Wetland InSAR

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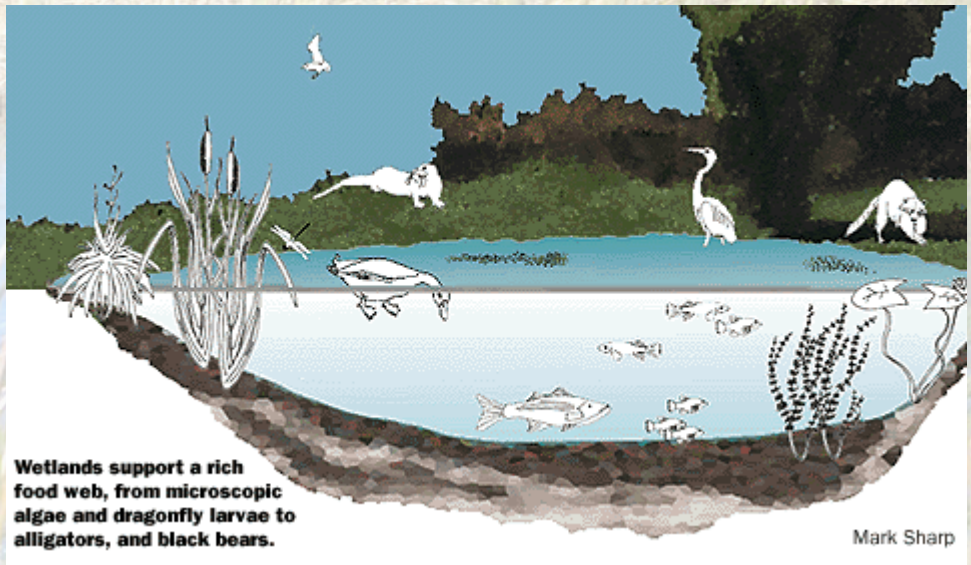
- Wetlands
- InSAR observations
- Hydrological implications
- Summary & acknowledgements

What are Wetlands?

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season

Wetlands are transition zones where the flow of water, the nutrient cycling, and the sun energy meet to produce a unique and very productive ecosystem.



Wetlands support a rich food web, from microscopic algae and dragonfly larvae to alligators, and black bears.

Mark Sharp

Type of wetlands

Marshes are periodically saturated, flooded, or ponded with water and characterized by herbaceous (non-woody) vegetation adapted to wet soil conditions.

Swamps are fed primarily by surface water inputs and are dominated by trees and shrubs.

Other - Bogs and **Fens** peatforming Wetlands (northern climate).

Why protect wetlands?

- **Water storage.** Wetlands function like natural tubs or sponges, storing water and slowly releasing it.
- **Flood protection.**
- **Water quality.** Wetlands have important filtering capabilities for intercepting surface-water runoff from higher dry land before the runoff reaches open water
- **Biological productivity.** Wetlands are among the most productive ecosystems in the world, comparable to tropical rain forests and coral reefs.
- **Shoreline erosion.** Wetland plants hold the soil in place with their roots, absorb the energy of waves, and break up the flow of stream or river currents.
- **Economic.** We use a wealth of natural products from wetlands, including fish and shellfish, blueberries, cranberries, timber, and wild rice.
- **Recreation and Aesthetics.** Wetlands have recreational, historical, scientific, and cultural values.

Threats to wetlands

Human activities cause wetland degradation and loss by:

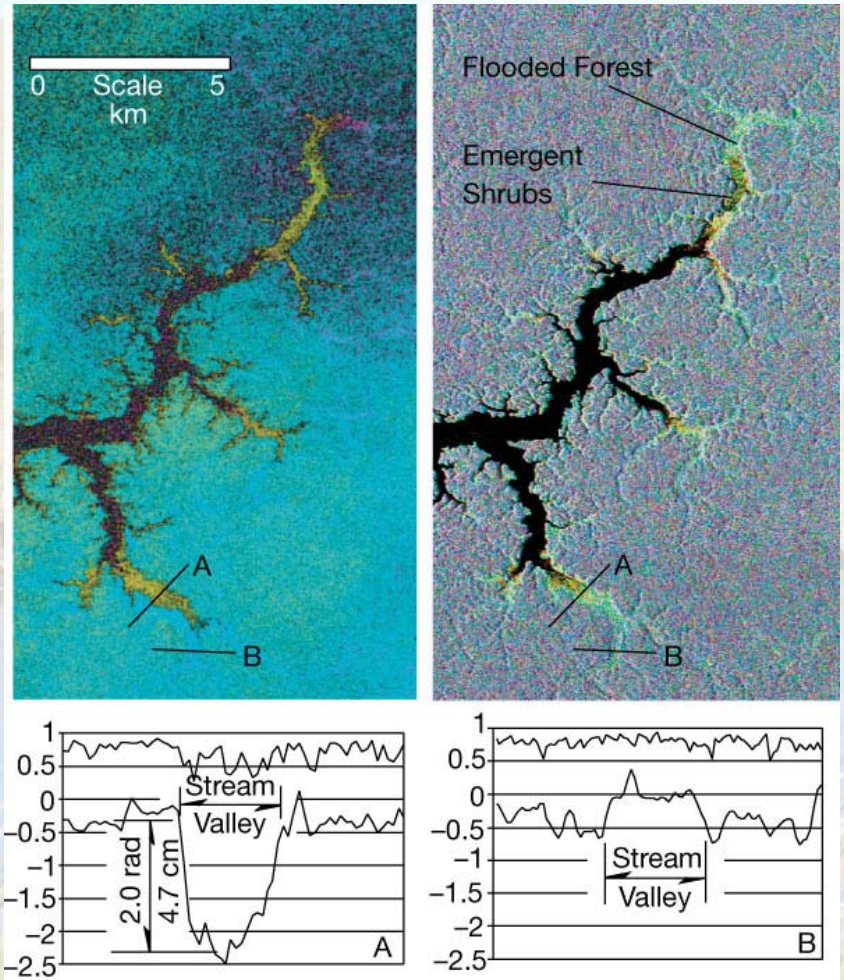
- **Hydrological alteration.** changing water quality, quantity, and flow rates.
- **Pollution.** increasing pollutant inputs.
- **Vegetation damage.** changing species composition as a result of disturbance and the introduction of nonnative species.

Wetland restoration

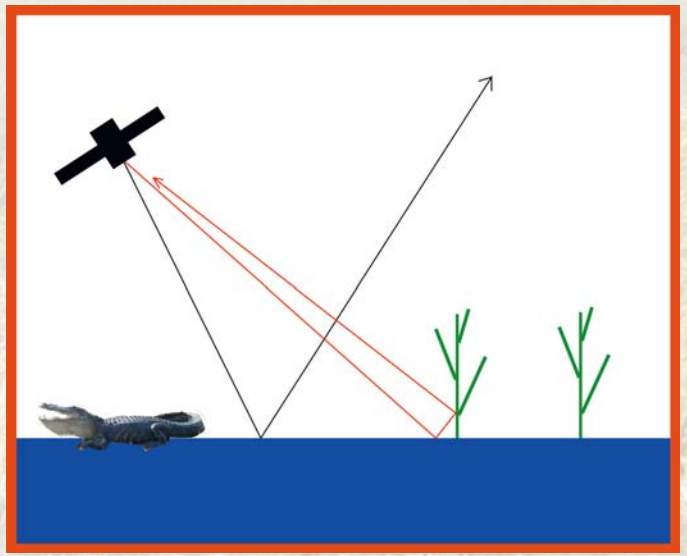
Restoration is the return of a degraded wetland or former wetland to its preexisting naturally functioning condition, or a condition as close to that as possible.

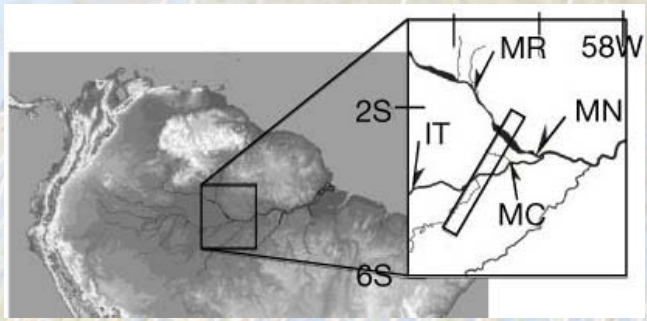
It is a complex process that requires expertise, resources, and commitment from many different stakeholders.

InSAR of Floodplains



Double bounce effect

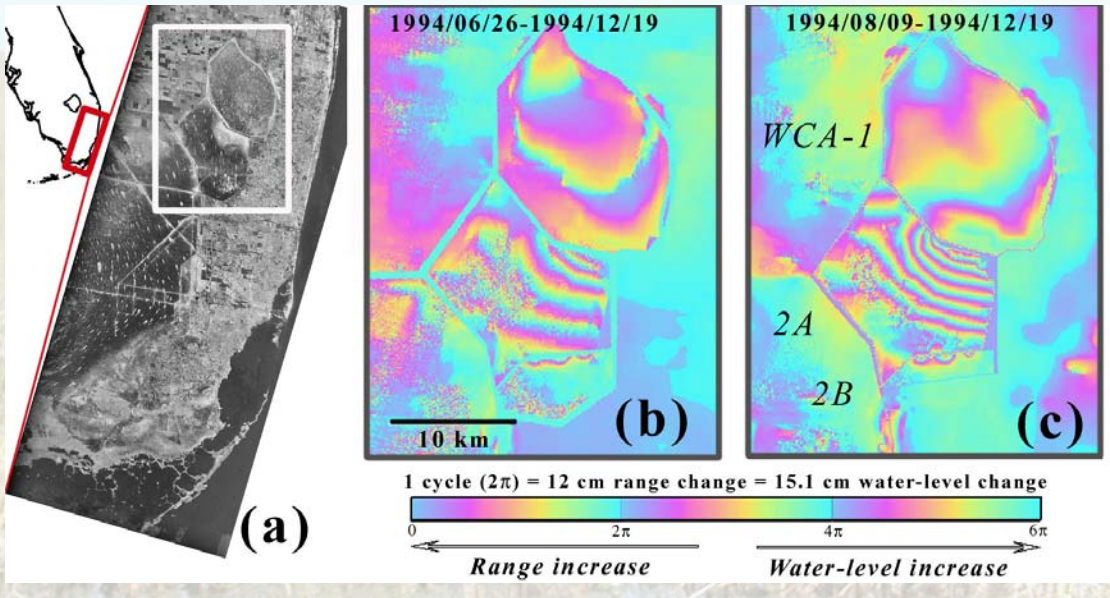




Works with SAR L-band data in vegetated areas.

