The California-Baja California Border Region, Water Related Remote Sensing Applications.

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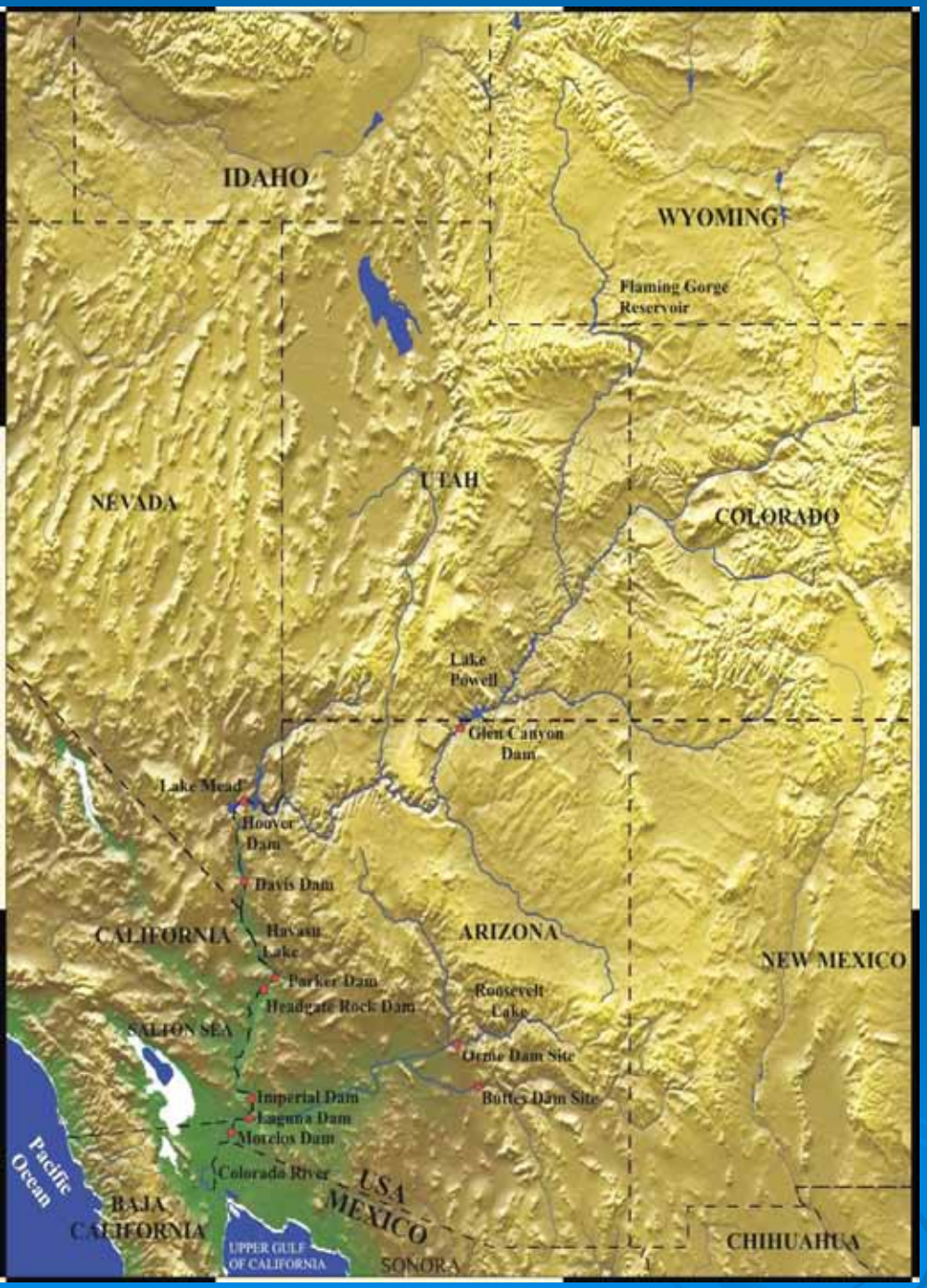
Present 3 stories

- Colorado River Delta, a Landsat perspective of Inundated areas
- Water Bodies in Ca-BC Peninsular Range Draining to the Pacific, detection and measurement
- April 4th 2010 M7.2 earthquake, effects though remote sensing data and techniques

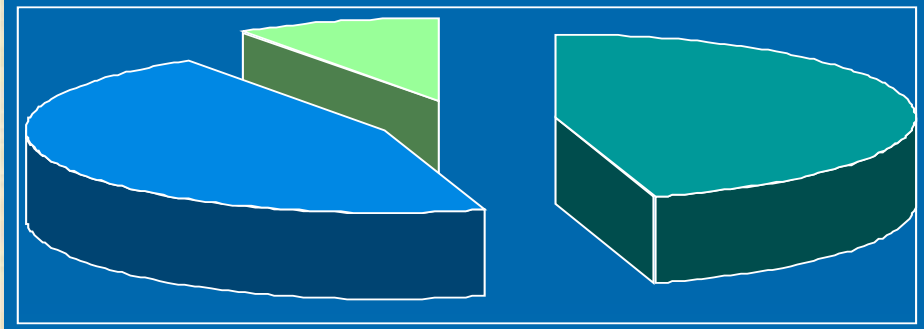
Landsat Perspective of Colorado River Delta

- Inundated areas(1972-2002) in the Colorado river (CR) delta and relation with flow US->Mex

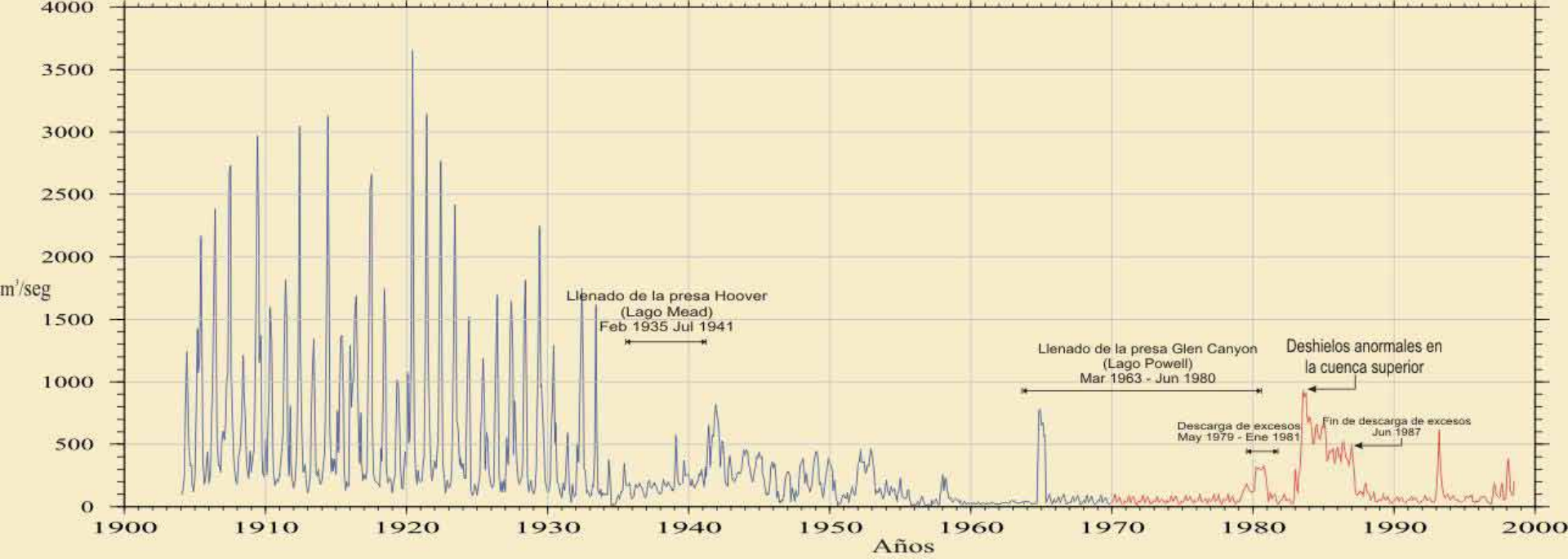
Colorado River Water allocation



Mexico
9%
1.5 MAF / 1,851 Mm^3

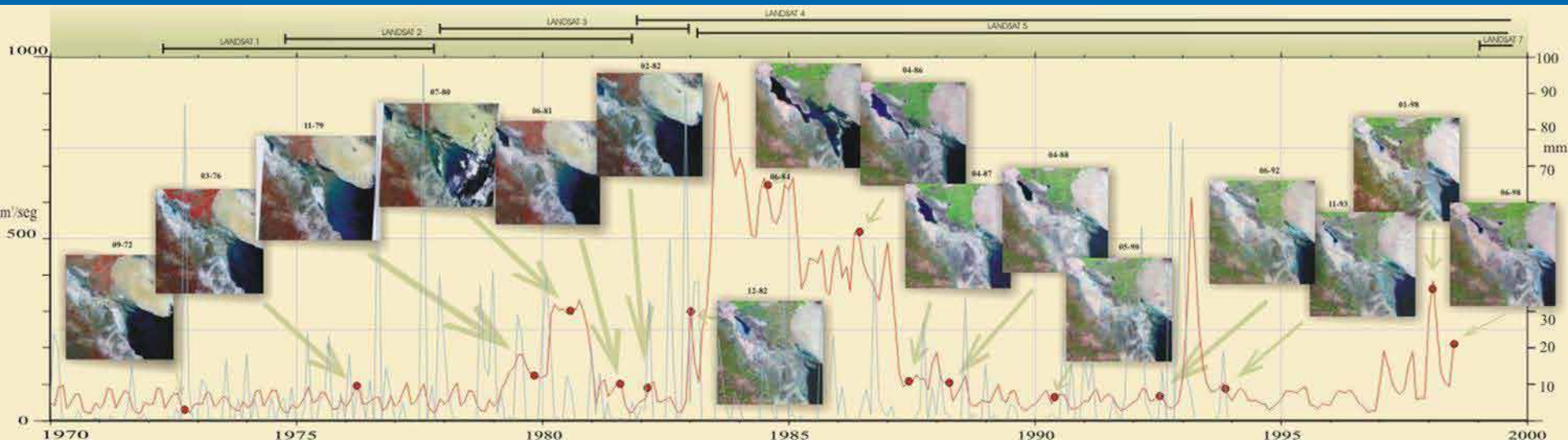


U.S. Lower/Upper Basins
45% each
7.5 MAF / 9,251 Mm^3



Flujo de agua del río Colorado a través de la frontera Estados Unidos - México. Datos para 1904 - 1949 de Yuma (Arizona), y para 1950 - 1998 de la Presa Morelos (fuentes: Yuma, USGS; Presa Morelos, CILA - CONAGUA).

US->MEX CR Flow under Landsat Record



Landsat images used

250 Landsat previews 1972-2002
Assemble contemporal mosaics
Delineate water bodies

Landsat Scenes 84-06

Date	Path/Rows
13 April 1984 24 May 1990 3 Jun 2002 * 25 Aug 2006	38/37-38, 38/38*
06 June 1984 25 May 1990 23 April 2002 * 9 May 2005 17 Sep 2006	39/37-38, 39/38 *
1 May 1988 ! 2 April 1989 * 31 Oct 1999 ! 24 April 2000 14 April 2005 08 Sep 2006	40/37-38 40/37 * 40/38 !

