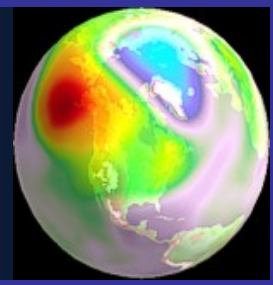
JCSDA 5th Workshop on Satellite Data Assimilation
May 1-2, 20067

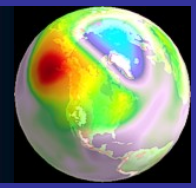


Improved Photochemical Parameterizations of Stratospheric O_3 and H_2O for NWP models

John McCormack
john.mccormack@nrl.navy.mil
Naval Research Laboratory, Washington DC, USA

http://uap-www.nrl.navy.mil/dynamics/html/chem2dopp/chem2d_opp.html

CHEM2D Ozone Photochemistry Parameterization: CHEM2D-OPP



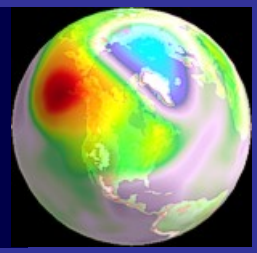
CHEM2D-OPP is based on the approach of *Cariolle and Deque* (1986), where ozone mixing ratio tendency is expressed as a Taylor series expansion about a mean state (f_o, T_o, c_{O3o}):

$$\frac{df}{dt} = \underbrace{(P-L)^o}_{1} + \underbrace{\frac{\partial(P-L)}{\partial f}\bigg|_o}_{2}(f-f^o) + \underbrace{\frac{\partial(P-L)}{\partial T}\bigg|_o}_{3}(T-T^o) + \underbrace{\frac{\partial(P-L)}{\partial c_{O_3}}\bigg|_o}_{4}(c-c^o_{O_3})$$

- **Photochemistry coefficients 1- 4 are computed offline with zonally averaged CHEM2D model of the middle atmosphere with full photochemistry**
- **f_o, T_o, c_{O3o} are specified from climatology.**
- **Zonal monthly mean coefficients stored as lookup tables (1000-0.001 hPa).**

