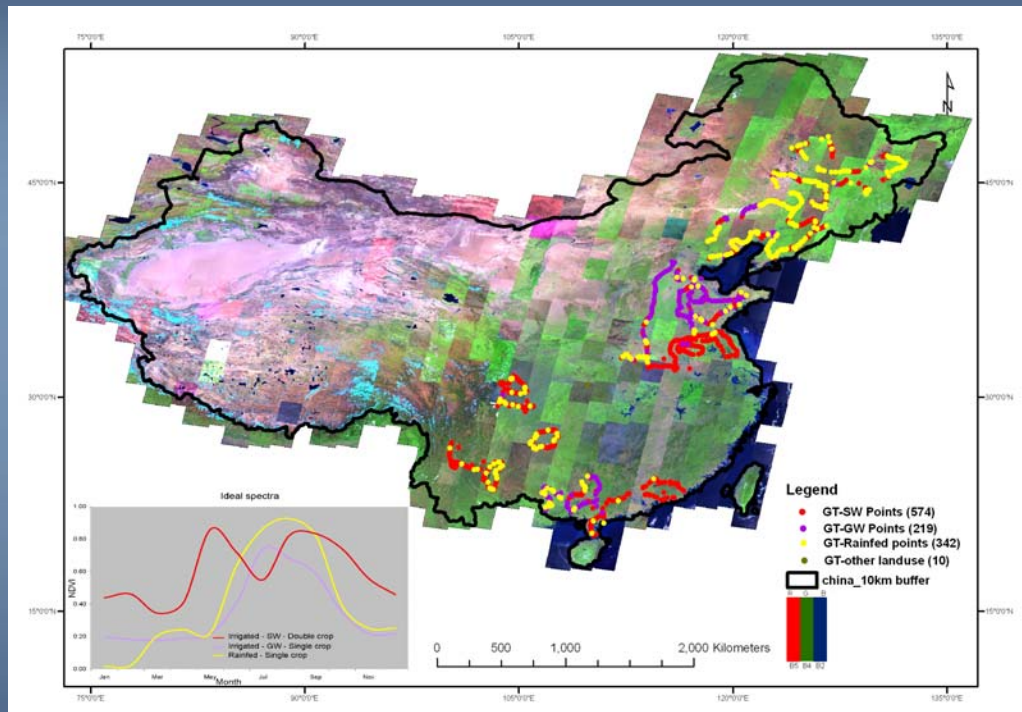
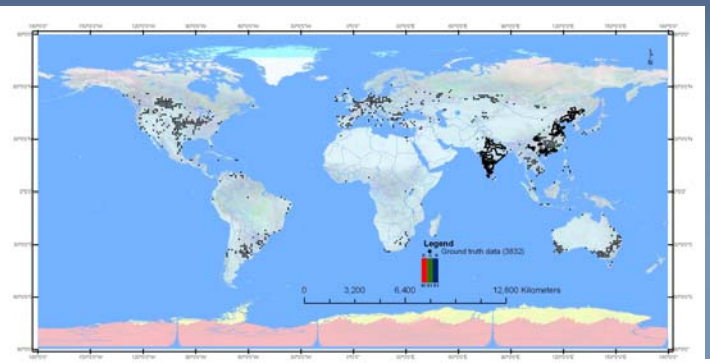
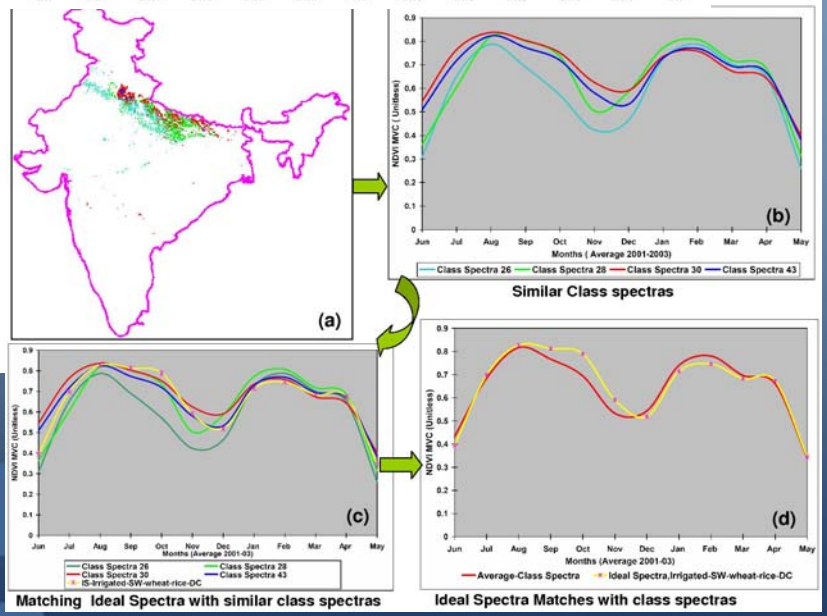
# Developing Ideal Spectral Signatures of Irrigated Areas

for use in

## Spectral Matching Techniques and Decision Trees





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**Presented @ the Landsat Science Meeting**
**Reston, Virginia, USA. July 15-17, 2008**

# Overview

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## Ideal or Target Spectral Data Bank (ISDB) for Irrigated Areas

# Overview

1. Need of ISDB for irrigated areas;
2. Definition of ISDB for irrigated areas;
3. Collection and synthesis of ISDB of irrigated areas for China;
4. Application of ISDB in mapping irrigated areas.

# Why we need Ideal Spectra?

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# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## NEED

1. **Irrigation and water use is a complex phenomenon. For global mapping, a deeper understanding of that is only possible if we have extensive and intensive global knowledge of the same;**
2. **Remote sensing is obvious choice for mapping irrigated areas at global level; and**
3. **However, in order to effectively use remote sensing for global irrigated area mapping, we need an understanding of spectral profiles of complex sets of global irrigated areas and how they differ from each other and from other land use\land cover classes.**

# What is
## Ideal Spectral Data Bank (ISDB)?

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## Ideal or Target Spectral Data Bank (ISDB) for Irrigated Areas

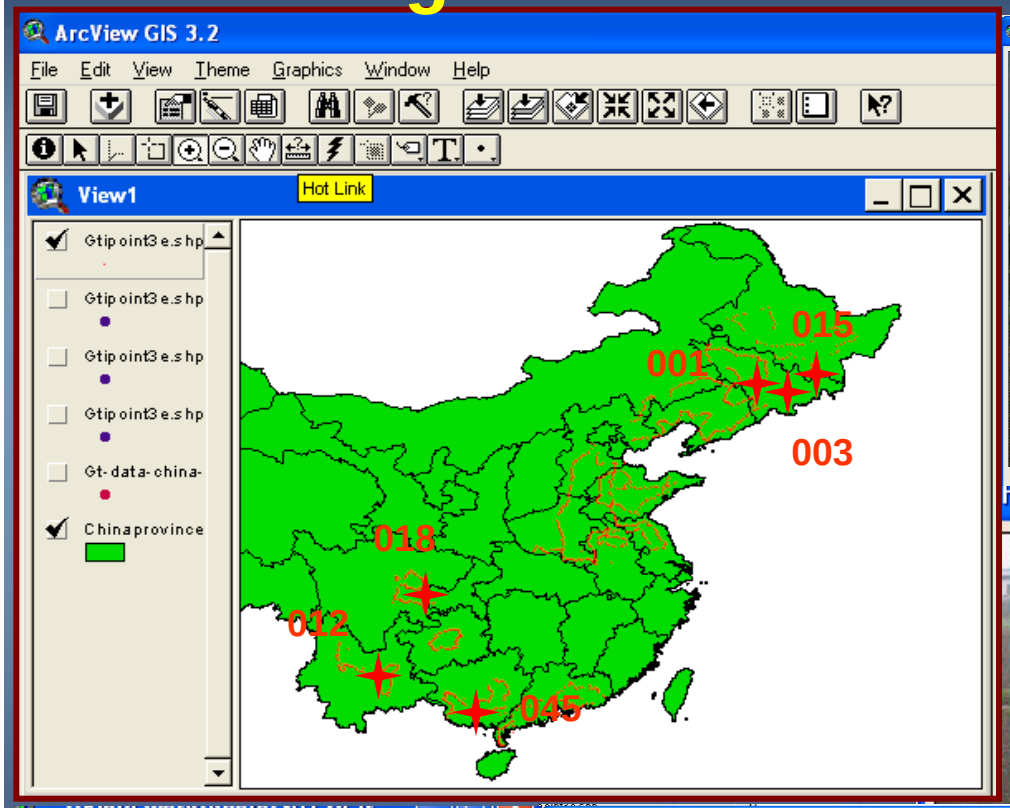
## Definition

**"Developing Spectral Signatures of various types of irrigated areas based on well understood knowledge-base on irrigated areas gathered from precise geographic locations in standardized format"**

**Note: "Ideal spectra" is a general term. It can be spectral spectral reflectivity of hyperspectral imagery, NDVI profiles in time-series imagery, or spectral profiles of other indices or wavebands. In this study, "ideal spectra" is the typically referred to NDVI or other index time-series profiles of various well defined irrigated areas.**

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Gathering Precise Knowledge from Field Visits





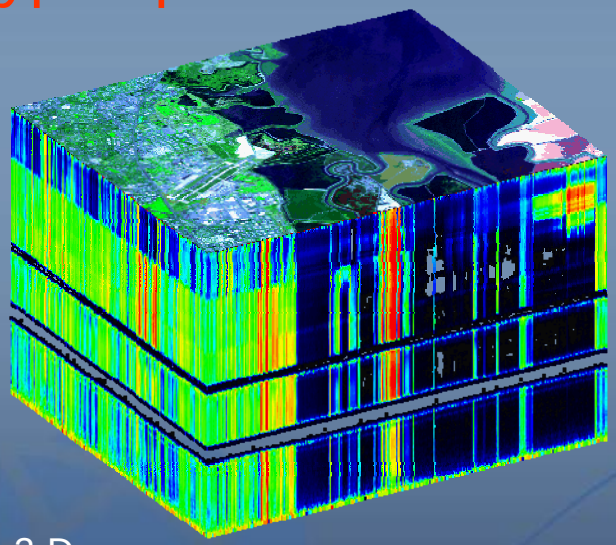





Add all the GT data into ArcView database, and inquire randomly

# Spectral Profiles from
## Hyperspectral Imagery vs. Time-Series Data

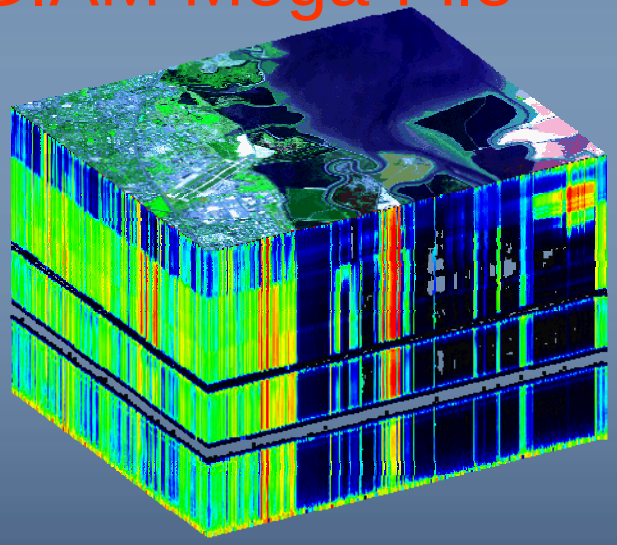
### Hyperspectral data-cube



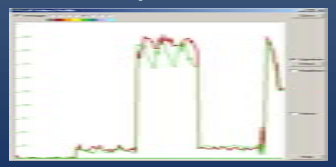
3-D
100s of bands
Produces n-dimensional scatter plot

Single date,
Single-satellite/camera
Mostly Primary dataset

### GIAM Mega-File



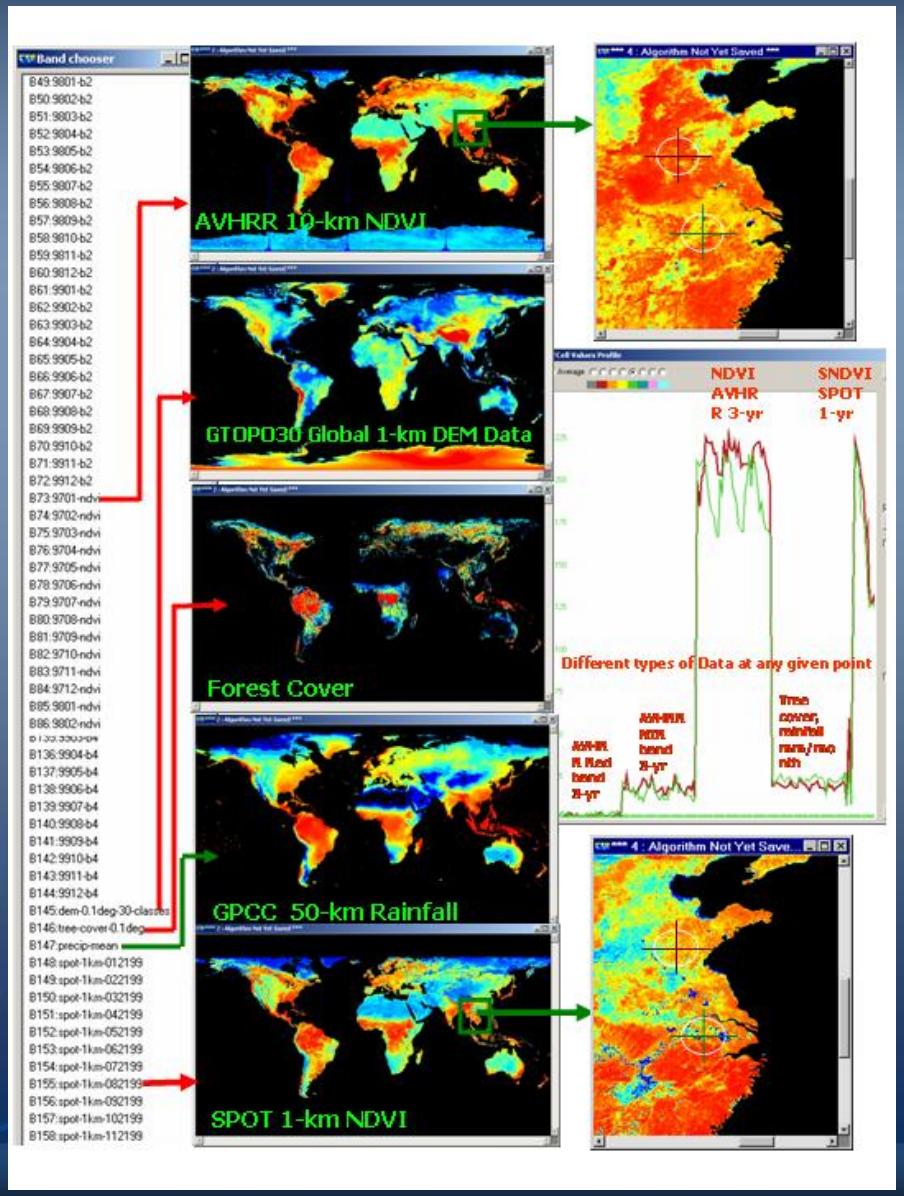
3-D
100s of bands
Produces n-dimensional scatter plot



