Evaluation of 4-km WRF simulations for California during May and June 2010

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Met. results accepted to Monthly Weather Review

Are the simulations any good?

- CalNex air quality and climate study
  - May-June 2010
- A series of WRF runs:
  - Informed by campaign data
  - Targeted to improve specific aspects
- COAMPS also shown for comparison
- Data:
  - P3 profiles and tracks
  - Wind profilers at LAX and Chowchilla
  - CalTech surface site
  - Buoys
  - R/V Atlantis measurements

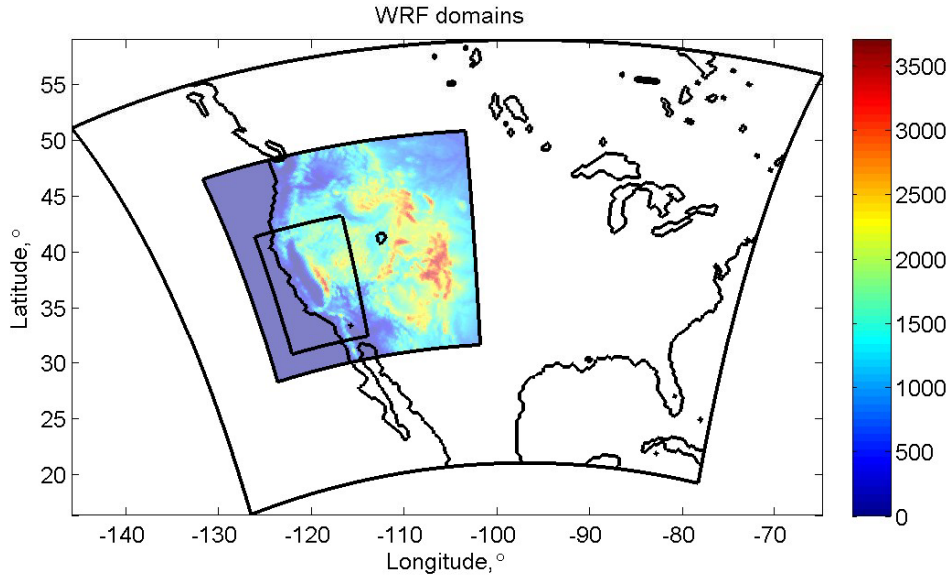
Model configurations

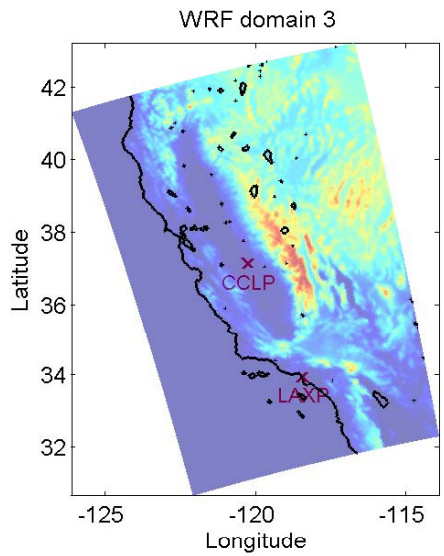
Name	Initialization	PBL scheme	Grid spacing	WRF version	Vertical levels	LSM, data
GM4	GFS	MYJ	4 km	3.2.1	40	Slab, USGS
GT4	GFS	TEMF	4 km	3.2.1	40	Slab, USGS
EM4S	ERA	MYJ	4 km	3.3	60	Slab, USGS
EM12S	ERA	MYJ	12 km	3.3	60	Slab, USGS
EM4N	ERA	MYJ	4 km	3.3	60	Noah, UCM, Modis
ET4N	ERA	TEMF	4 km	3.3	60	Noah, UCM, Modis

