Re-dimensioned CFS Reanalysis data for easy SWAT initialization

Daniel R Fuka, Charlotte MacAlister, Solomon Seyoum, Allan Jones, Raghavan Srinivasan
Cornell University
IWMI East Africa
Texas A&M

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If you like what you see….

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If you have any complaints….

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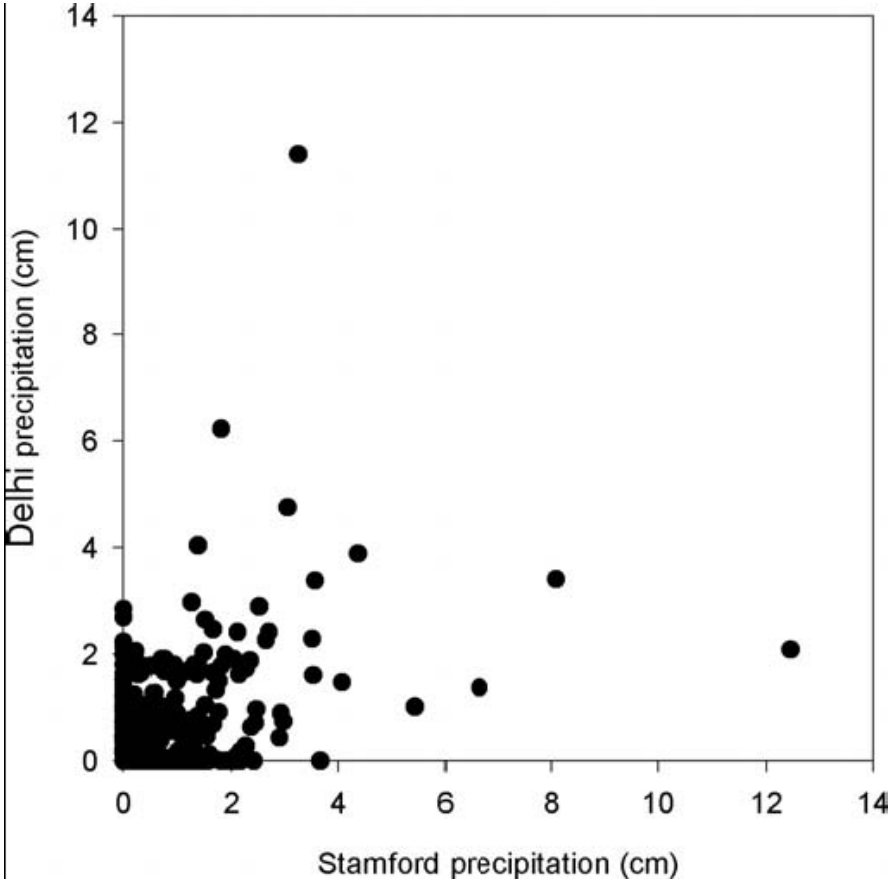
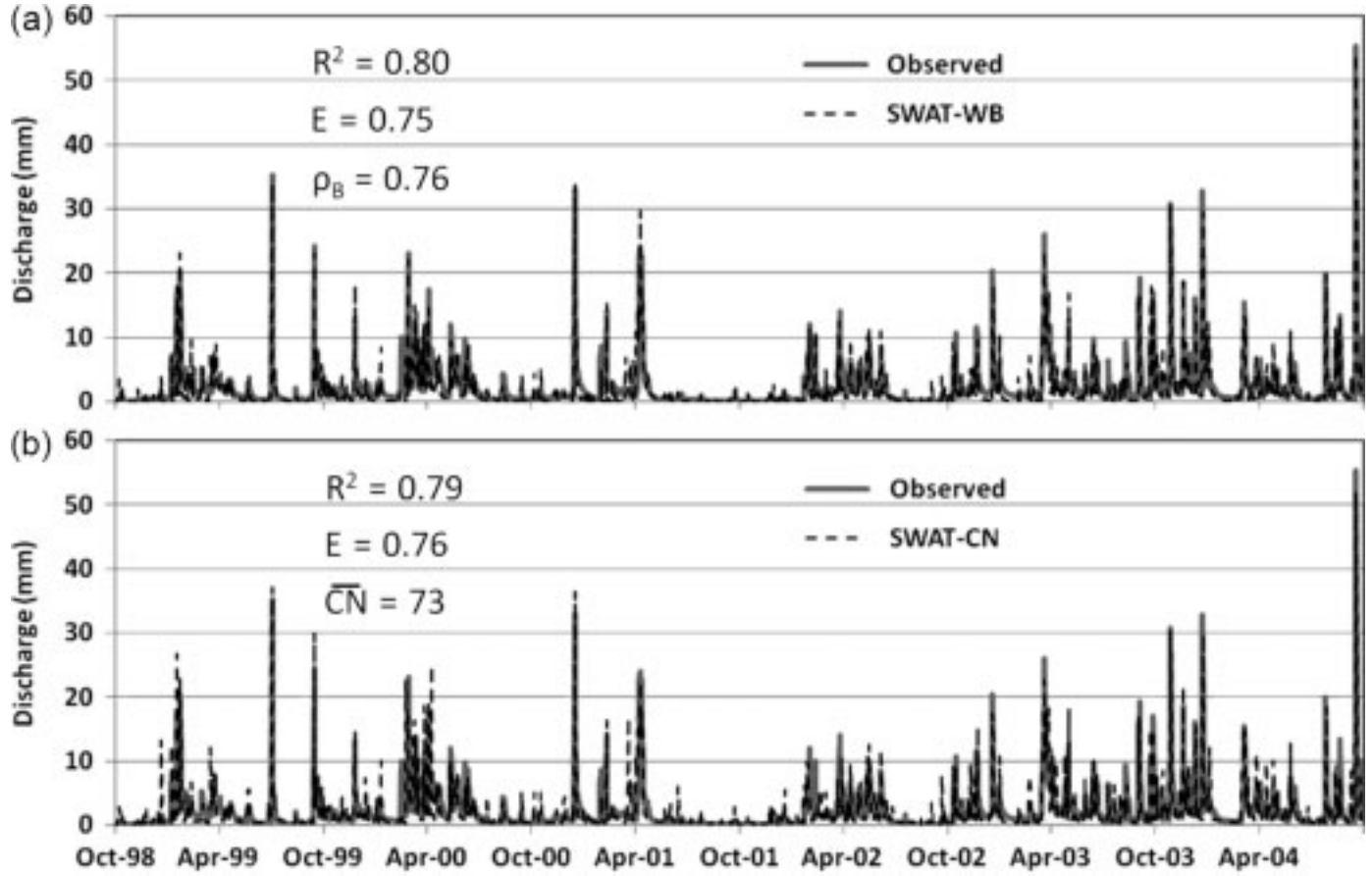
Issues in Hydrologic Modeling

- Assuming nearest real-time reporting station for PPT.
  - 30km apart, PPT r^2 .23
    - Mehta, V.K. et. al. 2004.
- Finding a set of stations to run with real-time at 30km is unlikely.
- This type of agreement would be a dream situation for us!



Previously Published/Expected



Typical weather massaging required

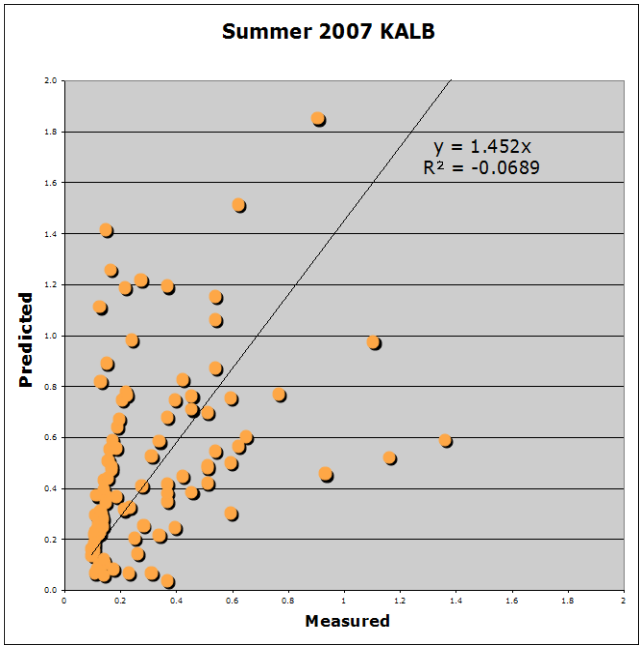
Meteorological data: Daily precipitation data were collected from the five nearest weather stations, Kortright, Stamford, Pratsville, Arkville, and Delhi, NY. The input precipitation for the watershed was determined using an inverse distance-squared weighting procedure to create one time series. Daily minimum and maximum temperature data were collected at the Northeast Regional Climate Center (NRCC) station in Stamford, NY. Daily solar radiation and wind speed data were obtained from the NRCC station in Binghamton, NY. Daily potential ET rates were calculated in the SWAT model using the Penmen-Monteith method and default values were used for all unavailable parameters.

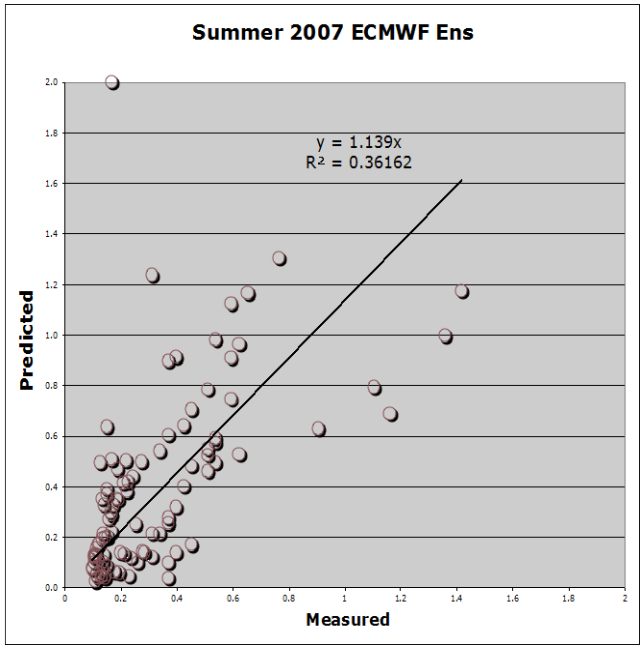
HELP!

