Surface Albedo for ARM over Southern Great Planes (SGP) area from ground and satellite observations

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Outline

ARM SGP area

SGP area and land cover

Satellite data

Merging MODIS, VGT/SPOT, AVHRR/NOAA –

1995-2004 - 10years of multispectral BRDF/Albedo product

1km –10 day intervals

Ground network and spectral albedo field campaigns

Satellite albedo and GCM

ECMWF and MODIS over ARM SGP area

MODIS albedo vs ISCCP albedo

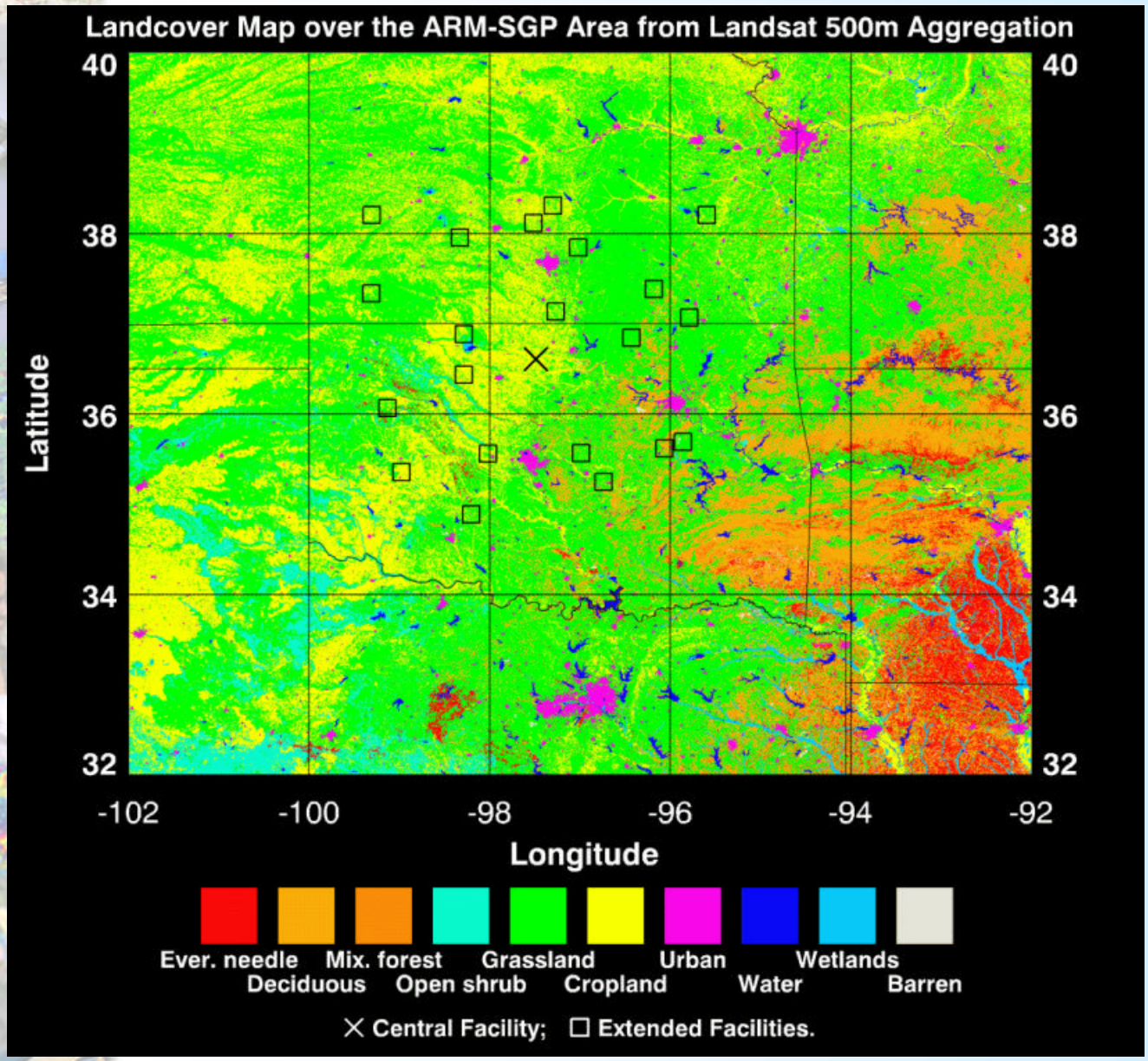
Issues

Validation: Up-scaling/ Down-scaling

BRDF from cross-track sun-synch observations

Need for wide-swath multi-angular sensor

Entire SGP CART area (32N-40N; 102W-92W) ~ 1000x1000km^2



Approach:

- 10-day intervals
- 1km x 1km for historical (pre-MODIS) period and 500m for MODIS period
- Spatially and temporally complete (no gaps)
- Linear kernel-driven bi-directional reflectance distribution function BRDF
- BRDF parameters for each pixel
- Combining multi-satellite observations

Major results:

- Satellite Albedo/BRDF from MODIS Terra&Aqua were generated @ 500m spatial resolution and 10-day intervals 03/2000- 2004. No gaps: Space-time landcover based interpolation technique has been developed to fill missing data

- Satellite Albedo/BRDF product from VEGETATION/SPOT was generated 04/1998 – 2004: @1km, 10-day intervals; No gaps.

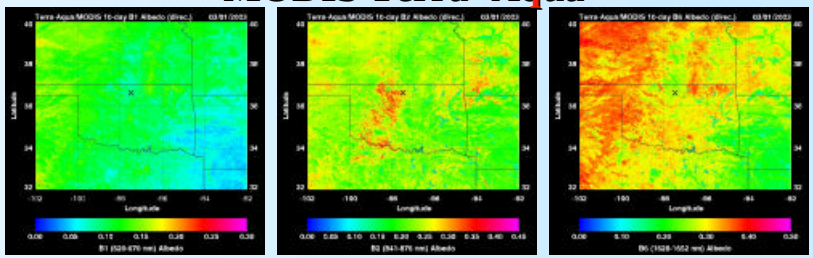
- AVHRR Albedo/BRDF product was generated 02/1995 – 2000: @1km, 10-day intervals; No gaps

- Landcover map produced at 500m spatial resolution over the ARM SGP CART area;

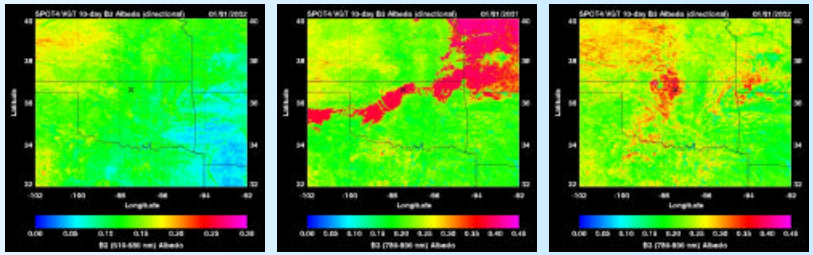
- Some validation has been conducted using Landsat, MISR, POLDER, aircraft and ground observations.

- Data have been transferred to ARM archive and also available from CCRS ftp site **ftp://ftp.ccrs.nrcan.gc.ca/ad/CCRS_ARM**

