



**The Abdus Salam
International Centre for Theoretical Physics**



2210-6

**MedCLIVAR Workshop on: "Scenarios of Mediterranean Climate
Change under Increased Radiative Active Gas Concentration and the
Role of Aerosols**

23 - 25 September 2010

Role of teleconnections in extreme precipitation climate events in the Mediterranean

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Role of teleconnections in extreme precipitation climate events in the Mediterranean region

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23-25 Sept 2010 MedClivar
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Extreme precipitation climate events (EPCE) - Monthly periods with high frequency of extreme precipitation

Outline

- Role of atmospheric dynamics
- Role of midlatitude and tropical teleconnections

Characteristics of atmospheric dynamics

Dynamic (PV based) Tropopause Pressure (dry dynamics)

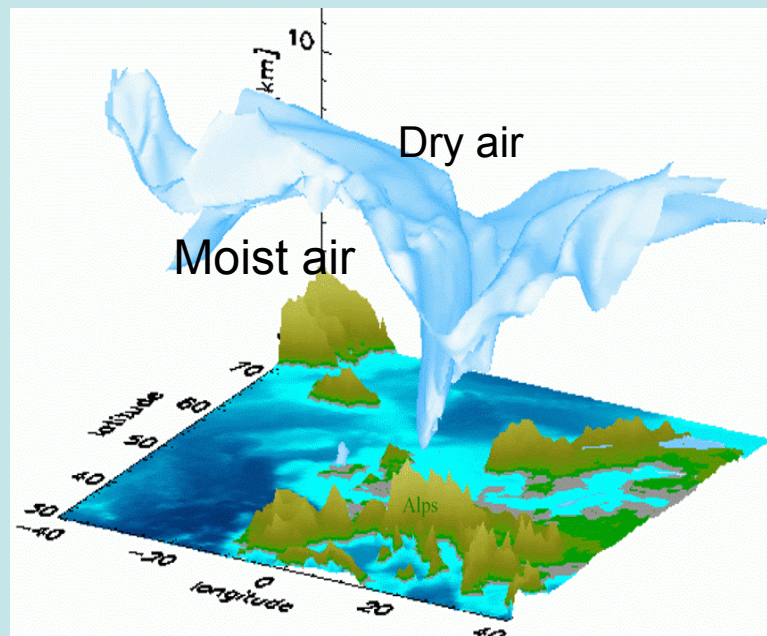
Precipitable Water (moist dynamics)

Potential Vorticity

Mathematical Definitions of PV

- Rossby: $P_R = \frac{(f + \zeta_\theta)}{-\Delta p / g}$
 - Ertel: $P = -g(f + \zeta_\theta) \left(\frac{\partial \theta}{\partial p} \right) = \frac{-(f + \zeta_\theta)}{-(\Delta p / \Delta \theta) / g}$
- Vorticity times static stability

The dynamic tropopause is defined as the 2.0 PVU surface
1 PVU = 10⁶ m² s⁻¹ K kg⁻¹



Precipitable Water

- Precipitable water is the column integrated water vapor

$$PWTR = \frac{1}{g} \int_{p_1}^{p_2} w \, dp$$

To evaluate the role of atmospheric dynamical processes, two variables representing dry and moist dynamics, - dynamic tropopause pressure and column integrated water vapor content (precipitable water) are accounted.

A certain day is considered as an “extreme-day” for that parameter when its rate exceeds the 75% quantile (Carril et al. 2008). The same threshold value is adopted for determining the frequencies of extreme events in precipitation, dynamic tropopause pressure and precipitable water. The threshold score is a function of both the grid point and the calendar day (calculated for a 5-day window centered on each calendar day, in the period). In the case of daily precipitation, only days with nonzero precipitation amounts are accounted.

Time series with the frequencies [number of days within each month] with extreme values of precipitation (ExtPrecF), dynamic tropopause pressure (DynTroPF) and precipitable water (PrecWatF) have been constructed and patterns with spatial correlations of the time series with those of several teleconnection indices constructed.

Carril AF, et al., Heatwaves in Europe: areas of homogeneous variability and links with the regional to large-scale atmospheric and SSTs anomalies, 2008, *Climate Dynamics*, 30, 77-98.

Data used

Mediterranean rainy season

September, November, January, March

Current climate (1961-2000)

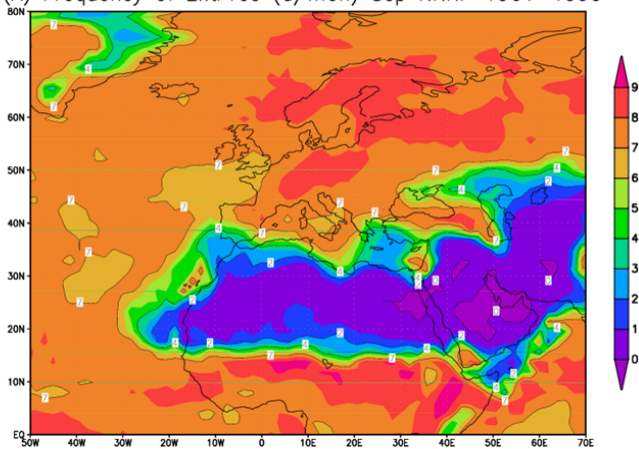
- NNRP (2.5x2.5 deg) wind, temperature, precipitation rate, IWV, DynProP [daily];
- NOAA CPC indices of teleconnection(North Atlantic Oscillation (NAO),Scandinavian Pattern (SCAND); East Atlantic Western Russia pattern (EAWR); El Nino Southern Oscillation – ENSO (NINO3.4), IOD, EAWM (computed)

Frequency of extreme events

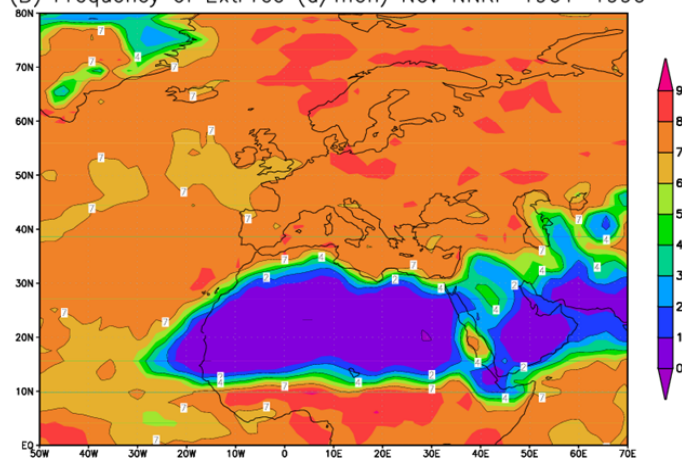
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Frequency of days with extreme Precipitation

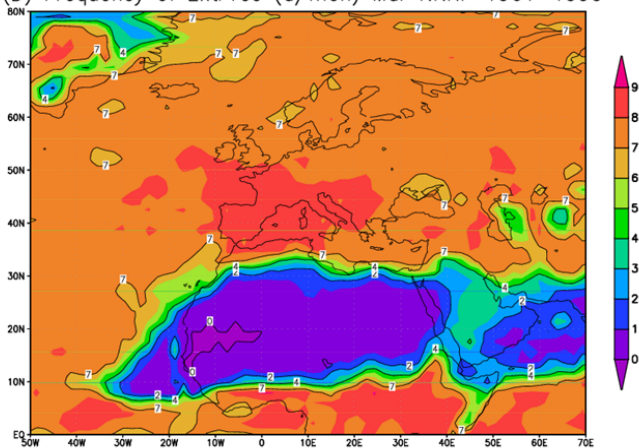
(A) Frequency of ExtPrec (d/mon) Sep NNRP 1961–1990



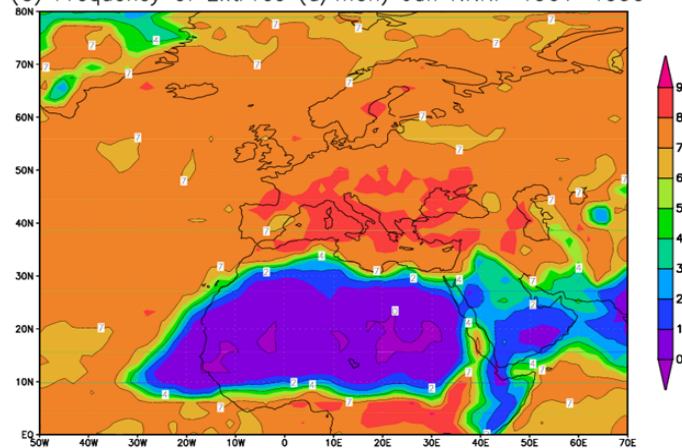
(B) Frequency of ExtPrec (d/mon) Nov NNRP 1961–1990



(D) Frequency of ExtPrec (d/mon) Mar NNRP 1961–1990

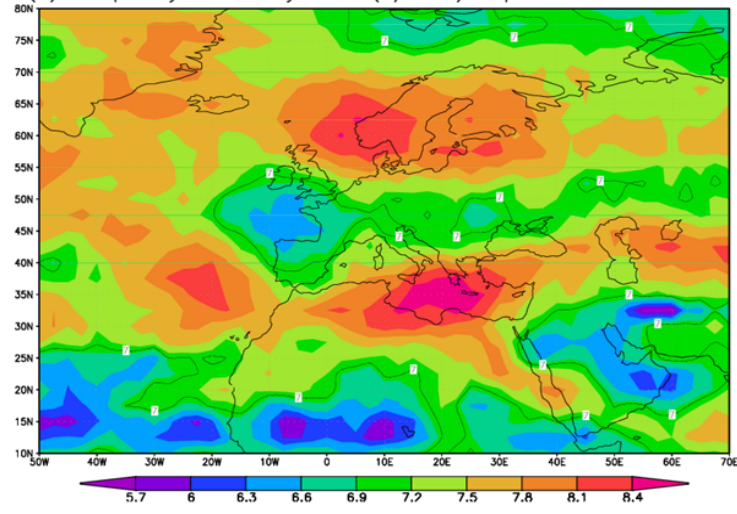


(C) Frequency of ExtPrec (d/mon) Jan NNRP 1961–1990

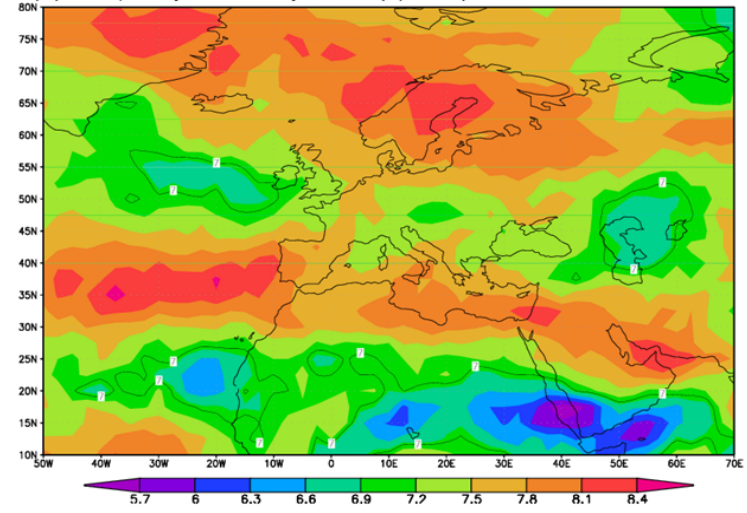


Frequency of days with extreme dynamic tropopause pressure

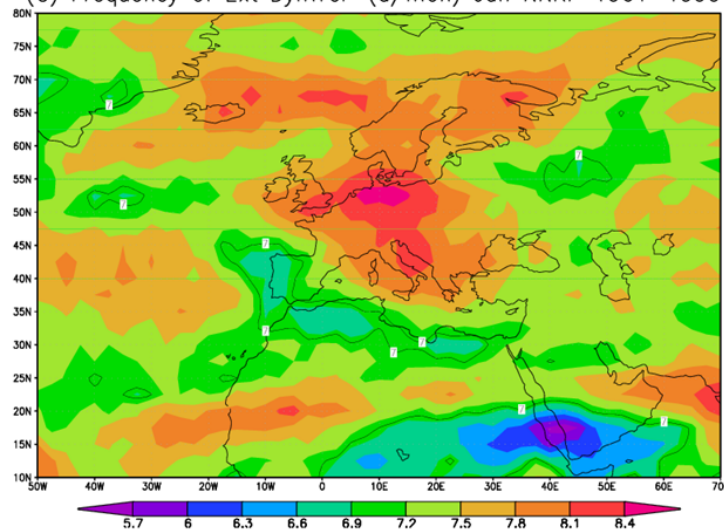
(A) Frequency of Ext DynTroP (d/month) Sep NNRP 1961–1990



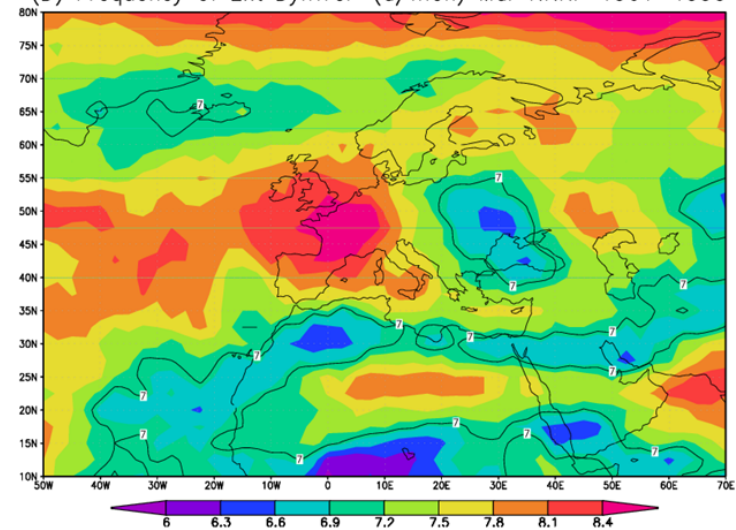
(B) Frequency of Ext DynTroP (d/month) Nov NNRP 1961–1990



