



Recalibration and Decomposition of SSU Measurement for Stratospheric Temperature Trend Investigation



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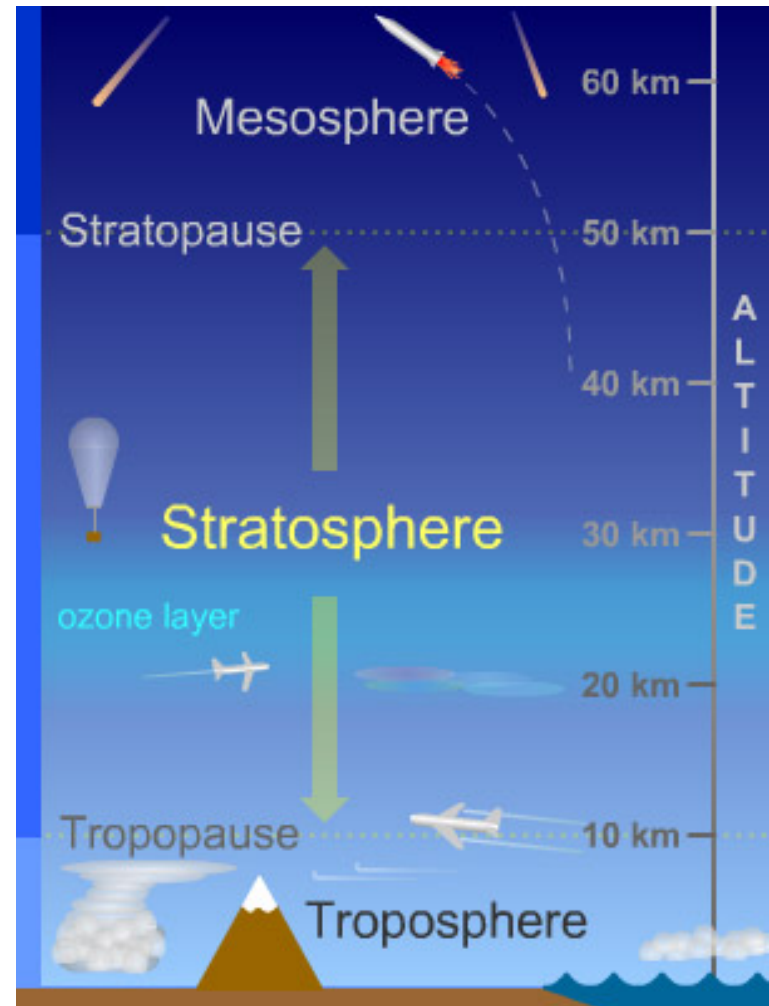
NOAA/NESDIS/Center For Satellite Applications and Research

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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





SSU Instrument

- One of the NOAA TOVS instruments (MSU, HIRS, SSU) from 1978-2007
- Flown on seven NOAA polar orbiting satellites
- Infrared radiometer use pressure modulation technique to measure atmospheric radiation from CO₂ 15- μ m v₂ band
- An interference filter allows only 15- μ m band to pass through
- A cell of CO₂ gas is placed in the instrument's optical path with its pressure modulated in a cyclic manner
- Cloud effect minimal in stratosphere
- Global coverage

