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OBSERVED EDDY TRANSPORT OF WATER VAPOR OVER ARGENTINA

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Abstract

In this paper a basic analysis of eddy water vapor transport considering radiosonde data over Argentina is presented. Monthly mean water vapor transports associated with the transient eddies were calculated and the annual evolution of fields were analyzed, using daily wind components and humidity data for 1958–82 period. Transient eddy fluxes are associated with the rapidly developing and decaying weather disturbances of mid-latitudes, which generally move eastward with the prevailing flow and contribute much of the variations of wind, temperature and humidity, especially during winter. Results are shown for transient eddy zonal and meridional transport.

Through analysis of fields of transient eddy zonal transport, it is observed the occurrence of negative values (westward transport) over southern central Argentina and Northern Patagonia from late spring to early autumn, indicating an increase of humidity when circulations are from Atlantic Ocean. Westerly transport is observed in summer over Northeastern subtropical and central Argentina, otherwise over southern Patagonia westerly transports are dramatically intensified during early autumn. During winter easterly transport are only found over northwestern Argentina and humidity transports are mainly due to the westerly transient eddies, with maximum values over Northeast Argentina. In mean latitudes, the transient eddy zonal transport of water vapor presents a considerable degree of east-west detail with centers of eastward transport alternating with centers of westward eddy transport; these characteristics (negative transports) are noticeable over southern Patagonia during winter (July).

The meridional flux of moisture over Argentina varies considerably with the seasons but is predominantly poleward throughout the year. Maximum values are observed over Eastern subtropical region in October, meanwhile minimum intensities from the north are found over central Argentina during winter.

INTRODUCTION

To get a better understanding of different mechanisms responsible for the water vapor transports we can considered the total humidity transports how the contributions of humidity transport by mean circulation which dominates in the tropics; of the transports associated with the mean stationary eddies of general circulation and of transports of moisture due to the transient perturbations which develop along the polar front and in the intertropical convergence zone (Peixoto and Oort, 1992). Then, the transport is mainly accomplished by baroclinic lows associated with the polar front and by stationary eddies, such as subpolar lows and subtropical anticyclones, together their transient pulsations.

The purpose of this study is to evaluate monthly mean water vapor transports associated with the transient eddies over subtropical and mid-latitudes over southern South America using daily wind components and humidity data for 1958–82 period and to analyze their contribution to the annual evolution of total humidity transport fields.

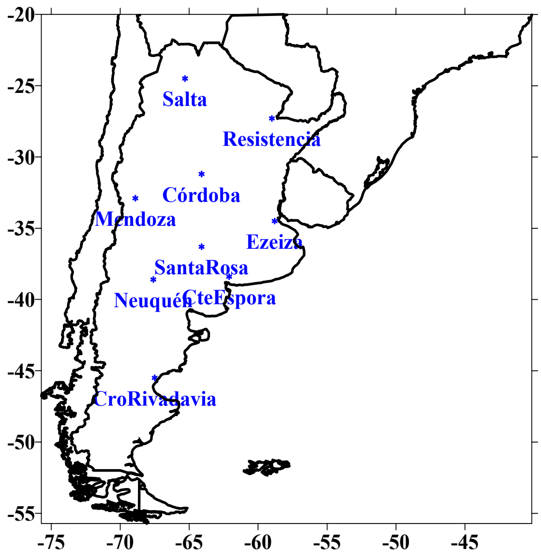

Figure 1: Aerological argentinian network.

Fluxes of moisture over the referred region vary considerably with the seasons and month to month; so monthly mean transport of humidity are analyzed.

DATA AND METODOLOGY

Aerological daily data from the Argentinean network (showed in Figure1) were used for 1958–82 records. From daily radiosonde data, monthly mean specific humidity (qm) , monthly mean wind components (um ,vm) were calculated for each pressure levels.

Also, mean product of (q)*(u) and (q)*(v)
and mean product of anomalies
{(q – qm)*(u – um) } and {(q – qm) *(v – vm) }

Total mean water vapor transport were calculated by integrating the fluxes (q)*(u) and (q) *(v), respectively, between 850 hPa and 400 hPa using trapezoidal rule.

For calculating the contributions of transient eddies, same methodology were used considering
{(q – qm)*(u – um)} and {(q – qm)*(u – um)} , respectively.

TOTAL MOISTURE TRANSPORT:
ANNUAL EVOLUTION

Different fields of mean total monthly zonal and meridional moisture transport, vertically integrated from 900 hPa to 400 hPa for each aerological station in Argentina, are analyzed in Figure 2 and 3, respectively.

In general, the marked differences between the monthly fields show their large monthly variability, particularly during the equinox seasons. The green isolines indicate convergence zones of circulation from the north and the south and the change in zonal circulation from the east or the west.