(C) Frequency of Ext DynTroP (d/month) Jan NNRP 1961–1990

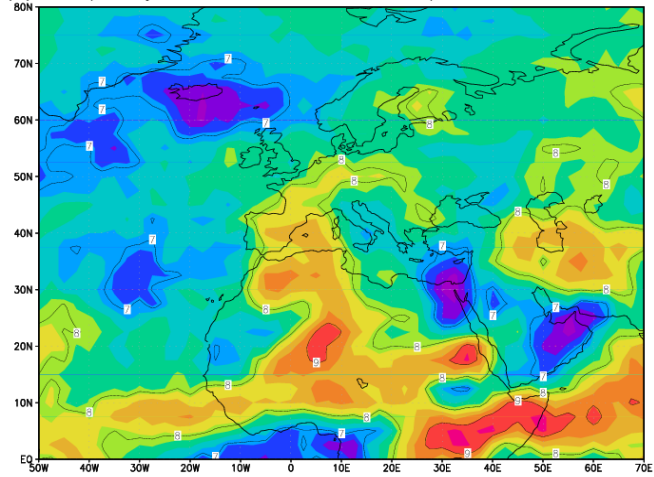


(D) Frequency of Ext DynTroP (d/month) Mar NNRP 1961–1990

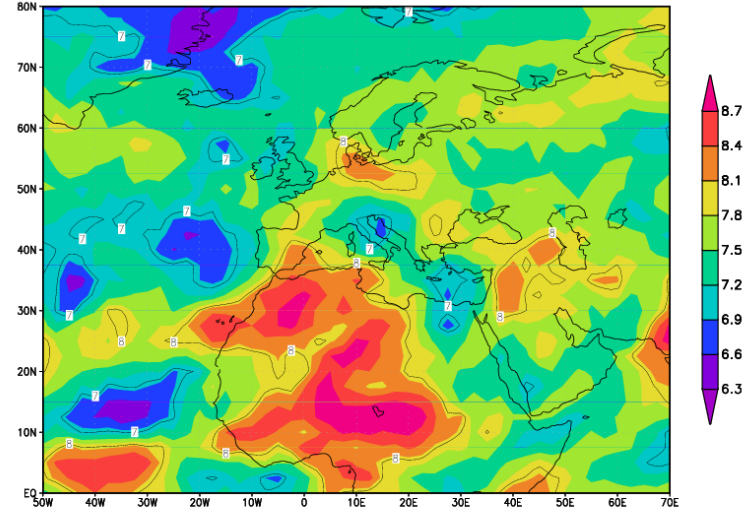


Frequency of days with extreme precipitated water content

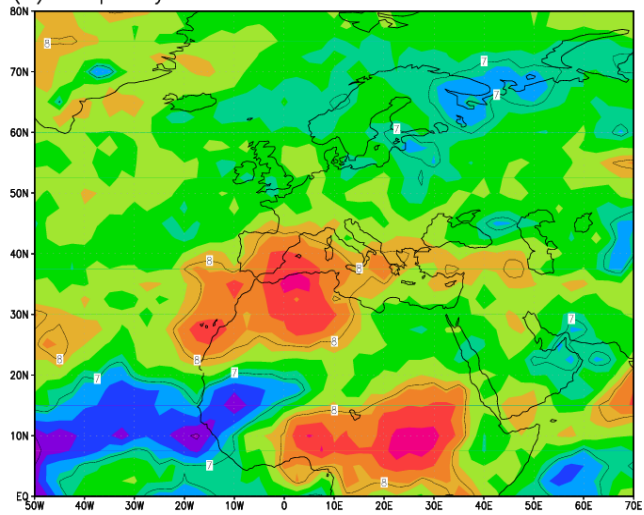
(A) Frequency of Extreme PrecWat Sep NNRP 1961–1990



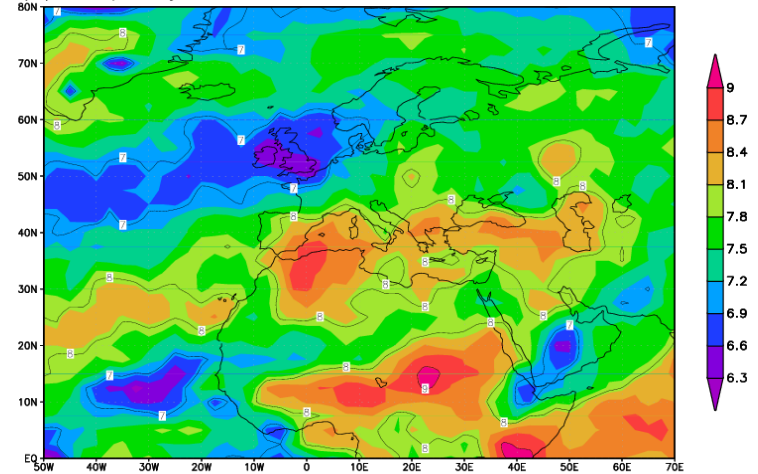
(B) Frequency of Extreme PrecWat Nov NNRP 1961–1990



(C) Frequency of Extreme PrecWat Jan NNRP 1961–1990



(D) Frequency of Extreme PrecWat Mar NNRP 1961–1990

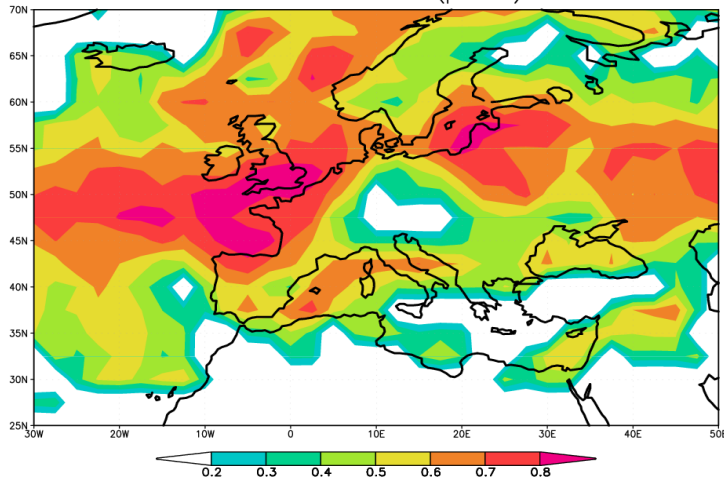


Role of atmospheric dynamics in extreme precipitation

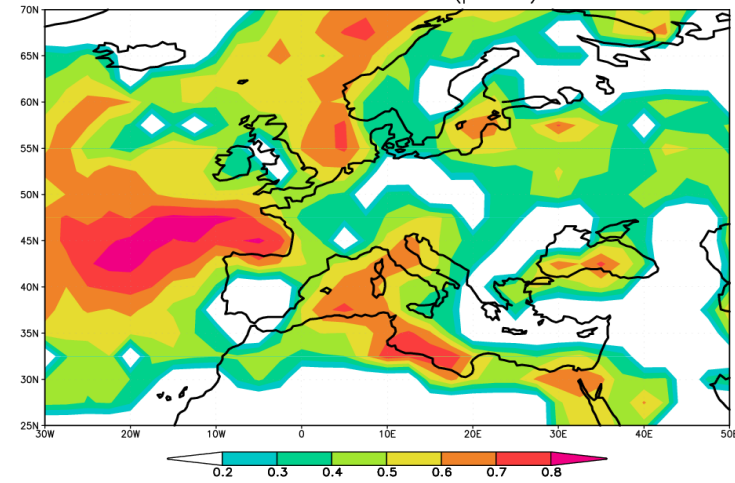
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Role of dynamic tropopause

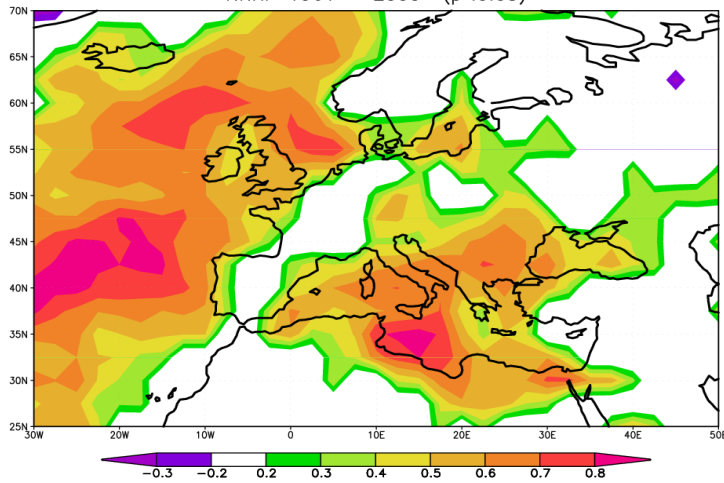
(A) Correlation: PrecF – DynTroPF Sept
NNRP 1961 – 2000 ($p < 0.05$)



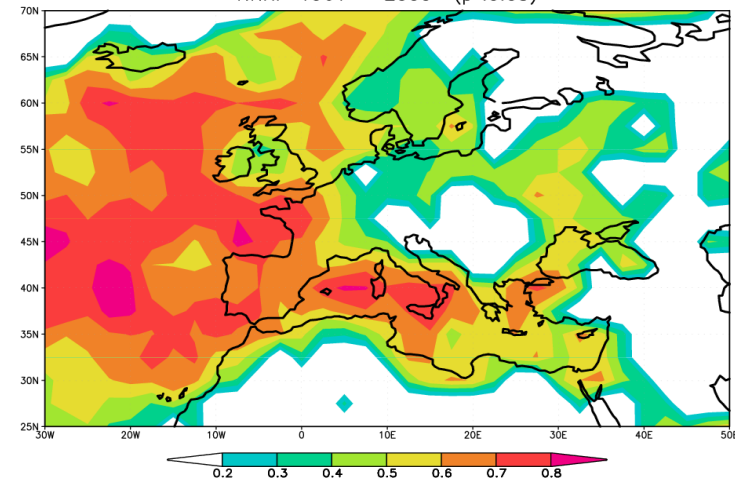
(B) Correlation: PrecF – DynTroPF Nov
NNRP 1961 – 2000 ($p < 0.05$)



(C) Correlation: PrecF – DynTroPF Jan
NNRP 1961 – 2000 ($p < 0.05$)

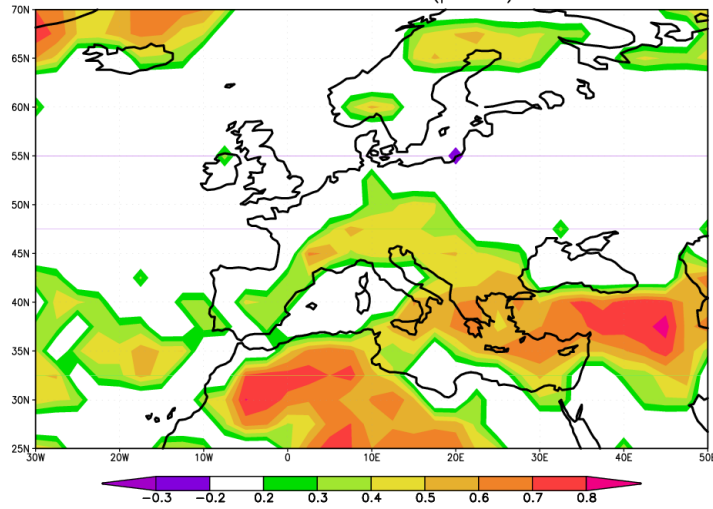


(D) Correlation: PrecF – DynTroPF Mar
NNRP 1961 – 2000 ($p < 0.05$)

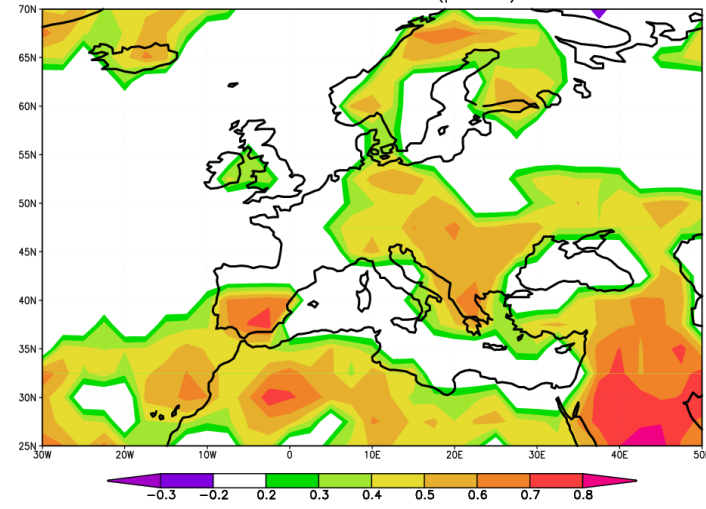


Role of effects of air moisture

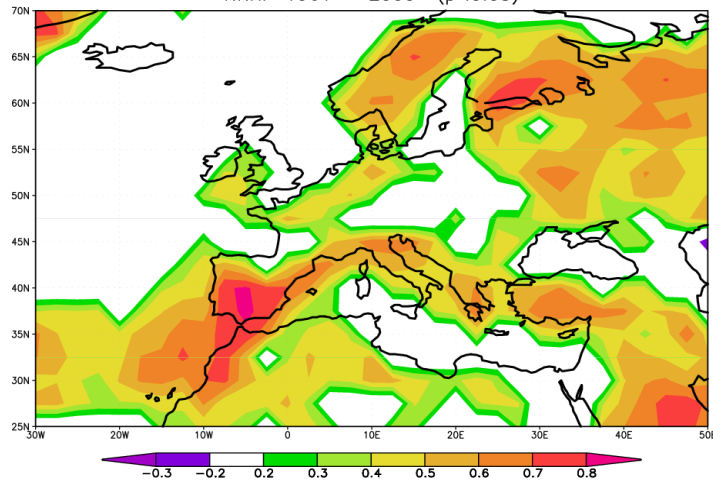
(A) Correlation: PrecF – PrecWatF Sept
NNRP 1961 – 2000 ($p < 0.05$)



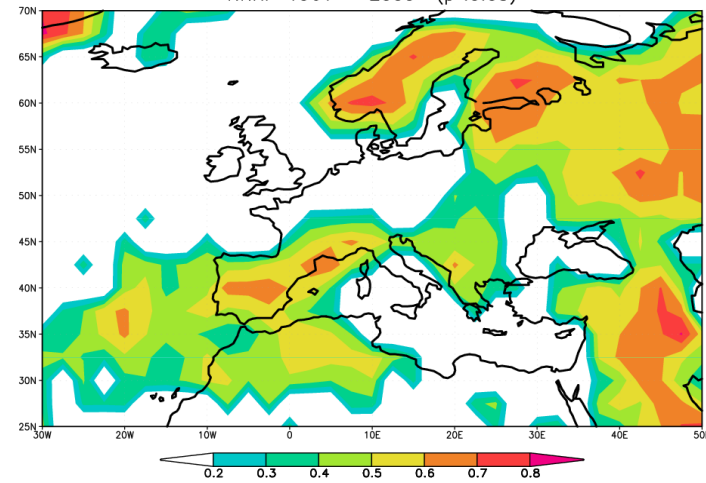
(B) Correlation: PrecF – PrecWatF Nov
NNRP 1961 – 2000 ($p < 0.05$)



(C) Correlation: PrecF – PrecWatF Jan
NNRP 1961 – 2000 ($p < 0.05$)



(D) Correlation: PrecF – PrecWatF Mar
NNRP 1961 – 2000 ($p < 0.05$)



Extreme dynamic tropopause pressure conditions are favorable for the EPE over the areas with sufficient amounts of moist air.

