PERSEUS
POLICY-ORIENTED MARINE
ENVIRONMENTAL RESEARCH IN
THE SOUTHERN EUROPEAN SEAS

Mediterranean Sea atmospheric surface function data

Deliverable Nr. 4.1

SEVENTH FRAMEWORK PROGRAMME

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To contact the authors:
Tomas Lovato (tomas.lovato@cmcc.it)

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EXECUTIVE SUMMARY / ABSTRACT

The activity provides the atmospheric forcing functions (surface fluxes of momentum, heat and mass) necessary to run Southern European Sea basin scale and regional models over the MSFD time horizon (1980-2020), accounting for both natural and indirect anthropogenic pressures.

The atmospheric data rely on the output of the CMCC-CM climate model that is part of the to the Climate Model Intercomparison Project 5.

In coordination with the other partners of WP4, a set of atmospheric variables were extracted from the climate model data repository to comply with the specific surface boundary conditions needed for each modeling application.

The atmospheric forcing data for the basin and regional scales are available on the CMCC FTP site for distribution within the project WPs.

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SCOPE

The deliverable 4.1 set the stage for the application of Southern European Sea basin scale and regional models, by distributing the atmospheric forcing functions needed to provide surface boundary conditions for the modelling activities.

With regards to the overall objective of the WP4, the distribution of the atmospheric forcing is crucial as it provides a hindcast on the recent past climate and the prediction of near future conditions.

This information will serve as a basis to force the numerical models dealing with both the reconstruction of land-based fluxes toward the costal areas and the investigation of ecosystem dynamics in the Mediterranean and Black Seas. Moreover, the forcing functions will contribute to the definition of the physical grounds for the upgrade of existing models towards an Ecosystem End to End.

Ultimately, the atmospheric dataset represents an essential element in the definition of the MSFD descriptors, in particular for the hydrogeographical conditions of the marine environment (D7).

ATMOSPHERIC DATA FOR THE MEDITERRANEAN BASIN

General information

The reference Southern European Seas atmospheric forcing data for PERSEUS originated from the EU projects CIRCE and COMBINE, and they are part of the CMCC contribution to the Climate Model Intercomparison Project 5 (CMIP5, http://cmip-pcmdi.llnl.gov/cmip5). Data are available to partners for scientific use in the framework of the present project and cannot be distributed to other parties.

The coupled climate model is CMCC-CM (http://www.cmcc.it/data-models/models/cmcc-cm), that implements the ECHAM5 atmospheric model on a Gaussian grid (T159) corresponding to a resolution of about 0.75° x 0.75 ° (see details in Scoccimarro et al., 2011).

The chosen future climate scenario is RCP8.5 (Reference Concentration Pathway, Meinshausen et al., 2011), the high reference scenario with a projected increase of the Earth radiative forcing of about 8.5 W m^{-2} at the end of this century (Fig. 1). It is important to note that all scenarios are somewhat equal in the target period considered by PERSEUS.

The PERSEUS forcing dataset was generated from the original GRIB archives by using the CDO software (www.mpimet.mpg.de/fileadmin/software/cdo) for the extraction of specific information on a regular grid in the NetCDF format. Note that, all the operations carried out to compose the final archives are recorded in the history attribute of each NetCDF file.

The data are distributed to partners via an FTP server set up at the CMCC and access request should be addressed to Tomas Lovato (tomas.lovato@cmcc.it).

Dataset organization

The atmospheric forcing data for the period 1980-2020 are distributed in the original spatial and temporal resolution, which ensures the maximum flexibility for the choice of the optimal interpolation strategy in each regional application.

Data are contained into two subfolders:

- MED-HRT159, atmospheric data over the Mediterranean Sea (see Fig. 2),
- DRAIN-HRT159, meteorological fields for the Mediterranean drainage basin (see Fig. 3).

Both folders contain monthly files of the selected variables, which are identified by a reference number set in agreement with the ECMWF standard table 128 (http://www.ecmwf.int/services/archive/d/parameters).

