



# Making consistent measurements from MODIS, ATSR and AVHRR reflective solar bands for generating Fundamental Climate Data Records (FCDRs)

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# Critical issues with FCDRs

- Two major questions: **where** and **what**
  - **Where** – geolocation accuracy (L1A)
  - **What** - radiometric accuracy (L1B)
- MODIS –  $\Delta r < 0.050\text{km}$ ,  $\Delta\rho < 1\text{-}2\%$
- AVHRR -  $\Delta r > 2\text{-}3\text{km}$ ,  $\Delta\rho < 15\% \text{-}20\%$  (historical sensors)
- ATSR -  $\Delta r > ???\text{km}$ ,  $\Delta\rho < ???$
- Requirements:  $\Delta r < 1/3 \text{ pix\_size}$ ,  $\Delta\rho < 3\text{-}5\%$  (1-2%) ?
- How one can achieve this ?
- Geolocation - MODIS is considered as a reference, unlikely can be updated dramatically
  - » AVHRR requires GCP matching, orbital/sensor modeling cannot meet requirement. Agencies that keep historical data should generate **AVHRR-GEO** files with precise geolocation (including georectification)
  - » ATSR – ???
- Radiometric calibration - MODIS is considered as a reference, unlikely can be updated dramatically
  - » for AVHRR and ATSR there are potential approaches
  - » a) calibration against reference sensors (simultaneous clb): SNO
  - » b) calibration against reference targets: Tropical Deep Convective Clouds (TDCC), deserts (Libyan), Greenland, Antarctica – Dome-C or any other well-characterized targets
- Factors to be taken into account:
  - » Spectral response differences between sensors
  - » Differences in solar constants
  - » Variable atmospheric state if not SNO
  - » Dual gain for AVHRR-3 (NOAA-15 and up)