Multi-date,
Multi-satellite
Contains both primary and secondary datasets

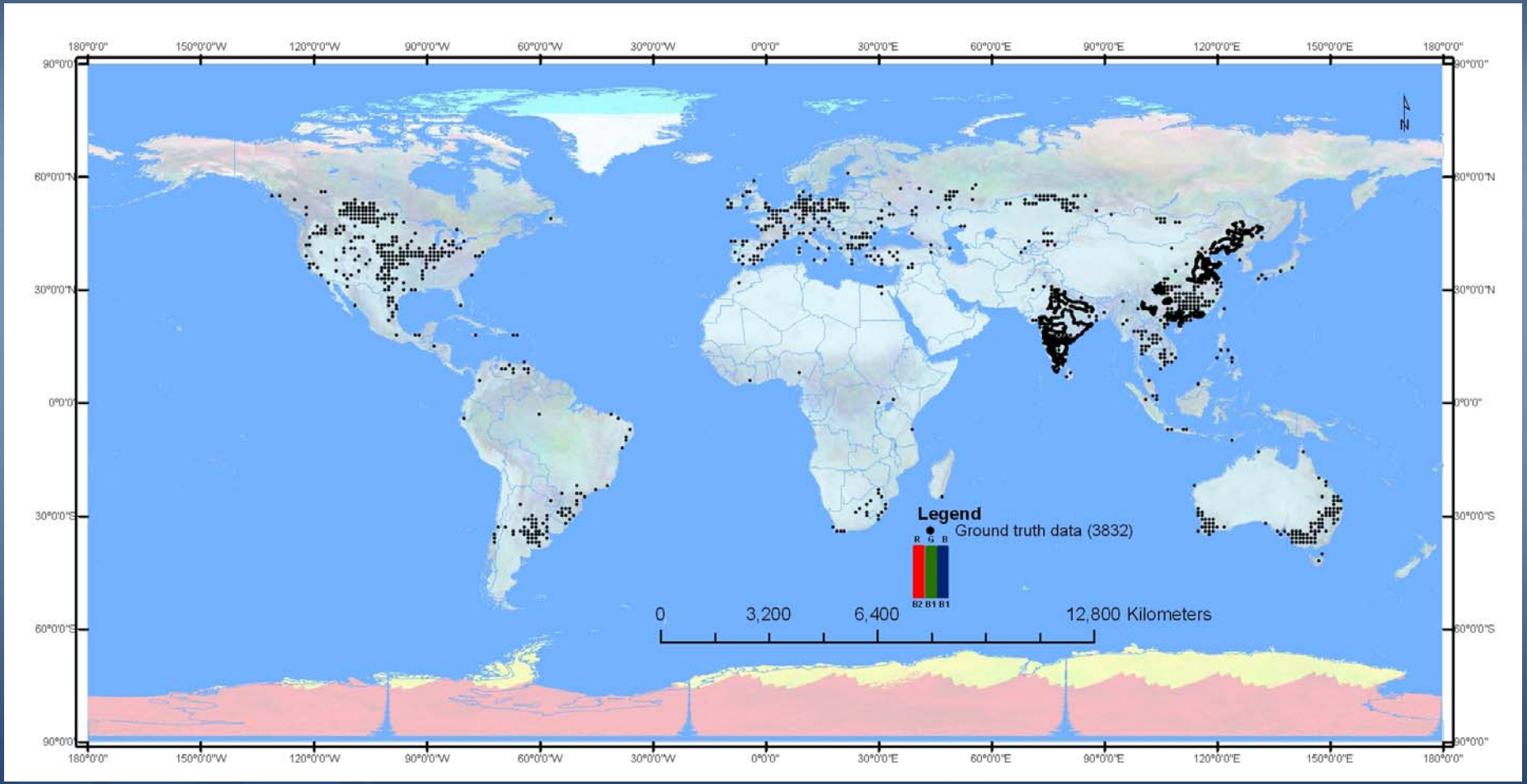
# Spectral Profiles from time-series Data

## Time-series multi-date, multi-sensor data Akin to hyperspectral data



# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Data Points Available for the World from which ISDB can be Generated




**Data points shown on AVHRR 10-km mosaic of the World. The points can be used to generate signatures from any other type of imagery…….for India and China we have the greatest confidence as these data were gathered by our teams.**

# Strategy for Gathering
## Ideal Spectral Data Bank (ISDB)

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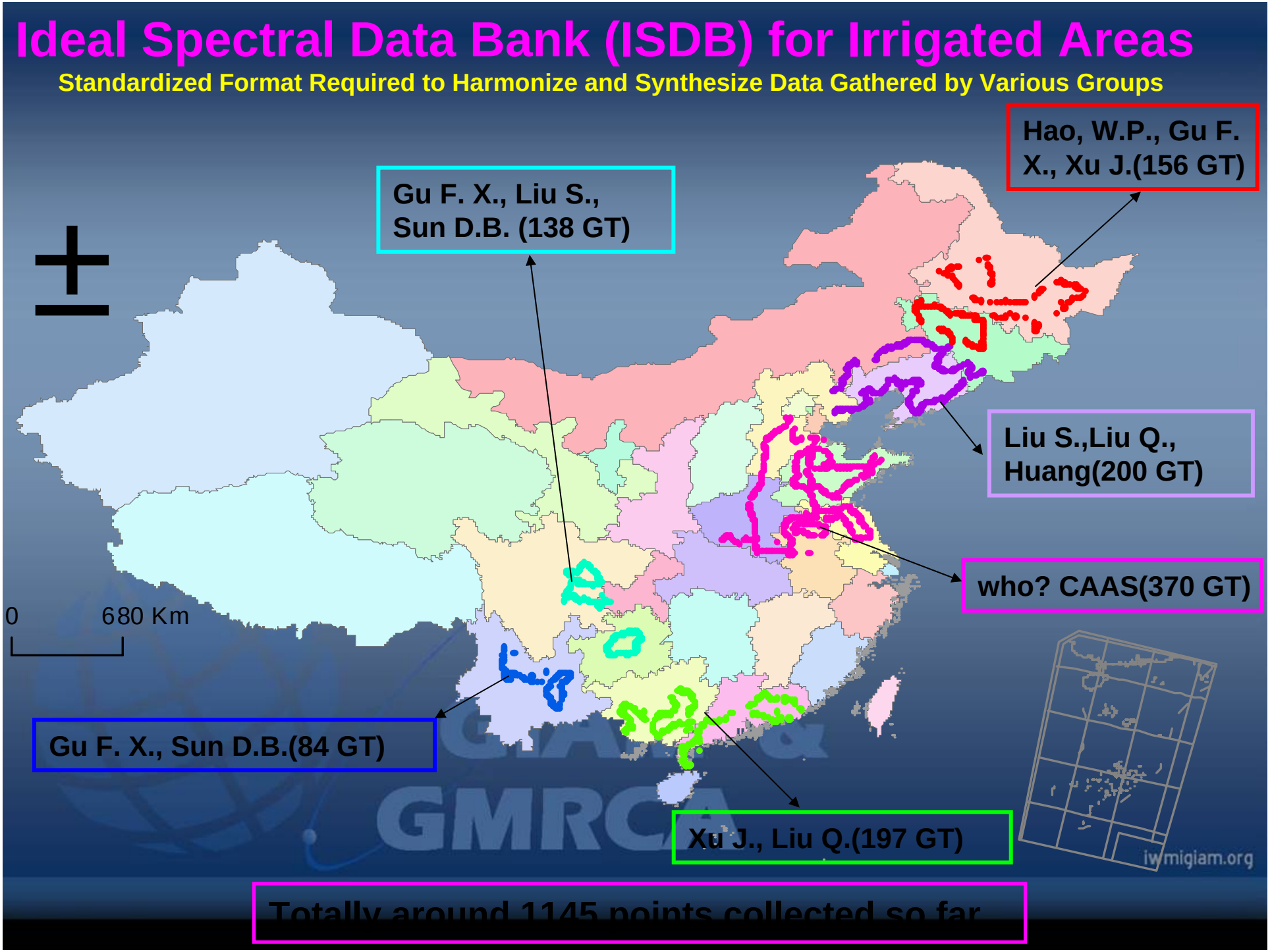
# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

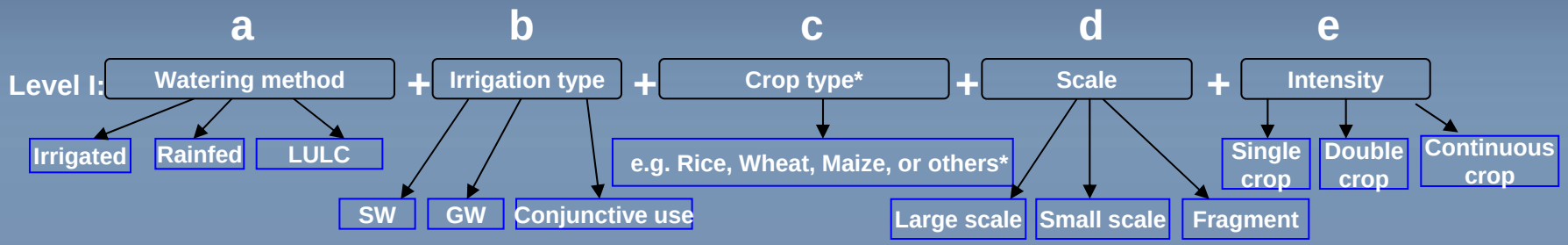
**Standardized Format Required to Harmonize and Synthesize Data Gathered by Various Groups**

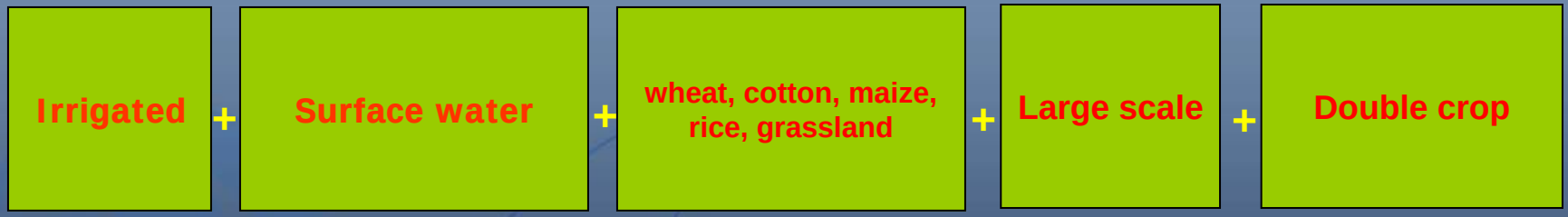



Totally around 1145 points collected so far

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Standardized Format of Data Gathering