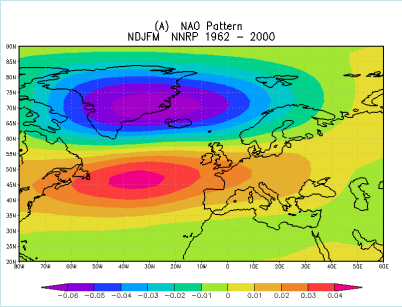
Extreme precipitable water conditions play more important role in air moisture availability over continental areas

Role of teleconnections

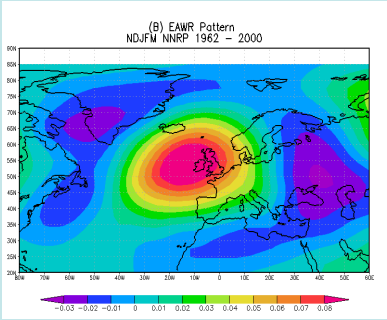
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Midlatitude teleconnections

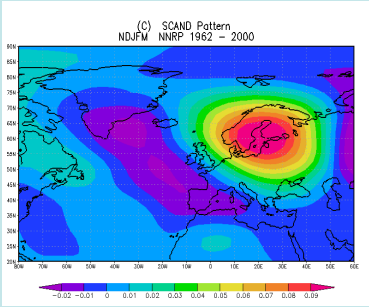
NAO



EAWR

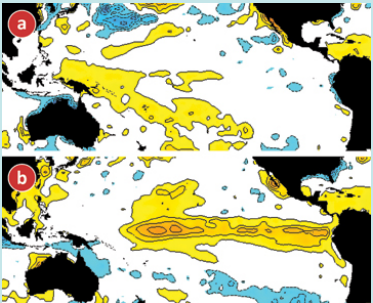


SCAND

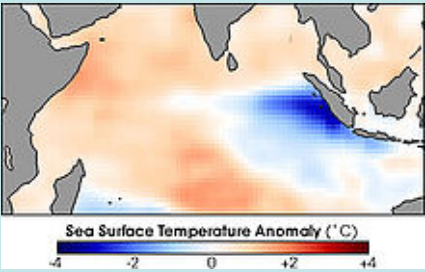


Tropical teleconnections

ENSO

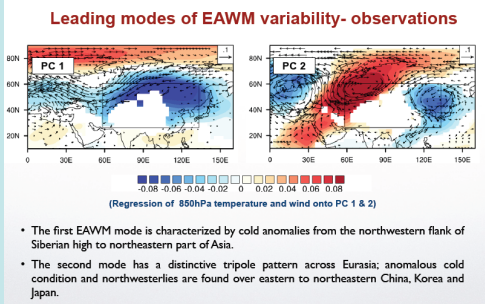


IOD



The Indian Ocean Dipole (IOD) - irregular oscillation of sea-surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean.

EAWM



- The first EAWM mode is characterized by cold anomalies from the northwestern flank of Siberian high to northeastern part of Asia.
- The second mode has a distinctive tripole pattern across Eurasia; anomalous cold condition and northwesterlies are found over eastern to northeastern China, Korea and Japan.

(Tam et al. 2008)

The circulation of the East Asian winter monsoon encompasses a large meridional domain with cold air outbreaks emanating from the Siberian high and penetrates deeply into the equatorial Maritime Continent region.

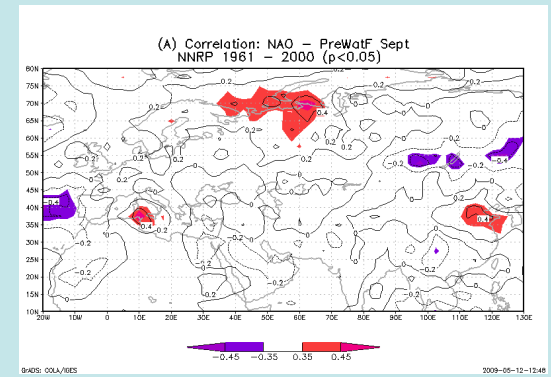
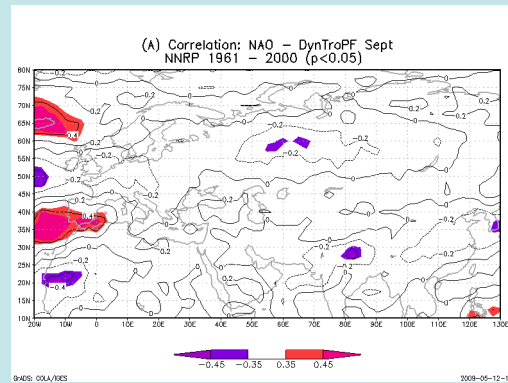
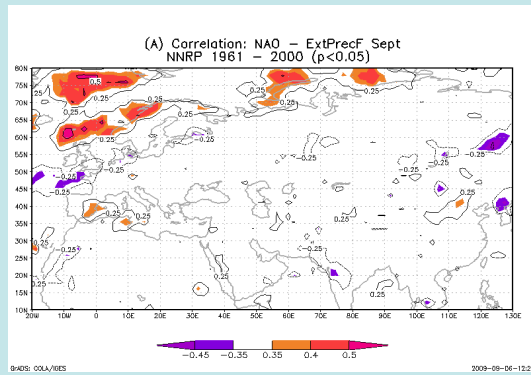
Role of midlatitude teleconnections

Rainy MR season: September, November, January, March

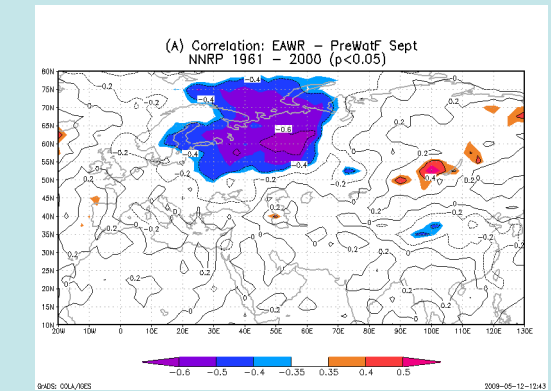
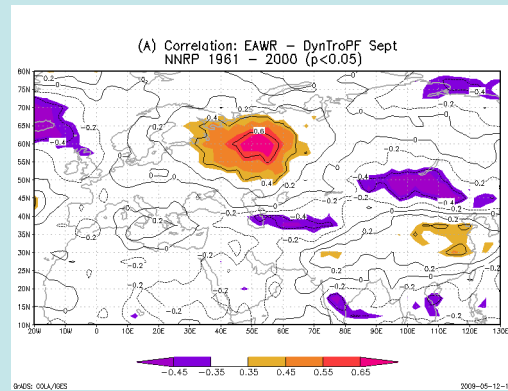
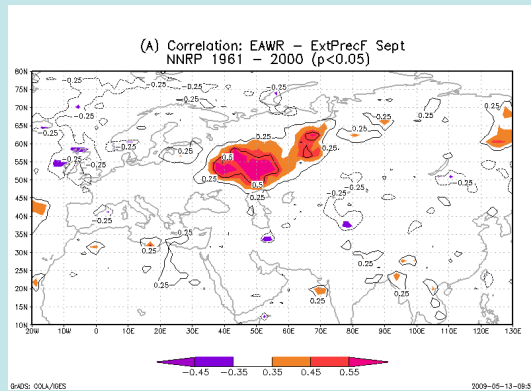
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September

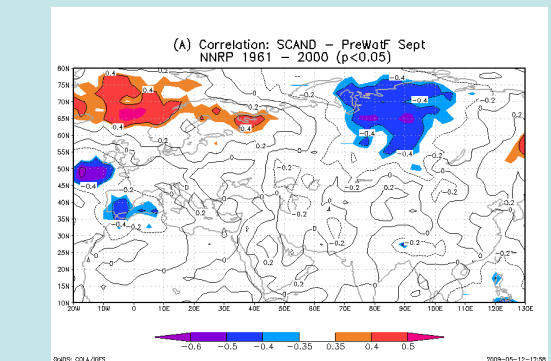
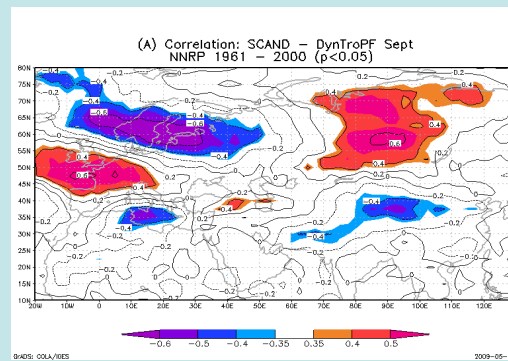
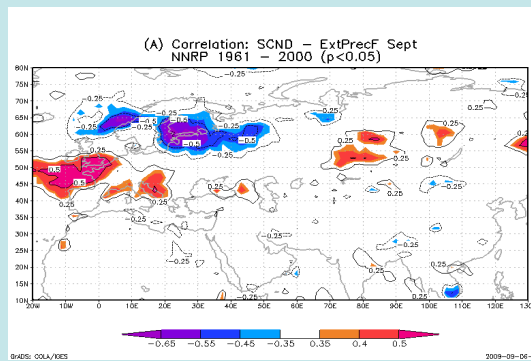
NAO



EAWR



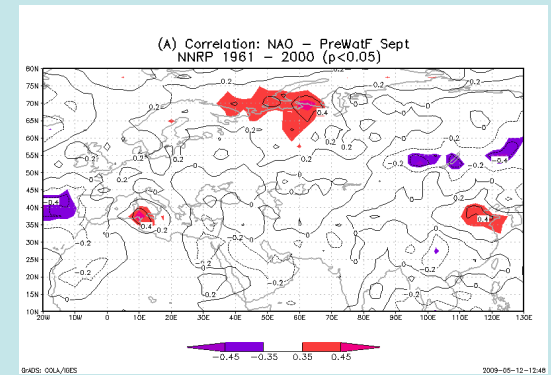
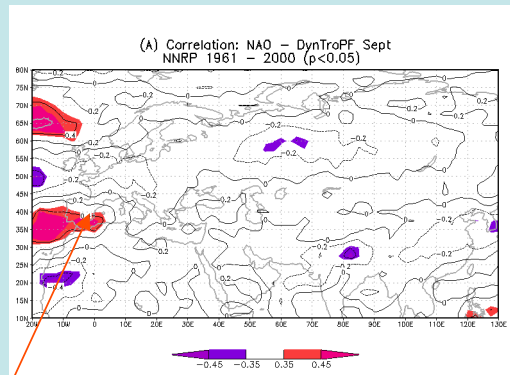
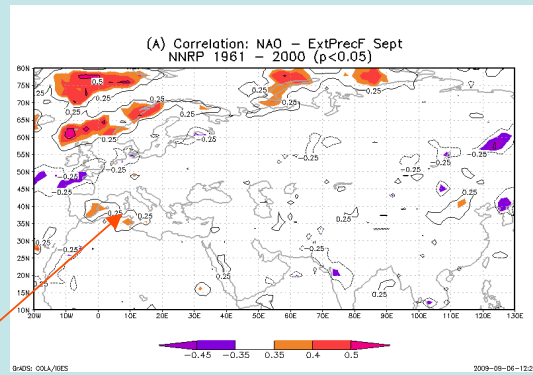
SCAND



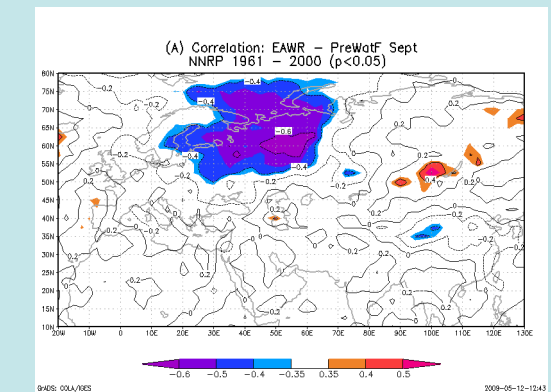
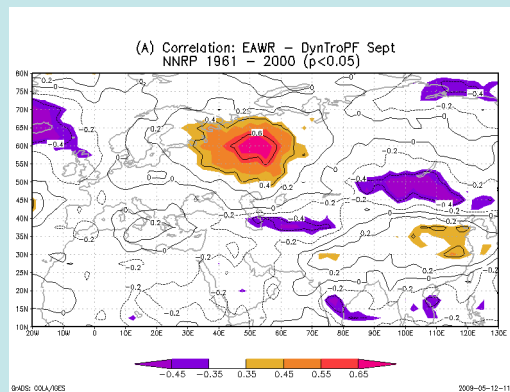
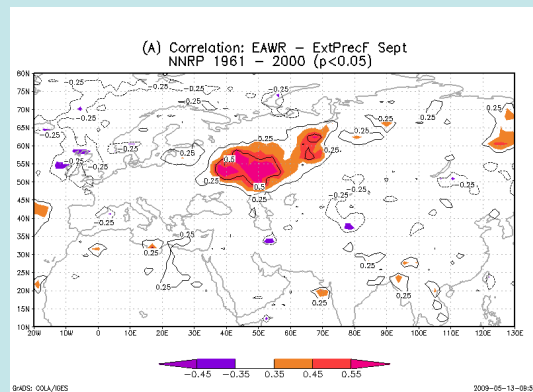
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September