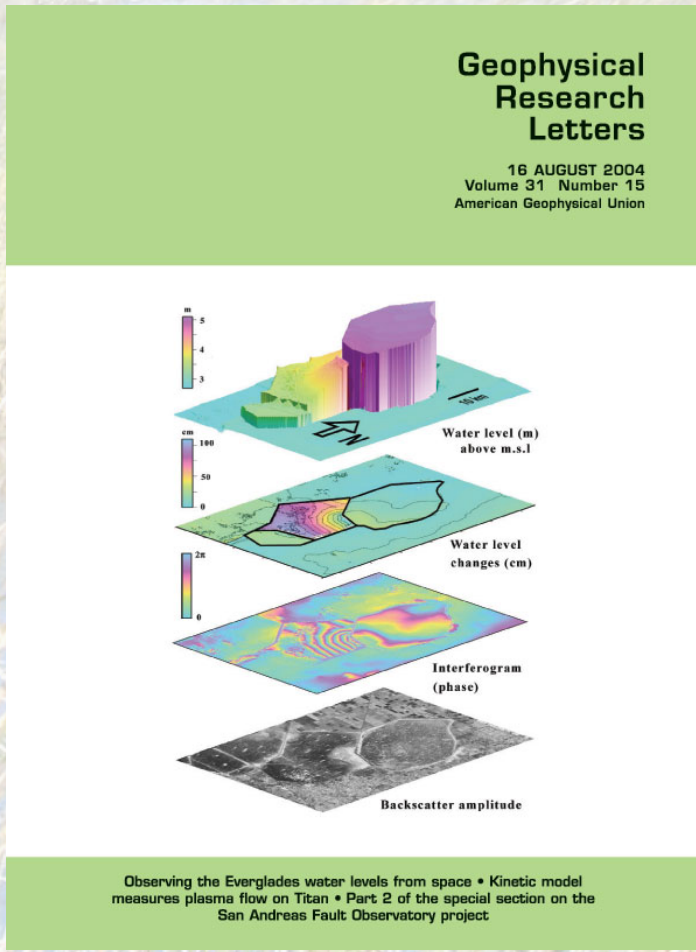
Alsdorf et al. [2000]

InSAR of Wetlands



JERS-1 (L-band) interferograms of the Everglades wetlands, south Florida

Wdowinski et al. [2004]

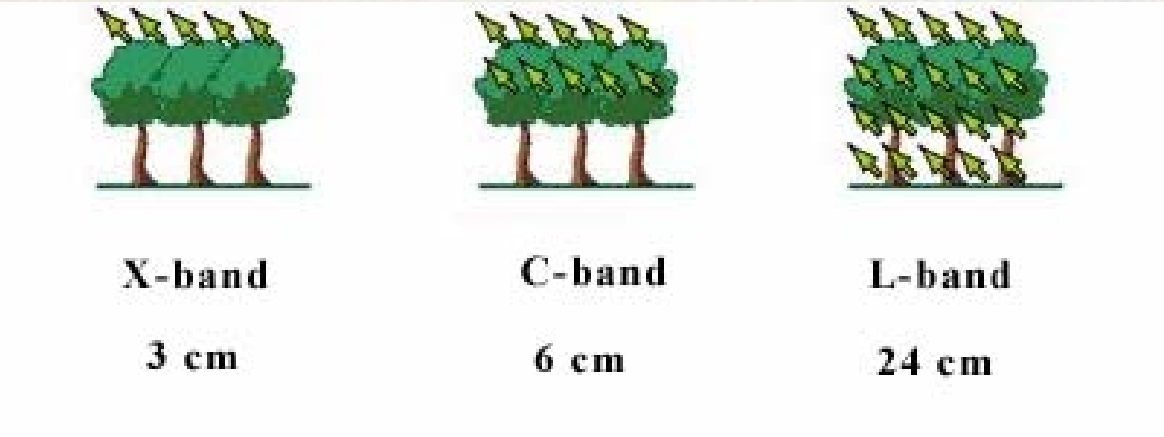


Wetland application of InSAR

- What SAR data are suitable for this application?
  - Data type: L-band, C-band, X-band
  - Acquisition parameters: HH/VV, incidence angle, ascending/descending, time span.
- Where does wetland-InSAR work?
  - Wetland type, dimension, seasons
- Why using (developing) the application?
  - Scientific and practical reasons.

Suitable data type: SAR and vegetation

Short wavelength radar signal interacts more with vegetation and tends to back-scatter from tree canopies



L-band – 24.1 cm wavelength
- JERS-1 - operated 1992-1998
- ALOS – 2006

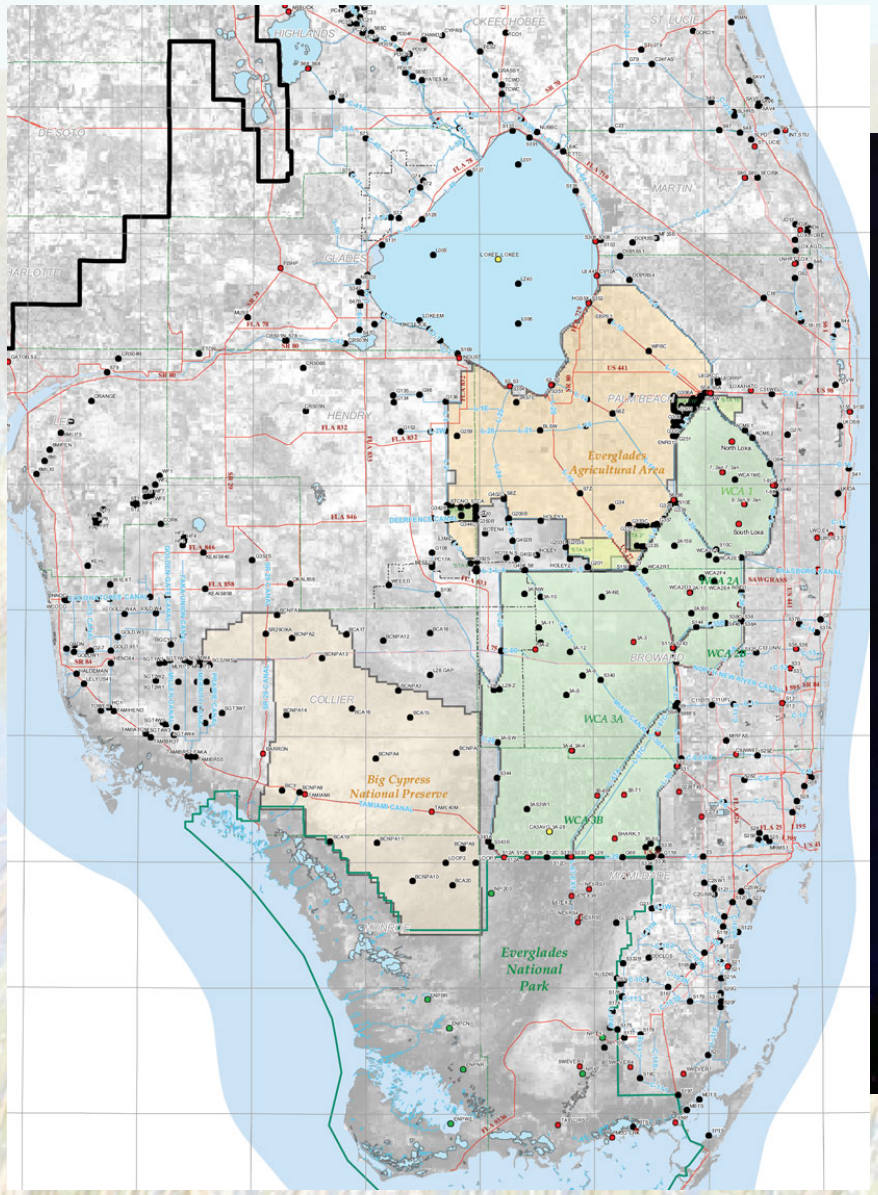
X-band – 3.1 cm wavelength
- TerraSAR-X - 2007 (?)

C-band – 5.6 cm wavelength
- ERS-1 (1991-1996)
- ERS-2 (1995-2000)
- ENVISAT (2002-present)
- RADARSAT-1 – (1995-present)
- RADARSAT-2 – 2007 (?)

