Trend and Variability of the Atmospheric Water Vapor: a Mean Sea Level Issue

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References :
[1] M. Ablain, A. Cazenave, G. Valladeau and S. Guinehut, A new assessment of the error budget of global mean sea level rate estimated by satellite altimetry over 1993-2008, *Ocean Sci* 5 (2009), 193-201.
[2] K. E. Trenberth, J. Fasullo and L. Smith, Trends and variability in column-integrted atmospheric water vapor, *Climate Dynamics* 24 (2005), 741
[3] S. Brown, Tracking Water Above the Oceans: A 19-year Water Vapor and Cloud Water Climatology from the Altimeter Radiometers ; OSTST 2011 –San Diego.

Overview

❖ The wet tropospheric path delay (dh) is presently the main source of error in the estimation of the mean sea level. This correction on altimetric measurements highly depends on the atmospheric integrated water vapor content (wv): $1g/cm^2(wv) \sim 64mm(dh)$.

❖ Nowadays, water vapor products from microwave radiometers are relatively close but important discrepancies remain. Understanding those differences can help us improve water vapor products and reduce at the same time the error on the mean sea level.

❖ This poster shows the first results of the comparison between AMSR-E, MWR (ENVISAT) and JMR (JASON1) water vapor products. AMSR-E products are used as reference. The purpose of this study is to characterize both temporally and spatially the behavior of the discrepancies.

Data and methodology

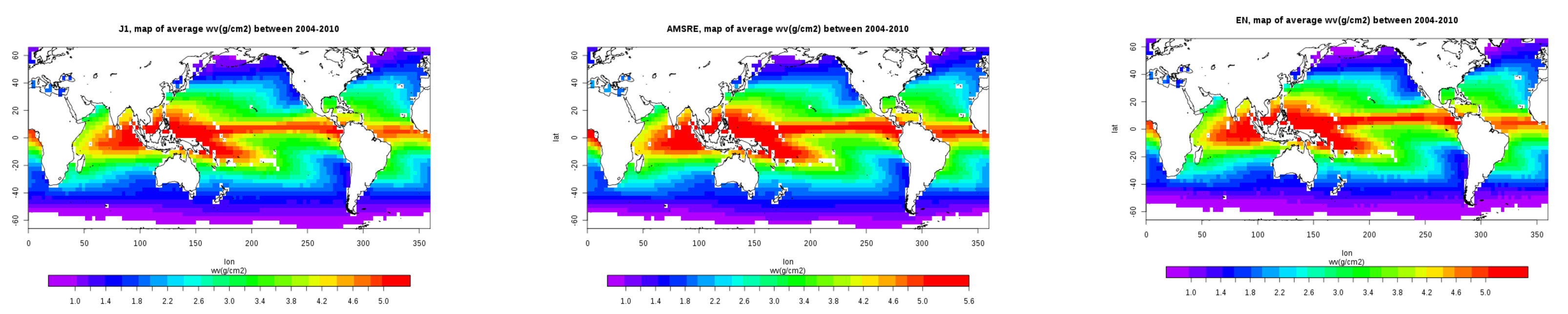
❖ AMSR-E data are produced by Remote Sensing Systems and sponsored by the NASA Earth Science MEaSUREs DISCOVER Project and the AMSR-E Science Team. Data are available at www.remss.com. ASMR-E data are provided in daily ascending and descending orbit grids with a resolution of 0.25°.

❖ ENVISAT and JASON1 datasets of water vapor are composed of standard 1-Hz along-track products.