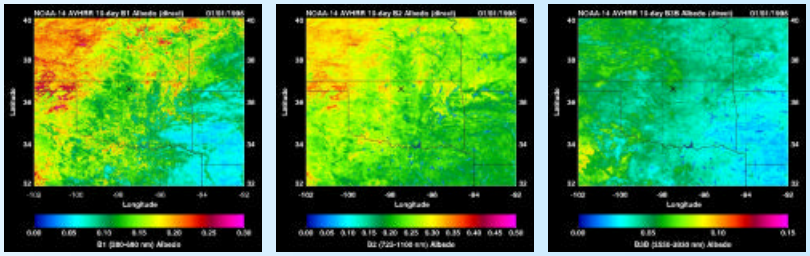
MODIS Terra+Aqua



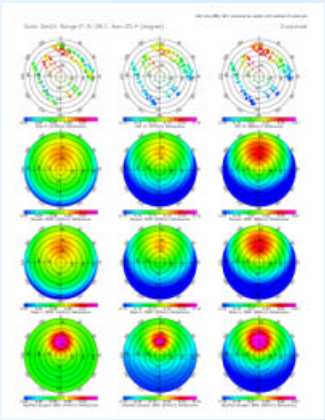
VGT/SPOT4&5

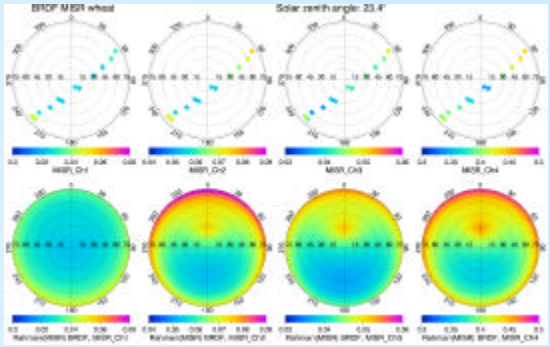


AVHRR/NOAA-14

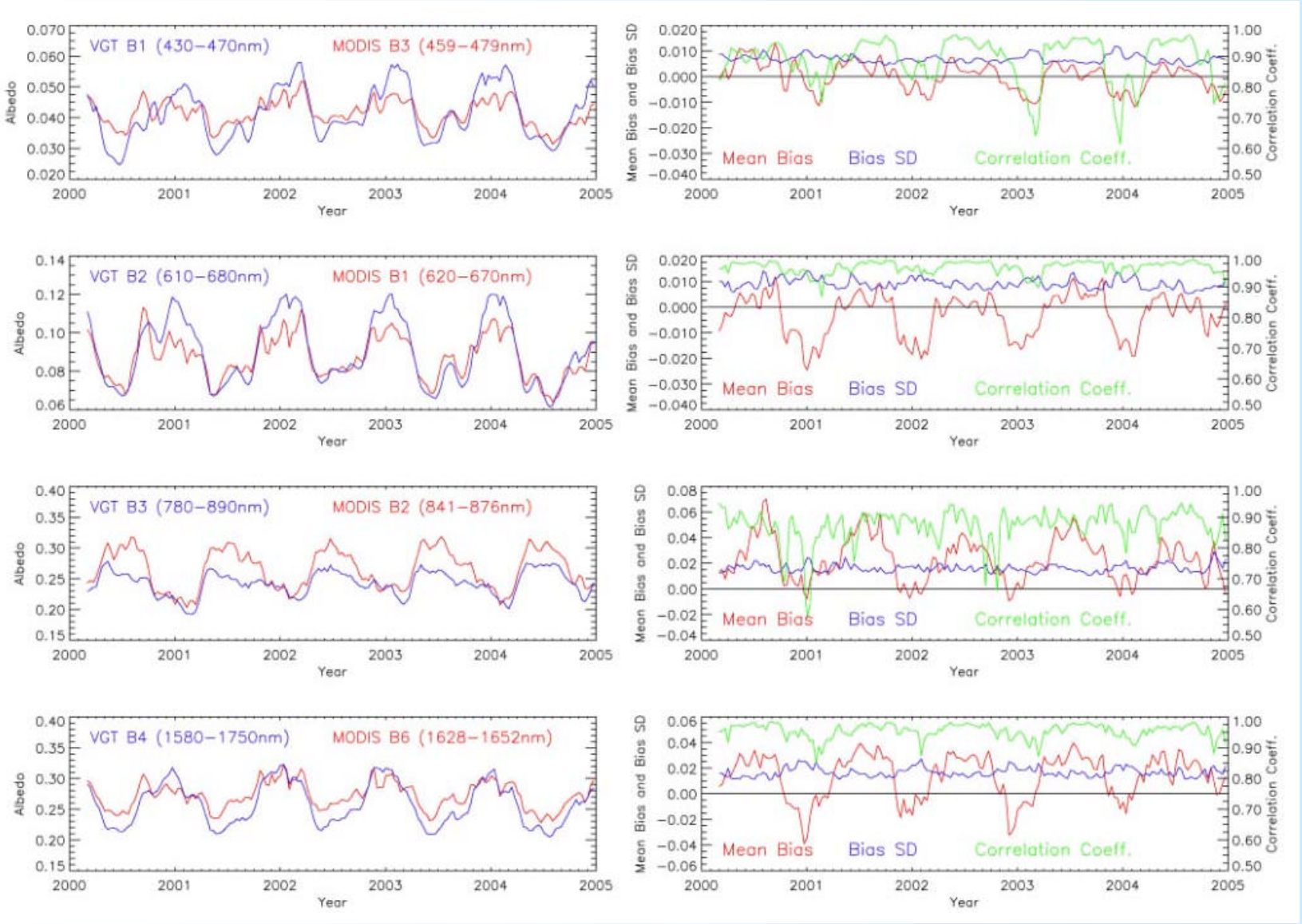


Validation





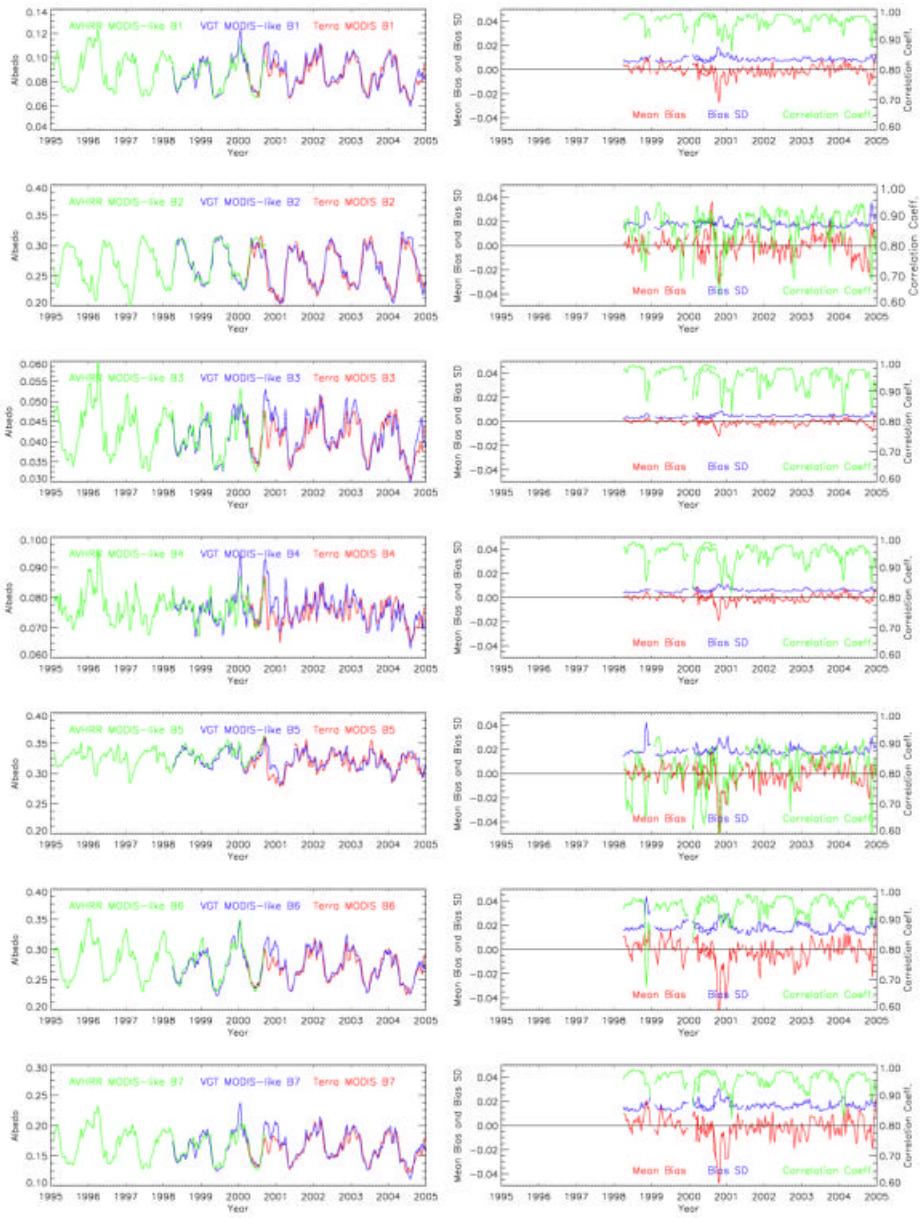
VGT vs MODIS

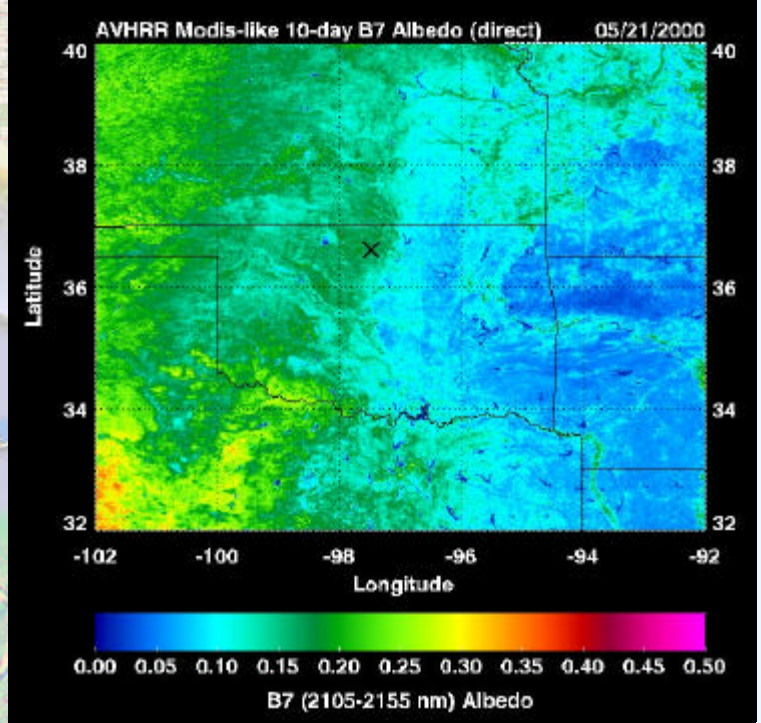

VGT B1 (430–470nm)
MODIS B3 (459–479nm)
VGT B2 (610–680nm)
MODIS B1 (620–670nm)
VGT B3 (780–890nm)
MODIS B2 (841–876nm)
VGT B4 (1580–1750nm)
MODIS B6 (1628–1652nm)
Albedo
Year
Mean Bias and Bias SD
Correlation Coeff.
Mean Bias
Bias SD
Correlation Coeff.

MODIS as anchor dataset

- Assuming that MODIS calibration and atmospheric correction is superior to all other sensors
  - Used MODIS and anchor instrument
  - Tuned VGT and AVHRR to MODIS
  - Generated MODIS-like channels (non existing) using regression based on available channels, landcover map and NDVI on monthly basis