TOTAL ZONAL MOISTURE TRANSPORT:
SPATIAL AND TEMPORAL VARIATIONS

Figure 2 shows the scalar monthly fields of zonal fluxes vertically integrated in the troposphere (total zonal water vapor transport). Zonal transport from the west is observed to dominate the region. Absolute maximum values are located in the center –south region over Comandante Espora during the whole year except in March and April when maximum values are displaced to the south. The maximum absolute intensities of westerly water vapor transport (1100 g/cm s) are observed in summer. Zonal moisture transport expands towards the northwest and the south, with decreasing intensity: latitudinal variation in the subtropical region predominates during the summer months. Towards winter and spring, variation tends to be meridional: the greatest transport from the west is located on the northeastern area and its intensity decreases towards the Andes. The minimum values spread in this region up to 35ºS. In the northwest, close to the tropic, transport from the west is weaker than in the south: zonal transport from the east occurs in Salta, only in February (Figure 2, February). In the east of the subtropical region, transport from the west is greater in Resistencia than in Córdoba throughout the year (isolines in the meridional direction), except in summer (Figure 2) when intensities at both stations are similar (isolines with a more zonal orientation in the subtropical region). By the end of winter and in spring, the fields show zones with maximum and minimum contributions from the west which alternate latitudinally: the maximum value zones have centers over Resistencia and Comandante Espora; and the minima (relative fluxes from the east) are over Ezeiza and the Gulf of San Jorge in Patagonia.

TOTAL MERIDIONAL MOISTURE TRANSPORT:
SPATIAL AND TEMPORAL VARIATION

Figures 3 show the monthly meridional water transport fields. Water vapor coming from the north dominates the subtropical region and the west of the central area up to 40ºS, to the north of Patagonia during the year, except in November. In summer (December, January and February), in the east of the center south region and to the south of 40º S, there is a southerly moisture fluxes. In January and February the flow from the south becomes more intense in the center – east region.

The region of convergence of northerly and southerly flows is located at 34º S in February. This feature could be related to the relative location of the maximum cyclogenesis centers, referred to in Figure 2 a-d in Gan et al (1991). In March (Figure 3), moisture coming from the north dominates subtropical and central Argentina. Circulation from the south intensifies in autumn (Figure 3) to the east of the center north region and in winter it dominates the east of the central area.

In June, (Figure 3), the latitudinal variation of northerly transport in the eastern subtropical region intensifies remarkably, a fact that is possibly associated to the development of the maximum cyclogenesis over Uruguay during this season of the year, as indicated in Gan´s Figure 2c in the paper mentioned above. There is a marked transition of moisture transport from the north to the south along parallel 34ºS. In November, the circulation that transports moisture is enhanced in the central region, affecting Ezeiza, Santa Rosa and Mendoza stations. Transport in Neuquén, to the west of the region mentioned before, maintains its northerly direction during that month.

WATER VAPOR TRANSPORTS ASSOCIATED WITH TRANSIENT PERTURBATIONS:

Cyclones and anticyclones are the drivers of most weather variations at midlatitudes and give rise to great meridional transport of momentum, heat and moisture. These disturbances are accompanied by large wind and humidity variations on scales of several thousand kilometers, and do not appear in the zonal average though they deeply affect the mean zonal climate. Such fluctuations associated with weather are known as transient disturbances and are represented by departures from the temporal averages.

The influence in space and time of moisture contributions due to transient disturbances will be described in the following paragraphs.

ZONAL WATER VAPOR TRANSPORTS ASSOCIATE WITH TRANSIENT PERTURBATIONS: SPATIAL AND TEMPORAL VARIATION

Figure 4 shows the annual variation of zonal moisture transport due to transient disturbances. Green lines indicate the transition between westerly (red) and easterly (blue) transports.

In summer, the eastern parts of the subtropical and central regions receive moisture contributions from the west. Transient disturbances bring moisture from the east to the western region close to the Andes, and to the north and center of Patagonia. In early autumn, during March, the westerly contribution to the south of Patagonia intensifies outstandingly. In autumn and winter the domain area of easterly contributions reduces its size to the northwest and disturbances bring moisture from the west over the whole region, with absolute maxima in Resistencia and weak intensities over the central region. During July, easterly contributions are observed in southern Patagonia, which is related to the post-frontal anticyclonic circulation that occurs over that region in that season of the year. In September, the easterly transport domain expands again over the Andes region. As from October these contributions prevail in the west of the central region and in the north of Patagonia and they become more intense in November. The gradient of westerly transports in the eastern subtropical region is outstandingly marked when those contributions peak over Resistencia.

