WCRP OCS 2011

Linking Weather and Climate

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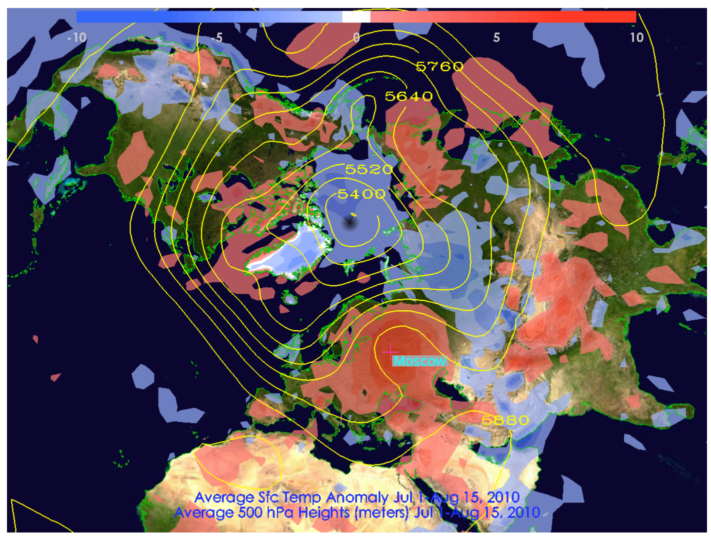


Recent Examples

- *2009-2010 Boreal Winter* – Severe Eurasian cold/snow, "Snowmageddon" in eastern U.S., UK

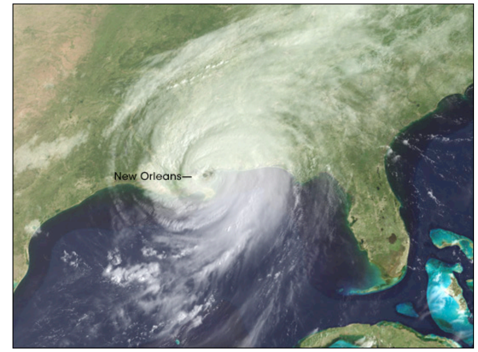
- *2010 Boreal Summer* – Extreme heat wave/drought in western Russia, floods in central Europe, Pakistan, northeast China

- *2010-2011 Boreal Winter* – Bitter European cold/snow Nov.-Dec., Australia floods, U.S. "Snowpocalypse" (snownami, snOMG, etc. …).

- *2011 Spring-Summer* – Floods in US Midwest, record cold spring, heavy snows in Pacific Northwest, Texas-Oklahoma record drought and heat

Such events can evolve significantly or entirely within the course of a season. They link shorter-term weather events with longer-term climate variations and change, often with disastrous consequences.

Weather and climate extremes in a variable and changing climate



A crucial challenge is to provide society with information needed on extreme events across all time scales, from disaster early warning and preparedness to longer-term adaptation decisions.

Beyond a few days, an increasing array of earth system processes and their interactions become relevant to predictions.

The 2010 Russian Heat Wave

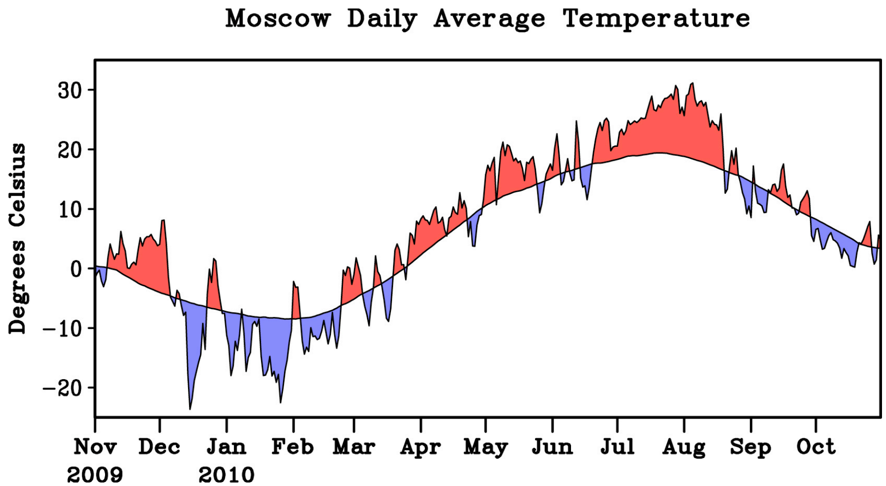
- Exceptional intensity, all-time temperature records set at many locations.
- Extreme heat and poor air quality from fires greatly increased death rates.
- A large fraction of Russian grain crops were lost, leading to a ban on exports.

