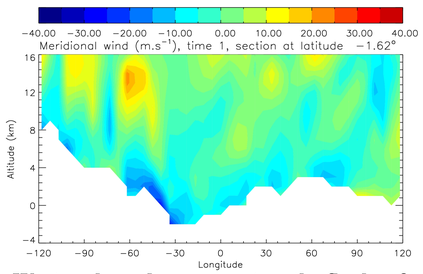
A NEW MESOSCALE MODEL FOR THE MARTIAN ATMOSPHERE

Aymeric Spiga (spiga@lmd.jussieu.fr) and François Forget

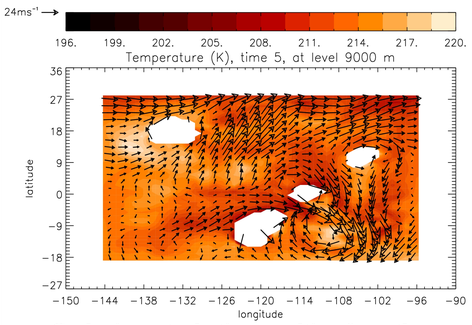
Laboratoire de Météorologie Dynamique, Université Pierre et Marie Curie, Paris – France

Transition from synoptic to meso scales, cyclogenesis and frontology



Western boundary current on the flanks of the Tharsis region

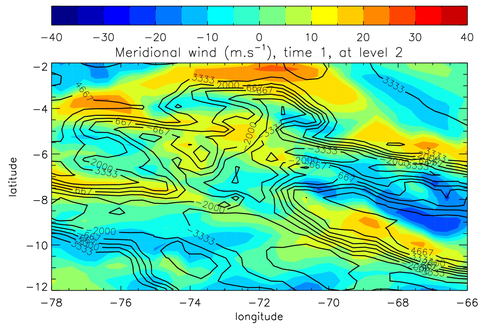
Longitude-altitude cross-section of meridional wind at sol 389 (after 18 elapsed simulation sols), 00h UTC. 43x33x30 / Hydrostatic mode / dx=200 km / dt=185 s / dz=1.3 km (above 2 km) / dtphys=0.5 h

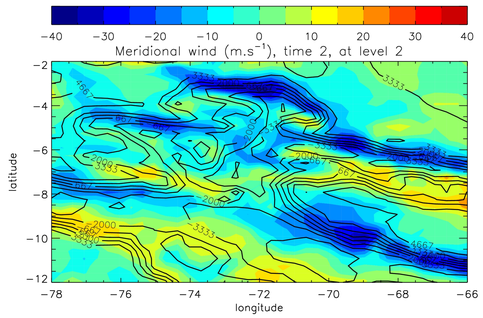


Cyclonic perturbation resulting from the interaction of two converging jets

Horizontal section of temperature with horizontal winds superimposed at sol 389 (after 18 elapsed sols), 00h LT (08h UTC). 50x50x50 / Hydrostatic mode / dx=60 km / dt=74 s / dz=700 m (above 2 km) / dtphys=0.5 h

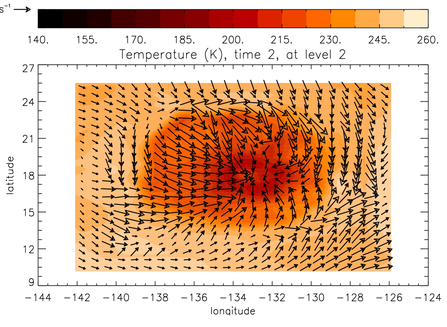
Slope winds and topographical forcings at regional scales

