The trip included five major components/subjects, the dates and contact persons of these meetings are summarised in Table 1.

1.) I attended the *Fourth International Asia-Pacific Environmental Remote Sensing Symposium*, where I presented our work and was hoping to get feedback from the participants. Other interests were in getting updates on AVHRR (Advanced Very High Resolution Radiometer) calibration activities, MODIS (Moderate Resolution Imaging Spectroradiometer) cross-calibration and recent advances in CLAVR (Clouds from AVHRR). I organised meetings with Fred Wu and Eric Vermote (NOAA and University of Maryland respectively) to discussions long-term calibration strategies, techniques and issues in comparison with the MAD (Multivariate Alternate Detection) method.
2.) The meeting with Doelling et al. (NASA) was arranged to discuss cross-calibration opportunities for AVHRR data with other sensors.
3.) The meeting at VITO with the SPOT-Vegetation Group was initiated to discuss long-term sensor calibration strategies and cross-calibration opportunities with SPOT-Vegetation data.
4.) The meeting in Bonn was to get recent updates about base processing and applications (including change detection) using long-time series remotely sensed data.

Table 1: Trip overview.

Date	Meeting	Organisation	Location
8-11. November	SPIE Conference 5658	SPIE	Hawaii, USA
13. November	Fred Wu	NOAA	Washington DC, USA
13. November	Eric Vermote	University of Maryland	Maryland, USA
15. November	Dave Doelling	NASA	Langley, USA
17. November	Else Swinnen	VITO	Mol, Belgium
23. November	Matthias Braun	Centre for Remote Sensing	Bonn, Germany

This trip report represents my ***SPIE Fourth International Asia-Pacific Environmental Remote Sensing Symposium*** attendance and the following appointments with scientists. The overall objective of this travel was to present and discuss ideas of the NOAA AVHRR data calibration (channel 1and 2) and understand how other groups are handling the problem of changing calibration coefficients. I was also interested in understanding similarities and differences in methods used for sensor calibration based on other satellite sensors.

I describe at the beginning the comments after my talk and a report about a working-lunch with A. Heidinger. Following this is a description of posters and presentations that I found interesting and worth mentioning. Detailed protocols of the personal meetings with the different groups after the SPIE conference, that I contacted prior to my departure, are then reported.

I attended the ***Remote Sensing of the Atmosphere, Ocean, Environment, and Space*** conference 8-11 November 2004, in Hawaii (USA) – conference number 5658: *Applications with Weather Satellites II*. A CDrom with the proceedings of all conferences will be shipped to me shortly.

The title of our talk was:
Towards an internally consistent calibration for 11 AVHRR instruments in a 20-year time series of satellite data – M. Schmidt, E.A. King and T.R. McVicar

Discussion and questions after the talk:
Question (A. Heidinger, NESDIS): Are there any estimates of the high gains for NOAA 16 and onwards possible with this method?

Answer: No, but there might be in combination with another method, such as the analysis of high tropical clouds in combination of the MAD based method for the low gains, or the MAD method might be applied only on the masked areas as a secondary processing step. We did not have the time yet to test this.

Suggestion (B. Guenther, Goddard Spaceflight Centre): the polarisation of the sensor might introduce some seasonal effects in the calibration. It might be worth having a look at the sensor construction.

Comment (Alexander Ignatov, NESDIS): The orbital drift might influence the drop in the calibration coefficient curve of our approach towards the end of the test period, when NOAA 14 overpasses later in the day.

I talked with John Le Marshall during the following coffee break about his calibration approach using clouds. He was interested in what was done and is planned; he is happy to be contacted.

During the following lunch break I arranged an appointment with A. Heidinger to discuss several issues concerning cloud masking and calibration:
We talked about the work done at their and our group and opportunities for further calibration work.

NOAA 12 is in his opinion very interesting as an instrument that currently delivers data and has overlapping data records with most other AVHRR instruments. He was thus interested in our dataset, as NOAA 12 is still recorded at the Australian AVHRR receiving stations. The reason for the interest in NOAA 12 is the problem of the derivation of absolute values for the calibration. Therefore NOAA 12 might be useful in combination with NOAA 9 to bridge a gap towards the aircraft underflight.

I reported on the problems with CLAVR for NOAA 14 that we had over central and northern Australia.

He is interested in the CLAVR performance over Australia, as a regional study – as most of his applications have/had to fulfil global requirements.
Since October 2004 his group is operationally producing cloud masks with an improved CLAVR-X algorithm that uses buoy data over the oceans (see Poster from Alexandr Jelenak, NOAA/NESDIS). He suggested running the CLAVR-X algorithm for our NOAA 14 test data. If the improved CLAVR algorithm works better over Australia he is happy to share the code with us, and for this code to be implemented in CAPS.

