CBRFC Snow Data Research and Development

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March 27 2012

CBRFC Snow-related R&D Efforts

Motivations

- ❑ Snow (water equivalent, covered area) is a primary predictor for streamflow
- ❑ Snowpack in recent years has exhibited extremes in both directions (high, low)
- ❑ A number of geospatial datasets for monitoring snowpack have existed for the last decade (the 'EOS Era'). These datasets have potential to improve model estimates of the snowpack at the RFC.

➢ **Datasets to be evaluated:**

→ MODIS-based 500-m snow cover grids – 2000-present, twice daily overpass by **satellites**
>two different algorithms for deriving fractional snow covered area (FSCA) from MODIS

NASA **MOD10A**
(Dorothy Hall, GSFC)

NASA **MODSCAG**
(Tom Painter, JPL)

→ NWS NOHRSC **SNODAS** – modeled 1 km snow cover and SWE grids
~2000 to present, 3 times daily

➢ **Note** – despite potential for use, snow data impacts on RFC streamflow predictions need to be evaluated in a research/experimental mode at the RFC to explore this potential

CBRFC Snow-related R&D Efforts

Opportunities related to Snow Data

- CWCB sponsored a 2011 RTi effort to QC and process MOD10A fSCA and SNODAS grids for western US RFCs (CB, MB, WG) – yielding timeseries (for RFC model areas) and grids
- JPL+CBRFC awarded NASA grant in 2012 to bring MODSCAG grids and timeseries into CBRFC
- NCAR/CU/CBRFC NOAA grant 2011-2014 for alternative snow modeling approaches
- NWS CHPS modeling system allows for incorporation of external snow data
- New RFC Snow Modeling and Data Assimilation (SMADA) testbed helps RFC partner with external groups to evaluate snow modeling and use of data (NCAR, GSFC, JPL, OHD, etc.)

CBRFC Snow-related R&D Efforts

General Plans for the Snow Datasets

- **Qualitative:**
  - → Develop familiarity and understanding of dataset characteristics, especially in periods of interest
  - → Compare the MODIS-based (both versions – Hall and JPL/Painter) and the SNODAS-based snow datasets to RFC model estimates
  - → Use the data as a way to "sanity check" the model estimates when the estimates differ substantially
- **Quantitative:**
  - → Diagnose significant differences in the snow analyses and evaluate in context of flow simulation errors
  - → Where warranted, use the MODIS-based and SNODAS-based datasets in assimilation experiments in the snow models
  - → Generate operational snow imagery products for watersheds of interest

CBRFC Snow-related R&D Efforts

Current Specific Goals

In 2012:

- ❑ set up real time datafeeds and ingest MODIS-based (Hall and Painter/MODSCAG versions) for in-house RFC experimentation; SNODAS ingest is done.
- ❑ obtain historical data as available for the Painter/MODSCAG version and for the SNODAS-based datasets
- ❑ evaluate MODIS- and SNODAS-based snow datasets for potential use in an operational environment
- ❑ compare datasets to MODIS-RFC snow model estimates of snowpack (qualitatively *and* quantitatively)

Future

- ❑ investigate other sources of snow observations
- ❑ explore possibilities for data assimilation

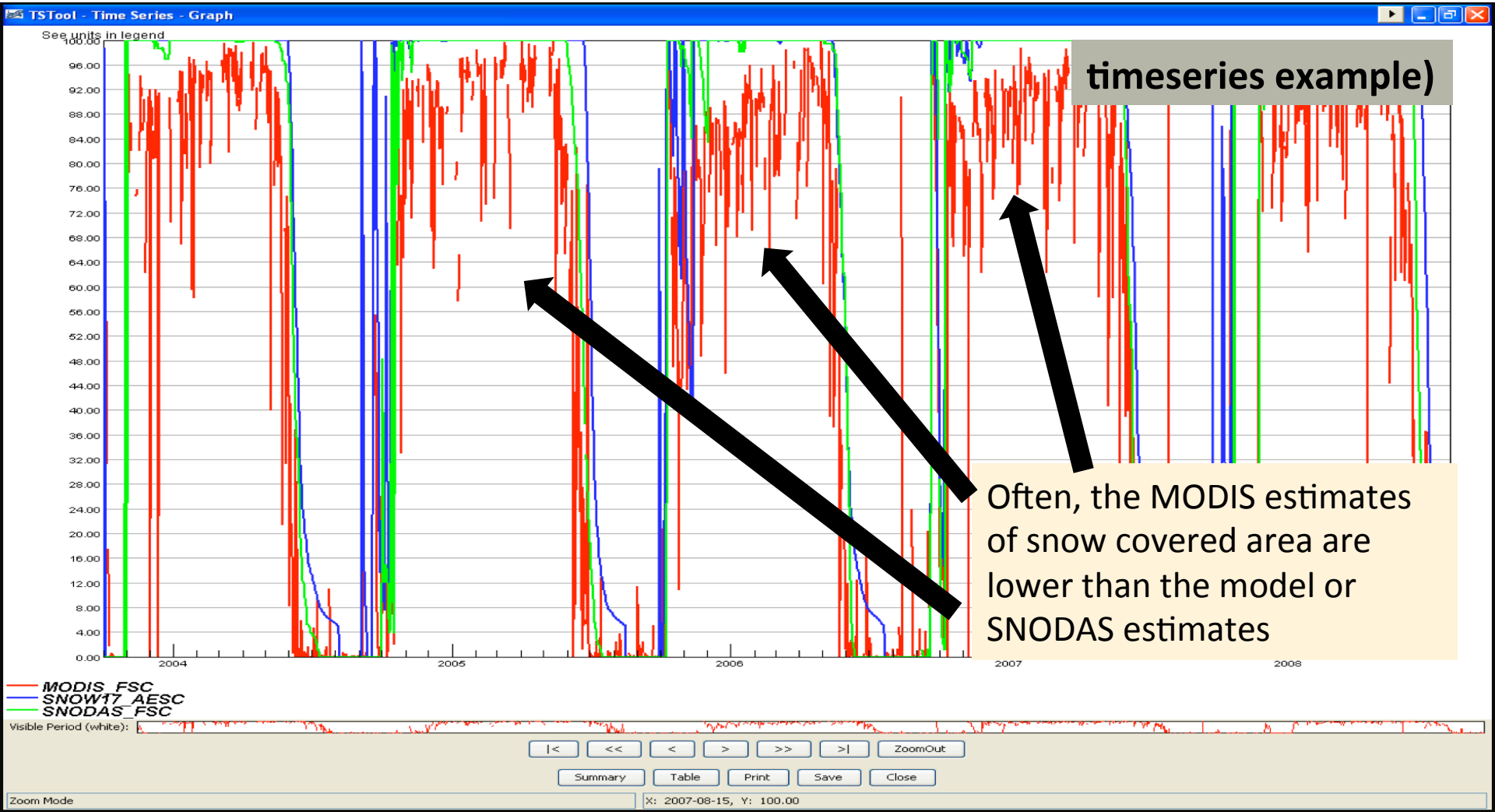
Datasets: MOD10A FSCA (Hall alg.)

