Intercomparison and fusion of EOS/MLS and TIMED/SABER mesospheric temperatures

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Satellite data are a rich source of global data streams that can be input to NWP models with middle atmospheres.

EOS-Aura and TIMED missions have provided continuous, global data coverage of the MLT since December 2001 (TIMED) and July 2004 (AURA). Temperatures from SABER on TIMED and MLS on Aura can potentially define or initialize a model middle atmosphere. However…

…Historically, middle atmosphere satellites are sun-synchronous or slowly precessing in local time, and thus undersample the atmosphere on a daily basis.

Temporal undersampling becomes problematic in the mesosphere and lower thermosphere (MLT) where tidal amplitudes are strong and variable.

Tidal and quasistationary motions can be inferred using data from precessing satellites gathered over long enough time intervals (36 days for UARS, 72 days for TIMED). ***However, the tides and the background atmosphere are generally changing on faster timescales.***

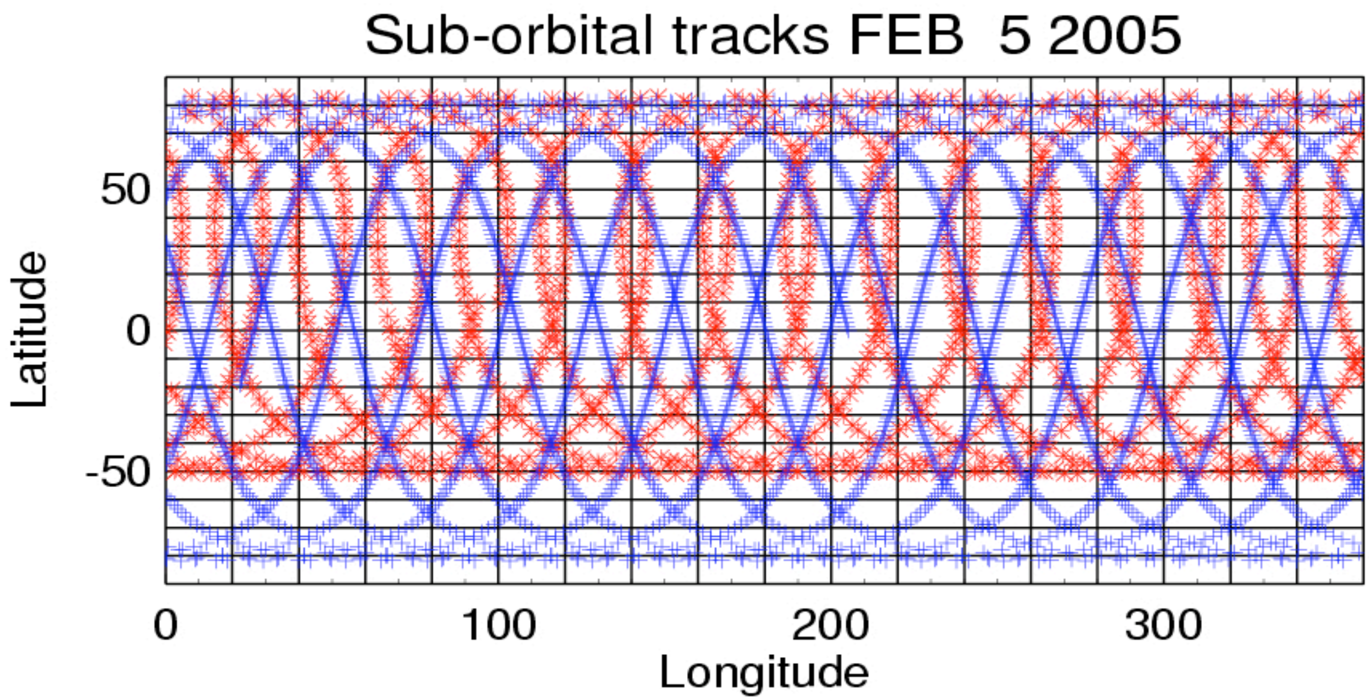
Combining daily measurements from satellites with different local time crossings enhances daily spatial/temporal coverage, and shortens tidal definition periods.

Today, we examine the feasibility of combining TIMED-SABER and EOS-MLS to increase short-term scientific yield in the MLT.

Outline

1. **Sampling patterns.**
2. **Intercomparison of SABER and EOS T.**
3. **Implications of tidal variability.**
4. **Error estimates using virtual dataset.**

