



THE SSU TEMPERATURE CLIMATE DATA RECORD VERIFYING ANTHROPOGENIC GLOBAL WARMING THEORY



Cheng-Zhi Zou

NOAA/NESDIS/Center For Satellite Applications and Research

Haifeng Qian

Earth Resource Technology, Inc.

ITSC-20, Lake Geneva, Wisconsin, October 28-November 3, 2015



Acknowledgement

- Dr. Fuzhong Weng/STAR for program support



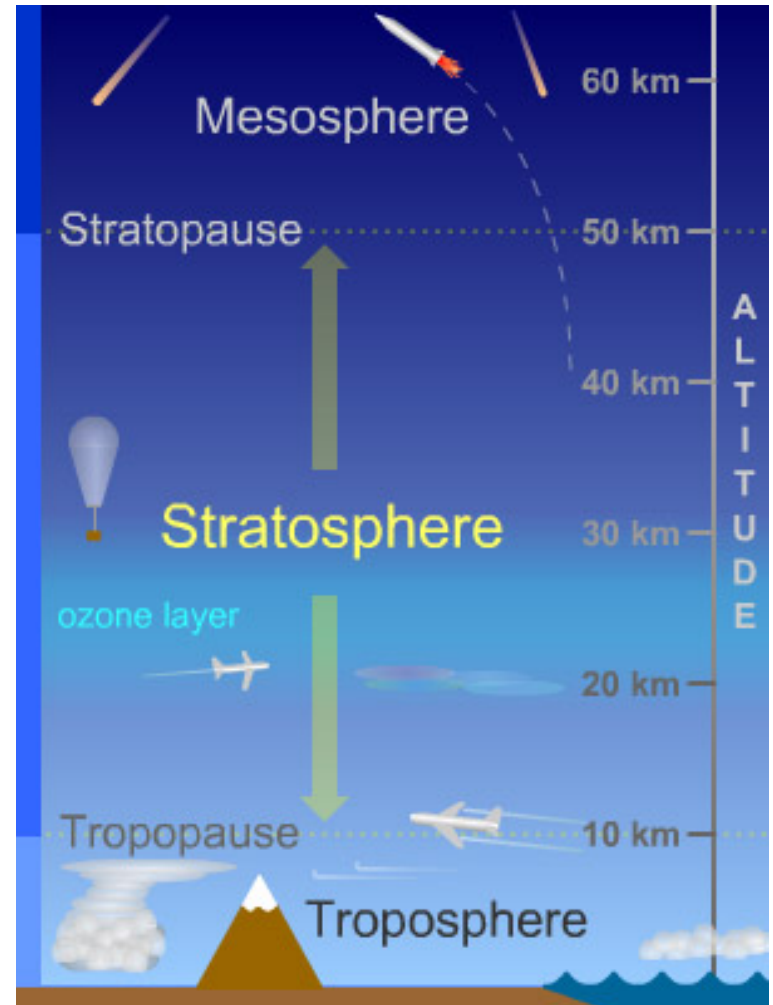
Outline

- Introduction
- The SSU Instrument
- NOAA SSU Processing History
- NOAA SSU CDR Processing Procedure
- Verifying Anthropogenic Global Warming Theory
- Conclusion



Introduction

- Stratospheric temperature trend is an important indicator of anthropogenic global warming
- Stratospheric cooling:
 - Ozone depletion
 - Increasing carbon dioxide and other greenhouse gases
- Radiosonde observations difficult to reach to mid-upper stratospheres
- Lidar observations are sparse
- Rely on satellite observations to determine trend

