Contribution of POLDER to Water Vapor observation

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POLDER1 algorithm
examples of use
POLDER2 algorithm
experimental results over dark surfaces
POLDER instrument:
Polarization and Directionality of Earth Reflectances

Onboard ADEOS-1 (NASDA-CNES) and ADEOS-2
- sunsynchronous ~ 10h30
- swath ~ 2400 km
- full resolution 6 -7 km; products @ 20km² or 60 km²

November 1996 to June 1997

April 2003 until now

solar domain: 443\textsuperscript{P}, 490, 565, 670\textsuperscript{P}, 763, 765, 865\textsuperscript{P}, 910 nm

for water vapour: 865 nm et 910 nm
absorption contrast
between 865 & 910 nm  (clear sky)

white surface hypothesis

\( R_{surf910} \sim R_{surf865} \)

\[
\chi = \frac{R_{910}}{R_{865}} \approx \frac{t_{910}}{t_{865}}
\]
Total Column Water Vapour content

\[ TCWV = U = \int_{0}^{p_{\text{surf}}} \frac{q(p)}{g} \, dp \quad (\text{kg} \cdot \text{m}^{-2}) \]

degree of polynomial fit

\[ m \cdot TCWV = a2 \ln(X)^2 + a1 \ln(X) \]

two-way air mass

\[ m = \frac{1}{\theta_0} + \frac{1}{\theta} \]
polynomial fit

\[ m \cdot TCWV = a_2 \ln(X)^2 + a_1 \ln(X) \]

coefficients from radiative transfer simulations
overestimation of large contents
POLDER 1: Validation

overestimation of large contents

HITRAN 1992 > HITRAN 2000
POLDER 1: Validation over land

surface bias
underestimation of small contents
POLDER 1: Validation over land

surface bias
underestimation of small contents

off line surface correction

fct (R865/R765)
off line correction

RMSE = 2.8 kg/m²
< radiosondes ~ 5 kg/m²
retrieval limitations

near-infrared solar domain
- daytime only
- 1 obs per day only

absorption based technique
- clear sky only

small scattering effects

high surface-reflected signal
- land and ocean glitter

/scattering effects
POLDER water vapor content

LAND: valuable spatial coverage (clear sky)
OCEAN: ~ 1/3 of the swath (clear sky and glitter)
Comparisons to meteorological analyses

ECMWF - POLDER (1996-1997)

DEC
961221
961222
961223
961224
961225

APR
970421
970422
970423
970424
970425

MAY
970526
970527
970528
970529
970530

Vesperini, RSE, 2002
assimilation experiments

POL - CTRL ANALYSES

max drying: 0.35 g/kg

Manouvrier and Vesperini, LOA & Meteo France, 2000
POLDER CLASSE 2 algorithm

calibration over ocean glitter targets
reference to SSMI F10 - Wentz algo version 5

SSMI = 1.00 RS + 0.33 (kg.m\(^{-2}\))

RMS = 1.55 kg/m\(^2\)
POLDER CLASSE 2 algorithm:

for selected clear sky glitter scenes (POLDER lev1 / SSMI)

weak absorption:
\[ m.U_{h2o} = a_2 \ln(X)^2 + a_1 \ln(X) \]

strong absorption:
\[ m.U_{h2o} = a_2 \ln(X)^2 \]
POLDER CLASSE 2: land surface correction

\[ Y = 0.1 - 0.13 \ln(X87) \]
POLDER water vapor (total column)

experimental algorithm over ocean in any geometry

operational product over land or in glitter geometry

- clear sky
- daily (1 a day)
- $\sim 3 \text{ kg/m}^2$ precision

sensitive to the lower troposphere

to complement sounding instruments
African Monsoon Multidisciplinary Analysis project need for water budget

provide fine scale humidity analyses over land and ocean
differential absorption retrievals over land
(POLDER/MODIS/MERIS)
+ µwave and IR sounding
in any viewing geometry
small reflectance for the surface
coupling between scattering and water vapor absorption
Instrument noise on top-of-atmosphere signal
Effects of Aerosol Scattering

All cases

As a function of $a$ and $H_a$. 
Water vapor over land and ocean

Water vapor content:
Continuity between land and ocean is observed
Comparisons with SSMI data

Histogram: SSMI - POLDER

Comparisons SSMI/POLDER

Mean $\sim +1.8 \text{ kg/m}^2$: due to the accuracy of the radiative transfer code
RMS error $\sim 4 \text{ kg/m}^2$: overestimation of large contents
Radiative Transfer Modeling

Radiative transfer code : GAME

- Absorption: correlated k-distribution from a Line-By-Line (LBL) code for gaseous absorption
- Spectral resolution: $10 \text{ cm}^{-1}$.
- HITRAN 2000 spectroscopic database
- CKD2.4 parameterization for the water vapor continuum
- Discrete Ordinates Method (DOM) for absorption, emission and multiple scattering processes.
- Sea-surface reflectance: specular and diffuse reflection
Differential Absorption Technique Over Ocean

Reflectance Ratio calculated with the GAME code:

Without aerosol
Rayleigh scattering
Over Land or Ocean
Solar angle $0 < \_s < 60^\circ$
View angle $0 < \_v < 60^\circ$
$4 < U_{h2O} < 60 \text{ kg/m}^2$
Aerosol properties:

Optical Thickness:\n$\tau_a (550\text{nm}): 0.1$ to $0.3$

Maritime model (Mie theory)

Scale Height $H_a$: $1$ and $3$ km
POLDER oxygen bands:
At 863 and 865 nm
Estimate of the surface pressure $P_s$
From the airmass $m$ and the reflectance ratio $R(863/865\text{nm})$
- Look-Up-Tables: calculated with the radiative transfer code polynomial regressions for:
  \[ mU_{h2o} = R_{H2O} \ (910\text{nm}/865\text{nm}) \]
  \[ mP_{s}^2 = R_{O2} \ (763\text{nm}/765\text{nm}) \]
  as a function of \( \sim \) is and \( H_a \)

- \( R_{H2O} \) and \( R_{O2} \) are deduced from POLDER data
- \( \sim \) is a POLDER product
- \( H_a \) is estimated from an iterative procedure when:
  \[ P_{\text{app}} \ (H_a) = P_s \ (ECMWF) \]
Study Case over East Asia

Polder scene over East Asia

Reflectance and reflectance ratio in the POLDER channels at 865 and 910 nm
POLDER aerosol Product

Aerosol Optical thickness at 865 nm from the POLDER algorithm
Conclusion

POLDER water vapor (total column)

Operational product over land or in sunglint conditions

clear sky, daily (1 a day)

$\sim 2\ \text{kg/m}^2$ precision

Experimental algorithm over ocean:

first results: satisfactory agreement for a case study
improvement of the method: line-by-line approach
global validation to test the robustness of the method
effects of thin clouds