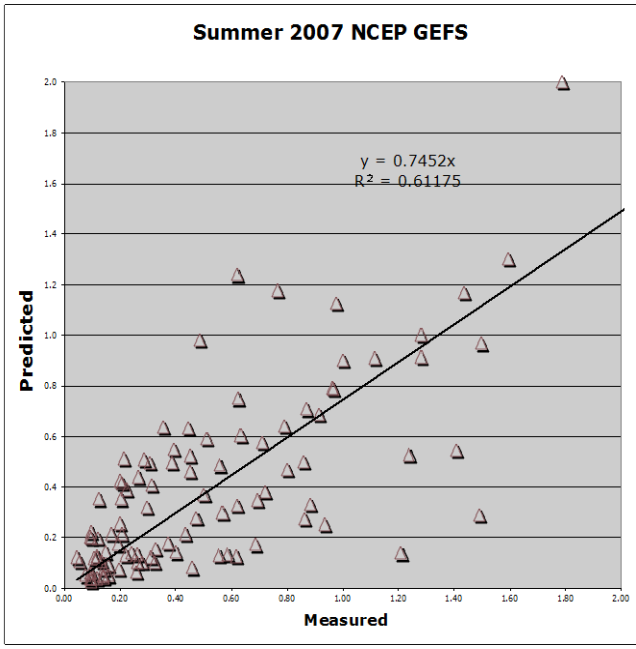
- 8 man months of prep work to see a pretty hydrograph?
- If that is what it takes to start getting viable results in high met station density, we need something simpler to start with.

TIGGE 24 hour forecasts as forcing data History

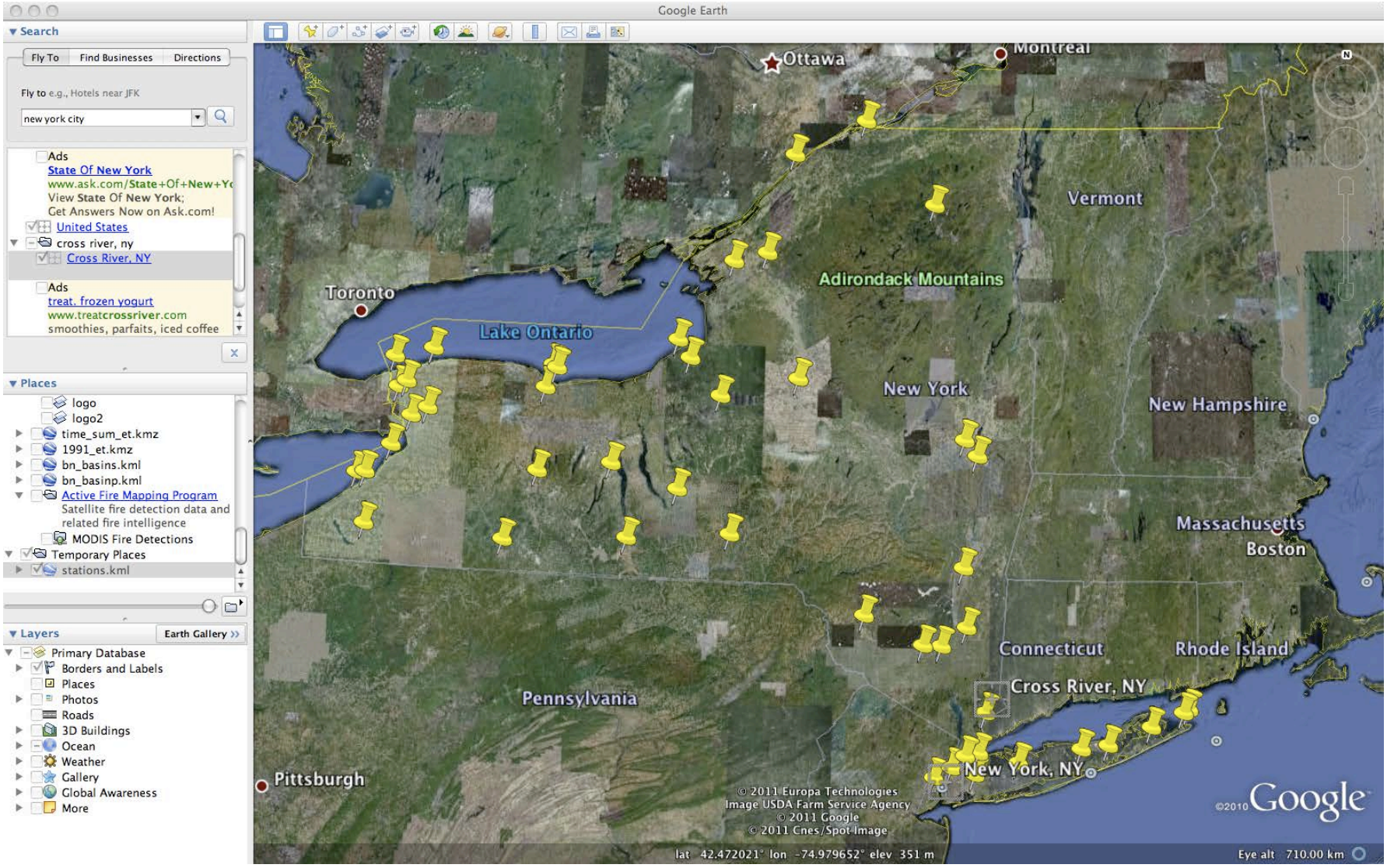
- Ensemble forecasts for hours 6-30 better represented weather than station 80km away (Townbrook to KALB)
- Needed to find higher density of stations
- Recent projects in Ethiopia required longer histories



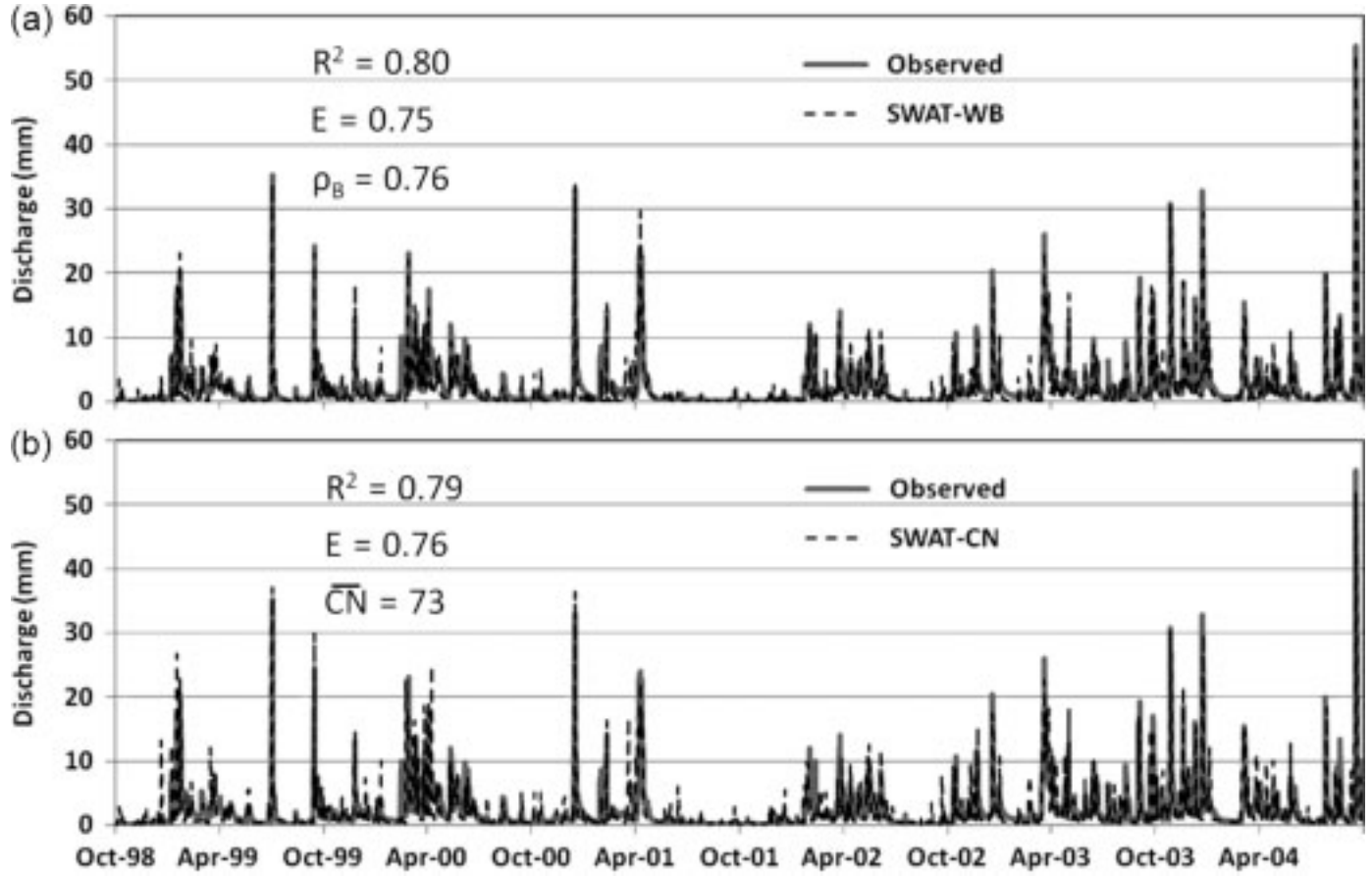




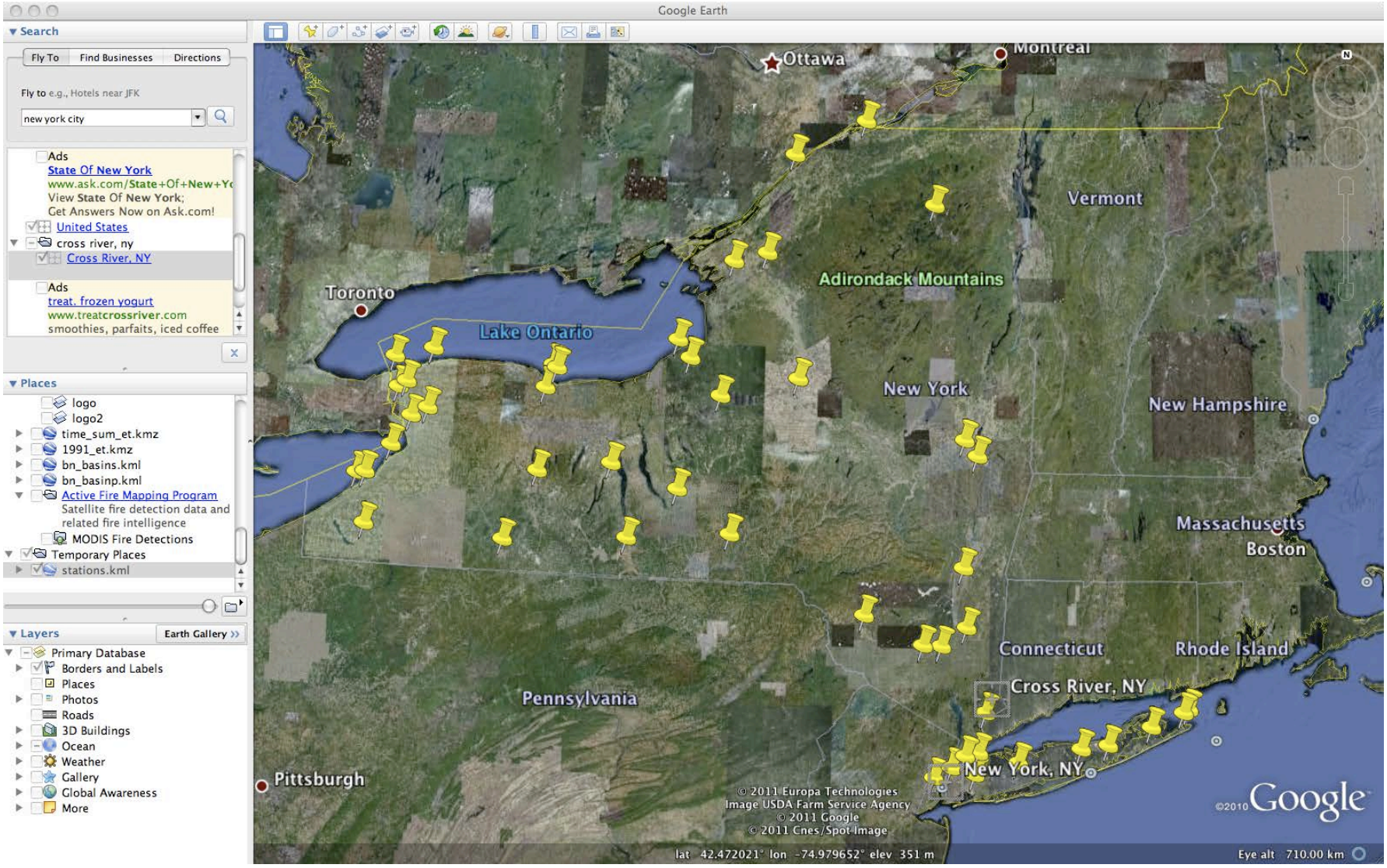
Managers/Flood Forecasters Have:



