

# **RIMS: Rapid Integrated Mapping and Analysis System with Application to Siberia**

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<http://earthatlas.sr.unh.edu/maps>

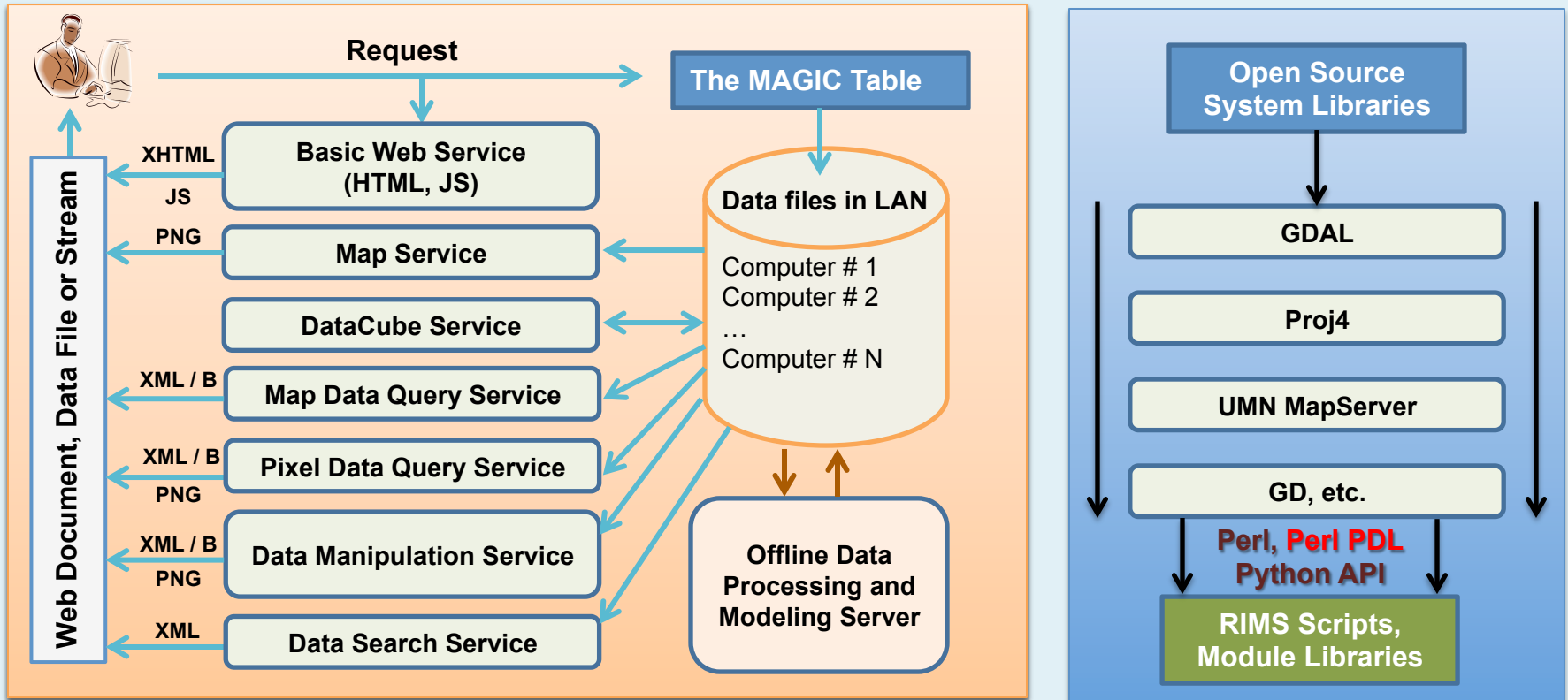
<http://neespi.sr.unh.edu/maps>

<http://nh-rims.sr.unh.edu/maps>

<http://www.riverthreat.net/maps>

<http://riceghg.sr.unh.edu/maps>

# Conceptual software design for the RIMS



*A Web user generates a sequence of requests to the RIMS system which are evaluated, processed and assembled to a document, graphics or data file utilizing a number of stand-alone services that use the same pool of raw data which, in turn, has all its metadata summarized in the Manipulation and Geographic Inquiry Control (MAGIC) Table. New data becomes immediately available to a user as soon as its metadata is added.*

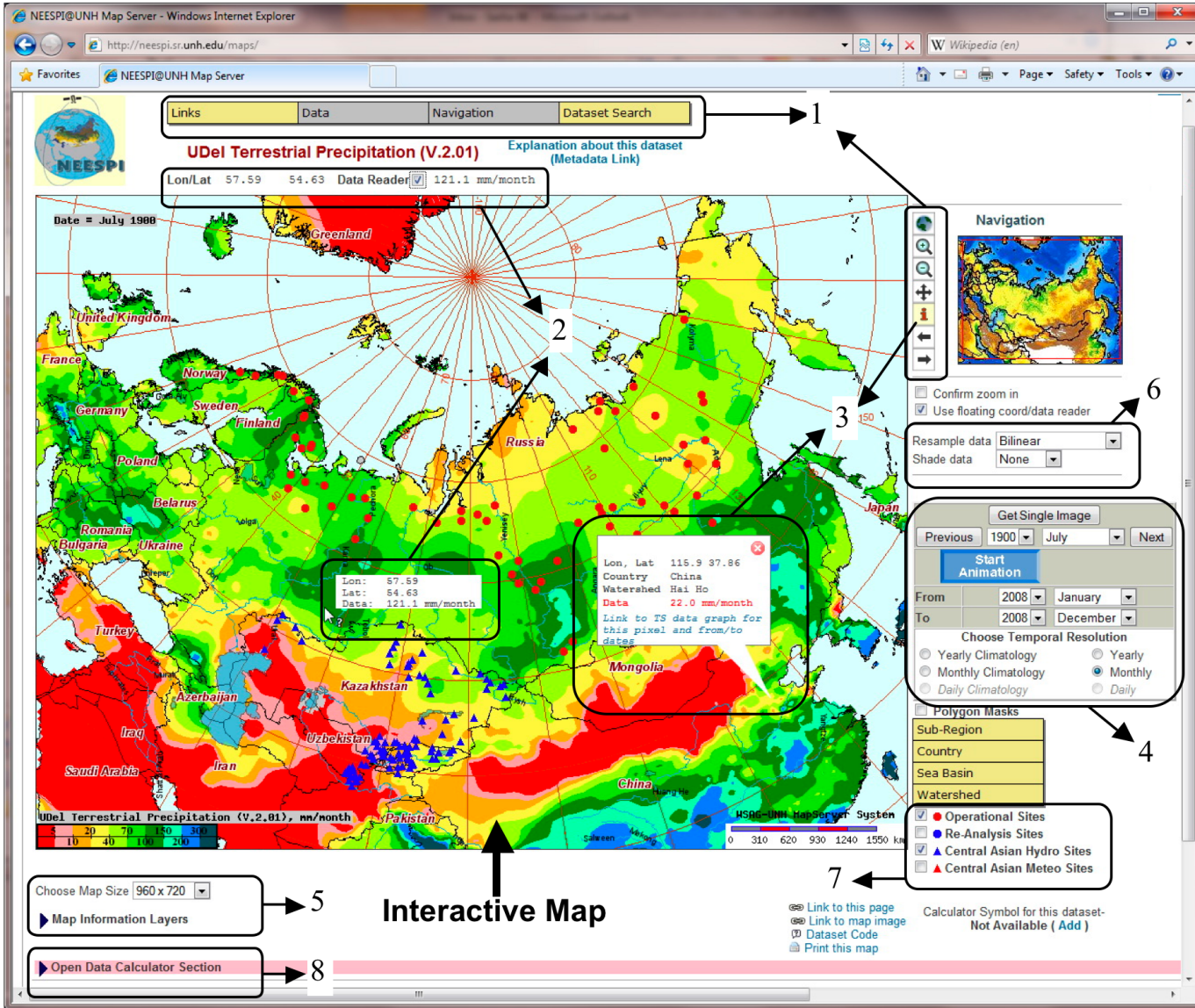
# Examples of data requests to RIMS using *Map Data Query Service*

## 1. Using HTTP protocol-

```
http://rimsServer.sr.unh.edu/data/?  
  dataID=NCEP_T2m_H&  
  date=2011-07-10T00:00..2011-07-12T18:00&  
  extent=50,35,60,45&  
  size=100x100&  
  projection=epsg:4326&  
  interpolate=bilinear&  
  format=NetCDF:temperature
```

## 2. Using a function call (returns reference to 3D array)-

```
double myData = getGDALdata(  
  'NCEP_T2m_H', # Data ID  
  ['2011-07-10T00:00', '2011-07-12T18:00'], # Dates  
  [50,35,60,45], # Extent  
  [100,100], # Size  
  'epsg:4326', # Projection  
  BILINEAR # Interpolation Method  
);
```



# Web Client application for the RIMS system

1) data search/selection, spatial navigation, metadata link, etc.;

2) coordinate and map data value reader;

3) pixel query tool (i-tool) gets coordinates, country, watershed, and map data value;

4) time series navigation tool;

5) map size and base layer choices;

6) data interpolation and shading tools;

7) point/station data list with clickable symbols that open station pages in a separate browser window;

8) fold-out section to run the Data Calculator application to perform mathematical and logical functions over gridded or vector datasets;



# Point/Station data linked to RIMS system

Stream Discharge Station Data - Windows Internet Explorer

http://rims.unh.edu/data/station/station.cgi?station=6342

Google Search Bookmarks Check AutoFill More >> alex.p... Convert Select

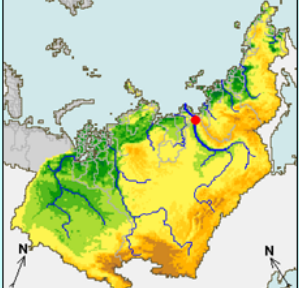
Favorites Stream Discharge Station Data Page Safety Tools

### Station Information

**ArcticRIMS**

## Stream Discharge Station Data

Station Name: **LENA AT KUSUR**

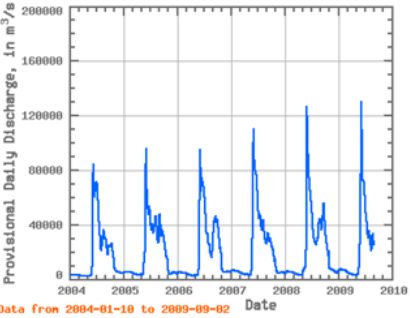


Station Code:	R-ArcticNet ID:	ArcticRIMS ID:	
3821	6342	3	
Source:	Latitude:	Longitude:	Continent:
ROSHYDROMET, Russia	70.68	127.39	Asia
Drainage area:	Contributing area:	Interstation area:	Next Upstream Station:
2430000 km <sup>2</sup>	2430000 km <sup>2</sup>	6342 km <sup>2</sup>	6147 6236 6266
Operational Site			Next Downstream Station(s):
			6344

### Monthly Climatology and other Graphs

Graph Type:	
Beginning Date:	Ending Date:
1936	2000
Discharge Climatology	
Archival Monthly Discharge	
1936	2000
January	December
Archival Daily Discharge	
1978	1999
January	December
1	31
Provisional Monthly Discharge	
2000	2009
January	August
Provisional Daily Discharge	
2004	2009
January	September
10	2
Provisional Monthly Stage	
2000	2009
January	August
Provisional Daily Stage	
2000	2009
January	September
10	2