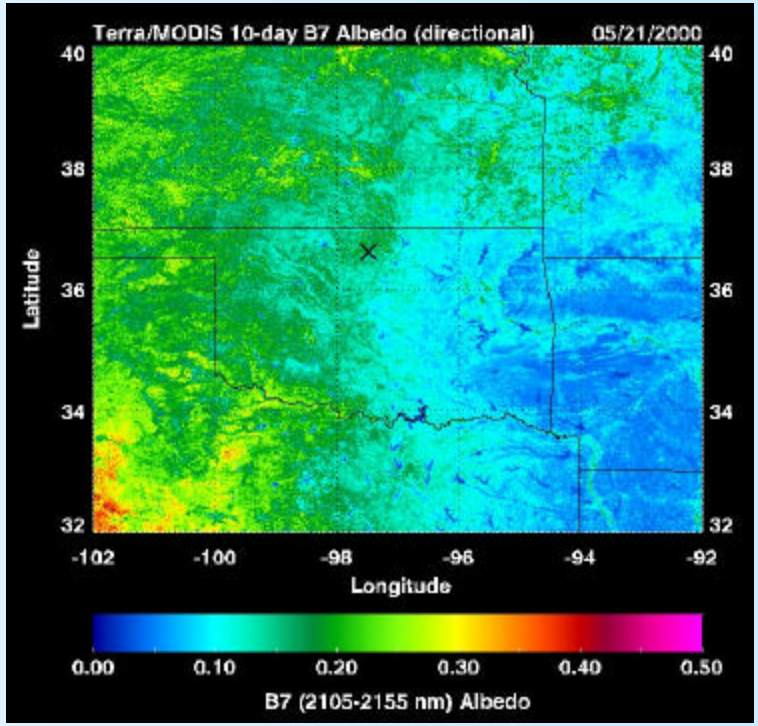
MODIS-like AVHRR&VGT-based albedo

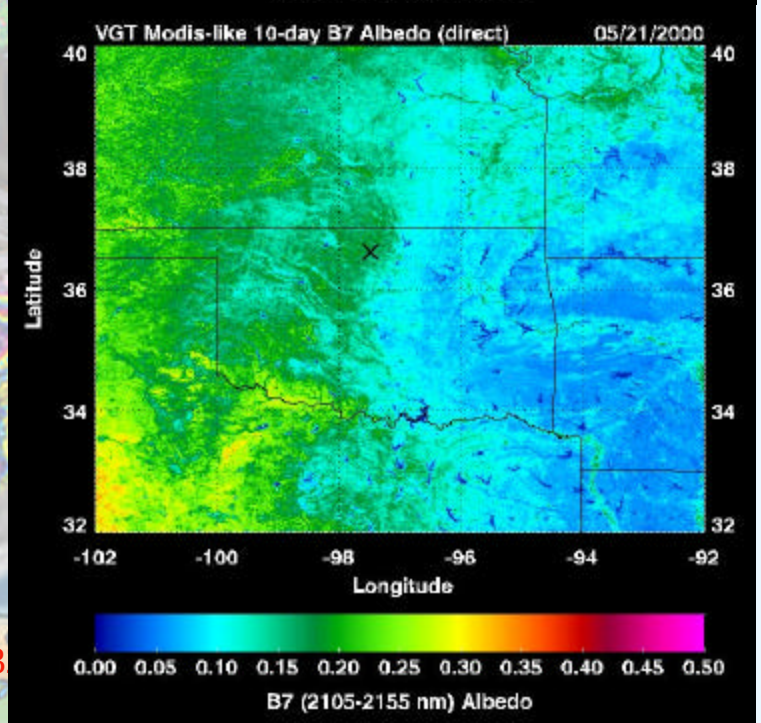




MODIS-like AVHRR ch.7

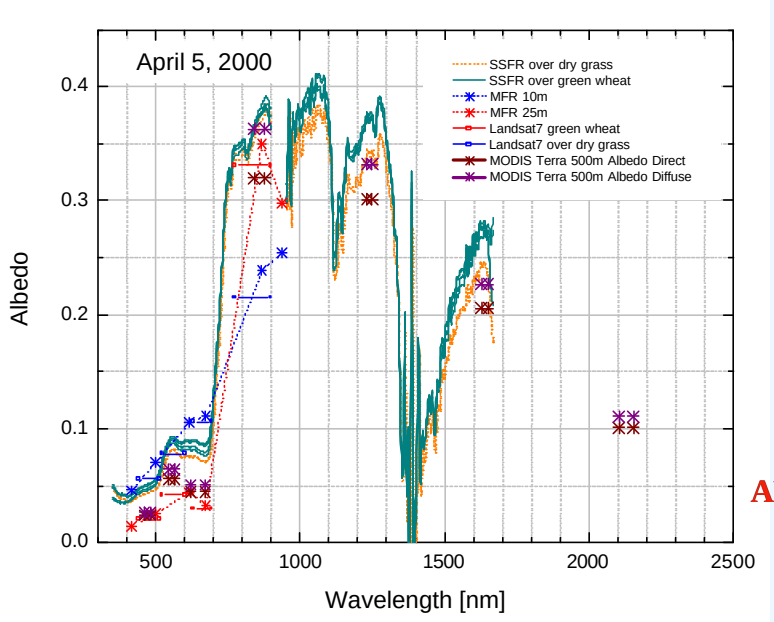
MODIS ch.7





MODIS-like VGT ch.7

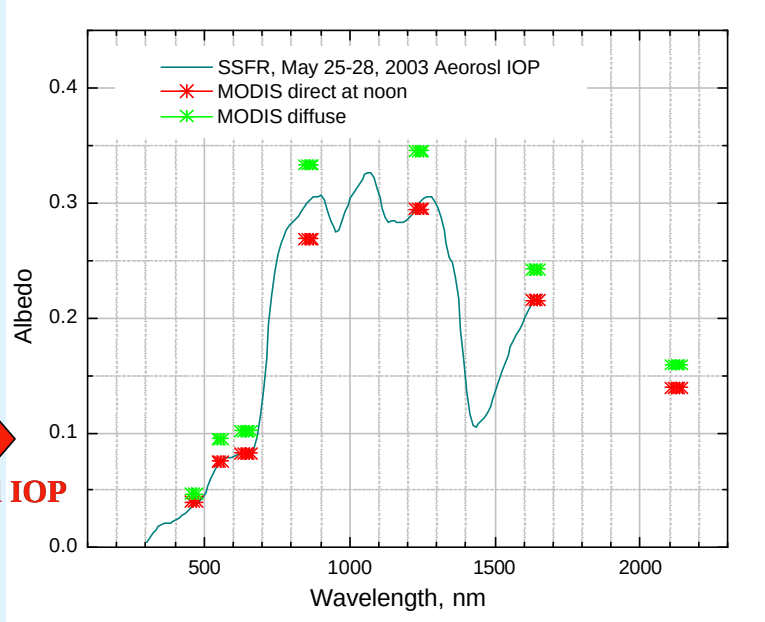
Validation against independent observations

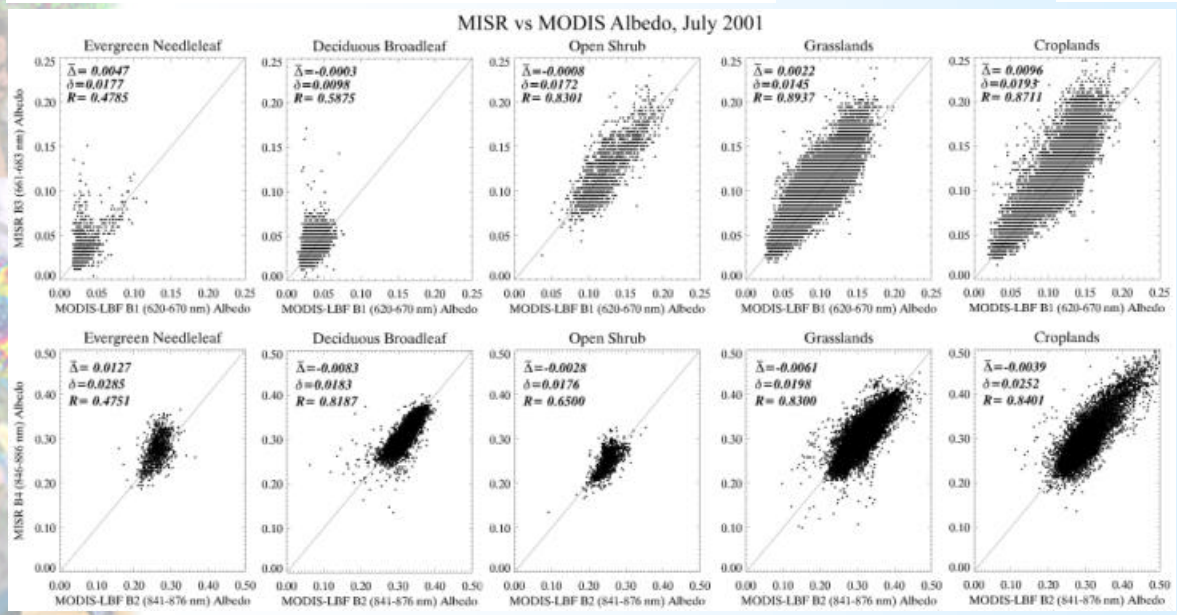


MODIS
SSFR aircraft
Ground obs
Landsat ETM+

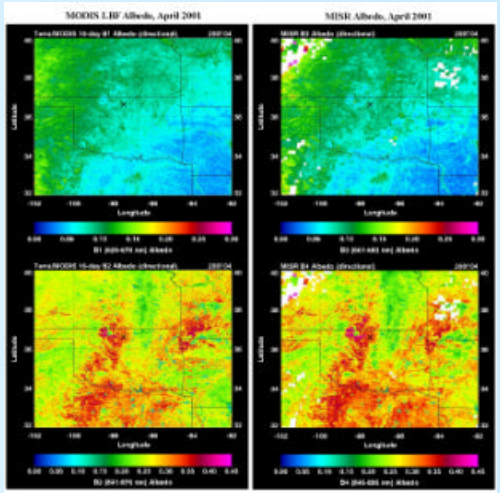
ARESE-II

Aerosol IOP 2003

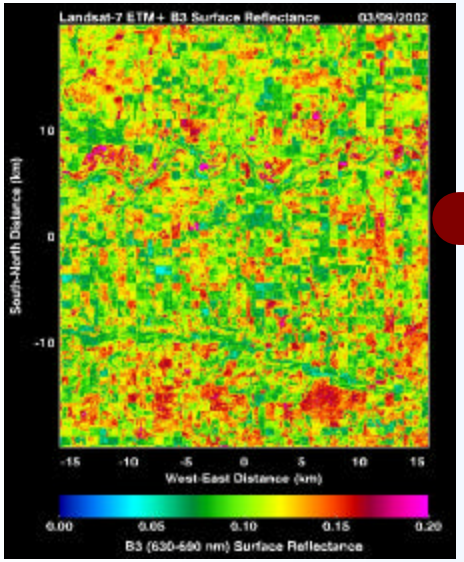




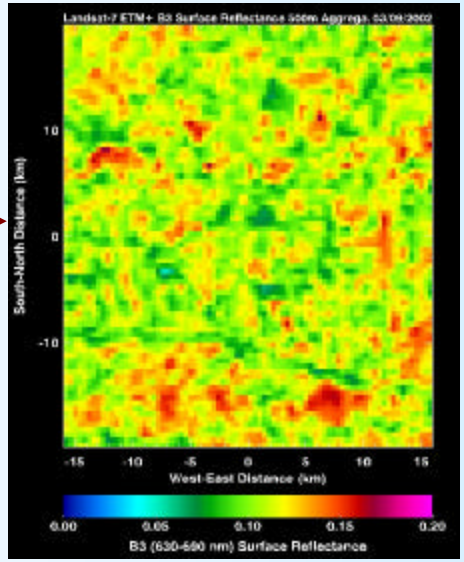
MODIS and MISR



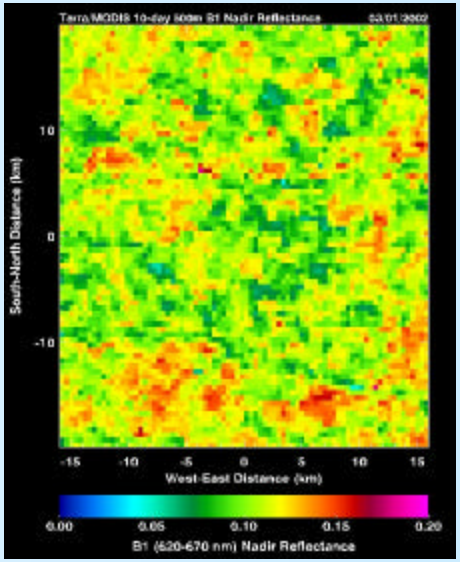
Landsat-7 Surface Reflectance 30-m Pixel

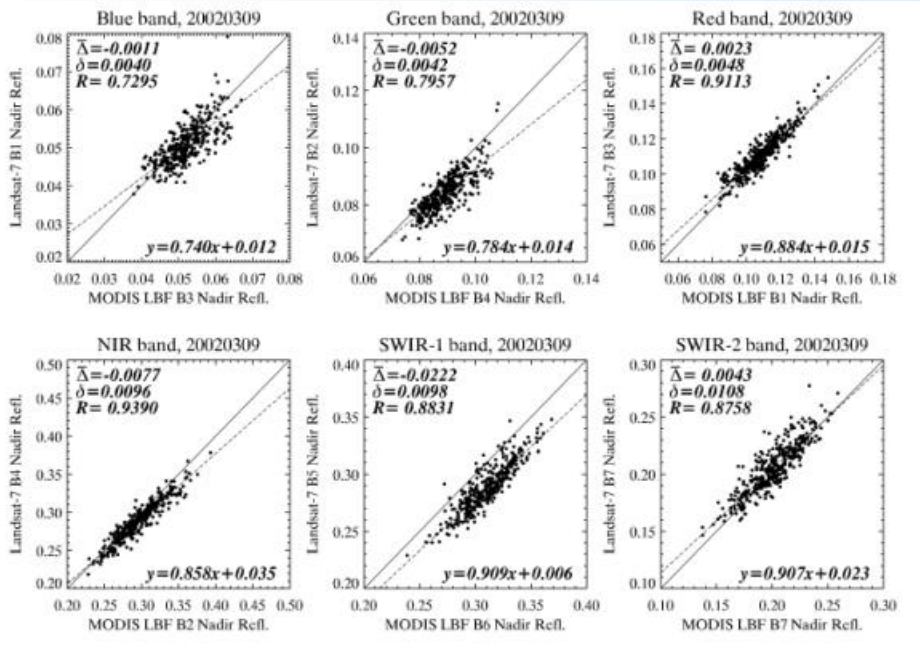


Landsat-7 Surface Reflectance 500-m Aggregation



MODIS Surface Reflectance 500-m Pixel





MODIS and Landsat

Ground observations

- Regular albedo are collected at CF and EF from BB and MFRSR spectral observations. ?? How representative these data to validate satellite products ??
- We also conducted 4 surface albedo IOP
  - August 2002
  - May 2003 (as part of ARM Aerosol IOP)
  - February 2004 (snow and snow-free conditions)
  - October 2004
- Data are available from ARM IOP archive and

ftp://ftp.ccrs.nrcan.gc.ca/ad/CCRS_ARM

Surface Albedo IOPs

Ground observations of
BRDF and Hemispherical Albedo
Several hundred spectra for various targets in ARM IOP archive

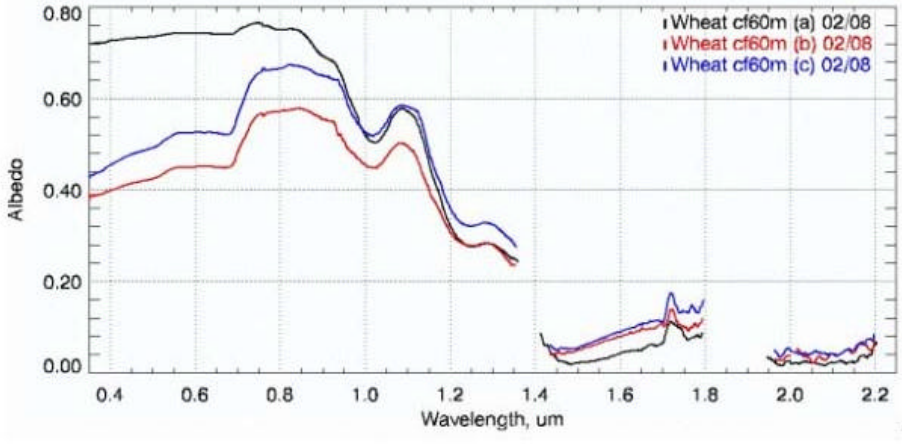


Fig.-6. ° Spectra·observed·for·wheat·covered·with·snow.¶

Fig.-7. ° Wheat·field·near·CF60m,·a.m.¶

Fig.-8. ° Wheat·field·near·CF60m,·p.m.¶

¶

Spectra·obtained·for·wheat·field·near·CF60m·are·shown·in·Fig.·6.·Corresponding·surface·conditions·are·shown·in·Fig.·7·(morning)·and·Fig.·8·(in·the·afternoon).·It's·seen·that·even·for·fully·snow·covered·vegetation,·NDVI·is·not·equal·to·1·(curve·(a)·in·Fig.·6).¶

