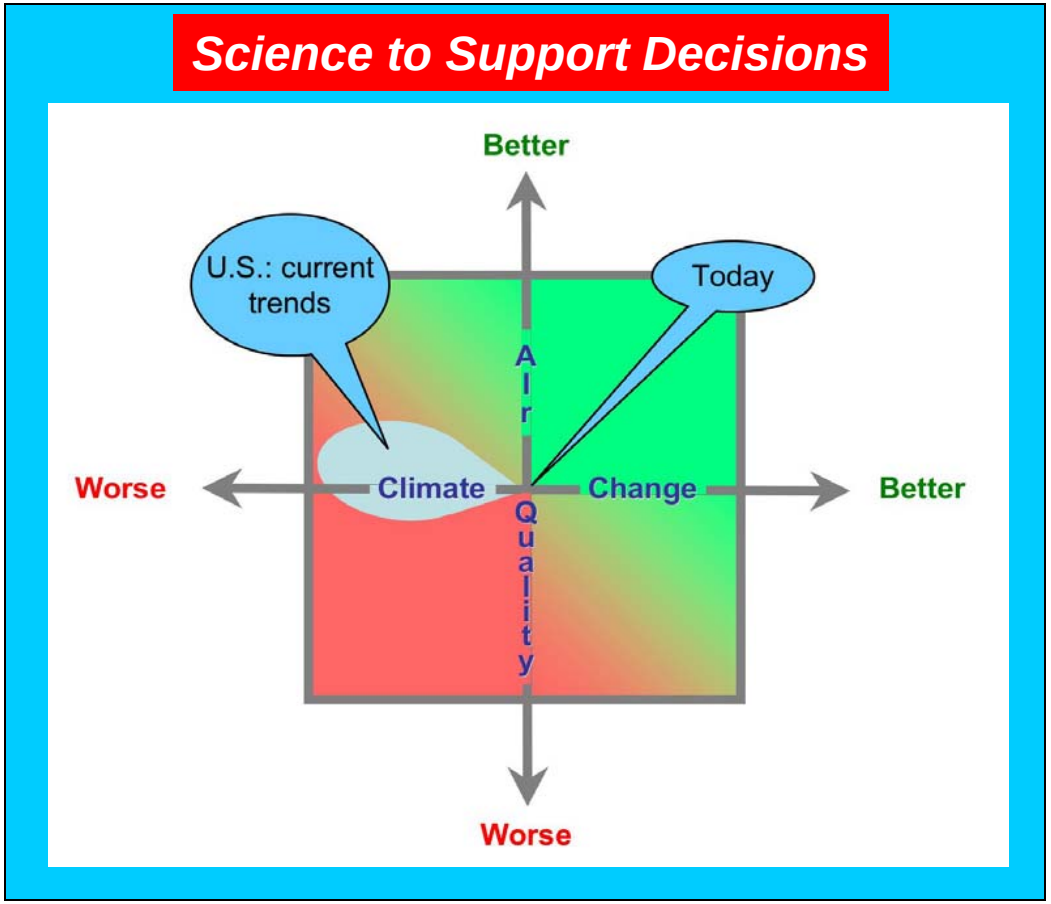
CalNex Global Modeling and Satellite Assimilation

R. Bradley Pierce
NOAA/NESDIS

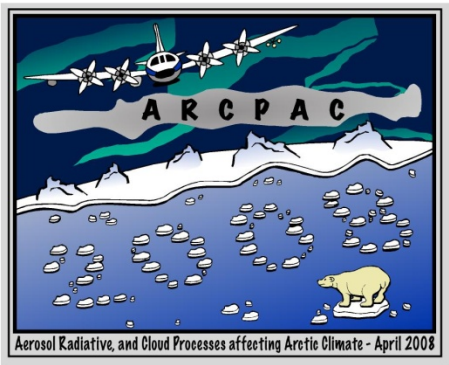


CalNex 2010 Public Meeting
February 5, 2009 Sacramento, CA

Real-time Air Quality Modeling System (RAQMS)

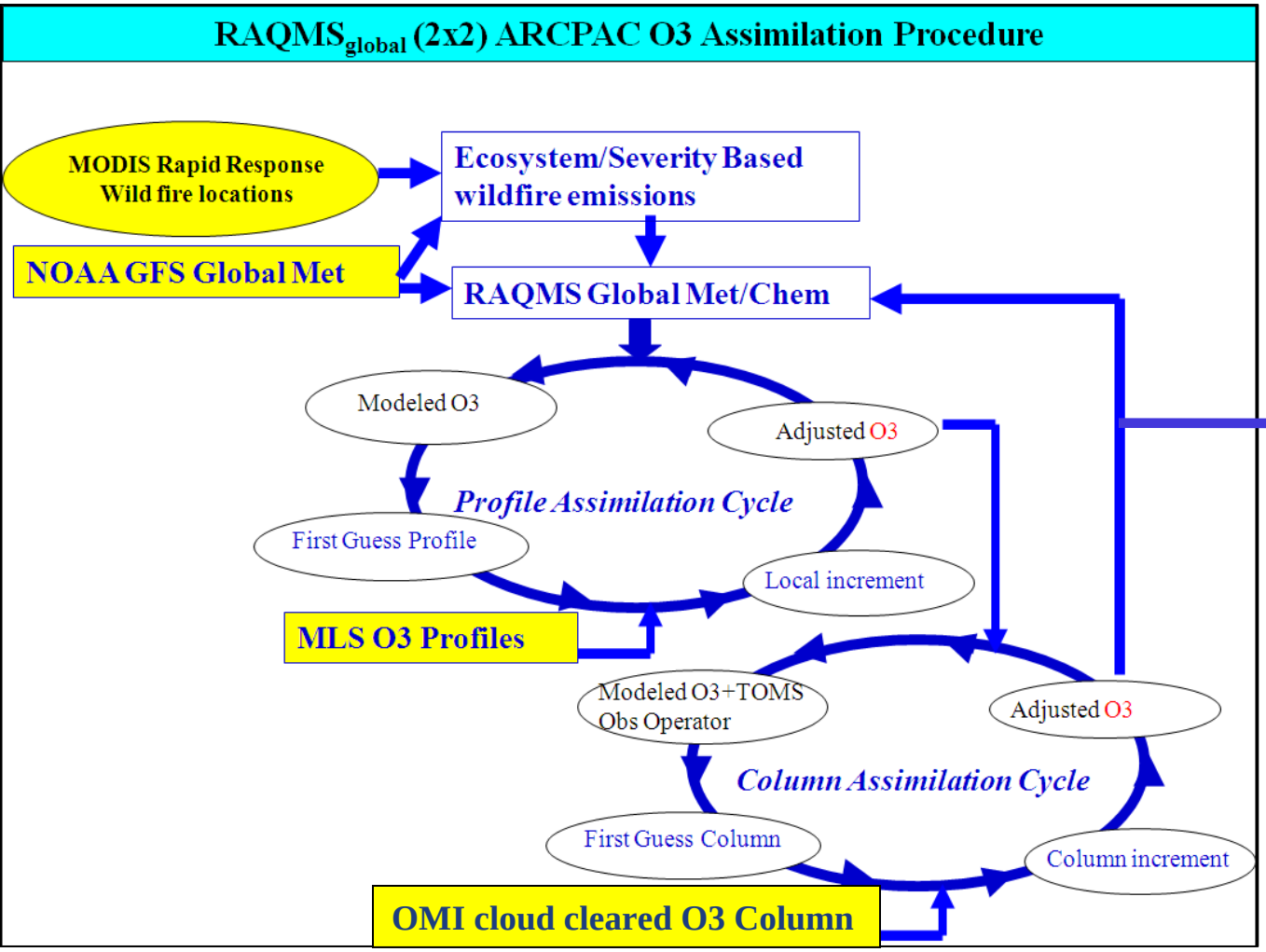
1) **Online global chemical and aerosol assimilation/forecasting system**
2) **University of Wisconsin sigma-theta hybrid coordinate model (UW-Hybrid) dynamical core**
3) **Unified stratosphere/troposphere chemical prediction scheme (LaRC-Combo) developed at NASA LaRC**
4) **Aerosol prediction scheme (GOCART) developed by Mian Chin (NASA GSFC).**
5) **Statistical Digital Filter assimilation system developed by James Stobie (NASA/GFSC)**

RAQMS has been used to support airborne field missions [Pierce et al, 2003, 2007, 2008], develop capabilities for assimilating satellite trace gas and aerosol retrievals [Fishman et al., 2008, Sunita et al., 2008] and assess the impact of global chemical analyses on regional air quality predictions [Song et al., 2008, Tang et al., 2008]



Will focus on results from the June 2008 NASA/CARB ARCTAS-CA field mission

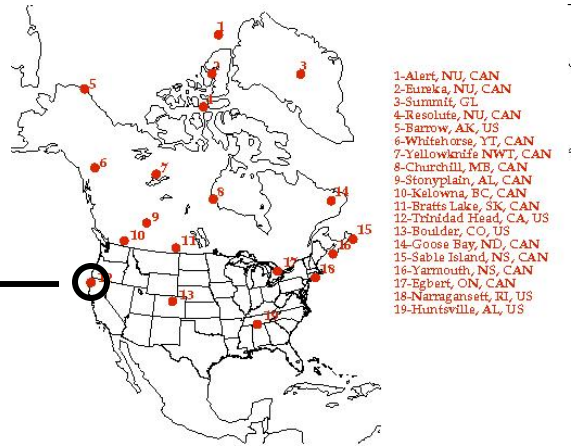
RAQMS Real-time O3 Assimilation/Prediction