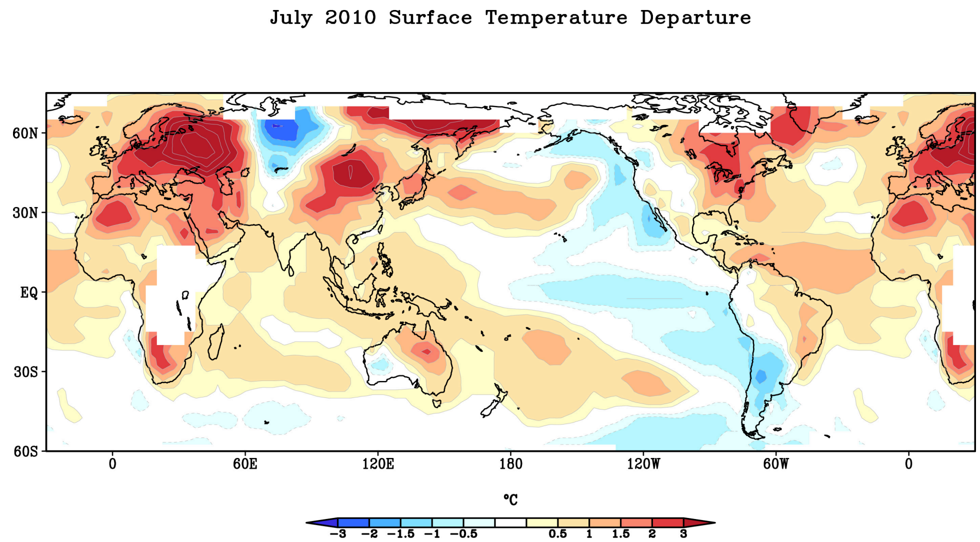
Could the 2010 Russian Heat Wave Have Been Anticipated?

- **What were the primary factors contributing to the extreme intensity of the 2010 Russian heat wave?**
- **Could such an extreme event have been anticipated from prior regional climate trends or natural and human-caused climate forcings?**
- **What are the implications for climate model predictions and projections?**
- How might such heat waves change in the future?

<u>Additional references:</u>
Dole, R., et al., 2011, *GRL*. See also:
Perlwitz, J. et al poster – Thursday session C39 on Climate Extremes
Dole, R. et al poster - Thursday session C41 on Attribution