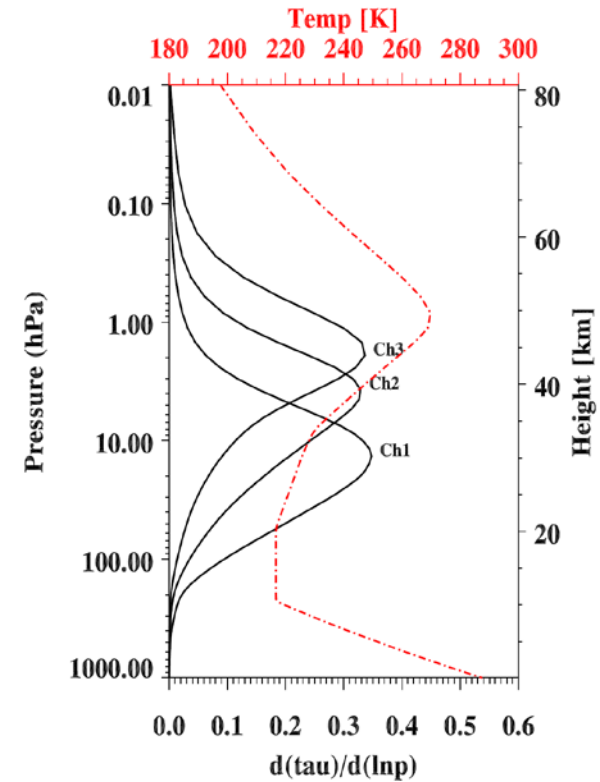




The SSU Instrument

- One of the TOVS instruments (MSU, HIRS, SSU) onboard NOAA TIROS-N polar-orbiting satellite series from 1978-2007; seven satellites equipped with SSU
- Supplied by UK Met Office
- Infrared radiometer using pressure modulation technique to measure atmospheric radiation from CO₂ 15-μm ν₂ band
- Three cells of CO₂ gas were placed in the optical path with different gas pressures which allowed three channels for a single CO₂ band

$$P(\text{peak}) \sim P(\text{cell}) / [\text{CO}_2]^{1/2}$$



SSU channel weighting functions determined by cell pressure values

Channel	1	2	3
Peak of WF	15mb	5mb	1.5mb



NOAA SSU Processing History/Summary— 1978-2007

- Raw SSU data and satellite orbital information were operationally processed at NOAA/NESDIS for each satellite along with other TOVS instruments and saved in operational level-1b files
- level-1b files were distributed to world-wide users and archived in NOAA/NCDC Comprehensive Large Array-data Stewardship System (CLASS)
- Level-1c radiances can be calculated from calibration coefficients stored in level-1b files
- UK Met Office conducted instrument testing and developed its version of SSU time series
- Technical notes available for NOAA operational processing and UKMO instrument testing, but information for instrument calibration was insufficient and sometimes even missing



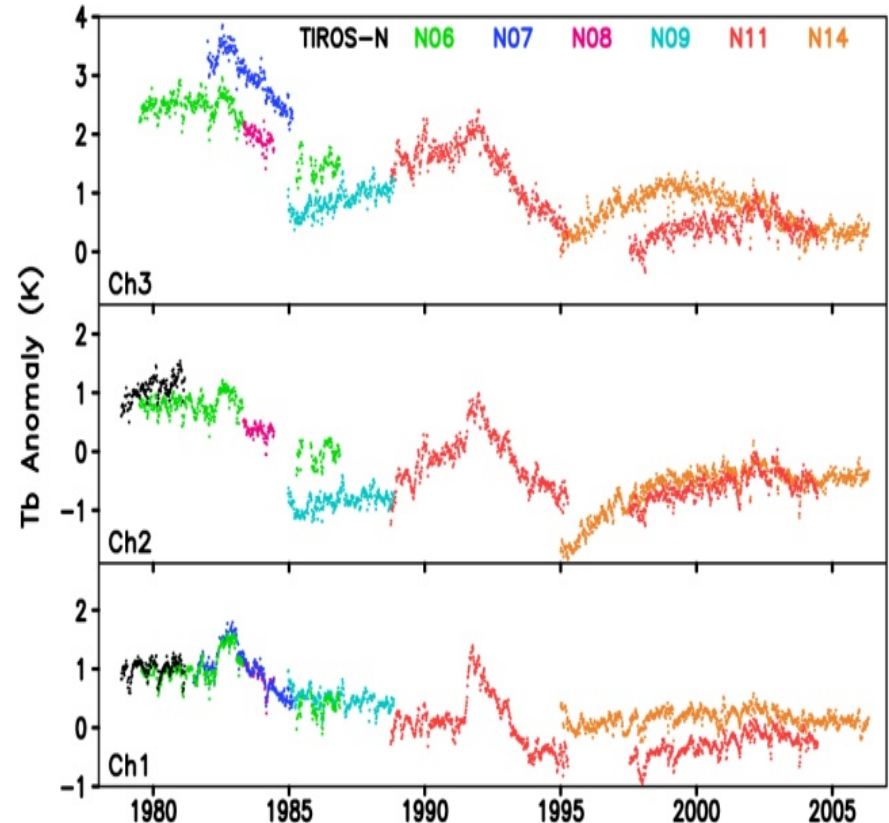
NOAA SSU Processing History/Summary– 2008-present

- STAR began to develop SSU temperature time series using operational level-1c radiances in 2008
- STAR developed SSU radiative transfer model as part of CRTM (Liu and Weng 2009, Chen et al. 2011)
- Released its first version of SSU time series in 2011 (Wang et al. 2012)
- Thompson et al. (2012) documented SSU trend differences between NOAA and Met Office versions and their difference from climate model simulations and called for re-investigation of the SSU problems
- STAR recalibrated the SSU observation and developed consistent radiance FCDR and its Version 2 temperature time series in 2014 (Zou et al. 2014)
- Merged SSU and AMSU to extend the time series from 1978 to present in 2015