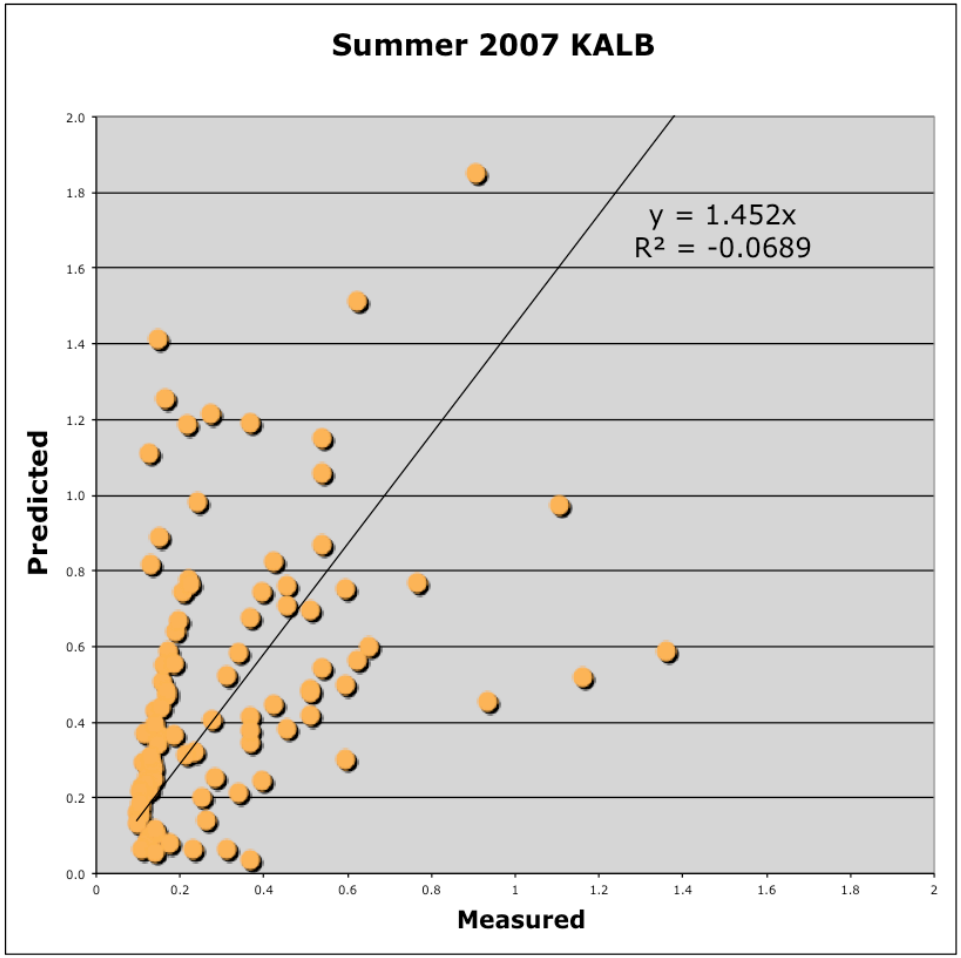
If Flood Forecasters used our Research for Townbrook, NY…..



Managers/Flood Forecasters Have:



With closest station KALB They would get these Results



Overview of Global Climate Data Sources

Product	Spatial Resolution	Temporal Resolution	Time Horizon	Variables
CMAP	2.5 degree	Monthly	1979 - 2009	Precipitation
GPCP	2.5 degree	Monthly	1979 - 2010	Precipitation
GPCC	0.5 degree	Monthly	1951 - 2010	Precipitation
WorldClim	30 sec	Monthly	Climatology	Precipitation Min, mean and max temp
TRMM	0.25 degree	3-hr, Daily	1957 - 2002	Precipitation
R1, R2	2.5 degree	6-hr, Daily	1948 – 2009 (present)	Climate variables
ERA40	2.5 degree	6-hr, Daily	1979 - 2001	Climate variables
CFSR	0.312 degree (~38km)	Hourly, Daily	1979 - 2010	Climate variables, and Hydrological quantities

Meteorological Reanalyses Systems

First Generation Products:

- National Oceanic Atmospheric Administration (NOAA)/National Centers Environmental Prediction (NCEP)/ National Centers Atmospheric Research (NCAR) reanalysis R1: 1948-present, R2: 1979-2009
- European Centre for Medium Range Weather Forecasts (ECMWF) ERA-15(40): 1979-83, ERA-40: 1957-2002
- Global Modeling and Assimilation Office (GMAO) NASA GCFC: 1980-94

Latest Generation:

- Japanese 25-year Reanalysis JRA-25: 1979-2004, JCDAS: 2005-present
- ECMWF Interim Reanalysis ECMWF-Interim: 1979-present
- NASA Modern-Era Retrospective analysis for Research and Applications MERRA: 1979-present
- NCEP Climate Forecast System Reanalysis: CFSR 1979-2010 (>present)

Changes to the Basic Concept

- CFSR is just a 6 hour Global forecasting system
  - BUT.. Is CFSR is representative of GFS short term forecasting accuracy?
    - It has a9 hr coupled guess forecast to build analysis
- The basis of our weather forecasts

Study Overview

- Climate Forecast System Reanalysis (CFSR)
  - Hourly 1979 – Today
- Closest Weather Stations.
  - Closest Stations in Ethiopia
  - Distance vs Performance in US
- Hydrologic Model Performance Relates to Weather Data Quality
  - SWAT
- Variables.
  - PPT, as well as Max and Min Temperature.

Climate Forecast System (CFS) implementation

Two essential components:

A new Reanalysis (Every 6 hours) of the atmosphere, ocean, sea ice and land over the 31-year period (1979-2009) is required to provide consistent initial conditions for:

A complete Hourly Reforecast of the new CFS over the ~30-year period (1979-2011), in order to provide stable calibration and skill estimates of the new system, for operational seasonal prediction at NCEP

Figure 1 (upper half) shows the CFSR execution of one day of reanalysis, which can be itemized as follows:

• Atmospheric T382L64 (GSI) analysis is made at 0000, 0600, 1200, and 1800 UTC, using a coupled 9-h guess forecast.

• Ocean and sea ice analysis (GODAS with MOM4) is made at 0000, 0600, 1200, and 1800 UTC, using the same 9-h coupled guess forecast.

• From each of the four cycles, a 9-h coupled guess forecast (GFS at T382L64) is made with 30-min coupling to the ocean (MOM version 4).

• Land (GLDAS) analysis, using observed precipitation with the Noah land model, is made only at 0000 UTC. •

The lower half of Fig. 1 shows the layout of the coupled 5-day forecast, from every 0000 UTC initial condition, which is made with an identical but reduced horizontal resolution (T126L64) version of the atmosphere, for a sanity check.

Although the analysis is carried out every 6 h, 9-h forecast guess fields are required to accommodate \ both the data window and to handle information about the time derivative.

Before the actual production phase of the CFSR, a “light” version (CFSR-Lite) of the analysis was carried out to sweep through the entire data inventory. This was done with the uncoupled atmospheric model of the CFSR at T62L64 resolution.

Each year was a single stream.