MOD10A (one version of MODIS-based snow cover data)

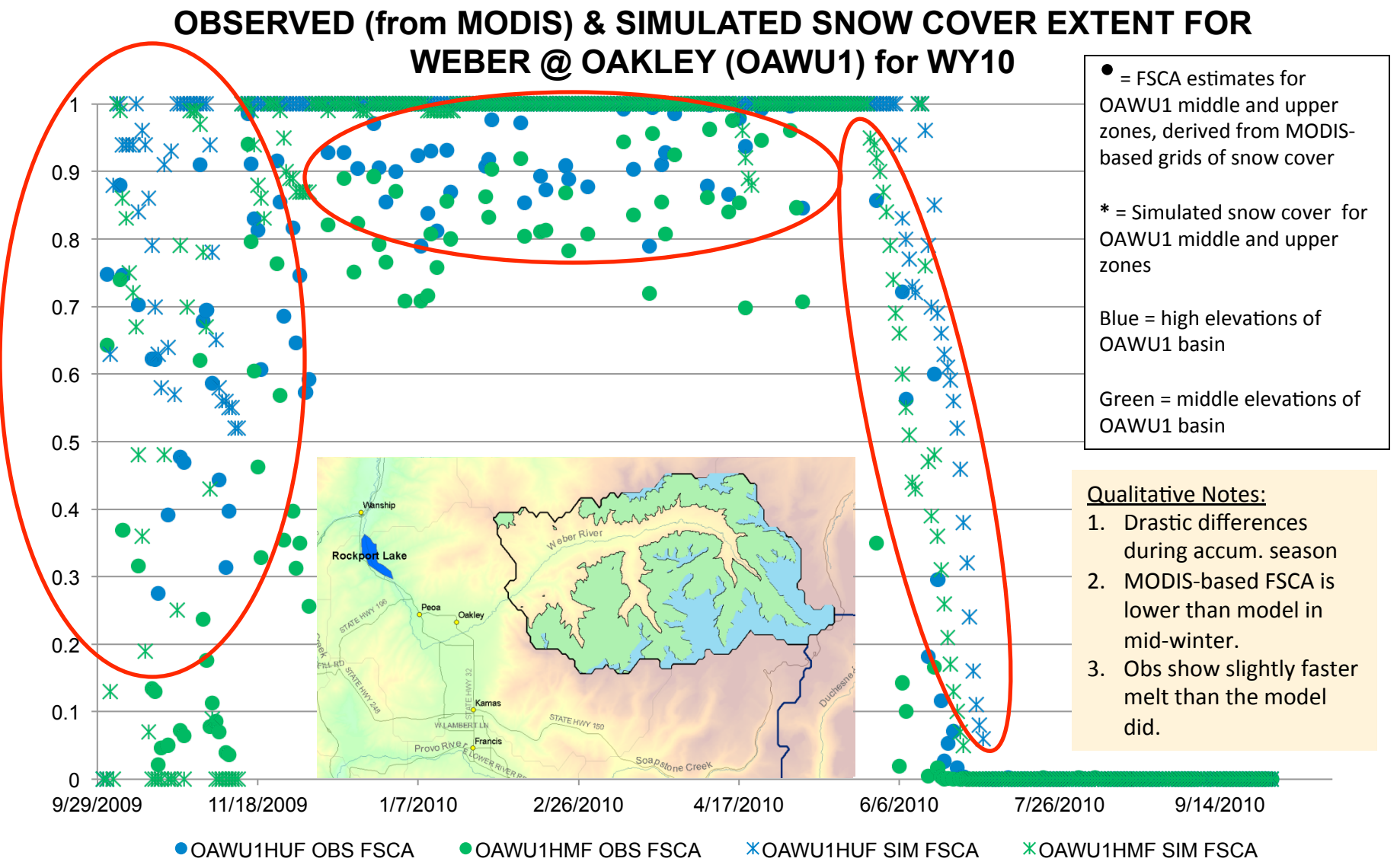
- Data availability:
  - Grids are available from NASA and NSIDC in real time
    - → RFC working on operational ingest
  - Historical data for the period of 2/2000-6/2011 were processed in 2011 by RTi for the Upper Colorado R. and the Great Basin
    - → RTi provided grids and FSCA estimates for RFC basins
    - → RFC has these in house already and is starting analysis
- FSCA is determined using the Hall/GSFC algorithm (based on linear regressions)

Datasets: MOD10A FSCA Time Series

- Sample FSCA time series from RTI (MOD10A)
  - Red = MODIS-based estimate of FSCA
  - Blue = RFC model estimate of FSCA
  - Green = SNODAS-based estimate of FSCA



