Mars Models for Herschel

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Summary from Earlier Meetings

Mars might be a good primary flux density scale calibrator for HIFI, and the current models of Rudy et al., Lellouch et al., Griffin et al. agree fairly well.

We still need to add some additional effects that we know are not included in the current models.

We can get to 10%, and maybe 5%, but 3% will take more work.

Glenn's List

2. Repeat JCMT submm observations of Mars, Uranus, and Neptune
5. See whether the archival JCMT data (Jenness 2002) can be recalibrated to consistency using the Griffin model spectrum for Mars, rather than the Wright model (constant Tb for its longest wavelengths), or - if dates/times are available - to the modified Rudy model [LWS E(l)]
6. Look at differences between Rudy, Wright, Griffin, Butler et al., models for Mars
7. When available use the BIMA data for Mars, Jupiter, Saturn, Uranus, and Neptune referenced by Cohen
9. IRAM 30-m data?

My own additions:

0. Fix up Rudy model: surface roughness; atmosphere; ice extent and properties (new MGS and Odyssey stuff); new thermal inertia & albedo; E(λ) to match LWS
1. Get Wood & Vasavada model
2. Extend Jenness analysis to today (Goran will try to do this?)

Progress

6. Look at differences between Rudy, Wright, Griffin, Butler et al., models for Mars

[Some of this has been done, including comparing the Rudy model to the published Griffin et al. Model]

9. IRAM 30-m data?

[We will hear about this from Raphael (from Carsten) today, I think]

My own additions:

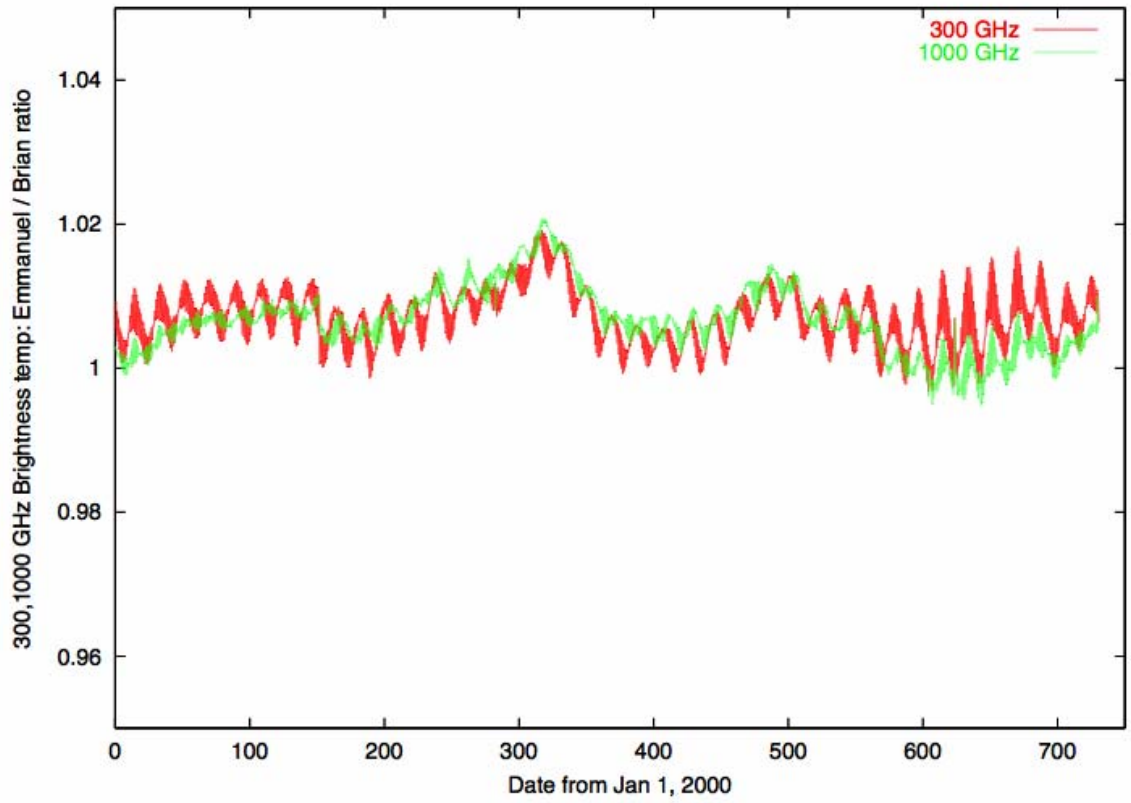
0. Fix up Rudy model: surface roughness; atmosphere; ice extent and properties (new MGS and Odyssey stuff); new thermal inertia & albedo; E(λ) to match LWS