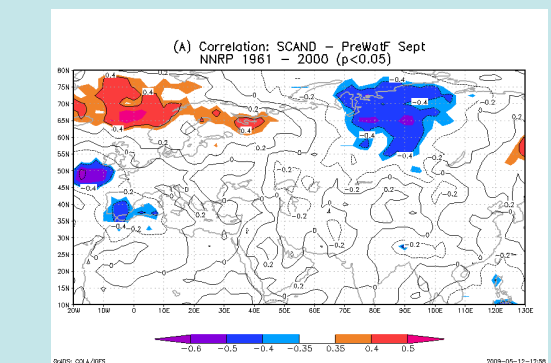
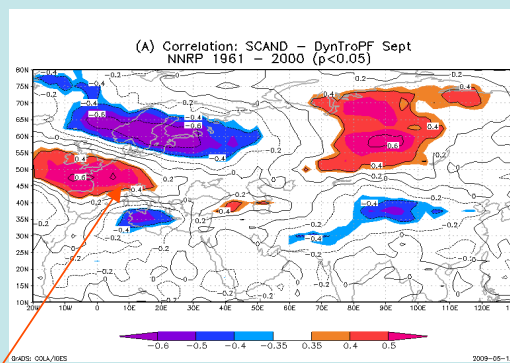
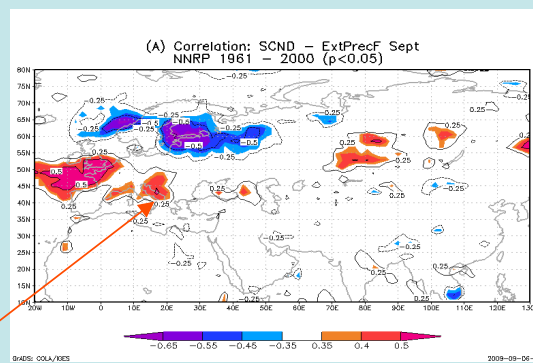
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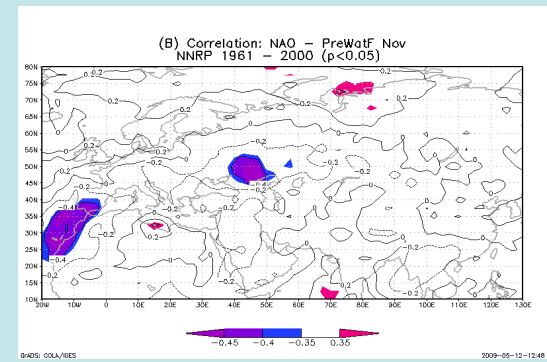
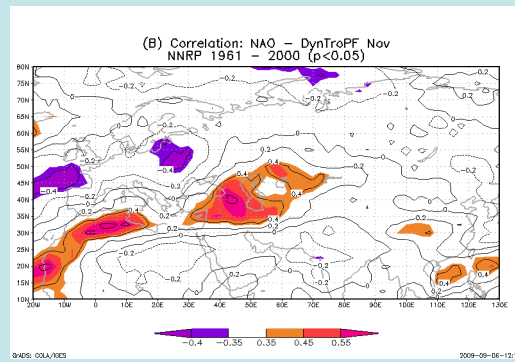
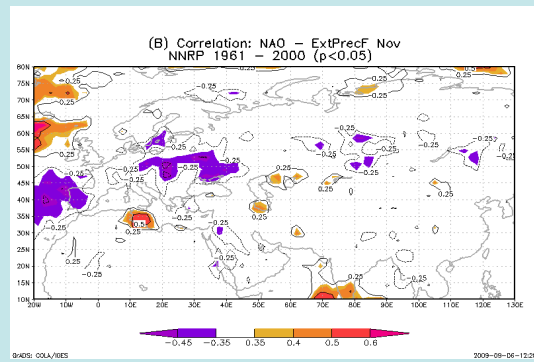


Dry dynamics

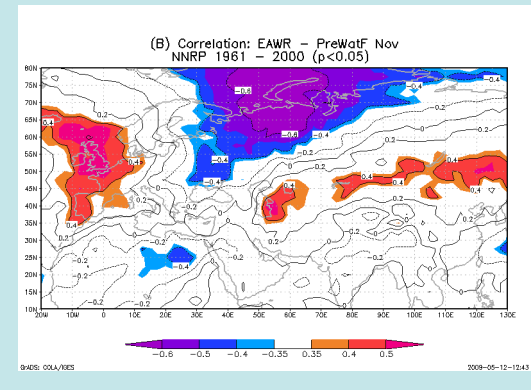
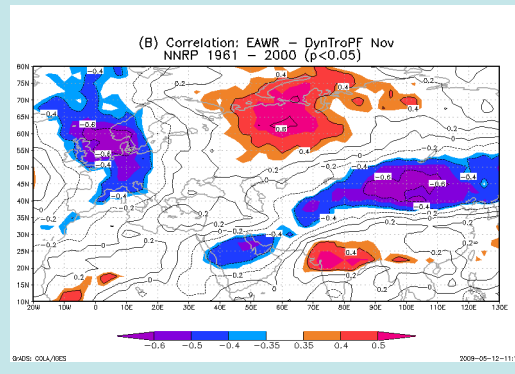
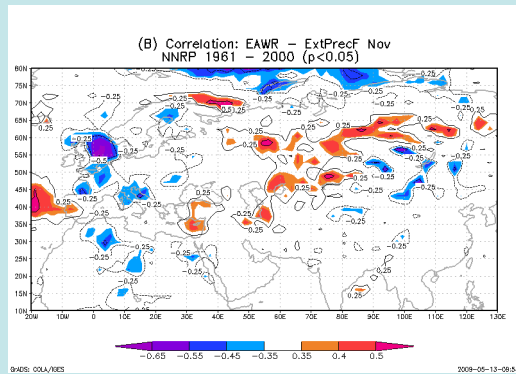
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November

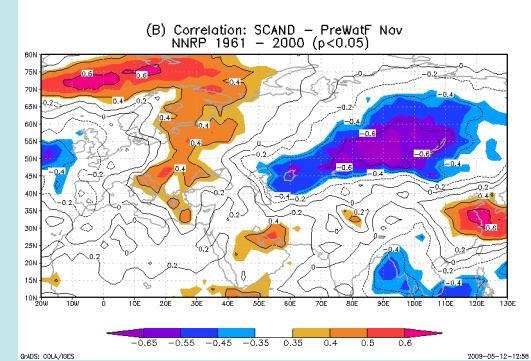
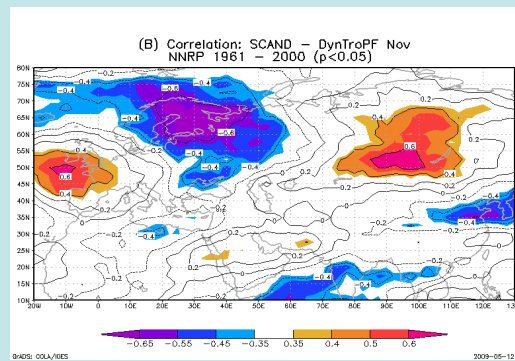
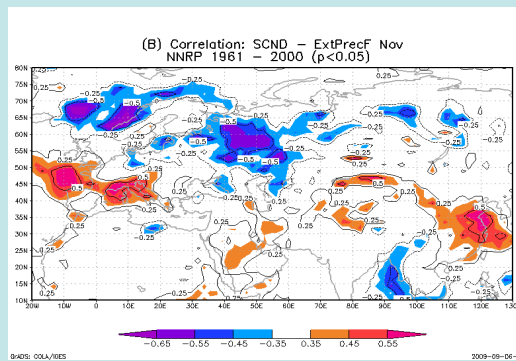
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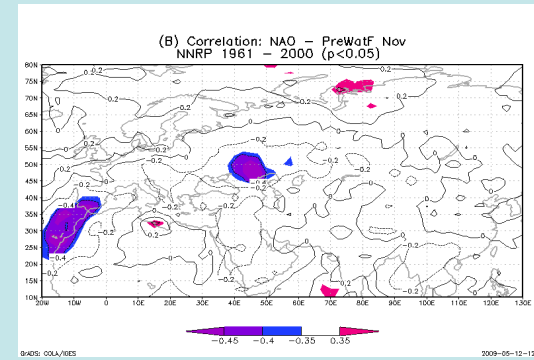
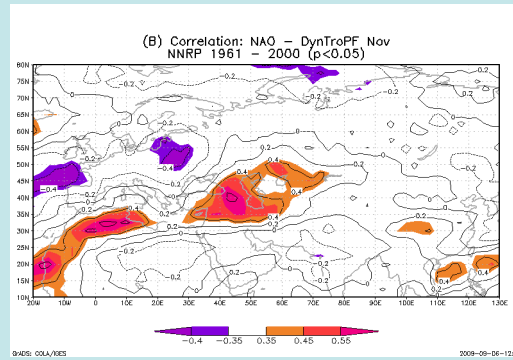
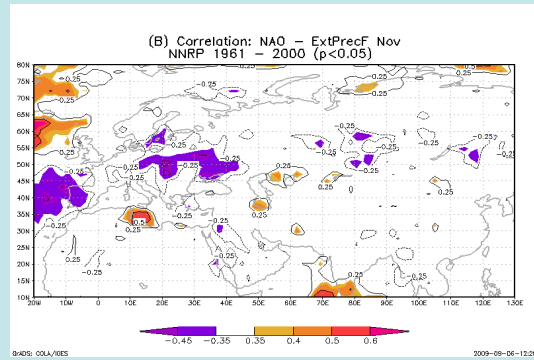


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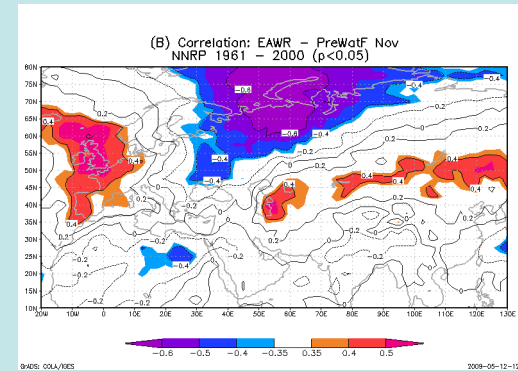
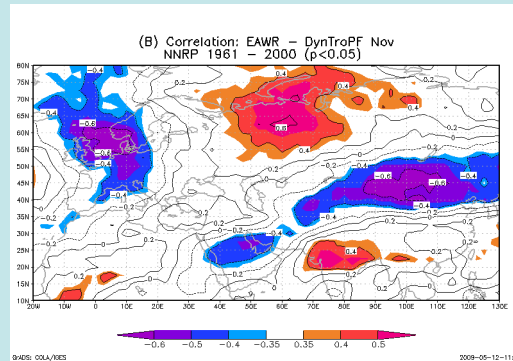
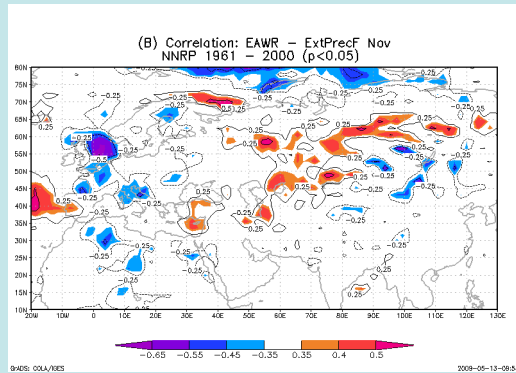


November

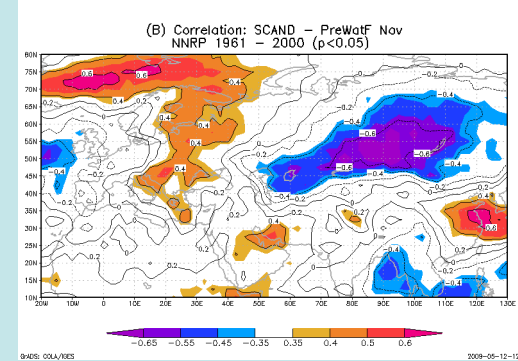
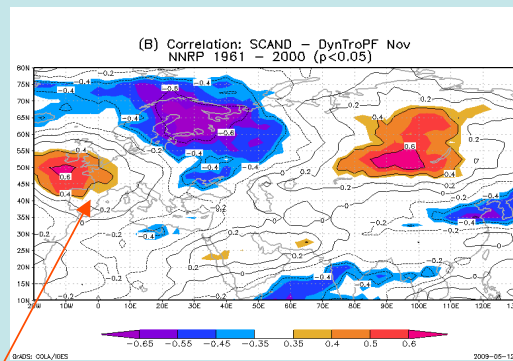
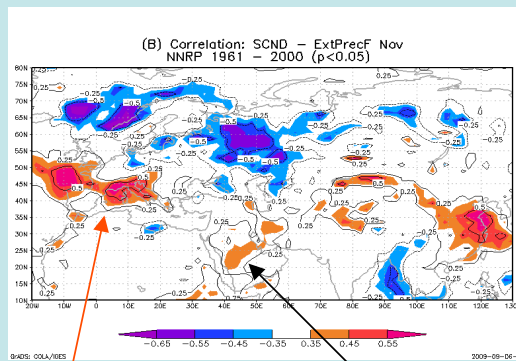
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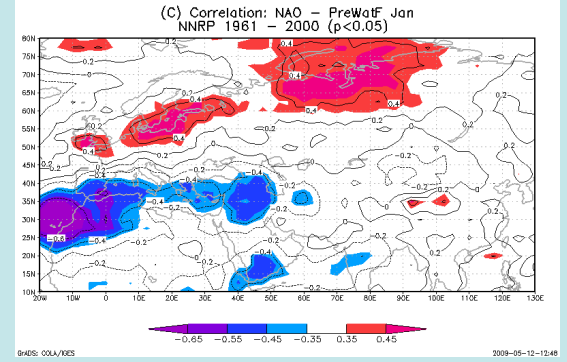
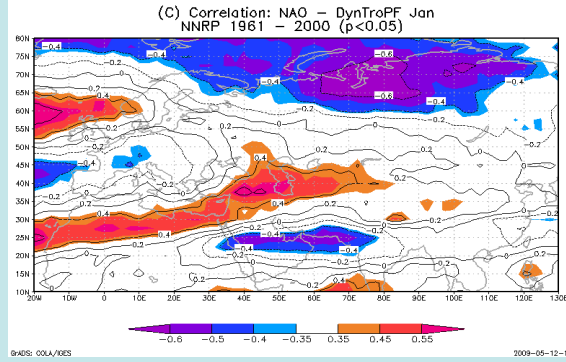
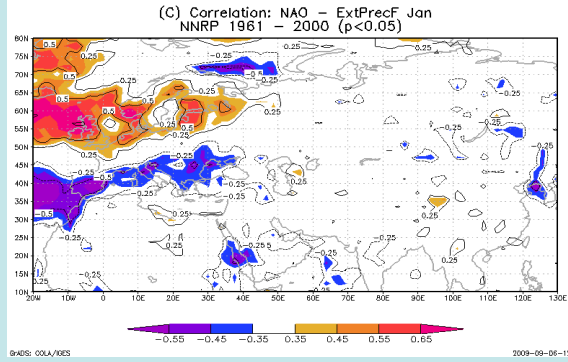
Effects of dry dynamics