Discharge Graph Units -  m<sup>3</sup>/s  km<sup>3</sup>  mm



Data from 2004-01-10 to 2009-09-02

### Available Data Downloads

Data Type	Daily	Monthly
Archival Discharge, m <sup>3</sup> /s	<a href="#">Range from 1978-01-01 to 1999-12-31</a>	<a href="#">Range from 1936-01 to 2000-12</a>
Archival Stage, m	N/A	N/A
Provisional Discharge, m <sup>3</sup> /s	<a href="#">Range from 2000-01-10 to 2009-09-02</a>	<a href="#">Range from 2000-01 to 2009-08</a>
Provisional Stage, m	<a href="#">Range from 2000-01-10 to 2009-09-02</a>	<a href="#">Range from 2000-01 to 2009-08</a>

### Station Lists Sorted by

<a href="#">R-Arctic Net ID</a>	<a href="#">Arctic RIMS ID</a>	<a href="#">Station Code</a>	<a href="#">Station Name</a>	<a href="#">Continent</a>	<a href="#">Drainage Area</a>	<a href="#">Annual Discharge</a>
---------------------------------	--------------------------------	------------------------------	------------------------------	---------------------------	-------------------------------	----------------------------------

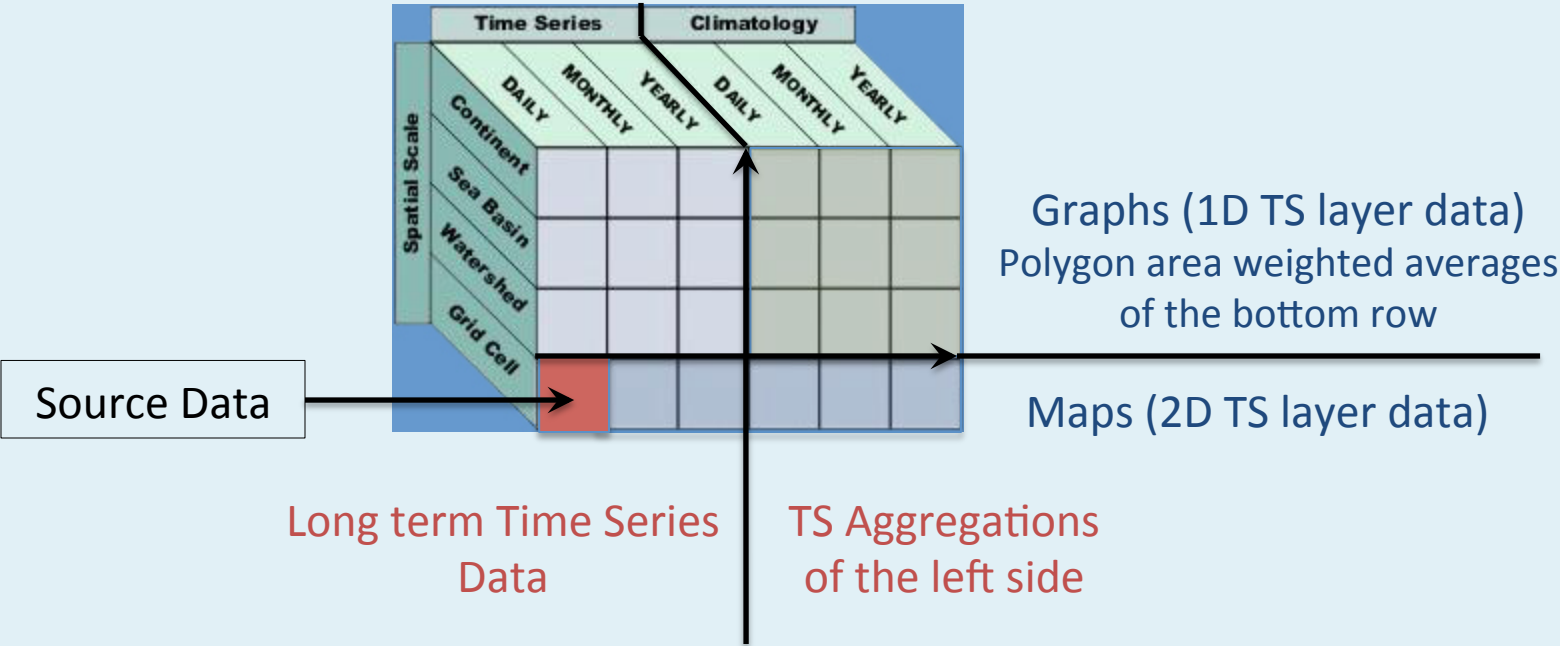
Done

Internet | Protected Mode: On 75%

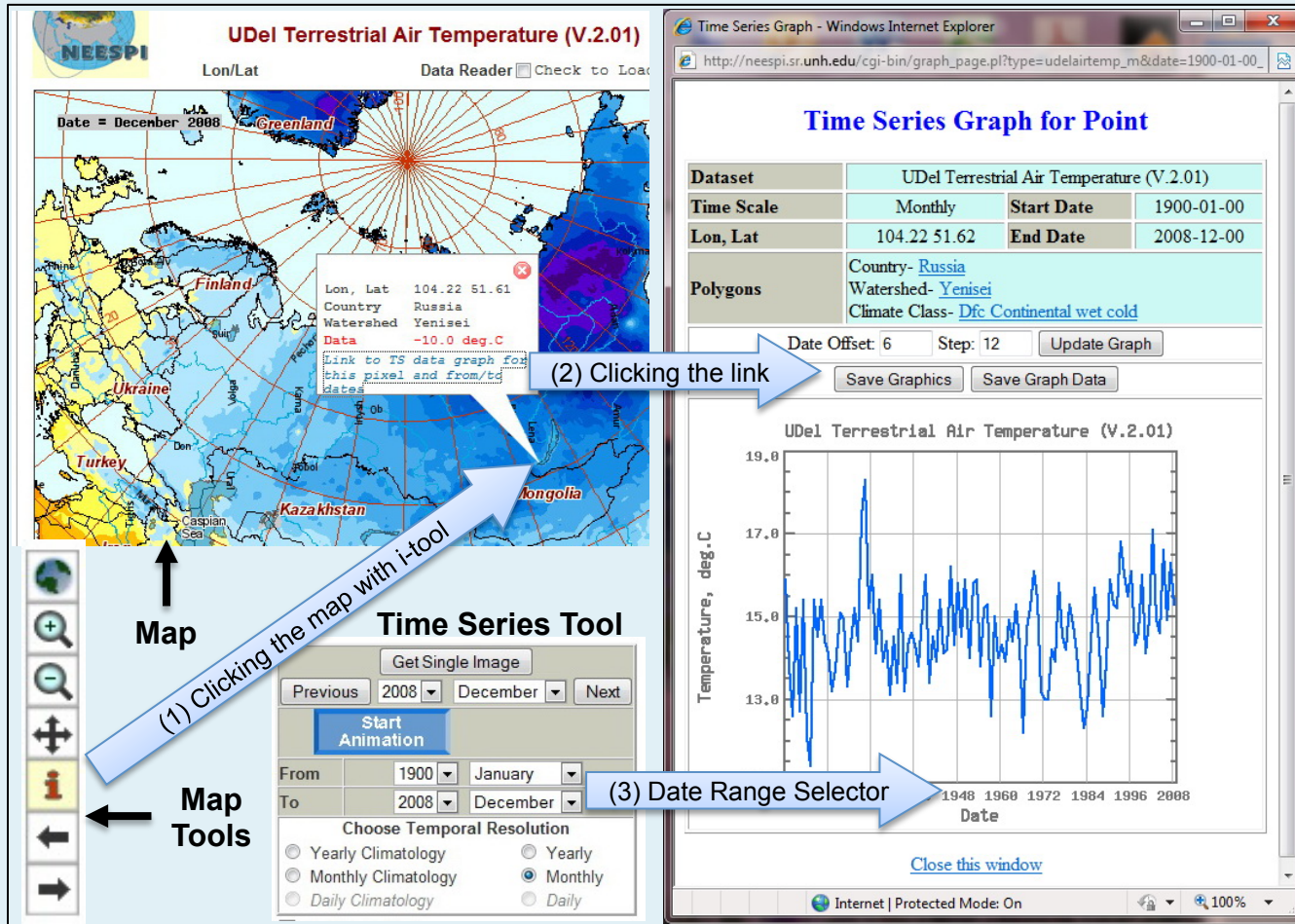
# Summary of RIMS data holdings

Earth System Science Data Category	Key Sources	Examples of Major Parameters	Current Dataset Count	
			Source	Source + DataCube
Hydrology	UNH, CCNY	Discharge, runoff, river networks, irrigation, dams	200	250
Climatology	NASA, NOAA, UDel, Princeton U.	Temperature, precipitation, evapotranspiration (ET), heat radiation, pressure, wind	70	140
	NCEP		42	160
Future Climate and Hydrology	IPCC, UNH	Temperature, precipitation, ET, snow, runoff, discharge	4050	4100
Remote Sensing	MODIS, UNH, UOklahoma	Vegetation indices, soil moisture, clouds	48	60
Physical Geography	NASA, USGS, UNH	Elevation, bathymetry, Blue Marble, Lon/Lat	28	22
Oceanography	NOAA, NCOF	SST, sea ice	3	4
Land Cover	UM, NASA, USGS	Land cover, vegetation, permafrost, freeze/thaw	60	80
Sociology and Economics	CIESIN, World Bank, US CIA, UNH	Population, GDP, industry, mortality/ birth/malnutrition rates	30	60
Agriculture	UWisc, Various	Crop land, crops, fertilizer loads, greenhouse emissions	160	200
Polygon Masks	UNH	Watershed, sea/ocean catchments, continents, countries, administrative units	18	18
Station Data	UNH	Hydrology and climate	8	8
<b>Total</b>			~4700	~5100

# Illustration of DataCube Data Aggregation Concept Used in RIMS



# Components of RIMS Web client application that utilize Pixel Data Query Service



*In this example a time series graph for city of Irkutsk for summer month of July is displayed over a date range from 1900 to 2008. (1) Clicking the map with i-tool selected on the map toolbox brings a pixel information call-out box where basic data for the pixel is displayed such as coordinates, country, watershed, data value along with a link to time series data.*

*(2) Clicking the link brings a pop-up window for pixel time series data display where a user can choose options of a) data selector with date offset and step, b) saving graph with full information, c) saving graph data in a spreadsheet compatible format for analysis outside of the system, d) switch to polygon data and graphs where the selected pixel is present (in this example it is a country polygon for Russia, watershed polygon for Yenisei, and climate type polygon for Dfe class). (3) The date range for the graph is taken off the Time Series Tool on the map page (Figure 2), and a user can set a Date offset and Step in a Web form above the graph to plot any specific month or day of the year over a given range of years.*



