Establishing Standard Water Quality Criteria Using Satellite Products for Texas

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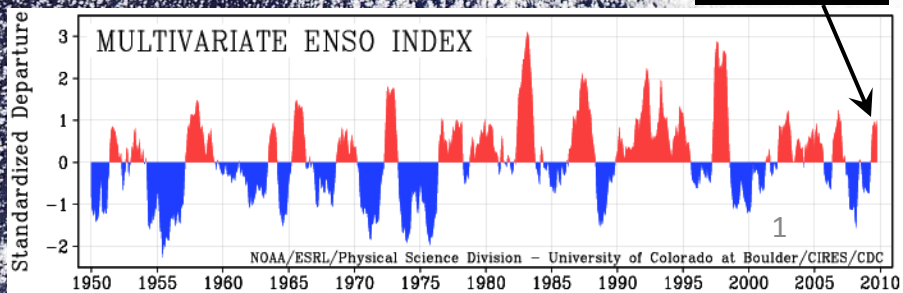


Source: NASA (Gulf of Mexico plume in October 2009)

Gulf of Mexico Alliance (GOMA) Nutrients Priority Issue Team

- Action Items:
  - N-1: Nutrient Characterization
  - N-2: Nutrient Criteria Development
  - N-3: Hypoxia
  - N-4: Nutrient Reduction Strategies
- End-users: State water quality agencies

GOMA (2008) Suggested Research Questions

- Can we use satellite products to enhance spatio-temporal resolutions of stressors related to nutrients, and link this information to ecosystem responses and management?
- Do CDOM, CHLA and TSS co-vary?
- Do water quality indicators (CHLA, CDOM and TSS) correlate with environmental variables and satellite DN?
- Can simple approaches suggested above (i.e., regressions to relate field measurements with at-sensor radiances) provide reasonable synoptic maps, or a representative value for each estuary?
- What is the optimum spatial resolution in remote sensing of estuaries?
- Are improvements of sensor calibration/characterization, atmospheric correction, and bio-optical algorithms necessary to make operational and quantitative use of the satellite products (e.g., MODIS and Landsat)?

GOMA (2008) Gulf of Mexico Alliance Nutrients Criteria Research Framework. Gulf of Mexico Alliance Nutrient Study Design workshop, NOAA National Marine Fisheries Service, Galveston, TX.

NASA ROSES 2008

Earth Science for Decision-Making-Gulf of Mexico Regions

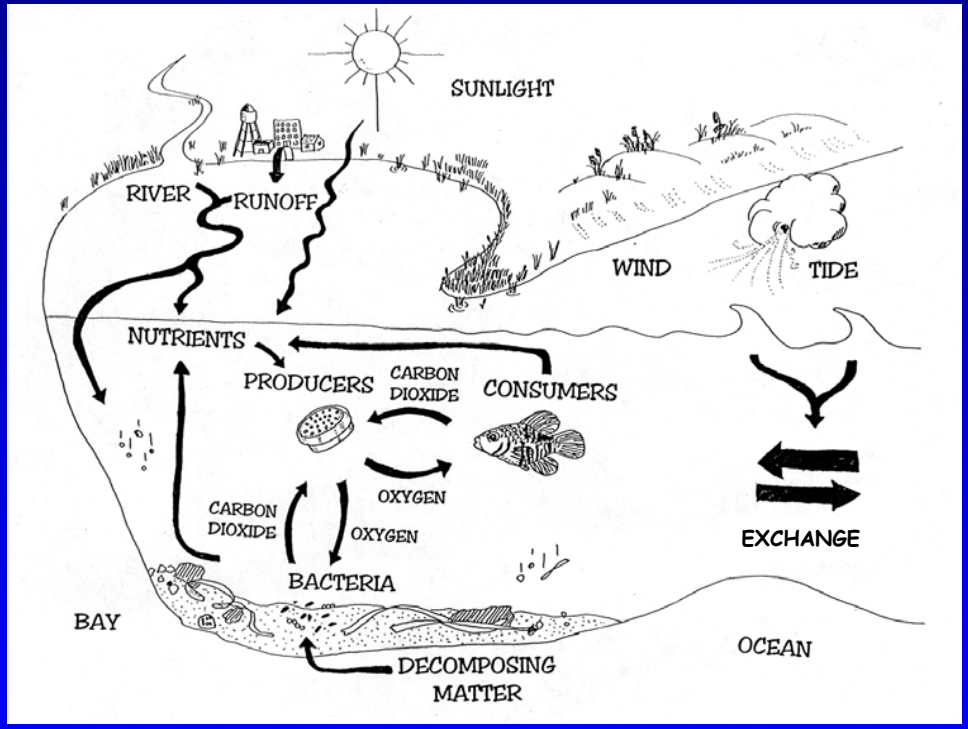
- NASA Objectives:
  - Address needs of the GOMA
- Proposed Project goals:
  - Support GOMA nutrient priority team objective to establish nutrient criteria
  - Assess water quality on local and regional scales
  - Determine stressor effects using NASA products
  - Facilitate integration of resources

