



# Addressing errors in land surface initial conditions within the Global Forecast System Ensemble (GEFS)

Philip Pegion<sup>1,2</sup>, Maria Gehne<sup>1,2</sup>, Tom Hamill<sup>2</sup>, Gary Bates<sup>1,2</sup>

1- CIRES/University of Colorado, Boulder, CO

2- NOAA/ESRL/PSD Boulder, CO

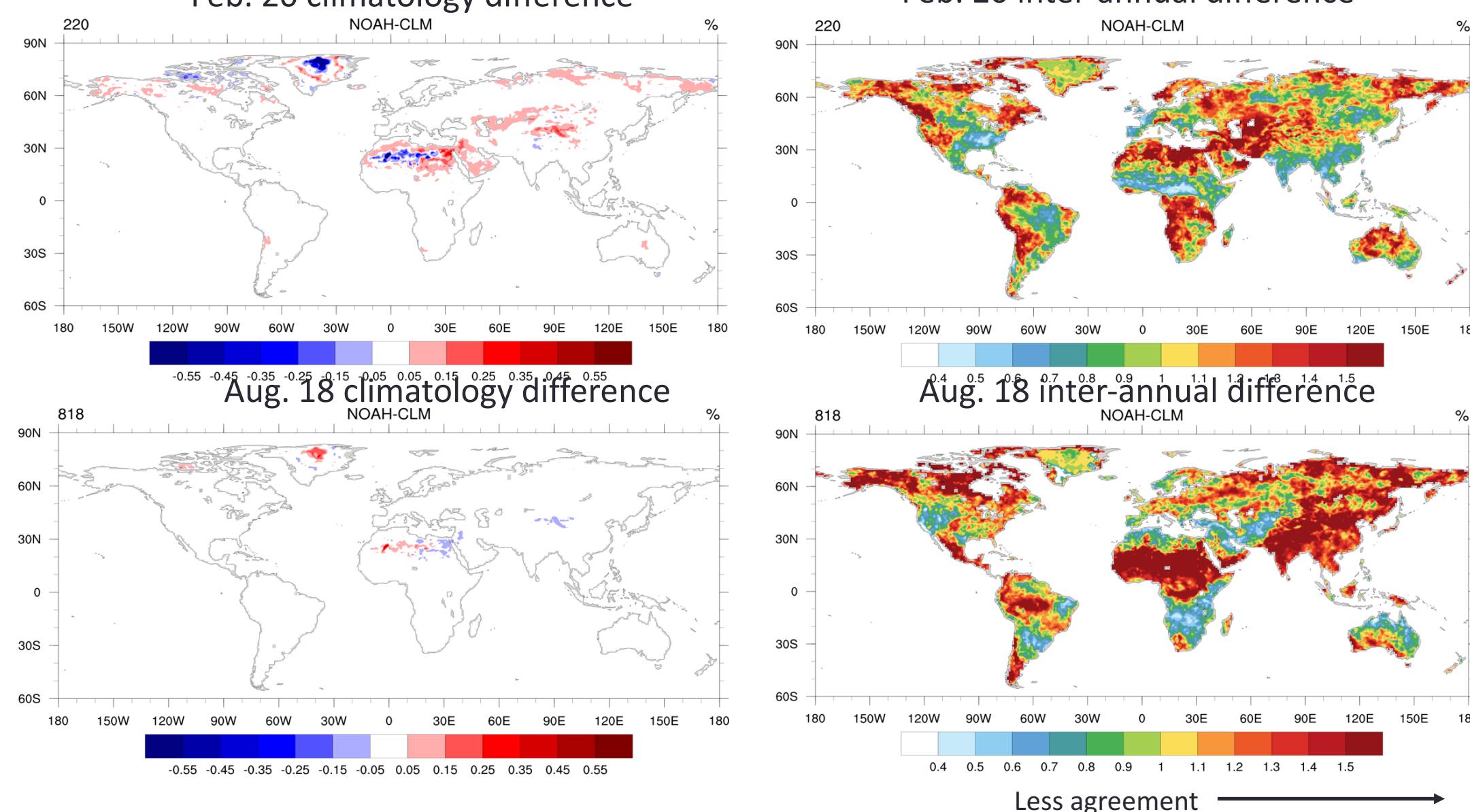


## Introduction

- Surface Variables such as 2 meter temperature have much larger errors relative to ensemble spread compared to upper-air variables, such as 500 hPa Height.
