Chemical and Aerosol Data Assimilation Activities during CalNex

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NOAA/NESDIS/STAR

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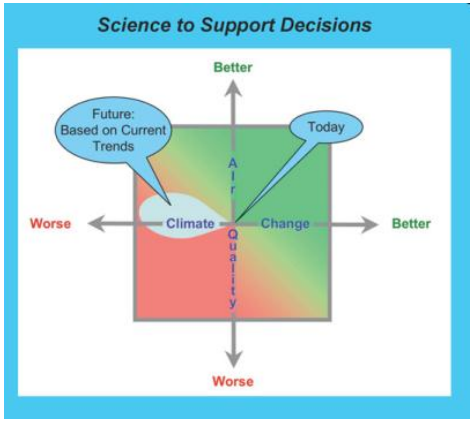
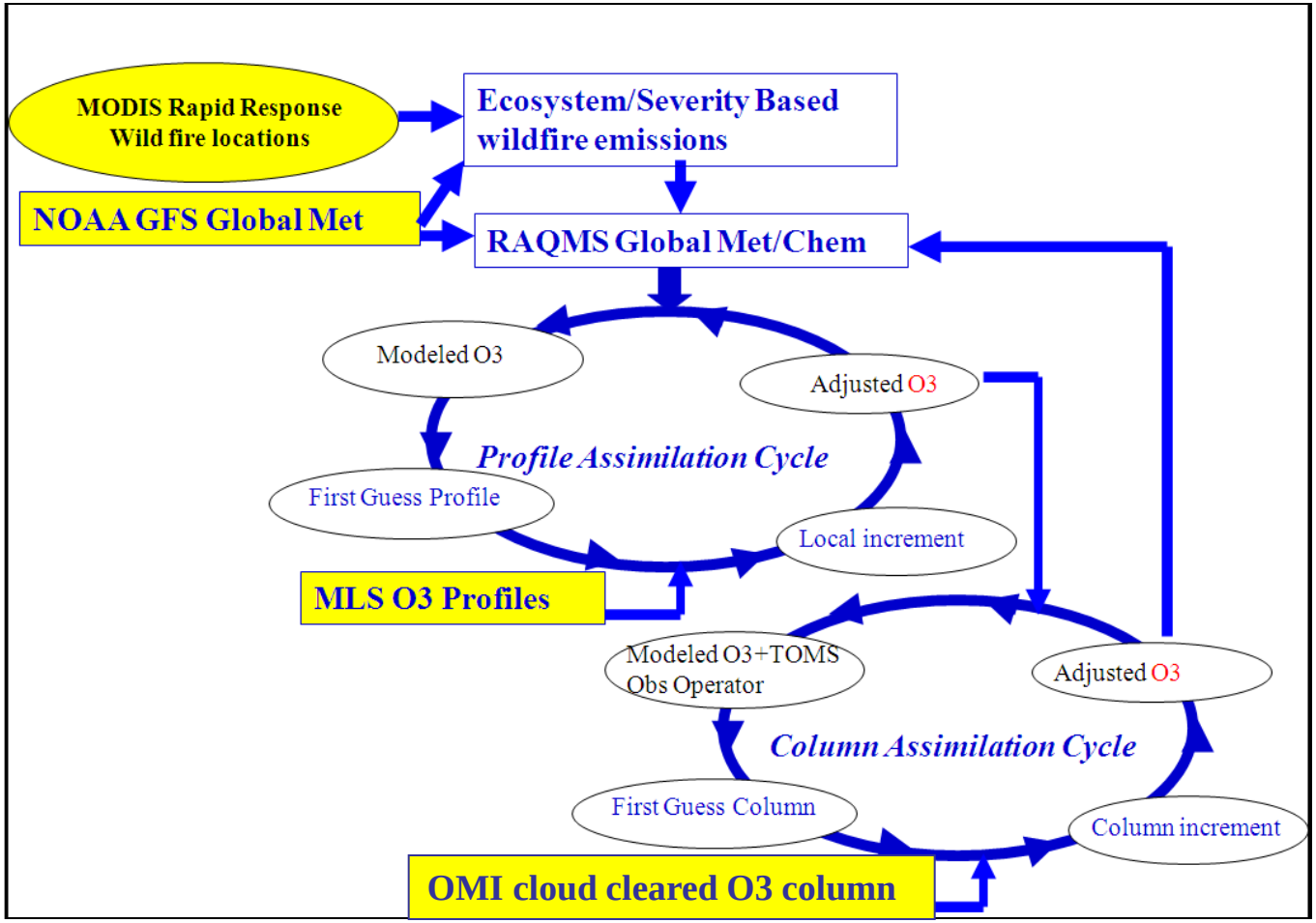
[1] University of Wisconsin-Madison, [2]NOAA ESRL Chemical Sciences Division, Boulder, CO, [3]NASA Langley Research Center, Hampton, VA



CalNex 2010 Data Analysis Workshop May 16 – 19, 2011, Sacramento CA

RAQMS CalNex O3 Assimilation Procedure

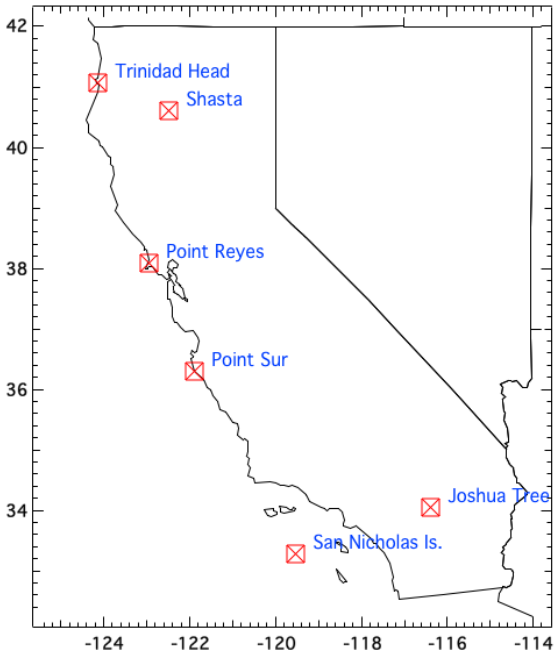


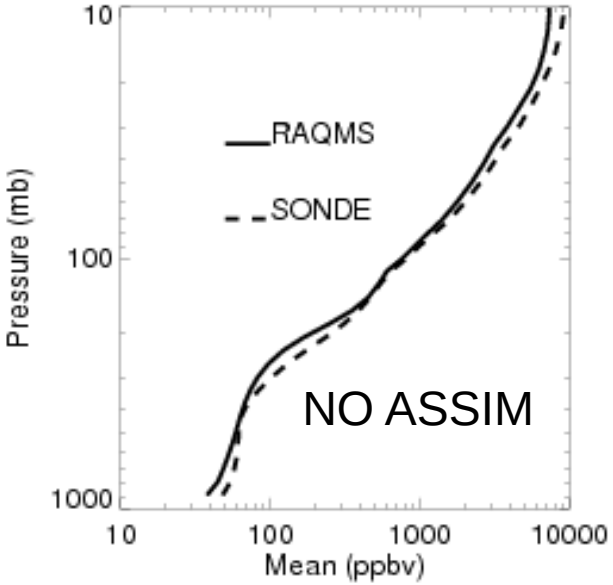
Demonstration of:

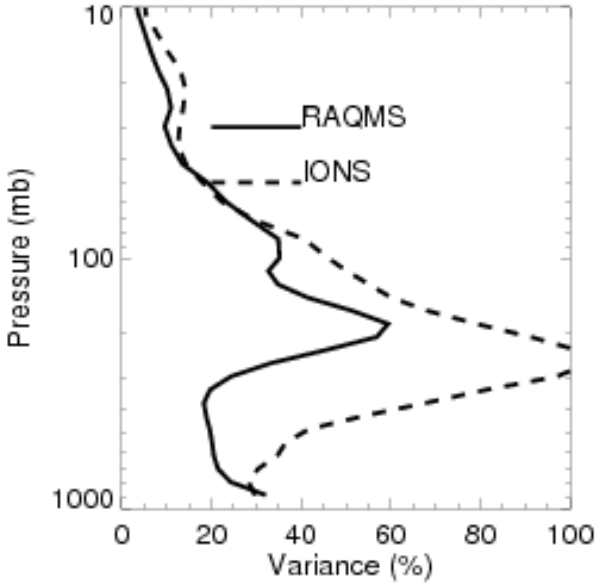
- **Real-time assimilation of Microwave Limb Sounder (MLS) stratospheric ozone profiles**
- **Real-time assimilation of Ozone Monitoring Instrument (OMI) total ozone column**
- **Real-time incorporation of Moderate Resolution Imaging Spectroradiometer (MODIS) fire detection**

CalNex-2010 O_3 sondes – Owen Cooper (NOAA ESRL)

CalNex Ozonesonde

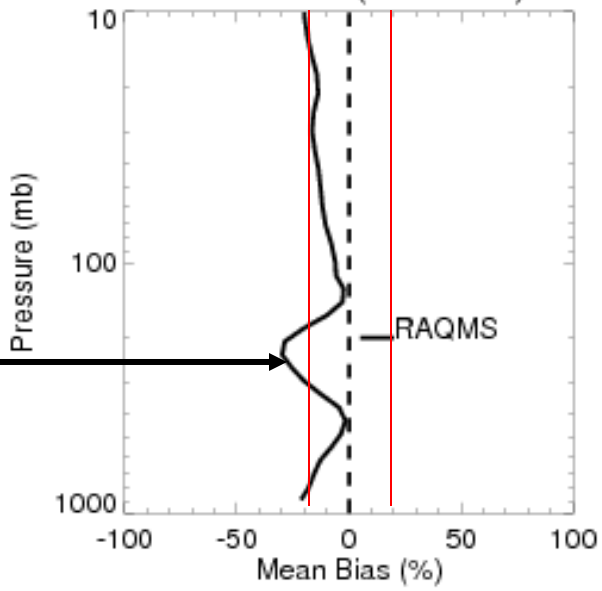


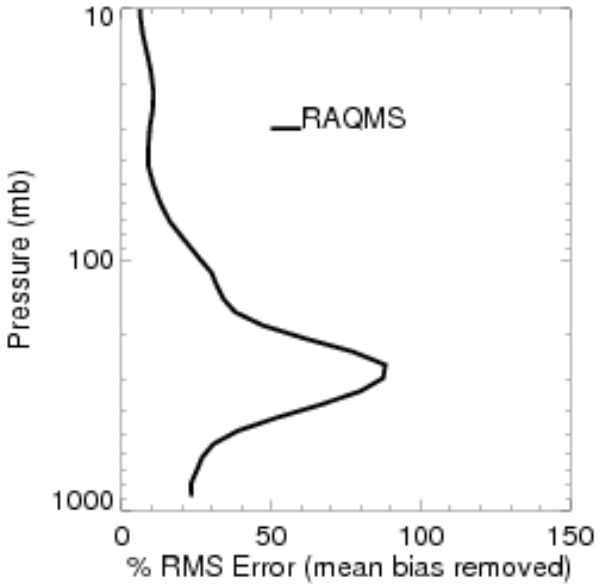




CalNex IONS May-June, 2010 RAQMS NO ASSIM/Sonde O3
(178 sondes)

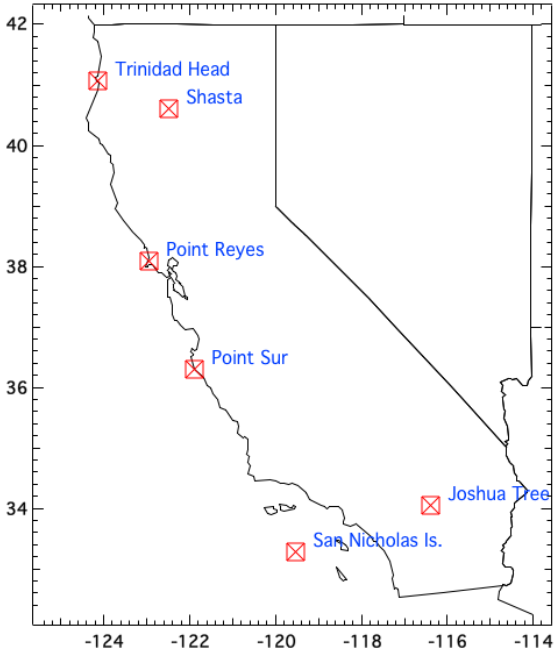
RAQMS <u>NO ASSIM</u>
is low biased up to
30% of Ozonesonde

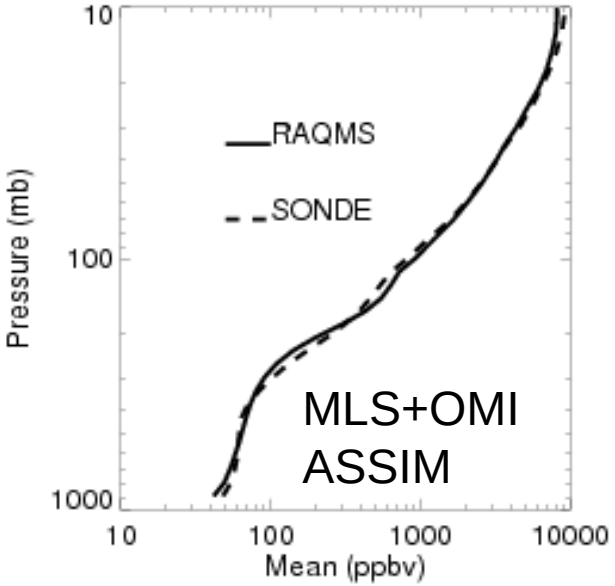


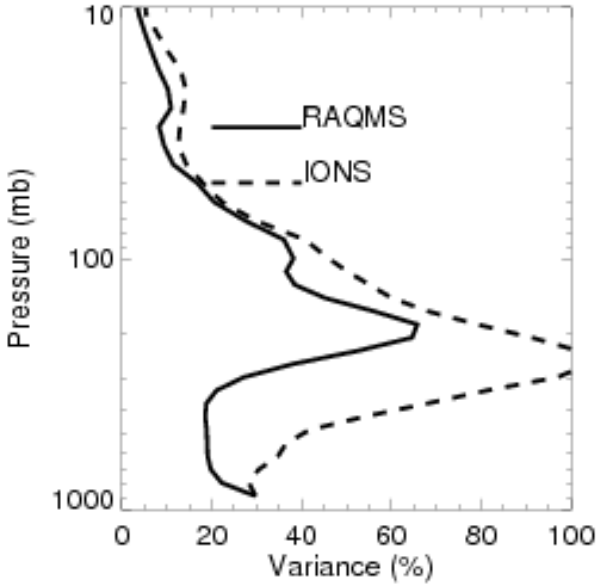


CalNex-2010 O_3 sondes – Owen Cooper (NOAA ESRL)

CalNex Ozonesonde

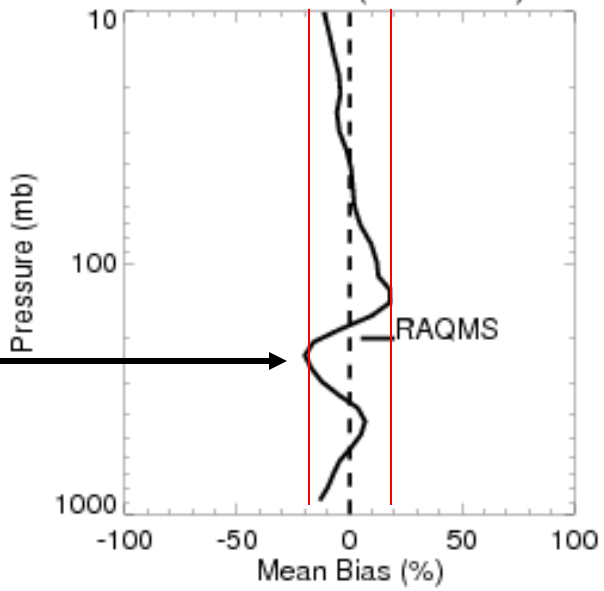


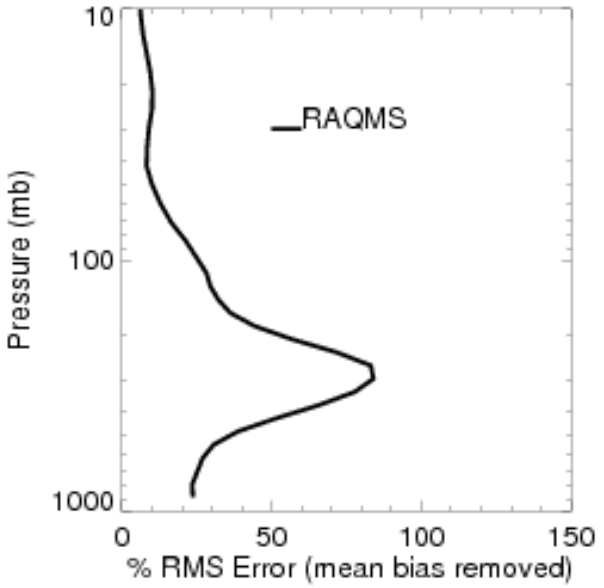




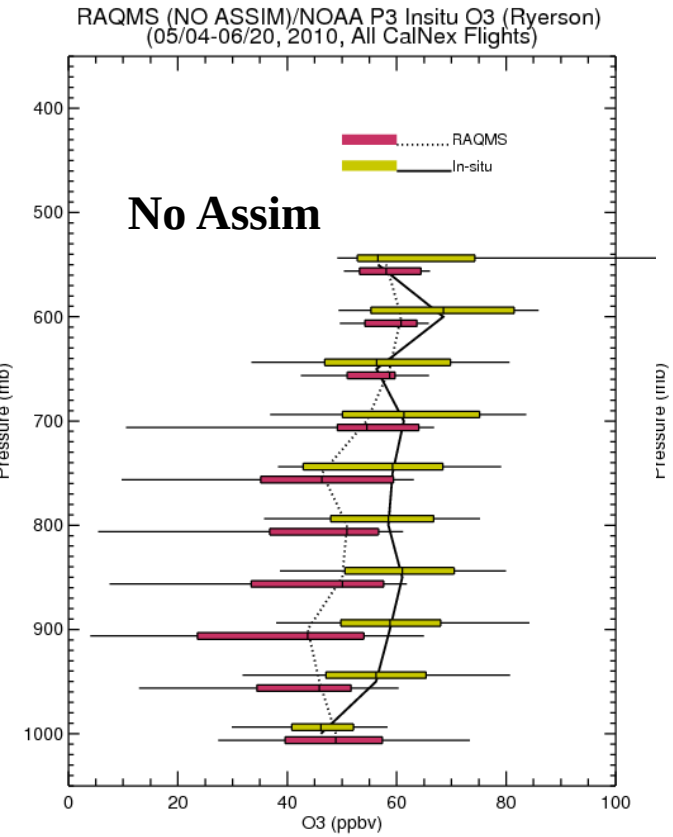
CalNex IONS May-June, 2010 $RAQMS_{Realtime\ MLS+OMI}$/Sonde O3
(178 sondes)

