Development of Gridded Innovations and Observations supplement to MERRA-2

Michael Bosilovich and Arlindo da Silva

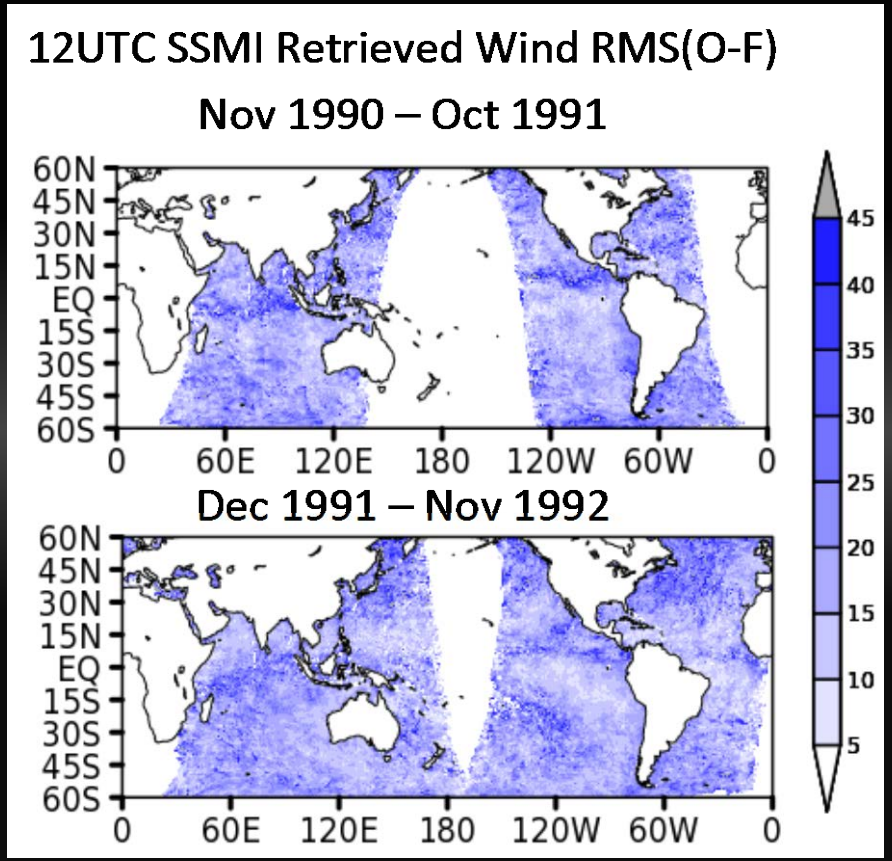
Acknowledgements: King-Sheng Teng, Rob Lucchesi, Will McCarty and Ron Gelaro

Atmospheric Reanalyses

- A retrospective quantitative analysis of meteorological observations (some systems include land, ocean, biology analysis)
- 3 Critical Components
  - Observations, provides reality, but the data is irregularly available in space and time, and many different types
  - Model, provides a complete and consistent background estimate and forecast
  - Data assimilation, considers the uncertainty of the model and obs data, merge for a forecast initial condition
- A global continuous representation of the atmosphere

Why grid the obs?

- "Are X observations assimilated at Y region during Z time period?"
- Global and regional assimilation statistics over almost 40 years
- Assess the consistency of the observation records
- Education – Students and non traditional users
- Reference data for comparing development systems
- Data Fusion?



Name	Dim	Description	Units
bang_gps	tzyx	GPSRO Bending Angle	1
ps_drift	tyx	DRIFTING BUOY: Surface Pressure	hPa
ps_land	tyx	LAND SURFACE: Surface pressure	hPa
ps_paob	tyx	PAOB SURFACE: Synthetic surface pressure	hPa
ps_raob	tyx	RADIOSONDE: Surface pressure	hPa
ps_sea	tyx	SEA SURFACE: Surface pressure	hPa
qv_acraft	tzyx	AIRCRAFT: Specific humidity	g/kg
qv_raob	tzyx	RADIOSONDE: Specific humidity	g/kg
qv_sea	tyx	SEA SURFACE: Specific humidity	g/kg
sst_sea	tyx	SEA SURFACE: Sea surface temperature	K
tv_acraft	tzyx	AIRCRAFT: Virtual temperature	K
tv_drift	tyx	DRIFTING BUOY: Virtual Temperature	K
tv_mls	tyx	MLS: Virtual Temperature	K
tv_raob	tzyx	RADIOSONDE: Virtual temperature	K
tv_sea	tyx	SEA SURFACE: Virtual temperature	K
u_acraft	tzyx	AIRCRAFT: Zonal wind	m/s
u_amv	tzyx	ATMOS MOTION VECTORS: Zonal wind	m/s
u_drift	tyx	DRIFTING BUOY: Zonal wind	m/s
u_prof	tzyx	PROFILER: Zonal wind	m/s
u_raob	tzyx	RADIOSONDE: Zonal wind	m/s
u_scat	tyx	SCATTEROMETER: Zonal wind	m/s
u_sea	tyx	SEA SURFACE: Zonal wind	m/s
v_acraft	tzyx	AIRCRAFT: Meridional wind	m/s
v_amv	tzyx	ATMOS MOTION VECTORS: Meridional wind	m/s
v_drift	tyx	DRIFTING BUOY: Meridional wind	m/s
v_prof	tzyx	PROFILER: Meridional wind	m/s
v_raob	tzyx	RADIOSONDE: Meridional wind	m/s
v_scat	tyx	SCATTEROMETER: Meridional wind	m/s
v_sea	tyx	SEA SURFACE: Meridional wind	m/s
w_ssmi	tyx	SSMI: Wind speed	m/s