- One potential source of error is the land surface initialization
- Currently, the GEFS only address initial condition uncertainty in the atmosphere with EnKF perturbations, the land surface is identical for all 20-members
- We quantify the uncertainty in estimating the land state, and use that uncertainty to create an initial ensemble of land states

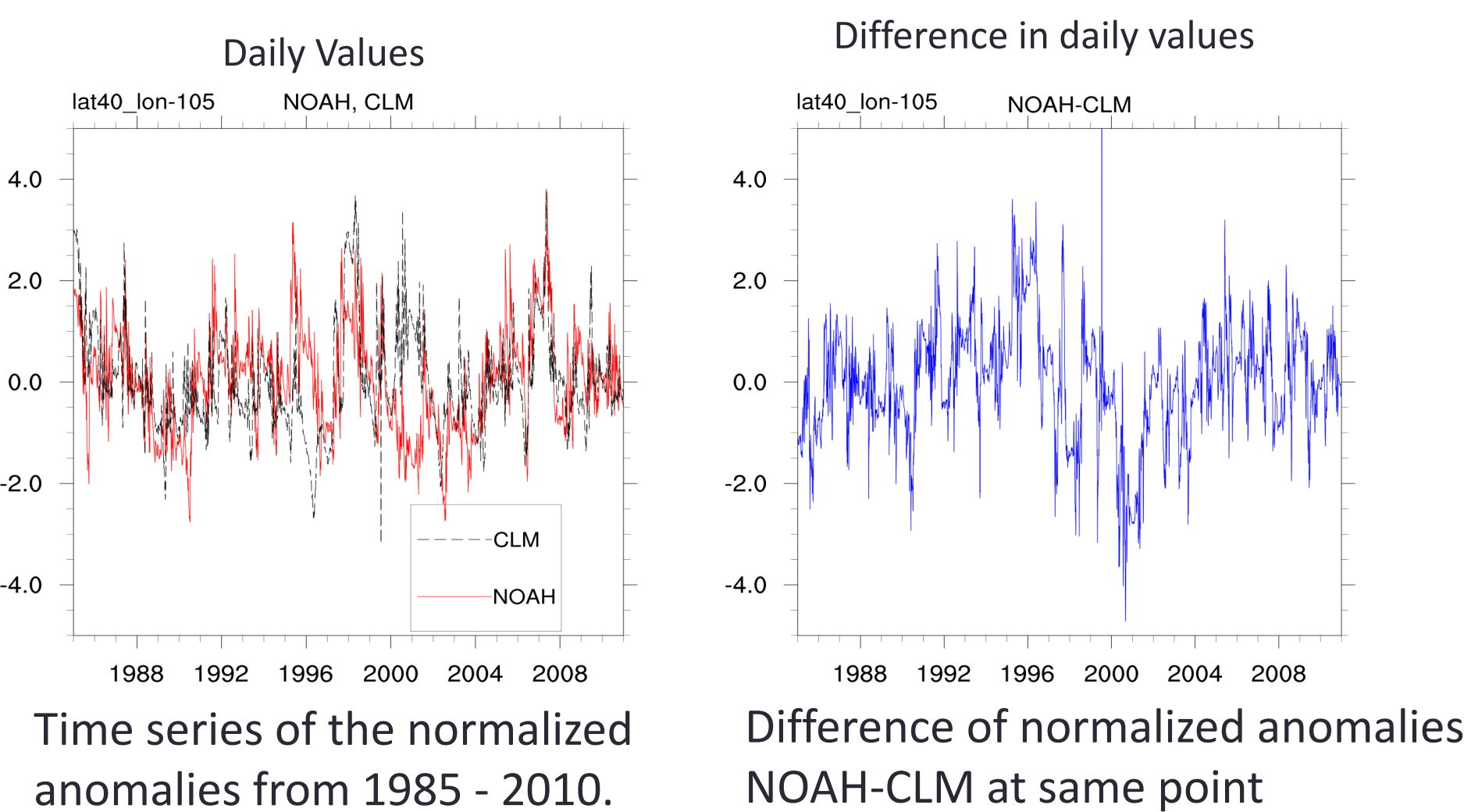
## Uncertainty in estimating the land state

