Federal Service for Hydrometeorology
and Environmental Monitoring

VOEIKOV
MAIN GEOPHYSICAL
OBSERVATORY

Since 1849

Information that global modelers need from regional and sub-grid scale

Vladimir Kattsov

Workshop “NEA land surface properties and change and its role in the global earth system and models”, AGCI, Aspen, 12-17 August 2007

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

Projection credibility aspects

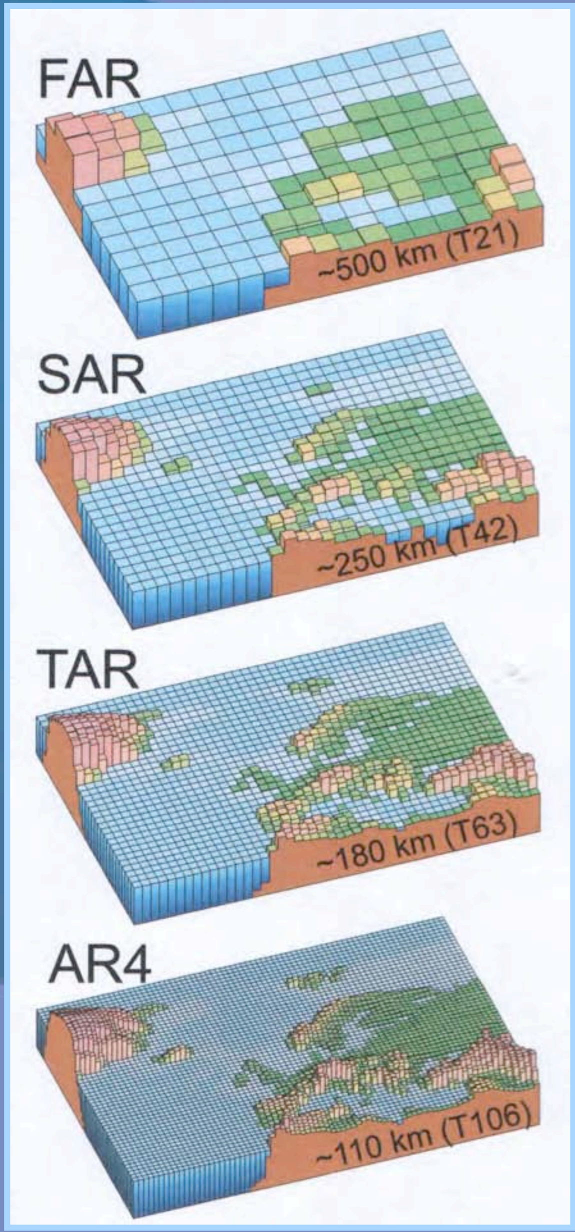
- ✓ Sensitivity to external forcing
- ✓ Systematic errors