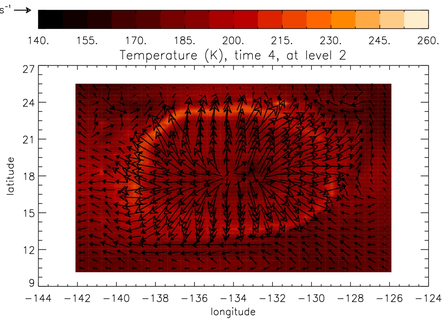




Daytime upslope and nighttime downslope winds in the Valles Marineris canyon

Horizontal section of meridional wind at sol 391 (after 4 elapsed simulation sols), 13h LT and 19h LT (18h UTC and 00hUTC). 50x50x50 / Non-Hydrostatic mode / dx=20 km / dt=25 s / dz=700 m (above 2 km) / dtphys=100 s

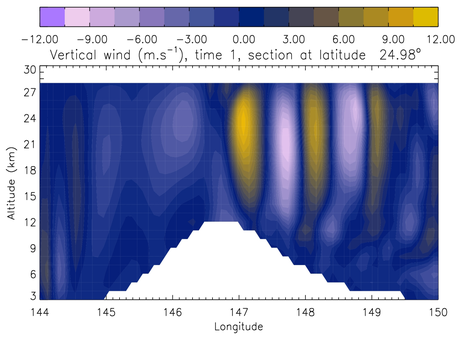


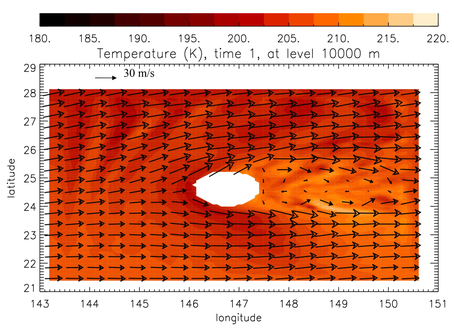


Daytime upslope and nighttime downslope winds on Olympus Mons

Horizontal section of temperature with horizontal winds superimposed at sol 391 (after 4 elapsed simulation sols), 15h LT and 03h LT (00h UTC and 12hUTC). 50x50x50 / Non-Hydrostatic mode / dx=20 km / dt=25 s / dz=700 m (above 2 km) / dtphys=100 s

Atmospheric gravity waves and mesoscale oscillations

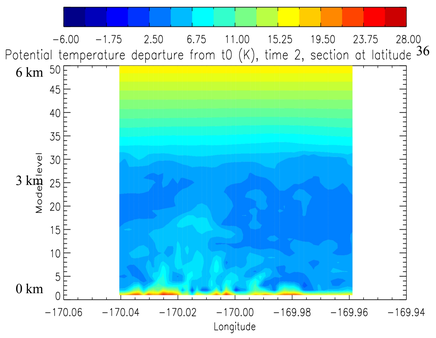


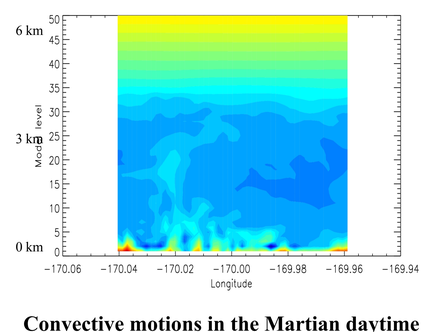


Mountain wave and turbulent disturbances in the wake of Elyseum Mons with low-level jet conditions

Longitude-altitude cross-section of vertical wind and horizontal section of temperature with winds superimposed at sol 391 (after 4 elapsed simulation sols), 10h LT (00hUTC). 90x90x50 / Non-Hydrostatic mode / dx=5 km / dt=10 s / dz=600 m (above 1.5 km) / dtphys=100 s

PBL, turbulence and convection (Large Eddy Simulations)





Convective motions in the Martian daytime planetary boundary layer in the Amazonis Planitia region

Longitude-altitude cross-section of potential temperature departure from 220K with northern fall conditions (after 1 elapsed Martian hour), 13h LT (00h UTC). Lateral boundary conditions are periodic. 50x50x50 / Non-Hydrostatic mode / dx=100 m / dt=0.5 s / dz=131 m (above 300 m) / dtphys=30 s

Dynamical core

Adapted to the planet Mars from the new generation WRF-ARW (Advanced Research Weather Research and Forecasting Model) 3D terrestrial model.

