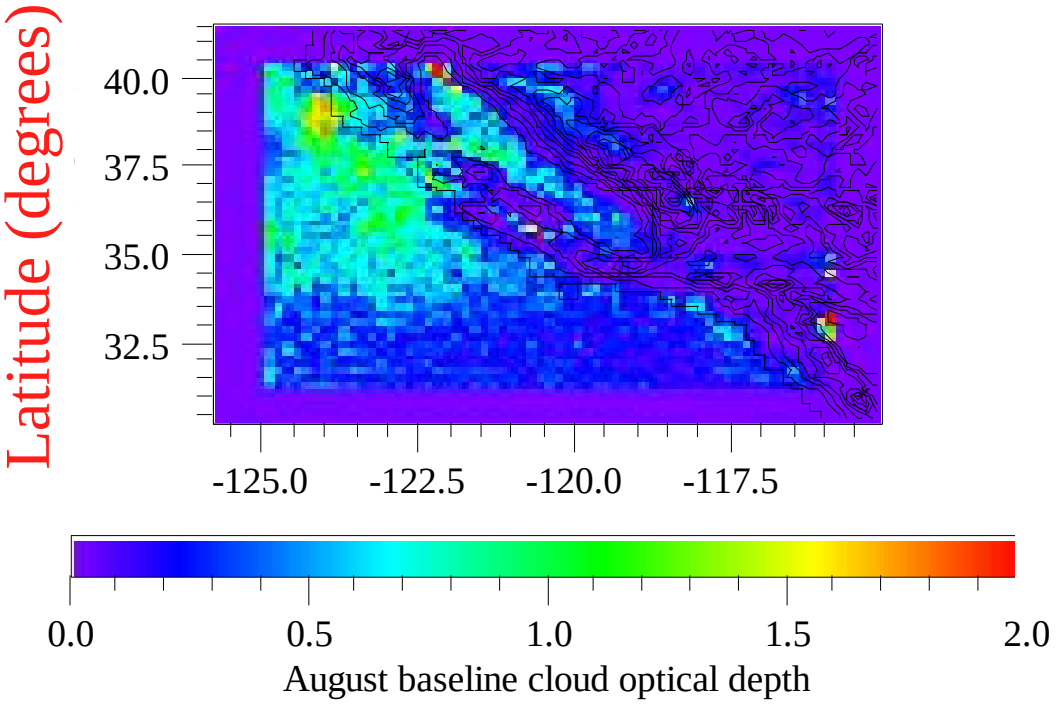


Feb/Aug Aerosol 550 nm Optical Depth Dif. w-w/o AAPPG

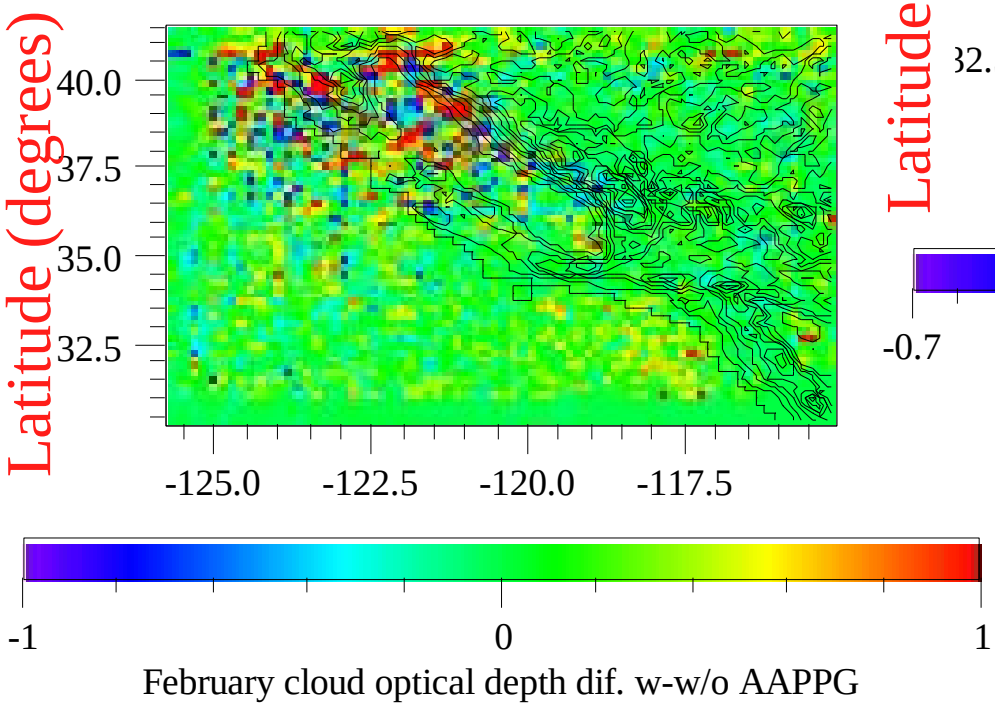


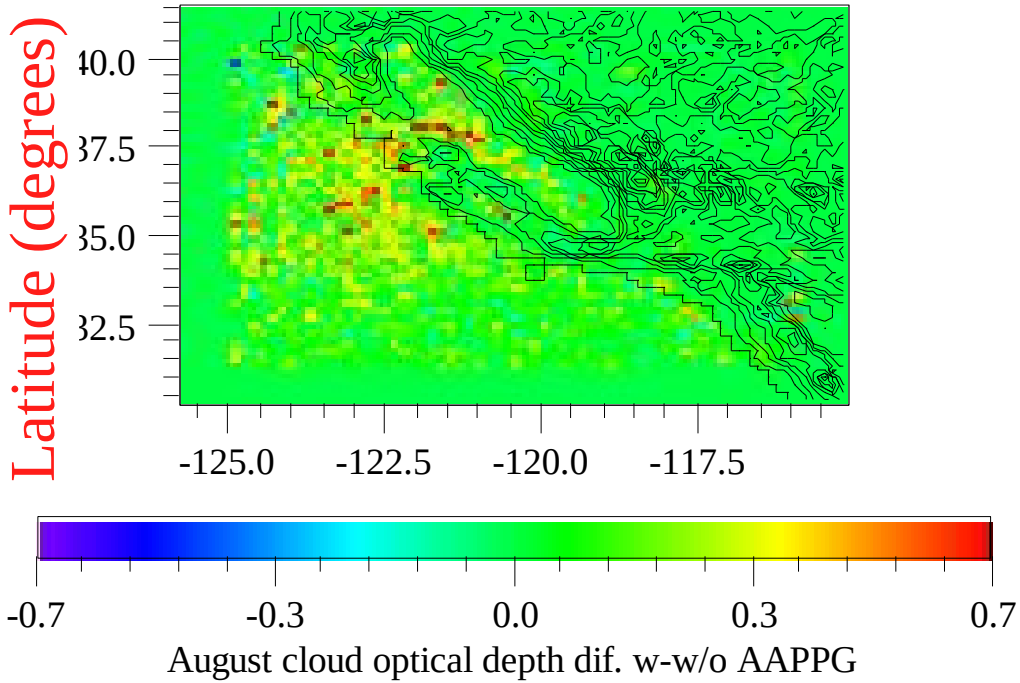
Feb/Aug Baseline Cloud Opt. Depth



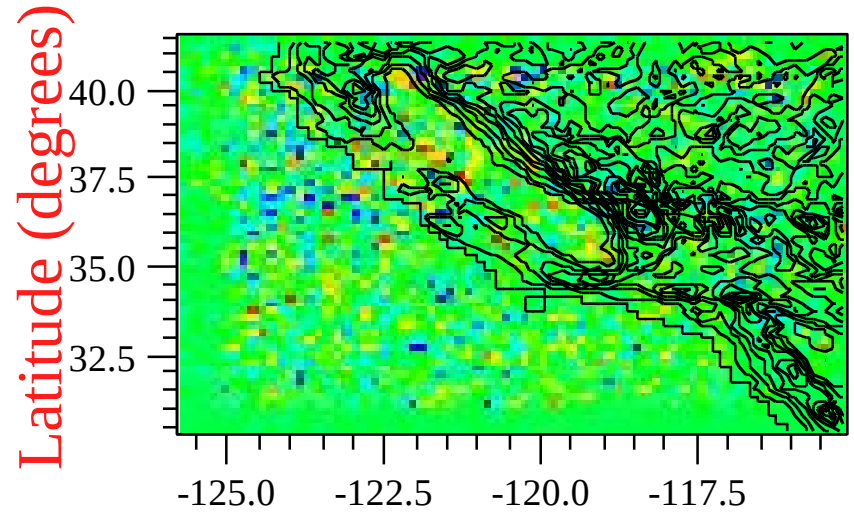


Feb/Aug Cloud Optical Depth Dif. w-w/o AAPPG

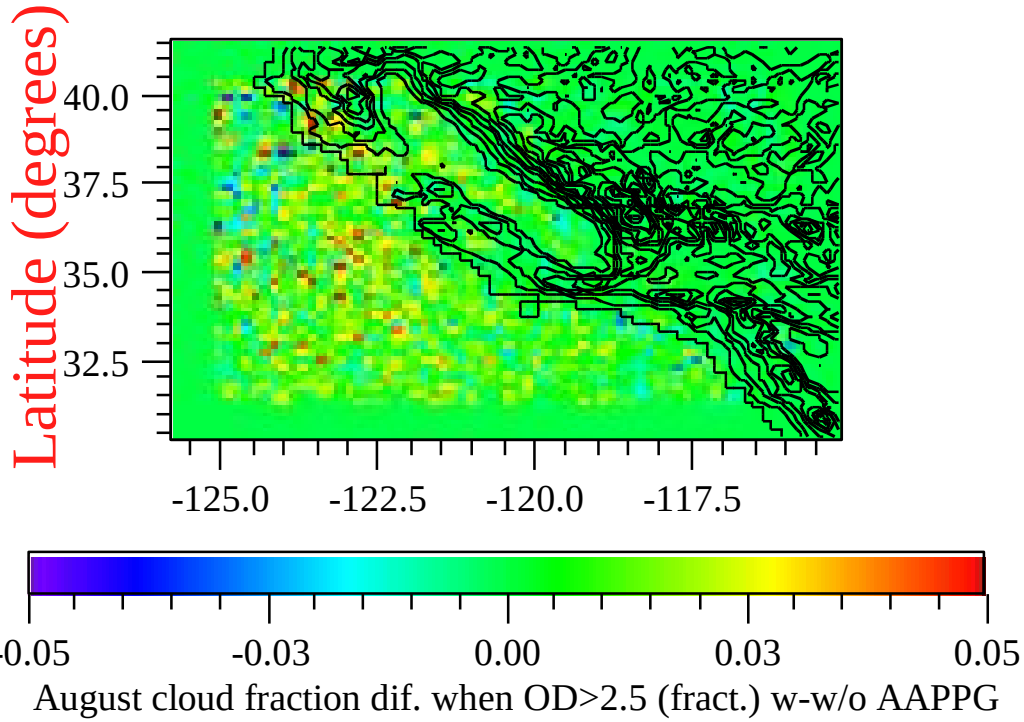




Feb/Aug Near-Surface Cloud Fraction Dif. w-w/o AAPPG