[Fixes put in for surface roughness and E(λ) to match LWS]

Comparisons

Comparisons of
Griffin et al. 198
(maximum discre

Comparisons of
hoping Emmanu
agreement (maxi



A New Web Tool

I've put the Rudy et al. model on the web, at:
http://www.aoc.nrao.edu/~bbutler/work/mars/model

This incorporates the full model, with roughness, and the ability to use the Burgdorf et al. emissivity if desired.

Mars Emission Model Tool

This is a tool set up to help those interested in the prediction of the emission of Mars at IR and longer wavelengths. The model was originally written by Don Rudy while a graduate student at Caltech, and is described in:
Rudy, D.J., et al. 1987, Icarus, 71, 159 and Muhleman, D.O., & G.L. Berge 1991, Icarus, 92, 263

The model was based on data taken at the VLA in the A-configuration (most spread out - maximum baselines of ~36 km). The data were calibrated in flux density with observations of 3C286, using the Baars et al. flux density scale. Images were made, averaged over time (so longitudinally smeared). These maps were then fit with a full thermophysical model, fitting for a dielectric constant separately for each of the wavelengths, a radio absorption length common to both wavelengths, all as a function of latitude. A whole-disk average dielectric constant was also fitted for, which is independent of the flux density scale (as it relies on the polarization response). These bulk properties were then fed into a much more sophisticated thermophysical model which used results from Viking (thermal inertia and albedo as a function of location), and derived a surface and subsurface temperature profile as a function of both longitude (7.5 deg bins) and latitude (5 deg bins). This was done for a suite of models of varying electrical and thermal parameters, and then a best fit to the maps was performed to get the best fit parameters on the above grid. At the time, the north polar seasonal CO_2 cap was large, and easily seen in the images, so they also fit for the effective thermal parameters of the CO_2 caps.

Since the original model, it has been updated to include surface roughness effects, proper sub-pixel gridding, and potential resolution of the disk by whatever antenna might be used to observe it.

This model has been commonly used to calibrate observations in the millimeter and submillimeter wavelength regions, and seems to work quite well. There are, however, a number of caveats that should be kept in mind when applying it:

- No separate surface roughness was included in the original model - the roughness was lumped in with the effective bulk dielectric constant of the surface. Because of this, adding in a separate surface roughness after the fact may give slightly erroneous answers.
- There is no subsurface scattering included in the model.
- There is no lateral heat transport included in the model.
- The model for the extent of the seasonal CO_2 ice caps is fairly crude.
- Outdated maps of thermal inertia and albedo were used when deriving the thermophysical parameters.
- There is no atmosphere included in the model, which can cause the wrong surface temperatures to be derived, for example if there is a large (global, in the end case) dust storm.

Year 2004 Month 1 Day 1 UT Hour (including fraction) 0

Frequency (GHz) 8500

Beam FWHM (asec) 0 beam type: (•) Gaussian ( ) Besselian

mean surface slope (deg) 0 roughness type: (•) Gaussian ( ) Exponential

dielectric (0 for default, -1 for Burgdorf et al.) 0

show geometry image [x] show model image [x]

Calculate Model

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Last Modified on 2006-Sep-25

Left To Do

- Still don't have the atmosphere in there
- Polar caps not quite right in Rudy model
- Still don't have modern observations (MGS, Odyssey, MEX, MRO, etc.) incorporated
- What's happening with Wood & Vasavada; Richardson
- Cross-comparisons with other calibrators