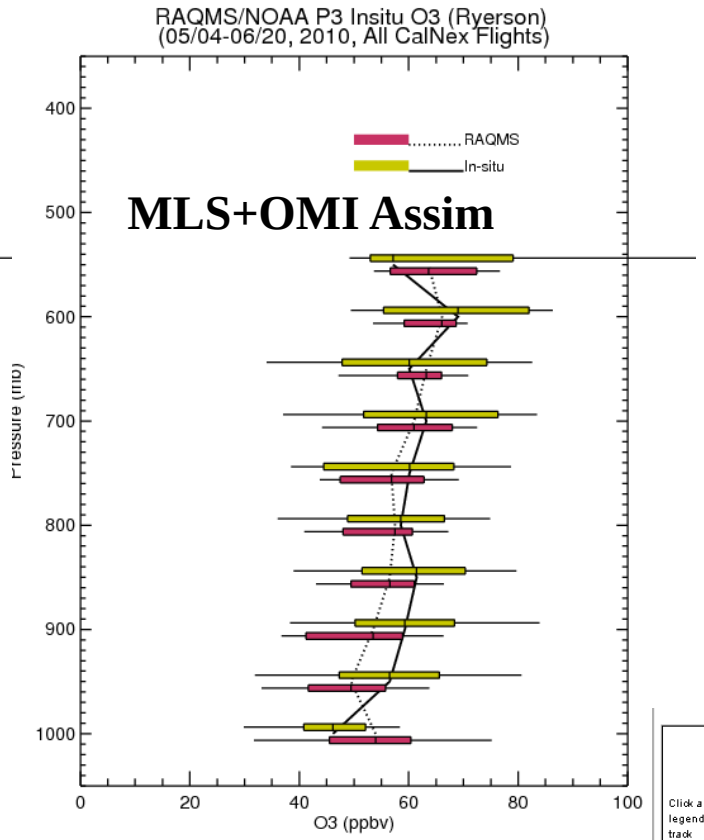
RAQMS <u>MLS+OMI</u> analysis is within 20% of Ozonesonde



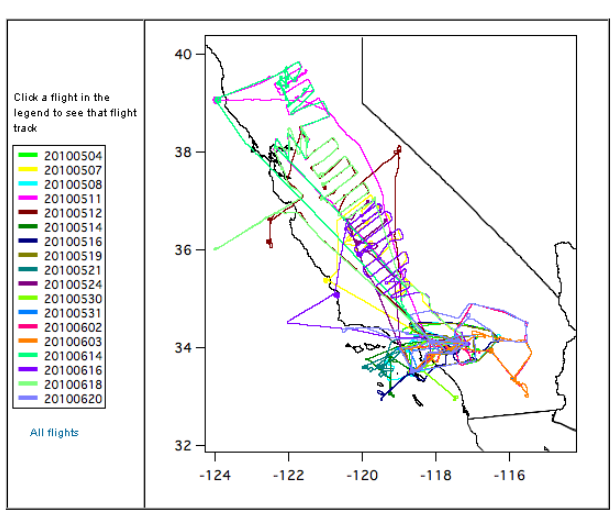


Comparison with NOAA P3 Insitu O3 Measurements (Primarily LA Basin/Central Valley)



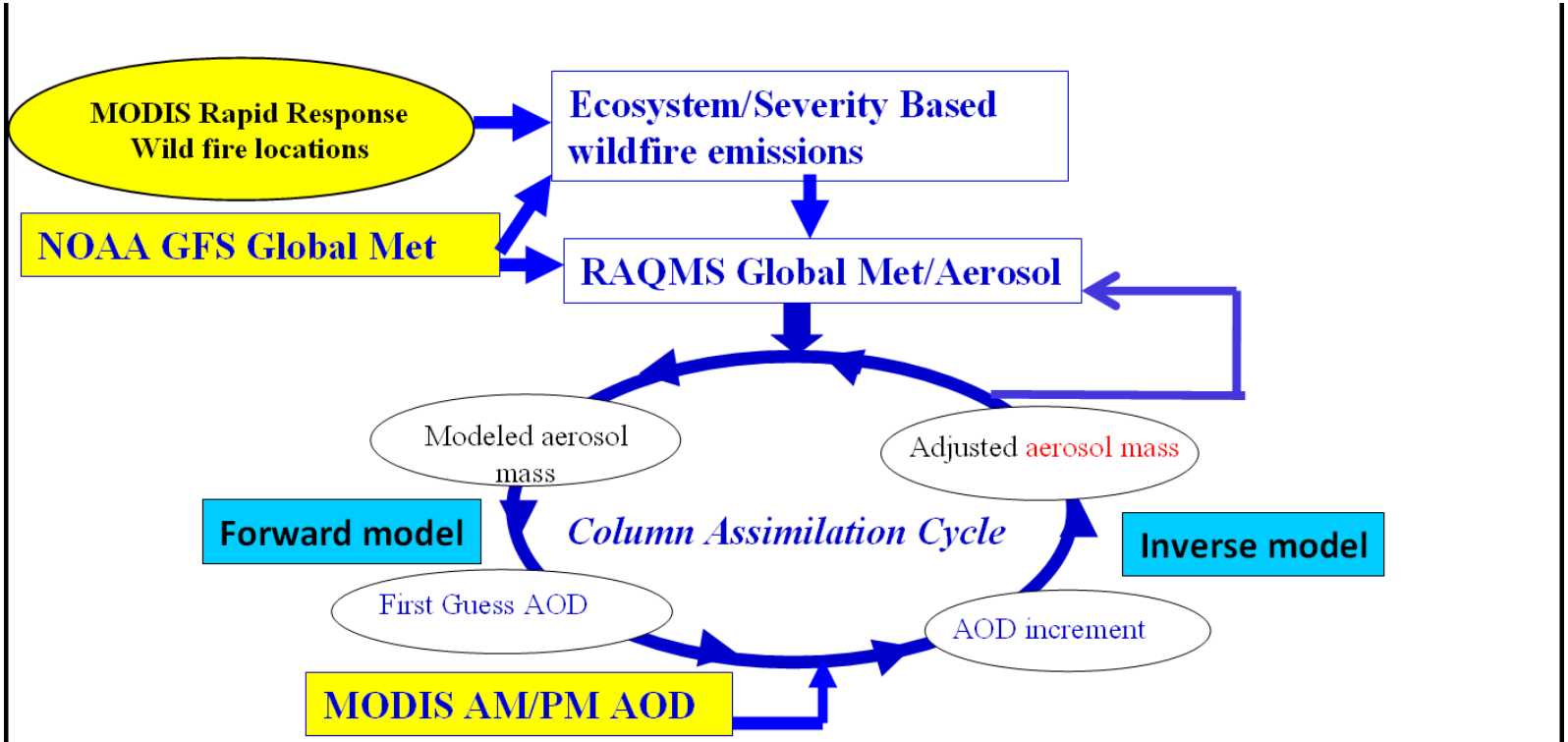


Assimilation of MLS+OMI O3 retrievals results in increased lower-tropospheric O3 (and improved agreement with airborne insitu O3) over Southern California



Insitu O3 from Tom Ryerson, NOAA ESRL

RAQMS CalNex AOD Assimilation Procedure



Forward model:
Compute layer/species extinction based on tabulated extinction efficiency and hydroscopic growth factors

Inverse model:
Distribute total AOD increment across aerosol dry mass based on layer/species extinction accounting for extinction due to hydroscopic growth

Demonstration of:

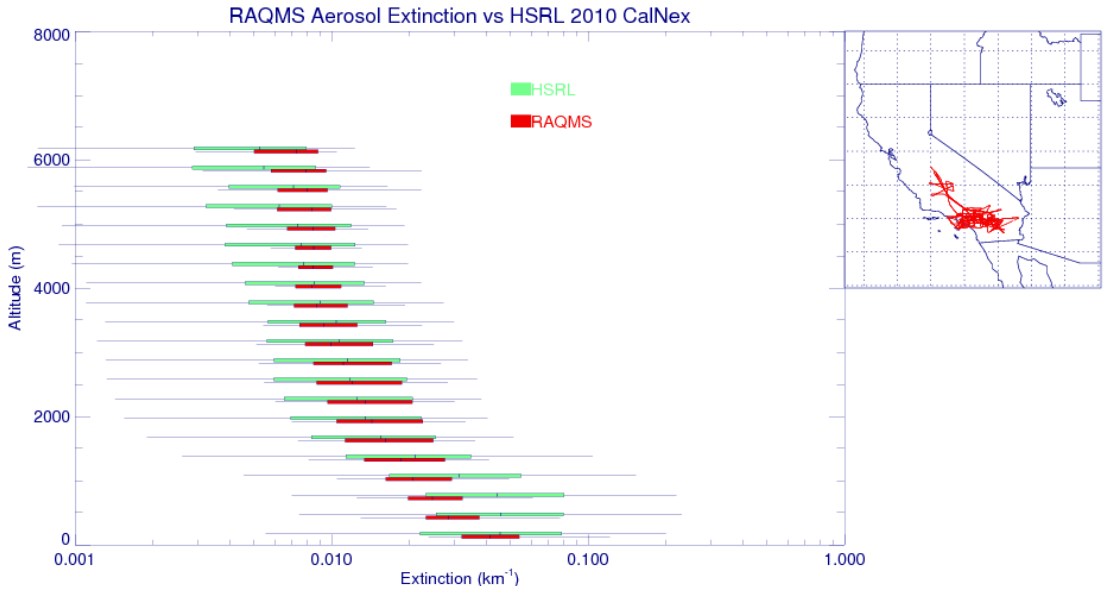
- Real-time assimilation of MODIS Aerosol Optical Depth (AOD)
- Real-time incorporation of MODIS based biomass burning emissions

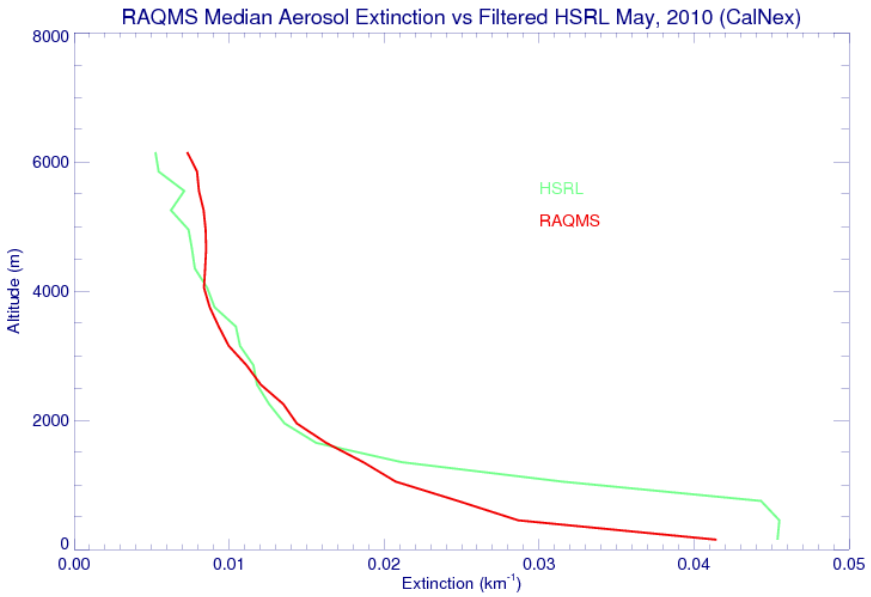
Comparison with HSRL Lidar Measurements (Primarily LA Basin, Chris Hostetler, NASA LaRC)

RAQMS free tropospheric median aerosol extinction is in very good agreement with HSRL

Variability is underestimated, particularly for lower values of aerosol extinction

Largest biases are found within the LA Basin Boundary Layer (below 1000m) were RAQMS median extinction is low





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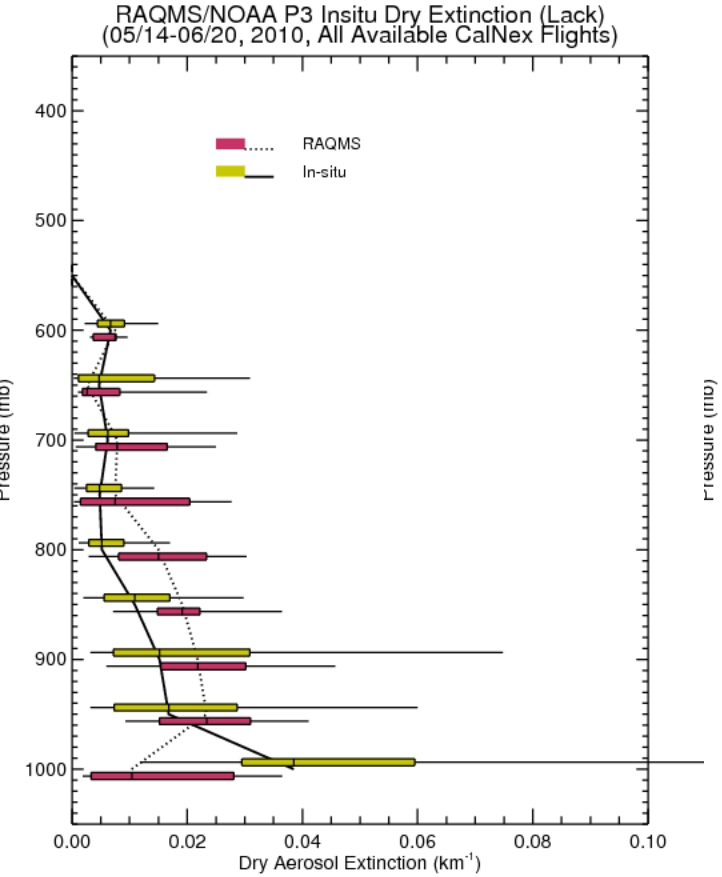
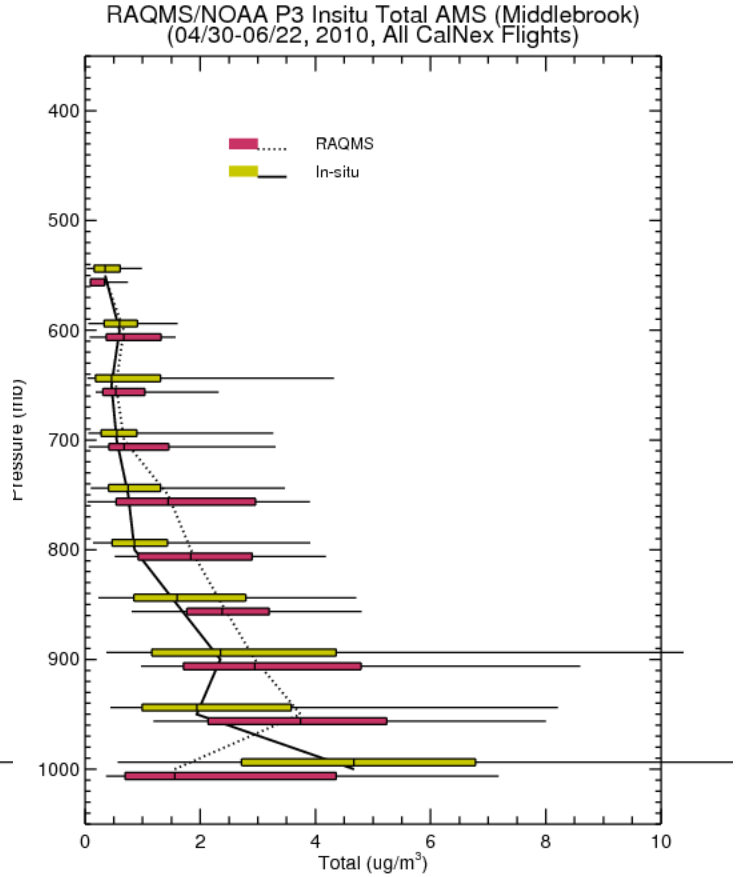




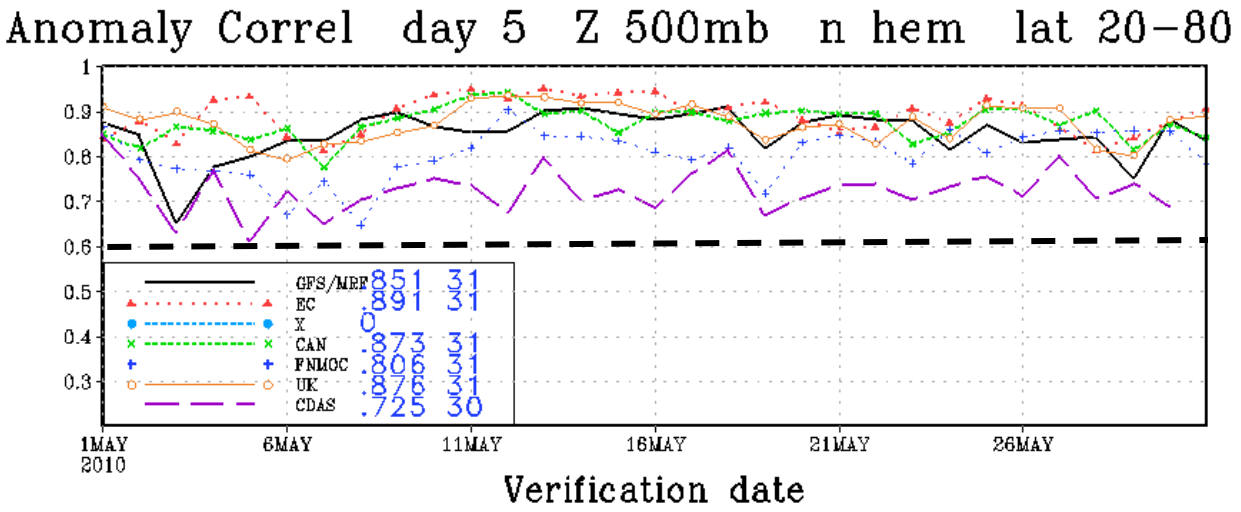
Need to better understand size range of measured insitu dray mass and Extinction measurements

•Boundary Layer extinction underestimates arise due to underestimates in local LA sources and neglect of nitrate aerosol in GOCART module

•Assimilation of MODIS AOD results in overestimates of free tropospheric aerosol dry mass due to uncertainties in hydroscopic growth