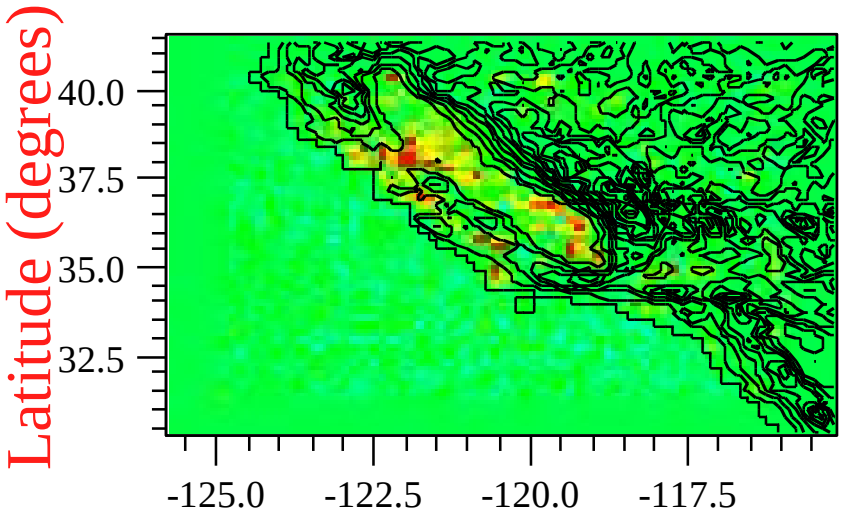


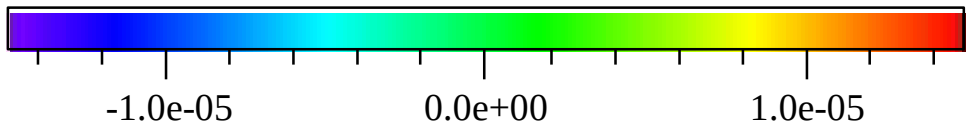
February cloud fraction dif. when OD>2.5 (fract.) w-w/o AAPPG



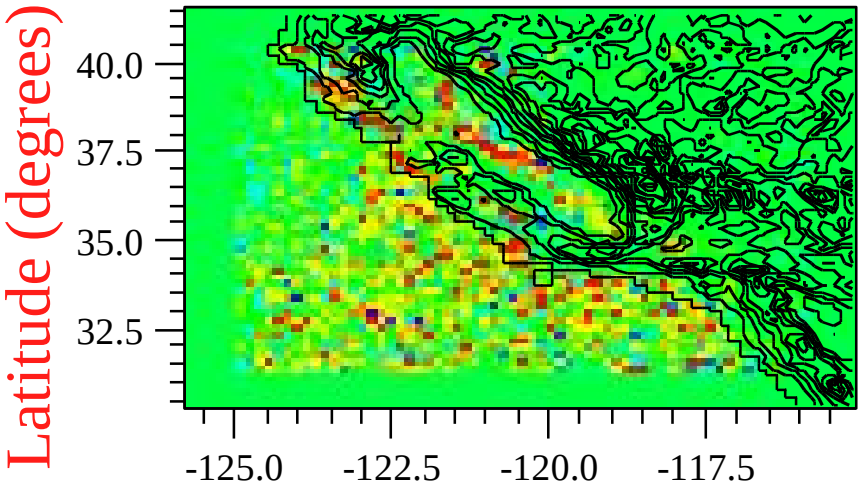
August cloud fraction dif. when OD>2.5 (fract.) w-w/o AAPPG

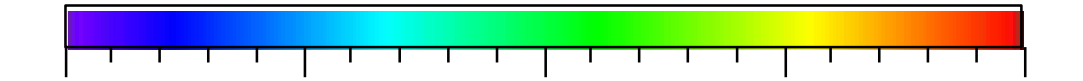
Feb/Aug Cloud LWC Dif. w-w/o AAPPG





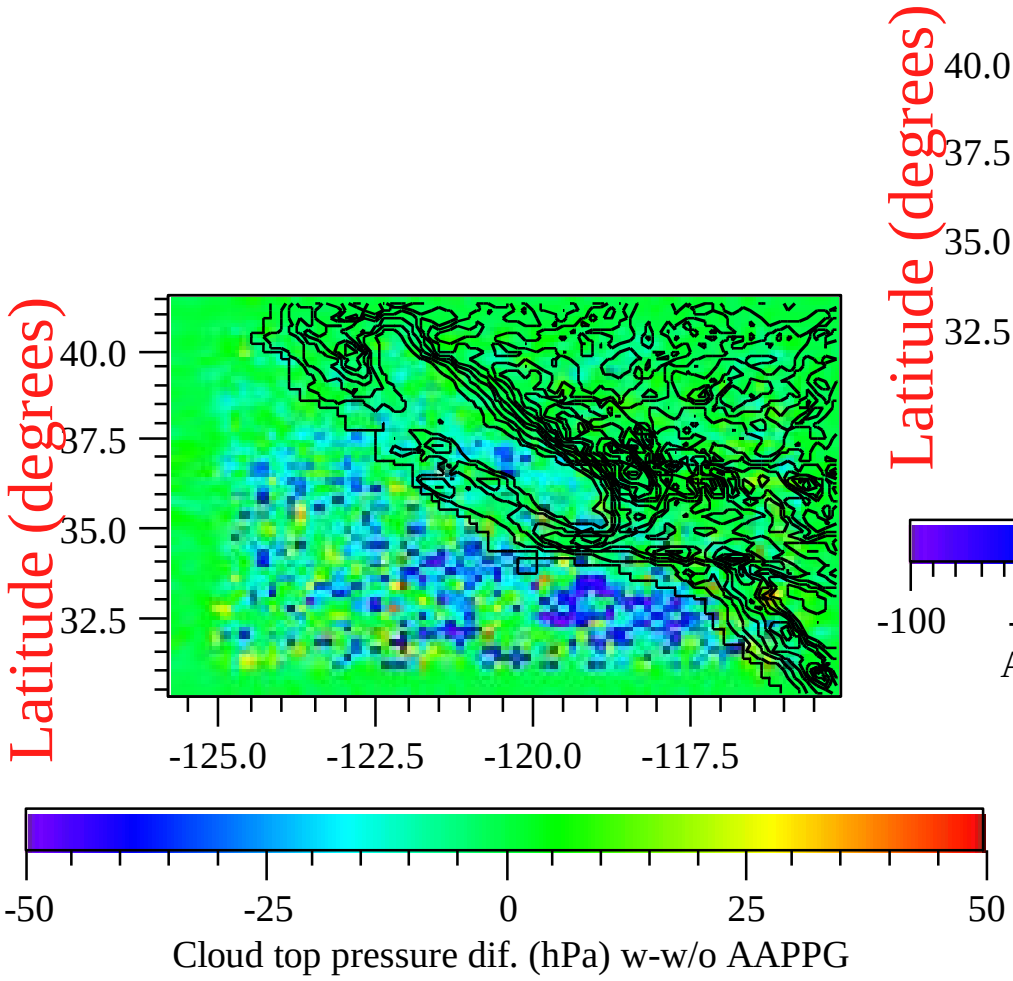
February near-surface cloud LWC dif. (kg/kg) w-w/o AAPPG