1984 Flood
1990 Drought

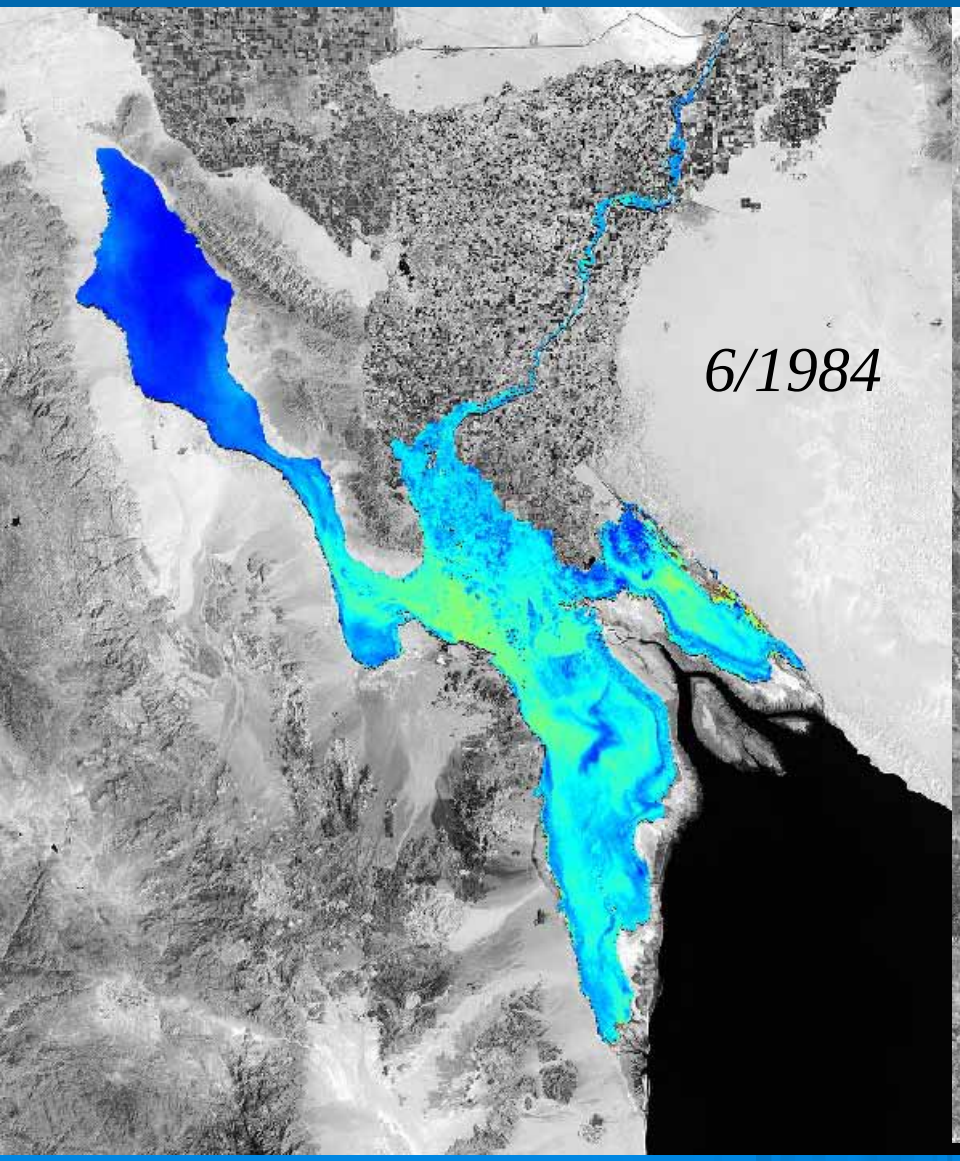
Colorado River Delta 1985

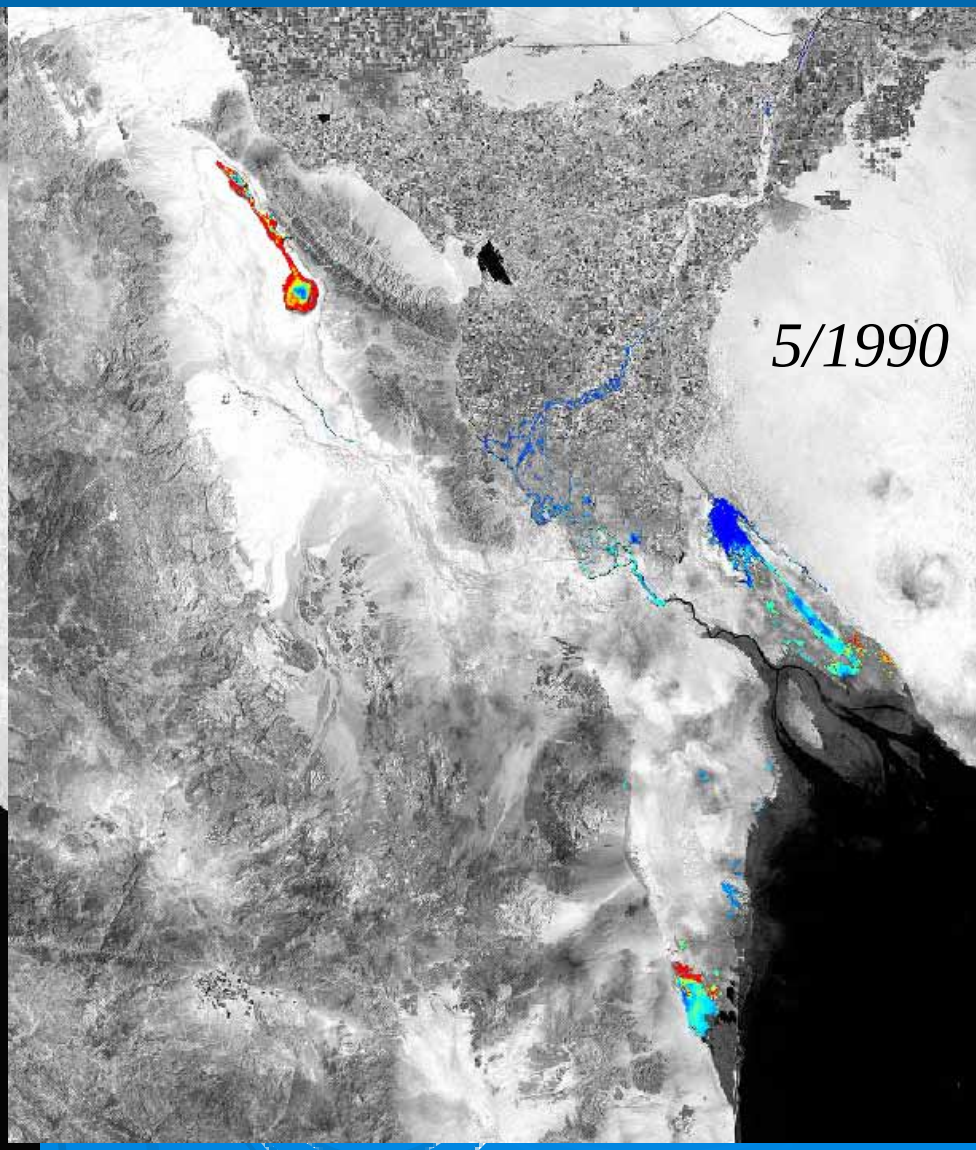
mosaic from previews

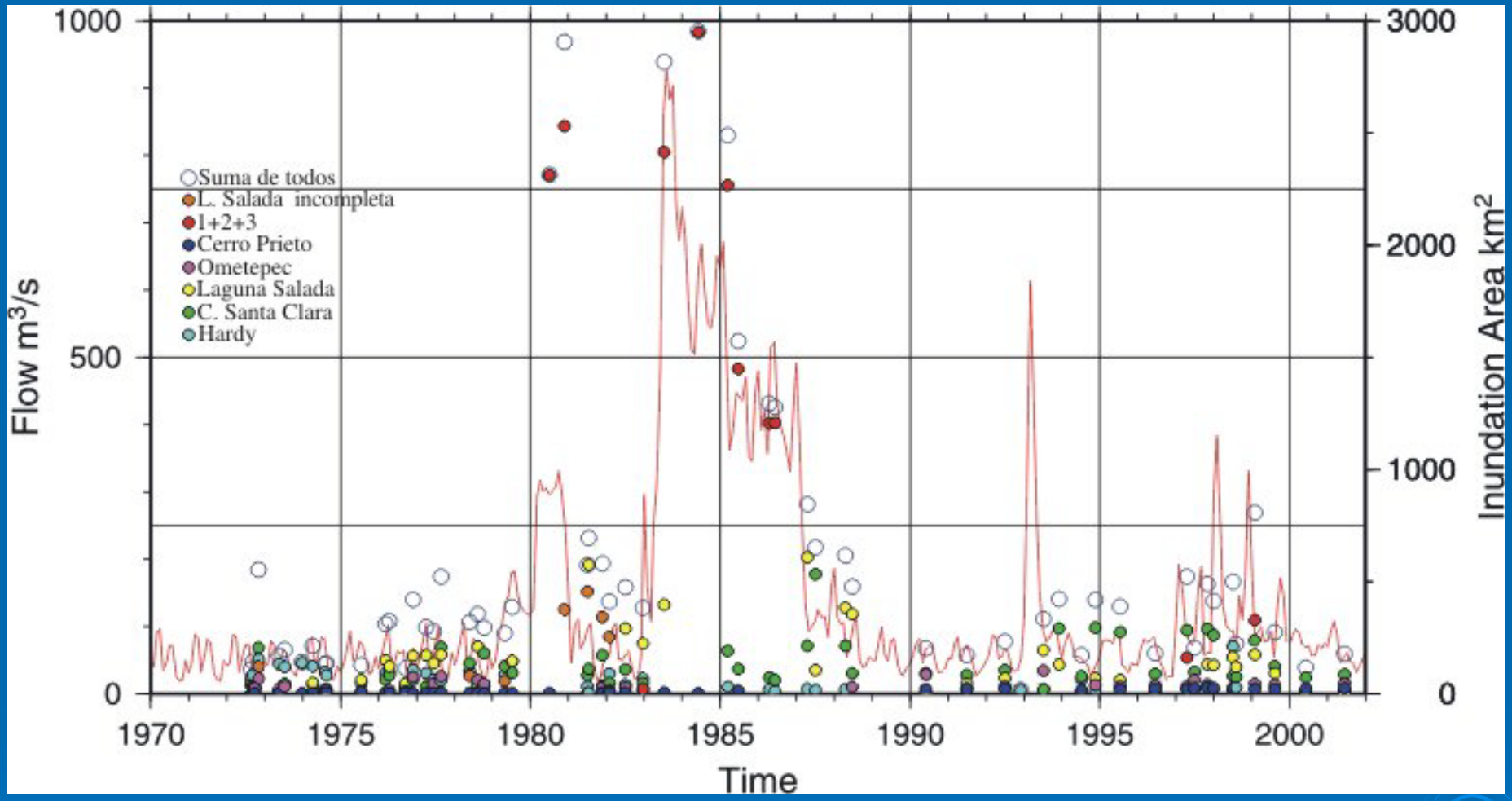
- *Laguna Salada*
- *Cerro Prieto*
- *S. Ometepec*
- *C. Sta. Clara*
- *Rio Hardy*

CR delta extreme cases

water detection with TM band 5

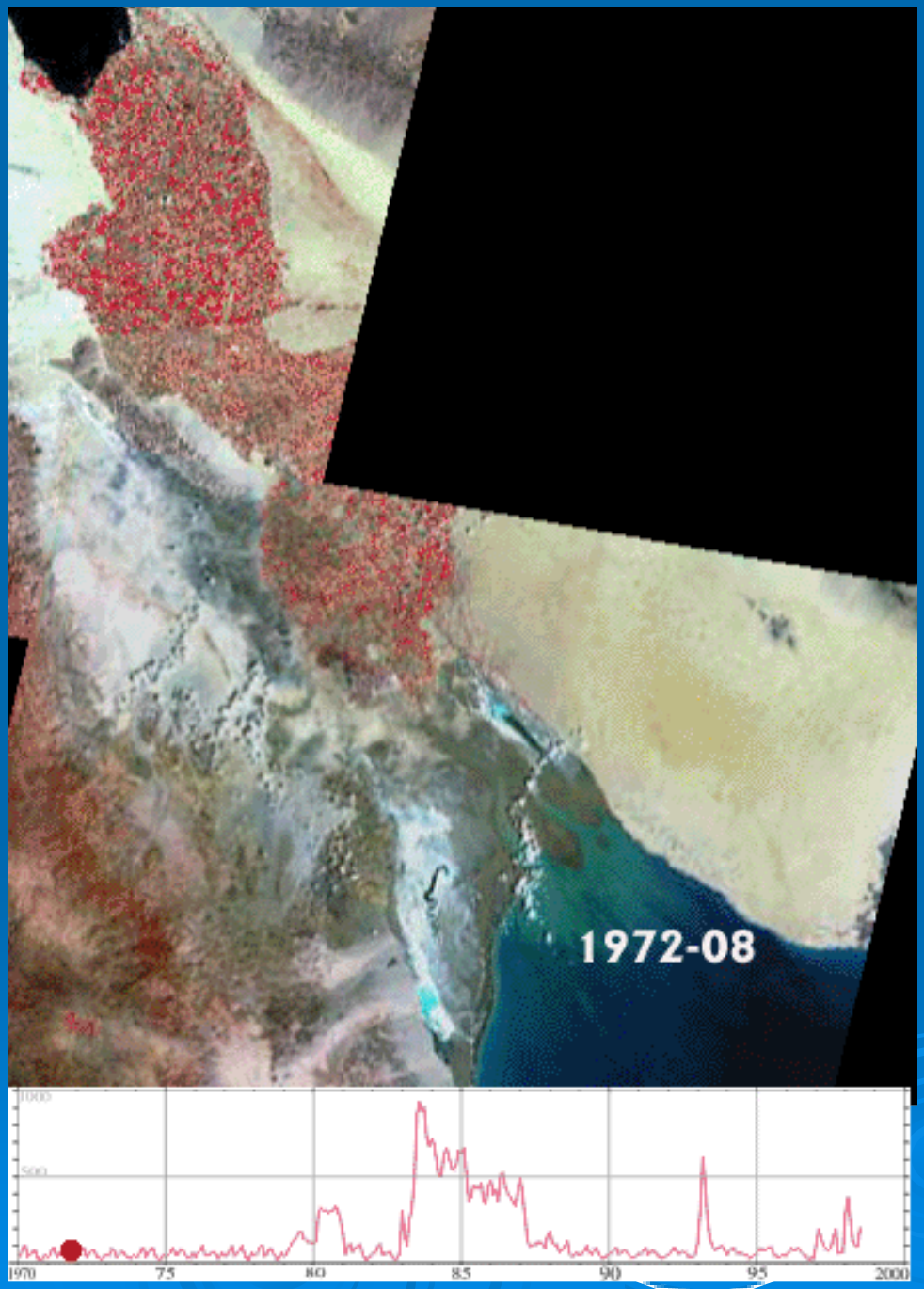






Colorado River flow record U.S.A => México 1970-2002 and areal extent of inundation of wetlands

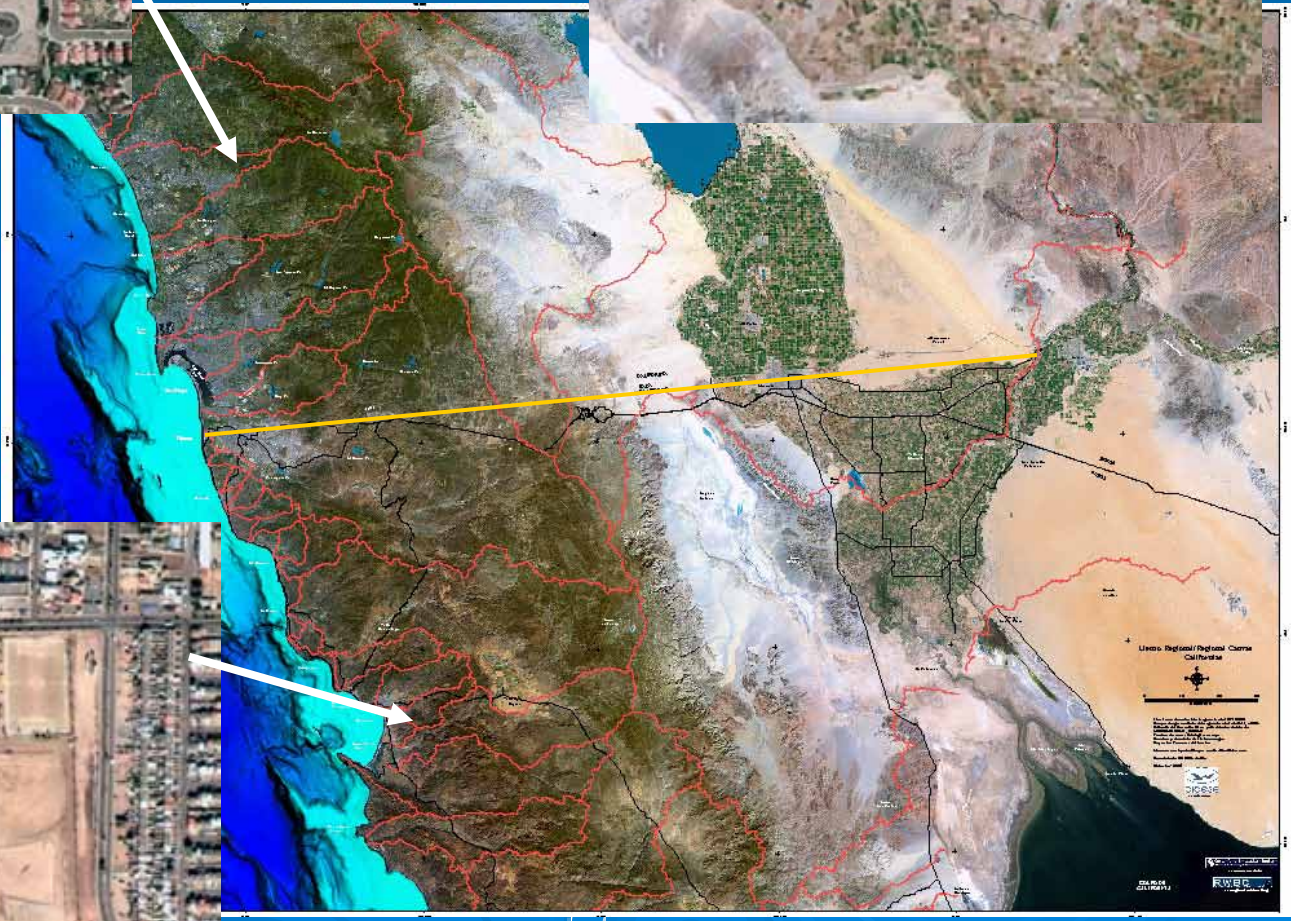
Delta
1972-2002



Water Bodies(WB) in Peninsular Ranges draining to the Pacific, detection and measurement

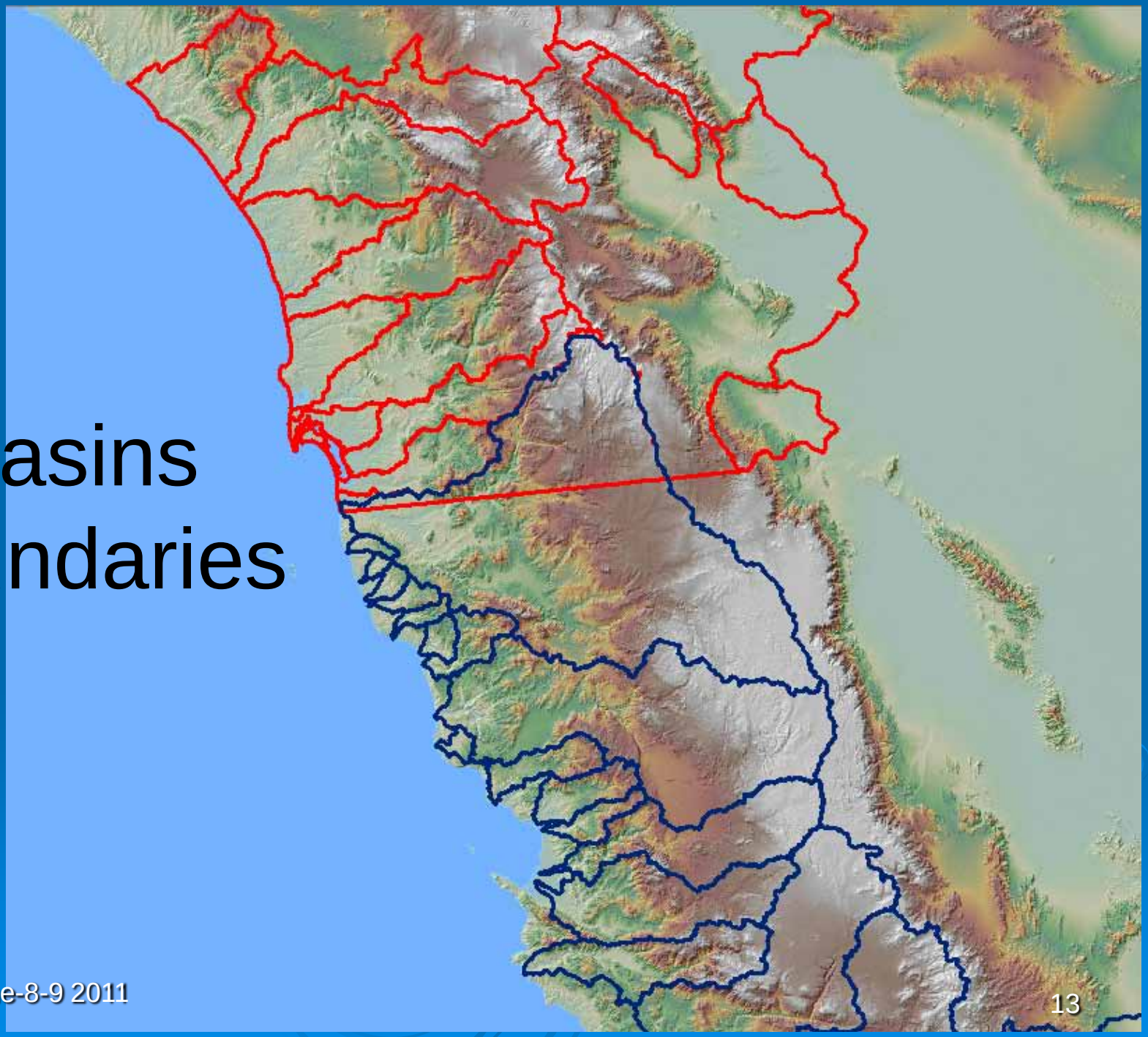
- Dataflow (process) to detect WB based on water absorption/reflective properties of water under Landsat TM spectral bands (band 5; 1.55-1.75 μm)
- Atenuate the effects of false WB detections due to terrain/cloud shadows
- Test WB detection and areal estimation on Landsat TM images 1984,1990, 2000, 2005 and 2006.