Issues in Unadjusted SSU Radiances

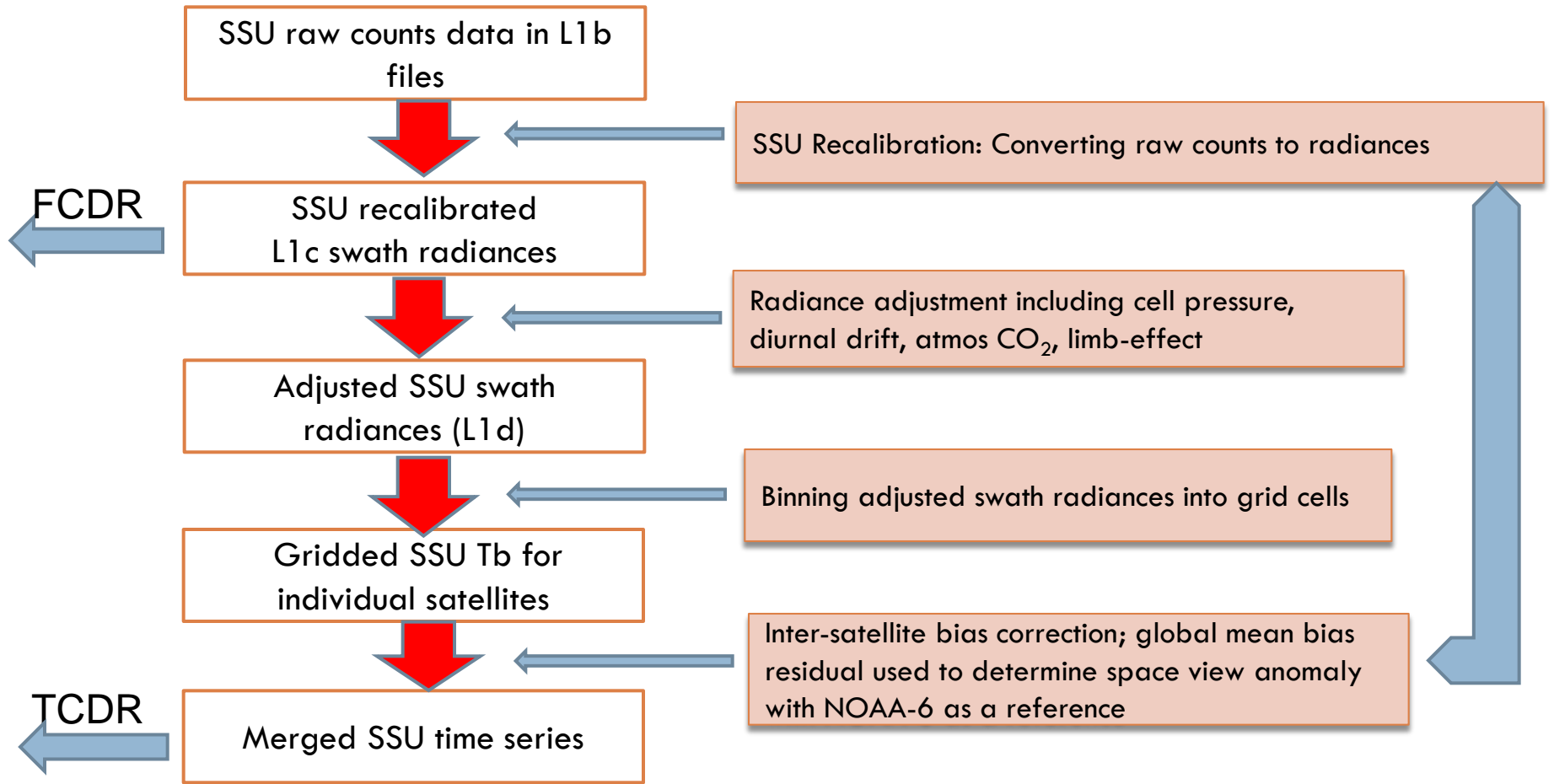
- Insufficient documentation—lost or no record of certain calibration parameters
- Bad data from bad calibration (NOAA-7 channel 2)
- Space view anomaly—directly affects level-1c radiances
- Blackbody target
- Gas leaking in the CO₂ cell → weighting function variation
- atmospheric CO₂ variations
- limb-effect
- diurnal drift effect → semi-diurnal tides
- Residual biases



