

# International Nusantara Stratification and Transport Program (**INSTANT**)

## INTRODUCTION/OVERVIEW OF INSTANT

### INDONESIAN THROUGHFLOW 2004-2006 AS OBSERVED BY INSTANT

**A.Gordon, D.Susanto, S.Wijffels, J.Sprintall, R.Molcard, H.Van Aken, A.Ffield, Agus Supangat and Indra Jaya**

Other INSTANT presentations in this session:

Velocity and Temperature Variability of the **Makassar Strait** Throughflow

R.D. Susanto, A. L. Gordon, A. Ffield, W. Pranowo, and S. Wirasantosa

The Indonesian Throughflow in the **Outflow Passages** as Measured by INSTANT.

Janet Sprintall, Susan Wijffels, Robert Molcard, and Indra Jaya

*Not submitted due to deadline problems:* THE DEEP INDONESIAN THROUGHFLOW THROUGH

THE LIFAMATOLA PASSAGE AS MEASURED BY INSTANT Hendrik M. van

Aken, Indra Jaya, and Irsan S. Brodjonegoro



**INSTANT**, a multi-national program with Indonesia, Australia, France, Netherlands, USA, with the primary objective to measure the Indonesian throughflow [ITF] **simultaneously**, from the Pacific inflow at **Makassar Strait and Lifamatola Passage** to the Indian Ocean export channels of **Timor, Ombai and Lombok**, over a **3-year period** so as to capture the ITF seasonal and annual cycle over a range of ENSO phases.

We Did It! record of the ITF from December 2003 to December 2006!