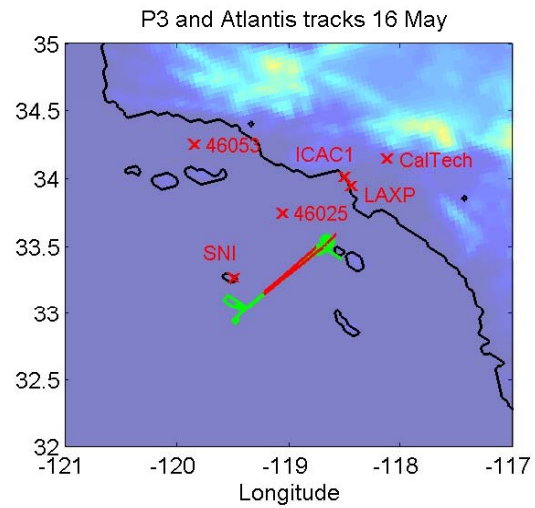
Orientation

36, 12, and 4 km domains

4 km grid covers all of California and then some



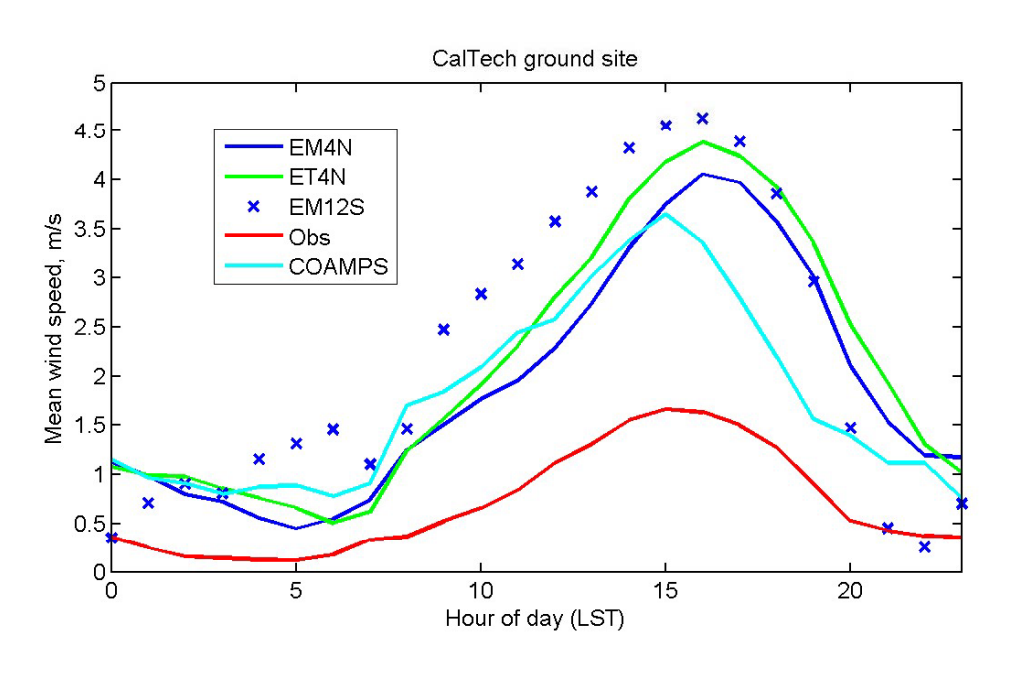




CalTech surface winds

All models overestimate wind speed

12 km is worst: Near steep terrain, poorly resolved

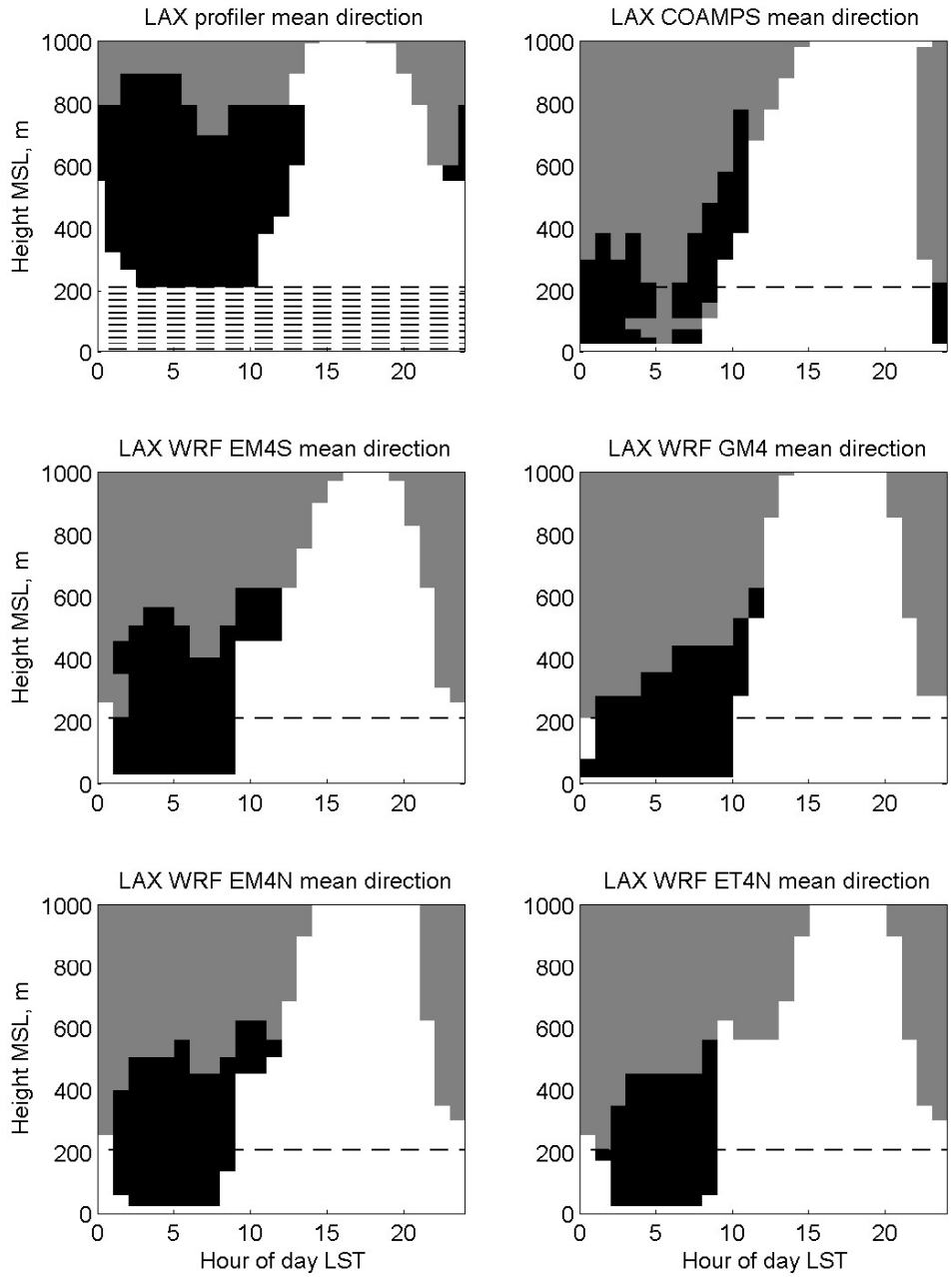


LAX land-sea breeze pattern

All simulations are roughly similar to each other and obs, but all have flaws

Black = land breeze
White = sea breeze

