

# **IDEA-I: A Globally Configurable Software Package in Support of Air Quality Forecasts; High Aerosol Concentrations and Stratospheric Intrusions of Ozone**

**James Davies, Kathy Strabala, Nadia Smith, Elisabeth Weisz, Rebecca Cintineo, Eva Schiffer, R. Bradley Pierce\*, Allen Huang**

**Cooperative Institute for Meteorological Satellite Studies  
(CIMSS), University of Wisconsin-Madison**

**\*NOAA/NESDIS/STAR/ASPB**



# IDEA-I: A GLOBALLY CONFIGURABLE IMAPP MODIS SOFTWARE PACKAGE IN SUPPORT OF AIR QUALITY FORECASTS

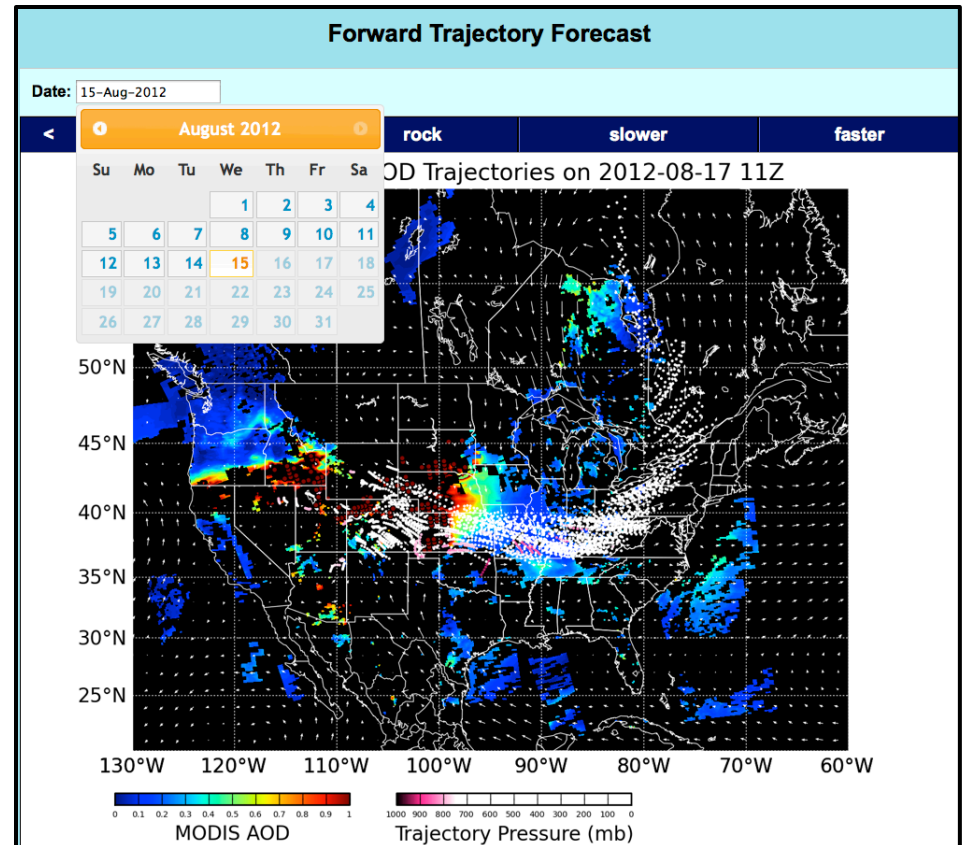
James Davies, Kathy Strabala, Eva Schiffer, R. Bradley Pierce#,  
Hung-Lung (Allen) Huang

*Space Science and Engineering Center (SSEC/UW-Madison), Madison, WI, USA*

*#NOAA/NESDIS/STAR/ASPB*

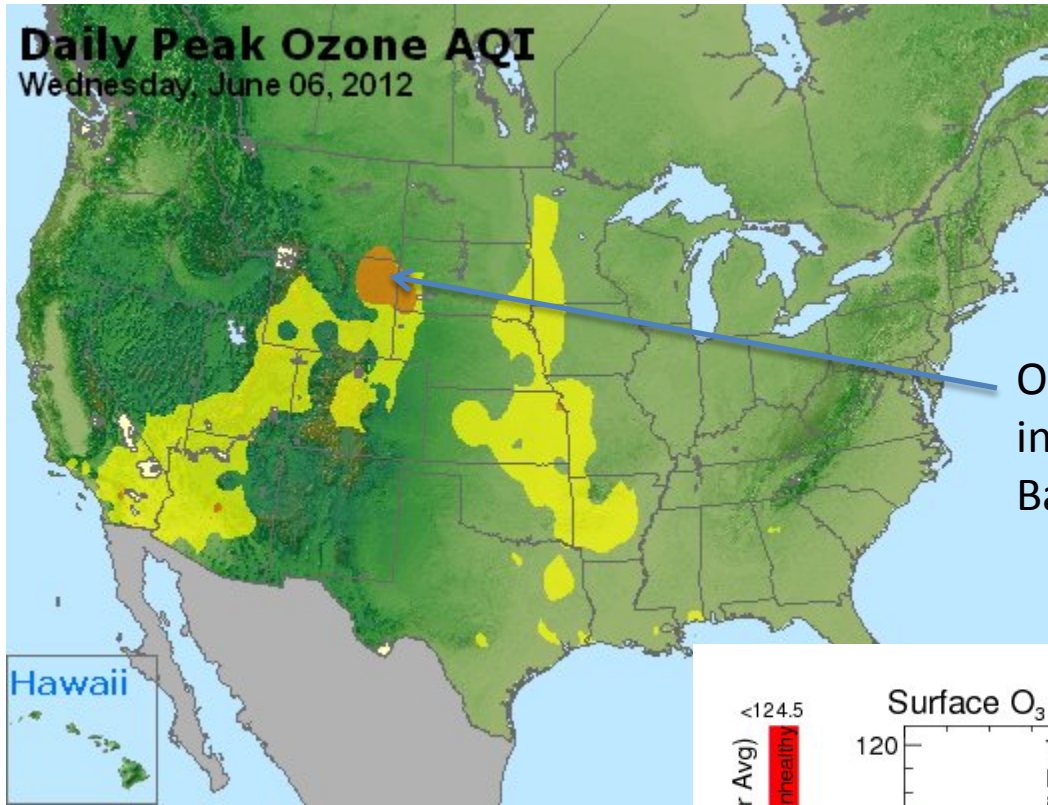
*jim.davies@ssec.wisc.edu*

- ❑ IDEA-I is newly added part of the International Moderate Resolution Imaging Spectroradiometer (MODIS) Atmospheric Infrared Sounder (AIRS) Processing Package (IMAPP) and provides to the DB community a version of Infusing satellite Data into Environmental air quality Applications (IDEA).
- ❑ It is globally configurable and freely available, using Terra or Aqua MODIS MOD04 Aerosol Optical Depth (AOD) retrievals to identify local regions of high aerosol loading from which trajectories are initialized.
- ❑ A trajectory model provides a forecast of the horizontal and vertical movement of the aerosol-laden air parcels over the next 48 hours.
- ❑ The package includes netCDF output data files as well as hourly trajectory forecast images, which can be viewed from a web browser using PHP software (that is also included, credit to Bill Bellon).



