The use of NASA numerical weather models for evaluation of atmospheric opacity at ngVLA sites

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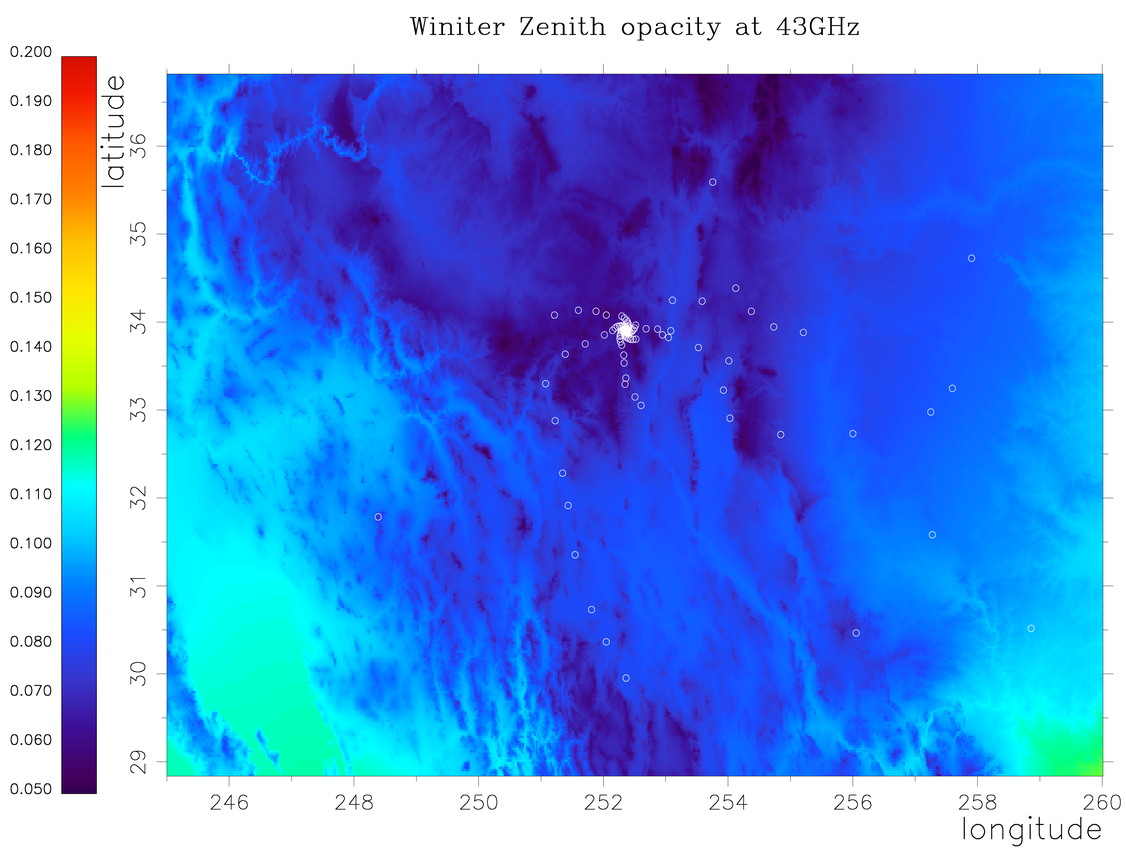
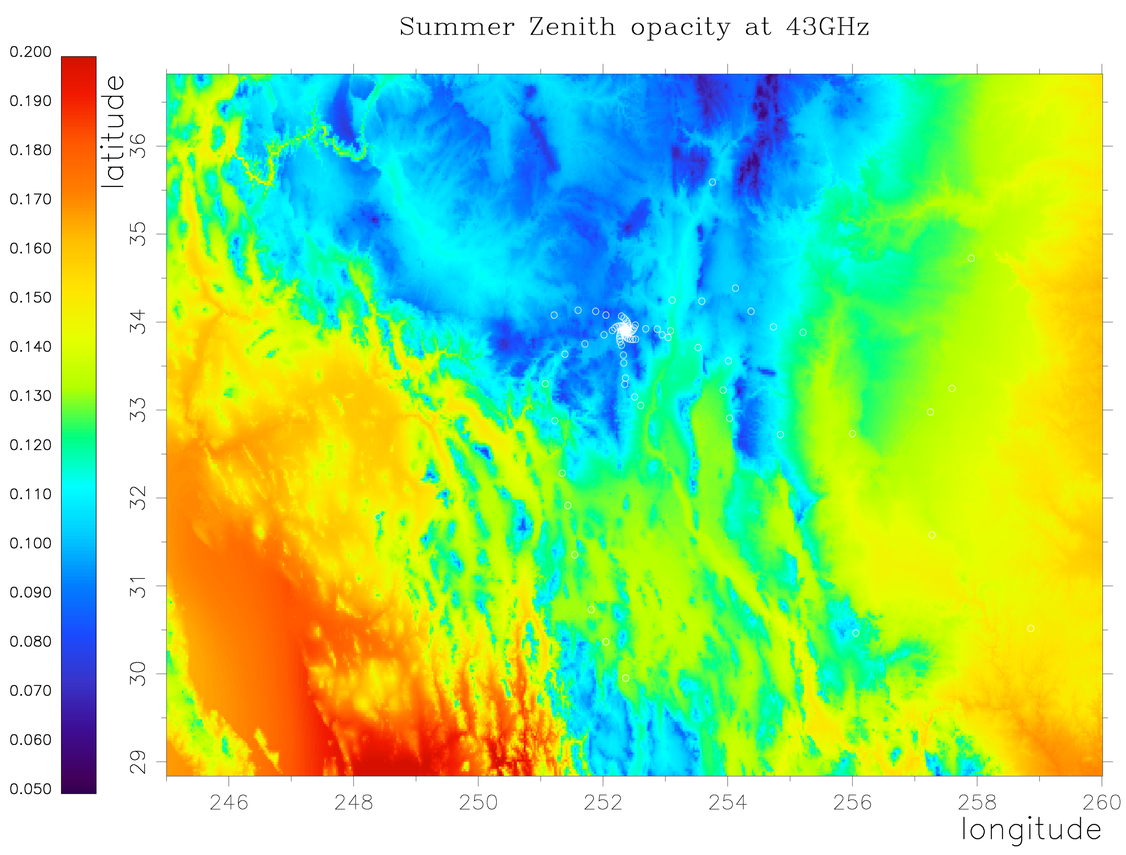
NASA Global Modeling and Assimilation Office (GMAO) runs global numerical weather model at spatial resolutions $0.25° \times 0.25° \times 72$ layers an time resolution three hours. The assimilation model has latency $9–16^h$. Morel forecast up to 10^d in the future is provided. State of the atmosphere can be derived from the output of numerical model. Integrating of wave propagation and radiative transfer equations, we can get atmospheric path delay, atmosphere opacity and brightness temperature at specified frequencies.

