Comparing modes of variability in observations with (A)GCMs

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Statistical model

Seasonal mean of a climate variable, x, can be considered as a statistical random variable consisting of signal and noise

$$x_{ym} = \mu_y + \varepsilon_{ym}$$

(y = 1, …, Y; m = 1, 2, 3; at each point r)

- ε_{ym} = "intraseasonal" component (noise). Due to forcings with time scales from about two weeks to a season.
- μ_y = "slow" component (signal). Due to external forcings and slowly varying internal (atmospheric) dynamics.
- Components cannot be directly calculated, but covariance can be estimated:

$$\hat{V}(\mu_y, \mu'_y) = \hat{V}(x_{yo}, x'_{yo}) - \hat{V}(\varepsilon_{yo}, \varepsilon'_{yo})$$

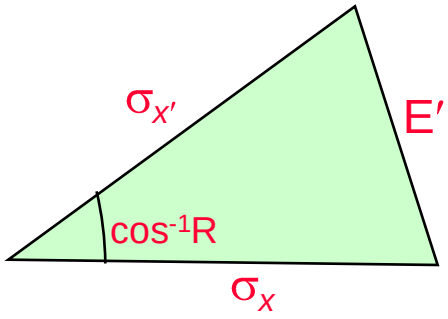
(components at points r and r')

- Modes of variability can be estimated by eigenvalue decomposition of each covariance matrix.

Comparing EOFs from different samples

Taylor (2001) noted the relationship between centred RMS difference E′:

$$E'^2 = \sigma_x^2 + \sigma_{x'}^2 - 2\sigma_x\sigma_{x'}R$$



and the cosine rule:

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$

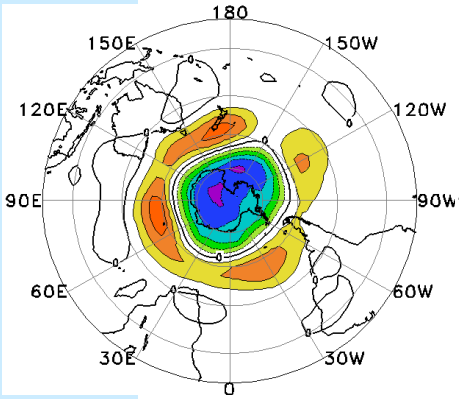
By interpolating sample variable *x′* onto the same grid as reference variable *x*:

1. The pattern correlation of the eigenvectors (EOFs) gives the correlation R.
2. If EOFs are normalised to unit length, the eigenvalues are the variance for each mode of variability.
3. The estimates of the standard deviations σ and σ' will be comparable.

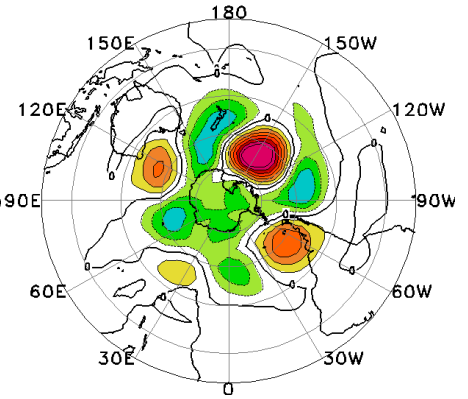
500hPa Geopotential Height SH DJF 1951-2000
NCEP Reanalysis EOFs

Intraseasonal

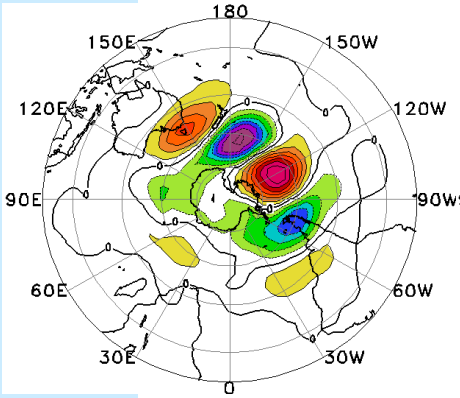
IEOF-1 (247.1)