Fig.-23 ° Grass·field·near·CF10m.¶

Fig.-24 ° Pasture·field.¶

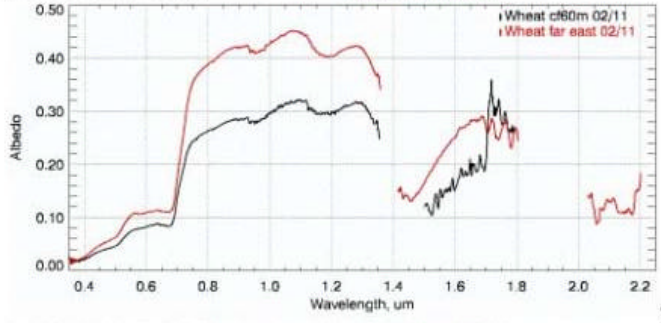


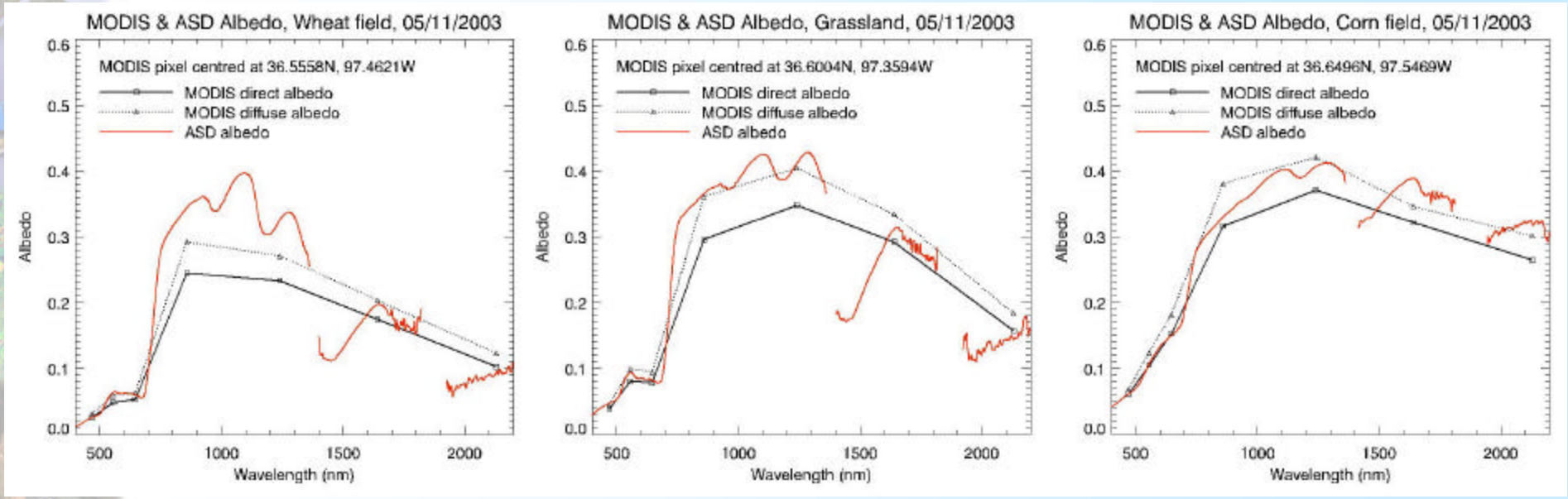
Fig.-25 ° Albedo·spectra·of·wheat·near·CF60m·and·the·wheat·field·far·east·of·CF.¶

5.→Wheat·field·near·60·m·tower·(Fig.·26).·Spectral·albedo·(Fig.·25)·and·PAR·under·overcast·conditions.¶
6.→PAR·and·Spectral·albedo·over·wheat·(far·east·of·CF,·corner·turn·to·Ponca·City)·(Fig.·27).¶
7.→Land·cover·types·distribution·survey·in·the·eastern·part·of·area.¶

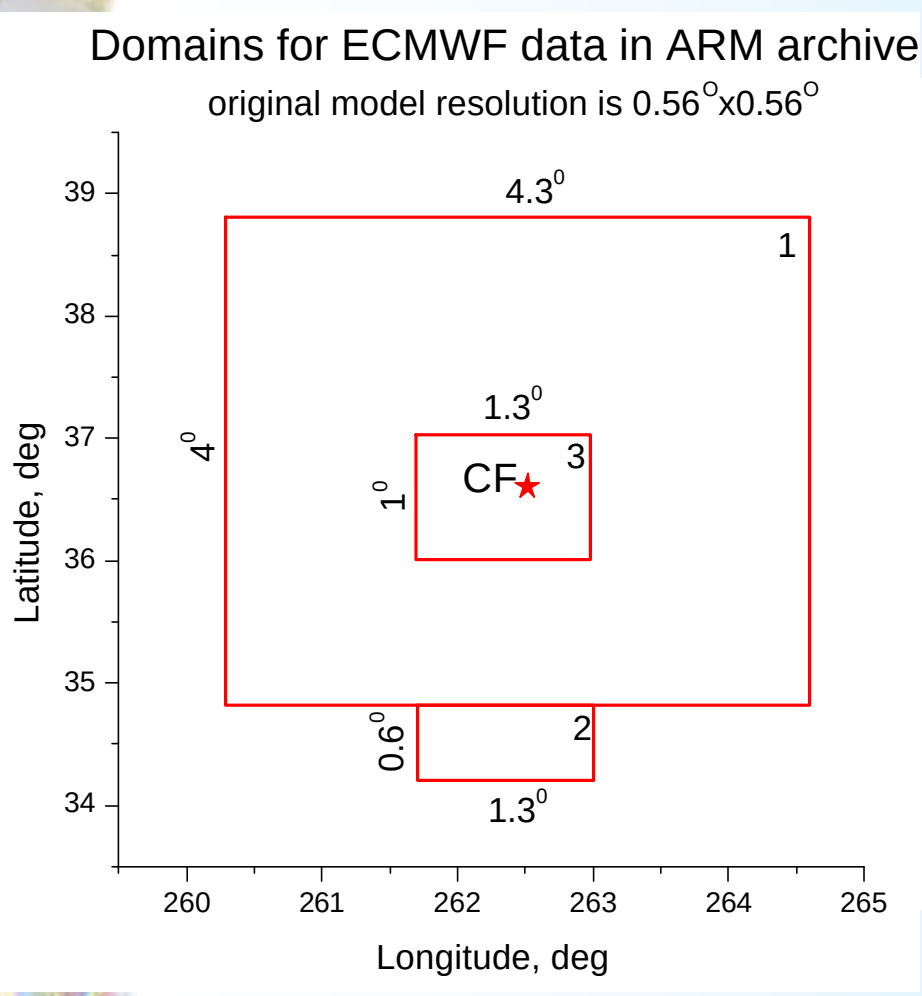
Fig.-26 ° Wheat·field·near·CF60m.¶

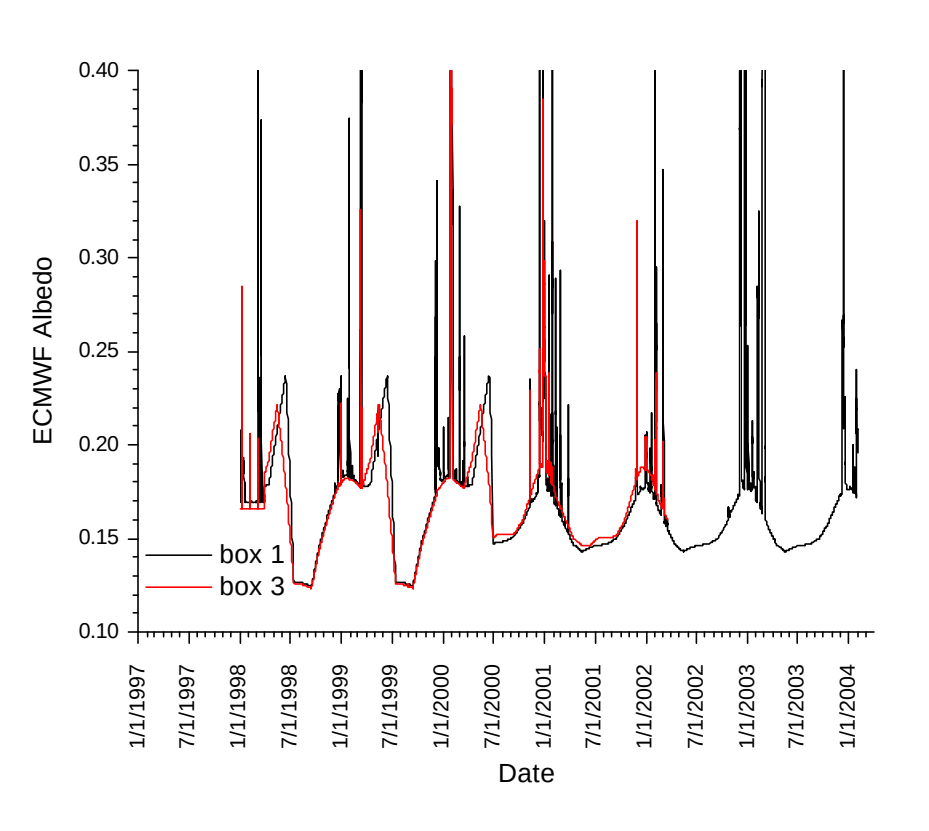
Fig.-27 ° Wheat·field·far·east·of·CF.¶

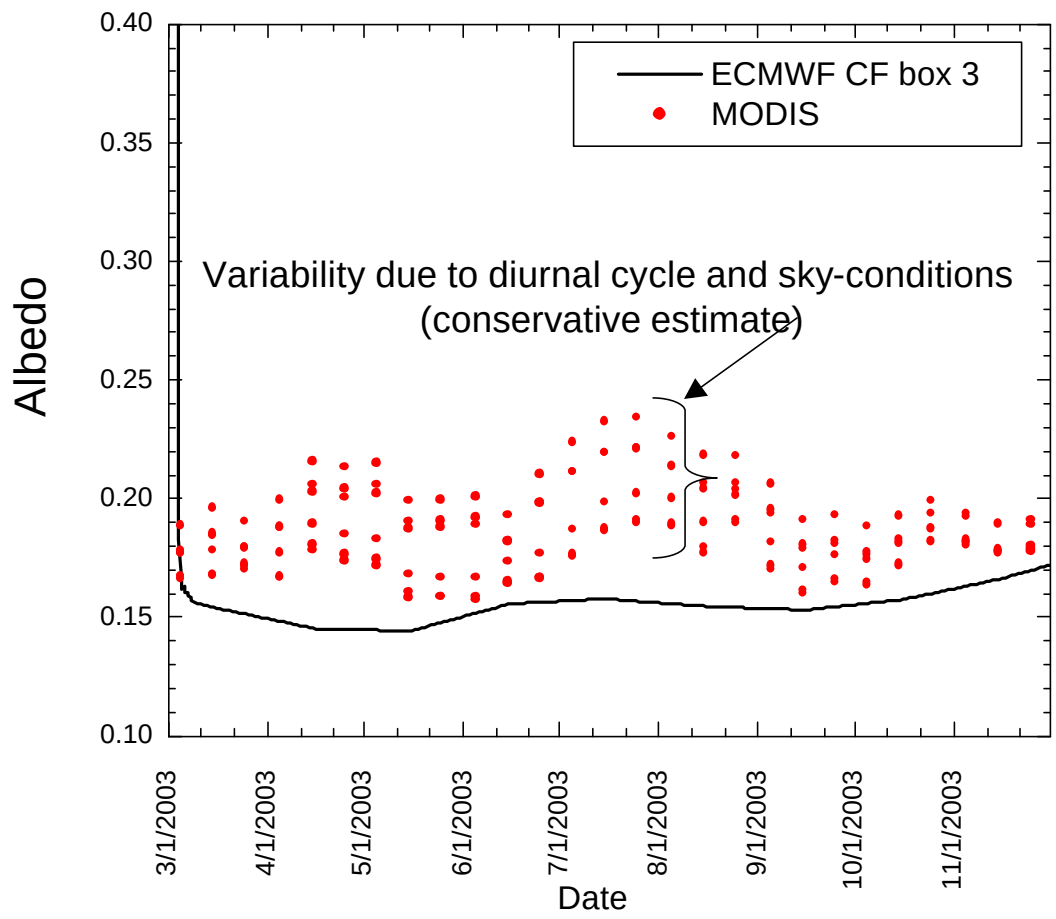
Validation of albedo with ground measurements