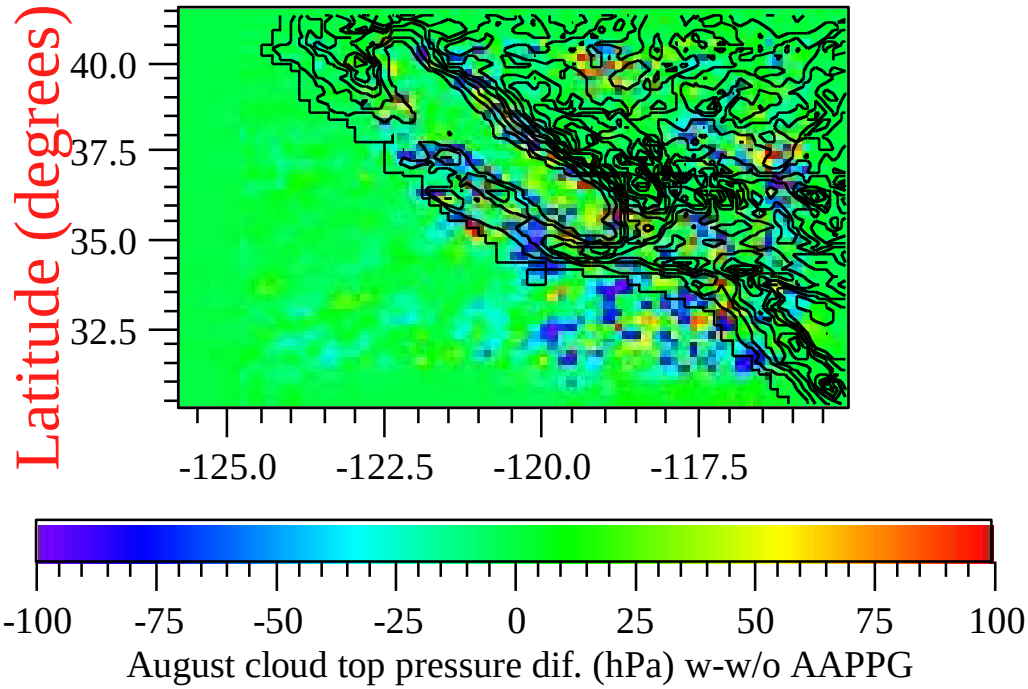




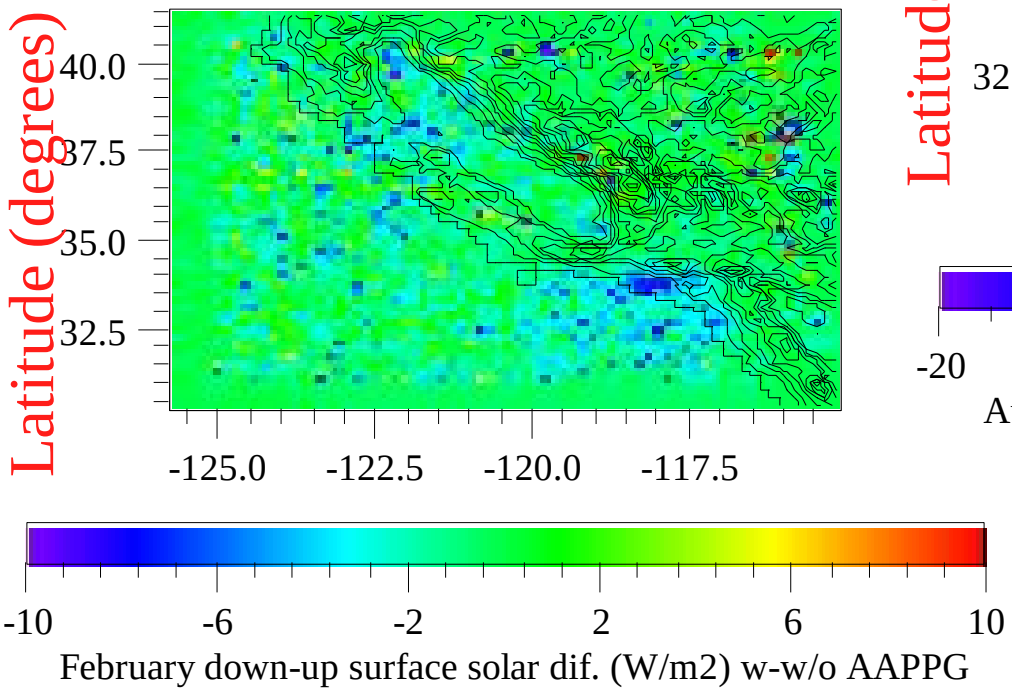
August near-surface cloud LWC dif. (kg/kg) w-w/o AAPPG

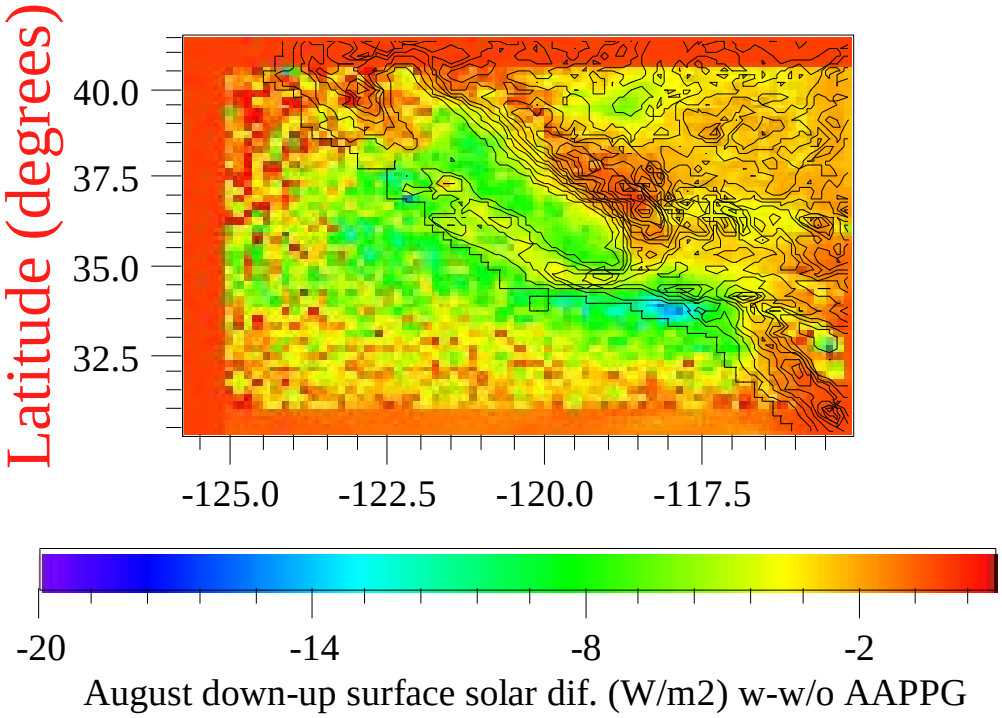
Feb/Aug Cloud Top Pressure Dif. w-w/o AAPPG