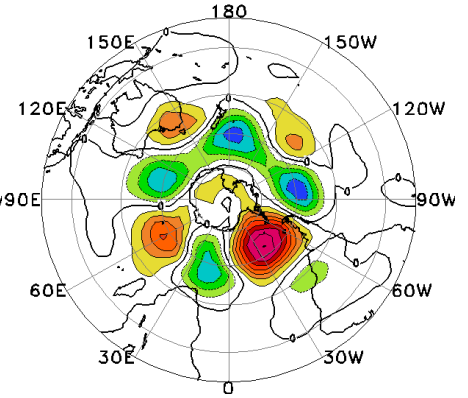
IEOF-2 (179.8)



IEOF-3 (155.1)

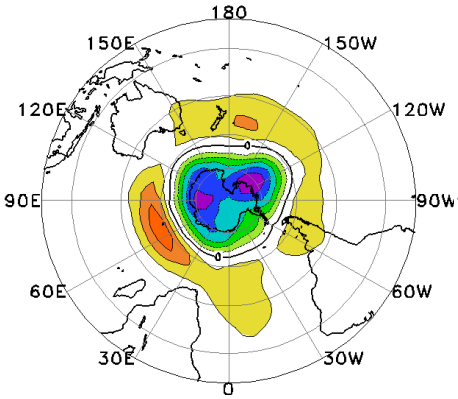


IEOF-4 (137.1)

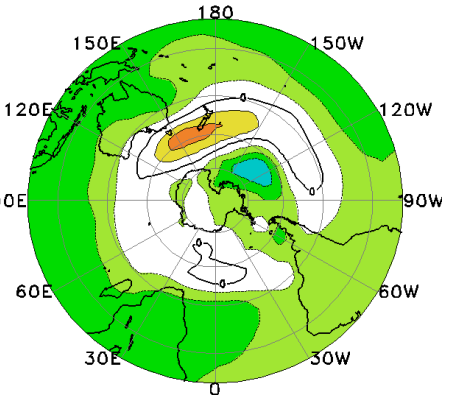


Slow

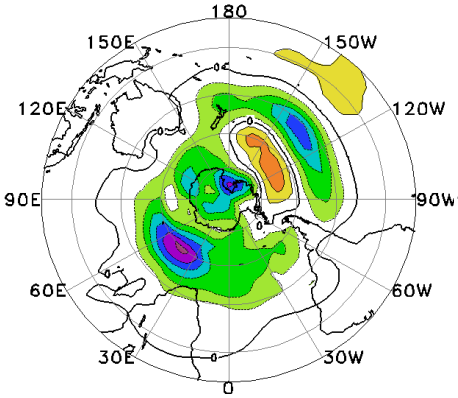
SEOF-1 (404.4)



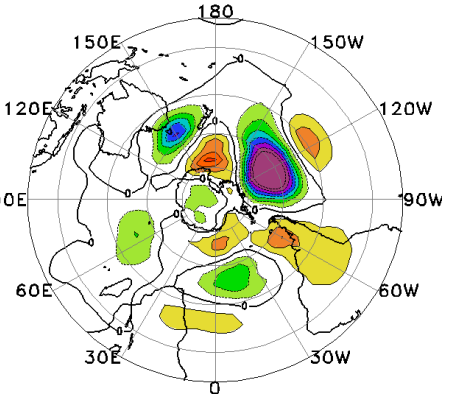
SEOF-2 (225.9)

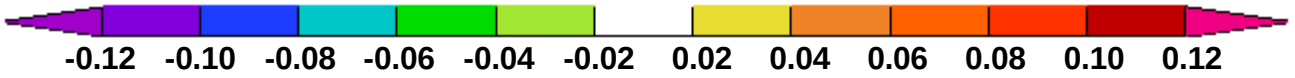


SEOF-3 (141.0)



SEOF-4 (114.1)