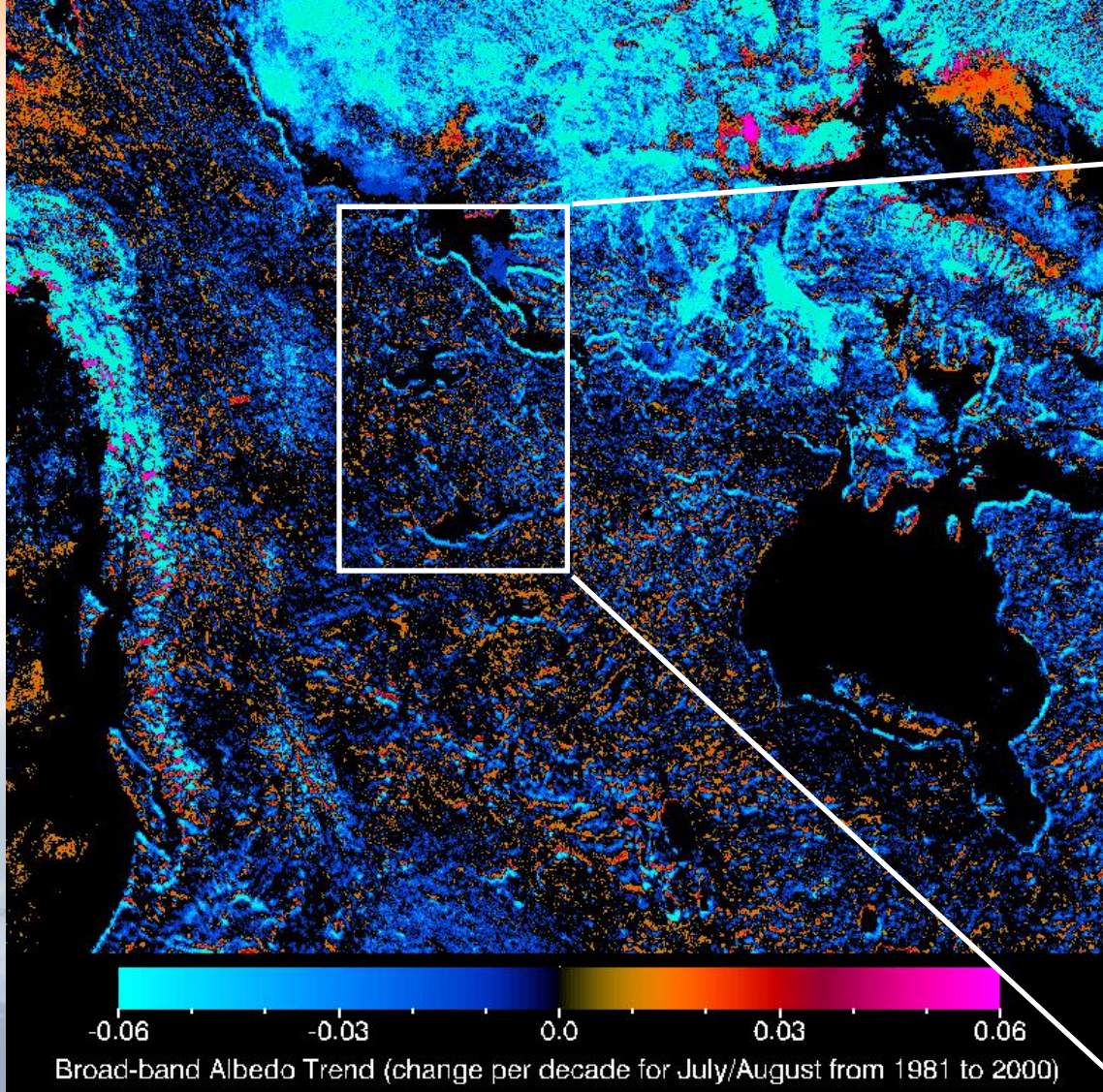
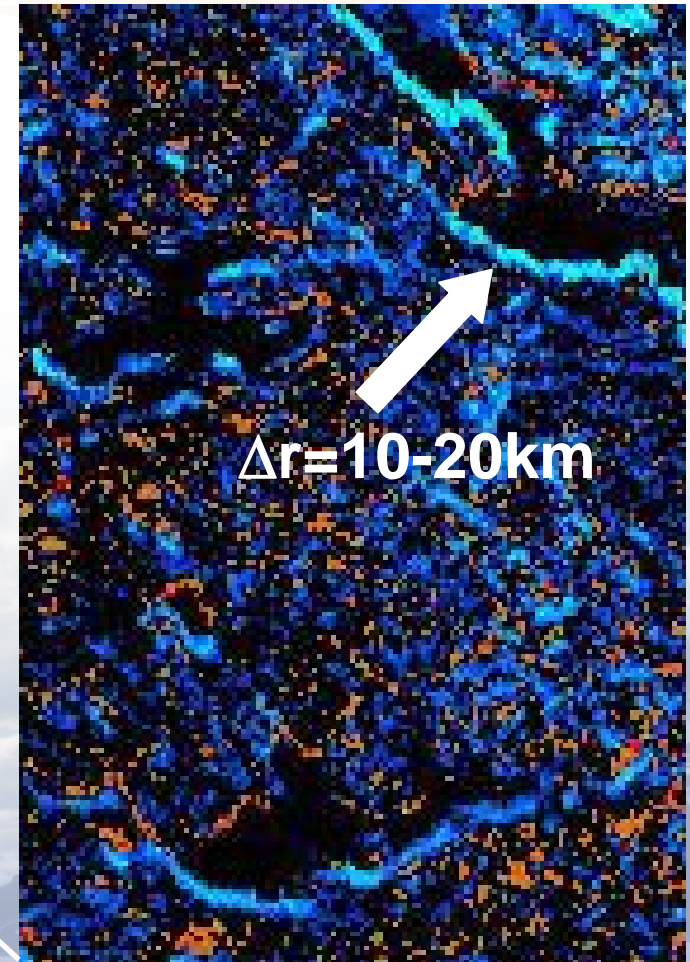




# Change detection using data with spatial noise



400km



-0.06    -0.03    0.0    0.03    0.06  
Broad-band Albedo Trend (change per decade for July/August from 1981 to 2000)



