# The impact of super-parameterization on the sub-seasonal forecast skill

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***Q**: How does prediction skill and fidelity change when **resolution is increased** in combination for the various components of the prediction system? How can we diagnose and address model behaviors that lead to the sensitivity? Are there specific or **related processes** in the coupled system that drive prediction error in the short-term forecast and climate simulation bias? **What resolutions are necessary to adequately resolve these processes?***

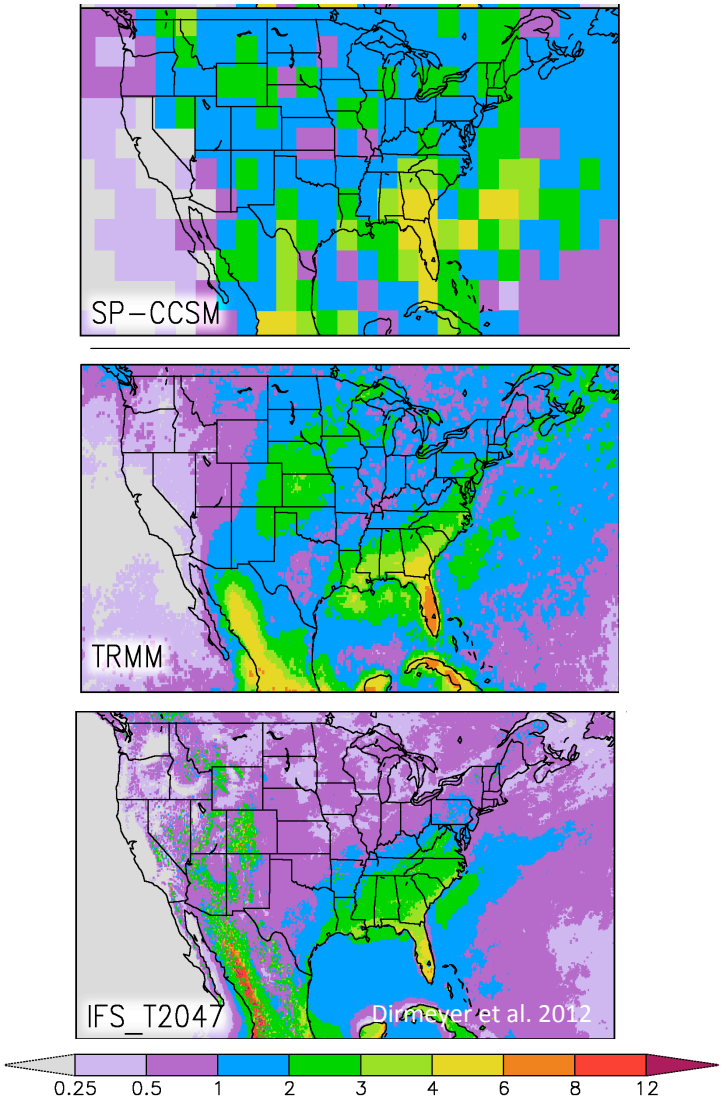
***A**: Resolution should be increased to the limit of allowing the explicit representation of cloud processes in the atmosphere*

# Motivation

- Hohenegger et al. 2009 showed that in the Alpine region the positive soil-moisture precipitation feedback simulated by a low-resolution, parameterized convection model became negative in the high-resolution, resolved convection version of the model.

- Taylor et al. 2013 also found that low-resolution models with parameterized convection tend to erroneously simulate a positive feedback between soil moisture and precipitation. Increasing the resolution alone did not have an impact on the simulation of land-atmosphere interactions.

- Dirmeyer et al., 2012 found that increasing resolution alone has little impact on the timing of daily rainfall in IFS with parameterized convection, yet the amplitude of the diurnal cycle does improve along with the representation of mean rainfall. Introduction of an embedded cloud model within the NCAR model significantly improves global statistics of the seasonal mean and diurnal cycle of rainfall, as well as many regional features.