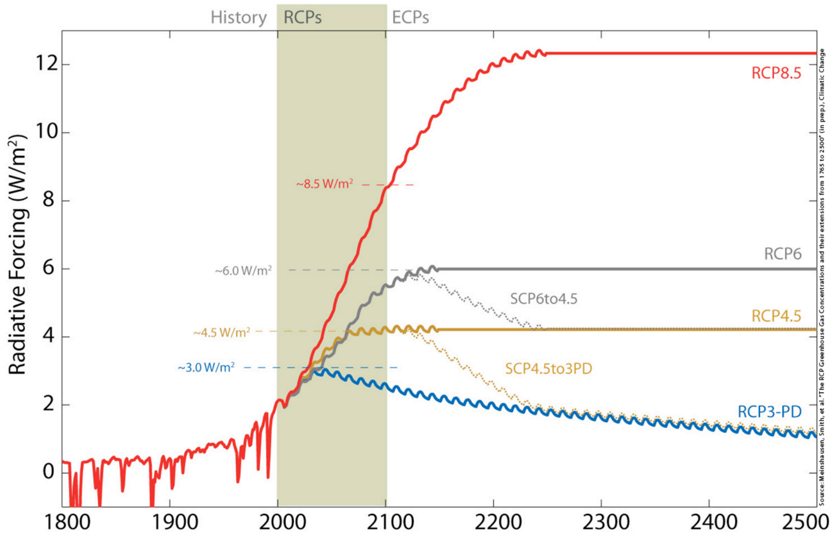
The time horizon was further split in two separated folders to maintain a distinction between the data produced for the current (historical) and the future climate scenarios (RCP8.5).

Table 1 contains the list of all the parameters distributed for the Mediterranean basin, while only a subset of data (surface temperature, total and convective precipitation) was made available for the computation of river runoff to the SES (D4.3), as specified by the partners involved in this activity.

Please address any further query to Tomas Lovato (tomas.lovato@cmcc.it).

Table 1. Atmospheric forcing data available for the Mediterranean region. Parameters noted with * are the only ones available in the drainage basin archive.

ECMWF code	Long Name	Short name	Units
134	Surface pressure	Aps	Pa
142*	Large scale precipitation	Aprl	kg/m^{2}s
143*	Convective precipitation	Aprc	kg/m^{2}s
146	Sensible heat flux	ahfs	W/m^2
147	Latent heat flux	ahfl	W/m^2
157	Relative humidity	rhumidity	0-1
164	Total cloud cover	aclcov	0-1
165	10m u-velocity	u10	m/s
166	10m v-velocity	v10	m/s
167	2m temperature	temp2	K
168	2m dew point temperature	dew2	K
169*	Surface temperature	tsurf	K
175	Surface albedo	albedo	(0-1)
176	Net surface SW radiation	srads	W/m^2
177	Net surface LW radiation	trads	W/m^2
182	Evaporation	evap	kg/m^{2}s



Source: Meinshausen, Smith, et al. "The RCP Greenhouse Gas Concentrations and their extensions from 1765 to 2500" (in prep.), Climatic Change

Figure 1. Global Anthropogenic Radiative Forcing for the high RCP8.5, the medium-high RCP6, the medium-low RCP4.5 and the low RCP3-PD.

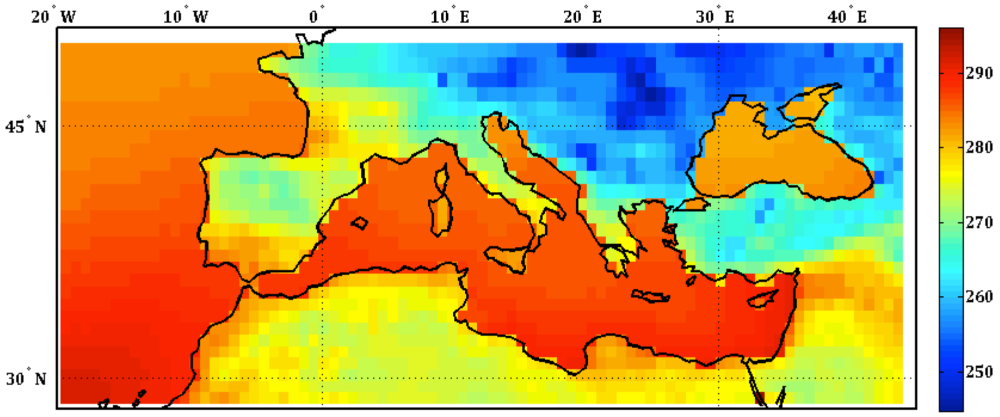


Figure 2. Air temperature at the surface (°K) over the Mediterranean Sea region in January 2000.