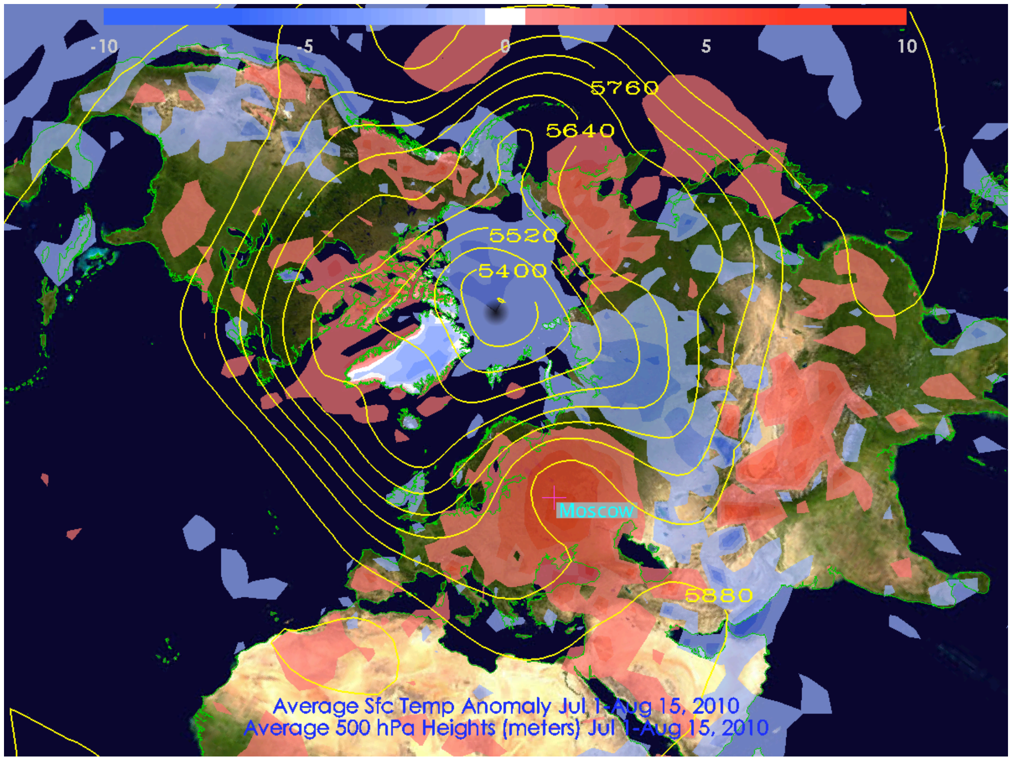
Surface Temperatures





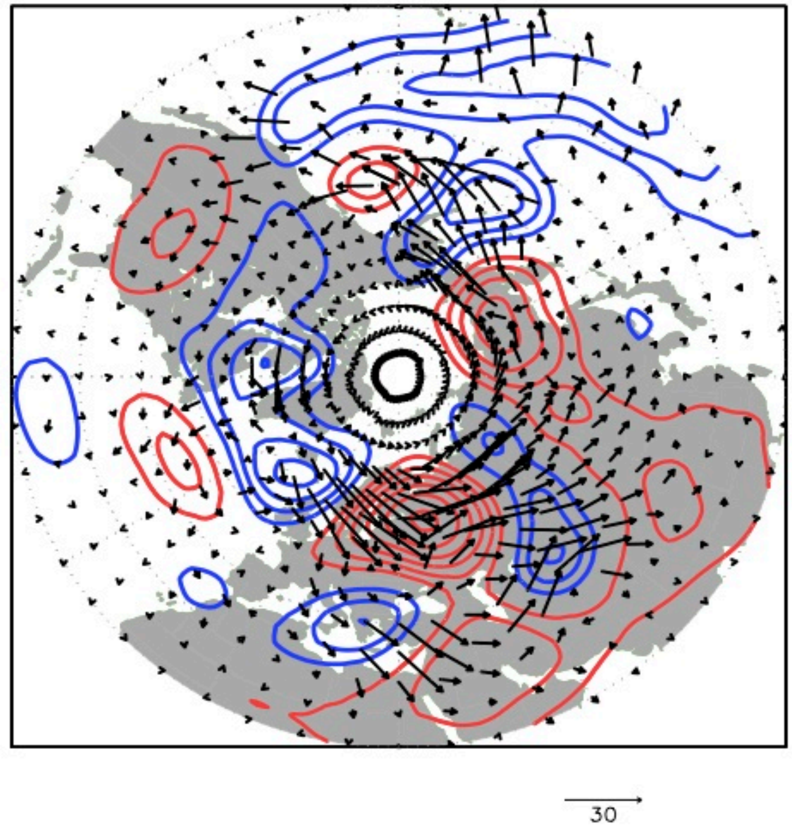
- The heat wave occurred nearly in phase with the peak in the annual cycle, exacerbating impacts. It began in late June and terminated in mid-August.
- The intensity was unprecedented in modern observational data: **10.7^o C for 31-day mean**, **12.3^o C for 15-day mean** (Barriopedro et al 2011).
- The heat wave occurred within a larger wave-like pattern of temperature anomalies, with a global-average anomaly of about +0.6^o C

500 hPa heights **T'_{sfc}**



July 1 – August 15

300 hPa Stationary Wave Activity Flux
(Plumb 1985)