Difference of two land models forced with the same observations  
**NOAH:** Noah LSM (NCEP,OSU,AFWA,AFRL) **CLM:** Community Land Model (NCAR)  
 Feb. 20 climatology difference Feb. 20 inter-annual difference



Long term mean and standard deviation of NOAH-CLM normalized anomalies. Left panels show long term mean differences. Right panels show the standard deviation of NOAH-CLM normalized anomalies for February 20 (top) and August 18 (bottom).

Time series a single grid point at 40N, 105W.

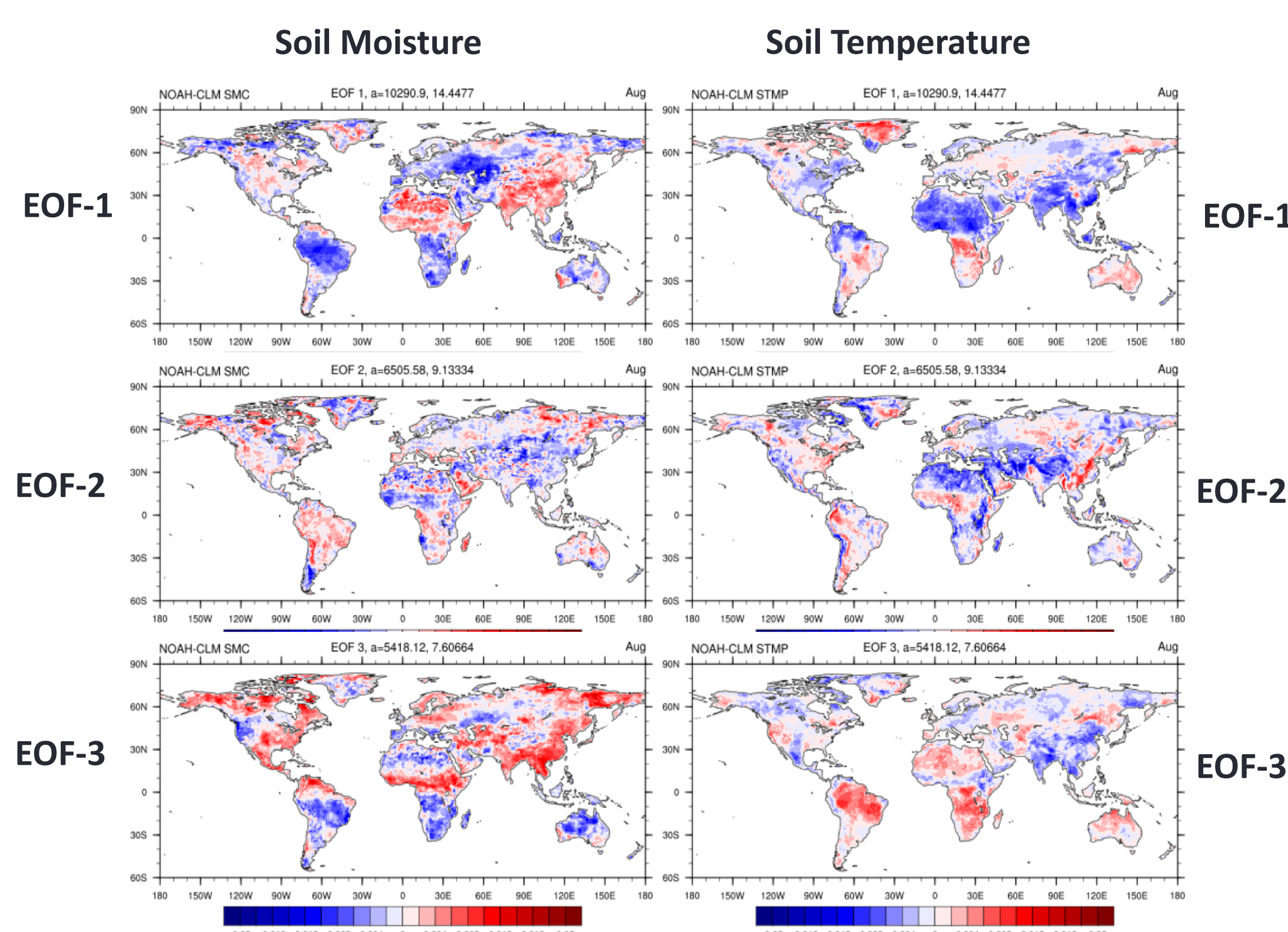


Time series of the normalized anomalies from 1985 - 2010.

Difference of normalized anomalies NOAH-CLM at same point

## Leveraging Uncertainty for Ensemble Initialization

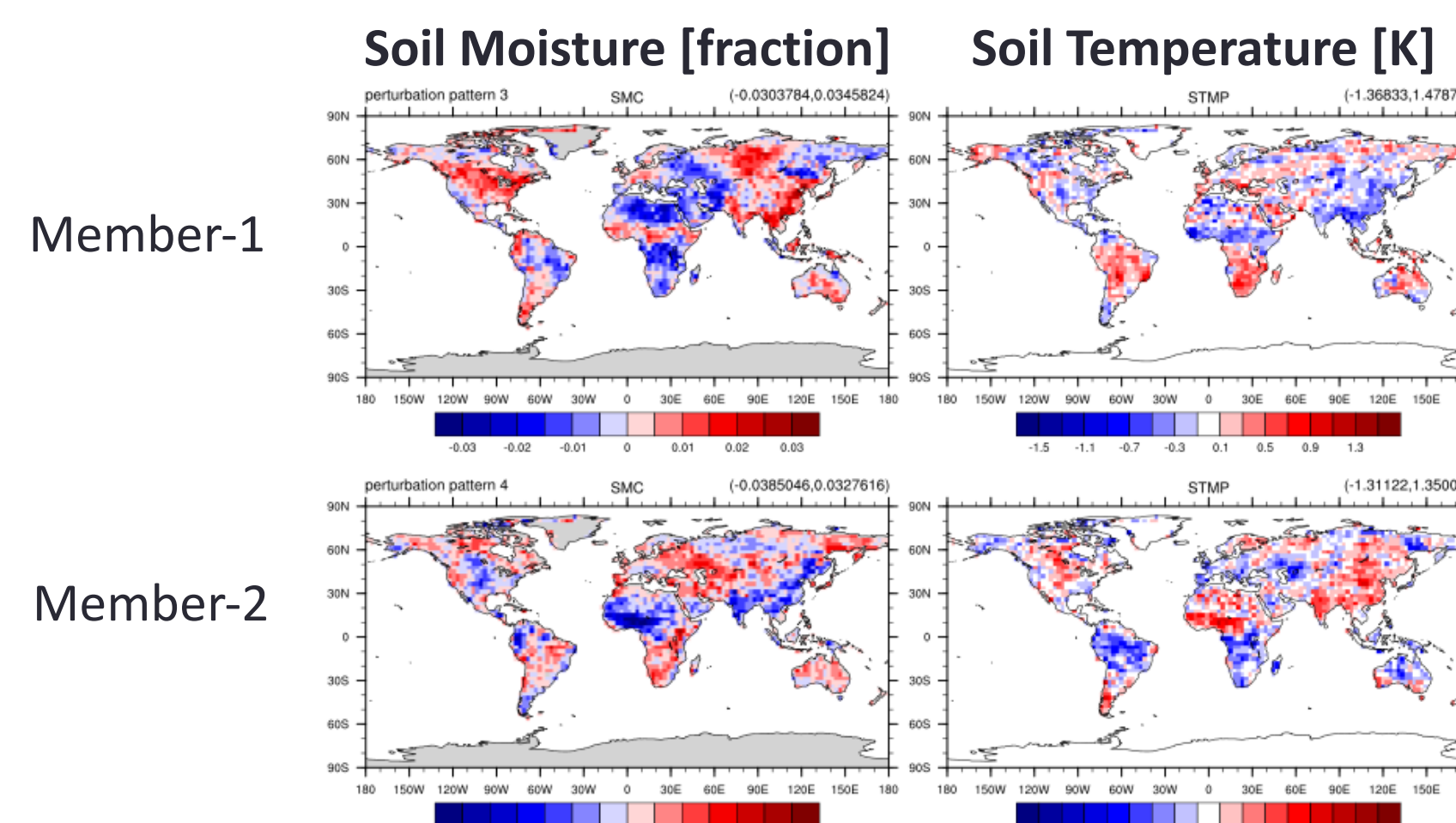
EOFs of the differences of the two estimates provide spatial patterns which Will be used to generate initial perturbations for ensemble forecasts