Datasets: MOD10A FSCA Time Series



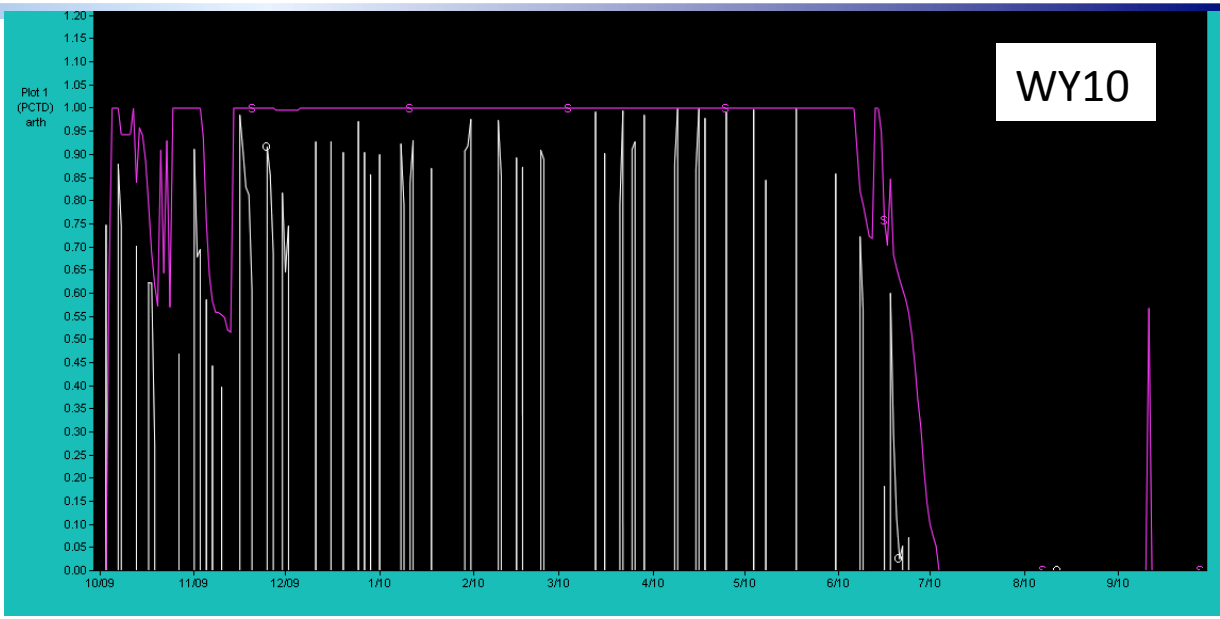
Datasets: MOD10A FSCA Time Series

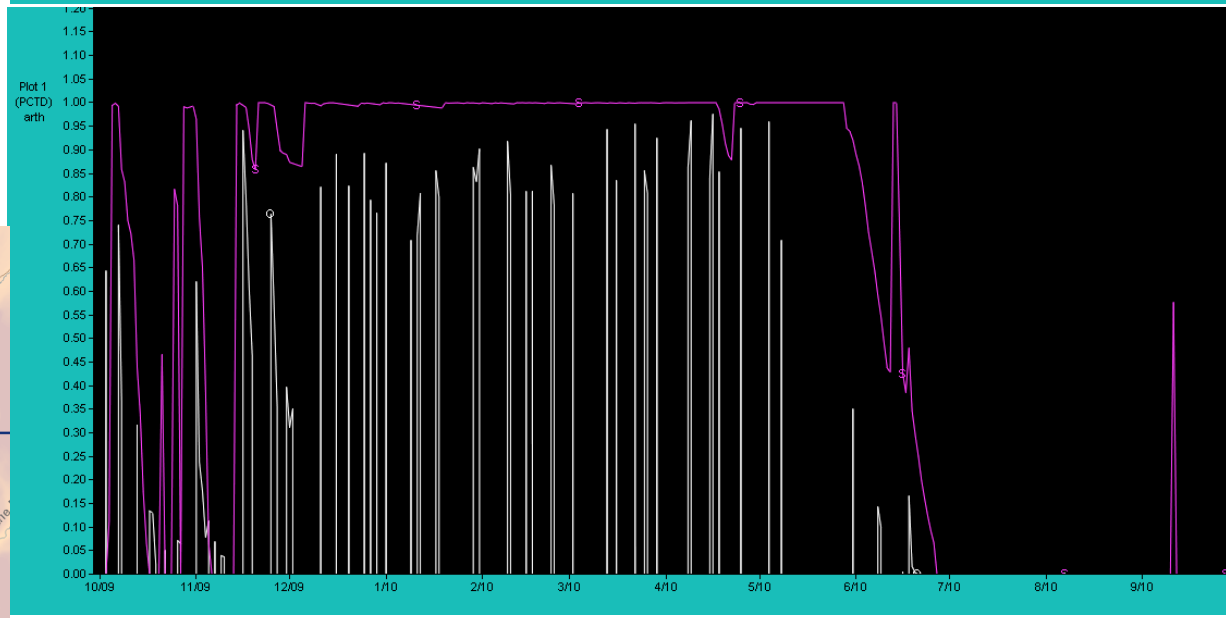
Purple = Simulated snow cover extent

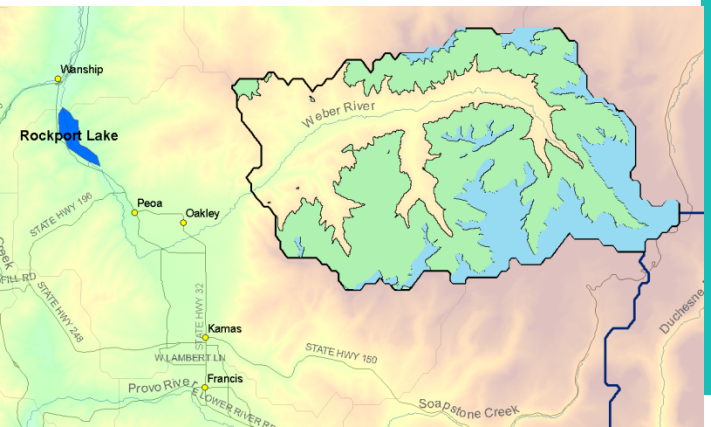
White = Observed snow cover extent from MODIS (Hall alg.), when it non-missing (clouds sometimes block the view).

Upper Elevations of OAWU1 →

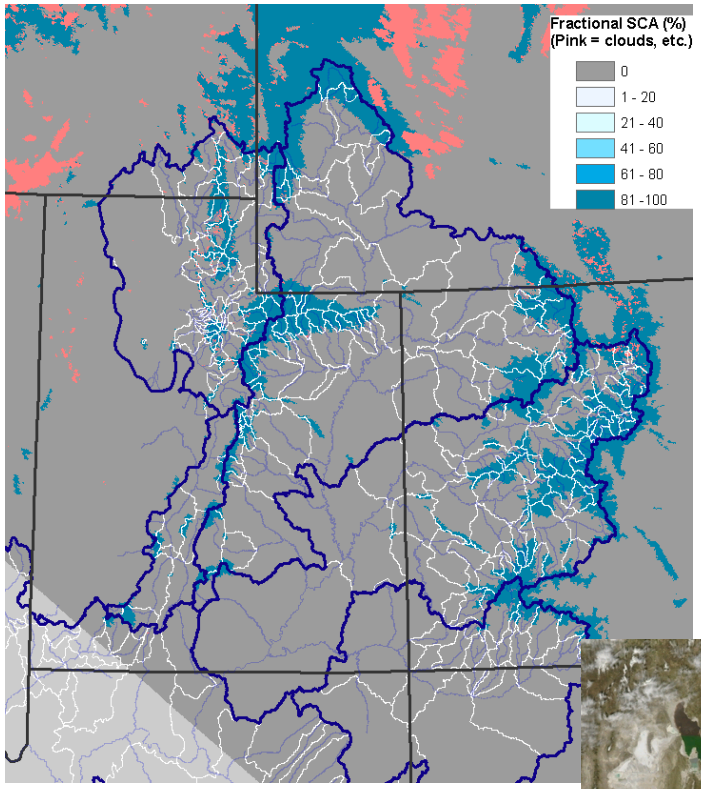
Middle Elevations of OAWU1 →

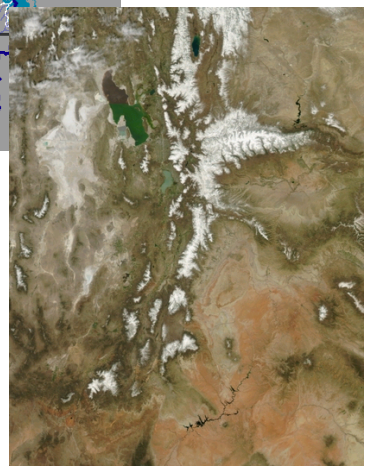




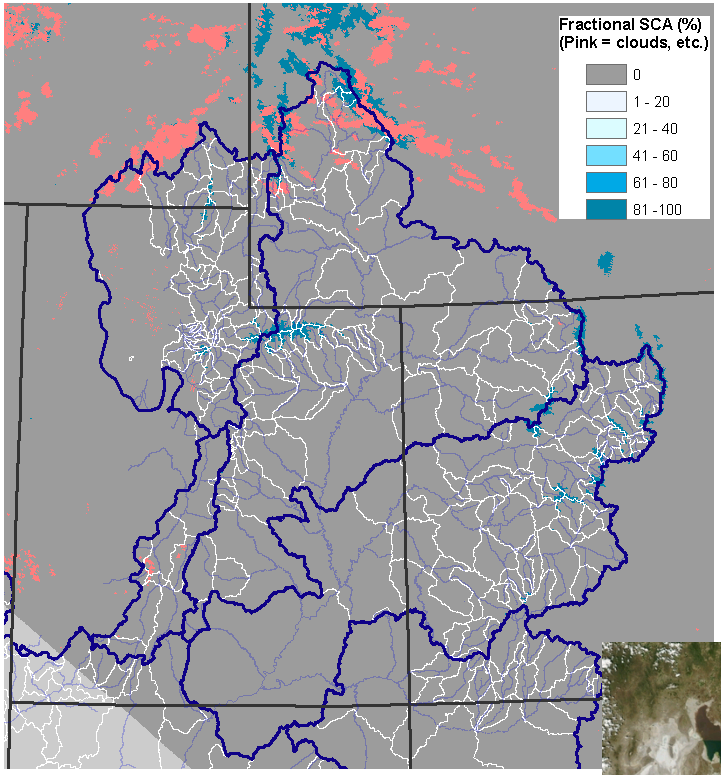


Datasets: MOD10A FSCA Grids





May 5, 2011
→ MODIS FSCA Grid from RTi
→ MODIS Visible image from USFS (http://activefiremaps.fs.fed.us/imagery.php?op=fire&passID=130779)