Andrew had no clear idea why the seasonality in our calibration approach is present, but promised to think about it and is happy to be kept informed about our further work.
He encouraged me to meet Fred Wu and others at NOAA; I had arranged such meetings prior to departure from Australia.

Suggestion from Andrew Heidinger: after I get back from this trip we should get in touch for evaluating the improved CLAVR algorithm for the different AVHRR sensors.

Poster presentation: Validation of CLAVR-X cloud detection over ocean using AVHRR GAC sea surface data. From A. Jelenak and A. Heidinger (NOAA/NESDIS).
Global distributed buoy data are used to set up an algorithm for cloud cover detection. These data are operationally used to validate cloud cover detection. For this purpose a record of all available buoy data was compiled – from permanent and temporary buoys. A high concentration of data is found in the North Atlantic Ocean, while in Australasian oceans only few datasets were available. The masks as validated over the oceans are also valid over land. The author proposed that CLAVR-X improved the cloud detection, also over land areas. His plan is to re-process all available AVHRR and make the masks available on the internet.

Poster presentation: In flight measurements of space count in the AVHRR solar reflective bands. A. Iganov, C. Cao, J.T. Sullivan, R.H. Levin, X. Wu (NOAA) presented a poster about the derivation of spacecounts. The authors postulate a new and better way to calculate the space-counts (see conference proceedings) and are happy to be contacted and to share his knowledge.

Oral presentation: A. Iganov and L.Lazlo: Equatorial crossing times for NOAA satellites. The talk was touching the topic of the calculation of the exact calculation of the equatorial crossing times of the NOAA satellites. The authors are also willing to share is expertise in this respect.

Oral presentation, about the possibility to detect trace gas and estimates of their quantities in hyperspectral data – possible applications might be forest fire emission estimates or applications in urban/industrial areas. A problem seems to be the validation. Matched filtering techniques were used to unmix the hyperspectral datasets (AHI) by utilising gas spectra from spectral libraries. More questions todavidj@epa.gov or at http://www.higp.hawaii.edu/ahi.

Meeting with Xiangqian "Fred" Wu at NOAA, Washington DC, USA
Start of the meeting: 12.04.2004, 10.am, duration 2.5hours.
Fred presented the work performed at NOAA over stable desert targets and explained, that he basically took over from Rao two years ago and was mainly busy to catch up with Rao's work. He said that he recently got a bit frustrated by the work over desert sites. He is interested in the derivation of calibration coefficients shortly after the launch of the satellite; he is not really willing to wait for 18 month of data to be collected to avoid their seasonal effects. He said that the first estimate of starting coefficients after the satellite launch is something that users are very keen on and that he is still looking for a good method to do so within one month of satellite launch and instrument operation.

He tried to use a stable desert site as big as possible to reduce the inhomogeneity of his area. He used a rectangular polygon which is longer in north-south direction (in the direction of the flight path).
The method includes several checks before the pixels within this polygon are selected for the calibration coefficient derivation, checks include:

- clouds;
- precipitation;
- surface changes; and
- water vapour (works satisfactorily).

He always looks at the seasonal characteristics of the derived no change pixels and tries to fit a sinusoidal curve through his data-points in time, from which he estimates the general trend in the data. If there is a trend line he corrects it to be horizontal and thus has his calibration coefficients.

A recent idea of his is to utilise the standard geometry of the relative position of satellite to sun to compare pixels more frequently (rather than to wait for a complete year), but this is nothing but an idea at this stage he said this needs more thinking.

I presented what we have been doing and he was very interested and mentioned that he might try something similar. We discussed the presentation and I gave further explanations of the MAD method itself.

Fred Wu mentioned that it is difficult to explain the drop of the calibration curve towards the end of our test period, because it is hard to tell wether this is due to the orbital drift or if the sensor sensitivity is truly not degrading linearly. There might also possibly be other factors that come into play, such as the operation of the mirror, or possible damage to the mirror due to solar wind or particles. If these changes are caused due to a change in the sensor sensitivity, changes in the physical properties of the senor or the orbital drift we do not know and can not tell at this stage. The different ground reflectivity introduced by the sun illumination or viewing geometry might be higher or lower, in his opinion, as we can not assume that these surfaces are Lambertian. So that it is hard to model the changing view geometries and the resulting surface reflectance values.

He is very interested in the MAD approach that we are using, because he has problems with GOES (Geostationary Operational Environmental Satellite) data. This data seems to have on to of the calibration difficulties also large errors in the geo-location. Overall GOES seems not the appropriate sensor for a cross calibration, because it has more problems than AVHRR data have. I pointed out to him that either the MAD but more like a combination with Nielson's MAF method might be useful in his case.

Fred Wu was interested in using data from other regions of the world other than Northern Africa and Mexico. Especially a site in the southern hemisphere interested him, in order to study if seasonal effects are similar on both hemispheres or if there are other influencing factors that disturb the calibration.

