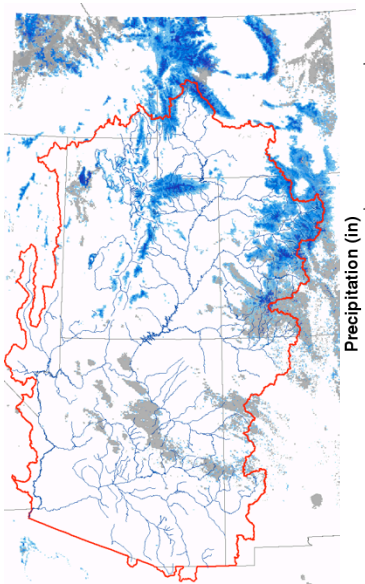
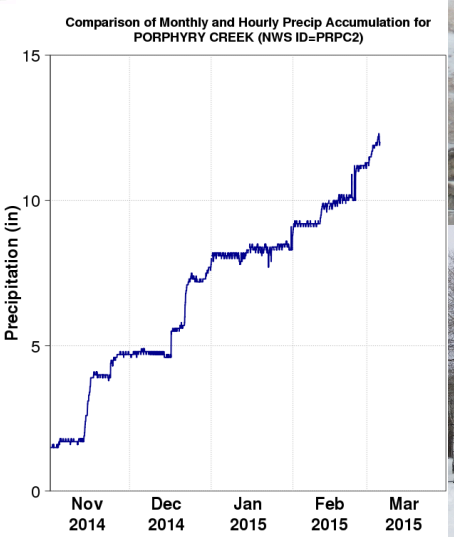
Snow Model Adjustment Methods at NOAA/CBRFC

