Strong influences of Land Use Land Cover characterization on National Air Quality Forecast Capability (NAQFC)

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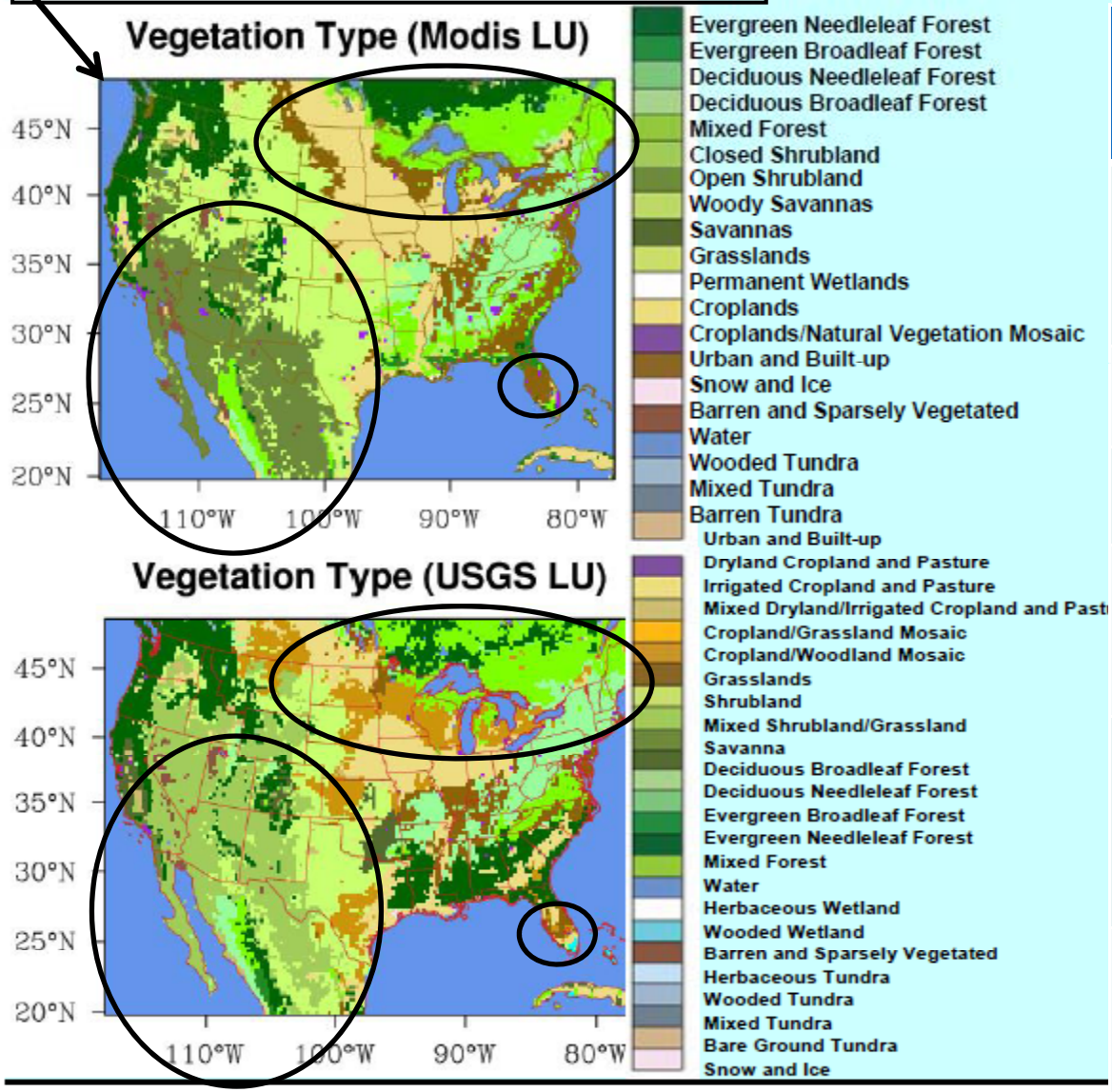
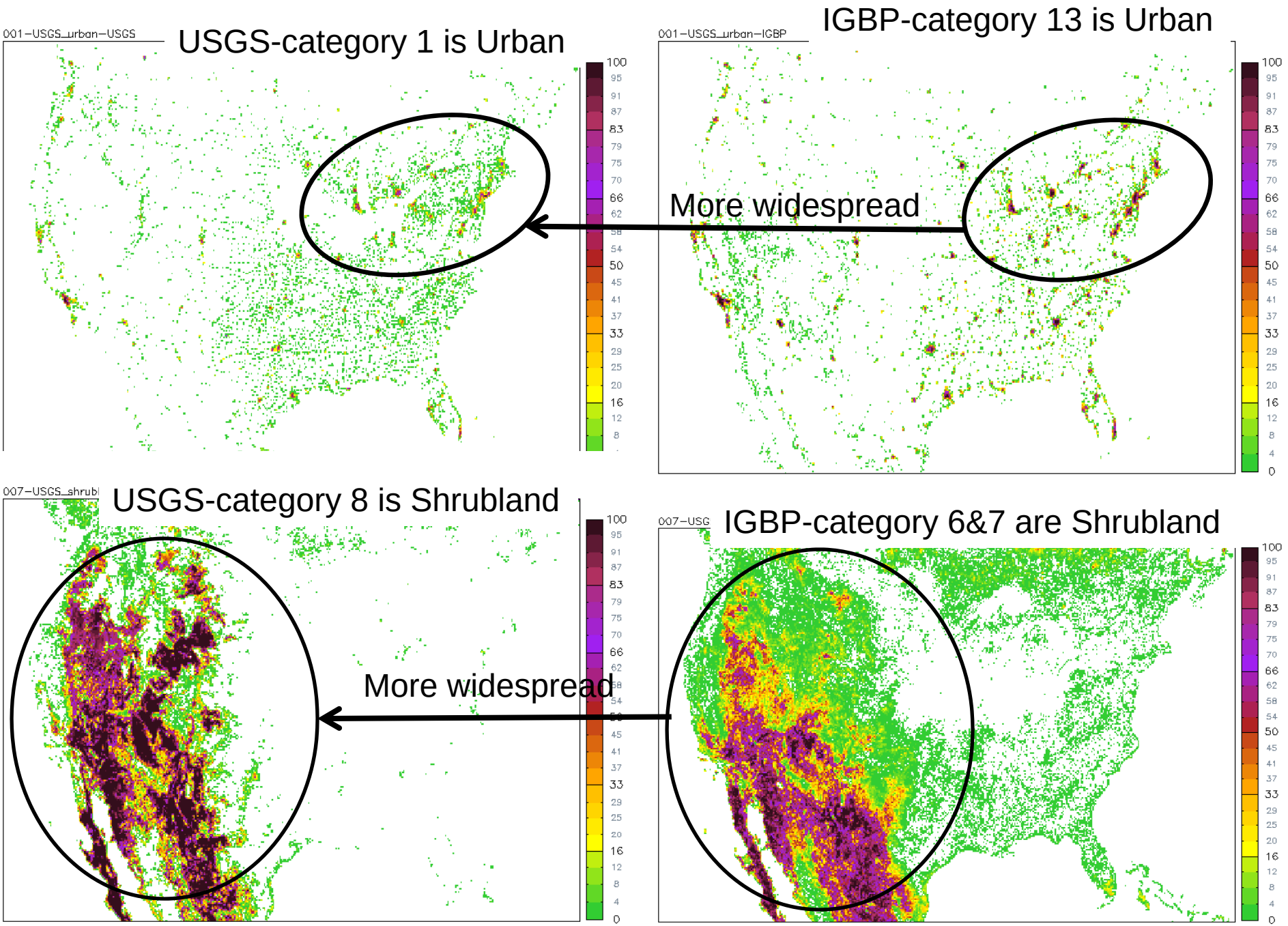
Modis Vs USGS Landuse

Implemented in NAM Oct 18th 2011



Classified Scheme	IGBP	USGS
Satellite Instr.	MODIS 2001-2005	AVHRR 1992-1993
Coastline	detailed	
Urban	More	
Evergreen	More in Alaska & Canada	More in SE of US
Deciduous Broadleaf		More
Shrubland	More	


001-USGS_urban-USGS
USGS-category 1 is Urban
001-USGS_urban-IGBP
IGBP-category 13 is Urban
More widespread
007-USGS_shrubl
USGS-category 8 is Shrubland
007-USG
IGBP-category 6&7 are Shrubland
More widespread
100
95
91
87
83
79
75
70
66
62
58
54
50
45
41
37
33
29
25
20
16
12
8
4
0

