Impact of climate change on air quality

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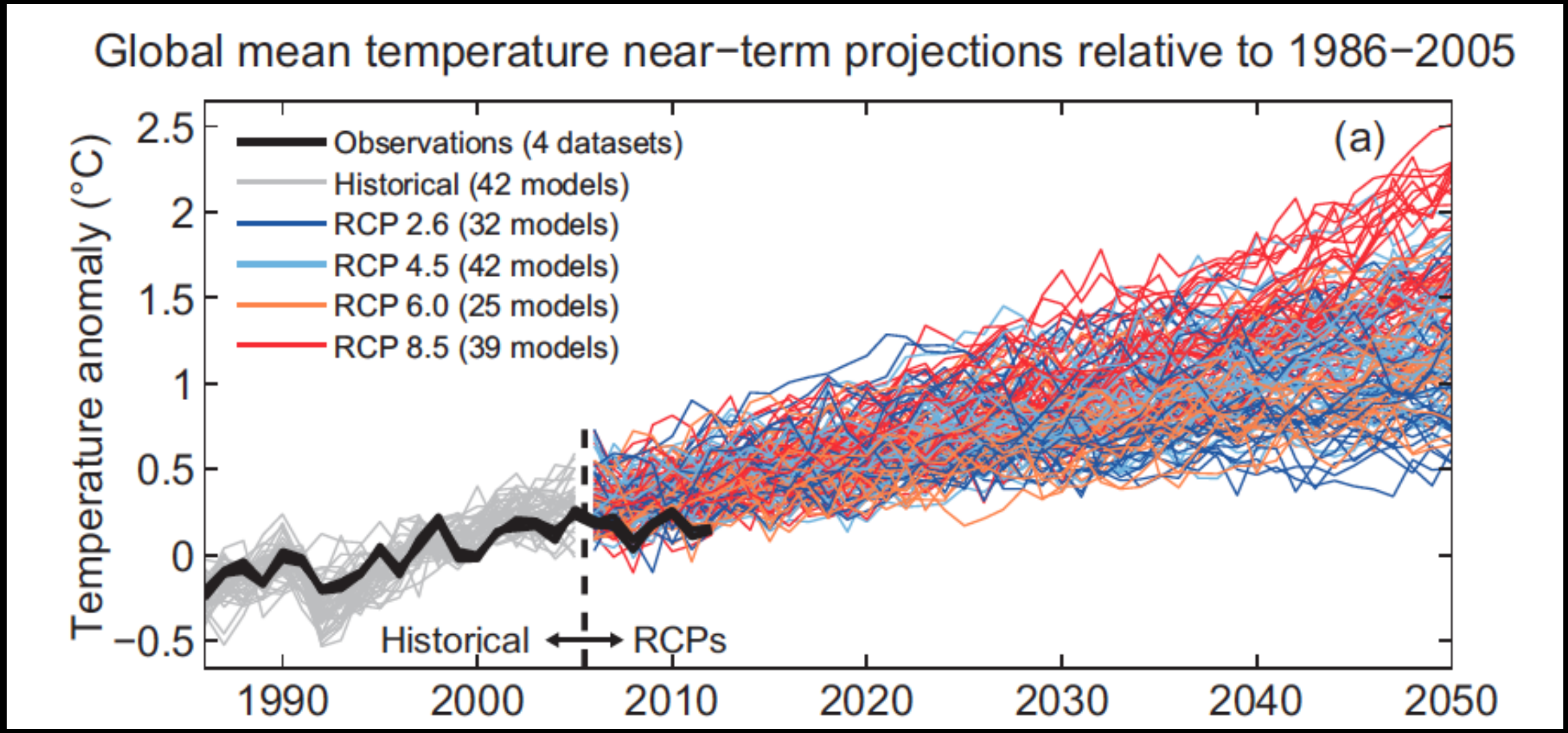
Climate scenarios: CMIP5 four Representative Concentration Pathways (RCPs)



IPCC AR5 - Figure TS.14(a)

How can we project future air quality in "affordable way"?

Global-scale or US-regional air quality models are EXPENSIVE!

Number of processors used to compute CMAQ (4km x 4km) and how long does it take to run 10 years of summer