Atmosphere

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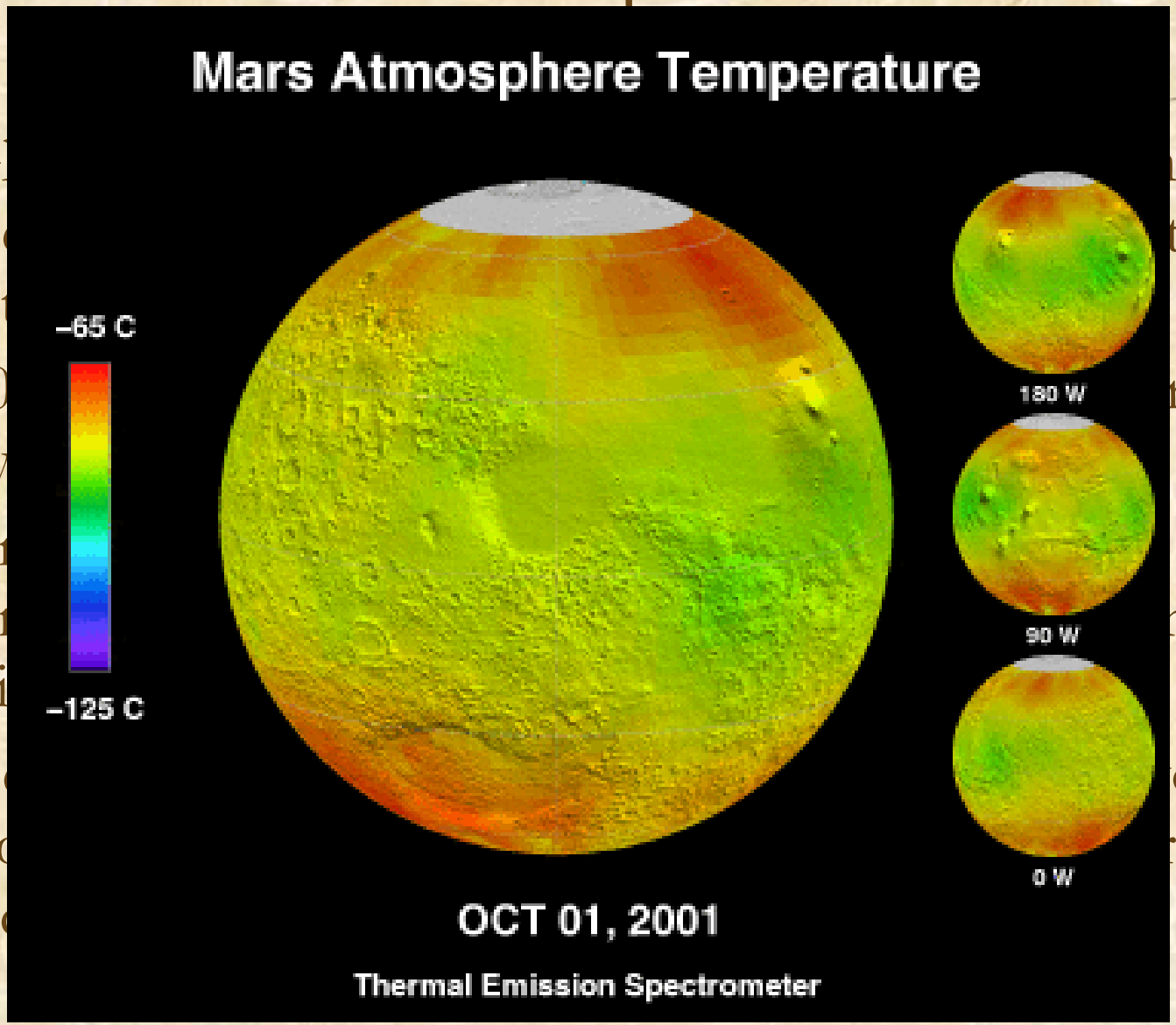