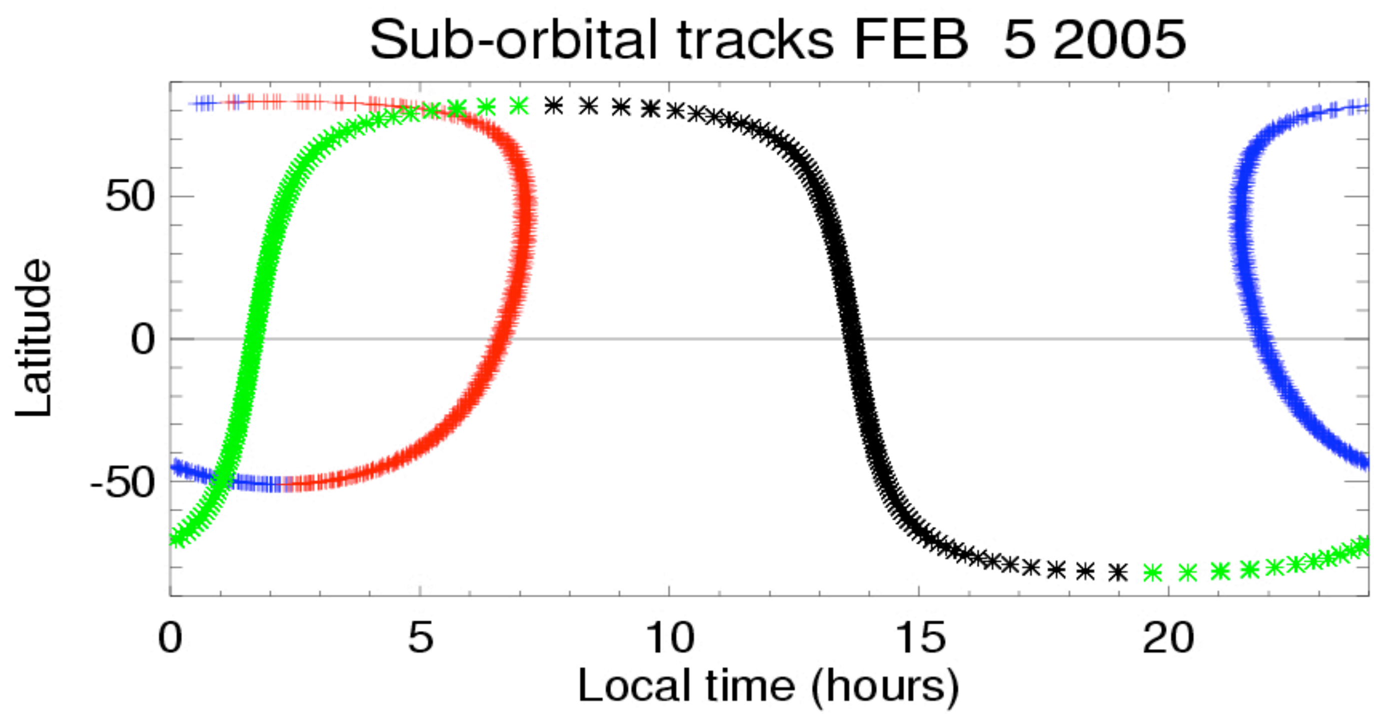
Latitude-longitude sampling



SABER

EOS-Aura

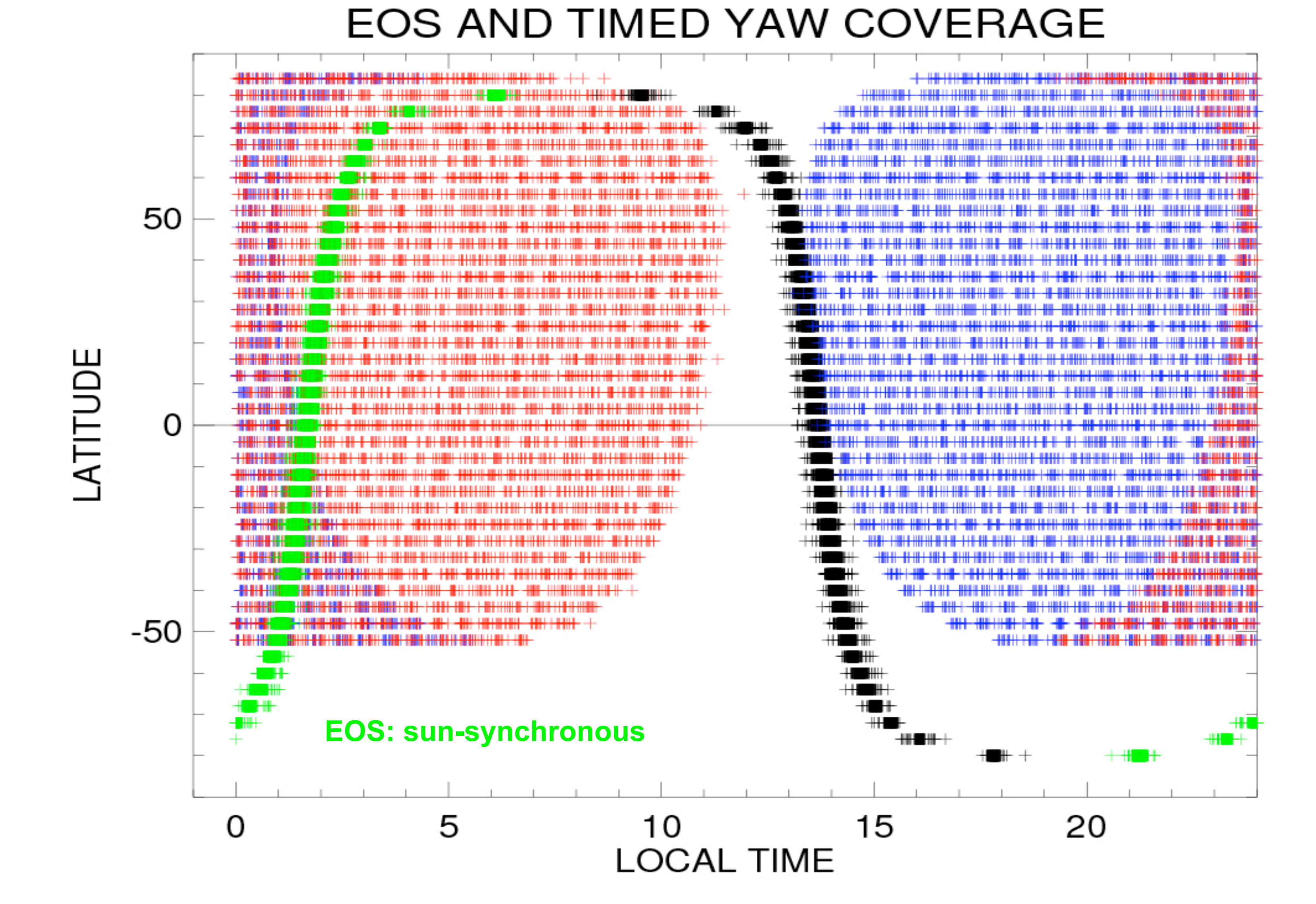
Local time-latitude sampling



SABER asc.
SABER desc.

Aura asc.
Aura desc.