June 22, 2011
→ MODIS FSCA Grid from RTi
→ MODIS Visible image from USFS (http://activefiremaps.fs.fed.us/imagery.php?op=fire&passID=136716)

Datasets: MODSCAG FSCA

MODSCAG (another version of MODIS-based snow cover data)

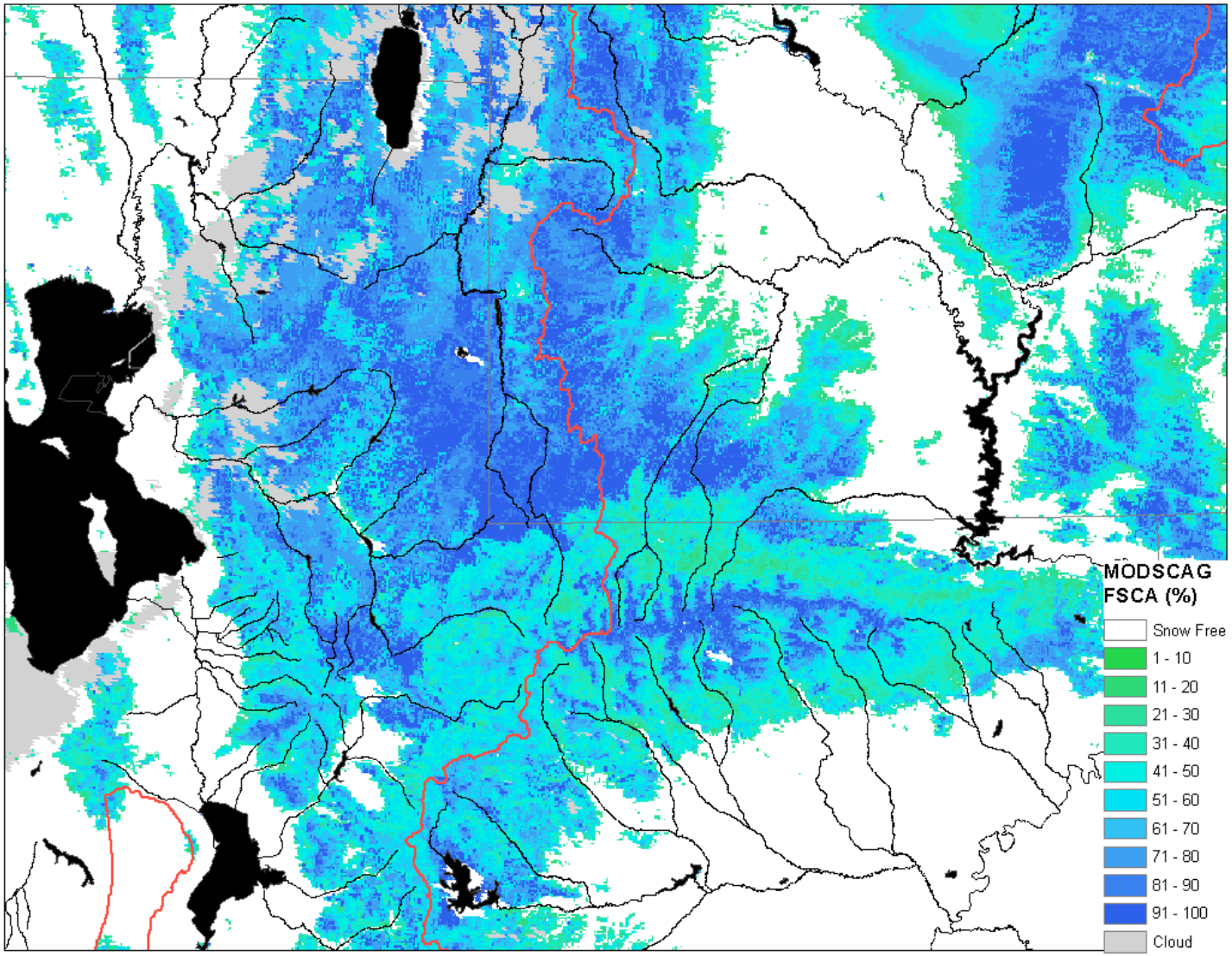
- Data availability:
  - Current grids are available from NASA/JPL in real time (per Tom Painter on 3/26)
    - → RFC is currently working on getting these in-house
  - RFC (or NOHRSC) will process grids into FSCA estimates for individual basins (not available yet)
  - Historical grids:
    - → will be available in a few weeks per Painter, as JPL group is reprocessing w/ improved cloud masking and de-striping.

- MODSCAG algorithm determines FSCA in a different way than the Hall/GSFC algorithm
  - Hall/GSFC based on regressions
  - MODSCAG based on spectral mixture models

Datasets: MODSCAG FSCA

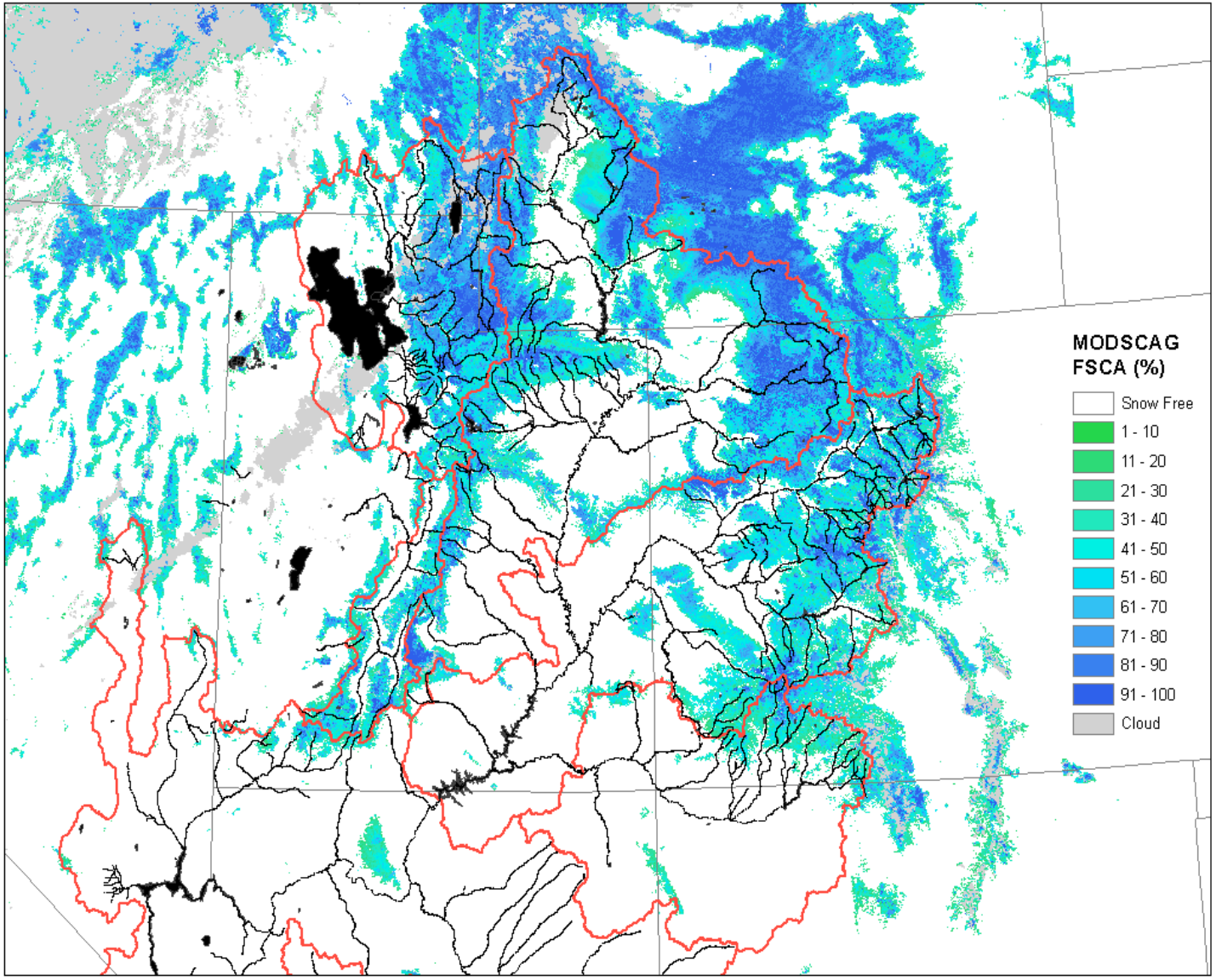
JPL ready to start serving operational grids to CBRFC