Simulated land breeze is too shallow and late

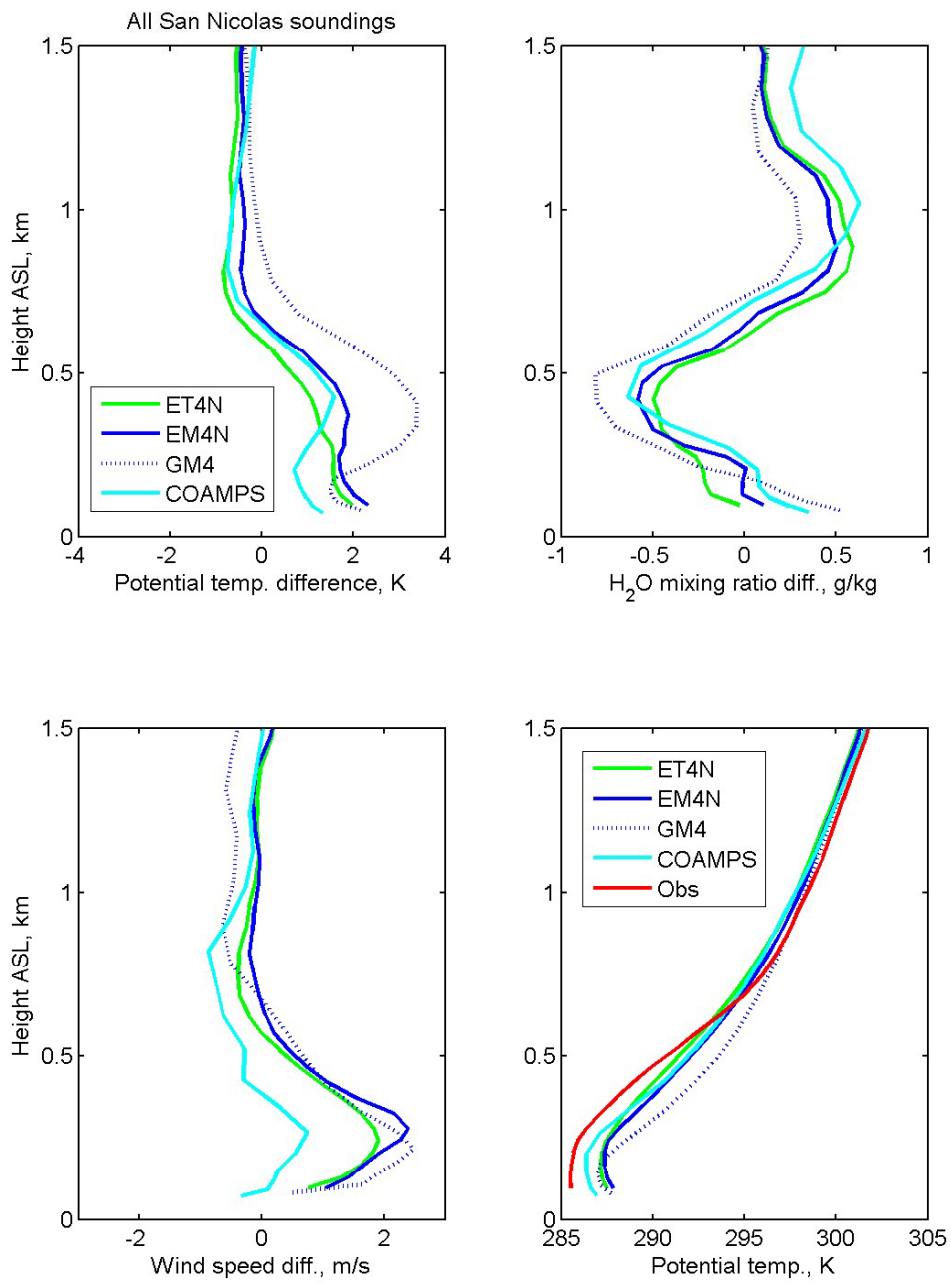


Offshore boundary layer

BL in So.Cal. bight often has broken to solid stratocumulus, which maintains the BL height

Difficult to simulate

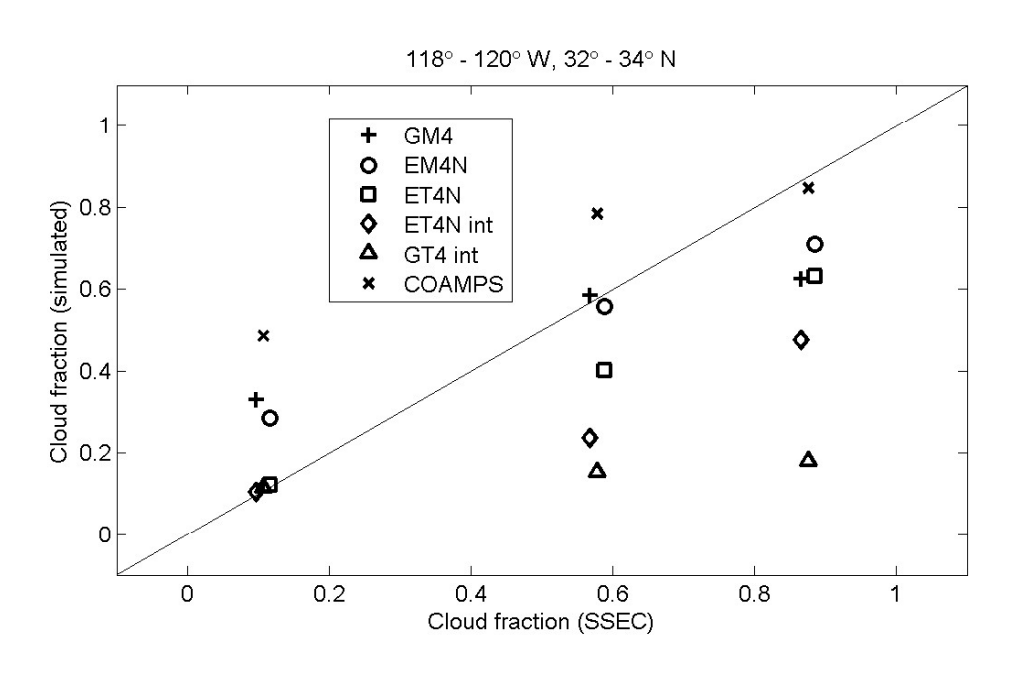
ET4N (ERA-Interim init, TEMF PBL) is best WRF run, COAMPS also good



Offshore cloud

Comparing simulated vs. observed cloud fraction, binned, over 2°x2° box including bight

Various flaws, ET4N best(?)