NAQFC versions of CMAQ is hardwired to USGS-LULC

IGBP category used in NAM is mapped to USGS category

	IGBP			USGS
1	Evergreen Needleleaf Forests		14	Evergreen Needleleaf Forest
2	Evergreen Broadleaf Forest		13	Evergreen Broadleaf Forests
3	Deciduous Needleleaf Forests		12	Deciduous Needleleaf forest
4	Deciduous Broadleaf Forests		11	Deciduous broadleaf forest
5	Mixed Forests		15	Mixed forest
6	Closed Shrublands		8	shrublands
7	Open Shrublands		8	Shrublands
8	Woody Savannas		10	Savanna
9	Savannas		10	Savanna
10	Grasslands		7	Grassland
11	Permanent Wetlands		17	Herbaceous wetland
12	Croplands		2	Dryland cropland and pasture
13	Urban and built-up lands		1	Urban and built-up land
14	Cropland/Natural		5	Cropland/grassland mosaic
15	Snow and Ice		24	Snow or ice
16	Barren		19	Barren or sparsely vegetated
17	Water Bodies		16	Water bodies
18	Wooded Tundra		21	Wooded tundra
19	Mixed Tundara		22	Mixed tundara
20	Bare Ground Tundra		23	Bare ground tundra

Advantages

GLOBAL CHANGE IGBP International Geosphere-Biosphere Programme

AQ-forecasting Perspective:

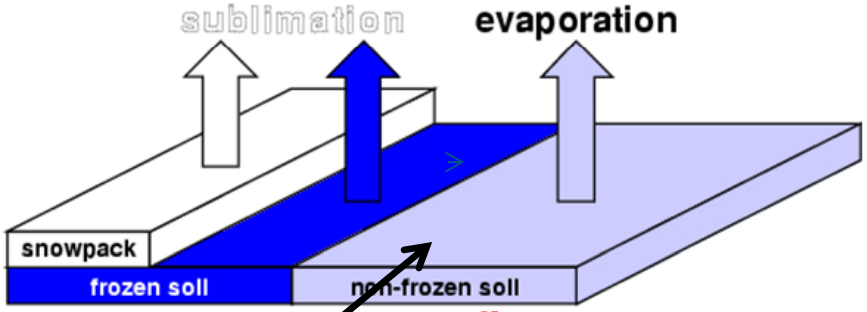
Data harmony with ***international climate*** **research programs**
Monthly fractional green vegetation cover associate with IGBP classes

Science issues to be examined:

- **Sensible & latent fluxes between surface and air:**
- **Soil skin temperature, urban heat-island,…**
- **Soil thermo-conductivity is strongly dependent (mineral composition)**
- **Radiative (Albedo,…) e.g snow-cover**
- **Temperature, RH, PBL modifications in the lowest model layers**

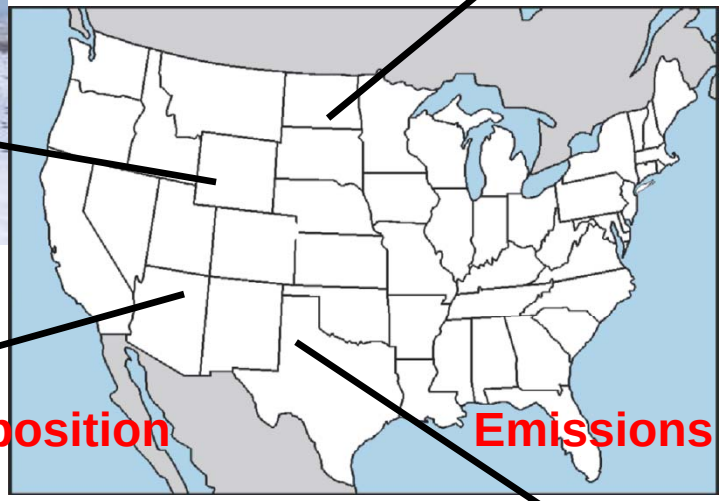
- **Greenness fraction more rapid updates from MODIS**
- **Dry deposition velocities modifications**
- **Emission modifications (Guenther eq,…)**

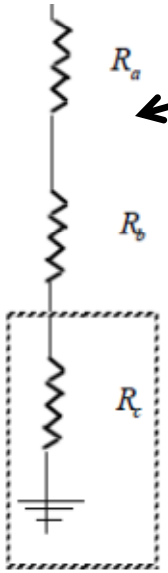
LULC categories change in NAM will impact NAQFC



Heat fluxes

Albedo





Dry deposition

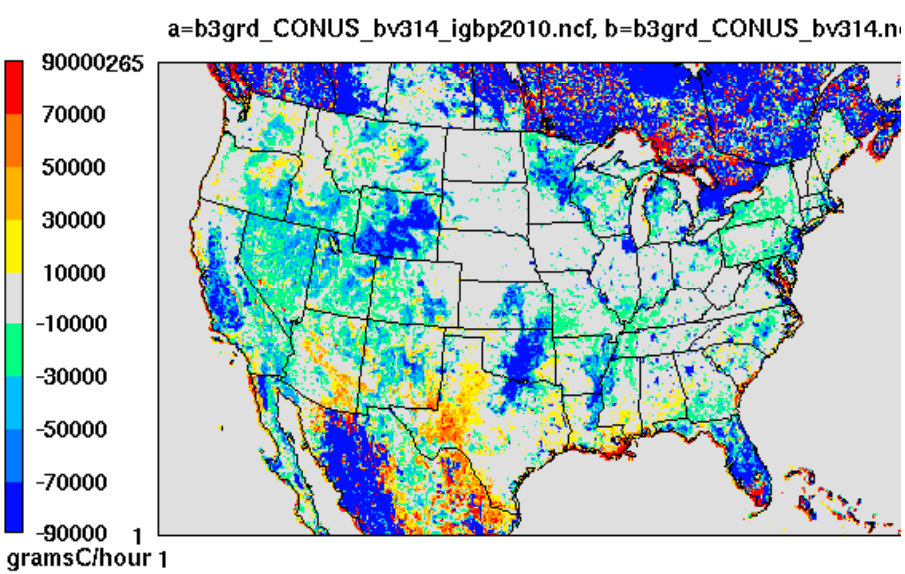
Emissions e.g. Biogenic

Guenther equation:

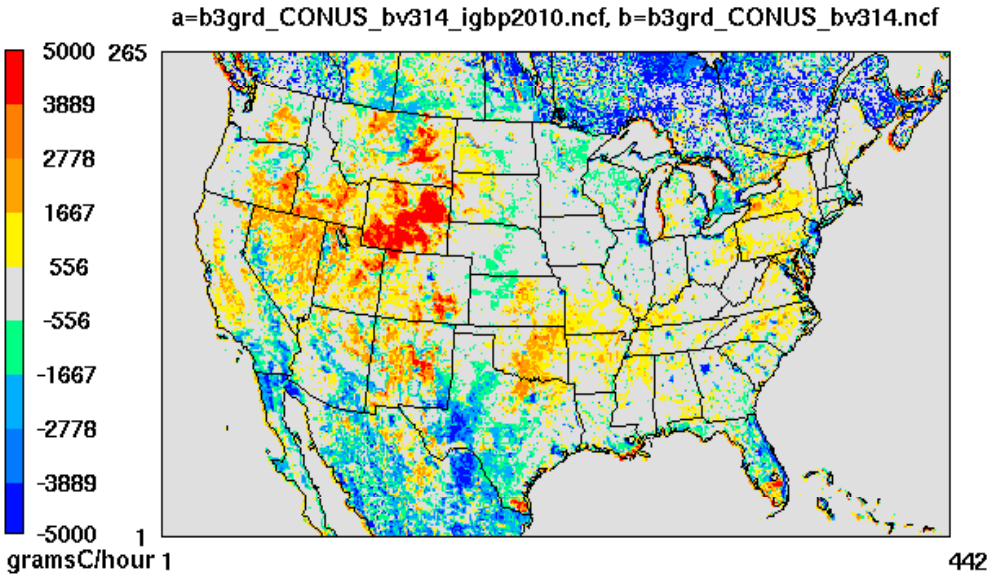
$$C_L = \frac{\alpha c_{L1} L}{\sqrt{1 + \alpha^2 L^2}}$$

α = 0.0027 in Guenther et al. (1993); now is 0.001 in BEIS;
C_{L1} = 1.066 in Guenther et al. (1993); now is 1.42 in BEIS;
L is PAR flux (umol m^{-2} s^{-1});