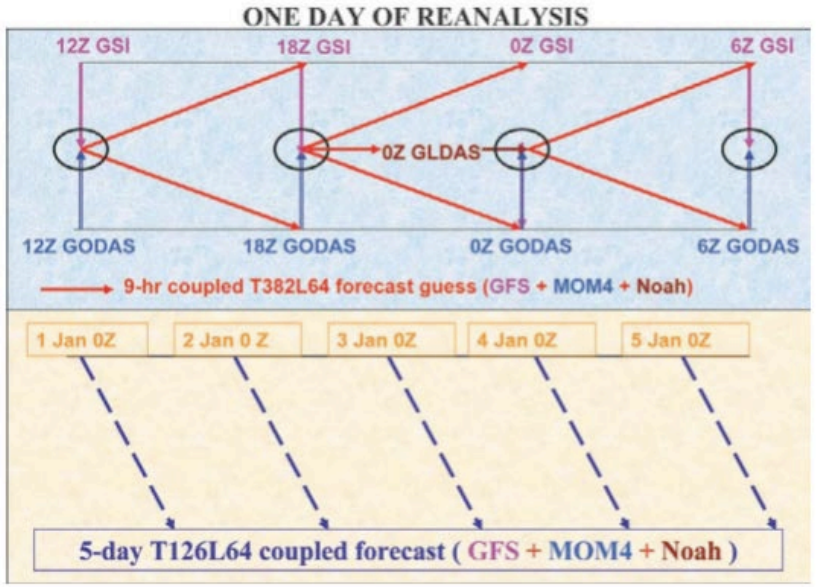
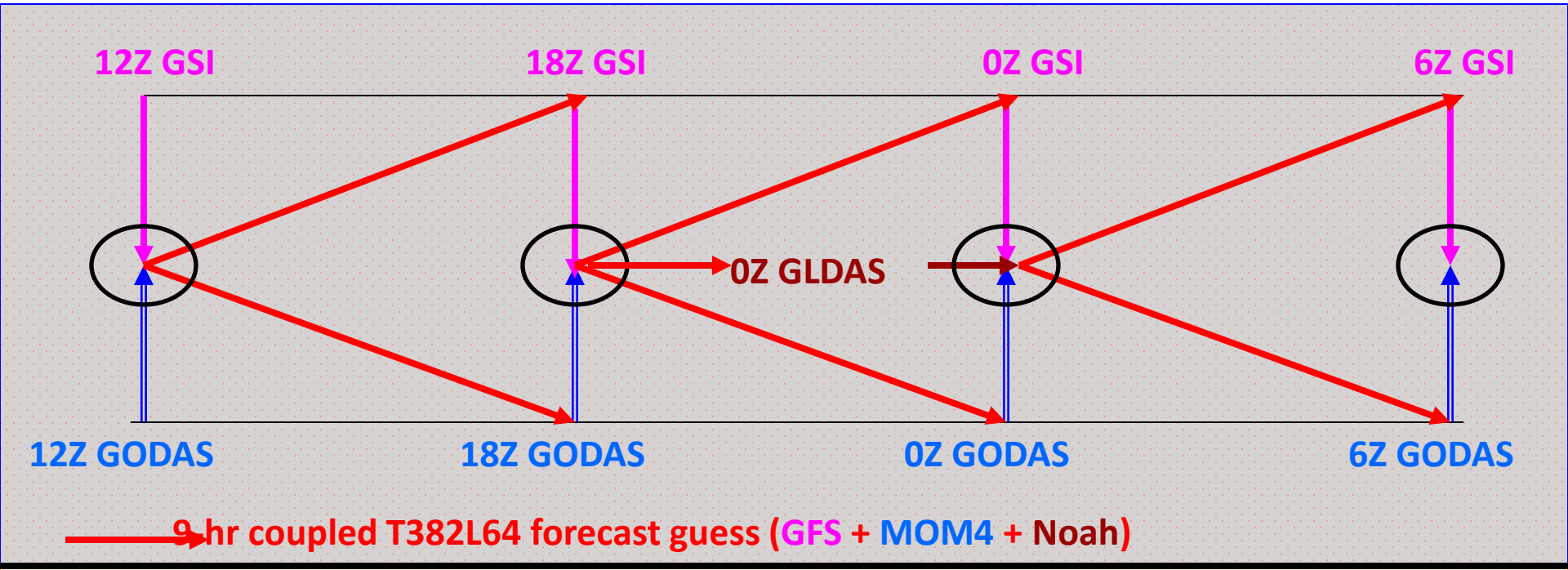
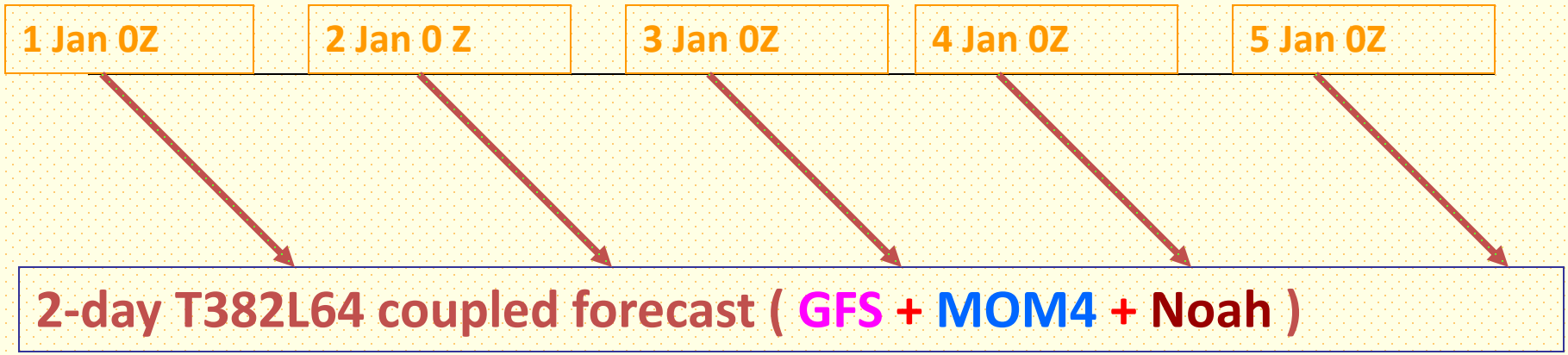
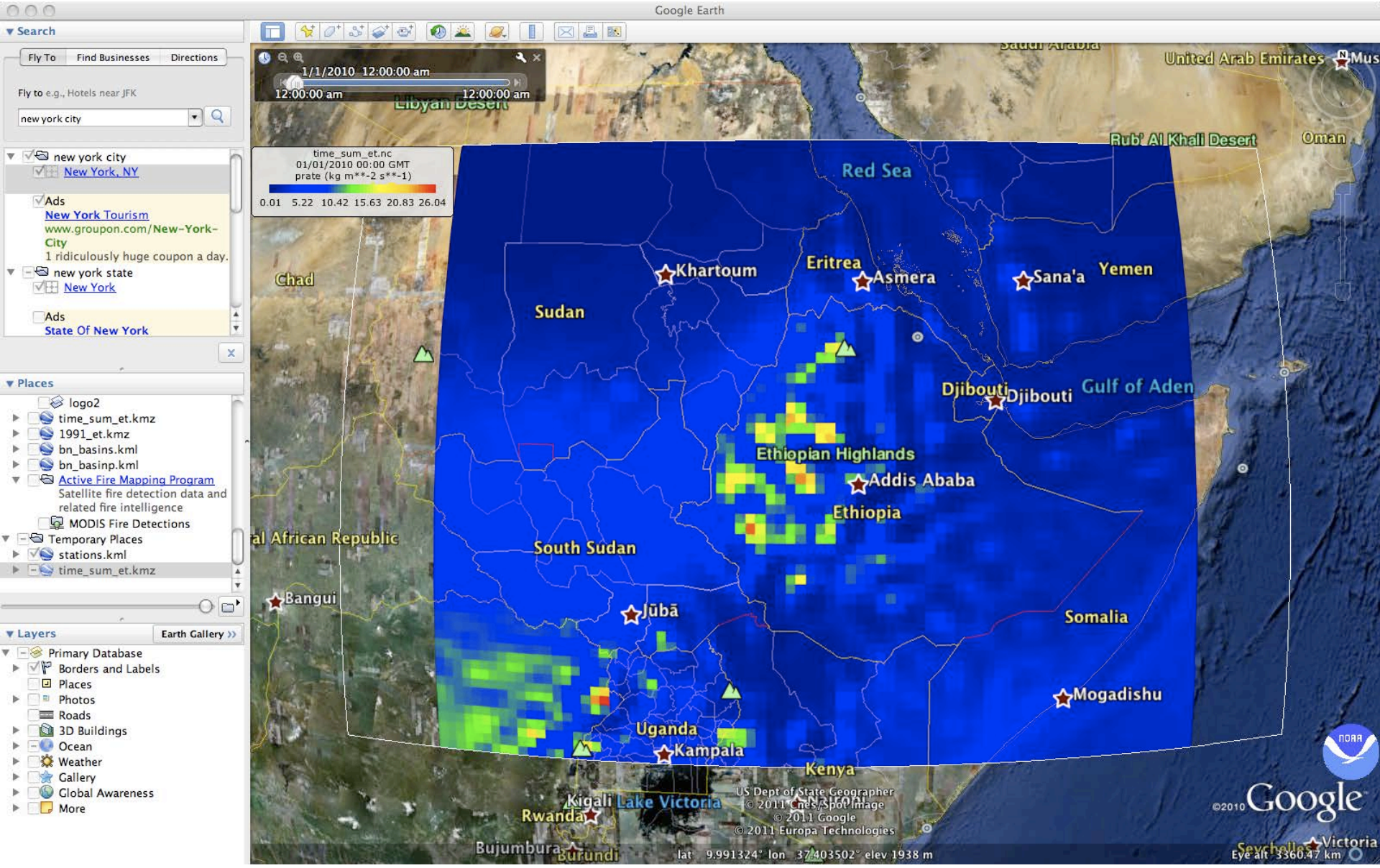


FIG. 1. Schematic of the execution of 1 day of the (top) CFS reanalysis and (bottom) layout of the 5-day forecasts to monitor the quality of the analysis.

