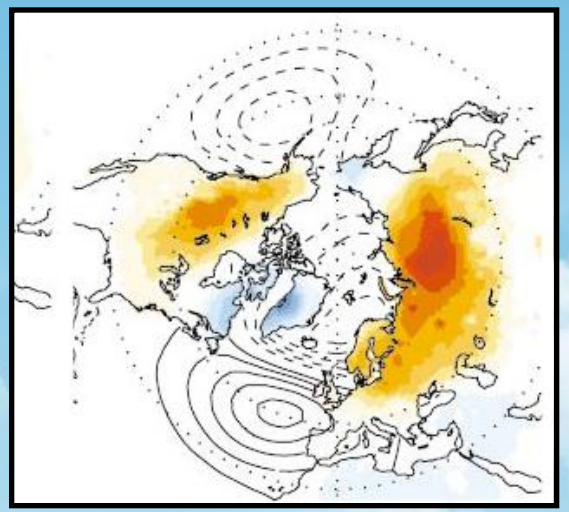
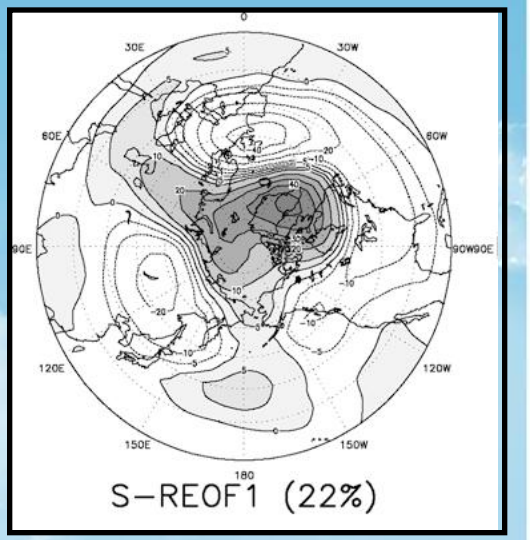
Evaluation of regional climatic models to reproduce the hihg and low frequency variability and their influences on the occurrence, intensity and duration of regional extremes over North America



Philippe Roy
PhD Projet
11 september 2009



Supervisor : Philippe Gachon
Co-supervisor : René Laprise

1.1 Overview

- Focus :
  - Regional extremes that are characterized by occurrence, intensity and duration (i.e., drought, heavy rainfall, wet days);
  - Influences of the atmospheric variability, as defined by teleconnections patterns (i.e., NAO, PNA) on surface variable (temperature and precipitation) and on their seasonal extremes;
  - Regional Climatic Models (RCM) are an interesting tool to investigate the simulated fine-scale of the atmospheric variability
- Objectives
  - Validation of the models on their capacity to reproduce the interannual and intra-seasonal variability
  - Quantification of the links between the teleconnections patterns of low frequency (NAO, PNA) and the occurrence, intensity and duration of the regional extremes

