Application of artificial neural networks to the development of improved multi-sensor retrievals of near-surface air temperature and humidity over ocean

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Outline

• Background

• Approach

• Results

• Conclusions and Future Work
Motivation for Retrieving Surface Parameters

• Estimating the surface heat fluxes from satellite requires:
  • Sea surface temp (SST)
  • Specific humidity (Qa)
  • Air temperature (Ta)
  • Wind speed (Wspd)

• Current estimates show systematic differences of 25-50Wm⁻²

• Qa & Ta differences are a major driver of the differences between these products.

Large-scale patterns are similar but amplitudes can be very different.
Retrievals of near-surface parameters from microwave brightness temperatures

- Observations at microwave frequencies show dependencies on:
  - Water Vapor (QV)
  - Surface wind speed
  - Sea Surface Temperature

- This sensitivity is state dependent
  - Presence of clouds

- Sensitivity to surface layer (i.e. within 10m) is low

Based on simulations from CRTM Forward and Jacobian model.
Sources of information in successful retrievals of near-surface temperature and humidity

• There is a strong connection between the near surface air-temperature and humidity.
  • Clausius-Clapeyron

• The sea surface temperature and air temperature are typically strongly correlated
  • Narrow distribution of (SST-TA)

• Studies have shown total columnar water vapor (precipitable water) and surface air temperature to be highly correlated (Liu, 1988).

• Nonlinearity arises:
  • Dependence on atmospheric state
  • Dependence on surface conditions
  • Inherent relationships between moisture and temperature.

From Roberts et al. (2010)
Inverse retrieval approach

\[ TB = F(X) \]
\[ X = F^{-1}(TB) \]

**GOAL:** FIND \( F^{-1}(\cdot) \)

**LINEAR**
- Stepwise linear regression (Jackson et al., 2006)

**NON-LINEAR**
- Neural Network (Jones et al., 1999)
- Genetic Algorithms (Singh et al., 2006)
- Neural Network with first guess (Roberts et al., 2010)
Data Fusion: Merging AMSR-E and AMSU-A

**Training dataset**

- Direct *in situ* measurements are co-located with satellite-observations.
- CRTM-based simulations can be used to supplement the *in situ* dataset.

*AMSR-E and AMSU-A sensors on AQUA have co-located footprints with minimal time between samples.*

- Co-located measurements between AMSR-E and AMSU-A are available from mid-2002.
Improved Surface Humidity Retrieval

**AQUA Advantage**

- AMSU-A contains channels sensitive to lower troposphere temperature
- AMSR-E contains channels sensitive to PW, CLW, and SST
- Results in improved surface humidity retrievals.

![Graph showing 1st Attempt AMSU + AMSRE; QA with RMSE 1.3 g/kg and BIAS -0.03 g/kg]
Improved Surface Temperature Retrieval

- Overall improvements are found for near-surface temperature.
- The near-surface stability is also better represented.
- Improved by taking information directly related to the surface temperature and temperatures in the lower troposphere.
Conclusions

• A statistical retrieval methodology for surface parameters is improved using a nonlinear approach
  • Due to nonlinear nature of the problem

• Retrieval of the near-surface parameters is improved through use of multiple sensors
  • Additional information is available for inversion

• It is important to include a synthetic component of the training dataset; choices arises regarding sampling

• Future work: add *a priori* information to help regularize the network (i.e. a Bayesian approach).
References