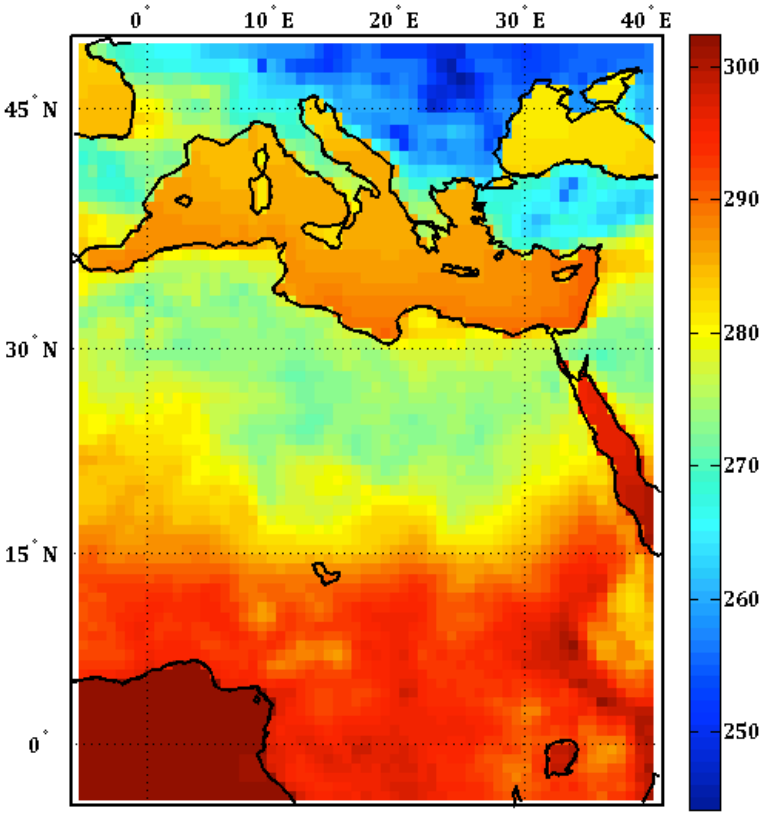


Figure 3. Air temperature at the surface (°K) over the Mediterranean drainage basin domain for January 2000.

APPENDIX

A.1 Bias correction of atmospheric boundary conditions

As described in the Summary, the present deliverable focuses on the current and future atmospheric boundary conditions for further modeling activities in the framework of PERSEUS project.

The atmospheric fields made available for the modeling activities within PERSEUS were produced by the high-resolution coupled atmospheric and oceanic general circulation model CMCC-CM (Scoccimarro et al., 2011). In particular, the future climate variability of the CMCC-CM simulations account for both RCP4.5 and RCP8.5 scenarios (details in Moss et al., 2010).

An error analysis of the CMCC-CM atmospheric data was performed against the ERA-Interim reanalyses fields (Dee et al., 2011) to assess the presence of systematic errors. In fact, a known limitation of the global atmospheric and oceanic general circulation models (AOGCM) is the occurrence of strong biases when focusing on specific regional domains (see Berg et al., 2012; Cattiaux et al., 2013; Lafon et al., 2013).

The overall comparison of the monthly climatologies computed for two dataset over the period 1980-2010 indicates that remarkable differences affect the air and dew point temperature fields of the Southern European Seas area (see Fig. A.1). So, in order to reduce the spatiotemporal biases of the air temperature data, a correction technique was selected to adjust the CMCC-CM data or the atmospheric fields produced by regional climate models, which make use of this dataset (e.g., COSMO CLM).

The monthly bias correction of the temperature fields was achieved through the linear scaling approach (see, e.g., Teutschbein and Seibert 2012). It consists in subtracting a corrective factor, calculated as the difference between simulated and observed monthly mean temperature, to the model data. The corrected temperature values are obtained as follows:

$$T_{corr}^{m}\left(d\right)=T_{sim}^{m}\left(d\right)-\left(\overline{T}_{sim}^{m}-\overline{T}_{obs}^{m}\right) \tag{A.1}$$

where, for the day d of the month m, $T_{corr}^{m}(d)$ is the corrected value, $T_{sim}^{m}(d)$ is the originally simulated daily temperature, $\overline{T}_{obs}^{m}$ and $\overline{T}_{sim}^{m}$ are respectively the observed and simulated monthly mean temperature, averaged over a reference period, for the month m. The procedure has to be performed on each grid node of the original atmospheric fields.

