Geolocation Correction for Microwave Instruments (AMSU-A, -B and MHS) Onboard NOAA POES Satellites

Isaac Moradi[1], Huan Meng[2], Ralph Ferraro[2]

[1] NOAA Cooperative Institute for Climate and Satellites (CICS), ESSIC, University of Maryland (imoradi@umd.edu)
[2] Center for Satellite Applications and Research (STAR), NOAA (Huan.Meng@noaa.gov & Ralph.R.Ferraro@noaa.gov)

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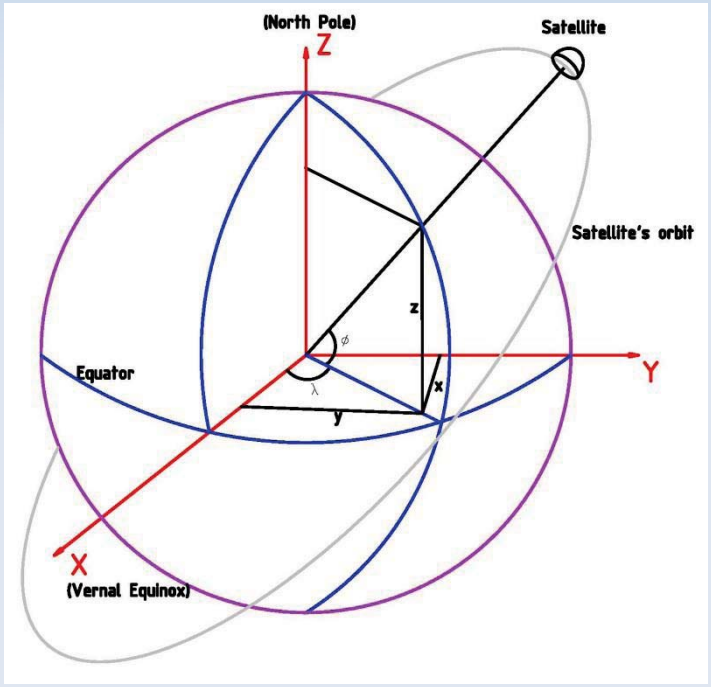
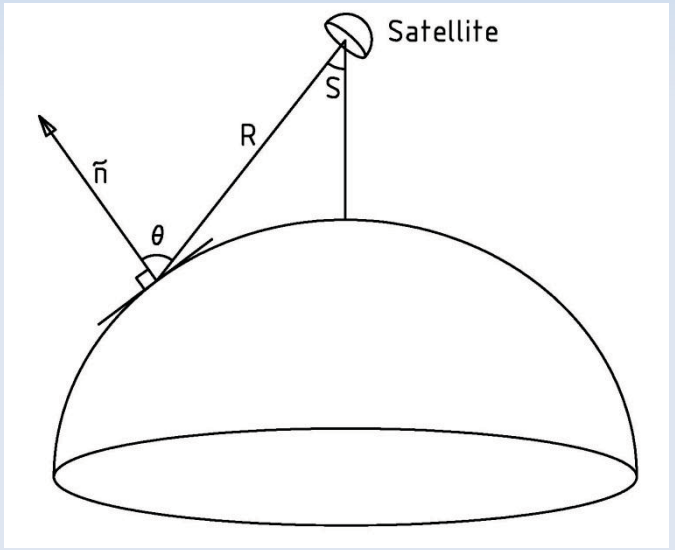
Geolocation Algorithm

Geolocation algorithm includes two steps:

1. Finding the satellite position in its orbit
2. projecting the satellite position to the earth surface and finding the location of each spot on the earth surface





$$\varphi_{gd} = \arctan\left[\frac{r_e^2 \cdot Z_{ECF}}{r_p^2 \cdot \sqrt{X_{ECF}^2 + Y_{ECF}^2}}\right]$$

$$\lambda = \arctan\left[\frac{Y_{ECF}}{X_{ECF}}\right]$$

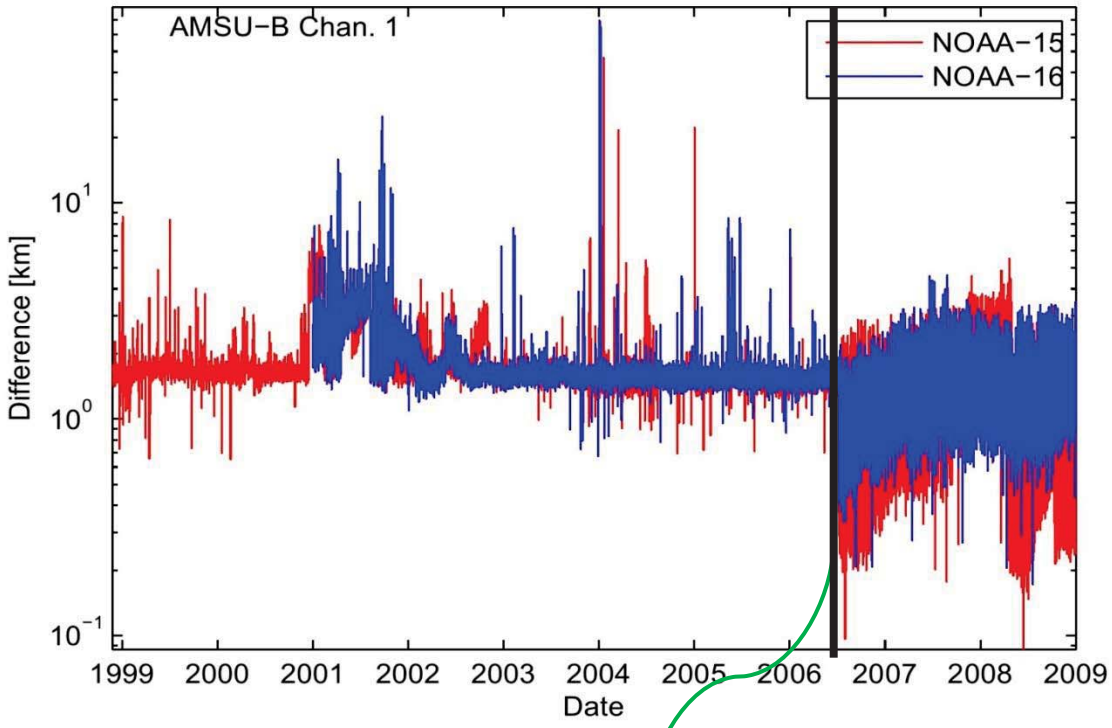
$$\begin{Vmatrix} X_{spot} \\ Y_{spot} \\ Z_{spot} \end{Vmatrix} = \begin{Vmatrix} X_{sat} \\ Y_{sat} \\ Z_{sat} \end{Vmatrix} + R \begin{Vmatrix} d_x \\ d_y \\ d_z \end{Vmatrix}$$

NOAA Level 1b Geolocation Problems

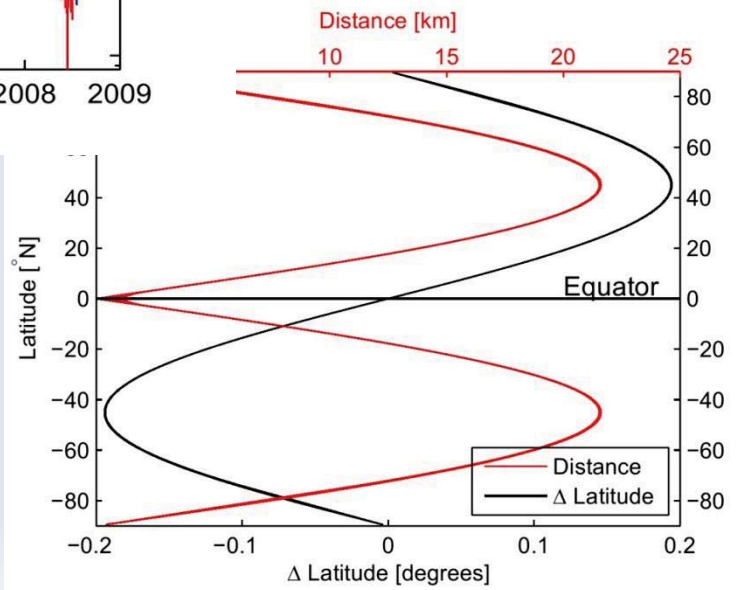
Level 1b Geolocation Problems

- L1b geolocation data are **geocentric** until 07/06/2006.
- L1b geolocation is very **unreliable in the beginning of 2004**
- NOAA has used a **wrong value for the MHS step angle** until 2005-217, the correct value is 10/9 but NOAA has used 1.1 in the beginning
- NOAA-17 clock offset that can be up to a second is not corrected
- Some sensors like **NOAA15 AMSU-A** Channels 1 and 2 have **mounting error**. This requires correction and can be applied via satellite attitude angles

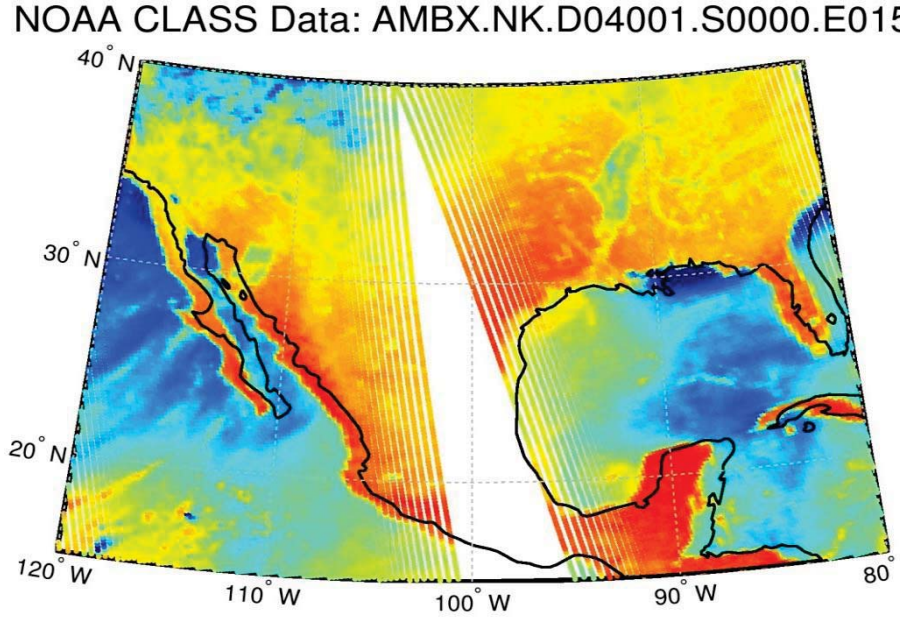
Difference between NOAA-L1b and new geolocation