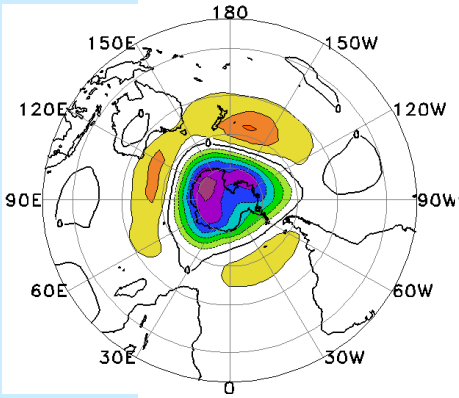




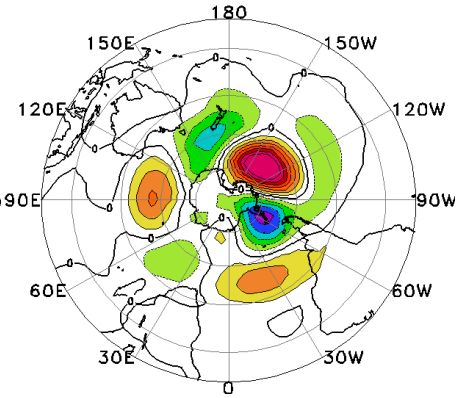
500hPa Geopotential Height SH JJA 1951-2000
NCEP Reanalysis EOFs

Intraseasonal

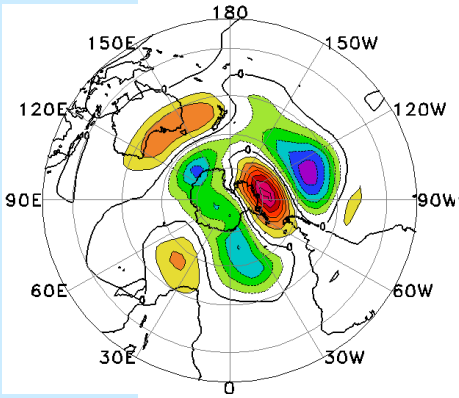
IEOF-1 (297.8)



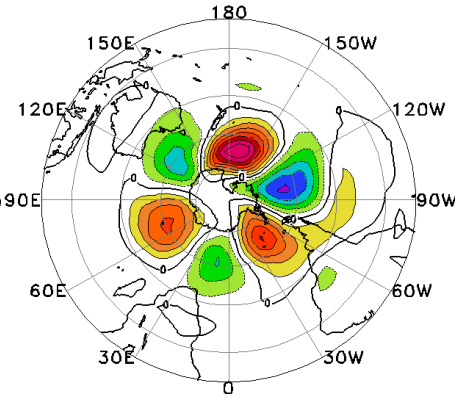
IEOF-2 (250.5)



IEOF-3 (195.4)

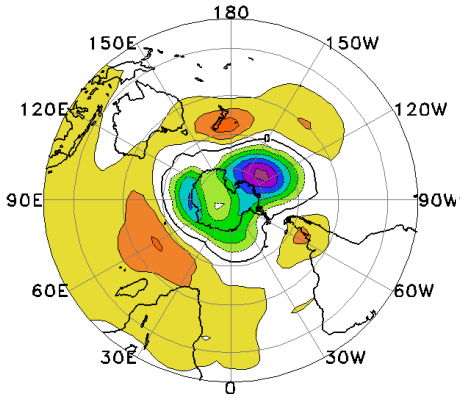


IEOF-4 (177.7)