ISOP Summer: IGBP-USGS

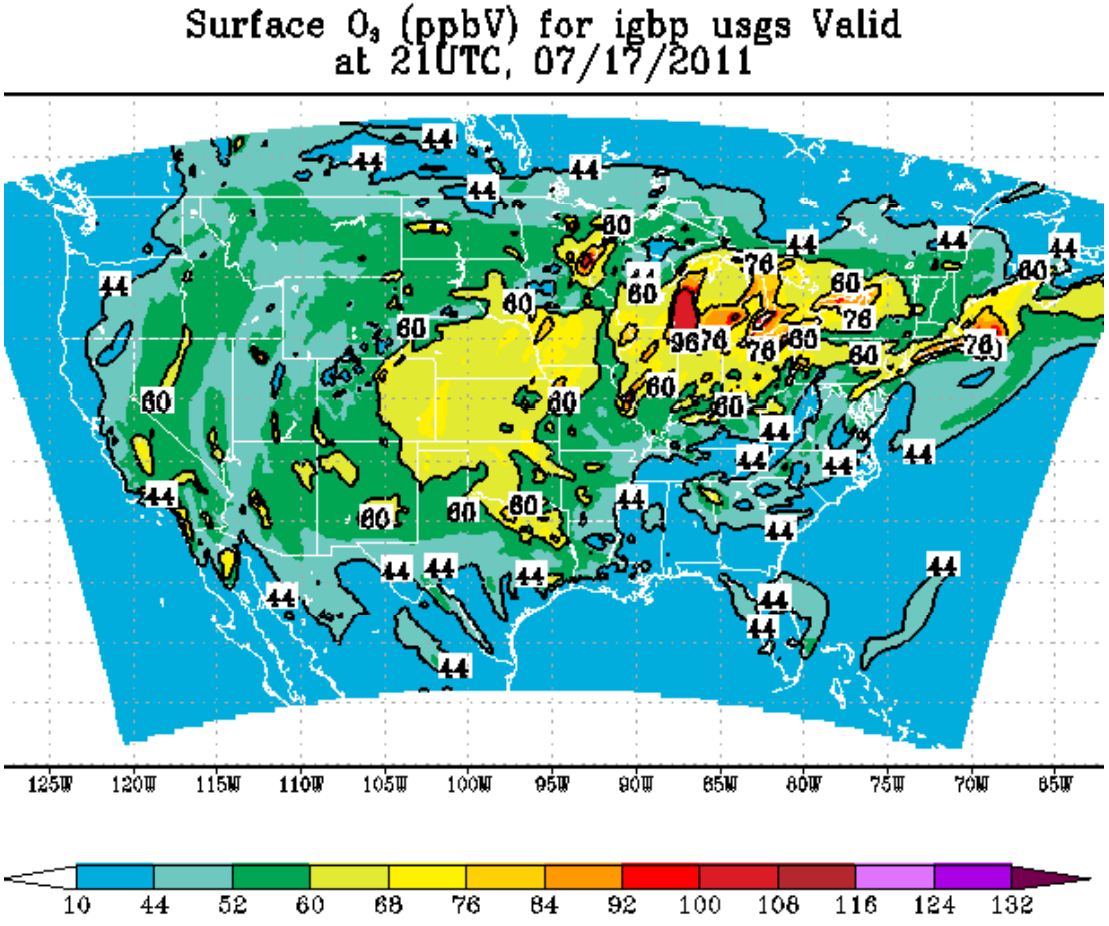


Sesquiterpene: IGBP-USGS



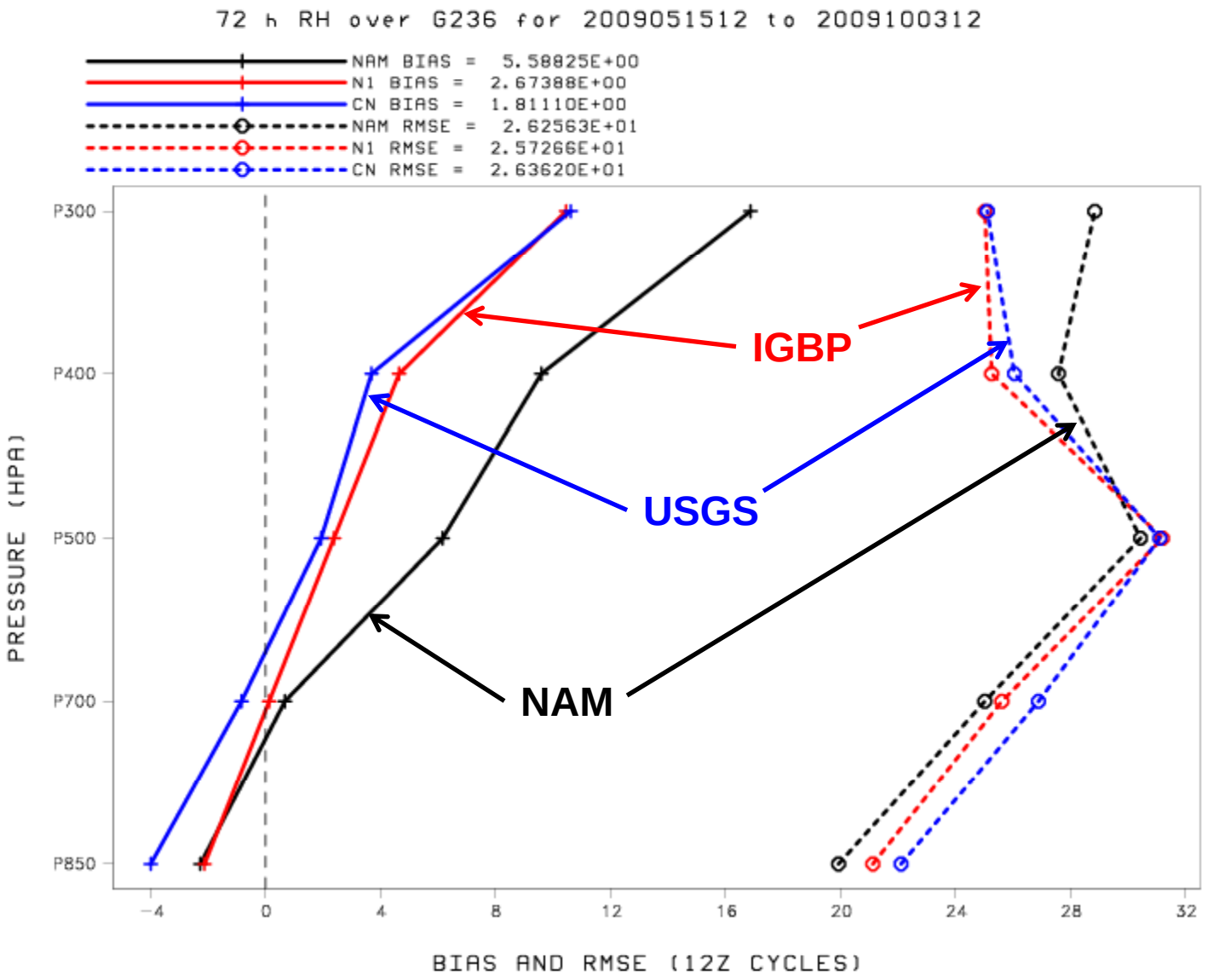
Changes in Isoprene and sesquiterpene emission expressed as normalized emission factor for summer, 2010 (Gram-C $hour^{-1}km^{-2}$)

- **NMMB**
  - 706 x 583 horizontal grid points, 60 vertical layers, 12 km horizontal resolution
  - GFDL radiation, Betts-Miller-Janjic convection, Ferrier microphysics, Mellor-Yamada-Janjic turbulence closure and surface layer schemes, Noah LSM
- **CMAQ 4.6 in NAQFC-Expr**
  - 442 x 265 horizontal grid points, 12 km horizontal resolution, 22 vertical layers
  - CB05 gas-phase & Aero-4 aerosol chemistry
- **Emissions**
  - NEI 2005
  - BEIS v3.10
- **Studying period**
  - July 1st ~ July 31, 2011
- **Verification: FVS (grid2obs)**
  - All available met observational data
  - Airnow data