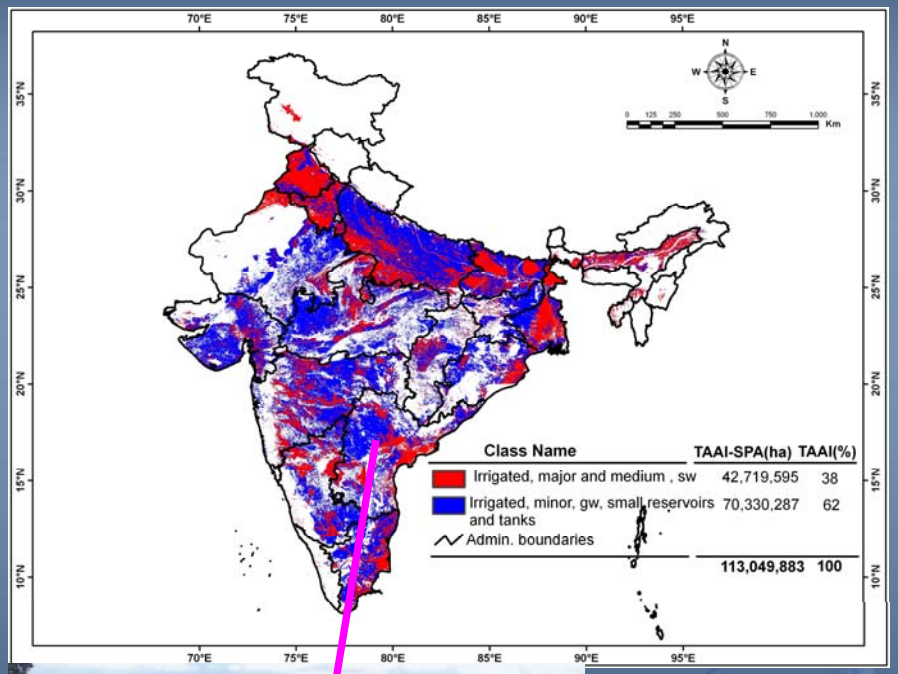



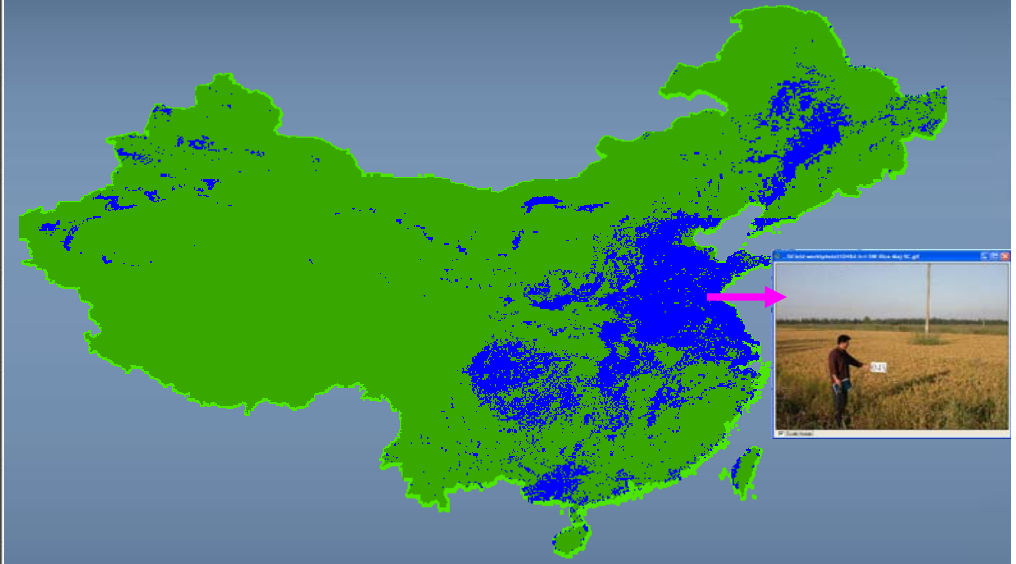


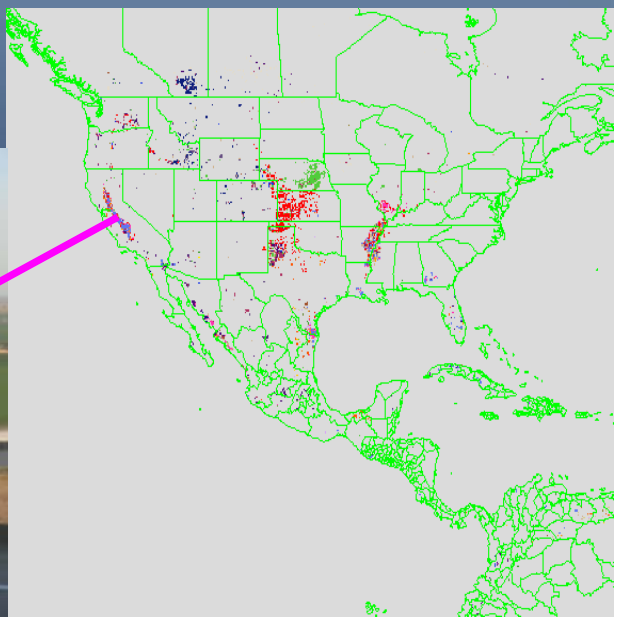

http://www.iwmigiam.org

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

**Regions where it is easy to find Large Scale Contiguous Major Irrigated Areas**

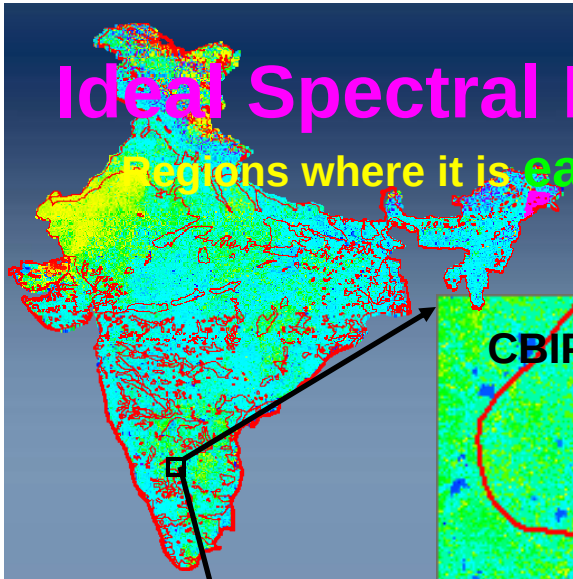


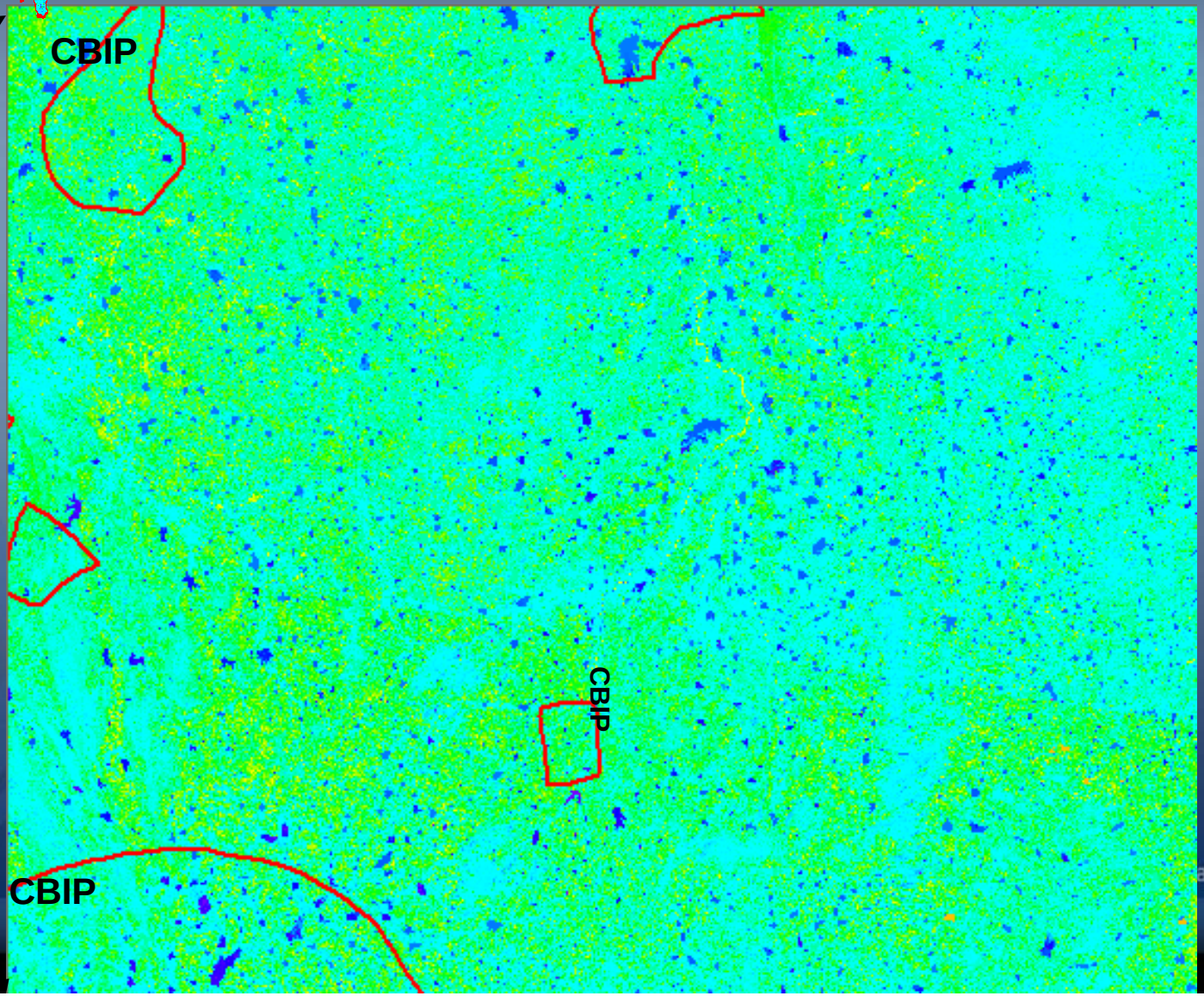





# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

**Regions where it is easy to find Small scale but Contiguous Minor Irrigated Areas**






**Landsat Data highlighting minor irrigation from small tanks in India**

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

**Regions where it is difficult to find Large Scale Contiguous Irrigated Areas**

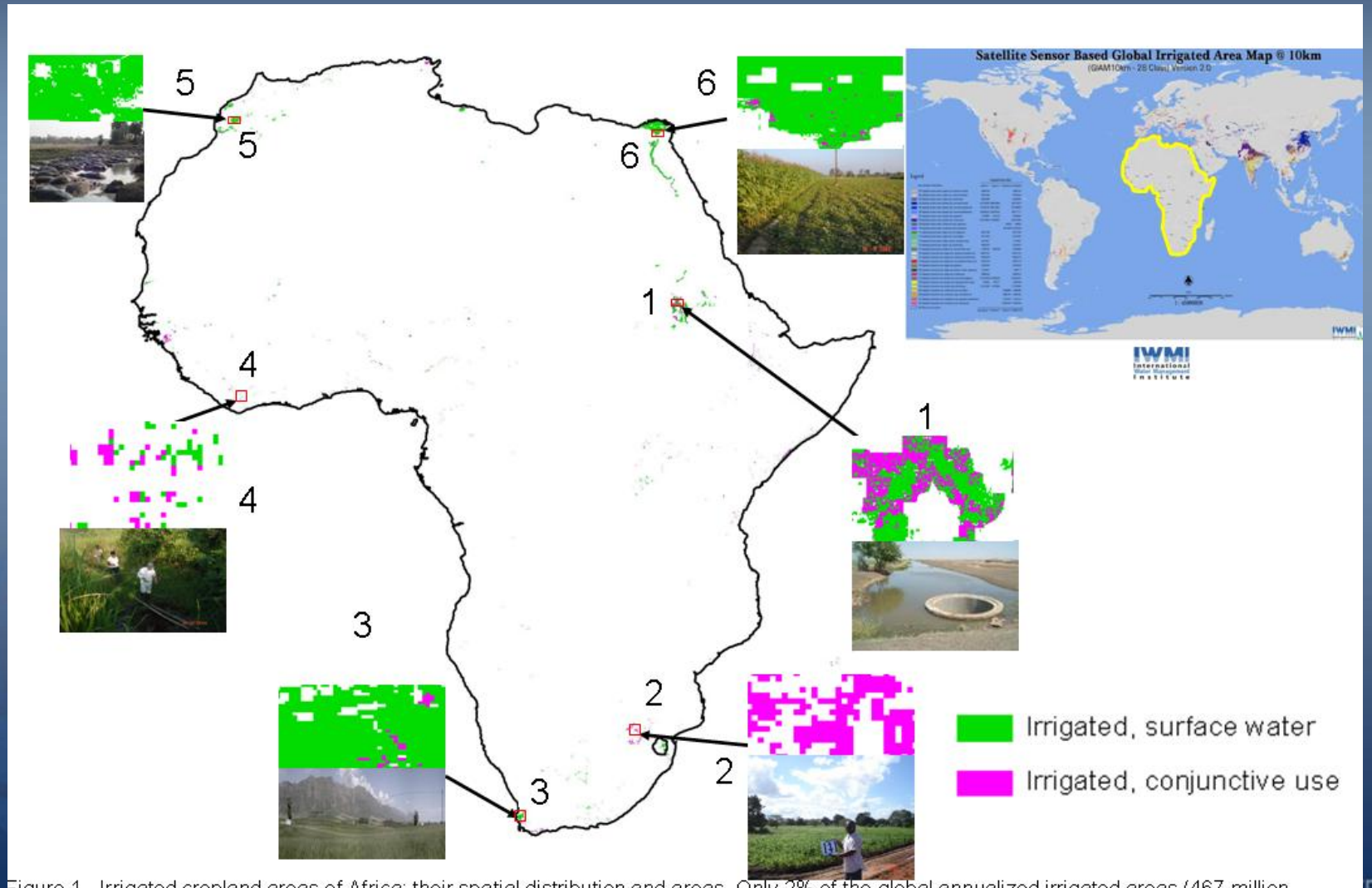



Figure 1. Irrigated cropland areas of Africa: their spatial distribution and areas. Only 2% of the global annualized irrigated areas (467 million hectares is in Africa even though it has 14% of the global population. (Note: Annualized areas conceders intensity are seasonality).