EOFs of differences in daily soil moisture and temperature for all August Days (1985-2010)

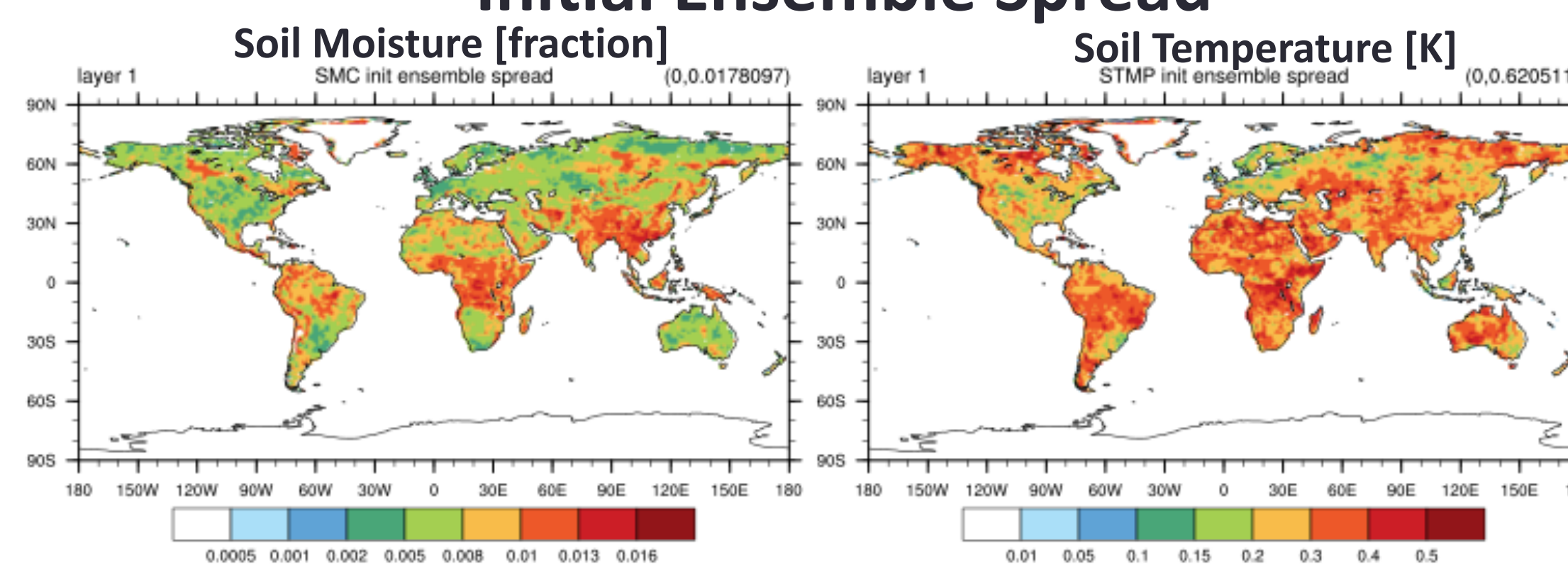
## Creating initial perturbations

Random Linear combination of EOFs produce perturbations for initial conditions.



Examples of perturbation patterns for two ensemble members.

## Initial Ensemble Spread

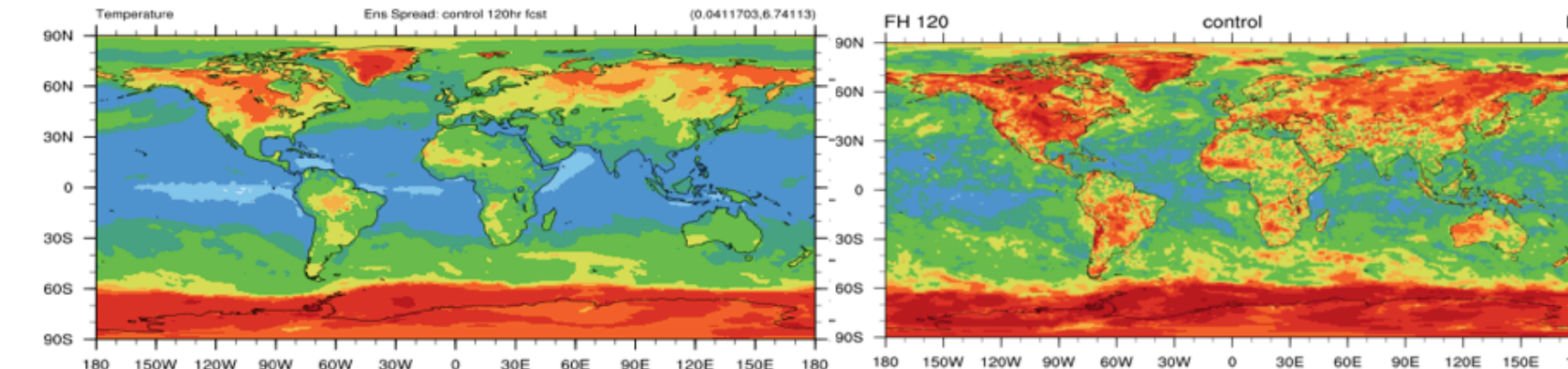


Spread of the initial conditions among ensemble members for soil moisture (left) and soil temperature (right). Units are volumetric soil moisture (0-1) and Kelvin respectively. Soil moisture spread is around 0.5-0.8% volumetric soil moisture in the mid-latitudes and 1-1.3% in the tropics. Soil temperature is 0.2-0.3K for most regions.