Effects of moist dynamics

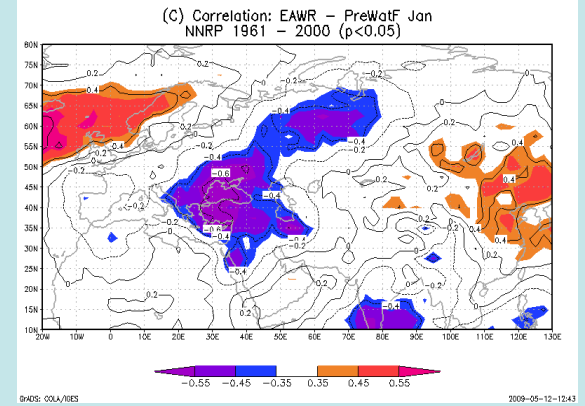
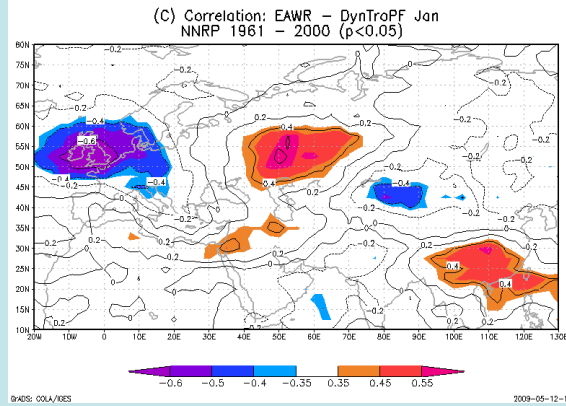
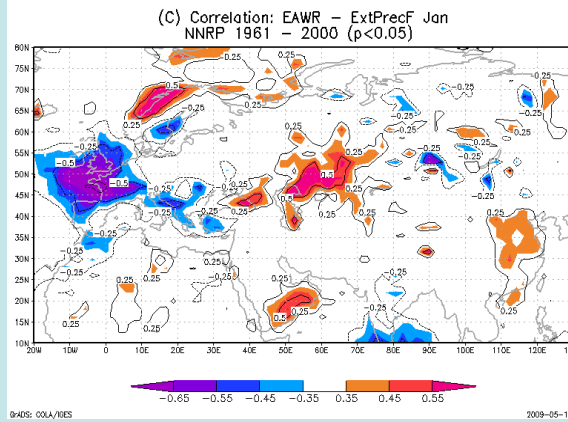
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January

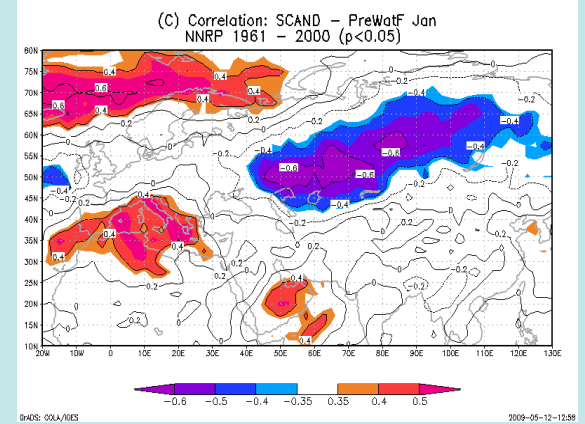
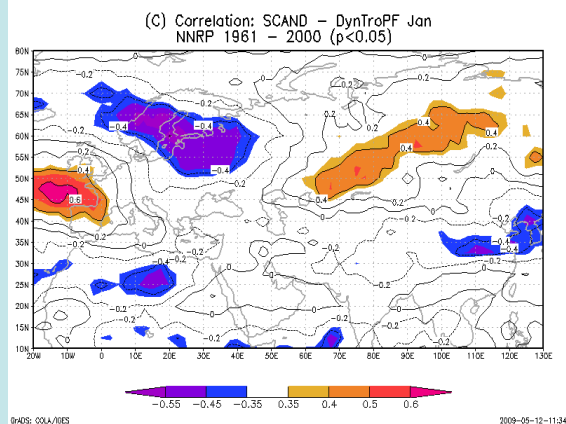
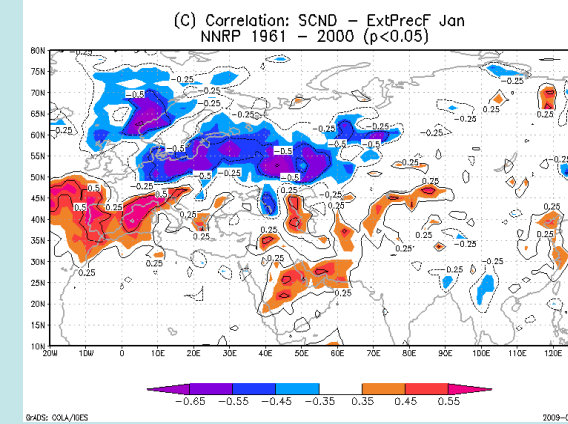
NAO



EAWR

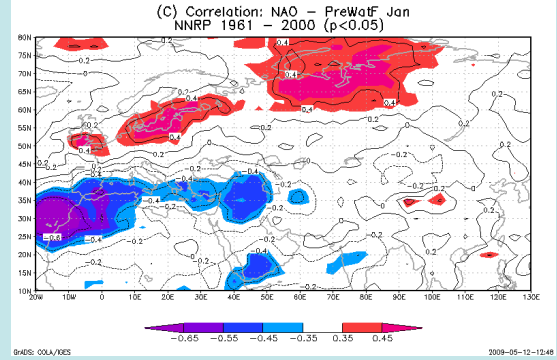
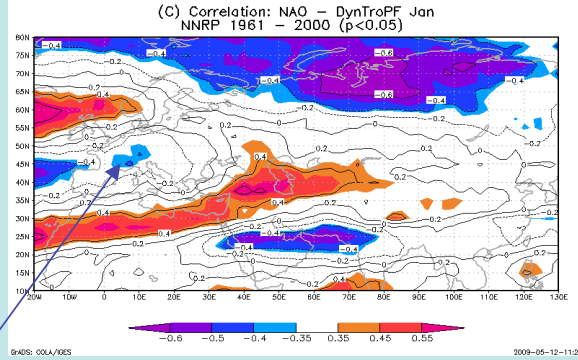
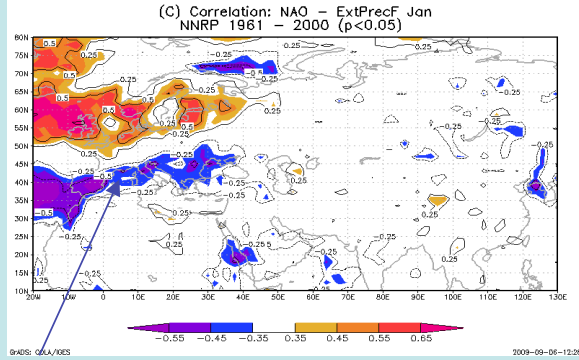


SCAND



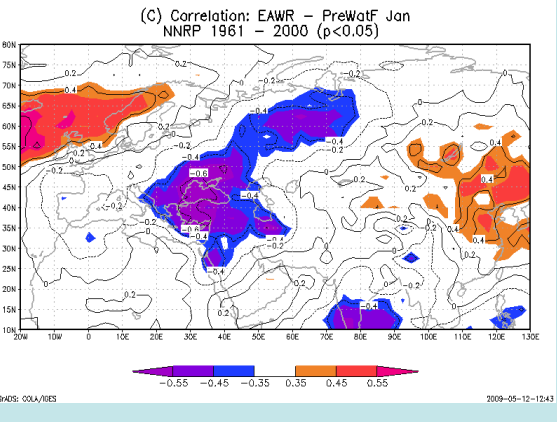
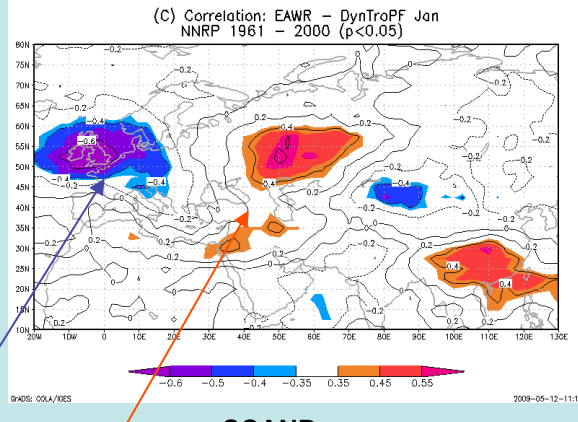
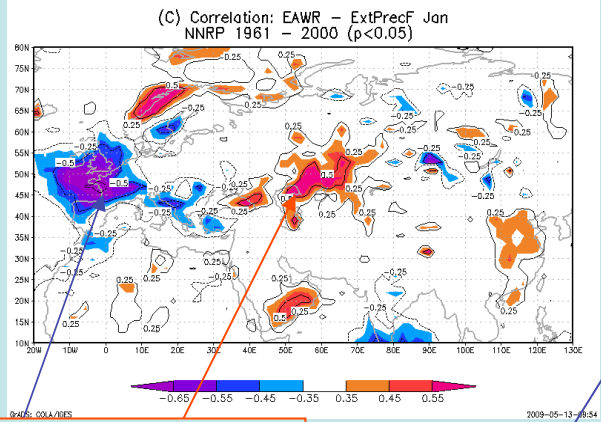
January

NAO



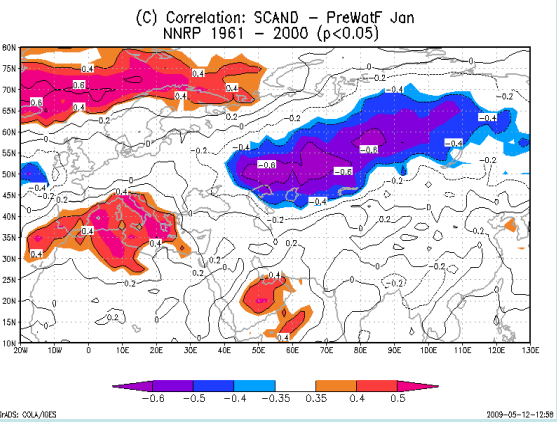
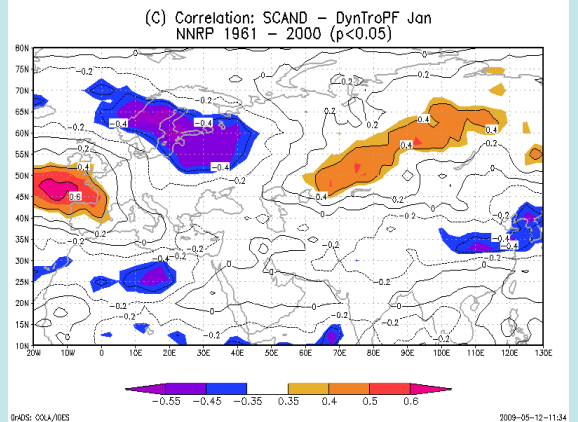
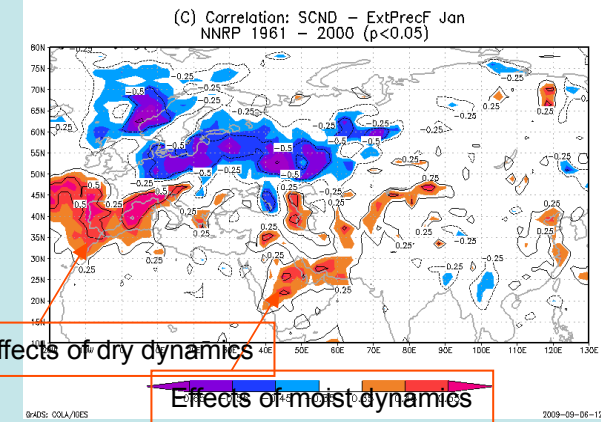
Effects of dry/moist dynamics

EAWR



Effects of dry dynamics

SCAND

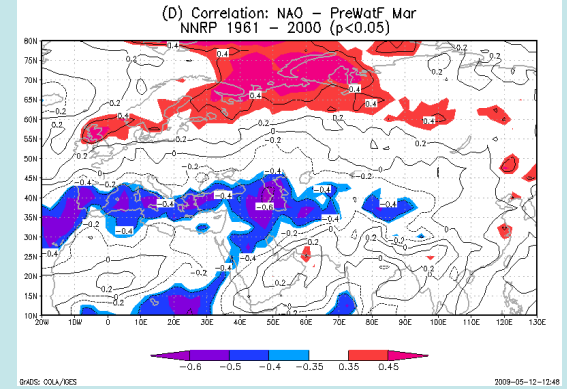
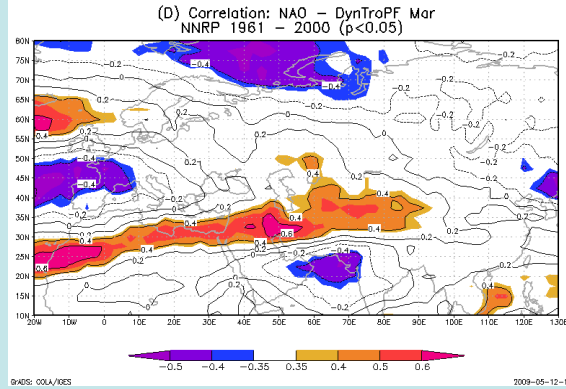
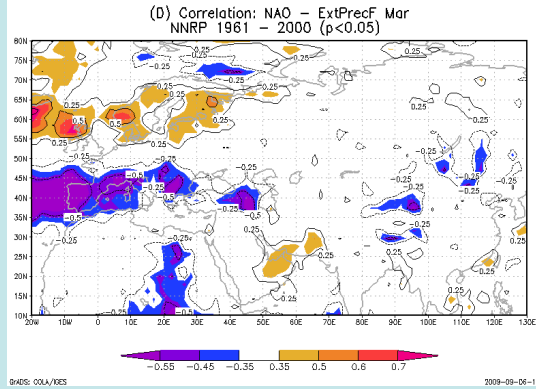