Testing CHEM2D-OPP in NOGAPS-ALPHA

NOGAPS with Advanced Level Physics-High Altitude

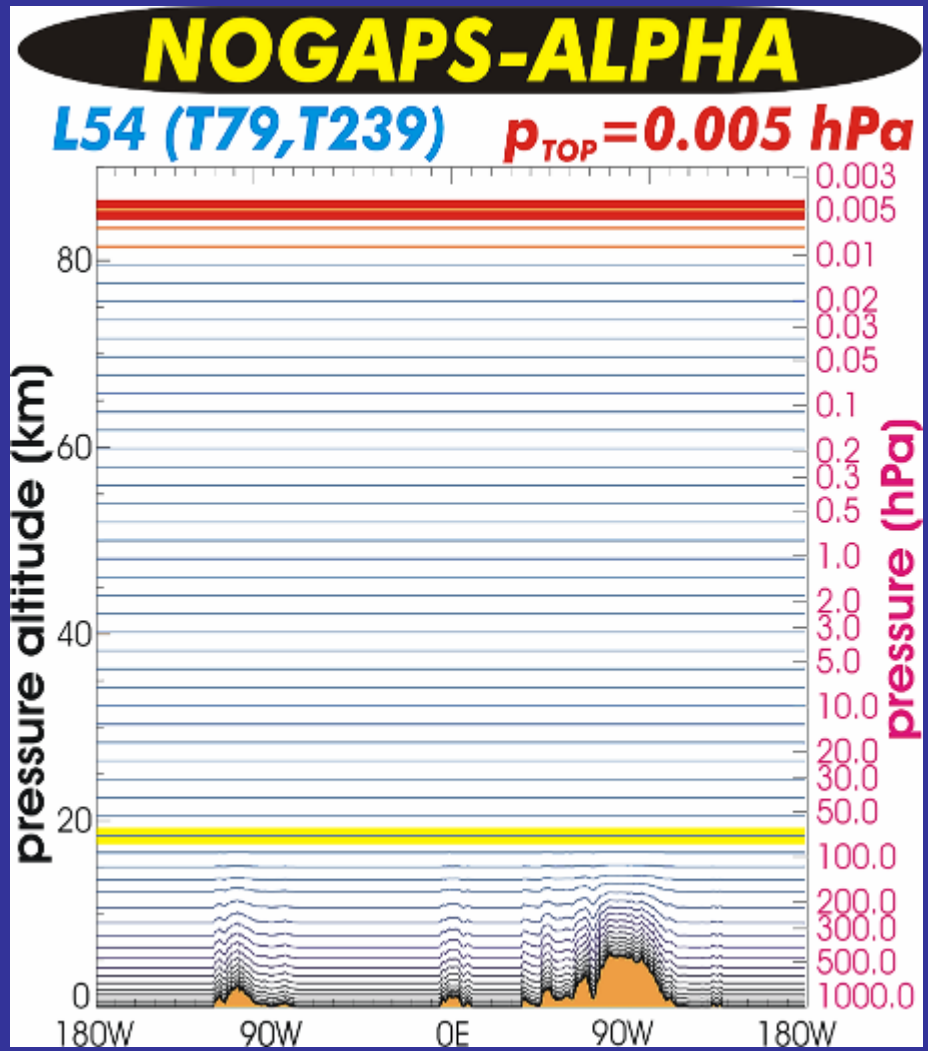


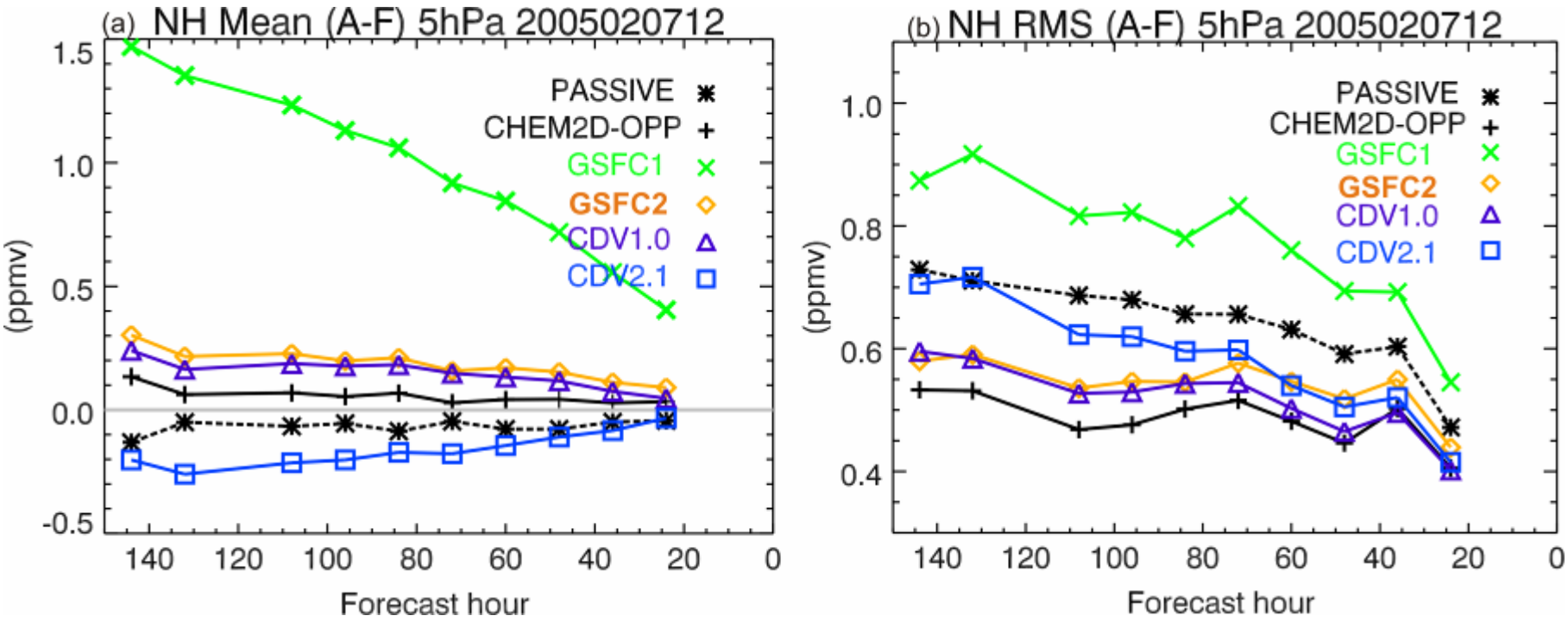
- **Hindcast mode**: *6-day free running simulations initialized with meteorological analyses, compared with satellite and in-situ O3 profile measurements (McCormack et al., ACP, 2004 & 2006)*