ECMWF and MODIS Albedo

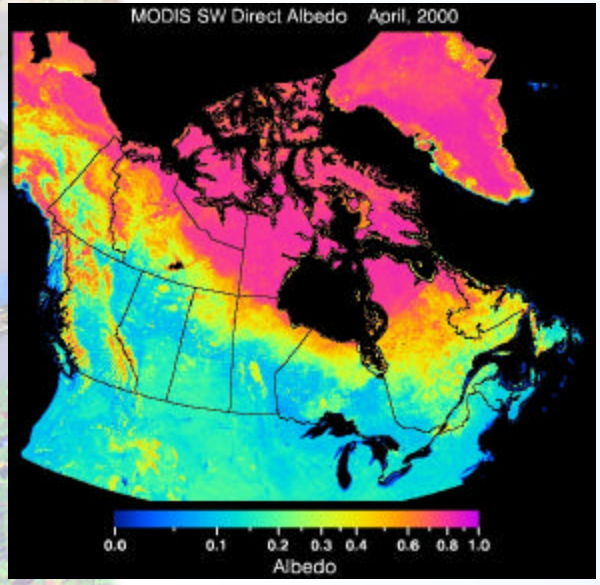




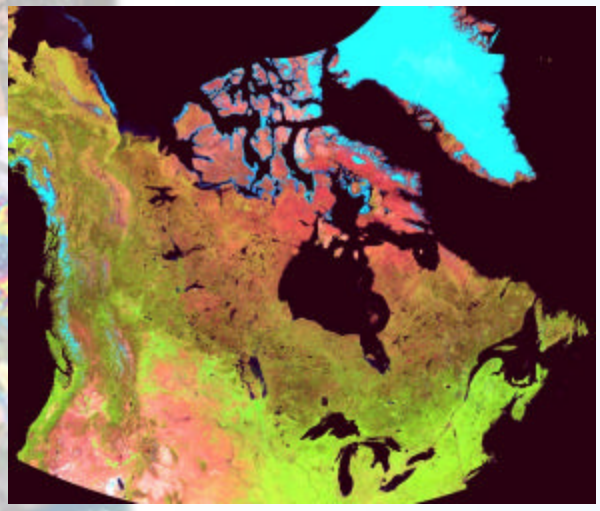


MODIS data (in consistency with ground observations) show diurnal cycle of albedo and variations due to sky-conditions (dir/dif ratio and spectral distribution) unlike the ECMWF results

