Using Satellite and Fully Coupled Regional Hydrologic, Ecological, and Atmospheric Models to Study Complex Coastal Environmental Processes

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2nd Year Progress

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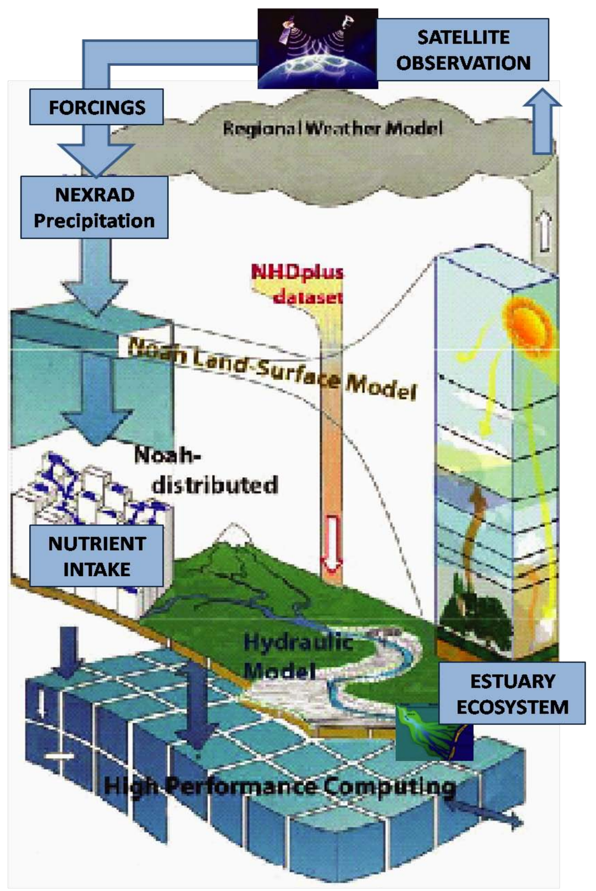
OBJECTIVES

Improving our understanding of how linked upland and estuarine ecosystem responds to combined changes in the hydrological and nutrient cycles that result from variation in climate and land use /land cover (LULC).

Integrating research expertise from a diversity of fields that includes climate modeling, remote sensing analyses, biogeochemical cycling in watersheds, surface hydrology and estuary ecology.



RESEARCH QUESTIONS

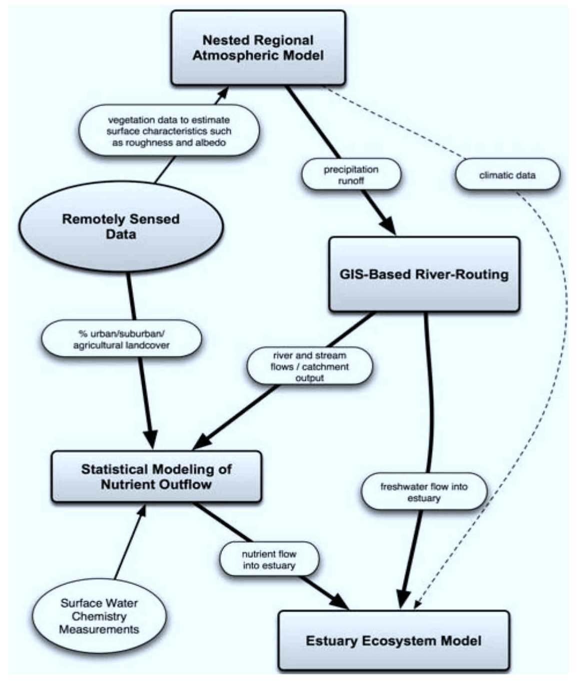
(1) What is the relationship between global climate forcing and seasonal-to-interannual climate variability and extreme storm events over the Gulf Coast region?

(2) What are the spatial patterns in LULC as defined by satellite data in the Gulf Coast region?

(3) How does riverine nutrient export to Gulf Coast estuaries vary with LULC patterns and hydrologic conditions?

