

A map of the United States is shown with a dark blue background. Overlaid on the map are several concentric, irregular contour lines in various colors including orange, yellow, green, blue, and purple. These lines represent areas of climate variability, likely related to winter weather patterns. The lines are more densely packed in some areas, particularly in the central and eastern parts of the country.

Making \$ - Data mining winter climate variability for the U.S. natural gas market

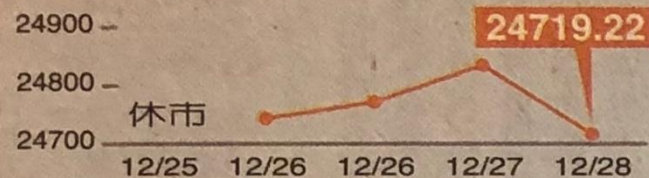
Simon S-Y Wang, Utah State University

from movie Limitless (2011), stocks trading scene

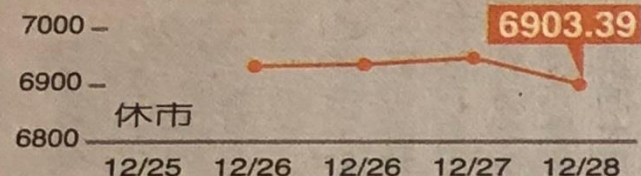


(a dose of superpower – big data)

美股道瓊指數



美股那斯達克指數



上周主要貨幣兌美元升貶幅

貨幣	升貶幅(%)	29日收盤價
人民幣	▲ 0.94	6.5067
日圓	▲ 0.53	112.69
韓元	▲ 1.13	1,067.40
新台幣	▲ 0.4	29.848

資料來源／中央銀行

■ 聯合報

極地寒流來襲

50年最冷跨年 美國天然氣大漲

【編譯黃智勤／綜合報導】在極地冷氣團侵襲下，美國東北部、中西部地區居民將在天寒地凍中迎接新年。這波寒流在美國帶動天然氣價格大漲，且可能導致農作物受損、流感疫情提早報到。

美國氣象局預報，卅一日氣溫可能降至攝氏零下約十二度或更低，為半世紀來最寒冷跨年夜。

據氣象預測，紐約平均溫在新年過後將維持在華氏十九度（約攝氏零下七度），在寒風吹襲之下體感溫度更低，對百萬跨年人潮形成考驗。

由於寒冬推升暖氣需求，紐約天然氣二月期貨廿九日收盤上漲百分之一點三至每百萬英制熱量單位（MMBtu）二點九五三元，盤中最高觸及三點〇〇八美元，為十二月四日以來最高。當周漲幅逾百分之十，為一年來最高。不過，由於今年天然氣產量創紀錄，天然氣期貨今年來仍下挫近百分之廿一。

農業氣象學家則指出，寒流侵襲北美大平原，可能影響冬麥收成，尤其是美國最大冬麥產區堪薩斯州。

該州主要生產適合用來製作西點用麵粉的硬紅冬麥，收成量若受到影響，將使得供應量更為緊繃，因為含高蛋白質的硬紅冬麥在市面已短缺。

在寒冬侵襲與流感疫苗接種率偏低下，美國流感疫情今年也提早報到。美國疾病管制與預防中心公布的數據顯示已接獲卅六個州流感大範圍傳播報告，其中有廿一個州出現較大數量的病案。



BEST STATES



Rising Energy Costs Eyed Amid Brutal Cold Snap Gripping US

Plunging temperatures across half the US underscore stark reality heating aid dollars won't go as far this winter because of rising energy costs;

上周主要貨幣兌美元升貶幅

貨幣	升貶幅(%)	29日收盤價
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資料來源／中央銀行

聯合報

在寒冬侵襲，美國疾病預防控制中心（CDC）已接獲卅多個州流感大範圍傳播報告，其中有廿一個州出現較大數量的病案。

極地寒流來襲 50年最冷跨年

美國天然氣大漲

Arctic cold air intruding

Coldest New Year in 50 years

U.S. natural gas price shooting up!

【編譯黃智勤／綜合報導】在極地冷氣團侵襲下，美國東北和中西部地區居民將在寒地凍中迎接新年。這波寒流在美國引發天然氣價格大漲，且可能導致農作物受損、流感流行。早報到。美國氣象局預報，卅一氣溫可能降至攝氏零下約十二度或更低，為半世紀來最寒冷新年夜。

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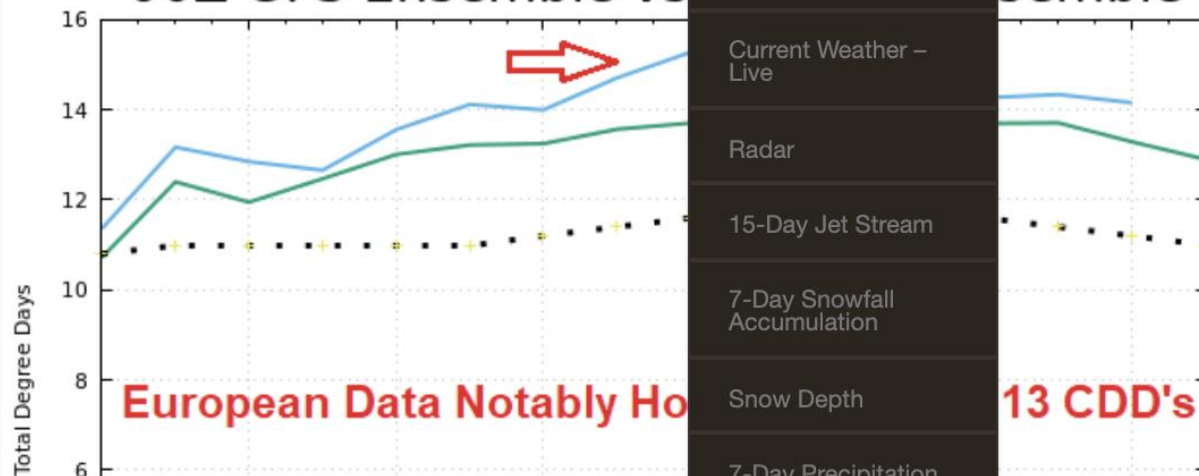
該州生產適合用來製作西點用麵粉的硬冬麥，收成量將受到影響，將使得供應更為緊繃，因含有高蛋白質的硬紅麥在市面已短缺。

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Image of the

NatGasWeather.com Releases Machine Learning/Artificial Intelligence Services! For a free trial or complementary report, email us at helpdesk@natgasweather.com

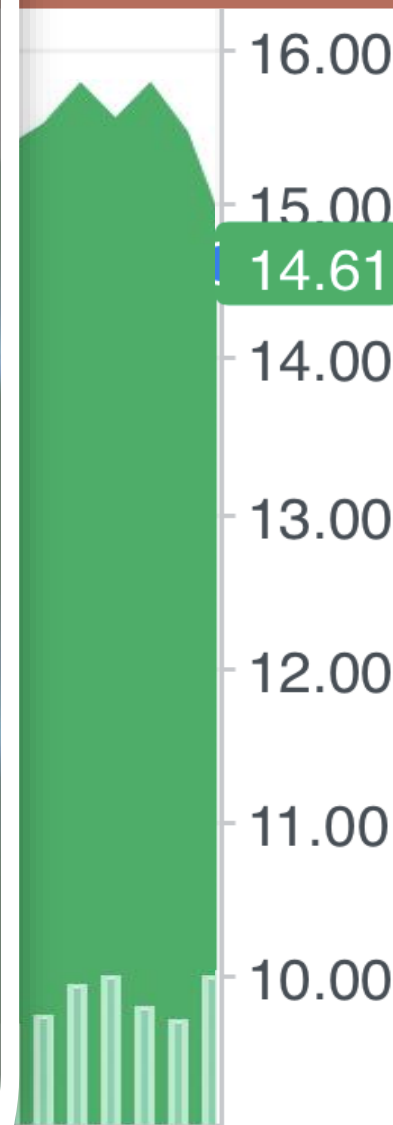
00Z GFS Ensemble vs European Data

[15-Day High's Forecast](#)[15-Day Low's Forecast](#)[7-Day Temperatures vs Normal](#)[CPC/NOAA Outlooks](#)[Current Weather - Live](#)[Radar](#)[15-Day Jet Stream](#)[7-Day Snowfall Accumulation](#)[Snow Depth](#)[7-Day Precipitation](#)

This Weeks Nat Gas Demand



July 9-15: The Southern US remains hot with highs of 90s from Texas to the Southeast, 100s over the Southwest, although with heavy showers over the Southeast for local cooling. Hot high pressure over the southern US will expand to include the northern US the next couple days with highs of upper 80s to near 90°F returning from Chicago to NYC, then cooling back down a few degrees late in the week as a weather system tracks through. The West will be very warm to hot besides the Northwest where showers will lead to cooling. Overall, nation



Feb

A small team of traders at Goldman Sachs made \$100 million betting on natural gas —

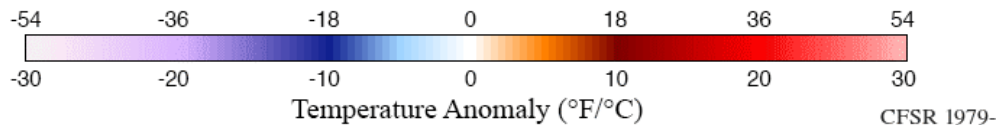
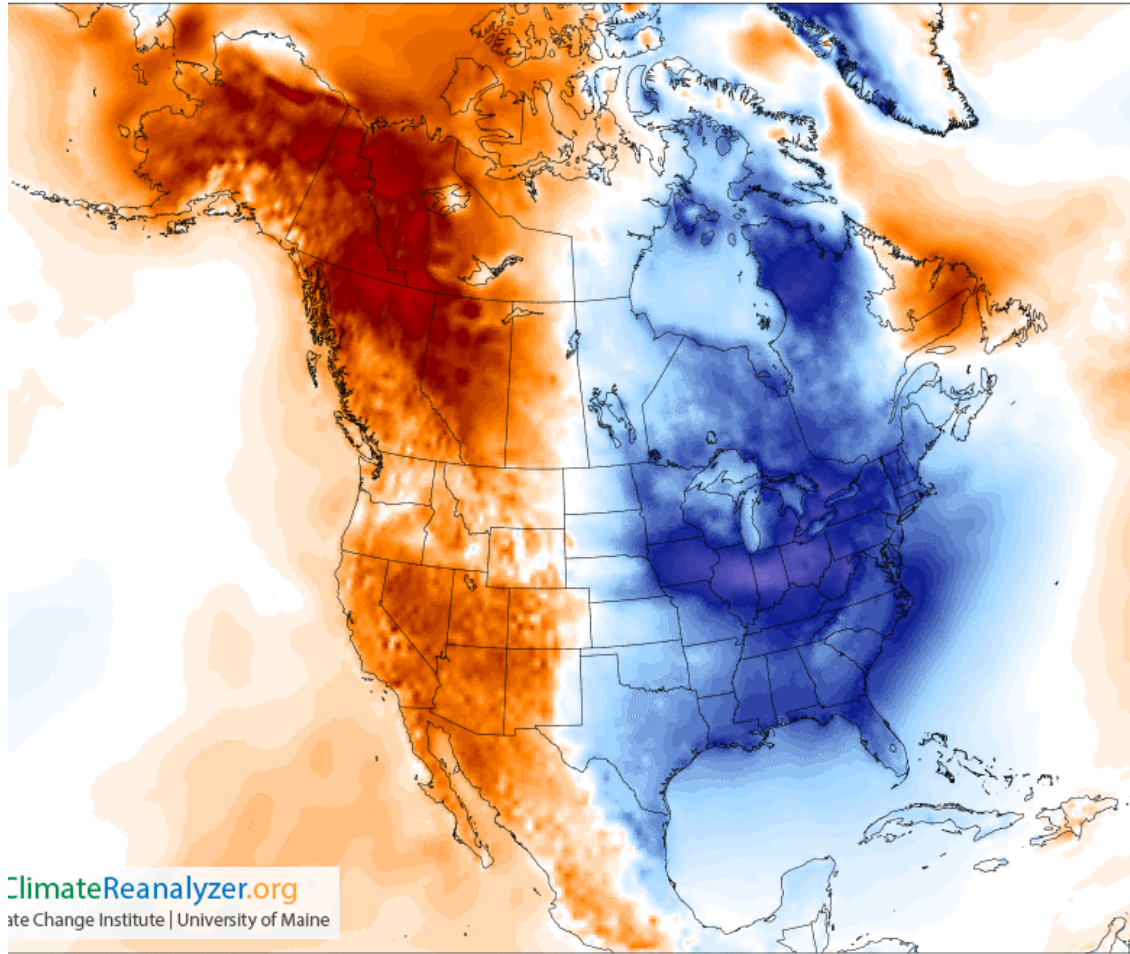
Dakin Campbell Oct. 8, 2018, 7:00 AM

BUSINESS
INSIDER

- Natural-gas prices set records in early January when below-average temperatures accompanied by snowstorms dubbed the "bomb cyclone" led to soaring demand for the commodity,

Temperature Departure from Average
2 GFS 0.25°x0.25°

5-day Forecast Average
Tuesday, Jan 2, 2018



The Washington Post

Business • Analysis

The Bomb Cyclone Breezes Into the Natural Gas Market: Gadfly

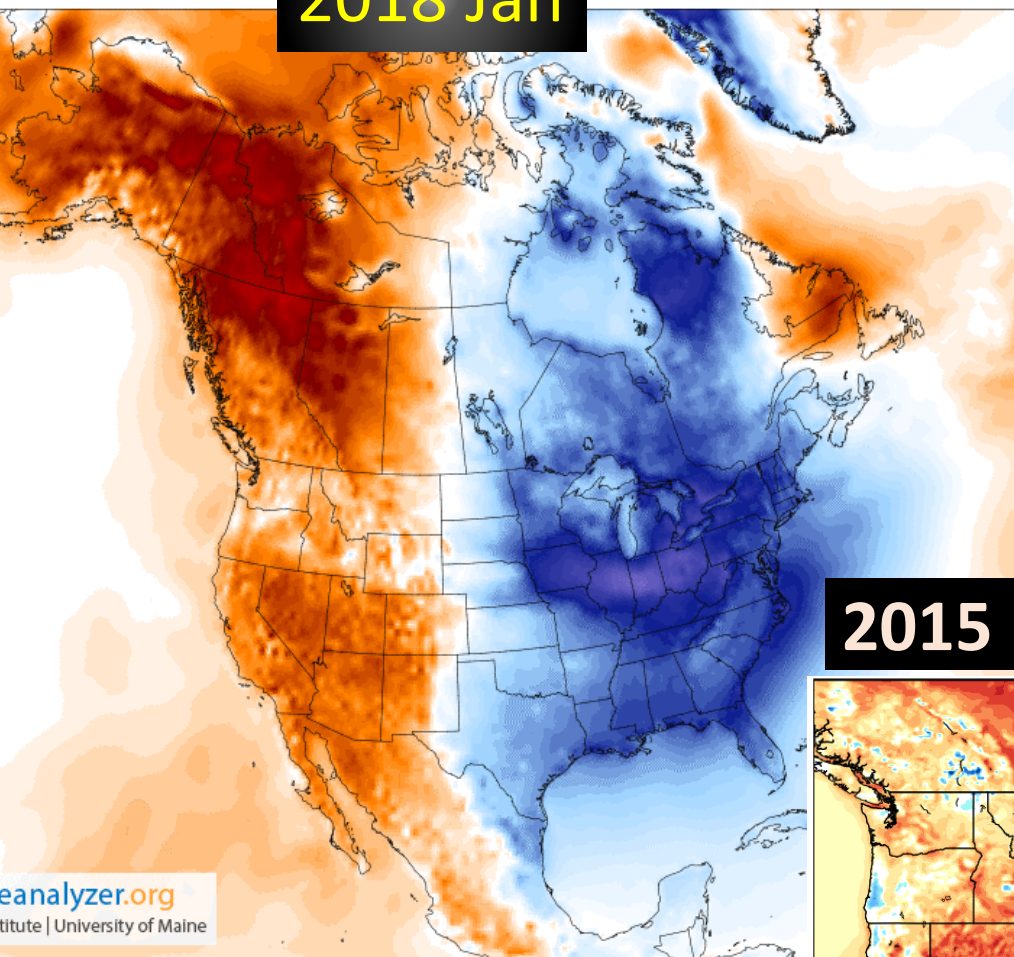
Jan 4, 2018

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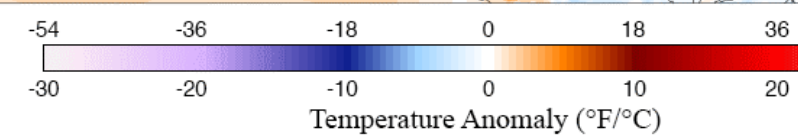
Departure from Average
5°x0.25°

2018 Jan

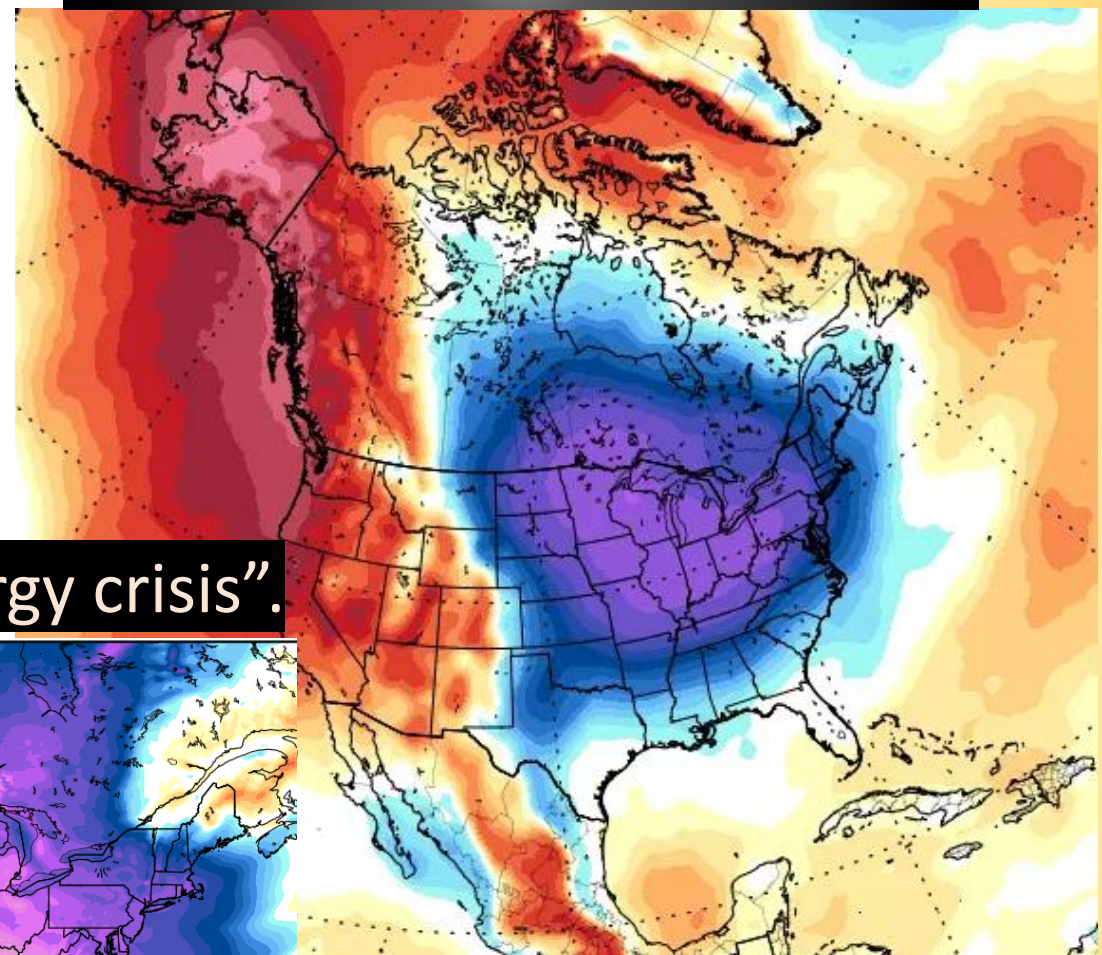
5-day Forecast Average
Tuesday, Jan 2, 2018