Local time precession



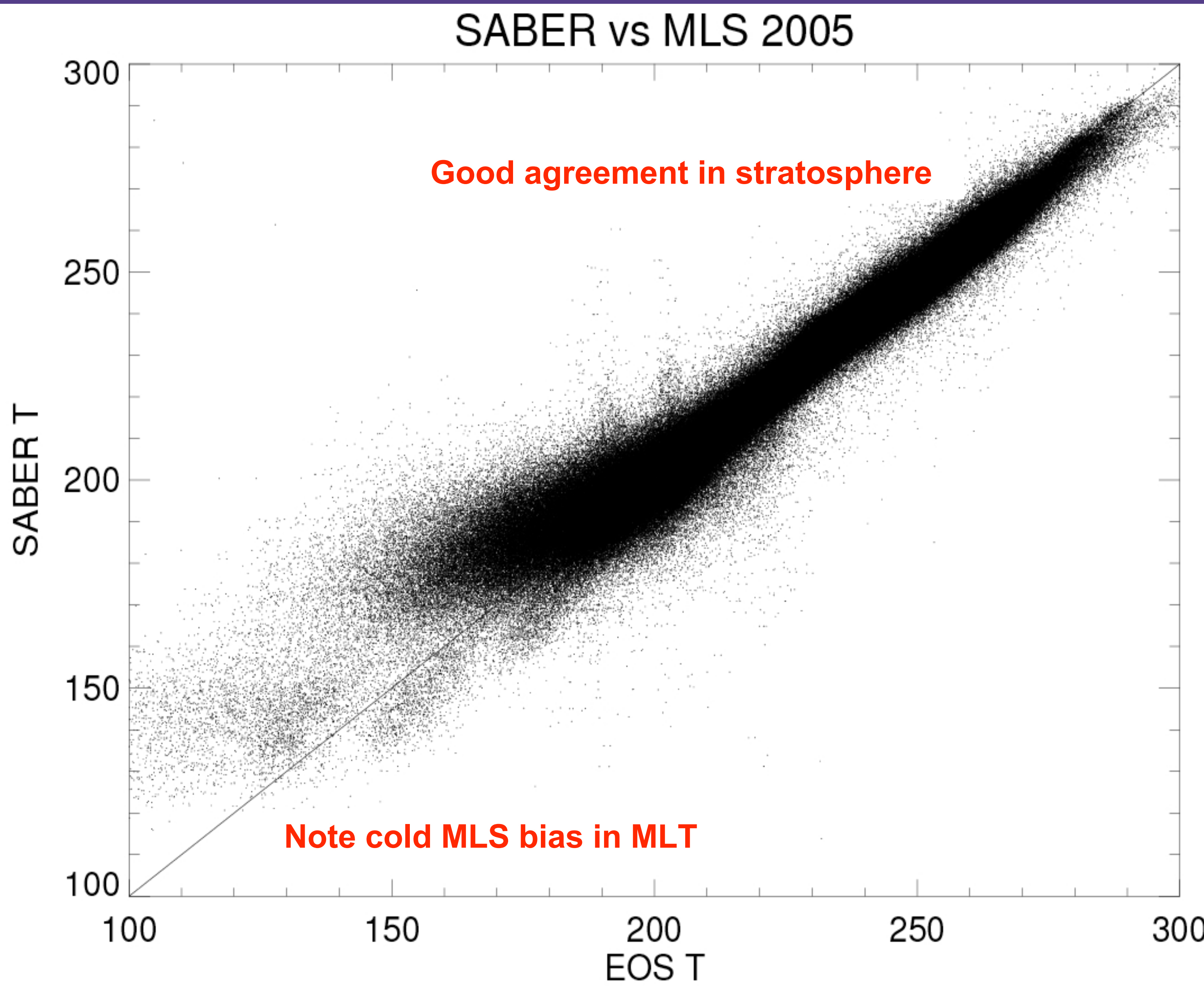
- **SABER** measures daytime and nighttime vertical emission profiles in the near- to mid-infrared. **Temperatures** inferred from the **15 μm CO_2** emissions; **non-LTE** conditions accounted for (Mertens et al., 2004).

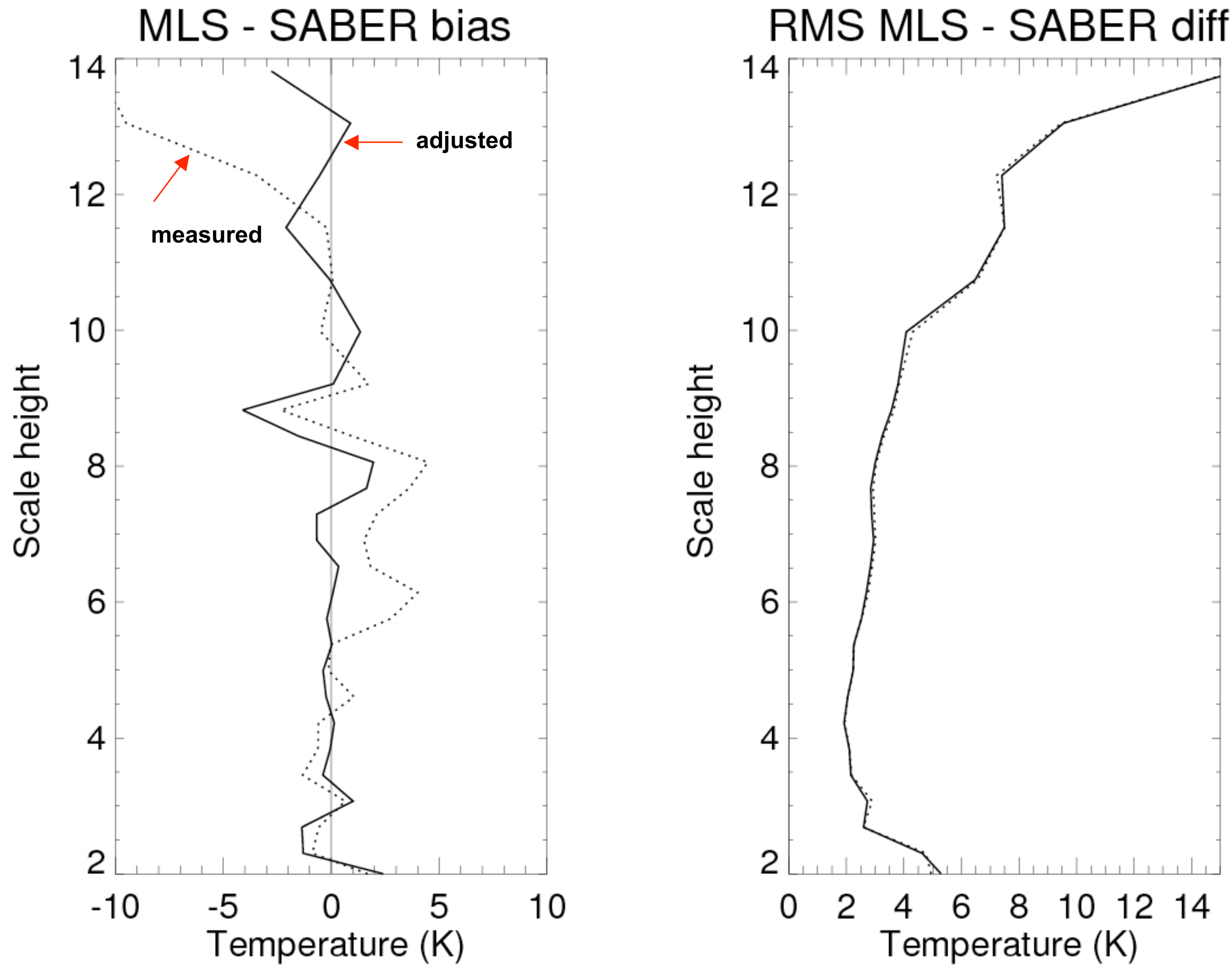
Vertical resolution: 2 km

- **MLS** measures the **118 GHz O_2 (microwave)** emission between 316-1.41 hPa, along with **190 GHz** emission between 1-0.001 hPa.

