Tracking Blackmon’s Storm Tracks

Gerald R. North
Texas A&M
Today's Items

- First Encounter with MLB: 1974
- Blackmon’s 1970s, 80s Storm Track Papers
- Whither Storm Tracks (..2007..)
- Water in Texas, SW US
1974-75

The Correlated Trails of MLB and GRN up to 1974

Advanced Study Program (ASP) in those Days

1974 Residents of the Fifth Floor Tower

And What a Time it was! (and we never looked back)
Rogues’ Gallery of Fifth Floor Frequenters
1974-75

Chuck Leith, Phil Thompson, Jack Herring, Mike Wallace, Will Kellogg, Peter Gilman, Annick Pouquet, ...

Occasionally: Bernhard Haurwitz, Steve Orszag, Robert Kraichnan, ..
Jerry and Physics Prof. Emeritus Charles J. Goebel*
November 2006 in Madison

*PhD Advisor to GRN, but Coauthor with MLB
Storm Track

- Height Field Fluctuations
- Filtering
- Paths of Fluctuations
- Covariances in Space/Time
- Connection to Traditional Storm Tracks
A Climatological Spectral Study of the 500 mb Geopotential Height of the Northern Hemisphere

MAURICE L. BLACKMON

National Center for Atmospheric Research, Boulder, Colo. 80303
(Manuscript received 19 September 1975, in revised version 21 April 1976)

ABSTRACT

A 10-year record of the 500 mb geopotential height for the Northern Hemisphere has been expanded into spherical harmonics and filtered in the time domain. Maps of the root-mean-square (rms) height have been constructed corresponding to different spatial scales and frequency bands. The spatial scales and frequency bands were chosen to emphasize blocking and cyclogenesis and to help isolate spurious, high-frequency parts of the field from the physically meaningful parts. We find that low-frequency fields are dominated by planetary-scale waves at high latitudes and by synoptic-scale waves at mid-latitudes. The medium-frequency fields get substantial contributions from the waves of synoptic scale and shorter.

Power spectra of the spherical harmonic expansion coefficients are presented, as well as quadrature spectra for each pair of cosine and sine expansion coefficients. We find large-scale waves have a large amount of low-frequency power and a spectrum rapidly decreasing with frequency. Shorter waves have less low-frequency power but have more slowly decreasing power with frequency. We also find westward propagation dominating the longer waves while the shorter waves propagate eastward.

All calculations are performed for both the winter and summer seasons.
Spatial Filtering

Fig. 1. Positions of the nonzero expansion coefficients in $n, m$ space. The dots ($m=0$) signify one nonzero coefficient while the crosses indicate two nonzero coefficients. The triangle and the trapezoids divide the wavenumbers into the three regimes discussed in the text.
and Temporal..

**Fig. 2.** The amplitudes of the filters as a function of frequency.
Winter Mid Pass Filtered rms 500 mb Heights

waves in Regime II, contour interval 2 m

Blackmon 76
Mid Pass Filtered rms 500 mb Heights

Blackmon 76
**Table 2a. Power spectra as a function of wavenumber and frequency for the winter season. Units: m² rad**

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**Hint:** Cyclostationary Methods might be useful here
For both summer and winter, the power is greatest for relatively small $n$ and $m$, the maximum in winter and summer occurring at wavenumber $(n,m) = (5,1)$. There is much less power in summer than in the winter. Also, the decrease in power in wavenumber space away from $(n,m) = (5,1)$ is less rapid in summer than in winter.
An Observational Study of the Northern Hemisphere Wintertime Circulation

Maurice L. Blackmon
National Center for Atmospheric Research, Boulder, Colo. 80303

John M. Wallace, Ngar-Cheung Lau and Steven L. Mullen
University of Washington, Seattle 98195

(Manuscript received 17 November 1976, in revised form 29 March 1977)
Relationship between Cyclone Tracks, Anticyclone Tracks and Baroclinic Waveguides

JOHN M. WALLACE AND GYU-HO LIM
Department of Atmospheric Sciences, University of Washington, Seattle, Washington