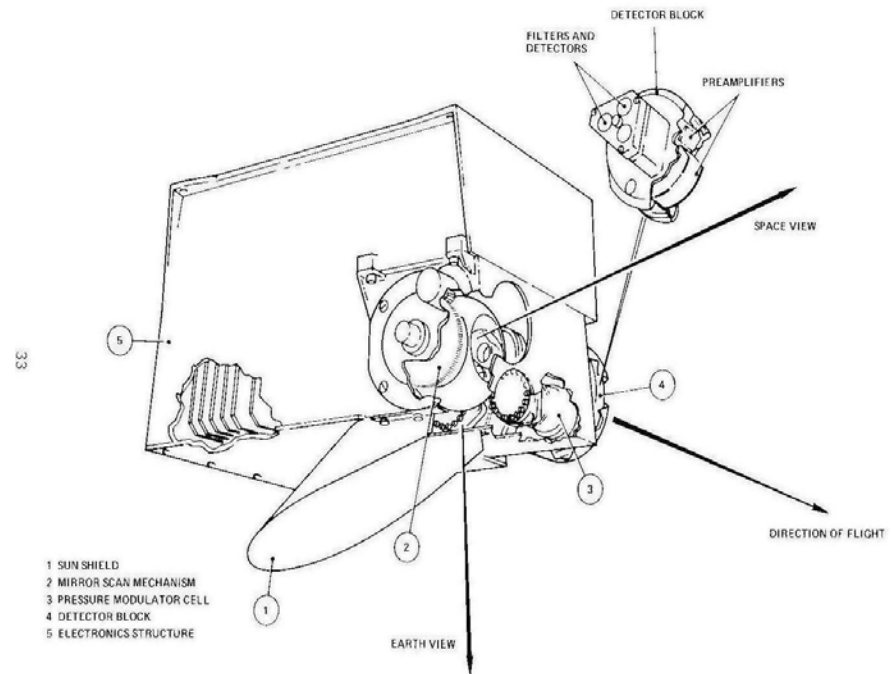


Figure 9.--The complete SSU, showing the views to earth and to space

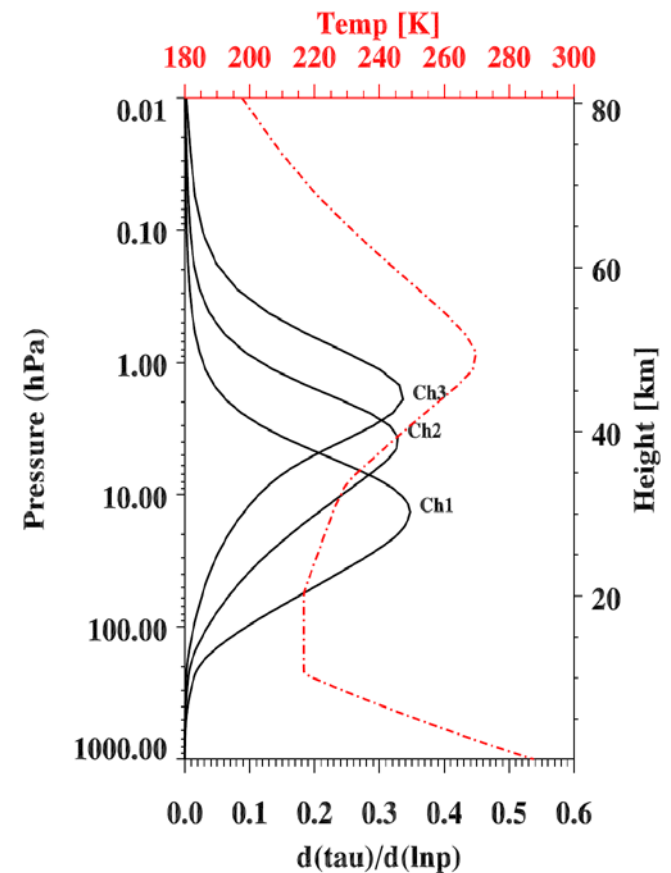


SSU Channels

- Weighting function determined by the pressure values

Channel Number	Cell pressure (specification)	weighting function (Pre-launch specification)
1	100 (hPa)	15mb (29km)
2	35 (hPa)	5mb (37km)
3	10 (hPa)	1.5mb (45km)

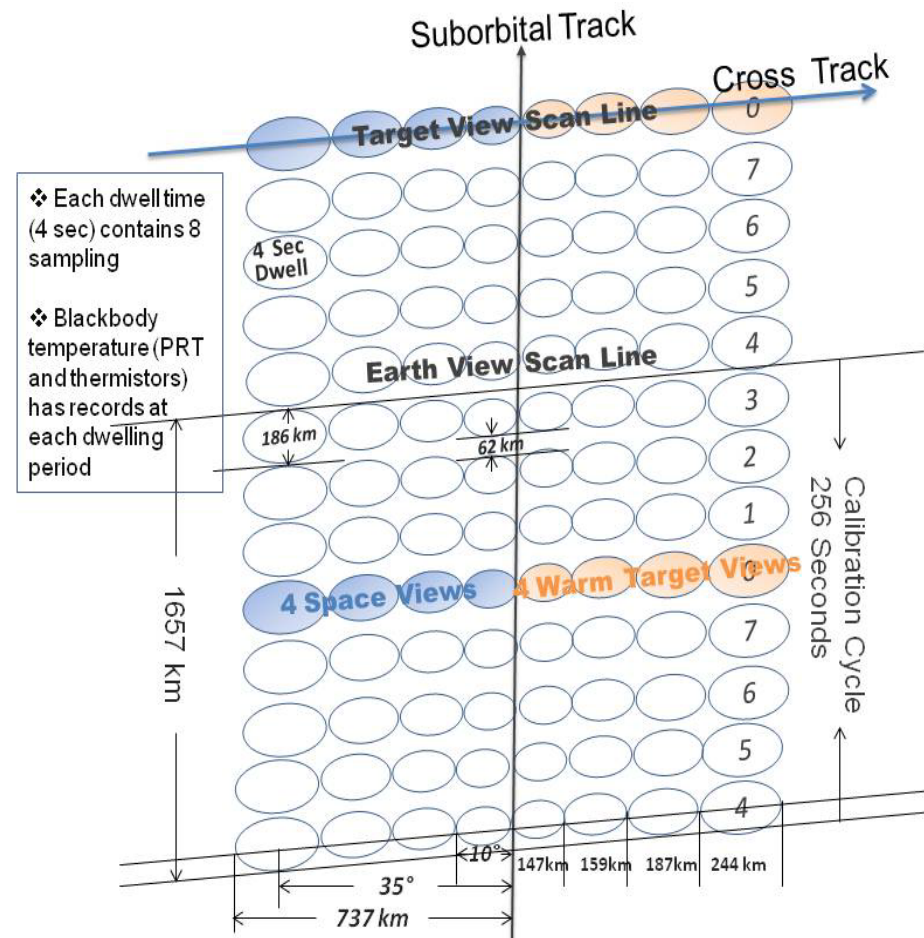
$$P(\text{peak}) \sim P(\text{cell}) / [\text{CO}_2]^{1/2}$$