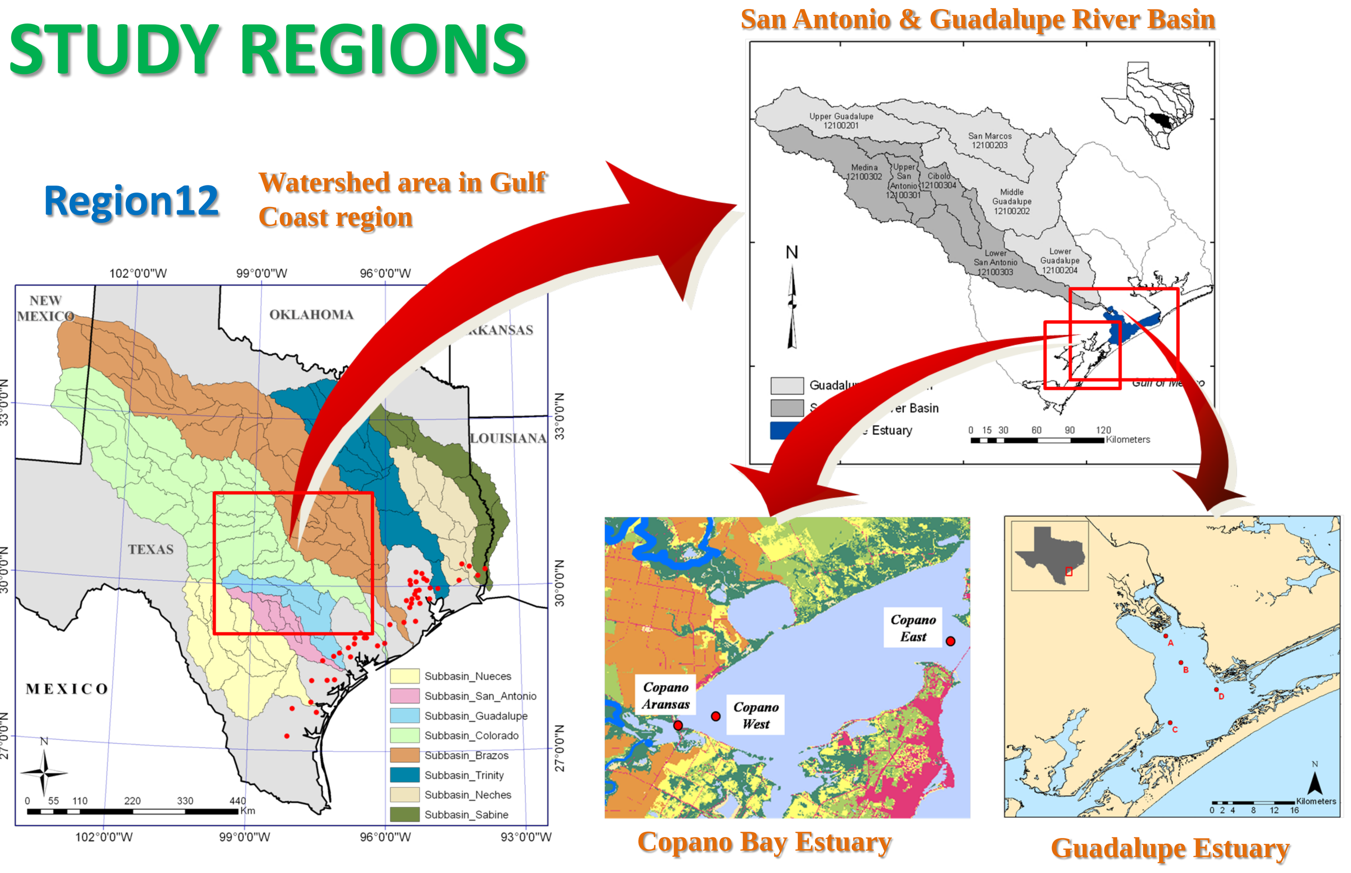
(4) What is the relationship between the frequency of extreme events in the hydrologic and nutrient cycles and the mean productivity and the resiliency of productivity in Gulf Coast estuaries?

(5) Can we use the answers to the questions above to predict the response of Gulf Coast estuaries to future climate perturbations?



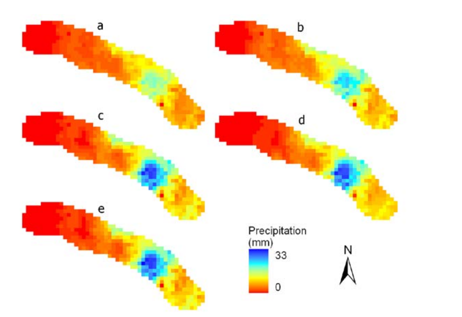
Schematic representations of the flow of data among the five components of this project. It consists of bias-corrected dynamical downscaling model, hydrological model, river routing model, water quality model, and estuary ecosystem model.