Teleconnections patterns

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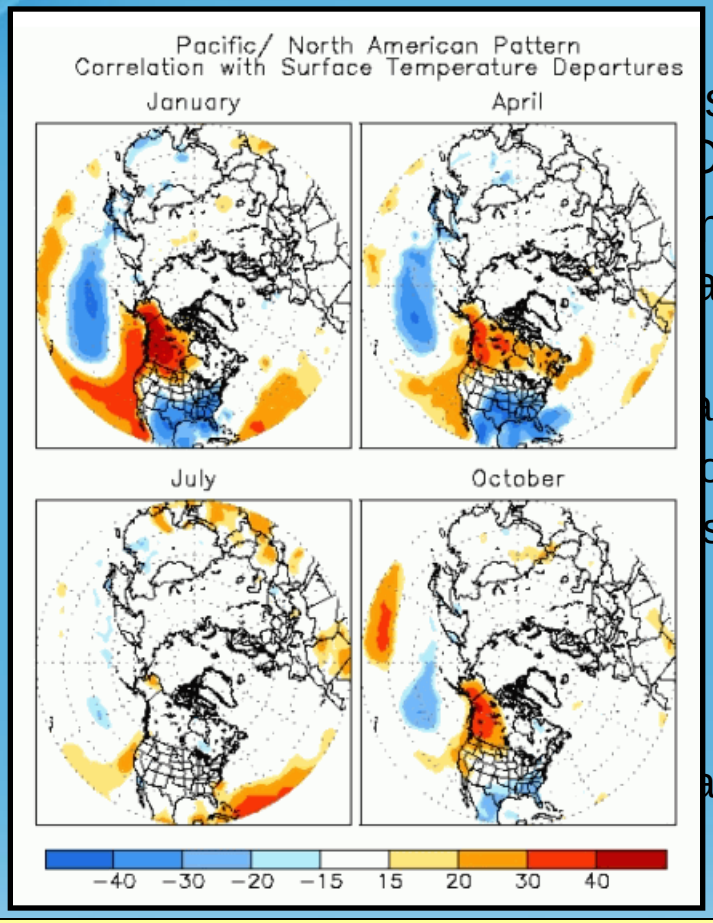
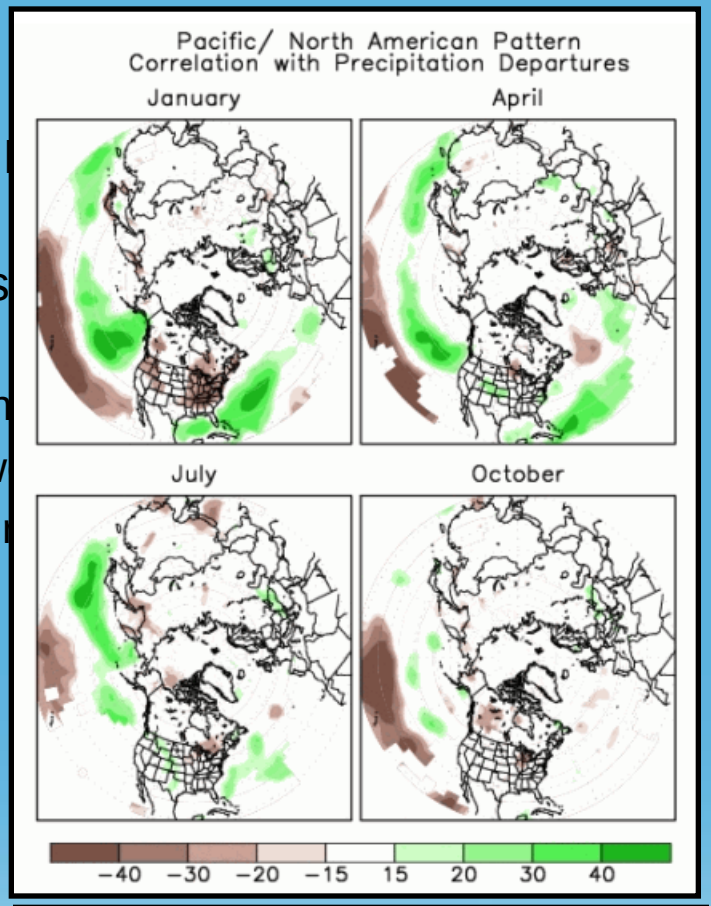