# Small but Contiguous Patches

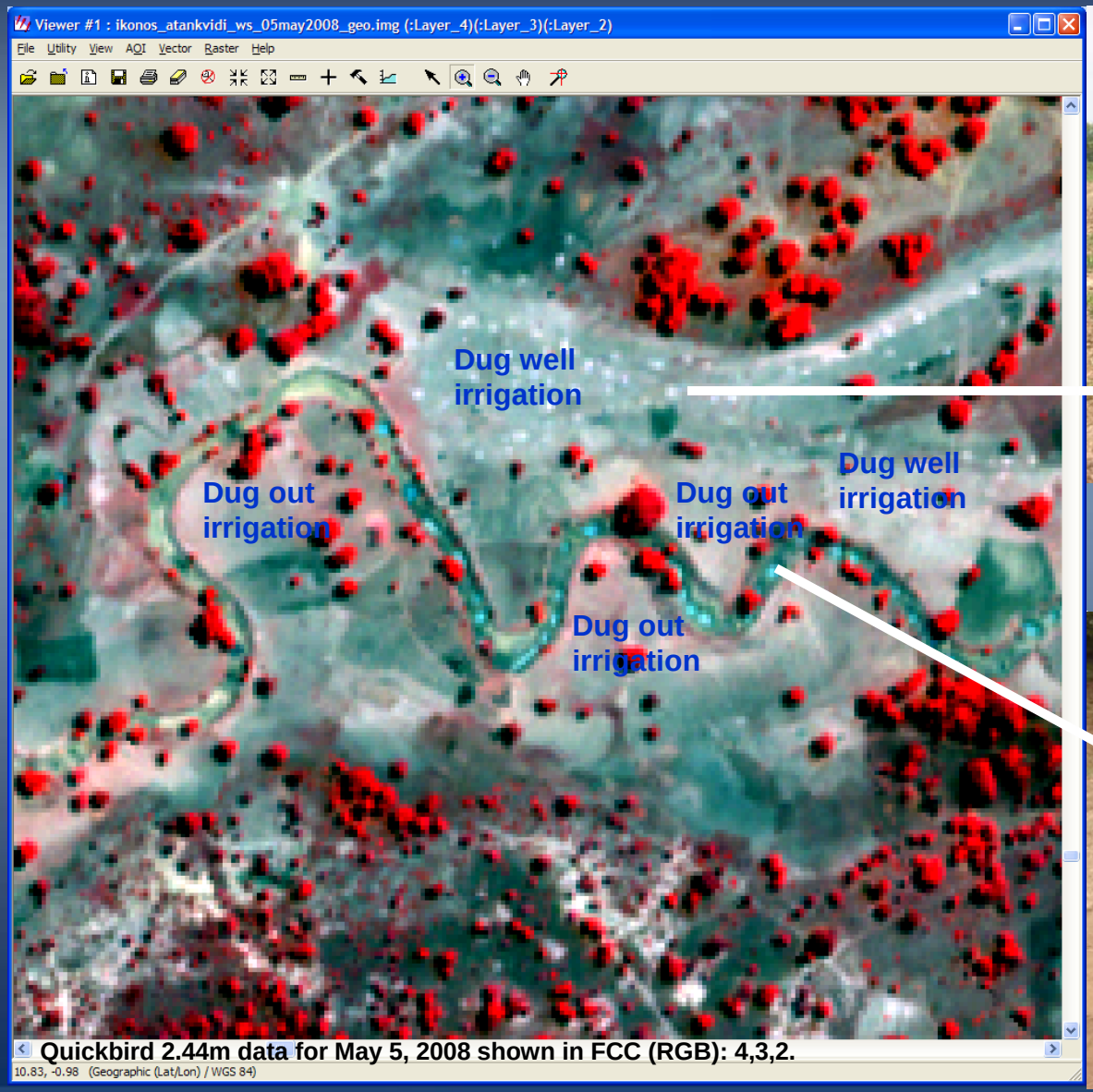
## Atankwidi Watershed in Ghana\Burkina Faso

### Shallow Dug wells


### Dugout in River bed


# The Need for Finer Resolution Data in Detecting Irrigated Areas

## Dug Wells vs. Dug Outs in Atankwidi watershed Ghana and Burkina Faso



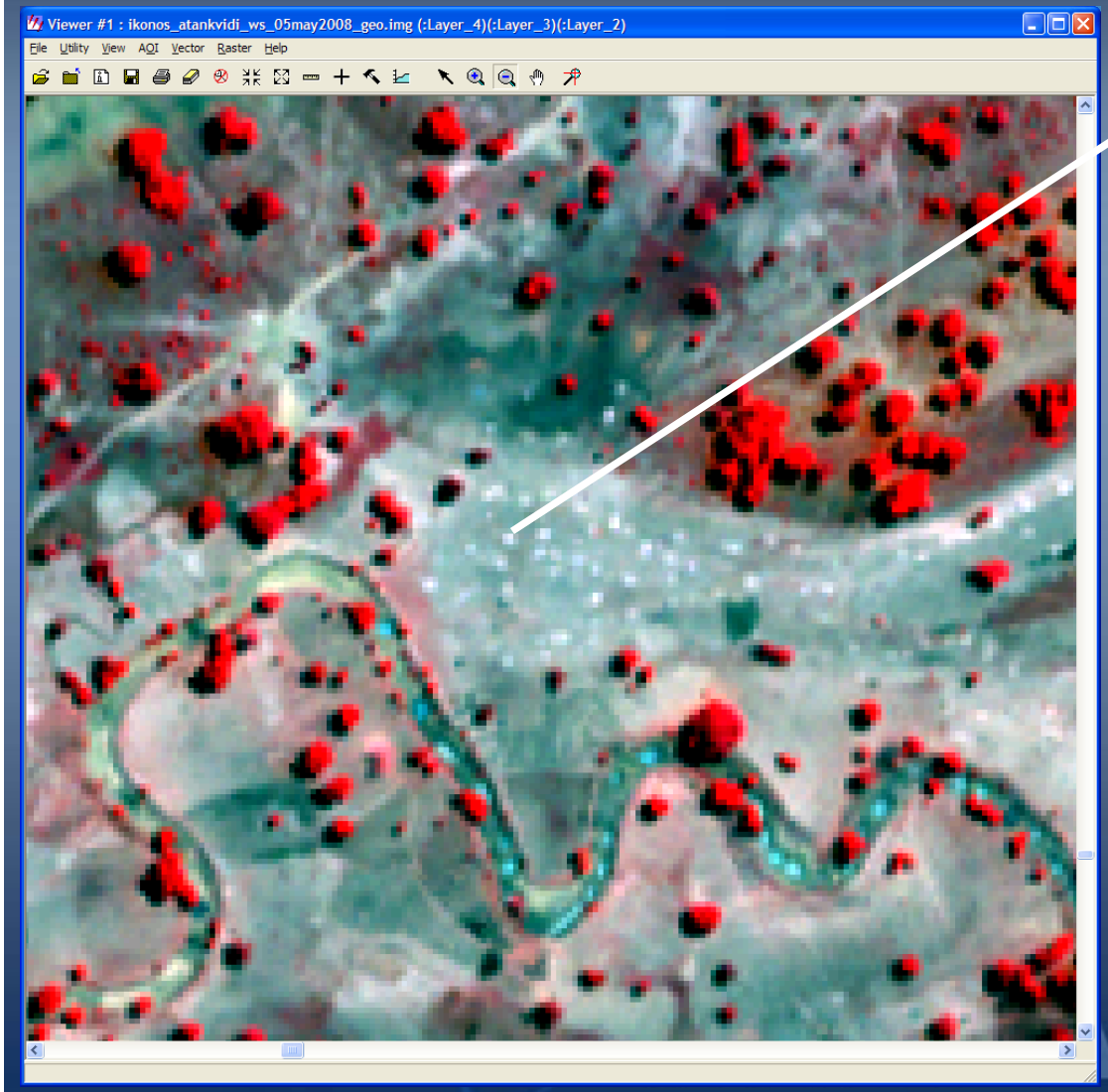

Quickbird 2.44m data for May 5, 2008 shown in FCC (RGB): 4,3,2.


Quickbird imagery highlighting dug-wells and dug-outs in Ghana\Burkina


**Often coarser resolution data misses out such irrigation. But it is significant in areas and water use in many parts of the World……at times, main irrigation in a region or Country…..**

# Shallow Ground Water Irrigation in Atankwidi Watershed, Ghana\Burkina

## Dug Wells

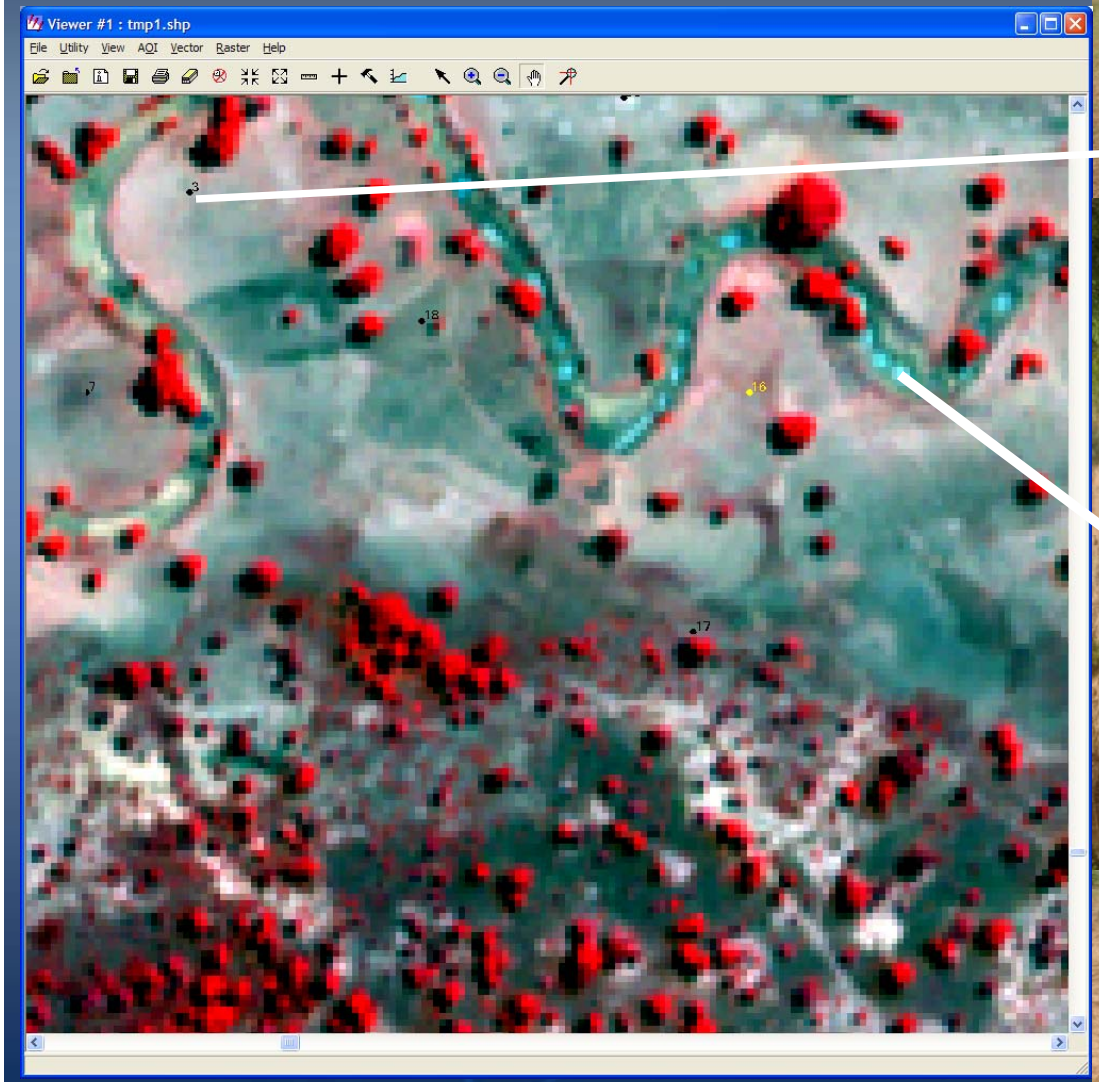



1. 3-5 m in depth;
2. About 0.75 m in diameter;
3. Irrigates about 400-500 $m^2$ area;
4. Visible in very high resolution imagery as white bright spots;
5. Irrigation during dry season (January-May). Crops: vegetables;
6. Rainy season (June-October) will have rainfed crops: Guinea Corn and rice.

Quickbird 2.44m data for May 5, 2008 shown in FCC (RGB): 4,3,2.
The white bright dots are dug wells.

# Shallow Ground Water Irrigation in Atankwidi Watershed, Ghana\Burkina

## Dug Outs (in river bed)





Quickbird 2.44m data for May 5, 2008 shown in FCC (RGB): 4,3,2. The area irrigated along the river course through dug outs (using pumps).

# Gathering Knowledge-base on Irrigated Areas at the Ground:

## Examples from China

GIAM & GMRCA

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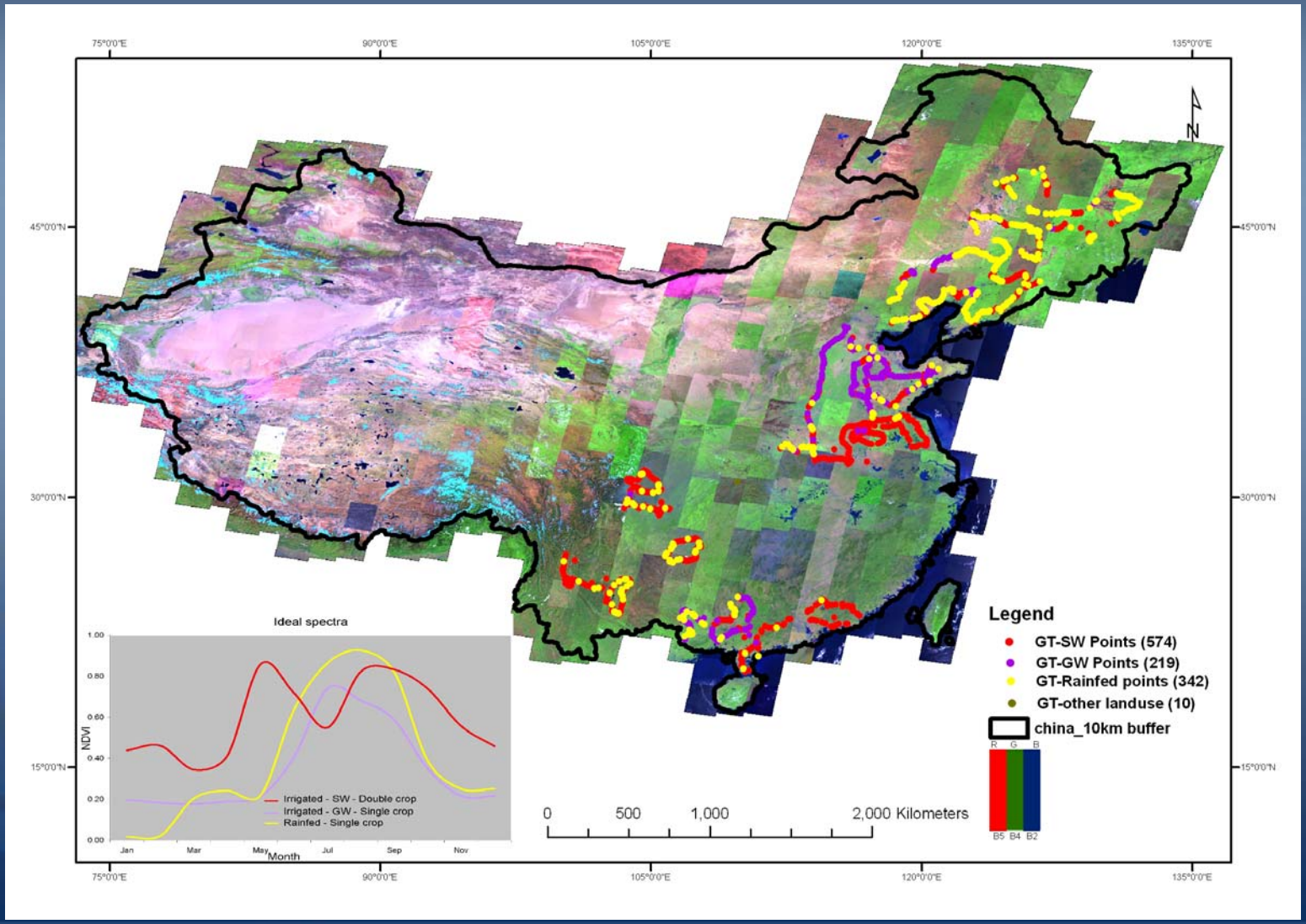
# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Gathering Ideal Spectra: China example




