P2.12

Operational and Scientific Applications of Ozone Data from NPP and NPOESS

John Hornstein[1], Lawrence Flynn[2], Craig Long[3], Rich McPeters[4], Degui Gu[5], Dorothy Durnford[6], John Gyakum[6], Eyad Atallah[6], Marco Carrera[6]

[1]Naval Research Laboratory, [2] NOAA/NESDIS, [3] NOAA/NCEP, [4]NASA/GSFC, [5]Northrop Grumman, [6]McGill University

NPOESS and NPP

NPOESS
- Replaces the NOAA and DMSP polar orbiting constellations
- Joint project of NOAA, NASA, and DoD
- Polar Sun-synchronous orbit, 05:30 and 13:30 ascending
- Launch of first satellite in 2013

NPP (NPOESS Preparatory Project)
- Pathfinder for some of the main NPOESS sensors
- Joint project of NPOESS and NASA
- Polar Sun-synchronous orbit (10:30 descending node)
- Launch in 2009

NPOESS and NPP Ozone Sensors

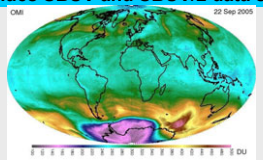
- OMPS (Ozone Mapping and Profiler Suite): primary source of the NPOESS/NPP ozone products
- CrIS (Cross-Track Infrared Sounder): supplemental source

NPP and NPOESS Ozone Data will be Crucial

Apart from OMPS and the instruments on MetOp, the NPP and NPOESS eras will not have many sources of data on ozone. The pipeline is nearly empty.

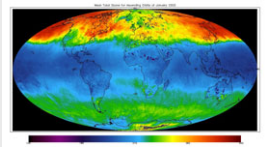
The OMPS Ozone Sensors

- Measure the imprint of ozone absorption on the spectrum of scattered sunlight
  - Can measure only on the day side of each orbit (hence not in polar night)
- Nadir Total Column
  - Backscattered UV sunlight (300 to 380 nm)
  - Continues TOMS and OMI data sets
- Nadir Profile, vertical resolution 7 to 20 km
  - Backscattered UV sunlight (250 to 310 nm)
  - Continues SBUV and SBUV/2 data sets



CrIS

- Cross-track Infrared Sounder
- Nadir-viewing FTIR
- Data (3.9 to 15.4 μm) includes the 9.6 micron ozone band
- Will provide an alternative measurement of the ozone total column
- Night side of orbit as well as day side
  - Can measure in polar night
- Less affected by space radiation (South Atlantic Anomaly, Auroral Ovals)
- On NPP and on the 05:30 and 13:30 NPOESS orbits
- CrIS is part of the Cross Track Infrared and Microwave Sounder Suite (CrIMSS)



Operational Uses of the Ozone Data

Weather Forecasting and Atmospheric Data Assimilation

Major weather prediction centers worldwide are developing methods of assimilating satellite data on ozone, and of forecasting stratospheric ozone

ECMWF, UK Met Office, NESDIS, NRL/Monterey and FNMOC

Long-Term (6-10 day) Forecasting

Stratospheric ozone → Stratospheric heating/cooling
→ Temperature structure in the stratosphere
→ Winds in the stratosphere, including jets

-- Short term forecasts implicitly take ozone heating into account when they use updated satellite data on temperature profiles.
-- Long term forecasts must forecast temperature profiles more days in advance, hence depend more on the ozone distribution used.

Short-Term Forecasting

Ozone total column data can be used to compensate for gaps in the radiosonde + aircraft observational network, avoiding temporary blindness to strengthening troughs.

See over→

UV index

Correction of IR data for absorption by zone

Climate monitoring
-- CDRs (Climate Data Records) will be produced by NASA (and NOAA?)

Scientific Uses of the Ozone Data

Process studies
-- Ozone hole
-- Sudden stratospheric warmings, and other polar vortex dynamics
-- Ozone mini-holes due to synoptic scale uplift
-- Exchange between the stratosphere and the troposphere
Continuation of existing time series.
Climate science
Data assimilation

Operational and Scientific Uses of Ozone-Related Data

Auxiliary data products, mostly to be produced as NOAA-unique data products, separate from the NPP and NPOESS IDPS
-- Aerosol index, fires, volcanoes
-- PMCs (from Nadir Profiles)
-- High PSCs (from Nadir Profiles)
-- Fires, aerosol index, volcanoes (TC)
-- SO2 index (a potential product)

Ozone Data Can Help Prevent Forecasting Fiascos

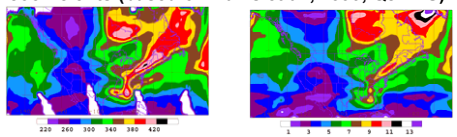
(Dorothy Durnford, John Gyakum, Eyad Atallah, Marco Carrera, McGill U., building on Davis *et al.*, 1999, QJRMS)

Numerical Weather Predictions (NWP) are initialized by nudging a first guess field towards the observed data.
Where there are no data to assimilate, the initial fields consist entirely of the first guess field.
Over the United States (US) there are dense observation networks of radiosondes and aircraft, but the network is less dense over the oceans and even over many continental regions, including Canada.
A weather system developing in any of these data sparse regions can surprise the forecast models, and result in a forecast fiasco over the US.
Unlike radiosondes and aircraft, satellite fields provide nearly uniform global coverage, and can help prevent nasty surprises.
In particular, satellite measurements of the ozone total column (TC) contain dynamical information because they are correlated with the mean potential vorticity (PV) over the layer from 400-50 hPa.

Example discussed here: the "surprise" East coast snow storm of 24-25 January 2000.

We found that TC ozone fields generated better NWP initial conditions than did the operational initial conditions, for the 24-25 January 2000 event.

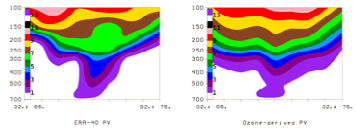
Our algorithm for generating NWP initial conditions from a TC ozone field:
1) Calculate the 2D field of mean layer PV from the 2D ozone TC field, using linear regression and correlation coefficients (based on Davis et al., 1999, QJRMS):



(18 UTC 24 January 2000)

Total column ozone (DU) Ozone-derived layer mean PV (PVU)

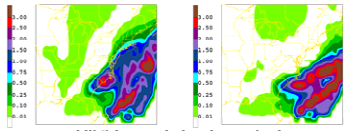
2) Calculate the 3D PV field from the 2D field of mean layer PV, using statistical PV profiles (based on Davis et al., 1999, QJRMS);



PV vertical cross sections at 32N (PVU)

3) Invert the 3D PV field to obtain initializing winds, temperatures and heights (based on Davis and Emanuel, 1991, MWR).

NWP forecast: used the limited area, non hydrostatic Mesoscale Compressible Community model (MC2), which uses a semi-implicit, semi-Lagrangian scheme. All model runs use identical boundary conditions, a horizontal resolution of 32 km, and 35 levels to 30 km.



The ozone-derived accumulated precipitation totals were smaller than those from ERA-40 and from the operational 24/18 Eta. But the ozone-derived forecast contains a significant onshore region having more than 1 inch of precipitation. The ozone-derived field is better than the 24/12 operational Eta field: the onshore precipitation values are comparable, but the Eta's heavy precipitation region is too far north. The good general agreement is significant, considering that the onshore precipitation was induced by an upstream trough that had been over land for four days, helping the operational models, while the ozone-derived field was based on a single 2-dimensional dataset.