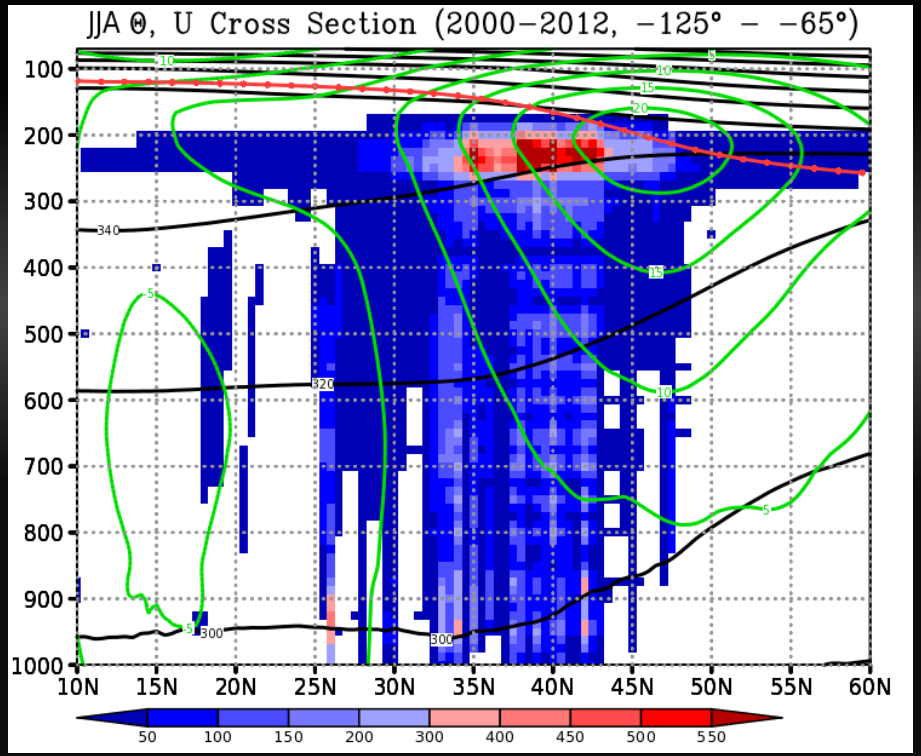
Conventional Observations

- Conventional data all in one 3D gridded file
- Different components of the analysis are separated into files

6hourly	mean	Mean of the variable observations in a grid box (obs, oma, omf)
	nobs	Number of data points in the mean (obs, oma, omf)
	stdv	Standard Deviation of the variable data in the grid box (obs, oma, omf)
	obs	Observation value
	oma	Observation minus analysis value
	omf	Observation minus forecast value
Monthly and Diurnal	means	Monthly Mean of the variable (obs, oma, omf)
	obrate	Number of observations divided by the number of analysis times (obs, oma, omf)
	rms	root mean square difference of the variable over time (obs, oma, omf)
	obs	Observation value
	oma	Observation minus analysis value
	omf	Observation minus forecast value