Sample imagery in Utah, April 2010

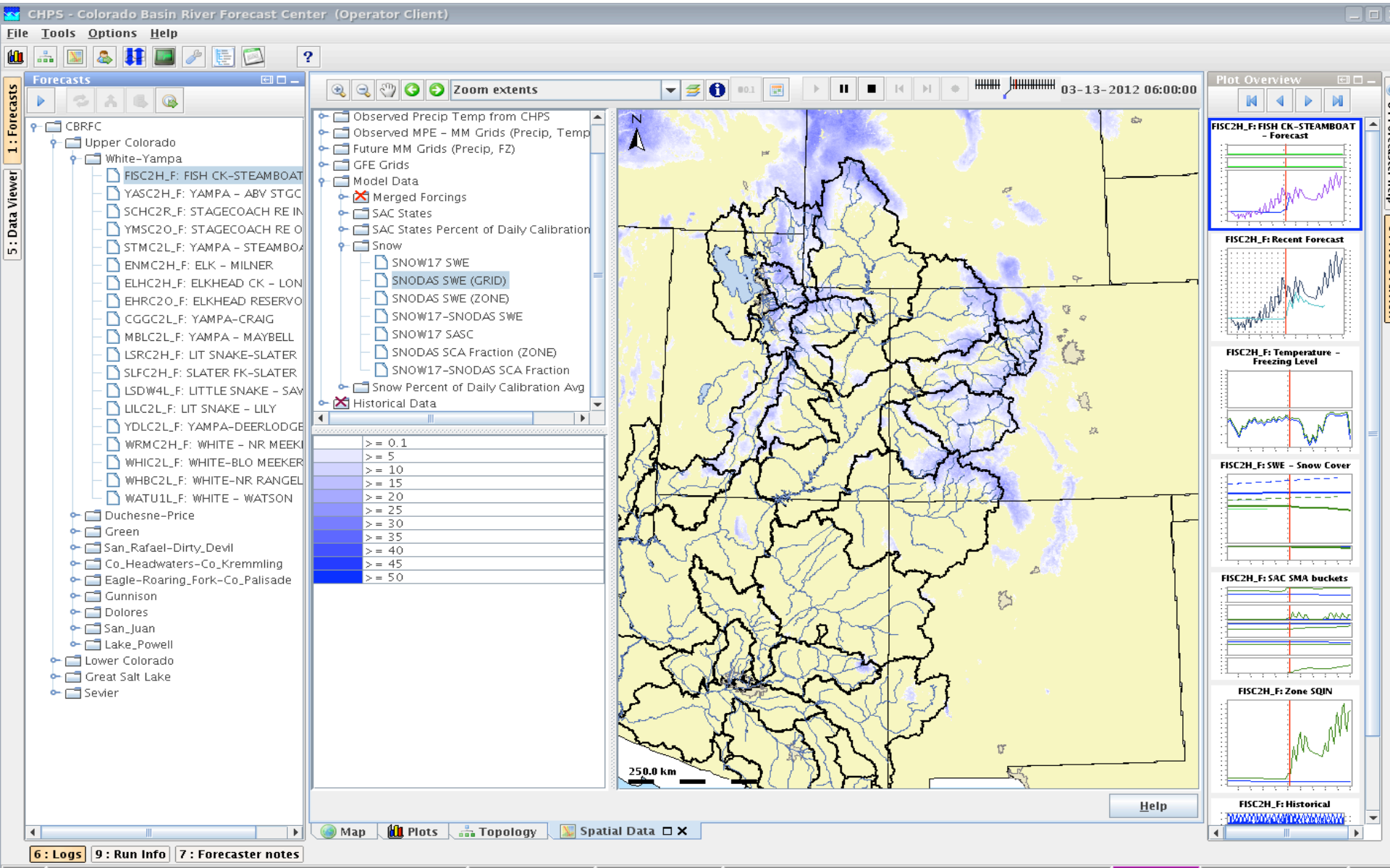


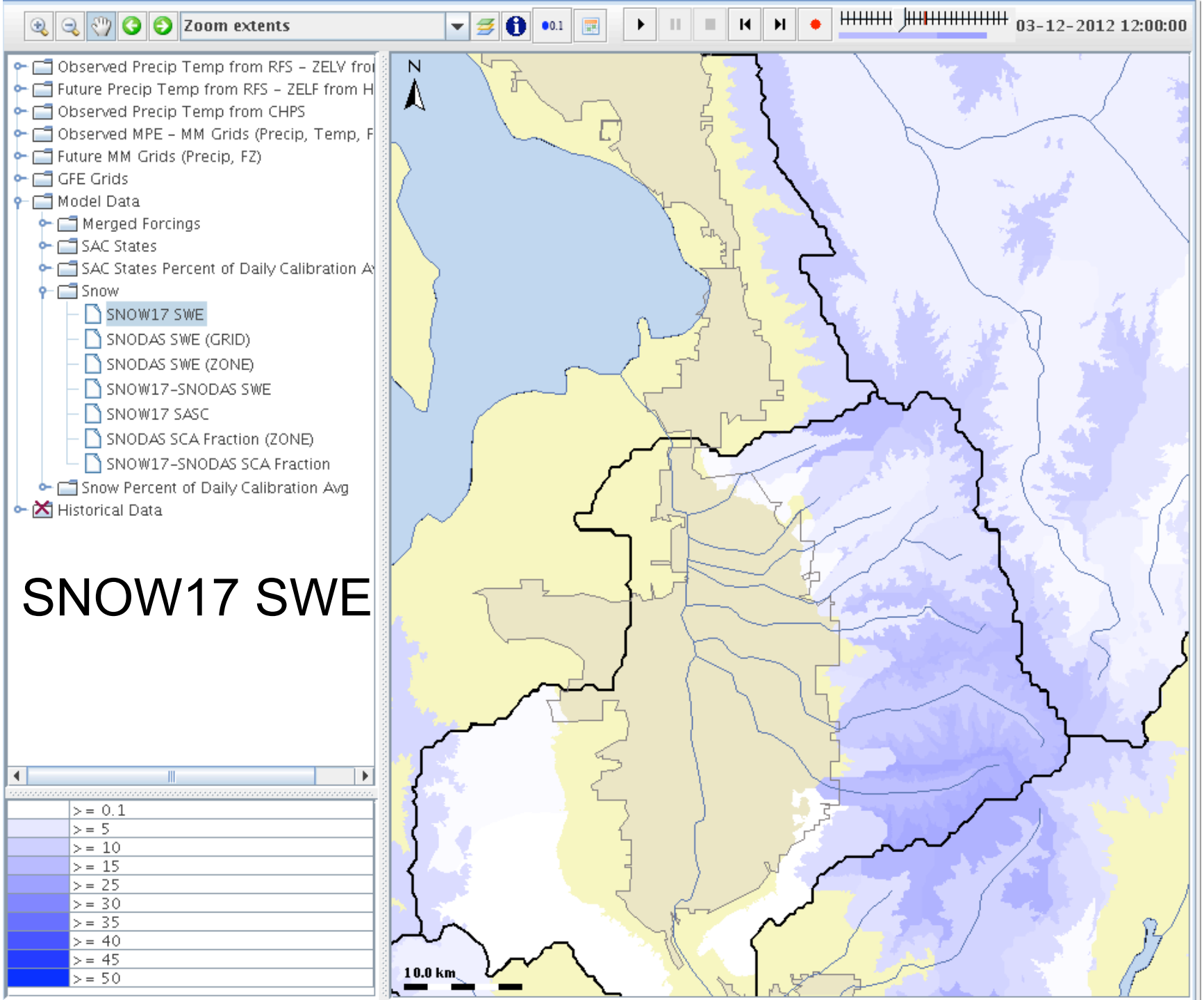
Datasets: MODSCAG FSCA

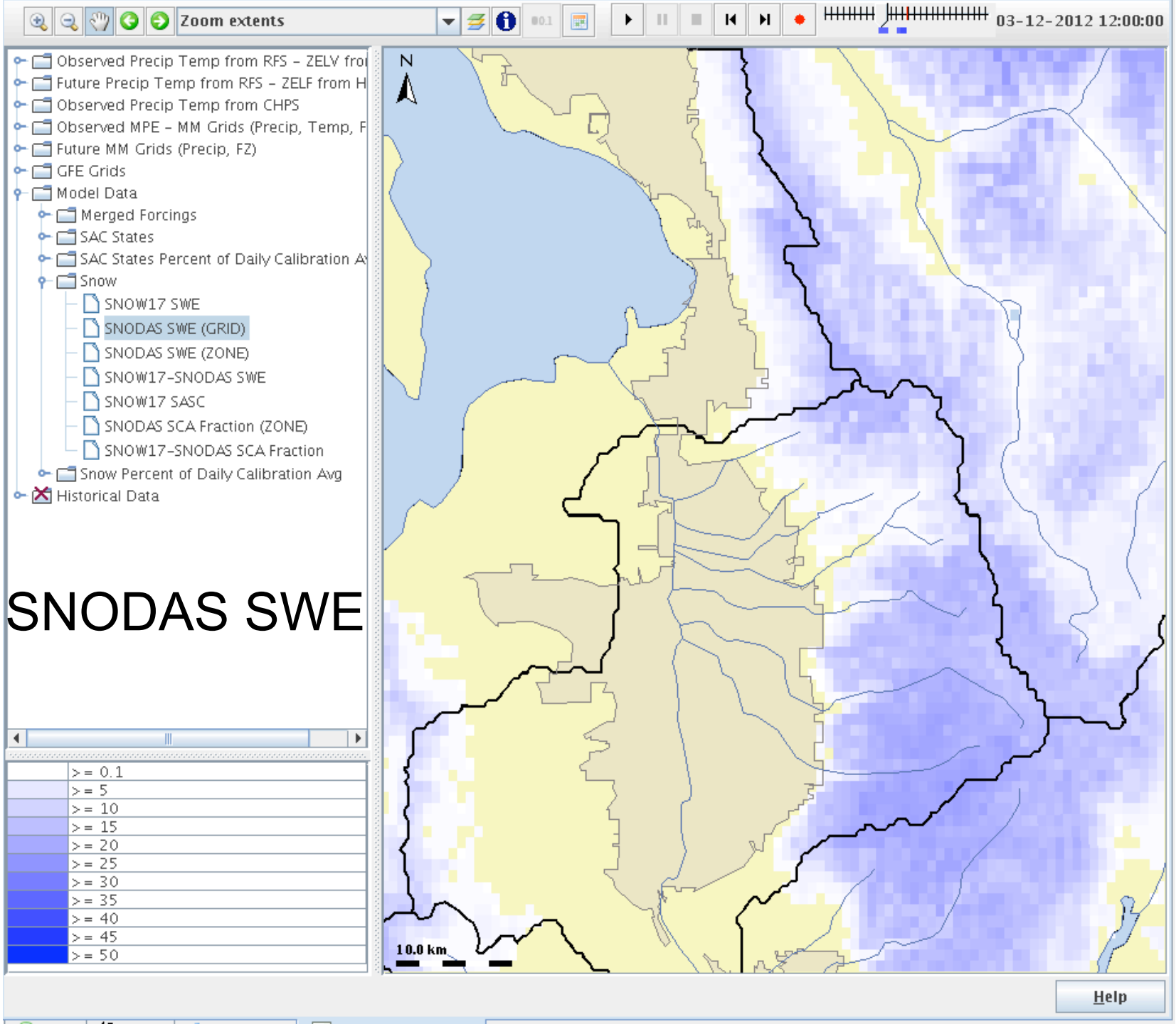
Sample imagery for upper Colorado Basin April 2010



RFC SNODAS investigation




Zoom extents
03-12-2012 12:00:00
Observed Precip Temp from RFS – ZELV fro
Future Precip Temp from RFS – ZELF from H
Observed Precip Temp from CHPS
Observed MPE – MM Grids (Precip, Temp, F
Future MM Grids (Precip, FZ)
GFE Grids
Model Data
Merged Forcings
SAC States
SAC States Percent of Daily Calibration A
Snow
SNOW17 SWE
SNODAS SWE (GRID)
SNODAS SWE (ZONE)
SNOW17–SNODAS SWE
SNOW17 SASC
SNODAS SCA Fraction (ZONE)
SNOW17–SNODAS SCA Fraction
Snow Percent of Daily Calibration Avg
Historical Data
SNOW17 SWE
>= 0.1
>= 5
>= 10
>= 15
>= 25
>= 30
>= 35
>= 40
>= 45
>= 50
N
10.0 km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Help