# Daily Peak Ozone AQI

Wednesday, June 06, 2012



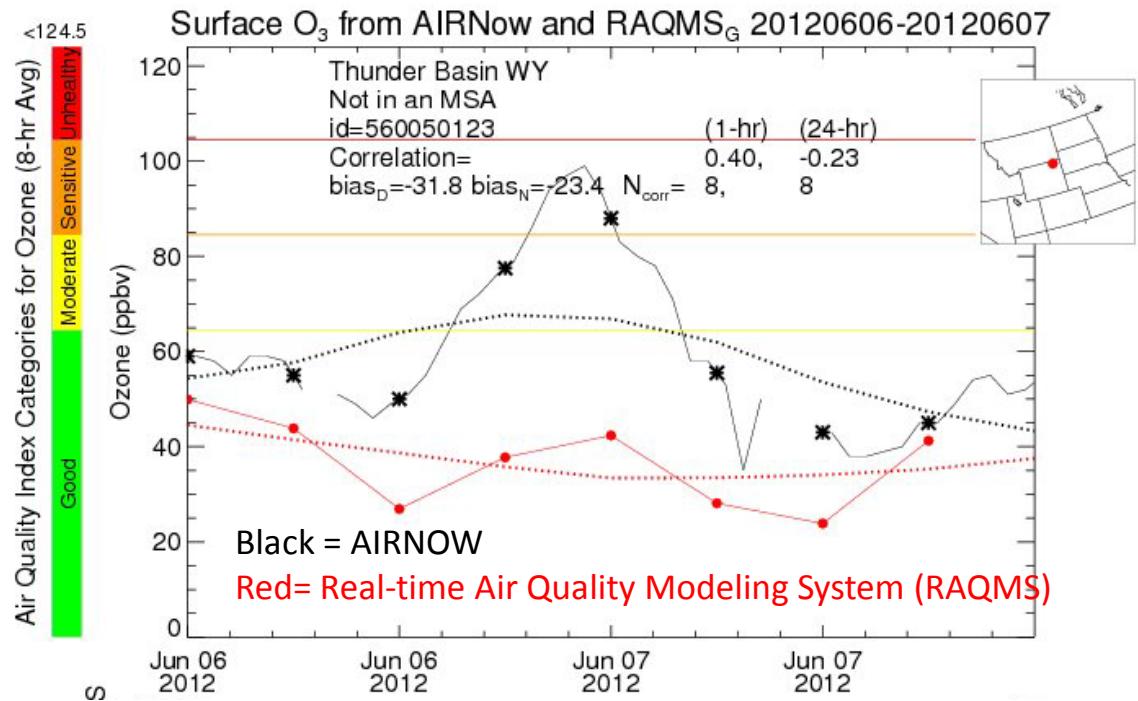
<http://airnow.gov>

June 6, 2012

Ozone in "sensitive" range (85-105 ppbv) in NE corner of Wyoming (Thunder Basin). Why?



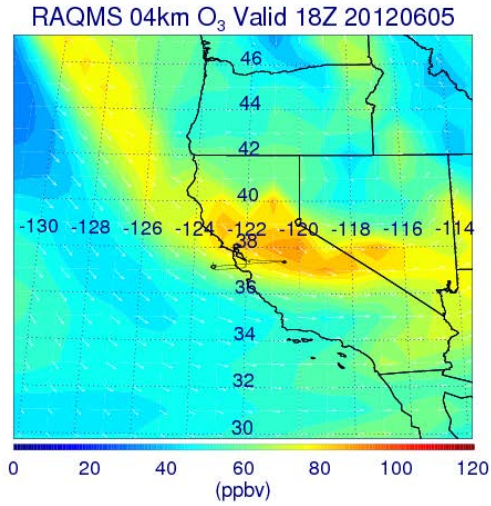
## MOTIVATION



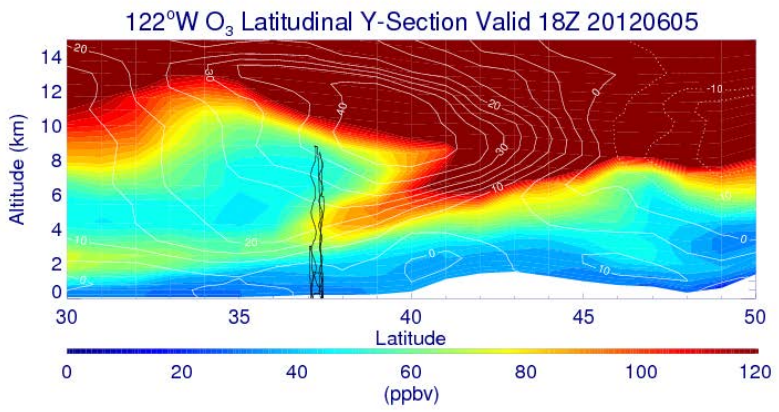
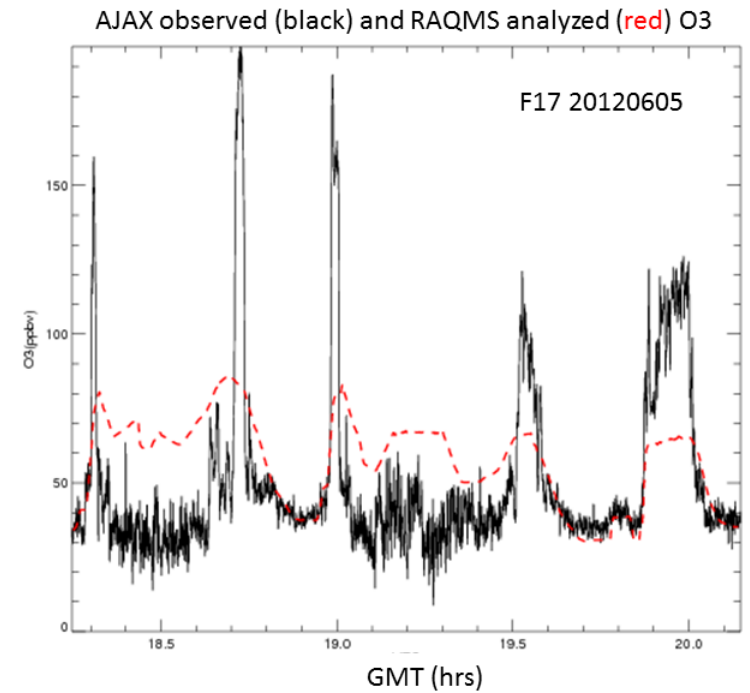


<http://raqms.ssec.wisc.edu/>

[http://geo.arc.nasa.gov/ajax/ajax\\_index.html](http://geo.arc.nasa.gov/ajax/ajax_index.html)