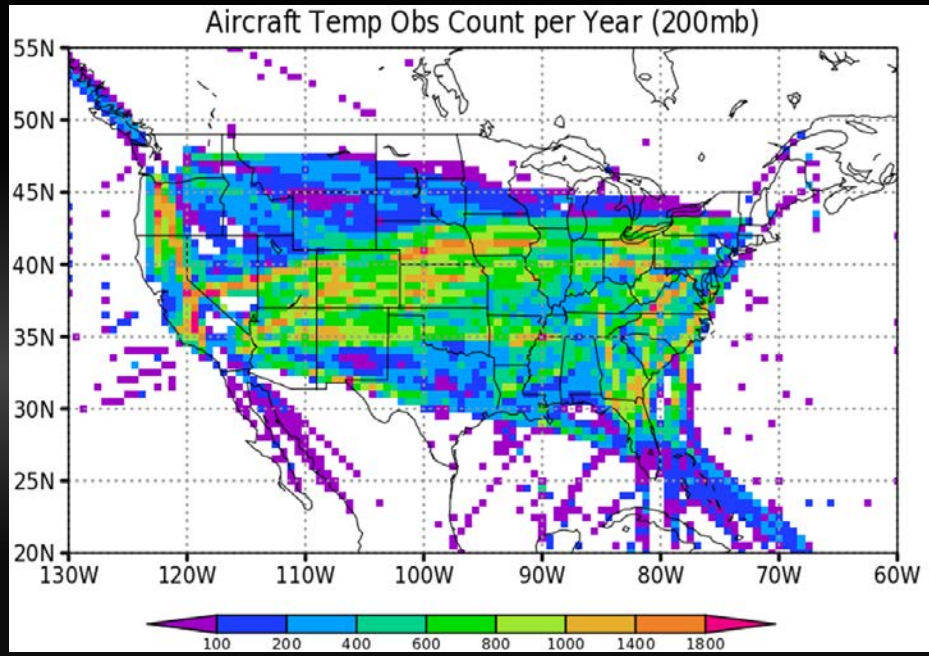
Strengths and Limitations

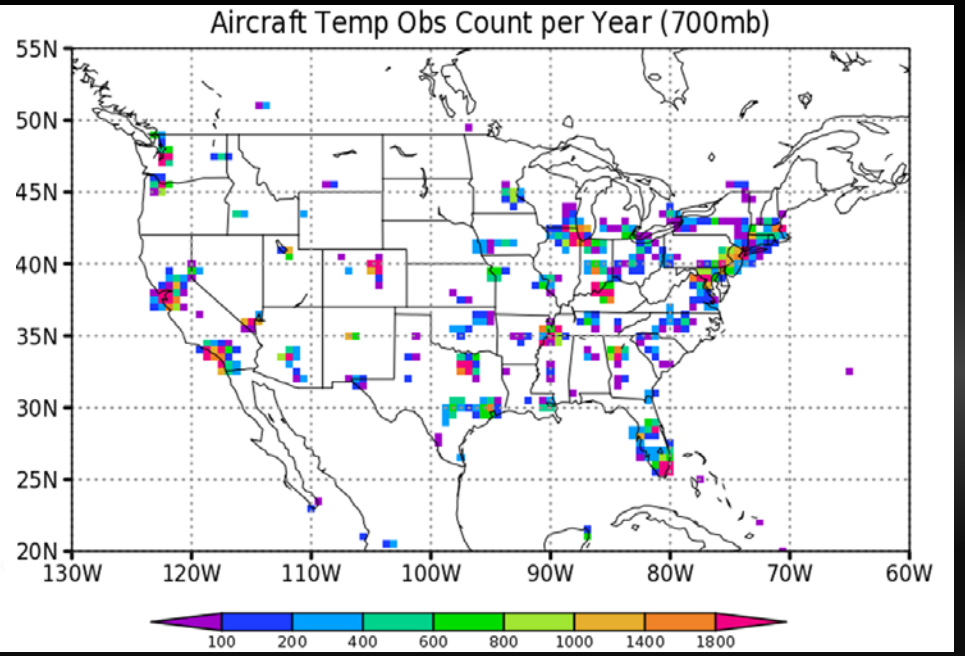
Aircraft Temperature Data Count



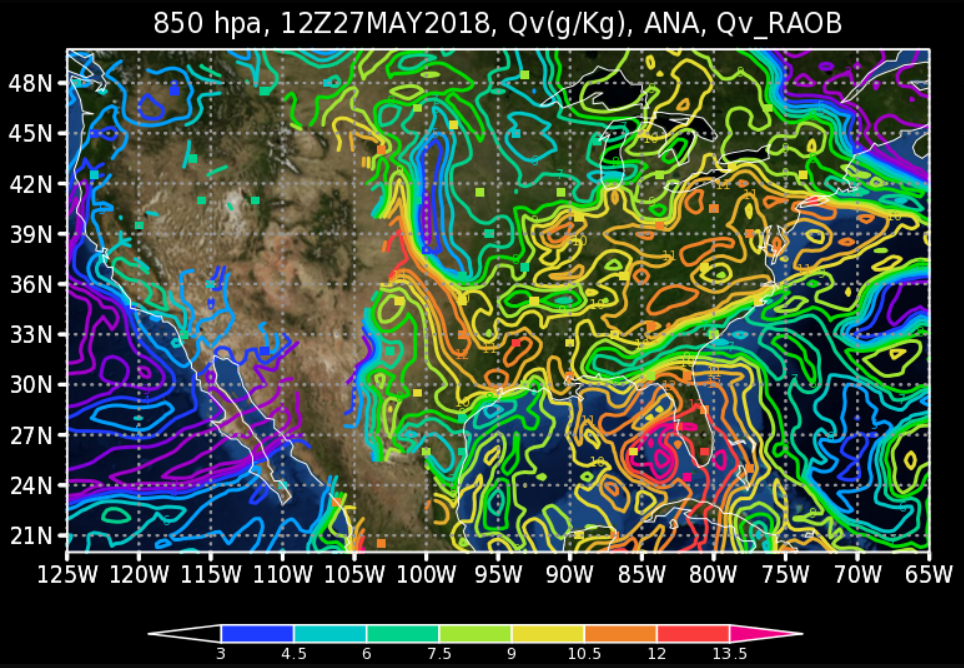
- Need to account for Count in any grid box when doing an area/time average
- Data are binned to a x,y,p grid
- Lots of info is lost, in the binning, and loss of meta data
- RAOBs can drift out of the station grid box

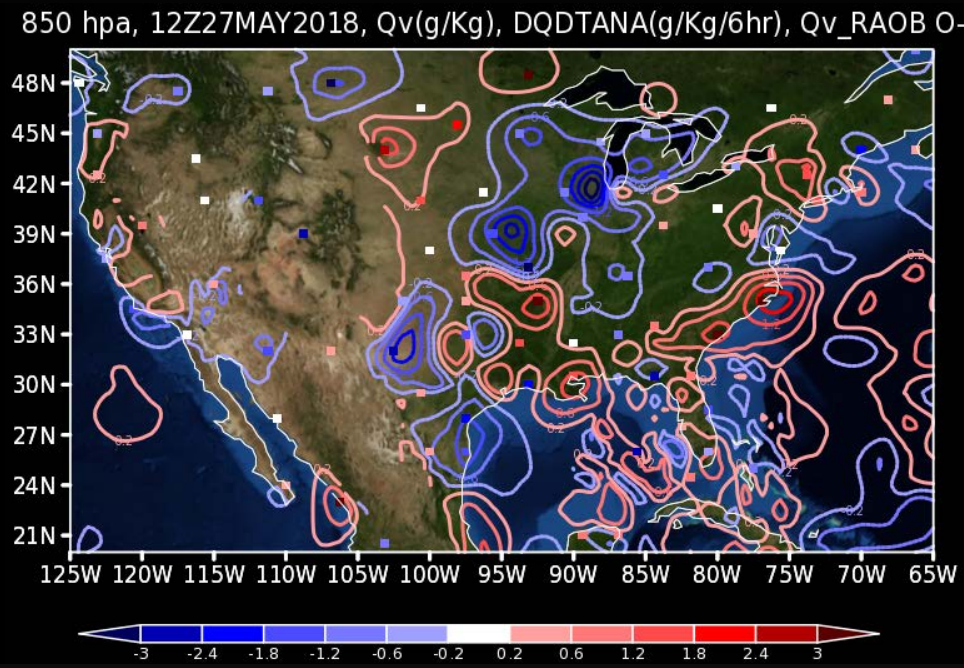
Aircraft Observation Count at Different Levels





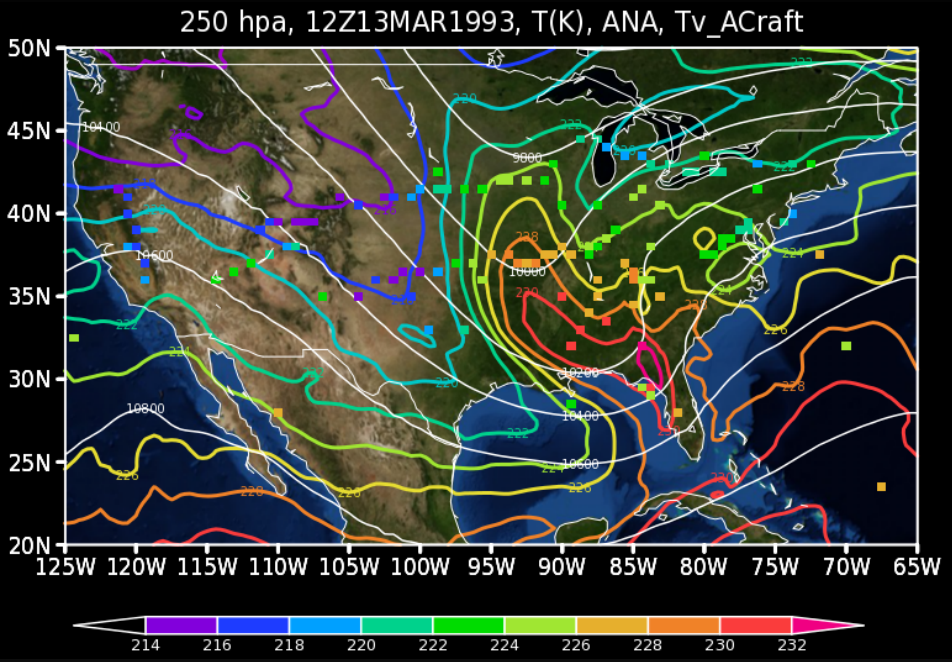
Evaluating Observations at the Weather Scale

