An Integrated Earth System Science Approach for Predicting Nutrient Transports from the Land to the Ocean

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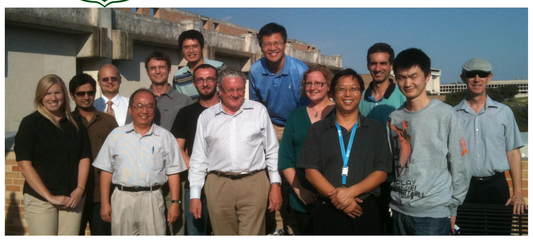
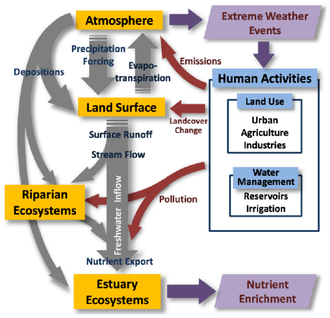


OBJECTIVES

Extreme disturbances such as "hundred-year" floods and extreme droughts not only have major impacts on human society, but also will shape the future Earth system. Hence, a holistic Earth system approach is needed to understand the physical, chemical and biological interactions and feedbacks among the atmosphere, the land surface, the oceans, and the humans. The overall primary objective of this proposal is to improve our understanding of how terrestrial and aquatic ecosystems that are connected by watersheds respond to combined changes in the hydrological and biogeochemical cycles that result from changes in climate and land use. A secondary objective is to develop and utilize a model framework for predicting how terrestrial and coastal estuary ecosystems may change in response to future perturbations.



The complex pathways of nutrients and water

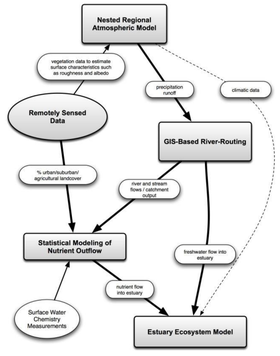
RESEARCH QUESTIONS

1) What are the entire pathways of particulates and solutes from the atmosphere through terrestrial and riverine environments to the coastal waters in the west Gulf of Mexico?

2) How are these pathways affected by climate change and land use change?

3) What are the effects of atmospheric dry and wet N deposition on riverine N exports and estuarine ecosystem functions?

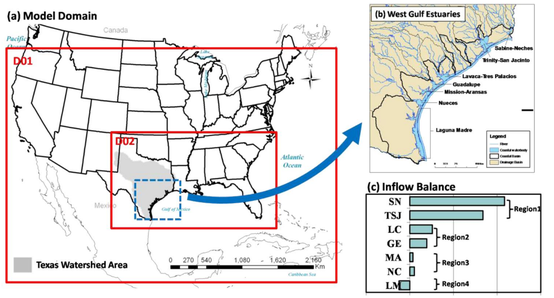
4) What are the effects of changing climate and land use on terrestrial runoff and associated nutrient export to and availability within ocean margin waters?



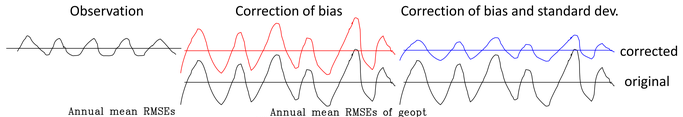
Schematic representation of the flow of data among the five components of this project

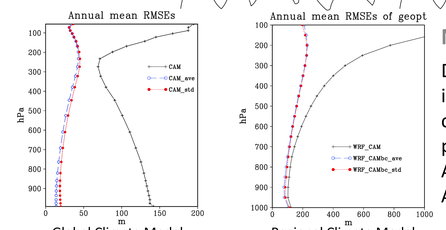
STUDY DOMAIN

(a) Design of model domains (D01 and D02) for the nested regional atmospheric model (WRF-CHEM) following Liang et al. (2001). Horizontally, D01 has 175×125 grids (30 km) and D02 has 235×172 grids (10 km). (b) Major coastal basins, watersheds and estuaries along the southern Texas Gulf Coast for the multi-domain model. (c) Texas estuary locations and inflow balance. Abbreviations: SN=Sabine-Neches Estuary; TSJ=Trinity-San Jacinto Estuary; LC=Lavaca-Colorado Estuary; GE=Guadalupe Estuary; MA=Mission-Aransas Estuary; NC=Nueces-Corpus Christi Estuary; and LM=upper and lower Laguna Madre.