MERIDIONAL MOISTURE TRANSPORT DUE TO TRANSIENT DISTURBANCES: **SPATIAL AND TEMPORAL VARIATION**

Figure 5 shows the monthly meridional moisture transport fields caused by transient disturbances in Argentina, which come from the north during the whole year. Fluxes transition area is located in the western Andean region at the end of winter and in spring. Maximum values are recorded in the east of the subtropical region in October. In general, they decrease meridionally from east to west. Maximum meridional gradients are also observed in October. In April and November, the area of maximum intensities extends from the northeast to the center (axis from Córdoba to Resistencia) reaching the area of Santa Rosa in December. A **minimum intensity zone from the north is observed in winter over the central area (axis in the Mendoza–Comandante Espora direction), indicating the influence of relative circulation from the south.**

ANNUAL EVOLUTION OF MOISTURE FLUX AT EACH STATION OF THE ARGENTINEAN AEROLOGICAL NETWORK: VECTORIAL REPRESENTATION

The annual evolution of a) the total water vapor flux, and b) the flux due to mean circulation and c) the flux due to transient disturbances, expressed vectorially were analyzed, respectively. Vectors were obtained from the corresponding meridional and zonal components.

The most outstanding features appear from comparing contributions to total moisture fluxes by the transient disturbances, during the year.

The mean zonal flow and the mean meridional circulation cells carry moisture from the west in the middle and low troposphere, over the east and south of the central region and in Patagonia (not shown).

An outstanding feature is the contribution made by transient disturbances to the region (Figure 7).

In Comodoro Rivadavia, northeasterly circulation dominates the lower levels up to 700 hPa and weakens gradually with height. Similar contributions are observed in Neuquén, during the year except in winter, when transient flow is relatively attenuated; in Santa Rosa, those fluxes are also, weak in winter and enhanced in spring.

On the other hand, transient circulation brings moisture from the north and the northwest to

Comandante Espora and Ezeiza throughout the year and in autumn and summer in Santa Rosa.

While the mean circulation gives rise to an easterly moisture flux, from the 1000 hPa to the 850 hPa levels, in Resistencia (not shown), the contribution from transient disturbances can be clearly seen as coming from the northwest; which means that fluxes associated with transients perturbations comes from the Amazonian region to the subtropical region in Argentina. Both contributions impose their features on the evolution of total moisture fluxes in Resistencia (Figure 6). The features of transient contribution also affect the center of the subtropical region in Córdoba.

Transient moisture fluxes close to the central and northern Andes, particularly in Mendoza and Salta are weak and of variable direction up to the 800 hPa level. Major fluxes from the east are recorded at both stations, during spring and summer between 800 hPa and 400 hPa.

Mean circulation contributes with southerly moisture fluxes at low levels in Mendoza; while in Salta, the fluxes are from the northeast. Flow is from the west at relatively higher layers at both stations (not shown, here).

CONCLUSIONS

Maximum northwesterly total transport domain over northeastern subtropical Argentinean region during early winter (June and July). Mean meridional transports change from north to south and maximum values of westerly transports occur during late spring, suggesting that baroclinic lows reach northeastern Argentina and travel into southern Brazil during referred period. Intensified westerly waves travel across southern central region between 36ºS and 40ºS during early winter.

Transient perturbations contribute with easterly transports over southern central region during late spring, summer and early autumn indicating that the air is relatively dry with westerly transport (from Andes mountain) and relatively humid when easterly circulations are dominant from Atlantic Ocean (anticyclonic circulations).

Easterly contribution of transient perturbation to mean zonal transports is shown over western subtropical region, thought whole year.

The analysis of the meridional transient eddy field's shows a strong northerly fluxes over eastern Argentina with maximum values on Resistencia during all months of year and they are expanded over eastern central region from late spring to early summer. Southerly transports are only localized near Mendoza during winter and early spring.

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Peixoto, J. P. and Oort, A. H., 1992: Physics of Climate. Springer-Verlag, 520 pgs.