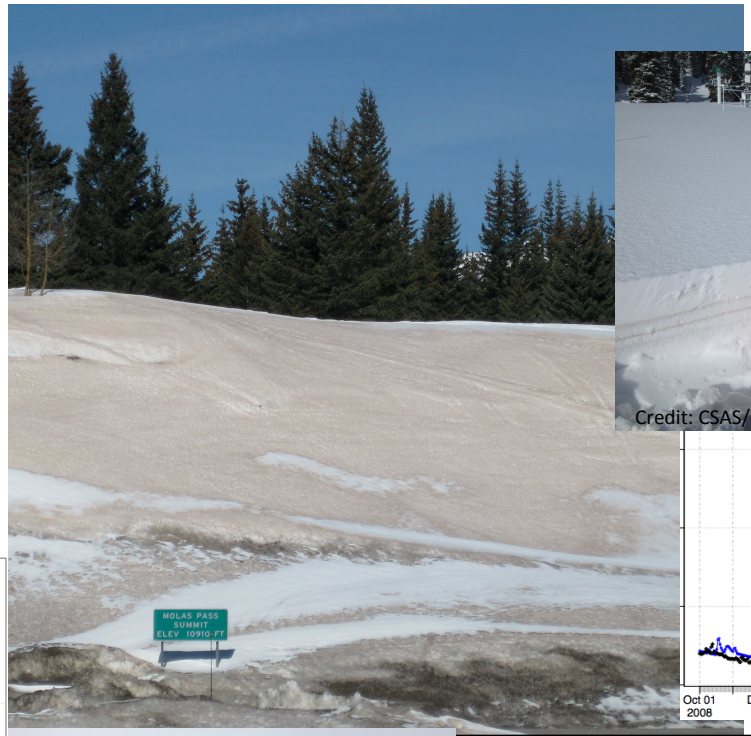
CBRFC Stakeholder Forum

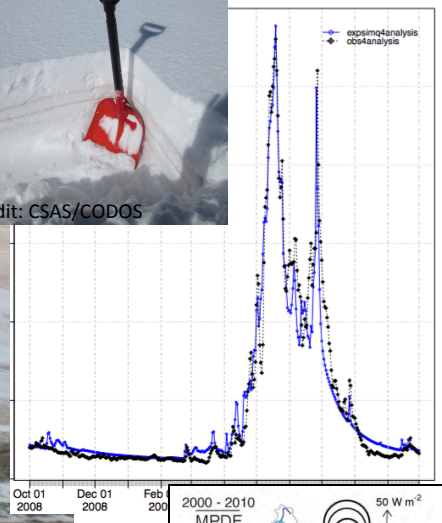
Salt Lake City

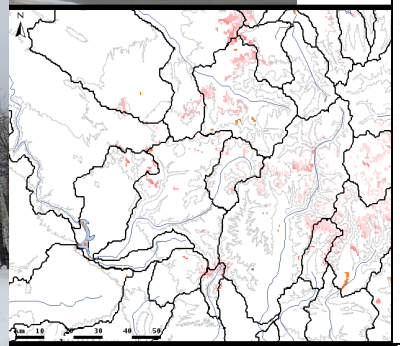
October 20, 2015

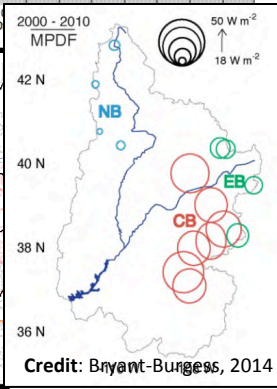












Credit: Bryant-Burgess, 2014

Operational CBRFC Snow Model

Operational CBRFC Snow Model: SNOW17

Overview of Methods

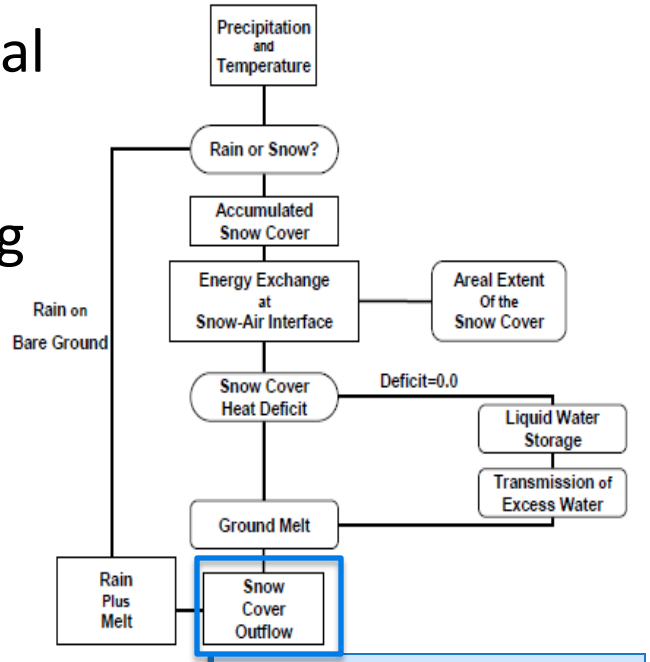
Current Operational Adjustment Method (SWE)

Research/ Experimental Methods (SWE, melt rate)

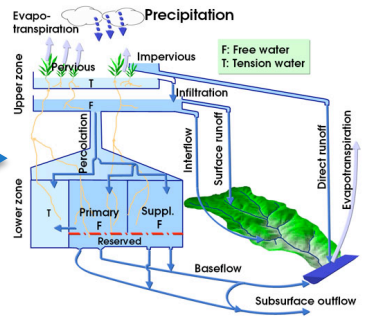
Questions and Comments

Operational Snow Model at CBRFC: SNOW17

- minimum inputs and computational power needed
- manually calibrated at CBRFC using 1981-2010 historical data
- temperature-index model (air temperature used as proxy for energy/radiation)
- forecasts snowmelt **pretty well under near-normal conditions** of the calibration period
- ***doesn't* do so hot when conditions deviate from near-normal** – adjustments needed



Water output from SNOW17 is then input to the soil moisture model (Sac-SMA)



Snow Model Adjustment Methods

Operational CBRFC Snow Model: SNOW17

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How can we adjust SNOW17 states computations in hopes of making better snowmelt-driven streamflow forecasts?

Adjust the SNOW17 **SWE**

- **Impacts:** forecasted flow and forecasted runoff volumes
- **RFC speak**: "make a WECHNG mod"
- **Modify the SWE using**:
  - Closely QC'd SNOTEL precipitation data
  - Statistical relationships between SNOTEL SWE obs and SNOW17-simulated SWE
  - fractional snow-covered area (fSCA) data from remote sensing (from NASA/ Jet Propulsion Lab)

Adjust the SNOW17 **melt rate**

- **Impacts:** forecasted timing of streamflow
- **RFC speak**: "feed modified input temperatures to SNOW17"
- **Modify the melt rate using**:
  - "dust on snow" data from remote sensing (from NASA/Jet Propulsion Lab)

Current Operational SWE Adjustment Method: Using SNOTEL Precip

Operational CBRFC Snow Model: SNOW17

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Getting from point precip observations → SNOW17 SWE

SNOTEL (point) precip data

SNOTEL station weightings (multipliers determined in manual calib process)