Conventional Parameterization vs. Super-Parameterization

Same horizontal resolution (~1 deg)

CCSM4 vs. SP-CCSM4

# Super-Parameterization Improvements

## Uncoupled

1. **The diurnal cycle of precipitation over the land**: Khairoutdinov et al., 2005; DeMott et al. 2007; Pritchard and Sommerville 2009

2. **Some aspects of the Madden Julian Oscillation**: Khairoutdinov et al. 2005; Thayer-Calder and Randall 2009; Jiang et al. 2015

3. **The large-scale distribution of precipitation in the equatorial Pacific**: Khairoutdinov and Randall 2001

4. **The implied ocean heat transport**: DeMott et al. 2009

## Coupled

1. **The Madden Julian Oscillation**: Stan et al. 2010; Stan and Xu 2014; DeMott et al. 2014; Jiang et al. 2015

2. **Summer Indian Monsoon**: Stan et al. 2010; DeMott et al. 2012; Krishnamurthy et al. 2013; Stan and Xu 2014

3. **West African Monsoon**: Stan and Xu 2014; McCrary et al 2014(a); McRary et al. 2014(b)

4. **South American Monsoon**: Krishnamurthy and Stan 2014

5. **Tropical Atlantic Cyclones**: Stan 2012

6. **El Niño – Southern Oscillation**: Stan et al. 2010; Nattala 2013

7. **Precipitation distribution in the Tropics**: Stan et al. 2010; Stan and Xu 2014