Vertical resolution:

~5 km	316-100 hPa
~4 km	31-3.16 hPa
~8 km	1-.316 hPa
~14 km	0.1 hPa


SABER vs MLS 2005
Good agreement in stratosphere
Note cold MLS bias in MLT
SABER T
EOS T
100
150
200
250
300


MLS - SABER bias
adjusted
measured
Scale height
Temperature (K)
RMS MLS - SABER diff
Scale height
Temperature (K)

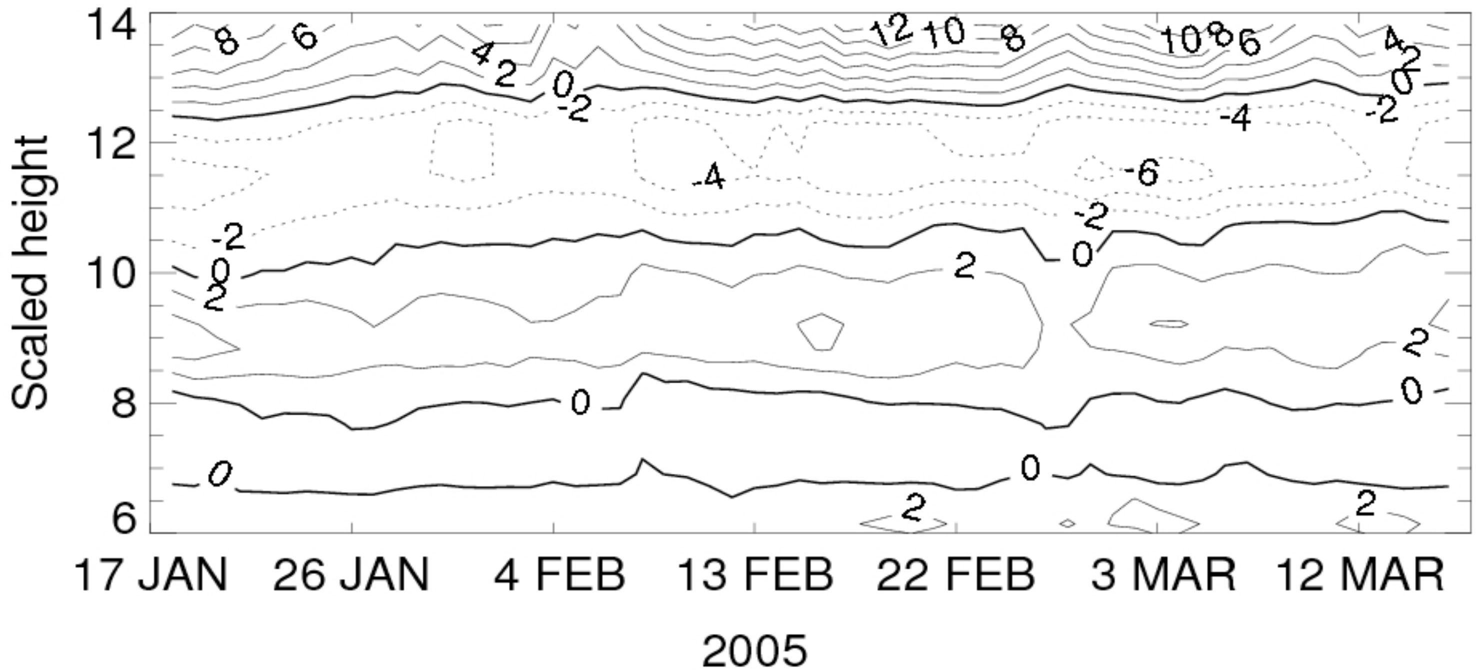
MLS and SABER exhibit increasing RMS differences above 10 km. The cause has not been definitively examined, however it may be related to greater sensitivity of SABER to small-vertical-scale phenomena.

We proceed to examine the impact of combining the two datasets upon tidal analysis.

Diurnal tides are fit to daily ascending-descending node temperature differences (~nearly 12 hours for MLS and ~9 hours for SABER). This procedure minimizes aliasing by slowly evolving planetary waves and the mean state.