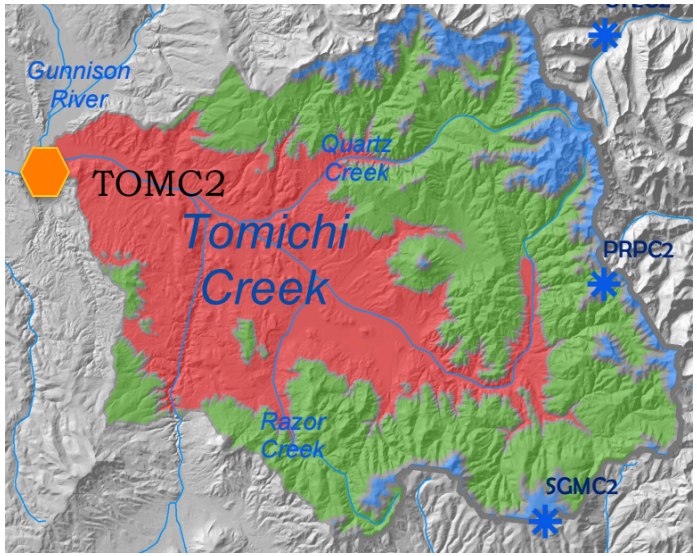
Precipitation estimate for the elevation zone

Freezing level information (so SNOW17 can type the precip as rain or snow)

If freezing and precip is typed as snow, **add precip as SWE to SNOW17 snowpack.**	If not freezing and precip is typed as rain, don't add SWE to SNOW17 snowpack.

Point precip observations → SNOW17 SWE process is run for each elevation zone

Elevation Zone	SNOTEL Stations Used to Compute Elev Zone Precip Value
TOMC2LUF (Upper)	PRPC2 (Porphyry Creek)
TOMC2LMF (Middle)	PRPC2 (Porphyry Creek)
TOMC2LLF (Lower)	No SNOTELs used (COOP station CCRC2 is used)



Current Operational SWE Adjustment Method: Using SNOTEL Precip

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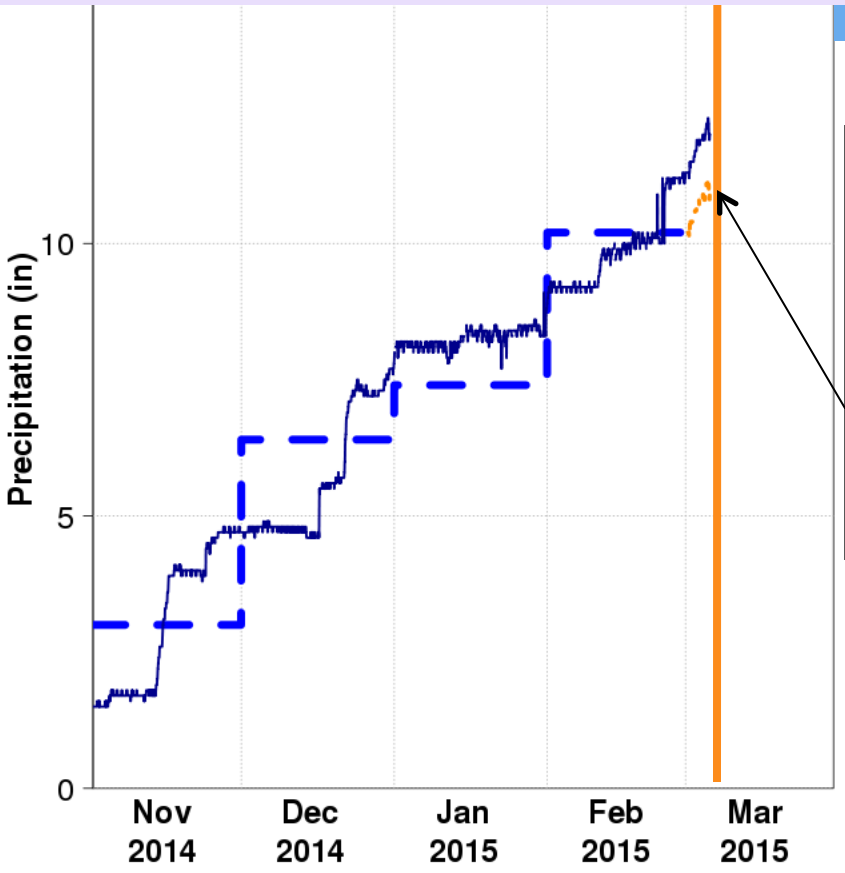
Upcoming experiment:

NRCS (Jordan Clayton) has contributed a set of manually-QC'd, hourly accumulated precip data for select SNOTEL sites

- Eliminates most of the "jumpiness" in accumulated SNOTEL precip data
- CBRFC will test.



Example Update Date = Mar 4

accumulated, closely QC'd monthly precipitation data

+ accumulated, real-time precip data (hourly) for any partial months

= "updated" precipitation accumulation (using Mar 4 as an example)

Then, run new "updated" precip accumulation through precip → elev zone SWE computations.

Model is then run forward in time with the new, "updated" estimate of SWE accumulation.

