Proceedings of the Third SPREP Meeting on Climate Change and Sea Level Rise in the South Pacific Region.
Noumea, New Caledonia, 18–22 August 1997.

ENSO SIGNALS IN THE VICINITY OF NEW CALEDONIA: PAST, PRESENT AND PROBABLE FUTURE ANOMALIES

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ABSTRACT

Various data types collected in an area enclosing New Caledonia (21°S–23°S, 160°E–170°E) are analysed in order to assess the regional impacts of past (1972–1996) El Niño Southern Oscillation (ENSO) events. Particular emphasis is placed on studying ENSO-related changes in sea surface temperature and salinity, surface wind stress, as well as satellite-derived and in-situ precipitation. Changes in river flows, cyclone incidences and dengue fever occurrences are also discussed, as well as the expected future anomalies associated with the on-going 1997 ENSO.

INTRODUCTION

On average, the equatorial Pacific is characterised by warm (>28°C) sea surface temperature (SST) in its western half, the so-called warm pool, and relatively cold (<24°C) surface water in its eastern half reflecting the equatorial upwelling. This spatial SST distribution is associated with southeasterly (southern hemisphere) and northeasterly (northern hemisphere) trade winds which, schematically, push the warm surface water to the west. The thermocline, which separates the warm surface water from the cold lower water, is shallow in the eastern part (30m) and relatively deep in the western part (150–200m).

During an El Niño event, the warm surface water spreads toward the central and eastern equatorial Pacific, with the thermocline plunging in the east and rising in the west. This ocean perturbation is accompanied by strong atmospheric changes such as an eastward displacement of the convection and precipitation zone and a weakening of the trade winds throughout the Pacific.

Numerous indices are used to characterise the basin-scale El Niño Southern Oscillation (ENSO) phenomenon. Two frequently-used indices are:

- An atmospheric index: the Southern Oscillation Index (SOI) which is related to the surface atmospheric pressure difference between Tahiti, French Polynesia, and Darwin, Australia. A negative (positive) SOI denotes an El Niño (La Niña) situation.
- An oceanic index: the sea surface temperature (SST) anomaly in the so-called NINO3.4 region located in the central equatorial Pacific (5°N–5°S; 170°W–120°W). A warm (cold) SST anomaly in the NINO3.4 region denotes an El Niño (La Niña) situation.

The excellent agreement between these two indices (figure 1) illustrates that ENSO is a coupled ocean atmosphere phenomenon. These two indices are used hereafter to compare the basin-scale ENSO signal to the ENSO-related signal in the vicinity of New Caledonia (hereafter referred to as the "local" signal).

PAST ENSO SIGNALS IN NEW CALEDONIA

Although New Caledonia is located relatively far (~2200km) from the equator, its climatic environment is affected by ENSO (e.g. Morliere and Rebert, 1986; Delcroix and Lenormand, 1997). This is exemplified in figures 2 and 3 which compare the interannual anomalies of different climatic parameters measured around New Caledonia (21°S–23°S, 160°E–170°E) versus the interannual SST anomalies measured in the NINO3.4 region. The interannual anomalies were computed by filtering the monthly time series with a 12-month Hanning filter (Blackman and Tukey,