Global mean anomaly time series for each satellite for radiances before adjustment and merging



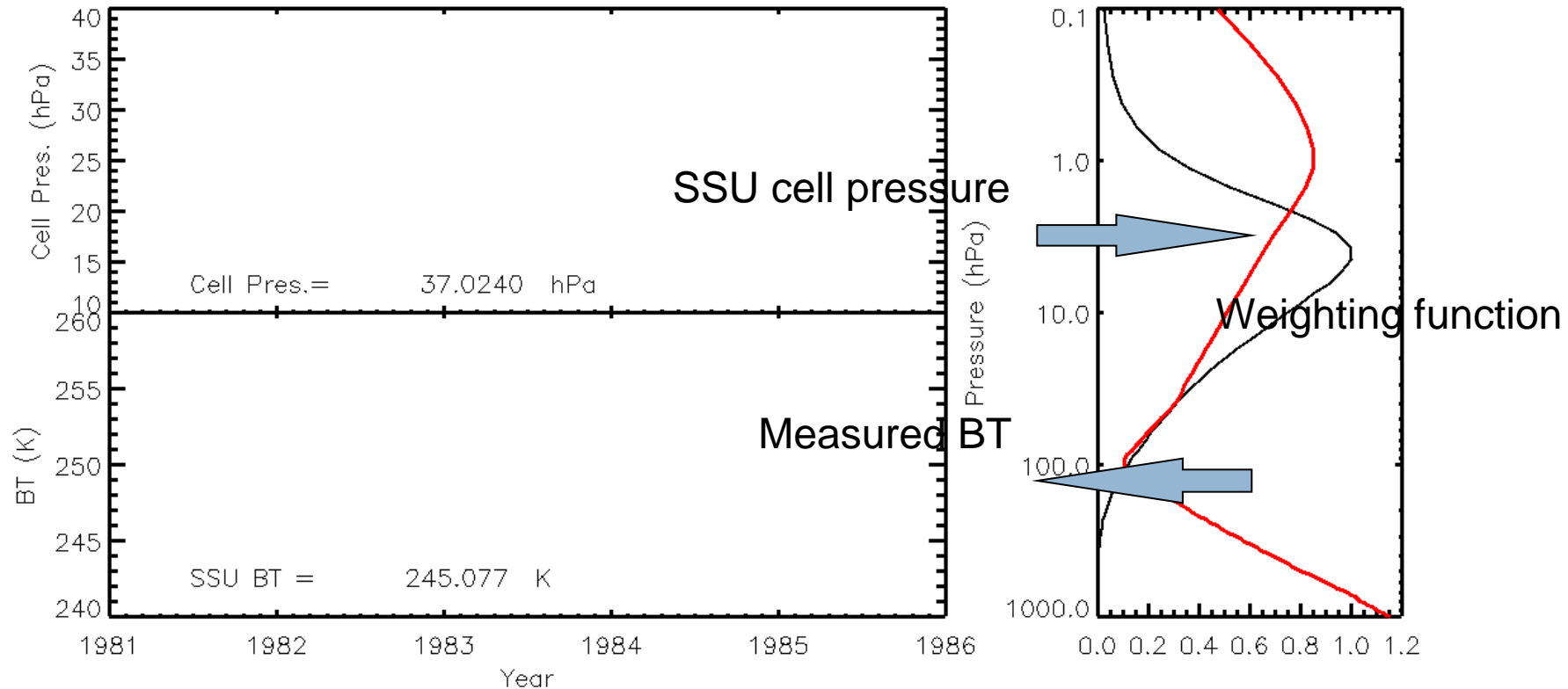
NOAA SSU FCDR and TCDR Processing Flow Chart