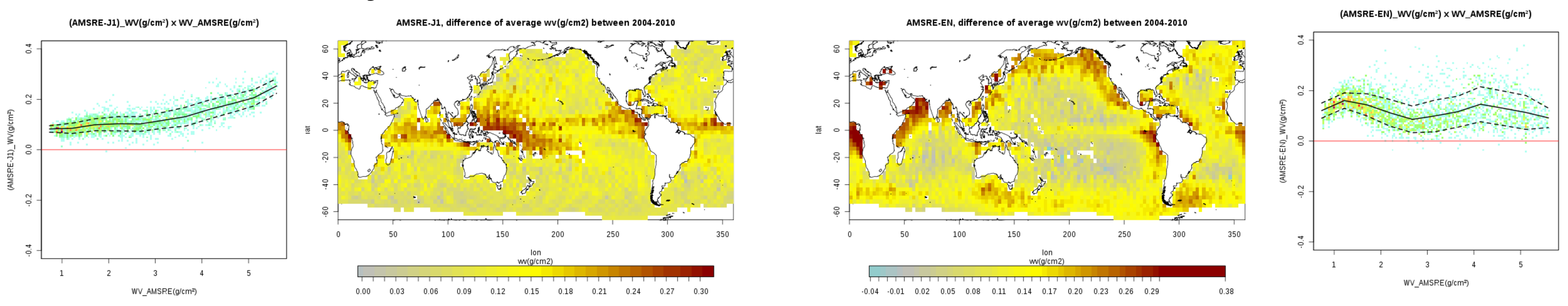
❖ Both AMSR-E, JASON1 and ENVISAT datasets are transformed into monthly gridded maps of water vapor with a spatial resolution of 3°. For each dataset, only validated measures are taken. Measures of ENVISAT and JASON1 whose distance to the coast is inferior to 100km are rejected before the construction of the gridded maps. For each mission only bins of 3 degrees with more than 50 measures are kept. Bins are selected such as the spatial coverage of data for both AMSRE, J1 and ENVISAT maps remains identical at each time.

Spatial analysis : differences of average water vapor maps

JASON1 AMSR-E ENVISAT



AMSR-E-JASON1 AMSR-E-ENVISAT



Results

AMSR-E-JASON1

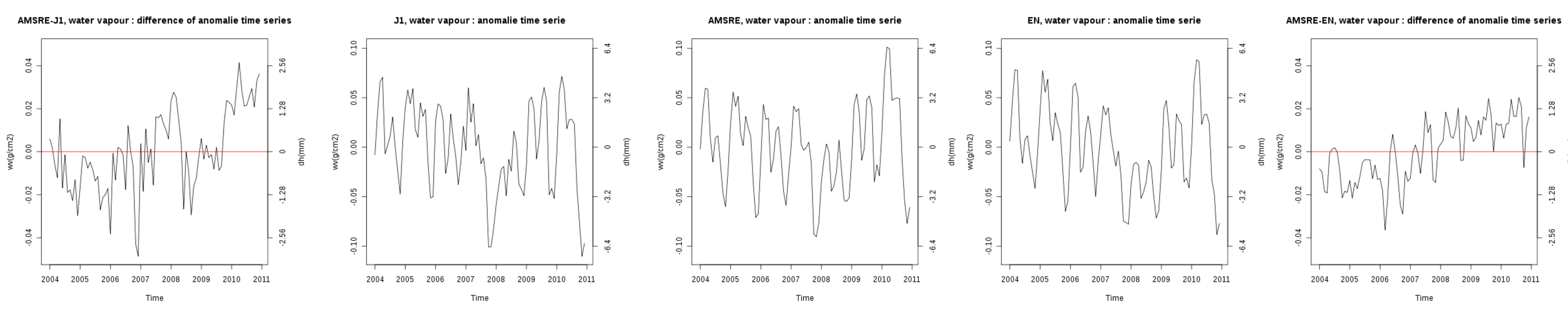
❑ JASON1 underestimates water vapor with respect to AMSR-E.
❑ The main differences are located in the tropics.
❑ The differences increase as the water vapor content increases.

AMSR-E- ENVISAT

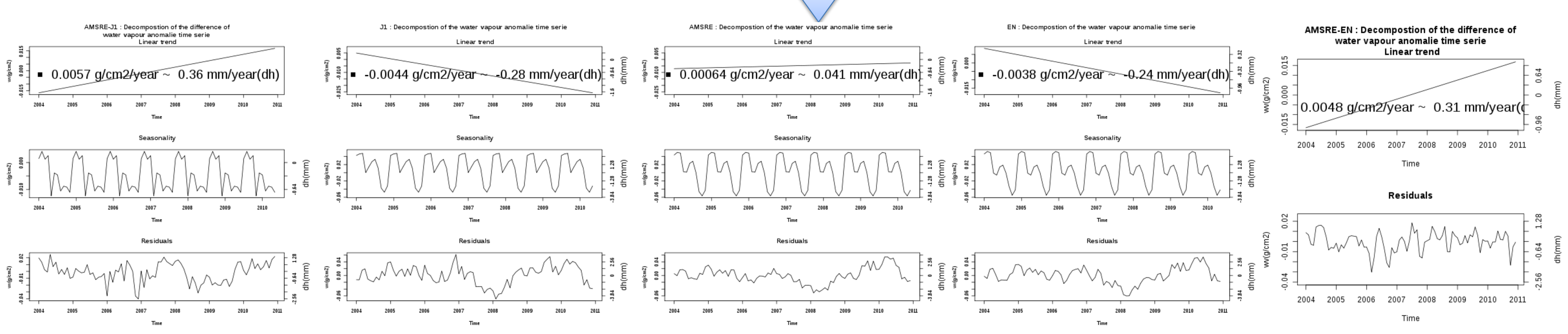
❑ ENVISAT underestimates water vapor with respect to AMSR-E.
❑ The main differences are located in coastal regions and upwelling areas.
❑ The largest differences mainly concern low contents of water vapor ($wv<1g/cm^2$).