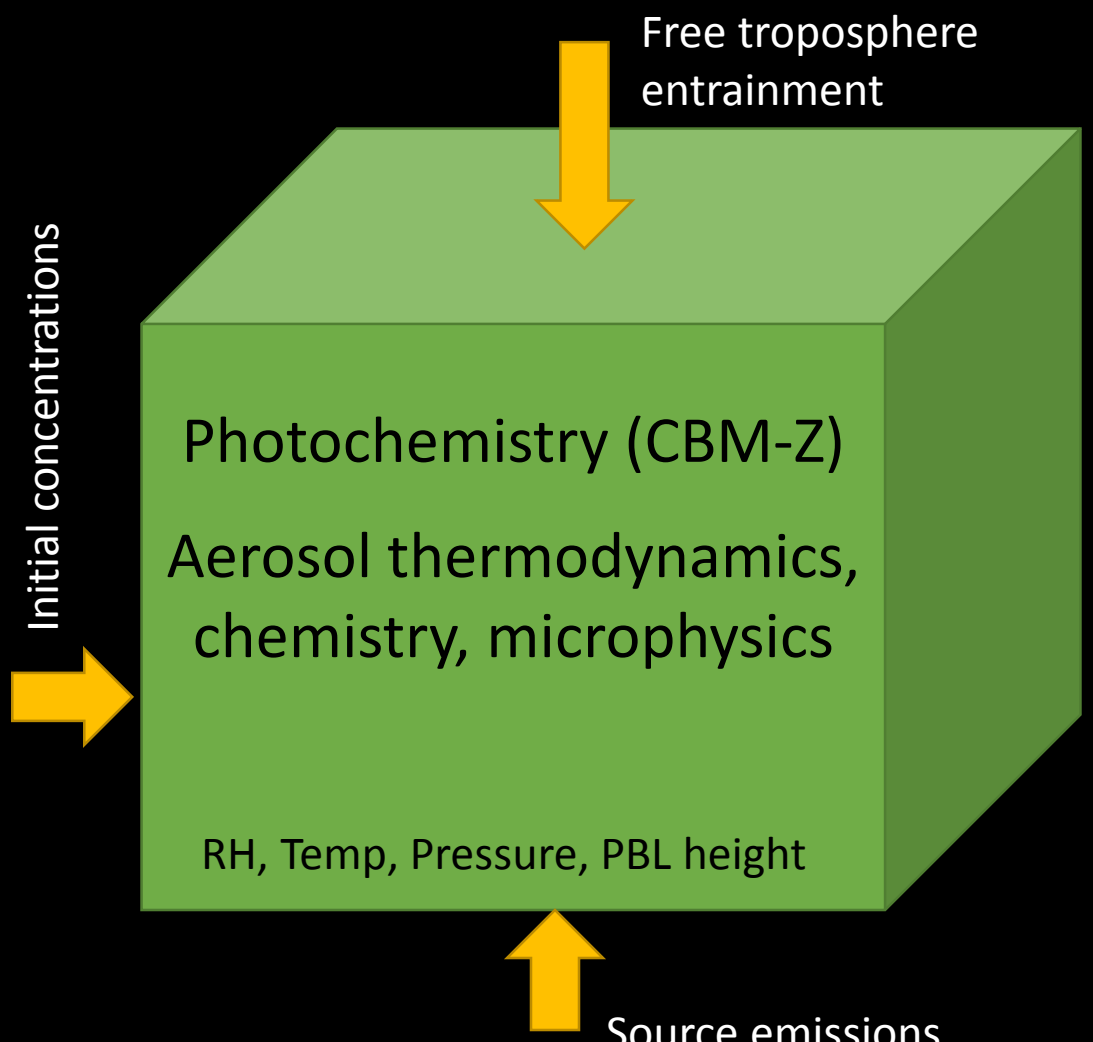
Lagrangian air quality box model

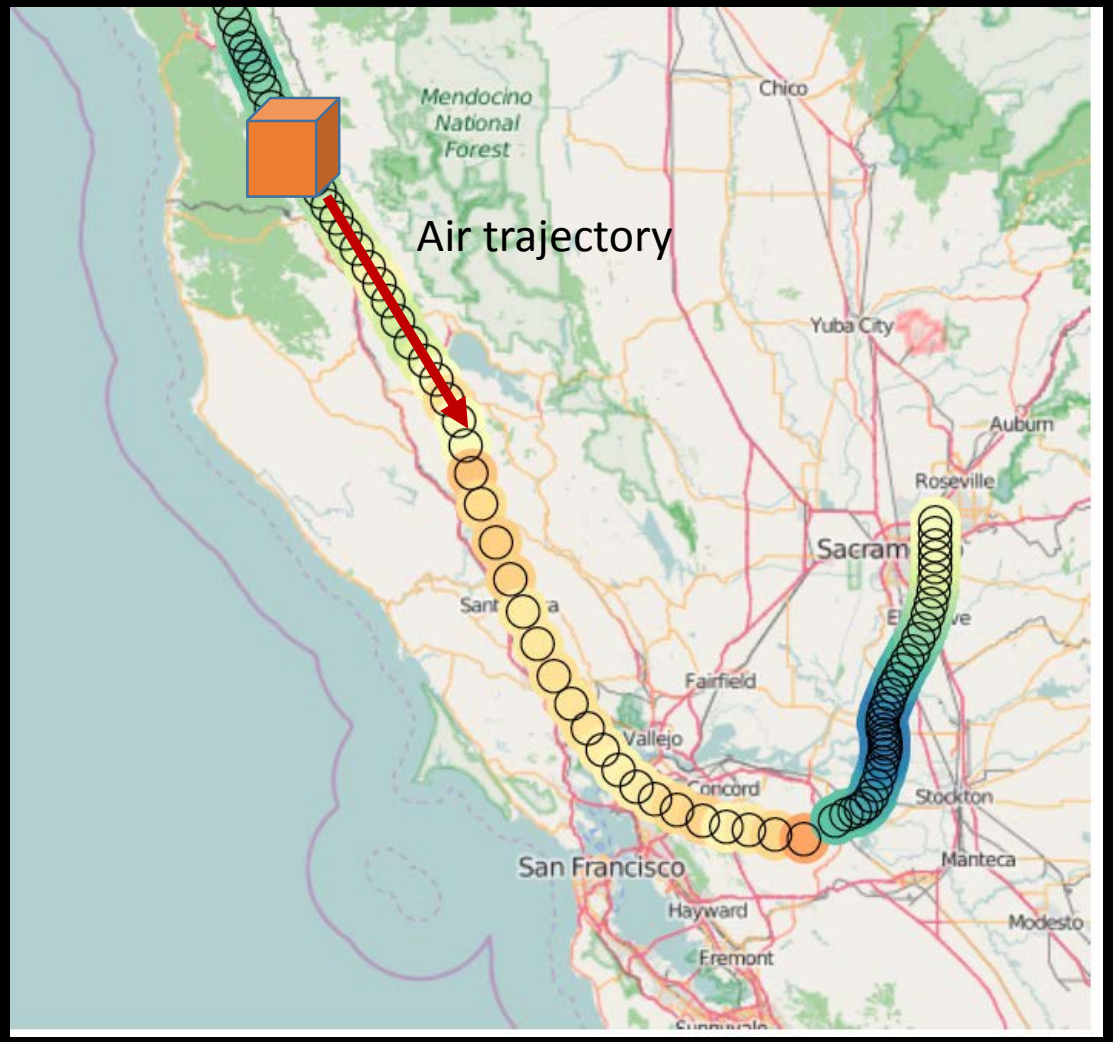
✓Computationally affordable

✓Prescribe air trajectory

✓Like CMAQ, it requires reasonable initial and background concentrations

Model for Simulating Aerosol Interactions and Chemistry (MOSAIC)





Ensemble analysis of global change projections for US air quality using a novel combination of Lagrangian and gridded air quality models

