Attribution of Climate Events

Day 1……Tuesday 17 August

Overarching Question I

What are the science requirements and capabilities for near-realtime attribution?

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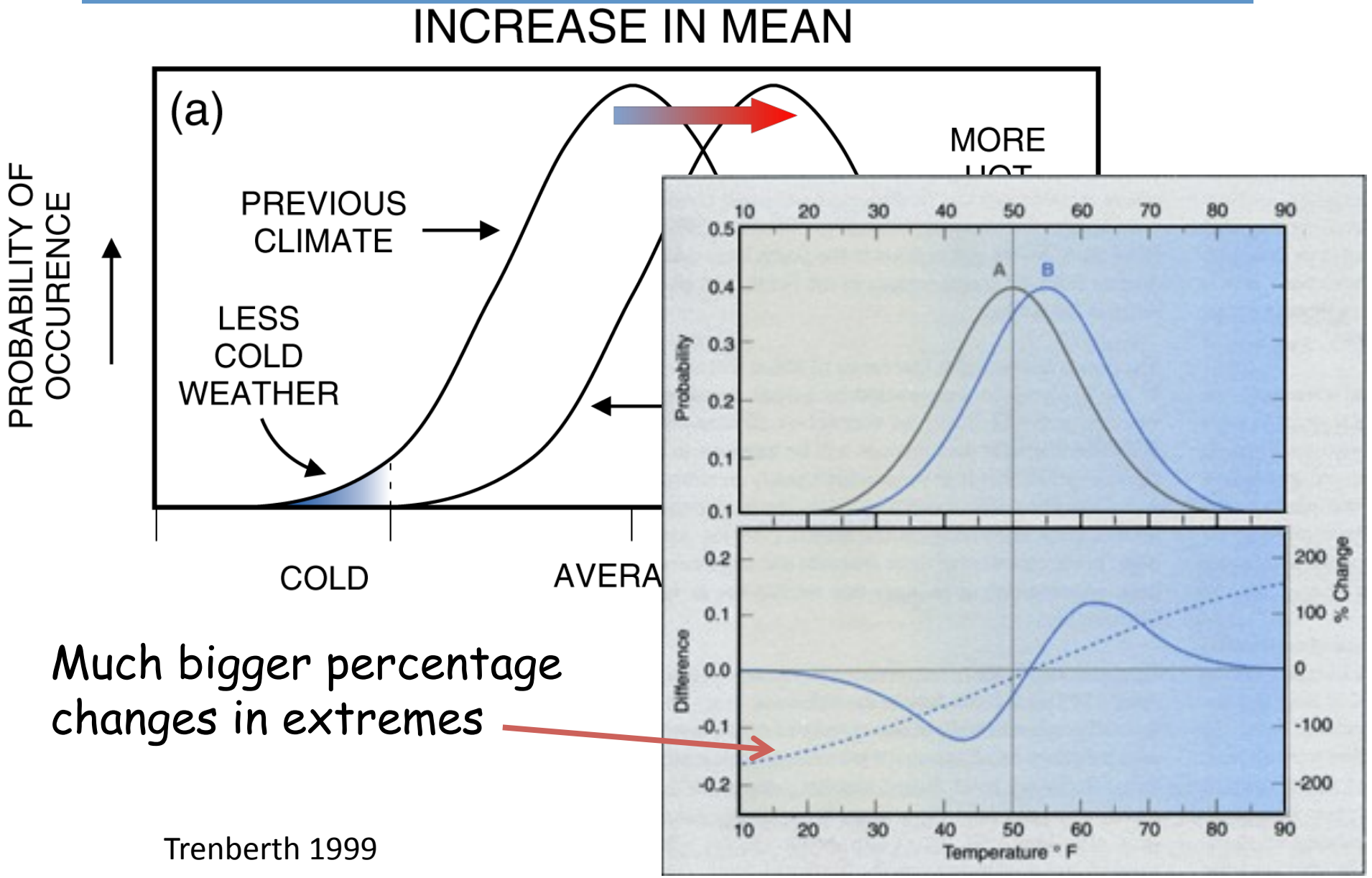
Issues

- What is an event?
- What gaps exist?
- What tools?
  - Observations, analysis, models
- How good are the datasets?
- How well do we know? -trends, etc?
- We need **context**: as long a record as possible and good estimates of the variability (pdf) and extremes
- We need to build confidence in all the links in the chain of events/causality
- What forcings?
- We should perform model studies, numerical experimentation, in real time

Reason for focus on extremes



Much bigger percentage changes in extremes

Trenberth 1999

Framing question

What is goal of attribution?