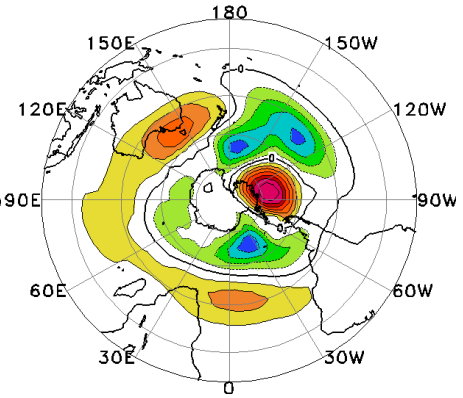


Slow

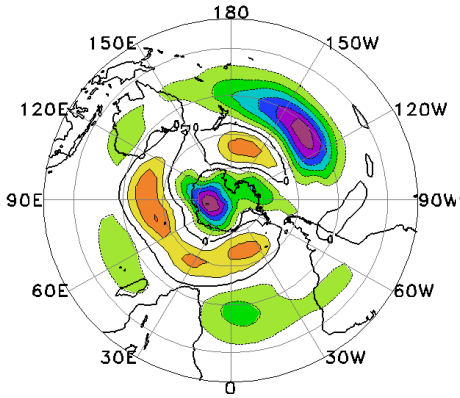
SEOF-1 (342.8)



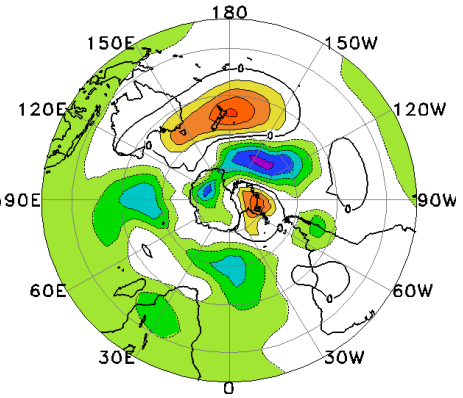
SEOF-2 (230.1)

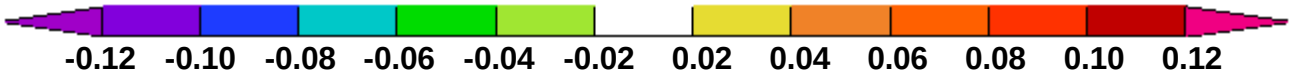


SEOF-3 (177.4)



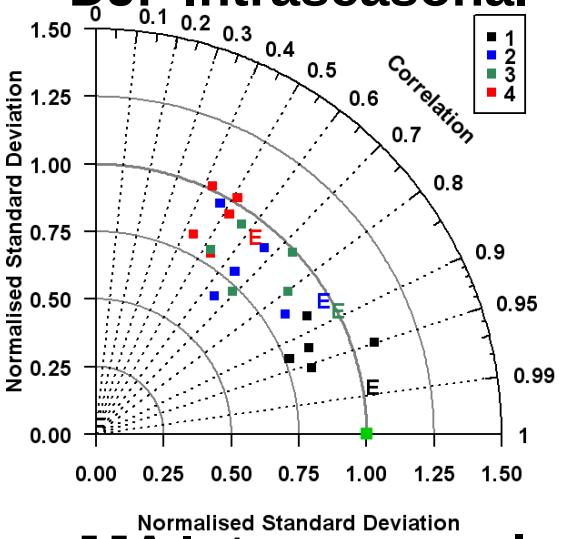
SEOF-4 (165.9)



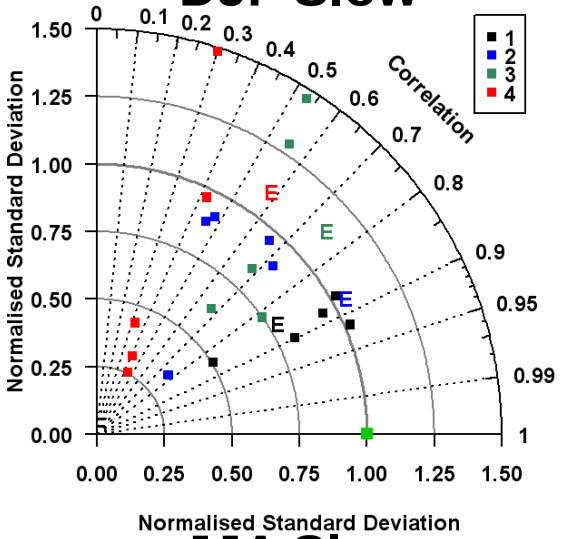


500hPa Geopotential Height – SH 1951-2000
Comparison between NCEP Reanalysis and C20C