ONE DAY OF REANALYSIS



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Search
Fly To
Find Businesses
Directions
Fly to e.g., Hotels near JFK
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new york city
New York, NY
Ads
New York Tourism
www.groupon.com/New-York-City
1 ridiculously huge coupon a day.
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Active Fire Mapping Program
Satellite fire detection data and related fire intelligence
MODIS Fire Detections
Temporary Places
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Weather
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Oman
United Arab Emirates
Yemen
Sana'a
Eritrea
Asmera
Khartoum
Sudan
Chad
Djibouti
Djibouti
Gulf of Aden
Ethiopian Highlands
Addis Ababa
Ethiopia
South Sudan
Somalia
Mogadishu
Bangui
Jūbā
Uganda
Kampala
Kenya
Kigali
Lake Victoria
Rwanda
Bujumbura
Burundi
US Dept of State Geographer
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© 2011 Google
© 2011 Europa Technologies
©2010 Google
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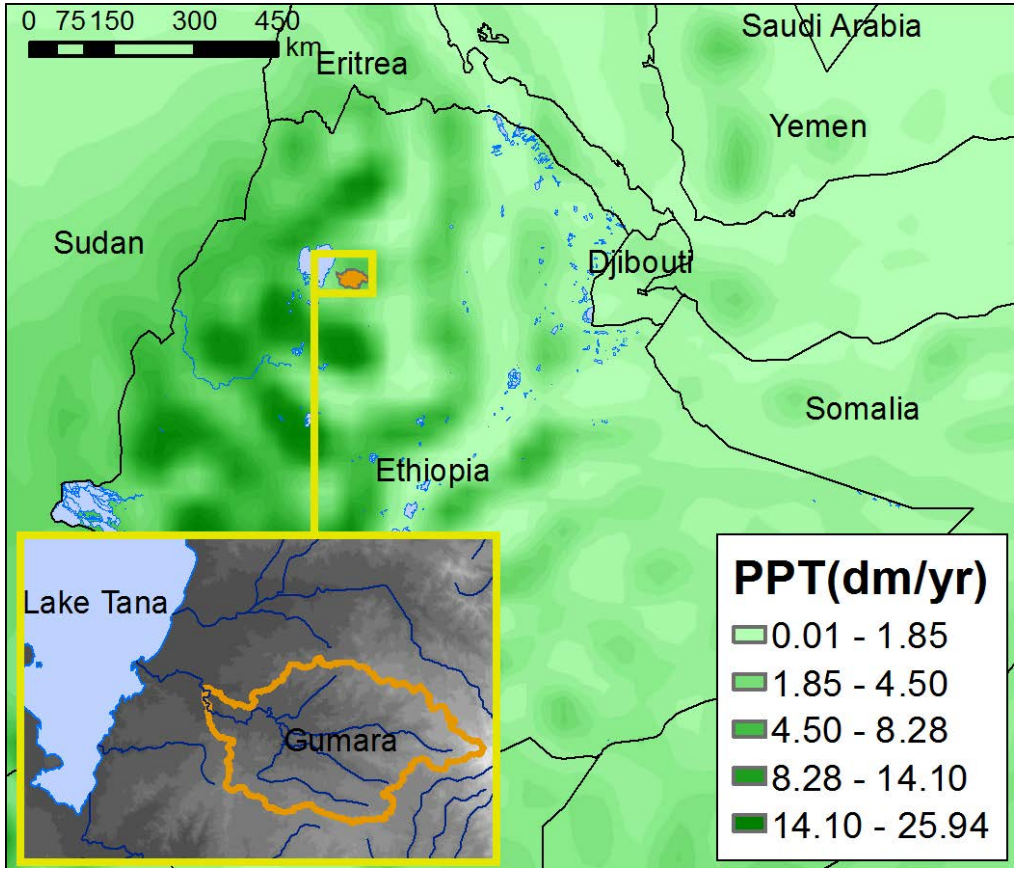
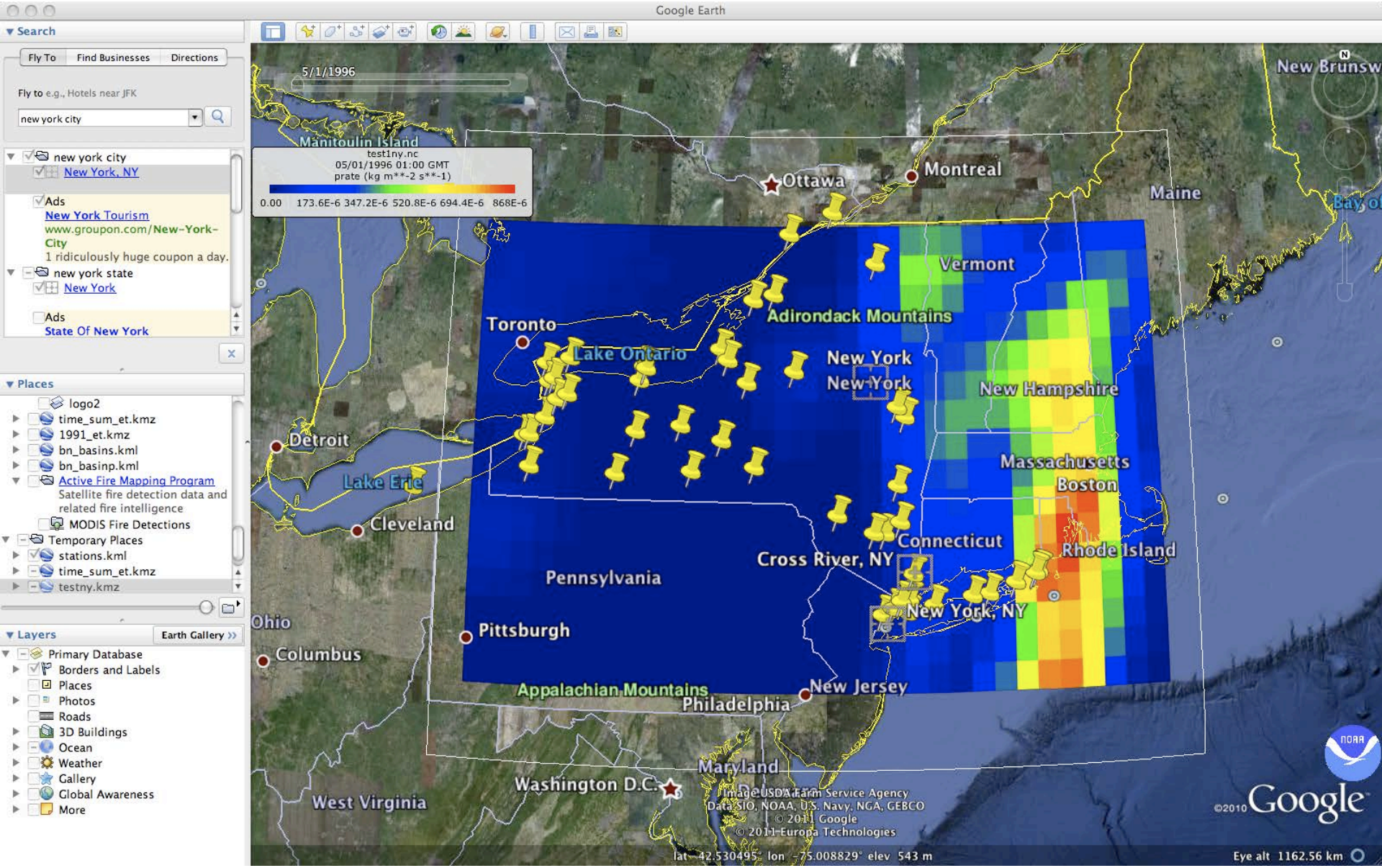
Eye alt 3360.47 km



Location in Ethiopia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Search
Fly To
Find Businesses
Directions
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New York Tourism
www.groupon.com/New-York-City
1 ridiculously huge coupon a day.
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3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
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prate (kg m**-2 s**-1)
0.00 173.6E-6 347.2E-6 520.8E-6 694.4E-6 868E-6
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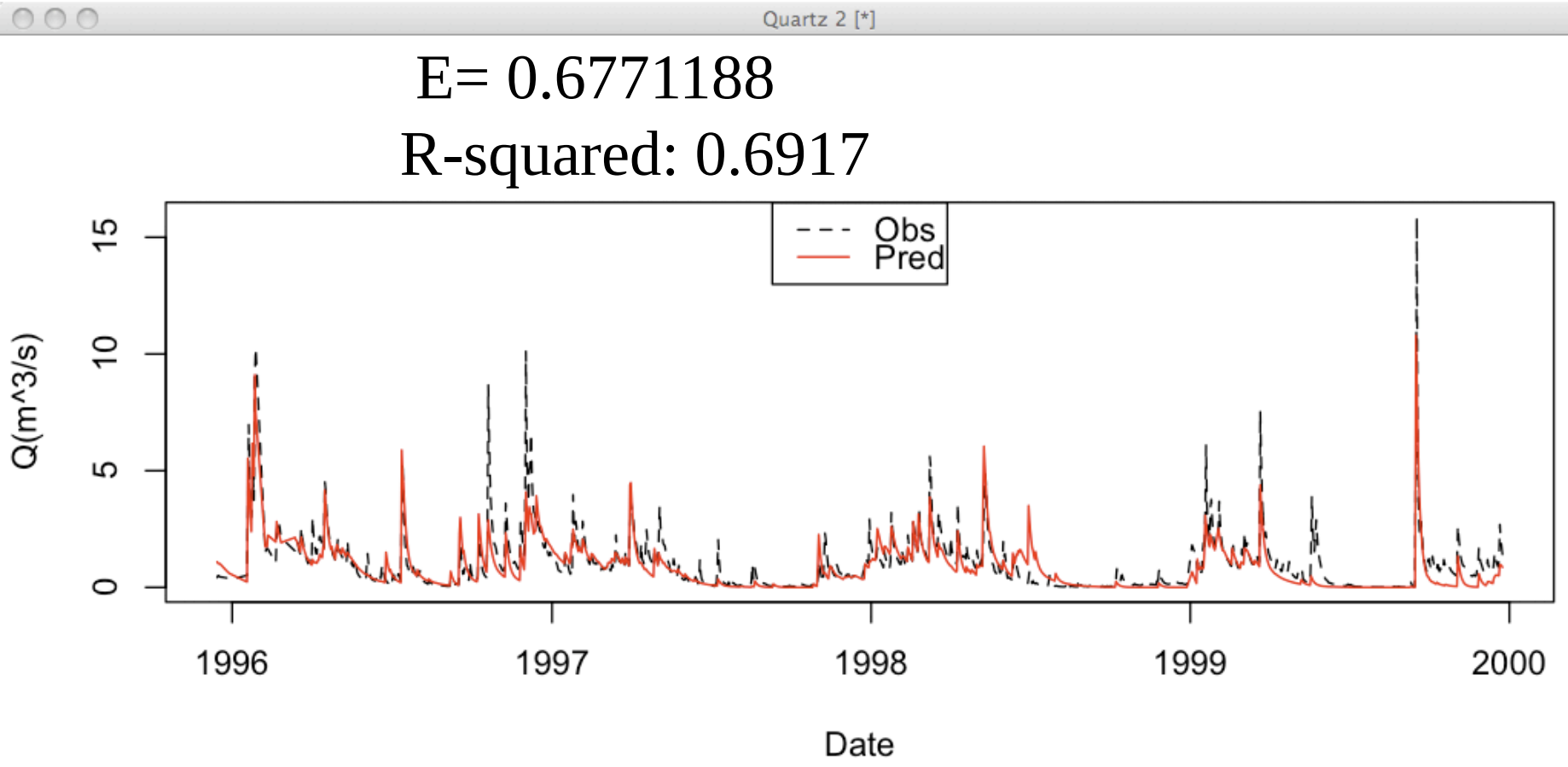
Ottawa
Montreal
Maine
Vermont
Adirondack Mountains
Toronto
Lake Ontario
New York
New York
New Hampshire
Detroit
Lake Erie
Massachusetts
Boston
Cleveland
Connecticut
Rhode Island
Cross River, NY
Pennsylvania
New York, NY
Ohio
Pittsburgh
Columbus
Appalachian Mountains
New Jersey
Philadelphia
Maryland
Washington D.C.
West Virginia
Image USDA Farm Service Agency
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2011 Google
© 2011 Europa Technologies
©2010 Google
lat 42.530495° lon -75.008829° elev 543 m
Eye alt 1162.56 km