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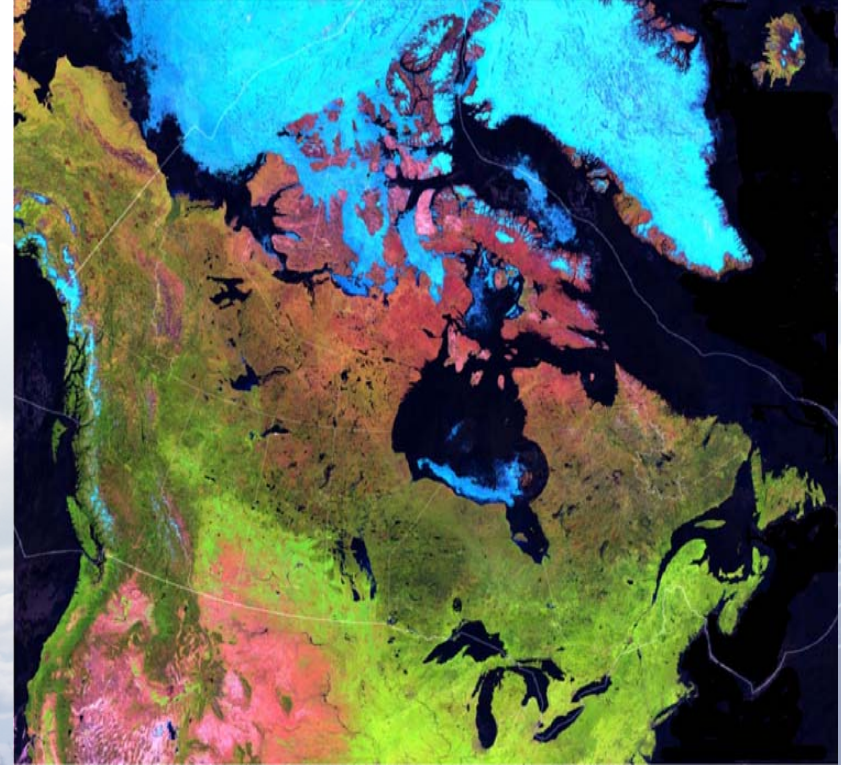
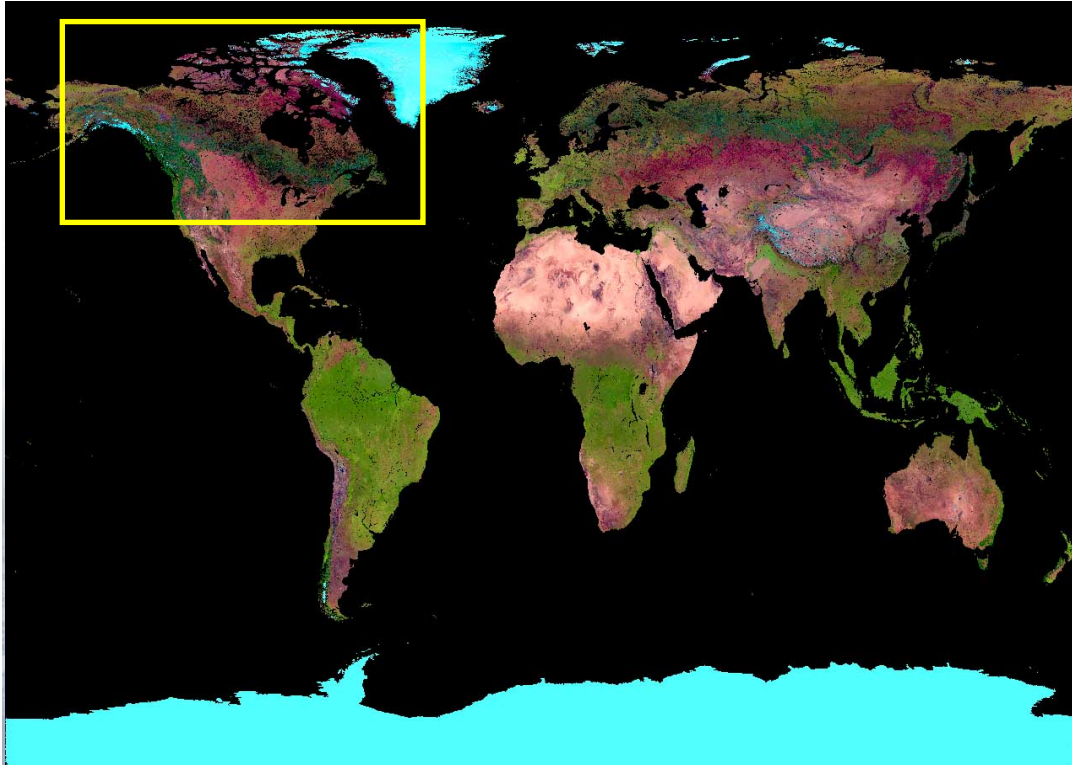




# Historical 1-km AVHRR at CCRS



We at the Canada Centre for Remote Sensing (CCRS) are focused mostly on Canada's territory, although region of data collection also includes Northern US, Alaska, Greenland, Iceland and surrounding oceans



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## Improving georeferencing accuracy for historical AVHRR 1-km data