DYNAMICAL CLIMATE DOWNSCALING



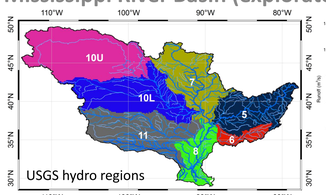


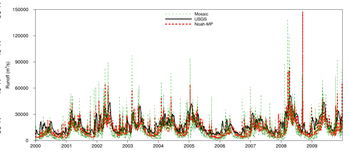
New correction method

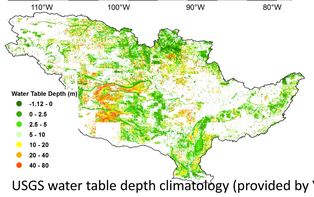
Developed to improve dynamically-downscaled climate projections
Applied to North America

LAND SURFACE MODELING

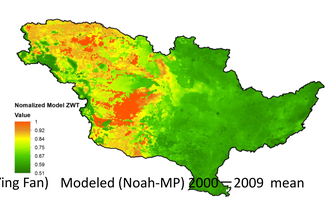
Mississippi River Basin (exploratory research)







USGS water table depth climatology (provided by Ying Fan)

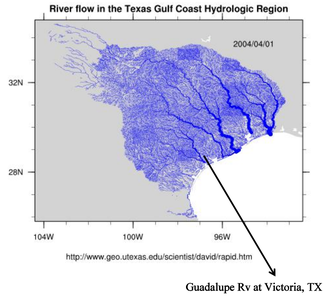


Modeled (Noah-MP) 2000 – 2009 mean

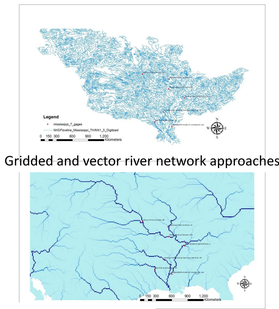
- Land surface modeling using the Noah model with multi-parameterization options forced by NLDAS2 atmospheric data (2000-2009)
- Calibration of surface dryness factor, hydraulic conductivity and saturated soil moisture

RIVER MODELING

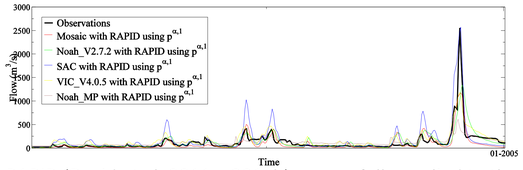
Texas Gulf Coast Hydrologic Region



Mississippi River Basin



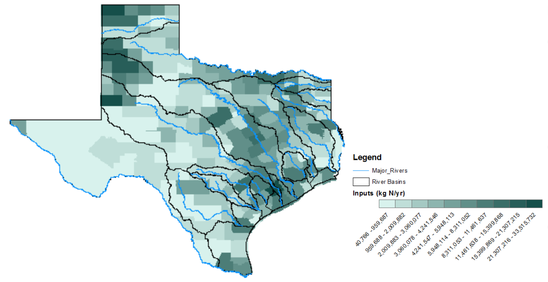
Gridded and vector river network approaches



- RAPID (David et al. 2011a, 2011b) successfully applied to the Texas Gulf Coast Hydrologic Region and to the Mississippi River Basin (using 50,000 – 200,000 river reaches). RAPID parameters optimized using observations from the USGS National Water Information System
- Runoff data from 4 NLDAS2 land surface models and 1 regional model

TEXAS-SCALE NUTRIENT BUDGET

Agricultural nitrogen input for 2007 (fertilizer and livestock)



Agriculture

Using datasets (completed)

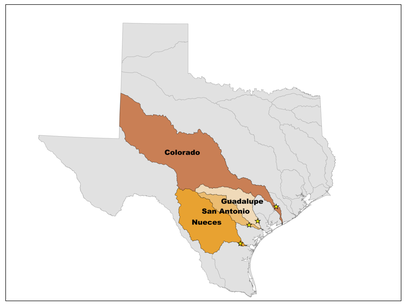
- Fertilizer (Fertilizer Tonnage Distribution Report, Texas State Chemist Office)
- Livestock (2007 census of aggriculture + numbers from Boyer et al. 2002)
- Fixation in crop & pasture lands (based on estimates of G.Smith - Texas A&M)

Atmospheric Deposition

Using WRF-Chem and the National Acid Deposition Project (ongoing)