Corrélation Températures - PNA
http://www.cpc.noaa.gov



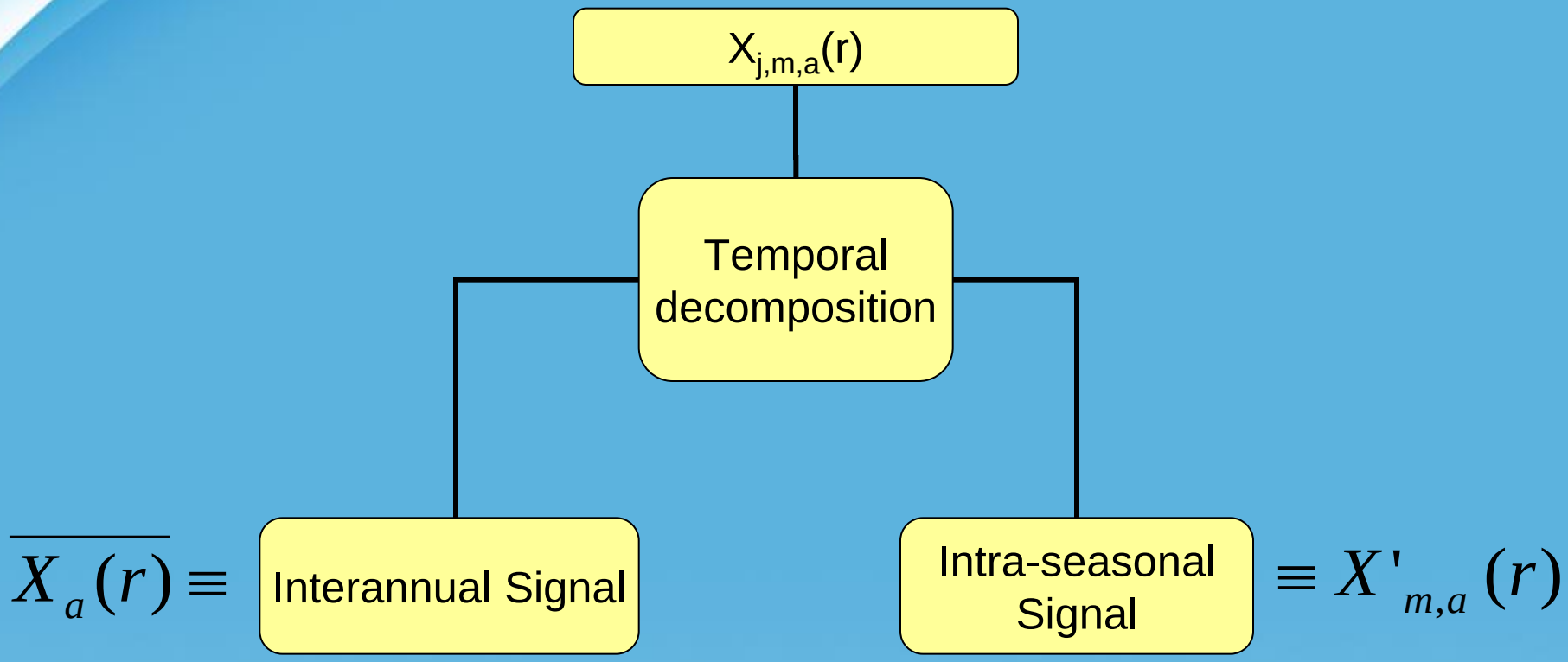
Corrélation Précipitation - PNA
http://www.cpc.noaa.gov

Regional Climate Models

Model Name	Projection	Domain Specification
CRCM (MRCC)	Polar Stereographic	Long. range: 199.9-326.5 Lat. range: 20.6-73.3
ECPC (RSM)	Polar Stereographic	Long. range: 211.5-316.3 Lat. range: 21.2-67.6
MM5 (MM5, MM5P)	Lambert Conformal Conic	Standard parallel: 30, 60 Central meridian (long): -97 Projection origin (lat): 47.5
RCM3 (RegCM3)	Transverse Mercator	Central meridian (long): -97 Projection origin (lat): 47.5 Scale factor at central meridian: 1 False easting: 3925000 False northing: 3175000
WRFP (WRF)	Lambert Conformal Conic	Standard parallel: 30, 60 Central meridian (long): -97 Projection origin (lat): 47.5

Objective #1 : Validation of the simulated variability

Schematics



Objective #1 : Validation of the simulated variability

Temporal decomposition

Days : j = 1,…, J(m)
Month : m = 1, 2, 3
Year : a = 1, …,A
r = Geographical point