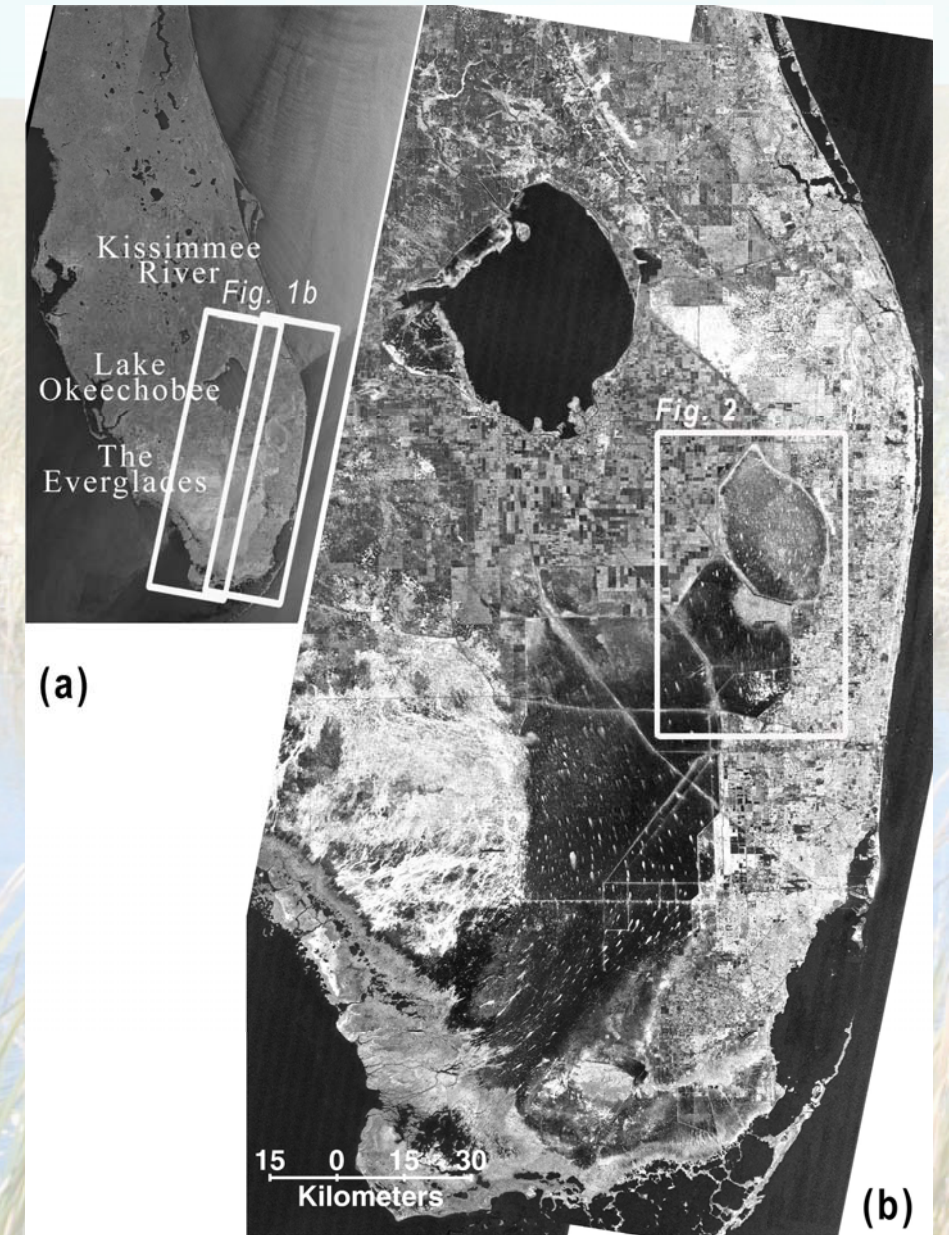
Suitable data type: Test area

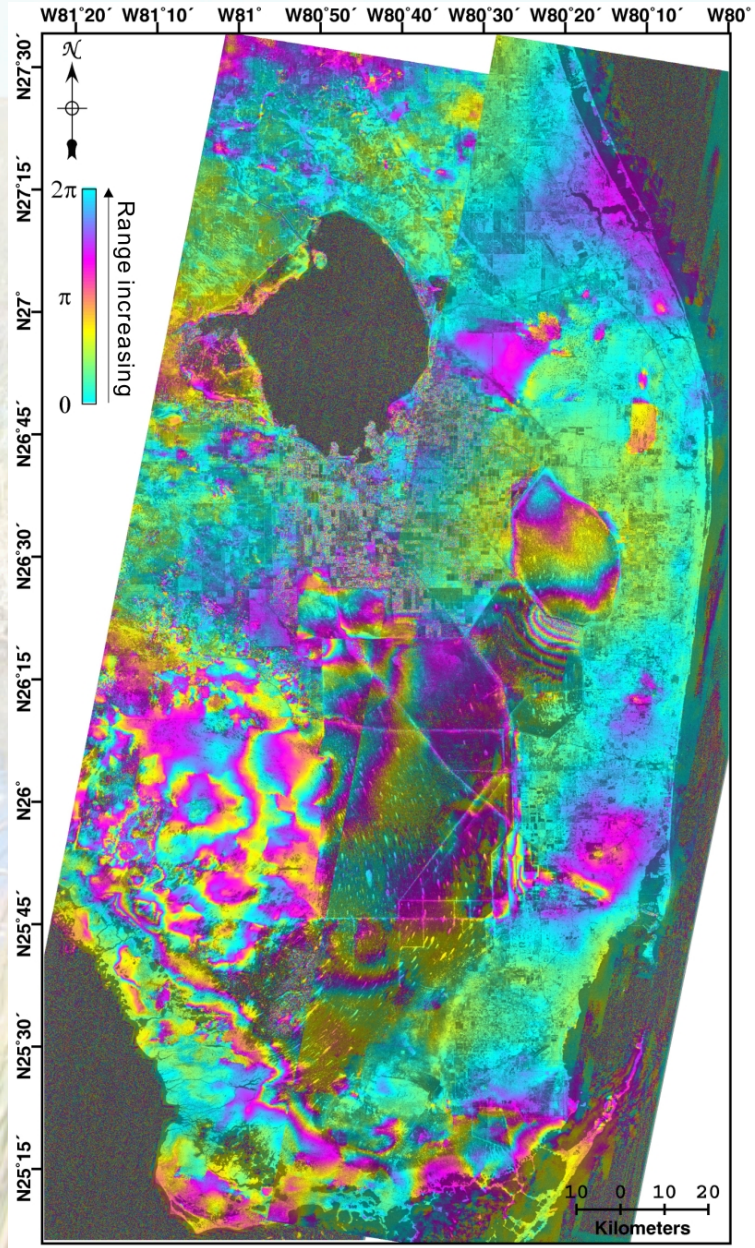
South Florida

- Various environments:
  - Wetlands
  - Agriculture
  - Urban
- Various wetland types
  - Woody
  - Herbaceous
  - Mangrove
- Various wetland environments
  - Natural
  - Controlled
- Dense stage station network

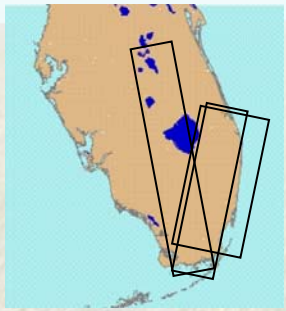


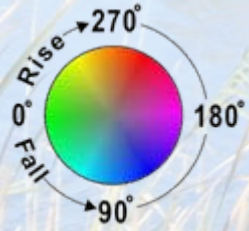
Data type: L-band

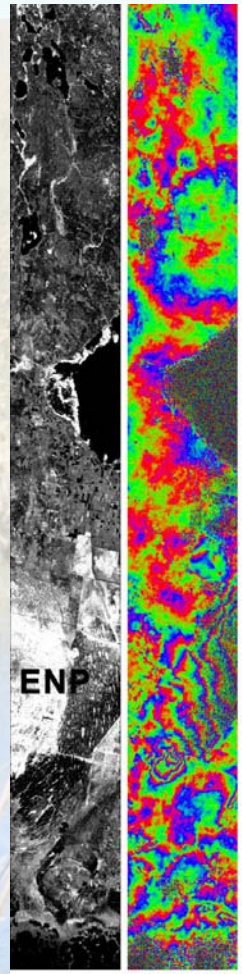




Data type: C-band

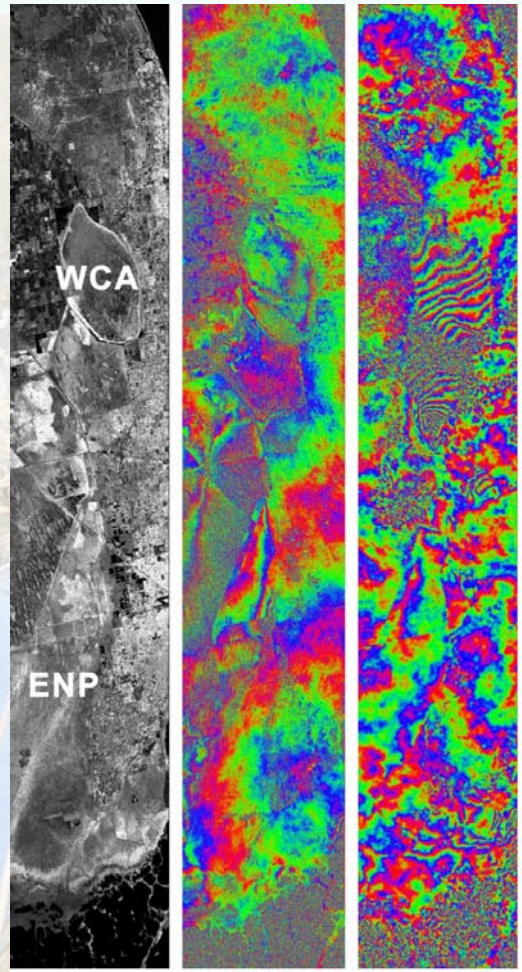






2004-10-24/
2004-11-17
Bperp=114 m

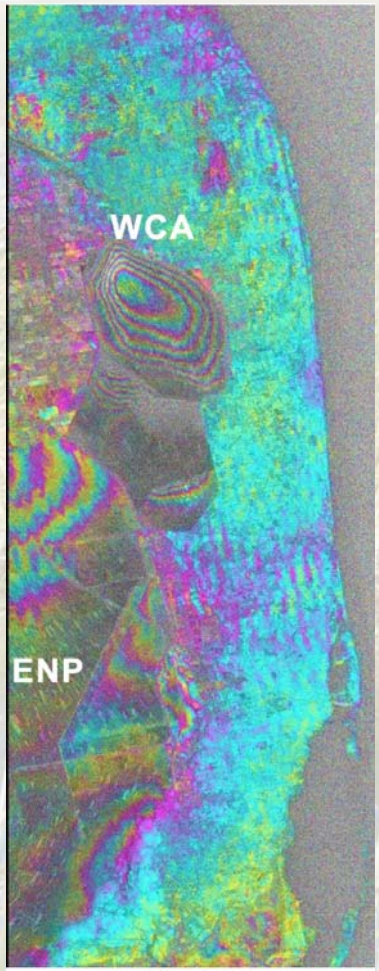
(a) (b)