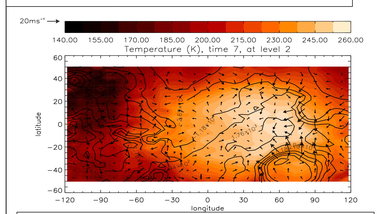
- Fully compressible non-hydrostatic Euler equations.
- Mass-based terrain-following vertical coordinates
- Arakawa horizontal C-grid.
- Different possible map projections on the sphere.
- Temporal integration by 3rd order Runge-Kutta split-explicit scheme.
- Forward-in-time scheme for tracer dynamics.
- Interactive nesting of domains of computation.
- Gravity-wave absorbing layer at the top of the model.
- Lateral boundary conditions : periodic, open, or specified from GCM inputs.
- Preprocessing system for interpolation of static and meteorological fields necessary to initialize the simulations.

Martian physics

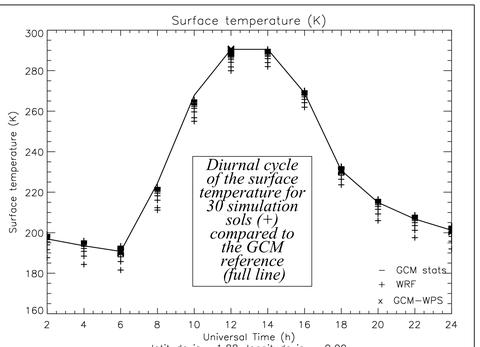
The new mesoscale model benefits from the LMD/AOPP/IAA consistent and carefully validated physical representation of the Martian CO2, dust, water and aerosols cycles. The whole LMD/AOPP/IAA Martian physics are interfaced with the adapted WRF dynamical core.

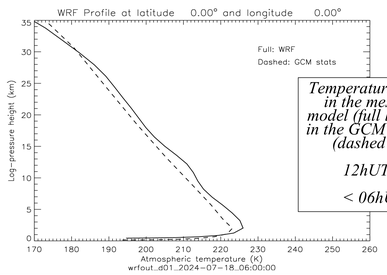
- Radiative transfer with CO2 gas absorption/emission and dust absorption, emission and diffusion.
- Turbulent diffusion scheme.
- Convective adjustment scheme.
- Soil thermal conduction model.
- Tracer (water ice, dust, chemical species) transport, dust sedimentation and lifting.
- CO2 condensation processes, microphysics, chemistry.
- NLTE processes in the upper atmosphere.

Validation in large-scale hydrostatic mode



Horizontal section of temperature with horizontal winds superimposed at 12hUTC, 20 m above the surface. See the "western boundary current" case for further comments.

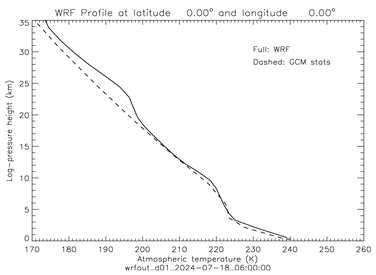




Temperature profiles in the mesoscale model (full lines) and in the GCM reference (dashed lines)

12hUTC >

< 06hUTC



References

Skamarock et al. (2005), NCAR Tech. Note / Laprise (1992), MWR 120. / Klemp et al. (2007), acc. MWR. / Forget et al. (1999), JGR 104. / Hourdin et al. (1993), JAS 50. / Forget et al., this issue. / Spiga et al. (2007), JGR 112 + this issue. / Rafkin et al. (2001), Icarus 151. / Toigo et al. (2002), JGR 107. / Tyler et al. (2002), JGR 107. / Michaels & Rafkin (2002), QJRMS 128.

Acknowledgements

AS and FF acknowledge support from ESA (contract #11369) and CNES.
AS acknowledges support from Ecole Polytechnique and Univ. Pierre et Marie Curie.