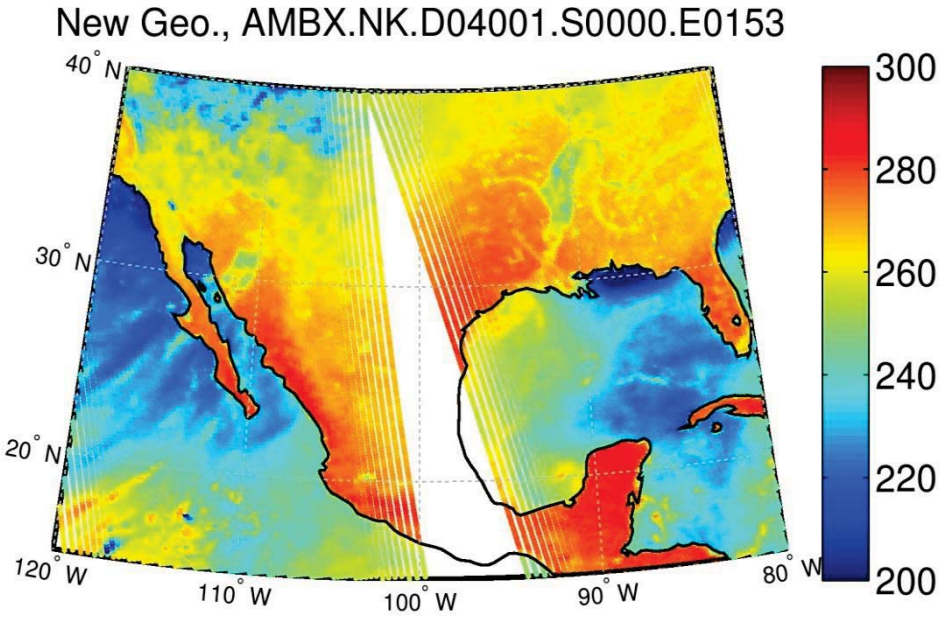


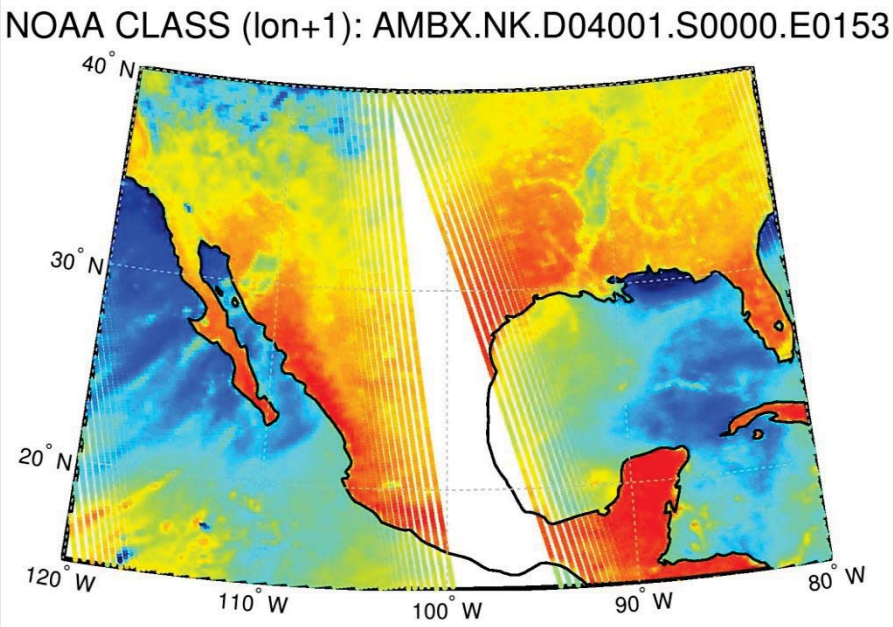
Change from geocentric to geodetic

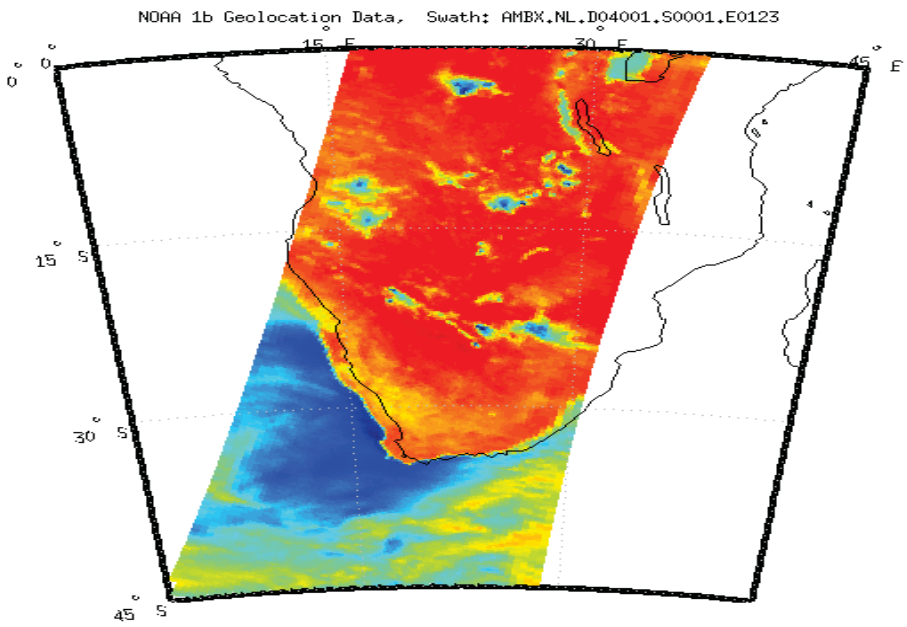


NOAA Level 1b geolocation problems







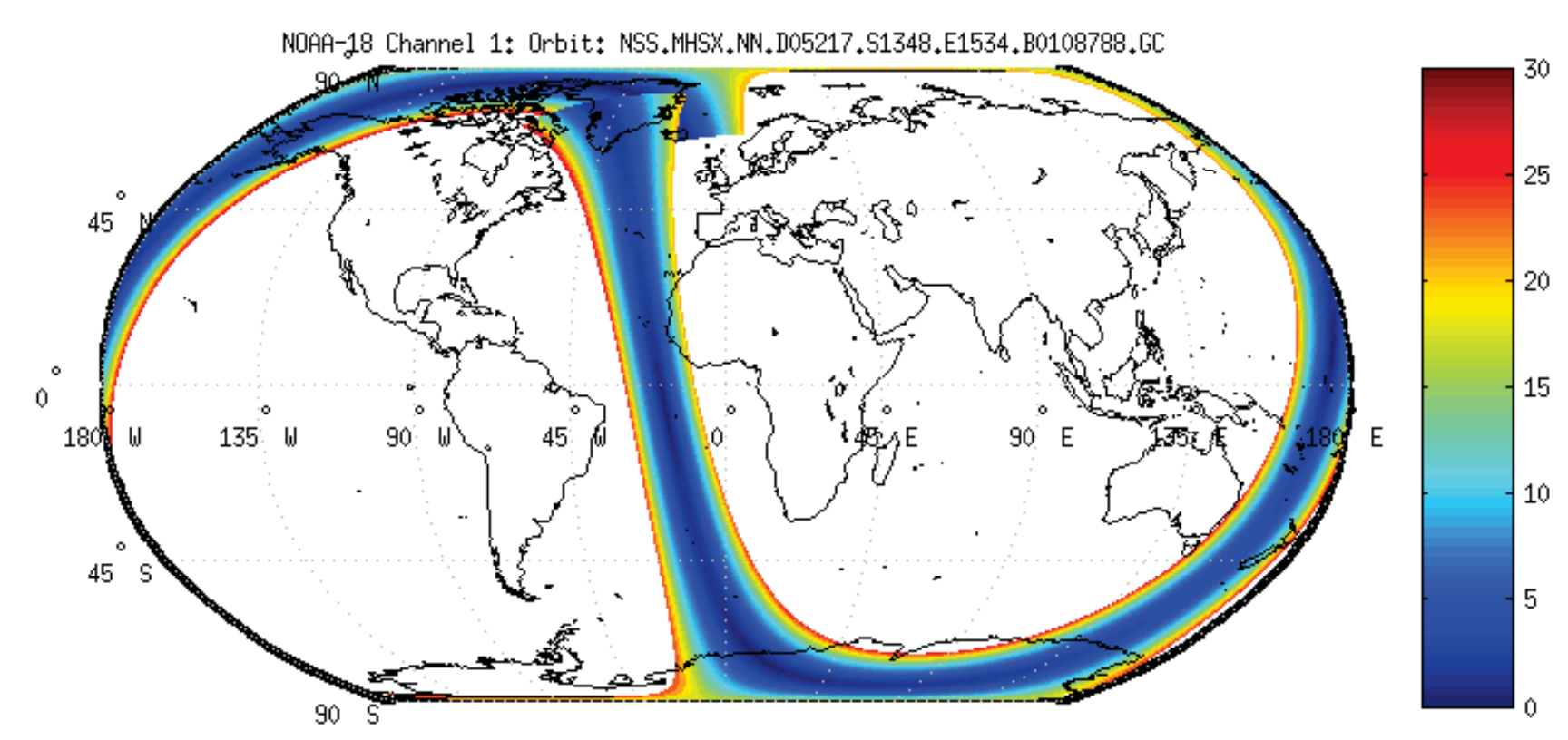


Error in MHS Step Angle

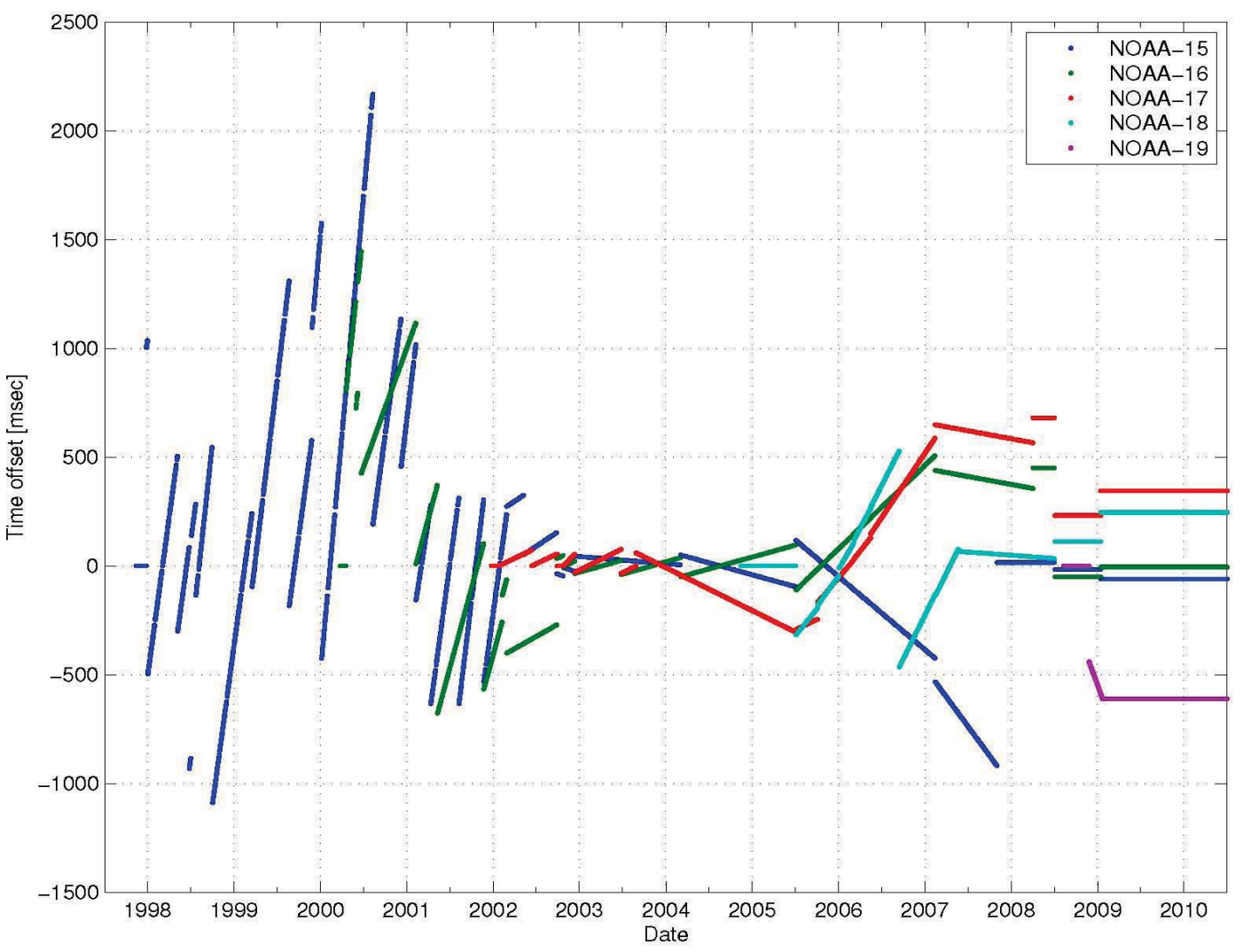
MHS Step Angle is 10/9 but was taken as 1.1 until 05-217.

The first orbit with correct step angle is

SS.MHSX.NN.D05217.S1529.E1714.B0108889.GC



Clock offset is not corrected for NOAA-17



How to quantify the geolocation error?

Sources of geolocation errors

Main sources of the geolocation errors

1. **Satellite attitude offset and sensor pointing errors**

   Satellite attitudes are known as Pitch, Roll and Yaw (in mathematics: Euler Angles)

   and are included in the geolocation algorithm by a rotation matrix

2. **Poor spacecraft ephemeris data**

3. **Satellite clock offset**

The implemented correction method will take care of all sources of errors.

The method is just applicable to the microwave window channels

Channel No.	Frequency (GHz)	Polarization at nadir	Atmospheric transmission (tropical)	(winter subarctic)
1	23.8	V	0.78	0.99
2	31.4	V	0.89	0.96
3	50.3	V	0.63	0.68
4	52.8	V	0.29	0.32
5	53.596 ± 0.115	H	0.11	0.13
6	54.40	H	0.02	0.02
7	54.94	V	0.00	0.00
8	55.50	H	0.00	0.00
9	57.290 = ν	H	0.00	0.00
10	ν ± 0.217	H	0.00	0.00
11	ν ± 0.322 ± 0.048	H	0.00	0.00
12	ν ± 0.322 ± 0.022	H	0.00	0.00
13	ν ± 0.322 ± 0.010	H	0.00	0.00
14	ν ± 0.322 ± 0.0045	H	0.00	0.00
15	89.0	V	0.61	0.91

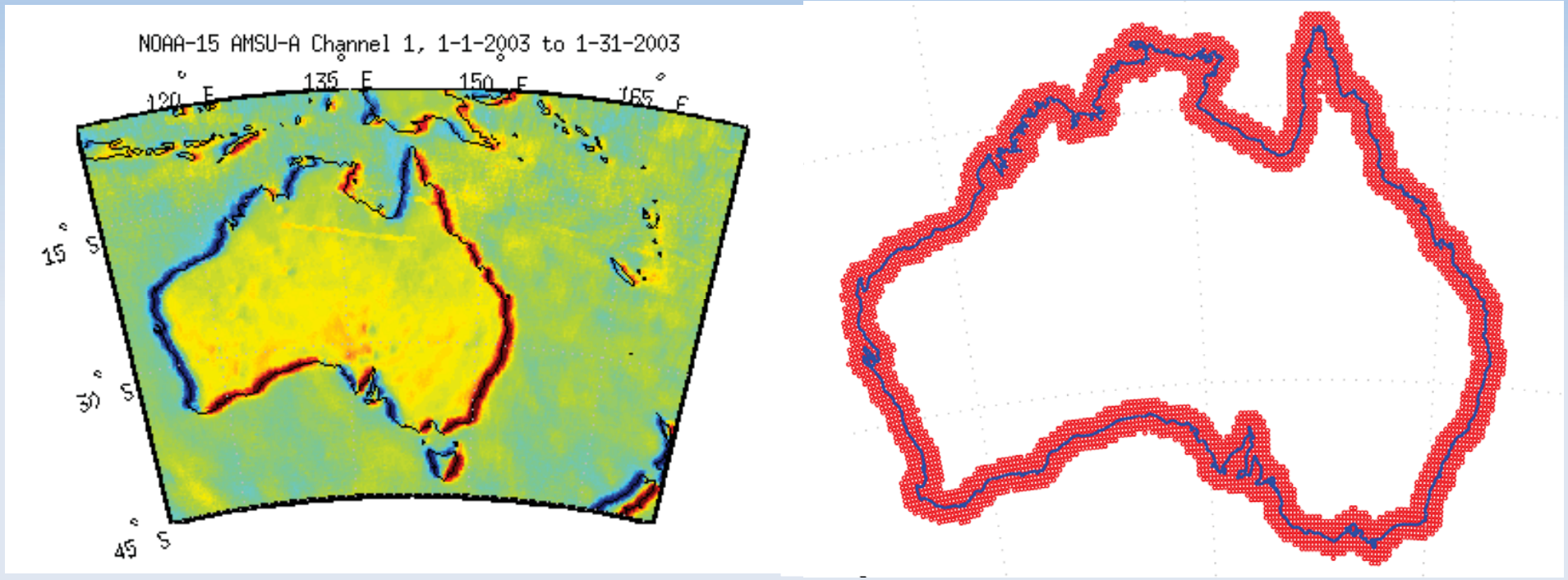
Quantifying the geolocation error

➢No geolocation error => ΔTB, ascending – descending, is very small (diurnal variation, environmental conditions, limb effect).