Instrument Calibration

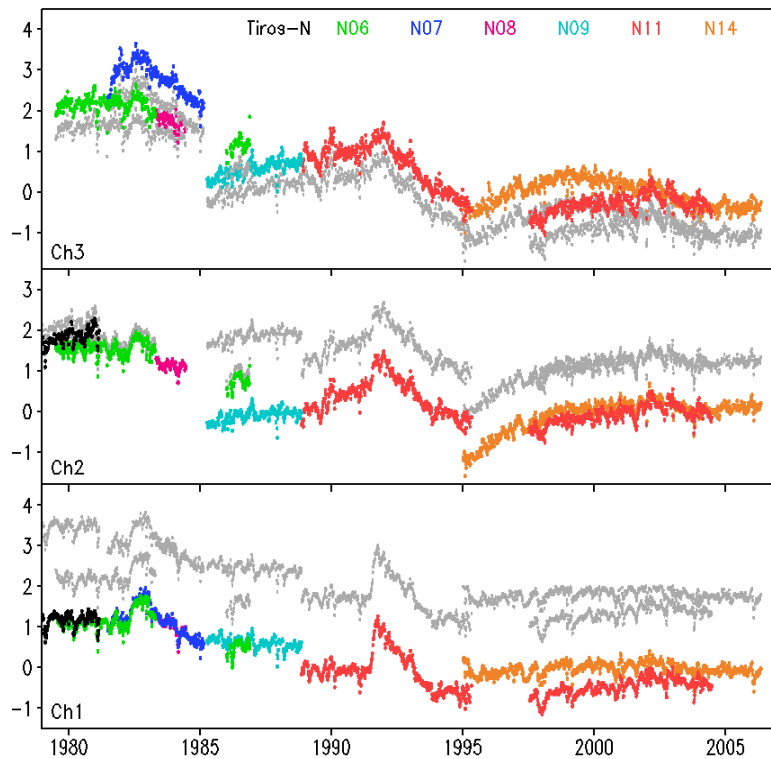
- 8 radiometric samples used to obtain raw counts: 6 samples also tested
- Averages of 4 space views and 4 warm target views to calibrate all Earth views within a calibration cycle
- Line Scheme (1-3, 4-7) used: sensitivity tested with different line schemes
- Measurements from space side Thermistor used to represent warm target temperature: PRT and sun side thermistor also tested
- Cold space correction implemented: NOAA-6 laboratory test data used as reference, other satellites were determined from inter-satellite biases
- Asymmetry correction: implementation depends on community requirement
- Quality control on calibration coefficients