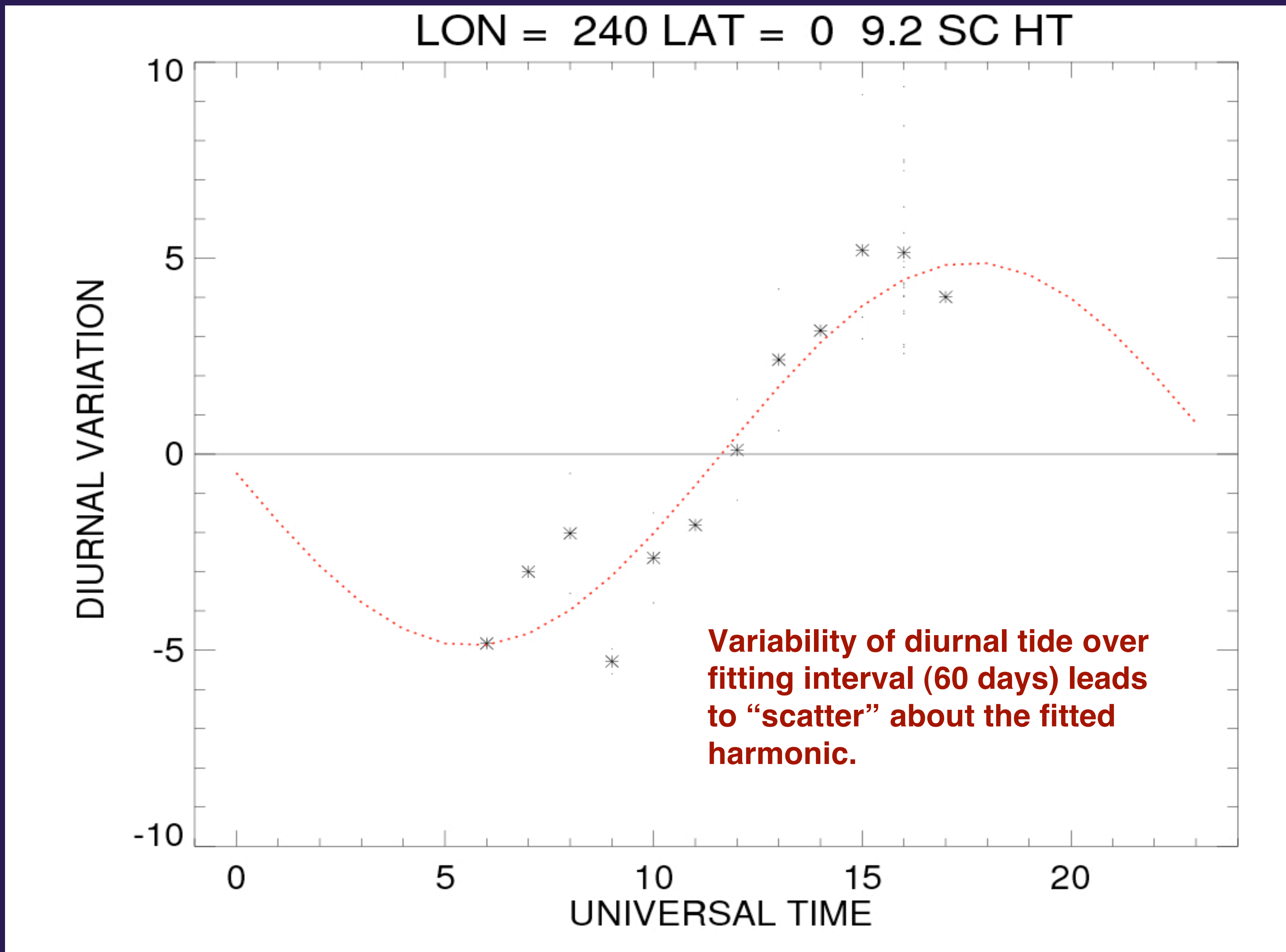
12-Hour Difference as Diurnal Proxy

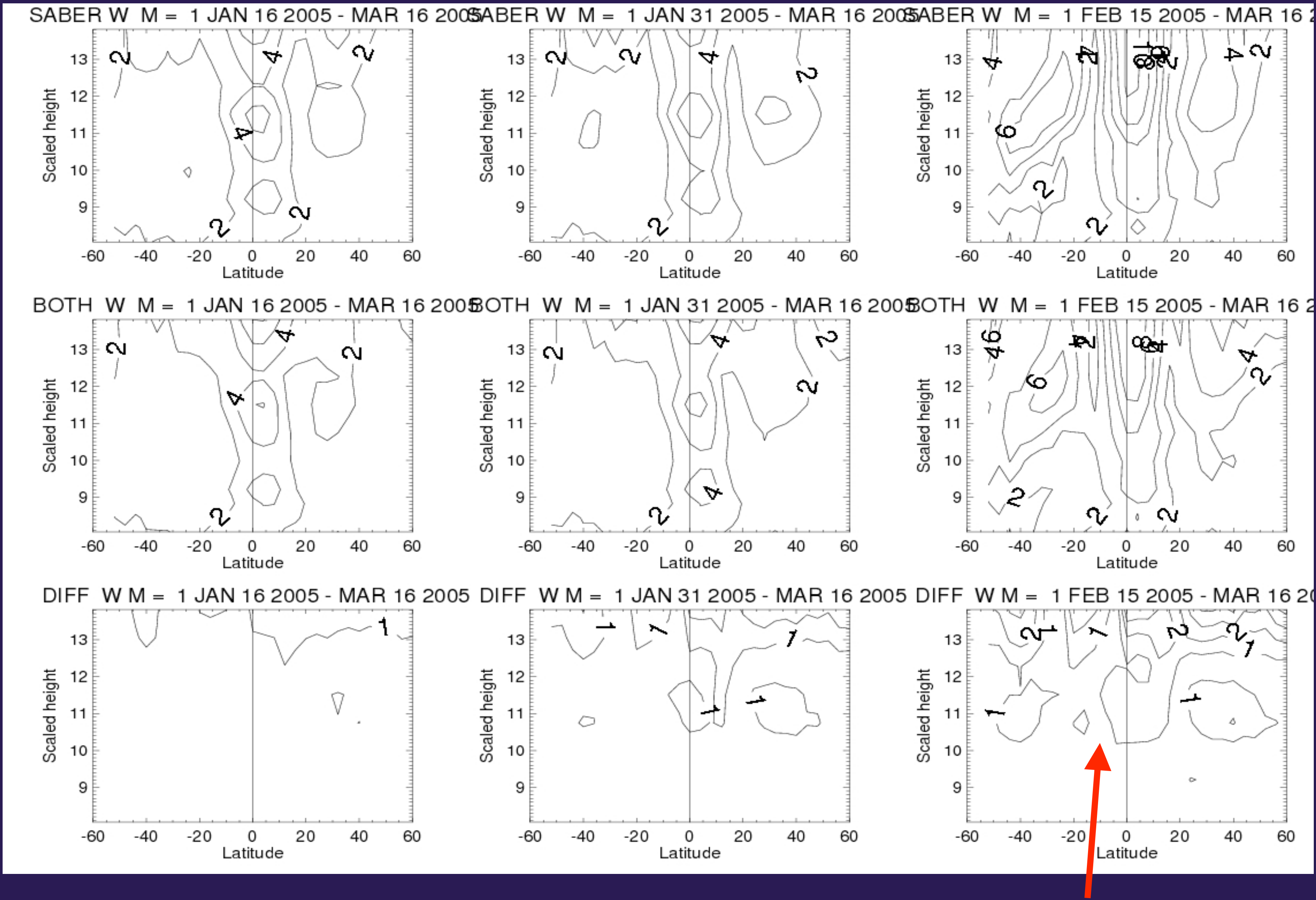
EOS MLS ASCENDING-DESCENDING EQ TEMPERATURE



Migrating diurnal tide has seasonal and sub-seasonal variability that becomes more pronounced at higher altitudes.