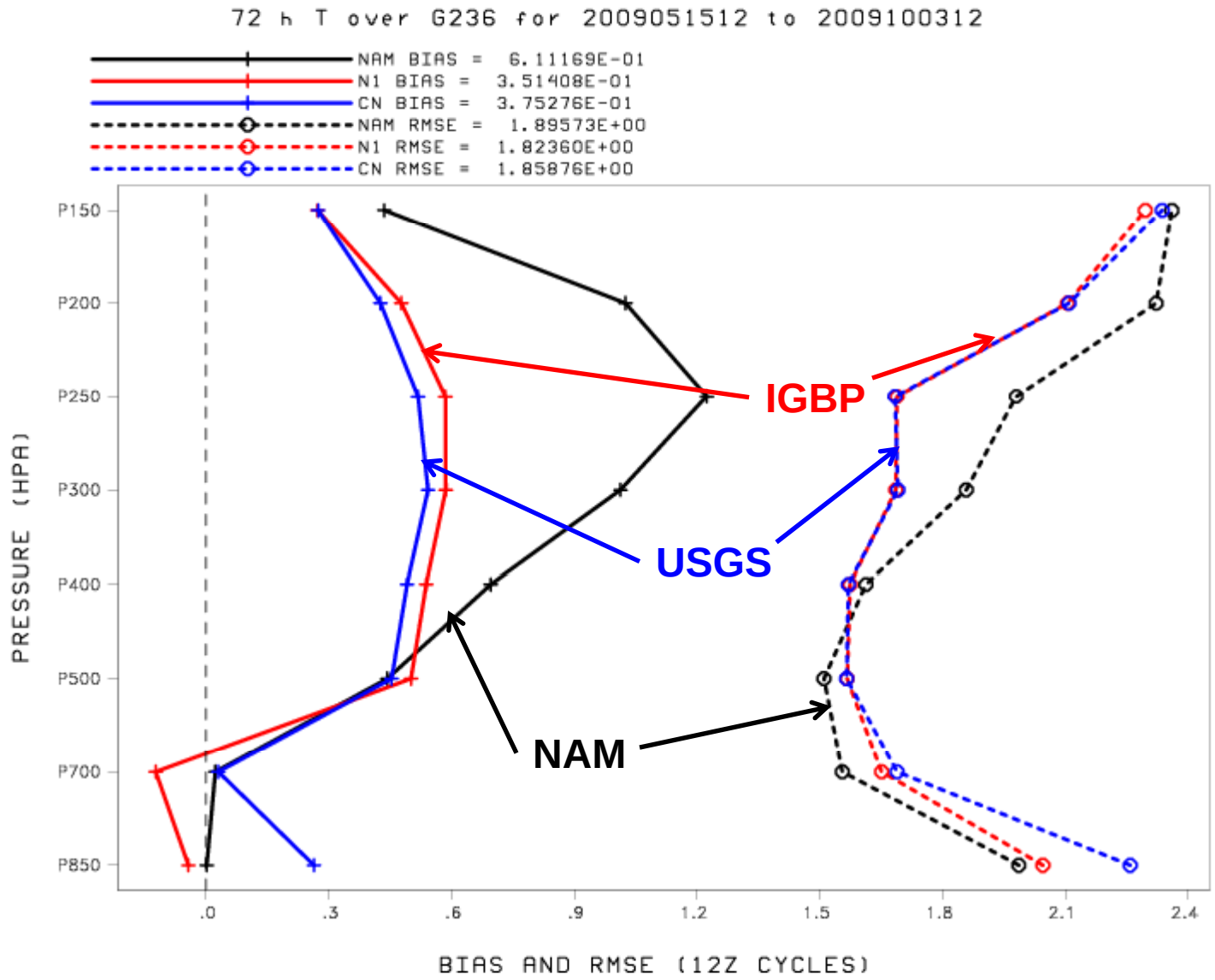
Model-predicted hourly avg surface O_3

Relative Humidity Bias & Root-mean-square Error



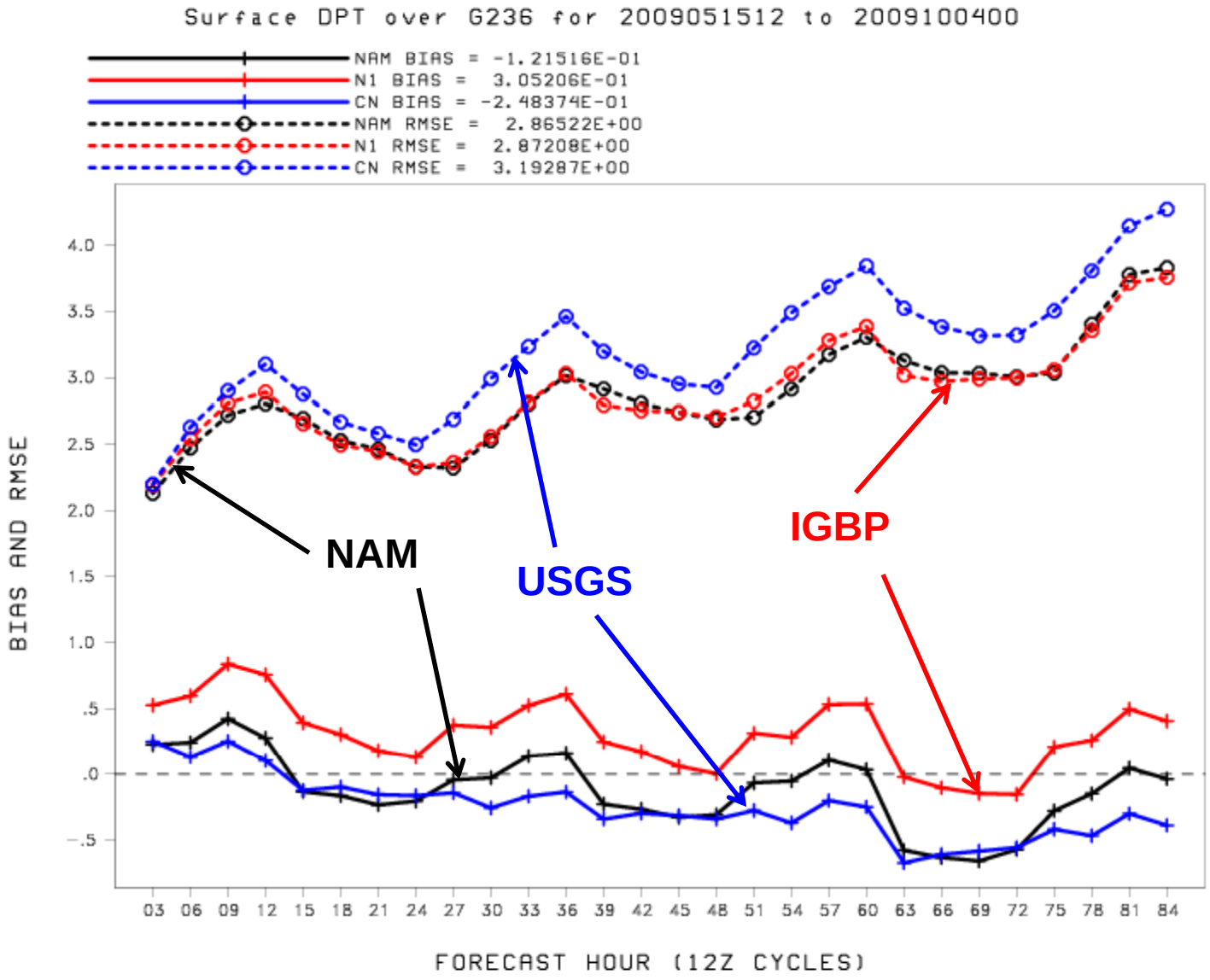
Courtesy: Vince Wong and Mike Ek (NCEP)

Temperature Bias & Root-mean-square Error



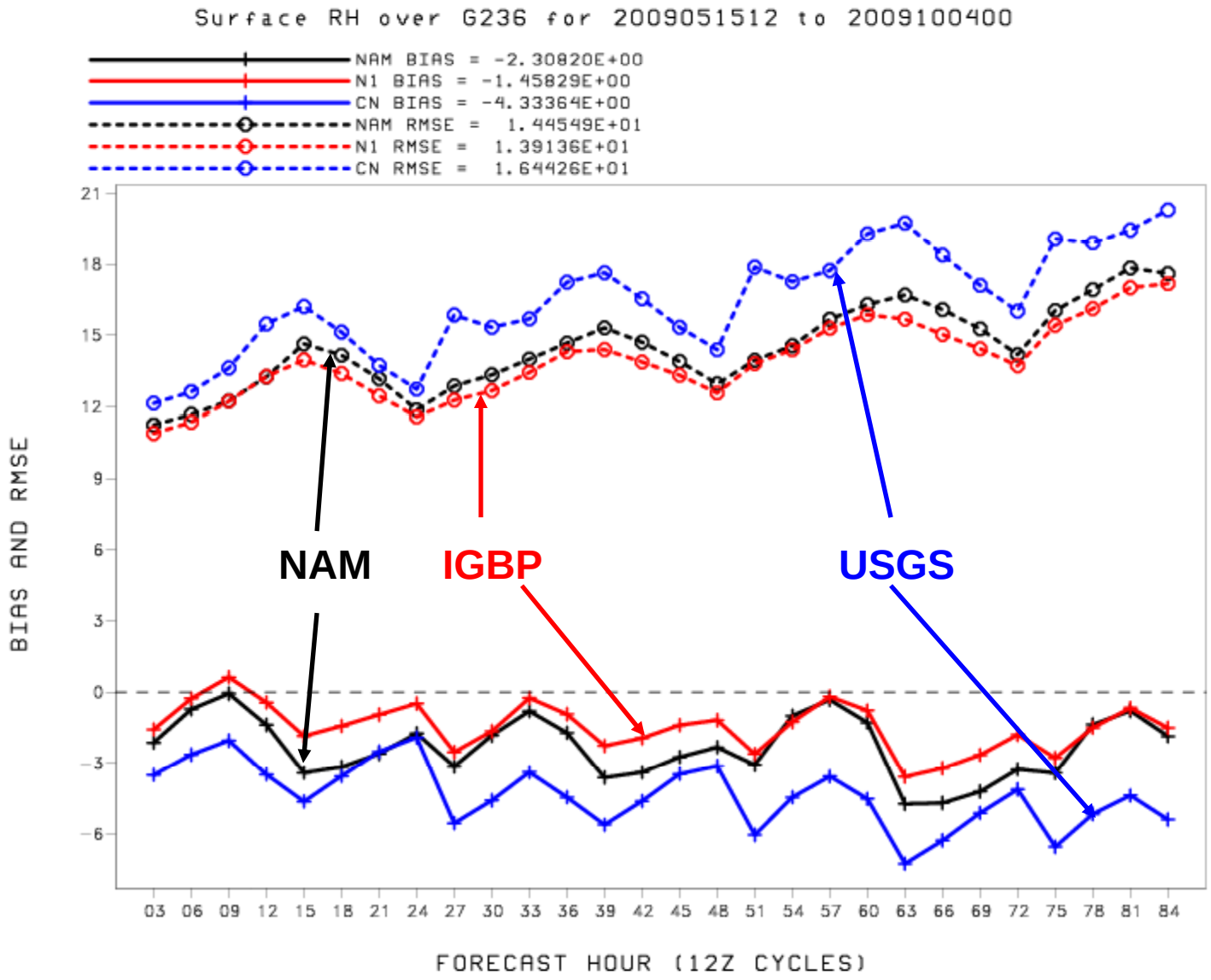
Courtesy: Vince Wong and Mike Ek (NCEP)