MAURICE L. BLACKMON
National Center for Atmospheric Research, Boulder, Colorado

(Manuscript received 24 March 1987, in final form 4 September 1987)
Space-Time Lagged Correlations

fingerprint of randomly excited, damped waves
Oops, these tracks for highs and lows don’t match those of synoptic experience

Highs go one way, lows another

Non-gaussian, non-linear stuff at work

Still these storm tracks are a very interesting development.

\[
\frac{\partial^2 \psi}{\partial t^2} = \frac{1}{c^2} \frac{\partial^2 \psi}{\partial x^2} - b\psi + \text{Noise}
\] , [not so fast]
Part 3

What Happens with Global Warming?

Hadley Cell expands?

Storm Tracks move polewards?

Implications?
Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America

Richard Seager,1 Mingfang Ting,1 Isaac Held,2,3 Yoichiro Kushnir,1 Jian Lu,4 Gabriel Vecchi,2 Huei-Ping Huang,1 Nili Harnik,3 Ants Leetmaa,2 Ngar-Cheung Lau,2,4 Cuihua Li,1 Jennifer Velez,1 Naomi Naik1

1Lamont Doherty Earth Observatory of Columbia University, Palisades, NY, USA. 2NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA. 3Program in Atmospheric and Oceanic Sciences, Department of Geosciences, Princeton University, Princeton, NJ, USA. 4National Center for Atmospheric Research, Boulder, CO, USA. 5Tel Aviv University, Tel Aviv, Israel.

How anthropogenic climate change will impact hydroclimate in the arid regions of Southwestern North America has implications for the allocation of water resources and the course of regional development. Here we show that there is a broad consensus amongst climate models that this region will dry significantly in the 21st century and that the transition to a more arid climate should already be underway. If these models are correct, the levels of aridity of the recent multiyear drought, or the Dust Bowl and 1950s droughts, will, within the coming years to decades, become the new climatology of the American Southwest.
Climate Model Results: Future SW Moisture

Fig. 1. Modeled changes in annual mean precipitation minus evaporation over the American Southwest (125°W to 95°W and 25°N to 40°N, land areas only), averaged over ensemble members for each of the 19 models. The historical period used known and estimated climate forcings, and the projections used the SRES A1B emissions scenario. The median (red line) and 25th and 75th percentiles (pink shading) of the $P - E$ distribution among the 19 models are shown, as are the ensemble medians of $P$ (blue line) and $E$ (green line) for the period common to all models (1900–2098). Anomalies (Anom) for each model are relative to that model’s climatology from 1950–2000. Results have been 6-year low-pass Butterworth-filtered to emphasize low-frequency variability that is of most consequence for water resources. The model ensemble mean $P - E$ in this region is around 0.3 mm/day.

Seager et al., Science, 2007

**Bottom Line:** Much Less Water in the Southwest
Storm Tracks and Climate Change

LENNART BENGTSSON AND KEVIN I. HODGES

Environmental System Science Centre, University of Reading, Reading, United Kingdom

ERICH ROECKNER

Max Planck Institute for Meteorology, Hamburg, Germany

(Manuscript received 25 April 2005, in final form 11 September 2005)

ABSTRACT

Extratropical and tropical transient storm tracks are investigated from the perspective of feature tracking in the ECHAM5 coupled climate model for the current and a future climate scenario. The atmosphere-only part of the model, forced by observed boundary conditions, produces results that agree well with analyses from the 40-yr ECMWF Re-Analysis (ERA-40), including the distribution of storms as a function of maximum intensity. This provides the authors with confidence in the use of the model for the climate change experiments. The statistical distribution of storm intensities is virtually preserved under climate change using the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) A1B scenario until the end of this century. There are no indications in this study of more intense storms in the future climate, either in the Tropics or extratropics, but rather a minor reduction in the number of weaker storms. However, significant changes occur on a regional basis in the location and intensity of storm tracks. There is a clear poleward shift in the Southern Hemisphere with consequences of reduced precipitation for several areas, including southern Australia. Changes in the Northern Hemisphere are less distinct, but there are also indications of a poleward shift, a weakening of the Mediterranean storm track, and a strengthening of the storm track north of the British Isles. The tropical storm tracks undergo considerable changes including a weakening in the Atlantic sector and a strengthening and equatorward shift in the eastern Pacific. It is suggested that some of the changes, in particular the tropical ones, are due to an SST warming maximum in the eastern Pacific. The shift in the extratropical storm tracks is shown to be associated with changes in the zonal SST gradient in particular for the Southern Hemisphere.
Robust Responses of the Hydrological Cycle to Global Warming