iwmigiam.org

**Signatures generated using MODIS 250m time-series. Image shown above is Landsat 30m mosaic of China.**

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Standardized Format of Data Composition: one example

| | A | B | C | D | E | F | EE |
|---|---|---|---|---|---|---|---|
| 1 | Plot No | Country | Province | Longitude | Latitude | Date(mm/dd/yy) | LULC |
| 2 | 1001 | China | Hebei | 118.36626 | 39.71004 | 9.20.2007 | Irri-Conjunctivne-Corn-Maj-DC |
| 3 | 1002 | China | Hebei | 118.41333 | 39.79445 | 9.20.2007 | Rainfed-Corn-Sweet potato-SC |
| 4 | 1003 | China | Hebei | 118.50219 | 39.86303 | 9.20.2007 | Rainfed-Corn-Orchard-SC-CC |
| 5 | 1004 | China | Hebei | 118.68648 | 39.86858 | 9.20.2007 | Rainfed-Corn-Ground nut-SC |
| 6 | 1005 | China | Hebei | 118.79559 | 39.87612 | 9.20.2007 | Maj-DC |
| 7 | 1006 | China | Hebei | 118.95707 | 39.89490 | 9.20.2007 | Rainfed-Sweet potato-Corn-SC |
| 8 | 1007 | China | Hebei | 119.11656 | 39.90773 | 9.20.2007 | Rainfed-Corn-SC |
| 9 | 1008 | China | Hebei | 119.26834 | 39.88048 | 9.20.2007 | Irri-GW-Corn-VegetableS-Maj-DC |
| 10 | 1009 | China | Hebei | 119.50363 | 39.94761 | 9.20.2007 | potato-SC |
| 11 | 1010 | China | Hebei | 119.64212 | 39.98221 | 9.20.2007 | Rainfed-Corn-SC |
| 12 | 1011 | China | Hebei | 119.78445 | 40.02985 | 9.21.2007 | Vegetable-Maj-SC |

| | A | B | C | D | E | F | EE | EF |
|---|---|---|---|---|---|---|---|---|
| 1 | Plot No | Country | Province | Longitude | Latitude | Date(mm/dd/yy) | LULC | PIC1 |
| 2 | 3001 | China | Hebei | 115.55.32 | 39.25.01 | 11.12.2007 | Irrgated-GW-Wheat-Major-Doubie | GT照片\DSC00420.JPG |
| 3 | 3002 | China | Hebei | 115.47.23 | 39.14.22 | 11.12.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00424.JPG |
| 4 | 3003 | China | Hebei | 115.43.16 | 39.29.27 | 11.12.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00428.JPG |
| 5 | 3004 | China | Hebei | 115.36.48 | 39.00.06 | 11.12.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00432.JPG |
| 6 | 3005 | China | Hebei | 115.33.99 | 38.55.38 | 11.12.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00436.JPG |
| 7 | 3006 | China | Hebei | 115.24.05 | 38.49.26 | 11.12.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00441.JPG |
| 8 | 3007 | China | Hebei | 115.15.30 | 38.45.57 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00446.JPG |
| 9 | 3008 | China | Hebei | 115.07.30 | 38.40.48 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00451.JPG |
| 10 | 3009 | China | Hebei | 115.00.50 | 38.35.02 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00455.JPG |
| 11 | 3010 | China | Hebei | 114.53.52 | 38.29.15 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00460.JPG |
| 12 | 3011 | China | Hebei | 114.49.00 | 38.24.30 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00464.JPG |
| 13 | 3012 | China | Hebei | 114.42.38 | 38.21.44 | 11.13.2007 | Irrgated-GW-Wheat-Major-Double | GT照片\DSC00468.JPG |

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

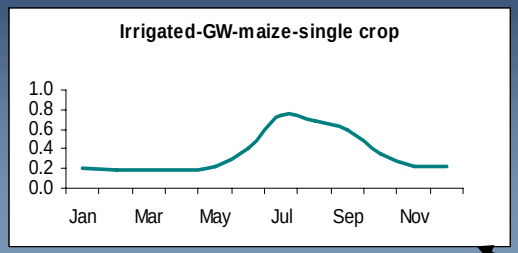
## Standardized Format of Data Composition: another example

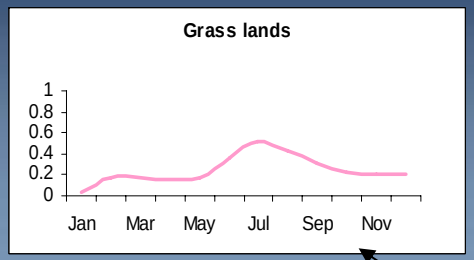
| | A | C | D | E | F | EE | EF |
|---|---|---|---|---|---|---|---|
| 1 | Plot No | Province | Longitude | Latitude | Date(mm /dd/yy) | LULC | PIC1 |
| 2 | 1001 | Hebei | 118.36626 | 39.71004 | 09/20/07 | Irrigated-Conjunctivne-Corn-Major-DC | ..\Photo\1001a-Irri-Conjunctivne-Corn-Maj-DC.gif |
| 3 | 1002 | Hebei | 118.41333 | 39.79445 | 09/20/07 | Rainfed-Corn-Sweet potato-SC | ..\Photo\1002a-Rainfed-Corn-Sweet potato-SC.gif |
| 4 | 1003 | Hebei | 118.50219 | 39.86303 | 09/20/07 | Rainfed-Corn-Orchard-SC-CC | ..\Photo\1003a-Rainfed-Corn-Orchard-SC-CC.gif |
| 5 | 1004 | Hebei | 118.68648 | 39.86858 | 09/20/07 | Rainfed-Corn-Ground nut-SC | ..\Photo\1004a-Rainfed-Corn-Ground nut-SC.gif |
| 6 | 1005 | Hebei | 118.79559 | 39.87612 | 09/20/07 | Irrigated-GW-Corn-Ground nut-Orchard-Major-DC | ..\Photo\1005a-Irri-GW-Corn-Ground nut-Orchard-M |
| 7 | 1006 | Hebei | 118.95707 | 39.89490 | 09/20/07 | Rainfed-Sweet potato-Corn-SC | ..\Photo\1006a-Rainfed-Sweet potato-Corn-SC.gif |
| 8 | 1007 | Hebei | 119.11656 | 39.90773 | 09/20/07 | Rainfed-Corn-SC | ..\Photo\1007a-Rainfed-Corn-SC.gif |
| 9 | 1008 | Hebei | 119.26834 | 39.88048 | 09/20/07 | Irrigated-GW-Corn-VegetableS-Major-DC | ..\Photo\1008a-Irri-GW-Corn-VegetableS-Maj-DC.gi |
| 10 | 1009 | Hebei | 119.50363 | 39.94761 | 09/20/07 | Rainfed-Corn-Ground nut-Sweet potato-SC | ..\Photo\1009a-Rainfed-Corn-Ground nut-Sweet pot |
| 11 | 1010 | Hebei | 119.64212 | 39.98221 | 09/20/07 | Rainfed-Corn-SC | ..\Photo\1010a-Rainfed-Corn-SC.gif |
| 12 | 1011 | Hebei | 119.78445 | 40.02985 | 09/21/07 | Irrigated-SW-Grape-Corn-Orchard-Vegetable-Major-SC | ..\Photo\1011a-Irri-SW-Grape-Corn-Orchard-Vegeta |
| 13 | 1012 | Liaoning | 119.89914 | 40.07320 | 09/21/07 | Rainfed-Corn-SC | ..\Photo\1012a-Rainfed-Corn-SC.gif |
| 14 | 1013 | Liaoning | 119.98923 | 40.13558 | 09/21/07 | Irrigated-SW-Corn-ORCAH-VegetableS-Minor-SC | ..\Photo\1013a-Irri-SW-Corn-ORCAH-VegetableS-M |
| 15 | 1014 | Liaoning | 120.11576 | 40.19731 | 09/21/07 | Irrigated-SW-Rice-Major-SC | ..\Photo\1014a-Irri-SW-Rice-Maj-SC.gif |
| 16 | 1015 | Liaoning | 120.26346 | 40.28868 | 09/21/07 | Irrigated-SW-Corn-Soybean-Minor-SC | ..\Photo\1015a-Irri-SW-Corn-Soybean-Min-SC.gif |

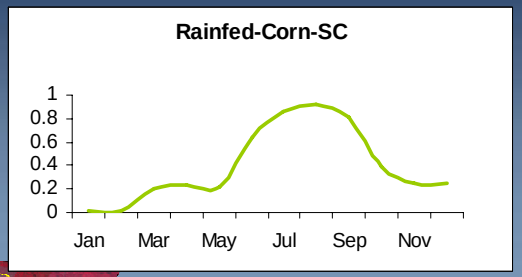
Ground-truth-data_China

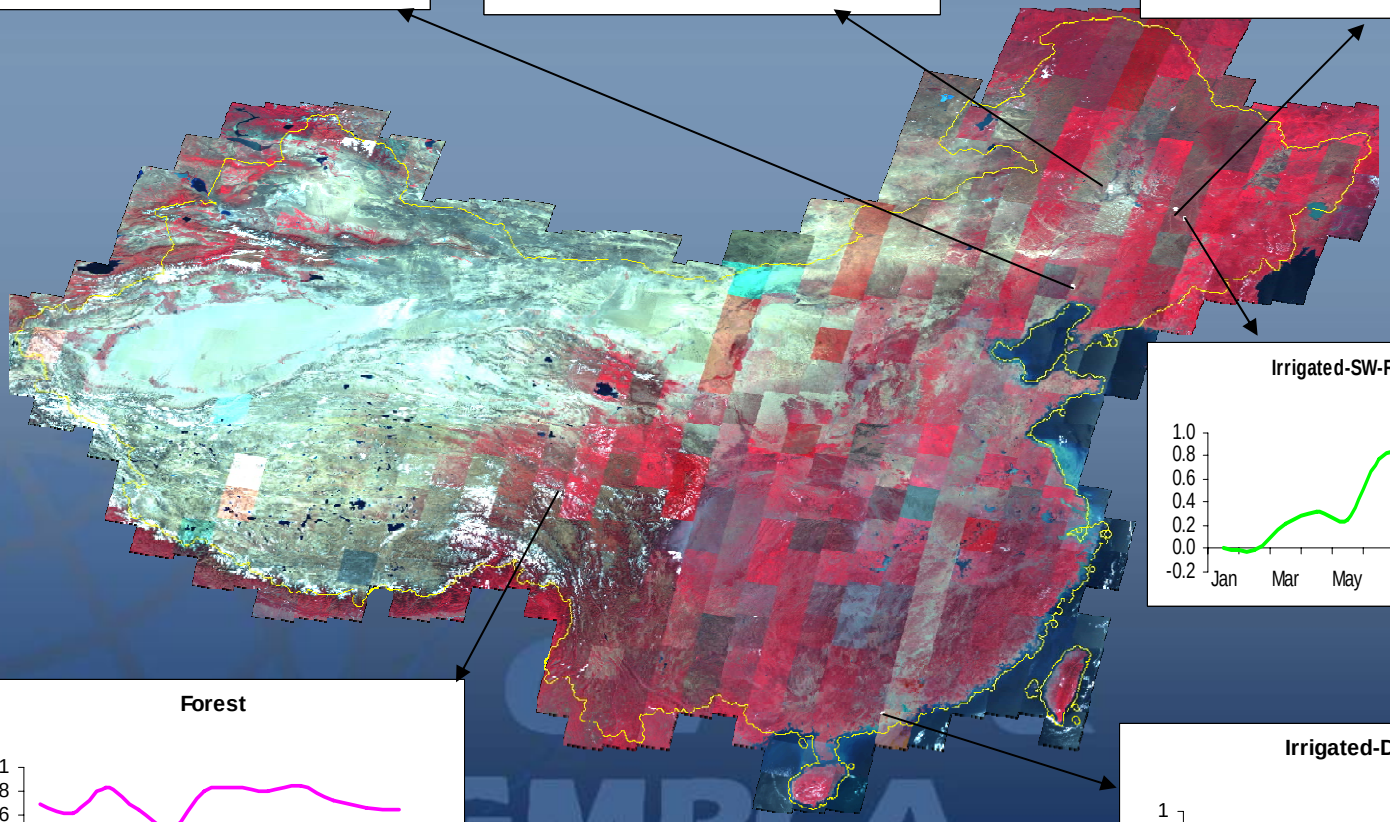
# Ideal Spectral Data Bank (ISDB) for

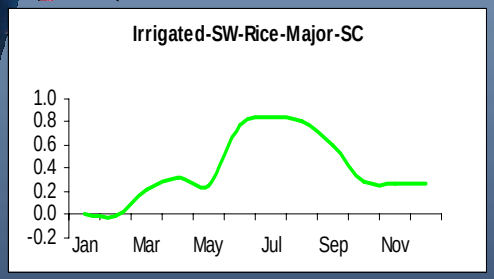
## Illustration: Gathering Data for Various land use\land cover (LULC) Classes

