Physical Process Underlying the Water Cycle

- NOAA Water Services
  - River Forecast Centers
    - Main stem river stages
    - >6 hrs to 3 days
    - Lumped runoff & snowmelt models (Sacramento, Snow-17)
  - Weather Service Forecast Offices
    - Flash floods
    - <6 hrs, small catchment or debris basins
    - Empirical statistics based on historical rain/event data
  - Growing need for seasonal to decadal outlooks for water

Physical Process Underlying the Water Cycle

- NOAA forecast system works well in vast majority of the time
- Some (spectacular) failures related to extreme events (rain in dry basins, very heavy rain)
  - Outside experience of current models/stats
  - New paradigm of physically-based models in some situations
  - New observations to support those models
- Changing world obsoletes previous calibrations

Why do hydro prediction models fail?

- That is, what are the critical physical processes that aren't handled well?
  - Rain/snow transitions
  - Rain on snow events (rapid melt)
  - Regional effects (including human activities) and space/time scales drive the physics
  - Ground water storage and proper handling of antecedent conditions (arid environments)
  - Bad QPF!

How to facilitate research toward next generation paradigm of hydro forecasting

- Academic researcher/forecaster exchange
- Inventory of model failures & historical data for quantitatively evaluation of progress
- Testbed for hydro technique/model evaluation
  - RFC & WSFO problems
  - Not necessarily the same place (water center??)
- Focused integrated field experiments (HMT expansion?)

Improvements to QPF

- Atmospheric model improvements
  - Microphysics
  - Radiation
  - Boundary-layer process (e.g., evaporation)
- Coupled hydro/atmos models
  - feedbacks
- Data assimilation systems
  - Dual-pol radar
  - Soil moisture
- Role of testbeds
  - Evaluation of process parameterizations (e.g., sub surface storage, fluxes)

Is It Time to Move Toward a Community Hydro Model?

- NWS/CHIPS provides structure
- CUHAI support
- More rapid transition from research results to operations
- “Modules” that fit within the framework. Each could be tested within a testbed

Integration of physics, observations, and models

- Improved physics must be guided by observations
- Integrated long-term observatories with advanced hydrometeorological observations (HMT) with experimental watersheds
  - PUT THEM IN THE SAME PLACE!!

Laundry-list of Physical Processes

- Processes known but scale dependencies need to be figured out
- HUMAN actions
- snow processes & cold region physics
- ground water (connection to surface, flow rates to deep aquifers, water quality)
- Over-lake evaporation
- Multi-physics thermal/moisture packages and vegetation phenology
- sensitivity of hydrologic model to atmos persistence
- Atmospheric river duration and movement – better characterization of water vapor transport
- Cloud microphysics & Aerosols
- Land surface heat fluxes feedback to atmosphere, land use changes
- drought and low flow issues
- sensitivity of hydro models to precip (QPE/QPF)
- Low-flow conditions - droughts

Low Flow

- New direction for NOAA
  - Predict the entire flow duration curve
- Models must incorporate new processes
  - Vegetation dynamics
  - Hillslope and riparian ET
  - Gaining and losing channels
  - Human actions
  - Channel geomorphology
  - New routing techniques
  - …