# Remote Teleconnection Influences on Atmospheric Blocking in the Community Earth System Model (CESM)

Rich Neale

AMP/CGD

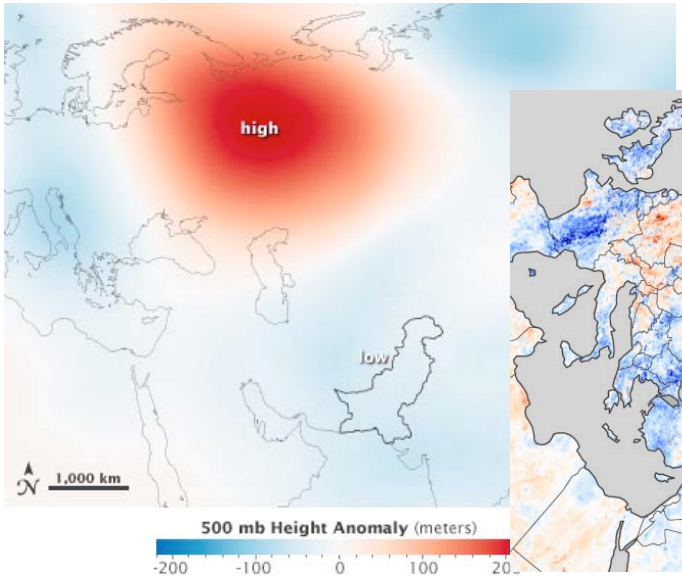
National Center for Atmospheric Research

Boulder, Colorado

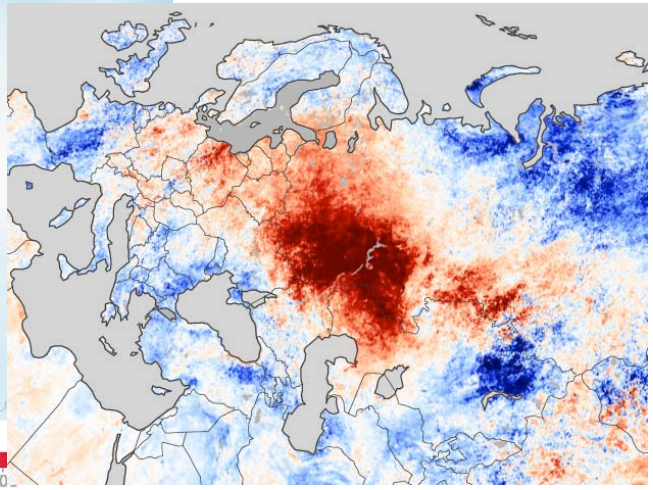
# Atmospheric Blocking

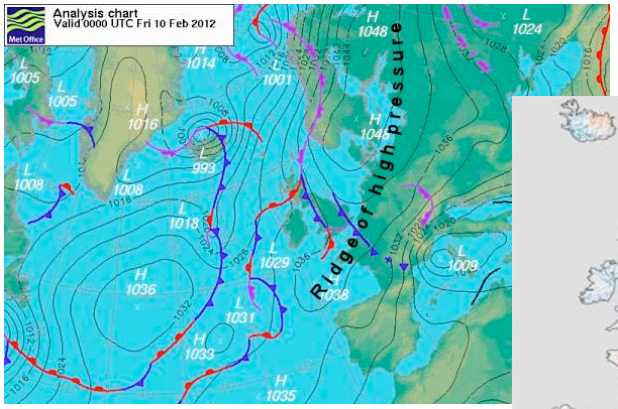
## *What, why, when*

- ✓ Surface high pressure systems in all seasons, generally infrequent
- ✓ Can persist for many days (blocks other systems).
- ✓ Has poorly understood initation/maintenance/decay mechanisms (contrast with baroclinic theory)
- ✓ Significant impacts on extreme events (heat/cold snaps, atypical weather)
- ✓ In climate models it may be a proxy for extreme events when resolution is insufficient

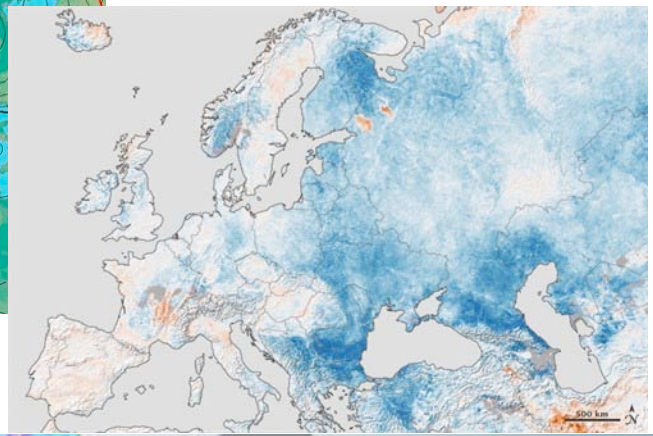



June 2010






Feb 2012



# Atmospheric Blocking in CESM

1. WHAT ARE THE DIFFERENCES IN BLOCKING IN RECENT CESM VERSIONS?
2. IS THERE AN OBSERVED TROPICAL INFLUENCE ON BLOCKING?
3. DOES CESM CAPTURE THESE RELATIONSHIPS?

# ANALYSIS

**NCAR-DOE Community Earth System Model (CESM) fully coupled simulations**
**Daily means of many quantities (Z500,T2m,precip,(u,v)200mb)**

**Reanlyses (1979-2010)**

**MERRA (NASA)**
**ERA-interim (ECMWF)**

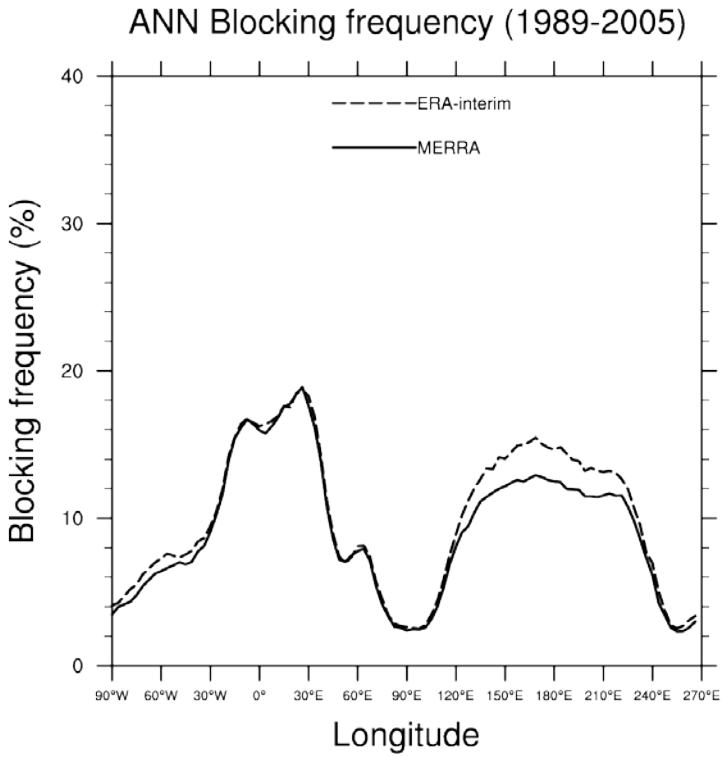
**Model simulations (1 degree/fully coupled 20th century simulations)**

