Introduce Sediment Module to the National Water Model (WRF-Hydro)

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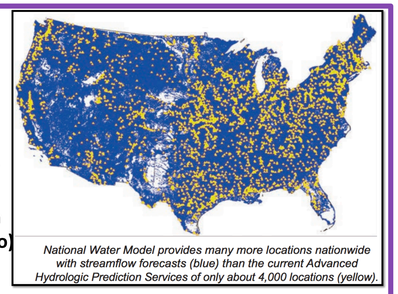
1 National Water Model (NWM)

- **NWM**
  - Simulates Water Cycle across CONUS
  - Output
    - Streamflow of 2.7 million river reaches
    - 250m CONUS Ponded water depth
    - 1km CONUS Land Surface Energy and Water Flux
  - **Computational Core: NCAR Weather Research and Forecasting Hydrologic model (WRF-Hydro)**

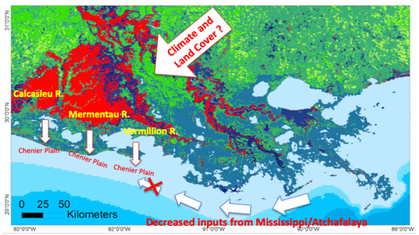


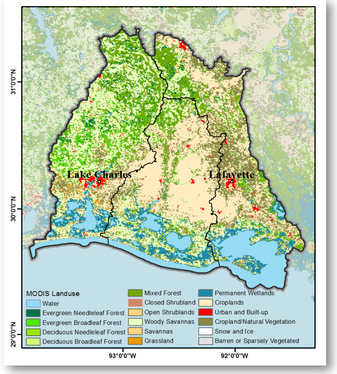
National Water Model provides many more locations nationwide with streamflow forecasts (blue) than the current Advanced Hydrologic Prediction Services of only about 4,000 locations (yellow).

2 Application in SW Louisiana

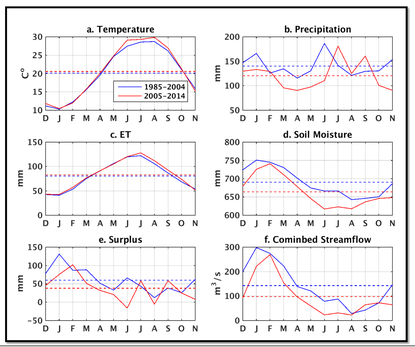
- **Question 1**

How will climate, both long-term and short-term, and land use, land cover change effect coastal river basin's hydrological cycle as well as the downstream Chenier Plain?





MODIS Landuse & Land cover



A comparison of monthly climatology for the period of 1985-2004 (blue) against that of the period of 2005-2014 (red).

2005-2014: A Dry Decade

- A warmer summer and dryer winter characterize the local climate during the period of 2005-2014;
- The annual mean temperature increased slightly while precipitation experienced a **14.2%** decrease;
- The higher temperature and reduced precipitation result in a **36.4%** drop of water surplus

- **Question 2**

As the water and sediment from the Mississippi and Atchafalaya River being reduced by flood control and river diversions, will water and **sediments** delivered by local coastal rivers become more important to the Chenier Plain's sustainability?

However, WRF-Hydro does not incorporate any sediment module

3 Sediment Module Development

WRF-Hydro

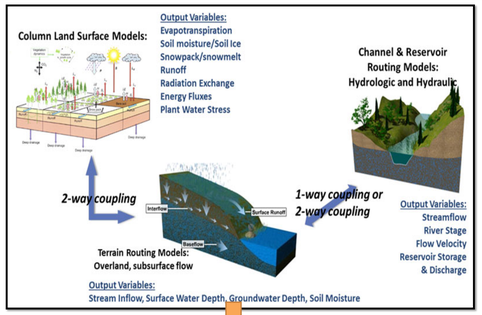
- NCAR Weather Research and Forecasting model (WRF) hydrological modeling system (Gochis et al., 2018).
- Currently being implemented at National Water Center for U.S. national hydrologic prediction.
- Modularized model coupling interfaces for surface runoff, channel flow, lake/ reservoir flow, sub-surface flow, land-atmosphere exchanges.