Experimental SWE Adjustment Method: Statistical Models and SNOTEL SWE

Operational CBRFC Snow Model: SNOW17

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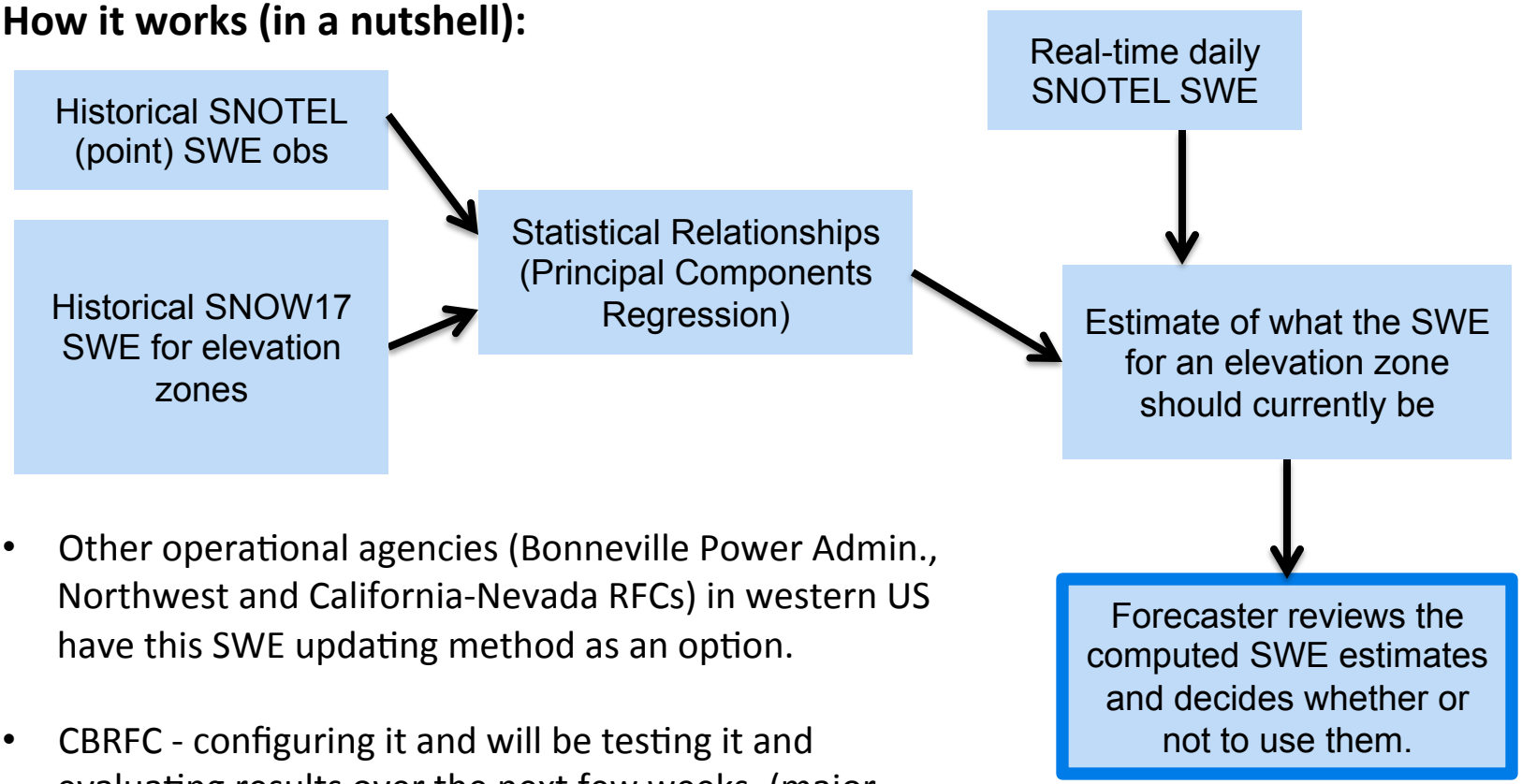
How it works (in a nutshell):



- Other operational agencies (Bonneville Power Admin., Northwest and California-Nevada RFCs) in western US have this SWE updating method as an option.
- CBRFC - configuring it and will be testing it and evaluating results over the next few weeks. (major credit to Taylor Dixon and Kevin Berghoff at NWRFC for assistance to CBRFC)
- Depending on results, possibly implement it as an optional method of SWE updating for spring 2016.