The ship



The agreement- December 13, 2002



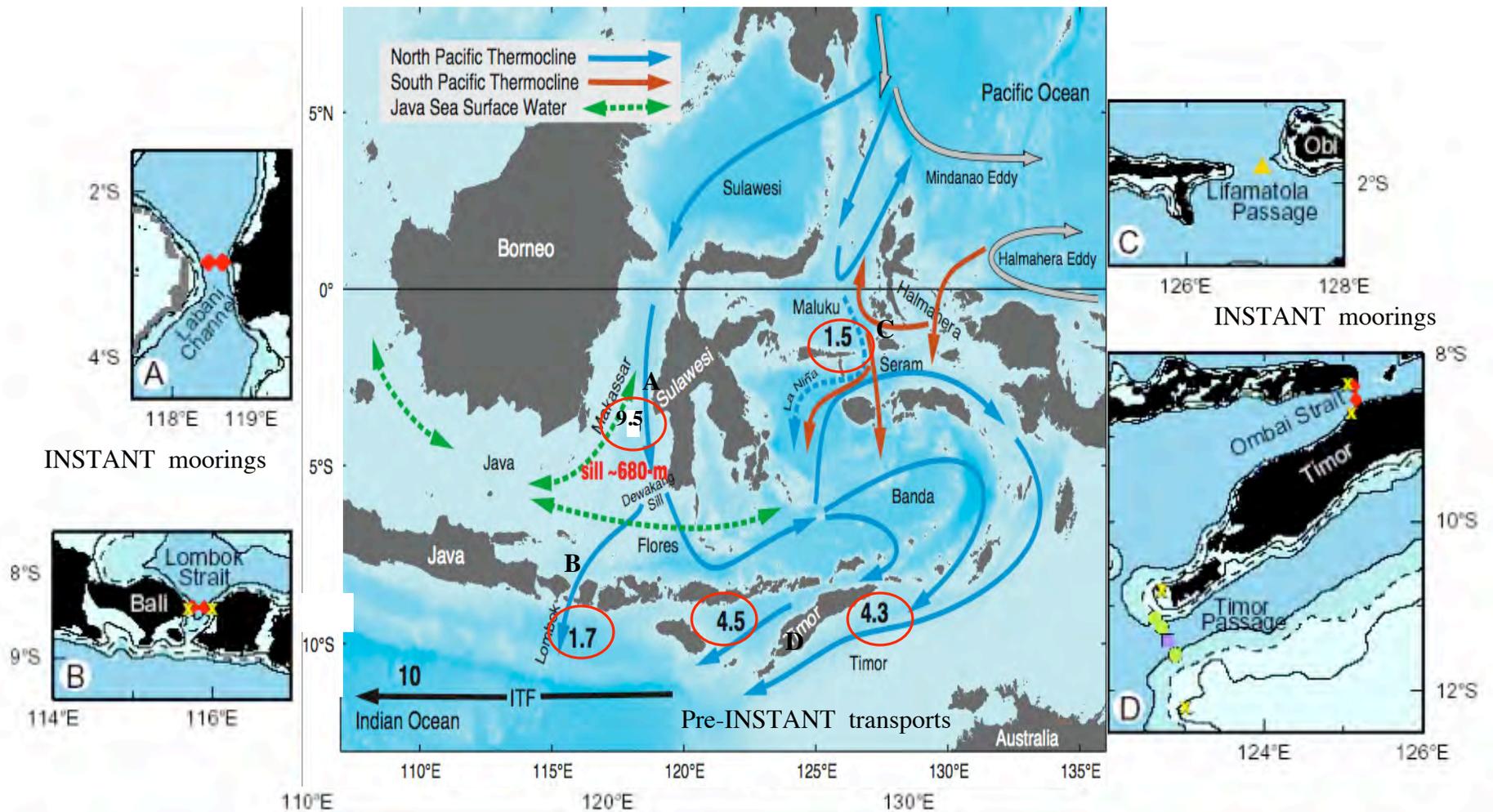
The people



The work

Before INSTANT the major passages were measured, but each at different times, and generally only over a year...*do their transport values tell the real story of the ITF?*

Inflow  $9.5 + 1.5 = 11$ ; Outflow  $1.7 + 4.5 + 4.3 = 10.5$   
 Difference of  $\sim 0.5$  Sv is well within the uncertainty  
 **$\sim 11$  Sv ITF**



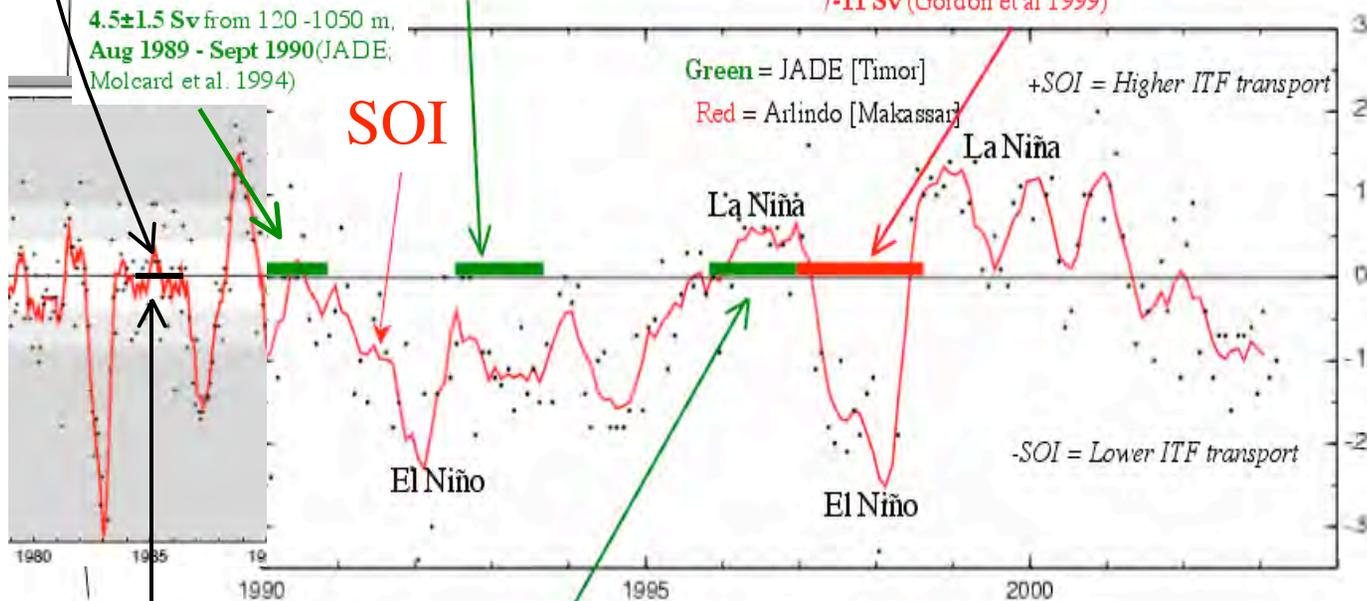
# Prior ITF measurements often in strong El Niño, during which there is reduced ITF

January to March 1985, the estimated overflow transport through the Lifamatola Passage deeper than 1500 m is 1.5 Sv (Van Aken et al. 1988)

March 1992 to April 1993 the average transport within the Timor Passage (south of Timor) measured during the JADE French-Indonesian program, from the 0 to 1250 m was 3.4 to 5.3 Sv (Molcard et al. 1996).

Arlindo Makassar moorings dec 96-july 98 7-11 Sv (Gordon et al 1999)

4.5±1.5 Sv from 120 -1050 m, Aug 1989 - Sept 1990 (JADE; Molcard et al. 1994)