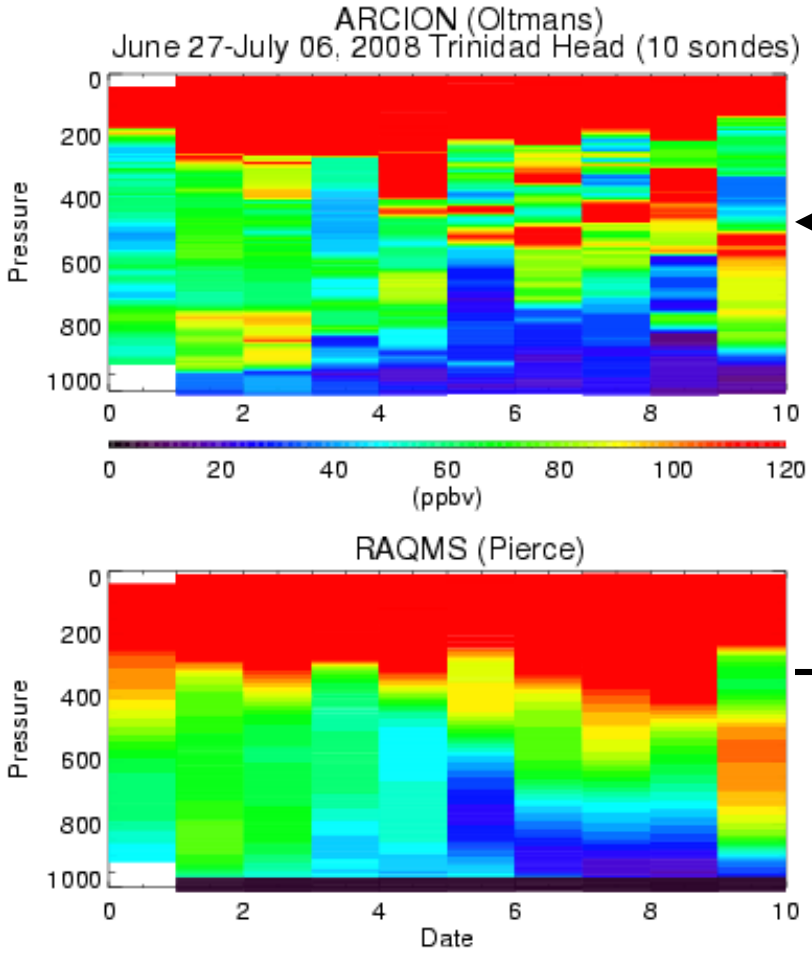


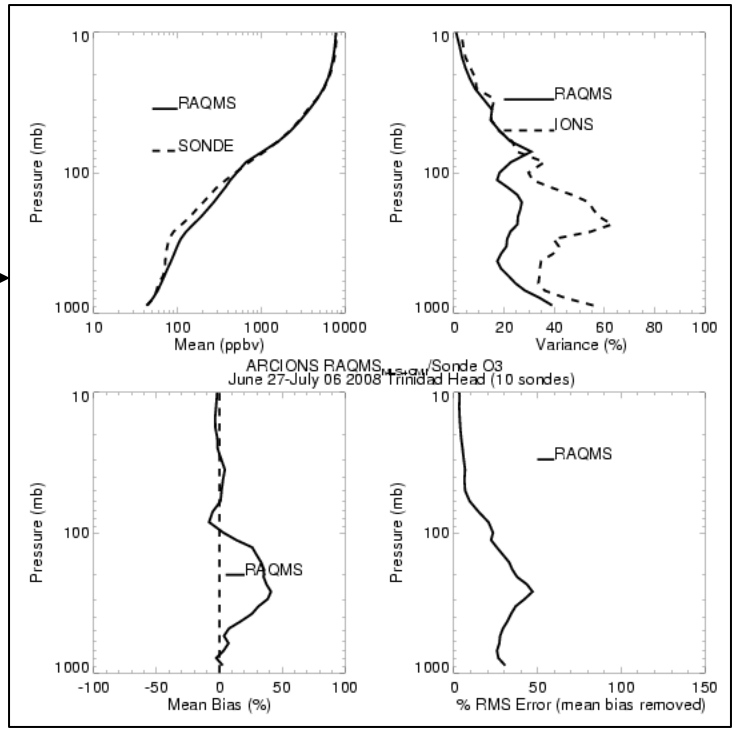
2x2 degree Global online strat/trop chemistry
Aerosol/photolysis feedback
Statistical Digital Filter (SDF) univariate OI assimilation

O3 validation: Trinidad Head CA

http://croc.gsfc.nasa.gov/arcions/





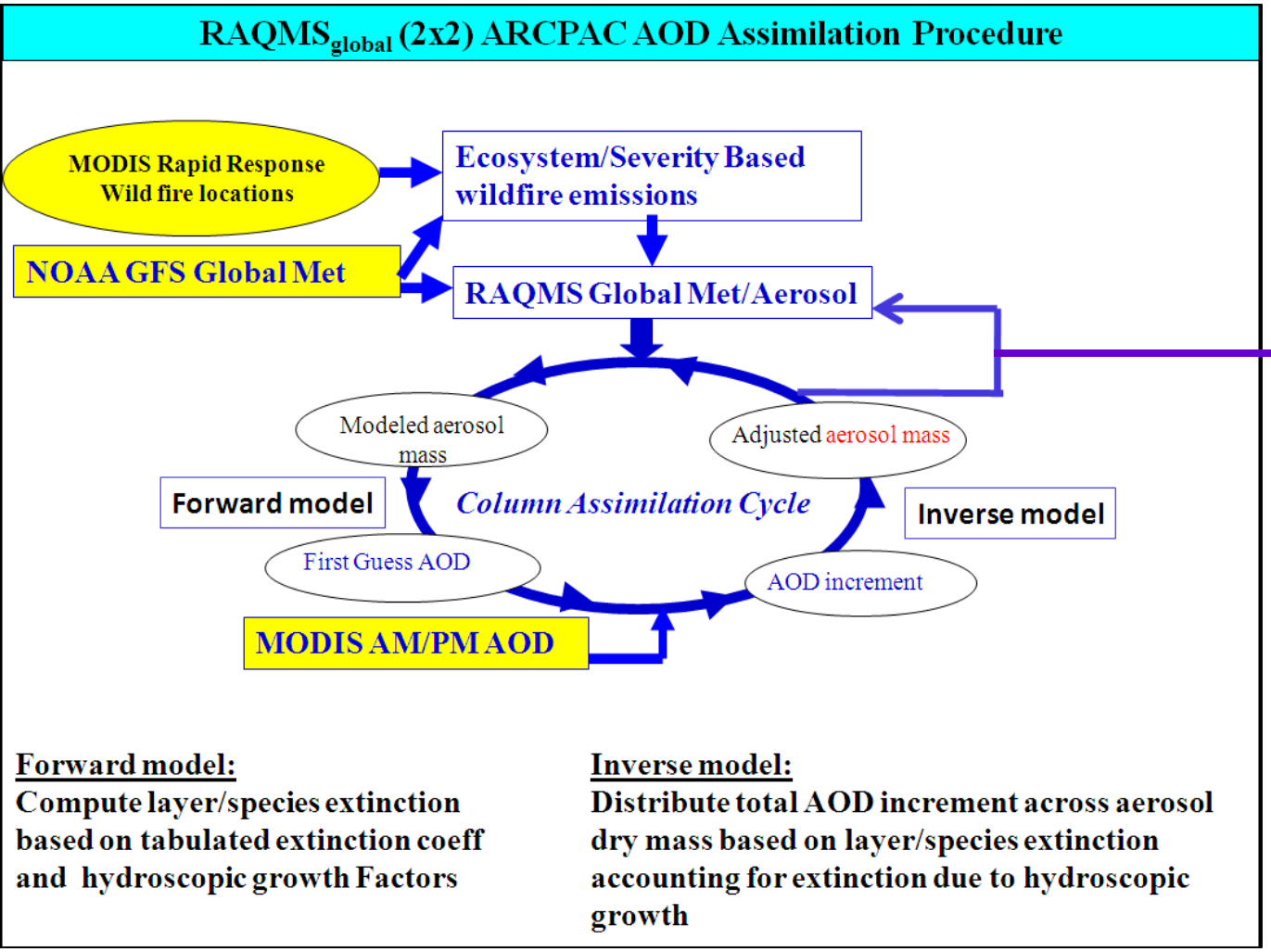


•Current RAQMS O3 analysis overestimates mean upper tropospheric ozone mixing ratios and underestimates upper tropospheric variability.

•Assimilation of TES tropospheric ozone profiles should improve upper troposphere

Arctic Intensive Ozonesonde Network Study (ARCIONS) data provided by Samuel Oltmans, NOAA/ESRL

RAQMS Real-time Aerosol Optical Depth (AOD) Assimilation/Prediction

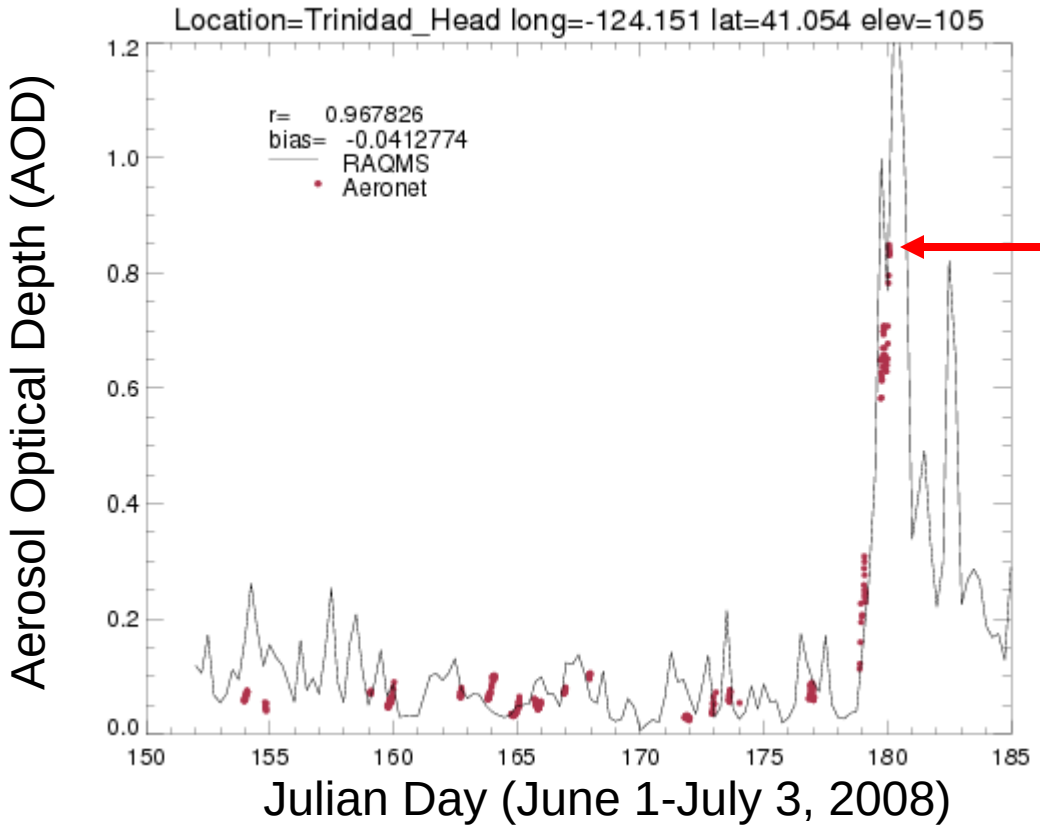


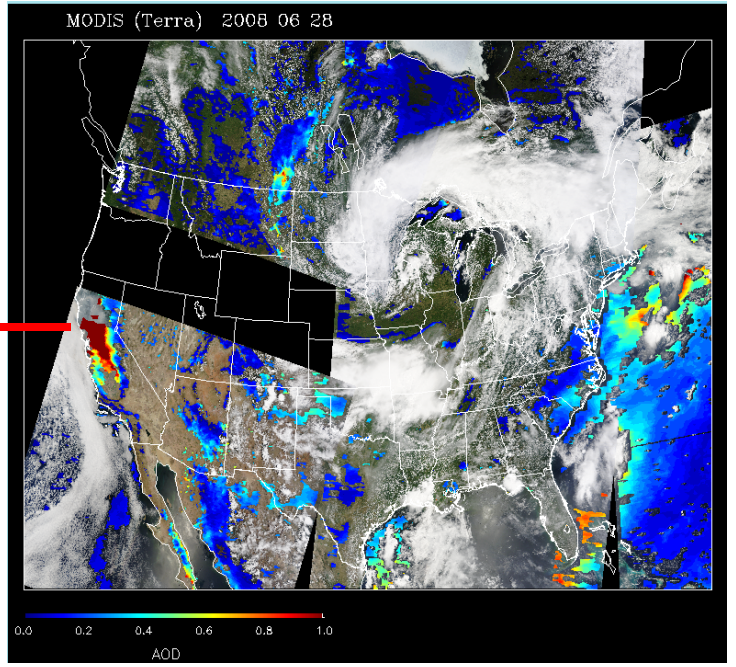
5-day 2°x2° Global Met/Aerosol Forecast

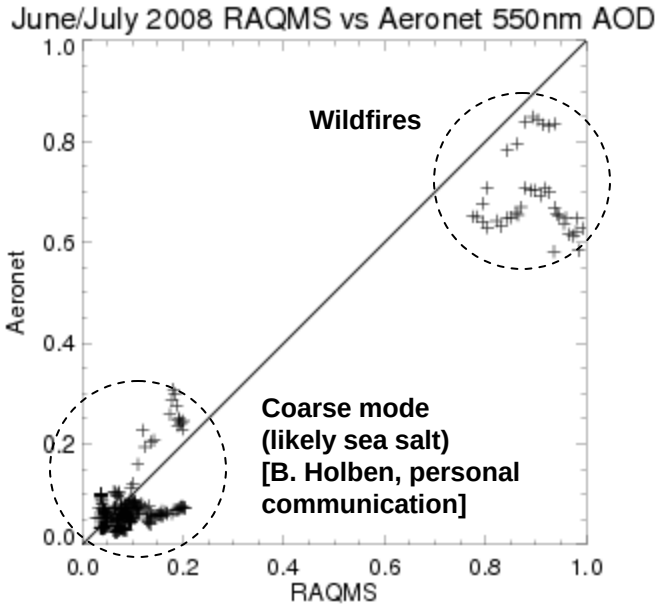
2x2 degree Global online aerosol (GOCART)
Statistical Digital Filter (SDF) univariate OI assimilation applied to SO4, Dust, BC, OC (not Sea Salt)