**CCSM3 (AR4,5EM) – Poor blocking activity**

**CCSM4 (AR5,1EM) – Tropical convection changes (better)**

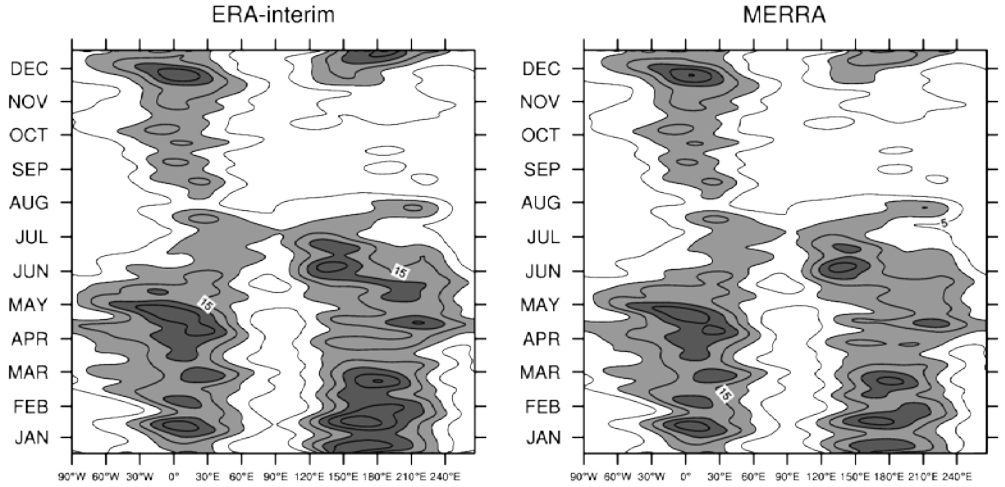
**CESM1 (AR5,6EM) – Cloud, shallow convection, microphysics and radiation changes (best)**

# Reanalyses




Daily data 500-mb geopotential height

*D'Andrea (1998)*




$$GHGS = \frac{Z(\phi_0) - Z(\phi_s)}{\phi_0 - \phi_s}$$

$$GHGS = \frac{Z(\phi_n) - Z(\phi_0)}{\phi_n - \phi_0}$$

where

$\phi_n = 78.75\,^{\circ}N + \Delta$

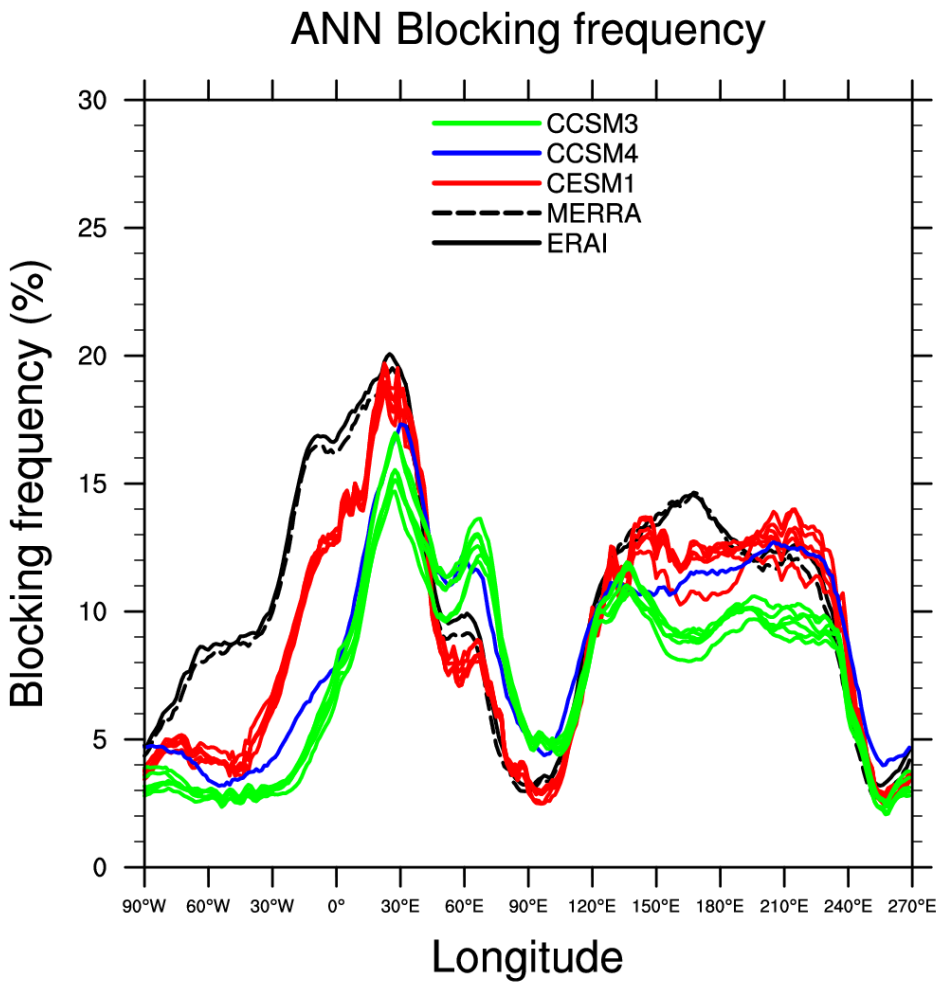
$\phi_0 = 60\,^{\circ}N + \Delta$

$\phi_s = 41.25\,^{\circ}N + \Delta$

with

$\Delta = -3.75^{\circ}, 0^{\circ}, 3.75^{\circ}.$

# Model (CESM) Blocking Statistics




Ensemble spread show well separated characteristics

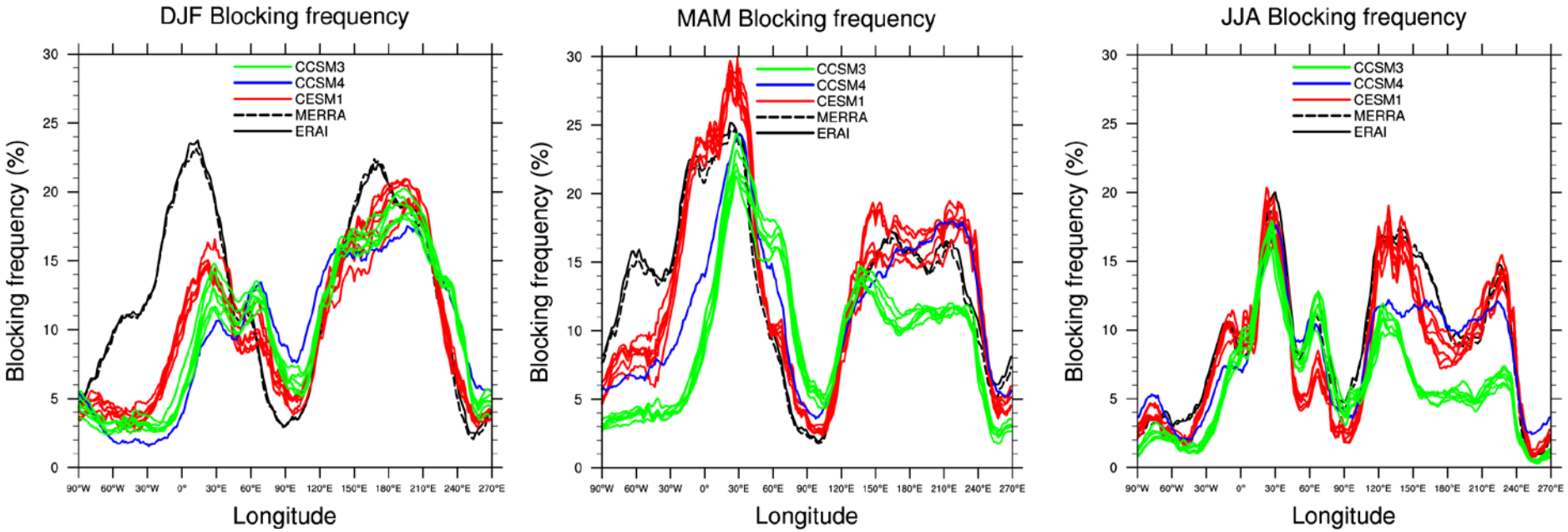
Systematic improvement in blocking Activity from CCSM3->CCSM4->CESM1