Goal

to improve our understanding of the effects of global change on future PM levels in the western US.

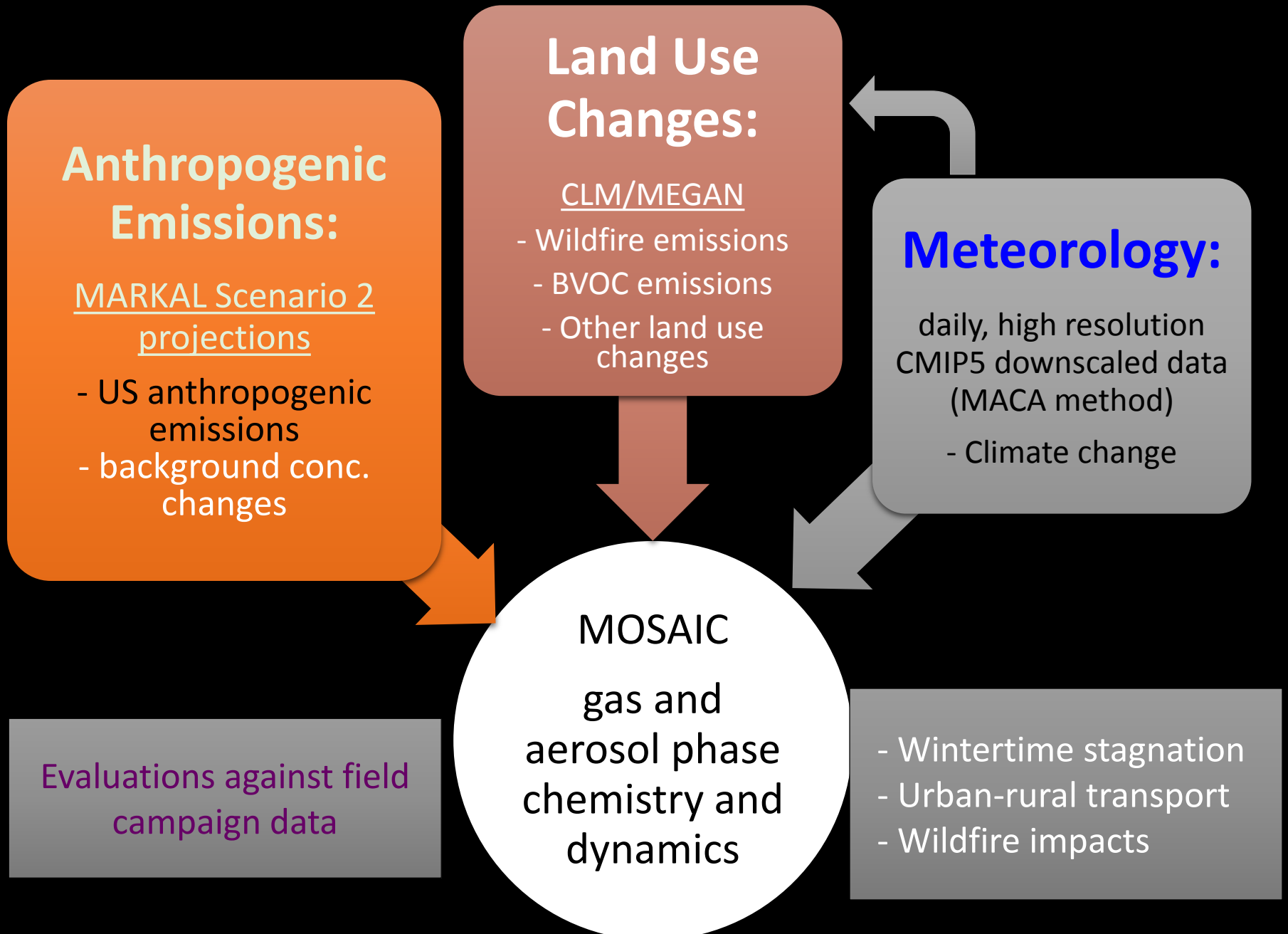
Objectives:

1) to develop and apply a novel application of Lagrangian box modeling using an ensemble of high resolution and bias corrected downscaled climate conditions
2) to use the modeling approach to provide comprehensive descriptions of PM changes due to various global change factors.