AOD validation: Trinidad Head CA

http://www.star.nesdis.noaa.gov/smcd/spb/aq/



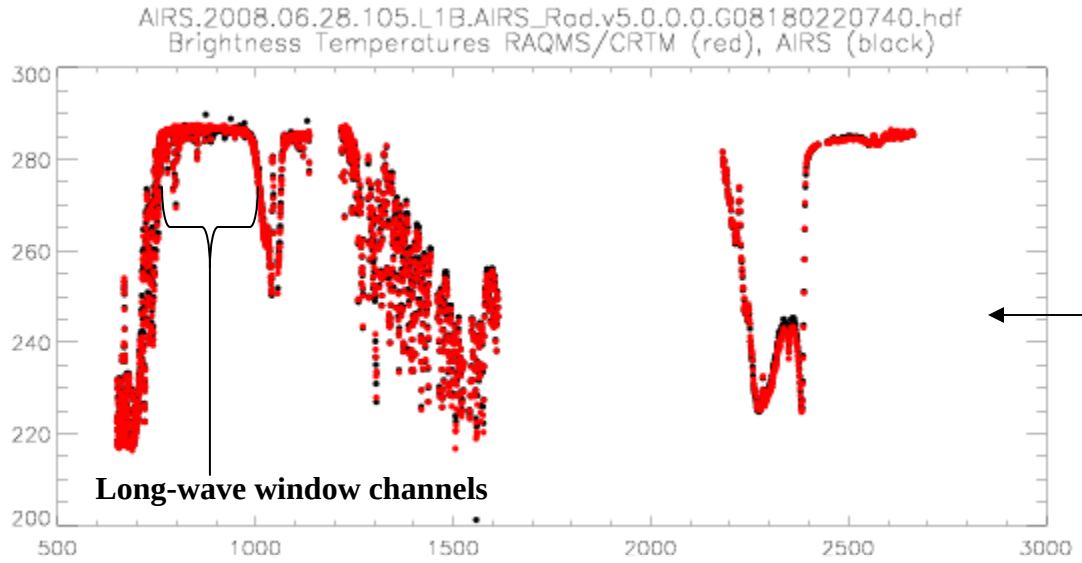


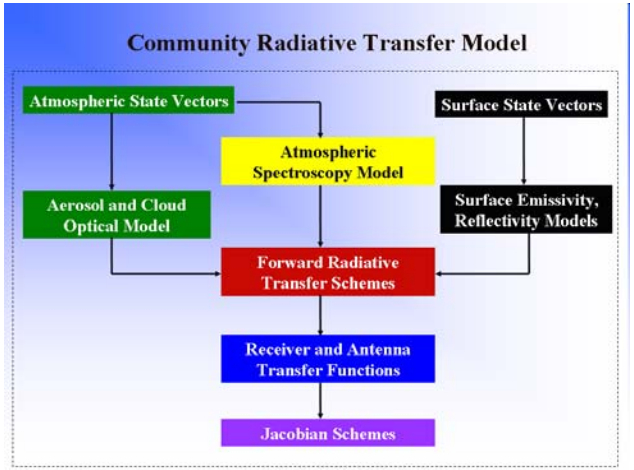


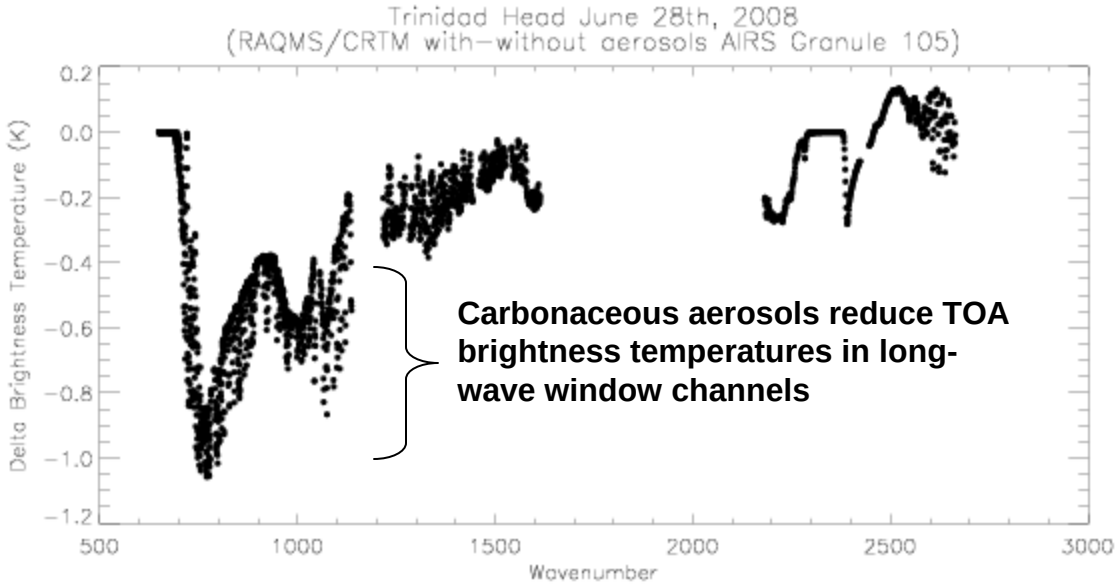
•RAQMS AOD analysis is in good agreement with Trinidad Aeronet measurements but overestimates Wildfire AOD during the later part of June/early July

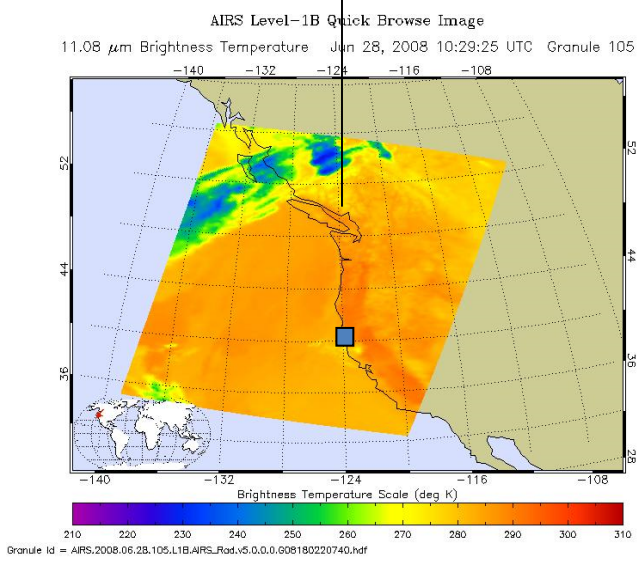
Aeronet AERONET Level 2.0. Quality Assured Data provided by Ellsworth G. Dutton and Brent Holben

Observed and RAQMS/CRTM simulated AIRS spectrum 1200 UTC 28 June 2008 (Trinidad Head)









http://www.star.nesdis.noaa.gov/smcd/spb/CRTM/

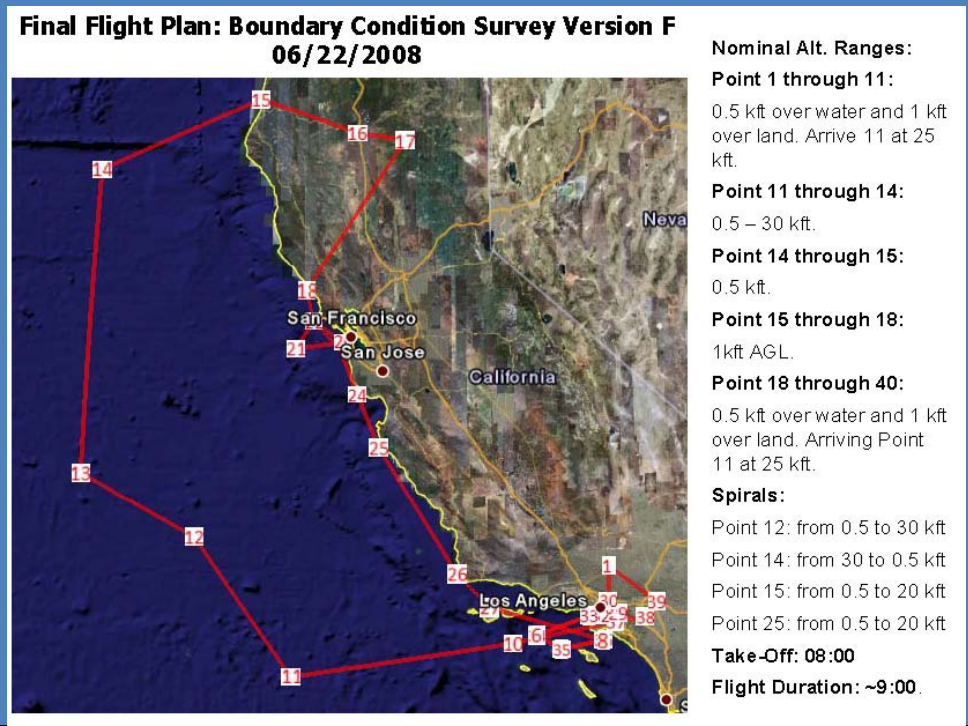
Illustration of CalNex mission Support activities

- **Flight Planning (long-range transport focus)**
- **Data synthesis (linking remote satellite, aircraft and ground-based measurements)**