Particularly in main error region (Eastern Atlantic)

Significantly different atmospheres CAM3->CAM4->CAM5

**Seasonal dependence?**

# A Tale of 3 Seasons

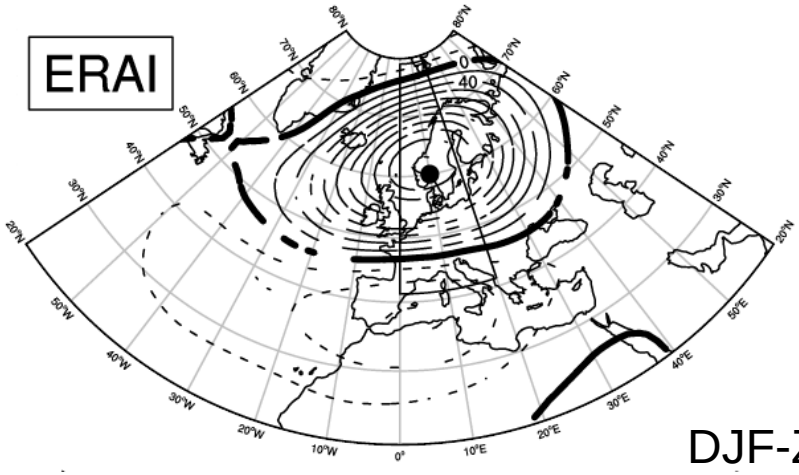


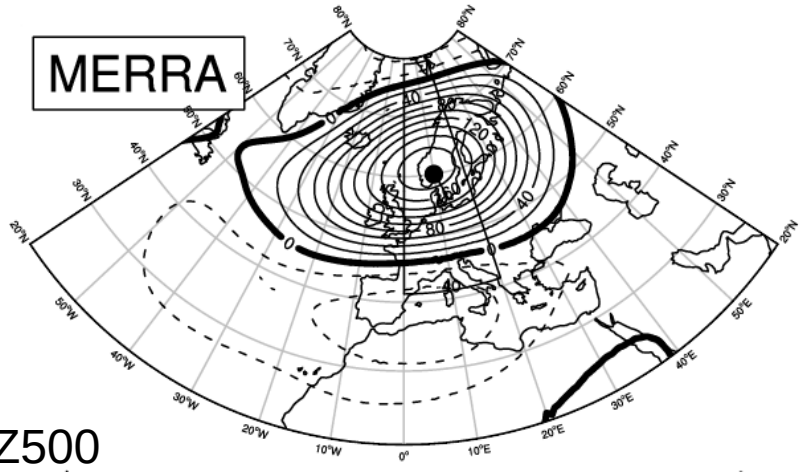

- DJF has largest seasonal bias in Atlantic region: No model improvements
- MAM smaller Atlantic biases: Significant model improvements through CESM1
- JJA has largest Pacific biases: Significant improvements though CCSM4/CESM1

## Is there a remote tropical influence?

# Composite Patterns

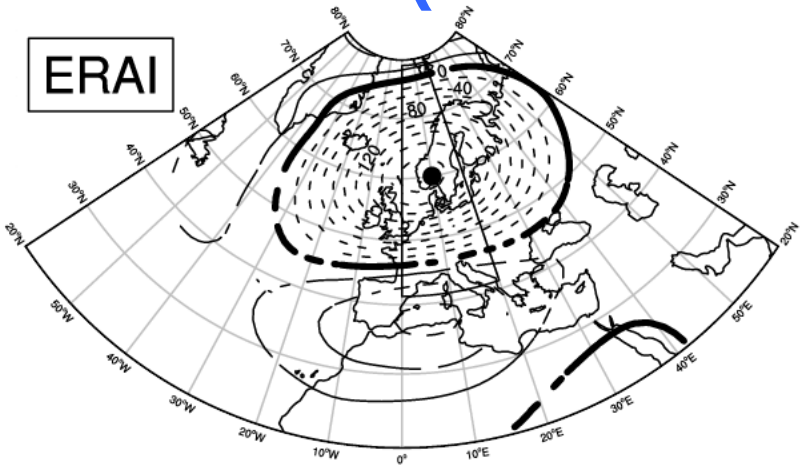
# Blocked (top 20%)