Priorities

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

- ✓ Higher resolution
- ✓ More components
- ✓ Larger ensembles

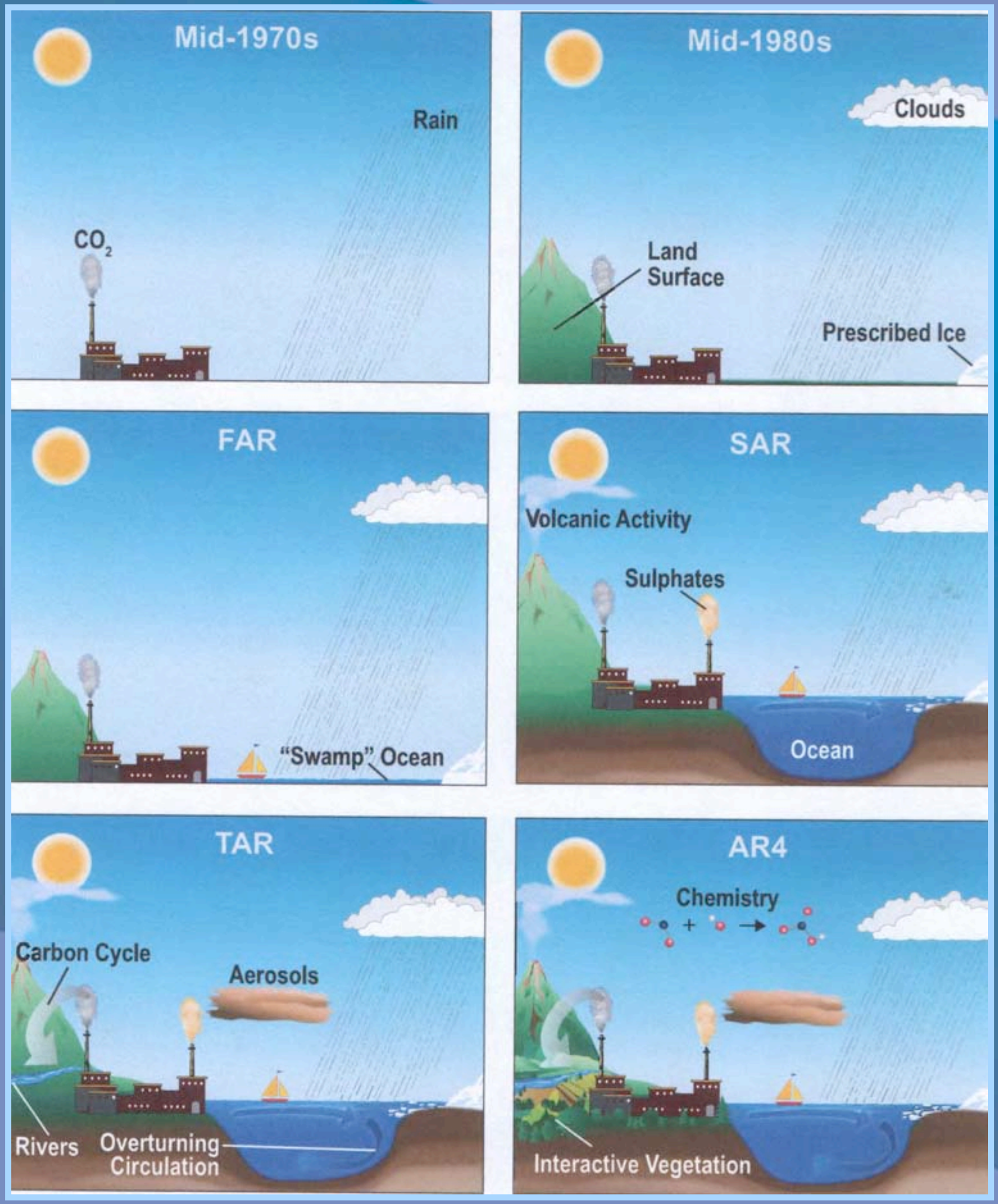
Climate model resolution



IPCC, 2007

Climate model components

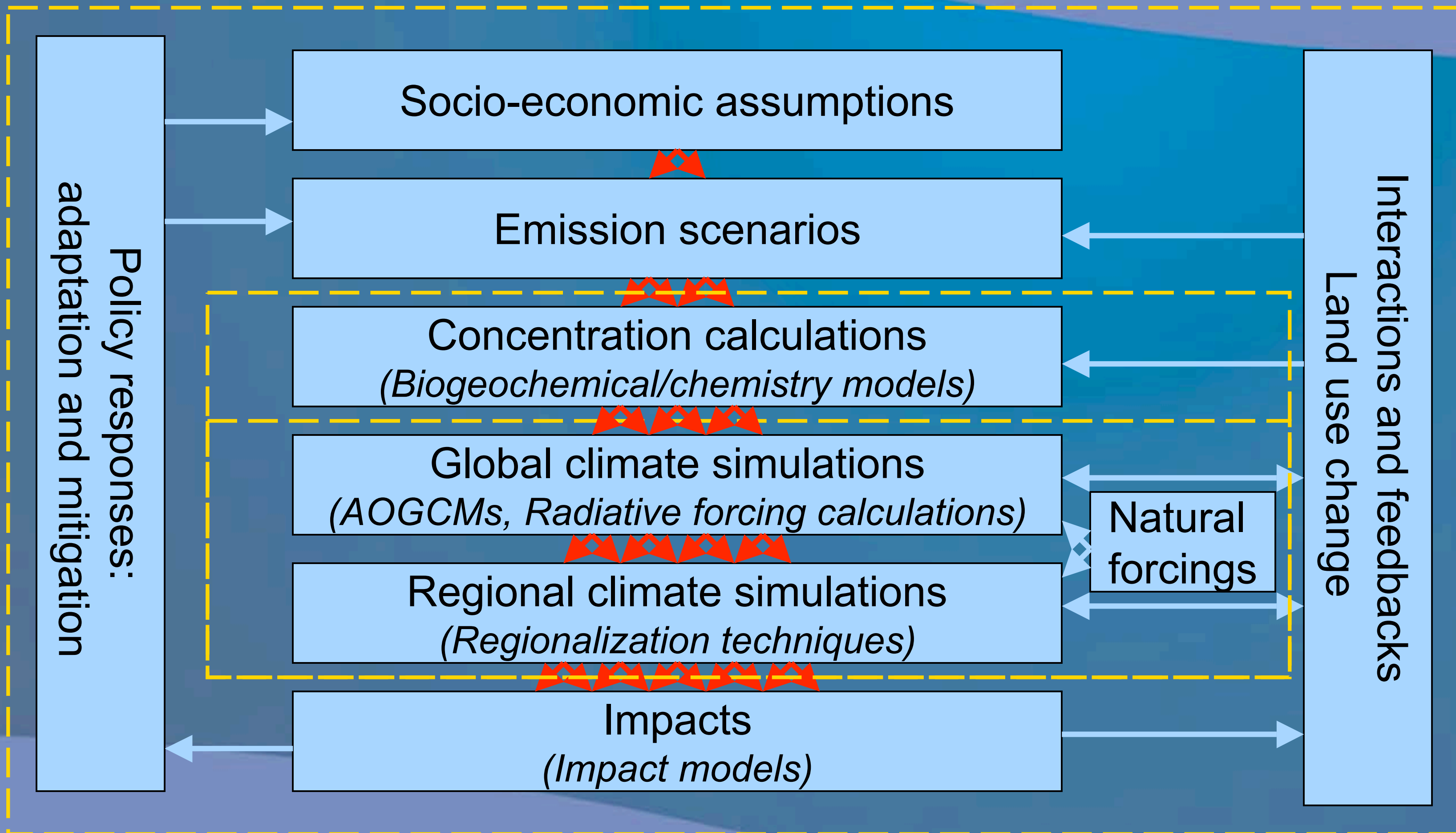
VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



IPCC, 2007

Projection uncertainty cascade

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



Giorgi, 2005

WCRP CMIP3 multi-model dataset

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

Model name	Country
BCCR-BCM2.0	Norway
BCC-CM1	China
CCSM3	USA
CGCM3.1(T47)	Canada
CGCM3.1(T63)	Canada
CNRM-CM3	France
CSIRO-Mk3.0	Australia
FGOALS-g1.0	China
ECHAM5/MPI-OM	Germany
ECHO-G	Germany/Korea
GFDL-CM2.0	USA
GFDL-CM2.1	USA
GISS-AOM	USA
GISS-EH	USA
GISS-ER	USA
INM-CM3.0	Russia
IPSL-CM4	France
MIROC3.2 (hires)	Japan
MIROC3.2 (medres)	Japan
MRI-CGCM2.3.2	Japan
PCM	USA
UKMO-HadCM3	UK
UKMO-HadGEM1	UK

Unprecedented model experiment:
23 models, 16 centers, 11 countries, 32 Tb, 1000+ scientists.

PCMDI

http://www-pcmdi.llnl.gov

New generation of AOGCMs

VOEIKOV
MAIN
GEOPHYSICAL
OBSERVATORY

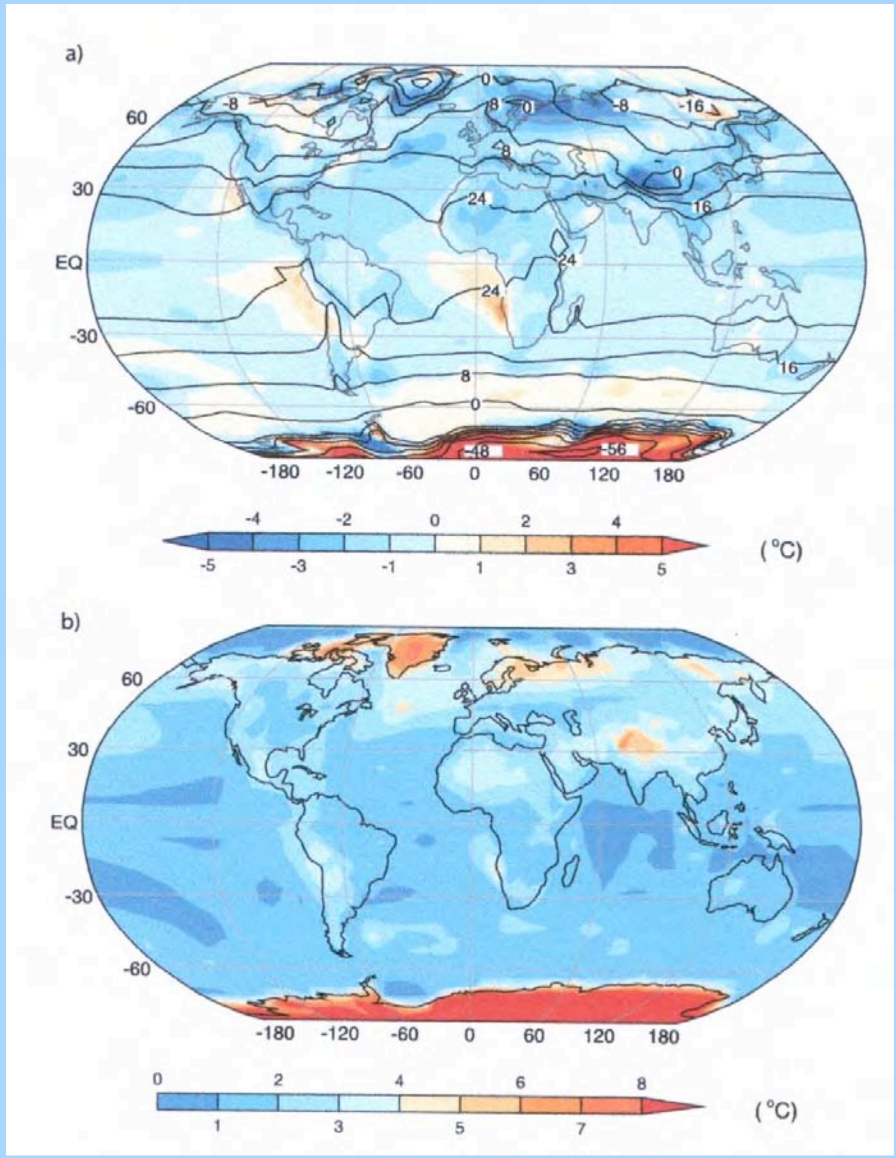
- Resolution
- Grids
- Components
- Flux correction
- Modes of natural variability
- Extremes
- Southern Ocean
- Sensitivity
- Dynamic sea ice