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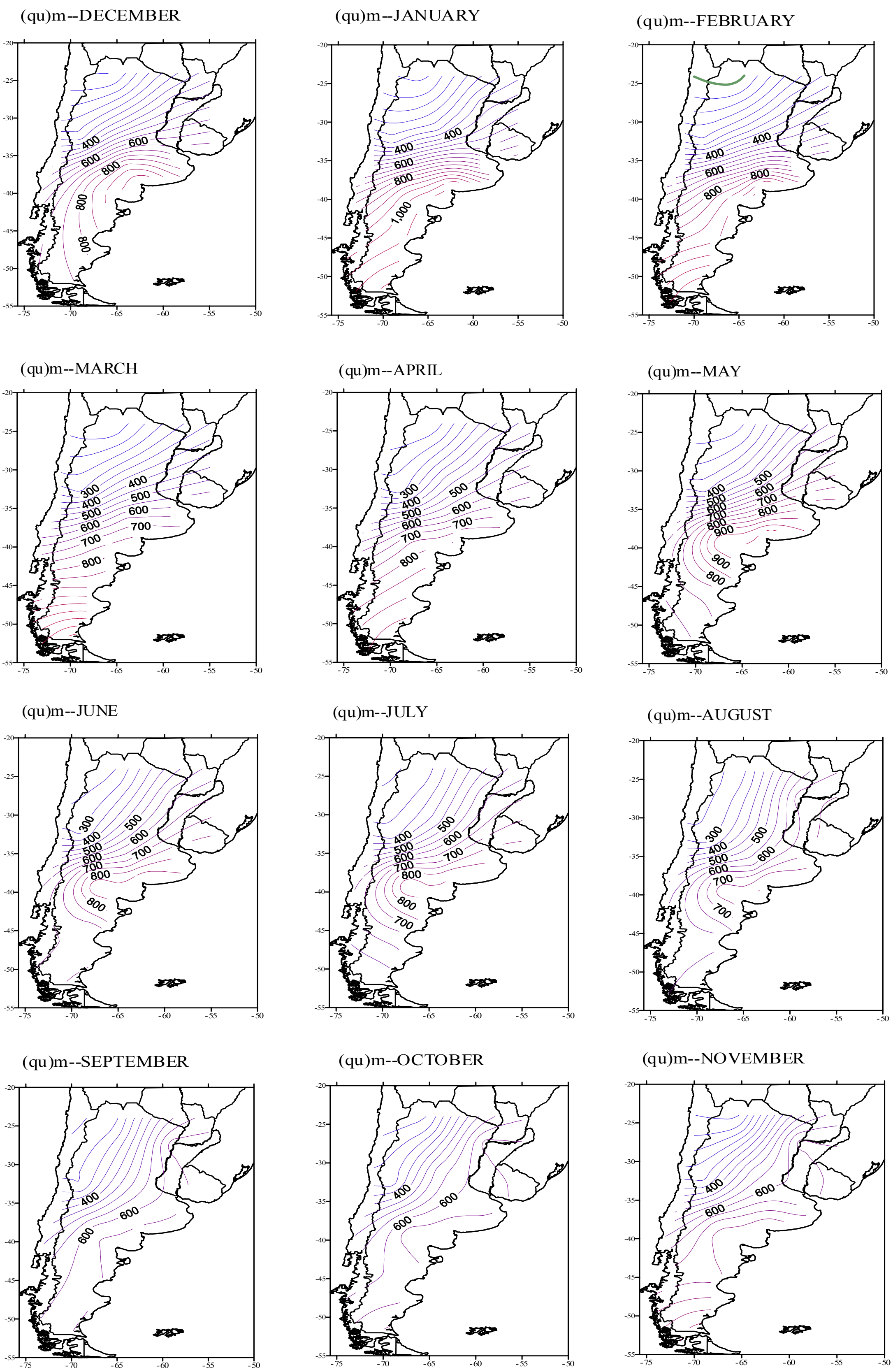

Figure 2: Annual evolution of mean zonal total humidity transports over Argentina.