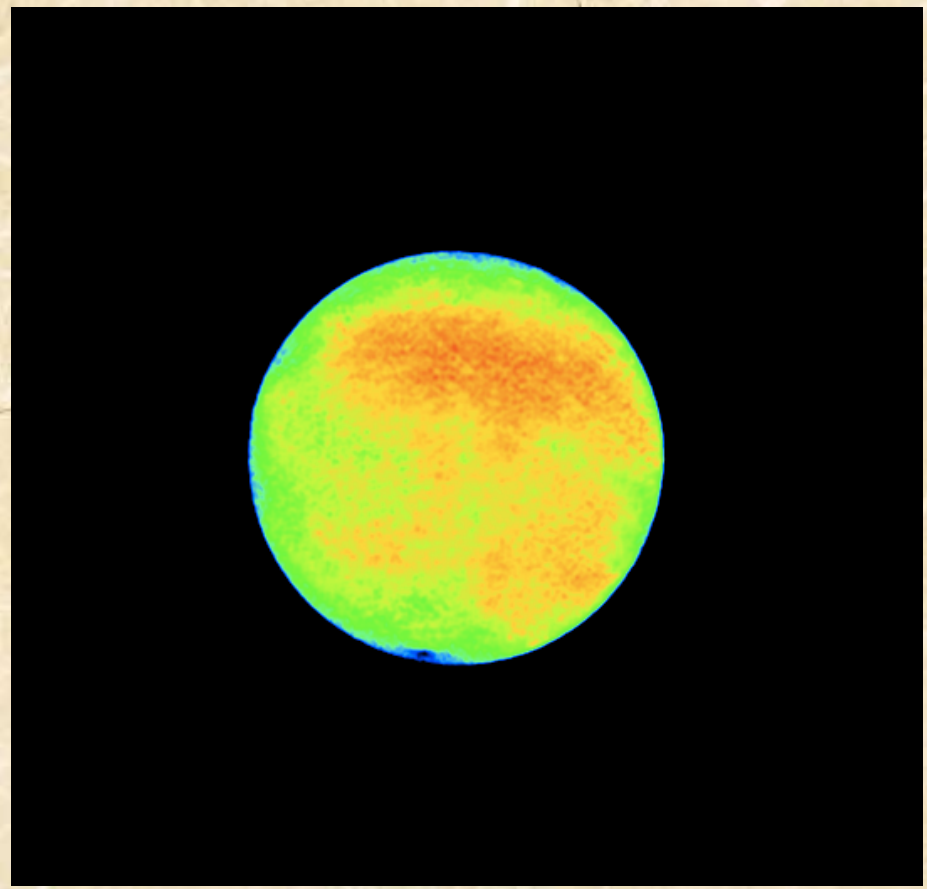
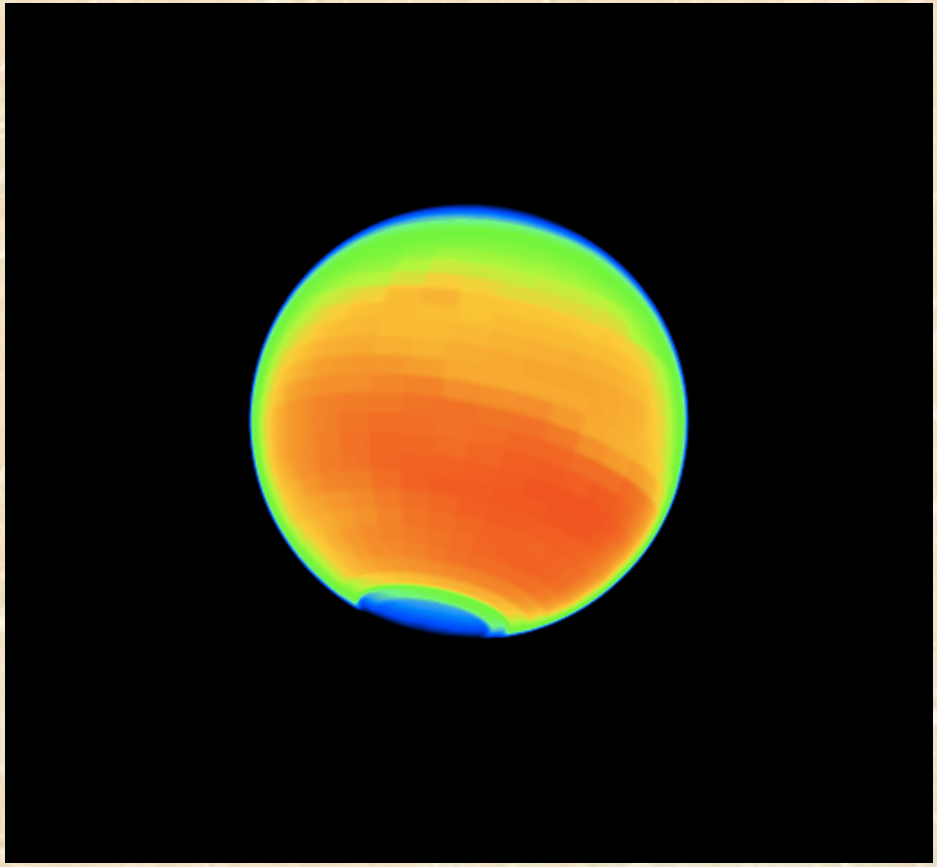