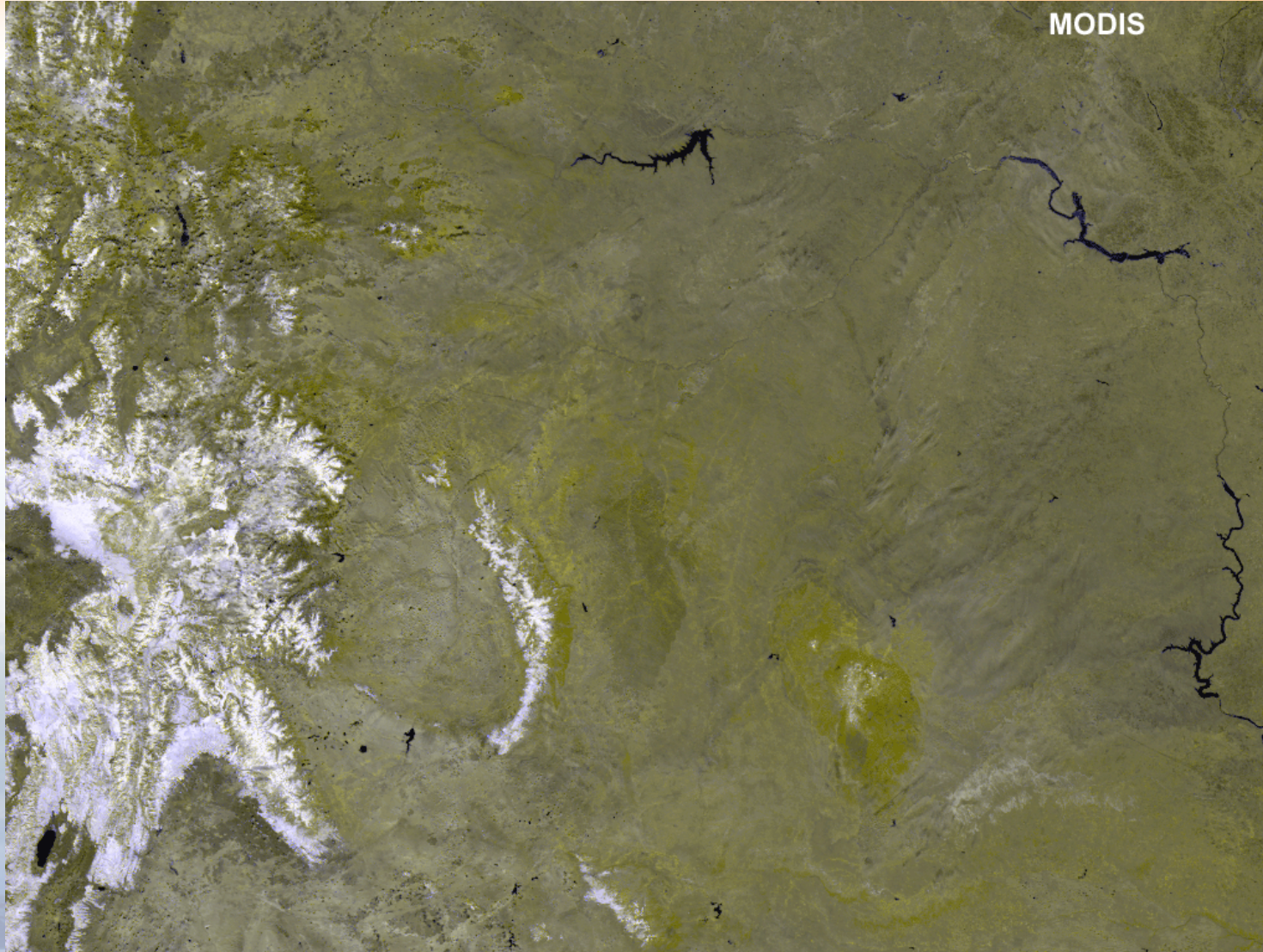
- Approach entirely based on orbit/scanning modeling cannot provide sub-pixel accuracy for AVHRR/NOAA especially historical sensors. Error is usually  $> 2-3\text{km}$  and frequently even larger;
- Ground Control Point (GCP) and precise attitude angles information are required to achieve sub-pixel accuracy. MODIS achieved the accuracy in pixel geolocation  $\sim 50\text{m}$  globally;
- New processing system – Canadian/CCRS AVHRR Processing System (**CAPS**) is being developed at CCRS to achieve sub-pixel geolocation accuracy using GCP refining procedure in native swath projection
  - Use MODIS composite imagery as a reference
  - GCP chip matching in native swath projection
  - Sensor attitude angles and  $\Delta t$  are used to get best fits
  - Approach works uniformly over the entire swath ( no extrapolation errors)
  - Geolocation/pointing files (similar to MOD03) can be produced for each image file
  - Achieved better than 0.5 pixel geolocation accuracy