STUDY REGIONS



IMPROVED NEXRAD PRECIPITATION

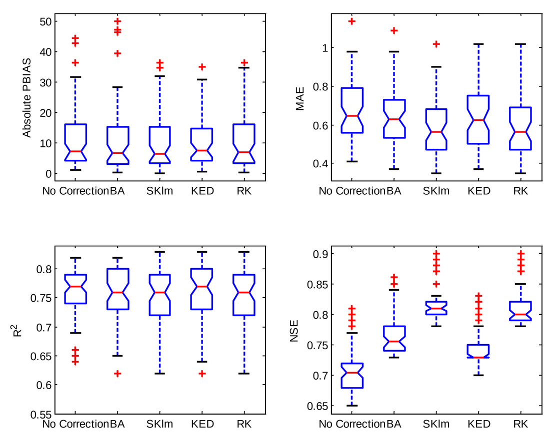
To provide more improved and accurate precipitation as input to the Noah Land Surface Model (LSM), NEXRAD Stage IV data have been examined and processed for the Gulf of Mexico Coastal region.



Spatial precipitation estimated by different methods (b: BA, c: SKlm, d: KED, e: RK) compared with the original NEXRAD map (a) at the same hour 8th on April 24, 2004.

Spatial downscaling using parsimonious physically-based multivariate-regression algorithm, which includes rain pixel clustering and optimizing (Guan et al., 2007).

Data accuracy examination using bias adjustment (BA), simple kriging with varying local means (SKlm), kriging with external drift (KED), and regression kriging (RK) methods. These methods have been evaluated by percentage bias (PBIAS), mean absolute error (MAE), coefficient of determination (R^2), and Nash-Sutcliffe efficiency (NSE).



Box-and-whisker plot of the *PBIAS, MAE, R^2 and NSE* values of the 50 rain gauge for four different methods. Results show that the average performance of SKlm is similar to or better than the other three methods.

NEW DEVELOPMENT IN NOAH LSM

Equipped with multiple parameterization options

1. Application of a separated canopy layer that distinguishes the canopy temperature from the ground temperature.

2. A modified two-stream radiation transfer scheme for the 3-D canopy structure effects on radiation transfer.

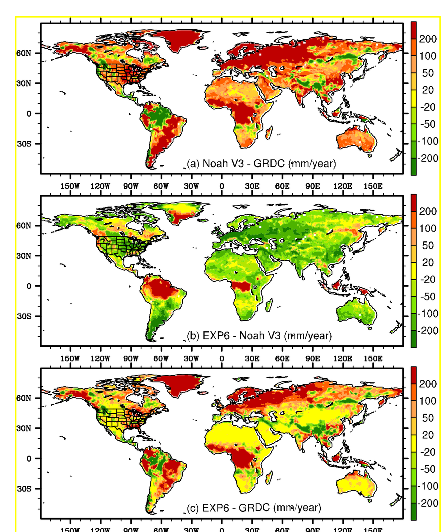
3. A Ball-Berry type stomatal resistance scheme.

4. A short-term dynamic vegetation model which accounts for photosynthesis, allocation of the assimilated carbon to various carbon pool such as leaf, stem, and wood, respiration of each carbon pool.

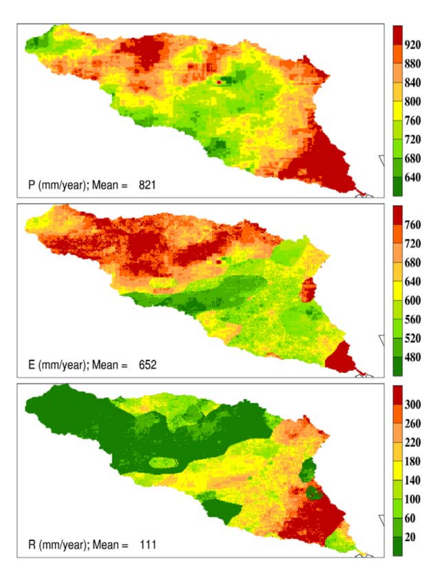
5. Application of a simple TOPMODEL-based runoff scheme and groundwater model (Niu et al., 2005; Niu et al., 2007).