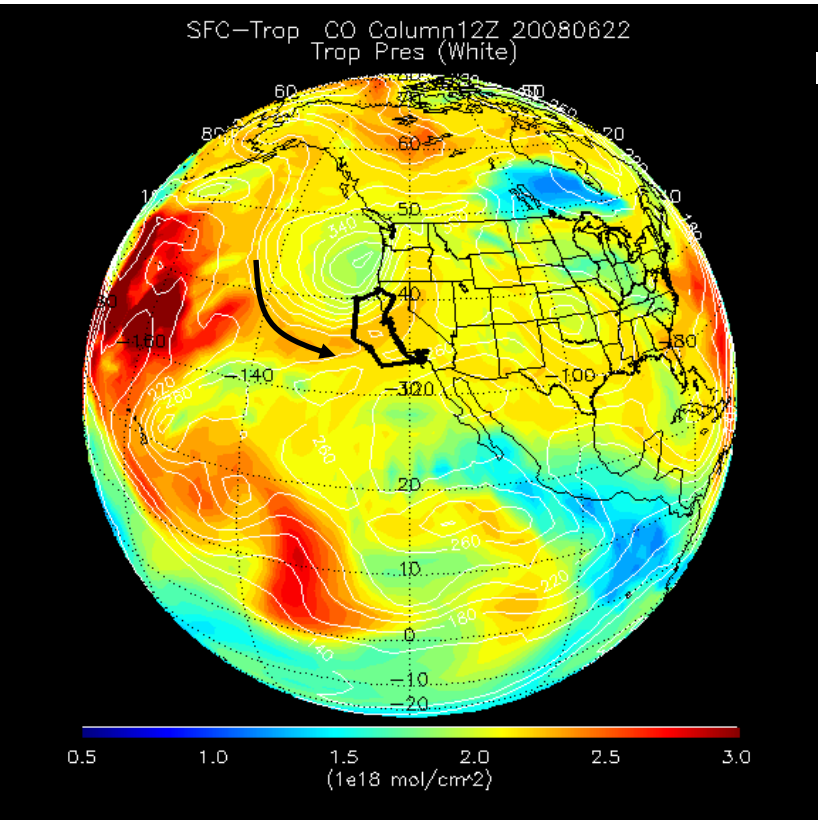
Arctic **R**esearch of the **C**omposition of the **T**roposphere from **A**ircraft and **S**atellites- California (ARCTAS-CA)

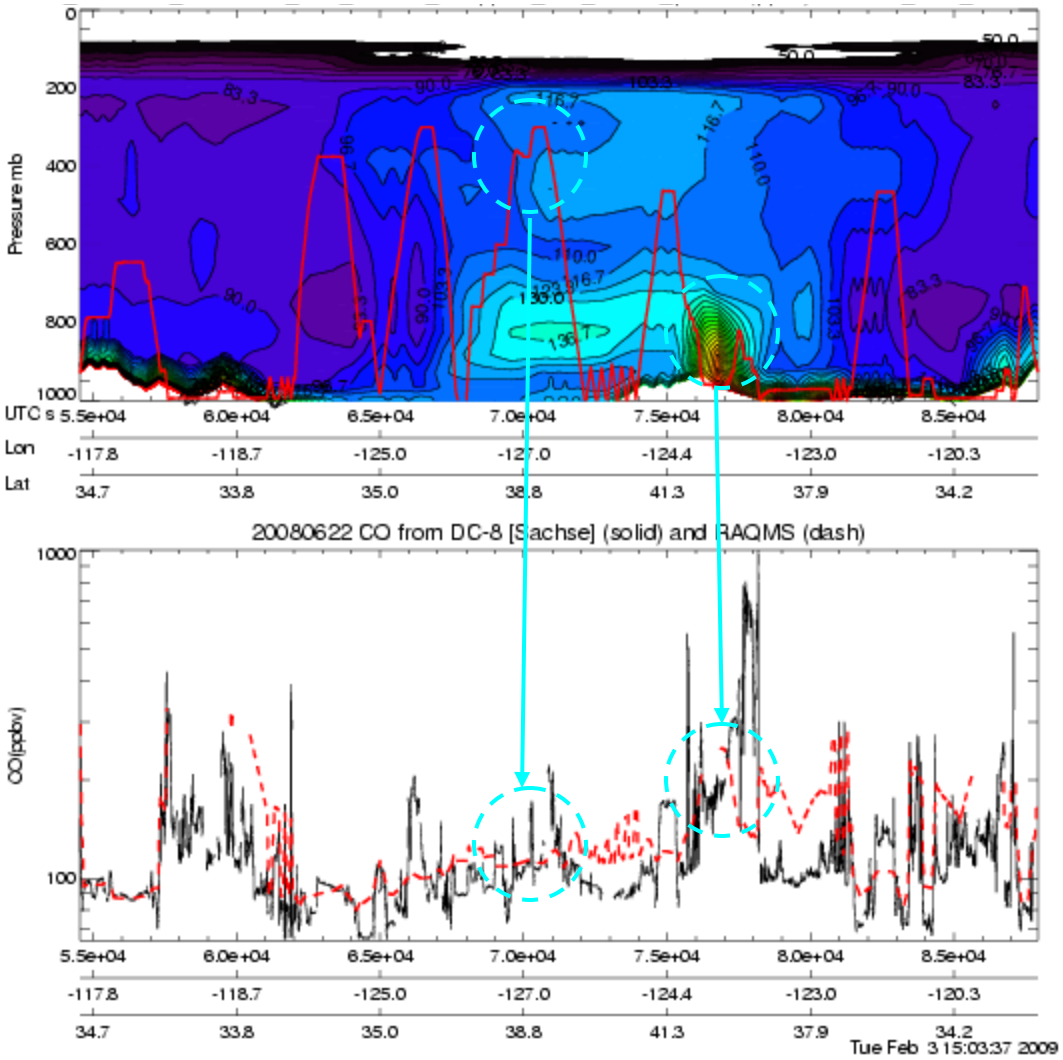
- ARCTAS-CA was CARB/ NASA collaboration dedicated to California air quality and climate change objectives

- Field campaign during June 15-30, 2008



RAQMS vs DC8 CO measurements ARCTAS-CA Flight 20080622

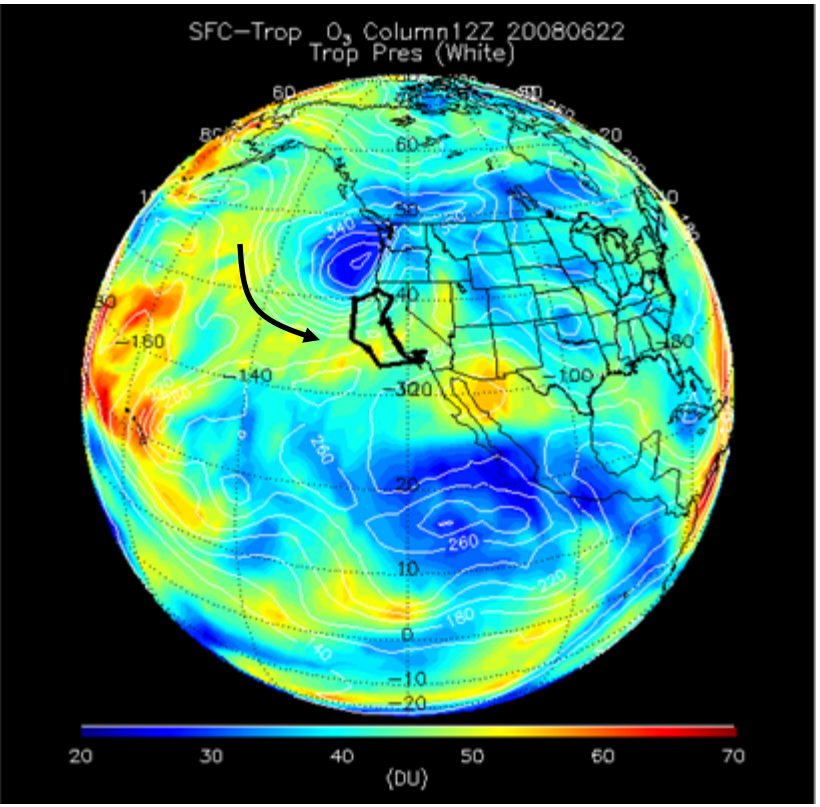


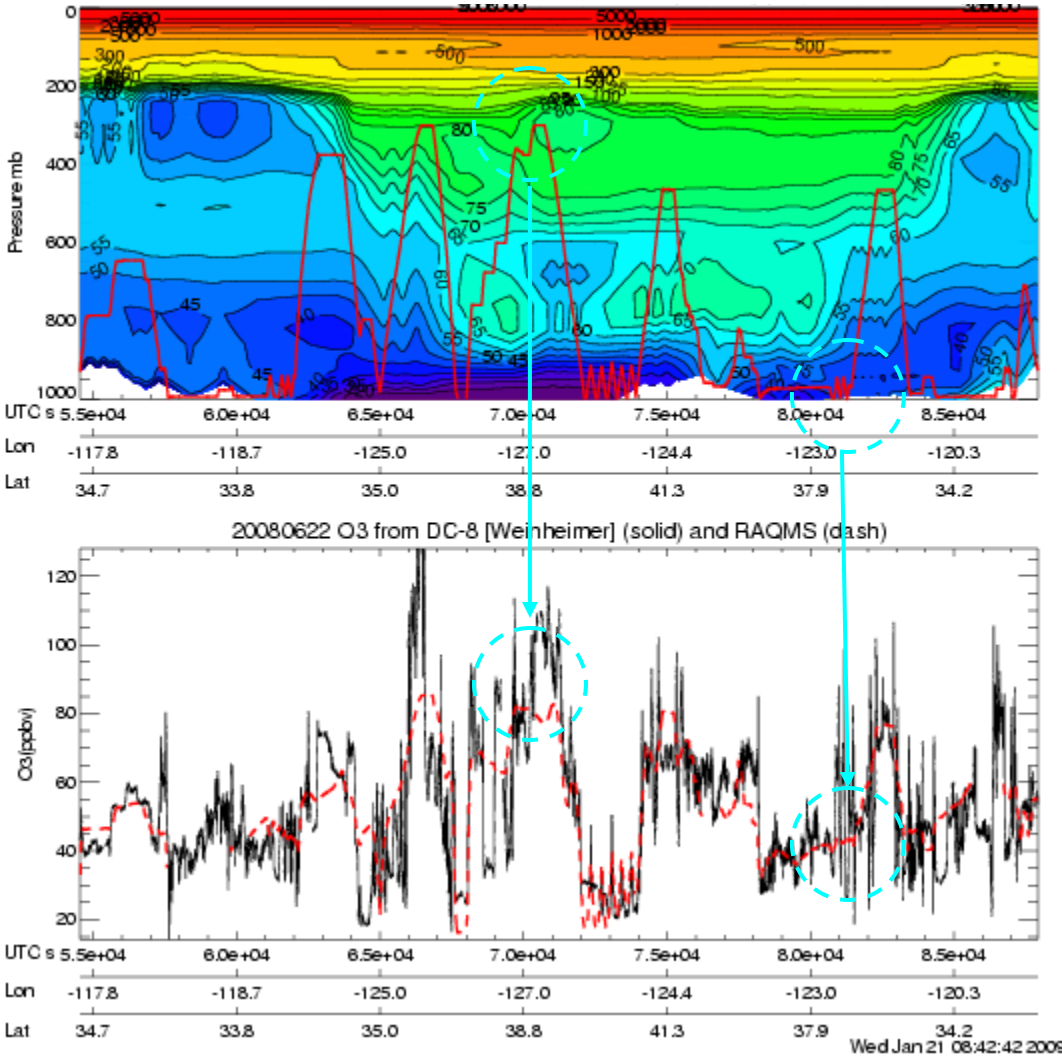


- RAQMS analysis captures large scale upper tropospheric ozone enhancements observed by the DC8.
- RAQMS underestimates CO mixing ratios associated with wildfire plume