- NO3
- NH4
- Inorganic N deposition

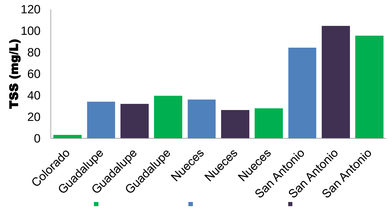
RIVERINE NUTRIENT SAMPLING



Four Texas Basins currently sampled

River	Date	TSS (mg/L)	Q (m3/s)	T (°C)	pH	Salinity (PSU)	DO(% sat)
Nueces	7/27/2011	36.14	3.908	29.56	8.14	0.27	89.5
San Antonio	7/27/2011	84.33	3.540	32.17	8.59	0.65	131.2
Guadalupe	7/27/2011	34.12	5.975	31.95	8.25	0.28	106.2
Nueces	8/11/2011	26.24	4.559	29.62	8.14	0.52	86
San Antonio	8/11/2011	104.55	1.784	30.75	8.67	0.01	111.3
Guadalupe	8/11/2011	32.14	4.531	31.56	8.14	0.28	99.3
Nueces	9/8/2011	27.80	5.522	25.04	7.63	0	88
San Antonio	9/8/2011	95.31	1.614	24.77	8.48	0	108.4
Guadalupe	9/8/2011	39.51	3.851	27.24	8.27	0.25	100.2
Colorado	9/8/2011	3.25	9.996	27.89	9.18	0.13	119.6

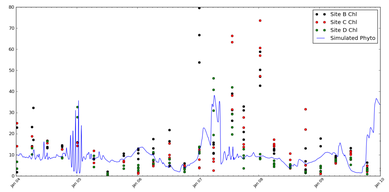
Sampling performed under extreme drought conditions

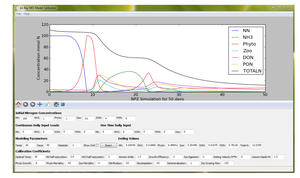


ESTUARY MODELING

San Antonio Bay

Modeled Chlorophyll-a in San Antonio Bay 2004 – 2010





Kim and Montagna model

- Modeling estuary chlorophyll response using a nutrient-phytoplankton-zooplankton (npz) method.
- Daily river nutrient inputs are used to match historical quarterly observations.

Papers supported by this grant (published and in preparation)

David, C. H., S. Hong and Z.-L. Yang, Regional-scale river flow modeling using off-the-shelf runoff products, thousands of mapped rivers and hundreds of stream flow gauges, (in preparation).

Smith, V. B., C. H. David, M. B. Cardenas and Z.-L. Yang, Tendency for 21st century regional loss of active streams and vegetation inferred from modern patterns, (in preparation).

Xu, Z.-F., Z.-L. Yang, An improved dynamical downscaling method with GCM bias corrections, (in preparation).

Papers supported by NASA IDS NNX07AL79G and related to this current project (published and in preparation)

David, C. H., D. R. Maidment, G.-Y. Niu, Z.-L. Yang, F. Habets and V. Eijkhout, (2011) River network routing on the NHDPlus dataset, Journal of Hydrometeorology, DOI: 10.1175/2011JHM1345.1

Hong, S., and Z.-L. Yang (2011), Assessing Noah-MP Hydrological Simulations Over Small River Basins in Texas, US, (in preparation).

Kim , H.-C., P. A. Montagna (2009), Implications of Colorado river (Texas, USA) freshwater inflow to benthic ecosystem dynamics: A modeling study, Estuarine, Coastal and Shelf Science, 83(4), 491-504, doi:10.1016/j.ecss.2009.04.033

Niu, G.-Y., Z.-L. Yang, K. E. Mitchell, F. Chen, M. B. Ek, M. Barlage, A. Kumar, K. Manning, D. Niyogi, E. Rosero, M. Tewari, and Y.-L. Xia, 2011: The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements, J. Geophys. Res., 116, D12109, doi:10.1029/2010JD015139.

Yang, Z.-L., G.-Y. Niu, K. E. Mitchell, F. Chen, M. B. Ek, M. Barlage, L. Longuevergne, K. Manning, D. Niyogi, M. Tewari, and Y.-L. Xia, 2011: The community Noah land surface model with multiparameterization options (Noah-MP): 2. Evaluation over global river basins, J. Geophys. Res., 116, D12110, doi:10.1029/2010JD015140.