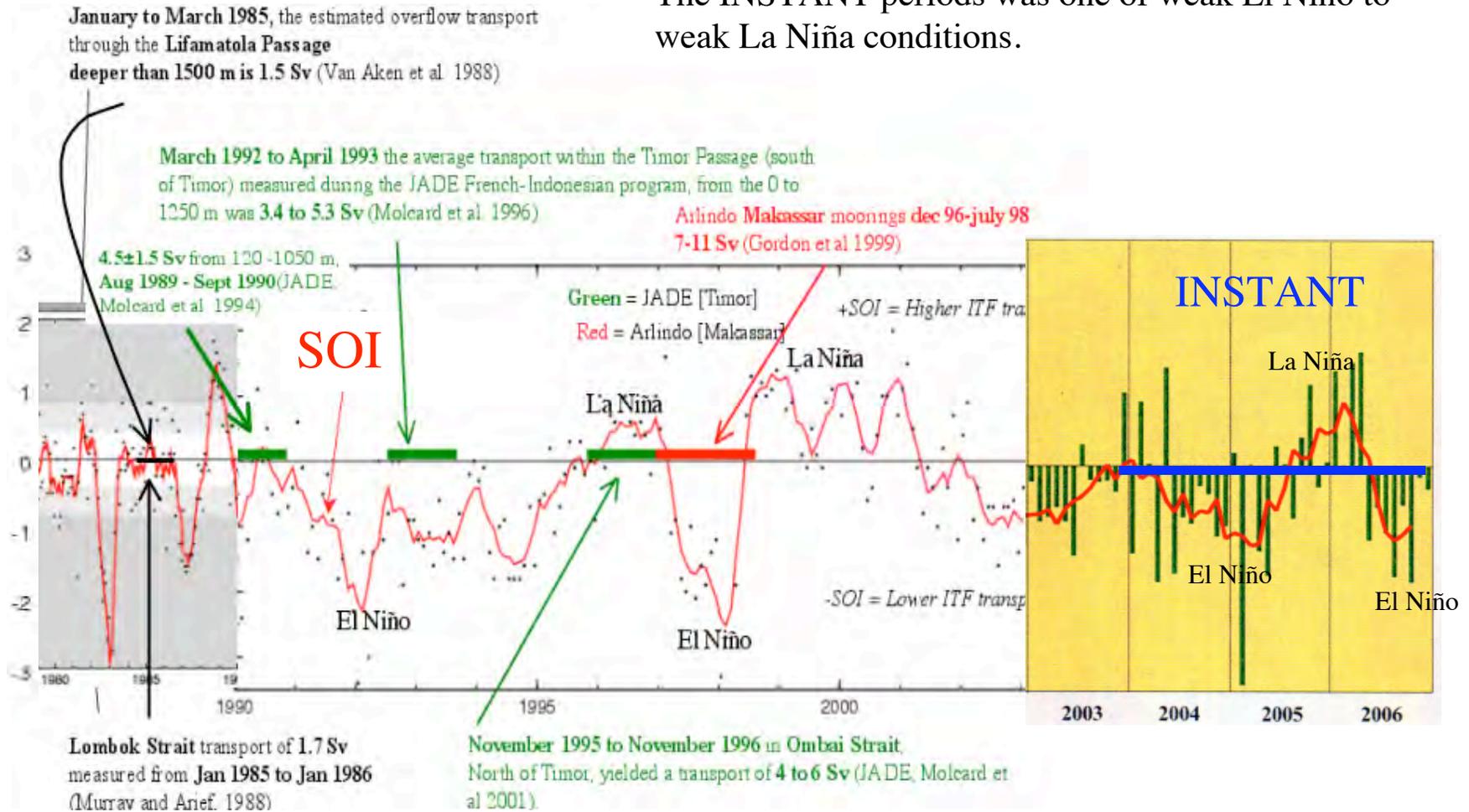


Lombok Strait transport of 1.7 Sv measured from Jan 1985 to Jan 1986 (Murray and Arief, 1988)

November 1995 to November 1996 in Ombai Strait, North of Timor, yielded a transport of 4 to 6 Sv (JADE; Molcard et al 2001).