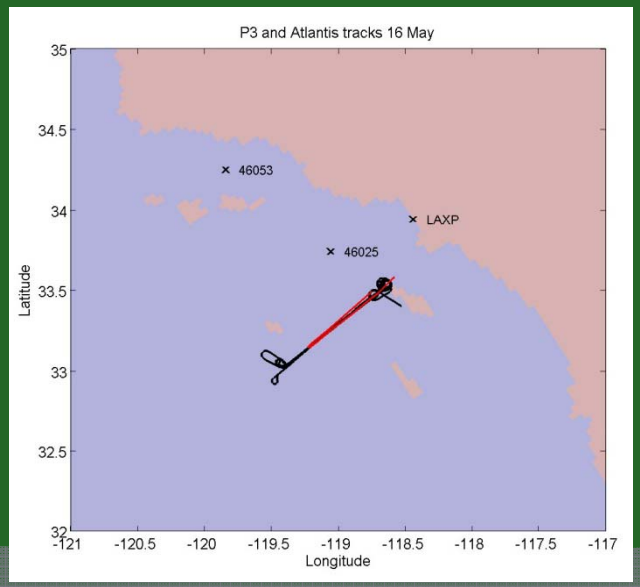


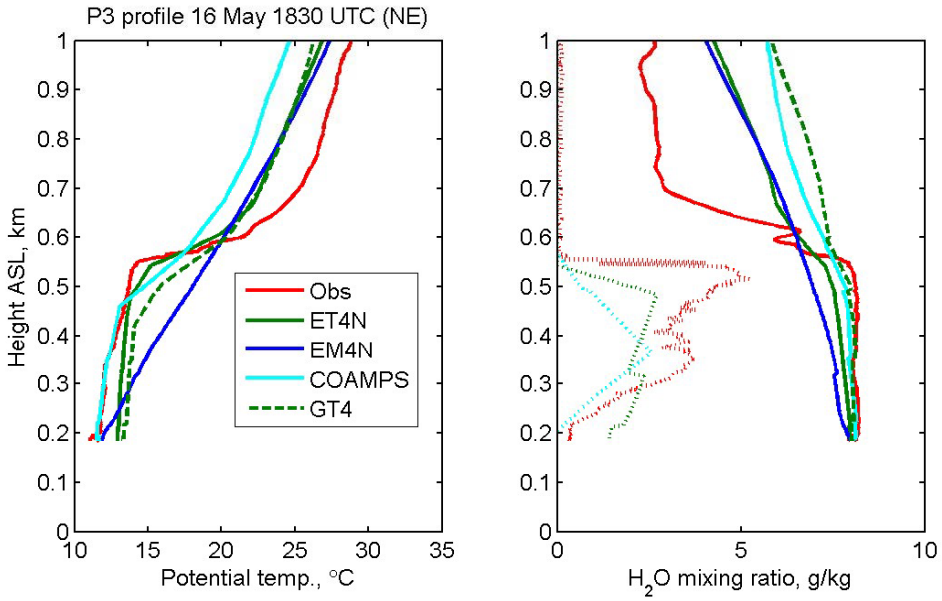
Offshore BL

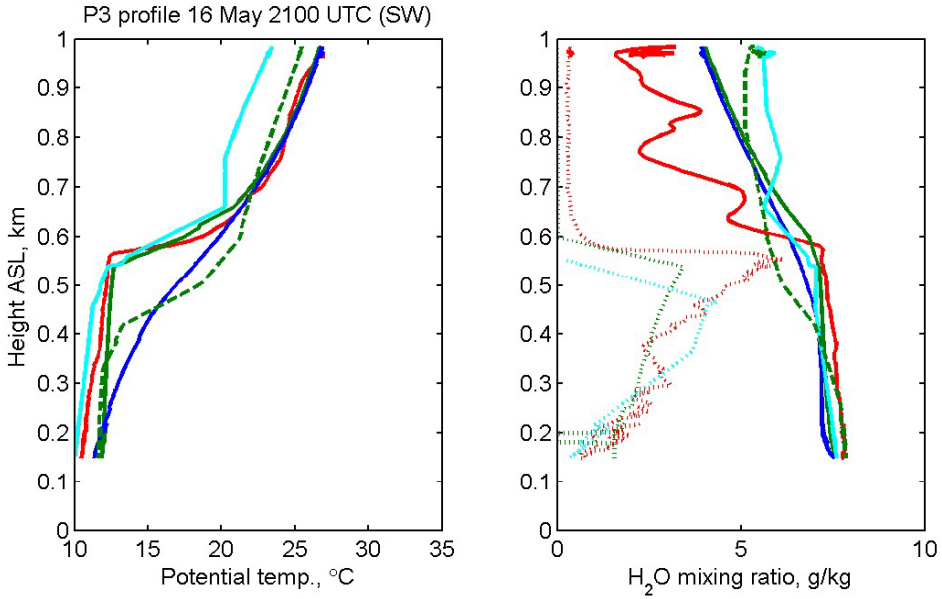
P3 profiles in bight on 16 May

ET4N with ERA-Interim init and TEMF PBL is best WRF

COAMPS also good

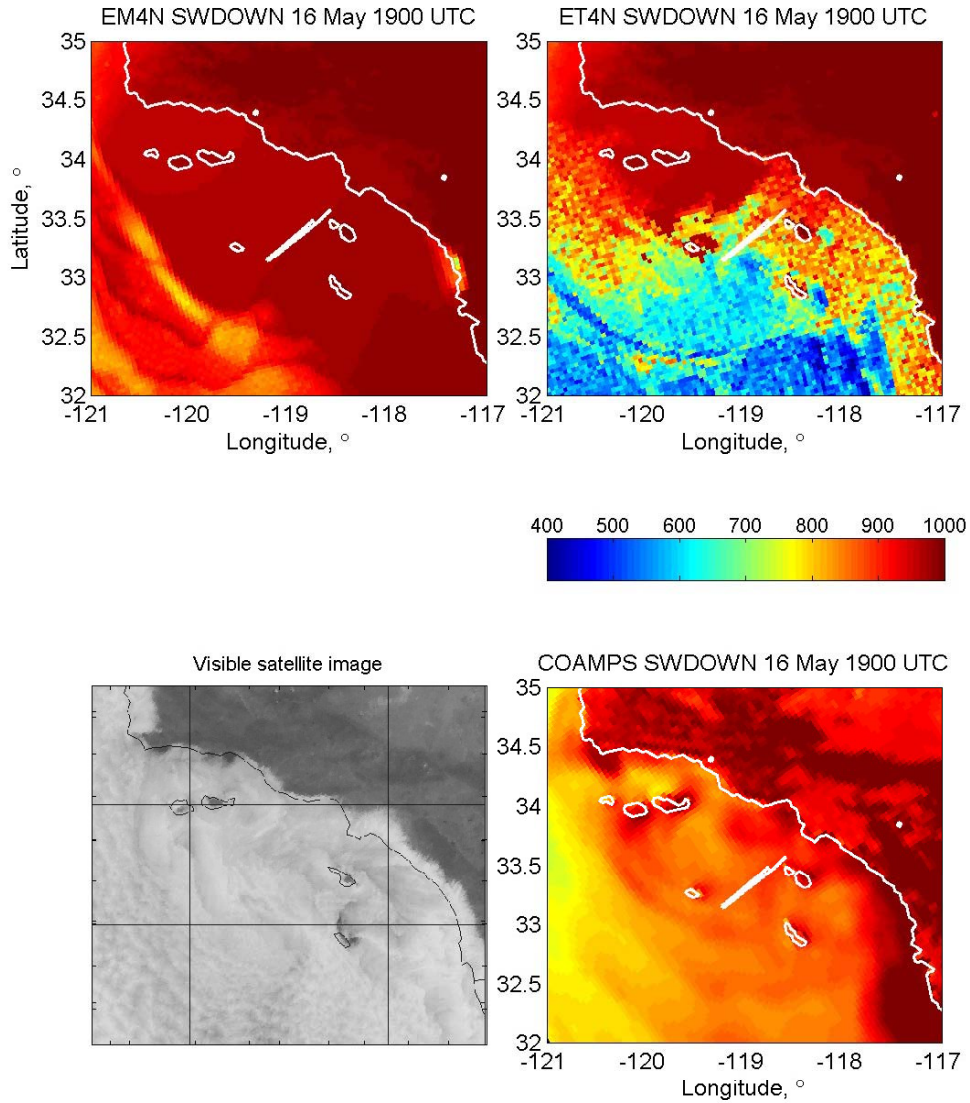