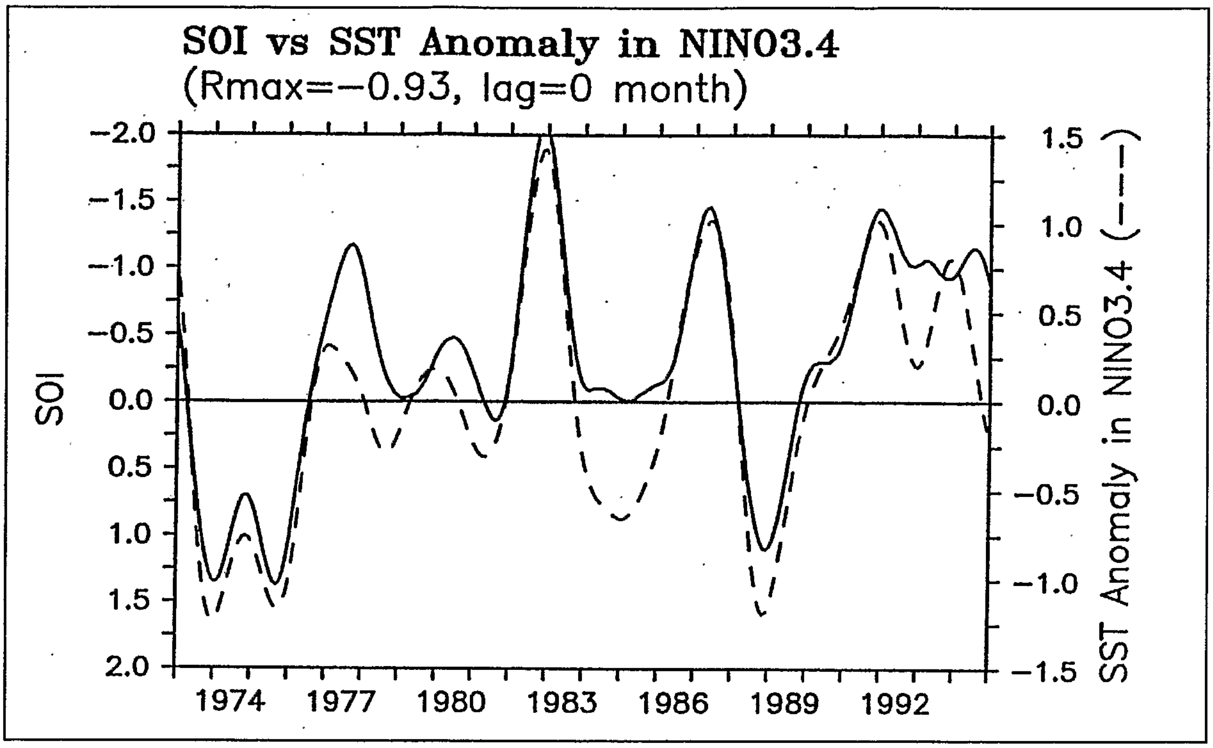

Figure 1. Comparison between the low-pass filtered Southern Oscillation Index (SOI, full line, left axis) versus the sea-surface temperature anomaly within the NINO3.4 (5°N–5°S; 170°W–120°W) region (dashed line, right axis). Rmax denotes the maximum correlation coefficient at given lag between the two curves.

1958). This filter passes almost no signal at periods of one year and shorter, and passes about 90% of the signal at periods of 4 years which is the mean El Niño return interval (Enfield and Cid, 1991).

During an El Niño event, the local SST anomaly decreases slightly (~0.5°C) contrasting with the NINO3.4 SST anomaly. The local Sea Surface Salinity (SSS) anomaly increases (~0.3°C) about a year after the mature El Niño phase, and local southerly wind anomaly are observed (Figure 2). An El Niño event is generally associated with a regional rainfall shortage (-0.5 m/yr), as revealed by satellite (data from Xie and Arkin, 1995) and in situ (Noumea and Koumac; data from Météo-France) measurements (figure 3). Opposite anomalies occur during a La Niña event.

A bit of caution is required regarding the relationships between local precipitation changes and ENSO. First, it is worth noting that the very strong 1982–83 El Niño was not clearly associated with a local rainfall deficit. Then, the seasonal cycle in P and cyclone incidences both modulate the local ENSO-related precipitation changes. In the vicinity of New Caledonia, the precipitation is maximum in March and minimum in September (see Morliere and Rebert, 1986; their table 1). Cyclone incidence shifts northward and eastward during El Niño events, with a tendency to ignore (but not to exclude) the New Caledonia sector (Basher and Zheng, 1995); conversely, during La Niña events, cyclones are more frequently observed in the vicinity of New Caledonia. The influence of both the seasonal cycle in P and cyclone incidences is illustrated in figure 4 for Koumac. Though the SOI presents a quite good correspondence with the rainfall tendency in Koumac, notable precipitation changes are observed in the beginning of each year in relation to the rainy seasons (corresponding to the southernmost position of the South Pacific Convergence Zone) and with cyclone incidences such as Esau and Fran in March 1992 and Beti in March 1996.