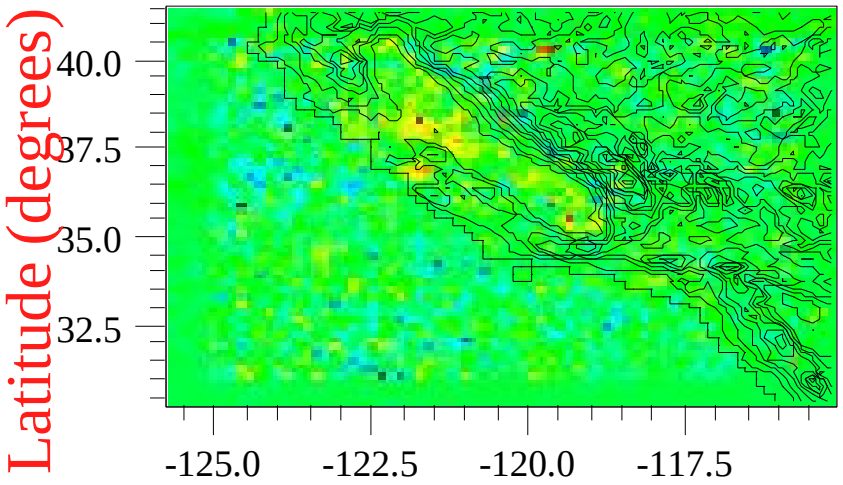


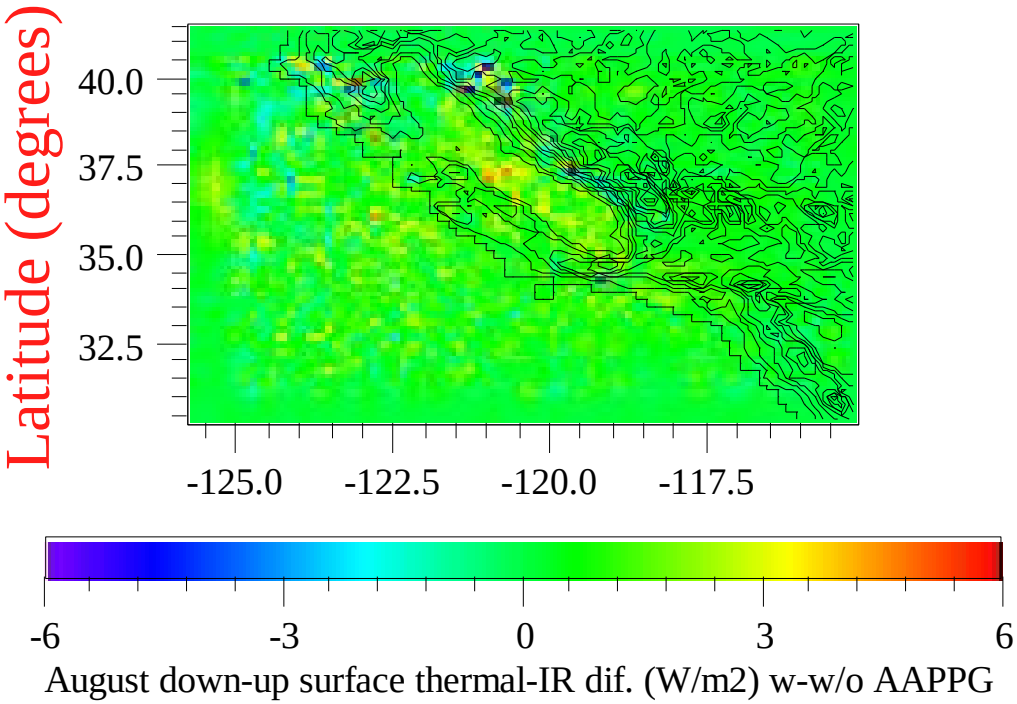
Feb/Aug Down-Up Surface Solar Radiation Dif. w-w/o AAPPG



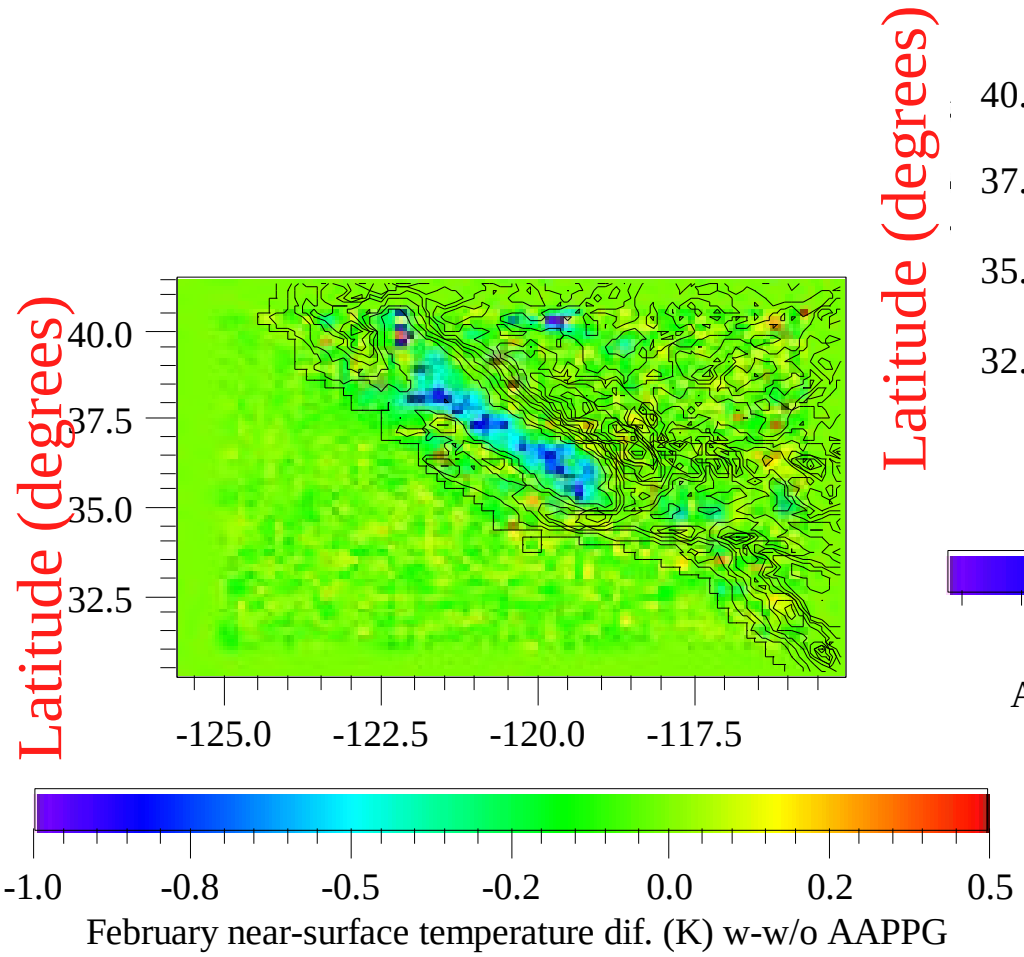


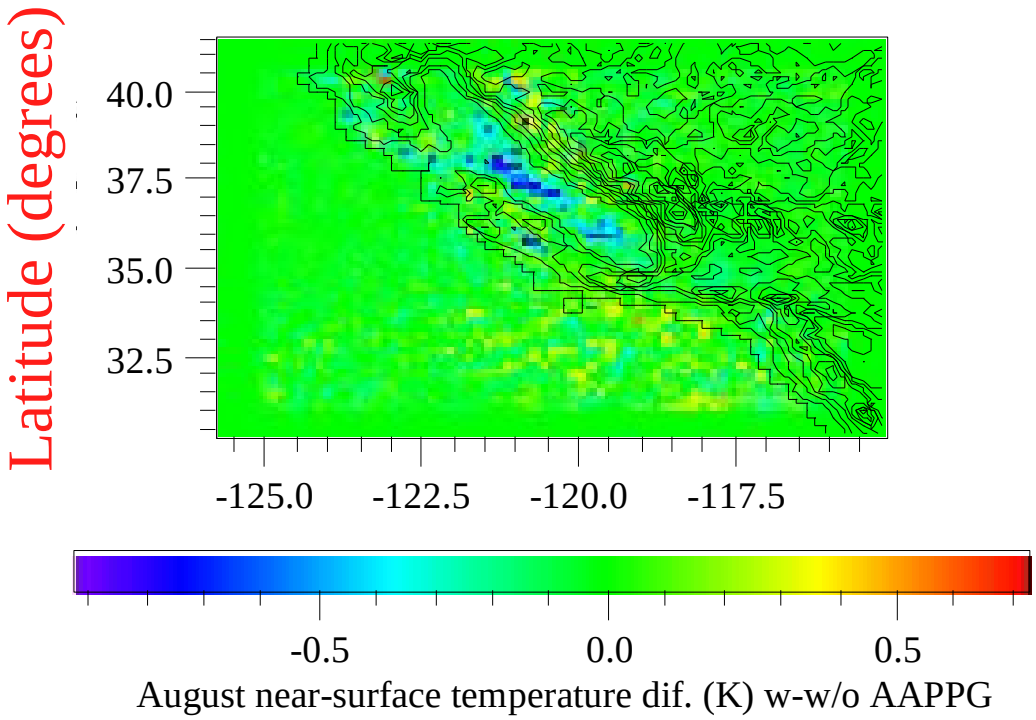
Feb/Aug Down-Up Surface Thermal-IR Radiation Dif. w-w/o AAPPG



