A SIMPLIFIED MODEL FOR THE STUDY OF SMOKE PLUME DISPERSION FROM GRASSFIRES AND A METHODOLOGY FOR FORECASTS VALIDATION WITH SATELLITE IMAGERY

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INTRODUCTION

GRASSFIRES IN THE PARANA RIVER DELTA
- Due to agricultural management practices for land clearing
  - In April and May 2008
  - Up to 570 fire locations and 70,000 hectares burnt out.

SMOKE EVENTS IN THE LA PLATA RIVER REGION
- Smoke propagated far away from that region in some cases
  - Uncontrolled during April 16-20, affected Buenos Aires city in an extreme event without historical precedent.

METEOROLOGICAL CONDITIONS

Drought and persistence of anomalous northwesterly winds contributed to that situation, which under normal conditions for that time of the year would not have occurred.

SEVERE LOCAL AND REGIONAL IMPACT
- Increased health problems, eye irritation, etc.
- Hazardous driving conditions and accidents that forced the intermittent closure of highways, and inoperability of ports and airports.

THE HIRHYLTAD MODEL

High-Resolution Hybrid Lagrangian and Atmospheric Dispersion model

It is hybrid because:
- It uses a Lagrangian coordinate system (mobile) to calculate the trajectories of individual elements of the smoke plume, and an Eulerian framework (fixed) to calculate concentrations in a high resolution grid.
- It was created from a smoke line model, whose input is a forecasted wind field at discrete time intervals, and from the Gaussian model, which assumes homogeneous and stationary conditions, as well as variability.

Adaptation of the Gaussian model (sumary)

(HIRHYLTAD STEPS):

1. SMOKE LINE
   - with lagrangian trajectories

2. SMOKE PUFFS IN THE HORIZONTAL
   - with Pasquill-Diffusion dispersion coefficients and Pasquill stability classes

3. SMOKE CONCENTRATIONS IN A HIGH RESOLUTION GRID
   - for a z-dependent vertically integrated

RESULTS AND DISCUSSION

6 EXPERIMENTS PERFORMED, COMBINING:
- etaSM / MBLM / obs
- MBLM / etaSM
- Diagnostic mode
- Prognostic mode

SMOKE PLUME SIMULATIONS

1. Single-source smoke
   - Error score:
     - EXP1: 86.7%
     - EXP2: 67.8%
     - EXP3: 73.6%

2. Multiple-source plumes
   - Error score:
     - EXP1: 56.7%
     - EXP2: 63.3%

FACTORS THAT AFFECT ERRORS

- Meteorological Models
- Dispersion model
- Methodology
- Level of accuracy
- Displacement
- Validation

METEOROLOGICAL MODELS AND EXPERIMENTS

EtaSM REGINAL MODEL
- Developed in the 70s in the former Yugoslavia by Mecking and Janjic, and subsequently improved and upgraded at NCEP, implemented at SMN in 2002
  - Horizontal: T40 L91 N and 4x5° Grid
  - Boundary conditions system
  - Convective and initial conditions are provided by the GFS model
  - Smokey in a hydrostatic mode, for 28 hydrostatic pressure levels in the vertical.
  - It is operated and run twice a day (00 and 12 UTC) performing 12-hour forecasts at 3-hour intervals.

MESOSCALE BOUNDARY LAYER MODEL (MBLM)
- Primitive equation, dry and hydrostatic
- High definition of the water-land temperature gradient
- Horizontal resolution 0.01° (2 Km)
- Vertical domain 12 levels distributed according to a log-linear spacing
  - S0.01: 0, 0.4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096
  - Upper boundary condition: geostrophic wind at the model top.
  - Lower boundary condition: definition of a surface heating function at z=0
  - Delta assimilation from observations (MBLM, Meso) or large-scale model outputs

SELECTION OF SMOKE EVENTS (ie. associated fires) AND DIGITIZATION

Subjective process: smoke outlines are produced manually onto the MODIS 500m-resolution imagery MCD12Q2 automated fire detection product was NOT used (false classifications + no detections)

OBSERVATION + DIGITIZATION

SIMULATION with HIRHYLTAD

VALIDATION with true direction index

EXAMPLE 1

Single smoke plume

PM2.5 = 1.9, PM10 = 3.2

EXAMPLE 2

Multiple-source plumes

PM2.5 = 1.9, PM10 = 3.2