Effects of dry dynamics

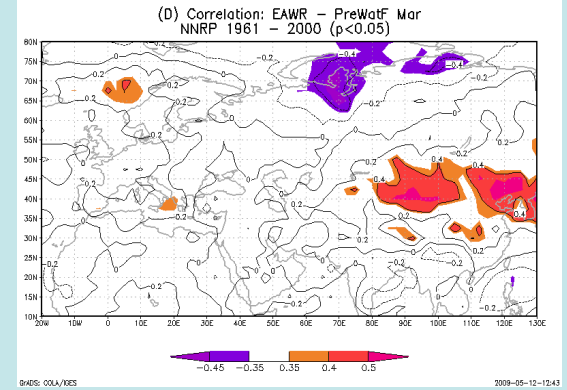
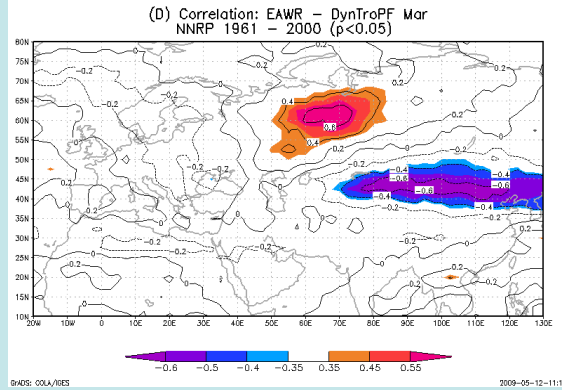
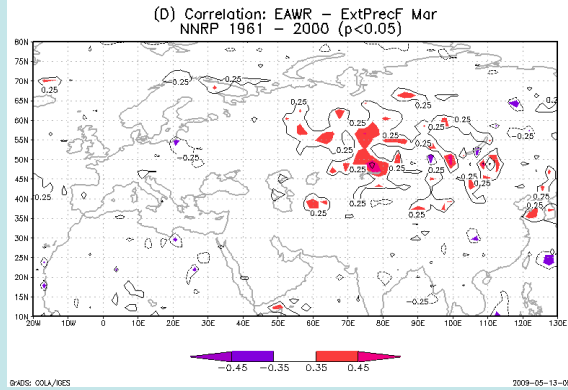
Effects of moist dynamics

March

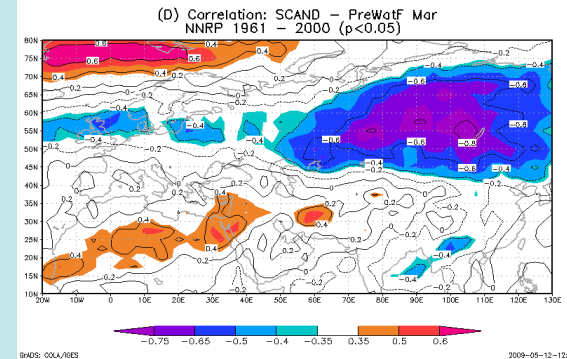
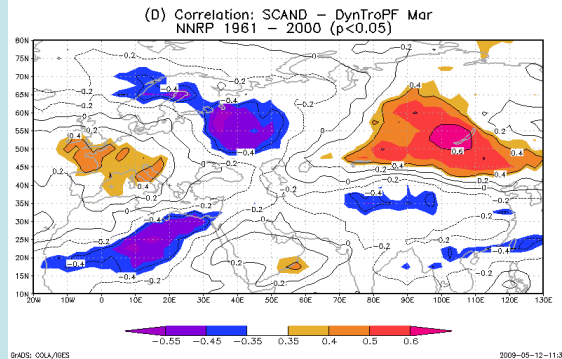
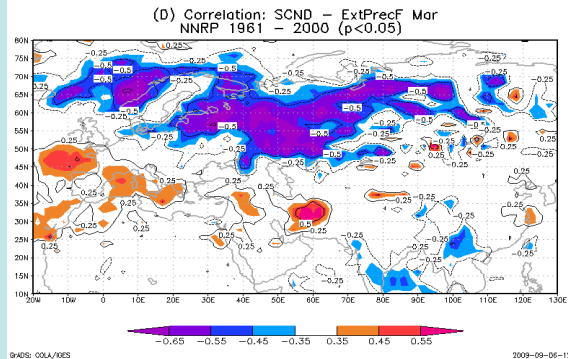
NAO



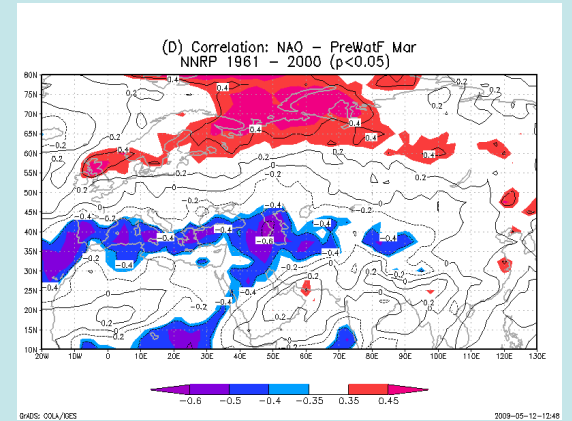
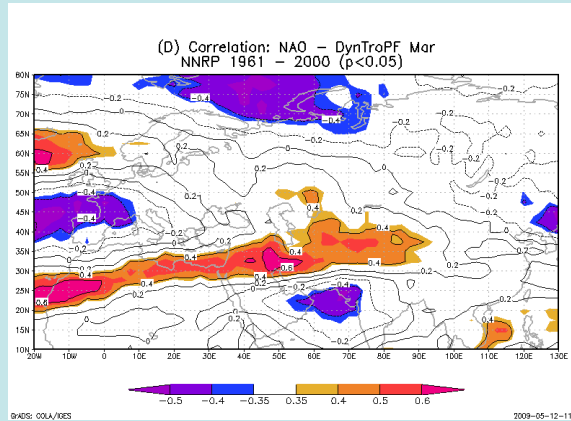
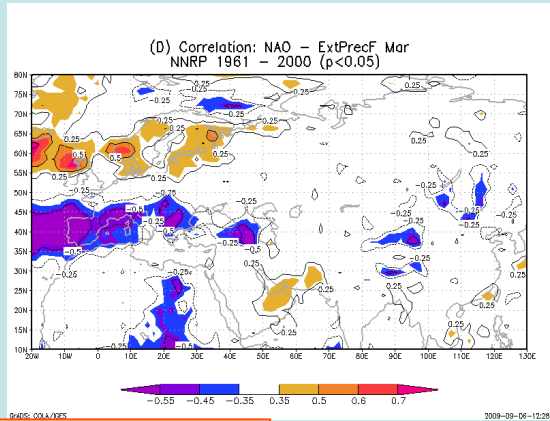
EAWR



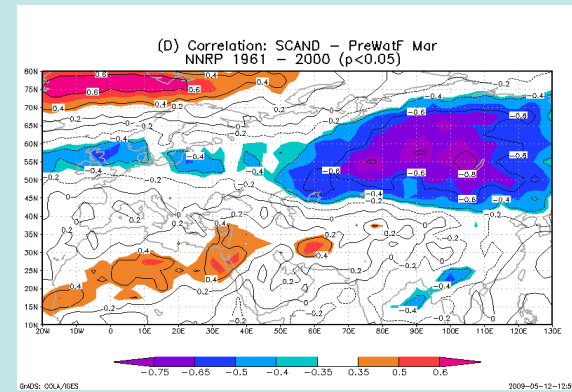
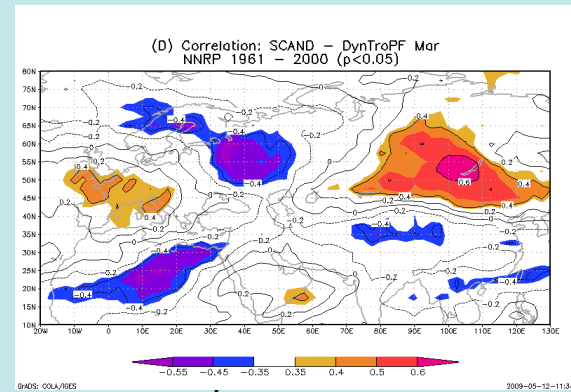
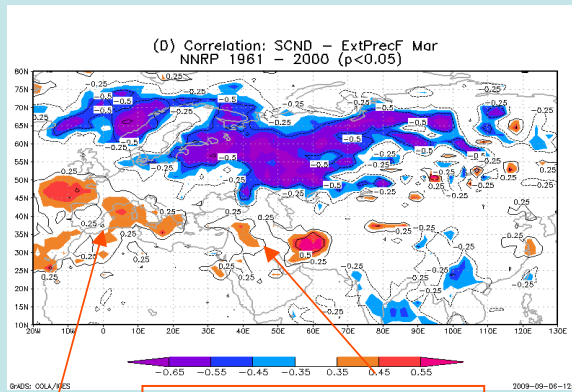
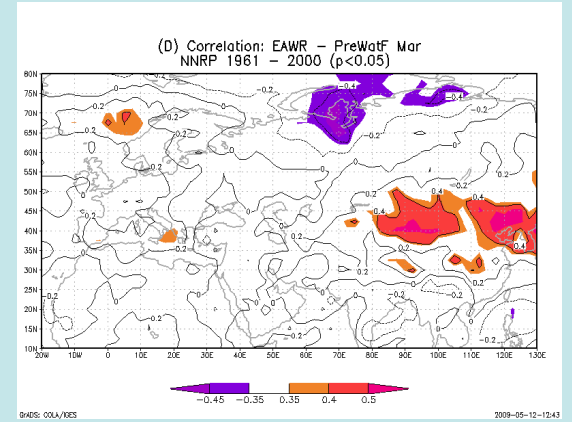
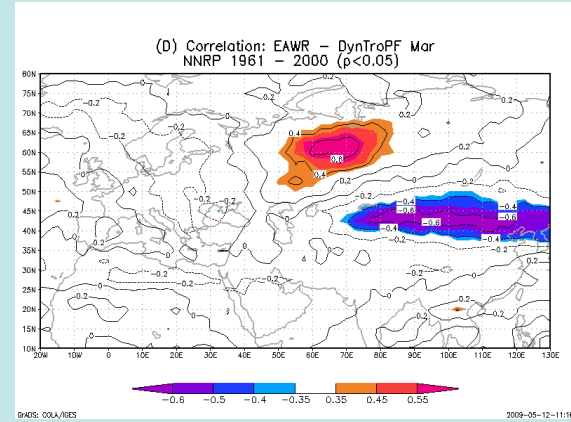
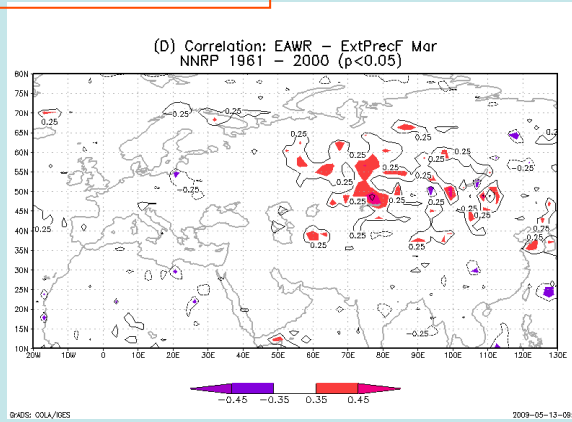
SCAND



March



Effects of dry dynamics



Effects of moist dynamics

Effects of dry dynamics

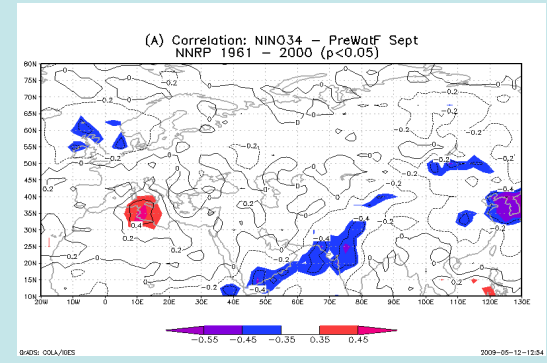
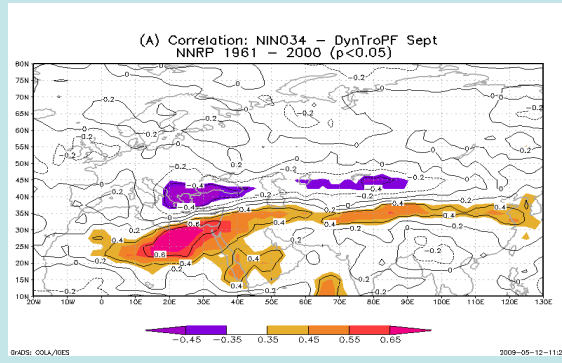
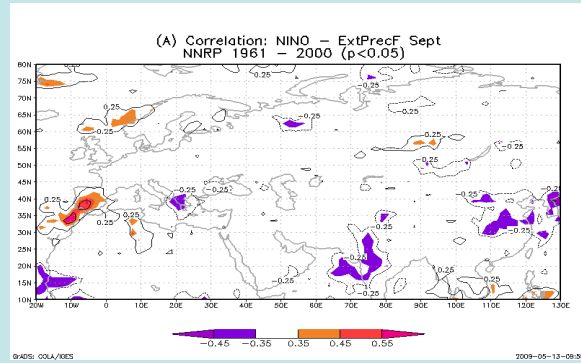
Role of tropical teleconnections

Rainy MR season: September, November, January, March

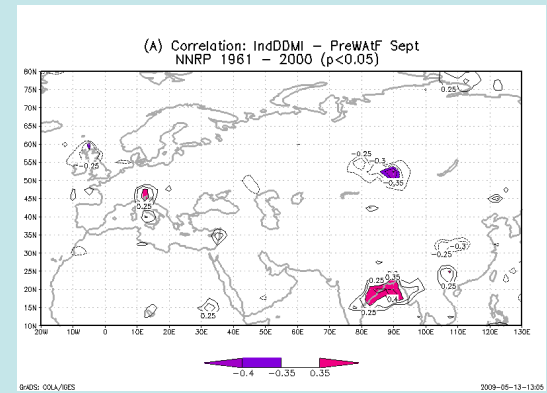
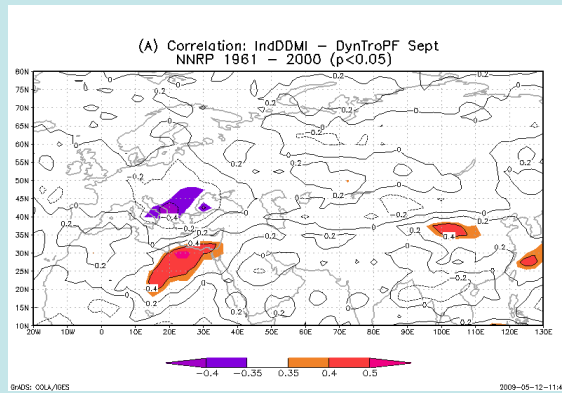
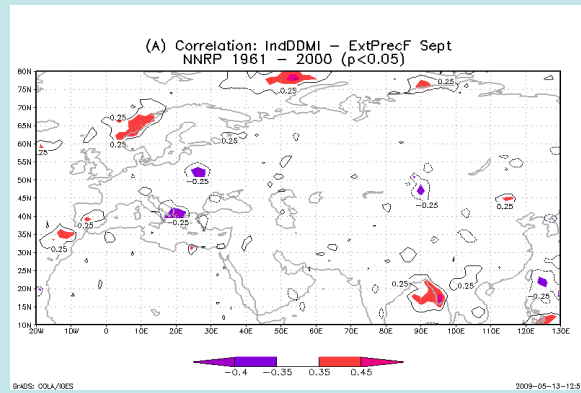
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September