Objectives and Questions

- Use NASA products to support GOMA objective to monitor nutrients and develop nutrient criteria
- Specific research questions:
  - Can we use the Texas coast for a test-bed?
  - Are inflow differences (driven by the spatial and temporal climatic variability along the Texas coast) responsible for differences in the optical characteristics of water quality in Texas estuaries?
  - If so, can we link those differences to nutrient quantities

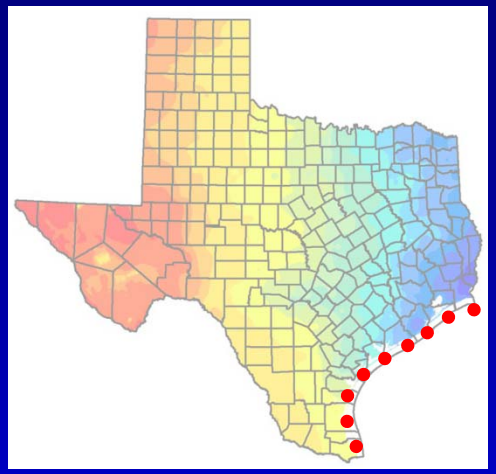
Relevant Water Quality Indicators

- Chlorophyll a (CHL) ~ microalgal biomass
  - Eutrophication can cause high CHL
  - Cause lowered dissolved oxygen leading to hypoxia (e.g., "dead zone" off Louisiana coast)
- Total Suspended Sediment (TSS)
  - Contributes to turbidity and high light attenuation coefficients (K_d)