Model Configuration;

- *T79 & T239 spectral truncation*
- *Radiation scheme uses model O_3*

- **3 different O_3 photochemistry schemes tested**
  - *GSFC 2D model (P-L)*
  - *ECMWF Cariolle and Deque*
  - *NRL CHEM2D-OPP*



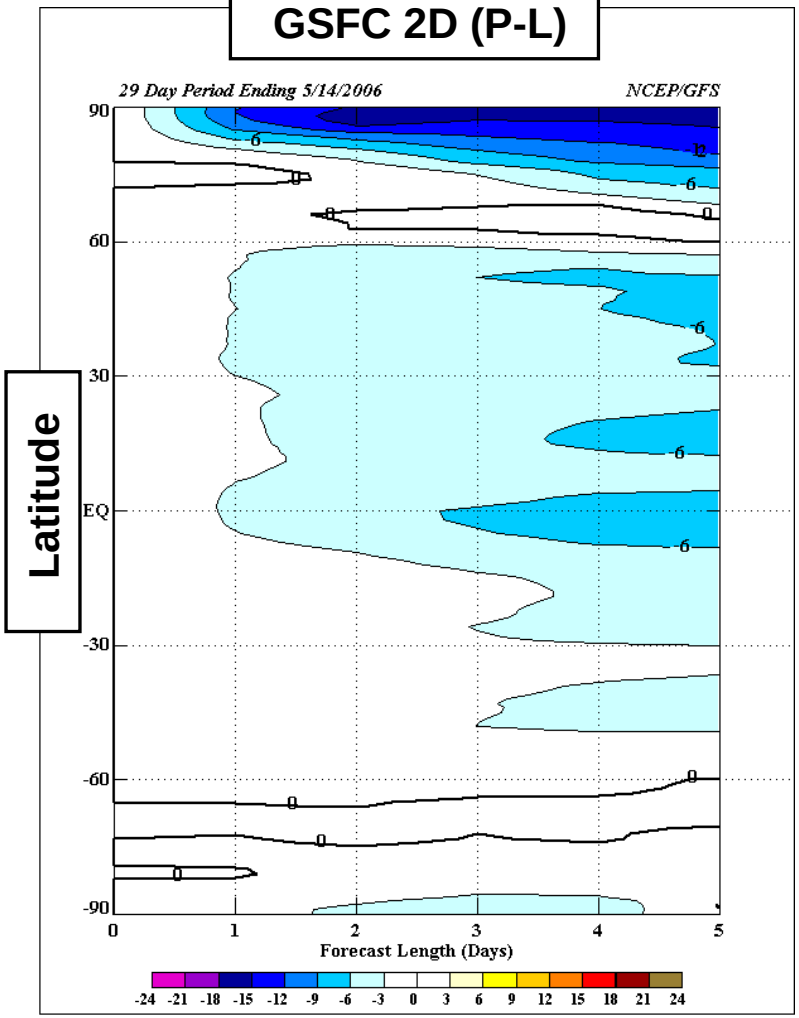


- **NOGAPS-ALPHA ozone "forecasts" (F) using different photochemistry parameterizations are compared with NASA GEOS4 ozone analyses (A).**
- **In the NH, CHEM2D-OPP yields smallest mean and RMS (A-F) among the different schemes over forecast times 24-144 hrs for 7 Feb 2005 12UT.**