Assessment of Global 850mb O3 and Aerosol Extinction Forecast Skill

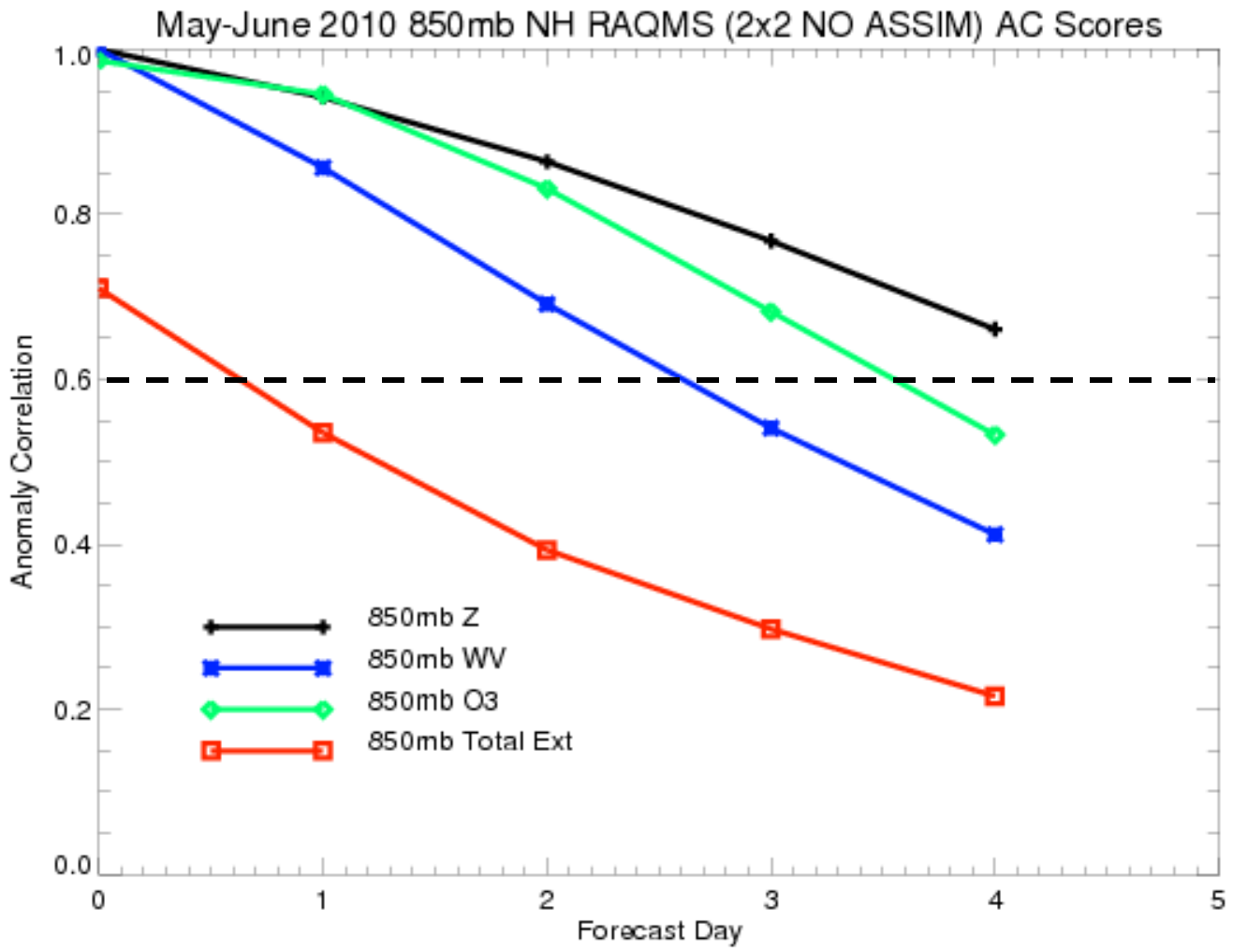
- Anomaly Correlations (AC)
  - Correlation between forecast and analysis
  - May-June mean removed
  - Spectrally truncated to wavenumber 20
  - Averaged from 20N-80N



useful Skill

http://www.emc.ncep.noaa.gov/gmb/STATS/html/monarch.html

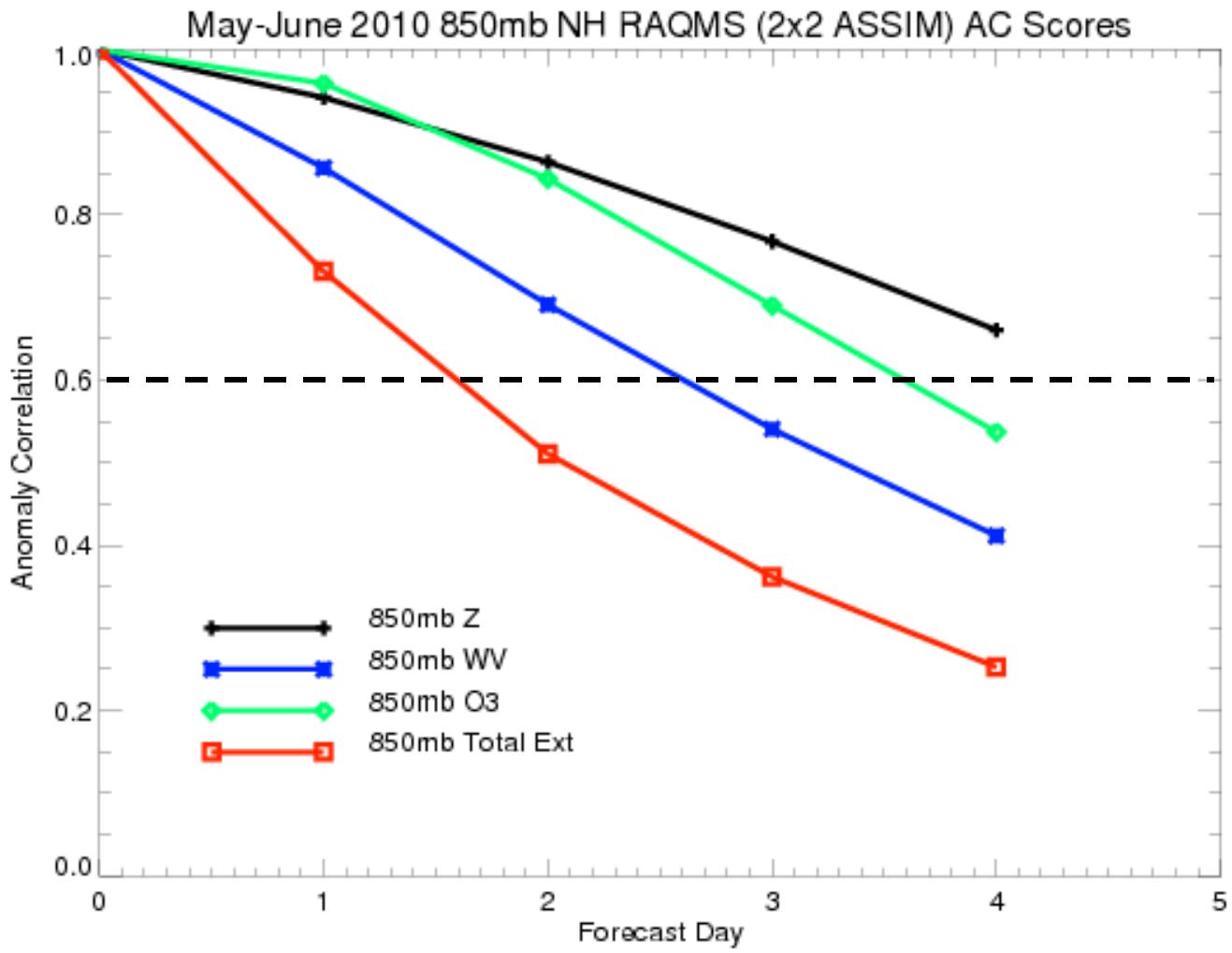
Northern Hemisphere 850mb May-June 2010 Anomaly Correlations (AC) (No Assimilation)



useful Skill

- 850mb ozone forecasts have useful skill past 3 days (significantly better than water vapor)
- 850mb extinction forecasts do not have useful skill at 1 day

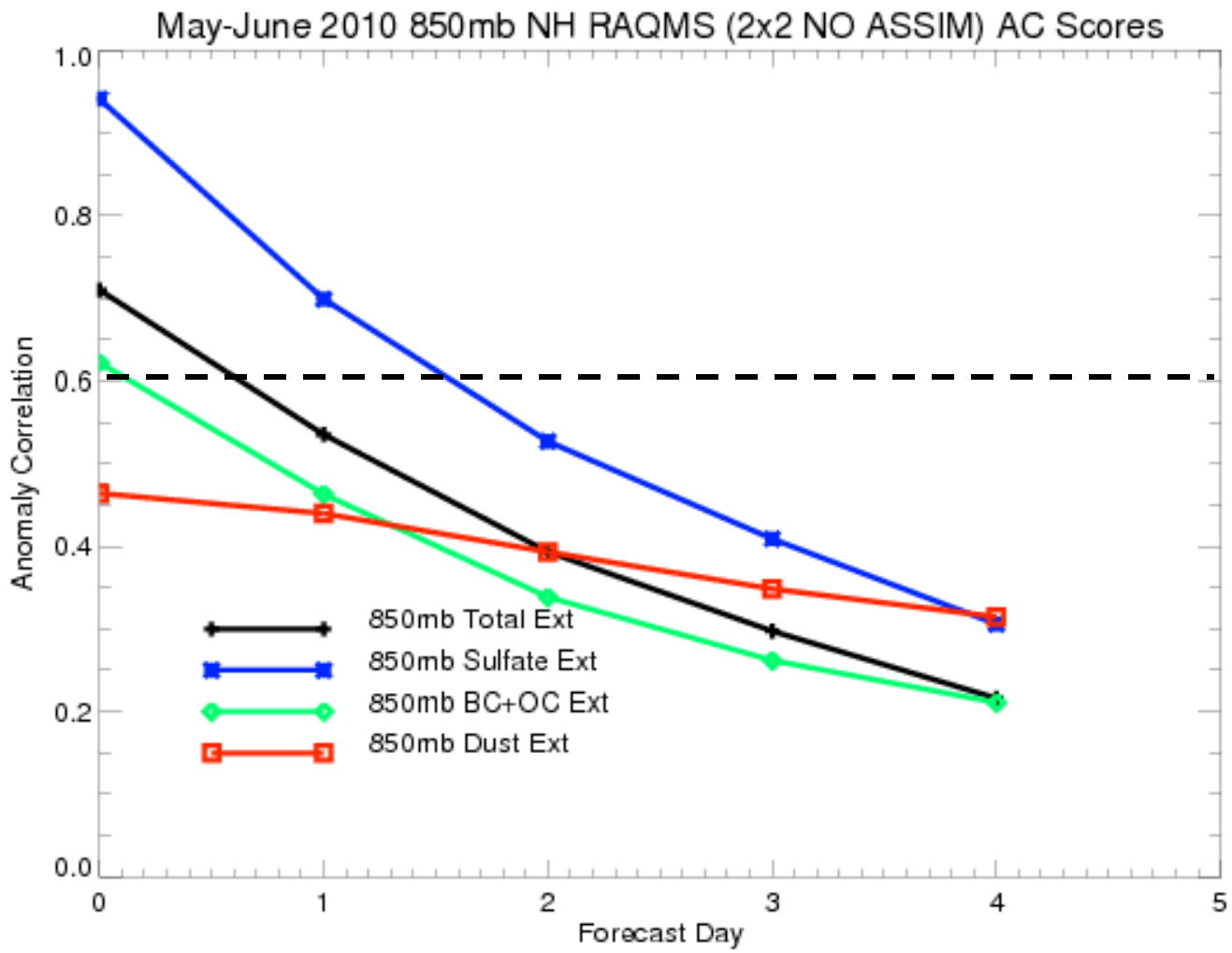
Northern Hemisphere 850mb May-June 2010 Anomaly Correlations (AC) (With MLS/OMI/MODIS Assimilation)



useful Skill

- Assimilation of O3 retrievals results in slight improvements in 850mb ozone forecasts
- Assimilation of AOD retrievals results in significant improvement in 850mb extinction forecasts with useful skill at ~1.5 days

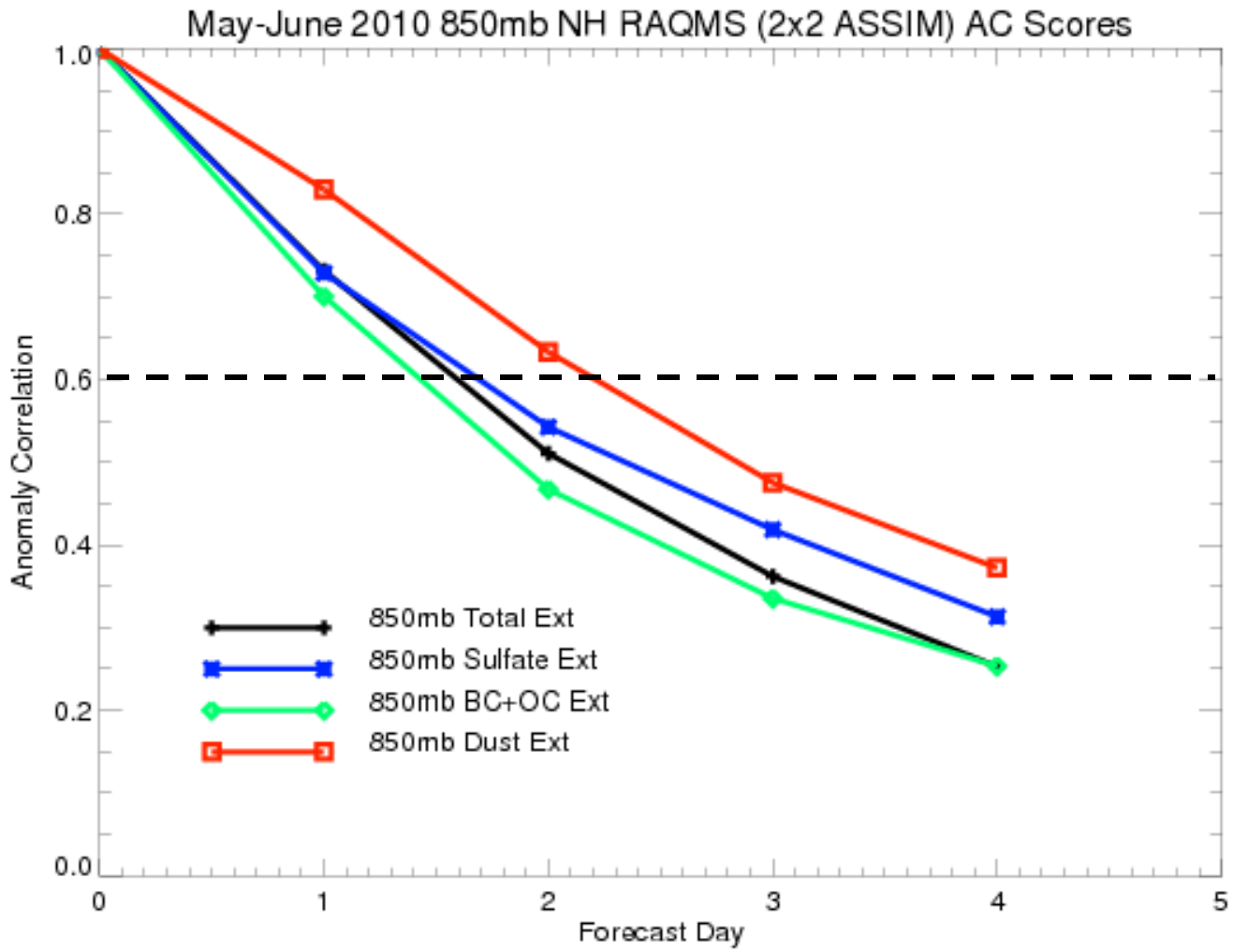
Northern Hemisphere 850mb May-June 2010 Anomaly Correlations (AC) (No Assimilation)



useful Skill

- Only 850mb SO4 extinction forecasts useful skill past 1 day
- Black and organic carbon (BC+OC) and dust extinctions are both poorly initialized and forecasted

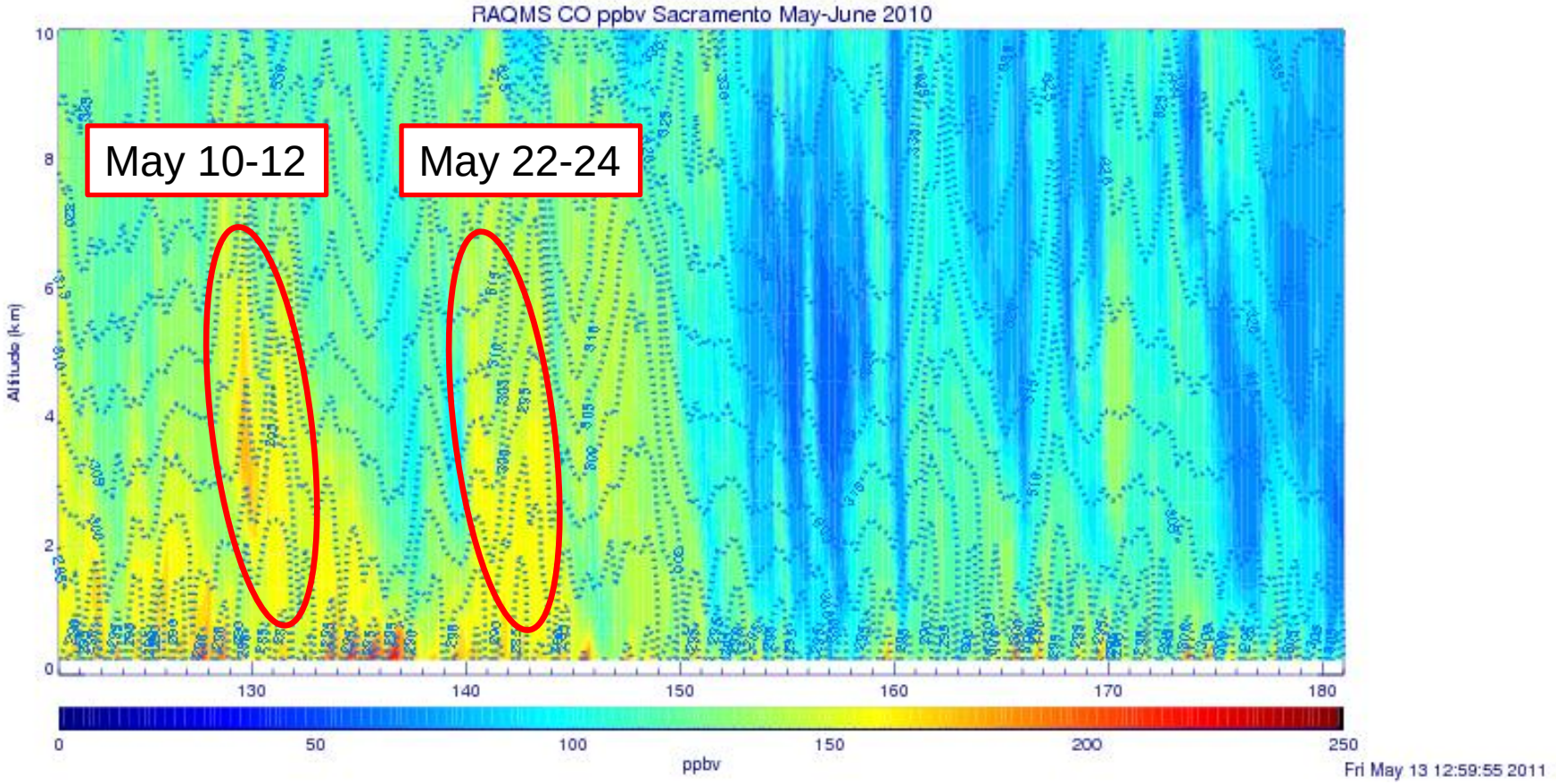
Northern Hemisphere 850mb May-June 2010 Anomaly Correlations (AC) (With MODIS Assimilation)