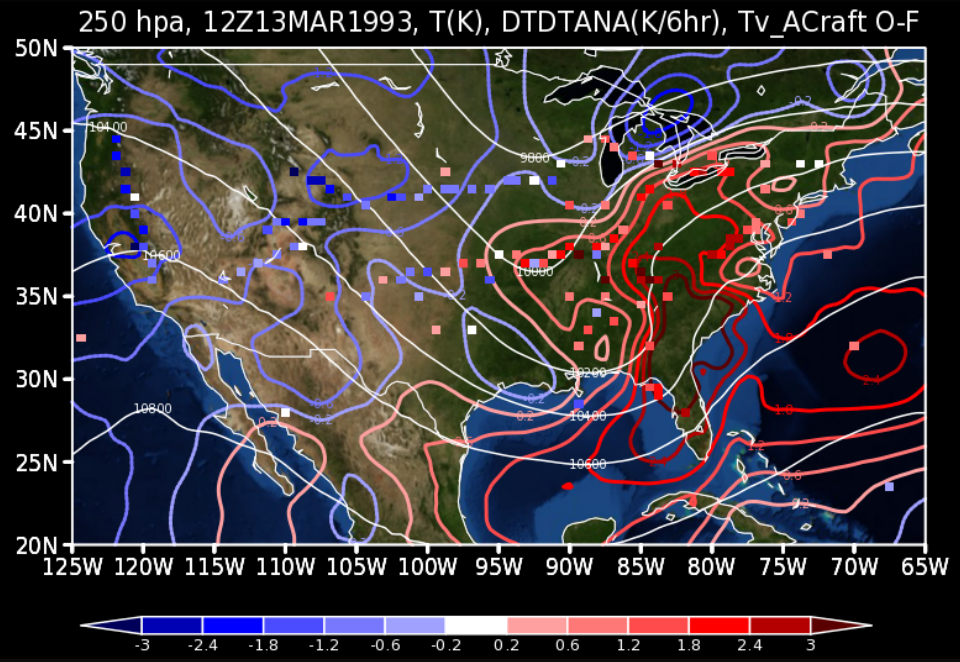




- May 27, Extreme Precipitation (9in 2.5 Hr storm total) over Ellicott City MD
- Strength of MERRA-2 is characterizing the large scale environment that extreme weather forms

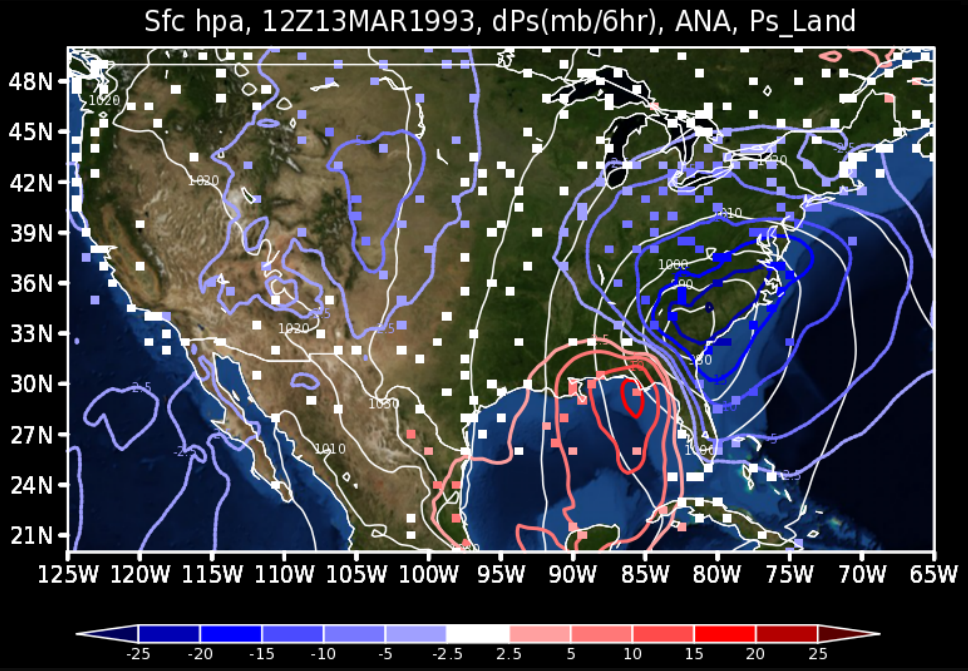
Evaluating Observations at the Weather Scale