6. A physically-based 3-layer snow model to accommodate snowpack internal processes.

7. A more permeable frozen soil to separate a grid cell into a permeable fraction and an impermeable fraction.



Differences of annual runoff climatology, a) the Noah baseline model minus Global Runoff Data Center (GRDC), b) modified Noah (EXP6) minus the Noah baseline model, and c) modified Noah minus GRDC.

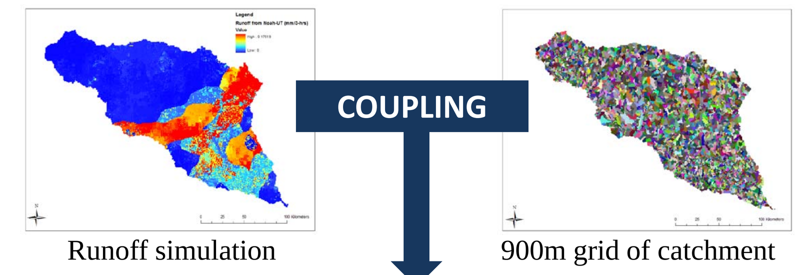


Application to Guadalupe and San Antonio river basins : precipitation (upper), evapotranspiration (middle), runoff (lower).

RIVER ROUTING MODEL

A river network model called RAPID (Routing Application for Parallel computation of Discharge) has been used to produce stream flow estimation from runoff simulations by the Noah LSM.

Coupling of RAPID and the Noah LSM is facilitated by a flux coupler which is designed to convert the gridded runoff into lateral inflow for a river network extracted from the NHDPlus dataset.



Runoff simulation

900m grid of catchment

Runoff is spatially averaged for catchments surrounding NHDPlus flow lines.

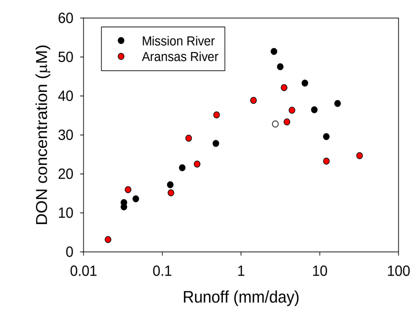
	AVG daily Discharge 2004 ~ 2007 (m^3/s)			Bias (m^3/s) Model – OBS		RMSE (m^3/s)		NSE	
	OBS	Lumped	RAPID	Lumped	RAPID	Lumped	RAPID	Lumped	RAPID
Tivoli at GS	57.94	124.82	123.18	66.88	65.24	202.48	191.22	-67.48	-60.07
Victoria at GS	80.93	61.95	61.96	-18.98	-18.97	94.80	77.73	0.53	0.69
Sattler at GS	22.03	6.61	6.62	-15.42	-15.41	39.40	39.22	-0.02	-0.01
Victoria at CC	3.99	13.73	13.73	9.74	9.74	26.42	26.84	-0.32	-0.36
Goliad at SAR	37.53	34.96	34.97	-2.57	-2.56	42.09	44.84	0.57	0.51

Evaluation of modeled stream flow at five locations in the Guadalupe and San Antonio River Basins (GS: Guadalupe River, CC: Coleto Creek, SAR: San Antonio River).

