MAP D-PHASE – High Resolution Guidance in Steep Terrain
Recherche en Prevision Numerique

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   i) Roughness length case study (23 July 2007)
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4) Precipitation verification and model comparison
5) Impact on 2010 Olympics project
MAP D-PHASE Description

• Fourth phase of the Mesoscale Alpine Project (MAP), a Swiss-led project that evaluated high resolution numerical guidance in the Swiss Alps (MC2)

• Demonstration of Probabilistic Hydrological and Atmospheric Simulation of flood Events in the Alpine region

• 2nd WWRP Forecast Demonstration Project
MAP D-PHASE Description

Project Steering Committee:

Bouttier, Francois  Météo France
Buzzi, Andrea  Institute of Atmospheric Sciences and Climate (ISAC-CNR)
Dorninger, Manfred  Universität Wien
Frustaci, Giuseppe  CNMCA
Mylne, Ken  UK Met Office
Ranzi, Roberto  Università di Brescia
Richard, Evelyne  Laboratoire d’Aéorologie CNRS/UPS
Rossa, Andrea  Centro Meteorologico Teolo ARPA Veneto
Rotach, Mathias  MeteoSwiss
Schär, Christoph  Institute for Atmospheric and Climate Science (IACETH)
Staudinger, Michael  ZAMG - Wetterdienststelle Salzburg
Volkert, Hans  Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Wulfmeyer, Volker  Universität Hohenheim

MeteoSwiss Leads: Marco Arpagaus and Felix Ament

WG Data Interface: Andrea Montani (ARPA-SIM Emilia-Romagna)

WG Hydrology: Roberto Ranzi (Università di Brescia) and Christoph Hegg (Eidg. Forschungsanstalt WSL)

WG Verification: Manfred Doringer (Universität Wien)

WG Data Policy: Mathias Rotach (MeteoSwiss)

Participants: Over 130 participants, primarily from Europe
D-PHASE forecasting strategy for heavy precipitation and flash flood events is to establish:

“an end-to-end forecasting system for Alpine flood events that will be set up to demonstrate state-of-the-art forecasting of precipitation-related high impact weather”.

MAP D-PHASE Implementation Plan
MAP D-PHASE Description

Research problems relevant to D-PHASE:

– Numerical simulation of the physical mechanisms responsible for heavy orographic precipitation
– Ensemble prediction approach (standard and high resolution)
– High resolution (< 4 km) operational numerical guidance for use in the forecasting and decision-making process
– Coupled and offline hydrological models
– Evaluation of radar estimates of precipitation in steep terrain
MAP D-PHASE Description

- Models provide guidance on European domain
- Forecasts for Alpine region only
<table>
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<th>D-PHASE Description</th>
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</thead>
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<tr>
<td><strong>DOP Limited-Area Ensemble</strong></td>
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<tr>
<td><strong>Prediction Systems (5)</strong></td>
</tr>
<tr>
<td>ARPA – Italy (CLEPS [16: 10km])</td>
</tr>
<tr>
<td>ARPA – Italy (CSREPS [16: 10km])</td>
</tr>
<tr>
<td>UK Met – England (MOGREPS [24: 25km])</td>
</tr>
<tr>
<td>INM – Spain (INMSERPS [20: 27km])</td>
</tr>
<tr>
<td>DWD – Germany (PEPS [X: 7km])</td>
</tr>
</tbody>
</table>

| **DOP High Resolution Ensembles (1)** |
| DWD – Germany (MPEPS [5: ~2]) |
| AROME - France |
| CMCGEM – Canada |
| COSMOCH2 – Switzerland |
| ISACMOL2 - Italy |
| LMK - Germany |

| **DOP High Resolution Deterministic Models (11)** |
| MeteoSwiss – Switzerland (COSMO [7,2.2]) |
| U.Hohenheim – Germany (MM5 [10,3.3,1.1]) |
| Meteo-Fance – France (AROME [11, 4.4]) |
| ARPA – Italy (COSMO [7,2.8]) |
| CNMCA – Italy (COSMO [7,2.8]) |
| DWD – Germany (COSMO [7,2.8]) |
| CNR – Italy (MOLOCH [2.2]) |
| ARPA – Italy (BOLAM/MOLOCH [7,2.2]) |
| APAT – Italy (BOLAM [33,11]) |
| IMK – Germany (MM5 [50,15,3.75]) |
| IMK – Germany (WRF [60,20,5]) |
| ZAMG – Austria (ALADIN [9.6]) |
| CMC – Canada (GEM [15,2.5]) |
DOP forecasters use an “alerts” system:

- 2-5 day lead: probabilistic
- 48 h lead: mixed deterministic
- 6 h lead: nowcasting
MAP D-PHASE Description

- Links to other projects in the region:
  - COPS: Convection and Orographically-induced Precipitation Study – enhanced ground-based and airborne observations over the German Alps [June-Aug]
  - GOP: General Observation Period [Jan-Dec]

- Shared implementation plan and data archive at the World Data Centre for Climate (WDCC)
MAP D-PHASE Description

- Enhanced precipitation observations from both *in-situ* and remote sensed platforms
- Only preliminary data is available in real-time
- “Quicklooks” are currently available, with WDCC entries to occur before the end of the GOP

Source: GOP Overview
MAP D-PHASE Description

• Collaborators for each of the European projects has access to data collected in all projects
• Projects maintain separate real time protected websites

Time line for coordinated European projects D-PHASE, COPS and GOP.
Canadian Contribution to D-PHASE

• Canada provided daily high resolution (3 km) guidance during MAP (Sept-Nov 1999) using MC2

• MSC researchers supported forecasting at the MAP operational centre in Innsbruck, and collaborated extensively with European researchers

• Participation in D-PHASE consists of delivering high resolution (2.5 km) forecast guidance products
Canadian Contribution to D-PHASE

- High resolution (2.5 km) GEM model run once-daily over the MAP D-PHASE domain
- Analysis from meso-global used as IC for driving model
- High resolution forecast to 18 h lead
Canadian Contribution to D-PHASE

- GEM model runs daily in LAM configuration driven by the meso-global
- Nesting 35 : 15 : 2.5 km
Canadian Contribution to D-PHASE

- Model and version: GEM (LAM) v3.3.0
- Summary of configuration:

<table>
<thead>
<tr>
<th></th>
<th>GEM Driving Model</th>
<th>High Resolution Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Grid (km)</td>
<td>15 km</td>
<td>2.5 km</td>
</tr>
<tr>
<td>Vertical Levels (#)</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Domain size (#x;#y)</td>
<td>174; 199</td>
<td>600; 413</td>
</tr>
<tr>
<td>Step length (s)</td>
<td>300 s</td>
<td>60 s</td>
</tr>
<tr>
<td>Orography Growth (h)</td>
<td>4 h</td>
<td>4 h</td>
</tr>
<tr>
<td>PBL Scheme</td>
<td>Moist TKE</td>
<td>Moist TKE</td>
</tr>
<tr>
<td>Convective Scheme</td>
<td>Kain-Fritsch</td>
<td>–</td>
</tr>
<tr>
<td>Explicit Scheme</td>
<td>Milbrandt-Yau (single) yes</td>
<td>Milbrandt-Yau (single)</td>
</tr>
<tr>
<td>Roughness Reduction</td>
<td>no</td>
<td></td>
</tr>
</tbody>
</table>
Canadian Contribution to D-PHASE

- D-PHASE runs are class experimental
- Daily runs are completed by ~0730 UTC (30 min)
- Guidance: ~0800 UTC
- Archive: ~1030 UTC
Canadian Contribution to D-PHASE

- GEM Driving Model (15 km)
  - Grib Encoding
  - Gridpt Creation
- GEM HiRes Model (2.5 km)
  - Grib Encoding
  - Gridpt Creation

Gridpt Creation

CFS Gridpt Database

D-PHASE Images

D-PHASE Alerts

- D-PHASE Visualization Platform (MeteoSwiss)
- Hamburg Data Archive (WDCC)
- COPS OC
- U. Vienna
- DWD

Internal

External

VERA Grids

PEPS Grids

D-PHASE Images

COPS Images

11/02/07

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Canadian Contribution to D-PHASE

Key features of GEM v3.3.0 exploited during D-PHASE:

- “Hollow cube” initialization and updates parallelizes nesting and improves delivery time by >1h for the D-PHASE grid

- Nested M-Y microphysics allows for continued development of the advanced bulk parameterization scheme