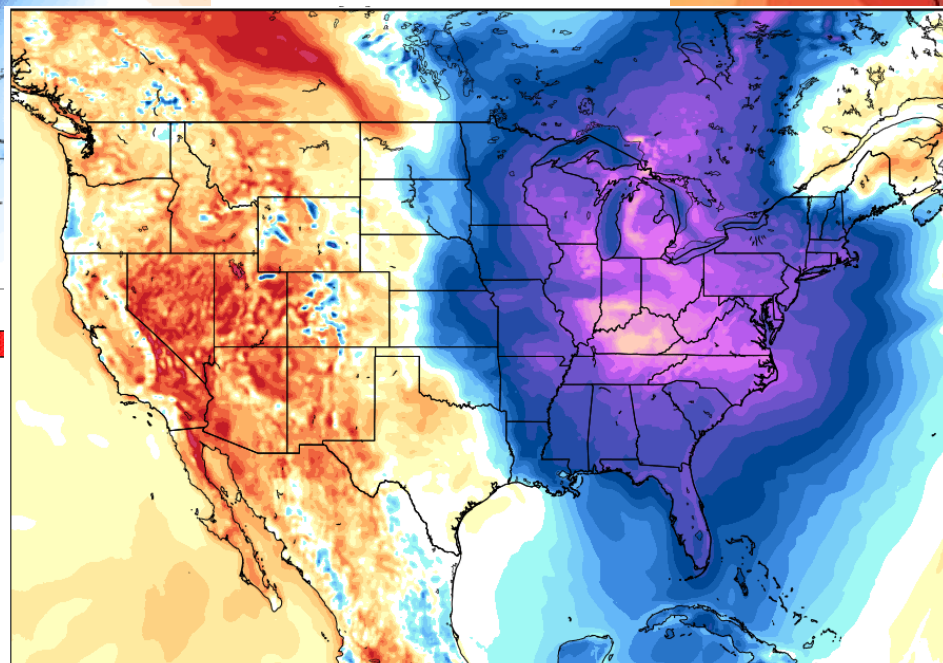
weatheranalyzer.org
Institute | University of Maine



2014 January "polar vortex"



2015 February "energy crisis".



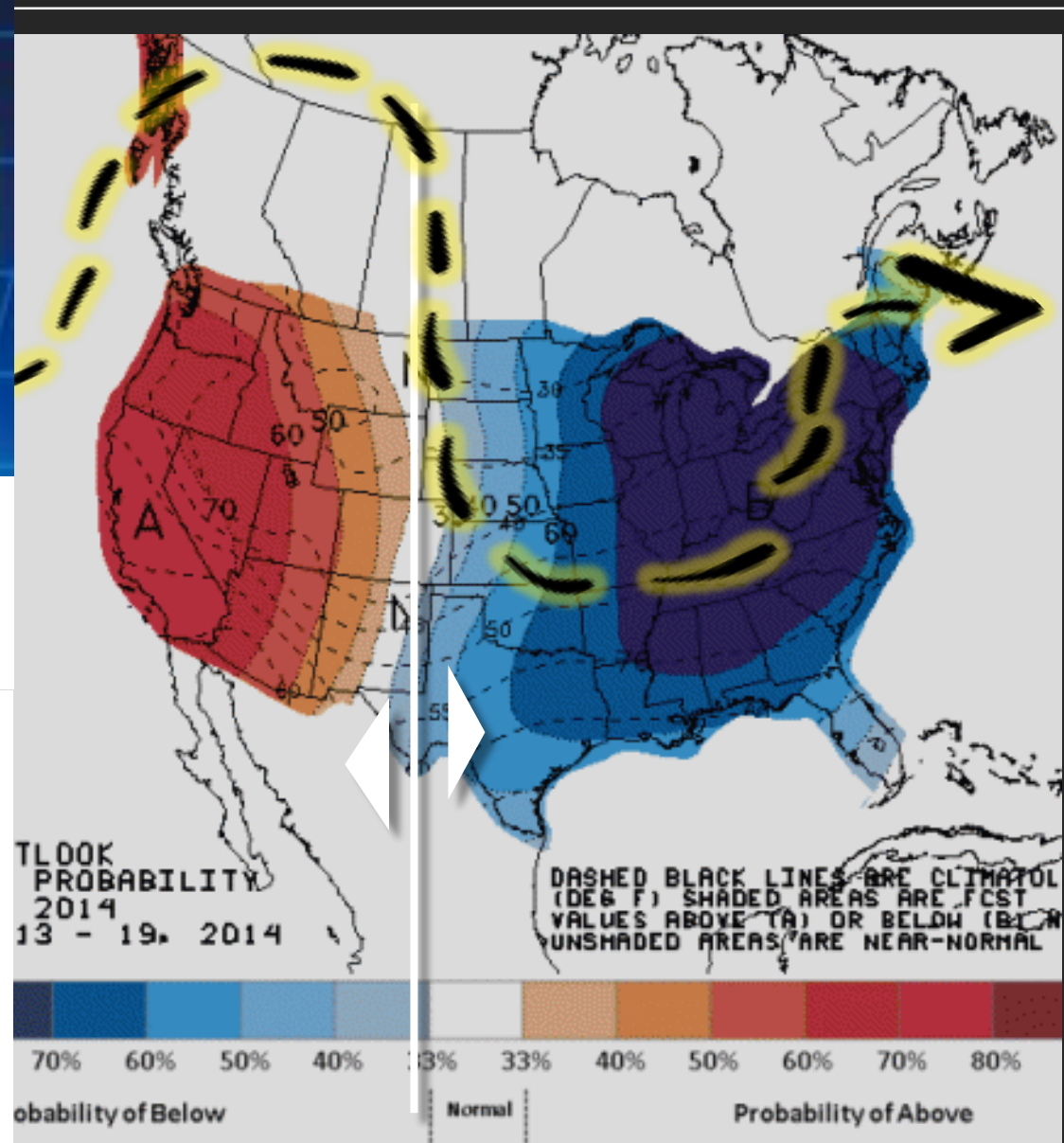


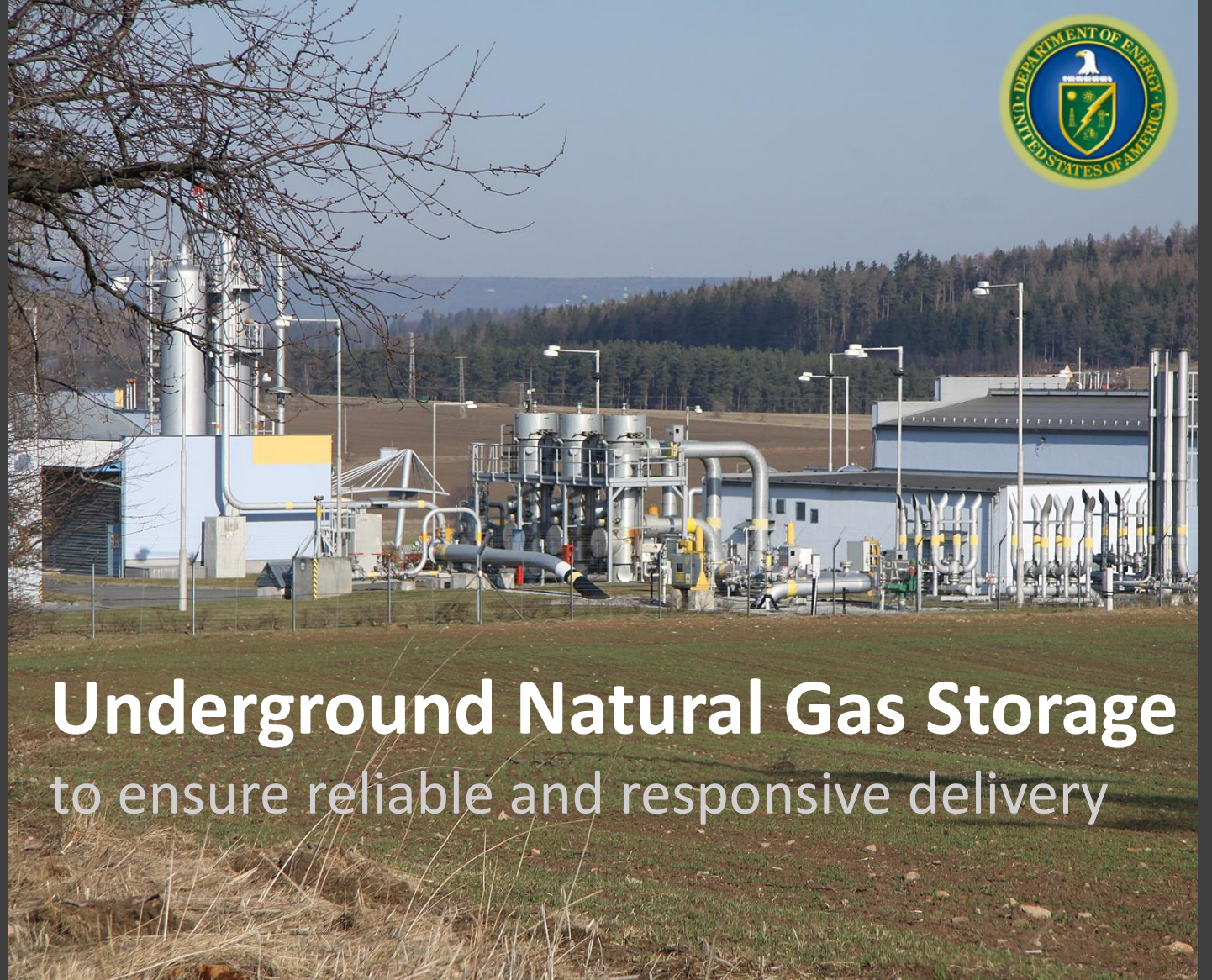
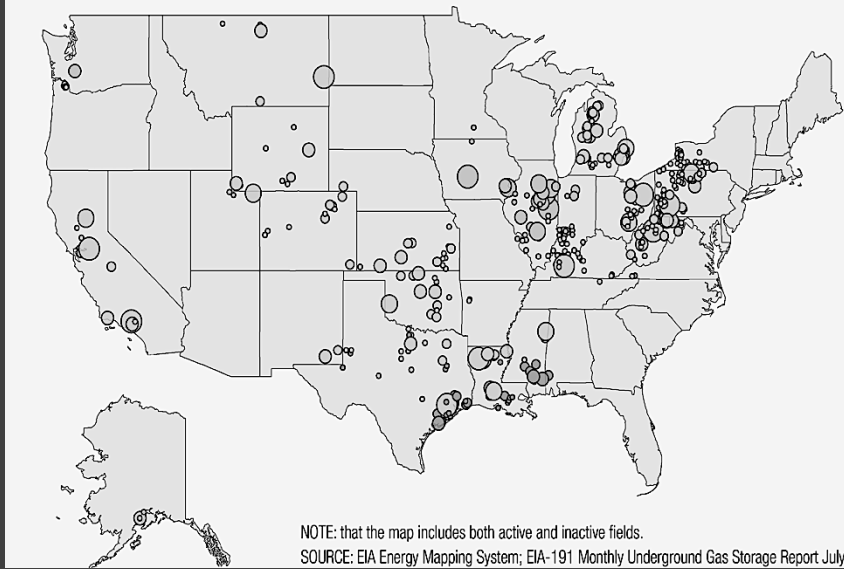
SCIENTIFIC AMERICAN DECEMBER 2014

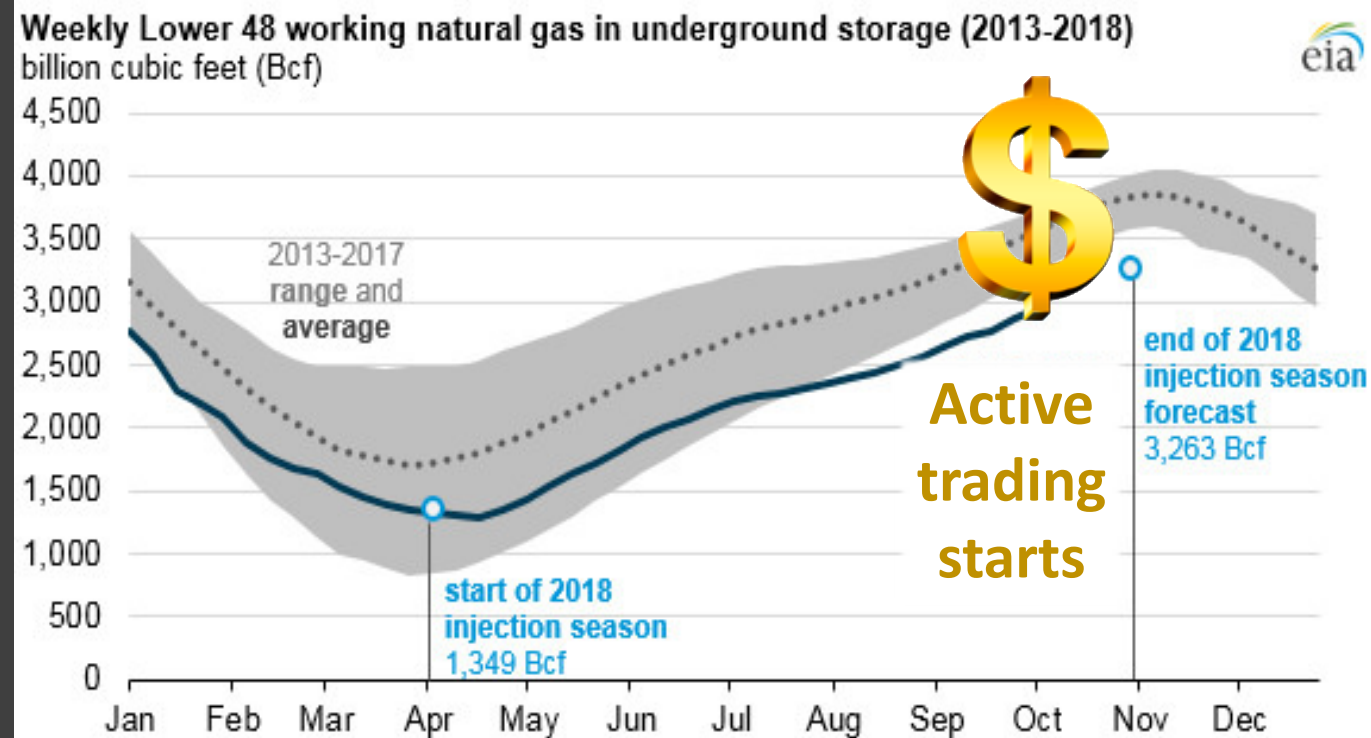
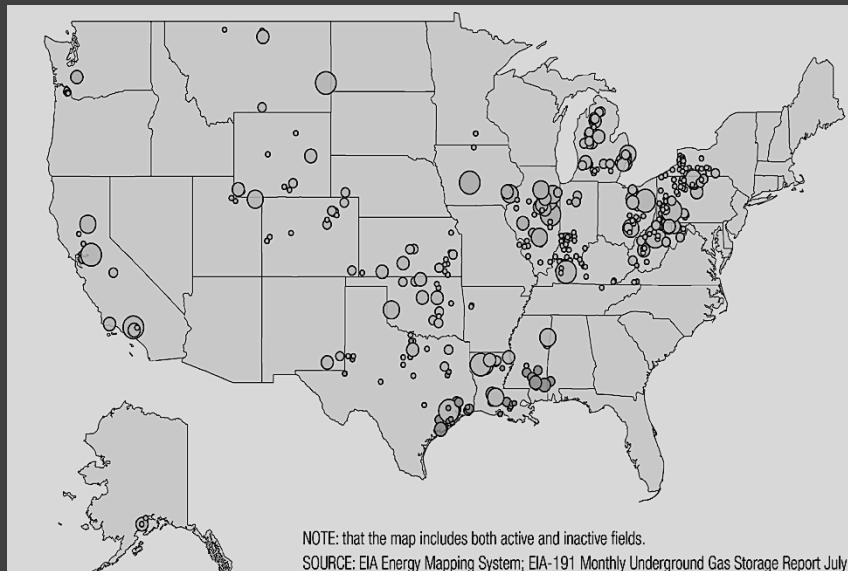
A Wacky Jet Stream Is Making Our Weather Severe

來自「北極暖化 全球震盪。美國科學人雜誌第 155 期」的資訊：

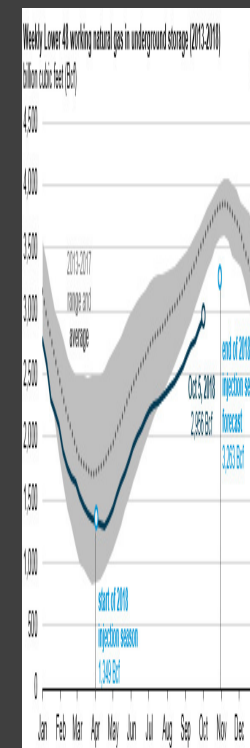
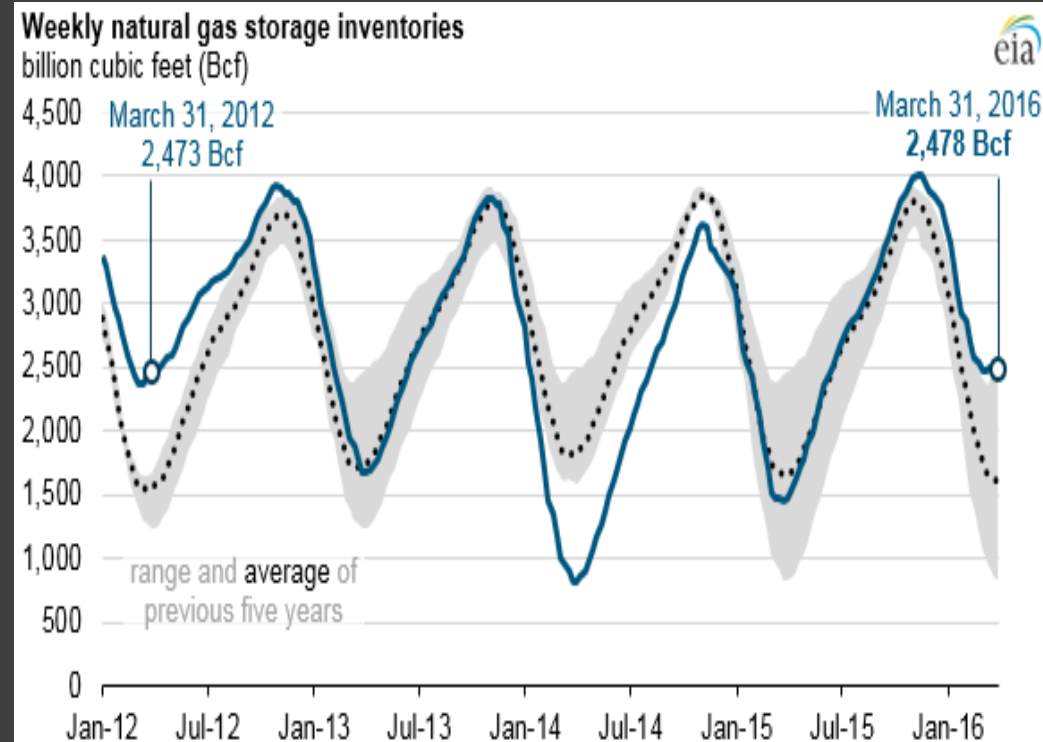
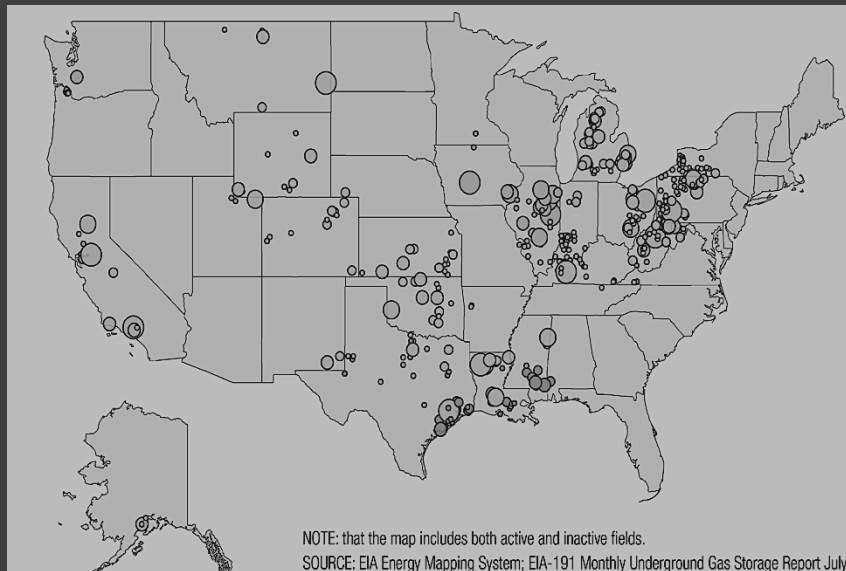
... 美國猶他州立大學的**王世宇**與研究團隊發現，那段時期北美洲上空的噴射氣流為史上最劇烈起伏的形態。