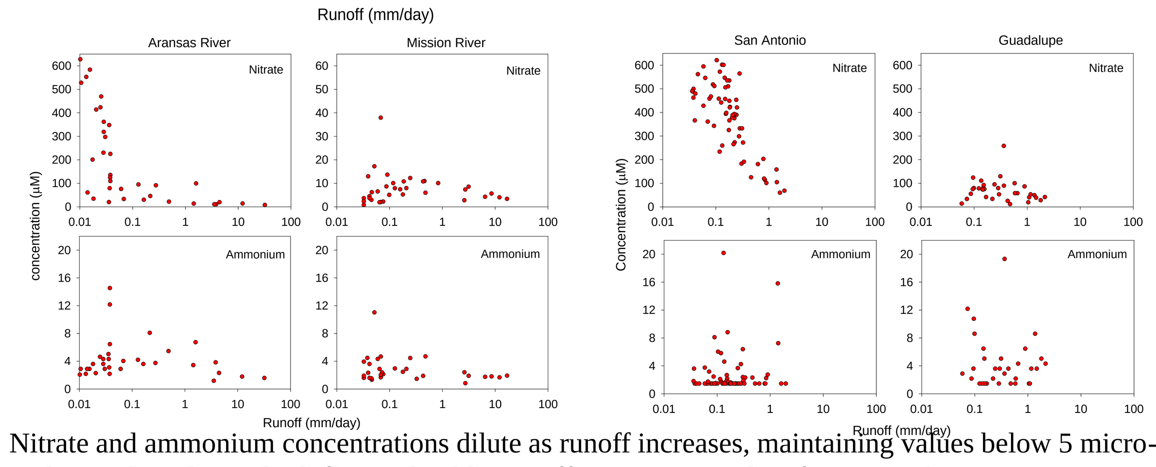
NUTRIENT EXPORT STUDY

River water sampling in the Guadalupe, San Antonio, Mission, and Aransas rivers during storm events as well as base flow conditions is increasing our understanding of how nutrient concentrations and export vary with flow.

Water quality data from independent research and monitoring efforts in Copano Bay have been compiled to support the estuarine ecosystem modeling component. The dataset for Copano Bay is exceptionally rich because it has been the focus of a NOAA sponsored study on watershed export events during the past two years and because the Mission Aransas National Estuarine Research Reserve (MANERR) maintains two monitoring stations in the bay.



Dissolved organic nitrogen (DON) concentrations increase as runoff increases, maintaining values between ~25 and 55 micromoles per liter during high flow

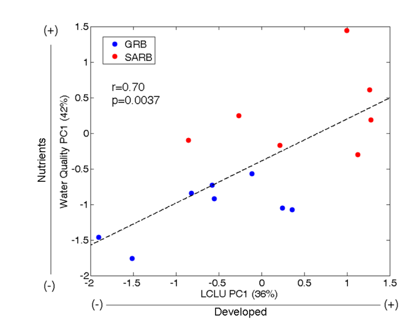


Nitrate and ammonium concentrations dilute as runoff increases, maintaining values below 5 micromoles per liter during high flow. The dilution effect is more evident for nitrate than ammonium.

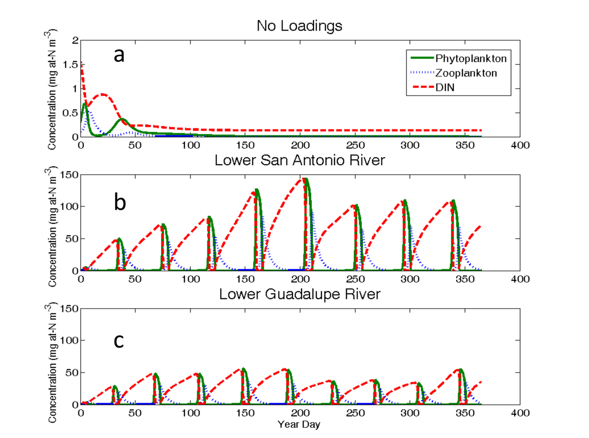
ESTUARY ECOSYSTEM MODELING

Quarterly sampling has been accomplished in July 2008, October 2008, January 2009, and April 2009.

Differing basin characteristics, such as size, population, land use, permitted discharges, precipitation and flow, can lead to changes in nutrient loadings, and model simulations revealed different ecosystem responses (e.g., timing, duration and magnitude of dissolved inorganic nitrogen, phytoplankton and zooplankton) to different scenarios of nutrient loading.



Relationship between the first principal components of water quality (Water Quality PC1) and land use/land cover (LCLU PC1) data for HUC and year (1992 and 2001) in the Guadalupe (GRB) and San Antonio (SARB) River Basins.



Temporal dynamics of prognostic variables under three different scenarios of DIN loading: a. no daily DIN loads, b. daily DIN loads only from Lower San Antonio River, and c. daily DIN loads only from Lower Guadalupe River. All three assumed a condition that only 50% of detrital matters is remineralized, and the remaining 50% sinks to bottom.

FUTURE WORK

Developing soil and water assessment tool (SWAT) for water quality estimation.

Simulating more accurate runoff for Region12 through parameterization of vegetation properties with utilization of remote sensing data such as LULC and NDVI.

Developing more realistic ecosystem loadings-based model and expanding work to other river basins along Texas coast.

Investigating LULC changes in Texas to asses their effects on land surface and estuary ecosystem processes.

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