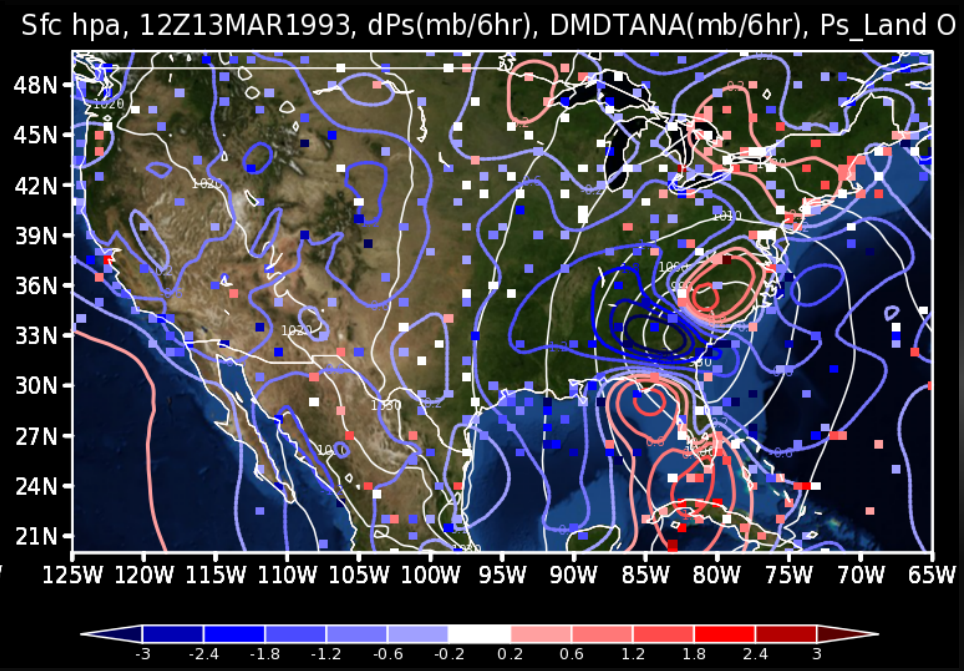




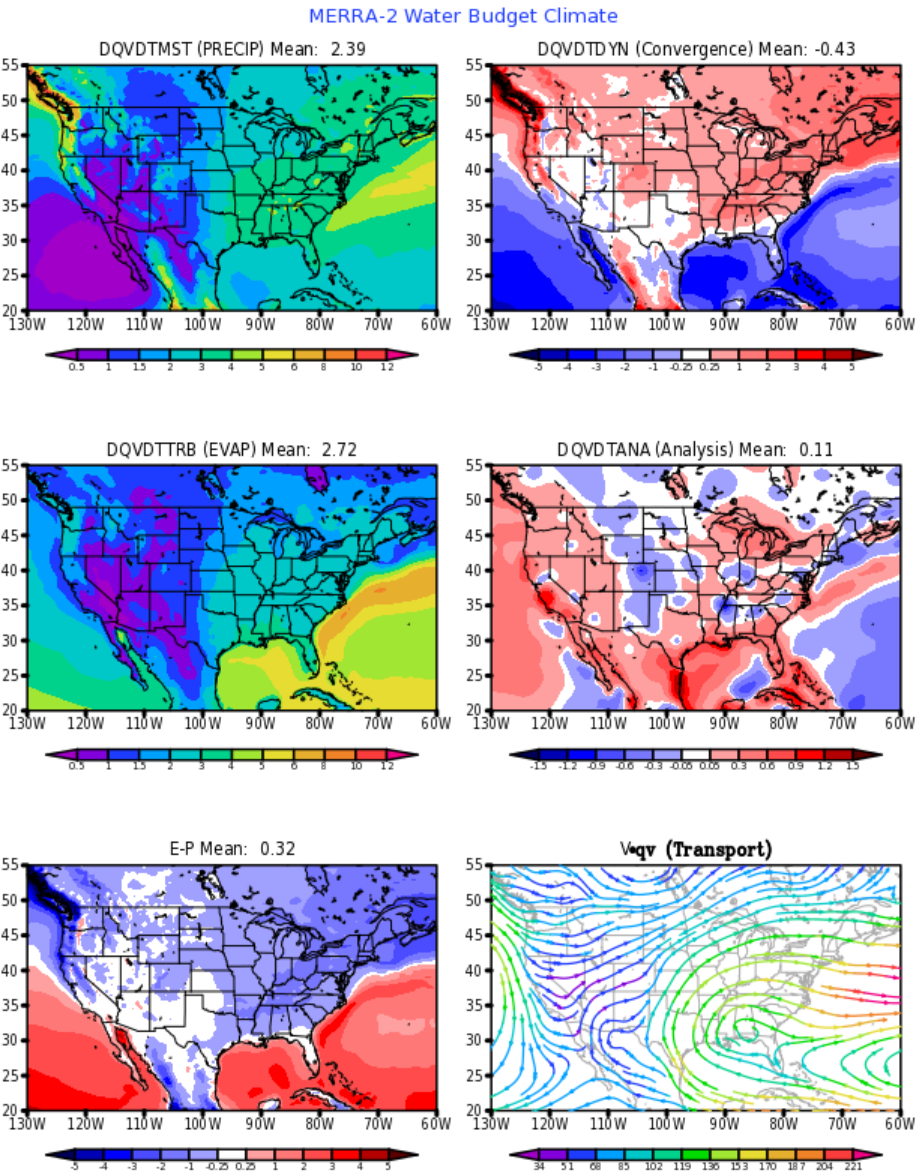
- 250 hPa T – 13MAR1993 – “Storm of the Century”

Evaluating Observations at the Weather Scale





- 6hr Sfc Pressure change, and Sfc Pressure increments
- “Storm of the Century”