Underground Natural Gas Storage
weekly levels ↑↑

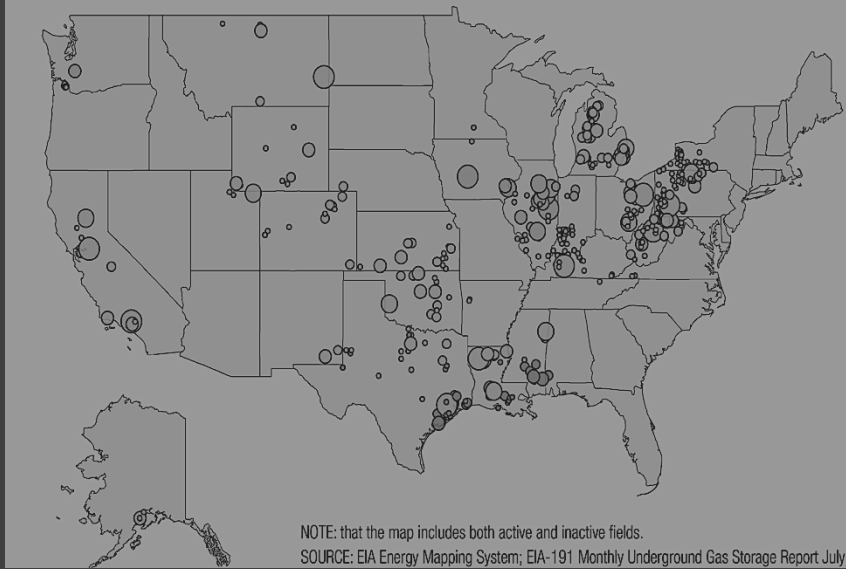


2012 **2014** 2016 **2018**

weekly levels ↑

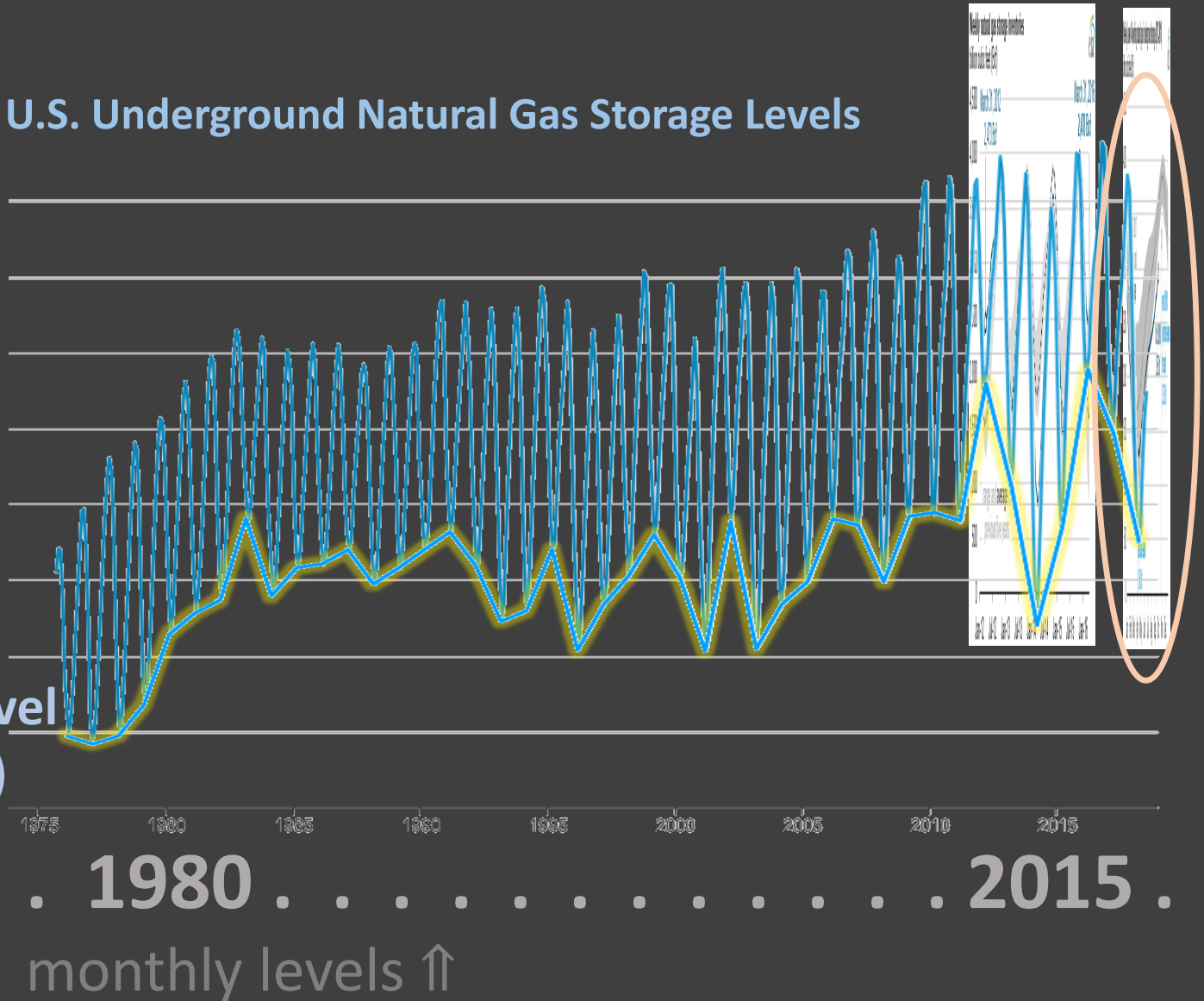


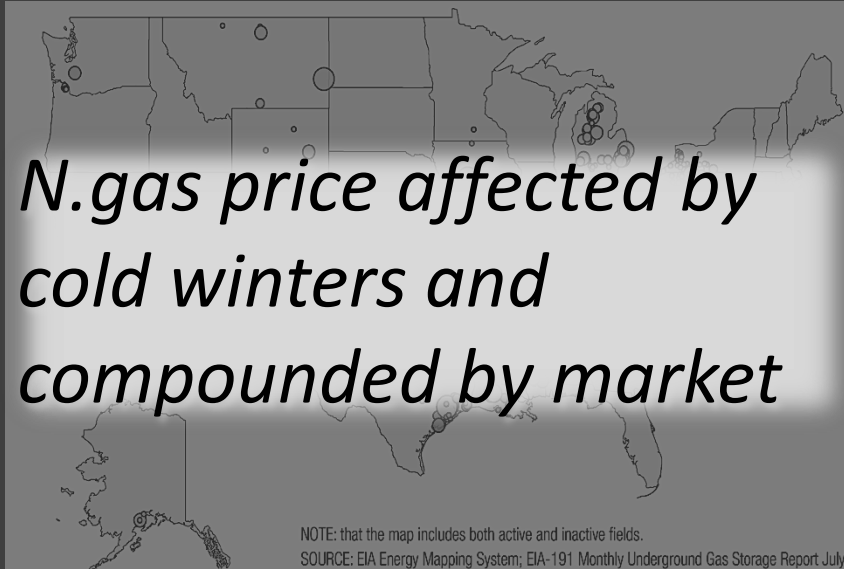
BUSINESS INSIDER | **team of traders at Goldman Sachs**



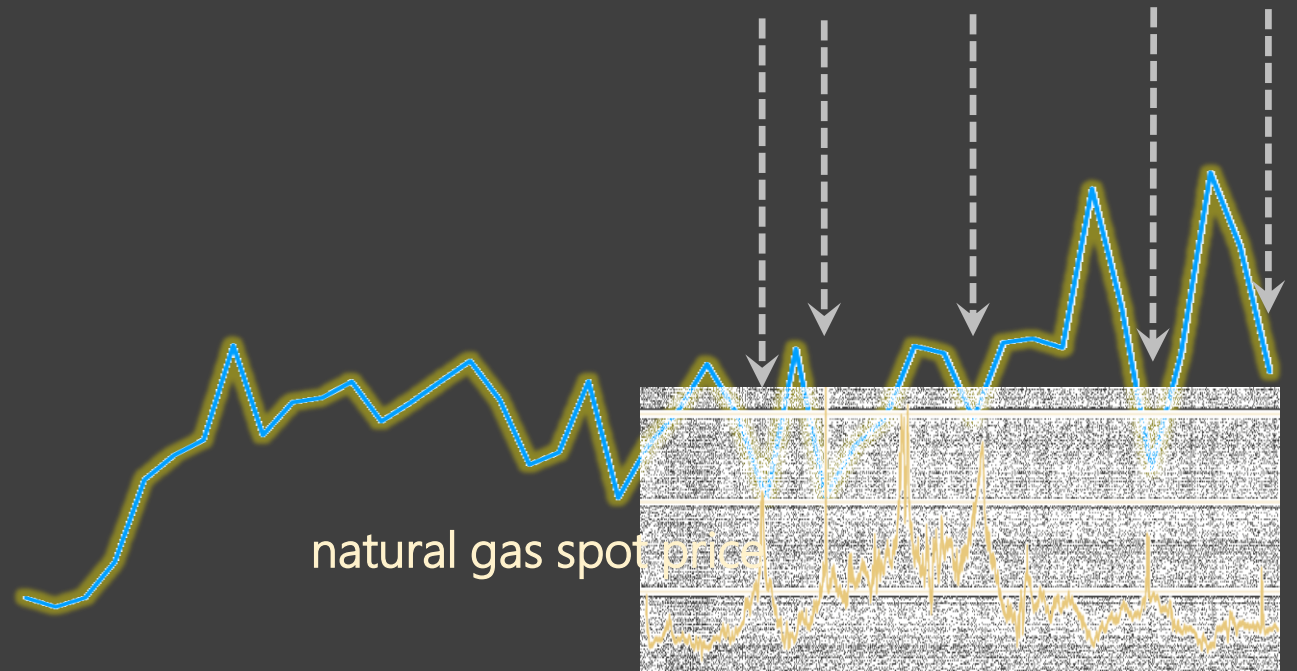
U.S. Underground Natural Gas Storage Levels

Minimal level
(~March)





cold winters, high price



. 1980 2015 .

<

UNG

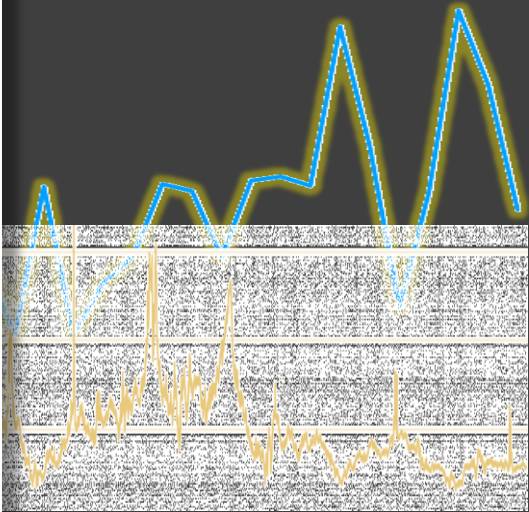
United States Natural Gas Fund

\$35.81

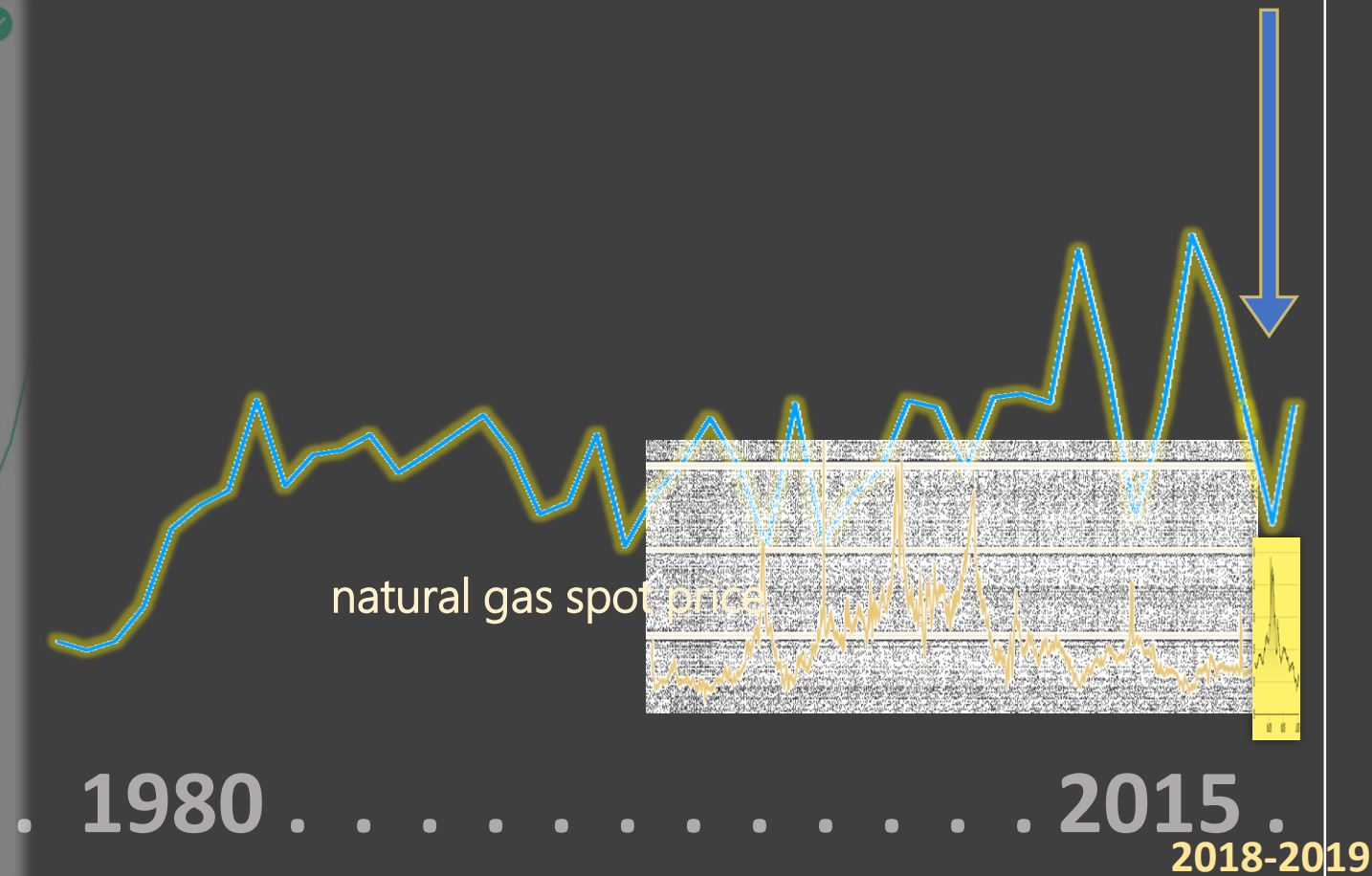
+\$7.00 (24.30%) PAST WEEK

UNG

United States Natural Gas Fund

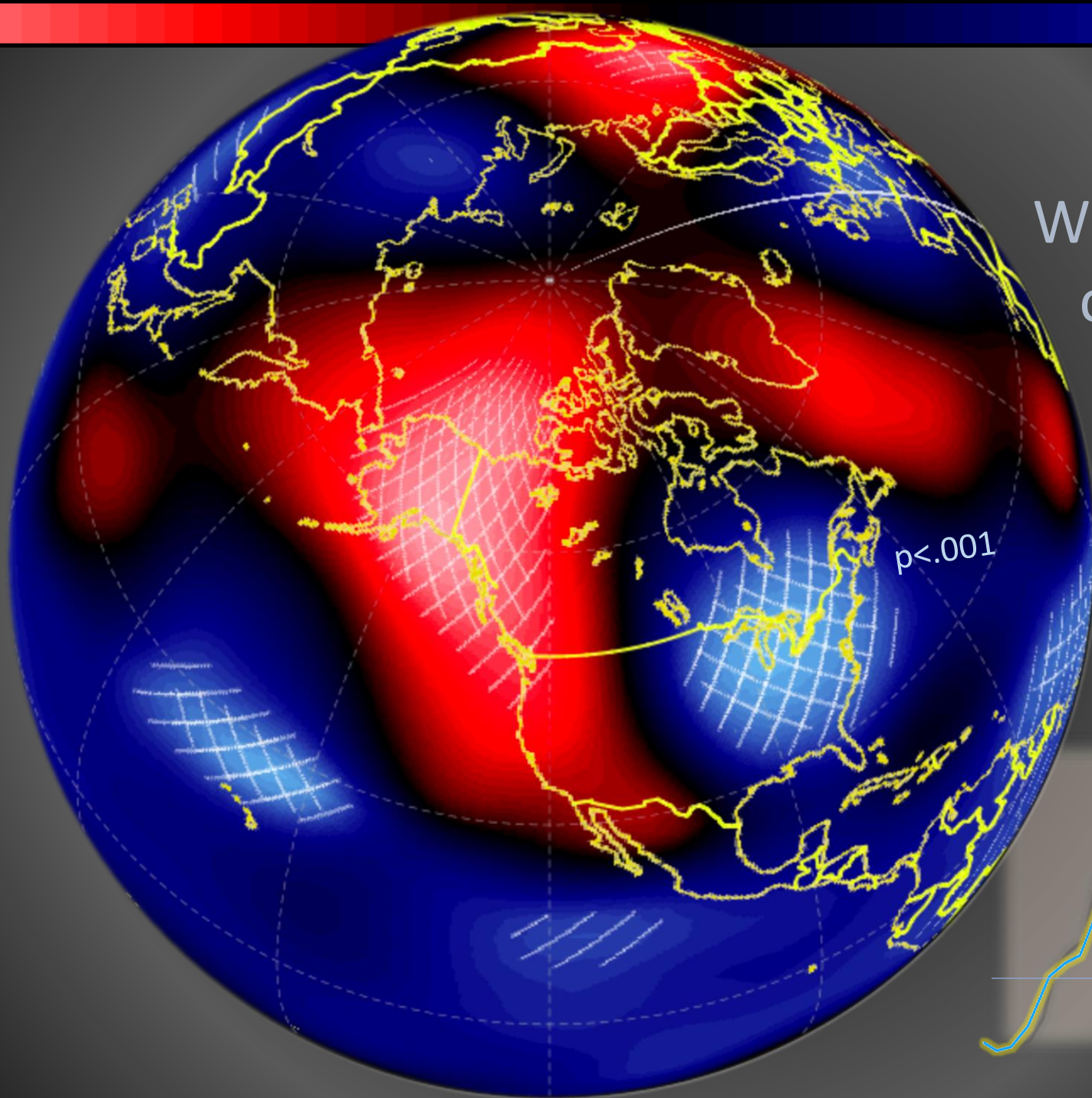


... 2015 .