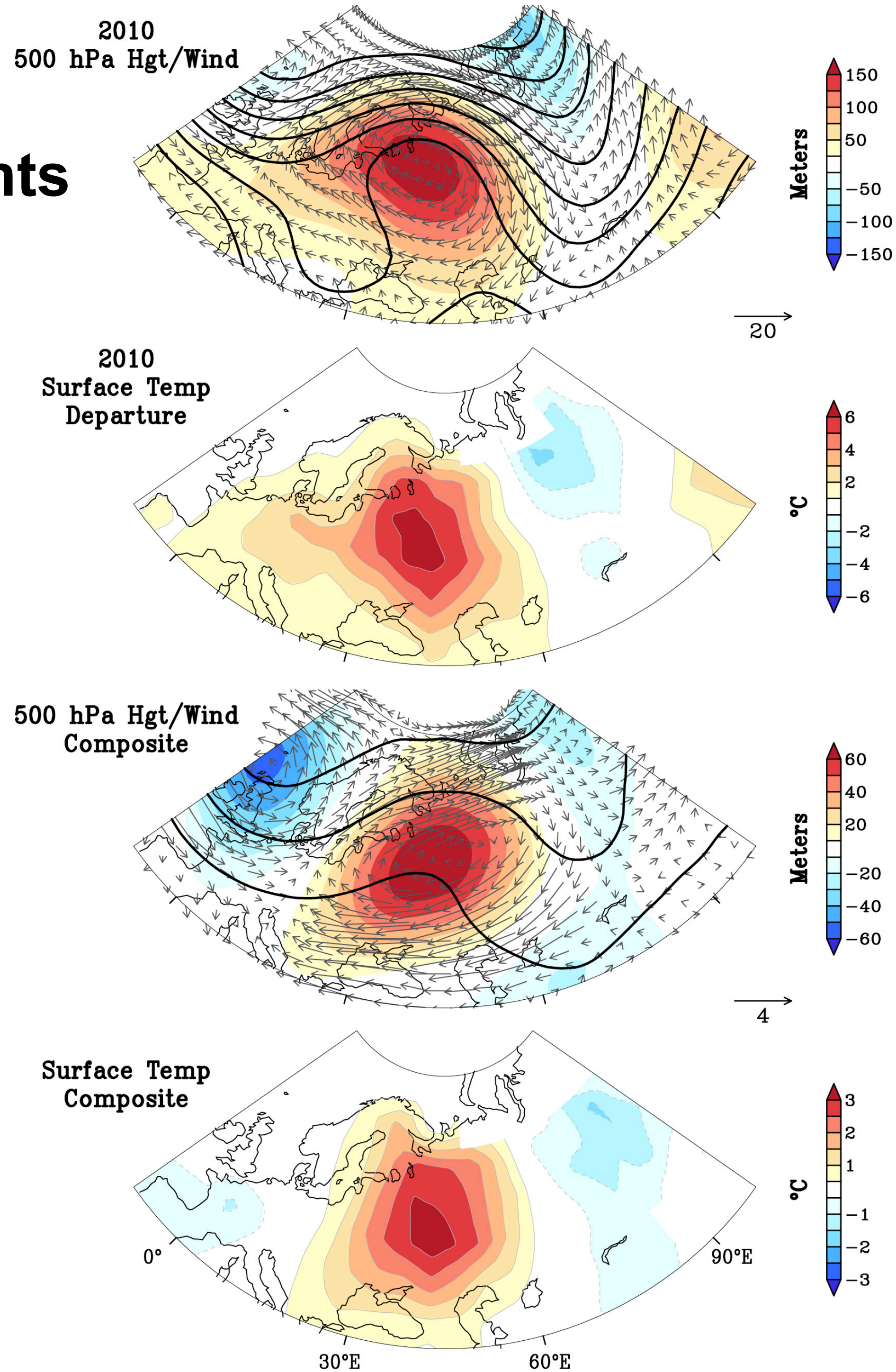


July 2010

500 hPa heights

July 2010

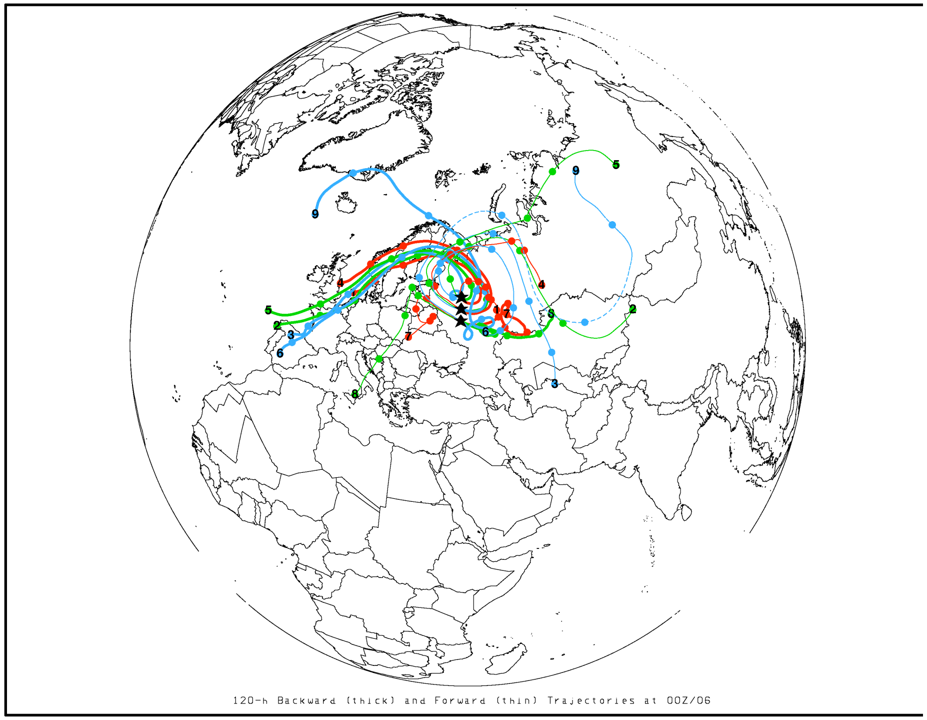
T'_{sfc}



Composite of 10 prior heat waves

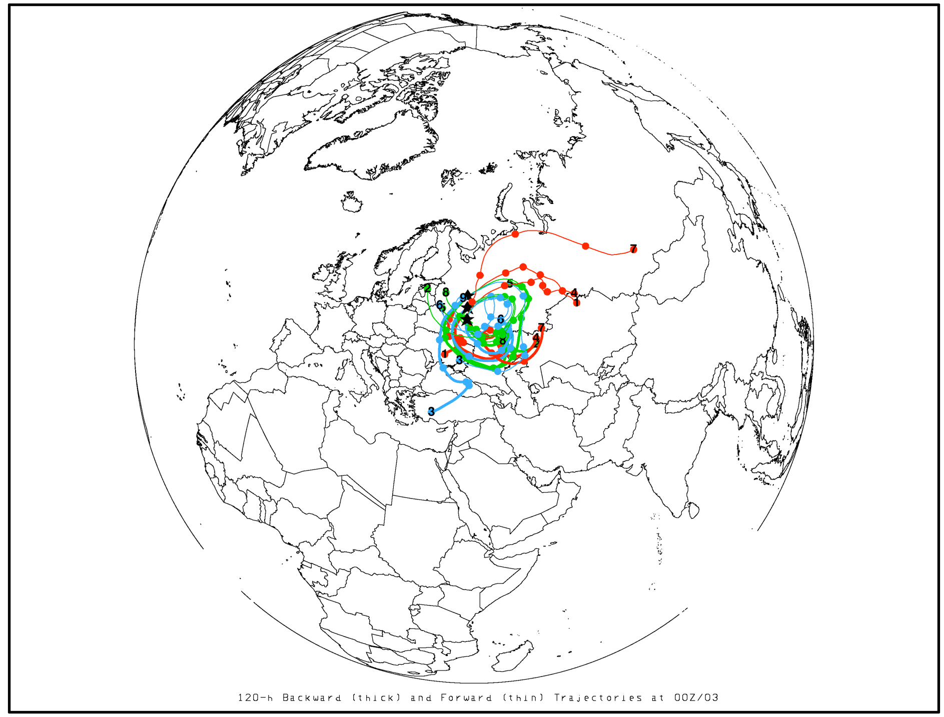
120-h backward (thick) and forward (thin) trajectories

Early Phase