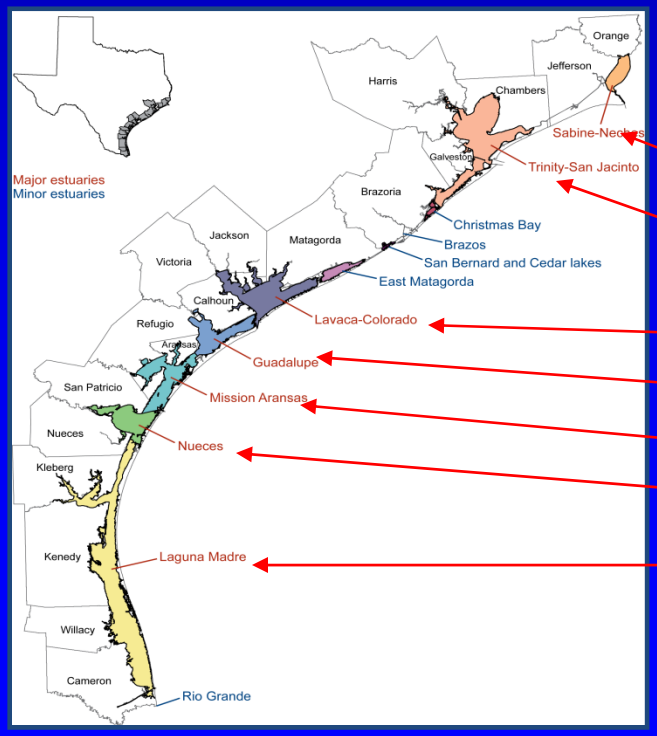


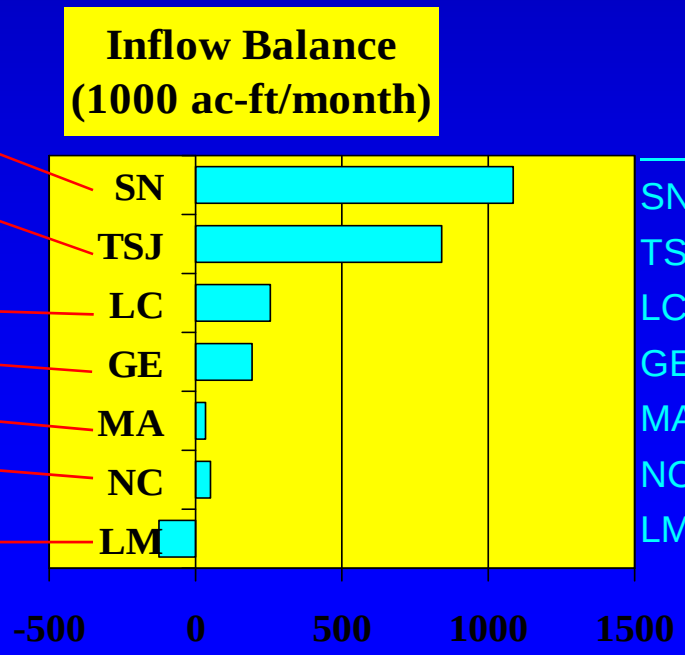
Source: Montagna et al. (1996)
http://www.cbbep.org/publications/virtuallibrary/ccbnep08.pdf

Climate Gradient along Texas Estuaries



- 7 major estuarine systems along 370-mile coast
- Climatic (rain, inflow) gradient from dry SW to wet NE
  - SW estuaries neutral: inflow ~ outflow
  - Except for Laguna Madre, which is a negative estuary
- Inflow transports nutrients, sediments, and organic matter