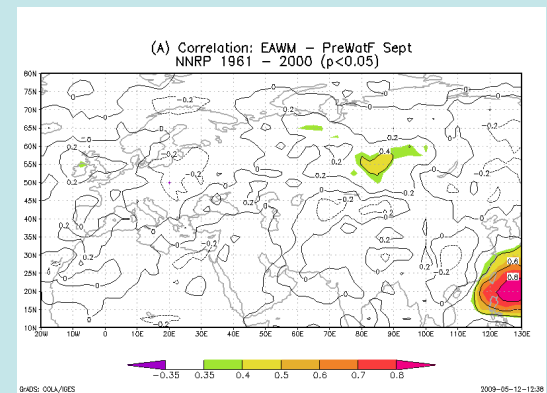
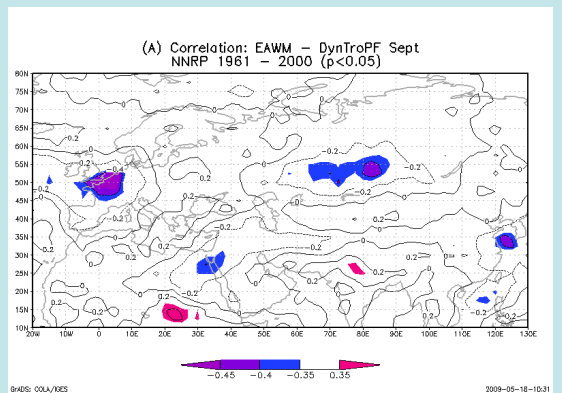
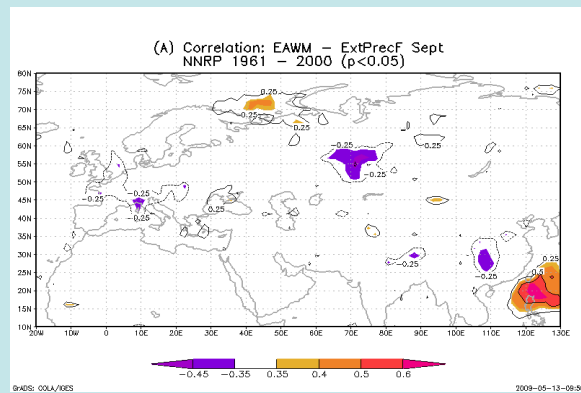
ENSO



IOD



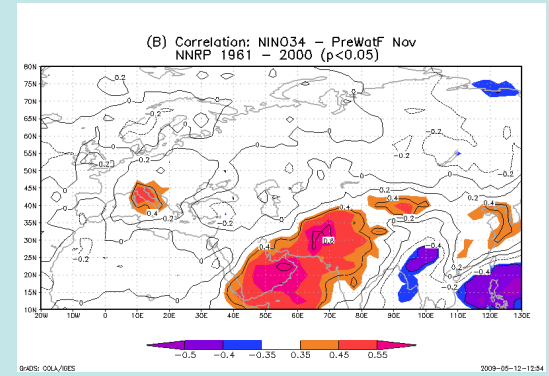
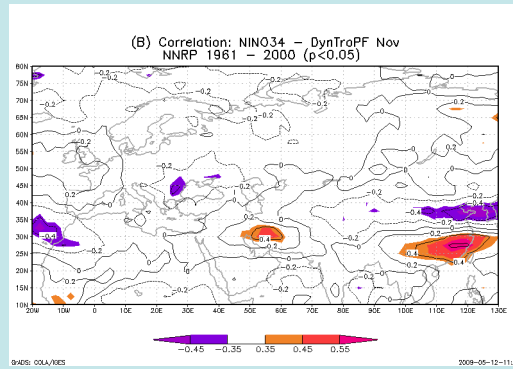
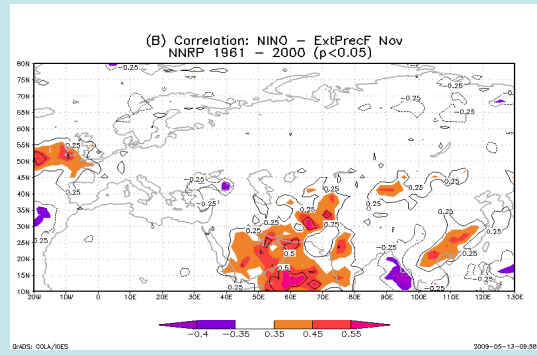
EAWM



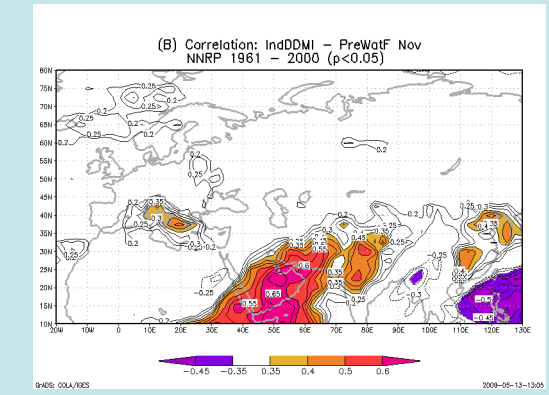
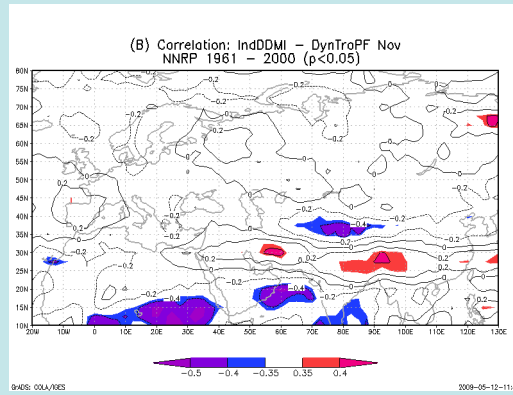
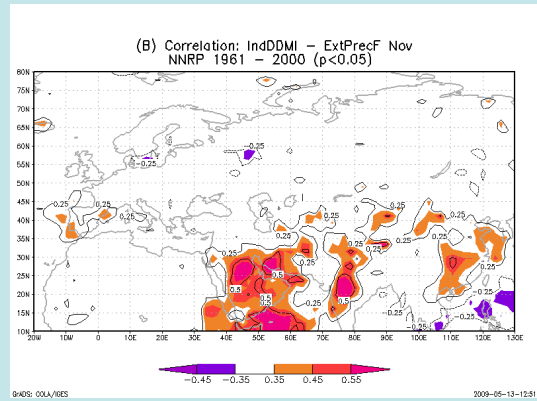
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November

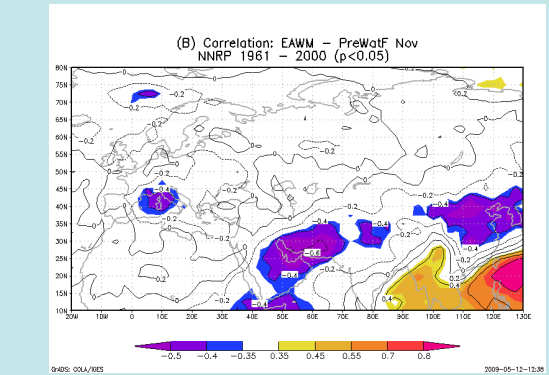
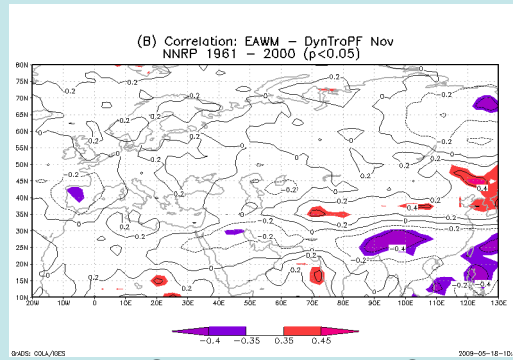
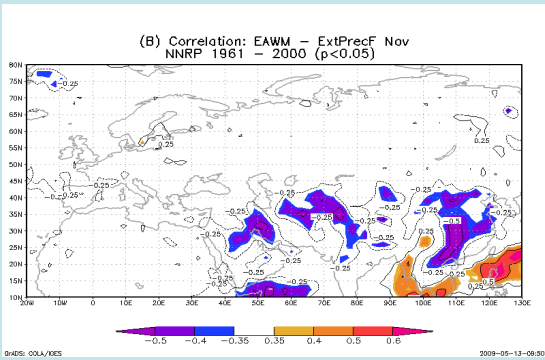
ENSO



IOD



EAWM

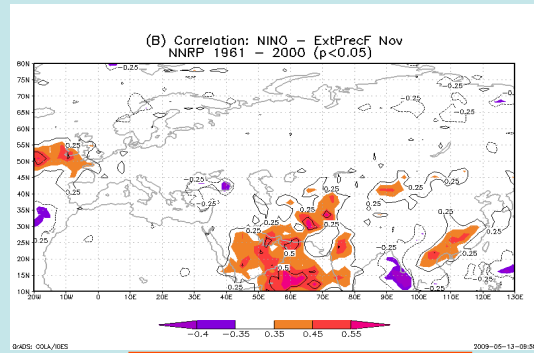


Effects of moist dynaics

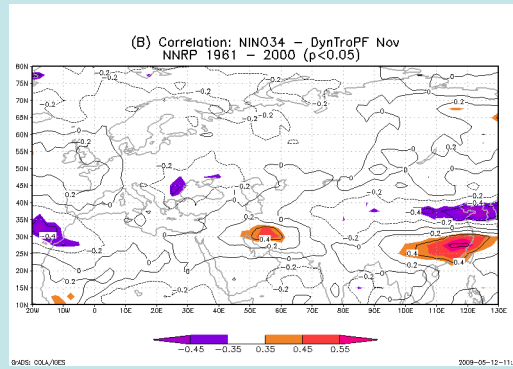
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November

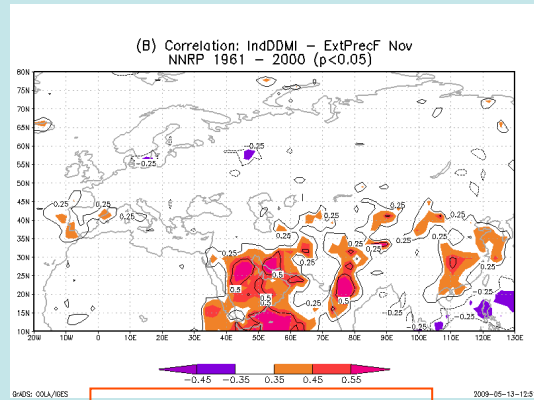
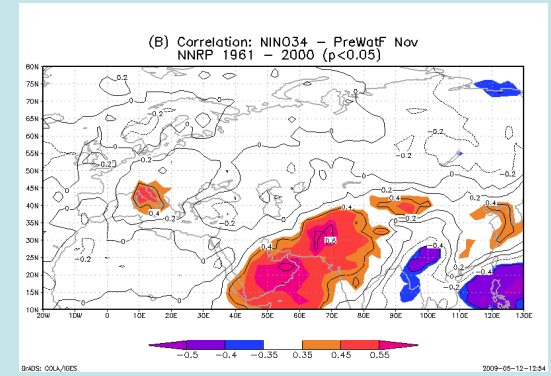
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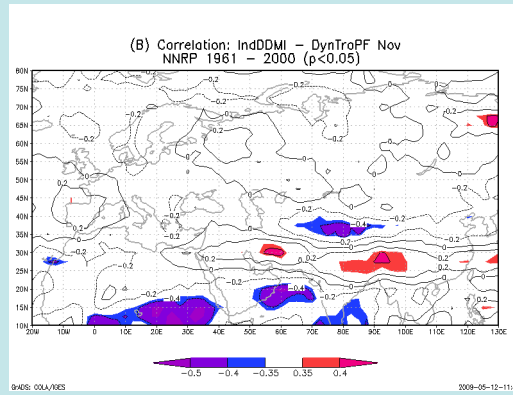
Effects of moist dynamics



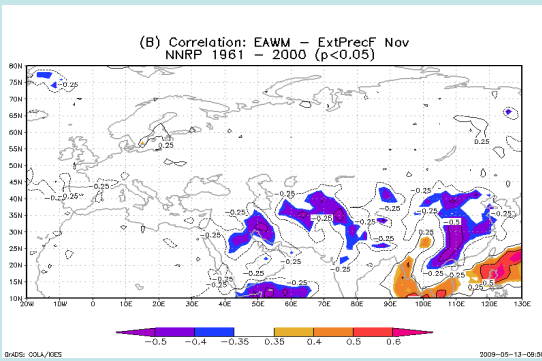
IOD



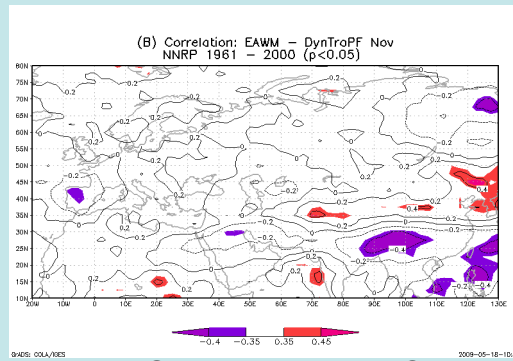
Effects of moist dynamics



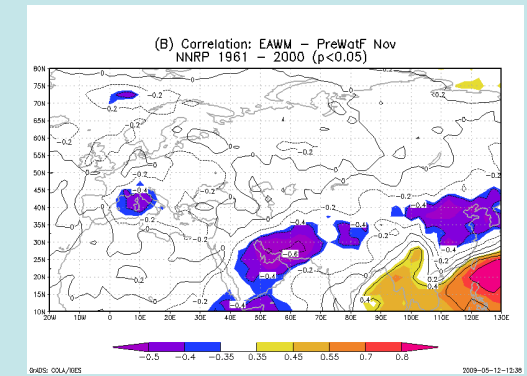
EAWM



Effects of moist dynamics

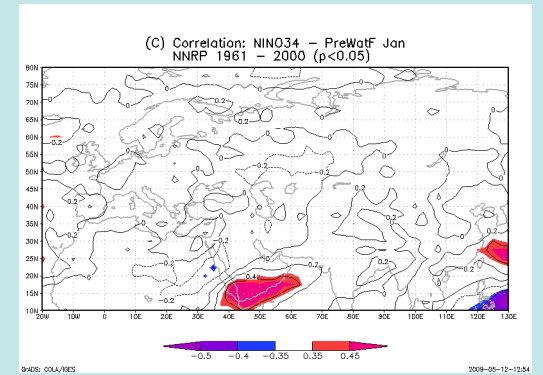
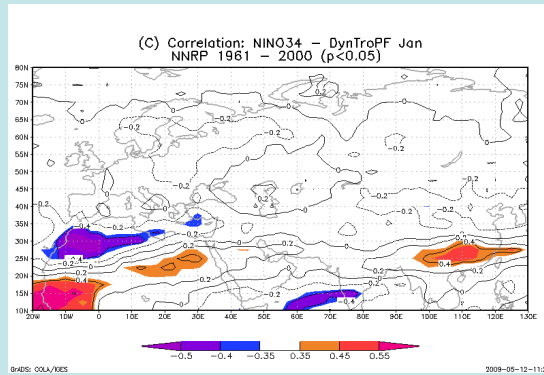
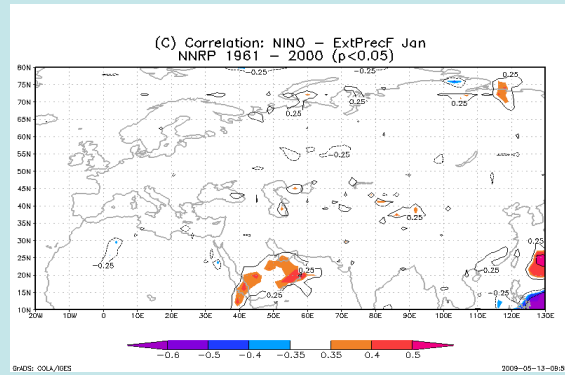