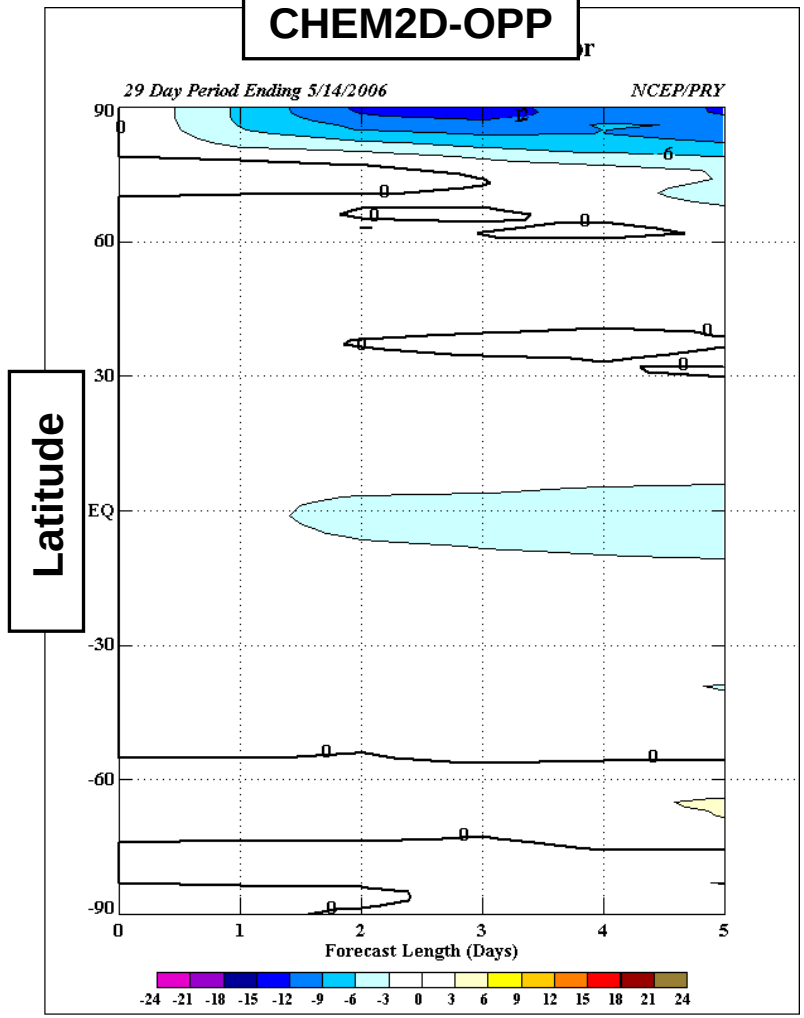
McCormack, J., S. Eckermann, D. Siskind, and T. McGee, "CHEM2D-OPP: A new linearized gas-phase ozone photochemistry parameterization for high-altitude NWP and climate models", *Atmos. Chem. Phys*., *6*, 4943-4972, 2006.

Testing CHEM2D-OPP in NCEP GFS

GSFC 2D (P-L)