Temperature

VOEIKOV
MAIN
GEOPHYSICAL
OBSERVATORY

bias

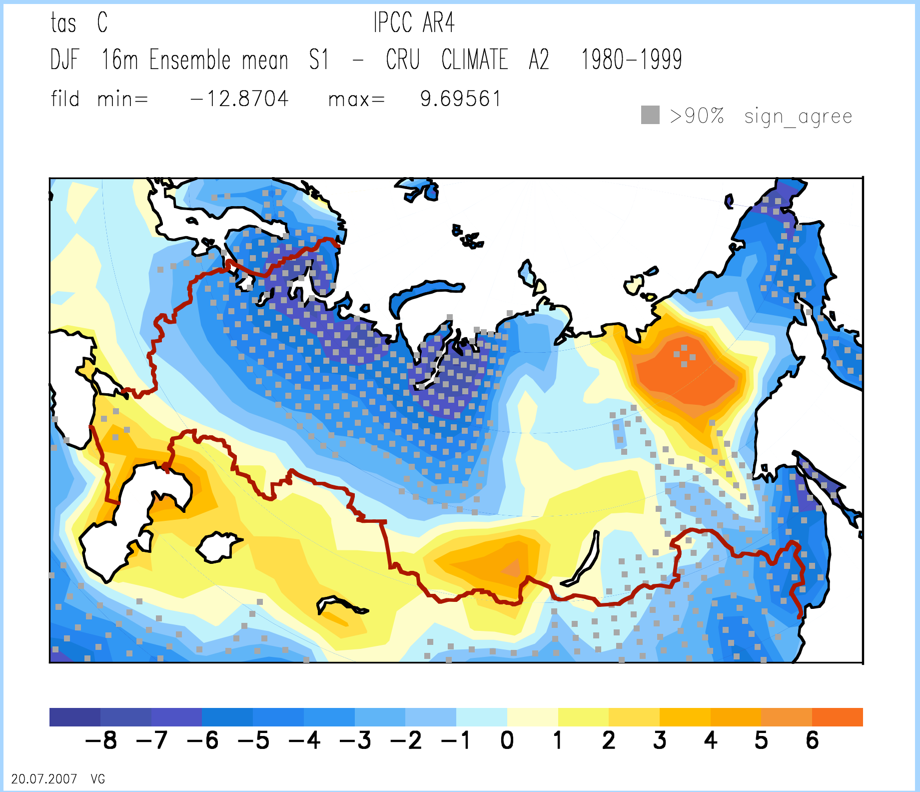
rmse

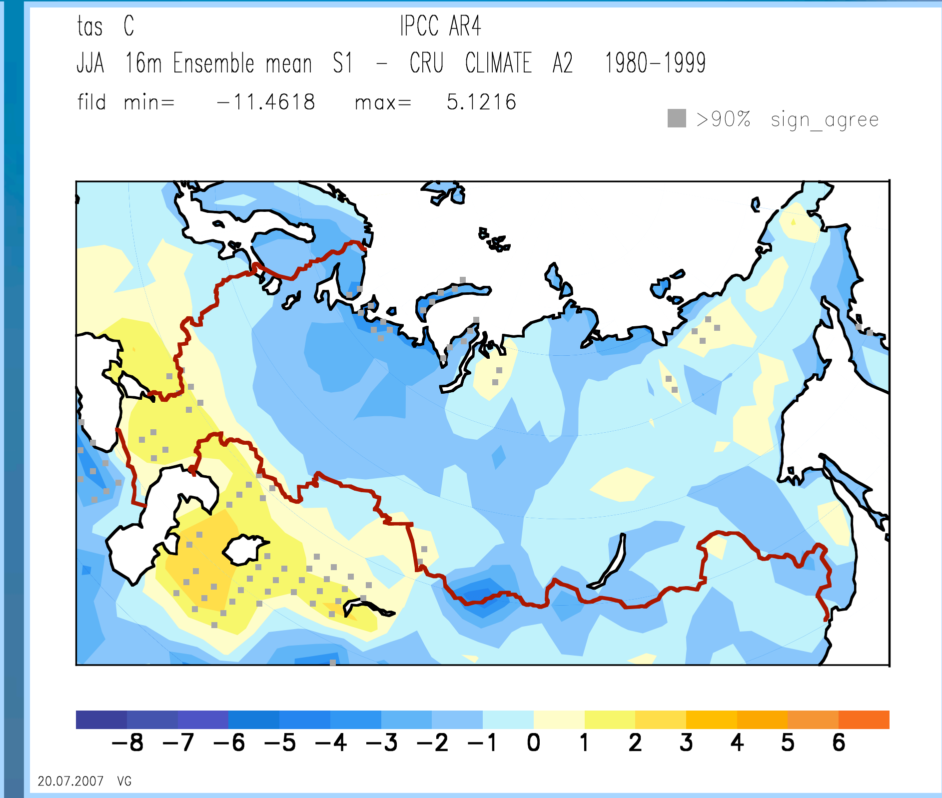


IPCC, 2007

Temperature

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



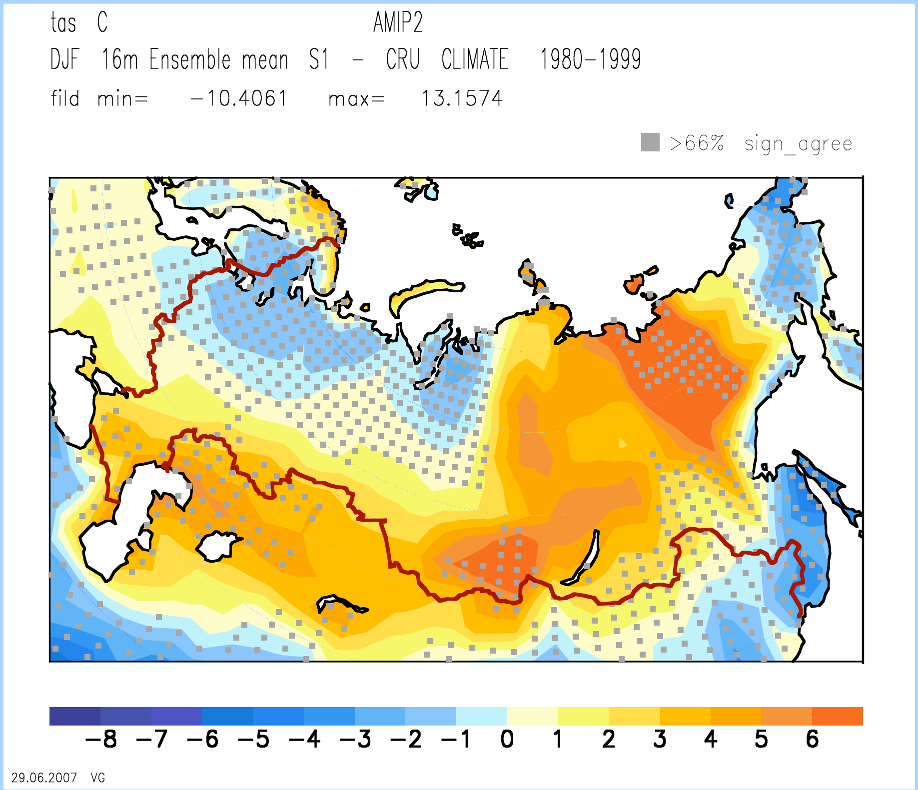


DJF

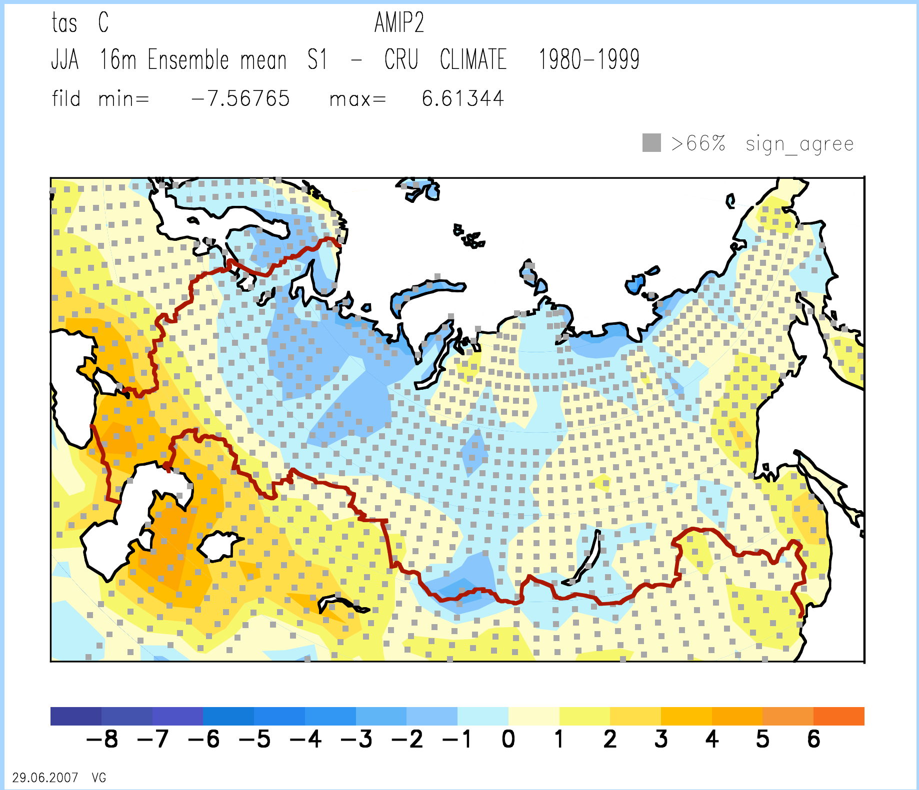
JJA

Meleshko et al., 2007

Temperature (stand-alone AGCMs)