# GCP chip matching in swath projection



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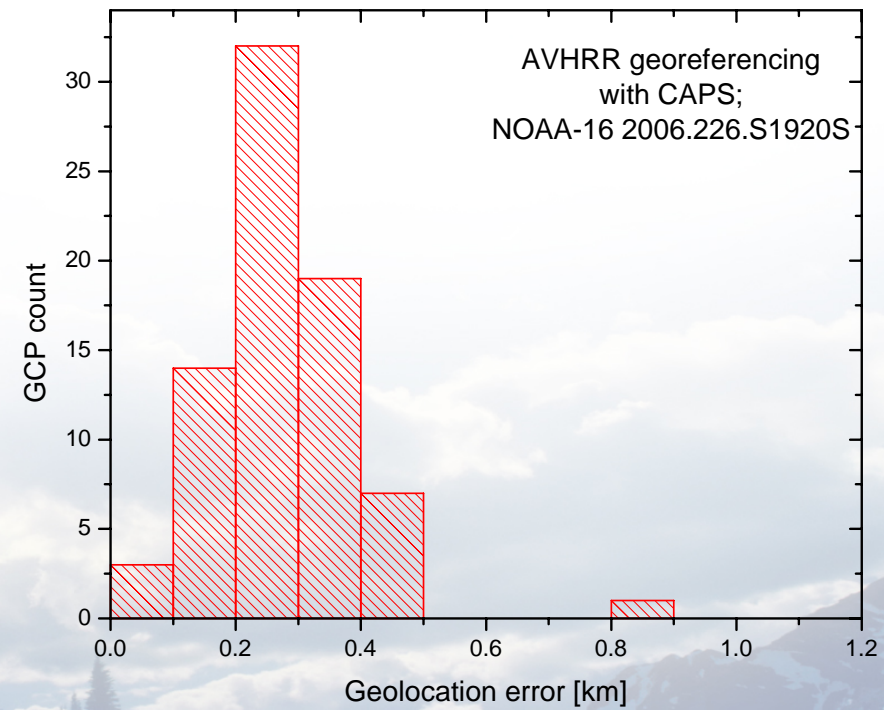
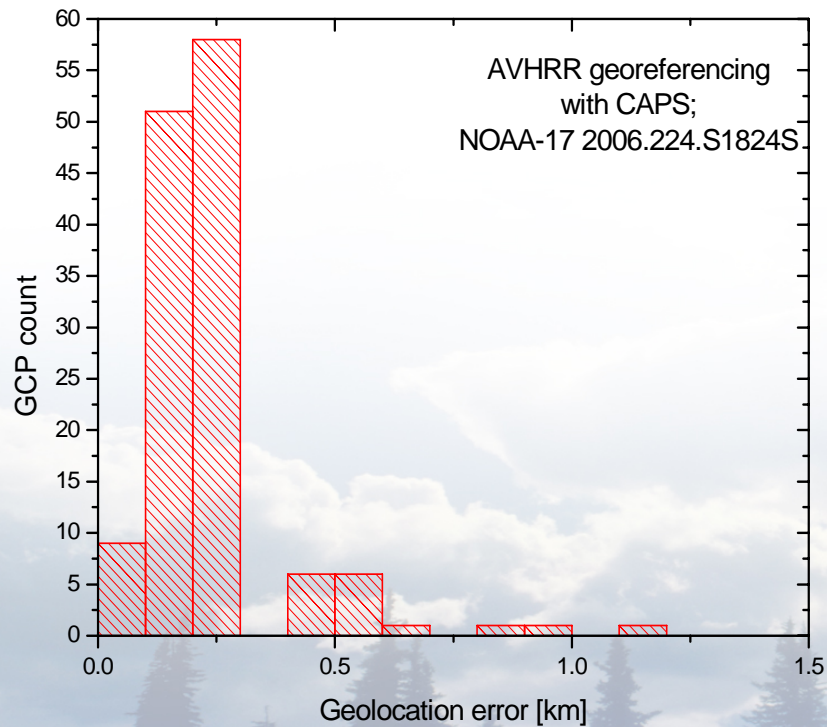
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# Typical georeferencing accuracy for new CCRS AVHRR processing system **CAPS**