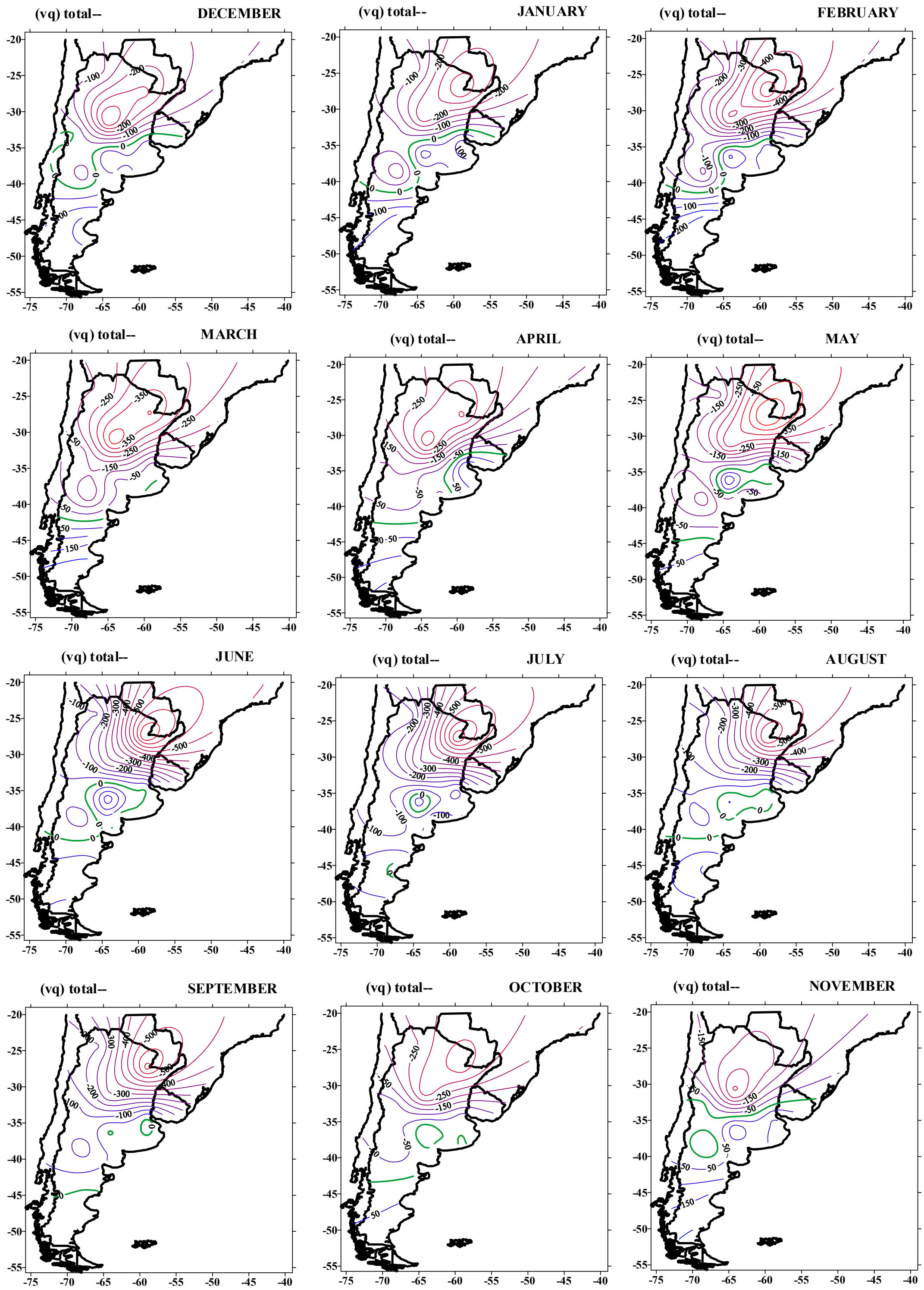

Figure 3: Annual evolution of mean meridional total humidity transports over Argentina.