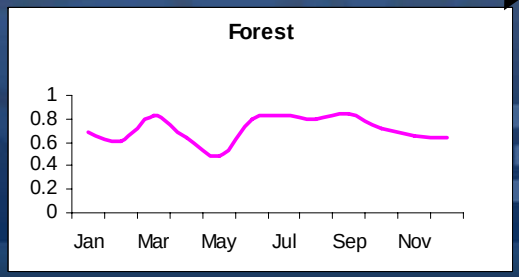


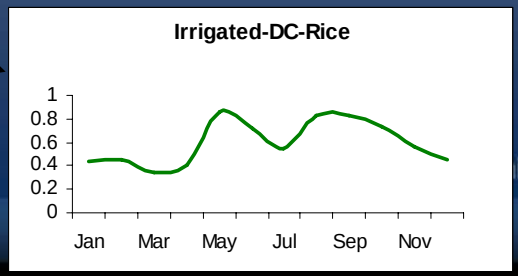





# Harmonization and Synthesis of Ideal Spectral Data Bank (ISDB) for Irrigated Areas

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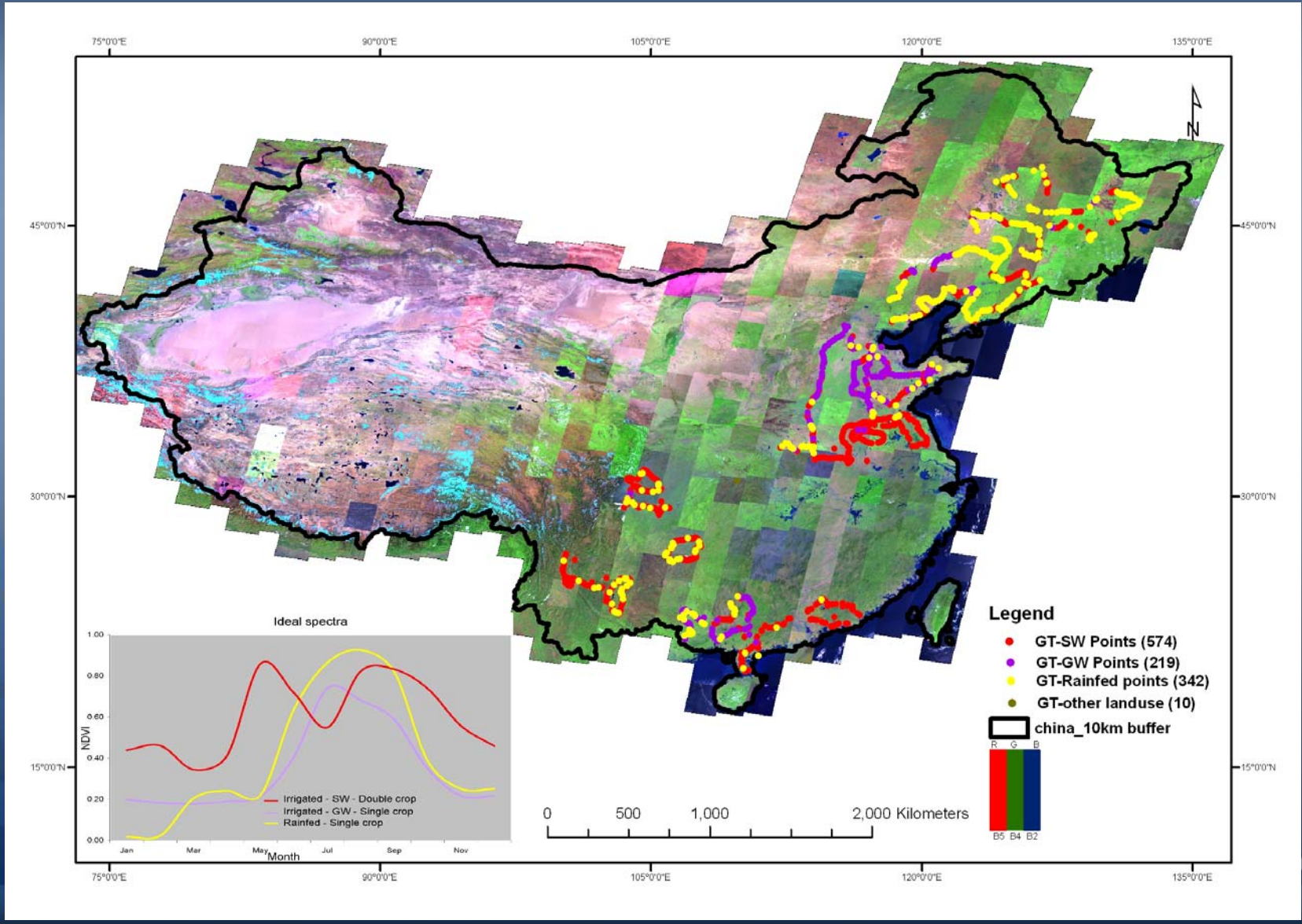
# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

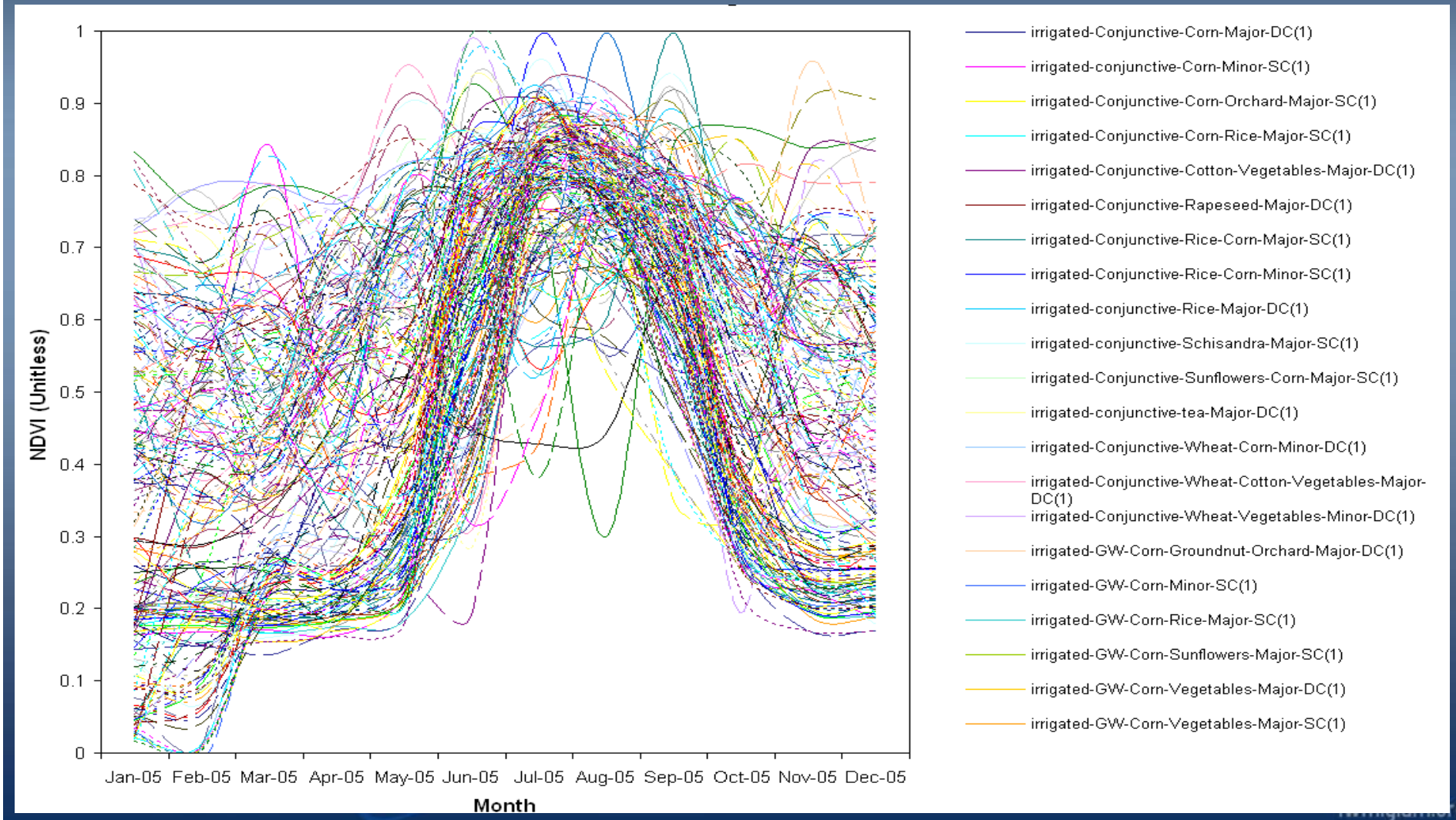
## Harmonization and Synthesis leading to Unique Signatures: China example




**Spatial distribution of irrigated surface water Vs. ground water vs. rainfed vs. other LULC**

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Harmonization and Synthesis leading to Unique Signatures: China example




**Dis-aggregated signatures**

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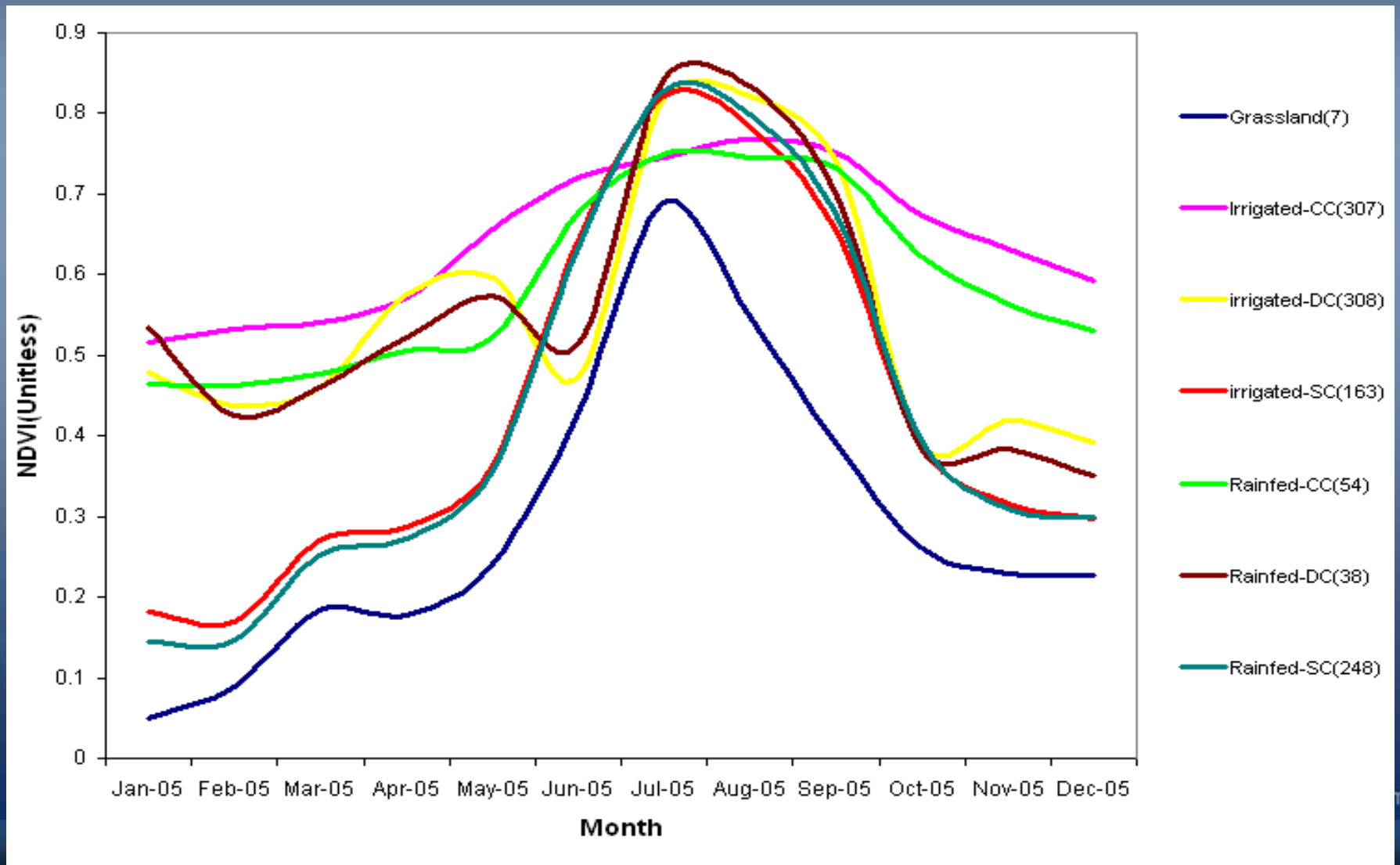


Aggregated signatures involving 7 distinct classes (see sample sizes in brackets of legend)