Insitu data provided by G. Diskin (NASA/LaRC)

RAQMS vs DC8 O3 measurements ARCTAS-CA Flight 20080622

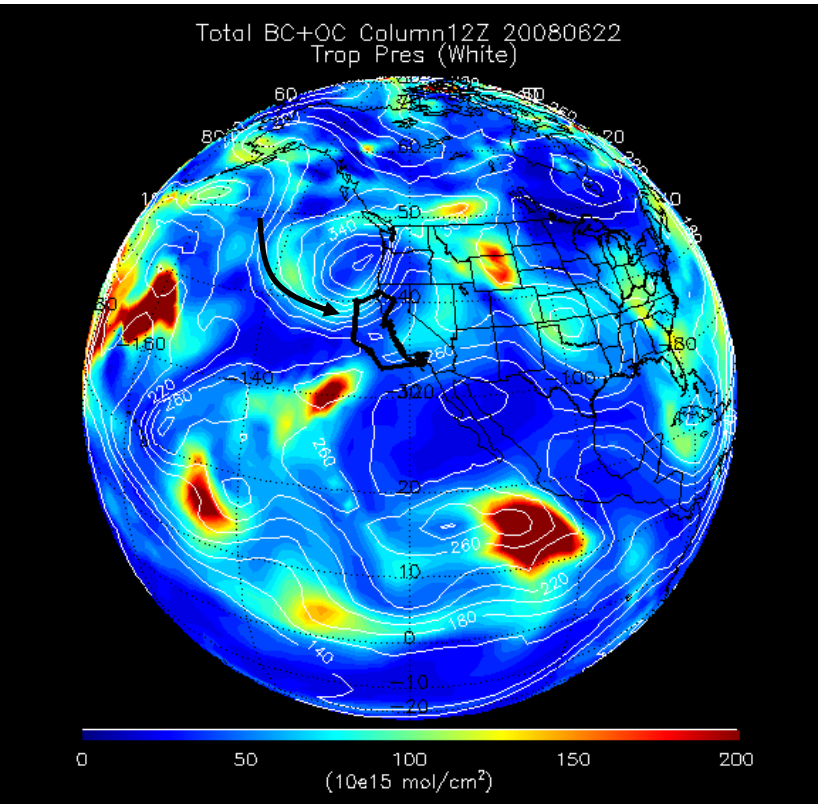


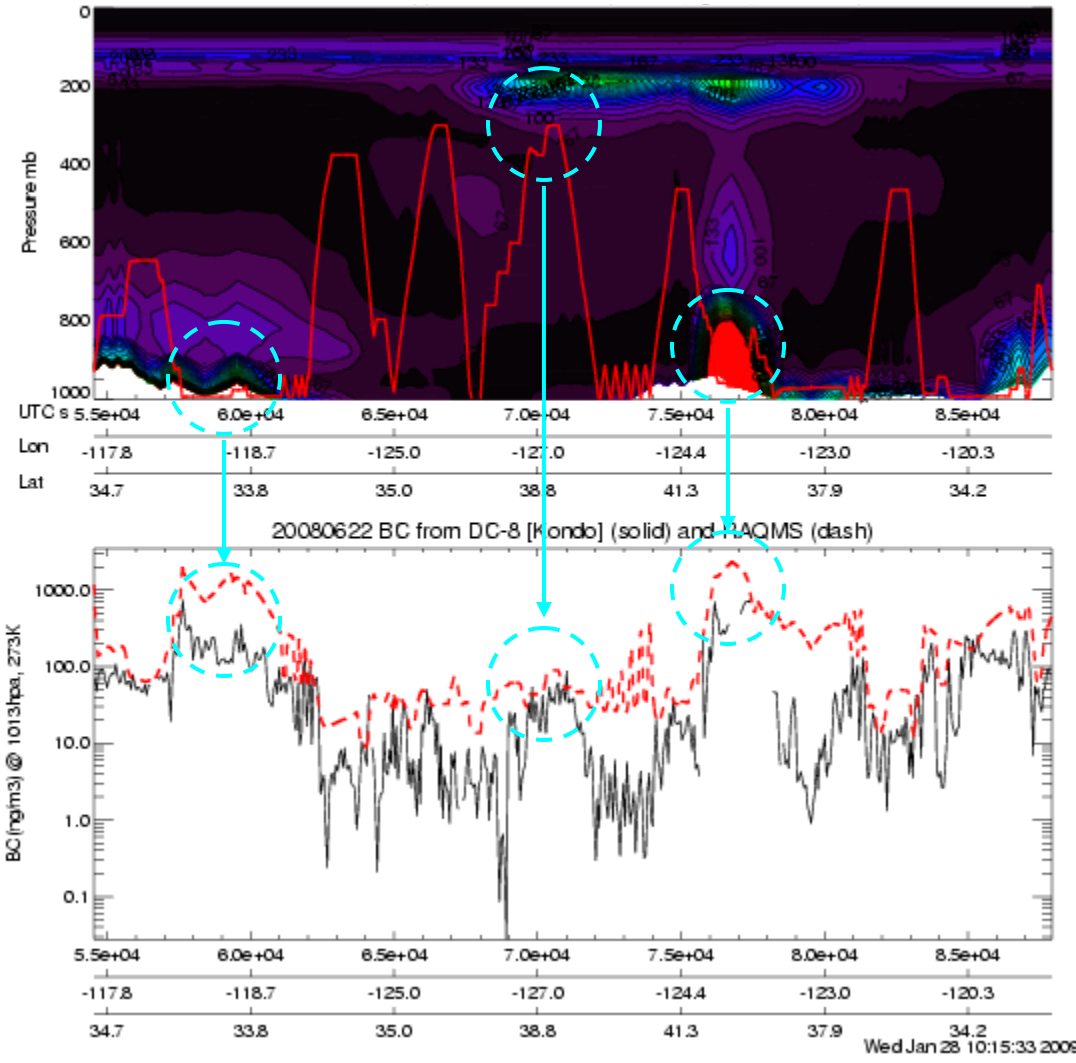


- RAQMS analysis captures large scale upper tropospheric ozone enhancements observed by the DC8.
- RAQMS does not resolve finescale structure within the PBL

Insitu data provided by A. Weinheimer (NCAR)

RAQMS Black Carbon vs DC8 SP2 measurements
ARCTAS-CA Flight 20080622

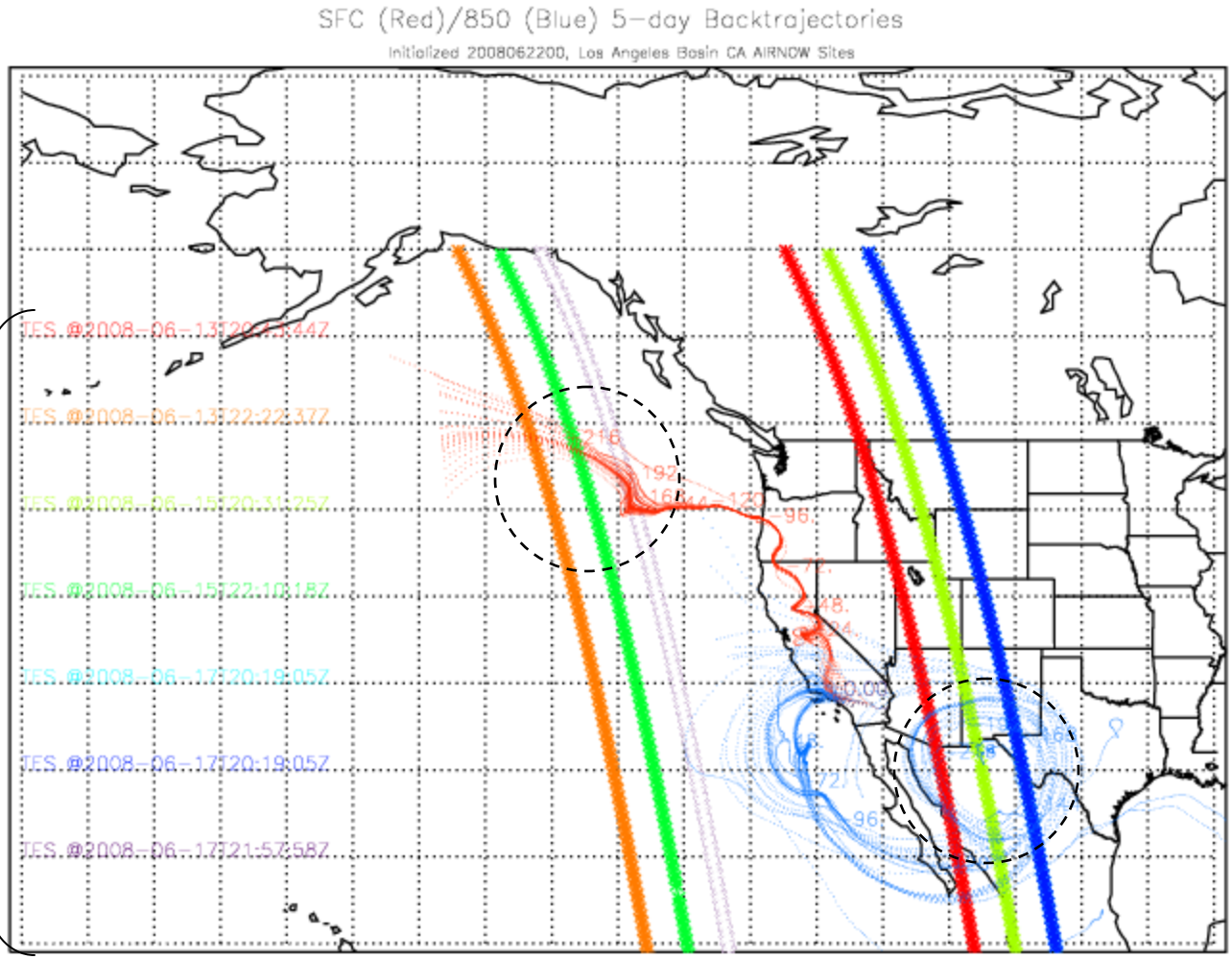




- RAQMS analysis overestimates black carbon aerosol associated with local wildfire activity
- DC8 SP2 measurements support analyzed black carbon aerosol enhancement aloft

Insitu data provided by Y. Kondo (Univ Tokyo)

Lagrangian estimates of background chemistry
Los Angeles Basin, CA June 22, 2008



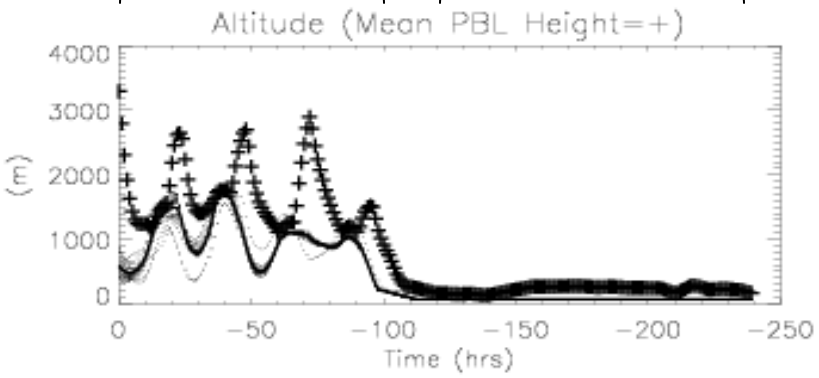
Near coincident TES Step&Stare Observations

