Stratospheric Temperature Monitoring: Impact of Temporal Sampling

Beatriz M. Funatsu[1], Chantal Claud[1], and Philippe Keckhut[2]

[1]Laboratoire de Météorologie Dynamique/IPSL, Palaiseau; [2]Service d'Aéronomie/IPSL, Verrières Le Buisson

funatsu@lmd.polytechnique.fr, Chantal.Claud@lmd.polytechnique.fr, Philippe.Keckhut@aero.obs-mip.fr

1. MOTIVATION and OBJECTIVES

Satellite data is the only global source of middle-atmospheric temperature data, however suffers from temporal discontinuity, coarse vertical resolution, and orbital drift.

Lidar data provides temperature measurements throughout the stratosphere (30-80 km) and time series are available for one or two decades, but there is only few stations available. In addition, measurements are done only in nights without visible clouds.

Because an accurate monitoring of stratospheric temperature is essential to a better understanding of climate dynamics and climate change, we propose here to evaluate the impact of temporal sampling on temperature trend calculations by cross-validating temperature data from lidar measurements at the Observatoire de Haute-Provence (OHP), in central France, and the Advanced Microwave Sounding Unit (AMSU) data.

2. DATA

2.1 AMSU

- Flying onboard NOAA satellites starting in 1998
- Module A – designed to give information on temperature; horizontal resolution at nadir: 48 km
- Stratospheric channels: 9-14

IN THIS WORK:

- Period considered: 2001-2007
- We use NOAA-16 AMSU-A channels 12-14 which sample the mid- and upper stratosphere (Fig. 1).
- Only night-time, near-nadir measurements falling over [40-45°N, 10°W-20°E] are used to calculate monthly means.

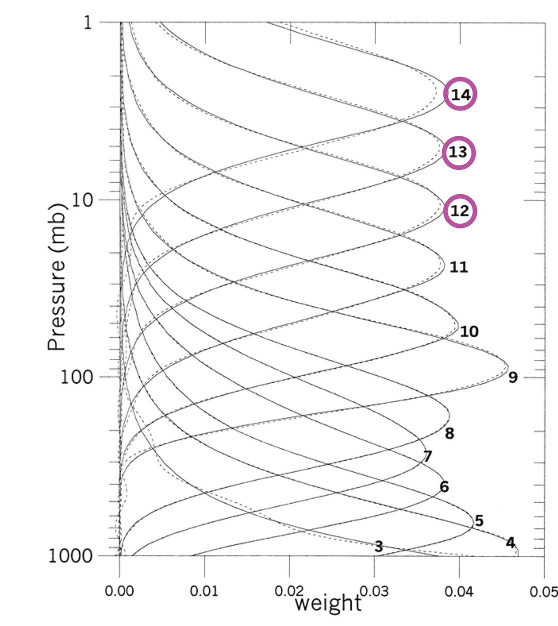


Figure 1: AMSU-A weighting functions

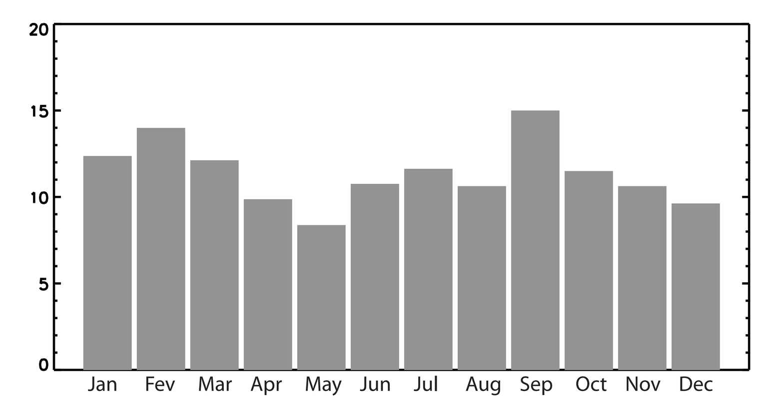


Figure 2: Average number of days in a month with lidar measurement

2.2 OHP (44°N, 6°E) Lidar

- Measurements since 1979
- T profiles derived from molecular scattering caused by emission of a short-duration laser pulse in zenith direction.
- Average number of days with measurements by month (2001-2007), is shown in Fig. 2.
- Lidar data is vertically averaged over a thin layer of 3 km.