Estuaries

SN: Sabine-Neches

TSJ: Trinity-San Jacinto

LC: Lavaca-Colorado

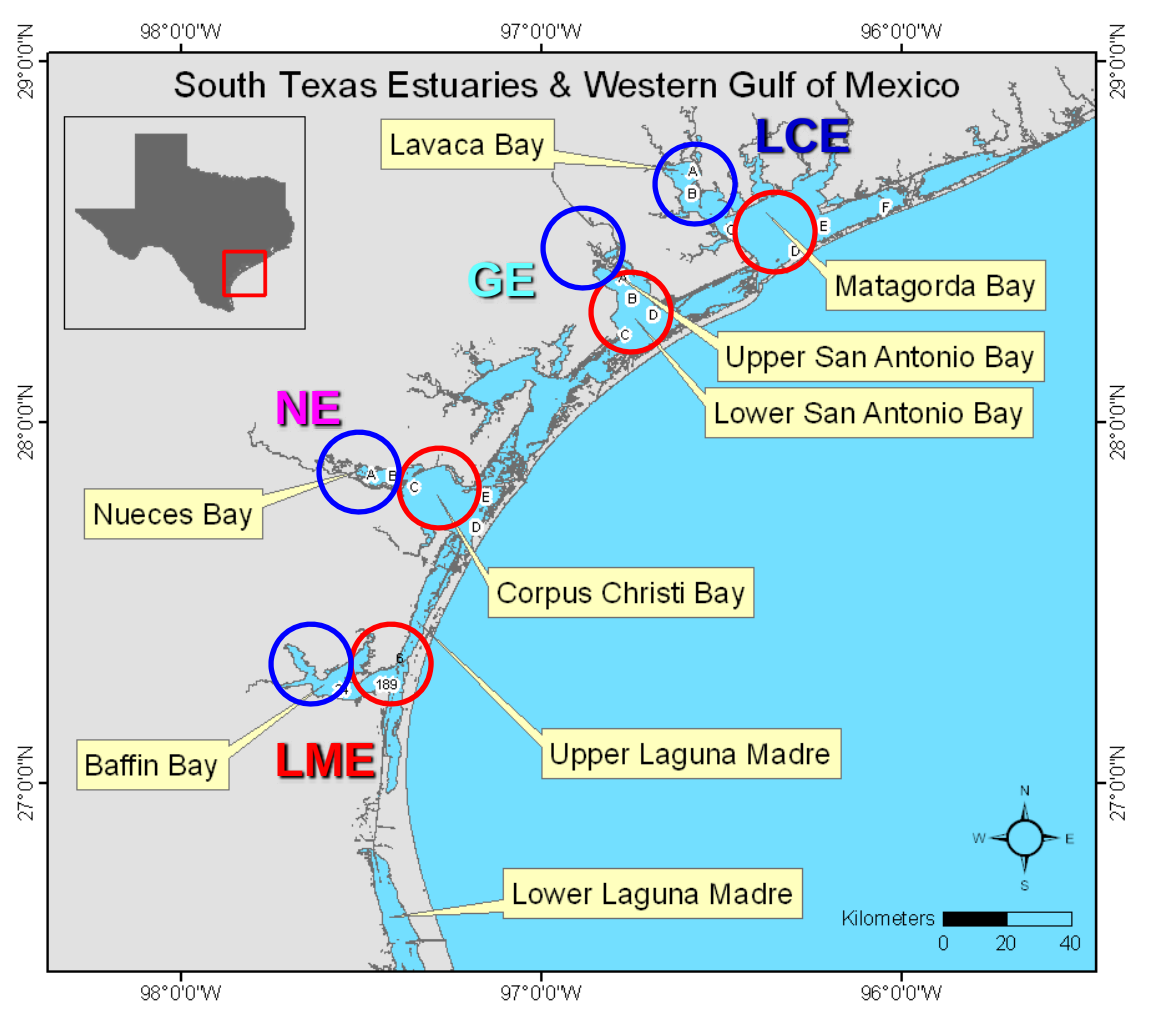
GE: Guadalupe

MA: Mission-Aransas

NC: Nueces-Corpus Christi

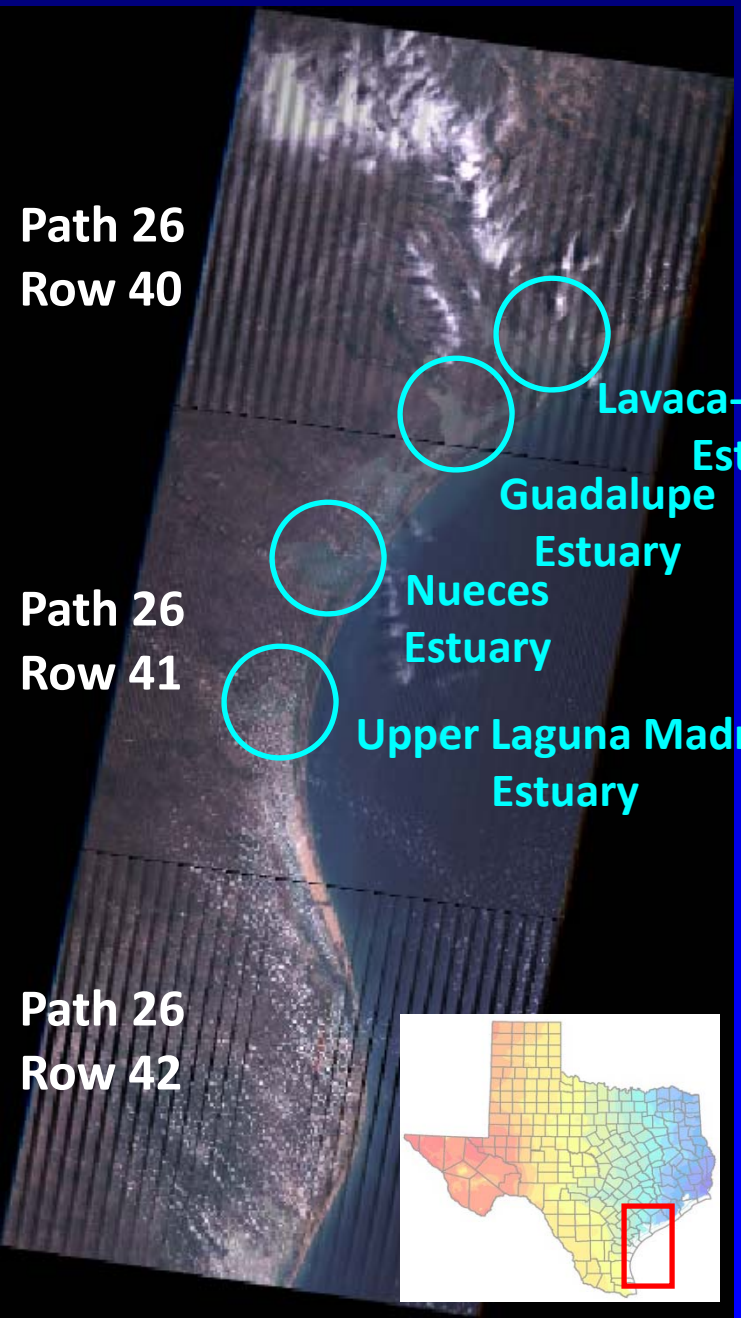
LM: Laguna Madre

Study Area: Texas Lagoonal Estuaries



- Large, but shallow (2-3 m)
- River sources ~30-50 km from Gulf inlet
- 1˚ bay (oceanic) & 2˚ bay (riverine) system
- Salinity gradient: 2˚ bay < 1˚ bay < lagoon
- Environmental and biological variables have been collected since 1988 for all bays

NASA Earth Science Products Used



Moderate Resolution Imaging Spectroradiometer (MODIS) deployed on the *Aqua* and *Terra*; Thematic Mapper (TM); and Enhanced Thematic Mapper Plus (ETM+) on the Landsat 4/5 and Landsat 7 spacecraft

Images are Landsat 7, ETM+, bands 1, 2, and 3 collected on different days (note: striping is due to scan-line corrector malfunction)