➢Geolocation error => ΔTb is very large along the coast lines because the land TB is much higher than ocean TB

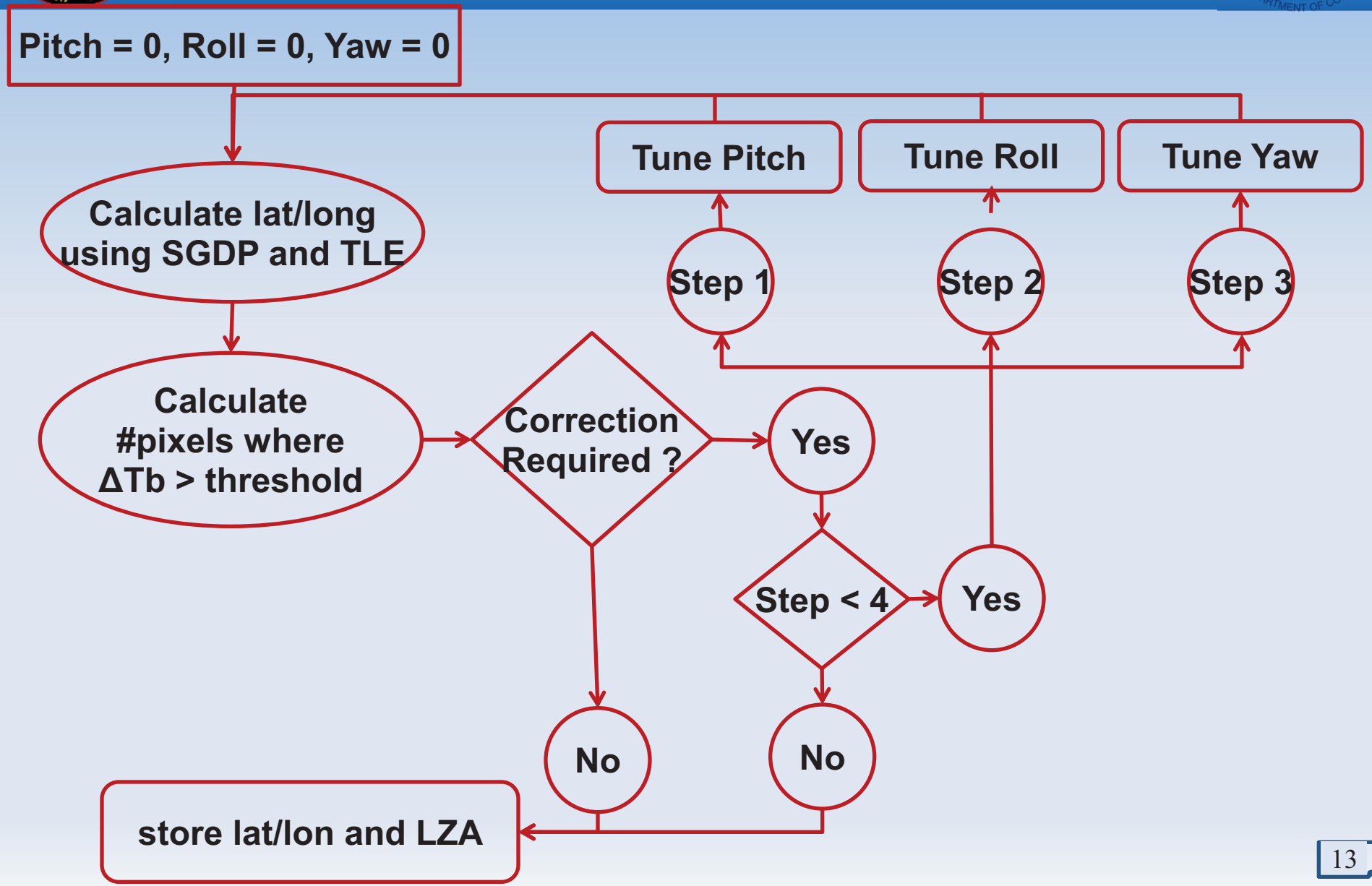
- ***negative alongtrack offset => northern coastlines will have a cold edge, and southern coastlines will have a warm edge.***
- ***negative crosstrack offset => western coastlines will have a cold edge and the eastern coastlines will have a warm edge***

Sample difference map

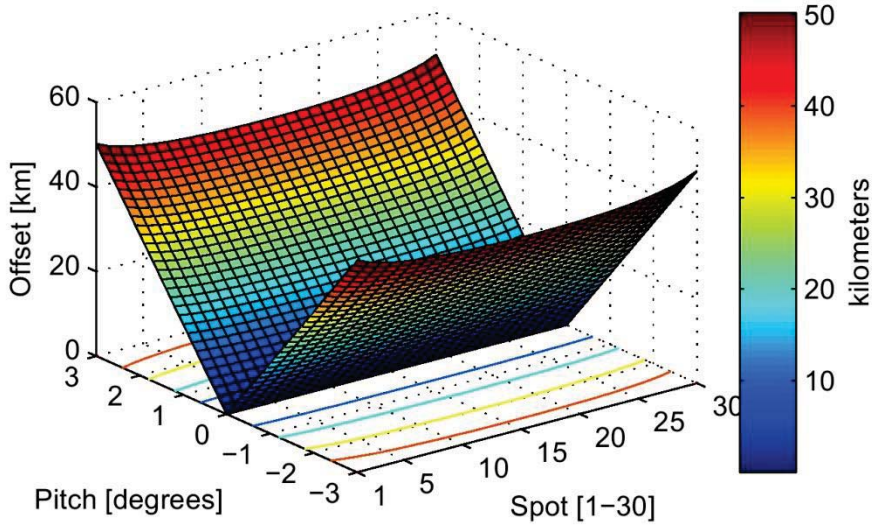


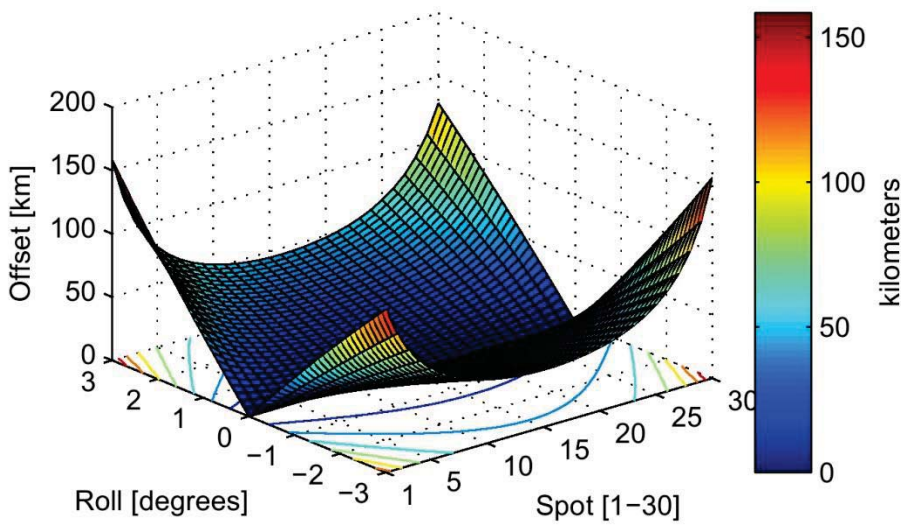
Index = number of pixels along the coastlines where ΔTb > threshold

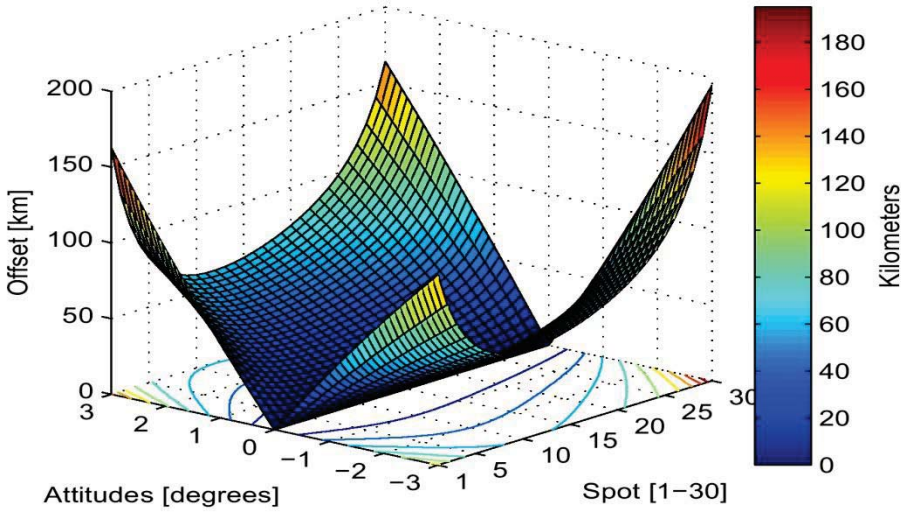
How to tune pitch, roll, and yaw?