End Products

1) The end products will be an extensive set of simulations explicitly addressing the effects of climate change, emission changes and land cover changes upon PM and ozone for key air quality issues and locations in the western US.
2) A special effort will be made to summarize the full range of results in terms accessible and useful for air quality managers.

Time period: Present, 2030s and 2050s



Framework to link MOSAIC With gridded emis/met

Use master shell script
take air trajectory (time,lat,lon, alt)
read emis/met data along the trajectory
Convert emissions species (saprac07t) to mosaic tracers(CMB-Z)

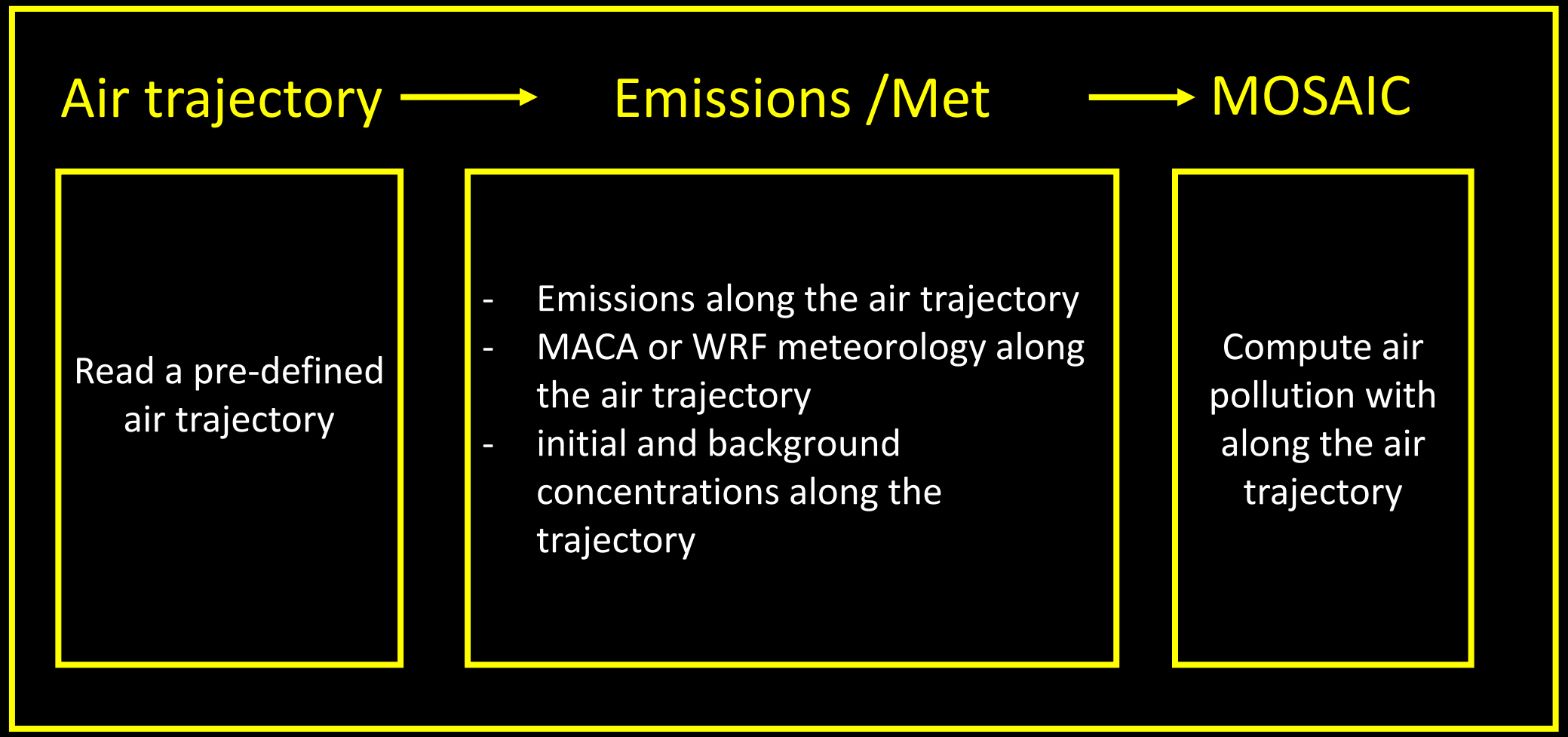
Air trajectory

- CARES evaluation: assume straight line trajectory between T0 and T1 sites
- Obtain air trajectory using the weather analog used by John's group in U of Idaho (32 km resolution)

Initial and boundary concentrations

- CARES evaluation: use WRF-Chem output
- explore a few options : CMIP5 runs (NASA GISS), CMAQ runs, simple calculations
- Convert model species to mosaic tracers(CBM-Z)

Modeling Framework



What affects MOSAIC species concentrations?