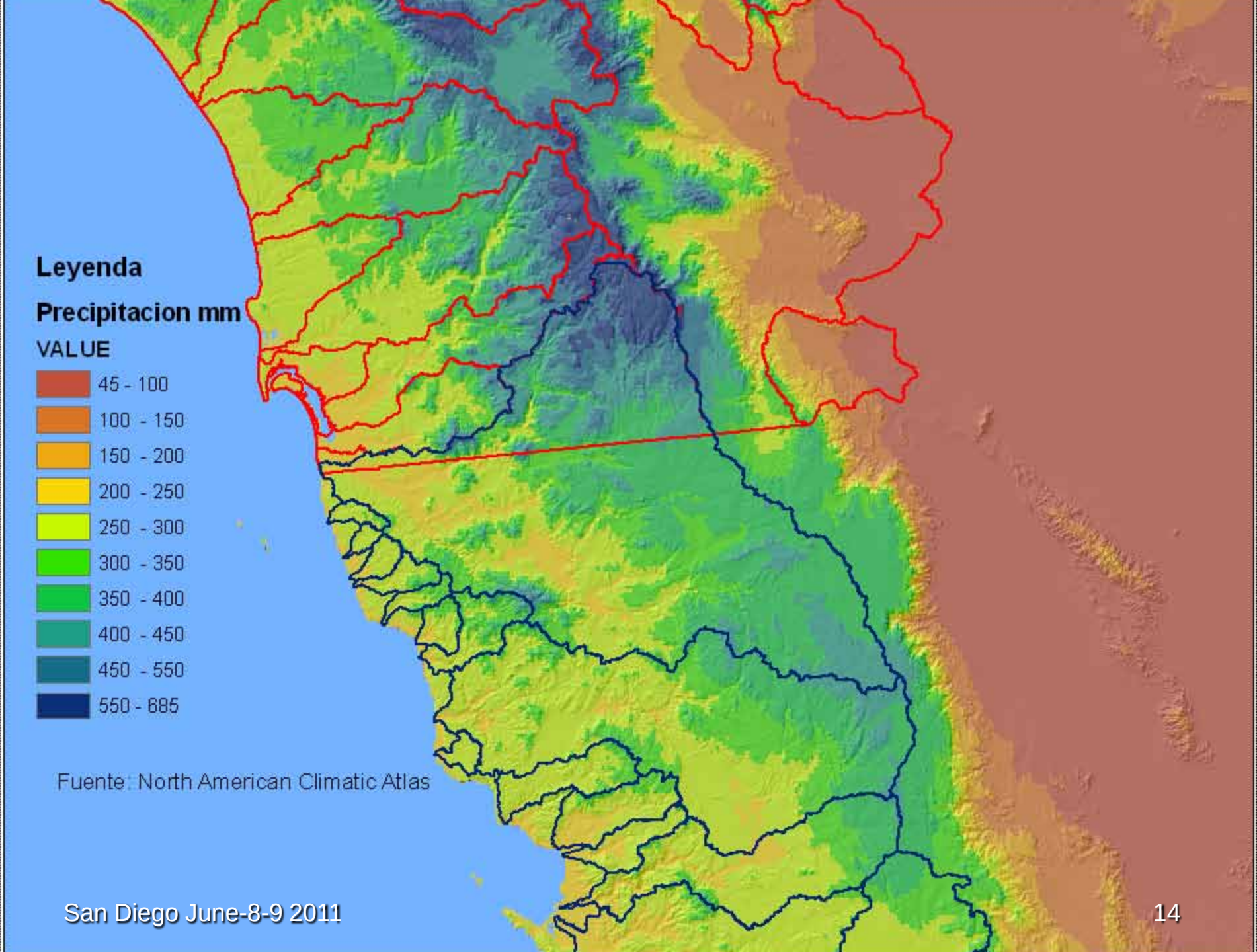
Ca-BC Region



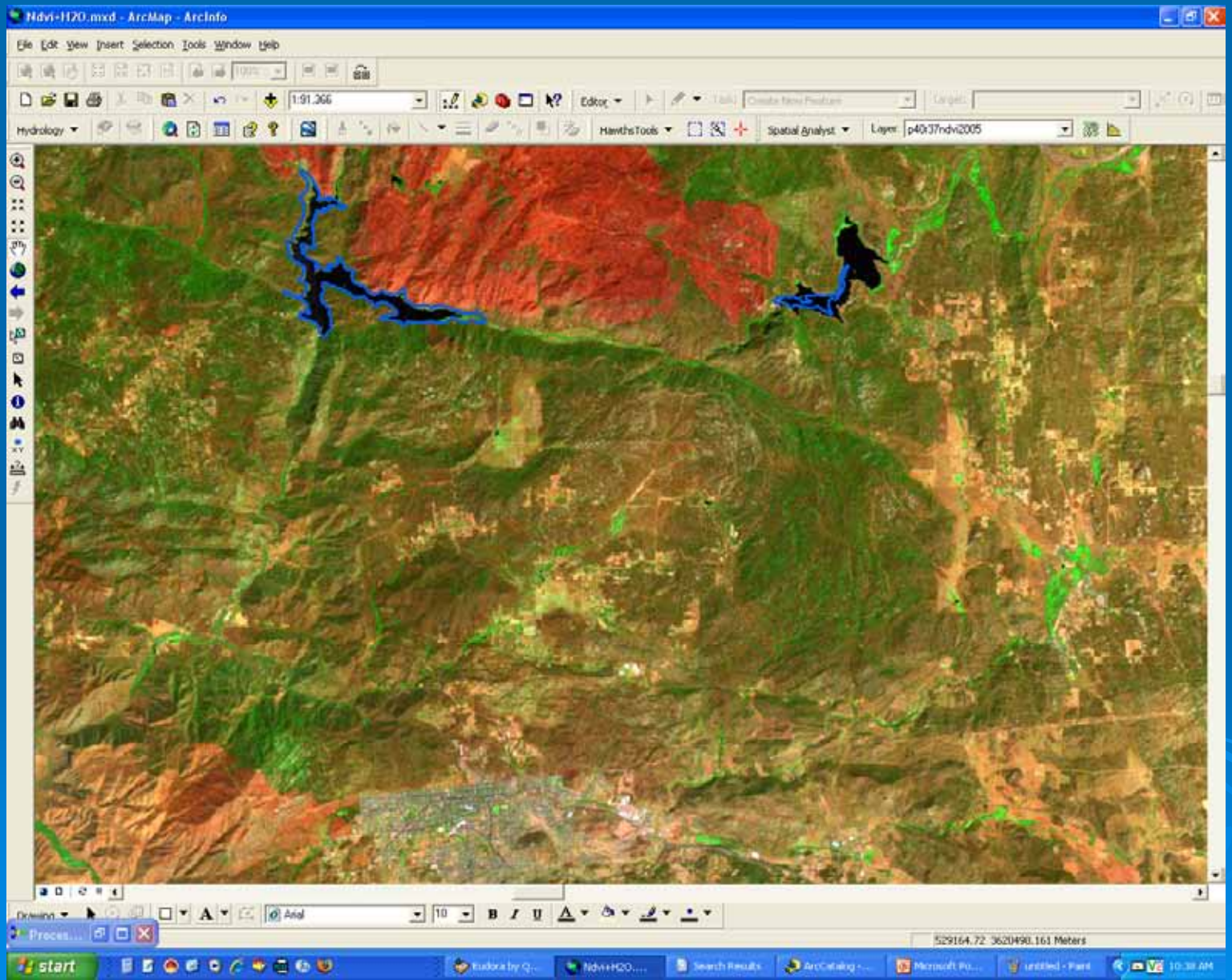
San Diego June-8-9 2011

Basins Boundaries

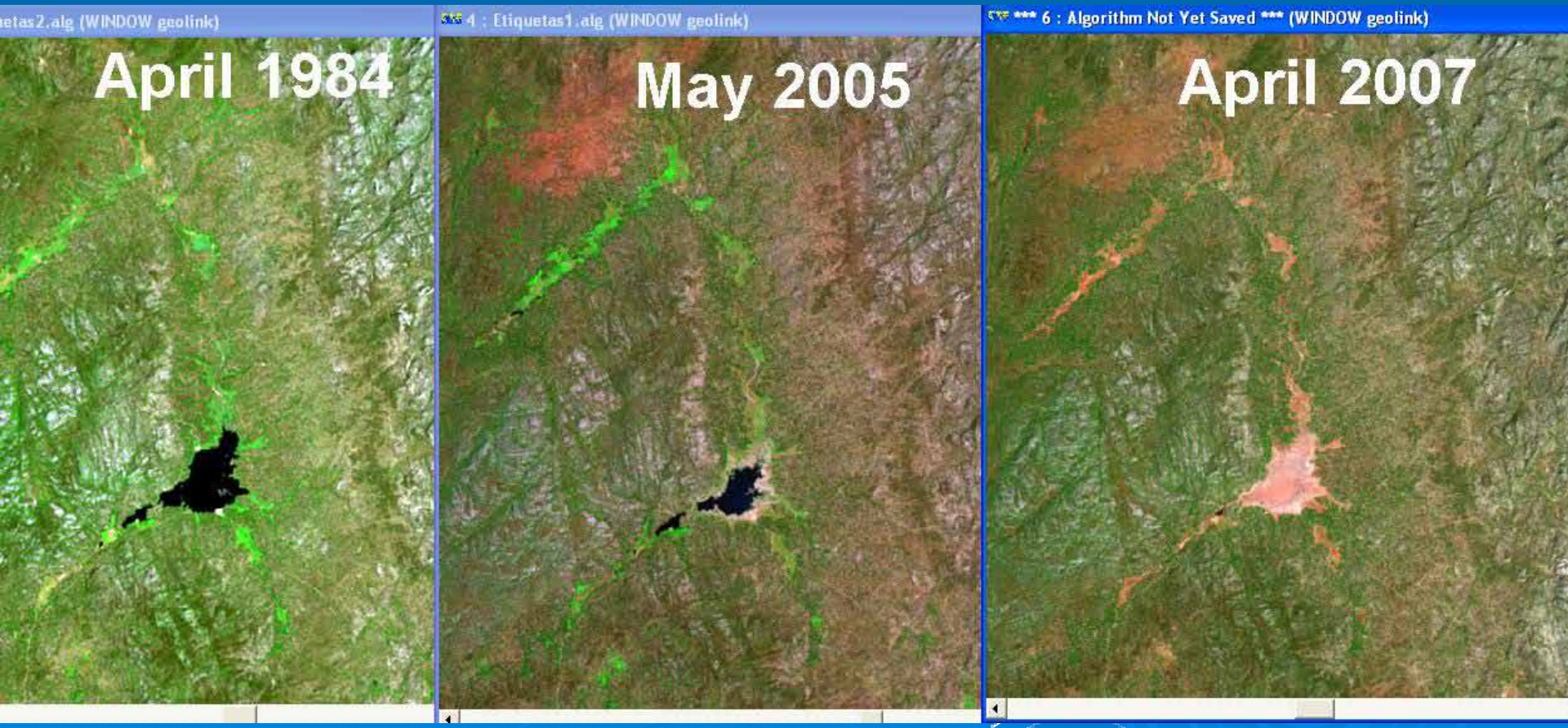



Leyenda
Precipitacion mm
VALUE
45 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
350 - 400
400 - 450
450 - 550
550 - 685
Fuente: North American Climatic Atlas