A description for the estimated biases is given in section A.3.

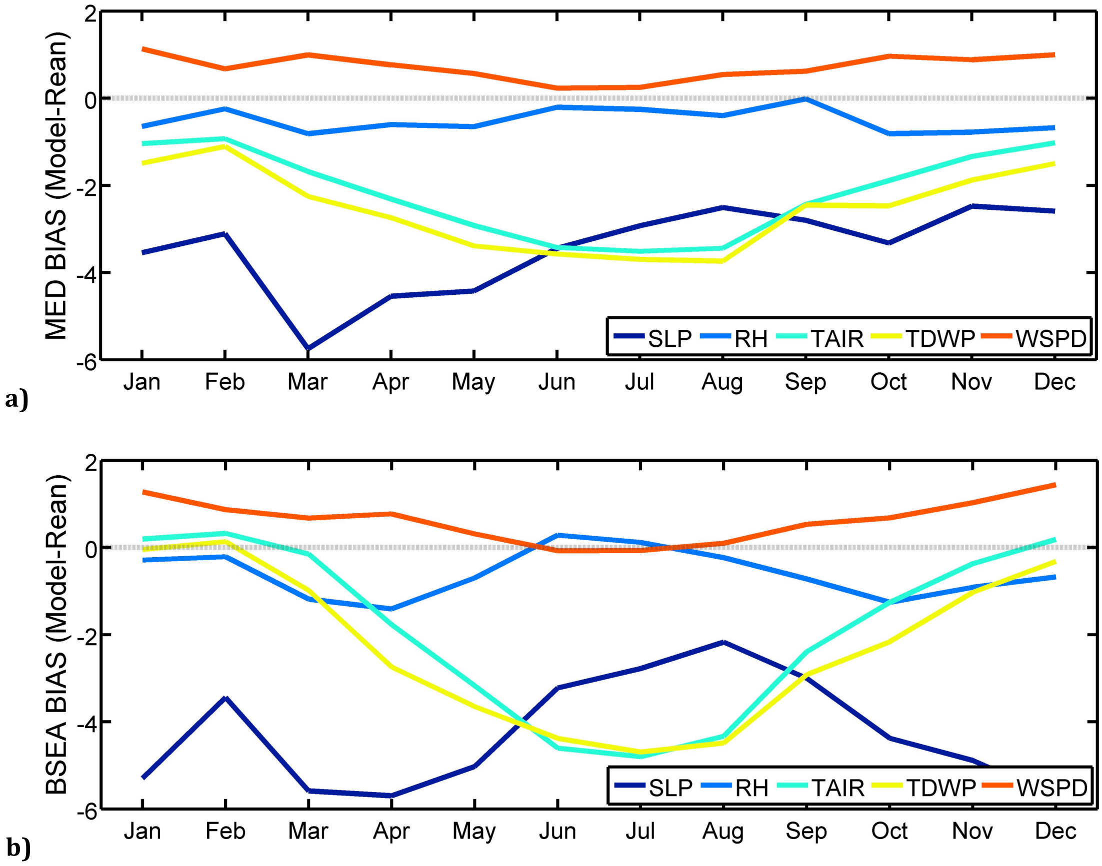


Figure A.1. Time series of the difference between the CMCC-CM and ERA-Interim monthly climatologies over the Mediterranean Sea (a) and the Black Sea (b) for the period 1980-2010. Variables in the plot: SLP - sea level pressure (hPa); RH – relative humidity (%); TAIR – Air temperature at 2 m (°C); TDWP – Dew Point temperature at 2m (°C); WSPD – Wind speed module (m/s). Positive values indicate an overestimation of the CMCC-CM data with respect to ERA-Interim Reanalyses.

A.2 How to apply the correction fields

The monthly correction fields are provided in a separate file, as they represent an *a posteriori* revision of the originally data made available to all PERSEUS partners.