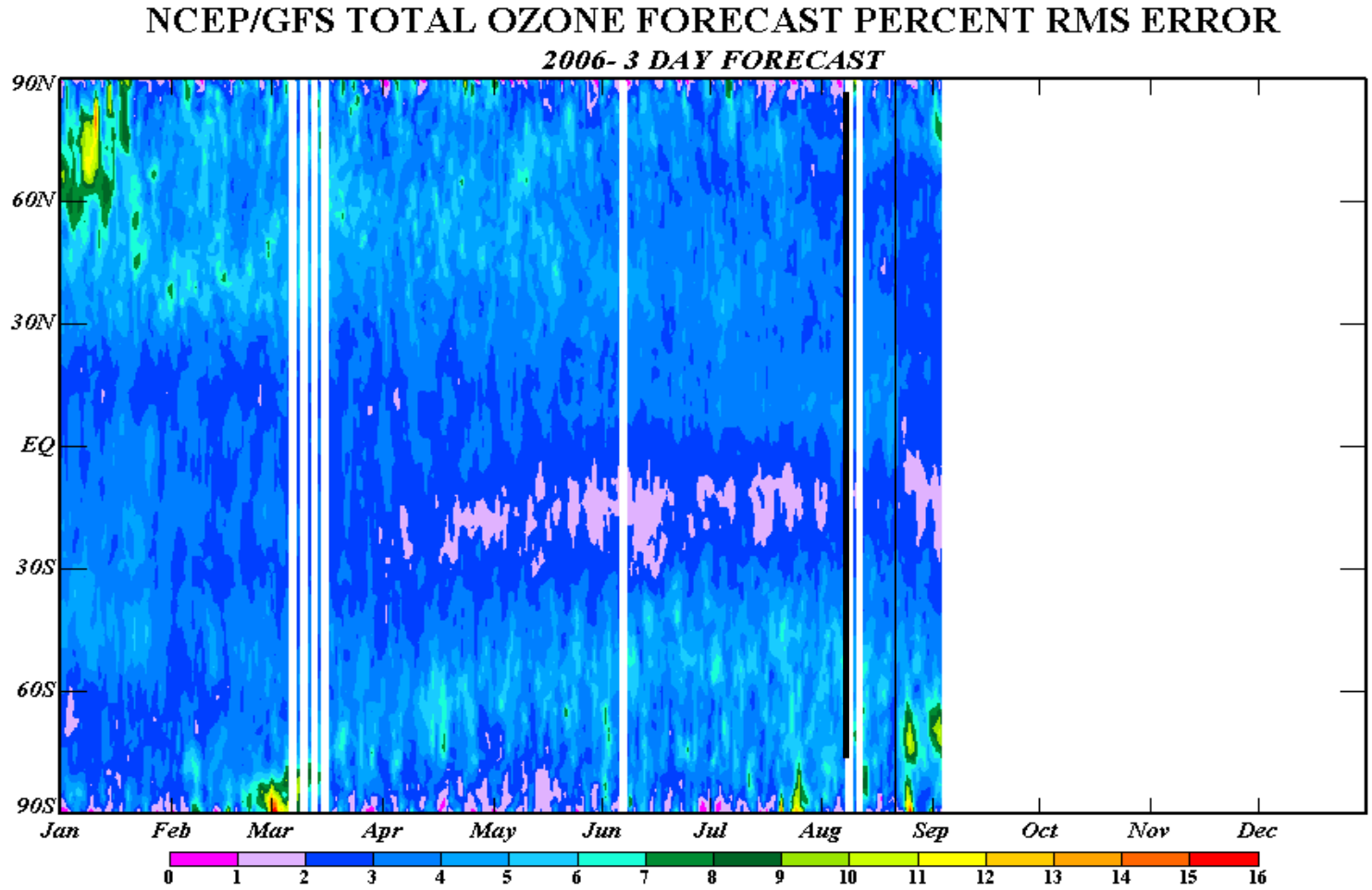


CHEM2D-OPP



NCEP GFS total ozone forecast errors are much lower with 2-term CHEM2D-OPP in place of GSFC 2D model O_3 production/loss rates.

(JCSDA Quarterly Newsletter 15, June 2006. Figure courtesy C. Long, NCEP/CPC)



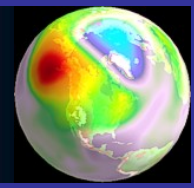
> Zonal Mean Percent RMS Error for forecast day 3

➢ Black vertical line denotes date of new code implementation (22 Aug).

> Noticeable effects between 40N and 40S. Little effect poleward of 40°.

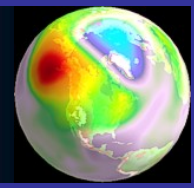
(Figure courtesy C. Long, NCEP/CPC)

FY06 Accomplishments and Deliverables Under JCSDA grant



- Implementation of NRL CHEM2D ozone photochemistry parameterization (CHEM2D-OPP) in Navy's high altitude NWP model, NOGAPS-ALPHA.
- Comparison of CHEM2D-OPP performance with existing operational ozone photochemistry schemes: NCEP GSFC 2D model rates (GFS) and ECMWF CD86 coefficients (IFS).
- Results published in Atmospheric Chemistry and Physics (*McCormack et al., ACP, 6, 4943-4972, 2006*).
- CHEM2D-OPP transitioned to NCEP and FNMOC.
- CHEM2D-OPP tested in 30-day GFS parallel run. Results published in July 2006 *JCSDA Newsletter*.
- CHEM2D-OPP in operational GFS as of 22 August, 2006.

Future Work



- Calculate CHEM2D stratospheric CH_4 oxidation rates and mesospheric H_2O photolysis rates as functions of latitude, altitude, and month. ✓ (done)
- Compare CHEM2D-based H_2O photochemistry parameterization with 1D ECMWF scheme. (ongoing)
- Implement both 1D ECMWF and CHEM2D H_2O photochemistry schemes in NOGAPS-ALPHA, compare model middle atmospheric H_2O with EOS Aura MLS measurements.
- Incorporate new CHEM2D O_3 and H_2O photochemistry parameterizations in high-altitude version of Navy's data assimilation system – NAVDAS.