Starting at 06 July 2010 00Z

Late Phase

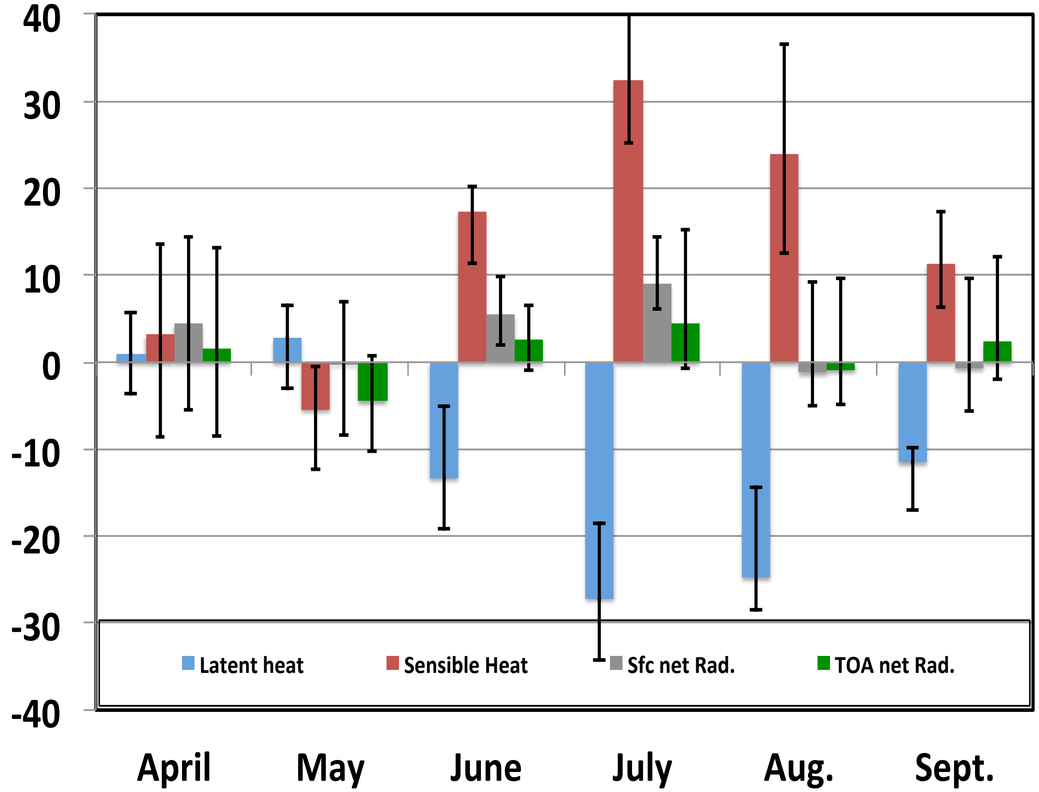


Starting at 03 August 2010 00Z

★ **Starting location – "Day 0"**

Starting level (above MSL):
1500 m (trajectory # 1, 4, 7)
3000 m (trajectory # 2, 5, 8)
5000 m (trajectory # 3, 6, 9)