Need two processing cycles to complete

Physics of Cell Pressure Changes

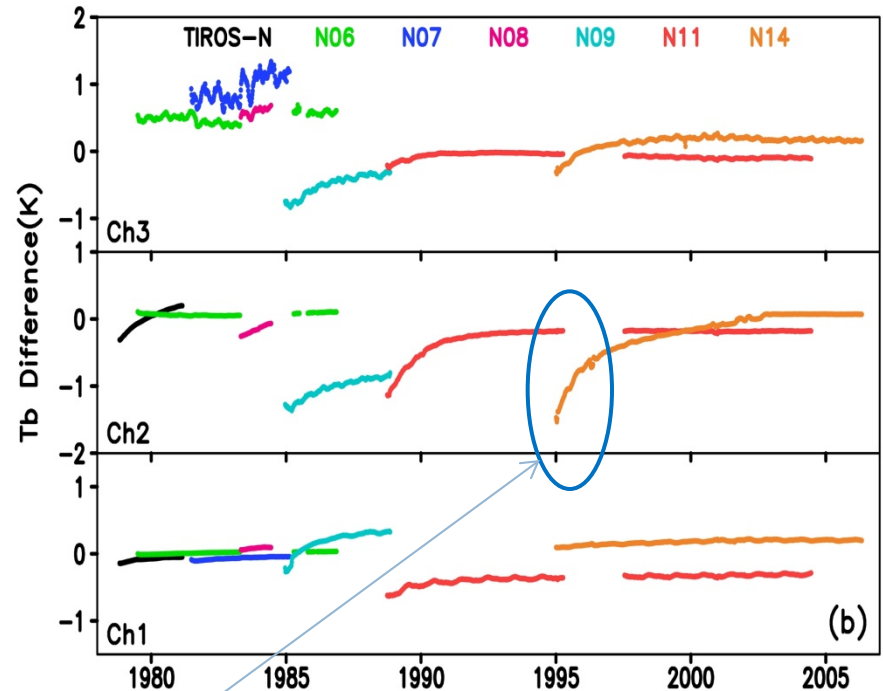
CO₂ cell pressure decreasing -> weighting function peaks higher -> because of increasing lapse rate, measured Tb increasing -> warm bias





Correction Time Series Due to Cell Pressure Change

- Cell pressure changes were derived from piston frequency changes for each satellite and channel (Kobayashi et al. 2009)
- STAR developed the Brightness temperature correction time series using the CRTM SSU model (Wang et al. 2012)
- Time series changed with time, larger at the beginning of a satellite's life cycle due to large cell pressure decreases during that time period



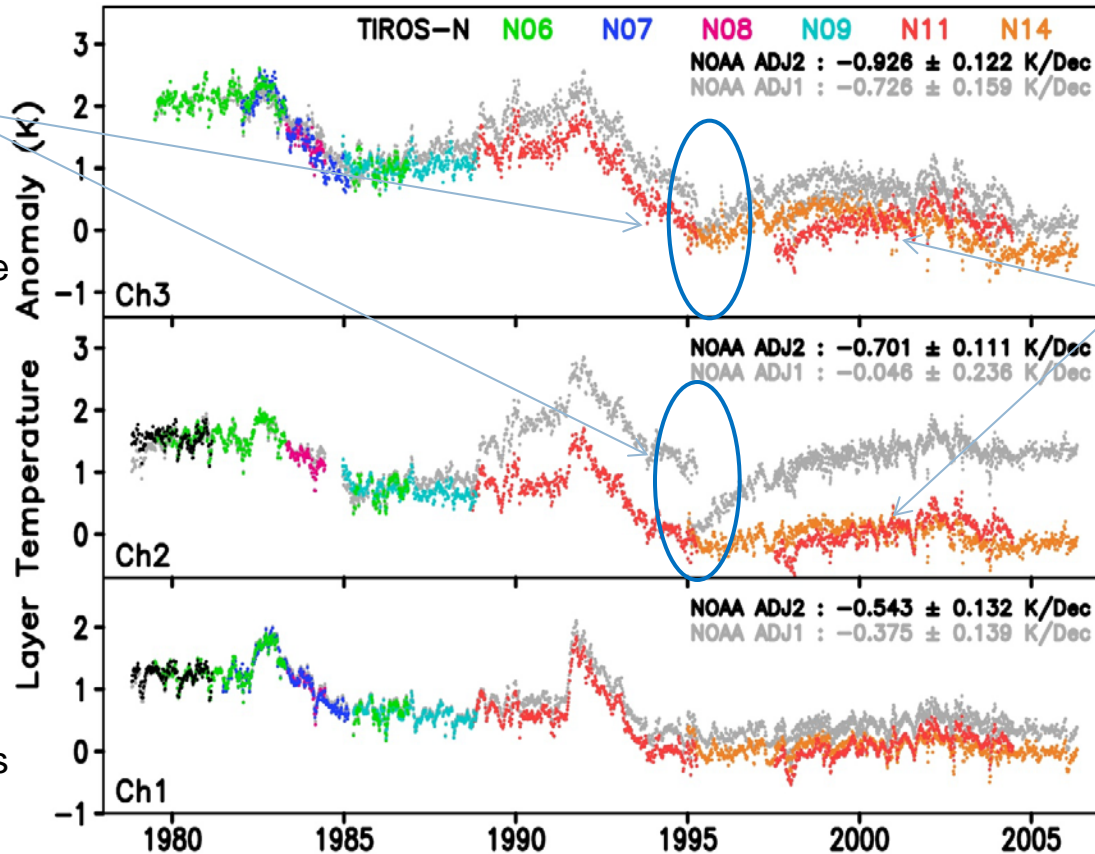
CRTM simulated brightness temperature correction time series due to cell pressure changes relative a reference close to pre-launch specification