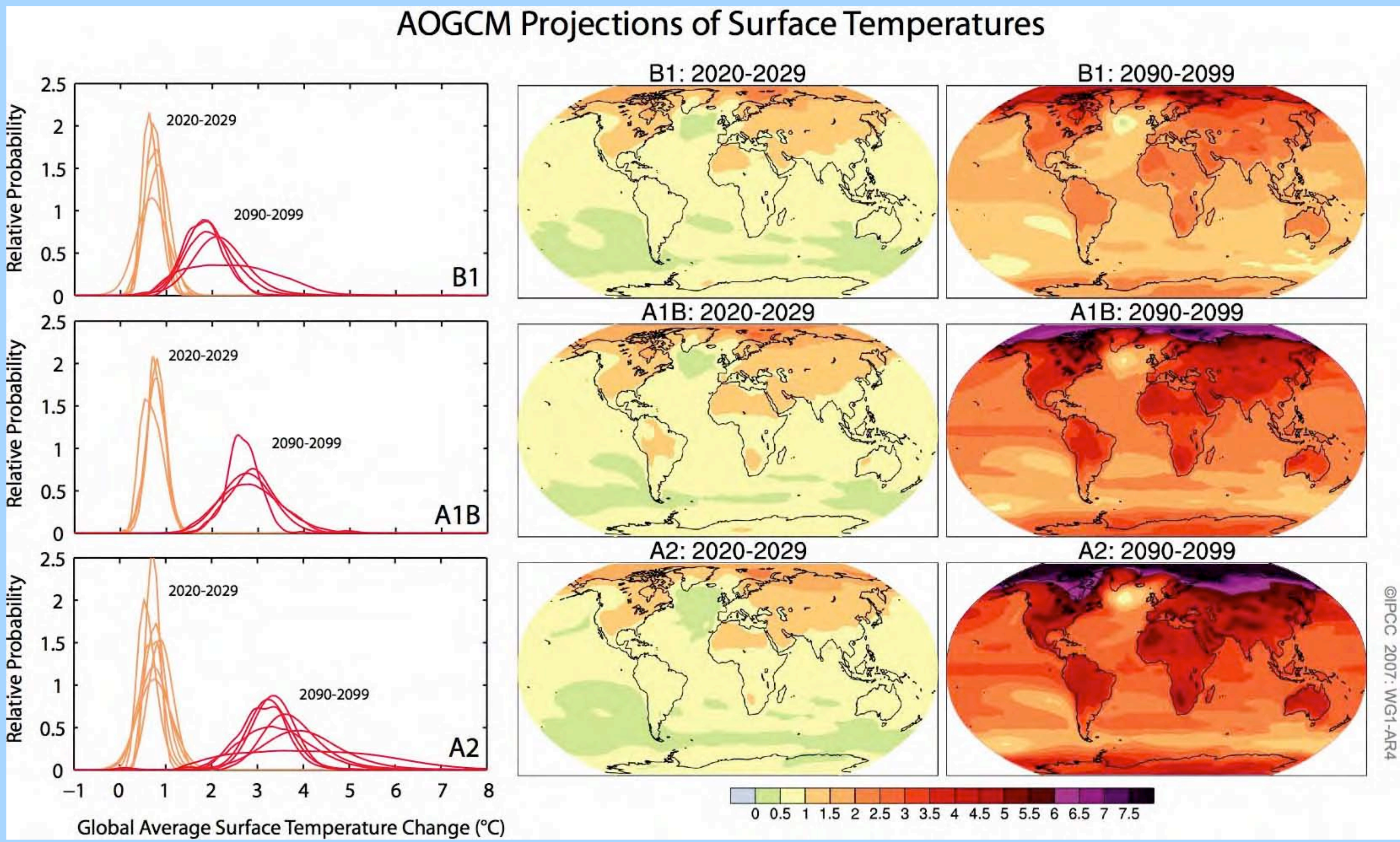
DJF



JJA

Meleshko et al., 2007

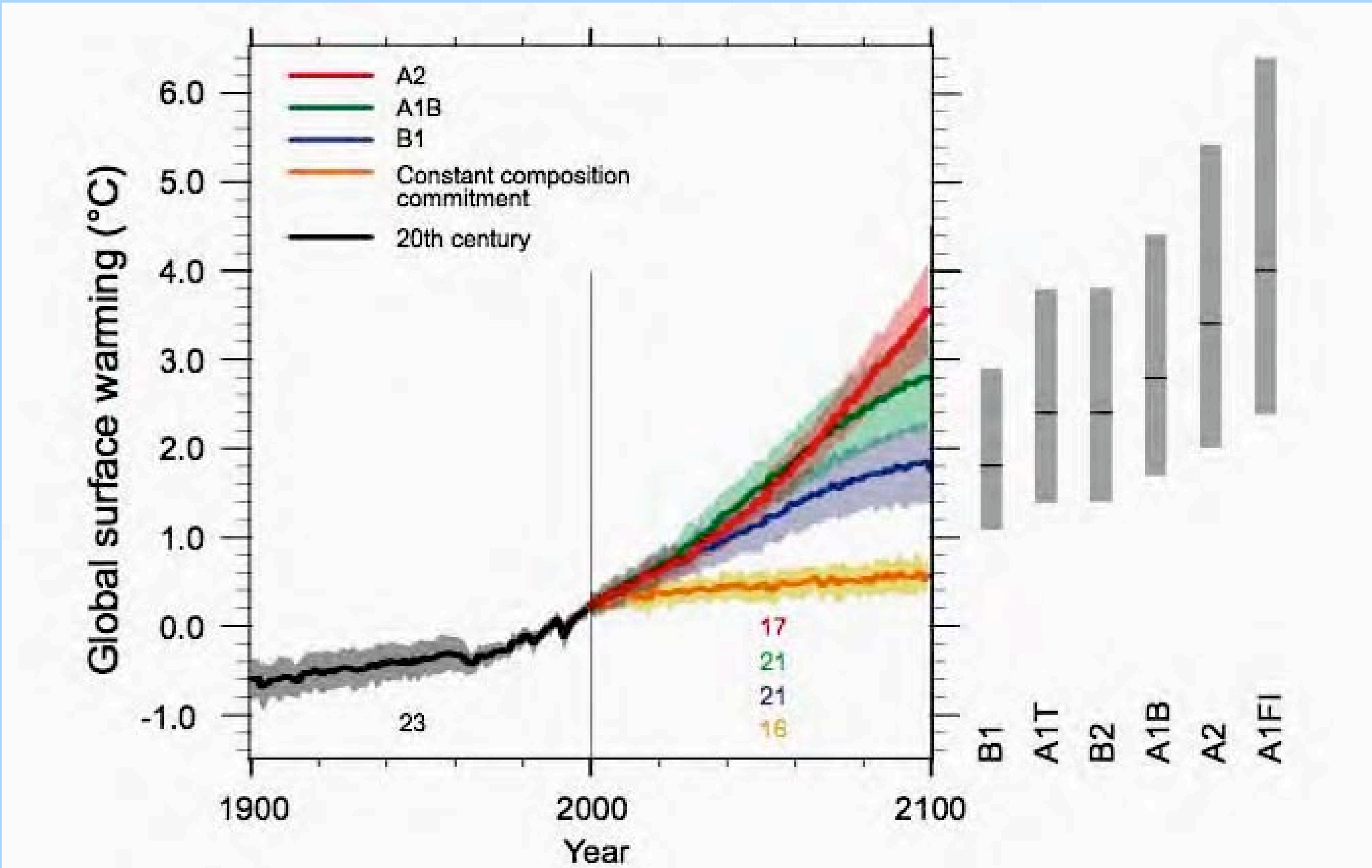
Temperature



IPCC, 2007

Projections

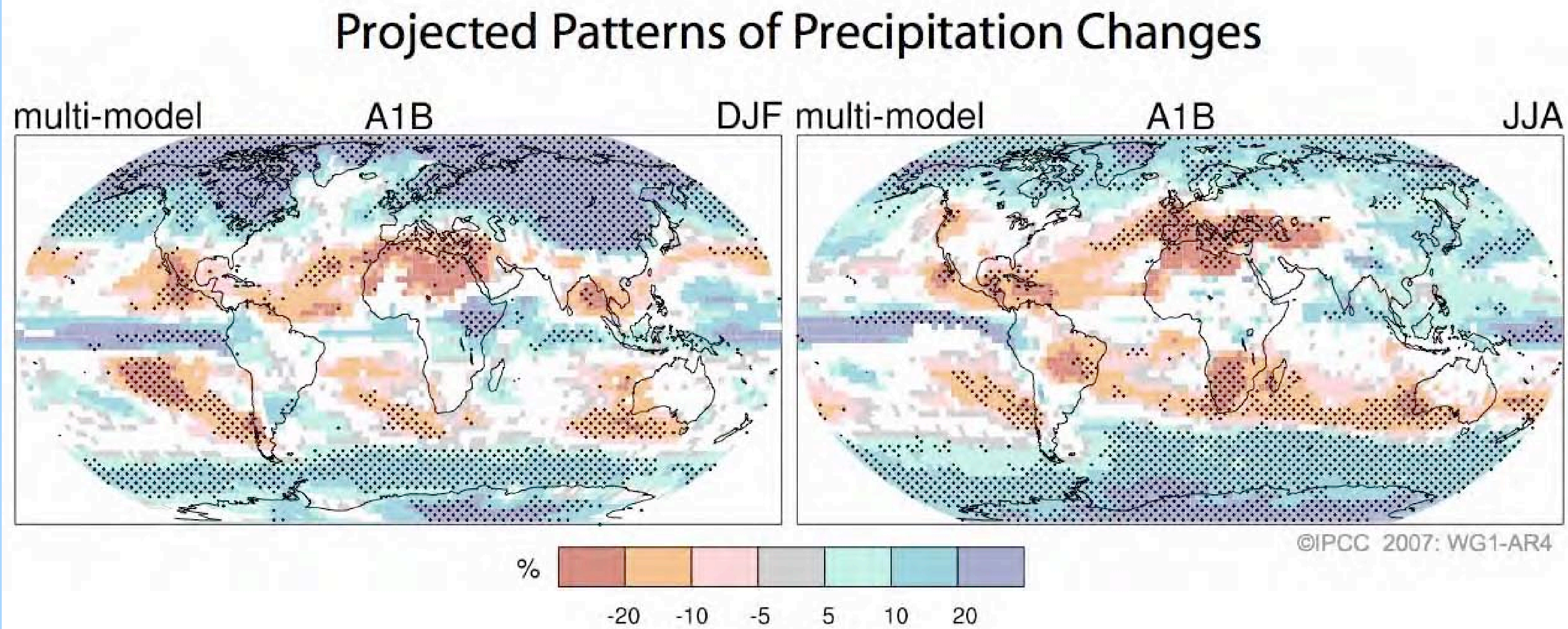
VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



IPCC, 2007

IPCC WG1 AR4 highlights

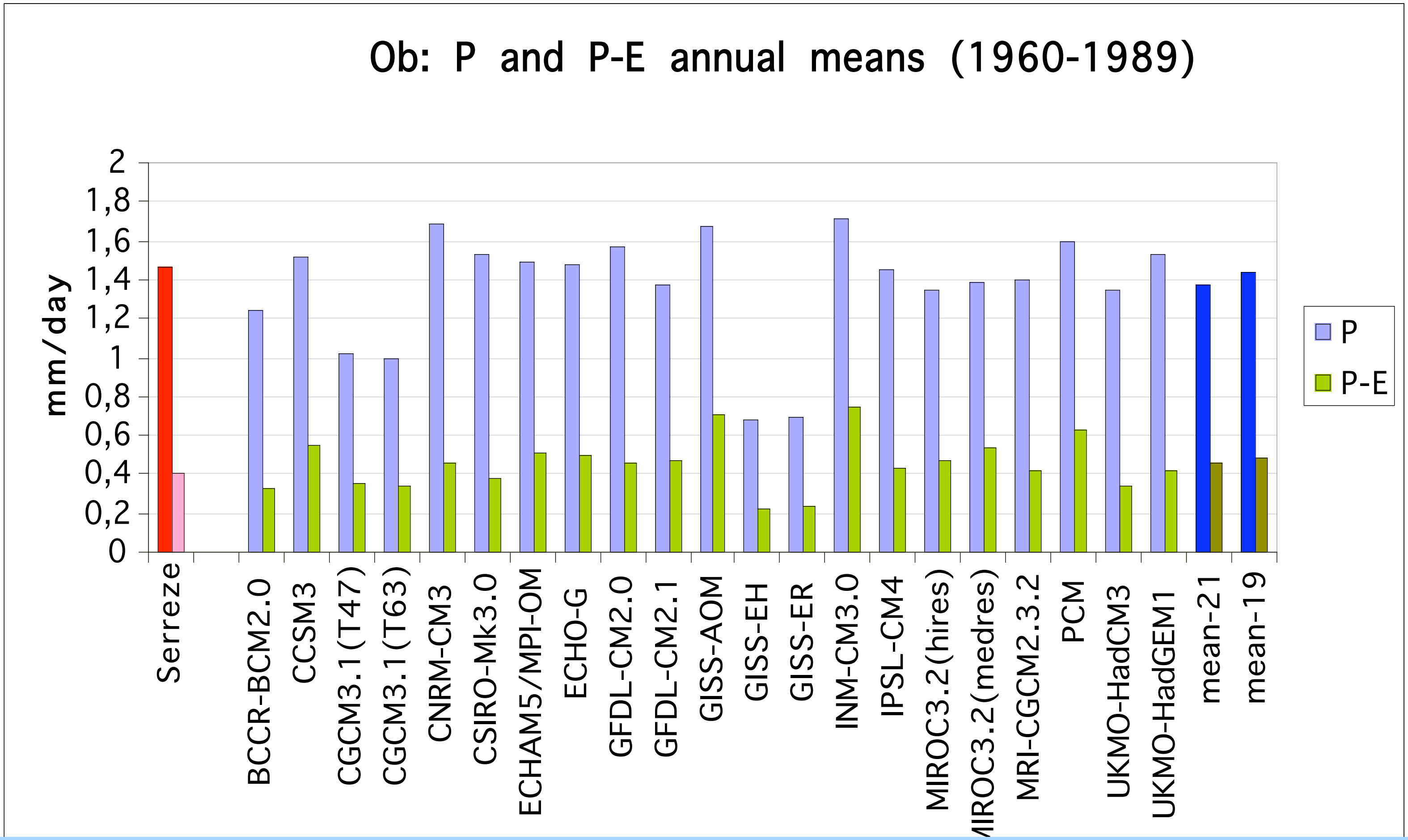
VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