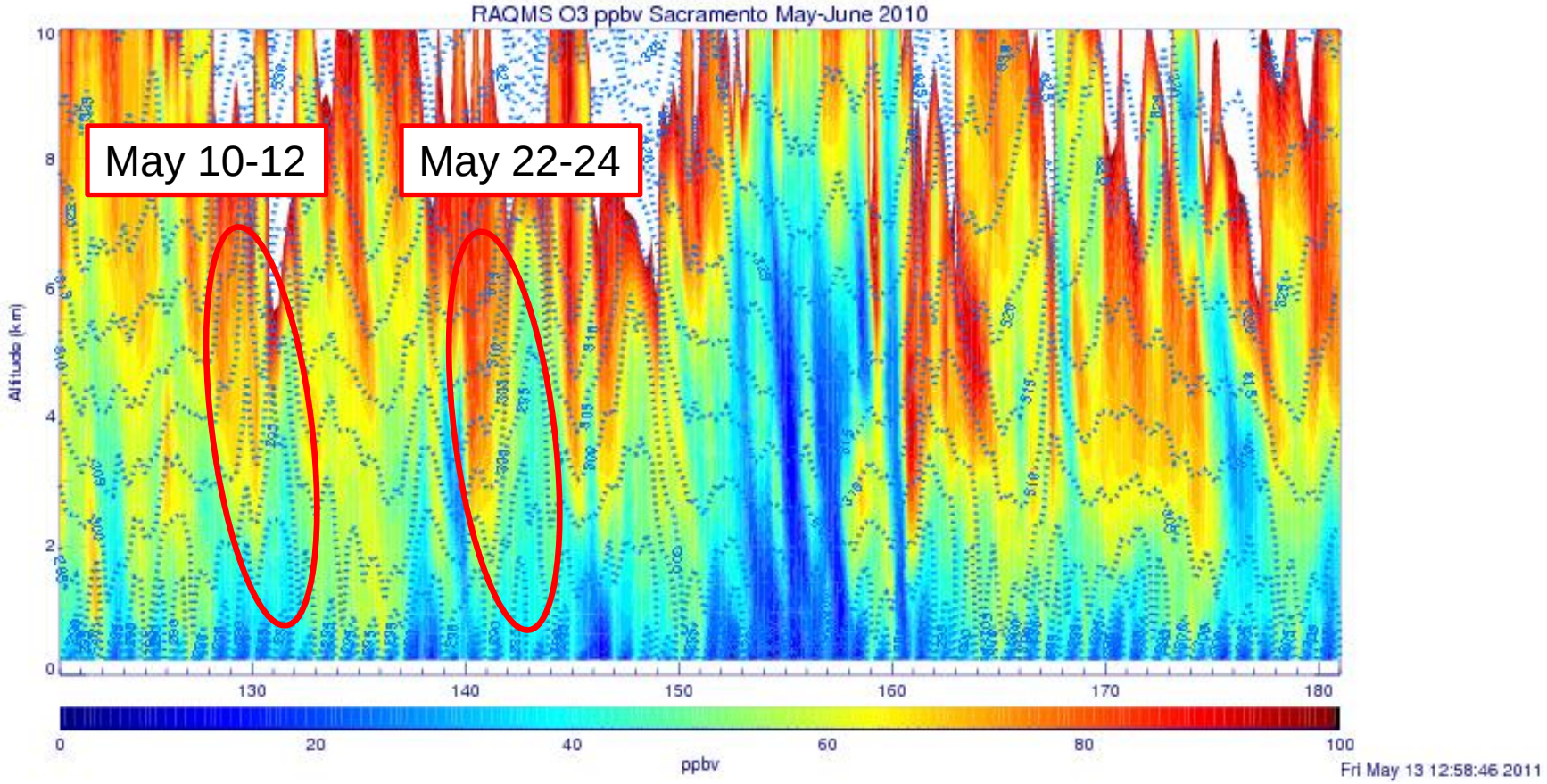
useful Skill

- MODIS AOD assimilation results in small changes in 850mb SO4 extinction forecasts
- MODIS AOD assimilation results in significant improvements in black and organic carbon (BC+OC) and dust forecast skill (dust prediction useful at 2 days)

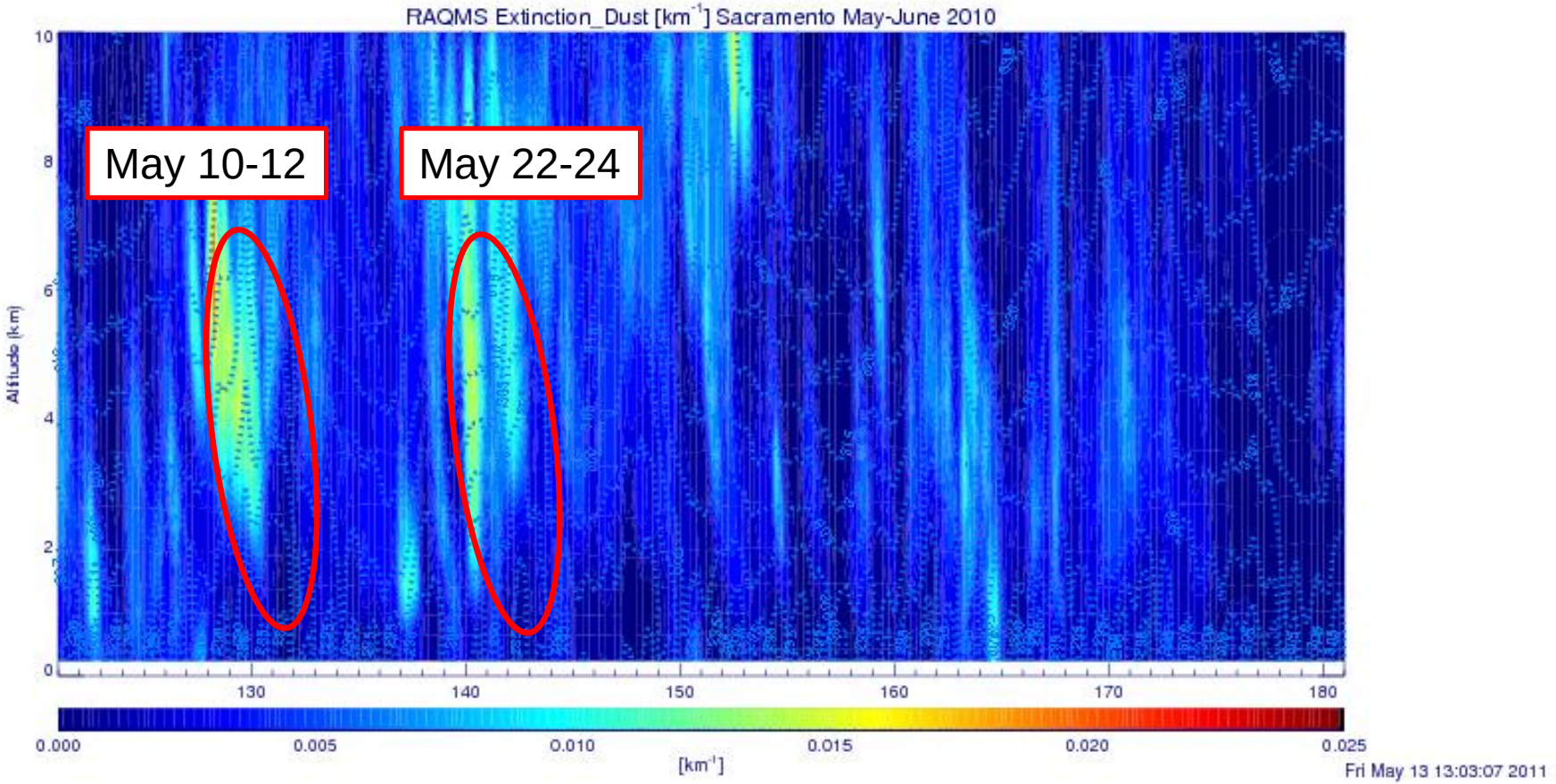
Sacramento CO May-June 2010
RAQMS 1x1 Degree Re-analysis



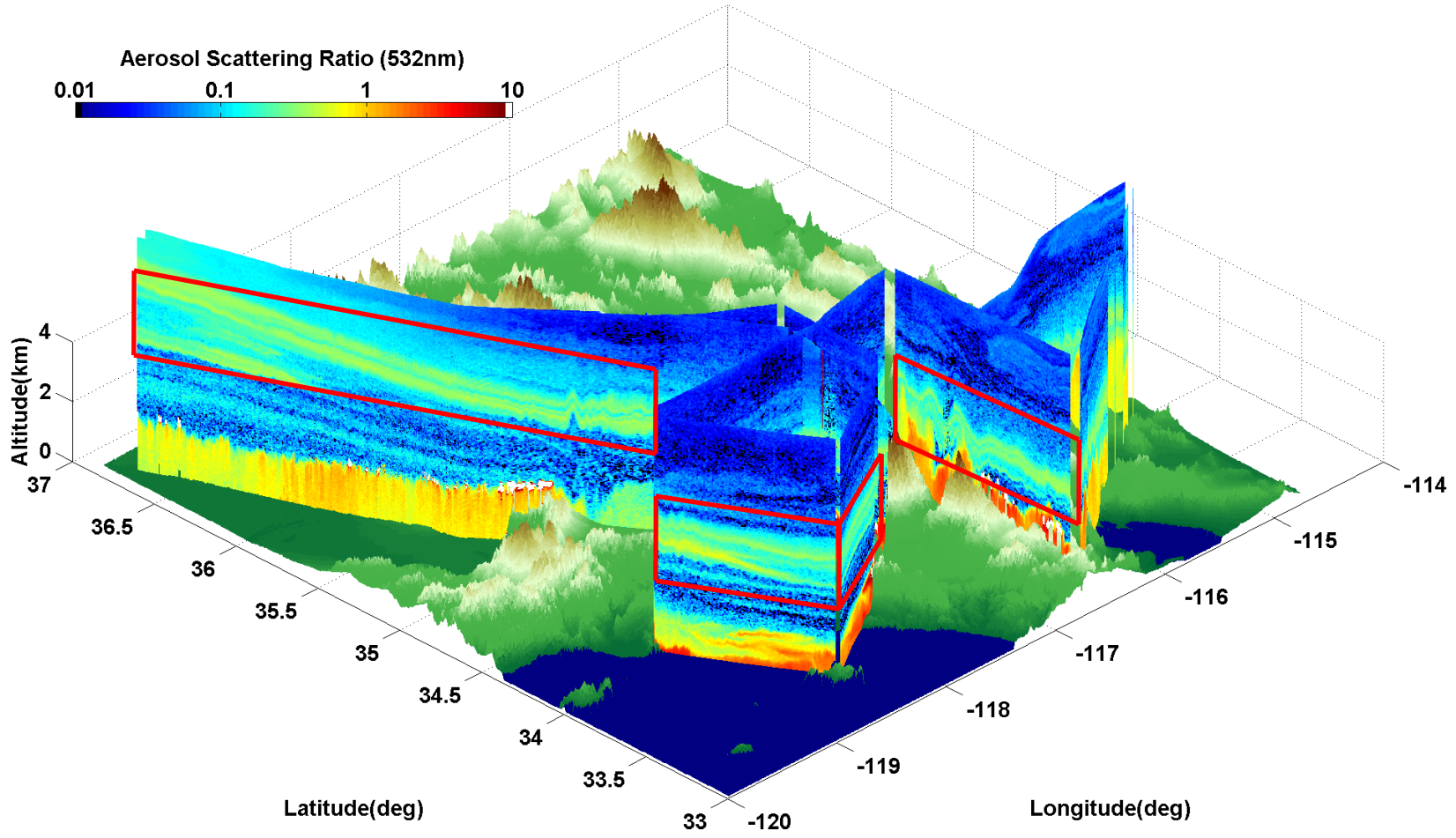
Sacramento O3 May-June 2010
RAQMS 1x1 Degree Re-analysis