It is strongly suggested to use the available correction fields that are distributed in a single NetCDF file via an FTP server set up at the CMCC. Access request should be addressed to Tomas Lovato (tomas.lovato@cmcc.it).

The file contains a 12 months climatology of the biases computed at each grid node of the climate model for the reference period 1980-2010. In agreement with the methodology illustrated in section A.1, the bias represents a systematic error of the climate model and, thus, the correction has to be applied to the air temperature fields produced by the CMCC-CM model for both current climate and scenario data.

The available correction fields are named according to the atmospheric variable they applies to, which are identified by the number convention described in the ECMWF GRIB API table (http://www.ecmwf.int/publications/manuals/d/gribapi/param/).

Partners should apply the correction field by subtracting the monthly air temperature bias from the fields of the respective month for all the user-selected years of the original dataset. For example, a partner wants to correct the data of the air temperature at 2m (var167) for the month of April 2015. This operation can be accomplished by means of the following CDO commands (www.mpimet.mpg.de/fileadmin/software/cdo):

```
cdo -monsub \
    -selname,var167 -selmon,mm Data_yyyymm.nc \
    -setdate,yyyy-mm-01 -selname,var167 -selmon,mm  biasfile.nc \
    yyyymm _out.nc
```

where *mm* is the month (04 for April), *yyyy* the year (2015), -monsub is the subtraction operator fro monthly values, -selname is used to select a specific variable, -selmon allows to select a specific month as a number, -setdate reset the time to a specific value, *Data_yyyymm.nc* contains the 6-hourly simulated data, *biasfile.nc* contains the correction monthly fields, and *out.nc* contains the corrected fields for the user-selected variable.

Note that, the bias correction of the present deliverable addresses only to the air temperature fields, while a methodology to correct also the 2m dew point temperature is described in section A.3.

A.3 Estimation of atmospheric biases

The error analysis of the CMCC-CM atmospheric data over the Southern European Seas (Fig. A.1) showed remarkable differences with the ERA-Interim monthly climatologies for the period 1980-2010. In the case of the Mediterranean Sea, the air temperature data simulated with the CMCC-CM are remarkably underestimated throughout the year, with a maximum bias of -3.5°C in July. Similarly, the dew point temperature of the air presents a maximum difference of -3.7°C in August. The other variables have instead a relatively uniform bias, with the exception of the SLP that is characterized by larger errors in the spring period. Nevertheless, the magnitude of the SLP bias is very small when compared with the mean values of the sea level atmospheric pressure over the domain, which is of about 1015 hPa.

The present activity focuses on the two temperature variables, as they are the main atmospheric drivers in the study of climate variability scenarios.

On the one hand, the estimation of the air temperature at 2m bias was computed immediately as the difference between the CMCC-CM and ERA-Interim monthly climatologies. On the other hand, the computation of the dew point temperature bias cannot be achieved directly as in previous case, but it was reconstructed. As the differences in the relative humidity were not relevant (see Fig. A.1), the relative humidity climatological field was used in combination with the unbiased air temperature to calculate a corrected dew point temperature by means of the Magnus formula (Lawrence, 2005).

In Fig. A.2 are depicted the estimated biases for the air temperature at 2m for January and August, meant to be representative of the error distribution over the Mediterranean Sea.