- “Growing orography” reduces initial gravity wave generation

- Roughness length reduction limits sub-gridscale impact
Canadian Contribution to D-PHASE

- Experimental implementation for D-PHASE from 1 June – 30 Nov 2007
- Three major upgrades to the experimental system since 1 June:
  - Roughness length reduction
  - Reduced hydrometeor fall speeds
  - Reduced source/sink in microphysics
Case Study: Roughness Length

- 12 h forecast initialized 0000 UTC 23 July
- “Low” resolution orographic database leads to very large effective roughness length ($z_{\text{eff}}$) in steep terrain
- Using vegetation-only roughness length in the model improves wind speed predictions
Case Study: Roughness Length

In statically neutral conditions:

\[ U(z) = \left( \frac{u_*}{k} \right) \ln \left[ \frac{(z - d)}{z_o} \right] \]

- \( U(z) \) wind speed at height \( z \)
- \( u_* \) friction velocity
- \( k \) von Karman constant
- \( d \) displacement height
- \( z_o \) aerodynamic roughness length

The aerodynamic roughness length corresponds to the height and density of individual roughness elements but is **not** equal to their height.
Case Study: Roughness Length

• Effective roughness lengths are used in models instead of the “vegetative” (aerodynamic) value to account for:
  – turbulent shear stresses
  – pressure forces

• The total surface drag is therefore represented in $z_{\text{oeff}}$

• Subgrid orographic effect on $z_{\text{oeff}}$ is poorly computed with a low resolution orographic database
Case Study: Roughness Length

Original Surface Roughness Fields

1 June - 25 July

Modified Surface Roughness Fields

26 July - 30 Nov
Case Study: Roughness Length

6h forecast near-surface winds (colour bar) and observations (white numbers) valid 1200 UTC 23 July

Full Roughness vs Observations

Modified Roughness vs Observations
Case Study: Roughness Length

Reduced effective roughness length eliminates severely underpredicted wind speeds, most of which occur over the Alps.
Case Study: Roughness Length

Reduced effective roughness length eliminates severely underpredicted wind speeds, most of which occur over the Alps.
Case Study: Roughness Length

<table>
<thead>
<tr>
<th></th>
<th>Original zoeff</th>
<th>Modified zoeff</th>
<th>Meso-Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias (kt)</td>
<td>-1.6</td>
<td>0.6</td>
<td>-4.5</td>
</tr>
<tr>
<td>RMSE (kt)</td>
<td>6.3</td>
<td>5.3</td>
<td>8.1</td>
</tr>
<tr>
<td>MAE (kt)</td>
<td>3.9</td>
<td>3.5</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Observations: 141

- Reduction of the effective roughness length improves the forecast for near-surface winds in the Alpine region
- More detailed study of the effective roughness length at high resolution are planned (Alexander and Ayrton)
Case Study: Mountain Wave

• Mountain wave observed at Baden Airpark in southwestern Germany at 1700 UTC 26 July 2007

• Unlike MAP, the main objective of D-PHASE is not processes-based so no flights were scheduled

• The GEM forecasts show internal gravity wave development and feedback on moist physics

Source: Bernhard Mühr
Case Study: Mountain Wave

A consistent formulation of the hybrid coordinate vertical motion eliminates noise from the idealized Schar mountain wave case (Claude and Andre).

Source: Claude Girard

11/02/07
Case Study: Mountain Wave

Omega vertical motion shows a perturbed mountain wave structure upshear (southwest) of Baden Airpark in the 11h forecast (valid 1700 UTC)
As a result of a locally-increased Brunt-Vaisala frequency, internal gravity waves are generated upshear of the Rhine Valley but not downshear.
Case Study: Mountain Wave

Upwards motion in the mountain waves feeds back on the model through microphysical processes by 2300 UTC.
Case Study: Mountain Wave

- Observed mountain wave is represented in the GEM forecast for 23 July 2007
- Fine structures suggest that the new hybrid coordinate vertical motion computation may improve the prediction
- The importance of moist process feedbacks suggests that correct handling of internal gravity waves is potentially very important in complex terrain
Precipitation Verification

• Upgrades to the Milbrandt-Yau microphysics scheme (Jason) eliminate an observed dry bias and result in a wet bias