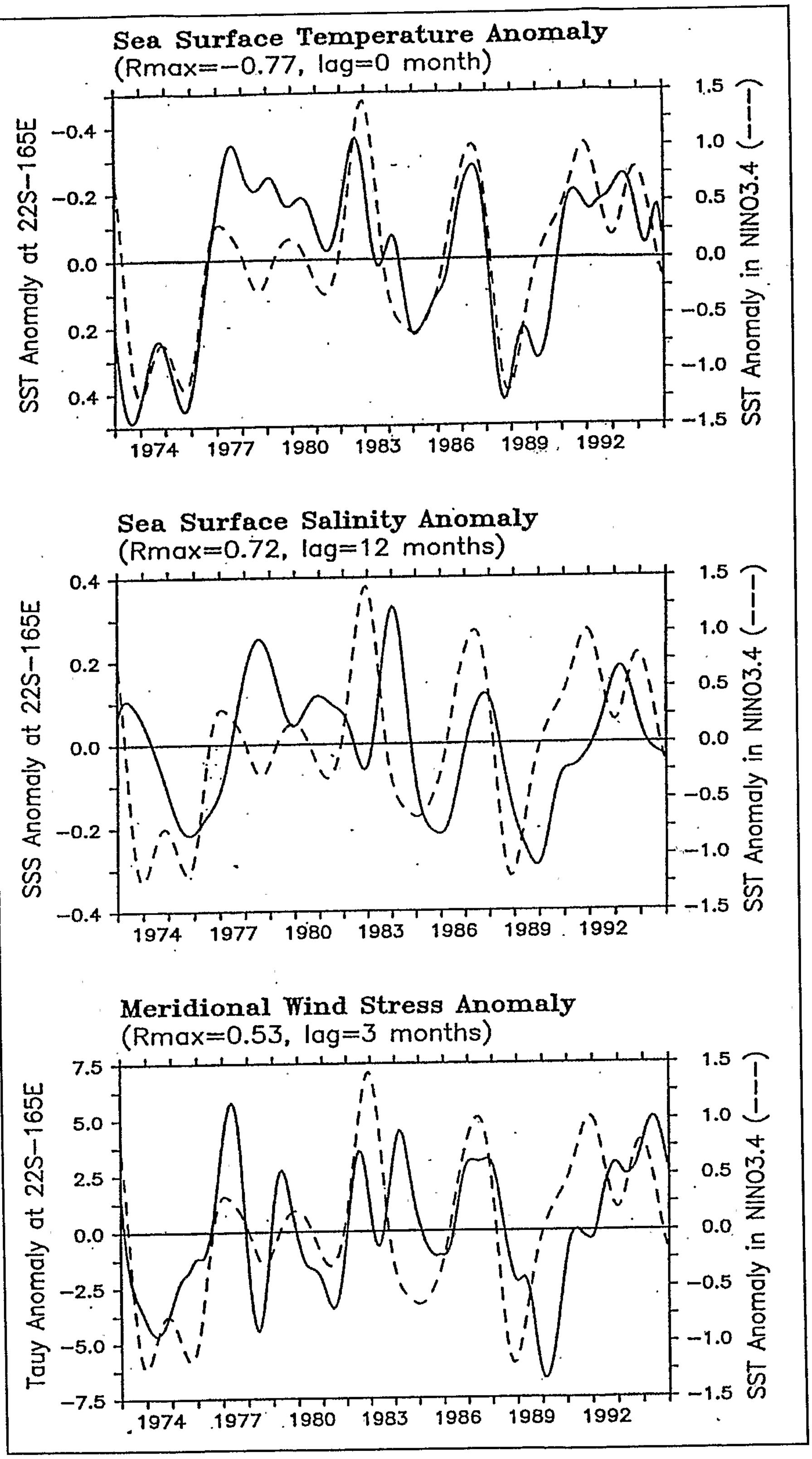

Figure 2. Comparison between low-pass filtered sea-surface temperature (top panel, °C), sea surface salinity (middle panel), meridional pseudo wind stress (bottom panel, m^2s^{-2}) anomalies in the vicinity of New Caledonia (21°S–23°S, 160°E–170°E), versus the sea surface temperature anomaly within the NINO3.4 region (dashed lines and right axes). For each panel, Rmax denotes the maximum correlation coefficient at given lag between the two curves.