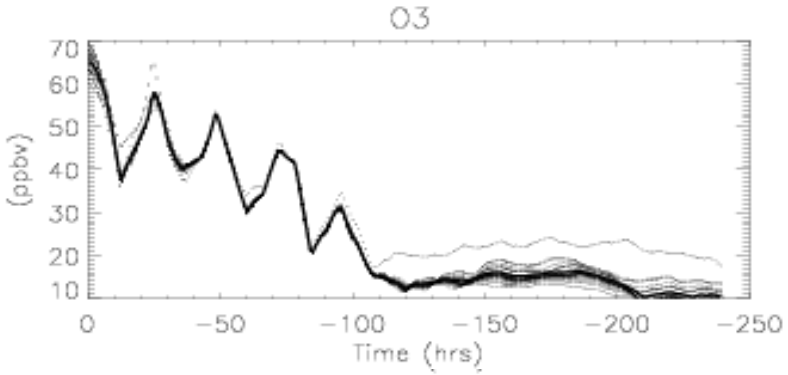
RAQMS chemical analyses are used to provide estimates of background composition along ensemble back trajectories that are initialized from surface ozone monitoring stations within the Los Angeles Basin [ala Pierce et al., submitted to TEXAQS Special Issue, 2008]

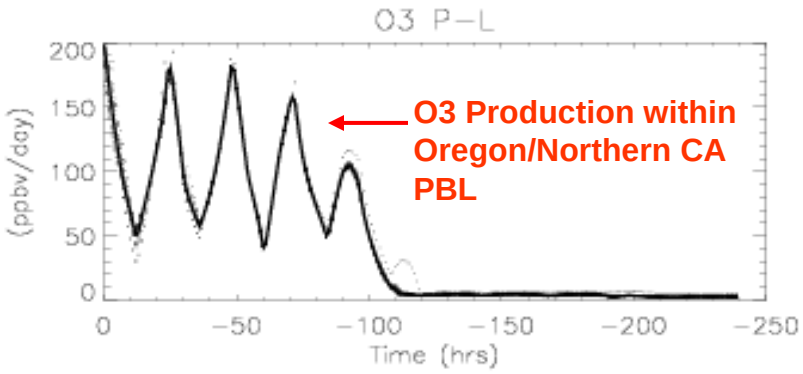
Los Angeles Basin, CA June 22, 2008

SFC Lagrangian Evolution

Continental BL | Marine BL

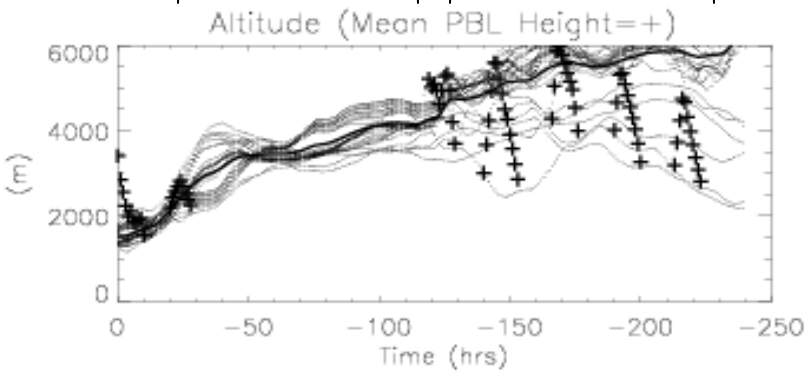


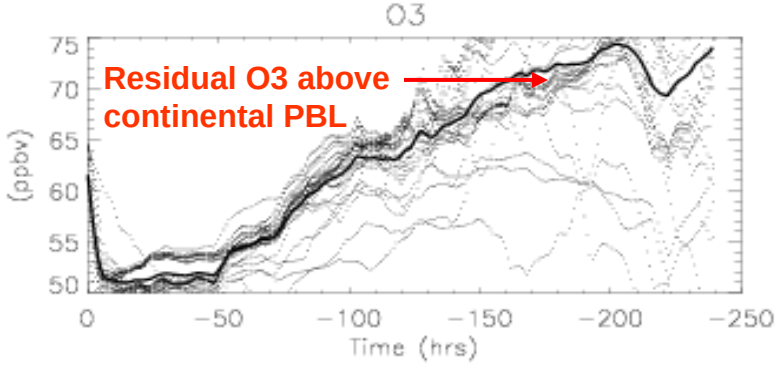


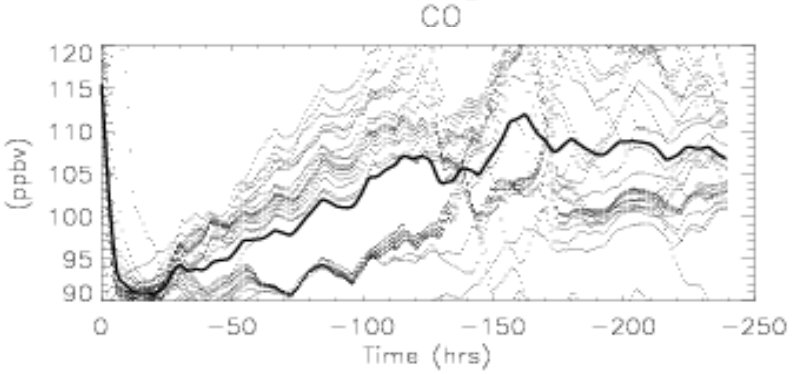


850mb Lagrangian Evolution

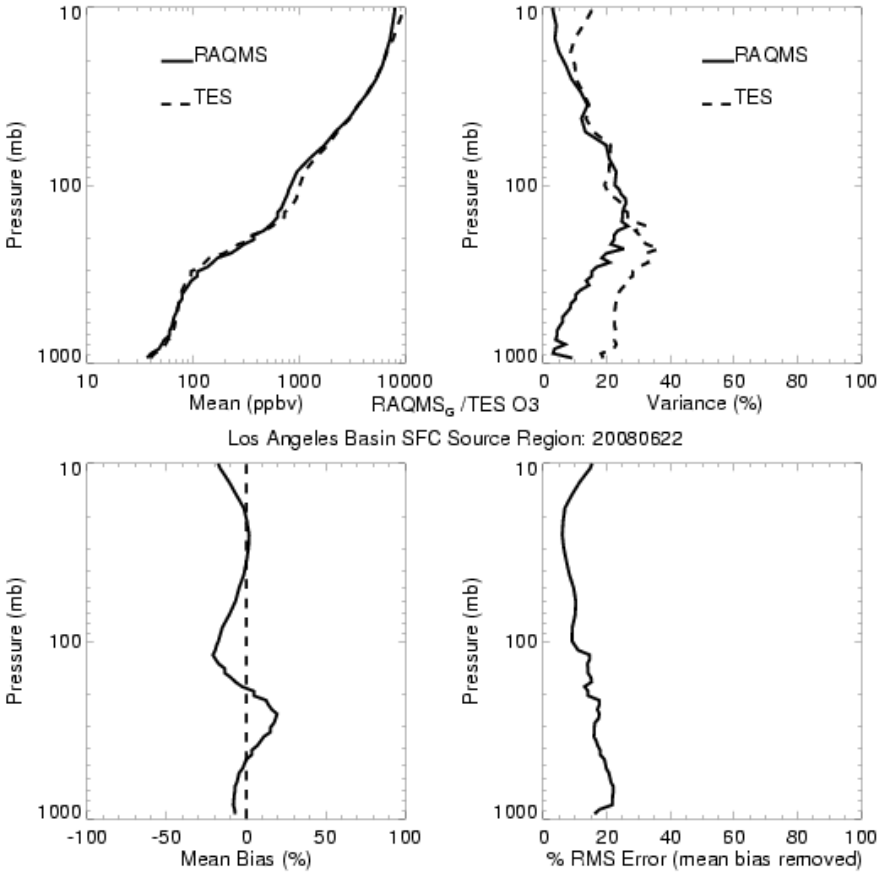
Marine FT | Continental BL/FT





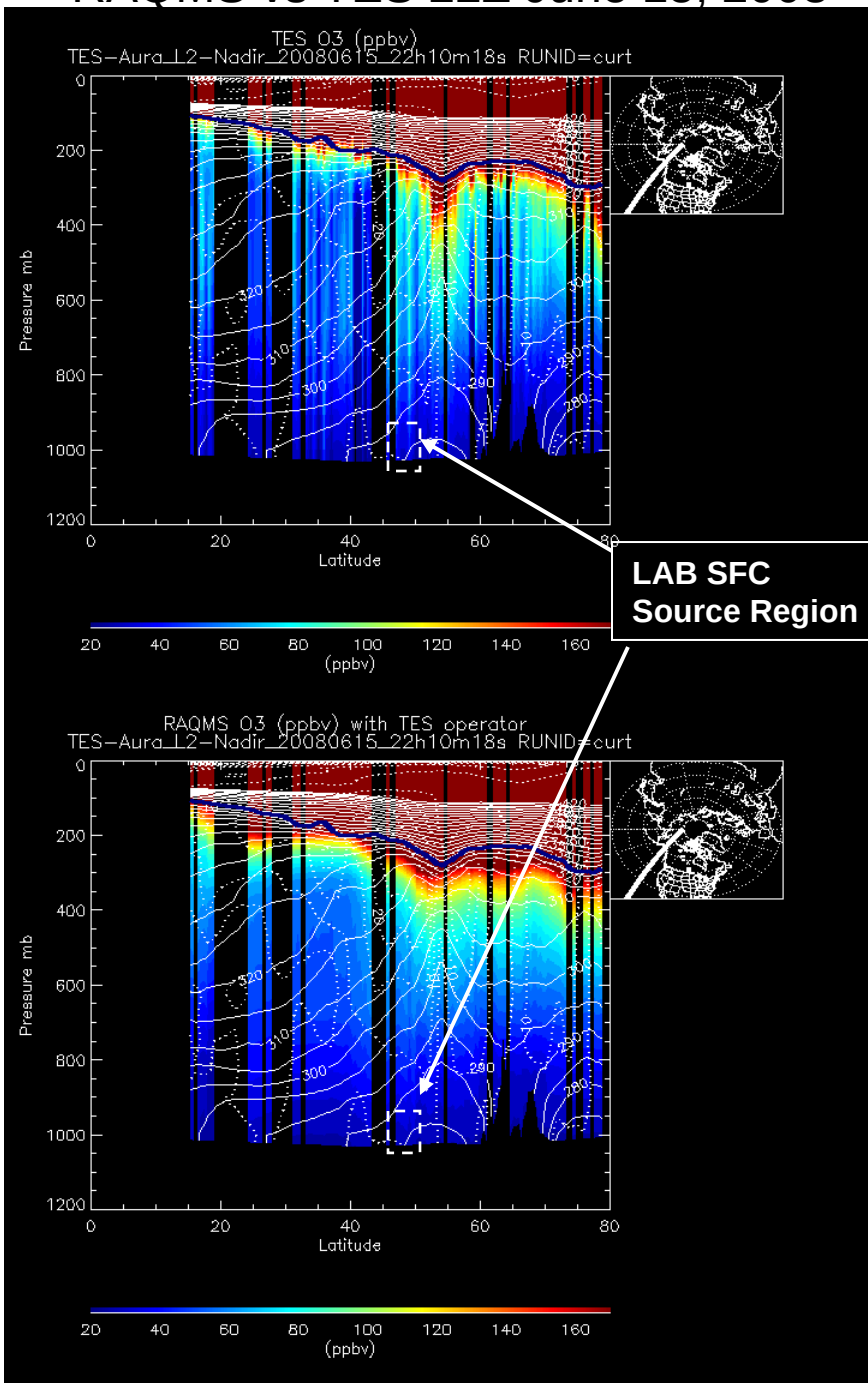


Verification of RAQMS O3 along TES Pacific Step&Stare observations (June 13, 15, 17, 2008)