IPCC, 2007

Ob watershed:
annual mean precipitation and P-E

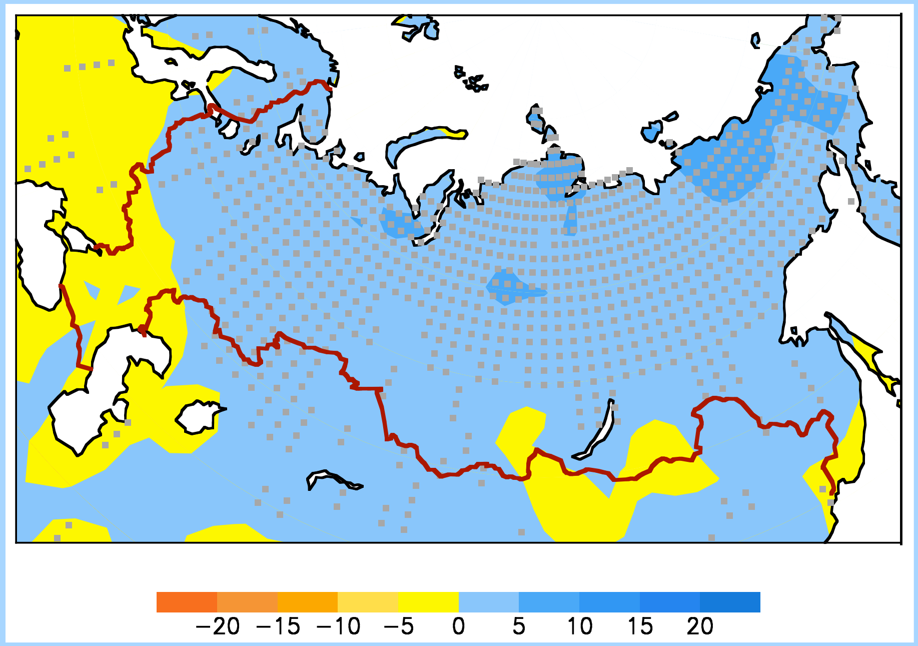
VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

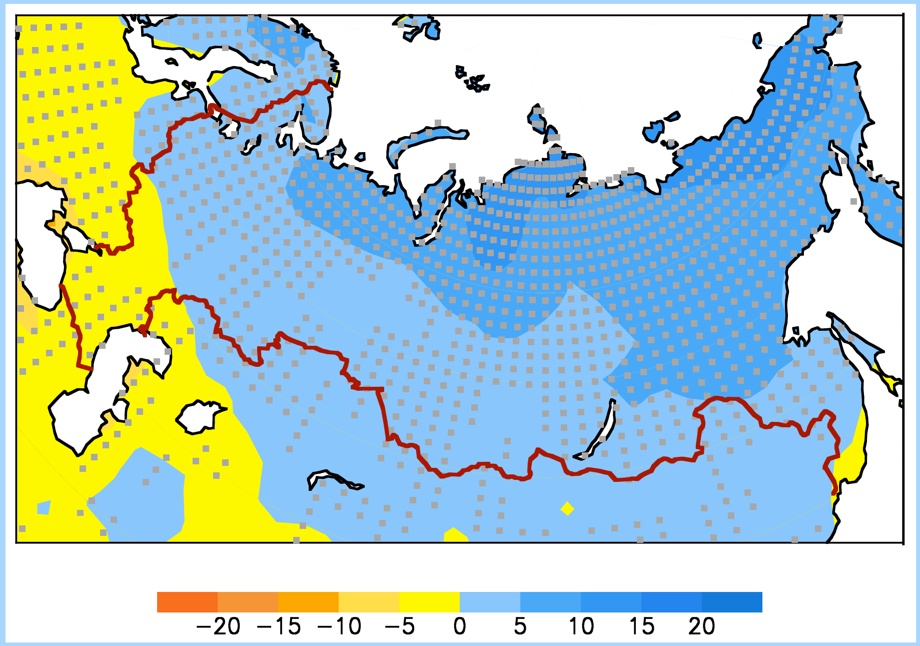


Kattsov et al., 2007

Runoff change (%)