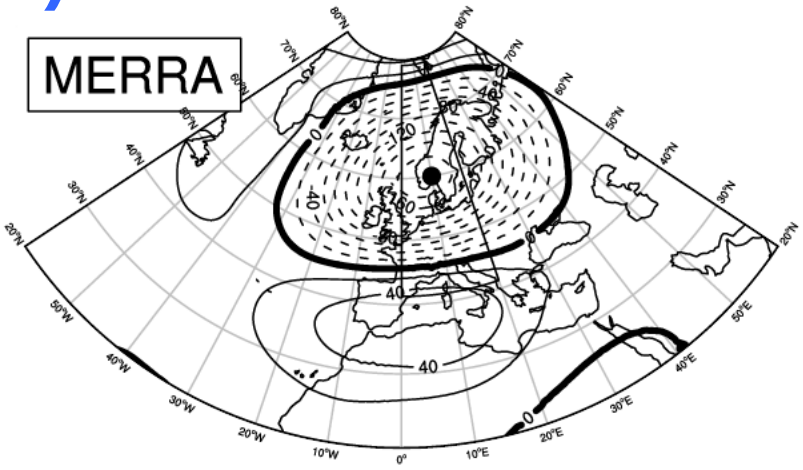


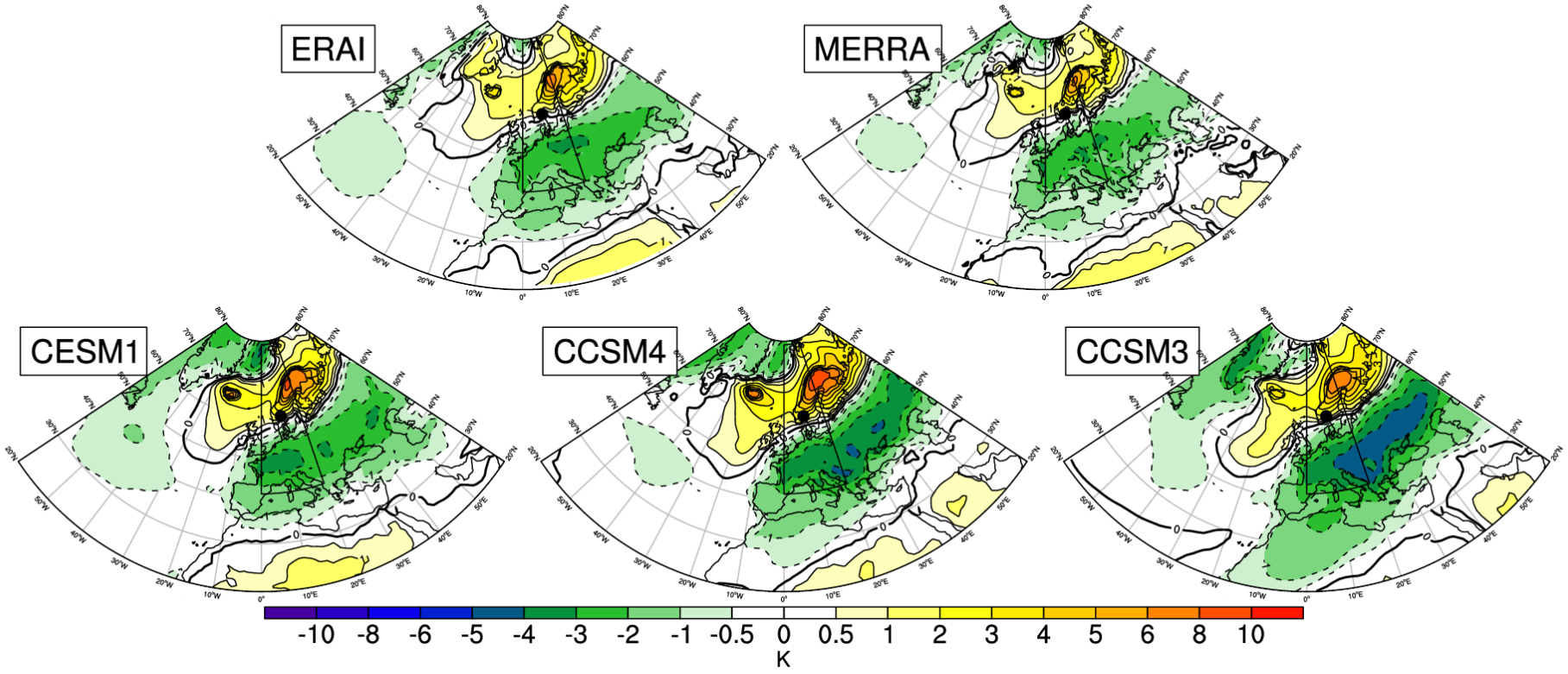

DJF-Z500

# Baroclinic (bottom 20%)

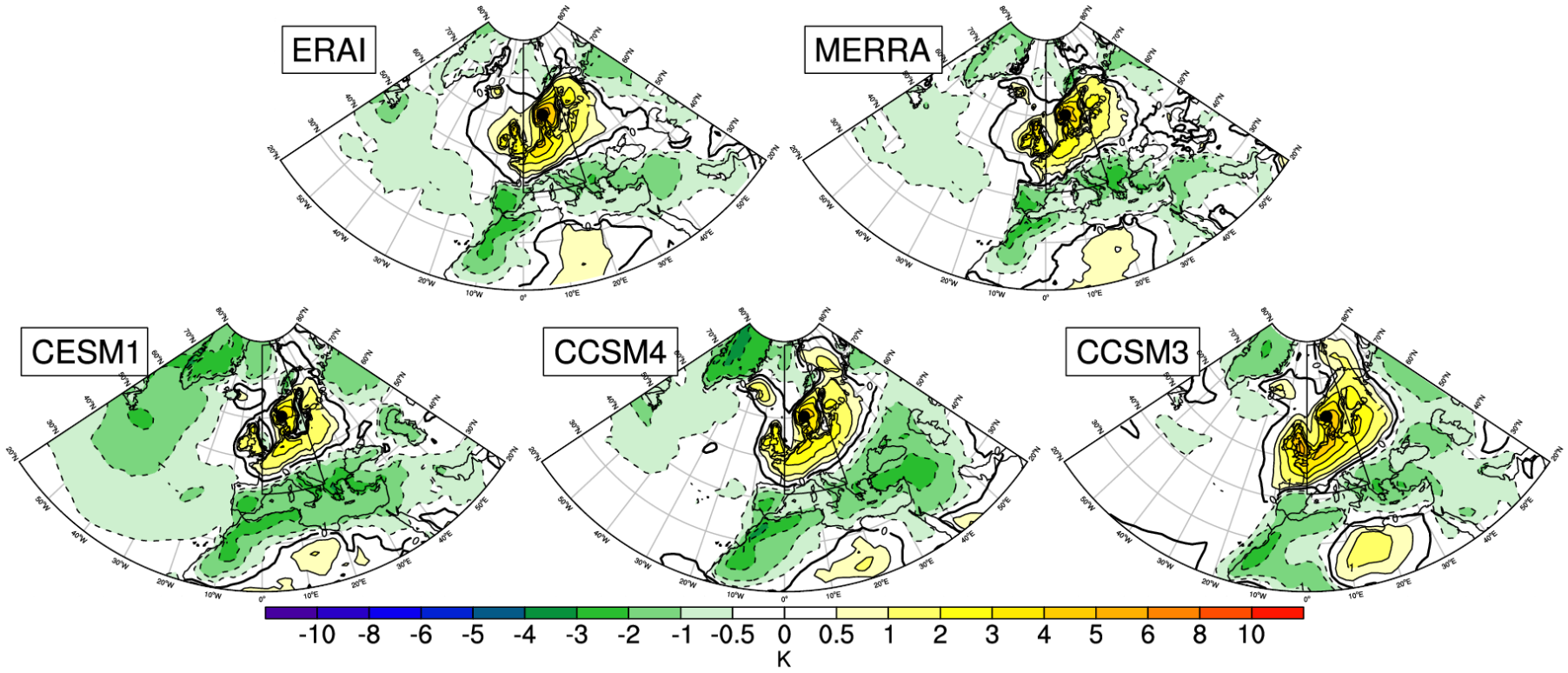


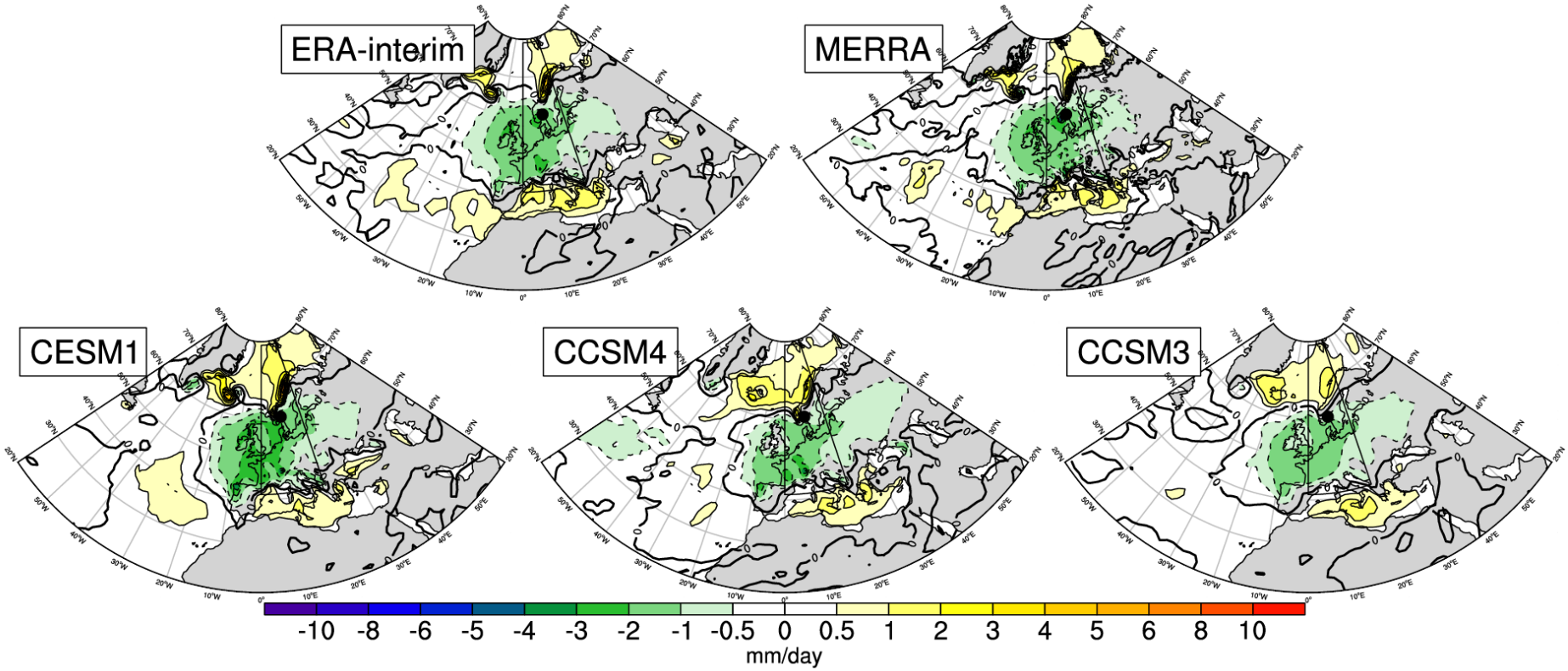
# Surface air temperature (K) - High Z500 composite - DJF