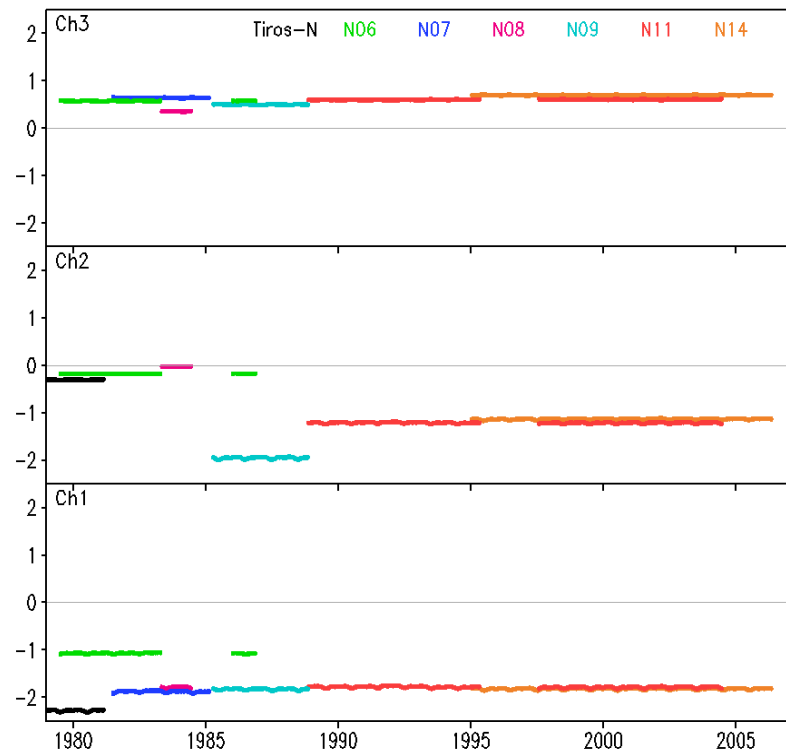
Scan and Calibration Cycle

Recalibrated Radiances—With Cold Space Correction

- Recalibration difference from operational calibration by a constant

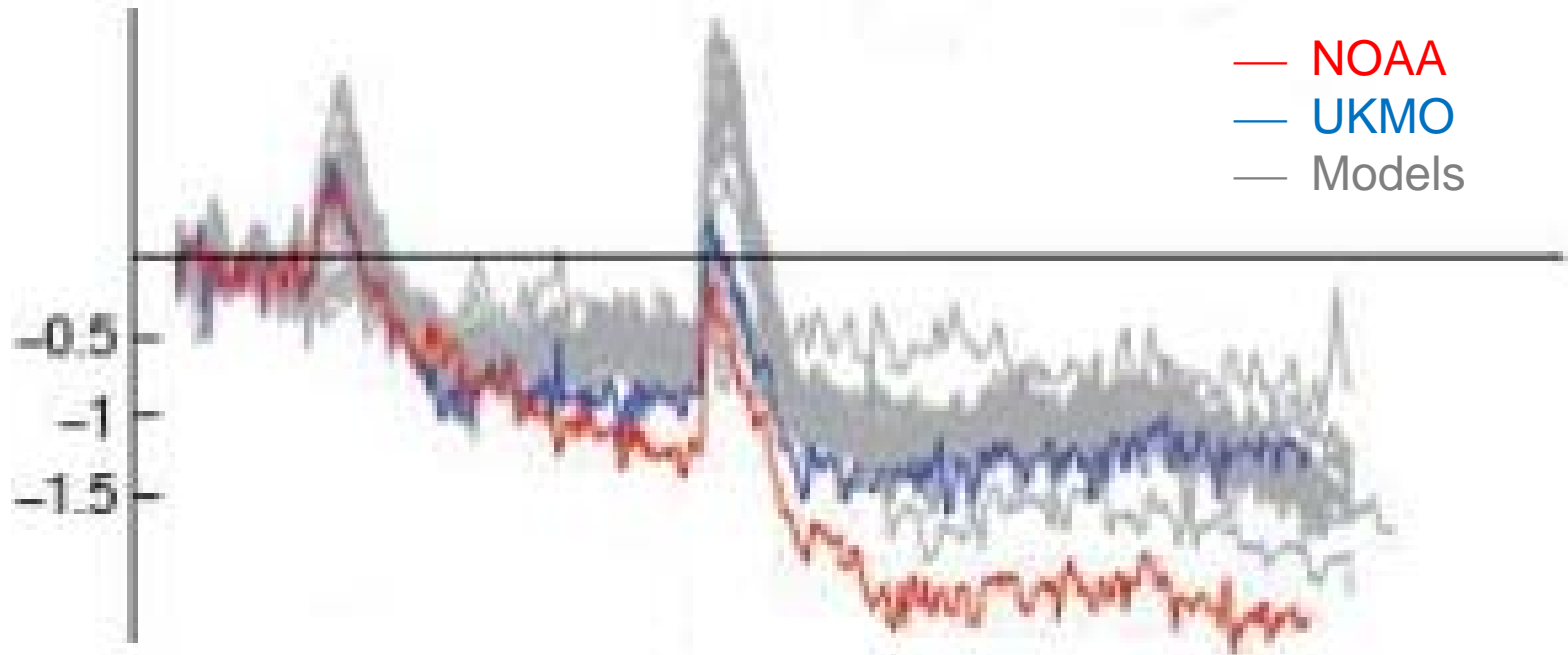


Recalibrated versus operational calibrated anomaly time series



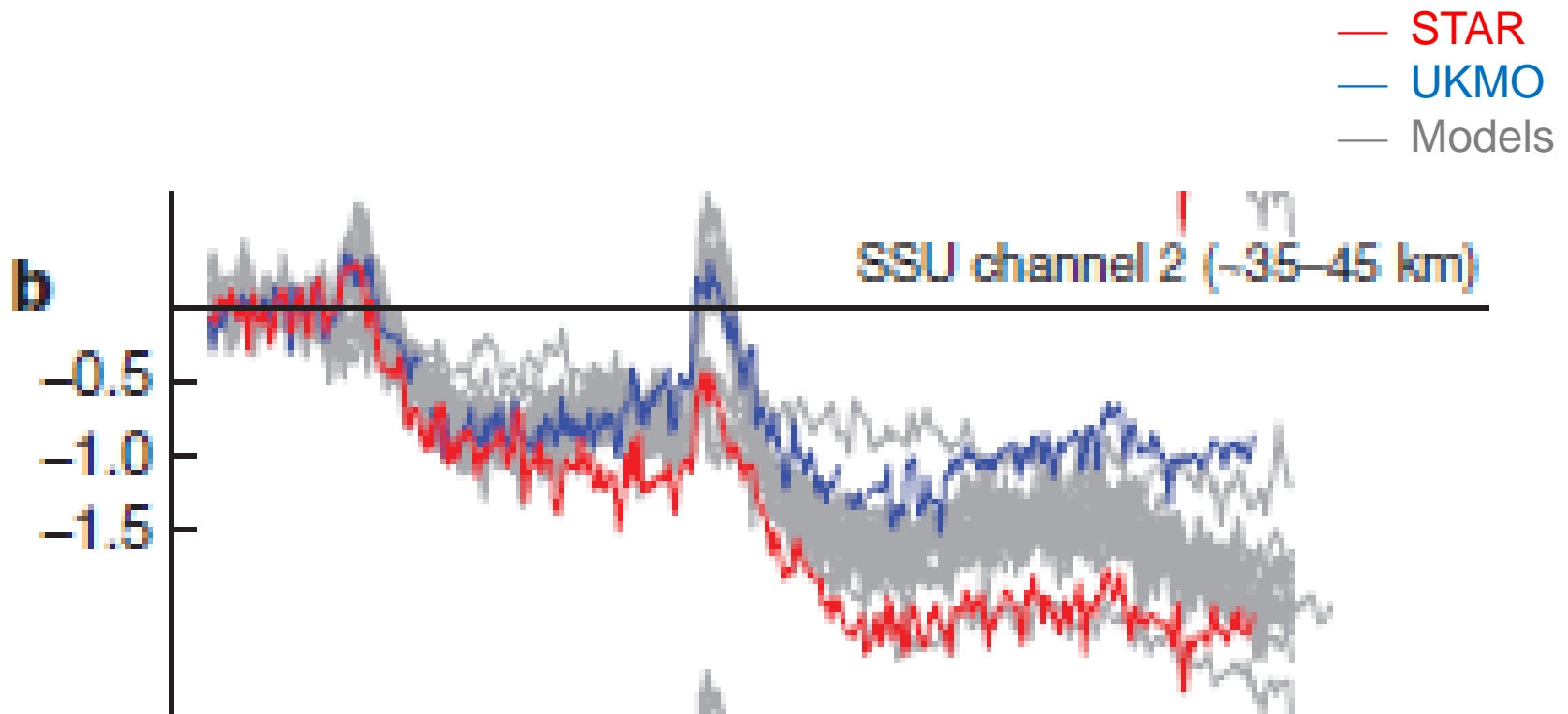
Differences between recalibration and NOAA operational calibration