Temporal analysis : differences of water vapor trends (2004-2010)

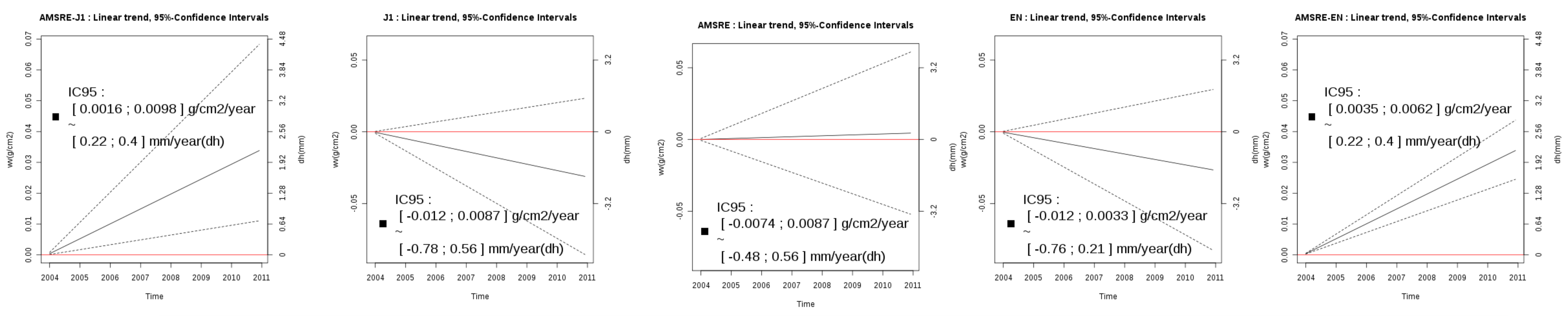
AMSR-E-JASON1 JASON1 AMSR-E ENVISAT AMSR-E-ENVISAT



Decomposition of time series (Trend + Seasonality + Residuals)



Construction of confidence intervals from the residuals modeled by AR(1) processes.



Results

❑ None of the radiometer water vapor trends is statistically different from 0 with a level of significance α=0.05.

❑ The difference of trend between AMSRE and the two other radiometers is statistically different from 0 with a level of significance α=0.05.

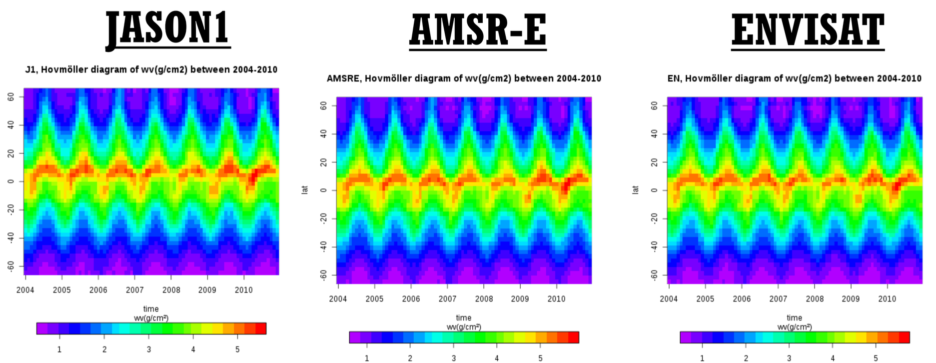
❑ The annual cycle is statically significant, for α=0.05, to explain discrepancies between the AMSRE and the JASON1 time series.

❑ Seasonality is not statically significant, for α=0.05, in the modeling of monthly water differences between AMSRE and ENVISAT.