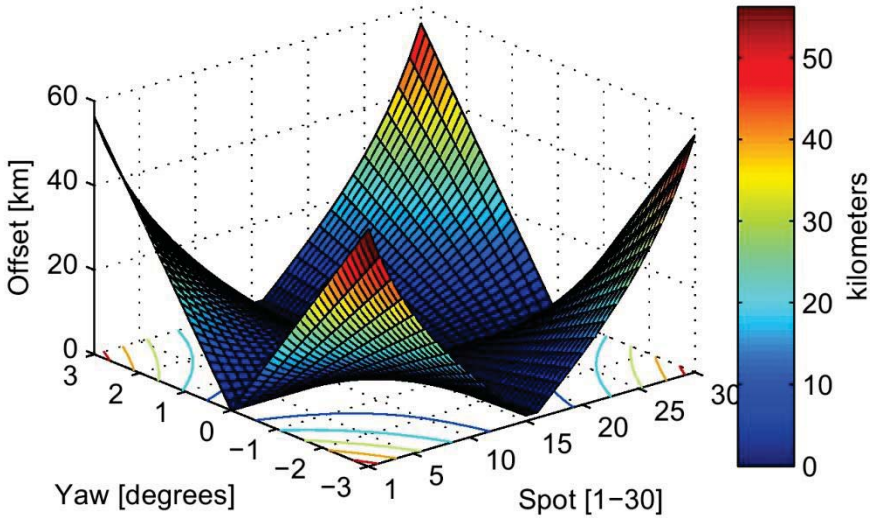


Sensitivity analysis



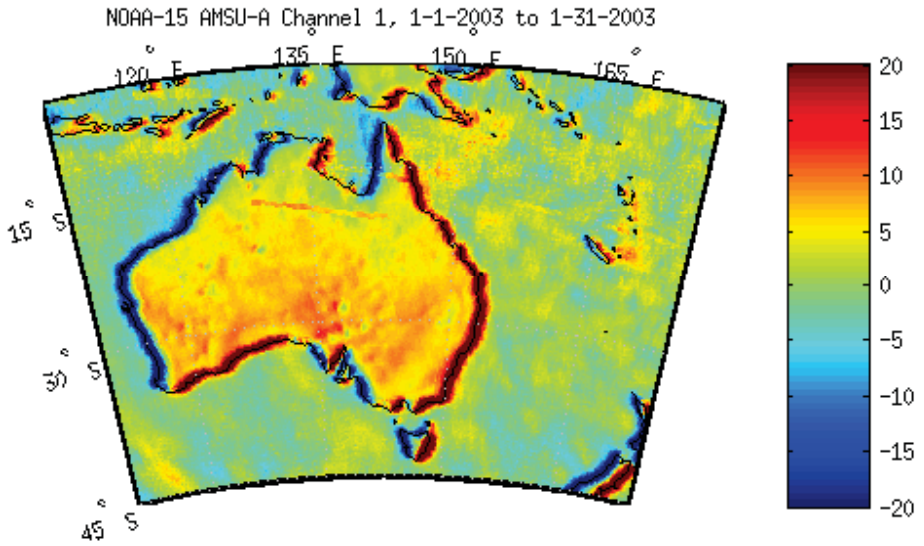


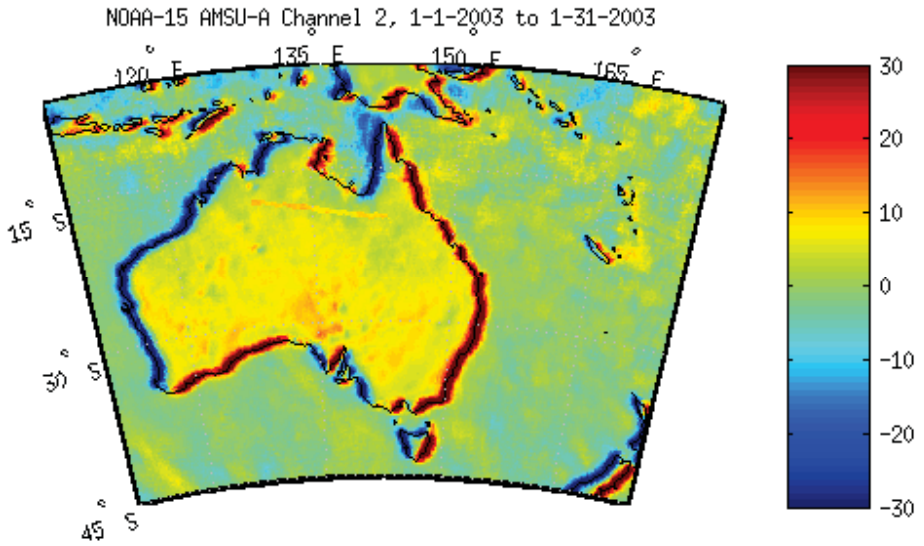


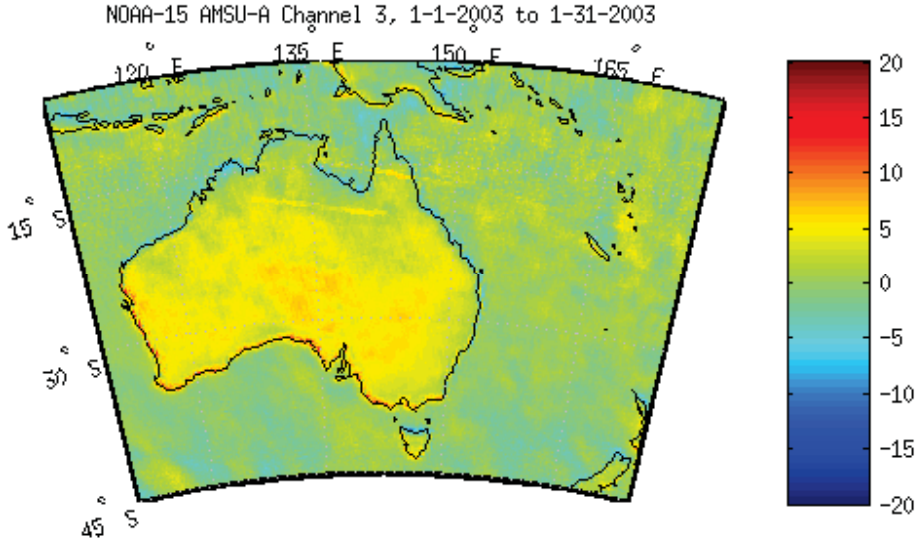


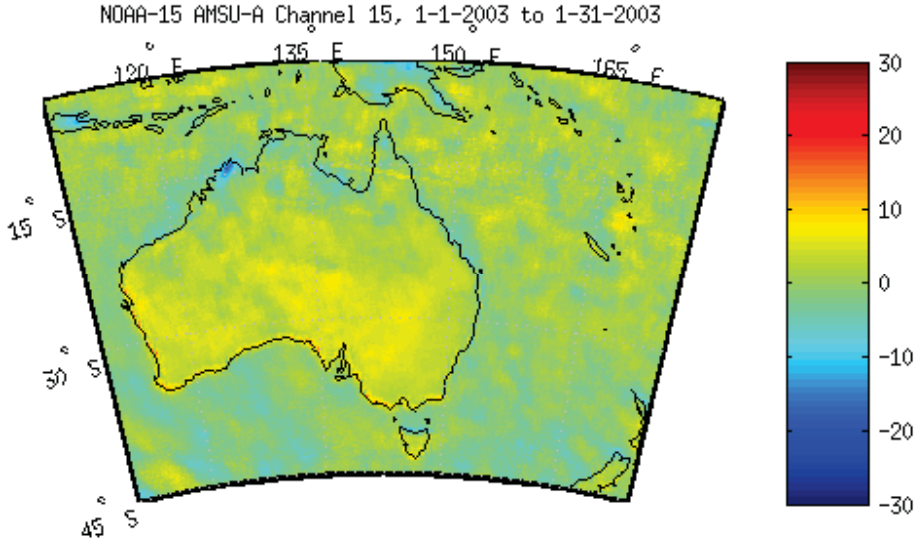
Results

NOAA15 AMSU-A Diff. Maps

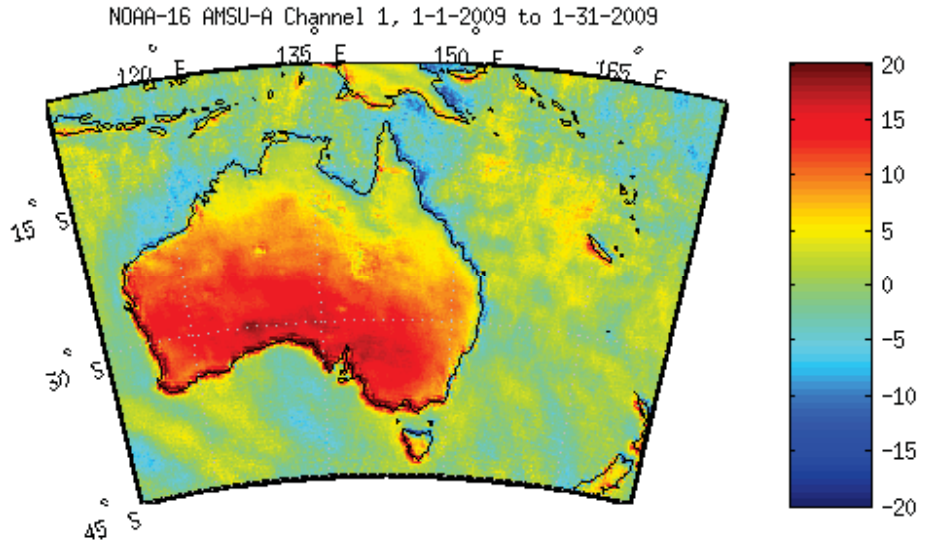


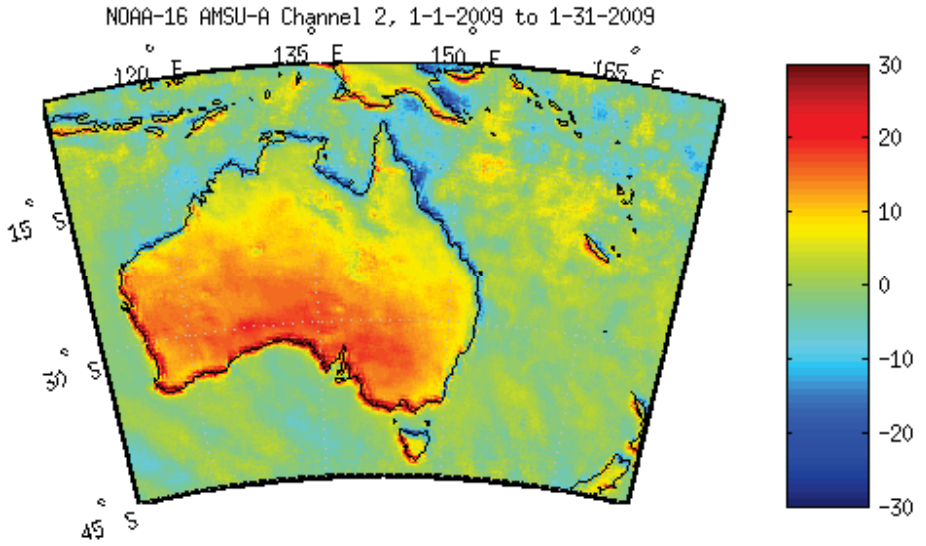


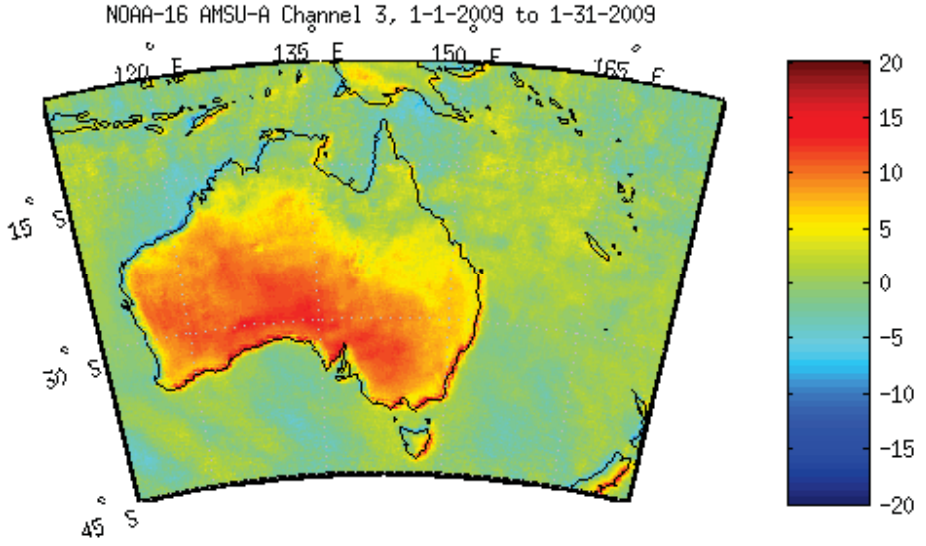