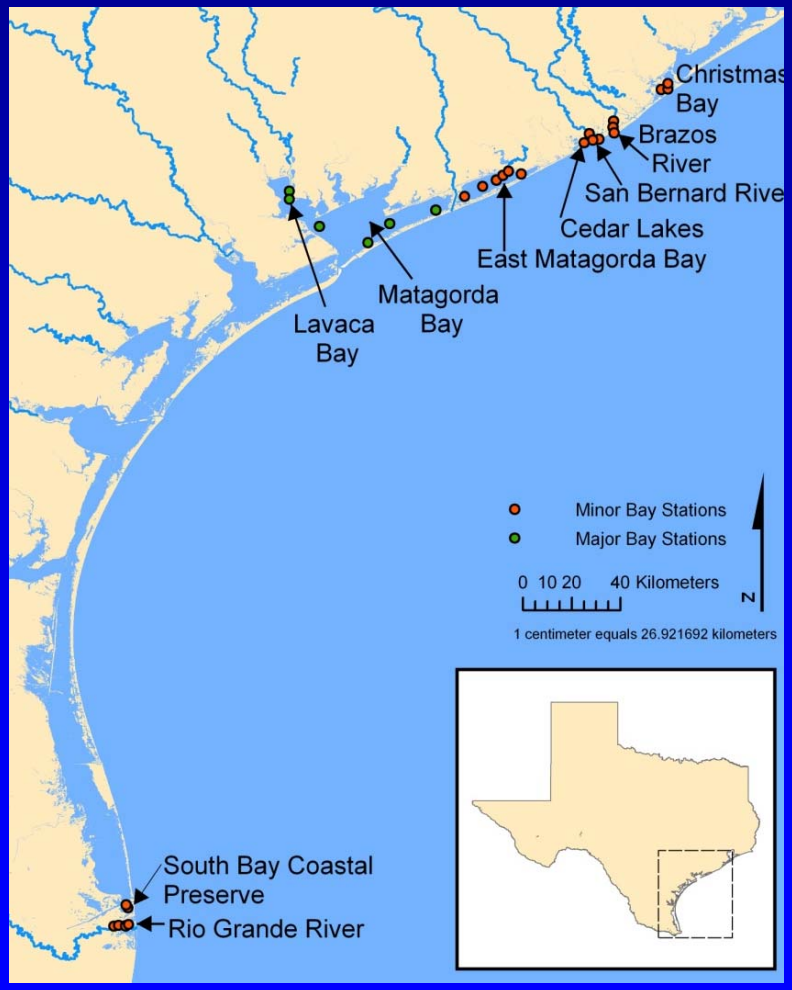
Sources of *In Situ* Field Measurements

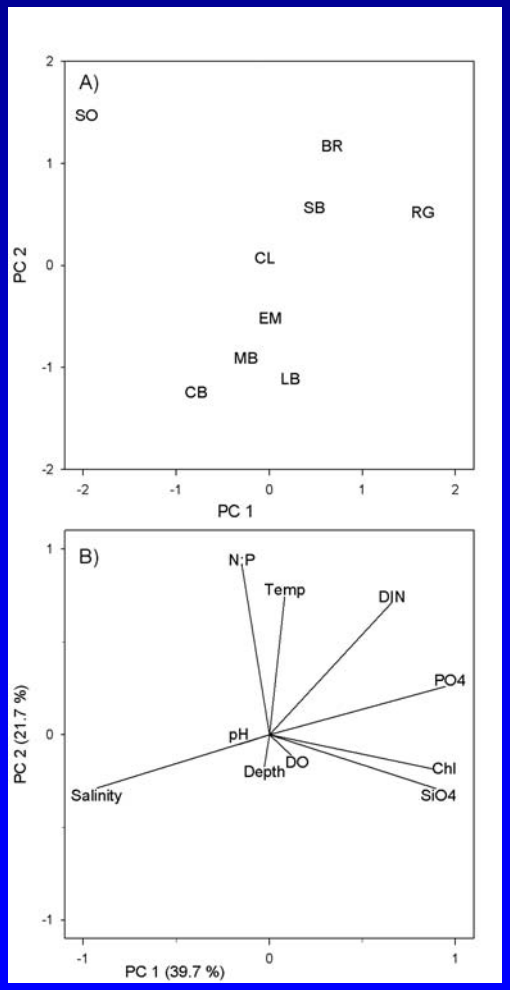
Category	Data	Sources
Hydrology	rain, runoff, gauged, returns, evaporation, diversions	TWDB, USGS
Water Quality	salinity, temperature, dissolved oxygen, nutrients, chlorophyll	HRI, TCEQ, TPWD, USEPA
Habitats	area, geo-referenced locations	TGLO, NOAA, USGS
Watersheds	locations, water quality	TCEQ, USEPA
Biological	fish, epifauna, infauna, juveniles, oysters	HRI, TPWD
Socioeconomic	population, land use, economic	HRI, NOAA, TNRIS

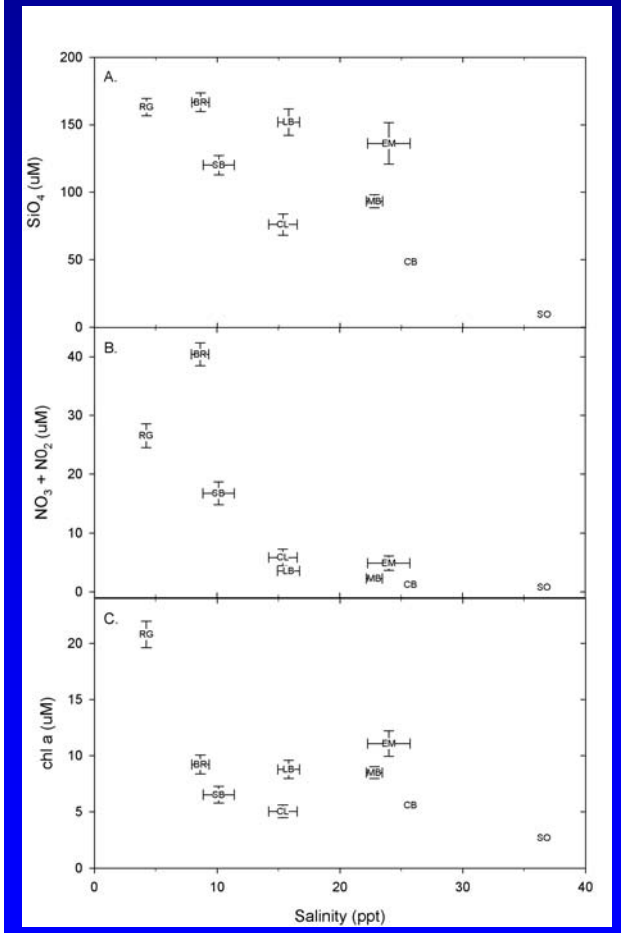
Federal Agencies: USGS; USEPA; NOAA

State Agencies: Texas Water Development Board **(TWDB)**; Texas Commission on Environmental Quality **(TCEQ)**; Texas General Land Office **(TGLO)**; Texas Parks and Wildlife Department **(TPWD)**; Texas Natural Resource Information System **(TNRIS)**