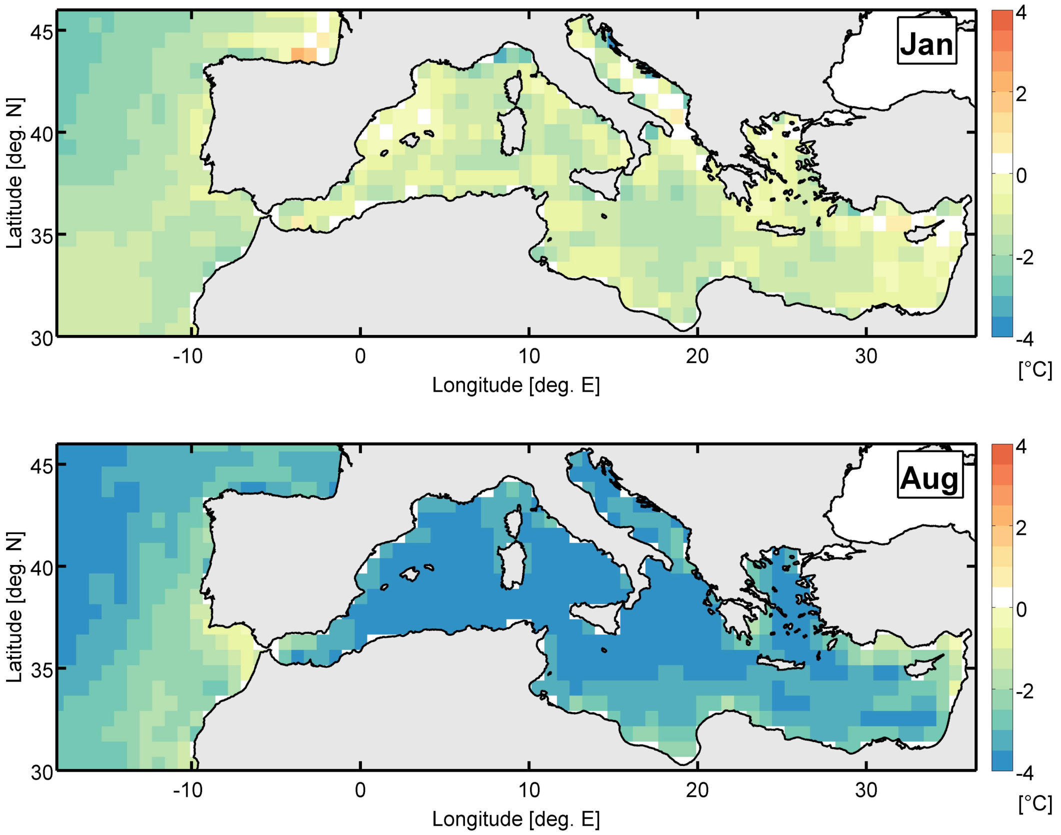


Figure A.2. Mean monthly biases of air temperature at 2 m between the ERA-Interim and CMCC-CM for January (top) and August (bottom) in the period 1980-2010. Positive values indicate an overestimation of the CMCC-CM data with respect to ERA-Interim Reanalyses.

References

Berg, P., Feldmann, H., Panitz, H.-J., 2012: Bias correction of high resolution regional climate model data. Journal of Hydrology 448-449, 80-92.

Cattiaux, J., Douville, H., Peings, Y., 2013: European temperatures in CMIP5: origins of present-day biases and future uncertainties. Climate Dynamics, doi: 10.1007/s00382-013-1731-y.

Dee, D. P., Uppala, S.M., Simmons, A. J., Berrisforda, P., Polia, P., Kobayashi, S., et al. 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system. Quarterly Journal of the Royal Meteorological Society 137,553-597.

Lafon, T., Dadson, S., Buys, G., Prudhomme, C., 2013: Bias correction of daily precipitation simulated by a regional climate model: a comparison of methods, International Journal of Climatology, 33 (6), 1367-1381.

Lawrence, M.G, 2005: The Relationship between Relative Humidity and the Dewpoint Temperature in Moist Air. A Simple Conversion and Applications. Bulletin of the American Meteorological Society 86, 225-233.

Meinshausen, M., S. J. Smith, K. V. Calvin, J. S. Daniel, M. L. T. Kainuma, J.-F. Lamarque, K. Matsumoto, S. A. Montzka, S. C. B. Raper, K. Riahi, A. M. Thomson, G. J. M. Velders and D. van Vuuren (2011). "The RCP Greenhouse Gas Concentrations and their Extension from 1765 to 2300." Climatic Change (Special Issue), DOI: 10.1007/s10584-011-0156-z

Moss, R.H., Edmonds, J.A., Hibbard, K.A., Manning, M.R., Rose, S.K., et al. 2010: The next generation of scenarios for climate change research and assessment. Nature 463, 747-756.

Scoccimarro, E., S. Gualdi, A. Bellucci, A. Sanna, P. Giuseppe Fogli, E. Manzini, M. Vichi, P. Oddo, and A. Navarra (2011), Effects of tropical cyclones on ocean heat transport in a high-resolution coupled general circulation model, J. Climate, 24(16), 4368–4384, 10.1175/2011JCLI4104.1.

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