3. COMPARISON BETWEEN LIDAR AND AMSU

3.1 ANNUAL CYCLE & TIME SERIES

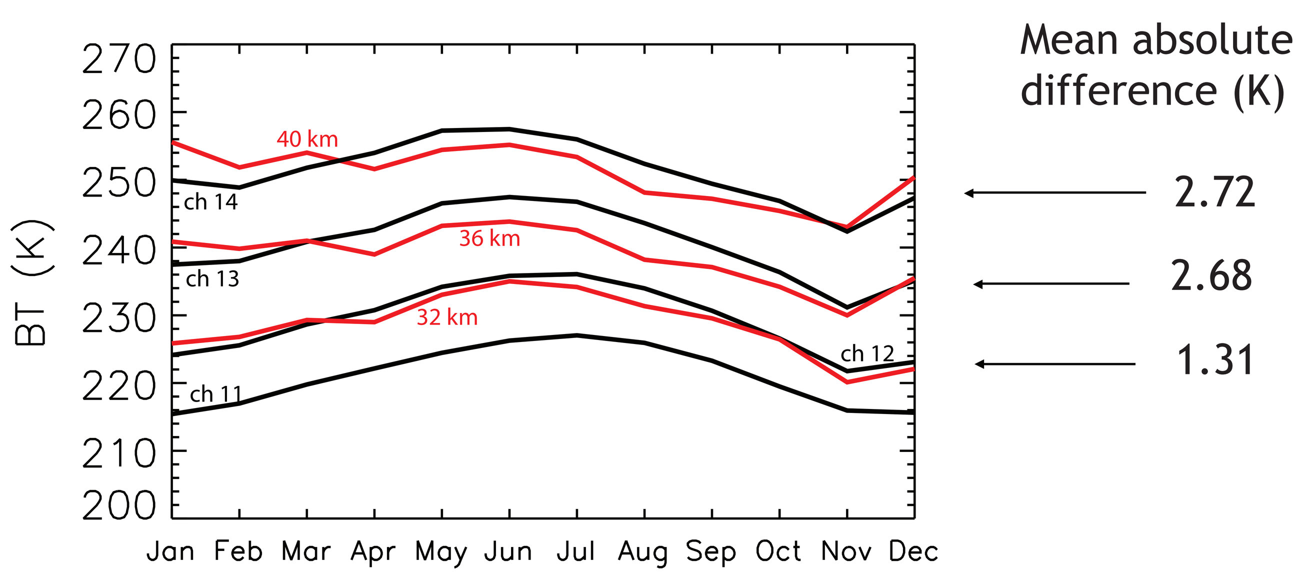


Figure 2: AMSU-A brightness temperature (K) annual cycle for different stratospheric channels (black), and temperature (K) annual cycle for selected altitudes of OHP lidar measurements (red).