Surface Dew Point Temperature Bias & Root-mean-square Error



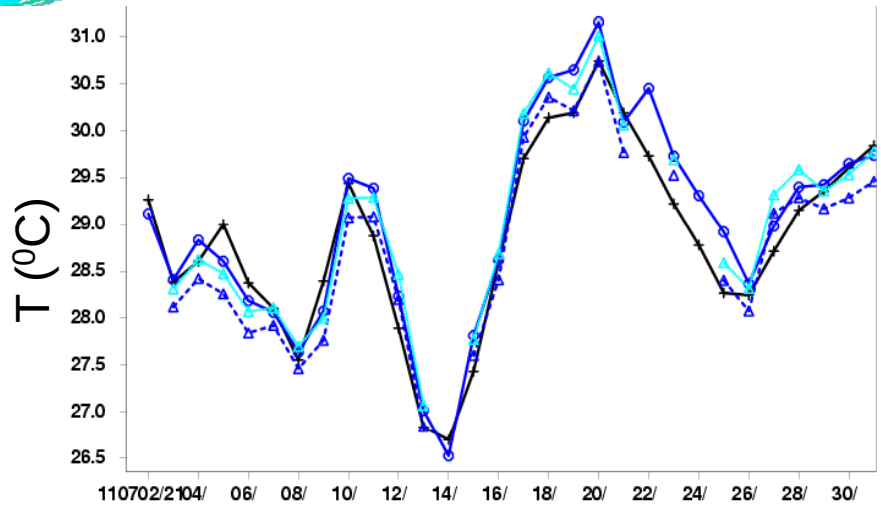
Courtesy: Vince Wong and Mike Ek (NCEP)

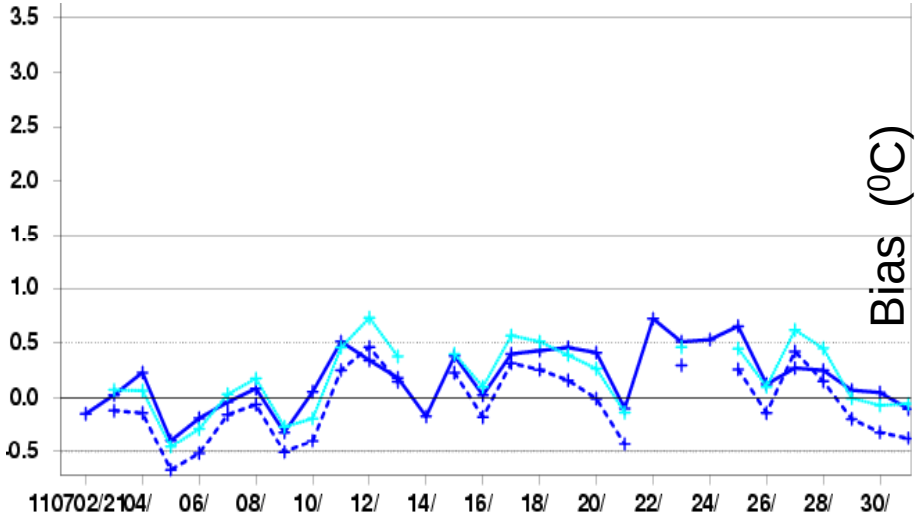
Surface Relative Humidity Bias & Root-mean-square Error

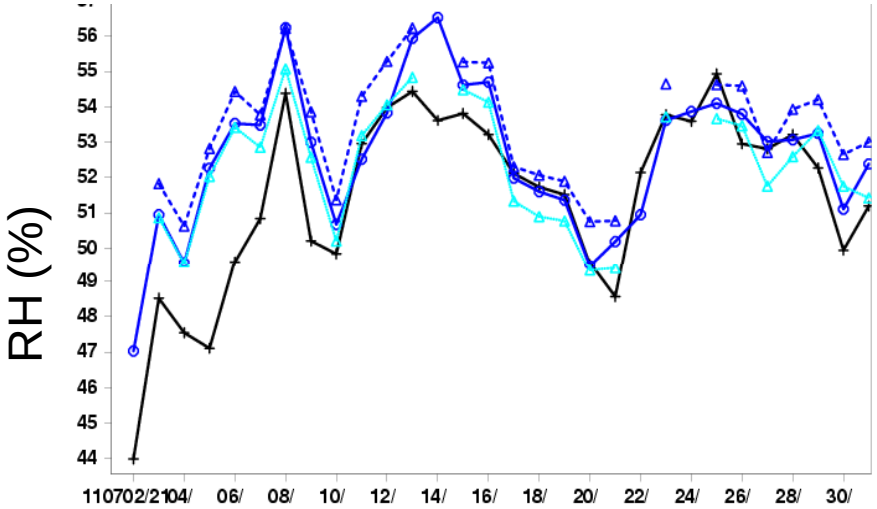


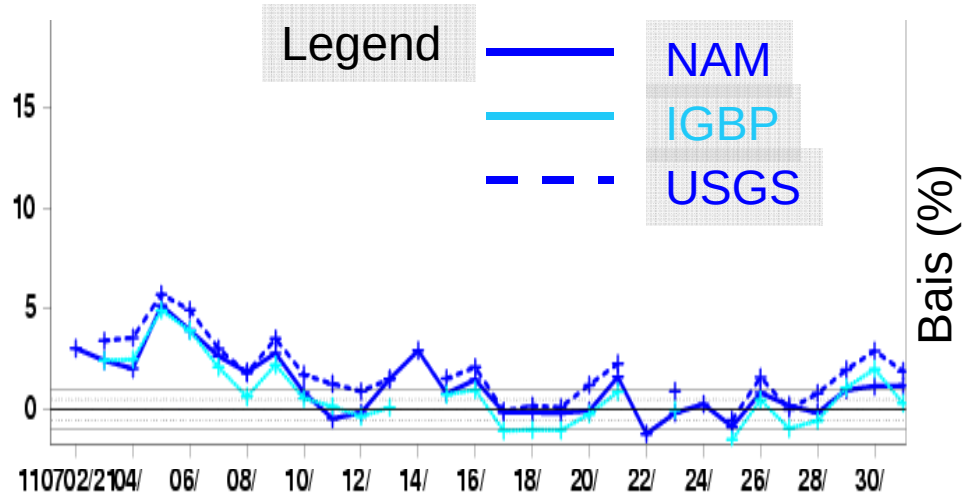
Courtesy: Vince Wong and Mike Ek (NCEP)