The Trend Debate — channel 1



Plot from Thompson et al. 2012 in Nature

The Trend Debate – Channel 2



Plot from Thompson et al. 2012 in Nature



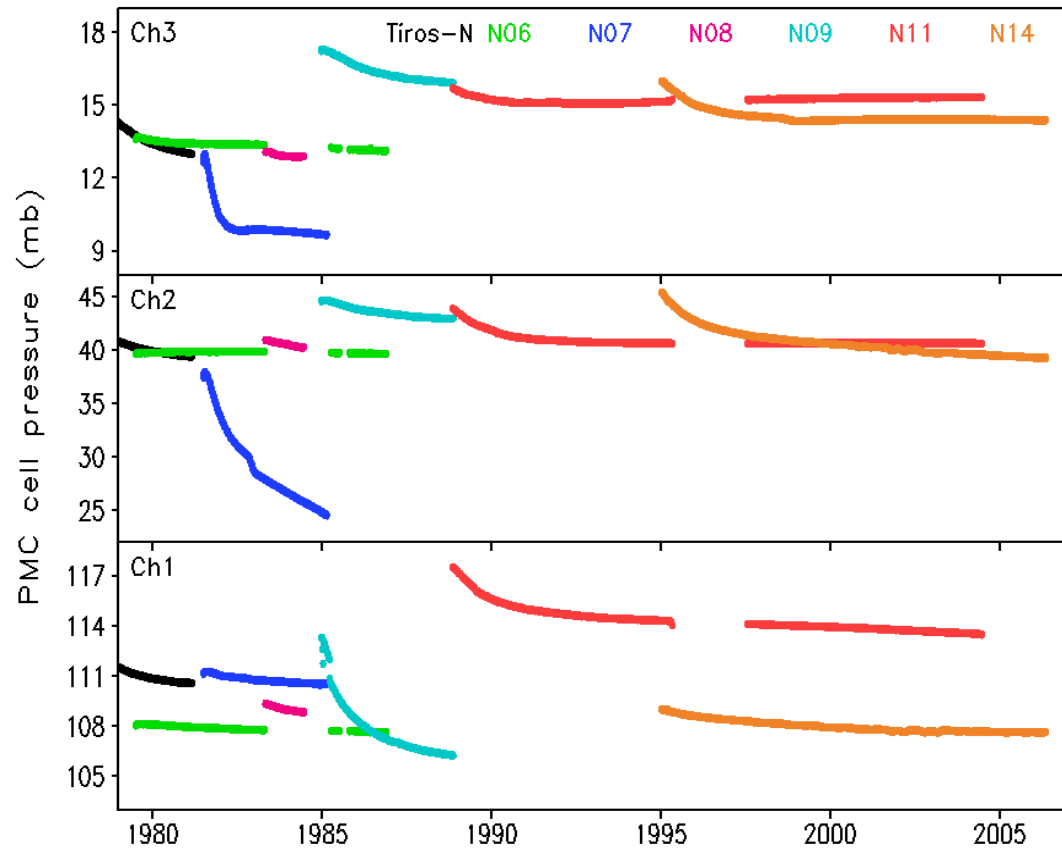
Issues in SSU Observations

- Gas leaking problem in the CO₂ cell
- atmospheric CO₂ variations
- diurnal drift effect → semi-diurnal tides
- Limb-effect
- inter-satellite biases



Cell Pressure Time Series from Gas Leak

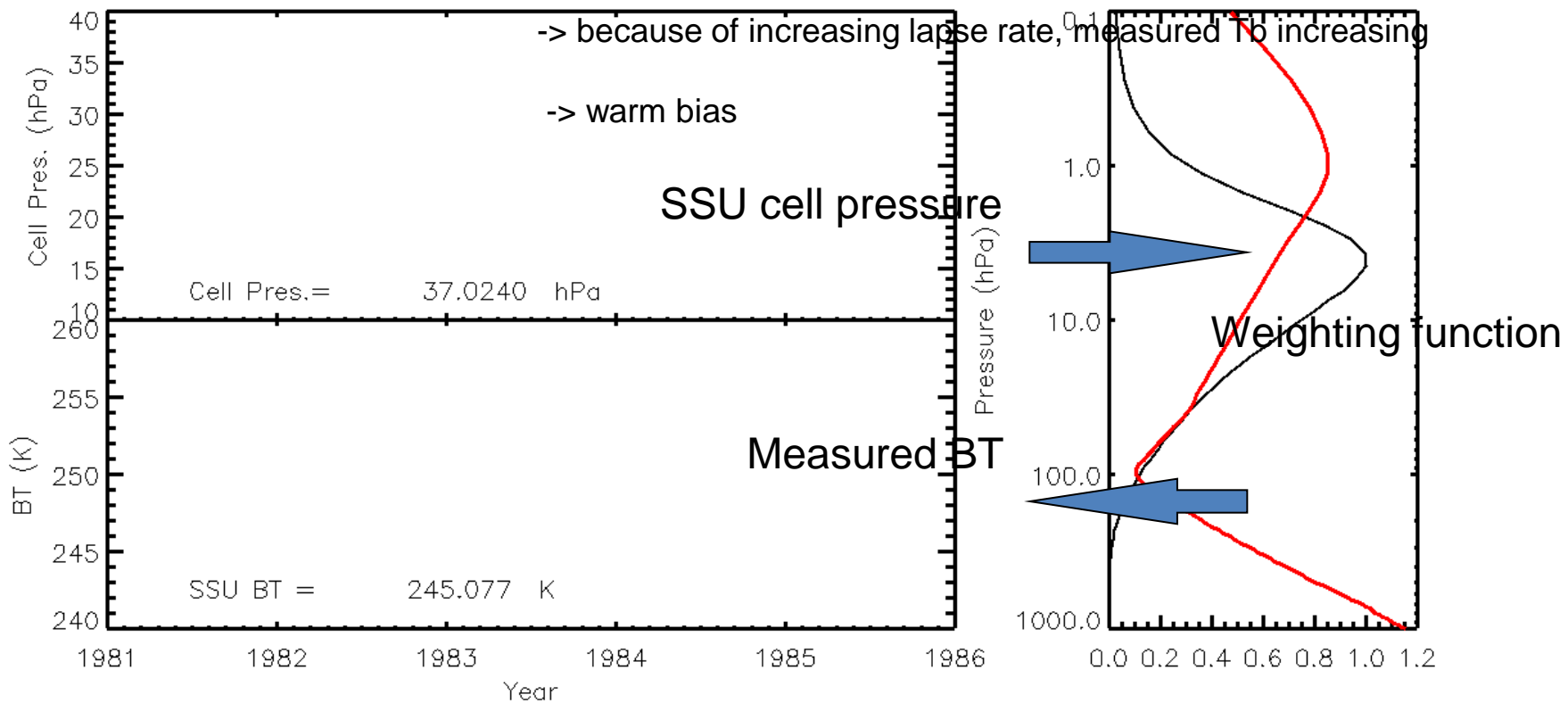
- CO₂ cell placed between sensor and medium to be Observed
- Cell pressure determine high Of weighting function
- Cell pressure decreasing due to gas leaking