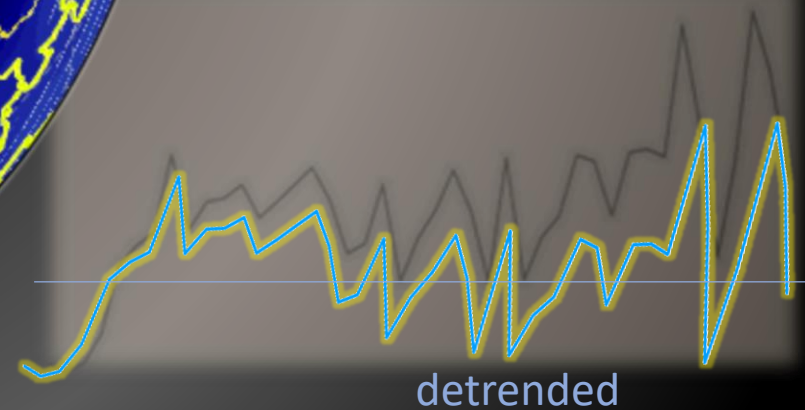
-0.6

0.6



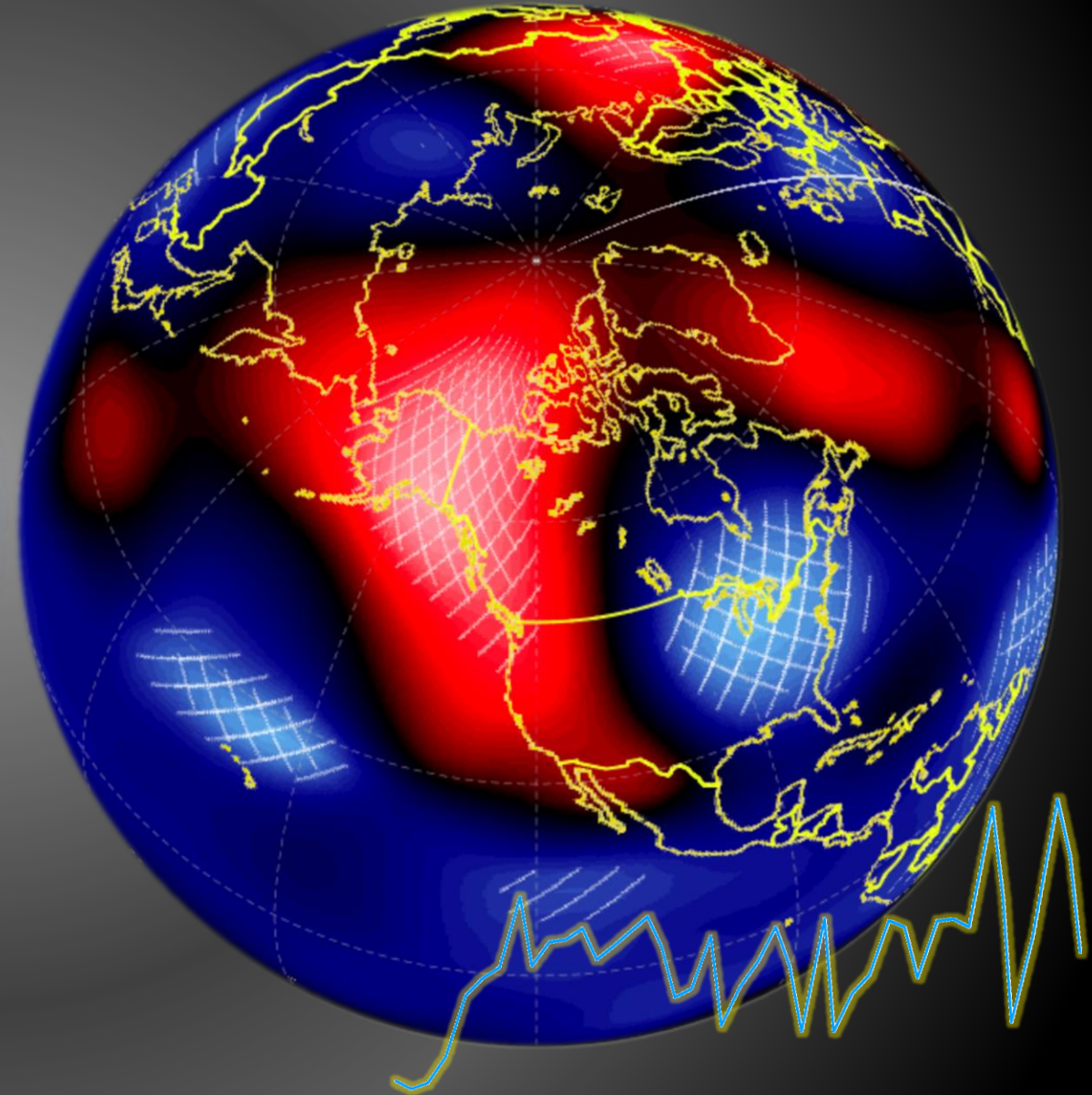
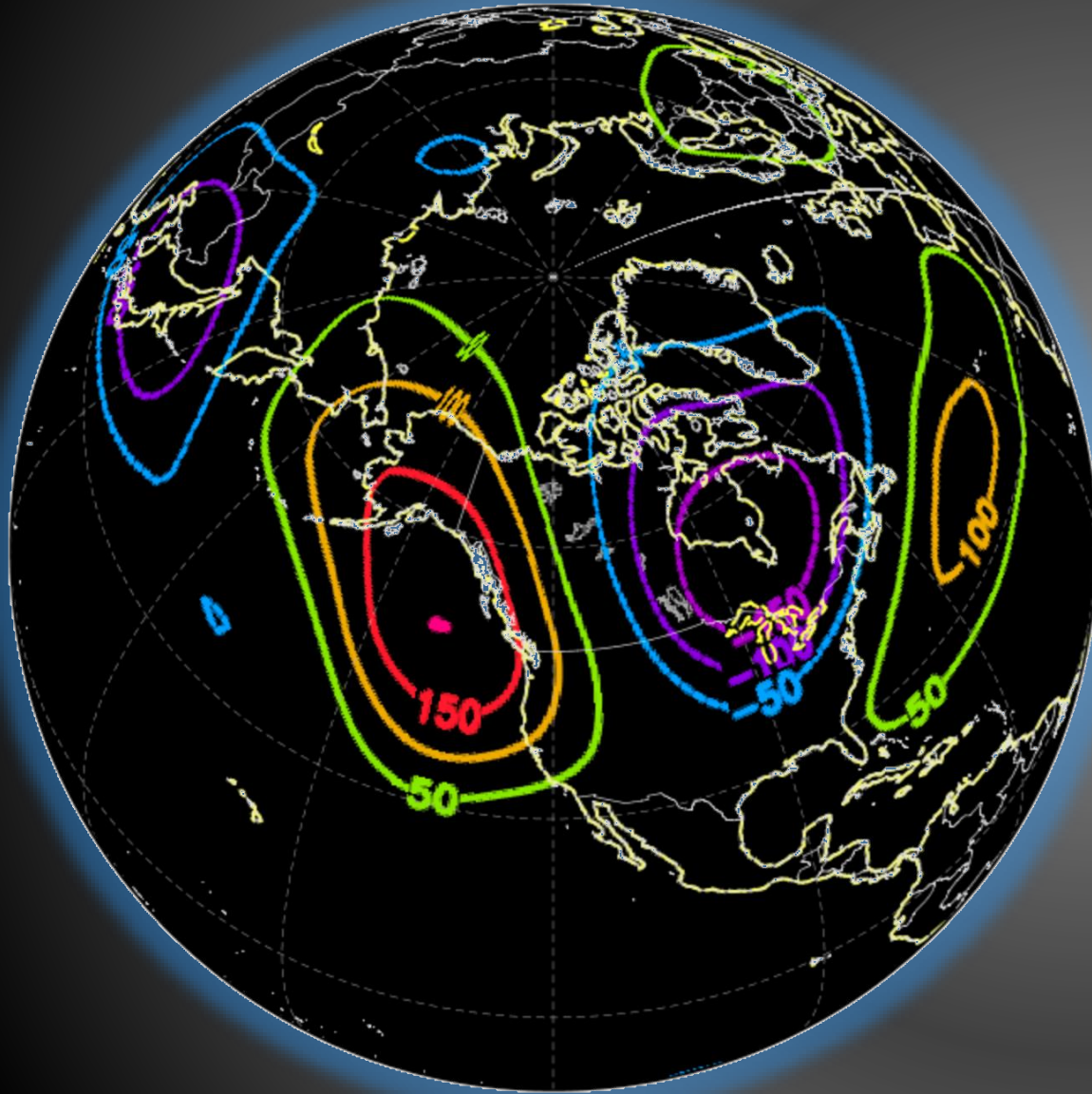
Winter (NDJ) HGT250
correlated with min
natural gas storage
1975-2018 detrend

$p < .001$

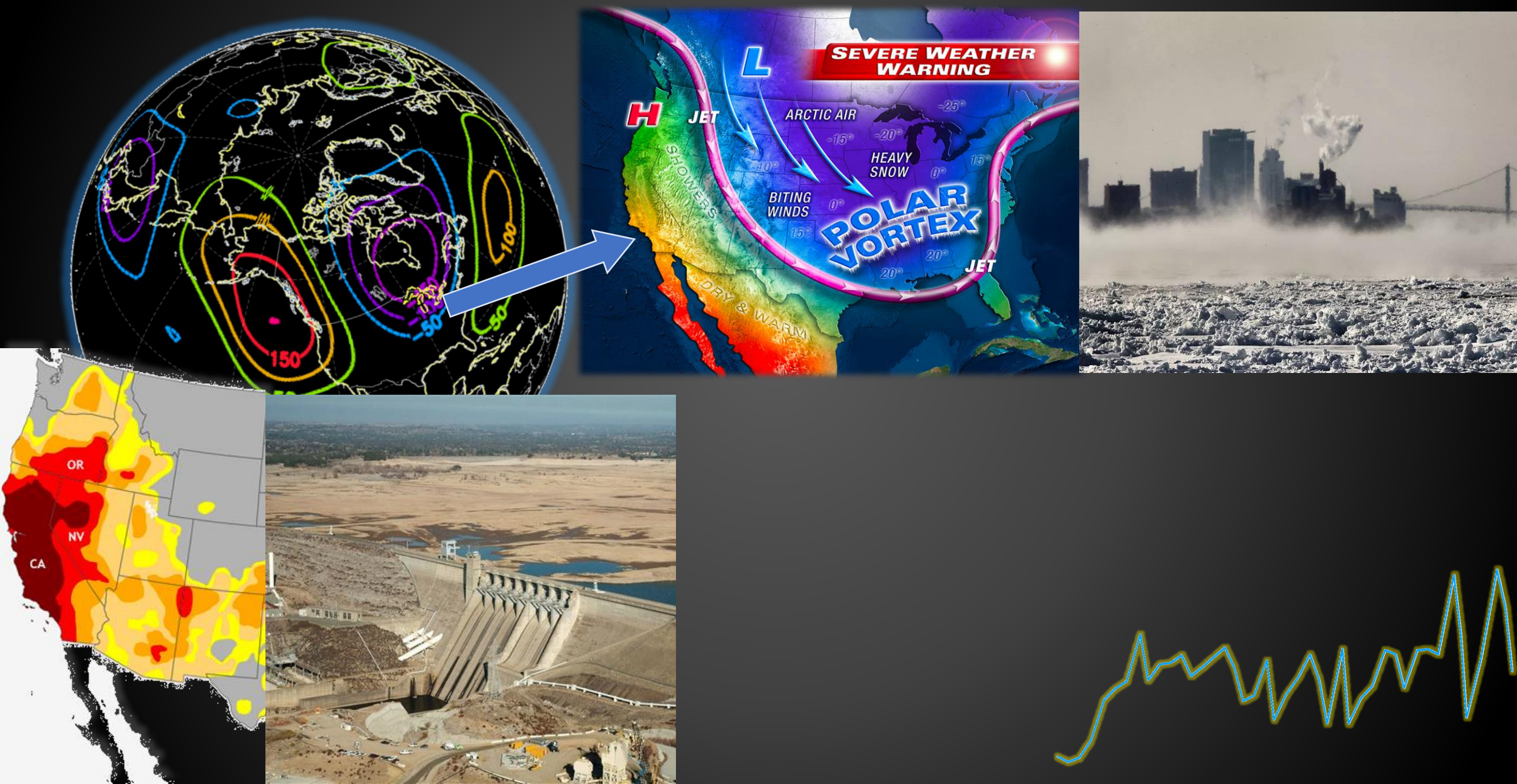


2013-14 winter HGT anomaly

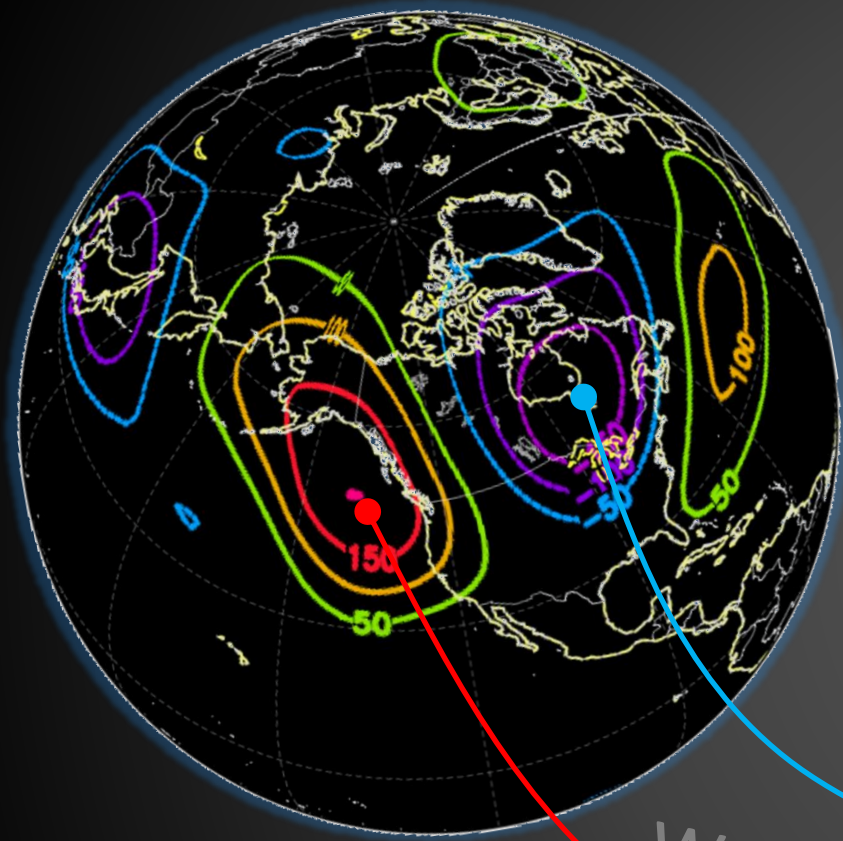
winter HGT250 correlation with spring Natural Gas storage: 1975-2018
-0.6 0.6



2013-14 winter HGT anomaly



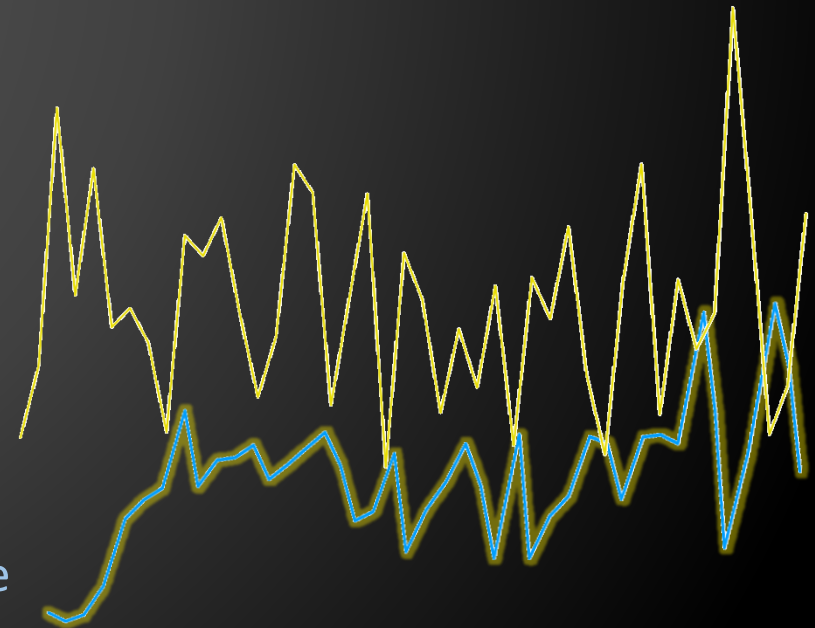
2013-14 winter HGT anomaly



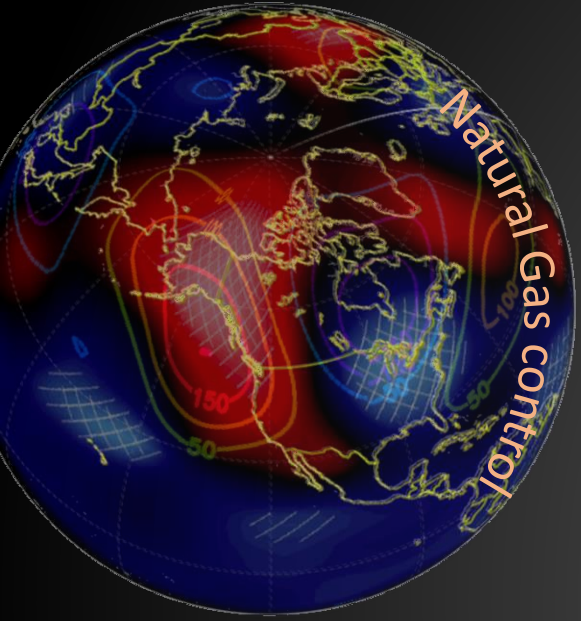
West minus East

correlation ≈ -0.65

U.S. Natural Gas Storage



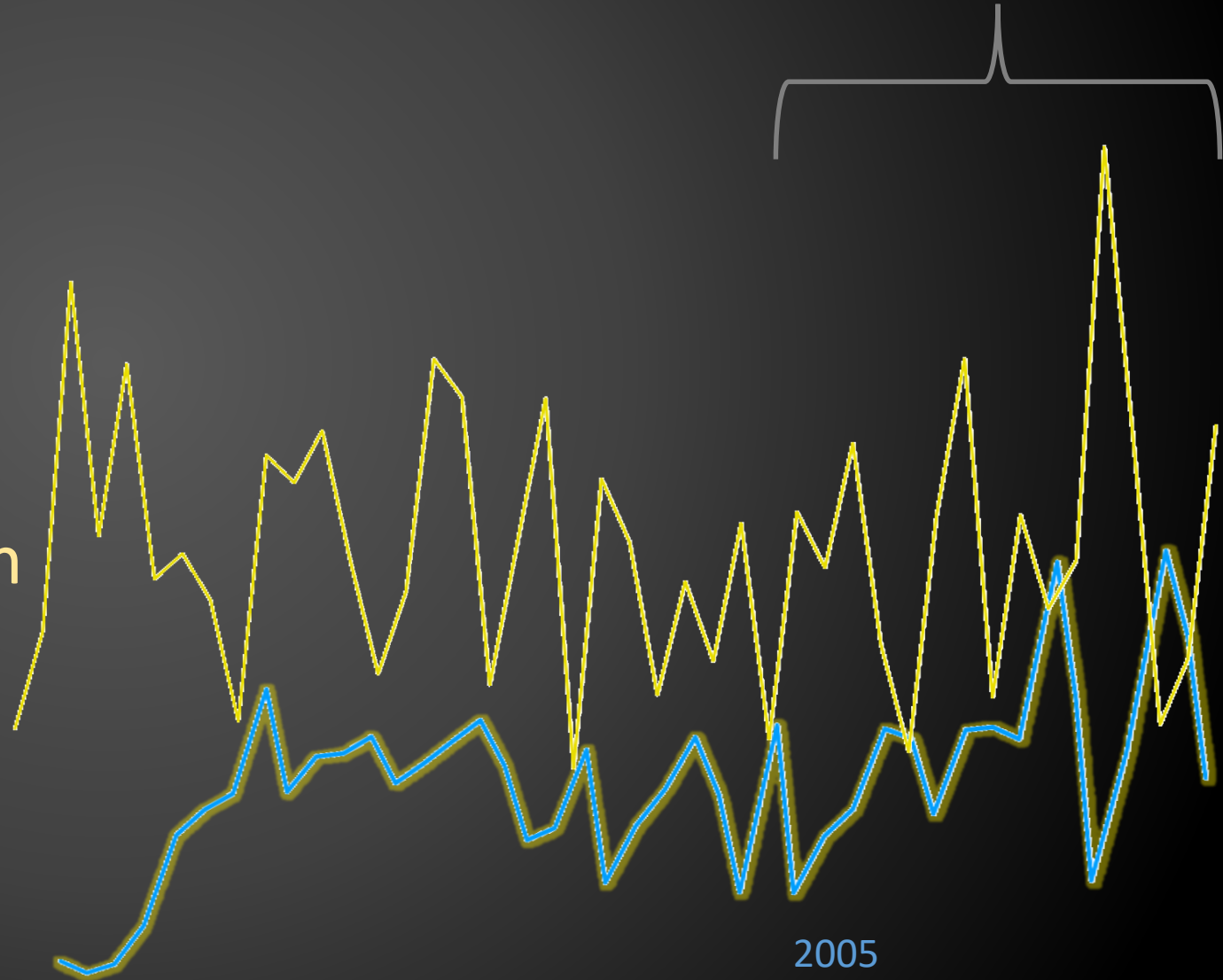
2013-14 anomaly



NDJ Index of
Circulation Pattern

March Minimum of
Natural Gas Storage

correlation ≈ -0.85



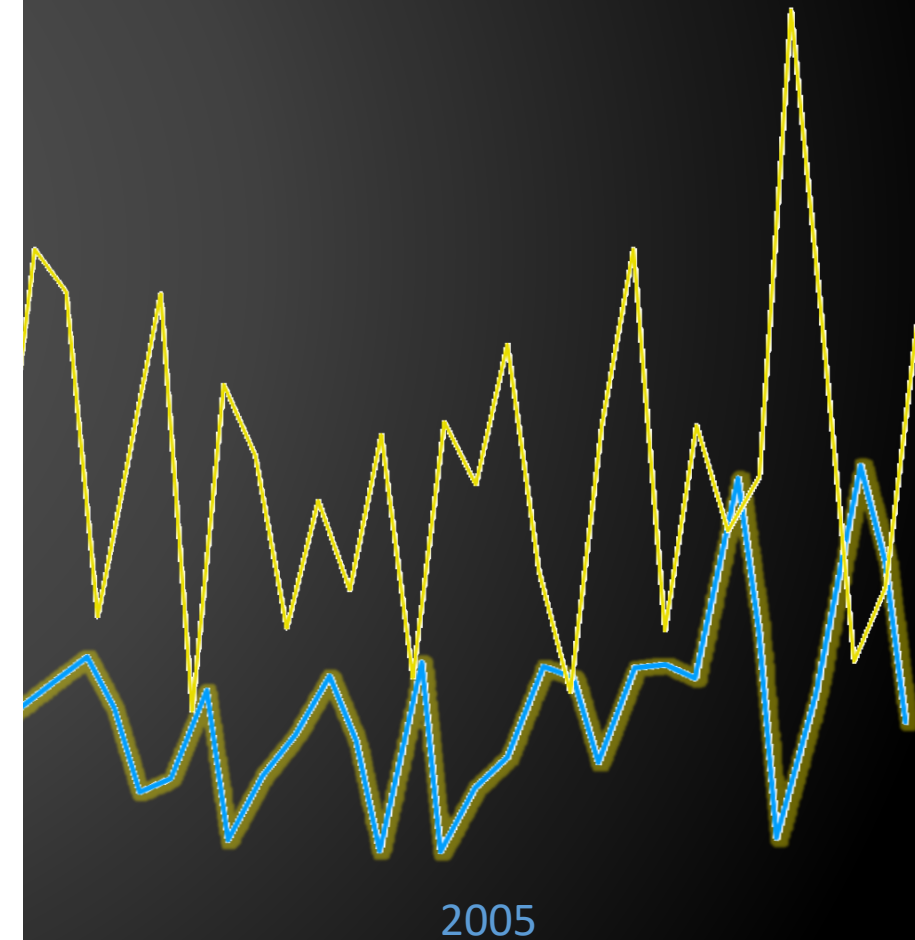
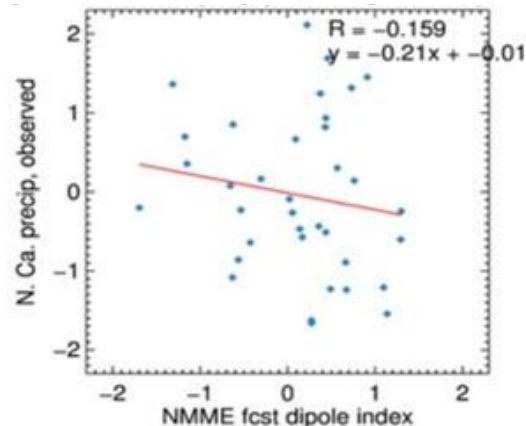
North American Multi-Model Ensemble Teleconference