Causes dramatic effect on time series



Effect of cell pressure correction

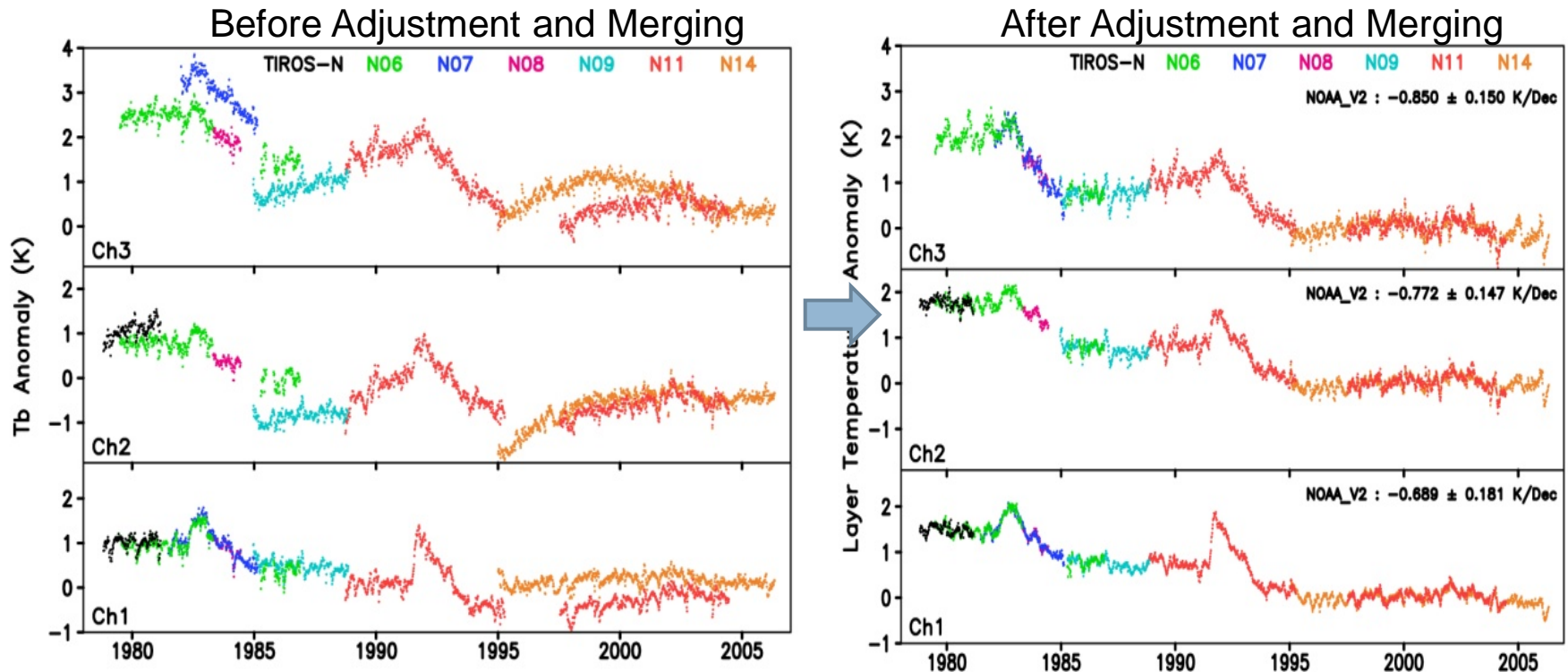
- Cell pressure correction dramatically removed the satellite transition jumps
- Suggests cell pressure correction has good accuracy
- Suggests that the NOAA-14 observations just after its start were good data
- Channel 2 trend significantly lower than those from constant bias correction (grey lines)



Mismatch between NOAA-11 and NOAA-14 will be taken care of by diurnal drift correction