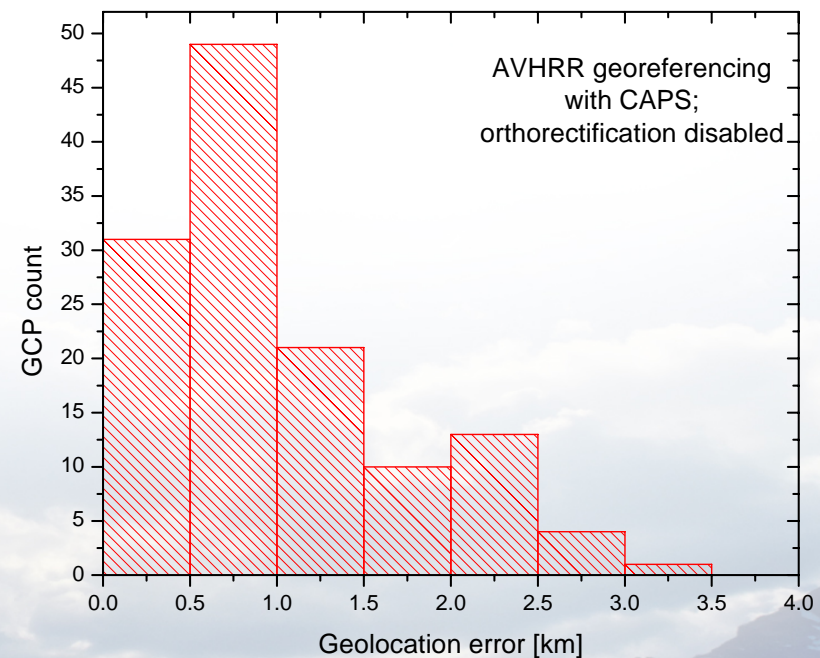
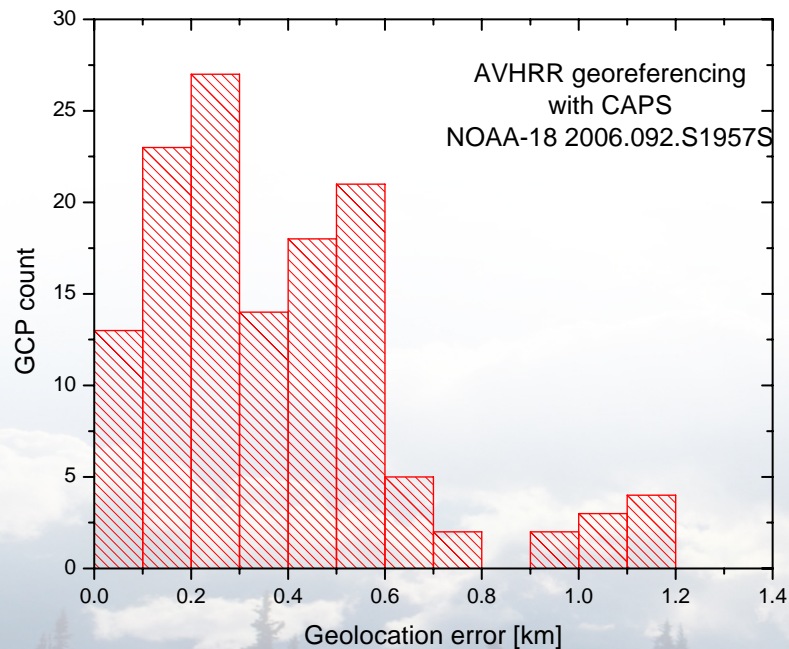
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## AVHRR georeferencing with CAPS (complex winter scene)



Geolocation error is calculated by comparison the reprojected AVHRR scene with MODIS reference (composite) image in LCC projection.  
Comparison is performed by chip matching.  
Here, the MODIS composite for April 01-10, 2006 was used.



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## CCRS plans wrt AVHRR geolocation

- Complete automation and reading all historical HRPT formats by the end of March/2008
- Input formats: NOAA CLASS (SAA) and CCRS NOAA-AVHRR Transcription and Archive System (NATAS) format – modified HRPT;
- Start re-processing entire AVHRR archive 1982-2007
  - Geolocation files **AVHRR-GEO** with lat, lon, elevation for each pixel, orbital parameters and attitude angle corrections will be generated for each scene (swath HRPT) in our historical archive over Canada (similar to **MOD03**)
  - Planning to start re-processing in April/2008 and finish it in ~ 6months
- Data can (will) be made available to all interested parties



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## Absolute radiometric calibration and consistency

- We have produced some updated calibration coefficients for AVHRR ch1&2 NOAA-6 to 14 calibration using Tropical Deep-Convective Cloud statistics from MODIS and VIRS/TRMM (as reported at previous CEOS WGCV meeting in UK);
- CCRS is interested in collaboration to achieve consensus calibration of all historical AVHRR optical channels (collaboration with NASA, workshop on AVHRR calibration);
- Consolidation of solar constants and spectral adjustment/correction factors for all AVHRR sensors and reference sensors used for intercalibration is required.