Sacramento Dust Extinction May-June 2010
RAQMS 1x1 Degree Re-analysis

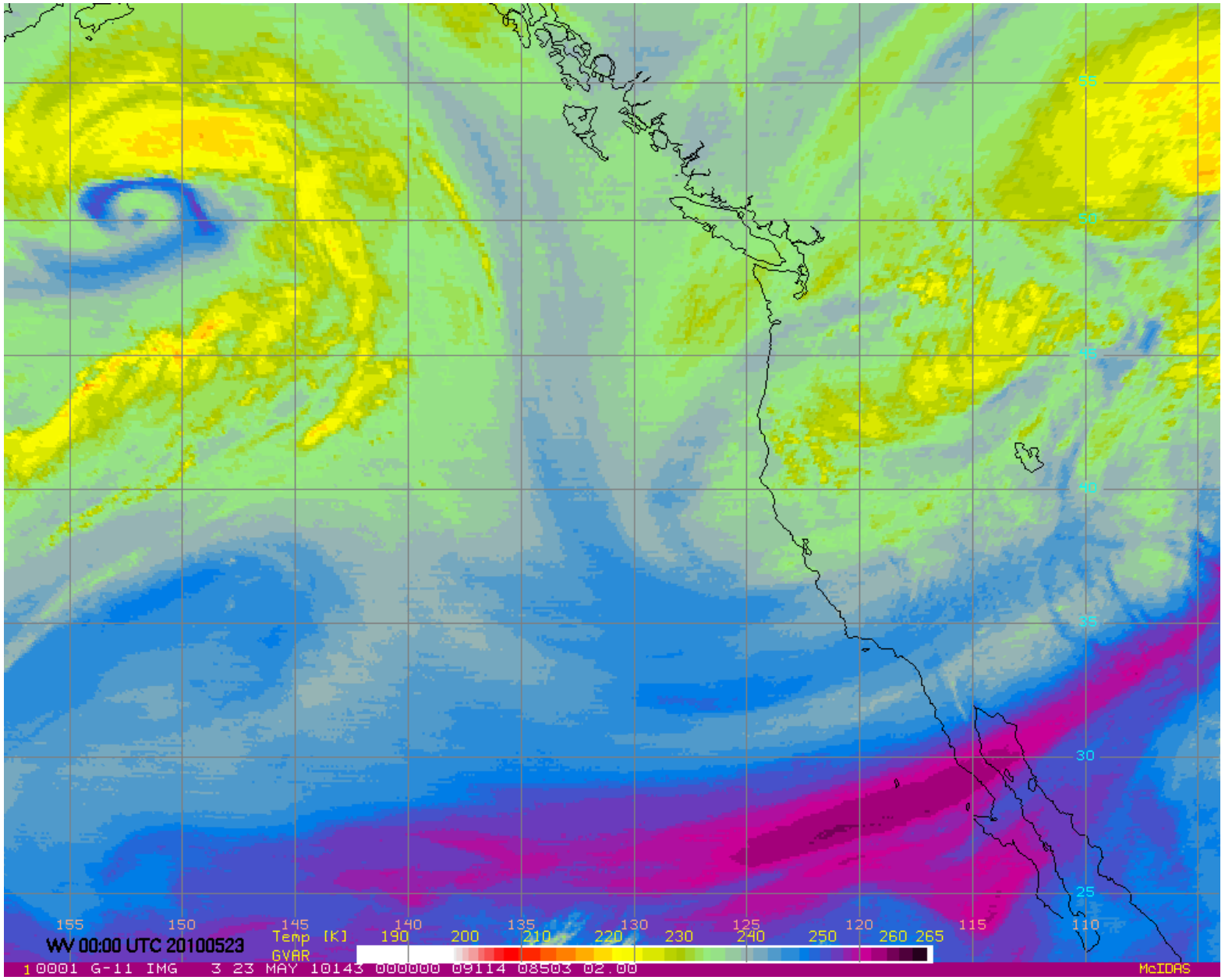


HSRL aerosol Scattering Ratio
Saturday, May 22, 2010

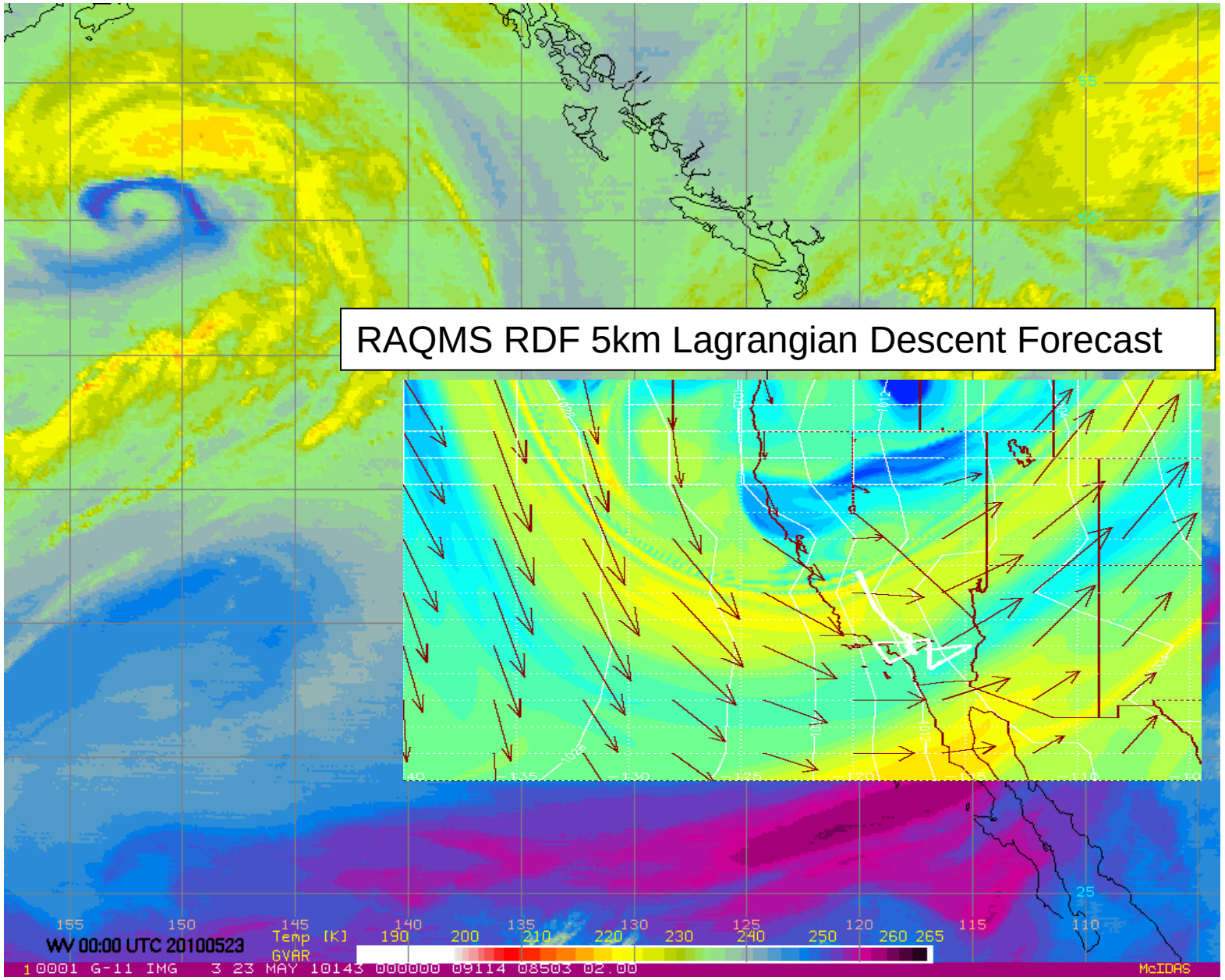


HSRL data from Chris Hostetler and Rich Ferrare, NASA LaRC

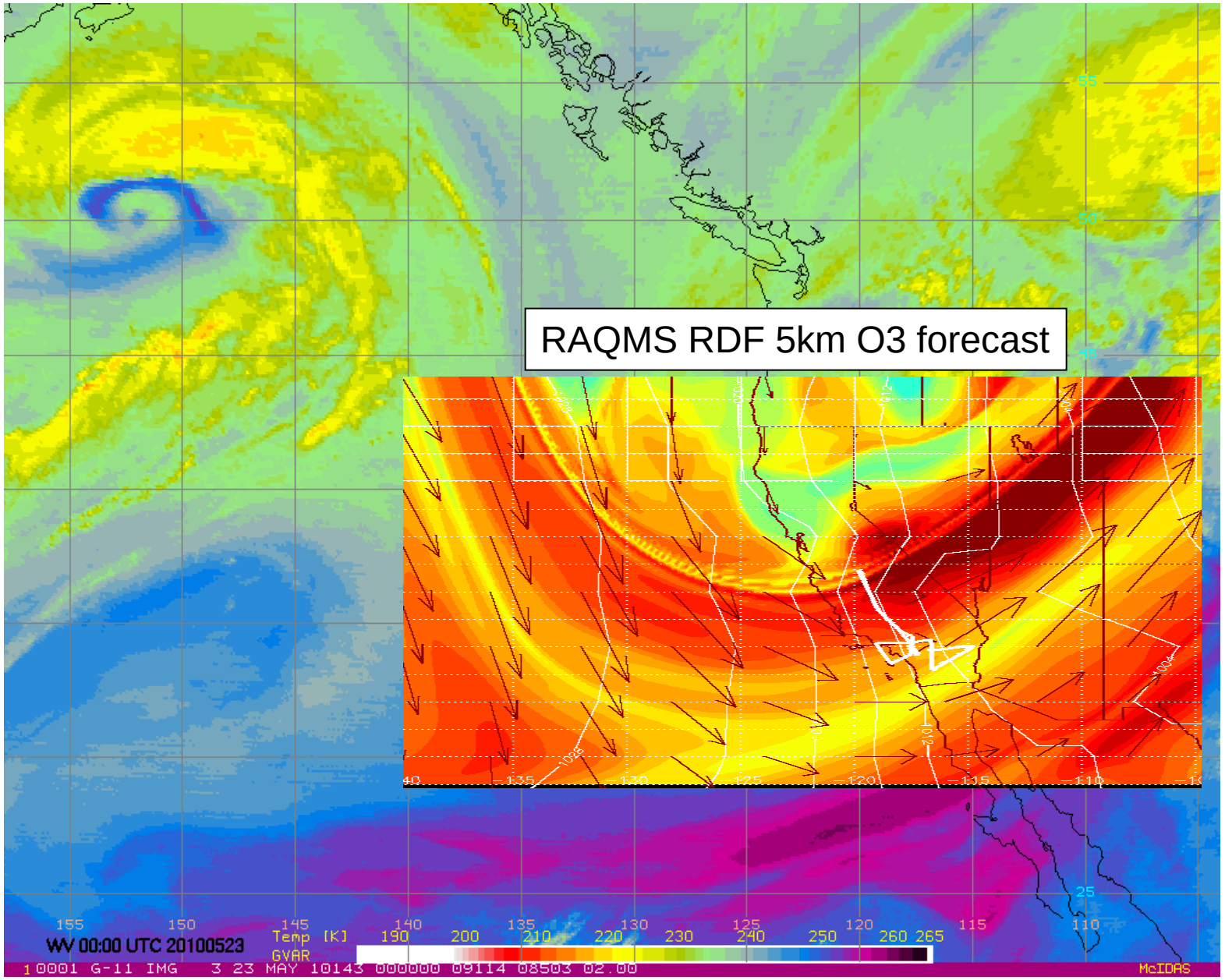
GOES WV 00Z 20100523 (Saturday Afternoon)



GOES WV 00Z 20100523 (Saturday Afternoon)



GOES WV 00Z 20100523 (Saturday Afternoon)



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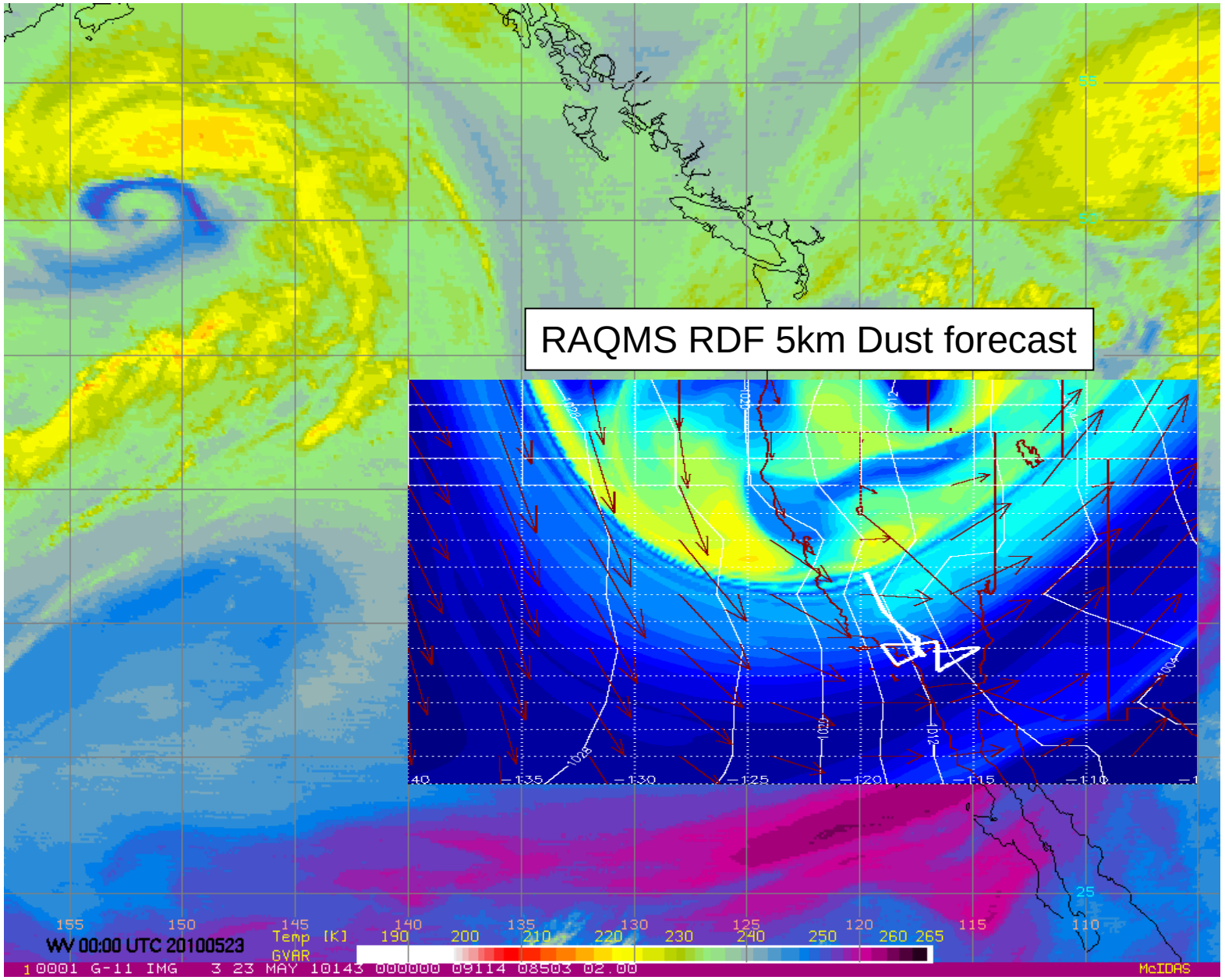

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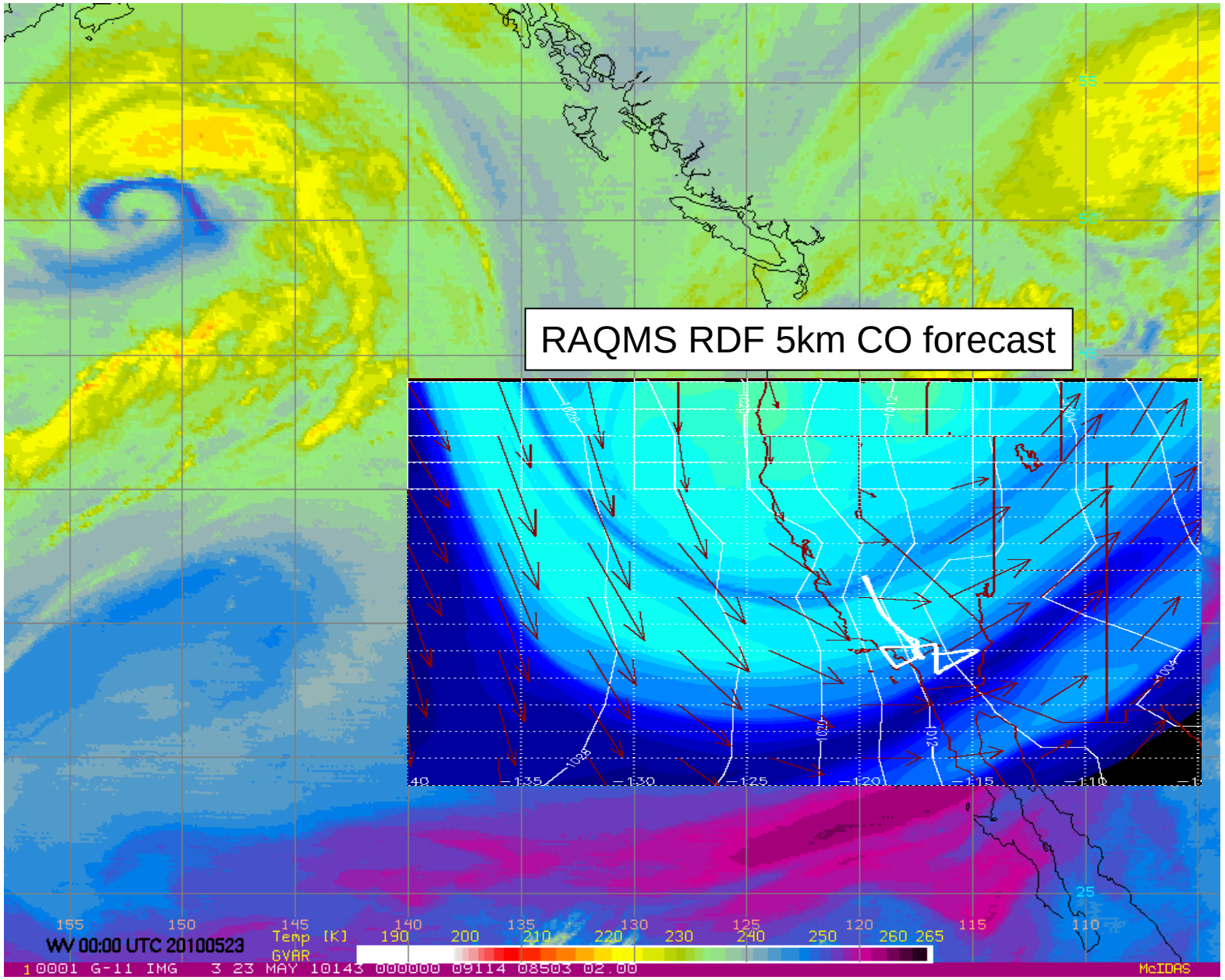
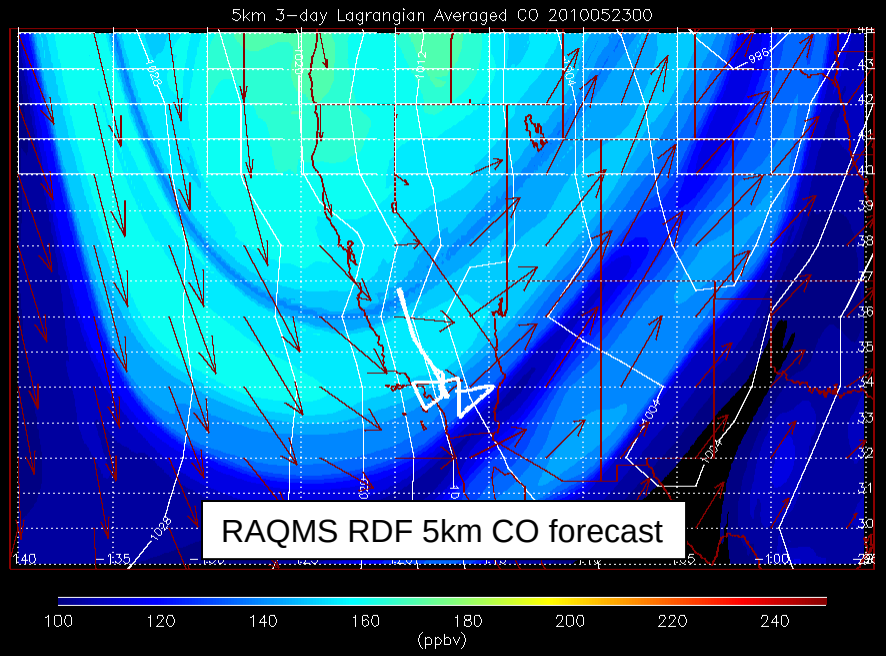
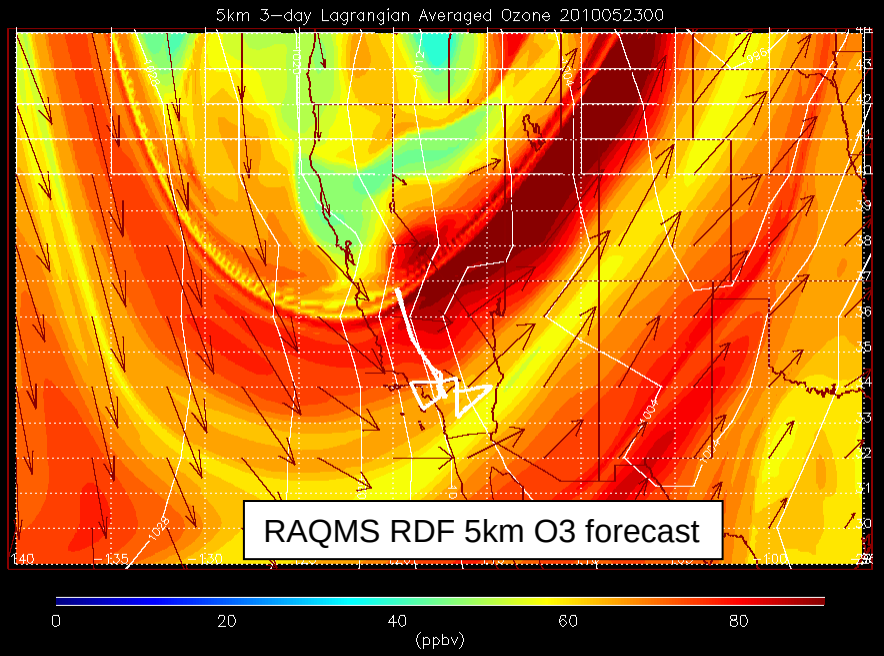
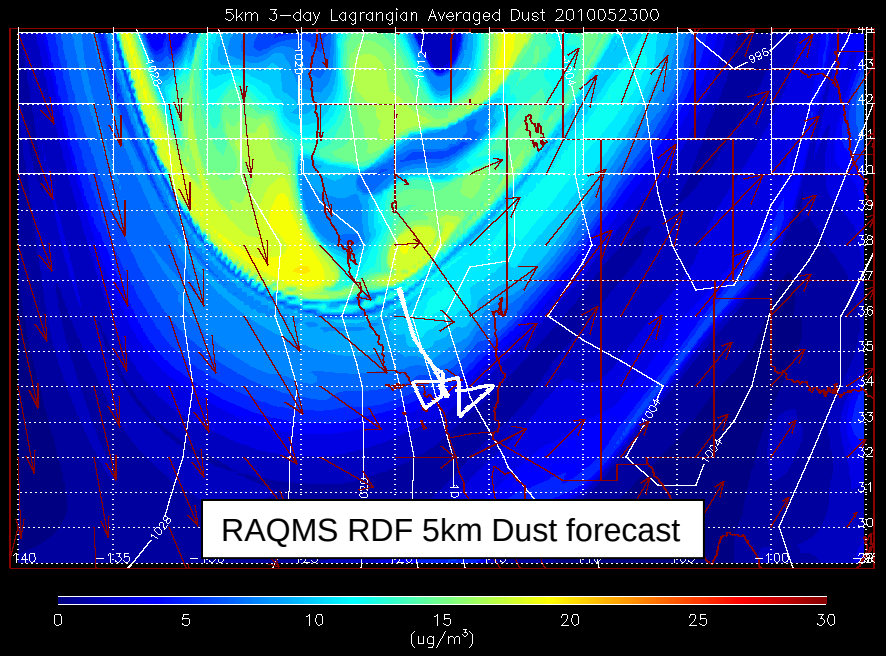
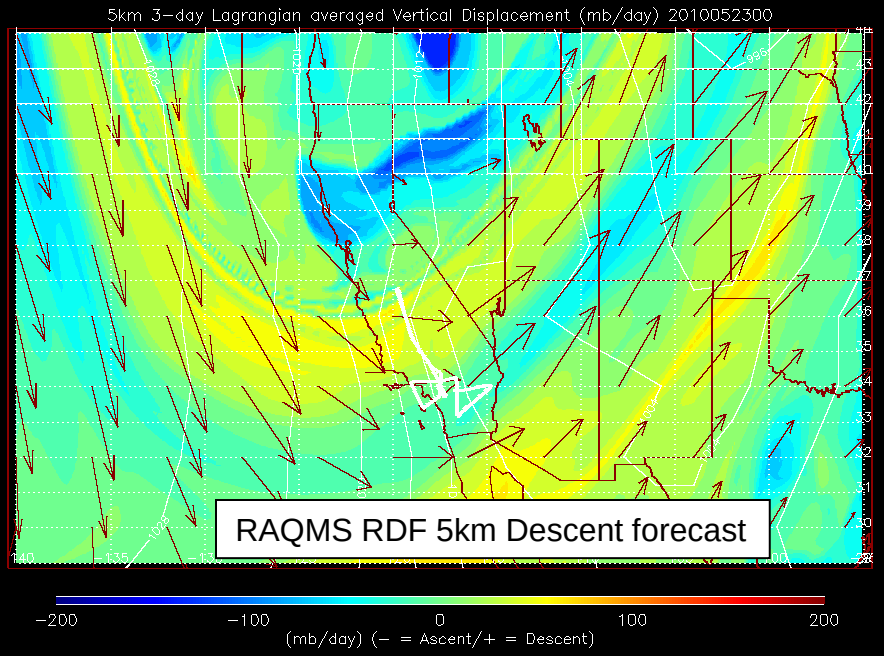