8. **Atlantic Meridional Overturning Circulation**: Stan and Xu 2014

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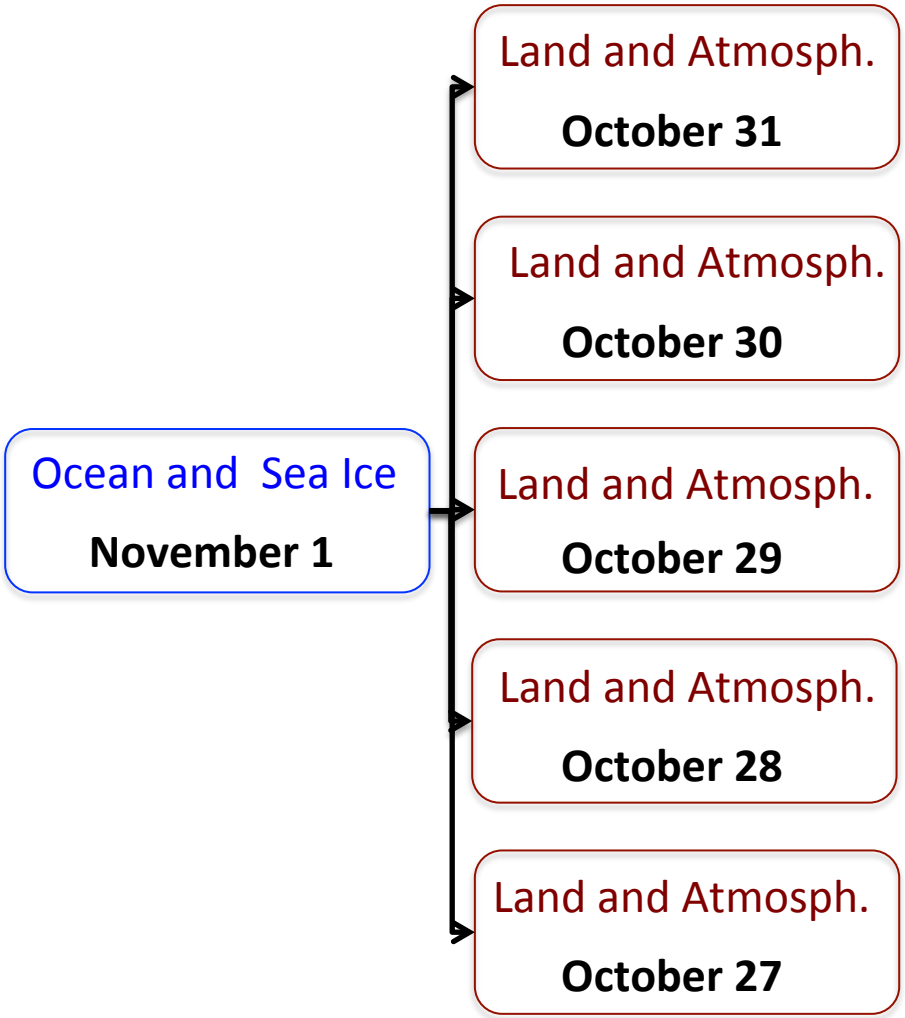
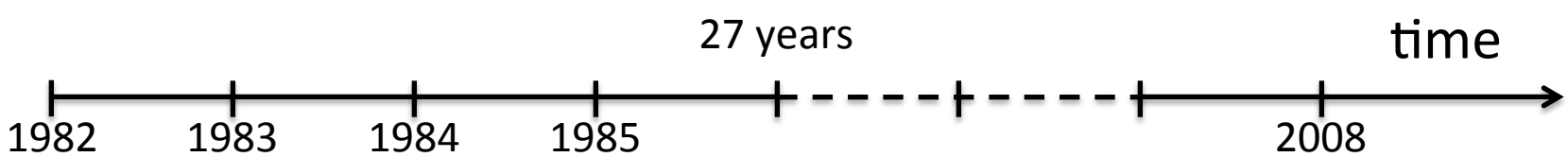
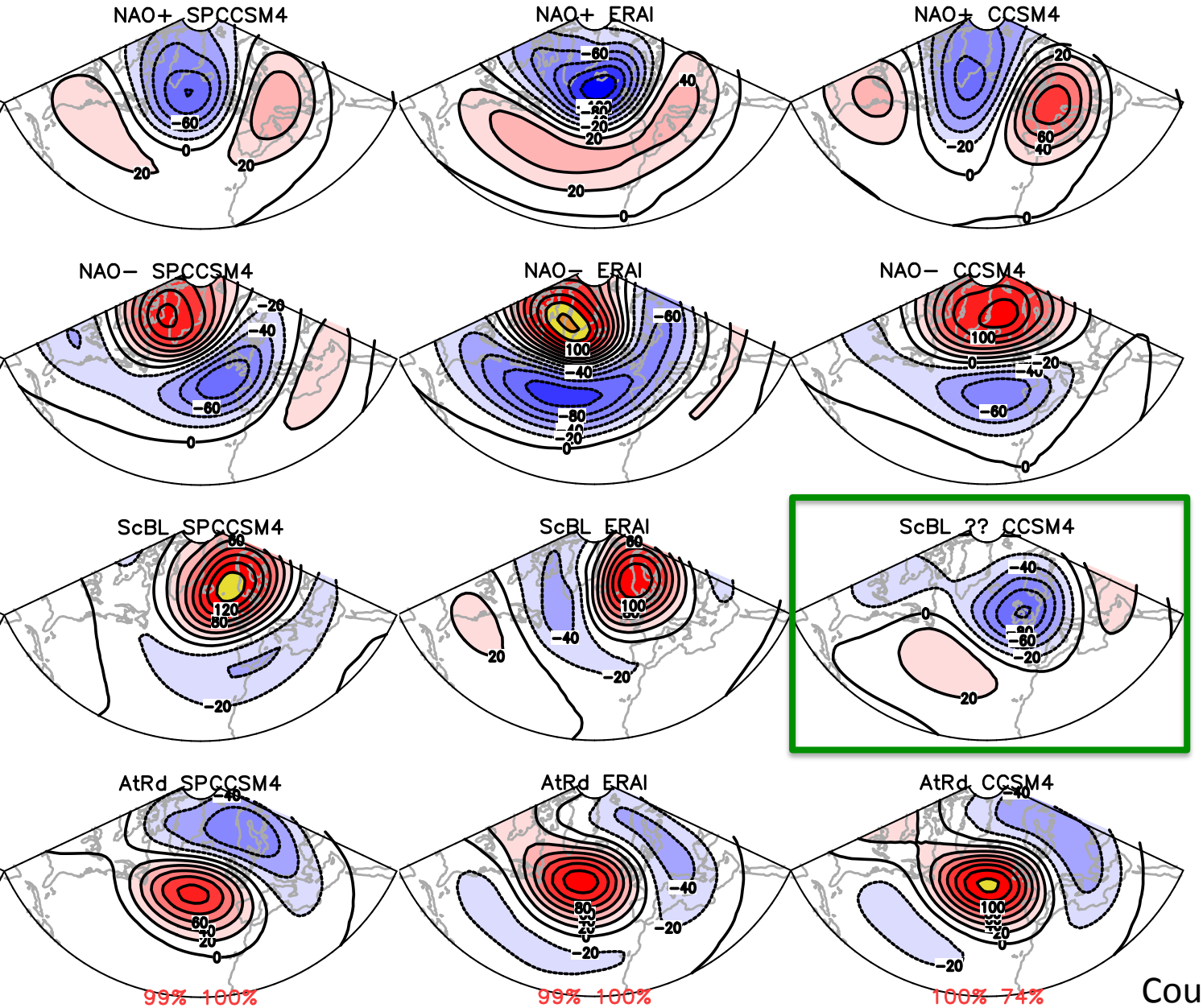
# *Hindcast Experiments Design*