Plot from S.Kobayashi et al. 2009

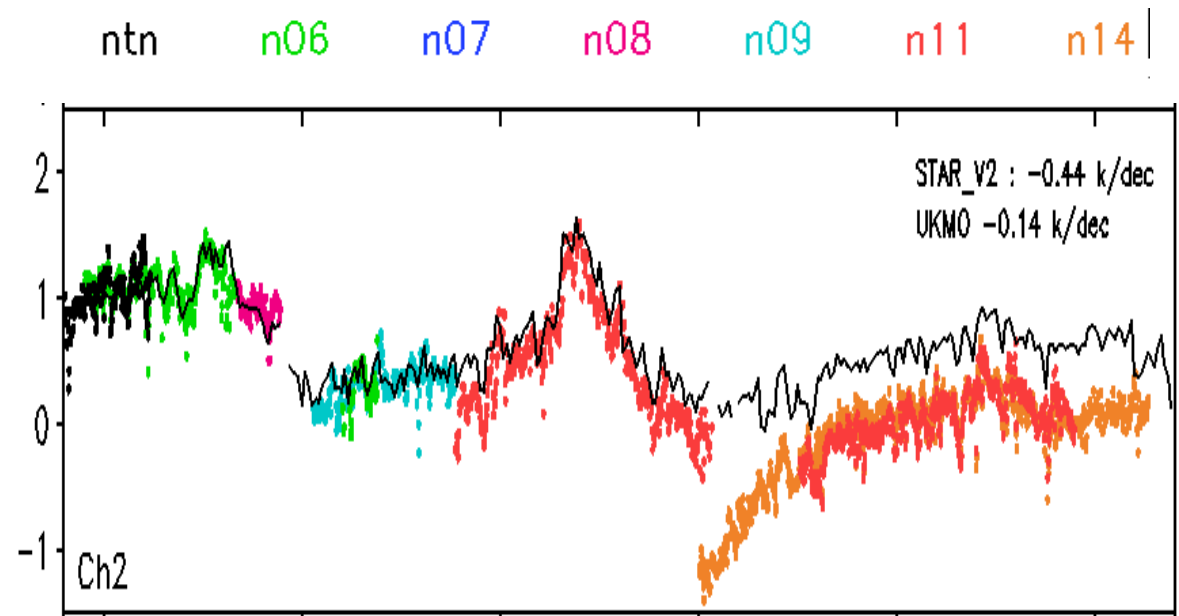
Effect of Cell Pressure Decreasing

CO₂ cell pressure decreasing -> weighting function peaks higher

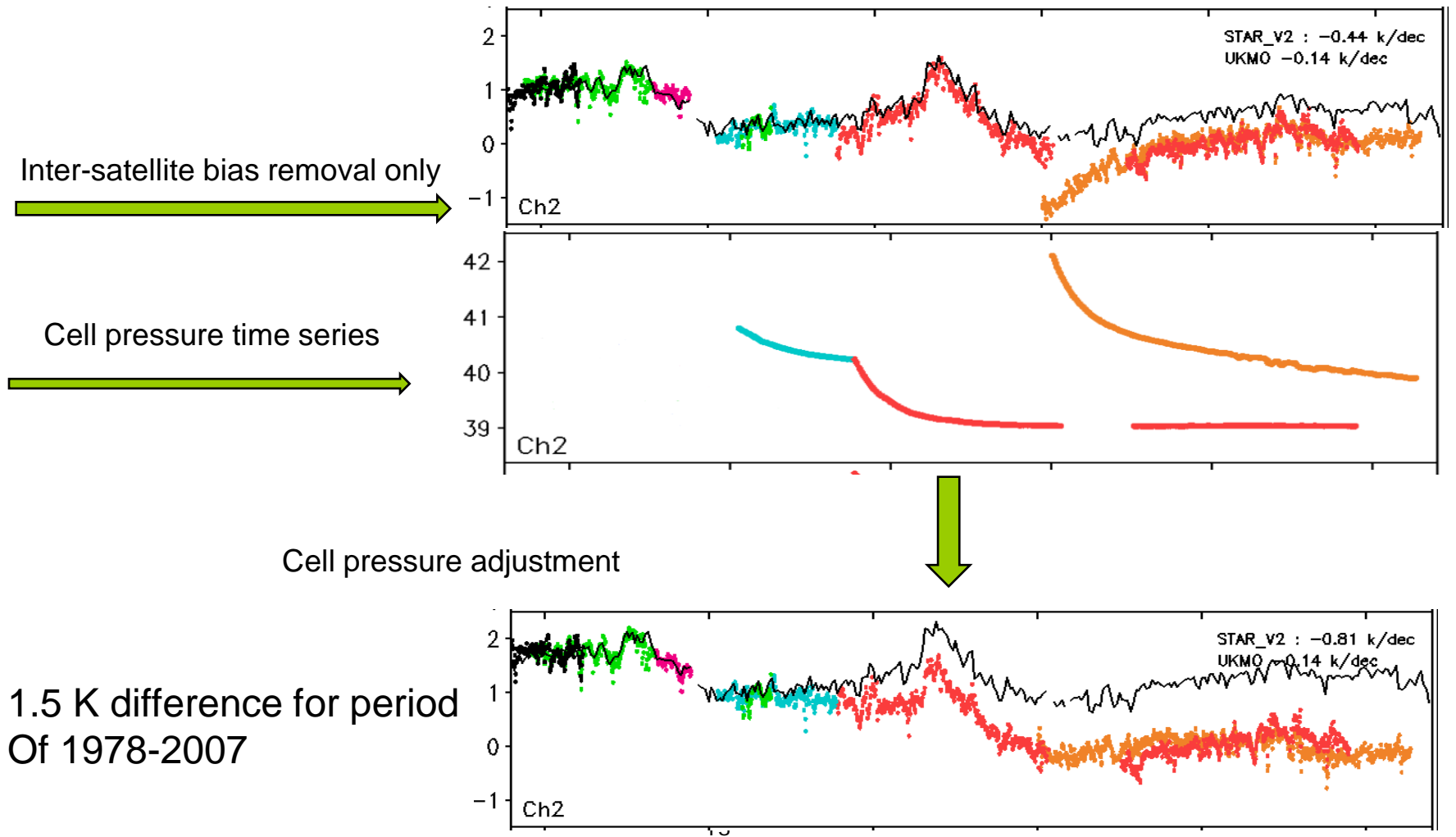


Time Series of the Basic Radiances – Channel 2