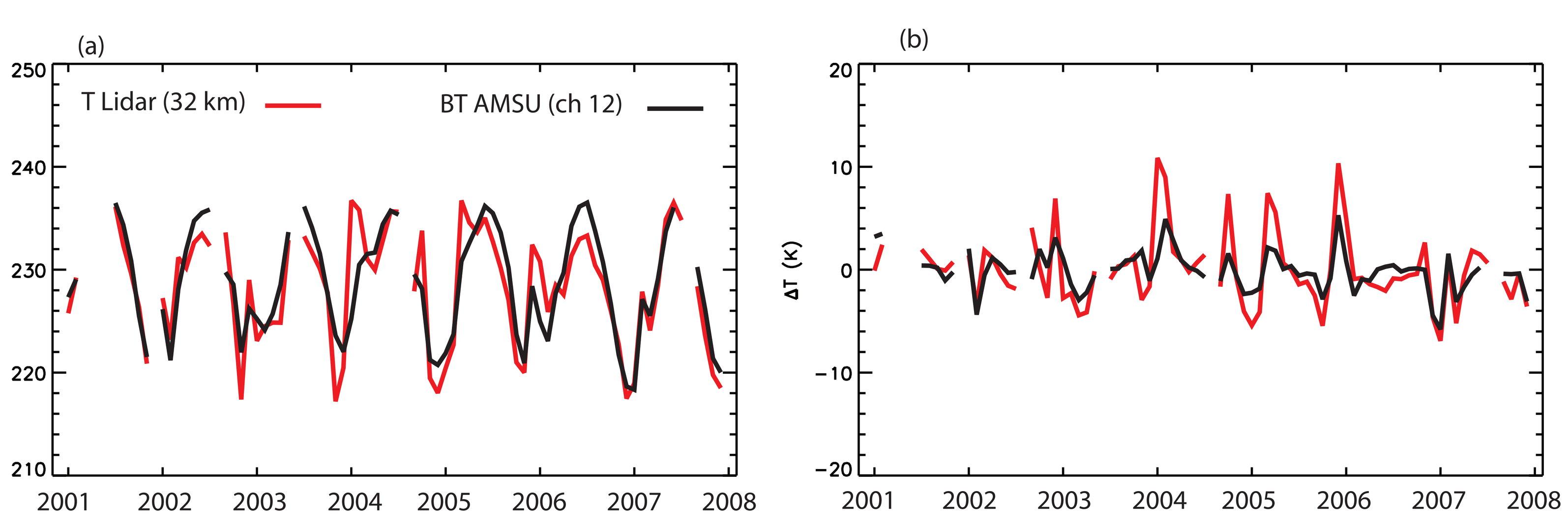
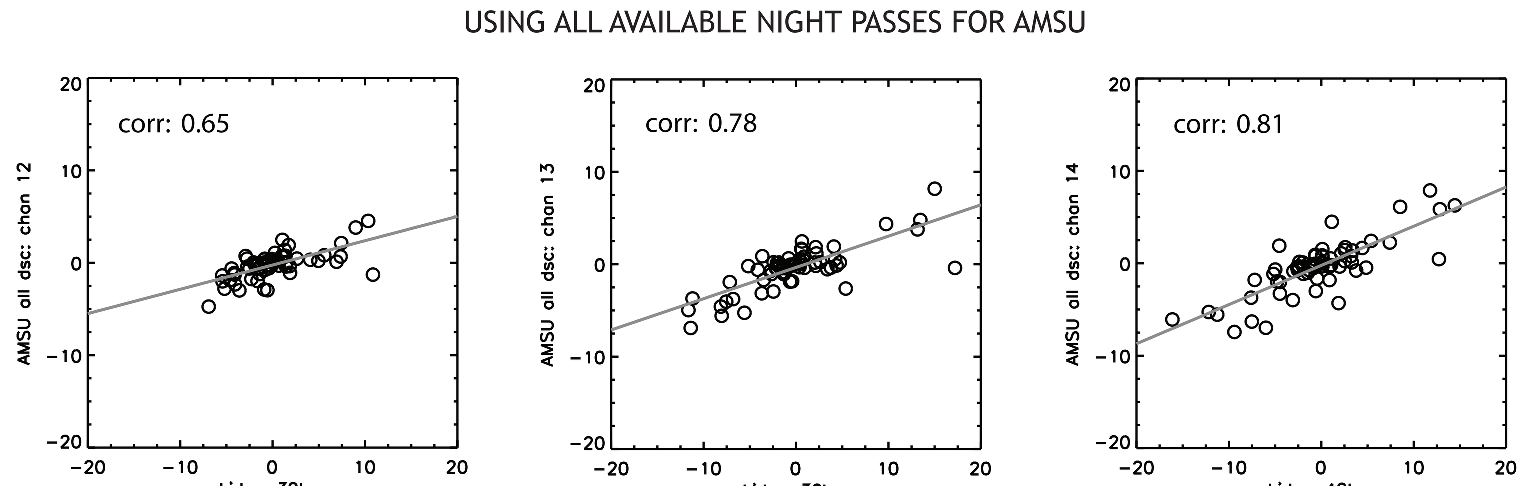


Figure 3: (a) Time series and (b) time series with annual cycle removed, of temperature at 32 km measured by lidar and brightness temperature from AMSU-A channel 12.