ISAAC M. HELD
National Oceanic and Atmospheric Administration/Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey

BRIAN J. SODEN
Rosenstiel School for Marine and Atmospheric Science, University of Miami, Miami, Florida

(Manuscript received 13 September 2005, in final form 17 March 2006)

ABSTRACT

Using the climate change experiments generated for the Fourth Assessment of the Intergovernmental Panel on Climate Change, this study examines some aspects of the changes in the hydrological cycle that are robust across the models. These responses include the decrease in convective mass fluxes, the increase in horizontal moisture transport, the associated enhancement of the pattern of evaporation minus precipitation and its temporal variance, and the decrease in the horizontal sensible heat transport in the extratropics. A surprising finding is that a robust decrease in extratropical sensible heat transport is found only in the equilibrium climate response, as estimated in slab ocean responses to the doubling of CO₂, and not in transient climate change scenarios. All of these robust responses are consequences of the increase in lower-tropospheric water vapor.
Southern Hemisphere Atmospheric Circulation Response to Global Warming

Paul J. Kushner, Isaac M. Held, and Thomas L. Delworth

NOAA/Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey

(Manuscript received 24 February 2000, in final form 1 August 2000)

ABSTRACT

The response of the Southern Hemisphere (SH), extratropical, atmospheric general circulation to transient, anthropogenic, greenhouse warming is investigated in a coupled climate model. The extratropical circulation response consists of a SH summer half-year poleward shift of the westerly jet and a year-round positive wind anomaly in the stratosphere and the tropical upper troposphere. Along with the poleward shift of the jet, there is a poleward shift of several related fields, including the belt of eddy momentum-flux convergence and the mean meridional overturning in the atmosphere and in the ocean. The tropospheric wind response projects strongly onto the model’s “Southern Annular Mode” (also known as the “Antarctic oscillation”), which is the leading pattern of variability of the extratropical zonal winds.
A consistent poleward shift of the storm tracks in simulations of 21st century climate

Jeffrey H. Yin
ESSL/Climate and Global Dynamics Division, National Center for Atmospheric Research, Boulder, Colorado, USA

Received 9 June 2005; revised 12 August 2005; accepted 18 August 2005; published 17 September 2005.

[1] A consistent poleward and upward shift and intensification of the storm tracks is found in an ensemble of 21st century climate simulations performed by 15 coupled climate models. The shift of the storm tracks is accompanied by a poleward shift and upward expansion of the midlatitude baroclinic regions associated with enhanced warming in the tropical upper troposphere and increased tropopause height. The poleward shift in baroclinicity is augmented in the Southern Hemisphere and partially offset in the Northern Hemisphere by changes in the surface meridional temperature gradient. The poleward shift of the storm tracks also tends to be accompanied by poleward shifts in surface wind stress and precipitation, and a shift towards the high index state of the annular modes. These results highlight the integral role that the storm tracks play in the climate system, and the importance of understanding how and why they will change in the future. Citation: Yin, J. H. (2005), A consistent poleward shift of the storm tracks in simulations of 21st century climate, Geophys. Res. Lett., 32, L18701, doi:10.1029/2005GL023684.
Projected Expansion of Dry Regions During Global Warming

TRMM Data, my arrows
March of Seasonal Precipitation (present climate)
Blackmon’s Storm Tracks and their Responses to GW might affect his home state of Texas!