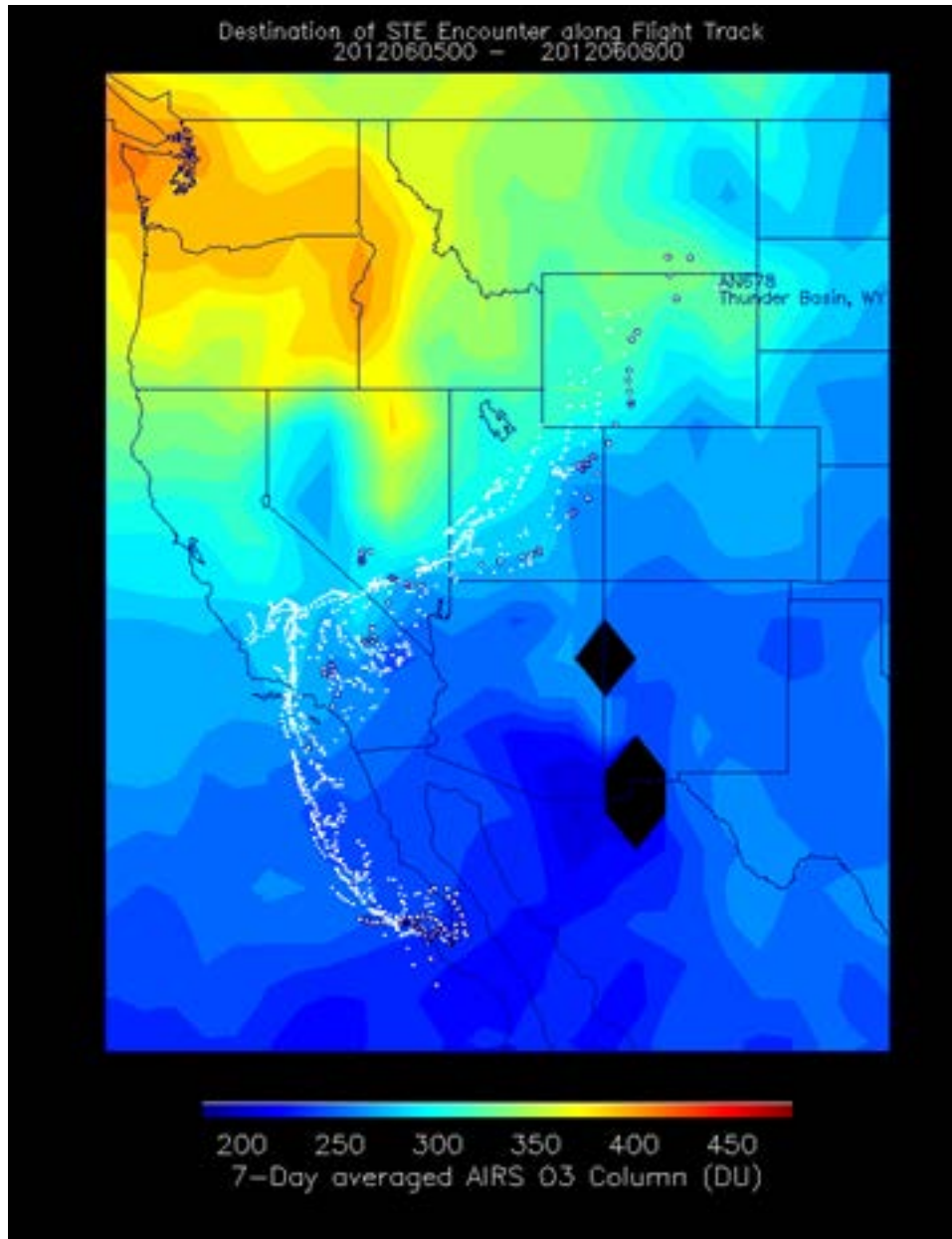


June 5  
(day before)



RAQMS 4km O3 (ppbv, upper left panel) map and 122°W cross section (ppbv, lower left panel) on 5 June 2012 at 1800 UTC. The aircraft flight track is shown in black. Note the tropopause fold indicated by the tongue of high ozone extending from the lower stratosphere into the mid-troposphere.





Maps of 7-day averaged (June 05-June 12, 2012) AIRS total column O3 (DU) with forward trajectory history (white) and destination (white with blue edges) at 00Z 06/08 for Stratospheric Intrusion encounter on AJAX Flight 47.



State of Wyoming  
Department of  
Environmental  
Quality/Air Quality  
Division

**Exceptional Event Demonstration Package  
for the Environmental Protection Agency**

**Thunder Basin, Wyoming Ozone Standard  
Exceedance June 6, 2012**

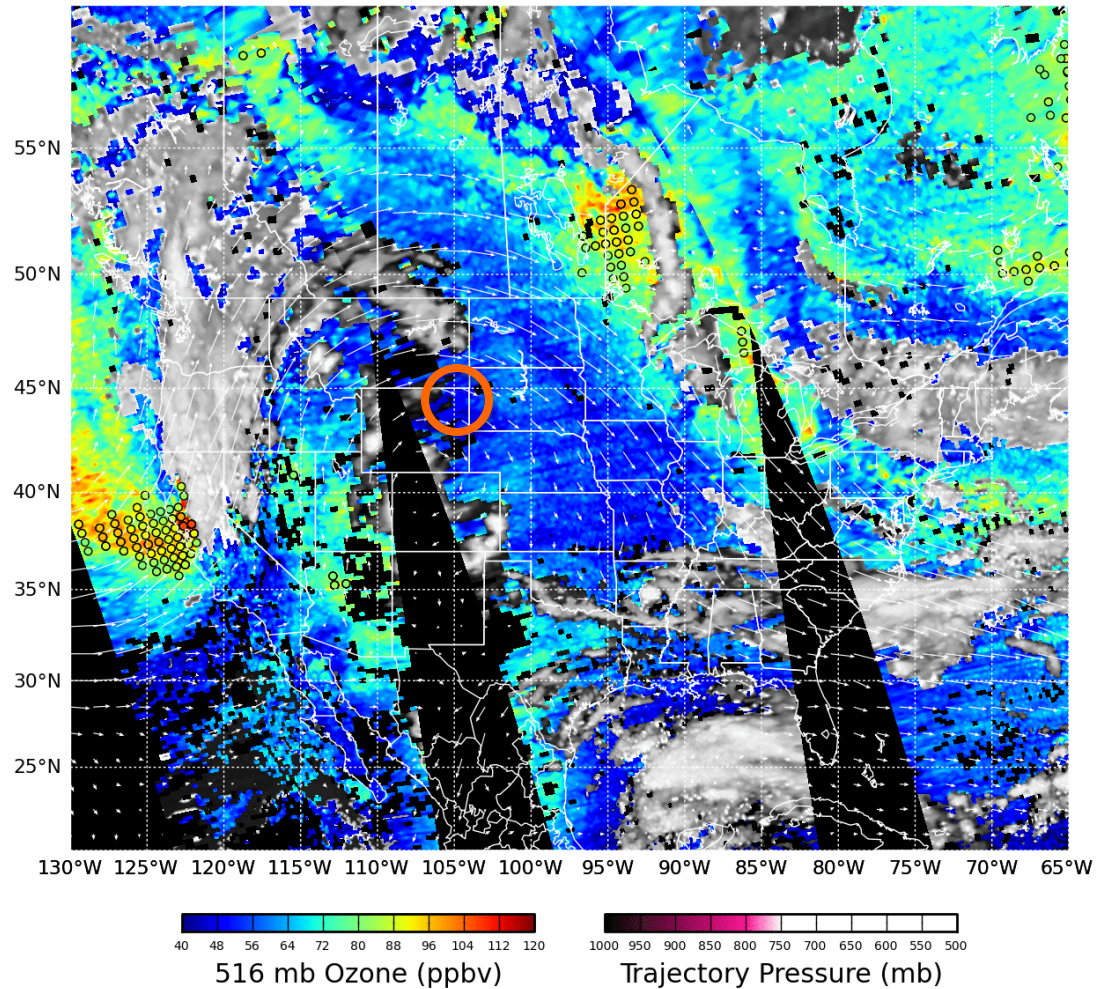
# AIRS trajectory forecast showing descent into WY

Plan A: <http://sunset.ssec.wisc.edu/idea-test2>

Starting June 4  
(two days before)