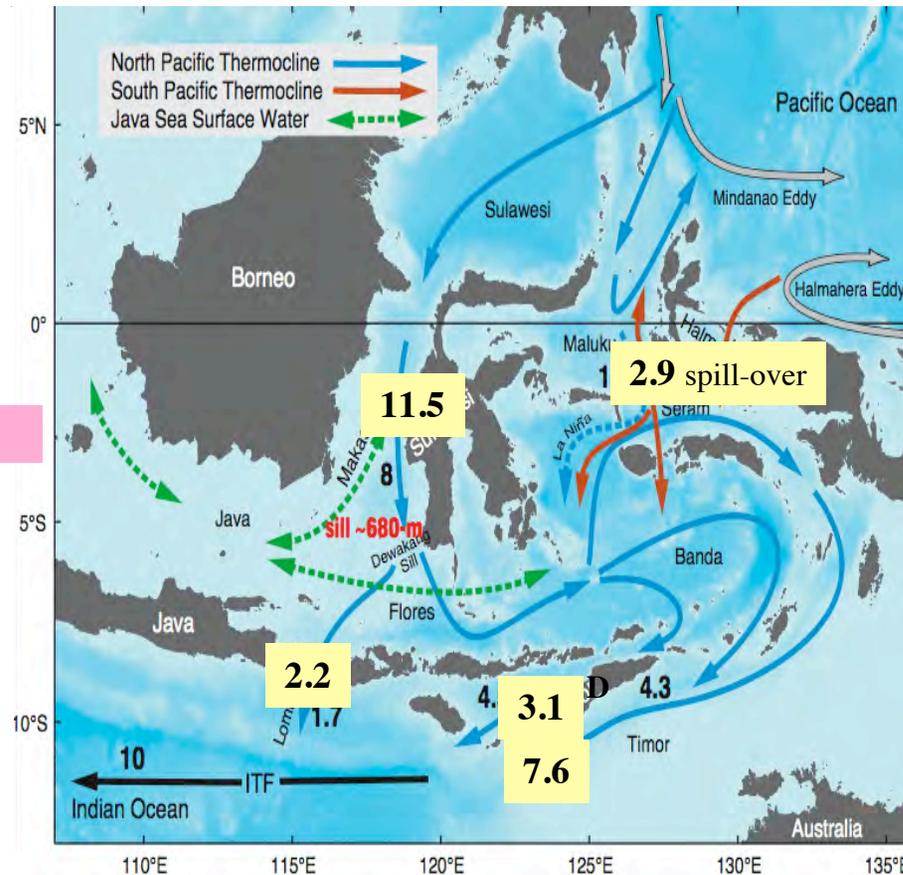
Prior ITF measurements often in strong El Niño, during which there is reduced ITF

The INSTANT periods was one of weak El Niño to weak La Niña conditions.



preliminary INSTANT ITF 3 year means  $\sim 13-14$  Sv!!!

Karimata,  $\sim 1$  Sv?



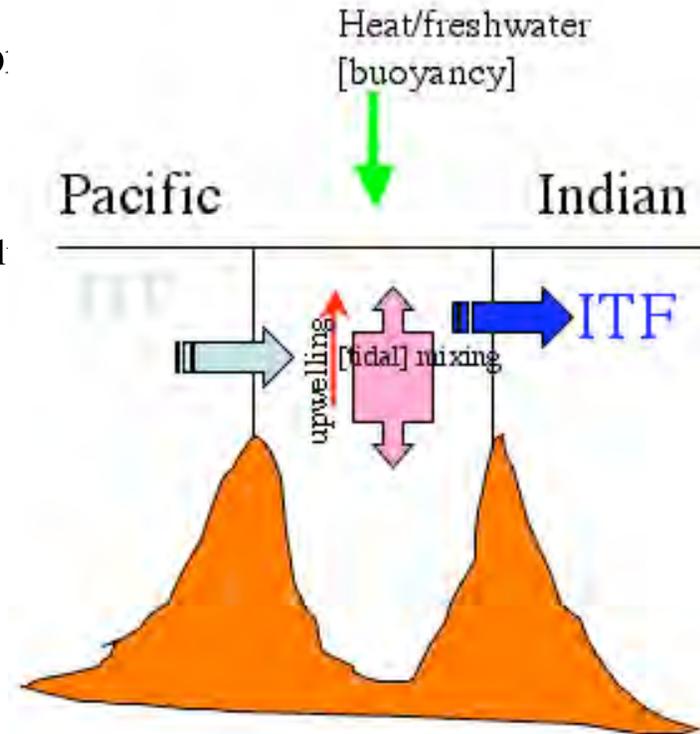
Inflow:  $11.5 + 2.9 = 14.4$ ; Outflow:  $2.2 + 3.1 + 7.6 = 12.9 \pm 2$  or  $3$  sv  
 $\sim 2$  or  $3$  Sv larger than pre-INSTANT, this may not overly significant, but again inflow is greater than outflow

Uncertainty: due to experiment design, instrument behavior and real variability in ITF at  $>$  sampling interval

But the ITF is more than its annual mean,  
there are:

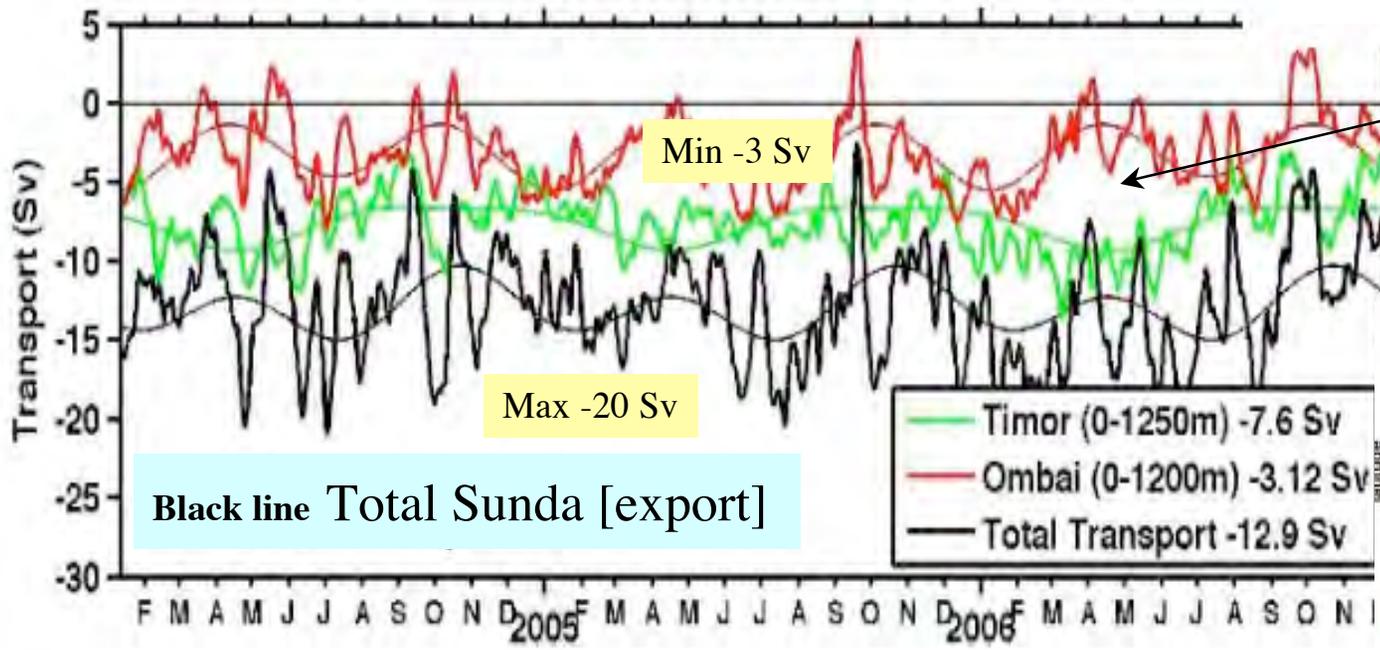
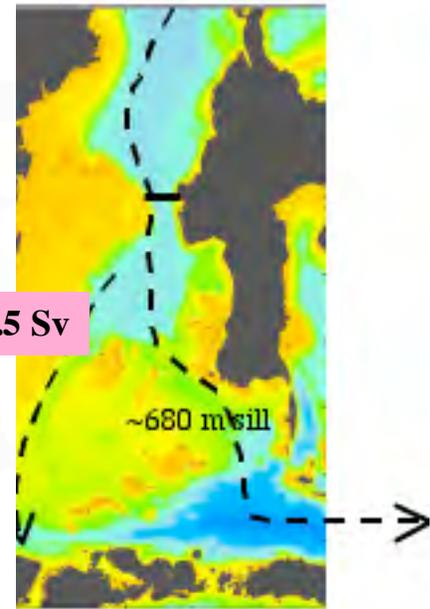
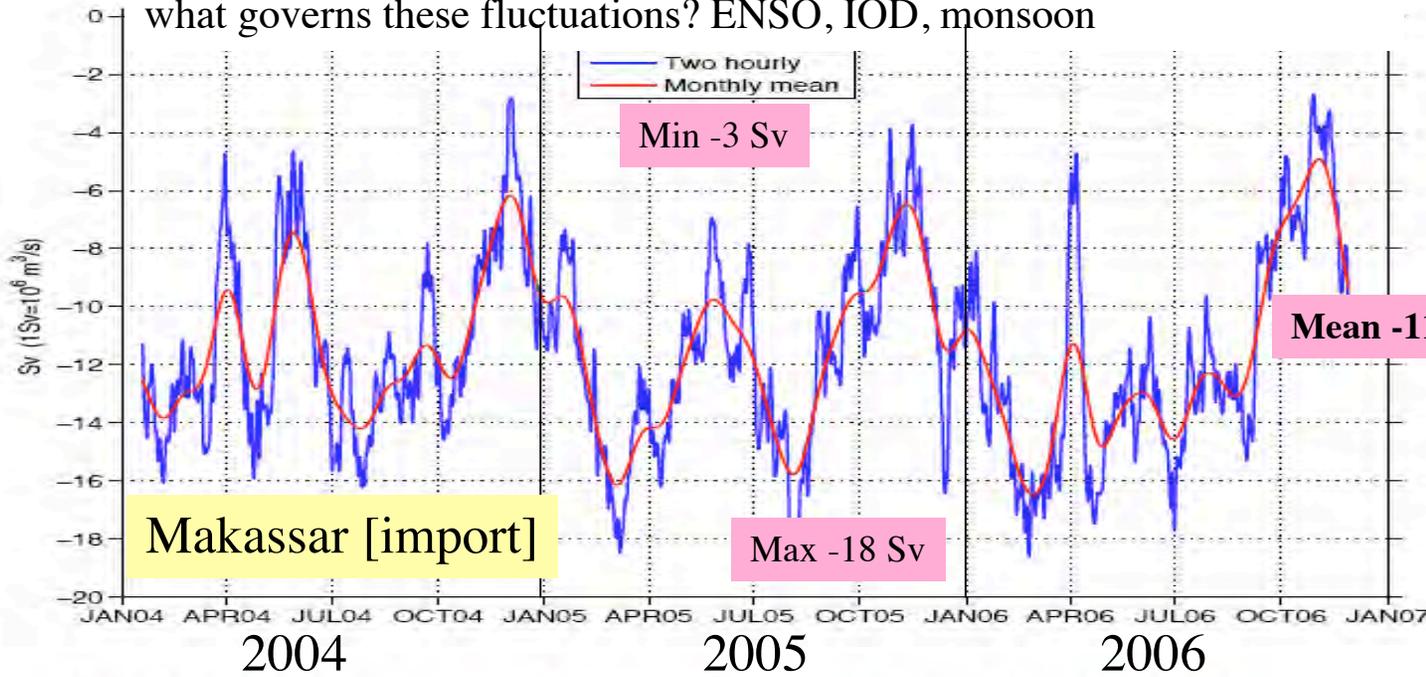
- transport fluctuations;
- inflow and outflow are not in balance for weeks to months;
- transport profile changes [of heat/freshwater fl relevance];