- Assigning FAR? Numerical values?
- Determine processes and physical mechanisms? Causes?
- What is human influence?

Questions

- Are models the right tools?
- What can be said from data? How extreme?

Answer:

- Depends on timescale
- Influences on the atmosphere from modeling studies: esp SSTs, boundary forcing
- Processes involved
- Valuable to understand phenomena and predictability
- Human influence has predictability

Reasons for attribution

- If we understand what is going on and why, then it provides a strong basis for future prediction
- Provides tests for models and understanding
- If we can not attribute: either not predictable, or tools not adequate
- May not be predictable (if chaotic)
- Useful to know implications for planning
  - Human influence continues
  - Trends continue
  - Is the past an indicator of the future?

Real climate change is manifested as individual events at local places, not all places at once

Issues for extremes

- Data are "messy", limited length
- Often data are not available with right sampling
- Spatial scales vary: tornadoes to droughts
- Spurious trends (e.g. tornadoes, from more people)
- Extremes are inherently rare
- Terminology: High impact but not really extreme?
- Model definitions are often different
- Model grid box value may not be comparable to mean of grid box from observations
- Model data often not available (e.g. hourly)

Global Warming is Unequivocal

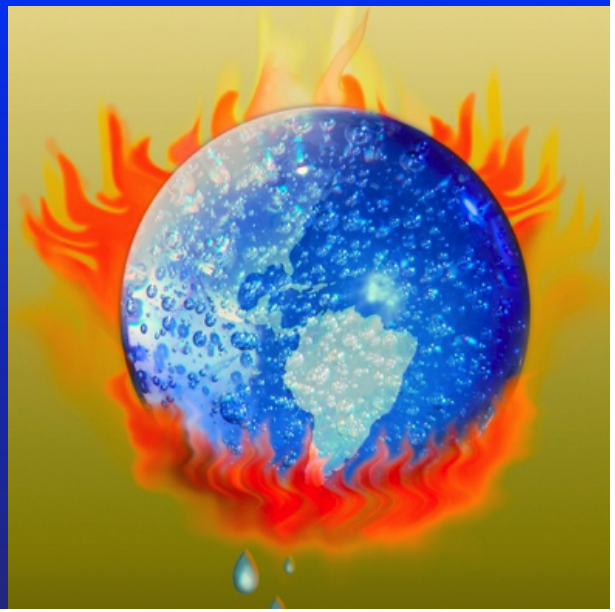
IPCC: approved 113 govts

Since 1970, rise in:

- Global surface temperatures
- Tropospheric temperatures
- Global SSTs, ocean Ts
- Global sea level
- Water vapor
- Rainfall intensity
- Precipitation extratropics
- Hurricane intensity
- Drought
- Extreme high temperatures
- Heat waves
- Ocean acidity

Decrease in:

- NH Snow extent
- Arctic sea ice
- Glaciers
- Cold temperatures



Global warming is unequivocal

Given the above conclusion from IPCC AR4 what should the null hypothesis be?

1) There is no human contribution; or

2) There is a human contribution (1°C warming, 5% increase in precipitation, etc)

The community makes too many type 2 errors

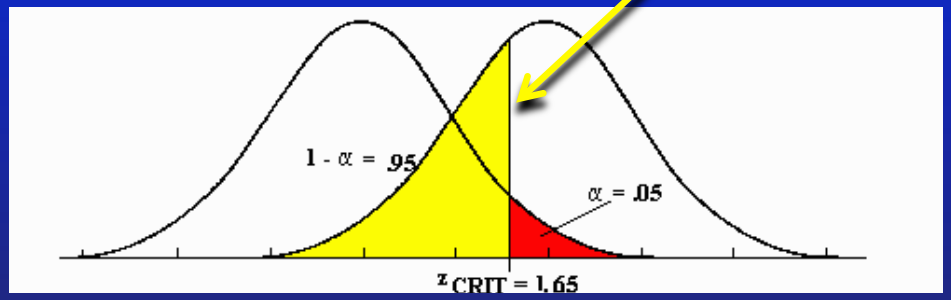
Null hypothesis:

"There is no human influence on climate"

Burden of proof is high. Scientists typically require 95% confidence level (5% significance level)

Type I errors: False positive. Wrongly concluding there is a human influence when there isn't.