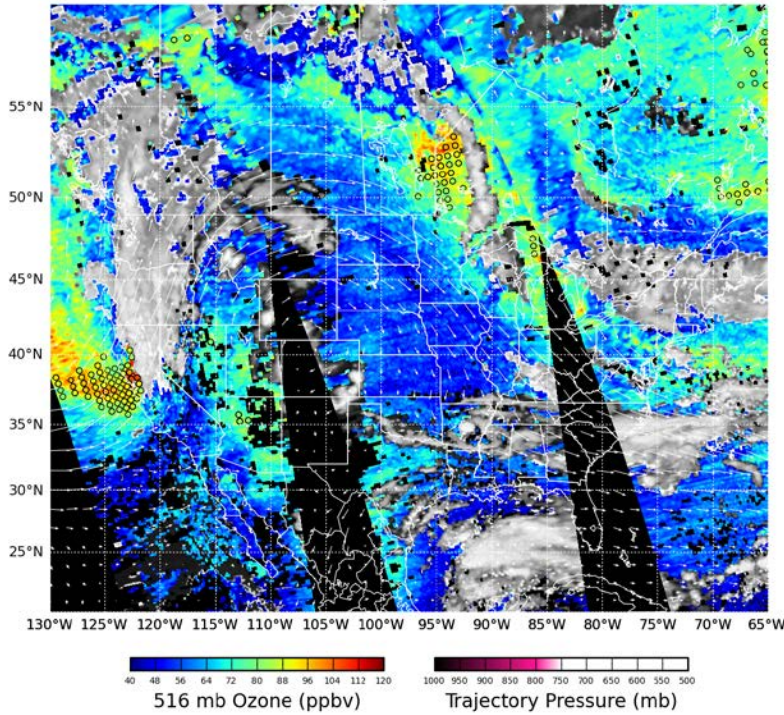
Plan B:

AIRS Ozone & Ozone Trajectories on 2012-06-04 17Z





AIRS Ozone & Ozone Trajectories on 2012-06-04 17Z



Starting June 4  
(two days before)

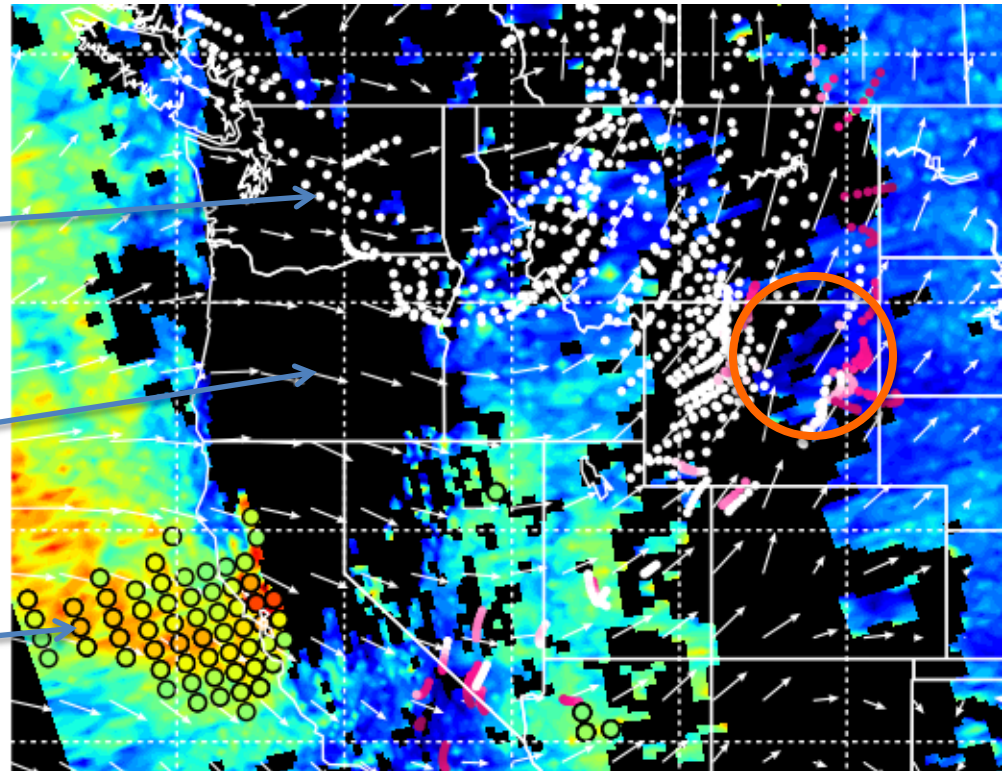
AIRS trajectory forecast  
showing descent into WY

Last frame of web animation @ 2012-06-07 00Z

Each "worm" is 6 hours  
of air parcel history

500 hPa GFS winds

Initialization points



45°N

40°N

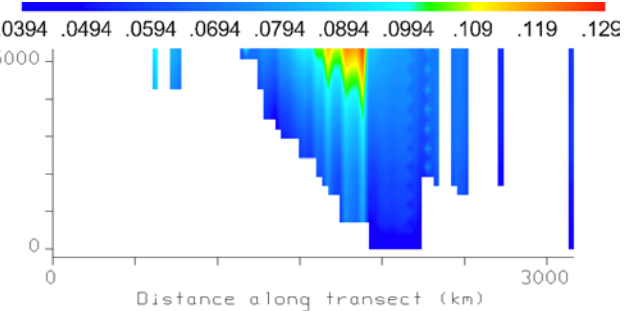
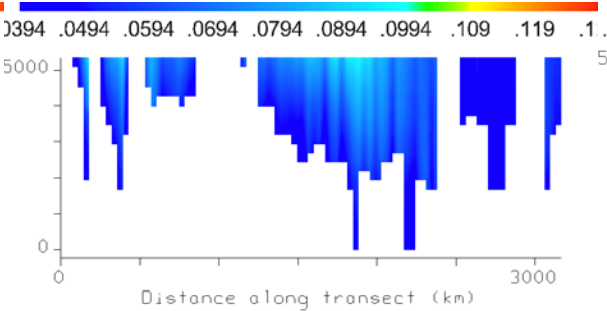
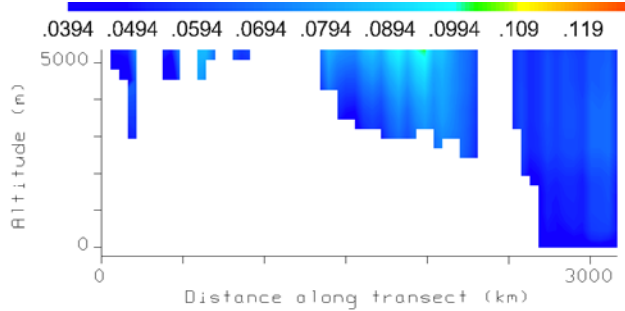
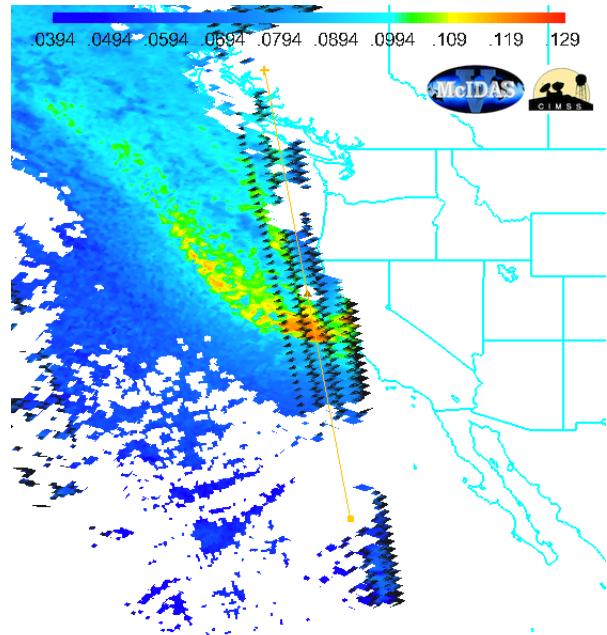
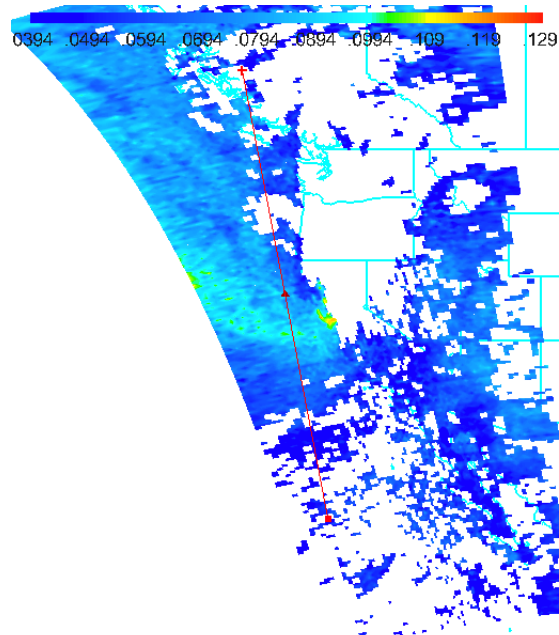
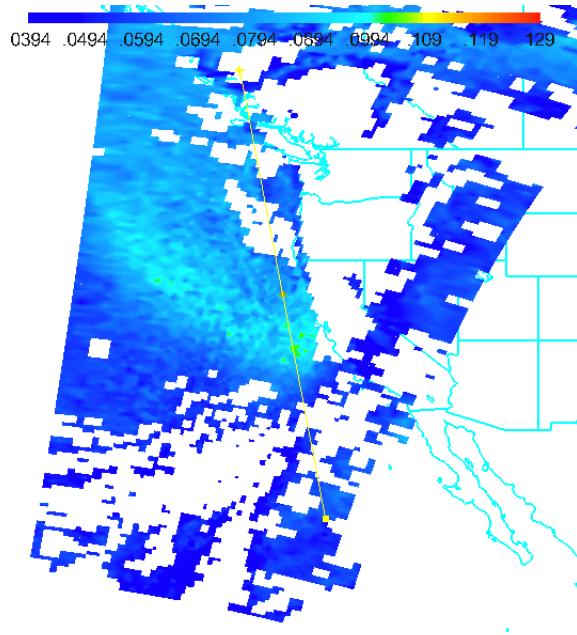
35°N