# Surface air temperature (K) - High Z500 composite - JJA



# Total precipitation (mm/day) - High Z500 composite - DJF



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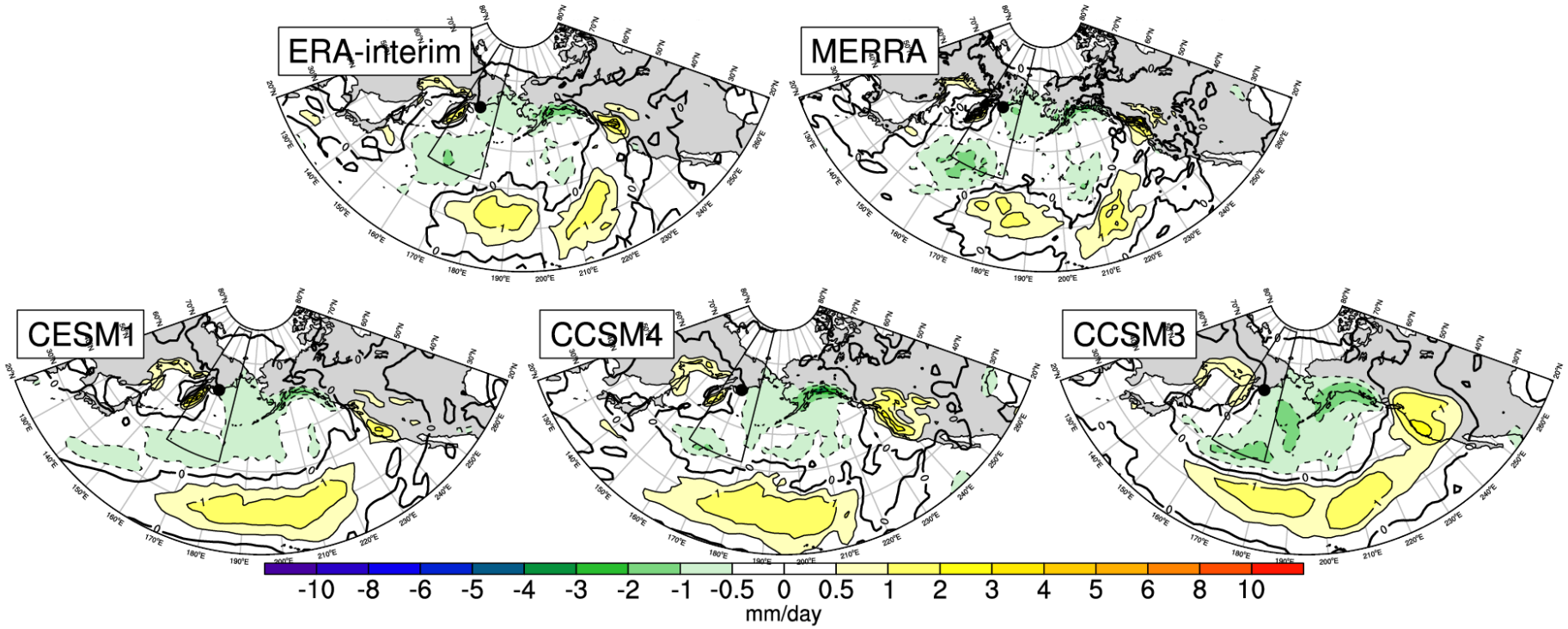
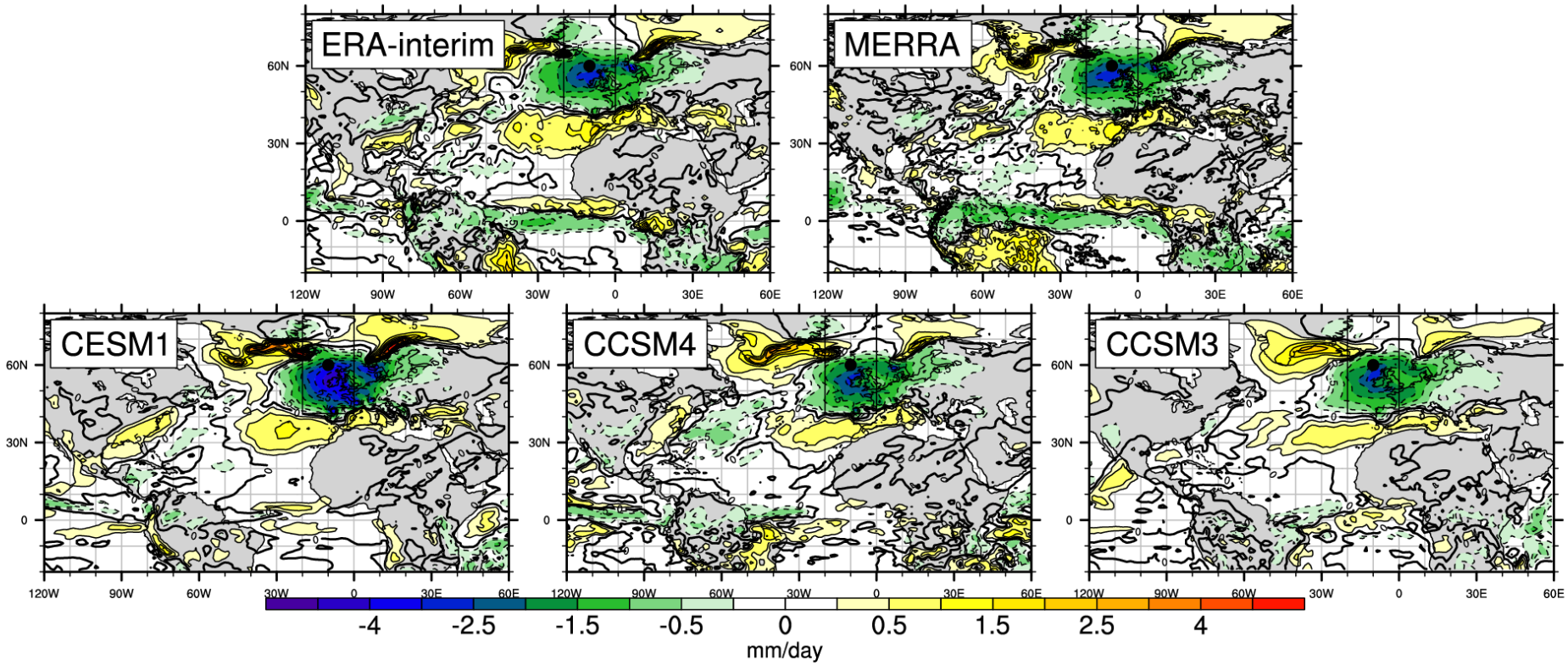