Assessment of variances and NAD-NorCal precipitation relationship in NMME forecast

April 4, 2019 Drs. Huug van den Dool and Emily Becker of Climate Prediction Center (CPC)

North American Dipole (NAD)'s seasonal predictability by NMME

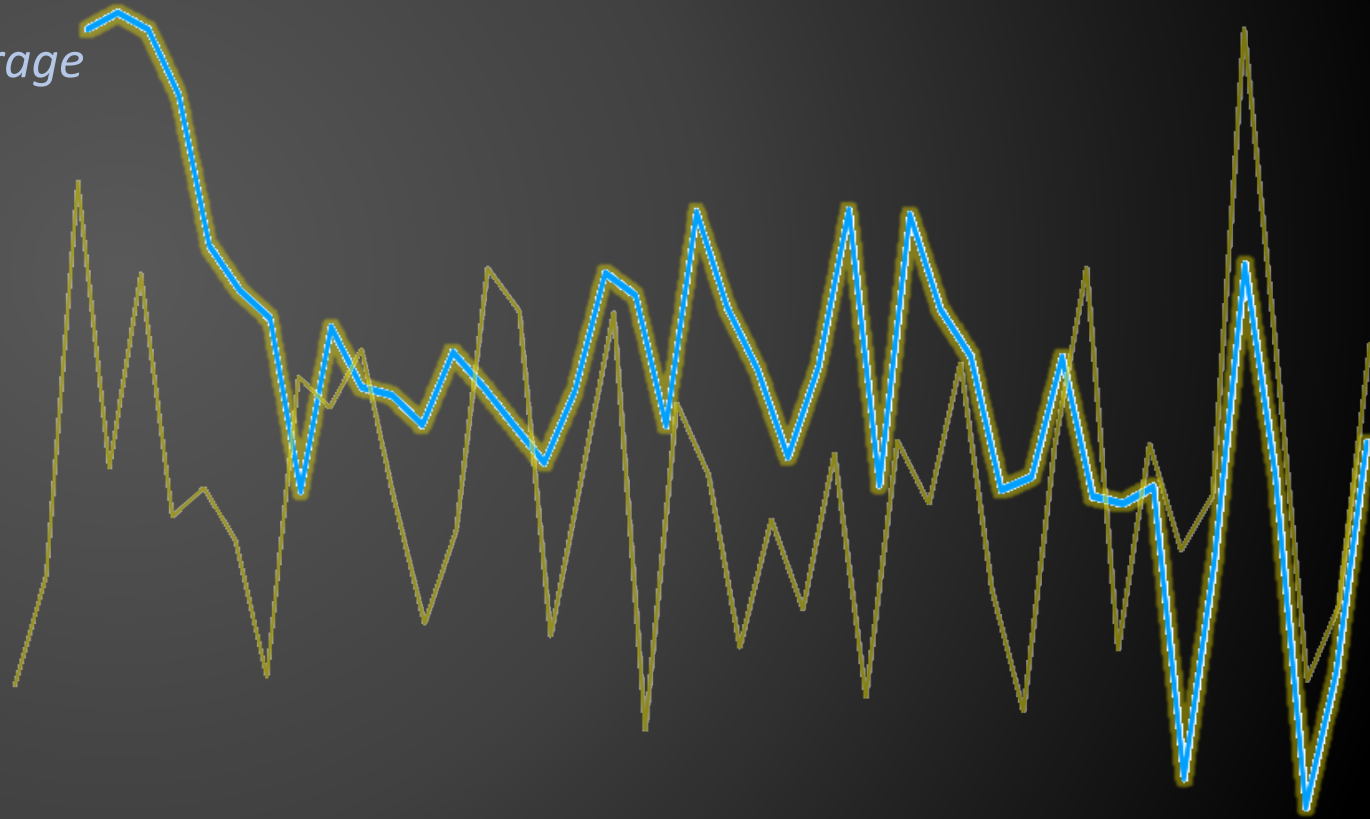
CPC NMME Lead Dr. Becker explored the relationship between northern California (NorCal) precipitation and “North American Dipole” (NAD), a peak/trough of stationary wave pattern revealed in an early work by Wang et al. (2014). Her study demonstrated the relationship between DJF NAD index and NorCal precipitation was fairly strong ($r=-0.55$, Fig. 1 top panel) in observation and even stronger ($r=-0.88$) in NMME ensemble mean forecast

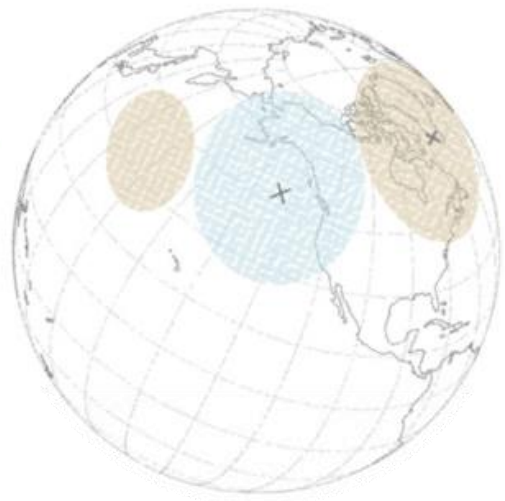


Has winter become colder?



– *Natural Gas Storage*

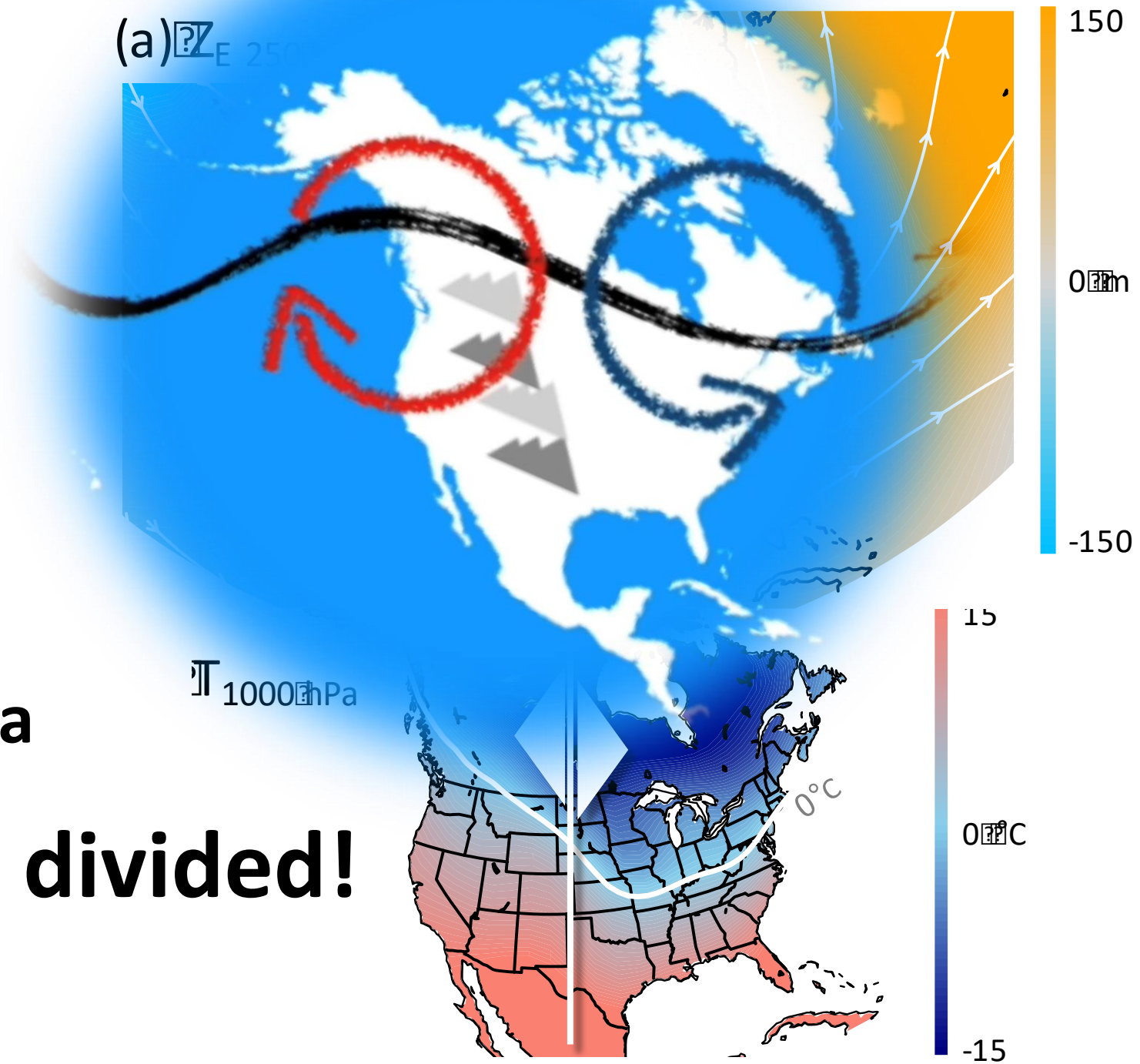




Dipole, what is it?

- “dipole” is *not* a new mode (but it has grown)
- dipole “spells” *North American wintertime stationary waves*

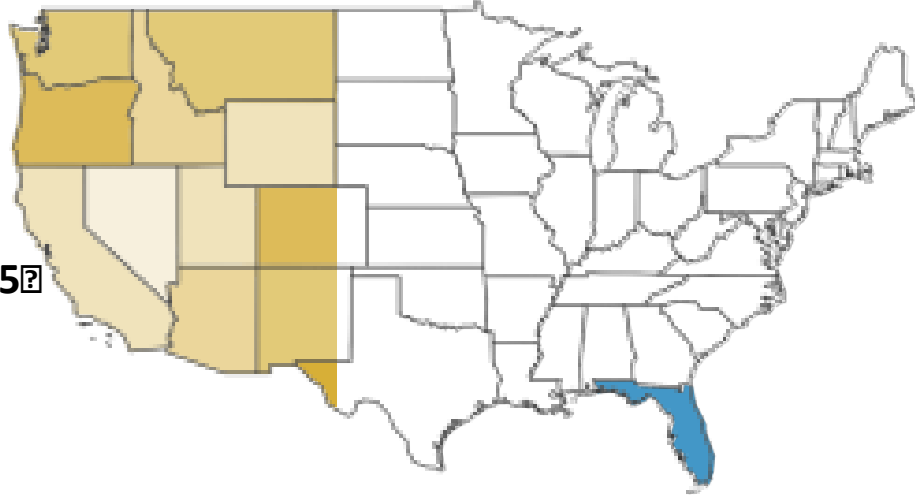
**Winter of North America
is climatologically divided!**



Billion-Dollar Disasters By State (CPI-Adjusted)

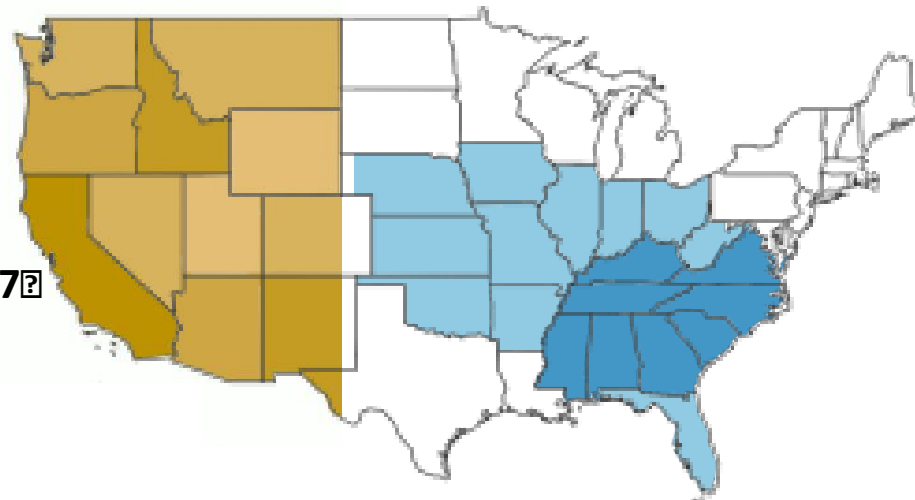
Drought Freeze

1985-2005

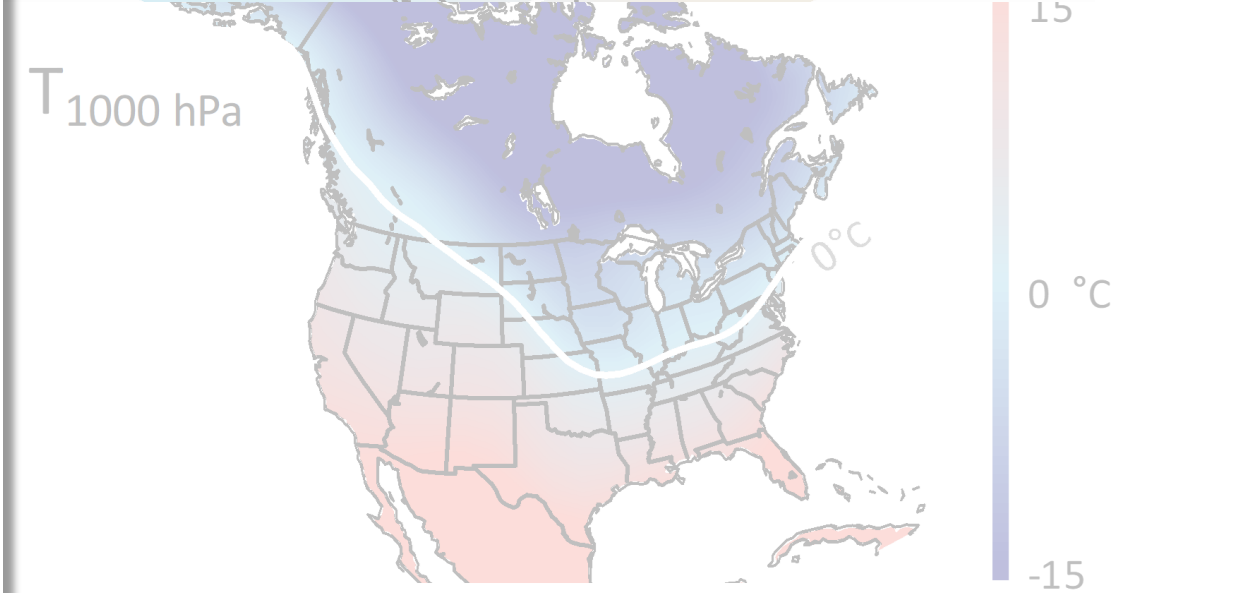
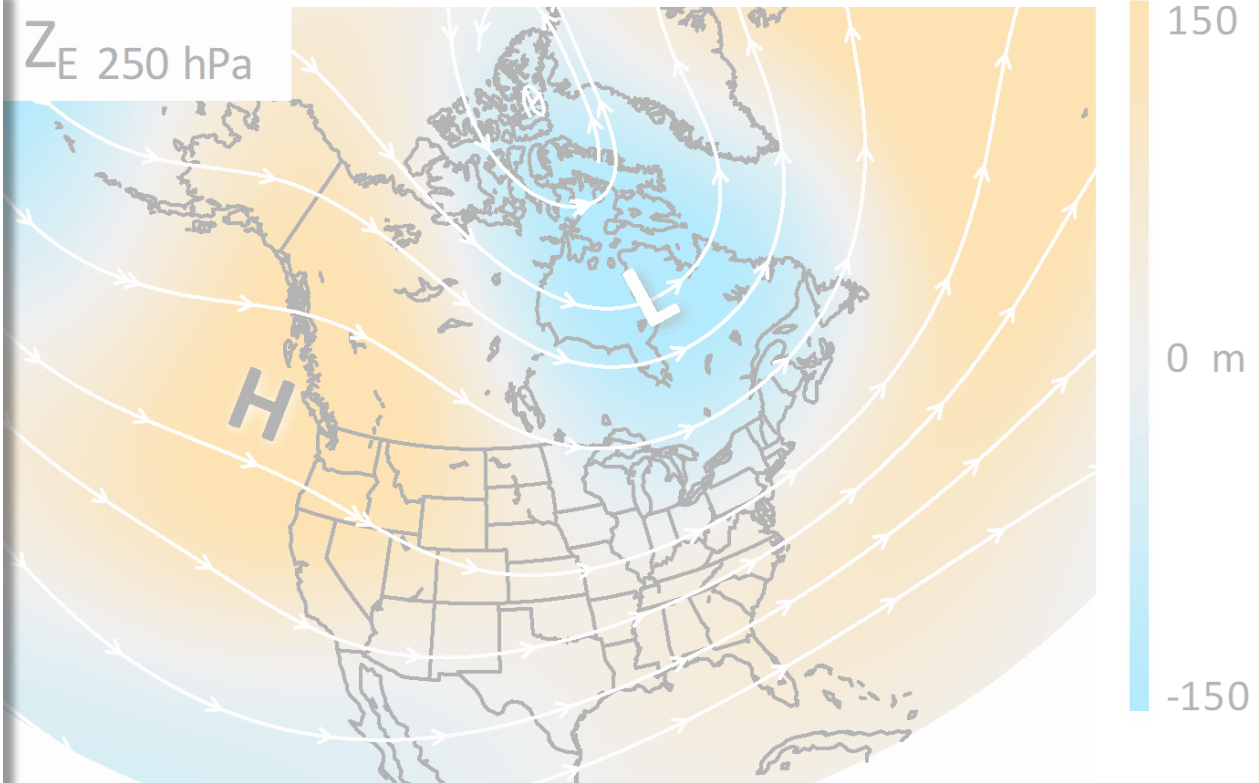


Drought Freeze

2006-2017

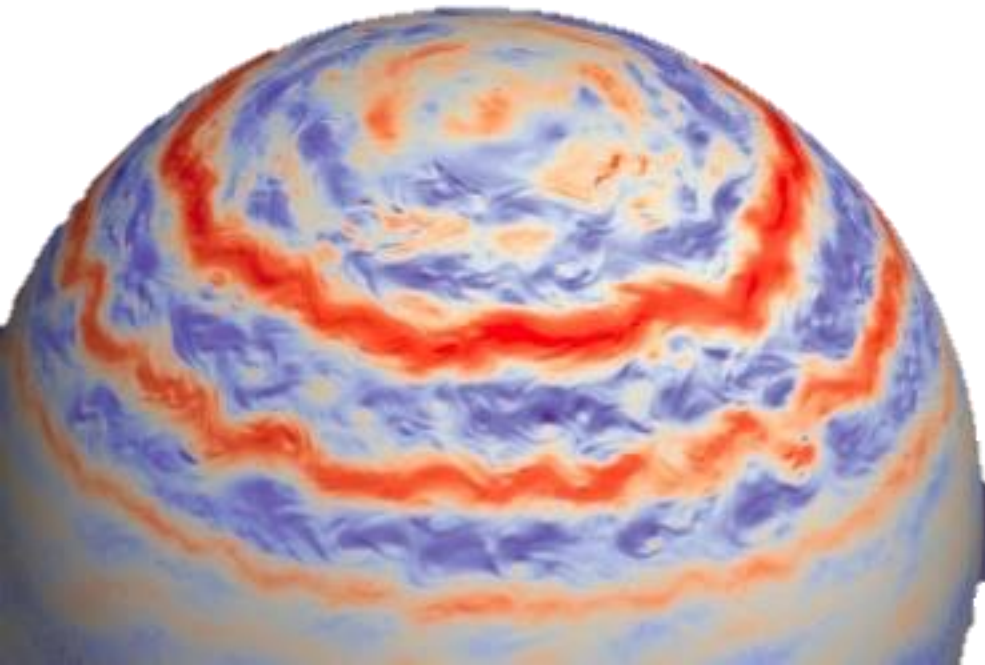


0 8 frequency 0 2



What's winter
stationary wave?