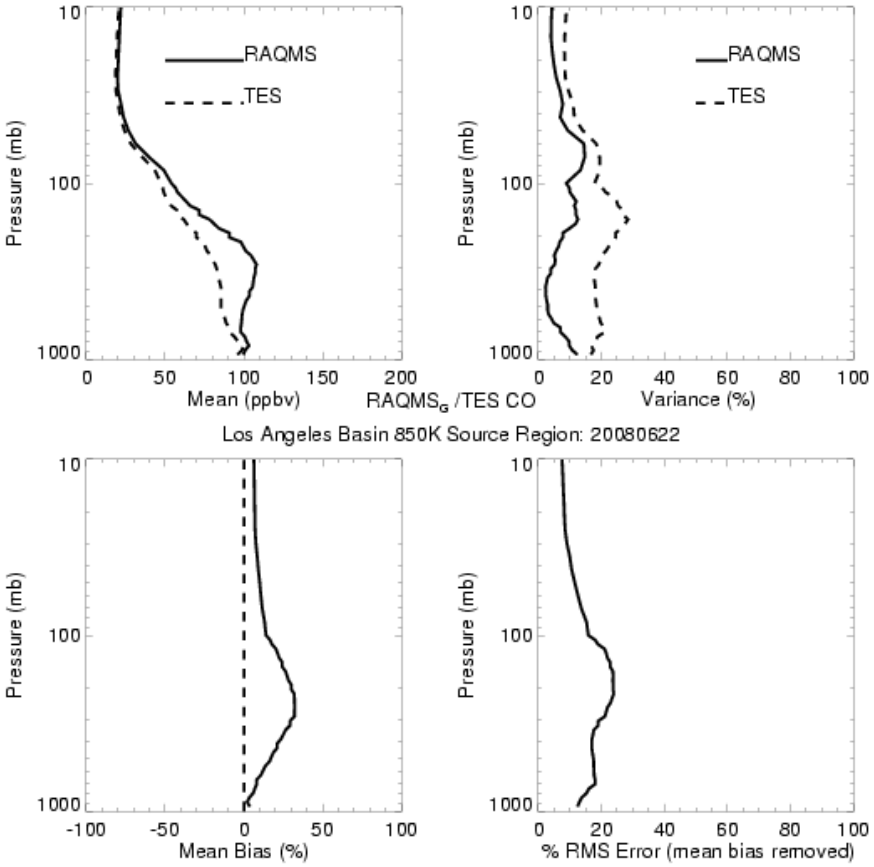


- RAQMS is in good agreement with TES at LAB SFC Source Region
- TES shows sharper O3 gradients at the tropopause

RAQMS vs TES 22Z June 15, 2008

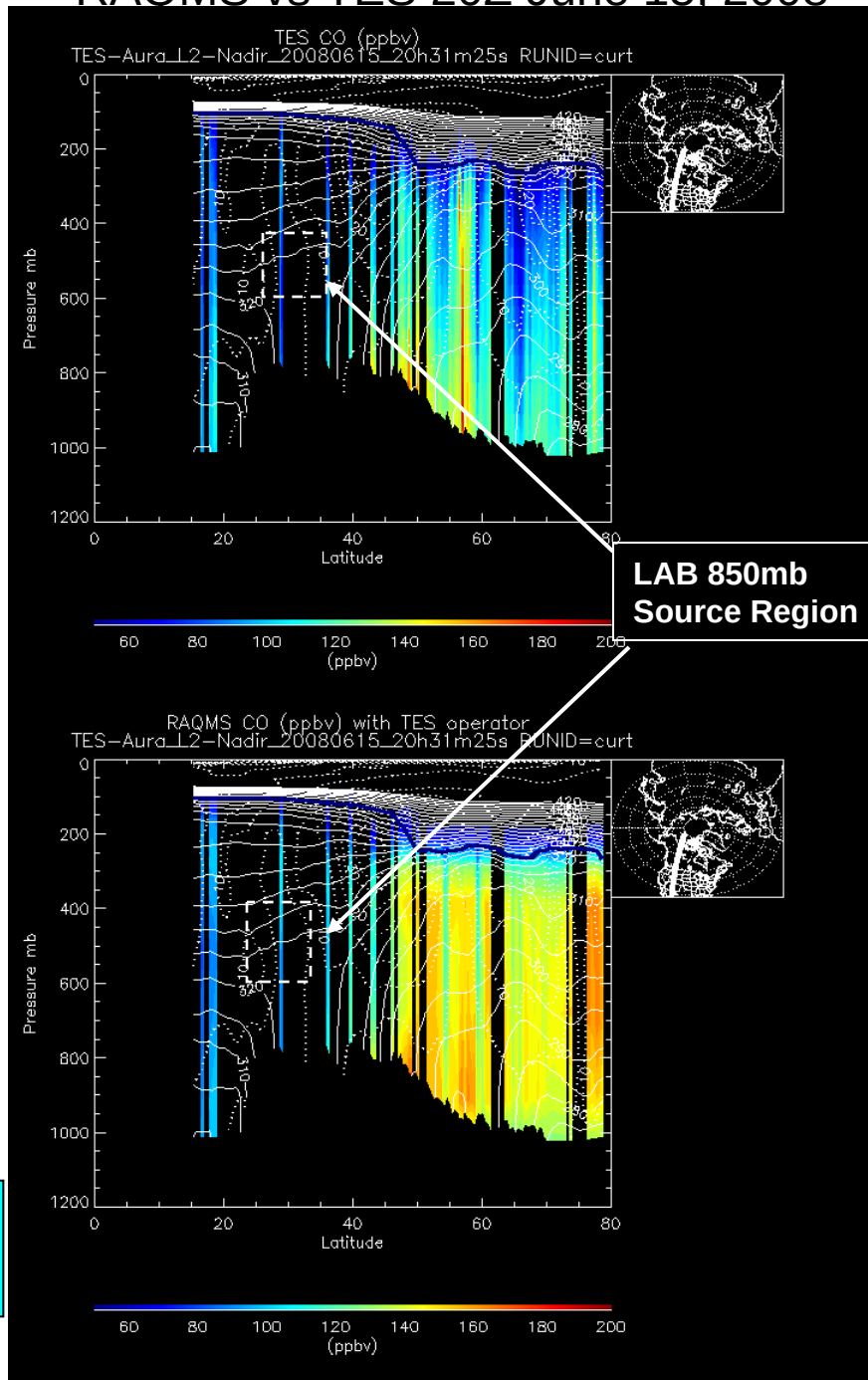


Verification of RAQMS CO along TES Continental Step&Stare observations (June 13, 15, 17, 2008)