Polígonos cuerpos agua y límites de cuencas

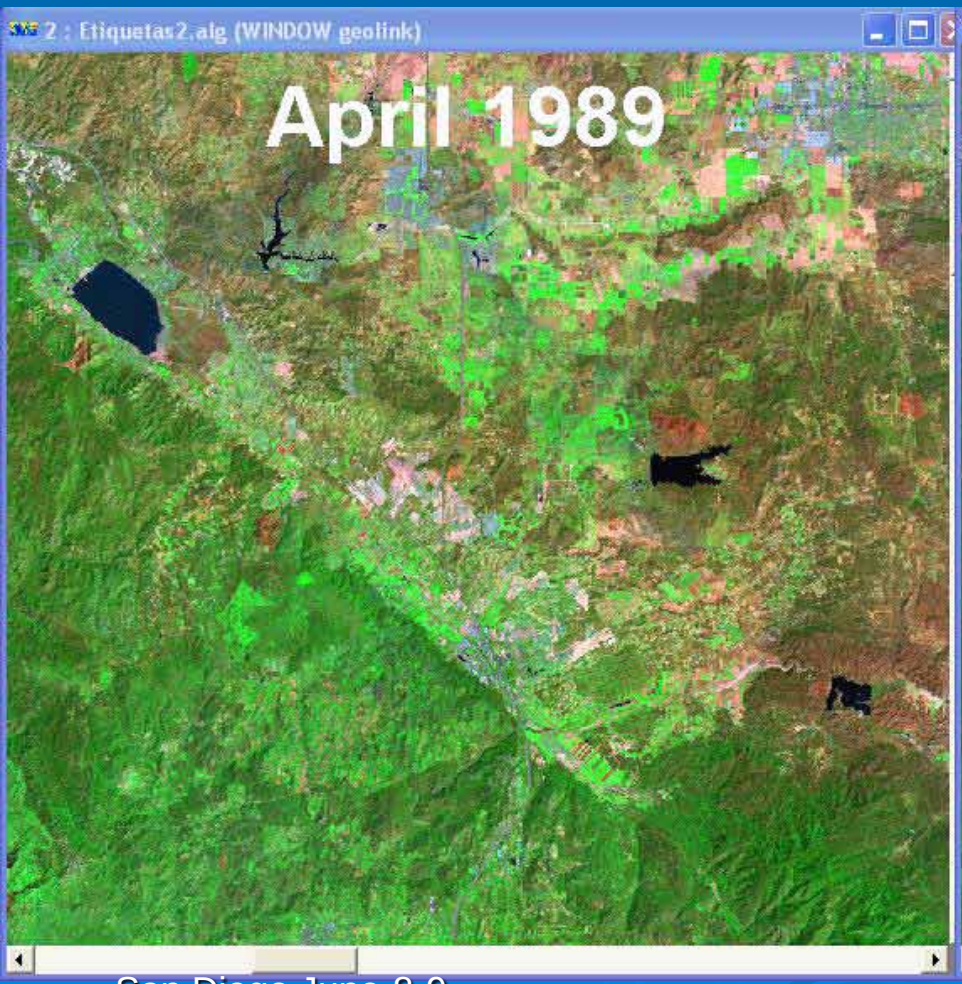


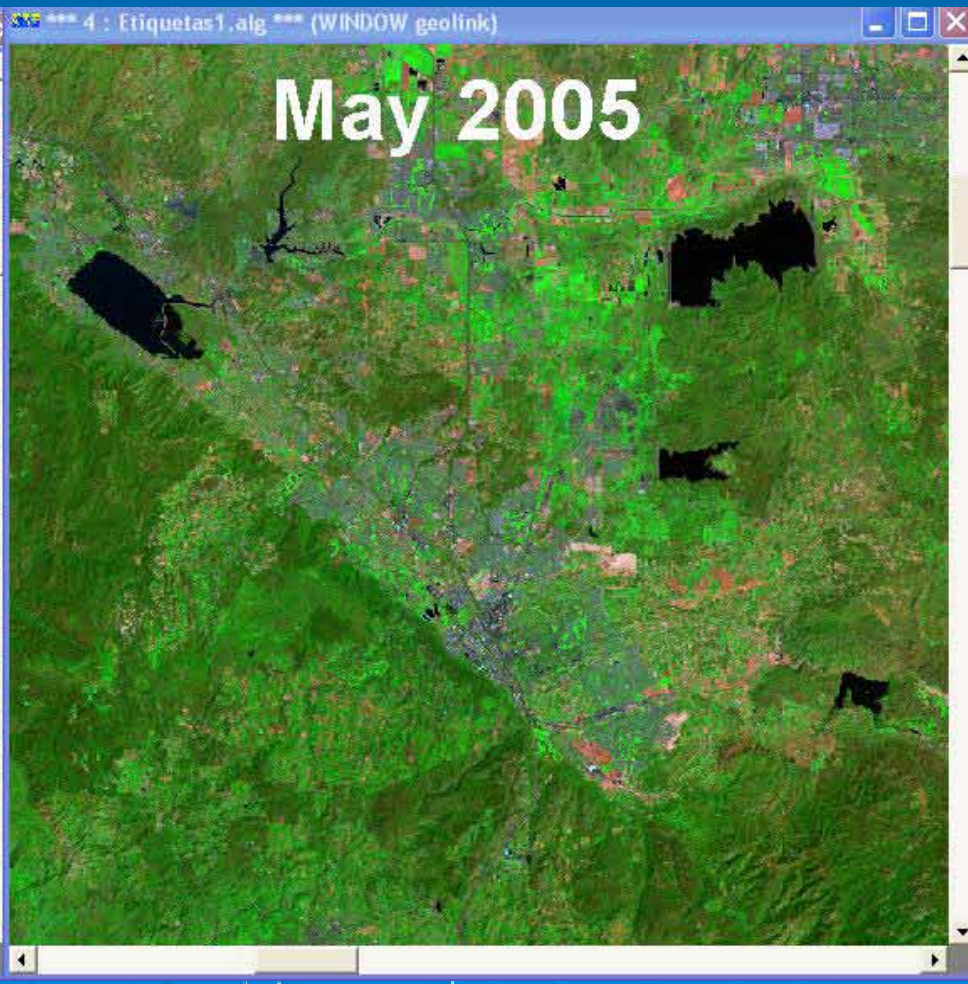
Laguna Hanson, Sierra Juarez



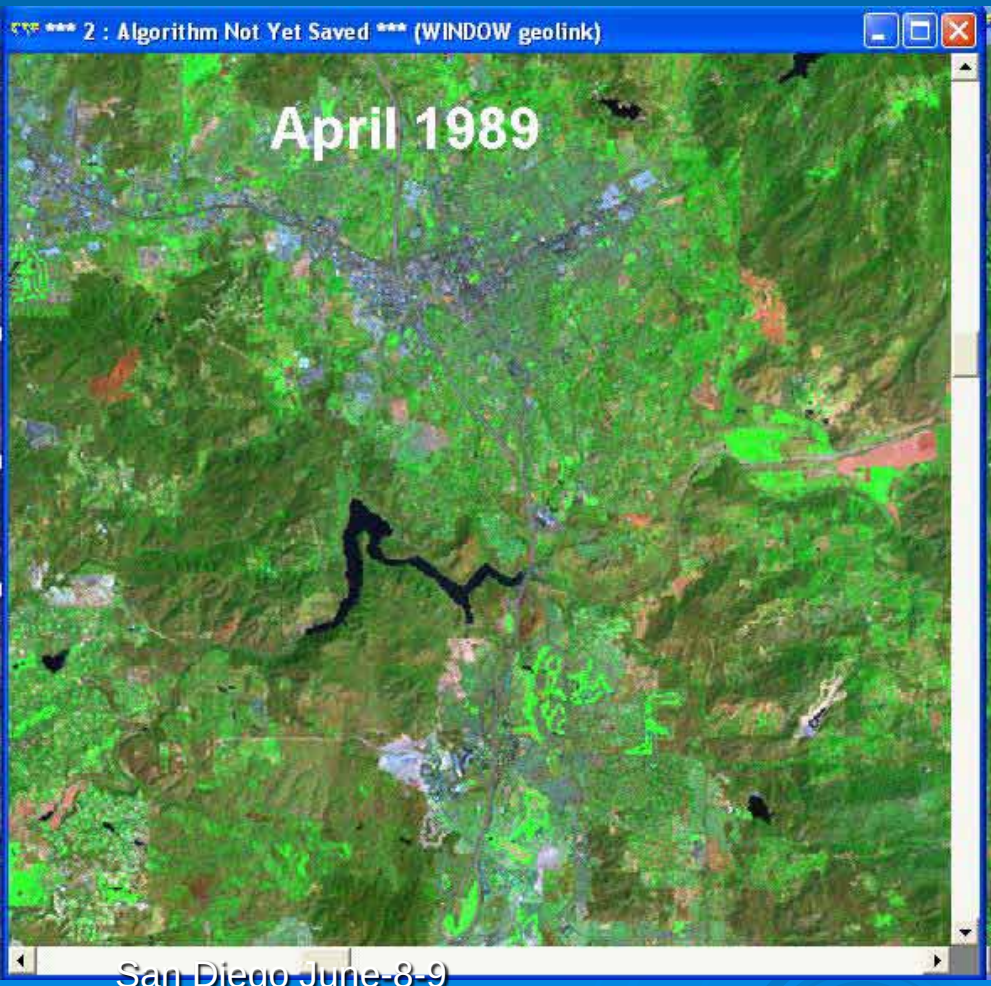
Presa Abelardo Rodríguez, Tijuana

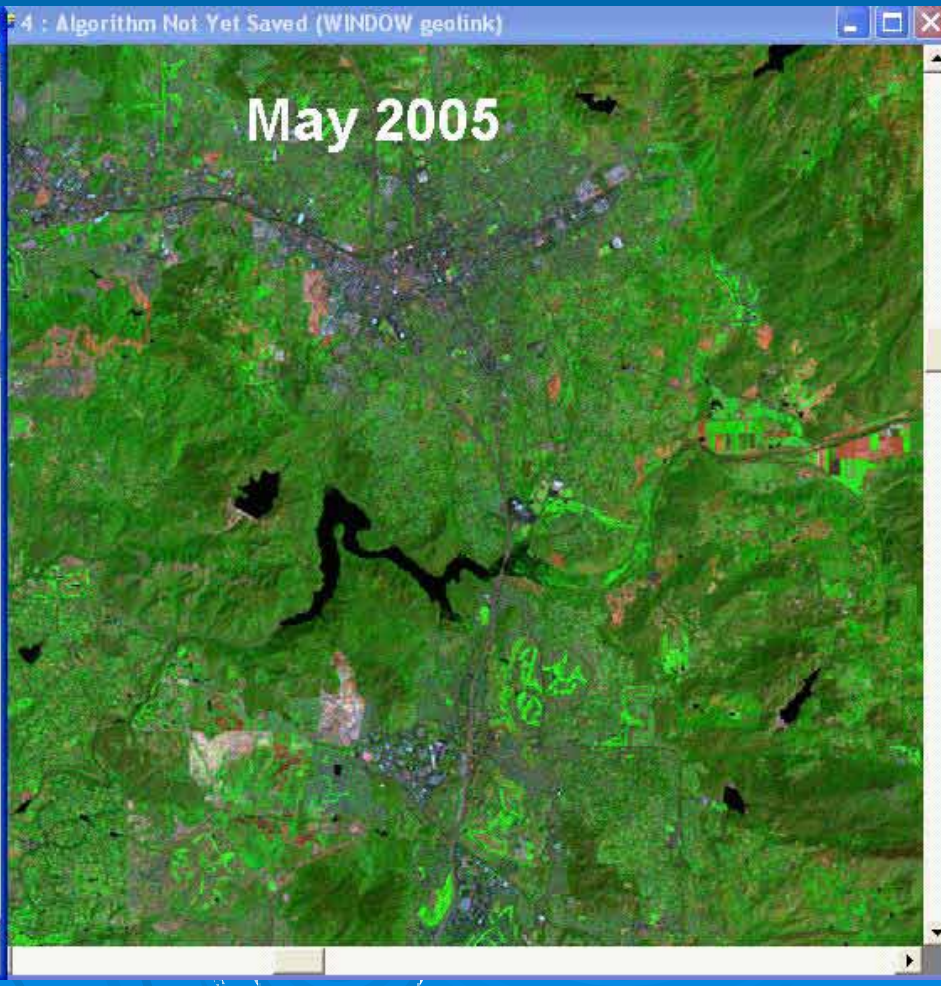
Diamond Valley Lake, Ca.



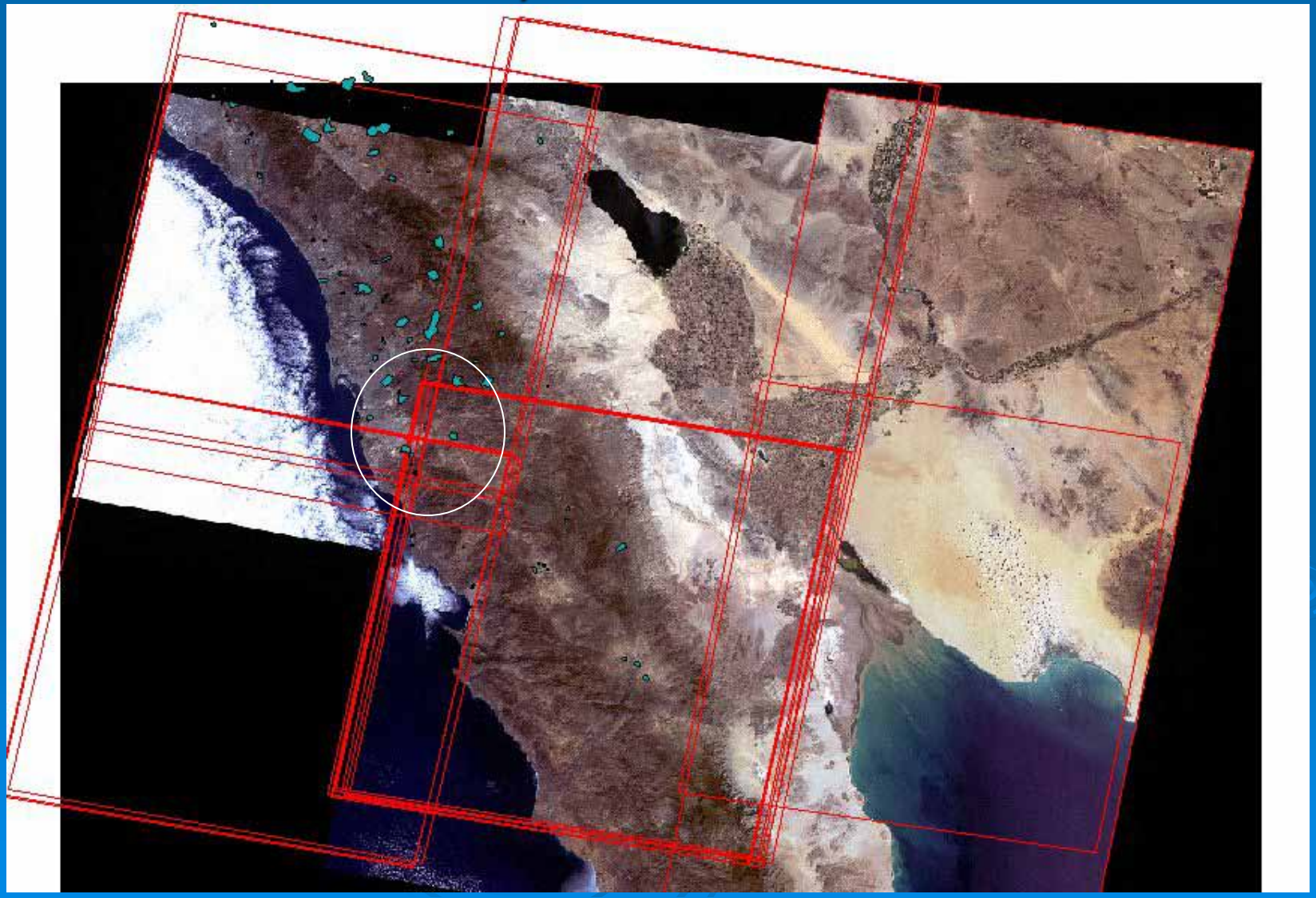


Olivenhein Reservoir, Ca.



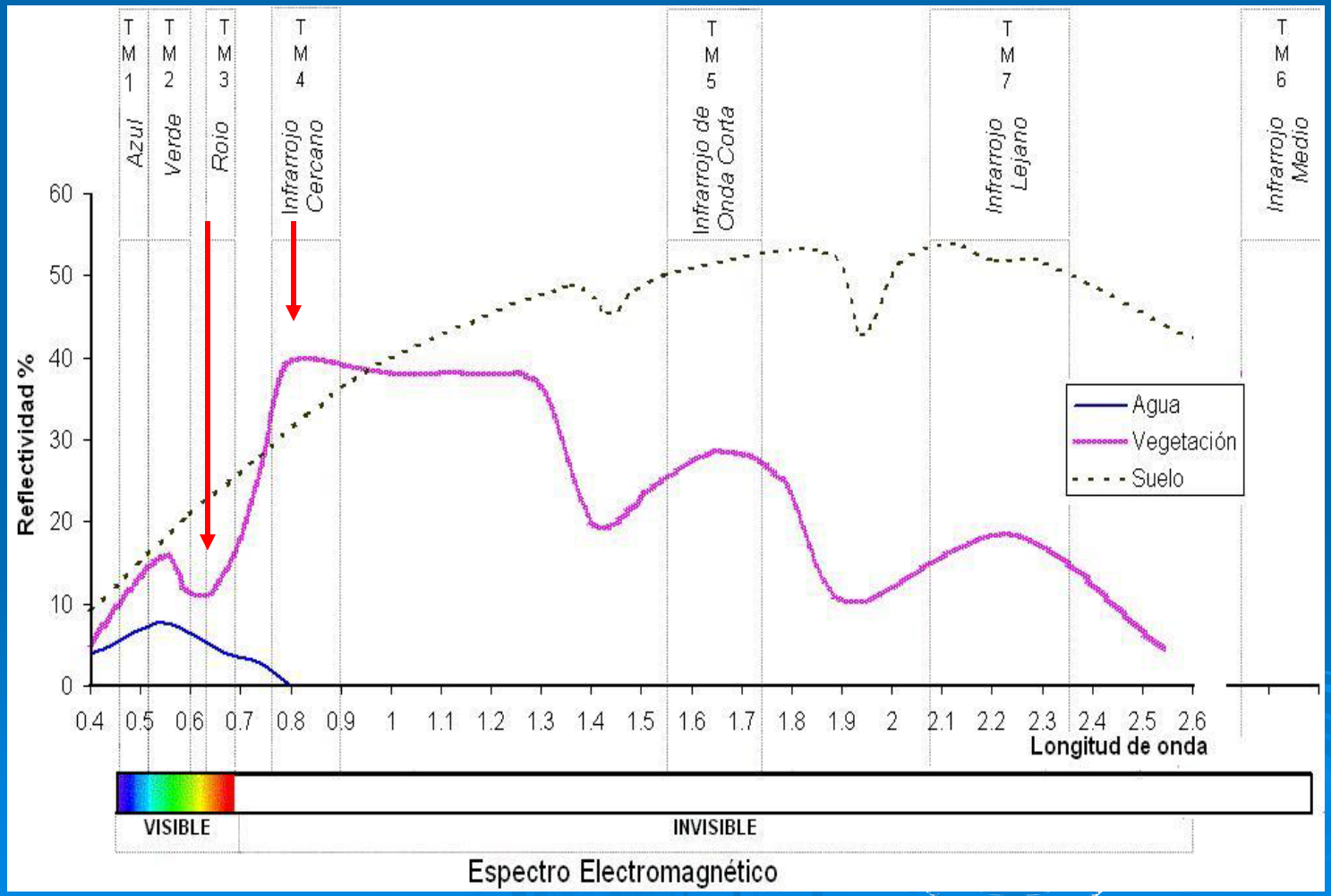


Water bodies in mountain range draining to the Pacific from Landsat TM Images(1984-2007) 17 scenes



Landsat TM spectral bands

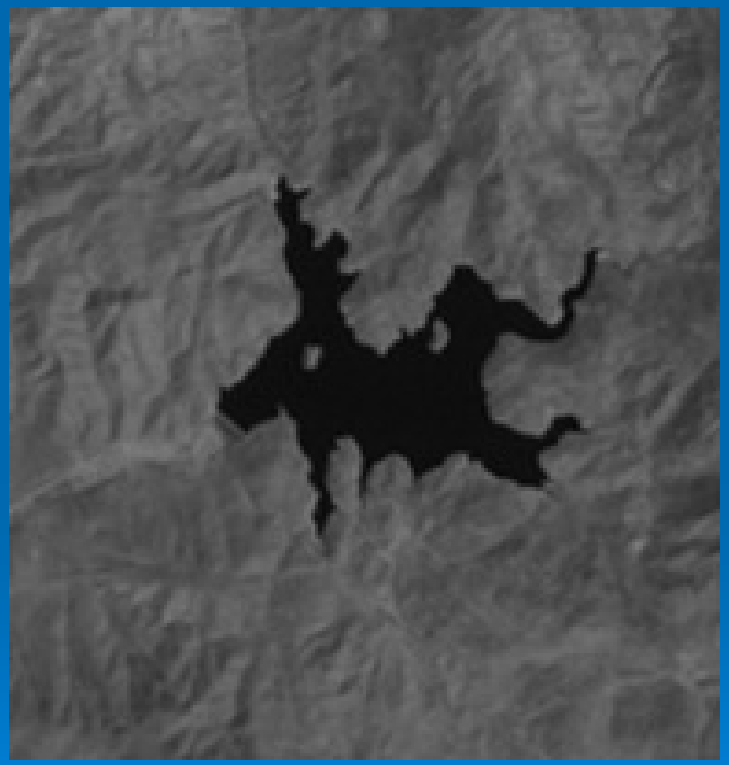
Vegetation and water have a distinctive energy reflective/absorption properties

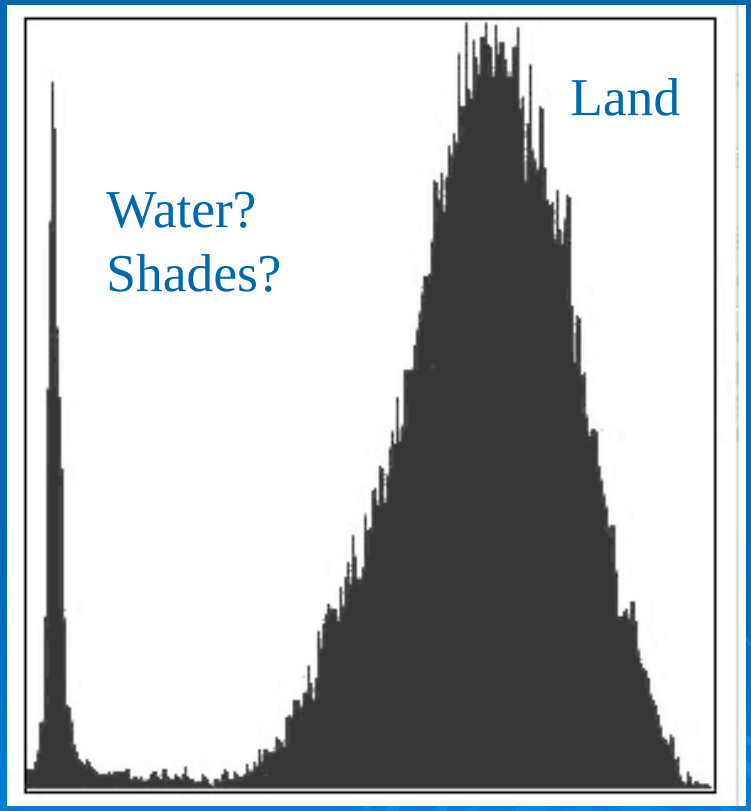


Histogram of B5 Presa El Carrizo

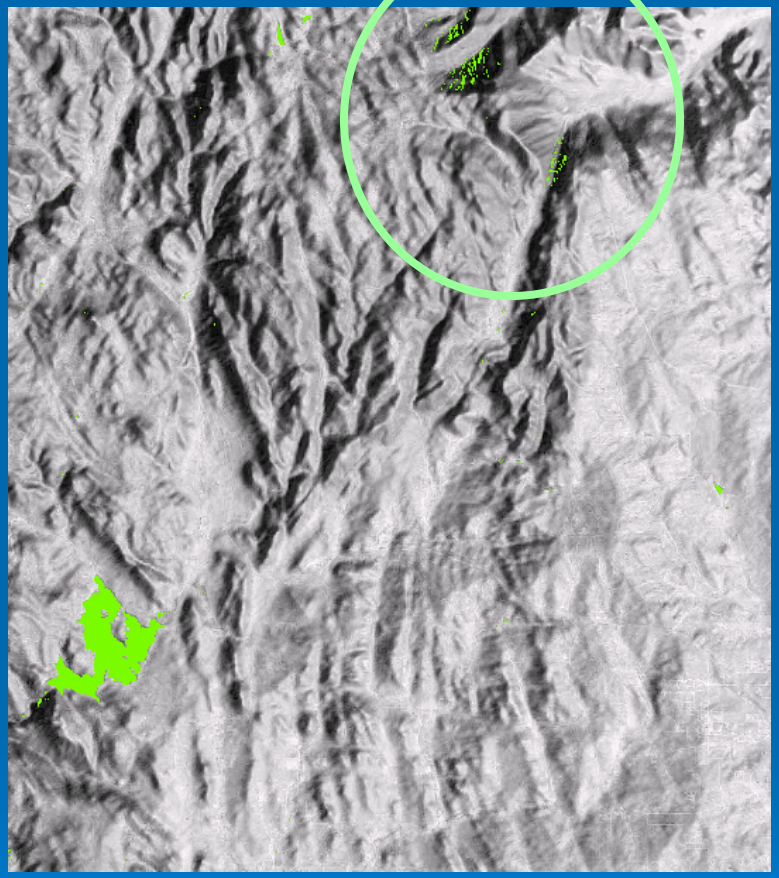
If B5 < Threshold

then WATER (First approach)