2005-2-3/
2005-2-27
Bperp=321 m

2004-10-6/
2004-10-30
Bperp=759 m

(c) (d) (e)



1998-2-5/
1998-3-12
Bperp=23 m

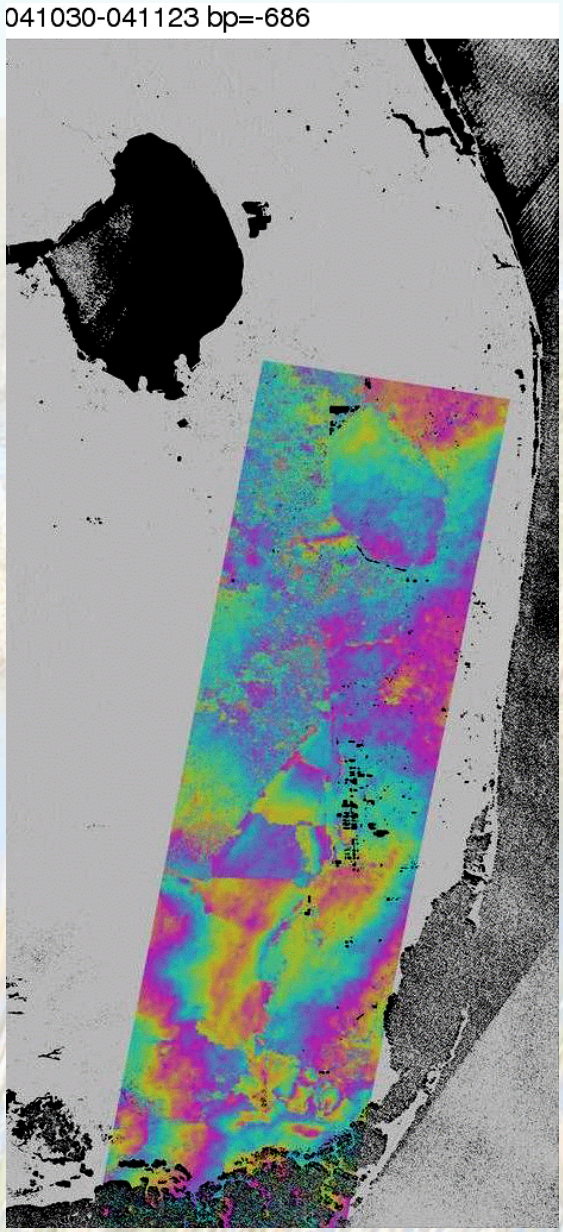
(f)

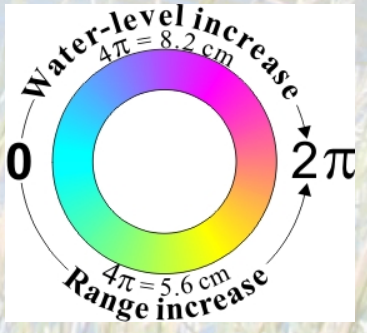
RADARSAT-1 interferogram time-series

RADARSAT
(Fine beam 5)
Oct.2004 – Jan.2006

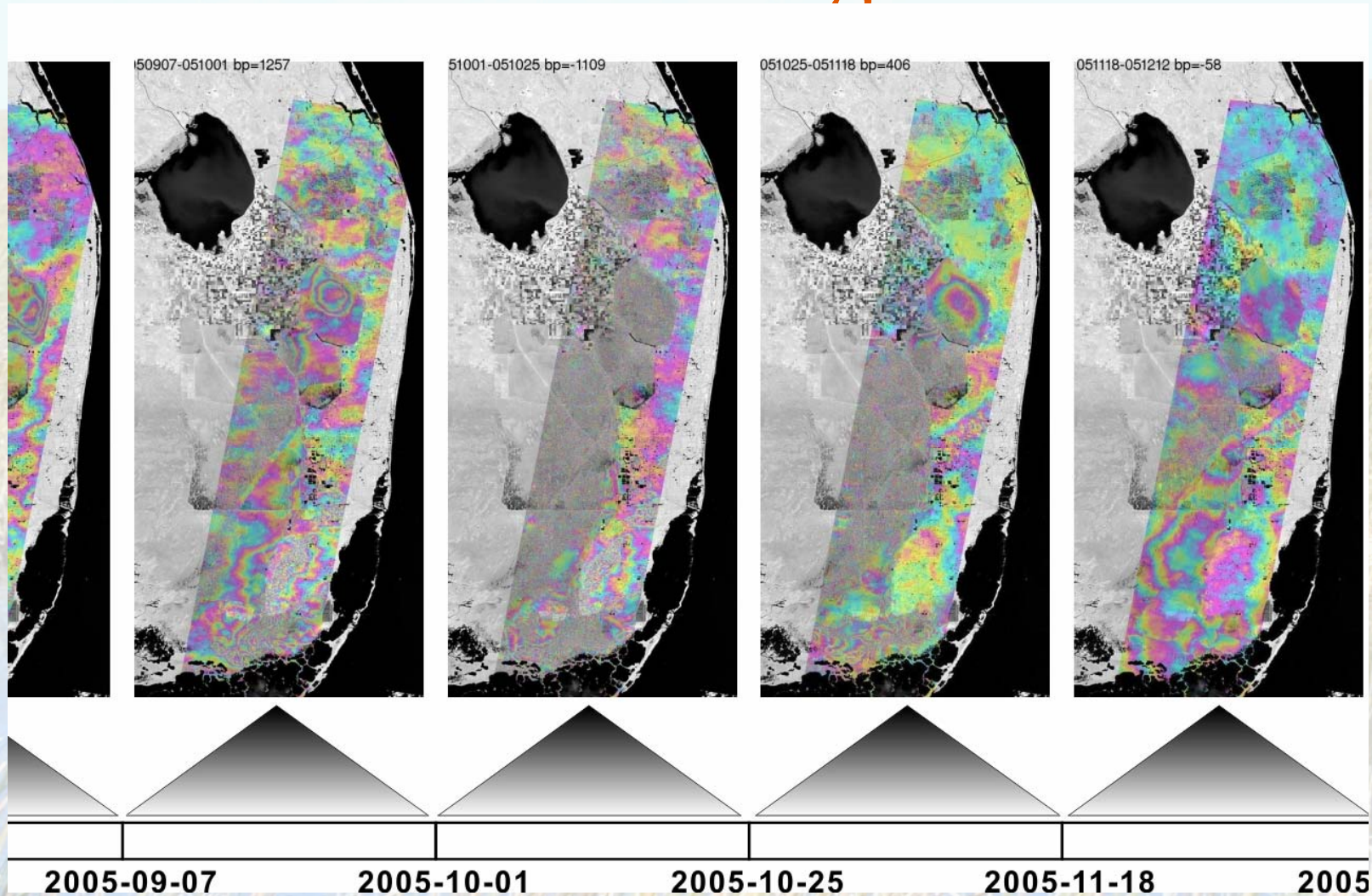
24-day interferogram
using CSTARS system