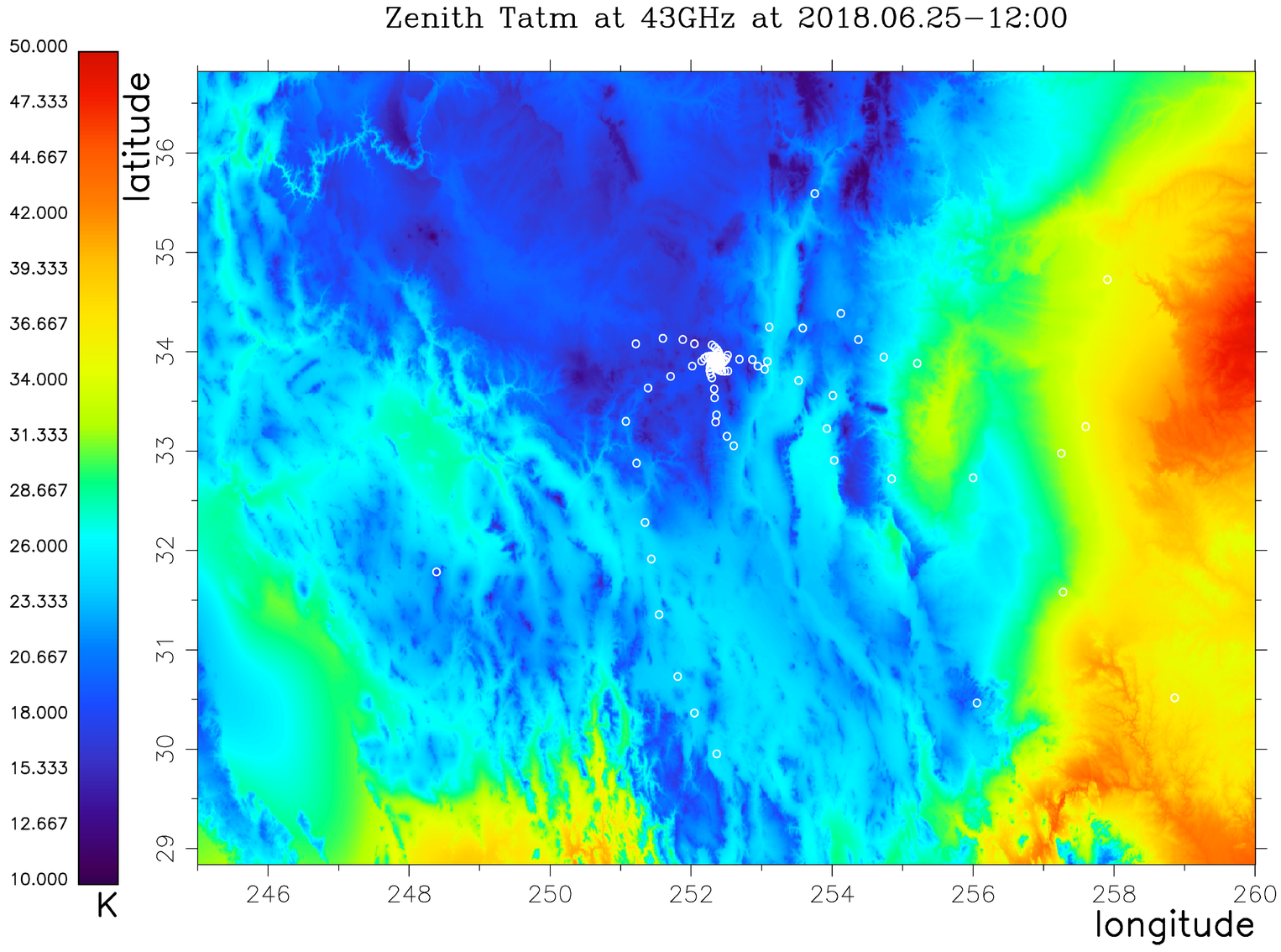
Zenith atmospheric opacity averaged over January–February 2018. White circles show suggested ngVLA sites. Resolution: 3×3 km. Numerical weather model: GEOS-FP.