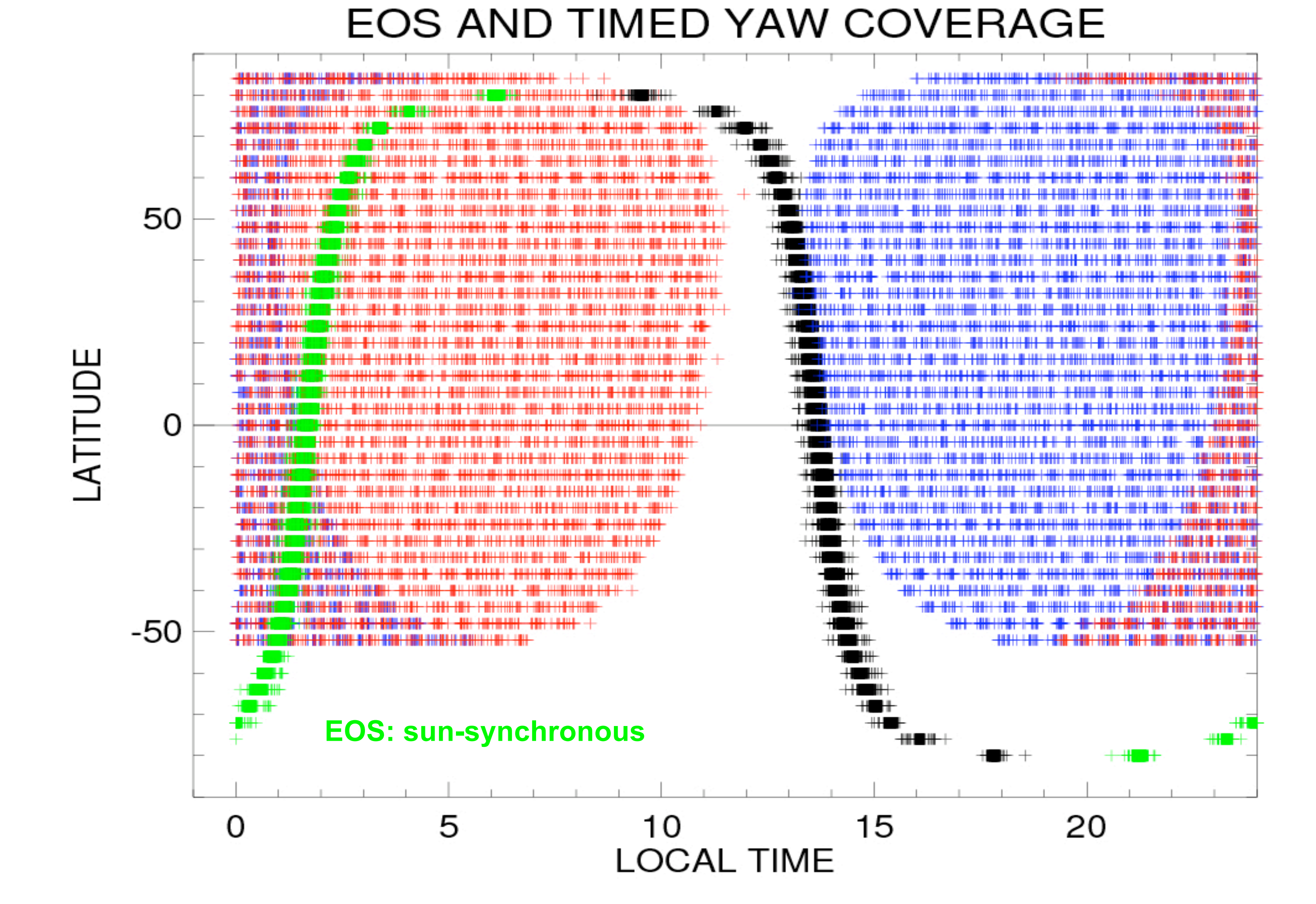
Diurnal Fitting: 60 day collection interval





Influence of combining MLS & SABER increases, as the data-gathering interval decreases.

Local time precession

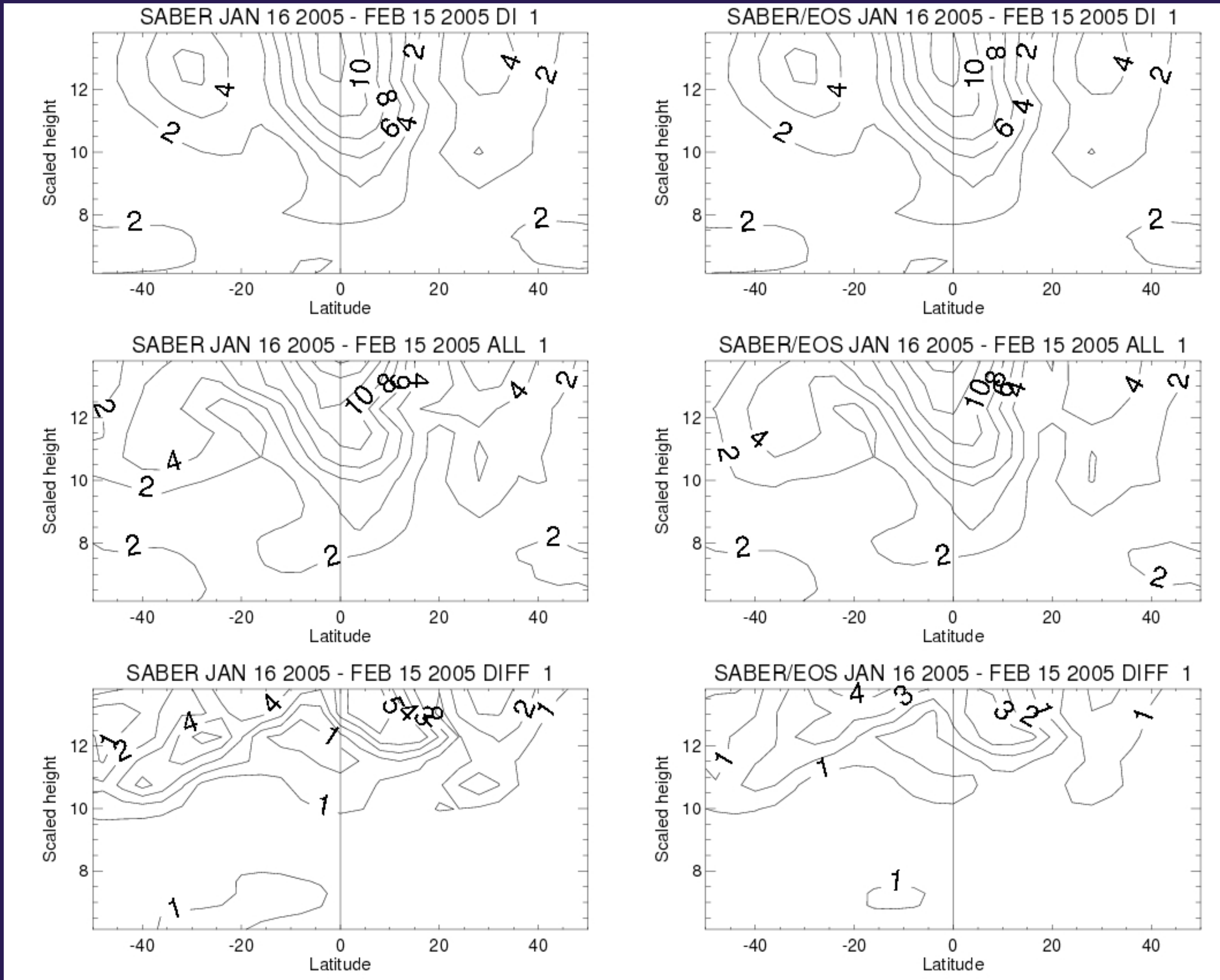


We have observed the following:

1. **Diurnal tide amplitudes are variable in time.**
2. **Longer sampling interval ⇒more averaging and less influence of combining MLS & SABER.**
3. **Shorter sampling interval ⇒less averaging and greater influence of combining MLS & SABER.**

…But what determines how "good" these retrievals are?