## Ensemble Forecast Results: Day-5

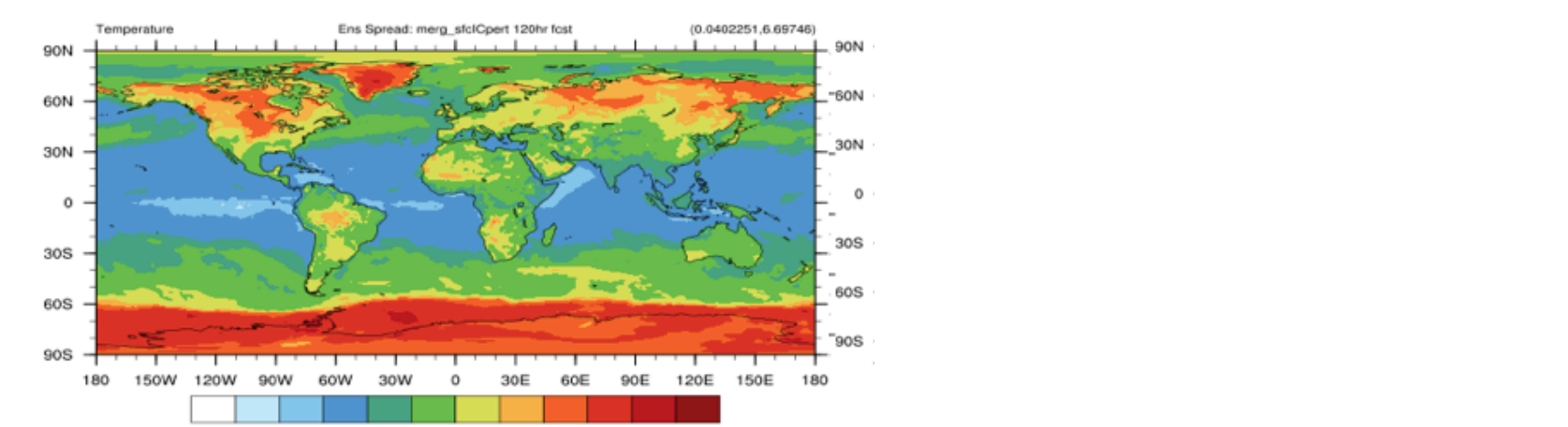
20-member ensemble of T574-GFS, Initialized every 3<sup>rd</sup> day at 00z in August,2014