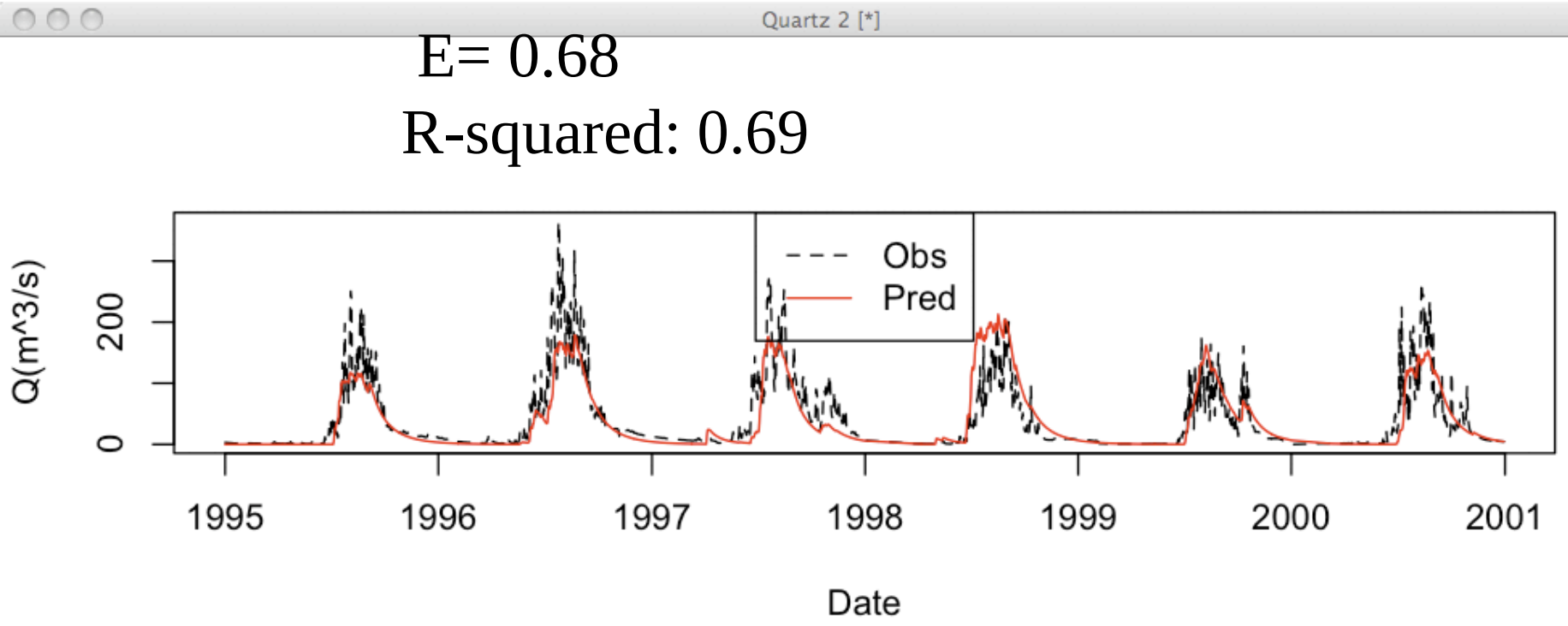
Current Results Cross, NY



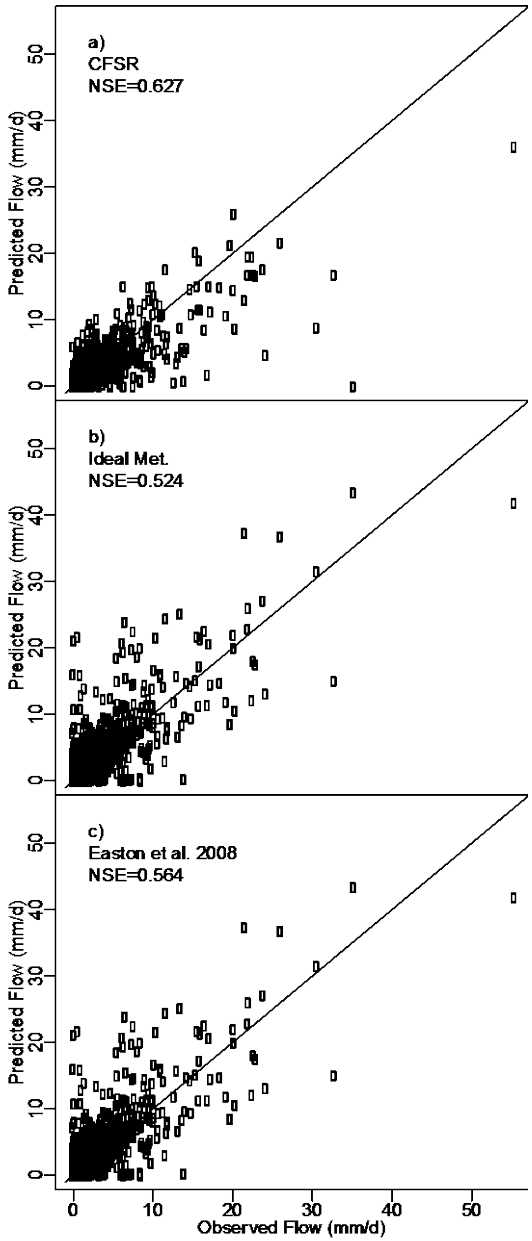
Current Results Gumara, ET

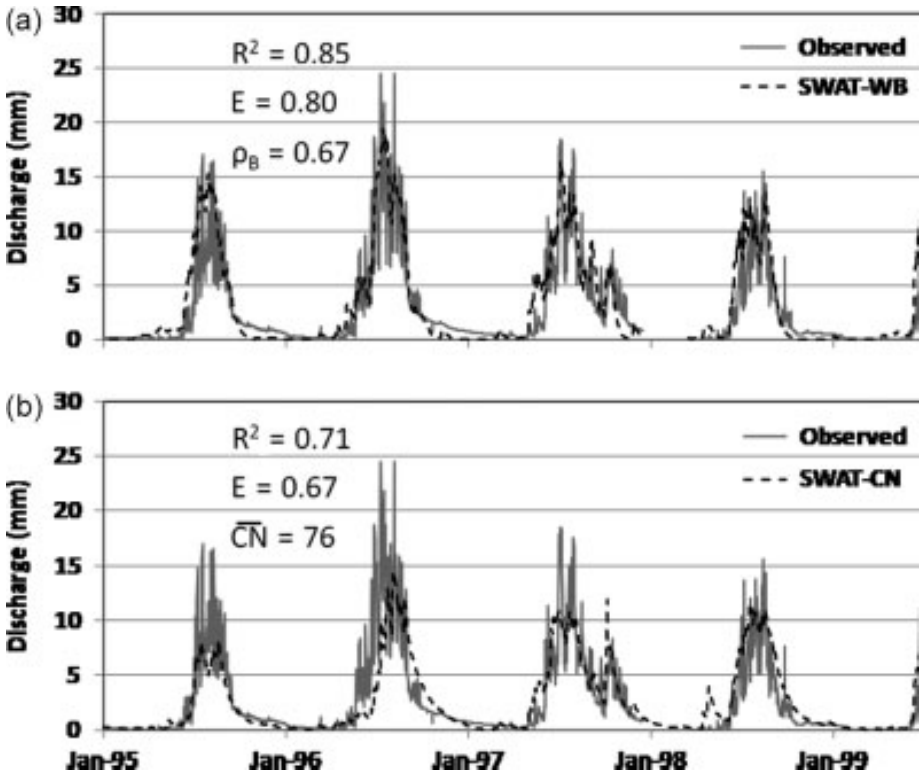
E= 0.68

R-squared: 0.69



Townbrook, NY
Now and Then

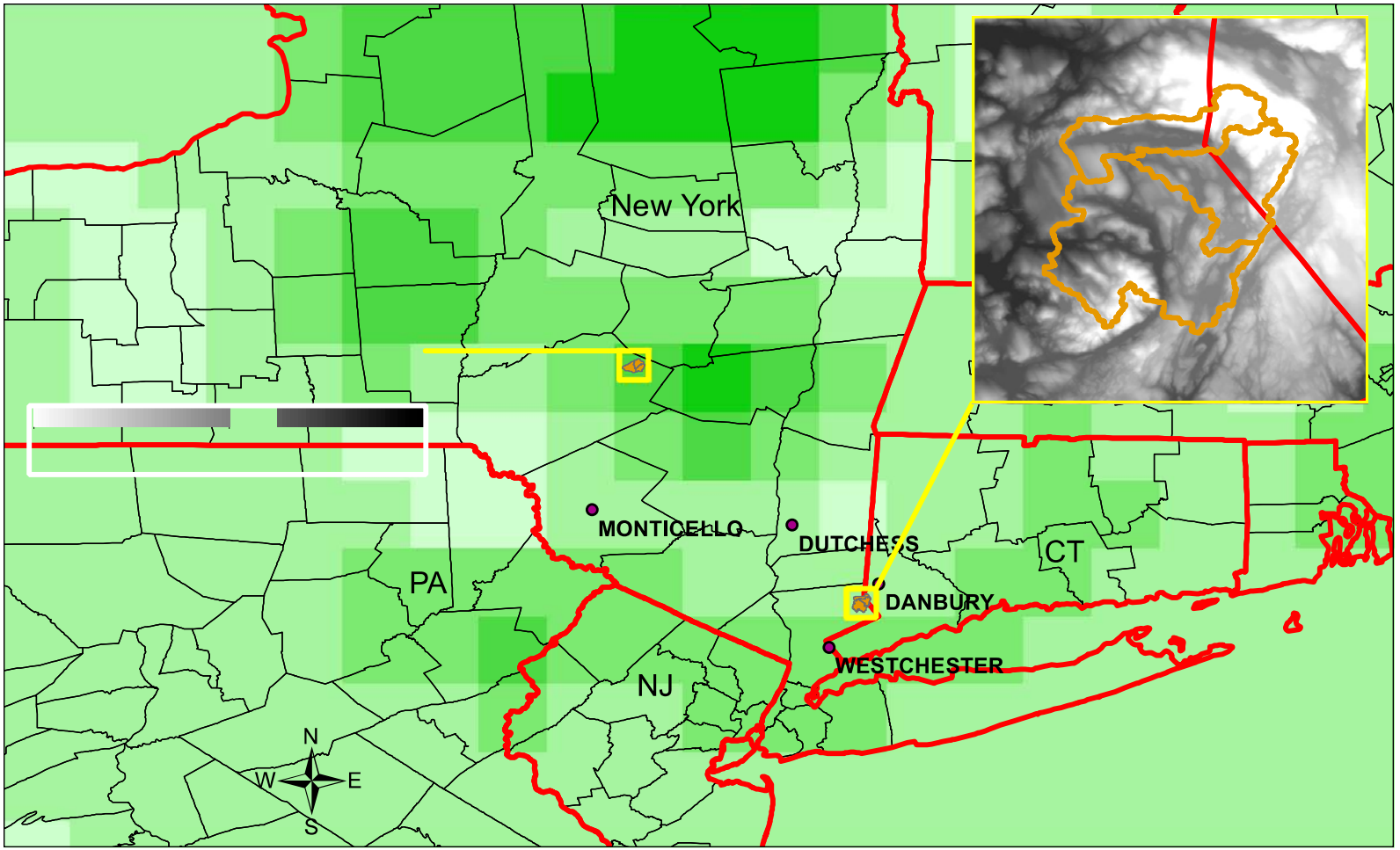


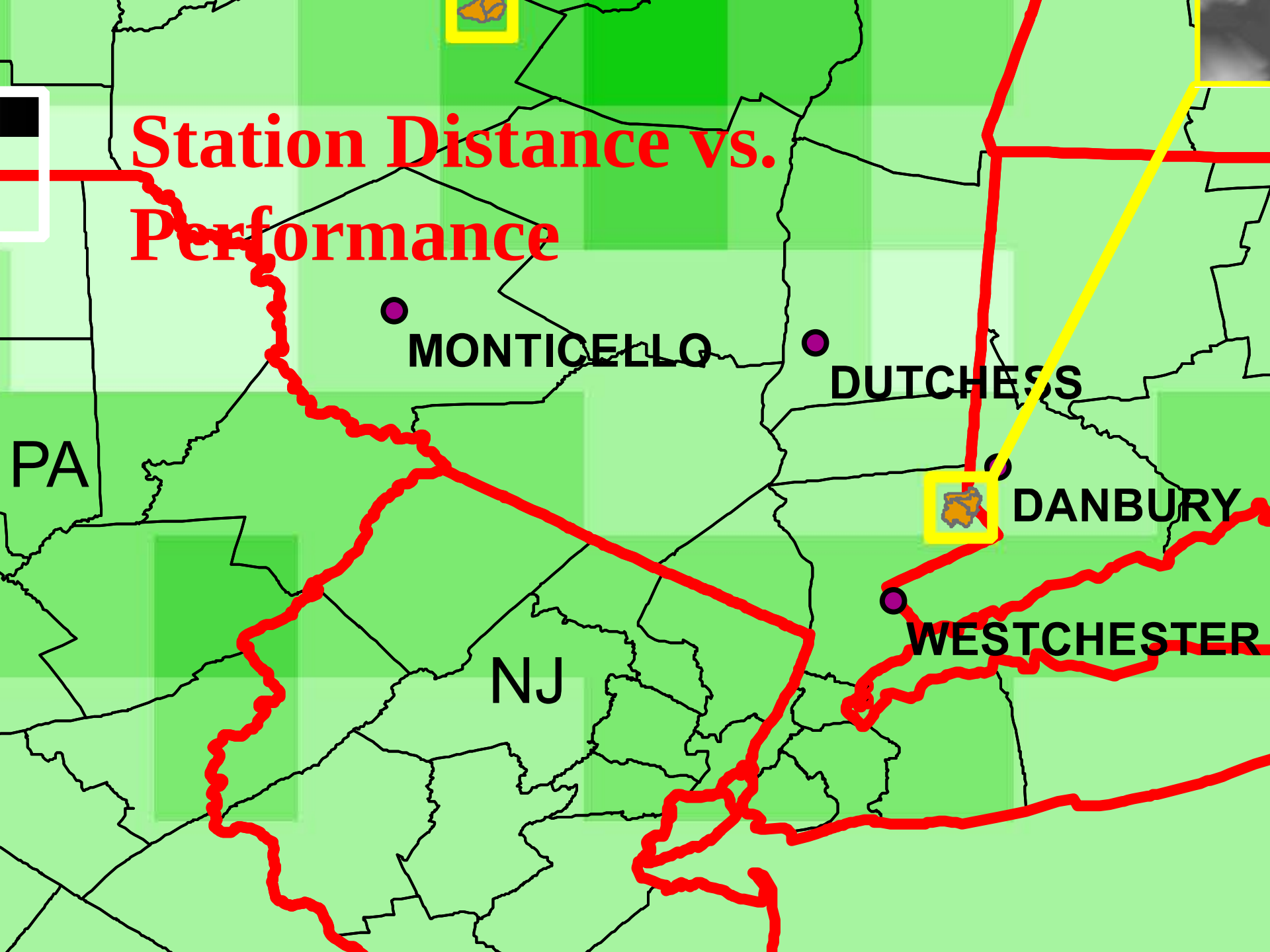


Results Summary

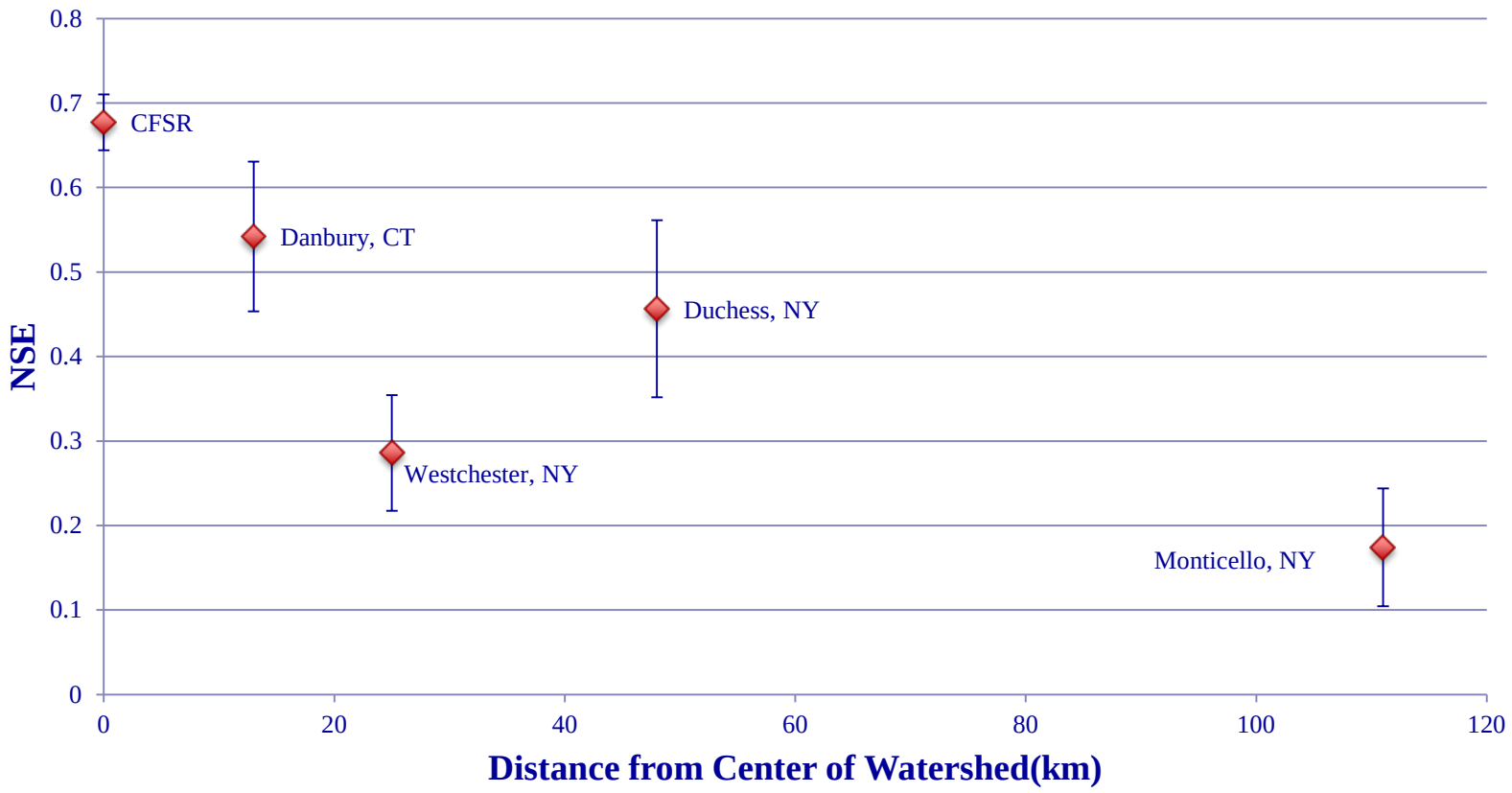