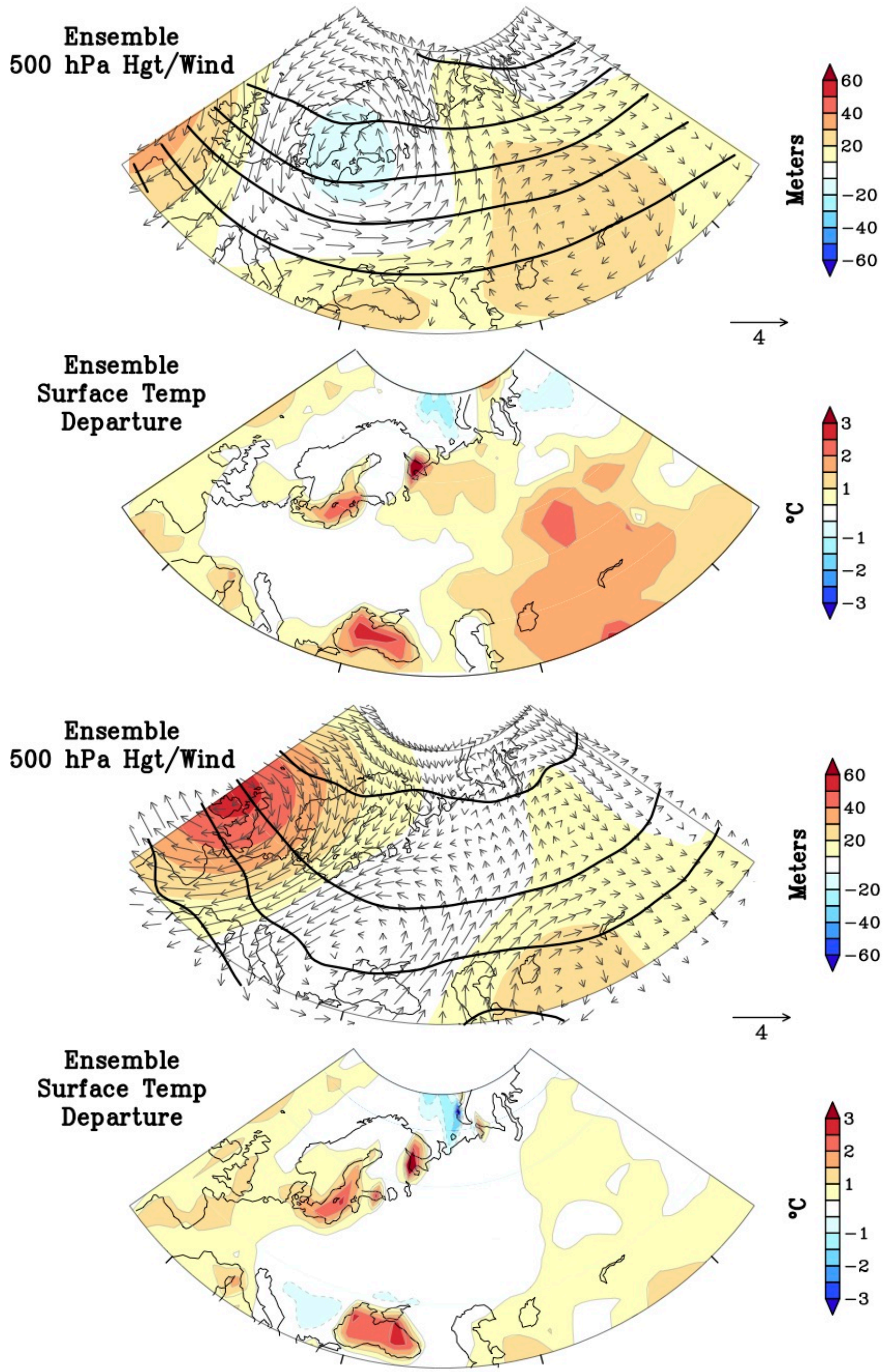
Land Surface Feedbacks



- Late spring - surface energy fluxes are near normal
- June - reduced LH fluxes, increased SH fluxes
- July-August – drought conditions, land surface feedbacks become extreme

Model Responses to observed GHG, SSTs and sea ice

(50-member ensembles)



GFDL AM2.1

July 2010 Ensemble-mean Response

MA-ECHAM5

July 2010 Ensemble-mean Response

Case Summary

- The 2010 Russian heat wave was due primarily to unusually strong and long-lived regional blocking. The observed pattern resembles prior heat wave patterns, as well as Schubert et al.'s (2011) leading mode of summer subseasonal variability.

- Stationary wave activity fluxes indicate a strong wave source over the NE Atlantic, plausibly related in part to anomalous eddy fluxes upstream of the block.

- The heat wave intensity was increased by strong land surface feedbacks.