MET inputs for July 2011





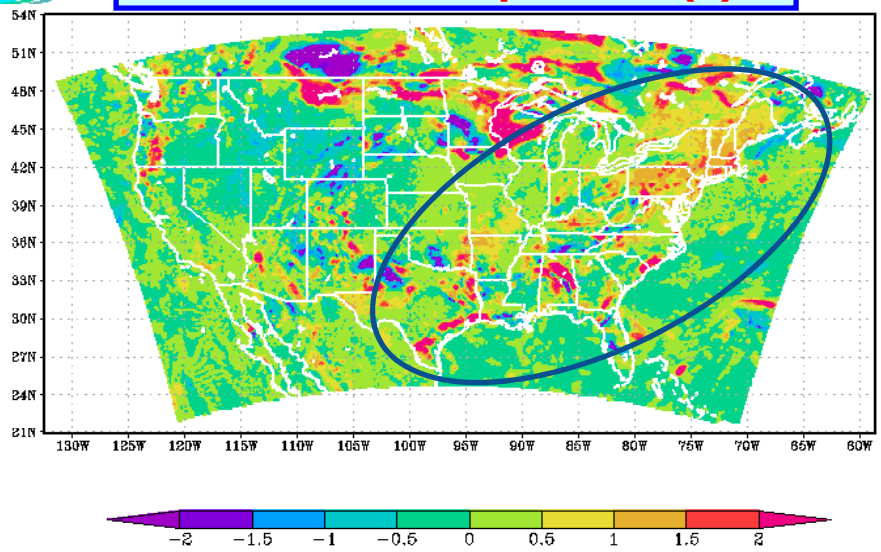




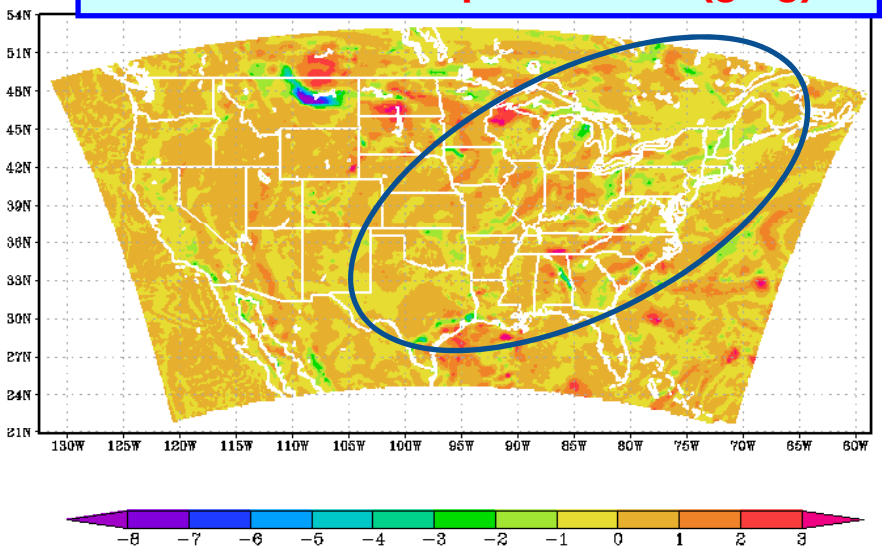
LULC changes met inputs

At 21 UTC July 17, 2011

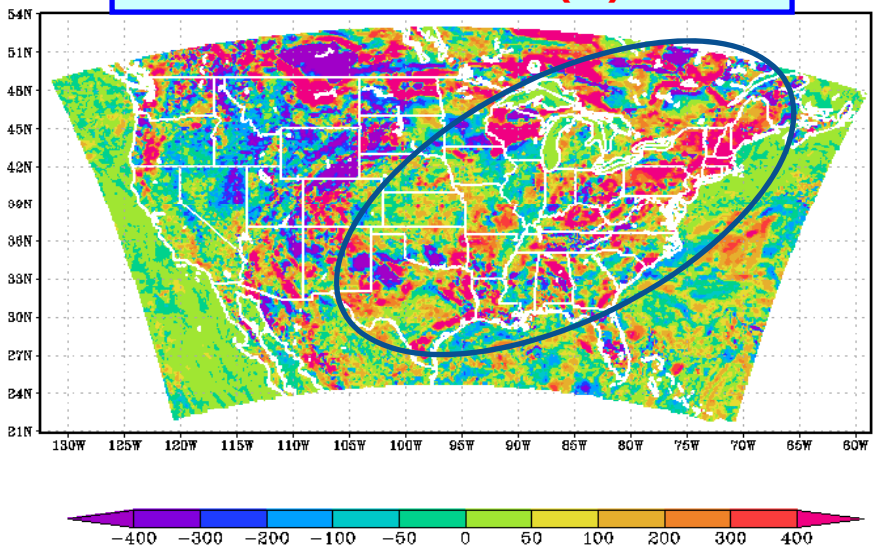
Diff. of air temp at 2m (k)



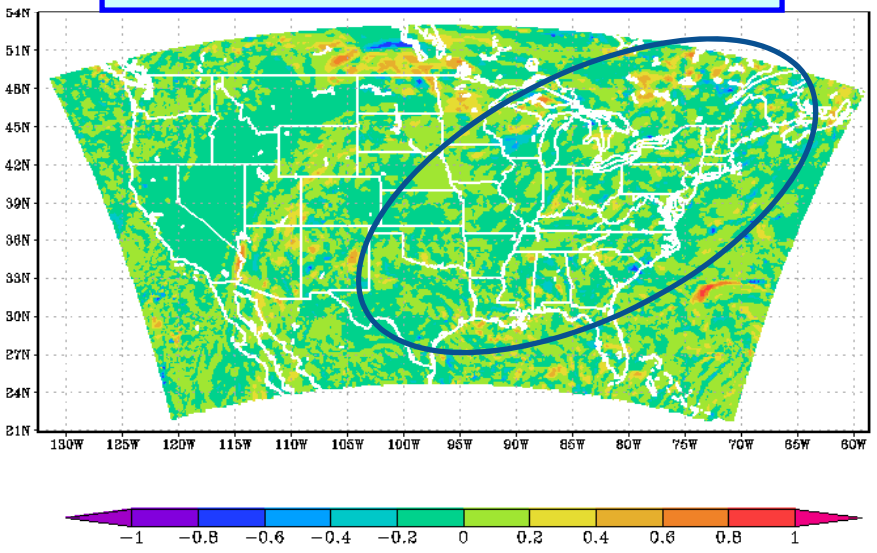
Diff. of water vapor at lev 1 (g/kg)



Diff. of PBLH (m)



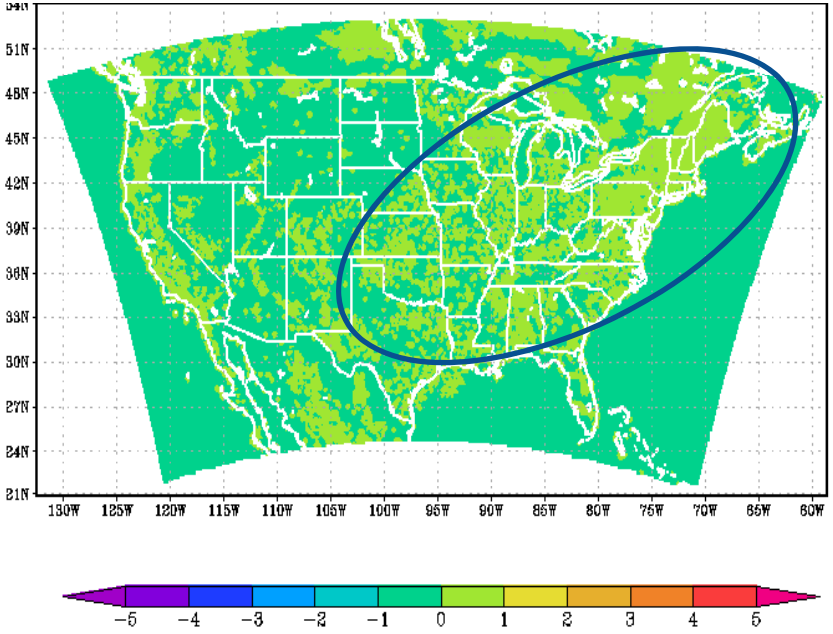
Diff. of total cloud fraction



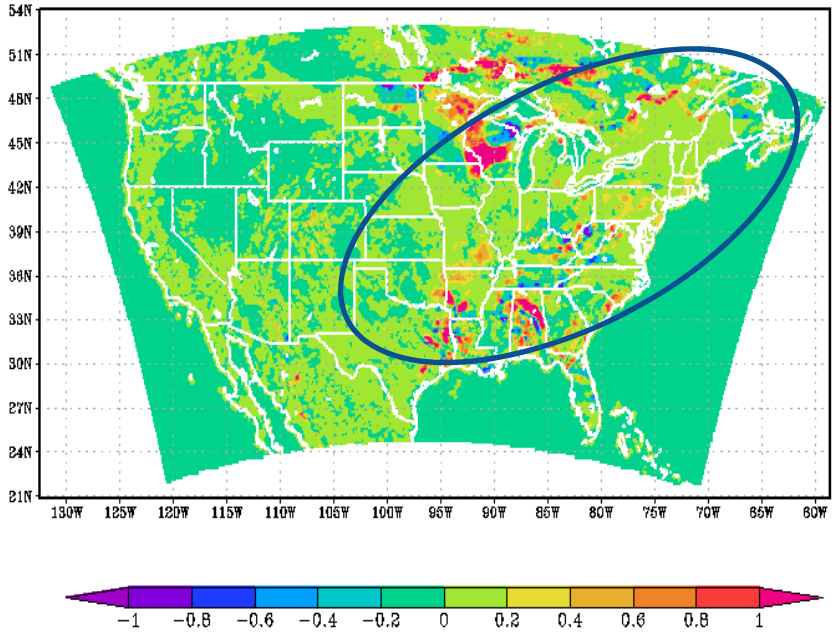
LULC changes emissions

At 21 UTC July 17, 2011

Diff. of NO emission (mole/s)



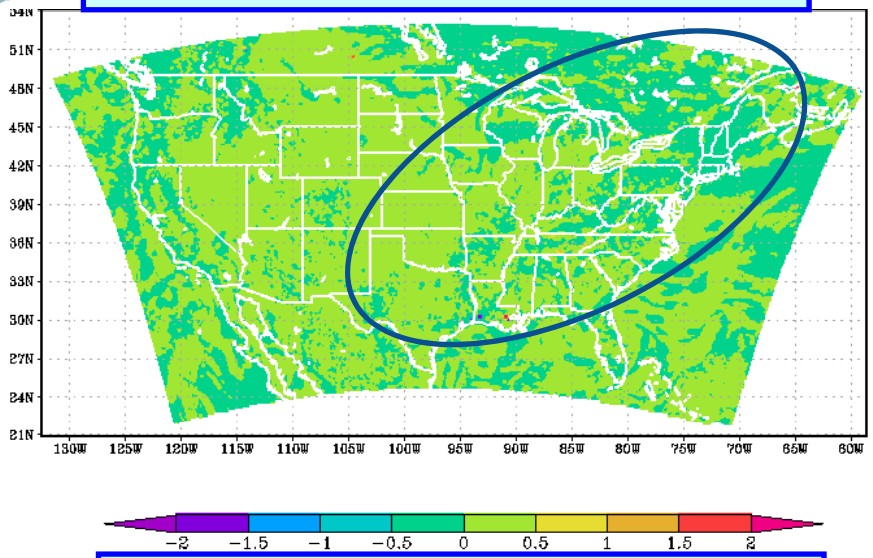
Diff. of isoprene emission (mole/s)