# Tropical Connections

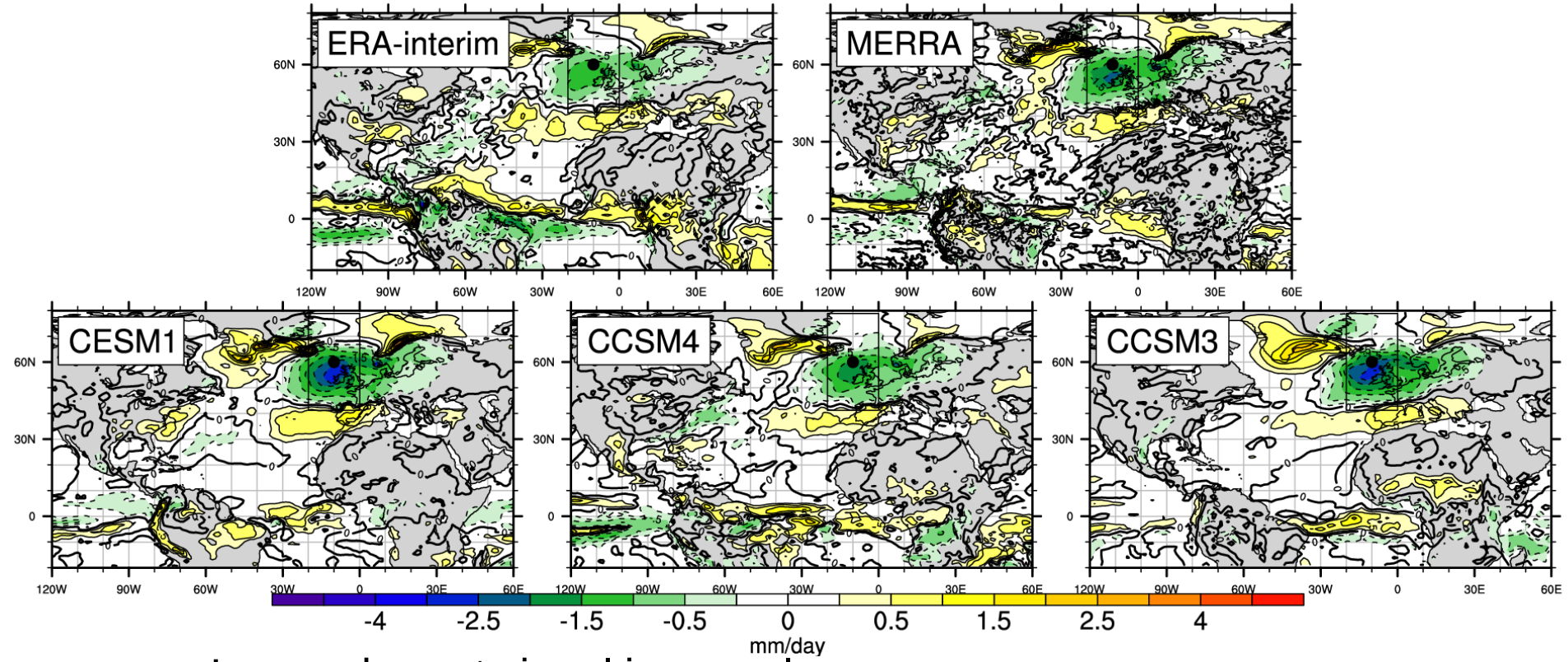
## Total precipitation (mm/day) - High Z500 composite - DJF




Moving central analysis longitude to region of blocking model spread

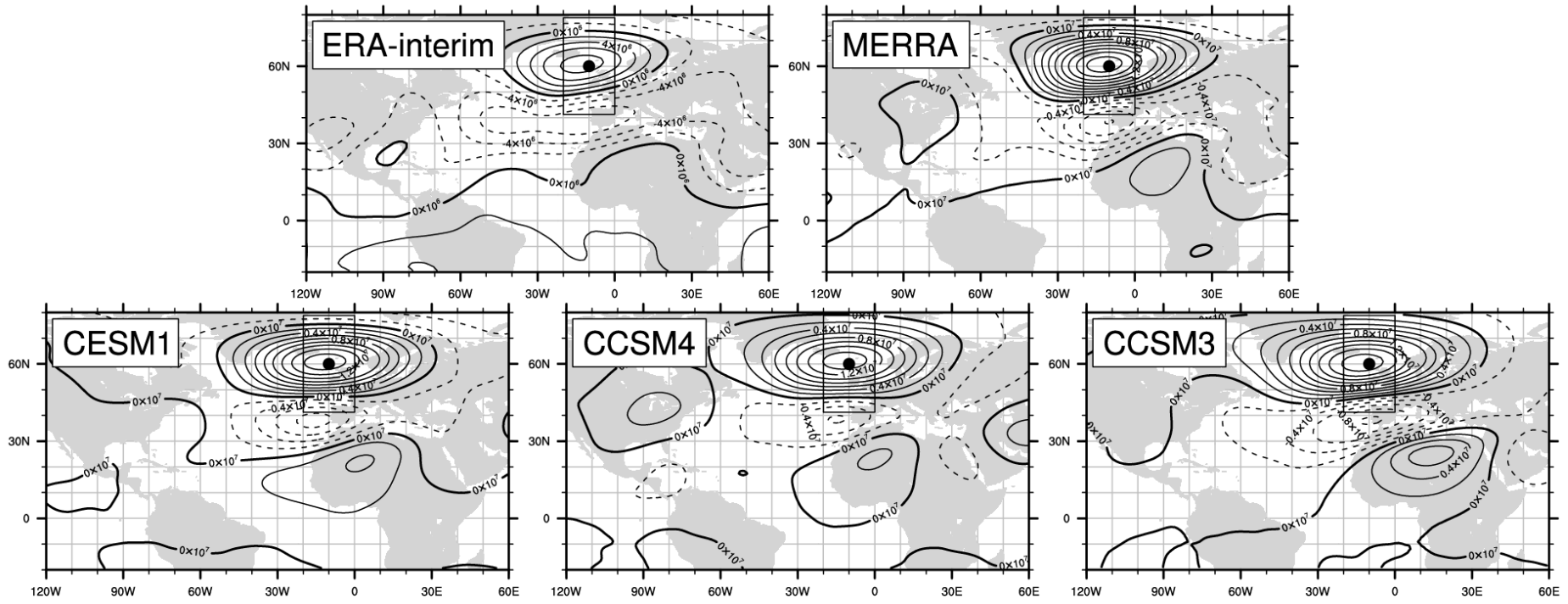
- Coherent non-local signal as large as local signal in reanalysis
- Little tropical signal in models