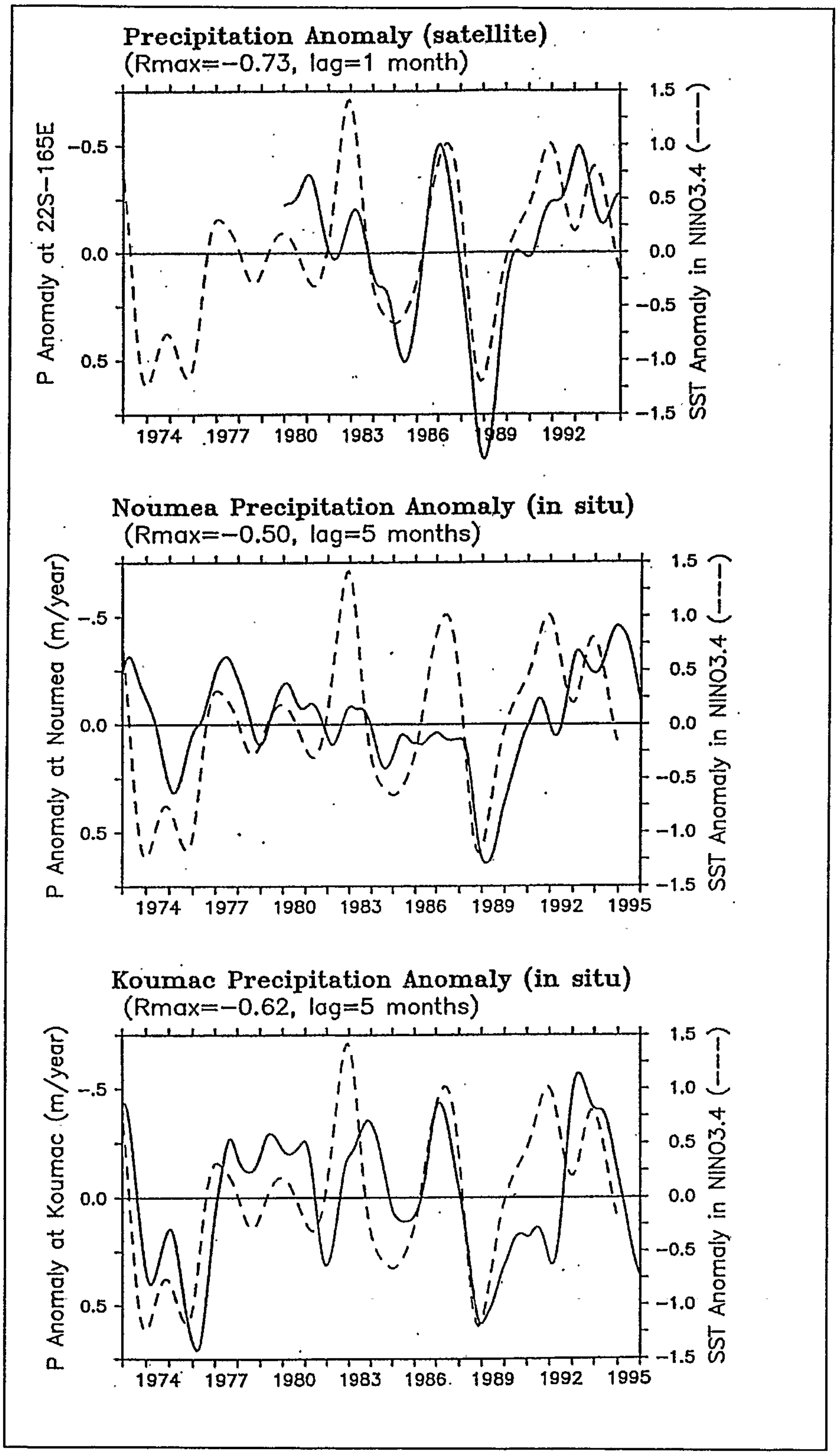

Figure 3. Comparison between low-pass filtered (21°S–23°S, 160°E–170°E) satellite-derived (top panel, m/yr), in situ Noumea (middle panel, m $year^{-1}$), in situ Koumac (bottom panel, m/year) precipitation anomalies, versus the sea surface temperature anomaly within the NINO3.4 region (dashed lines and right axes). For each panel, Rmax denotes the maximum correlation coefficient at given lag between the two curves.