Global mean time series for individual satellites after cell pressure correction

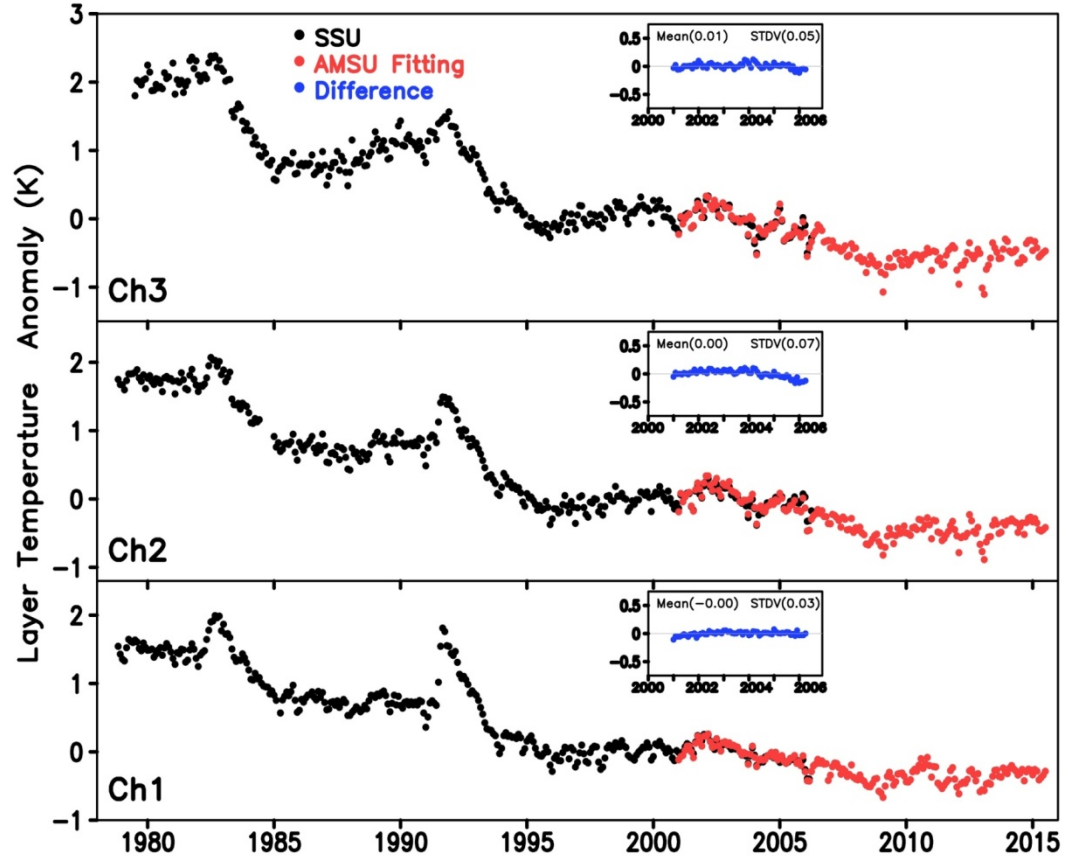
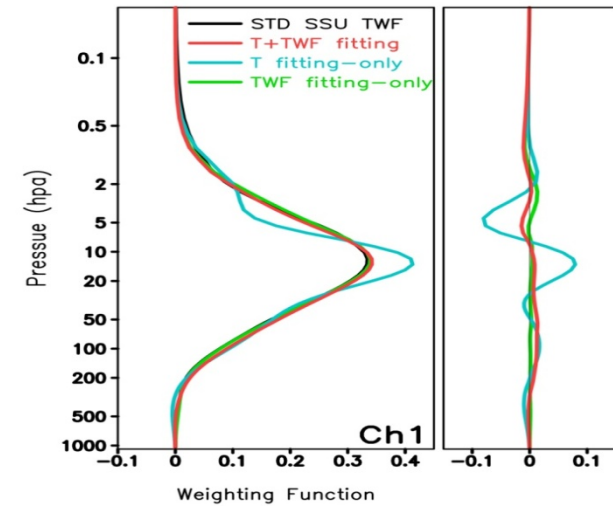
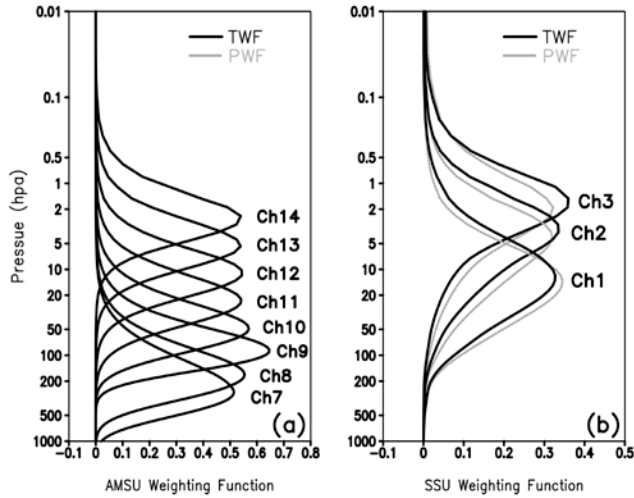
NOAA Version 2.0 SSU Time Series