ISCCP vs MODIS

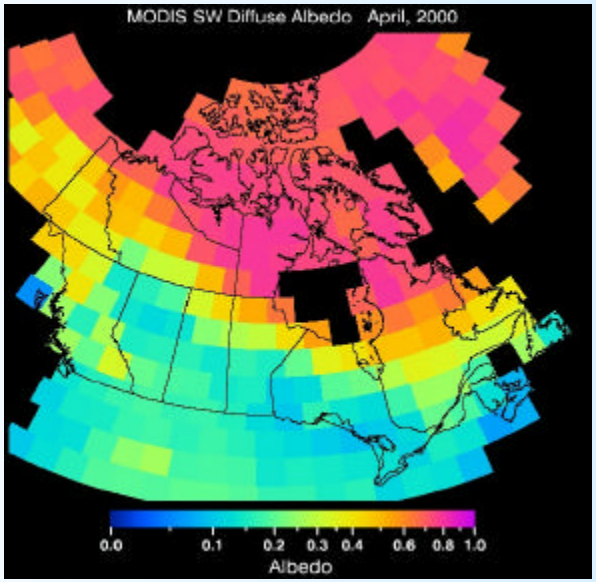


MODIS 1-km resolution

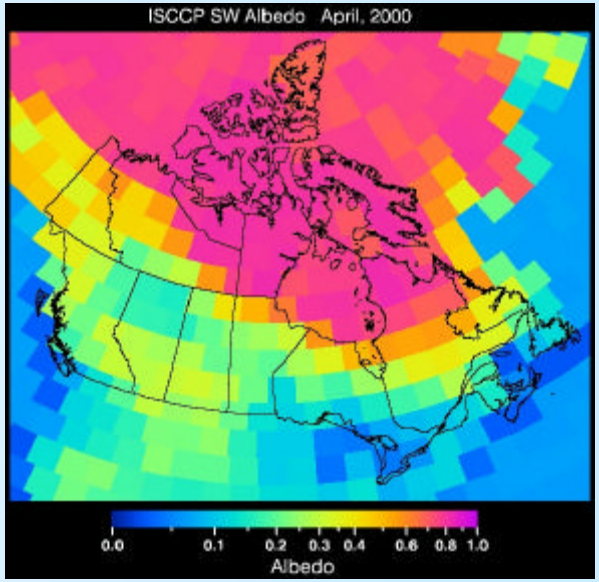


Monthly mean comparison

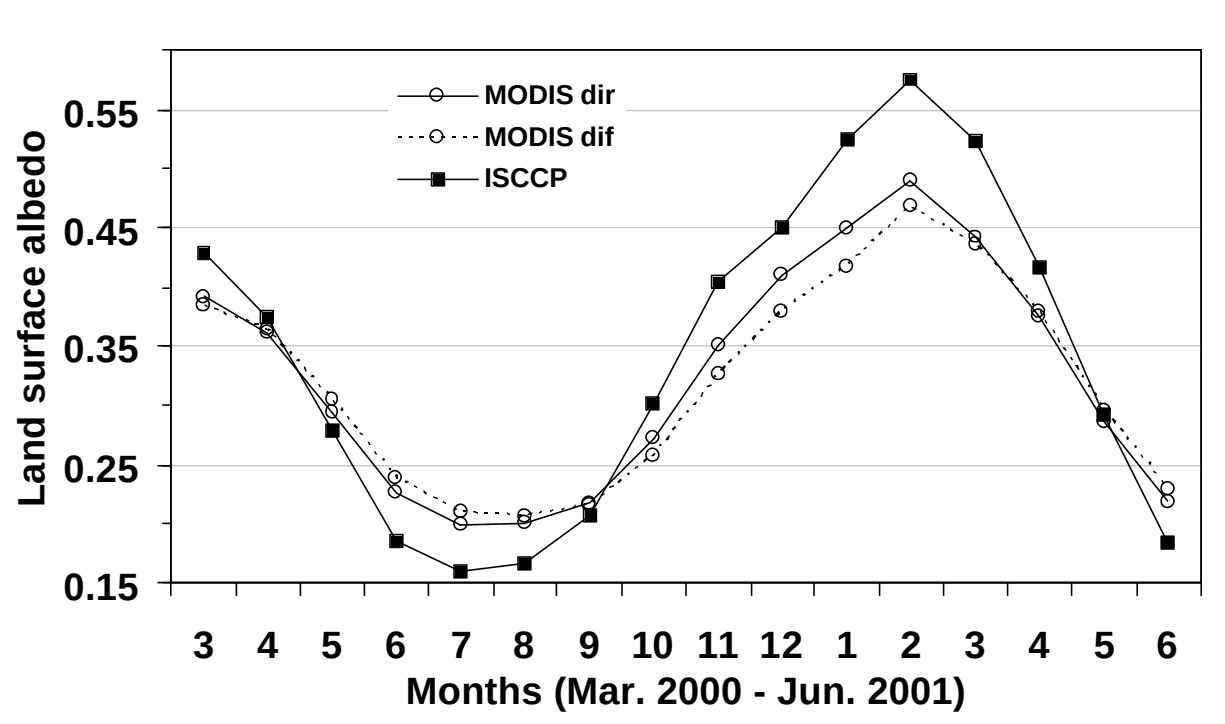
MODIS
Coarse resolution

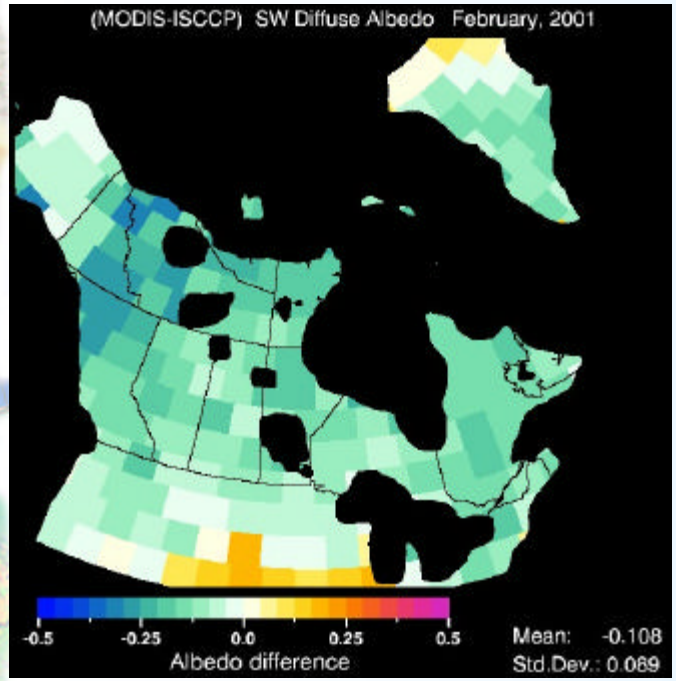


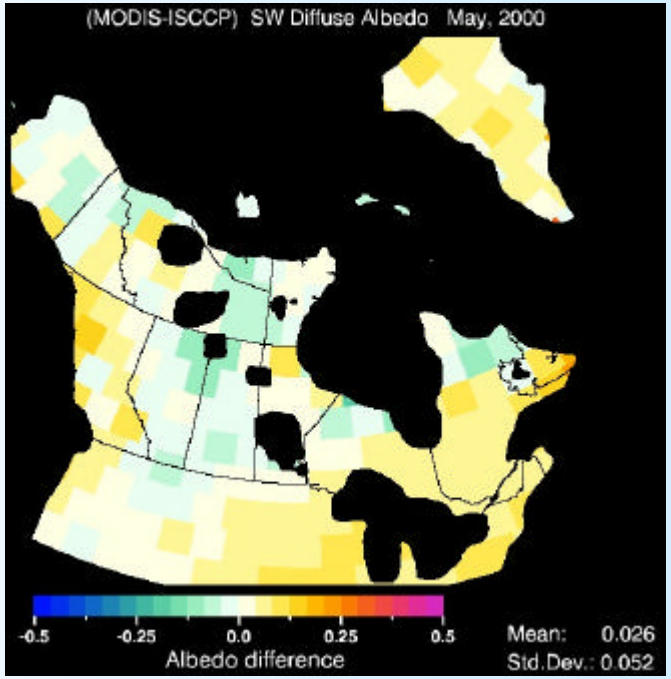
ISCCP

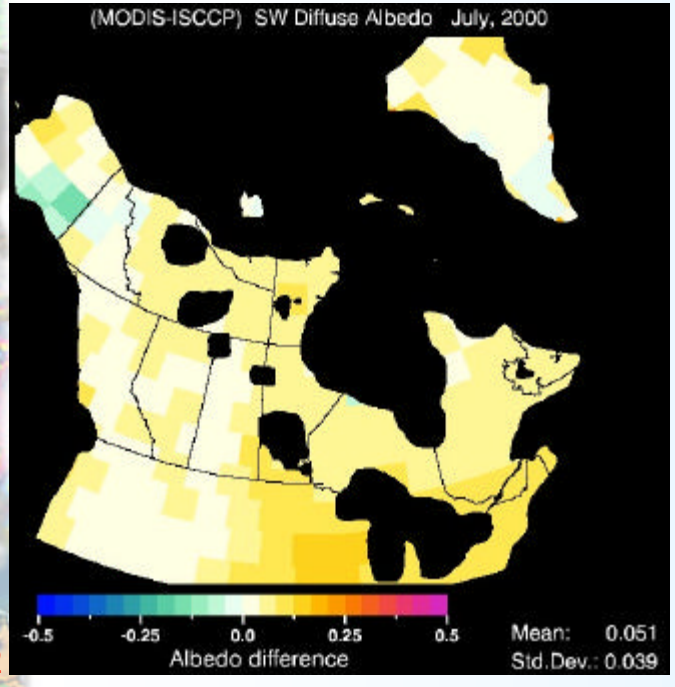


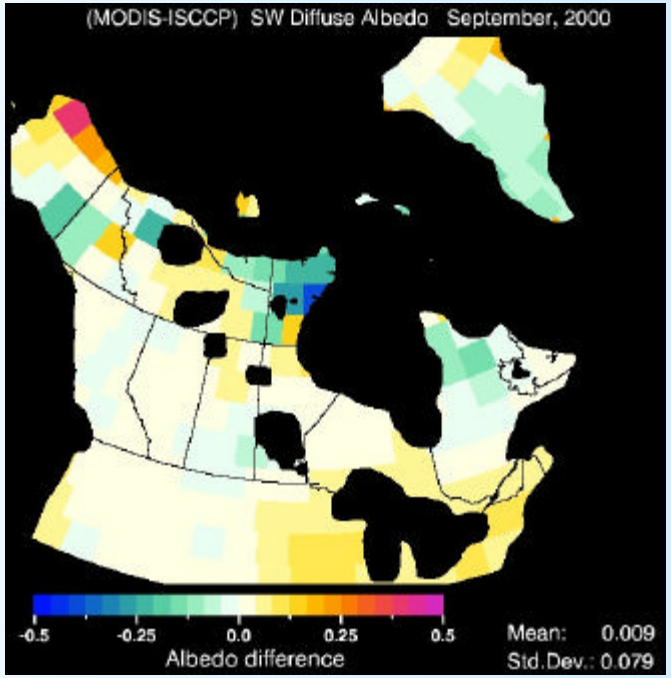
MODIS vs ISCCP




(MODIS-ISCCP) SW Diffuse Albedo February, 2001
-0.5
-0.25
0.0
0.25
0.5
Albedo difference
Mean: -0.108
Std.Dev.: 0.069


(MODIS-ISCCP) SW Diffuse Albedo May, 2000
-0.5
-0.25
0.0
0.25
0.5
Albedo difference
Mean: 0.026
Std.Dev.: 0.052


(MODIS-ISCCP) SW Diffuse Albedo July, 2000
-0.5
-0.25
0.0
0.25
0.5
Albedo difference
Mean: 0.051
Std.Dev.: 0.039


(MODIS-ISCCP) SW Diffuse Albedo September, 2000
-0.5
-0.25
0.0
0.25
0.5
Albedo difference
Mean: 0.009
Std.Dev.: 0.079

MODIS-ISCCP

Issues

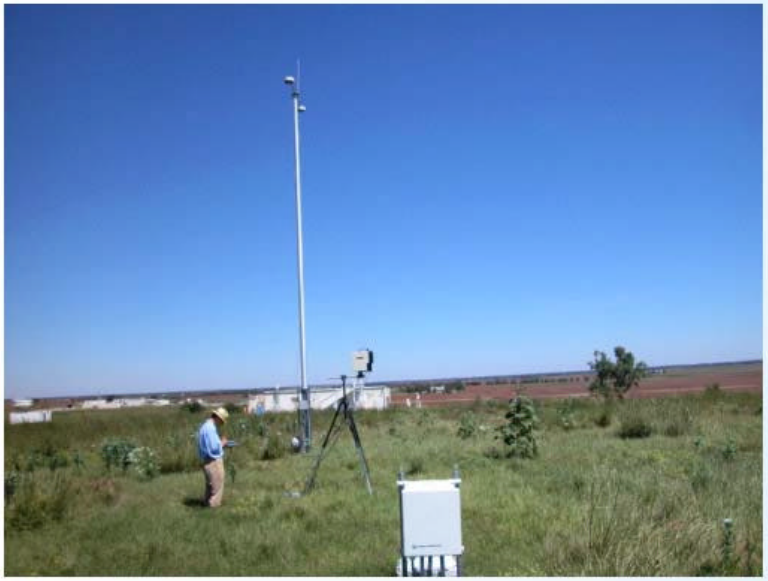
Surface inhomogeneity and validation of satellite products using ground data