**Pacific water is converted into a unique Indonesian stratification before injected into the Indian Ocean**

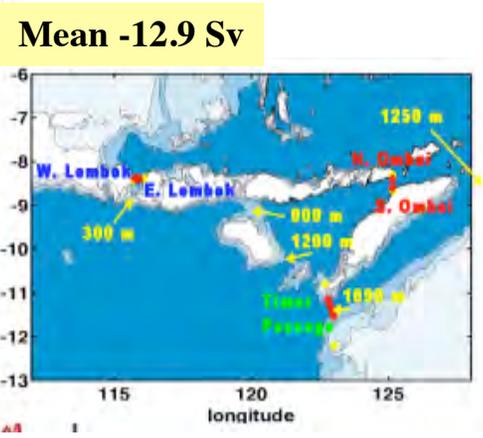


*Lets look a bit at some of these complexities*

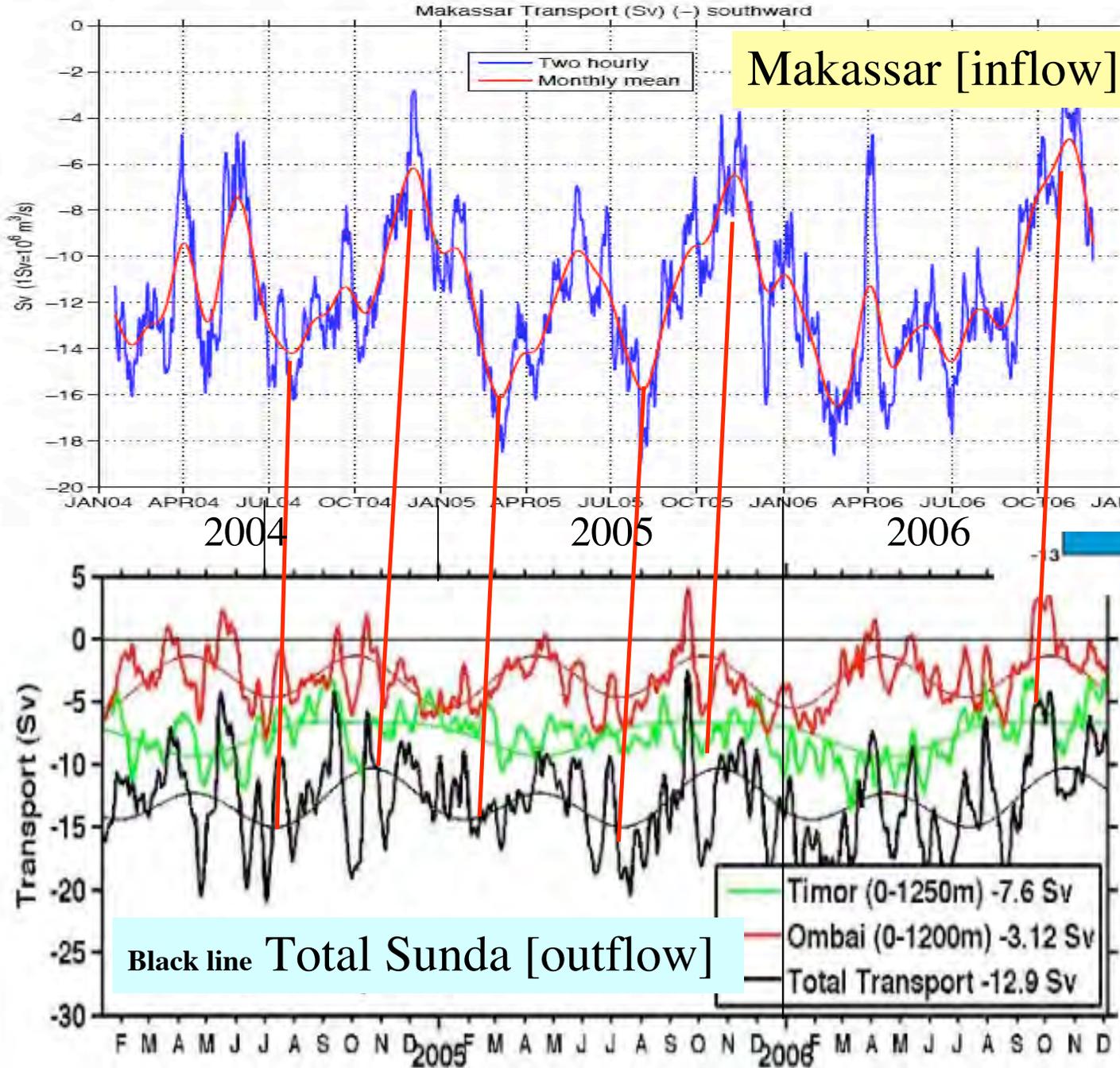
Transport fluctuations - interannual, annual, semi-annual, intraseasonal;  
 what governs these fluctuations? ENSO, IOD, monsoon