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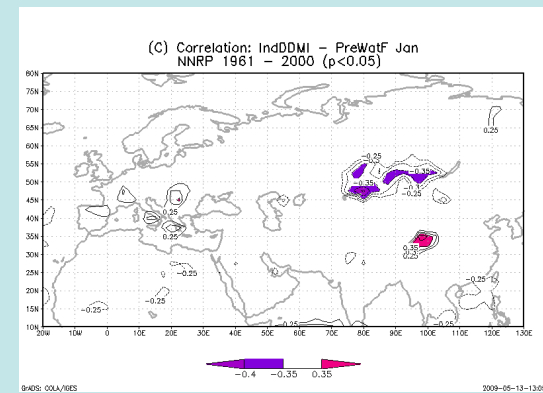
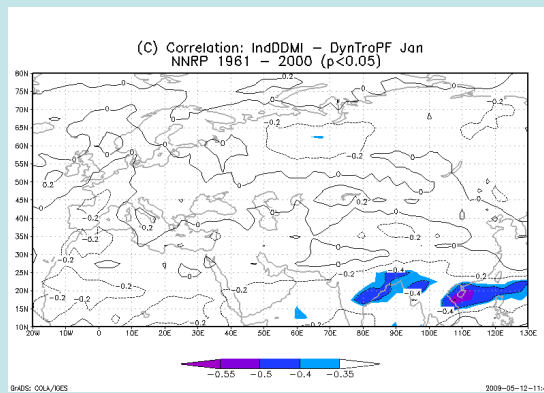
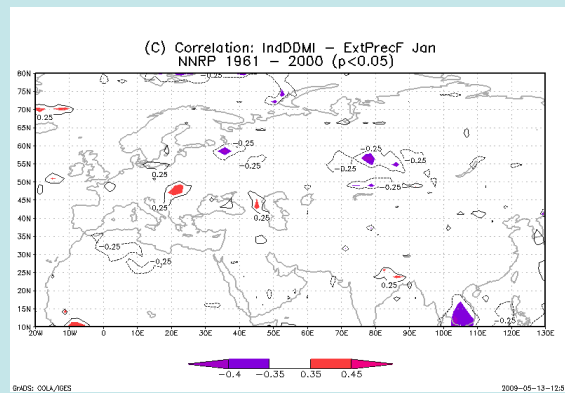


January

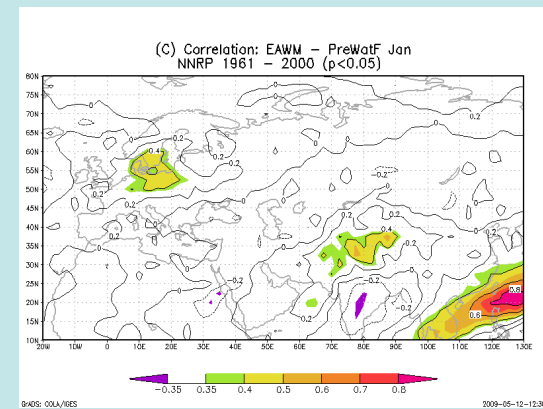
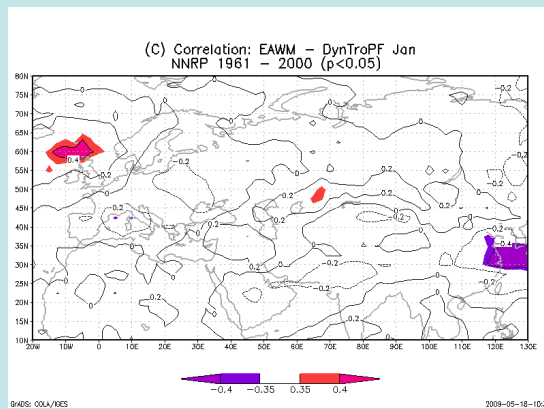
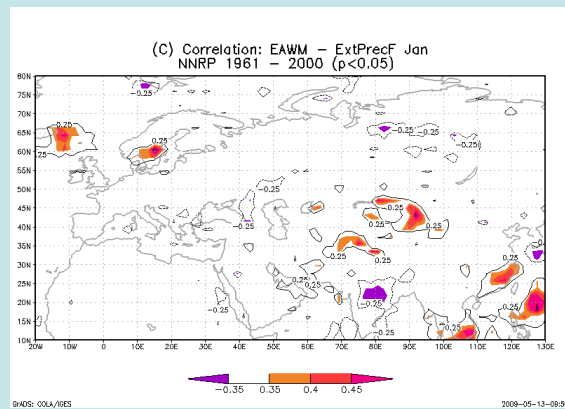
ENSO



IOD

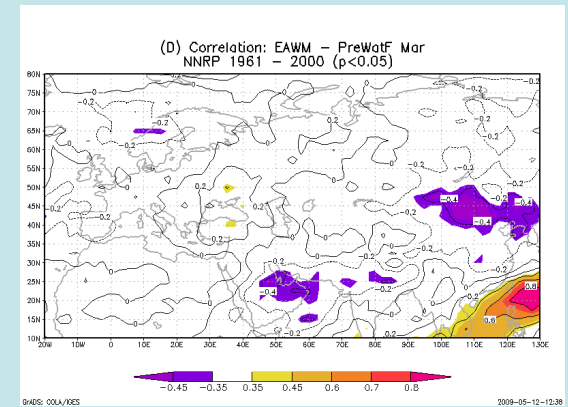
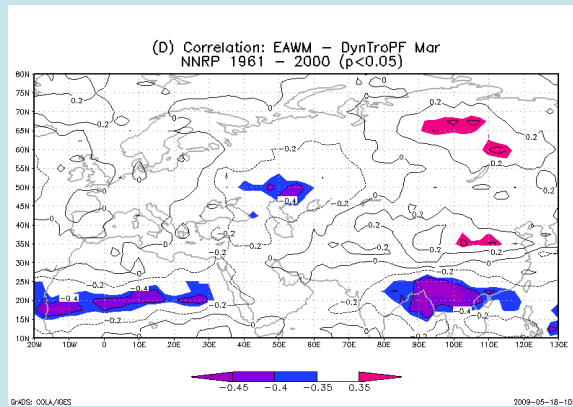
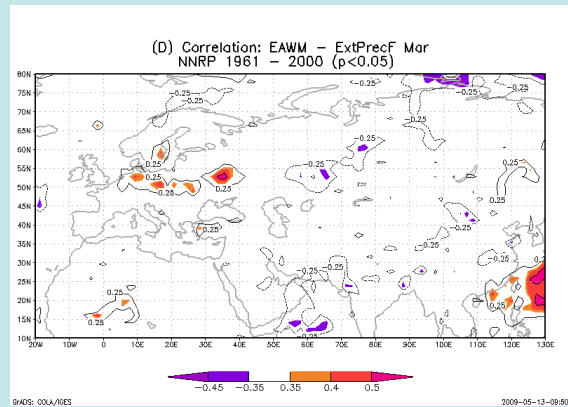
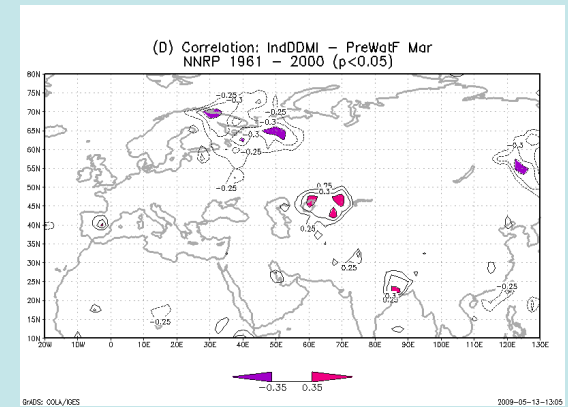
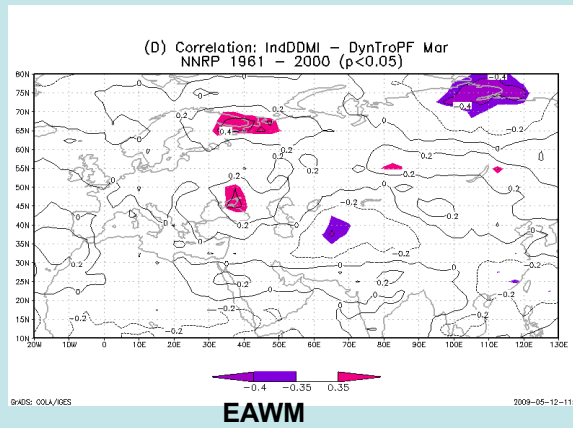
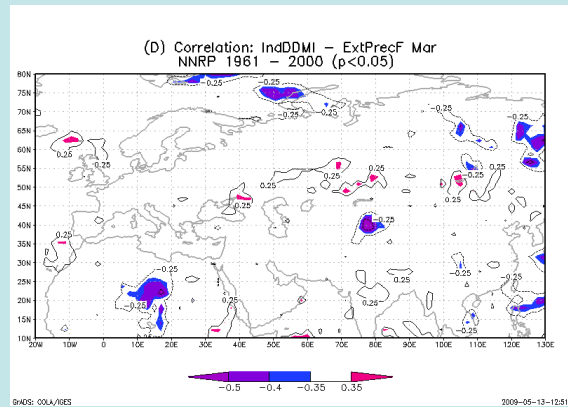
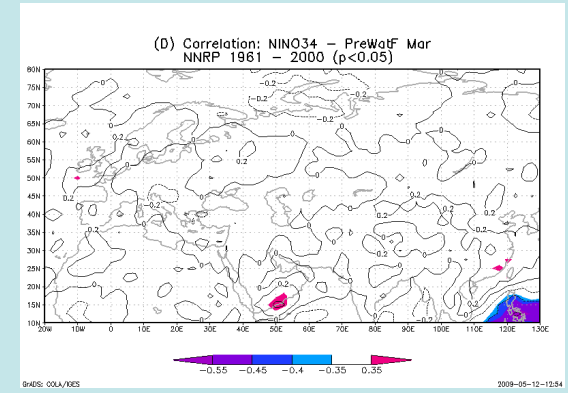
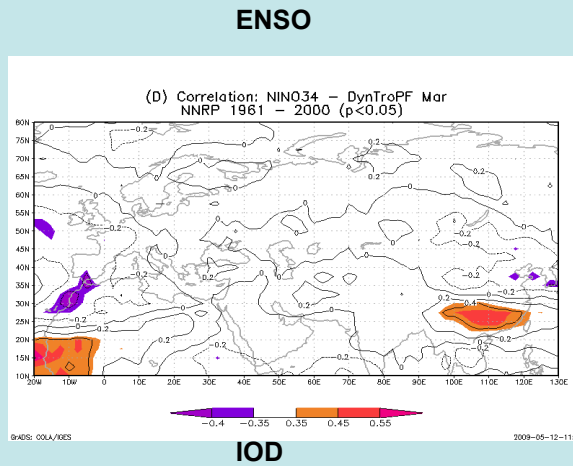
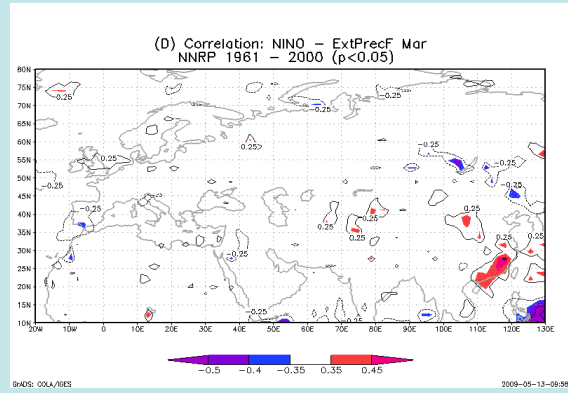


EAWM



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March



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Summary

Remote circulation anomalies, identified as teleconnection indices, influence EPCE formation through their impact on wet and dry atmospheric dynamical processes in the upper troposphere.

The mid-latitude and tropical teleconnections influence MR precipitation through somewhat different synoptic mechanisms, each affecting the intensity of dry and moist atmospheric dynamics.

Role of the mid-latitude teleconnections

-The NAO and EAWR are mainly exciting EPCE over the MR through their impact on the frequency of formation of intense the STJ.

-The SCAND teleconnection is mainly affecting EPCE by influencing the intensity of air moisture transport along the PFJ, and also by favoring the formation of events with intense northward advection of warm and moist air masses over the southern and southeastern MR.

Role of the tropical teleconnections

The three tropical teleconnections considered (ENSO, IOD, EAWM) are strongly affecting the MR weather by influencing the intensity of the STJ.

Effects of the teleconnections on the EPCE over the EM are associated with their role in controlling advection of moist tropical air into the area (mainly during late autumn) .