June 4 (two days before)

IASI 1840Z

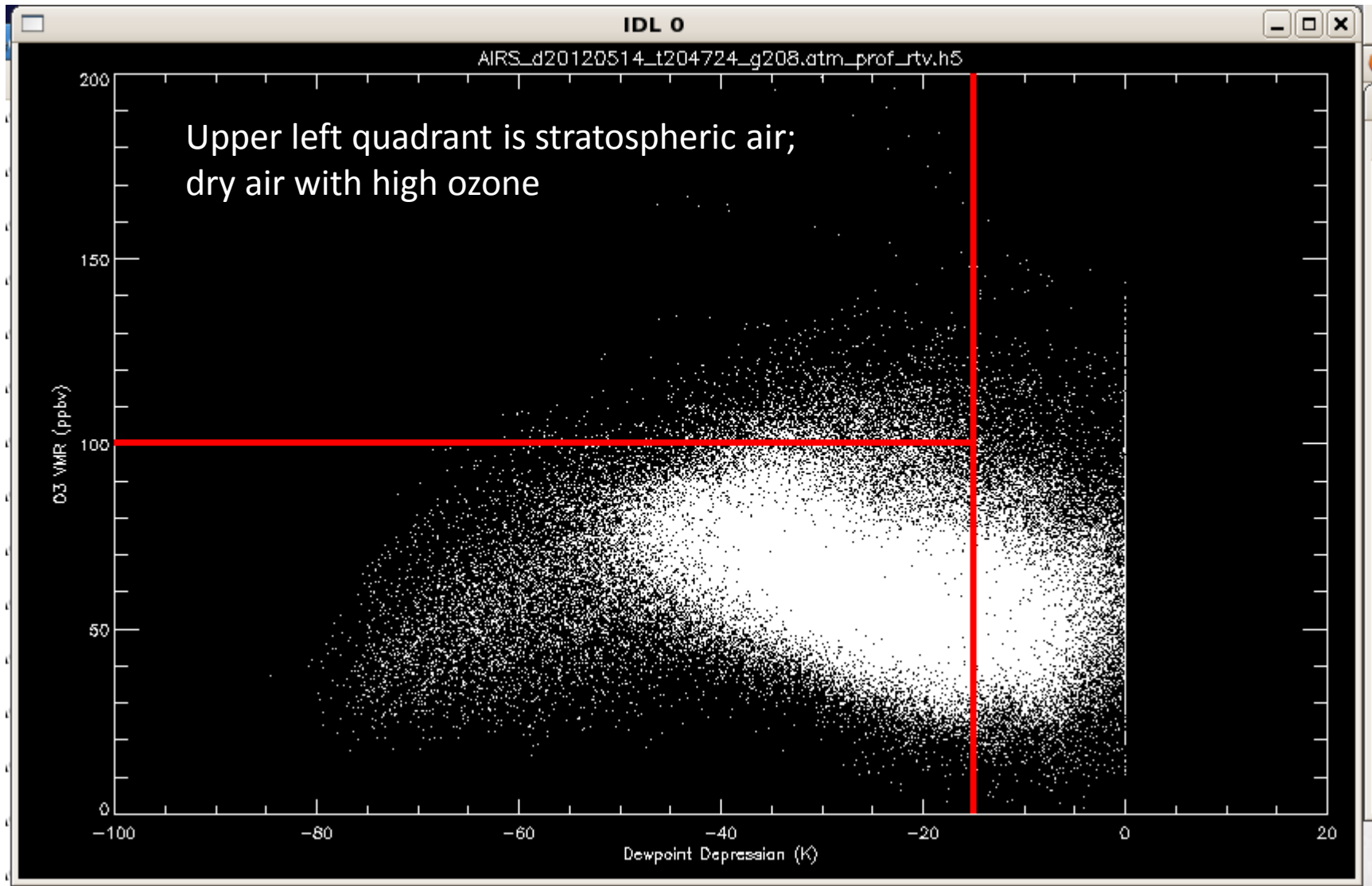
AIRS 2100Z

CrIS 2150Z





## Basis for initialization point selection criteria



14 May, 2012

Plevs threshold: >500mb  
O3VMR threshold: >0.10 (100ppbv)  
Dewpnt-Tair threshold: <-15K

# Example configuration file for IDEA-I-CrISozone

```
REGION_NAME = USA Test Region
OUTPUT_DIR = {IDEA-I_home}/output/USA_Day_Ozone/CrIS/{YYYY}{MM}{DD}
TMPDIR = /scratch/jimd/tmp
```

Where to put the output files and the temporary directory name

```
MAP_PROJECTION = cylindrical
TOP_LEFT_LON_LAT = -130, 60
BOTTOM_RIGHT_LON_LAT = -65, 20
NODE = ascending
REGION_GMT = after_12Z
```

Location of domain and whether in this domain the data is all after noon and ascending or descending node

```
MINDPD = 15      # minimum dew point depression in K
MINO3VMR = 0.08  # minimum aggregated O3 mixing ratio in ppmv
PRIORITY = DPD   # DPD or O3VMR
MAXTRAJ = 500    # maximum number of trajectories to start
SUPIX = 3        # aggregation pixel side-length
NPIX = 4         # minimum number of pixels in aggregation
```