- **November 1st initial conditions**
- Initial conditions: **CFSR**
- Forecast length: **12 months**
- Hindcasts: 5 x 27 = **135 experiments**



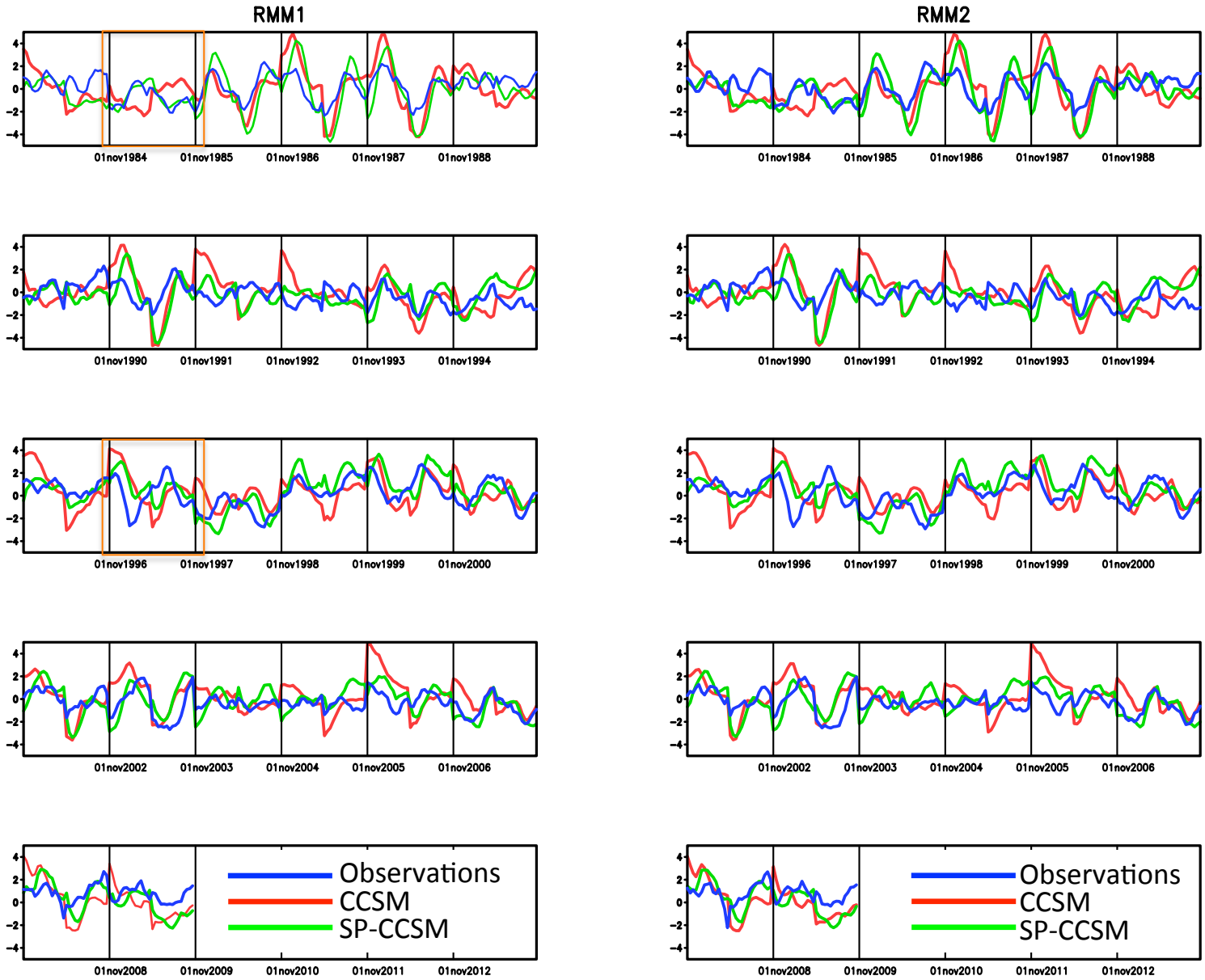
# Euro-Atlantic Sector Clusters




The sign reversal is not a coding error

Courtesy of David Straus