50 m resolution
cm scale accuracy (?)
Water level change map





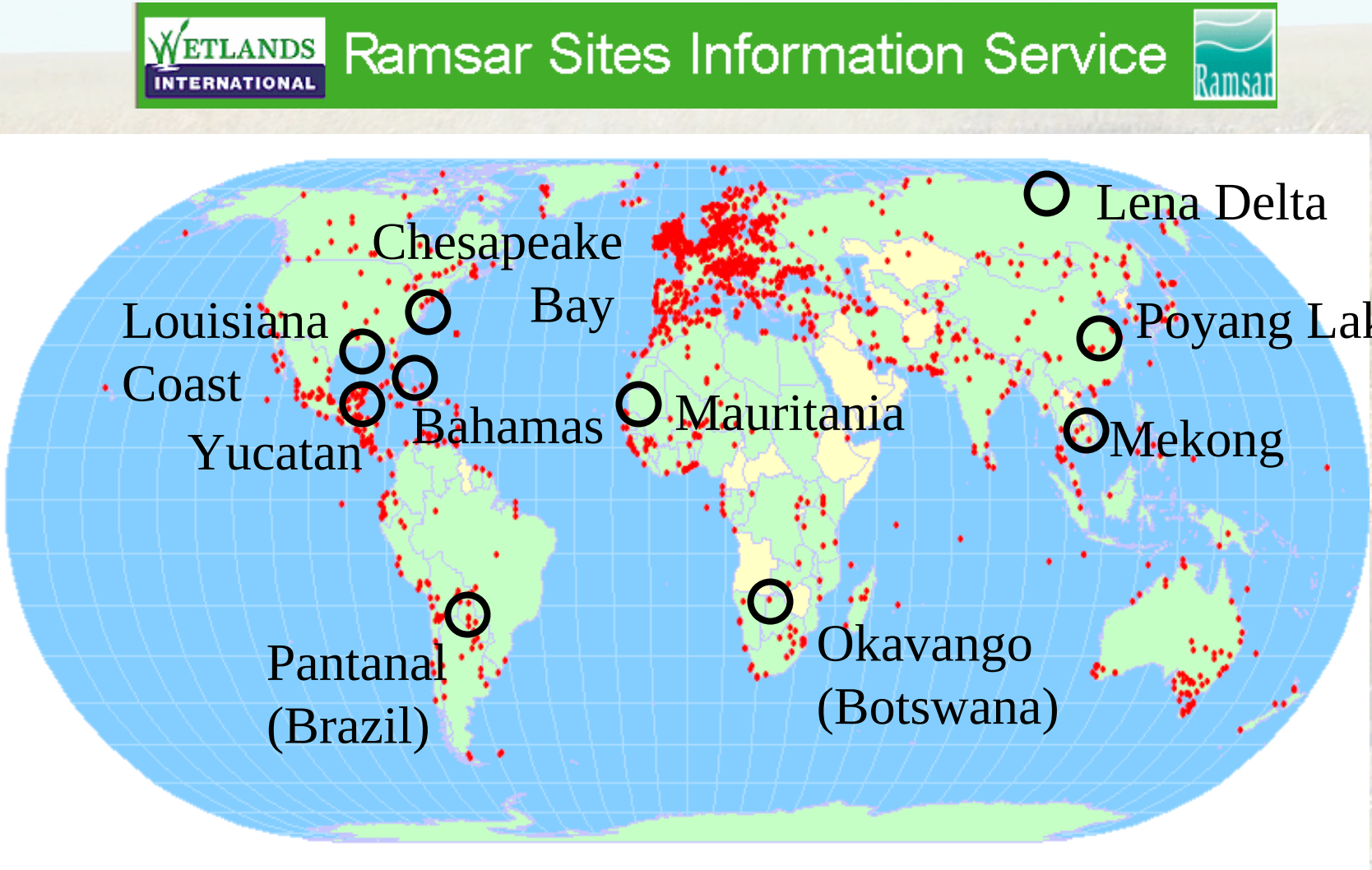
RADARSAT-1 interferogram time-series



Coherence lost in herbaceous wetlands (2005-10-01 to 2005-11-18)

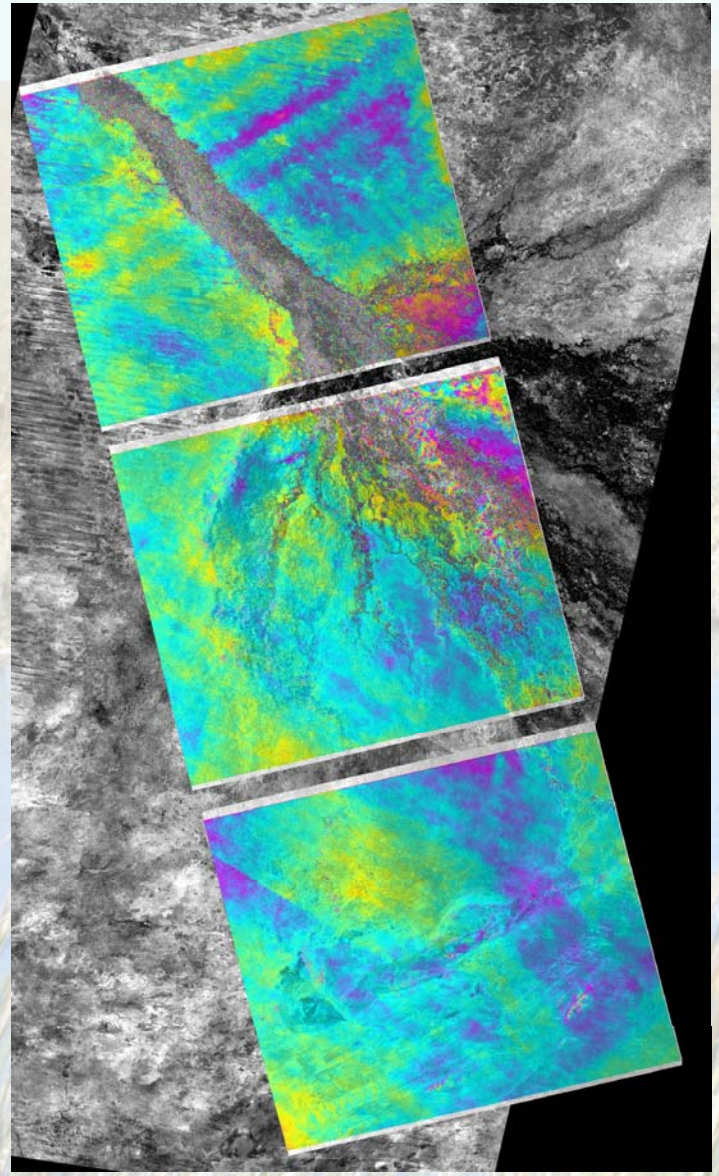
Wilma – 2005-10-24; Katrina – 2005-8-25 (heavy rain)

Other wetlands



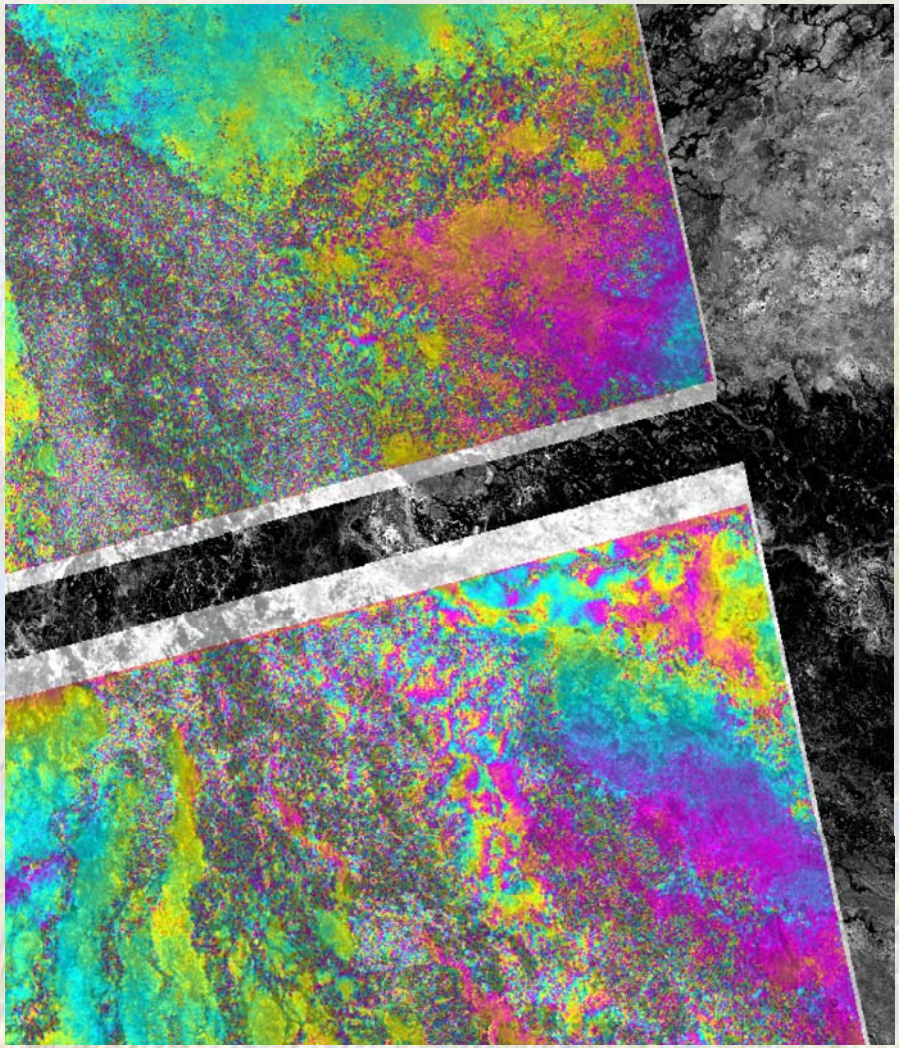
The Ramsar Convention's 1469 sites in 146 Contracting Parties

Okavango Delta: ENVISAT (VV)