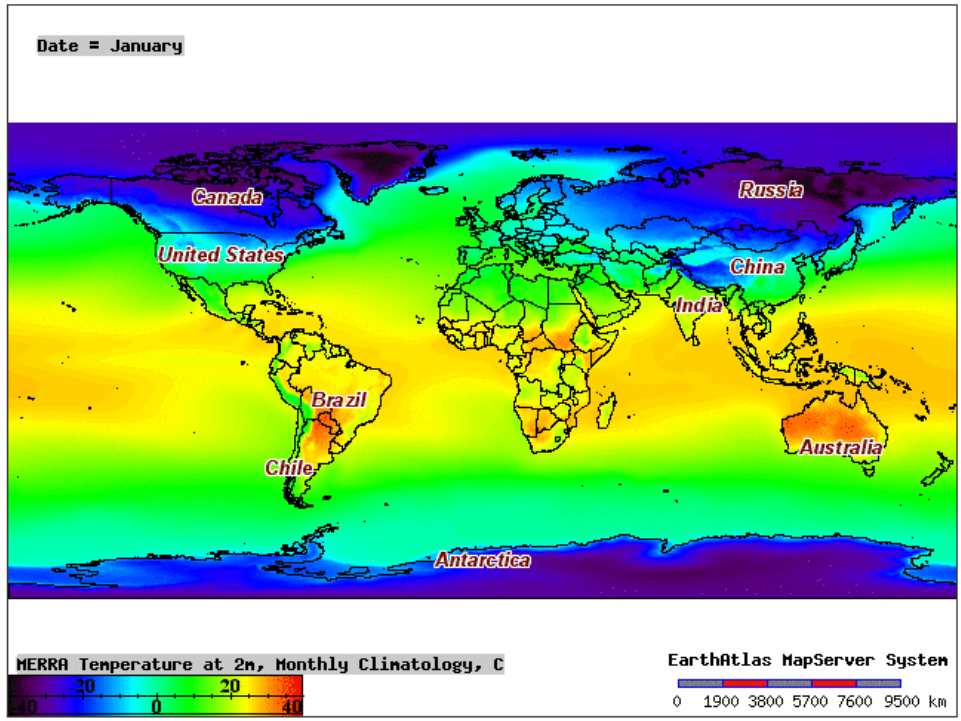


Data Navigation Dataset Search Data Manipulation

### MERRA Temperature at 2m, Monthly Climatology

[Explanation about this dataset \(Metadata Link\)](#)

Lon/Lat Data Reader  Check to Load



#### Navigation

Confirm zoom in  
 Use floating coord/data reader

Resample data

Shade data

Get Single Image

Previous January Next

**Start Animation**

From January To December

**Choose Temporal Resolution**

Yearly Climatology     Yearly  
 Monthly Climatology     Monthly  
 Daily Climatology     Daily

Choose Map Size

[Map Information Layers](#)

- [Link to this page](#)
- [Link to map image](#)
- [Dataset Code](#)
- [Print this map](#)

Calculator Symbol for this dataset - Not Available (Add)

[Open Data Calculator Section](#)

# Demo # 4: The Data Calculator

Calculation of temperature difference between summer and winter

Equation:

$$\max(T2mMerraMC\{0000-01-00..0000-12-00\}) - \min(T2mMerraMC\{0000-01-00..0000-12-00\})$$

NB

NEESPI@UNH Map Server - Windows Internet Explorer

http://neespi.sr.unh.edu/maps/

Close Data Calculator Section

Macro Calculator for Selected Area

Land Characteristics Ocean Climate Hydrology-1 Hydrology-2 Other **User Defined**

Symbol	Dataset	Units	Symbol
T2mMerraYC	MERRA Temperature at 2m, Yearly Climatology	C	Roff_A1B_MC
T2mNcepYC	NCEP Air Temperature at 2m	C	T2mMerraMC
T2mNcepM	NCEP Air Temperature at 2m	C*	
T2mNcepMC	NCEP Air Temperature at 2m	C*	

\*Time Series datasets- See instructions.

Pixel Equation:  $\max(T2mMerraMC\{0000-01-00..0000-12-00\}) - \min(T2mMerraMC\{0000-01-00..0000-12-00\})$

Area Integral:  d A (km<sup>2</sup>)

Area Average:  Area Weighted Mean = Area Integral (above) / Area

Instructions:

Stat Functions:  Data Options:

Examples:  Color Options:

TS-Range, {} = YYYY-MM-DD ... YYYY-MM-DD

Calculation Results for Selected Area

Equation used -  $\max(T2mMerraMC\{0000-01-00..0000-12-00\}) - \min(T2mMerraMC\{0000-01-00..0000-12-00\})$  Calculated in 1 min 2 sec

Frequency Histogram for the Calculated Data

Pixel Average = 27,263

Frequency, %

Calculated Data

LEGEND

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Internet | Protected Mode: On



# Demo # 4: The Data Calculator

Calculation of number of days with Temperature above average in July 2010

NEESPI@UNH Map Server - Windows Internet Explorer

http://neespi.sr.unh.edu/maps/

Close Data Calculator Section

### Macro Calculator for Selected Area

Land Characteristics
  Ocean
  Climate
  Hydrology-1
  Hydrology-2
  Other
  User Defined

Symbol	Dataset	Units	Symbol	Dataset	Units
T2mMerraYC	MERRA Temperature at 2m, Yearly Climatology	C	Roff_A1B_MC	Distu	
T2mNcepYC	NCEP Air Temperature at 2m	C	T2mMerraMC	MEP	
T2mNcepM	NCEP Air Temperature at 2m	C*	T2mMerraD	MEP	
T2mNcepMC	NCEP Air Temperature at 2m	C*			

\*Time Series datasets- See instructions.

Pixel Equation: `sum( map(($_-T2mMerraMC{0000-07-00})>0, T2mMerr: Operators/F`

Area Integral: `d A (km²)` Stat Functions

Area Average:  Area Weighted Mean = Area Integral (above) / Area

Instructions:

Examples:   Use Log Scale

TS-Range, {} = YYYY-MM-DC ... YYYY-MM-DC

### Calculation Results for Selected Area

Equation used - Calculated in 1 min 22 sec

```
sum( map(($_-T2mMerraMC{0000-07-00})>0, T2mMerraD{2010-07-01..2010-07-31}) )
```

Frequency Histogram for the Calculated Data

Pixel Average = 19.429

LEGEND

©2009, University of New Hampshire. Programming by Alex Prusevich

Internet | Protected Mode: On

NB ←

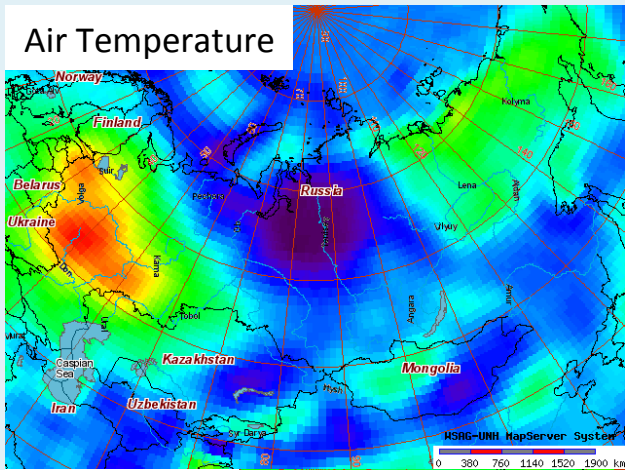
Equation:  
`sum( map(($_-T2mMerraMC{0000-07-00})>0, T2mMerraD{2010-07-01..2010-07-31}) )`

# Analysis of 2010 extreme summer in Russia

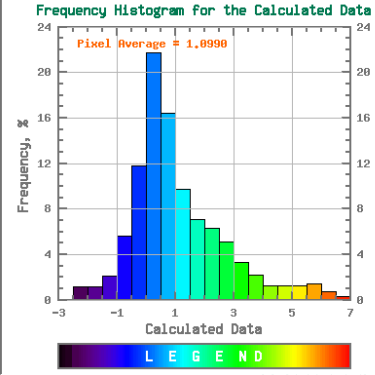
*Example of RIMS Application to a Regional Research*



# Air Temperature

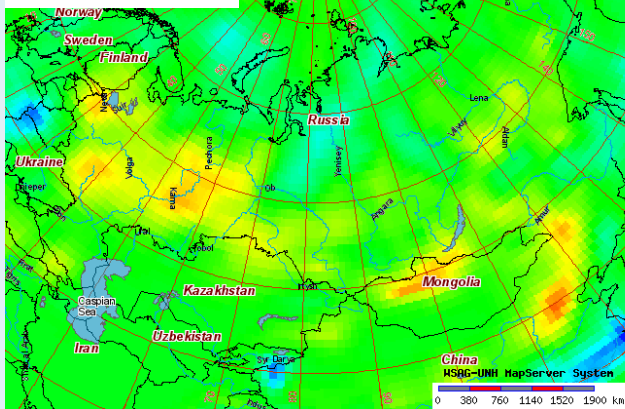


Equation used - Calculated in 0 min 14 sec  
 $\text{average(NCEP\_T\_MT[2010-07-00, \dots, 2010-08-00])} - \text{average(NCEP\_T\_HC[0000-07-00, \dots, 0000-08-00])}$

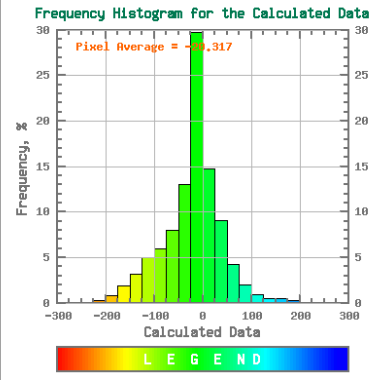


Deviation of mean July-August air temperature in 2010 from LTM over 1948-2010 (NCEP data)

# Precipitation

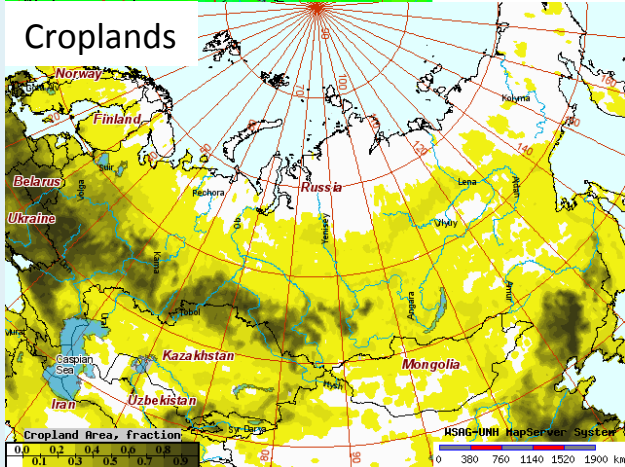


Equation used - Calculated in 0 min 13 sec  
 $\text{sum(NCEP\_P\_MTS[2010-07-00, \dots, 2010-08-00])} - \text{sum(NCEP\_P\_HC[0000-07-00, \dots, 0000-08-00])}$



Deviation of sum of precipitation over July-August 2010 from LTM over 1948-2010 (NCEP data)