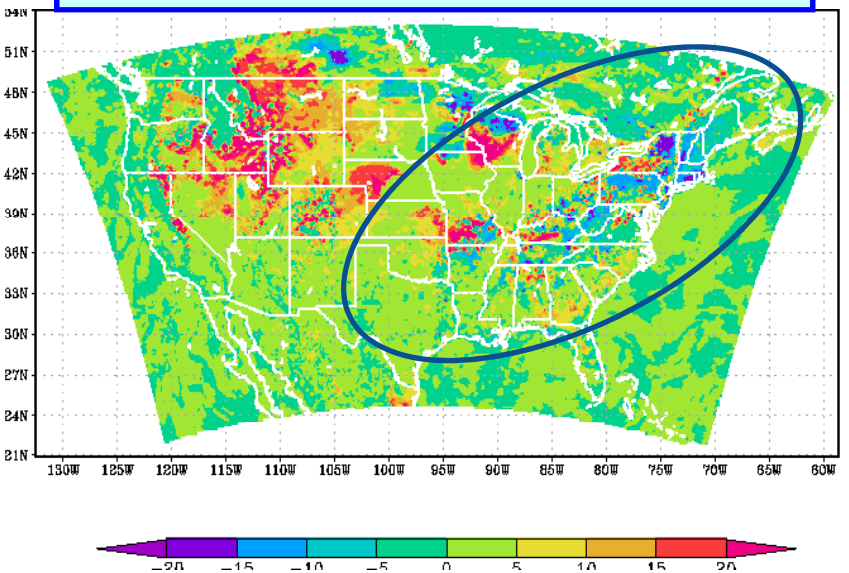
LULC changes dry deposition

At 21 UTC July 17, 2011

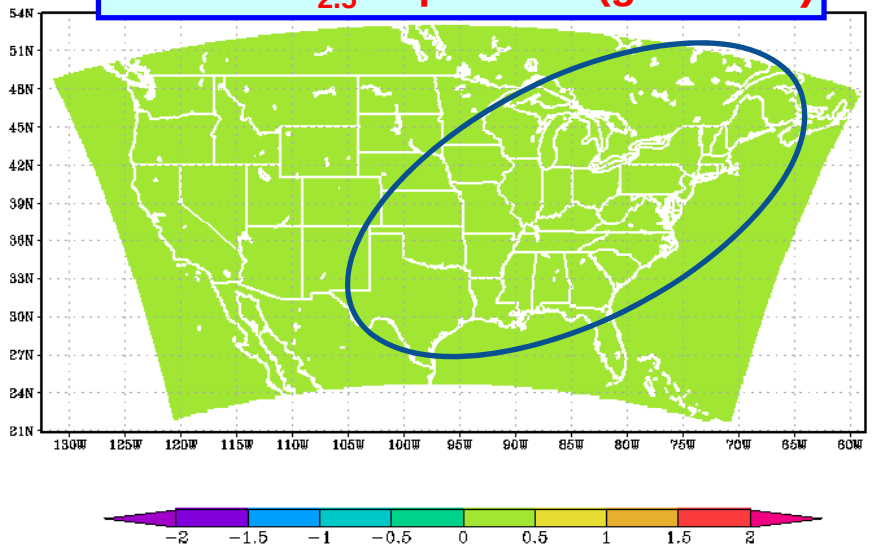
Diff. of NO_x deposition (g/hectare)



Diff. of O_3 deposition (g/hectare)



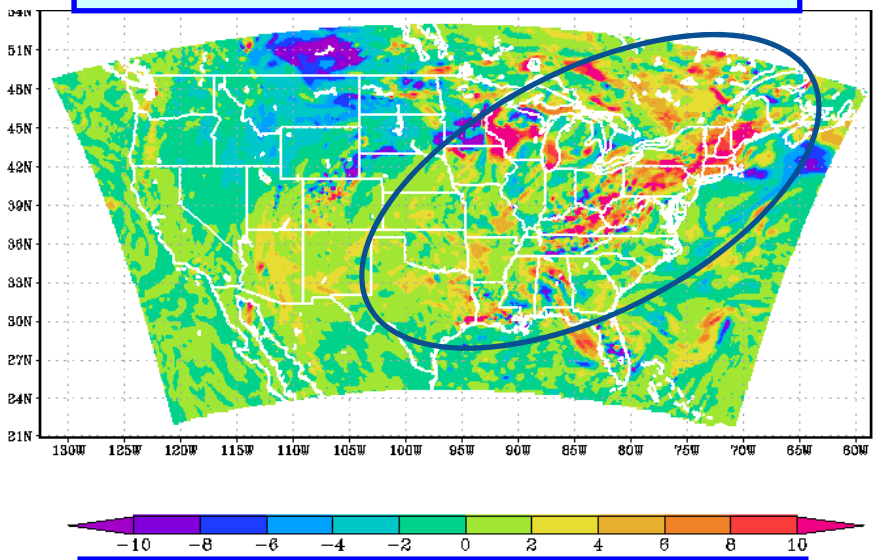
Diff. of $PM_{2.5}$ deposition (g/hectare)



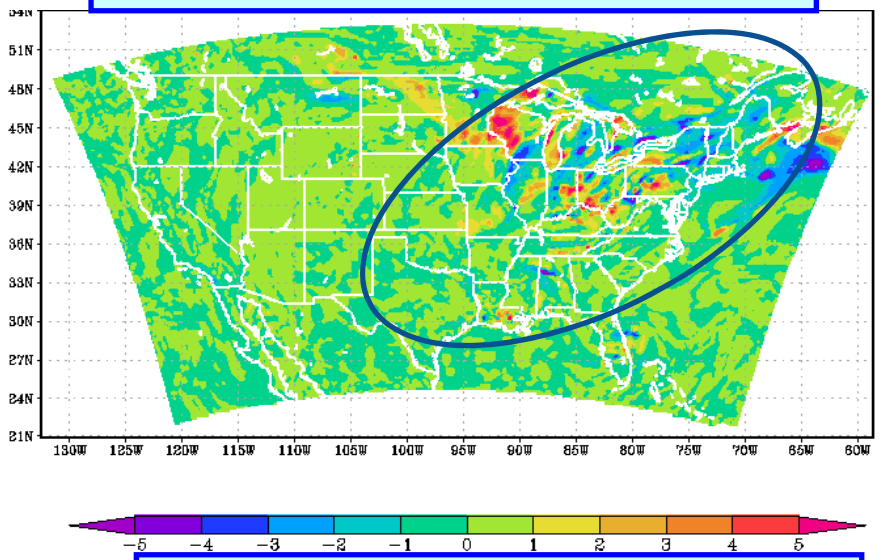
LULC changes dry deposition

At 21 UTC July 17, 2011

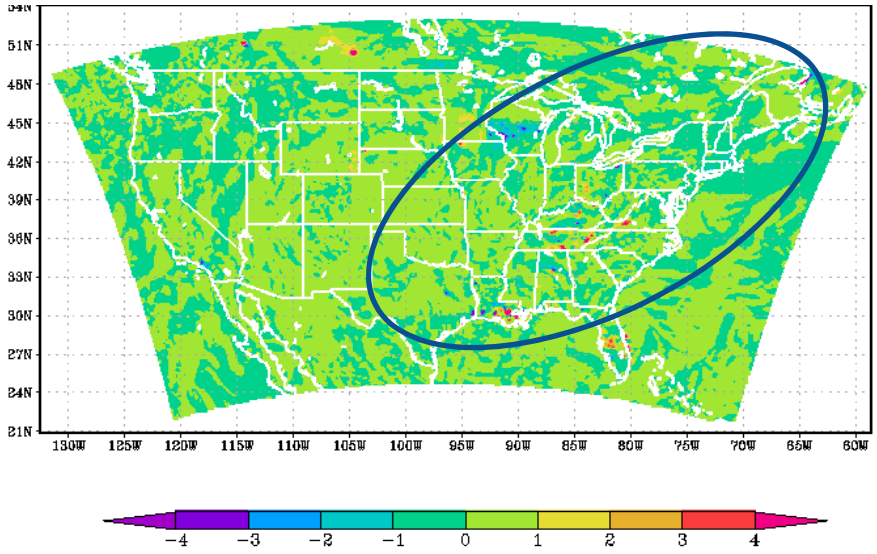
Diff. of surface O_3 (ppb)



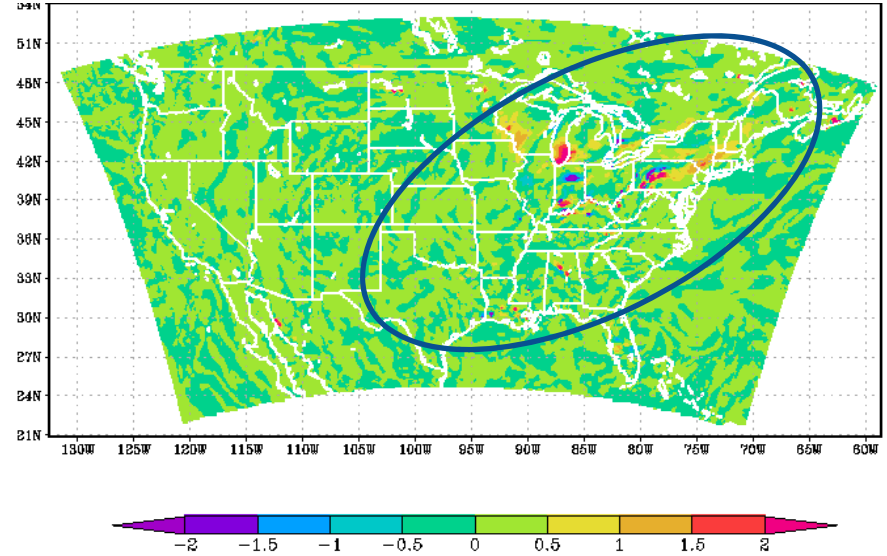
Diff. of surface PM2.5 (ug/km^3)