- Observed Precip Temp from RFS – ZELV fro
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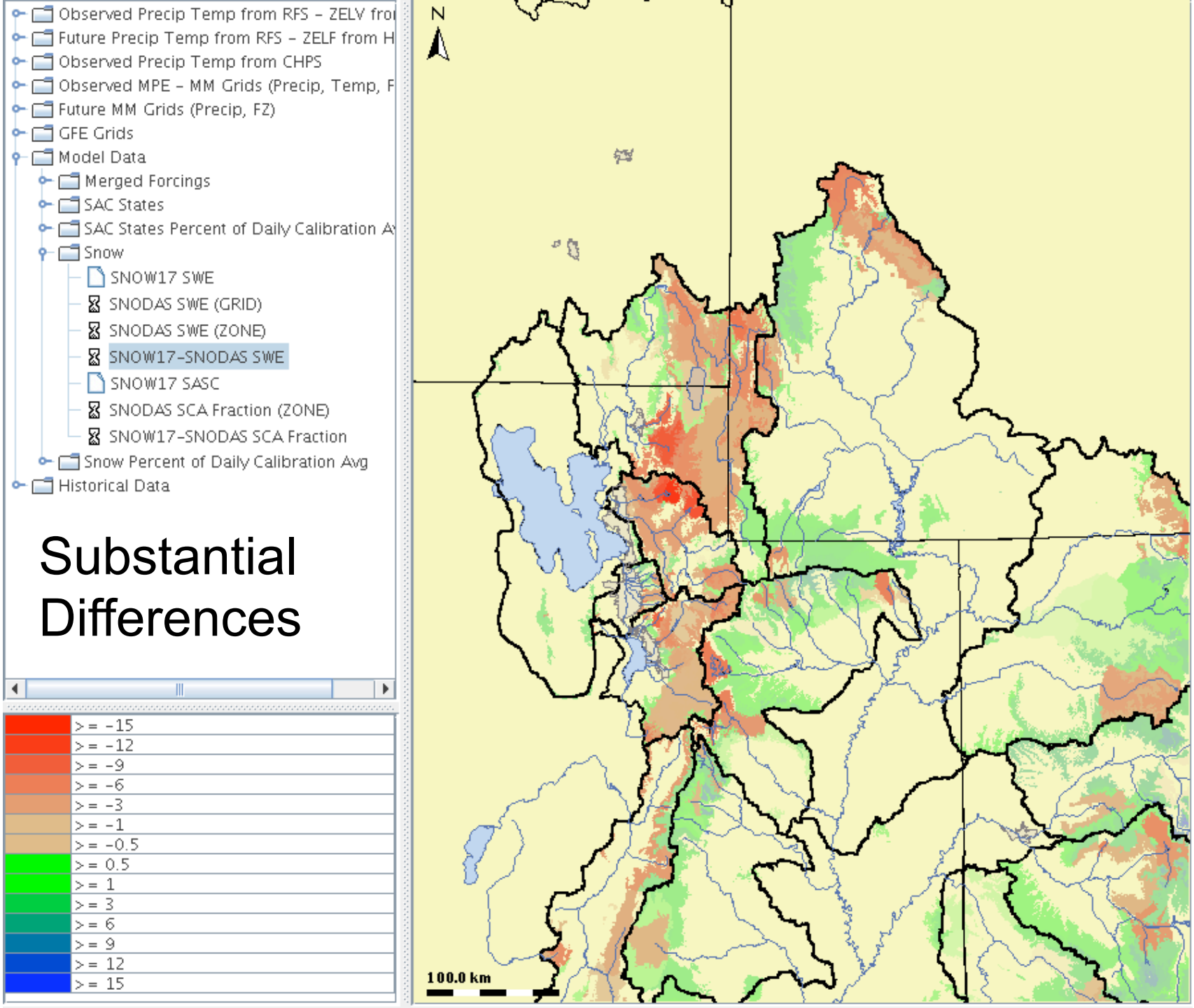
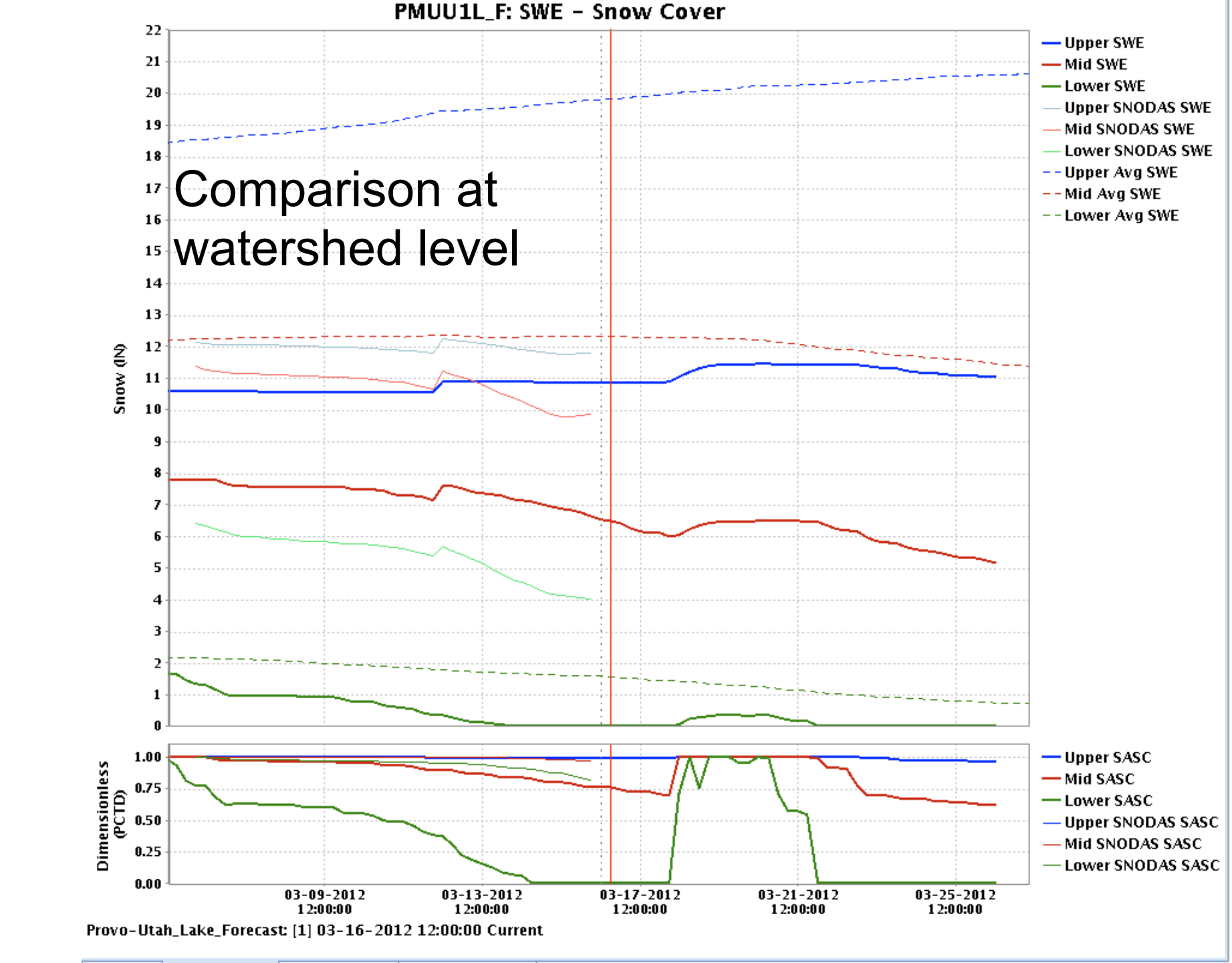
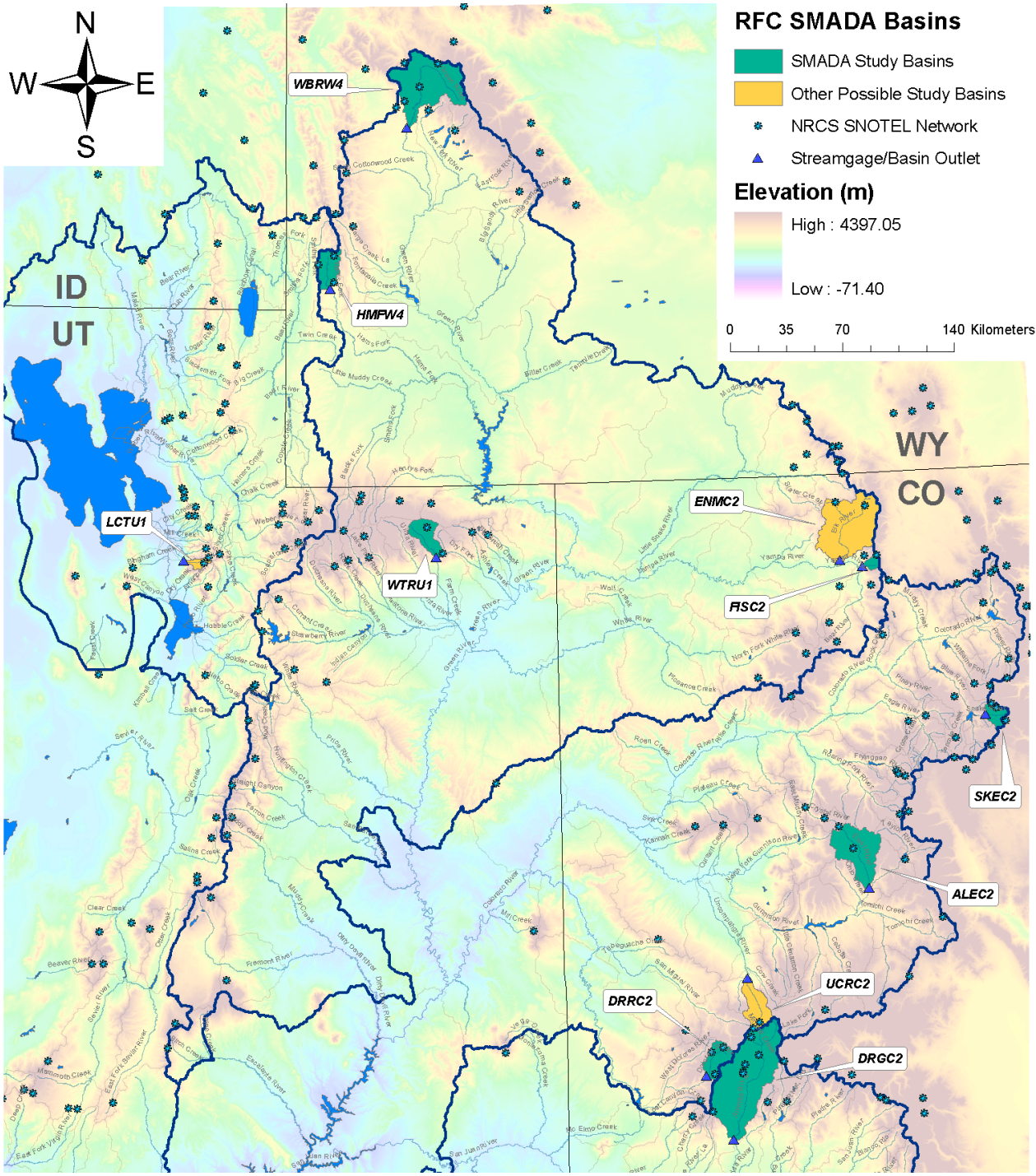
    - SNODAS SCA Fraction (ZONE)
    - SNOW17-SNODAS SCA Fraction
  - Snow Percent of Daily Calibration Avg
- Historical Data