Type II errors: False negative. Wrongly concluding there is no human influence, when there is. This kind of error is very common!



Measured / Perceived	Reality: True	Reality: False
True	Correct ☺	Type I False Positive
False	Type II False Negative	Correct ☺

What can be done in real time?

- What is a climate event? (more than a weather instability)
- Hypothesize the chain of events: the factors likely involved
- Compile the statistics, also the trends (can the changing pdf be estimated?)
- Compile the stuff already worked on: understanding well in hand
- Some numerical experimentation
  - Specify anomalous SSTs, sea ice, soil moisture
  - If successful, can then try to say why they are anomalous: role of ENSO, GW etc
  - What are metrics for success?
- Carry out assessment

There is a whole lot that can be said in real time to the public

Ask the right question!

- Is it global warming?
- Is it natural variability?

These are **not** the right questions: do not have answers.

We can estimate how rare an event was based solely on observations (requires good long data and assumptions of stationary climate)

We may be able to state that the odds are remote that the event could have occurred without warming (or without natural variability).

We may be able to give the change in return period: 100 yr events are now 30 year events

Always a combination of both.

Statements to be made

NOT:

- We can not attribute a single event to global warming
- Depends…

What kinds of statement should be made?

- The human influence of global warming has undoubtedly played a role in this event, and will continue to be a factor in future
- Individual events are dominated by aspects of natural variability, and these vary from event to event
- The way climate change is experienced is through individual extreme events, whose odds increase with global warming

Russian heat wave attribution

Train of causation /evidence

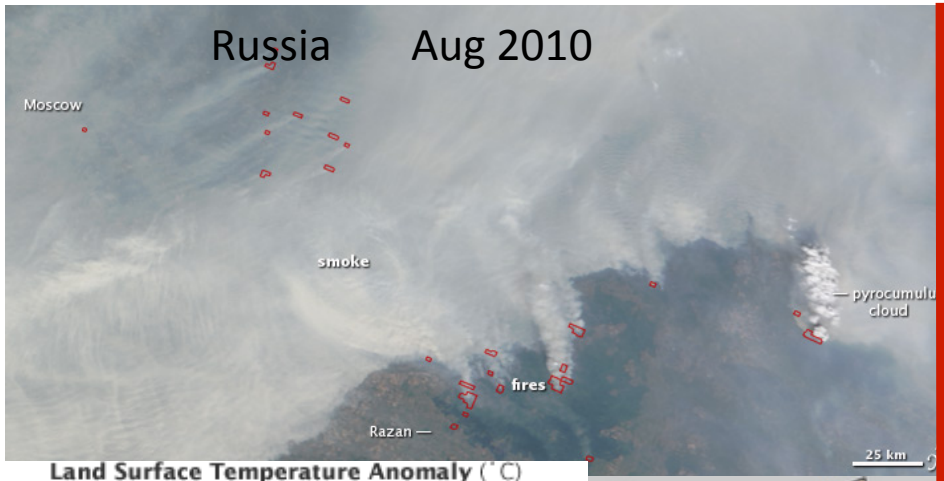
There is a climate event, with observational evidence:

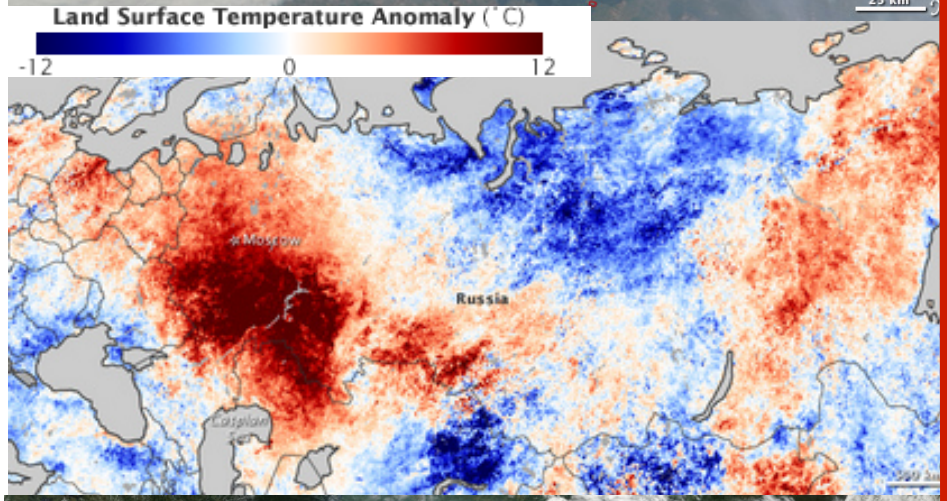
1) Record high temperatures in Russia, heat waves, wild fires, over a month
2) High SSTs in tropical Indian Ocean, western Pacific
   - Role of global warming
   - Role of El Nino/La Nina
3) Arctic sea ice loss: near record low
4) High precipitation, flooding in Pakistan, India, China: SE Asia
   - Extra moisture from high SSTs in monsoonal flow
   - Distribution linked to La Nina