Polar Caps

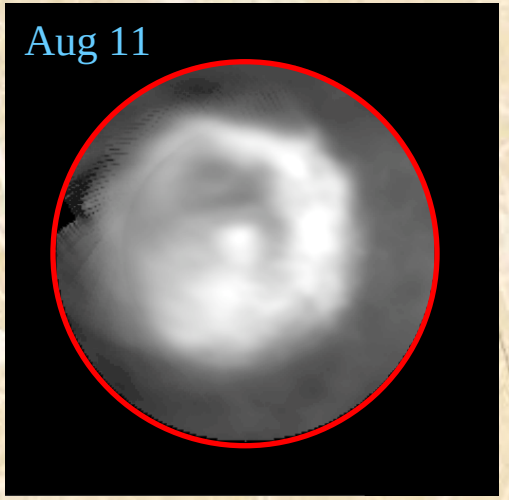
Observed in August 2003 (VLA)

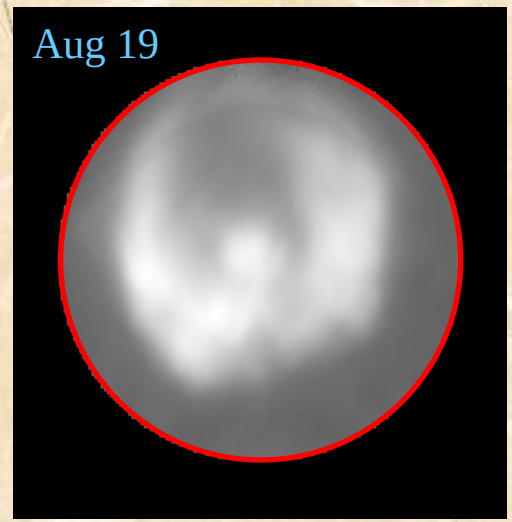


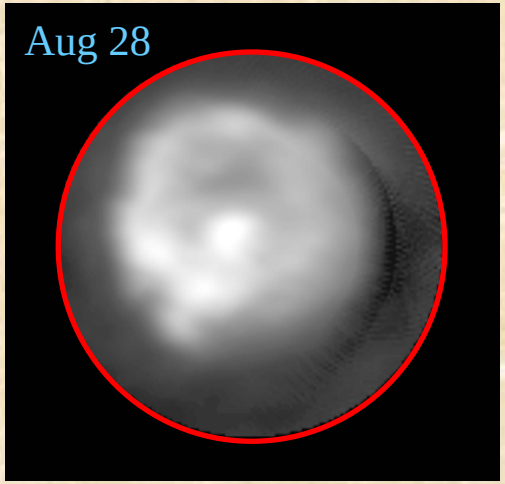
Model

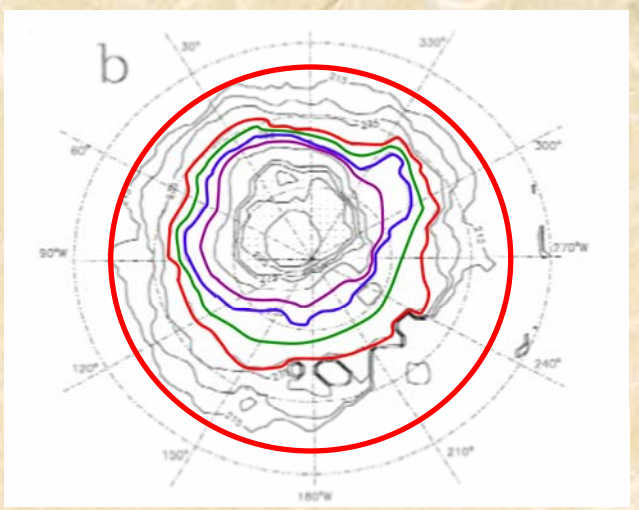


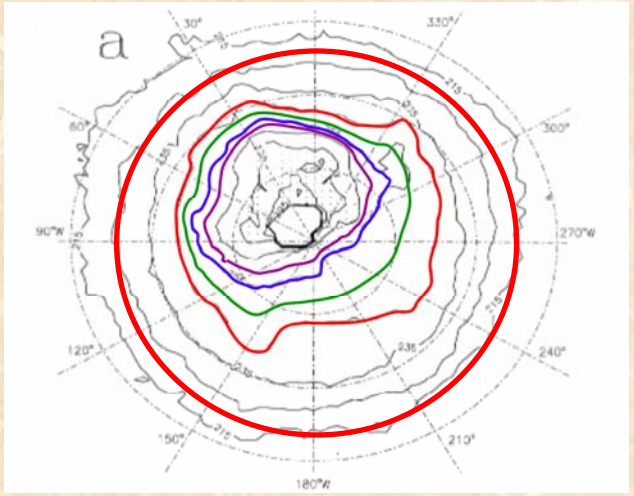
Polar Caps





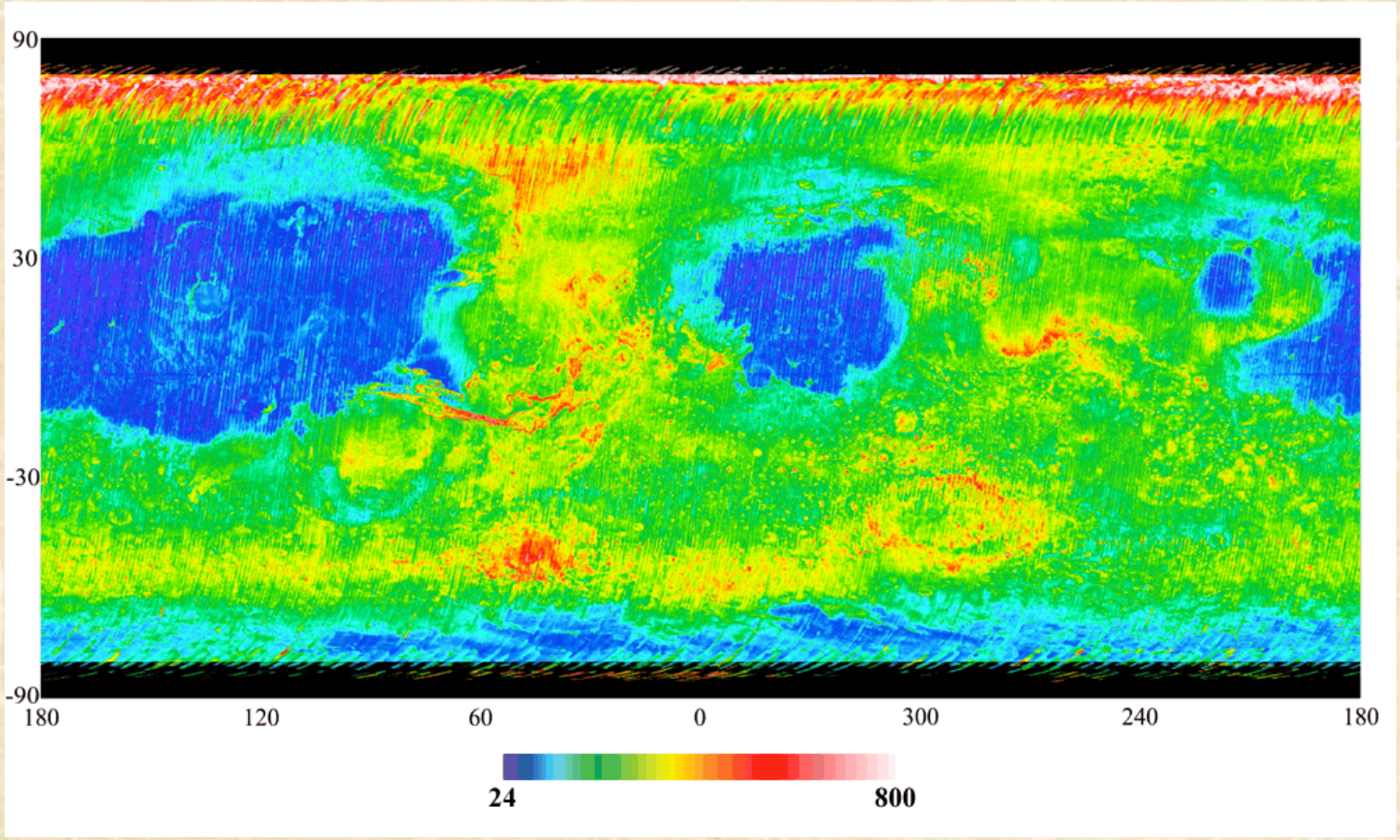






Kieffer et al. 2000

New Measurements - Thermal Inertia



Mellon et al. 2002

New Measurements - Dielectric

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

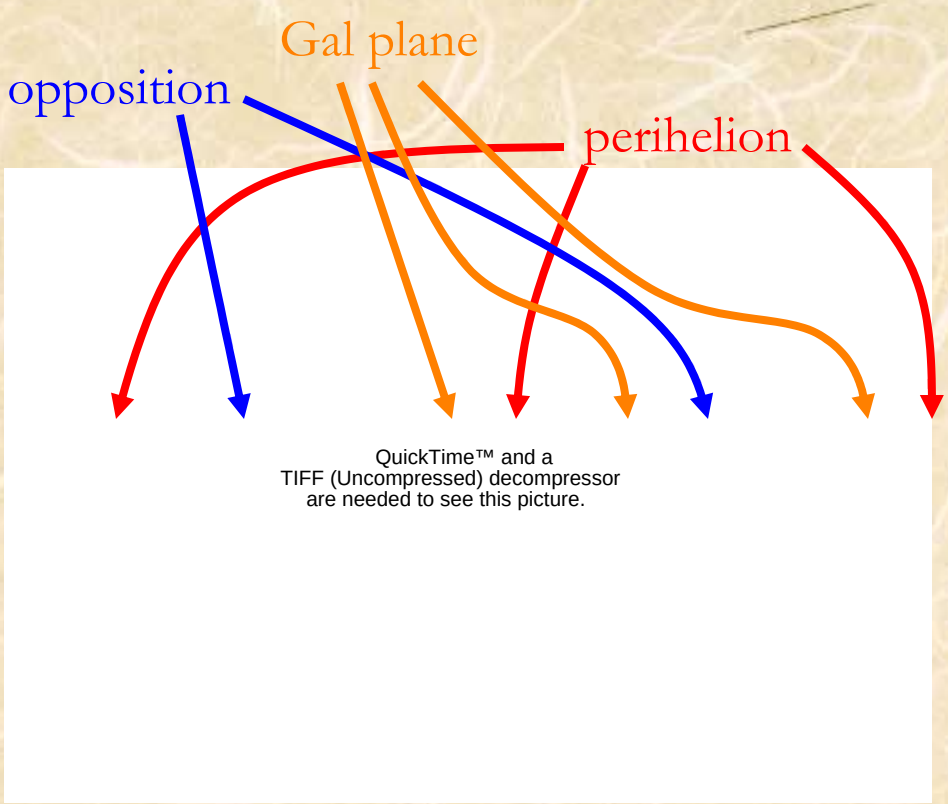
Heggy 2005; Heggy & Pommerol 2005

Cross Comparisons

- At the VLA, Rick Perley and I have been observing Mars along with other planets and "standard" radio-wavelength calibrators since the mid-1990's from 330 MHz to 45 GHz. Work is in progress, but see, e.g., Zijlstra, van Hoof, & Perley 2008 for NGC7027 results.
- Peter Barnes will tell us about what they've been doing at ATCA (this is continuation of work done for some time there as well).
- Ongoing work of Orton, Hofstadter, Gurwell, Butler, et al. cross-comparing observations and models of Mars, Uranus, and Neptune.

To Remember

- Visibility
- Likelihood of dust storms
- Apparent diameter
- Galactic latitude



Herpin, Gerin, & Cramer 2003

Conclusions

- Mars will certainly be a valuable calibration source for HIFI (but should only be considered one of several).
- Observations and modeling will continue to refine and enhance our understanding of the time-variability of the expected emission from Mars, as a function of wavelength.