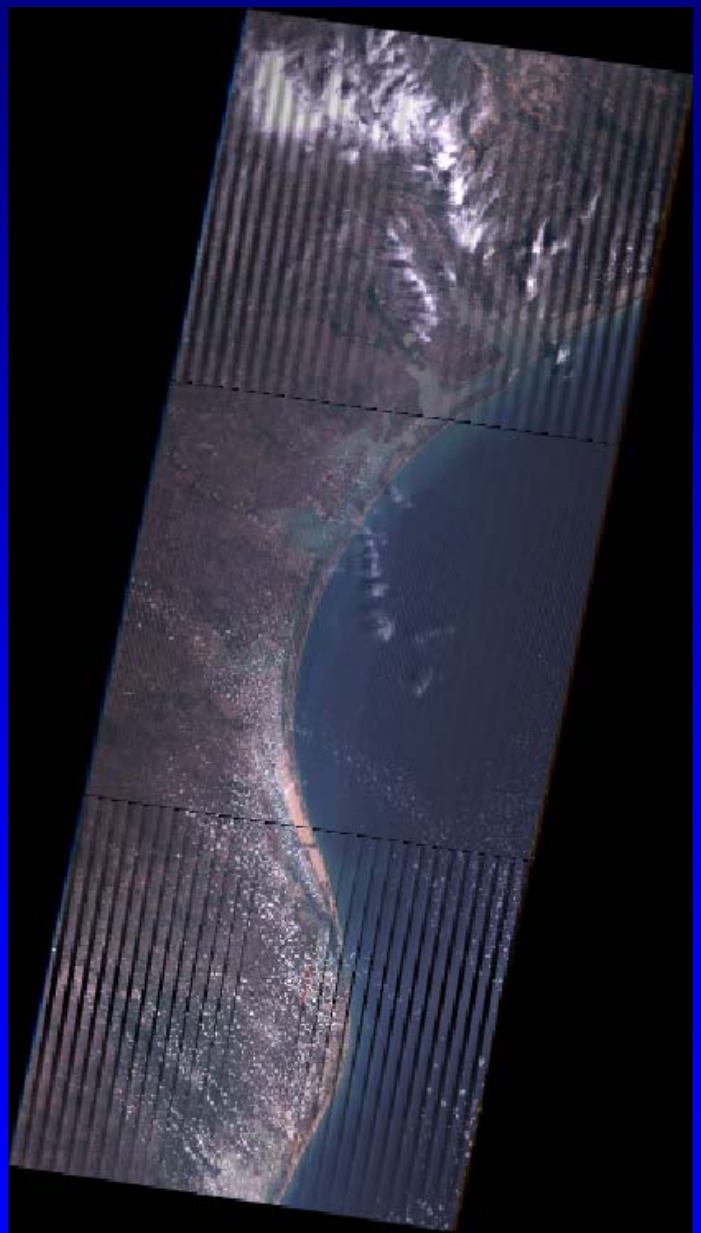
Relationship Between Flow and Water Quality