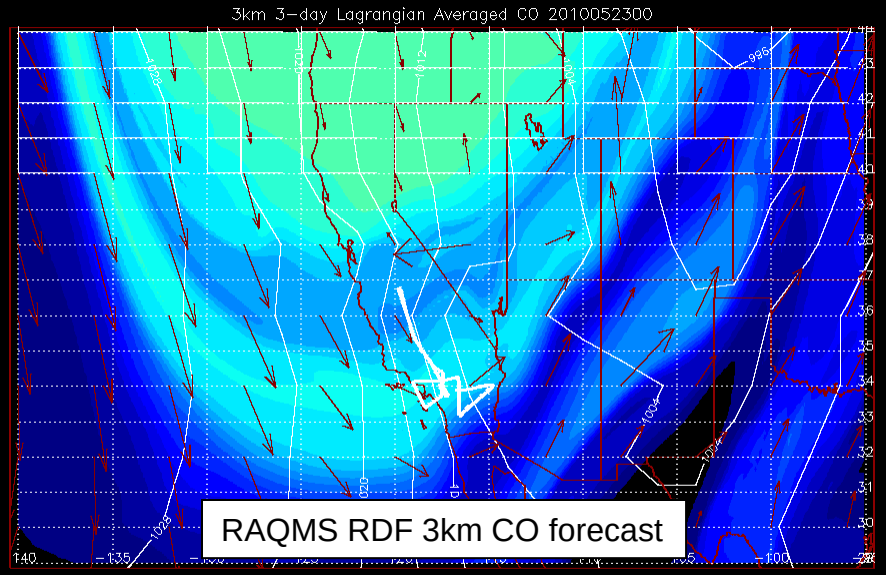


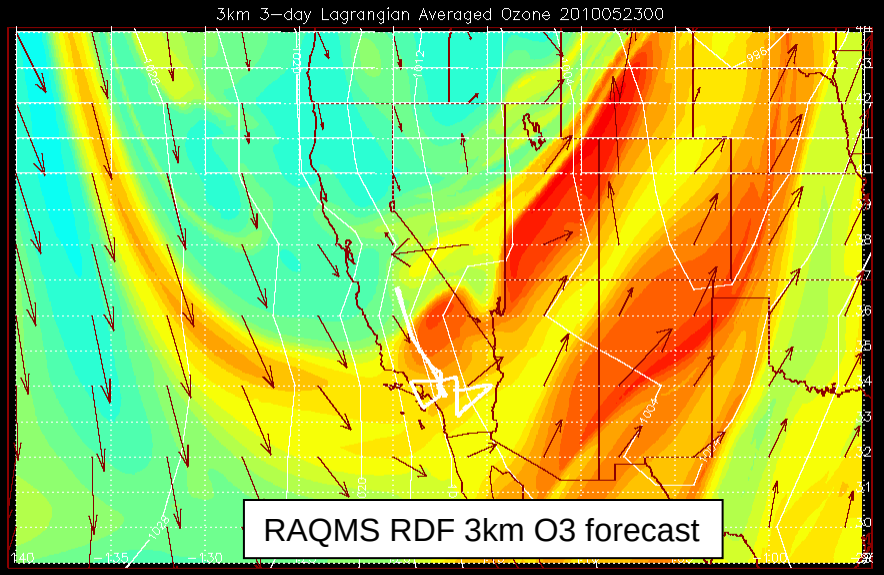


5km RDF CO, O3, Dust, and Vertical Displacement 00Z 20100523 (Saturday Afternoon)

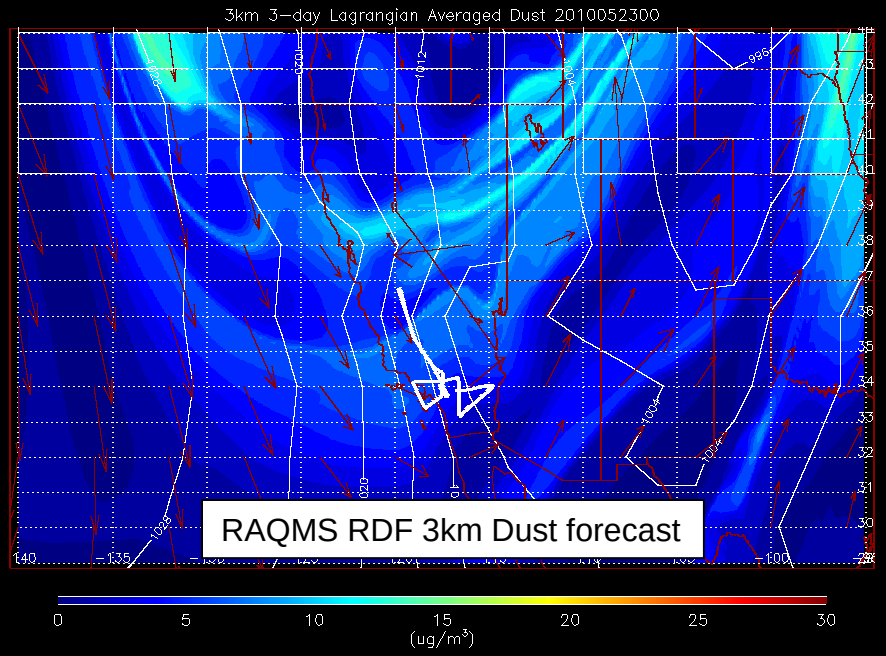


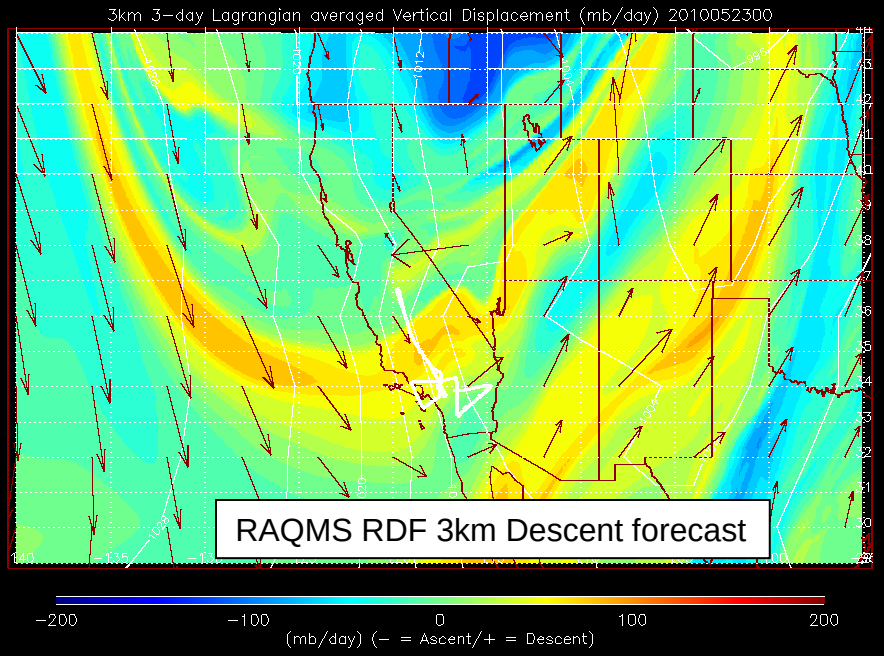


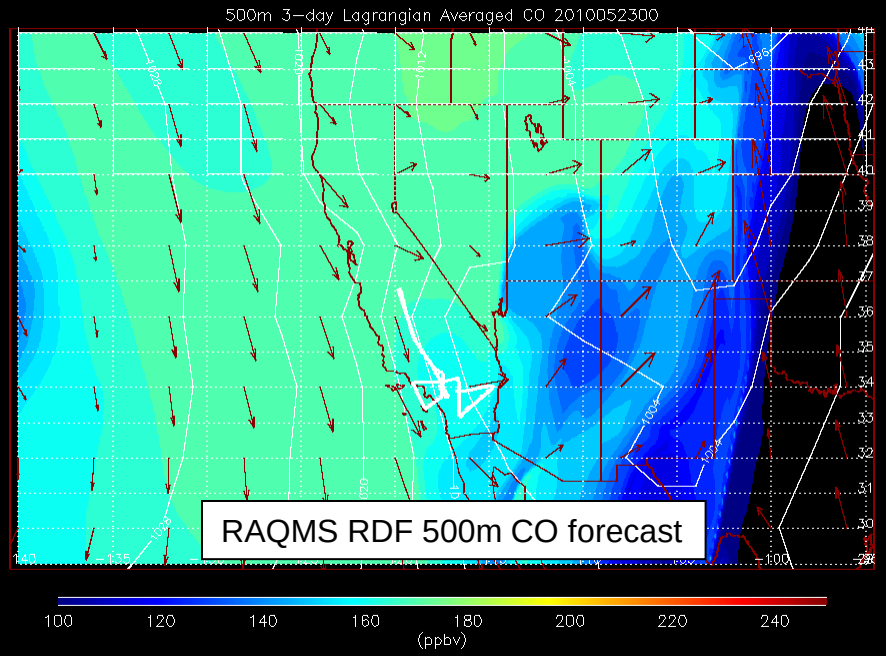


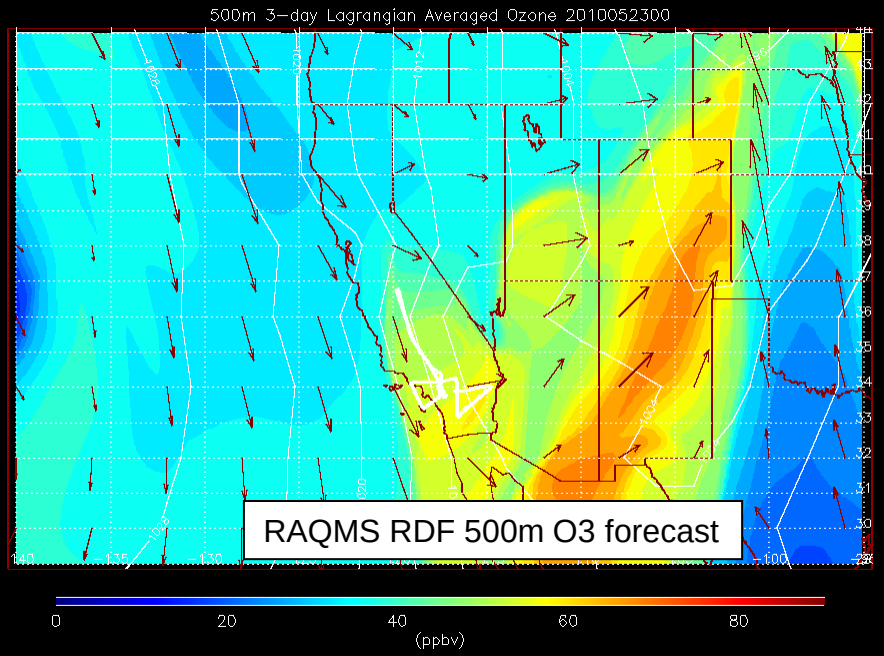


3km RDF CO, O3, Dust, and Vertical Displacement 00Z 20100523 (Saturday Afternoon)

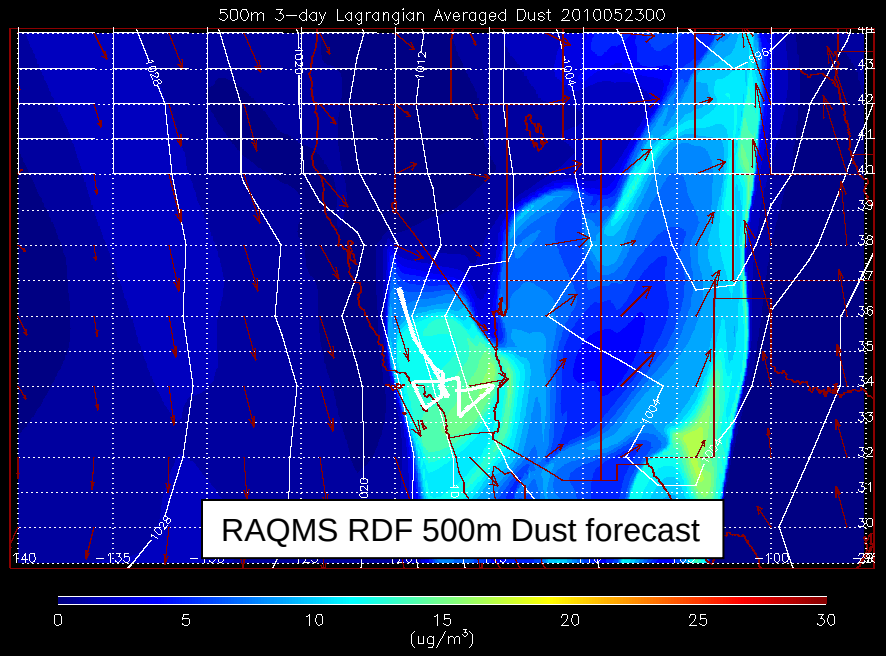


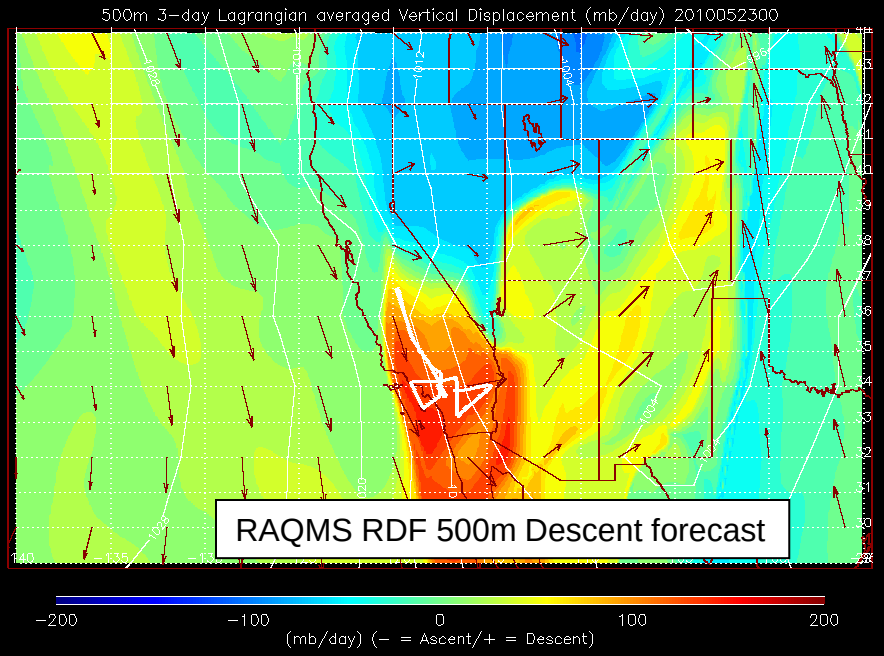






500m RDF CO, O3, Dust, and Vertical Displacement 00Z 20100523 (Saturday Afternoon)





NAM-CMAQ CalNex Experimental Runs

- **Fixed Lateral Boundary Conditions**
- **RAQMS Lateral Boundary Conditions**

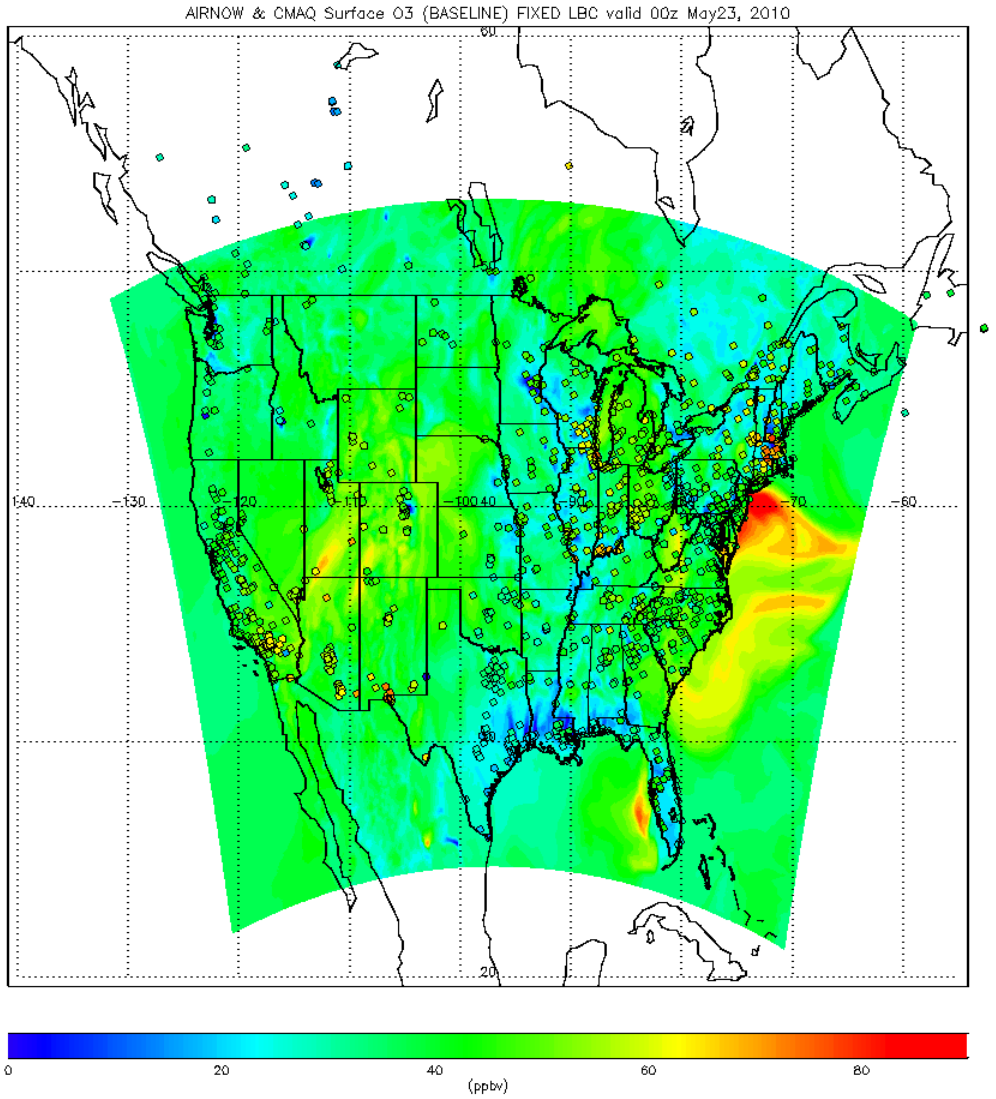
Two real-time experimental NAM-CMAQ CB5 runs were conducted by NCEP (Y. Tang) during CalNex

- **one with Fixed lateral boundary conditions (LBC)**
- **one with RAQMS LBC.**

We are conducting NAM-CMAQ post-mission studies focusing on assimilation of GOES Total Column Ozone.

Here we look at the "Baseline" (no assimilation) results.