Main user controls on how ozone and dew point depression data are used to select trajectory initialization points

```
H5DUMP = {IDEA-I_home}/bin/h5dump
NCGEN = {IDEA-I_home}/bin/ncgen
WGRIB2 = {IDEA-I_home}/bin/wgrib2
TRAJECT = {IDEA-I_home}/bin/GFS_trajectory_3d_v01.x
```

Supplied executables (but you can point to your own, even recompile 3D trajectory model since source is supplied)

```
LFTP = /usr/local/bin/lftp
CONVERT = /usr/local/bin/convert
```

We don't supply these, but we do give instructions on how to get them

```
GFSFTP = ftp.ssec.wisc.edu
GFSAUTH = anonymous:noname@nowhere
GFSREMOTE = pub/eosdb/ancillary/{YYYY}_{MM}_{DD}_{ddd}/forecast
GFSLOCAL = /data3/jimd/Downloads/GFS/SSEC/{YYYY}_{MM}_{DD}_{ddd}_{HH}
GFSTEMPLATE = gfs.p5.{YYYY}{MM}{DD}_{HH}_0{ff}.ldm.grib2
GFSFETCH = YES
GFSKEEPDAYS = forever
```

Where GFS files are on local disk and where to fetch them from (if not there)

```
CrISFTP = ftp.ssec.wisc.edu
CrISAUTH = anonymous:noname@nowhere
CrISREMOTE = /pub/eosdb/npp/cris
CrISLOCAL = /data3/jimd/Downloads/CrIS
CrISTEMPLATE = {YYYY}_{MM}_{DD}_{ddd}_{hh}{mm}/edr/CrIS_d{YYYY}{MM}{DD}_t{hh}{mm}{ss}.atm_prof_rtv.h5
CrISFETCH = YES
CrISKEEPDAYS = forever
```

Where CrIS files are on local disk and where to fetch them from (if not there)

\$ ./IDEA-I-AIRSozone.pl -GFX -f=USA\_Day\_AIRSozone.cfg -d=TODAY

-v

run in verbose mode  
[default is quiet]

-G

update GFS data from remote FTP site  
[default is don't update them]

-F

update AIRS data from remote FTP site  
[default is don't update them]

-X

execute trajectory model  
[default is don't execute it]

-n

do-nothing (rehearsal) mode; just check that it WILL run  
(this does mean - possibly - creating some directories)  
[default is run script normally]

-R

reprocess with trajectory model even if results exist  
[default is don't reprocess; -R implies & forces -X]

-P

purge aged files only and quit  
[default is purge at end of processing; -P ignores all except -v & -n]

-d date

A date like any of: YYYYMMDD YYYYddd YYYY-MM-DD YYYY-ddd YESTERDAY TODAY  
where...

YYYY is four digit year

MM is 2 digit month, but can be 1 digit in the hyphenated form

DD is 2 digit day, but can be 1 digit in the hyphenated form

ddd is 3 digit day of year, but can be 1 or 2 digits in hyphenated form

[default is TODAY]

-f config\_file

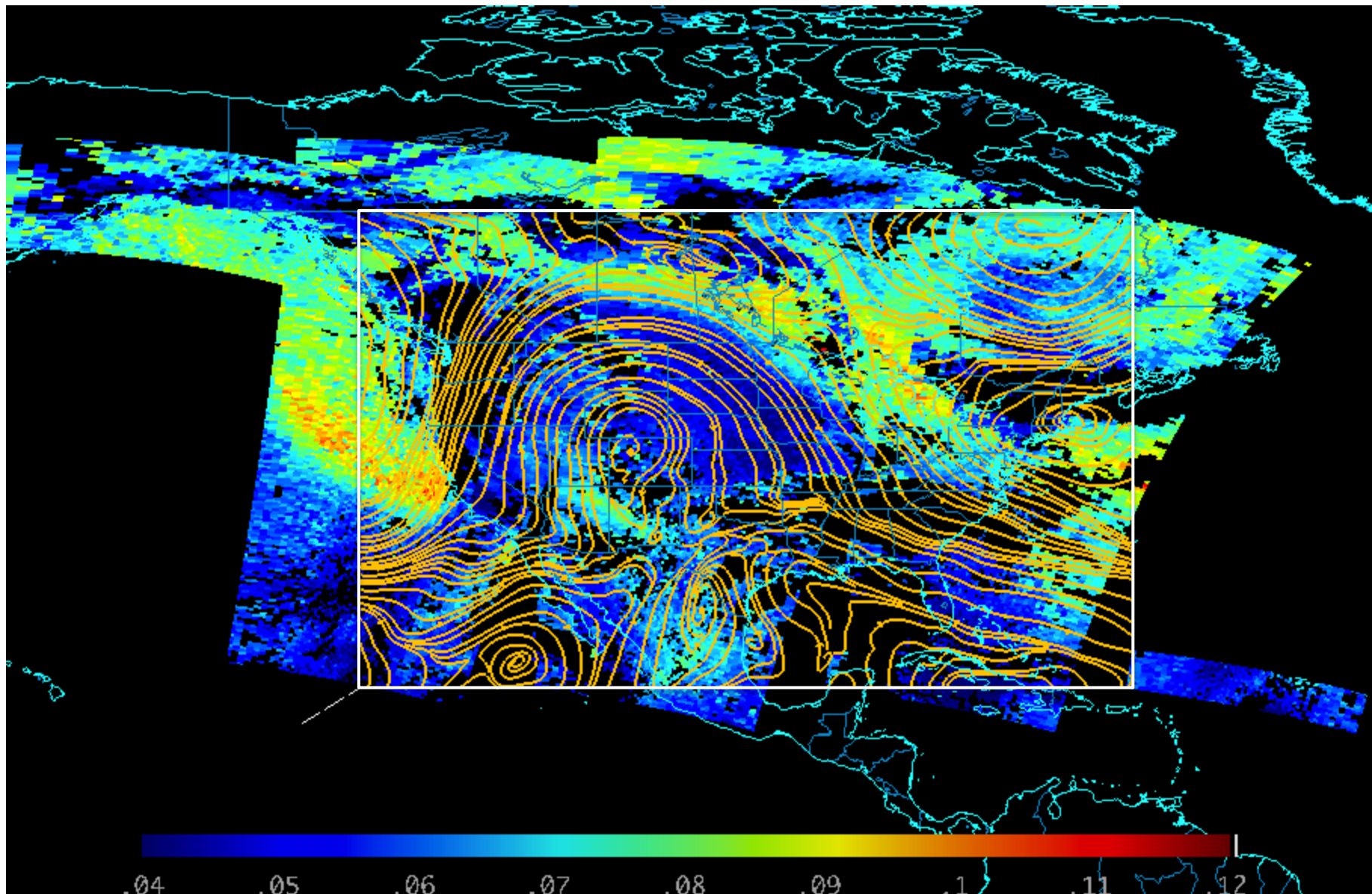
read configuration information from config\_file

(if no path prefix to config\_file, look here: /home/jimd/svn/dbidea/config/)

[no default]



Gridded data netCDF file includes retrieval product swaths (here IASI) and GFS data fields

