Objective Variational Analysis of TWP-ICE Data

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Analysis Method

The objective variational analysis method developed by *Zhang and Lin (1997)* is used to process TWP-ICE data:

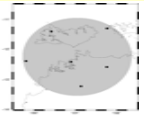
- Domain-averaged surface and TOA observations are used as the constraints to adjust the balloon soundings in order to satisfy the conservation of column integrals of mass, heat, and moisture
- The resulting analyzed data are dynamically and thermodynamically consistent
- The derived large-scale forcings can be used to drive SCMs/CRMs

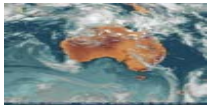
Ground Observation Network

Data Integrated Through the Analysis

- Radiosondes at the five boundary stations and the ARM Darwin site
- ECMWF data as the background fields
- BOM radar precipitation
- Surface radiation and turbulence fluxes from Ship and land stations
- Surface meteorological fields
- Cloud liquid path
- Satellite data (MTSAT)

BOM Precip Radar Coverage

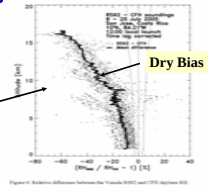




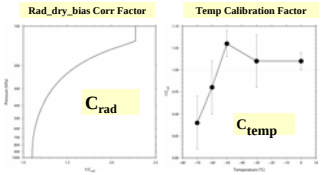
Key Issues

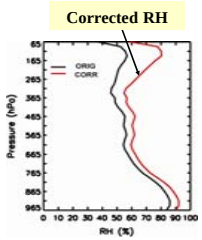
Dry Bias in RS-92 Sondes

A radiation heating dry bias in RS-92 sondes, especially in the middle and upper troposphere found by comparing with Cryogenic Frostpoint Hygrometer measurements (Figure from Vomel et al. 2007)



Correction



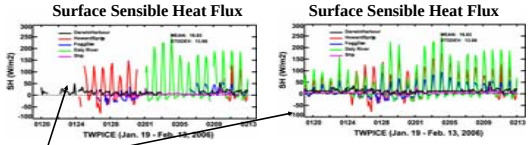


Correction based on Vomel et al. 2007

- $RH^* = RH * /(C_{rad} * C_{temp})$
- Crad is only applied during the day; C_{temp} is applied in both daytime and nighttime (*see T. Hume's poster for details*)

Uncertainties in Area-mean Surface Fluxes

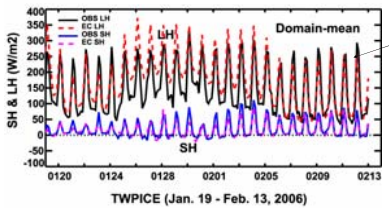
- Only a limited number of stations available
- Both ocean and land area contained
- Large missing gap in the measurements



Missing gaps in the measurements are filled with ECMWF data

- Strong spatial variability over land
- Strong ocean-land contrast

ECMWF Data vs. OBS



Domain Mean

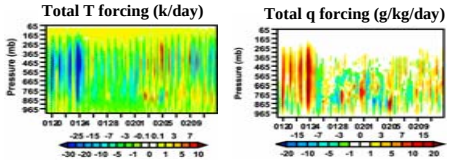
Domain mean is a weighted average based on the surface type represented by each flux site

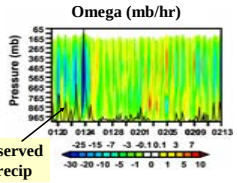
Analysis Products

- The large-scale forcing data for driving SCMs and CRMs
  - Vertical velocity
  - Horizontal advective tendencies of T and q
- Apparent heat sources q1 and apparent moisture sinks q2 for budget studies
- Mean quantities suitable for model evaluations
  - Sounding data
  - Surface and TOA fluxes
  - Surface meteorology fields
  - Cloud information retrieved from satellite data and ARM surface measurements
  - …

Data will be available in the ARM archive soon

Examples of Analyzed Fields





Observed Precip

The analyzed fields show strong upward motion, advective cooling, and moisture convergence Corresponding to the observed precipitation,

Future Work

- Examine how sensitive the analyzed forcing fields are to uncertainties in the surface fluxes
- Examine how SCMs/CRMs respond to potential uncertainties in the derived forcing fields.

Reference: *Zhang and Lin (1997): Constrained variational analysis of sounding data based on column-integrated budgets of mass, heat, moisture, and momentum. JAS, 54, 1503-1524*

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