Zenith atmospheric opacity averaged over July–August 2018. White circles show suggested ngVLA sites. Resolution: 3×3 km. Numerical weather model: GEOS-FP.



Atmosphere brightness temperature at 43 GHz on 2018.06.25 12 UTC. Spatial resolution: 1 km.



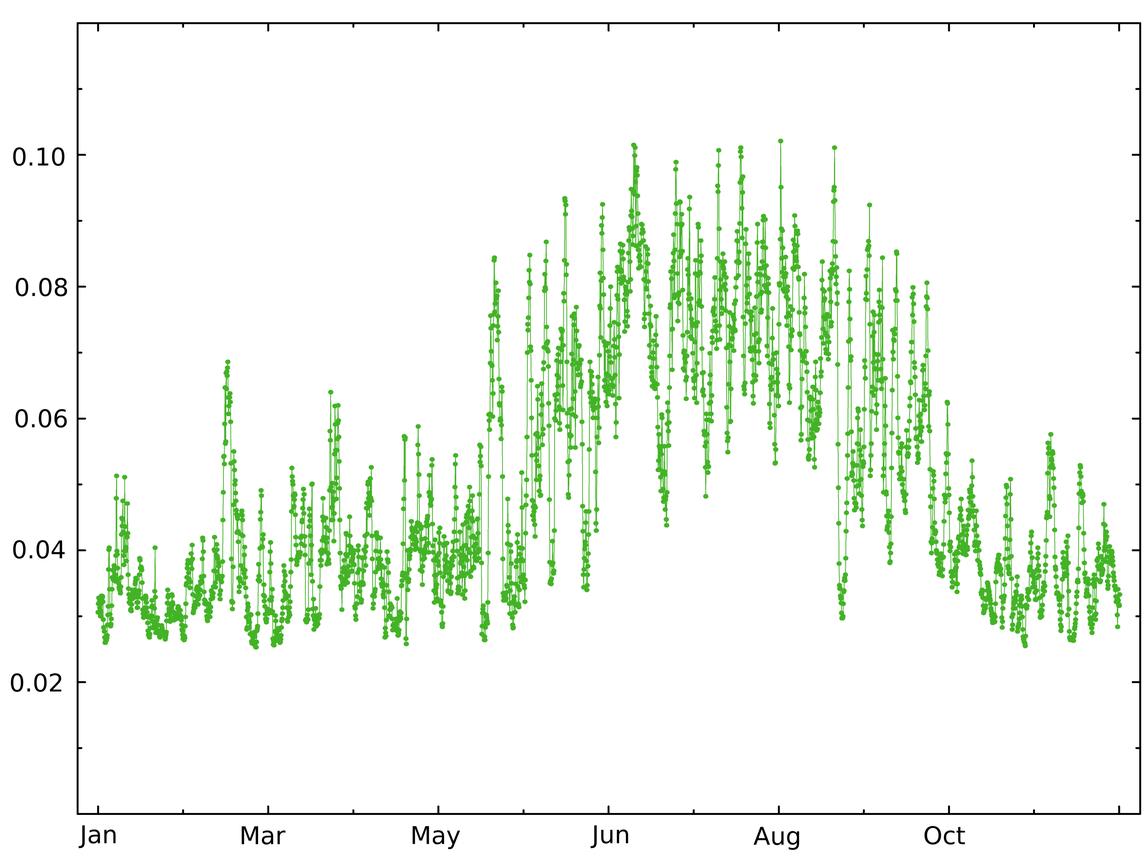
Mean winter and summer atmosphere opacity at 22.35 GHz for prospective ngVLA sites

sta	winter	summer
m105	0.197	0.324
m078	0.201	0.335
m044	0.202	0.339
...	...	...
m075	0.227	0.420
m077	0.228	0.420
m076	0.230	0.421
...	...	...
pr2	0.353	0.423
sc1	0.366	0.439
hi1	0.370	0.444

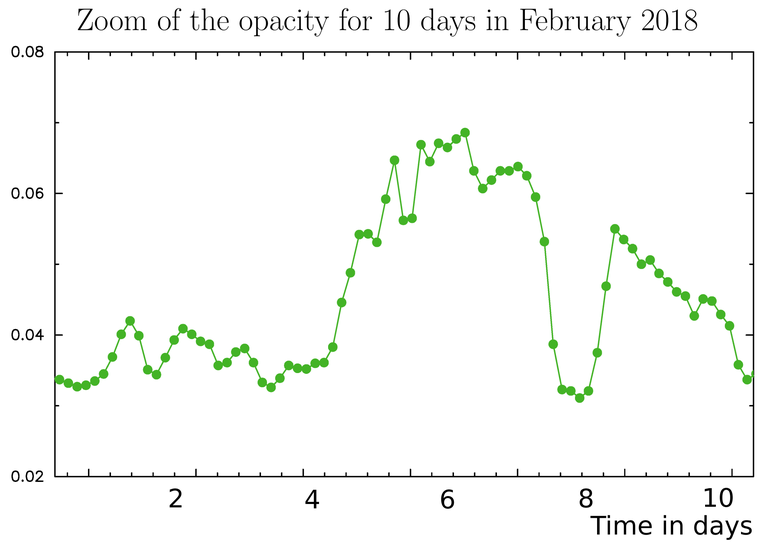
Mean winter and summer atmosphere brightness temperature at 86 GHz for prospective ngVLA sites (K)

sta	winter	summer
m105	15.1	43.2
m078	16.3	46.6
m027	16.8	48.6
...	...	...
m115	25.9	71.8
m076	26.4	73.5
m118	29.7	76.1
...	...	...
pr2	79.5	95.7
hi1	80.1	99.8
sc3	87.2	105.1

Zenith atmosphere opacity at 32 GHz at prospective ngVLA site m101 ($\phi = 32°.73, \lambda = 256°.00, h = 1170$) in 2018:



Zoom of the opacity for 10 days in February 2018



The output of 4D assimilation numerical weather model can be used for computation of path delay, atmosphere opacity, and brightness temperature. The time series of these parameters are very use for assessment of astroclimate. Precomputed path delay for 459 VLBI and ALMA sites can be found at http://pathdelay.net