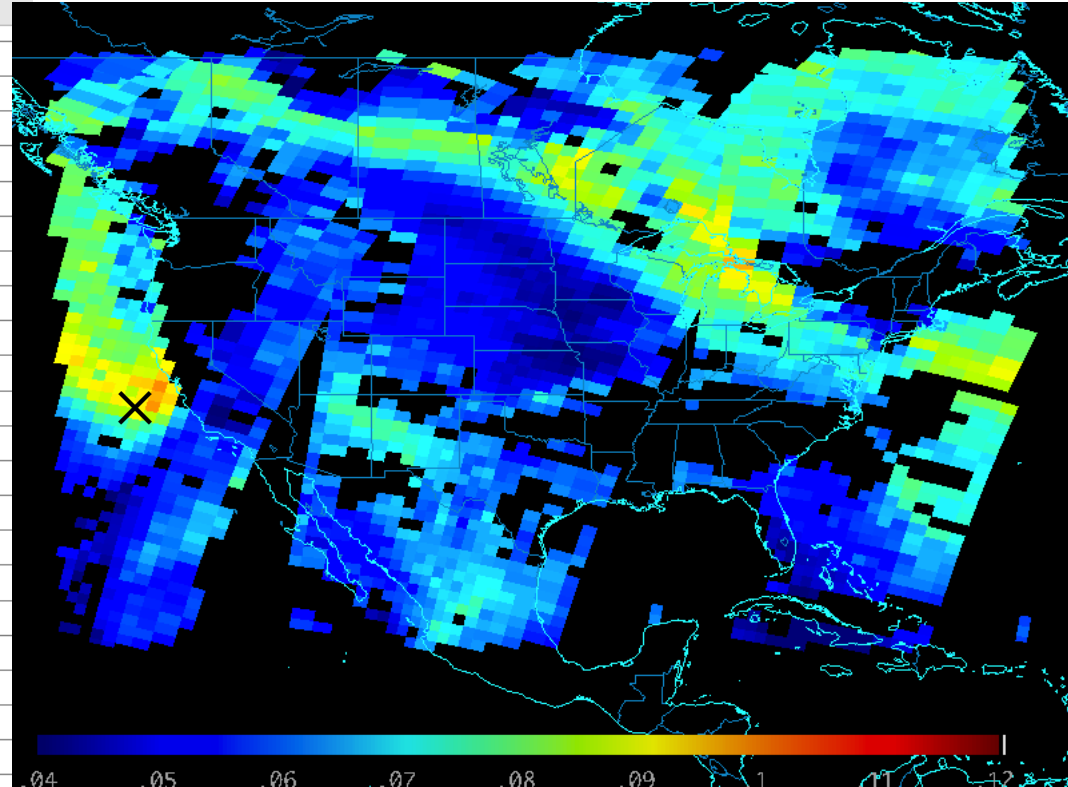
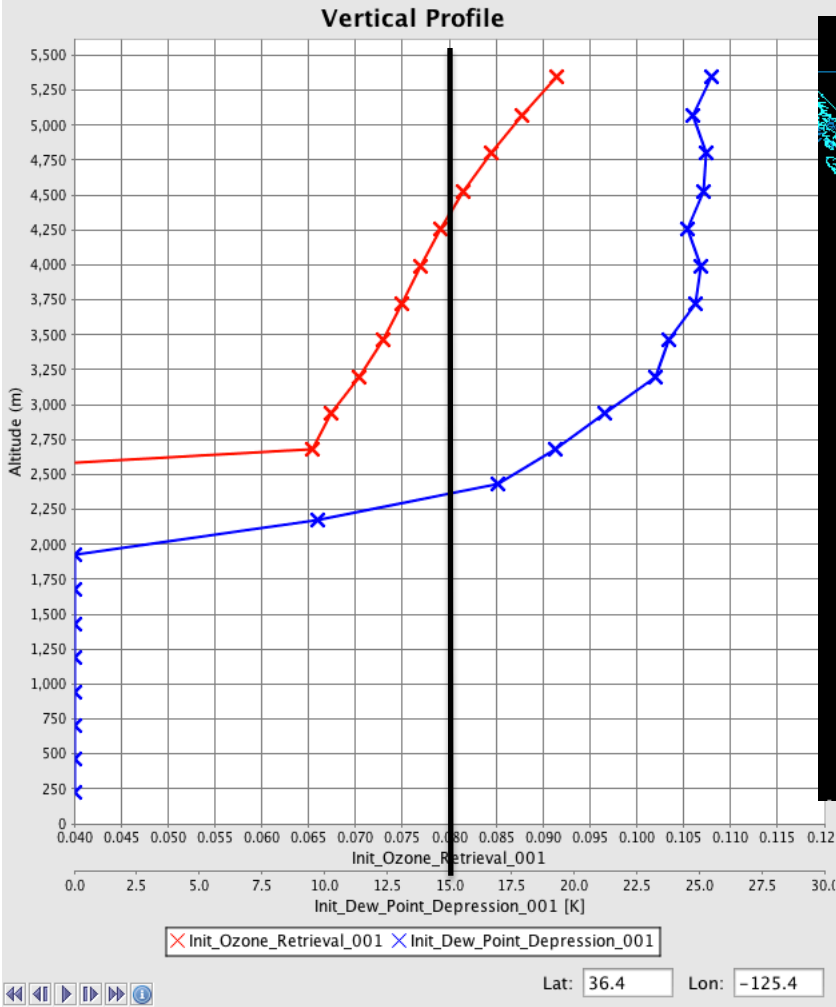


516 hPa ozone (ppmv)

# Initialization points from application of thresholds to aggregates

**O3VMR (ppmv)**    **DPD (K)**

**IASI**



516 hPa ozone (ppmv) aggregated to 3 x 3

# Some product parameters

```
# Global variable definitions
# .....
# These definitions are to avoid using "magic numbers" in the script - BUT this does not mean
# that you can simply change these, use data from other sources and with different dimensions,
# and expect the script to work; a little more code maintenance than that is required!
our $FILLVAL = -9999;   # _FillValue for generated netCDF files, which I changed to match AIRS missing_value
our $GFSNCOL = 720;    # number of columns of GFS data at 0.5 degree resolution, lon = 0:359.5
our $GFSNROW = 361;   # number of rows of GFS data at 0.5 degree resolution, lat = -90:90
our $GFSSTEP = 6;     # time step of GFS forecast in hours (that we download and use)
our $GFSLAST = 60;    # end of GFS forecast in hours (that we download and use)
our $A03SWATH = 90;   # swath width of the AIRS 03 product
our $A03NLEV = 101;   # number of layers in AIRS 03 product
our $PTOP4APP = 500;  # pressure level in hPa above which we discard data for this application
our $HOURSPAN = 8;    # maximum time span of granules in space-window, used in AIRS file selection logic
our $MAXDPD = 99;     # maximum dew point depression (DPD); if DPD > $MAXDPD then DPD <- $MAXDPD
```