- MOSAIC chemistry/dynamics
- Air trajectory
  Emissions
  Dilution with free troposphere concentrations :
  $(\ln(PBL_{new}/PBL_{old})/time\_step)$
- Initial concentrations

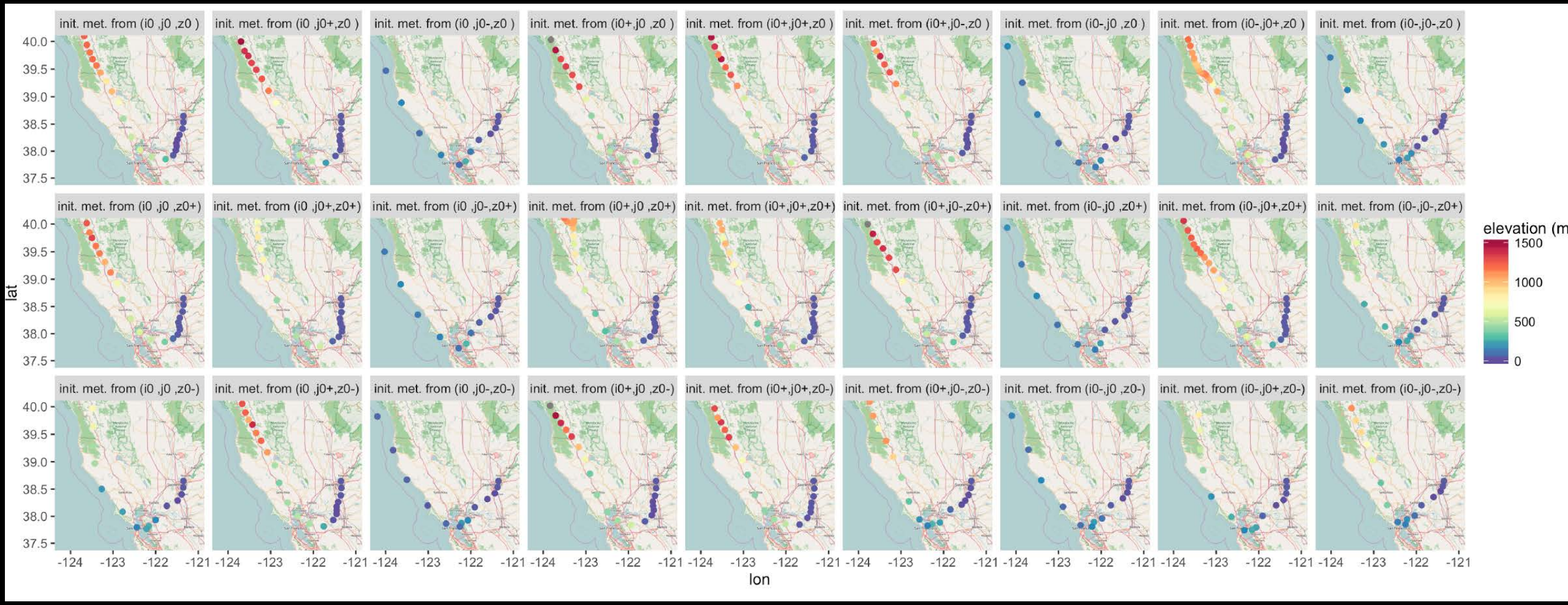
CARES (Carbonaceous Aerosol and Radiative Effects Study)

June 2010 in Central Valley, CA (Centered in Sacramento)