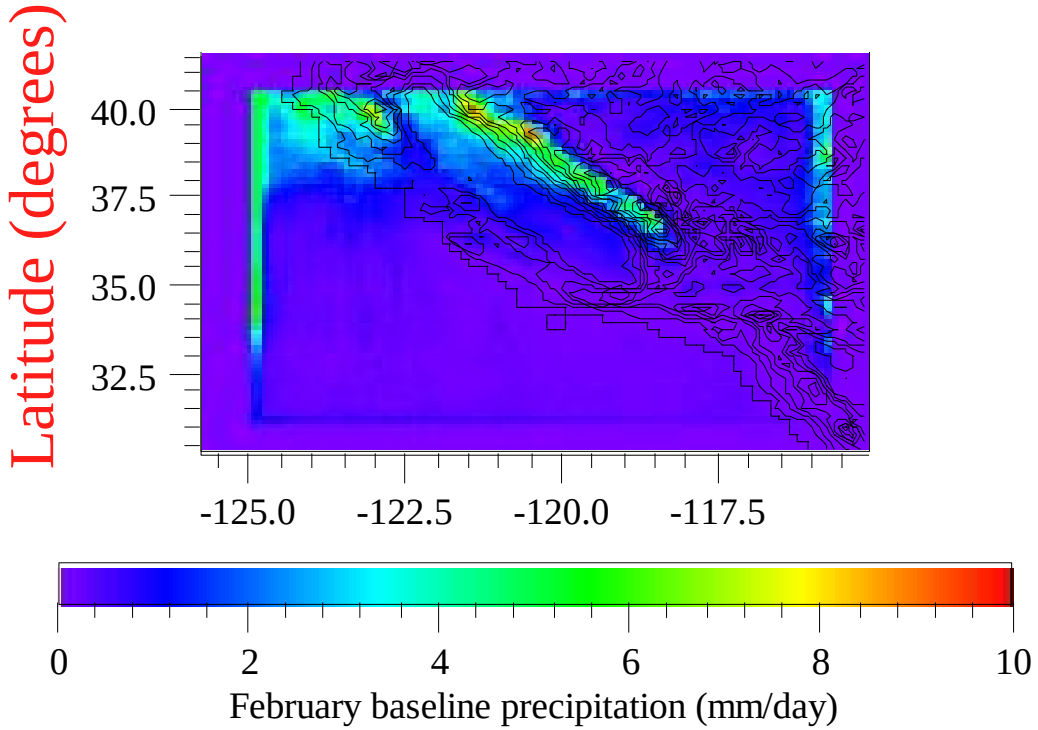


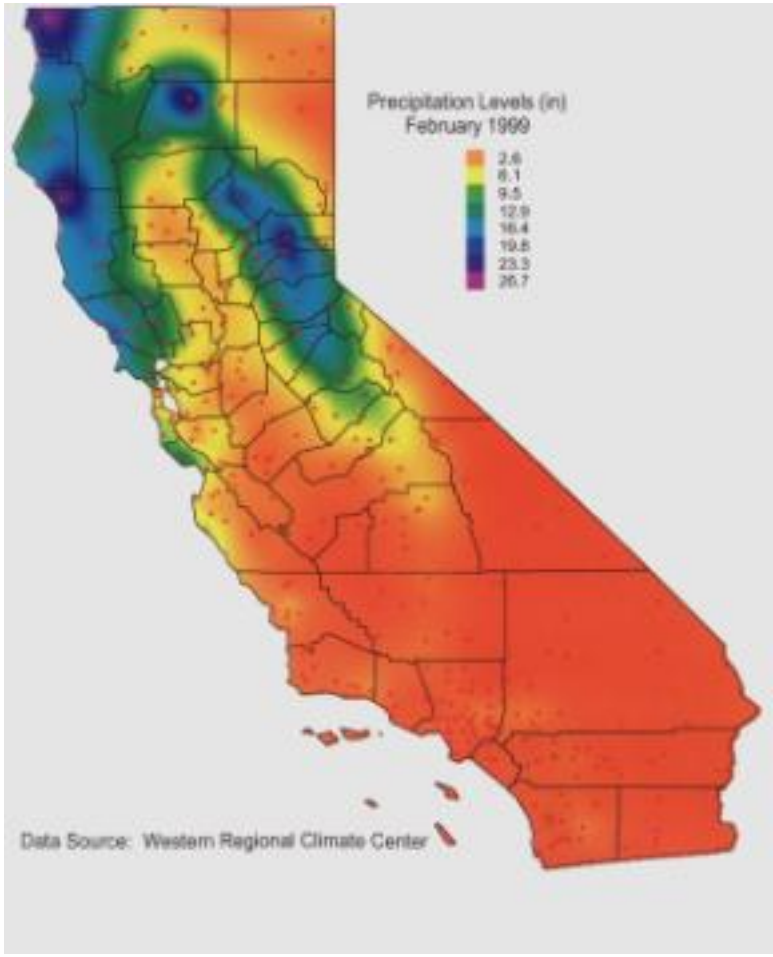
Feb/Aug Near-surface Temperature Dif. w-w/o AAPPG