Pawhuska EF

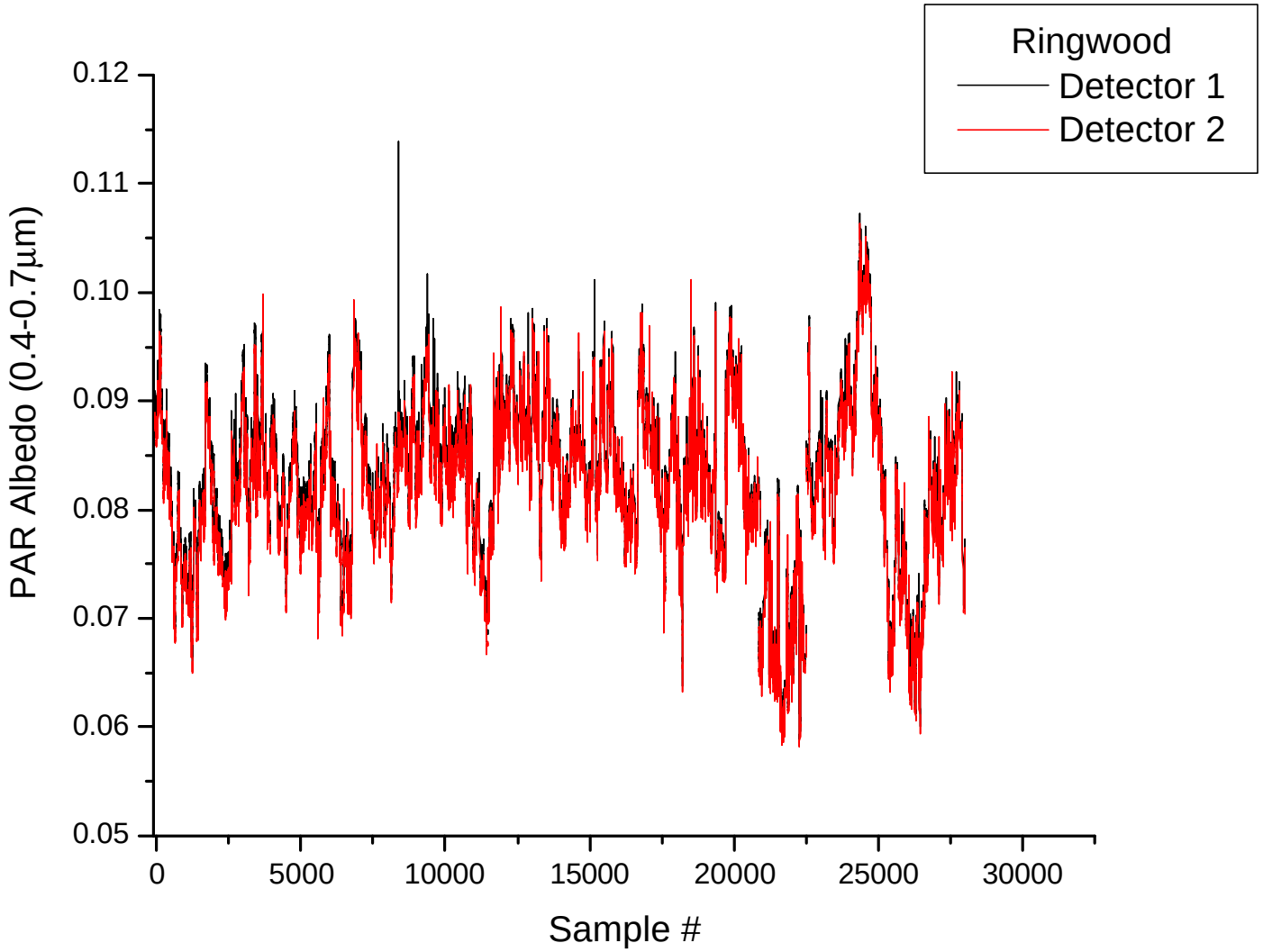
El-Reno EF

Meeker EF

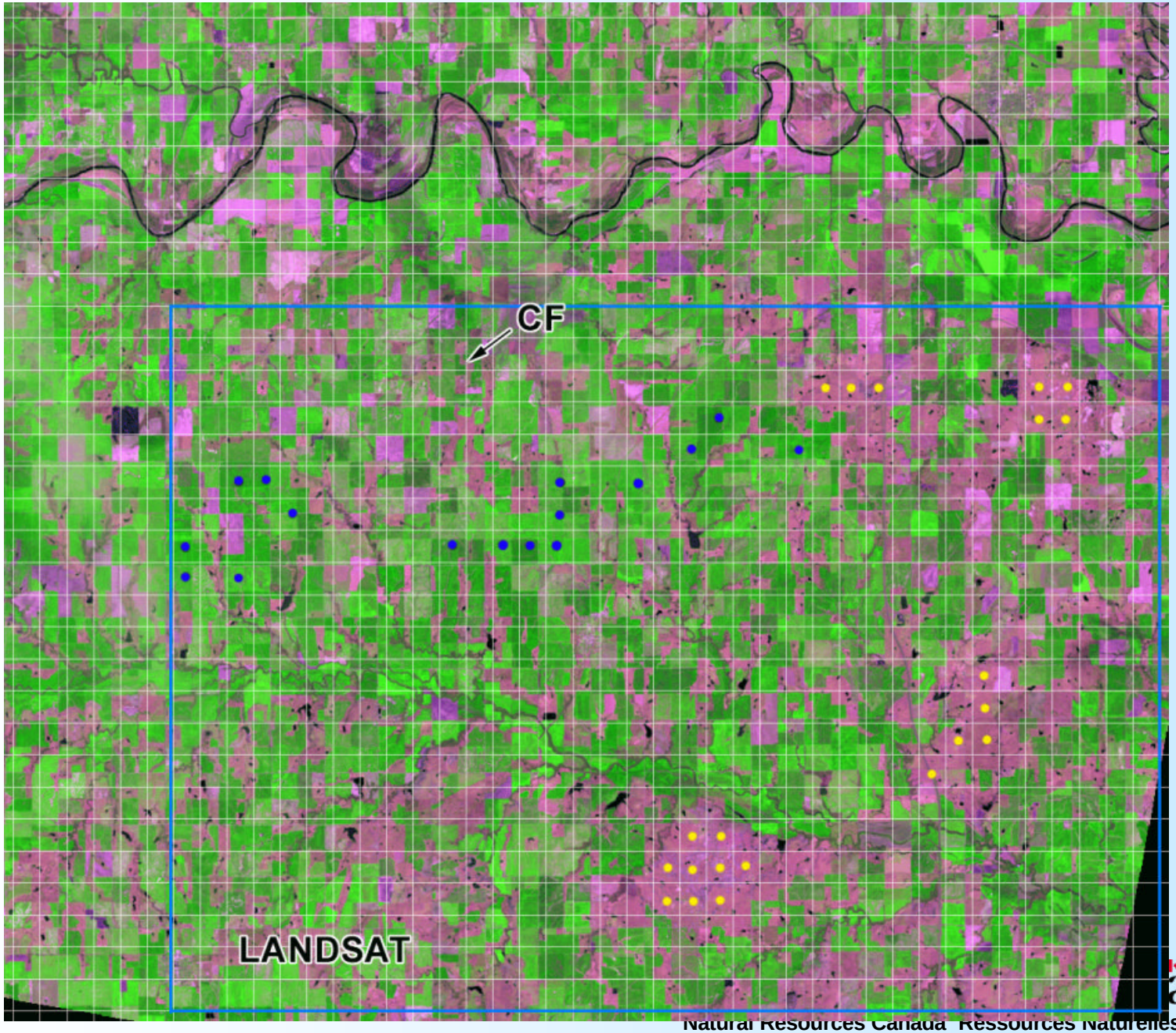
ARM SGP area in August 2002



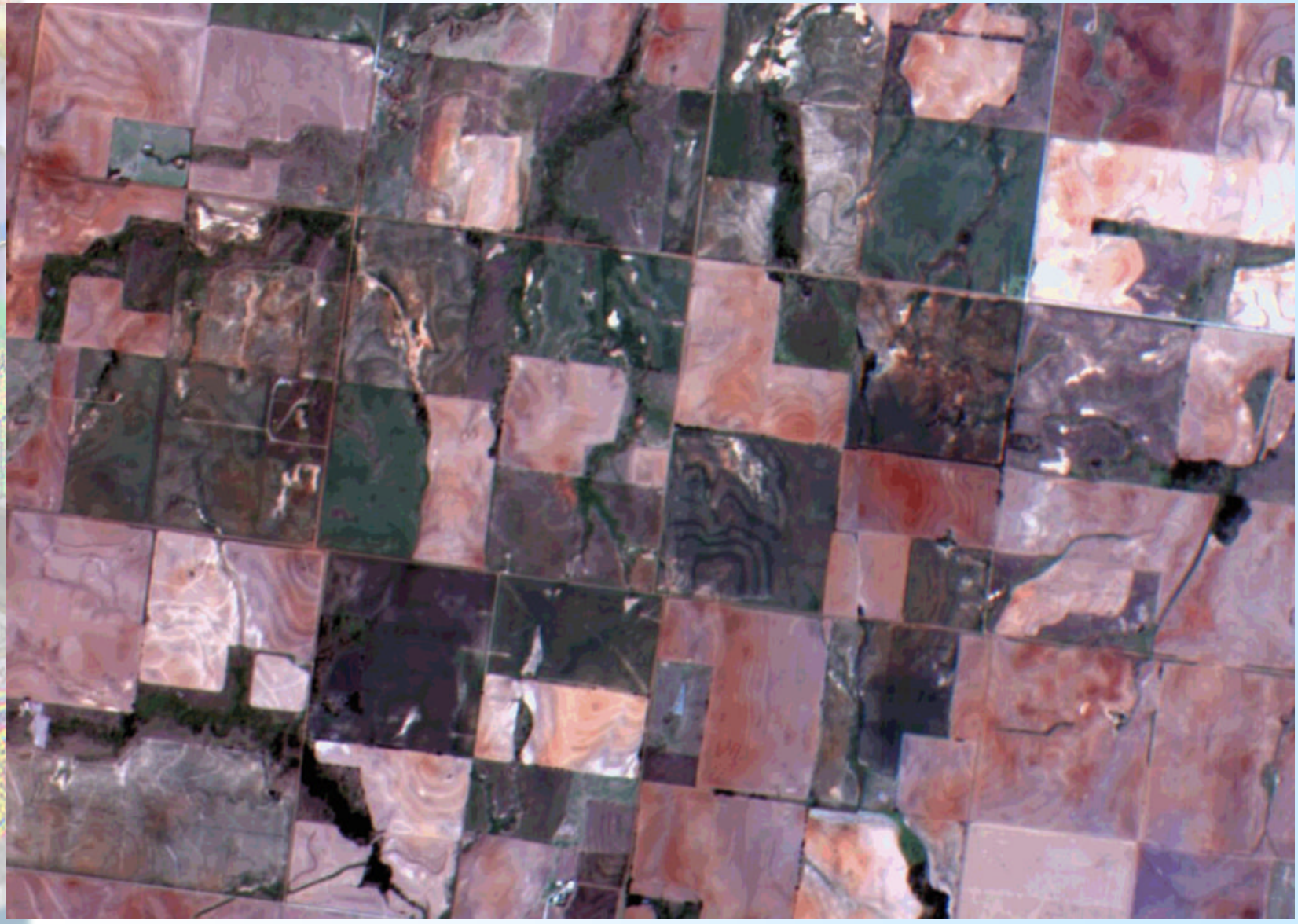
Example of measurements in August 2002 with PAR radiometer TRAC



Surface inhomogeneity from Landsat and MISR images



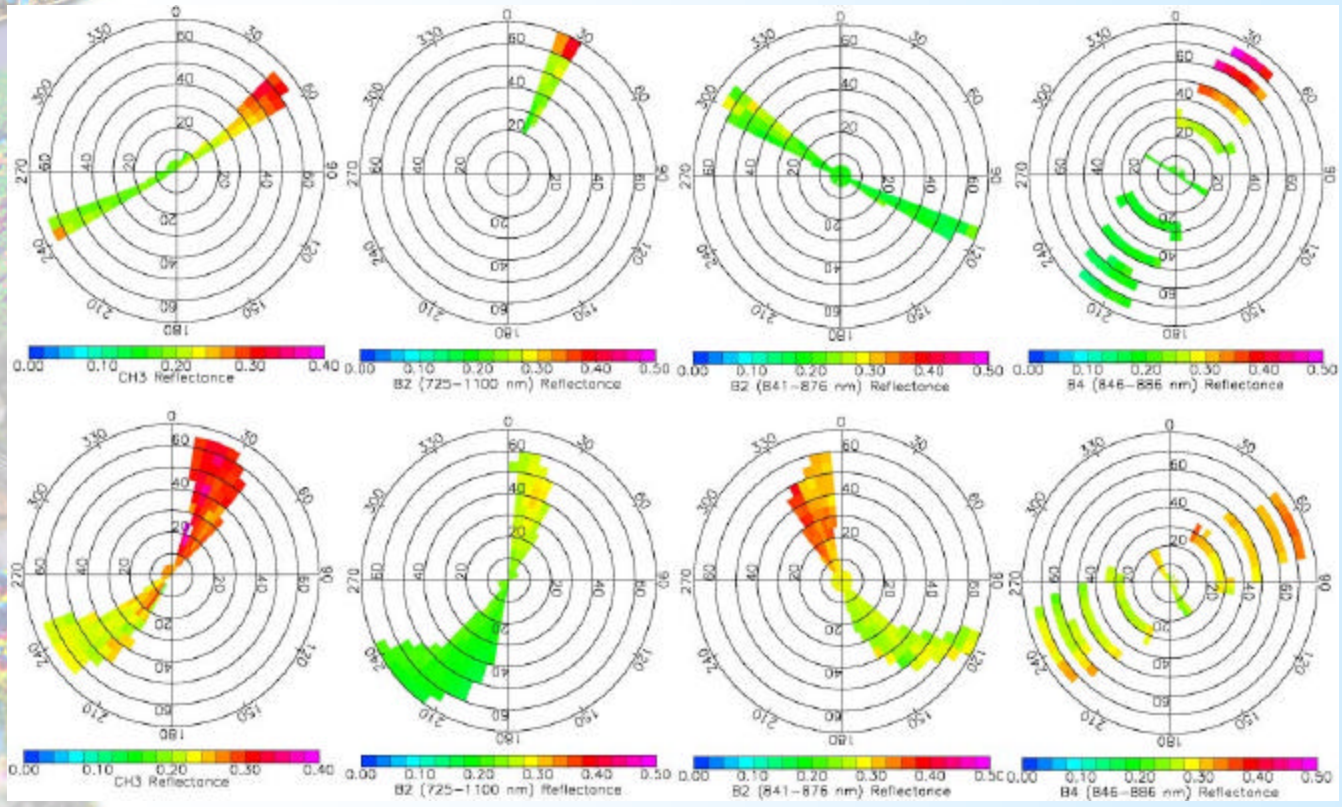
Surface inhomogeneity around ARM SGP CF from MTI



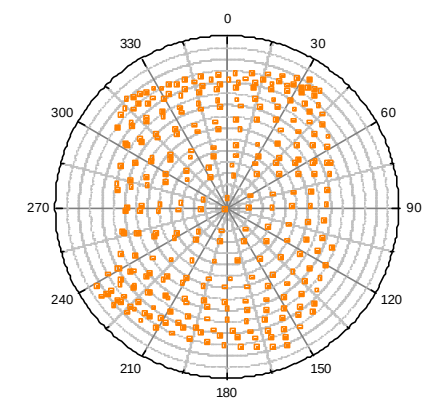
BRDF shape from limited angular sampling

BRDF retrievals are from limited angular sampling

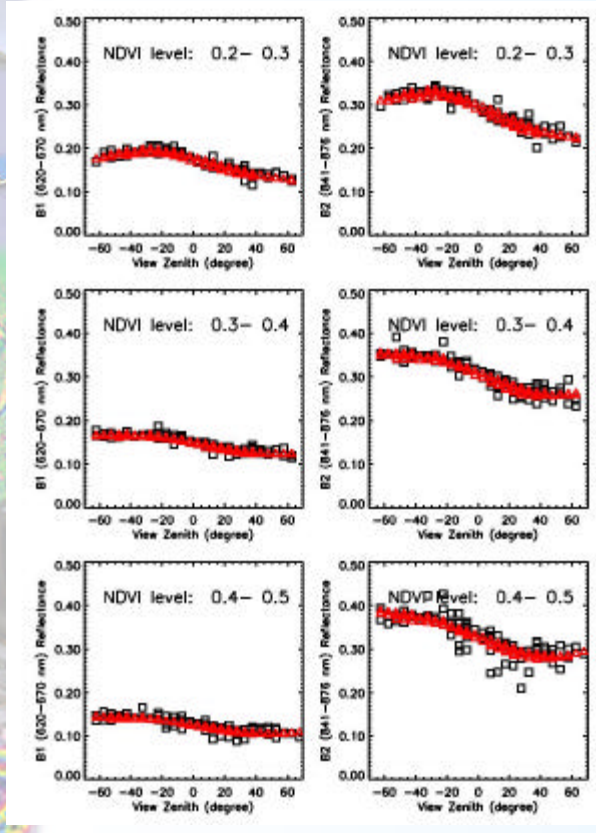
VGT **AVHRR** **MODIS** **MISR**

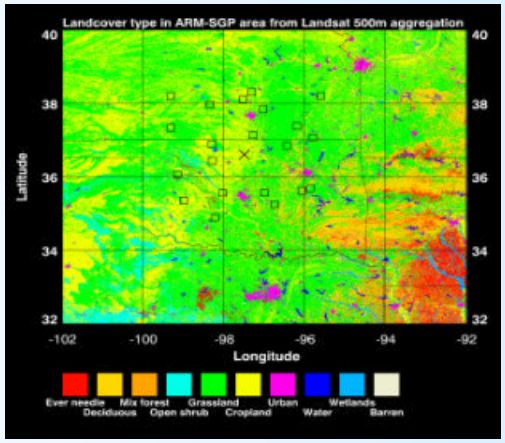


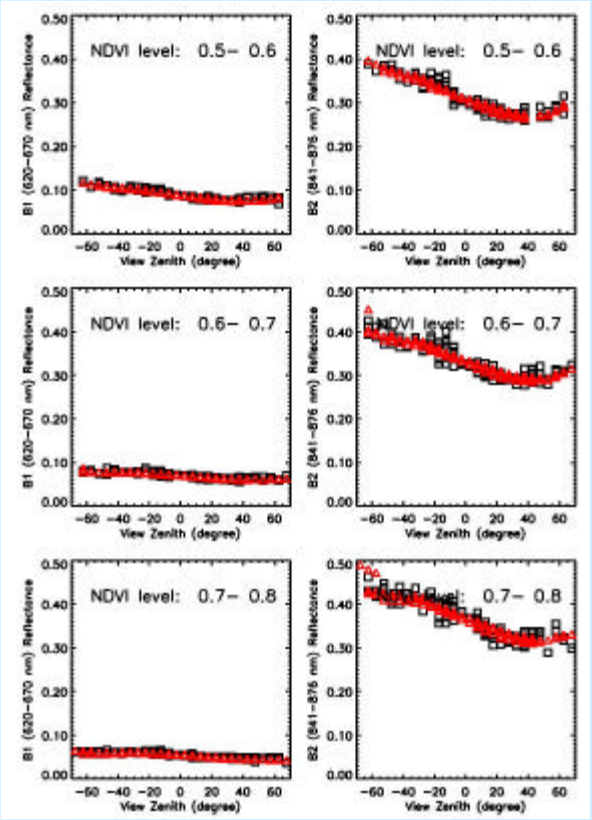
POLDER



New MODIS albedo product
10-day time intervals @ 500x500m^2 from clear-sky composites (MOD09)
March 2000 – March 2005