Aug 2010 Pakistan

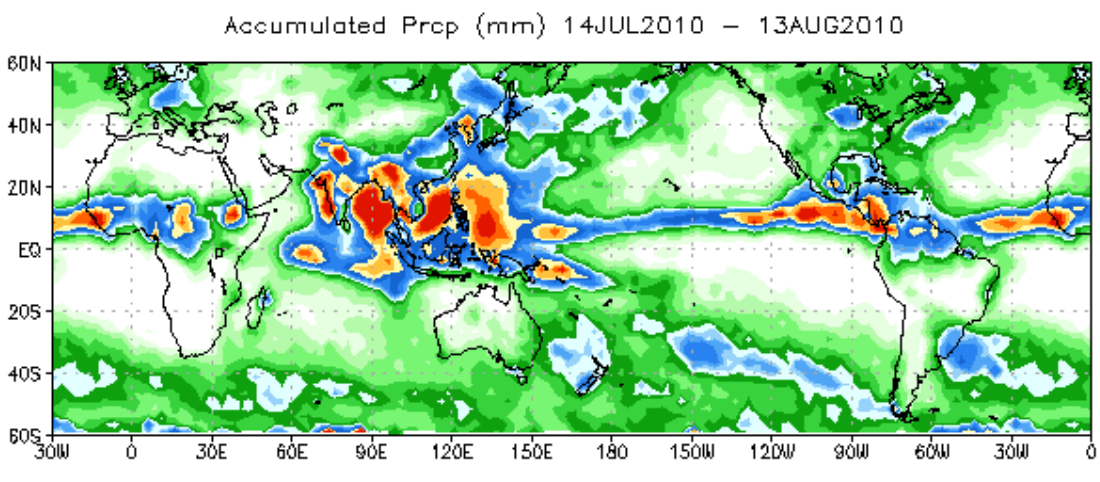
Russia

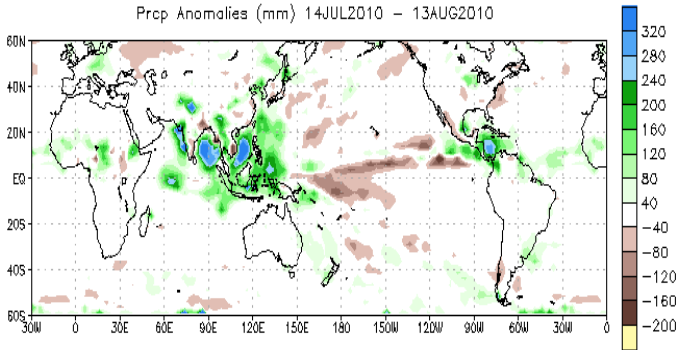
China

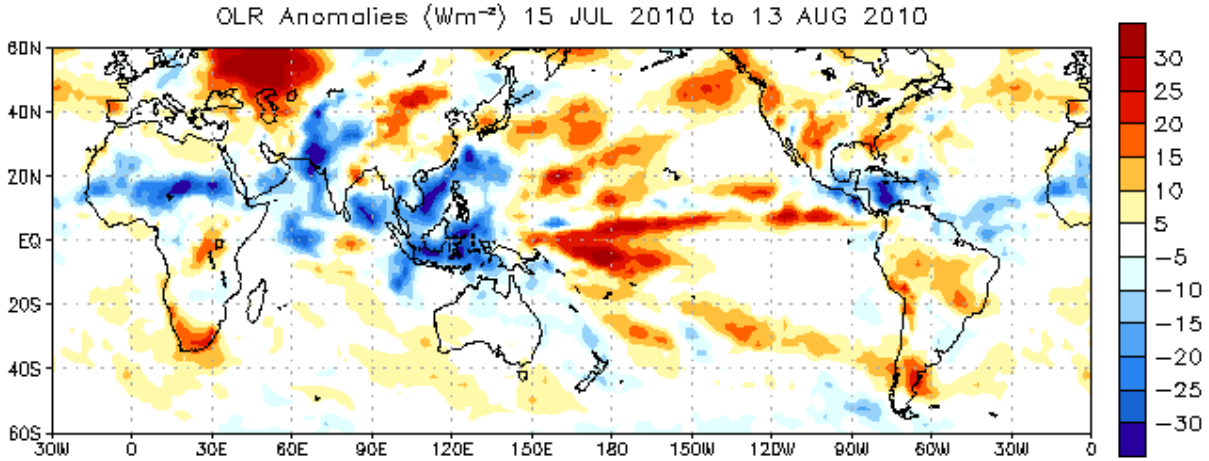


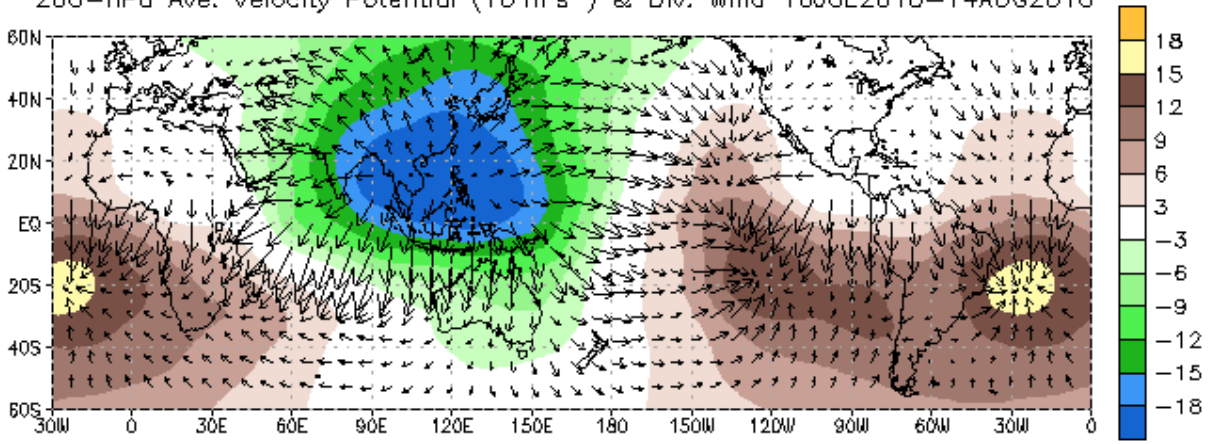


