DELAYED ENSO IMPACT ON SPRING PRECIPITATION OVER NORTH/ATLANTIC EUROPEAN REGION

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Aim

- Investigation of delayed winter (JFM) ENSO impact on spring precipitation over the North Atlantic/European (NAE) region
- Dynamical interpretation underpinning time delayed tropical-extratropical teleconnections
- Relative contribution of contemporaneous (AMJ) and delayed (JFM) ENSO impact

Experimental design

Time period: 1901 – 2002

NAE region: 25 N-75 N; 20 W-60 E

DATA

Precipitation: *Climate Research Unit (CRU)* gridded monthly dataset (0.5 0.5)

Sea-surface temperature: NOAA_ERSST_V2 data (provided by NOAA/OAR/ESRL PSD, USA)

Sea-ice climatology: provided by Hadley Centre, UK

***MODELLED DATA*:** ensembles of numerical simulations performed by ICTP AGCM (T30L8)

- ***CTRL*** *experiment:* ensemble of 20 ICTP AGCM integrations forced with observed global monthly SST anomalies
- ***MIX*** *experiment:* ensemble of 10 integrations performed by ICTP AGCM coupled with a passive slab ocean mixed layer in North Atlantic while SST anomalies were prescribed in the tropics
- ***MIX_winter_ENSO*** *experiment:* same as MIX experiment but with tropical SST forcing prescribed during the cold part of year (Oct, Nov, Dec, Jan, Feb, Mar)
- ***MIX_summer_ENSO*** *experiment:* same as MIX experiment but with tropical SST forcing prescribed during the warm part of every year (Apr, May, Jun, Jul, Aug, Sep)

- **Analysis**: seasonal anomalies calculated as 3-month averages (JFM, FMA, MAM ...)
- **COMPOSITE ANALYSIS:**

  Warm (El Niño) ENSO events: JFM PC1 (SSTA Niño3.4) > 1
  Cold (La Niña) ENSO events: JFM PC1 (SSTA Niño3.4) < -1

References

Herceg Bulić I, Branković Č ENSO forcing of the Northern Hemisphere climate in a large ensemble model simulations. (*Climate Dyn 2007)*

Herceg Bulić I, Branković Č, F. Kucharski Winter ENSO teleconnections in a warmer climate (*Climate Dyn 2011)*

Herceg Bulić I The sensitivity of climate response to the wintertime Niño3.4 sea surface temperature anomalies of 1855–2002. (*Int J Climatol 2011*)

Herceg Bulić I, Kucharski F Delayed ENSO impact on spring precipitation over North/Atlantic European region (Climate Dyn; submitted)

CORRELATION MAPS

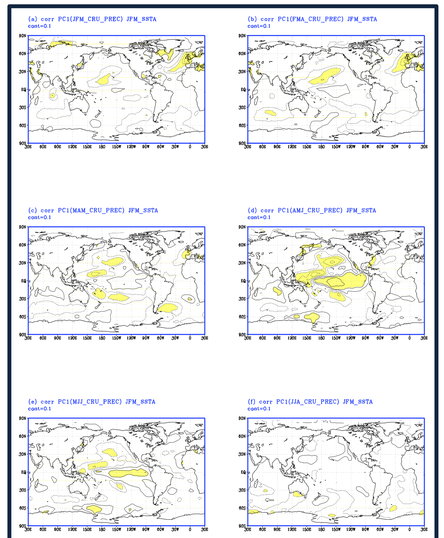

Fig.1 Correlation maps representing correlations between global winter (JFM) SST anomalies and PC associated with the first EOF mode of a) JFM; b) FMA; c) MAM; d) AMJ; e) MJJ and f) JJA CRU precipitation anomalies over the NAE region. Correlations exceeding the 98% confidence level of the *t* statistics are *shaded*.

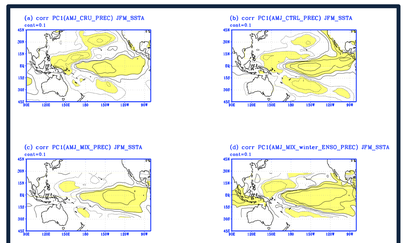

Fig. 2 Correlation maps representing correlations between tropical Pacific winter (JFM) SST anomalies and PC associated with the first EOF mode of AMJ precipitation anomalies obtained from following datasets: a) CRU; b) CTRL experiment, c) MIX experiment and d) MIX_winter_ENSO experiment. Correlations exceeding the 98% confidence level of the *t* statistics are *shaded*.

***Time-lagged correlations*:** suggestion of time delayed (JFM → AMJ) impact of tropical Pacific SST anomalies on spring precipitation in the NAE region. The experiment with tropical Pacific SST forcing restricted to the cold part of the year (MIX_winter_ENSO experiment) confirms delayed precipitation response.