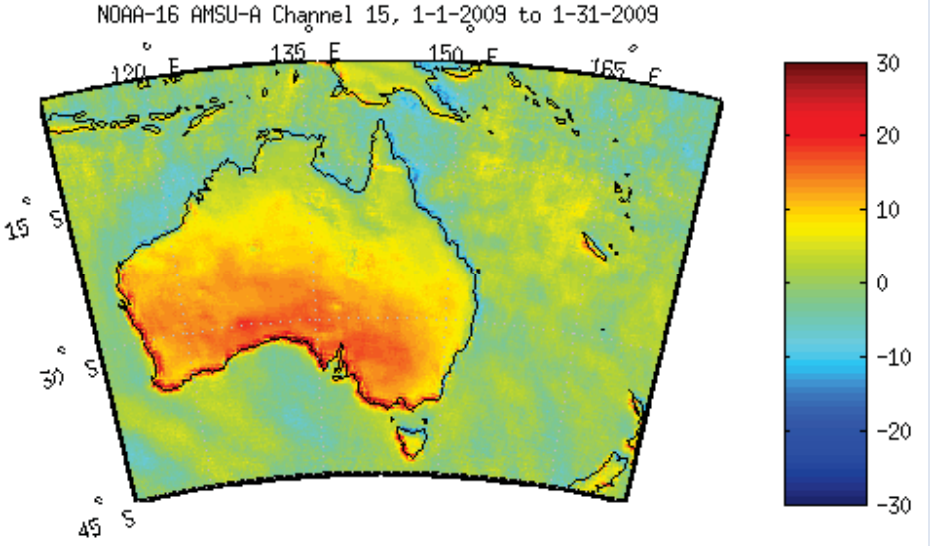


NOAA16 AMSU-A Diff. Maps

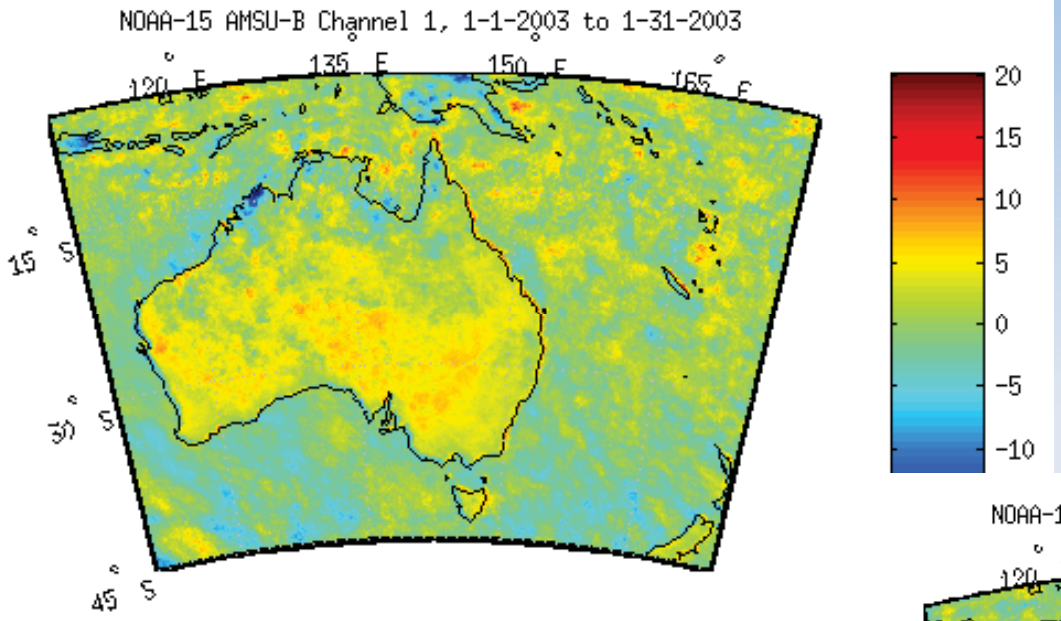


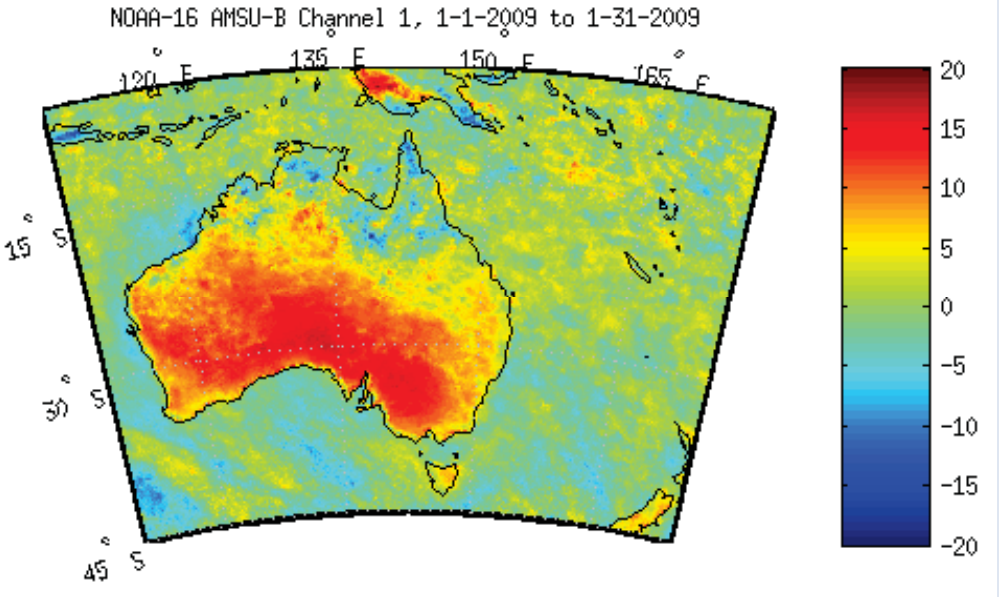




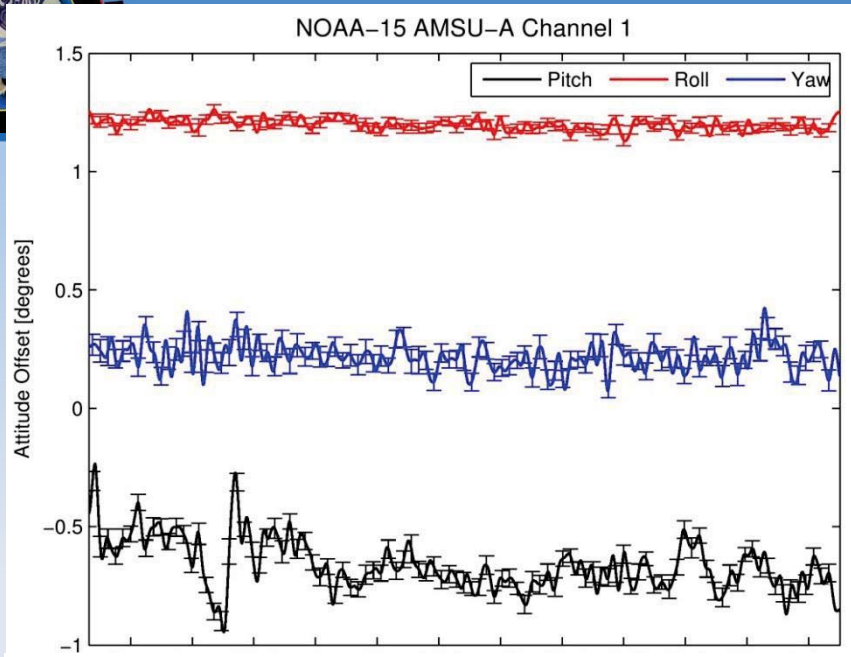


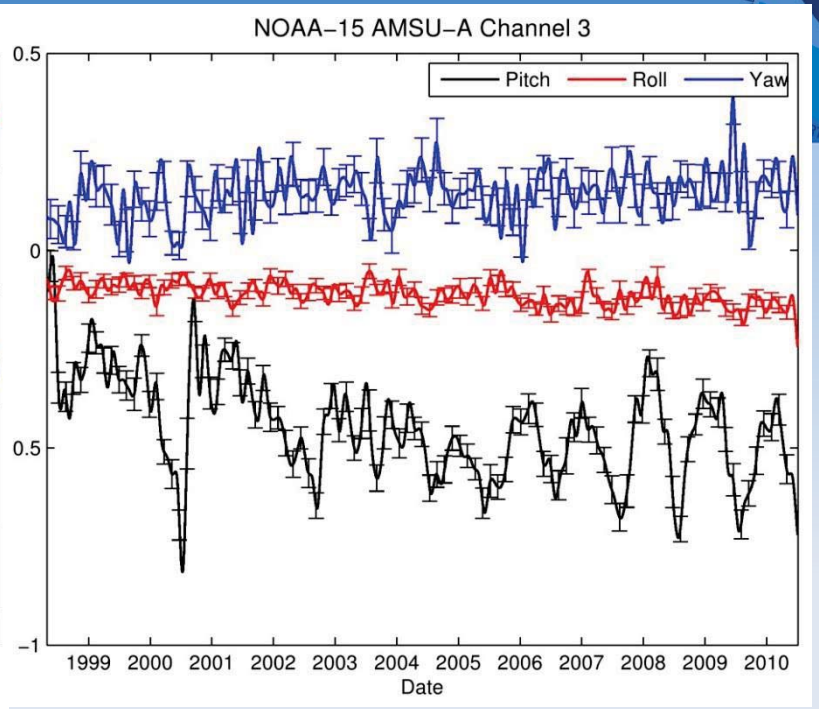
AMSU-B Diff. Maps

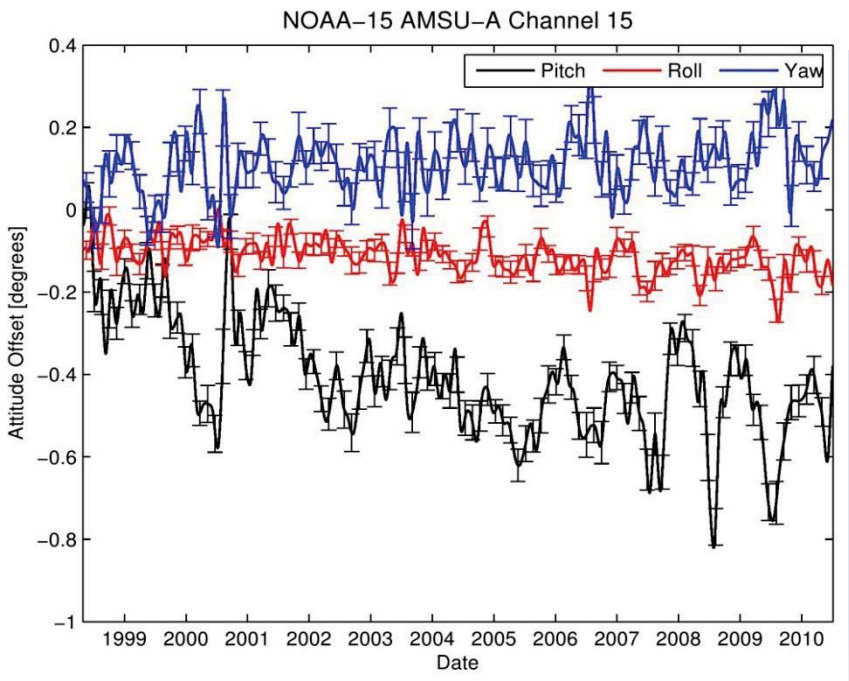




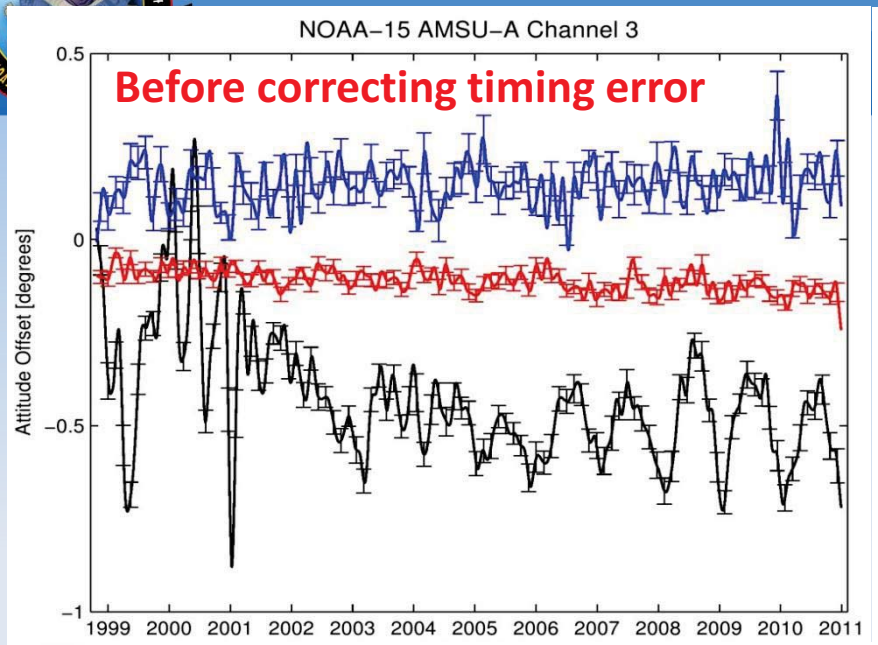
NOAA-15 Attitudes (Pitch, Roll, Yaw)