We agreed, that it would be very good to keep in touch about the activities in the data calibration approaches and that we both are interested in possible future collaboration.

After this meeting I drove straight to the University of Maryland to meet Eric Vermote.

Meeting with Eric Vermote, at University of Maryland, Maryland, USA
Start of the meeting: 12.11.2004, 1.30 pm, duration 2 hours.
After a short introduction why I came over to Washington DC, I presented the conference talk to Eric Vermote. We discussed the method and the outcomes. I gave additional explanation of the MAD method.
Eric suggested looking at large scale seasonal effects that might influence the whole approach, such as the variations in ozone concentration. He mentioned that this is the only shortcoming of the conference presentation that he can think of. Data about the ozone concentration are available with which, in his opinion, this can be corrected.
The influence of the seasonal effect as well as the orbital drift is in his opinion hard to tell/differentiate at this stage. Eric suggested using a decent BRDF correction (he uses the MODIS algorithms). He is interested in an Australian desert site as a comparison to his work in African deserts.

We discussed results from a study of his from a cross calibration study (Vermote and Saleous) over stable desert targets over North Africa, using Terra MODIS and Aqua MODIS data – which will be published soon. From his point of view MODIS data are well calibrated, better than 2%. He assumes that AVHRR data cannot be better calibrated than 5% with any method, so that he believes that the use of MODIS data to cross-calibrate AVHRR is worth while.
He uses thresholds and outlier statistics, cloud screening and a MODIS based water vapour estimate (using channel 31 and 32), that he did transfer to AVHRR data using the thermal channels (but less successfully).

Although they apply a BRDF correction, a weak seasonality is (still) visible in the data-plots over time. The method over stable desert target and the cross calibration is very close to the results if using the method of Vermote and Kaufmann over oceans and clouds over oceans.

A possibility of collaboration might be to apply our method to their data and vice versa.

Eric Vermote and David Roy are involved in a project to apply Eric's method to re-calibrate the global GAC/AVHRR dataset for all NOAA satellites.

I made it clear that we are interested in the best possible calibration technique and that we want to apply this to our whole archive that is recorded at both the high (1.1 km at nadir or HRPT) and low resolutions (5.0 km or GAC format). So that we surely are very interested in this further work and are happy to assist/collaborate to derive calibration coefficients.

Meeting with Dave Doelling and 4 others working with different instruments, rather on the physical side of things (they were only introduced by their first names).
Start of the meeting: 15.11.2004, 10.00 pm, duration 5 hours.

NASA at Langley mainly conducts research focussing on atmospheric processes and finally the analysis of the climate and climate change. For this reason different scientists are working with various satellite data to derive products as input for climate and energy balance models. NASA/Langley derives various products from AVHRR data that are available from NOAA/SAA (Satellite Active Archive). Examples are cloud optical depth or drop size.

After a short welcoming and a little chat I started with my presentation, explaining the specific problems about AVHRR including a short review of vicarious calibration techniques.
We discussed the strength and weaknesses of the MAD based method after the presentation. I asked the audience if someone could give a plausible explanation on the seasonal effects in our plots; which could not be given. Dave Doelling mentioned that every group that has calibrated time series satellite data has this residual seasonal effect in their data and that to his knowledge no-one has found a way to explain or to get around this problem. He suggested that the utilising different calibration techniques were beneficial for the science community.

Potential weaknesses of the MAD based calibration method and the AVHRR instruments were identified as:

- ozone variations (possibly seasonal);
- variation in the aerosol content;
- potential changes in the spectral bandwidth;
- uncertainty in the operation of the spectral filter; and
- orbital drift.

One idea might be to include some of the NASA derived AVHRR products to use for corrections prior to the calibration analysis. This needs careful attention not to make circular conclusions. A list of products is available from their web-pages.

Dave Doelling gave a short review on the satellite data calibration currently being performed at NASA/Langley. Basically two methods are used:

1. high tropical clouds for the inter-satellite calibration; and
2. collocated satellite overpasses of various sensors for intra-satellite calibration.

After a lunch break Dave Doelling demonstrated few of the results of the calibration work to me. The intra-satellite calibration is based on the condition that only data of common overpasses within 15 minutes were utilised. All satellite view angles need to be within 5 degrees and the pixels were reduced to 0.5 degree resolution. The analysis is preformed over ocean areas, preferably clouded images. The view angle of both of the satellites is reduced to 15 degrees off nadir. This limitation is necessary to reduce the scatter. A lower angle results in too few data points.

If no direct intra-satellite calibration is possible or to prove the performance of the utilised method, it might be a good to calibrate in a circular way using an intermediate satellite e.g. a geostationary satellite. The use of data from another (geostationary) satellite might also be useful to analyse AVHRR and MODIS calibration coefficients with data from a satellite of which the calibration coefficients do not need to be known. The draw back of this method might be error propagation and thus an unavoidable uncertainty.
Both methods have been applied successfully at NASA/Langley.