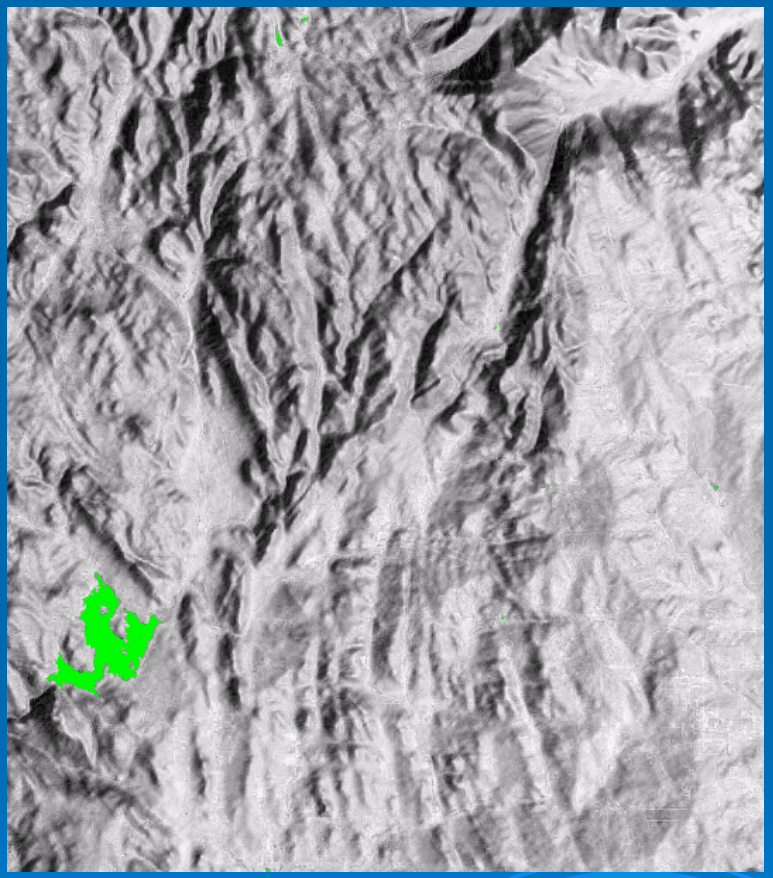




Segmenting
Band 5 vs. Band ratio 5/1

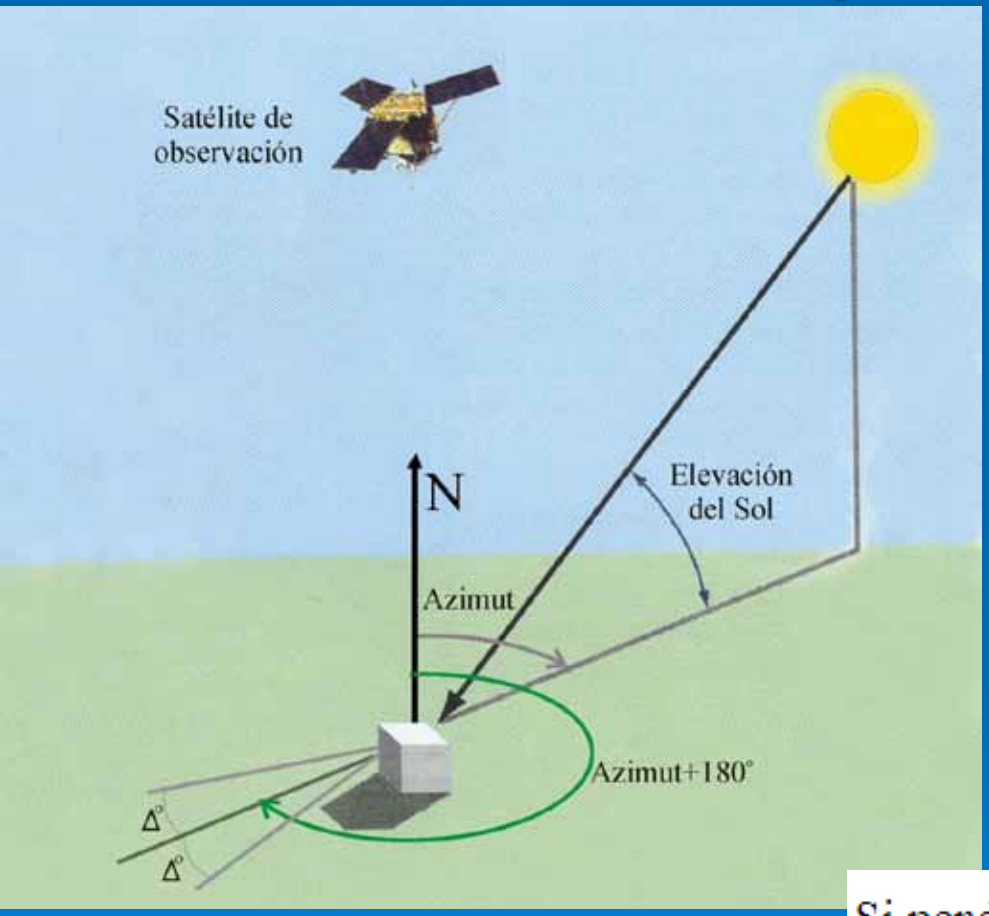


Morena lake detected with B5



Morena lake detected with a B5/B1

Shades prediction on images based on Sun position



Sombras producidas por relieve o nubes producen firma similar al agua en la banda 5 (gran absorción).

• Para cada imagen conocemos la posición del sol.

•Se acentúa el efecto en imágenes de otoño e invierno

Podemos inferir sombras por relieve utilizando

• Elevación y azimut del Sol
• Modelo digital de elevacion SRTM

Si pendiente es > umbral pendiente
y aspecto es $(\text{Azimut} + 180°) \pm \Delta°$
Entonces posible zona productora de Sombra

General Algorithm to infer shades and WB

Shaded Areas prediction(DEM, Sun's Azimuth & Elevation)

IF SLOPE > SlopeThreshold

AND ASPECT between (Azimut +180º) ± D° (30..45°)

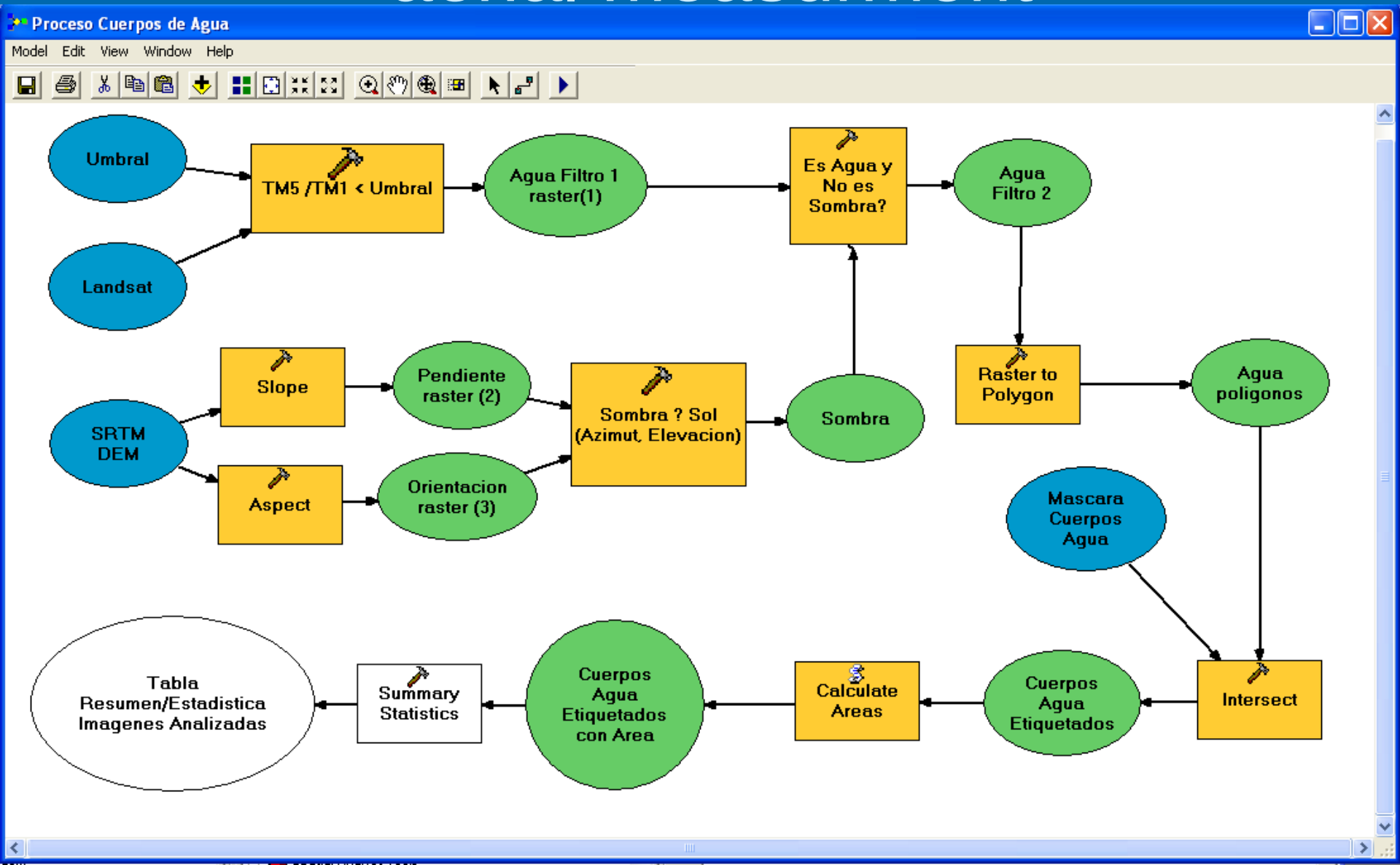
THEN SHADE

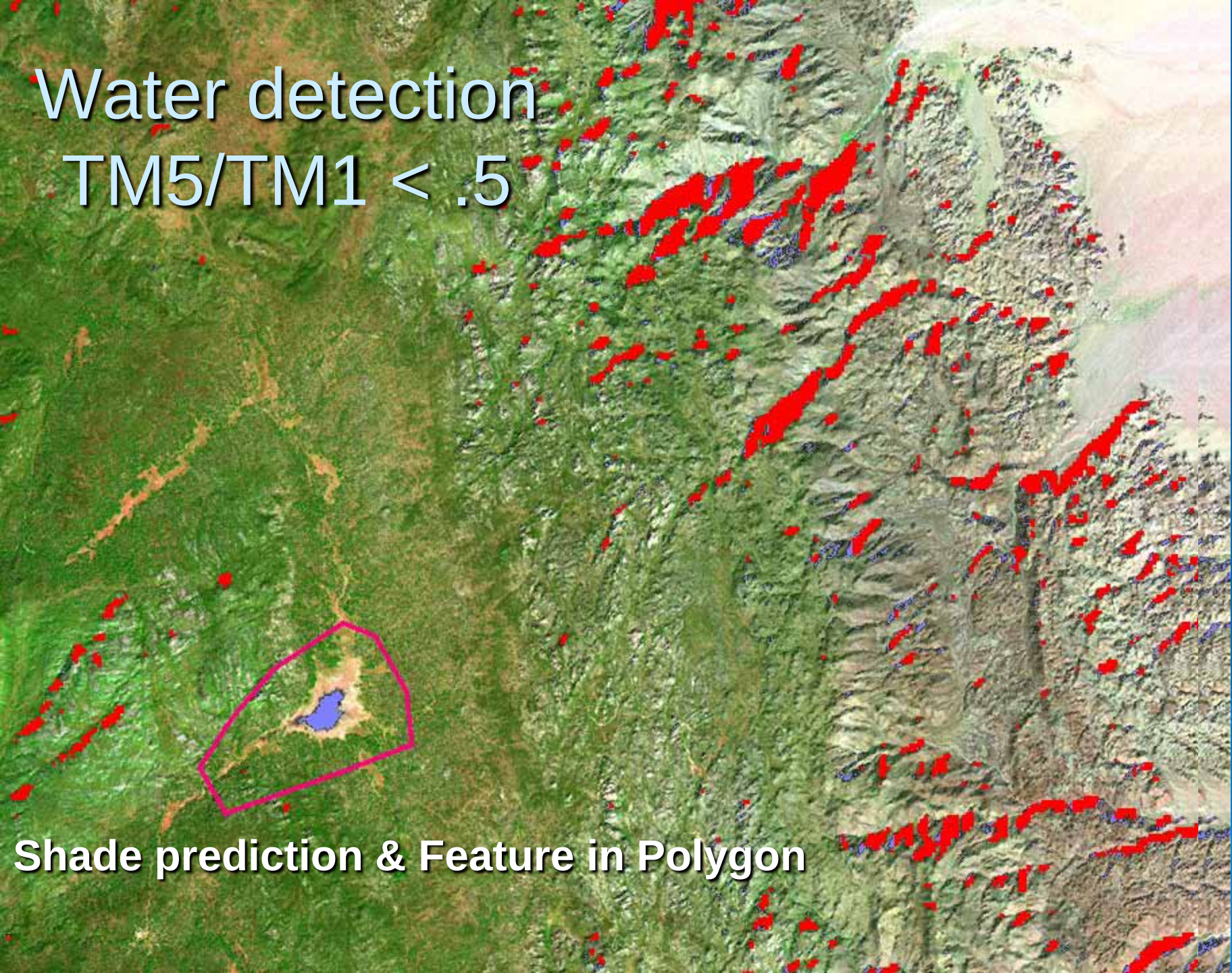
Water detection

IF B5/B1 < Threshold AND NOT a SHADE

THEN WATER

Workflow for WB detection and aerial measurment




Water detection
TM5/TM1 < .5
Shade prediction & Feature in Polygon

Morena lake CA area estimates in Ha from 5/1

1984

580 ha

1990

98 ha

2000

343 ha

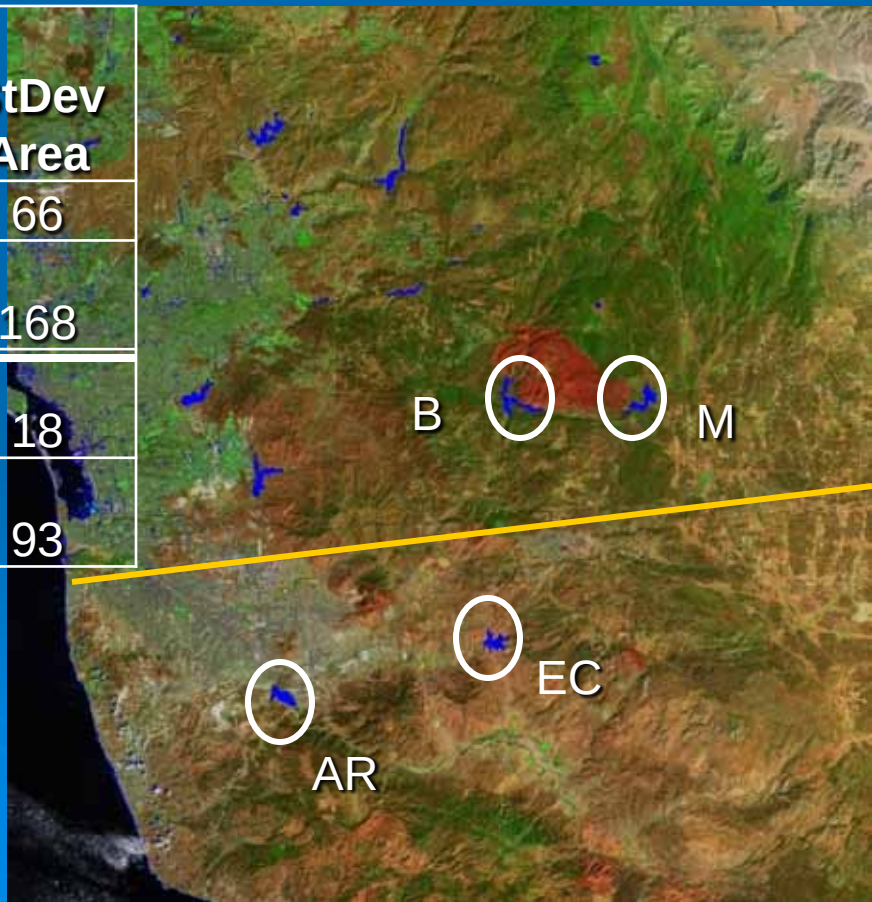
2006

188 ha

Aerial report summary for 4 WB 1984-2007 (17 Scenes)

B= Barret Lake, M=Morena Reservoir, EC=El Carrizo Dam, AR=Abelardo Rodriguez Dam

Water Body	Mín Area Ha (Year)	Max Area Ha (Year)	Scenes	Avg Area	StDev Area
B	104(89)	287(84)	8	201	66
M	98(90)	580(84)	9	294	168
EC	152(89)	217(05)	11	196	18
AR	68(89)	314(05)	7	179	93



Water Bodies concentrate for the California-Baja California Region, 1984-2007 (17 Scenes)

State-Cty	Sum of Max Areas in Ha	Number WB > 4 Ha	Avg size WB in Ha	Largest WB in Ha
BC-Mex	867.	12	41.	314.
Ca-USA	11851.	62	127.	1865.