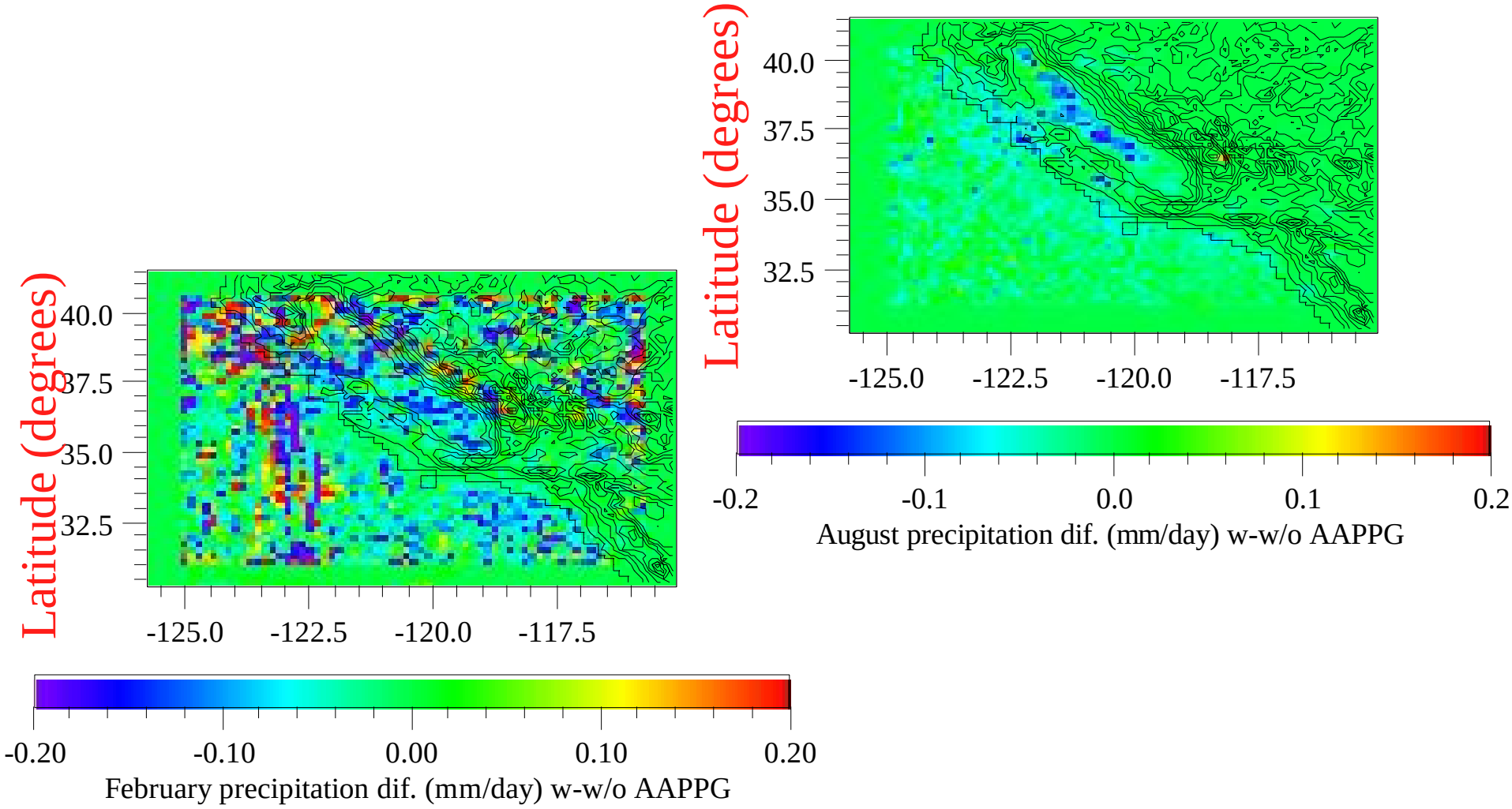


Modeled vs. Measured Feb. 1999 Precipitation

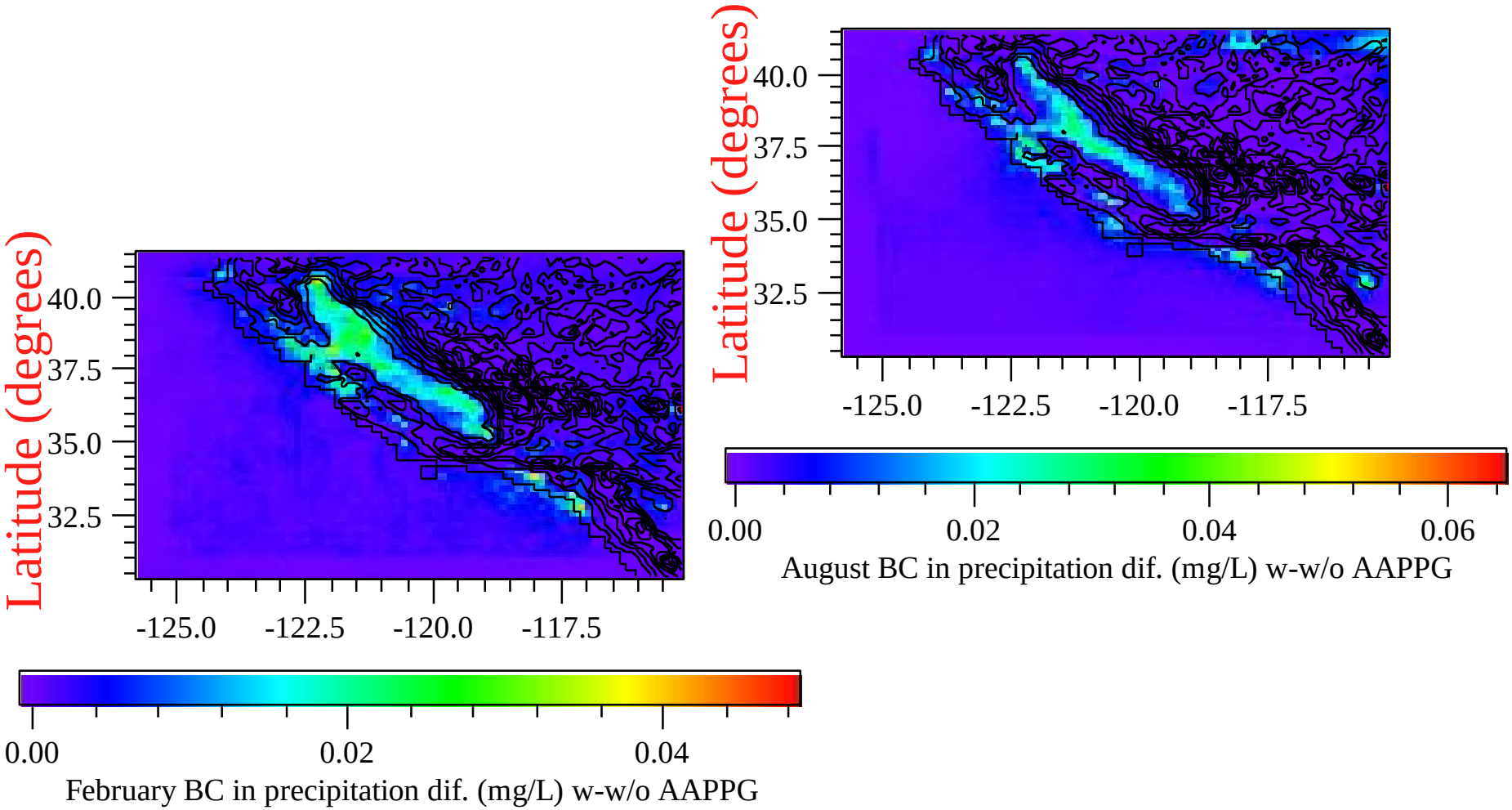




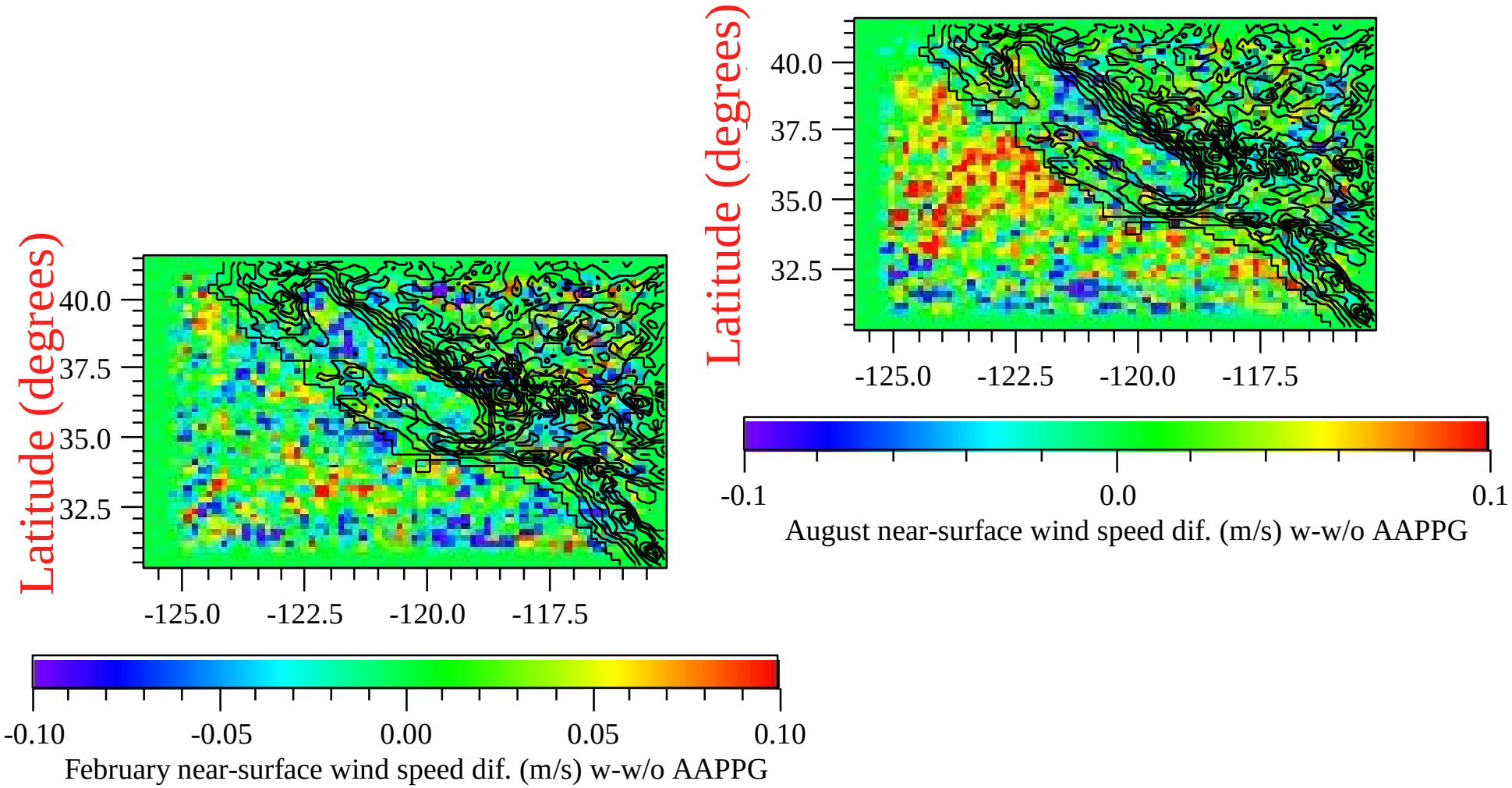
Feb/Aug Precipitation Dif. w-w/o AAPPG