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY





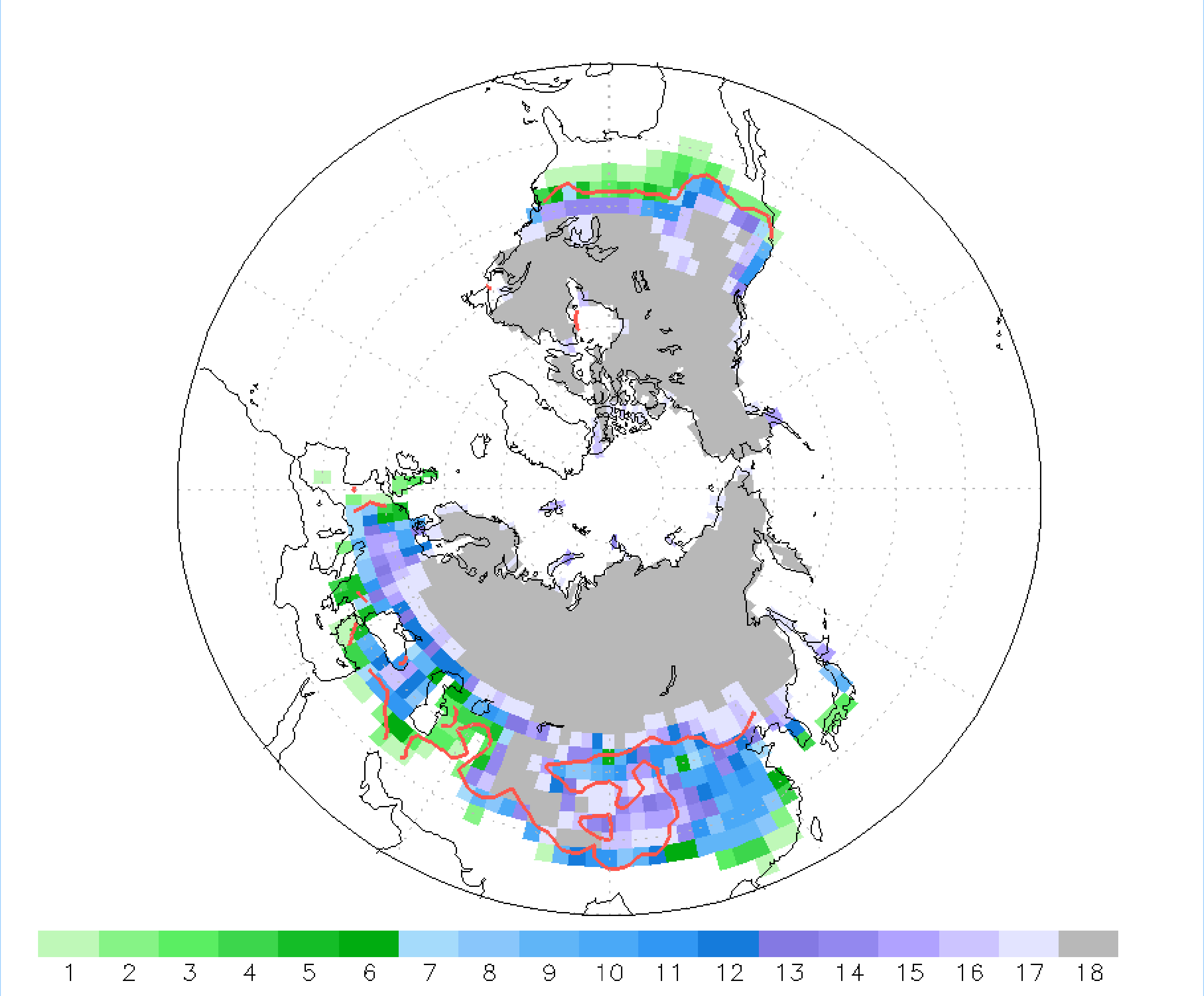
2011-2030

2041-2060

Meleshko et al., 2007

Snow

VOEIKOV
MAIN
GEOPHYSICAL
OBSERVATORY

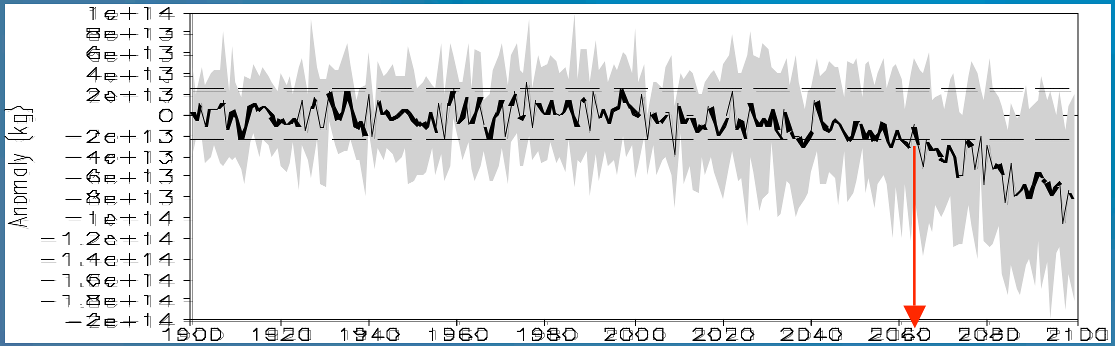


Pavlova et al., 2007

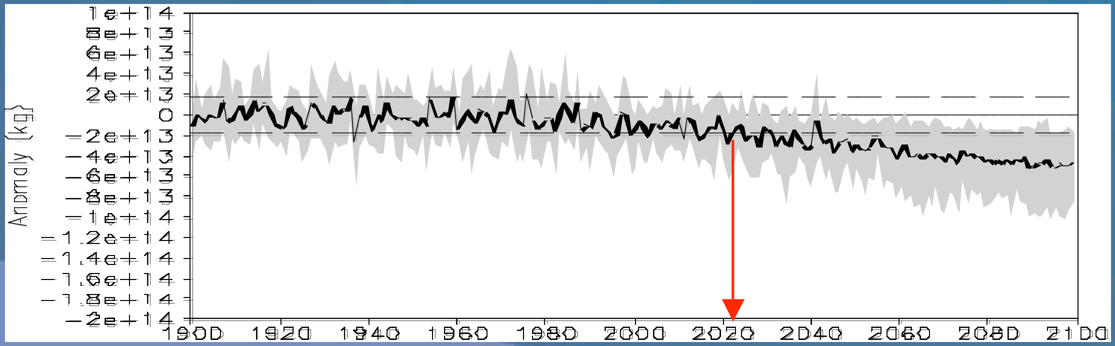
The Ob catchment:
Snow mass anomaly (kg) evolution
as simulated by the ensemble of IPCC AOGCMs (_2)

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

March



May

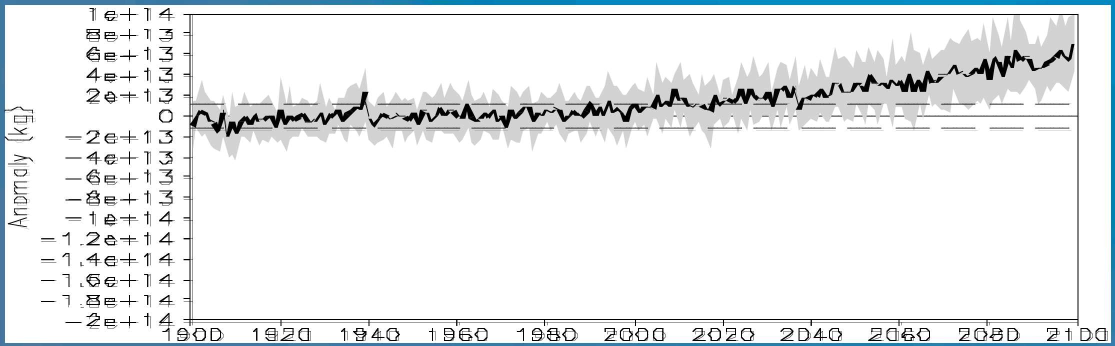


Pavlova et al., 2007

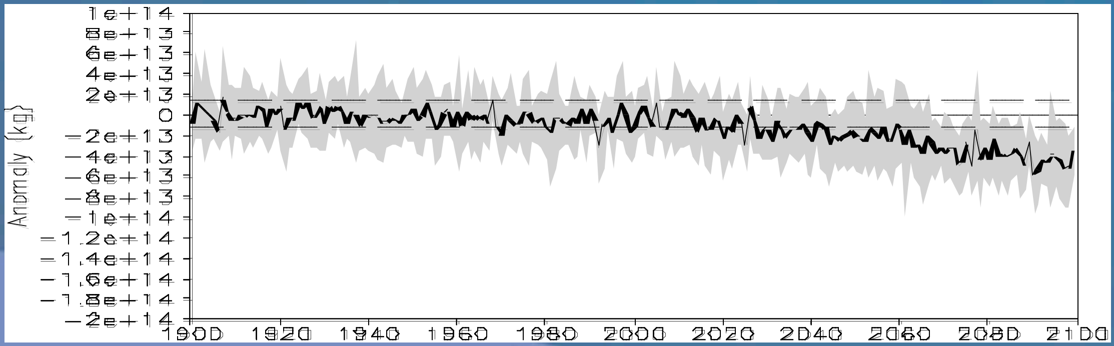
The Lena catchment:
Snow mass anomaly (kg) evolution
as simulated by the ensemble of IPCC AOGCMs (_2)