# Croplands

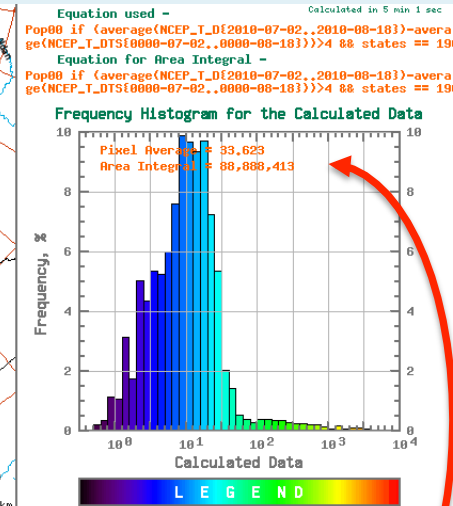
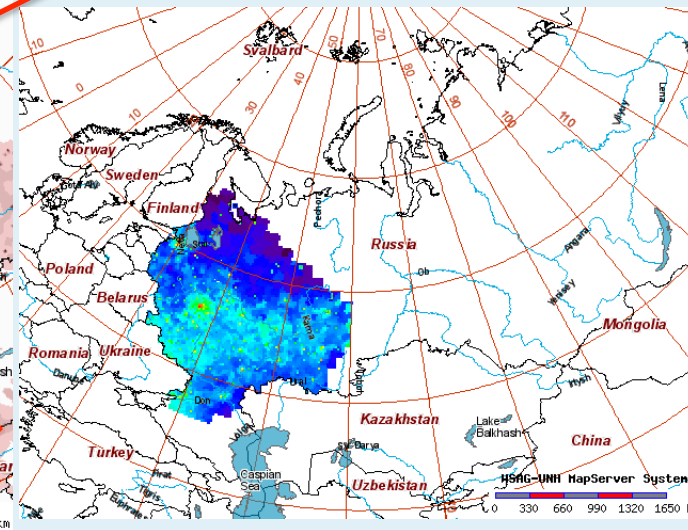
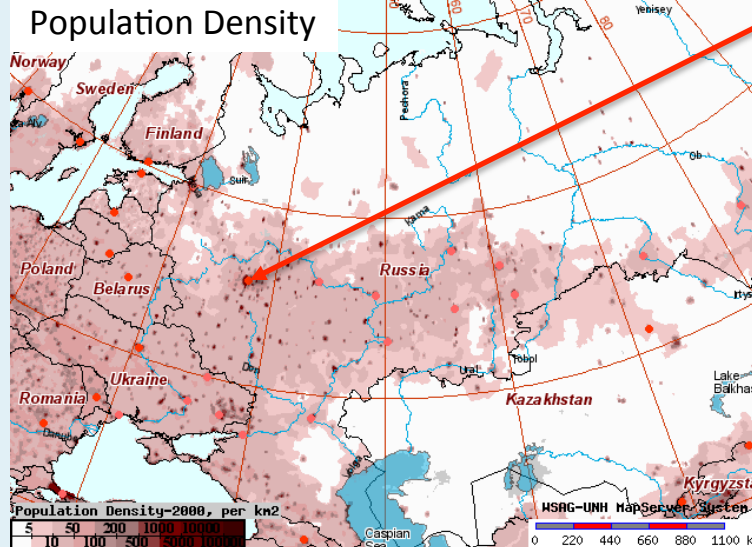
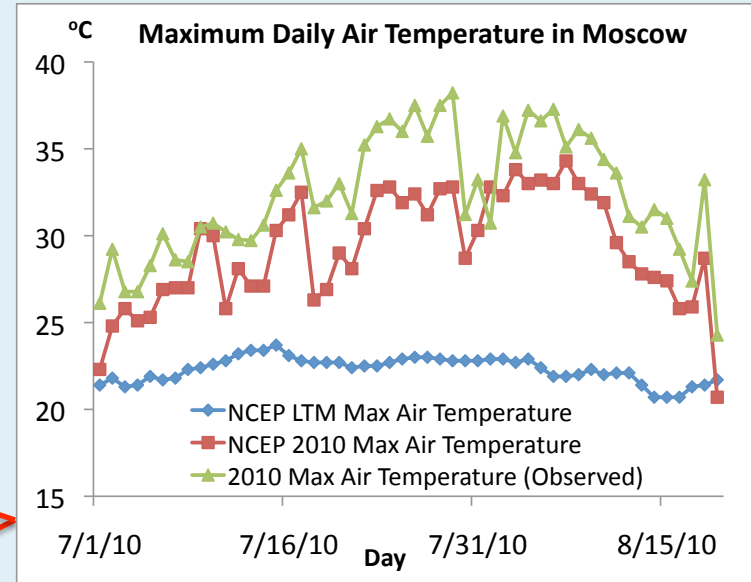
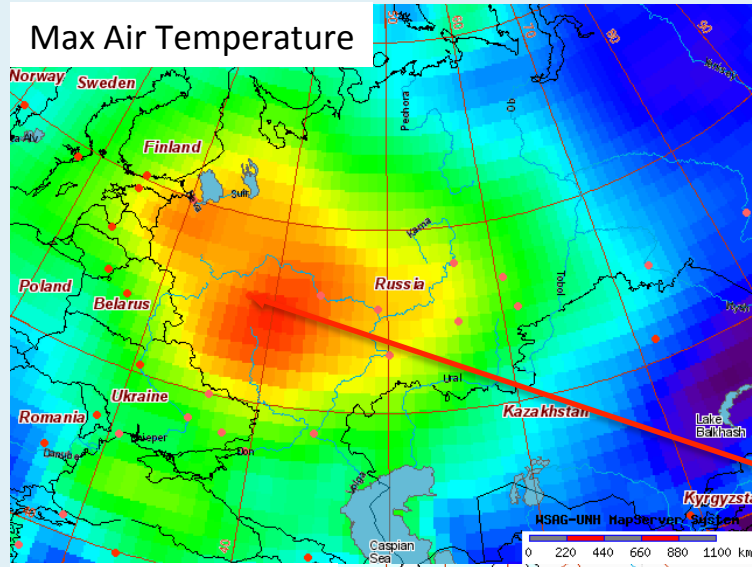


Distribution of cropland area



# Analysis of air temperature and population in summer 2010

Deviation of daily max air temperature over July2-Aug18, 2010 from LTM

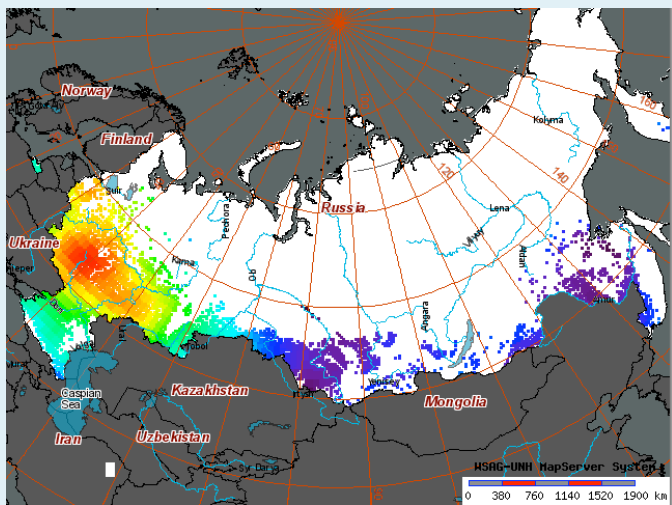


Distribution of population density

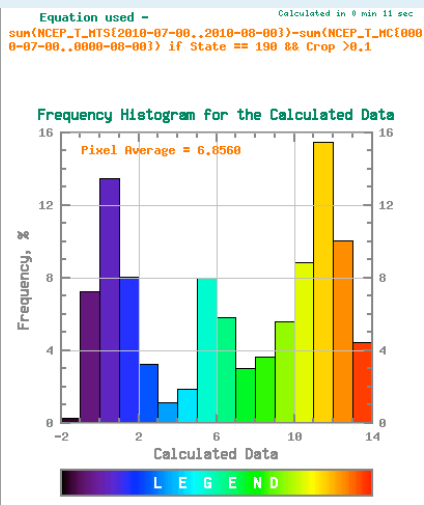
Calculation of area and population in Russia where mean daily air temperature over the period 07-02-2010 to 08-18-2010 was 4°C higher than LTM. This heat effected about 90 million people or ~ 60% of total Russian population

# Anomalies of air temperature and precipitations in summer 2010 from long-term mean over 1985-2010 for Russian cropland area (cropland >10% per grid cell)

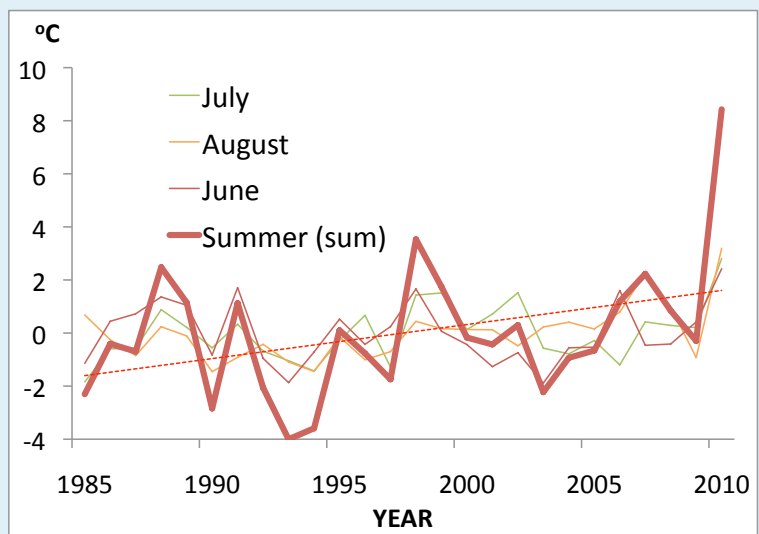
Anomalies of summer 2010 from LTM



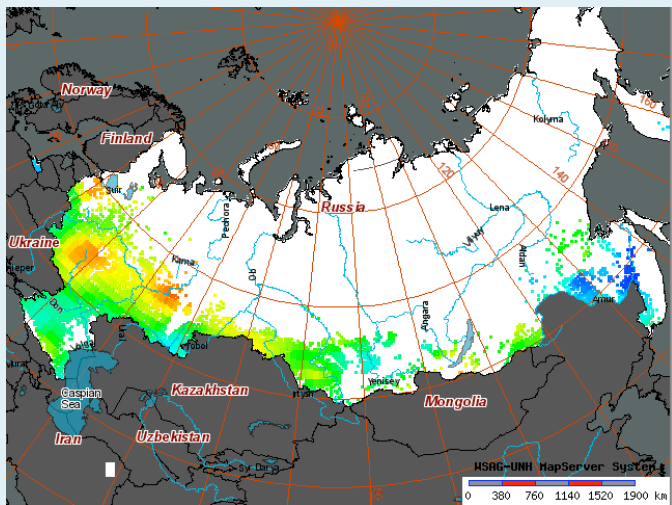
## Air Temperature



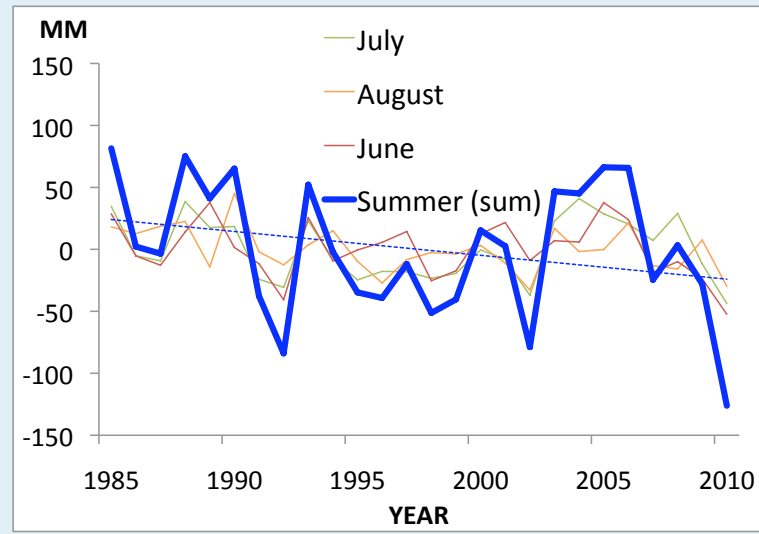
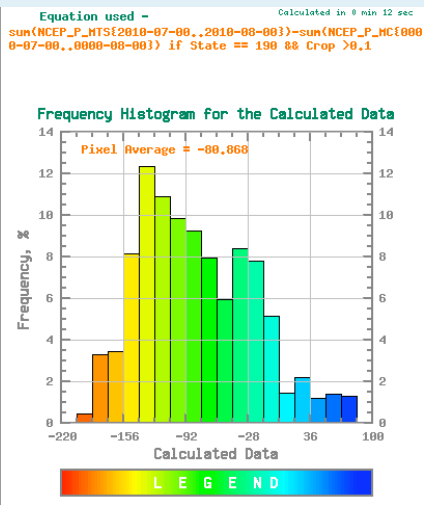
Anomalies of over 1985-2010