• Verification against Swiss radar precipitation accumulation retrievals supports in-house verification of M/Y
The GEM driving (CMCGEML) and high resolution (CMCGEMH) forecasts are too dry for the JJA period compared to both observations and the other D-PHASE models.
A 50% domain-averaged underprediction bias (JJA) has been replaced with an October overprediction bias following September M/Y upgrades suggesting that further sensitivity testing will be beneficial.
Summary

• The MAP D-PHASE DOP runs 1 June – 30 Nov 2007
• Primary focus is QPF and extreme event forecasting
• Canadian contribution is 2.5 km deterministic guidance
• Recent version of GEM with additional features designed for steep terrain simulation is used
• Case studies and verification provide guide development
Context

• Feedback, case studies and verification results continue to guide development for the experimental NA LAMs

• The D-PHASE model and configuration serve as a prototype for the Vancouver 2010 system

The D-PHASE data is available for all researchers – collaboration on projects to improve steep terrain guidance will be very important for the lead up to the 2010 Olympics.
Resources

MAP D-PHASE DOP URL:  http://www.d-phase.info
(contact Ron for user name and password)
MAP D-PHASE Homepage:
http://www.map.meteoswiss.ch/map-doc/dphase/dphase_info.htm
COPS IOP URL:  http://www.cops2007.de
(contact Ron for user name and password)
COPS Homepage:  https://www.uni-hohenheim.de/spp-iop
GOP Homepage:  http://gop.meteo.uni-koeln.de
WDCC (Hamburg) Data Archive:  http://cera-www.dkrz.de/WDCC/ui/Index.jsp
OCM Suite and Job Names:  gemlam/DL00, gemlam/DH06
CMC GRIDPT Database Path:
  driving model:  /data/gridpt/dbase/prog/lam.spinup/dphase.[(eta)(pres)]
  high resolution:  /data/gridpt/dbase/prog/lam/dphase.[(eta)(pres)]
It's over ...  
What are you doing, Dave?
MAP D-PHASE Description

Primary D-PHASE and collaborations products:
• Production of daily hydrometeorological forecasts
• Generation of high resolution ensemble products
• DOP Forecaster evaluation of numerical guidance
• Real time radar and VERA-based objective verification
• Model and observational data archival for future evaluations and comparisons
Case Study: Mixed Precipitation

• Moderate/heavy mixed precipitation event on 22 October 2007 (runs from 0000 UTC 22 October)
• Low centre over eastern Italy with rain/cloud extending from Italy to the Ukraine
• Single and double moment versions of the M/Y scheme are compared against extensive observations
Case Study: Mixed Precipitation

Eumetsat infrared image for 2200 UTC 22 October shows the low centre over the Adriatic and extensive cloud over eastern Europe.
Case Study: Mixed Precipitation

Total run (18h) precipitation accumulations from both single and double moment M/Y schemes compare well with AMSU-retrieved values.

Source: http://kermit.bham.ac.uk
Case Study: Mixed Precipitation

M/Y single moment D-PHASE 9h forecast valid 1500 UTC 22 October and verifying obs / radar imagery

Forecast precipitation generally matches synop observations

Source: http://www.smr.arpa.emr.it
Case Study: Mixed Precipitation

M/Y double moment experimental 9h forecast valid 1500 UTC 22 October and verifying obs / radar imagery

ENE/WSW band over Croatia is better handled in double moment M/Y
Case Study: Mixed Precipitation

Rain (red hash on black), snow (white hash) and mixed precipitation (red hash on colour) and temperature (colour bar) for D-PHASE 6-h forecast valid 1200 UTC 22 October
Case Study: Mixed Precipitation

Rain (red hash on black), snow (white hash) and mixed precipitation (red hash on colour) and temperature (colour bar) for double moment 6-h forecast valid 1200 UTC 22 October
VERA analyses are performed hourly using a background “fingerprint” conceptual models appropriate to the regional topography.
Case Study: Mixed Precipitation

- Both schemes accurately predict sustained heavy precipitation over Forli, Italy
- Double moment produces more precipitation and a stronger band that moves northwestward across Croatia and Slovenia after 1200 UTC
- Schemes perform similarly for mixing to snow
Precipitation Verification

APPENDIX

Radar-based verification scores for the pre-upgrade (JJA) M/Y scheme
The size of the PEPS ensemble varies daily and within the forecast range as lagged high resolution (<4km) members are added and dropped from the system.

Source: http://www.dwd.de