Substantial Differences




PMUU1L_F: SWE - Snow Cover
Comparison at watershed level
Snow (IN)
Upper SWE
Mid SWE
Lower SWE
Upper SNODAS SWE
Mid SNODAS SWE
Lower SNODAS SWE
Upper Avg SWE
Mid Avg SWE
Lower Avg SWE
Dimensionless (PCTD)
Upper SASC
Mid SASC
Lower SASC
Upper SNODAS SASC
Mid SNODAS SASC
Lower SNODAS SASC
03-09-2012 12:00:00
03-13-2012 12:00:00
03-17-2012 12:00:00
03-21-2012 12:00:00
03-25-2012 12:00:00
Provo-Utah_Lake_Forecast: [1] 03-16-2012 12:00:00 Current

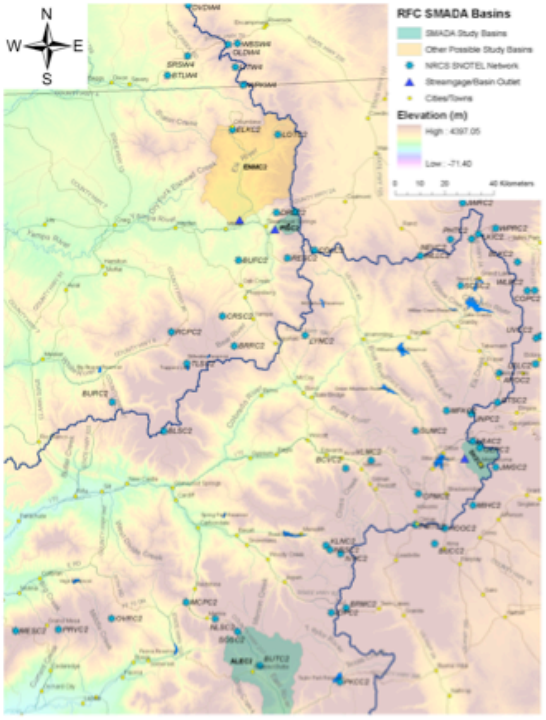
- **Snow Modeling and Data Assimilation (SMADA) Testbed**
  - ~10 watersheds
  - relatively unimpaired
  - good SWE and flow observations



SMADA

- Collectively, the datasets help define state of current RFC practice
- The staging of models & data facilitates/focuses research in an RFC-relevant context

Fish Creek near Steamboat Springs, CO
basin id: FISC2



Map in English Units

NWSRFS Calibration Deck (as of March 22, 2011)

MAT, MAP forcings from most recent calibration (1980-2010)

- Upper Tier MAT
- Lower Tier MAT
- Upper Tier MAP
- Lower Tier MAP

Daily SWE obs from nearby SNOTELs

- Time period: earliest ob that CBRFC has through Sept 30, 2011
- Stations: tarball contains daily SWE observations for the following SNOTEL sites:
  - DRLC2
  - TOWC2

6-Hourly Simulated SWE in mm (1980-2010)

- Upper Tier
- Lower Tier

Obs. Mean Daily Q in cfs (all obs CBRFC has)

Sim. Mean Daily Q in cms/d (1980-2010)

The whole nine yards (all datasets in one tarball)

Currrent SWE plots for nearby SNOTEL stations:

- Dry Lake (DRLC2)
- Tower (TOWC2)

Current Flow Plot for FISC2

USGS web page for FISC2

Next Steps

Snow Data Grid & Timeseries Evaluation

- Visualizing SNODAS and MODIS products side-by-side with RFC simulations in CHPS
- Event-focused assessment for particular basins (eg 2010, 2011 melt periods)
  - Can information from these 'new' datasets increase the accuracy of RFC modeling?

Research Partnerships (using SMADA)

- Alternative snow modeling approaches (with Martyn Clark, Drew Slater, Pedro Restrepo, Andy Wood)
- MODSCAG applications in RFCs (with Tom Painter, Andy Wood, Stacie Bender, Kevin Werner)
- Data assimilation projects (with DOE PNNL, NASA GSFC – still being scoped)

Snow Product Development

- providing watershed or basin-focused spatial imagery from various sources
  - current states
  - trends – eg, changes in last few days, week

Feedback from Water Users

- guidance for product development