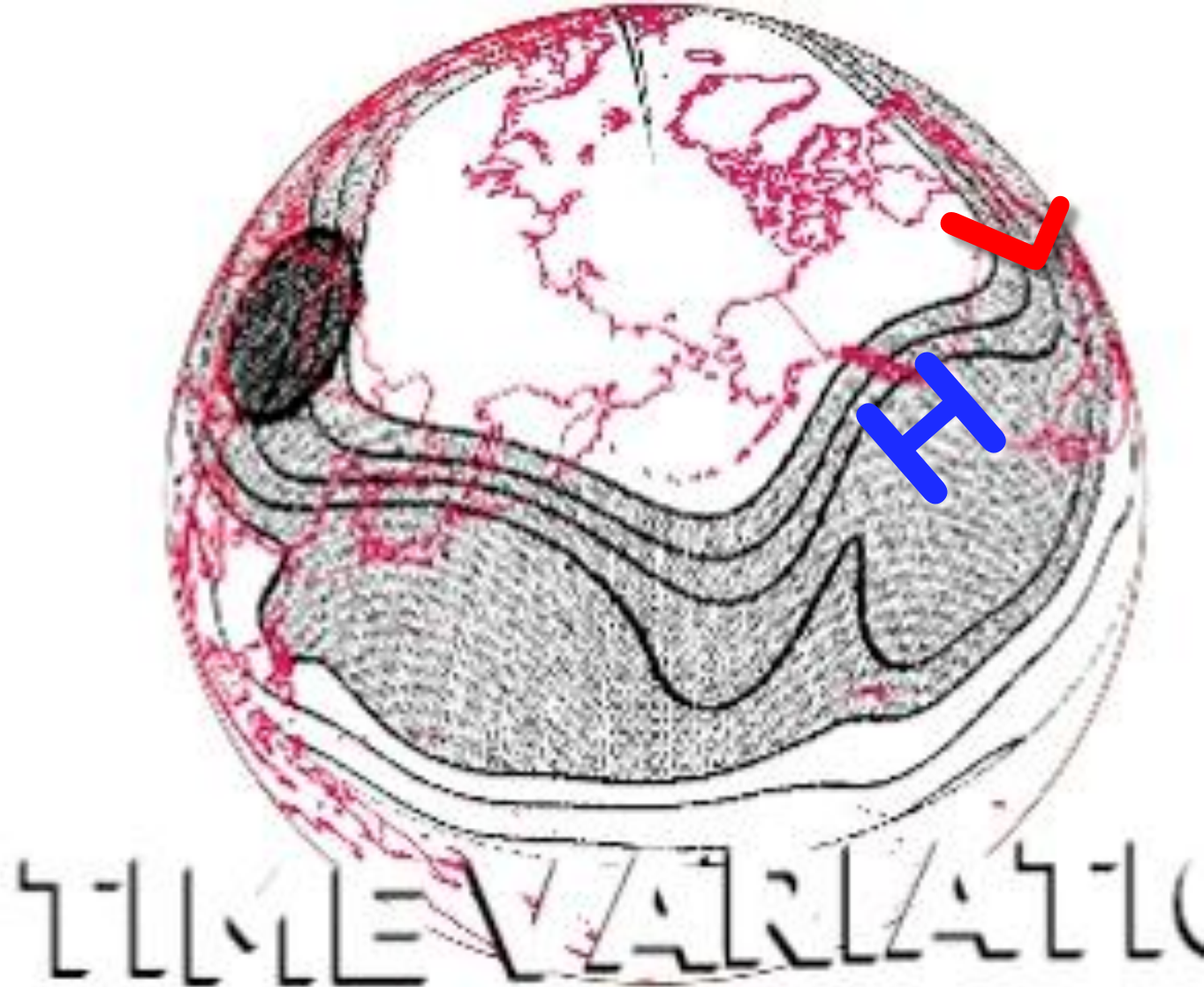
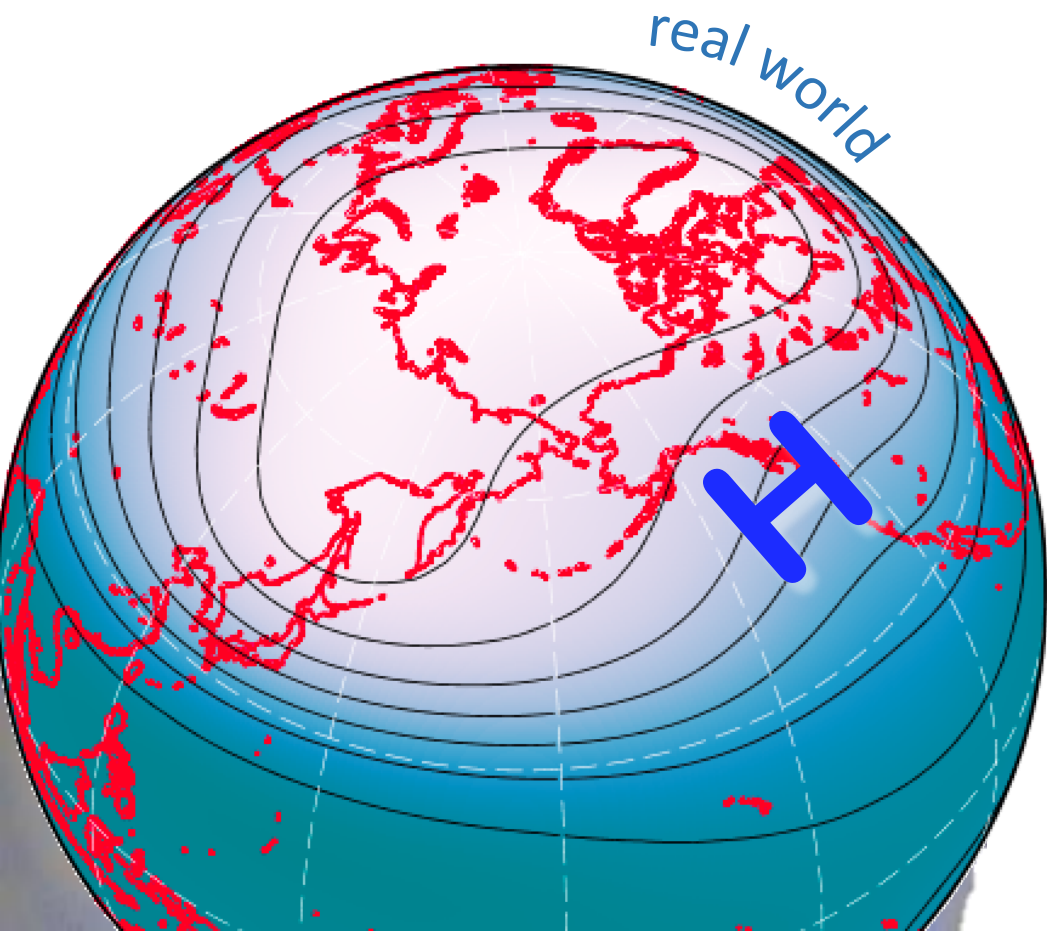
*Jet streams in an aqua
planet (no mountain)*



topography induces waves

Jet stream + orography = stationary waves

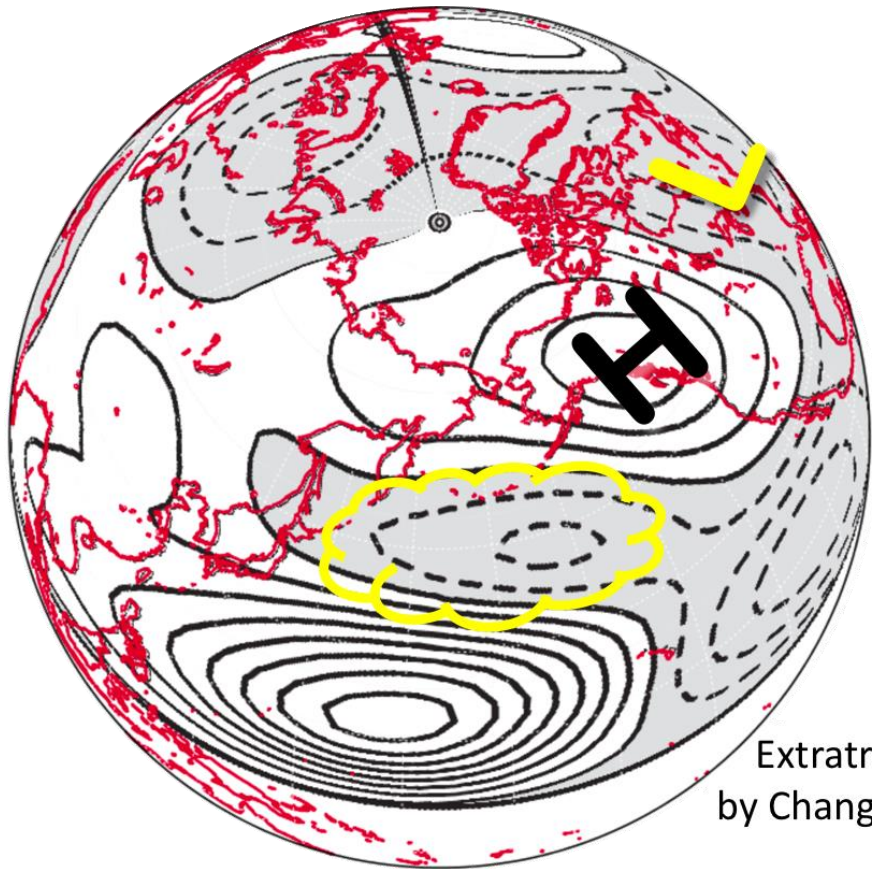
POLVANI ET AL. (1999)



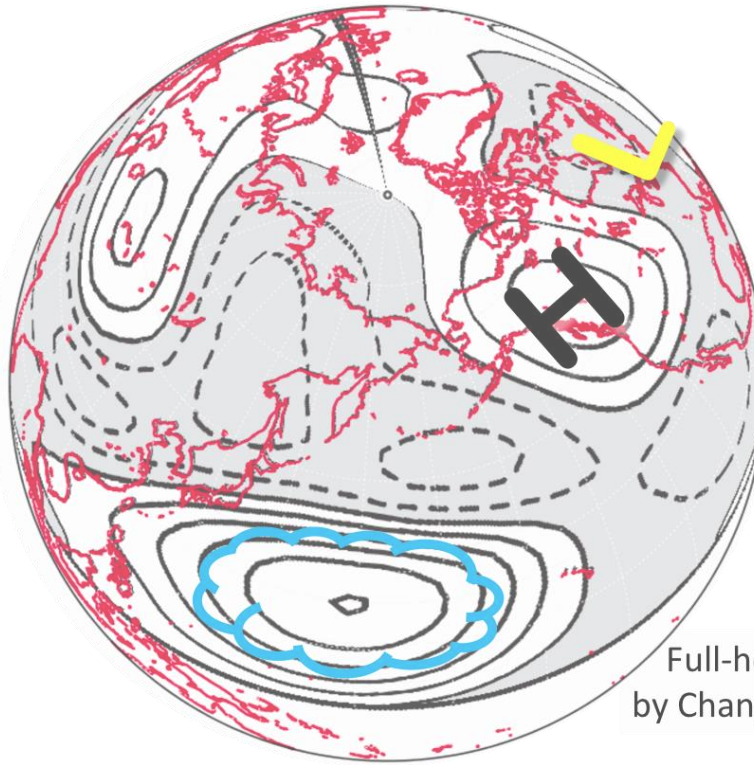
Jet stream and orography

+ tropical heating

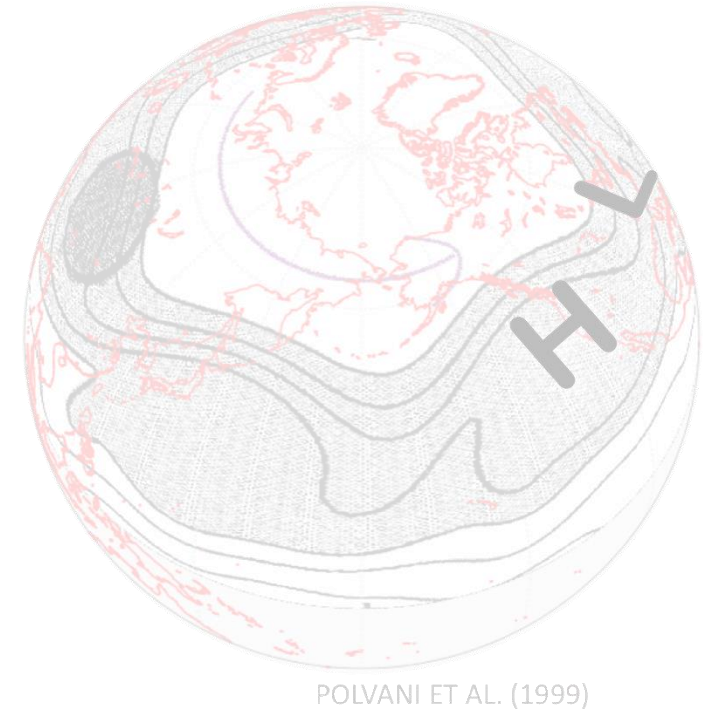
+ extra-tropical heating



Extratropical heating + orographic exp.
by Chang, E. (2009)



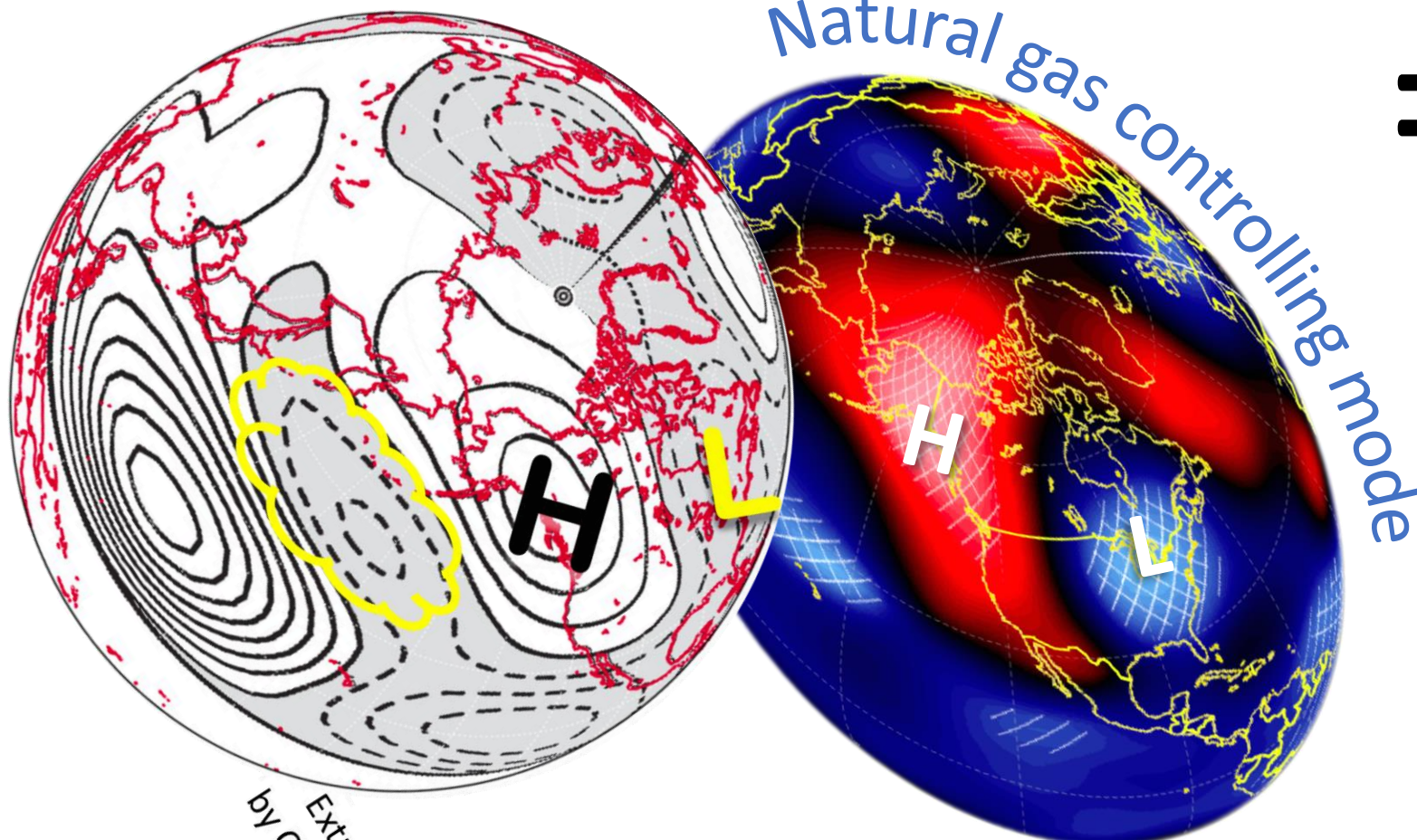
Full-heat orographic exp.
by Chang, E. (2009)



POLVANI ET AL. (1999)

Jet stream and orography + heating

mean state: + variability:



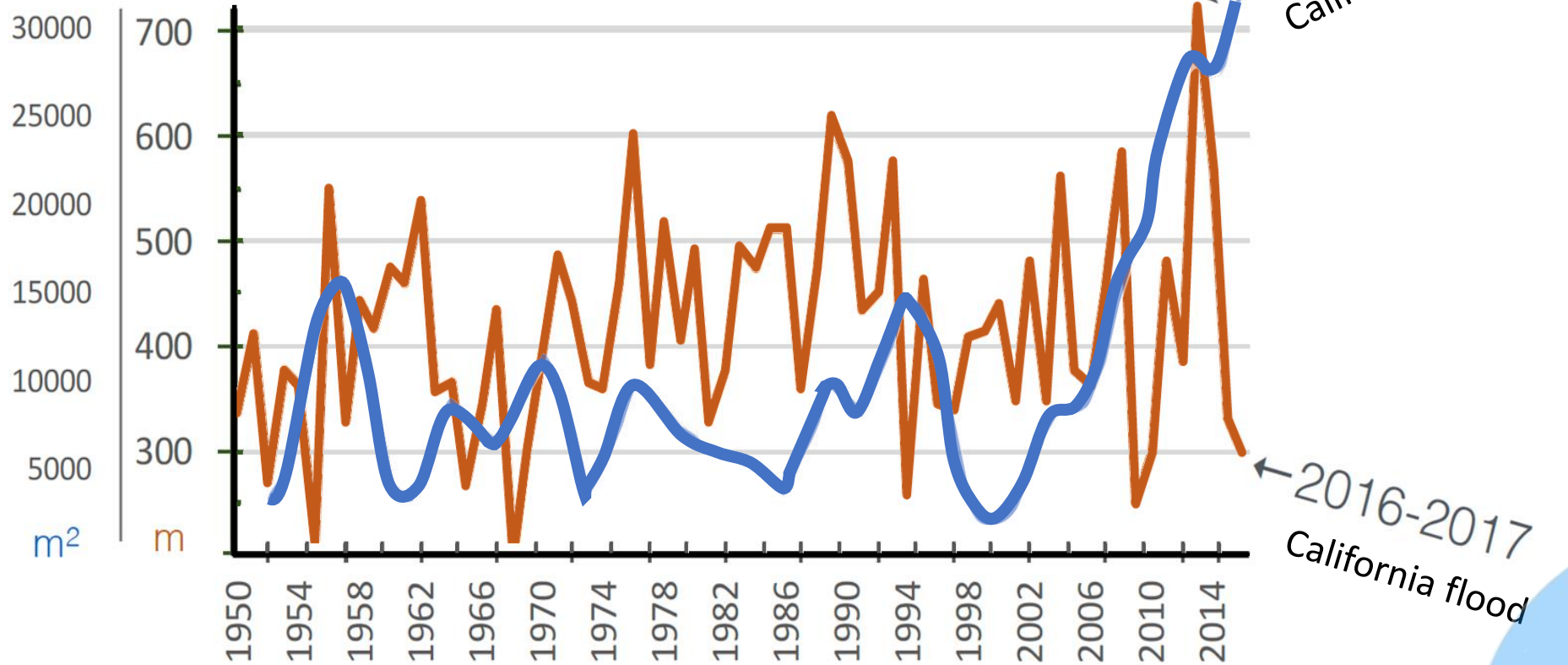
=

the dipole:



250-hPa GHP difference

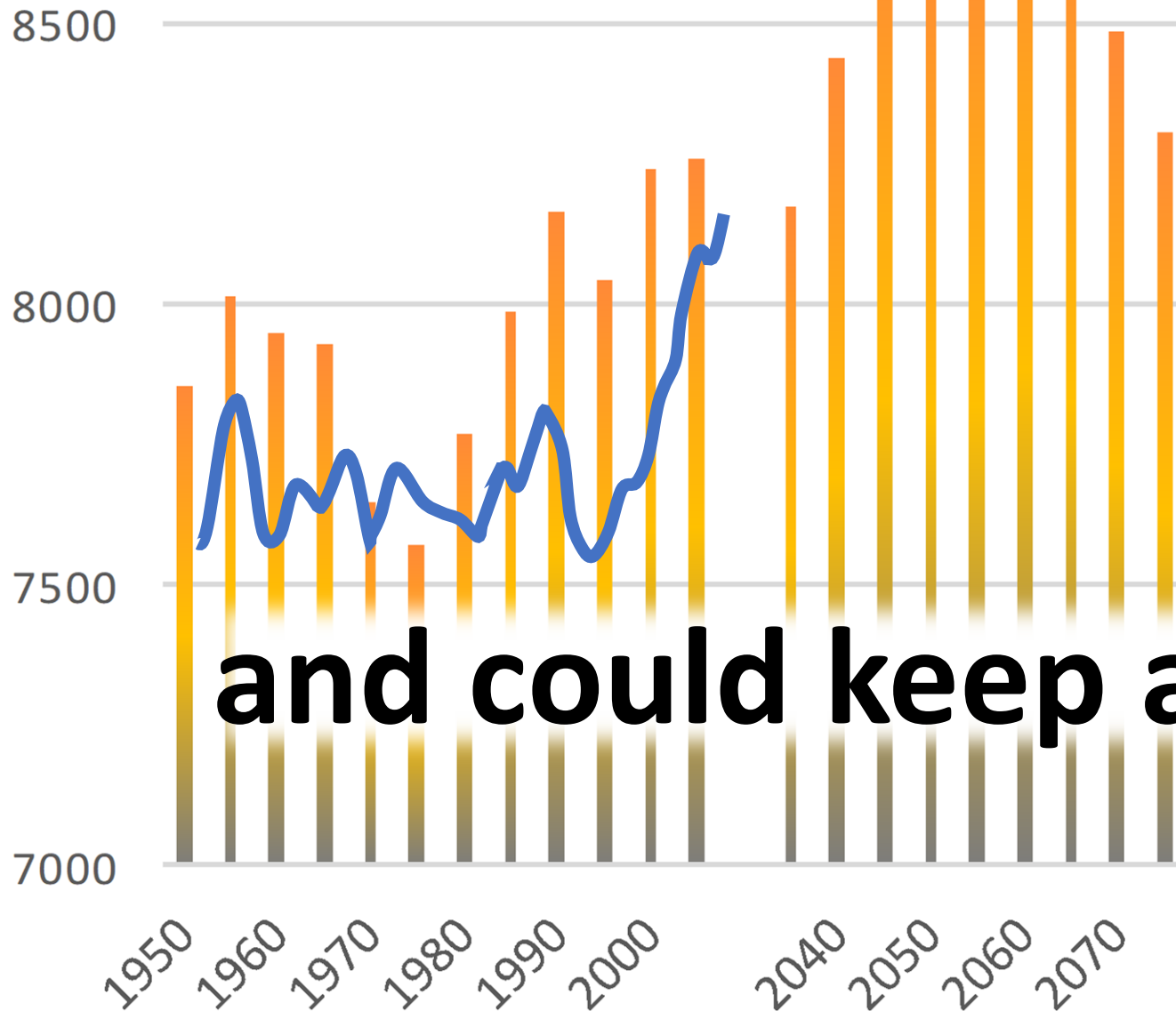
Dipole index & running variance



the dipole has amplified



CESM Large Ensemble (x40):
30-yr dipole variance



and could keep amplifying

(Tang and Wang 2019)

Geophysical Research Letters

AN AGU PUBLICATION

The online journal of the Earth and Planetary Science Society

Is climate change implicated in the 2013–2014 California drought? A hydrologic perspective

Yixin Mao, Bart Nijssen, Dennis P. Lettenmaier
First Published: 21 April 2015

Contribution of anthropogenic warming to California drought during 2012–2014

A. Park Williams, Richard Seager, John T. Abatzoglou, Benjamin I. Cook, Jason E. Smerdon, Edward R.

A tale of two California droughts: Lessons amidst record warmth and dryness in a region of complex physical and human geography

Daniel L. Swain
First Published: 20 November 2015

Abstract | Full Text (HTML) | PDF | References
Journal Highlights

Letters

Evolution of hydrological conditions in California by human management

He, Yoshihide Wada, Niko Justin Sheffield
First Published: 17 February 2017

Full Text (HTML) | PDF | References

Insights on the causes of historically low 2015 snowpack in the western United States

Wolfe, David E. Rupp, Sihan Sharp, Friederike Otto, Dennis P. Myles R.

2016
Full Text (HTML) | PDF

Characterizing the extreme 2015 snow deficit in the Sierra Nevada (USA) and the implications for recovery

Margulis, Gonzalo Cortés, Girotto, Laurie S. Huning, J. Michael Durand
First Published: 10 October 2016

Full Text (HTML) | PDF | References
Journal Highlights

Seasonal evaporation in California during droughts and floods

Jiangpeng Wei, Qinqian Jin, Zong-Liang Yang, Paul A. Dirmeyer
First Published: 20 June 2016

Abstract | Full Text (HTML) | PDF (4.8MB) | References

Global warming and changes in risk of concurrent climate extremes: Insights from the 2014 California drought

Amir AghaKouchak, Linyin Cheng, Omid Mazdiyasn, Alireza Farahmand

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[Pacific sea surface temperature and the winter of 2014](#)

CHANGE IN THE LEADING MODE OF NORTH AMERICA'S WINTERTIME

STATIONARY EDDIES

by

Yu-Tang Chien

細節就略過吧...

of

MASTER OF SCIENCE

in

Climate Science



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Att

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Andrew J. Miller, Dennis P. Lettenmaier, Andrew J. Eischeid, Judith P. Cheng
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Benjamin J. Hatchett, Douglas Boyle, Aaron E. Putnam, Steven A. Bassett
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Characterizing the extreme 2015 snowpack deficit in the Sierra Nevada (USA) and the implications for drought recovery

Steven A. Margulis, Gonzalo Cortés, Manuela Girotto, Laurie S. Huning, Donevue Li, Michael Durand

a book chapter

and many more...

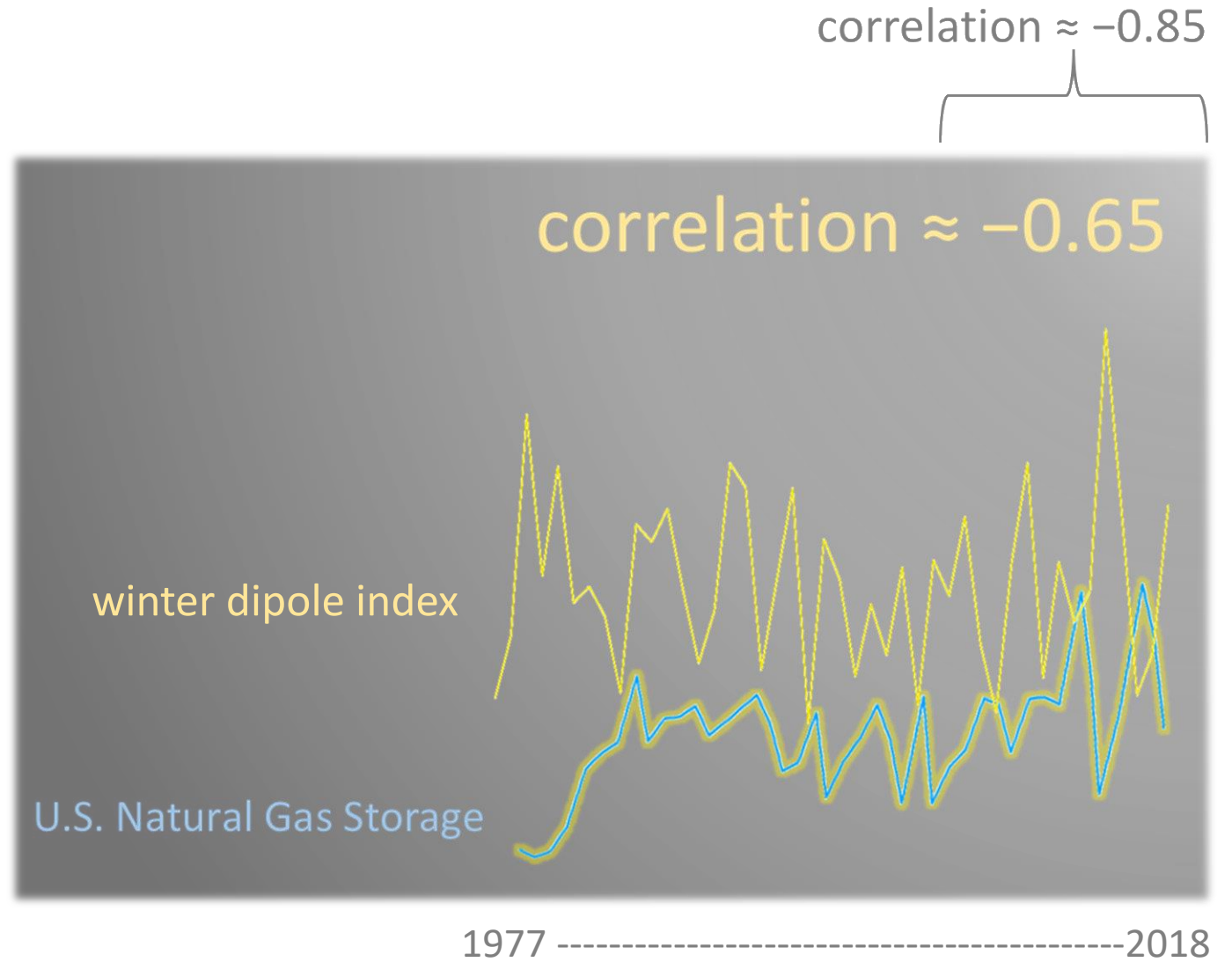


- HiLat region
- Jet stream (Tibet)
 - Cloud/convection
 - Ocean heat
- ...

The complexity

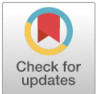
Will the amplified
dipole further
stress the U.S.
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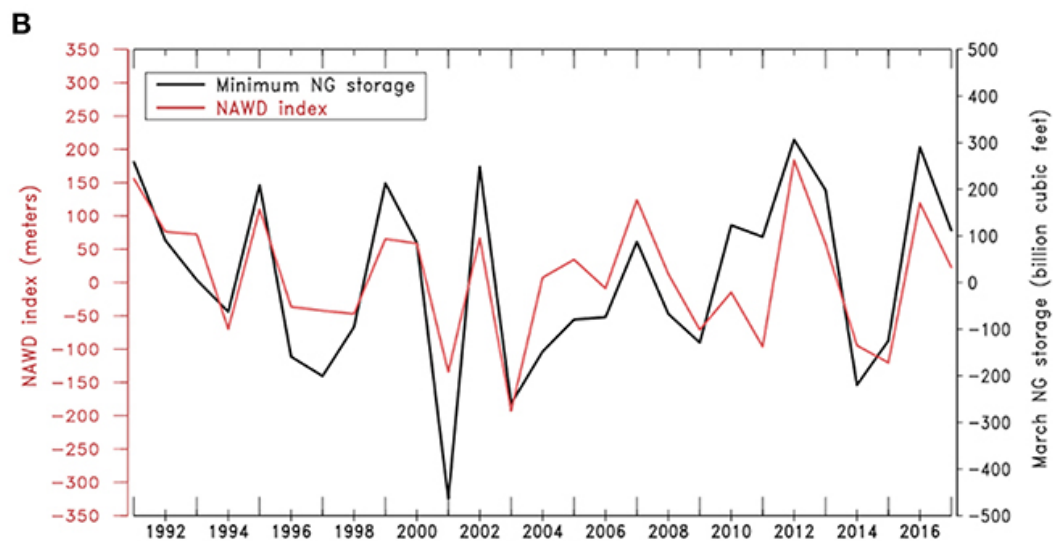
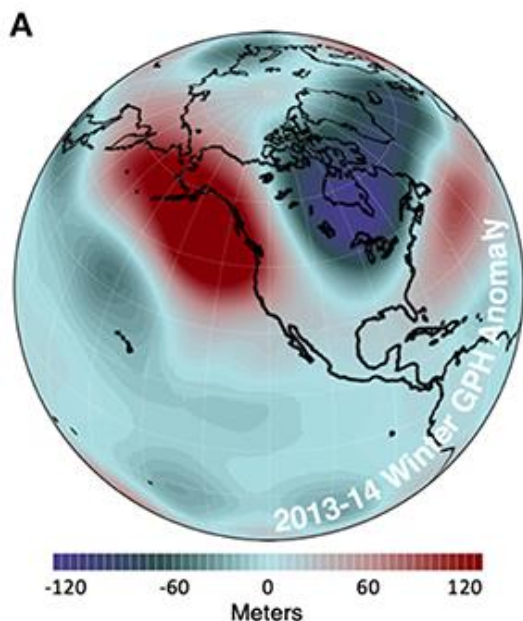


Data Mining Climate Variability as an Indicator of U.S. Natural Gas

 **Jacob Stuivenvolt-Allen** and  **Simon S.-Y. Wang***

Department of Plants, Soils and Climate, Utah Climate Center, Utah State University, Logan, UT, United States





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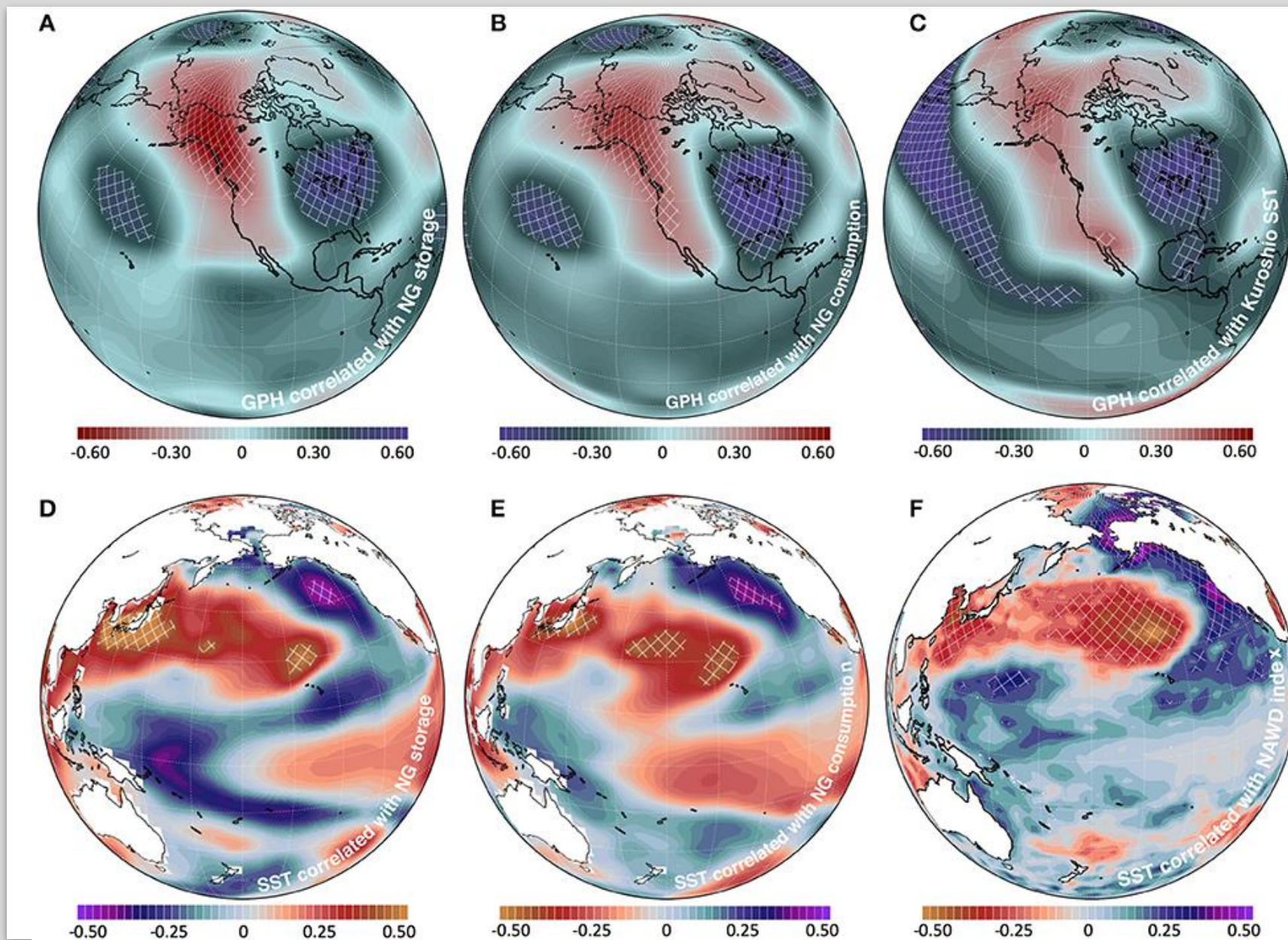
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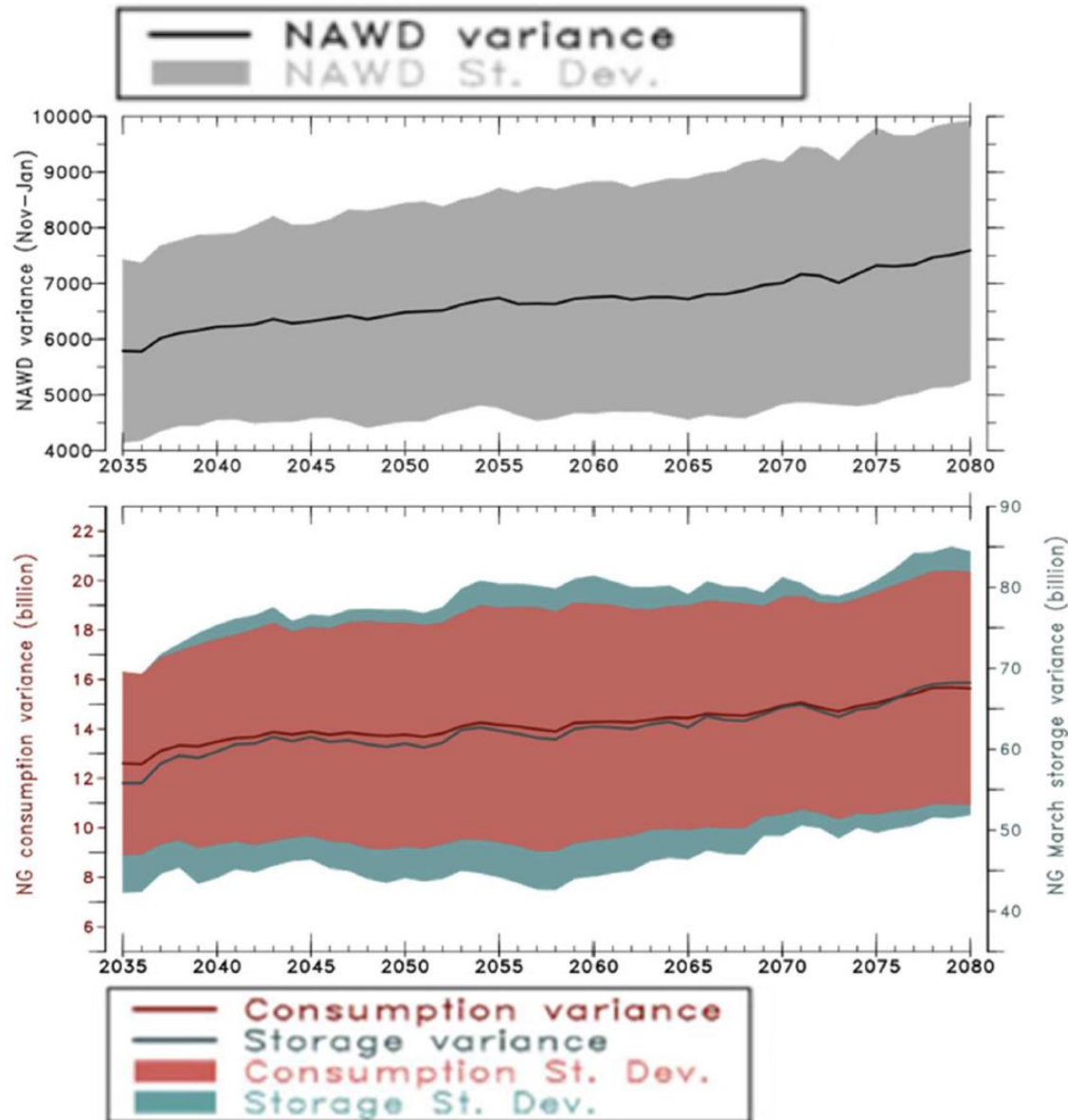
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(A) Correlation map of GPH at 250 hPa correlated with March (minimum annual) NG storage from 1990 to 2018. **(B)** GPH at 250 hPa correlated with residential and commercial NG consumption for November through January from 1978 to 2018. **(C)** GPH at 250 hPa correlated with Kuroshio region SST for November through January from 1950 to 2014 (from twentieth Century Reanalysis). **(D)** SST correlation with NG March storage from 1990 to 2018. **(E)** SST correlated with residential and commercial consumption from 1973 to 2018. **(F)** SST correlated with the NAWD index from November through January from 1950 to 2014. The linear trend has been removed from all data.