Dave Doelling's suggestion was to start off with the methods described in the former paragraph with data over Australia and then compare against similar or even the same studies that people at NASA/Langley were doing in order to have independent tests. Especially a comparison with the results from the MAD method would then be useful. He mentioned that he surely would be interested in further communications and the involvement of other studies, mentioning that his group do program a lot but sometimes do not find the time to publish the results sufficiently.

From Langley I drove straight to Washington Dulles Airport for an evening flight to London and Brussels.

Meeting at VITO (Vlaamse Instelling voor Technologisch Onderuoek), Mol, Belgium.
Start of the meeting: 18.11.2004, 10.30 am, duration 4 hours.

VITO is the Flemish research institute for technological research with a major focus on sustainable technological development. One centre of expertise is in remote sensing and located in Mol.

Else Swinnen welcomed me and introduced me to several of her colleagues. She started with a short presentation on what VITOs objectives are in general and about the organisation structure and the situation of the group at TAP: Vito Remote Sensing and Earth Observation Processes.

I was asked to give a short background of what CSIRO does and in breadth of the research performed in the organisation.
She invited several colleagues to a presentation that I was meant to give. It turned out, that the audience was more interested in the operational data processing facilities at the EOC rather than the actual calibration issue. So I gave a talk about Web-CATS and the computer cluster. The audience was very interested in the AVHRR processing and seemed especially impressed by the capabilities of CAPS. The geometric correction (still) seems to be a problem in the software-packages used at VITO.
Other questions in the discussion were regarding the computer cluster and CAPS. The audience seemed to be surprised, that CAPS is freely available following an open source concept.

After this talk a few participants left the room and I presented the calibration talk. Again the audience was very interested in our findings and made interesting comments. During lunch, together with other visitors including John Tucker, things from the calibration side were further discussed. Upon return to Australia there will continued interaction with John Tucker to discuss satellite inter-calibration using AVHRR and SPOT VEGATATION data.
Else Swinnen presented results of her current work on AVHRR data which was basically a demonstration of the necessity for the application of a BRDF correction.
The drawback of her approach was that her model needs 12 days of data to work, but especially in her cloudy test regions this approach was not suitable. So she needs to re-process data again for another region in Africa. VITO has access to AVHRR data over Europe, South Africa and for some time periods over China (due to some contract work).

Unfortunately the person most knowledgeable about the calibration accuracy of the SPOT VEGETATION data was on sick leave the day I visited.
Else Swinnen promised to ask this person to send recent article or report about the calibration precision to me. I will follow this up on my return to Australia. I mentioned to her that we would be interested in checking if simultaneous overpasses of AVHRR and VEGETATION existed and that that we possibly would evaluate the capability of the inter-satellite calibration of the two instruments.
Two programmers from the operational side at VITO asked me for a short meeting and expressed particular interest in CAPS; asking about the modular structure, in which

language it is programmed and if it is well documented and available over the internet. I suggested they contact Peter Turner or Edward King in this respect. They particularly asked if the geo-location code is (well) documented – which I denied.
The background for their detailed questions is an upcoming project at VITO, where a portal needs to be programmed in which all their data processing streams can be incorporated.
Also this interest indicated to me that we should proceed quickly with our CAPS geo-location accuracy paper

At the very end Else Swinnen handed me a user manual/conference proceedings from 2000 regarding SPOT VEGETATION, of which I brought the CDrom version.

I meet Matthias Braun, the project coordinator and administrator of the centre for remote sensing (ZFL) in Bonn, Germany, where I was invited to give a talk.
Start of the meeting: 23.11.2004, 4.30 pm, duration 2 hours.

In 2001, ZFL was established as an interdisciplinary research and teaching centre for remote sensing at the University of Bonn.
After a general overview of projects and activities at the ZFL we moved over to the lecture theatre were I started my talk at 5.15pm in front of an audience of about 40 participants.

Title of the talk:

Recent advances in AVHRR data processing and availability of the CSIRO Earth Observation Center (EOC) data archive

After a general introduction about CSIRO I outlined the current situation of the AVHRR data archive at the EOC and described the hardware concept. I talked about the AVHRR time series processing facilities, Web-CATS and our calibration approach.
Various questions arose from the audience, about CAPS and our web approach as well as questions on the calibration. During the following discussion I answered all questions, but no new ideas in the senses of calibration issues came up.
The dinner afterwards was a short update on the topics of which various people are working on, but nothing in great detail, so that I decided to meet staff from the University of Bonn and the ZFL that is currently working on time series data the next day for lunch. This appointment did not come to happen due to me being sick.