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

March



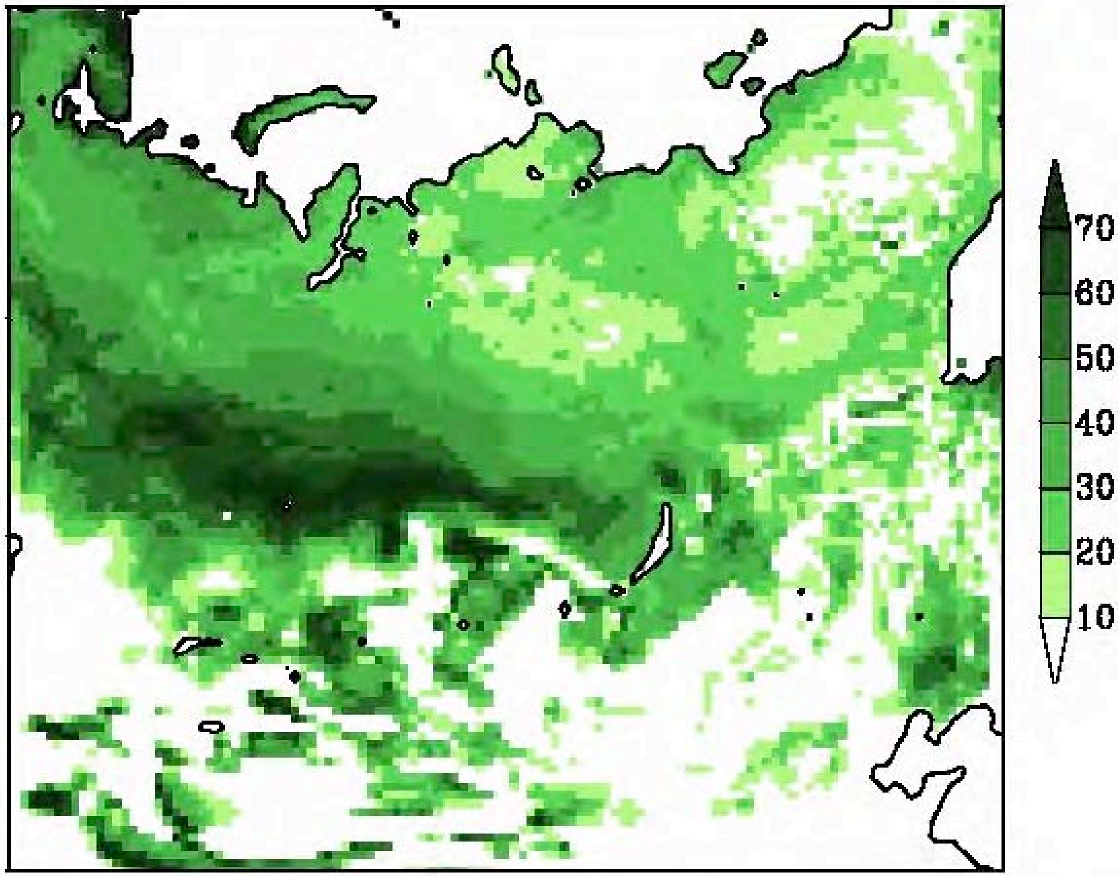
May



Pavlova et al., 2007

Change of stable snow cover duration by the end of the 21st century (days, A2)

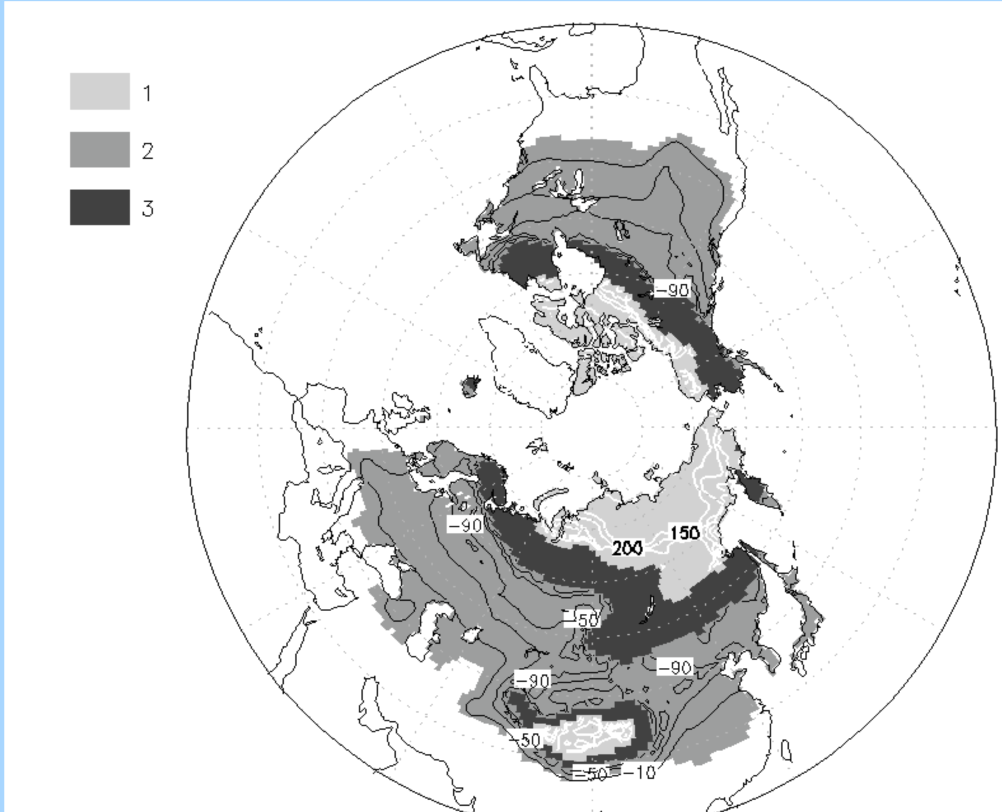
VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



Shkolnik et al., 2007

Permafrost

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY



Pavlova et al., 2007

Depth changes of seasonally thawing layer (white lines, cm) and seasonally frozen layer (black lines, cm) in 2080-2099 (A2) relative to 1980-1999.

1- region of seasonal thawing retained by the end of the 21st century,

2- same but for seasonal freezing,

3- region where seasonal thawing is replaced by seasonal freezing in the upper 3 m layer/

Pavlova et al., 2007

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

Among IPCC AR4 key uncertainties:

Changes in key processes that drive some global and regional climate changes are poorly known (e.g., ENSO, NAO, blocking, MOC, **land surface feedbacks**, tropical cyclone distribution). {11.2–11.9}

The magnitude of future **carbon cycle feedbacks** is still poorly determined. {7.3, 10.4}

Some priorities

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

- ✓ Effects of vegetation dynamics and interaction with land-surface on NEA energy and water cycles (e.g. snow+vegetation=albedo+water flux seasonality)
- ✓ Effects of cryospheric and vegetation changes on the chemical composition of the atmosphere (e.g. GHG from thawing permafrost or black carbon from forest fires)
- ✓ Land surface mosaic and upscaling techniques

Shift of climatic zones in the warming climate

VOEIKOV
MAIN
GEOPHYSICAL
OBSERVATORY

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

Acknowledgements:

We acknowledge the modeling groups for making their simulations available for analysis, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) for collecting and archiving the CMIP3 model output, and the WCRP's Working Group on Coupled Modelling (WGCM) for organizing the model data analysis activity. The WCRP CMIP3 multi-model dataset is supported by the Office of Science, U.S. Department of Energy. Some of the results presented above were obtained under the projects supported by the US National Science Foundation via the International Arctic Research Center of the University of Alaska Fairbanks (subaward UAF05-0074 of OPP-0327664) and by the Russian Foundation for Basic Research (Grant 05-05-65093).

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

All models that treat the coupling of the carbon cycle to climate change indicate a positive feedback effect with warming acting to suppress land and ocean uptake of CO_2, leading to larger atmospheric CO_2 increases and greater climate change for a given emissions scenario, but the strength of this feedback effect varies markedly among models.

Future concentrations of many non-CO_2 greenhouse gases and their precursors are expected to be coupled to future climate change. Insufficient understanding of the causes of recent variations in the CH_4 growth rate suggests large uncertainties in future projections for this gas in particular.

Future emissions of many aerosols and their precursors are expected to be affected by climate change.

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY

IPCC AR4 robust findings:

Natural processes of CO_2 uptake by the oceans and terrestrial biosphere remove about 50 to 60% of anthropogenic emissions (i.e., fossil CO_2 emissions and land use change flux). Uptake by the oceans and the terrestrial biosphere are similar in magnitude over recent decades but that by the terrestrial biosphere is more variable. {7.3}

Future warming would tend to reduce the capacity of the Earth system (land and ocean) to absorb anthropogenic CO_2. As a result, an increasingly large fraction of anthropogenic CO_2 would stay in the atmosphere under a warmer climate. This feedback requires reductions in the cumulative emissions consistent with stabilisation at a given atmospheric CO_2 level compared to the hypothetical case of no such feedback. The higher the stabilisation scenario, the larger the amount of climate change and the larger the required reductions. {7.3, 10.4}