- Forced responses from AMIP simulations with observed global SSTs and sea ice and Climate Forecast System predictions initialized in early June were weak and dissimilar to observations.*

- Using TIGGE ensemble forecasts Matsueda (2011) found high *weather* predictability out to 9 days for much of this event.

Caveat: Most climate models have major challenges in simulating blocking, as well other processes that could affect estimates of potential predictability.

Some Implications

Blocking and time-evolving land-atmosphere feedbacks were two key features that will need to be represented well in models. These are significant modeling challenges, but where there are also pathways for progress (e.g., Scaife et al 2010; Koster, next talk).

More generally, a diverse array of processes within the earth system can contribute significantly to variability and potential predictability, e.g., ocean-atmosphere interactions and modes of variability (MJO, ENSO, NAO….), sea ice and snow cover, atmospheric composition, tropical-extratropical interactions, stratospheric-tropospheric interactions ….

In essence, what is needed are state-of-the-art earth system models coupled with advanced data assimilation systems, seamlessly connecting weather and climate (Shapiro et al. 2010; Hazeleger et al 2010 and presentations later this session).

Large ensemble sizes, including multiple models or stochastic parameterizations, will also be required for estimating the likelihoods of such extreme events.

The Path Forward: Common Science Priorities

World Weather Research Programme (WWRP) *THORPEX*
- Accelerate improvements in the accuracy of forecasts of 1-day to **2-week** high impact weather conditions

World Climate Research Program (WCRP) - Address the seamless prediction problem from **weeks** to centuries in advance.

World Modelling Summit for Climate Prediction – (Shukla et al. 2009) – " … climate and weather as a seamless problem"

Strengthening the Connections

Scientists associated with the WWRP and WCRP have proposed **increased collaborations between the weather and climate communities** to accelerate progress on predictions at the sub-seasonal to seasonal time scales (Brunet et al. 2010). Four main areas of collaboration have been proposed:

1) Seamless weather/climate prediction, including ensemble prediction systems

2) Multiscale organization of tropical convection and its two-way interactions with the extratropics (DYNAMO, YOTC)

3) Data assimilation and initialization for coupled models

4) Utilization of subseasonal and seasonal predictions for social and economic benefits

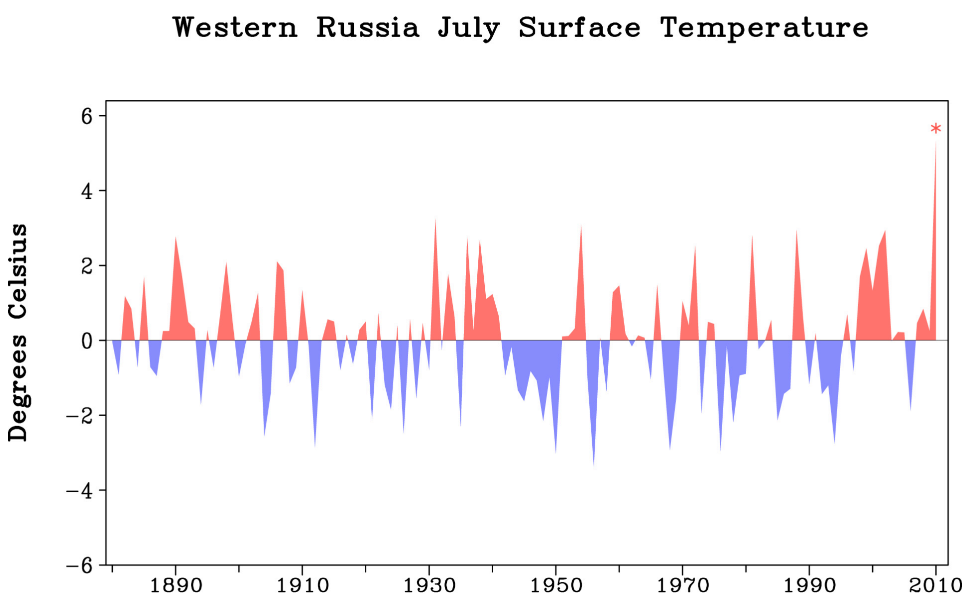
Conclusion

Weather and climate are intrinsically connected. The success of understanding each will require improved understanding of both.