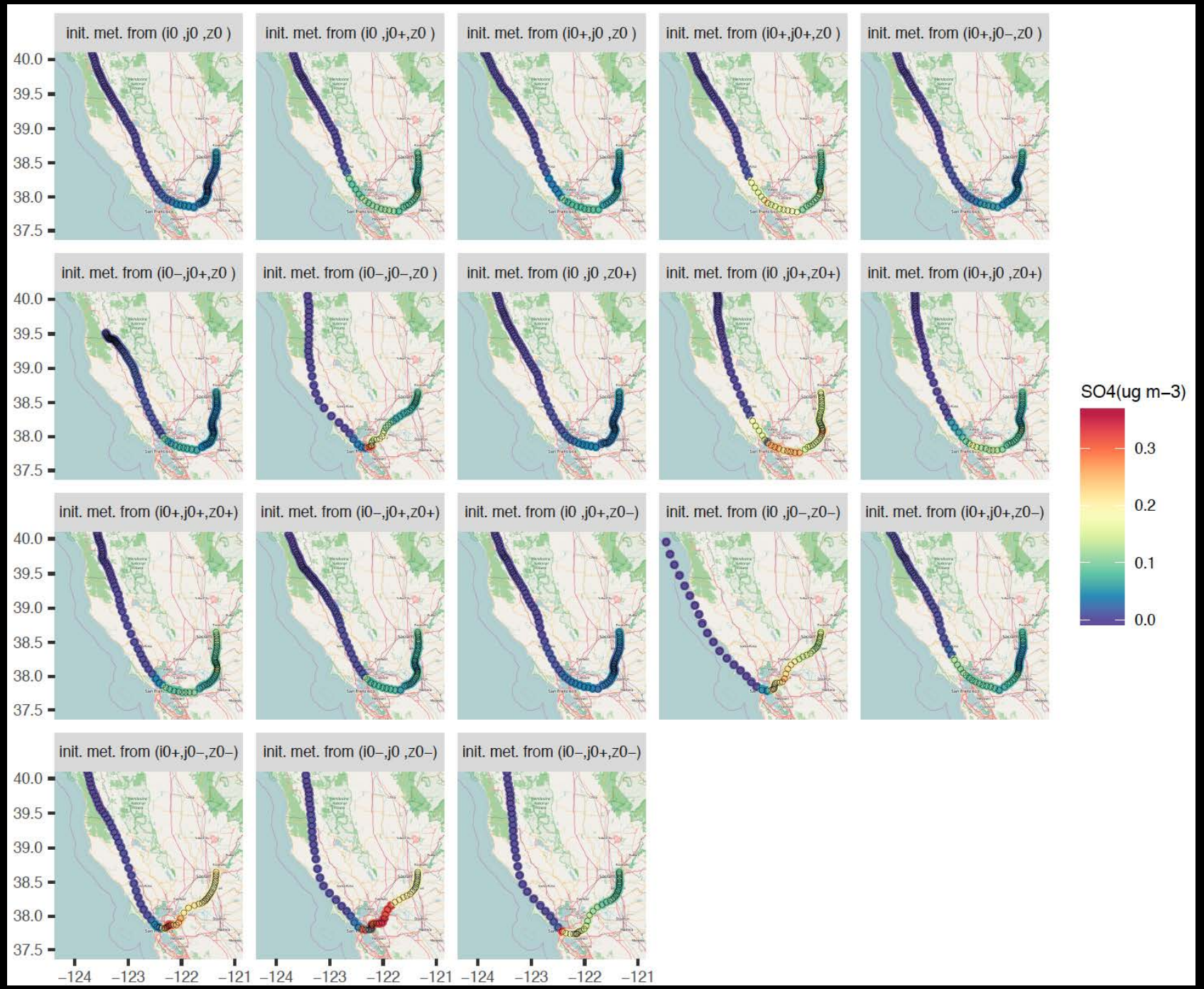
- "TO"site in Sacramento
  (lat: 38.65, lon: -121.35, alt: ~ 30 m)
- "T1" site in Cool, CA
  (lat: 38.87, lon: ~121.02, alt: ~450 m)
- Three aircraft measurements: DOE G1 aircraft, NASA B200 aircraft and NOAA Twin Otter aircraft

Investigate the evolution of secondary organic and black carbon aerosols and their climate-related properties in the Sacramento urban plume, which is routinely transported into the Sierra Nevada forest area

back trajectory from T0 site on June 15, 2010 at 17:00:00 UTC using HYSPLIT with WRF-Chem outputs