Ratio CA/BC of 13 in Area and 5 in number of WB

April 4th 2010 M7.2 earthquake, Mexicali Earthquake effects though remote sensing data and technique.

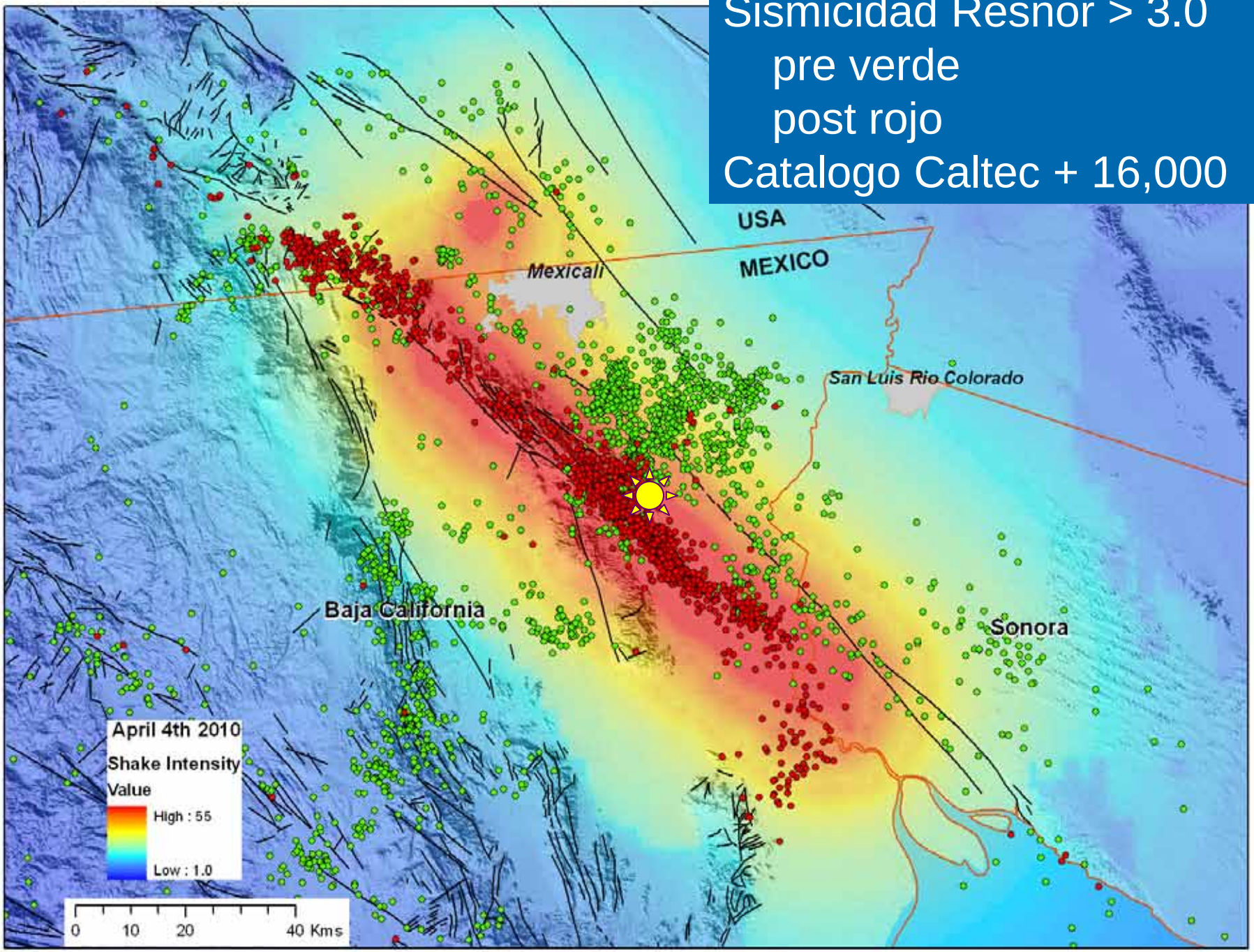
A story of:

•Perfect target area: previously measured, scarcely vegetated, close to the border

•Spontaneous binational collaboration, mutual interest, started form personal contacts.

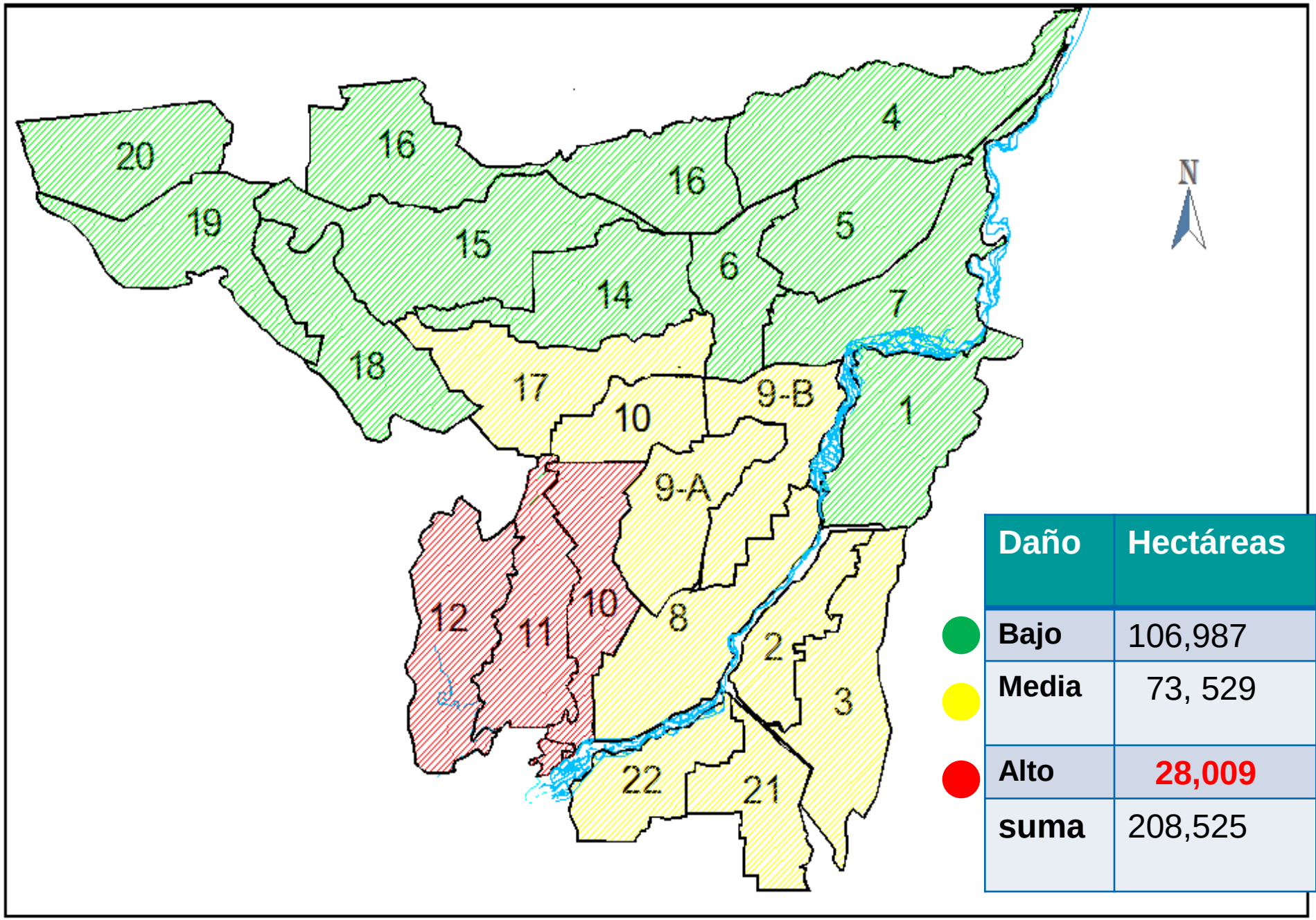
•Before and after the EQ with different RS techniques

- Laser ranging (LIDAR) aerial and terrestrial
- Radar interferometry
- Optical images correlation
- GPS, seismic,…..



Source shake maps: http://earthquake.usgs.gov/shakemap/sc/shake/

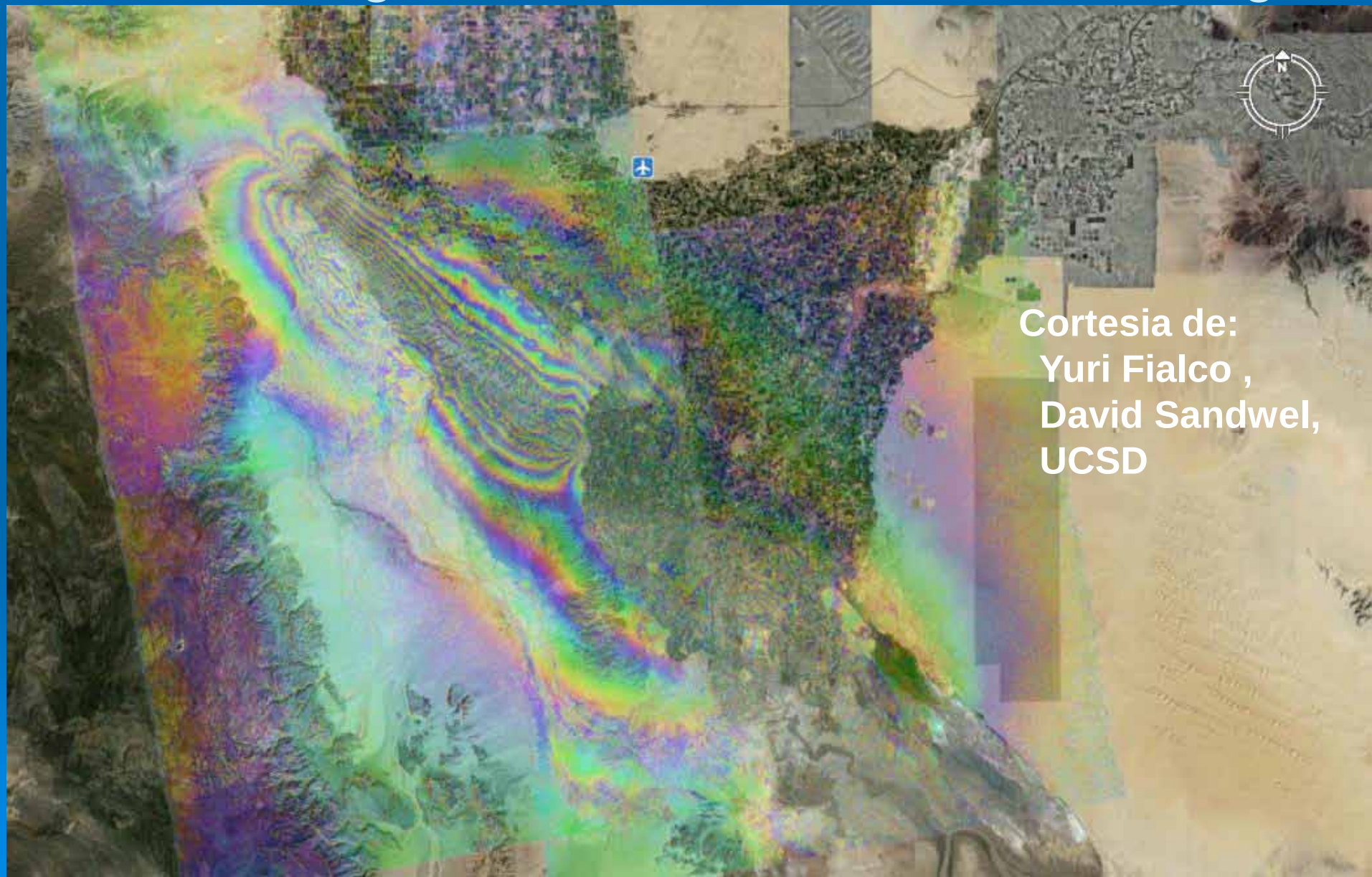
PLANO SEMAFORO DE DAÑOS EN LA INFRAESTRUCTURA HIDROAGRICOLA DEL DISTRITO DE RIEGO 014, RIO COLORADO B.C. Y SON.



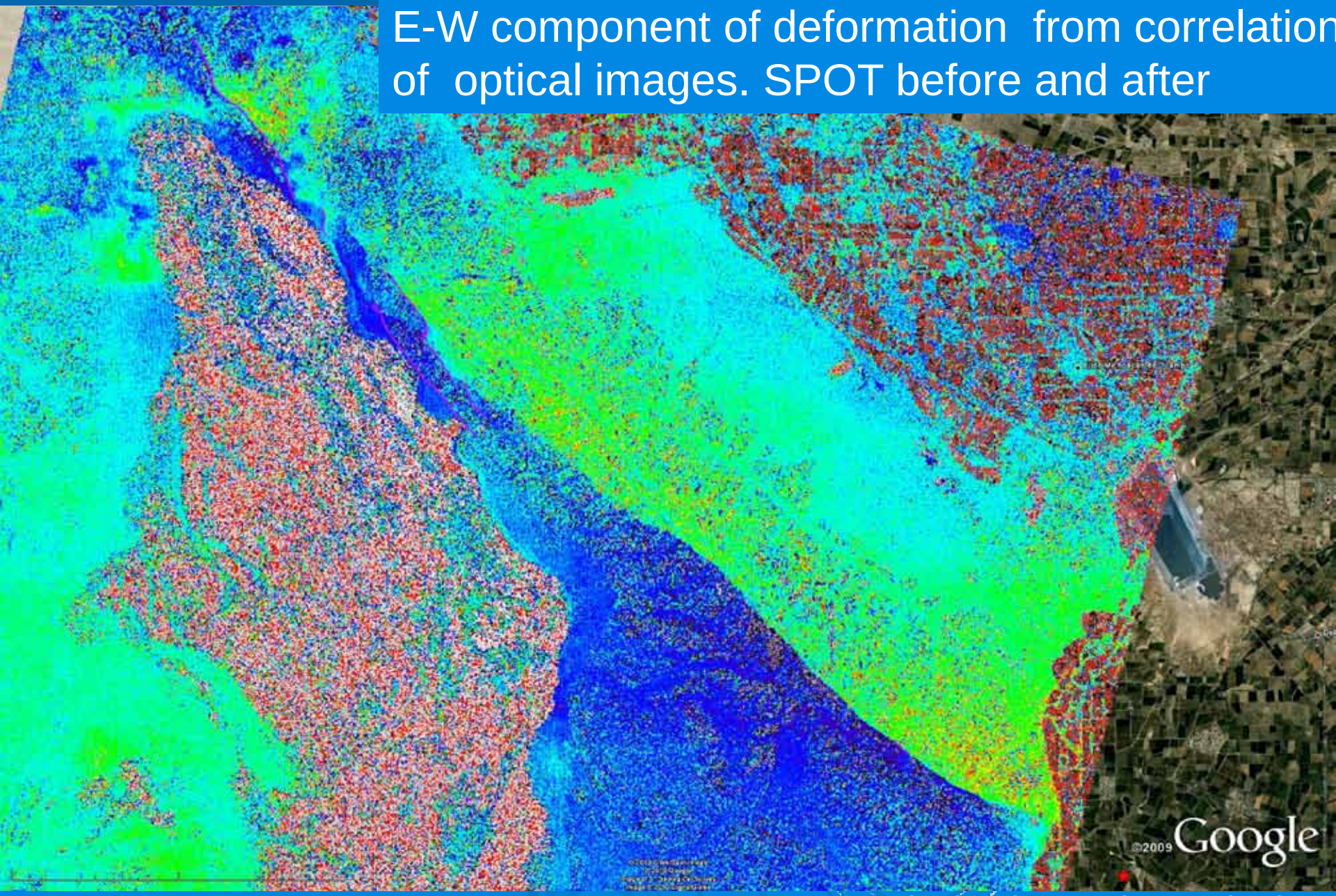
Daño	Hectáreas
Bajo	106,987
Media	73, 529
Alto	28,009
suma	208,525

Recent US-México agreement, differed delivery of 320 Mm3 ~ 28,000Ha affected by EQ to 640 km of irrigation canals.

Locating surface rupture with RS: INSAR fringes before-after ALOS radar images



E-W component of deformation from correlation of optical images. SPOT before and after



Courtesy of Sebastien Leprince, Caltech

Fotos: John Fletcher

Foto: John Fletcher, CICESE

Antes

Después

Digital Globe

J. Fletcher

Imagen satelital Antes

foto aérea Después

Digital Globe

J. Fletcher

Airborne Lidar survey Finance

- NFS RAPID proposal
  - Airborne Lidar Scan of the 4 April 2010 Sierra El Mayor, Baja California Earthquake Rupture.
    - PI Mike Oskin UC Davis,
    - CoPI Ramon Arrowsmith ASU
    - Colaboradoes Alejandro Hinojosa y John Fletcher (CICESE)
      - NCALM (National Center for Airborne Laser Mapping)
- SCEC y USGS complementary funds
- CONACyT, CICESE, UCSD,…..
- Importance of 2006 Lidar survey by INEGI, lower resolution.