Location	Watershed Area (km^2)	Best Met Distance (km)	Best Met NSE	CFSR NSE
Cross River	44	13	0.54	0.68
Town Brook	37	0/3	0.52	0.63
Gumara	1200	0/30	0.68	0.70

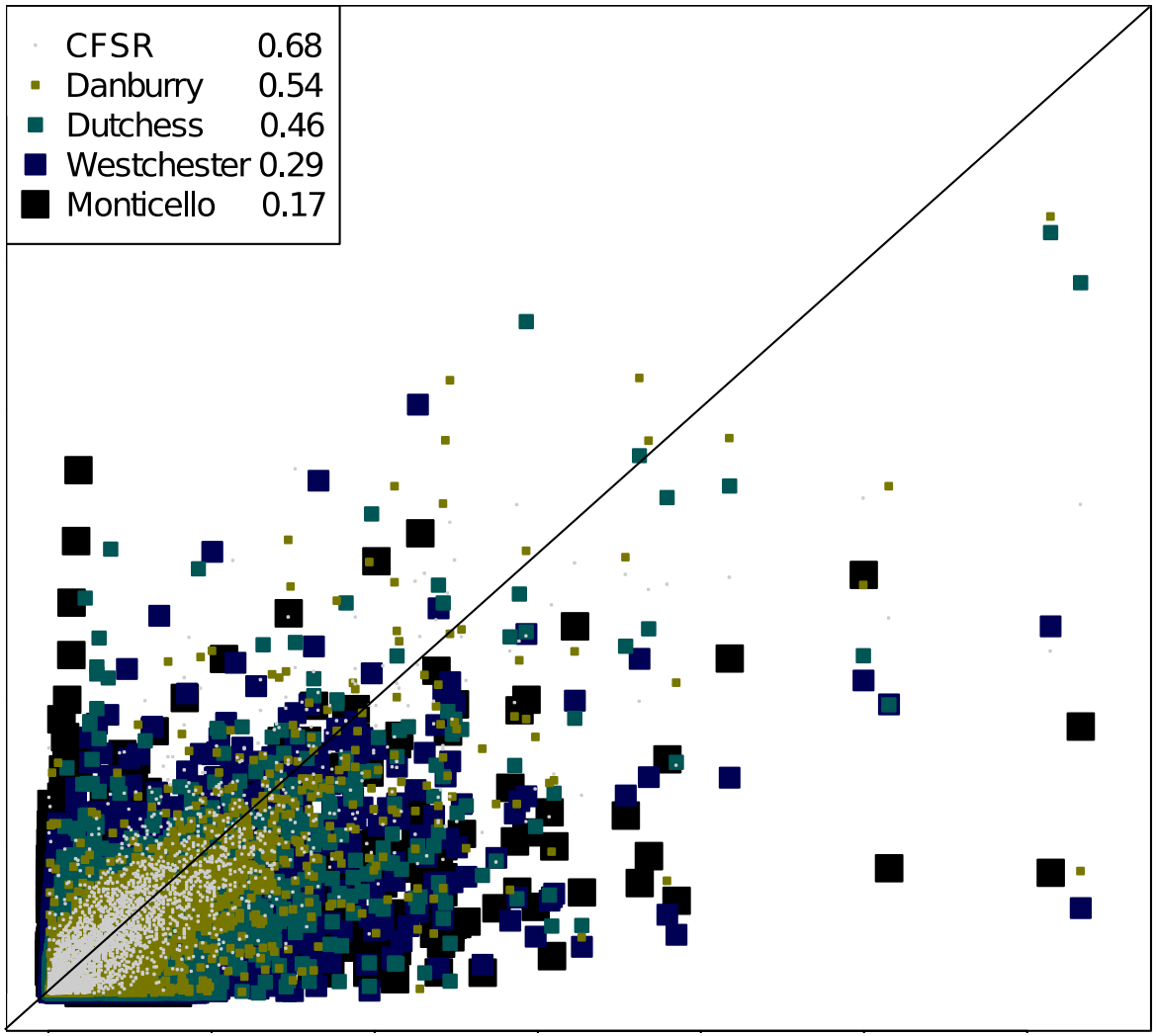
New York Basins




Station Distance vs. Performance
MONTICELLO
DUTCHESS
DANBURY
WESTCHESTER
PA
NJ

Station Distance vs. Performance




CFSR 0.68
Danburry 0.54
Dutchess 0.46
Westchester 0.29
Monticello 0.17

Our Problem?