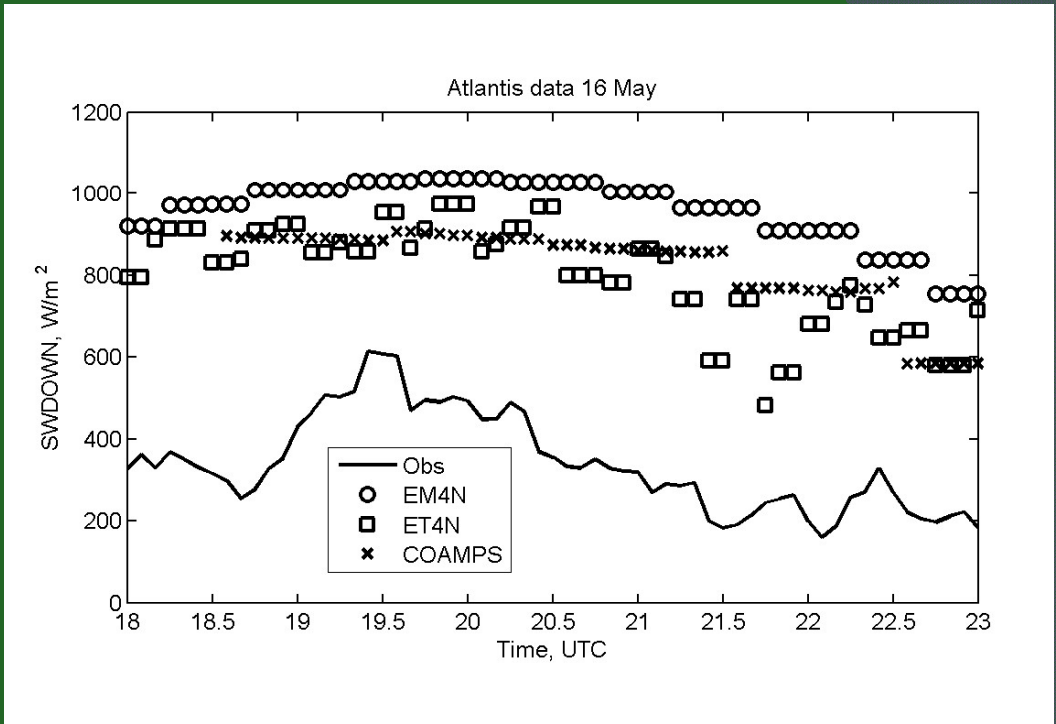
Offshore cloud

EM4N and COAMPS have too little cloud optical depth (too much downward shortwave)



Offshore cloud

Even ET4N (most cloud / least incoming shortwave) still has too little optical depth on Atlantis track