Anomalies of summer 2010 from LTM

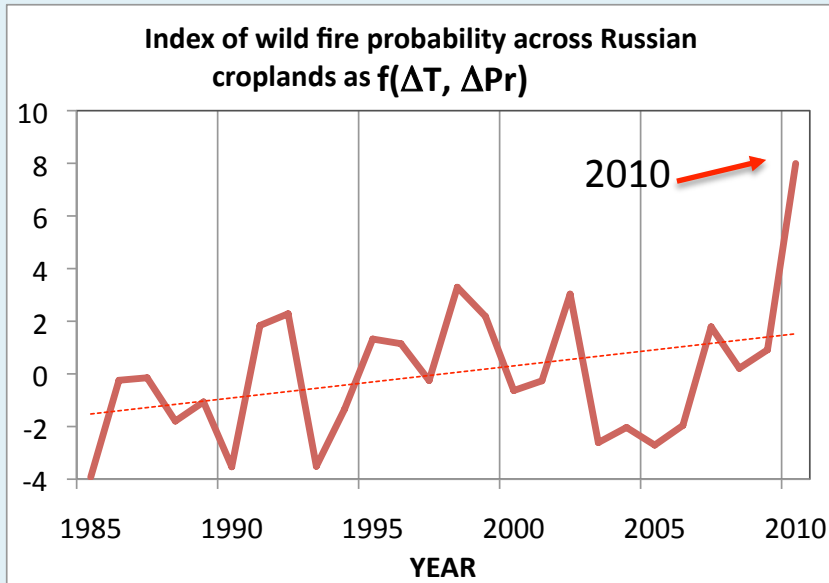


## Precipitation

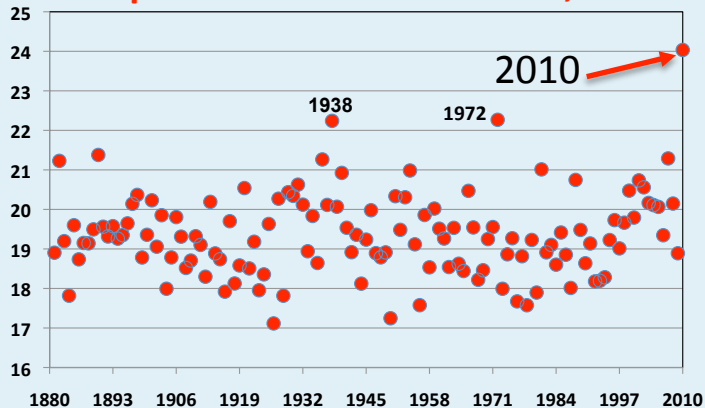


2010 wheat yield in Russia was ~40% less than in 2008, 2009

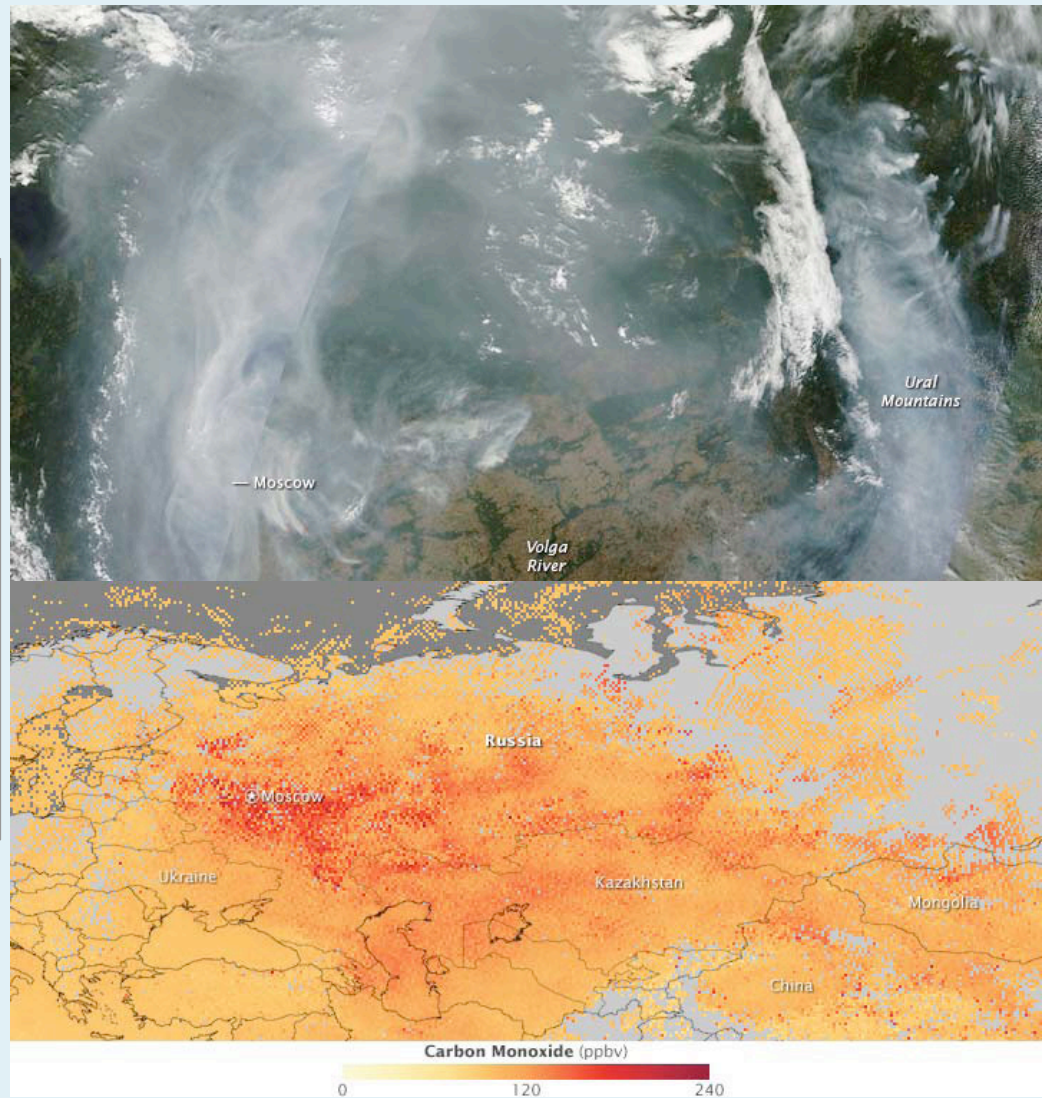
Using air temperature and precipitation data in NEESPI RIMS we evaluated index of wild fire probability for summer months from 1985 to 2010



**July-August surface air temperatures, over European Russia south of 60°N, °C**



Anomalies from the mean for the 1961-1990 period were used for area-averaging with the following restoration of actual values; GHCN-v2 data (NCDC 2010)



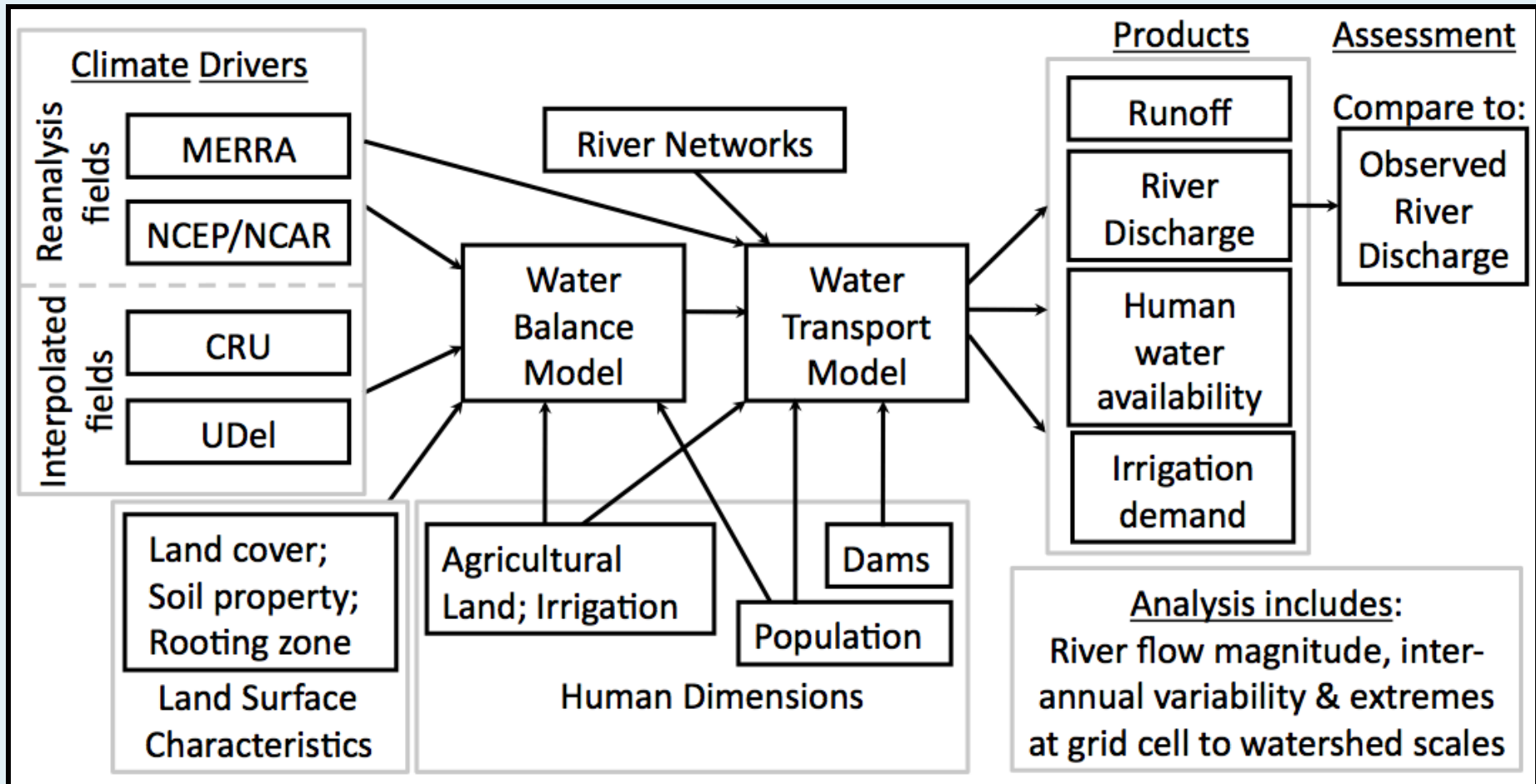
Carbon monoxide concentrations in the atmosphere between 2 and 8 km above Russia as recorded from 1 to 8 August 2010 by NASA (MOPITT). Ground concentrations of this dangerous gas are reported to be much higher, causing people to report headaches, dizziness, and other more serious conditions.