P494
P496
KCXL
Mexicali
LPUR
VM15
CP13
MAYR

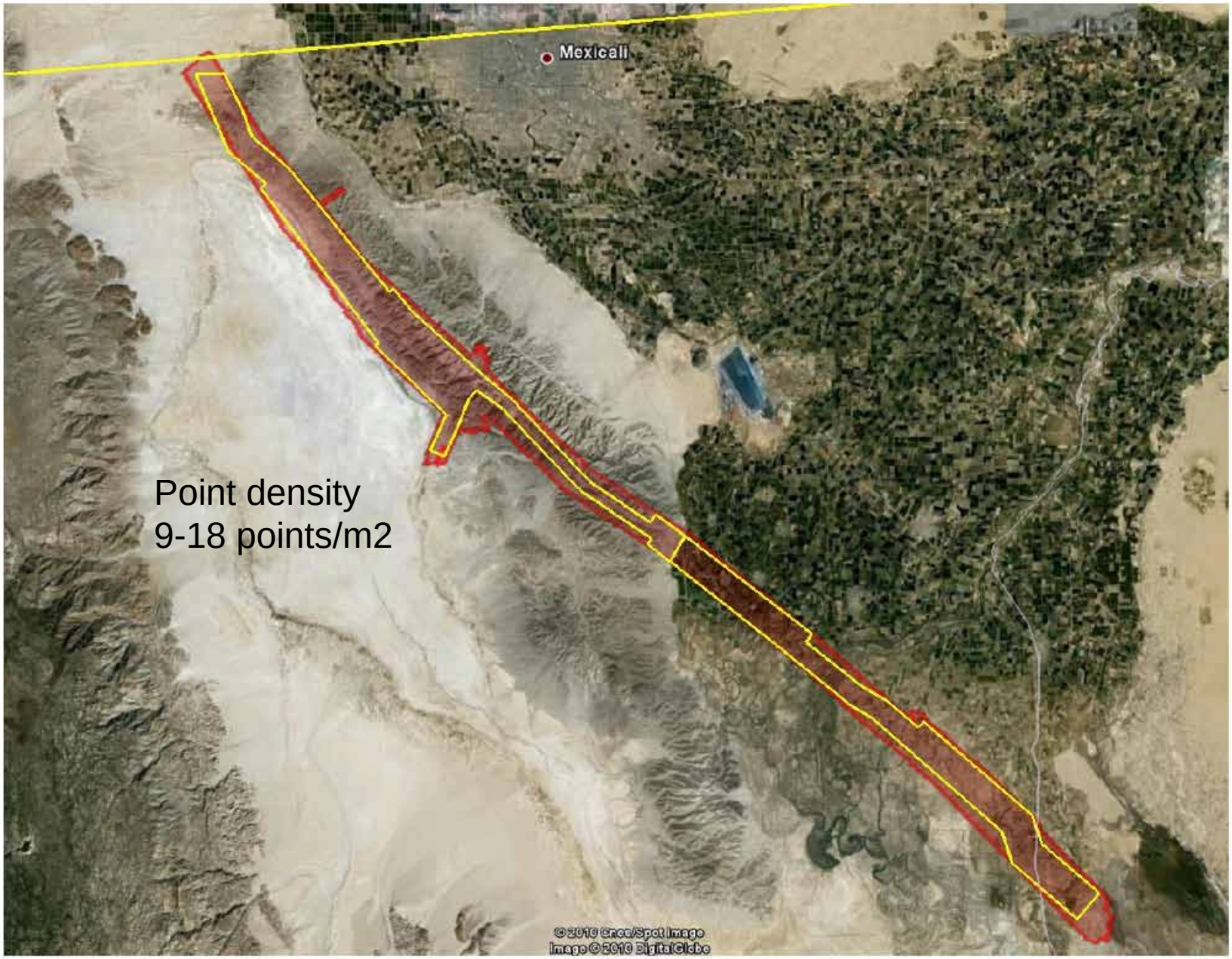
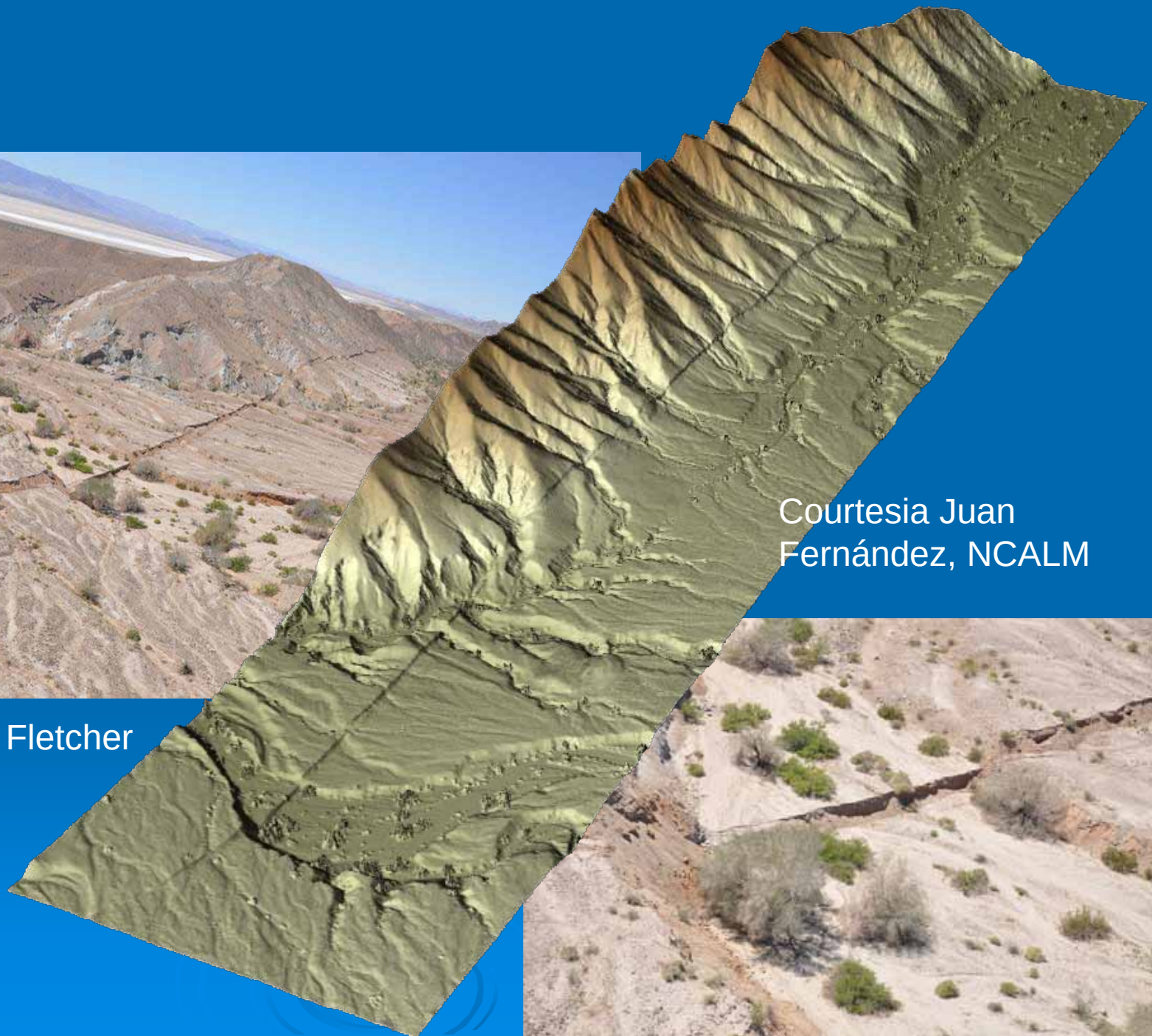


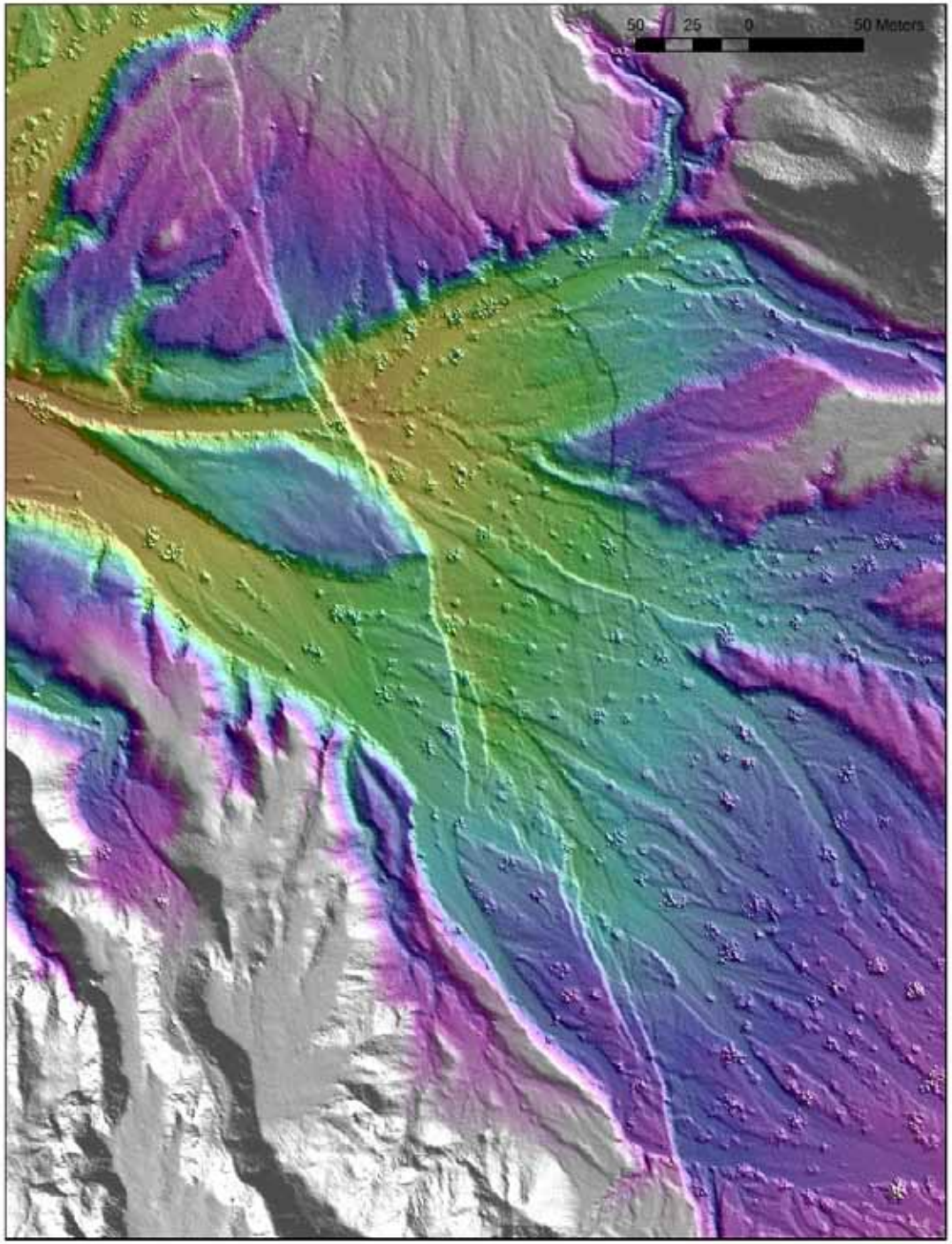
Figure 1 – Shape and location of survey polygon (Google Maps).

Fotos: John Fletcher

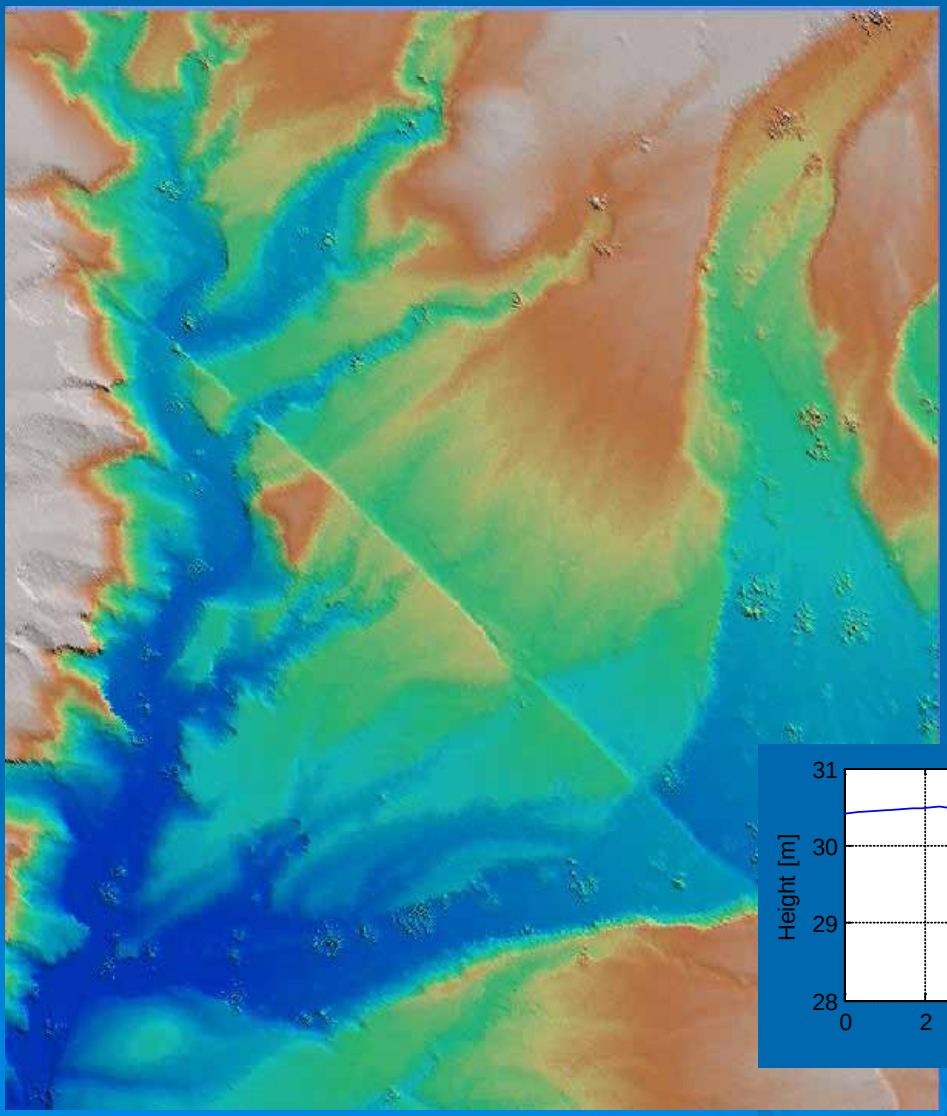


Courtesia Juan Fernández, NCALM

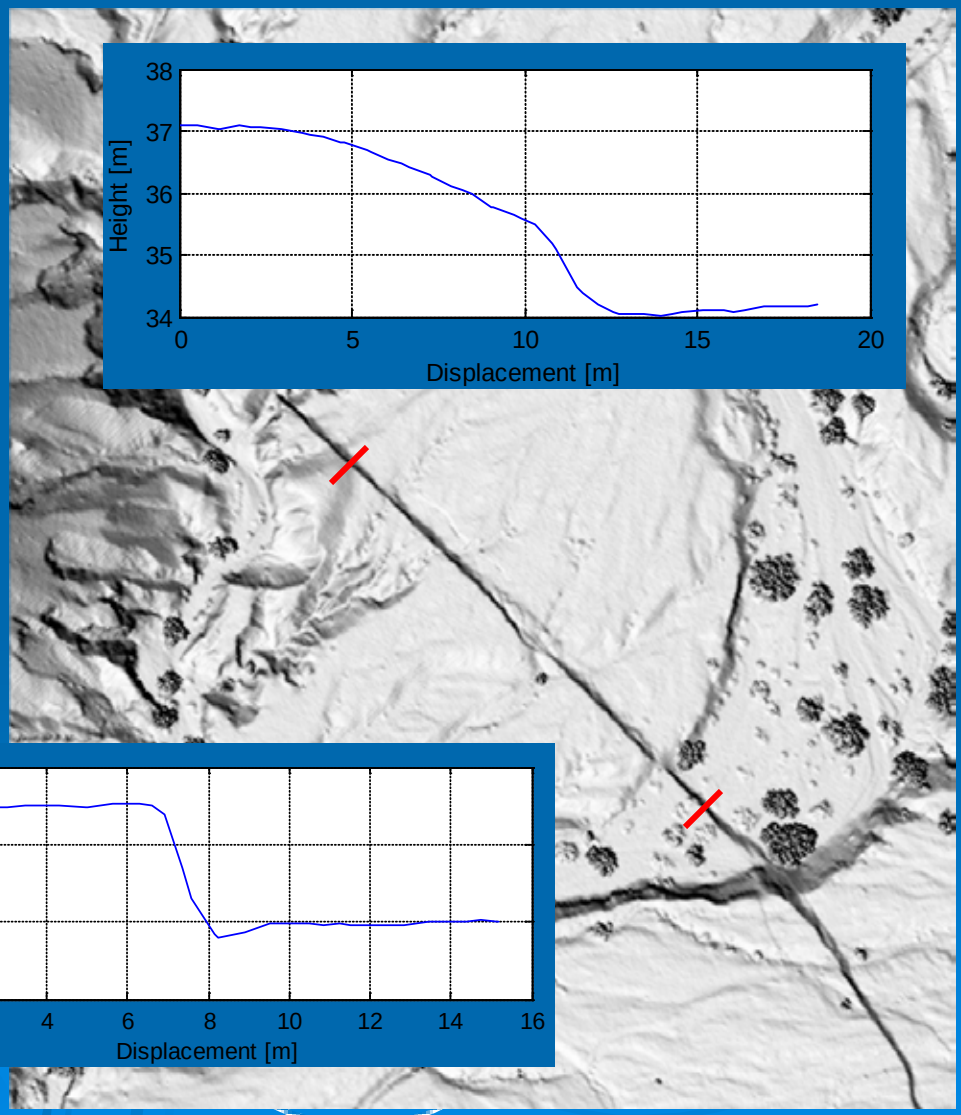
Modelo de elevación generado levantamiento Lidar aéreo con 50cm de resolución