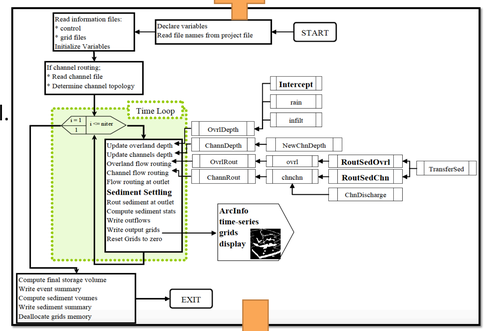
CASC2D-SED

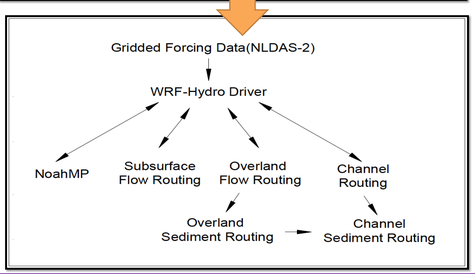
- CASCade 2 Dimensional SEDiment (CASC2D-SED, Rojas et al., 2002) model.
- 2-D overland sediment flow routing is used to simulated upland sediment transport processes for three particle sizes.
- 1-D channel sediment routing is simulated using Engelund and Hansen (1967) transport equation

WRF-Hydro-SED

- CASC2D-SED is adapted to WRF-Hydro.
- Overland sediment erosion and transport process is simulated either 1 way or 2 way.
- 1-D Channel sediment routing process is simulated based on gridded channel flow routing.

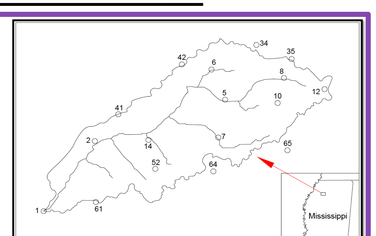






4 Test Case : Goodwin Creek Watershed

- **Study Area**
  - Goodwin Creek Watershed(GCEW), 21.3km^2.
  - Operated by National Sedimentation Laboratory
  - Highly Instrumented: 32 Rain gages+14 stream and sediment gages.
- **Data Availability**
  - Rainrate:14 gages, 30 minutes interval.
  - Discharge: Gage 01(outlet), 10minutes interval.
  - Sediment Concentration: Gage 01(outlet), 10minutes interval.



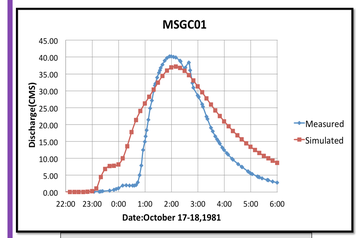
Goodwin Creek Watershed and Gages used in this study

5 Model Setup & Calibration

- Meteorological Forcing: NLDAS-2 (Xia, et al., 2012)
- Land Surface Model: Noah-MP (Niu et al., 2011):
  - Grid Size:1km Time step:300s
- Terrain Routing: Grid:280*220, Grid Size:50m, Time Step:6s
- Channel Routing: Time Step:6s, Routing Method: Gridded Routing (1 Dimensional Diffusive Wave)
- DEM: NHDPlus V2

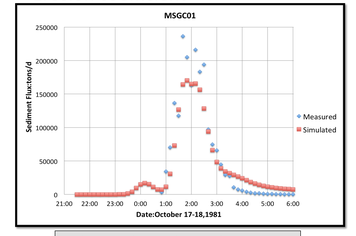
- **Calibration Event**
  - Rainfall event on October 17~18, 1981
  - Rainfall Started at 21:20, lasted 5 hours
  - Mean rainfall intensity 14.7mm/h

- **Calibration Results**



Channel Flow Hydrograph at Gage01

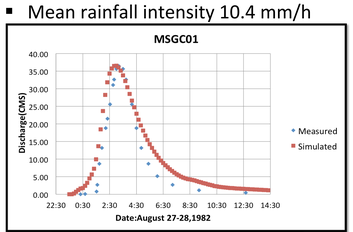
- **Calibrated Parameters**
  - Channel Parameters: Side Slope, manning coefficient
  - Surface runoff parameter: refkdt
  - Multiplier on maximum retention depth :RETDEPRTFAC
  - Soil Erodibility factor
  - Cropping-management factor
  - Conservation practice factor
  - Erosion coefficient



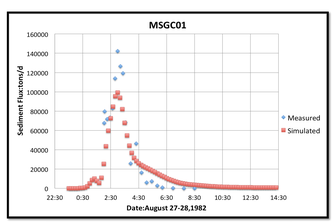
Sediment Flux Hydrograph at Gage01

6 Model Validation

- **Validation Event**
  - Rainfall event on August 27~28, 1982; Rainfall Started at 23:30, lasted 4.5 hours
  - Mean rainfall intensity 10.4 mm/h



Channel Flow Hydrograph at Gage01



Sediment Flux Hydrograph at Gage01

7 Next Steps

- Coupling between WRF-Hydro and Ocean Model
- Watershed Carbon and Nutrient Cycles

References

- Gochis, D.J., M. Barlage, A. Dugger, K. FitzGerald, L. Karsten, M. McAllister, J. McCreight, J. Mills, A. RafieeiNasab, L. Read, K. Sampson, D. Yates, W. Yu, (2018). The WRF-Hydro modeling system technical description, (Version 5.0). NCAR Technical Note. 107 pages. Available online at: https://ral.ucar.edu/sites/default/files/public/WRFHydroV5TechnicalDescription.pdf.
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