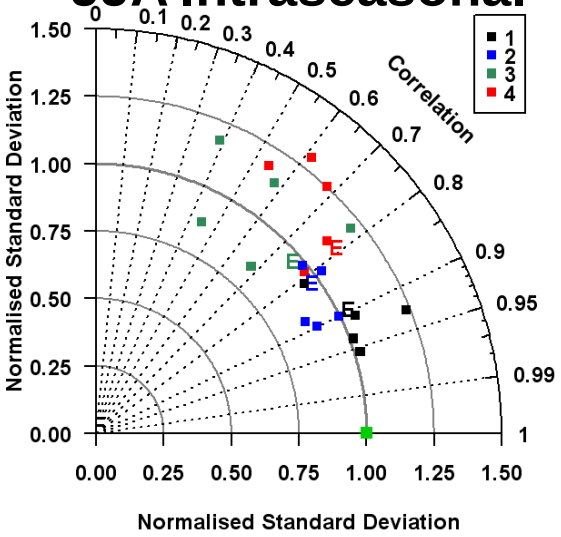
DJF Intraseasonal



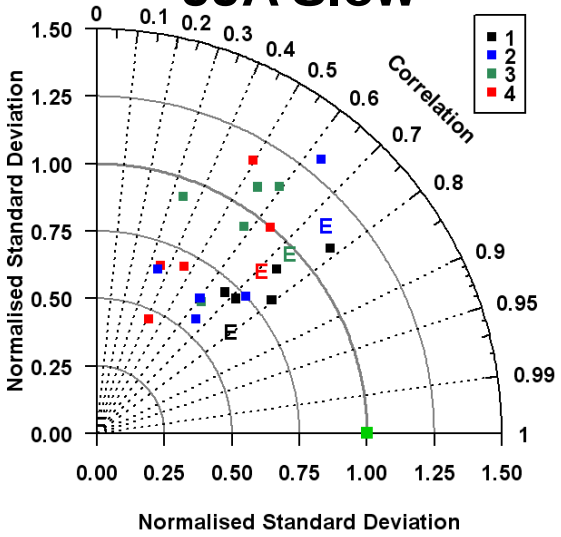
DJF Slow



JJA Intraseasonal

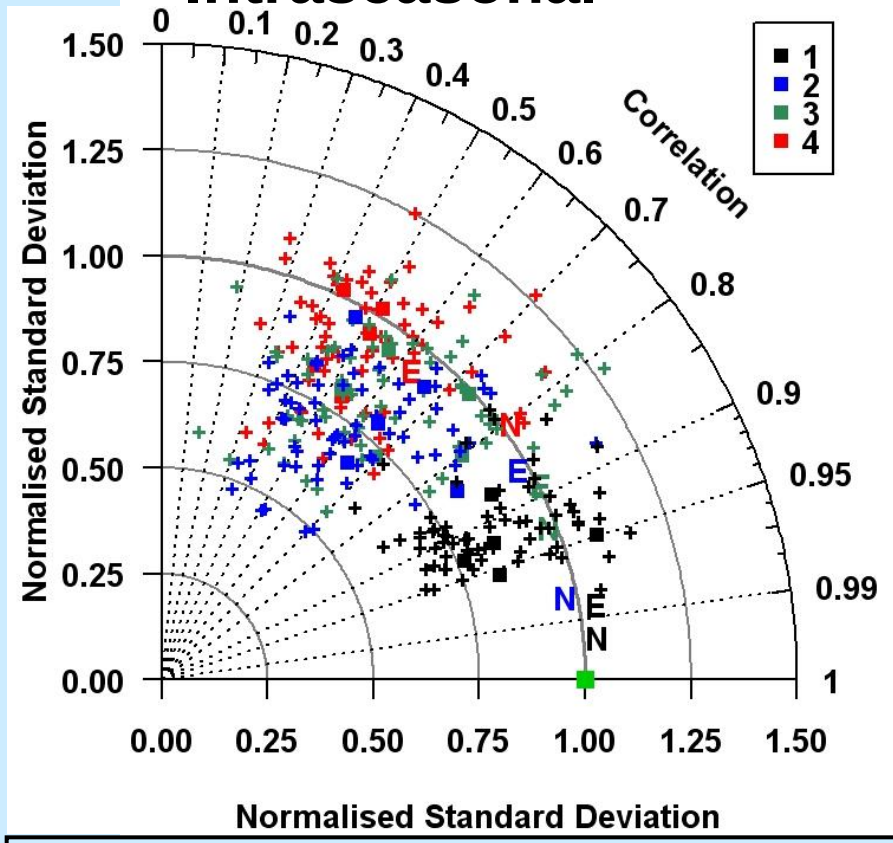


JJA Slow

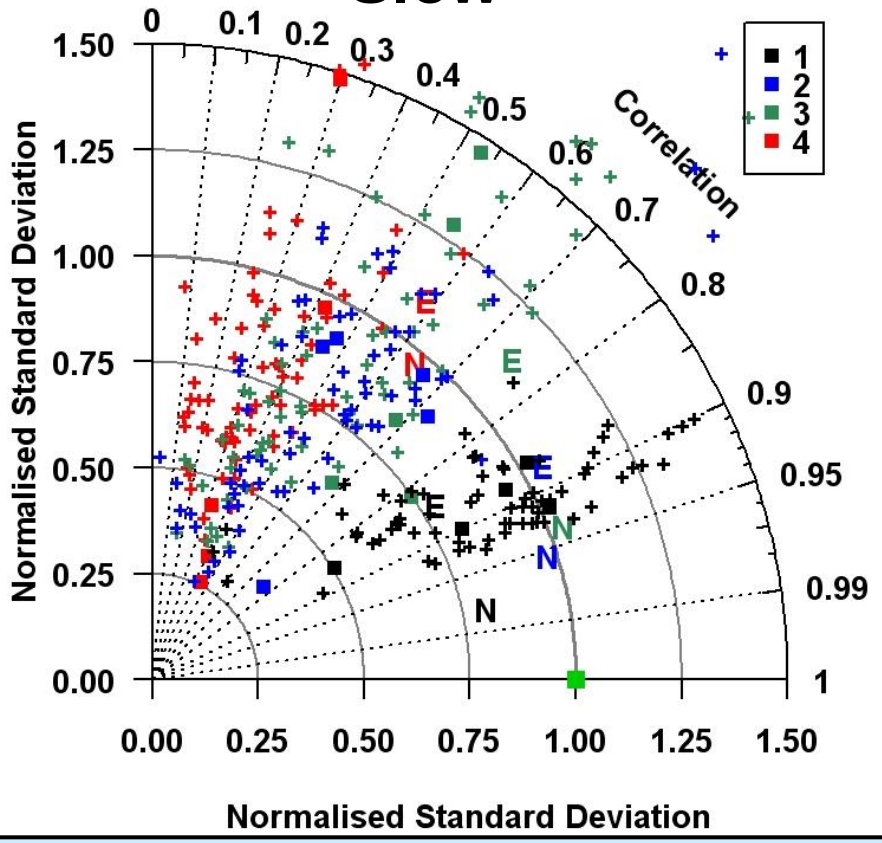


500hPa Geopotential Height – SH DJF 1951-2000
NCEP Reanalysis against ERA40/C20C/CMIP3

Intraseasonal



Slow



GCMs have the same atmospheric modes of variability independent of what forcings are fixed (more or less)

Diagnosis of UM runs

- (1x) AMIP
  - Possibly intraseasonal; slow component subject to sampling error
- 1x 40+ year SST-forced
  - How well does the UM atmosphere reproduce (spatially) the response to intraseasonal and slow forcings?
- 6+x 50 year SST-forced: (≡ C20C)
  - Assessment of temporal reproduction (regression)
  - Assessment of slow internal and external modes of variability
- CMIP3 and beyond
  - Assessment of UM ocean (right forcing?) and UM atmosphere-ocean interaction (right response?)
  - Assessment of atmospheric circulation variability under climate change scenarios