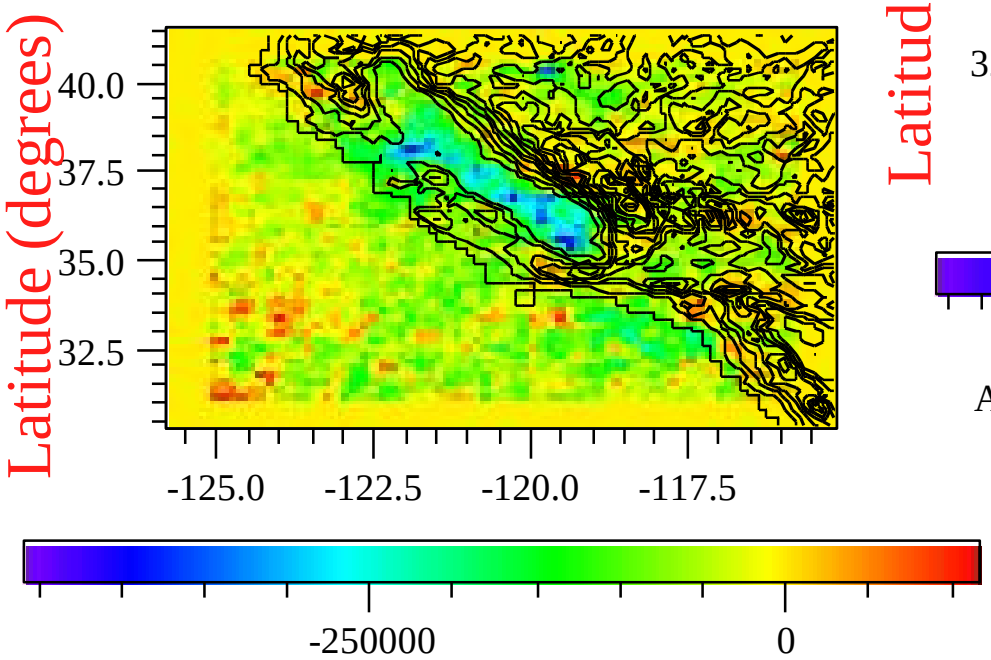
Feb/Aug BC in Fog and Precip. Dif. w-w/o AAPPG



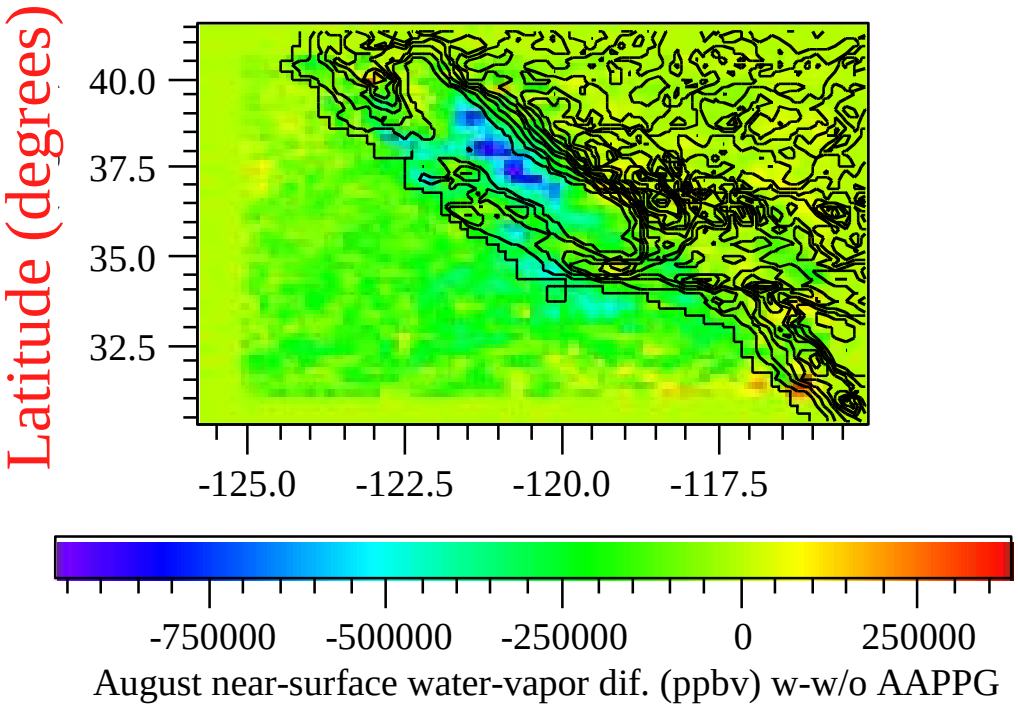
Feb/Aug Near-Surface Wind Speed Dif. w-w/o AAPPG