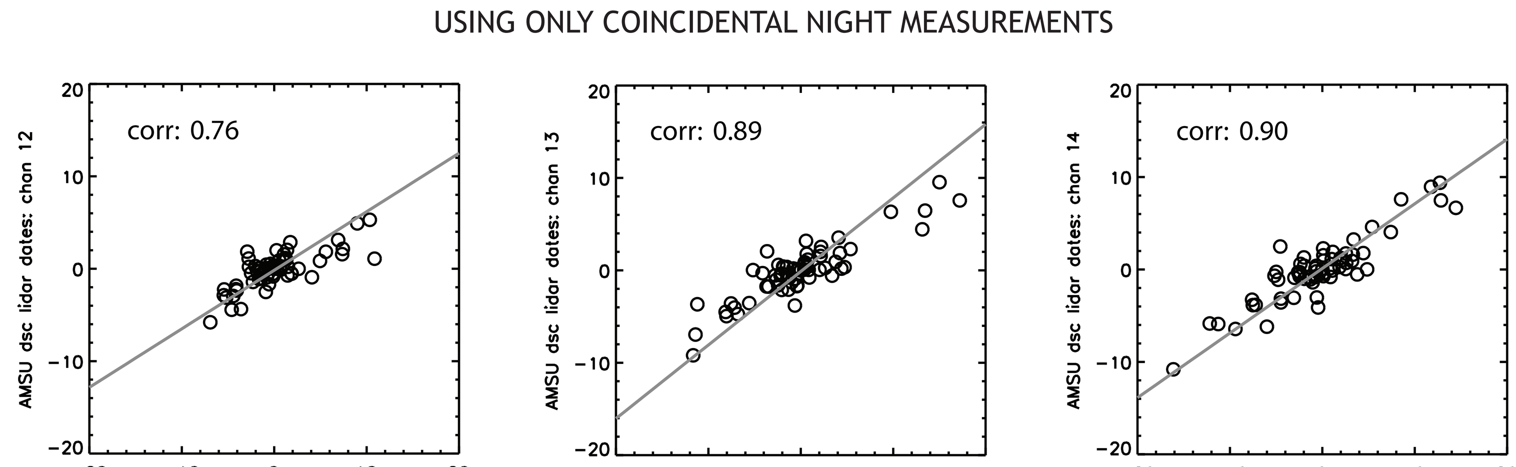
- Time series of temperatures correspond well (Fig. 3a).
- Time series of temperatures with annual cycle removed present larger (local) discrepancies (Fig. 3b). These are partly due to the effect of « vertical sampling ».
- « Vertical sampling »: Lidar data is representative of a layer of 3 km, while AMSU BT gives integrated information over a much deeper layer (see Fig. 1), therefore smoothing local peaks.

3.2 CORRELATION BETWEEN LIDAR T AND AMSU BT

USING ALL AVAILABLE NIGHT PASSES FOR AMSU



USING ONLY COINCIDENTAL NIGHT MEASUREMENTS



- Lidar and AMSU observations are well correlated, despite instrument/spatial resolution differences
- Correlation is less good when using non-coincidental dates of AMSU and lidar.