- ❑ Large jumps between N11 and N14 during 1995 for ch2 due to cell pressure change effect
- ❑ Structure errors in ch2
- ❑ Ch2 VERY close to UKMO Before NOAA-14 started in 1995



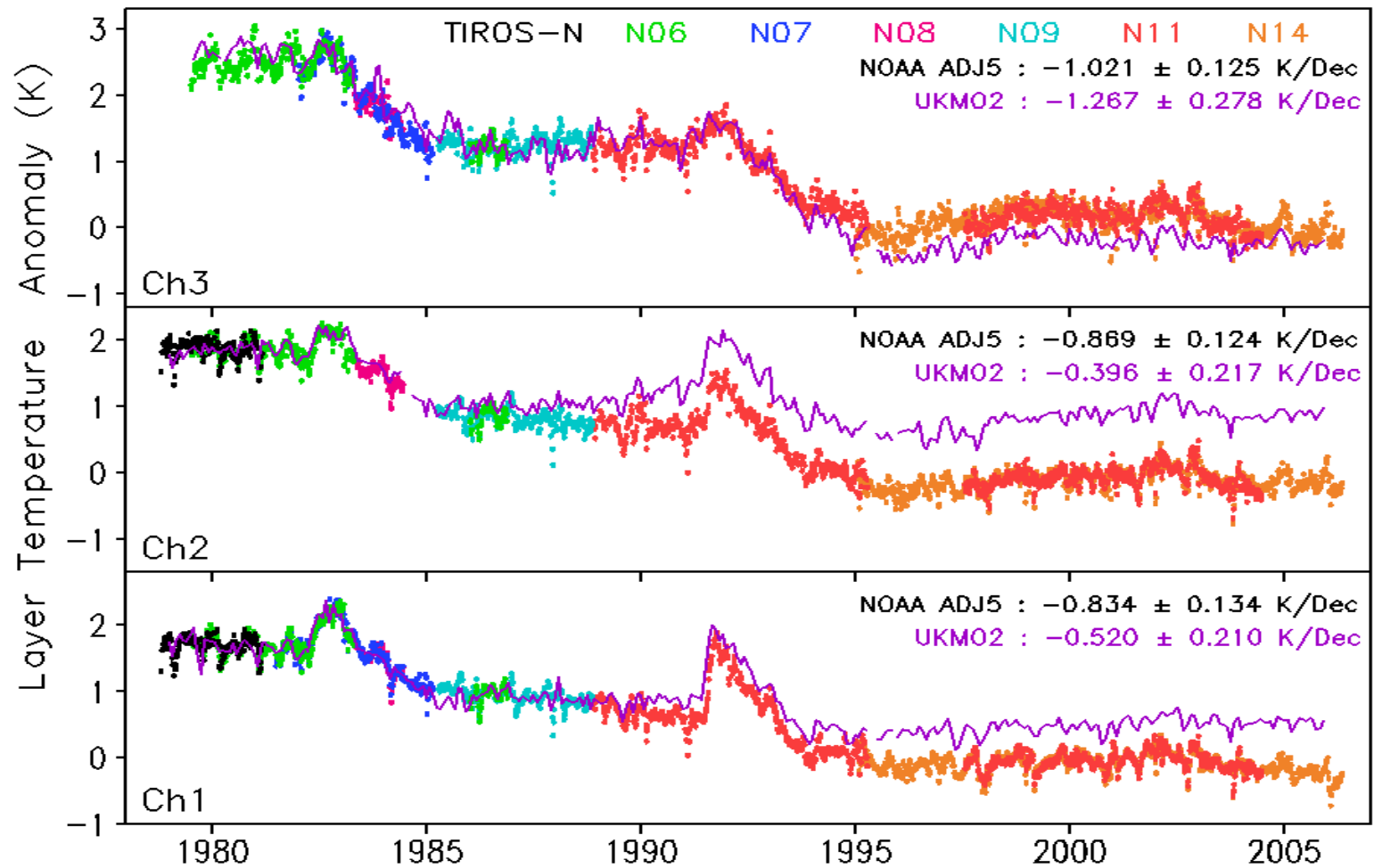
Reasons for Trend Differences Between NOAA and UKMO data—Channel 2