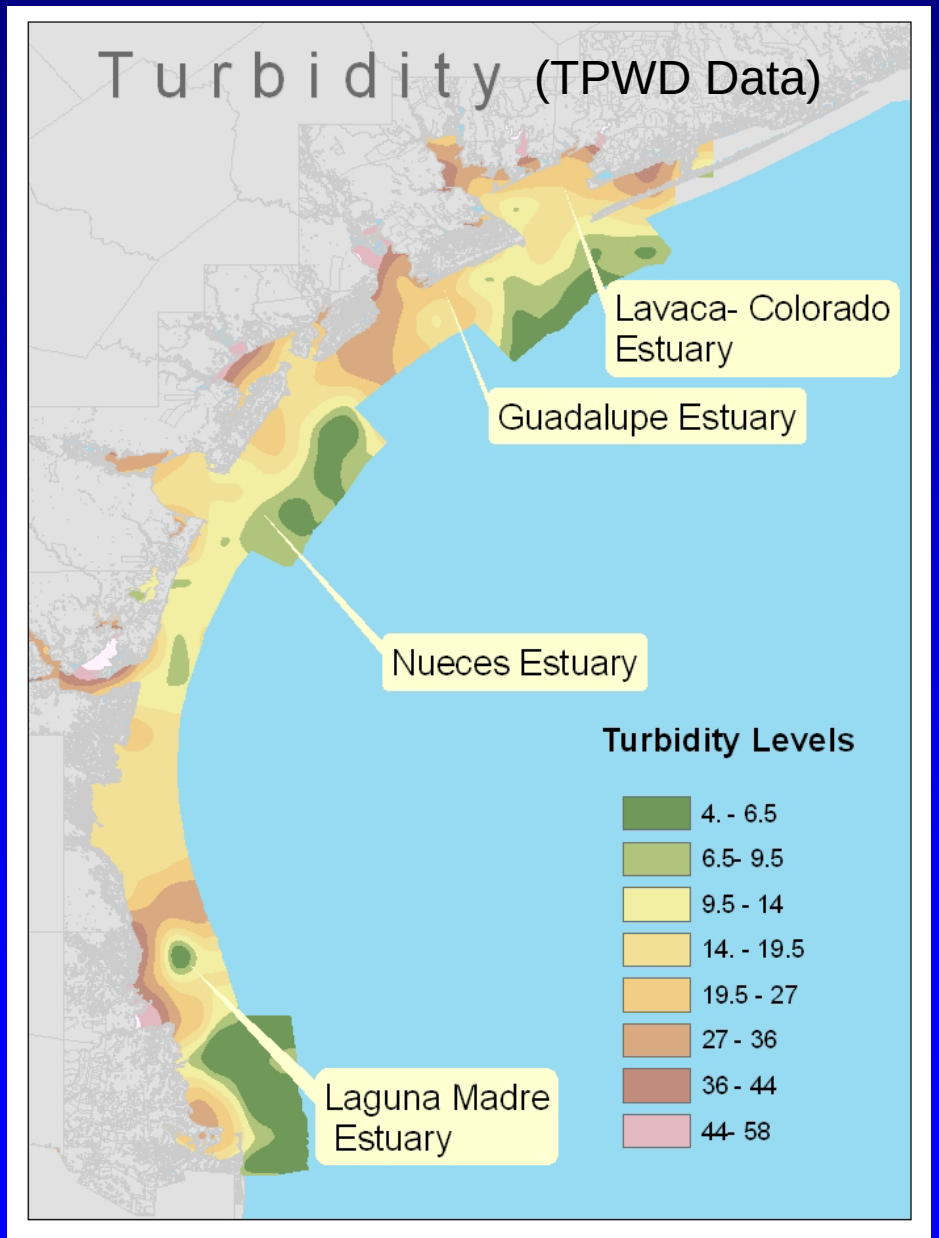






Relationship With Turbidity





Linking in situ Measurements with Remote Sensing

Three approaches will be taken :

1. **Statistical correlation** (e.g., satellite digital number (DN) vs. *in situ* water quality parameters (CHLA, CDOM, and TSS), K_d is estimated from concentration of measured parameters and thus linked to satellite DN)

2. ***In situ*** inherent and apparent optical properties (IOP's and AOP's) vs. *in situ* water quality parameters (CHLA, CDOM, and TSS) related to a direct connection to K_d and a statistical correlation to satellite DN

3. **Analytical relationship** (e.g., radiances from the sensor vs. *in situ* IOP's and AOP's coupled with *in situ* water quality parameters, CHLA, CDOM, and TSS)

Data Products and Deliverables (for this study)

1) **Time series of MODIS-derived products** - specifically for each estuary, a sequence of monthly, seasonally, and annually averaged images of CHLA, CDOM, TSS, CDOM, and K_d - at 250/500-m and 1-km resolution if scale and estuary size permit
2) **Time series of Landsat-derived products** - extending the MODIS time series back in time, for each area a sequence of averaged images of CHLA, CDOM, TSS, and K_d -averages will be created from as many useable available images as possible and aggregated to MODIS resolution
3) **A merged dataset of Landsat and MODIS products** with new algorithms refined based on new in situ sampling data and improved inter-sensor cross-calibration methods

Questions?