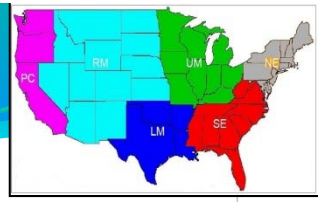
Diff. of surface NO_2 (ppb)

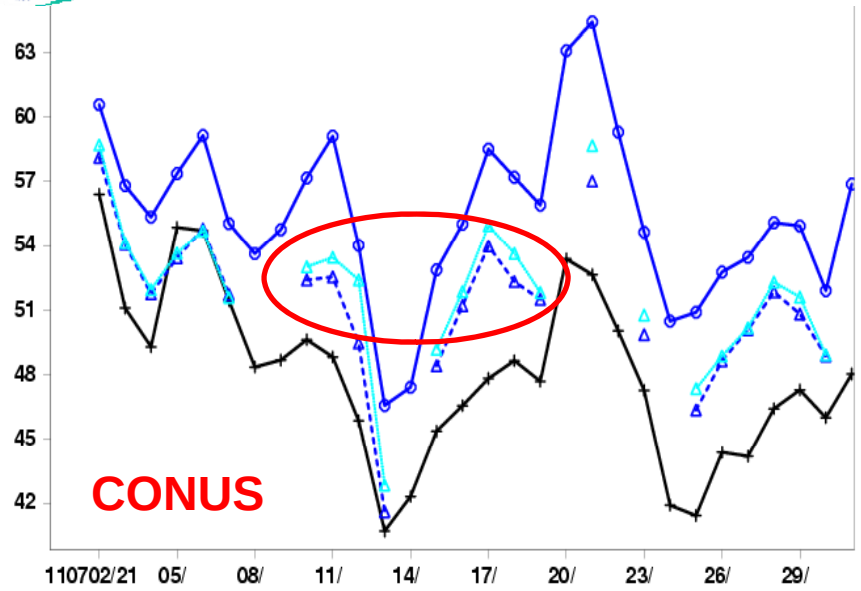


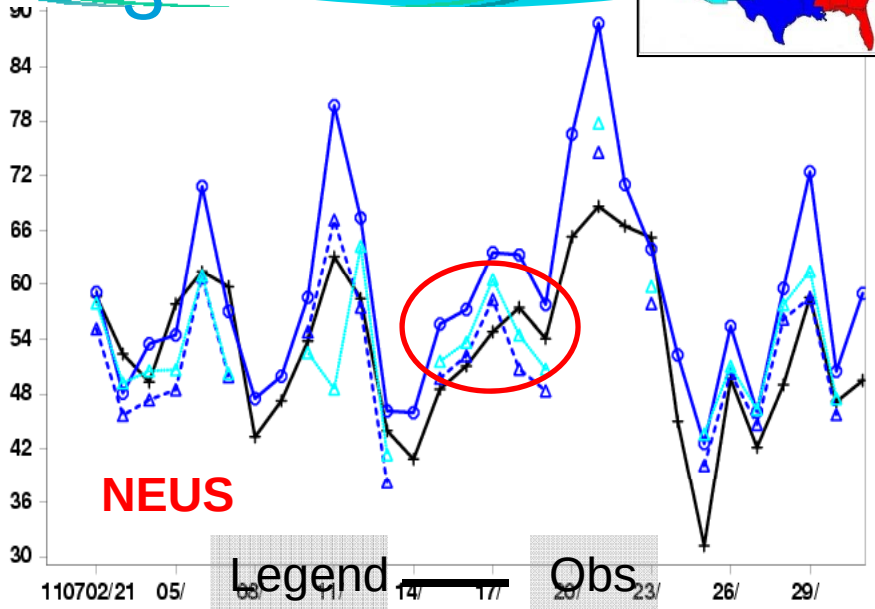
Diff. of surface SO_2 (ppb)

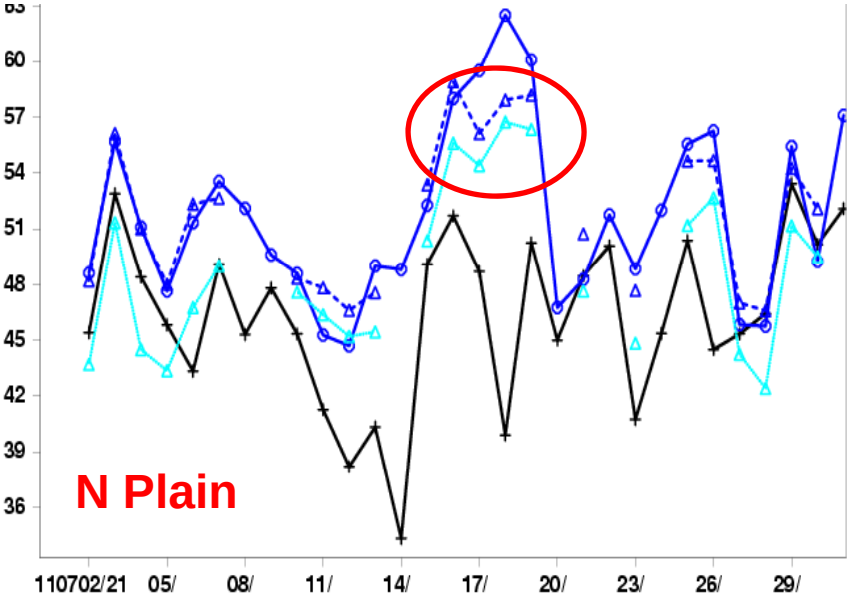


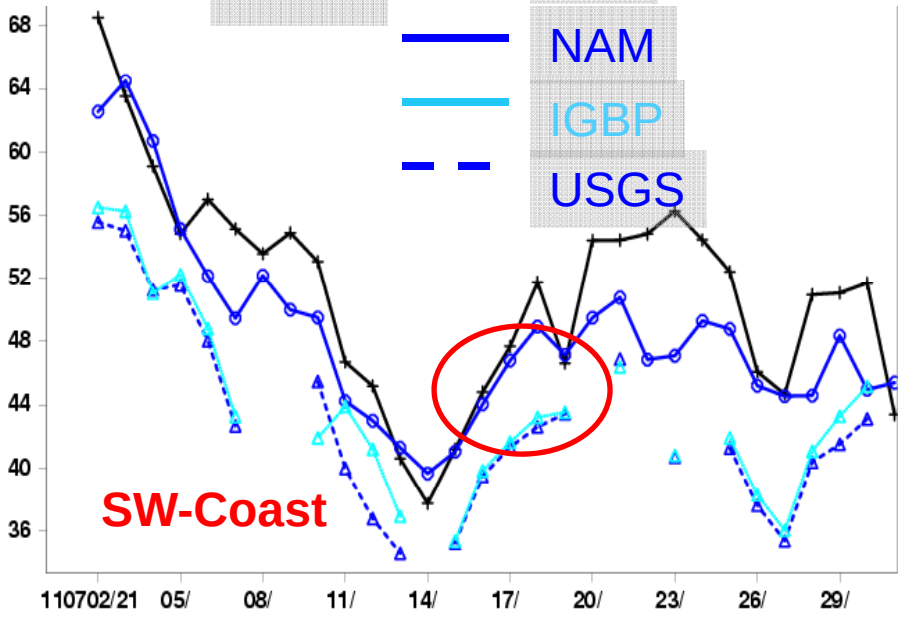
Verification of O_3 forecast











Legend
Obs
NAM
IGBP
USGS

Summary

MODIS-based IGBP LULC category was adopted into NWS's NAM on Oct18, 2011. This study examines the advantages and implications of this change.

- IGBP data have more urban area as it was a more recent data set. There are species changes esp. crops in Central Plains & Shrubland in West.
- July 2011 Retrospective Run – A pre-implementation testing:

1. For predicted met variables, heat-related variables such as surface heat fluxes, temperature, PBLH are more sensitive to LULC characteristics than moisture-related variables such as water vapor and cloud fraction. In general, the IGBP-based run predicts higher surface fluxes, 2 m temperature, higher water vapor mixing ratio, and higher PBLH than the USGS-based run.
2. Biogenic emissions (e.g., isoprene) are more sensitive to LULC characteristics than anthropogenic emissions such as NO_x.
3. For dry deposition, O_3 is more than sensitive to LULC than other species (e.g, NO_x and $PM_{2.5}$).
4. Met input variables exert different impacts on air quality predictions. Overall, the IGBP-based run has slightly higher O_3 prediction than the case with USGS-based run over CONUS. July 2011 represented a hot month. Its results of minimal impact in adopting the IGBP LULC categorization gives some upper-bound of the influences.