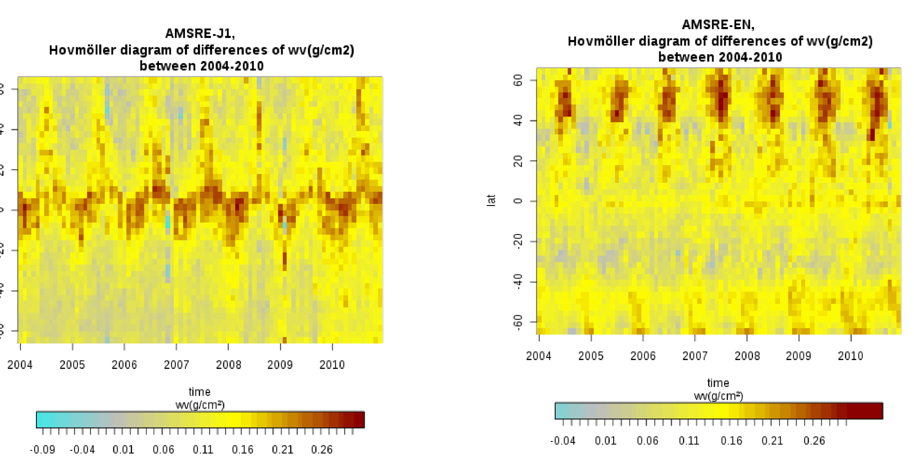
Spatiotemporal analysis of the differences in water vapor contents