ENSO COMPOSITES

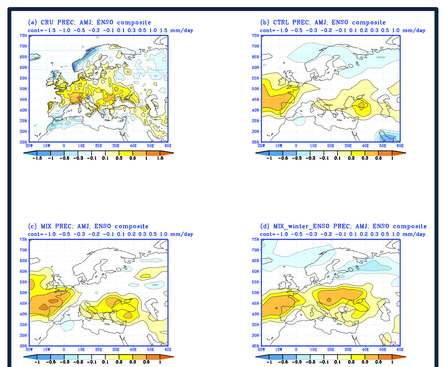

Fig. 3 Warm ENSO composites of spring (AMJ) precipitation anomalies for a) CTRL; c) MIX; d) MIX_winter_ENSO and cold ENSO composites of spring (AMJ) precipitation anomalies for b) CTRL; d)MIX; f) MIX_winter_ENSO experiment.

EOF1 PATTERNS

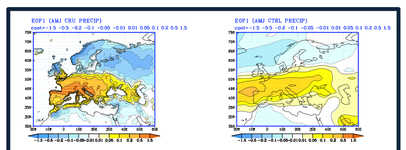

Fig. 4 First EOF mode of spring (AMJ) precipitation over the NAE region for a) CRU experiment and b) CTRL experiment.

- COMPOSITES: Similar response patterns are obtained for all SPEEDY experiments as well as for CRU data
- Warm ENSO events: associated with unusually dryer (wetter) precipitation conditions at the north (south) part of the domain
- Cold ENSO events: associated with unusually wetter (dryer) precipitation conditions at the north (south) part of the domain
- Spatial distributions of the composites project onto EOF1 spatial pattern

PHYSICAL MECHANISM

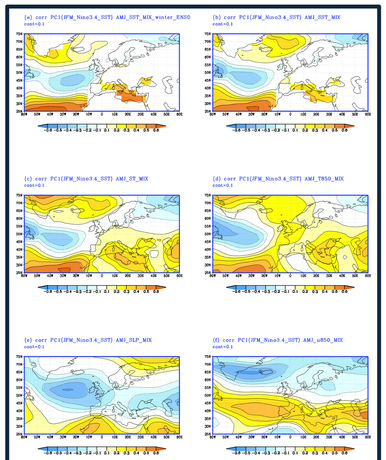

Fig. 5 Correlation map representing correlations between PC associated with the first EOF mode of winter (JFM) SST anomalies in Niño3.4 region and spring (AMJ) a) MIX_winter_ENSO SST anomalies; b) MIX SST anomalies; c) MIX surface temperature; d) MIX temperature at 850 hPa level; e) MIX sea-level pressure and f) MIX zonal wind at 850 hPa level.

A chain of air-sea interactions:
Tropical Pacific and eastern North Atlantic are connected by a wave-train of Rossby waves ("atmospheric bridge") → ocean response to atmospheric forcing resulting in SST anomalies in eastern N. Atlantic (with time-delay of one season) → eastern N. Atlantic forcing of the underlying atmosphere: changes of zonal wind and onshore moisture advection → downstream MSLP and precipitation modification.

CONTAMPORENOUS AND DELAYED ENSO IMPACT

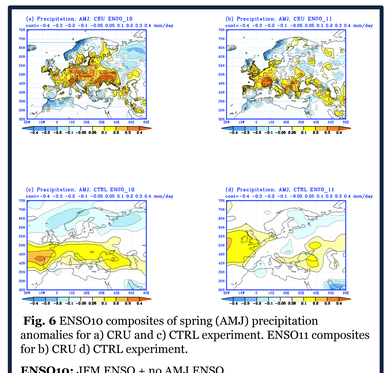

Fig. 6 ENSO10 composites of spring (AMJ) precipitation anomalies for a) CRU and c) CTRL experiment. ENSO11 composites for b) CRU d) CTRL experiment.

ENSO10: JFM ENSO + no AMJ ENSO
ENSO11: JFM ENSO + AMJ ENSO

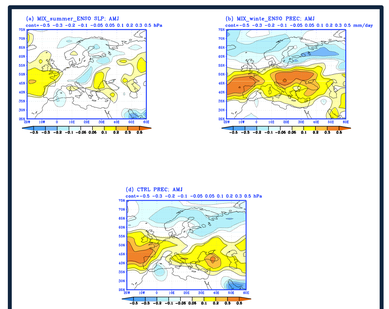

Fig. 7 ENSO composites of spring (AMJ) precipitation anomalies for a) MIX_summer_ENSO; b) MIX_winter_ENSO and c) CTRL experiment.

CONCLUSIONS

- Observed as well as modelled data show significant time-delayed NAE precipitation response to the winter ENSO forcing
- JFM warm (cold) ENSO events are associated with wetter (drier) AMJ precipitation conditions in the central part of the NAE region
- Results obtained by SPEEDY simulations with the ENSO forcing restricted to the cold part of year underlie those findings and exclude ENSO seasonal persistence as a major mechanism causing delayed atmospheric response
- Physical mechanism underpinning time-delayed atmospheric response to the ENSO forcing includes Rossby wave-train which constitutes atmospheric bridge between the tropical Pacific and North Atlantic. Induced mid–latitude Atlantic SST anomalies interact with the overlaying atmosphere altering westerly winds and onshore moisture advection. As a result, downstream sea-level pressure pattern is modulated likewise the precipitation
- Contemporaneous and delayed ENSO impact induce opposite precipitation response over the central continental part of the NAE region; thus the strongest precipitation response is expected for the years with developed winter ENSO that does not persist till the spring

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