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# Spectral correction



- Spectral response function (SRF) differences
  - impact on calibration
  - impact on reflectance and land products
- SRF impact for AVHRR/N-6 to AVHRR/N-16 and MODIS was discussed in Trishchenko et al., RSE 2002
- We have just completed computations for AVHRR/N-16,17,18, METOP



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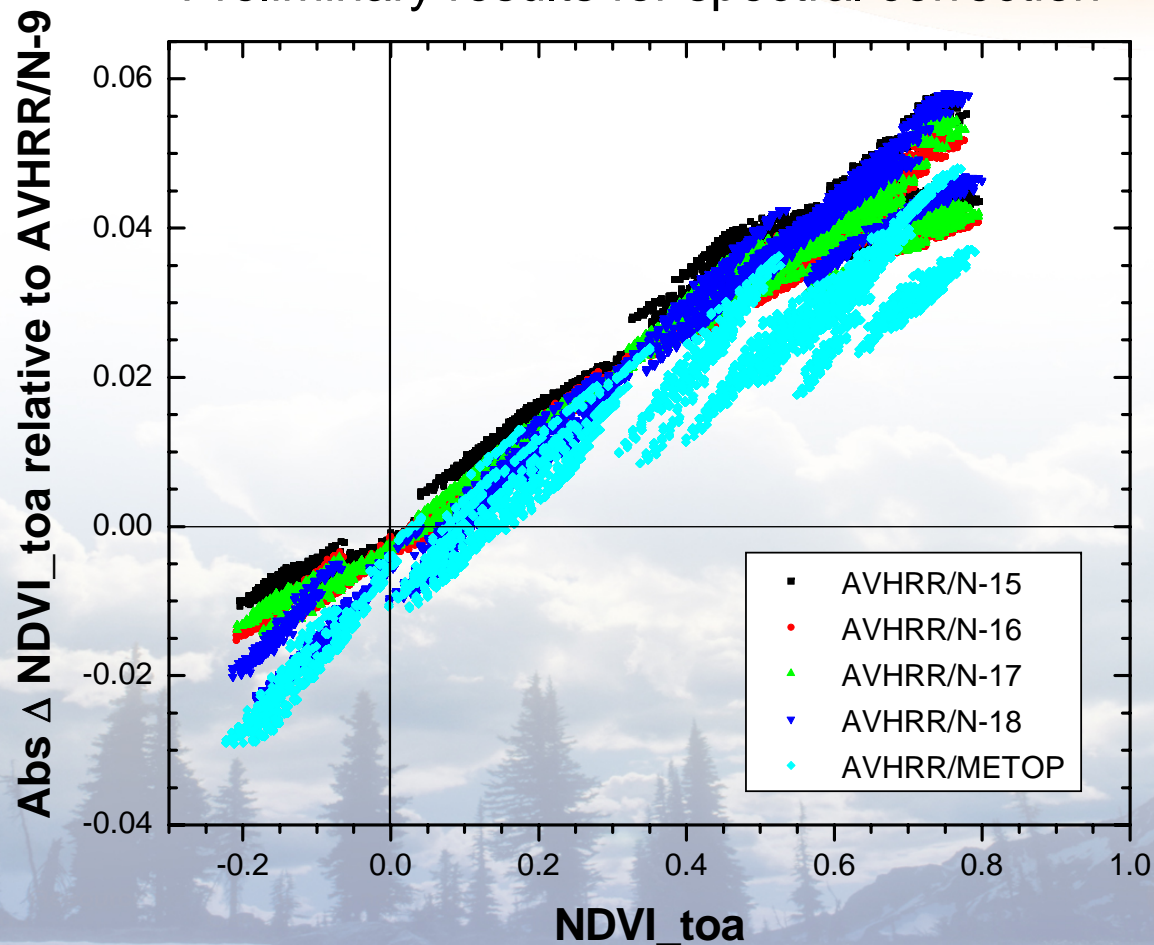
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# Spectral correction for NDVI AVHRR/ NOAA-15,16,17,18,METOP relative to NOAA-9