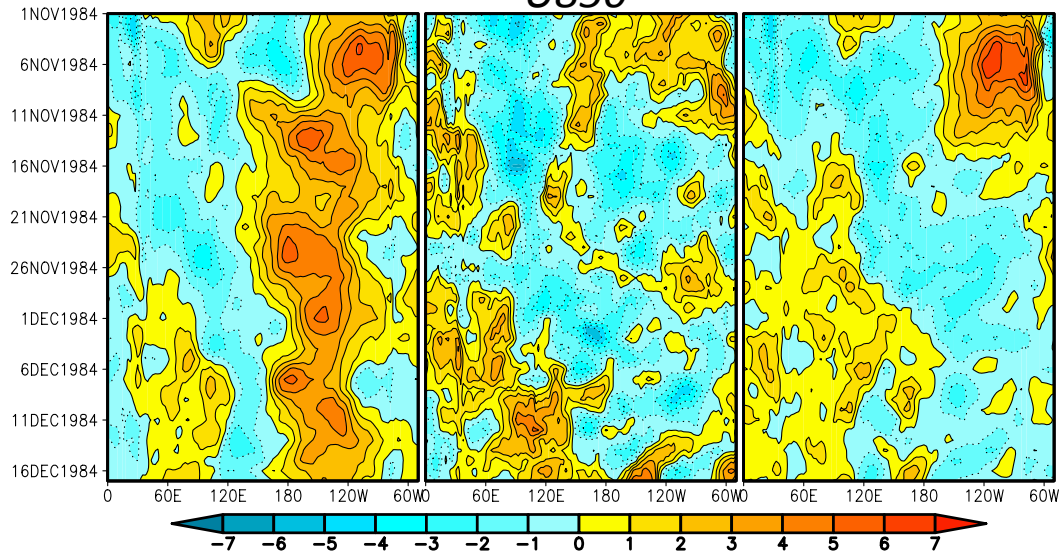
# RMM1 and RMM2



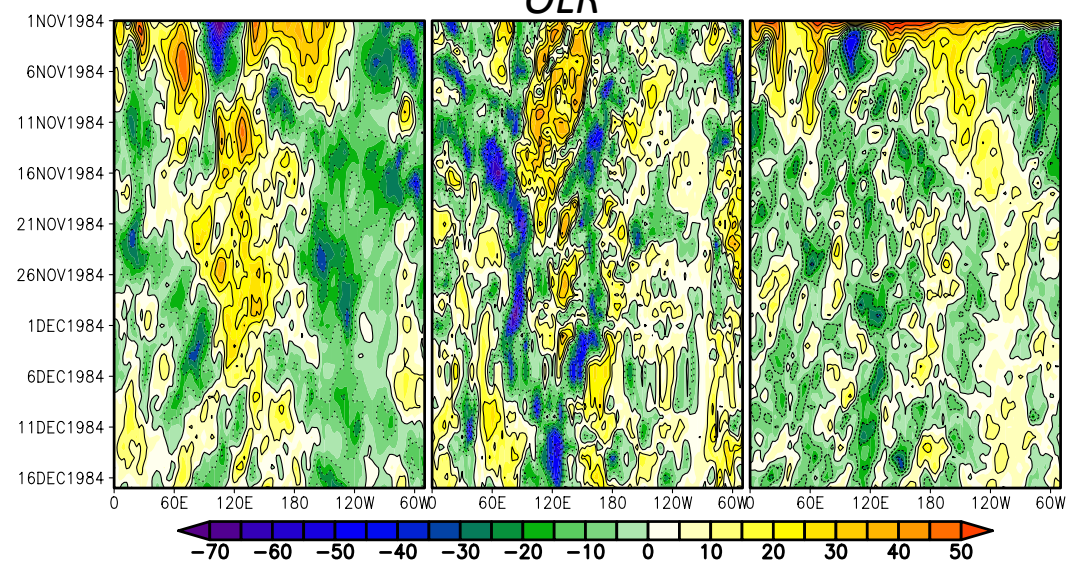
# November 1984

CCSM ERA-I SP-CCSM

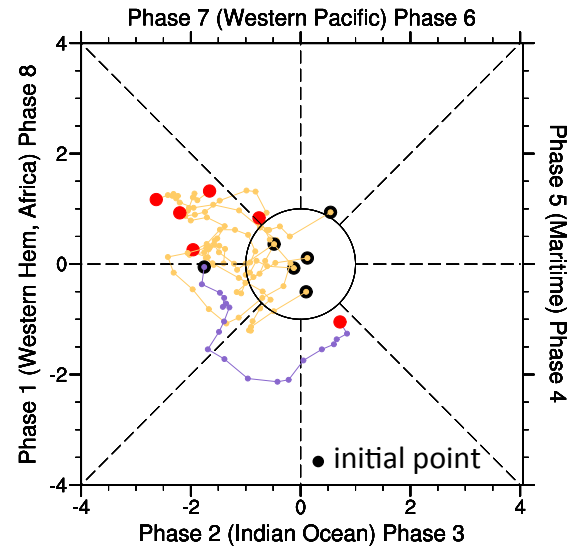
*U850*



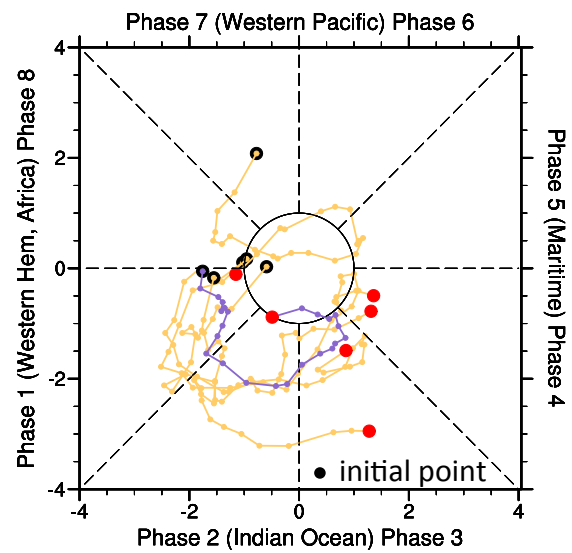

*OLR*




CCSM



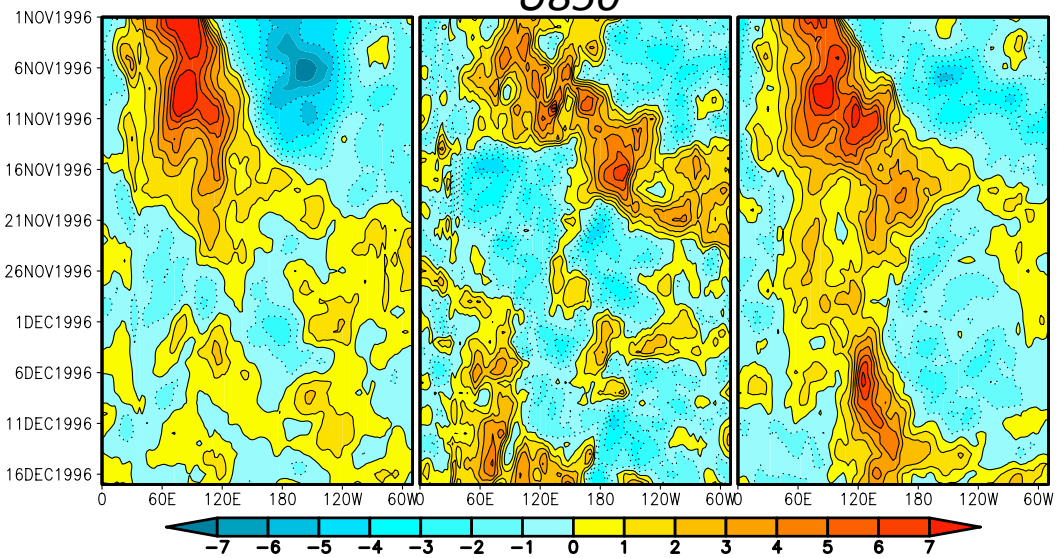

SP-CCSM