Control Spread

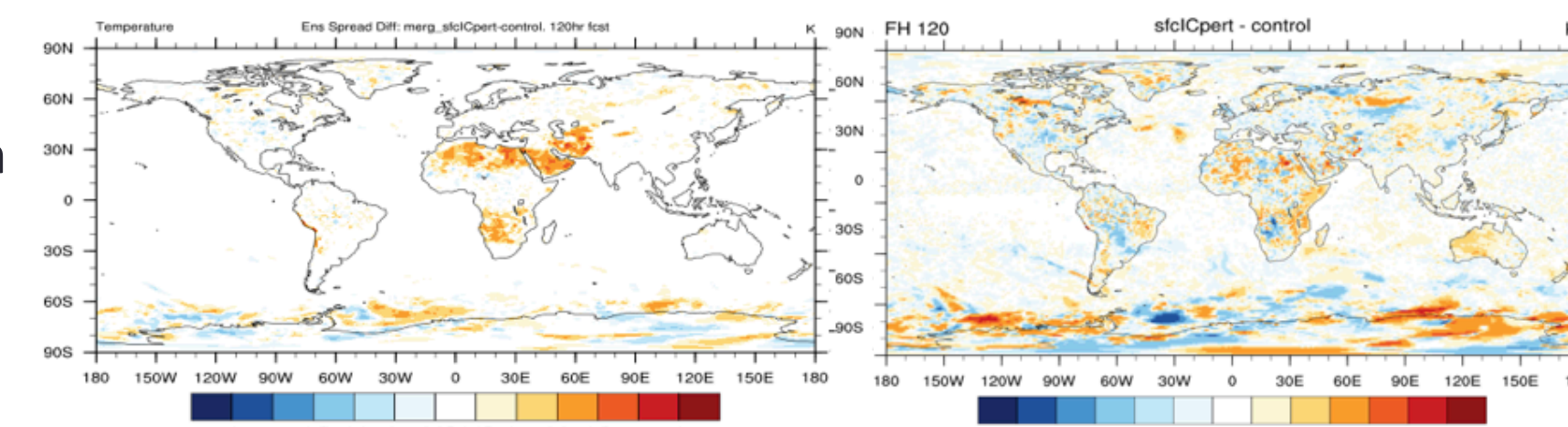


Control RMSE

Perturbed Land initial conditions spread



Small increase in nighttime 2m temperature

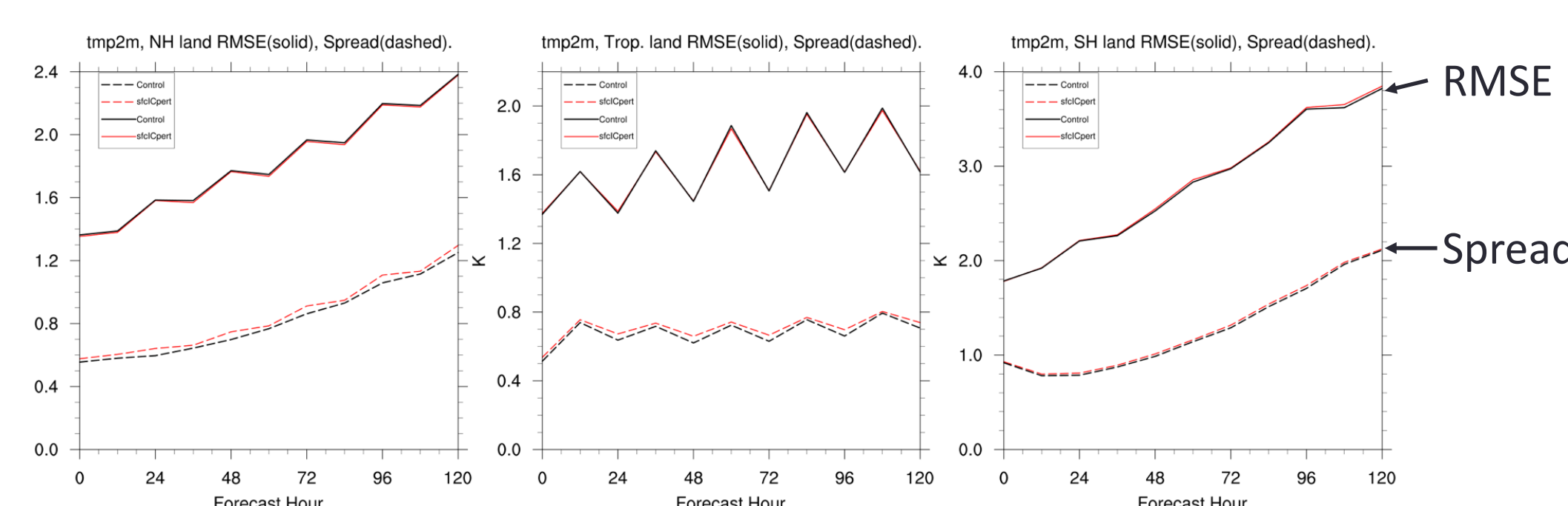


No net change in error.

Ensemble spread (left) and RMSE (right) at forecast hour 120 for 2m temperature. Left column shows control spread (top), surface IC perturbation experiment spread (middle) and the difference (bottom). The right column show control RMSE (against consensus analysis, top) and difference with surface IC perturbation experiment RMSE (bottom).

## Ensemble Forecast Results By Region

tmp 2m, Spread, Land, 9 Cases, Aug 2014.



Spread and RMSE for control and surface IC perturbation experiment averaged across the northern hemisphere (left), tropics (center) and the southern hemisphere (right).

## Conclusions

- The uncertainty in estimated the land state is quantified
- This estimate is used to generate perturbations to initial conditions through the random linear combination of EOFs
- Impact on ensemble spread of forecasts is minimal