Experimental SWE Adjustment Method: MODSCAG (satellite-based) fSCA

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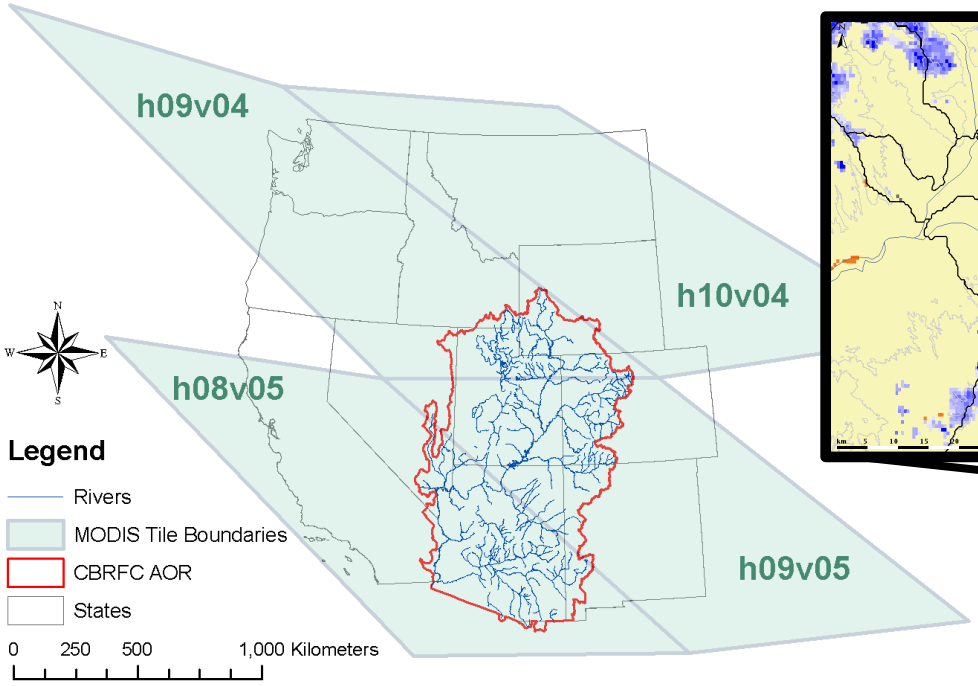
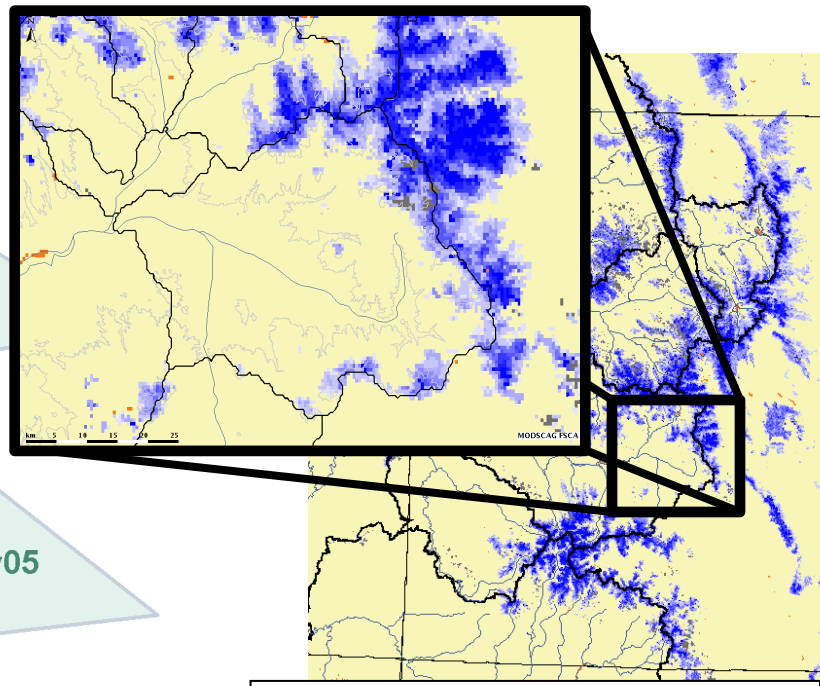
- MODSCAG fSCA = global, satellite-based fractional snow-covered area (fSCA) product from NASA/JPL

NASA Jet Propulsion Laboratory California Institute of Technology

- May be able to use MODSCAG fSCA to estimate SNOW17 SWE
- JPL is generating a clean fSCA dataset for full record (2000-present)
- CBRFC will finish testing when JPL makes newest version available





MODSCAG fSCA April 29, 2015

Experimental Melt Rate Adjustment Method: MODDRFS (satellite-based) "dust on snow" data

Operational CBRFC Snow Model: SNOW17

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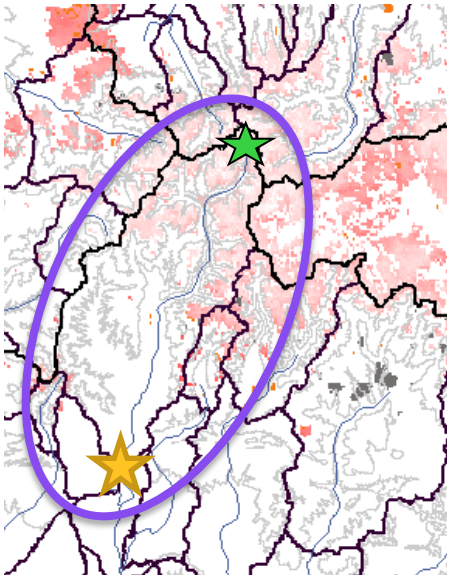
MODDRFS = MODIS Dust Radiative Forcing in Snow