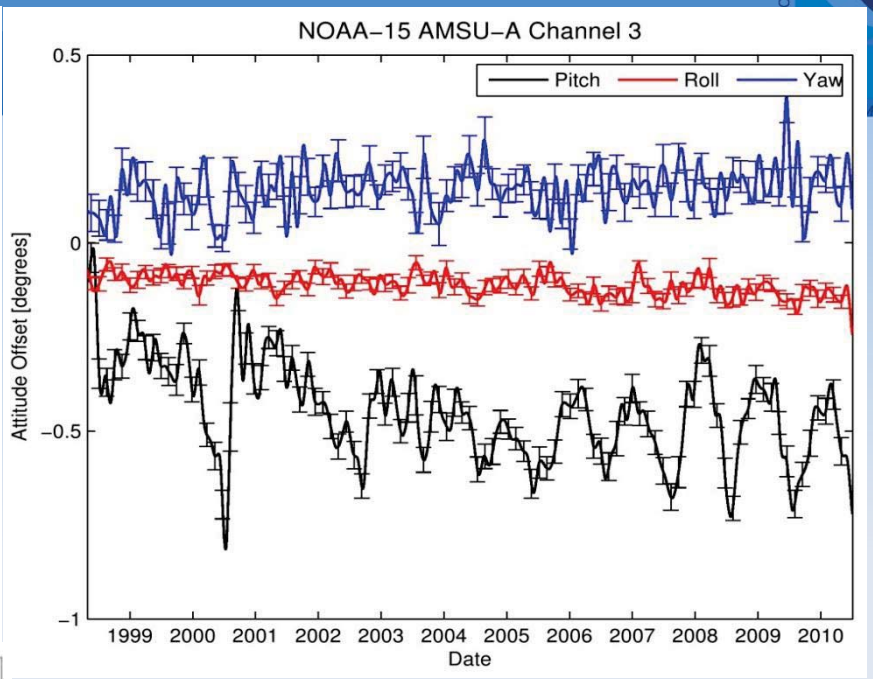


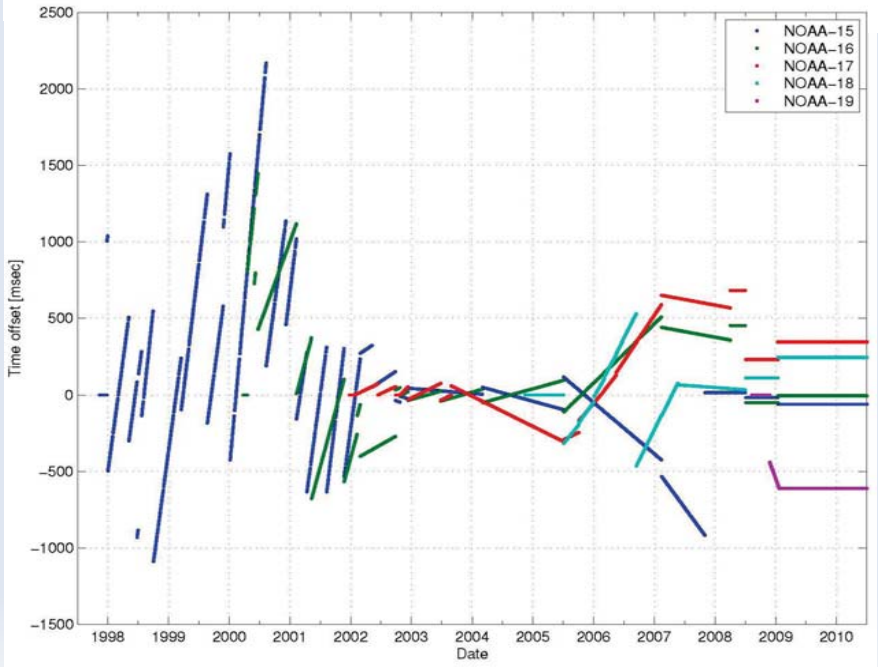




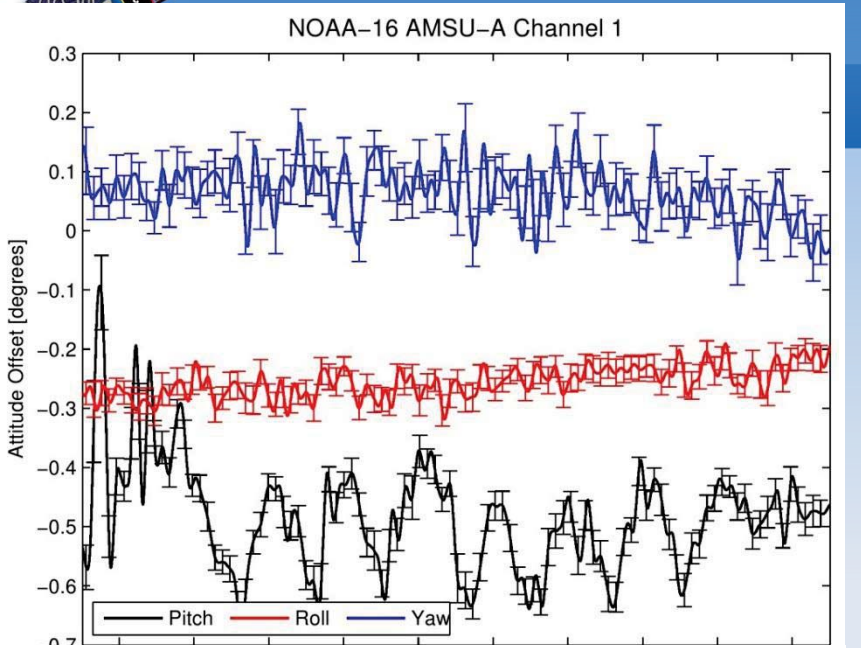
Effect of timing error on geolocation

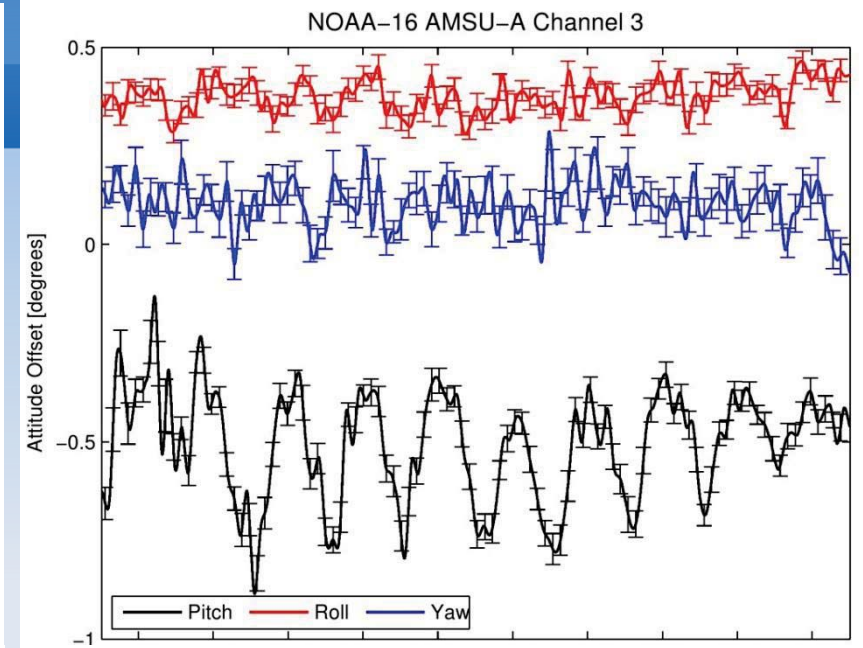


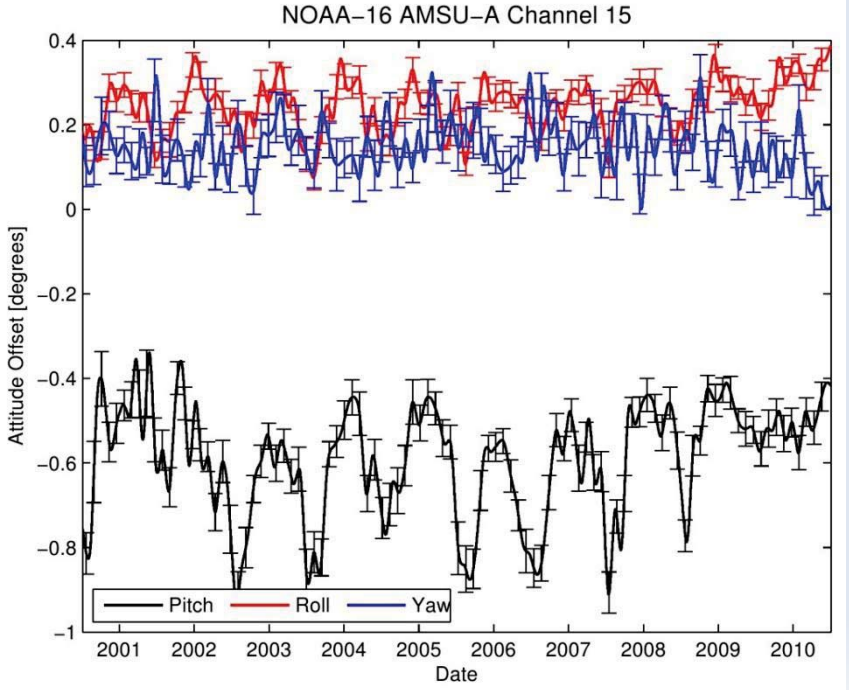


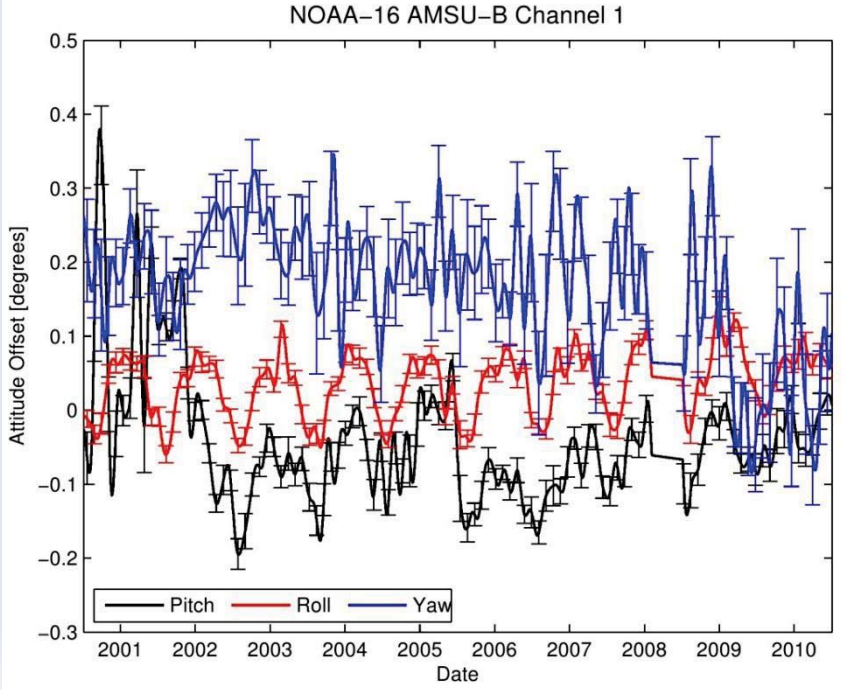


NOAA-16 AMSU-A and AMSU-B

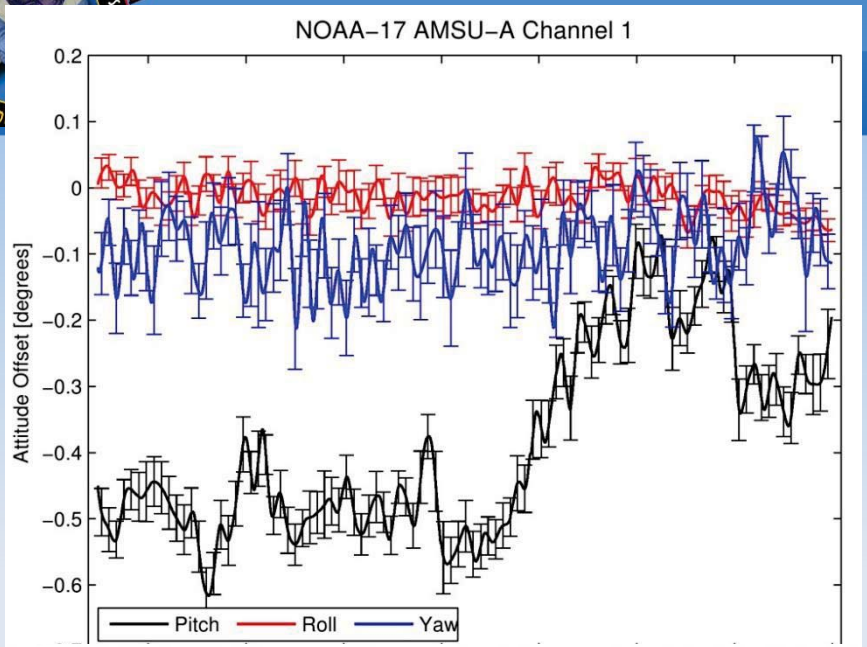


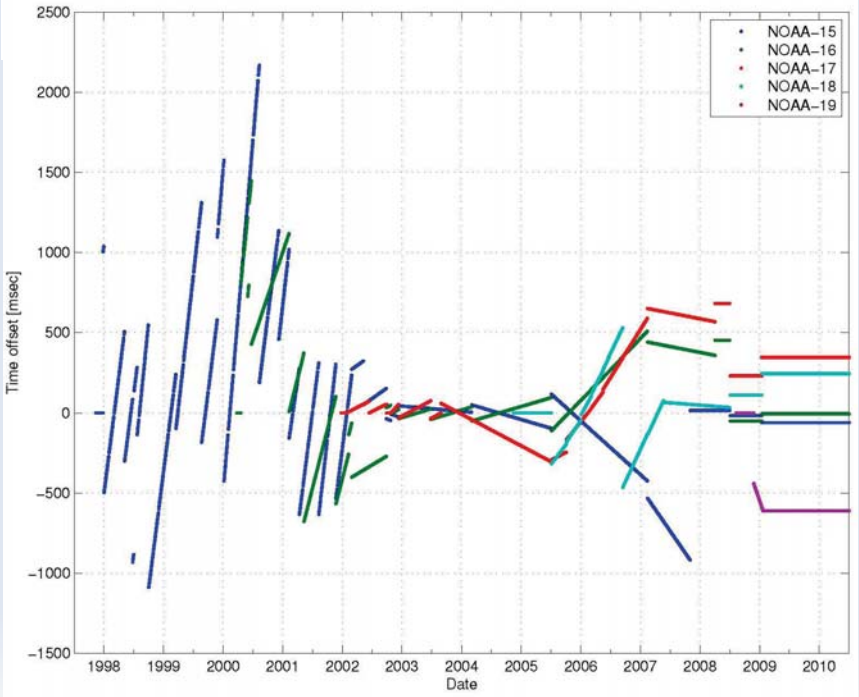


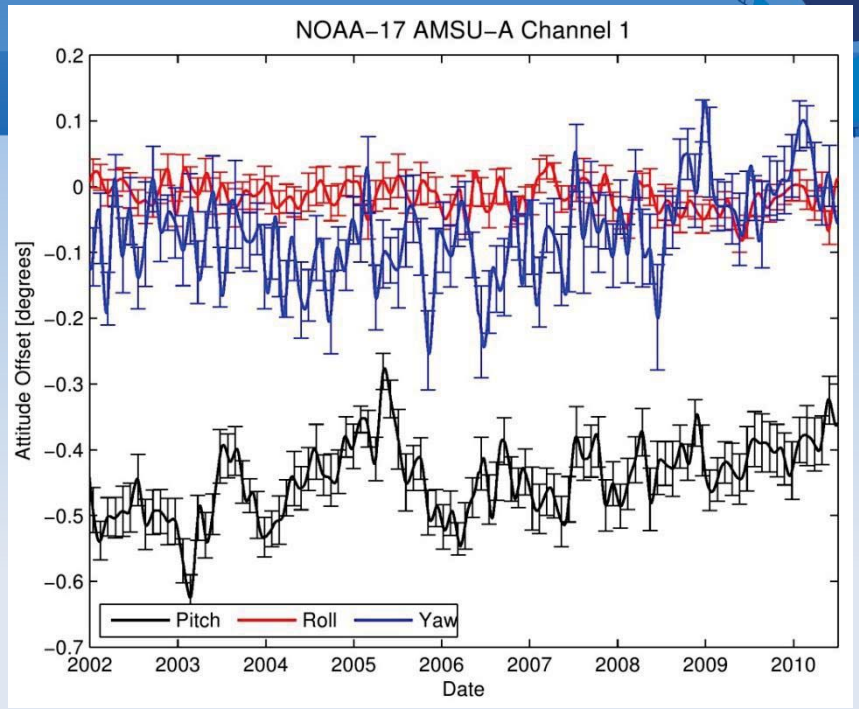




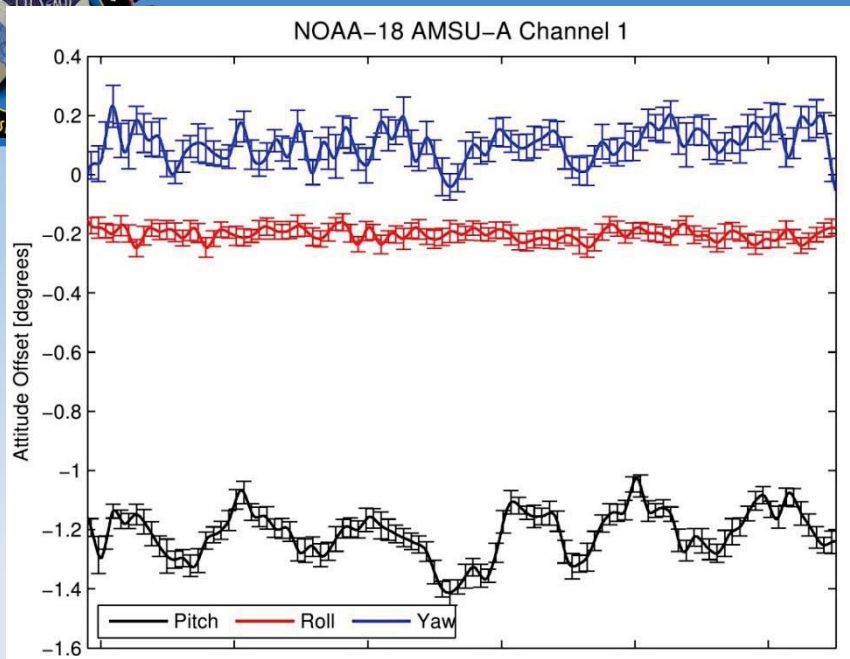
NOAA-17 AMSU-A

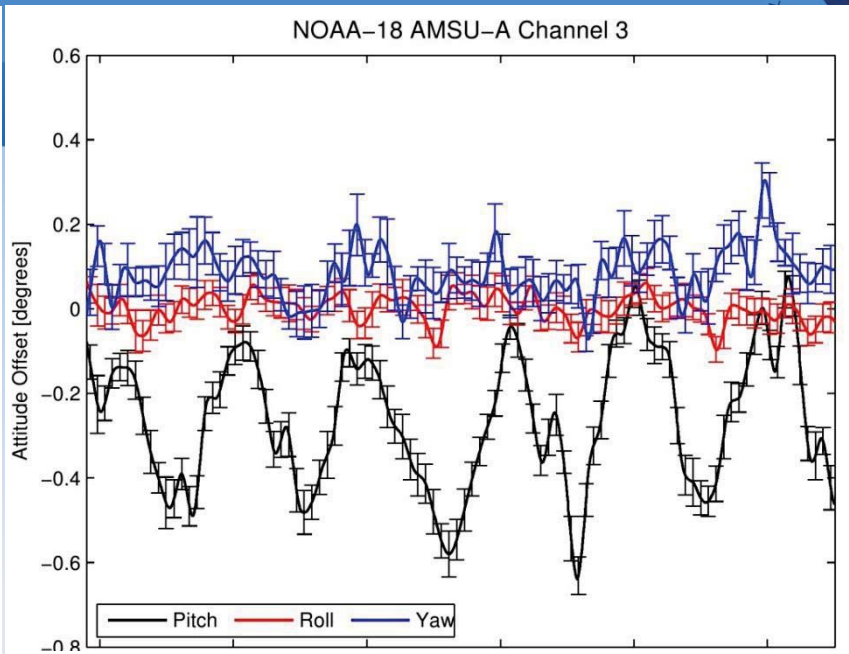


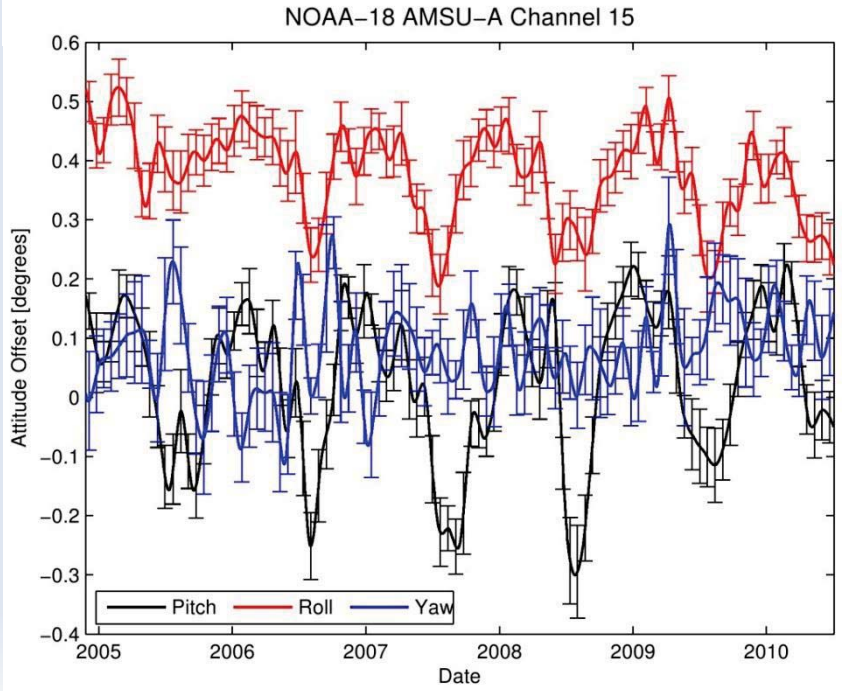


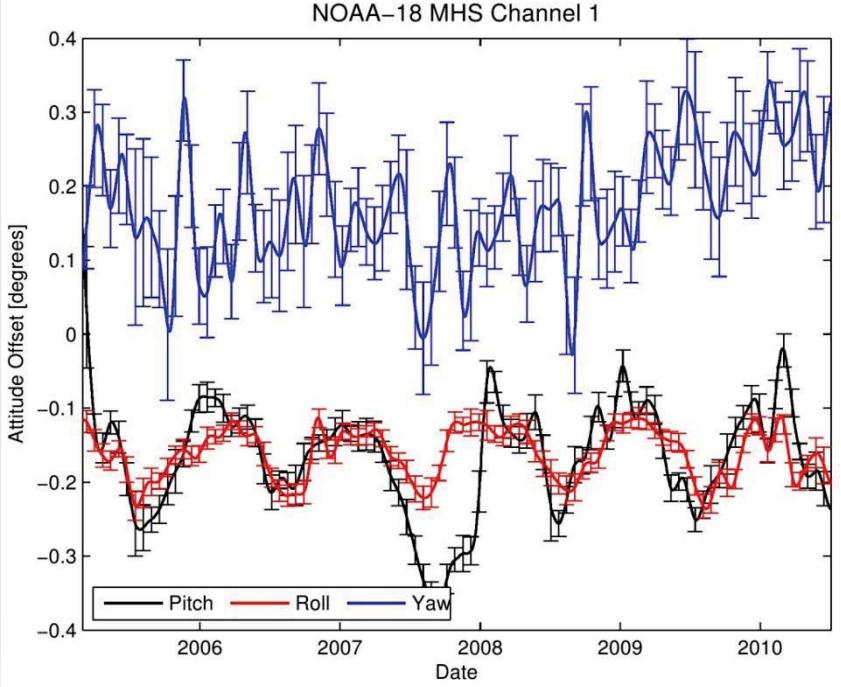