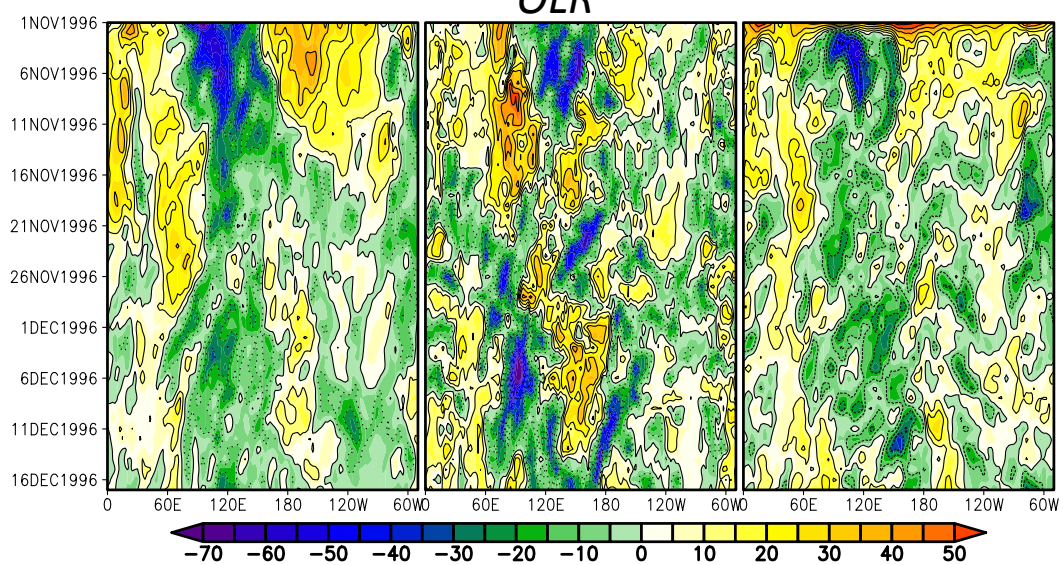
# November 1996

CCSM ERA-I SP-CCSM

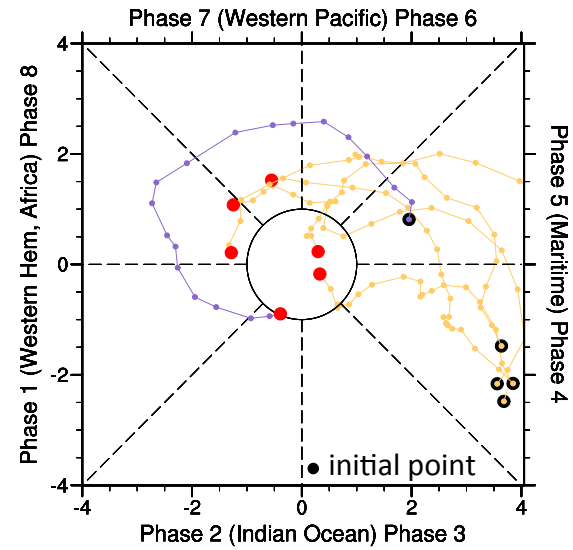
*U850*



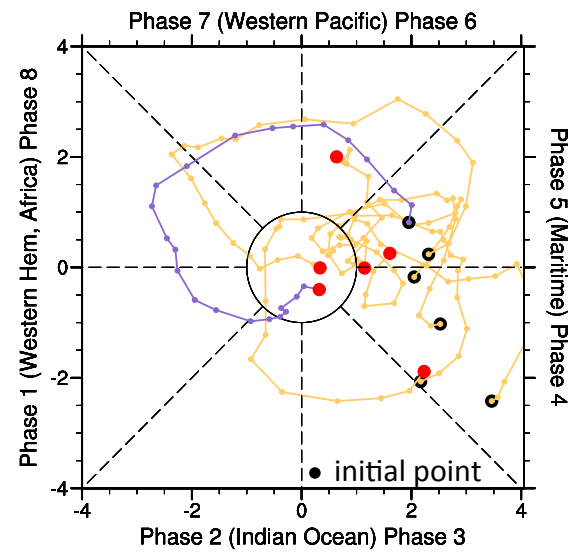

*OLR*




CCSM




SP-CCSM



# Summary

- The explicit representation of cloud processes through super-parameterization affects has an impact on the forecast skill of the intraseasonal variability predicted by an ocean-atmosphere climate model

- The pattern and significance of the large-scale patterns in the Euro-Atlantic sector are sensitive to the cloud parameterization

- The uncertainties in the initial conditions are important for the MJO forecast.