Courtesy NASA





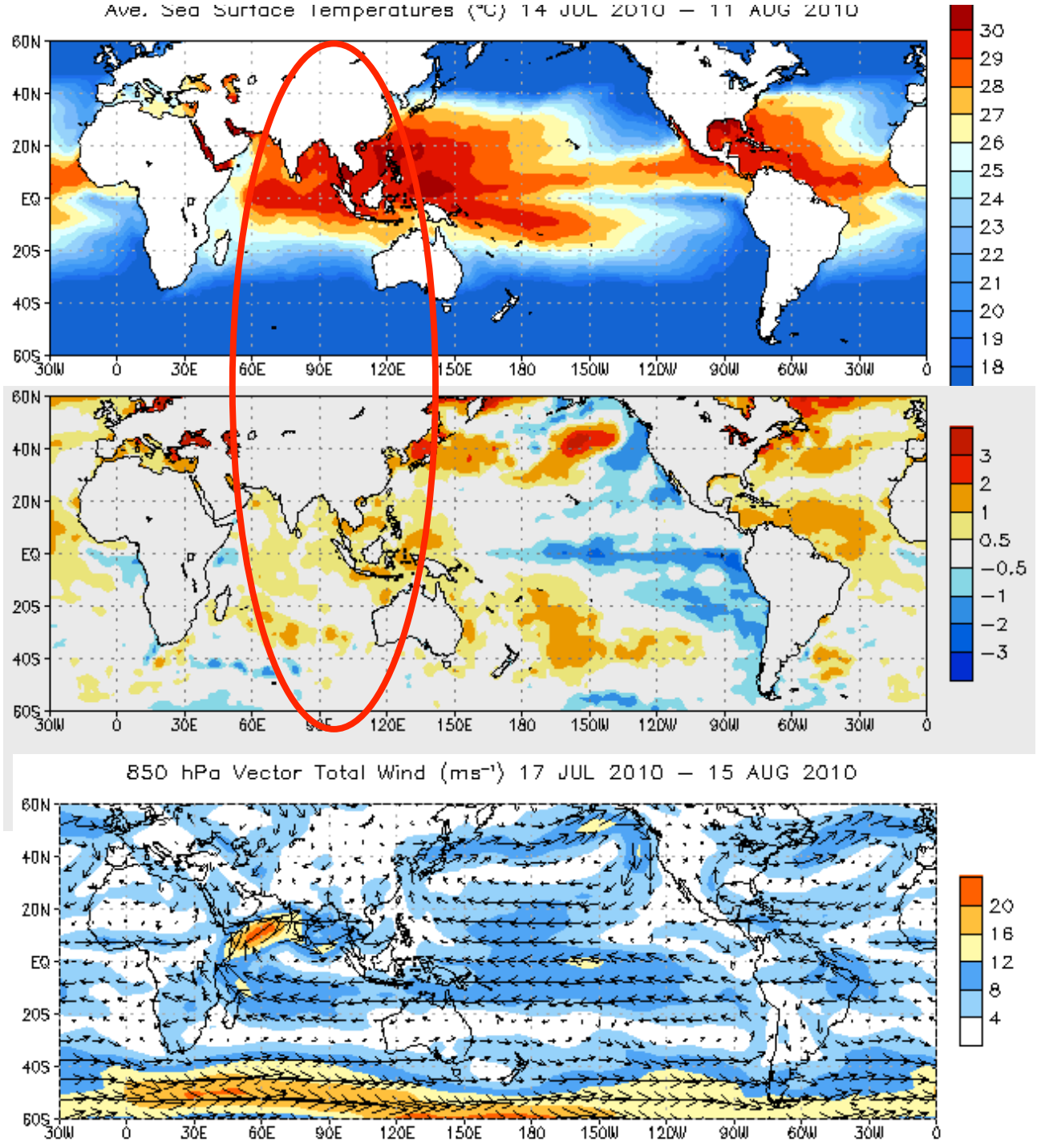




Mid July-mid Aug

Are there links between floods in Asia and heat waves and wild fires in Russia?