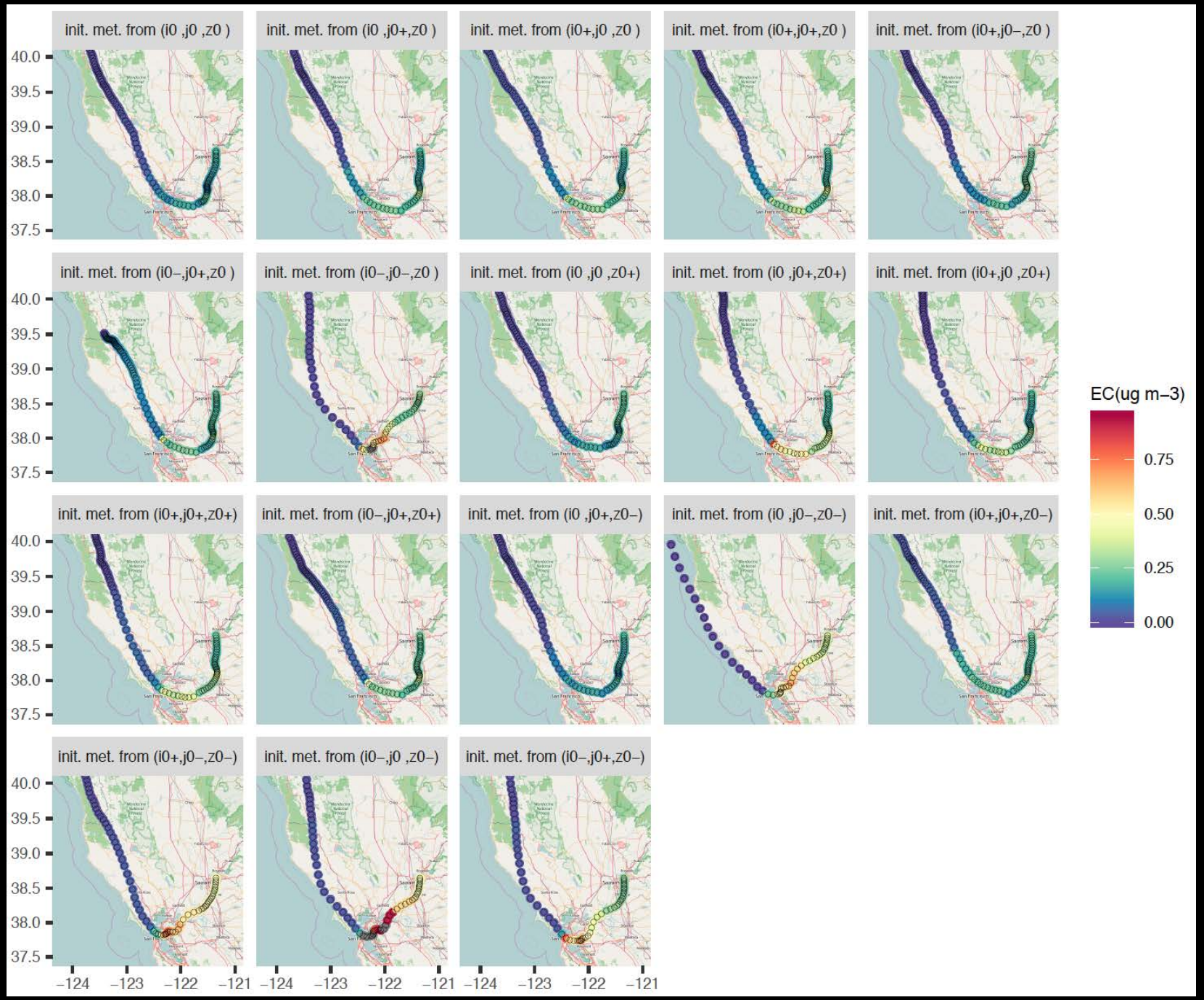


Air quality along the back trajectories**



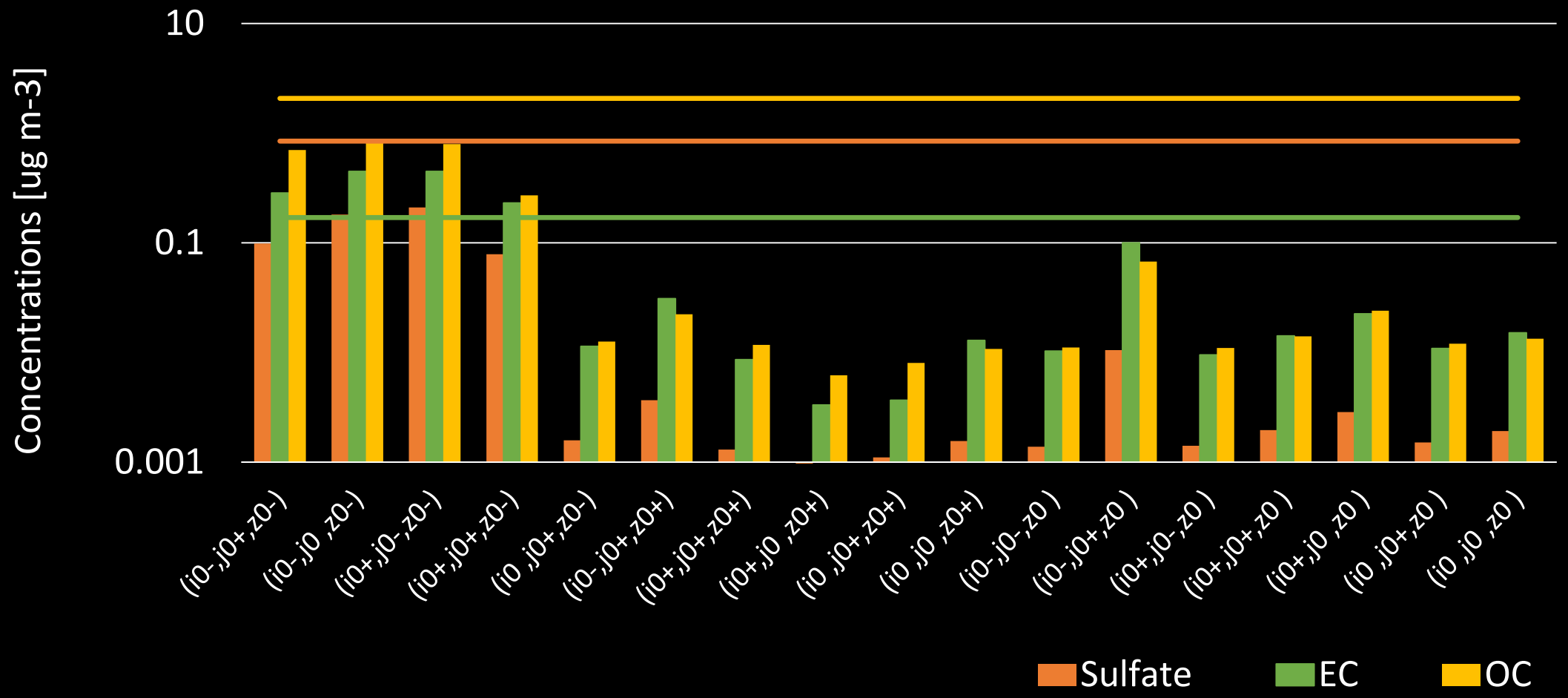
** Some trajectories are out of emission domain, so it is not included.