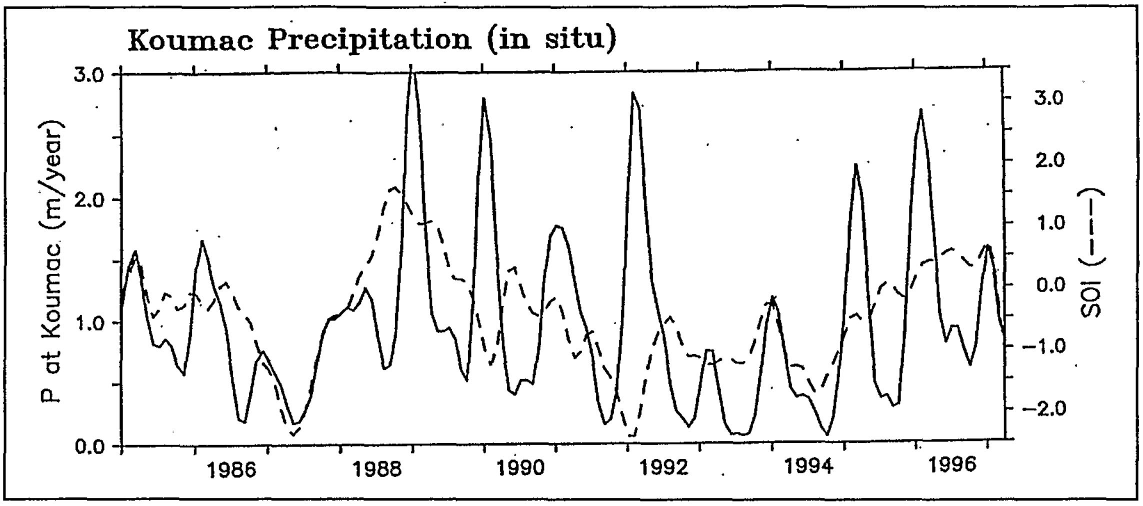

Figure 4. Comparison between the monthly precipitation at Koumac (full line, left axis, m/yr) versus the Southern Oscillation Index (dashed line, right axis).

In agreement with precipitation changes associated with ENSO, the river flow anomalies in New Caledonia present below average (above average) values during El Niño (La Niña) events. This is exemplified in figure 5 for the Tontouta and Ouenghi rivers which are among the main rivers of the western coast (data from the ORSTOM Hydrological Laboratory). Also, the tendency for above average rainfall during La Niña events (SOI>0) seems to be associated with above average dengue fever occurrences (data from the Pasteur Institute), as diagnosed during the 1989 and 1996 summer seasons.

THE 1997 ENSO AND PROBABLE FUTURE ANOMALIES

Owing to numerous observational networks (not detailed here) settled down during the last 10–15 years through fruitful international cooperation, it is now possible to monitor the basin-scale 1997 ENSO in near real-time via internet. Based on web sites (e.g. http://www.pmel.noaa.gov/togatao/home-.html), it is clear that the warm water pool (SST>28°C) usually located in the western equatorial Pacific started to migrate eastward around March 1997 and progressively overspread the whole equatorial region in 4–6 months. At the time of writing (August 1997), unusually warm SST anomalies do occur in the eastern half of the equatorial Pacific (e.g. >2–3°C in the NINO3.4 region), westerly wind anomalies are observed in all the equatorial band, and the sea level is clearly above-average (below average) in the eastern (western) half of the basin. Nothing similar in magnitude was observed for 30 years, except during the 1982–83 ENSO.

What is going to happen? Different and complementary experimental approaches are used for few years to derive prediction products for ENSO-related anomaly (e.g. via coupled ocean-atmosphere general circulation model, canonical correlation analysis, linear inverse modelling; modified Cane and Zebiak model). Using two of these products, now available on web sites (e.g. http://nic.fb4.noaa.gov/), the predicted 3-month average SST anomalies in the tropical Pacific from a coupled general circulation model (Ji *et al,* 1996) suggest that warm episode conditions will continue throughout the remainder of 1997 and into February–April 1998. In New Caledonia, the predicted rainfall (and the associated skill) for Noumea and Koumac from canonical correlation analysis (He and Barnston, 1996) suggest that a probable rainfall shortage will occur during the October/November/December 1997 season in the two locations. As noted by all these last authors,