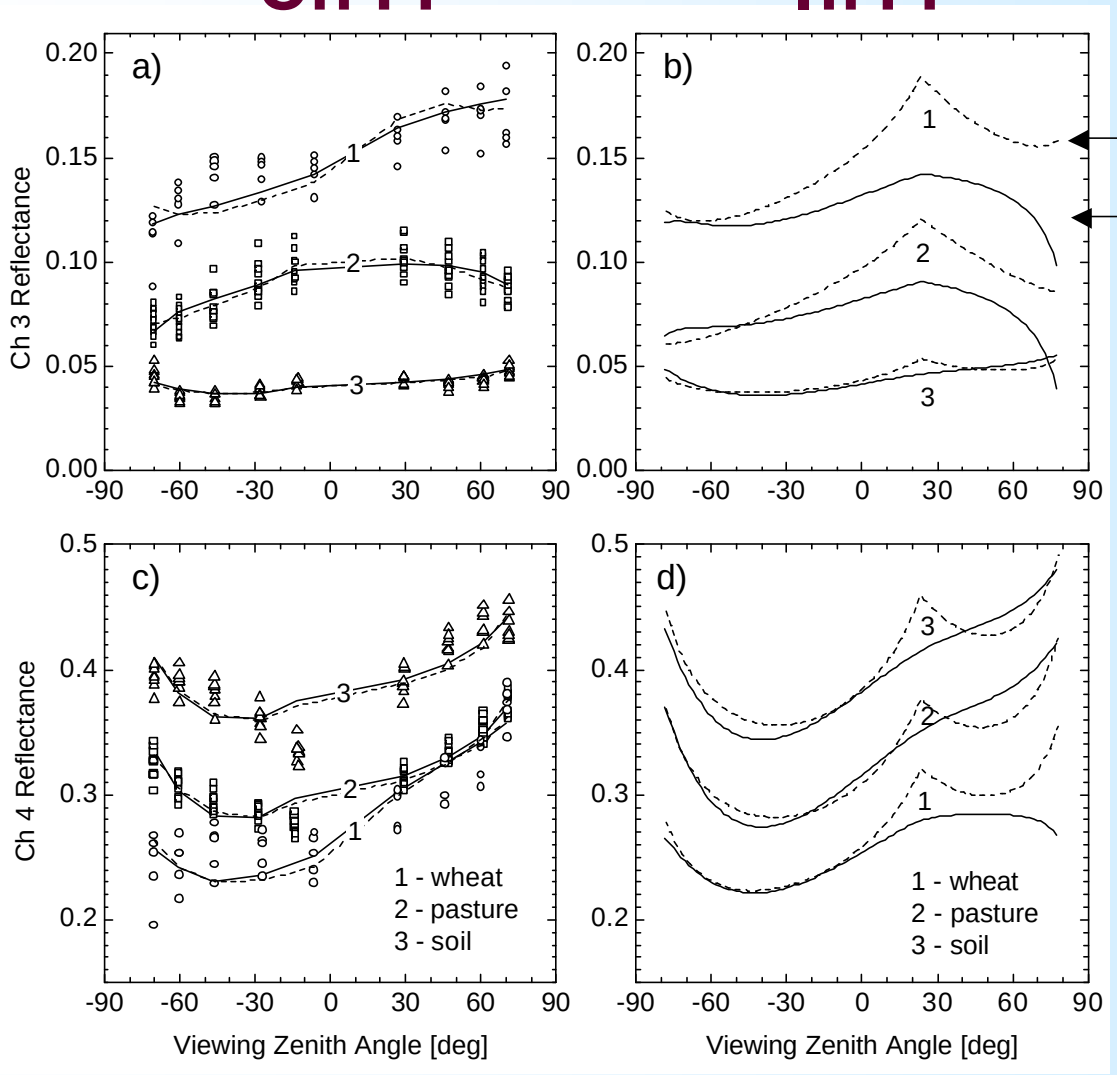




Luo, Trishchenko et al. JGR, 2005

Extrapolation can cause large uncertainties in BRDF shape

Off PP **In PP**



Raman (MISR)

Ross-Li (MODIS)

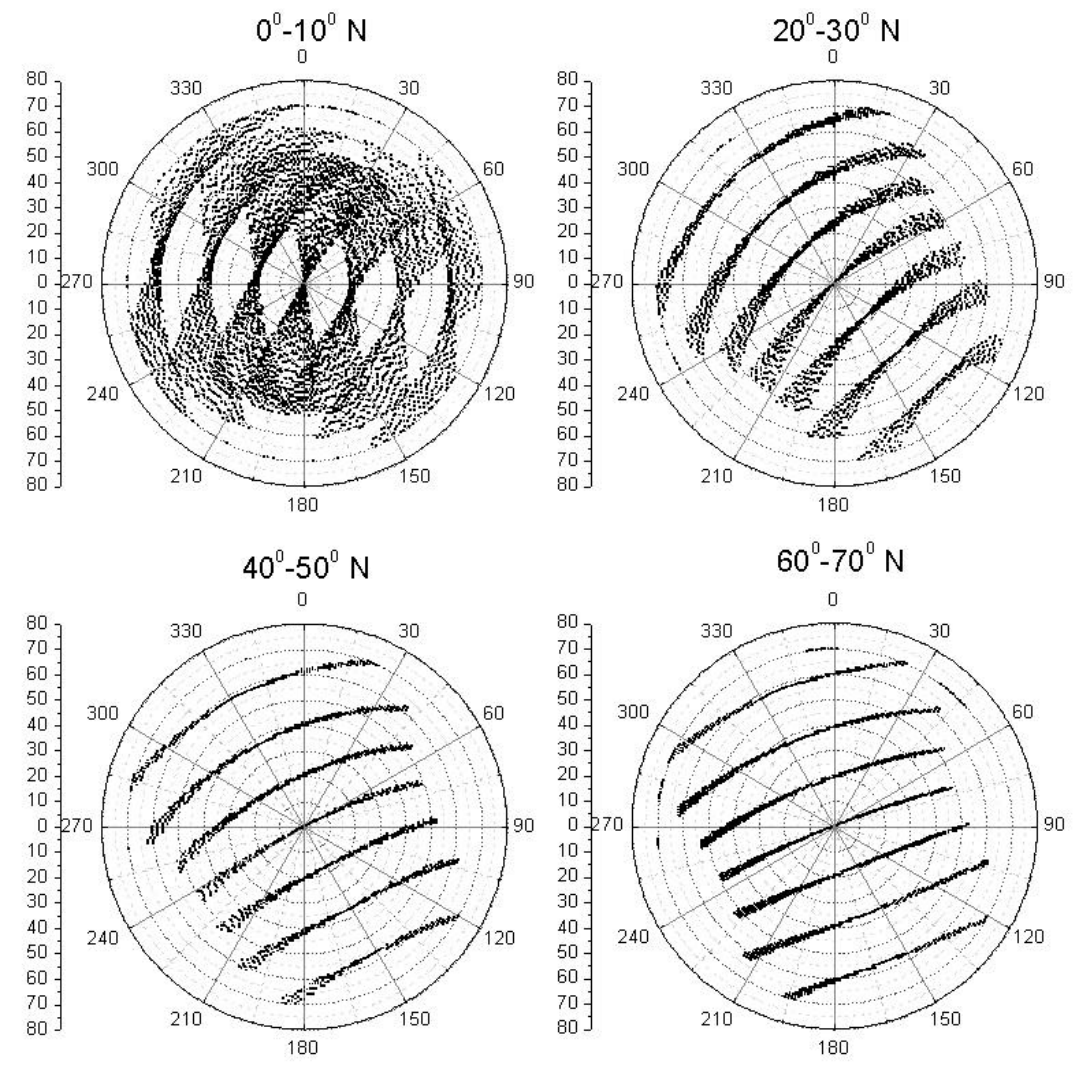
BRDF properties from cross-track scanners on Sun-synchronous platforms => limited angular sampling

Need for new space platform/instrument that is capable of better angular sampling of surface BRDF @ ~ 300-500m spatial resolution

=> Advanced (MISR+POLDER)

- **~ 10 spectral channels (VIS, IR, SWIR and IR)**
- **5-7 angles**
- **~ 2000 km swath**
- **Special orbit, rotating azimuth or multiple platforms**
- Concept of a new mission -Advanced Multiangular MEdium Resolution System - **AMMERS** is proposed to address this gap (Trishchenko, 2004)

Example of angular sampling for multiangular sensor with 7 angles, 42° cross-track and 48° along track observations



13:00 EqCT

Summary

1) ARM Central Facility (10m and 25m) and 21 Extended Facilities (10m) provide ground observations of SW BB and spectral albedo. However, due to spatial inhomogeneity and seasonal changes in landcover properties care should be taken when these data used for validation of satellite products

2) In addition to standard MODIS data product (1km-16day) available since 03/2000, we generated special product over the ARM SGP area at 500m and 10-day intervals for MODIS period and 1-km, 10-day intervals for period from 02/1995 to 03/2005 using AVHRR and VGT data.

3) Due to superior quality of MODIS data, other regular data streams (VGT and AVHRR) were tuned to MODIS.

4) Using correlation between MODIS and other sensors, it was possible to generate MODIS-like channels for entire period of time. Although these are surrogate data, they look very interesting, show high degree of correlation with MODIS and may be useful for certain applications.

5) All data are available from the CCRS ftp site at **ftp://ftp.ccrs.nrcan.gc.ca/ad/CCRS_ARM**

6) Satellite data products from MODIS (standard and experimental) agree with each other well when properly aggregated. Comparison with MISR, LANDSAT and other sensors revels good general agreement also.

Summary (continue...)

1) To derive unbiased BRDF shape, sampling over entire geometrical plane is required which can only be accomplished only from wide-swath multi-angular satellite sensor with spatial medium resolution (**AMMERS**). Cross-track sun-synch scanners cannot provide this feature

2) ISCCP albedo show high degree of correlation with MODIS over Northern part of NA landmass, however for snow free conditions MODIS SW BB albedo is lower by ~0.1 and for snow-free conditions higher by ~0.05.

3) Many GCM models do not account for surface albedo anisotropy (SZA dependence) which leads to biases in the diurnal cycle of surface radiation budget.

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