Preliminary results for spectral correction



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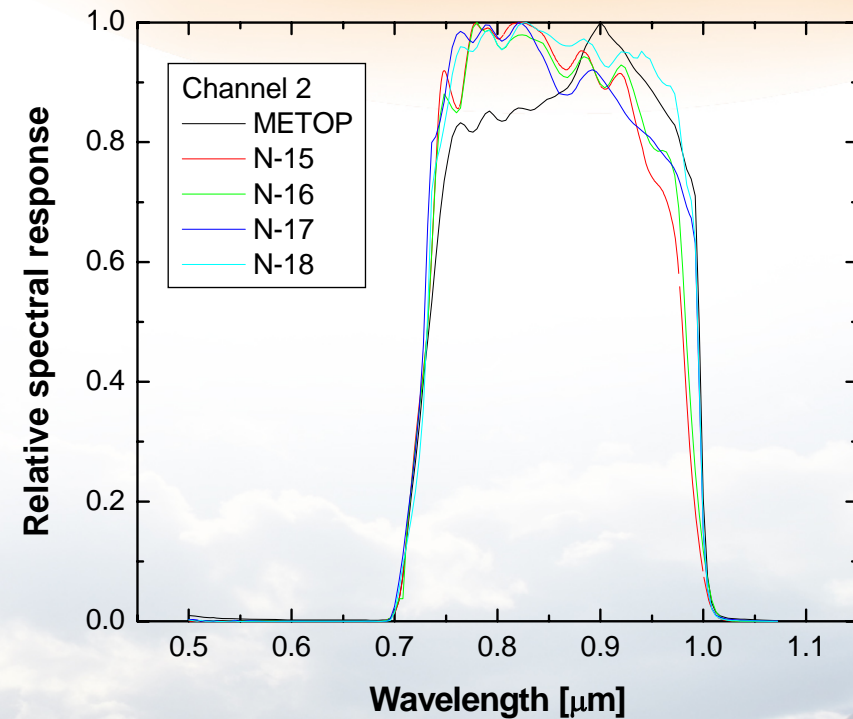
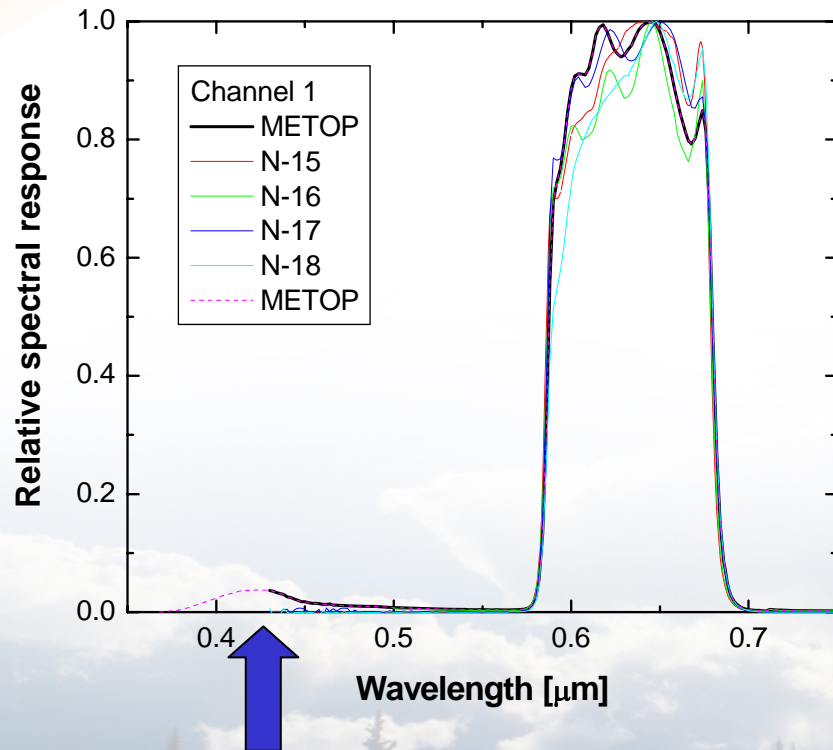
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## Spectral response functions for recent AVHRRs



Significant spectral leak in the blue region for AVHRR/METOP ch.1.





## Conclusions

- CEOS recommendations serve as basis and guidance for our work on generating Satellite CDR at CCRS over Canada;
- CCRS is working to generate AVHRR-GEO files with sub-pixel geolocation accuracy (including ortho-rectification) from 1982 to the present;
- Spectral adjustments/corrections for Ch1&2 have been determined for entire AVHRR record from NOAA-6 to NOAA-18 & METOP
- Looking for collaboration to achieve consensus radiometric calibration of all historical AVHRR sensors and complete AVHRR/FCDR within next 6-12 months over Canada region.

## Acknowledgements

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