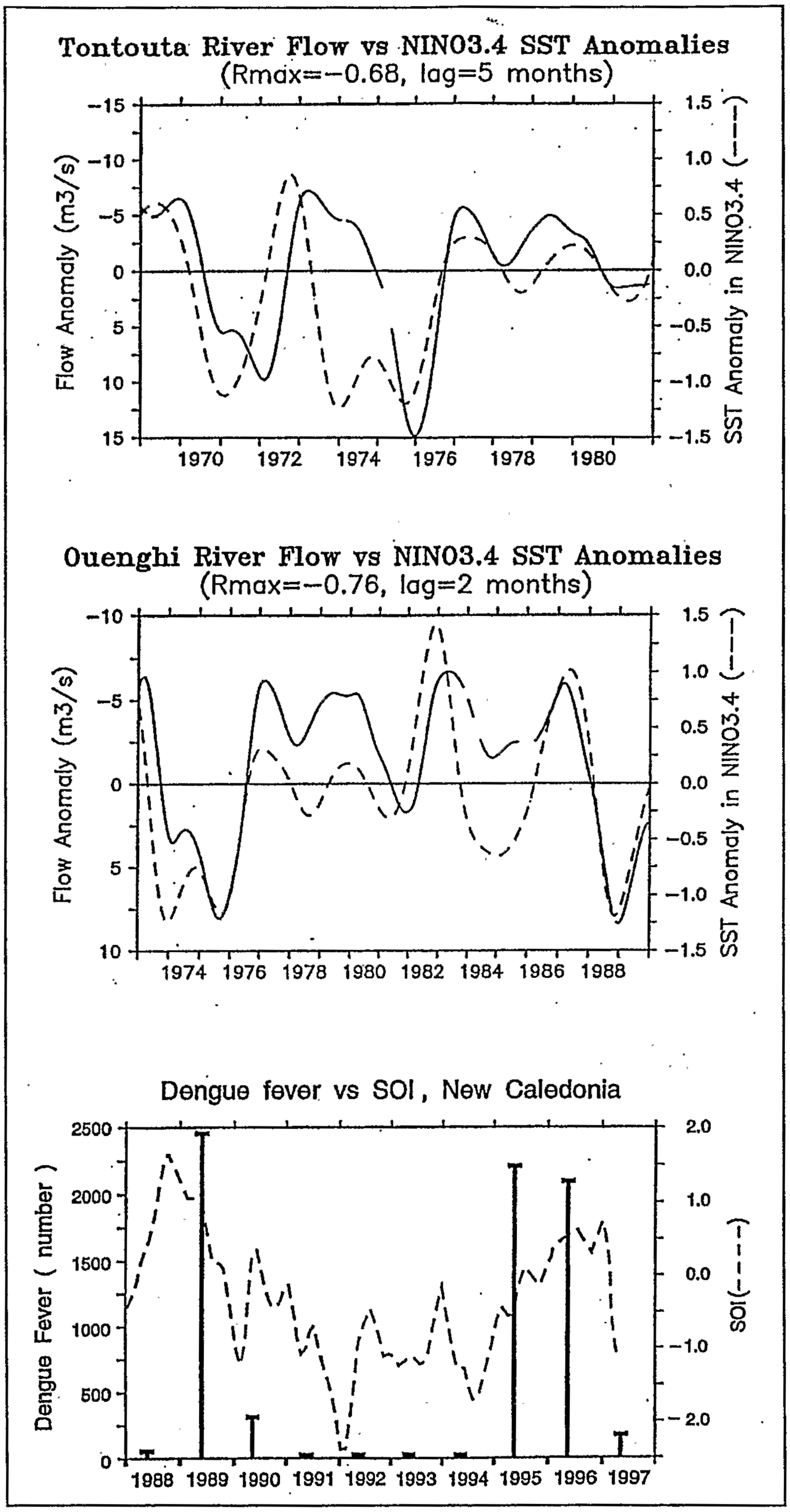

Figure 5. Comparison between low-pass filtered Tontouta river flow (top panel, m^3s^{-1}), Ouenghi river flow (middle panel, m^3s^{-1}) anomalies, versus the sea surface temperature anomaly within the NINO3.4 region (dashed lines and right axes). Note the different time period for the top and middle panels where Rmax denotes the maximum correlation coefficient at given lag between the two curves. The bottom panel compares the dengue fever occurrences (vertical bars, left panel) versus the Southern Oscillation Index (dashed line, right axis).

only a modest skill can be expected for this experimental predictive information. While there is no doubt that past ENSO events influenced the environment around New Caledonia, the future evolution of the on-going 1997 ENSO will enable us to refine our analysis and, moreover, to test the values of the prediction products both at basin-scale and in the vicinity of New Caledonia.

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