- Satellite-based remote sensing dataset from NASA/Jet Propulsion Laboratory

Jet Propulsion Laboratory
California Institute of Technology

MODDRFS on April 10, 2014 (W m^{-2})



Durango, CO

	>= 0.1
	>= 50
	>= 100
	>= 150
	>= 200
	>= 250
	>= 300
	>= 350
	N/A - Unrealistic value
	Clouds (2000)
	Edge of sin proj (2300)
	Not processed by JPL (2350)
	Clouds (2500)

White = clean

Red = dusty

Photo: Dust layer D4 emerging on April 10, 2014, in the upper Animas watershed (along Hwy 550 south of Red Mountain Pass). Courtesy Center for Snow and Avalanche Studies, Colorado Dust-on-Snow Program, Silverton, CO

Experimental Melt Rate Adjustment Method: MODDRFS (satellite-based) "dust on snow" data

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MODDRFS-informed manual (pre-WY16) adjustments to snowmelt rate by CBRFC forecasters are helpful but time-consuming and subjective.

- Need a more efficient, objective method of incorporating MODDRFS "dust-on-snow" data into CBRFC modeling and forecasting for WY 16 and beyond

- MODDRFS "dust on snow" data
  - use it to tweak input temperatures for snow model (SNOW17, which is a temperature-index snow model)

Experimental Melt Rate Adjustment Method: MODDRFS (satellite-based) "dust on snow" data

Operational CBRFC Snow Model: SNOW17

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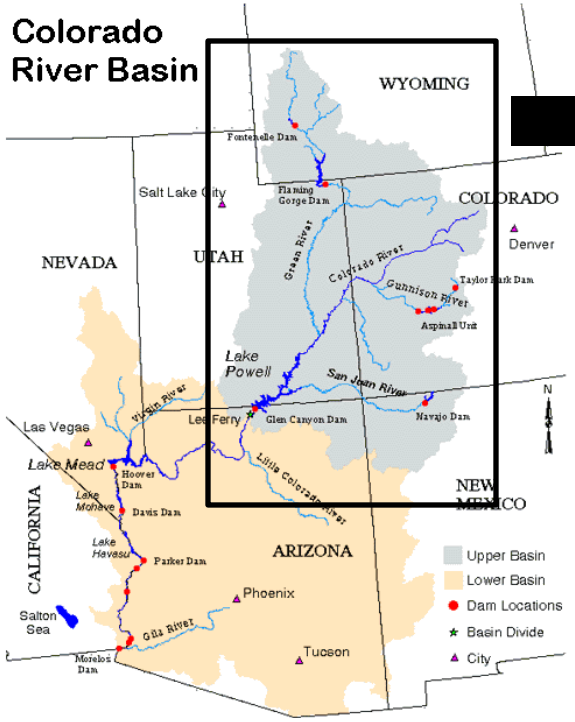
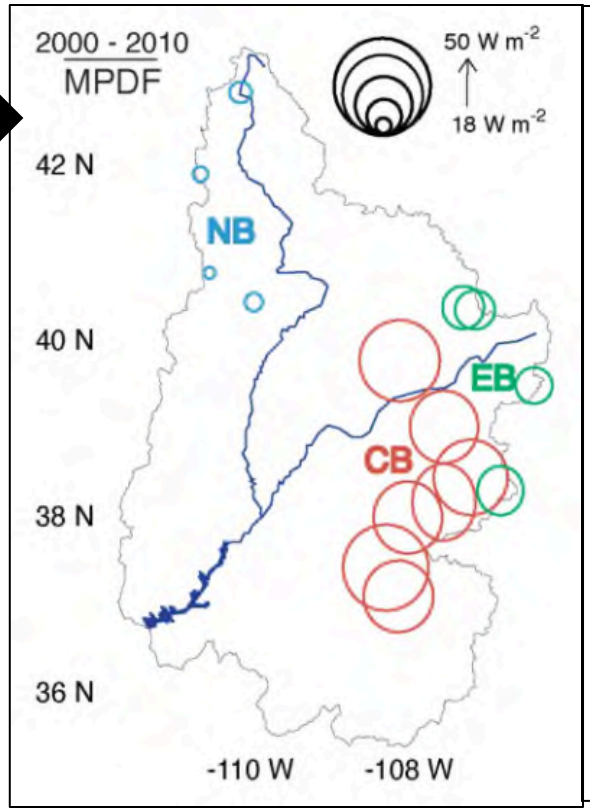
Where to start experiments w/ "dust on snow"-informed SNOW17 input-temperature-adjustment method?