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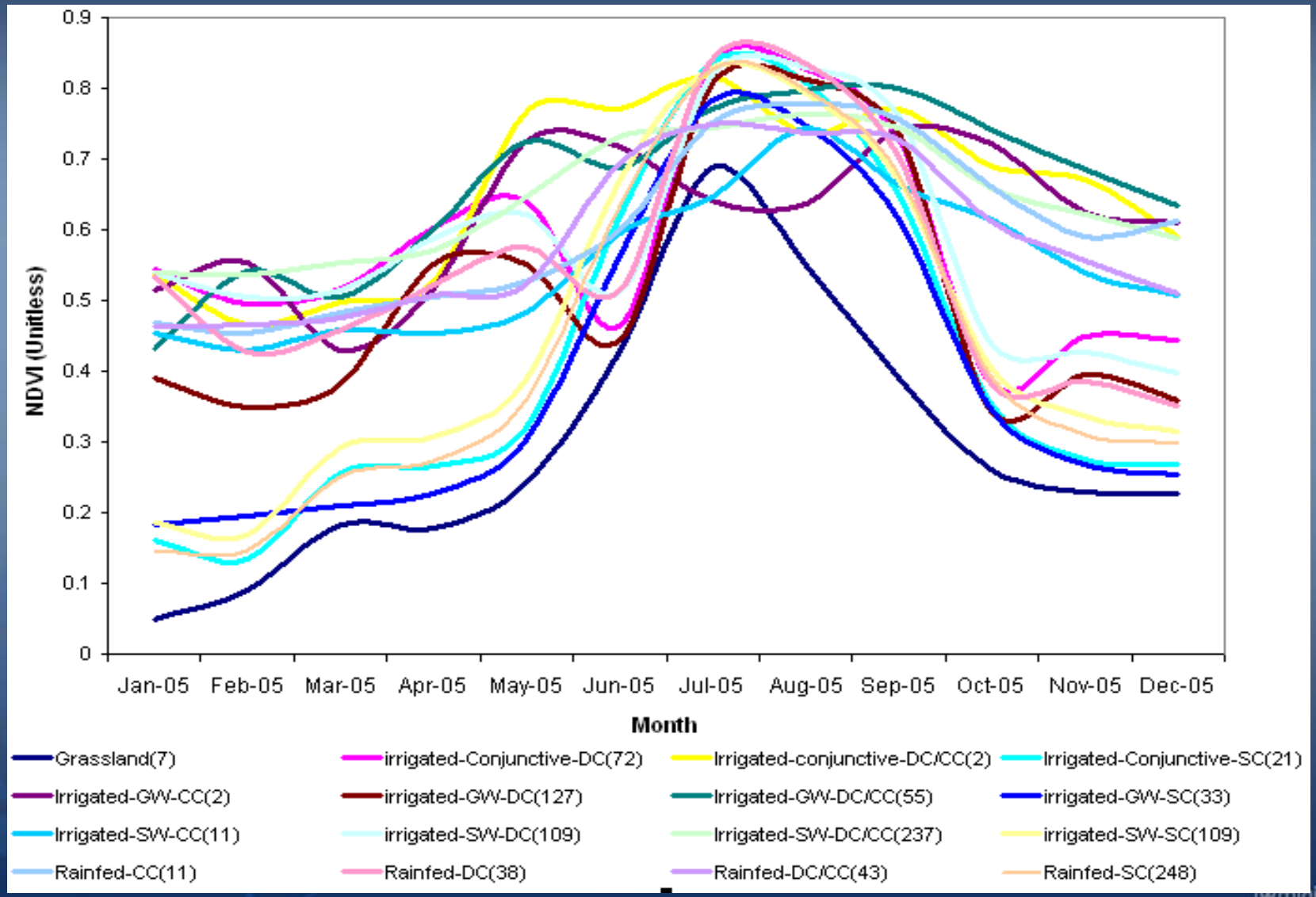


**Aggregated signatures involving 7 distinct classes (see sample sizes in brackets of legend)**

# Use of Ideal Spectral Data Bank (ISDB) on Irrigated Areas

**Example 1: ISDB used in Spectral Matching Techniques (SMTs) to identify and label classes**

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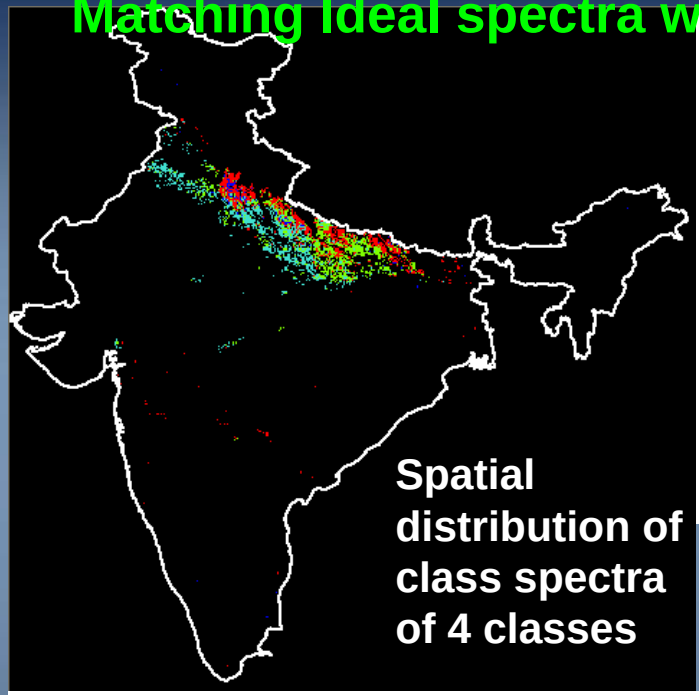
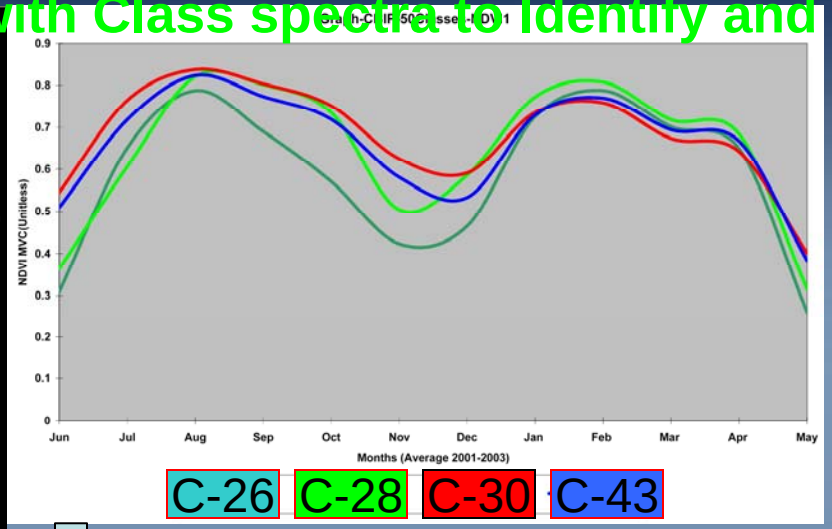
# Use of Ideal Spectral Data Bank (ISDB) on Irrigated Areas

## Matching Ideal spectra with Class spectra to Identify and Label Classes

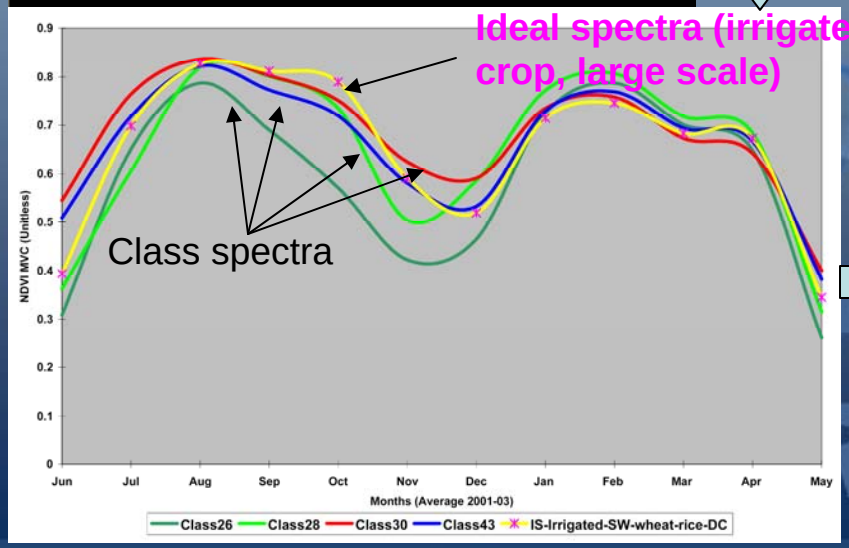


Spatial distribution of class spectra of 4 classes

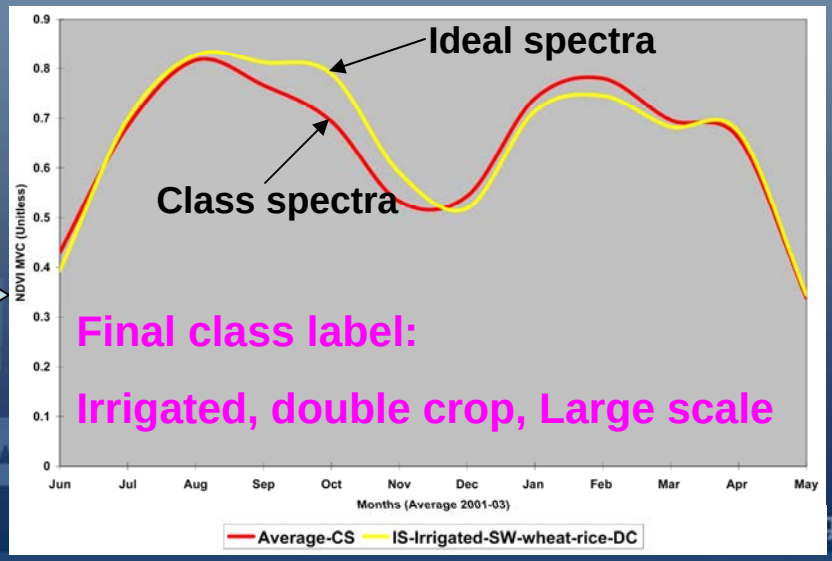



Spectral profile of 4 Classes based on ISOCLASS Clustering

**Note**: "class spectra" are generated through classification (e.g., Isoclass clustering)




Matching Ideal Spectra with individual class spectra's

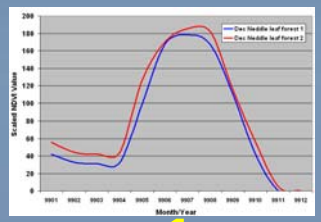



Matching Ideal Spectra with Grouped class spectra's

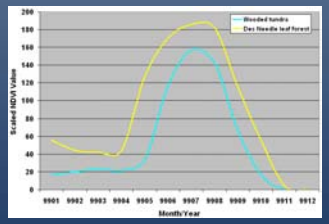
# Use of Ideal Spectral Data Bank (ISDB) on Irrigated Areas

## Matching Ideal spectra with Class spectra to Identify and Label Classes

**QSMTs compare class spectra of one class with class spectra of every other class & determine, quantitatively, similarities and dissimilarities between classes through automated process; facilitates rapid identification of classes.**



1. **Spectral Correlation Similarity (SCS)**
   - a. shape measure
   - b. Values vary between 0 to 1 (theoretically between -1 and +1). Negative values have no meaning here. Ignore.
   - c. Greater the SCS greater is the similarity between class spectra and target spectra



2. **Spectral Similarity Value (SSV)**
   - a. Shape and magnitude measure
   - b. Values vary between 0 to 1.415
   - c. Smaller the SSV value greater the similarity between class spectra and target spectra

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas
# How to Use them in Spectral Matching Techniques

**For reliable, automated, rapid identification and labeling of classes**

Thenkabail, P.S., GangadharaRao, P., Biggs, T., Krishna, M., and Turral, H., 2007. **Spectral Matching Techniques** to Determine Historical Land use/Land cover (LULC) and Irrigated Areas using Time-series AVHRR Pathfinder Datasets in the Krishna River Basin, India. Photogrammetric Engineering and Remote Sensing. 73(9): 1029-1040. (**Second Place Recipients of the 2008 John I. Davidson ASPRS President's Award for Practical papers**).