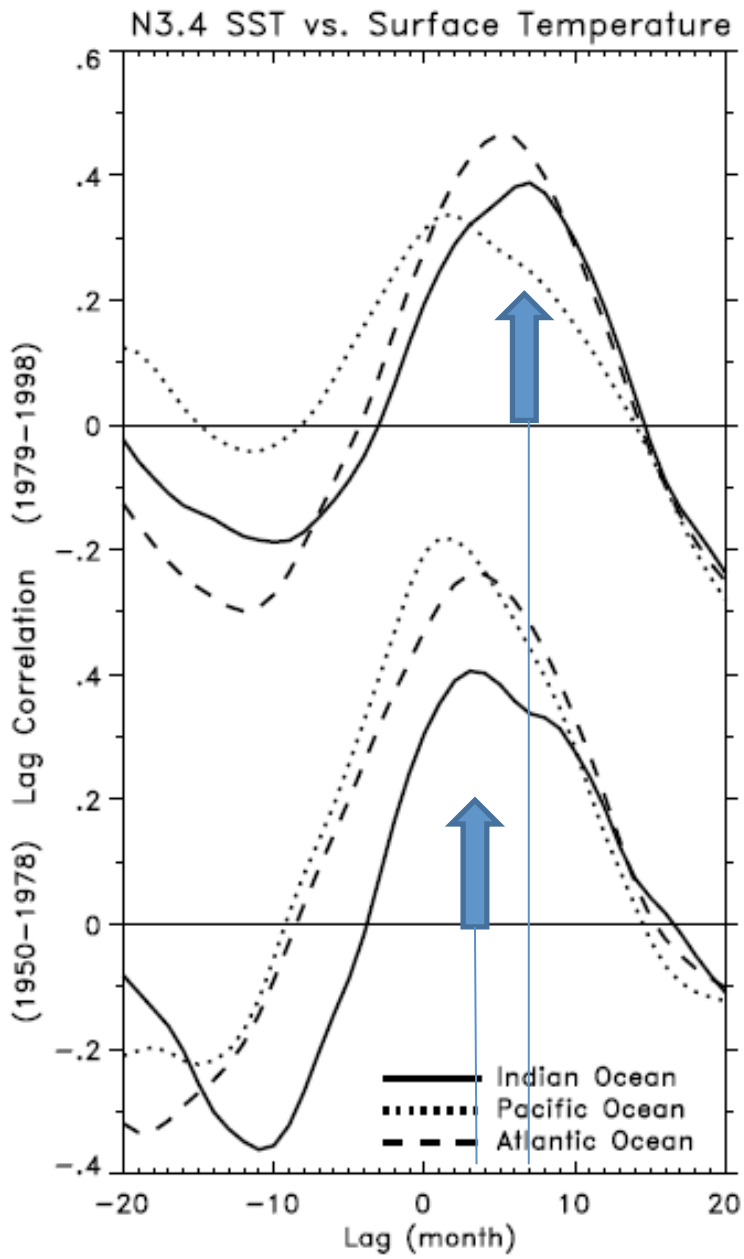
From CPC, NOAA



14 Jul-11 Aug

In tropical Indian Ocean, SSTs were over 29°C, and 1°C above pre 1970 values.

Contributes to 8% extra moisture in the onshore monsoons winds and has undoubtedly contributed to the excessive rains and flooding in India, China and Pakistan



Indian Ocean SSTs lag Nino3.4 by 4 to 7 months: the high IO SSTs in July-Aug 2010 are partly a response to the May 2009—May 2010 El Nino from light winds (less evaporative cooling) and sunny skies.

SSTs were also higher than pre-1970 values by about 0.5°C from global warming

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Train of causation /evidence

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   - Distribution linked to La Nina
5) Anomalous diabatic heating of atmosphere: anomalous OLR
6) Anomalous overturning circulation and teleconnections
7) Anomalous persistent blocking over Russia for many weeks
8) Drought
   - Role of GW: longer, more persistent, more intense
9) High temperatures, heat waves
10) Wild fires, air pollution
11) Deaths (1000s), breathing problems, discomfort, hospitals full
12) Economic losses

Proactive: Hurricane example

- What happened to all the expected hurricanes in Atlantic in 2010?
- What was the role of very active Indian Ocean sector?
  - The excessive action over IO suppresses activity in Atlantic
- Record high SSTs, but action through mid August modest at best.
  - Could pick up in latter August and September

Capabilities

- Context: observations, time series, statistical analysis, reanalyses, paleo-data
- Diagnostic tools
- Some modeling capabilities available:
  - Recognize limitations
  - Depends on time scale
- Recognize train of possible factors in the event(s)
- Various assessment reports available (IPCC, SAPs)
- Detailed analysis of event, and likely factors involved
- Numerical experimentation:
  - Limited in real time

Needs and improvements

- Real time observations and processing
- More and better observations
- Longer time series: homogeneous, reprocessed
- Improved and additional quantified diagnostics
- Better models
- More computer time

Attribution is an essential part of climate services

Communication

- Spread of different opinions in NOAA, in NASA etc. makes communication with public and decision makers difficult
- Scientists argue at cutting edge
- What can we agree on?
- Can we say this consistently and stay on message?
- Lead with what you know, not what you don't know.
- Emphasize "facts", evidence, understanding and then where uncertainties lie
  - Is it global warming?
  - Is it natural variability?
  - These are the wrong questions
- It is always both. The question is how much?
- What is the right question?
- Need right framing
- Real climate change is manifested as individual events at local places, not all places at once