Hövmoller diagrams

JASON1 AMSR-E ENVISAT



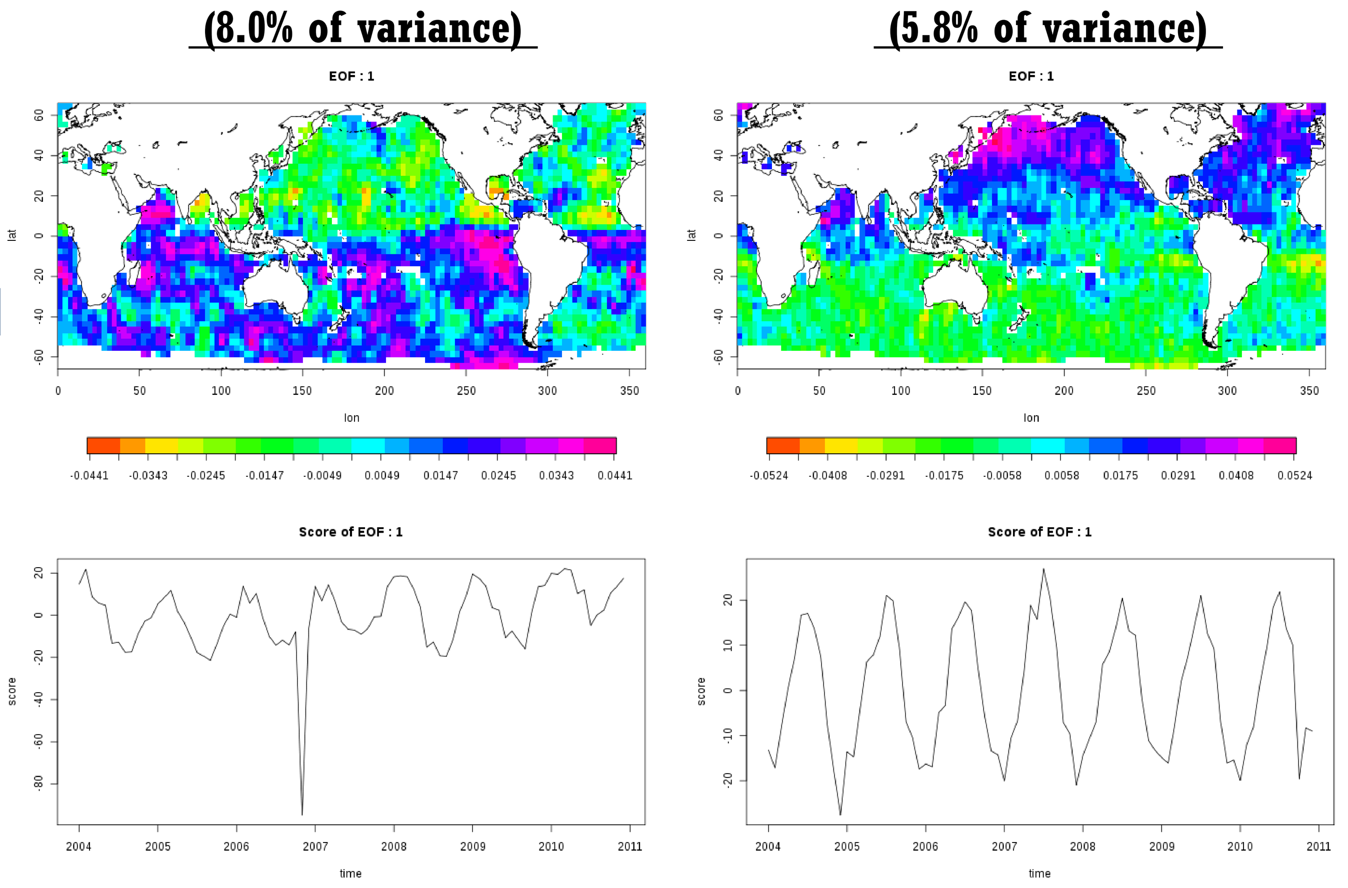
AMSR-E-JASON1 AMSR-E-ENVISAT



EOF analysis (1st EOF)

AMSR-E-JASON1 (8.0% of variance)

AMSR-E-ENVISAT (5.8% of variance)



Results

❑ For JASON1 and ENVISAT, the strongest signal to explain the discrepancies with AMSRE-E corresponds to the annual cycle. It opposes both hemispheres of the Earth. For ENVISAT, this annual signal can not be seen on the monthly time series.

❑ For ENVISAT, the highest differences appears in summer for each hemisphere. The amplitude of the annual cycle is higher in the northern hemisphere.

❑ The score of the first EOF shows an atypical behavior of JASON1 water vapor products at the end of 2006.

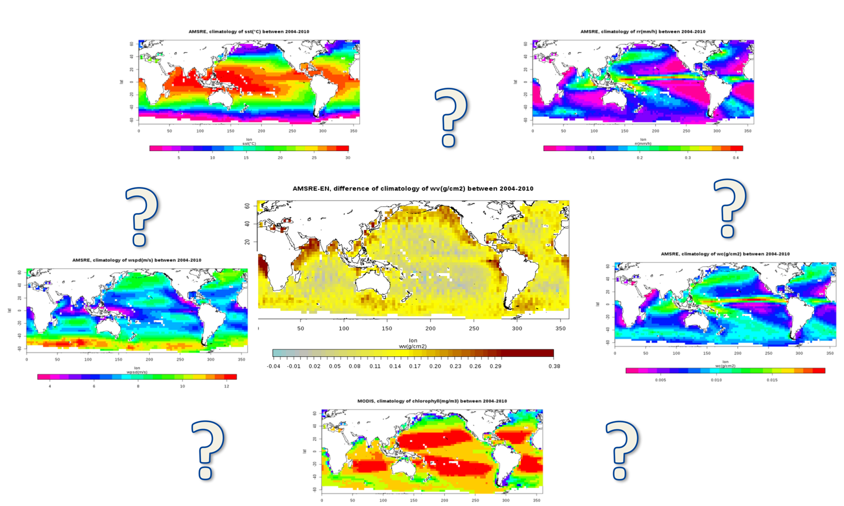
❑ Only 8.0% and 5.8% of the variance are respectively explained by the first EOFs : the discrepancies are composed of a lot of small signals.

Conclusions and perspectives

❖ Water vapor products from AMSRE, J1 and ENVISAT are qualitatively in good agreements However, quantitative differences exist between the products both spatially and temporally. For instance, the differences of trend between AMSRE and ENVISAT is 0.005 $g/cm^2/year$ which is important in regard to the MSL problematic. Indeed, it represents a difference in the wet troposheric path delay trend of about 0.32 mm/year, about one tenth of the MSL trend between 1992 and 2011.

❖ Part of the behavior of the discrepancies has been characterized temporally and spatially. For JASON1, the discrepancies increase with the water vapor content. Thus, the largest differences concern the tropical regions. These differences fluctuate according to annual cycle. For ENVISAT, the discrepancies are stronger in coastal region of the northern hemisphere. Regionally, the discrepancies follow an annual cycle with a peak in summer. The differences mainly concern low values of water vapor content.

❖ However, the origin of these differences are still under investigation. The aim is to identify specific meteorological and oceanographic conditions that induce important discrepancies in the retrieval of water vapor. Impacts of sea surface temperature, wind speed, cloud water, rain rate, or even chlorophyll, and unusual profiles of pressure and temperature are also to be explored. Those discrepancies may be related to differences on the instrumental or mission designs and on ground processing (in-flight calibration, retrieval algorithms and editing criteria).



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