Daily anomaly : $X_{j,m,a}(r)$

Concept : $\overline{X_{m,a}(r)} = \overline{X_a(r)} + X'_{m,a}(r)$

---

1. Seasonal mean $\overline{X_a(r)} = \frac{1}{M \cdot J} \sum_{M=3} \sum_{J(m)} X_{j,m,a}(r)$

Phase II : Evaluation of the day-to-day variability
i.e. VAR[$X_{j,m,a}$]

2. Mo

J $j=1$

3. Monthly departure $X'_{m,a}(r) = \overline{X_{m,a}(r)} - \overline{X_a(r)}$

Interannual variability : $\sigma^2_{IA} = VAR\left[\overline{X_a(r)}\right]$

Intra-seasonal variability $\sigma^2_{IS} = VAR\left[X'_{m,a}(r)\right]$

Objective #2 : Links between teleconnections patterns and regional extremes

Definitions

- Characterization of regional extremes
  - Occurrence
  -

Extreme Indice	Definition	Unit	Type
Prcp1	No of wet days: precipitation>1 mm (Prcp1)	%	Occurrence
SDII	Precipitation intensity: rain/rainday (SDII)	mm/day	Intensity
CDD	Max No of consecutive dry days (precipitation<1 mm) (CDD)	day	Duration
R3d	Greatest 3 days total rainfall (R3d)	mm	Intensity
Prec90pc	90th percentile of rainday amounts (Prec90pc)	mm/day	Intensity
Tmin10pb	10th percentile of daily minimum temperature (Tmin10pb)	°C	Intensity
Tmax90pb	90th percentile of daily maximum temperature (Tmax90pb)	°C	Intensity
Fr/Th	Number of Frost/Thaw days (Tmax > 0°C et Tmin < 0°C)	Days	Occurrence

Source : STARDEX, Gachon et al., 2005

Objective #2 : Links between teleconnections patterns and regional extremes

Analysis

- Analysis :
  - Separation of the extremes indices according to the phase of the teleconnections patterns → 2 distinct distributions
    - Comparison of the statistical moments of every distribution

Once we have quantiffied these links, we can look for the importance of local processes responsible for the regional extremes

- Set-up :

Observed indices of teleconnections patterns (NAO, PNA)

Observed extremes at stations

Vs.

Calculated indices of teleconnections patterns (GCM)

Simulated extremes at nearest grid-point

Outcomes

- Are the RCMs able to generate intra-seasonal variability?
- A better understanding of what drives the regional seasonal extremes (local processes and large-scale forcing)
- Extreme analysis :
    - From monthly to daily analysis
    - Large-scale and local forcing of regional extremes