Chowchilla BL heights

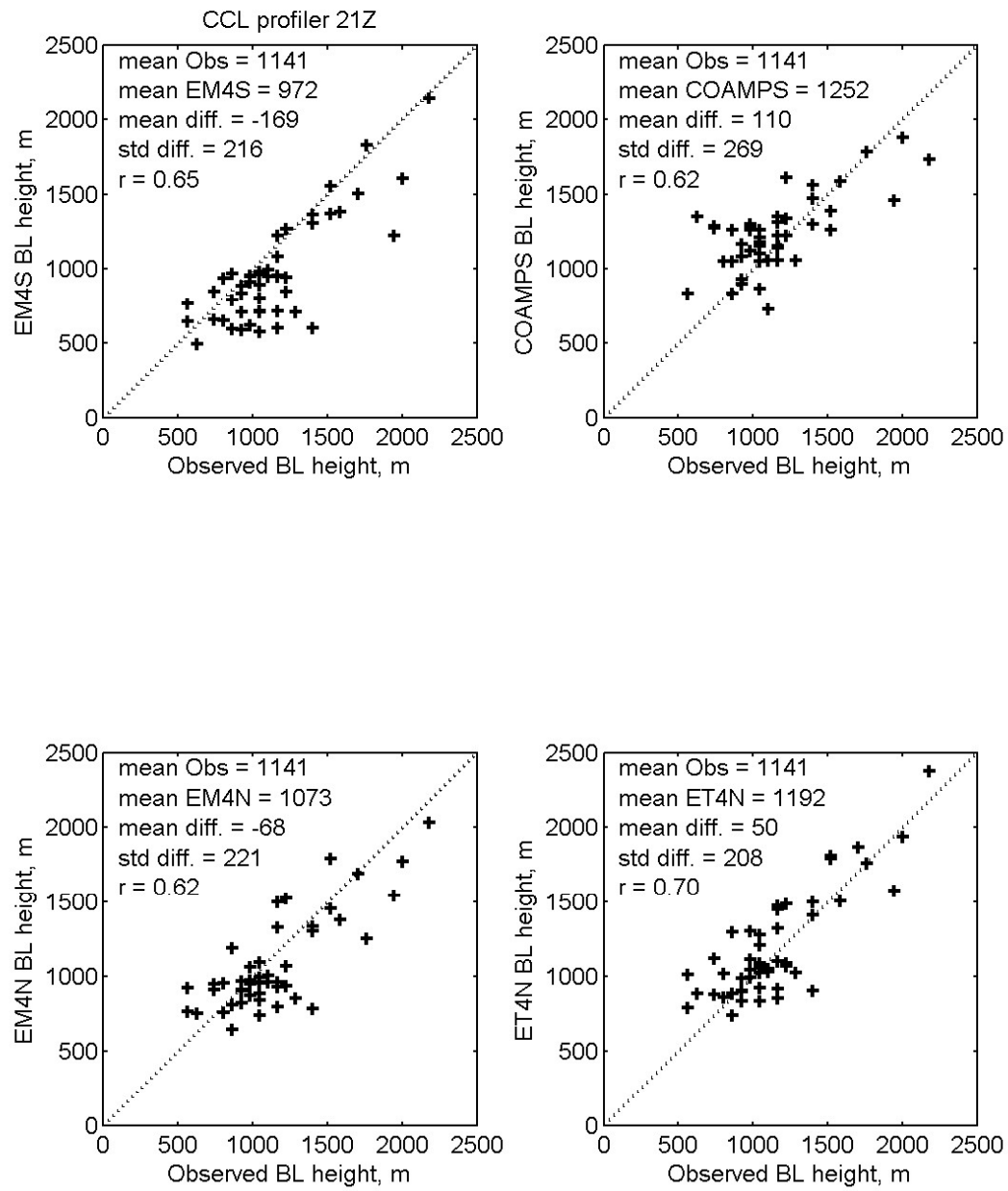
Central San Joaquin Valley location

WRF with Slab land surface was too shallow, fixed with Noah

Not a general endorsement of Noah

Irrigation not properly represented in any setup

TEMF slightly deeper than MYJ

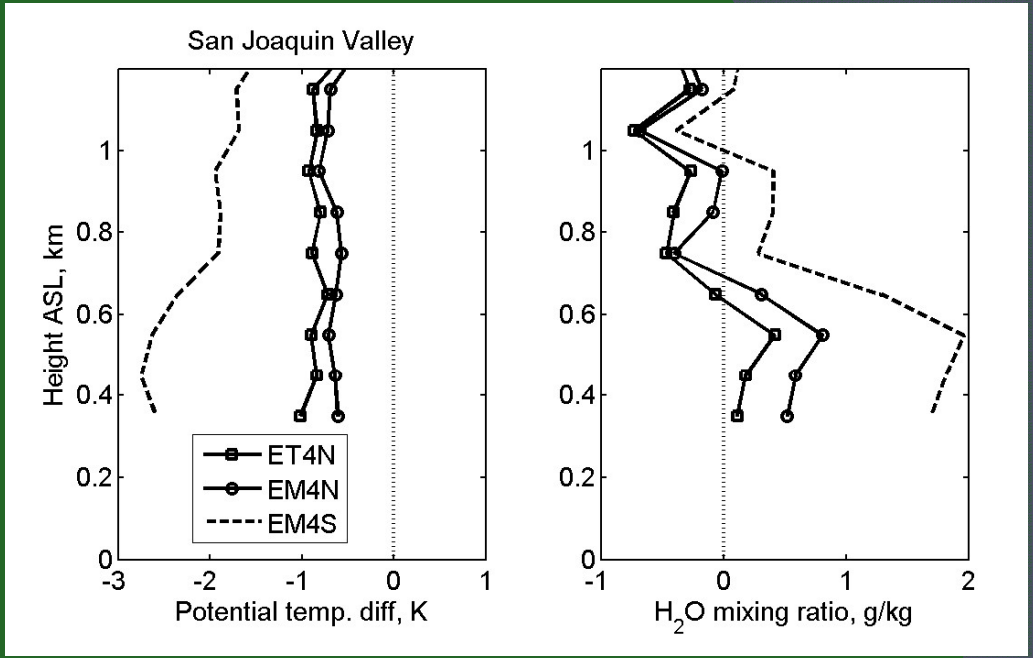


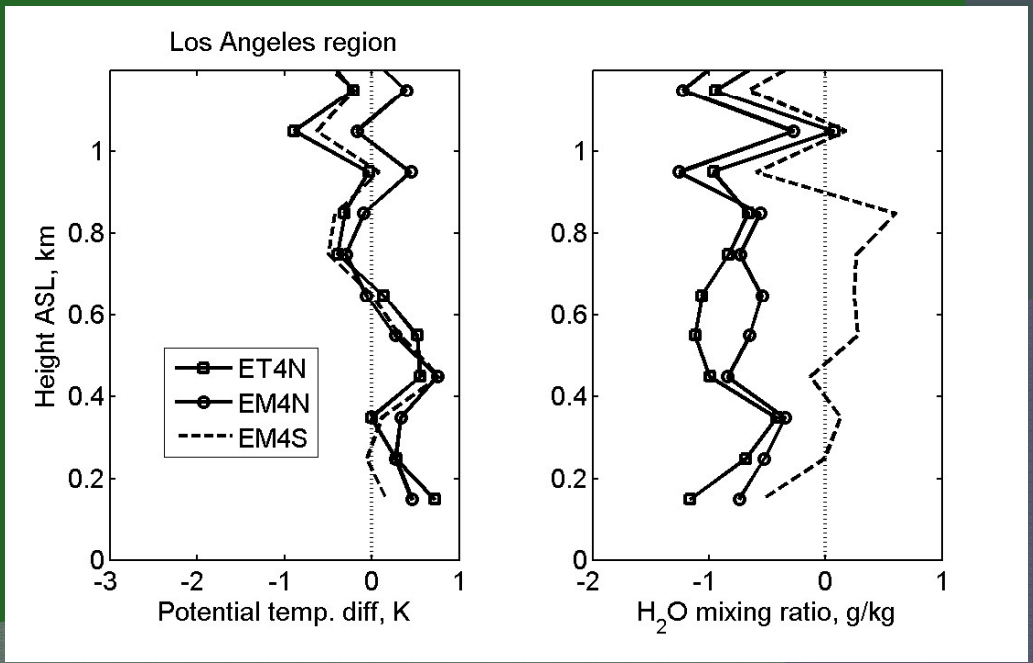
P3 profiles

In San Joaquin Valley, Slab land surface too cool and moist in this period

Changing to Noah LSM made LA area too hot and dry (not shown)