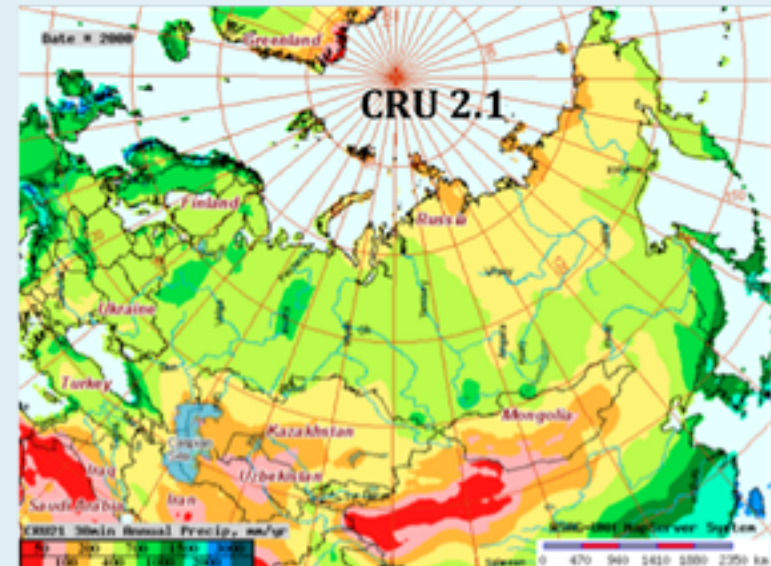
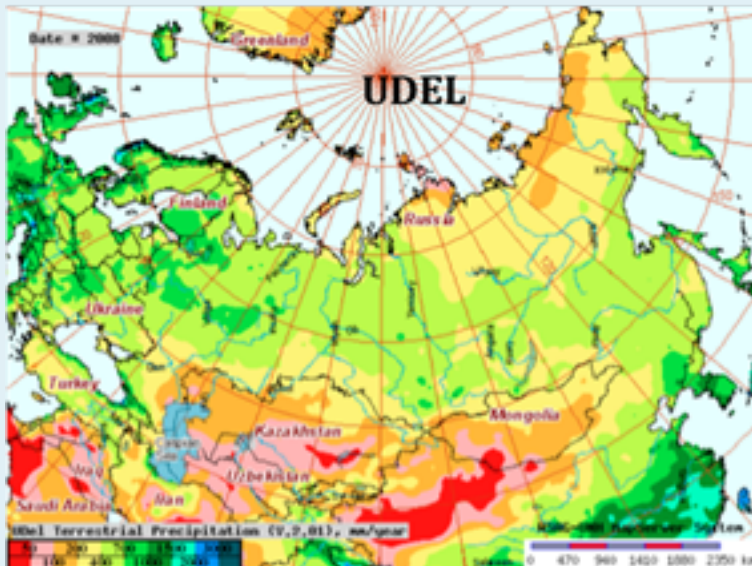
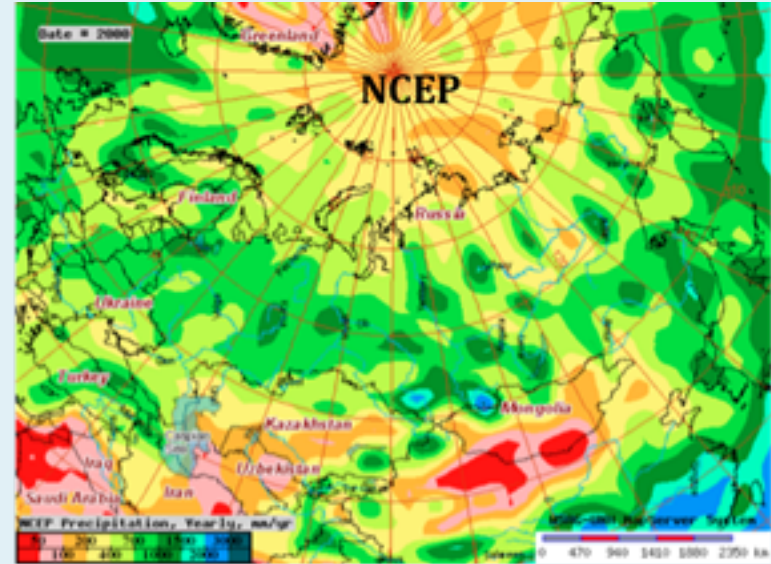
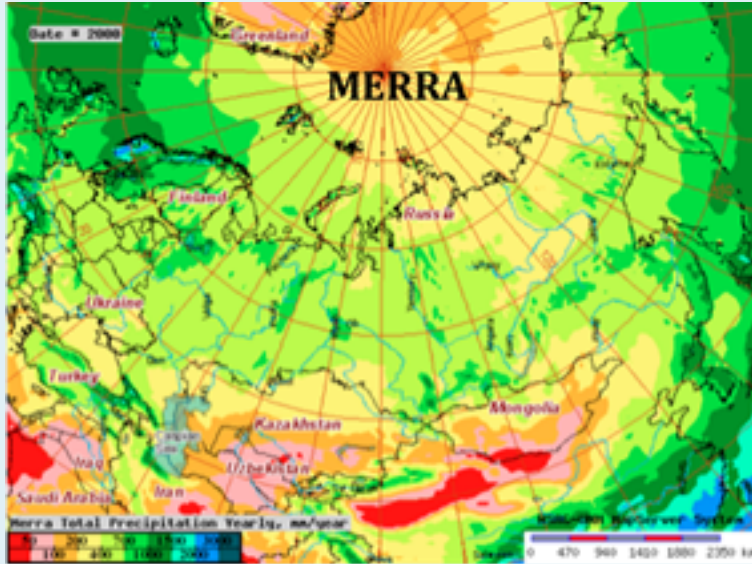
# Regional climate change impact analysis



# Schematic representation of information flows from data streams, through the modeling environment to the output data sets, summary statistics, and the validation stage



# Comparison of mean annual total precipitation for the year 2000 for MERRA and NCEP reanalysis (top row) with UDEL and CRU interpolated observations (bottom row)





# Future hydroclimatology with WBMPlus and IPCC GCMs

AO GCM presented in NEESPI RIMS web site

No	AO GCM	Country	Spatial resolution
1	ECHAM5/MPI-OM	Germany	1.9°x1.9°
2	CGCM3.1(T63) (ccc_t63)	Canada	2.8°x2.8°
3	UKMO-HadCM3	Great Britain	1.25°x1.875°
4	BCCR-BCM2	Norway	2.8°x2.8°
5	NCAR_CCSM3	USA	1.4°x1.4°
6	INM-CM3 PAH	Russia	3.0°x4.0°
7	GFDL-CM2.1	USA	2.0°x2.5°
8	MIROC3.2(medres) (ccsr_me)	Japan	2.8°x2.8°

Climate scenarios:

20C3M - contemporary

SRES A1b- future

SRES A2 - future

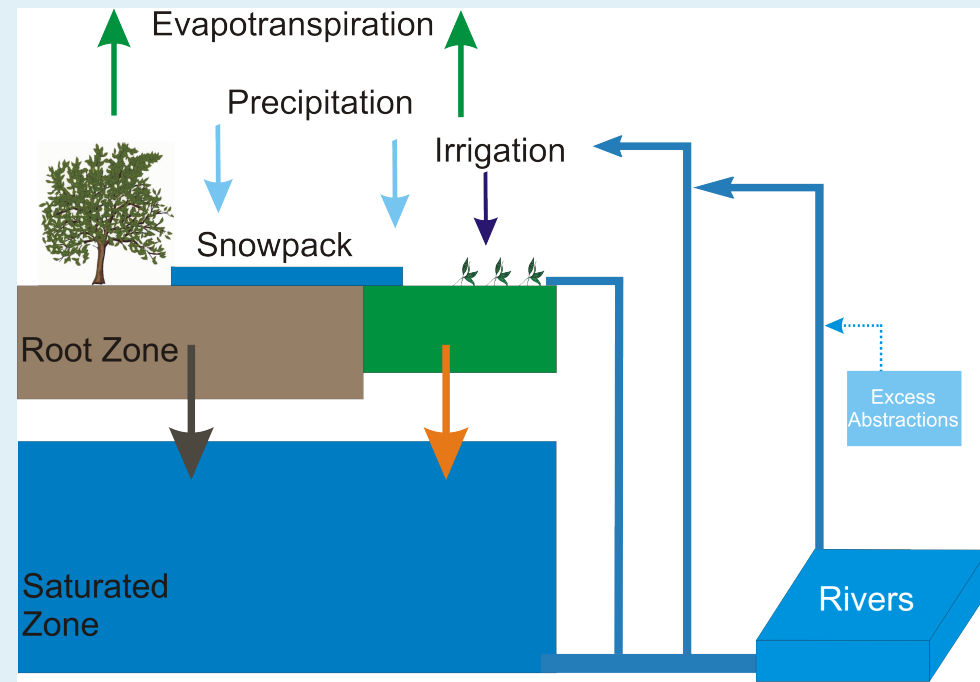
SRES B1 - future

## WBMPlus

- WBM + irrigation + reservoirs; daily time step (real time routing, irrigation, reservoirs)

Model modes: Pristine and Disturbed

Basic Output Parameters: Discharge,  
Runoff,  
Evapotranspiration,  
Soil Moisture,  
Snow Depth,  
Irrigation Demand