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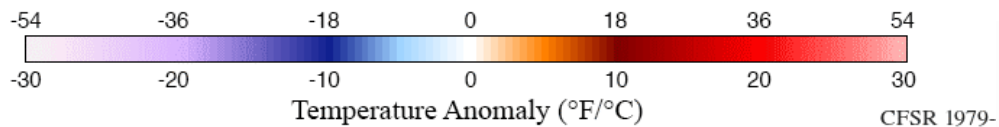
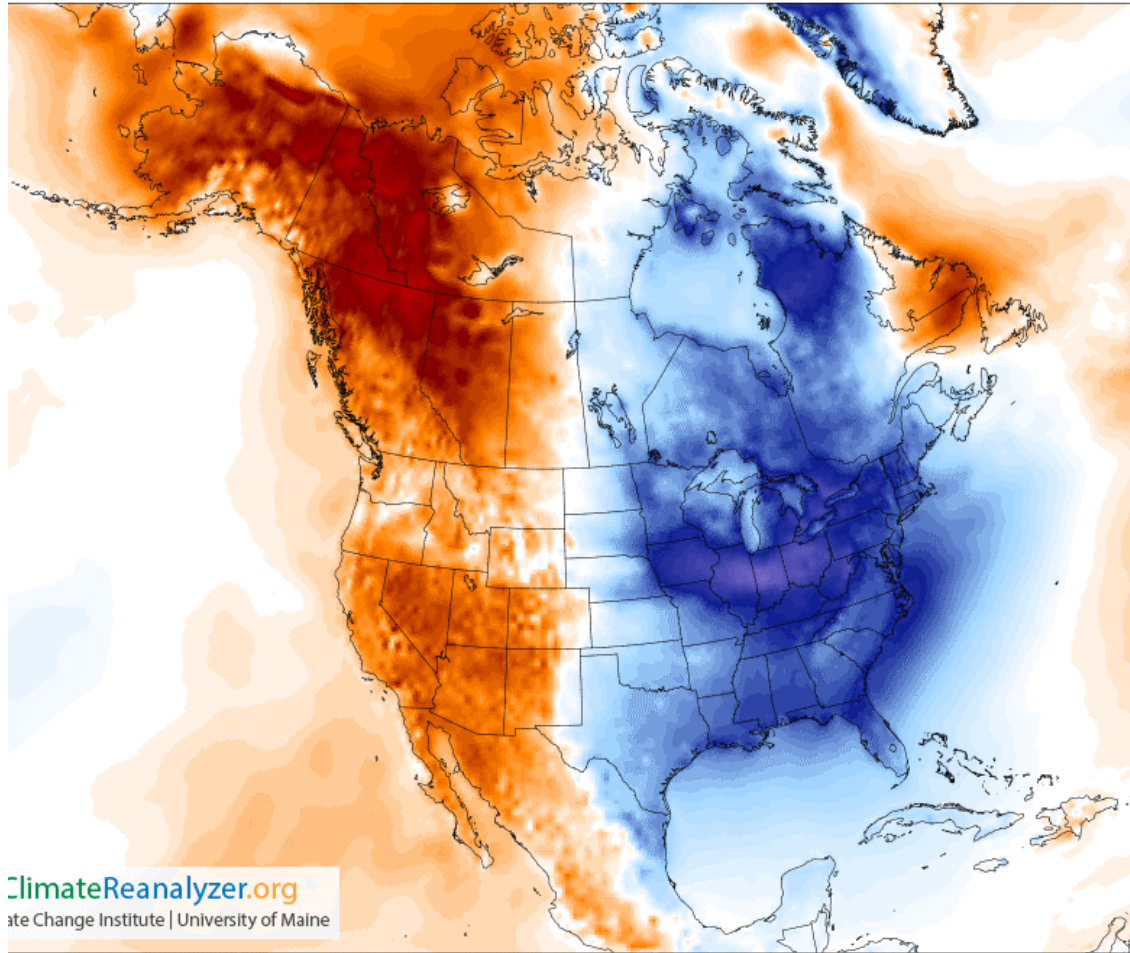
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Temperature Departure from Average
2 GFS 0.25°x0.25°

5-day Forecast Average
Tuesday, Jan 2, 2018



The Washington Post

Business • Analysis

The Bomb Cyclone Breezes Into the Natural Gas Market: Gadfly

Jan 4, 2018

in early January when below-average temperatures accompanied by snowstorms dubbed the "bomb cyclone" led to soaring demand for the commodity,

Capsule abstract:

Extreme winter cyclones significantly impact energy in the United States. The January 2018 “Bomb Cyclone” highlighted the pathway in which similarly intense winter cyclones amplify the fluctuation in domestic energy use.



(in review)

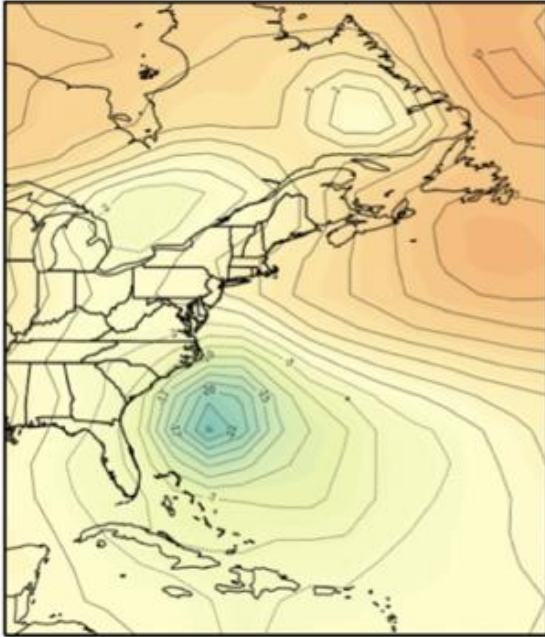
January 2018 Bomb Cyclone: a resounding shockwave for U.S. natural gas and energy

Jacob Stuivenvolt-Allen and Simon S.-Y. Wang

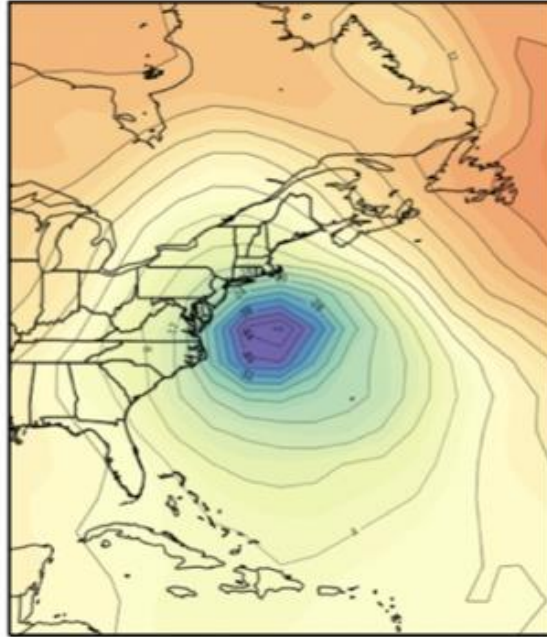
Department of Plants, Soils and Climate, Utah Climate Center, Utah State University, Logan, UT, USA

(a) MSLP anomaly (hPa)

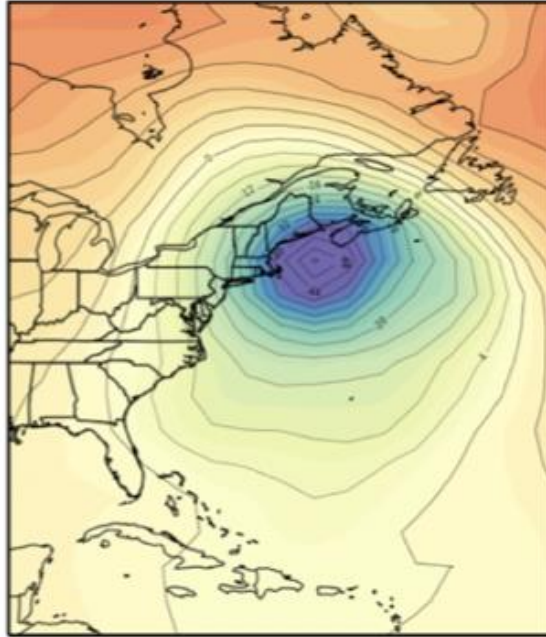
2018:1:4:0



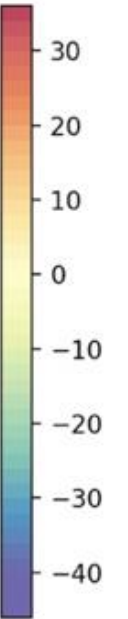
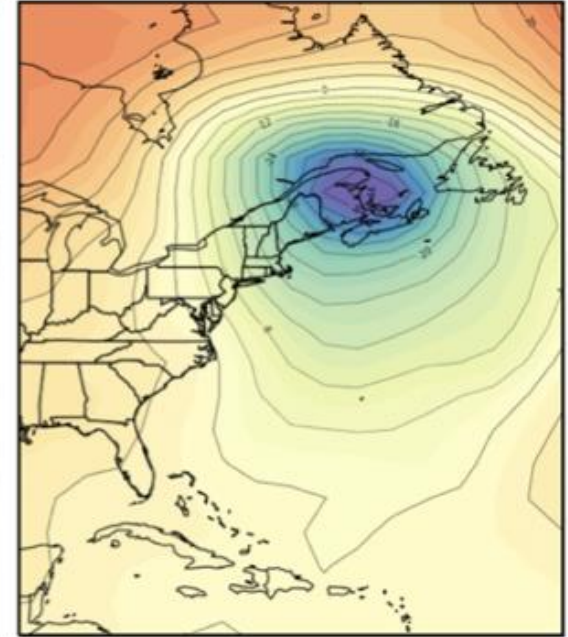
2018:1:4:12



2018:1:5:0



2018:1:5:12



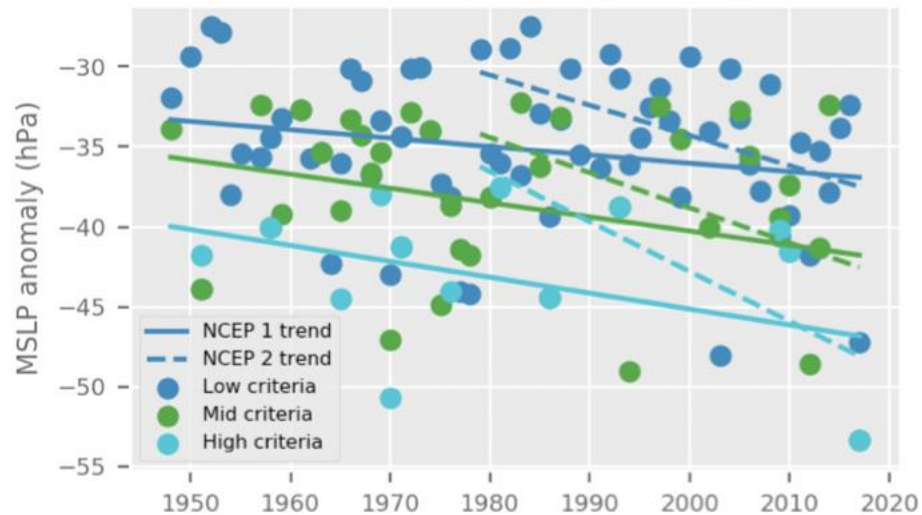
Developed criteria for tracking

January 2018 Bomb Cyclone: a resounding shockwave for U.S. natural gas and energy

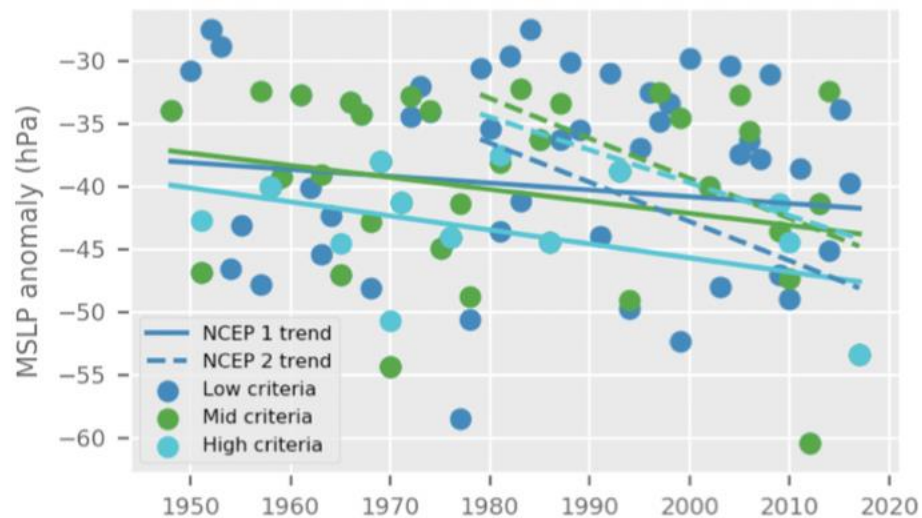
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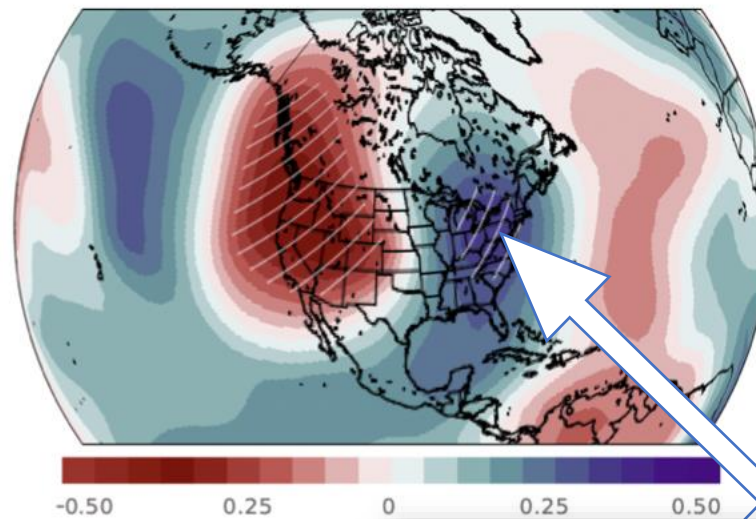
(a) NCEP lowest winter cyclone mslp anomaly



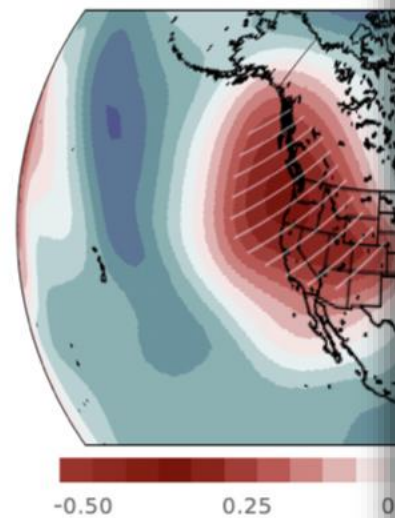
(b) NCEP average winter cyclone mslp anomaly



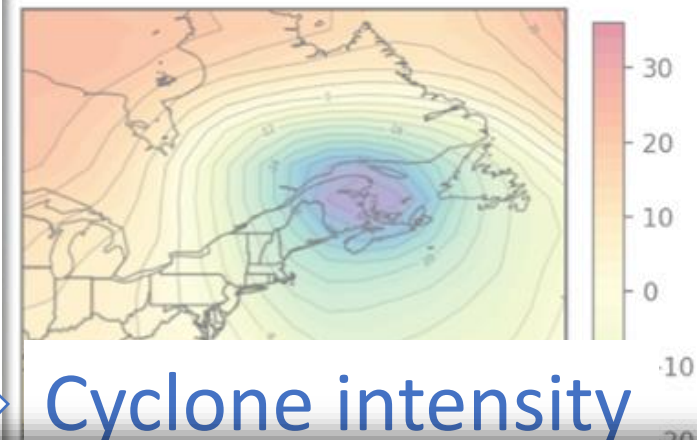
(d) Minimum winter cyclone correlation with z250



(e) Average winter cyclone

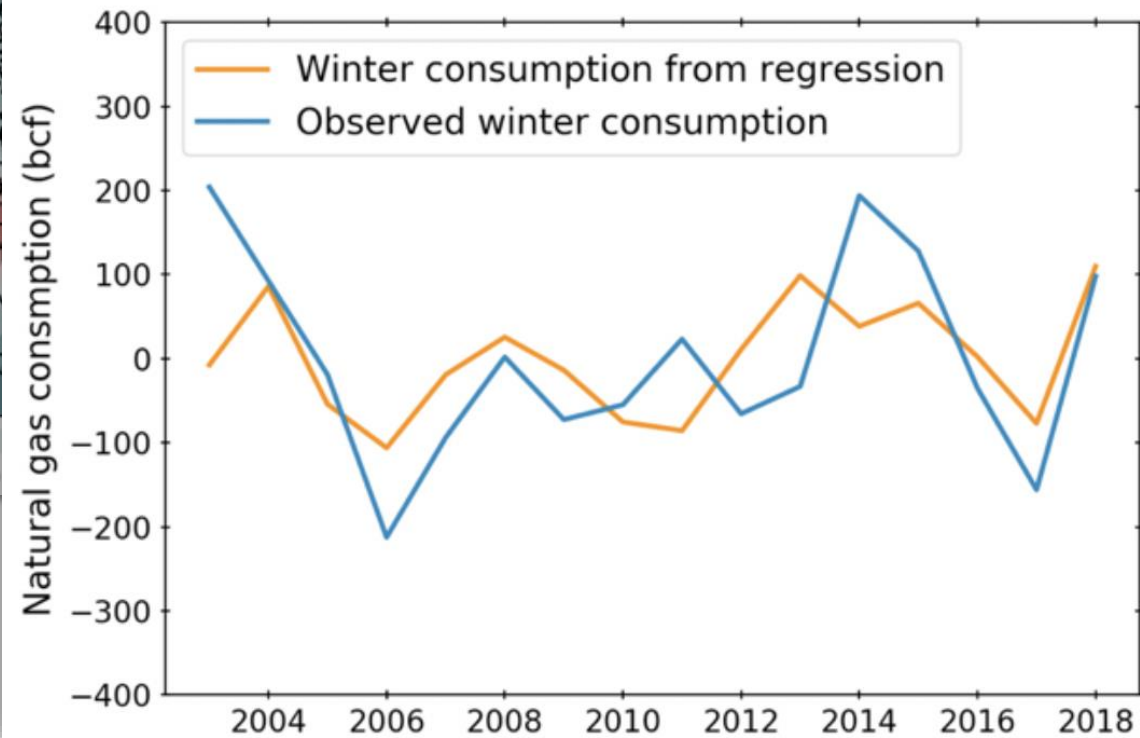


2018:1:5:12



Cyclone intensity

(c) Natural gas consumption regression





Climate

- N Amer Dipole index



Weather

- Bomb cyclone



Energy

- Natural gas market



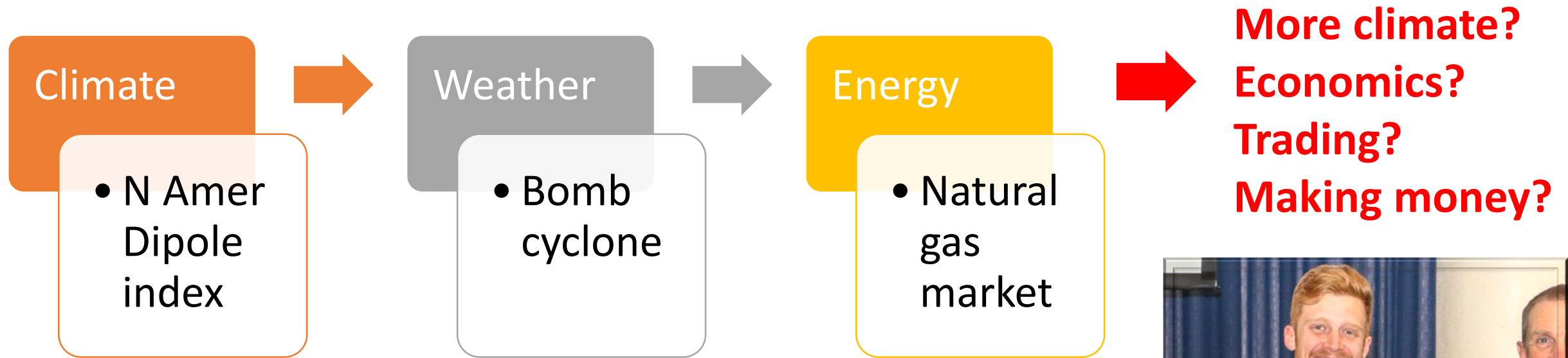
(in review)

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Jacob Stuivenvolt-Allen and Simon S.-Y. Wang

Department of Plants, Soils and Climate, Utah Climate Center, Utah State University, Logan UT, USA

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