4. EFFECT OF TEMPORAL SAMPLING

4.1 ON MONTHLY MEANS

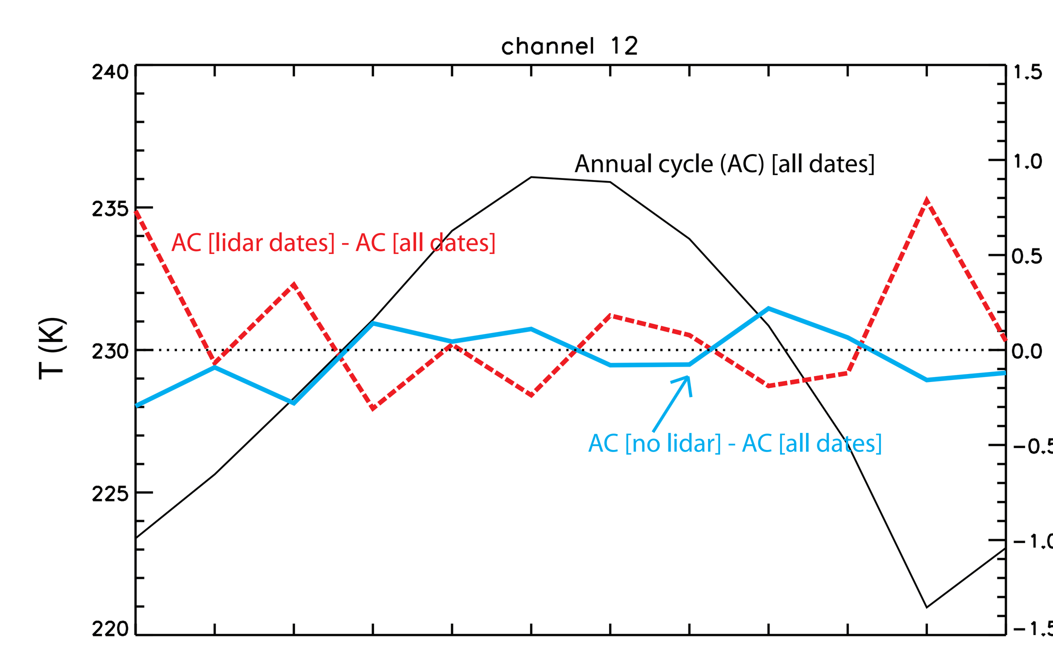


Figure 5 : NOAA-16 AMSU-A channel 12 annual cycle brightness temperature (in K; black), using all dates, and differences between annual cycle temperatures using only days with OHP lidar measurements (in K; red), or only dates without lidar measurements (in K; blue).

- From mid-October to mid-March differences reach several tenths of degree, and there is large variability.
- Between March and October, the absolute difference is smaller, around 0.3 K (order of or smaller than the instrument noise).

4.2 ON THE ESTIMATION OF TENDENCIES

Table: Coefficients of linear regression of temperature with respect to time, for lidar and AMSU measurements, for the period 2001-2007. The coefficient constant (A) is given in units of degrees K, while tendencies (B) are in units of K/decade.

	Lidar OHP			AMSU lidar dates			AMSU all dsc	
	A(K)	B(K/dec)		A(K)	B(K/dec)		A(K)	B(K/dec)
32 km	1.2	-2.5 ± 2.6	ch 12	0.9	-2.8 ± 1.1	ch 12	0.5	-1.6 ± 0.7
36 km	2.0	-4.4 ± 3.2	ch 13	1.7	-4.6 ± 1.8	ch 13	0.9	-2.5 ± 1.2
40 km	2.2	-5.0 ± 3.2	ch 14	1.8	-4.8 ± 2.0	ch 14	0.9	-2.5 ± 1.4

- When using coincidental dates only, tendencies of stratospheric temperature anomalies calculated using Lidar or AMSU data are congruent.
- However, tendencies estimated using all available dates for AMSU show a sharp reduction, indicating that temporal sampling may have an important impact on calculation of long-time trends.

5. CONCLUSIONS

- There is good agreement between AMSU and OHP lidar monthly averaged temperatures, seasonal cycle and trends, when considering coincidental dates.
- This indicates that although lidar measurements are spatially restricted they can represent a much larger domain. However, vertical sampling differences cause 'local' (timewise) discrepancies.
- Temporal sampling effect is more pronounced:
  > Weaker correlation between AMSU and lidar when different days are considered.
  > Annual cycle (for AMSU) is affected mostly during cold season (affecting subsequently the calculation of T anomalies).
  > Temperature tendencies are more negative when using only clear-skies dates.
- A longer series of AMSU temperatures are required to estimate present temperature trends.

This work is a contribution to the project GEOmon (Global Earth Observation and Monitoring of the atmosphere). AMSU data was obtained through the French Mixed Service Unit ICARE.