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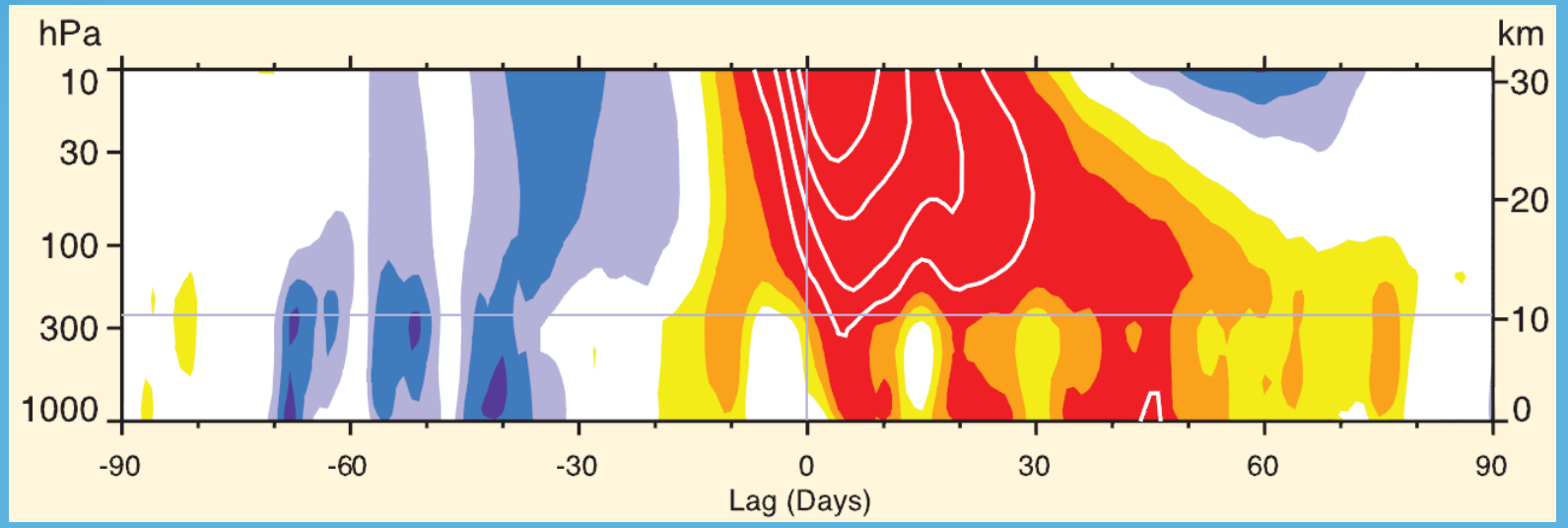
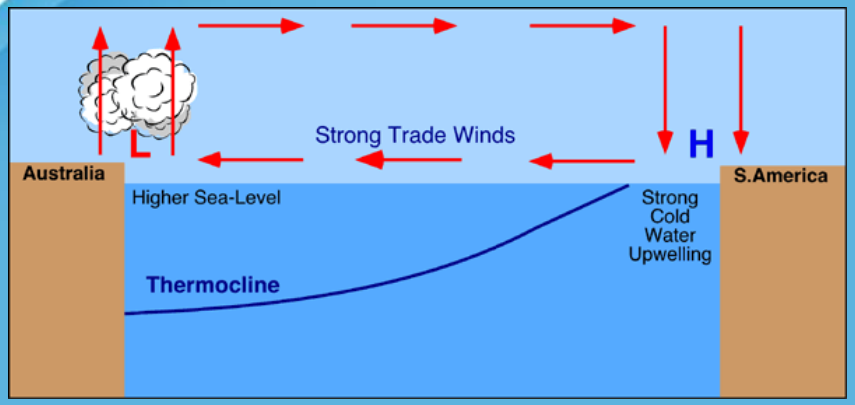
Annexes
NAO

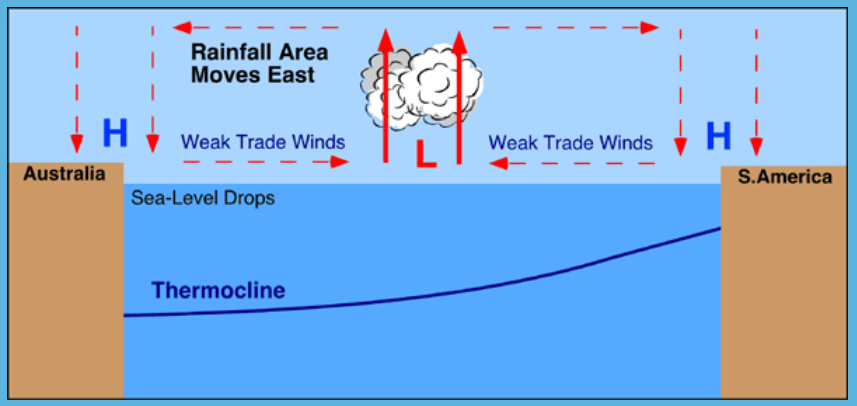


Source : GIEC, 2007

1.3 Modes de variabilité interannuelle

Phénomène de couplage
« El Niño – Oscillation Australe » (ENSO)