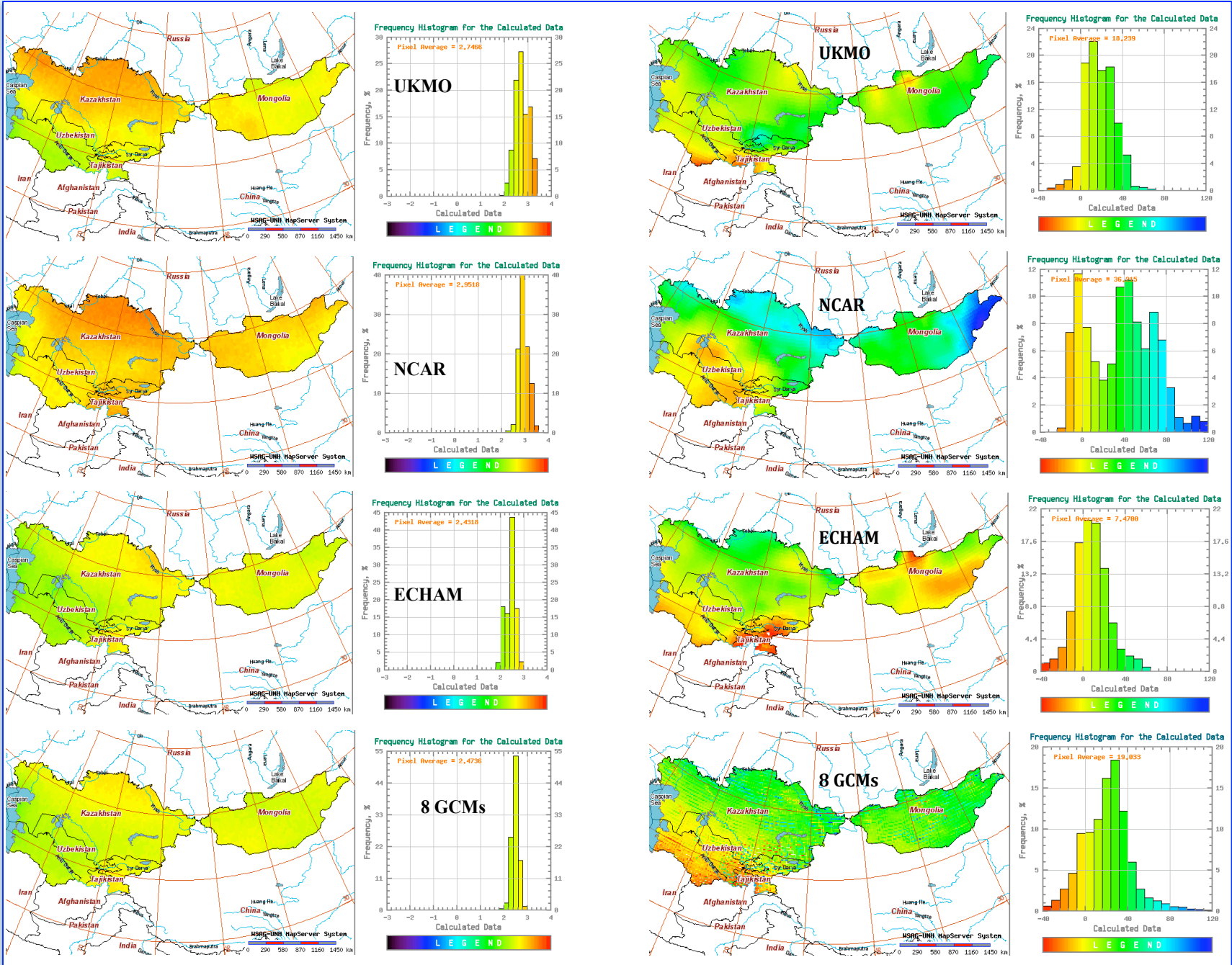


# IPCC Data Holding on RIMS/NEESPI (Precip. Example)

Variable	Scenario	Model	Link* (see footnote)
<b>Precipitation</b>	20c3m	bccr_bcm2_0	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-bccr_bcm2_0-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-bccr_bcm2_0-pr</a>
		cccma_cgcm3_1	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-cccma_cgcm3_1-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-cccma_cgcm3_1-pr</a>
		gfdl_cm2_1	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-gfdl_cm2_1-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-gfdl_cm2_1-pr</a>
		inmcm3_0	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-inmcm3_0-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-inmcm3_0-pr</a>
		miroc3_2_medres	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-miroc3_2_medres-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-miroc3_2_medres-pr</a>
		mpi_echam5	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-mpi_echam5-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-mpi_echam5-pr</a>
		ncar_ccsm3_0	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-ncar_ccsm3_0-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-ncar_ccsm3_0-pr</a>
		ukmo_hadcm3	<a href="http://neespi.sr.unh.edu/maps/?type=20c3m-ukmo_hadcm3-pr">http://neespi.sr.unh.edu/maps/?type=20c3m-ukmo_hadcm3-pr</a>
	sresa1b	bccr_bcm2_0	<a href="http://neespi.sr.unh.edu/maps/?type=sresa1b-bccr_bcm2_0-pr">http://neespi.sr.unh.edu/maps/?type=sresa1b-bccr_bcm2_0-pr</a>
		cccma_cgcm3_1	<a href="http://neespi.sr.unh.edu/maps/?type=sresa1b-cccma_cgcm3_1-pr">http://neespi.sr.unh.edu/maps/?type=sresa1b-cccma_cgcm3_1-pr</a>
		gfdl_cm2_1	<a href="http://neespi.sr.unh.edu/maps/?type=sresa1b-gfdl_cm2_1-pr">http://neespi.sr.unh.edu/maps/?type=sresa1b-gfdl_cm2_1-pr</a>
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miroc3_2_medres		<a href="http://neespi.sr.unh.edu/maps/?type=sresb1-miroc3_2_medres-pr">http://neespi.sr.unh.edu/maps/?type=sresb1-miroc3_2_medres-pr</a>	
mpi_echam5		<a href="http://neespi.sr.unh.edu/maps/?type=sresb1-mpi_echam5-pr">http://neespi.sr.unh.edu/maps/?type=sresb1-mpi_echam5-pr</a>	
ncar_ccsm3_0		<a href="http://neespi.sr.unh.edu/maps/?type=sresb1-ncar_ccsm3_0-pr">http://neespi.sr.unh.edu/maps/?type=sresb1-ncar_ccsm3_0-pr</a>	
ukmo_hadcm3		<a href="http://neespi.sr.unh.edu/maps/?type=sresb1-ukmo_hadcm3-pr">http://neespi.sr.unh.edu/maps/?type=sresb1-ukmo_hadcm3-pr</a>	

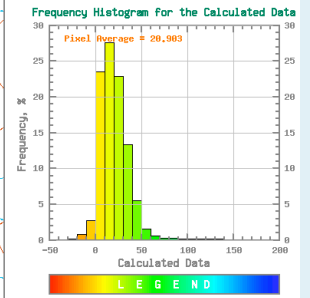
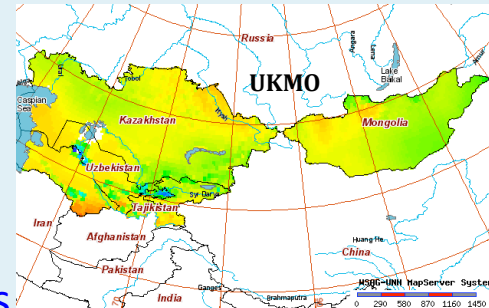
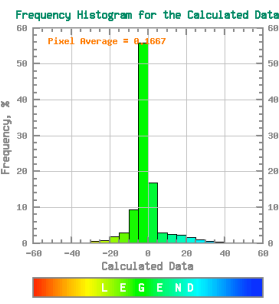
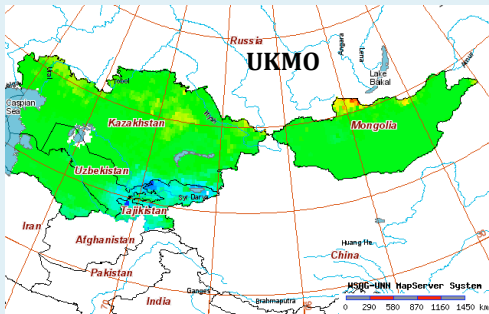
URL links are for the original IPCC monthly datasets mounted on the UNH RIMS MapServer system. From this page a user can navigate to processed IPCC data that are aggregated on temporal and spatial scales- Monthly data are re-processed for monthly climatology, yearly and yearly climatology temporal resolutions. And each of those are spatially aggregated over country and watershed polygons. To view time series graphs for any pixel on the map or polygons that contain that pixel, please, use, "i" tool (it is located next to the index map on the right).

# Deviations of Annual Air Temperature (left) and Precipitations (right) over 2031-60 from 1959-1999

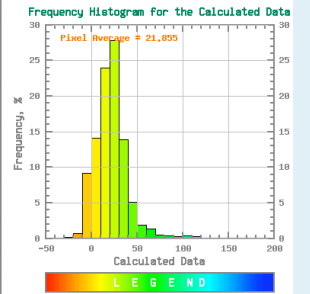
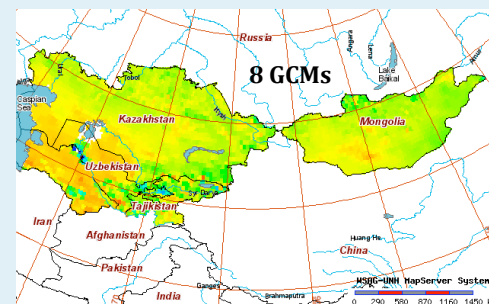
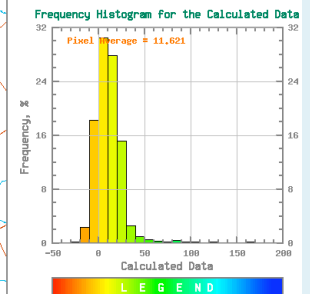
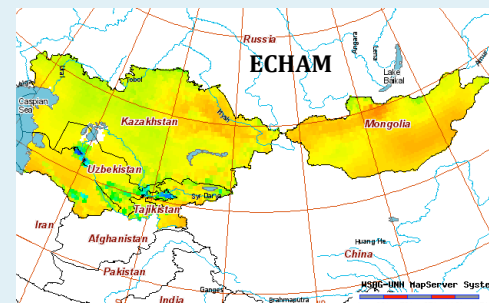
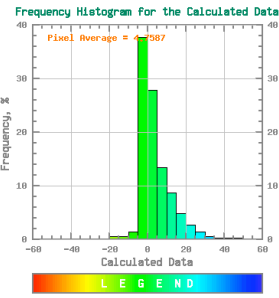
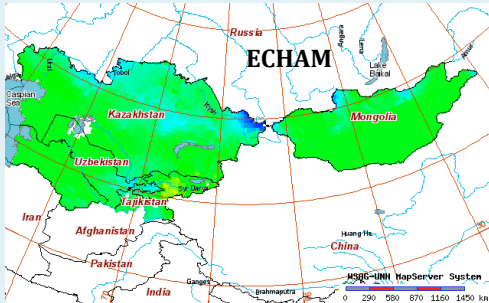
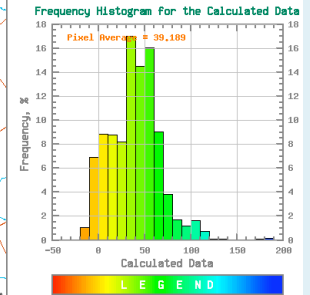
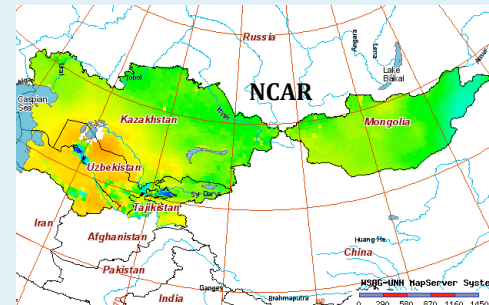
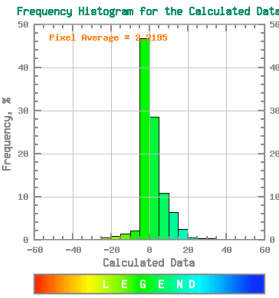
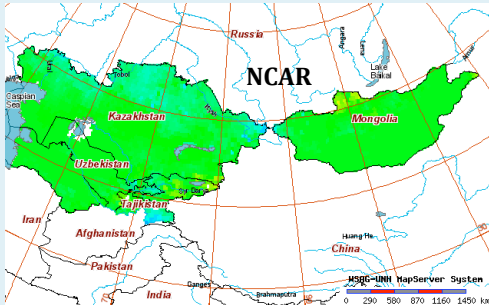