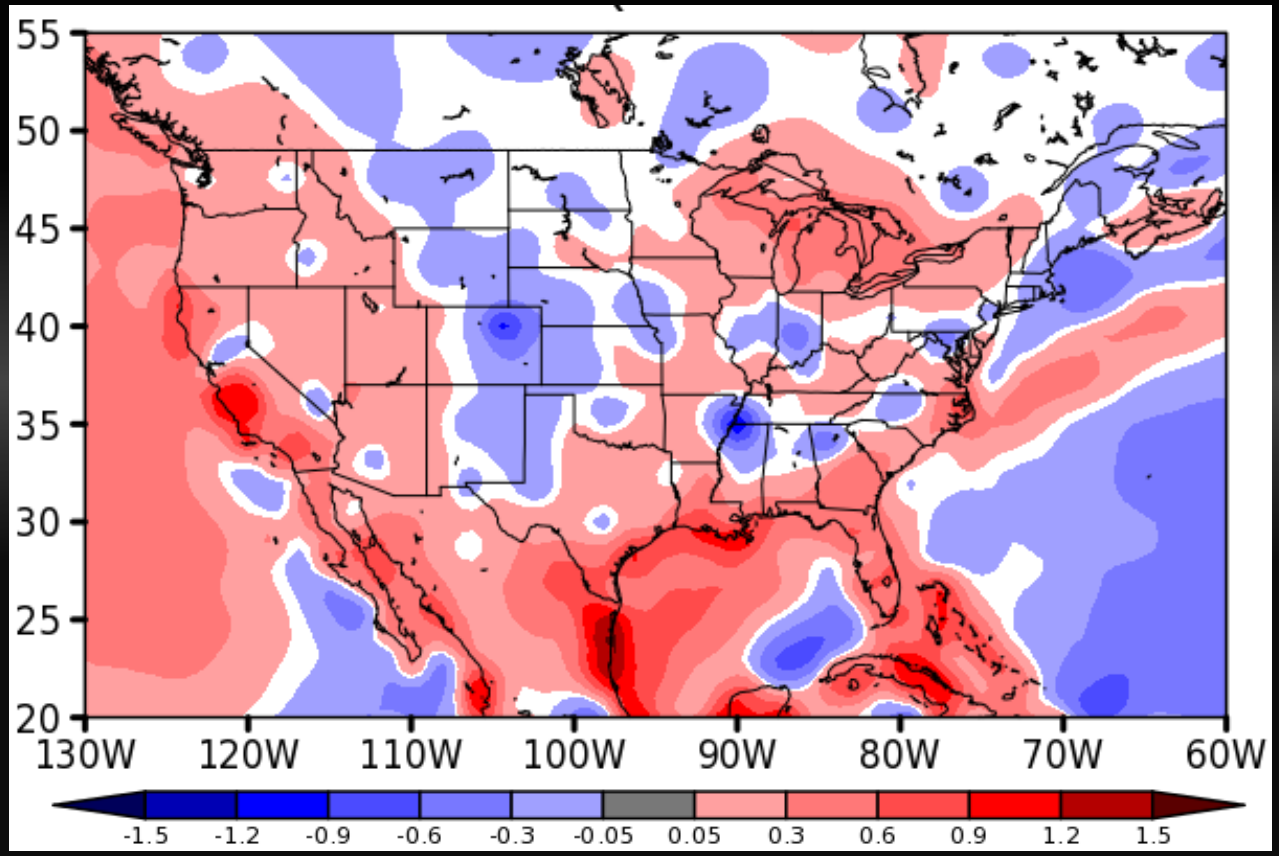


US Water Budget Terms

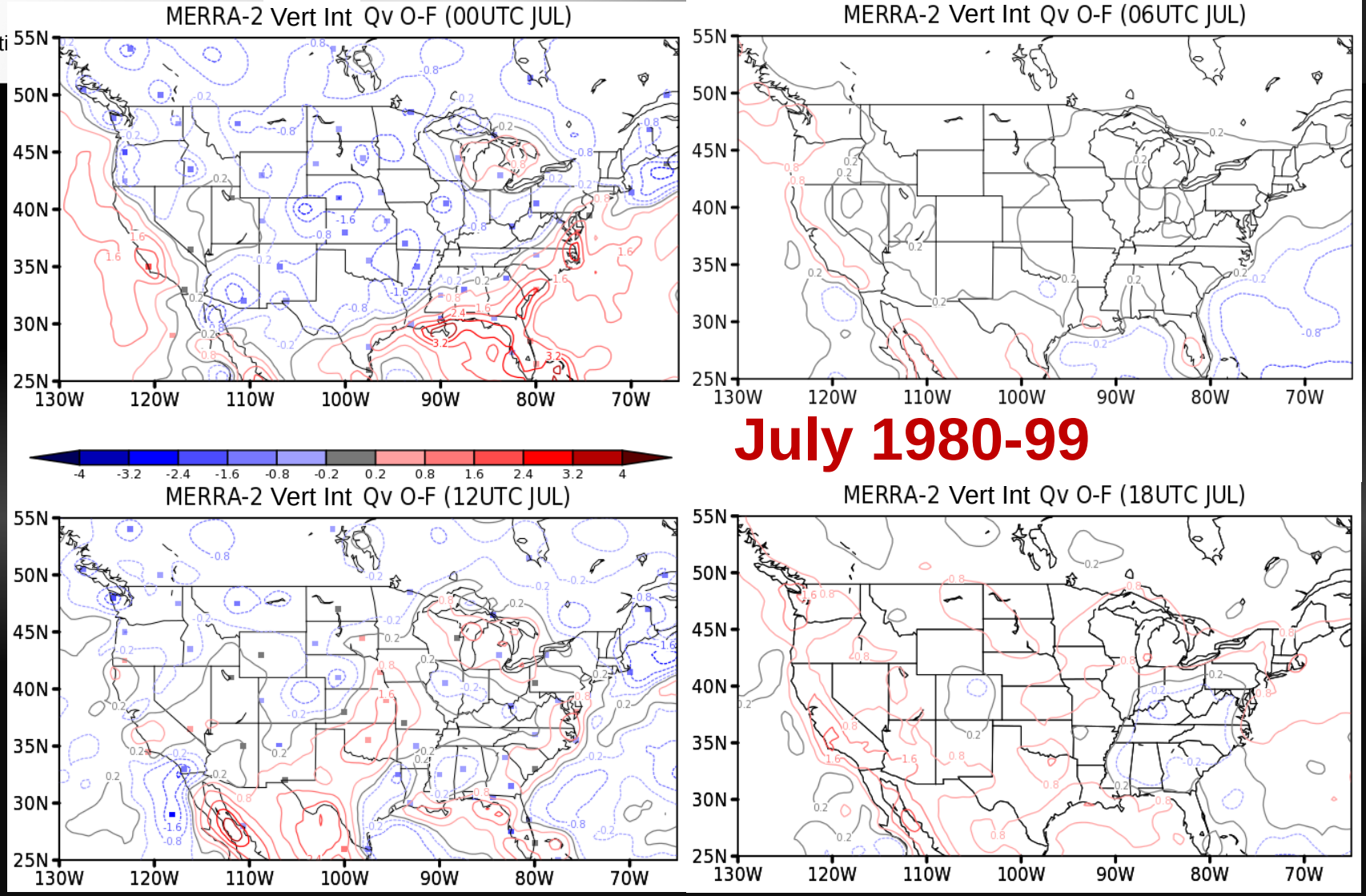
- Long term Average MERRA-2 vertically integrated water budget
- E-P and Convergence correlate nicely
- Generally more P than E over land
- Mean increments are generally small, but inconsistent