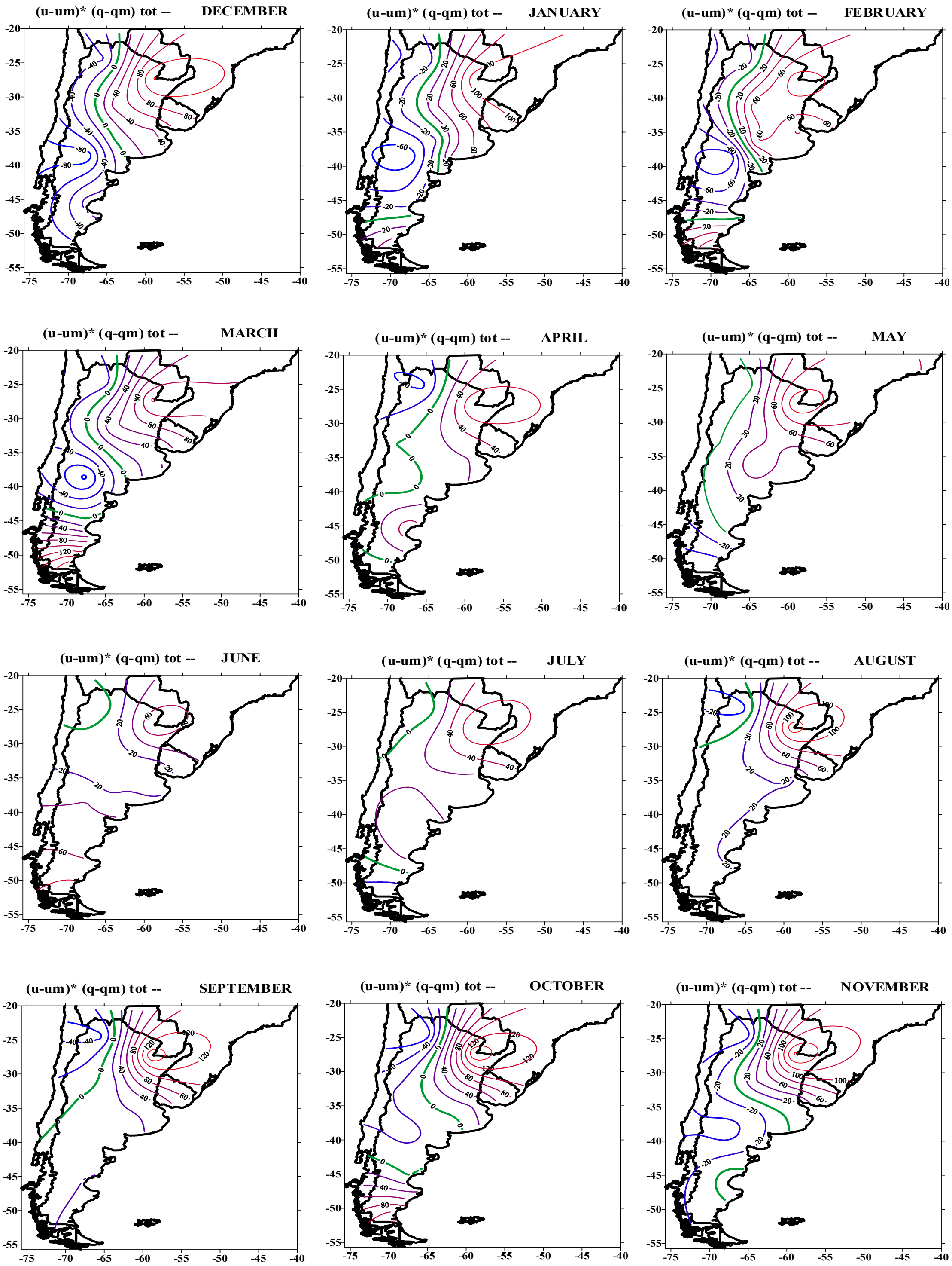

Figure 4: Annual evolution of mean zonal humidity transports due to transient perturbations over Argentina.