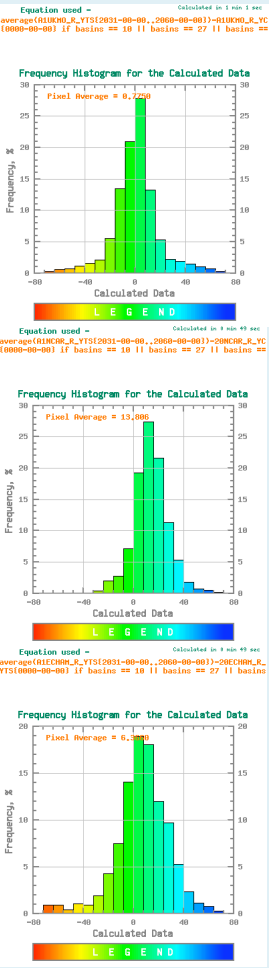
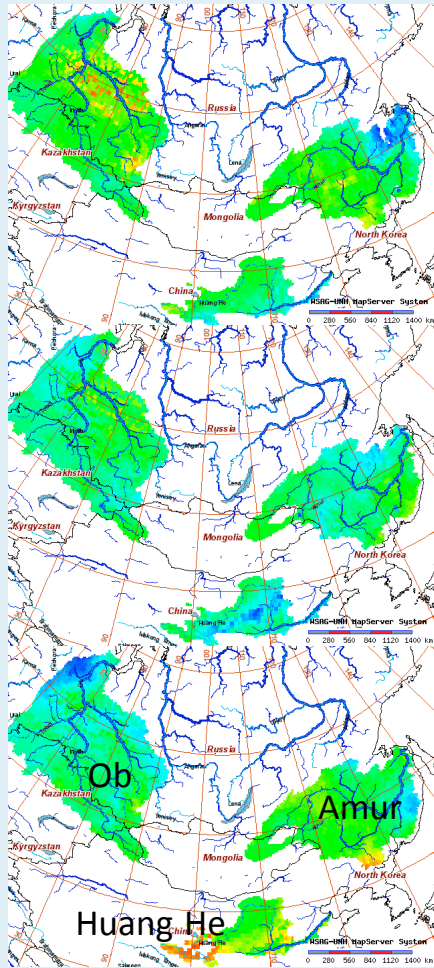
# Deviations of Annual Runoff (left) and Evapotranspiration (right) over 2031-60 from 1959-1999



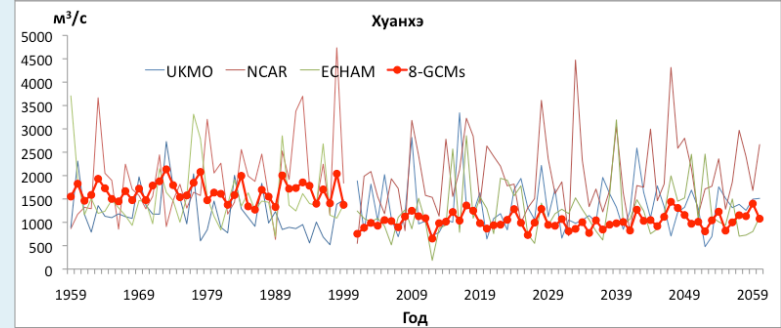
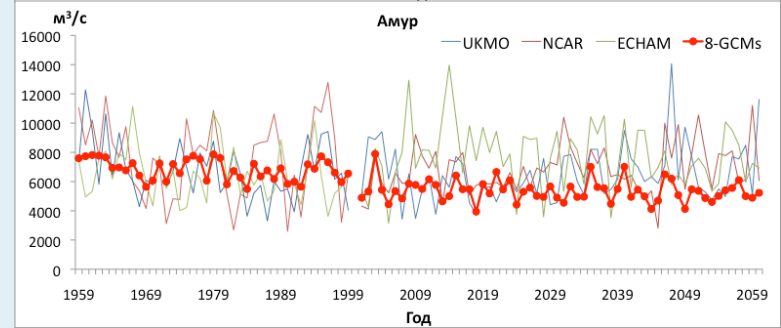
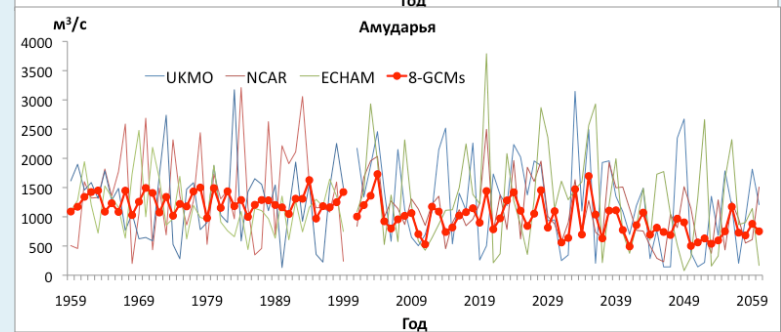
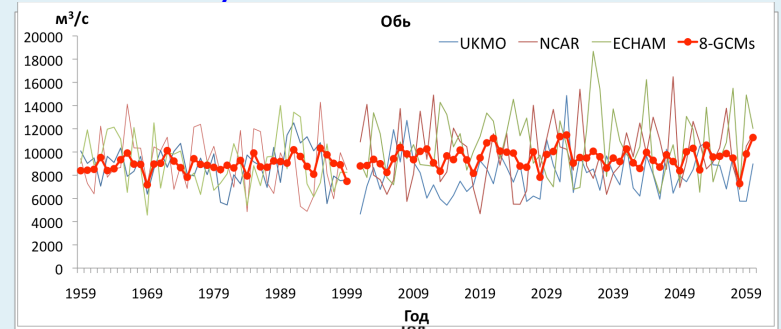
SRES A1b  
WBMPPlus  
Simulations



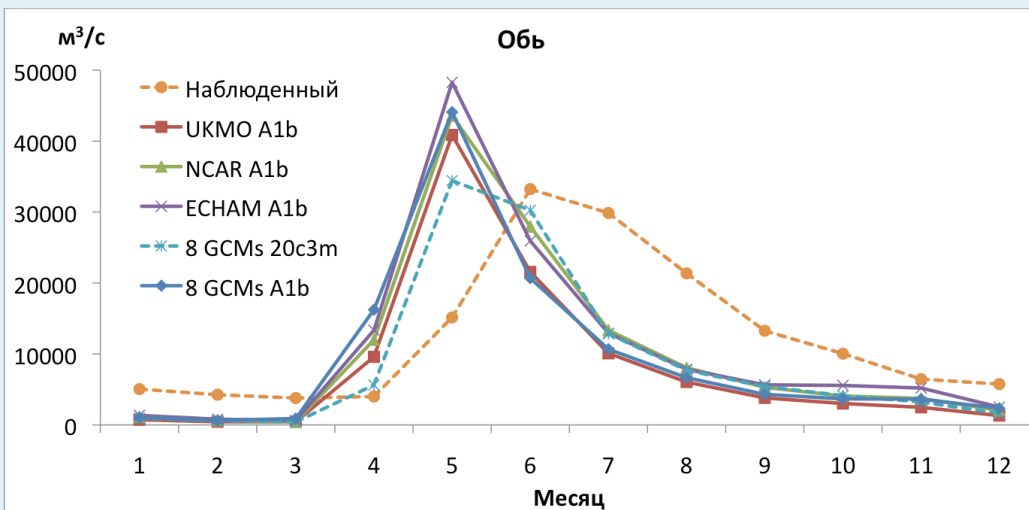
# Deviations of Annual Runoff over 2031-60 from 1959-1999 and discharge variability from 1959 to 1999 (scenario 20c3m) and from 2001 to 2006 (scenario A1b)



SRES A1b  
WBMPPlus  
Simulations

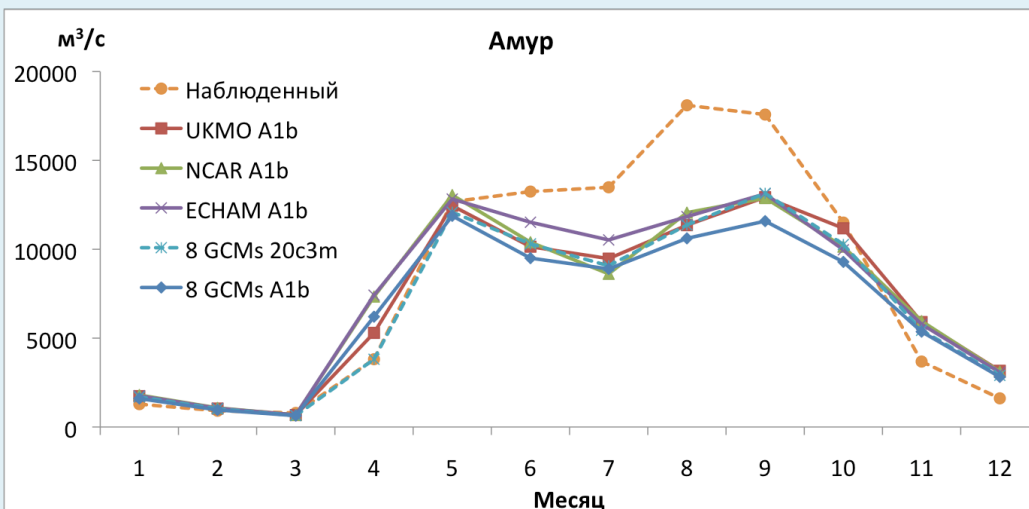


# Discharge simulations with WBMPlus using IPCC GCMs



**A1b – mean monthly discharge over 2031-2060**

**20c3m and Observed – mean monthly Discharge over 1959-1999**



**Monthly discharge simulation for A1b scenario from different GCMs are consistent**

# Summary for the Science Application Examples

- 1) **NEESPI RIMS ( Regional Integrated Mapping and Analysis System) contains a set of Web based and online research and data analysis services and tools that can be used for scientific gridded, vector, and point (station) datasets. It is integrated into a hydrological modeling framework that combines data mining, model runs, and data delivery to end users.**
- 2) **Rapid analysis of various phenomena and events can be done with NEESPI RIMS.**
- 3) **Analysis of meteorological characteristics of summer 2010 in Russia shows:**
  - a) **the summer was extremely warm and dry;**
  - b) **these conditions impacted most Russian cropland;**
  - c) **about 60% of Russian population was affected by this hot weather.**
- 4) **Hydrology- Water Cycle across the Northern Eurasia is intensifying.**
- 5) **The intensification is more significant in winter and summer-fall periods.**
- 6) **IPCC GCMs have wide variability for the region, but there are consistent patterns between models.**
- 7) **NEESPI RIMS allows analysis of a wide range of scenarios and models online.**



# Thank You!

## Acknowledgements-

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