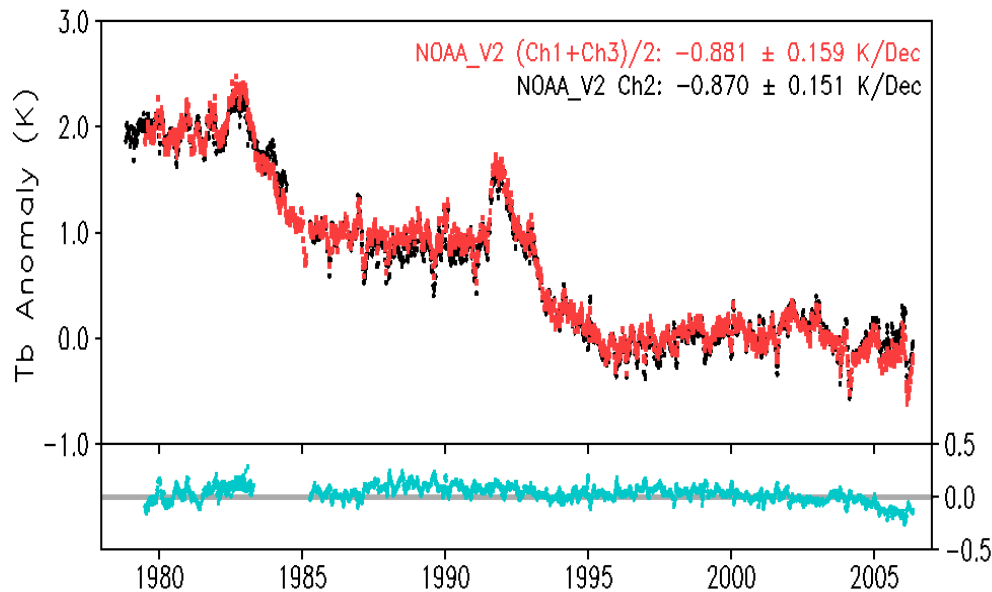
Note Tb changes in NOAA-14 corresponding to its cell pressure changes



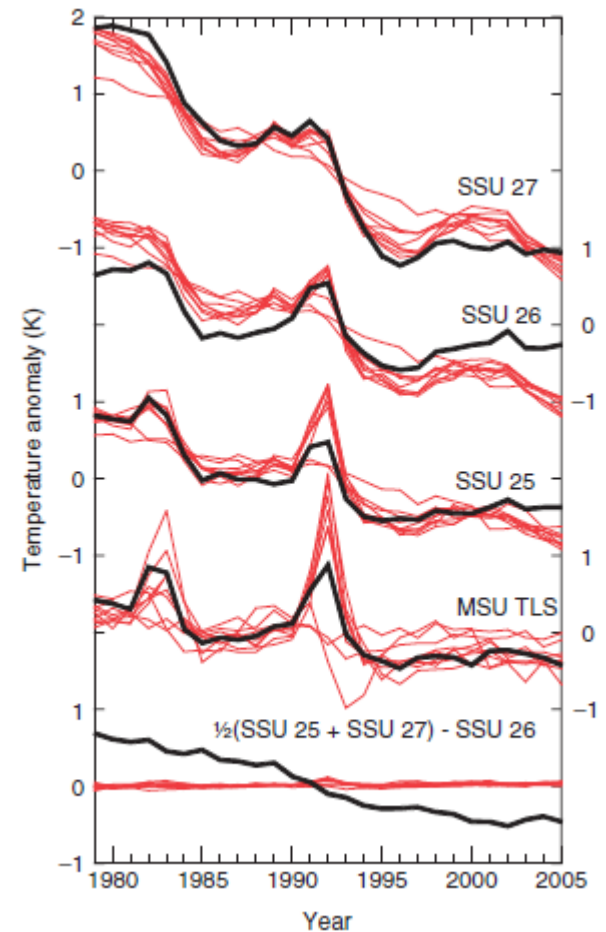
NOAA and UKMO Datasets



Relationship between Ch1, Ch2, and Ch3



NOAA Version 2 SSU dataset



Plot from Seidel et al. 2011



Conclusion

- ❑ Understood the trend differences between NOAA and UKMO data versions; Established confidence on NOAA reprocessing
- ❑ Certain channel features in climate model simulations were also observed in NOAA SSU dataset, which provided validation of accuracies in climate model simulations to a certain extent