Air quality along the back trajectories**

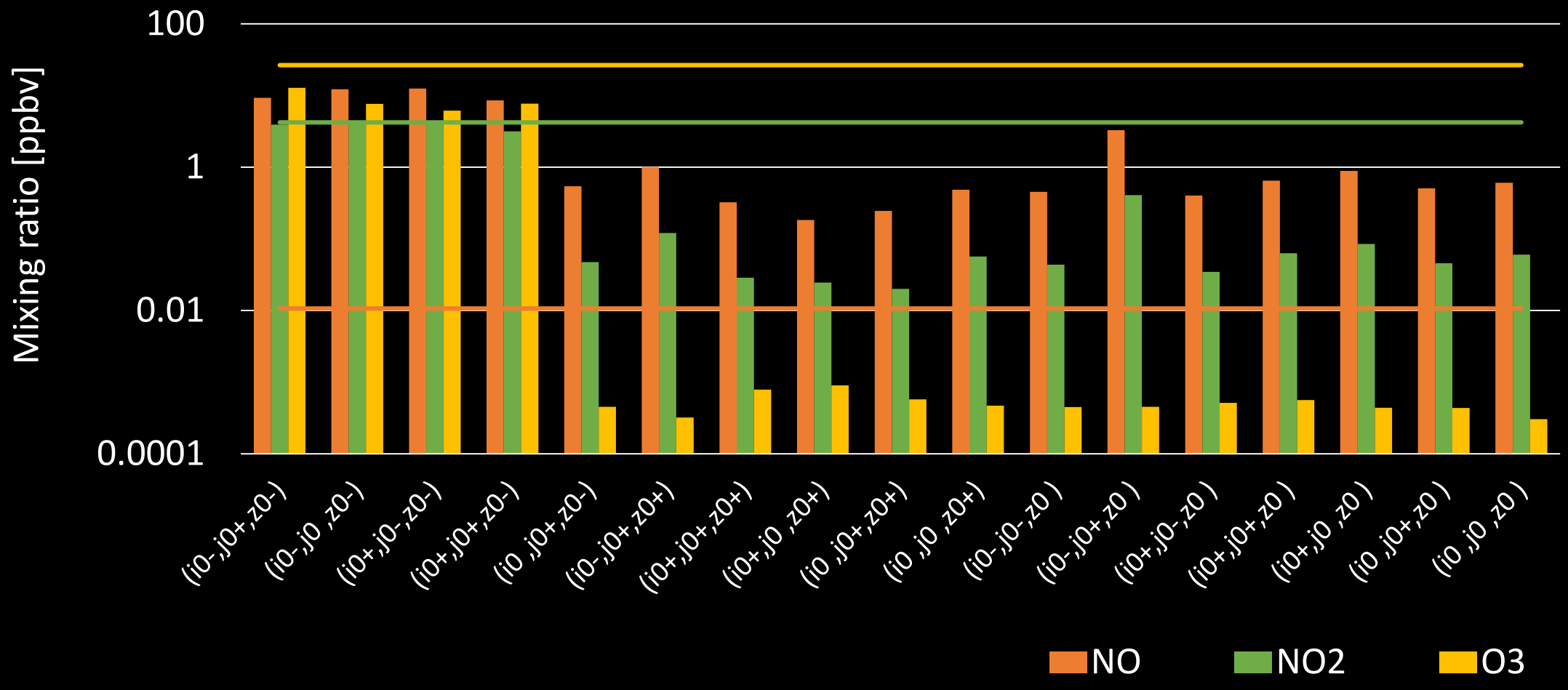


** Some trajectories are out of emission domain, so it is not included.

T0 site: SO_4, EC and OC



T0 site: NO, NO_2 and O_3



Representative climate change for current decade, 2030's 2050's

MACA (Multivariate Adaptive Constructed Analogue) 4 km gridded downscaled climate conditions (Abatzoglou and Brown, 2011)

- bias-corrected data for CMIP5 4 RCP scenarios: RH, Temp, Winds, Precip, etc
- Historical MACA data exist from 1950 to 2005
- Future RCP projections extend from 2006 to 2100 for each CMIP5 model

** How to obtain representative simulations for each case and each period

** How to define representative trajectories using downscaled climate MACCA data

Potential Sites	Field Study for Model Evaluation	Category			Attribution Cases				
		Summertime Urban to Rural	Wild Fires	Winter-time	Climate	BVOC	Land Use	Anthro. Emissions	Back-ground Conc.
Sacramento/ San Francisco	CARES								
San Joaquin Valley	Discover AQ								
Southern CA	CALNEX								
Phoenix, AZ									
Denver Front Range									
Seattle, WA									
Portland, OR									
central ID fires	BBOP								
Yakima Valley, WA	YAWNS								
Boise, ID	Treasure Valley								
Salt Lake City, UT	PCAP								
Northern CA fires									
New Mexico fires									

Next Steps

- Continue to develop the gridded framework as the basis for linking MOSAIC to CLM and to gridded emissions
- Work on definition of representative trajectories using downscaled climate MACCA data
- Define time frames and protocols for running MOSAIC to capture current and future global change conditions
- Link our model outputs to AQ regulations

  (e.g., 24hr PM concentrations, 8hr Max O_3)