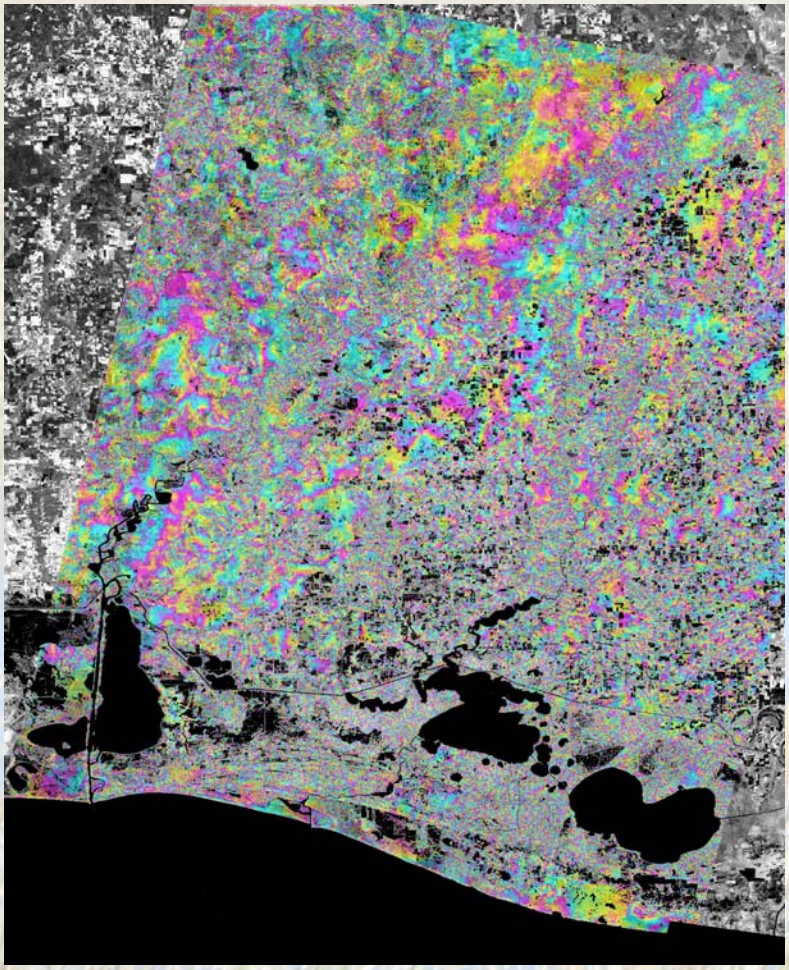
2005/05/23-2005/06/27

Baseline: 637 m



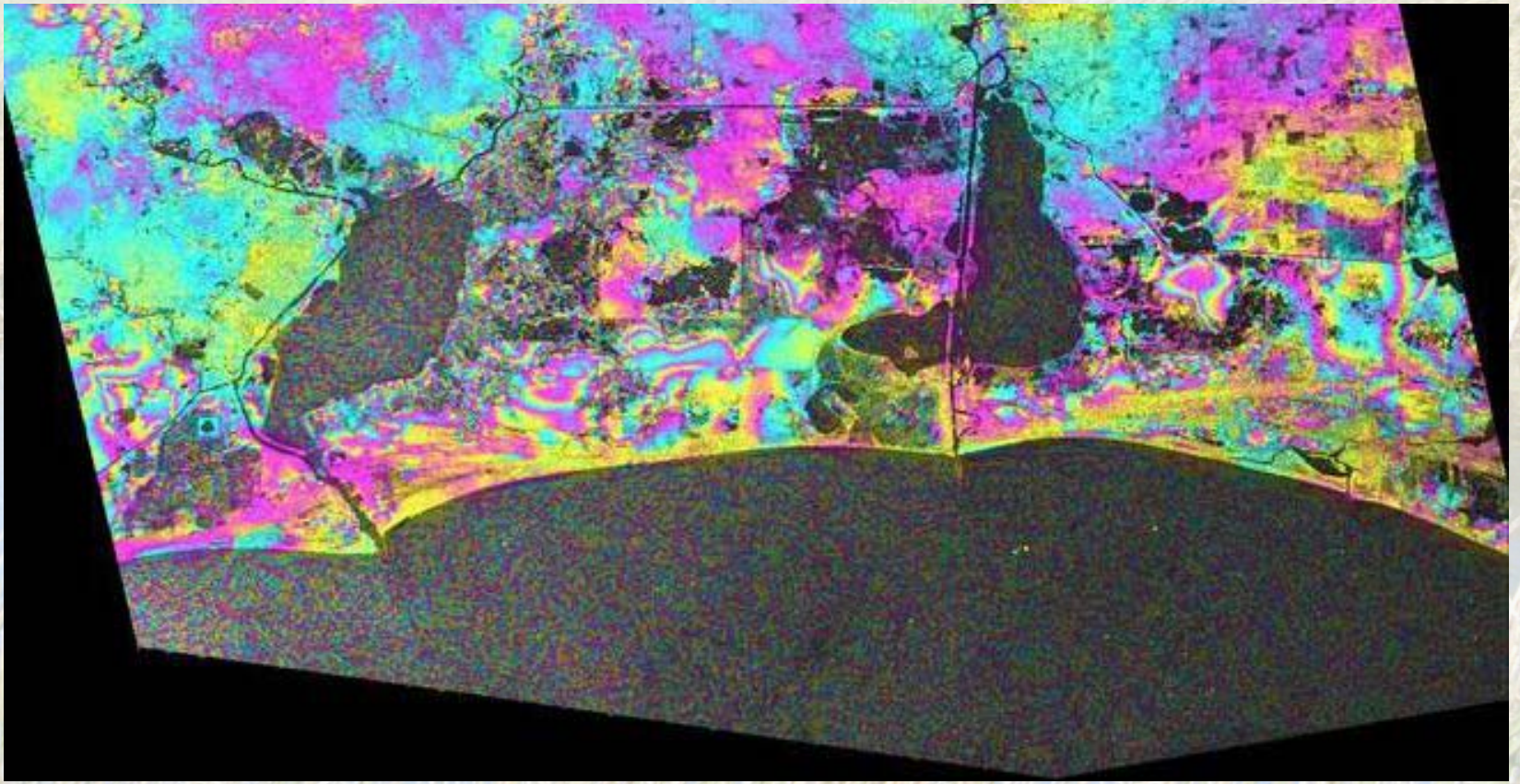
Western Louisiana: ENVISAT (VV)
(Chenier Plain)

2005/04/25-2005/07/04
Baseline: 131 m



Western Louisiana: RADARSAT-1 (HH)
(Chenier Plain)

2003/03/21-2003/04/14
Baseline: 347 m

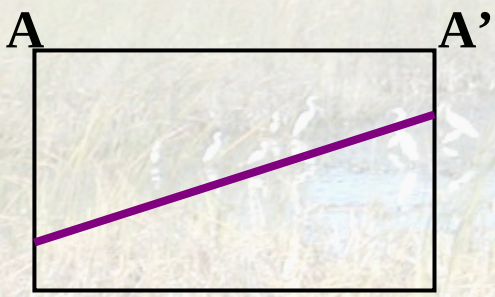


Wetland InSAR Application

- **Non-trivial:** Observations are **relative** in space and time
- Wetland hydrology requires "absolute" (w/r to a datum) measurements

Water level change

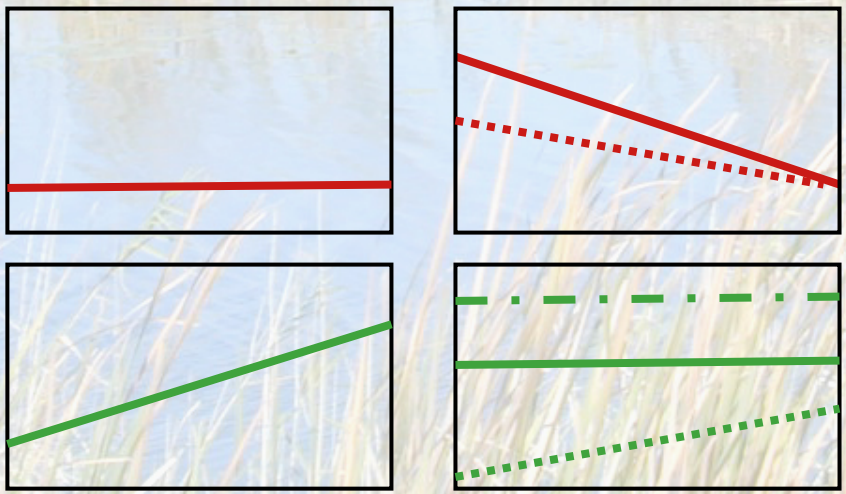
Interferogram

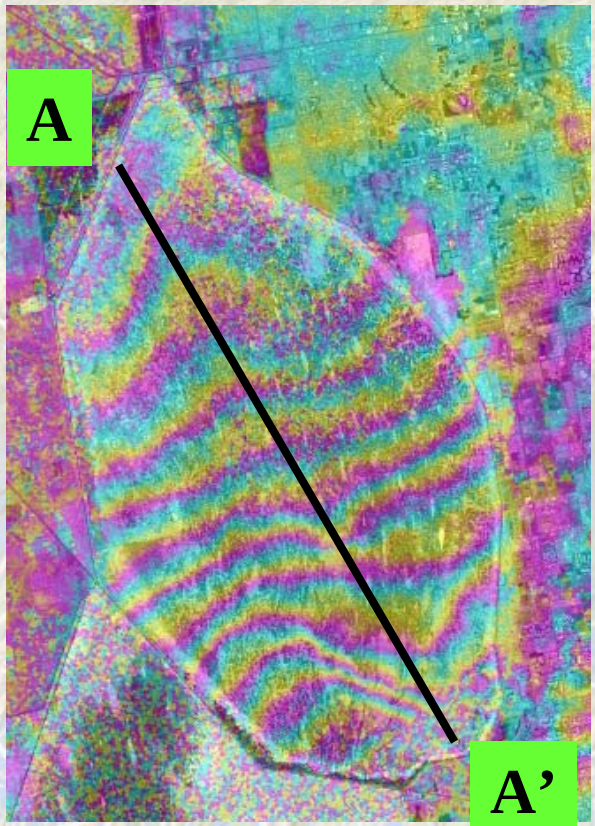


Water level ("Abolute")

