Assimilating SWOT Water Surface Elevations into the WRF-Hydro Modeling System in Alaska using HydroDART

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1. Background

- Surface Water Ocean Topography (SWOT) mission (Rodriguez 2016; Biancamaria et al. 2016)
  - 2021 launch
- Wide-swath (120 km), bistatic, Ka-band (36 GHz) radar interferometer
  - 10 m spatial resolution
- Global measurements of channel water surface elevation (WSE) for rivers with widths greater than 50–100 meters
- Weather Research and Forecasting (Skamarock et al. 2008) hydrological extension package (WRF-Hydro) (Gochis et al. 2018)
  - High-resolution hydrologic routing and streamflow modeling framework
- Couples column land surface, terrain routing, and channel routing modules (Figure 1)
  - Acts as the basis of the NOAA National Water Model (NWM; OWP 2018)

2. Motivation

- In situ stream gauges are spatially limited networks and declining globally (Pavelsky et al., 2014)
- Lack of data assimilation in operational hydrologic forecast systems limits forecast accuracy and skill (Liu et al., 2012)
- SWOT mission will provide high spatial coverage of stream observations at spatial resolutions ideal for assimilating into hydrologic models to improve model initialization

3. Model Configuration

- WRF-Hydro coupled with 1-km resolution Noah Land Surface Model with Multi-Parameterization options (Noah-MP) (Niu et al. 2011)
  - Regridded, 2 arc-second National Elevation Dataset (NED/USGS 2017) for WRF-Hydro subsurface flow, overland flow, and diffusive wave channel routing
  - Global Land Data Assimilation System Version 2 (GLDAS-2; Rodell et al. 2004) meteorological forcing (0.25° spatial resolution)
- Fraternal twin experiment (i.e., observation system simulation experiment) consisting of control and corrupted simulations (Figure 2)
  - Control (“nature”) run (100 m WRF-Hydro simulation)
    - Calibrated against USGS stream gauges Mar 2011 – Mar 2014 for parameters shown in Table 1
  - 8-year model spin-up (Mar 2009 – Mar 2017)
  - Control simulation is assumed to be free of errors and representative of true state
  - Used to derive virtual gauges (Section 4)
  - Corrupted run (uncalibrated 250 m WRF-Hydro simulation)
    - 4-year model spin-up (Mar 2013 – Mar 2017)
    - Virtual gauge observations assimilated into WRF-Hydro channel routing module using HydroDART Ensemble Kalman Filter (EnKF; Evensen 1994)
    - 80 ensemble members for EnKF created by randomly varying calibration parameters within valid parameter ranges (Table 1)
    - Validated against control run

4. Generating Virtual Gauges

- Synthetic SWOT WSE generated following Biancamaria et al. (2016) (Figure 3)
- SWOT orbit was simulated for Mar 2013 – Oct 2017
  - At each SWOT overpass, the WSE was calculated for every channel point within SWOT swath extent and with stream order 4 (rough estimate for rivers with widths greater than 100 m)
  - Randomly generated noise (σ=0.25 m) was added to calculated WSE to mimic SWOT instrument error
  - To create virtual gauge for approximately each channel reach, domain was split into 0.1° lat/lon grid
  - A single WSE point was randomly selected within each grid box and designated as the virtual gauge
- The virtual gauge is then assimilated into the 250-m corrupted run using HydroDART

5. Results

- The corrupted run overestimates streamflow compared to the control run (truth) (Figure 4)
- High correlation indicates the model captures the timing of individual precipitation events well, but magnitude of the long-term baseflow is overestimated
  - Results for the corrupted run with synthetic SWOT data assimilation are forthcoming
- It is expected that the corrupted run will more closely match the control run when the virtual gauges are assimilated into WRF-Hydro

References