SSU Version 2 Temperature Anomaly Time Series

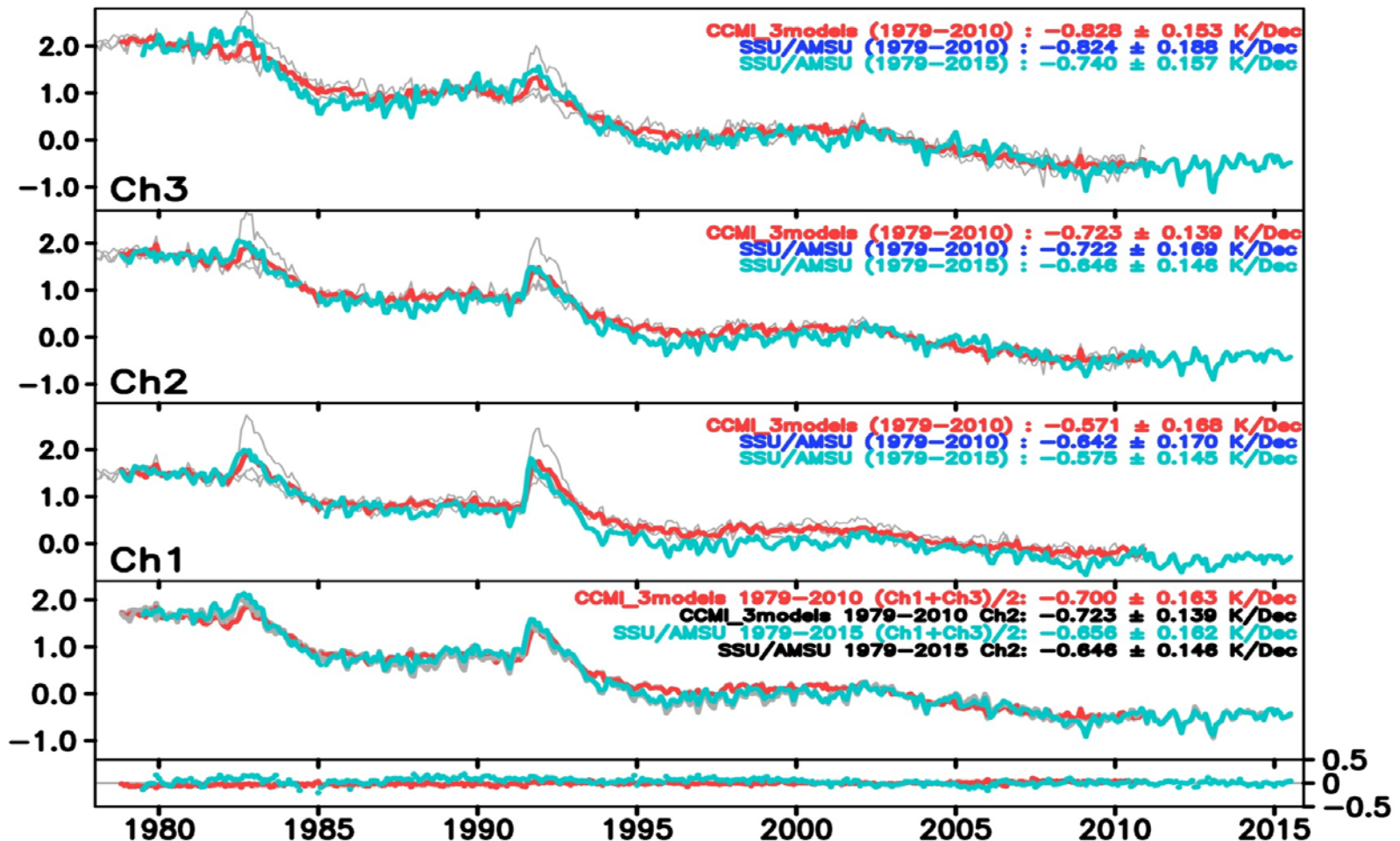


SSU and AMSU-A Merging





Verifying Model Simulations of the Anthropogenic Global Warming Theory





Conclusion

- NOAA Version 2.0 SSU time series were developed through careful adjustment and merging; adjustment included effects from cell pressure changes, diurnal drift, atmospheric CO₂ variation, and viewing angle differences
- SSU were merged together with AMSU-A observations which allow the time series to span from 1979 to present
- Time series and mean trends from CCMI model simulations are nearly identical to SSU/AMSU data for SSU2 and SSU3; their differences were a little larger for SSU1 but is within uncertainty estimates
- NOAA SSU V2.0 dataset became a credible CDR to verify anthropogenic global warming theory and its climate model simulations