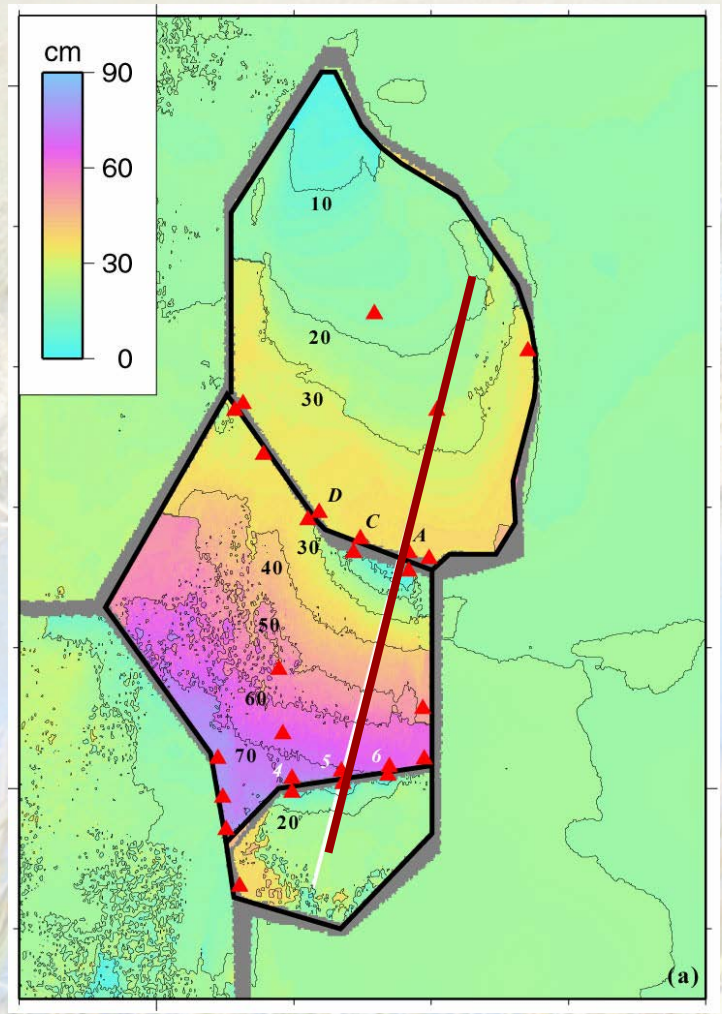
Initial

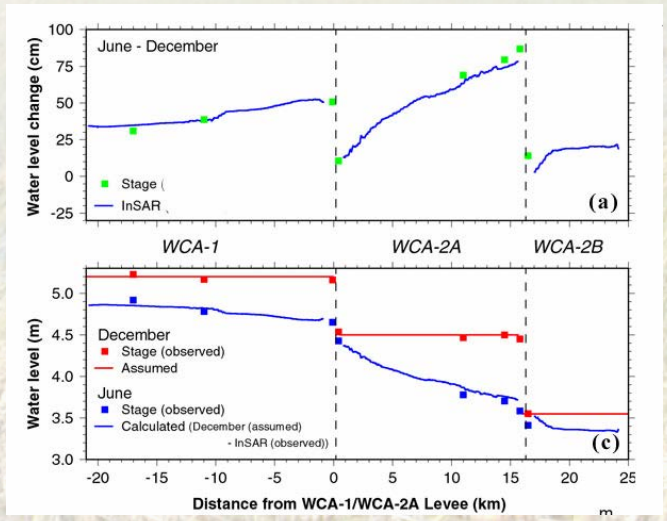
Final

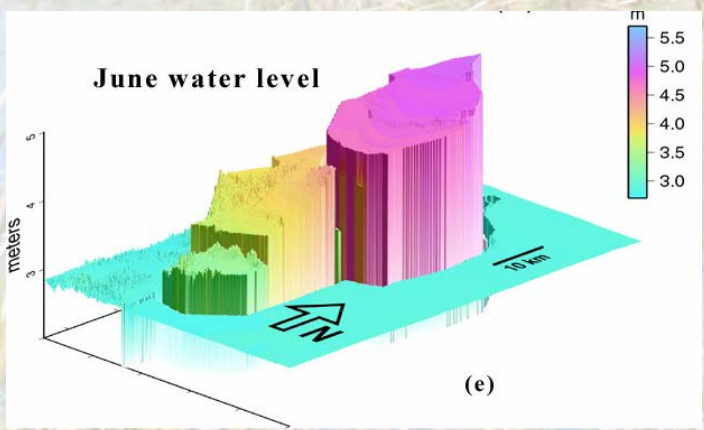




Wetland InSAR Application:
Integration with terrestrial-based stage data

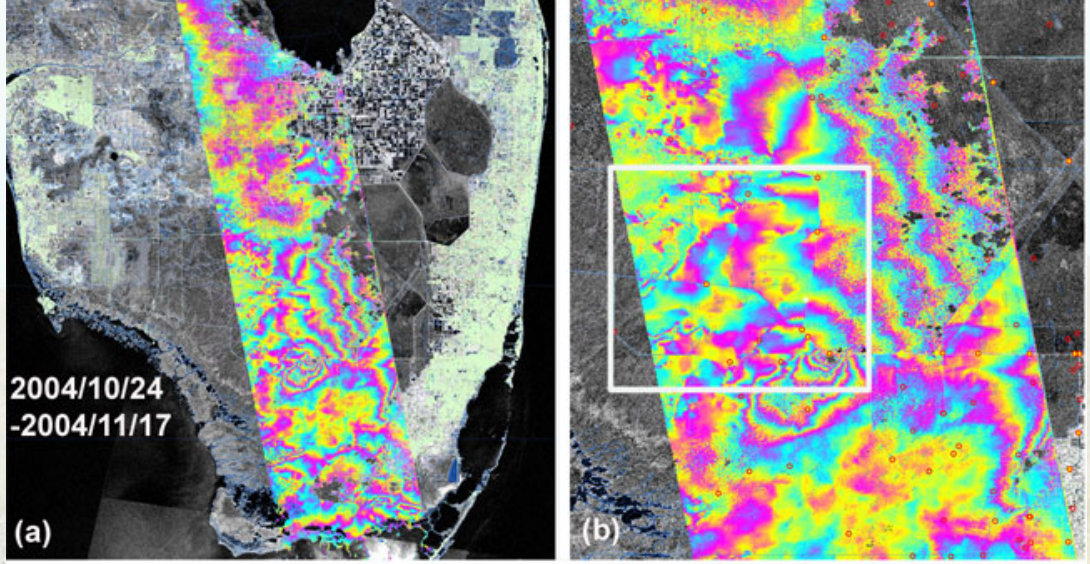


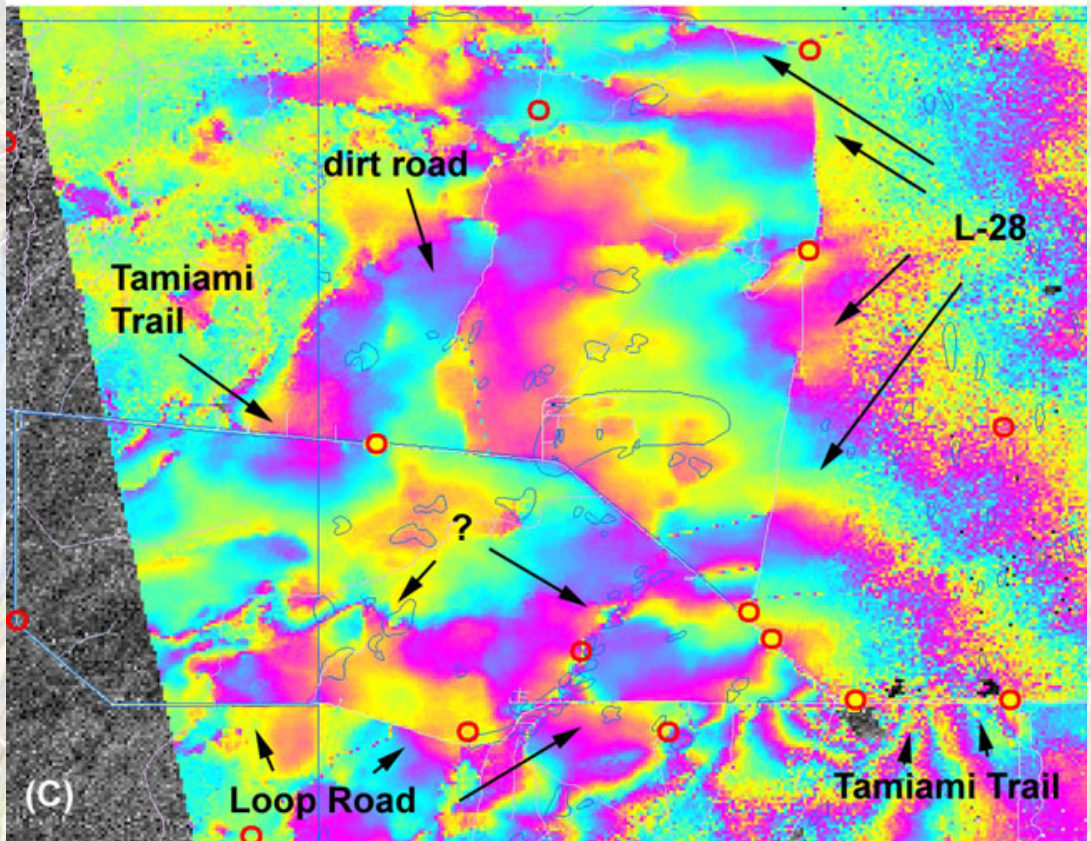




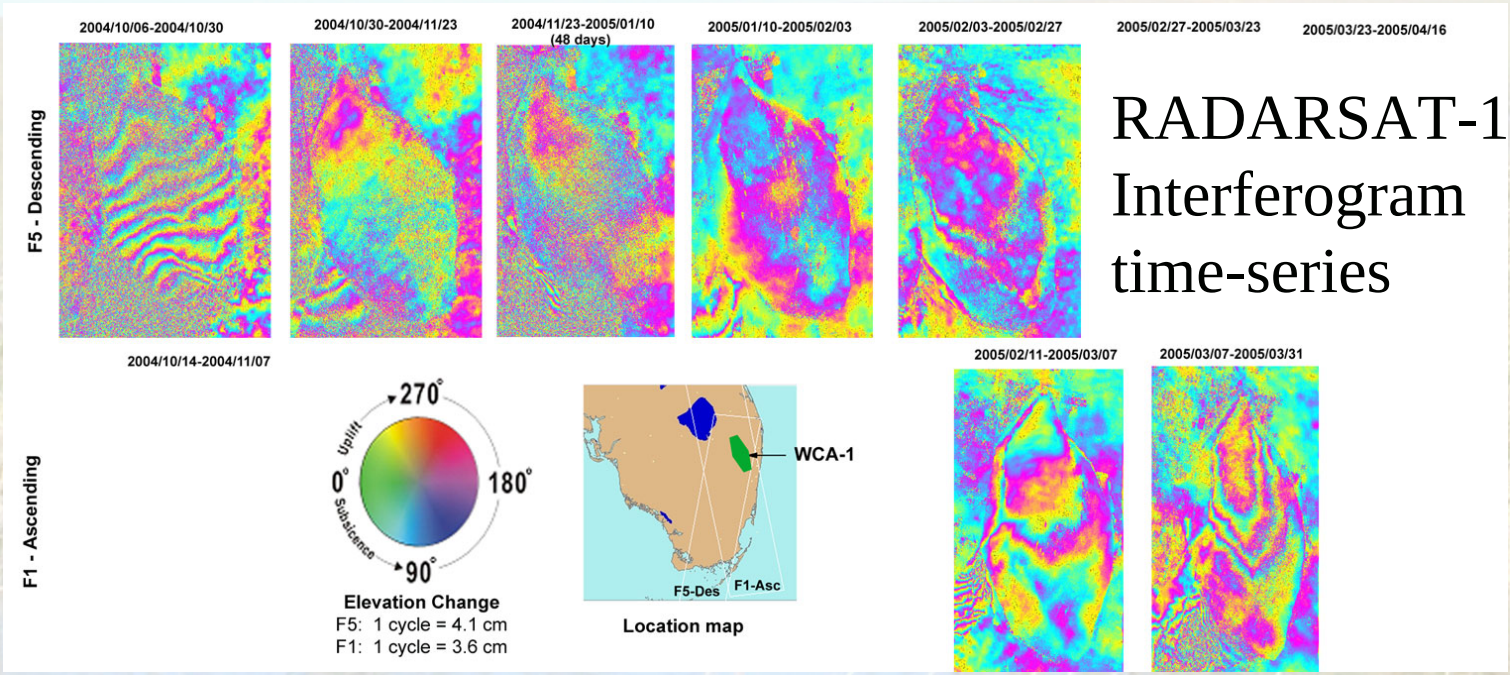
Wdowinski et al. [2004]

Wetland InSAR Application: Detection of flow discontinuities

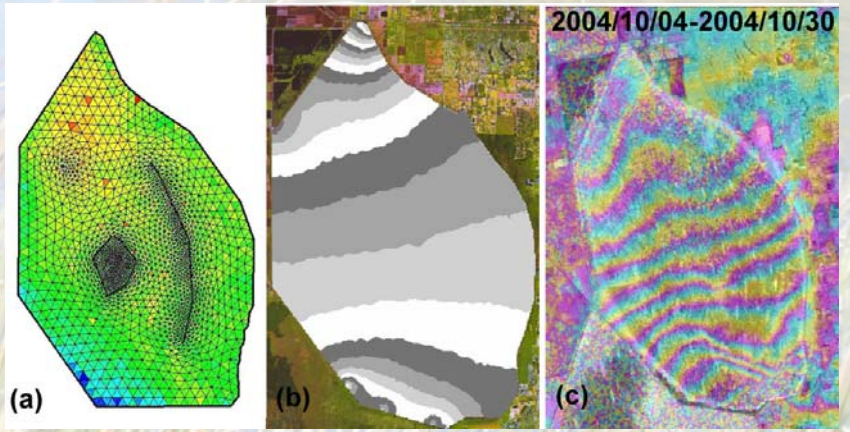




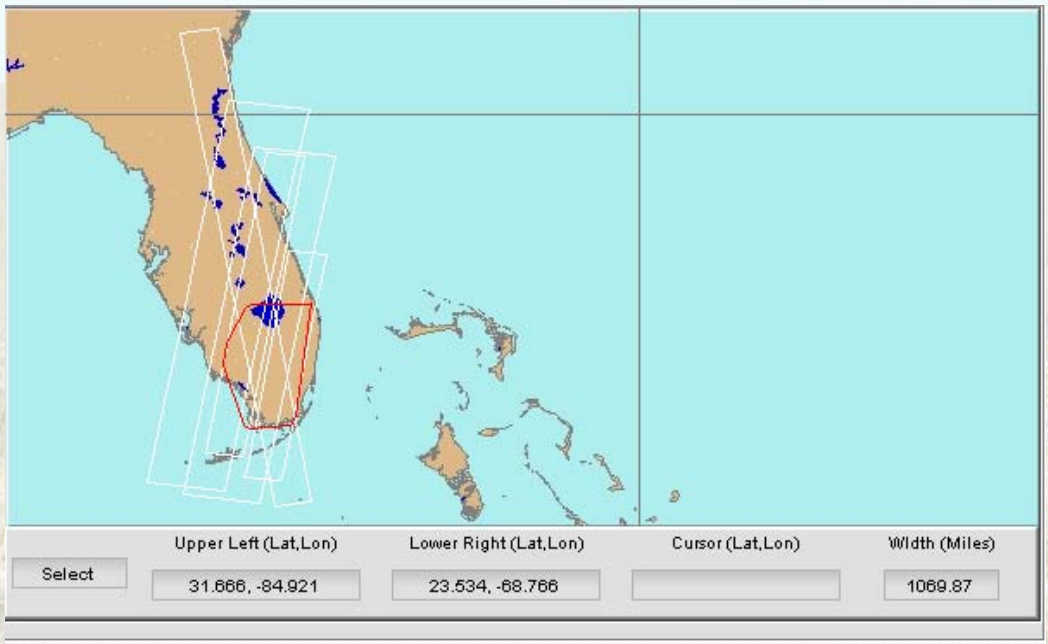
Wetland InSAR Application:
Development of high-resolution flow models



Finite element flow
Model of WCA-1



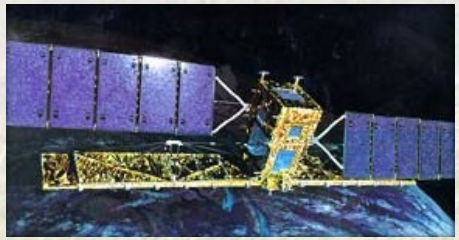
Real-time monitoring – data acquisition



Catalog Browse Query Results — Result Size: 5

Workorder	Sat	Inst	Date	Product
CA_RSAT1_Redun...	RSAT1	RSAT1	2006-03-21 11:19:1...	STF
CA_RSAT1_Redun...	RSAT1	RSAT1	2006-03-18 11:07:2...	STF
CA_RSAT1_Redun...	RSAT1	RSAT1	2006-03-12 23:32:0...	STF
CA_RSAT1_Redun...	RSAT1	RSAT1	2006-03-11 11:11:0...	STF
CA_RSAT1_Redun...	RSAT1	RSAT1	2006-03-04 11:15:1...	STF

RADARSAT-1



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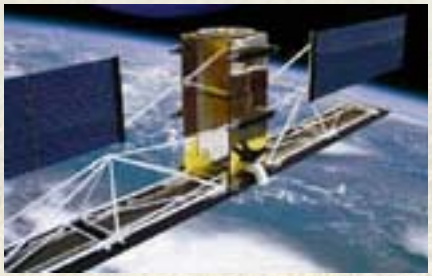
CENTER FOR SOUTHEASTERN TROPICAL ADVANCED REMOTE SENSING

Downlink at CSTARS