Feb/Aug Near-Surface Water-Vapor Dif. w-w/o AAPPG

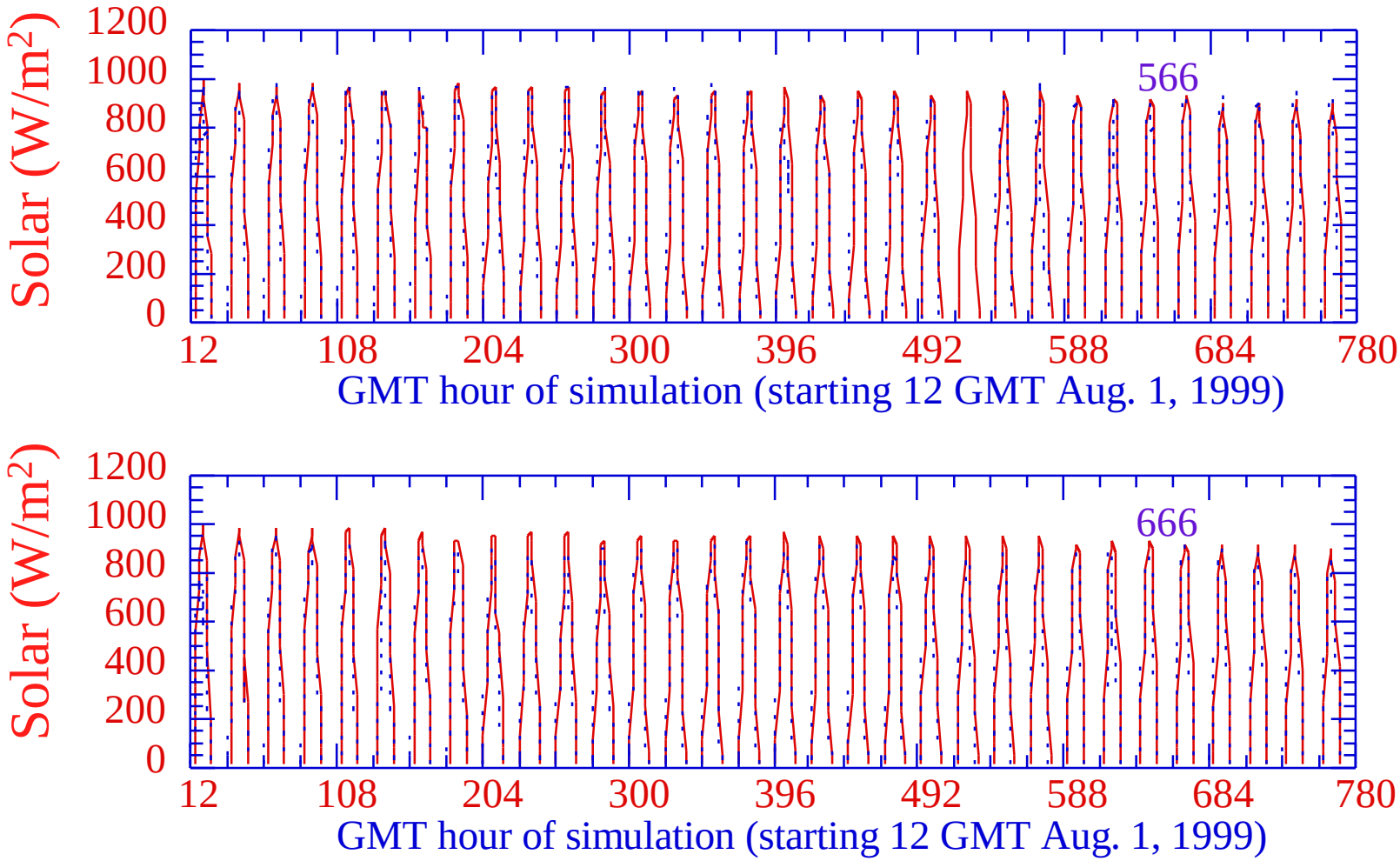


February near-surface water vapor dif. (ppbv) w-w/o AAPPG

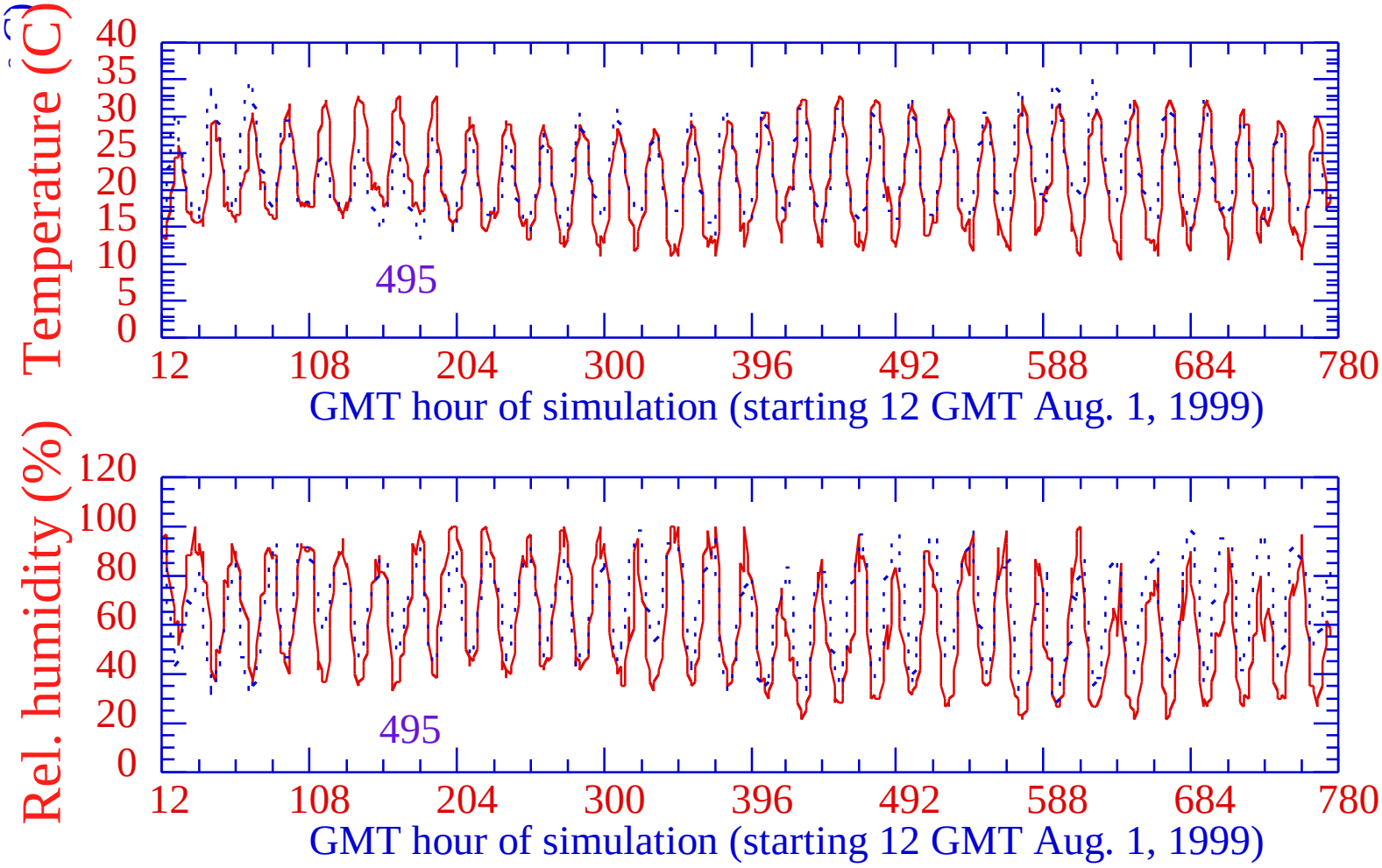


August near-surface water-vapor dif. (ppbv) w-w/o AAPPG

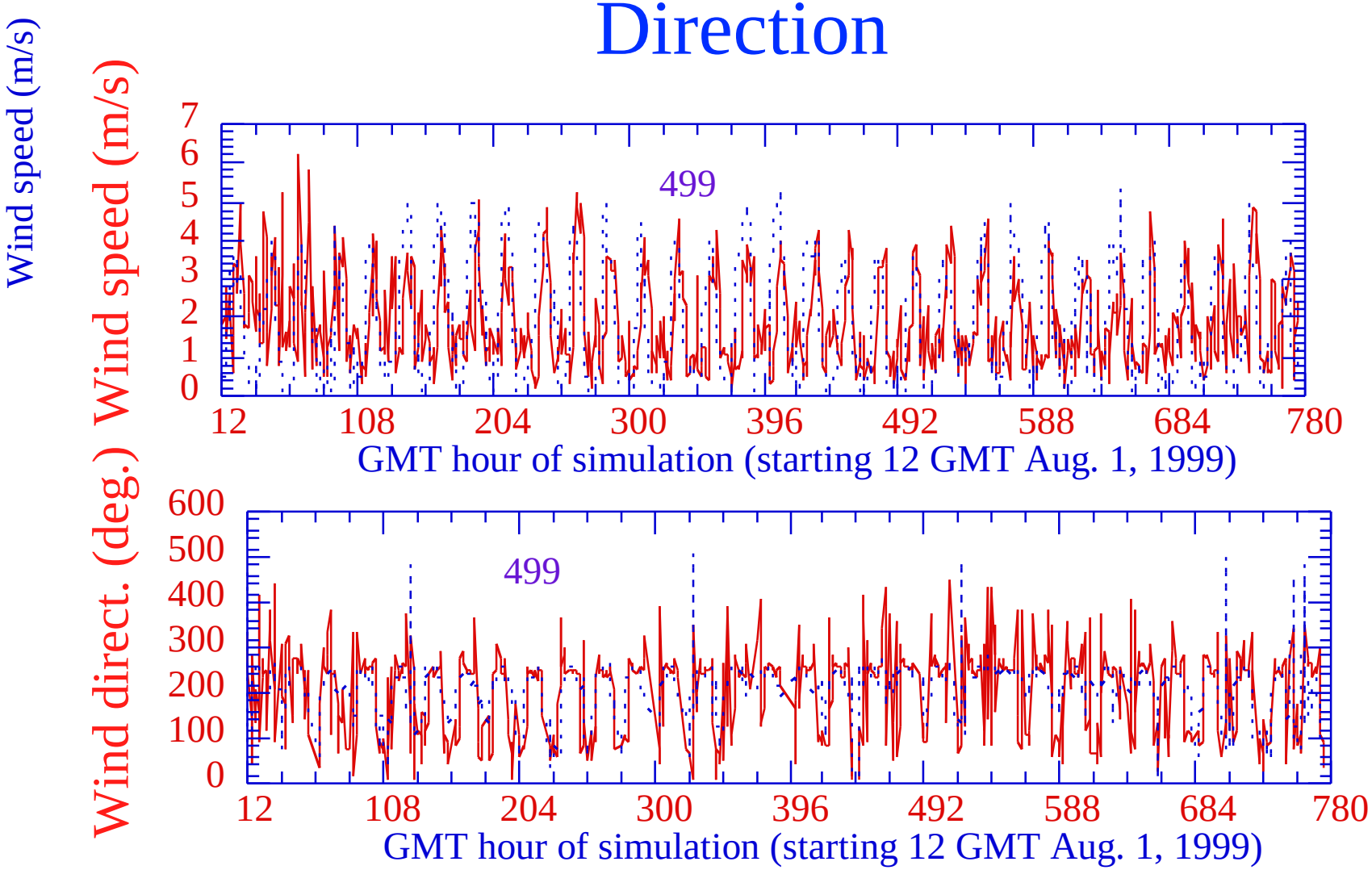
Paired-in-Time-and-Space Modeled (Red) v. Measured Solar Radiation



Paired-in-Time-and-Space Modeled (Red) v. Measured T and RH



Paired-in-Time-and-Space Modeled (Red) v. Measured Wind Speed & Direction



Summary

Anthropogenic aerosols and gas precursors in California and the South Coast Air Basin were found to

- decrease near-surface wind speeds
- decrease rainfall in the Central Valley, South Coast, and mountains (e.g., Sierras, San Bernardino)
- increase the pollution content of rainfall
- increase cloud optical depth, fraction, LWC, top height
- decrease near-surface air temperatures
- stabilize the boundary layer
- decrease UV, solar radiation at surface
- increase thermal-IR radiation at surface