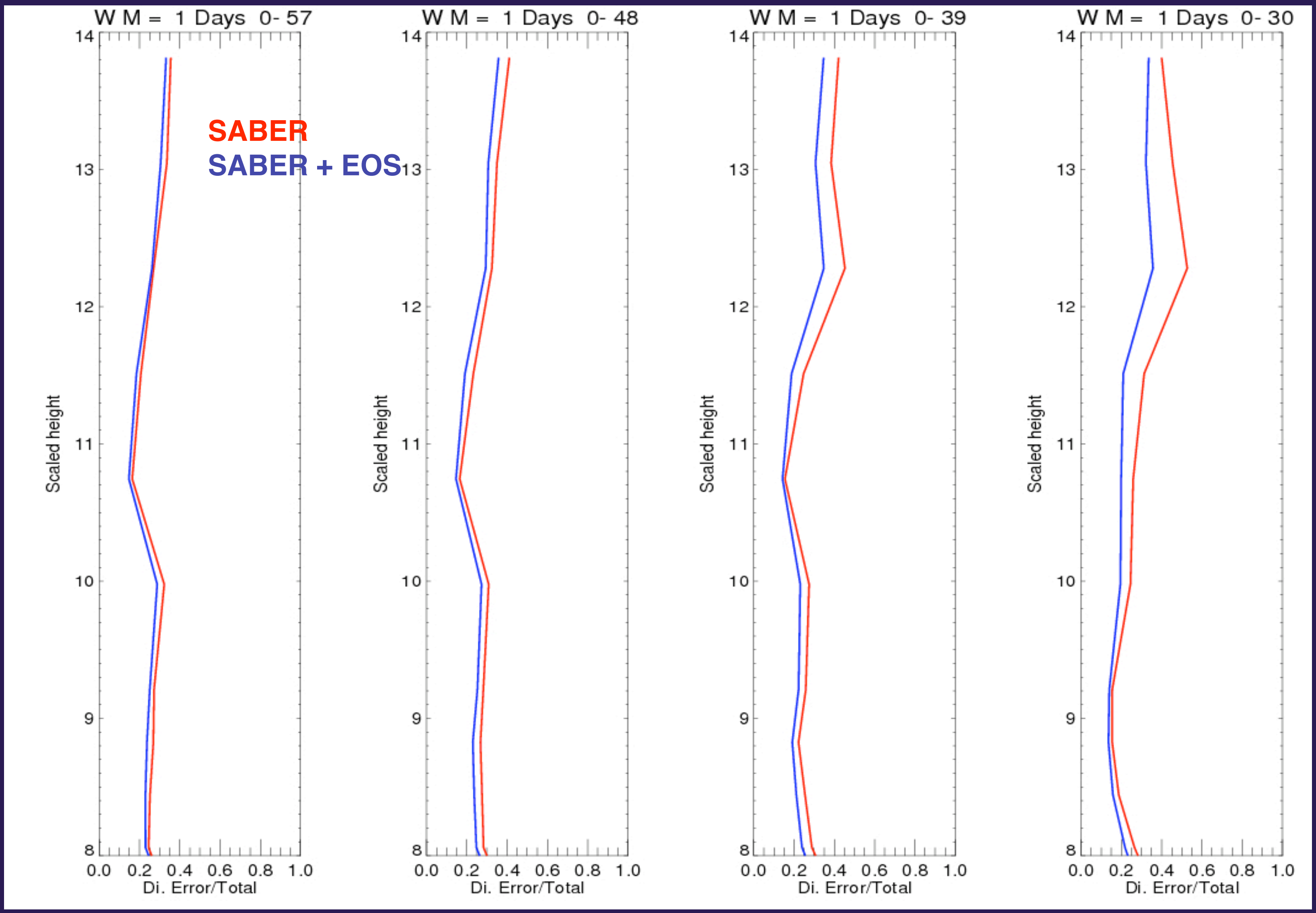
SABER sampling only | **SABER + EOS sampling**