Map credit: Colorado River Commission of NV, available via http://crc.nv.gov/images/colorado_river_basin.gif)



Mean 2000-2010 melt period dust forcing, where colors denote the **Central Basin** region, **Eastern Basin** region, and **Northern Basin** region (Bryant-Burgess, 2014)

Nutshell:
Larger circles indicate more dust, on average

→ **Initial focus area = southwestern Colorado (most impacted by dust events)**

- UT and WY are less-impacted by dust events (differences in weather events, dust sources, dust deposition event characteristics…)

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Methodology, in a nutshell**:

** → If you want details, just ask!

Original, unadjusted input temperatures	+	DRFS values (remote sensing of dust-on-snow)	+	Land Cover Info (coniferous veg.)	=	"dust on snow"-informed, adjusted temperatures that can be input to SNOW17

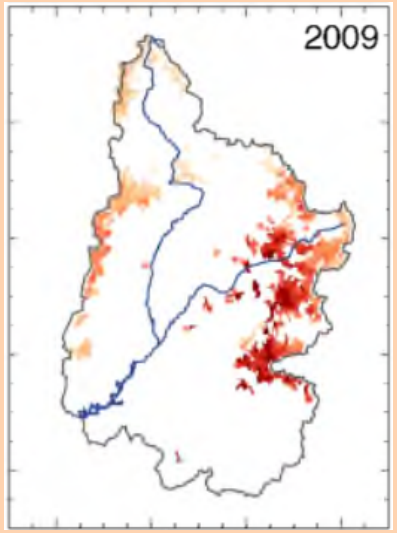
Preliminary Results for Uncompahgre R. in SW CO – NWS id = UCRC2:

- Minimal (+/- 3%) impacts on water year and seasonal runoff **volumes** (Apr-Jul)
- **Timing** of melt (and snowmelt-driven streamflow) *within the April-July runoff period* is altered by incorporation of MODDRFS ("dust on snow") data into SNOW17

Example case for SW CO in WY2009 (heavy dust):

2009 Dust:
→ Heavier, more than normal

2009 AMJJ runoff:
→ 118% average



Map credit: Bryant-Burgess, 2014

Experimental Melt Rate Adjustment Method: MODDRFS (satellite-based) "dust on snow" data