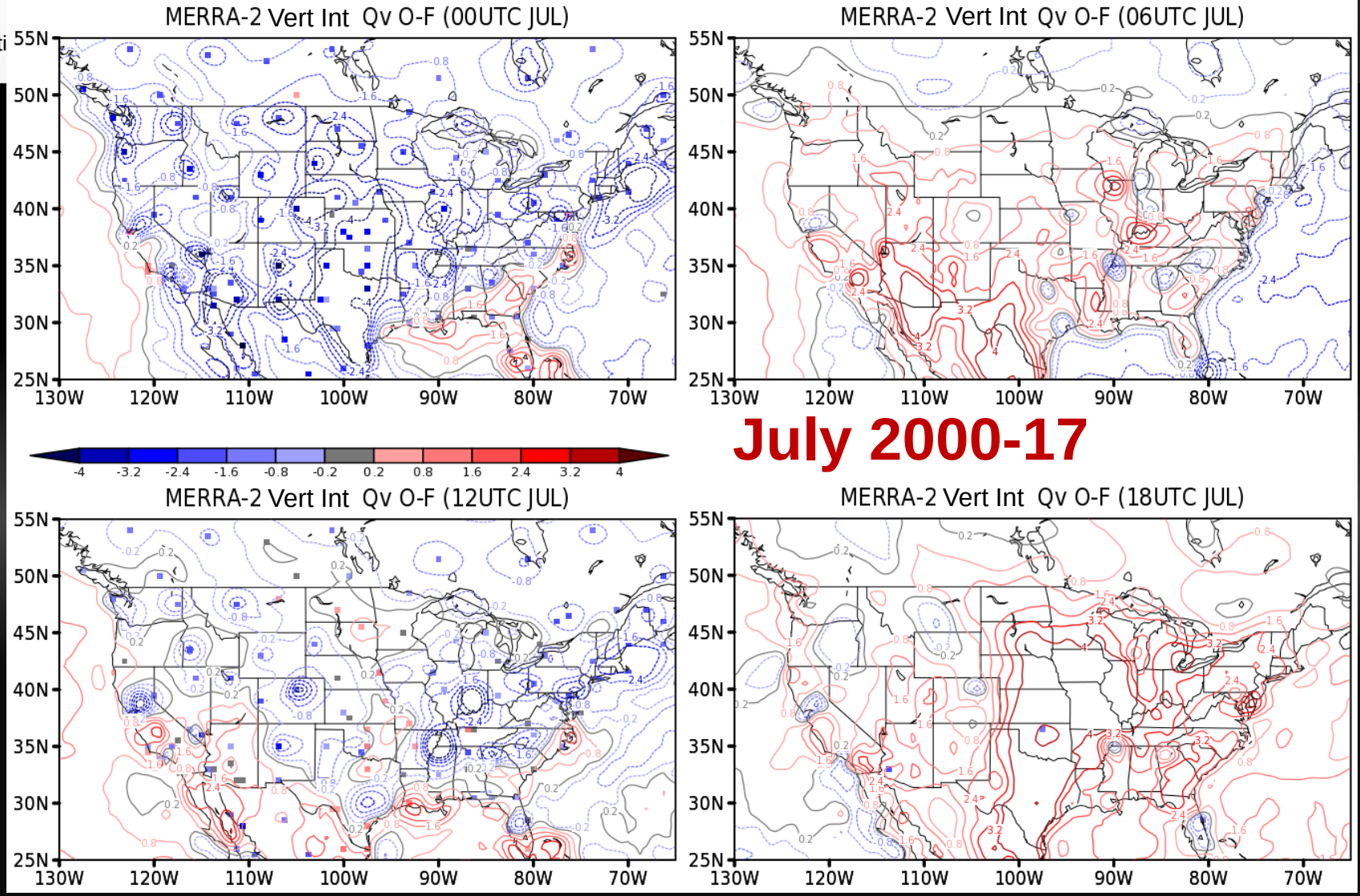
Islands of blue in a sea of red

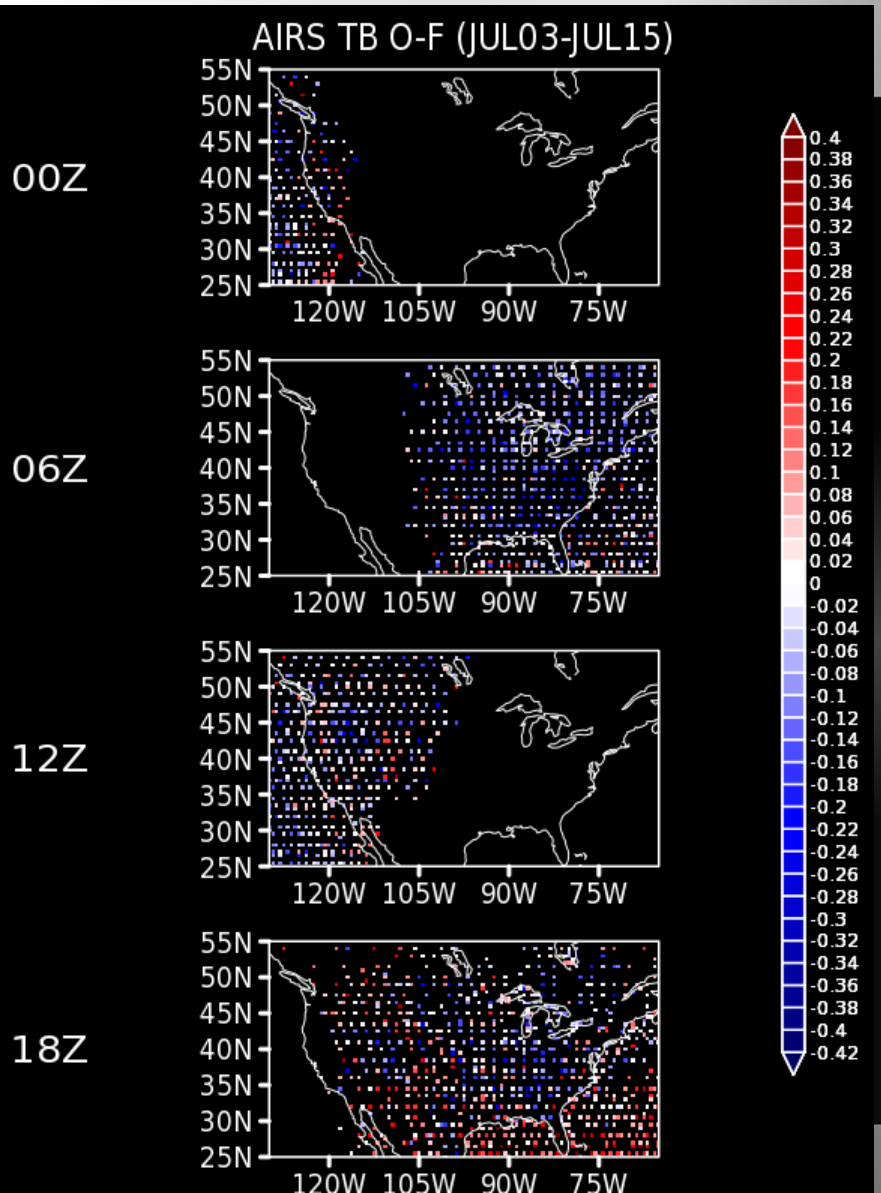
1980 – 2017 Mean water vapor increment (mmd d^{-1})