WACCM diurnal input

Full WACCM 30-day spectral input

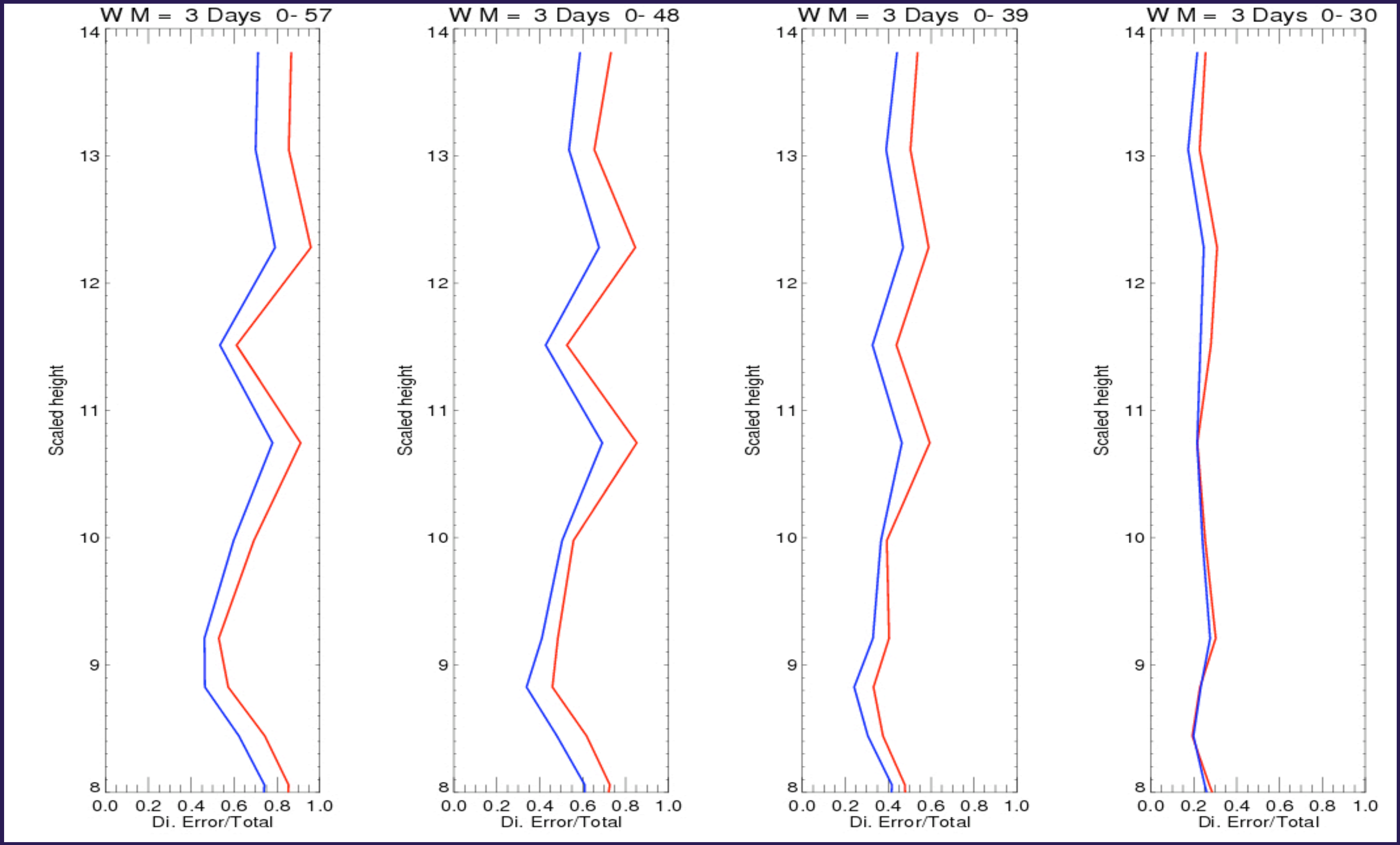
Spectral leakage due to non-diurnal variations



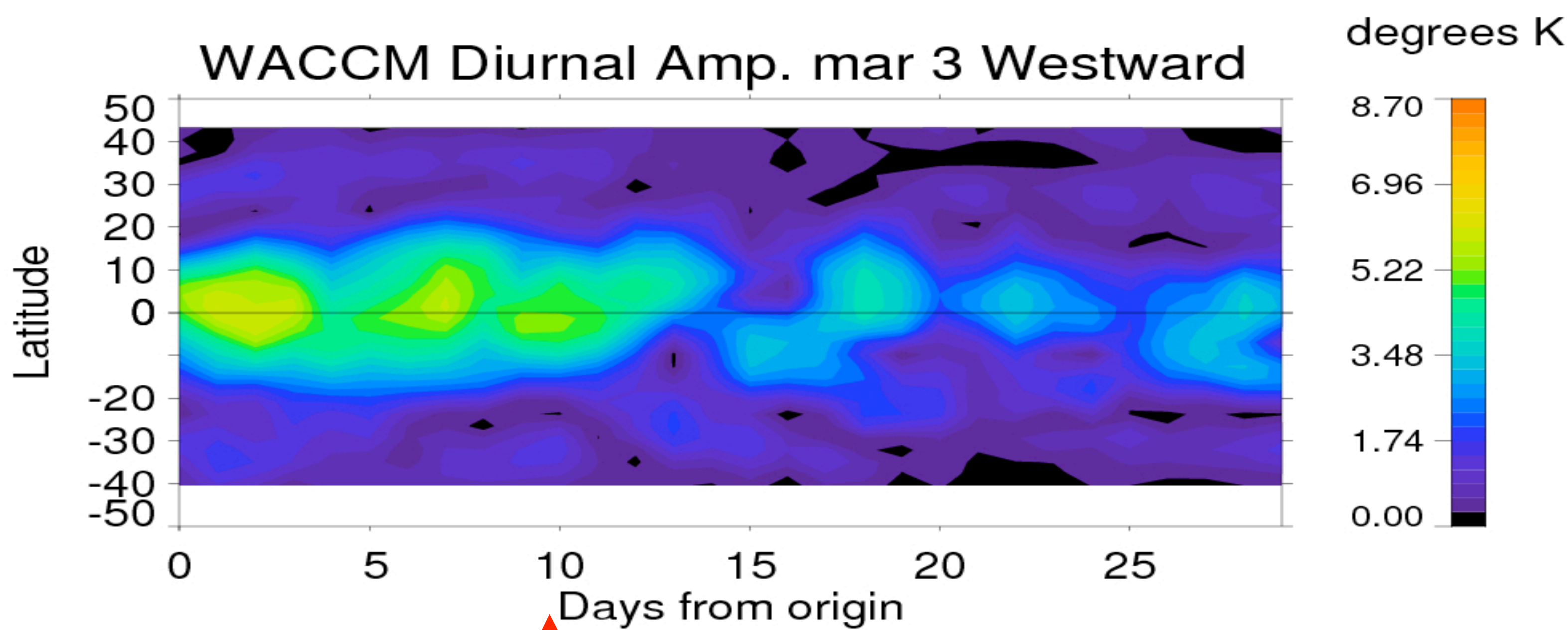
For migrating tide, spectral leakage is lowest for longer sampling intervals.

For shorter intervals the influence of merging MLS and SABER is more apparent.

Do longer sampling intervals ⇒less uncertainty?



Not when tide is highly variable in amplitude and phase. In this case, shorter sampling intervals provide better definitions.



Abrupt change of phase here

Summary

Satellite data are valuable for initializing, evolving and constraining MLT features that are strong and dissipating (tides and PW), gravity-wave drive (MSAO), or in-situ (instabilities).

Attention must be paid to the local time sampling patterns, which for an individual satellite tend to be deficient on a daily basis for separating tidal from quasi-stationary motions.

To mitigate the problem of local time undersampling , we combined data from EOS and TIMED satellites, and examined the diurnal tides.

Retrieval of tidal parameters over a yaw period (or portion thereof) is optimized when

1. Tides are not highly variable over sampling interval.
2. Analysis methods (e. g., forming 12-hour differences) minimize aliasing due to slowly evolving background states.

Combining EOS and TIMED data minimizes errors arising from 1.

Ability to better define migrating tides ⇒better definitions of zonally averaged winds (Lieberman 1999).

Some remaining challenges:

Shorter tide/mean wind definition intervals.

Diagnose cause of RMS differences between MLS and SABER T's, formulate appropriate error variances (take into account differing vertical resolution?)