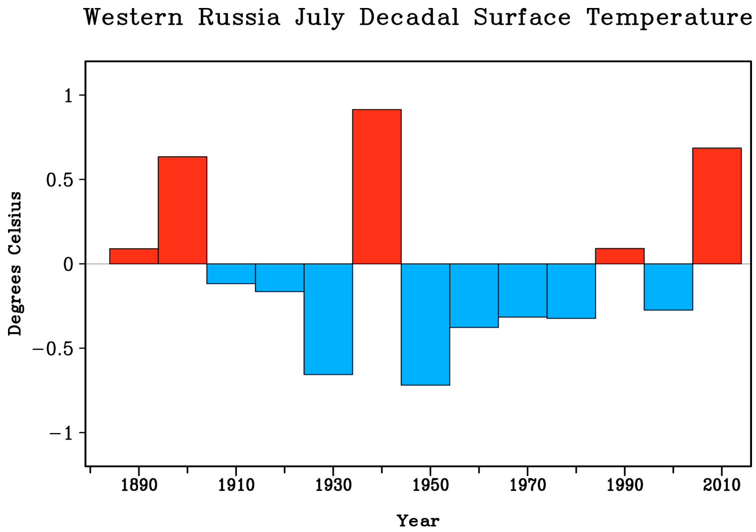
Addressing many of the most urgent societal challenges we face, from early warning on potential disasters to longer-term adaptation, will require a more unified approach than in the past toward understanding and predicting phenomena that connect short-term weather with longer-term climate variations and change.

Toward this end, increased collaborations between the weather and climate communities can play a vital role in accelerating progress.

Additional Slides

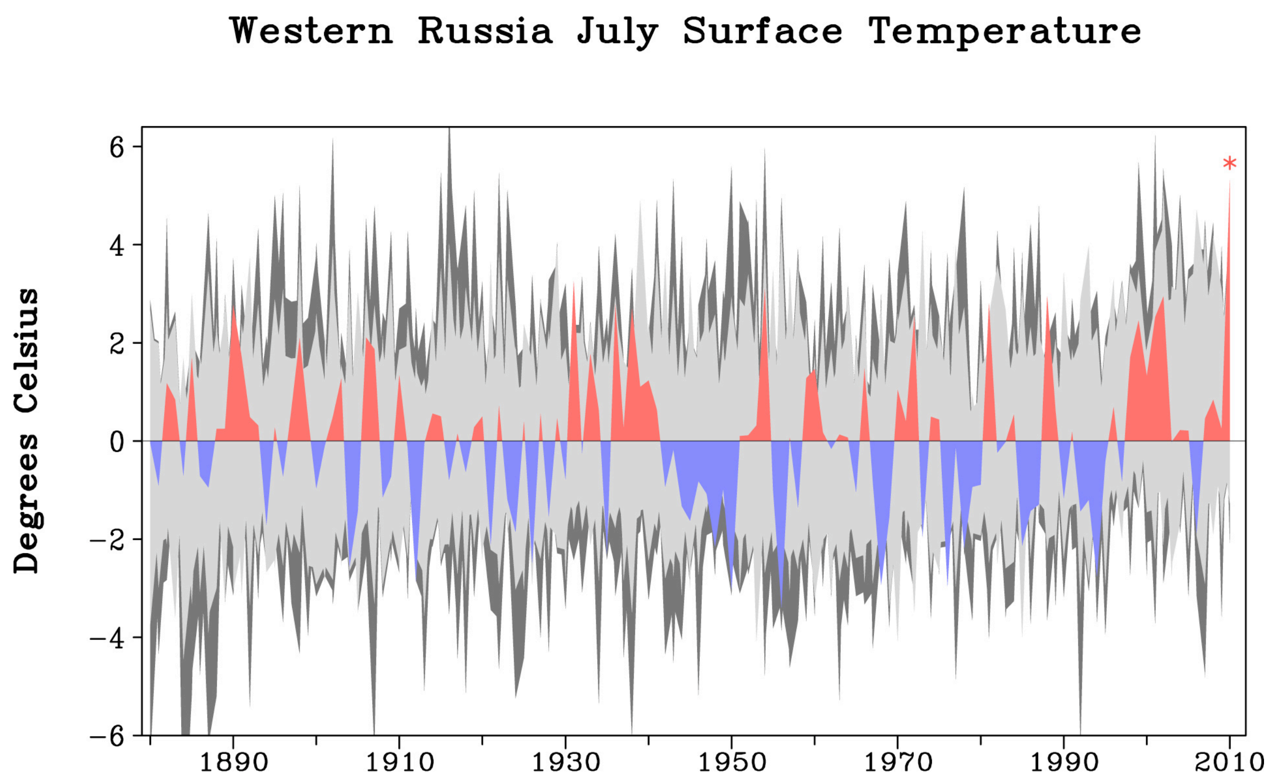


Decadal variability



- July Surface Temperature change over 130 years near zero (0.0 to -0.4^{o}C)
- Prior large heat waves were distributed throughout the period
- No statistically significant changes in either mean temperatures or variability
- Between first and second halves of 130-year period

CMIP3 Model Simulations 1880 to present



Red/Blue – observed temperatures
Black – range of CMIP3 model simulations
Grey– CMIP3 simulations scaled by obs. 1880-2009 variability

- **CMIP3 models show mean warming (0.7° C) but no trend or clustering in extreme warm events**
- **Observed heat wave was within the range produced by models**