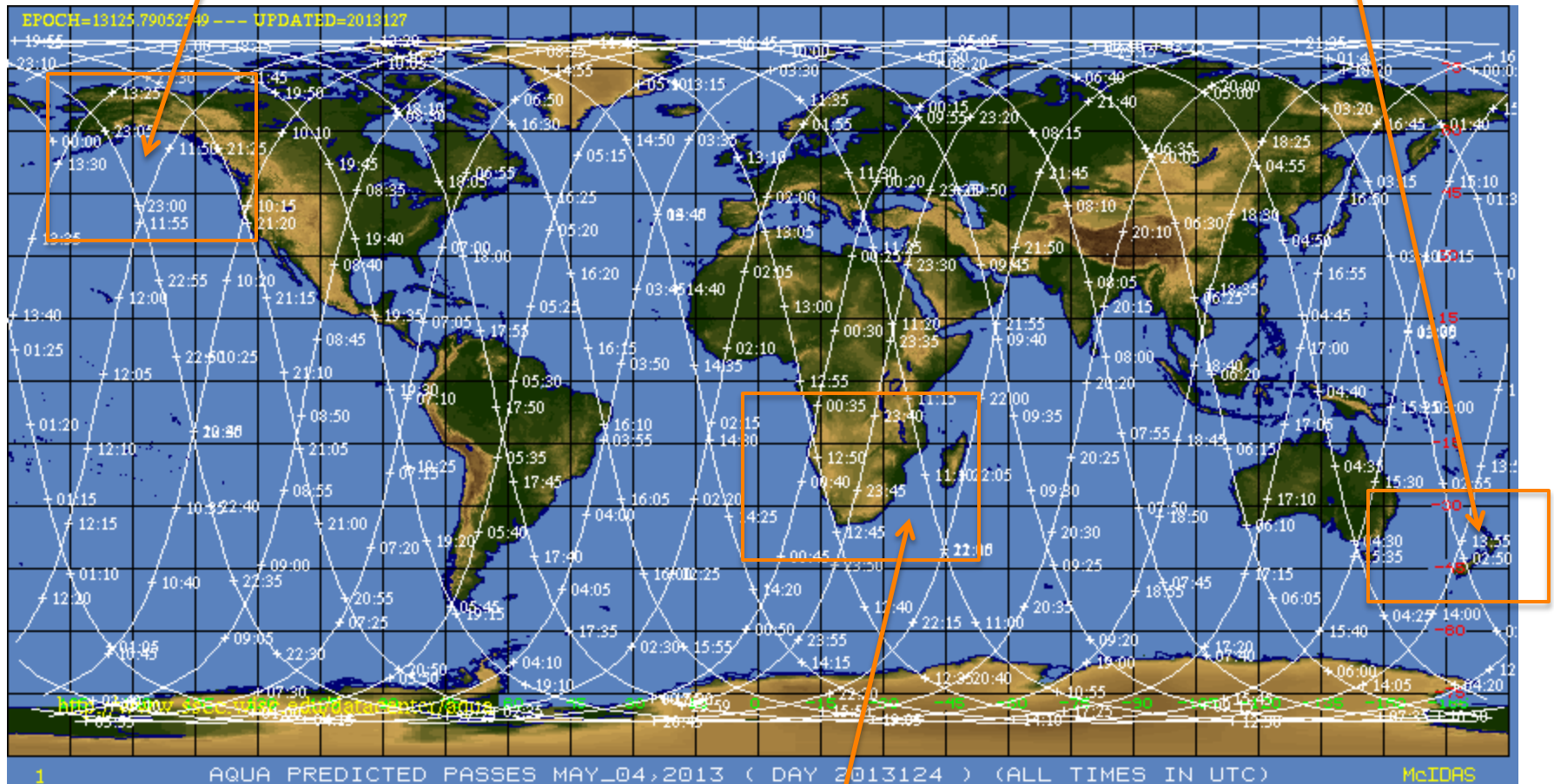
- ▧ accumulated precipitation
- ▧ planetary boundary layer height
- ▧ surface pressure
- ▧ tropopause pressure
- ▧ zonal wind at 500 mb
- ▧ zonal wind at 700 mb
- ▧ zonal wind at 850 mb
- ▧ meridional wind at 500 mb
- ▧ meridional wind at 700 mb
- ▧ meridional wind at 850 mb
- ▧ surface geopotential height



# Works everywhere (but projection not good for polar regions)

Domain spans UTC  
yesterday/today

Domain spans dateline



Domain spans 12Z

# Updated browser software (tabs, zoom, pan)

<http://cimss.ssec.wisc.edu/imapp-jsani-test/idea-i/aqua/test.html>

Optionally, you can use additional sub-folders to organize the data folders under the top level folder specified by "dataDir". Example:

```
products
  satellite_1
    region_1
      20120105
        images ...
      20120107
        images ...
    region_2
      20120105
        images ...
      20120107
        images ...
  satellite_2
  and so on ...
```

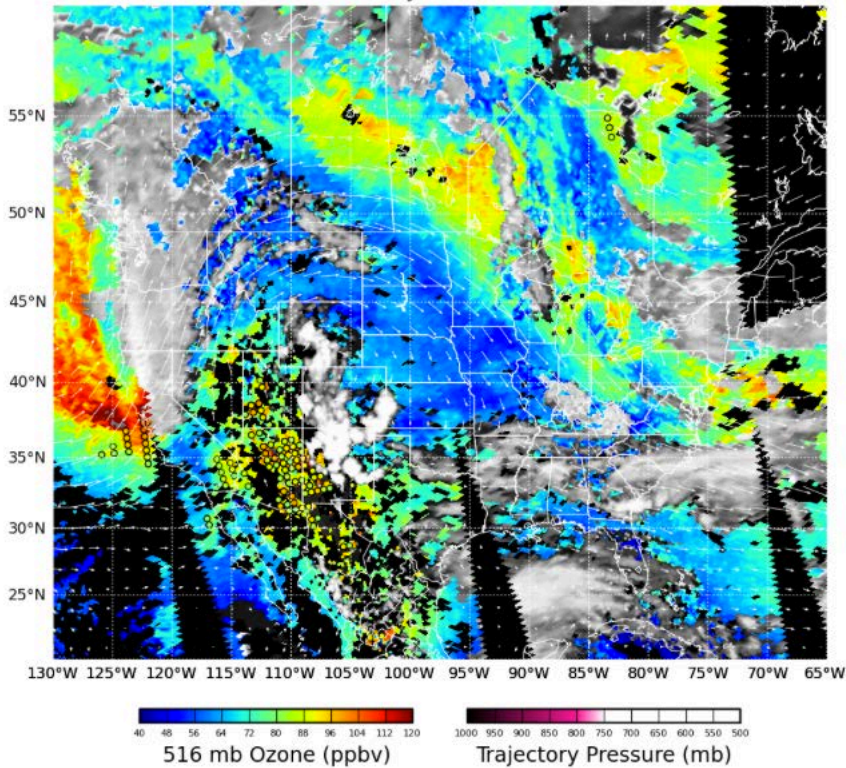
Satellite:  AIRS  CrIS  IASI

Forward Trajectory Forecast

Satellite:  AIRS  CrIS  IASI » Date: 04-Jun-2012

< play > rock slower faster

CrIS Ozone & Ozone Trajectories on 2012-06-04 12Z



\$ tree -d products  
products

- |-- AIRS
- | |-- 20120604
- | |-- 20120605
- | |-- 20120606
- | `-- 20120607
- |-- CrIS
- | |-- 20120514
- | |-- 20120604
- | |-- 20120605
- | |-- 20120606
- | `-- 20120607
- `-- IASI
- |-- 20120604
- |-- 20120605
- |-- 20120606
- `-- 20120607

Could also include night as well as day – i.e. 6 looks per 24 hours!



# Final Comments

- ❑ Leveraged the development of IDEA-I for high aerosol event forward trajectories to apply to stratospheric inclusions (SI) of high ozone concentrations.
- ❑ Ozone profile retrievals are/will be part of IMAPP/CSPP
- ❑ Updated web software for multi-tab display (which means one could configure for night/day, or by sensor, or by product, ...)
- ❑ Reduced the memory footprint (for this application it climbed to 1.5Gb+ but code refactor got us to ~850 Mb)
- ❑ For next release (summer 2013): Some validation, check global coverage still works, sensor and product in netCDF filenames, add VIIRS EDR aerosol product, add selection criteria rules and image resolution options.
- ❑ **Onwards?** High CO trajectories to identify inter-continental transport and wildfires, FHS initialization (maybe by next release).