NOAA-18 AMSU-A

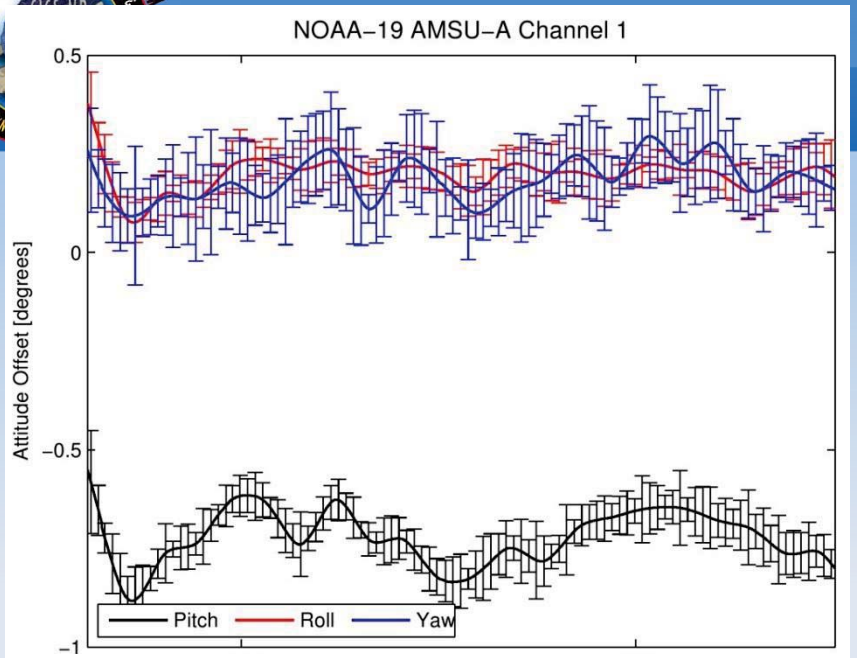


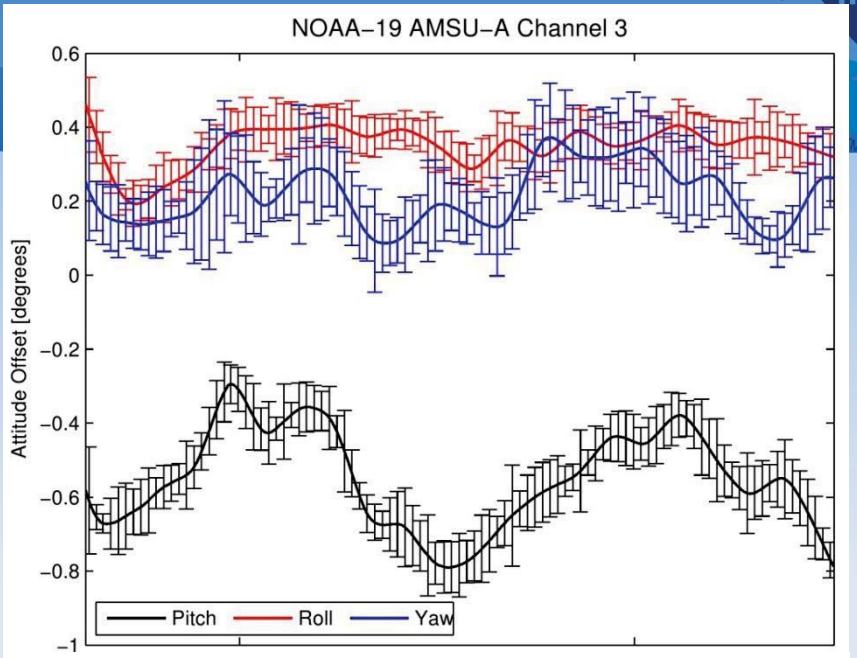


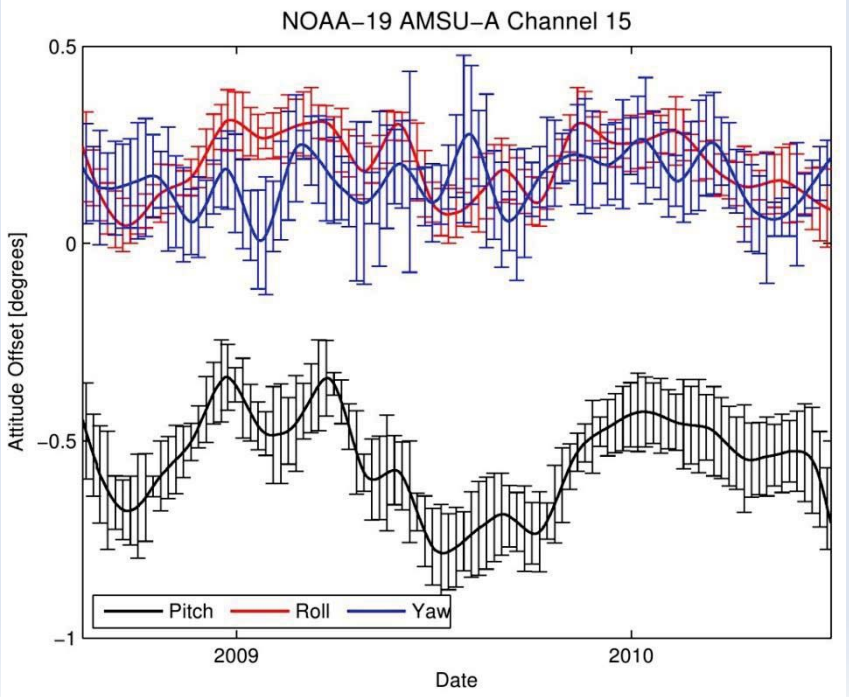


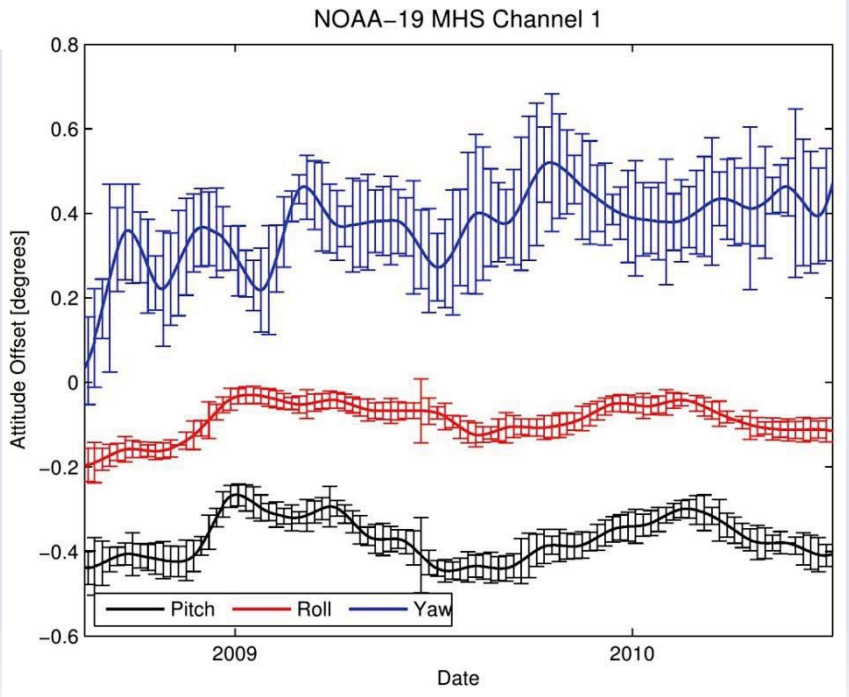


NOAA-18 AMSU-A

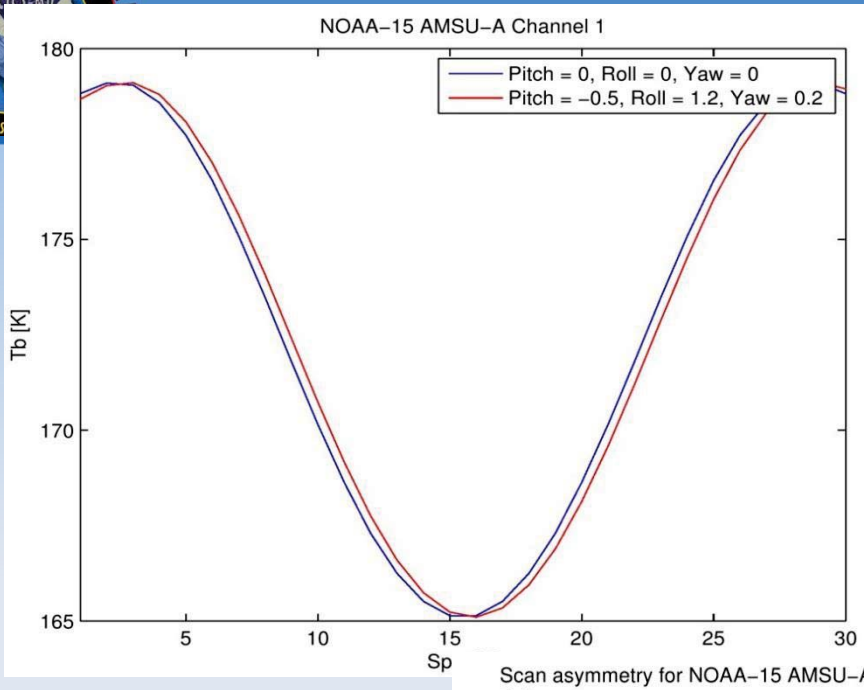


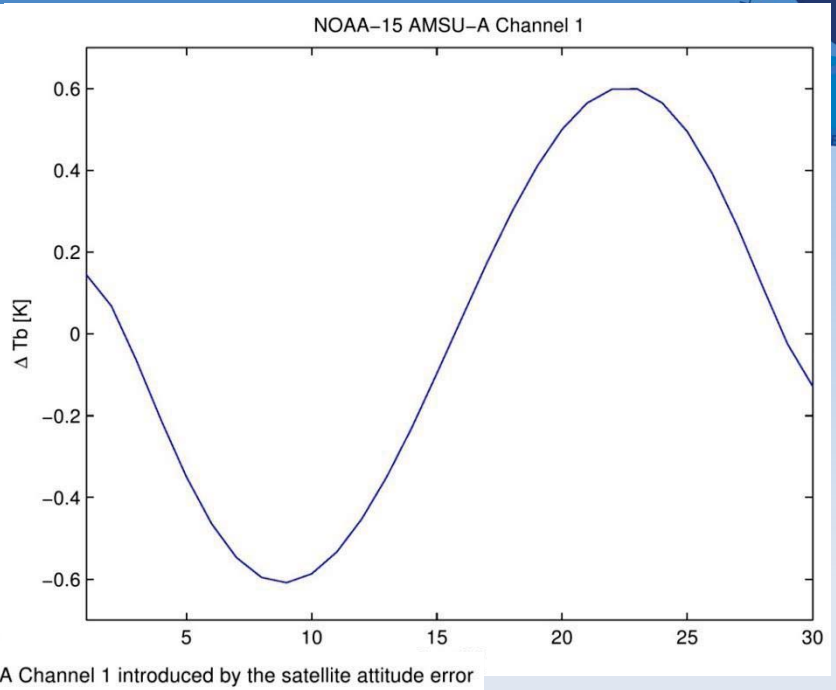


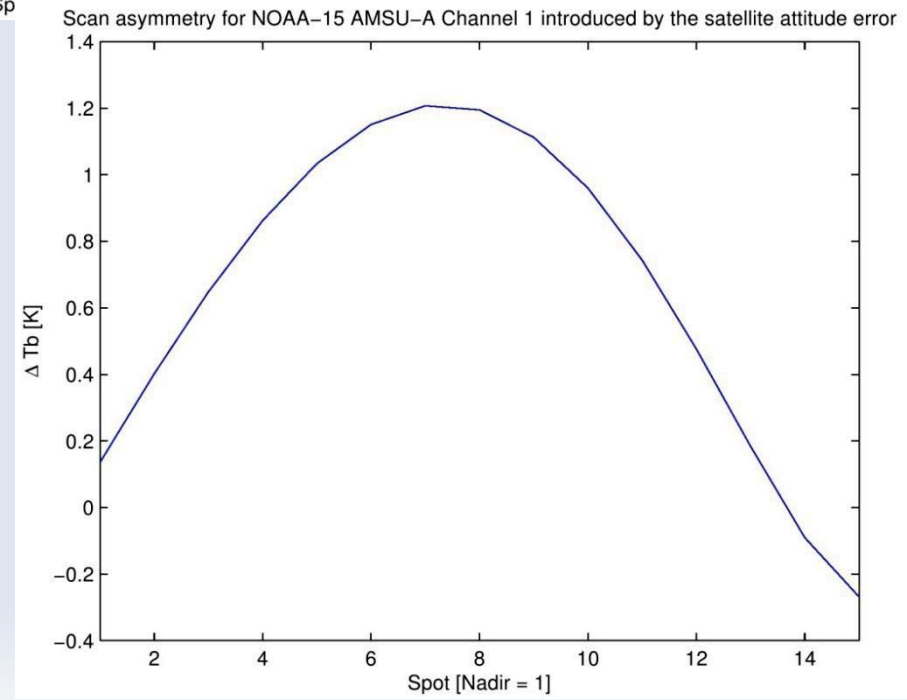




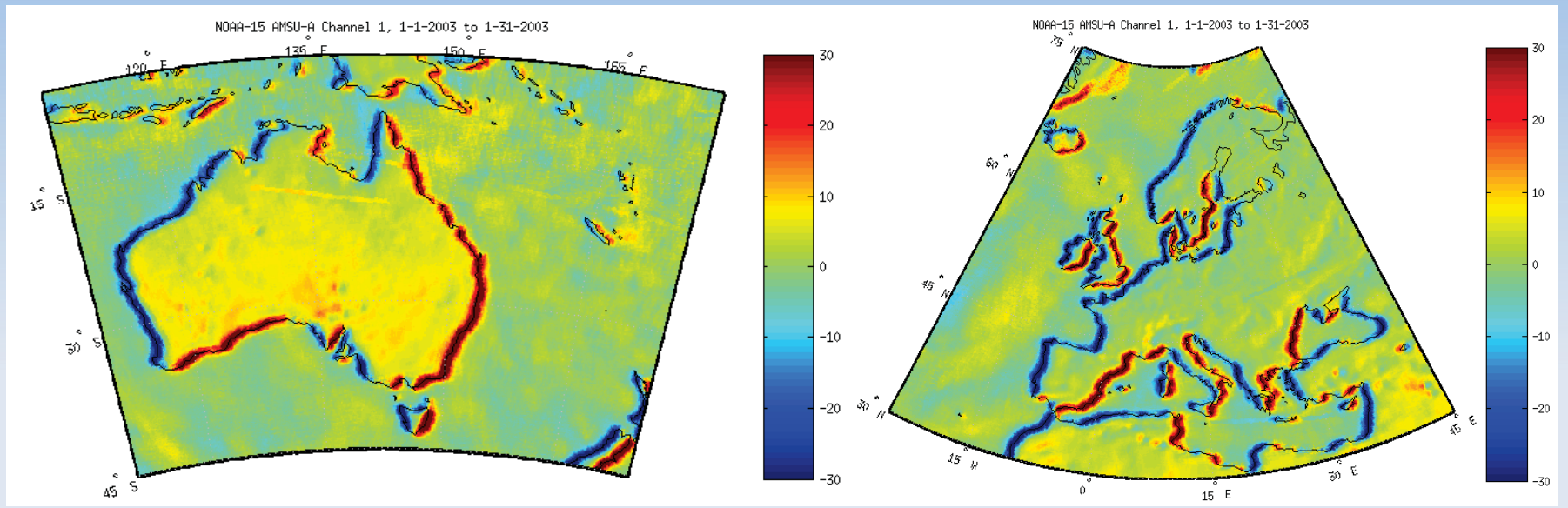
Sensitivity of scan asymmetry to geolocation error

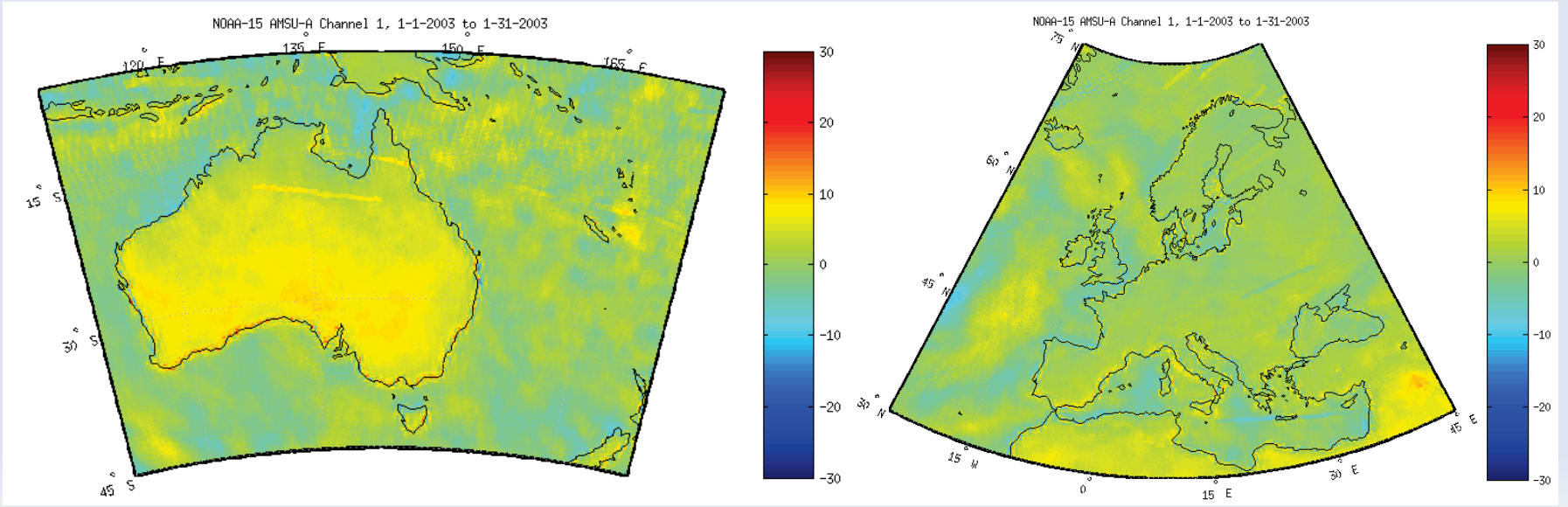




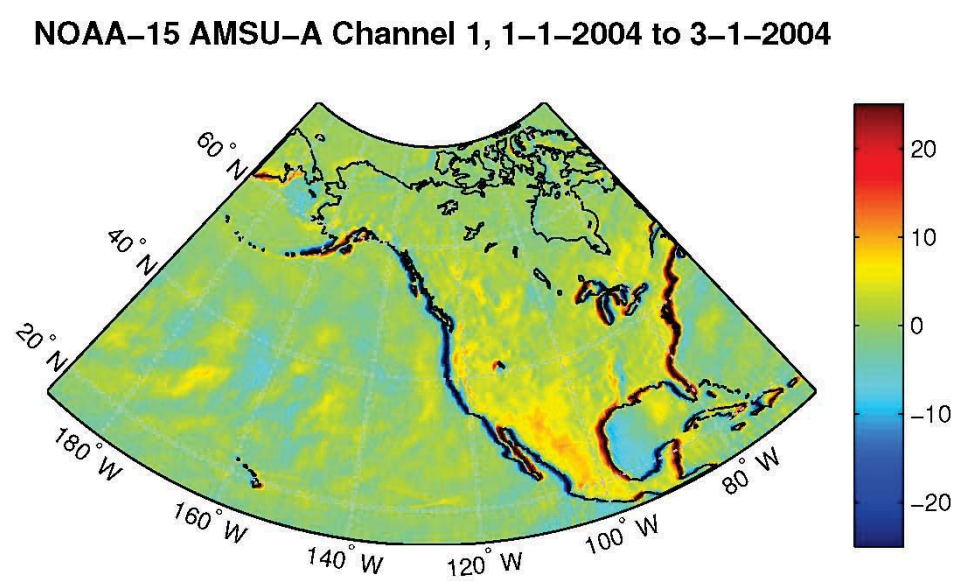


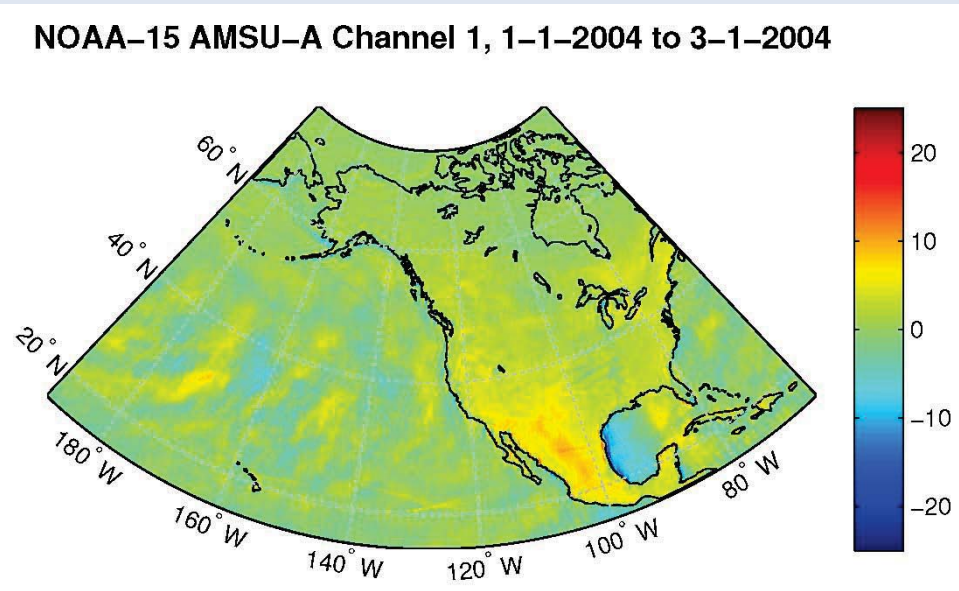
Before and After Correction





Before and After Correction





Summary

- NOAA AMSU/MHS geolocation is subject to inaccuracy that can be up to 70 km in some cases.

- The geolocation is affected by the sensor mounting and satellite attitudes offset which require correction

- The geolocation inaccuracy can seriously influence sensor/satellite pointing angles which are very important for RT calculations

- The quality of AMSU/MHS products is highly affected by the geolocation accuracy. The effect of any inaccuracy is especially important along the coast lines

- A method was developed to correct the geolocation errors. All AMSU-A/-B/MHS data will be corrected soon in the AMSU CDR project.


THANK YOU