- RAQMS overestimates upper tropospheric CO at LAB 850mb Source Region

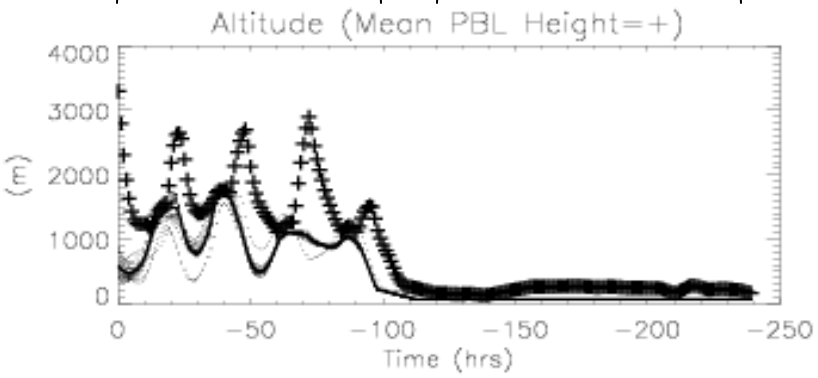
RAQMS vs TES 20Z June 15, 2008

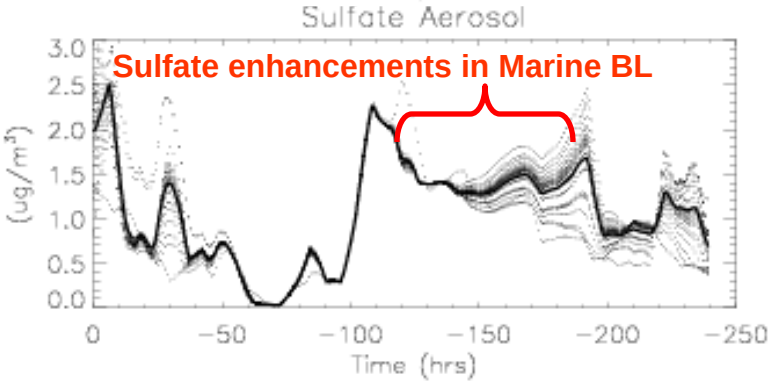


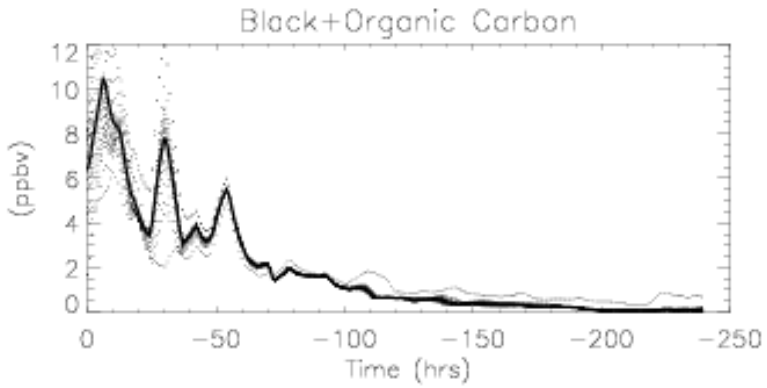
Los Angeles Basin, CA June 22, 2008

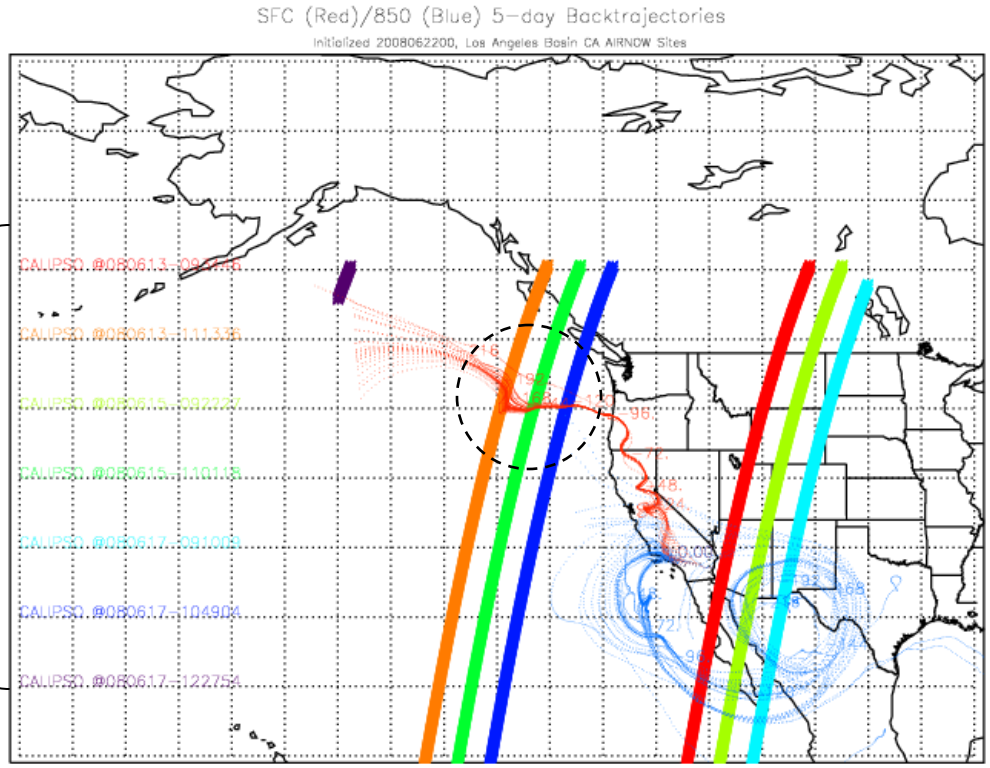
SFC Lagrangian Evolution

Continental BL **Marine BL**



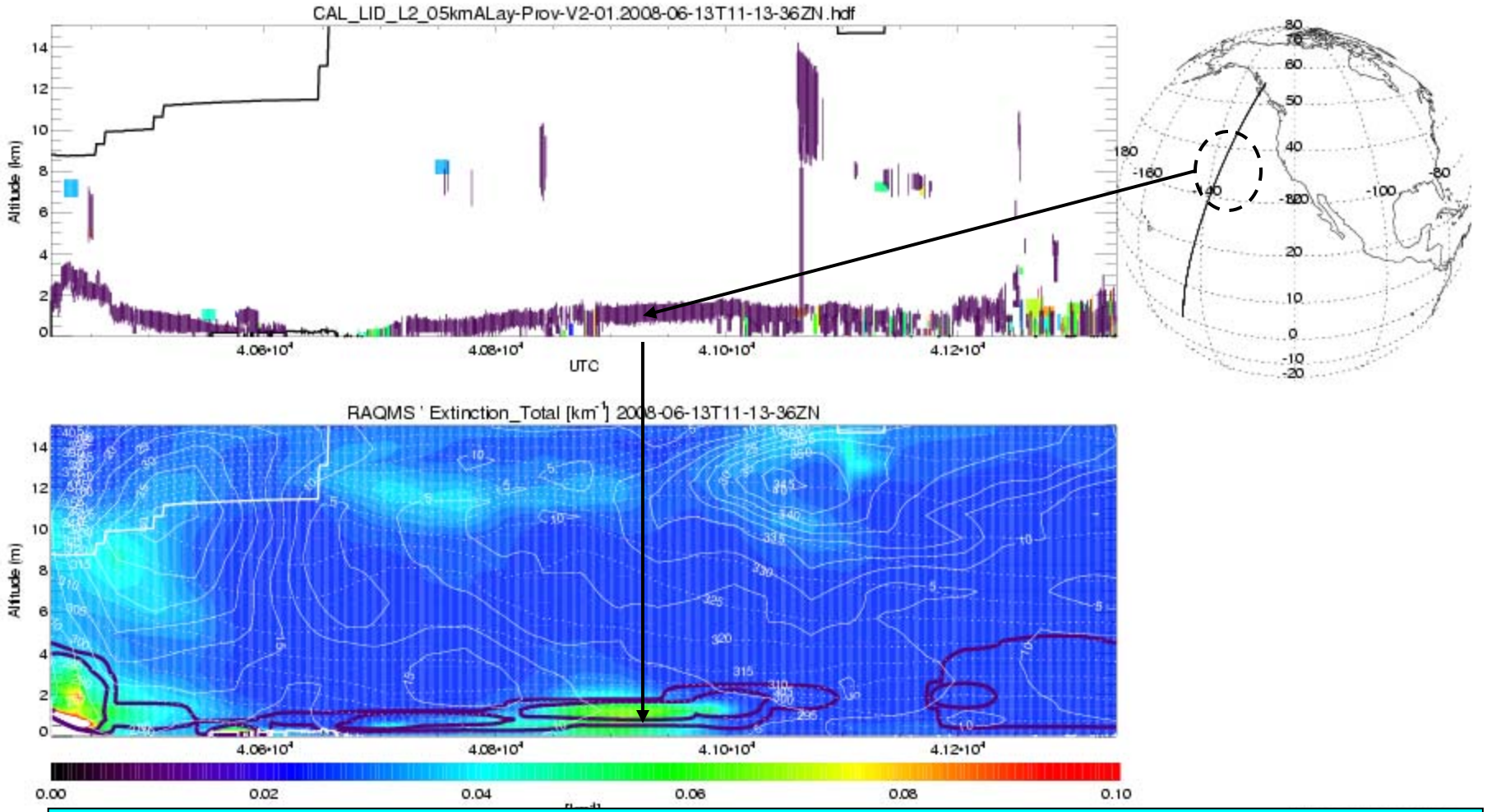






Near coincident CALIPSO Observations

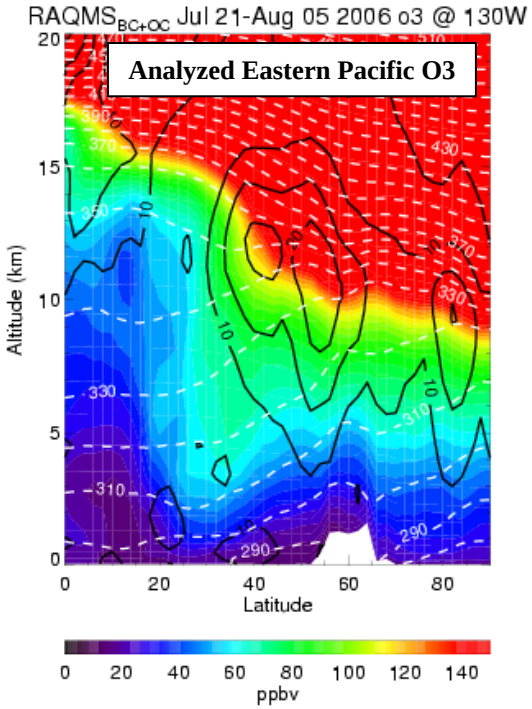
Verification of RAQMS Aerosol Extinction along CALIPSO Pacific observations (June 13, 2008)

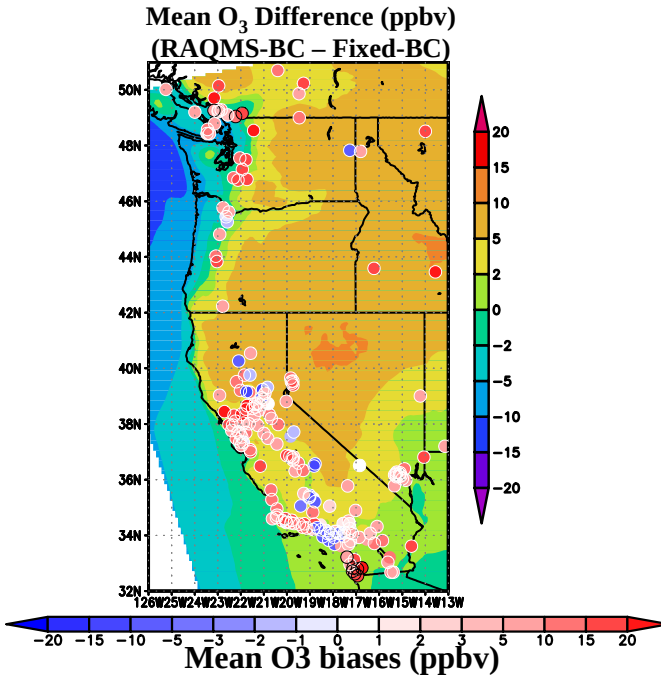


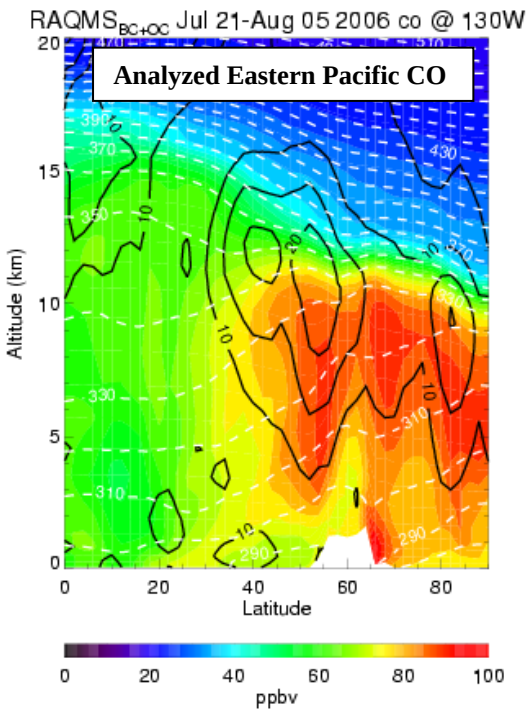
- Marine Stratus clouds preclude verification of RAQMS sulfate aerosol extinction
- CALIPSO does not show enhanced aerosol extinction in upper troposphere

Impact of Global BC on regional AQ Prediction[1]

Assessment using pre-operational NOAA/NWS NAM-CMAQ 12km forecast (July 21-August 5, 2006)







- **RAQMS lateral Boundary Conditions (BC) show enhanced O3 and CO between the Sub-tropical and Polar Jets**
- **RAQMS lateral Boundary Conditions lead to 10-15 ppbv reductions in off-shore surface ozone and 5-10 ppbv increases in surface ozone over mountain regions of the western US.**
- **Comparison with EPA AIRNow surface ozone west of -115°W shows improved slope and correlations but increased positive bias.**

NAM-CMAQ vs AIRNOW

	West of -115°W
Static BC	S=0.804 R=0.691 MB=4.7 ppbv
RAQMS BC	S=0.914 R=0.703 MB=7.1 ppbv

[1]Tang, Y., et al., (2008) "The impact of chemical lateral boundary conditions on CMAQ predictions of tropospheric ozone over the continental United States", Environ Fluid Mech, August 2008

Potential NESDIS/STAR activities for CALNEX

- Provide RAQMS chemical and aerosol analyses and forecasts for regional modeling BCs and Flight planning
- Provide California AIRNow ensemble trajectories sampling RAQMS chemical and aerosol forecasts for continental scale source attribution studies
- Provide CALIPSO and TES forward trajectories sampling RAQMS chemical and aerosol forecasts
- Provide fire emissions based on MODIS/WF-ABBA fire detection

STAR Center for Satellite Applications and Research

formerly ORA — Office of Research and Applications