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# Use of Ideal Spectral Data Bank (ISDB) on Irrigated Areas

## Example 2: ISDB used in Decision Trees to identify and label classes

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# Decision Tree Rules Leading to Unique Groups of Spectra

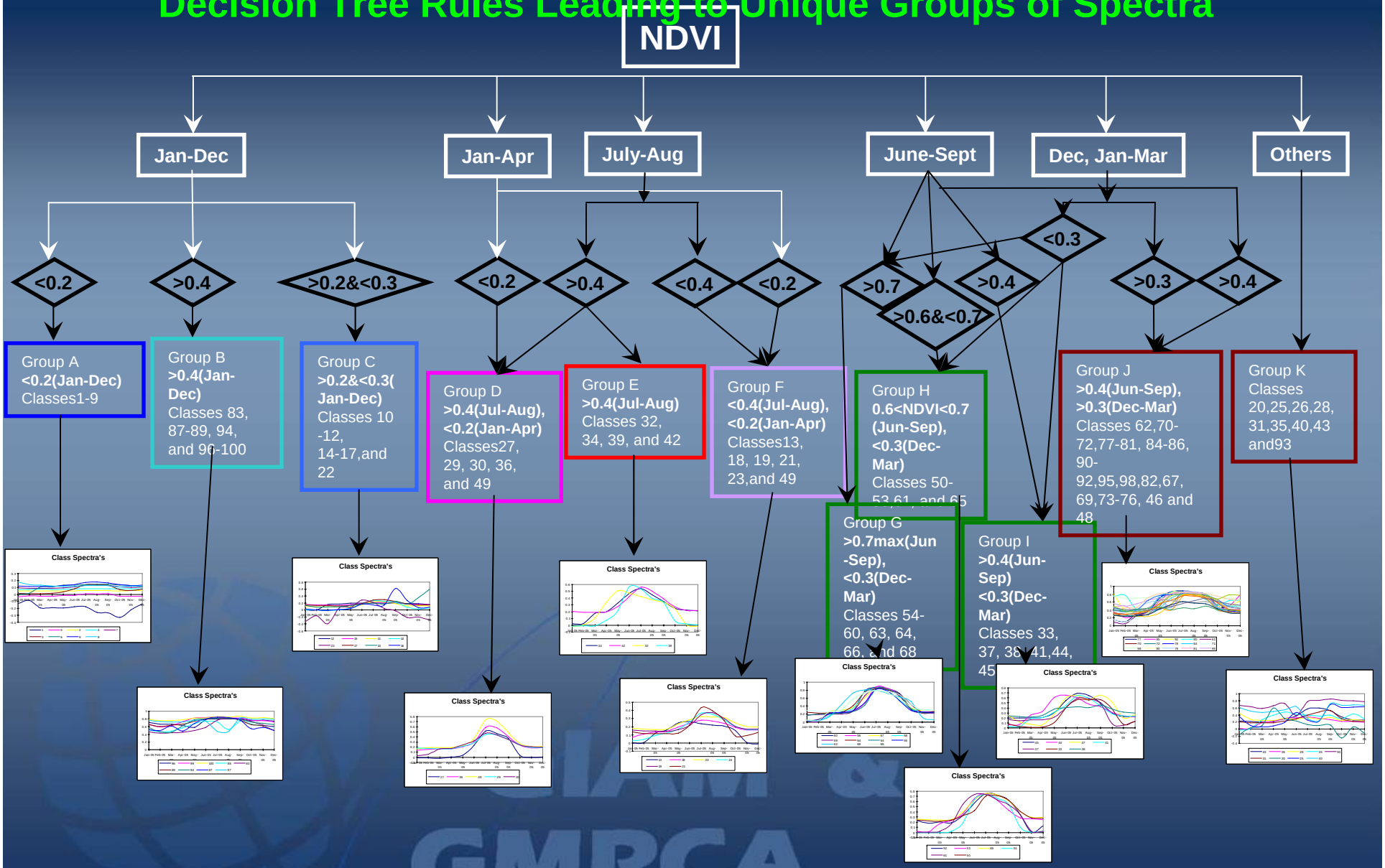


**Figure XX: Decision tree algorithm for resolving 100 classes derived from MODIS 250m data. The MODIS250m time series data of year 2005 was classified and class NDVI spectral signatures plotted. The above decision tree helped to group the classes in to 9 distinct categories.**

# Decision Tree Rules to Split and Group Classes

| Group | | | Condition | Cls | Recode |
|---|---|---|---|---|---|
| Group A | Group A1 | Group A11 | <0.2 (Jan-Dec) &>0.15(Jul-Sep) &<0.18 (Jul-Aug) | 164, 229, 246 | 1 |
| | | Group A12 | <0.2 (Jan-Dec) &>0.15(Jul-Sep) &>0.18,<0.19 (Jul-Aug) | 217, 240 | 2 |
| | | Group A13 | <0.2 (Jan-Dec) &>0.15(Jul-Sep) &>0.19 (Jul-Aug) | 166, 193, 225, 234 | 3 |
| | Group A2 | Group A21 | <0.2 (Jan-Dec) &<0.15(Jun-Sep) &>0.1(Jun-Sep) &<0.13(Jul-Aug) | 178 | 4 |
| | | Group A22 | <0.2 (Jan-Dec) &<0.15(Jun-Sep) &>0.1(Jun-Sep)& >0.13,<0.14(Jul-Aug) | 212, 249, 250 | 5 |
| | | Group A23 | <0.2 (Jan-Dec) &<0.15(Jun-Sep)&>0.1(Jun-Sep)&>0.14(Jul-Aug) | 208, 237, 244 | 6 |
| | Group A3 | | <0.2 (Jan-Dec) &<0.1(Jun-Sep) | 222, 227, 239 | 7 |
| | Group A4 | | <0.2(Jan-Dec)& >0.14(Jul-Aug)&<0.15(Sep)&>0.11(Oct) | 195, 198, 210 | 8 |
| | Group A5 | | <0.2(Jan-Dec)&>0.1(Jul-Aug)&<0.11(Sep) | 190, 248 | 9 |
| Group B | Group B1 | Group B11 | >0.4 (Jan-Dec) &>0.8(Jul-Aug) &<0.5(Mar) | 36, 37, 43, 46-49, 51, 54, 56, 58, 60, 64, 67, 69 | 10 |
| | | Group B12 | >0.4 (Jan-Dec)&>0.8(Jul-Aug)&>0.5(Mar) | 7, 9, 15, 19, 22, 29, 31,32, 39 | 11 |
| | Group B2 | | >0.4 (Jan-Dec) &<0.81(Jul) &<0.5(Jan-Mar) | 35, 44, 62, 63, 72, 76, 77, 79, 86, 89, 92, 98 | 12 |
| | Group B3 | Group B31 | >0.4(Jan-Dec) &<0.815(Jul)& >0.5(Jan)<0.65(Dec) | 5, 16, 21, 25-27, 34, 38, 40, 41, 57, 59, 65, 74 | 13 |
| | | Group B32 | >0.4(Jan-Dec) &<0.815(Jul)& >0.5(Jan)>0.65(Dec) | 10, 12, 14, 17, 20, 24 | 14 |
| Group C | Group C1 | | >0.4 (Jul-Aug) &<0.4(Sep-Jun)&<0.2(Nov-Dec) | 196, 207, 218 | 15 |
| | Group C2 | | >0.4 (Jul-Aug) &<0.4(Sep-Jun) &>0.2(Nov-Dec)&>0.22(Nov) | 2, 113, 169, 171, 177, 181 | 16 |
| | Group C3 | | >0.4 (Jul-Aug) &<0.4(Sep-Jun)) &>0.2(Nov-Dec)&,0.22(Nov) | 175, 184, 187, 197, 201, 209, 226 | 17 |
| Group D | Group D1 | Group D11 | <0.3 (Nov-Jun)&<0.4(Jul-Sep)&>0.2(Jul-Sep)&>0.1(Nov-Dec) &<0.25(Jul) | 127, 152, 154, 174, 232, 241, 242 | 18 |
| | | Group D12 | <0.3 (Nov-Jun)&<0.4(Jul-Sep)&>0.2(Jul-Sep)&>0.1(Nov-Dec) &>0.25(Jul)&<0.3(Jul) | 137, 140, 144, 149, 176, 188, 200, 203, 205, 206, 216, 220, 223, 230, 236, 243, 247 | 19 |
| | | Group D13 | <0.3 (Nov-Jun)&<0.4(Jul-Sep)&>0.2(Jul-Sep)&>0.1(Nov-Dec) &>0.3(Jul) | 118, 132, 135, 157, 159, 192, 202, 204, 211, 213, 214, 221, 224, 228, 231, 238 | 20 |
| | Group D2 | | <0.3 (Nov-Jun)&<0.4(Jul-Sep)&>0.2(Jul-Sep)&<0.1(Nov-Dec) | 245 | 21 |
| Group E | Group E1 | Group E11 | >0.4(Apr-Nov)&<0.4(Feb)&>0.65(Jul-Aug)&<0.6(Jun) | 93, 103, 105, 108 | 22 |
| | | Group E12 | >0.4(Apr-Nov)&<0.4(Feb)&>0.65(Jul-Aug)&>0.6(Jun)&<0.7(Jun) | 23, 68, 73, 78, 83-85, 87, 88, 90, 91, 96, 97, 99, 101 | 23 |
| | | Group E13 | >0.4(Apr-Nov)&<0.4(Feb)&>0.65(Jul-Aug)&>0.7(Jun) | 28, 42, 45, 52, 53, 61, 66, 70, 71, 75, 80, 82 | 24 |
| | Group E2 | | >0.4(Apr-Nov)&<0.4(Feb) &<0.65(Jul-Aug) | 81 | 25 |
| Group F | Group F1 | Group F11 | >0.4(Jul-Sep)&<0.4(Apr) >0.5(Jun-Sep)&<0.6(Sep) | 33,112,114-117,119,124-126,129,134,136,138,139,141,143,145,148,153,165 | 26 |
| | | Group F12 | >0.4(Jul-Sep)&<0.4(Apr) >0.5(Jun-Sep)&>0.6(Sep) | 11,13,18,50,55,94,95,100,102,104,106,107,109,110,111,121,122,128,131 | 27 |
| | Group F2 | Group F21 | >0.4(Jul-Sep)&<0.4(Apr) >0.5(Jul-Aug)&<0.5(Jun)&<0.55(Aug) | 6, 123, 130, 142, 156, 162, 163, 182, 185, 199 | 28 |
| | | Group F22 | >0.4(Jul-Sep)&<0.4(Apr) >0.5(Jul-Aug)&<0.5(Jun)&>0.55(Aug) | 120, 133, 146, 150, 151, 155, 158, 160, 167, 168, 172, 179, 189 | 29 |
| | Group F3 | | >0.4(Jul-Sep)&<0.4(Apr)&<0.5165(Jul-Aug)&>0.3(Nov-Dec) | 30 | 30 |
| | Group F4 | | >0.4(Jul-Sep)&<0.4(Apr)&<0.5165(Jul-Aug)&<0.3(Nov-Dec) | 161, 170, 173, 180, 191, 194 | 31 |
| Group G | | | >0.2(Sep-Jun)&<0.2 (Jun-Sep) | 147, 183, 186, 215, 219, 233, 235 | 32 |
| Group H | Group H1 | | >0.2(Aug,Oct-Dec) &<0.4(Aug,Oct-Dec) &>0.4(Sep) | 1 | 33 |
| | Group H2 | | >0.2(Aug,Oct-Dec) &<0.4(Aug,Oct-Dec) &<0.4(Sep) | 3, 4, 8 | 34 |

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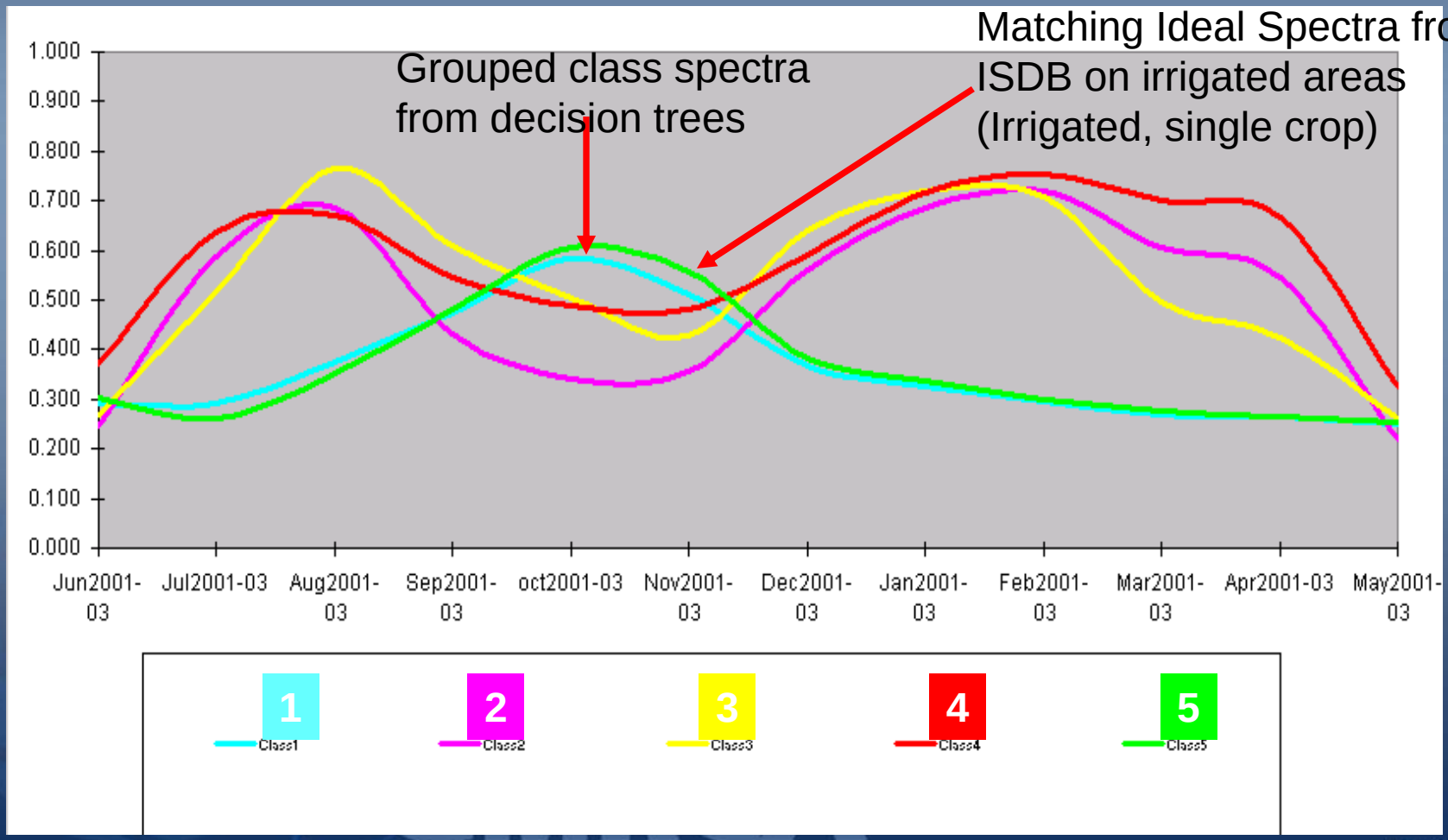

# Conclusions

# Ideal Spectral Data Bank (ISDB) for Irrigated Areas

## Conclusions

1. Need and value of ISDB for irrigated areas (similarly for other studies) has been highlighted;
2. ISDB on irrigated areas for China and India developed using time-series MODIS and AVHRR data is available with us and is comprehensive (but not released since it is ongoing research);
3. ISDB on irrigated areas will be used to map irrigated areas of the World using Landsat 30m Data in fusion with MODIS 250\500m time-series.