Ombai and Timor out of phase in feb-june time frame. ITF pathway pattern varies seasonally

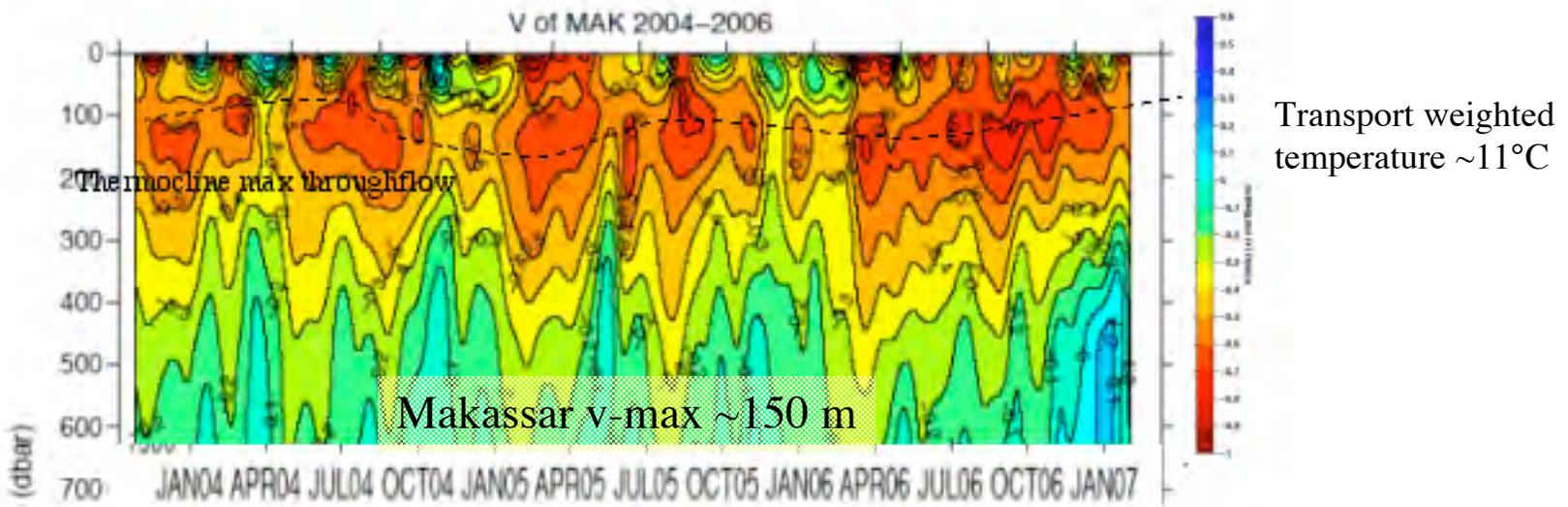


# Imbalance between inflow and outflow



**Might there be a ~ week to month lead in transport min/max peaks in Sunda relative to Makassar?**

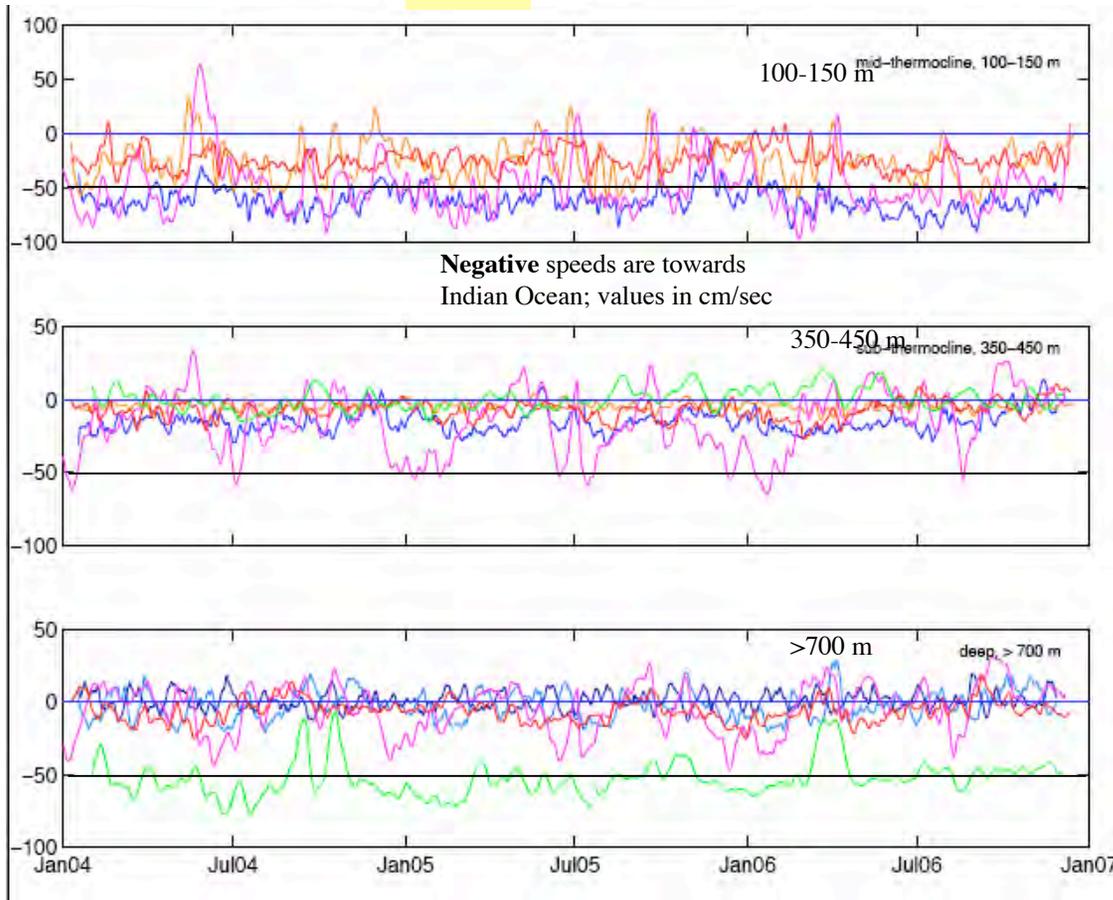
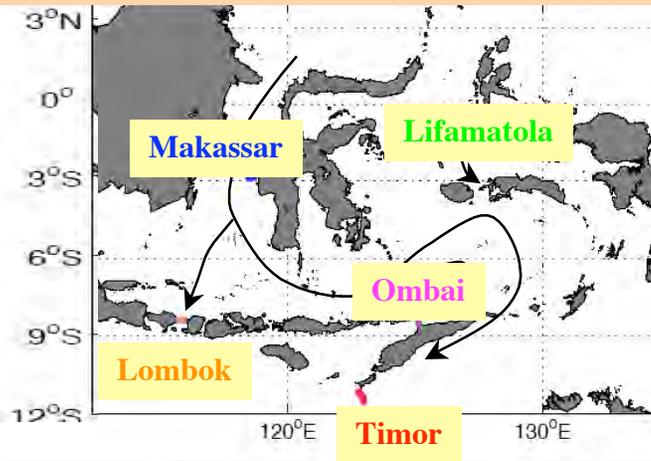
**Increase/decrease in interior sea storage? when sunda ITF is low relative to Makassar: surplus of thermocline water in interior seas; when sunda ITF is high relative to Makassar: removal of thermocline water from the interior seas**



Ombai & Timor [major outflow channels]: Generally near surface transport peak in June-Nov, but subsurface often  $\sim 200\text{m}$  in January February.

Makassar profile is modified within Banda Sea by seasonal Ekman pumping [Banda upwelling June-sept; downwelling Dec-march] before export to the Indian Ocean.

# A composite view of the 3.0 years of INSTANT along channel flow



## Some observations-

- **Makassar** and **Timor** throughflow are relatively steady, in comparison to Lombok and Ombai.
- **Lombok** and **Ombai** rich are in intraseasonal oscillation; **Lombok** leads by ~5 days;
- **Lifamatola** sill overflow into Banda is very vigorous ~1 kt.

Lifamatola ~300 m above sill of 1950 m. negative speeds along the channel axis, 124°

## **Summary:**

- **ITF 13-14 Sv**
- **Significant interannual, annual, semi-annual, intraseasonal fluctuations**
- **Profile and T/S modifications within Banda Sea**
- **Intraseasonal fluctuations varies greatly from passage to passage**

What is presented here is preliminary:

Now the fun begins as we delve into the INSTANT data to more fully understand the regional and larger scale forces that give rise to the ITF and its fluctuations, so that they can be properly simulated within ocean and climate models.