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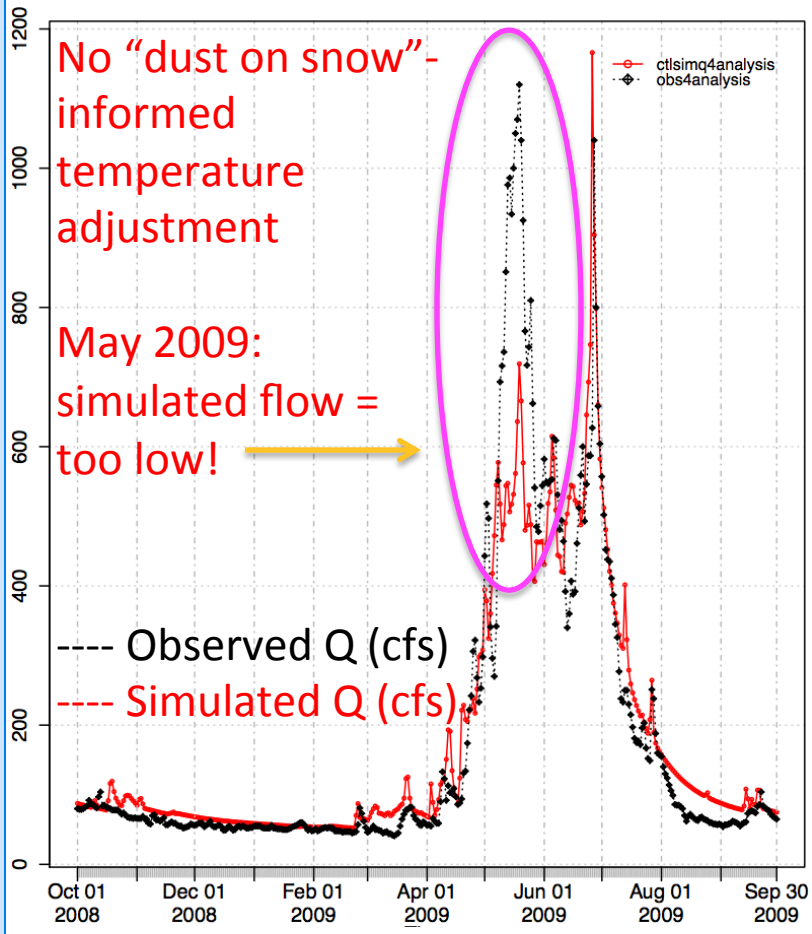
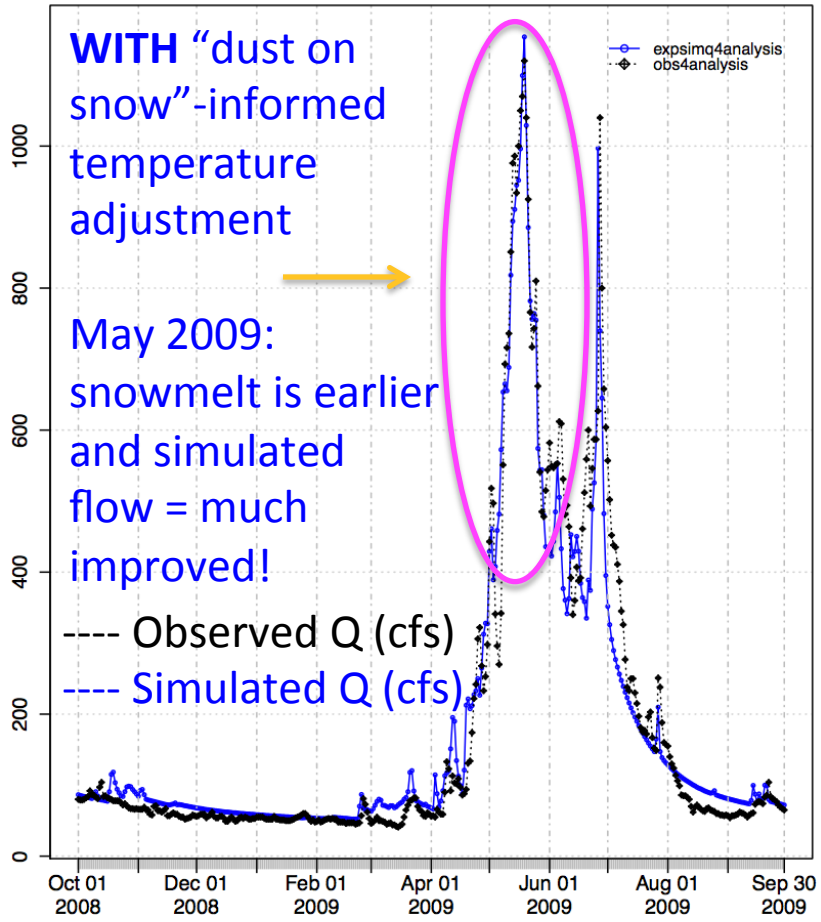
Let's look at the hydrographs for WY2009 (more dust than normal in WY09):

- Uncompahgre River in southwestern CO (NWS ID = UCRC2)
- WY2009 – "heavy dust" year





Experimental Melt Rate Adjustment Method: MODDRFS (satellite-based) "dust on snow" data

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Breaking down results/error statistics <u>within</u> the April-July runoff period:

2009 (heavy dust) UCRC2 Case:

Including "dust on snow" remote sensing info accelerates the simulated snowmelt (what we would expect with a dusty snowpack in real world)

- much more runoff in May
- much less in June and July

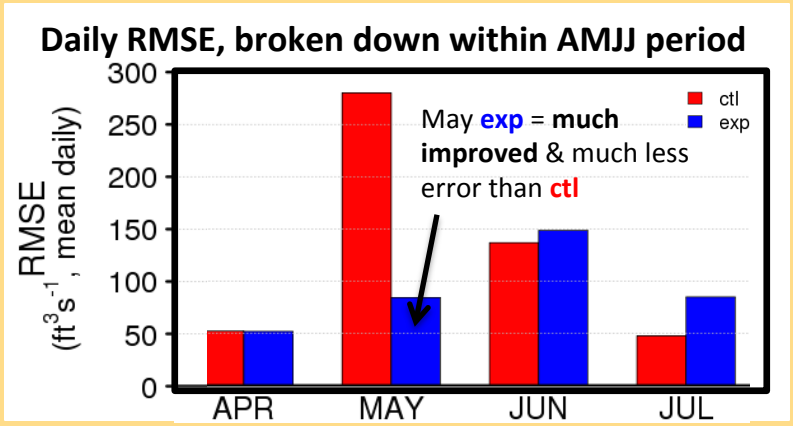
Comparing error in control simulation (no "dust on snow" info) with error in experimental simulation (WITH "dust on snow" info)

→ Apr = no change

→ May = **most** improvement in error

→ Jun = small change, exp is a bit worse

→ Jul = larger change, exp is worse



It's a "bargain"! Answer one question, get 2 more!

→ need to check further into other error sources… as always

Questions, Comments, and Acknowledgements

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Questions and Comments

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NRCS Snow Surveys: www.wcc.nrcs.usda.gov/snow

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