Urban Canopy model required to make Noah result reasonable, but still slightly warmer and drier than Slab version





Flexpart "CO" profiles

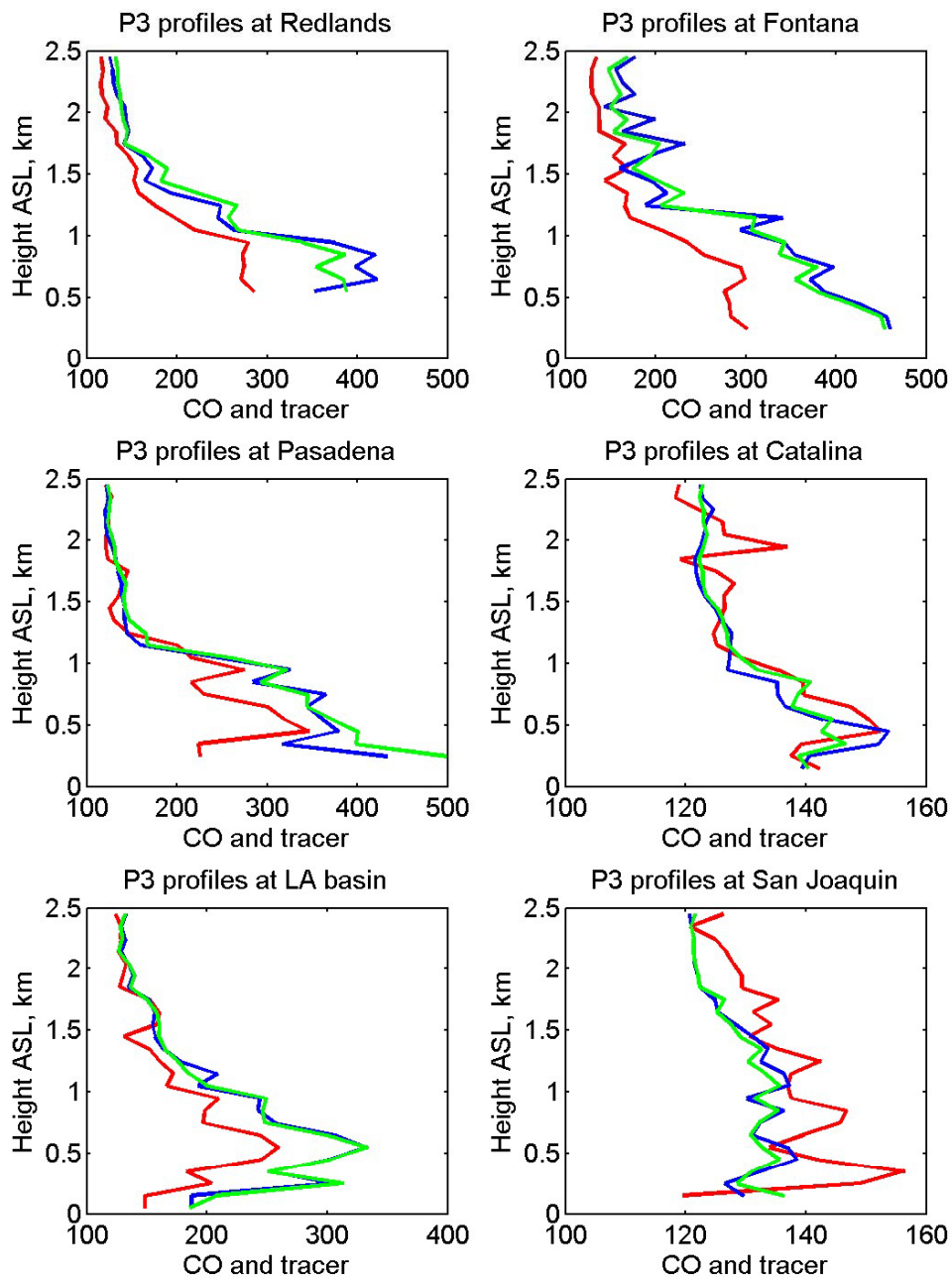
WRF EM4N and ET4N used to drive Flexpart Lagrangian Particle Dispersion model

Tracer emitted as on-road only CO (NEI 2005) with Harley (2005) diurnal cycle

Compared to average P3 measured CO (120 ppb background added)

Amounts differ but vertical profiles look good

Lowest levels less reliable (sampling?)