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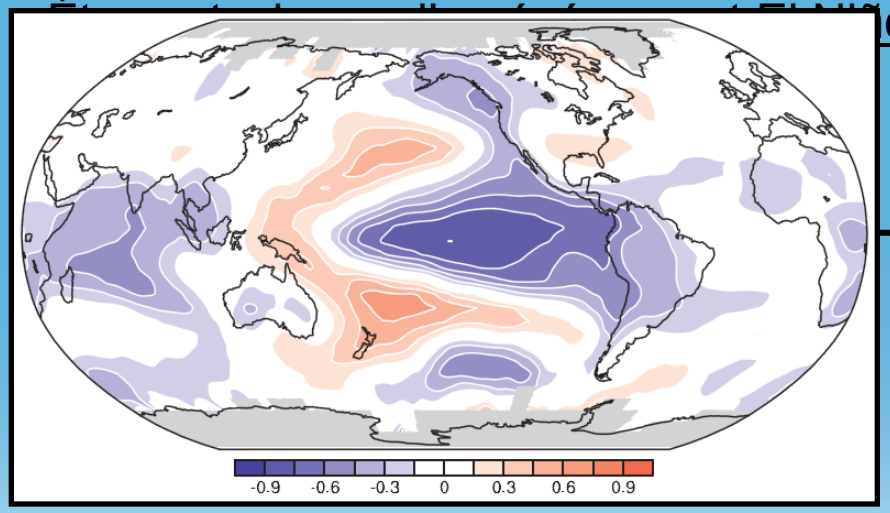
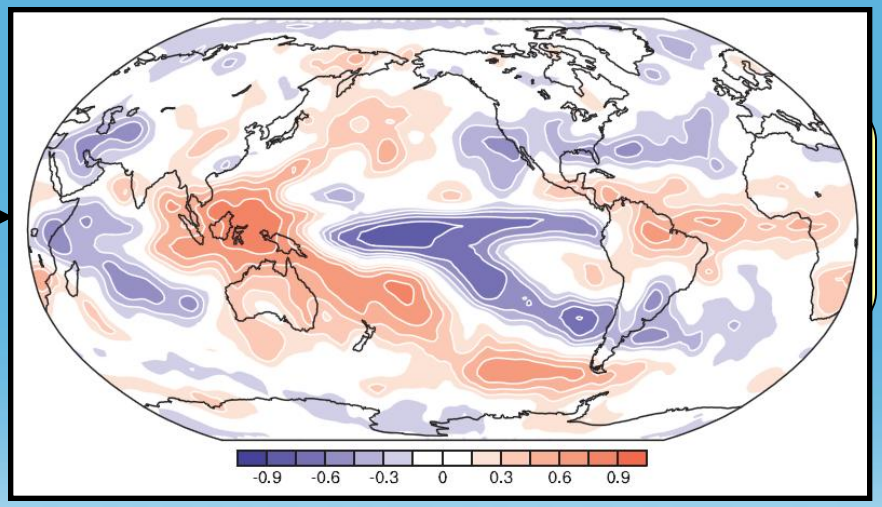
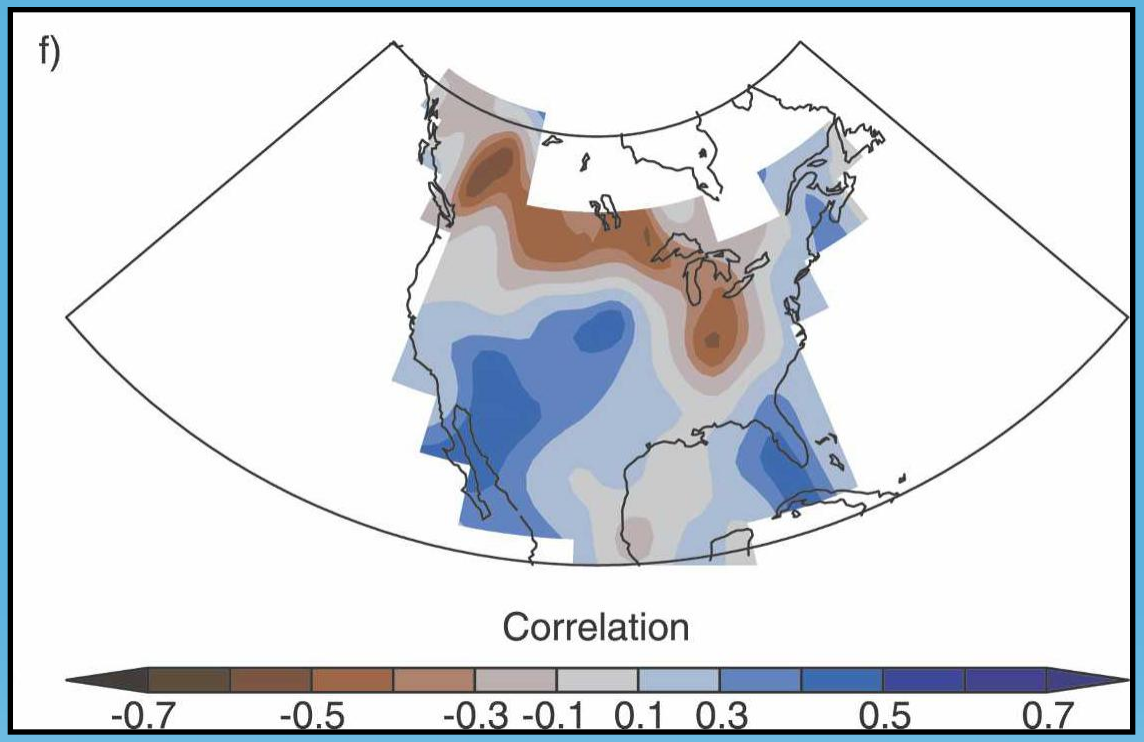