We are trying to find:

- What distance historical forecast archives better represent environment.
- So far, we can not find a case where station data is better, but there are 30 stations left to test.
- Hope to find a way to explore more watersheds around the world.
- Currently adding to the study a handful of test cases around the US where we have more high quality weather gage datasets.
  - Santa Fe, NM
  - Las Angeles, CA

Could we conclude:

- The combined reanalysis is an actual representation of the met station data, though interpolated over the surface, many stations.
- This analysis may better represent the spatial characteristics of ppt.
- Temporal reliability (every hour exists) of the reanalysis might overcome the error of interpolation.

Bringing it to the public

- Re-dimensioning CFSR to simplify hydrologic modeling data access
  - Single small basin (<1400km^2) would require only about 1/165000 of the dataset
  - 3 meg of 10TByte data set
- Multi-center hosted repository
  - TAMU
  - IWMI/CGIAR
  - Cornell?
  - Me??
  - You???

Interfaces

- Current
  - Website
    - http://tamu-cornell.drfuka.org/
    - Soon on http://swatmodel.tamu.edu
  - R Just install.package("SWATmodel")
    - CRAN SWATmodel package
    - EcoHydRology will load as well
    - get_cfsr_latlon(declat,declon,email,offset)
    - hist_wx=get_cfsr_latlon(45,-72,"dan@dan.com",timeoff=0,interppow=2)
  - ArcMap toolbox
    - ArcSWAT required
    - Monitor ArcSWAT google list for beta

CFSR Query

Lat? 28.636965

Lon? 77.220154

Time Offset? 0 used to adjust for morning or afternoon base measurements.

email? drf28@cornell.edu

Interpolation Power 2

Submit Reset

Hello at:180.149.52.46

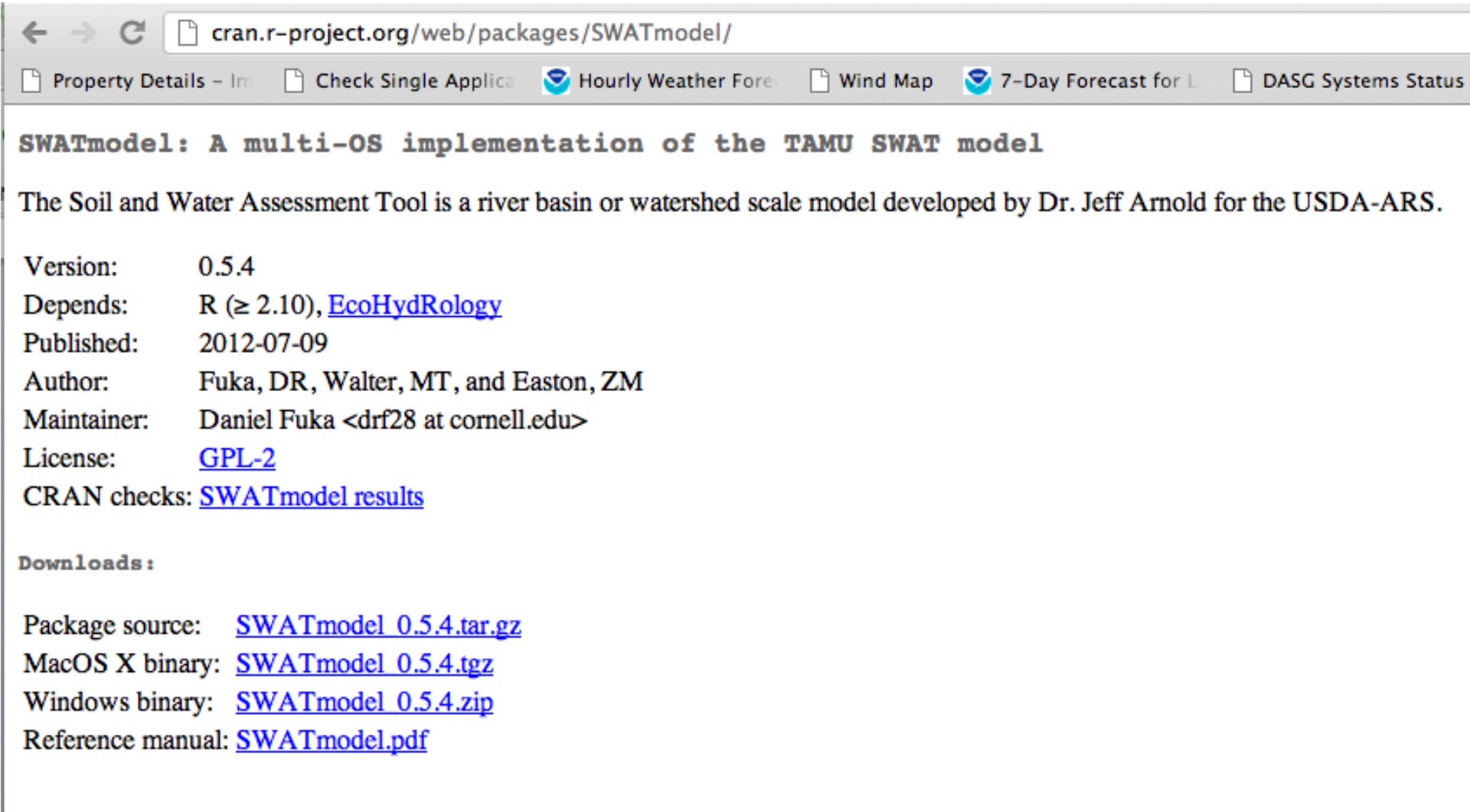
Assuming total time zone offset (Timezone and measure) for UTC:5

Processing time(seconds) : 59

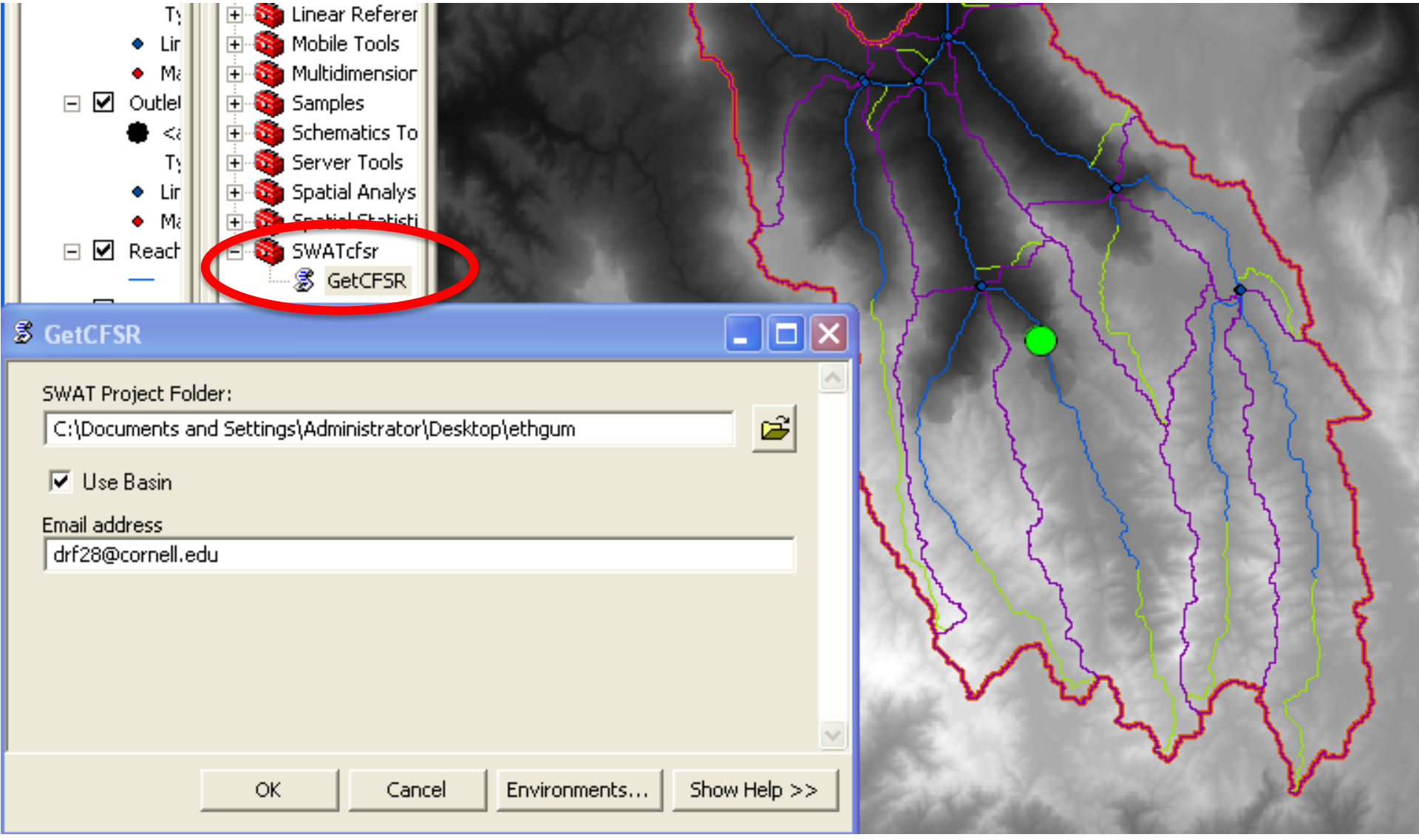
DATE	TMX	TMN	PRECIP	WIND	AVGRH	MAXRH	MINRH	SOLAR
1979-01-01	21.85	5.80	0.00	1.34	36.93	60.45	19.15	14.10
1979-01-02	22.28	5.41	0.00	2.62	41.44	68.78	24.26	13.04
1979-01-03	22.73	7.42	0.00	2.74	42.80	70.74	24.43	13.78
1979-01-04	22.04	7.32	0.00	4.27	41.28	63.76	23.50	14.08
1979-01-05	22.05	6.48	0.00	4.60	38.64	53.32	23.00	14.26
1979-01-06	22.58	4.50	0.00	0.75	56.31	78.51	27.37	14.21

SWATmodel R Package

Next week some catch up with SWAT2012



Arc Toolbox
ArcSWAT Compatible



To Do

- Add in weather generator file generation
  - Adding to spreadsheet available at TAMU
  - Adding to database process in future
- Determine current best product to fill 2011-present gap
  - CFSR absent
  - GFS may work
  - Study to determine bias from CFSR to gap fill product
- Integrate real-time CFSR update
  - Currently run as real-time forecasting system at NCEP
  - Not exactly the same product

Thanks for your time!