- Localized features in the mean US increments – RAOBs, but what's the details behind it
- Some are related to radiosonde station areas, some not
- Why so much increasing water vapor, when the radio sondes are working hard to decrease the water
- July, after 2000


MERRA-2 Vert Int Qv O-F (00UTC JUL)
MERRA-2 Vert Int Qv O-F (06UTC JUL)
July 1980-99
MERRA-2 Vert Int Qv O-F (12UTC JUL)
MERRA-2 Vert Int Qv O-F (18UTC JUL)
-4 -3.2 -2.4 -1.6 -0.8 -0.2 0.2 0.8 1.6 2.4 3.2 4
55N 50N 45N 40N 35N 30N 25N
130W 120W 110W 100W 90W 80W 70W


MERRA-2 Vert Int Qv O-F (00UTC JUL)
MERRA-2 Vert Int Qv O-F (06UTC JUL)
MERRA-2 Vert Int Qv O-F (12UTC JUL)
MERRA-2 Vert Int Qv O-F (18UTC JUL)
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
-4
-3.2
-2.4
-1.6
-0.8
-0.2
0.2
0.8
1.6
2.4
3.2
4
July 2000-17



Checking AIRS TB

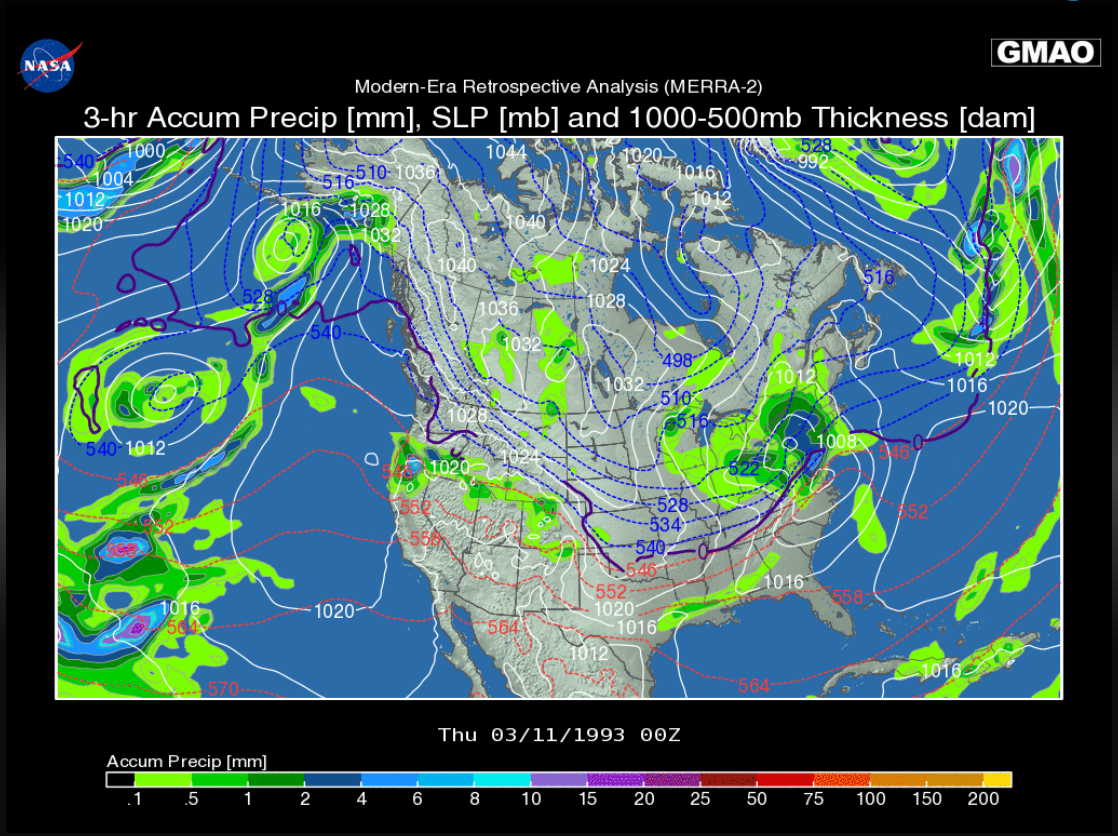
- AIRS channels are binned
  - Ch#166-223, 8-4.55µm
  - Weighting peaks sfc-279hPa*
  - Needs more granularity

*Thanks RadMon!

GIO Future

- Updating AIRS (and IASI), looking at 6-hour, different combinations of channels
- Aerosol data has not yet been included
- Adding channel meta into the NC files and docs
- Looking into storing the conventional **rejected observations**
- Testing the routines built into the system, to turn on/off as needed, maybe useful for field campaigns and other reanalyses

Thanks! – Michael.Bosilovich@nasa.gov



1993 March Snow from the MERRA-2 Historical Weather Maps
https://fluid.nccs.nasa.gov/reanalysis/