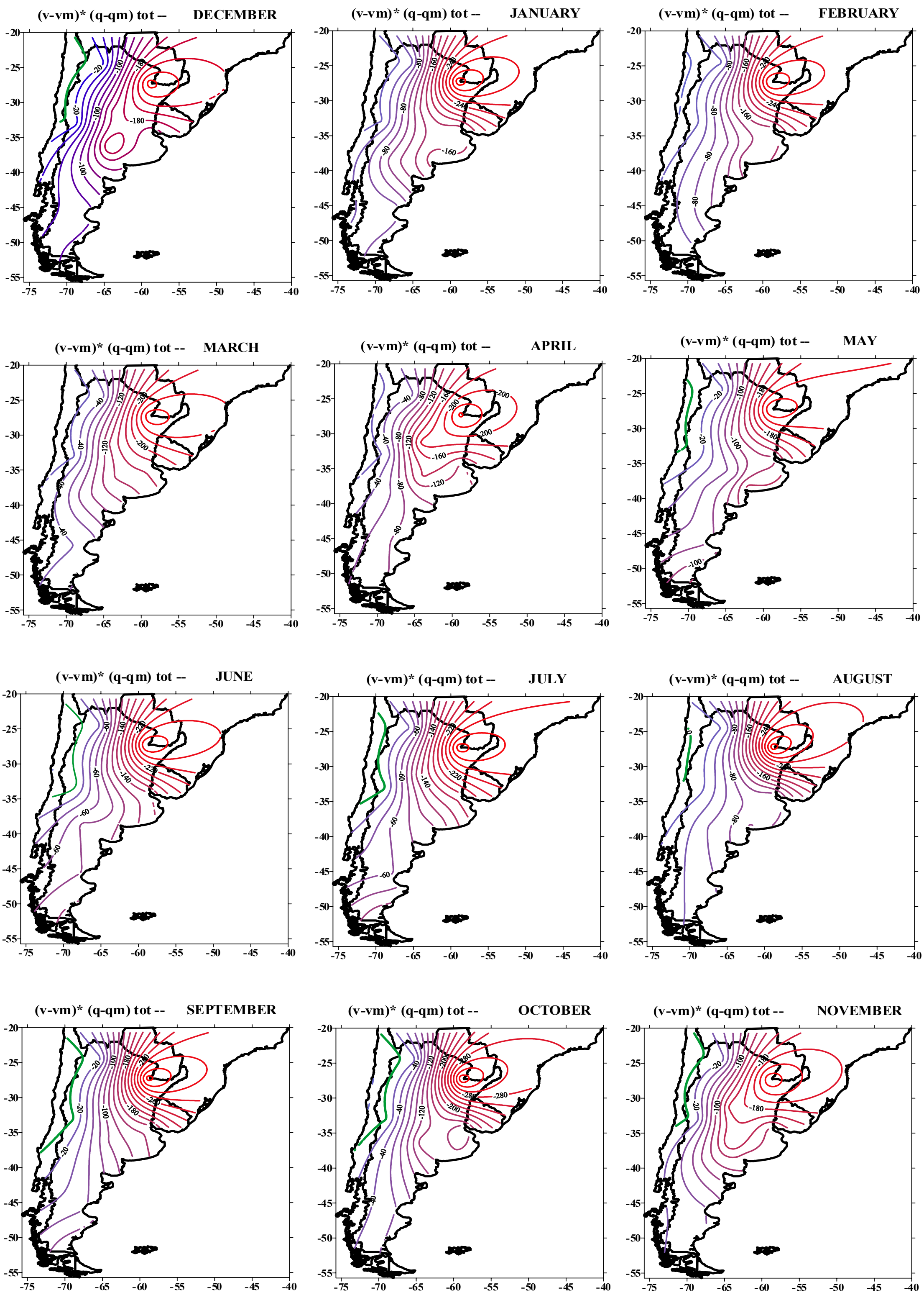

Figure 5: Annual evolution of mean meridional humidity transports due to transient perturbations over Argentina.

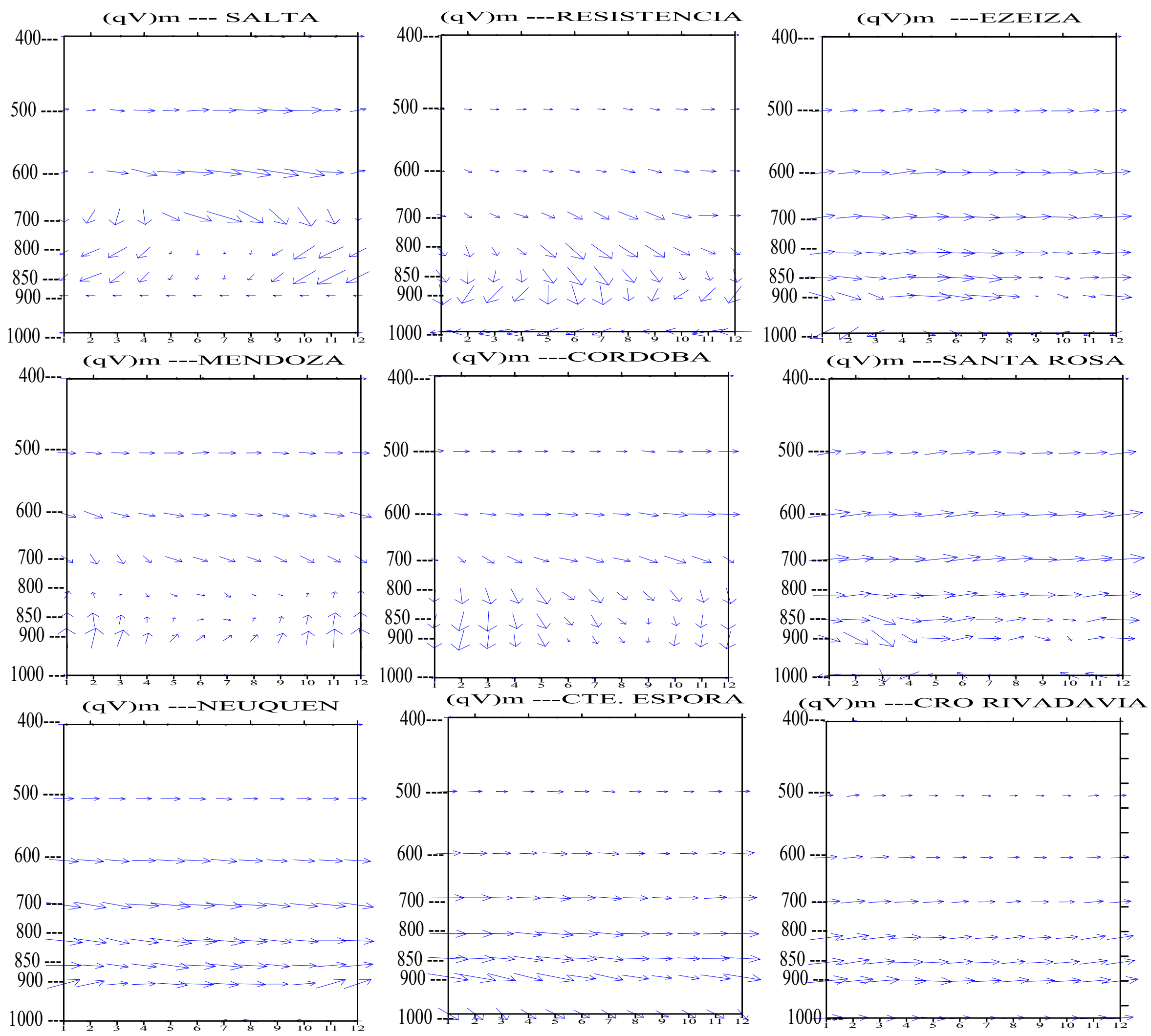

Figure 6: Annual evolution of total humidity fluxes (vectors), for each aerological argentinian stations