- 5 DARs (Data Acquisition Request)
- 24-days repeat orbit (3 Fine beam, 2 Standard beam)
- New acquisition every 5-7 days

Real-time monitoring – data processing

RADAR SAT



Downlink at CSTARS

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CENTER FOR SOUTHEASTERN TROPICAL ADVANCED REMOTE SENSING

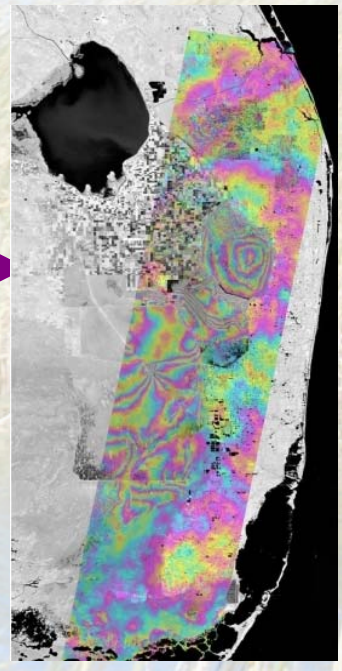
New data

Initial processing (FOCUS)

Archived data

Search for a pair in the archive

Water level change map



Interferometric processing within hours

Conclusions

- What SAR data are suitable for this application?
  - JERS-1 – L-band, HH
  - RADARSAT-1 – C-band, HH, 24-day repeat orbit
  - ERS-1/2, ENVISAT – sometimes (HH is better)
- Where does wetland-InSAR work?
  - Everglades
  - Eastern Louisiana, Yucatan, Okavango
- Why using (developing) the application?
  - Integration with stage data to obtain “absolute” levels
  - Detection of flow discontinuities
  - Constraining flow models (e.g., the TIME model)
  - Development of high resolution flow models

Acknowledgements

SAR data

- JAXA (NASDA) – JERS-1 L-band data
- CSA – NASA - ASF – RADARSAT-1 C-band data
- ESA – ERS-1/2 C-band data (CAT-1)
  ENVISAT C-band data (CAT-1)

Support

- National Institute for Water Research (USGS)
- NASA
- ONR