# Total precipitation (mm/day) - High Z500 composite - MAM



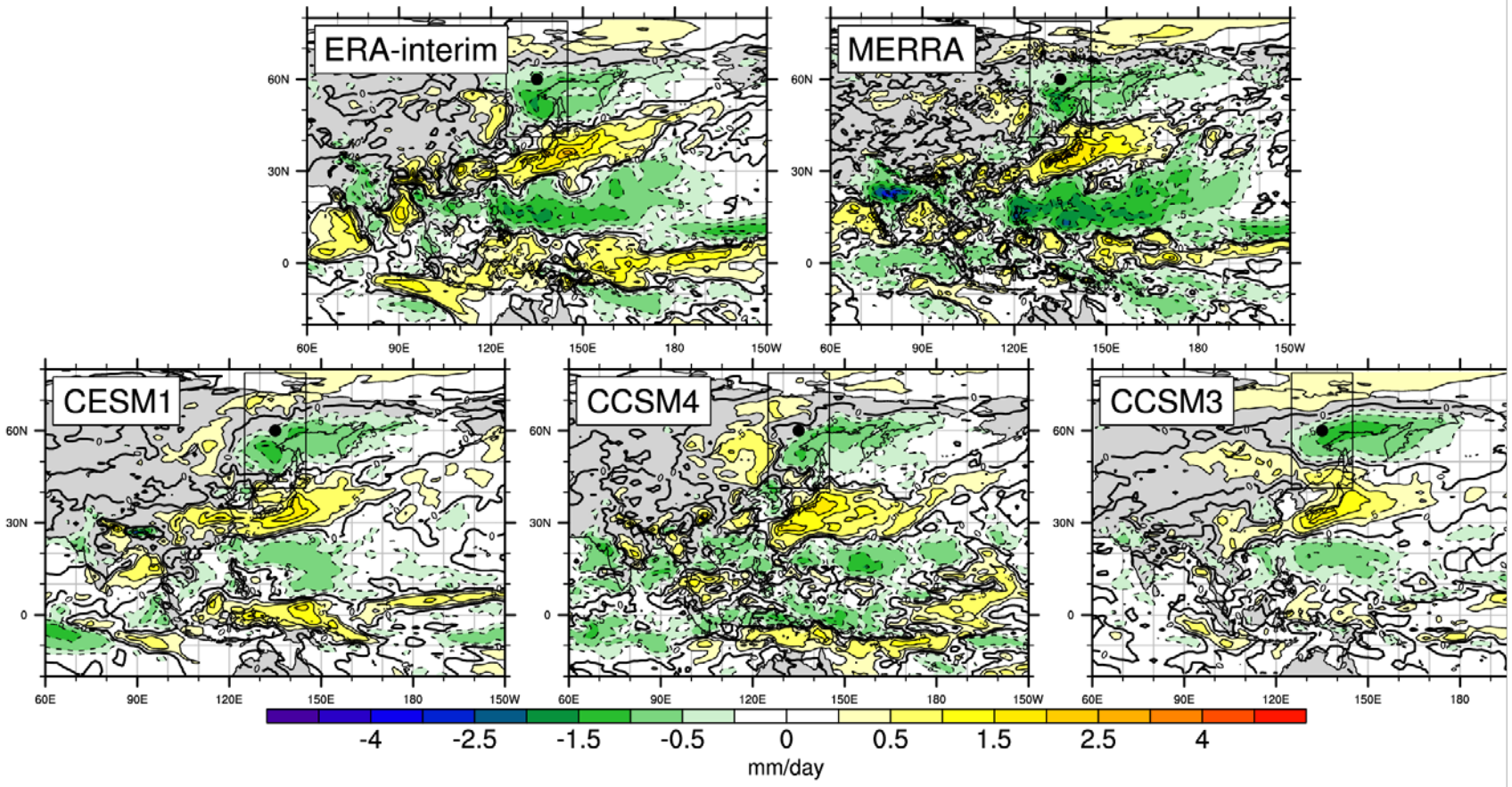

- Less coherent signal in reanalyses
- Signal shifts to South America in models CCSM/CESM1

# 200-mb Streamfunction ($m^2s^{-2}$) - High Z500 composite - MAM



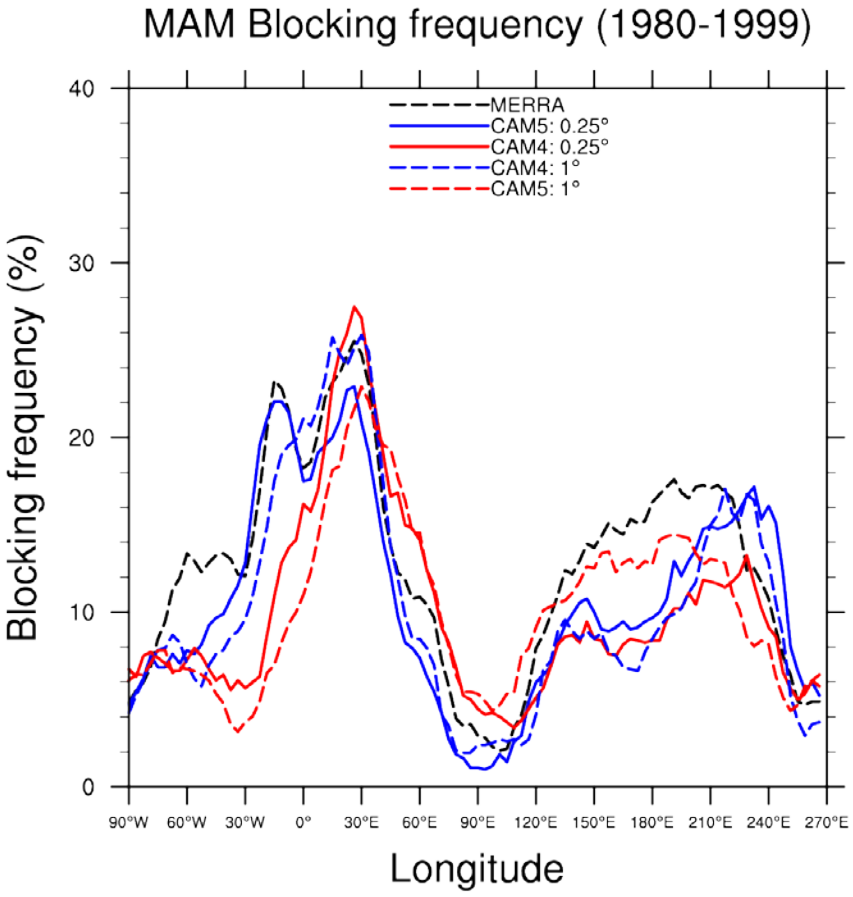

- Less coherent signal in reanalyses
- Signal shifts to South America in models CCSM/CESM1