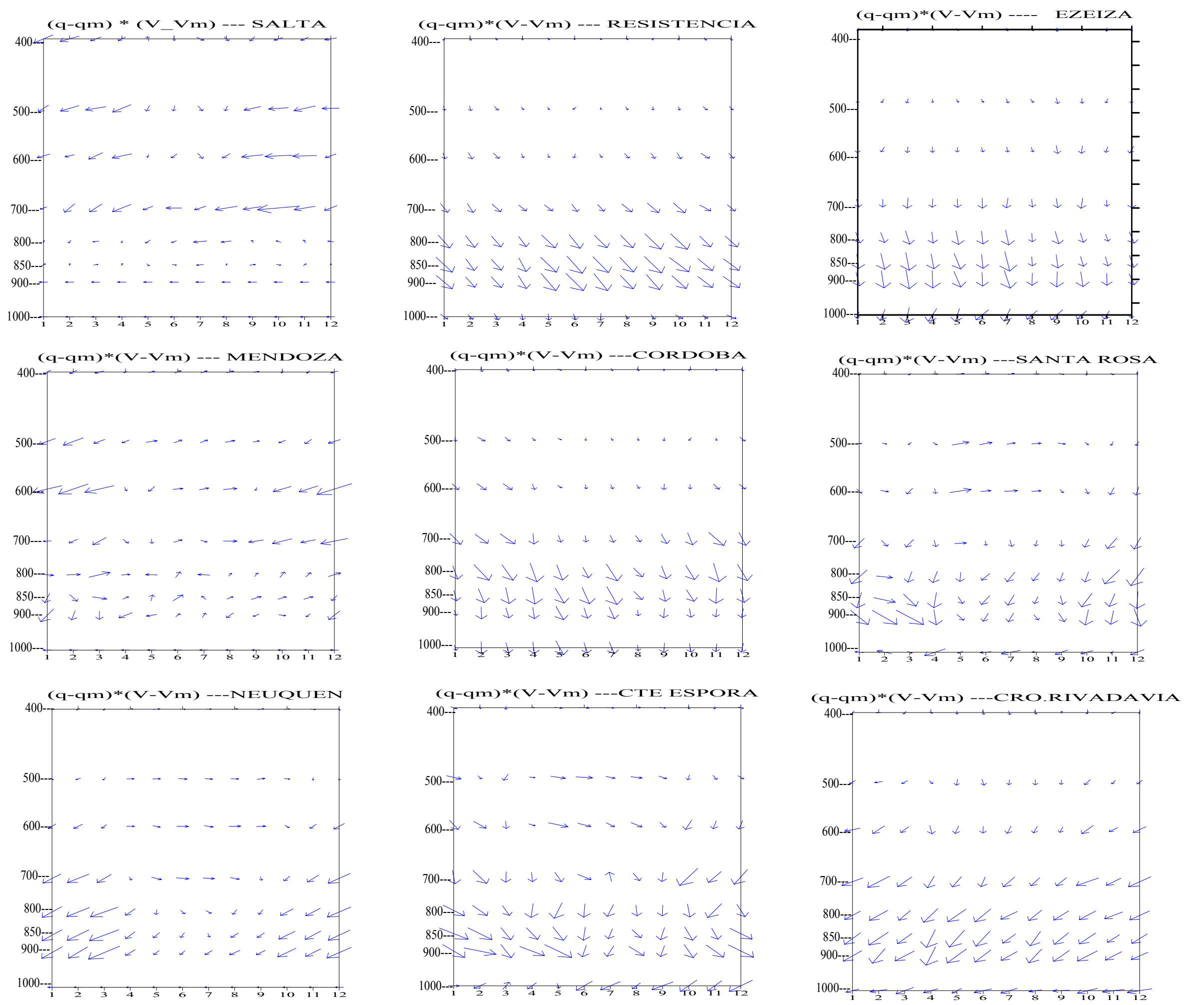

Figure 7: Annual evolution of humidity fluxes (vectors) due to transients perturbations, for each aerological argentinian stations.