The Future Evolution of the Western Iberian Coastal Low-Level Wind Jet in a Warming Climate

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Looking at Global Wind

A coastal jet (CJ) is a low-tropospheric mesoscale wind feature driven by the pressure gradient produced by a sharp contrast between high temperatures over land and lower temperatures over sea. (Cross 2003)

CLLJs occur along equator-ward cold eastern boundary currents, and play an important role in the regional climate of those areas (wind, water vapor, fog, stratus clouds, upwelling, waves, etc.).

Era-Interim wind speed

Boreal Summer

Austral Summer

(Ranjha et al 2013)
A coastal low-level jet (CLLJ) is a low-tropospheric mesoscale wind feature driven by the pressure gradient produced by a sharp contrast between high temperatures over land and lower temperatures over sea (Cross 2003).
CLLJs occur in the eastern boundary current systems and play an important role in the regional climate.

Coastal upwelling systems associated with eastern boundary currents are the most biologically productive ecosystems in the ocean.

Capone and Hutchins (2013) Nature
Main Ingredients

- Synoptic forcing: high pressure over the ocean and a thermal-low inland
  (coast parallel winds – geostrophic adjustment)
- Colder water at the coast (upwelling)
- Sharp thermal (pressure) gradient at the coast
- (Coastal topography)
Global CLLJ climatology

CLLJ= low level wind maxima + temp. Inversion

Detection criteria:

- The height of the jet maximum is within the lowest 1 km in the vertical;
- The wind speed at the jet maximum is at least 20% higher than the wind speed at the surface, and then decreases;
- The jet maximum occurs within the temperature inversion.

biggest hurdle to use CMIP5 and CORDEX available data: model levels data needed!!!! high temporal sampling desired!!!

Ranjha et al. (2013)
Global CLLJ climatology
ERA-Interim results

6 areas of CLLJ “in agreement” with Winnant et al 1988:

- North America (California) - NACJ
- South America (Peru-Chile) - SACJ
- Iberian Peninsula (Portugal-Spain) - IPCJ
- North Africa (Morocco to Senegal) - NAFCJ
- South Africa (Namibia to Angola) - SACJ
- Australia - AUCJ
- Arabian Peninsula (Oman) - APCJ

6-hourly

Ranjha et al. (2013)
EC-EARTH (2 members) 

Present climate

1971-2000

Coastal low-level jet frequency of occurrence

Semedo et al. (2016)
EC-EARTH (2 members)

Future climate RCP8.5

2071-2100 minus 1971-2000

CLLJ anomalies of the frequency of occurrence

Semedo et al. (2016)
The Iberian Coastal Low-Level Wind Jet in present and future climate

Soares et al. (2014)
Cardoso et al. (2016)
Semedo et al. (2016)
Soares et al. (2016)
EURO-CORDEX (WRF at 50km)

Hindcast, present climate (1989-2008), forced by ERA-Interim

Climate projections: Historical (1971-2000) and RCP8.5 (2071-2100), both forced by EC-EARTH
EURO-CORDEX (WRF at 50km) CLLJ results

Present climate JJA

Coastal low-level jet frequency of occurrence

Wind Speed (m s\(^{-1}\))

Frequency (%)

ERA-Interim (1989-2009)
HISTORICAL (1971-2000)

JJA

Height (m)

Frequency (%)

ERA-Interim (1989-2009)
HISTORICAL (1971-2000)

JJA
EURO-CORDEX (WRF at 50km) CLLJ results

Future climate JJA

Anomalies of CLLJ frequency of occurrence

-18 -14 -10 -6 -2 0 2 6 10 14 18

%
(a) Mean sea level pressure

(b) Geostrophic Wind

JJA (2071-2100)
MSLP
Wind speed at ~400m

(c) MSLP - anomalies

(d) Wind speed - anomalies

JJA anomalies against historic MSLP
Wind speed at ~400m

Shaded grey areas are non statistically significant
Higher Resolution RCM (WRF at 27 and 9 km)

Present climate (1989-2008) forced by ERA-Interim

Climate projections
Historical (1971-2000)
RCP8.5 (2071-2100) forced by EC-EARTH

Hourly data

Soares et al. (2014)
Vertical cross section of wind speed (ms$^{-1}$) and potential temperature (19 August 2007 at 2100LT)

Soares et al. (2014)
Iberian Peninsula CLLJ

Frequency of occurrence (%) (WRF 9 km)

Hindcast

One in three days having IPCJ in JJA

Soares et al. (2014)
Future climate forced by EC-EARTH

Anomalies
Future minus Historical

(e) DJF  
(f) MAM

(g) JJA  
(h) SON

(%)
Changes in frequency of occurrence and wind speed
Summary

- An increase of the CLLJ occurrence along the Iberian is expected for future climate

- This augment seems to apply to other NH CLLJs

- High resolution matters

- Multi-model ensembles with model levels information are crucial for extending this study to other regions and to assess the associated uncertainty
Thank you!