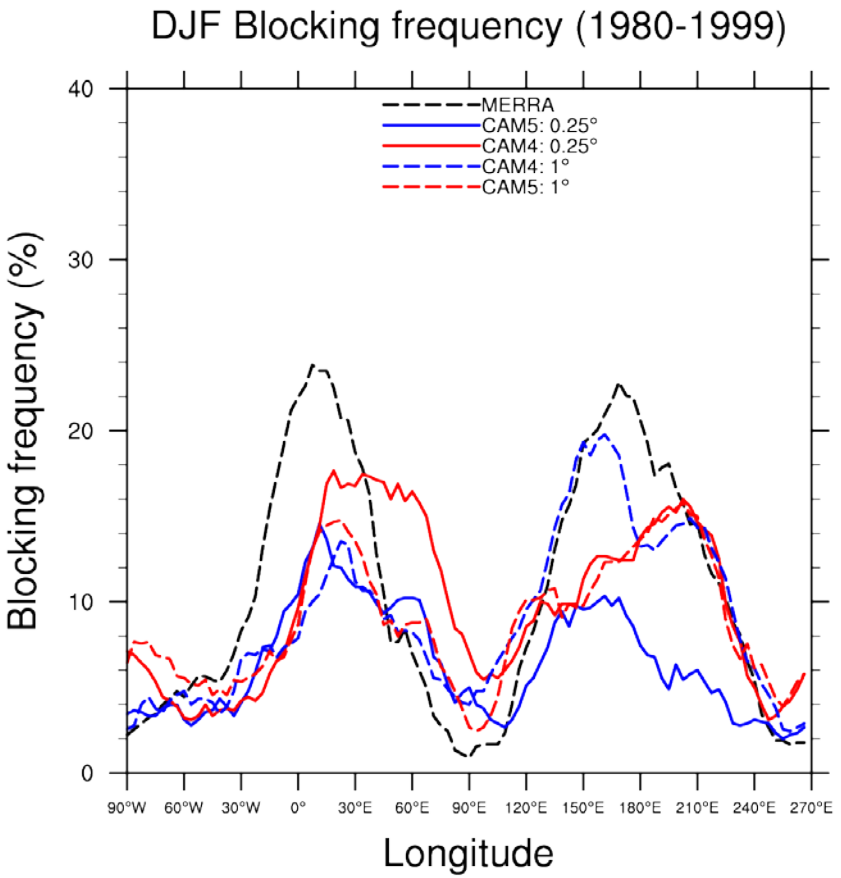
# Total precipitation (mm/day) - High Z500 composite - JJA



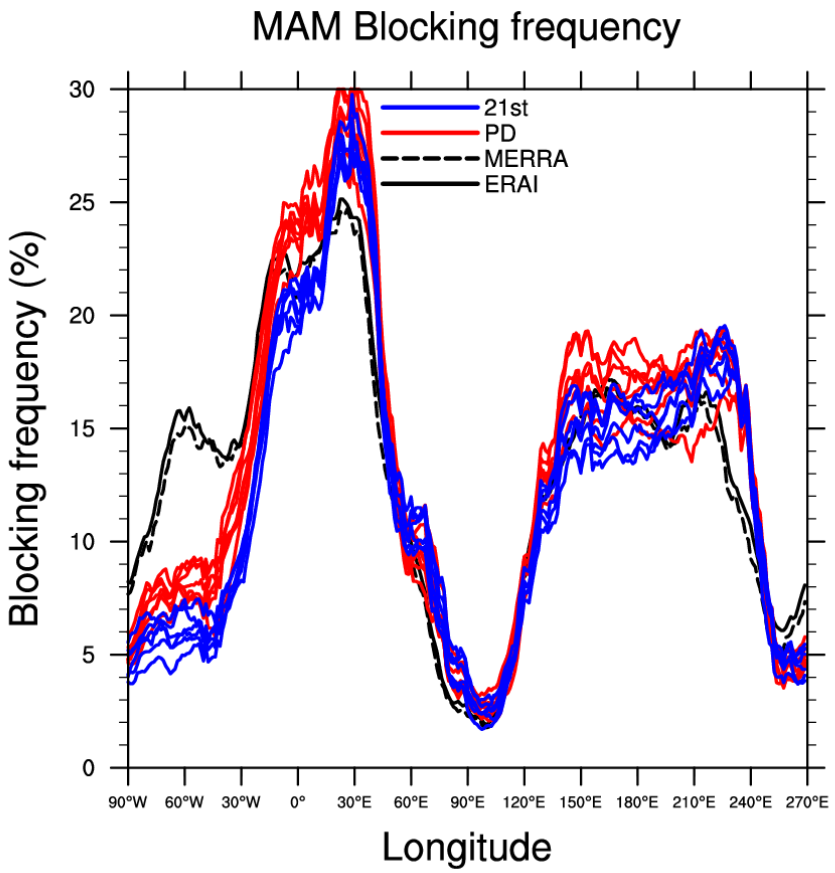
# Resolution and Future Climate

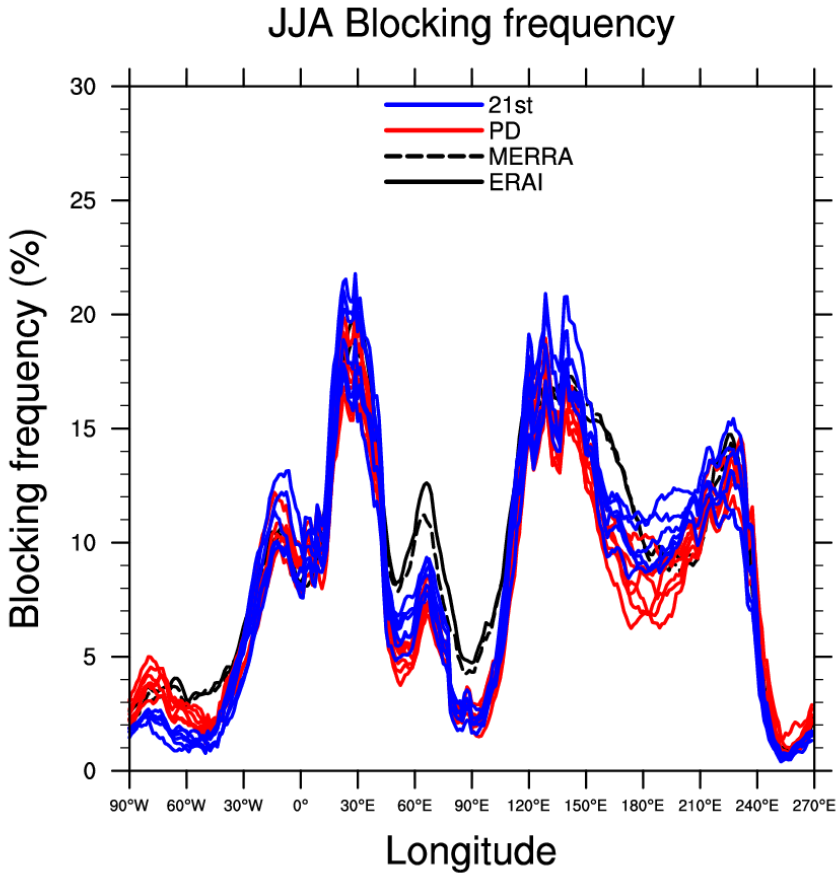
# Resolution Impacts



# Climate Change Signal?



# Summary

Systematic improvements with model version (CCSM3->CCSM4->CESM1)

DJF no systematic improvements

MAM/JJA improvements in Atlantic/Pacific

Local composite response in good agreement with reanalyses

Indications of tropical co-variability; weakest agreement in Atlantic (DJF)

Small resolution dependence; small blocking decrease in future

**Next Steps**

**Can we attribute atmosphere model changes to blocking improvements?**

TMS, micro, shCU, DeepCU, dy-core, radiation