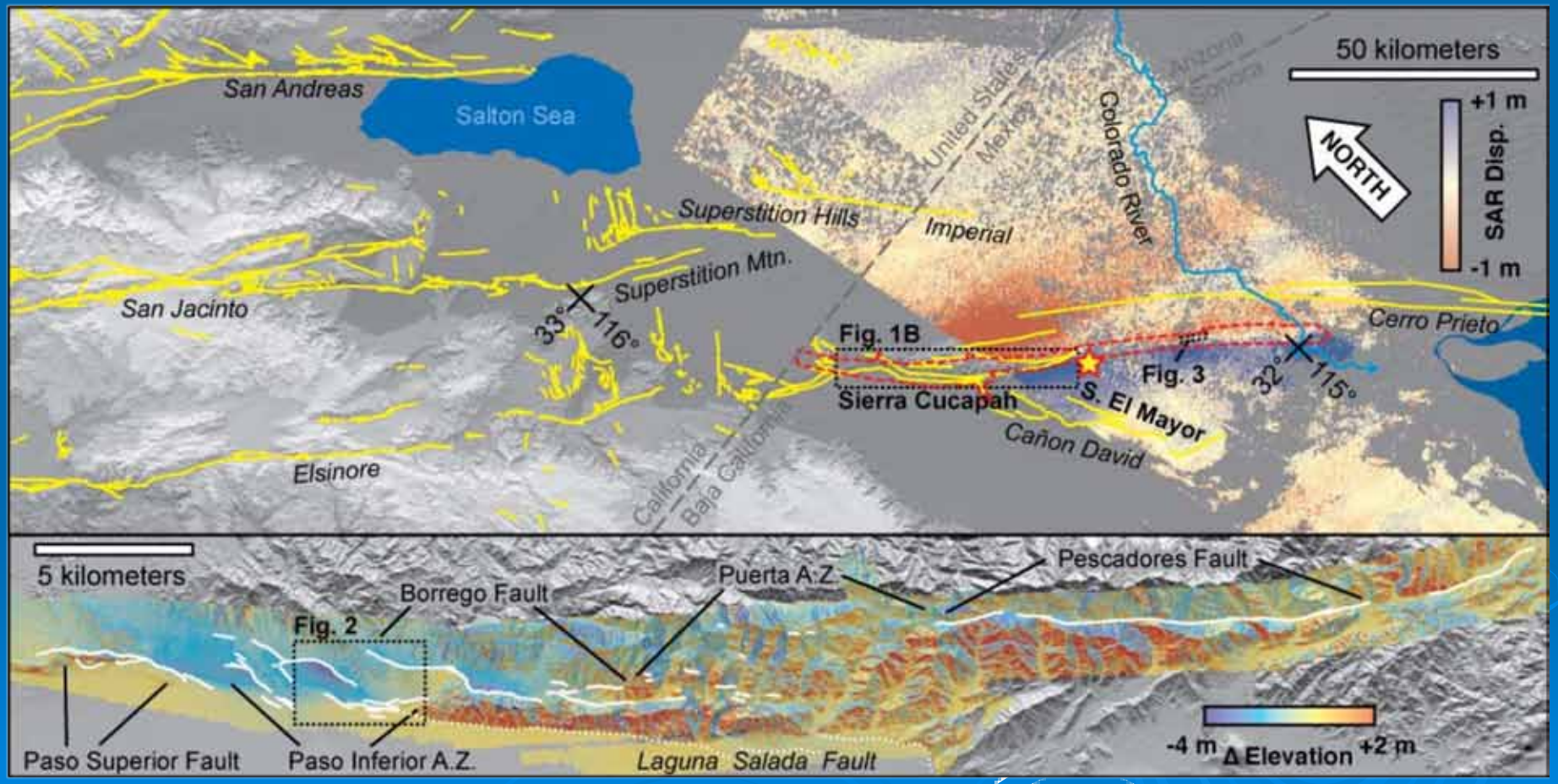
LiDAR 0.5 m DEM



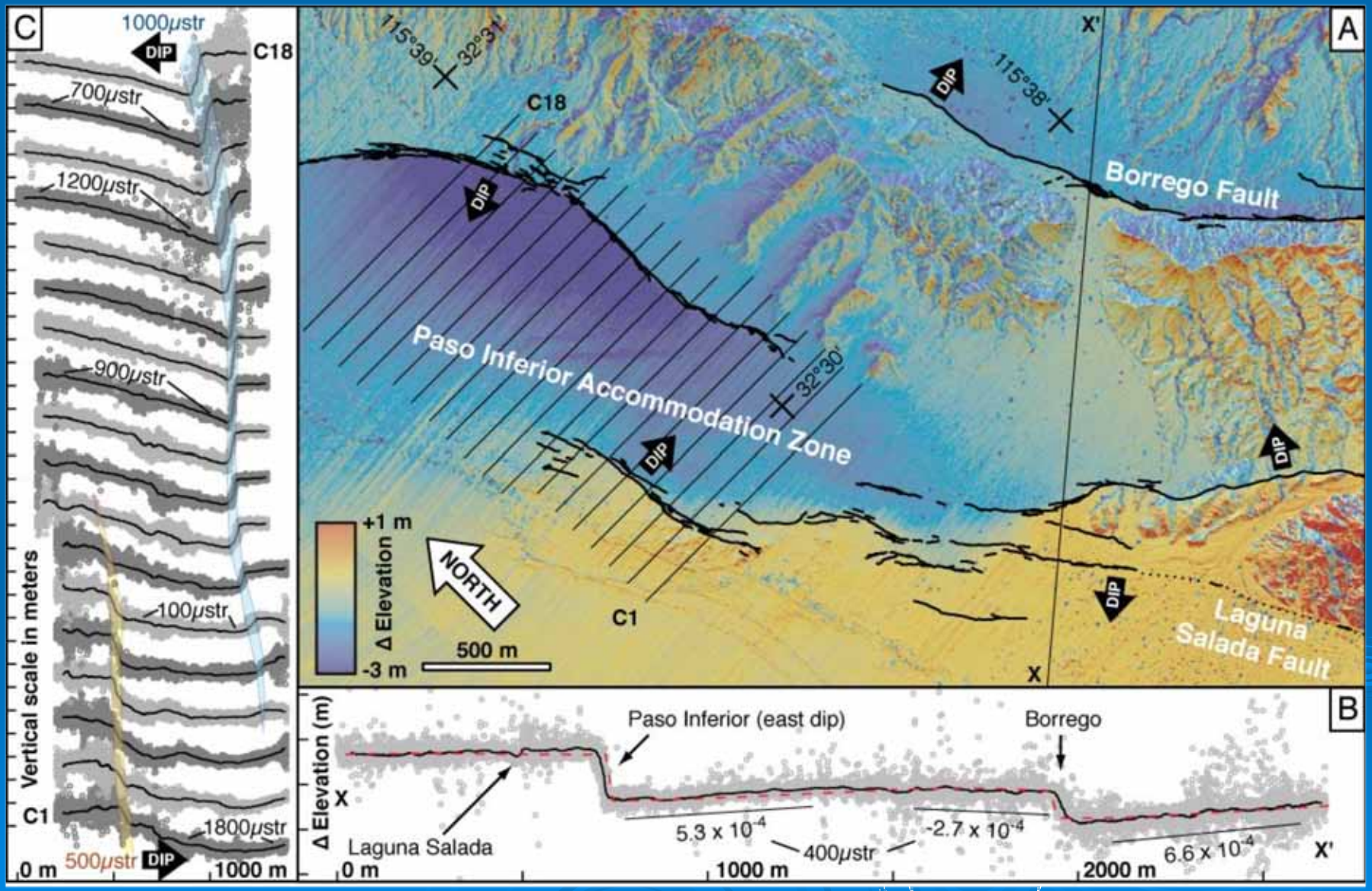
LiDAR 0.5 m shaded relief DEM



J. Fletcher / A. Hinojosa CICESE


San Andreas
Salton Sea
Superstition Hills
Superstition Mtn.
San Jacinto
Elsinore
33°
116°
Imperial
United States
Mexico
Colorado River
Arizona
Sonora
California
Baja California
Fig. 1B
Fig. 3
Sierra Cucapah
S. El Mayor
Cañon David
32°
115°
Cerro Prieto
50 kilometers
NORTH
+1 m
SAR Disp.
-1 m
5 kilometers
Fig. 2
Borrego Fault
Puerta A.Z.
Pescadores Fault
Paso Superior Fault
Paso Inferior A.Z.
Laguna Salada Fault
-4 m
Δ Elevation
+2 m

Transects across the difference map, before – after Lidar derived DEMs



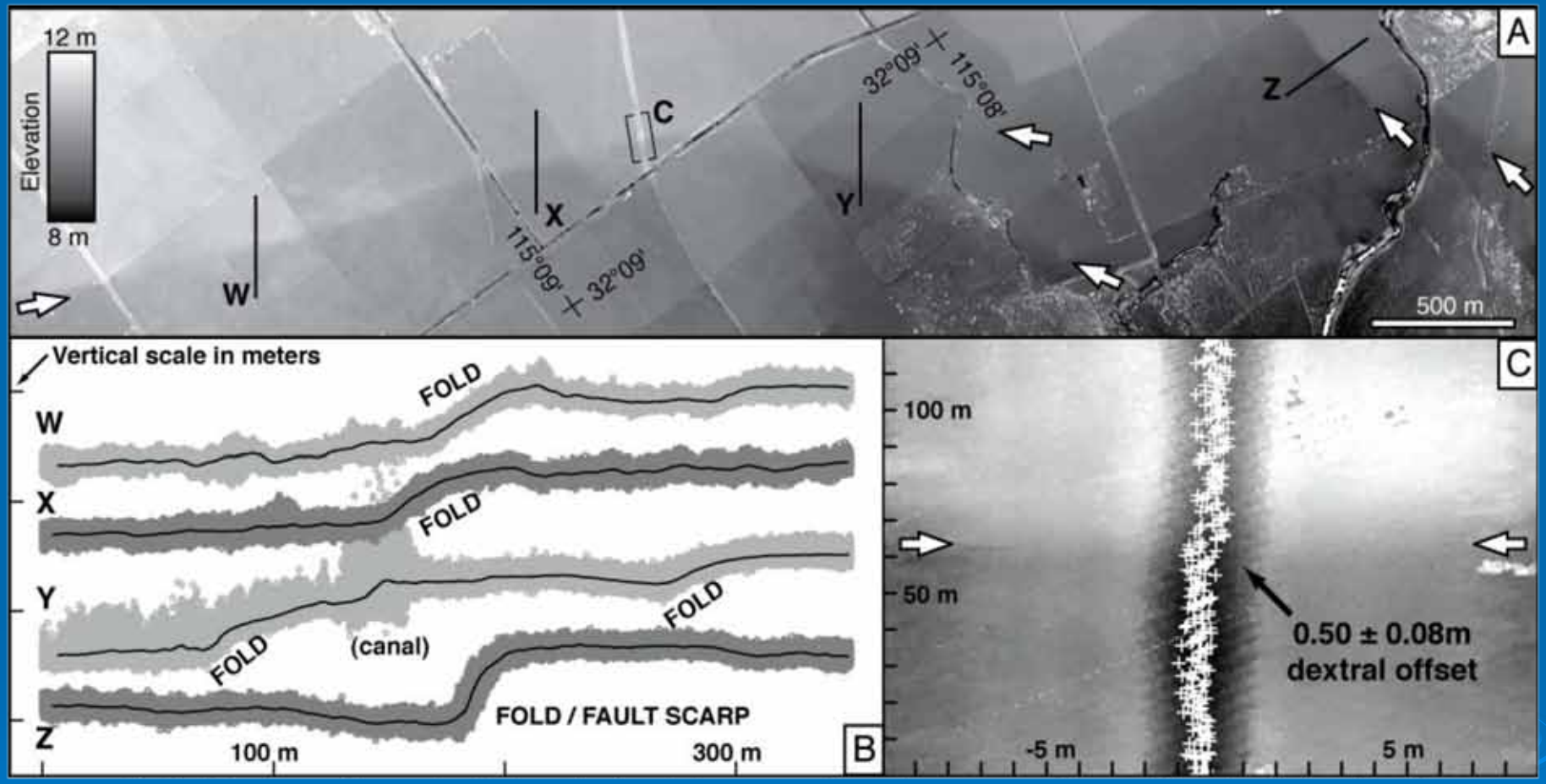
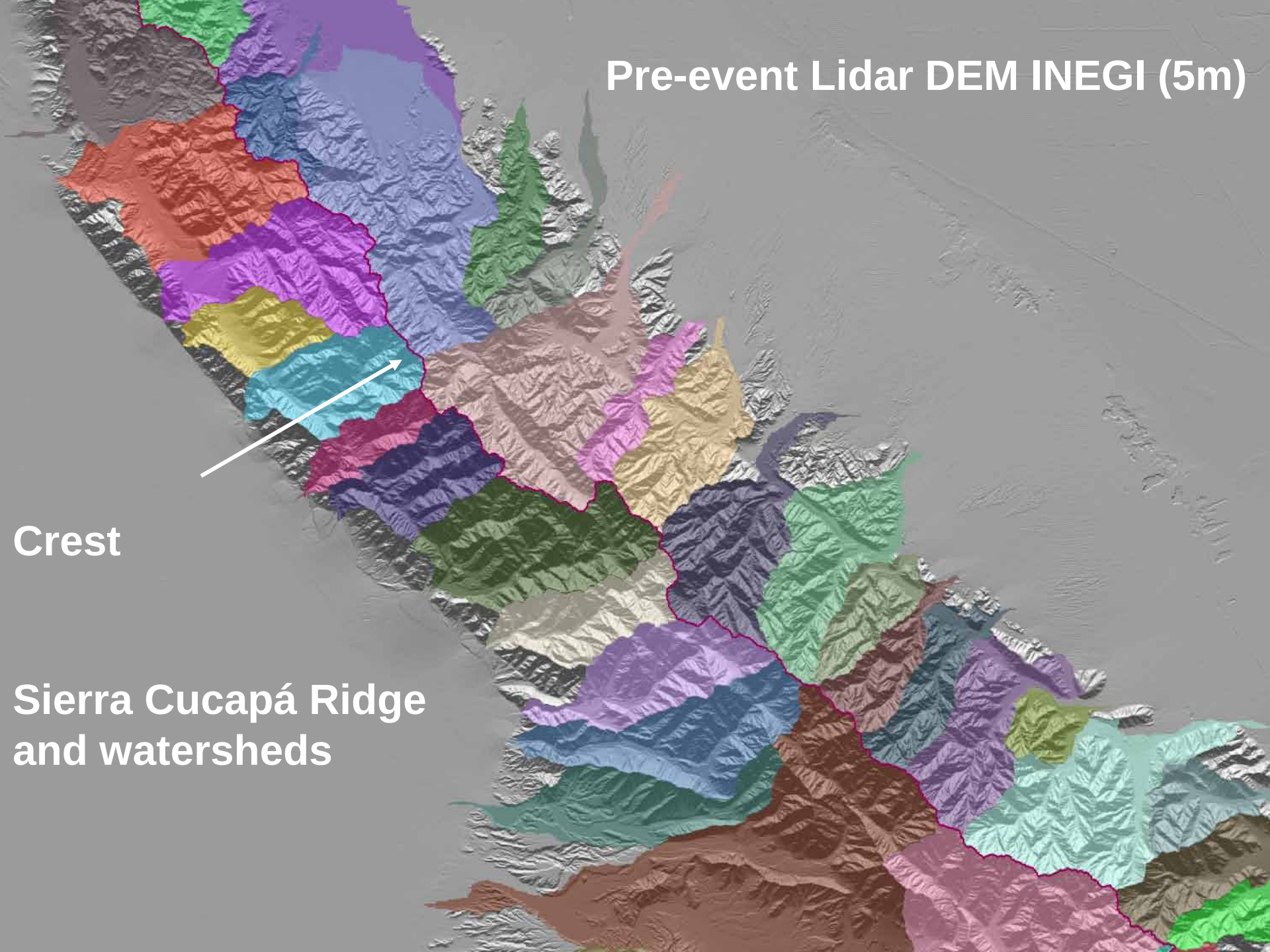


Figure 3: A. Post-earthquake lidar-derived topography along a portion of the Indiviso fault. Arrows highlight end points of recognizable shear zones. Other elevation steps and lineaments are canals and the boundaries of leveled agricultural fields. B. A set of four swath profiles,


Pre-event Lidar DEM INEGI (5m)
Crest
Sierra Cucapá Ridge
and watersheds

31.03.2011 06:50

Terrestrial Lidar Surveys (TLS) surface rupture: UC Davis, U Kansas, CICESE

- 2010 (+12 days EQ)
- 2011 (+ ~ year)

31.03.2011 13:18

Comentarios finales

- Proceso de asimilación de tecnología Resultados preliminares
- Análisis de la los efectos del sismo a través de la comparación de modelos de elevación pre-post sismo
- Asimilación de otras tecnologías mulitemporales:
  - Cosi-CORR(satelital y fotos aéreas) e
  - interferometria de radar

Final comments

- Importance of RS archives, it enables to study our changing world, value of Landsat record (1972-current)
- Importance of personal contacts
- Multisensor approach to analyze the same phenomena, enlightening experience
- Simple useful RS applications

Thank you!

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Final Comments

- Landsat record and RS/GIS techniques enable to quantify the contrasts related to water and vegetation along the CaUSA-BCMex border region
- The TM5/TM1 segmentation, simple technique to detect surface water although confusing shades (clouds and landscape) have to taken care:
  - Shade prediction using DEM and Sun's Position
  - Max Bounding polygons
- Ratio CA/BC WBs of 13 in Area and 5 in number of WB