FIXED LBC 00Z May 23, 2010

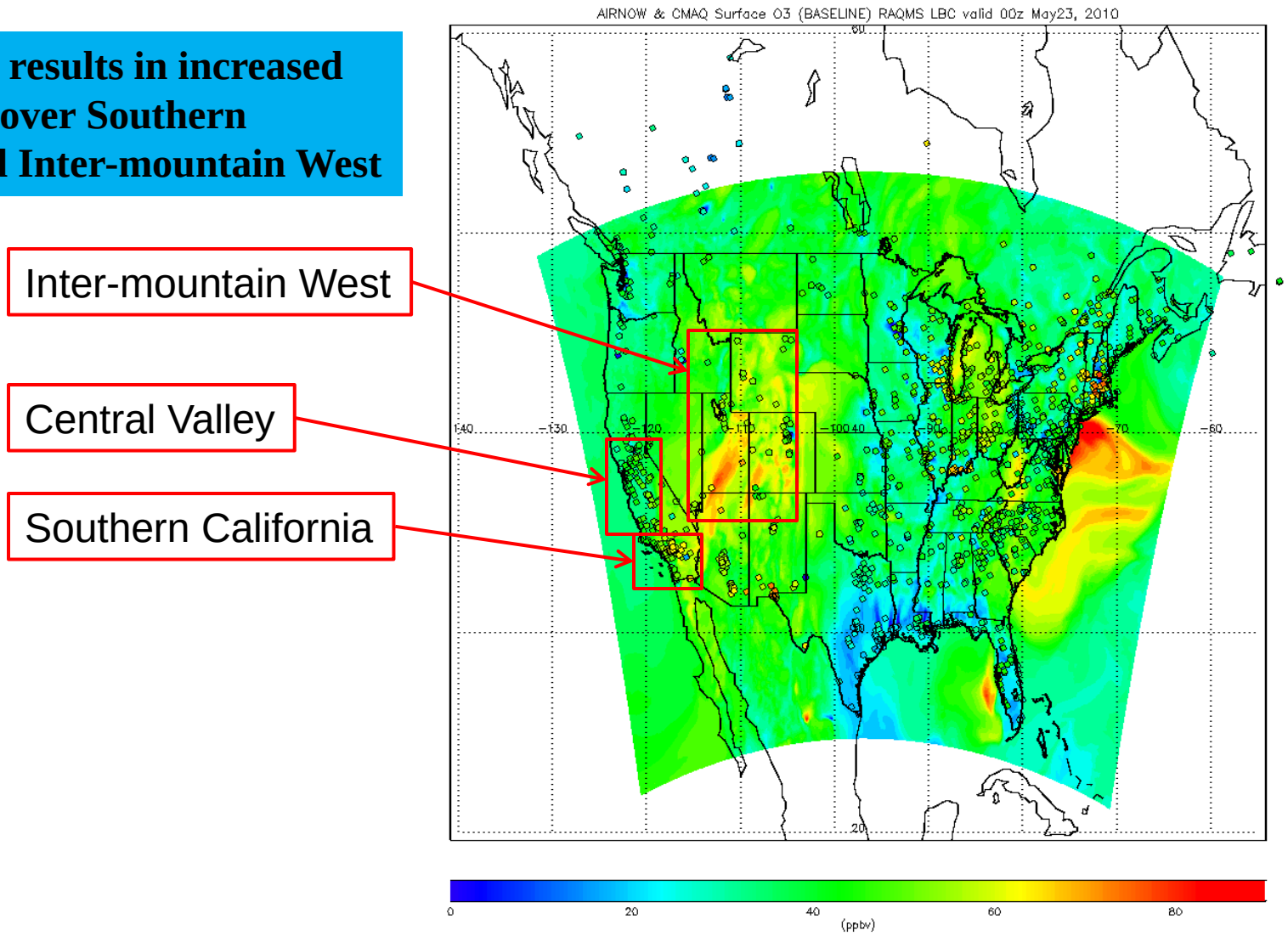


NAM-CMAQ CalNex Experimental Runs

- **Fixed Lateral Boundary Conditions**
- **RAQMS Lateral Boundary Conditions**

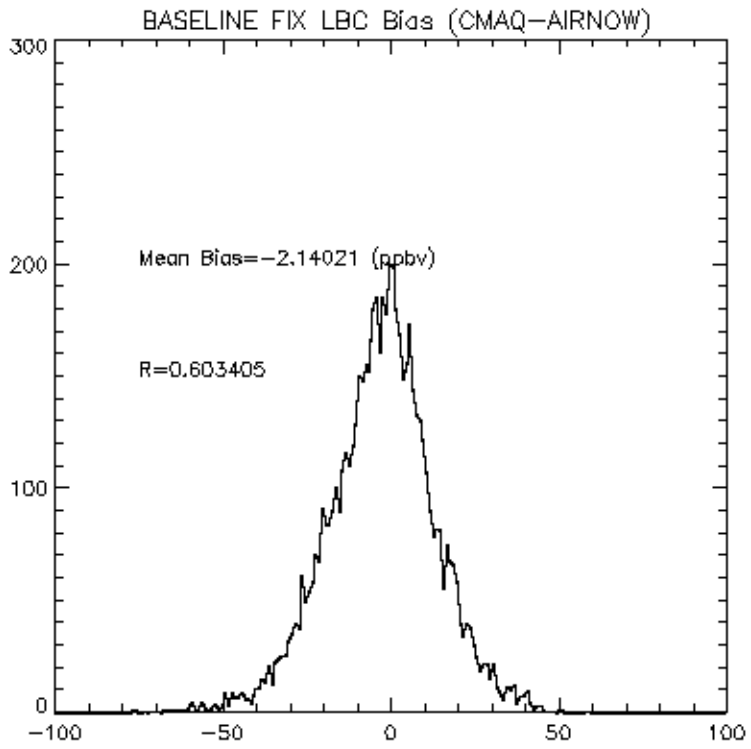
RAQMS LBC 00Z May 23, 2010

RAQMS LBC results in increased surface ozone over Southern California and Inter-mountain West



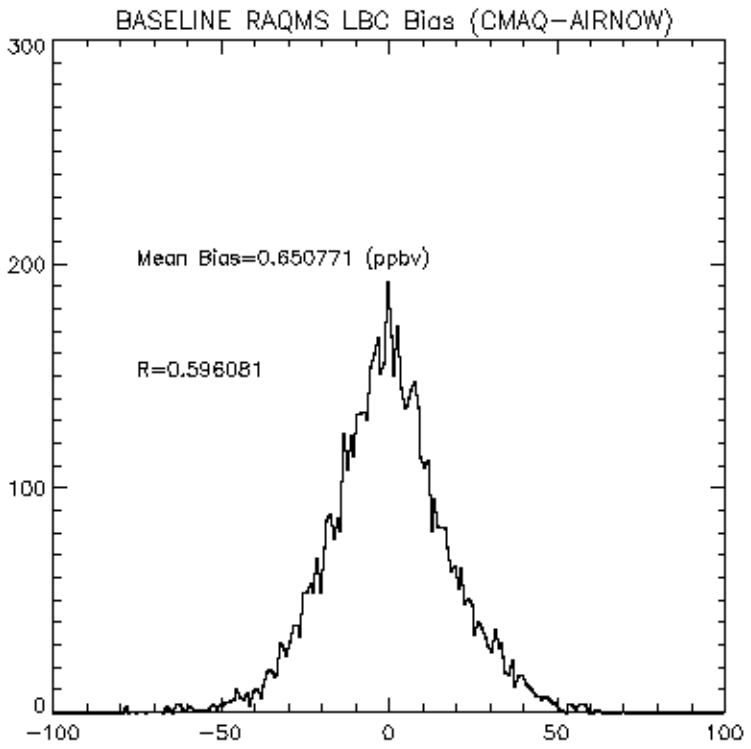
NAM-CMAQ verses AIRNOW May 22-June 30, 2010
Southern California (33N-35N 121W-114W)

FIXED LBC



Bias = -2.14 ppbv

RAQMS LBC

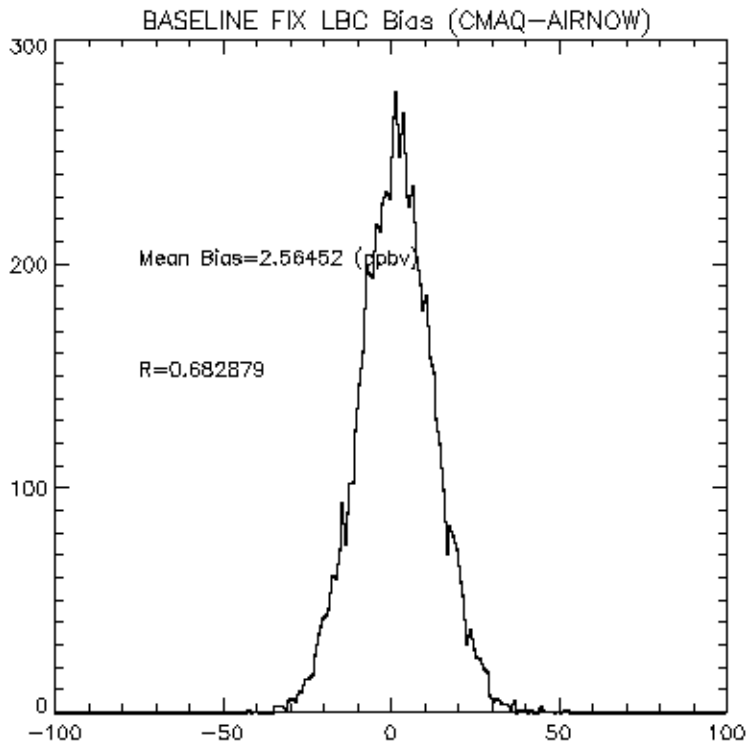


Bias = 0.65 ppbv

RAQMS LBC increases Southern California surface ozone and reduces bias

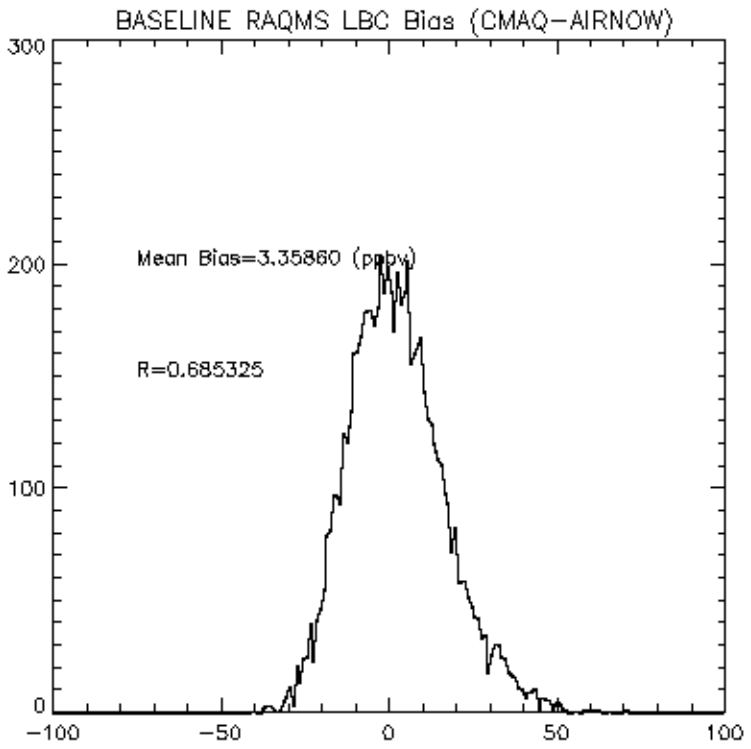
NAM-CMAQ verses AIRNOW May 22-June 30, 2010
Central Valley (35N-39N 124W-118W)

FIXED LBC



Bias = 2.56 ppbv

RAQMS LBC

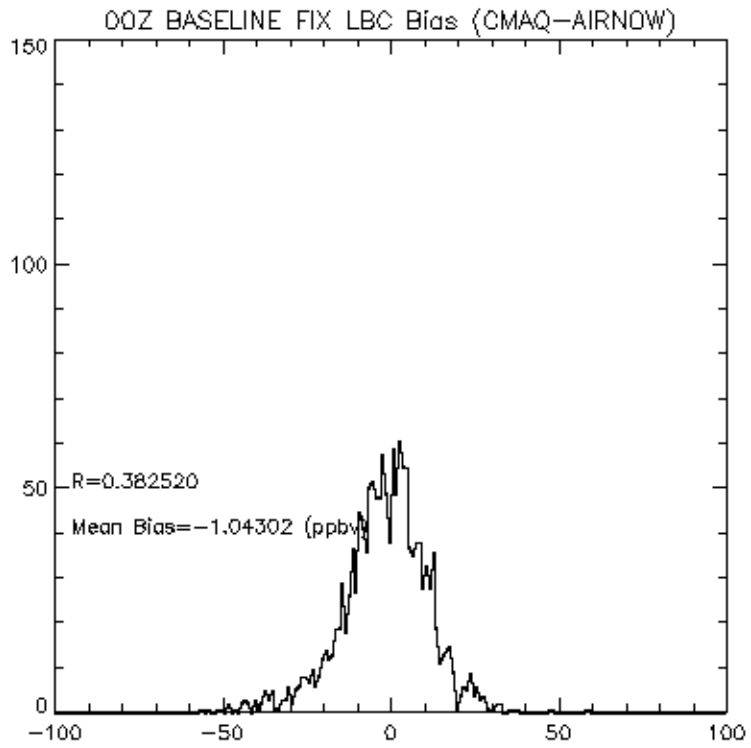


Bias = 3.35 ppbv

RAQMS LBC increases Central Valley surface ozone and increases bias

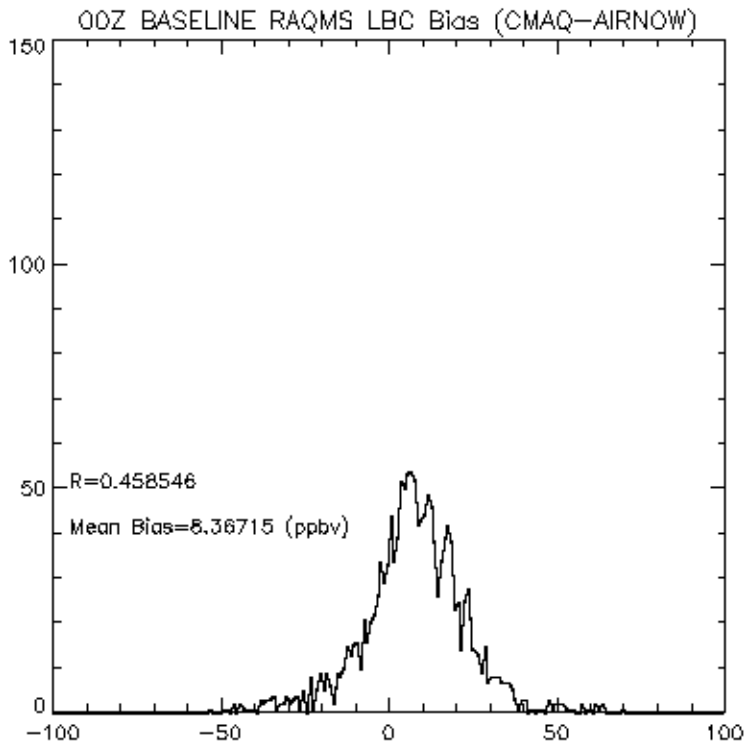
NAM-CMAQ verses AIRNOW May 22-June 30, 2010
Inter-mountain West (35N-45N 115W-105W)

FIXED LBC



Bias = -1.04 ppbv

RAQMS LBC

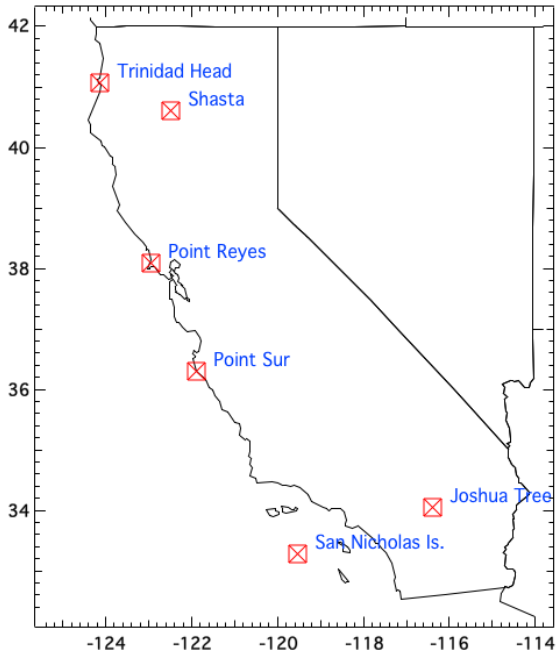


Bias = 8.36 ppbv

RAQMS LBC increases Inter-mountain surface ozone and increases bias

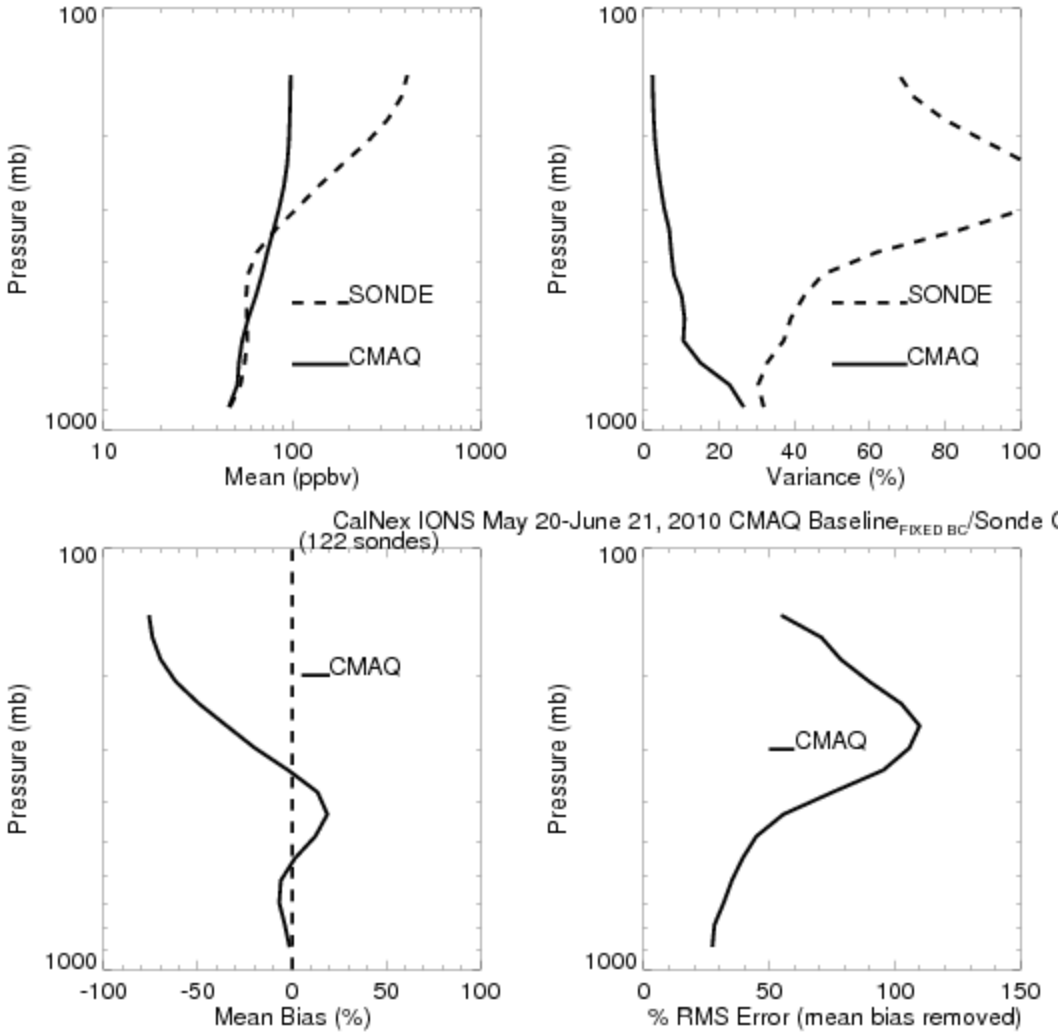
CalNex-2010 O_3 sondes – Owen Cooper (NOAA ESRL)