Corrélation Températures-SOI
Source : GIEC, 2007

Corrélation Précipitations-SOI
Source : GIEC, 2007

PNA



Corrélation entre Précipitation (NCEP/NCAR) et PNA (Janvier à Mars)
Ewen et al., 2008

2.4.2 Analyse de la variabilité

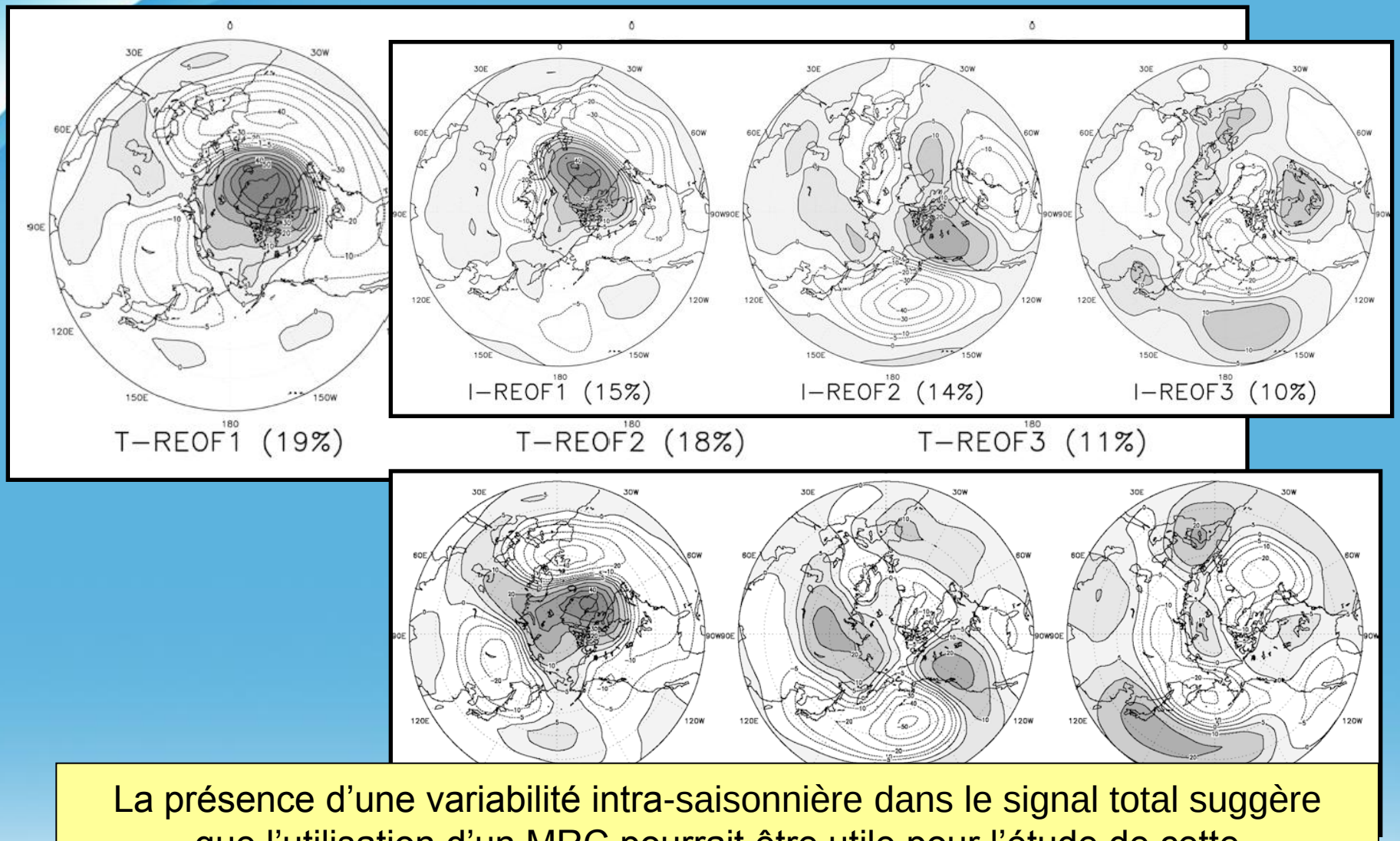
Fonctions Empiriques Orthogonales (1/2)

La technique des EOFs permets de construire mathématiquement les principaux modes de variabilité d'une variable

Type	Avantages	Désavantages
EOF		• Orthogonalité dans l'espace et le temps •Fonction du domaine d'étude • Corrélation spatiale seulement
REOF	• Indépendant du domaine d'étude • Contrainte d'orthogonalité relaxée	
EEOF	• Prends en compte la corrélation temporelle	

2.4.2 Analyse de la variabilité

Fonctions Empiriques Orthogonales (2/2)



La présence d'une variabilité intra-saisonnière dans le signal total suggère que l'utilisation d'un MRC pourrait être utile pour l'étude de cette variabilité de haute fréquence

Source : Frederic

1.5 Modèles

Modèles climatiques globaux (MCG)

- Liens entre la circulation générale de l'atmosphère et les températures de surface généralement bien reproduit

Modes de variabilité	Réussites	Problèmes
NAO	• Amplitude de la variabilité interannuelle	• Amp. de la variabilité intra-saisonnière trop élevé • Amp. de la variabilité inter-decénnale trop faible
PNA		• Patron spatial dépendant d'ENSO
ENSO	• Patron spatial • Fréquence des événement El Nino	• Climat moyen • Variabilité naturelle

1.3 Variabilité
Modes de variabilité

- Causes de la variabilité aux latitudes moyennes (Wallace et Hobbs, 2006) :
  - Variabilité interannuelle :
    - Température de surface des océans (SST) tropicaux
    - Variation dans l'humidité au sol
    - Variation dans la végétation
  - Variabilité intra-saisonnière :
    - Processus dynamiques interne à l'atmosphère

- Deux types de forçages :
  - Dynamique interne à l'atmosphère
  - Couplage de l'atmosphère avec d'autres modules

Références

- Ajouter

Références

- Ajouter

Références

- Ajouter