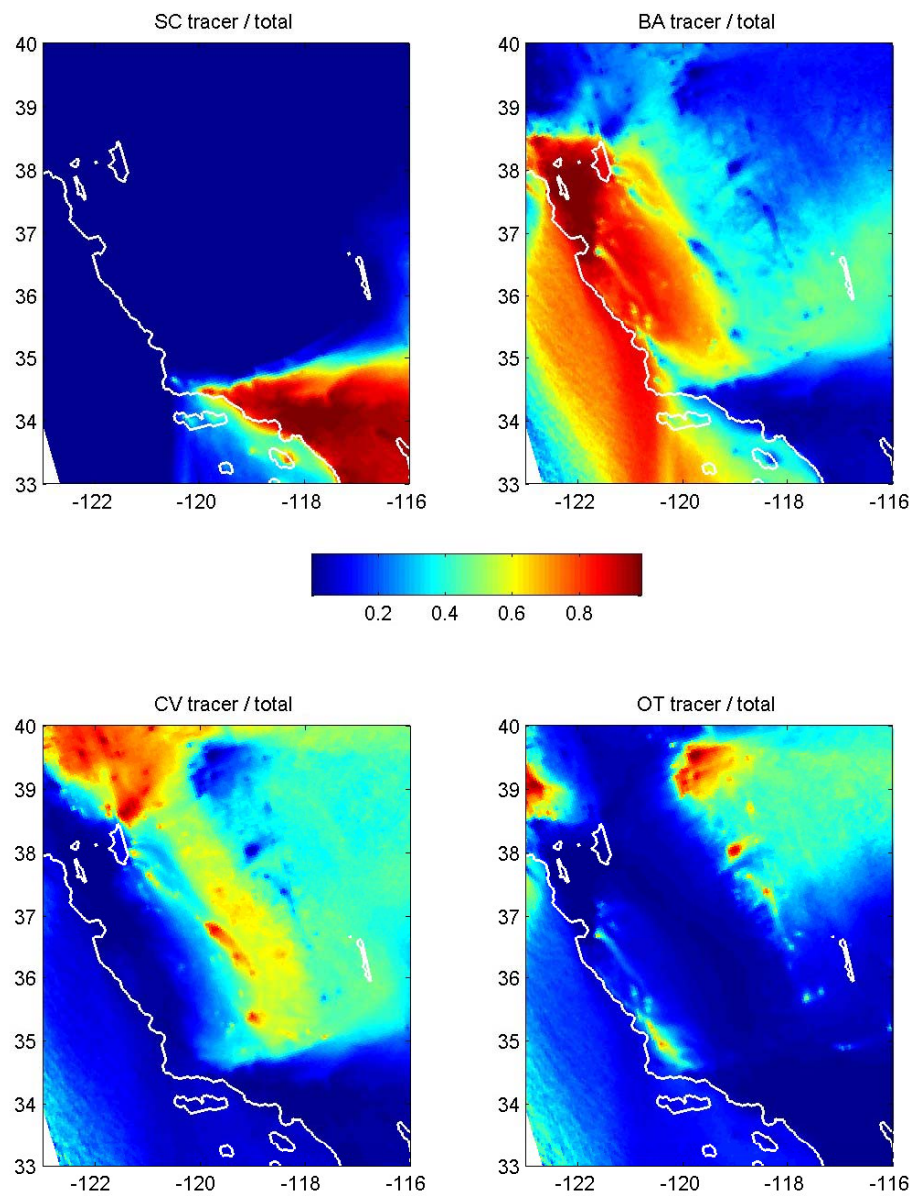
Flexpart "CO" simulations

Tracer ratios in lowest model level

Four tracers:

- Southern California
- Bay Area
- Central Valley
- Other

Average 1-15 June



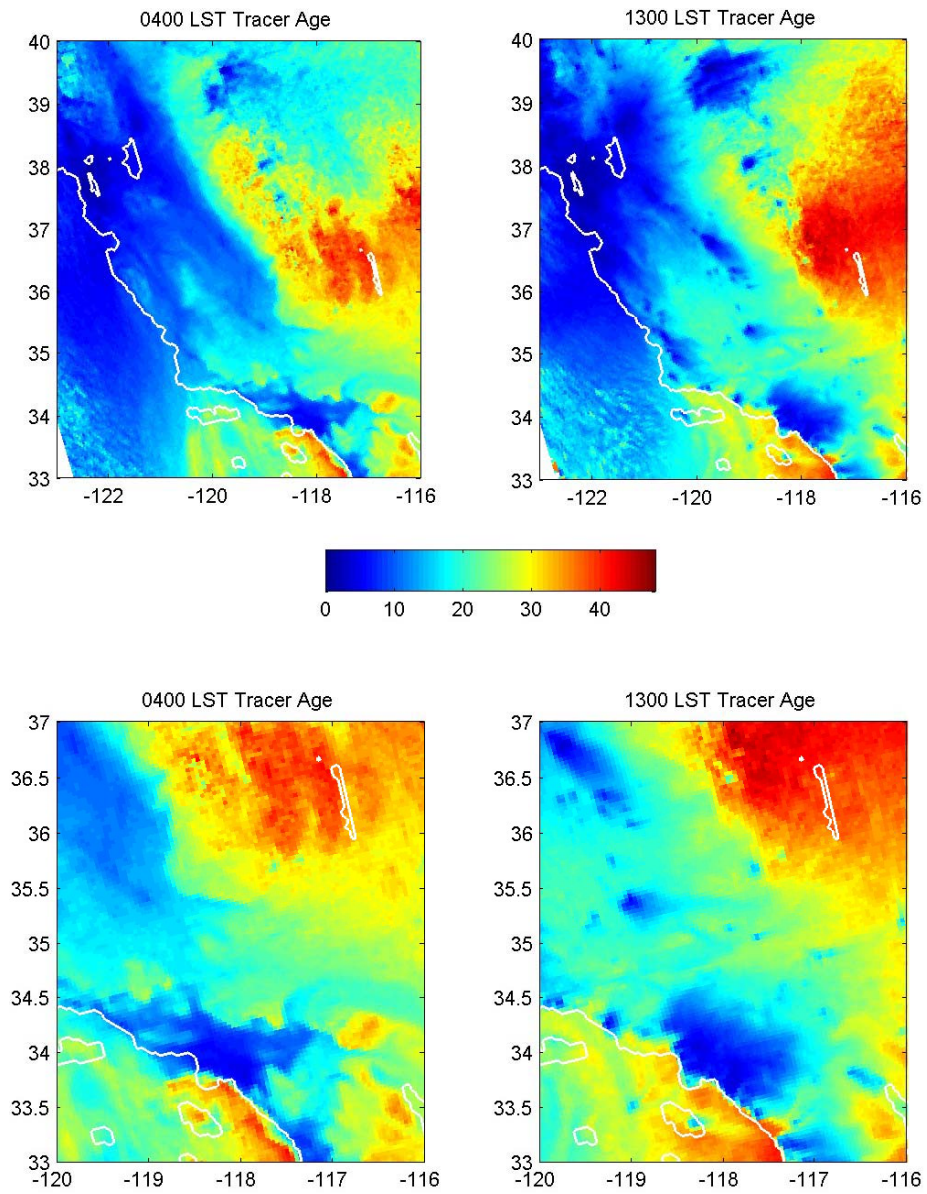
Flexpart "CO" simulations

Tracer age in lowest model level (hours)

Early morning (0400 LST) and early afternoon (1300 LST)

Average 1-15 June

Lower panels zoomed in on Southern California



Conclusions

Grid spacing: 4 km better than 12 km. Good enough?

Cloud-aware TEMF PBL scheme improves performance in cloudy areas (over the bight), not better in general

ERA-Interim initialization improves boundary layer structure over the water, not elsewhere

Noah land surface model with urban canopy model and MODIS land use data improved performance in the San Joaquin Valley, with only slight degradation in the Los Angeles basin

Flexpart/WRF as adapted at ESRL gives good vertical structure of CO profiles

COAMPS works well over water, using data assimilation

Paper accepted at Monthly Weather Review

The whole system matters!

Thanks to:

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