CalNex Ozonesonde



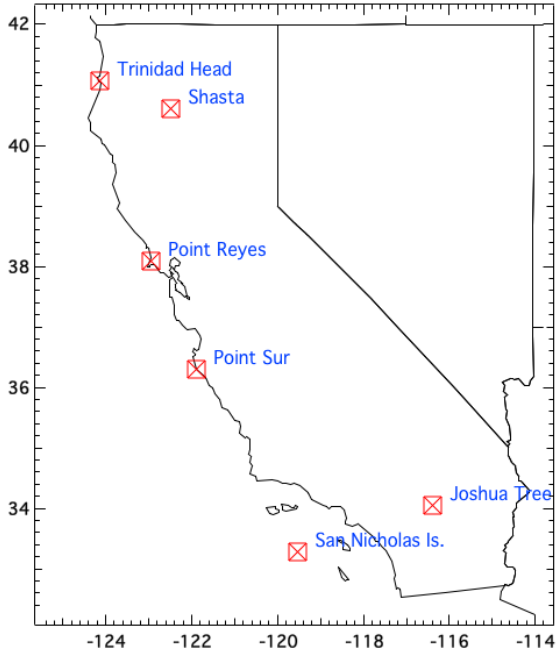
FIXED LBC NAM-CMAQ experiment significantly underestimates upper tropospheric (<300mb) ozone and free tropospheric (<900mb) variance

NAM-CMAQ FIXED LBC



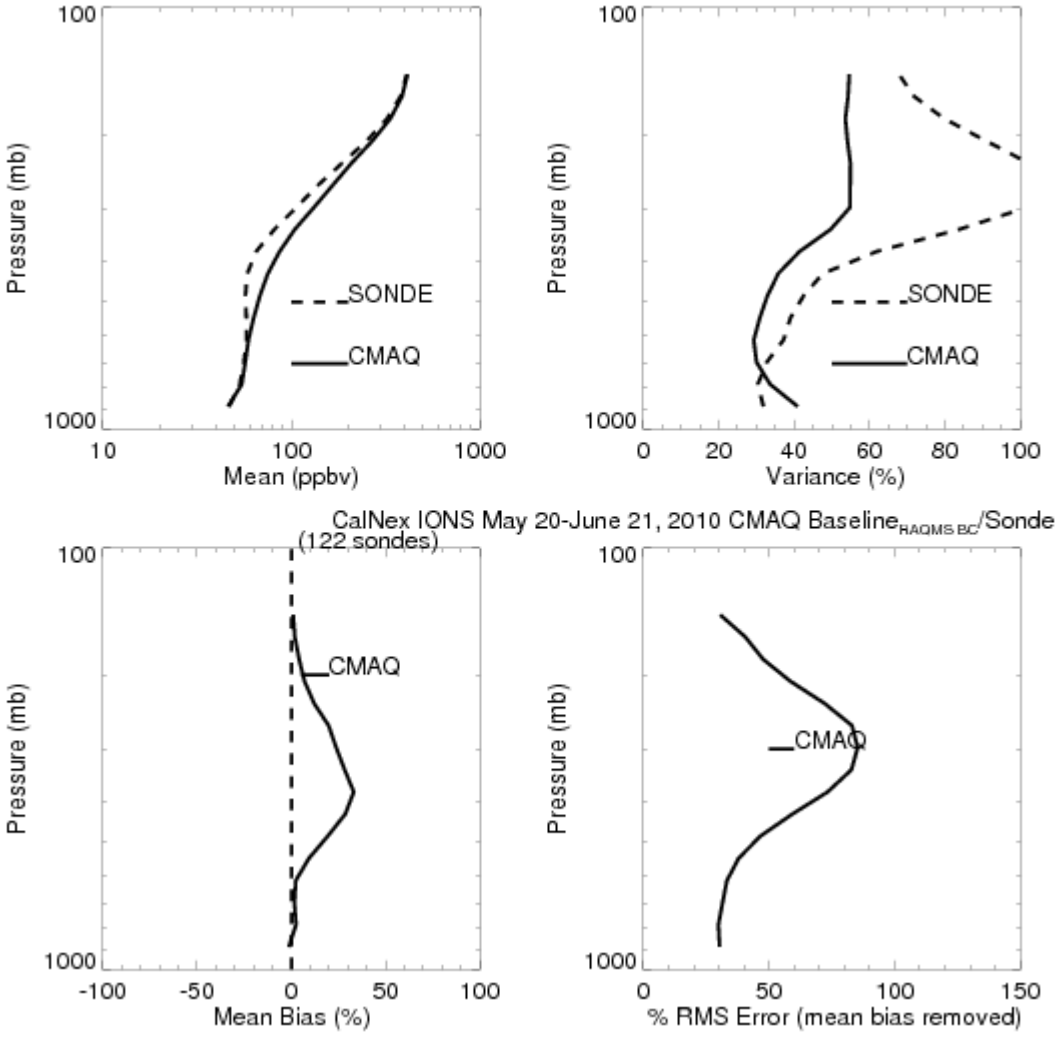
CalNex-2010 O_3 sondes – Owen Cooper (NOAA ESRL)

CalNex Ozonesonde

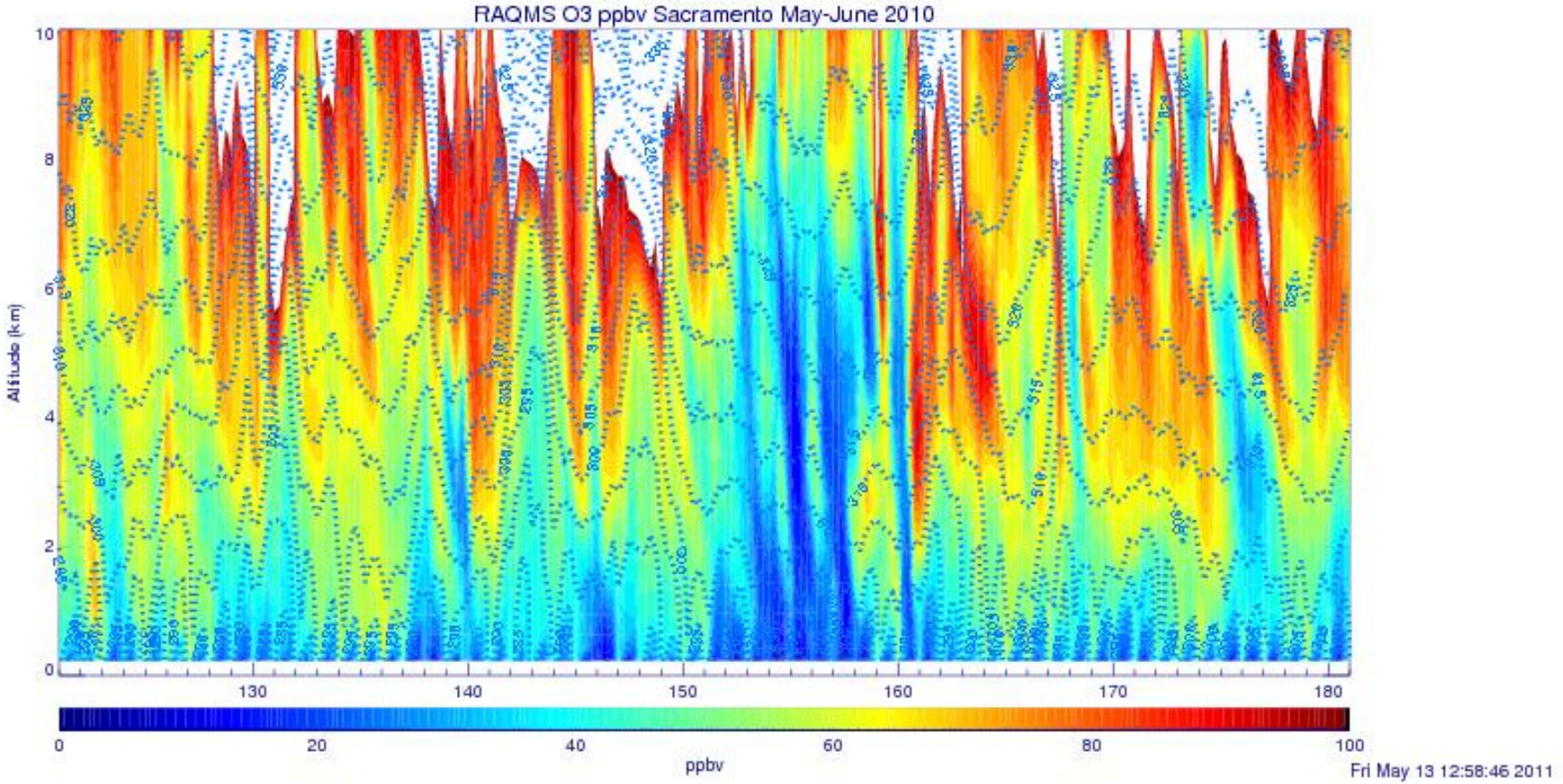


RAQMS LBC NAM-CMAQ experiment overestimates free tropospheric (600-200mb) ozone and boundary layer (>900mb) variance but shows improved agreement in free tropospheric variance

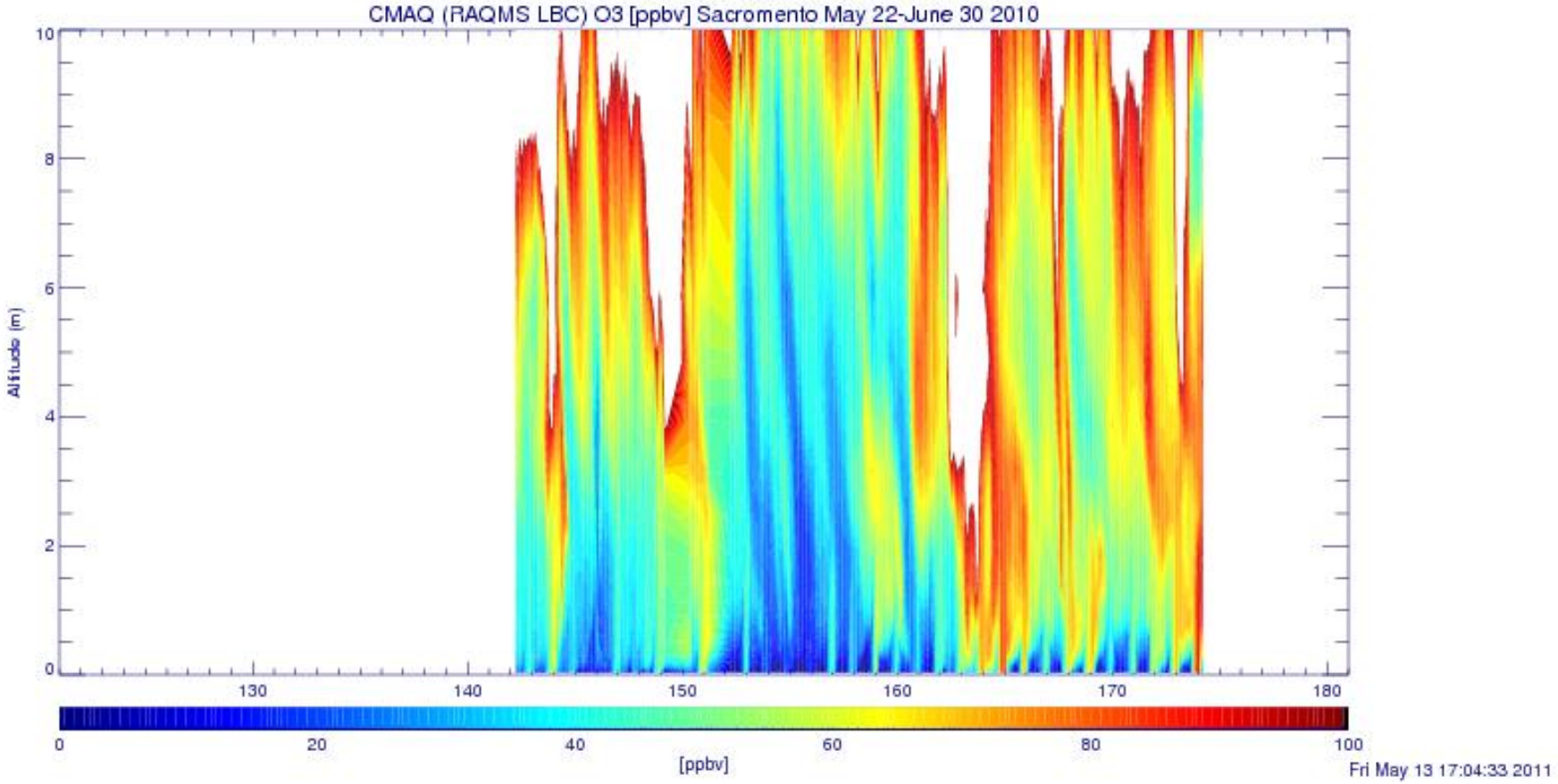
NAM CMAQ RAQMS LBC



Sacramento O3 May-June 2010
RAQMS 1x1 Degree Re-analysis



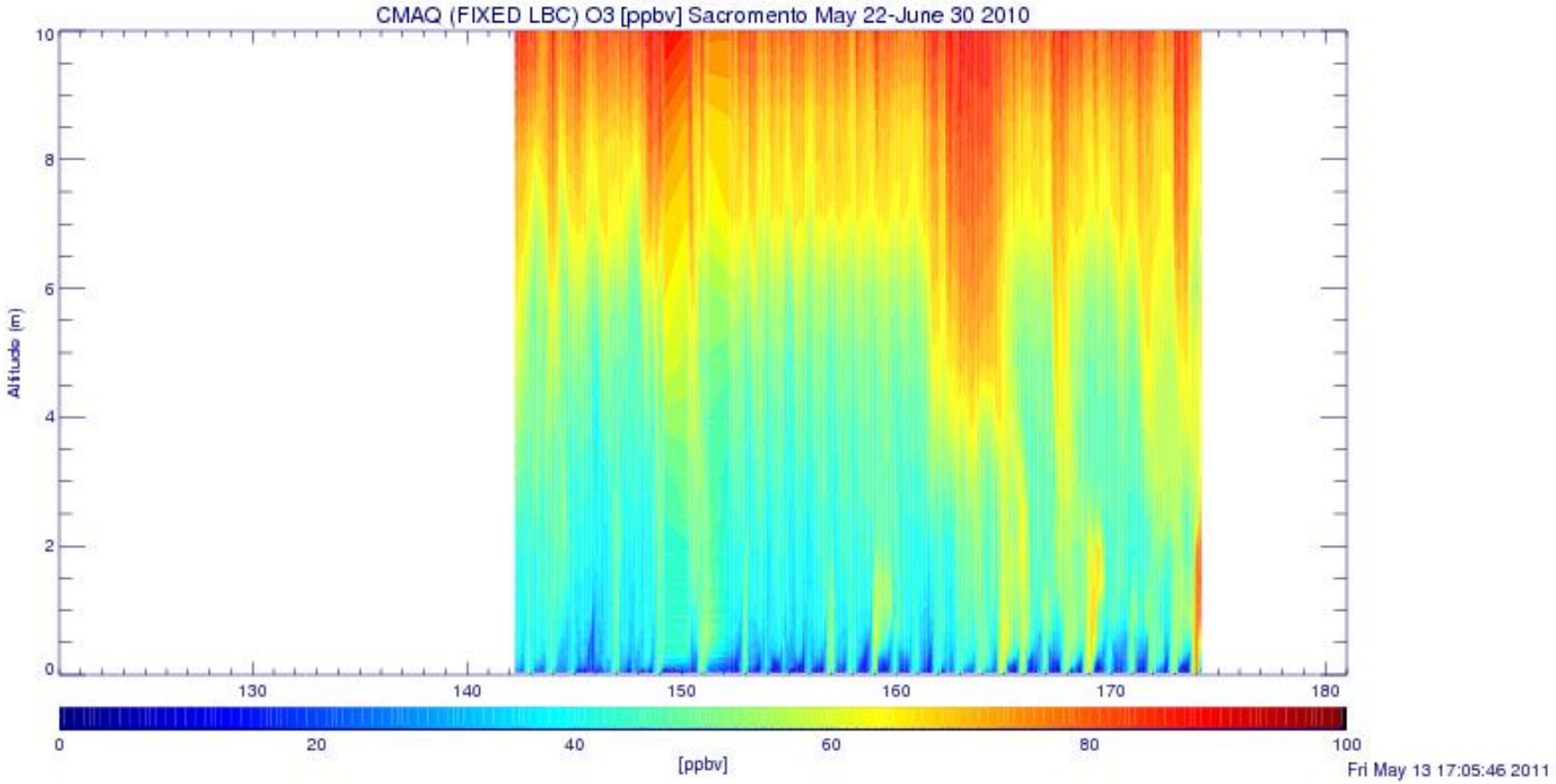
Sacramento O3 May 22 -June 22 2010
NAM-CMAQ with RAQMS LBC



- **NAM-CMAQ RAQMS LBC experiment shows more descent of high ozone air than RAQMS 1x1 re-analysis which may lead to overestimates in surface ozone**

- **Points to the need for improved vertical resolution in NAM-CMAQ upper troposphere/lower stratosphere**

Sacramento O3 May 22 -June 22 2010
NAM-CMAQ with FIXED LBC



- **FIXED LBC experiment shows less descent of high ozone air then RAQMS LBC experiment**

- **FIXED LBC experiment shows less variance then either RAQMS or the RAQMS LBC experiment**

Summary:

- **Assimilation of global satellite ozone retrievals results in improved agreement with CalNex P3 airborne and ozonesonde ozone measurements and slight improvements in large-scale ozone forecasts**

- **Assimilation of global aerosol retrievals results in improved agreement with CalNex HSRL airborne aerosol extinction measurements and significant improvements in large-scale dust forecasts**

  - **Leads to overestimates of insitu aerosol dry mass and extinction**

  - **Need to understand the contribution from large aerosols to ambient extinction**

- **Use of real-time RAQMS LBC within experimental CB5 NAM-CMAQ leads to improved agreement with UTLS ozonesonde measurements and improved representation of free tropospheric variance but leads to overestimates in surface ozone over the inter-mountain west**

  - **Need to increase the vertical resolution of NAM-CMAQ in the UTLS**

- **Forecasting exceedances under the proposed ozone National Ambient Air Quality Standards (NAAQS) will require improved treatment of free tropospheric ozone within regional AQ forecasting and assessment systems**